

## Fachverband Teilchenphysik (T)

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## Übersicht der Hauptvorträge und Fachsitzungen

(Hörsäle H 1, 2, 3, 4; JUR 2, 3, 4, 5, 253, 372, 490, 498;  
 VSH 05, 06, 07, 10, 11, 17, 18, 19, 116, 118; S 2, 9, 055; Poster F Foyer)

### Plenarvorträge

PV I	Mo	11:00–11:45	H 1	<b>The CNO cycles</b> — ●MICHAEL WIESCHER
PV II	Mo	11:45–12:30	H 1	<b>Das Higgs-Boson – Charakterisierung seiner Natur</b> — ●MARKUS SCHUMACHER
PV III	Di	18:30–19:30	S Aula	<b>Lise-Meitner-Lecture: Erforschung von Urknallmaterie an der Weltmaschine LHC</b> — ●JOHANNA STACHEL
PV IV	Mi	8:30– 9:15	H 1	<b>Advancing Molecular Imaging with Total-Body Positron Emission Tomography</b> — ●SIMON R. CHERRY
PV V	Mi	9:15–10:00	H 1	<b>Heavy Quarks: From Hadron to Particle Physics</b> — ●THOMAS MANNEL
PV VI	Mi	11:40–12:10	H 1	<b>Kinetic theory of waves and quanta</b> — ●HERBERT SPOHN
PV VII	Mi	12:10–12:40	H 1	<b>Topological Insulators: a New State of Matter</b> — ●LAURENS W. MOLENKAMP
PV VIII	Mi	12:40–13:10	H 1	<b>Gravitationswellenastronomie: Wir können das dunkle Universum hören!</b> — ●KARSTEN DANZMANN
PV IX	Mi	20:00–21:00	H 1	<b>Max-von-Laue-Lecture: From the “Vergangenheit der Physik” to the “Future of Physics”: Monolingualism and the Transformation of a Science</b> — ●MICHAEL D. GORDIN
PV X	Do	11:00–11:45	H 1	<b>Searching for the identity of the dark matter in our local neighbourhood</b> — ●CARLOS S. FRENK
PV XI	Do	11:45–12:30	H 1	<b>Hot QCD matter produced in heavy-ion collisions at the LHC</b> — ●SILVIA MASCIOCCHI
PV XII	Do	20:00–21:00	H 1	<b>Früher war alles besser – aber nicht die Batterien</b> — ●MARTIN WINTER

### Hauptvorträge

T 1.1	Mo	9:00– 9:45	H 1	<b>Searches for Lepton number violation with neutrinoless double beta decay</b> — ●BERNHARD SCHWINGENHEUER
T 1.2	Mo	9:45–10:30	H 1	<b>Elektroschwache Physik und QCD am LHC</b> — ●JAN KRETZSCHMAR
T 27.1	Di	8:30– 9:10	H 1	<b>Zukünftige Beschleuniger für die Teilchenphysik und Ihre Herausforderungen</b> — ●OLIVER BRUENING
T 27.2	Di	9:10– 9:50	H 1	<b>Ungelöste Rätsel und bisher keine Neue Physik in Sicht. - Was lernen wir vom Higgsboson?</b> — ●MILADA MARGARETE MÜHLLEITNER
T 27.3	Di	9:50–10:30	H 1	<b>Kosmische Strahlen vom Knie zum Knöchel - Erkenntnisse und offene Fragen</b> — ●ANDREAS HAUNGS
T 97.1	Do	8:30– 9:10	H 1	<b>Die Akte Higgs - Fünf Jahre Higgsphysik am LHC</b> — ●ROGER WOLF
T 97.2	Do	9:10– 9:50	H 1	<b>Neutrinos: wer seid ihr – und wenn ja, wie viele?</b> — ●SEBASTIAN BÖSER
T 97.3	Do	9:50–10:30	H 1	<b>New results from LHCb</b> — ●MIKA VESTERINEN
T 119.1	Fr	8:45– 9:25	H 1	<b>Dem Standardmodell auf den Zahn gefühlt: Neue Resultate vom Top-Quark</b> — ●BORIS LEMMER
T 119.2	Fr	9:25–10:05	H 1	<b>Suche nach neuer Physik am LHC</b> — ●ROMAN KOGLER
T 119.3	Fr	10:05–10:45	H 1	<b>The quest for Axions and Axion-like particles</b> — ●JAVIER REDONDO
T 120.1	Fr	11:15–11:55	H 1	<b>From Multi-Wavelength to Multi-Messenger Astrophysics: a success story</b> — ●STEFAN FUNK

T 120.2	Fr	11:55–12:35	H 1	<b>The Belle II Experiment</b> — ●CARLOS MARINAS
T 120.3	Fr	12:35–13:15	H 1	<b>Beyond the Standard Model: status and remaining hopes</b> — ●CHRISTOPHE GROJEAN

## Eingeladene Vorträge

T 47.1	Di	14:00–14:27	H 1	<b>ATLAS Search for Scalar Leptoquarks at <math>\sqrt{s}=13</math> TeV</b> — ●RUTH PÖTTGEN
T 47.2	Di	14:27–14:54	H 1	<b>Search for new physics with leptons in the final state</b> — ●SWAGATA MUKHERJEE
T 47.3	Di	14:54–15:21	H 1	<b>Suche nach vektorartigen Quarks mit Zerfällen in geboosteten Endzuständen mit dem ATLAS-Experiment</b> — ●JANET DIETRICH
T 47.4	Di	15:21–15:48	H 1	<b>Falsifying High-Scale Baryogenesis</b> — ●JULIA HARZ
T 47.5	Di	15:48–16:15	H 1	<b>The COSINUS project - development of new NaI-based detectors for direct dark matter search</b> — ●KAROLINE SCHÄFFNER
T 48.1	Di	14:00–14:27	H 3	<b>Status of the neutrino mass experiment KATRIN</b> — ●FLORIAN FRÄNKLE
T 48.2	Di	14:27–14:54	H 3	<b>The search for neutrinoless double beta decay with EXO-200 and nEXO</b> — ●THILO MICHEL
T 48.3	Di	14:54–15:21	H 3	<b>Top-Antitop Pair Production Near Threshold in Electron-Positron Annihilation</b> — ●JAN PICLUM
T 48.4	Di	15:21–15:48	H 3	<b>Ausblick auf Neue Physik durch das Higgs-Fenster</b> — ●OLEG BRANDT
T 48.5	Di	15:48–16:15	H 3	<b>Measuring the Higgs Self-coupling at the International Linear Collider</b> — ●CLAUDE DÜRIG
T 98.1	Do	14:00–14:27	H 1	<b>Exploring the LHC flavour anomalies</b> — ●LARS HOFER
T 98.2	Do	14:27–14:54	H 1	<b>Semileptonic <math>b</math>-decays: Preparing theory predictions for the era of high-luminosity experiments</b> — ●DANNY VAN DYK
T 98.3	Do	14:54–15:21	H 1	<b>Physics Prospects at Belle II</b> — ●DANIEL GREENWALD
T 98.4	Do	15:21–15:48	H 1	<b>Studies towards optimisation of a highly granular calorimeter for future linear collider detectors</b> — ●HUONG LAN TRAN
T 98.5	Do	15:48–16:15	H 1	<b>The CMS Tracker Upgrades – Pushing the Limits</b> — ●BENEDIKT VORMWALD
T 99.1	Do	14:00–14:27	H 3	<b>Photons at ultra-high energies - a new window to the universe</b> — ●DANIEL KUEMPEL
T 99.2	Do	14:27–14:54	H 3	<b>First results from TAIGA HiSCORE</b> — ●MARTIN TLUCZYKONT
T 99.3	Do	14:54–15:21	H 3	<b>Suche nach neuen Phänomenen mit Jet Substruktur Methoden und hoch-energetischen Topquarks beim ATLAS Experiment</b> — ●CHRISTOPH ANDERS
T 99.4	Do	15:21–15:48	H 3	<b>Exotic Hadrons with Hidden Charm</b> — ●SEBASTIAN NEUBERT
T 99.5	Do	15:48–16:15	H 3	<b>QCD measurements at the CMS experiment</b> — ●PAOLO GUNNELINI

## Topical Workshop: Anomalies in Flavour Physics

T 61.5	Di	18:35–19:00	H 4	<b>New Physics Scenarios for B Anomalies</b> — ●MARTIN BAUER
T 61.1	Di	16:45–17:20	H 4	<b>Anomalies in the flavour sector: experimental overview</b> — ●STEFANIE REICHERT
T 61.2	Di	17:20–17:45	H 4	<b>New physics in <math>b \rightarrow (u, c)\tau\nu</math> transitions</b> — ●MARTIN JUNG
T 61.3	Di	17:45–18:10	H 4	<b>Status of global <math>b \rightarrow s\ell\ell</math> fits in 2017</b> — ●DANNY VAN DYK
T 61.4	Di	18:10–18:35	H 4	<b>Lepton flavour non-universality in rare B decays</b> — ●SOPHIE RENNER

## Topical Workshop: Gravitational Waves and Particle Physics

T 110.1	Do	16:45–17:15	H 4	<b>Gravitational waves from cosmological phase transitions</b> — ●GERALDINE SERVANT
T 110.2	Do	17:15–17:45	H 4	<b>Bubble wall dynamics - from friction to runaway</b> — ●DIETRICH BÖDEKER
T 110.3	Do	17:45–18:15	H 4	<b>The string soundscape at gravitational wave detectors</b> — ●SVEN KRIPPENDORF
T 110.4	Do	18:15–18:45	H 4	<b>Probing Dark Sectors at Gravitational Wave Detectors and Elsewhere</b> — ●JOERG JAECKEL, VALYA KHOZE, MICHAEL SPANNOVSKY

## Dissertationspreis-Symposiums SYDI

Am Montag, 27.3.2017, 14:00h, findet im H1 das Dissertationspreis-Symposium der Fachverbände Gravitation und Relativitätstheorie (GR), Hadronen und Kerne (HK) und Teilchenphysik (T) statt. Die Kurzfassungen zu den Beiträgen der Kandidatinnen und Kandidaten werden rechtzeitig vor der Tagung auf <http://www.dpg-verhandlungen.de> veröffentlicht.

## Hauptvorträge des fachübergreifenden Symposiums SYDM

Das vollständige Programm dieses Symposiums ist unter SYDM aufgeführt.

SYDM 1.1	Mi	14:00–14:35	H 1	<b>Effective field theories for dark matter direct detection</b> — •MARTIN HOFERICHTER
SYDM 1.2	Mi	14:35–15:10	H 1	<b>Direct dark matter detection</b> — •MANFRED LINDNER
SYDM 1.3	Mi	15:10–15:45	H 1	<b>A search for the invisible: Dark Matter and LHC</b> — •MONICA DUNFORD
SYDM 1.4	Mi	15:45–16:20	H 1	<b>Indirect detection of dark matter - status and perspectives</b> — •JAN CONRAD

## Fachsitzungen

T 1.1–1.2	Mo	9:00–10:30	H 1	<b>Hauptvorträge 1</b>
T 2.1–2.9	Mo	16:45–19:00	JUR 3	<b>Higgs Boson 1 (Zerfälle)</b>
T 3.1–3.9	Mo	16:45–19:00	JUR 5	<b>Higgs-Boson 2 (assoziierte Produktion)</b>
T 4.1–4.9	Mo	16:45–19:00	JUR 4	<b>Top Quark 1 (Produktion)</b>
T 5.1–5.9	Mo	16:45–19:00	JUR 372	<b>Elektroschwache Wechselwirkung 1</b>
T 6.1–6.8	Mo	16:45–18:45	VSH 10	<b>QCD</b>
T 7.1–7.7	Mo	16:45–18:35	JUR 490	<b>CP-Verletzung und Mischungswinkel 1</b>
T 8.1–8.8	Mo	16:45–18:45	JUR 498	<b>Suche nach Supersymmetrie 1</b>
T 9.1–9.10	Mo	16:45–19:20	JUR 2	<b>Suche nach neuen Teilchen 1</b>
T 10.1–10.8	Mo	16:45–18:45	VSH 116	<b>Suche nach Dunkler Materie 1 (LHC)</b>
T 11.1–11.9	Mo	16:45–19:05	VSH 17	<b>Neutrinoophysik 1 (Neutrinomassen)</b>
T 12.1–12.9	Mo	16:45–19:05	VSH 118	<b>Neutrinoophysik 2 (Doppelbetazerfall)</b>
T 13.1–13.9	Mo	16:45–19:05	H 1	<b>Neutrinoastronomie 1</b>
T 14.1–14.9	Mo	16:45–19:05	H 2	<b>Gammaastronomie 1</b>
T 15.1–15.9	Mo	16:45–19:00	H 3	<b>Kosmische Strahlung 1</b>
T 16.1–16.9	Mo	16:45–19:05	H 4	<b>Kosmische Strahlung 2</b>
T 17.1–17.9	Mo	16:45–19:00	VSH 11	<b>Quantenfeldtheorie (perturbativ)</b>
T 18.1–18.7	Mo	16:45–18:30	VSH 05	<b>Top Quark (Theorie) 1</b>
T 19.1–19.9	Mo	16:45–19:00	VSH 06	<b>Flavourphysik (Theorie)</b>
T 20.1–20.9	Mo	16:45–19:00	VSH 19	<b>Beyond the Standard Model (Theorie) 1</b>
T 21.1–21.9	Mo	16:45–19:00	JUR 253	<b>Experimentelle Methoden 1 (Computing, Machine Learning, Statistik)</b>
T 22.1–22.8	Mo	16:45–18:50	S 9	<b>Experimentelle Techniken der Astroteilchenphysik 1</b>
T 23.1–23.9	Mo	16:45–19:00	S 055	<b>Experimentelle Techniken der Astroteilchenphysik 2</b>
T 24.1–24.8	Mo	16:45–19:00	F 102	<b>Gasgefüllte Detektoren 1 (gemeinsam mit HK)</b>
T 25.1–25.8	Mo	16:45–19:00	F 234	<b>Streifendetektoren 1 (gemeinsam mit HK)</b>
T 26.1–26.9	Mo	16:45–19:00	S 2	<b>Pixeldetektoren 1</b>
T 27.1–27.3	Di	8:30–10:30	H 1	<b>Hauptvorträge 2</b>
T 28.1–28.5	Di	11:00–12:15	JUR 3	<b>Higgs-Boson 3 (assoziierte Produktion)</b>
T 29.1–29.6	Di	11:00–12:30	JUR 4	<b>Top Quark 2 (Zerfälle)</b>
T 30.1–30.6	Di	11:00–12:30	JUR 372	<b>Elektroschwache Wechselwirkung 2</b>
T 31.1–31.6	Di	11:00–12:30	JUR 490	<b>Flavourphysik 1</b>
T 32.1–32.6	Di	11:00–12:30	JUR 498	<b>Suche nach Supersymmetrie 2</b>
T 33.1–33.5	Di	11:00–12:15	JUR 2	<b>Suche nach neuen Teilchen 2</b>
T 34.1–34.4	Di	11:00–12:10	VSH 118	<b>Neutrinoophysik 3</b>
T 35.1–35.6	Di	11:00–12:30	H 2	<b>Gammaastronomie 2</b>
T 36.1–36.6	Di	11:00–12:35	H 3	<b>Kosmische Strahlung 3</b>
T 37.1–37.7	Di	11:00–12:45	H 4	<b>Kosmische Strahlung 4</b>
T 38.1–38.5	Di	11:00–12:15	VSH 11	<b>Quantenfeldtheorie (nicht-perturbativ)</b>
T 39.1–39.6	Di	11:00–12:30	VSH 06	<b>Higgs-Physik (Theorie) 1</b>
T 40.1–40.6	Di	11:00–12:30	VSH 05	<b>Top Quark (Theorie) 2</b>

T 41.1–41.6	Di	11:00–12:30	VSH 19	Beyond the Standard Model (Theorie) 2
T 42.1–42.4	Di	11:00–12:00	VSH 17	Astroteilchenphysik/Kosmologie (Theorie) 1
T 43.1–43.6	Di	11:00–12:30	F 102	Gasgefüllte Detektoren 2 (gemeinsam mit HK)
T 44.1–44.5	Di	11:00–12:20	F 073	Pixeldetektoren 2 (gemeinsam mit HK)
T 45.1–45.5	Di	11:00–12:15	VSH 116	Detektorsysteme 1
T 46.1–46.6	Di	11:00–12:30	JUR 5	Elektronik
T 47.1–47.5	Di	14:00–16:15	H 1	Eingeladene Vorträge 1
T 48.1–48.5	Di	14:00–16:15	H 3	Eingeladene Vorträge 2
T 49.1–49.9	Di	16:45–19:00	JUR 3	Higgs-Boson 4 (Zerfälle in Fermionen)
T 50.1–50.6	Di	16:45–18:15	JUR 5	Higgs-Boson 5 (assoziierte Produktion)
T 51.1–51.9	Di	16:45–19:00	JUR 4	Top Quark 3 (Produktion)
T 52.1–52.7	Di	16:45–18:30	JUR 490	CP-Verletzung und Mischungswinkel 2
T 53.1–53.7	Di	16:45–18:30	JUR 498	Suche nach Supersymmetrie 3
T 54.1–54.9	Di	16:45–19:00	JUR 2	Suche nach neuen Teilchen 3
T 55.1–55.9	Di	16:45–19:10	VSH 19	Suche nach Dunkler Materie 2 (Direkter Nachweis)
T 56.1–56.9	Di	16:45–19:05	VSH 118	Neutrinoophysik 4 (Doppelbetazerfall und Massen)
T 57.1–57.9	Di	16:45–19:05	VSH 07	Neutrinoophysik 5 (Reaktor-neutrinos)
T 58.1–58.9	Di	16:45–19:10	H 1	Neutrinoastronomie 2
T 59.1–59.9	Di	16:45–19:10	H 2	Gammaastronomie 3
T 60.1–60.6	Di	16:45–18:20	H 3	Kosmische Strahlung 5
T 61.1–61.5	Di	16:45–19:00	H 4	Topical Workshop: Anomalies in Flavour Physics
T 62.1–62.8	Di	16:45–18:45	VSH 17	Astroteilchenphysik/Kosmologie (Theorie) 2
T 63.1–63.9	Di	16:45–19:05	JUR 253	Experimentelle Methoden 2 (Flavour-, Photon, Elektronidentifikation)
T 64.1–64.9	Di	16:45–19:00	VSH 18	Experimentelle Techniken der Astroteilchenphysik 3
T 65.1–65.9	Di	16:45–19:00	S 055	Experimentelle Techniken der Astroteilchenphysik 4
T 66.1–66.8	Di	16:45–18:50	JUR 372	Grid-Computing
T 67.1–67.9	Di	16:45–19:00	VSH 116	Pixeldetektoren 3
T 68.1–68.6	Di	16:45–18:20	VSH 10	Detektorsysteme 2
T 69.1–69.9	Di	16:45–19:00	VSH 11	Halbleiterdetektoren (Strahlenschäden, neue Konzepte)
T 70.1–70.6	Di	16:45–18:25	VSH 06	Myondetektoren
T 71.1–71.9	Di	16:45–19:00	VSH 05	Trigger und DAQ 1
T 72.1–72.12	Di	16:45–19:00	F Foyer	Postersitzung Teilchenphysik
T 73.1–73.9	Mi	16:45–19:00	JUR 3	Higgs-Boson 6 (Zerfälle in Tau-Leptonen)
T 74.1–74.10	Mi	16:45–19:15	JUR 5	Higgs-Boson 7 (Paarproduktion, Quantenzahlen)
T 75.1–75.9	Mi	16:45–19:00	JUR 4	Top Quark 4 (Eigenschaften)
T 76.1–76.9	Mi	16:45–19:05	JUR 490	Flavourphysik 2
T 77.1–77.9	Mi	16:45–19:00	JUR 498	Suche nach Supersymmetrie 4
T 78.1–78.9	Mi	16:45–19:05	JUR 2	Suche nach neuen Teilchen 4
T 79.1–79.9	Mi	16:45–19:10	VSH 19	Suche nach Dunkler Materie 3 (Direkter Nachweis)
T 80.1–80.9	Mi	16:45–19:10	H 2	Neutrinoophysik 6 (Szintillatorexperimente)
T 81.1–81.9	Mi	16:45–19:10	VSH 118	Neutrinoophysik 7 (Doppelbetazerfall, sterile Neutrinos)
T 82.1–82.8	Mi	16:45–18:50	H 1	Neutrinoastronomie 3
T 83.1–83.9	Mi	16:45–19:05	H 3	Kosmische Strahlung 6
T 84.1–84.9	Mi	16:45–19:00	VSH 11	Gittereichtheorie
T 85.1–85.8	Mi	16:45–18:45	VSH 10	QCD (Theorie)
T 86.1–86.6	Mi	16:45–18:15	VSH 06	Higgs Physik (Theorie) 2
T 87.1–87.9	Mi	16:45–19:00	VSH 05	Neutrinoophysik (Theorie)
T 88.1–88.7	Mi	16:45–18:30	H 4	Andere Gebiete der Theorie
T 89.1–89.9	Mi	16:45–19:00	JUR 253	Experimentelle Methoden 3
T 90.1–90.9	Mi	16:45–19:00	S 9	Experimentelle Techniken der Astroteilchenphysik 5
T 91.1–91.9	Mi	16:45–19:00	F 102	Streifendetektoren 2 (gemeinsam mit HK)
T 92.1–92.9	Mi	16:45–19:00	F 234	Strahlenschäden (gemeinsam mit HK)
T 93.1–93.9	Mi	16:45–19:00	JUR 372	Detektorsysteme 3 (Kalorimeter, Myonsysteme)
T 94.1–94.9	Mi	16:45–19:05	VSH 116	Pixeldetektoren 4
T 95.1–95.8	Mi	16:45–18:50	S 2	Pixeldetektoren 5
T 96.1–96.8	Mi	16:45–18:45	VSH 17	Trigger und DAQ 2
T 97.1–97.3	Do	8:30–10:30	H 1	Hauptvorträge 3
T 98.1–98.5	Do	14:00–16:15	H 1	Eingeladene Vorträge 3
T 99.1–99.5	Do	14:00–16:15	H 3	Eingeladene Vorträge 4
T 100.1–100.9	Do	16:45–19:05	JUR 3	Higgs-Boson 8 (BSM-Zerfälle)

T 101.1–101.9	Do	16:45–19:00	JUR 4	<b>Top Quark 5 (Eigenschaften)</b>
T 102.1–102.9	Do	16:45–19:00	JUR 490	<b>Flavourphysik 3</b>
T 103.1–103.9	Do	16:45–19:00	JUR 498	<b>Suche nach Supersymmetrie 5</b>
T 104.1–104.9	Do	16:45–19:00	JUR 2	<b>Suche nach neuen Teilchen 5</b>
T 105.1–105.9	Do	16:45–19:00	JUR 5	<b>Suche nach neuen Teilchen 6</b>
T 106.1–106.8	Do	16:45–18:55	VSH 19	<b>Suche nach Dunkler Materie 4</b>
T 107.1–107.8	Do	16:45–18:45	H 2	<b>Neutrino-physik 8</b>
T 108.1–108.9	Do	16:45–19:10	VSH 118	<b>Neutrino-physik 9 (sterile Neutrinos)</b>
T 109.1–109.9	Do	16:45–19:05	H 3	<b>Kosmische Strahlung 7</b>
T 110.1–110.4	Do	16:45–18:45	H 4	<b>Topical Workshop: Gravitational Waves and Particle Physics</b>
T 111.1–111.9	Do	16:45–19:00	JUR 253	<b>Experimentelle Methoden 4 (Rekonstruktion)</b>
T 112.1–112.9	Do	16:45–19:00	S 9	<b>Experimentelle Techniken der Astroteilchenphysik 6</b>
T 113.1–113.8	Do	16:45–19:00	F 102	<b>Gasgefüllte Detektoren 3 (gemeinsam mit HK)</b>
T 114.1–114.8	Do	16:45–19:00	F 073	<b>Pixel-detektoren 6 (gemeinsam mit HK)</b>
T 115.1–115.8	Do	16:45–19:05	F 234	<b>Kalorimeter (gemeinsam mit HK)</b>
T 116.1–116.9	Do	16:45–19:05	VSH 17	<b>Detektorsysteme 4</b>
T 117.1–117.7	Do	16:45–18:35	VSH 06	<b>Myonendetektoren 2</b>
T 118.1–118.6	Do	16:45–18:20	VSH 05	<b>Trigger und DAQ 3</b>
T 119.1–119.3	Fr	8:45–10:45	H 1	<b>Hauptvorträge 4</b>
T 120.1–120.3	Fr	11:15–13:15	H 1	<b>Hauptvorträge 5</b>

## Mitgliederversammlung Fachverband Teilchenphysik

Donnerstag 19:15–20:15 Raum H3

- Berichte
- Wahl des FV-Vorsitzenden
- Verschiedenes

## T 1: Hauptvorträge 1

Zeit: Montag 9:00–10:30

Raum: H 1

**Hauptvortrag**

T 1.1 Mo 9:00 H 1

**Searches for Lepton number violation with neutrinoless double beta decay** — ●BERNHARD SCHWINGENHEUER — Max-Planck-Institut Kernphysik, Heidelberg

Lepton number violation is likely the key to understand the origin of the baryon asymmetry of the universe. Depending on the physics beyond the Standard Model neutrinoless double beta decay is the prime channel to see this violation. The talk reviews the motivation, the current experiments and some future proposals with emphasis on those using Ge-76.

**Hauptvortrag**

T 1.2 Mo 9:45 H 1

**Elektroschwache Physik und QCD am LHC** — ●JAN KRETZSCHMAR — University of Liverpool, UK

Die LHC-Experimente konnten in den letzten Jahren sehr erfolgreich

Daten bei den Schwerpunktsenergien von 7, 8 und 13 TeV nehmen. Das Studium dieser Daten ermöglicht eine große Menge an detaillierten Tests der elektroschwachen und starken Wechselwirkungen, welche die Grundlage des Standardmodells der Elementarteilchenphysik bilden. Die Analysen nutzen die herausragenden Fähigkeiten der Detektoren für Messungen mit höchster Präzision oder mit Fokus auf seltene, bisher unbeobachtete Prozesse. Damit liefern die LHC-Experimente einen signifikanten Beitrag zur Messung Protonstruktur, zum Test von QCD Korrekturen bei hohen Transversalimpulsen, zur Messung fundamentaler elektroschwacher Parameter wie der W Boson Masse, sowie zum systematischen Studium der Selbstwechselwirkung der elektroschwachen Eichbosonen. Potentielle Abweichungen von den Standardmodellvorhersagen würden Hinweise auf neue Physik liefern.

Der Vortrag gibt einen Überblick über die neuesten Ergebnisse der LHC-Experimente zur QCD und elektroschwachen Wechselwirkung und diskutiert vertieft einige ausgewählte Beispiele.

## T 2: Higgs Boson 1 (Zerfälle)

Zeit: Montag 16:45–19:00

Raum: JUR 3

T 2.1 Mo 16:45 JUR 3

**Messung der HZZ-Tensorstruktur in  $pp \rightarrow H \rightarrow ZZ^* \rightarrow 4\ell$ -Zerfällen mit dem ATLAS-Detektor** — ●KATHARINA ECKER, VERENA WALBRECHT, SANDRA KORTNER und HUBERT KROHA — Max-Planck-Institut für Physik, München, Deutschland

Ein wichtiger Zerfallskanal für die Messungen der Eigenschaften des im Jahr 2012 entdeckten Higgs-Bosons am LHC, ist der Zerfall in zwei Z-Bosonen,  $H \rightarrow ZZ^* \rightarrow 4\ell$ . Der Endzustand mit vier Leptonen aus Z-Boson-Zerfällen kann vollständig rekonstruiert werden. Messungen mit Daten aus den Jahren 2011 und 2012 haben bereits gezeigt, dass die vom Standardmodell vorhergesagte Hypothese eines Teilchens mit Spin-0 und positiver CP-Quantenzahl gegenüber anderen Hypothesen bevorzugt ist. Unter der Annahme eines Spin-0-Teilchens wurde nach anomalen und CP-verletzenden Kopplungen des Higgs-Bosons an Z-Bosonen gesucht, die auf Physik jenseits des Standardmodells zurückzuführen sind.

Der Vortrag behandelt die Untersuchung der Kopplungseigenschaften des Higgs-Bosons an Z-Bosonen mit dem ATLAS-Detektor und Run-II-Daten des LHC. Um die große Anzahl von Kopplungsparametern korreliert messen zu können, wurde die sogenannte analytische Morphing-Methode zur Erstellung des Signalmodells entwickelt. Im Vortrag wird die Messung der HZZ-Kopplungsstruktur und die Anwendung der Morphing-Methode im Zerfallskanal  $H \rightarrow ZZ^* \rightarrow 4\ell$  vorgestellt.

T 2.2 Mo 17:00 JUR 3

**Messung der HZZ-Tensor-Kopplung in  $pp \rightarrow H \rightarrow ZZ^* \rightarrow 4\ell$ -Zerfällen mit dem ATLAS-Detektor** — ●VERENA WALBRECHT, KATHARINA ECKER, SANDRA KORTNER und HUBERT KROHA — Max-Planck-Institut für Physik, München

Im Jahr 2012 wurde das Higgs-Boson von den Experimenten ATLAS und CMS am LHC entdeckt. Ein wichtiger Zerfallsprozess für die Entdeckung und Messung der Eigenschaften des Higgs-Bosons ist der in zwei Z-Bosonen, die jeweils in ein  $e^+e^-$ - oder  $\mu^+\mu^-$ -Paar zerfallen:  $pp \rightarrow H \rightarrow ZZ^* \rightarrow 4\ell$ .

Im Standardmodell wird das Higgs-Boson als Spin-0 Teilchen mit positiver CP-Quantenzahl vorhergesagt. Diese Hypothese wird auch von den Run-I-Daten bevorzugt. Dabei sind kleine Beimischungen anomaler, möglicherweise auch CP-verletzender Kopplungen an Z-Bosonen nicht ausgeschlossen, die von Theorien jenseits des Standardmodells vorhergesagt werden.

In diesem Vortrag wird die Messung der Higgs-Boson-Produktion und der Tensorstruktur der Higgs-Bosonkopplung an Z-Bosonen mit den Run-II-Daten des ATLAS-Detektors im Kanal  $pp \rightarrow H \rightarrow ZZ^* \rightarrow 4\ell$  diskutiert.

T 2.3 Mo 17:15 JUR 3

**Messung des Produktionswirkungsquerschnittes für Higgs-**

**Bosonen in der Vektorbosonfusion im Zerfallskanal  $H \rightarrow WW^{(*)}$  mit dem ATLAS-Detektor** — ●MARC GEISEN, VOLKER BÜSCHER, FRANK FIEDLER und CHRISTIAN SCHMITT — Johannes Gutenberg-Universität Mainz

Die Entdeckung des Higgs-Bosons am LHC im Jahr 2012 war ein wichtiges Ereignis der modernen Teilchenphysik. Zum Test von Standardmodellvorhersagen müssen jedoch möglichst viele Produktionsmechanismen und Zerfallskanäle präziser vermessen werden. Zur Vermessung der Kopplung zwischen Higgs-Boson und schweren Vektorbosonen eignet sich insbesondere die Untersuchung von Ereignissen, in denen das Higgs-Boson durch Fusion zweier Vektorbosonen erzeugt wird und in zwei W-Bosonen zerfällt. Der Prozess zeichnet sich experimentell durch ein gutes Verhältnis von Signal- zu Untergrundereignissen aus. In diesem Vortrag werden vorläufige ATLAS-Ergebnisse bei einer Schwerpunktsenergie von 13 TeV und integrierter Luminosität von  $5,8 \text{ fb}^{-1}$  vorgestellt. Ferner behandelt er neue Methoden zur Optimierung der Higgs-Ereignisselektion in der VBF  $H \rightarrow WW$ -Analyse.

T 2.4 Mo 17:30 JUR 3

**Untersuchung von Eigenschaften des Higgs-Bosons im Vektorbosonfusions-Produktionskanal mit Zerfall  $H \rightarrow WW \rightarrow \ell\nu\ell\nu$  mithilfe der Morphing-Methode bei ATLAS** — ●ADAM KALUZA, VOLKER BÜSCHER, FRANK FIEDLER und CHRISTIAN SCHMITT — Johannes Gutenberg Universität Mainz

Der Zerfallskanal  $H \rightarrow WW$  des Higgs-Bosons liefert aufgrund der klaren Signatur der Zerfallsprodukte sowie des hohen Verzweigungsverhältnisses einen geeigneten Zugang zur Untersuchung der Eigenschaften des Teilchens, um die Übereinstimmung mit den Vorhersagen des Standardmodells zu prüfen und mögliche Abweichungen festzustellen. Ereignisse, in denen das Higgs-Boson über Fusion zweier Vektorbosonen erzeugt wird, weisen durch die zwei zusätzlichen Jets eine charakteristische Signatur auf und lassen sich mit einem guten Verhältnis von Signal- zu Untergrundereignissen selektieren. Die spezielle Ereignistopologie kann dazu genutzt werden, die Kopplungsstruktur des Higgs-Bosons an W-Bosonen zu studieren. Die Kopplungen werden mit einer effektiven Langrange-Dichte parametrisiert. Um den multidimensionalen Parameterraum effektiv analysieren zu können, wird die Morphing-Methode benutzt. Im Vortrag werden die Methode präsentiert und erste Ergebnisse aus der Analyse von Proton-Proton-Kollisionen am ATLAS-Experiment am LHC-Beschleuniger bei einer Schwerpunktsenergie von 13 TeV vorgestellt.

T 2.5 Mo 17:45 JUR 3

**Messung des Wirkungsquerschnitts der assoziierten Produktion von Higgs-Bosonen mit einem W-Boson im Zerfallskanal  $H \rightarrow WW \rightarrow \ell\nu\ell\nu$  mit dem ATLAS-Detektor** — ●NATALIE WIESEOTTE, VOLKER BÜSCHER, FRANK FIEDLER und CHRISTIAN SCHMITT — Johannes Gutenberg-Universität Mainz

Nach der Entdeckung des Higgs-Bosons am LHC-Beschleuniger

konnten Masse und Spin als wesentliche Eigenschaften bereits bestimmt werden. Der nächste Schritt sind der Nachweis in allen Produktions- und Zerfallskanälen und die Präzisionsmessung der Kopplungen. Die assoziierte Produktion des Higgs-Bosons mit einem W-Boson bei anschließendem Zerfall in zwei W-Bosonen eignet sich zur Messung der Kopplung zwischen W- und Higgs-Boson besonders gut, da das Higgs-Boson bei dieser Reaktion ausschließlich an W-Bosonen koppelt. Eine Messung von Kopplungen des Higgs-Bosons hat das Potential, Erweiterungen des Standardmodells zu testen, und ist auch daher von großer Bedeutung.

Für die vorläufige Messung mit einem Teil der bei einer Schwerpunktsenergie von 13 TeV am ATLAS-Experiment gesammelten Daten,  $5.8 \text{ fb}^{-1}$ , ergibt sich für die auf Schnitten basierte Analyse nur eine geringe Signifikanz. Unter Anwendung multivariater Methoden kann der Untergrund ohne signifikanten Signalverlust deutlich stärker unterdrückt und somit die Sensitivität erhöht werden. Der Vortrag stellt diese, sowie weitere Optimierungen der Analyse mit dem vollständigen bei 13 TeV aufgezeichneten Datensatz bei einer integrierten Luminosität von etwa  $36 \text{ fb}^{-1}$  vor.

T 2.6 Mo 18:00 JUR 3

**Search for  $H/X \rightarrow Z(l^+l^-)\gamma$  at 13 TeV with the ATLAS Detector** — •DANIEL RAUCH — DESY, Hamburg, Germany

In summer 2012 the ATLAS and CMS collaborations announced the discovery of a new boson observed in the decays to a pair of photons as well as pairs of  $W$  and  $Z$  bosons, reconstructed from their leptonic decay products. Further investigations indicate that, within the present uncertainties, this boson has properties compatible with those expected for the SM Higgs boson.

Besides the aforementioned final states the Higgs boson will also decay to a  $Z$  boson and a photon, which happens with a similar frequency as the decays to a pair of photons. Reconstructing the  $Z$  boson decay from pairs of charged leptons reduces the available number of events by about one order of magnitude, but allows for a signal that can be reconstructed based on lepton triggers.

The final state featuring a photon and a leptonically decaying  $Z$  boson can also be exploited to search for new high-mass resonances  $X$ .

In this talk the ATLAS  $H/X \rightarrow Z(l^+l^-)\gamma$  analysis strategy for  $pp$  collision data recorded at 13 TeV will be presented and studies on systematic theoretical uncertainties will be shown.

T 2.7 Mo 18:15 JUR 3

**Suche nach unsichtbaren Zerfällen des Higgs-Bosons mit dem ATLAS-Detektor** — •JOHANNES BALZ, KATHARINA BIERWAGEN, VOLKER BÜSCHER, FRANK FIEDLER, KATHARINA JAKOBI, MANUEL LORNATUS, ANDREAS REISS, JAN SCHÄFFER und CHRISTIAN SCHMITT — Institut für Physik, Johannes Gutenberg-Universität Mainz

Nach der Entdeckung des Higgs-Bosons im Jahr 2012 am LHC ist eine der großen Aufgaben am ATLAS-Detektor die Untersuchung der Eigenschaften des Higgs-Bosons und die Suche nach möglichen Abweichungen von den Vorhersagen des Standardmodells.

In diesem Vortrag geht es um die Suche nach direkten, unsichtbaren Zerfällen des Higgs-Bosons, die nur mit Modellen jenseits des Standardmodells beschrieben werden können. Bei ATLAS wurde dies bisher nur in den Higgs-Produktionskanälen Vektor-Bosonen-Fusion und Assoziierte Produktion untersucht. In dem am LHC dominanten Produktionskanal Gluon-Fusion werden unsichtbare Higgs-Boson-Zerfälle nur sichtbar, wenn im Anfangszustand zusätzliche Abstrahlungen stattfinden. Diese unterscheiden sich von den Abstrahlungen im dominanten Untergrundprozess  $Z \rightarrow \nu\nu$  durch unterschiedliche Quark- und Gluonjetanteile. Dadurch ist eine Untergrundunterdrückung mithilfe von Quark-Gluon-Tagging möglich.

Im Vortrag wird der aktuelle Stand der Analyse bei einer Schwerpunktsenergie von  $\sqrt{s}=13 \text{ TeV}$  vorgestellt.

T 2.8 Mo 18:30 JUR 3

**Search for standard model Higgs boson decays to two muons at 13 TeV** — CARINA BRANDT, ADRIAN PERIEANU, •OLIVER RIEGER, PETER SCHLEPER, DANIEL TROENDLE, and ANNIKA VAN-HOEFER — Universität Hamburg

A search is presented for the standard model Higgs boson decay to two muons based on LHC run2 data recorded by the CMS detector in proton-proton collisions at a center-of-mass energy of 13 TeV. The sensitivity of this search is enhanced when distinct event topologies of the Higgs boson production are taken into account. Events are also classified according to their dimuon mass resolution. The results are shown for different topological event categories and their combination.

T 2.9 Mo 18:45 JUR 3

**Measuring the branching ratio of  $h \rightarrow \mu^+\mu^-$  at the International Linear Collider** — •SHIN-ICHI KAWADA, JENNY LIST, and MIKAEL BERGGREN — Deutsches Elektronen-Synchrotron (DESY), Notkestraße 85, 22607 Hamburg, Germany

After the discovery of a Higgs boson at the LHC, the precise characterization of this particle is one of the most important topics in particle physics. Any deviation from the Standard Model (SM) prediction of its properties would indicate the existence of physics beyond the SM. In this talk, we will present the prospects measuring the branching ratio of  $h \rightarrow \mu^+\mu^-$  at the International Linear Collider (ILC). The focus will be a new study in full, Geant4-based detector simulation assuming  $4 \text{ ab}^{-1}$  at 500 GeV, as foreseen in the official running scenario. The result will be discussed in the context of projections for operating the ILC at 1 TeV, as well as for the HL-LHC.

## T 3: Higgs-Boson 2 (assoziierte Produktion)

Zeit: Montag 16:45–19:00

Raum: JUR 5

T 3.1 Mo 16:45 JUR 5

**Study of the production of Higgs bosons in association with a top-antitop quark pair with the ATLAS experiment in Run2** — •MATTEO MANTOANI, MARIA MORENO LLACER, ELIZAVETA SHABALINA, and ARNULF QUADT — II. Physikalisches Institut, Georg-August-Universität Göttingen

The  $t\bar{t}H(H \rightarrow b\bar{b})$  channel is a very important and challenging channel to measure the production of the Higgs Boson because its cross section is proportional to the Yukawa coupling of the Higgs boson to top and bottom quarks and because it is a channel in which the Higgs Boson only couples to quarks. The main background to  $t\bar{t}H(H \rightarrow b\bar{b})$  is the  $t\bar{t}b\bar{b}$  process. Since it is an irreducible background, sophisticated techniques are required to distinguish the signal from this overwhelming background. The goal of this work is the search for the Higgs Boson in the  $t\bar{t}H(H \rightarrow b\bar{b})$  channel during Run II at the LHC using events recorded by the ATLAS detector. The analysis uses multivariate techniques (MVA) to discriminate the signal from the background in the selection regions with significant  $t\bar{t}H$  contribution. The MVA are built using Neural Networks (NN). The NN are particularly useful when no single variable which exhibits a clear separation between signal and background is available. Variables used to build the NN are defined and validated in order to increase the separation power of the NN as much as possible.

T 3.2 Mo 17:00 JUR 5

**Studien zur Modellierung des  $t\bar{t}+ \text{Jets}$ -Untergrundes der  $t\bar{t}H(b\bar{b})$ -Prozesses bei CMS** — KARIM EL MORABIT, MARCO A. HARRENDORF, ULRICH HUSEMANN, HANNES MILDNER, FELIX RIESE, •ANDREJ SAIBEL, MATTHIAS SCHRÖDER, MICHAEL WASSMER und SHAWN WILLIAMSON — Institut für Experimentelle Kernphysik (IEKP), KIT

Die genaue Kenntnis der Kopplung des Higgs-Bosons an das Top-Quark ist von besonderem Interesse, da sie wichtige Beiträge zu vielen Schleifenprozessen liefert. Diese Kopplung kann modellunabhängig in der assoziierten Produktion des Higgs-Bosons mit einem Top-Quark-Antiquark-Paar ( $t\bar{t}H$ ) gemessen werden. Die besondere Herausforderung bei der Messung des  $t\bar{t}H(b\bar{b})$ -Prozesses liegt in der Bestimmung des Untergrundes, bei dem das Top-Quark zusammen mit zusätzlichen Jets ( $t\bar{t}+ \text{Jets}$ ) erzeugt wird. Die Signal- und Untergrundprozesse werden mit Hilfe von Monte-Carlo-Methoden simuliert. Die Monte-Carlo-Simulation muss deshalb akkurat sein und möglichst kleine systematische Unsicherheiten aufweisen.

Es werden Studien zur Modellierung des  $t\bar{t}+ \text{Jets}$ -Prozesses mit POWHEG und MG5aMC@NLO in führender und nächstführender Ordnung vorgestellt. In besonderem Fokus steht dabei die Simulation des Prozesses, bei dem das Top-Quark-Antiquark-Paar mit zusätzlichen Bottom-Quarks erzeugt wird, da dieser den irreduziblen Unter-

grund des  $t\bar{t}H(b\bar{b})$ -Prozesses darstellt. Zusätzlich werden Methoden vorgestellt, die das Kombinieren Monte-Carlo-simulierter Datensätze in verschiedenen Flavor-Schemata erlauben.

T 3.3 Mo 17:15 JUR 5

**$t\bar{t}H$  Analyse mit Keras und einem tiefen neuronalen Netz** — ●JOHANNES MELLENTIN, MARÍA MORENO LLÁCER, ARNULF QUADT und ELIZAVETA SHABALINA — II. Physikalisches Institut, Georg-August-Universität Göttingen

Das Top-Quark ist das schwerste Elementarteilchen des Standardmodells und koppelt dadurch besonders stark an das Higgs-Boson. Ein theoretisch präzise vorhergesagter, jedoch noch nicht beobachteter Produktionsmechanismus ist die Erzeugung eines Higgs-Bosons mit Top-Quarks ( $t\bar{t}H$ ). Dabei ist es möglich, die Top-Yukawa-Kopplung, welche von großer Bedeutung für theoretische Vorhersagen und die Wechselwirkung von Elementarteilchen ist, direkt zu bestimmen. Hierzu werden Daten des ATLAS-Experimentes bei einer Schwerpunktsenergie von 13 TeV verwendet. Für den  $t\bar{t}H(H \rightarrow b\bar{b})$  Kanal ist der dominierende Untergrund  $t\bar{t}b\bar{b}$ . Da dieser irreduzibel ist, müssen komplexe Methoden verwendet werden, um Signal von Untergrund zu trennen. In diesem Vortrag wird untersucht, wie gut dies mit Keras, einer Bibliothek für maschinelles Lernen, mittels eines tiefen neuronalen Netzes möglich ist.

T 3.4 Mo 17:30 JUR 5

**Untersuchung des  $t\bar{t}+b\bar{b}$ -Prozesses im Rahmen einer CMS  $t\bar{t}H, H \rightarrow b\bar{b}$ -Analyse** — ●MARCO A. HARRENDORF, ULRICH HUSEMANN und MATTHIAS SCHRÖDER — Institut für Experimentelle Kernphysik (IEKP), KIT

Für die Suche nach dem Higgs-Boson in assoziierter Produktion mit einem Top-Quark-Antiquark-Paar ( $t\bar{t}H$ ) am CMS-Experiment stellt der  $t\bar{t}+b\bar{b}$ -Prozess einen bedeutenden, irreduziblen Untergrund dar, wenn man den Higgs-Bosonzerfall in zwei Bottom-Quarks ( $H \rightarrow b\bar{b}$ ) betrachtet. Die Simulation des  $t\bar{t}+b\bar{b}$ -Prozesses durch Monte-Carlo-Ereignisgeneratoren und die Abgrenzung des Prozesses zum inklusiven  $t\bar{t}+\text{Jets}$ -Untergrund stellt eine Herausforderung dar. Deswegen müssen in der Regel in  $t\bar{t}+b\bar{b}$ -dominierten Analysen – wie beispielsweise der  $t\bar{t}H, H \rightarrow b\bar{b}$ -Analyse – relativ große systematische Unsicherheiten für diesen Untergrund angenommen werden. Im Rahmen des Vortrages werden Untersuchungen zur verbesserten  $t\bar{t}+b\bar{b}$ -Untergrundabschätzung vorgestellt, die auf eine Verringerung der systematischen Unsicherheiten in der  $t\bar{t}H, H \rightarrow b\bar{b}$ -Analyse abzielen, aber langfristig auch für andere  $t\bar{t}+b\bar{b}$ -dominierten Analysen von Bedeutung sein könnten.

T 3.5 Mo 17:45 JUR 5

**Multivariate Analyse zur Suche nach dem Higgs-Boson in assoziierter Produktion mit einem Top-Quark-Antiquark-Paar am CMS-Experiment** — ●KARIM EL MORABIT, MARCO A. HARRENDORF, ULRICH HUSEMANN, HANNES MILDNER, ANDREJ SAIBEL, MATTHIAS SCHRÖDER, FELIX RIESE, MICHAEL WASSMER und SHAWN WILLIAMSON — Institut für Experimentelle Kernphysik (IEKP), KIT

Eine Messung des Wirkungsquerschnittes für die Higgs-Boson-Produktion in Assoziation mit einem Top-Quark-Antiquark-Paar ( $t\bar{t}H$ ) ermöglicht eine direkte Bestimmung der Top-Higgs-Yukawa-Kopplung. Mit der erhöhten Schwerpunktsenergie des LHC-Run-2 wird ein deutlicher Anstieg der Produktionsrate dieses Prozesses und somit eine höhere Präzision der Messung erwartet. Bisher konnte der Prozess bei dieser Schwerpunktsenergie jedoch nicht entdeckt werden.

In der vorgestellten Analyse werden Ereignisse mit einem semileptonisch zerfallenden  $t\bar{t}$ -Paar und einem in ein  $b\bar{b}$ -Paar zerfallenden Higgs-Boson aus den vom CMS-Experiment aufgenommenen Daten selektiert. Den dominanten Untergrund nach der Selektion stellen  $t\bar{t}$ -Ereignisse mit zusätzlichen Jets dar. Zur Identifikation dieser Untergrundereignisse werden multivariate Methoden verwendet.

Dieser Vortrag stellt eine multivariate Analyse mit *Boosted Decision Trees* und einer Matrix-Element-Methode zur Klassifikation von Ereignissen als Untergrund- oder Signal-Ereignisse vor.

T 3.6 Mo 18:00 JUR 5

**Analysis of  $t\bar{t}H(b\bar{b})$  at 13 TeV with the CMS Experiment** — ●MARCEL RIEGER, MARTIN ERDMANN, BENJAMIN FISCHER, ROBERT FISCHER, YANNIK RATH, and FLORIAN RALF VON CUBE — RWTH

Aachen University, Aachen, Germany

The measurement of Higgs boson production in association with top-quark pairs ( $t\bar{t}H$ ) is a primary goal of the second run of the LHC. It allows for a direct measurement of the underlying Yukawa coupling, and therefore, represents a decisive probe of the Standard Model of particle physics. Due to the complex event topology and the presence of experimentally irreducible backgrounds from  $tt$  events, the analysis of events with the Higgs boson decaying into a pair of bottom-quarks is challenging.

We present an analysis performed with the CMS detector at a center-of-mass energy of 13 TeV. In order to increase measurement sensitivity, applied methods are extensively based on multi-variate methods such as Boosted Decision Trees (BDT) and Deep Neural Networks (DNN). Results are presented in terms of 95% CLs limits on the signal strength and expected sensitivity, and also of the measurement if released by CMS prior to the conference.

T 3.7 Mo 18:15 JUR 5

**Event Categorization Using Deep Neural Networks for  $t\bar{t}H(H \rightarrow b\bar{b})$  at the CMS Experiment** — ●YANNIK RATH, FLORIAN VON CUBE, MARTIN ERDMANN, BENJAMIN FISCHER, ROBERT FISCHER, ERIK GEISER, THORBEN QUAST, and MARCEL RIEGER — III. Physikalisches Institut A, RWTH Aachen University

The analysis of top-quark pair associated Higgs production enables a direct measurement of the top-Higgs Yukawa coupling. In  $t\bar{t}H(H \rightarrow b\bar{b})$  analyses, multiple event categories are commonly used in order to simultaneously constrain signal and background processes. A typical approach is to categorize events according to both their jet and b-tag multiplicities.

The performance of this procedure is limited by the b-tagging efficiency and decreases for events with high b-tag multiplicity such as in  $t\bar{t}H(H \rightarrow b\bar{b})$ .

Machine learning algorithms provide an alternative method of event categorization. A promising choice for this kind of multiclass classification problem are deep neural networks (DNNs). In this talk, we present a categorization scheme using DNNs that is based on the underlying physics processes of events in the semileptonic  $t\bar{t}H(H \rightarrow b\bar{b})$  decay channel. Furthermore, we discuss different methods employed for improving the network's categorization performance.

T 3.8 Mo 18:30 JUR 5

**Search for  $t\bar{t}H$  production in the  $H \rightarrow b\bar{b}$  decay channel in ATLAS** — ●ANDREA KNUE and STEFAN KLUTH — Max-Planck-Institut für Physik, Munich

The top quark is by far the heaviest particle in the Standard Model with a mass close to the scale of electroweak symmetry breaking. It is hence supposed to have the largest coupling to the Higgs-boson (called Yukawa coupling). This coupling can be directly measured in the associated production of a Higgs-boson with a top-quark pair. Due to the large mass of these particles, the process is strongly suppressed and has not been observed yet. The search presented here is performed in the lepton+jets channel of the  $t\bar{t}$  decay, using the  $H \rightarrow b\bar{b}$  final state. This final state has large irreducible background from  $t\bar{t}b\bar{b}$  production and also large combinatorial background. The current status of the search will be presented using data collected at a centre-of-mass energy of 13 TeV with the ATLAS detector.

T 3.9 Mo 18:45 JUR 5

**Search for Higgs Boson Production in Final States with b-Quarks with the LHC Run II data** — ●ROSTYSLAV SHEVCHENKO and RAINER MANKEL — DESY, Hamburg, Germany

The discovery of a 125 GeV Higgs boson in July 2012 was a huge milestone for particle physics. While the properties of this particle agree with the predictions of the Standard Model (SM) at the current precision of measurements, it could well be only the first member of an extended Higgs sector. Different theoretical models, such as Supersymmetry and Compositeness, require additional Higgs bosons. This work focuses on the search for high mass Higgs bosons in final states with b-quarks. The analysis was performed with data collected by the CMS experiment at a center-of-mass energy of 13 TeV in the year 2016, corresponding to an integrated luminosity of 36.9 fb<sup>-1</sup>. The results are interpreted within models, including the Minimal Supersymmetric Standard Model.



## T 4: Top Quark 1 (Produktion)

Zeit: Montag 16:45–19:00

Raum: JUR 4

T 4.1 Mo 16:45 JUR 4

**Measurements of top-quark pair differential cross-sections in  $e\mu$  events at the ATLAS detector at  $\sqrt{s} = 13$  TeV** — ●ABIGAIL O’ROURKE — DESY, Hamburg

Measurements of top-quark pair differential cross-sections are a test of the Standard Model and quantum chromodynamics, and can be sensitive to possible new physics. They also provide inputs for modelling top-quark kinematics in simulations and can constrain PDF uncertainties. Proton-proton data collected at ATLAS at a centre-of-mass energy of  $\sqrt{s} = 13$  TeV are used to measure differential cross-sections as functions of top variables. The  $t\bar{t}$  events are selected by requiring one electron and one muon of opposite electric charge, and at least two jets, one of which must be tagged as containing a  $b$ -hadron. The measured differential cross-sections are compared to predictions of next-to-leading order generators matched to parton showers.

T 4.2 Mo 17:00 JUR 4

**$t\bar{t}$  cross section measurement in the lepton+jets channel at 8 TeV with the ATLAS experiment** — ●ARWA BANNOURA, PETER MAETTIG, and DOMINIC HIRSCHBUEHL — Bergische Universität Wuppertal, Wuppertal, Germany

The measurement of the inclusive top-quark pair-production cross section in the lepton+jets channel is performed with  $20.2 \text{ fb}^{-1}$  of  $pp$  collision data recorded with the ATLAS detector at  $\sqrt{s} = 8$  TeV in 2012. Events are selected by requiring one lepton (electron or muon), missing transverse momentum and at least four high- $p_T$  jets, where at least one of the jets is required to be  $b$ -tagged. Event shape based observables are fed into an artificial neural network (NN) in order to improve the separation strength between the signal and the backgrounds. The  $t\bar{t}$  production cross-section is obtained from a binned maximum-likelihood fit to the neural-network discriminant and the reconstructed mass of the hadronically decaying  $W$  boson. The main background which is  $W$  + jets is estimated from a data-driven method. Also, new ideas are proposed to constrain systematic uncertainties in order to improve the precision of the measurement.

T 4.3 Mo 17:15 JUR 4

**Measurement of the differential cross section for top-quark-pair production in the dilepton channel at  $\sqrt{s} = 13$  TeV with the CMS detector** — ●MYKOLA SAVITSKYI, TILL ARNDT, CARMEN DIEZ PARDOS, ALEXANDER GROHSJEAN, ALI HARB, JOHANNES HAUKE, JAMES KEAVENEY, and MARIA ALDAYA — Deutsches Elektronen-Synchrotron (DESY), Notkestrasse 85, D-22607 Hamburg

Measurements of differential top-quark-pair ( $t\bar{t}$ ) production cross sections are performed using final states with two leptons ( $e^+e^-$ ,  $\mu^+\mu^-$ , and  $e^\pm\mu^\mp$ ) in proton-proton collisions at  $\sqrt{s} = 13$  TeV at the CERN LHC. The data were recorded with the CMS detector. The  $t\bar{t}$  production cross section is measured as a function of kinematic properties of the top quarks and the  $t\bar{t}$  system, as well as of the top quark decay products. The measurements are confronted with several modern Monte Carlo predictions, and are also compared with different perturbative QCD calculations of beyond-NLO accuracy.

T 4.4 Mo 17:30 JUR 4

**Measurement of the top-quark pair production cross section in the dilepton channel with 2016 data from the CMS experiment** — ●TILL ARNDT<sup>1</sup>, MARIA ALDAYA<sup>1</sup>, CARMEN DIEZ PARDOS<sup>1</sup>, ALEXANDER GROHSJEAN<sup>1</sup>, ALI HARB<sup>1</sup>, JOHANNES HAUKE<sup>1</sup>, JAN KIESELER<sup>2</sup>, ANDREAS B. MEYER<sup>1</sup>, and MYKOLA SAVITSKYI<sup>1</sup> — <sup>1</sup>Deutsches Elektronen-Synchrotron (DESY), Notkestrasse 85, D-22607 Hamburg — <sup>2</sup>CERN, CH-1211, Geneva 23

The precision measurement of the top-quark pair production cross section in proton-proton collisions is an important goal of the LHC physics program. The measured cross section can be compared to precise theory predictions available to next-to-next-to-leading order accuracy. Precision measurements and theory predictions can be used to determine key standard model quantities such as the top quark mass or the strong coupling constant. Limits on contributions from new physics can also be set. We present results for the top-quark pair production cross section at  $\sqrt{s} = 13$  TeV using data recorded by the CMS detector in 2016. We will specifically focus on systematic uncertainties.

T 4.5 Mo 17:45 JUR 4

**Rekonstruktion von  $t\bar{t}(Z)$ -Ereignissen mit drei Jets mittels eines kinematischen Likelihood-Fits** — ●DAVID GROTE, BORIS LEMMER und ARNULF QUADT — II. Physikalisches Institut, Georg-August-Universität Göttingen

Als schwerstes Teilchen des Standardmodells nimmt das Top-Quark eine besondere Stellung ein, wodurch seine Eigenschaften sehr von Interesse sind. Eine gängige Methode der Rekonstruktion von Top-Quark-Ereignissen ist mittels eines kinematischen Fits, wie sie vom kinematischen Likelihood-Fitter (KLFitter) verwendet wird. Dieser benötigt zur Rekonstruktion von Top-Quark-Paaren bzw. Top-Quark-Paaren mit zusätzlich abgestrahlten Z-Boson die kinematischen Daten der Objekte der jeweils verwendeten Ereignissignaturen. Allerdings liegt bei einigen dieser Ereignisse auf Grund der Ereigniskinetik ein Jet außerhalb der Rekonstruktionsakzeptanz und wird somit nicht als solcher erkannt und rekonstruiert, wodurch der KLFitter nicht mehr in der Lage ist, mit solchen Ereignissen umzugehen. In solchen Fällen ist der fehlende Jet meist Teil des Zerfalls des hadronischen W-Bosons. Eine Möglichkeit, dieses Problem zu lösen, ist die künstliche Rekonstruktion des fehlenden Jets mittels korrelierter kinematischer Daten des Partnerjets. Dies in KLFitter zu implementieren und somit den KLFitter in die Lage zu versetzen, 3-Jet-Ereignisse rekonstruieren zu können, ist Inhalt dieses Vortrags ist.

T 4.6 Mo 18:00 JUR 4

**Suche nach  $t\bar{t}W$ - und  $t\bar{t}Z$ -Ereignissen im tripletonischen Kanal bei 13 TeV am ATLAS-Detektor mit Daten von 2015 und 2016** — BORIS LEMMER, MARIA MORENO LLÁCER, ARNULF QUADT, ●NILS-ARNE ROSIEN und ELIZAVETA SHABALINA — II. Physikalisches Institut, Georg-August-Universität Göttingen

Die Produktion von Top-Quark-Paaren in Assoziation mit einem  $W$ -Boson ( $t\bar{t}W$ ) oder  $Z$ -Boson ( $t\bar{t}Z$ ) ist von besonderem Interesse in der Top-Quark-Physik. Insbesondere durch den Prozess  $t\bar{t}Z$  wird es das erste Mal möglich sein, die Kopplung des  $Z$ -Bosons an das Top-Quark zu vermessen, lange bevor Top-Quark-Paare an Elektron-Positron-Collidern wie dem ILC oder CLIC über die elektroschwache Wechselwirkung erzeugt werden können. Dies ermöglicht es zum Beispiel, den schwachen Isospin des Top-Quarks zu vermessen. Außerdem sind  $t\bar{t}W$  und  $t\bar{t}Z$  wichtige Untergründe in vielen anderen Analysen, wie z.B. in  $t\bar{t}H$  und einigen SUSY-Suchen. Ein wichtiges Augenmerk bei der Analyse von  $t\bar{t}W$  und  $t\bar{t}Z$  liegt auf dem tripletonischen Kanal, für den die höchste Signifikanz erwartet wird.

Die Datenmenge, die im Jahr 2016 am ATLAS-Detektor genommen worden ist, übersteigt die von 2015 um mehr als Zehnfache. Dies ermöglicht die Implementierung von Analysemethoden, die für diesen Kanal bei 13 TeV bisher nicht verwendet werden konnten. In diesem Vortrag werden Studien für diesen Kanal mit Daten vom ATLAS-Detektor von 2015 und 2016 gezeigt.

T 4.7 Mo 18:15 JUR 4

**Studie zur Messung des  $t\bar{t}Z$ -Wirkungsquerschnitts im 1 Lepton-Kanal** — ●FLORIAN FISCHER, OTMAR BIEBEL und JEANNINE WAGNER-KUHR — Ludwig-Maximilians-Universität München

Die Produktion von Top-Quark-Paaren in Assoziation mit einem  $Z$ -Boson ist von besonderem Interesse in der Top-Quark-Physik, da man mit diesem Prozess sensitiv auf die Kopplung des  $Z$ -Bosons an das Top-Quark ist. Beiträge neuer Physik jenseits des Standardmodells der Teilchenphysik würden diese Kopplung beeinflussen. Außerdem ist  $t\bar{t}Z$  ein wichtiger Untergrundprozess in vielen anderen Analysen wie z.B.  $t\bar{t}H$ , und einigen Suchen nach Supersymmetrie (SUSY).

In diesem Vortrag werden Studien zur Messung des  $t\bar{t}Z$ -Wirkungsquerschnitts im Zerfallskanal mit einem Lepton gezeigt, der durch ein großes Verzweigungsverhältnis, aber auch durch großen Untergrund charakterisiert ist. Dazu werden in 2015 und 2016 vom ATLAS-Experiment (LHC) aufgezeichnete 13 TeV-Daten sowie Monte Carlo-Simulationen mit einer integrierten Luminosität von  $40 \text{ fb}^{-1}$  verwendet. Um das Signal  $t\bar{t}Z$  von dem dominierenden  $t\bar{t}$ +Jets-Untergrund zu separieren, wird eine multivariate Analyse benutzt.

T 4.8 Mo 18:30 JUR 4

**Measurement of the  $t\bar{t}Z$  cross section in the  $4\ell$ -channel with the ATLAS experiment at 13 TeV** — NELLO BRUSCINO, JULIEN

CAUDRON, MARKUS CRISTINZIANI, MAZUZA GHNEIMAT, CARLO ALBERTO GOTTARDO, ●SEBASTIAN HEER, VADIM KOSTYUKHIN, ANDREA SCIANDRA, and KAVEN YAU WONG — Physikalisches Institut of University of Bonn

The  $t\bar{t}Z$  process is sensitive to the  $tZ$  coupling and deviations of the measured cross section from the Standard Model prediction would indicate new physics. The decay channel with 4 leptons in the final state has the smallest branching ratio (0.5% of all  $t\bar{t}Z$  decays) but also the signal with the highest purity. In the Standard Model, the available processes that also have 4 leptons in the final state are few, with the  $ZZ$ , the  $tWZ$  and the  $t\bar{t}H$  processes being the dominant ones.

This talk will present the latest results, using the full 2015 and 2016 dataset of  $36.5 \text{ fb}^{-1}$  taken by the ATLAS detector at a centre-of-mass energy of 13 TeV. The analysis is split into signal regions according to the lepton flavour and number of  $b$ -tagged jets and a region, to control the  $ZZ$  background. With the increase of the centre-of-mass energy from 8 to 13 TeV the cross sections of all processes are predicted to change differently with respect to each other. Therefore an optimization of the signal regions will also be shown.

T 4.9 Mo 18:45 JUR 4

**Measurement of the  $t\bar{t}\gamma$  production cross section in  $pp$  collisions in the dilepton channel at  $\sqrt{s} = 13 \text{ TeV}$  with the ATLAS detector** — NELLO BRUSCINO, JULIEN CAUDRON, MARKUS CRISTINZIANI, ●MAZUZA GHNEIMAT, CARLO ALBERTO GOTTARDO, SEBASTIAN HEER, VADIM KOSTYUKHIN, ANDREA SCIANDRA, and KAVEN YAU WONG — Physikalisches Institut, Universität Bonn

The cross section measurement of a top-quark pair in association with a photon allows a direct measurement of the top quark electromagnetic coupling. The analysis is performed at 13 TeV with the data collected by the ATLAS detector. The signal template is estimated from Monte Carlo (MC) simulation. The major background contribution is  $t\bar{t}$  events with a hadron misidentified as a photon, a so-called hadron fake. The contribution from hadron fakes is estimated using a data-driven technique. The second major contribution in the dilepton channel is  $Z$ +jets events with an emission of a prompt photon, this contribution is estimated from MC simulation.

In this talk, we present a preliminary estimation of the signal and background contributions to the cross section measurement. We also present the preparation for unfolding the kinematic distributions of the photons to recover the differential cross sections in a limited phase-space region.

## T 5: Elektroschwache Wechselwirkung 1

Zeit: Montag 16:45–19:00

Raum: JUR 372

T 5.1 Mo 16:45 JUR 372

**Measurement of the  $W$  boson mass with the ATLAS detector** — ●SAMUEL WEBB<sup>1</sup>, JAKUB CUTH<sup>1</sup>, SASHA GLAZOV<sup>2</sup>, MIKHAIL KARNEVSKIY<sup>2</sup>, TAI-HUA LIN<sup>1</sup>, MATTHIAS SCHOTT<sup>1</sup>, GIOVANNI SIRAGUSA<sup>3</sup>, RAIMUND STRÖHMER<sup>3</sup>, and CHRISTOPH ZIMMERMANN<sup>1</sup> — <sup>1</sup>Johannes Gutenberg-Universität, Mainz, Germany — <sup>2</sup>DESY, Hamburg, Germany — <sup>3</sup>Julius-Maximilians-Universität, Würzburg, Germany

A measurement of the  $W$ -boson mass is presented based on  $4.6 \text{ fb}^{-1}$  of proton-proton collision data recorded in 2011 at a centre-of-mass energy of 7 TeV with the ATLAS detector at the LHC. The selected data sample consists of  $7.8 \times 10^6$  candidates in the  $W \rightarrow \mu\nu$  channel and  $5.9 \times 10^6$  candidates in the  $W \rightarrow e\nu$  channel. The  $W$ -boson mass is determined using template-fits to the reconstructed distributions of the transverse momentum of the charged leptons and the transverse mass of the  $W$  bosons in the electron and muon decay channels. The dominant experimental systematic uncertainties will be discussed, as well as those due to the modelling of the vector boson production and decay.

T 5.2 Mo 17:00 JUR 372

**Studien zum hadronischen Rückstoß für die Bestimmung der Masse des  $W$ -Bosons mit dem ATLAS Experiment** — ●VERENA HERGET, GIOVANNI SIRAGUSA und RAIMUND STRÖHMER — Universität Würzburg

Im Dezember 2016 wurde die Messung der Masse des  $W$ -Bosons mit den Daten des ATLAS Experiments bei einer Schwerpunktsenergie von 7 TeV veröffentlicht. Der gemessene Wert von  $m_W = 80.370 \pm 19 \text{ MeV}$  ist ein wichtiger Meilenstein für Präzisionstests des Standardmodells. Für die sehr präzise Modellierung der verschiedenen Komponenten der Analyse wurden aufwendige Methoden entwickelt und das hierbei gewonnene Wissen kann nun auf andere Datensätze, wie beispielsweise Daten bei einer Schwerpunktsenergie von 8 TeV, angewendet werden. Eine wichtige Methode ist die Messung des hadronischen Rückstoßes, aus dem sich die fehlende Energie des Neutrinos bestimmen lässt. Die systematischen Unsicherheiten, die die Standardalgorithmen für die fehlende Energie bieten, sind für diese Präzisionsmessung nicht ausreichend. Es wurden daher spezielle Algorithmen verwendet, die mit Ereignissen aus  $Z$ -Zerfällen kalibriert werden. Die Auflösung des hadronischen Rückstoßes wird bei der höheren Luminosität der 2012er Daten stark durch den höheren Pileup beeinflusst, weswegen eine Reoptimierung der Algorithmen nötig ist. Gleichzeitig bietet es sich hierbei aber auch an, die Methoden mit den Erfahrungen der 7 TeV Messung in Hinblick auf den Gesamtfehler weiterzuentwickeln.

In diesem Vortrag sollen mögliche Aspekte für die Messung des hadronischen Rückstoßes bei 8 TeV vorgestellt werden.

T 5.3 Mo 17:15 JUR 372

**Measurement of  $Z$  boson production cross section in the dilepton channels in  $pp$  collisions at  $\sqrt{s} = 13 \text{ TeV}$  with the ATLAS detector** — ●NATALIJA ZAKHARCHUK — Deutsches Elektronen-Synchrotron, Hamburg, Germany

A measurement of  $Z$  boson production cross sections in  $pp$  collisions at a centre-of-mass energy  $\sqrt{s} = 13 \text{ TeV}$  is presented. Results are obtained in both  $Z \rightarrow \mu\mu$  and  $Z \rightarrow ee$  channels, based on data corresponding to an integrated luminosity of  $3.2 \text{ fb}^{-1}$  collected with the ATLAS detector at the LHC during the year 2015 operating at 25 ns bunch spacing. The selection criteria of the measurement are optimized to be as close as possible to the measurement of the  $t\bar{t}$  production cross section in order to reduce uncertainties for cross-section ratios between the channels. The experimental results, including the results from  $\sqrt{s} = 7$  and 8 TeV, are compared to the predictions of perturbative QCD calculations at next-to-next-to-leading orders using various sets of parton distribution functions (PDFs) including electroweak corrections. The comparison is performed using an open-source xFitter package. Moreover, the measured cross sections are used to estimate the impact on top mass measurement using PDF profiling method.

T 5.4 Mo 17:30 JUR 372

**Analysis of  $Z$  boson pair production with ATLAS at  $\sqrt{s}=13 \text{ TeV}$ : Background determination and search for anomalous triple gauge couplings** — ●MAURICE BECKER and STEFAN TAPPROGGE — Universität Mainz

The LHC gives a great opportunity to test the Standard Model of particle physics at a high energy regime. One of the predictions that the electro weak sector of the Standard Model does is the production of two  $Z$  bosons. This process is not only a background contribution of many analyses that are done at the LHC, it can also be used to search for couplings that do not occur in the Standard Model like the coupling of three neutral gauge bosons.

An overview of an analysis with two  $Z$  bosons in the final state with data that were taken with the ATLAS detector in 2015 and 2016 at  $\sqrt{s}=13 \text{ TeV}$  is presented. The analysis is done for two on shell  $Z$  bosons ( $66 \text{ GeV} < m_{l+l-} < 116 \text{ GeV}$ ) using only electron or muon final states due to the low background contribution in this decay channel. The focus is set on the determination of background that arise from misidentified electrons or muons or leptons from second decay vertices. Since this background is difficult to model a data driven approach is chosen. Furthermore it is shown how a search for anomalous couplings can be done using the  $p_T$  distribution of the  $Z$  boson with higher transverse momentum.

T 5.5 Mo 17:45 JUR 372

**Messung des differentiellen  $W \rightarrow e\nu$  Wirkungsquerschnitts mit dem ATLAS-Experiment bei  $\sqrt{s} = 7 \text{ TeV}$**  — ●FELIX BÜHRER und CHRISTIAN WEISER — Physikalisches Institut, Universität

Freiburg

Die Produktion von  $W$ - und  $Z$ -Bosonen gehört zu den am häufigst vorkommenden Prozessen am LHC. Die präzise Messung der Produktionswirkungsquerschnitte leptonisch zerfallender  $W$  und  $Z$ -Bosonen kann zur Bestimmung der Partonverteilungsfunktionen des Protons und zum Vergleich mit Rechnungen in NNLO benutzt werden. Von besonderer Bedeutung sind dabei die Rapiditätsverteilungen der  $W$ -Bosonen, sowie derer Zerfallsprodukte, da diese direkt mit den Impulsanteilen der an der Wechselwirkung teilnehmenden Partonen verknüpft sind.

Präsentiert wird die differentielle Messung der inklusiven  $W \rightarrow e\nu$  Produktionswirkungsquerschnitte in der Pseudorapidität des detektierten Elektrons bei  $\sqrt{s} = 7$  TeV. Insbesondere wird dabei auf die Abschätzung des Untergrundes der QCD-Multijet-Produktion mithilfe einer Anpassung an teilweise aus Daten bestimmten Template-Verteilungen eingegangen.

Darüber hinaus wird die mit weiteren Zerfallsanälen kombinierte Messung mit theoretischen Vorhersagen verglichen sowie deren Einfluss auf Partonverteilungsfunktionen dargelegt.

T 5.6 Mo 18:00 JUR 372

**Untergrundabschätzung für eine Messung der WZ-Streuung mit dem CMS-Experiment bei einer Schwerpunktsenergie von 13 TeV** — •SVENJA FONTANA, MATTHIAS MOZER und THOMAS MÜLLER — Institut für Experimentelle Kernphysik (IEKP), KIT

Da die Vektor-Boson-Streuung (VBS) durch Interferenzeffekte eng mit dem Higgs-Mechanismus verknüpft ist, eignet sich der Prozess besonders gut, um die elektroschwache Symmetriebrechung näher zu untersuchen. Darüber hinaus sind VBS-Prozesse geeignet, um nach Neuer Physik im elektroschwachen Sektor zu suchen, die üblicherweise durch anomale trilineare und quartische Eichkopplungen parametrisiert wird.

In diesem Vortrag wird eine Messung der VBS mit dem CMS-Experiment bei einer Schwerpunktsenergie von 13 TeV vorgestellt. Es wird hierbei die WZ-Streuung im leptonischen Zerfallskanal  $WZ \rightarrow l\nu l'$  mit  $l, l' = e, \mu$  betrachtet. Der Schwerpunkt der Präsentation liegt auf der Untergrundabschätzung mit datenbasierten Methoden. Bei Prozessen mit 3 Leptonen, besteht ein erheblicher Anteil des Untergrunds aus fehlidentifizierten Leptonen. In diesem Vortrag wird eine Methode vorgestellt, mit der dieser Untergrund abgeschätzt werden kann.

T 5.7 Mo 18:15 JUR 372

**Measurement of the  $W^+W^-$  cross section in pp collisions at  $\sqrt{s} = 13$  TeV at the ATLAS Detector** — •BAISHALI DUTTA — DESY Zeuthen, Zeuthen, Germany

The production of pairs of electroweak gauge bosons plays an important role for both, tests of the Standard Model and searches for new physics. With the first run of data-taking at LHC, the  $W^+W^-$  cross section has already been measured at both ATLAS and CMS experiments.

With the data collected by the ATLAS experiment in 2015 comprising an integrated luminosity of  $3.16 \text{ fb}^{-1}$ , the fiducial and total  $W^+W^-$  cross section have been measured at a centre-of-energy  $\sqrt{s} = 13$  TeV. The events are selected in the leptonic decay channel i.e both  $W$  decaying into two leptons (electrons, muons) and associated missing transverse momentum. This talk reports the results of this cross section measurement in 2015 and shows prospects of more precise and differential measurements with 2016 data.

T 5.8 Mo 18:30 JUR 372

**Electroweak  $pp \rightarrow W^\pm W^\pm jj$  production and its experimental challenges** — •GIULIA GONELLA, KARSTEN KÖNEKE, and KARL JAKOBS — Albert-Ludwigs-Universität Freiburg

The measurements of the electroweak sector of the Standard Model are one way to probe the mechanism of electroweak symmetry breaking (EWSB) at the LHC. In this context, the scattering of vector bosons is a key process. In particular, the scattering amplitude of the production of a pair of  $W$  bosons increases with energy, violating unitarity, while the exchange of  $Z/\gamma^*$  and Higgs bosons should cancel these divergences. The cancellations are exact if the vector bosons self-couplings and their couplings to the Higgs boson have the values predicted by the Standard Model. Deviations from these predictions would lead to changes in the production rate as a function of invariant diboson mass. Therefore,  $W$  boson scattering provides a crucial test of EWSB and constrain possible contributions from new physics.

In this talk an analysis of electroweak  $pp \rightarrow W^\pm W^\pm jj$  production is presented, in the final signature of two leptons with the same electric charge, missing transverse energy and two jets, within the ATLAS experiment at LHC. The final state of two leptons with the same charge is chosen to suppress contributions from  $WW$  production accompanied by jets from initial state radiation, but is experimentally more challenging due to the contributions from the opposite-sign di-lepton production, where the charge of one electron is wrongly reconstructed. This experimental issue will be clarified and ways to measure or reduce its contributions in the context of this analysis will be presented.

T 5.9 Mo 18:45 JUR 372

**Jet Energy Calibration in CMS with Z+Jets events** — •THOMAS BERGER — Karlsruher Institut für Technologie

Jet Energy Calibration (JEC) is a fundamental task to precise measurements in particle physics. Correction factors to account for detector effects and to translate measured energy depositions into the energy of the originating particle jet are derived from both data and simulation. After introducing the basic calibration steps of CMS, a detailed description of the workflow with Z+jet events is presented that is performed in Karlsruhe as part of the official CMS jet calibration task. The latest status on this most precise channel for the absolute jet energy calibration will be reported.

## T 6: QCD

Zeit: Montag 16:45–18:45

Raum: VSH 10

T 6.1 Mo 16:45 VSH 10

**Bestimmung der PDFs des Protons durch Messungen des Z+Jet-Wirkungsquerschnitts im myonischen Zerfallskanal** — •ANNA FRIEDEL, GÜNTER QUAST, KLAUS RABBERTZ, STEFAN WAYAND, GEORG SIEBER und THOMAS BERGER — Institut für Experimentelle Kernphysik, Karlsruher Institut für Technologie

Die Messung des Wirkungsquerschnitts der Z+Jet Produktion ist ein Prozess, der hervorragend geeignet ist, um die Vorhersagen des Standardmodells zu überprüfen und die Verteilungsfunktionen der Partonen im Proton (PDFs) mit hoher Genauigkeit zu bestimmen. Der Grund hierfür liegt in der klaren Signatur des Prozesses und der präzisen Rekonstruktion des Z-Bosons im myonischen Zerfallskanal. Analysiert werden Daten, die vom CMS-Detektor am LHC im Jahr 2016 aufgenommen wurden. Detektoreffekte werden durch Anwendung von Effizienzgewichten und Entfaltung berücksichtigt. Mit Hilfe von Monte Carlo Simulationen werden Vorhersagen des Wirkungsquerschnitts der Z+Jet-Produktion unter unterschiedlichen Annahmen für die PDFs berechnet. Aus dem Vergleich der Daten mit den Theorievorhersagen können die Proton-PDFs bestimmt werden.

T 6.2 Mo 17:00 VSH 10

**Measurements of top-pair to Z-boson cross section ratios at center-of-mass energies of  $\sqrt{s} = 13, 8, 7$  TeV with the ATLAS detector and evaluation of measured cross sections constraints on PDFs and strong coupling constant.** — •ARTUR TROFYMOV — DESY, Hamburg, Germany

Ratios of top-quark pair to Z-boson production ( $Z \rightarrow \ell^+\ell^-$  where  $\ell = e, \mu$ ) cross sections at center-of-mass energies of  $\sqrt{s} = 13, 8, 7$  TeV are measured using data recorded by the ATLAS experiment at the LHC. Data at  $\sqrt{s} = 13$  TeV for both analyses are collected in 2015 with total integrated luminosity of  $3.2 \text{ fb}^{-1}$ . Previously published Z-boson and top-quark pair cross sections measured at  $\sqrt{s} = 8$  and 7 TeV are corrected to phase space of measurements at  $\sqrt{s} = 13$  TeV and used for the ratios calculation. Single cross section ratios at a given  $\sqrt{s}$  for the two processes and same process at different  $\sqrt{s}$ , as well as double ratios of two processes at different  $\sqrt{s}$ , are evaluated. The ratio results are compared to the predictions calculated at next-to-next-to-leading order for different parton distribution functions (PDFs). The correlated cross section measurements are used to obtain constraints on PDFs and the strong coupling constant  $\alpha_s$ .

T 6.3 Mo 17:15 VSH 10

### Measurement of the Associated Production of $W+c$ in 13 TeV $pp$ -Collisions with the CMS Experiment — BENOIT ROLAND, KATERINA LIPKA, and ●SVENJA PFLITSCH — DESY

The measurement of the  $W+c$  production cross-section provides an opportunity to directly access the strange quark content of the proton at the electroweak scale.

This can lead to a significant reduction of the uncertainties connected to the strange-quark parton density functions.

We will focus on  $W \rightarrow \ell\nu$  and  $c \rightarrow D^*$  as probes of  $W+c$  since both,  $W$ -boson and  $D$ -Meson, can be measured with good accuracy by the CMS-detector. Furthermore, the fragmentation of charm quarks into  $D$ -mesons is well measured.

The data taken by the CMS-experiment at the LHC in 2016 offers sufficient statistics for an analysis of the pseudorapidity-distribution of the muon in detail and thus for an investigation of strange-, anti-strange-quark asymmetry.

T 6.4 Mo 17:30 VSH 10

### Determination of the Strong Coupling Constant from Inclusive Jet Data — GÜNTER QUAST, KLAUS RABBERTZ, ●DANIEL SAVOIU, and GEORG SIEBER — Karlsruhe Institute of Technology

Inclusive jet production cross sections are among the most precise and well-understood jet-related observables measured at hadron colliders. In light of this, such measurements are an important asset for the determination of fundamental physical parameters, such as the strong coupling constant  $\alpha_s(M_Z)$ , to the high precision required by studies of QCD phenomenology. In this talk, we present a procedure for the determination of the strong coupling constant  $\alpha_s(M_Z)$  from a combined set of measurements performed at multiple hadron colliders, as well as the results obtained.

T 6.5 Mo 17:45 VSH 10

### Production of $b$ jets and pairs of $b$ jets with associated jets — ●PATRICK CONNOR, HANNES JUNG, and PAOLO GUNNELINI — DESY, Hamburg, Germany

In the Standard Model, the  $b$  quark is the heaviest quark that can hadronise, and is therefore an excellent probe for higher-order QCD contributions. The CMS detector provides a sufficient resolution to measure the production of  $b$ -jets and pairs of  $b$ -jets and associated jets. In particular, we will investigate transverse-momentum effects in the parton density functions (TMDs). In the talk, we present Monte-Carlo studies and preliminary results from 13 TeV data.

T 6.6 Mo 18:00 VSH 10

### NLO predictions for dijet azimuthal correlations — ●ARMANDO BERMUDEZ MARTINEZ, DANIELA DOMINGUEZ DAMIANI, and HANNES JUNG — DESY, Hamburg, Germany

Factorization theorems and the matching of matrix elements (ME) to parton showers (PS) are highly relevant topics of discussion especially in the simulation of hadron collider physics. For the study of possible breaking of factorization the so-called resummation region is particularly interesting. Within perturbative QCD, the resummation or Sudakov regions are sectors of the phase space where any fix order

calculation does not give a reliable result and an all order computation approach is needed. MC generators implement this "all order" approximate calculation by means of PS. Here we present a study of the inclusive dijet cross section as a function of the azimuthal separation between the leading jets. We focus on the Sudakov region for high  $p_T$  leading jets scenarios. The studies were performed using 3 final partons @ NLO ME as well as POWHEG three jets NLO matched to  $p_T$  ordered PS.

T 6.7 Mo 18:15 VSH 10

### Determination of the total cross section in proton-proton collisions at the LHC at $\sqrt{s} = 8$ from elastic scattering using the ALFA sub-detector of ATLAS — ●CHRISTIAN HEINZ, HASKO STENZEL, and MICHAEL DÜREN — Universität Gießen, 2. Physikalisches Institut

The ALFA (Absolute Luminosity for ATLAS) Roman Pot detector system is part of the forward instrumentation of ATLAS located about 240 m away from the interaction point in the LHC tunnel in both directions. ALFA consists of a scintillating fibre tracker housed in vertical Roman Pots which enables the measurement of elastic proton-proton scattering at small scattering angles. In 2012 data were recorded at a centre-of-mass energy of  $\sqrt{s} = 8$  TeV during a fill with special beam optics of the LHC with  $\beta^* = 90$  m and parallel-to-point focusing.

The four-momentum transfer  $t$  is measured for elastically scattered protons and used to extract the differential elastic cross section. The differential elastic cross section is fitted at small  $|t|$  using the optical theorem. In this talk the published results of the determination of the total cross section and of the slope of the elastic cross section is reported.

T 6.8 Mo 18:30 VSH 10

### Hadron Production in Photon-Photon Processes at the International Linear Collider — ●KOLLASSERY SWATHI SASIKUMAR<sup>1,2</sup>, CARL MIKAEL BERGGREN<sup>1</sup>, and JENNY LIST<sup>1</sup> — <sup>1</sup>Deutsches Elektronen Synchrotron, Hamburg, Germany — <sup>2</sup>Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

The International Linear Collider (ILC) is a proposed  $e^+e^-$  collider, tunable at a centre-of-mass energy between 250 - 500 GeV (with the possibility to upgrade to 1 TeV). Being an  $e^+e^-$  collider ILC has the prospect of providing very clean physics environment for making high precision measurements e.g. of the Higgs bosons and to search for new particles. In addition to the desired  $e^+e^-$  collisions, parasitic collisions of real and virtual photons radiated off the  $e^+e^-$  beams occur at the rates of upto 1.2  $\gamma\gamma$  collisions per bunch crossings. The  $\gamma\gamma$  centre-of-mass energies reach from few 100 MeV to the full  $e^+e^-$  centre-of-mass energy. At all these energies, in particular the production of hadrons need to be modelled correctly in order to estimate the impact of these backgrounds which pile-up on each  $e^+e^-$  event. It is equally important to develop advanced methods to remove these backgrounds from the important physics processes where the current methods remain inadequate. Thus in this contribution we discuss the simulations for  $\gamma\gamma \rightarrow$  low  $P_T$  hadron processes, evaluate their impact on the detector and discuss the method developed to remove them from interesting physics events.

## T 7: CP-Verletzung und Mischungswinkel 1

Zeit: Montag 16:45–18:35

Raum: JUR 490

### Gruppenbericht

T 7.1 Mo 16:45 JUR 490

### Measurement of the Tau Polarisation in $Z$ Boson Decays — VLADIMIR CHEREPANOV, JORDY DEGENS, PETER FACKELDEY, GÜNTER FLÜGGE, OLENA HLUSHCHENKO, BASTIAN KARGOLL, WOLFGANG LOHMANN, ●THOMAS MÜLLER, ALEXANDER NEHRKORN, CLAUDIA PISTONE, HALE SERT, ACHIM STAHL, and ALEXANDER ZOTZ — RWTH Aachen University, Physics Institute III B

The parity violation in the weak interaction leads to a non-vanishing polarisation of tau leptons in the decay of  $Z$  bosons. The measurement of the polarisation provides a handle to access fundamental parameters of the Standard Model, such as the weak mixing angle  $\sin^2\theta_{\text{eff}}$ . The polarisation of a tau leptons is inferred from angular distributions of their decay products. Basic tools for accessing the tau polarisation developed for this analysis can then also be applied in the study of the CP quantum number in Higgs boson decays into pairs of tau leptons.

This presentation gives an overview of the analysis techniques in the main hadronic tau decay modes and provides a sensitivity estimation for measurements of the neutral current couplings of the tau lepton and the weak mixing angle.

T 7.2 Mo 17:05 JUR 490

### Reoptimierung des Flavour-Taggings für LHCb Run II — ALEX BIRNKRAUT, ULRICH EITSCHBERGER, ●KEVIN HEINICKE, VANESSA MÜLLER und JULIAN WISHAH für die LHCb-Kollaboration — TU Dortmund

Die indirekte Suche nach Neuer Physik mit Hilfe von Präzisionsmessungen ist wesentlicher Bestandteil des LHCb-Physikprogramms. Dies beinhaltet Messungen von  $CP$ -Verletzung in der Interferenz zwischen Zerfall und Zerfall nach Mischung neutraler  $B$ -Mesonen. Hierbei wird der initiale Flavour der Teilchen benötigt, welcher durch das sogenann-

te Flavour-Tagging bestimmt wird.

Die Schwerpunktsenergie der  $pp$ -Kollisionen am LHC wurde 2015 für die zweite Datennahmeperiode (Run II) auf 13 TeV erhöht. Da dies zu veränderten Eigenschaften der rekonstruierten Ereignisse führt, ist eine Reoptimierung und -kalibrierung der multivariaten Flavour-Tagging-Algorithmen nötig. In diesem Zuge werden neue Algorithmen zur Identifizierung des initialen Teilchenflavours getestet und die Unterschiede vor und nach der Erhöhung der Schwerpunktsenergie untersucht.

T 7.3 Mo 17:20 JUR 490

**Messung von zeitabhängiger  $CP$ -Verletzung im Zerfallskanal  $B_s^0 \rightarrow D_s^\mp K^\pm$  mit dem LHCb-Experiment** — ALEX BIRNKRAUT, •ULRICH EITSCHBERGER und JULIAN WISHAH für die LHCb-Kollaboration — Experimentelle Physik 5, TU Dortmund

Im Zerfallskanal  $B_s^0 \rightarrow D_s^\mp K^\pm$  treten die tree-level Übergänge  $b \rightarrow cs\bar{u}$  und  $b \rightarrow u\bar{c}s$  auf, deren Übergangswahrscheinlichkeiten in derselben Größenordnung liegen. Das sind ideale Voraussetzungen für Interferenz zwischen direktem Zerfall und Zerfall nach Mischung der  $B_s^0$ -Mesonen. Durch Messung der resultierenden zeitabhängigen  $CP$ -Asymmetrien lassen sich fünf  $CP$ -Parameter bestimmen, welche ihrerseits sensitiv auf den CKM-Winkel  $\gamma$  sind. Im Vortrag wird das Ergebnis der Messung mit dem Run I Datensatz des LHCb-Experiments vorgestellt.

T 7.4 Mo 17:35 JUR 490

**Messung der  $CP$ -Observablen  $\sin(2\beta)$  in den Zerfällen  $B^0 \rightarrow J/\psi(ee)K_S^0$  und  $B^0 \rightarrow \psi(2S)(\mu\mu)K_S^0$  mit dem LHCb-Experiment** — CHRISTOPHER HASENBERG, •PATRICK MACKOWIAK, VANESSA MÜLLER, RAMON NIET und JULIAN WISHAH — Experimentelle Physik 5, TU Dortmund

Die Messung der  $CP$ -Verletzung in der Interferenz zwischen  $b \rightarrow c\bar{c}s$ -Zerfall und Zerfall nach  $B^0$ - $\bar{B}^0$ -Mischung ermöglicht eine direkte Bestimmung des CKM-Winkels  $\beta$ . Der Kanal  $B^0 \rightarrow J/\psi(\mu\mu)K_S^0$  eignet sich besonders gut für eine zerfallszeit aufgelöste Messung der  $CP$ -Verletzung. Um die Sensitivität weiter zu steigern, wird in dieser Analyse der Zerfall  $B^0 \rightarrow J/\psi K_S^0$  durch den Zerfall des  $J/\psi$  Mesons in zwei Elektronen rekonstruiert. Außerdem wird der Zerfall  $B^0 \rightarrow \psi(2S)(\mu\mu)K_S^0$  genutzt.

In diesem Vortrag wird der aktuelle Stand der Analyse mit dem Run I Datensatz des LHCb-Experiments, dessen Größe einer integrierten Luminosität von  $3\text{ fb}^{-1}$  entspricht, vorgestellt.

T 7.5 Mo 17:50 JUR 490

**Messung der  $CP$ -Verletzung im Zerfallskanal  $B^0 \rightarrow J/\psi K_S^0$  mit Run II Daten des LHCb-Experiments** — •CHRISTOPHER HASENBERG, PATRICK MACKOWIAK, VANESSA MÜLLER, RAMON NIET und JULIAN WISHAH für die LHCb-Kollaboration — TU Dortmund

Der Zerfallskanal  $B^0 \rightarrow J/\psi(\mu\mu)K_S^0$  ist bekannt als der goldene Kanal, um  $CP$ -Verletzung im Sektor der  $B^0$ -Mesonen zu messen. Diese lässt sich auf  $CP$ -Verletzung in der Interferenz zwischen direktem Zerfall und Zerfall nach Mischung zurückführen. Durch Bestimmung der  $CP$ -

Asymmetrie kann der Parameter  $\sin 2\beta$  gemessen werden. Dabei bezeichnet  $\beta$  den Winkel, in einem Unitaritätsdreieck der CKM-Matrix, der mit hoher Präzision gemessen wurde.

Diese Analyse verwendet Run I sowie Run II Daten des LHCb-Experiments, welche einer integrierten Luminosität von  $3\text{ fb}^{-1}$  bzw.  $2\text{ fb}^{-1}$  entsprechen. Die Rekonstruktion des Zerfalls erfolgt über die Zerfälle von  $J/\psi$  in zwei Myonen bzw. zwei Elektronen. Um die Sensitivität weiter zu steigern, wird zusätzlich der Zerfallskanal  $B^0 \rightarrow \psi(2S)(\mu\mu)K_S^0$  betrachtet. Aus dieser Analyse wird die weltbeste Messung von  $\sin 2\beta$  erwartet. In diesem Vortrag soll der Stand der Analyse vorgestellt und diskutiert werden.

T 7.6 Mo 18:05 JUR 490

**Messung direkter  $CP$ -Verletzung im Zerfall  $B^+ \rightarrow J/\psi \rho^+$**  — MICHEL DE CIAN, SEVDA ESEN und •JASCHA GRABOWSKI für die LHCb-Kollaboration — Physikalisches Institut, Universität Heidelberg

Aufgrund ihrer hohen Masse können B-Mesonen über eine Fülle von Zwischenresonanzen zerfallen. Abhängig von den genauen Zerfallsamplituden kann es hierbei zur Verletzung der  $CP$ -Symmetrie kommen, deren genaue Vermessung eines der Ziele des LHCb-Experiments ist.

Die vorgestellte Analyse befasst sich mit dem Zerfall  $B^+ \rightarrow J/\psi \rho^+$  mit  $J/\psi \rightarrow \mu^+ \mu^-$  und  $\rho^+ \rightarrow \pi^0 \pi^+$ . In diesem Kanal kann der Flavour der B-Mesonen über die Ladung des Pions bestimmt werden.

Um den statistischen Fehler zu minimieren, werden in der Messung Daten aus Run I und II verwendet.

T 7.7 Mo 18:20 JUR 490

**Freed-Isobar Partial-Wave Analysis** — •FABIAN KRINNER — Technische Universität München, Deutschland

Large data samples of multibody decays of heavy and light mesons, as collected by modern particle physics experiments like BELLE or COMPASS, are challenging to analyze. For such processes, usually Partial-Wave Analyses (PWA) are performed, that allow to extract CP-violation.

For final states with three or more particles, however, PWA models usually rely on the isobar model, which describes the decay as a chain of subsequent two-body decays. This model relies on knowledge from previous experiments as input for the parameterization of the mass dependence of the decay amplitudes of the appearing intermediate resonances, the so-called isobars  $\xi$ . In the most simple case, these are Breit-Wigner amplitudes with measured masses and widths. We present a method that circumvents the necessity for this kind of prior knowledge by employing sets of step-like functions instead of fixed shapes. Doing so, we find under certain conditions mathematical ambiguities in the resulting analysis model and discuss methods to resolve them.

As a simple example, we present the analysis of the decay of a pseudoscalar particle with  $J^{PC} = 0^{-+}$  into three pions via two different isobars with  $J_\xi^{PC} = 0^{++}$  ( $f_0$ -like) and  $J_\xi^{PC} = 1^{--}$  ( $\rho$ -like).

## T 8: Suche nach Supersymmetrie 1

Zeit: Montag 16:45–18:45

Raum: JUR 498

T 8.1 Mo 16:45 JUR 498

**Suche nach Supersymmetrie mit Charm Jets** — JOHANNES BALZ, KATHARINA BIERWAGEN, VOLKER BÜSCHER, KATHARINA JAKOBI, MANUEL LORNATUS, ANDREAS REISS und •JAN SCHÄFFER — Johannes Gutenberg-Universität, Mainz, Deutschland

Das Standardmodell liefert eine gute Beschreibung der beobachteten Phänomene, jedoch können einige offene Fragen nicht beantwortet werden. Ein möglicher Lösungsansatz ist die Supersymmetrie (SUSY), welche zu jedem bekannten Standardmodell-Teilchen einen supersymmetrischen Partner voraussagt. Das Stop-Quark - der SUSY-Partner des Top-Quarks - ist besonders interessant, da das Top-Quark eine starke Yukawa-Kopplung besitzt und sein Partner somit große Schleifenkorrekturen auf die Masse des Higgs-Bosons liefert.

Ein wichtiger und gleichzeitig anspruchsvoller Kanal ist der Zerfall des Stop-Quarks in ein Charm-Quark und das leichteste Neutralino, welcher dominant für kleine Massendifferenzen zwischen dem Stop-Quark und dem leichtesten Neutralino ist. Dies führt zu einer Signatur mit fehlender transversaler Energie und Jets aus Charm-Quarks. Ein weiterer in dieser Analyse betrachtete Kanal ist der Zerfall des skalaren

Charm-Quarks in den selben Endzustand.

Der Vortrag beschreibt die Optimierung der Signal- und Kontrollregionen für die ATLAS Suche nach Supersymmetrie in diesen Zerfallskanälen. Es werden die aktuellen Ergebnisse der Analyse mit dem gesamten Datensatz aus 2015 und 2016 bei einer Schwerpunktsenergie von  $\sqrt{s} = 13\text{ TeV}$  präsentiert.

T 8.2 Mo 17:00 JUR 498

**Suche nach Top-Squarks im hadronischen Endzustand mit dem ATLAS-Detektor -  $b + \tilde{\chi}_1^\pm$ -Zerfallsmode und Multijet-Untergrund** — •CHRISTIAN LÜDTKE, PHILIPP MOGG, KILIAN ROSBACH und FREDERIK RÜHR — Universität Freiburg

Bei der Suche nach Top-Squark-Paarproduktion wird oft ein Massenspektrum angenommen, bei dem  $m_{\tilde{t}_1} > m_{\tilde{\chi}_1^\pm} > m_{\tilde{\chi}_1^0}$ , wobei  $\tilde{\chi}_1^0$  das leichteste supersymmetrische Teilchen ist. Daher gibt es zwei Zerfallsmode:  $\tilde{t}_1 \rightarrow t + \tilde{\chi}_1^0$  und  $\tilde{t}_1 \rightarrow b + \tilde{\chi}_1^\pm$ . Im Fall  $\tilde{t}_1 \rightarrow t + \tilde{\chi}_1^0$  kann man den großen fehlenden Transversalimpuls und zwei Top-Quarks ausnutzen, wohingegen man im Endzustand der  $\tilde{t}_1 \rightarrow b + \tilde{\chi}_1^\pm$ -Mode zwei harte b-Jets erwartet. Es kann auch eine Mischung aus beiden Zerfallsmo-

den auftreten, die besonders im Fall, wenn beide Zerfallsmoden gleich wahrscheinlich sind, wichtig wird. In meinem Vortrag werde ich die Ergebnisse für den  $\tilde{t}_1 \rightarrow b + \tilde{\chi}_1^\pm$ -Zerfallskanal vorstellen, und zeigen, wie man bessere Sensitivität erhalten kann.

Zudem werde ich die Abschätzung des Multijet-Untergrundes in dieser Analyse erklären. Dieser ist durch Selektion von hohen fehlenden Transversalimpulsen zwar unterdrückt, aber schwer zu bestimmen.

T 8.3 Mo 17:15 JUR 498

**Suche nach schweren Top-Squarks mit dem ATLAS-Detektor im Endzustand mit hadronischen Top-Quarks und fehlendem Transversalimpuls** — ●PHILIPP MOGG, CHRISTIAN LÜDTKE, FREDERIK RÜHR und KILIAN ROSBACH — Albert-Ludwigs-Universität Freiburg

Falls Supersymmetrie in der Natur realisiert ist, könnte der Partner des Top-Quarks, das Top-Squark (kurz: Stop), eines der leichtesten supersymmetrischen Teilchen und daher mit ATLAS detektierbar sein. Die Untersuchung von vereinfachten Modellen mit Top-Squark-Paarerzeugung, bei denen das Top-Squark eines der leichtesten und ein Neutralino das leichteste SUSY-Teilchen ist, wird daher mit hoher Priorität vorangetrieben. Je nach Massenspektrum sind unterschiedliche Top-Squark-Zerfallskanäle möglich, einer davon ist der Zerfall des Stops in ein Top-Quark und ein Neutralino, welches den Detektor ohne Wechselwirkung verlässt und sich als fehlender Transversalimpuls bemerkbar macht. In diesem Vortrag wird die Analyse mit zwei hadronischen Top-Quarks im Endzustand vorgestellt. Dies umfasst die Erläuterung der für diesen Endzustand wichtigen Variablen, die Konstruktion von Signal-Regionen, sowie aktuelle Ergebnisse, die auf ICHEP2016 vorgestellt wurden (<https://cds.cern.ch/record/2206250>), und wie die Sensitivität verbessert werden kann.

T 8.4 Mo 17:30 JUR 498

**ATLAS SUSY Search in 0-Lepton Channel** — ●MANFREDI RONZANI — Albert-Ludwigs-Universität Freiburg

Many extensions of the Standard Model (SM) include heavy coloured particles, such as the squarks and gluinos of supersymmetric (SUSY) theories, which could be accessible at the Large Hadron Collider (LHC) and detected by ATLAS. Large number of R-parity-conserving models predict squarks and gluinos produced in pairs and decaying through  $\tilde{q} \rightarrow q\tilde{\chi}_1^0$  and  $\tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0$ , or via intermediate production of charginos as  $\tilde{q} \rightarrow q\tilde{\chi}^\pm$  and  $\tilde{g} \rightarrow q\tilde{q}\tilde{\chi}^\pm$ , with subsequent chargino decay to  $W^\pm\tilde{\chi}_1^0$ . The neutralino  $\tilde{\chi}_1^0$  is assumed to be the Lightest Supersymmetric Particle (LSP) and escape undetected, resulting in large missing transverse momentum which, in addition to the jets resulting from the quark decays, form the final states investigated in the 0-Lepton SUSY analysis.

This talk presents the latest results of the ATLAS 0-Lepton SUSY analysis using data recorded in 2015 and 2016 by the ATLAS experiment in  $\sqrt{s}=13$  TeV proton-proton collision during the LHC Run2.

T 8.5 Mo 17:45 JUR 498

**Datenbasierte Untergrundabschätzung für die Suche nach top-Squarks im vollhadronischen Zerfallskanal mit dem ATLAS-Detektor** — ●NICOLAS KÖHLER und OLIVER KORTNER — Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München

Eines der Hauptziele des ATLAS-Experiments am LHC ist die Suche nach Supersymmetrie. Dabei stehen, motiviert durch das Hierarchieproblem, besonders die Superpartner der top-Quarks im Fokus. Die in Run 2 des LHC erhöhte Schwerpunktsenergie von  $\sqrt{s} = 13$  TeV und die integrierte Luminosität von inzwischen  $33\text{ fb}^{-1}$  führt zu einer deutlich erhöhten Sensitivität für schwere top-Squarks bzw. zu wesentlich stärkeren Ausschlussgrenzen.

Bei der Suche nach schweren top-Squarks bilden die top-Quark Paarproduktion sowie die Erzeugung einzelner top-Quarks und W-Bosonen mit zusätzlichen Jets den Großteil des reduzierbaren Untergrundes, der verlässlich mit datenbasierten Methoden unter Benutzung sogenannter Kontrollregionen, die vom Untergrund dominiert sind, abgeschätzt werden muss.

Die Auswahl und Optimierung dieser Kontrollregionen werden vorgestellt und Verbesserungen gegenüber Run 1 und frühen Run 2 Daten diskutiert.

T 8.6 Mo 18:00 JUR 498

**Multivariate Optimierung der Signalregion für die Suche nach top-Squarks im vollhadronischen Zerfallskanal mit dem ATLAS-Detektor** — ●JONAS GRAW, NICOLAS KÖHLER, OLIVER KORTNER und HUBERT KROHA — Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München

Bei der Suche nach Supersymmetrie am ATLAS-Experiment werden Signalregionen meist durch Schnitte auf diskriminierende Variablen definiert. Dieser Ansatz kann bei zunehmender integrierter Luminosität und bei den durch die starken Ausschlussgrenzen bedingten extremeren Phasenräumen durch multivariate Methoden ergänzt werden. Am Beispiel der Suche nach dem Superpartner des top-Quarks im vollhadronischen Zerfallskanal soll die erwartete Sensitivität bei Anwendung von multivariaten Methoden getestet werden. Die Auswahl von geeigneten Variablen und mögliche Verbesserungen gegenüber den herkömmlichen Analysetechniken werden diskutiert.

T 8.7 Mo 18:15 JUR 498

**Exploiting boosted scenarios in supersymmetric searches for squarks and gluinos in final states with jets and missing transverse momentum with the ATLAS detector** — ●VERONIKA MAGERL — Albert-Ludwigs-Universität Freiburg

Under the hypothesis of R-parity conservation, SUSY partners are produced in pairs and decay to the Lightest Supersymmetric Particle (LSP) which is stable and escapes detection. In a large variety of models this particle is assumed to be the lightest neutralino  $\tilde{\chi}_1^0$ . The undetected  $\tilde{\chi}_1^0$  would result in substantial missing transverse momentum, while the rest of the cascade, originating from the decays of squarks and gluinos, would yield final states with multiple jets and possibly leptons. Some of these models consider a one-step cascade decay of squarks ( $\tilde{q}$ ) and gluinos ( $\tilde{g}$ ) via an intermediate production of charginos ( $\tilde{\chi}^\pm$ ), subsequently decaying into  $W^\pm\tilde{\chi}_1^0$ . Depending on the mass parameter space ( $\tilde{g}/\tilde{q}, \tilde{\chi}^\pm, \tilde{\chi}_1^0$ ), W resonances can be boosted such that they are reconstructed as a single jet. This occurs for small mass differences between  $\tilde{g}/\tilde{q}$  and  $\tilde{\chi}^\pm$  and large mass differences between  $\tilde{\chi}^\pm$  and  $\tilde{\chi}_1^0$ .

This talk presents the latest studies on design and optimisation of possible signal regions for the ATLAS SUSY 0-Lepton analysis targeting boosted boson signatures in several different SUSY simplified model scenarios.

T 8.8 Mo 18:30 JUR 498

**Suche nach skalaren Quarks im Endzustand mit Jets und fehlender Transversalenergie mit dem ATLAS-Experiment** — JOHANNES BALZ, KATHARINA BIERWAGEN, VOLKER BÜSCHER, ●KATHARINA JAKOBI, MANUEL LORNATUS, ANDREAS REISS und JAN SCHÄFFER — Institut für Physik, Universität Mainz, Deutschland

Der Nachweis neuer Physik jenseits des Standardmodells ist eines der wichtigsten Ziele des ATLAS-Experiments am Large Hadron Collider am CERN. Die in diesem Vortrag präsentierte Analyse wurde für die Suche nach supersymmetrischen Quarks  $\tilde{q}$ , die in ein Quark  $q$  und ein Neutralino  $\tilde{\chi}_1^0$  zerfallen,  $\tilde{q} \rightarrow q + \tilde{\chi}_1^0$ , für verschiedene Quarkflavour entwickelt. Bei einem Endzustand mit zwei Quark-Jets und fehlender Transversalenergie stellt der hohe hadronische Untergrund eine Herausforderung dar. Zur Extraktion des Signals werden die Unterschiede in den Formen der Verteilungen von Signal und Untergrund in verschiedenen diskriminierenden Variablen ausgenutzt. Da die Analyse eine möglichst lockere Selektion verwendet, ist sie vergleichsweise modellunabhängig und komplementär zur bereits existierenden 0-Lepton Analyse. Durch die Betrachtung von Systemen mit hoch-energetischen Abstrahlungen im Anfangszustand liegt der Schwerpunkt auf Modellen mit mittlerem und kleinem  $\Delta m$  zwischen  $\tilde{q}$  und  $\tilde{\chi}_1^0$ . Der aktuelle Stand dieser Analyse mit dem Datensatz von 2015 und 2016 bei einer Schwerpunktsenergie von 13 TeV wird in diesem Vortrag vorgestellt.

## T 9: Suche nach neuen Teilchen 1

Zeit: Montag 16:45–19:20

Raum: JUR 2

## Gruppenbericht

T 9.1 Mo 16:45 JUR 2

**Search for singly-produced vector-like quarks in lepton and jets final state with the ATLAS detector in run-II** — •DUSTIN BIEDERMANN<sup>1</sup>, ANJISHNU BANDYOPADHYAY<sup>4</sup>, IAN BROCK<sup>4</sup>, JANET DIETRICH<sup>1</sup>, HEIKO LACKER<sup>1</sup>, DENNIS SPERLICH<sup>1</sup>, TOBIAS KUPFER<sup>2</sup>, JOHANNES ERDMANN<sup>2</sup>, DANILO FERREIRA DE LIMA<sup>3</sup>, FERDINAND SCHENCK<sup>1</sup>, and DIDIER ALEXANDRE<sup>1</sup> — <sup>1</sup>Humboldt-Universität zu Berlin — <sup>2</sup>Technische Universität Dortmund — <sup>3</sup>Universität Heidelberg — <sup>4</sup>Universität Bonn

Vector-like quarks are predicted by many extensions of the Standard Model of particle physics. They provide the possibility to solve some long-standing problems such as the hierarchy problem and also might help to explain the b-quark forward-backward asymmetry in  $e^+e^-$  collisions measured at LEP. Candidates for these vector-like quarks are the top-like T and the Y quark. The Y quarks decay exclusively into a W-boson and a b-quark, which appears also to be the dominant decay channel of the T quarks in a T-singlet model.

We present the search strategy, the results of the limit setting procedure and the interpretation of the limits in terms of the couplings to third generation quarks for singly-produced T/Y quarks using the LHC run-II data recorded by the ATLAS detector in 2015 and 2016.

T 9.2 Mo 17:05 JUR 2

**Suche nach Vektor-artigen Top-Quarks in Endzuständen mit einem Lepton, Jets und fehlender transversaler Energie am ATLAS Experiment bei  $\sqrt{s} = 13$  TeV** — •JAN KÜCHLER, FRANK ELLINGHAUS, PETER MÄTTIG und SOPHIO PATARAIA — Bergische Universität Wuppertal

Verschiedene Modelle für neue Physik beinhalten Vektor-artige Top-Quarks, d.h. schwere Top-Quark Partnerteilchen deren rechts- und links-händige Komponenten gleichartig unter schwacher Wechselwirkung transformieren. Es werden drei möglichen Zerfallskanäle angenommen, entweder in ein W Boson und ein Bottom-Quark, ein Higgs-Boson und ein Top-Quark, oder ein Z-Boson und ein Top-Quark. In dieser Analyse wird die hohe fehlende transversale Energie, die bei einem Zerfall des Z-Boson in Neutrinos auftritt, zur Unterscheidung zum Standardmodell Untergrund benutzt. Die hohen Massen der Vektor-artigen Top-Quarks führen zusätzlich zu einem starken Boost der Zerfallsprodukte, der sich in einer kollimierte Topologie äußert. Die Analyse der ATLAS  $pp$  Daten von 2015 und 2016 wird diskutiert.

T 9.3 Mo 17:20 JUR 2

**Search for single production of a vector-like T quark decaying into a top quark and a Higgs boson** — •SVENJA SCHUMANN, HEINER THOLEN, ALEXANDER SCHMIDT, and IVAN MARCHESINI — Universität Hamburg

Many extensions of the Standard Model (SM) like the composite Higgs model or extra dimensions try to explain open questions which can not be explained by the SM. Several of these models predict heavy vector-like quarks.

This analysis searches for single produced vector-like T quarks in  $pp$ -collisions at a center of mass energy of 13 TeV with the CMS experiment at the LHC. Targeted is the decay of the vector-like T quark into a Higgs boson and a leptonically decaying top quark.

The substructure of boosted jets is used to reconstruct Higgs candidates while top candidates are taken from the combination of leptons, missing transverse energy and jets. From the higgs and top candidates the hypothetical vector-like T quark is reconstructed. Results from the search vector-like T quarks at 13 TeV with the data from 2016 will be shown.

T 9.4 Mo 17:35 JUR 2

**Suche nach vektorartigen Quarks im Zerfallskanal  $tW$  mit dem CMS-Detektor** — •DANIEL GONZALEZ, JOHANNES HALLER, ROMAN KOGLER, THOMAS PEIFFER und ALEXANDER SCHMIDT — Universität Hamburg, Institut für Experimentalphysik

Vektorartige Quarks sind schwere Teilchen, die von einer Vielzahl von möglichen Erweiterungen des Standard-Modells der Teilchenphysik vorhergesagt werden. Anders als eine chirale vierte Generation von Quarks werden diese nicht durch die Beobachtung des Higgs-Bosons bei 125 GeV ausgeschlossen. Nach vektorartigen Quarks wird am LHC in Paarproduktion als auch in Einzelproduktion gesucht. Durch die

Suchen nach Paarproduktion sind sie bis Massen von circa 1 TeV ausgeschlossen.

In diesem Vortrag wird die Suche nach Quarks in Einzelproduktion bei einer Schwerpunktsenergie von 13 TeV vorgestellt, die in ein Top-Quark und W-Boson zerfallen. Die Topologie der einzeln produzierten vektorartigen Quarks wird bestimmt durch einen Jet im Vorwärtsbereich des Detektors und ihrer hohen Masse. Die vorgestellte Suche betrachtet Endzustände mit einem Myon oder Elektron und nutzt verschiedene Jetsubstruktur-Algorithmen.

T 9.5 Mo 17:50 JUR 2

**Search for heavy gauge bosons decaying via vector-like top-quarks in the all-hadronic channel** — •SIMON KUDELLA<sup>1</sup>, ULRICH HUSEMANN<sup>1</sup>, MATTHIAS SCHRÖDER<sup>1</sup>, and EMANUELE USAI<sup>2</sup> — <sup>1</sup>Institut für Experimentelle Kernphysik (IEKP), KIT — <sup>2</sup>Institute of Experimental Physics, Universität Hamburg

Many theoretical models Beyond the Standard Model of Particle Physics motivate the existence of heavy gauge bosons (e.g.  $Z'$ ) as well as non-chiral (vector-like) quarks. These vector-like quarks receive their mass from direct mass terms and, therefore, are compatible with Higgs boson measurements. In this talk, the search for such a neutral heavy  $Z'$  decaying via a top-like non-chiral quark into all hadronic final states will be presented. A general overview of the analysis within the CMS experiment and the analysis techniques will be given. Since Monte Carlo predictions for multijet final states are not very reliable for the probed center-of-mass-energy range of  $> 1500$  GeV/ $c^2$ , special focus will be put on data driven background-estimation techniques.

T 9.6 Mo 18:05 JUR 2

**Studien zur Umgewichtung von Theorie-Parametern und deren Einfluss auf Endzustandskinematiken für die einzelne Produktion von vektorartigen Quarks bei  $\sqrt{s} = 13$  TeV mit dem ATLAS-Detektor** — •TOBIAS KUPFER, DIANE CINCA, JOHANNES ERDMANN und KEVIN KRÖNINGER — TU Dortmund, Experimentelle Physik IV

Vektorartige Quarks (VLQ) sind die einfachste Ergänzung von farb- geladenen Fermionen zum Standardmodell (SM), welche noch nicht experimentell ausgeschlossen ist und werden von hypothetischen Erweiterungen zum Standardmodell, wie Composite-Higgs-Modellen, vorhergesagt. Diese VLQ erhalten ihre Masse nicht über die Yukawa-Kopplung, und ihre rechts- und links-händigen Komponenten transformieren gleich unter der  $SU(2)$ . Die Eigenschaft der VLQ mit Standardmodell Quarks zu mischen ermöglicht die Produktion einzelner VLQ, welche überwiegend an die dritte Quark-Generation koppeln.

Einzeln produzierte VLQ ermöglichen bei einer Schwerpunktsenergie von  $\sqrt{s} = 13$  TeV, im Vergleich zur VLQ-Paarproduktion, Suchen bis hin zu besonders hohen Massen. Für einzeln produzierte vektorartige Y-Quarks, welche durch den Zerfall  $Y \rightarrow Wb$  zu einem Endzustand mit einem einzelnen, geladenen Lepton und starkem Lorentz-Boost der Zerfallsprodukte führen, werden Monte-Carlo-basierte Studien präsentiert. Es wird der Einfluss verschiedener Kopplungsstärken in der Monte-Carlo-Produktion auf die Kinematik der Endzustandsteilchen untersucht und eine Methode zur Umgewichtung zwischen unterschiedlichen Parametern vorgestellt.

T 9.7 Mo 18:20 JUR 2

**Suche nach vektorartigen Quarks im Kanal  $Q\bar{Q} \rightarrow Zq + X$  bei  $\sqrt{s} = 13$  TeV am ATLAS-Experiment** — KEVIN KRÖNINGER, JOHANNES ERDMANN und ELENA FREUNDLICH — Experimentelle Physik IV, TU Dortmund

Bei der Suche nach Physik jenseits des Standardmodells spielen Composite-Higgs- und Little-Higgs-Modelle als Erweiterung hin zu einer fundamentalen Theorie eine wichtige Rolle. Diese Modelle sagen vektorartige Quarks (VLQ) voraus, deren links- und rechtshändiger Anteil die gleichen Transformationseigenschaften unter der  $SU(2)$  besitzen.

Es wird eine Analysestrategie im hochenergetischen (geboosteten) Bereich zur Suche nach VLQ bei  $\sqrt{s} = 13$  TeV am ATLAS-Experiment mit  $\int L dt = 3.2 \text{ fb}^{-1}$  vorgestellt, welche in Paaren durch die starke Wechselwirkung erzeugt werden. Die betrachteten Zerfälle sind  $T \rightarrow Zt$  und  $B \rightarrow Zb$ . Die betrachteten Ereignisse enthalten unter anderem ein Z-Boson, das in ein Leptonenpaar  $\ell^+\ell^-$  zerfällt, eine bestimmte An-



zahl an  $b$ -Jets und Jets mit vergrößertem Radiusparameter von  $R = 1$ . Nach einer optimierten Selektion werden untere Massenlimits mit 95% CL auf die Paarproduktion der vektorartigen Quarks  $T$  und  $B$  gesetzt.

T 9.8 Mo 18:35 JUR 2

**Suche nach Single Vectorlike Quarks und Monotop-Produktion** — ●SONJA BARTKOWSKI, JOHANNES ERDMANN und KEVIN KRÖNINGER — TU Dortmund, Experimentelle Physik IV

Vectorlike Quarks (VLQ) sind farbgeladene Fermionen, die wie Vektoren unter der  $SU(2)$  transformieren. Sie kommen in vielen Erweiterungen des Standardmodells vor. Immer höhere Massenlimits machen die Suche nach Single VLQ am LHC attraktiv, da für große VLQ-Massen in  $pp$ -Kollisionen bei  $\sqrt{s} = 13$  TeV die Einzelproduktion einen größeren Wirkungsquerschnitt als die Paarproduktion aufweisen kann.

VLQ können über flavorändernde neutrale Ströme zerfallen. Mit einer Schwerpunktsenergie von  $\sqrt{s} = 13$  TeV eröffnen sich über Identifikationsmethoden für geboostete Teilchen Zugänge zu bisher kaum nutzbaren Zerfallskanälen. Signaturen mit hadronischem Topquark-Zerfall und transversal fehlendem Impuls können sowohl für die Suche nach VLQ als auch Monotop-Produktion genutzt werden.

Vorgestellt werden Studien zur Untergrundbeschreibung und Selektionsoptimierung.

T 9.9 Mo 18:50 JUR 2

**Studien zur einzelnen Produktion von vektorartigen B-Quarks im Zerfall  $B \rightarrow bH$  im  $H \rightarrow \gamma\gamma$  Kanal bei  $\sqrt{s} = 13$  TeV mit dem ATLAS-Detektor** — ●FREDERIC SCHRÖDER, ISABEL NITSCHKE, DIANE CINCA, JOHANNES ERDMANN und KEVIN KRÖNINGER — TU Dortmund, Experimentelle Physik IV

Die einfachste, nicht ausgeschlossene Erweiterung zum Standardmodell (SM) der Teilchenphysik mit farbgeladenen Fermionen sind vektorartige Quarks (VLQ). In dieser Studie wird die Produktion von einem einzelnen vektorartigen B-Quark über die schwache Wechselwirkung betrachtet. Die Produktion eines einzelnen VLQ zeichnet sich durch die Möglichkeit der Suche bis zu hohen Massen aus, da in dieser Region der Wirkungsquerschnitt der einzelnen Produktion gegenüber der

VLQ-Paarproduktion überwiegen kann. In vielen Theorien wird eine dominante Kopplung der VLQ an die dritte Quark-Generation angenommen und VLQ mischen in Zerfällen mit diesen SM-Quarks. Es wird der Zerfall in ein SM- $b$ -Quark und ein Higgs-Boson betrachtet, mit dem Zerfall des Higgs-Bosons in zwei Photonen. Trotz des geringen Verzweigungsverhältnisses ermöglichen die beiden Photonen aus dem Higgs-Zerfall eine gute Massenauflösung und es wird wenig Untergrund erwartet.

Der betrachtete Prozess zeichnet sich durch den Endzustand  $\gamma\gamma b\bar{b}q$  aus, in dem je ein  $b$ -Quark mit niedrigem und hohem Transversalimpuls erwartet wird. Es wird eine Analysestrategie vorgestellt und die Verwendung der  $b$ -Tagging-Diskriminante zur Signal-Untergrund-Trennung untersucht.

T 9.10 Mo 19:05 JUR 2

**Suche nach Single Vector-like Quarks in  $T \rightarrow Z_{\text{inv}} t_{\text{had}}r$  am ATLAS-Experiment** — ●VOLKER AUSTRUP, SONJA BARTKOWSKI, JOHANNES ERDMANN und KEVIN KRÖNINGER — TU Dortmund, Experimentelle Physik IV

Vector-like Quarks (VLQ) sind hypothetische Spin-1/2-Teilchen und das einfachste Beispiel für farbgeladene Fermionen, das noch nicht durch experimentelle Daten ausgeschlossen wurde. Ihre Existenz wird von verschiedensten Theorien jenseits des Standardmodells postuliert.

VLQs könnten sowohl über Paarproduktion als auch einzeln über schwache Wechselwirkung erzeugt werden. Da der Wirkungsquerschnitt der Paarproduktion im Vergleich zur Einzelproduktion bei größeren VLQ-Massen deutlich schneller abnimmt, ist aufgrund steigender Massenlimits vorheriger Studien die Suche nach Single VLQ immer interessanter. Als attraktiver Kanal könnte sich dabei der Zerfall eines Vector-like Top-Partners  $T \rightarrow Zt$  mit  $Z \rightarrow \nu\bar{\nu}$  und hadronischem Topzerfall erweisen. Eine Schwerpunktsenergie von  $\sqrt{s} = 13$  TeV in Run II erlaubt die Suche bei großen VLQ-Massen, welche stark geboostete Zerfallsprodukte implizieren und damit den Einsatz von Top-Tagging-Methoden erlauben.

Im Vortrag werden Studien zur Ereignisselektion und der erwarteten Sensitivität präsentiert. Dabei werden Daten von 2015 und 2016 verwendet, die vom ATLAS-Experiment aufgenommen wurden.

## T 10: Suche nach Dunkler Materie 1 (LHC)

Zeit: Montag 16:45–18:45

Raum: VSH 116

T 10.1 Mo 16:45 VSH 116

**Search for Dark Matter in Vector Boson Fusion- and Monojet-Topologies with the ATLAS Experiment at 13 TeV** — ●MANUEL PATRICE GEISLER — Kirchhoff-Institut für Physik, Heidelberg

The nature of Dark Matter (DM) is one of the big open questions in modern physics. Although the cosmological evidence is strong, the nature of DM has yet to be unraveled. This talk covers a new search for DM with the ATLAS detector at CERN using the 2015 dataset of proton-proton collisions. As DM particles would escape the detector without leaving any trace, their production in association with quarks and gluons can result in significant amounts of missing transverse momentum (MET). Two high-MET final states are investigated, which differ in jet kinematics and minimum number of required jets (1-jet and 2-jet) and which are designed to be as generic as possible. Additionally, the 2-jet final state is particularly sensitive to vector boson fusion. In this talk, general aspects of the search as well as details on background estimations will be covered.

T 10.2 Mo 17:00 VSH 116

**Suche nach Dunkler Materie im Mono-Higgs-Kanal mit dem ATLAS-Detektor bei einer Schwerpunktsenergie von 13 TeV** — ●RAINER RÖHRIG, SANDRA KORTNER, HUBERT KROHA und PATRICK RIECK — Max-Planck-Institut für Physik, München, Deutschland

Dunkle Materie dominiert die Materie im Universum und ist einer der wichtigsten Hinweise auf Physik jenseits des Standardmodells. Die Teilchennatur der Dunklen Materie ist bisher unbekannt, jedoch wird vermutet, dass sie aus massiven schwach wechselwirkenden Elementarteilchen bestehen könnte. Solche Teilchen können am LHC erzeugt und im ATLAS-Detektor in Ereignissen mit hoher fehlender transversaler Energie beobachtet werden. Die Paarproduktion von Teilchen

der Dunklen Materie mit einem Higgs-Boson ( $pp \rightarrow h + \chi\bar{\chi}$ ) in  $pp$ -Kollisionen im sogenannten Mono-Higgs-Kanal liefert eine neue Signatur für Dunkle Materie, wonach nach der Entdeckung des Higgs-Bosons an Beschleunigern gesucht werden kann. Am vielversprechendsten ist dabei die Suche im Endzustand mit Higgs-Bosonzerfällen in  $b\bar{b}$ -Paare. Die Higgs-Bosonen werden hier mit hohen Impulsen erzeugt, was zu einer starken Kollimation der beiden  $b$ -Quarks im Endzustand führt, die daher als ein gemeinsamer Hadron-Jet mit großem Radiusparameter rekonstruiert werden. Die Substruktur solch großer Jets liefert zusätzliche Kriterien zur Unterdrückung des Untergrunds. Für die Suche nach Mono-Higgs-Ereignissen bei erhöhter Schwerpunktsenergie des LHC wurde die Sensitivität für verschiedene Signalmodelle untersucht und die aufgenommenen Daten der Jahre 2015 und 2016 analysiert.

T 10.3 Mo 17:15 VSH 116

**Sensitivity optimisation of the search for Dark Matter produced in association with a Higgs boson decaying to a pair of  $b$  quarks with the ATLAS detector at  $\sqrt{s}=13$  TeV using 36 fb-1 of data** — ●DANIEL NARRIAS-VILLAR — Heidelberg University, Im Neuenheimer Feld 227, 69120 Heidelberg

The recent discovery of the Higgs boson motivates collider-based searches for new physics models, where Dark Matter is produced in association with a Higgs boson. The signature of this search is a pair of  $b$  quarks from the Higgs boson decay, recoiling against missing transverse momentum from Dark Matter particle(s). To increase the sensitivity of the search, various studies are performed and applied in the analysis. The dominant background from  $t\bar{t}b\bar{b}$  production is reduced by about 70% for a signal loss of about 10%; as a result the irreducible background from  $Z(\nu\nu)+\text{jets}$  production became the dominant background contribution. These improvements result in a substantial increase of sensitivity of up to 50%. In case of no significant excess, limits at 95% confidence level over a parameter phase space of signal models will be provided using 36 fb-1 of data.



T 10.4 Mo 17:30 VSH 116

**From the trigger to model-independent limits: A search for Dark Matter produced in association with a Higgs boson decaying to a pair of  $b$ -quarks with the ATLAS detector at  $\sqrt{s} = 13$  TeV using 36 fb<sup>-1</sup> of data** — ●STANISLAV SUCHEK and OLEG BRANDT — Kirchhoff-Institut für Physik, Universität Heidelberg

Cosmological observations combined with the recent discovery of the Higgs boson motivate collider-based searches for new physics models, where Dark Matter is produced in association with a Higgs boson. This search focuses on the signature of a pair of  $b$ -quarks from the Higgs boson decay and missing transverse momentum from Dark Matter particle(s). One of the challenges of this analysis is the missing transverse energy trigger. Its performance in 36 fb<sup>-1</sup> of data collected by the ATLAS detector in 2015 and 2016 is studied. A particular focus is placed on the low missing transverse energy region, where triggers are not fully efficient, and Monte Carlo-to-data corrections are derived. Furthermore, trigger efficiencies are calculated for different signal models, such as  $Z'$ -2HDM and effective field theories. In case of no significant excess, model-independent limits at 95% confidence level on  $\sigma \times A \times \epsilon$ , the combination of production cross-section of potential new physics processes, detector acceptance, and the reconstruction efficiency, will be presented for different missing transverse energy regions.

T 10.5 Mo 17:45 VSH 116

**Dark Matter search in connection with top quark pair production** — ●NICOLE STEFANOV, CHRISTIAN SCHWANENBERGER, KELLY BEERNAERT, GERRIT VAN ONSEM, ALEXANDER GROHSJEAN, and AFIQ AIZUDDIN ANUAR — DESY, Hamburg

There are hints on dark matter from astrophysical observations since the early 20th century. To explain the observed rotation velocity of galaxies with the Newtonian law of gravity, more matter needs to be present than the visible one. Otherwise galaxies would fly apart into their individual components. Today over 80 percent of the total matter of the universe is assumed to be dark matter and the origin of dark matter is completely unknown.

At the CERN Large Hadron Collider we search for dark matter using data from the CMS experiment. In this talk I present a search for dark matter in association with top quark pair production.

Tools and methods how to increase the sensitivity in extracting dark matter events from the obtained data will be discussed.

T 10.6 Mo 18:00 VSH 116

**Search for dark matter in events with a  $Z$  boson and missing transverse energy at CMS** — ●ANDREAS ALBERT, THOMAS HEBBEKER, and ARND MEYER — III. Physikalisches Institut A, RWTH Aachen University, Aachen

Understanding the origin of dark matter (DM) is one of the most pressing tasks in physics today. As ample astrophysical evidence has shown, DM occupies a significant fraction of the cosmological energy budget, for which the standard model of particle physics cannot account. If DM consists of particles, it may be produced in particle collisions.

A search for dark matter in proton-proton collision events with a center-of-mass energy of 13 TeV at the CERN LHC is presented. The analysis is based on a dataset corresponding to an integrated luminos-

ity of approximately 36/fb collected in the CMS experiment in 2016. Since hypothetical DM particles would not be directly detectable in CMS, events with large missing transverse energy (MET) are selected. Additionally, a muon or electron pair compatible with the decay of a  $Z$  boson from initial state radiation is required in order to select a well-defined topology. A shape analysis of the MET spectrum then allows to search for a signal.

In addition to DM production, the search can be interpreted in terms of other new physics phenomena producing undetectable particles, such as unparticles and gravitons.

Following an introduction to the analysis concepts, recent developments in the used experimental techniques and results of the analysis are presented.

T 10.7 Mo 18:15 VSH 116

**Search for Dark Matter in association with a hadronically decaying vector boson in  $pp$  collisions at  $\sqrt{s} = 13$  TeV using 2015+2016 data collected with the ATLAS detector** — ●XUANHONG LOU — Deutsches Elektronen-Synchrotron, 22607 Hamburg, Germany

We present a search for Dark Matter pair production in association with a hadronically decaying vector boson using 36 fb<sup>-1</sup> of  $pp$  collisions at  $\sqrt{s} = 13$  TeV recorded by the ATLAS detector at the Large Hadron Collider. Events are characterized by large missing transverse momentum and a  $W$  or  $Z$  boson reconstructed as either a pair of small-radius jets or a single large-radius jet with substructure information. The results will be interpreted in terms of simplified models and effective field theories which are used to describe the interaction between Dark Matter and the Standard Model particles. The data are consistent with the Standard Model predictions and no statistically significant excess is observed.

T 10.8 Mo 18:30 VSH 116

**Suche nach Dunkler Materie in Assoziation mit einem hadronisch zerfallenden  $W$ - oder  $Z$ -Boson mit den Run-2-Daten des ATLAS-Detektors** — ●PHILIPP GADOW, SANDRA KORTNER, HUBERT KROHA und PATRICK RIECK — Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München

Die Existenz Dunkler Materie wird durch zahlreiche astrophysikalische Hinweise untermauert, jedoch steht ein Nachweis der genauen Teilchennatur noch immer aus. Hypothetische Teilchen der Dunklen Materie können in  $pp$ -Kollisionen am LHC in Paaren gemeinsam mit Teilchen des Standardmodells erzeugt und so über Signaturen mit fehlendem Transversalimpuls nachgewiesen werden. Dieser Vortrag stellt die Suche nach Dunkler Materie in assoziierter Produktion mit einem hadronisch zerfallenden  $W$ - oder  $Z$ -Boson vor, basierend auf den Run-2-Daten des ATLAS-Detektors. Die Signalsignatur ergibt sich aus den als Jets rekonstruierten Zerfallsprodukten der Vektorbosonen und dem fehlenden Transversalimpuls der nicht mit dem Detektor wechselwirkenden Teilchen der Dunklen Materie. Bei hoher Geschwindigkeit des Vektorbosons ist es möglich, dass die Zerfallsprodukte als einzelner Jet mit großem Radiusparameter rekonstruiert werden. Bei der Identifizierung der Vektorbosonen kommen daher Jet-Substruktur Techniken zum Einsatz. Die Ergebnisse werden im Rahmen von vereinfachten Modellen sowie einer effektiven Feldtheorie interpretiert.

## T 11: Neutrinophysik 1 (Neutrinomassen)

Zeit: Montag 16:45–19:05

Raum: VSH 17

### Gruppenbericht

T 11.1 Mo 16:45 VSH 17

**Status of the KATRIN Experiment** — ●FABIAN HARMS for the KATRIN-Collaboration — Karlsruhe Institute of Technology (KIT), Institute for Nuclear Physics (IKP)

The Karlsruhe Tritium Neutrino (KATRIN) Experiment is a large-scale experiment for the model independent determination of the effective mass of the electron-antineutrino with a sensitivity of 200 meV/ $c^2$  (90% C.L.). It investigates tritium  $\beta$ -decay close to the kinematic endpoint of the energy spectrum with a high-resolution electrostatic spectrometer ( $\Delta E = 0.93$  eV at 18.6 keV).

The KATRIN experimental setup consists of a high luminosity windowless gaseous tritium source (WGTS), a magnetic electron transport system with differential and cryogenic pumping for tritium retention, a series of two electrostatic spectrometers (pre-spectrometer and main

spectrometer) for energy analysis, and a detector system based on a segmented silicon PIN diode detector for efficient counting of transmitted  $\beta$ -electrons.

With all main components on site at KIT, the experiment celebrated 'FirstLight' on 14<sup>th</sup> October 2016 by successfully transmitting electrons through the 70-m long experimental setup. The talk will present the current status of the experiment and give an overview on the results of the recent FirstLight measurement campaign.

We acknowledge the support by KSETA, BMBF (05A14VK2), HAP and the Helmholtz association.

T 11.2 Mo 17:05 VSH 17

**Project 8: Towards measuring the neutrino mass using CRES** — ●CHRISTINE CLAESSENS and SEBASTIAN BÖSER — Institut für Physik, Johannes Gutenberg-Universität Mainz

The Project 8 collaboration seeks to measure the absolute electron neutrino mass by investigating the endpoint of the tritium beta decay spectrum using a frequency based method. To this purpose the collaboration has recently established Cyclotron Radiation Emission Spectroscopy (CRES) as a new method to determine the energy of relativistic electrons. By trapping electrons from krypton decay in a magnetic field to increase the integration time, the detection of single electrons and the reconstruction of their kinetic energy from the measured cyclotron frequency has successfully been demonstrated (Phys. Rev. Lett. 114, 162501). In this talk the proof of principle prototype design and current results are presented. Furthermore, insight on one of the main challenges for the forthcoming scale-up of the experiment, the development of a fast frequency based trigger, is given.

T 11.3 Mo 17:20 VSH 17

**The Electron Capture in  $^{163}\text{Ho}$  experiment** — ●FEDERICA MANTEGAZZINI for the ECHO-Collaboration — Kirchhoff-Institute for Physics, Heidelberg University, Germany

The Electron Capture in  $^{163}\text{Ho}$  (ECHO) experiment is designed to investigate the electron neutrino mass with sub-eV sensitivity by the analysis of the electron capture spectrum of  $^{163}\text{Ho}$ . The sensitivity on the electron neutrino mass is crucially related to the energy available for the decay  $Q_{\text{EC}} = 2833(30_{\text{stat}})(15_{\text{sys}})$  eV, which has been precisely determined by the ECHO collaboration. Accordingly, a sensitivity below 10 eV at the end of the present phase of the experiment, ECHO-1k, is expected. During this phase about 1 kBq of high purity  $^{163}\text{Ho}$  source will be implanted in arrays of low temperature metallic magnetic calorimeters operated in a reduced background environment. The goals of the current phase are the precise characterization of the parameters describing the spectrum, the optimization of the detectors production and the identification and reduction of the background sources. These results will pave the way to the second phase of the experiment, ECHO-1M, where an activity of 1 MBq will be used, in order to reach a sub-eV sensitivity on the electron neutrino mass. Furthermore, the high statistics and high resolution measurement of the  $^{163}\text{Ho}$  electron capture spectrum will allow the investigation of the existence of sterile neutrinos at the eV- and keV-scale up to a mass value of  $Q_{\text{EC}}$ . In this contribution, a general overview of the ECHO experiment is presented and the current status as well as the future perspectives are discussed.

T 11.4 Mo 17:35 VSH 17

**Description of the calorimetrically measured Ho-163 spectrum** — ●DOROTHEA FONNESU for the ECHO-Collaboration — Kirchhoff-Institute for Physics, Heidelberg University

The study of the end-point region of calorimetrically measured Ho-163 electron capture spectrum will allow, in the next future, to achieve sub-eV sensitivity on the electron neutrino mass. Within the ECHO experiment, first high statistics Ho-163 spectra have been measured with very high energy resolution. Such precise measurements allowed the identification of structures in the Ho-163 spectrum which are not described if only first order excited states, consisting in a hole in the electronic shells of the daughter atom left by the captured electron, are considered. Second order excited states in the daughter dysprosium atoms characterized by two holes in the atomic shells could be the reason of the additional structure in the spectrum. We present the comparison of the high statistics Ho-163 spectra acquired in a low background environment with theories including second order excited states. At the present status there is not a clear agreement between theory and data. We discuss how new high statistic measurements of the Ho-163 spectrum and new experiments could provide inputs to better understand the role of higher order excited states occurring after electron capture processes.

T 11.5 Mo 17:50 VSH 17

**FirstLight measurements of the KATRIN experiment** — ●MORITZ HACKENJOS — Karlsruhe Institute of Technology (KIT), Institute for Technical Physics (ITEP)

The Karlsruhe TRitium Neutrino (KATRIN) experiment aims to determine the effective mass of the electron-antineutrino with a sensitivity of  $200 \text{ meV}/c^2$  (90% C.L.) by the investigation of the endpoint energy-region of the tritium  $\beta$ -spectrum in a direct and model-independent way. Therefore, Molecular tritium gas will be injected continuously in the center of a Windowless Gaseous Tritium Source (WGTS).  $\beta$ -electrons from tritium decay are then guided via superconducting solenoids along the 70-m long experimental beamline towards two electrostatic spectrometers used for high-precision energy

analysis. A segmented detector at the end of the beam line efficiently counts those electrons which overcome the retarding potential of the spectrometers.

With only  $2 \times 10^{-13}$   $\beta$ -electrons found in the last 1-eV region of the tritium  $\beta$ -spectrum, it is of utmost importance to use most of the WGTS high luminosity. Therefore an adiabatic guidance of the  $\beta$ -electrons along the experimental setup without energy or statistics loss is crucial to reach the KATRIN design sensitivity.

In fall 2016 the full KATRIN beamline was run in joint operation for the first time during a FirstLight commissioning measurement campaign. This talk will focus on the overall beam line alignment of KATRIN which was studied in a series of dedicated measurements during FirstLight.

T 11.6 Mo 18:05 VSH 17

**Simulation of global beamline alignment of the KATRIN experiment** — ●MARCO DEFFERT for the KATRIN-Collaboration — Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

The Karlsruhe TRitium Neutrino (KATRIN) experiment aims to determine the effective mass of the electron anti-neutrino with a sensitivity of  $200 \text{ meV}/c^2$  (90 % C.L.) by investigating the kinematics of tritium  $\beta$ -decay. For this purpose it uses a high luminosity windowless gaseous tritium source ( $A = 10^{11}$  Bq) combined with a high resolution electrostatic spectrometer ( $\Delta E = 0.93 \text{ eV}$  at  $18.6 \text{ keV}$ ). In fall 2016 First Light measurements were performed with the full KATRIN beamline when electrons were guided magnetically through the 70-m long setup for the first time.

In order to simulate the electron transport and interactions in KATRIN the KASSIOPEIA particle tracking framework has been developed. This talk will focus on the implementation of the full KATRIN beamline into KASSIOPEIA and first results on simulations of the electron transport with regards to the First Light measurements.

We acknowledge the support by KSETA, BMBF (05A14VK2), HAP and the Helmholtz association.

T 11.7 Mo 18:20 VSH 17

**First results of the commissioning of the Windowless Gaseous Tritium Source of the KATRIN experiment** — MORITZ HACKENJOS, ALEXANDER MARSTELLER, and ●HENDRIK SEITZ-MOSKALIUK for the KATRIN-Collaboration — Karlsruher Institut für Technologie, Institut für experimentelle Kernphysik, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

KATRIN will perform a direct, kinematics-based measurement of the neutrino mass with a sensitivity of  $200 \text{ meV}$  (90 % C. L.) reached after 3 years of measurement time. The neutrino mass is obtained by determining the shape of the spectrum of tritium beta decay electrons close to the endpoint of  $18.6 \text{ keV}$  with a spectrometer of MAC-E filter type. Important requirements to achieve this goal are the temperature stability and homogeneity of the beam tube of the Windowless Gaseous Tritium Source (WGTS). The temperature stability is specified to be within  $\pm 30 \text{ mK/h}$  and the temperature homogeneity is specified to be within  $\pm 30 \text{ mK}$  along the 10 m long WGTS beam tube.

During the first light measurement campaign in fall 2016, the cryogenic performance of the WGTS was tested in detail. This talk presents the results of this first cryo-test of the source cryostat showing that the WGTS is ready for standard KATRIN operation.

This work is supported by BMBF (05A14VK2) and the Helmholtz Association.

T 11.8 Mo 18:35 VSH 17

**Project 8: Atomic Tritium Motivation and Source Design** — ●ALEX LINDMAN, SEBASTIAN BÖSER, and PETER PEIFFER — Institut für Physik, Johannes Gutenberg Universität Mainz

Project 8 is a phased approach to measuring the absolute neutrino mass with Cyclotron Radiation Emission Spectroscopy (CRES) of tritium beta decay electrons. This talk will discuss the motivations for an atomic T source and the supporting apparatus design in light of engineering feasibility and the design sensitivity. All existing T  $\beta$ -decay  $m_\nu$  measurements use molecular  $\text{T}_2$ , which has a relatively broad final states spectrum. An atomic T source and a few cubic meter trap volume will enable the target sensitivity. Parallel technology development efforts in Project 8 aim to deliver a trap with magnetic field uniformity of  $10^{-7}$ , filled with tritium having a  $\text{T}_2$  contamination less than  $10^{-6}$  and instrumented with a spatially resolving phased antenna array to measure the femtowatt CRES signals. In such a trap, one year of runtime with  $10^{18}$  T atoms should provide  $40 \text{ meV}$  sensitivity to the neutrino mass.

T 11.9 Mo 18:50 VSH 17

**Production, Separation and Implantation of  $^{163}\text{Ho}$  for Electron Neutrino Mass Measurements** — ●TOM KIECK<sup>1</sup>, HOLGER DORRER<sup>1</sup>, CHRISTOPH E. DÜLLMANN<sup>1</sup>, KLAUS EBERHARDT<sup>1</sup>, RAPHAEL HAAS<sup>1</sup>, ULLI KÖSTER<sup>2</sup>, CHRISTOPH MOKRY<sup>1</sup>, JÖRG RUNKE<sup>1</sup>, SEBASTIAN SCHMIDT<sup>1</sup>, FABIAN SCHNEIDER<sup>1</sup>, LEONARD WINKELMANN<sup>1</sup>, and KLAUS WENDT<sup>1</sup> for the ECHo-Collaboration — <sup>1</sup>Johannes Gutenberg-Universität, Mainz, Germany — <sup>2</sup>Institut Laue-Langevin, Grenoble, France

The ECHo collaboration aims at measuring the electron neutrino mass by recording the spectrum following electron capture of  $^{163}\text{Ho}$  using

metallic magnetic calorimeters (MMC). Presently kBq amounts of the radioisotope  $^{163}\text{Ho}$  were produced from enriched  $^{162}\text{Er}$  in the ILL high flux nuclear reactor, chemical and mass spectrometric separated and embedded into  $250 \times 250 \mu\text{m}^2$  Au-absorbers.

The application of resonance ionization at the RISIKO mass separator provides optimum elemental and isotopic selectivity for ultra-pure  $^{163}\text{Ho}$  ion implantation. After improvement of efficiency and stability of laser ion source and mass separator, post focusing ion optics were installed and characterized for minimum loss implantation with sub millimeter beam spot size. An in-situ deposition of gold using the technique of pulsed laser deposition (PLD) generates a homogeneous  $^{163}\text{Ho}/\text{Au}$  layer as absorber of the MMC.

## T 12: Neutrinophysik 2 (Doppelbetazerfall)

Zeit: Montag 16:45–19:05

Raum: VSH 118

### Gruppenbericht

T 12.1 Mo 16:45 VSH 118

**Status of the CUORE  $0\nu\beta\beta$  decay search** — ●BENJAMIN SCHMIDT for the CUORE-Collaboration — Institute for Nuclear and Particle Astrophysics, Lawrence Berkeley National Laboratory, Berkeley, CA, USA

Observation of neutrinoless double beta decay ( $0\nu\beta\beta$ ) would establish lepton number violation, would indicate that neutrinos are Majorana particles, and could provide information on the absolute neutrino mass scale. CUORE, the Cryogenic Underground Observatory for Rare Events, uses a cryogenic array of 988  $\text{TeO}_2$  bolometers to target the  $0\nu\beta\beta$  decay candidate isotope  $^{130}\text{Te}$ . It is the first tonne-scale cryogenic bolometer experiment featuring a total detector mass of about 740 kg of natural tellurium. Recently the detector installation at the Laboratori Nazionali del Gran Sasso (LNGS) has been completed and data taking is scheduled to begin in early 2017. We will discuss the status of the CUORE experiment and present the most recent results from CUORE-0, a single-tower array of 52 crystals, operated at LNGS between 2013-2015.

T 12.2 Mo 17:05 VSH 118

**The nEXO experiment** — ●JUDITH SCHNEIDER, JÜRGEN HÖSSL, PATRICK HUFSCHEIDT, AKO JAMIL, LUKAS MADERER, MICHAEL WAGENPFIL, TOBIAS ZIEGLER, GISELA ANTON, and THILO MICHEL — Erlangen Centre for Astroparticle Physics, 91058 Erlangen, Germany

The question whether the neutrino is its own antiparticle or not is still not answered. The most feasible way to investigate this is the search for the neutrinoless double beta decay. The nEXO experiment, which is currently under development, will search for this decay. Its baseline concept is a single-phase liquid xenon (LXe) time projection chamber (TPC) filled with about 5 tons of LXe enriched to about 80%  $\text{Xe-136}$  as double beta decay nuclide as well as detection material. In order to achieve an excellent energy resolution, a position-resolving, low-noise charge readout as well as very efficient light detection is mandatory. For the purpose of very low background levels, radiopure Silicon Photomultipliers (SiPMs) have to be used to detect the scintillation light of LXe. In this talk, the baseline-concept of the experiment will be presented.

T 12.3 Mo 17:20 VSH 118

**Characterization of a VUV-sensitive Silicon Photomultiplier for the nEXO experiment** — ●TOBIAS ZIEGLER, PATRICK HUFSCHEIDT, AKO JAMIL, JUDITH SCHNEIDER, MICHAEL WAGENPFIL, GISELA ANTON, and THILO MICHEL — ECAP, Friedrich-Alexander-Universität Erlangen-Nürnberg

The future nEXO experiment will use about  $4\text{m}^2$  of SiPMs for the detection of the VUV (vacuum ultraviolet) scintillation light ( $\lambda = 175\text{nm}$ ) from LXe to search for the neutrinoless double beta ( $0\nu\beta\beta$ ) decay of  $^{136}\text{Xe}$ . Besides suffering from correlated avalanches, such as crosstalk and afterpulsing, most commercially available SiPMs are not sensitive to UV light. The core criteria, for having an energy resolution of about 1% ( $\sigma$ ) at the  $Q$ -value of the  $0\nu\beta\beta$  decay of  $^{136}\text{Xe}$  at 2457.8 keV, are a photon detection efficiency (PDE) of at least 15% at 175 nm and a correlated avalanche probability of less than 20%. We present measurements with a new device dedicated to detect VUV light. These SiPMs were investigated at  $-100^\circ\text{C}$  both in the absence of light as well as using Xe scintillation light with respect to the requirements by the nEXO experiment.

T 12.4 Mo 17:35 VSH 118

**Development of Large Area Silicon Photomultipliers in Noble Liquids for the nEXO Experiment** — ●AKO JAMIL<sup>1,2</sup>, ALEXIS SCHUBERT<sup>2</sup>, GAOSONG LI<sup>2</sup>, IGOR OSTROVSKIY<sup>2</sup>, GIORGIO GRATTA<sup>2</sup>, GISELA ANTON<sup>1</sup>, and THILO MICHEL<sup>1</sup> — <sup>1</sup>Friedrich-Alexander-Universität Erlangen Nürnberg — <sup>2</sup>Stanford University

The nEXO experiment will reach a half-life sensitivity of  $5 \times 10^{27}$  yrs for the neutrino-less double beta decay of  $^{136}\text{Xe}$ . nEXO will use Silicon Photomultipliers (SiPM) for the detection of the 175nm scintillation light of xenon. Simulations have shown that to reach the desired energy resolution of 1% ( $\sigma$ ), a total of  $4\text{m}^2$  of photo detectors are required, which would have to detect at least 5% of the scintillation light. Recent measurements show promising results from various SiPM vendors, where the detectors exceed the necessary 15% photon detection efficiency and meet our correlated avalanche rate requirement. The nEXO collaboration is also investigating solutions for reading out  $\text{m}^2$  of SiPMs, which has not been done before. A prototype, with a photo detector area of about  $40\text{cm}^2$ , has been developed and tested in a liquid xenon TPC. In this talk we will report the development of solutions for light detection in nEXO, highlighting the technologies that are pioneered by the collaboration, especially VUV sensitive SiPMs and large area integration as well as readout in liquid xenon.

T 12.5 Mo 17:50 VSH 118

**Investigations on electron drift in the EXO-200 TPC** — ●GERRIT WREDE, SEBASTIAN SCHMIDT, GISELA ANTON, JÜRGEN HÖSSL, and THILO MICHEL — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, 91058 Erlangen

The EXO-200 experiment searches for the neutrinoless double beta decay of  $\text{Xe-136}$  with a cylindrical LXe TPC.

The double-sided, single-phase TPC provides the position (X,Y,Z) of events and the deposited energy in LXe by simultaneously detecting the scintillation light and the amount of released charge.

For charge collection, electrons drift in the electric field towards the end plates on each side of detector, where they induce currents in a first plane of wires and are collected by a second plane of wires. In order to improve the accuracy of the position reconstruction an analysis of drift field inhomogeneities at the side wall of the cylindrical TPC was carried out.

In this contribution we present the results of our investigations on the non-uniformities of the electric field close to the field-shaping rings and our work on the charge drift simulation to account for these non-uniformities to eventually increase the fiducial volume in the data analysis.

T 12.6 Mo 18:05 VSH 118

**Pulse Shape Discrimination for the GERDA Experiment** — ●VICTORIA WAGNER for the GERDA-Collaboration — Max-Planck Institut für Kernphysik, Heidelberg

The GERDA experiment searches for neutrinoless double beta decay of  $^{76}\text{Ge}$  using high purity germanium (HPGe) detectors operated in liquid argon (LAR). The aim is to explore half-lives of the order of  $10^{26}$  yr. Therefore, GERDA relies on improved active background reduction techniques such as pulse shape discrimination (PSD) in which the time structure of the germanium signals is analyzed to discriminate signal- from background-like events. Two types of HPGe detectors

are operated: semi-coaxial detectors previously used in the Heidelberg-Moscow and IGEX experiments and new BEGe detectors. For semi-coaxial detectors a method based on an artificial neural network is used. Due to their special geometry, BEGe detectors feature an enhanced PSD. The analysis is based on a single parameter, the ratio of the maximum amplitude of the current pulse over the energy,  $A/E$ . 76 % of the background events in the region of interest are rejected while keeping a signal efficiency of 87 %. In GERDA Phase I, a background index of the order of  $10^{-2} \frac{\text{cts}}{\text{keV} \cdot \text{kg} \cdot \text{yr}}$  has been achieved. The Phase II upgrade features an active veto based on the read-out of argon scintillation light (LAr veto) for further background discrimination. Together, PSD and LAr veto achieve a BI of the order of  $10^{-3} \frac{\text{cts}}{\text{keV} \cdot \text{kg} \cdot \text{yr}}$ . With this unprecedented BI, less than one background event is expected until an exposure of 100 kg·yr. The talk reviews the applied PSD methods and their impact on the experimental sensitivity.

T 12.7 Mo 18:20 VSH 118

**In-situ measurement of the light attenuation in liquid argon in the GERDA cryostat** — ●BIRGIT SCHNEIDER for the GERDA-Collaboration — TU Dresden, Institut für Kern- und Teilchenphysik, Germany

GERDA is an experiment searching for the neutrinoless double beta decay in  $^{76}\text{Ge}$ . It operates the enriched germanium detectors bare in liquid argon (LAr), which serves both as a coolant and a shield for external radiation. Phase II of GERDA aims for an exposure of 100 kg·yr with a background index (BI) of  $10^{-3} \text{ cts}/(\text{kg} \cdot \text{yr} \cdot \text{keV})$ . One of the major improvements compared to Phase I is the instrumentation of the LAr to readout its scintillation light to further reduce the BI. Recently, first results of Phase II were published which have shown that the aimed BI could be reached. Hence, GERDA is operating quasi background-free and has the lowest background ever achieved with Ge-based  $0\nu\beta\beta$ -experiments. The attenuation of the scintillation light in LAr limits the effective active volume of the LAr veto and is therefore a key parameter to characterize the instrumentation.

In order to measure the light attenuation in LAr, a setup was designed that could be deployed directly into the cryostat. This setup contains a movable beta source and a PMT to detect the scintillation light at different distances.

The talk will present the acquired data as well as a detailed description of the performed analysis, the results and a comparison with a dedicated simulation.

This project is partially funded by BMBF.

T 12.8 Mo 18:35 VSH 118  
**Background characterization in GERDA Phase II** — ●ANN-KATHRIN SCHÜTZ for the GERDA-Collaboration — Eberhard Karls Universität Tübingen, Germany

The GERDA collaboration aims to determine the half-life of the neutrinoless double beta decay ( $0\nu\beta\beta$ ) of  $^{76}\text{Ge}$ . In Phase II additional 20 kg of isotopically enriched germanium detectors are operated. To further increase the sensitivity for the half-life of neutrinoless double beta decay the identification and suppression of the background is of great importance. The application of active background-suppression techniques, such as a liquid argon scintillation light read-out and pulse shape discrimination of germanium detector signals allowed to reduce the background index to the intended level of  $10^{-3} \text{ cts}/(\text{keV} \cdot \text{kg} \cdot \text{yr})$ . The background components at  $Q_{\beta\beta}$  have been identified to be mainly due to  $\beta$ - and  $\gamma$ -induced events from close sources originating from the U-series, the Th-series, K and  $\alpha$  emitting isotopes from the  $^{226}\text{Ra}$  decay chain. (Anti-)coincidences between germanium detectors and with the liquid argon veto enlarges the tools of identification compared to Phase I. A background study based on results of material screening or the observation of characteristic structures in the energy spectrum was performed and will be presented in this talk.

T 12.9 Mo 18:50 VSH 118

**Characterization of a new Ge detector type for future  $0\nu\beta\beta$  search experiments** — ●YOANN KERMAIDIC for the GERDA-Collaboration — Max Planck Institut für Kernphysik

The search for a neutrinoless double decay ( $0\nu\beta\beta$ ) is a very sensitive tool for probing whether neutrino are Dirac or Majorana particles. A potential discovery has far reaching consequences for particle physics and cosmology (leptogenesis).

$^{76}\text{Ge}$  based experiments, like GERDA, are leading in the field because of the superior energy resolution and the lowest background. A new collaboration has been founded with the goal to boost the half-life sensitivities by two orders of magnitude.

In this talk, I will show recent works on a new  $^{76}\text{Ge}$  detector type, called Small-Anode Germanium Well (SAGe) detector, manufactured by Canberra. Its working principle is similar to Broad Energy Germanium detectors used in GERDA but its unique geometry allows highly efficient particle interaction discrimination by pulse shape analysis with a detector mass that can be as high as 2.7 kg. Simulations are here compared to data. I will finally discuss the design and goals of the new  $^{76}\text{Ge}$  experiment.

## T 13: Neutrinoastronomie 1

Zeit: Montag 16:45–19:05

Raum: H 1

### Gruppenbericht

T 13.1 Mo 16:45 H 1

**Towards a search for optically hidden supernovae in 8 years of IceCube data** — ●GIULIO MOMENTE<sup>1</sup>, LUTZ KÖPKE, and BENJAMIN EBERHARDT for the IceCube-Collaboration — ETAP, Johannes Gutenberg-Universität, Mainz

At the present date, IceCube offers the highest statistics to study the neutrino light curve of an exploding Supernova in our galaxy.

In this talk, recent improvements in the IceCube data taking and analysis software and on the integration with networks such as GCN (Gamma-ray Coordination Network) and SNEWS (Supernova Early Warning System) will be presented.

Furthermore, an overview on an ongoing search for optically hidden supernovae with neutrinos in IceCube will be presented.

T 13.2 Mo 17:05 H 1

**Gravitational waves and Supernovae** — LUTZ KÖPKE and ●ALEXANDER FRITZ for the IceCube-Collaboration — Johannes-Gutenberg Universität Mainz, 55128 Mainz

While Supernovae release 99% of their energy in form of neutrinos and antineutrinos, they also exhibit different phases in which gravitational waves may be produced. IceCube is capable of detecting MeV-neutrinos from Supernovae using the inverse  $\beta$ -decay reaction. For a galactic Supernova at 10 kpc, IceCube will detect a few 100000 unresolved neutrino interactions. That leads us to the possibility to resolve fine structures of time changes in the flux. In this presentation I am going to quantify correlation between the gravitational wave signal and the neutrino signal of Supernovae for a specific three dimensional

simulation. Notably, correlations are seen in periods, where standing accretion shock instability (SASI) arise.

T 13.3 Mo 17:20 H 1

**Search for ultra-high energy neutrinos and follow-up search of gravitational wave events with the Pierre Auger Observatory\*** — ●MICHAEL SCHIMP for the Pierre Auger-Collaboration — Bergische Universität Wuppertal

The surface detector (SD) of the Pierre Auger Observatory allows to distinguish air showers induced by neutrino interactions deep in the atmosphere from other air showers. Moreover, it has a very large acceptance. As a result, it is sensitive to neutrinos at zenith angles above  $60^\circ$  and energies of 0.1 EeV – 100 EeV in contrast to current neutrino telescopes that have their peak sensitivities at a few PeV and below.

The searches for a neutrino flux at energies above 0.1 EeV can constrain the composition, propagation, and source properties of cosmic rays. Among the source candidates for cosmic rays and ultra-high energy neutrinos are the sources of gravitational wave (GW) events that were recently discovered by the LIGO collaboration.

We present the current status of a search for ultra-high energy neutrinos with the Pierre Auger SD, focusing on the analysis at low-zenith angles ( $< 75^\circ$ ). Furthermore, we present the most recent results of a corresponding follow-up search of the published LIGO GW events.

\*Gefördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A14PX1).

T 13.4 Mo 17:35 H 1

**Search for cross-correlations of cosmic neutrinos and ultra-high-energy cosmic rays** — ●LISA SCHUMACHER, CHRISTIAN HAACK, LEIF RÄDEL, RENÉ REIMANN, SEBASTIAN SCHOENEN, and CHRISTOPHER WIEBUSCH for the IceCube-Collaboration — III. Physikalisches Institut B, RWTH Aachen

Cosmic rays have been discovered a century ago, however, their sources remain unidentified. It is believed that the same environments that accelerate cosmic rays also produce neutrinos by hadronic interactions. Recently, the IceCube Neutrino Observatory has discovered a flux of high-energy astrophysical neutrinos, and a joint analysis with the Pierre-Auger Observatory and the Telescope Array found hints for a possible directional correlation of neutrino events and cosmic-ray events. First studies for a follow-up analysis including additional data are presented.

T 13.5 Mo 17:50 H 1

**Multiwavelength follow-up of a rare IceCube neutrino multiplet** — ●NORA LINN STROTJHANN for the IceCube-Collaboration — Desy Zeuthen

IceCube's optical and X-ray follow-up program searches for several neutrino candidates consistent with a point source origin which are detected within 100 s. Follow-up observations can be triggered within minutes to look for an electromagnetic transient that would reveal the nature of the neutrino source.

In February 2016, we detected, for the first time, three neutrino candidates within 100 s. The detection of such a multiplet due to the chance alignment of atmospheric background events is expected once every 13.7 years (0.38 background events expected since the start of the program in 2008).

We triggered extensive multiwavelength follow-up observations spanning from the optical regime to very-high-energy gamma rays. No likely transient neutrino source was identified and due to the good data coverage we can rule out the presence of a close-by supernova, a bright GRB, or a high-energy AGN flare.

T 13.6 Mo 18:05 H 1

**Identification of Neutrinos and Gamma-Rays from the Cygnus-X Complex** — ●MEHMET GUENDUEZ<sup>1</sup>, JULIA BECKER TAUS<sup>1</sup>, BJÖRN EICHMANN<sup>1</sup>, and FRANCIS HALZEN<sup>2</sup> — <sup>1</sup>RAPP Center TP IV Ruhr-Universität Bochum, Bochum, Germany — <sup>2</sup>IceCube Collaboration University of Wisconsin, Madison, USA

The Cygnus X region is known as the richest star-forming region within a few kpc and is home to many particle accelerators such as supernova remnants, pulsar wind nebulae or massive star clusters. The abundance of accelerators and the ambient conditions make Cygnus X a natural laboratory for studying the life cycle of the cosmic-ray. The correlation between radio and gamma radiation from this region has been examined, where emissions from both leptonic and hadronic processes have been taken into account. In doing so, the transport and loss mechanism in Cygnus is investigated, such that the resulting neutrino spectrum is derived. By considering the rigidity differences between electrons and protons and a steady state description of a plasma, the total source of the high energy CRs has been calculated as generally as possible. Since only minute pieces of information about local processes in Cygnus are available and small inhomogeneities vanish at larger scales, a spherically symmetric and spatially homogeneous vicinity is assumed. Moreover, the influence of continuous losses and catastrophic losses due to diffusion and advection is investigated in order to provide

a realistic picture of Cygnus-X.

T 13.7 Mo 18:20 H 1

**Completing the Picture: Neutrinos from 1ES 1959+650** — ●THOMAS KINTSCHER<sup>1</sup> and KAI KRINGS<sup>2</sup> for the IceCube-Collaboration — <sup>1</sup>DESY (Zeuthen) — <sup>2</sup>TU München

The IceCube neutrino observatory is a 1 km<sup>3</sup> in-ice Cherenkov detector at the Geographic South Pole. While it has observed an astrophysical flux of neutrinos, individual sources have yet to be found.

The high-peaked BL Lac object 1ES 1959+650 is an intriguing candidate, as it exhibited an “orphan flare” in 2002: Such behaviour of a TeV gamma-ray flare without a simultaneous X-ray flare is hard to accommodate in leptonic SSC models, making this a potential site of hadronic acceleration and thus a prime source candidate for neutrinos.

A recent increase of activity in gamma-rays from this source between May and July of 2016 now prompts for a dedicated analysis of IceCube data, looking for neutrinos correlated with the flaring states. This talk will present the model-independent approaches looking only for an excess of neutrinos, as well as a complementary search for a timely correlation between the neutrinos and gamma-ray data.

T 13.8 Mo 18:35 H 1

**Astrophysical Neutrino Production Diagnostics with the Glashow Resonance** — ●DANIEL BIEHL<sup>1</sup>, ANATOLI FEDYNITCH<sup>1</sup>, ANDREA PALLADINO<sup>2</sup>, TOM WEILER<sup>3</sup>, and WALTER WINTER<sup>1</sup> — <sup>1</sup>DESY, Platanenallee 6, 15738 Zeuthen, Germany — <sup>2</sup>Gran Sasso Science Institute, L'Aquila (AQ), Italy — <sup>3</sup>Department of Physics & Astronomy, Vanderbilt University, Nashville, TN 37235, USA

We study the Glashow resonance as diagnostic of the production processes of ultra-high energy neutrinos. Photohadronic interactions in astrophysical environments do not produce any electron antineutrinos via the Delta resonance. In contrast, proton-proton sources show a significant fraction of electron antineutrinos. This difference results in different event rates at the detector, making both processes distinguishable from each other after a certain exposure even after mixing. However, under realistic assumptions, also in the photohadronic case there is a significant contamination by electron antineutrinos. Thus, it is extremely challenging to discriminate between a pp and pγ scenario, even with IceCube-Gen2. Nevertheless, we find that the Glashow resonance can serve as a smoking gun signature of neutrino production from photohadronic interactions of heavier nuclei. Finally, we quantify the exposures for which the non-observation of the Glashow resonance exerts pressure on certain scenarios.

T 13.9 Mo 18:50 H 1

**Searching for Neutrino Clusters with IceCube in Real-Time** — ●THOMAS KINTSCHER, KONSTANCA SATALECKA, and ELISA BERNARDINI for the IceCube-Collaboration — DESY (Zeuthen)

The IceCube neutrino observatory is a 1 km<sup>3</sup> detector for Cherenkov light in the ice at the South Pole. Having observed the presence of a diffuse astrophysical neutrino flux, static point source searches have come up empty handed. Thus, transient and variable objects emerge as promising, detectable source candidates.

An unbiased, full-sky clustering search – running in real time – can find neutrino events with close temporal and spatial proximity. The most significant of these clusters serve as alerts to third-party observatories in order to obtain a complete picture of cosmic accelerators. The talk will showcase the status and prospects of this project.

## T 14: Gammaastronomie 1

Zeit: Montag 16:45–19:05

Raum: H 2

### Gruppenbericht

T 14.1 Mo 16:45 H 2

**Highlights from MAGIC in 2016** — ●KARL MANNHEIM for the MAGIC-Collaboration — Institut für Theoretische Physik und Astrophysik, Universität Würzburg

The MAGIC Collaboration has carried out observations of cosmic gamma ray sources with the full efficiency and nominal sensitivity of its stereoscopic 17m telescope system throughout the year of 2016. Here, we report some outstanding results such as the detection of the gravitationally lensed blazar QSO B0218+357 at a cosmological redshift of 0.96, multiple emission components in blazars, gamma ray pulses from the Crab pulsar at TeV energies, and improved dark matter limits from

the Perseus cluster and from dwarf galaxies. We also give a perspective on recent developments regarding follow-up observations of transients in the multi-messenger era of astroparticle physics.

T 14.2 Mo 17:05 H 2

**Towards an automated data analysis for MAGIC** — ●ROBERT BERSE for the MAGIC-Collaboration — TU Dortmund University, Germany

MAGIC consists of two Imaging Atmospheric Cherenkov Telescopes with a diameter of 17 m each. The system is dedicated to the observation of very-high-energy (VHE) gamma-rays from Galactic and

extragalactic sources. The MAGIC analysis software is designed as a collection of executables for different analysis tasks. Performing an analysis of a specific source, several user interactions are required, such as the data selection and the adjustment of executable settings according to the data. The data selection and analysis are dependent on observation conditions, including e.g. the atmospheric transmission, sky brightness, zenith angle of the telescope and many more.

An automation will not only simplify this analysis procedure, it will also allow for consistent analyses of long-term observations or systematic analyses of weak sources. The first step for this automation is to improve the data selection procedure. For this purpose, a database is developed, providing access to all required parameters.

In this talk, the concept of an automated analysis and the development of a database are presented.

T 14.3 Mo 17:20 H 2

**Observation tailored instrument response functions for the MAGIC telescopes** — CHRISTIAN FRUCK, •MARCEL C. STRZYS, and IEVGEN VOVK — Max-Planck-Institut für Physik, München

Over the recent years the sensitivity of Imaging Air Cherenkov Telescopes (IACs) has greatly improved, enabling the observations of weaker sources, often having complex morphology. This creates a challenge to the traditional analysis techniques based on “aperture photometry” like approaches. Due to this, we develop more advanced likelihood analysis methods, which are common practice in space high-energy observatories, but rely on an accurate knowledge of the detector response. Here, we will report on the next step towards this goal - the software package describing the MAGIC off-axis performance for different energies. This package relies on Monte-Carlo simulations and provides the accurate description of the instrument. This allows to easily adapt the data analysis to any source shape or observational conditions. Though right now this method is developed for MAGIC, in the future it can be transferred also to other IACs - such as the up-coming Cherenkov Telescope Array (CTA).

T 14.4 Mo 17:35 H 2

**Deep learning algorithms applied to camera images of the MAGIC telescopes** — •KONRAD MIELKE for the MAGIC-Collaboration — TU Dortmund University, Germany

MAGIC is a system of two ground-based Imaging Air Cherenkov Telescopes with a diameter of 17 meters, designed for the detection of very-high-energy gamma-rays. Its cameras are equipped with 1039 photomultiplier tubes each, providing a charge curve for every camera pixel. Integrated pixel charges and arrival times are extracted from these curves and combined to one camera image per event. Subsequent to the image cleaning, the image parameters are calculated to estimate the type of the incident particle as well as its direction and energy. Currently, this is achieved by individual methods. As an alternative, these tasks could be accomplished all at once, using machine learning algorithms on the uncleaned camera images which would render the image cleaning and the image parameter calculation redundant.

A promising and novel approach in the field of astroparticle physics - especially suited for the task of image classification - is the application of deep learning algorithms (DLAs). They consist of multiple layers of neurons addressing different levels of data abstraction. The aim of this work is to obtain a DLA and compare its performance to that of the currently used methods.

In this talk, the project of applying DLAs to camera images of MAGIC is introduced and the current status is presented.

T 14.5 Mo 17:50 H 2

**Perspektiven für Multiwellenlängenanalysen von aktiven galaktischen Kernen durch das Radioteleskop Astropheiler** — •KEVIN SCHMIDT<sup>1</sup>, WOLFGANG HERRMANN<sup>2</sup>, ELKE FISCHER<sup>2</sup> und THOMAS BUCHSTEINER<sup>2</sup> — <sup>1</sup>Technische Universität Dortmund, Deutschland — <sup>2</sup>Astropheiler Stockert e.V., Bad Münstereifel, Deutschland

Multiwellenlängenanalysen sind ein wichtiger Bestandteil in der Astroteilchenphysik, um Aufschluss über die Emissionsmechanismen und die Variabilität kosmischer Quellen zu geben. Da viele Teleskope keinen großen Himmelsbereich messen können, sondern interessierende Quellen einzeln observieren, ist ihre Messzeit für Multiwellenlängen-Kampagnen stark begrenzt. Dies kann dazu führen, dass nicht alle Wellenlängenbereiche in einer simultanen Multiwellenlängenanalyse abgedeckt werden. Das Radioteleskop Astropheiler besitzt viel freie Messzeit, die zur Beobachtung ausgewählter Quellen verwendet werden kann, da der regelmäßige wissenschaftliche Betrieb eingestellt wurde.

Somit bietet der Astropheiler die Möglichkeit, gezielt Daten von aktiven galaktischen Kernen im Radiobereich zu sammeln, damit diese für Multiwellenlängenanalysen verwendet werden können. Die Flexibilität des Astropheilers ist insbesondere für bildgebende Cherenkov-Teleskope von Interesse, da diese in ihrer Messzeit sehr eingeschränkt sind und eine simultane Messung in anderen Wellenlängenbereichen oft nicht realisierbar ist. In diesem Vortrag wird anhand exemplarischer Messungen von Flachspektrum-Radioquasaren gezeigt, dass der Astropheiler für Messungen von aktiven galaktischen Kernen geeignet ist.

T 14.6 Mo 18:05 H 2

**FACT - Monte Carlo Noise Generation** — •MICHAEL BULINSKI for the FACT-Collaboration — TU-Dortmund, Germany

The generation of the Monte Carlo data for the First G-APD Cherenkov Telescope (FACT) consists of several steps, one of them being the creation of noise. This includes varying night sky background light and contributions from the electronics. The current approach is simulating each contribution individually and adding them up. This has several shortcomings, as it needs full knowledge about all the different noise sources and their structure.

In this contribution, instead of trying to simulate the static noise sources, we evaluate the option of extracting the necessary noise information from real data, taken directly with the detector. This is done by using dedicated measurements with a random trigger as background which is then superimposed with simulations of Cherenkov showers. We will present the method used and compare it to the current approach.

T 14.7 Mo 18:20 H 2

**FACT - Towards 100% Observation Efficiency** — •DOMINIK NEISE and THOMAS BRETZ — ETH Zürich, Schweiz

The First G-APD Cherenkov Telescope (FACT) is monitoring the brightest gamma-ray sources since 2012. Due to automatic operation and if weather permits FACT's observation efficiency reaches 93%.

Imaging Atmospheric Cherenkov Telescopes (IACs) typically observe a source displaced from camera center to estimate the hadronic background from locations away from the source position. In order to mitigate effects of camera inhomogeneities, the telescope is periodically repositioned and the trigger thresholds are adjusted to the modified star field. This is called wobble mode.

FACT's camera trigger is divided into patches, whose threshold is regulated to keep the rate per patch at about 0.1Hz. Measuring such low rates with high enough precision needs some time before optimal observation conditions are reached, and can hardly deal with stars moving fast through the field-of-view.

We investigate methods to further increase an IAC's ontime. The orbit observation mode allows to let the source position continuously revolve around the camera center and thus avoids repositioning time. But this causes stars to move faster through the field-of-view than with the wobble mode. A novel threshold regulation entirely based on the supply current of each photon detector can react faster on varying ambient light conditions and allows to omit dedicated threshold adjustments. In this talk, the concept and first tests will be presented.

T 14.8 Mo 18:35 H 2

**FACT - Time-Resolved Spectral Energy Distributions from Blazar Flares** — •DANIELA DORNER<sup>1</sup> and THOMAS BRETZ<sup>2</sup> for the MWL-group-Collaboration — <sup>1</sup>Universität Würzburg, Germany — <sup>2</sup>RWTH Aachen, Germany

The First G-APD Cherenkov Telescope (FACT) is monitoring blazars at TeV energies. Based on the results of a fast quick look analysis, alerts are sent to the astronomy community with low latency. This allows to set up target-of-opportunity programs, as it has been done with the X-ray satellites Swift, INTEGRAL and XMM-Newton.

While FACT provides the monitoring at TeV energies on a nightly basis, Swift monitors weekly at X-rays to check for time-lags or correlations. In case FACT measures a flux above 70 events/hour, more sensitive observations with INTEGRAL or XMM-Newton are triggered to study the evolution of the spectrum during and after the flare.

Based on this program, time-resolved spectral energy distributions are compiled and used to discern radiation mechanisms such as synchrotron-self-Compton emission (X-ray flux and gamma-ray flux strictly correlated) from photo-hadronic cascade emission, allowing more complex variability patterns.

Here, we present preliminary results of simultaneous and time-resolved broadband observations of Mrk 421 during a moderate-high flux state in December 2015, which were triggered by FACT and include simultaneous observations with the X-ray telescopes Swift and

INTEGRAL.

T 14.9 Mo 18:50 H 2

**Gravitational microlensing and gamma-ray emission of Active Galactic Nuclei** — ●IYEVGEN VOVK for the MAGIC-Collaboration — Max Planck Institute for Physics, Munich, Germany

The Active Galactic Nuclei (AGNs) constitute half of all known gamma-ray sources. Their high-energy emission is believed to be produced in the jets, powered by the central supermassive black holes. At the same time the location of the emission region within the jet is presently uncertain – mainly due to its extremely small angular size, far

beyond the capabilities of the existing gamma-ray instruments. However, in the rare case of the gravitationally lensed AGNs, it is possible to use the natural “magnifying lens” to assist the situation. I will review the recent observation Fermi/LAT and MAGIC observations of such lensed sources, which have led to the first detection of the gravitational microlensing effect for two gamma-ray loud AGNs – PKS 1830-211 and B0218+357. This allowed for the first time to resolve their emission regions, providing strong arguments for their connection with the direct vicinities of the corresponding central black holes. I will further describe the potential of the microlensing observations for the studies of the AGN physics and give the prospects for the upcoming CTA observatory.

## T 15: Kosmische Strahlung 1

Zeit: Montag 16:45–19:00

Raum: H 3

T 15.1 Mo 16:45 H 3

**Searching High energy muons in IceCube** — ●JOHANNES WERTHEBACH for the IceCube-Collaboration — TU Dortmund

Most events measured with the IceCube detector are atmospheric muons. By analysing the high energetic component of these muons it is possible to determine the contribution of the prompt muons to the overall energy spectra. This talk presents a machine learning based selection of these high energetic muons. These selected muons can eventually be used to reconstruct the muons energy spectrum via unfolding.

T 15.2 Mo 17:00 H 3

**Das Energiespektrum der höchstenergetischen kosmischen Strahlung im Licht großskaliger Anisotropien** — ●DANIELA MOCKLER für die Pierre Auger-Kollaboration — Karlsruher Institut für Technologie

Die großskalige Verteilung der Ankunftsrichtung kosmischer Strahlung liefert Hinweise auf ihre Propagation, sowie auf die Verteilung ihrer Quellen. Neueste Analysen der höchstenergetischen kosmischen Strahlung, wie sie mit dem Pierre-Auger-Observatorium gemessen wird, deuten auf eine großskalige Dipolanisotropie hin. Solch eine Dipolstruktur wird durch Ablenkung in Magnetfeldern, aber auch durch die Bewegung der Erde und ihrer Nachbarschaft relativ zum Ruhesystem der kosmischen Strahlung erwartet.

In diesem Beitrag werden mögliche Auswirkungen dieser Dipolstruktur auf das Energiespektrum diskutiert. Dabei wird das Energiespektrum in unterschiedlichen Koordinatensystemen betrachtet und nach Differenzen im Strahlungsfluss in verschiedenen Koordinatenbereichen gesucht.

T 15.3 Mo 17:15 H 3

**Atmospheric Neutrino Flux Measurement using the IceCube/DeepCore detector** — ●JOAKIM SANDROOS and SEBASTIAN BÖSER for the IceCube-Collaboration — Staudingerweg 7, 55128 Mainz

Atmospheric neutrinos are one of the most readily available neutrino sources and while the spectrum has been studied in detail over the past decades, it is still associated with considerable uncertainty. Accurate knowledge of the flux is important for other measurements of atmospheric neutrino properties. We present the first steps toward a precision measurement of the atmospheric neutrino flux, using the DeepCore array of the IceCube neutrino detector, in the energy range from  $\sim 5$  to  $\sim 500$  GeV. We employ a Bayesian (D’Agostini) iterative unfolding approach in order to make the measurement independent from theoretical predictions, and will discuss the method in some detail. In this scenario about 500.000 simulated events are necessary in order to adequately describe the detector response and systematic impacts. Background subtraction is done in our unfolding. In the final analysis we must also consider systematic effects from several other sources such as ice properties, quantum efficiency of the optical modules and input from oscillation parameters.

T 15.4 Mo 17:30 H 3

**Photon/Hadron-Unterscheidung in Hybrid-Ereignissen des Pierre-Auger-Observatoriums mit Hilfe der Observable  $S_4$**  — MARCUS NIECHCIOL, MARKUS RISSE und ●PHILIP RUEHL — Universität Siegen, Department Physik

Die Frage nach der Zusammensetzung der kosmischen Strahlung bei

den höchsten Energien (oberhalb von  $10^{18}$  eV) ist eine Schlüsselfrage der Astroteilchenphysik. Der Nachweis ultrahochenergetischer Photonen spielt dabei eine entscheidende Rolle und wäre nicht nur für Astrophysik und Teilchenphysik, sondern auch für die fundamentale Physik von großer Bedeutung. Das Pierre-Auger-Observatorium bei Malar-güe, Argentinien, ist das größte Luftschauerexperiment zum Nachweis ultrahochenergetischer kosmischer Strahlung. Es besteht aus  $\sim 1660$  Wasser-Čerenkov-Detektoren, die eine Fläche von  $\sim 3000$  km<sup>2</sup> abdecken. Eine zusätzliche, unabhängige Nachweismethode ermöglichen 27 Fluoreszenzteleskope an vier Standorten am Rand des Detektorfeldes.

Die Luftschauerobservable  $S_4$  wird in aktuellen Studien verwendet, um Photon-induzierte Luftschauer von hadronischen zu unterscheiden. In diesem Beitrag wird der Einfluss der Detektorgeometrie auf  $S_4$  erläutert. Weiterhin werden verschiedene Methoden diskutiert, einen daraus resultierenden systematischen Fehler zu vermeiden. Gefördert durch die BMBF-Verbundforschung Astroteilchenphysik und die Helmholtz-Allianz für Astroteilchenphysik.

T 15.5 Mo 17:45 H 3

**IceScint: A surface scintillation detector array for IceCube-Gen2** — ●THOMAS HUBER<sup>1,2</sup>, ASWATHI BALAGOPAL V<sup>2</sup>, ANDREAS HAUNGS<sup>2</sup>, TIMO KARG<sup>1</sup>, SAMRIDHA KUNWAR<sup>1</sup>, AGNIESZKA LESZCZYNSKA<sup>2</sup>, HARALD SCHIELER<sup>2</sup>, and ANDREAS WEINDL<sup>2</sup> — <sup>1</sup>Deutsches Elektronen-Synchrotron, (DESY) — <sup>2</sup>Institut für Kernphysik (IKP), Karlsruher Institut für Technologie (KIT)

To increase the amount of detected high-energy neutrinos of cosmic origin IceCube-Gen2 is under development.

In addition to in-ice veto strategies, cosmic-ray showers can be directly vetoed on the ice surface. A surface veto detector built up by scintillators and extended to large areas of several tens of km<sup>2</sup> can be used to detect cosmic-ray showers and veto the in-ice muons and neutrinos they produce.

For the readout of the scintillators SiPMs (*Silicon Photomultiplier*) are foreseen. These solid-state sensors are similar in detection efficiency compared to classical photomultiplier tubes. Beside this, SiPMs have additional advantages like a more compact structure, a low bias voltage and provide a better performance at low temperatures like found at the South Pole.

The detector design and first prototype measurements will be presented in this talk.

T 15.6 Mo 18:00 H 3

**A Method of Reconstructing Ultra-High Energy Cosmic Rays at the Pierre Auger Observatory using Deep Learning** — ●JONAS GLOMBITZA, DAVID WALZ, MARCUS WIRTZ, GERO MÜLLER, and MARTIN ERDMANN for the Pierre Auger-Collaboration — III. Physikalisches Institut A, Aachen, Deutschland

The surface detector of the Pierre Auger Observatory in Argentina measures the footprint of muons and electromagnetic particles of ultra-high energy cosmic ray induced air showers on ground level. Reconstructing the properties of the primary cosmic ray such as energy, direction and mass with optimal resolution remains a challenging task. Recently, great progress has been made in multiple fields of machine learning by using deep neural networks and associated techniques. In this talk we present a new method to reconstruct the properties of the ultra-high energy cosmic rays, by training deep neural networks to the detector response of the surface detector. By training the network to identify suitable features in all the available event information,

this method has the potential to surpass currently employed methods which build on algorithms processing selected observables. In this context we discuss suitable data representations and compare different network architectures and training procedures. Finally, we assess the performance of the method on simulated air showers.

T 15.7 Mo 18:15 H 3

**High-Energy Atmospheric Muons in IceCube and IceTop** — •FREDERIK TENHOLT for the IceCube-Collaboration — Ruhr-Universität Bochum

High-energy atmospheric muons can yield information about the prompt contribution to atmospheric lepton fluxes also relevant for neutrino studies as well as complement results from collider experiments in the forward region of particle physics.

In this talk, two different analyses studying high-energy atmospheric muons are presented. In order to obtain a suitable event sample, cut parameters capable of tagging events that contain a muon dominant within the bundle are introduced and validated. In the first analysis, the resulting sample is used to obtain the differential muon flux between  $\sim 6$  TeV and  $\sim 400$  TeV in the zenith range  $0^\circ < \theta < 34.6^\circ$ . In the second analysis, a proof of concept for the measurement of an effective Feynman- $x$  of atmospheric muons, quantifying the forwardness of these particles, is presented, resulting in an observable well correlated with the true value obtained from simulations.

This project is BMBF-supported (FKZ: 05A14PC1).

T 15.8 Mo 18:30 H 3

**Mass discrimination using air shower universality at the Pierre Auger Observatory** — •ARIEL BRIDGEMAN, ALEXANDER SCHULZ, and MARKUS ROTH for the Pierre Auger-Collaboration — Karlsruhe Institute of Technology, Karlsruhe, Germany

Data from the Pierre Auger Observatory's surface detector is used to

study the primary composition of cosmic rays at the highest energies. Updates to a reconstruction based on the paradigm of air shower universality have reduced the bias in and improved the resolution of reconstructed mass-sensitive variables—namely, the depth of shower maximum and number of muons. By fitting measured distributions of those variables to predictions from various hadronic interaction models, we examine the implied composition and derive the multiplicative shift needed to correct for the deficit of the number of muons found when comparing simulations to data. Systematic uncertainties stemming from the measurements of the surface and fluorescence detectors are detailed. Initial studies involving the enrichment of a light sample for anisotropy purposes are also shown.

T 15.9 Mo 18:45 H 3

**Simulation study for an extended IceTop Detector for IceCube-Gen2** — •AGNIESZKA LESZCZYŃSKA<sup>1</sup>, ASWATHI BALAGOPAL V.<sup>1</sup>, ANDREAS HAUNGS<sup>1</sup>, and THOMAS HUBER<sup>1,2</sup> for the IceCube-Collaboration — <sup>1</sup>KIT, Karlsruhe, Germany — <sup>2</sup>DESY, Zeuthen, Germany

The next generation of the IceCube experiment will be a powerful high-energy neutrino detector, sensitive to resolve the sources of astrophysical neutrinos. The new facility will be able to measure the GZK neutrino flux providing also information about the composition of the highest energy cosmic-rays. The big challenge of the measurements is here to discriminate the astrophysical signal from the atmospheric background. This can be resolved by a large surface extension of present IceTop with scintillation detectors. If the in-ice event is detected in coincidence with the air-shower signal at the surface detectors it can be vetoed obtaining only the astrophysical neutrinos. The first step is the enhancement of IceTop in the present area, which will also improve the cosmic-ray composition measurements of IceCube. This talk will show a simulation study for the first phase of the deployment of scintillator detectors.

## T 16: Kosmische Strahlung 2

Zeit: Montag 16:45–19:05

Raum: H 4

### Gruppenbericht

T 16.1 Mo 16:45 H 4

**Tunka-Rex, die Tunka-Radioerweiterung für Luftschauer kosmischer Strahlung** — •FRANK G. SCHRÖDER für die Tunka-Rex-Kollaboration — Institut für Kernphysik, Karlsruher Institut für Technologie (KIT)

Tunka-Rex (Tunka Radio Extension) ist die Radioerweiterung des Tunka-Experiments in Sibirien in der Nähe des Baikalsees. Im Herbst 2016 wurde Tunka-Rex von 44 auf 63 Antennen-Stationen erweitert, die auf einer Fläche von etwa 1 km<sup>2</sup> verteilt sind. Die Antennen sind an die beiden anderen Detektorsysteme von Tunka für kosmische Strahlung angeschlossen: Tunka-133, ein Messfeld für Cherenkovlicht von Luftschauern, und Tunka-Grande, ein Messfeld aus Teilchendetektoren. Immer wenn eines dieser beiden Detektorsysteme einen Luftschauer registriert, werden auch die Radioantennen ausgelesen. Die Detektionsschwelle konnte abhängig von der Ankunftsrichtung des Luftschauers auf etwa 10<sup>17</sup> eV gesenkt werden, indem auch Ereignisse mit nur einer Antennenstation zur Energierekonstruktion verwendet werden. Seit 2012 wurde mehrere 100 Luftschauer mit Tunka-Rex gemessen, ihre Energie und Richtung bestimmt. So konnte kürzlich die Energieskala von Tunka mit dem KASCADE-Grande-Experiment und seiner Radioerweiterung LOPES verglichen werden - beide Energieskalen sind auf 10% konsistent. Weiterhin kann für Luftschauer mit hoher Messqualität des Radiosignals die Zusammensetzung der kosmischen Strahlung untersucht werden.

T 16.2 Mo 17:05 H 4

**Surface Radio Air-Shower Detection in IceCube-Gen2** — •ASWATHI BALAGOPAL V., AGNIESZKA LESZCZYŃSKA, ANDREAS HAUNGS, and THOMAS HUBER for the IceCube-Collaboration — Karlsruher Institut für Technologie

IceCube-Gen2 is the planned extension of the IceCube Neutrino Observatory, at the South Pole. IceTop, the existing surface veto and air shower array consists of 81 stations of Cherenkov tanks that detect the incoming cosmic-ray air showers. Combining these particle detectors with radio detectors will give more information about cosmic-ray air showers. It is well known that radio detection of air showers helps

in the reconstruction of X<sub>max</sub> and the energy of the shower with a reasonable accuracy and can thereby provide a more efficient reconstruction. Using a radio extension at the South Pole can also help in the detection of rare events like photons approaching the Earth from the galactic center. The Galactic center is visible from the South Pole throughout the year, at an inclination of around 70 degrees. High energy gammas, upon entering the Earth produce inclined air showers. Since radio emission of inclined showers leaves a huge footprint on the ground, detection of such events using radio technique can be possible. An overview of the ongoing studies of radio detection of inclined air showers from gammas of energy around 10 PeV will be reported.

T 16.3 Mo 17:20 H 4

**Radio emission and muons of air showers as parameters for mass composition studies at the Pierre Auger Observatory** — •EWA MARLEN HOLT for the Pierre Auger-Collaboration — Institut für Kernphysik, Karlsruher Institut für Technologie

Cosmic rays constantly traverse the Earth's atmosphere. They interact with atmospheric molecules, inducing a cascade of secondary particles named extended air showers. The type and energy of the cosmic ray defines the development of the air shower through the atmosphere. Especially in later stages it mainly consists of electrons, positrons and muons. Thereby, the ratio of those particles is a measure of the mass of the cosmic ray primary particle. In Argentina, the Pierre Auger Observatory is dedicated to measure those air showers with different detection techniques. Water-Cherenkov tanks measure all air shower particles reaching ground. In the so-called Infill area, they form AMIGA ('Auger Muons and Infill for the Ground Array') together with buried scintillators measuring purely muons. The electrons and positrons induce emission of radio waves along the shower, which is measured from the radio antennas of AERA ('Auger Engineering Radio Array'). For the first time, all of these detection techniques are combined for mass composition studies.

T 16.4 Mo 17:35 H 4

**Niedrigenergie-Spektrum von Luftschauern mit der HEAT-Erweiterung des Pierre-Auger-Observatoriums\*** — •INGOLF



JANDT für die Pierre Auger-Kollaboration — Bergische Universität Wuppertal, Gaußstraße 20

Der Fluoreszenzdetektor (FD) des Pierre Auger Observatoriums misst Lichtsignale von Luftschaubern mit Beiträgen aus Fluoreszenz- und Cherenkovstrahlung. Die High Elevation Auger Telescopes (HEAT) können als Niedrigenergie-Erweiterung des FD steiler in die Atmosphäre blicken. So messen sie mehr teleskopnahe, niederenergetische Luftschauber, doch auch höhere Anteile des vorwärtsgerichteten Cherenkovlichts und zeitlich verkürzte longitudinale Schauerprofile. Aus diesen wenigen Messpunkten die Geometrie des Schauers zu rekonstruieren gelingt mit den bisherigen Methoden nur begrenzt. Der Profile Constrained Geometry Fit (PCGF) bezieht im Gegensatz zur Standardrekonstruktion die longitudinale Schauerentwicklung in die Geometriebestimmung mit ein. Damit lässt sich die Messung des Energiespektrums bis unterhalb  $10^{16}$  eV erweitern. Systematiken und Energieauflösung der Rekonstruktion bei diesen Energien und hohen Cherenkovlicht-Anteilen werden betrachtet. Die Abschätzung der Exposure führt zu einem ersten Spektrum.

\* Gefördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A14PX1)

T 16.5 Mo 17:50 H 4

**Blitzdetektion am Pierre-Auger-Observatorium zur Korrelation mit komischer Strahlung\*** — ●SIMON STROTMANN und JULIAN RAUTENBERG für die Pierre Auger-Kollaboration — Bergische Universität Wuppertal

Mit einer Größe von  $3000 \text{ km}^2$  ist das Pierre-Auger-Observatorium nicht nur bestens geeignet Fragestellungen zur kosmischen Strahlung zu bearbeiten, sondern auch der hypothetischen Korrelation von kosmischer Strahlung und Blitzen nachzugehen. Dazu ist ein Netzwerk von fünf Blitzmessstationen aufgebaut worden, welches in Echtzeit Blitze detektiert und deren Ort rekonstruiert. Die Datennahme der Oberflächendetektoren kann Luftschauber erst ab einer Energie von  $3 \cdot 10^{18}$  eV mit voller Effizienz nachweisen. Kosmische Strahlung bei diesen Energien ist zu selten um sie mit den seltenen Blitzereignissen korrelieren zu können. Deshalb ist ein zusätzlicher Trigger entwickelt worden, der Einzeldetektoren auf Basis der rekonstruierten Blitzpositionen ausliest. Damit können Luftschauber ab einer Energie von  $10^{15}$  eV für die Korrelationsanalyse detektiert werden. Erste Ergebnisse der Analyse sowie der neu entwickelte Ereignisbetrachter werden vorgestellt.

\* Gefördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A14PX1).

T 16.6 Mo 18:05 H 4

**Construction and performance of the Scintillator Surface Detectors for the Upgrade of the Pierre Auger Observatory** — ●ALEXANDER STREICH, RADOMIR SMIDA, DARKO VEBERIC, and RALPH ENGEL for the Pierre Auger-Collaboration — Karlsruher Institut für Technologie, Deutschland

Since the beginning of measurements of the Pierre Auger Observatory in 2001, the determination of the mass composition and the analysis of the flux suppression of ultra-high energy cosmic rays at the far end are two major science topics of the Pierre Auger Collaboration. To distinguish the best fitting model describing the energy spectrum of cosmic rays, several parts of the Observatory will be upgraded in the following two years. One major part of this upgrade is the installation of scintillator detectors on top of each of the 1660 water-Cherenkov tanks of the surface detector. With a different response to the muonic and the electromagnetic particles when compared to the existing detectors these Scintillator Surface Detectors provide an improved determination of the mass and type of cosmic rays. In this presentation we show the construction and discuss the performance of the first scintillator detectors built for the Engineering Array at the KIT.

T 16.7 Mo 18:20 H 4

**Calibration of the AMIGA integrator at the Pierre Auger**

**Observatory** — ●ANA MARTINA BOTTI for the Pierre Auger-Collaboration — Institut für Kernphysik, Karlsruher Institut für Technologie — Instituto de Tecnologías en Detección y Astropartículas (ITeDA), Buenos Aires, Argentina

The Auger Muons and Infill for the Ground Array (AMIGA) upgrade aims to extend the range of detection at the Pierre Auger Observatory, to observe cosmic rays of lower energies (down to  $\leq 10^{17}$  eV) and to study the transition from extragalactic to galactic cosmic rays. AMIGA consists of an infill of surface detectors (Cherenkov radiation detection in water) and muon counters. The AMIGA muon counters are composed of an array of buried modules of 64 scintillator bars, optic fibres and a photo-detector: formerly a multi-pixel Photo Multiplier Tube (PMT) and currently an array of 64 silicon photomultipliers (SiPM). The corresponding electronic of acquisition works in tandem with the surface detector.

Currently, the transition from PMTs to SiPMs is taking place. The new SiPM electronics allows the module to work not only as a counter, but also as an integrator. The counter allows direct counting of muons as they reach the detector. On the other hand, the integrator estimates the number of muons by dividing the total charge of the signals by the average charge of a muon. In this talk, a calibration method for the AMIGA integrator, using the muon counter, will be presented. In addition, first results with data in the field will also be shown. Finally, a first approach to the integrator simulations will also be presented.

T 16.8 Mo 18:35 H 4

**Studies of the muon content of extensive air showers with AMIGA data** — ●SARAH MÜLLER and MARKUS ROTH for the Pierre Auger-Collaboration — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

The number of muons in an extensive air shower is an important observable to discriminate between different masses of primary cosmic rays. The engineering array of the AMIGA enhancement (Auger Muons and Infill for the Ground Array) of the Pierre Auger Observatory consists of a hexagon of seven underground muon detectors with  $30 \text{ m}^2$  surface and  $750 \text{ m}$  spacing and has been completed in February 2015. We present an analysis of one year of data and compare results with previous muon detection experiments. To construct a fair sample of events, a parametrization of the lateral trigger probability is derived and bias corrections are applied. The muon lateral distribution is parameterized and a comparison to simulations as well as data from other experiments will be shown.

T 16.9 Mo 18:50 H 4

**AugerPrime scintillator simulations for the Pierre Auger Observatory** — ●DAVID SCHMIDT, MATTHIAS KESSLER, ALVARO TABOADA, DARKO VEBERIC, and MARKUS ROTH for the Pierre Auger-Collaboration — Karlsruhe Institute of Technology, Karlsruhe, Germany

Measurement of both the primary energy and muon content of extensive air showers is integral to reconstructing the mass of ultra-high-energy cosmic rays on an event-by-event basis. The Pierre Auger Observatory is currently upgrading its surface array by placing a  $4 \text{ m}^2$  scintillator on top of each of the existing 1660 water Cherenkov detectors. In tandem, the two sub-detectors provide the necessary information to disentangle and accurately reconstruct the muonic and electromagnetic shower components, which allows for reconstruction of primary mass. Prior to deployment, the responses of 12 prototype scintillator detectors were measured using a muon telescope of the KASCADE experiment. In turn, these measurements were used for tuning Geant4 simulations implemented inside the Offline shower reconstruction software. Photoelectron signal and timing models derived from prototype measurements, their implementation in simulations, and comparisons between the simulations and muon telescope measurements are presented here.

## T 17: Quantenfeldtheorie (perturbativ)

Convenor: C. Bogner, P. Maierhöfer

Zeit: Montag 16:45–19:00

Raum: VSH 11

T 17.1 Mo 16:45 VSH 11

**Diagrammatic coaction of one-loop Feynman integrals** — •SAMUEL ABREU<sup>1</sup>, RUTH BRITTO<sup>2</sup>, CLAUDE DUHR<sup>3</sup>, and EINAN GARDI<sup>4</sup> — <sup>1</sup>Albert-Ludwigs-Universität, Freiburg, Germany — <sup>2</sup>Trinity College Dublin, Dublin, Ireland — <sup>3</sup>CERN, Geneva, Switzerland & Université Catholique de Louvain, Louvain-La-Neuve, Belgium — <sup>4</sup>Edinburgh University, Edinburgh, United Kingdom

We conjecture a completely diagrammatic representation of the so-called coaction of Feynman integrals, an operator that, amongst other things, encodes information about their discontinuities and differential equations. As a consequence, we obtain a very simple differential equation satisfied by one-loop integrals with a completely general configuration of internal and external masses, valid to all orders in dimensional regularisation. Equivalently, we show how to iteratively construct the symbol of arbitrary one-loop integrals.

T 17.2 Mo 17:00 VSH 11

**Aspects of the Unitarity Approach for Multi-Loop Amplitudes in QCD** — •BEN PAGE — Albert-Ludwigs-Universität Freiburg, Germany

The unitarity method has become a useful tool for computing one-loop amplitudes of phenomenological interest. We explore conceptual aspects of the method as a preparation towards new applications.

T 17.3 Mo 17:15 VSH 11

**Finding canonical bases of master integrals with epsilon** — •MARIO PRAUSA — RWTH Aachen, Aachen, Germany

The calculation of master integrals is a crucial point in any multiloop calculation. In 2013, Henn proposed a special basis for a certain class of master integrals, which are expressible in terms of iterated integrals (e.g. generalized polylogarithms). In this basis the master integrals obey a differential equation, where the right hand side is proportional to  $\epsilon$  in  $d = 4 - 2\epsilon$  space-time dimensions. An algorithmic approach to find such a basis was found by Lee. We present an efficient implementation of Lee's algorithm based on the **Fermat** computer algebra system as computational backend.

T 17.4 Mo 17:30 VSH 11

**Transforming multi-loop Feynman integrals to a canonical basis with CANONICA** — •CHRISTOPH MEYER — Humboldt-Universität zu Berlin, Berlin, Germany

In the past years the method of differential equations has proven itself to be a powerful tool for the computation of multi-loop Feynman integrals. This method relies on the choice of a basis of master integrals in which the dependence on the dimensional regulator factorizes. I will present an algorithm that automatizes the transformation to such a basis, starting from a given basis that is obtained for instance by one of the publicly available Laporta implementations. The algorithm is applicable to differential equations with multiple scales and rational dependence on the dimensional regulator. An implementation of the algorithm in mathematica will be shown and its application to multi-scale problems will be illustrated.

T 17.5 Mo 17:45 VSH 11

**Nonlinear QED in null fields** — •IBRAHIM AKAL<sup>1</sup> and GUDRID MOORTGAT-PICK<sup>2</sup> — <sup>1</sup>Theory Group, Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — <sup>2</sup>II. Institute for Theoretical Physics, Hamburg University, Hamburg, Germany

QED in an external coherent background field gives rise to various non-linear phenomena. In this talk we discuss the non-linear Compton process in an electromagnetic null field. We compare the total scattering probability by confronting the bosonic and fermionic energies with the natural electric (magnetic) field amplitude far below the critical Sauter-Schwinger limit. For various parameter combinations the emission probabilities are calculated. We focus on the comparison between the intense low-frequency and the weak high-frequency regime. The former case is completely behaving classically where the fermion becomes highly relativistic and hence strongly radiative. However, a sufficient number of scattered field photons has to be taken into account. Conversely, in the perturbative high-frequency regime the energy

of absorbed field quanta approaches the energy of the dressed fermion. Thus, recoil drastically quenches the emission probability. Effects of this kind can be reduced by increasing the field amplitude such that comparable probabilities become achievable even for moderate intensities.

T 17.6 Mo 18:00 VSH 11

**Nichtlineare Compton-Streuung: Anwendung der Operator-Methode** — •ARNE MÜLLER and GUDRID MOORTGAT-PICK — Universität Hamburg, Hamburg, Deutschland

Im Rahmen einer Masterarbeit stellen wir die von Baier et al. entwickelte Operator-Methode vor. Wir zeigen, wie man damit die Selbstenergie berechnet und mit Hilfe des optischen Theorems daraus die nichtlineare Compton-Streuung ableiten kann. Wir vergleichen die hieraus gewonnenen Spektren mit Berechnungen, die für das Elektron explizite Volkov Zustände ansetzen. Die jeweils zugrundeliegenden Näherungen und die Anwendbarkeit der Methoden für die verschiedenen kinematischen Bereiche werden diskutiert.

T 17.7 Mo 18:15 VSH 11

**Three-loop beta functions in the Standard Model and beyond** — •FLORIAN HERREN<sup>1</sup>, LUMINITA MIHAILA<sup>2</sup>, and MATTHIAS STEINHAUSER<sup>1</sup> — <sup>1</sup>Institut für Theoretische Teilchenphysik, Karlsruhe Institute of Technology (KIT) — <sup>2</sup>Institut für Theoretische Physik, Universität Heidelberg

We review the beta functions of the Standard Model (SM) couplings to three-loop order. In particular, we provide a first independent calculation of the Yukawa coupling beta functions and discuss our calculational setup and the treatment of  $\gamma_5$ .

Furthermore, we turn to extensions of the SM and present the gauge and Yukawa coupling beta functions for the general two-Higgs-doublet model.

T 17.8 Mo 18:30 VSH 11

**Towards an automation of EW NLO corrections with Sherpa and Recola** — •STEPHAN BRÄUER and STEFFEN SCHUMANN — II. Physikalisches Institut, Georg-August-Universität Göttingen

In order to keep up with the ever increasing experimental precision, higher-order perturbative corrections need to be considered in corresponding theoretical predictions.

This talk provides an overview over the recent developments in the automation of electroweak next-to-leading order correction with the Monte Carlo event generator Sherpa and the one-loop generator Recola. We report on the implementation and validation of an interface to access Recola loop amplitudes from the Sherpa framework for carrying out next-to-leading order QCD and EW computations. Furthermore, first results for NLO QCD+EW calculations with Sherpa+Recola are shown and the remaining challenges for fully automated calculations of NLO EW corrections are outlined.

T 17.9 Mo 18:45 VSH 11

**Unitarization for Vector Boson Scattering at the LHC** — •GENESSIS PEREZ, MARCO SEKULLA, and DIETER ZEPPENFELD — Institute for Theoretical Physics, KIT, Karlsruhe, Germany

Weak vector boson scattering (VBS) at high energies will be one of the key measurements in current and upcoming LHC runs: it is very sensitive to new physics associated with electroweak symmetry breaking. However, a pure effective Lagrangian analysis is insufficient because observable deviations from the SM typically lead to unitarity violation within the energy reach of the LHC.

To obtain valid predictions, the T/K-matrix unitarization prescription is widely used. However, an implementation of this scheme is only available for a small number of effective Lagrangian operators for VBS due to the difficulty to handle VBS with arbitrarily polarized off-shell vector bosons in the full  $VVjj$  production process.

In this Talk, I introduce a procedure of the T/K-matrix unitarization scheme for generic operators within VBS and describe its implementation in the Monte Carlo generator VBFNLO. The implementation can be used for further studies at the LHC as I will show with some exemplary distributions.

**T 18: Top Quark (Theorie) 1**

Convenor: M. Worek, S. Westhoff

Zeit: Montag 16:45–18:30

Raum: VSH 05

T 18.1 Mo 16:45 VSH 05

**Multi-TeV top-quark pair production at the LHC** — ●DAVID HEYMES — University of Cambridge, Cavendish Laboratory (HEP), Cambridge, United Kingdom

Measurements including the top quark have evolved from its discovery at Tevatron to precision physics at the LHC. Especially, top-quark pair production is measured to high accuracy inclusively and differentially.

Precision predictions for top-quark pair production at the LHC are therefore indispensable in order to understand top-quark properties to the accuracy reached at experiments. I will summarize recent developments in next-to-next-to-leading order computations for top-quark pair production and show differential results in a wide kinematic regime.

T 18.2 Mo 17:00 VSH 05

**Polarised amplitudes for top quark pair production at NNLO** — ●RENE PONCELET and MICHAL CZAKON — RWTH Aachen University Institute for Theoretical Particle Physics and Cosmology, Aachen, Germany

More than 20 years after its discovery, the investigation of the top-quark and its properties is in a high-precision phase. The LHC plays a central role in this investigation since it provides a large number of  $t\bar{t}$ -pairs. Precise top-quark measurements are an excellent tool for precision measurements of the Standard Model and searches for new physics. An important ingredient for this kind of measurements are precise theory predictions. Meanwhile, NNLO QCD predictions for  $t\bar{t}$ -pair production at the LHC became available for comparison to data. Inclusive or differential, these predictions have in common that they assume stable top-quarks and use spin-summed matrix-elements. The information about spin-correlations with decay products is therefore lost. I present here the first calculation of amplitudes for production of polarized on-shell  $t\bar{t}$ -pairs at NNLO QCD which is a necessary ingredient to incorporate spin-correlated top-decays in Narrow-Width-Approximation. The full calculation including higher order corrections to the decays can be used to extract the top-quark mass parameter more precisely from the examination of differential distributions of decay products.

T 18.3 Mo 17:15 VSH 05

**Top-quark pair production at next-to-next-to-leading order QCD in electron positron collisions** — ●LONG CHEN — Institut f. Theoretische Teilchenphysik u. Kosmologie, RWTH Aachen

We set up a formalism, within the antenna subtraction framework, for computing the production of a massive quark-antiquark pair in electron positron collisions at next-to-next-to-leading order in the coupling  $\alpha_s$  of quantum chromodynamics at the differential level. Our formalism applies to the calculation of any infrared-safe observable. We apply this set-up to the production of top-quark top antiquark pairs in the continuum. We compute the production cross section and several distributions. We determine, in particular, the top-quark forward-backward asymmetry at order  $\alpha_s^2$ . Our result agrees with previous computations of this observable.

T 18.4 Mo 17:30 VSH 05

**QCD Korrekturen zur Produktion einzelner Top-Quarks in Assoziation mit einem Higgs-Boson** — ●SASCHA PEITZSCH — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstraße 15, 12489 Berlin

Die hadronische Produktion einzelner Top-Quarks in Assoziation mit einem Higgs-Bosons erlaubt das Studium der Top-Quark Kopplung an das Higgs-Boson und ermöglicht präzise Tests des Standardmodells. Da Vorhersagen in Bornapproximation oft große theoretische Unsicher-

heiten aufweisen, wurden für eine verlässliche Vorhersage die QCD Korrekturen berechnet. Der Vortrag gibt einen Überblick über die für die QCD Korrekturen relevanten virtuellen und reellen Korrekturen. Da die hier präsentierten Ergebnisse Anwendung in der Matrixelementmethode in nächstführender Ordnung finden sollen, wurde zur Kürzung der Infrarot-Singularitäten die sogenannte “Phase-Space-Slicing” Methode verwendet. Es werden Ergebnisse für den inklusiven Wirkungsquerschnitt für den LHC bei einer Schwerpunktenenergie  $\sqrt{s} = 13$  TeV vorgestellt. Darüber hinaus werden auch Resultate für differentielle Verteilungen für verschiedene Observablen präsentiert. Schließlich werden die theoretischen Unsicherheiten auf Grund der Skalenvariation behandelt.

T 18.5 Mo 17:45 VSH 05

**Measuring the Top Yukawa Coupling at 100 TeV** — MICHELANGELO MANGANO<sup>2</sup>, TILMAN PLEHN<sup>1</sup>, ●PETER REIMITZ<sup>1</sup>, TORBEN SCHELL<sup>1</sup>, and HUA-SHENG SHAO<sup>2</sup> — <sup>1</sup>Institut für Theoretische Physik, Universität Heidelberg, Germany — <sup>2</sup>Cern, PH-TH, 1211 Geneva 23, Switzerland

We propose a measurement of the top Yukawa coupling at a 100 TeV hadron collider, based on boosted Higgs and top decays. We find that the top Yukawa coupling can be measured to 1%, with excellent handles for reducing systematic and theoretical uncertainties, both from side bands and from  $t\bar{t}H/t\bar{t}Z$  ratios.

T 18.6 Mo 18:00 VSH 05

**Heavy Higgs boson production and decay into top quarks at the LHC** — WERNER BERNREUTHER<sup>1</sup>, ●PETER GALLER<sup>2</sup>, CLEMENS MELLEIN<sup>1</sup>, ZONG-GUO SI<sup>3</sup>, and PETER UWER<sup>2</sup> — <sup>1</sup>Institut für Theoretische Teilchenphysik und Kosmologie, RWTH Aachen University, 52056 Aachen, Germany — <sup>2</sup>Institut für Physik, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — <sup>3</sup>School of Physics, Shandong University, Jinan, Shandong 250100, China

We investigate the impact of heavy, neutral Higgs bosons on top-quark pair production at the LHC. For definiteness we consider the type-II two-Higgs-doublet model with two heavy, neutral Higgs bosons with masses larger than twice the top-quark mass. These heavy Higgs bosons can appear as resonances in the  $t\bar{t}$  decay channel. We calculate the resonant production of heavy Higgs bosons and their decay into top-quark pairs including the interference with the standard model (SM) background at next-to-leading order (NLO) QCD. The non-resonant SM contribution to  $t\bar{t}$  production is also taken into account at NLO QCD including weak corrections. Using representative CP-conserving as well as CP-violating parameter scenarios we study different observables and compare their sensitivity to heavy Higgs bosons in the  $t\bar{t}$  channel. In particular, we study spin dependent observables and show that they can enhance the sensitivity significantly.

T 18.7 Mo 18:15 VSH 05

**Monte Carlo tuning for ttbar production with Herwig 7** — ●LUDOVIC SCYBOZ — Max-Planck-Institut für Physik

With ever-increasing integrated luminosity at LHC, the comparison of high-accuracy ttbar measurements from ATLAS with Monte Carlo generator predictions requires improved tunes of the generator parameters. The current study towards defining a new tune for ttbar production is based on the new Herwig7 generator. Samples generated with Herwig7 are compared with recent differential measurements using 8 and 13 TeV data recorded with the ATLAS experiment. The comparisons are performed using the Rivet and the Professor framework. In this talk, first results with the Herwig7 generator are presented and compared to the tunes currently used by the ATLAS experiment.

## T 19: Flavourphysik (Theorie)

Convenor: M. Blanke, M. Jung

Zeit: Montag 16:45–19:00

Raum: VSH 06

T 19.1 Mo 16:45 VSH 06

**Leptoquark Flavor Patterns and B Decay Anomalies** — GU-DRUN HILLER<sup>2</sup>, DENNIS LOOSE<sup>2</sup>, and •KAY SCHÖNWALD<sup>1</sup> — <sup>1</sup>DESY — <sup>2</sup>TU Dortmund

By embedding leptoquarks into flavor symmetries that explain masses and mixings in the SM it is possible to construct patterns for the leptoquarks' couplings to the SM fermions. These patterns are used to address current B decay anomalies, namely  $R_{D^{(*)}}$  and  $R_K$ .

We find that effects in  $R_{D^{(*)}}$  are generally too small to account for the experimental data, while a natural explanation of  $R_K$  is possible.

T 19.2 Mo 17:00 VSH 06

**Flavour signatures in Pati-Salam** — •MARTA MOSCATI and MONIKA BLANKE — Karlsruher Institut für Technologie, Karlsruhe, Germany

We analyse the Pati-Salam model, based on the gauge group  $SU(4) \otimes SU(2)_L \otimes SU(2)_R$ . The interest in this model is motivated by the possibility of embedding it into a larger, unified gauge group (GUT) and, from a phenomenological point of view, by the presence of vector and scalar Lepto-Quarks. In particular, we focus on the possible signatures of these particles in the flavour sector.

T 19.3 Mo 17:15 VSH 06

**Precision calculation of  $B \rightarrow X_c \tau \bar{\nu}$  and the  $R(D^{(*)})$  puzzle** — •FARNOUSH SHAHRIARAN, THOMAS MANNEL, and ALEKSEY V. RUSOV — University of Siegen

We calculate the decay width of inclusive  $B \rightarrow X_c \tau \bar{\nu}$  process including power corrections up to  $\Lambda_{QCD}/m_b^3$  order and radiative corrections to the partonic level. We show that our result is in a tension with the sum of the rates of the exclusive  $B \rightarrow D \tau \bar{\nu}$ ,  $B \rightarrow D^* \tau \bar{\nu}$  and  $B \rightarrow D^{**} \tau \bar{\nu}$  decays.

For solving this puzzle, we include contributions from two possible new physics four-Fermi operators, (NP vector right-handed and left-handed scalar operators), with arbitrary couplings that can accommodate the measured central value of the ratio  $R(D)$  and  $R(D^*)$ . We performed the calculation of the decay with of the process  $B \rightarrow X_c \tau \bar{\nu}$  in the presence of theses operators at tree level at leading order in  $1/m_b$  expansion. The updated prediction is consistent with the sum of the branching fractions of exclusive modes.

T 19.4 Mo 17:30 VSH 06

**The Axiflavor** — •ROBERT ZIEGLER — KIT, Karlsruhe, Germany

I will discuss how solving the flavor problem of the Standard Model with a simple  $U(1)$  flavor symmetry naturally leads to an axion that solves the strong CP problem and constitutes a viable Dark Matter candidate. In this framework, the ratio of the axion mass and its coupling to photons is related to the SM fermion masses and predicted within a small range, as a direct result of the observed hierarchies in quark and charged lepton masses. The same hierarchies determine the axion couplings to fermions, making the framework very predictive and experimentally testable by future axion and precision flavor experiments.

T 19.5 Mo 17:45 VSH 06

**Exclusive  $B_{(s)} \rightarrow \pi(K)\ell^+\ell^-$  decays at large recoil and CKM matrix elements** — ALEXANDER KHODJAMIRIAN and •ALEKSEY RUSOV — Universität Siegen

We propose a way to determine the Wolfenstein parameters  $A, \rho, \eta$  of the CKM matrix from the observables in semileptonic exclusive FCNC decays, combining the branching fractions and direct CP-asymmetry of  $B \rightarrow \pi\ell^+\ell^-$  decays with the branching fraction of  $B \rightarrow K\ell^+\ell^-$  processes. To this end, we calculate the required hadronic input involved in the binned observables in the large recoil region, taking into account, in addition to the form factors, the nonlocal hadronic matrix elements. The latter are obtained combining QCD factorization and light-cone sum rules (LCSR) with hadronic dispersion relations. For form factors we use revisited LCSR results taking also the recent estimate of the higher twist effects into account. Moreover, we calculate the hadronic

input for a yet unexplored channel  $B_s \rightarrow K^0\ell^+\ell^-$ .

T 19.6 Mo 18:00 VSH 06

**QCD Factorization for  $B \rightarrow \pi\pi\ell\nu$  Decays at Large Dipion Masses** — •PHILIPP BÖER<sup>1</sup>, DANNY VAN DYK<sup>2</sup>, and THORSTEN FELDMANN<sup>1</sup> — <sup>1</sup>Universität Siegen — <sup>2</sup>Universität Zürich

$B \rightarrow \pi\pi$  form factors are an essential non-perturbative ingredient for  $B \rightarrow \pi\pi\ell\nu$  decays as well as three-body  $B \rightarrow \pi\pi\pi$  decays. We introduce a factorization formula for these form factors in the limit of large pion energies and large dipion invariant mass. We explicitly check this formula by calculating the leading contributions in a combined expansion in the strong coupling and powers of  $\Lambda_{QCD}/m_b$ . Our results provide useful theoretical constraints for phenomenological models that aim to analyze the complete  $B \rightarrow \pi\pi\ell\nu$  phase space.

T 19.7 Mo 18:15 VSH 06

**CP violation in non-leptonic three-body B decays** — KERI VOS<sup>1</sup>, •REBECCA KLEIN<sup>1</sup>, JAVIER VIRTO<sup>2</sup>, and THOMAS MANNEL<sup>1</sup> — <sup>1</sup>Universität Siegen — <sup>2</sup>Universität Bern

Three-body decays, which form a large part of the B meson branching fraction, contain much more information than two-body decays, because of their non-trivial kinematic structure. Recently, progress was made to study three-body decays using a QCD factorization framework. We use this framework to study CP violation in three-body decays. Experimental data shows a rich CP structure with large local CP asymmetries. We study if these measured CP patterns can be explained using our factorization framework.

T 19.8 Mo 18:30 VSH 06

**Pseudo-scalar D-meson decay constants from three-flavour lattice QCD** — SARA COLLINS<sup>2</sup>, •KEVIN ECKERT<sup>1</sup>, JOCHEN HEITGER<sup>1</sup>, STEFAN HOFMANN<sup>2</sup>, and WOLFGANG SÖLDNER<sup>2</sup> — <sup>1</sup>Institut für Theoretische Physik, Universität Münster — <sup>2</sup>Institut für Theoretische Physik, Universität Regensburg

We report on the status of an ongoing effort by the RQCD and ALPHA Collaborations, aimed at determining masses and leptonic decay constants of charmed mesons. Our analysis is based on large-volume ensembles generated within the CLS effort, employing  $N_f = 2 + 1$  non-perturbatively  $\mathcal{O}(a)$  improved Wilson quarks, tree-level Symanzik-improved gauge action and open boundary conditions. The ensembles cover lattice spacings from  $a \approx 0.09$  fm to  $a \approx 0.05$  fm, with pion masses varied from 420 to 200 MeV. Furthermore we report on our implementation of distance preconditioning for the calculation of heavy quark propagators and resulting accuracy improvements for the extraction of charmed meson masses and decay constants. To extrapolate to the physical masses, we follow both the  $(2m_l + m_s) = \text{const.}$  and the  $m_s = \text{const.}$  line in parameter space.

T 19.9 Mo 18:45 VSH 06

**Rare radiative D-decays in QCD factorization** — THORSTEN FELDMANN, •BASTIAN MÜLLER, and DIRK SEIDEL — Uni Siegen

The idea of the QCD factorization approach (QCDF) is to disentangle short- and long-distance dynamics in exclusive heavy-quark decays. The short-distance processes can be calculated in perturbation theory, the long-distance effects are contained in universal hadronic matrix elements that can be addressed by means of non-perturbative methods. QCDF involves a simultaneous expansion in the strong coupling constant  $\alpha_s$  and in the ratio  $\Lambda_{QCD}/M_h$ , where  $\Lambda_{QCD}$  is the typical QCD scale and  $M_h$  the mass of a heavy hadron. In the past, QCDF has been successfully applied to charmless B-meson decays, including rare radiative decays into a light vector or pseudoscalar mesons at large recoil energy, like  $B \rightarrow K^{(*)}\ell^+\ell^-$  or  $B \rightarrow K^*\gamma$ . However, it has been queried whether QCDF would result in a reasonable description of the analogous D-meson decays, since the expansion might not converge and non-factorizable long-distance effects might be dominant. In order to shed more light on this issue, the project presented in this talk addresses rare radiative D-meson decays,  $D \rightarrow \rho\gamma$  and  $D \rightarrow \rho(\pi)\ell^+\ell^-$  in the framework of QCDF in order to carefully assess the hadronic uncertainties related to spectator-scattering and annihilation topologies.

## T 20: Beyond the Standard Model (Theorie) 1

Convenor: A. Kulesza, H. Rzehak

Zeit: Montag 16:45–19:00

Raum: VSH 19

T 20.1 Mo 16:45 VSH 19

**Kaluza-Klein spectrum and altered dispersion relations of fermions in asymmetrically warped five dimensional space-times** — ●DOMINIK DÖRING — Technische Universität Dortmund, Germany

Warped extra dimensions have been a powerful tool for model builders to solve the hierarchy problem since the late 1990's.

We studied properties of SM singlet fermions in a compactified and asymmetrically warped extra dimensional spacetime, such as the Kaluza-Klein (KK) mass spectrum and the alteration of the dispersion relation (ADR) on the visible 3-brane. These ADRs induce new phenomenology on neutrino oscillations between active brane neutrinos and sterile bulk neutrinos.

An analytical analysis showed that the KK mass spectrum of such a model does not differ from symmetrically warped models, although the dispersion relation on the 3-brane is altered by operators that arise from KK decomposition. We were able to show that the effect on active-sterile neutrino oscillation bears resemblance with matter effects on active neutrino oscillation.

T 20.2 Mo 17:00 VSH 19

**Prospects for three-body Higgs decays into extra light scalars** — ●ALEXANDER HELMBOLDT and MANFRED LINDNER — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Within models containing a very light scalar particle coupled to the 125 GeV Higgs boson, I will present the first study of Higgs decays into *three* of these light scalars. I will introduce model-independent conditions which the scalar sector after electroweak symmetry breaking has to satisfy in order for the three-body channel to become relevant. Using a specific model – the real scalar singlet-extension of the Standard Model (SM) – we have identified scenarios, where the rates of scalar three-body Higgs decays are comparable to or even exceed those of the well-studied two-body channel. All those scenarios were shown to be compatible with current experimental and theoretical constraints. I will finally argue that scalar three-body Higgs decays lead to exciting new collider signatures with *six* SM fermions in the final state. In particular, I will demonstrate that e.g. six-muon or six-tau final states may be in reach of dedicated searches at the LHC or ILC experiments.

T 20.3 Mo 17:15 VSH 19

**Extrapolation of LEP limits to non-SM Higgs couplings for a future lepton collider with high luminosity** — ●PETER DRECHSEL<sup>1</sup>, GUDRID MOORTGAT-PICK<sup>1,2</sup>, and GEORG WEIGLEIN<sup>1</sup> — <sup>1</sup>DESY, Notkestraße 85, D-22607 Hamburg, Germany — <sup>2</sup>II. Institute for Theoretical Physics, University of Hamburg, Luruper Chaussee 149, D-22761 Hamburg, Germany

The particle discovered in the Higgs boson searches at the LHC with a mass of about 125 GeV can be identified with one neutral Higgs boson in a variety of Beyond the Standard Model (BSM) theories with an extended Higgs sector. Limits on the couplings between additional Higgs fields to the electroweak gauge-bosons in such theories can be obtained by model-independent Higgs searches at lepton colliders. We present an extrapolation of the limits obtained at LEP for a future lepton collider. In a second step, we apply the extrapolated limits on different BSM models with an extended Higgs-sector.

T 20.4 Mo 17:30 VSH 19

**CP-odd invariants for multi-Higgs models: applications with discrete symmetry** — ●THOMAS NEDER — Instituto de Física Corpuscular, C.S.I.C./Universitat de València, Valencia, Spain

CP-odd invariants provide a basis independent way of studying the CP properties of Lagrangians. We propose powerful methods for constructing basis invariants and determining whether they are CP-odd or CP-even, then systematically construct all of the simplest CP-odd invariants up to a given order, finding many new ones. The CP-odd invariants are valid for general potentials when expressed in a standard form. We then apply our results to scalar potentials involving three (or six) Higgs fields which form irreducible triplets under a discrete symmetry, including invariants for both explicit as well as spontaneous CP violation. The considered cases include one triplet of Standard Model (SM) gauge singlet scalars, one triplet of SM Higgs doublets,

two triplets of SM singlets, and two triplets of SM Higgs doublets. For each case we study the potential symmetric under one of the simplest discrete symmetries with irreducible triplet representations, namely  $A_4$ ,  $S_4$ ,  $\Delta(27)$  or  $\Delta(54)$ , as well as the infinite classes of discrete symmetries  $\Delta(3n^2)$  or  $\Delta(6n^2)$ .

T 20.5 Mo 17:45 VSH 19

**Lepton-flavour violation in a Pati-Salam model with gauged flavour symmetry** — THORSTEN FELDMANN, CHRISTOPH LUHN, and ●PAUL MOCH — Theoretische Physik 1, Uni Siegen, Walter-Flex-Straße 3, 57068 Siegen

Combining Pati-Salam (PS) and flavour symmetries in a renormalisable setup, we devise a scenario which produces realistic masses for the charged leptons. Flavour-symmetry breaking scalar fields in the adjoint representations of the PS gauge group are responsible for generating different flavour structures for up- and down-type quarks as well as for leptons. The model is characterised by new heavy fermions which mix with the Standard Model quarks and leptons. In particular, the partners for the third fermion generation induce sizeable sources of flavour violation. Focusing on the charged-lepton sector, we scrutinise the model with respect to its implications for lepton-flavour violating processes such as  $\mu \rightarrow e\gamma$ ,  $\mu \rightarrow 3e$  and muon conversion in nuclei.

T 20.6 Mo 18:00 VSH 19

**Lepton flavour violation and the muon anomalous magnetic moment** — MANFRED LINDNER, ●MORITZ PLATSCHER, and FARINALDO S. QUEIROZ — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

In the quest for the UV completion of the Standard Model, one should study not only direct collider signatures of new physics, but also the effects which currently inaccessible physics might have on low-energy observables. Lepton flavour violating decays and measurements of the leptonic magnetic moments offer gripping tests for new physics from low to high energies. In this talk the interplay between both signatures is described in a model-independent way and their usefulness is highlighted for several specific UV completions of the Standard Model. We stress that the potential excess observed in the measurement of the muon magnetic moment over the Standard Model prediction in recent experiments could be testable in the near future through lepton flavour violation.

T 20.7 Mo 18:15 VSH 19

**Partial Unification and Local Baryon Number** — PAVEL FILEVIEZ PÉREZ<sup>1</sup> and ●SEBASTIAN OHMER<sup>2</sup> — <sup>1</sup>Case Western Reserve University, Cleveland — <sup>2</sup>Max-Planck-Institut für Kernphysik, Heidelberg

We investigate the possibility to find an ultraviolet completion of the simple extensions of the Standard Model where baryon number is a local symmetry. A simple theory based on  $SU(4)_C \otimes SU(3)_L \otimes SU(3)_R$  where baryon number is embedded in a non-Abelian gauge symmetry is introduced. We discuss the main features of the theory and the possible implications for experiments.

T 20.8 Mo 18:30 VSH 19

**Predictions from a flavour-GUT model combined with a SUSY breaking sector** — ●CHRISTIAN HOHL<sup>1</sup> and STEFAN ANTUSCH<sup>1,2</sup> — <sup>1</sup>University of Basel, Switzerland — <sup>2</sup>Max-Planck-Institut für Physik, München, Germany

We discuss how flavour GUT models in the context of supergravity can be completed with a simple SUSY breaking sector, such that the flavour-dependent (non-universal) soft breaking terms can be calculated. As an example, we discuss a model based on an  $SU(5)$  GUT symmetry and  $A_4$  family symmetry, plus additional discrete “shaping symmetries” and an  $\mathbb{Z}_4^R$  symmetry. We calculate the soft-terms and identify the relevant high scale input parameters, and investigate the resulting predictions for the low scale observables, such as e.g. for flavour processes, the sparticle spectrum and for the dark matter relic density.

T 20.9 Mo 18:45 VSH 19

**Domestic Axion** — GIA DVALI<sup>1,2,3</sup> and ●LENA FUNCKE<sup>1,2</sup> —

<sup>1</sup>Arnold Sommerfeld Center, Ludwig-Maximilians-Universität, Theresienstraße 37, 80333 München, Germany — <sup>2</sup>Max-Planck-Institut für Physik, Föhringer Ring 6, 80805 München, Germany — <sup>3</sup>Center for Cosmology and Particle Physics, Department of Physics, New York University, 4 Washington Place, New York, NY 10003, USA

We attempt to identify a phenomenologically viable solution to the strong  $CP$  problem in which the axion is composed entirely out of Standard Model fermion species. The axion consists predominantly of the  $\eta'$  meson with a minuscule admixture of a pseudoscalar bilinear composite of neutrinos,  $\eta_\nu$ . The Peccei-Quinn symmetry is an axial symmetry that acts on the up quark and the neutrino species and is

spontaneously broken by the QCD condensate of quarks as well as the condensate of neutrinos triggered by chiral gravitational anomaly. The up-quark mass is spontaneously generated by the neutrino condensate which plays the role of an additional composite Higgs doublet with the compositeness scale of the order of the neutrino masses. Such a scenario is highly economical: it solves the strong  $CP$  problem, generates the up-quark and neutrino masses from fermion condensates and simultaneously protects the axion shift symmetry against gravitational anomaly. The phenomenology is different from the standard hidden axion case. One of the experimental signatures is the existence of a gravity-competing isotope-dependent attractive force among nucleons at (sub)micron distances.

## T 21: Experimentelle Methoden 1 (Computing, Machine Learning, Statistik)

Zeit: Montag 16:45–19:00

Raum: JUR 253

T 21.1 Mo 16:45 JUR 253

**Design and Execution of make-like Distributed Analyses** — ●ROBERT FISCHER, RALF FLORIAN VON CUBE, MARTIN ERDMANN, BENJAMIN FISCHER, and MARCEL RIEGER — III. Physikalisches Institut A, RWTH Aachen

In particle physics, workflow management systems are primarily used as tailored solutions in dedicated areas such as Monte Carlo production. However, physicists performing data analyses are usually required to steer their individual workflows manually, which is time-consuming and often leads to undocumented relations between particular workloads. We present a generic analysis design pattern that copes with the sophisticated demands of end-to-end HEP analyses. The approach presents a paradigm shift from executing parts of the analysis to defining the analysis. Our tools allow to specify arbitrary workloads and dependencies between them in a lightweight and scalable structure. Further features are multi-user support, automated dependency resolution and error handling, central scheduling, and status visualization. The WLCG infrastructure is supported including CREAM-CE, DCAP, SRM and GSIFTP. Due to the open structure, additional computing resources, such as local computing clusters or Dropbox storage, can be easily added and supported. Computing jobs execute their payload, which may be any executable or script, in a dedicated software environment. Software packages are installed as required, and input data is retrieved on demand. We develop and test our system alongside ttbb and ttH cross section measurements. The clear interface and dependencies between individual workloads enables a make-like execution.

T 21.2 Mo 17:00 JUR 253

**Aktuelle Entwicklungen des Meta-Monitoring Frameworks HappyFace** — ●ARTUR IL'DAROVIC AKHMETSHIN, SEBASTIAN BROMMER, MANUEL GIFFELS, GEORG SIEBER und GÜNTER QUAST — Karlsruhe Institute of Technology, Karlsruhe, Germany

Um die Verfügbarkeit, Auslastung und Effizienz von Computing-Ressourcen zu überwachen, ist eine solide Monitoring Software heutzutage nicht wegzudenken. Solche Software muss einfach erweiterbar sein und die gewünschten Informationen zu den einzelnen Ressourcen anschaulich, aber vollständig darstellen können. Die Software sollte in der Lage sein diese Informationen anhand von festgelegten Kriterien zu bewerten und gegebenenfalls den Nutzer zu warnen, damit dieser auf Probleme rechtzeitig reagieren kann. Außerdem ist die effiziente Sammlung und Verarbeitung einer Vielzahl verschiedener Informationsquellen und die Kombination dieser Informationen ein wichtiges Merkmal. Im Rahmen dieses Vortrags werde ich die aktuellen Entwicklungen und Einsatzgebiete des HappyFace Meta-Monitoring Frameworks vorstellen, welches sich seit mehreren Jahren im produktiven Betrieb bewährt hat.

T 21.3 Mo 17:15 JUR 253

**First steps towards an improved tuning method for Monte Carlo generators** — ●FABIAN KLIMPEL<sup>1,2</sup>, STEFAN KLUTH<sup>1</sup>, and ANDREA KNUE<sup>1</sup> — <sup>1</sup>Max Planck Institut fuer Physik, Munich — <sup>2</sup>Technical University Munich

In high energy physics, Monte Carlo (MC) generators are used for the simulation of physics processes. In the simulation, parameters in the hard interaction and in the parton shower can be varied in a well defined range to achieve a better description of the data distributions (MC tuning). To do a full tuning, several parameters are varied and

each parameter set leads to a simulated sample which is compared to the data. A binwise parametrization of the parameter variations is performed using the "Professor 2.4" framework. These functions are then optimized with respect to the measured data which are provided in the "Rivet" framework. This optimization should deliver the requested parameter values. In this talk an investigation of the stability of the fixed order polynomial interpolation performed by "Professor 2.4" is presented. This will be shown in comparison to a binwise adaptive fitting method. The optimization performed by "Professor 2.4" will be compared to a tuning performed using the Bayesian Analysis Toolkit (BAT).

T 21.4 Mo 17:30 JUR 253

**Application of the VISPA web-platform for deep-learning based physics analyses** — ●BENJAMIN FISCHER, MARTIN ERDMANN, ROBERT FISCHER, ERIK GEISER, CHRISTIAN GLASER, GERO MÜLLER, THORBEN QUAST, MARCEL RIEGER, MARTIN URBAN, FLORIAN VON CUBE, DAVID WALZ, and CHRISTOPH WELLING — Physics Institute III A, RWTH Aachen

VISPA (Visual Physics Analysis) is a web-platform allowing to conduct browser-based analyses including access to facilities for exploiting deep learning methods. Opportunistic resource allocation and modular extensibility ensure the versatility to tackle a broad range of challenges.

VISPA's architectural concept and basic functions will be briefly outlined alongside the most recent developments. An overview on the available specialized tools for physics analyses will be given and explicitly illustrated in the scope of an in-progress analysis using deep learning. These include native-format data browsers for various file formats (e.g. ROOT) and methods for exploring highly ramified file-trees.

VISPA is used for high energy physics and astro particle physics as well as for university-level education.

T 21.5 Mo 17:45 JUR 253

**Development of morphing algorithms for Histfactory using information geometry** — ●ANJISHNU BANDYOPADHYAY<sup>1</sup>, IAN BROCK<sup>1</sup>, and KYLE CRANMER<sup>2</sup> — <sup>1</sup>University of Bonn — <sup>2</sup>New York University

Many statistical analyses are based on likelihood fits. In any likelihood fit we try to incorporate all uncertainties, both systematic and statistical. We generally have distributions for the nominal and  $\pm 1\sigma$  variations of a given uncertainty. Using that information, Histfactory morphs the distributions for any arbitrary value of the given uncertainties. In this talk, a new morphing algorithm will be presented, which is based on information geometry. The algorithm uses the information about the difference between various probability distributions. Subsequently, we map this information onto geometrical structures and develop the algorithm on the basis of different geometrical properties. Apart from varying all nuisance parameters together, this algorithm can also probe both small ( $< 1\sigma$ ) and large ( $> 2\sigma$ ) variations. In this talk, it will be also shown how this algorithm can be used for performing interpolation on Monte Carlo distributions of physical variables.

T 21.6 Mo 18:00 JUR 253

**Multivariate Regression on the Example of Missing Transverse Energy Estimation** — ●NICOLA ZÄH, RAPHAEL FRIESE, GÜNTER QUAST, and ROGER WOLF — Institut für Experimentelle Kernphysik, Karlsruhe, Germany

Boosted decision trees are commonly used for classification in the field of particle physics. A similar technique, gradient boosted regression trees, can be applied to regression tasks. The resolution of missing transverse energy is an important quantity in particle physics and can be improved by using multivariate analysing techniques.

In this talk the performance of gradient boosted regression trees will be compared with other methods to calculate this quantity.

T 21.7 Mo 18:15 JUR 253

**Konfidenzintervalle und Ausschlussgrenzen am Beispiel der Analyse des Verzweungsverhältnisses von  $B_s^0 \rightarrow \mu\mu\mu\mu$**  — JOHANNES ALBRECHT<sup>1</sup>, •TITUS MOMBÄCHER<sup>1</sup>, STEFANIE REICHERT<sup>1</sup> und KONSTANTIN SCHUBERT<sup>2</sup> für die LHCb-Kollaboration — <sup>1</sup>TU Dortmund — <sup>2</sup>ehemals TU Dortmund

Auf der Suche nach Widersprüchen zwischen experimentellen Befunden und Standardmodellvorhersagen sind korrekte statistische Methoden essenziell, um die Präzision von Vorhersagen und Messungen von Parametern zu quantifizieren. Dazu werden Konfidenzintervalle und Ausschlussgrenzen definiert, die mit einer festgelegten Häufigkeit den wahren Parameterwert enthalten.

Bei der Konstruktion der Konfidenzintervalle haben unterschiedliche Herangehensweisen unterschiedliche Vor- und Nachteile.

In diesem Vortrag werden verschiedene Methoden zur Bestimmung von Konfidenzintervallen und Ausschlussgrenzen erläutert und anhand der Messung der oberen Ausschlussgrenze auf das Verzweungsverhältnis des Zerfalls  $B_s^0 \rightarrow \mu\mu\mu\mu$  mit dem LHCb Experiment diskutiert.

T 21.8 Mo 18:30 JUR 253

**Kontinuumsunterdrückung mit Deep Learning Techniken für das Belle II-Experiment** — •DENNIS WEYLAND, MICHAEL FEINDT, JOCHEN GEMMLER, PABLO GOLDENZWEIG, THOMAS HAUTH, MARTIN HECK und THOMAS KECK — IEKP, KIT, Karlsruhe

Das sich im Bau befindliche Belle II-Experiment wird den Großteil seiner Datennahme auf der Energie der  $\Upsilon(4S)$  Resonanz durchführen, jedoch entsteht dabei nicht immer ein  $B\bar{B}$ -Mesonenpaar. Der Zerfall  $e^+e^- \rightarrow q\bar{q}$  ist der dominante Untergrund und wird Kontinuum genannt. Um in Analysen  $B\bar{B}$ -Mesonenpaare von Kontinuum zu unterscheiden, besitzt das Belle II-Software Framework bereits einen multivariaten Klassifizierungs-Algorithmus. Deep Learning Techniken, die das Trainieren von Neuronalen Netzen in deutlich größeren Dimensionen ermöglichen, finden in letzter Zeit immer häufiger Einzug in physikalische Klassifizierungs-Aufgaben. Aus diesem Grund wird untersucht, wie man Deep Learning in der Kontinuumsunterdrückung einbringen kann, um bessere Resultate als die etablierte Technik zu erzielen.

Dieser Vortrag wird eine Übersicht beider Techniken geben und erste Resultate präsentieren.

T 21.9 Mo 18:45 JUR 253

**Modern Machine Learning Methods in HEP** — RAPHAEL FRIESE, GÜNTER QUAST, ROGER WOLF, and •STEFAN WUNSCH — Institut für Experimentelle Kernphysik, Karlsruhe, Germany

Modern machine learning methods such as deep neural networks are an active field of research in many scientific disciplines. Also the HEP community puts increasing effort in this emerging technology.

In particle physics, commonly used machine learning methods are boosted decision trees and shallow neural networks, which have proven their superior classification power over conventional cut based event selection in the last decade. Currently, deep learning shows again first signs of a significantly improved performance compared to these algorithms, which the HEP community aspires to exploit for its analyses.

This talk puts emphasis on the state-of-the-art usage of these modern machine learning methods and the application on event classification in particle physics.

## T 22: Experimentelle Techniken der Astroteilchenphysik 1

Zeit: Montag 16:45–18:50

Raum: S 9

### Gruppenbericht

T 22.1 Mo 16:45 S 9

**Integration of a TARGET-based Readout Module into GCT** — •PETER DEIML<sup>1</sup>, ADRIAN ZINK<sup>1</sup>, MANUEL KRAUS<sup>1</sup>, DAVID JANKOWSKY<sup>1</sup>, STEFAN FUNK<sup>1</sup>, JUSTUS ZORN<sup>2</sup>, MAURICE STEPHAN<sup>3</sup>, ARNIM BALZER<sup>3</sup>, and THE CTA CONSORTIUM<sup>4</sup> for the GCT-Collaboration — <sup>1</sup>Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, D-91058 Erlangen, Germany — <sup>2</sup>Max-Planck-Institut für Kernphysik, Heidelberg — <sup>3</sup>GRAPPA, University of Amsterdam — <sup>4</sup>Full consortium author list at <http://cta-observatory.org>

TARGET is an Application Specific Integrated Circuit (ASIC) designed for digitisation and readout of different photosensors in various types of experiments. One application is the next generation ground-based observatory for gamma-rays, the Cherenkov Telescope Array (CTA). There, it is integrated into the camera of the Gamma Cherenkov Telescope (GCT), one proposed candidate for the small size telescopes (SSTs). To be affordable while meeting the demands made to CTA, the camera consists of 32 readout modules with four TARGET-ASICs each. Key features are a high sampling frequency of 1 GSa/s, a deep analog buffer, a compact design, a dynamic range of >10 bits, a moderate power consumption and affordability. We give an overview of the GCT architecture and its operating principle and how the TARGET-based readout modules are integrated. Finally, we discuss performance tests measured with TARGET-C modules, the newest generation of TARGET-based readout modules.

T 22.2 Mo 17:05 S 9

**The FlashCam cameras for the medium-sized telescopes of the Cherenkov Telescope Array** — •MARC PFEIFER for the FlashCam-Collaboration — ECAP, Friedrich-Alexander Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, D 91058 Erlangen, Germany

The Cherenkov Telescope Array (CTA) will be the next generation of ground-based gamma-ray observatory. It will be formed of several dozens of telescopes of different sizes. For the success of such an observatory, cost-efficient cameras with high reliability and a superior

performance are mandatory. FlashCam is a camera system that has been developed for this purpose and is proposed for the medium-sized telescopes of CTA.

The design of FlashCam follows a horizontal architecture. A fully-digital signal processing chain is implemented in the readout electronics, based on commercially available parts only. The FlashCam team has built a full-size camera prototype which has been equipped with the complete readout system during 2016.

Our contribution will give an overview of the architecture of FlashCam and will show results from the performance verification of the camera.

T 22.3 Mo 17:20 S 9

**IceAct, Imaging Air Cherenkov Telescopes with SiPMs at the South Pole for IceCube-Gen2** — JAN AUDEHM, •JAN AUFFENBERG, THOMAS BRETZ, ERIK GANSTER, MAURICE GÜNDER, LASSE HALVE, THOMAS HEBBEKER, JAN PAUL KOSCHINSKY, LUKAS MIDENDORF, TIM NIGGEMANN, LEIF RÄDEL, MARTIN RONGEN, TOBIAS SÄLZER, MERLIN SCHAUFEL, SEBASTIAN SCHOENEN, JOHANNES SCHUMACHER, AATIF WAZA, and CHRISTOPHER WIEBUSCH for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen University

IceCube-Gen2 is planned to extend the IceCube Neutrino Observatory at the geographic South Pole. For neutrino astronomy, a large background-free sample of well-reconstructed astrophysical neutrinos is essential. The main background for this signal are muons and neutrinos which are produced in cosmic-ray air showers in the Earth's atmosphere. The coincident detection of these air showers by the surface detector IceTop has been proven to be a powerful veto for atmospheric neutrinos and muons in the field of view of the Southern Hemisphere. This motivates a large extension of IceTop to more efficiently detect cosmic rays. Part of these extension plans is IceAct, small imaging air cherenkov telescopes based on SiPM cameras and optimized for harsh environments. Compared to IceTop stations, these telescopes potentially lower the detection threshold for air showers. The South Pole environment promises a very good duty cycle. We will present the progress and future plans of the IceAct project including

first coincident data of IceAct with IceCube.

T 22.4 Mo 17:35 S 9

**Development of a 61-Pixel Camera for the IceAct Imaging Air Cherenkov Telescope** — •JAN PAUL KOSCHINSKY, JAN AUDEHM, JAN AUFFENBERG, THOMAS BRETZ, LASSE HALVE, THOMAS HEBBEKER, TIM NIGGEMANN, MARTIN RONGEN, TOBIAS SÄLZER, MERLIN SCHAUFEL, JOHANNES SCHUMACHER, AATIF WAZA, and CHRISTOPHER WIEBUSCH for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen University, D-52056 Aachen, Germany

Part of the Gen2 extension of the IceCube Neutrino Observatory at the geographic South Pole is a surface air shower detector. Primary goal is to veto atmospheric muons and neutrinos as background for the measurement of astrophysical neutrinos. One possible technology are compact imaging air Cherenkov telescopes, IceAct, that exhibit a lower energy threshold compared to surface particle detectors. The IceAct telescope design is adapted from the FAMOUS fluorescence telescope which achieves a large field of view. It consists of a Fresnel lens allowing for an enclosed optical system protecting the camera from the harsh environment. The camera is based on light collecting Winston cones and SiPMs allowing a high duty cycle. Here we will present the development of a new 61-pixel camera that is intended to replace the 7-pixel camera, currently operating with an IceAct prototype at the South Pole.

T 22.5 Mo 17:50 S 9

**First evaluation of the prototype 19-modules camera for the Large Size Telescope of the CTA** — •TSUTOMU NAGAYOSHI for the CTA-Japan-Collaboration — Saitama Univ., Saitama-shi, Japan — Max-Planck-Inst. fuer Phys., Munich, Germany

The Cherenkov Telescope Array (CTA) represents the next generation of ground based observatory for very high energy gamma rays. This observatory will be an array of about 100 Cherenkov telescopes of three different sizes, will be ten times more sensitive than the current generation telescopes, and will expand the energy coverage to be from 20 GeV to more than 300 TeV. The Large Size Telescope (LST), which has 23 m diameter mirror dish, dominates the sensitivity of CTA below 200 GeV, which is the energy range with the largest discovery potential, including the detection of many pulsars or distant ( $z > 1$ ) blazars or GRBs. The LST camera consists of 265 photo sensor modules, each of them containing seven photomultiplier tubes (PMTs), a slow control board, a readout board, and a 2-level trigger logic. The PMTs (R11920, Hamamatsu Photonics) have 1.5 inch size photo-cathode and 8 stages of dynodes. In addition, for each PMT, Cockcroft\*Walton type DC-DC converter and a preamplifier ASIC are assembled. We carried out the quality control of all PMTs, and constructed the first prototype mini-camera consisting of 19 PMT modules. In this talk I will present the results of the quality control and the first evaluation of the integration tests of the 19-modules camera prototype.

T 22.6 Mo 18:05 S 9

**FAMOUS/HAWC - A small size air-Cherenkov telescope for a ground detector array - a possible future extension?** —

•MERLIN SCHAUFEL — RWTH Aachen, Germany

The fluorescence telescope FAMOUS turned out to be a versatile and multi-use instrument. After the successful measurement of Cherenkov light originating from air showers with the 7-pixel prototype and the commissioning of the FAMOUS-type IceAct at the South Pole, the new 61 pixel telescope is now operational.

A joint measurement of the FAMOUS telescope, in sync with the gamma ray observatory HAWC (Serra Negra, Mexico), will allow a detailed characterization of the telescope performance using the additional reconstruction information from the array with real events. Furthermore, it will test the technology of small IACTs as a possible extension of array type detectors to improve i.a. the energy resolution for the high energy range. In this talk, I present the current status of the integration of an external detector system into the HAWC DAQ and the possible opportunities of such a combination.

T 22.7 Mo 18:20 S 9

**First Observation of Coincident Air Showers with IceAct and IceCube** — •TOBIAS SÄLZER, JAN AUFFENBERG, THOMAS BRETZ, ERIK GANSTER, MAURICE GÜNDER, LASSE HALVE, THOMAS HEBBEKER, JAN PAUL KOSCHINSKY, LUKAS MIDDENDORF, TIM NIGGEMANN, LEIF RÄDEL, MARTIN RONGEN, MERLIN SCHAUFEL, SEBASTIAN SCHOENEN, JOHANNES SCHUMACHER, AATIF WAZA, and CHRISTOPHER WIEBUSCH — III. Physikalisches Institut, RWTH Aachen University, D-52056 Aachen, Germany

One planned component of the IceCube-Gen2 Neutrino Observatory is an array of compact imaging air Cherenkov telescopes called IceAct. The goal is to reduce the atmospheric background for astrophysical neutrino searches by identifying air showers above the detector. A prototype of an IceAct telescope featuring a seven-pixel SiPM camera has been installed at the South Pole and operated over the course of 2016. The acquired data is synchronized with IceCube and analyzed. We present results on the performance of the prototype based on events observed in coincidence with the other detectors of the observatory.

T 22.8 Mo 18:35 S 9

**Investigation of the potential of composition measurements with IceTop and IceAct** — •AATIF WAZA, JAN AUFFENBERG, THOMAS BRETZ, THOMAS HEBBEKER, JAN PAUL KOSCHINSKY, TIM NIGGEMANN, MARTIN RONGEN, TOBIAS SÄLZER, MERLIN SCHAUFEL, and JOHANNES SCHUMACHER for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen University, D-52056 Aachen, Germany

IceAct is planned as an array of SiPM-based Imaging Air Cherenkov Telescopes as one surface component of IceCube-Gen2. Goal of this array would be to efficiently detect cosmic rays below the threshold of IceTop and improve composition measurements of the IceCube Neutrino Observatory. Within the hybrid measurement of cosmic rays by IceTop, IceCube, and IceAct, IceTop mainly provides the direction and energy of the shower, IceCube a measurement of the high-energy muon component, and IceAct the particle density along the air shower axis. We present first results from CORSIKA-based simulations of air showers with proton and iron primary particles.

## T 23: Experimentelle Techniken der Astroteilchenphysik 2

Zeit: Montag 16:45–19:00

Raum: S 055

T 23.1 Mo 16:45 S 055

**Deep Learning für Neutrinooteleskope** — •STEFAN GEISSELSÖDER für die ANTARES-KM3NeT-Erlangen-Kollaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg — ECAP

Neutrinooteleskope erlauben uns Erkenntnisse sowohl über die Flüsse hochenergetischer kosmischer Neutrinos als auch über deren teilchenphysikalische Eigenschaften zu gewinnen. Die benötigte Datenanalyse, speziell die Identifikation und Rekonstruktion von Neutrinointeraktionen, ist jedoch bei allen existierenden und geplanten Neutrinooteleskopen eine herausfordernde Aufgabe, die signifikanten Einfluss auf den Erfolg späterer Analysen hat.

Deep Learning bezeichnet eine gegenwärtig in vielen Anwendungsbereichen sehr erfolgreiche und flexibel einsetzbare Gruppe von Algorithmen, die einen hohen Grad an automatisch erzielter Abstraktion gemeinsam haben. Der Vortrag zeigt Methoden und Ideen, wie mittels

Deep Learning Frameworks (hier Tensorflow und CNTK) verschiedene Ansätze (Convolutional Neural Networks und Recurrent Neural Networks) genutzt werden können, um die Genauigkeit der Datenanalyse für Neutrinooteleskope zu verbessern. Dabei ist insbesondere die Art der betrachteten Daten interessant, da sie bei Neutrinooteleskopen, im Gegensatz zu im Rahmen von Deep Learning häufig betrachteten zweidimensionalen Bilddaten, drei Raum- und eine Zeitdimension aufweisen. Die Entwicklungen werden am Beispiel des KM3NeT Neutrinooteleskops gezeigt, das gegenwärtig am Grund des Mittelmeeres im Aufbau ist, sind jedoch größtenteils allgemein anwendbar.

T 23.2 Mo 17:00 S 055

**Deep Learning für KM3NeT** — •CHRISTOPH BIERNOTH für die ANTARES-KM3NeT-Erlangen-Kollaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg — ECAP

Der Wasser-Cherenkov-Detektor KM3NeT/ARCA wird aktuell auf



dem Grund des Mittelmeeres vor der sizilischen Küste in einer Wassertiefe von 3500m errichtet. Das Hauptaugenmerk ist die Untersuchung der Quellen des Flusses hochenergetischer kosmischer Neutrinos, dessen Existenz inzwischen von IceCube nachgewiesen wurde. Das Neutrino-teleskop besteht aus einem dreidimensionalen Aufbau von optischen Senormodulen, die unter anderem die Ankunftszeit des Cherenkovlichtes aus Neutrino-Reaktionen registrieren.

Ein (künstliches) neuronales Netz ist durch Nervenzellvernetzungen im Gehirn motiviert. Es besteht aus in Ebenen angeordneten Neuronen, welche miteinander verknüpft sind und kann mittels Beispieldaten darauf trainiert werden, Korrelationen in den Daten zu erkennen und damit die Daten in Klassen einzuordnen. Der Vortrag zeigt, wie verschiedene Ansätze von tiefen neuronalen Netzen genutzt werden können, um bestimmte Merkmale wie die Teilchenart, aus Roh- oder bereits vorverarbeiteten Daten zu abstrahieren. Dabei werden die zwei verwendeten Frameworks Tensorflow und CNTK sowie verschiedene Netzwerkstrukturen wie Convolutional Neural Networks und Recurrent Neural Networks vorgestellt. Eine Besonderheit im Vergleich zu gängigen Anwendungsfällen ist hierbei der vierdimensionale Parameterraum bestehend aus Ort und Zeit der registrierten Photonen.

T 23.3 Mo 17:15 S 055

**Deep Learning in Physics exemplified by the reconstruction of muon-neutrino events in IceCube** — ●MIRCO HÜNNFELD for the IceCube-Collaboration — TU Dortmund, Dortmund, Germany

Recent advances, especially in image recognition, have shown the capabilities of deep learning. Deep neural networks can be extremely powerful and their usage is computationally cheap once the networks are trained. While the main bottleneck for deep neural networks in the traditional domain of image classification is the lack of sufficient labeled data, this usually does not apply to physics where millions of Monte Carlo simulations exist.

At the IceCube Neutrino Observatory, the reconstruction of muon-neutrino events is one of the key challenges. Due to limited computational resources and the high data rate, only very basic and simplified reconstructions limited to a small subset of data can be run on-site at the South Pole. However, in order to perform online analysis and to issue real-time alerts, a fast and powerful reconstruction is necessary.

In this talk I will present how deep learning techniques such as those used in image recognition can be applied to IceCube waveforms in order to reconstruct muon-neutrino events. These methods can be generalized to other physics experiments.

T 23.4 Mo 17:30 S 055

**Mining for Spectra - The Dortmund Spectrum Estimation Algorithm** — ●TIM RUHE — Technische Universität Dortmund, Dortmund, Deutschland

Obtaining energy spectra of incident particles such as neutrinos or gamma-rays is a common challenge in neutrino- and Air-Cherenkov astronomy, as the particle's energy cannot be observed directly but has to be inferred from other observables e.g. energy losses of secondary particles utilized for detection. The task is further made difficult by the fact that the production of secondaries, e.g. in a neutrino-nucleon interaction is governed by stochastic processes. Mathematically this corresponds to an inverse problem, which is described by the Fredholm integral equation of the first kind. Several algorithms for solving inverse problems exist, which are, however, somewhat limited, for example in the number of input variables or in the sense that only the unfolded distribution is returned and information on individual events is lost. We present the Dortmund Spectrum Estimation Algorithm (DSEA), which aims at overcoming the afore mentioned obstacles by treating the inverse problem as a multinomial classification task. This results in a modular and highly flexible algorithm that can easily be tailored to a problem at hand. To avoid a potential bias on the class distribution used for the training of the learner, DSEA can be used iteratively using a uniform class-distribution as input.

T 23.5 Mo 17:45 S 055

**Online Classification of IceCube Events using Neural Networks** — ●JOSHUA LUCKEY for the IceCube-Collaboration — Technische Universität Dortmund, Deutschland

The IceCube neutrino detector is located at the geographic South Pole and consists of 5160 digital optical modules, each containing a photomultiplier tube, deployed into the ice. With an instrumented volume of 1 km<sup>2</sup> IceCube detects events at a rate of about 3000 Hz. The first data processing steps are done by a system of online filters, which are applying reconstruction algorithms to the data. An analysis on the data at

this early stage bears the advantage of being independent of time- and CPU-intensive data preprocessing. In this talk a classification of online data of the IceCube detector is presented. The classification is based on the topology of the events in the detector. At first the events can be separated into the two classes of track-like and cascade-like events and from there further classifications can be carried out. With the recent advancements in other fields of research in mind, Deep Learning algorithms in conjunction with neural networks are used to conduct the afore-mentioned classification as early in the data acquisition process as possible. A classification at this early stage could be beneficial to analyses focusing on just one type of event. Furthermore an optimization of the used neural net, with the aim of minimizing the classification time, could be performed to classify every detected event.

T 23.6 Mo 18:00 S 055

**Improvement of energy reconstruction by using machine learning algorithms in MAGIC** — ●KAZUMA ISHIO<sup>1</sup>, GALINA MANEVA<sup>2</sup>, ABELARDO MORALEJO<sup>3</sup>, DAVID PANEQUE<sup>1</sup>, JULIAN SITAREK<sup>4</sup>, and PETAR TEMNIKOV<sup>2</sup> for the MAGIC-Collaboration — <sup>1</sup>Max-Planck-Institut für Physik, München, Germany — <sup>2</sup>Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria — <sup>3</sup>Institut de Física d'Altes Energies (IFAE), Barcelona, Spain — <sup>4</sup>University of Lodz, Lodz, Poland

The MAGIC telescopes perform gamma-ray astronomy at energies above 50 GeV and extending to about 50 TeV. The energy of the detected gamma ray is estimated with a set of parameters extracted from the shower image on the cameras and using Look-Up-Tables (LUTs) derived from Monte Carlo simulations. The current strategy yields an energy bias smaller than 5% with a resolution of approximately 20%, depending on energy range. The talk focuses on the usage of machine learning strategies, namely artificial neural network (ANN) and random forest (RF), for the determination of the gamma-ray energy. I will show that these strategies provide independent ways of reconstructing the energy, which are very helpful for cross-checks, and they also yield an improvement in the performance for energies above 1 TeV with respect to LUTs.

T 23.7 Mo 18:15 S 055

**Neural Networks for Energy Reconstruction in the IceCube Neutrino Observatory** — ●MARTIN BRENZKE, JAN AUFFENBERG, CHRISTIAN HAACK, RENÉ REIMANN, and CHRISTOPHER WIEBUSCH for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen University, D-52056 Aachen, Germany

Energy reconstruction of track-like events induced by muons is an essential part of the data analysis of the IceCube Neutrino Observatory. There already are sophisticated methods to reconstruct the energy of those events. However, the progress achieved in the recent decade in deep learning techniques makes them an interesting candidate for an alternative method for energy reconstruction, which might perform as well as or even better than the established algorithms. We focus on supervised learning techniques using recurrent neural networks and present first results of performance studies as well as comparisons to commonly used reconstruction methods.

T 23.8 Mo 18:30 S 055

**Event Identification for KM3NeT/ARCA** — ●THOMAS HEID for the ANTARES-KM3NeT-Erlangen-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

KM3NeT is a distributed neutrino research infrastructure in the Mediterranean sea. KM3NeT/ARCA is the high energy part of it, which is dedicated for the search of extraterrestrial neutrino sources in the TeV-PeV range. One major goal is to study the source of the recently discovered neutrino flux by IceCube. Furthermore KM3NeT/ARCA is optimised to study galactical neutrino point sources. More insight into neutrino sources can be achieved by distinguishing between neutrino flavours. Neutrinos can have different interactions inside or near the detector which lead to various event topologies. These topologies can be differentiated with machine learning algorithms. Here neural nets were trained on selected event features, for example based on time-residual distributions. Five target topologies are differentiated: double bang events, cascades and three different track-like topologies. Based on the topologies, the neutrino flavour composition can be inferred on a statistical basis. In addition, computationally complex, tailored reconstruction algorithms can be employed based on the event topology.

T 23.9 Mo 18:45 S 055

**Dealing with Data/Simulation Mismatches in Machine Learning based Analyses** — ●MATHIS BÖRNER, JENS BUSS, and THORSEN MENNE for the IceCube-Collaboration — Technische Universität Dortmund, Dortmund, Deutschland

The widespread use of machine learning algorithms in physical analyses require an intensive check for the compatibility between measured data and simulations. Since all frequently used algorithms use us more than one observable as the input. Therefore, the typical univariate comparison might not be sufficient. Furthermore, simulations always

have finite mismatches, so it is necessary to decide whether they can be neglected or not. In this talk an approach utilizing machine learning algorithms to tackle both challenges is presented. The approach can be used exploratory to discover observables and areas in the observable space with significant mismatches. In a different application the approach is applicable to select observables with the lowest mismatch from a large set. Moreover, a way to show that no significant mismatches are presented in the simulation is shown. All presented methods are illustrated with results based on IceCube data.

## T 24: Gasgefüllte Detektoren 1 (gemeinsam mit HK)

Zeit: Montag 16:45–19:00

Raum: F 102

**Gruppenbericht** T 24.1 Mo 16:45 F 102

**Towards the mass production of readout chambers for the upgrade of the ALICE TPC** — ●ALEXANDER DEISTING for the ALICE-Collaboration — GSI, Darmstadt, Deutschland — Physikalisches Institut, Heidelberg, Deutschland

The LHC will provide, during run 3 (2021 onwards) lead-lead collisions at interaction rates as high as 50 kHz. In order to cope with this luminosity the ALICE Time Projection Chamber (TPC) will be upgraded with new readout chambers and new readout electronics.

The goal of this upgrade is to allow continuous readout of the TPC, while preserving its excellent momentum and  $dE/dx$  resolution. Therefore the ion back flow into the drift volume must be less than 1%, otherwise the field distortions due to space-charge build-up would decrease the performance significantly. Extensive R&D was performed to develop new readout chambers, meeting these goals. The resulting chambers employ a stack of four Gas Electron Multipliers (GEMs) with a special high voltage configuration.

With the long shutdown 2 approaching at the end of 2018, the design parameters have been finalized and the mass-production of the GEM-based readout chambers has started. In this talk the status of the ALICE TPC upgrade will be given. In particular the design of the chambers is presented. An overview of the recent R&D activities will be shown as well. These include stability studies of the four GEM setup, tests to ensure the quality of the GEM foils during mass-production and the commissioning of the first front-end cards. In addition we report on the challenges of the mass production.

T 24.2 Mo 17:15 F 102

**Studies of space-charge distortions in the ALICE TPC** — ●ERNST HELLBÄR<sup>1</sup>, JENS WIECHULA<sup>1</sup>, MARIAN IVANOV<sup>2</sup>, and RUBEN SHAHOYAN<sup>3</sup> for the ALICE-Collaboration — <sup>1</sup>Institut für Kernphysik, Goethe-Universität Frankfurt — <sup>2</sup>GSI — <sup>3</sup>CERN

The Time Projection Chamber (TPC) is the main tracking and particle identification detector of the ALICE experiment at the CERN LHC. With the advent of high luminosity data in LHC RUN 2, unexpectedly large local distortions of the drift paths of ionization electrons are observed at the edges of specific readout chambers. These distortions are caused by ions which originate at the readout chambers, leading to local space-charge accumulation in the drift volume of the TPC. A dedicated correction procedure that was initially developed for the high-rate TPC operation in RUN 3 and beyond has been implemented into the current detector calibration framework to correct the distortions with sufficient precision. The observed distortions will be shown as well as results of the investigation of their origin. Moreover, the correction procedure and its performance will be presented.

Supported by BMBF and the Helmholtz Association.

T 24.3 Mo 17:30 F 102

**Development and construction of InGrid based gaseous detectors** — KLAUS DESCH, JOCHEN KAMINSKI, CHRISTOPH KRIEGER, and ●TOBIAS SCHIFFER — Physikalisches Institut, Universität Bonn, Nußallee 12, 53115 Bonn

Gaseous detectors are used in many particle physics experiments and applications. Especially multipattern gaseous detectors like Micromegas are able to achieve high spatial resolution through their granularity. To make full use of this granularity one has to combine the highly granular gas amplification stage with a readout structure of similar feature size, e.g. a pixelized readout chip like the Timepix and Timepix3 ASICs. The Micromegas stage can be produced directly on top of the chip by means of photolithographic postprocessing technol-

ogy which allows for an almost perfect alignment between grid holes and pixels. This integrated gas amplification stage is called InGrid.

One application for detectors based on the InGrid technology is the detection of low energy X-ray photons exploiting the capability to detect individual primary electrons. To be able to detect low energy X-ray photons this kind of detector needs to fulfill special requirements which will be discussed.

Meanwhile the first InGrids on top of Timepix3 ASICs, the successor of the Timepix ASIC, are available. For testing purposes a versatile test detector is constructed and will be presented.

T 24.4 Mo 17:45 F 102

**Improving Hough transform algorithm for the track reconstruction of a Time Projection Chamber** — ●AMIR NOORI SHIRAZI and IVOR FLECK — Department Physik, Universität Siegen, Walter-Flex-Str. 3, 57068 Siegen, Germany

A Time Projection Chamber (TPC) is foreseen as the main tracking detector for the International Large Detector (ILD) one of the two detectors for the next candidate collider named International Linear Collider (ILC).

GridPix, which is a combination of micro-pattern gaseous detector with a pixelized readout system, is one of the candidate readout systems for the TPC. One of the challenges in the track reconstruction is the large numbers of individual hits along the track (around 100 per cm). Due to the small pixel size of  $55 \times 55 \mu\text{m}^2$ , the hits are not consecutive. This leads to the challenge of assigning the individual hits to the correct track. Hits within a given distance from a reconstructed track are called inliers. Consequently, finding inliers within the many hits and noise is difficult for pattern recognition and this difficulty is increased by diffusion effects in the TPC.

In this analysis, a Hough transform is used. Instead of collected the inliers in the image space they are collected directly in the Hough space using a bivariate normal distribution based on the covariance matrix calculated from the diffusion defects. Results for track reconstruction efficiency and double track resolution will be presented.

T 24.5 Mo 18:00 F 102

**A Time Projection Chamber for the CBELSA/TAPS experiment** — ●JONATHAN OTTNAD, MARKUS BALL, REINHARD BECK, DIMITRI SCHAAB, and BERNHARD KETZER — Helmholtz-Institut für Strahlen und Kernphysik, Bonn, DE

The CBELSA/TAPS experiment in Bonn aims to investigate the excitation spectrum of baryons and the properties of baryon resonances. Up to now, only the neutral decay products of the baryonic resonances are observed by the Crystal Barrel (CB), a high resolution electromagnetic calorimeter. A Time Projection Chamber (TPC) is foreseen to grant access to charged reaction channels in addition. Besides tracking, a TPC provides particle identification via the specific energy loss.

A TPC consists of a gas-filled, cylindrical volume with very low material-budget. The combination of electric and magnetic fields allows a three-dimensional track reconstruction. Constraints from the experimental setup limit the size of the fieldcage (length: 727.8 mm, outer diameter: 308 mm). The experiment's fixed target geometry results in a strong forward boost of the reaction products. Therefore the readout-electronics can only be mounted on one side of the TPC, which means one HV-cathode and one segmented readout-anode. For the gaseous amplification stage Gas Electron Multipliers were chosen.

This talk will cover the implementation of a TPC at the CBELSA/TAPS experiment, the current status of the TPC-prototype and its connected soft- and hardware infrastructure, as well as the

development of a field calibration system.

Supported by SFB/TR 16.

T 24.6 Mo 18:15 F 102

**Track Reconstruction for the CBELSA/TAPS TPC** — •PHILIPP BIELEFELDT, MARKUS BALL, JONATHAN OTTNAD, and BERNHARD KETZER — Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn, DE

The CBELSA/TAPS Experiment at the ELSA accelerator facility in Bonn is a photo-production experiment that studies the spectrum and properties of baryon resonances. The current set-up is well-suited for the identification of neutral particles. For a future upgrade, a gas-filled Time Projection Chamber (TPC) with Gas Electron Multiplier (GEM) based amplification is under construction. It will allow studies of charged final states and provide improved particle identification capabilities and suppression of low-energetic electron background.

Track reconstruction will be done using GENFIT II, a sophisticated, experiment-independent tracking framework. It offers an abstract way to describe detector measurements and material handling as well as fitting routines, i. a. a Kálmán fitter. By design, measurement dimensionality and detector plane orientation need not be constrained, making it especially useful for a TPC, where the passage of particles is not measured on predefined planes.

In this talk, the implementation of the GENFIT II framework for the CBELSA/TAPS experiment will be discussed. An overview of the pattern recognition and fitting algorithms for the experiment will be given, as well as information on the expected performance of the GEM-TPC upgrade for the CBELSA/TAPS set-up.

Supported by SFB/TR 16.

T 24.7 Mo 18:30 F 102

## T 25: Streifendetektoren 1 (gemeinsam mit HK)

Zeit: Montag 16:45–19:00

Raum: F 234

T 25.1 Mo 16:45 F 234

**Präzisions Siliziumteleskop für den DESY Teststrahl** — TIES BEHNKE, •UWE KRÄMER, MARCEL STANITZKI und DIMITRA TSIONOU — DESY, Hamburg, Deutschland

Der DESY Teststrahl ist eine Nutzereinrichtung, in der Elektronenstrahlen mit Energien bis zu 5 GeV zur Verfügung stehen. Ein Solenoidmagnet liefert ein Feld von einem Tesla zur Messung von Detektoreigenschaften in einem Magnetfeld. Um die Nutzung der Einrichtung weiter zu verbessern, soll ein hochauflösender Silizium basierender Spurdetektor in den Magneten eingebaut werden. Bis zu sechs Lagen von Silizium sollen drei Raumpunkte vor und drei Raumpunkte hinter dem zu testenden Gerät liefern. Um das verfügbare Volumen im Magneten möglichst wenig einzuschränken, muss der Detektor auf der einen Seite eine sehr hohe Ortsauflösung liefern, auf der anderen Seite mit sehr wenig Bauraum auskommen.

Im Rahmen des AIDA2020 Projektes soll ein solcher Detektor aufgebaut werden. Er basiert auf großflächigen Silizium Streifensensoren die ursprünglich für einen Siliziumtracker am International Linear Collider, ILIC, entwickelt worden sind, und die eine Ortsauflösung von etwa 10  $\mu\text{m}$  erreichen. Der Sensor wird mit einem Chip ausgelesen, der direkt auf den Sensor gebondet ist und dadurch eine sehr kompakte Bauform erlaubt. In dem Vortrag werden Studien und erste Testergebnisse eines solchen Detektors vorgestellt, und seine Nutzung im Rahmen von Studien zur Entwicklung einer hochauflösenden TPC diskutiert.

### Gruppenbericht

T 25.2 Mo 17:00 F 234

**The Silicon Tracking System of the CBM Experiment at FAIR** — •OLGA BERTINI for the CBM-Collaboration — GSI Darmstadt, Germany

The Compressed Baryonic Matter experiment will explore the phase diagram of strongly interacting matter in nucleus-nucleus collisions in the region of high net baryon densities using a number of rare probes and bulk observables. Its main component – the Silicon Tracking System (STS) – has to enable the reconstruction of up to 1000 charged particle trajectories per  $N$ - $N$  collision at interaction rates of up to 10 MHz. The system design employs high-granularity sensors matching the non-uniform track density and fast self-triggering electronics needed for free streaming data acquisition system and online event selection. The required momentum resolution of  $\Delta p/p \sim 1.5\%$  dictates

### Transverse Diffusion in the TPC of the T2K Near Detector

— PHILIP HAMACHER-BAUMANN, LUKAS KOCH, •THOMAS RADERMACHER, STEFAN ROTH, and JOCHEN STEINMANN — III. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen

Transverse diffusion affects the spatial resolution in a Time Projection Chamber (TPC). In the TPCs of the T2K near detector it can be derived from the charge distribution on the Micromegas plane. The electron cloud width is reconstructed from the charge fraction detected by the individual anode pads. This cloud width is investigated in dependence of the drift distance and the transverse diffusion coefficient is extracted.

T 24.8 Mo 18:45 F 102

**Multicomponent drift gas mixtures for the SHiP Muon Magnetic Spectrometer** — •STEFAN BIESCHKE, CAREN HAGNER, DANIEL BICK, JOACHIM EBERT, and WALTER SCHMIDT-PARZEFALL — Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

SHiP is a proposed beam dump experiment to Search for Hidden Particles. It has a dedicated subdetector for neutrino physics that is equipped with a Muon Magnetic Spectrometer. For the spectrometer, upgraded drift tubes from the OPERA experiment are foreseen. The drift gas mixture used at OPERA had a high maximum drift time and a non-linear  $rt$ -relation. Due to the high rates at a beam dump experiment, a faster drift gas is needed. By adding small amounts of Nitrogen to the drift gas mixture, the maximum drift time was significantly reduced and the  $rt$ -relation became more linear. The drift gas mixture Ar:CO<sub>2</sub>:N<sub>2</sub> 96:3:1 was found to be best suited candidate for a linear and fast drift gas mixture at atmospheric pressure.

the need of a low-mass design with material budget of 0.3-1% $X_0$  per station. The eight tracking stations of the STS are located in the aperture of a dipole magnet with 1 T field, and will cover an active area of 4.2 m<sup>2</sup>, corresponding to polar the polar angles between 2.5° and 25°. The STS will comprise about 1000 detector modules consisting of double-sided silicon microstrip sensors, ultra-thin readout cables and front-end electronics that are mounted onto lightweight carbon fiber support structures. The assembly of the detector module components into full-scale prototypes and the engineering of the mechanical structure of the STS detector will be presented as well as progress with the final components, in particular sensors, readout cables and front-end electronics.

T 25.3 Mo 17:30 F 234

**Proton beam tests of silicon microstrip sensors for the CBM experiment** — •MAKSYM TEKLIŠYN<sup>1,2</sup>, OLGA BERTINI<sup>3</sup>, JOHANN HEUSER<sup>3</sup>, ANTON LYMANETS<sup>3,2</sup>, HANNA MALYGINA<sup>3,4,2</sup>, and IEVGENIIA MOMOT<sup>3,4,2</sup> for the CBM-Collaboration — <sup>1</sup>FAIR, Darmstadt — <sup>2</sup>KINR, Kyiv, Ukraine — <sup>3</sup>GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — <sup>4</sup>Goethe Universität Frankfurt

The physics aim of the Compressed Baryonic Matter (CBM) experiment is to explore the phase diagram of strongly interacting matter at highest net baryon densities and moderate temperatures in the range reachable with heavy ions collisions between 2 – 45 AGeV, initially 2 – 14 AGeV (SIS 100).

Double-sided 300  $\mu\text{m}$  thick silicon microstrip sensors are planned to be used in the Silicon Tracking System (STS). The performance of recent sensor prototypes was studied with the beam of 1.6 GeV/c protons at COSY, Jülich. The Alibava system, based on the Beetle front-end chip, served as read-out electronics.

We performed various tests with the sensor prototypes: the charge collection efficiency was studied for the set of connection schemes for the different penetration angles of incident particles. The analysis of the data, collected with the proton beam, improves our understanding of the charge collection mechanism, relevant for the sensor production readiness.

Supported by HGS-HiRe and the EU-H2020 project CREMLIN.

T 25.4 Mo 17:45 F 234

**Testmessungen zur CO<sub>2</sub>-Kühlung der 2S-Module für das Phase-2-Upgrade des CMS-Trackers** — LUTZ FELD, WACŁAW KARPINSKI, KATJA KLEIN, MARIUS PREUTEN, ●MAX RAUCH, NICOLAS RÖWERT und MICHAEL WLOCHAL — RWTH Aachen, 1. Physikalisches Institut B

Im Rahmen des Phase-2-Upgrades von CMS am LHC (CERN) wird der derzeitige Siliziumspurdetektor (Tracker) ausgetauscht werden, voraussichtlich ab dem Jahr 2023. Im Phase-2-Tracker werden etwa 8000 Stück der neuartigen 2S-Siliziumstreifenmodule eingesetzt werden. Die 2S-Module sollen mit einer Trägerstruktur aus einem Aluminium-Kohlefaser-Verbundmaterial gebaut werden, über die auch die Anbindung an das 2-phasige CO<sub>2</sub>-Kühlsystem erfolgt, das bei einer nominellen Temperatur von  $-30^\circ\text{C}$  betrieben werden soll.

Es wurde ein Aufbau entwickelt, in dem 2S-Modul-Prototypen thermisch mit einem zweiphasigen CO<sub>2</sub>-Kühlsystem bei  $-30^\circ\text{C}$  bei kontrollierter Umgebungstemperatur vermessen werden können. Die Messergebnisse werden mit Ergebnissen aus FE-Simulationen verglichen und die Resultate diskutiert.

T 25.5 Mo 18:00 F 234

**Hit position error estimation for the CBM Silicon Tracking System** — ●HANNA MALYGINA<sup>1,2,3</sup>, FRIESE VOLKER<sup>3</sup>, and MAKSYM ZYK<sup>3</sup> for the CBM-Collaboration — <sup>1</sup>Goethe Universität Frankfurt — <sup>2</sup>KINR, Kyiv, Ukraine — <sup>3</sup>GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

The Compressed Baryonic Matter experiment (CBM) at FAIR is a heavy-ion experiment that will investigate dense QCD matter by measuring nuclear collisions in the beam energy range 2–45 GeV/nucleon. Its main features are a high track-density environment at extreme interaction rates of up to 10 MHz. As the central detector component, the Silicon Tracking System (STS) is based on double-sided micro-strip sensors. Accurate detector modeling in simulations is crucial to assess the physics performance of the device and to arrive at a proper design choice.

The response of the silicon double-sided strip detector is included in the STS digitizer which simulates a complete chain of physical processes caused by charged particles traversing the detector, from charge creation in silicon to a digital output signal. Using the current implementation, one can test the influence of each physical processes on hit reconstruction separately. We have developed a new unbiased cluster position finding algorithm and a hit error estimation method for it. The estimated errors were verified using the hit pull and track  $\chi^2$  distributions.

Supported by HGS-HiRe.

T 25.6 Mo 18:15 F 234

**Progress with System Integration of the CBM Silicon Tracking Detector** — ●JOHANN M. HEUSER for the CBM-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

The Silicon Tracking System (STS) is the central detector for charged-particle track measurement and momentum determination in the CBM experiment. It comprises about 900 low-mass detector modules, based

on double-sided silicon micro-strip sensors. The read-out electronics is self-triggering and capable of acquiring data without event pile-up at beam-target collision rates up to 10 MHz. The STS modules are arranged on 106 carbon-fiber support ladders, which in turn are mounted onto 18 mechanical half-units to form 8 low-mass tracking stations. Cooling of the electronics is provided at the top and bottom periphery of the units to remove about 40 kW dissipated power total. The sensors will be operated at below  $-5^\circ\text{C}$  to limit leakage currents and radiation damage effects. The STS will be enclosed by thermally insulating walls and installed in the gap of a superconducting dipole magnet.

In the presentation, progress with the system integration of the STS detector will be discussed to meet the performance goals with respect to mechanical and operational precision as well as maintenance. The overview will include module and ladder assembly, cooling, mechanical prototyping of a unit, the powering concept, cabling within the STS box and connectivity towards the supply, control and acquisition systems.

T 25.7 Mo 18:30 F 234

**Bau und Test von Prototypen für den ATLAS-Streifendetektor** — SILKE ALTENHEINER, CLAUS GÖSSLING, REINER KLINGENBERG, KEVIN KRÖNINGER, ●JONAS LÖNKER, DANIELA RÖTTGES und FELIX WIZEMANN — TU Dortmund, Experimentelle Physik IV

Um die gesteigerten Anforderungen durch das Upgrade auf den HL-LHC erfüllen zu können, ist geplant, den Inneren Detektor des ATLAS-Experiments zu ersetzen. Der neue Spurdetektor, genannt Inner Tracker (ITk), soll in den äußeren Lagen aus Silizium-Streifenmodulen aufgebaut werden, die aus Sensor und PCB inkl. Auslesechips (ASICs) bestehen. Die einzelnen Komponenten werden durch Kleber mechanisch und per Wirebonds elektrisch miteinander verbunden.

Vorgestellt werden Maßnahmen und Ergebnisse der geplanten Qualitätssicherung während der Produktion hinsichtlich einheitlicher Klebedicken und elektrischen Eigenschaften in Dortmund.

T 25.8 Mo 18:45 F 234

**Testbeam Analyse von Prototyp-Streifenmodulen des ATLAS ITK** — ●MORITZ WIEHE, MARC HAUSER, RICCARDO MORI, ULRICH PARZEFALL, SUSANNE KÜHN, BRIAN MOSER und KARL JAKOBS — Albert-Ludwigs-Universität Freiburg

Der innere Spurdetektor des ATLAS-Experiments erfährt im Zuge des Ausbaus des LHC zum HL-LHC ein umfassendes Upgrade (ATLAS Phase II Upgrade). Zur Bestimmung der Leistungsfähigkeit der Siliziumstreifenmodule wurden im Juli 2016 bestrahlte und unbestrahlte Prototypen im Testbeam am CERN untersucht. Die getesteten Prototypen bestehen aus Miniatur- und Full-Size-Sensoren, sowie realistischen Hybriden und ASICs, wie sie für die spätere Verwendung im ATLAS-Experiment geplant sind. Ergebnisse der Analyse der rekonstruierten Daten werden hier präsentiert. Unser Ziele waren es die Sensorperformance in Abhängigkeit der Spurposition, mit besonderem Blick auf Effizienz, Auflösung und 'Charge Sharing', zu bestimmen, sowie die Funktionalität der Ausleseelektronik zu prüfen.

## T 26: Pixeldetektoren 1

Zeit: Montag 16:45–19:00

Raum: S 2

T 26.1 Mo 16:45 S 2

**A combined MIMOSA26 and ATLAS FE-I4 test beam telescope with parallel triggerless readout** — ●MICHAEL DAAS, TOMASZ HEMPEREK, TOKO HIRONO, FABIAN HÜGGING, HANS KRÜGER, DAVID-LEON POHL, PASCAL WOLF, and NORBERT WERMES — Physikalisches Institut der Universität Bonn

Beam telescopes, such as the EUDET/AIDA telescope, are a commonly used tool for testing and characterization of pixel detector prototypes. Based on the MIMOSA26 telescope planes and an ATLAS FE-I4 reference plane, a fast, high resolution test beam telescope with continuous triggerless readout was derived. For the integration of this telescope into the Python-based data acquisition framework pyBAR, a new readout system was developed. It features a continuous, triggerless readout of the MIMOSA26 planes and precise event time-stamping from the FE-I4 as well as real-time data quality assessment. This new readout system was successfully tested and operated at the Bonn Electron Stretcher and Accelerator facility (ELSA) using a custom-made

readout board. As the analysis of the test run suggests, the readout can cope with particle rates up to 20 kHz, while allowing track reconstruction with efficiencies of more than 99%.

T 26.2 Mo 17:00 S 2

**Measurements at the new external beam line at ELSA with a Mimosas telescope** — ●YANNICK DIETER, TOMASZ HEMPEREK, TOKO HIRONO, FABIAN HÜGGING, JENS JANSSEN, HANS KRÜGER, DAVID-LEON POHL, NORBERT WERMES, and JOCHEN DINGFELDER — Physikalisches Institut der Universität Bonn

A new beam line was constructed at the electron accelerator ELSA (Elektronen-Stretcher-Anlage) in Bonn to provide a test area for detector tests. The accelerator delivers an electron beam of a variable energy of maximum 3.2 GeV with an available current of 100 pA which corresponds to a rate of about 600 MHz. The extraction can be steered with a feedback scintillator to achieve a constant beam rate. To test new detectors the ANEMONE (A Nice Eudet Mimosas Bonn Telescope) beam

telescope which was developed by the EUDET project is installed. It consists of six Mimosa26 sensors and one ATLAS FE-I4 module. Besides a high-precision beam tracking, the telescope allows for a high-rate time stamping. In this talk, a setup to take test beam data with the telescope and the analysis of the recorded test beam data are presented, with a focus on beam characteristics like rate stability, beam size and divergence will be presented.

T 26.3 Mo 17:15 S 2

**ATLAS Pixel Teststrahlkampagnen** — •TOBIAS BISANZ, JÖRN GROSSE-KNETTER, ARNULF QUADT und JENS WEINGARTEN — II. Physikalisches Institut, Georg-August-Universität Göttingen

Für das Upgrade zum High-Luminosity-LHC wird unter anderem der ATLAS Detektor überarbeitet. Die erhöhte Luminosität erfordert sowohl strahlenhärtere Komponenten, als auch eine neue Auslese, um mit den höheren Okkupanzen umzugehen, zumindest in den innersten Lagen. Durch die Nähe zum Wechselwirkungspunkt sind diese Anforderungen besonders für den Pixeldetektor eine Herausforderung. Um Pixelmodule und -sensoren für das Upgrade zu charakterisieren und zu testen, werden neben Labormessungen auch Teststrahlstudien durchgeführt.

Der Vortrag beschäftigt sich mit der Rekonstruktion und Analyse dieser Teststrahlmessungen. Es wird auf die Teststrahlrekonstruktion mittels EU Telescope eingegangen. Dabei werden vor allem auch Neuentwicklungen, wie beispielsweise die Rekonstruktion im Magnetfeld, vorgestellt. Desweiteren werden auch Neuerungen des ATLAS-Pixel Testbeam-DAQ-Frameworks, basierend auf USBPix und STcontrol, gezeigt. Konkret geht es um die Integration des USBPix 3.0 Auslesesystems in das DAQ-System des verwendeten Strahlteleskops.

T 26.4 Mo 17:30 S 2

**Bestimmung der Detektionseffizienz und abgeleiteter Eigenschaften von Makropixelsensoren für das CMS-Tracker Phase II Upgrade** — ALEXANDER DIERLAMM, THOMAS MÜLLER, DANIEL SCHELL und •GREGOR VOLLMER — Institut für Experimentelle Kernphysik (IEKP), KIT

Der Betrieb des CMS-Detektors nach dem High-Luminosity Upgrade des Large Hadron Colliders (HL-LHC) setzt neue Entwicklungen in der verwendeten Detektortechnologie voraus. Durch die mehr als doppelt so hohe instantane Luminosität fällt eine entsprechend höhere Menge an Daten an, die vom Detektor erfasst, reduziert und für die spätere Analyse gespeichert werden muss. Ein Ansatz um die Datenmenge zu reduzieren, ist die Entwicklung von neuen Modulen für den CMS-Spurdetektor, die zwischen Teilchen mit hohem und niedrigen Transversalimpuls unterscheiden können. Diese Information ermöglicht es, schon auf Level-1-Trigger-Niveau interessante Ereignisse vorzuselektieren. Verschiedene Gruppen der CMS-Kollaboration befassen sich gemeinsam mit der Entwicklung des „Macro Pixel Subassemblies“ (MaPSA), das zusammen mit einem Streifensensor als kombiniertes Pixel- und Streifen-Modul (PS-Modul) im CMS-Spurdetektor eingesetzt werden soll. Dafür werden unter anderem in Karlsruhe verschiedene Geometrien des PS-P Sensors entwickelt und untersucht.

In diesem Vortrag werden die Ergebnisse einer Strahlteststudie eines möglichen Makropixel-Prototypen vorgestellt und Einblicke in die verwendeten Analysemethoden gegeben.

T 26.5 Mo 17:45 S 2

**Test beam results for neutron and proton irradiated MuPix7 prototypes** — •LENNART HUTH — Physikalisches Institut, Universität Heidelberg

The MuPix7 prototype is a high voltage monolithic active pixel sensor (HV-MAPS), which is developed for the Mu3e experiment. The MuPix7 features a fully integrated data driven readout, as well as on chip timestamps and an on chip transmitter sending a serial 1.25 GBit/s data stream to the readout FPGA.

To study effects of radiation damage, samples were irradiated with protons (PS) up to a dose of  $7.8 \cdot 10^{15}$  protons/cm<sup>2</sup> and neutrons (Ljubljana) up to  $5 \cdot 10^{15}$  neutrons/cm<sup>2</sup>. The irradiated sensors were characterized at three test beams at PSI and DESY using the MuPix Telescope.

This presentation will discuss the cooling setup and cover the working principle of the MuPix7. Test beam results of the irradiated MuPix7 performance in terms of efficiency, noise, time resolution and crosstalk are presented.

T 26.6 Mo 18:00 S 2

**Charakterisierung von DEPFET-Pixelmodulen in der Inte-**

**grationskampagne des Belle-II Vertexdetektors im DESY-Teststrahl** — JOCHEN DINGFELDER, LEONARD GERMIC, TOMASZ HEMPEREK, HANS KRÜGER, BARBARA LEIBROCK, FLORIAN LÜTTICKE, CARLOS MARINAS, •BOTHO PASCHEN und NORBERT WERMES für die Belle II-Kollaboration — Universität Bonn

Die derzeit stattfindende Aufrüstung der B-Fabrik am KEK in Japan wird die Luminosität für die Datennahme mit dem Belle II-Experiment um einen Faktor 40 auf  $8 \cdot 10^{35} \text{ cm}^{-2}\text{s}^{-1}$  erhöhen. Aufgrund der erwarteten höheren Datenrate ist ein Neudesign des Vertexdetektors notwendig. Zusätzlich zu einem vierlagigen Streifendetektor werden zwei Lagen eines neuen Silizium-Pixeldetektors als dem Interaktionspunkt am nächsten liegende Detektorkomponente eingebaut werden.

Die Pixeldetektormodule bestehen aus monolithischen Siliziumstrukturen mit integriertem Sensor, der auf  $75 \mu\text{m}$  gedünnt ist, und stabilen Randbereichen, die mit speziell entwickelten anwendungsspezifischen integrierten Schaltungen (ASICs) zur Steuerung und Signalauslese bestückt sind. Die Sensoren sind Matrizen aus p-Kanal Feldeffekttransistoren mit vollständig verarmtem Siliziumbulk (DEPFET) mit Pixelgrößen von  $(50-85) \times 50 \mu\text{m}^2$ .

Im Teststrahl des Deutschen Elektronen Synchrotron (DESY) hat eine Integrationskampagne mit Pixel- und Streifenmodulen des Vertexdetektors sowie der gesamten Ausleseketten des finalen Experiments stattgefunden. Die Ergebnisse von Messungen der Eigenschaften der Pixelmodule während dieser Kampagne werden vorgestellt.

T 26.7 Mo 18:15 S 2

**Study of the ALICE Investigator chip in view of the requirements at CLIC** — •MAGDALENA MUNKER — CERN — University of Bonn

CLIC is an option for a future linear  $e^+e^-$  collider at CERN in the post-LHC era. The CLIC machine is designed to reach centre-of-mass energies ranging from a few hundred GeV up to 3 TeV. The staging scenario is optimised to explore different physics processes. To achieve high precision measurements, e.g. of the Higgs-width, challenging requirements are imposed on the CLIC detector. A single point tracking resolution of  $7 \mu\text{m}$  and a material budget of  $1-2\%X_0$  per layer are required for the tracker. Moreover, to suppress background hits from beam-beam interactions, a fast time slicing of 10 ns is needed. To address these requirements, a large area silicon tracker is foreseen for the detector at CLIC. In this context, integrated technologies are promising candidates to achieve large scale production and low material budget. The Investigator chip, an integrated HR-CMOS test-chip developed for the ALICE ITS upgrade, has been investigated in various test-beam campaigns in view of the requirements at CLIC. This talk presents results on spacial and timing resolutions, as well as efficiency measurements.

T 26.8 Mo 18:30 S 2

**Measurement of the Lorentz angle in CMS pixel detector modules** — •PAUL SCHÜTZE and DANIEL PITZL — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

For the upgrade of the CMS experiment, the previous pixel detector was replaced by a new, four layer pixel detector during the extended 2016/17 shutdown. By using a new readout chip the detector will be able to operate at instantaneous luminosities of up to  $2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  without significant efficiency losses.

In the pixel detector barrel the 3.8 T magnetic field of the CMS solenoid will, due to deflection of the drifting charge carriers in the  $285 \mu\text{m}$  thick silicon sensor, cause charge sharing along the short side of the  $150 \mu\text{m} \times 100 \mu\text{m}$  pixel cells and thus improve the intrinsic resolution of the detector modules. The Lorentz angle in the CMS barrel pixel detector modules was measured at the DESY Test Beam Facility using a 1.3 T magnetic field. Furthermore, simulations of the setup based on the AllPix framework and the pixelav package were performed.

In this contribution the experimental setup is presented, measurement and simulation results are shown and compared.

T 26.9 Mo 18:45 S 2

**Planare  $n^+$ -in- $n$  Quadmodule für das ITK-Upgrade des ATLAS-Experiments** — SILKE ALTENHEINER<sup>1</sup>, KAROLA DETTE<sup>1,2</sup>, SASCHA DUNGS<sup>1</sup>, •ANDREAS GISEN<sup>1</sup>, CLAUD GÖSSLING<sup>1</sup>, MARIUS GROTHE<sup>1</sup>, REINER KLINGENBERG<sup>1</sup>, KEVIN KRÖNINGER<sup>1</sup>, RAPHAEL MICHALLEK<sup>1</sup> und MAREIKE WEERS<sup>1</sup> — <sup>1</sup>TU Dortmund, Experimentelle Physik IV — <sup>2</sup>CERN

Der innerste Spurdetektor des ATLAS-Experiments besteht aus plana-

ren  $n^+$ -in- $n$ -Silizium-Pixelsensoren. Um den Anforderungen des High Luminosity LHC (HL-LHC) gerecht werden zu können, wird es nötig sein, den aktuellen Tracker zu ersetzen. Deswegen wird aktuell ein neuer Spurdetektor geplant, der sogenannte Inner Tracker (ITk). In dessen Pixeldetektor sind Vierchip- bzw. Quadmodule vorgesehen. Diese bestehen aus einem Siliziumsensor, der zusammen mit vier Auslesechips eine Einheit bildet.

Erste Prototypen planarer  $n^+$ -in- $n$  Quadmodule wurden nun im Labor und im Testbeam charakterisiert. Dabei wurde der Schwerpunkt auf die Regionen zwischen den Auslesechips gelegt, besonders auf den zentralen Bereich zwischen den vier Auslesechips. Dort befinden sich spezielle Pixelzellen auf dem Sensor, die die Lücke zwischen den Auslesechips berücksichtigen.

## T 27: Hauptvorträge 2

Zeit: Dienstag 8:30–10:30

Raum: H 1

**Hauptvortrag** T 27.1 Di 8:30 H 1  
**Zukünftige Beschleuniger für die Teilchenphysik und Ihre Herausforderungen** — ●OLIVER BRÜENING — CERN, CH-1211, Geneva 23, Switzerland

Der Vortrag gibt einen Überblick über potentielle und geplante zukünftige Beschleuniger Projekte und beschreibt deren technischen, kulturellen und politischen Herausforderungen.

**Hauptvortrag** T 27.2 Di 9:10 H 1  
**Ungelöste Rätsel und bisher keine Neue Physik in Sicht. - Was lernen wir vom Higgsboson?** — ●MILADA MARGARETE MÜHLEITNER — Karlsruher Institut für Technologie (KIT)

Mit der Entdeckung des Higgsbosons im Jahr 2012 ist das Standardmodell (SM) formal komplett. Das SM wurde in den bisherigen Experimenten mit höchster Präzision getestet, und auch das Higgsboson verhält sich sehr SM-artig. Dennoch gibt es Fragen, die im Rahmen des SMs nicht beantwortet werden können, und die nahelegen, dass das SM die Niederenergie-Näherung einer viel fundamentaleren Theorie ist. Eines der Hauptziele des Large Hadron Colliders (LHC) ist daher die Suche nach Physik jenseits des SMs. Entgegen den ursprünglichen Erwartungen wurden bisher keinen direkten Hinweise auf Neue Physik gefunden. In dieser Situation gewinnt der Higgssektor eine immer größere Bedeutung. Das Higgsboson, das früher Ziel der experimentellen Suchen war, wird nun selbst ein Instrument auf der Suche nach Neuer Physik. Was aber können wir vom Higgsboson lernen? Welche Hinweise auf die Struktur der zugrunde liegenden Theorie kann es uns

geben? Welche ungelösten Rätsel lassen sich damit beantworten? Und schließlich, was sind die Herausforderungen sowohl an das Experiment als auch die Theorie, um das Higgsboson für die Suche nach Neuer Physik bestmöglich nutzen zu können?

**Hauptvortrag** T 27.3 Di 9:50 H 1  
**Kosmische Strahlen vom Knie zum Knöchel - Erkenntnisse und offene Fragen** — ●ANDREAS HAUNGS — KIT - Karlsruher Institut für Technologie, Deutschland

Kosmische Teilchen mit Energien oberhalb von 1 PeV müssen über ausgedehnte Luftschauer nachgewiesen werden. Während die höchsten Energien extragalaktischen Ursprungs sind, wird im Energiebereich zwischen den beiden signifikanten Strukturen im Spektrum der kosmischen Strahlung, dem Knie bei 2-3 PeV und dem Knöchel bei wenigen EeV, ein Übergang von galaktischem zu extragalaktischem Ursprung erwartet. Trotz großer experimenteller Fortschritte in den letzten 2 Dekaden durch Experimente wie KASCADE-Grande, IceCube/IceTop oder Tunka-133 ist die Astrophysik dieses Übergangs noch nicht geklärt. Dies liegt auch an der Unsicherheit der Interpretation der ausgedehnten Luftschauer, die im Wesentlichen auf den Vorhersagen von hadronischen Wechselwirkungsmodellen basieren. Es zeigt sich, dass diese Modelle trotz LHC immer noch nicht vollständig die gemessenen Daten reproduzieren können, insbesondere bei Kern-Kern-Wechselwirkungen und in der Kinematik der extremen Vorwärtsrichtung. Der Vortrag fasst den momentanen Stand, die offenen Fragen und die Zukunfts-Aktivitäten in diesem Forschungsfeld zusammen.

## T 28: Higgs-Boson 3 (assoziierte Produktion)

Zeit: Dienstag 11:00–12:15

Raum: JUR 3

T 28.1 Di 11:00 JUR 3  
**Search in the Associated Higgs Boson Top-Quark Production Channel  $t\bar{t}H \rightarrow 2\ell + 1\tau_{\text{had}}$  at  $\sqrt{s} = 13$  TeV with ATLAS** — ●ANDRE SOPCZAK<sup>1</sup>, BABAR ALI<sup>1</sup>, MARINE KUNA<sup>2</sup>, and SIMONETTA GENTILE<sup>2</sup> — <sup>1</sup>IEAP CTU in Prague — <sup>2</sup>Universita di Roma, La Sapienza, INFN

After the discovery of a Higgs boson, the measurements of its properties are at the forefront of research. The determination of the associated production of a Higgs boson and a pair of top quarks is of particular importance as the  $t\bar{t}H$  Yukawa coupling is large, and thus a probe for physics beyond the Standard Model.

The  $t\bar{t}H$  production was analysed in the final state with two same-sign light leptons (electrons or muons) and a hadronically decaying tau lepton:  $t\bar{t}H \rightarrow 2\ell + 1\tau_{\text{had}}$ . The analysis was based on data taken by the ATLAS experiment recorded from 13 TeV proton-proton collisions. It contributed to the combined ATLAS results of four multi-lepton final state analyses. These results were further combined with other ATLAS  $t\bar{t}H$  analyses where  $H \rightarrow \gamma\gamma$  and  $H \rightarrow b\bar{b}$ . The combined results are consistent with the Standard Model (SM) expectation allowing models beyond the SM to be constrained.

T 28.2 Di 11:15 JUR 3  
**Optimization studies for the search of Higgs bosons in association with a top-antitop quark pair with the ATLAS experiment in Run 2** — MARIA MORENO LLACER, ARNULF QUADT, ELIZAVETA SHABALINA, and ●GAOYUAN WANG — II. Physikalisches Institut, Georg-August-Universität Göttingen

The measurement of the production of the Higgs boson in association with a  $t\bar{t}$  pair ( $t\bar{t}H$ ) where the Higgs boson decays into a  $b\bar{b}$  pair

( $H \rightarrow b\bar{b}$ ) is very interesting because it is the only possible simultaneous measurement of the Yukawa coupling of the Higgs boson to top and bottom quarks. This is the channel with the strongest coupling between the Higgs boson and quarks. The major background of our study is the production of  $t\bar{t}$  along with a  $b\bar{b}$  quark pair. The goal is to observe the  $t\bar{t}H$  channel out of all the backgrounds using data collected by the ATLAS detector during the LHC Run 2.

One can optimize the analysis already presented using a partial dataset by tightening the jet momenta threshold for the hardest ones and loosening the threshold for the softer ones in order to reject as much background as possible and keep the soft jets coming from the  $W$  decay, which are useful for the final state reconstruction. An optimized neural network to discriminate the backgrounds from the signal in this optimized configuration can also be exploited.

T 28.3 Di 11:30 JUR 3  
**Spin-korrelierte Variablen in der Suche nach dem Higgs-Boson in assoziierter Produktion mit einem Top-Quark-Antiquark-Paar am CMS-Experiment** — ●MICHAEL WASSMER, KARIM EL MORABIT, MARCO A. HARRENDORF, ULRICH HUSEMANN, HANNES MILDNER, ANDREJ SAIBEL, MATTHIAS SCHRÖDER, FELIX RIESE und SHAWN WILLIAMSON — Institut für Experimentelle Kernphysik (IEKP), KIT

Die assoziierte Produktion eines Higgs-Bosons mit einem Top-Quark-Antiquark-Paar ( $t\bar{t}$ ) bietet die Möglichkeit, die Top-Higgs-Yukawa-Kopplung direkt zu messen. Im Kanal mit dem Zerfall  $H \rightarrow b\bar{b}$  und einem semileptonischem  $t\bar{t}$ -Zerfall muss der dominante Untergrund  $t\bar{t} + \text{jets}$ , besonders jedoch dessen irreduzibler  $t\bar{t}b\bar{b}$  Anteil, vom Signalprozess unterschieden werden. Variablen, welche die Spinkorrela-

tionen des  $t\bar{t}$ -Systems ausnutzen, wurden mit dem Ziel der verbesserten Trennung von Signal und Untergrund untersucht. Ausgenutzt wird dabei der Einfluss des Higgs-Bosons auf die Helizitätszusammensetzung der Top-Quarks. In diesem Vortrag werden Winkelvariablen der Zerfallsprodukte des  $t\bar{t}$ -Systems in verschiedenen Bezugssystemen gezeigt. Eingegangen wird hierbei auf deren gute Modellierung sowie den Einfluss auf das Analyseergebnis.

T 28.4 Di 11:45 JUR 3

**Boosted-Kategorie in der Suche nach dem Higgs-Boson in assoziierter Produktion mit einem Top-Quark-Antiquark-Paar am CMS-Experiment** — ●FELIX RIESE, KARIM EL MORABIT, MARCO A. HARRENDORF, ULRICH HUSEMANN, HANNES MILDNER, ANDREJ SAIBEL, MATTHIAS SCHRÖDER, MICHAEL WASSMER und SHAWN WILLIAMSON — Institut für Experimentelle Kernphysik (IEKP), KIT

Die assoziierte Produktion eines Higgs-Bosons mit einem Top-Quark-Antiquark-Paar ( $t\bar{t}$ ) bietet die Möglichkeit, die Top-Higgs-Yukawa-Kopplung direkt zu messen. Ein aufgrund seines vergleichsweise hohen Verweignungsverhältnisses vielversprechender Kanal ist dabei der Endzustand, in dem das  $t\bar{t}$ -Paar semileptonisch und das Higgs-Boson in ein B-Quark-Antiquark-Paar zerfällt. Allerdings enthalten Ereignisse dieses Prozesses viele Jets und die Zuordnung dieser Jets zu den zugrunde liegenden Zerfallsteilchen ist ein aufwändiges kombinatorisches Problem.

Dieses Problem lässt sich weitgehend lösen in Ereignissen, in de-

nen das Higgs-Boson und das hadronisch zerfallende Top-Quark hohe Transversalimpulse haben ("boosted regime"). Dies führt dazu, dass mehrere Jets eines Zerfallsteilchens in große Jets kollimiert werden, die sich mit speziellen Algorithmen identifizieren lassen.

In diesem Vortrag werden aktuelle Methoden in der Boosted-Kategorie und der Einfluss auf das Analyseergebnis vorgestellt.

T 28.5 Di 12:00 JUR 3

**Ereignis-Rekonstruktion und -Klassifikation bei der Suche nach der assoziierten Produktion von Higgs-Bosonen mit Einzel-Top-Quarks mit dem CMS-Experiment** — THORSTEN CHWALEK, NILS FALTERMANN, KEVIN FLÖH, ANDREAS MEYER, DENISE MÜLLER, THOMAS MÜLLER, ●JOHANN RAUSER, FRANK ROSCHER, MATTHIAS SCHNEPP und DAVID SEITH — Institut für Experimentelle Kernphysik (IEKP), KIT

Die Kopplungen von Fermionen und Vektor-Bosonen an das Higgs-Boson sind wichtige Test-Größen für die Konsistenz des Standardmodells. Ein vom Standardmodell abweichendes Verhalten dieser Kopplungen würde den Wirkungsquerschnitt der assoziierten Produktion von Higgs-Bosonen und Einzel-Top-Quarks signifikant verändern.

Einer der Kernaspekte bei der Analyse solcher Prozesse ist die Unterscheidung zwischen Signal- und Untergrund-Prozessen. In diesem Vortrag wird die Rekonstruktion von Ereignissen unter verschiedenen Hypothesen vorgestellt, sowie die anschließende Klassifikation unter Verwendung multivariater Analyse-Methoden.

## T 29: Top Quark 2 (Zerfälle)

Zeit: Dienstag 11:00–12:30

Raum: JUR 4

T 29.1 Di 11:00 JUR 4

**Direkte Messung der Zerfallsbreite des Top-Quarks im  $t\bar{t}$  Lepton+Jets-Kanal bei  $\sqrt{s} = 8$  TeV mit dem ATLAS-Detektor** — BORIS LEMMER, ARNULF QUADT und ●PHILIPP STOLTE-CORD TO KRAX — II. Physikalisches Institut, Georg-August-Universität Göttingen

Eine Größe des Top-Quarks, die zuvor noch nicht bei ATLAS als einem der beiden Vielzweckdetektoren am LHC direkt gemessen wurde, ist die Zerfallsbreite des Top-Quarks. Obschon in vielen Messungen entsprechend der Standardmodell (SM)-Erwartung als Input verwendet, steht eine experimentelle Verifikation dieser Größe noch aus. Eine derartige direkte Analyse ist den bislang vorwiegend realisierten indirekten vorzuziehen, da sie modellunabhängiger ist - auf weniger Annahmen aus dem SM beruhend - und da sie entsprechend eine große Vielzahl von Modellen zur Physik außerhalb jenes Modells besser zu testen vermag.

In diesem Vortrag wird der Status einer direkten Messung der Zerfallsbreite des schwersten aller Quarks mit dem ATLAS-Detektor im Lepton+Jets-Kanal vorgestellt, basierend auf Daten, die bei einer Schwerpunktsenergie von  $\sqrt{s} = 8$  TeV in 2012 aufgenommen wurden.

Zentrale Schwerpunkte werden dabei auf Studien zur verwendeten Fit-Methode, mit welcher die Breite aus den Messdaten extrahiert werden wird, und die Evaluierung sowie Reduzierung von systematischen Unsicherheiten gelegt. Diesbezüglich wurden zahlreiche Tests zu möglichen Schnitten, zu verschiedenen infrage kommenden Observablen, zur Dimension des Fits und auch zur Validierung desselben durchgeführt.

T 29.2 Di 11:15 JUR 4

**Methoden zur jetladungsgestützten Boosted-Top-Rekonstruktion** — ●NICOLAS LANG und PETER MÄTTIG — Bergische Universität Wuppertal, Wuppertal, Deutschland

Die Rekonstruktion hadronischer Top-Quark-Zerfälle bei hohen Transversalimpulsen stellt eine besondere Herausforderung dar, da die Jets der Zerfallskomponenten häufig zu sogenannten Large-R-Jets kollimiert sind. Übliche Verfahren zur Rekonstruktion verwenden meist Jetmassen und Kalorimeterjeteigenschaften. In diesem Vortrag wird ein komplementärer Ansatz vorgestellt, der sich die Ladungsverteilung der Large-R-Jets zunutze macht. Es wird untersucht, wie mithilfe assoziierter Tracks und Trackjets die Identifizierung von Top-Quarks verbessert werden kann.

T 29.3 Di 11:30 JUR 4

**Studies of top tagging in CMS** — ●TORBEN DREYER, JOHANNES

HALLER, ROMAN KOGLER, ALEXANDER SCHMIDT, and SVENJA SCHUMANN — Institut für Experimentalphysik, Universität Hamburg

High Lorentz boosts pose a challenge to the reconstruction of hadronically decaying top quarks ( $t \rightarrow bW \rightarrow bqq'$ ) as the decay products of the top quark are collimated and a reconstruction in three separate jets is no longer possible. Instead, the decay products merge and are reconstructed in one large jet. Top tagging uses the substructure of large jets to identify these jets. An efficient identification of top quark jets increases the sensitivity in searches for heavy new particles and opens the high momentum phase space for standard model measurements of the top quark.

This contribution includes studies of top-tagging algorithms with the CMS detector at 13 TeV. The performance of established algorithms and new approaches is studied in simulation and data. Scale factors are derived to correct for potential differences in the efficiencies and misidentification rates between data and simulation.

T 29.4 Di 11:45 JUR 4

**Measurement of the jet mass distribution in boosted top quark decays** — ●DENNIS SCHWARZ, JOHANNES HALLER, and ROMAN KOGLER — Institut für Experimentalphysik, Universität Hamburg

The production of top quarks with very high transverse momenta results in collimated decays, where all decay products merge into a single jet. The distribution of the jet mass is important for jet substructure applications (top tagging) and shows sensitivity to the top quark mass. Studies for a measurement of the jet mass distribution unfolded to the particle level are presented, using data recorded by the CMS detector at a centre of mass energy of 13 TeV. The measurement is performed in the lepton+jets channel, which offers a good suppression of non- $t\bar{t}$  backgrounds while retaining a high selection efficiency.

The choice of a suitable jet algorithm is essential to reduce pile up effects but ensure that all decay products are merged into a single jet. Performance studies using different jet algorithms, especially the XCone jet algorithm, are presented.

T 29.5 Di 12:00 JUR 4

**Search for charged lepton flavour violation in top quark decays** — NELLO BRUSCINO, JULIEN CAUDRON, MARKUS CRISTINZIANI, MAZUZA GHNEIMAT, ●CARLO ALBERTO GOTTARDO, SEBASTIAN HEER, VADIM KOSTYUKHIN, ANDREA SCIANDRA, and KAVEN YAU WONG — Physikalisches Institut, Universität Bonn

Lepton flavour violation is not allowed by the Standard Model (SM), yet it has been observed in neutrinos. The physics responsible for

neutrino oscillations and masses is still unknown and it may allow charged lepton flavour violation (CLFV). Evidence for CLFV processes, strongly suppressed according to the SM, would shed light on the nature of New Physics.

Studies towards a search for CLFV will be presented using 13 TeV data collected in 2015 and 2016 by the ATLAS detector.

The analysis investigates the decay of a top quark into a pair of opposite-sign different-flavour leptons and a light quark. The search, never performed before in this channel, benefits from the clear signature and the large top quark pair production cross section in proton-proton collision at the Large Hadron Collider. The theoretical description is given in the framework of an effective field theory, allowing for a model-independent search.

T 29.6 Di 12:15 JUR 4

**Kalibration des ATLAS B-Taggers mittels  $t\bar{t}$  Ereignissen im dileptonischen Kanal** — ●JANNIK GEISEN, MARÍA MORENO LLÁCER, ARNULF QUADT und ELIZAVETA SHABALINA — II. Physikalisches Institut, Georg-August-Universität Göttingen

Das zuverlässige Identifizieren von Bottom-Quarks ist essenziell für die HEP-Experimente am LHC, denn diese Quarks spielen beim Zerfall sowohl von Top-Quarks, als auch von Higgs-Bosonen und somit bei vielen aktuellen Analysen der LHC-Experimente eine signifikante Rolle. Insbesondere die Produktion eines Higgs-Bosons in Assoziation mit der Top-Antitop-Paarproduktion, bei der das Higgs-Boson in ein Bottom-Antibottom-Paar zerfällt, weist vier Bottom-Jets im Endzustand auf und ist eine der großen Herausforderungen des LHC-Physikprogramms in Run II.

Die Identifikation in ATLAS geschieht mithilfe von multivariaten Analyse-Programmen, die mit Informationen aus dem inneren Detektor gespeist werden, weshalb die Aufrüstung des ATLAS-Detektors im Run II des LHC die Identifikation deutlich verbessert.

Vorgestellt werden die Kalibrationsmethode des ATLAS B-Taggers, Ergebnisse der Kalibration im dileptonischen  $t\bar{t}$  Zerfallskanal mit aktuellen Monte-Carlo-Simulationen und mit den vom ATLAS-Experiment gesammelten Datensätzen des Run II, sowie Studien zum Einfluss der Selektion von Bottom-Jets mit hohem Transversalimpuls auf die Kalibration.

## T 30: Elektroschwache Wechselwirkung 2

Zeit: Dienstag 11:00–12:30

Raum: JUR 372

T 30.1 Di 11:00 JUR 372

**Messung des CKM-Winkels  $\gamma$  im Zerfall  $B_s^0 \rightarrow D_s^+ K^- \pi^+ \pi^-$  mit dem LHCb Experiment** — ●MATTHIEU KECKE für die LHCb-Kollaboration — Physikalisches Institut Heidelberg

Mit der präzisen Bestimmung der CKM-Phasen lassen sich die Vorhersagen der schwachen Wechselwirkung im Standardmodell der Teilchenphysik überprüfen. Insbesondere erlaubt die genaue Vermessung des Unitaritätsdreiecks die Suche nach möglichen Effekten neuer Physik. Der CKM-Winkel  $\gamma$  ist dabei die bis heute am ungenauesten bestimmte Größe des Unitaritätsdreiecks.

Für die vorgestellte Messung von  $\gamma$  wird ein Maximum-Likelihood-Fit an die Lebensdauerverteilung von  $B_s^0$  Signal-Kandidaten durchgeführt. Der in der Lebensdauerverteilung auftretende Akzeptanzeffekt, welcher durch die Geometrie des LHCb Detektors und den Prozess der Ereignisrekonstruktion hervorgerufen wird, wird untersucht und korrigiert. Die zeitliche Auflösung des Detektors wird mithilfe prompter  $D_s^+$  Kandidaten bestimmt und im Fit berücksichtigt. In der Analyse werden Daten benutzt, welche in den ersten beiden Läufen des LHC bei Schwerpunktsenergien von  $\sqrt{s} = 7, 8$  und  $13 \text{ TeV}$  gesammelt worden sind.

T 30.2 Di 11:15 JUR 372

**Die Suche nach den seltenen Zerfällen  $B_{(s)}^0 \rightarrow \mu^+ \mu^- \mu^+ \mu^-$  mit Daten des LHCb-Experimentes** — ●TOBIAS TEKAMPE und JOHANNES ALBRECHT — TU Dortmund

Seltene Zerfälle von  $B$ -Mesonen bieten eine vielversprechende Möglichkeit für die Suche nach Physik jenseits des Standardmodells (SM). Das für den Zerfall  $B_{(s)}^0 \rightarrow \mu^+ \mu^- \mu^+ \mu^-$  vom SM vorhergesagte Verzweungsverhältnis ist von der Ordnung  $10^{-11}$ . In Erweiterungen des SM, in denen der Zerfall über neue skalare und pseudoskalare Teilchen stattfinden kann, ist dieses Verzweungsverhältnis stark erhöht. Das LHCb-Experiment hat den weltgrößten Datensatz an  $B$ -Mesonzerfällen aufgezeichnet, mit dem die präzise Messung dieser seltenen Zerfälle möglich ist. In diesem Vortrag wird die kürzlich veröffentlichte Messung des Verzweungsverhältnisses des Zerfalls  $B_{(s)}^0 \rightarrow \mu^+ \mu^- \mu^+ \mu^-$  auf einem mit dem LHCb-Detektor aufgezeichneten Datensatz entsprechend einer integrierten Luminosität von  $3 \text{ fb}^{-1}$  vorgestellt.

T 30.3 Di 11:30 JUR 372

**Search for rare  $B \rightarrow (\pi^0, \eta, \eta') l^+ l^-$  decays at Belle** — ●MARYAM SALEHI<sup>1</sup>, THOMAS KUHR<sup>2</sup>, and MARTIN RITTER<sup>2</sup> — <sup>1</sup>University of Malaya — <sup>2</sup>Ludwig Maximilians Universitaet

In the Standard Model (SM), the decay  $B \rightarrow (\pi^0, \eta, \eta') l^+ l^-$  proceeds through the flavor changing neutral current (FCNC)  $b \rightarrow dl^+ l^-$ . These decays are forbidden at tree level and can only occur in higher orders. Therefore the predicted branching fractions in the SM are of the order of  $10^{-8}$ . The  $b \rightarrow dl^+ l^-$  and  $b \rightarrow sl^+ l^-$  transitions provide a promising avenue to search for New Physics (NP). Amplitudes from these NP contributions can interfere with those from the SM, and significantly enhance the branching fractions from the SM predictions.

We will present a search for rare neutral current decays  $B \rightarrow (\pi^0, \eta, \eta') l^+ l^-$ , ( $l = e, \mu$ ), using a sample of  $772 \times 10^6 \text{ } B\bar{B}$  pairs collected with the Belle detector at the  $e^+e^-$  asymmetric collider KEKB.

T 30.4 Di 11:45 JUR 372

**Measurement of Tau Polarization in Z Boson Decays at ATLAS** — ●BENEDICT WINTER, WILLIAM DAVEY, and JOCHEN DINGFELDER — Physikalisches Institut, Universität Bonn

Decays of the Z boson in the Standard Model violate parity, leading to a net polarization of the decay products. Z boson decays to pairs of tau leptons provide a unique opportunity to measure the tau polarization by using the kinematics of the subsequent tau decays, hence testing the Standard Model predictions. They also provide a unique opportunity to pioneer experimental techniques that assess the tau helicity and may be used in searches for new particles and to study the Higgs boson.

In this talk the status of a measurement of the tau polarization in  $Z \rightarrow \tau\tau$  decays is presented. The analysis is based on the  $20.3 \text{ fb}^{-1}$  collected at a center of mass energy of  $\sqrt{s} = 8 \text{ TeV}$  by the ATLAS experiment. The tau polarization is measured in events in which one tau decays leptonically and the other decays hadronically by using the kinematics of the hadronic decay.

T 30.5 Di 12:00 JUR 372

**Polarization Measurement at the International Linear Collider (ILC)** — ●ROBERT KARL<sup>1,2</sup> and JENNY LIST<sup>1</sup> — <sup>1</sup>DESY Hamburg — <sup>2</sup>University of Hamburg

The ILC is a planned electron-positron collider with center-of-mass energies of up to 500 GeV, upgradeable to 1 TeV. Thereby, the electron beam will be polarized to 80% and the positron beam up to 60%. This allows a very precise measurement of the standard model parameters (e.g. for top quarks) and accurate searches for physics beyond the standard model.

To fully exploit the ILC potential, the precision of the polarization has to be known at the permille-level. This is roughly a factor 2 to 5 better than previously achieved at comparable accelerators. In addition to the direct measurement with Compton-polarimeters, the polarization can also be extracted from the long-term cross section measurement of very well known standard model processes.

In this contribution, a unified approach for measuring the luminosity-weighted average polarization will be presented combining the cross-section measurements from all suitable processes, as well as constraints from the polarimeters considering all statistical and systematical uncertainties including their correlations. In the context of the up to date ILC running scenario, the achievable precision will be presented for different center-of-mass energies. In that respect, the importance of a fast helicity reversal for both beams, which enables the cancellation of time-dependent systematic uncertainties, will be discussed.



T 30.6 Di 12:15 JUR 372

**Building a Tracking Detector for the P2 Experiment** — ●MARCO ZIMMERMANN for the P2-Collaboration — Institute for Nuclear Physics, Johannes Gutenberg University, Mainz — PRISMA Cluster of Excellence

The P2 Experiment aims to measure the weak mixing angle at low  $Q^2$  via the parity violating asymmetry in elastic electron-proton scattering. It will be located at the new Mainz Energy Recovery Superconducting Accelerator (MESA), which will provide a 150  $\mu\text{A}$  beam of alternately polarized 150 MeV electrons.

While the main asymmetry measurement is performed with integrating Cherenkov detectors, the tracking system is developed in order to determine the average momentum transfer of the electron and

to reconstruct individual electron tracks for systematic studies. It will be built using the new technology of High Voltage Monolithic Active Pixel Sensors (HV-MAPS) made of silicon thinned to 50  $\mu\text{m}$ . Each of the tracking layers is envisaged to have a disc-like geometry. They are arranged as two double layers.

The high signal and background particle rates are the main challenge for the tracking system. The expected rate of electrons that are scattered in the liquid hydrogen target and hit the tracking system is of the order  $10^5 \text{mm}^{-2} \text{s}^{-1}$  and is overwhelmed by partly more than  $10^7 \text{mm}^{-2} \text{s}^{-1}$  bremsstrahlung photons. Background particle rates of photons and other secondary particles are analysed in a Geant4-based Monte-Carlo simulation. In addition, measurements of the sensor response to photons are presented and compared to the simulation.

## T 31: Flavourphysik 1

Zeit: Dienstag 11:00–12:30

Raum: JUR 490

T 31.1 Di 11:00 JUR 490

**Study of  $D^0 \rightarrow \pi^+\pi^-\pi^+\pi^-$  at Belle** — ●JOHANNES RAUCH — Technische Universität München

Singly Cabibbo suppressed decays of charm mesons are expected to show a very small CP asymmetry, if any, in the Standard Model. Therefore, these channels provide a good probe for new physics. Spectroscopy of various decay channels in multi-hadronic states have seldomly been undertaken in the current era of large data sets provided e.g. by the Belle experiment. We will present the current status of an analysis of  $D^0 \rightarrow \pi^+\pi^-\pi^+\pi^-$ . Preliminary results of event selection and partial wave analysis will be shown.

T 31.2 Di 11:15 JUR 490

**Search for New Physics in Singly Cabibbo Suppressed D Decays at the Belle Experiment** — ●DMYTRO LEVIT, DANIEL GREENWALD, JOHANNES RAUCH, and STAPHAN PAUL — Physikdepartment E18, Technische Universität München, Garching, Deutschland

The Standard Model predicts CP-Violation effects to be confined to  $\Delta I = 1/2$  amplitudes in singly Cabibbo suppressed D decays. Therefore the measurement of CP violation in  $\Delta I = 3/2$  amplitudes will provide evidence of new physics.

In our analysis we undertake the first measurement of the branching ratio for the  $D^\pm \rightarrow K_c^0 K^\mp \pi^\pm \pi^\pm \pi^0$  decay using the data sample of the Belle experiment. Additionally an amplitude analysis of the decay will be performed to estimate the effect of the new physics contribution to the decay.

The current status of the first step of the analysis, the branching ratio measurement, will be presented in the contribution.

T 31.3 Di 11:30 JUR 490

**Messung der Massen und Isospinaufspaltung von  $\Sigma_c$  Baryonen am LHCb Experiment** — ●NIS MEINERT — Universität Rostock, Rostock, Deutschland

Die Massen und Isospin Aufspaltung von Baryonen sind hinsichtlich dem Verständnis der starken Wechselwirkung bei geringen Energien interessante Größen. Insbesondere für schwere Baryonen, wie  $\Sigma_c$  Baryonen, ist die Vorhersage dieser Größen theoretisch anspruchsvoll. Verschiedene theoretische Modelle liefern zur Zeit nur Vorhersagen mit hohen Unsicherheiten. Der experimentell ermittelte Weltmittelwert wird durch eine Einzelmessung dominiert.

Ziel dieser Analyse ist daher die Messung der Massen  $m(\Sigma_c^{0/++})$  und die Bestimmung der Massendifferenz  $m(\Sigma_c^0) - m(\Sigma_c^{++})$ . Da sich bei Letzterem viele Unsicherheiten gegenseitig aufheben, kann diese Isospin Aufspaltung mit einer hohen experimentellen Genauigkeit angegeben werden.

Zur Analyse werden Messdaten des LHCb Experimentes am CERN aus den Jahren 2011 und 2012 verwendet. Die Rekonstruktion erfolgt in dem Zerfall  $\Sigma_c \rightarrow \Lambda_c(pK\pi)\pi$ . Die angestrebte Präzision wird mit einer Rekalibrierung der absoluten Impulsskala an der  $\Lambda_c$  Masse und der Massendifferenz  $m(D^{*+}) - m(D^0)$  ermöglicht. Desweiteren wird die Erstmessung von  $\Xi_c \rightarrow \Lambda_c \pi$  bestätigt.

Die Ergebnisse dieser Analyse werden präsentiert. Sie sind hinsichtlich ihrer Unsicherheiten mit der weltbesten Einzelmessung vergleichbar.

T 31.4 Di 11:45 JUR 490

**Suche nach dem Zerfall  $\Lambda_b \rightarrow K^- \mu^+$**  — ●OLIVER GRÜNBERG für die LHCb-Kollaboration — Institut für Physik, Uni Rostock, Rostock

Die Beschreibung der beobachteten Materie-Antimaterie Asymmetrie in unserem Universum ist von zentraler Bedeutung in der Kosmologie. Einen Erklärungsansatz liefern die Sacharowkriterien die u.a. die Existenz von Zerfällen mit Verletzung der Baryon- und Leptonzahl fordern, die im Standardmodell jedoch verboten sind. Aus astrophysikalischen Messungen ist das Baryon-zu-Photon Verhältnis,  $\eta$ , in der Größenordnung von  $10^{-10}$  bekannt und liefert so einen Hinweis auf die Skala für solche Prozesse. Einen experimentellen Zugang bietet die exklusive Rekonstruktion von Zerfällen schwerer Hadronen unter Verletzung der Baryon- und Leptonzahl. In diesem Vortrag werden die Ergebnisse der erstmaligen Suche nach dem Zerfall  $\Lambda_b \rightarrow K^- \mu^+$  vorgestellt. Grundlage der Messung sind die Run I Daten des LHCb Experiments mit etwa 50 Milliarden  $\Lambda_b$  Baryonen.

T 31.5 Di 12:00 JUR 490

**First observation of the decays  $\Lambda_b^0 \rightarrow \Lambda_c^+ \bar{D}^{(*)0} K^-$  with the LHCb experiment** — ●MARIAN STAHL for the LHCb-Collaboration — Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg

The decays  $\Lambda_b^0 \rightarrow \Lambda_c^+ \bar{D}^{(*)0} K^-$  allow to search for the open charm decays  $\Lambda_c^+ \bar{D}^{(*)0}$  of the  $P_c$  pentaquark candidates recently discovered by LHCb.

Here, the first observation of  $\Lambda_b^0 \rightarrow \Lambda_c^+ \bar{D}^{(*)0} K^-$  is reported and its branching fraction relative to  $\Lambda_b^0 \rightarrow \Lambda_c^+ D_s^-$  is measured. Charm hadrons are reconstructed in the  $pK^- \pi^+$ ,  $K^+ \pi^-$  and  $K^+ K^- \pi^-$  final states for  $\Lambda_c^+$ ,  $\bar{D}^0$  and  $D_s^-$  respectively. The decay involving  $\bar{D}^*(2007)^0$  is partially reconstructed with a missing  $\pi^0$  or  $\gamma$ .

A future amplitude analysis will profit from an optimized selection of signal candidates and the determination of efficiencies across the  $\Lambda_c^+ \bar{D}^{(*)0} K^-$  Dalitz plots, carried out in this analysis.

T 31.6 Di 12:15 JUR 490

**CLAWS: Beam background monitoring in the commissioning of SuperKEKB** — ●MIROSLAV GABRIEL, FRANK SIMON, HENDRIK WINDEL, and NAOMI VON DER KOLK — Max Planck Institute for Physics

The SuperKEKB collider, is designed to achieve unprecedented luminosities, 40 times higher than the record-breaking luminosity of the former KEKB machine. With the first beams being circulated between February and July 2016, the machine successfully conducted its first commissioning phase. A precise understanding of the backgrounds at the interaction point of the accelerator are crucial for the operation of the Belle II detector and, in particular, its pixel vertex detector. To study these conditions prior to the final installation of the Belle II experiment, a dedicated detector setup called **Beam Exorcism for A Stable Experiment II** (BEAST II) was installed during the first commissioning phase. BEAST II consists of several subsystems each for a different type of measurements. Among those systems is **sCintillation Light And Waveform Sensors** (CLAWS), consisting of eight plastic scintillator tiles with directly coupled silicon photomultipliers (SiPMs), specifically used for determining the time dependence of backgrounds from injection bunches over millisecond time frames. This contribution will discuss results from the BEAST experiment and their implications on the operation of Belle II, with particular emphasis on measurements of the time evolution of injection backgrounds with CLAWS.

## T 32: Suche nach Supersymmetrie 2

Zeit: Dienstag 11:00–12:30

Raum: JUR 498

T 32.1 Di 11:00 JUR 498

**Estimating QCD backgrounds at CMS detector with Rebalance and Smear method** — SAM BEIN<sup>1</sup>, SIMON KURZ<sup>1</sup>, ●MAREK NIEDZIELA<sup>1</sup>, CHRISTIAN SANDER<sup>2</sup>, PETER SCHLEPER<sup>1</sup>, and JORY SONNEVELD<sup>1</sup> — <sup>1</sup>Institut für Experimentalphysik Universität Hamburg — <sup>2</sup>DESY

Searches for new physics in the CMS and ATLAS experiments at the LHC rely on accurate predictions of backgrounds, especially from QCD processes.

A method for predicting this QCD background called "rebalance and smear" has been developed for a search of new physics in the CMS collaboration that is based on multijet events with large missing transverse momentum produced in 13 TeV proton-proton collisions. The performance of rebalance and smear technique is compared with an alternative QCD background estimation method.

T 32.2 Di 11:15 JUR 498

**SUSY Searches with Jets and Missing Transverse Momentum: Lost Lepton Background and Results** — SAMUEL BEIN<sup>1</sup>, ●SIMON KURZ<sup>1</sup>, MAREK NIEDZIELA<sup>1</sup>, CHRISTIAN SANDER<sup>2</sup>, PETER SCHLEPER<sup>1</sup>, and JORY SONNEVELD<sup>1</sup> — <sup>1</sup>Institut für Experimentalphysik, Universität Hamburg — <sup>2</sup>DESY

Supersymmetry (SUSY) is one of the most promising extensions of the Standard Model of particle physics (SM), since it provides solutions of various shortcomings of the Standard Model. In many SUSY models final states with jets, no electrons or muons and large amounts of missing transverse energy are expected.

An important part of the SM background arises from events where a neutrino is produced and the associated electron or muon is "lost", i.e. out of acceptance, not reconstructed or not isolated. The talk focuses on a data-driven prediction of this background.

Furthermore, an overview of a search for SUSY is provided in which this background estimation method is used and its performance is illustrated.

T 32.3 Di 11:30 JUR 498

**Natural SUSY with a R-(S)neutrino LSP** — ●FABER THOMAS<sup>1</sup>, POROD WERNER<sup>2</sup>, JONES JOEL<sup>3</sup>, and VELAZCO NHELL<sup>4</sup> — <sup>1</sup>Julius-Maximilians-Universität Würzburg — <sup>2</sup>Julius-Maximilians-Universität Würzburg — <sup>3</sup>Pontificia Universidad Católica del Perú — <sup>4</sup>Pontificia Universidad Católica del Perú

We added a light right-handed neutrino superfield to the minimal supersymmetric Standard Model (MSSM). In this case, we are able to explain neutrino data and having an alternative dark matter candidate. Our goal is to find out how existing LHC data constraints slepton and sneutrino masses. For this we have implemented recent LHC analysis in CheckMATE and explore various parameter regions using Monte Carlo tools.

T 32.4 Di 11:45 JUR 498

**SCYNET: Parametrizing the LHC Search results for SUSY using a Neural Net Regression** — PHILIP BECHTLE<sup>1</sup>, MATTHIAS HAMER<sup>1</sup>, TIM KELLER<sup>2</sup>, ●ABTIN NARIMANI<sup>1</sup>, BJÖRN SARRAZIN<sup>1</sup>, JAN SCHÜTTE-ENGEL<sup>2</sup>, and JAMIE TATTERSALL<sup>2</sup> — <sup>1</sup>University of Bonn — <sup>2</sup>RWTH Aachen

The LHC has already excluded many signatures of New Physics based on searches for various topologies. Each of the individual searches for different topologies measures a background expectation and a measured number of events along with statistical and systematical uncertainties. These published results can be used to set limits on new models of New Physics. A possible tool for such a study is e.g. CheckMATE. For each model it tests against the LHC results, it generates events, uses a fast detector simulation, performs the selection, and then

compares the selected number of signal events to the background and data. This is a very general approach, however, it is very slow.

In order to make this approach useful for global fits, the evaluation of each model point must take  $O(< 1)$  s. In SCYNET, this is realized by training an Artificial Neural Net regression on  $O(800k)$  simulated SUSY model points using CheckMATE for 8 TeV and 13 TeV LHC SUSY searches. In a direct approach, the parameters of the pMSSM11 are trained against a  $\chi^2$  characterizing the agreement of signal and background with the data in all independent searches. In the indirect approach, pseudo-observables such as the number of partons are used to parametrize the net, such that any model of New Physics and not only a specific SUSY model can be used.

T 32.5 Di 12:00 JUR 498

**SUSY parameters from measurements of light higgsinos at the International Linear Collider** — ●SUVI-LEENA LEHTINEN<sup>1</sup>, HOWARD BAER<sup>2</sup>, MIKAEL BERGGREN<sup>1</sup>, KEISUKE FUJII<sup>3</sup>, JENNY LIST<sup>1</sup>, TOMOHIKO TANABE<sup>4</sup>, and JACQUELINE YAN<sup>3</sup> — <sup>1</sup>DESY, Hamburg, Germany — <sup>2</sup>University of Oklahoma, Norman, USA — <sup>3</sup>KEK, Tsukuba, Japan — <sup>4</sup>ICEPP, University of Tokyo, Tokyo, Japan

Natural SUSY with light, nearly mass-degenerate higgsinos is a theoretically well motivated scenario which would in general escape LHC searches. A high-energy electron-positron collider like the International Linear Collider with a centre-of-mass energy of 500 GeV would provide a clean environment where the higgsinos would be either discovered or excluded. Higgsino pair production has been studied with a detailed simulation of the International Large Detector. It is expected that higgsino masses and polarised cross sections can be measured to the percent-level accuracy. We show that these precise measurements, together with precise measurements of the Higgs, allow determining some of the underlying SUSY parameters with Fittino. In particular the weak scale gaugino mass parameters can be determined. We quantify the possibilities for running the gaugino mass parameters to the GUT scale and for distinguishing between different supersymmetry breaking scenarios. In addition, the properties of some heavy sparticles can be predicted, giving motivation for new high-energy colliders.

T 32.6 Di 12:15 JUR 498

**Constraints on Higgsino-like Neutralinos from Dark Matter Constraints in the Constrained Next-to-Minimal Supersymmetry Scenarios** — ●CONNY BESKIDT<sup>1</sup>, WIM DE BOER<sup>1</sup>, DMITRI KAZAKOV<sup>1,2</sup>, and STEFAN WAYAND<sup>1</sup> — <sup>1</sup>Karlsruhe Institute of Technology (IEKP) — <sup>2</sup>JINR, ITEP, Moscow, Russia

The lightest neutralino in supersymmetric models is a perfect dark matter (DM) candidate since it is neutral, weakly interacting and can provide the right amount of dark matter but the nature of the neutralino is still unknown. However, no DM particle has been found so far in deep underground laboratories, where the recoil of a nuclei from a collision with a DM particle is searched for, which is either proportional to the spin (spin dependent SD) or mass of the nucleus (spin independent SI) of the target material. The resulting limits on the scattering cross section from direct DM searches can be used to restrict the allowed parameter space of SUSY models. In the constrained minimal supersymmetric standard model (CMSSM) where the lightest neutralino is almost a pure bino, the parameter space excluded by the SD searches is already excluded by limits on the SI cross section. In contrast, within the NMSSM the SD searches yield additional constraints. We provide a scan over the NMSSM parameter space for different specific NMSSM scenarios to show the impact of the DM constraints. We show that the natural scenarios which predict a singlino-like lightest neutralino are in agreement with the current DM data while neutralinos with a significant amount of Higgsino admixture are under pressure and will be tested in future direct DM experiments.

## T 33: Suche nach neuen Teilchen 2

Zeit: Dienstag 11:00–12:15

Raum: JUR 2

T 33.1 Di 11:00 JUR 2

**Identification of boosted Higgs bosons in the search for their pair-production in final states with four b quarks with the ATLAS detector at  $\sqrt{s}=13$  TeV using  $36\text{ fb}^{-1}$  of data** — ●MERVE SAHINSOY and OLEG BRANDT — Kirchhoff Institute for Physics, University of Heidelberg

The Higgs sector is one of the least explored regions of the Standard Model (SM) and therefore of high importance in the search for new physics. Many new physics models predict rates of Higgs boson pair-production that are significantly higher than the SM rate. Using  $36\text{ fb}^{-1}$  of data collected by ATLAS detector in 2015 and 2016, this analysis searches for Higgs boson pair-production with two  $b\bar{b}$  pairs in the final state. The focus of this analysis is the boosted kinematic regime defined by large transverse momenta of the Higgs boson, which aims at fully exploiting the kinematic regime made accessible by the increased centre-of-mass energy in Run II of the LHC. In this extreme kinematic regime, the two b-quark jets from a Higgs boson decay are merged into one large-radius jet. Boosted Higgs boson tagging techniques to separate signal from background are presented in the context of this search, and the impact of recent improvements on the sensitivity of the analysis is discussed.

T 33.2 Di 11:15 JUR 2

**Search for high mass resonances decaying into a pair of Higgs bosons in the  $b\bar{b}\tau\tau$  fully-hadronic final state with  $36.2\text{ fb}^{-1}$  at  $\sqrt{s} = 13$  TeV** — ●MATTEO DEFRANCHIS<sup>1</sup>, CAMILLA GALLONI<sup>2</sup>, PIETRO GOVONI<sup>3</sup>, NHAN TRAN<sup>4</sup>, and CATERINA VERINIERI<sup>4</sup> — <sup>1</sup>DESY, Hamburg, Germany — <sup>2</sup>University of Zurich, Zurich, Switzerland — <sup>3</sup>INFN and University of Milano-Bicocca, Milan, Italy — <sup>4</sup>Fermi National Accelerator Laboratory, Batavia, Illinois

A model independent search for narrow high-mass resonances decaying into a pair of Higgs bosons in the  $b\bar{b}\tau\tau$  fully-hadronic final state is presented. The analysis is performed using proton-proton collisions data at  $\sqrt{s} = 13$  TeV collected by the CMS detector during 2016 data taking, which correspond to an integrated luminosity of  $36.2\text{ fb}^{-1}$ . Dedicated reconstruction algorithms are exploited in order to identify the decay products of boosted Higgs bosons with high efficiency. Expected upper limits on the production cross section as a function of the resonance mass are estimated on the basis of Monte Carlo simulations and are found to be competitive with the ones obtained by similar searches.

T 33.3 Di 11:30 JUR 2

**Large Extra Dimension Searches with the CMS Experiment** — ●MARKUS RADZIEJ, THOMAS HEBBEKER, ARND MEYER, and TOBIAS POOK — RWTH Aachen, III. Phys. Inst. A

With the Higgs Boson discovery at a mass of 125 GeV, the hierarchy problem becomes a pressing issue. One of the most prominent, potential solutions is the addition of extra spatial dimensions. A particularly interesting model has been suggested by Arkani-Hamed, Dimopoulos and Dvali, allowing for non-resonant excesses in the dilepton mass spectra at high energies.

Topic of the presented analysis is the dimuon final state. The results are based on the data recorded by the CMS experiment during 2016 at a center-of-mass energy of  $\sqrt{s} = 13$  TeV.

T 33.4 Di 11:45 JUR 2

**Search for heavy diboson resonances decaying to  $W \rightarrow \ell\nu$  and  $h \rightarrow \tau\tau$  with CMS** — ●THOMAS ESCH, THOMAS HEBBEKER, KERSTIN HOEPFNER, and SWAGATA MUKHERJEE — III. Physikalisches Institut A, RWTH Aachen, Germany

Heavy resonances that decay to two bosons could be an interesting signature for new physics. With increasing resonance masses, the two bosons get higher momenta and their decay products get closer to each other.

In this talk, the analysis for a search for heavy charged Wh resonances with the full CMS dataset of 2016 for the case where the W boson decays leptonically and the h boson decays to  $\tau$  leptons will be presented. It will concentrate on semileptonic and fully hadronic  $h \rightarrow \tau\tau$  decays and the reconstruction techniques for nearby  $\tau$  decay products.

T 33.5 Di 12:00 JUR 2

**First 13 TeV search for new heavy spin-0 resonances decaying into top quarks at CMS** — ●AFIQ ANUAR, KELLY BEERNAERT, ALEXANDER GROHSJEAN, CHRISTIAN SCHWANENBERGER, and GERRIT VAN ONSEM — Deutsches Elektronen Synchrotron (DESY), Notkestrasse 85, D-22607 Hamburg

Many beyond the Standard Model (SM) theories include an extended Higgs sector. Being the most massive particle in the SM, the top quark is of primary interest as the main probe with which these theories can be subjected to experimental scrutiny. Here a search for a heavy spin-0 resonance decaying into a top quark pair in the dilepton channel where both W bosons from the top decays decay leptonically is presented. The search is performed using data taken by the CMS experiment in 2016 at 13 TeV. Both the pseudoscalar A and scalar H scenarios, including their interference effects with SM top pair production process are taken into account. The search exploits simultaneously the peak-dip structure of the top pair mass spectrum and spin correlation observables for improved sensitivity.

## T 34: Neutrinophysik 3

Zeit: Dienstag 11:00–12:10

Raum: VSH 118

## Gruppenbericht

T 34.1 Di 11:00 VSH 118

**The OPERA Experiment: Concluding the Neutrino Oscillation Analysis** — ●ANNIKA HOLLNAGEL for the OPERA-Hamburg-Collaboration — Universität Hamburg, Institut für Experimentalphysik

The long-baseline neutrino oscillation experiment OPERA has been designed for the direct observation of  $\nu_\tau$  appearance in the CNGS  $\nu_\mu$  beam.

The OPERA detector was located at the LNGS underground laboratory, with a distance of 730 km from the neutrino source at CERN. It was a hybrid apparatus built of about 150000 Emulsion Cloud Chamber modules providing micrometric resolution and Electronic Detector elements for online readout, interaction location, and the measurement of particle charge and momentum.

CNGS beam data taking lasted from 2008 to 2012, and the detector has now been decommissioned.

With the observation of 5  $\tau$  neutrino events, the experiment was able to report the discovery of  $\nu_\mu \rightarrow \nu_\tau$  oscillations at a significance larger than  $5\sigma$ . Combining all oscillation channels accessible at OPERA - including  $\nu_e$  appearance and  $\nu_\mu$  disappearance - the neutrino oscillation

analysis will conclude in 2017.

## Gruppenbericht

T 34.2 Di 11:20 VSH 118

**Neutrino Physics within the SHiP Experiment** — ●CAREN HAGNER, DANIEL BICK, STEFAN BIESCHKE, JOACHIM EBERT, and WALTER SCHMIDT-PARZEFALL — Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

The SHiP experiment (Search for Hidden Particles) requires a high intensity beam dump, which could be realized by a new facility at the Cern SPS accelerator. In total  $2 \times 10^{20}$  protons of 400 GeV will hit the molybdenum-tungsten target and produce, amongst others, neutrinos of all flavors from decaying mesons. Therefore an additional neutrino subdetector, based on the high resolution emulsion cloud chamber technology of Opera, Chorus and Donut, will be placed upstream of SHiPs detector for the hidden sector. We expect a total of  $O(2M)$   $\nu_\mu$  events,  $O(1M)$   $\nu_e$  events and  $O(5K)$   $\nu_\tau$  events. A main goal is the measurement of  $\nu_\tau$  cross sections, where the present statistics of a few events will be increased by three orders of magnitude. The first observation of  $\bar{\nu}_\tau$  is also within reach. Neutrino-nucleon deep-inelastic scattering is another challenging topic, especially the first measurement of structure

functions  $F_4$  and  $F_5$ .

T 34.3 Di 11:40 VSH 118

**Coherent elastic neutrino nucleus scattering as a window to new physics** — ●THOMAS RINK — Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland

With the next generation of low-energy Germanium detectors Coherent Elastic Neutrino Nucleus Scattering is close to first confirmation. Besides establishing a new neutrino reaction channel which is predicted by the standard model for over forty years now, CENNS provides also many opportunities to test recent theoretical models including eV-mass sterile neutrinos as well as non-standard neutrino interactions. Further, another possibility of measuring the Weinberg angle would be established, complementing the rare data situation at lowest energies. This talk shows that the combination of highest possible neutrino fluxes, a sophisticated shielding design and lowest detection energies proves well to reach this aim. By referring to a feasibility study adapted to this requirements, prospects of measuring the signal itself are presented and an outlook of constraining the mentioned BSM models is given. The critical influence of quenching, the conversion of nuclear recoils to ionization signals within the crystal, in such attempts shall be emphasized.

T 34.4 Di 11:55 VSH 118

**Investigation of the target of the COMET muon to electron conversion-experiment** — ●ANDREAS JANSEN, DOMINIK STÖCKINGER, and KAI ZUBER — TU Dresden, Institut für Kern- und Teilchenphysik, Germany

COMET is an experiment searching for coherent neutrinoless transition of muons to electrons in the surrounding of atomic nuclei. Since this process violates charged lepton flavor conservation it is highly suppressed in the Standard Model and therefore it provides an excellent channel to search for new physics. With an expected single-event sensitivity of  $3 \cdot 10^{-15}$ , Phase-I of COMET aims to improve the current world's best limit by a factor of 100.

The number of stopped muons is attained by measuring characteristic X-rays from muonic atoms. To maximize the number of stopped muons the target consists of multiple thin aluminum disks. In order to account for this complex structure, a replication of the original setup was designed to measure the detection efficiency and solid angle dependencies in regard to each single disk.

The talk will present the design of the test setup built at TU-Dresden, the underlying Monte-Carlo simulations as well as the acquired data and the performed analysis.

## T 35: Gammaastronomie 2

Zeit: Dienstag 11:00–12:30

Raum: H 2

T 35.1 Di 11:00 H 2

**Readout calibration of Cherenkov telescope data acquired by Domino Ring Sampler v.4 chips - a status report after one year of research** — ●MARIO HÖRBE — Ruhr-Universität Bochum, Germany

Very-high-energy gamma-ray astronomy aims to give insights into the most energetic phenomena in our Universe. Earthbound Cherenkov telescopes measure Cherenkov light emitted by constituents in atmospheric showers which are initiated by primary high-energy particles. Current Cherenkov telescope cameras, e.g. operated in the MAGIC and FACT experiments, utilize the fourth generation of Domino Ring Sampler (DRS4) chips to acquire data at a high pace. The future Cherenkov Telescope Array (CTA) will implement this technology and acquire vast amounts of DRS4-based data, requiring precise calibration. We aim at developing readout data calibration techniques between the requirements of calibration precision and computational resource consumption, to be operated in CTA. The status as well as the challenges and objectives of the project will be presented.

T 35.2 Di 11:15 H 2

**Measurement of aspherical mirrors with PMD** — ●ANDREAS SPECIOVUS, CHRISTOPHER VAN ELDIK, ANDRÉ WÖRNLEIN, and ALEXANDER ZIEGLER — Friedrich-Alexander-Universität Erlangen-Nürnberg

The future Cherenkov Telescope Array (CTA) will consist of about 100 single telescopes with a total reflecting surface of  $\sim 10.000 \text{ m}^2$  made of numerous mirror facets. An efficient way to reliably reconstruct the surface of specular free-forms is Phase Measuring Deflectometry (PMD). PMD is routinely used to characterize the focal distance and point spread function of spherical CTA prototype mirrors. To investigate the possibility to measure the surface properties of aspherical mirrors, the standard PMD evaluation used for spherical telescope mirrors has been applied to one type of the aspherical mirror facets of the medium-sized prototype Schwarzschild-Couder Telescope (SCT). Experiences, implemented improvements and first results of this analysis are shown.

T 35.3 Di 11:30 H 2

**The Photon Stream, a Novel IACT Event Representation** — ●SEBASTIAN A. MUELLER<sup>1</sup> and JENS BUSS<sup>2</sup> for the FACT-Collaboration — <sup>1</sup>ETH Zuerich — <sup>2</sup>TU Dortmund

Imaging Atmospheric Cherenkov Telescopes (IACTs) observe extensive air showers during the night to probe the very high energetic gamma ray sky on an event to event basis. Both a Cherenkov photon and a Night Sky Background (NSB) photon generates an indistinguishable electric pulse in IACT cameras. However, the separation of Cherenkov photons from the pool of NSB photons is crucial for the air shower reconstruction. Using silicon sensors, the single photon performance of

the First G-APD Cherenkov Telescope (FACT) is stable enough that at least in dark nights a single photon reconstruction can be applied. This results in a list of photon arrival times for each pixel in contrast to the common main-pulse amplitude and main-pulse arrival time for each pixel. In this contribution, we first present our single photon extractor for FACT and evaluate its performance, second we introduce an IACT event representation which stores only the arrival times of the individual photons in each pixel (Photon Stream). Finally, we give a brief outlook into possible improvements in air shower reconstruction and show why the Photon Stream is a very natural IACT event format and why it has potential to be very compact, efficient and interchangeable.

T 35.4 Di 11:45 H 2

**FACT – Towards Robotic Operation** — ●MAXIMILIAN NÖTHE<sup>1</sup> and DOMINIK NEISE<sup>2</sup> for the FACT-Collaboration — <sup>1</sup>TU Dortmund, Dortmund, Deutschland — <sup>2</sup>ETH Zürich, Zürich, Schweiz

Situated on the Canary Island of La Palma at the Observatorio del Roque de los Muchachos, the First G-APD Cherenkov Telescope (FACT) continuously monitors bright gamma-ray sources.

IACTs usually need a crew of two to five shifters on site to operate. One of the major goals of the FACT collaboration is robotic operation. Since first light in October 2011, great progress has been made towards this goal. A first step, remote operation without shifters on site, was implemented in summer 2012. Since then, streamlined web interfaces replaced more complicated or unreliable ones via ssh or VNC and VNP. At this point, shifters were only required to startup the telescope in the evening, shut it down in the morning and monitor telescope state and environmental conditions in between. These efforts lead to a data taking efficiency of  $\sim 95 \%$  and a total of over 2300 hours of physics data in the past twelve months.

In this talk, the current effort to go to full robotic operation will be presented. A new software was introduced, to go to a mode of operation where the telescope takes data completely on its own, only notifying a shifter if and when human interaction is necessary. It can reach to a shifter via phone, text messages and even send plots and images. The software continuously monitors the telescope status, environmental conditions and quick look analysis results.

T 35.5 Di 12:00 H 2

**FACT - Machine Learning Analysis** — ●KAI BRÜGGE, JENS BUSS, and MAXIMILIAN NÖTHE for the FACT-Collaboration — TU Dortmund, Dortmund, Deutschlands

Imaging Atmospheric Cherenkov Telescopes like FACT (First G-APD Cherenkov Telescope) produce a continuous flow of data during observation. One major task of a monitoring system is to detect changes in the gamma-ray flux of a source, and to alert other experiments if some predefined limit is reached in order to possibly trigger multi

wavelength observations. Thus analyzing the data with low latency is essential for understanding the acceleration mechanisms in bright gamma-ray sources like active galactic nuclei.

In order to calculate the fluxes of an observed source, it is necessary to calculate the instrument response function (IRF) and effectively minimize background noise. This analysis relies heavily on the usage of machine learning methods to perform background suppression and energy estimation. We describe how multi-variate models are applied to FACT's data stream with low latency, show IRFs, present fluxes and compare results to an existing analysis which does not use machine learning.

T 35.6 Di 12:15 H 2

**FACT - DRS Temperature Calibration** — ●FLORIAN SCHULZ for the FACT-Collaboration — TU-Dortmund, Germany

The camera of the first G-APD Cherenkov Telescope (FACT) is comprised of 1440 individual pixels which are equipped with a silicon based photosensor (SiPM) each. The readout electronics is based on the Domino Ring Sampler 4 (DRS4-Chip). Every chip comprises  $9 \times 1024$  capacitors and operates with a sampling frequency of 2 GHz during standard data acquisition. In standard operation, 300 samples (150ns), the so-called region of interest (RoI) are read out for each triggered event. It is necessary to calibrate the properties of all the capacitors of the 160 DRS4-Chips.

Taking drs calibration runs is one way to determine values like Base-line and Gain for every capacitor. The temperature dependence of the calibration parameters is studied. The final goal is to be able to calculate the required calibration constants based on the temperature measurement and reduce the recording of calibration runs to a minimum during the night. The effect on the data is studied.

## T 36: Kosmische Strahlung 3

Zeit: Dienstag 11:00–12:35

Raum: H 3

### Gruppenbericht

T 36.1 Di 11:00 H 3

**Das Pierre-Auger-Observatorium: Status, aktuelle Ergebnisse und Perspektiven** — ●MARCUS NIECHCIOL für die Pierre Auger-Kollaboration — Department Physik, Universität Siegen

Das Pierre-Auger-Observatorium ist mit einer Fläche von  $3000 \text{ km}^2$  das weltweit größte Experiment zur Untersuchung kosmischer Strahlung mit Energien oberhalb von  $0,1 \text{ EeV}$  ( $10^{17} \text{ eV}$ ). Zusätzlich zu den primären Detektorsystemen (Teilchendetektorfeld und Fluoreszenzteleskope) wurden verschiedene Erweiterungen installiert, z.B. Radioantennen (AERA) oder Untergrund-Myon-Detektoren (AMIGA). Zu den wichtigsten bisherigen Ergebnissen zählen der Nachweis einer Flußunterdrückung oberhalb von  $\sim 40 \text{ EeV}$  sowie der Nachweis einer gemischten Massenzusammensetzung im Energiebereich um  $\sim 5 \text{ EeV}$ . Eine wichtige noch offene Frage ist allerdings die genaue Zusammensetzung der kosmischen Strahlung bei den höchsten Energien. Damit verknüpft sind Fragen nach der Ursache der Flußunterdrückung (d.h. GZK-Effekt oder Maximalenergie der Quellen) sowie nach der Möglichkeit, bei den höchsten Energien mit leichten Elementen Astronomie betreiben zu können. Zur Klärung dieser Fragen wird im Rahmen des AugerPrime-Upgrades in den nächsten Jahren das Detektorfeld mit zusätzlichen Szintillationsdetektoren ausgerüstet, um eine Separierung der elektromagnetischen und myonischen Luftschauerkomponenten zu erzielen. Im Vortrag wird ein Überblick über den aktuellen Status des Pierre-Auger-Observatoriums, ausgewählte Ergebnisse und das AugerPrime-Upgrade gegeben.

T 36.2 Di 11:20 H 3

**AugerPrime - The Pierre Auger Observatory Upgrade** — ●RADOMIR SMIDA for the Pierre Auger-Collaboration — KIT, Karlsruhe, Germany

The Pierre Auger Observatory has begun a major upgrade, known as AugerPrime, of its already impressive capabilities, with an emphasis on improved mass composition determination at the highest energies. While a strong suppression of the particle flux at the highest energies has been established unambiguously, the dominant physics processes related to this suppression cannot yet be identified. Complementing the water-Cherenkov detectors of the surface array with scintillator detectors and installing new surface detector electronics will extend the composition sensitivity of the Observatory into the flux suppression region. These improvements will allow us to estimate the primary mass of the highest energy cosmic rays on a shower-by-shower basis. In addition to measuring the mass composition, AugerPrime will open the possibility to search for light primaries at the highest energies, to perform composition-selected anisotropy studies, and to search for new phenomena including unexpected changes in hadronic interactions beyond the LHC's reach.

After introducing the physics motivation for upgrading the Pierre Auger Observatory, the planned detector upgrade and the first results from the deployed Engineering Array are presented. In the second part of this contribution, the expected performance and improved physics sensitivity of the upgraded Auger Observatory are discussed.

T 36.3 Di 11:35 H 3

**Studying the cosmic-ray shadows of the Sun and the Moon with the IceCube neutrino telescope** — ●FABIAN BOS, FREDERIK

TENHOLT, and JULIA BECKER TJUS for the IceCube-Collaboration — Ruhr-Universität Bochum

Cosmic rays are energetic charged particles from outer space that continuously impinge on Earth from all directions. As cosmic rays are blocked by the Sun and the Moon, a deficit in the number of cosmic rays is observed at Earth from the direction of these celestial bodies. The study of these cosmic-ray shadows has been traditionally used to characterize the angular resolution and absolute pointing of cosmic-ray detectors. We report on a significant variation of the Sun shadow during a five-year observation with the IceCube neutrino telescope, located at the South Pole. A dependence of the Sun shadow on solar activity is expected as particles propagating in the Sun's vicinity are influenced by its magnetic field. This opens the possibility for future analyses to probe different coronal magnetic field models. This project is BMBF-supported (FKZ: 05A14PC1).

T 36.4 Di 11:50 H 3

**Low Energy Cosmic Ray Physics with the Pierre Auger Observatory** — ●MARTIN SCHIMASSEK, DARKO VEBERIC, and RALPH ENGEL for the Pierre Auger-Collaboration — Karlsruher Institut für Technologie, Deutschland

The Pierre Auger Observatory was built to measure cosmic rays with the highest energies and lowest flux. For this purpose 1660 surface detectors cover an area of about  $3000 \text{ km}^2$  and are overlooked by four telescope stations. Next to the high energy events, periodically also various non-event data are recorded for each of the surface detectors. These data are mainly used for hardware calibration and performance monitoring of the array. Nevertheless, they indirectly carry also interesting information about particles with energies in a MeV to GeV range and can therefore as well be used for physics analyses aimed at the low-energy part of the cosmic ray spectrum. The sensitivity of such analyses to small changes in rates of low-energy cosmic rays is due to the large statistics collected by the array of 1660 stations, each having an area of about  $10 \text{ m}^2$ . With these data we can for example observe changes in solar activity and Forbush decreases in the rate of low-energy cosmic rays.

T 36.5 Di 12:05 H 3

**Erste Analysen des AugerPrime Engineering Arrays\*** — ●SONJA SCHRÖDER für die Pierre Auger-Kollaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal

Das Pierre-Auger-Observatorium in Argentinien ermöglicht es, kosmische Strahlung der höchsten Energien zu detektieren und zu untersuchen. Mit Hilfe der 1660 Wasser-Cherenkov-Detektoren (SD) und 27 Fluoreszenzteleskope kann die Komposition der Primärteilchen von ausgedehnten Luftschauern bestimmt werden. Um die Genauigkeit dieser Messungen weiter zu verbessern, wurde das Upgrade AugerPrime konzipiert. Durch Szintillationsdetektoren (SSD) auf der Oberfläche der Detektorstationen kann so die Separation von elektromagnetischer und myonischer Komponente eines Teilchenschauers optimiert werden. In diesem Vortrag wird die Datenqualität des SSD anhand von zwei unmittelbar benachbarten Detektorstationen untersucht. Diese Doppelstation befindet sich im Zentrum eines hexagonalen Sub-Arrays, in dem die Abstände der Detektorstationen von 1500 m auf 433 m verringert

wurden. Dadurch ergibt sich eine Herabsetzung der Energieschwelle auf  $\sim 10^{16.5}$  eV, sowie eine mindestens 10 mal höhere Ereignisstatistik im Vergleich zum regulären Feld.

\*Gefördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A14PX1).

T 36.6 Di 12:20 H 3

**Erste Resultate des AugerPrime-Engineering-Detektorfelds** — ●ALEXANDER SCHULZ für die Pierre Auger-Kollaboration — KIT, Karlsruhe

Das Pierre-Auger-Observatorium in Argentinien ist der weltgrößte Detektor für ultra-hochenergetische kosmische Strahlung. Zahlreiche fundamentale Entdeckungen, z.B. die Unterdrückung des Flusses bei höchsten Energien, wurden in den letzten 12 Jahren mithilfe von Auger etabliert. Mit dem geplanten Upgrade zu AugerPrime sollen gezielt

offene Fragen der Astroteilchenphysik gelöst werden, z.B. die genaue Massenzusammensetzung der hadronischen Strahlung bei höchsten Energien. Dazu wird unter anderem jeder der 1700 Wasser-Cherenkov-Detektoren um einen  $4\text{ m}^2$  Plastiksintillator auf dem Tank erweitert. Die sehr unterschiedliche Detektorantwort der beiden Detektoren auf verschiedene Sekundärteilchen erlaubt den Rückschluss auf den Signalanteil, der von Myonen erzeugt wurde. Da dieser Signalanteil stark mit der Primärmasse korreliert ist, folgt daraus eine deutlich verbesserte Sensitivität auf die Primärmasse auf Basis individueller Ereignisse.

In diesem Beitrag wird der Status und erste Resultate des AugerPrime-Engineering-Detektorfelds vorgestellt, welches aus 10 neuen Detektoren besteht und seit Oktober 2016 Daten nimmt. Es wird auf die Signalkalibrierung der unterschiedlichen Detektoren eingegangen und neue Resultate von Luftschauermessungen bei höchsten Energien gezeigt. Erste Resultate der Luftschauer-Rekonstruktion und physikalische Implikationen werden diskutiert.

## T 37: Kosmische Strahlung 4

Zeit: Dienstag 11:00–12:45

Raum: H 4

T 37.1 Di 11:00 H 4

**Cosmic ray radio detection: fast forward model and imaging** — ●DAVID BUTLER<sup>1</sup>, TIM HUEGE<sup>1</sup>, TORSTEN ENSSLIN<sup>2</sup>, and OLAF SCHOLTEN<sup>3</sup> — <sup>1</sup>Institut für Kernphysik, Karlsruher Institut für Technologie — <sup>2</sup>Max-Planck-Institut für Astrophysik, München — <sup>3</sup>Center for Advanced Radiation Technology, University of Groningen

The radio detection method for cosmic rays relies on coherent emission from electrons and positrons which is beamed in a narrow cone along the direction of the primary particle. Currently the only models to reproduce this emission with sufficient accuracy are Monte Carlo based simulations of the particle physics, which require large investments of computation time. Even then the final analysis relies on simple metrics and empirically determined correlations to retrieve quantities of interest.

The work presented here focuses on condensing the simulation results into a semi-analytical model, preserving the accuracy of the microscopic interactions while significantly reducing the computation time required for end-user analyses.

Going further one could use this knowledge to perform a tomographic reconstruction of the air shower, i.e. infer its development history only from ground-based measurements. This would open new avenues beyond the standard Xmax reconstruction, allowing more detailed analyses of individual air showers.

T 37.2 Di 11:15 H 4

**Search for Cosmic Particles on the ZeV Scale with the Moon and LOFAR** — ●TOBIAS WINCHEN<sup>1</sup>, A. BONARDI<sup>2</sup>, S. BUITINK<sup>1</sup>, A. CORSTANJE<sup>2</sup>, J. E. ENRIQUEZ<sup>2</sup>, H. FALCKE<sup>2,3,5</sup>, J. R. HÖRANDEL<sup>2,3</sup>, P. MITRA<sup>1</sup>, K. MULREY<sup>1</sup>, A. NELLES<sup>2,3,7</sup>, J. P. RACHEN<sup>2</sup>, L. ROSSETTO<sup>2</sup>, P. SCHELLART<sup>2,8</sup>, O. SCHOLTEN<sup>4,6</sup>, S. THOUDAM<sup>2</sup>, T.N.G. TRINH<sup>4,6</sup>, and S. TER VEEN<sup>5</sup> — <sup>1</sup>Vrije Universiteit Brussel (Belgium) — <sup>2</sup>Radboud University Nijmegen (The Netherlands) — <sup>3</sup>NIKHEF (The Netherlands) — <sup>4</sup>KVI-CART (The Netherlands) — <sup>5</sup>ASTRON (The Netherlands) — <sup>6</sup>University of Groningen (The Netherlands) — <sup>7</sup>Now at University of California Irvine (USA) — <sup>8</sup>Now at Princeton University (USA)

A significant challenge to answer the long standing question about the origin and nature of ultra-high energy cosmic rays (UHECR) is given by their extremely low flux. Even lower fluxes of neutrinos with energies beyond the ZeV ( $10^{21}$  eV) scale are predicted in certain Grand-Unifying-Theories (GUTs) and e.g. models for super-heavy dark matter (SHDM). The significant increase in detector volume required to detect these particles can be achieved by employing Earth's moon as detector and search for radio pulses that are emitted when a particle interacts in the lunar rock with a radio telescope. Here, we give an overview on the design and status of a corresponding search with the LOFAR radio telescope.

T 37.3 Di 11:30 H 4

**Measuring the depth of shower maximum with SKA1-low: a first simulation study** — ●ANNE ZILLES<sup>1</sup>, STIJN BUITINK<sup>2</sup>, and TIM HUEGE<sup>3</sup> — <sup>1</sup>Institut für Experimentelle Kernphysik, Karlsruher Institut für Technologie, Deutschland — <sup>2</sup>Astrophysical Institute, Vrije Universiteit Brussel, Belgien — <sup>3</sup>Institut für Kernphysik, Karlsruher

Institut für Technologie, Deutschland

As LOFAR has already demonstrated, using a dense array of radio antennas for detecting extensive air showers initiated by cosmic rays in the Earth's atmosphere makes it possible to measure the depth of shower maximum for individual showers with a statistical uncertainty of less than  $20\text{ g/cm}^2$ . This allows detailed studies of the mass composition in the energy region around  $10^{17}$  eV where the transition from a galactic to an extragalactic origin could occur.

As of 2023, the Square Kilometre Array will constitute the world's largest telescope in radio astronomy. Since SKA1-low, the low frequency part, ideally suited to detect extensive air showers initiated by cosmic ray via radio emission, will provide a much denser and very homogeneous antenna array with roughly 70.000 antenna on an area of about  $0,5\text{ km}^2$  and a large bandwidth of  $50 - 350\text{ MHz}$  it is expected to reach an even smaller uncertainty on the shower-maximum reconstruction. We present results of a first simulation study with focus on the potential to reconstruct the depth of shower maximum for individual showers measured with SKA1-low, showing that a mean reconstruction uncertainty of less than  $10\text{ g/cm}^2$  seems to be achievable.

T 37.4 Di 11:45 H 4

**Radio emission from a particle cascade in a dense medium and in magnetic fields: Modelling and its experimental validation with the SLAC T-510 experiment** — ●ANNE ZILLES for the SLAC T-510-Collaboration — Institut für Experimentelle Kernphysik, Karlsruher Institut für Technologie, Deutschland

The SLAC T-510 experiment was designed to compare controlled laboratory measurements of radio emission of particle showers to particle-level simulations, which are relied upon in ultra-high-energy cosmic-ray air shower detection. Established formalisms for the simulation of radio emission physics, the "end-point" formalism and the "ZHS" formalism, lead to results which can be explained by a superposition of magnetically induced transverse current radiation and the Askaryan (charge-excess) effect. Here, we present the comparison of the results of Geant4 simulations, including the formalisms, and measured data of the SLAC T-510 experiment within the scope of e.g. linearity with magnetic field and angular distribution of the signal amplitude showing that microscopic simulations reproduce the measurements within uncertainties and give a very good description of the data.

T 37.5 Di 12:00 H 4

**Systematische Unsicherheit der Energiebestimmung von Luftschauern mittels Radioemission\*** — ●MARVIN GOTTOWIK und JULIAN RAUTENBERG für die Pierre Auger-Kollaboration — Bergische Universität Wuppertal

Mit dem Auger Engineering Radio Array (AERA) beim Pierre-Auger-Observatorium konnte kürzlich gezeigt werden, dass sich die absolute Energie von Primärteilchen der kosmischen Strahlung aus der Radioemission des Luftschauers präzise bestimmen lässt. Zur Abschätzung der systematischen Unsicherheit dieser Beziehung werden die zwei verschiedene Monte-Carlo-Simulationen CoREAS und ZHAireS verglichen. Die Simulationen werden bestmöglich mit gleichen Einstellungen durchgeführt. Insbesondere wird einheitlich SIBYLL 2.1 als

Modell für die hadronischen Interaktionen sowie dieselbe Modellierung der Atmosphäre verwendet. Verbleibende Unterschiede können auf die Berechnung der Radioemission mit dem Endpunkt-Formalismus- bzw. dem ZHS-Algorithmus zurückgeführt werden. Aus dem Vergleich einer Vielzahl von Luftschauern mit unterschiedlicher Energien und Richtungen lässt sich die systematische Unsicherheit auf die Energie der elektromagnetischen Komponente bestimmen.

\* Gefördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A14PX1).

T 37.6 Di 12:15 H 4

**Non-thermal radiation from cloud-disk collisions in active galactic nuclei** — ●ANA LAURA MÜLLER<sup>1,2</sup> and GUSTAVO ESTEBAN ROMERO<sup>1,3</sup> — <sup>1</sup>Instituto Argentino de Radioastronomía (CCT-La Plata, CONICET; CICPBA), Villa Elisa, Argentina — <sup>2</sup>Karlsruher Institut für Technologie, Karlsruhe, Germany — <sup>3</sup>Facultad de Ciencias Astronómicas y Geofísicas (Universidad Nacional de La Plata), La Plata, Argentina

The ultraviolet and optical spectra of active galactic nuclei (AGN) have prominent broad emission lines, produced close to the central black hole. The emitting gas is contained in the so-called broad line region (BLR). Clouds with velocities in the range from  $\sim 1000 \text{ km s}^{-1}$  to  $\sim 5000 \text{ km s}^{-1}$  exist within this region. Because of the random velocity distribution of the clouds, direct collisions with the accretion disk feeding the AGN should occur. Assuming the typical parameters for clouds and an accretion disk, we estimate that  $\sim 10^{43} \text{ erg}$  can be

released per impact. The collision produces two shock waves, one propagating through the disk and the other moving through the cloud. This scenario might be in principle favorable to the acceleration of particles by first order Fermi mechanism. We present estimates of the cosmic ray production inside the shocked cloud and model the non-thermal emission. We also offer a brief discussion of the contribution of this process to the total variability of AGNs.

T 37.7 Di 12:30 H 4

**A test of the existence of primary protons in cosmic rays** — ●PHILIPP HEIMANN<sup>1</sup>, KEVIN LOPATA<sup>1</sup>, MARKUS RISSE<sup>1</sup>, and ALEXEY YUSHKOV<sup>2</sup> for the Pierre Auger-Collaboration — <sup>1</sup>Universität Siegen, Department Physik — <sup>2</sup>Instituto de Tecnologías en Detección y Astropartículas, Buenos Aires, Argentinien

We present a method to test whether at a certain primary energy, protons exist in the cosmic-ray beam. We introduce a probability measure for air shower events in a sample to be produced by helium, which includes all uncertainties of a detector. If this probability is small one can exclude helium or heavier nuclei as the primary candidates, leading thus to a conservative conclusion that the shower was produced by a primary proton. We show that even a single deep event might be enough to conclude that protons exist in the primary beam up to the event's energy.

Gefördert durch die BMBF-Verbundforschung Astroteilchenphysik sowie der Helmholtz-Allianz für Astroteilchenphysik.

## T 38: Quantenfeldtheorie (nicht-perturbativ)

Convenor: C. Bogner, P. Maierhöfer

Zeit: Dienstag 11:00–12:15

Raum: VSH 11

T 38.1 Di 11:00 VSH 11

**Dynamically assisted Sauter-Schwinger effect—from nonperturbative to perturbative** — GREGER TORGRIMSSON, ●CHRISTIAN SCHNEIDER, and RALF SCHÜTZHOLD — Fakultät für Physik, Universität Duisburg-Essen

The dynamically assisted Sauter-Schwinger effect is a tremendous increase in the probability of nonperturbative pair creation by the combination of a strong electric field and a weak, time dependent one. Especially the very sensitive dependence on the exact field profile of the weak pulse has not yet been fully understood. We present both detailed numerical data and new analytical results that agree remarkably well, allowing us to explain how these differences arise.

T 38.2 Di 11:15 VSH 11

**Doubly assisted Sauter-Schwinger effect** — GREGER TORGRIMSSON, ●JOHANNES ORTEL, and RALF SCHÜTZHOLD — Fakultät für Physik, Universität Duisburg-Essen

We study electron-positron pair creation by a strong and slowly varying electric field, assisted by a weaker and more rapidly changing field (e.g., in the keV regime) plus an additional high-energy (say MeV) photon. It turns out that this combination can yield a pair creation probability which is exponentially larger than in the case where one (or more) of the three ingredients is missing. Apart from a deeper understanding of these nonperturbative phenomena, this double enhancement may pave the way for an experimental verification of this fundamental prediction.

T 38.3 Di 11:30 VSH 11

**Semiconductor analog of the Dirac equation and Sauter-Schwinger pair creation** — ●MALTE F. LINDER and RALF SCHÜTZHOLD — Fakultät für Physik, Universität Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany

There is an analogy between  $E$ -field-induced tunneling of Dirac-sea electrons to the upper energy continuum in Dirac theory (Sauter-Schwinger effect) and electron-hole pair creation in direct-gap semiconductors via interband (Landau-Zener) tunneling due to external  $E$  fields. In this talk, we show that in 1+1 spacetime dimensions, the Bloch electrons in the vicinity of the band gap obey a Dirac equation with effective physical constants in arbitrary external fields  $E(t, x)$ , provided the fields predominantly stimulate tunneling-type excitations

(low photon energies, large wavelengths). Condensed-matter analogs of relativistic quantum physics could be useful to study high-energy effects in the laboratory.

T 38.4 Di 11:45 VSH 11

**Soliton-like solution in quantum electrodynamics** — ●OLEG D. SKOROMNIK<sup>1</sup>, ILYA D. FERANCHUK<sup>2,3,4</sup>, and CHRISTOPH H. KEITEL<sup>1</sup> — <sup>1</sup>Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany — <sup>2</sup>Atomic Molecular and Optical Physics Research Group, Ton Duc Thang University, 19 Nguyen Huu Tho Str., Tan Phong Ward, District 7, Ho Chi Minh City, Vietnam — <sup>3</sup>Faculty of Applied Sciences, Ton Duc Thang University, 19 Nguyen Huu Tho Str., Tan Phong Ward, District 7, Ho Chi Minh City, Vietnam — <sup>4</sup>Belarusian State University, 4 Nezavisimosty Ave., 220030, Minsk, Belarus

A novel soliton-like solution [1] in quantum electrodynamics is obtained via a self-consistent field method. By writing the Hamiltonian of quantum electrodynamics in the Coulomb gauge, we separate out a classical component in the density operator of the electron-positron field. Then, by modeling the state vector in analogy with the theory of superconductivity, we minimize the functional for the energy of the system. This results in the equations of the self-consistent field, where the solutions are associated with the collective excitation of the electron-positron field—the soliton-like solution. In addition, the canonical transformation of the variables allowed us to separate out the total momentum of the system and, consequently, to find the relativistic energy dispersion relation for the moving soliton.

[1] arXiv:1608.01245

T 38.5 Di 12:00 VSH 11

**Renormalization group flow of the Higgs sector** — ●RENÉ SONDENHEIMER — Theoretisch-Physikalisches Institut, FSU Jena, Germany

We investigate the nonperturbative renormalization flow of the Higgs potential and reanalyze the conventional arguments that relate a lower bound for the Higgs mass with vacuum stability in the framework of the FRG. Especially, we discuss the impact of generalized bare Higgs potentials from an effective field theory point of view on the lower mass bound and identify a renormalization group mechanism to diminish this bound without introducing a metastability in the effective Higgs potential.

**T 39: Higgs-Physik (Theorie) 1**

Convenor: M. Wiesemann

Zeit: Dienstag 11:00–12:30

Raum: VSH 06

T 39.1 Di 11:00 VSH 06

**Hadronic Higgs Decay to order  $\alpha_s^4$**  — JOSHUA DAVIES, MATTHIAS STEINHAUSER, and •DAVID WELLMANN — Institut für Theoretische Teilchenphysik, Karlsruher Institut für Technologie (KIT), D-76128 Karlsruhe

In this talk, we present analytic results for the total cross section for the decay of the Standard Model Higgs Boson into hadrons up to the fourth order in the strong coupling constant. We complement the results available in the literature with top-quark-induced correction terms which are taken into account by means of an effective-field-theory approach.

T 39.2 Di 11:15 VSH 06

**Exclusive radiative Higgs decays in the Standard Model and beyond** — •STEFAN ALTE — PRISMA Cluster of Excellence and Mainz Institute for Theoretical Physics, Johannes Gutenberg University, 55099 Mainz

We present a detailed analysis of the rare exclusive Higgs-boson decays  $h \rightarrow MV$  into a single meson  $M$  and an electroweak gauge boson  $V = Z, W, \gamma$ . We discuss these decays within the Standard Model and investigate the possibility of using these processes as probes for non-standard Higgs couplings. To this end, we employ an effective Lagrangian with modified Higgs couplings to account for possible new-physics effects in a model-independent way. We show that measurements of the decays  $h \rightarrow MZ$  can be used to extract information about the CP-even and CP-odd  $h\gamma Z$  couplings. Some of the  $h \rightarrow MW$  decay modes exhibit a very strong dependence on the flavour-changing Higgs couplings involving the top quark. The decays  $h \rightarrow M\gamma$  can serve as probes of the light-quark Yukawa couplings.

T 39.3 Di 11:30 VSH 06

**NLO QCD-Korrekturen zur Higgspaarpromuktion via Gluonfusion** — •SERAINA GLAUS — Theorie-Gruppe LTP, PSI, Schweiz

Die gemessenen Eigenschaften des unlängst am CERN detektierten Teilchens weisen darauf hin, dass es sich um das langgesuchte Higgs-boson des Standardmodells handeln könnte. Jedoch lassen die theoretischen und experimentellen Unsicherheiten Zuordnungen zu anderen erweiterten Modellen zu. Deshalb ist es von ausschlaggebender Bedeutung, die Eigenschaften des Teilchens zu bestimmen. Die Bestimmung des Higgspotentials spielt eine zentrale Rolle, um zu prüfen, ob dieses Teilchen verantwortlich für die elektroschwache Symmetriebrechung ist. Zur Messung des Higgspotentials, muss die Selbstwechselwirkungsstärke zwischen Higgsbosonen direkt bestimmt werden. Dies ist einzig über Higgspaarpromuktion als erster Schritt für die trilineare Kopplung möglich. Der dominante Prozess der Higgspaarpromuktion ist die loop-induzierte Gluonfusion über eine Top- und Bottomquarkschleife. In dieser Arbeit werden die NLO QCD-Korrekturen unter Berücksichtigung der vollen Top- und Bottomquarkmassen-Abhängigkeit im Rahmen des Standardmodells berechnet. Die relevanten Zwei-Loop-Integrale können nur numerisch berechnet werden. Zum Zweck der Extraktion der ultravioletten, infraroten und kollinearen Divergenzen der Matrixelemente wird eine geeignete Endpunktsabtraktion der 6-dimensionalen Feynman-Integrale und eine semi-analytische Integrati-

on der Endpunktbeiträge durchgeführt. Zur Behebung der numerischen Instabilitäten der regularisierten Feynman-Integrale oberhalb der virtuellen Schwellen, wird der extensive Integranden partiell integriert.

T 39.4 Di 11:45 VSH 06

**Constraining the Higgs trilinear coupling from single-Higgs processes in the SMEFT** — STEFANO DI VITA<sup>1</sup>, CHRISTOPHE GROJEAN<sup>1,2</sup>, GIULIANO PANICO<sup>3</sup>, MARC RIEMBAU<sup>1,3</sup>, and •THIBAUD VANTALON<sup>1,3</sup> — <sup>1</sup>DESY, Notkestrasse 85, D-22607 Hamburg, Germany — <sup>2</sup>Institut für Physik, Humboldt-Universität zu Berlin, D-12489 Berlin, Germany — <sup>3</sup>IFAE, Barcelona Institute of Science and Technology (BIST) Campus UAB, E-08193 Bellaterra, Spain

In scenarios where the only anomalous contribution to single-Higgs observables originates from the Higgs cubic self coupling, it has been recently noticed that the bounds on the Higgs trilinear from those observables might complement and compete with the constraints coming from double Higgs production. We study to what extent this statement holds true when one considers a general deviation on Higgs couplings in the EFT framework. We show that inclusive observables are not enough to isolate the Higgs trilinear effect from the other deviations. However, we present a strategy to disentangle this flat direction using the kinematic information in the differential cross sections.

T 39.5 Di 12:00 VSH 06

**New physics effects in gluon-induced Higgs-Z production** — •JONAS KLAPPERT — RWTH Aachen, Aachen, Germany

The associated Higgs-Z boson production via gluon fusion could be a candidate process in the search for new physics due to its loop-mediated nature. To systematically analyze this process, we have created a framework which consists of the automatic calculation of helicity amplitudes and the numerical evaluation of cross-sections and transverse momentum distributions. We have studied the influence of effective operators of dimension 5 and 6 and an additional vector-like top quark partner at the LHC and compared these results to the SM.

T 39.6 Di 12:15 VSH 06

**Higgs production in association with off-shell top-antitop pairs at NLO EW and QCD at the LHC** — •MATHIEU PELLEN and ANSGAR DENNER — Universitaet Wuerzburg, Wuerzburg, Germany

As the Higgs production in association with top-antitop pairs is about to be measured at the LHC, precise and realistic predictions are of prime importance. We present NLO electroweak (EW) corrections to the full process where all interference, off-shell and non-resonant contributions are taken into account. The EW corrections turn out to be below one per cent for the integrated cross section but can exceed 10% in certain phase-space regions. The results of the full computation are supported by two calculations in the double-pole approximation. These also allow to infer the effect of off-shell contributions. Finally, we provide combined predictions featuring both NLO EW and QCD corrections in a common set-up. The methods used and some exemplary results will be presented.

**T 40: Top Quark (Theorie) 2**

Convenor: M. Worek, S. Westhoff

Zeit: Dienstag 11:00–12:30

Raum: VSH 05

T 40.1 Di 11:00 VSH 05

**Off-shell effects for  $t\bar{t}j$  in the dilepton channel** — •MANFRED KRAUS — Humboldt Universitaet zu Berlin, Berlin, Germany

We present results for the top-quark pair production in association with one hard jet including leptonic decays of the top quarks. The NLO QCD calculation for the LHC Run II energy of 13 TeV includes resonant as well as continuum production and all interference and off-shell contributions from top-quarks, W and Z bosons. We present a detailed comparison of uncertainties for integrated and differential cross sections as obtained by an independent variation of the renormalization

and factorization scales for fixed and dynamical choices of the scale. Finally, also the impact of PDF uncertainties are addressed. We also briefly discuss the influence of off-shell effects on the extraction of the top-quark mass parameter.

T 40.2 Di 11:15 VSH 05

**NLO electroweak corrections to off-shell top-antitop production with leptonic decays at the LHC** — •MATHIEU PELLEN and ANSGAR DENNER — Universitaet Wuerzburg, Wuerzburg, Germany

The increased centre-of-mass energy of the LHC makes the inclusion



of electroweak corrections extremely relevant as they are particularly large in the Sudakov regime where new physics is expected to be probed. For the first time the NLO electroweak corrections to the full off-shell production of two top quarks that decay leptonically are presented. This includes all off-shell, non-resonant and interference effects. At the cross section level, the electroweak corrections are below one per cent. At the distribution level, they can grow large (up to 20 %) in the high transverse momentum region. To support our results, we have performed two different pole approximations. One assumes on-shell top quarks while the second features two on-shell W bosons. Only the latter gives a very good description of the full calculation. The methods used and some exemplary results will be presented.

T 40.3 Di 11:30 VSH 05

**NLO QCD Predictions for off-shell  $t\bar{t}$  and  $t\bar{t}H$  Production and Decay at a Linear Collider** — ●CHRISTIAN WEISS<sup>1,4</sup>, BILAN CHOKOUFÉ<sup>1</sup>, JÜRGEN REUTER<sup>1</sup>, JONAS LINDERT<sup>2,3</sup>, STEFANO POZZORINI<sup>2</sup>, and WOLFGANG KILIAN<sup>4</sup> — <sup>1</sup>Desy Hamburg — <sup>2</sup>Zürich University — <sup>3</sup>Durham University — <sup>4</sup>Siegen University

We present predictions for  $t\bar{t}$  and  $t\bar{t}H$  production and decay at future lepton colliders including non-resonant and interference contributions up to next-to-leading order (NLO) in perturbative QCD. The obtained precision predictions are necessary for a future precise determination of the top-quark Yukawa coupling, and allow for top-quark phenomenology in the continuum at an unprecedented level of accuracy. Simulations are performed with the automated NLO Monte-Carlo framework WHIZARD interfaced to the OpenLoops matrix element generator.

T 40.4 Di 11:45 VSH 05

**$\overline{\text{MS}}$ -On-Shell quark mass relation at four loops** — PETER MARQUARD<sup>1</sup>, ALEXANDER SMIRNOV<sup>2</sup>, VLADIMIR SMIRNOV<sup>3</sup>, MATTHIAS STEINHAUSER<sup>4</sup>, and ●DAVID WELLMANN<sup>4</sup> — <sup>1</sup>Deutsches Elektronen-Synchrotron (DESY), 15738 Zeuthen, Germany — <sup>2</sup>Research Computing Center, Moscow State University, 119991 Moscow, Russia — <sup>3</sup>Skobeltsyn Institute of Nuclear Physics, Moscow State University, 119991 Moscow, Russia — <sup>4</sup>Institut für Theoretische Teilchenphysik, Karlsruher Institut für Technologie (KIT), 76128 Karlsruhe, Germany

We present the relation between heavy quark masses defined in the modified minimal subtraction and the on-shell schemes up to order  $\alpha_s^4$ . Special emphasis is put on the numerical evaluation of the master

integrals using the method of Mellin-Barnes integrals. We furthermore discuss the relation of the  $\overline{\text{MS}}$  mass to the other short-distance masses and comment on the uncertainty of the pole mass due to renormalon divergence.

T 40.5 Di 12:00 VSH 05

**Calibration of the top quark mass for Monte Carlo event generators** — ●BAHMAN DEHNADI<sup>1</sup>, ANDRE H. HOANG<sup>2</sup>, VICENT MATEU<sup>3</sup>, MORITZ PREISSER<sup>2</sup>, and IAIN W. STEWART<sup>4</sup> — <sup>1</sup>University of Siegen, Siegen, Germany — <sup>2</sup>University of Vienna, Vienna, Austria — <sup>3</sup>Universidad de Salamanca, Salamanca, Spain — <sup>4</sup>MIT, Cambridge, Massachusetts, USA

The most precise top quark mass measurements use direct reconstruction methods, determining the top mass parameter of a Monte Carlo event generator,  $m_t^{\text{MC}}$ . Due to hadronization and parton shower dynamics, relating  $m_t^{\text{MC}}$  to a field theory mass is difficult. We present a calibration procedure to determine this relation by exploiting hadron level QCD predictions for observables closely related to reconstruction. We demonstrate the procedure using fits to the 2-Jettiness distribution in  $e^+e^-$  annihilation and show the calibration results for  $m_t^{\text{MC}}$  in Pythia 8.205 for the MSR mass at the scale 1 GeV and the pole mass at NNLL+NLO accuracy. To the extent that a given MC makes consistent descriptions of experimental data for  $e^+e^-$  versus pp collisions our method may be used to calibrate measurements of  $m_t^{\text{MC}}$  in current LHC and Tevatron analyses in terms of field theory mass schemes.

T 40.6 Di 12:15 VSH 05

**The Matrix Element Method at next-to-leading order QCD at (hadron) colliders** — ●TILL MARTINI and PETER UWER — Humboldt-Universität zu Berlin, Germany

The Matrix Element Method (MEM) has proven beneficial to make maximal use of the information available in experimental data. However, so far it has mostly been applied in Born approximation only. In this talk we discuss the extension to NLO QCD accuracy. As a prerequisite we present an efficient method to calculate event weights for jet events at NLO accuracy. As illustration and proof of concept we apply the method to the measurement of the top-quark mass in single top production at the LHC. We observe significant differences when moving from LO to NLO which may be relevant for the interpretation of top-quark mass measurements at hadron colliders relying on the MEM.

## T 41: Beyond the Standard Model (Theorie) 2

Convenor: A. Kulesza, H. Rzehak

Zeit: Dienstag 11:00–12:30

Raum: VSH 19

T 41.1 Di 11:00 VSH 19

**Towards the next generation of simplified dark matter models at the LHC** — JAN HEISIG, MICHAEL KRÄMER, and ●PHILIPP MÜLLENDER — Institut für Theoretische Teilchenphysik und Kosmologie, RWTH Aachen, Deutschland

Simplified models have become a standard tool for a bottom-up exploration of dark matter models. However, in general simplified dark matter models do not respect gauge invariance and as a consequence perturbative unitarity may be violated for either too large couplings or too large center-of-mass energies. New mechanisms have to be introduced to these simplified extensions of the SM to ensure perturbative unitarity. One possible solution to these problems is to insist on gauge invariance in the introduced interactions. It is known that demanding gauge invariance strongly constrains the couplings of the mediator to the SM particles and to dark matter. Nevertheless, these models enrich the phenomenology of dark matter searches at the LHC and provide a more realistic ansatz to the underlying theory. We explore possible breakdowns of overly simplified dark matter models which are not UV complete and discuss the simplest completion to these models to ensure self-consistency.

T 41.2 Di 11:15 VSH 19

**NNLL-fast: Predictions for Squark and Gluino Production at the LHC with Soft and Coulomb Gluon Resummation** — WIM BEENAKKER<sup>1</sup>, ●CHRISTOPH BORSCHENSKY<sup>2</sup>, MICHAEL KRÄMER<sup>3</sup>, ANNA KULESZA<sup>4</sup>, and ERIC LAENEN<sup>5</sup> — <sup>1</sup>Radboud University Nijmegen, The Netherlands — <sup>2</sup>Eberhard Karls Universität

Tübingen — <sup>3</sup>RWTH Aachen — <sup>4</sup>WWU Münster — <sup>5</sup>Nikhef Theory Group, Amsterdam, The Netherlands

With the Large Hadron Collider (LHC) now operating at 13 TeV and extending its reach for new physics, the search for supersymmetry (SUSY) requires theoretical predictions to be more precise than ever. Beyond leading order in perturbation theory, large logarithmic terms arise which endanger the validity of the perturbative expansion in certain kinematic regions. Threshold resummation is a technique to sum these terms up to all orders in a systematic manner, restoring the predictive power and significantly impacting the production cross sections.

In my talk, I will present the program NNLL-fast, providing state-of-the-art cross sections and theoretical uncertainty estimates for the production of squarks and gluinos at the LHC. The cross sections include the resummation of soft gluons up to next-to-next-to-leading logarithmic accuracy as well as Coulomb and bound-state effects in the Mellin-moment space approach. The resummed corrections are positive and in general lead to a reduction of theoretical uncertainties with respect to previous results at lower accuracies.

T 41.3 Di 11:30 VSH 19

**Einfluss der CP-Verletzung auf die Masse und den Mischungscharakter des Dunkle-Materie-Kandidaten im MSSM** — ●PIA BREDT and GUDRID MOORTGAT-PICK — Universität, Hamburg, Deutschland

CP-verletzende Phasen haben Einfluss auf die Masse und den Mischungscharakter des leichtesten Neutralinos im MSSM. Dieses supersymmetrische Teilchen gilt mit einer bestimmten SUSY-

Parametereinschränkung als geeigneter Dunkle-Materie-Kandidat. Der Einfluss von CP-Phasen auf Masse und Mischungscharakter führt in manchen Fällen zu einer starken Abhängigkeit der berechneten Reliktdichte des Neutralinos von der CP-verletzenden Phase. Folglich kann der Beitrag der Neutralinodichte zur experimentell erforschten Dunkle-Materie-Dichte signifikant beeinflusst werden. Um dies zu untersuchen, werden Reliktdichten für zwei Szenarien auf Änderungen mit der Phase analysiert und diese anhand der Phasenabhängigkeit der Massen und der Mischungsanteile gedeutet.

T 41.4 Di 11:45 VSH 19

**Einfluss des Neutralino Mischungscharakters auf Vorhersagen der dunklen Materie im NMSSM** — ●SIMON SCHNAKE und GUDRID MOORTGAT-PICK — Universität Hamburg, Deutschland

Dunkle Materie ist eines der größten ungelösten Rätsel unserer Zeit. In etwa 80% der gravitativen Masse des Universums ist sie nicht sichtbar und ihre Natur und Eigenart ist größtenteils unbekannt. Dunkle Materie ist nicht im Standardmodell der Teilchenphysik enthalten. Eine Möglichkeit dunkle Materie zu beschreiben ist die Erweiterung des Standardmodells, beispielsweise mit supersymmetrischen Theorien, die sich unter anderem dadurch auszeichnen, dass sie ein leichtestes supersymmetrisches Teilchen (LSP) liefern, die einen ausgezeichneten Kandidaten für dunkle Materie darstellen. Wir konzentrieren uns in der gegenwärtigen Studie vor allem auf Parameterbereiche im Next-to-Minimal Supersymmetric Standard Model (NMSSM). In dieser Analyse ist der Kandidat für dunkle Materie das Neutralino, das einen vielschichtigen Mischungscharakter aufweisen kann. Um die Auswirkungen der Änderung von Parametern des NMSSM auf diesen Mischungscharakter, Coannihilationskanäle und den damit einhergehenden Vorhersagen für die Reliktdichte zu betrachten, wurde die Software micrOMEGAs genutzt. Im Rahmen einer Bachelor-Arbeit wurden interessante Bereiche des Parameterraumes diesbezüglich analysiert und werden hier vorgestellt.

T 41.5 Di 12:00 VSH 19

**Neutralino annihilation into a pair of gluons with DMNLO** — MICHAEL KLASSEN, KAROL KOVARIK, and ●OLEH FEDKEVYCH — Institute for Theoretical Physics, Wilhelm-Klemm-Str. 9 48149 Münster Germany

The Minimal Supersymmetric Standard Model (MSSM) is a well-motivated extension of the Standard Model with enlarged space-time symmetry group and a rich particle spectrum. If R-parity is conserved, the lightest MSSM particle cannot decay and represents a good cold

dark matter (CDM) candidate. A precise understanding of MSSM (co-)annihilation processes is then crucial to explain the amount of CDM we currently observe in the Universe.

The DM@NLO code is a numerical tool to compute (co-)annihilation cross-sections in the MSSM at next-to-leading order in  $\alpha_S$ . The current version includes the following classes of processes:

Gaugino pair-annihilation into quark pairs,  
gaugino-squark coannihilation into a quark and a gauge or Higgs boson, and  
squark-antisquark annihilation into electroweak final states.

We report on the implementation of neutralino annihilation into a pair of gluons. The corresponding one-loop diagrams are computed and implemented using the Passarino-Veltman reduction technique. We explore the importance of this process for the determination of relic density in the MSSM.

T 41.6 Di 12:15 VSH 19

**Departure from chemical equilibrium in dark matter co-annihilation** — MATHIAS GARNY<sup>1</sup>, JAN HEISIG<sup>2</sup>, ●BENEDIKT LÜLF<sup>2</sup>, and STEFAN VOGL<sup>3</sup> — <sup>1</sup>Technical University Munich — <sup>2</sup>RWTH Aachen — <sup>3</sup>Max-Planck-Institut für Kernphysik, Heidelberg

The observed dark matter density may be explained by the presence of a thermal relic which is often assumed to be a weakly interacting massive particle freezing out during an early stage of the hot universe. In theories beyond the standard model, like e.g. supersymmetry, regions with co-annihilations are of particular interest. They potentially allow us to reconcile the tightening limits from dark matter searches and the explanation of the observed relic density. In general, the evolution of the involved particle densities are described by a system of coupled Boltzmann equations. The standard method of solving these equations assumes chemical equilibrium between dark matter and co-annihilating particles. This assumption allows us to reduce the coupled system of differential equations to a single Riccati-like equation by summing over the whole sector of annihilating particles. The equation can then be solved numerically or e.g. in the freeze-out approximation. In this work, we investigate the validity of the assumption of chemical equilibrium during freeze-out and show examples where it breaks down and hence requires the solution of the full set of coupled differential equations. In particular, in the framework of a simplified dark matter model, we find examples where the standard method (assuming chemical equilibrium) undershoots the correct prediction for the relic density by orders of magnitude.

## T 42: Astroteilchenphysik/Kosmologie (Theorie) 1

Convenor: M. Garny, B. Herrmann

Zeit: Dienstag 11:00–12:00

Raum: VSH 17

T 42.1 Di 11:00 VSH 17

**Evolution of Chemical Potentials at Large Lepton Asymmetries** — ●MANDY M. WYGAS and DIETRICH BÖDEKER — Universität Bielefeld, Deutschland

An important phase in the early universe is the quark-hadron transition. It is well established that the order of the transition depends on the baryon density, or equivalently on the baryonchemical potential  $\mu_B$ . In the QCD phase diagram in the  $\mu_B - T$  plane, the cosmic QCD transition is commonly assumed to take place at vanishing baryonchemical potential  $\mu_B \approx 0$ . However, as the baryon chemical potential also depends on lepton flavour asymmetries, this is only valid for a total lepton asymmetry  $l$  of the order of the baryon asymmetry,  $|l| \approx \mathcal{O}(b)$ . While the magnitude of the baryon asymmetry,  $b \simeq 10^{-10}$ , can be determined by observations,  $l$  is only poorly constrained by observations and might be orders of magnitude larger than  $b$ ,  $|l| \lesssim 10^{-2}$ . Thus potentially large lepton flavour asymmetries induce a large  $\mu_B$ .

T 42.2 Di 11:15 VSH 17

**Gauge Corrections to Leptogenesis I** — FREDERIK DEPTA, ●ANDREAS HALSCH, and OWE PHILIPSEN — Institut für Theoretische Physik, Goethe-Universität Frankfurt, Max-von-Laue-Str. 1, 60438 Frankfurt am Main, Germany

An attractive scenario for baryogenesis in the early universe is provided by leptogenesis through the decay of heavy Majorana neutrinos and subsequent conversion of lepton number to baryon number. We consider

the quantum field theoretical calculation of the lepton asymmetry by solving Kadanoff-Baym equations as a systematic alternative to solving Boltzmann equations. In particular, we discuss the necessity for inclusion of gauge corrections and identify the relevant diagrams to be computed.

T 42.3 Di 11:30 VSH 17

**Gauge Corrections to Leptogenesis II** — ●FREDERIK DEPTA, ANDREAS HALSCH, and OWE PHILIPSEN — Institut für Theoretische Physik, Goethe-Universität Frankfurt, Max-von-Laue-Str. 1, 60438 Frankfurt am Main, Germany

We discuss a systematic calculation of gauge corrections to leptogenesis, which requires resummations for a consistent and complete evaluation of the leading order contribution in the framework of Kadanoff-Baym equations. The resulting lepton number matrix includes all leading order Standard Model gauge corrections. It consists of a multidimensional integral over solutions of partial differential equations. We present prospects for its numerical solution.

T 42.4 Di 11:45 VSH 17

**Nonequilibrium dynamics of inhomogeneous quantum fields** — ●THOMAS GARRATT — Julius-Maximilians-Universität Würzburg

The dynamics of inhomogeneous quantum fields out of equilibrium are especially relevant for the study of first-order phase transitions. It is our aim to calculate how critical bubbles of the new phase, that form in

such a process, propagate for different models. The Electroweak phase transition in the early universe is of particular interest, since Baryogenesis can potentially explain the matter-antimatter asymmetry in the Universe for fitting dynamical properties of the phase transition and the bubble collisions result in gravitational waves. To calculate the dy-

namics of quantum bubbles we have developed a computer program that solves the non-equilibrium equations of motion in the so called *2PI-Formalism*. As a starting point we have simulated the dynamics of bubbles in a scalar  $\lambda_4\phi^4 + \lambda_6\phi^6$  toy model in (1+1)-dimensions.

## T 43: Gasgefüllte Detektoren 2 (gemeinsam mit HK)

Zeit: Dienstag 11:00–12:30

Raum: F 102

T 43.1 Di 11:00 F 102

**The tracking system for NA64 at CERN SPS** — ●MICHAEL HÖSGEN, NA64 COLLABORATION, and BERNHARD KETZER — Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn, Deutschland

NA64 is a new experiment at CERN SPS, which conducts a direct search for invisible decays of sub-GeV dark photons ( $A'$ ). The  $A'$  might be produced by 100 GeV electrons incident on an active target Electromagnetic Calorimeter (ECAL) in the reaction  $e^-Z \rightarrow e^-ZA'$  via kinetic mixing with photons. The  $A'$ 's supposedly decay invisibly into dark matter particles resulting in a large amount of missing energy.

To verify the momentum of the incident electrons and to clean-up the event sample, tracking of the electrons is crucial for this experiment. The tracking system utilises four Micromegas (MM) and two Gas Electron Multiplier (GEM) detectors. The GEM detectors used in the tracking system have three  $10 \times 10 (cm)^2$  standard GEM foils and a two layer strip readout resulting in 256 channels per plane. As conversion gas an Ar/CO<sub>2</sub> (70/30) mixture is used. Tracks will be reconstructed using the tracking framework GENFIT II.

In this talk the performance of the tracking system, especially the GEMs, will be presented. I will also show new limits on the  $\gamma - A'$  mixing deduced from a first run in 2016.

T 43.2 Di 11:15 F 102

**Entwicklung und Beamtestergebnisse eines GEM-basierten TPC-Auslesesystems** — ●PAUL MALEK für die LCTPC-Deutschland-Kollaboration — Deutsches Elektronen-Synchrotron DESY — Universität Hamburg, Institut für Experimentalphysik

Für den *International Large Detector* (ILD) am geplanten *International Linear Collider* (ILC) ist eine Zeitprojektionskammer (*Time Projection Chamber*, TPC) als zentraler Spurdetektor geplant. Um die nötige Spurauflösung zu erreichen, ist ein Gasverstärkungs- und Auslesesystem mit mikrostrukturierten Gasdetektoren (*Micro Pattern Gaseous Detectors*, MPGD) vorgesehen. Eine der untersuchten Möglichkeiten für die Gasverstärkung und Detektion sind Gas-Electron-Multiplier (GEM).

In dem Beitrag wird ein GEM Modul vorgestellt, dass mit Hilfe von Keramikstrukturen eine sehr grosse Abdeckung der Fläche erreicht, bei gleichzeitiger Minimierung des Materials. Durch Entwicklung von geeigneten Prozeduren und Werkzeugen zur Produktion konnten die Parameter des Module wie Flachheit und Stabilität deutlich verbessert werden. Ergebnisse umfangreicher Messungen im DESY Teststrahl werden vorgestellt. Der Einfluss der besseren Modul Parameter auf Auflösung und insbesondere für die Messung des spezifischen Energieverlustes,  $dE/dx$ , werden diskutiert.

T 43.3 Di 11:30 F 102

**Study of electrostatic charge-up phenomena in Gas Electron Multipliers** — ●PHILIP HAUER, STEFFEN URBAN, MARKUS BALL, and BERNHARD KETZER — Helmholtz-Institut für Strahlen- und Kernphysik, Bonn, DE

Gas Electron Multipliers (GEM) are widely used as amplification stage in gaseous detectors exposed to high rates, e.g. in the Time Projection Chamber of the ALICE (A Large Ion Collider Experiment) experiment after its upgrade. The GEM consists of a polyimide foil which is coated by two thin copper layers. GEM have a high density of holes, where charges are multiplied if suitable voltages are applied. One critical property is the electrostatic charge-up of GEM. It occurs when the trajectories of drifting ions or electrons end on the polyimide surface. Since polyimide is a very good insulator, the charge remains there. The charge-up influences key properties of the GEM, e.g. the gain.

The characteristics of the charge-up process are studied in simulations. The electrostatic environment is calculated with a finite-element method. Afterwards, the movement of single particles in the electro-

static environment is simulated. The possibility to study the behaviour of single charges gives insight on the charge-up process. Furthermore, the simulated properties are cross-checked with measurements. Results of the measurements and simulations of the charge-up effect will be presented. Additionally, the influence of different parameters, e.g. the rate of incoming radiation, on the time constant of the charge-up process will be discussed.

Supported by BMBF.

T 43.4 Di 11:45 F 102

**Status of the Digitization for the Upgraded ALICE GEM-TPC** — ●ANDREAS MATHIS<sup>1</sup> and JENS WIECHULA<sup>2</sup> for the ALICE-Collaboration — <sup>1</sup>TU München, Physik Department E62, Excellence Cluster 'Universe', Garching — <sup>2</sup>Institut für Kernphysik, Goethe-Universität, Frankfurt am Main

The ALICE Collaboration is planning a major upgrade of its central barrel detectors to be able to cope with the increased LHC luminosity beyond 2019. In order to record at an increased interaction rate of up to 50 kHz in Pb–Pb collisions, the TPC will be operated in an ungated mode with continuous readout. This demands for a replacement of the currently employed gated Multi-Wire Proportional Chambers by GEM-based (Gas Electron Multiplier) readout chambers, while retaining the performance in particular in terms of particle identification capabilities via the measurement of the specific energy loss.

The increase in interaction rate and the requirements of a triggerless, continuous readout demand for significant modifications of the front-end cards, the computing system and the corresponding calibration, reconstruction and simulation framework. In particular, the upgraded readout scheme of the TPC with GEMs requires a complete re-design of the digitization, which includes a detailed simulation of the detector response after electron amplification in a stack of four GEM-foils.

This research was supported by the DFG cluster of excellence 'Origin and Structure of the Universe' and BMBF-Verbundprojekt ALICE at High Rate 05P15WOCA1.

T 43.5 Di 12:00 F 102

**Discharge studies with a double GEM setup** — ●ALEXANDRA DATZ<sup>1,2</sup> and ALEXANDER DEISTING<sup>1,2</sup> for the ALICE-Collaboration — <sup>1</sup>GSI, Darmstadt — <sup>2</sup>Physikalisches Institut, Heidelberg

The interaction rate of lead-lead collisions at the LHC will increase to 50 kHz during run 3. Hence an upgrade of the readout chambers of the Time Projection Chamber (TPC) of ALICE is necessary. New readout chambers equipped with stacks of four Gas Electron Multipliers (GEMs) have been developed. These allow for a continuous readout and preserve the momentum and  $dE/dx$  resolution of the current TPC. However, the new chambers have a higher risk to be damaged during a discharge than the current wire chambers. It has been confirmed at beam tests that the high voltage (HV) settings of the GEM stacks have a sufficiently low discharge probability. In order to understand the discharge mechanism and to further minimize the discharge probability, studies with small detectors have been carried out and will be presented here.

Our detector consists of two GEMs ( $10 \times 10 \text{ cm}^2$ ), a drift cathode and a readout plane. Discharges are triggered intentionally by increasing the voltage of one of the GEMs and releasing alpha particles in the gas (Ar-CO<sub>2</sub> 90-10). The potentials on the GEM sides and the signal at the readout plane are recorded to study the influence of different parameters, such as different resistors in the HV supply lines for the GEMs, on the discharge behavior. Results on secondary discharge probabilities are also shown.

T 43.6 Di 12:15 F 102

**GEM discharge protection with a resistive copper oxide layer** — ●OLEKSIY FEDORCHUK for the LCTPC-Deutschland-Collaboration

— Deutsches Elektronen-Synchrotron, Hamburg, Deutschland

For the International Large Detector (ILD) at the planned International Linear Collider (ILC) a Time Projection Chamber (TPC) is foreseen as the main tracking detector. The gas amplification will be done by Micro Pattern Gaseous Detectors (MPGD). One option is to use Gas Electron Multipliers (GEM). While the applicability of GEMs for the gas amplification in a TPC readout has been shown, the focus of the current research is to study the discharge processes and improve

the long term high voltage stability of the readout modules. This is a crucial requirement for the operation in the final ILD TPC.

The main focus of the research presented in this talk is on studies of the discharge stability and operational features of large area  $22 \times 18 \text{ cm}^2$  GEM foils. A novel treatment of the GEM foils by applying a resistive layer of copper oxide will be presented. The impact of this treatment on the high voltage stability and the GEM performance will be discussed. First results from using these GEMs in a prototype TPC will be presented.

## T 44: Pixeldetektoren 2 (gemeinsam mit HK)

Zeit: Dienstag 11:00–12:20

Raum: F 073

T 44.1 Di 11:00 F 073

**MuPix8 - a large HV-MAPS prototype** — ●HEIKO AUGUSTIN for the Mu3e-Collaboration — Physikalisches Institut, Universität Heidelberg

The Mu3e experiment is dedicated to the search for the lepton flavour violating decay  $\mu^+ \rightarrow e^+ e^- e^+$  with an unprecedented sensitivity of one in  $10^{16}$  decays. In the Standard Model this decay is suppressed to a branching ratio below  $10^{-54}$ . Thus, any observation of a signal is a clear sign for New Physics. To reach the sensitivity goal a pixel tracker with low material budget and high rate capability is required. The technology of choice are High Voltage Monolithic Active Pixel Sensors (HV-MAPS) produced in an AMS  $180 \text{ nm}$  HV-CMOS process.

The MuPix7 prototype showed the tremendous possibilities of this technology to build fast, monolithic pixel sensors of  $50 \mu\text{m}$  thickness.

In this talk the architecture of the first large  $2 \times 1 \text{ cm}^2$  prototype MuPix8 is presented. It houses three  $1.25 \text{ Gbit/s}$  data links and tests circuits for timewalk suppression, aiming to improve the time resolution below  $10 \text{ ns}$ .

Further the road map for the characterisation and future R&D towards the final pixel sensor for the Mu3e pixel tracker is depicted.

T 44.2 Di 11:15 F 073

**Large Area Monolithic Pixel Detectors for HL-LHC & Future High Rate Experiments** — ●TAMASI RAMESHCHANDRA KAR, ADRIAN HERKERT, and ANDRÉ SCHÖNING — Physikalisches Institut, Universität Heidelberg, Germany

The high luminosity upgrade of the LHC (HL-LHC) aims to increase the luminosity to five times the designed luminosity to explore and better understand several interesting physics processes. This poses several challenges to the present design of the detector due to increased occupancy, very high pileup ( $\sim 200$ ) and radiation dense environment.

Recent advancements in HV-CMOS technology gave birth to thin, radiation hard monolithic pixel detectors at a cost per unit area comparable to traditional strip detectors. This opens up the possibilities unthinkable in the past, e.g. it is possible to construct large area pixel detectors for experiments like ATLAS, CMS and other future collider experiments.

Track triggers are on the wish-list for many experiments as a key trigger to harvest interesting physics. A track trigger based on a triplet design comprising of three layers of monolithic pixel sensors is proposed for the ATLAS inner tracker. The feasibility of such a track trigger operated at the first level at  $40 \text{ MHz}$  is exploited based on a full Geant4 simulation. In addition a design proposal for such a triplet trigger using Mupix8, a first large High Voltage Monolithic Active Pixel Sensor (HV-MAPS) prototype will be presented.

### Gruppenbericht

T 44.3 Di 11:30 F 073

**The vertex detector of NA61/SHINE\*** — ●MICHAEL DEVEAUX for the NA61/SHINE-Collaboration — Goethe Universität Frankfurt

The vertex detector of NA61/SHINE at the CERN SPS aims to collect open charm data in Pb+Pb collisions at high SPS energies. In a first phase, the so-called Small Acceptance Vertex Detector (SAVD) was developed and installed. It consists of four layers of  $50 \mu\text{m}$  thin MIMOSA-26AHR CMOS sensors providing a spatial resolution of  $\sim 3.5 \mu\text{m}$ . The sensors are integrated on the new ultra-lightweight support and cooling carbon fiber structures developed for the ALICE ITS upgrade. The readout of the detector and the techniques for integrating the sensors

were derived from the prototype of the CBM Micro Vertex Detector.

We discuss the concept and design of the detector and show first results on the detector performance as obtained from a beam test with a  $150 \text{ A GeV}/c$  Pb+Pb beam carried out in December 2016. Moreover, we give an outlook toward the construction of a full vertex detector.

\* Supported by the Polish NCN (2014/15/B/ST2/02537), St-Petersburg Univ. (11.38.242.2015) and HIC for FAIR.

T 44.4 Di 11:50 F 073

**Performance Studies of Belle II DEPFET Pixel Ladders in Test Beams** — ●PHILIPP WIEDUWILT, ULF STOLZENBERG, HARRISON SCHREECK, BENJAMIN SCHWENKER, and ARIANE FREY — Georg-August-Universität Göttingen

The construction of the new  $e^+e^-$ -accelerator at the Japanese Flavour Factory (KEKB) has been finalized and the commissioning of its detector experiment (Belle II) is planned to be finished early 2017. The improved  $e^+e^-$  collider "SuperKEKB" will deliver an instantaneous luminosity of  $8 \cdot 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$ , which is 40 times higher than the world record set by KEKB. In order to be able to fully exploit the increased number of collision events, and to provide high precision measurements of the decay vertices of the B meson systems in such a harsh environment, the Belle II detector will be equipped with a newly developed silicon vertex detector, which is based on the DEPFET technology. The DEPFET pixels are field effect transistors on a fully depleted silicon bulk and they combine signal detection and amplification per pixel. The new pixel detector is located closest to the interaction point and consists of two layers of active pixel sensors. Belle II will use DEPFET sensors thinned to  $75 \mu\text{m}$  with low power consumption and low intrinsic noise. Beam test campaigns were conducted in order to study the performance of the pixel sensor modules. This talk will present the collected results of the April 2016 beam test and performance studies of the latest front-end read-out ASIC designs.

T 44.5 Di 12:05 F 073

**Evaluation of Innovative Cooling Concepts with High Performance Carbon Material for Vertex Detectors operated in Vacuum** — ●DANIELA MIJATOVIĆ for the CBM-MVD-Collaboration — Goethe-Universität Frankfurt

Vertex detectors operating in vacuum have to feature, besides a low material budget, also an excellent cooling performance to ensure the efficiency of the sensors. High-performance, carbon-based materials allow to resolve this contradiction, following the concept of heat conduction to guide the heat dissipated by the sensors to heat converters located outside the detector acceptance.

Sensor carrier materials based on graphite (e.g. low-cost Thermal Pyrolytic Graphite (TPG)) and Chemical Vapor Deposited (CVD) diamond were systematically studied. To do so, IR thermography is employed supplemented by PT100 sensors to quantitatively examine the thermal performance of MVD detector modules in vacuum. In addition, we compare the results with dedicated simulations (Autodesk CFD Motion) on the heat load of detector modules.

This contribution presents our work in designing and testing innovative carrier material assemblies to efficiently cool ultra-thin vertex detectors in the context of constructing the Micro-Vertex-Detector (MVD) for CBM at the future FAIR facility.

\* This work has been supported by BMBF (05P15RFFC1), GSI and HIC for FAIR.

## T 45: Detektorsysteme 1

Zeit: Dienstag 11:00–12:15

Raum: VSH 116

T 45.1 Di 11:00 VSH 116

**Quality assurance tests of scintillating fibres for the LHCb SciFi Tracker** — •LAURA GAVARDI<sup>1</sup>, JOHANNES ALBRECHT<sup>1</sup>, CHRISTIAN JORAM<sup>2</sup>, LUKAS GRUBER<sup>2</sup>, and ANA BARBARA RODRIGUES CAVALCANTE<sup>3</sup> — <sup>1</sup>TU Dortmund — <sup>2</sup>European Organization for Nuclear Research (CERN) — <sup>3</sup>Centro Brasileiro de Pesquisas Físicas (CBPF)

An upgrade of the LHCb detector is scheduled to take place during the long shutdown LS2 of the LHC in 2019 and 2020. The upgrade of the current downstream tracking system is the SciFi detector, a tracker composed of scintillating fibres read out by silicon photomultipliers. The SciFi project is currently undergoing a transition from the R&D phase to serial production. During this phase 11,000 km of scintillating fibres need to be geometrically refined while their quality is inspected by tests such as measurements of the attenuation length, light yield, diameter, cladding integrity and radiation hardness. In this talk the basic strategy and results of the quality assurance measurements will be presented, focusing on the radiation hardness test.

T 45.2 Di 11:15 VSH 116

**Simulation von szintillierenden Fasern für das LHCb Upgrade** — •MARTIN BIEKER, ROBERT EKEHOF, STEPHAN ESCHER und JULIAN WISHAHI — Experimentelle Physik 5, TU Dortmund

Im Rahmen des Upgrades des LHCb Experiments, geplant für das Jahr 2019, wird das bisherige Trackingsystem durch einen Subdetektor aus szintillierenden Fasern, ausgelesen durch Silicon Photomultiplier (SiPMs), ersetzt. Für diese Detektorkomponente werden Fasern aus einem szintillierenden Polymer mit einem Durchmesser von 0,25 mm zu Matten verklebt.

Zur Beurteilung und zur Optimierung der Leistungsfähigkeit dieses Trackers ist ein detailliertes Verständnis der Eigenschaften der verwendeten Fasern notwendig. Hierfür werden Simulationen eingesetzt, insbesondere wenn Messungen aufwendig oder nicht umsetzbar sind. Das trifft zum Beispiel auf die Wechselwirkung zwischen einzelnen Fasern, den so genannten Crosstalk, zu. In diesem Vortrag werden Ergebnisse verschiedener Simulationsstudien vorgestellt.

T 45.3 Di 11:30 VSH 116

**Scintillator tiles with SiPM readout for fast timing in SuperKEKB commissioning** — •HENDRIK WINDEL, MIROSLAV GABRIEL, MARGARETE KATTAU, NAOMI VAN DER KOLK, and FRANK SIMON — Max-Planck-Institut für Physik, München

For the first commissioning phase of the SuperKEKB collider from February to June 2016, a dedicated experimental setup was installed at the interaction point to study different backgrounds in dependence of accelerator parameters prior to the roll-in of the Belle II experiment in 2017. One of the subsystems of this BEAST II commissioning detector is CLAWS, a detector optimized for the study of the time structure of injection background. The CLAWS system used in the first commissioning phase consists of a total of 8 independent scintillator tiles, each with an embedded silicon photomultiplier for light readout. These de-

tectors are capable of sub-nanosecond time resolution for minimum ionizing particles, and provide the possibility to continuously record the waveform of the photon detector signal for several 10s of milliseconds, corresponding to thousands of turns of the accelerator. In this contribution, a detailed overview of the Claws setup and its calibration is given. In addition, the effects observed originating from the radiation exposure of the detectors will be discussed.

T 45.4 Di 11:45 VSH 116

**Entwicklung und Test eines auf szintillierenden Fasern basierenden Spurdetektors für das LHCb-Experiment** — •SIMON NIESWAND, ROMAN GREIM, WACLAW KARPINSKI, THOMAS KIRN, STEFAN SCHAEEL, ARNDT SCHULTZ VON DRATZIG, GEORG SCHWERING und MICHAEL WLOCHAL für die LHCb-Kollaboration — I. Physikalisches Institut, RWTH Aachen University

Am Large Hadron Collider am CERN untersuchen Wissenschaftler mithilfe komplexer Detektorsysteme die Vorhersagen des Standardmodells und suchen nach Anzeichen neuer physikalischer Phänomene. Eines dieser Systeme ist das LHCb-Experiment, welches gezielt für die Untersuchung seltener Zerfälle in der B-Physik konzipiert wurde.

Aufgrund der Erhöhung der Strahlenergie und der Luminosität des LHCs nach dem Long Shutdown 2 in 2018/19, müssen Teile des Detektors ausgetauscht und verbessert werden. Zu diesem Zweck wird derzeit ein neues, modulares Tracking-System entwickelt, welches auf szintillierenden Fasern (250  $\mu\text{m}$ ) basiert, die durch Silizium-Photomultiplier ausgelesen werden. Insgesamt werden für das Tracking-System 1024 sechslagige Fasermatten an mehreren Standorten produziert.

In diesem Vortrag werden die Teststände für die Qualitätskontrolle der Fasermatten vorgestellt und Ergebnisse präsentiert. Zu den überprüften Eigenschaften gehören beispielsweise Ortsauflösung, Effizienz und Lichtausbeute, zu deren Messung unter anderem Strahlentests am CERN durchgeführt wurden.

T 45.5 Di 12:00 VSH 116

**TORCH - a Cherenkov based Time-of-Flight PID Detector for the LHCb Upgrade at CERN** — •KLAUS FÖHL for the TORCH-Collaboration — now at II. Physikalisches Institut, Heinrich-Buff-Ring 16, Justus Liebig University Giessen, D-35392 Giessen

TORCH is proposed for the LHCb experiment at CERN to provide positive particle identification for low momentum (2 to 10 GeV/c) kaons, and is currently in the Research-and-Development phase. In general TORCH is a large-area (6 $\times$ 5 m<sup>2</sup>) precision time-of-flight DIRC-type detector wall, where a fraction of the produced Cherenkov light is propagating by total internal reflection inside a 10 mm thick amorphous fused silica radiator plate, and entering at the edges into readout optics that focusses them onto fast, position-sensitive single-photon detectors. An overview of the required large-scale focussing optics, the micro-channel plate photon sensor development, and the custom-made electronics will be given. Recent results achieved in the laboratory and in charged particle beam tests will be reported, and the latest developments towards a final full-scale module prototype will be introduced.

## T 46: Elektronik

Zeit: Dienstag 11:00–12:30

Raum: JUR 5

T 46.1 Di 11:00 JUR 5

**KLauS: A low power Silicon Photomultiplier Charge Readout ASIC in 0.18 $\mu\text{m}$  UMC CMOS Technology** — •KONRAD BRIGGL for the CALICE-D-Collaboration — KIP, Universität Heidelberg

The CALICE collaboration is developing highly granular calorimeters for future linear collider experiments. The high channel count, as well as the little space for cooling infrastructure, pose stringent requirements on the integrated readout electronics, limiting the allowed power consumption to 25  $\mu\text{W}$  per channel by the use of powergating techniques. We present the development of KLauS, a low power mixed mode ASIC for charge readout of Silicon Photomultipliers (SiPMs). The analog front-end is designed to achieve sufficient signal to noise ratio for single pixel signals using novel low-gain SiPMs, while allowing charge measurements over the full dynamic range of these sensors. It

consists of an input stage, two charge measurement branches and a fast comparator for timestamping and autotriggered operation. A successive approximation register (SAR) ADC with a resolution of 10 bits was implemented to digitize the pulse height informations. An additional pipelined SAR stage allows to increase the quantization resolution to 12 bit in order to digitize single pixel charge spectra. Characterization measurements and design details of a 7 channel mixed signal prototype ASIC will be presented.

T 46.2 Di 11:15 JUR 5

**MuTRiG: a Mixed-Signal SiPM Readout ASIC with High Timing Resolution and High Event Rate Capability** — •HUANGSHAN CHEN, KONRAD BRIGGL, PATRICK ECKERT, TOBIAS HARION, YONATHAN MUNWES, WEI SHEN, VERA STANKOVA, and

HANS-CHRISTIAN SCHULTZ-COULON for the Mu3e-Collaboration — Kirchhoff Institut für Physik, Heidelberg University, Heidelberg, Germany

MuTRiG is a mixed-signal Silicon Photomultiplier readout ASIC developed in UMC 180 nm CMOS technology. It is dedicated to the readout of the tile detector and the fiber detector of the Mu3e experiment. A good timing resolution of 100 ps ( $\sigma$ ) and 500 ps ( $\sigma$ ) is required for the Mu3e tile detector and the Mu3e fiber detector respectively, in order to reduce the accidental background at high rates. An event rate as high as 1.3 MHz/channel in the Mu3e fiber detector poses another challenge for the development of MuTRiG. MuTRiG is designed with 32 fully differential analog front-end channels and 50 ps time binning TDCs, which both have been extensively characterized in STiCv3 ASIC and have proven an excellent timing resolution. The recorded event data are processed by the integrated digital circuits and transferred to the data acquisition system (DAQ) via a gigabit LVDS data link with 8b/10b encoding. The gigabit data link is accomplished by a dedicated double data rate serializer and a customized LVDS transmitter. An external validation functionality is implemented to reduce the load of data link. The design of the MuTRiG chip and the characterization results of the analog front-end, TDC and the gigabit data link will be presented.

T 46.3 Di 11:30 JUR 5

**Design of the new testboard for the SPIROC2e BGA package** — •AMINE ELKHALIL for the CALICE-D-Collaboration — Wuppertal University

The CALICE Collaboration is developing calorimeters for a future  $e^+e^-$  linear collider. These calorimeters have a high granularity in order to allow Particle Flow Analysis and to achieve a jet energy resolution of 3-4%. One of these concepts is the Analog Hadronic Calorimeter (AHCAL) based on  $3 \times 3 \times 0.3 \text{ cm}^3$  scintillator tiles with individual Silicon Photo-multiplier (SiPM) readout. A former physics prototype of the AHCAL has proven the performance and suitability of a such concept. The current focus of the second generation engineering prototype is to have a  $1 \text{ m}^3$  detector, which is fully scalable to a linear collider detector with all its constraints. A huge amount of components have therefore to be tested before assembly, including the SPIROC ASIC developed by Omega. This chip provides the readout for 36 SiPMs, including individual bias voltages, self-triggering, timing measurements and 12-bit signal resolution, while maintaining a very low power consumption of  $25 \mu\text{W}$  per channel. Around 1000 of these ASICs have to be characterised and tested for the prototype in 2017. This talk will focus on the development of the test stand and the first results on the testing and characterisation of the chips.

T 46.4 Di 11:45 JUR 5

**Design and evaluation of a versatile sub-ns LED pulser** — •MARTIN RONGEN and MERLIN SCHAUFEL — III. Physikalisches Institut, RWTH Aachen

Many experimental setups for the calibration of photosensors require light sources with sub-nanosecond timing precision. Such sources are commercially available. However, often their costs prohibit applications with large numbers of sources. In contrast, simple circuits commonly used in the community, such as the Kapustinsky pulser, are limited to

light pulses of few nanosecond duration. In this talk we present the design and evaluation of a sub-nanosecond light pulser based on an avalanche transistor. The choice of LED paired with variable biasing allows for a wide range of output intensities at an arbitrary wavelength. This device will be used for the timing calibration of photosensors for IceCube-Gen2 and the IceAct air Cherenkov telescope.

T 46.5 Di 12:00 JUR 5

**Online Track and Vertex Reconstruction on GPUs for the Mu3e Experiment** — •DOROTHEA VOM BRUCH for the Mu3e-Collaboration — Institut für Kernphysik, Johannes Gutenberg-Universität Mainz

The Mu3e experiment searches for the lepton flavour violating decay  $\mu^+ \rightarrow e^+e^-e^+$ , aiming at a branching ratio sensitivity better than  $10^{-16}$ . To reach this sensitivity, rates above  $10^9 \mu/s$  are required. A high precision silicon tracking detector combined with excellent timing resolution from scintillating fibers and tiles will measure the momenta, vertices and timing of the decay products of muons stopped in the target to suppress background.

During the first phase of the experiment, a rate of  $10^8 \mu/s$  will be available, resulting in a data rate of  $\sim 10 \text{ GB/s}$  of zero-suppressed data. The trigger-less readout system consists of optical links and switching FPGAs sending the complete detector data for a time slice to one node of the filter farm. As we can only store  $\sim 100 \text{ MB/s}$  of data, a full online reconstruction is necessary for an event selection. The highly parallel structure of graphics processing units (GPUs) is ideal for this purpose. An FPGA inside the filter farm PC therefore transfers the event data to the GPU via PCIe direct memory access. The GPU finds and fits tracks using a 3D tracking algorithm for multiple scattering dominated resolution. In a second step, a three track vertex selection is performed, reducing the output data rate to below  $100 \text{ MB/s}$  by removing combinatorial background. The talk discusses the implementation of the track fit and vertex selection on the GPU.

T 46.6 Di 12:15 JUR 5

**Flexprint Design Studies for the Mu3e Experiment** — •JENS KRÖGER for the Mu3e-Collaboration — Physikalisches Institut, Universität Heidelberg

The Mu3e experiment will search for the lepton-flavour violating decay  $\mu^+ \rightarrow e^+e^-e^+$  with a sensitivity of one in  $10^{16}$  decays. To reach this sensitivity, an excellent momentum resolution as well as a very good vertex reconstruction are crucial. Since the muons will be stopped before decaying, their decay products will have very low momenta. Hence multiple scattering is a major issue that is tackled by minimizing the material budget of the tracking detector. In order to achieve this, the silicon pixel sensors will be thinned to  $50 \mu\text{m}$  and mounted on flexprints consisting of very thin Kapton and aluminium (and possibly copper) traces for signals, power and ground. The material budget of the flexprints will be less than 0.5 % of the radiation length of aluminium.

This talk will cover the design of the Mu3e pixel detector, focussing on the use of flexprints for the readout and supply of the pixel sensors. Results from measurements with flexprint prototypes as well as future designs will be discussed.

## T 47: Eingeladene Vorträge 1

Zeit: Dienstag 14:00–16:15

Raum: H 1

### Eingeladener Vortrag

T 47.1 Di 14:00 H 1

**ATLAS Search for Scalar Leptoquarks at  $\sqrt{s} = 13 \text{ TeV}$**  — •RUTH PÖTTGEN — Universität Stockholm

In the Standard Model, there are many striking similarities between the quark and the lepton sector, like the number of families and the mass hierarchy between them. Leptoquarks are hypothetical particles that occur in various models for physics beyond the Standard Model and provide a connection between the two sectors. They are commonly assumed to couple to quarks and leptons of the same fermion generation but this need not be the case. This contribution gives an overview of the motivation for and presents important aspects of the search for scalar leptoquarks performed by the ATLAS collaboration using proton-proton collision data collected at a centre-of-mass energy of  $\sqrt{s} = 13 \text{ TeV}$ .

### Eingeladener Vortrag

T 47.2 Di 14:27 H 1

**Search for new physics with leptons in the final state** — •SWAGATA MUKHERJEE — RWTH Aachen, 3A

Numerous new physics models predict the existence of heavy particles decaying to leptonic final states. Experimental signatures involving leptons are one of the cleanest probes of new physics at the LHC. This talk presents searches for physics beyond the standard model in final states with leptons (including hadronically decaying tau leptons) with the CMS detector, focusing on the recent results obtained using the data collected during the 2016 proton-proton run of the LHC at the centre of mass energy of  $13 \text{ TeV}$ .

### Eingeladener Vortrag

T 47.3 Di 14:54 H 1

**Suche nach vektorartigen Quarks mit Zerfällen in geboos-**

**teten Endzuständen mit dem ATLAS-Experiment** — ●JANET DIETRICH — Humboldt-Universität zu Berlin

Die im Jahre 2015/2016 mit dem ATLAS-Detektor am LHC genommenen Daten bei einer Proton-Proton-Schwerpunktsenergie von 13 TeV ermöglichen die Suche nach neuer Physik auf der TeV-Skala und erlauben erstmals einen Blick auf vorher nicht zugängliche Phasenraumbereiche. Vektorartige Quarks, die überwiegend an die dritte Quarkgeneration koppeln, sind die einfachste Ergänzung von farbgeladenen Fermionen zum Standardmodell. Sie sind experimentell noch nicht ausgeschlossen und werden von einer Vielzahl von möglichen Standardmodellerweiterungen wie zum Beispiel Composite-Higgs-Modellen vorhergesagt. Der Fokus dieses Vortrages liegt auf der Suche nach schweren vektorartigen Quarks, die in Top- oder Bottomquarks und W-, Z- oder Higgs-Bosonen mit großen Impulsen zerfallen. Es werden exemplarisch einige Analysen, sowie deren experimentelle Herausforderungen in der Rekonstruktion dieser Zerfallsprodukte diskutiert. Kurz vor dem LHC-Neustart nach der Winterpause 2016/2017 werden außerdem die aktuellen Massen- und Kopplungsausschlussgrenzen vorgestellt und erörtert.

**Eingeladener Vortrag** T 47.4 Di 15:21 H 1  
**Falsifying High-Scale Baryogenesis** — ●JULIA HARZ — Sorbonne Universités, Institut Lagrange de Paris (ILP), 98bis Boulevard Arago, F-75014 Paris, France — Sorbonne Universités, UPMC Univ Paris 06, UMR 7589, LPHE, F-75005 Paris, France — CNRS, UMR 7589, LPHE, F-75005 Paris, France

One of the open fundamental questions which points towards physics beyond the standard model is the baryon asymmetry of our Universe, which can be experimentally quantified by the baryon-to-photon ratio. Given the multiplicity of models, a way to push our field further is to think about strategies how to test or at least to falsify certain ideas or theories. I will give a brief overview of different ways to di-

rectly test certain models of leptogenesis. Mainly, I will focus on model independent approaches combining LHC physics, neutrinoless double beta decay, and searches for lepton flavour violation in order to falsify high-scale models of baryogenesis. I will conclude by commenting on their limitations.

**Eingeladener Vortrag** T 47.5 Di 15:48 H 1  
**The COSINUS project - development of new NaI-based detectors for direct dark matter search** — ●KAROLINE SCHÄFFNER — Gran Sasso Science Institute, L'Aquila, Italy

Dark matter makes up more than a quarter of the matter-energy composition of the Universe and until today its presence is discerned by gravitational interactions only. Remarkably though, several direct dark matter searches, in particular the DAMA/LIBRA experiment, observe an annual modulation signal which matches the expected signal from particle dark matter, but is inconsistent with null-results of most other direct dark matter searches. Since different experiments use diverse target materials, a direct comparison of their results is only possible if taking into account certain assumptions. So, the only way of providing a model independent cross-check of the DAMA/LIBRA dark matter claim is the use of the same target material, but in a different experiment. Within the COSINUS project we aim to develop a cryogenic scintillating calorimeter operated at around ten milli-Kelvin using undoped sodium iodide (NaI) scintillating crystals as target for direct dark matter search which allows for a direct comparison to DAMA/LIBRA, and the additional and unique feature of providing a lower nuclear recoil threshold combined with particle discrimination. In this talk I will give an introduction to low temperature detectors and their potential in the field of rare event searches. Furthermore, I will discuss in detail the COSINUS detector concept and the differences to already existing NaI-based detectors. I will conclude with achieved results within the first year of the project and its future perspectives.

## T 48: Eingeladene Vorträge 2

Zeit: Dienstag 14:00–16:15

Raum: H 3

**Eingeladener Vortrag** T 48.1 Di 14:00 H 3  
**Status of the neutrino mass experiment KATRIN** — ●FLORIAN FRÄNKLE for the KATRIN-Collaboration — Institute for Nuclear Physics, Karlsruhe Institute of Technology (KIT)

The Karlsruhe TRitium Neutrino (KATRIN) experiment is a large-scale experiment with the objective to determine the effective electron anti-neutrino mass with an unprecedented sensitivity of 200 meV/c<sup>2</sup> at 90% CL in a model-independent way. The measurement method is based on precision  $\beta$ -decay spectroscopy of molecular tritium. The experimental setup consists of a high luminosity windowless gaseous tritium source, a magnetic electron transport system with differential and cryogenic pumping for tritium retention, and an electro-static spectrometer section for energy analysis, followed by a segmented detector system for counting transmitted  $\beta$ -electrons. First commissioning measurements of the complete beamline were performed in November 2016.

This talk will give an overview of the current status of the KATRIN experiment and will present results from the first beamline commissioning measurements.

This work is supported by KSETA, BMBF (05A14VK2), HAP, US DOE (DE-FG02-97ER41020) and the Helmholtz association.

**Eingeladener Vortrag** T 48.2 Di 14:27 H 3  
**The search for neutrinoless double beta decay with EXO-200 and nEXO** — ●THILO MICHEL — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg  
 Are neutrinos Dirac- or Majorana-fermions? Still today, this question has not been answered although huge efforts have been made to search for neutrinoless double beta decay which is the most practical way to get an answer. Furthermore, a possible detection of this decay could give valuable information about the masses of the neutrino mass eigenstates as the half-life depends on the effective Majorana neutrino mass. The Enriched Xenon Observatory EXO-200 has carried out one of the most sensitive searches for this decay channel in <sup>136</sup>Xe with two years of data. The EXO-200 detector is a double-sided, single-phase liquid xenon time-projection-chamber. EXO-200 started a second phase of data taking in April 2016. The next-generation, tonne-scale experiment

nEXO is the successor of EXO-200. With its single-sided, single-phase time-projection-chamber filled with 5 tonnes of enriched liquid xenon nEXO will be able to probe the possible effective Majorana neutrino masses in the inverted mass hierarchy regime. Light-detection in nEXO will be carried out with silicon photomultipliers. The charge measurement will be realized with a checkerboard style electrode matrix. With the projected energy resolution of 1% ( $\sigma$ ) at the Q-value of the decay, nEXO aims at a half-life sensitivity of  $6.2 \times 10^{27}$  years at 90% C.L. after 5 years of measuring time. In this talk, the EXO-200 experiment and the development of nEXO will be presented.

**Eingeladener Vortrag** T 48.3 Di 14:54 H 3  
**Top-Antitop Pair Production Near Threshold in Electron-Positron Annihilation** — ●JAN PICLUM — Universität Siegen, Siegen, Germany

A future electron-positron collider like the envisioned International Linear Collider will offer the possibility to measure the cross section for the production of top-antitop quark pairs close to the production threshold with high precision. From a comparison of the measured cross section to a theoretical calculation, one can then determine properties of the top quark like its mass and decay width. This requires a precise prediction of the cross section, which makes it necessary to compute it to high order in perturbation theory. In this talk I will explain the effective theory framework that is employed in this calculation and present results at next-to-next-to-next-to-leading order in QCD. I will also discuss the inclusion of electroweak corrections, for example due to virtual Higgs bosons, which are also important at this level of precision.

**Eingeladener Vortrag** T 48.4 Di 15:21 H 3  
**Ausblick auf Neue Physik durch das Higgs-Fenster** — ●OLEG BRANDT — Universität Heidelberg, Kirchhoff-Institut für Physik

Als eine der am wenigsten erforschten Regionen des Standardmodells ist der erst einige Jahre junge Higgs-Sektor sehr bedeutend als "Fenster" für Suchen nach Neuer Physik. Viele Erweiterungen des Standardmodells sagen erhöhte Raten für die paarweise Produktion von Higgs-Bosonen und/oder ihre assoziierte Produktion mit elektroschwa-

chen Eichbosonen voraus; ferner fungiert das Higgs-Boson in vielen potentiellen Szenarien als Portal zwischen Teilchen des Standardmodells und Dunkler Materie. In diesem Vortrag werden Suchen nach Neuer Physik im Higgs-Sektor in Proton-Proton-Kollisionen bei 13 TeV mittels des ATLAS-Detektors vorgestellt; ein besonderer Fokus wird auf hadronische Endzustände, die das höchste Verzweungsverhältnis und damit oft die höchste Sensitivität auf Neue Physik in sich vereinen, gelegt.

**Eingeladener Vortrag** T 48.5 Di 15:48 H 3  
**Measuring the Higgs Self-coupling at the International Linear Collider** — •CLAUDE DÜRIG — DESY, Hamburg Germany

Since the discovery of the Higgs boson at the LHC in 2012, the precise exploration of the Higgs sector is one of the key goals of future particle collider experiments. A planned next generation particle collider project is represented by the International Linear Collider (ILC), offering model-independent precision measurements of particle properties.

The Higgs physics programme of the ILC includes a model-independent precision measurement of the Higgs self-coupling, which can either verify the SM mechanism of electroweak symmetry breaking or uncover new physics. At a centre-of-mass energy of 500 GeV information on the Higgs self-coupling can be extracted from a model-independent cross-section measurement of double Higgs-strahlung ZHH. However, the small signal production cross section poses challenges to the detector and event reconstruction techniques.

The prospects of the Higgs self-coupling measurement at the ILC in the context of a 20-year-long physics programme are studied in a full detector simulation for a 125 GeV Higgs boson, using TDR detector parameters. In this presentation, recent results of the Higgs self-coupling measurement and its connection to new physics are outlined. We also discuss the prospects of an 1 TeV energy upgrade, which offers complementary capabilities for the observation of double Higgs production and the Higgs self-coupling. This contribution gives an overview of the study, focussing on the application of kinematic fits.

## T 49: Higgs-Boson 4 (Zerfälle in Fermionen)

Zeit: Dienstag 16:45–19:00

Raum: JUR 3

T 49.1 Di 16:45 JUR 3  
**Search for neutral Higgs Bosons Production in Final States with b-quarks in the semi-leptonic channel** — •ANTONIO VAGNERINI — Desy

The LHC discovery of a Standard-Model like Higgs particle in 2012 motivates searches of additional Higgs bosons predicted both in the Minimal-Supersymmetry Extension of the SM and the two-Higgs doublet model. These are characterised by heavy Higgs states with large branching fractions for decays into b-quarks. This analysis focuses on the semi-leptonic channel, which has significantly lower trigger rates for low transverse momentum ( $p_T$ ) jets than the full-hadronic channel. B-hadrons have a large component of semi-leptonic decays, hence the presence of muons in final states is a probe for b-tagging. The new upgraded semi-leptonic trigger development and validation is also presented. Finally, we determine upper limits in the sensitivity analysis to complement and extend the reach of the high- $p_T$  jet full-hadronic analysis.

T 49.2 Di 17:00 JUR 3  
**Lorentzinvariante Observablen für die Messung des Standardmodell- $H \rightarrow b\bar{b}$ -Zerfalls mit ATLAS** — ALESSANDRA BETTI, GÖTZ GAYCKEN, •STEPHAN HAGEBÖCK, RUTH JACOBS, VADIM KOSTYUKHIN, TATJANA LENZ, ALEXANDER MELZER, ELISABETH SCHOPF, ECKHARD VON TÖRNE und NORBERT WERMES — Physikalisches Institut, Universität Bonn

Seitdem im Jahr 2012 das Higgs-Boson von ATLAS und CMS entdeckt wurde, konnte nicht nachgewiesen werden, dass es in  $b$ -Quarks zerfällt. Das Standardmodell sagt bei einer Masse von 125 GeV ein Verzweungsverhältnis von 58% vorher. Obwohl  $H \rightarrow b\bar{b}$  damit der wahrscheinlichste Zerfall ist, ist er wegen des enormen  $b$ -Jet Untergrundes am LHC schwierig zu messen.

In diesem Vortrag wird eine ATLAS-Analyse vorgestellt, die sich auf die Higgs-Produktion in Assoziation mit leptonisch zerfallenden W- oder Z-Bosonen beschränkt. Auf den Daten des Jahres 2012 werden Boosted Decision Trees mit Lorentzinvarianten Observablen verwendet, um die Signalstärke von  $H \rightarrow b\bar{b}$ -Zerfällen zu messen.

T 49.3 Di 17:15 JUR 3  
**Search for the  $H \rightarrow b\bar{b}$  and  $H \rightarrow c\bar{c}$  decay in associated production with vector bosons using ATLAS run 2 data** — •ELISABETH SCHOPF, NORBERT WERMES, TATJANA LENZ, GÖTZ GAYCKEN, VADIM KOSTYUKHIN, STEPHAN HAGEBÖCK, RUTH JACOBS, ALESSANDRA BETTI, ALEXANDER MELZER, and ECKHARD VON TÖRNE — Physikalisches Institut, Nussallee 12, 53115 Bonn

After the discovery of the Higgs boson in 2012 in the  $\gamma\gamma$ ,  $ZZ$  and  $WW$  decay channels the hunt for the Higgs boson in fermionic decay channels continues up to this day. In particular, no evidence was found using LHC run 1 data in the decay channel with the highest branching ratio of 56%,  $H \rightarrow b\bar{b}$ .

This talk will present the latest ATLAS results of the  $V(H \rightarrow b\bar{b})$  search using  $13.2 \text{ fb}^{-1}$  LHC data collected at a collision energy of 13 TeV. It will introduce the multivariate analysis that was utilised as

well as new ideas and techniques for the complete LHC run 2 dataset. In addition, a new analysis searching for the  $V(H \rightarrow c\bar{c})$  decay is introduced and an outlook will be given.

T 49.4 Di 17:30 JUR 3  
**Analyse von  $H \rightarrow b\bar{b}$  Zerfällen mit dem topologischen Prozessor des Level 1-Triggers bei ATLAS** — •JOHANNES DAMP, SEBASTIAN ARTZ, VOLKER BÜSCHER, FRANK FIEDLER und CHRISTIAN SCHMITT — Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 7, 55099 Mainz

Im Jahr 2012 wurde durch die Auswertung bosonischer Zerfallskanäle ein Boson entdeckt, welches kompatibel mit den Vorhersagen des Standardmodells für das Higgs-Boson ist. Um die Eigenschaften dieses Bosons vollständig zu untersuchen, ist es notwendig, sämtliche Zerfallskanäle zu betrachten, insbesondere auch die fermionischen Kanäle.

Im Standardmodell ist der Zerfall  $H \rightarrow b\bar{b}$  mit einem Verzweungsverhältnis von  $\sim 57\%$  dominant. Eine Untersuchung dieses Zerfalls ist aufgrund des dominanten QCD-Multijetuntergrundes jedoch schwierig. Ein möglicher Lösungsansatz ist die Analyse assoziierter Higgsproduktion mit einem Vektorboson, indem leptonische Zerfallskanäle des Vektorbosons im Trigger zur Untergrundunterdrückung verwendet werden.

In diesem Vortrag wird ein neuer Ansatz vorgestellt, welcher zur Untersuchung rein hadronischer Produktion den topologischen Prozessor des Level 1-Triggers am ATLAS-Experiment verwendet. Da dieses Modul programmierbar ist, können online Histogramme erzeugt und gespeichert werden, es kann also eine Analyse ohne die Notwendigkeit einer Triggerselektion durchgeführt werden. In diesem Vortrag wird eine Machbarkeitsstudie vorgestellt, welche Ansätze zur Identifizierung von  $b$ -Jets und zur Behandlung verschiedener Untergründe diskutiert.

T 49.5 Di 17:45 JUR 3  
**Embedding - A data driven  $Z \rightarrow \tau\tau$  estimation method for  $H \rightarrow \tau\tau$**  — •JANEK BECHTEL, STEFAN WAYAND, ARTUR AKHMETSHIN, ROGER WOLF, and GÜNTER QUAST — Institut für Experimentelle Kernphysik, Karlsruher Institut für Technologie, Karlsruhe

The decay of the Higgs boson into  $\tau$ -leptons is the easiest accessible signal to examine the coupling of the Higgs boson to fermions. The largest irreducible background for this signature results from  $Z$  bosons in the same decay channel. *Embedding* is a data driven method to model this background. Here, muons originating from  $Z \rightarrow \mu\mu$  events are replaced by simulated  $\tau$ -leptons. Compared to a full Monte Carlo background estimation, this method benefits from using data and thus reducing background uncertainties. To guarantee a good performance of this technique, a deep understanding of the event reconstruction with the CMS detector is required. In this talk, major developments, current results using 2016 data, and applications of the *embedding* technique are presented.

T 49.6 Di 18:00 JUR 3  
**Z+jets modelling and systematics uncertainties for the SM  $H \rightarrow \tau\tau$  analysis** — •THÉO MEGY, LEI ZHANG, KARSTEN KÖNEKE, and KARL JAKOBS — Albert-Ludwigs-Universität Freiburg



The  $Z \rightarrow \tau\tau$  process is an important and irreducible background in the analysis searching for  $H \rightarrow \tau\tau$  decays. It is therefore crucial to understand this process well and validate the simulation of this process with suitable data control regions. However, no such control region with sufficient purity is available in data.

Assuming that the  $Z \rightarrow \tau\tau$  and  $Z \rightarrow \ell\ell$  processes have identical kinematics regarding the production of the  $Z$  boson, it is possible to validate this aspect of the  $Z \rightarrow \tau\tau$  process using a pure  $Z \rightarrow \ell\ell$  data control region containing a large number of such events. Utilizing these events, one can derive corrections to the simulated  $Z \rightarrow \tau\tau$  sample, including corresponding systematic uncertainties of such corrections. The status of these studies will be presented in this talk.

T 49.7 Di 18:15 JUR 3

**Suche nach dem SM Higgs-Boson in  $H \rightarrow \tau_{had}\tau_{had}$  Zerfällen bei  $\sqrt{s} = 13$  TeV  $pp$  Kollisionen mit ATLAS** — ULLA BLUMENSCHNEIN, •ERIC DRECHSLER, ARNULF QUADT und ZINONAS ZINONOS — II. Physikalisches Institut, Georg-August-Universität Göttingen

In den Jahren 2015 und 2016 wurde der LHC nach einer Upgradepause mit einer erhöhten Schwerpunktsenergie von  $\sqrt{s} = 13$  TeV betrieben. Mit einem optimierten Detektorsetup gelang es der ATLAS-Kollaboration, eine Datenmenge von  $36.0 \text{ fb}^{-1}$   $pp$ -Kollisionen aufzuzeichnen.

Ein wichtiges experimentelles Ziel des ATLAS-Experiments im zweiten LHC-Lauf ist die Beobachtung des Higgs-Bosons im Zerfall in zwei  $\tau$ -Leptonen. Nach der Entdeckung in bosonischen Zerfällen ist der Zerfall in Fermionen ein wichtiger Schlüssel zum Verständnis der Natur des Higgs Teilchens und dessen Kopplungseigenschaften.

Die Etablierung einer solchen, statistisch signifikanten Beobachtung setzt eine korrekte Identifizierung und Rekonstruktion von  $\tau$ -Leptonen unter den experimentellen Neuerungen voraus. Zusätzlich erfordert das höherenergetische kinematische Regime analysespezifische Optimierungen und neue schnittbasierte sowie multivariate Strategien.

Dieser Vortrag stellt eine Zusammenfassung der Suche nach dem Prozess  $H \rightarrow \tau_{had}\tau_{had}$  in  $\sqrt{s} = 13$  TeV dar. Es wird eine Übersicht über die Strategie, den aktuellen Stand der Analyse, sowie den Zielsetzungen geboten.

T 49.8 Di 18:30 JUR 3

**Measurement of quark and gluon fake rates for hadronically decaying tau leptons with the ATLAS experiment** — •TIMO DREYER, STAN LAI, and MICHEL JANUS — II. Physikalisches Institut, Georg-August-Universität Göttingen

The tau lepton is the heaviest lepton in the Standard Model and therefore an important probe for physics at high energy scales. Due to its high mass, it has a strong coupling to the Higgs boson, which makes the decay mode  $H \rightarrow \tau\tau$  one of the best candidates for the measurement of the Higgs boson coupling to fermions.

For all signatures involving hadronically decaying tau leptons, it is important to have a good understanding of the tau reconstruction and identification algorithms that are used for data analysis in the ATLAS experiment. In particular, the probability for jets originating from quarks and gluons to be misidentified as hadronically decaying tau leptons (the so-called *fake rate*), is important for background estimation from a variety of sources. This fake rate depends on kinematic variables, as well as the quark-gluon composition of the process in question.

This talk presents an approach to measure the fake rate using the tag-and-probe technique in two kinematic regions in 13 TeV ATLAS data. In addition, a template fit is used to determine the fraction of quark- and gluon-initiated jets in the regions. These two measurements are combined in an attempt to extract pure quark and gluon fake rates.

T 49.9 Di 18:45 JUR 3

**Optimization studies for the event selection in the  $H \rightarrow \tau_{lep}\tau_{lep}$  decay channel at  $\sqrt{s} = 13$  TeV with the ATLAS detector** — •BENJAMIN ROTTLE, MARKUS SCHUMACHER, and DUC BAO TA — Physikalisches Institut, Universität Freiburg

The analysis of the decay of the Higgs boson to  $\tau$  leptons allows the determination of the  $\tau$  lepton Yukawa coupling as well as the coupling strength and structure of the Higgs boson to weak gauge bosons and gluons.

With the data collected in Run-1 of the LHC the ATLAS and CMS experiments individually observed evidence for the Higgs to tau decay. Due to the larger integrated luminosity in Run-2 and the enhanced cross section at  $\sqrt{s} = 13$  TeV an observation of the  $H \rightarrow \tau\tau$  decay is expected using only the data collected by the ATLAS experiment. This enables more precise measurements of the Higgs to tau coupling and Higgs boson properties.

The selection for Run-2 can be optimized to the new run conditions and reconstruction tools with the help of multivariate analysis (MVA) techniques by maximizing the expected significance. In this talk the optimization of the event selection in the  $H \rightarrow \tau_{lep}\tau_{lep}$  channel will be discussed for the full 2015 and 2016 Run-2 datasets corresponding to an integrated luminosity of  $36 \text{ fb}^{-1}$  at a center-of-mass energy of  $\sqrt{s} = 13$  TeV.

## T 50: Higgs-Boson 5 (assoziierte Produktion)

Zeit: Dienstag 16:45–18:15

Raum: JUR 5

T 50.1 Di 16:45 JUR 5

**Optimierung der Suche nach der assoziierten Produktion von Higgs-Bosonen mit Einzel-Top-Quarks mit dem CMS-Experiment** — THORSTEN CHWALEK, NILS FALTERMANN, KEVIN FLÖH, ANDREAS MEYER, •DENISE MÜLLER, THOMAS MÜLLER, JOHANN RAUSER, FRANK ROSCHER, MATTHIAS SCHNEPF und DAVID SEITH — Institut für Experimentelle Kernphysik (IEKP), KIT

Die assoziierte Produktion von Higgs-Bosonen mit Einzel-Top-Quarks ermöglicht die Untersuchung der Kopplungen des Higgs-Bosons an Top-Quarks sowie an Vektor-Bosonen. Diese Kopplungen können durch Physik jenseits des Standardmodells so verändert werden, dass der Produktionswirkungsquerschnitt signifikant ansteigen kann.

Bei einer Analyse mit Daten, die 2015 bei einer Schwerpunktsenergie von 13 TeV aufgenommen wurden, war es bisher noch nicht möglich, eine abschließende Aussage über die Natur der Higgs-Boson-Kopplungen zu liefern. Hierbei wird der Zerfall des Higgs-Bosons in ein Bottom-Quark-Antiquark-Paar betrachtet. In diesem Vortrag werden verschiedene Methoden vorgestellt, die die Suche nach der assoziierten Produktion von Higgs-Bosonen mit Einzel-Top-Quarks optimieren können.

T 50.2 Di 17:00 JUR 5

**Systematische Unsicherheiten in der Analyse der assoziierten Produktion eines Higgs-Bosons mit Einzel-Top-Quarks mit dem CMS-Experiment** — THORSTEN CHWALEK, NILS FALTERMANN, KEVIN FLÖH, ANDREAS MEYER, DENISE MÜLLER, THOMAS MÜLLER, JOHANN RAUSER, FRANK ROSCHER, MATTHIAS SCHNEPF und •DAVID SEITH — Institut für Experimentelle Kernphysik (IEKP),

KIT

Die assoziierte Produktion eines Higgs-Bosons mit Einzel-Top-Quarks erlaubt es die Kopplung des Higgs-Bosons an Top-Quarks sowie an Vektor-Bosonen zu untersuchen. Unter unterschiedlichen Hypothesen für die Kopplungen wurden Daten untersucht, die 2016 bei einer Schwerpunktsenergie von 13 TeV am LHC genommen wurden. Dies ermöglicht die Berechnung von Ausschlussgrenzen auf Kopplungen jenseits des Standardmodells. Zur besseren Trennung zwischen Untergrund und Signal werden multivariate Methoden verwendet. In diesem Vortrag werden die wichtigsten systematischen Unsicherheiten in der Analyse der assoziierten Produktion von Higgs-Bosonen mit Einzel-Top-Quarks diskutiert.

T 50.3 Di 17:15 JUR 5

**Search for top associated Higgs production with the final state of two electrons or muons and one hadronically decaying tau at 13 TeV with ATLAS** — •DAVID HOHN, NELLO BRUSCINO, MARKUS CRISTINZIANI, JÜRGEN KROSEBERG, ANDREA SCIANDRA, and NORBERT WERMES — Physikalisches Institut, Universität Bonn

The production of the Higgs boson in association with a top quark pair ( $t\bar{t}H$ ) is predicted by the Standard Model (SM), but not yet experimentally measured. The discovery of this process will provide knowledge of the top Yukawa coupling, which is important to understand the origin of mass of the fermions. This coupling is constrained from other measurements that involve top quarks in virtual loops. The  $t\bar{t}H$  process involves the direct interaction between a Higgs boson and top quarks

and is therefore able to directly measure the coupling. The measurement will be another probe of the consistency of the Higgs boson with the SM.

Analyses with many leptons and jets are sensitive to the  $t\bar{t}H$  process. The channel with two electrons or muons of opposite electric charge and one hadronic tau has been analysed with 13 TeV data from ATLAS. The main background is  $t\bar{t}$  production with jets faking hadronic taus. This background is estimated with a data-driven method and suppressed using boosted decision trees. The preliminary estimated sensitivity is competitive with other  $t\bar{t}H$  analysis channels.

T 50.4 Di 17:30 JUR 5

**Search for the production of the Higgs boson in association with a pair of top quarks in the three lepton final state at 13 TeV in ATLAS** — ●NELLO BRUSCINO, JULIEN CAUDRON, MARKUS CRISTINZIANI, MAZUZA GHNEIMAT, CARLO ALBERTO GOTTARDO, SEBASTIAN HEER, DAVID HOHN, VADIM KOSTYUKHIN, ANDREA SCIAN-DRA, and KAVEN YAU WONG — Physikalisches Institut, Universität Bonn

The observation of the Higgs boson in association with a top quark pair will open a window to the direct study of the Yukawa coupling of the top quark, which is the fermion expected to couple most strongly to the Higgs boson. Thanks to the LHC upgrade to 13 TeV  $t\bar{t}H$  events are expected to be produced with a significantly higher cross section than at 8 TeV. Final states with high lepton multiplicity, targeting the  $H \rightarrow WW^*/\tau\tau/ZZ^*$  decay channels, can consequently be exploited to research the presence of a Standard Model Higgs boson.

The three lepton analysis requires a total lepton charge of  $\pm 1$  and at least three reconstructed jets.  $t\bar{t}Z$  and diboson contributions are suppressed vetoing events with an opposite-sign same-flavour lepton pair with the invariant mass within 10 GeV of the Z boson mass.

The analysis uses a boosted decision tree algorithm to discriminate between signal and Standard Model background. The dominant non-prompt background and the subdominant ones ( $t\bar{t}V$  and diboson backgrounds) are estimated using a simultaneous fit technique, which exploits three dedicated regions enriched of each process.

T 50.5 Di 17:45 JUR 5

**Search for the production of the Higgs boson in association with a pair of top quarks in the four leptons final state at 13 TeV in ATLAS** — NELLO BRUSCINO, JULIEN CAUDRON, MARKUS CRISTINZIANI, MAZUZA GHNEIMAT, CARLO ALBERTO GOTTARDO, SE-

BASTIAN HEER, DAVID HOHN, VADIM KOSTYUKHIN, ●ANDREA SCIAN-DRA, and KAVEN YAU WONG — Physikalisches Institut, Universität Bonn

The top Yukawa coupling is predicted to be large by the Standard Model and can be directly accessed by measuring  $t\bar{t}H$  production at LHC. Depending on the decay of the Higgs boson and the top quark pair several final states are possible. The four lepton channel is statistically limited by the small branching fraction, but it has an extremely high purity, excellent signal-to-background ratio, and is not highly affected by non-prompt backgrounds, events whose leptons are not coming from the primary interaction vertex.

The analysis selects events with exactly four reconstructed leptons and multiple jets. The most dominant backgrounds are  $t\bar{t}Z$ , whose four leptons have a kinematics very similar to that of leptons in signal events, and diboson, whose cross section is much higher. I will present the ATLAS public analysis performed with  $13 \text{ fb}^{-1}$  and further improvements with the full dataset at  $36 \text{ fb}^{-1}$ .

T 50.6 Di 18:00 JUR 5

**Studien zur Suche nach  $t\bar{t}H/tH$ -Produktion mit  $H \rightarrow \gamma\gamma$  bei  $\sqrt{s} = 13 \text{ TeV}$  mit dem ATLAS-Experiment** — ●ISABEL NITSCHE, DIANE CINCA, JOHANNES ERDMANN und KEVIN KRÖNINGER — TU Dortmund, Experimentelle Physik IV

Die assoziierte Produktion eines Higgs-Bosons mit Top-Quarks, bei der das Higgs-Boson direkt von einem Top-Quark abgestrahlt wird, ermöglicht eine direkte Messung der Yukawa-Kopplung des Top-Quarks  $Y_t$ . Das Higgs-Boson kann dabei über die starke Wechselwirkung mit einem Top-Quark-Paar ( $t\bar{t}H$ ) oder über die elektroschwache Wechselwirkung mit einem einzelnen Top-Quark ( $tH$ ) produziert werden. Bei der  $tH$ -Produktion besteht außerdem die Möglichkeit, dass das Higgs-Boson von dem W-Boson aus der Produktion abgestrahlt wird. Im Standardmodell interferieren diese beiden Prozesse destruktiv, was zu einem geringen Wirkungsquerschnitt führt. Diese Interferenz ermöglicht es jedoch, im Gegensatz zu  $t\bar{t}H$ , zusätzlich das relative Vorzeichen von  $Y_t$  zur Kopplung des Higgs-Bosons an das W-Boson zu messen.

Der betrachtete  $H \rightarrow \gamma\gamma$  Zerfallskanal ist herausfordernd aufgrund des niedrigen Verzweigungsverhältnisses. Er ist allerdings auch viel-sprechend wegen der guten Energieauflösung der Photonen und des geringen Untergrundes.

Eine Analysestrategie für die Suche nach  $t\bar{t}H/tH$ -Produktion im  $H \rightarrow \gamma\gamma$  Zerfallskanal bei  $\sqrt{s} = 13 \text{ TeV}$  mit dem ATLAS-Experiment wird präsentiert und die erwartete Sensitivität wird diskutiert.

## T 51: Top Quark 3 (Produktion)

Zeit: Dienstag 16:45–19:00

Raum: JUR 4

T 51.1 Di 16:45 JUR 4

**Single top production in association with a Z boson with ATLAS** — ●IRINA CIOARĂ and IAN C. BROCK — Physikalisches Institut, University of Bonn

The 13 TeV data collected by the ATLAS collaboration in Run2 is used to investigate the electroweak process in which a Z boson is radiated in the  $t$ -channel single top-quark production ( $tZq$  channel). This has the potential to constrain the top-quark to Z boson coupling, and is an irreducible background for flavour changing neutral current decays of the top quark.

The trilepton decay topology of this process produces one jet originating from a  $b$  quark, three charged leptons with high transverse momentum (including an opposite sign, same flavour pair), one light-quark jet that tends to be in the forward direction and one neutrino. Despite the very low branching fraction, this channel is chosen because it has the best signal to background ratio and hence, the best potential for discovery.

The analysis is performed using the full dataset collected with the ATLAS detector in 2015 and 2016 and the strategy includes using a neural network for separating signal and background and performing a binned likelihood fit in order to extract the measured cross-section. A cut-and-count approach is also studied.

T 51.2 Di 17:00 JUR 4

**Measurement of differential cross-sections of a single top quark produced in association with a W boson with ATLAS at  $\sqrt{s} = 13 \text{ TeV}$**  — ●RUI ZHANG, IAN C. BROCK, and REGINA MOLES

VALLS — Rheinische Friedrich-Wilhelms-Universität Bonn

The cross-section to produce a W boson in association with a top quark is measured differentially with respect to several particle-level final-state observable quantities. The measurements are performed using  $36.2 \text{ fb}^{-1}$  of pp collision data with  $\sqrt{s} = 13 \text{ TeV}$  collected in 2015 and 2016. Cross-sections are measured in a fiducial phase-space defined by the presence of two charged leptons and exactly one jet identified as containing a B hadron. Absolute cross-sections are presented as well as measurements normalised to the fiducial cross-section, for which several of the main uncertainties cancel. Results are compared with predictions from Monte Carlo generators.

T 51.3 Di 17:15 JUR 4

**Messung des Einzel-Top-Quark-Wirkungsquerschnitts im  $t$ -Kanal bei einer Schwerpunktsenergie von 13 TeV mit dem CMS-Experiment** — THORSTEN CHWALEK, ●NILS FALTERMANN, ANDREAS MEYER und THOMAS MÜLLER — Institut für Experimentelle Kernphysik (IEKP), KIT

Einzel-Top-Quarks werden im Standardmodell durch die Wechselwirkung eines W-Bosons und eines Bottom-Quarks produziert. Im Gegensatz zur Top-Quark-Paarproduktion erlauben diese Prozesse einen Einblick in den elektroschwachen Sektor des Standardmodells und sind sensitiv auf mögliche Abweichungen in diesem Bereich. Die Produktion im  $t$ -Kanal ist hierbei der wahrscheinlichste Prozess.

Dieser Vortrag beschreibt eine von der CMS-Kollaboration veröffentlichte Analyse aus dem Jahr 2016 zur Messung des Produktions-wirkungsquerschnitts von Einzel-Top-Quarks im  $t$ -Kanal. Die Analyse

beruht auf Daten von Proton-Proton-Kollisionen des LHC bei einer Schwerpunktsenergie von 13 TeV aus dem Jahr 2015.

T 51.4 Di 17:30 JUR 4

**Messung des Wirkungsquerschnittes der elektroschwachen Einzel-Top-Quark-Erzeugung im t-Kanal mit dem ATLAS Experiment** — ●PHILIPP TEPEL, DOMINIC HIRSCHBÜHL und WOLFGANG WAGNER — Bergische Universität Wuppertal

Die elektroschwache Erzeugung einzelner Top Quarks wird am LHC vom Austausch eines virtuellen  $W$ -Bosons im  $t$ -Kanal dominiert. Das  $W$ -Boson wird typischerweise von einem Valenzquark der kollidierenden Protonen abgestrahlt. Ziel dieser Analyse ist eine möglichst präzise Messung des  $t$ -Kanal Produktionswirkungsquerschnitts mit dem ATLAS-Detektor und einer Datenmenge von  $20.2 \text{ fb}^{-1}$ . Die Messung des Produktionswirkungsquerschnitts, bei einer Schwerpunktsenergie von  $\sqrt{s} = 8 \text{ TeV}$ , ermöglicht es, das CKM-Matrixelement  $|V_{tb}|$  zu bestimmen, ohne die Unitarität der CKM-Matrix vorauszusetzen.

In dieser Analyse wird das Signal, nach einer schnittbasierten Vorselektion, mittels multivariaten Analysemethoden (Neuronale Netze) von den Untergrundprozessen getrennt. Der Wirkungsquerschnitt wird bezogen auf den zugänglichen Phasenraum gemessen (fiducial cross-section) und zusätzlich auf den gesamten Phasenraum extrapoliert (total cross-section). Vergleiche mit den Vorhersagen verschiedener Generatoren werden vorgenommen.

T 51.5 Di 17:45 JUR 4

**Associated single top quark+ Z boson production in a dilepton final state at ATLAS** — IAN BROCK, IRINA CIOARĂ, and ●DOROTHEE WOHLLEBEN — Physikalisches Institut, University of Bonn

The investigation of the associated single top quark+ Z boson production in a dilepton final state at ATLAS at 13 TeV is interesting, because it has the potential of giving further insight into the top quark- Z boson coupling. It is also an important background in analyses investigating flavor changing neutral current decays of the top quark.

There are in total four different final states that occur in  $tZq$  production, depending on the combination of the  $t$  quark and Z boson decay. In case of the dilepton channel, the Z boson decays into two leptons while the  $t$  quark decays into a  $b$  quark and a W boson. The W boson in turn decays into two quarks.

The dominant background for the dilepton channel is the Z boson+jets, having a very similar final state as the  $tZq$  events. Because of this and the very high cross-section of the background processes compared to  $tZq$ , the selection has to be optimized in order to increase the signal to background ratio. Additionally, the sensitivity of a  $tZq$  analysis in this channel is evaluated after using a neural network in order to improve the separation between the signal and background events.

T 51.6 Di 18:00 JUR 4

**Validation of Madgraph5\_aMC@NLO with Herwig7 using the FxFx scheme in top physics for ATLAS** — ●KRISHNA KULKARNI — O2.314, Building 1c, ATLAS Group, DESY, Notkestraße 85, 22607 Hamburg

For top physics, ATLAS commonly used MC events produced using NLO matrix element generation matched with QCD radiation simulated with parton shower codes. However, the description is sub-optimal for hard or wide angle QCD radiation. Including hard QCD radiation in the matrix element calculation improves the predictions and reduces theoretical uncertainties. Multi-leg matrix element generators calculating hard QCD radiation already exist. But their predictions need to be merged with the NLO matrix element generation.

FxFx is one of the schemes for this merging. The main goal of this

analysis is to check the FxFx predictions on recently measured observables sensitive to additional QCD radiation in top pair production, where the matrix element is calculated by Madgraph5\_aMC@NLO and the showering is performed with Herwig7 using the FxFx scheme for top physics. The events were simulated using the newly developed ATLAS interface at 13 TeV.

T 51.7 Di 18:15 JUR 4

**Differenzieller  $t\bar{t}$  Wirkungsquerschnitt am ATLAS Experiment mit dem HEPTopTagger** — ●ARTHUR BOLZ, DANILO FERREIRA DE LIMA und MYKHAILO LISOVYI — Physikalisches Institut, Universität Heidelberg, Deutschland

Die Zerfallsprodukte hadronisch zerfallender Topquarks mit hohem transversalem Impuls sind im Laborsystem kollimiert und können innerhalb eines einzigen Jets mit großem Radiusparameter  $R$  rekonstruiert werden. Der HEPTopTagger wurde entwickelt, um solche Topquark Zerfälle gegen Jets aus Untergrundprozessen zu selektieren.

Es wird eine Studie zur Messung des auf Teilchenlevel entfalteten differentiellen  $t\bar{t}$  Wirkungsquerschnitts mit hadronisch zerfallenden Topquarks präsentiert. Die Messung beschränkt sich auf Topquarks mit moderatem  $p_T \gtrsim 250 \text{ GeV}$ , die über  $C/A$  Jets ( $R = 1.5$ ) rekonstruiert und mit dem HEPTopTagger selektiert werden. Der dominierende Multijet-Untergrund wird über Kontrollregionen aus Daten abgeschätzt.

Der zugrunde liegende Datensatz wurde 2015 und 2016 vom ATLAS Experiment bei  $s = \sqrt{13} \text{ TeV}$   $p\bar{p}$  Kollisionen im LHC aufgezeichnet.

T 51.8 Di 18:30 JUR 4

**Messung des Wirkungsquerschnittes der Einzel-Top-Quark-Erzeugung im t-Kanal mit dem ATLAS-Detektor bei 13 TeV** — ●GUNNAR JÄKEL, DOMINIC HIRSCHBÜHL und WOLFGANG WAGNER — Bergische Universität Wuppertal

Die elektroschwache Erzeugung einzelner Top-Quarks wird am LHC vom  $t$ -Kanal-Austausch dominiert. In diesem Kanal erzeugt ein virtuelles  $W$ -Boson, das von einem leichten Quark aus der Proton-Proton-Kollision abgestrahlt wird, das einzelne Top-Quark. Präsentiert wird eine Analyse zur Messung der Top-Quark- und Top-Antiquark- $t$ -Kanal-Produktionswirkungsquerschnitte mit dem ATLAS-Detektor und einer Datenmenge von  $3.2 \text{ fb}^{-1}$  bei einer Schwerpunktsenergie von  $\sqrt{s} = 13 \text{ TeV}$ . Das Ziel ist eine möglichst präzise Messung der Wirkungsquerschnitte, deren Verhältnis  $R_t$  und des CKM-Matrixelements  $|V_{tb}|$ . Zur Trennung von Signal und Untergrundprozessen werden Neuronale Netze verwendet.

T 51.9 Di 18:45 JUR 4

**Suche nach der Produktion einzelner Top-Quarks im s-Kanal bei einer Schwerpunktsenergie von 13 TeV mit dem CMS-Experiment** — THORSTEN CHWALEK, NILS FALTERMANN, ANDREAS MEYER, THOMAS MÜLLER und ●FABIAN SCHENKEL — Institut für Experimentelle Kernphysik (IEKP), KIT

Als schwerstes Elementarteilchen nimmt das Top-Quark eine besondere Rolle in vielen Theorien neuer Physik ein. Da die Produktion einzelner Top-Quarks im Gegensatz zur Top-Paarproduktion über die elektroschwache Wechselwirkung stattfindet, ist diese besonders sensitiv auf Physik jenseits des Standardmodells. Im Vergleich zu den anderen Produktionsprozessen, hat die Entstehung eines einzelnen Top-Quarks über den  $s$ -Kanal nur einen geringen Anteil, was eine gute Trennung zwischen Signal- und Untergrundereignissen voraussetzt.

In diesem Vortrag wird die Analyse zur Bestimmung des Wirkungsquerschnitts der Einzel-Top-Quark-Produktion mit Messdaten des CMS-Experiments vorgestellt. Verwendet wurden Proton-Proton-Kollisionsdaten des LHC, die im Jahr 2016 bei einer Schwerpunktsenergie von 13 TeV gesammelt wurden.

## T 52: CP-Verletzung und Mischungswinkel 2

Zeit: Dienstag 16:45–18:30

Raum: JUR 490

T 52.1 Di 16:45 JUR 490

**Measurement of the Branching Fractions of Semileptonic Kaon Decays and Extraction of the CKM Parameter  $|V_{us}|$**  — ●MARIO VORMSTEIN — Institut für Physik, Johannes Gutenberg-Universität, Mainz, Deutschland

Semileptonic kaon decays ( $K_{l3}^+ = K^+ \rightarrow \pi^0 l^+ \nu$  with  $l = e, \mu$ ) pro-

vide a clean way to extract the parameter  $|V_{us}|$  of the Cabibbo-Kobayashi-Maskawa (CKM) quark mixing matrix. It is one of the fundamental parameters of the Standard Model and is only accessible via experimental measurement. The NA62 collaboration collected  $K^+$  decay data in 2007 which are analyzed in the presented work. In total  $28 \cdot 10^6 K_{\mu 3}^+$ ,  $37 \cdot 10^6 K_{e 3}^+$ , and  $2 \cdot 10^6 K_{2\pi}^+$  candidates were extracted from the data set and used to compute the ra-

tios of branching fractions  $\text{Br}(K_{\mu 3}^+)/\text{Br}(K_{2\pi}^+)$ ,  $\text{Br}(K_{e 3}^+)/\text{Br}(K_{2\pi}^+)$ , and  $\text{Br}(K_{\mu 3}^+)/\text{Br}(K_{e 3}^+)$ . The semileptonic branching fractions  $\text{Br}(K_{\mu 3}^+) = 3.321(19)\%$  and  $\text{Br}(K_{e 3}^+) = 5.027(22)\%$  follow from the world average of  $\text{Br}(K_{2\pi}^+)$  measurements. They are used to extract the CKM parameter  $|V_{us}| = 0.2219(10)$ . The new  $|V_{us}|$  result leads to the unitarity relation  $|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 0.9983(6)$  which disagrees by 2.8 standard deviations with the CKM unitarity prediction.

The  $e - \mu$  lepton universality is tested with the ratio of the semileptonic branching fractions  $\text{Br}(K_{\mu 3}^+)/\text{Br}(K_{e 3}^+)$  and agrees with the Standard Model prediction.

T 52.2 Di 17:00 JUR 490

**Study of time-integrated CP asymmetry in  $D^0 \rightarrow h^- h^+$  decays with the LHCb experiment** — ●SIMON STEMMLE for the LHCb-Collaboration — Physikalisches Institut Universität Heidelberg, Deutschland

CP violation in the D meson system is not observed so far and is predicted to be small in the Standard Model. A measurement of the time-integrated CP asymmetry in the Cabibbo-suppressed decay  $D^0 \rightarrow K^- K^+$  is presented. For this study, the full data sample of proton-proton collisions, recorded with the LHCb experiment in LHC Run 1 is used, corresponding to an integrated luminosity of  $3 \text{ fb}^{-1}$ . The  $D^0$  mesons used for this analysis originate from the decays  $D^{*+} \rightarrow D^0 \pi^+$  and  $D^{*-} \rightarrow \bar{D}^0 \pi^-$ . Thereby, the flavour of the neutral charm meson at production is determined by the charge of the pion. In order to evaluate the additional production and detection asymmetry arising from the  $D^{*+}$  meson and the pion, three Cabibbo-favoured charm meson decays are used as calibration channels.

Former LHCb analysis are combined with this measurement to give a complete picture of time-integrated CP asymmetry in  $D^0 \rightarrow h^- h^+$  decays. The obtained result is compatible with the hypothesis of no CP violation.

T 52.3 Di 17:15 JUR 490

**Amplitudenanalyse von Vierkörperzerfällen unter Zuhilfenahme von Grafikkarten** — JOHANNES ALBRECHT<sup>1</sup>, ●CHRISTOPH HASSE<sup>1</sup>, STEFANIE REICHERT<sup>1</sup> und MICHAEL D. SOKOLOFF<sup>2</sup> — <sup>1</sup>Technische Universität Dortmund — <sup>2</sup>University of Cincinnati

Das GPU-Softwarepaket GooFit, welches für Funktionsanpassungen auf Grafikkarten verwendet wird, wurde in seiner Funktionalität erweitert. Es erlaubt nun die Konstruktion und den anschließenden Fit eines zeitabhängigen Amplitudenmodells für Zerfälle von pseudoskalaren Mesonen in vier pseudoskalare Endzustände, wobei der Zerfall als Kombination verschiedener Zweikörper-Resonanzen modelliert wird. Da ein Modell dieser Art ein sechsdimensionales Problem darstellt und äußerst rechenintensiv ist, erlaubt die Verwendung von Grafikkarten eine Durchführung solcher Fits in praktikablen Zeitskalen, sogar bei mehreren anzupassenden Parametern. Diese Funktionalität wurde genutzt, um die Sensitivität auf die  $D^0 - \bar{D}^0$  Mischungsparameter  $x$  und  $y$  in einer zeitabhängigen Amplitudenanalyse des Zerfalls  $D^0 \rightarrow K^+ \pi^- \pi^+ \pi^-$  abzuschätzen.

T 52.4 Di 17:30 JUR 490

**Feasibility study of  $B^0 \rightarrow \pi^0 \pi^0$  at the Belle II Experiment** — ●FERNANDO ABUDINEN for the Belle II-Collaboration — Max-Planck-Institut für Physik, München

The measurement of the time-dependent CP violation parameters for the decay channel  $B^0 \rightarrow \pi^0 \pi^0$  is crucial for the determination of the unitarity angle  $\phi_2$ . At former B-factories, only the direct CP violation parameter  $\mathcal{A}_{CP}$  could be measured. For the mixing-induced CP violation  $S_{CP}$ , a time-dependent analysis is required: a highly challenging task because of the small branching fraction around  $10^{-6}$  and the fact that only a very small fraction of events provide information to reconstruct the  $B^0$  vertex. These are events where a  $\pi^0$  decays via the so-called Dalitz decay  $\pi^0 \rightarrow e^+ e^- \gamma$ , or where one of the photons from  $\pi^0 \rightarrow \gamma \gamma$  converts within the innermost detector material.

With an expected integrated luminosity of about  $50 \text{ ab}^{-1}$  at SuperKEKB and the capabilities of the new Pixel Vertex Detector, the Belle II experiment could provide enough statistics to make this measurement feasible. In this work we develop a strategy for the CP violation analysis of  $B^0 \rightarrow \pi^0 \pi^0$  in order to exploit maximally the new data set and to characterize the sensitivity of Belle II for this channel.

T 52.5 Di 17:45 JUR 490

**Untersuchung der CP-Verletzung im Kanal  $B^0 \rightarrow D^- \pi^+$  am LHCb-Experiment** — ●ALEX BIRNKRAUT, ULRICH EITSCHBERGER und JULIAN WISHAH für die LHCb-Kollaboration — Experimentelle Physik 5, TU Dortmund

Am LHCb-Experiment werden unter anderem CP-verletzende Prozesse im System der neutralen  $B^0$ -Mesonen zeitaufgelöst gemessen. Untersucht man die zeitabhängigen Zerfallsraten der  $B^0$ - und  $\bar{B}^0$ -Mesonen, findet man bei bestimmten CP-verletzenden Prozessen eine Asymmetrie in der Interferenz zwischen direktem Zerfall und Zerfall nach Mischung der  $B^0$ - und  $\bar{B}^0$ -Mesonen.

Bei der zeitaufgelösten Messung der Zerfallsmoden  $B^0 \rightarrow D^\pm \pi^\mp$  und  $\bar{B}^0 \rightarrow D^\mp \pi^\pm$  werden die Asymmetrien zwischen den Zerfällen initialer  $B^0$  und  $\bar{B}^0$  in den jeweils gleichen Endzustand gemessen. Dabei kann der CKM-Winkel  $\gamma$  mit geringen theoretischen Unsicherheiten bestimmt werden. Da der Zerfall  $B^0 \rightarrow D^+ \pi^-$  gegenüber dem Zerfall  $B^0 \rightarrow D^- \pi^+$  stark Cabibbo-unterdrückt ist müssen Asymmetrien in der Produktion, der Detektion und der Bestimmung des Anfangszustandes der B-Mesonen sehr genau bekannt sein, um diese Effekte von einer CP-Asymmetrie zu separieren.

In diesem Vortrag wird der Stand der Analyse zur Messung der CP-Verletzung in dem Zerfallskanal  $B^0 \rightarrow D^- \pi^+$  auf dem Run I Datensatz des LHCb-Experiments, dessen Größe einer integrierten Luminosität von  $3 \text{ fb}^{-1}$  entspricht, vorgestellt.

T 52.6 Di 18:00 JUR 490

**Messung der zeitabhängigen CP-Asymmetrie im Zerfall  $B^0 \rightarrow D^+ D^-$  mit dem LHCb-Experiment** — PHILIPP IBIS, FRANK MEIER, ●MARGARETE SCHELLENBERG und JULIAN WISHAH für die LHCb-Kollaboration — Experimentelle Physik 5, TU Dortmund

Der CP-Parameter  $\beta$  lässt sich mit geringen theoretischen Unsicherheiten in dem Zerfall  $B^0 \rightarrow J/\psi K_S^0$ , in dem ein  $b \rightarrow c\bar{c}s$  Übergang stattfindet, messen. In  $b \rightarrow c\bar{c}d$  Übergängen, wie in  $B^0 \rightarrow D^+ D^-$  Zerfällen, ist der Beitrag aller loopartiger Feynmandiagramme zur Übergangsamplitude gegenüber dem Treediagramm nicht unterdrückt. Somit wird bei der Analyse der CP-Verletzung in  $B^0 \rightarrow D^+ D^-$  Zerfällen  $\beta_{\text{eff}}$  gemessen, welches eine Phasenverschiebung  $\Delta\phi_d$  gegenüber  $\beta$  beinhaltet.

In der Kombination der Messungen von  $\beta$  und  $\beta_{\text{eff}}$  kann diese Phasenverschiebung bestimmt werden.

Unter Ausnutzung der neuesten Flavour-Tagging-Algorithmen wurde mit dem vollen Run I Datensatz des LHCb-Experiments von insgesamt  $3 \text{ fb}^{-1}$  die CP-Asymmetrie in  $B^0 \rightarrow D^+ D^-$  Zerfällen gemessen. Die Ergebnisse dieser Messung werden im Vortrag vorgestellt.

T 52.7 Di 18:15 JUR 490

**Studien zu den Zerfällen  $B^0 \rightarrow D_s^+ D^-$  und  $B_s^0 \rightarrow D_s^- D^+$  mit dem LHCb-Experiment** — ●PHILIPP IBIS, FRANK MEIER, MARGARETE SCHELLENBERG und JULIAN WISHAH — Experimentelle Physik 5, TU Dortmund

Ein Ziel des LHCb-Experimentes ist die präzise Messung von CP-Verletzung in Zerfällen neutraler B-Mesonen. Die Analyse der flavour-spezifischen Zerfälle  $B^0 \rightarrow D_s^+ D^-$  und  $B_s^0 \rightarrow D_s^- D^+$  ermöglicht die zerfallszeitabhängige Messung direkter CP-Verletzung.

Dieser Vortrag behandelt die Untersuchung der zerfallszeitabhängigen CP-Asymmetrie in beiden Zerfallskanälen und die Messung der relativen Zerfallsbreite  $\mathcal{B}(B_s^0 \rightarrow D_s^- D^+)/\mathcal{B}(B^0 \rightarrow D^- D^+)$ . Hierzu werden Daten des LHCb-Experimentes verwendet, die bei Schwerpunktsenergien von  $\sqrt{s} = 7 \text{ TeV}$  bzw.  $8 \text{ TeV}$  aufgenommen wurden und einer integrierten Luminosität von  $3 \text{ fb}^{-1}$  entsprechen.

## T 53: Suche nach Supersymmetrie 3

Zeit: Dienstag 16:45–18:30

Raum: JUR 498

T 53.1 Di 16:45 JUR 498

**Suche nach Supersymmetrie in Ereignissen mit einem Lepton, fehlender transversaler Energie und vielen Jets am ATLAS Experiment** — ●NIKOLAI HARTMANN und JEANETTE LORENZ — Ludwig-Maximilians-Universität München

Die inklusive Suche nach den supersymmetrischen Partnern der Quarks (Squarks) und Gluonen (Gluinos) in Endzuständen mit einem Lepton konnte mit Hilfe der ATLAS-Daten aus 2015 und einem Teil der Daten aus 2016 Massen bis zu etwa 1,8 TeV (Gluinos) und 1,1 TeV (Squarks) ausschließen. Dabei lag der Fokus auf einem Szenario, bei dem die supersymmetrischen Teilchen über nur eine Zwischenstufe in Standardmodellteilchen und das stabile leichteste supersymmetrische Teilchen zerfallen. Hierfür wurden Signalregionen mit 2 bis 6 Jets im Endzustand verwendet.

Dieser Vortrag präsentiert eine Erweiterung der Analyse auf Szenarien mit mehrstufigen Zerfällen und auf Modelle aus dem Parameterraum des phänomenologischen minimalen supersymmetrischen Standardmodells (pMSSM). Durch eine Signalregion mit höherer Jet-Multiplizität kann die Sensitivität hier erheblich gesteigert werden. In dieser Region ist der Untergrund durch Prozesse dominiert, bei denen zusätzlich zum „harten“ Prozess mehrere Jets abgestrahlt werden. Die Analyse verwendet ein datengestütztes Verfahren, um die Abhängigkeit von Simulationen zu minimieren, die in diesem Regime sehr approximativ sind. Es wird der vollständige ATLAS-Datensatz von 2015 und 2016 verwendet.

T 53.2 Di 17:00 JUR 498

**Search for SUSY in single lepton final state with CMS** — ●AKSHANSH SINGH<sup>1</sup>, ISABELL MELZER PELLMANN<sup>1</sup>, ARTUR LOBANOV<sup>1</sup>, and CLAUDIA SEITZ<sup>2</sup> — <sup>1</sup>DESY, Hamburg, Germany — <sup>2</sup>Universität Zürich, Zürich, Switzerland

The search strategy for SUSY search with 1 lepton final state is presented. We search in categories of number of jets and b tagged jets, to be less dependent on new physics scale we also introduce separate search categories based on the scalar sum of all jet transverse momenta and on the scalar sum of the transverse missing momenta and the lepton. We further use angle between the lepton and W boson boost direction to suppress the background. The data driven background estimation is done with the Rcs method except for QCD background which is estimated differently from data. Then we present the main systematic uncertainties and results, interpreted in terms of simplified model of gluino pair production T1tttt.

T 53.3 Di 17:15 JUR 498

**Suche nach Supersymmetrie in Endzuständen mit einem Lepton, Jets und fehlender Transversalenergie** — JOHANNES BALZ, KATHARINA BIERVAGEN, VOLKER BÜSCHER, KATHARINA JAKOBI, ●MANUEL LORNATUS, ANDREAS REISS und JAN SCHÄFFER — Institut für Physik, Universität Mainz

Ein Fokus bei der Datenauswertung des ATLAS-Experiments liegt auf der Suche nach supersymmetrischen Teilchen (SUSY), deren Existenz bisher noch nicht nachgewiesen werden konnte. Am Large Hadron Collider (LHC) am CERN werden diese dominant über die starke Wechselwirkung produziert. Die erzeugten Squarks und Gluinos zerfallen dann über Kaskaden weiter in leichtere SUSY-Teilchen und Teilchen des Standardmodells. Dabei wird häufig der in dieser Analyse betrachtete Endzustand mit einem Lepton, Jets und fehlender Transversalenergie gebildet.

Im Jahr 2016 wurde eine Datennahme mit einer Schwerpunktsenergie von 13 TeV durchgeführt. Dabei wurden Daten mit einer integrierten Luminosität von 33,3 fb<sup>-1</sup> aufgezeichnet. Dies entspricht in etwa einer Verzehnfachung der verfügbaren Daten aus dem Vorjahr. Zur Steigerung der Entdeckungssensitivität der Analyse wurden die Signalregionen auf den größeren Datensatz neu optimiert. Dabei wurden zusätzlich Formunterschiede zwischen Signalen und Untergründen ausgenutzt.

Es werden die aktuellsten ATLAS-Ergebnisse mit dem vollen Datensatz der Datennahmen in 2015 und 2016 (36,5 fb<sup>-1</sup>) präsentiert.

T 53.4 Di 17:30 JUR 498

**Search for supersymmetry in final states with an isolated lep-**

**ton and a Higgs boson with the ATLAS detector** — ●DANIJELA BOGAVAC and JEANETTE MIRIAM LORENZ — LMU München Am Coulombwall 1, DE-85748 Garching

Supersymmetry (SUSY) is a well-established extension of the Standard Model that solves some of its shortcomings and predicts the existence of new particles. This talk presents a search for supersymmetric particles decaying into final states with one isolated lepton (e or  $\mu$ ), jets and large missing transverse energy. The search is performed with 36.5 fb<sup>-1</sup> proton-proton collision dataset at  $\sqrt{s} = 13$  TeV collected in 2015 and 2016 by the ATLAS detector at the Large Hadron Collider at CERN. Additional simplified models with a Higgs boson will be shown and methods using fat jets and Higgs-boson tagging will be discussed.

T 53.5 Di 17:45 JUR 498

**Search for top squark pair production in final states with one isolated lepton with the ATLAS detector** — ●DAVID HANDL, PAOLA ARRUBARENA, JOVAN MITREVSKI, and JEANNINE WAGNER-KUHR — LMU München

Natural supersymmetry suggests a relatively light stop quark  $\tilde{t}_1$ , which is the superpartner of the top quark, with a mass that should be within the reach of the LHC.

In this talk a search for stop quark pair production is presented. The analysis focuses on the decay channel with a single lepton in the final state, thus only events with exactly one isolated electron or muon, multiple jets and large missing transverse momentum are considered. The search is performed using data from proton-proton collisions recorded at a center-of-mass energy of  $\sqrt{s} = 13$  TeV by the ATLAS experiment, corresponding to an integrated luminosity of 36 fb<sup>-1</sup>. A particular scenario is considered where the mass difference between the stop quark and the neutralino  $\tilde{\chi}_1^0$  is smaller than the top quark ( $\Delta m \equiv m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} < m_t$ ), leading to a three-body decay  $\tilde{t}_1 \rightarrow bW\tilde{\chi}_1^0$ . The neutralino is taken to be the lightest supersymmetric particle (LSP) which only interacts weakly and is assumed to be stable.

This talk illustrates the characteristics of this particular signature, the analysis strategy is presented, search regions are defined and the sensitivity reach in the corresponding region is discussed.

T 53.6 Di 18:00 JUR 498

**Suche nach Topsquarkzerfällen in Neutralino und Topquark in Endzuständen mit einem Lepton nahe der Topmassendiagonalen am ATLAS Experiment** — ●JULIAN WOLLRATH und FREDERIK RÜHR — Physikalisches Institut, Universität Freiburg

Unter der Annahme eines hundertprozentigen Verzweungsverhältnisses von  $\tilde{t} \rightarrow t\tilde{\chi}_1^0$  wurde für hohe Topsquarkmassen bereits ein großer Bereich des Phasenraums ausgeschlossen. Eine Herausforderung bleibt die Suche für Topsquarkzerfälle mit Topsquarkmassen kleiner als 250 GeV, in Kombination mit Neutralinomassen für die  $m_{\tilde{\chi}_1^0} + m_t \approx m_{\tilde{t}}$  gilt. In diesem Vortrag werden Methoden vorgestellt, wie man in diesem Bereich des Phasenraums Sensitivität für supersymmetrische Modelle erhalten kann.

T 53.7 Di 18:15 JUR 498

**Suche nach Top Squarks in Endzuständen mit einem Lepton, Jets und fehlender transversaler Energie in  $\sqrt{s} = 13$  TeV am ATLAS Experiment** — ●DANIELA BÖRNER, PETER MÄTTIG und SOPHIO PATARAIA — Bergische Universität Wuppertal, Wuppertal, Deutschland

Dieser Vortrag stellt Methoden für die Suche nach Paarproduktion von Top Squarks im Rahmen des ATLAS-Experiments vor. Die Analyse zielt auf ein Modell von Top Squarks, welche dann in ein Top Quark und ein Neutralino (leichtestes supersymmetrisches Teilchen) zerfallen. Untersucht wird der semi-leptonische Zerfall dessen sichtbaren Endzustände dem Standardmodell  $t\bar{t}$ -Zerfall gleichen. Insbesondere für kleine Massenunterschiede zwischen dem Top Quark und dem Top Squark ist die Unterscheidung zwischen dem Signal und dem Standardmodell Untergrund herausfordernd.

Es werden die verbesserten Methoden vorgestellt, mit denen die Sensitivität im Vergleich zu der auf einfachen Schnitten basierenden Analyse erhöht werden sollen.

## T 54: Suche nach neuen Teilchen 3

Zeit: Dienstag 16:45–19:00

Raum: JUR 2

T 54.1 Di 16:45 JUR 2

**Model Unspecific Search in CMS - Introduction** — •TOBIAS POOK, DEBORAH DUCHARDT, THOMAS HEBBEKER, SIMON KNUTZEN, JONAS LIEB, ARND MEYER, and JONAS ROEMER — III. Physikalisches Institut A, RWTH Aachen University

The CMS Detector recorded a dataset of about  $39\text{fb}^{-1}$  during 2015 and 2016 at a center of mass energy of 13 TeV. This dataset presents a unique opportunity to find new phenomena. However no clear signs of physics beyond the Standard Model were detected yet and a broader view might be necessary to detect signals from not yet searched for or even thought of theories.

The majority of searches for new physics are optimized for an established signal hypothesis in one or few decay channels. These searches cover only a fraction of all observed final states with model dependent analysis strategies. The Model Unspecific Search in CMS (MUSiC) provides a unique procedure to prevent the CMS collaboration from missing new physics. This is ensured by an automated search for deviations between the measurement and standard model (SM) expectation after a complete detector simulation within every observed final state. Each event is categorized based on its object content (leptons, jets, etc.) in so called event classes. Distributions for three kinematic variables and their differential uncertainties are calculated and compared with the standard model expectation. This talk presents the motivation and methods used for the MUSiC analysis and gives an introduction to the interpretation of a global comparison of simulation and data.

T 54.2 Di 17:00 JUR 2

**Model Unspecific Search in CMS - Signal Studies** — •JONAS LIEB, DEBORAH DUCHARDT, THOMAS HEBBEKER, SIMON KNUTZEN, ARND MEYER, TOBIAS POOK, and JONAS ROEMER — III. Physikalisches Institut A, RWTH Aachen University

In 2015 and 2016, the CMS detector recorded proton-proton collisions at an unprecedented center of mass energy of  $\sqrt{s} = 13$  TeV. The Model Unspecific Search in CMS (MUSiC) offers an analysis approach of these data which is complementary to dedicated analyses: By taking all produced final states into consideration, MUSiC is also sensitive to indicators of new physics appearing in final states that are usually not investigated.

In a two step process, MUSiC first classifies events according to their physics content and then searches kinematic distributions for the most significant deviations between Standard Model Monte Carlo simulations and observed data.

To assess MUSiC's sensitivity, simulated signal events of new physics processes are mixed with Standard Model Monte Carlo background. The automated search is repeated on pseudo-data dived with this expectation and the analysis' response is statistically analyzed.

Complementing introductory presentations on the MUSiC event selection and classification, this talk will show how new physics would show up in MUSiC results.

T 54.3 Di 17:15 JUR 2

**Model Unspecific Search in CMS - Preliminary Results of the 2016 Data Analysis** — •JONAS ROEMER, DEBORAH DUCHARDT, THOMAS HEBBEKER, SIMON KNUTZEN, JONAS LIEB, ARND MEYER, and TOBIAS POOK — III. Physikalisches Institut A, RWTH Aachen University

In 2015 the LHC reached the unprecedented center of mass energy of  $\sqrt{s} = 13$  TeV. Due to the excellent performance of the LHC in 2016, CMS was able to record more than ten times the amount of data taken in 2015 which corresponds to an integrated luminosity of  $36.46\text{fb}^{-1}$ . With this increase in energy and luminosity, sensitivity to all theoretical models is gained in comparison to the  $\sqrt{s} = 8$  TeV dataset taken in 2012.

The Model Unspecific Search in CMS (MUSiC) searches for physics beyond the Standard Model independent of theoretical models. Using an automatic method, kinematic distributions of the data are compared with the Standard Model expectations in every final state. Therefore, MUSiC reduces the chance of overlooking new physics, since even distributions not covered by dedicated analyses are investigated.

This talk presents the analysis of the whole 2016 dataset with lepton triggered events.

T 54.4 Di 17:30 JUR 2

**Search for first and second generation scalar leptoquarks in  $pp$  collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector at the LHC: dilepton channel** — VOJTECH PLESKOT, STEFAN TAPPROGGE, and •ANTON WOLF — Institut für Physik, Johannes Gutenberg-Universität Mainz, Deutschland

Leptoquarks (LQs) are predicted in many extensions of the Standard Model (SM) and may provide an explanation for many observed similarities between the quark and lepton sectors of the SM. LQs are commonly assumed to couple to quarks and leptons of the same generation.

The talk will summarize results of a search for pair-produced first and second generation LQs. Channels where both LQs decay to a charged lepton and a quark are considered. The probed final states consist of exactly two same flavour opposite sign leptons (electrons or muons) and at least two jets. The dataset used was recorded in 2015 and 2016 by the ATLAS experiment. It corresponds to  $36.5\text{fb}^{-1}$  of  $pp$  collision data at center-of-mass energy of 13 TeV.

T 54.5 Di 17:45 JUR 2

**Search for pair production of leptoquarks decaying into a top quark and a tau lepton at the CMS experiment** — JOHANNES HALLER, ROMAN KOGLER, THOMAS PEIFFER, ARNE REIMERS, and •MARC STÖVER — Institut für Experimentalphysik, Universität Hamburg

A search for third generation leptoquarks at the LHC is presented, where the pair production of leptoquarks decaying into a top quark and a tau lepton is studied.

We focus on the lepton + jets channel where one of the top quarks decays hadronically and the other one leptonically. In addition, at least one tau lepton is required to decay hadronically. The study uses the full dataset of the year 2016 which was collected with the CMS detector at  $\sqrt{s} = 13$  TeV. The event selection is optimized for highest sensitivity. A data driven approach is used to estimate the standard model background arising from fake taus. Finally, the expected limits on the leptoquark production cross section are presented.

T 54.6 Di 18:00 JUR 2

**Search for pair production of leptoquarks decaying into a top quark and a muon at the CMS experiment** — JOHANNES HALLER, ROMAN KOGLER, THOMAS PEIFFER, •ARNE CHRISTOPH REIMERS, and MARC STÖVER — Institut für Experimentalphysik, Universität Hamburg

In this talk we present a search for pair produced scalar leptoquarks in  $pp$ -collisions of  $\sqrt{s} = 13$  TeV. The data have been collected by the CMS experiment in 2016. In this analysis, the production of scalar leptoquarks decaying into a top quark and a muon is studied.

Events are selected by requiring two isolated muons. In events containing an additional electron, the 4-momentum of a top quark candidate is calculated from information of the leading electron, missing transverse energy and at least one jet. Leptoquark hypotheses are then constructed via a  $\chi^2$  minimization using top quark candidates and muons. The dominating standard model background ( $t\bar{t}$ ) is estimated from data by selecting a control region and extrapolating the data using additional shape and normalization information from simulation. The expected sensitivity of the analysis and exclusion limits are derived.

T 54.7 Di 18:15 JUR 2

**Search for excited leptons in the four-lepton final state with CMS** — •CHRISTOPH SCHULER, KERSTIN HOEPFNER, THOMAS HEBBEKER, and THOMAS ESCH — III. Physikalisches Institut A, RWTH Aachen

In 2016, the CMS experiment at CERN has taken large amounts of data at a center of mass energy of 13 TeV ( $pp$  collision). These data allow to search for physics beyond the Standard Model. One possibility is the existence of excited leptons.

These excited leptons could be produced via contact interaction with an additional lepton, and subsequently decay via contact interaction to three leptons, giving a four lepton final state.

We searched for the existence of excited electrons and muons with the full 2016 CMS dataset.

T 54.8 Di 18:30 JUR 2

**Suche nach angeregten Top-Quarks mit dem CMS-Experiment** — JOHANNES HALLER, ROMAN KOGLER und JENS MULTHAUP — Institut für Experimentalphysik, Universität Hamburg

Im Standardmodell der Teilchenphysik nimmt das Top-Quark durch seine hohe Masse eine Sonderrolle ein und macht es zudem für Hinweise auf Physik jenseits des Standardmodells interessant. In einer möglichen Erweiterung des Standardmodells wird angenommen, dass es sich bei dem Top-Quark um ein zusammengesetztes Teilchen handelt. Eine Anregung auf ein höheres Energieniveau und die anschließende Abregung durch die Abstrahlung von Gluonen dient dabei als Signatur, nach der in der präsentierten Studie gesucht wird. Für den Nachweis angeregter Top-Quarks werden Daten des CMS-Experimentes aus pp-Kollisionen bei einer Schwerpunktsenergie von 13 TeV untersucht. In der präsentierten Analyse werden Ereignisse mit einem nicht-isolierten Myon und hoher Jetmultiplizität selektiert. Die Sensitivität der Suche wird durch die Forderung nach einem identifizierten Jet aus einem Top-Quark Zerfall verbessert. Des Weiteren wird die Massenrekonstruktion, basierend

auf einer  $\chi^2$ -Minimierung, und die parametrisierte Untergrundbestimmung aus Daten in diesem Beitrag besprochen.

T 54.9 Di 18:45 JUR 2

**Status of the search for excited bottom quarks decaying to tW at  $\sqrt{s} = 13$  TeV** — ALEXANDER FROELICH, JOHANNES HALLER, and ROMAN KOGLER — Universität Hamburg

A search is presented for an excited b quark ( $b^*$ ) decaying to tW, singly produced in proton-proton collisions at  $\sqrt{s} = 13$  TeV. The data used has been recorded with the CMS experiment in 2016. The search is performed in the semi-leptonic channel for  $b^*$  masses ranging from 1200 GeV to 3000 GeV. For increasing  $b^*$  masses, the resulting top quark decay products have an increasing probability to be merged into a single jet. In order to achieve high selection efficiency over the whole mass region, a new top tagger, the Heavy Object Tagger with Variable R (HOTVR), is tested and its performance is compared to standard algorithms used in CMS.

## T 55: Suche nach Dunkler Materie 2 (Direkter Nachweis)

Zeit: Dienstag 16:45–19:10

Raum: VSH 19

### Gruppenbericht

T 55.1 Di 16:45 VSH 19

**The DEAP-3600 Dark Matter Experiment** — TINA POLLMANN<sup>1</sup> and DEAP COLLABORATION<sup>2</sup> — <sup>1</sup>Technische Universität München — <sup>2</sup>SNOLAB, Sudbury, Canada

DEAP-3600 is a single-phase liquid-argon Dark Matter direct detection experiment located 2 km underground at SNOLAB, in Sudbury, Canada. With a 1 tonne fiducial mass, the target sensitivity to spin-independent scattering of 100 GeV weakly interacting massive particles (WIMPs) is  $10^{-46}$  cm<sup>2</sup>. The detector was designed and built to reach a background level of less than 0.6 events in 3 tonne-years exposure. This included designing all parts of the detector to prevent or veto backgrounds, radio-purity screening for all detector materials, working with suppliers to source radio-pure materials, and using construction techniques that limit contaminations with radio-isotopes. The largest remaining background - beta decays from Ar-39 - is mitigated offline through pulse shape analysis. DEAP-3600 finished commissioning in 2015 and is now taking physics data. This paper presents commissioning results and the status of the experiment.

### Gruppenbericht

T 55.2 Di 17:05 VSH 19

**Status of the XENON1T experiment** — ALEXANDER FIEGUTH for the XENON-Collaboration — Institut fuer Kernphysik WWU, Muenster, Deutschland

The XENON Collaboration aims for the direct detection of dark matter by spin-independent and spin-dependent scattering off xenon nuclei with a dual-phase time projection chamber (TPC) working in an ultra-low background environment at the Gran Sasso Underground Laboratory in Italy. After the successful operation of XENON100 with its 161 kg xenon target, the next step XENON1t with 3.3 tons of xenon has been started. The aim for its operation is to reach a sensitivity for the spin-independent WIMP-nucleon cross section of  $1.6 \times 10^{-47}$  cm<sup>2</sup> for a WIMP mass of 50 GeV/c<sup>2</sup> after a 2 ton-year exposure. We will present the status of the running XENON1T experiment. Additionally an outlook on its future upgrade XENONnT will be given. The work of the author is supported by BMBF under contract number 05A14PM1 and DFG (GRK 2149).

T 55.3 Di 17:25 VSH 19

**Calibration of the XENON1T detector** — CONSTANZE HASTEROK for the XENON COLLABORATION — Max-Planck-Institut für Kernphysik (MPIK)

Massive weakly interacting particles are a popular explanation for most of the dark matter evidences seen on several astrophysical scales. With its unprecedented sensitivity the new XENON1T detector will play a leading role in the direct detection search of WIMPs. It uses the time projection chamber (TPC) technique in combination with a liquid xenon target of 2 tons in the sensitive volume. A precise understanding of all detector properties is crucial for the dark matter analysis. Furthermore, calibration measurements are used to model the expected background which is important for the evaluation of the significance of a potential signal. For this purpose, several calibration sources have

been deployed. Short lived radioactive isotopes like 83mKr and 220Rn have been dissolved directly in the xenon target. External sources like the gamma emitting 228Th and the neutron emitter AmBe have been brought next to the cryostat. This talk will present the different calibration methods used at the XENON1T detector and their main results.

T 55.4 Di 17:40 VSH 19

**Online krypton removal at the XENON1T experiment** — MICHAEL MURRA for the XENON-Collaboration — Institut für Kernphysik, Münster

The operating XENON1T experiment, located in the Laboratori Nazionali del Gran Sasso (LNGS), is the next generation experiment for the direct detection of dark matter in the form of Weakly Interacting Massive Particles (WIMPs). The new detector utilizes about 3.3 tons of liquid xenon in order to reach a projected sensitivity of  $1.6 \times 10^{-47}$  cm<sup>2</sup> for a WIMP mass of 50 GeV/c<sup>2</sup>. A key requirement to reach this sensitivity is the reduction of radioactive backgrounds such as <sup>85</sup>Kr, which has a beta-decay with an endpoint energy of 687 keV. Due to the difference in vapor pressure, the concentration of natural krypton in xenon can be reduced by several orders of magnitude by using a cryogenic distillation column. Such a distillation column has been operated in a closed loop with the XENON1T detector system in order to reduce the krypton concentration below 1 ppt for the first dark matter run. This so-called online removal will be presented within this talk. Different aspects of this project have been funded by DFG Großgeräte, BMBF and Helmholtz-Alliance for Astroparticle Physics (HAP).

T 55.5 Di 17:55 VSH 19

**Simulations and Experiment with a small dual-phase xenon TPC** — MELANIE SCHEIBELHUT<sup>1</sup>, BASTIAN BESKERS<sup>1</sup>, PIERRE SISOUL<sup>1</sup>, UWE OBERLACK<sup>1</sup>, ARND JUNGHANS<sup>2</sup>, and ROLAND BEYER<sup>2</sup> — <sup>1</sup>Johannes Gutenberg-Universität Mainz — <sup>2</sup>Helmholtz-Zentrum Dresden-Rossendorf

The MainzTPC is a small dual-phase xenon Time Projection Chamber (TPC), built to measure the scintillation and ionization yield of low-energy nuclear and electronic recoils (few keV range). The goal is to deepen the understanding of liquid xenon as a detection material, especially in the low-energy regime which is important for e.g. direct Dark Matter search experiments. For the measurement we built a scattering experiment for both electronic and nuclear recoils. To measure the response to electronic recoils, a Cs137 source in a Compton-scatter setup in combination with a germanium detector was used for the energy measurement. For the nuclear recoils, neutrons produced at the nELBE neutron time-of-flight facility at the ELBE accelerator of the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) were used. For the detection of the scattered neutron, plastic scintillators were placed to measure the energy via time of flight or scatter angle. In addition, a detailed Monte Carlo simulation (GEANT4) of the experiment has been performed to compare it to the experimental results. Here we report about simulations with the MainzTPC at the HZDR.

T 55.6 Di 18:10 VSH 19

**Particle Identification via Liquid Argon-Xenon Scintillation** — ●ANDREAS HIMPSL<sup>1</sup>, THOMAS DANDL<sup>1</sup>, STEFAN SCHÖNERT<sup>1</sup>, ANDREAS ULRICH<sup>1</sup>, and JOCHEN WIESER<sup>2</sup> — <sup>1</sup>Physik Department E15, Technische Universität München — <sup>2</sup>Excitech GmbH, Branterei 33, 26419 Schortens, Germany

Intense infrared scintillation light with a center wavelength of 1173nm was found in liquid argon with a 10ppm xenon admixture (A. Neumeier EPL 109, 12001, 2015). The admixture also shifts the well known 130nm scintillation of argon to the corresponding xenon emission at 175nm. We present the results of a study in which we compare the intensity of the two emission bands (VUV and NIR) for excitation by different projectiles. Low energy (10keV) electrons and various ions such as carbon, sulfur, and iodine with energies of several MeV/u are used for that purpose. The scintillation light is detected with two phototubes with selective sensitivity in the VUV and NIR, respectively. The goal is to test whether the emission bands can be used for purely optical particle identification in liquid argon detectors with a xenon admixture. This work was supported by the DFG Excellenzcluster Origin and Structure of the Universe and the Maier-Leibnitz-Laboratorium Garching.

T 55.7 Di 18:25 VSH 19

**Absolute and Relative Reflectivity Measurements and Light Collection Efficiency Studies for the CRESST Experiment** — ●ALEXANDER LANGENKÄMPER, XAVIER DEFAY, JEAN-CÔME LANFRANCHI, ERIK LINDNER, ELIZABETH MONDRAGÓN, ANDREA MÜNSTER, CORBINIAN OPPENHEIMER, TOBIAS ORTMANN, WALTER POTZEL, STEFAN SCHÖNERT, HONG HANH TRINH THI, ANDREAS ULRICH, STEPHAN WAWOCZNY, MICHAEL WILLERS, and ANDREAS ZÖLLER — Technische Universität München, Physik Department Lehrstuhl E15 und Excellence Cluster Universe, James-Franck-Straße, D-85748 Garching

The CRESST experiment aims for the direct detection of Dark Matter via elastic scattering off nuclei in CaWO<sub>4</sub> single crystals. The detectors are operated at mK temperatures and consist of the target crystal as well as a separated light detector. The simultaneous readout of phonon and light detector is used for particle identification. To increase the light collection both detectors are surrounded by a reflecting and scintillating foil which is characterised in this work. The results of wavelength and angle dependent absolute reflectivity measurements at 300 K as well as relative reflectivity measurements between 300 K and 20 K will be presented. The results are implemented in a GEANT4 simulation to study the light collection efficiency in CRESST detector modules and first results will also be shown. This work was supported by the DFG Excellenzcluster Origin and Structure of the Universe and the Maier-Leibnitz-Laboratorium (Garching).

T 55.8 Di 18:40 VSH 19

**Production of Sputtered Tungsten TES for the CRESST III Experiment** — ●TOBIAS ORTMANN, XAVIER DEFAY, JEAN-CÔME LANFRANCHI, ALEXANDER LANGENKÄMPER, ERIK LINDNER, ELIZABETH MONDRAGÓN, ANDREA MÜNSTER, CORBINIAN OPPENHEIMER, WALTER POTZEL, STEFAN SCHÖNERT, HONG HANH TRINH THI, ANDREAS ULRICH, STEPHAN WAWOCZNY, MICHAEL WILLERS, and ANDREAS ZÖLLER — Technische Universität München, Physik Department Lehrstuhl E15 und Excellenzcluster Universe, James-Franck-Straße 1, D-85748 Garching

The CRESST experiment (Cryogenic Rare Event Search with Superconducting Thermometers) searches for nuclear recoils events induced by elastic scattering of dark matter particles off the target nuclei within CaWO<sub>4</sub> target crystals. The detectors are operated at a temperature of  $\mathcal{O}(10\text{ mK})$  and consist of the target crystal and a separate cryogenic detector. Both heat (phonon) and light signals are read out via a tungsten TES (Transition Edge Sensor) utilizing the superconduction phase transition of tungsten to measure the energy deposited in the absorbers. So far the TES are produced via electron beam evaporation. In this work the production via argon ion sputtering is investigated in terms of film quality and reproducibility. The first results are presented. This work was supported by the DFG Excellenzcluster Origin and Structure of the Universe and the Maier-Leibnitz-Laboratorium (Garching).

T 55.9 Di 18:55 VSH 19

**An alternative approach to Neganov-Trofimov-Luke cryogenic light detectors for Rare Event searches** — ●ELIZABETH MONDRAGÓN<sup>1</sup>, XAVIER DEFAY<sup>2</sup>, ALEXANDER LANGENKÄMPER<sup>1</sup>, JEAN-CÔME LANFRANCHI<sup>1</sup>, ERIK LINDNER<sup>1</sup>, ANDREA MÜNSTER<sup>1</sup>, CORBINIAN OPPENHEIMER<sup>1</sup>, TOBIAS ORTMANN<sup>1</sup>, WALTER POTZEL<sup>1</sup>, STEFAN SCHÖNERT<sup>1</sup>, HONG HANH TRINH THI<sup>1</sup>, ANDREAS ULRICH<sup>1</sup>, STEPHAN WAWOCZNY<sup>1</sup>, MICHAEL WILLERS<sup>1</sup>, and ANDREAS ZÖLLER<sup>1</sup> — <sup>1</sup>Technische Universität München, Physik Department Lehrstuhl E15, James-Franck-Straße 1, D-85748 Garching — <sup>2</sup>Excellence Cluster Universe, Boltzmannstraße 2, D-85748 Garching

There is a common need in Astroparticle experiments such as direct Dark Matter detection, for detectors with a very low energy threshold. By employing the Neganov-Trofimov-Luke Effect (NTLE) the thermal signal of photons interacting in a semiconductor absorber, operated at cryogenic temperatures, can be amplified by drifting electrons and holes in an electric field. One of the main problems with such detectors arises from an incomplete and unreliable charge collection. In this work a novel electrode geometry designed to improve the charge collection efficiency is investigated in NTLE detectors and first highly promising results will be presented – this design allows a complete charge collection and provides an outstanding energy resolution. This research was supported by the DFG cluster of excellence Origin and Structure of the Universe and by the Maier-Leibnitz-Laboratorium (Garching).

## T 56: Neutrinophysik 4 (Doppelbetazerfall und Massen)

Zeit: Dienstag 16:45–19:05

Raum: VSH 118

### Gruppenbericht

T 56.1 Di 16:45 VSH 118

**Status and Perspectives of the COBRA Experiment** — ●JAN TEBRÜGGE for the COBRA-Collaboration — Experimentelle Physik IV, TU Dortmund

The COBRA collaboration searches for neutrinoless double beta-decay. The detection of this decay would be a proof of lepton number violation and could answer several questions in neutrino physics. The collaboration operates a demonstrator setup at the Gran Sasso underground laboratory consisting of about 400g of CdZnTe detectors. This detector material is a commercially available room-temperature semiconductor. It contains nine double beta-decay isotopes, of which Cd-116 is the most promising one due to its high Q-value of 2813 keV. This talk gives an overview of the demonstrator and discusses the measurement of the fourfold-forbidden non-unique beta-decay of Cd-113. Its measurement allows the precise determination of the quenching of the  $g_A$  factor of this weak process. This dedicated investigation is being done at the moment. Furthermore, recent developments for the installation of the extended demonstrator (XDEM) are shown. XDEM will use larger detectors which have six times the volume of the current detectors. A new powerful tool for background reduction will be discussed which improves the veto capabilities of surface events by up to

two orders of magnitude.

T 56.2 Di 17:05 VSH 118

**Discrimination of single-site and multi-site events in CZT-CPG detectors for the COBRA experiment** — ●STEFAN ZATSCHLER for the COBRA-Collaboration — TU Dresden, Institut für Kern- und Teilchenphysik, Germany

The COBRA experiment is aiming to search for the rare neutrinoless double beta-decay ( $0\nu\beta\beta$ -decay) with CdZnTe detectors. Currently, a demonstrator setup is operated at the underground facility LNGS in Italy. Each monolithic detector of the  $4\times 4\times 4$  array is  $1\text{ cm}^3$  in size and equipped with a coplanar grid (CPG) readout. This demonstrator is used to characterize potential background components and to prove that stable operation over several years can be achieved. One key requirement for a high sensitivity is the ability to differentiate between signal and background events. In this context, pulse-shape analysis has been found to show excellent capabilities while maintaining a high signal efficiency. The  $0\nu\beta\beta$ -decay signal is expected to be almost always a single-site event (SSE) within only one detector. Hence, all multi-detector and multi-site events (MSEs), which are likely induced by multiply scattered photons in the same crystal, can be vetoed as background. The imprints on the recorded pulse-shapes caused by the drift



of multiple, separated charge clouds can be used to discriminate those MSEs from signal-like SSEs. In this talk, an overview of the developed technique to discriminate between both event types will be presented. Additionally, the results of a dedicated laboratory experiment, which makes use of coincident Compton scattering to create a library of SSEs, as well as an efficiency estimate will be shown.

T 56.3 Di 17:20 VSH 118

**The KATRIN Forward Beam Monitor Phase II commissioning** — ●STEPHANIE HICKFORD and SIMON SCHBOTZ for the KATRIN-Collaboration — Bergische Universität Wuppertal

The KATRIN collaboration aims to measure the neutrino mass with a sensitivity of 200 meV. This will be done by observing the  $\beta$ -electron spectrum from the decay of tritium. The tritium source properties need to be stable, and known to a high precision, in order to accurately measure the neutrino mass. For this reason the source will undergo extensive measurements from several monitoring systems.

The *Forward Beam Monitor* (FBM) is one such monitoring system. The Phase II commissioning of the FBM was recently carried out on-site at the KATRIN experiment. This commissioning phase was the first operation of the FBM in conjunction with the *Cryogenic Pumping Section* (CPS) of the KATRIN experiment, and covered three main measurement topics: Temperature influences, magnetic field scan, and absolute positioning. The data-taking procedure and results of these measurements will be presented.

T 56.4 Di 17:35 VSH 118

**Optimization of detector arrays and the cryogenic platform for the ECHo experiment** — ●CLEMENS HASSEL for the ECHo-Collaboration — Kirchhoff-Institute for Physics, Heidelberg University, Germany.

The Electron Capture in  $^{163}\text{Ho}$  experiment ECHo aims to probe the electron neutrino mass on a sub-eV level via the analysis of the calorimetrically measured high statistics electron capture spectrum of  $^{163}\text{Ho}$ . For this, metallic magnetic calorimeter arrays (MMC) will be used, which are operated at millikelvin temperatures. The performance achieved by first prototypes of MMC detectors show that an energy resolution of  $\Delta E_{\text{FWHM}} < 5$  eV and a signal rise time of  $\tau < 1$   $\mu\text{s}$  can be reached. These values, obtained with single channel read out, fulfill the requirements for the first phase of ECHo, ECHo-1k. The challenge is to keep the same performance using the multiplexed read out. We present the current status of the new design for the detector arrays to be used in ECHo-1k. This array design allows for parallel read out as well as for multiplexed read out. We discuss results obtained during the first characterization of these detectors. The first phase of ECHo will be performed in a new dedicated cryostat. The future plans for mounting read out cables and the design for the installation of the array on the experimental platform will be shown. Finally we discuss the present status of the ECHo-1k experimental set-up and present first results obtained with the new arrays operated in the new cryostat.

T 56.5 Di 17:50 VSH 118

**Background Studies for the ECHo Experiment** — ●STEPHAN SCHOLL for the ECHo-Collaboration — Kepler Center for Astro and Particle Physics, Eberhard-Karls-Universität Tübingen

The ECHo experiment is going to measure the endpoint of the spectrum of the  $^{163}\text{Ho}$  electron capture at 2.833 keV, which offers great potential to reach sub-eV sensitivity on the absolute neutrino mass  $m_{\nu_e}$ . In order to achieve this sensitivity, the low energy background below 3 keV has to be thoroughly understood and reduced as much as possible. The background spectra of radioactive contaminants  $^{40}\text{K}$ ,  $^{166\text{m}}\text{Ho}$  and  $^{210}\text{Pb}$  in the surrounding structures of the detectors have been investigated via GEANT4 Monte-Carlo simulations. The results of our studies with respect to the tolerable contamination levels and the necessary improvements in the simulation software are presented in this contribution.

T 56.6 Di 18:05 VSH 118

**Untergrund durch Radioaktive Zerfälle am KATRIN Experiment** — ●NIKOLAUS TROST für die KATRIN-Kollaboration — Karlsruher Institut für Technologie, Hermann-von-Helmholtzplatz-1, 76344 Eggenstein-Leopoldshafen

Für die modellunabhängige Messung der effektiven Neutrinomasse mit einer Sensitivität von 200 meV/ $c^2$  (90% C.L.) durch Untersuchung des Betaspektrums von Tritium am Endpunkt werden am **Karlsruher Tritium Neutrino Experiment** die Elektronen einer fensterlosen, gas-

förmigen Tritiumquelle, werden adiabatisch zu Vor- und Hauptspektrometer geführt, welche die Elektronenenergie nach dem MAC-E Filter Prinzip analysieren, und von einem Siliziumdetektor gezählt. Für das Erreichen der vollen Sensitivität werden weniger als  $10^{-2} \text{ s}^{-1}$  Untergrundereignisse benötigt.

Radioaktive Zerfälle von  $^{219/220}\text{Rn}$  im Volumen und  $^{210}\text{Pb}$  an der Wand der Spektrometer können aufgrund verschiedener Speicher- und Transportmechanismen durch Ionisation von Restgas im Vakuum ( $10^{-11}$  mbar) den Untergrund deutlich erhöhen. Für die somit sehr wichtige Simulation von Untergrund und Transmission wurde die modulare Particle Tracking Software KASSIOPEIA entwickelt und veröffentlicht [arXiv 1612.00262]. Dieser Beitrag stellt Ergebnisse von Messungen und Simulationen des Untergrunds am KATRIN Hauptspektrometer vor.

Gefördert durch das BMBF unter Kennzeichen 05A14VK2 und die Helmholtzgemeinschaft

T 56.7 Di 18:20 VSH 118

**Ion-induced background processes in the KATRIN main spectrometer** — ●WOO-JEONG BAEK for the KATRIN-Collaboration — Karlsruhe Institute of Technology (KIT), Institut für Experimentelle Kernphysik (IEKP)

The aim of the Karlsruhe TRItium Neutrino (KATRIN) Experiment is to determine the effective mass of the electron antineutrino with a sensitivity of 200 meV/ $c^2$  in a model-independent way by investigating the energy spectrum of tritium  $\beta$ -electrons near the endpoint. The experimental setup of KATRIN consists of a windowless gaseous tritium source (WGTS), a transport section for the signal electrons split in differential and cryogenic pumping sections for the extraction of gaseous tritium, a high-resolution electrostatic spectrometer system (pre- and main spectrometer) based on the MAC-E filter principle and a focal-plane detector system, that detects the transmitted electrons. The flux of positive ions, which originate in the decay of tritium, is reduced by several subsystems (e.g. blocking electrodes) in the pumping sections. In order to investigate the possibility to use the KATRIN spectrometers as sensitive ion detectors, a series of dedicated measurements were performed as part of the first commissioning measurement phase of the KATRIN beam line in November 2016.

This talk will present the results of these measurements focusing on the characteristics of ion-induced background processes in the main spectrometer. This work is supported by KSETA, BMBF (05A14VK2), HAP and the Helmholtz association.

T 56.8 Di 18:35 VSH 118

**Ion detection, blocking and removal in the KATRIN experiment** — ●MANUEL KLEIN for the KATRIN-Collaboration — Karlsruhe Institute of Technology

The Karlsruhe TRItium Neutrino (KATRIN) experiment aims at the model independent measurement of the electron neutrino mass. It is designed for a neutrino mass sensitivity of 0.2 eV (90% CL) after three years of measurement time. KATRIN measures the end point of the tritium beta-decay spectrum using a MAC-E filter and a Windowless Gaseous Tritium Source (WGTS). While neutral tritium gas molecules are pumped through the WGTS, the decay electrons are guided to the detector by a magnetic field. Tritium ions, however, would also follow the magnetic field lines to the Pre- and Main Spectrometer (PS and MS), where they could cause background by ionisation and contamination. Preventing this is imperative for KATRIN measurements.

Concepts of ion detection, blocking and removal were tested successfully during KATRIN First Light measurements in November 2016. Deuterium ions were detected with either the MS or PS at high voltage via secondary electrons, produced when the ions ionised residual gas. The ions were blocked in the beamtube by applying a positive potential with ring electrodes. Also, the ions were removed with dipole electrodes via  $E \times B$ -drift or with the PS at negative potential, moving the ions non-adiabatically into the PS walls. These results show that the methods of ion detection, blocking and removal work as intended.

Supported by BMBF (05A14VK2) and by the Helmholtz Association.

T 56.9 Di 18:50 VSH 118

**Einfluss des Magnetfelds auf die Transmissionseigenschaften und Systematik des KATRIN Experiments** — ●MORITZ ERHARD für die KATRIN-Kollaboration — KIT, Karlsruhe, Deutschland  
Ziel des Karlsruher Tritium Neutrino Experiments ist es, durch eine Endpunktsuntersuchung des  $\beta$ -Zerfallsspektrums von Tritium die effektive Masse des Elektronantineutrinos direkt und modellunabhängig

mit einer Sensitivität von  $200 \text{ meV}/c^2$  (90 % CL) zu bestimmen. Um diese hohe Sensitivität zu erreichen wird das KATRIN Hauptspektrometer mit dem MAC-E-Filter (Magnetic Adiabatic Collimation with Electrostatic Filter) Prinzip betrieben. Der genaue Magnetfeldverlauf innerhalb des Hauptspektrometers wird zur Bestimmung der Transmissionseigenschaften sowie der zu erwartenden Untergrundrate benötigt und ist damit von zentraler Bedeutung für die spätere Interpretation

der Tritiumdaten und der Extraktion der Neutrinomasse. Basierend auf Messungen mit einer Elektronenkanone und hoch präzisen Magnetometern wurden die Magnetfeldunsicherheit und die Transmissionseigenschaften bestimmend um in Ensembletest deren Einfluss auf die Systematische Unsicherheit zu ermitteln, die in diesem Vortrag vorgestellt werden. Gefördert durch KSETA, BMBF (05A14VK2), HAP und der Helmholtz Gemeinschaft.

## T 57: NeutrinoPhysik 5 (Reaktorneutrinos)

Zeit: Dienstag 16:45–19:05

Raum: VSH 07

### Gruppenbericht

T 57.1 Di 16:45 VSH 07

**Recent results of the Double Chooz reactor neutrino experiments** — ●CHRISTIAN BUCK for the Double Chooz-Collaboration — MPIK Heidelberg

The main goal of the Double Chooz reactor neutrino experiment is a precision measurement of the neutrino mixing angle  $\theta_{13}$ . This smallest of the three known mixing angles is determined from the disappearance of electron antineutrinos emitted by two nuclear reactors in Chooz, France. Neutrino interactions with the protons of an organic liquid scintillator produce a coincidence signal consisting of the energy depositions of a prompt positron and a delayed neutron allowing efficient background suppression. The reactor neutrino flux is measured in two detectors at different baselines to the source. The near detector at 400 m from the reactors provides a reference measurement almost without an oscillation effect. The far detector at 1.05 km distance is located close to the first oscillation minimum. First two detector results will be presented. A precise measurement of  $\theta_{13}$  with the running reactor neutrino experiments is a crucial input for upcoming projects sensitive to CP-violation and atmospheric mass hierarchy observables.

T 57.2 Di 17:05 VSH 07

**Consistencies of the neutron detection efficiency in the Double Chooz reactor neutrino detectors** — ●HELENA ALMAZAN, CHRISTIAN BUCK, JULIA HASER, and MANFRED LINDNER — Max-Planck-Institut für Kernphysik (MPIK)

The Double Chooz experiment, analysing the reactor antineutrino signal from the nuclear power plant in Chooz (France), aims for a precision measurement of the neutrino mixing angle  $\theta_{13}$  with the new data collected at the near and far detectors. An accurate and precisely known detection efficiency of the electron antineutrino interaction  $\bar{\nu}_e + p \rightarrow e^+ + n$ , called inverse beta decay (IBD), is required in order to reach that goal. The detection efficiency of the correlated signal caused by the IBD reaction produces strongly depends on the performance of the neutron detection, and it comprises one of the dominant uncertainties in the  $\theta_{13}$  estimation. Among other calibration methods, the deployment of a  $^{252}\text{Cf}$  radioactive source at the detector center and along a deployment tube is used to study the neutron capture signal in different detectors' inner volumes.

The recently collected  $^{252}\text{Cf}$  data has been studied and compared to Monte Carlo simulations. In that way, the fraction of n-captures on Gadolinium (atoms loaded in the neutrino target) has been estimated to prove the time stability and consistency between detectors, and to study the behaviour of the neutron captures at the inner volume borders. These results and the performed estimation of the systematic uncertainties of the neutron capture efficiency provide a crucial input for the antineutrino oscillation analysis with two detectors.

T 57.3 Di 17:20 VSH 07

**Background studies for the neutrino oscillation experiment Double Chooz** — ●MATTHIAS KOCH, SIMON APPEL, MARIANNE GÖGER-NEFF, LOTHAR OBERAUER, and STEFAN SCHÖNERT — Physik Department E15, Technische Universität München

The two detectors of the Double Chooz experiment in France are investigating the neutrino mixing angle  $\theta_{13}$ . In this work a background analysis for the first sample of data from the near detector with an absolute live time of 364 days was performed. The analysis was done by searching for the distinctive pattern of a beta particle from the decay of  $^{214}\text{Bi}$  and  $^{212}\text{Bi}$  followed by an alpha particle from the decay of  $^{214}\text{Po}$  and  $^{212}\text{Po}$  within a short time period, known as BiPo coincidence. Because  $^{214}\text{Bi}$  and  $^{214}\text{Po}$  are members of the uranium chain and  $^{212}\text{Bi}$  and  $^{212}\text{Po}$  are part of the thorium chain looking for BiPo coincidences is a good method to estimate the level of radiopurity inside

the detector. It was found that the number of coincidences is constant over the time indicating radioactive equilibrium in the uranium and the thorium decay chain. Also the mass concentration of uranium and thorium in the inner detector was calculated to be less than  $10^{-13} \text{ g/g}$ , which agrees well with the specification.

This work was supported by the DFG (GO 1729/1-1), the MLL at Garching and the Excellence Cluster 'Universe'.

T 57.4 Di 17:35 VSH 07

**Design and optimization of the Double Chooz final fit** — ILIA BEKMAN, DENISE HELLWIG, PHILIPP KAMPMANN, STEFAN SCHOPPMANN, ●PHILIPP SOLDIN, ACHIM STAHL, and CHRISTOPHER WIEBUSCH — RWTH Aachen University - III. Physikalisches Institut B

The Double Chooz experiment is a reactor anti-neutrino experiment for the purpose of a precise measurement of the neutrino mixing angle  $\theta_{13}$ . The experimental setup consists of two identical liquid scintillator detectors at an average baseline of about 400m and 1km to two reactor cores at the nuclear power plant in Chooz, France. The neutrinos are detected by measuring the signature of the inverse beta decay (IBD), which consists of a prompt positron signal and a delayed neutron capture signal. By performing a simultaneous likelihood fit and taking into account the detector neutrino rates, the energy spectral shape and all relevant backgrounds, the neutrino mixing angle  $\theta_{13}$  can be obtained. In this talk the method, design, performance and optimisation of such a likelihood fit are presented. Furthermore a crosscheck for the latest final fit results are shown.

T 57.5 Di 17:50 VSH 07

**A PMT Mass Testing Setup for the JUNO Experiment using commercial shipping containers** — ●ALEXANDER TIETZSCH<sup>1</sup>, DAVID BLUM<sup>1</sup>, CAREN HAGNER<sup>2</sup>, TOBIAS LACHENMAIER<sup>1</sup>, HENNING REBBER<sup>2</sup>, LISA STEPPAT<sup>2</sup>, TOBIAS STERR<sup>1</sup>, and BJÖRN WONSAK<sup>2</sup> — <sup>1</sup>Physikalisches Institut, Eberhard Karls Universität Tübingen — <sup>2</sup>Institut für Experimentalphysik, Universität Hamburg

To reach the goal of determining the neutrino mass hierarchy, an energy resolution of 3 % @ 1 MeV or better is a key property of the JUNO experiment, which is currently under construction in China. This can only be fulfilled with a high optical coverage in the experiment - realized by about 17000 20-inch-PMTs and up to 34000 3-inch-PMTs - and using PMTs with a high photon detection efficiency. Here it is necessary that every PMT used in JUNO hit some important requirements like high quantum efficiency, low dark noise rate and a sufficient time resolution. So, each of the 20-inch-PMTs has to be tested before being mounted into the detector. In this talk we present our concept of testing up to 20000 20-inch-PMTs by developing a testing facility using commercial shipping containers, that were equipped with all the necessary electronics for a mass characterization of all PMTs. We present the setup developed in Hamburg and Tübingen, report the progress during the last year and give an outlook for the soon starting PMT testing phase in spring 2017 at the JUNO site in China. This work is supported by the Deutsche Forschungsgemeinschaft.

T 57.6 Di 18:05 VSH 07

**Determination of the kB parameter of LAB based scintillators for the JUNO experiment** — ●KONSTANTIN SCHWEIZER, LOTHAR OBERAUER, SABRINA PRUMMER, and STEFAN SCHÖNERT — Technische Universität München, Physik Department, Lehrstuhl für experimentelle Astroteilchenphysik, James-Frank-Str. 1, 85748 Garching bei München

The planned JUNO experiment is a 20 kt liquid scintillator neutrino detector based on a three component scintillator technology. Its primary goal is the determination of the neutrino mass hierarchy. This will be done by precision measurements of the reactor antineutrino

survival probability. Due to the spherical detector's diameter of 35 m and the required energy resolution of 3% at 1 MeV, the optical parameters of the scintillator have to be known very precisely and have to be very good. Therefore, the kB parameter which describes the quenching factor of the scintillator has to be determined in order to interpret the results of the neutrino mass hierarchy correctly. In order to measure the kB parameter a coincidence experiment between a photomultiplier tube measuring the scintillation light and a high-purity germanium detector has been set up. This talk will give the status of this setup and its results. This work is supported by the DFG Cluster of Excellence "Origin and Structure of the Universe", the DFG research unit "JUNO" and the Maier-Leibniz-Laboratorium.

T 57.7 Di 18:20 VSH 07

**Online monitoring system for the liquid scintillator transparency in the JUNO Central Detector** — ●WILFRIED WALTER DEPNERING for the JUNO-Collaboration — JGU Mainz

In the last years, large-volume liquid scintillator (LS) detectors have made important contributions to low-energy neutrino physics. A future neutrino detector scaling this technology to 20 kt is the Jiangmen Underground Neutrino Observatory (JUNO). Its primary goal is to determine the neutrino mass hierarchy with at least  $3\sigma$  significance. To reach that goal, an energy resolution of 3% @ 1 MeV is required. Therefore, the transparency of the LS has to be sufficiently high and stable during the whole operation time (attenuation length  $\geq 20$  m). This talk is about a laser system inside the detector for an online measurement of optical LS properties. It allows to detect potential aging effects of the liquid and a gradient in its refractive index. The latter can be caused by a temperature gradient and will lead to curved light propagation, which has to be taken into account in spatial event reconstruction. This work is funded by the DFG research unit "JUNO".

T 57.8 Di 18:35 VSH 07

**An On-line Attenuation length Monitor for JUNO** — ●HEIKE ENZANN for the JUNO-Collaboration — Johannes Gutenberg-Universität, Ec Prisma, Mainz, Deutschland

The Jiangmen Underground Neutrino Observatory (JUNO) with its 20 kt liquid scintillator (LS) detector is designed to determine the neutrino mass hierarchy via a precise survival probability measurement of reactor antineutrinos. It is currently under construction in China and will start data taking in 2020.

To reach the required measurement precision, high optical purity of the LS is necessary. This talk covers the development and testing of an on-line attenuation length monitor for LS quality control. The device will be installed as part of the filling system to monitor the purity of each LS batch before it is inserted into the central detector via a measurement of the attenuation length. This work is supported by DFG research unit "JUNO".

T 57.9 Di 18:50 VSH 07

**Waveform reconstruction with the deconvolution method for JUNO** — LIVIA LUDHOVA and ●MICHAELA SCHEVER — Forschungszentrum Jülich GmbH, Jülich, Germany

To determine the neutrino mass hierarchy by measuring reactor antineutrinos 53 km baseline, the JUNO 20 kton liquid-scintillator detector has to achieve an outstanding energy resolution of  $3\%/\sqrt{E(\text{MeV})}$ . One of the prerequisites of this challenge is the ability to reconstruct the charge and arrival times of individual photons detected by each single PMT. The talk presents the current status of the waveform analysis for MeV neutrino events in Germany. The study is based on the deconvolution method which unfolds the photo-electron hit pattern and the single photo-electron response employing transforms of the signal between the time and frequency domain. An additional aspect is the reconstruction of the first hit time of muons.

## T 58: Neutrinoastronomie 2

Zeit: Dienstag 16:45–19:10

Raum: H 1

### Gruppenbericht

T 58.1 Di 16:45 H 1

**Das Neutrino teleskop ANTARES: Ergebnisse nach 10 Jahren Datennahme** — THOMAS EBERL und ●STEFFEN HALLMANN für die ANTARES-KM3NeT-Erlangen-Kollaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg / ECAP

Das ANTARES Experiment im Mittelmeer ist das erste erfolgreich in der Tiefsee betriebene Neutrino teleskop. Nach zehn Jahren Datennahme wird ANTARES noch über das geplante Ende seiner Laufzeit hinaus bis Mitte 2017 betrieben werden.

Verschiedene Analysen in ANTARES suchen nach punktförmigen, ausgedehnten und – u.a. mit Hilfe eines umfangreichen Multimessenger-Programms – transienten Neutrinoquellen. Durch seine Position auf der Nordhalbkugel ist ANTARES dabei besonders sensitiv für einen möglichen galaktischen Neutrinofluss. Insbesondere bei der Suche nach Dunkler Materie können sehr konkurrenzfähige obere Ausschlussgrenzen gesetzt werden.

Der Vortrag rekapituliert die Meilensteine des Experiments, geht auf die neuesten Ergebnisse ein und umreißt die weiteren Pläne nach dem Ende der Datennahme. Ein besonderes Augenmerk wird dabei auf Analysen gelegt, bei denen das Erlangen Centre for Astroparticle Physics (ECAP) maßgeblich beteiligt war und ist. *Das Projekt wurde durch das BMBF (05A11WEA) gefördert.*

### Gruppenbericht

T 58.2 Di 17:05 H 1

**Latest results and future perspectives of IceCube and IceCube-Gen2** — ●JAN AUFFENBERG for the IceCube-Collaboration — Physikalisches Institut III B, RWTH Aachen University

The IceCube Neutrino Observatory is a cubic kilometer ice Cherenkov neutrino detector, located at the geographic South Pole, detecting neutrinos down to energies of about 10 GeV. Thanks to its size, IceCube can probe small fluxes of high-energy neutrinos ( $> 10$  TeV) and in the last couple of years it has established the existence of a high-energy astrophysical neutrino flux at the level of  $0.5 - 2.5 \cdot 10^{-18} (E/100 \text{ TeV})^{-\gamma} \text{ GeV}^{-1} \text{ cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$  per flavor and a spectral index  $\gamma$  of  $2.0 - 2.7$  depending on the energy range and the underlying physics assumptions of the specific analysis. Features in the spectral shape, the flavor composition, and the identification of sources of this

astrophysical neutrinos are central points of current analysis and are benchmark for future plans with IceCube-Gen2. DeepCore, a region of denser instrumentation at the lower center of the detector, detects low-energy atmospheric neutrinos ( $< 100$  GeV), which are used to study neutrino oscillations with a precision comparable to that of the leading experiments in the field. The latest results and future plans of IceCube are discussed.

T 58.3 Di 17:25 H 1

**Search for weak neutrino point sources in 6 years of IceCube data using an angular-correlation analysis** — ●THEO GLAUCH<sup>1</sup>, PIOTR KALACZYNSKI<sup>1</sup>, MARTIN LEUERMANN<sup>1</sup>, RENÉ REIMANN<sup>1</sup>, JULIA TJUS<sup>2</sup>, LISA SCHUMACHER<sup>1</sup>, JOERAN STETTNER<sup>1</sup>, and CHRISTOPHER WIEBUSCH<sup>1</sup> — <sup>1</sup>RWTH Aachen — <sup>2</sup>Ruhr-Universität Bochum

The IceCube Neutrino Observatory has measured a diffuse all-sky all-flavor astrophysical neutrino flux above 30 TeV. Nevertheless, dedicated searches for astrophysical neutrino point sources have not yet been successful, and the question about the production sites of astrophysical neutrinos remains inconclusive. There are, however, several theoretical models predicting classes of extragalactic sources which are abundant, but too faint to be detected individually. These weak sources could leave an overall signature in an angular-correlation analysis.

This talk presents the latest results from an angular correlation analysis performed on 6 years of IceCube data using the multipole expansion coefficients of spherical harmonics. The resulting implications for particularly interesting source classes such as Blazars and Fanaroff-Riley or Starburst Galaxies are discussed.

T 58.4 Di 17:40 H 1

**Search for directional correlations of high-energy neutrinos in IceCube with astronomical source catalogs** — ●PIOTR KALACZYNSKI, THEO GLAUCH, MARTIN LEUERMANN, RENÉ REIMANN, LISA SCHUMACHER, JOERAN STETTNER, and CHRISTOPHER WIEBUSCH for the IceCube-Collaboration — III. Physics Institute B, RWTH Aachen, Aachen, Germany

The IceCube Neutrino Observatory has measured a diffuse astrophysical muon neutrino flux with good directional information. So far, ded-

icated searches for astrophysical neutrino point sources have not been successful, and the production sites of astrophysical neutrinos remain undetermined. Nevertheless, there are several theoretical models predicting classes of extra-galactic sources which would be abundant, but too faint to be detected individually. A cross-correlation analysis of neutrino arrival directions with astronomical source catalogs is presented. An example is the the NVSS catalog of radio sources. The analysis is based on the multipole expansion coefficients of the neutrino sky map that are compared to the expansion coefficients of the catalog.

T 58.5 Di 17:55 H 1

**IceCube results from blazar stacking searches using seven years of through-going muon data** — •MATTHIAS HUBER and STEFAN COENDERS for the IceCube-Collaboration — Technische Universität München, Physik-Department, James-Frank-Str. 1, 85748 Garching

Located at the South Pole, the IceCube Neutrino Observatory is the world largest neutrino telescope. It instruments one cubic kilometre of Antarctic ice at a depth of about 1500m to 2500m including 5160 light detecting Digital Optical Modules. Since its construction the IceCube neutrino detector experienced remarkable success. Besides the detection of the highest energy neutrinos worldwide, IceCube is the first experiment to observe an astrophysical high-energy neutrino flux. Although in the meantime the collaboration detected more than 50 high energy neutrino events, the origin of these neutrinos is still not identified. Blazars, being a subclass of Active Galactic Nuclei and consequently one of the most powerful objects in the universe are supposed to be one of the most likely sources of high energy neutrinos. This scenario can be examined using stacking methods testing the correlation between IceCube neutrinos and the accumulation of hypothetical sources. We present here the results for three different blazar catalogs. The analyses are performed on 7 years of through-going muon data, taken by the IceCube Collaboration between 2008 and 2015.

T 58.6 Di 18:10 H 1

**IceCube Punktquellenanalyse mit Core-Collapse Supernovae** — •ALEXANDER STASIK für die IceCube-Kollaboration — DESY, Zeuthen

Mit dem IceCube Neutrino-Detektor gelang der Nachweis von einem diffusen astrophysikalischen Neutrino-Fluss, dessen Quellen bisher unbekannt sind. Core-Collapse Supernovae gehören zu den plausiblen Quell-Klassen, da sie unter geeigneten Bedingungen hochenergetische Neutrinos produzieren. Dafür wird eine effiziente Beschleunigung von geladenen Teilchen (hauptsächlich Protonen) sowie ausreichend Target-Material benötigt, bei den in hadronischen Wechselwirkungen Neutrinos erzeugt werden. Diese Bedingungen sind gegeben bei der Explosion von massereichen Sternen in einer sehr dichten Sternumgebung oder innerhalb der Sternhülle. Die hier vorgestellte Analyse nutzt sieben Jahre IceCube Neutrino Daten für eine Korrelationsstudie zwischen optischen Supernova Daten und Neutrino-Ereignissen. Dabei werden die erwarteten Signale von verschiedenen Quellen kombiniert (Stacking). Um den atmosphärischen Untergrund zu verringern, wird die erwartete Zeitabhängigkeit des Neutrinosignals berücksichtigt. Diese Methode ist zum ersten Mal sensitiv genug einen Beitrag von Core-Collapse Supernovae zum astrophysikalischen Neutrinofluss zu entdecken oder den Modellparameteraum für Neutrinoproduktion in Core-Collapse SNe einzuschränken. Sensitivitäten für verschiedene Supernovae-Klassen und erste Ergebnisse werden vorgestellt.

T 58.7 Di 18:25 H 1

**Search for Neutrino Emission from the Galactic Plane with IceCube** — •CHRISTIAN HAACK, LEIF RÄDEL, RENÉ REIMANN, SEBASTIAN SCHOENEN, and CHRISTOPHER WIEBUSCH for the IceCube-Collaboration — III. Physikalisches Institut B, RWTH Aachen

The IceCube Neutrino Observatory has observed a diffuse all-sky all-flavor astrophysical neutrino flux above 30TeV. This flux has also been confirmed using up-going muon neutrinos above 200TeV from the Northern Hemisphere. In addition to searches for point sources, IceCube is able to probe models for diffuse neutrino emission from the galactic plane. In the galactic plane neutrinos are produced by the interaction of cosmic rays with the interstellar medium. The resulting neutrino energy spectrum is given by the cosmic ray propagation model and the properties of cosmic ray accelerators. In this talk, we will present results of a likelihood-based search for neutrino emission from the galactic plane, using six years of IceCube up-going muon neutrino data.

T 58.8 Di 18:40 H 1

**Search for neutrino emission from the Galactic plane with IceCube using starting events** — •KAI KRINGS<sup>1</sup> and CHRISTIAN HAACK<sup>2</sup> for the IceCube-Collaboration — <sup>1</sup>Technische Universität München, Physik-Department, James-Frank-Str. 1, 85748 Garching — <sup>2</sup>III. Physikalisches Institut B, RWTH Aachen, Otto-Blumenthal-Str., 52074 Aachen

The IceCube Neutrino Telescope has observed a diffuse all-sky all-flavor astrophysical neutrino flux above 30 TeV; no sources have been identified yet. We want to challenge the question if the flux is partly of Galactic origin, searching for an integrated neutrino signal along the Galactic plane. Complementary to the search with up-going muon neutrinos, which is constrained to the northern sky only, we use events from both hemispheres with energies above 1 TeV starting inside the IceCube detector. Thus, the entire Galactic plane can be observed, including the Galactic Center. We present results of a proof-of-concept analysis, based on a forward-folding likelihood template fit, using two years of starting event data and introduce a follow-up analysis with six years of data and combined with the up-going muon neutrino search.

T 58.9 Di 18:55 H 1

**Constraints on New Physics from IceCube Neutrino Flavor Composition Measurements** — •LUKAS LECHNER for the IceCube-Collaboration — DESY Zeuthen, Germany

IceCube measured for the first time the flavor composition of high-energy cosmic neutrinos ( $E > 10$  TeV). This measurement is a powerful tool to constrain the production mechanisms of astrophysical neutrinos and investigate potential deviations from Standard Model predictions. In this work, the influence of matter effects at the source, neutrino decay and light sterile neutrinos on the expected neutrino flavor ratio from astrophysical sources are studied. In particular, the effects on the flavor composition of pseudo-Dirac neutrinos with mass squared differences  $\delta m^2 < 10^{-16}$  eV<sup>2</sup> between the active and sterile states are examined. For such small mass differences oscillation phenomena could only be observed over cosmic baselines. The scenarios studied take into account current constraints and uncertainties on the neutrino mass differences and the  $3 \times 3$  mixing (sub-)matrix. The expected effects on the observable flavor composition are presented and compared to current constraints from the IceCube detector, as well as the expected sensitivity of the envisioned IceCube-Gen2 neutrino telescope.

## T 59: Gammaastronomie 3

Zeit: Dienstag 16:45–19:10

Raum: H 2

### Gruppenbericht

T 59.1 Di 16:45 H 2

**FACT - Results from Five Years of TeV Monitoring** — DANIELA DÖRNER<sup>1</sup> and •JENS BUSS<sup>2</sup> for the FACT-Collaboration — <sup>1</sup>Universität Würzburg, Germany — <sup>2</sup>TU Dortmund, Germany

The First G-APD Cherenkov Telescope (FACT) is monitoring blazars to study their variability and its origin. Pioneering the usage of SiPMs, the data taking efficiency was maximized reaching more than 2350 h of physics data in 12 months. Deriving a spectrum of the TeV standard candle Crab Nebula, the excellent performance of FACT was illustrated. To foster simultaneous multi-wavelength (MWL) observations,

crucial to understand blazar physics, the FACT quick look analysis provides results with low latency. Based on this, 40 alerts and six astronomer's telegrams (Atels) were sent since March 2014. An early alert in 2012, resulted in detailed observations by the neighboring MAGIC telescopes on Mrk 501 providing useful information for the associated MWL study. In 2014, the follow-up by H.E.S.S. to another alert on the same source provides a high resolution spectrum complementing FACT's dense long-term light curve. A moderate flux flare of Mrk 421 in Dec 2015 triggered the ongoing target-of-opportunity program with X-ray satellites resulting in time-resolved spectral energy distributions. In 2016, 1ES 1959+650 underwent the brightest flaring activity in TeV

energies since 2002. From FACT, an unprecedented dense light curve is available resulting in 26 alerts, five Atels and valuable MWL data. Studies about the long-term behaviour of several sources based on the FACT light curves are ongoing. The presentation summarizes experience and results from more than five years with FACT.

### Gruppenbericht T 59.2 Di 17:05 H 2

**M@TE - Monitoring at TeV Energies** — DANIELA DORNER<sup>1</sup>, •THOMAS BRETZ<sup>2</sup>, RUBEN ALFARO<sup>3</sup>, MAGDALENA GONZÁLEZ<sup>3</sup>, GAGIK TOVMASSIAN<sup>3</sup>, SIMONE DICHIARA<sup>3</sup>, and KARL MANNHEIM<sup>1</sup> — <sup>1</sup>Universität Würzburg, Germany — <sup>2</sup>RWTH Aachen, Germany — <sup>3</sup>Universidad Autónoma de México, Mexico

Blazars are extremely variable objects emitting radiation across the electromagnetic spectrum and showing variability on time scales from minutes to years. To study typical variability time scales from hours to minutes, continuous observations are crucial.

A dedicated long-term monitoring program for bright TeV blazars has been started by the FACT project about five years ago. Being limited to one site, gaps due to the rotation of the Earth remain in the measured light curves. To allow for systematic studies using continuous observations over up to 12 hours, a second telescope is being installed at the observatory in San Pedro Martir in Mexico.

For the M@TE (Monitoring at TeV energies) telescope, a mount from a previous experiment is being refurbished and will be equipped with a new camera. Using silicon based photo sensors like in FACT, an excellent and stable performance will be achieved. M@TE is a joint project of German and Mexican universities which aims at extending the blazar monitoring to so far unexplored time ranges.

In the presentation, the status of the project will be discussed.

### T 59.3 Di 17:25 H 2

**Study on the classification of blazars with machine learning techniques using multiwavelength information** — •KONSTANTIN PFRANG — Technische Universität Dortmund

The Third Fermi-LAT source Catalog (3FGL) is the deepest all sky survey in gamma-rays so far. Though there are significant achievements in classifying the objects to source types, 1010 sources could not be linked to any of them, and 573 are associated to Active Galactic Galaxies (AGNs) but without any further classification.

By now machine learning techniques have become an important tool for exploring astrophysical data. In previous works the classification with those techniques was only based on information from gamma-ray observation. The removal of the restriction on only one single energy regime provides further information about the energy spectrum. Therefore it is crucial to find counterparts to 3FGL sources in catalogs of other wavelengths.

In this talk, a method to identify possible counterparts for 3FGL sources is introduced and applied to the radio catalog NVSS. Furthermore, the performance of the machine learning algorithms is studied using the framework RapidMiner.

### T 59.4 Di 17:40 H 2

**MAGIC observations of the enigmatic Gamma Cygni supernova remnant** — •MARCEL C. STRZYS<sup>1</sup>, SHU MASUDA<sup>2</sup>, TAKAYUKI SAITO<sup>2</sup>, and IEVGEN VOVK<sup>1</sup> for the MAGIC-Collaboration — <sup>1</sup>Max-Planck-Institut für Physik, München — <sup>2</sup>Kyoto University, Kyoto, Japan

Gamma Cygni (G78.2+2.1) is one of the first supernova remnants (SNR) detected in the high-energy gamma-ray band. It is a middle-aged SNR ( $\approx 7000$  years old) situated in the Cygnus region. The high-energy observations by VERITAS and Fermi-LAT revealed a complex, energy-dependent morphology of the SNR in the GeV-TeV band, different from that observed in X-rays. G78.2+2.1 also hosts the pulsar PSR J2021+4026, which is the only variable gamma-ray pulsar known to date. Here we present the results from recent MAGIC observations of the Gamma Cygni nebula and pulsar complex. We discuss the TeV morphology of the source and possible origins of the gamma-ray emission in the multi-wavelength context.

### T 59.5 Di 17:55 H 2

**Monitoring FSRQs with MAGIC: the case of PKS1510-089** — •COSIMO NIGRO for the MAGIC-Collaboration — DESY Zeuthen, Germany

Among the VHE extragalactic  $\gamma$ -ray emitters, blazars are the most favorably detected by the stereoscopic Imaging Air Cherenkov Telescopes system of MAGIC. Sensitive to gamma-ray energies down to

50 GeV, MAGIC strongly contribute to increase their census, particularly with the type of Flat Spectrum Radio Quasars. Standing out as highly redshifted emitters of the blazar class, they are characterized by softer VHE  $\gamma$ -ray spectra and are favorably detected during short flares, making their multiwavelength monitoring crucial. PKS1510-089, detected by MAGIC also over extended periods, provides an interesting case of study for the low state of these sources. An overview of the source MWL monitoring program will be given along with a resume of its quiescent state observation with MAGIC during the 2015-2016 period.

### T 59.6 Di 18:10 H 2

**Revisiting a Compton/Pair-Telescope using Liquid Xenon TPC Technology** — •JAN PETER LOMMLER, MATTEO ALFONSI, CHRISTOPHER HILS, and UWE OBERLACK — Johannes Gutenberg-Universität Mainz

In the late 90's Aprile et al. were able to show the usability of liquid xenon time projection chambers for astronomical gamma ray imaging as a Compton telescope. Considering technological advancements and improved understanding of liquid xenon detector technology from Dark Matter searches, we are revisiting an extended concept for a Compton/Pair-Telescope in the energy range of  $\sim 0.3$  to  $\sim 10$  MeV in Compton mode and from  $\sim 10$  MeV to few GeV in pair-production mode, using an LXeTPC as position-sensitive calorimeter in combination with a tracker. At the current stage, we use Monte Carlo simulations to model instrument response and backgrounds to assess an expected performance envelope. The goal is to better understand design choices and to compare its performance against conventional current proposals, such as, e.g., eASTROGAM.

### T 59.7 Di 18:25 H 2

**Results from Observations of PSR B1259-63 with H.E.S.S.** — •THOMAS MURACH — DESY Zeuthen, Deutschland

PSR B1259-63/LS 2883 is a binary system consisting of the massive O-type star LS 2883 and the neutron star PSR B1259-63. It is one of the seven gamma-ray binaries known to date. These systems comprise a massive star orbited by a compact object. Only for PSR B1259-63/LS 2883 the type of the compact object is known. The orbit of this neutron star is very eccentric, resulting in small spatial separations of the two stars of less than 1 AU around periastron. Close to periastron, the neutron star crosses the circumstellar disk around the host star twice. Due to the variable interactions in this system, variable emission of light is observed in all wavelength bands.

PSR B1259-63/LS 2883 was observed with the H.E.S.S. telescopes in Namibia around the times of four different periastron passages. Extended observations were conducted with the full H.E.S.S.-II array around the 2014 periastron, for the first time covering the time of periastron itself as well as parts of the orbit before the first disk crossing and during the GeV flare observed by Fermi-LAT. Results from these recent observations are presented. Due to the inclusion of data taken with the large telescope in the centre of the H.E.S.S. array, the energy threshold of  $\lesssim 200$  GeV is unprecedentedly low for this source. A local flux minimum is observed at the time of periastron. High flux states are observed at the time of the GeV flare and, unexpectedly, before the first disk crossing. Predictions derived from a leptonic model are found to agree well with observations.

### T 59.8 Di 18:40 H 2

**FACT - Study of the TeV Blazar 1ES 1959+650 During a High Flux State in 2016** — •AMIT SHUKLA and DANIELA DORNER for the FACT-Collaboration — ITPA, University of Würzburg

The nearby TeV Blazar 1ES 1959+650 ( $z=0.047$ ) is a high-peaked BL Lacertae object and one of the main sources which has been monitored at very high gamma-ray energies (VHE) by the First G-APD Cherenkov Telescope (FACT) since October 2012. This source has been known to be in a low state of flux since its outburst in 2002 and did not show much of activity during the first three years of FACT monitoring. However, the source started showing enhanced activity in VHE gamma-rays during summer 2015 and reached a high flux state during summer of 2016. Several very bright flares were observed by FACT in June and July 2016, and four Atels were sent to alert the community. In this presentation, we will discuss the multiwaveband behavior of 1ES 1959+650 and evolution of the high state. A physics model that can explain several flaring episodes will be discussed.

### T 59.9 Di 18:55 H 2

**FACT - Long-Term Analysis of the Crab Nebula as Calibra-**

**tion Source** — ●JONAS OBERKIRCH for the FACT-Collaboration — TU Dortmund, Germany

The First G-APD Cherenkov Telescope (FACT) pioneers the use of silicon photo multipliers for Imaging Atmospheric Cherenkov telescopes (IACTs). To prove their usability, FACT's performance needs to be compared to other IACTs. For this comparison, the Crab Nebula is used as a "standard candle" due to its brightness and constant flux at TeV energies. FACT has been taking data since seeing first light in 2011.

IACTs see about 1000 hadronic air showers per photon-induced shower which are considered background. Since the amount of data taken during measurements is huge, machine learning methods are very well suited in the analysis for signal-background-separation and unfolding of the energy spectrum.

This analysis aims to extend the research done on one year of crab data to more of the data available and produce an energy spectrum as published before, taking into account changed hardware configurations, to estimate the performance of FACT.

## T 60: Kosmische Strahlung 5

Zeit: Dienstag 16:45–18:20

Raum: H 3

### Gruppenbericht

T 60.1 Di 16:45 H 3

**New results from the Auger Radio Engineering Array (Group report)** — ●FLORIAN BRIECHLE for the Pierre Auger-Collaboration — RWTH Aachen University, Aachen, Germany

The Auger Engineering Radio Array (AERA) is an extension of the Pierre Auger Observatory. It is designed to measure the radio emission of extensive air showers induced by ultra-high energy cosmic rays with energies above  $10^{17}$  eV. AERA consists of more than 150 autonomous dual-polarized radio stations on an area of  $17 \text{ km}^2$  with a spacing ranging from 150 m to 750 m and a frequency bandwidth of 30 - 80 MHz. Data taking started in 2011. It is used for gaining a better understanding of the radio emission processes and measuring properties of the incoming primary cosmic ray. A special focus is put on the energy reconstruction, which has the potential for an improved absolute energy calibration of the Pierre Auger Observatory.

This talk gives an overview of the current status of the experiment and of the latest scientific findings.

T 60.2 Di 17:05 H 3

**Suche nach einem diffusen Photonenfluss in der ultrahoch-energetischen kosmischen Strahlung mit dem Oberflächendetektor des Pierre-Auger-Observatoriums\*** — ●PHILIPP PAPENBREER — Bergische Universität Wuppertal

Durch Propagationseffekte der höchstenergetischen kosmischen Strahlung, sowie durch verschiedene exotische Modelle wird ein Fluss von ultrahochenergetischen Photonen erwartet, der bislang noch nicht nachgewiesen werden konnte. Trifft ein solches ultrahochenergetisches Photon auf die Erdatmosphäre, bildet sich eine Teilchenkaskade, die auf einem mehrere Quadratkilometer großen Gebiet am Erdboden nachgewiesen werden kann. Einen solchen Luftschauder eines Photonprimärteilchens von demjenigen eines leichten Atomkerns zu unterscheiden, stellt experimentell und analytisch jedoch eine Herausforderung dar. Der Oberflächendetektor des Pierre-Auger-Observatoriums ist mit seiner Fläche von  $3000 \text{ km}^2$  und seinem nahezu ununterbrochenen Dauerbetrieb seit etwa 10 Jahren von besonderem Interesse für eine solche Suche. In diesem Vortrag soll der aktuelle Stand der Analysen mit einer Kombination kompositionssensitiver Parameter vorgestellt werden. Dabei werden Simulationen mit den neuesten Wechselwirkungsmodellen verwendet und Verbesserungen der Analyse vorgestellt, um die Separation zwischen Photonen und Hadronen zu optimieren.

\*Gefördert durch die BMBF-Verbundforschung Astroteilchenphysik (Vorhaben 05A14PX1)

T 60.3 Di 17:20 H 3

**Analysis of Muon Ranges in Ice** — ●TOBIAS HOINKA for the IceCube-Collaboration — Technische Universität Dortmund, Deutschland

The IceCube Observatory is a neutrino detector located at the South Pole instrumenting a volume of about one cubic kilometer. Atmospheric muons produced in cosmic ray interactions amount for most of the events triggered in the observatory at a trigger frequency of about 3000 Hz. Although usually considered as background in the search for neutrinos, these events also provide a high statistics source of information about the cosmic ray flux. As muons lose their energy gradually along their tracks, the distance travelled in ice can be used to backtrace their original energy. The aim of this work is to calculate a depth spectrum of muons observed by IceCube. To achieve that, events containing stopping muons are selected with high precision using machine learning techniques. For these events the stopping depth and multiplicity is estimated and a spectrum of their ranges is extracted. Using this

procedure, muon ranges from about 1.5 km to 30 km, corresponding to energies of about 400 GeV to 1 PeV, can be identified.

T 60.4 Di 17:35 H 3

**Composition observables for the photon search at 0.1 EeV at the Pierre Auger Observatory** — ●NICOLAS MARTIN GONZALEZ PINTOS for the Pierre Auger-Collaboration — Instituto de Tecnologías en Detección y Astropartículas, Argentina — Institut für Kernphysik, Karlsruher Institut für Technologie

The Pierre Auger Observatory studies the ultra-high energy (UHE) cosmic rays (CR) which arrive to Earth with energies up to 300 EeV. Their composition varies between proton and iron, and no event compatible with a photon primary has been observed yet. The discovery of photons with energies around 1 EeV could be interesting since they are tracers of the highest-energy processes in the Universe. The Auger Collaboration has proposed several parameters to distinguish photon from hadron primaries. The muon component in extensive air showers (EAS) developed from the interaction between the CR and the atmosphere is one of the most promising approaches. The AMIGA detection system, an upgrade of the Auger Observatory, is composed by buried scintillation muon counters in a denser infilled area. It offers a unique opportunity to enhance the sensibility of the Observatory to a photon signal. In this work, several observables to distinguish a weak photon signal within the vast hadronic background will be explored. Information from the AMIGA muon counters and an associated surface detector will be combined to completely reject the hadronic background by using the Offline package developed by the Auger Collaboration. This criterion would be exploited in order to either find photons or to improve the existing upper limits to the photon flux.

T 60.5 Di 17:50 H 3

**Influence of the extragalactic background light and the extragalactic magnetic field on ultra-high-energy cosmic rays\*** — ●DAVID WITTKOWSKI and KARL-HEINZ KAMPERT — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal

Two of the main unresolved questions in astrophysics concern the origin of ultra-high-energy cosmic rays (UHECR, particle energies  $\geq 1 \text{ EeV}$ ) and the properties of their sources. To address these fundamental questions, the UHECR arriving at Earth are detected and computer simulations are carried out. In this talk we will report on sophisticated simulations of the propagation of UHECR that - in contrast to earlier simulations - take into account deflections of UHECR in cosmic magnetic fields as well as cosmological effects such as the redshift evolution of the photon background and the adiabatic expansion of the universe. Our simulations are performed assuming some recent models for the extragalactic background light (EBL) and for the extragalactic magnetic field (EGMF). Based on these simulations, we will show that the choice of the EBL and EGMF models has a strong influence on the energy spectrum and mass composition of the simulated UHECR and thus on the properties of the UHECR sources deduced by a simultaneous fit of the simulated energy spectrum and mass composition to the UHECR observed at the Pierre Auger Observatory. In addition, we will present predictions for the flux of neutrinos that results from interactions of the UHECR with the photon background. \*Gefördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A14PX1)

T 60.6 Di 18:05 H 3

**Korrelation der Geschwindigkeit des Sonnenwindes mit der Ratenmessung der niederenergetischen kosmischen Strahlung des Pierre Auger Observatoriums\*** — ●DANIEL ROSENBAUM und JULIAN RAUTENBERG für die Pierre Auger-Kollaboration — Bergische

Universität Wuppertal

Das Weltraumwetter beeinflusst die kosmische Strahlung insbesondere in der Heliosphäre. Das Diffusion-Konvektion-Modell sagt dabei eine Antikorrelation der Geschwindigkeit des Sonnenwindes mit dem Fluß der kosmischen Strahlung voraus. Die Rate der niederenergetischen kosmischen Strahlung wird in den Oberflächendetektoren des Pierre-Auger-Observatoriums zu Kalibrationszwecken gemessen. Diese

werden mit den von der NASA verfügbaren Sonnenwindgeschwindigkeiten korreliert. Dabei müssen sowohl transiente Sonneneffekte wie Forbush decreases, als auch langzeitliche Effekte wie Sonnenrotation und der elfjährige Sonnenzyklus gefiltert werden. Erste Ergebnisse der Korrelationsmessung werden vorgestellt.

*\*Gefördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A14PX1).*

## T 61: Topical Workshop: Anomalies in Flavour Physics

Convenor: J. Albrecht, W. Altmannshofer, G. Hiller

Zeit: Dienstag 16:45–19:00

Raum: H 4

### Eingeladener Vortrag

T 61.1 Di 16:45 H 4

**Anomalies in the flavour sector: experimental overview** — ●STEFANIE REICHERT — Technische Universität Dortmund

Over the past years, numerous tests of the Standard Model have been performed and some deviations from the Standard Model in the flavour sector have been found at different experiments, including LHCb, Babar and Belle. A pattern of anomalies has emerged in flavour changing neutral current  $b \rightarrow s\ell\ell$  transitions, including measurements of angular distributions, decay rates and tests of lepton flavour universality. Further deviations from the Standard Model have been observed in  $b \rightarrow c\ell\nu$  decays. The entity of these observed anomalies points towards possible effects of new physics. To shed light onto the nature of those anomalies, the extension of existing measurements to datasets with increased statistics and the inclusion of novel approaches are required. Promising analyses in the quest for new physics include the search for lepton flavour violating decays and the understanding of the tension of inclusive vs. exclusive measurements of the quark mixing matrix elements. This talk gives an overview of the most intriguing anomalies observed in the flavour sector and presents an outlook to possible future measurements.

### Eingeladener Vortrag

T 61.2 Di 17:20 H 4

**New physics in  $b \rightarrow (u, c)\tau\nu$  transitions** — ●MARTIN JUNG — Excellence Cluster Universe, Technische Universität München, Boltzmannstr. 2, D-85748 Garching, Germany

Measurements of  $B \rightarrow D^{(*)}\tau\nu$  transitions show presently a sizable deviation from the Standard Model (SM). Possible interpretations in terms of new physics (NP) are discussed, taking the most recent measurements from the Belle and LHCb experiments into account. This discussion focuses on the differentiation of not only the SM from NP,

but also between different NP models.

### Eingeladener Vortrag

T 61.3 Di 17:45 H 4

**Status of global  $b \rightarrow s\ell\ell$  fits in 2017** — ●DANNY VAN DYK — Universität Zürich, Winterthurerstrasse 190, 8057 Zürich, Schweiz

I will review the state of global fits for New Physics effects in rare  $b \rightarrow s\ell\ell$  transitions. Particular attention will be paid to differences in the used data sets and methodologies. I will briefly discuss the impact of non-local charm effects on the fits.

### Eingeladener Vortrag

T 61.4 Di 18:10 H 4

**Lepton flavour non-universality in rare B decays** — ●SOPHIE RENNER — JGU Mainz, Germany

I will discuss hints of lepton flavour non-universality in measurements of rare B decays involving the quark-level transition  $b \rightarrow s\ell^+\ell^-$ . If lepton flavour universality is violated this necessarily points to physics beyond the Standard Model. I will summarize some BSM models that could produce this effect, and further tests that could be done to constrain these models and to determine whether and by how much lepton universality is violated in rare B decays.

### Eingeladener Vortrag

T 61.5 Di 18:35 H 4

**New Physics Scenarios for B Anomalies** — ●MARTIN BAUER — ITP, Heidelberg University, Heidelberg, Germany

Many explanations for the anomalies measured in B decays have been discussed in the literature, including Leptoquarks, new gauge bosons and even scenarios that can include a Dark Matter candidate. I will give an accessible overview over these New Physics models and discuss their motivation in terms of more UV complete models.

## T 62: Astroteilchenphysik/Kosmologie (Theorie) 2

Convenor: M. Garny, B. Herrmann

Zeit: Dienstag 16:45–18:45

Raum: VSH 17

T 62.1 Di 16:45 VSH 17

**CP-violation and baryon-asymmetry from varying Yukawas at the weak scale.** — ●SEBASTIAN BRUGGESSER, GERALDINE SERVANT, and THOMAS KONSTANDIN — DESY theory group / Notkestrasse 85 / 22607 Hamburg

Varying Yukawas open new possibilities for electroweak baryogenesis. In particular varying Yukawas, if somehow related to the mechanism of electro-weak symmetry breaking, can account for a strongly first order phase transition and they can provide a new source of CP-violation. In this talk I will focus on the CP-violation and the calculation of the final baryon-asymmetry. Starting from first principles, I will derive the general form of the CP-violating force and the diffusion equations for models with varying Yukawa couplings. This represents a very general framework to determine the baryon-asymmetry generated in a given model. I will discuss the necessary ingredients for successful baryogenesis and I will apply this framework to different models and discuss the CP-violation and the amount of baryon-asymmetry produced.

T 62.2 Di 17:00 VSH 17

**Refined relic dark matter relic density calculation** — ●MICHAEL GUSTAFSSON — Göttingen University

A full phase-space calculation of chemical and kinetic freeze-out for

annihilating dark matter (DM) particles has, to our knowledge, not been presented in the literature. Considering the vast literature relying on standard DM freeze-out calculations, it seems interesting to scrutinize the canonical assumptions and investigate a full phase-space freeze-out calculation. For dark matter particle candidates with an exceptionally early kinetic decoupling a full phase-space calculation seems to be needed to achieve reliable results.

T 62.3 Di 17:15 VSH 17

**Dragon2 : A novel code for Cosmic-Ray transport in the Galaxy** — ●ANDREA VITTINO — Technische Universität München, Munich, Germany

We introduce Dragon2, the new version of the public software package designed to study cosmic-ray propagation in the Galaxy. Our aim is to illustrate the approach followed in the writing of the code and to present its most important features. We describe the properties of the numerical scheme that has been adopted in Dragon2 to implement the different processes related to cosmic-ray transport and we investigate its correctness by comparing our numerical results with a set of analytical solutions. Starting from these validation tests, we study in detail the performances of the code by probing the different factors that influence its accuracy and its speed under a wide range of differ-



ent conditions. Lastly, we investigate the new features introduced in Dragon2 in the treatment of diffusion, energy losses and reacceleration and their impact on the predicted fluxes, in comparison also with the results given by the previous version of the code.

T 62.4 Di 17:30 VSH 17

**A minimal model for dark matter and neutrino masses** — ●SONJA ESCH<sup>1</sup>, CARLOS YAGUNA<sup>2</sup>, and MICHAEL KLASSEN<sup>1</sup> — <sup>1</sup>WWU Münster — <sup>2</sup>MPI Heidelberg

We will present a minimal model for dark matter and neutrino masses. By adding one scalar and one fermionic doublet along with a scalar singlet and a fermion singlet to the Standard Model, it is possible to radiatively generate neutrino masses. A long with the new particles a Z2 symmetry is introduced, which stabilizes the new heavy particles, allowing the lightest one of them to be a dark matter candidate.

The coupling of the dark sector to the lepton sector, which generates the neutrino masses, on the one hand causes lepton flavour violation. On the other hand these new couplings can influence the dark matter relic density, while leaving the direct detection cross section nearly unaffected.

T 62.5 Di 17:45 VSH 17

**Dark matter decay through gravity portals** — OSCAR CATA<sup>1</sup>, ALEJANDRO IBARRA<sup>2</sup>, and ●SEBASTIAN INGENHÜTT<sup>2,3</sup> — <sup>1</sup>Ludwig-Maximilians-Universität München — <sup>2</sup>Technische Universität München — <sup>3</sup>Max-Planck-Institut für Physik (Werner-Heisenberg-Institut)

Motivated by the fact that, so far, the whole body of evidence for dark matter is of gravitational origin, we study the decays of dark matter into Standard Model particles mediated by gravity portals, i.e., through nonminimal gravitational interactions of dark matter. We investigate the decays in several widely studied frameworks of scalar and fermionic dark matter where the dark matter is stabilized in flat space-time via global symmetries. We find that the constraints on the scalar singlet dark matter candidate are remarkably strong and exclude large regions of the parameter space, suggesting that an additional stabilizing symmetry should be in place. In contrast, the scalar doublet and the fermionic singlet candidates are naturally protected against too fast decays by gauge and Lorentz symmetry, respectively. For a nonminimal coupling parameter  $\xi \sim \mathcal{O}(1)$ , decays through the gravity portal are consistent with observations if the dark matter mass is smaller than  $\sim 10^5$  GeV, for the scalar doublet, and  $\sim 10^6$  GeV, for the fermionic singlet.

T 62.6 Di 18:00 VSH 17

**Gravitational Waves as a New Probe of Dark Matter** — P. S. BHUPAL DEV<sup>1,2</sup>, MANFRED LINDNER<sup>1</sup>, and ●SEBASTIAN OHMER<sup>1</sup> — <sup>1</sup>Max-Planck-Institut für Kernphysik, Heidelberg — <sup>2</sup>Washington University, St. Louis

Dark Matter (DM) could be composed of ultralight bosons which form a Bose-Einstein condensate (BEC) in the early universe. We present a new method to test such a scenario by measuring the change of propagation speed of a gravitational wave passing through a BEC-DM halo. Current and future gravitational wave detectors can probe the entire parameter space of BEC-DM.

T 62.7 Di 18:15 VSH 17

**Gravitational waves from oscillons after inflation** — ●FRANCESCO CEFALÀ — University of Basel, Basel, Switzerland

We investigate the production of gravitational waves during the preheating process after inflation in the common case of field potentials that are asymmetric around the minimum where the universe reheats. In particular, we study the impact of oscillons, comparatively long lived and spatially localized regions where a scalar field (e.g. the inflaton) oscillates with large amplitude. Contrary to a previous study, which considered a symmetric potential, we find that oscillons in asymmetric potentials associated with a phase transition can generate a pronounced peak in the spectrum of gravitational waves, that largely exceeds the linear preheating spectrum. In my talk, I will discuss the possible implications of this enhanced amplitude of gravitational waves. For instance, for low scale inflation models, the contribution from the oscillons can strongly enhance the observation prospects at current and future gravitational wave detectors.

T 62.8 Di 18:30 VSH 17

**Formation and Evolution of Axion Minicluster** — JONAS ENANDER, ●ANDREAS PARGNER, and THOMAS SCHWETZ — Institut für Kernphysik, Karlsruher Institut für Technologie (KIT), Germany

We study the cosmological evolution of the axion field in a scenario where the Peccei-Quinn symmetry is broken after inflation. We evolve the initial random field to the time of matter radiation equality to find the power spectrum of axions produced via the vacuum realignment mechanism. The power spectrum is used to study the subsequent gravitational collapse of overdensities into bound objects. This allows us to make a prediction for the distribution of mass and size of axion miniclusters.

## T 63: Experimentelle Methoden 2 (Flavour-,Photon,Elektronidentifikation)

Zeit: Dienstag 16:45–19:05

Raum: JUR 253

### Gruppenbericht

T 63.1 Di 16:45 JUR 253

**Heavy flavor identification at CMS** — ●IVAN MARCHESINI, ALEXANDER SCHMIDT, and SVENJA SCHUMANN — Universität Hamburg

Many physics studies involving standard model processes as well as searches for physics beyond the standard model rely on the accurate identification of jets originating from bottom quarks (b jets). While constantly improving algorithms for the identification of b jets, the CMS Collaboration has recently developed also algorithms to identify charm quark jets (c jets). These new tools open the possibility to explore new channels and will play a key role in several physics studies.

As the excluded mass regions for new physics continue to increase, searches often focus on boosted final states characterized by particles with large transverse momenta. In the boosted regime the resulting decay products for hadronic decays of heavy particles tend to be collimated and can fall within a single jet. The CMS Collaboration has developed dedicated b jet identification tools for this challenging environment.

The state of the art techniques for b jet and c jet identification and their recent developments for boosted final states are presented. Their performance on data is also discussed, based on proton-proton collisions recorded by the CMS detector at a center of mass energy of 13 TeV.

T 63.2 Di 17:05 JUR 253

**Measurements of Light Jet Mistag Rate with The Nega-**

**tive Tag Method** — ●STEFANO CALI<sup>1</sup>, KRISZTIAN PETERS<sup>2</sup>, and MATTHIAS SAIMPERT<sup>3</sup> — <sup>1</sup>Deutsches Elektronen-Synchrotron, Hamburg, Germany — <sup>2</sup>Deutsches Elektronen-Synchrotron, Hamburg, Germany — <sup>3</sup>Deutsches Elektronen-Synchrotron, Hamburg, Germany

Abstract: The identification of jets containing b-hadrons is a procedure widely used in a lot of ATLAS analyses. An important information for the utilization of b-tagging algorithms are the efficiency of tagging a b-jet, as well as the efficiencies of tagging c-jets and light-jets. The efficiency of a b-tagging algorithm to tag a light jet, known as light jet mistag rate, has been measured with a data-driven method: the so-called negative tag method. We will outline the basic procedure of this method and present latest results for 13 TeV data and MC.

T 63.3 Di 17:20 JUR 253

**Measurement of electron identification efficiencies in the ATLAS detector** — ●ELIAS RÜTTINGER — DESY, Zeuthen

Most physics analysis using data collected by the ATLAS detector in 2016 with a center of mass energy  $\sqrt{s} = 13$  TeV need a deep understanding of electron identification requirements. Therefore efficiency corrections are applied to account for differences between the data and the Monte Carlo Modelling using detector simulation. It is crucial for the measurements of the efficiencies to be as precise as possible. The uncertainties and their sources need to be well defined in order to estimate their influence on the estimated total error. Possible sources of systematic errors are the applied background subtraction or kinematic biases due to energy losses of electron candidates. These energy



losses arise from bremsstrahlung in the magnetic field of the detector or of its material.

An overview over electron identification measurements using the signature of the  $Z$  boson is presented, as well as studies on the mentioned systematic sources.

T 63.4 Di 17:35 JUR 253

**Reconstruction efficiency measurements of low- $p_T$  muons in Run 2 at the ATLAS detector** — •MICHAEL HOLZBOCK and ALEXANDER MANN — LMU München

Soft leptons are an important signature of many promising searches for physics beyond the Standard Model and Standard Model measurements. Thus it is vital to address any mismodeling in Monte Carlo generators by comparing the reconstruction efficiencies in simulation and data.

This talk presents the reconstruction efficiency measurements for low- $p_T$  muons down to 4 GeV at the ATLAS detector from  $J/\psi \rightarrow \mu\mu$  events which are selected with the Tag&Probe method. Performing the measurements with different probe types allows for mutual validation of the results. The talk introduces the fitting procedure for computing the efficiency and the evaluation of systematic uncertainties. To reduce background contamination in particular for low- $p_T$  probes, the tracks of the tag-and-probe pair are matched to a  $J/\psi$  vertex candidate. The influence of this matching on the systematic uncertainties is discussed.

T 63.5 Di 17:50 JUR 253

**Measurement of the Photon Identification Efficiency in the ATLAS Experiment** — •FRÜD BRAREN — DESY, Hamburg, Deutschland

The detection and identification of photons in high-energy collisions is important for the physics program of the ATLAS experiment at the Large Hadron Collider. Photons produced in collisions in the ATLAS detector are relevant as a probe of QCD and the Standard Model processes in general, as well as the decay of the Higgs boson to a pair of photons. Also signatures of physics beyond the Standard Model may include photons. For measurements and searches involving photons it is vital to know the efficiency with which photons are being identified as such with high precision.

The identification of photons is based on the shape of the electromagnetic shower in the calorimeter and its efficiency needs to be measured using collision data. One of the three currently employed methods for measuring the photon identification efficiency is based on electrons from  $Z$ -boson decays using a Tag-and-Probe method. The electron showers, which are subsequently transformed into photon-like objects using shower-shape information from electron- and photon Monte-Carlo samples, can be used to measure the photon identification efficiency in the transverse-momentum range from about 25 GeV to about 120 GeV. This contribution presents the method and results of this measurement, using data corresponding to an integrated luminosity of  $36.5 \text{ fb}^{-1}$ , collected at a center-of-mass energy of  $\sqrt{s} = 13 \text{ TeV}$ .

T 63.6 Di 18:05 JUR 253

**Studies on Matching of Trajectories of charged Particles and Energy Deposits in the electromagnetic Calorimeter during Electron Reconstruction in ATLAS** — •RALF GUGEL, KARL JAKOBS, and KARSTEN KÖNEKE — Albert-Ludwigs-Universität Freiburg

An important test of the Standard Model is given by the investigation of the scattering of two  $W$  bosons. This process can be studied in final states with two same-charge leptons  $WW \rightarrow \ell^\pm \nu \ell'^\pm \nu'$ . These final states vastly reduce contributions from background processes compared to the different-charge case. The remaining background contributions in the same-charge final state are dominated by different-charge events in which the charge of one of the electrons is misreconstructed. Studies are shown trying to reduce these backgrounds through an improved matching algorithm for cases where multiple reconstructed charged-particle trajectories are found in the vicinity of an energy deposit in the electromagnetic calorimeter.

T 63.7 Di 18:20 JUR 253

**Messung der Photonidentifikationseffizienz mit der Matrixmethode bei  $\sqrt{s} = 13 \text{ TeV}$  beim ATLAS-Experiment** — •GREGOR GESSNER, DIANE CINCA, JOHANNES ERDMANN und KEVIN KRÖNINGER — TU Dortmund, Experimentelle Physik 4

Die gemessene Effizienz der Photonidentifikation und die daraus resultierenden Skalierungsfaktoren zwischen Simulation und Daten sind wichtige Bestandteile von Messungen verschiedener physikalischer Prozesse, in denen Photonen involviert sind, wie zum Beispiel  $H \rightarrow \gamma\gamma$ .

Es wird eine datenbasierte Methode vorgestellt, mit der die Effizienz der Photonidentifikation beim ATLAS-Experiment gemessen wird. Als Grundlage wird die Matrixmethode verwendet, bei der die Spurisolierung zur Unterscheidung zwischen prompten und fehlidentifizierten Photonen ausgenutzt wird. Die Daten wurden bei einer Schwerpunktsenergie von  $\sqrt{s} = 13 \text{ TeV}$  am ATLAS-Experiment aufgezeichnet und entsprechen dem vollen 13 TeV-Datensatz aus den Jahren 2015 und 2016.

T 63.8 Di 18:35 JUR 253

**Identifikation von Fake-Photonen aus hadronischen Zerfällen und Detektorsignaturen** — BORIS LEMMER, MARÍA MORENO LLÁCER, ARNULF QUADT, ELIZAVETA SHABALINA und •BENEDIKT VÖLKEL — II. Physikalisches Institut, Georg-August-Universität Göttingen

Das Higgs-Boson wurde im Jahr 2012 unter anderem durch den Zerfall  $H \rightarrow \gamma\gamma$  entdeckt. Dafür, genauso wie für viele Präzisionsmessungen wie etwa im Prozess  $pp \rightarrow t\bar{t}\gamma$  und Suchen nach Physik jenseits des Standardmodells, ist die verlässliche Rekonstruktion und Identifikation von Photonen im ATLAS-Experiment essenziell. In den meisten Analysen ist man dabei an sogenannten prompten Photonen interessiert, die direkt in der harten Interaktion der Teilchenkollision entstehen. Daneben gibt es jedoch einen nicht vernachlässigbaren Untergrund, der von Fake-Photonen herrührt. Eine dominante Gruppe bilden dabei hadronische Fake-Photonen. Darunter fallen im Folgenden sowohl Photonen, die nicht im harten Prozess sondern im Zerfall von Final-State-Hadronen entstehen, als auch Hadronen bzw. hadronische Jets, die aufgrund ihrer Detektorsignaturen als Photonen rekonstruiert und identifiziert werden. Der vorliegende Beitrag gibt eine Zusammenfassung darüber, mit welchen Methoden und Analyseverfahren hadronische Fake-Photonen derzeit berücksichtigt und wie hadronische Fake-Photonen-Raten bestimmt werden. Daran anschließend wird die Entwicklung eines neuen Frameworks basierend auf einem künstlichen neuronalen Netz vorgestellt, das hadronische Fake-Photonen zuverlässig erkennen und damit die Analysen, die Photonen einschließen, effizient unterstützen soll.

T 63.9 Di 18:50 JUR 253

**Teststand zur Bestimmung der Lichtausbeute von szintillierenden Fasermatten** — JAN-MARC BASELS, ROMAN GREIM, •DAMIAN IWANICKI, WACLAW KARPINSKI, THOMAS KIRN, SIMON NIESWAND, STEFAN SCHAELE, ARNDT SCHULTZ VON DRATZIG, GEORG SCHWERING und MICHAEL WLOCHAL für die LHCb-Kollaboration — I. Physikalisches Institut, RWTH Aachen University

Während des Long Shutdown 2 von LHC werden alle Subdetektoren von LHCb aufgerüstet. Die geplante integrierte Luminosität von 50/fb während des Runs 3, erfordert es sowohl die instantane Luminosität zu erhöhen als auch zu einer 40MHz-Auslese des gesamten Detektors ohne Level-1-Trigger überzugehen. Dadurch ist es insbesondere nötig, die Granularität und Totzeiten des Downstream Trackers zu verbessern, was bei LHCb durch einen szintillierenden Faser Tracker mit SiPM-Array-Auslese erreicht werden wird. Die Produktion der benötigten Fasermatten und -module hat Anfang 2016 begonnen und erfordert eine genaue kontinuierliche Qualitätskontrolle der wichtigsten Eigenschaften wie geometrische Präzision und Lichtausbeute. Im Vortrag wird ein Teststand zur Bestimmung der Lichtausbeute mit Hilfe einer Sr90-Quelle zusammen mit einer detaillierten Geant4-Simulationen vorgestellt.

## T 64: Experimentelle Techniken der Astroteilchenphysik 3

Zeit: Dienstag 16:45–19:00

Raum: VSH 18

T 64.1 Di 16:45 VSH 18

**Status and Performance of the Wavelength-shifting Optical Module for IceCube Gen2** — ●VINCENZO DI LORENZO, PETER PEIFFER, and SEBASTIAN BÖSER for the IceCube-Collaboration — Johannes Gutenberg-Universität Mainz

The Wavelength-shifting Optical Module (WOM) is a single photon sensor prototype for the next generation of the IceCube experiment. The most prominent features of this sensor are the large sensitivity area, its wavelength shifting properties and the extremely low dark noise rates. These features are stored by shifting the wavelength of abundant UV photons towards the blue, thus guiding and capturing the photons in a tube using two small PMTs. The development of the WOM prototype and its performance will be discussed. In particular, the efficiency of the sensor and the propagation time measurements of the photons inside the optical module will be shown in detail.

T 64.2 Di 17:00 VSH 18

**Simulation Studies on the Wavelength-shifting Optical Module for IceCube Gen2** — ●DUSTIN HEBECKER for the IceCube-Collaboration — HU-Berlin/DESY

The Wavelength-shifting Optical Module is a single-photon sensor that employs wavelength-shifting and light-guiding techniques to maximize the collection area while minimizing the dark noise rate. The prototype sensor is developed for application in ice-Cherenkov neutrino detectors, such as IceCube-Gen2 or MICA. It is aimed at decreasing the energy threshold as well as increasing the energy resolution and the vetoing capability of the neutrino telescope, when compared to a setup with optical sensors similar to those used in IceCube. The proposed sensor captures photons with wavelengths between 250 nm and 400 nm. The Wavelength-shifting Optical Module has been integrated in the IceCube simulation framework. In this talk the measurements on which the simulation is based followed by the first simulation results will be shown.

T 64.3 Di 17:15 VSH 18

**Investigation of tetraphenyl butadiene coatings for wavelength shifting fibers for the liquid argon veto in GERDA** — ●JULIAN KRATZ for the GERDA-Collaboration — Physik-Department and Excellence Cluster Universe, Technische Universität München, James-Frank-Straße 1, 85748 Garching

Liquid argon is a widely used medium in particle detectors, especially in the field of neutrino physics and dark matter searches. Liquid argon has a high photon yield of approximately 40 000 photons/MeV with the wavelengths of the photons in the vacuum ultraviolet region around 127 nm. The most common way of detecting the scintillation light of liquid argon is to shift it to longer wavelengths, where light detectors are sensitive. The GERDA (GERmanium Detector Array) neutrino-less double beta decay experiment uses liquid argon scintillation light to reject events where particles deposit part of their energy outside the germanium detectors in the surrounding liquid argon. For this purpose wavelength shifting (WLS) fibers with silicon photomultipliers (SiPM) connected to the end are coated with tetraphenyl butadiene (TPB). TPB has been demonstrated to be extremely efficient in converting vacuum ultraviolet photons into visible ones. This work focuses on the TPB coatings applied on WLS fibers for the light yield optimization of the liquid argon veto in GERDA. The work was partly funded by BMBF.

T 64.4 Di 17:30 VSH 18

**Characterization of a wavelength shifter coated SiPM** — ●PATRICK HUFSCHMIDT, JÜRGEN HÖSSL, ACO JAMIL, LUKAS MADERER, JUDITH SCHNEIDER, MICHAEL WAGENPFEL, TOBIAS ZIEGLER, GISELA ANTON, and THILO MICHEL — Erlangen Center for Astroparticle Physics, 91058 Erlangen, Germany

Silicon Photomultipliers (SiPMs) are promising candidates for photon counting experiments using next generation nobel gas detectors. Thus they can be an excellent choice for photon detection in experiments for which energy resolution of a signal - derived from scintillation light detection - is crucial. SiPMs offer a high radio purity and single photon resolution which makes them a good choice of photosensors in low background experiments. Since SiPMs are typically not sensitive to wavelengths in the VUV-region, where scintillation light from nobel

gases occurs, a wavelength shifter can be applied yielding sufficient quantum efficiency at VUV-wavelengths. We measured internal gain, temperature dependent breakdown voltage, crosstalk probability and photon detection efficiency for xenon scintillation light at cryogenic temperatures for a wavelength shifter coated SiPM. This contribution explains the working principle of a SiPM and their basic characteristics. Furthermore, characterization results are presented.

T 64.5 Di 17:45 VSH 18

**Design and comparison of a SiPM based detector module to PMT modules in the MAGIC telescopes** — ●ALEXANDER HAHN<sup>1</sup>, DAVID FINK<sup>1</sup>, DANIEL MAZIN<sup>1,2</sup>, RAZMIK MIRZOYAN<sup>1</sup>, and MASAHIRO TESHIMA<sup>1,2</sup> for the MAGIC-Collaboration — <sup>1</sup>Max-Planck-Institut für Physik, München, Deutschland — <sup>2</sup>Institute for Cosmic Ray Research, Tokyo, Japan

The MAGIC collaboration operates two Imaging Atmospheric Cherenkov Telescopes (IACTs) with 17 m diameter on the Canary Island La Palma. Both telescopes offer the great possibility to operate new light detectors alongside the existing camera equipped with 1039 photomultiplier tubes (PMTs). Within the Otto-Hahn working group of the MPG and the MAGIC collaboration we built a composite light detector module which consists of a large-size assembled matrix of silicon photomultipliers (SiPMs) with the same active area as PMT pixels. The aim is to evaluate their potential use as an alternative photo sensor for existing and future experiments as MAGIC and the Cherenkov Telescope Array (CTA). Special constraints on the design as for example operation at high ambient temperatures and high levels of background light have been addressed. We developed an analog summation circuit to combine the individual SiPM signals while preserving the pulse shape of a single sensor. With a dedicated analysis we perform a detailed comparison of our SiPM module to PMTs with data from regular telescope operations. In this presentation we show the design, our comparison to PMTs and the influences of our finding on the next iteration of prototypes.

T 64.6 Di 18:00 VSH 18

**SiPM performance in the Scintillator Upgrade of the Pierre Auger Observatory** — ●JULIAN KEMP, THOMAS BRETZ, THOMAS HEBBEKER, LUKAS MIDDENDORF, CHRISTINE PETERS, and JOHANNES SCHUMACHER for the Pierre Auger-Collaboration — III. Physikalisches Institut A, RWTH Aachen University

The Pierre Auger Observatory successfully measures cosmic-ray air-showers at the highest energies by detecting both the fluorescence light produced in the atmosphere and the particle density of the shower at the ground. Nevertheless, this procedure does not allow for a precise measurement of the muon to electron ratio of a single shower. As this quantity is connected to the mass of the primary particle, it allows for a cosmic-ray mass composition measurement. To improve the ability of separating muons from the electromagnetic component, scintillator based detectors will be added to each surface detector station. The basic design consists of several scintillator bars feeding the produced light into a bundle of wavelength shifting fibers. The light can be detected by either photomultiplier tubes (PMTs) or by silicon photomultipliers (SiPMs). The latter benefit from their high photon detection efficiency and robustness. Three prototype devices based on SiPMs have successfully been installed at the Pierre Auger Observatory in September 2016. Their performance is studied.

T 64.7 Di 18:15 VSH 18

**Silicon Photomultipliers (SiPM) in a Liquid Xenon Time Projection Chamber (TPC)** — ●CHRISTOPHER HILS<sup>1</sup>, MATTEO ALFONSI<sup>1</sup>, ANDREA BROGNA<sup>2</sup>, DANIEL WENZ<sup>1</sup>, and UWE OBERLACK<sup>1,2</sup> — <sup>1</sup>Johannes Gutenberg-Universität Mainz — <sup>2</sup>PRISMA Detektor Labor, Johannes Gutenberg-Universität Mainz

SiPMs are solid state light sensors with single photon count capabilities. With properties similar to the commonly used photomultiplier tubes (PMTs), they provide a higher granularity, they are operated at a much lower bias voltage and have possibly a smaller cost per area. A low background experiment like a liquid xenon TPC also benefits from their much smaller mass and dimensions. Xenon is scintillating in the VUV regime at 178 nm, but most commercially available SiPMs are not sensitive at this wavelength. To increase sensitivity the SiPMs have to

undergo a special treatment, in which the inactive entrance layer on top of the SiPM is thinned. We designed and built a test stand to observe the operational stability and to measure the sensitivity, crosstalk and afterpulse properties of VUV-sensitive SiPMs in liquid xenon. We use a  $^{241}\text{Am}$  source immersed in liquid xenon to provide scintillation light and are able to examine three SiPM samples and a 1" PMT for reference simultaneously.

T 64.8 Di 18:30 VSH 18

**Quantum efficiency measurements of the mDOM PMTs for IceCube-Gen2** — ●RAFFAELA BUSSE, LEW CLASSEN, and ALEXANDER KAPPES for the IceCube-Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster

A significant sensitivity gain for IceCube-Gen2 is anticipated to come from new optical sensor designs. One candidate is the Multi-PMT Digital Optical Module (mDOM), which incorporates 24 3" photomultipliers (PMTs). This design features a.o. an increased effective area and information on the photon arrival direction. To exploit its full potential, a detailed understanding of the PMTs is crucial. Therefore, the properties of all PMT components have to be investigated thoroughly. This talk focuses on the optical properties of the glass and the photocathode, in particular on the quantum efficiency and the wavelength- and angular dependencies. The talk presents measurements of these

aspects with a test stand that has been designed and set up in the framework of a master thesis.

T 64.9 Di 18:45 VSH 18

**Untersuchungen zu Dunkelraten bei Photomultipliern mit der Photokathode auf Hochspannung** — ●FLORIAN TRITTMACK<sup>1</sup>, SASKIA SCHMIEMANN<sup>2</sup>, LEW CLASSEN<sup>1</sup> und ALEXANDER KAPPES<sup>1</sup> für die IceCube-Kollaboration — <sup>1</sup>Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, Deutschland — <sup>2</sup>Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster, Deutschland

Eine wesentliche Steigerung der Sensitivität von IceCube-Gen2 wird von neuen Designs für die optischen Sensoren erwartet. Eines der favorisierten Designs ist das Multi-PMT Optical Module (mDOM), das 24 3" Photomultiplier in einen 14"-Druckkörper integriert. Für die Rekonstruktion von Ereignissen ist dabei eine stabile und möglichst geringe Dunkelrate der Photomultiplier wichtig, insbesondere da das Eis am Südpol optisch nahezu untergrundfrei ist. Dies hat sich bei Photomultipliern, die wie beim mDOM aufgrund der Elektronik mit negativer Hochspannung an der Photokathode betrieben werden, notorisch als schwierig herausgestellt. Der Vortrag präsentiert Untersuchungen, die diesen Aspekt und mögliche Ursachen genauer beleuchten.

## T 65: Experimentelle Techniken der Astroteilchenphysik 4

Zeit: Dienstag 16:45–19:00

Raum: S 055

T 65.1 Di 16:45 S 055

**Extended implementation of cross sections in the propagation tool of charged leptons PROPOSAL** — ●MARIO DUNSCH for the IceCube-Collaboration — TU Dortmund, Deutschland

The recorded data of large underground detectors like the neutrino telescope IceCube are at a stage where in many analyses the sensitivity is rather limited by systematic than the statistical uncertainties. The systematic ones occur from imprecise theoretical descriptions for the Monte Carlo simulations, wherefore it is necessary to improve such descriptions. One part of the Monte Carlo chain used for IceCube is the program PROPOSAL (Propagator with optimal precision and optimized speed for all leptons), which simulates the propagation of leptons through media. The aim of this thesis is to implement and to test improved cross sections in PROPOSAL, whereby the focus is placed on pair production and bremsstrahlung. Furthermore, improved cross sections for supersymmetric staus are implemented which can be used to probe physics beyond the standard model.

T 65.2 Di 17:00 S 055

**Corrections to Muon Cross Sections for IceCube Simulation** — ●JAN SOEDINGREKSO for the IceCube-Collaboration — TU Dortmund, Dortmund, Germany

An important analysis step for neutrino telescopes like IceCube is the energy reconstruction of the detected charged leptons based on Monte Carlo simulations. The energy of electrons and taus can be estimated with high precision, because they are contained events. High energy muons do usually not lose their entire energy within the detector volume, so the energy reconstruction is more complex and is estimated via the energy loss per distance. To reduce the systematic uncertainties of the energy reconstruction for detected muon events, the simulation chain has to be improved. For the propagation of charged leptons carried out by the simulation tool PROPOSAL the interactions with matter have to be known as accurate as possible. In the relevant energy range for astrophysical neutrinos the energy losses originate mainly from pair production, bremsstrahlung and photonuclear interactions. In this talk the current pair production cross section with systematic studies on the effective description of the nuclear interaction is presented.

T 65.3 Di 17:15 S 055

**Interaction Type Distinction for Cascade Events in IceCube** — ●ANNA STEUER and LUTZ KÖPKE for the IceCube-Collaboration — Universität Mainz

Cascade event signatures in IceCube originate either from a charged current interaction of electron or tau neutrinos or from a neutral current interaction of all neutrino flavors. The former induces an electro-

magnetic plus a hadronic shower while the latter initiates a hadronic cascade only. In my talk, I will present promising results of a feasibility study investigating whether an experimental distinction between these types is possible in IceCube. The study, using Geant4, Pythia and DIRE software, exploits the delayed photon signal from neutron capture events, which is more pronounced in hadronic showers.

T 65.4 Di 17:30 S 055

**Porting Simulation Software to Geant4 v10r3 and its Application to the Pierre Auger Observatory Surface Detector Simulations.** — ●ERIC MAYOTTE for the Pierre Auger-Collaboration — Bergische Universität Wuppertal

Geant4 is widely used for accurate simulation of particle detector response. Unfortunately, many implementations of Geant4 are built and tested early on in an experiment and then left unchanged for the lifetime of the project. This is understandable as stability of simulations is a highly desirable quality for all collaborations. However, Geant4 is constantly being improved, providing more accurate physics results and an optimized performance. The upgrade from Geant4 v9 releases to the new Geant4 v10 releases adds many new features and improvements, but also involves some significant changes to the user interface. The Pierre Auger Collaboration recently updated its surface detector (SD) simulations to use the new Geant4 versions. This talk will give a brief overview of the process of porting detector simulations to the new software. Examples of the resulting changes seen in the Pierre Auger Observatory SD simulations when updating from v9r4 to v10r3 will also be shown.

Funded by the BMBF Research Astroparticle Physics (grant 05A14PX1).

T 65.5 Di 17:45 S 055

**GEANT simulations of KATRIN FBM data** — ●NORMAN HAUSSMANN for the KATRIN-Collaboration — Bergische Universität Wuppertal

The Karlsruhe Tritium Neutrino (KATRIN) experiment aims to measure the effective neutrino mass in a model-independent way with a sensitivity of  $200 \text{ meV}/c^2$  (90 % C.L.).

In order to extract the neutrino mass, the Windowless Gaseous Tritium Source (WGTS) properties of KATRIN need to be known to a high precision. For this reason several monitoring systems are installed. One of them, situated in the transport section, is the Forward Beam Monitor (FBM). The FBM is capable of recording the electron rate ( $10^6 \text{ e/s} \cdot \text{mm}^2$ ) and the differential electron spectra with a high energy resolution and precision.

The FBM-detector electronics are shielded by a stainless steel plate with a cutout for two PIN-diodes. The effects of this plate as well as

the reflection of electrons on the source's rear-wall are investigated and their influence on the spectral shape.

Since the detector is situated far outside of the flux tube, the influence of secondary electrons has to be investigated, they originate from the source's and transport section's walls.

The simulations and the latest results are presented in this talk.

T 65.6 Di 18:00 S 055

**FACT - Time series analysis of unevenly sampled data** — ●MAX MAHLKE and THOMAS BRETZ — III. Physikalisches Institut A, RWTH Aachen University, Aachen, Germany

The light curves of astrophysical sources are the result of numerous underlying processes taking place simultaneously. The apparent complexity in the time-domain can be disentangled in the frequency-domain by successive application of statistical methods. As the light curves typically contain gaps due to factors such as bad weather and source visibility, the methods have to be suitable for unevenly spaced data. Arising systematic features in the spectra are reduced by iterative deconvolution with the spectral window. The significance of true peaks in the noisy background is assessed with bootstrapping and harmonic filters.

Blazars like Markarian (Mrk) 501 are hosts to various high-energy phenomena. Therefore, the light curves promise to contain interesting features in their power spectra. In the particular case of Mrk 501, a 23-day periodicity has been claimed in the past.

Among other sources, the First G-APD Cherenkov Telescope (FACT) has been monitoring Mrk 501 and Mrk 421 for the past five years. The light curves are subjected to the described time series analysis in the search for both systematic and source periodicities.

T 65.7 Di 18:15 S 055

**Reconstruction of Gamma Rays with AMS-02** — ●BASTIAN BEISCHER — RWTH Aachen University, Aachen, Germany

AMS-02 is a high-precision multi-purpose particle detector mounted externally on the International Space Station (ISS). Although primarily designed for the measurement of charged cosmic rays, AMS-02 is able to precisely reconstruct photons in two complementary modes. Electrons from photon conversions in the upper part of the detector can be reconstructed due to the excellent tracking capabilities of the detector. In addition AMS-02 features a 17 radiation length electromagnetic calorimeter with a standalone trigger, which allows for a precise measurement of the properties of showers induced by gamma rays. The AMS-02 Tracker, TRD and Time-of-Flight systems provide a reliable veto for charged cosmic rays.

Techniques for the analysis of photons in AMS-02 will be discussed.

T 65.8 Di 18:30 S 055

**Rejection of Transient Noise at the Auger Engineering Radio Array** — ●CHRISTOPH WELLING, CHRISTIAN GLASER, MARTIN ERDMANN, FLORIAN BRIECHLE, and RAPHAEL KRAUSE — III. Physikalisches Institut A, RWTH Aachen University

One of the challenges that radio detectors for air showers face is contamination by pulsed radio noise which may coincide with a cosmic-ray event. These noise pulses can originate from a multitude of sources, such as power lines or radiocommunication devices. In order to perform reliable cosmic-ray measurements it is necessary to be able to identify and reject such noise. In this talk, we present rejection methods based on the timing, shape and polarization of the measured radio pulse as well as the positions of the radio stations with a detected signal. The rejection algorithms were tested and optimized for use at the Auger Engineering Radio Array (AERA) in Monte Carlo studies using air shower simulations combined with a full detector simulation including on-site recordings of radio noise.

T 65.9 Di 18:45 S 055

**Accuracy of Energy Measurements at Cosmic-Ray Observatories** — ●CHRISTIAN GLASER, FLORIAN BRIECHLE, MARTIN ERDMANN, RAPHAEL KRAUSE, and CHRISTOPH WELLING — III. Physikalisches Institut A, RWTH Aachen University

Ultra-high-energy cosmic rays are measured indirectly via air showers which are huge particle cascades that develop in the atmosphere. Thereby the atmosphere acts as a giant calorimeter that is read out from the ground. The currently most accurate method is the measurement of fluorescence light where the systematic uncertainty in the energy measurement can be reduced to 14% requiring extensive monitoring efforts as the creation as well as the attenuation of fluorescence light depend on the actual conditions of the atmosphere. In this contribution, we present an alternative detection technique that is less dependent on atmospheric conditions and thus potentially reduces the systematic uncertainty in the cosmic-ray energy measurement significantly. Air showers emit short radio pulses in the MHz regime such that the cosmic-ray energy can be determined via the measurement of the energy radiated by the air shower in form of radio waves. Two attractive aspects are that the atmosphere is transparent to MHz radio waves and the radio emission can be calculated from first-principles using classical electrodynamics. We will present the systematic uncertainties of the radio method and the efforts to apply the radio technique for an improved absolute energy calibration of the Pierre Auger Observatory.

## T 66: Grid-Computing

Zeit: Dienstag 16:45–18:50

Raum: JUR 372

### Gruppenbericht

T 66.1 Di 16:45 JUR 372

**Computing strategy to cope with the upcoming massive HEP and HI data collection** — ●THOMAS KRESS<sup>1</sup> and KILIAN SCHWARZ<sup>2</sup> — <sup>1</sup>RWTH Aachen University, Physics Institute III B — <sup>2</sup>GSI, Helmholtzzentrum für Schwerionenforschung, Darmstadt

The LHC scientific program has led to numerous important physics results. This would not have been possible without an efficient processing of PetaBytes of data using the Worldwide LHC Computing Grid (WLCG). In the periods following the accelerator and detector upgrades, a huge increase in the data rate is expected. In addition, other big experiments like BELLE-2 and the FAIR collaborations will also take large amounts of data during the next years. So far the LHC computing strategy, based on Grid computing as a distribution of data and CPUs over a few hundred of dedicated sites, has met the challenges. However, to cope with substantially increased data volumes and correspondingly higher CPU requirements, new techniques like cloud computing and the usage of opportunistic resources are necessary. In parallel a reorganisation of the interplay of the computing sites is presently addressed by the evolving computing models of the affected experiments. Recently the Technical Advisory Board of the WLCG German Tier-1 site GridKa in Karlsruhe organised a meeting aimed to identify the guidelines for keeping German HEP and Heavy Ion computing excellent for future requirements. In a follow-up meeting working groups were launched in order to effectively organise the

work on the above topics. The presentation will address the challenges, the German strategy, and the current status of the work packages.

T 66.2 Di 17:05 JUR 372

**ATLAS simulation on ARM-64 bit servers; porting, validation and benchmarks** — GEN KAWAMURA, ARNULF QUADT, and ●JOSHUA WYATT SMITH — II. Physikalisches Institut, Georg-August-Universität Göttingen

The ATLAS experiment explores new hardware and software platforms that, in the future, may be more suited to its intensive workloads. An example is simulation; a CPU intensive workload that would profit drastically if it was more “portable” and therefore usable on a wider variety of platforms. We will present the latest results of the port of the ATLAS software stack onto new prototype ARM 64-bit servers. Patches were needed to introduce this new architecture into the build as well as correct for platform specific code that caused failures on non-x86 architectures. We will show selected results from the validation of the physics outputs on these ARM 64-bit servers. CPU, memory and IO intensive benchmarks using ATLAS specific environment and infrastructure have been performed, with a particular emphasis on the performance vs. energy consumption. From our results it is clear that the prototype ARM 64-bit server outperforms the standard Intel server in terms of Events/KWh.

T 66.3 Di 17:20 JUR 372

**Data intensive workflows in the Cloud** — GEN KAWAMURA<sup>1</sup>, OLIVER KEEBLE<sup>2</sup>, ARNULF QUADT<sup>1</sup>, and GERHARD RZEHOZ<sup>1,2</sup> —  
<sup>1</sup>II. Physikalisches Institut, Georg-August Universität Göttingen —  
<sup>2</sup>IT Department, CERN

Cloud computing in the Infrastructure as a Service case means to rent computing resources from commercial providers. For Monte-Carlo simulations, which record low data in- and output, running on the Cloud is mostly understood. This stems from the fact that no permanent storage is required and the network is not stressed. On the other hand, for data intensive workflows network and storage I/O can be crucial bottlenecks. Therefore, they are usually only computed on Grid sites that either have the required input data in their storage (fast interconnect) - or in a small number of cases the input is downloaded from other sites. This talk will provide answers on how to set up a Cloud to get the best workflow performance, addressing whether to implement a Cloud site with traditional Grid storage, whether to use object storage or even go storage-less altogether. Going further into detail, questions that will be answered are: How big is the influence of the computing to storage distance on the overall event throughput of the site? Can latency effects be mitigated by optimisation techniques? In order to assess this, the Workflow and Infrastructure Model with the output metric  $ETC = \text{Events/Time/Cost}$  is formed and applied. This output quantifies the different workflow and infrastructure configurations that are tested against each other in an understandable and comparable fashion.

T 66.4 Di 17:35 JUR 372

**On-demand provisioning of HEP compute resources on shared HPC centers** — FRANK FISCHER, GÜNTHER ERLI, MANUEL GIFFELS, THOMAS HAUTH, and GÜNTER QUAST — Karlsruher Institut für Technologie

Rather than solely relying on dedicated HEP computing centers, it is nowadays more reasonable and flexible to utilize remote computing capacity via virtualization techniques.

Since last year the remote HPC center (NEMO Cluster, Freiburg University) was scaled by a factor of 20. This contribution reports on challenges, experiences and recent developments with scaling dynamic deployment from a small prototype system to a TOP500 cluster.

The remote and local systems are tied together with the ROCED scheduler [1] such that, from the user perspective, local and remote resources form a uniform, virtual computing cluster with a single point-of-entry. This environment serves the needs of researchers participating in the CMS, AMS and Belle II experiments at KIT. A job volume of over 2 million CPU hours per month (in average) is managed with this system.

[1] O. Oberst et al. Dynamic Extension of a Virtualized Cluster by using Cloud Resources, J. Phys.: Conference Ser. 396(3)032081, 2012

T 66.5 Di 17:50 JUR 372

**Experience with Docker Container at Tier-3 Operations** — MATTHIAS J. SCHNEPF, CHRISTOPH HEIDECKER, FRANK FISCHER, MAX FISCHER, MANUEL GIFFELS, and GÜNTER QUAST — Karlsruhe Institute of Technology

Nowadays High Energy Physics (HEP) computing and analysis can profit a lot from available opportunistic resources and new technologies. The biggest challenges in taking advantages of these resources and technologies are the dedicated operating systems and software requirements by HEP.

A promising way to meet these challenges is the usage of Docker container technology, which allows to run HEP software on operating systems that are not officially support by HEP experiments.

The Institut für Experimentelle Kernphysik (IEKP) uses Docker container in combination with the batch system HTCondor to run physics analyses on desktop PCs and on dedicated worker nodes independent from their operating system.

This talk gives an overview about the experience with Docker containers in our infrastructure and possible upcoming projects.

T 66.6 Di 18:05 JUR 372

**Advantages of coordinated caching for run 2 analyses** — CHRISTOPH HEIDECKER, MAX FISCHER, MANUEL GIFFELS, and GÜNTER QUAST — Karlsruher Institut für Technologie

The current run 2 of the LHC delivers an enormous amount of data waiting for further processing. This includes not only big challenges to the storing capabilities, but also to the distribution of data to the end-user for further analyses. At the KIT, a coordinated caching on SSDs was designed to process large datasets on short turn around cycles. The typical workflow of an analysis at high energy physics requires an iterated execution of the analysis tools. Usually, this is done via a batch-system which allows a parallel execution on different worker nodes. The High Throughput Data Acquisition system caches the necessary datasets directly after the first execution on SSDs located at the worker nodes. This allows an faster processing of data from the second execution of the analysis. Hence, the processing time is reduced dramatically which allows a prompt deployment of new results. The iterated deployment of the jet energy corrections allowed an detailed testing of the caching system with an increasing amount of data. In this context, the developments and experiences of the Karlsruhe workgroup using this coordinated caching will be presented.

T 66.7 Di 18:20 JUR 372

**Virtualization of the ATLAS Software Environment on the bwForCluster NEMO** — ULRIKE SCHNOOR<sup>1</sup>, FELIX BUEHRER<sup>1</sup>, ANTON GAMEL<sup>1</sup>, KONRAD MEIER<sup>1,2</sup>, and MARKUS SCHUMACHER<sup>1</sup> —  
<sup>1</sup>Albert-Ludwigs-Universitaet Freiburg, Physikalisches Institut —  
<sup>2</sup>Albert-Ludwigs-Universitaet Freiburg, Rechenzentrum

High-Performance Computing (HPC) and other research cluster computing resources provided by universities can be useful as a supplement to the collaboration's own Grid computing resources for data analysis and production of simulated event samples. In Freiburg, the HPC cluster NEMO has been established as a part of the Baden-Württemberg (BW) HPC infrastructure and can be used by the BW particle physics community. The talk describes the concept and implementation of virtualizing the ATLAS software environment to run both data analysis and production on the NEMO host system. Main challenges include the integration into the NEMO and Tier-3 schedulers in a dynamic, on-demand way, providing access to the local user environment, as well as the automatic generation of a fully functional virtual machine image.

T 66.8 Di 18:35 JUR 372

**GridKa Tier-1 Zentrum - Status und Zukunft** — MAX FISCHER und ANDREAS PETZOLD — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

Als eines der weltweit 13 Tier-1 Zentren ist das GridKa am KIT ein zentraler Bestandteil des LHC Computing Grid. Mit den vier großen LHC-Experimenten, ALICE, ATLAS, CMS und LHCb, sowie anderen Kollaborationen als Nutzergruppen erfüllt das GridKa ein breites Spektrum an Anforderungen. Neben technischen Herausforderungen bildet es als Multi-VO Zentrum auch eine Basis für die Zusammenarbeit mit und zwischen Kollaborationen. Die Nähe zu Forschungsgruppen des KIT stellt dabei eine einzigartige Kombination aus Produktiv- und Forschungsbetrieb dar.

Um aktuellen und zukünftigen Anforderungen gerecht zu werden, wird die Infrastruktur am GridKa stetig weiterentwickelt. In diesem Rahmen werden beispielsweise die Rechenkapazitäten schrittweise auf das HTCondor Batch-System umgestellt. Als Tier-1 für mehrere VOs stellt das GridKa besonders auch Speicherkapazität für unterschiedlichste Ansprüche bereit. Hohe Anforderungen an langfristige Verfügbarkeit, Volumen und Durchsatz spiegeln sich sowohl in Technologie als auch Infrastruktur der verwendeten Speicher wieder.

Dieser Beitrag befasst sich mit dem aktuellen Status des GridKa als Multi-VO Tier-1. Fokus liegt dabei auf den Herausforderungen, um zukünftigen Anforderungen gerecht zu werden. Dies umfasst generell anwendbare Erfahrungen mit aktueller Technologie im WLCG-Umfeld.

## T 67: Pixeldetektoren 3

Zeit: Dienstag 16:45–19:00

Raum: VSH 116

T 67.1 Di 16:45 VSH 116

**Characterization and grading of the Pixel Vertex Detector modules** — ●PHILIPP LEITL for the Belle II-Collaboration — Max Planck Institute for Physics, Munich

For the upgrade of the Belle detector at the electron positron collider SuperKEKB in Tsukuba, Japan, the vertexing system is completed by a new pixel detector. This Pixel Vertex Detector (PXD) is based on the Depleted P-channel Field-Effect Transistor (DEPFET) technology.

The main production of the detector modules started at the end of 2016 and about 80 modules will be assembled until mid of 2017. During the numerous production steps, several quality assurance measurements are performed to monitor the production yield and to keep track of the performance of every single module.

After the last production step, a full characterization of each module is carried out. The module performance is analyzed with extensive tests and the results are documented in a database. Digital communication on the module and to the readout electronics as well as analog operation of the pixel matrix are covered. A radioactive Cd-109 source and an infrared laser system are used to optimize the response of the modules to signal.

According to the test results, the modules are categorized under a detailed grading scheme to identify the 40 best modules, which will finally form the full detector.

T 67.2 Di 17:00 VSH 116

**Characterization of pixel detectors using X-ray fluorescence** — ●DOREEN ACHNITZ, FABIAN HÜGGING, DAVID-LEON POHL, NORBERT WERMES, and JOCHEN DINGFELDER — Physikalisches Institut der Universität Bonn

The ATLAS FE-I4 pixel readout chip was designed for the ATLAS pixel detector at the Large Hadron Collider (LHC). The pixel detector makes use of the analogue charge information to improve the track and vertex measurement performance. Therefore an absolute charge calibration of each pixel is desired. In general for the characterization and calibration of new pixel detector designs, a known charge deposition in the sensor is needed. In this context, an experimental setup is being built to produce high intensity X-ray spectra of different energies. An X-ray tube is used with different fluorescence targets to generate a variety of characteristic X-ray lines which can be reconstructed by the pixel detector. The intensity allows for sufficient per pixel statistics, in particular needed for small prototypes. The setup has been characterized with a planar 200  $\mu\text{m}$  n-in-n sensor bump bonded to the ATLAS FE-I4 pixel readout chip. In this talk, the method and first results of the X-ray fluorescence spectroscopy measurements are presented. Additionally, further features of the ATLAS FE-I4 like the lowest achievable threshold and the maximal rate capabilities were investigated with the new setup.

T 67.3 Di 17:15 VSH 116

**Charakterisierung von Pixelmodulen für den CMS Phase 1 Pixeldetektor** — ●MARTIN LIPINSKI, LUTZ FELD, KATJA KLEIN, SAMUEL MÖLLER und FREDERIC STEPP — I. Physikalisches Institut B, RWTH Aachen University

Für das CMS-Experiment wurde im Rahmen des Phase-1 Upgrades ein neuer Pixeldetektor mit einer zusätzlichen vierten Lage gebaut. Durch eine Verbesserung des Auslesechips können mit diesem Detektor auch bei steigenden Teilchenflüssen weiterhin effizient Daten genommen werden.

An der RWTH Aachen wurden während der Serienproduktion 389 am KIT Karlsruhe gebaute Module qualifiziert. Dieser Vortrag stellt kurz die beiden dafür verwendeten Teststände und die Testprozeduren vor. Die Qualifikation beinhaltet elektrische Tests, thermisches Zyklieren sowie Hochratentests und eine Energiekalibration mit Röntgenstrahlung. Die Ergebnisse der Charakterisierung werden dargestellt.

T 67.4 Di 17:30 VSH 116

**Characterization of Through Silicon Vias (TSVs) on the ATLAS Pixel Chip** — MICHAEL DAAS, FLORIAN HINTERKEUSER, FABIAN HÜGGING, ●NIKOLAUS OWTSCHARENKO, DAVID-LEON POHL, and NORBERT WERMES — Physikalisches Institut der Universität Bonn

The high luminosity upgrade of the LHC requires new ATLAS detec-

tor systems. In particular the inner tracking system will be upgraded to an all-silicon detector covering an area of about 200m<sup>2</sup>, demanding new module technologies. New interconnection techniques allow area efficient optimisation module designs. A key element therein is the so-called through silicon via (TSV) applied through the FE-chip. It allows for minimized passive area, less or no wirebonds, and 4-side abutable modules. We report on TSV fabrication and characterisation in a Bonn/IZM-Berlin collaboration.

Processing of a sample of FE-I4B bare chips, a readout chip for 26880 hybrid pixels designed in a 130nm CMOS process for use in the ATLAS IBL, has been completed.

In this talk the IZM via last process on ATLAS FE-I4B chips is presented with focus on via resistance and process yield.

T 67.5 Di 17:45 VSH 116

**Vergleichsmessungen von planaren n-in-n und n-in-p Silizium Pixelsensoren** — SILKE ALTENHEINER<sup>1</sup>, KAROLA DETTE<sup>1,2</sup>, ●SASCHA DUNGS<sup>1</sup>, ANDREAS GISEN<sup>1</sup>, CLAUD GÖSSLING<sup>1</sup>, MARIUS GROTHE<sup>1</sup>, REINER KLINGENBERG<sup>1</sup>, KEVIN KRÖNINGER<sup>1</sup>, RAPHAEL MICHALLEK<sup>1</sup> und MAREIKE WEERS<sup>1</sup> — <sup>1</sup>TU Dortmund, Experimentelle Physik IV — <sup>2</sup>CERN

Pixelsensoren lassen sich aus verschiedenen Substraten realisieren. Bei planaren n-in-n Sensoren wird ein n-dotierter, bei den n-in-p Sensoren dagegen ein p-dotierter Silizium Wafer verwendet. Die Pixelimplantationen bestehen in beiden Fällen aus einem n-dotierten Substrat.

Um Gemeinsamkeiten und Unterschiede herauszustellen, wurden Design und Sensoren beider Arten untersucht und miteinander verglichen.

T 67.6 Di 18:00 VSH 116

**Characterization of a depleted monolithic active pixel sensor prototype in 130nm Toshiba technology** — ●CHRISTIAN BE-SPIN, TOMASZ HEMPEREK, TOKO HIRONO, FABIAN HÜGGING, TETSUICHI KISHISHITA, HANS KRÜGER, PIOTR RYMASZEWSKI, and NORBERT WERMES — Physikalisches Institut der Universität Bonn

For future applications of pixel detectors in high luminosity environments such as the HL-LHC new demands for detectors arise. While dealing with high data rates they need to withstand high radiation doses and keep the material budget low. A promising approach are CMOS silicon devices which are expected to perform better in future experiments than present day hybrid pixel detectors. A prototype of a depleted monolithic active pixel sensor (DMAPS) in 130 nm Toshiba technology is characterized.

It consists of three different flavors with a pixel pitch of 20  $\mu\text{m}$  and two with 40  $\mu\text{m}$  pitch. The pixels are read out using a 3T circuit. Results from gain and noise measurements are presented together with measurements with radioactive sources and a 3.5 GeV electron beam.

T 67.7 Di 18:15 VSH 116

**Design of a Depleted Monolithic CMOS Pixel sensor in a 150 nm CMOS Technology for the ATLAS Inner Tracker Upgrade** — MARLON BARBERO<sup>2</sup>, PATRICK BREUGNON<sup>2</sup>, YAVUZ DEGERLI<sup>3</sup>, STEPHANIE GODIOT<sup>2</sup>, FABRICE GUILLoux<sup>3</sup>, TOMASZ HEMPEREK<sup>1</sup>, TOKO HIRONO<sup>1</sup>, HANS KRÜGER<sup>1</sup>, JIAN LIU<sup>2</sup>, FABIENNE ORSINI<sup>2</sup>, PATRICK PANGAUD<sup>2</sup>, ALEXANDRE ROZANOV<sup>2</sup>, ●PIOTR RYMASZEWSKI<sup>1</sup>, PHILIPPE SCHWEMLING<sup>3</sup>, TIANYANG WANG<sup>1</sup>, and NORBERT WERMES<sup>1</sup> — <sup>1</sup>University of Bonn, Bonn, Germany — <sup>2</sup>CPPM, Marseille, France — <sup>3</sup>CEA-IRFU, Saclay, France

During the long shutdown the LHC will undergo an upgrade allowing for a big increase in luminosity, which will have a huge impact on the operation of the inner tracking detectors. Within ATLAS CMOS Pixel Collaboration a "CMOS demonstrator" initiative has been started with the goal of qualifying available CMOS technologies to build high performance, cost efficient detectors. This work presents one of designed prototypes - a monolithic particle sensor named LFMopix-01. This device, designed in LFoundry 150nm CMOS quadruple well process, features 250 $\mu\text{m}$ ×50 $\mu\text{m}$  pixels organized into a matrix of 129×36 pixels. The design exploits high bias voltage and high wafer resistivity to allow for a quick charge collection through drift. Signal is amplified and shaped in-pixel, obtained information is readout using "column drain" architecture. During the talk an overview of the design will be presented with a special focus on some of the faced challenges e.g. low noise operation, fast signal processing, design verification. Simulation

results will be compared with first measurement results.

T 67.8 Di 18:30 VSH 116

**High granularity low power monolithic active pixel detector in 180nm CMOS technology for the ATLAS ITK upgrade** — ●KONSTANTINOS MOUSTAKAS<sup>1</sup>, TIANYANG WANG<sup>1</sup>, IVAN BERDALOVIC<sup>2</sup>, THANUSHAN KUGATHASAN<sup>2</sup>, WALTER SNOEYS<sup>2</sup>, TOMASZ HEMPEREK<sup>1</sup>, HANS KRÜGER<sup>1</sup>, and NORBERT WERMES<sup>1</sup> — <sup>1</sup>Physikalisches Institut der Universität Bonn, Nussallee 12, Bonn, Germany — <sup>2</sup>CERN, Geneva, Switzerland

Active monolithic CMOS sensors (DMAPS) are emerging as a promising alternative for the HL-LHC upgrade. A low capacitance, high granularity DMAP sensor is currently being developed in a commercial TowerJazz 180nm process. The technology incorporates a p-epitaxial high resistivity substrate, full CMOS circuitry by deep p-well isolation and TID durability by usage of a thin gate oxide. The pixel pinch is smaller than 50 $\mu$ m, facilitating very high efficiency under the deep p-well through process modification and backbiasing to achieve full depletion. Instead of including the electronics inside the collection well, a separate n-well collection diode is implemented. The extremely small detector capacitance significantly reduces input noise and allows the use of a low power ALPIDE-like analog front-end. The front end circuit is modified and optimized for ToT enablement and the hit information is read-out by a token-based column drain architecture. A leakage current compensation scheme is also proposed to improve performance, allowing for independent input reset current setting from the collec-

tion diode leakage. Simulation results demonstrate high performance in terms of very low ENC and threshold dispersion (<20e)

T 67.9 Di 18:45 VSH 116

**Quellenmessungen und orts aufgelöste Untersuchungen zur Ladungssammlung in bestrahlten monolithischen Sensoren der 180nm TowerJazz Technologie im Rahmen der Entwicklung des neuen ATLAS Inner Tracker.** — ●CHRISTIAN RIEGEL<sup>1,2</sup>, DOUGLAS SCHAEFER<sup>1</sup>, MARCO DALLA<sup>3</sup>, ENRICO JUNIOR SCHIOPPA<sup>1</sup>, HEINZ PERNEGGER<sup>1</sup> und WOLFGANG WAGNER<sup>2</sup> — <sup>1</sup>CERN, Meyrin, Switzerland — <sup>2</sup>Bergische Universität Wuppertal, Wuppertal, Germany — <sup>3</sup>Universita e INFN, Bologna, Italy

Im Rahmen des zukünftigen Upgrades des ATLAS Detektors wird ein komplett neuer Inner Tracker (ITk) entwickelt. Zu den vielversprechenden Technologien zählen depleted monolithic active pixel sensor (DMAPS) aus Silizium. Dieser Vortrag präsentiert die laufenden Messungen an einem Forschungschip, der im 180nm TowerJazz Prozess hergestellt ist. Der Chip ist mit verschiedenen Pixelgrößen und Elektrodengeometrien ausgestattet. Die im letzten Jahr vorgestellten Ergebnisse in Bezug auf Strahlenhärte und Geschwindigkeit der Ladungssammlung waren der Auftakt zu weiteren, intensiven Quellenmessungen im Labor, sowie zu orts aufgelösten Untersuchungen in der Diamond Synchrotron Einrichtung und einem CERN SPS Testbeam mit Pionen. Diese Messungen eröffneten einen tieferen Einblick in die Eigenschaften der Ladungssammlung für Pixel verschiedener Größen und die Effizienz der Ladungssammlung vor und nach Bestrahlung.

## T 68: Detektorsysteme 2

Zeit: Dienstag 16:45–18:20

Raum: VSH 10

### Gruppenbericht

T 68.1 Di 16:45 VSH 10

**The EDM polarimeter development at COSY-Jülich** — ●FABIAN MÜLLER ON BEHALF OF THE JEDI COLLABORATION — Institut für Kernphysik, Forschungszentrum Jülich

The JEDI (Jülich Electric Dipole moment Investigations) collaboration performs a set of experiments at the COSY storage ring in Jülich, within the R&D phase to search for the Electric Dipole Moments (EDM) of charged particles. A measurement of proton and deuteron EDMs is a sensitive probe of yet unknown CP violation. The method of charged particle EDM search will exploit stored polarized beams and observe a miniscule rotation of the polarization axis as a function of time due to the interaction of a finite EDM with large electric fields. Key challenge is the provision of a sensitive and efficient method to determine the tiny change of the beam polarization. Elastic scattering of the beam particles on carbon nuclei will provide the polarimetry reaction.

This requires a solid data base: the corresponding measurements have been started at COSY and first preliminary results will be shown. In addition the EDM polarimeter needs to be developed. The polarimetry concept is based on a heavy crystal hadron calorimeter (LYSO). Results of beam tests with polarized deuterons of the new developed LYSO modules will be presented.

T 68.2 Di 17:05 VSH 10

**On the development of a novel waveguide RF Wien filter for Electric Dipole Measurements at COSY/Jülich** — ●JAMAL SLIM — Institute of High Frequency Technology, RWTH Aachen University, 52074 Aachen

The JEDI (Jülich Electric Dipole Investigations) Collaboration aims for measuring the electric dipole moments (EDMs) of deuterons and protons at the COoler SYnchrotron (COSY). In a magnetic storage ring like COSY, one way to do so, is via a new, high precision novel waveguide RF Wien filter. The basic idea is to modulate the spin of deuterons and protons with a Wien filter without perturbing the beam itself. With the field configuration generated by the device, the radial electric force is canceled by a vertical magnetic force, leading to zero Lorentz force acting on the particles. This field configuration is ensured by the propagation of the TM<sub>00</sub> mode in the waveguide. This allows to directly manipulate the polarization vector of the particles without introducing any beam oscillations. The RF Wien filter is designed to operate at some harmonics of the spin precession frequency ranging from 0.1 to 2 MHz. The conditions of the Wien filter operation are met by design while being capable of generating high quality electromagnetic

fields to the level of 10<sup>-5</sup>. With a 10 kW input power, the achieved B-field integral along the beam axis is approximately  $\int B \cdot dl = 0.0733$  T.m. For systematic investigations of sources of false EDM signals, the waveguide RF Wien filter can be rotated by 90° around the beam axis.

T 68.3 Di 17:20 VSH 10

**Light-Injection-System zur Kalibrierung von SiPMs** — JAN-MARC BASELS, ●ROMAN GREIM, DAMIAN IWANICKI, WACLAW KARPINSKI, THOMAS KIRN, SIMON NIESWAND, STEFAN SCHAEEL, ARNDT SCHULTZ VON DRATZIG, GEORG SCHWERING und MICHAEL WLOCHAL für die LHCb-Kollaboration — I. Physikalisches Institut, RWTH Aachen University

LHCb wird während des Runs 3 von LHC eine integrierte Luminosität von 50/fm aufzeichnen. Durch die erhöhte instantane Luminosität ist es nötig, die Granularität sowie die Totzeiten der Subdetektoren von LHCb zu verbessern. Im Falle des Downstream Trackers wird dies durch einen szintillierenden Faser Tracker mit SiPM-Array-Auslese erreicht. Ein kostengünstiges Kalibrationssystem ist zwingend erforderlich um die korrekte Betriebsspannung der mehr als 500000 Kanäle sowie die Komparator-Schwellen der Auslesechips einstellen zu können.

Lichtpulse kürzer als 5ns werden über optische Fasern zu den SiPMs geleitet um aus den entstehenden Signal-Spektren die interne Verstärkung der SiPMs zu bestimmen und so die gewünschte Betriebsspannung einzustellen. Die Lichtpulse werden von roten VCSELs in Kombination mit GBLD Gbit-Lasertreibern erzeugt. Im Vortrag wird der Aufbau des Systems sowie Tests zur Lichtausbeute, Stabilität, Strahlenhärte und zum elektrisches Übersprechen vorgestellt.

T 68.4 Di 17:35 VSH 10

**WOM - Prototypen für die Auslese des Flüssigszintillator Surround-Background-Taggers im SHiP-Experiment** — ●MAXIMILIAN EHLERT, HEIKO LACKER, PAUL ROSENAU, IEVGEN KÖROL, PLAMENNA VENKOVA und SANDRA GERLACH — Humboldt Universität zu Berlin Institut für Physik

SHiP ist ein Vorschlag, in einem Beamdump-Experiment, am CERN SPS-Beschleunigerkomplex nach sehr schwach wechselwirkenden, neutralen Teilchen im Massenbereich von 0,1 GeV - 10 GeV zu suchen. Hadronen aus den Proton-Proton-Kollisionen werden absorbiert und Myonen durch ein Magnetsystem ausgelenkt, so dass neben Neutrinos nur noch die neutralen Teilchen in einem etwa 50m langen Volumen vorhanden sind und in diesem zerfallen können. Dieses Zerfallsvolumen soll mit Flüssigszintillator umgeben sein (Surround-Background-Tagger = SBT), um Untergrund unterdrücken zu können. Die Szintil-



lationsphotonen sollen mit sogenannten Wavelength-Shifting-Optical-Modules (WOMs), die an Photosensoren angekoppelt werden, nachgewiesen werden.

Im Vortrag werden WOM-Prototypen, mit denen Flüssigszintillator-detektoren ausgelesen werden vorgestellt und diskutiert.

T 68.5 Di 17:50 VSH 10

**Verspiegelung von WOMs zur Steigerung der Nachweiseffizienz** — ●PAUL ROSENAU, HEIKO LACKER, MAXIMILIAN EHLERT, IEVGEN KOROL, PLAMENNA VENKOVA und SANDRA GERLACH — HU Berlin, Institut für Physik

SHiP ist ein Vorschlag in einem Beamdump-Experiment, am CERN SPS-Beschleunigerkomplex, nach sehr schwach wechselwirkenden, langlebigen, neutralen Teilchen im Massenbereich von 0,1-10 GeV zu suchen. Hadronen aus den Proton-Proton-Kollisionen werden absorbiert und Myonen durch ein Magnetsystem ausgelenkt, so dass neben Neutrinos nur noch die langlebigen neutralen Teilchen in einem etwa 50 m langen Volumen vorhanden sind und in diesem zerfallen können. Dieses Zerfallsvolumen soll mit Flüssigszintillator umge-

ben sein (Surround-Background-Tagger = SBT), um Untergrund unterdrücken zu können. Die Szintillationsphotonen sollen mit sogenannten Wavelength-Shifting-Optical-Modules (WOMs), die an Photosensoren angekoppelt werden, nachgewiesen werden. Im Vortrag werden Messungen mit Mini-WOMs diskutiert und insbesondere die Verbesserung der Nachweiseffizienz durch Verspiegelung.

T 68.6 Di 18:05 VSH 10

**Background Sources at the ILC and their Impact on SiD** — ●ANNE SCHÜTZ — DESY, KIT, Germany

The International Linear Collider is a linear  $e^+e^-$  accelerator, which is unique due to the clean environment and its capability for high precision measurements. To achieve these goals the machine backgrounds for linear colliders have to be understood in great detail, and both, the machine and the detectors, have to be optimized towards that goal. Different machine backgrounds were simulated and their impact on the SiD detector performance were studied. From these studies several suggestions towards machine and detector optimizations are brought forward.

## T 69: Halbleiterdetektoren (Strahlenschäden, neue Konzepte)

Zeit: Dienstag 16:45–19:00

Raum: VSH 11

T 69.1 Di 16:45 VSH 11

**Enhanced lateral drift sensors: simulation and production** — ●ANASTASIIA VELKYA and HENDRIK JANSEN — DESY Hamburg

One of the main goals in the R&D of tracker sensors technology is to improve the position resolution of the particle detector. There are two ways to achieve this. The most common way is to decrease the size of the read-out cell, i.e. to decrease the pixel or strip pitch. But in this case, the number of channels increases, which requires an increased bandwidth for the read-out. The other possibility to improve the position resolution of sensors is to increase the lateral size of the charge distribution already during the drift in the sensor material. In this case, it is necessary to carefully engineer the electric field in the bulk of this so-called enhanced lateral drift (ELAD) sensor. This new design is using implants deep inside the bulk. Implants constitute volumes with different values of doping concentration in comparison to the concentration in the bulk. This allows for modification of the drift path of the charge carriers in the sensor. The development of such a detector requires a good understanding of the entire production process. In order to find an optimal geometry and design of the detector, it is necessary to make reliable simulations, which are conducted using SYNOPSIS TCAD. The parameters that need to be defined are the geometry of the implants, their doping concentration and the position inside the sensor. For a realistic modeling of such implants, process simulations are used to provide input of their production-determined shapes. In this talk, the concept of ELAD is described. TCAD simulations and a description of the production process are presented.

T 69.2 Di 17:00 VSH 11

**The new edge-TCT setup at the University of Hamburg** — ●FINN FEINDT, CHRISTIAN SCHARF, ERIKA GARUTTI, GEORG STEINBRÜCK, and ROBERT KLANNER — Institute for Experimental Physics, Hamburg University, Luruper Chaussee 149, D-22761 Hamburg, Germany

The purpose of the edge Transient Current Technique (TCT) is to measure the drift velocity, electric field and charge collection in radiation-damaged silicon strip sensors. A new edge-TCT setup was developed in our laboratory.

In edge-TCT measurements, infrared light from a sub-ns pulsed laser is focused to a  $\mu\text{m}$ -size spot and scanned across the polished edge of a strip sensor. Thus electron-hole pairs are generated at a known depth in the sensor. Electrons and holes drift in the electric field and induce transient currents in the sensor electrodes. The transient currents are recorded as a function of the applied voltage and the position of the laser focus, and analyzed in order to determine the drift velocities, the electric field and the charge collection.

In this talk, the setup and procedures for preparation of the sensor and calibration are described, and results of first measurements on non-irradiated silicon strip sensors are presented.

T 69.3 Di 17:15 VSH 11

**Absorption of near infrared light in highly irradiated silicon** — ●CHRISTIAN SCHARF, ROBERT KLANNER, ERIKA GARUTTI, and FINN FEINDT — Institute for Experimental Physics, Hamburg University, Luruper Chaussee 149, D-22761 Hamburg, Germany

An increase of the absorption coefficient of near infrared light in silicon was investigated after irradiation with protons with momenta of 23 GeV to fluences of up to  $1.3 \cdot 10^{16} \text{ n}_{\text{eq}}/\text{cm}^2$ . Near infrared light is frequently used to study the radiation damage of silicon sensors. To interpret the measurements, the charge deposited by the laser light, which depends on the absorption coefficient, has to be known. The absorption coefficient of silicon was determined at room temperature as a function of the fluence and at wavelengths between 1000 and 1300 nm using a spectrophotometer. Additionally, the absorption coefficient of silicon was determined at a wavelength of 1052 nm as a function of the fluence and applied voltage at  $-20^\circ\text{C}$  and  $-30^\circ\text{C}$  using the University of Hamburg edge-TCT setup. An increase of the absorption coefficient of silicon with fluence and a decrease with the applied voltage were observed. The results are compared to charge collection measurements on irradiated pad diodes using pulsed laser light of 1064 nm wavelength.

T 69.4 Di 17:30 VSH 11

**Front Side Biasing: Qualifizierung vorderseitig betriebener Siliziumsensoren für den CMS-Spuredetektor** — FELIX BÖGELSBACHER, ALEXANDER DIERLAMM, ●MARIUS METZLER, THOMAS MÜLLER und PIA STECK — IEKP

Mitte der 2020er Jahre soll das Phase-II-Upgrade des Large Hadron Collider (LHC) und damit auch des Compact Muon Solenoid Detektors (CMS) umgesetzt werden. Neben den durch die Erhöhung der Luminosität steigenden Anforderungen an Sensormaterial, Elektronik und Datenerfassung, stellt auch die Zusammenführung der einzelnen Komponenten zu einem funktionsfähigen Modul, bestehend aus Sensorpaar, Front-End-Elektronik und Stabilisierungsstrukturen, eine Herausforderung dar. Aus praktischer Sicht müssen die Module so konstruiert werden, dass die Produktion von ungefähr 13000 Exemplaren so einfach, zuverlässig und schnell wie möglich durchgeführt werden kann.

Im konventionellen Modulbau wird an der Rückseite der n-in-p Streifensensoren eine negative Spannung und auf der Oberseite Masse angelegt. Es ist jedoch möglich, die Spannung ebenfalls auf der Vorderseite in der Nähe der Schnittkante anzulegen und die elektrischen Eigenschaften dieser auszunutzen, um einen Stromfluss zur Rückseite und somit den gewohnten Betriebszustand des Sensors zu erzeugen. Dies würde den Modulbauprozess stark vereinfachen. Ergebnisse einer entsprechenden Qualifizierungsstudie werden hierzu vorgestellt.

T 69.5 Di 17:45 VSH 11

**Laboruntersuchung modifizierter Pixelimplantationen** — SILKE ALTENHEINER<sup>1</sup>, KAROLA DETTE<sup>1,2</sup>, SASCHA DUNGS<sup>1</sup>, ANDREAS GISEN<sup>1</sup>, CLAUS GÖSSLING<sup>1</sup>, ●MARIUS GROTHE<sup>1</sup>, REINER KLINGENBERG<sup>1</sup>, KEVIN KRÖNINGER<sup>1</sup>, RAPHAEL MICHALLEK<sup>1</sup> und



MAREIKE WEERS<sup>1</sup> — <sup>1</sup>TU Dortmund, Experimentelle Physik IV — <sup>2</sup>CERN

Untersuchungen an segmentierten, bestrahlten Siliziumsensoren legen nahe, dass mit zunehmender elektrischer Feldstärke eine erhöhte Ladungssammlung erreicht werden kann. Aus diesem Grund wurden in Dortmund verschiedene modifizierte Pixel designs entwickelt, welche Feldstärkemaxima begünstigen sollen. Strukturen mit diesen Pixelimplantationen wurden zusammen auf einem Siliziumsensor platziert, welcher über einen FE-I4 Chip ausgelesen werden kann.

Ein Assembly, bestehend aus einem solchen Sensor und FE-I4 Chip, wurde mit einer Fluenz von  $5 \times 10^{15} \text{ neq cm}^{-2}$  bestrahlt und wird nun im Labor untersucht. Hierbei werden an den einzelnen Strukturen neben IV-Messungen insbesondere Messungen zur Ladungssammlung unter Nutzung einer Strontium Quelle vorgenommen. Durch das spezielle Design der Guardringe können die einzelnen Strukturen separat betrachtet werden.

T 69.6 Di 18:00 VSH 11

**Testbeamergebnisse modifizierter Pixelimplantation** — SILKE ALTENHEINER<sup>1</sup>, KAROLA DETTE<sup>1,2</sup>, SASCHA DUNGS<sup>1</sup>, ANDREAS GISEN<sup>1</sup>, CLAUS GÖSSLING<sup>1</sup>, MARIUS GROTHE<sup>1</sup>, REINER KLINGENBERG<sup>1</sup>, KEVIN KRÖNINGER<sup>1</sup>, RAPHAEL MICHALLEK<sup>1</sup> und MAREIKE WEERS<sup>1</sup> — <sup>1</sup>TU Dortmund, Experimentelle Physik IV — <sup>2</sup>CERN

Für das Upgrade des LHCs zum High Luminosity LHC werden neue Spurdetektoren für das ATLAS-Experiment benötigt, um der höheren instantanen Luminosität und dem höheren Teilchenfluss gerecht zu werden. Dazu wird ein neuer Tracker, der sogenannte Inner Tracker (ITk), verwendet.

Die dafür verwendeten Silizium-Pixel detektoren müssen eine hohe Effizienz beim Nachweis von Teilchen aufweisen. Zur Untersuchung des Einflusses der Struktur der Pixelimplantation auf die Effizienz wurden sechs verschiedene Pixel designs für planare  $n^+$ -in- $n$ -Silizium-Pixelsensoren entwickelt.

Bei der Charakterisierung der einzelnen Designs wird vor allem die Strahlenhärte berücksichtigt. Die Ergebnisse der Datenanalyse von verschiedenen Testbeams dieser sechs verschiedenen Pixel designs werden präsentiert, wobei sowohl bestrahlte, als auch unbestrahlte Sensoren verwendet wurden.

T 69.7 Di 18:15 VSH 11

**Characterization results of a 50 um thin Depleted Monolithic Active Pixel Sensor (DMAPS) prototype in a 150 nm multiple well CMOS technology with backside processing and a high resistive bulk (ESPROS)** — •THERESA OBERMANN, TOMASZ HEMPEREK, FABIAN HÜGGING, HANS KRÜGER, DAVID-LEON POHL, and NORBERT WERMES — Physikalisches Institut, Bonn, D-53115

The DMAPS concept is a new monolithic pixel detector concept which integrates the front-end circuitry and the sensor on the same silicon substrate which can be fully depleted. The realization of prototypes of

the DMAPS concept relies on the availability of multiple well CMOS processes and high resistive substrates. Two DMAPS prototypes were designed in the 150 nm process of the CMOS foundry ESPROS photonics and fabricated on a high resistive  $n$ -type wafer of 50 um thickness. The prototypes have 352 square pixels of 40 um pitch and small  $n$ -well charge collection node with very low capacitance ( $n^+$ -implantation size: 5 um by 5 um) and about 150 transistors per pixel (CSA and discriminator plus a small digital part). The performance of the prototypes was studied before and after an irradiation with neutrons up to  $5 \text{E}14 \text{ neq}$ . In this talk the final results of the characterization in the lab and beam test will be presented.

T 69.8 Di 18:30 VSH 11

**Inbetriebnahme des ATLAS Diamond Beam Monitors** — •BEN BRÜERS, JÖRN GROSSE-KNETTER, ARNULF QUADT und JENS WEINGARTEN — II. Physikalisches Institut, Georg-August-Universität Göttingen

Für die Überwachung der Position des Wechselwirkungspunktes im ATLAS Detektor, sowie zur Messung der instantanen Luminosität wurde für Run 2 der ATLAS Diamond Beam Monitor (DBM) installiert. DBM besteht aus vier Teleskopstationen auf jeder Seite des Wechselwirkungspunktes, wobei jedes Teleskop aus drei einzelnen Detektormodulen aufgebaut ist. Die Module bestehen aus pixelierten, polykristallinen CVD Diamantsensoren, welche von FE-I4B Chips ausgelesen werden.

Im Vortrag werden das Detektorsystem, sowie der Fortschritt der Aktivitäten zu dessen Inbetriebnahme vorgestellt.

T 69.9 Di 18:45 VSH 11

**Entwicklung eines 3D Diamantpixel detektors** — •HELGE CHRISTOPH BECK, ARNULF QUADT und JENS WEINGARTEN — II. Physikalisches Institut, Georg-August-Universität Göttingen

Für zukünftige Hochenergie teilchenexperimente mit höherer Luminosität werden strahlenharte Detektormaterialien für Spurdetektoren benötigt. Diamant ist für diese Herausforderungen ein guter Kandidat als Sensormaterial. Um das im Vergleich zu Silizium kleinere Signal und Ladungseinfang im Diamanten zu kompensieren, ist eine dreidimensionale Anordnung der Elektroden im Sensormaterial vorgeschlagen. Wegen der Stabilität der Diamanten wird ein Femtosekundenlaser verwendet, um die Kristallstruktur aufzubrechen. Sie formt sich danach neu in der thermodynamisch günstigeren Konformation Graphit, welches elektrisch leitend ist. Diese Graphitsäulen werden in einer Pixelgeometrie im Diamanten produziert. Metallisierung der Säulen und Bump-bonding auf einen Auslesechip sind die finalen Schritte zum Pixel detektor.

Im Rahmen der ATLAS Kollaboration wird ein Prototyp eines Diamantpixel detektors entwickelt und produziert. Der verwendete Auslesechip ist der FEI4-Chip, der schon im ATLAS Detektor benutzt wird. In diesem Vortrag werden der Weg zum Detektor und erste Ergebnisse präsentiert.

## T 70: Myondetektoren

Zeit: Dienstag 16:45–18:25

Raum: VSH 06

### Gruppenbericht

T 70.1 Di 16:45 VSH 06

**CMS DT muon chambers upgrade** — •DANIEL TEYSSIER — III Phys. Inst. A, RWTH Aachen

The CMS Drift Tubes (DT) muon chambers in the barrel will cope with higher pile-up as well as higher background conditions in the next High Luminosity (HL) LHC program. The failure rate of the components inside the gas volume is very low and there is no need to replace the chambers themselves for HL-LHC. But the increase of the trigger rate and the radiation environment requires an exchange of the on-board electronics in the detector. A new mini crate (MiC) is currently studied in order to keep the minimal functionality inside the detector and transfer the trigger level-1 to the service cavern area, which is accessible at any time in case of replacement of one component. Some longevity studies are also performed using the Gamma Irradiation Facility (GIF++) to simulate three times the HL-LHC equivalent dose. The new MiC will be tested in the same way before to be installed in the experimental cavern.

T 70.2 Di 17:05 VSH 06

**PoSSuMuS - Position Sensitive Scintillating Muon Detector with SiPM Readout** — •RALPH MÜLLER<sup>1</sup>, OTMAR BIEBEL<sup>1</sup>, RALF HERTENBERGER<sup>1</sup>, BERNHARD FLIERL<sup>1</sup>, MAXIMILIAN HERMANN<sup>1</sup>, PHILIPP LÖSEL<sup>1</sup>, CHRYSOSTOMOS VALDERANIS<sup>1</sup>, ISABEL FRANK<sup>1</sup>, FELIX KLITZNER<sup>1</sup>, ANDRE ZIBELL<sup>2</sup>, THORBEN SWIRSKI<sup>2</sup>, and JONATHAN BORTFELDT<sup>3</sup> — <sup>1</sup>LMU München — <sup>2</sup>JMU Würzburg — <sup>3</sup>CERN

A modularized plastic scintillating detector consisting of two optically separated trapezoids is investigated for two dimensional spatial resolution with trigger capability with 160 GeV Muons. Scintillation light is collected by wavelength shifting fibers (WLSFs) and guided to Silicon Photo-Multiplieres (SiPMs). The position resolution in one direction is achieved by comparing the light yield of the two detector halves which is proportional to the path length of the muon in the trapezoid. The second coordinate is calculated by the propagation time of light from the point of creation to the SiPMs on both sides of the module. Since the spatial resolution depends on the amount of scintillation light detected by the SiPMs, a new trapezoidal shape and an increased fiber diameter was used, compared to former prototypes. Those optimization's lead to a factor three increased light yield and spatial resolution

better than 1 cm.

We report on optimization of light-output and the spatial resolution of the detector, as well as its dependence on the length of the scintillator, which was studied using 10 cm and 30 cm long trapezoids.

T 70.3 Di 17:20 VSH 06

**Aging Studies of the CMS Drift Tube System** — ●CEMALI KILINC, THOMAS HEBBEKER, CARSTEN HEIDEMANN, MARKUS MERSCHMEYER, and DANIEL TEYSSIER — III. Physikalisches Institut A, RWTH Aachen University

In the second phase of the Large Hadron Collider (LHC), the luminosity will be increased by a factor of 5. This means that the CMS Drift Tube (DT) system will be exposed to large integrated radiation dose. The aging of the DT system becomes an important challenge that will be met during phase 2 upgrade. In order to confirm that the DT chambers will be efficient enough for muon reconstruction in these conditions, irradiation tests at high luminosity LHC level and aging simulations are performed.

T 70.4 Di 17:35 VSH 06

**Monte Carlo Studies on the Impact of Strip Misalignment on the Resolution of the ATLAS New Small Wheel Micromegas Detectors** — ●PATRICK SCHOLER, ULRICH LANDGRAF, and STEPHANIE ZIMMERMANN — Physikalisches Institut, Universität Freiburg

In the next long shutdown of the LHC in 2019/20, the innermost part of the end cap muon spectrometer of the ATLAS detector will be replaced. The new system is called New Small Wheel (NSW). It will use Micro Mesh Gaseous Detectors (Micromegas, MM) as one of its detector technologies; MMs have a high intrinsic spatial resolution and rate capability of  $>15\text{kHz/cm}^2$ .

The NSW MM system consists of 64 chambers per wheel. Each chamber has 4 active detection layers, and is build from 3-5 PCBs containing the readout-strips per layer. Therefore the mechanical precision with which readout PCBs can be positioned is a critical factor for the overall position resolution.

In this talk, the spatial resolution of the NSW MMs is investigated via a geometric Monte Carlo simulation by varying the position of the PCBs within the foreseen mechanical tolerances. Also non conformities of the strip pattern on the PCBs are taken into account. Furthermore a contactless position measurement tool will be presented. It uses a high resolution camera mounted on a CMM, which allows multi pat-

tern recognition with a spatial resolution of 30  $\mu\text{m}$ , i.e. to measure large area readout planes.

T 70.5 Di 17:50 VSH 06

**Muon Tomography with a Detector Test Facility** — ●MAXIMILIAN HERRMANN<sup>1</sup>, OTMAR BIBBEL<sup>1</sup>, BERNHARD FLIERL<sup>1</sup>, ISABEL FRANK<sup>1</sup>, RALF HERTENBERGER<sup>1</sup>, FELIX KLITZNER<sup>1</sup>, PHILIPP LÖSEL<sup>1</sup>, RALPH MÜLLER<sup>1</sup>, CHRYSOSTOMOS VALDERANIS<sup>1</sup>, and ANDRÉ ZIBELL<sup>2</sup> — <sup>1</sup>LMU München — <sup>2</sup>JMU Würzburg

Cosmic muons are well suited for the calibration of gaseous detectors used for the tracking of minimum ionizing particles. The LMU cosmic ray facility in Garching, built for the calibration of Monitored Drift Tube (MDT) chambers for the ATLAS muon spectrometer, is meanwhile used to calibrate large area micropattern detectors. Two reference MDT chambers are sandwiching the detector under investigation. The track prediction of both MDT chambers is then compared to the hit position reconstructed by the detector under investigation. Using muon entrance angles between  $0^\circ$  and  $30^\circ$  allows for the detection of deviations in the detector geometry from design values in 3D.

In this talk the capability of the cosmic ray facility to detect multiple scattering will be used for muon tomography. Geometrical properties and positions of material between the two MDT chambers can be detected by the reconstruction of the cosmic muon track in both detectors. The intersection of both tracks, when having a relative angle close to the multiple scattering prediction, allows to reconstruct complex objects. This will be demonstrated on the example of a large area Micromegas detector being under investigation between the two reference chambers.

**Gruppenbericht**

T 70.6 Di 18:05 VSH 06

**On chamber verification of new TDCs for CMS (DT) muon chamber upgrade** — ●CARSTEN HEIDEMANN and THOMAS HEBBEKER — III. Physikalisches Institut A RWTH Aachen University, Aachen

During the Phase II Upgrade of CMS the on chamber electronics of the CMS (DT) muon chambers will be replaced. Most of the on chamber logic is relocated to the service cavern, allowing access also during data taking periods. Only the time to digital conversion will still be located on the chambers. After testing the FPGA based TDC in the lab, now the required verification is done on a spare chamber. Measurements done on the demonstrator set-up will be presented.

## T 71: Trigger und DAQ 1

Zeit: Dienstag 16:45–19:00

Raum: VSH 05

T 71.1 Di 16:45 VSH 05

**Software-Optimierung und Suche nach ineffizienter Speicher-verwaltung mit externen Programmen** — ●JANNIK GEISEN, JÖRN GROSSE-KNETTER und ARNULF QUADT — II. Physikalisches Institut, Georg-August-Universität Göttingen

In einer Arbeitsgruppe oder Kollaboration, in der viele Personen an verschiedenen Teilen eines großen Software-Gerüsts arbeiten, kann es zu Fehloptimierungen wie redundante Speicherallokationen oder gar Speicherlecks im Programm kommen. Diese können die Leistung des Programmes beträchtlich einschränken oder es sogar unbrauchbar machen. Mit leistungsoptimierenden Programmen kann man gezielt und effizient nach solchen Problemen suchen.

Vorgestellt wird eine solche Suche mithilfe der "Google Performance Tools" am Beispiel der in ATLAS verwendeten PixelDAQ-Software. Die Steuerung des DAQ-Systems funktioniert über eigenständige Applikationen, von denen eine lange Laufzeit gefordert wird, was jedoch aufgrund redundanter Speicherallokationen nicht möglich ist. Dadurch kann beispielsweise ein mehrmaliges Hintereinanderausführen von Überprüfungen und Kalibrationen verschiedener Aspekte des Pixel-Detektors nicht stattfinden.

T 71.2 Di 17:00 VSH 05

**Entwicklung und Studie des softwaregestützten High-Level-Triggers für das Belle II Experiment** — ●NILS BRAUN<sup>1</sup>, MICHAEL FEINDT<sup>1</sup>, PABLO GOLDENZWEIG<sup>1</sup>, THOMAS HAUTH<sup>1</sup>, MARTIN HECK<sup>1</sup> und CHRISTIAN PULVERMACHER<sup>2</sup> — <sup>1</sup>IEKP, KIT, Karlsruhe — <sup>2</sup>KEK, Tsukuba

Das sich im Aufbau befindliche Belle II Experiment wird mit geplanten  $8 \cdot 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$  einen neuen Rekord in der instantanen Luminosität aufstellen. Um präzise und statistisch signifikante Resultate im Zeitrahmen des Experimentierbetriebs zu erreichen, muss sowohl die Kollisionsrate als auch die Datenverarbeitungsgeschwindigkeit sehr groß sein. Die Anforderungen an die Datenverarbeitung sowie den Speicherplatzbedarf zu decken ist nur möglich, indem frühzeitig physikalisch uninteressante Prozesse aussortiert werden.

Dieser Vortrag wird das geplante Konzept des High-Level-Triggers (HLT) für Belle II vorstellen, welcher der letzte Teil der Online-Filterkette ist und erste Laufzeitmessungen auf der geplanten Serverhardware und Effizienzstudien präsentieren.

T 71.3 Di 17:15 VSH 05

**Online data reduction with FPGA-based track reconstruction for the Belle II DEPFET Pixel Detector** — ●BRUNO DESCHAMPS, CHRISTIAN WESSEL, JOCHEN DINGFELDER, and CARLOS MARINAS — University of Bonn

The innermost two layers of the Belle II vertex detector at the KEK facility in Tsukuba, Japan, will be covered by high-granularity DEPFET pixel sensors (PXD). The large number of pixels leads to a maximum data rate of 256 Gbps, which has to be significantly reduced by the Data Acquisition System. For the data reduction the hit information of the surrounding Silicon strip Vertex Detector (SVD) is utilized to define so-called Regions of Interest (ROI). Only hit information of the pixels located inside these ROIs are saved. The ROIs for the PXD are computed by reconstructing track segments from SVD data and extrapolating them to the PXD. The goal is to achieve a data reduction

of up to a factor of 10 with this ROI selection. All the necessary processing stages, the receiving, decoding and multiplexing of SVD data on 48 optical fibers, the track reconstruction and the definition of the ROIs will be performed by the Data Acquisition Tracking and Concentrator Online Node (DATCON). The planned hardware design is based on a distributed set of Advanced Mezzanine Cards (AMC) each equipped with a Field Programmable Gate Array (FPGA). In this talk, the current status of the DATCON hardware as well as the plans for the next upcoming test beam at DESY are presented.

T 71.4 Di 17:30 VSH 05

**Background suppression with neural networks at the Belle II trigger** — ●SEBASTIAN SKAMBRACKS, SARA NEUHAUS, and CHRISTIAN KIESLING — Max-Planck-Institut für Physik, München

We present the neural network based first level track trigger for the upcoming Belle II detector at the high luminosity SuperKEKB flavor factory. Using hit and drift time information from the Central Drift Chamber (CDC), neural networks estimate the z-coordinates of single track vertex positions. Beam induced background, with vertices outside of the interaction region, can clearly be rejected. This allows to relax the track trigger conditions and thus enhances the efficiency for events with a low track multiplicity.

The expected performance of the neural networks is evaluated on simulated events and background. This involves a full machine simulation of the SuperKEKB accelerator using the physics models of the expected background types. After an introduction to the neural trigger system, the expected background types are introduced and their suppression will be discussed.

T 71.5 Di 17:45 VSH 05

**Online Track Reconstruction and Data Reduction for the Belle II Experiment using DATCON** — ●CHRISTIAN WESSEL, BRUNO DESCHAMPS, JOCHEN DINGFELDER, CARLOS MARINAS, and FLORIAN BERNLOCHNER — Universität Bonn

The new Belle II experiment at the asymmetric  $e^+e^-$  accelerator SuperKEKB at KEK in Japan is designed to deliver a highest instantaneous luminosity of  $8 \times 10^{35} \text{cm}^{-2}\text{s}^{-1}$ . To perform high-precision track reconstruction, e.g. for measurements of time dependent CPV decays and secondary vertices, the Belle II detector is equipped with a DEPFET pixel detector (PXD) of high granularity, containing 8 million pixels in total. The high instantaneous luminosity and short bunch crossing times produce a large stream of online data in the PXD, which needs to be reduced significantly for offline storage. This is done using an FPGA-based Data Acquisition Tracking and Concentrator Online Node (DATCON), which uses information from the Belle II strip vertex detector (SVD) surrounding the PXD to carry out online track reconstruction, extrapolation back to the PXD, and to define Regions of Interest (ROI) on the PXD. This reduces the data stream approximately by a factor of ten with an ROI finding efficiency of  $>90\%$  of PXD physics hits inside the ROI.

In this talk, I will present the current status of the FPGA-based implementation of the track reconstruction using the Hough transformation and the offline simulation.

T 71.6 Di 18:00 VSH 05

**Konzeption und Test des neuen Jet/Energiesummen-Moduls der ersten Triggerstufe des ATLAS-Detektors** — ●STEFAN RAVE, VOLKER BÜSCHER, ELENA ROCCO und STEFAN TAPPROGGE — Institut für Physik, Universität Mainz

Die höheren Schwerpunktsenergien und Luminositäten der kommenden Ausbaustufen des LHCs stellen eine Herausforderung an das Triggersystem des ATLAS-Detektors dar. Um unter diesen Anforderungen effizient interessante Ereignisse zu selektieren, muss das existierende System ausgebaut werden. Dieser Beitrag stellt den Prototypen für den Jet Feature Extractor (jFEX) vor. Dieses Modul soll ab dem Jahre 2020 die Berechnung von Jets und Energiesummen in der ersten Triggerstufe durchführen. Dazu werden die Daten des Kalorimeters mit einer feineren Granularität als bisher verarbeitet, um eine höhere Flexibilität bei der Jet-Definition zu gewährleisten. Dank der moderneren Hardware kann die Sensitivität für größere Jets verbessert werden, da die überarbeiteten Algorithmen mit größeren Radien arbeiten können. Die hierfür benötigte Inputrate von etwa 2 TB/s je Modul stellt zusammen mit der kurzen zur Verfügung stehenden Verarbeitungszeit von etwa 100 ns eine der größten Herausforderungen an dieses Sys-

tem dar. Ein weiterer, wichtiger Aspekt ist die Korrektur der Effekte von Pile-Up Ereignissen. Es wird kurz das Konzept des neuen Moduls vorgestellt, gefolgt von einem Überblick über die ersten Testergebnisse.

T 71.7 Di 18:15 VSH 05

**Entwicklung von algorithmischer Firmware für den Ausbau des ATLAS Level-1 Jet/MET Triggers** — VOLKER BÜSCHER, CHRISTIAN KAHRA, STEFAN RAVE, ELENA ROCCO, ULRICH SCHÄFER, STEFAN TAPPROGGE und ●MARCEL WEIRICH — Johannes Gutenberg-Universität Mainz

In den kommenden Ausbaustufen des LHC werden immer höhere Luminositäten erreicht. Dadurch werden auch immer größere Herausforderungen an das Triggersystem des ATLAS Detektors gestellt. Zusätzlich zu den steigenden Ereignisraten werden die Daten aus den elektromagnetischen und hadronischen Kalorimetern mit erhöhter Granularität übertragen. Um hierbei noch eine effiziente Selektion von Ereignissen zu gewährleisten, muss das existierende System ausgebaut werden. Bei einer Datenrate von 40 MHz muss in der ersten Triggerstufe eine Entscheidung innerhalb von  $2.5 \mu\text{s}$  getroffen werden.

Der jet Feature EXtractor, kurz jFEX, bildet eine Neuerung für den Ausbau des ATLAS Level-1 Triggers. Ab 2020 wird jFEX in erster Linie für die Identifikation von Jet-Kandidaten und zur Berechnung von Energiesummen eingesetzt. Pro Modul ist eine Eingangsbreite von mehreren Tb/s erforderlich, die sich auf 4 FPGAs verteilen. Für die dort laufenden Algorithmen stehen lediglich 100 ns zur Verfügung. Aus diesem Grund müssen diese eine hochparallele Struktur aufweisen. In diesem Vortrag werden erste Ergebnisse der sich zur Zeit in der Entwicklungsphase befindlichen Algorithmen vorgestellt.

T 71.8 Di 18:30 VSH 05

**Entwicklung eines Demonstrators für einen auf den ATLAS-Myondriftrohrkammern basierenden Level-0-Myontriggers für HL-LHC** — PHILIPP GADOW, OLIVER KORTNER, HUBERT KROHA, FELIX MÜLLER, ●SEBASTIAN NOWAK und ROBERT RICHTER — Max-Planck-Institut für Physik, München

Für den Ausbau des ATLAS-Detektors für hohe LHC-Luminositäten im Rahmen des HL-LHC-Upgrades wird eine Verbesserung der Impulsauflösung des Level-0-Myontriggers benötigt. Um einen Austausch der vorhandenen Triggerkammern zu vermeiden, sollen zusätzlich zu diesen die Myondriftrohrkammern (MDT-Kammern) mit ihrer hohen Ortsauflösung für den Myontrigger verwendet werden. Hierfür ist eine neue, schnelle Ausleseelektronik der MDT-Kammern erforderlich, sowie die Entwicklung von auf FPGAs und Mikrocomputern basierenden Triggerprozessoren, die die Myonspuren auch bei hohem Untergrund von Neutronen- und Gammastrahlung innerhalb der Level-0-Triggerlatenzzeit von ca.  $6 \mu\text{s}$  rekonstruieren können. Zur Demonstration der Realisierbarkeit des Triggerkonzepts wurde eine auf dem Xilinx SoC Zynq-7000 basierende Prototypversion der schnellen Ausleseelektronik entwickelt und mit Daten, die an einem Myonstrahl am CERN bei unterschiedlichen Untergrundraten von einer starken  $^{137}\text{Cs}$ -Gammastrahlungsquelle genommen wurde, getestet. Das Triggerkonzept, die Hardware-Architektur sowie die Ergebnisse des Prototypentests werden vorgestellt.

T 71.9 Di 18:45 VSH 05

**Entwicklung eines neuen Level-0 Myontriggers für das ATLAS-Experiment am High-Luminosity-LHC** — MARKUS FRAS, ●PHILIPP GADOW, OLIVER KORTNER, SANDRA KORTNER, HUBERT KROHA, FELIX MÜLLER, SEBASTIAN NOWAK und ROBERT RICHTER — Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München

Die erhöhte Luminosität des LHC nach dem High-Luminosity-Upgrade erfordert eine deutliche Erhöhung der Triggerselektivität. Dieser Vortrag stellt das Konzept für einen neuen Myontrigger in der ersten Triggerstufe des ATLAS-Experiments vor, bei der die Präzisionsspurdetektoren des Myonspektrometers, die Monitored Drift Tube (MDT)-Kammern, verwendet werden, um die Impulsauflösung auf der Triggersebene und somit die Triggerselektivität signifikant zu verbessern. Ermöglicht wird dies durch neue kontinuierliche Auslese der MDT-Kammern und schnelle Algorithmen, die Spurkonstruktion und Impulsbestimmung innerhalb einer Latenz von weniger als  $6 \mu\text{s}$  ermöglichen. Die Effizienzen verschiedener MDT-Triggeralgorithmen und die erreichbare Reduktion der Fehltriggerraten werden diskutiert.

## T 72: Postersitzung Teilchenphysik

Zeit: Dienstag 16:45–19:00

Raum: F Foyer

T 72.1 Di 16:45 F Foyer

**Reusing events for parameter scans with CheckMATE** — JAMIE TATTERSALL and ●FREDERIC PONCZA — Institute for Theoretical Particle Physics and Cosmology, RWTH Aachen, Germany

There are now a number of tools on the market that allow models of new physics to be tested against the latest LHC data. These tools fall into two categories, those that perform full event simulation and those that make use of simplified models.

The full event simulation tools have the drawback that they require significant computing power while simplified models are sometimes inaccurate when faced with unfamiliar models or decay chains. We propose a new technique of event transformation that promises the accuracy and generality of full event generation with the speed of simplified models and will be implemented in future versions of CheckMATE.

T 72.2 Di 16:45 F Foyer

**ATLAS ITk Silicon Strip Module Production in Dortmund** — SILKE ALTENHEINER, CLAUS GÖSSLING, REINER KLINGENBERG, KEVIN KRÖNINGER, JONAS LÖNKER, DANIELA RÖTTGES, and ●FELIX WIZEMANN — TU Dortmund, Experimentelle Physik IV

To be able to deliver satisfactory tracking performance after the LHC High Luminosity upgrade, the ATLAS inner detector will be replaced during Long Shutdown 3 with a new all-silicon-detector, the Inner Tracker (ITk), featuring pixel and strip sensors.

Modules for the strip endcaps will be produced in Dortmund. One endcap consists out of six disks and each disk will be populated by 32 petals. Each petal will include six different module designs. The necessary preparations for production as well as the assembly and testing of modules will be presented.

T 72.3 Di 16:45 F Foyer

**TARGET, An Integrated Readout Electronics for Cherenkov Telescopes** — DAVID JANKOWSKY<sup>1</sup>, ●ADRIAN ZINK<sup>1</sup>, MANUEL KRAUS<sup>1</sup>, JACKY CATALANO<sup>1</sup>, MANUEL LOOS<sup>1</sup>, JOHANNES SCHÄFER<sup>1</sup>, STEFAN FUNK<sup>1</sup>, LUIGI TIBALDO<sup>2</sup>, GARY VARNER<sup>3</sup>, and THE CTA CONSORTIUM<sup>4</sup> — <sup>1</sup>Erlangen Centre for Astroparticle Physics (ECAP) — <sup>2</sup>Max-Planck-Institut für Kernphysik, Heidelberg — <sup>3</sup>Department of Physics and Astronomy, University of Hawaii — <sup>4</sup>Full consortium author list at <http://cta-observatory.org>

TARGET is an Application Specific Integrated Circuit (ASIC) designed for the readout of different photosensors in various types of experiments. The ASIC is capable of sampling at high rates (typically 1 GSamples/s), digitizing with 12-bit precision and to supply trigger information. The small package size, high integration (16 channels/ASIC), deep buffer for trigger latency (16k samples) and low cost per channel make TARGET an excellent candidate for systems with large number of telescopes equipped with a compact silicon and multi-anode photomultipliers, like the Cherenkov Telescope Array (CTA). The TARGET concept and performance studies of the newest generation will be presented.

T 72.4 Di 16:45 F Foyer

**Interaction Depth Reconstruction in  $(20 \times 20 \times 15) \text{ mm}^3$  Coplanar-Quad-Grid CdZnTe Detectors** — ●ROBERT TEMMINGHOFF for the COBRA-Collaboration — Exp. Physik IV, TU Dortmund

The aim of the COBRA collaboration is to use CdZnTe detectors to search for neutrinoless double beta-decay. Currently, COBRA is investigating  $(20 \times 20 \times 15) \text{ mm}^3$  CdZnTe detectors that will be used in the extended demonstrator (XDEM) phase of the experiment. A coplanar-quad-grid (CPqG) read-out is used to capture the charge signal on these detectors. This electrode design allows to overcome the problem of hole trapping in CdZnTe by making use of single-polarity charge sensing achieved by the coplanar-grid. Using four grids on a single detector helps to further improve the spectroscopic performance of the device.

The coplanar-grid also allows to obtain information about the interaction depth of an event, a very powerful tool for COBRA. It allows to veto signals due to contaminations near the electrodes of the detector and thus to achieve a lower background level.

An investigation of the performance of the interaction depth reconstruction of a coplanar-quad-grid detector is shown. A collimated

<sup>137</sup>Cs-source was used to irradiate the detector at different depths. With this data it is possible to experimentally test the interaction depth reconstruction for coplanar-quad-grid detectors. Furthermore, two different formulas to calculate the interaction depth are compared.

T 72.5 Di 16:45 F Foyer

**Tests of final hardware revision of the Belle II PXD data reduction system** — ●DENNIS GETZKOW, WOLFGANG KÜHN, SÖREN LANGE, THOMAS GESSLER, KLEMENS LAUTENBACH, and SIMON REITER — Justus-Liebig-Universität Gießen, II. Physikalisches Institut

The Belle II physics data taking is scheduled in October 2018, with a planned factor  $\leq 40$  higher luminosity as its predecessor, the Belle experiment. For the pixel detector (PXD) DEPLETED Field Effect Transistors (DEPFET) are used, with  $\sim 8 \times 10^6$  pixels in total. As increased luminosity implies increased background, online filtering of incoming raw data of  $\sim 20 \text{ GB/s}$  is a crucial part of the PXD readout chain. The hardware platform is based upon ATCA (Advanced Telecommunications Architecture), Xilinx Virtex-5 FX70T FPGAs and high speed optical link technology (6.5 Gbps), and called ONline Selection Nodes (ONSEN). The reduction is based on calculated Regions-Of-Interest (ROIs), calculated by a high level trigger running on a PC farm. The full ONSEN system consists of 9 ATCA carrier boards with 33 daughter cards.

Tests procedures for final hardware will be presented.

This work was supported by the Bundesministerium für Bildung und Forschung under grant number 05H15RGKBA.

T 72.6 Di 16:45 F Foyer

**Investigations of the KATRIN interspectrometer Penning trap** — ●MARIIA FEDKEVYCH for the KATRIN-Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 9, 48149 Münster, Germany

The KARlsruhe TRitium Neutrino Experiment is a direct low-background measurement of the neutrino mass from the kinematics of tritium- $\beta$ -decay aiming for a sensitivity of  $0.2 \text{ eV}/c^2$ . To analyze energies of electrons, generated in the WGTS (windowless gaseous tritium source), KATRIN uses a pair of electrostatic spectrometers working in MAC-E-filter mode (called pre- and main-spectrometer). In the region between them, a Penning trap is created by the combination of retarding potentials of -18.3 kV in the pre-spectrometer and -18.6 kV in the main spectrometer together with a magnetic field of 4.5 T produced by a common superconducting magnet. Electrons accumulating in this trap can lead to discharges which create additional background and may present a certain danger for spectrometer and detector section of KATRIN. To counteract this problem, so-called *Penning wipers* were designed and implemented in the magnet between two spectrometers. A Penning wiper is a metal rod which can be moved in and out of the electron flux tube to remove trapped particles. In this presentation the general idea and the first test measurements are presented. Results of background measurements with different electric and magnetic field settings will be discussed. This work is supported under BMBF contract number 05A14PMA.

T 72.7 Di 16:45 F Foyer

**Chemical purification and a new method to synthesize high purity CaWO<sub>4</sub> powder used for CaWO<sub>4</sub> crystal production for the CRESST experiment** — ●HONGHANH TRINH THI<sup>1</sup>, XAVIER DEFAY<sup>2</sup>, ANDREAS ERB<sup>3</sup>, RAFAEL HAMPE<sup>1</sup>, JEAN LANFRANCHI<sup>1</sup>, ALEXANDER LANGENKÄMPER<sup>1</sup>, VASILY MORGALYUK<sup>1</sup>, ANDREA MÜNSTER<sup>1</sup>, ELIZABETH MONDRAGON<sup>1</sup>, CORBINIAN OPPENHEIMER<sup>1</sup>, WALTER POTZEL<sup>1</sup>, STEFAN SCHÖNERT<sup>1</sup>, HANS STEIGER<sup>1</sup>, ANDREAS ULRICH<sup>1</sup>, STEPHAN WAWOCZNY<sup>1</sup>, MICHAEL WILLERS<sup>1</sup>, and ANDREAS ZÖLLER<sup>1</sup> — <sup>1</sup>E15, TUM, 85748 Garching — <sup>2</sup>Excellence Cluster Universe, Garching — <sup>3</sup>Walther-Meißner Institut, Garching

The CRESST experiment (Cryogenic Rare Event Search with Superconducting Thermometers) uses CaWO<sub>4</sub> single crystals as targets for the direct search of dark matter particles. For rare event experiments, low intrinsic contaminations of the crystals play a crucial role. Since several years CaWO<sub>4</sub> crystals are grown at the Technische Universität München (TUM). Commercially available CaCO<sub>3</sub> and WO<sub>3</sub> powders are used for the synthesis of CaWO<sub>4</sub> powder. In order to improve the radiopurity of the crystals, it is necessary to reduce potential sources

of radioactive materials such as U, Th, Sr and Pb in CaWO<sub>4</sub> powder. In this poster, we present our studies of the chemical purification of raw materials and a new method to synthesize high purity CaWO<sub>4</sub> powder. This research was supported by the DFG cluster of excellence "Origin and Structure of the Universe", Boltzmannstr. 2, 85748 Garching, by the Helmholtz Alliance for Astroparticle Physics, by the Maier-Leibnitz-Laboratorium (Garching) and by the BMBF.

T 72.8 Di 16:45 F Foyer

**Geant4 simulations of the XENON1T dual-phase xenon TPC** — ●LUTZ ALTHÜSER — IKP, Westfälische Wilhelms-Universität Münster

The XENON Dark Matter Project uses the concept of a dual-phase xenon time projection chamber (TPC) for a direct detection of weakly interacting massive particles (WIMPs). In the current operating step, XENON1T, the sensitivity of the detector will be increased by two orders of magnitude compared to its predecessor XENON100.

Therefore the TPC is build to detect low intensity VUV light signals, generated either directly by the recoil produced by the scattering processes of incoming particles (S1) or through proportional scintillation (S2). The light collection efficiency (LCE) of these signals depends on the position of interaction in the active volume and on the optical properties of the materials. The settings of these MC parameters needs to be obtained from and checked against actual data during the operation.

This poster will focus on the implementation of the XENON1T Geant4 MC and its simulation of the LCE for S1 and S2 signals with regard to several optical parameters like the reflectivity of Teflon and the refraction index of liquid xenon.

This work is supported by BMBF under contract 05A14PM1.

T 72.9 Di 16:45 F Foyer

**Recent results of antiproton manipulation in the AEGIS collaboration** — ●INGMARI CHRISTA TIETJE — Route de Meyrin 385, 1217 Meyrin, Switzerland

In the beginning of the universe same amounts of matter and antimatter were produced from a singularity in energy. Most of the matter annihilated with antimatter immediately and ultimately gave rise to the cosmic background radiation. A small fraction of matter did not annihilate and formed the universe. But why do we observe primordial matter and no primordial antimatter in the universe and which are the reasons for the baryon asymmetry? At the antiproton decelerator (AD) at CERN low-energy antiprotons are provided to a number of different experiments. The collaboration of one of the experiments AEGIS (Antimatter Experiment: Gravity, Interferometry, Spectroscopy) aims for a test of the weak equivalence principle of antimatter. To approach this goal experimental techniques from different fields are required. One of these fields is plasma physics: A crucial step is to catch and store the negatively charged antiprotons provided by the AD in Penning traps. Through collisions with electrons in a cryogenic environment the antiprotons are sympathetically cooled as low as cryogenic temperatures. Here we present recent results of measurements carried out with antiprotons inside the AEGIS experimental setup. This comprises results about two-component electron-antiproton plasmas as well as ballistic transfer of antiprotons. The control we possess over the antiprotons enables us to pursue the ultimate goal of AEGIS - to test the weak equivalence principle with antihydrogen.

T 72.10 Di 16:45 F Foyer

**Krypton delayed coincidence and Radon alpha spectrometry analysis at the XENON1T experiment** — ●MIGUEL ANGEL VARGAS for the XENON-Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, Münster, Germany

The XENON1T experiment aims at finding direct evidence for dark matter through the scattering of Weakly Interacting Massive Particles (WIMPs) with target nuclei in an ultra-low background dual-phase

xenon Time Projection Chamber (TPC) based detector. The detector employs about 3.3 tons of liquid xenon in order to reach a projected sensitivity of  $2 \times 10^{-47} \text{ cm}^2$  for a WIMP mass of 50 GeV/ $C^2$ .

Among the most threatening sources to this sensitivity are those from radioactive background such as <sup>85</sup>Kr and radon isotopes, which are dispersed inside the entire liquid target and cannot be reduced by making use of the self-shielding properties of xenon. Thus, the importance in understanding these intrinsic contaminants is crucial to ensure the background interpretation of the experiment along to be able to monitor their removal.

This poster focuses on obtaining a coherent picture of these intrinsic radioactive backgrounds by using a delayed coincidence technique for <sup>85</sup>Kr, which has a beta-decay with an endpoint energy of 687 keV, and by reconstructing <sup>222</sup>Rn or <sup>220</sup>Rn subsequent decay products through alpha decay analysis (alpha spectrometry reconstruction)

T 72.11 Di 16:45 F Foyer

**The nEXO light detection system and photo-detector characterization efforts** — ●MICHAEL WAGENPFEIL, PATRICK HUF-SCHMIDT, AKO JAMIL, JUDITH SCHNEIDER, TOBIAS ZIEGLER, GISELA ANTON, JÜRGEN HÖSSL, and THILO MICHEL — ECAP, Friedrich-Alexander-Universität Erlangen-Nürnberg

The nEXO experiment is a planned 5-tonne LXe TPC designed for the search for the neutrinoless double beta decay of <sup>136</sup>Xe. In order to reach the prospected half-life of up to  $10^{28}$  years a good energy resolution of 1% (sigma) at the Q-value (2457.8 keV) and a good background suppression is crucial resulting in strong requirements on the collection efficiency of the VUV scintillation photons produced by any events in the LXe. The light detection system needs to be designed accordingly.

nEXO will use large area VUV-sensitive SiPMs as photo detectors covering the lateral surface of the cylindric TPC. Their intrinsic properties such as the photo detection efficiency (PDE) or number of events suffering correlated avalanches (such as Crosstalk and Afterpulsing) as well as the general layout of the nEXO TPC needs to be optimized to meet the requirements on the light detection system. For example, the PDE of any SiPM candidates needs to be at least 15% for LXe scintillation light ( $\lambda = 175 \text{ nm}$ ) to detect at least 7% of the overall scintillation light of a given event.

We report current aspects of the nEXO light detection system and characterization results of trending VUV-sensitive SiPMs examined by different collaboration members focussing on their performance at LXe temperatures.

T 72.12 Di 16:45 F Foyer

**Investigation on position reconstruction at the edges of the EXO-200 TPC** — ●SEBASTIAN SCHMIDT, GERRIT WREDE, GISELA ANTON, JÜRGEN HÖSSL, and THILO MICHEL — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, 91058 Erlangen

EXO-200 is an experiment searching for the neutrinoless double beta decay of Xe-136 using a TPC filled with enriched liquid xenon.

Events taking place in the bulk liquid lead to the emergence of scintillation light with a wavelength in the vacuum ultraviolet band and free charge in the form of electrons. The light and charge signals are used to determine the energy of an event. The position is reconstructed with the charge signal only.

A larger mass of the fiducial volume increases the sensitivity of the experiment. To improve this, further investigations of effects close to the border of the TPC are made in order to include events in this region and to extend the active volume as a consequence.

In this contribution we present our analysis of the standoff distance distribution - the shortest distance of an event vertex to the inner boundary of the TPC - for Monte Carlo data and compare the results to real data.

Additionally, a drift simulation of electrons in the TPC is used to get a better agreement of Monte Carlo and data taken by the experiment in order to eventually improve the detector sensitivity.

## T 73: Higgs-Boson 6 (Zerfälle in Tau-Leptonen)

Zeit: Mittwoch 16:45–19:00

Raum: JUR 3

T 73.1 Mi 16:45 JUR 3

**Analysis of the Higgs boson decaying to a pair of tau leptons using Run-2 data from ATLAS** — ●STEPHANIE YUEN, BENEDICT WINTER, WILL DAVEY, and JOCHEN DINGFELDER — Physikalisches Institut, Nussallee 12, 53115 Bonn, Deutschland

In 2014, the ATLAS and CMS collaborations reported the combined Run-1 result of the discovery of the Higgs boson decaying into a pair of tau leptons. This  $H \rightarrow \tau\tau$  decay channel has the highest sensitivity among channels directly probing the Higgs Yukawa couplings. With the increased luminosity expected in Run 2, ATLAS aims to not only independently establish  $5\sigma$  evidence for  $H \rightarrow \tau\tau$ , but also to measure fiducial and differential  $H \rightarrow \tau\tau$  cross sections with high precision. In addition, while CP studies in the bosonic decay channels of the Higgs indicate the compatibility of the Higgs boson's CP properties with that of SM predictions, fermions provide unique information on Higgs CP. This talk will discuss the analysis and background estimation methods for the  $H \rightarrow \tau\tau$  decay channel, where both taus decay hadronically, for Higgs coupling and CP measurements with Run-2 data at ATLAS.

T 73.2 Mi 17:00 JUR 3

**Higgs to Tau Pair coupling measurement in the lepton-hadron final state** — ULLA BLUMENSCHNIG<sup>1,2</sup>, ●ANTONIO DE MARIA<sup>1</sup>, ARNULF QUADT<sup>1</sup>, and ZINONAS ZINONOS<sup>1,3</sup> — <sup>1</sup>II. Physikalisches Institut, Georg-August-Universität Göttingen — <sup>2</sup>now at Queen Mary University of London — <sup>3</sup>now at Max Planck Institut für Physik

The decay of the Higgs boson into tau pair is currently the only accessible channel to establish the Higgs-Yukawa coupling to fermions. In this context, the final state in which one tau decays hadronically and the other one decays leptonically (lepton-hadron channel) plays an important role due to the high branching ratio and the moderate background. This talk outlines the main aspects of the ongoing analysis on the coupling measurement in this final state using data from proton-proton collisions recorded by the ATLAS detector at a center-of-mass energy of 13 TeV. In particular, the fitting strategy to extract the signal strength from the combination of the different signal/control regions is presented. The final part of the talk will be dedicated to the description and the demonstration of a new statistical tool, called Fit-Box, which is based on standard high-energy statistics software and provides important cross checks of the fit model.

T 73.3 Mi 17:15 JUR 3

**Ditau mass reconstruction techniques at the ATLAS experiment** — ●MICHAEL HÜBNER, PHILIP BECHTLE, KLAUS DESCH, CHRISTIAN GREFE, PETER WAGNER, and MAIKE HANSEN — Universität Bonn

Ditau mass reconstruction techniques play an important role in analyses involving the Higgs boson decaying to two tau leptons and are used to suppress background from  $Z \rightarrow \tau\tau$  processes. In particular, the Missing Mass Calculator (MMC) was used in the paper providing evidence for the Yukawa coupling of the Higgs boson to tau leptons.

I will introduce the Missing Mass Calculator and show first results of MMC using the new tau substructure reconstruction. Additionally, I will show a performance comparison between different ditau mass reconstruction techniques.

T 73.4 Mi 17:30 JUR 3

**Modelling of  $Z \rightarrow \tau\tau$  processes with  $\tau$ -embedded  $Z \rightarrow \mu\mu$  data in ATLAS** — ELIAS CONIAVITIS, ●ALENA LÖSLE, DIRK SAMMEL, MARKUS SCHUMACHER, and DUC BAO TA — Physikalisches Institut, Universität Freiburg

The decay channel  $H \rightarrow \tau\tau$  is of great interest as it allows to investigate the coupling of the Higgs boson to fermions. In this channel the dominant and irreducible background contribution is given by  $Z \rightarrow \tau\tau$  events. The embedding method allows to model  $Z \rightarrow \tau\tau$  processes in a data-driven way by selecting  $Z \rightarrow \mu\mu$  events in data and replacing the muons by  $\tau$ -leptons from simulated  $Z \rightarrow \tau\tau$  decays. The embedded  $Z \rightarrow \tau\tau$  sample then contains similar conditions as the analysed data set, such as underlying event and pile-up activity, while also the kinematics of additionally produced jets does not rely on simulation. In order to correctly embed simulated  $\tau$ -leptons in  $Z \rightarrow \mu\mu$  data events, all detector signatures arising from the original muons have to be identified and removed from the event in a first step. Here, one important task is the subtraction of the energy deposits by the muons in the electromagnetic and hadronic calorimeters. While this estimate currently relies on the simulation of  $Z \rightarrow \mu\mu$  events, a new method to access the information by using a parametrization of the energy deposits in data has been developed.

In this talk I will give an overview of the status of embedding in ATLAS for LHC Run 2 and present a new method to subtract the energy deposits by muons in the calorimeters.

T 73.5 Mi 17:45 JUR 3

**Data-driven estimation of backgrounds with jets misidentified as hadronic  $\tau$  decays in the semileptonic Higgs decay-channel  $H \rightarrow \tau_{had}\tau_{lep}$  at the ATLAS experiment.** — ●FABIAN BECHERER, ELIAS CONIAVITIS, DIRK SAMMEL, and MARKUS SCHUMACHER — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Germany

The discovery of a Higgs boson in 2012 at the LHC has led to studies aiming to measure the properties of this new particle, including its coupling to Standard Model particles. The most accessible way to measure the Higgs boson's couplings to leptons is to study its decay into a pair of  $\tau$ -leptons. Analysis of the full LHC Run 1 data collected by the ATLAS detector already provided evidence for this decay channel. The large integrated luminosity and the increased signal cross section at  $\sqrt{s}=13$  TeV of the LHC Run 2 are expected to enable a  $5\sigma$  observation of  $H \rightarrow \tau\tau$  decays at the ATLAS experiment. This talk will discuss the analysis in the case where one  $\tau$  decays leptonically and the other hadronically based on  $36\text{ fb}^{-1}$  of data collected in pp-collisions in 2015 and 2016. In particular, it will focus on the data-driven estimation of background processes with a jet misidentified as a hadronically-decaying  $\tau$ -jet, which are very important in this channel. This estimate is obtained using events with an inverted identification requirement on the  $\tau$ -jet, extrapolated to the signal region using process-dependent fake-factors, measured in separate control regions for each background process and signal category.

T 73.6 Mi 18:00 JUR 3

**Search for  $H \rightarrow \tau\tau$  decays using multivariate techniques in proton-proton collisions at  $\sqrt{s} = 13\text{ TeV}$  with the ATLAS Detector** — ●FRANK SAUERBURGER, MINORU HIROSE, KARSTEN KÖNEKE, and KARL JAKOBS — Albert-Ludwigs-Universität, Freiburg, Deutschland

A multivariate analysis (MVA) using machine learning techniques to study the standard model decay of the Higgs boson to two  $\tau$  leptons ( $H \rightarrow \tau^+\tau^-$ ) is presented. The analysis focuses on the decay channel, in which one  $\tau$  decays leptonically and the other  $\tau$  hadronically. The background is estimated with a combination of Monte Carlo simulation and data-driven methods. A boosted decision tree (BDT) is trained on the background and signal model and employed to classify events into background and signal in order to enhance the sensitivity of the analysis. The analysis is performed with a dataset of proton-proton collisions at a center-of-mass energy  $\sqrt{s} = 13\text{ TeV}$  taken with the ATLAS Detector at the LHC during Run 2.

T 73.7 Mi 18:15 JUR 3

**Establishment of the Standard Model  $H \rightarrow \tau\tau$  signal in LHC Run II** — ●RAPHAEL FRIESE, ROGER WOLF, ANDREW GILBERT, and GÜNTER QUAST — Institut für Experimentelle Kernphysik, Karlsruher Institut für Technologie (KIT)

The Standard Model  $H \rightarrow \tau\tau$  analysis of the CMS experiment in the LHC Run I observed the presence of a Higgs boson decaying to a pair of two  $\tau$ -leptons with a significance of  $3.2\sigma$ , with  $3.7\sigma$  expectation. The LHC run I took place in the years 2011 and 2012, incorporating an integrated luminosity of  $24.9\text{ fb}^{-1}$  at center-of-mass energies of 7 and 8 TeV.

The analysis presented here incorporates an integrated luminosity of  $12.9\text{ fb}^{-1}$  at a center-of-mass energy of 13 TeV, recorded in 2016 by the CMS experiment. The analysis covers the four most significant di- $\tau$  final states. It gets its significance from a classical approach doing cut-based event categorization. It is one step towards the full establishment of the  $H \rightarrow \tau\tau$  coupling with a significance of  $5\sigma$  the CMS collaboration is aiming to establish with the full dataset of 2016.

T 73.8 Mi 18:30 JUR 3

**Machine learning for  $H \rightarrow \tau\tau$**  — ●CARINA BRANDT, ADRIAN PERIEANU, OLIVER RIEGER, PETER SCHLEPER, DANIEL TROENDLE, and ANNIKA VANHOEFER — University of Hamburg

The search for  $H \rightarrow \tau\tau$  at the LHC is a challenging task, due to the overwhelming background from the  $Z \rightarrow \tau\tau$  process. Today, a dedicated mass reconstruction which is based on a likelihood method is used very successfully to reconstruct the mass of the higgs. With the significant advances in machine learning techniques in the last years, new and improved methods are now applicable to high energy physics data analysis. In this study modern machine learning (ML) algorithms have been exploited to improve the reconstruction of the mass and hence improve the separation of Higgs and Z Bosons processes at CMS. First results based on Monte Carlo simulation at a centre of mass energy  $\sqrt{s} = 13$  TeV will be presented.

T 73.9 Mi 18:45 JUR 3

**Measurement of the energy scale of charged and neutral pions**

## T 74: Higgs-Boson 7 (Paarproduktion, Quantenzahlen)

Zeit: Mittwoch 16:45–19:15

Raum: JUR 5

T 74.1 Mi 16:45 JUR 5

**New Physics in multi-Higgs boson final states** — WOLFGANG KILIAN<sup>1</sup>, SICHUN SUN<sup>2,3</sup>, QI-SHU YAN<sup>4,5</sup>, XIAORAN ZHAO<sup>6</sup>, and ●ZHIJIE ZHAO<sup>1</sup> — <sup>1</sup>Department of Physics, University of Siegen, 57072 Siegen, Germany — <sup>2</sup>Jockey Club Institute for Advanced Study, Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong — <sup>3</sup>Department of Physics, National Taiwan University, Taipei, Taiwan — <sup>4</sup>School of Physics Sciences, University of Chinese Academy of Sciences, Beijing 100039, China — <sup>5</sup>Center for future high energy physics, Chinese Academy of Sciences, Beijing 100039, China — <sup>6</sup>Centre for Cosmology, Particle Physics and Phenomenology (CP3), Universit  catholique de Louvain, Chemin du Cyclotron, 2, B-1348 Louvain-la-Neuve, Belgium

We explore the discovery potential of triple-Higgs signals via  $2b2l \pm 4j + \cancel{E}$  decay channel at a 100 TeV hadron collider and compare it with single and double Higgs productions. In the SM, the parton level analysis shows that the backgrounds of this channel can be reduced efficiently and a good significance can be obtained. After considering the possible parton shower and detector effect, however, we find that significance is decreased to 0.02. To observe the triple-Higgs production at a 100 TeV without beyond the standard model new physics, a detector with extreme good ability on jets reconstruction and leptons isolation is necessary. New dimension-6 effective operators can largely increase the cross section and/or modify the kinematics of the Higgs bosons in the final states.

T 74.2 Mi 17:00 JUR 5

**Search for Higgs boson pair production in the  $b\bar{b}\tau^+\tau^-$  final state with the ATLAS detector** — ●ALESSANDRA BETTI, TATJANA LENZ, and NORBERT WERMES — Physikalisches Institut, University of Bonn, Germany

In the Standard Model (SM) Higgs bosons can be produced in pairs via top loops or the Higgs trilinear self-interaction. Although the SM cross-section for Higgs pair production is very small and impossible to measure with the data currently collected at the LHC, in several extensions of the SM this cross-section can be enhanced. Non-resonant Higgs pair production can be significantly enhanced by modifications of the triple Higgs self-coupling  $\lambda_{hhh}$ . Other theories predict heavy resonances that could decay into a pair of Higgs bosons with  $m=125$  GeV, such as a neutral scalar heavy Higgs in the two Higgs doublet model and spin-2 Kaluza-Klein excitations of the graviton in the bulk Randall-Sundrum model. In the assumption of Higgs bosons with  $m=125$  GeV decaying with branching fractions according to the SM predictions, the  $b\bar{b}\tau^+\tau^-$  channel of the di-Higgs decay has the third largest branching fraction (7.4%) and it is relatively clean compared to channels with larger branching fractions but also larger backgrounds.

The search for resonant and non-resonant pair production of Higgs bosons in the  $b\bar{b}\tau^+\tau^-$  final state with the ATLAS detector and its latest results will be presented in this talk, with particular focus on the development of an MVA for improving the analysis sensitivity.

**in hadronic  $\tau$  decays at CMS** — VLADIMIR CHEREPANOV, GUNTER FLUGGE, ●OLENA HLUSHCHENKO, BASTIAN KARGOLL, WOLFGANG LOHMANN, THOMAS MULLER, ALEXANDER NEHRKORN, CLAUDIA PISTONE, HALE SERT, ACHIM STAHL, and ALEXANDER ZOTZ — III. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen

Decays of the Higgs bosons into two  $\tau$  leptons are most promising to study Higgs boson coupling to fermions. To calculate the mass of the di-tau system, any bias in the energy measurement of the tau lepton decay products must be determined and corrected for. Since charged and neutral pions are measured using different sub-detectors these corrections should be estimated separately.

For this purpose  $K_S^0$  mesons decaying either into two neutral or two charged pions are used and the procedure will be covered during the talk. Energies of the pions are scaled such that their invariant mass peak value equals to the nominal  $K_S^0$  mass.

This approach is explicitly interesting for all analyses involving  $\tau$ 's. Possible application in the context of  $H \rightarrow \tau\tau$  analysis is discussed.

T 74.3 Mi 17:15 JUR 5

**Search for resonant and non-resonant di-Higgs production in the decay channel  $\gamma\gamma WW^*$ , with hadronically decaying  $W$ -bosons in the boosted topology.** — ●KAI HENSSEN, JASON VEATCH, and STAN LAI — II. Physikalisches Institut, Georg-August-Universität G ttingen

The main reason to investigate non-resonant di-Higgs production is the determination of the trilinear Higgs coupling, which is directly related to the Higgs potential. Furthermore, several beyond-the-Standard-Model theories predict more than one Higgs boson. In particular, considering two-Higgs-doublet models, a neutral heavy scalar boson can decay into two light Higgs bosons consistent with those discovered at the LHC in 2012.

This presentation will explain the search for di-Higgs production, using  $\sqrt{s} = 13$  TeV data recorded by the ATLAS experiment. The decay channel under investigation is the one in which one light Higgs boson decays into two photons and the other into two  $W$  bosons, which in turn decay hadronically. For heavy Higgs bosons, the boosted topology is considered, where all quarks from the  $W$  bosons are reconstructed as a single large radius jet.

T 74.4 Mi 17:30 JUR 5

**Di-Higgs Suche in dem Zerfallskanal  $\gamma\gamma WW$  mit  $WW \rightarrow l\nu qq$  und der „boosted“ Topologie** — ●KIRA ABELING, JASON VEATCH und STAN LAI — II. Physikalisches Institut, Georg-August-Universität G ttingen

Seit der Entdeckung des Higgs-Bosons in 2012 wurden viele weitere Studien durchgef hrt, um seine Eigenschaften mit denen des vorhergesagten Standardmodell-Higgs-Bosons ( $h$ ) abzugleichen. Insbesondere ist eine direkte Messung der Selbstkopplungsst rke  $\lambda$  als endg ltiger Test des Higgs-Bosons interessant.

Dar ber hinaus ist bekannt, dass es Physik jenseits des Standardmodells geben muss. Eine m gliche Erweiterung sind weitere schwere Teilchen (Resonanzen), die in zwei (leichte) Higgs-Bosonen zerfallen k nnen, wie beispielsweise ein schweres Higgs-Boson, das in vielen Modellen jenseits des Standardmodells vorkommt.

In diesem Vortrag wird der Zerfallskanal  $hh \rightarrow \gamma\gamma WW$  basierend auf 13 TeV (Monte-Carlo-) Daten des ATLAS Experiments behandelt, der zwei essentielle Voraussetzungen verbindet: ein klares Signal auf der Photonseite und ein hohes Verzweungsverh ltnis der  $WW$  Seite. Im semileptonischen Zerfallskanal existiert zudem ein Lepton ( $e, \mu$ ), das einfach identifiziert werden kann. Die „boosted“ Topologie ergibt sich daraus, dass sehr schwere Resonanzen betrachtet werden, bei denen es nicht mehr m glich ist, die Jets aus dem  $W$ -Zerfall aufzul sen, sondern stattdessen als ein sogenannter „Large Radius Jet“ zusammengefasst werden.

T 74.5 Mi 17:45 JUR 5

**Suche nach einem schweren, pseudoskalaren Higgs-Boson  $A$  im Zerfallskanal  $Zh$ , mit  $Z \rightarrow \nu\bar{\nu}/\ell^+\ell^-$  und  $h \rightarrow b\bar{b}$ , in  $pp$ -Kollisionen bei 13 TeV mit dem ATLAS-Experiment**

— •HANNAH ARNOLD und CHRISTIAN WEISER — Albert-Ludwigs-Universität Freiburg

Nach der Entdeckung eines Higgs-Bosons am LHC im Jahre 2012 bleibt die Frage zu beantworten, ob es sich bei dem entdeckten Teilchen um das im Standardmodell (SM) vorhergesagte Higgs-Boson handelt, oder ob es zu einem erweiterten skalaren Sektor gehört. Eine mögliche Erweiterung des Brout-Englert-Higgs-Mechanismus stellen Zwei-Higgs-Duplett-Modelle (2HDM) dar, in denen ein zweites komplexes Duplett postuliert wird. Dies führt zur Vorhersage von fünf Higgs-Bosonen, unter anderem eines schweren, pseudoskalaren Higgs-Bosons  $A$ . Das am LHC entdeckte, SM-ähnliche Higgs-Boson mit einer Masse von 125 GeV, wird mit dem leichten, CP-geraden Higgs-Boson  $h$  identifiziert. In diesem Vortrag wird die Suche nach einem schweren, pseudoskalaren Higgs-Boson  $A$ , welches in ein  $Z$ -Boson und ein SM-ähnliches Higgs-Boson  $h$  zerfällt, mit dem ATLAS-Experiment in  $pp$ -Kollision bei einer Schwerpunktsenergie von  $\sqrt{s} = 13$  TeV vorgestellt. Die Analyse basiert auf dem kompletten Datensatz, der in 2015 und 2016 gesammelt wurde. Es werden Zerfälle des  $Z$ -Bosons in ein Lepton- oder Neutrino-paar, sowie des  $h$ -Bosons in ein  $b$ -Quark-Paar, betrachtet. Der untersuchte Massenbereich reicht von 220 GeV bis 2 TeV. Um insbesondere die Sensitivität im hohen Massenbereich zu erhöhen kommen bei der Rekonstruktion des  $h$ -Bosons auch *boosted* Techniken zum Einsatz.

T 74.6 Mi 18:00 JUR 5

**Measurement of the CP properties of the Higgs boson production** — VLADIMIR CHEREPANOV, •JORDY DEGENS, PETER FACKELDEY, GÜNTER FLÜGGE, OLENA HLUSHCHENKO, BASTIAN KARGOLL, WOLFGANG LOHMANN, THOMAS MÜLLER, ALEXANDER NEHRKORN, CLAUDIA PISTONE, HALE SERT, ACHIM STAHL, and ALEXANDER ZOTZ — RWTH Aachen University, Physics Institute III B

CP violation of the Higgs boson would indicate physics beyond the Standard Model. So far its manifestation is searched for by using the kinematic properties of the decay products of the Higgs boson. The analysis presented in this talk, however, focusses on the Higgs boson production via gluon fusion. Events with two jets radiated off from the gluons or heavy quarks in the loop carry information about the CP state of the Higgs boson: the angle between the two jets in the transversal plane,  $\Delta\phi_{jj}$ , is used to distinguish different CP hypotheses. The analysis is performed on Higgs boson events selected in the di- $\tau$  final state. The full 2016 data set from CMS is analysed and an outlook to larger integrated luminosities is given.

T 74.7 Mi 18:15 JUR 5

**Analysis of  $\tau$ -spin correlations in  $Z \rightarrow \tau^+\tau^-$  decays at ATLAS** — •MAIKE HANSEN, PHILIP BECHTLE, KLAUS DESCH, CHRISTIAN GREFE, MICHAEL HÜBNER, and PETER WAGNER — Universität Bonn

Many theories of physics beyond the Standard Model, such as supersymmetry, predict a CP-mixing in the Higgs to fermions sector which is not excluded by any previous measurement.

In the  $H \rightarrow \tau\tau$  decay channel, the CP-mixing is encoded in the  $\tau$ -spin correlations. These can be measured based on the angle between the two  $\tau$ -decay planes. In the hadronic  $\tau$ -decay modes, this measurement relies on a high purity  $\tau$ -decay mode classification and a good reconstruction of the (hadronic)  $\tau$ -decay products which is available now due to the particle flow based  $\tau$  reconstruction in ATLAS.

For this analysis, we focus on fully hadronic  $Z \rightarrow \tau\tau$  decays, the major, irreducible background for a Higgs CP-measurement. Using a kinematic cut, a theoretically well-defined CP-asymmetry can be constructed in  $Z \rightarrow \tau\tau$  which mimics the asymmetry in  $H \rightarrow \tau\tau$ . Therefore, a measurement of the angle between the  $\tau$ -decay planes in  $Z \rightarrow \tau\tau$  decays gives us the possibility to understand systematic effects and to calibrate and validate the used methods for the application in  $H \rightarrow \tau\tau$  decays.

In this way, we constrain systematic uncertainties on the angular distributions as well as the used tau particle flow reconstruction. This

will help to improve the sensitivity of the Higgs CP measurement.

T 74.8 Mi 18:30 JUR 5

**Study of the Higgs boson's CP properties in the  $\tau\tau$  decay channel with the CMS experiment** — VLADIMIR CHEREPANOV, GÜNTER FLÜGGE, OLENA HLUSHCHENKO, BASTIAN KARGOLL, WOLFGANG LOHMANN, THOMAS MÜLLER, ALEXANDER NEHRKORN, •CLAUDIA PISTONE, HALE SERT, ACHIM STAHL, and ALEXANDER ZOTZ — III. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen

In 2012 the discovery of a Higgs boson with mass of 125 GeV was announced by the ATLAS and CMS collaborations. Since then, efforts have focused on the measurement of its properties and thus the complete determination of the nature of this particle. We study the CP quantum number of the Higgs boson in its decay into tau lepton pairs. Our approach uses the distribution of the signed angle  $\varphi_{CP}^*$  between the decay planes of the tau leptons, which is sensitive to the Higgs boson's CP properties. The sensitivity of the observable is investigated by studying the resolution effects due to different sources. In particular, the reconstruction of the primary vertex and of the track impact parameters is a crucial point for the present analysis. In this talk the understanding and strategy to improve the reconstruction of these objects will be presented.

T 74.9 Mi 18:45 JUR 5

**Investigation of the CP Nature of the Higgs Boson in VBF  $H \rightarrow \tau\tau$  Events at  $\sqrt{s} = 13$  TeV** — •SERHAT ÖRDEK, MICHEL JANUS, and STAN LAI — II. Physikalisches Institut, Georg-August-Universität Göttingen

In 2012, ATLAS and CMS independently reported the observation of a new particle. So far, all measured properties of this particle are consistent with the Standard Model Higgs boson and the data seems to be compatible with a scalar boson. However, the available precision does not exclude a CP-mixed state, which could be a source of the baryon asymmetry in our universe.

This talk will describe studies of the “Optimal Observable” method used to measure the CP nature of the new particle as seen in its production via vector boson fusion in the context of the ATLAS experiment. Validation of the reweighting using 13 TeV Monte Carlo samples was performed, and tested on both LO and NLO signal events. Furthermore, additional studies on the calculation of the Optimal Observable are discussed.

T 74.10 Mi 19:00 JUR 5

**Untersuchung der CP-Natur des Higgs-Bosons in der Produktion durch Vektorbosonfusion mittels Optimaler Observable im Zerfallskanal  $H \rightarrow \tau\tau h$  mit dem ATLAS-Detektor bei  $\sqrt{s} = 13$  TeV** — ELIAS CONIATIS, •DIRK SAMMEL und MARKUS SCHUMACHER — Albert-Ludwigs-Universität Freiburg

Die Verletzung von C- und CP-Invarianz ist eines der Sacharowkriterien zur Erklärung der beobachteten Baryonenasymmetrie im Universum. Die gemessene Stärke der CP-Verletzung im Quarksektor erlaubt es nicht, im Rahmen des Standardmodells die Größe der Asymmetrie zu beschreiben.

Nach der Entdeckung des Higgs-Bosons sind durch die Untersuchung dessen Produktion und Zerfalls Möglichkeiten für die Suche nach neuen Quellen von CP-Verletzung gegeben. Die Produktion durch Vektorbosonfusion erlaubt es, die CP-Struktur der Kopplung des Higgs-Bosons an elektroschwache Eichbosonen zu untersuchen. Im Vortrag werden die dazu verwendete CP-ungerade *Optimale Observable* vorgestellt und erste Studien mit LHC Run-2 Daten präsentiert.

Die Analyse nutzt den Zerfall  $H \rightarrow \tau\tau h$  und verwendet die Daten des ATLAS-Experimentes aus den Jahren 2015 und 2016 mit einer integrierten Luminosität von  $\int \mathcal{L} = 36.5 \text{ fb}^{-1}$  bei einer Schwerpunktsenergie von  $\sqrt{s} = 13 \text{ TeV}$ .

## T 75: Top Quark 4 (Eigenschaften)

Zeit: Mittwoch 16:45–19:00

Raum: JUR 4

T 75.1 Mi 16:45 JUR 4

**Measurement of the top-quark mass using  $pp$  collision data at  $\sqrt{s} = 13$  TeV with the ATLAS detector** — •SEBASTIAN SCHULTE<sup>1,2</sup>, ANDREA KNUE<sup>1</sup>, STEFAN KLUTH<sup>1</sup>, and RICHARD NISIUS<sup>1</sup>

— <sup>1</sup>Max-Planck-Institut für Physik München — <sup>2</sup>Physik Department Technische Universität München

The top quark is the heaviest known elementary particle of the Standard Model. Precise measurements of its properties are important, not



only for the accurate understanding of the Standard Model, but also for the search for new physics processes. The mass of the top quark has been subject of intense studies at the Tevatron and the LHC, where it has been measured to so far unprecedented precision. In this talk, first studies of the top-quark mass based on 13 TeV  $pp$  collision data are presented. The data were recorded with the ATLAS experiment in 2015 and 2016. The studies are performed using top-quark pair events in the lepton+jets channel. A three dimensional template fit is employed in order to reduce the systematic uncertainties.

T 75.2 Mi 17:00 JUR 4

**Measurement of the Top Quark Mass in the Semi-Leptonic Decay Channel at 13 TeV using 2016 data** — PETER SCHLEPER<sup>1</sup>, HARTMUT STADIE<sup>1</sup>, •NATALIA KOVALCHUK<sup>1</sup>, CHRISTOPH GARBERS<sup>1</sup>, MARKUS SEIDEL<sup>2</sup>, FRED STÖBER<sup>1</sup>, and JOHANNES LANGE<sup>1</sup> — <sup>1</sup>Institut für Experimentalphysik, Universität Hamburg — <sup>2</sup>CERN

The precise measurement of the Standard Model parameters, such as the top quark mass  $m_t$ , is an important part of the LHC physics programme. It allows for consistency checks of the Standard Model and can also be used to place constraints on new physics models. The most accurate single measurement of the top quark mass was conducted by the CMS collaboration using the Run I data coming from the Large Hadron Collider (LHC). Therefore the same methodology is used here to analyse the LHC 2016 Run II data at a centre-of-mass energy of 13 TeV. We present early results of the top quark mass determination in the semi-leptonic decay channel. New Monte Carlo (MC) generators are used to simulate  $t\bar{t}$  events. A comparison between the real data and simulation will be presented, as well as the main steps towards the  $m_t$  extraction.

T 75.3 Mi 17:15 JUR 4

**Messung der  $t\bar{t}$ -Ladungsasymmetrie im Lepton+Jets Kanal in geboosteten Topologien bei ATLAS** — •SABRINA GROH, LUCIA MASETTI, MELANIE SCHEPP und EFTYCHIA TZOVARA — Institut für Physik, Johannes Gutenberg-Universität Mainz

Als das schwerste der bisher entdeckten Elementarteilchen ist das Top-Quark besonders geeignet für die Suche nach Effekten von Physik jenseits des Standardmodells, da seine Masse im Bereich der elektroschwachen Skala zu finden ist. Ein Hinweis darauf wäre beispielsweise eine Abweichung von der im Standardmodell vorausgesagten Ladungsasymmetrie bei der  $t\bar{t}$ -Produktion.

Die Verteilung der Rapiditätsdifferenz  $|y_t| - |y_{\bar{t}}|$  der Top-Quark Paare aus  $q\bar{q}$ -Annihilation weist eine Asymmetrie auf, die am LHC nur unterdrückt auftritt, da der symmetrische  $gg$ -Fusionsprozess dominiert. Durch die Auswahl von Ereignissen mit stark kollimierten (geboosteten) Top-Zerfällen erfolgt die Vermessung eines Phasenbereichs mit erhöhter Asymmetrie und zudem kann eine eindeutige Zuordnung der Zerfallsprodukte in der Rekonstruktion erfolgen.

In diesem Vortrag wird die Messung der  $t\bar{t}$ -Ladungsasymmetrie im Lepton+Jets Kanal in geboosteten Topologien mit dem ATLAS-Detektor am LHC bei  $\sqrt{s} = 13$  TeV vorgestellt. Besonderen Wert wird dabei auf die Methoden zur Untergrundabschätzung und zur Entfaltung gelegt.

T 75.4 Mi 17:30 JUR 4

**Bestimmung der top-Quarkmasse aus dem Lepton-Transversalimpuls** — •MICHAEL BENDER und OTMAR BIEBEL — Ludwig-Maximilians-Universität München

Aus Messdaten, die vom ATLAS Experiment bei 8 TeV Kollisionsenergie am LHC aufgezeichnet wurden, wird die Masse des top-Quarks im Lepton+Jets Kanal bestimmt. Die erzeugten top-Quark-Paare zerfallen jeweils fast ausschließlich in ein b-Quark und W-Boson. Als Lepton+Jets Kanal wird derjenige Zerfall bezeichnet, bei dem eines der beiden W-Bosonen hadronisch und das andere leptonisch zerfällt.

Anders als bei direkten Massenbestimmungen wird in dieser Messung der transversale Impuls des Leptons zur Bestimmung der top-Quarkmasse verwendet. Hierbei gilt, je größer die Masse des top-Quarks, desto höher der transversale Impuls des Leptons aus dem Zerfall des zugehörigen W-Bosons. Aus der gemessenen Verteilung der Lepton-Impulse kann daher die top-Quarkmasse bestimmt werden. Die vorgestellte Methode ergänzt hierbei direkte Massenbestimmungen auf Grund ihrer unterschiedlichen Sensitivität auf systematische Fehlerquellen.

In diesem Vortrag wird das Prinzip der Messung vorgestellt, Messergebnisse und systematische Unsicherheiten werden diskutiert.

T 75.5 Mi 17:45 JUR 4

**Interpretation von Topquark-Messungen im Rahmen effektiver Feldtheorien mit EFTfitter** — NUNO CASTRO<sup>1,2</sup>, JOHANNES ERDMANN<sup>3</sup>, •CORNELIUS GRUNWALD<sup>3</sup>, KEVIN KRÖNINGER<sup>3</sup> und NILS-ARNE ROSIEN<sup>4</sup> — <sup>1</sup>LIP & Universidade do Minho, Braga, Portugal — <sup>2</sup>Universidade do Porto, Porto, Portugal — <sup>3</sup>TU Dortmund, Experimentelle Physik IV — <sup>4</sup>Georg-August-Universität Göttingen, II. Physikalisches Institut

Das Topquark spielt in vielen Erweiterungen des Standardmodells eine Schlüsselrolle. Bei direkten Suchen am LHC bei bis zu  $\sqrt{s} = 13$  TeV wurden bislang allerdings keine signifikanten Abweichungen von den im Standardmodell vorhergesagten Eigenschaften des Topquarks gemessen. Sollte die Energieskala neuer Phänomene höher sein als am LHC erreichbar, so können deren Effekte im Rahmen effektiver Feldtheorien (EFT) parametrisiert werden. Messungen im Topsektor können dabei die Stärke der in EFT auftretenden Operatoren einschränken.

Das Tool EFTfitter ermöglicht die Interpretation experimenteller Ergebnisse im Rahmen effektiver Feldtheorien. Es erlaubt verschiedene Messungen einer oder mehrerer Observablen mithilfe bayesscher Statistik zu kombinieren um damit freie Modellparameter einzuschränken. Dabei werden in der Kombination der Ergebnisse insbesondere auch die experimentellen Korrelationen berücksichtigt.

In diesem Vortrag werden die aktuellen Entwicklungen und geplanten Erweiterungen des EFTfitters vorgestellt.

T 75.6 Mi 18:00 JUR 4

**Transferfunktionen für kinematische Likelihood-Fits von  $t\bar{t}$ -Ereignissen bei ATLAS** — BORIS LEMMER, ARNULF QUADT und •FABIAN SOHNS — II. Physikalisches Institut, Georg-August-Universität Göttingen

Eine Herausforderung in der Analyse von  $t\bar{t}$ -Ereignissen ist die Zuordnung von Objekten im Detektor zu Parton-Level-Objekten aus dem direkten Zerfall. Dies geschieht mithilfe einer Likelihoodfunktion, welche aus zwei Beiträgen besteht. Zum einen werden rekonstruierte Objekte mittels Transferfunktionen auf das Parton-Level abgebildet. Hierbei werden Variationen der gemessenen kinematischen Größen im Rahmen der Detektorauflösung, der Hadronisierung und der Showerbildung erlaubt. Zum anderen werden die Breit-Wigner-Funktionen der Top-Quark- und W-Boson-Massen aus den Parton-Level-Objekten gebildet. Für jede Permutation von rekonstruierten Objekten wird die Likelihood maximiert und die mit dem höchsten Wert ausgewählt. Die Entwicklung der Transferfunktionen für  $\sqrt{s} = 13$  TeV erfolgt mit dem Ziel, sämtliche Rekonstruktions- und Schwelleneffekte analytisch zu beschreiben. Die zu berücksichtigenden Effekte unterscheiden sich für geringe und hohe Energien, wodurch sich verschiedene Beiträge in den Transferfunktionen ergeben.

T 75.7 Mi 18:15 JUR 4

**Probing the  $t\bar{t}\gamma$  analysis at  $\sqrt{s} = 13$  TeV with ATLAS using Neural Networks** — BORIS LEMMER, MARIA MORENO LLACER, ARNULF QUADT, ELIZAVETA SHABALINA, and •JOSHUA WYATT SMITH — II. Physikalisches Institut, Georg-August-Universität Göttingen

Through the  $t\bar{t}\gamma$  process we can measure the electromagnetic couplings of the top quark. Evidence of this process was seen at CDF with  $\sqrt{s} = 1.96$  TeV, while observation occurred at the LHC at  $\sqrt{s} = 7$  and  $\sqrt{s} = 8$  TeV, with increasing precision. The largest source of uncertainty comes from the estimate of the background originating from *hadron-fakes*. These are photons from hadrons or hadron decays that are misidentified as prompt photons. Both analyses relied on “conventional” background estimation of these hadron-fakes using data-driven techniques. More advanced methods can be used to improve this estimate and potentially reduce this uncertainty (and others) even further. New approaches making use of Neural Networks will be discussed. One approach is to build a discriminating variable to distinguish real prompt photons from hadron-fakes. A working point would then be chosen to maximize purity of prompt photons. The major advantage is that this is not necessarily analysis specific and thus can serve as a general tool for the ATLAS community. Another approach is to build an analysis specific classifier. This is where the topology of the whole  $t\bar{t}\gamma$  event is important. Kinematics and isolation of the photon and other particles would play a major role in this classifier.

T 75.8 Mi 18:30 JUR 4

**Measurement of the W Boson Helicity Fractions in  $t\bar{t}$  Events at  $\sqrt{s} = 8$  TeV in the Lepton+Jets Channel with ATLAS** — •MOHAMAMD KAREEM, BORIS LEMMER, MARIA MORENO LLACER, ARNULF QUADT, and ELIZAVETA SHABALINA — II. Physikalisches Institut, Georg-August-Universität Göttingen

A summary of the measurement of the  $W$  boson helicity fractions in  $t\bar{t}$  decays is presented. Events produced via  $pp$  collisions at a centre-of-mass energy of 8 TeV, collected in 2012 by the ATLAS detector at the LHC, corresponding to an integrated luminosity of  $20.2 \text{ fb}^{-1}$  have been analysed. The measurement is performed in the lepton+jets channel characterized by one isolated electron or muon, missing transverse momentum and at least four energetic jets of which at least two are tagged as a  $b$ -jet.

Using a kinematic likelihood fit for the reconstruction of the top quarks, the angular distribution of the charged lepton (down type quark) in the leptonically (hadronically) decaying  $W$  boson rest frame is sensitive to the three possible helicity states. The fractions are obtained by performing a template fit to data. As the polarisation of the  $W$  bosons in top quark decays is sensitive to the  $Wtb$  vertex structure, limits on anomalous  $Wtb$  couplings are set.

T 75.9 Mi 18:45 JUR 4  
**Measurements of  $t\bar{t}$  pair azimuthal decorrelation in the boosted regime at 13TeV** — ●DANIELA DOMINGUEZ DAMIANI, PAOLO GUNNELINI, and HANNES JUNG — DESY

The production of  $t\bar{t}$  pairs at high pT, i.e. the so-called boosted regime, is characterized by two collimated jets which contain most of the particles originating from the top decays. We investigate a scenario with both top quarks decaying hadronically. We attempt a definition of "top jet", by considering the substructure of the selected "fat" jets resulting from the top decay and we study the contamination from QCD events. First results of differential cross sections as a function of the azimuthal difference between the two top jets, using 2016 data collected with the CMS experiment, are presented and analogies to generic QCD dijet topologies are highlighted.

## T 76: Flavourphysik 2

Zeit: Mittwoch 16:45–19:05

Raum: JUR 490

**Gruppenbericht** T 76.1 Mi 16:45 JUR 490  
 **$K^+ \rightarrow \pi^+ \nu \bar{\nu}$  sensitivity at NA62 with the 2016 data** — ●RADOSLAV MARCHEVSKI — Johannes Gutenberg University, Mainz, Germany

NA62 is a fixed target experiment at CERN, which operates since 2015 on the 400 GeV proton beam supplied by the CERN SPS accelerator. The main physics task of the experiment is a precise measurement of the rare kaon decay  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  using a decay-in-flight technique. In the Standard Model this channel is strongly suppressed to  $\mathcal{O}(10^{-10})$  and therefore is very sensitive to new physics, which could modify the decay rate. To measure this rare decay the experiment has to achieve a challenging background suppression of  $10^{12}$ . The background rejection capabilities as well as the sensitivity using the 2016 data will be presented.

T 76.2 Mi 17:05 JUR 490  
**Suche nach dem Zerfall  $B \rightarrow \mu\nu$  mit dem Belle-Datensatz** — MICHAEL FEINDT, PABLO GOLDENZWEIG, THOMAS HAUTH, MARTIN HECK und ●MARKUS PRIM — IEKP, KIT, Karlsruhe

Das Belle-Experiment am japanischen Forschungszentrum KEK hat im Zeitraum von 1999 bis 2010 einen Datensatz von 772 Millionen  $B\bar{B}$  Zerfällen der  $\Upsilon(4S)$  Resonanz aufgezeichnet. Seltene Zerfälle dieser  $B$ -Mesonen eignen sich um das Standardmodell der Teilchenphysik zu testen, da Physik jenseits des Standardmodells einen großen Einfluss auf das Verzweungsverhältnis dieser Zerfälle nehmen kann. Einer dieser seltenen Zerfallskanäle ist  $B \rightarrow \mu\nu$ . In diesem Vortrag wird die Suche nach diesem Zerfall mit inklusiver Tag-Seiten Rekonstruktion präsentiert. Es ist die erste Suche nach dem Zerfall mit dem vollständigen Belle-Datensatz.

T 76.3 Mi 17:20 JUR 490  
**Messung des Verzweungsverhältnisses  $B \rightarrow \tau\nu$  mit dem Belle-Datensatz unter Verwendung des Belle II-Software-Frameworks** — ●THOMAS KECK<sup>1</sup>, MICHAEL FEINDT<sup>1</sup>, MARTIN HECK<sup>1</sup>, CHRISTIAN PULVERMACHER<sup>2</sup>, PABLO GOLDENZWEIG<sup>1</sup> und THOMAS HAUTH<sup>1</sup> — <sup>1</sup>IEKP, KIT, Karlsruhe — <sup>2</sup>KEK, Tsukuba

Das im Aufbau befindliche Belle II-Experiment am japanischen Forschungszentrum KEK wird  $B\bar{B}$ -Mesonenpaare aus dem Zerfall der  $\Upsilon(4S)$  Resonanz untersuchen und wird voraussichtlich ab 2018 in Betrieb genommen. Das Belle II-Software-Framework enthält eine Konvertierungsschnittstelle, welche die Verarbeitung der vom Vorgängerexperiment Belle von 1999 bis 2010 aufgenommenen Daten ermöglicht. Der Belle-Datensatz kann daher zur Validierung der für das Belle II-Experiment entwickelten, verbesserten Rekonstruktionsalgorithmen verwendet werden. Am konkreten Beispiel der Messung des Verzweungsverhältnisses  $B \rightarrow \tau\nu$  wird die signifikante Verbesserung der Rekonstruktionseffizienz für seltene Zerfälle mit hadronischer und semileptonischer Markierungsseite bestätigt.

T 76.4 Mi 17:35 JUR 490  
**Analyse des seltenen Zerfalls  $B^+ \rightarrow \ell^+ \nu \ell \gamma$  am Belle-Experiment** — MICHAEL FEINDT, ●MORITZ GELB, PABLO GOLDENZWEIG, MARTIN HECK und FELIX METZNER — KIT

Das Belle-Experiment am Elektron-Positron-Speicherring KEKB in

Tsukuba, Japan hat während seiner Laufzeit eine integrierte Luminosität von  $710 \text{ fb}^{-1}$  erreicht. Auf diesem Datensatz konnte für den seltenen Zerfall  $B^+ \rightarrow \ell^+ \nu \ell \gamma$  ein oberes Limit von  $5.1 \times 10^{-6}$  bestimmt werden. Bei der Analyse wird eines der beiden  $B$ -Mesonen im Signalzerfall, das andere mit der sogenannten Vollständigen Ereignisrekonstruktion in einem hadronischen Kanal rekonstruiert.

Für das im Aufbau befindliche Belle II-Experiment werden momentan neue Analysewerkzeuge entwickelt. Diese neuen Methoden erlauben heute schon eine verbesserte Analyse auf dem Belle-Datensatz. In einer Monte-Carlo Studie konnte gezeigt werden, dass sich die Signaleffizienz im Vergleich zur Vorgängeranalyse nahezu verdoppelt. Ziel ist es nun, das Verzweungsverhältnis des Zerfalls erstmals zu messen.

T 76.5 Mi 17:50 JUR 490  
**Untersuchung des inklusiven  $B$ -Meson Zerfalls  $B \rightarrow X\tau\nu$  am Belle-Experiment** — ●JAN HASENBUSCH<sup>1</sup>, FLORIAN BERNLOCHNER<sup>1</sup>, PHILLIP URQUIJO<sup>2</sup> und JOCHEN DINGFELDER<sup>1</sup> — <sup>1</sup>Universität Bonn — <sup>2</sup>University of Melbourne, Australia

Zerfälle von  $B$ -Mesonen mit einem  $\tau$ -Lepton im Endzustand, wie der inklusive semileptonische Zerfall  $B \rightarrow X\tau\nu$ , sind besonders interessant, da sie sensitiv auf den möglichen Austausch eines geladenen Higgs-Bosons sind, das z. B. in supersymmetrischen Erweiterungen des Standardmodells auftritt. Exklusive Messungen von  $B \rightarrow D^{(*)}\tau\nu$  Zerfällen von LHCb, BABAR und Belle liegen vier Standardabweichungen von den Vorhersagen des Standardmodells entfernt. Die erste Untersuchung des inklusiven Zerfalls  $B \rightarrow X\tau\nu$  an einer der  $B$ -Fabriken stellt eine wichtige Gegenprobe zu den exklusiven Messungen dar.

Das Belle-Experiment am KEK in Tsukuba (Japan) hat einen großen Datensatz von rund  $771 \times 10^6$   $B\bar{B}$  Paaren aus  $e^+e^-$  Kollisionen auf der  $\Upsilon(4S)$ -Resonanz aufgenommen.

In jedem Ereignis wird eines der  $B$ -Mesonen in einem hadronischen Zerfallskanal vollständig rekonstruiert (hadronisches  $B$ -Tagging), das andere auf den Signalzerfall  $B \rightarrow X\tau\nu$  hin untersucht.

Der Vortrag beschreibt die Analyse von  $B \rightarrow X\tau\nu$  Zerfällen mit einem Lepton im Endzustand, das aus dem leptonischen Zerfall des  $\tau$ -Leptons stammt. Die Auswahl der Observablen zur Extraktion des Signals, eine Abschätzung der erwarteten Unsicherheiten und ein vorläufiges Ergebnis werden vorgestellt.

T 76.6 Mi 18:05 JUR 490  
**Messung des Verzweungsverhältnisses  $B_s^0 \rightarrow D^{*\pm} D^\mp$  mit dem LHCb-Experiment** — PHILIPP IBIS, FRANK MEIER, ●ANTJE MÖDDEN, MARGARETE SCHELLENBERG und JULIAN WISHAH für die LHCb-Kollaboration — Experimentelle Physik 5, TU Dortmund

In der Analyse des Zerfalls  $B^0 \rightarrow D^{*\pm} D^\mp$  muss in der Massenverteilung der  $B_s^0 \rightarrow D^{*\pm} D^\mp$ -Zerfall als exklusiver Untergrund betrachtet werden. Das Verzweungsverhältnis dieses Kanals ist noch nicht bekannt und soll in dieser Analyse erstmals mit dem LHCb-Experiment gemessen werden. Die Messung erfolgt relativ zum  $B^0 \rightarrow D^{*\pm} D^\mp$ -Kanal, um Unsicherheiten von Luminosität und Produktionswirkungsquerschnitt zu vermeiden. Die Rekonstruktion erfolgt über die Zerfälle  $D^{*+} \rightarrow D^0 \pi^+$ , wobei das  $D^0$  weiterzerfällt in  $\pi^+ K^-$ , sowie  $D^- \rightarrow \pi^- \pi^+ K^+$  und  $D^- \rightarrow \pi^- K^- K^+$ . Eine Herausforderung stellen insbesondere hadronische Untergründe dar.

In diesem Vortrag wird der aktuelle Stand der Analyse vorgestellt,

die auf den Run I und Run II Datensätzen des LHCb-Experimentes, entsprechend einer integrierten Luminosität von insgesamt  $5 \text{ fb}^{-1}$ , beruht.

T 76.7 Mi 18:20 JUR 490

**Untersuchung von  $B \rightarrow D^{(*)}\pi l \nu$  Zerfällen mit dem Belle-Experiment und Suche nach  $B \rightarrow D^{(*)}\pi \tau \nu$**  — ●MARIO ARNDT, FLORIAN BERNLOCHNER und JOCHEN DINGFELDER — Rheinische Friedrich-Wilhelms-Universität Bonn, Deutschland

Semileptonische Zerfälle von  $B$ -Mesonen erlauben die Präzisionsmessung der CKM-Matrixelemente  $|V_{cb}|$  und  $|V_{ub}|$ , sowie die Suche nach neuer Physik durch die Studie von Endzuständen mit  $\tau$ -Leptonen. Ein wichtiger Untergrund, den es bei exklusiven und inklusiven  $b \rightarrow cl \nu$  und  $b \rightarrow ul \nu$  Zerfällen zu verstehen gilt, sind semileptonische Zerfälle in Endzustände mit orbital angeregten Charm-Mesonen, sog.  $D^{**}$ -Mesonen. Das experimentelle Verständnis von solchen Beiträgen ist lückenhaft und die  $B \rightarrow D^{**}$  Formfaktoren sind bisher ungemessen. Darüber hinaus bietet die Studie von  $B \rightarrow D^{(*)}\pi \tau \nu$  Zerfällen einen alternativen Weg, um den beobachteten Überschuss in Messungen von  $B \rightarrow D^{(*)}\tau \nu$  weiter zu untersuchen. In diesem Vortrag wird der aktuelle Stand der Untersuchung von  $B \rightarrow D^{(*)}\pi l \nu$  Zerfällen und die Suche nach  $B \rightarrow D^{(*)}\pi \tau \nu$  vorgestellt.

T 76.8 Mi 18:35 JUR 490

**Studien von  $B \rightarrow DXl \nu$  Zerfällen und Messung des CKM-Matrixelements  $V_{cb}$  mit dem Belle-II Experiment** — ●MICHEL BERTEMES, JOCHEN DINGFELDER und FLORIAN BERNLOCHNER — Uni Bonn, Deutschland

Gegen Ende 2018 wird das Belle-II Experiment mit seinem Physikprogramm beginnen. Geplant ist die Aufzeichnung von  $5 \text{ ab}^{-1}$  an  $e^+e^- \rightarrow \Upsilon(4S) \rightarrow B\bar{B}$  Ereignissen während der ersten 2 Jahre. In dieser Zeit werden Messungen des CKM-Matrixelements  $|V_{cb}|$  ohne

Rekonstruktion des zweiten  $B$ -Mesons im Ereignis noch präziser sein als Analysen, in denen das zweite  $B$ -Meson voll rekonstruiert wird. In diesem Vortrag werden die vorläufigen Ergebnisse einer Studie von  $B \rightarrow DXl \nu$  Zerfällen vorgestellt: Das CKM-Matrixelement wird durch eine semi-inklusive Messung von  $B \rightarrow Dl \nu$  und  $B \rightarrow D^*l \nu$  Zerfällen bestimmt, wobei das  $D^*$ -Meson nicht rekonstruiert wird. Die Trennung von Signal und Untergrund erfolgt über die kinematischen Eigenschaften der Zerfälle. Um die Machbarkeit dieser Analyse mit Belle-II zu untersuchen, werden zunächst die 711 Millionen von Belle aufgezeichneten  $B\bar{B}$ -Paare analysiert. Die Analyse erfolgt im Belle-II-Framework durch Konversion der Belle-Daten in das Belle II-Datenformat.

T 76.9 Mi 18:50 JUR 490

**Development of a new Soft Muon Tagger in ATLAS** — NELLO BRUSCINO, JULIEN CAUDRON, MARKUS CRISTINZIANI, MAZUZA GHNEIMAT, CARLO ALBERTO GOTTARDO, SEBASTIAN HEER, VADIM KOSTYUKHIN, ●ANDREA SCIANDRA, and KAVEN YAU WONG — Physikalisches Institut, Universität Bonn

$b$ -tagging plays a fundamental role at LHC, as it helps in the identification of heavy particles that decay to bottom quarks, as the top quark and the Higgs boson or heavy exotic particles. The Soft Muon Tagger (SMT) allows to identify jets from  $b$ -quarks taking advantage of the presence of a muon coming from semileptonic decays of  $b$ -hadrons. The SVMT algorithm additionally uses a vertex reconstructed thanks to the high quality of the muon track. I will describe the development of these two new  $b$ -taggers in ATLAS, showing that, despite the low efficiency of the jet-muon association (based on the angular distance), the discriminating power of the associated muon and vertex variables is remarkable to reject light jets.

A performance enhancement has been reached at all light jet rejection working points by adding the SMT output to the best performing multivariate  $b$ -tagger in ATLAS. A good modelling of input and output variables is shown, comparing simulation with Run 2 data.

## T 77: Suche nach Supersymmetrie 4

Zeit: Mittwoch 16:45–19:00

Raum: JUR 498

T 77.1 Mi 16:45 JUR 498

**Suche nach direkter Produktion von skalaren Tau-Leptonen am LHC mit Run-2-Daten von ATLAS** — FEDERICA LEGGER, ●CLARA LEITGEB und ALEXANDER MANN — Ludwig-Maximilians-Universität, München

Supersymmetrie ist eine vielversprechende Ergänzung des Standardmodells der Teilchenphysik. Nach den von ihr zusätzlich vorhergesagten Teilchen und Prozessen wird u.a. mithilfe des ATLAS-Detektors am LHC gesucht. Einer dieser Prozesse ist die direkte Paar-Produktion von skalaren Tau-Leptonen (Staus) und deren anschließender Zerfall in jeweils ein Tau-Lepton und ein leichtestes Neutralino. Da hierfür nur ein sehr geringer Wirkungsquerschnitt zu erwarten ist, konnte im ersten Run des LHC bei 8 TeV Schwerpunktsenergie nur geringe Sensitivität erreicht werden. Die Erhöhung der Schwerpunktsenergie in Run 2 hat jedoch einen größeren Wirkungsquerschnitt für diesen Prozess zur Folge. Zusammen mit der höheren Luminosität in Run 2 bewirkt dies eine erhöhte Produktionsrate von Stau-Paaren. Allerdings sind ebenfalls größere Wirkungsquerschnitte der Untergrundprozesse zu erwarten und die Triggerselektion wird durch die höhere instantane Luminosität erschwert.

In diesem Vortrag wird eine entsprechende Suche nach der direkten Stau-Produktion mit Run-2-Daten von ATLAS bei einer Schwerpunktsenergie von 13 TeV vorgestellt, wobei sowohl der Fall zweier hadronisch zerfallender Tau-Leptonen als auch der Fall eines hadronisch und eines leptonisch zerfallenden Tau-Leptons auf seine Sensitivität untersucht wird.

T 77.2 Mi 17:00 JUR 498

**5.12, Search for supersymmetry with tau leptons in the CMS experiment** — ●ILYA BOBOVNIKOV, ALEXIS KALOGEROPOULOS, ISABELL MELZER-PELLMANN, and ALEXEI RASPEREZA — DESY

A search for SUSY in events with  $\tau$  leptons in the final state with  $36/\text{fb}$  of 13 TeV data taken during 2016 is presented. Results are interpreted in terms of direct  $\tilde{\tau}$ -pair production model, where each  $\tilde{\tau}$  is expected to decay to a  $\tau$  lepton and the lightest SUSY particle, and neutralino-chargino and chargino pair production model with decays to  $\tau$  leptons.

To optimize the sensitivity to various new physics topologies, we search in several exclusive categories, based on final states with one hadronically decaying  $\tau$  lepton, an electron or muon from the decay of the second  $\tau$ , and final states with one electron and one muon from the decay of the  $\tau$  leptons. Finally, exclusion limits on simplified SUSY models parameters are calculated.

T 77.3 Mi 17:15 JUR 498

**Latest Developments in the Search for Supersymmetry with Tau Leptons at the ATLAS Experiment** — PHILIP BECHTLE, FLORIAN BEISIEGEL, KLAUS DESCH, PHILIPP KÖNIG, ●OLIVER RICKEN, and STEFFEN SCHAEPE — Physikalisches Institut, Universität Bonn

The reliably running Large Hadron Collider (LHC) and the ATLAS experiment provide a new and unique discovery potential for physics beyond the Standard Model (SM). One of the most promising extensions to the successful yet incomplete SM is Supersymmetry (SUSY). Due to the quark-gluon composition of protons, particle-particle collisions of the latter favour production of new particles via the strong interaction. This fact motivates searches for strongly produced decay chains of SUSY. In addition, it is natural in models of SUSY that tau leptons and their distinct detector signatures are expected to be rather abundant.

This talk addresses the ongoing searches for hadronic tau final states in different models of strong production of SUSY. The analyses presented are based on the full 13 TeV ATLAS dataset. In contrast to the early Run-II analyses, this study exploits the increased amount of data available in various ways: in addition to improved background estimation approaches, new fitting procedures are utilised to extract results more efficiently.

This talk introduces the analyses pursued and presents the latest results available, focussing on the novelties with respect to the first studies of 2015 ATLAS data.

T 77.4 Mi 17:30 JUR 498

**Jet Smearing as a tool for the accurate description of QCD backgrounds in SUSY searches with tau leptons** — PHILIP

BECHTLE, •FLORIAN BEISIEGEL, KLAUS DESCH, OLIVER RICKEN, and STEFFEN SCHAEPE — University of Bonn

The estimation of all relevant backgrounds is very important for all kinds of analyses. Multijet background via QCD processes is notoriously hard to describe by simulation in kinematical regions with large missing transverse momentum because of the enormous requirement on Monte-Carlo statistics. This situation also arises in SUSY searches. Therefore, data-driven techniques need to be employed. Jet Smearing is such a data-driven technique for QCD estimation. It uses multijet events with very good transverse energy balance selected from data, which then are smeared using response functions of the average jet mismeasurement controlled from data.

In my talk, I will briefly introduce the principles of the Jet Smearing technique. Afterwards I will present the results of Jet Smearing in SUSY searches in strongly produced events with hadronically decaying tau leptons, jets and missing transverse momentum at  $\sqrt{s} = 13$  TeV for the  $3.16 \text{ fb}^{-1}$  of ATLAS data collected in 2015. Also the current status of Jet Smearing for the full 13 TeV ATLAS 2015 and 2016 data will be shown.

Furthermore an approach for the estimation of the uncertainties depending on the seed statistics will be presented.

Finally an outlook on future tasks and possible improvements will be given.

T 77.5 Mi 17:45 JUR 498

**Suche nach R-Paritätsverletzender Supersymmetrie in Ereignissen mit vier Leptonen am ATLAS-Detektor** — •ANDREA MATIC und JEANETTE LORENZ — Ludwig-Maximilians-Universität München

Mit der Erhöhung der LHC-Schwerpunktsenergie auf 13 TeV in Run-II konnte die Sensitivität auf die Paar-Produktion von Charginos deutlich gesteigert werden.

Diese Analyse ist auf ein vereinfachtes Signalmodell ausgerichtet, in dem durch den Zerfall eines Charginos ein Neutralino produziert wird, welches das leichteste supersymmetrische Teilchen (LSP) in diesem Modell ist. Das LSP ist jedoch nicht stabil, sondern zerfällt in einem R-Paritätsverletzenden Prozess in zwei geladene Leptonen und ein Neutrino. Daher werden als Signalkriterium mindestens vier geladene Leptonen im Endzustand gefordert. Während anfangs nur Szenarien mit Elektronen und Myonen betrachtet wurden, wird die Analyse nun um zwei Signalregionen erweitert, die ein bzw. zwei Taus im Endzustand enthalten. In diesen Signalregionen stellt die Abschätzung des Fake-Untergundes eine besondere Schwierigkeit dar.

Im Vortrag werden die Optimierungsstrategie für die Tau-Signalregionen und die sich ergebende Sensitivität vorgestellt. Weiterhin werden Studien zur Untergrundbestimmung gezeigt.

T 77.6 Mi 18:00 JUR 498

**Search for supersymmetry with the ATLAS detector at  $\sqrt{s} = 13$  TeV in final states with tau leptons and  $b$ -quarks** — MICHAEL HOLZBOCK, FERDINAND KRIETER, ALEXANDER MANN, and •BALTHASAR SCHACHTNER — LMU München, Am Coulombwall 1, DE-85748 Garching

Supersymmetry introduces a symmetry between fermions and bosons giving rise to so-called superpartners which can solve the hierarchy problem and provide a natural candidate for dark matter. A search for supersymmetry with final states including tau leptons and jets originating from  $b$ -quarks with the ATLAS detector is presented. It includes data taken with the LHC at a center-of-mass energy of 13 TeV in 2015 and 2016 with an integrated luminosity of about  $37 \text{ fb}^{-1}$ .

The analysis targets the direct production of scalar top quarks which decay to scalar taus,  $b$ -quarks and neutrinos. The scalar taus decay subsequently to gravitinos and Standard Model (SM) taus. The considered signature contains a light lepton from the tau decay and a hadronic tau, as well as two jets from  $b$ -quarks and missing transverse energy from the gravitinos and SM neutrinos. The main background arises from top quark production, possibly with jets misidentified as taus.

T 77.7 Mi 18:15 JUR 498

**Search for direct pair production of top squarks in final states with two hadronically decaying tau leptons in  $pp$  collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector** — MICHAEL HOLZBOCK, •FERDINAND KRIETER, ALEXANDER MANN, and BALTHASAR SCHACHTNER — Ludwig-Maximilians-Universität München

Supersymmetry can resolve several shortcomings of the Standard Model, one of them being the hierarchy problem. Due to its large contribution to radiative corrections of the Higgs boson mass, the top squark, the supersymmetric partner of the top quark, is expected to be relatively light and thus within the reach of the LHC. A search for direct pair production of top squarks in final states with two tau leptons,  $(b-)$ jets and missing transverse momentum is presented. The analysis uses  $36.5 \text{ fb}^{-1}$  of proton-proton collision data at a center of mass energy of  $\sqrt{s} = 13$  TeV, recorded with the ATLAS detector at the LHC in 2015 and 2016. Top squark candidates are searched for in events where both tau leptons decay hadronically and no light leptons are present. This talk aims to give an insight into the strategy and method of the analysis and an interpretation of the results using simplified models.

T 77.8 Mi 18:30 JUR 498

**Search for physics beyond the standard model with photons, missing transverse momentum and hadronic activity** — •MAXIMILIAN KNUT KIESEL, CHRISTIAN AUTERMANN, and LUTZ FELD — 1. Physikalisches Institut B, RWTH Aachen University

A search for physics beyond the standard model in proton-proton collisions with photons in the final state will be presented. Such final states are motivated by gauge mediated supersymmetry breaking models, in which a neutralino decays to an undetectable gravitino and a photon. If the neutralinos are produced through the strong interaction, the jets in the decay cascade lead to a large amount of hadronic activity. This search uses proton-proton collisions at a center-of-mass energy of 13 TeV recorded with the CMS detector in 2016, corresponding to an integrated luminosity of about  $36 \text{ fb}^{-1}$ . At least one high energetic photon, hadronic activity and missing transverse momentum are required. Multijet production with real photons or jets identified as photons can also pass this selection, and its contribution to the selection is estimated using data. In addition, the background from electrons misidentified as photons is also estimated using data. Cut-and-count experiments in several bins with high missing transverse momentum and high hadronic activity are performed to evaluate the presence of physics beyond the standard model.

T 77.9 Mi 18:45 JUR 498

**Suche nach elektroschwacher Produktion von Gauginos in Endzuständen mit Photonen und  $p_T^{\text{miss}}$  bei CMS** — •JOHANNES SCHULZ, CHRISTIAN AUTERMANN und LUTZ FELD — 1. Physikalisches Institut B, RWTH Aachen University

Supersymmetrische Modelle, in denen die Brechung durch Eichbosonen vermittelt wird (GMSB), sagen je nach Mischung der Gauginos Endzustände mit Photonen und Gravitinos vorher. Die nicht detektierbaren Gravitinos führen zu einem Ungleichgewicht des Impulses in der transversalen Ebene des Detektors ( $E_T^{\text{miss}}$ ). Die elektroschwache Produktion der Eichbosonen erzeugt Endzustände mit geringer hadronischer Aktivität.

Die Analyse untersucht Daten, die 2016 in Proton-Proton Kollisionen bei einer Schwerpunktsenergie von 13 TeV vom CMS Detektor aufgezeichnet wurden und die Triggeranforderung eines hochenergetischen Photons erfüllt haben. Der Datensatz korrespondiert zu einer integrierten Luminosität von  $36,42 \text{ fb}^{-1}$ . Die Analyse nutzt Daten zur Bestimmung der dominanten Standardmodell-Untergründe durch Monte-Carlo-Normalisierung oder vollständig datengetriebener Abschätzung. Prozesse geringfügigeren Beitrags werden durch Monte-Carlo Simulationen abgeschätzt. Ereignisse mit großem  $E_T^{\text{miss}}$  und großen transversalen Massen, rekonstruiert aus dem transversalen Impuls des höchstenergetischen Photons und  $E_T^{\text{miss}}$ , werden selektiert. Die Ergebnisse werden in GMSB und vereinfachten Modellen interpretiert und Ausschlussgrenzen berechnet.

## T 78: Suche nach neuen Teilchen 4

Zeit: Mittwoch 16:45–19:05

Raum: JUR 2

## Gruppenbericht

T 78.1 Mi 16:45 JUR 2

**Search for hidden particles with the SHiP experiment** — •DANIEL BICK, CAREN HAGNER, STEFAN BIESCHKE, JOACHIM EBERT, and WALTER SCHMIDT-PARZEFALL — Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

SHiP is a new general purpose fixed target facility, currently in the design phase at CERN. In its initial phase, the 400 GeV proton beam extracted from the SPS will be dumped on a heavy target with the aim of integrating  $2 \times 10^{20}$  pot in 5 years. A dedicated detector, based on a long vacuum tank followed by a spectrometer and particle identification detectors, will allow probing a variety of models with light long-lived exotic particles and masses below  $\mathcal{O}(10)$  GeV/ $c^2$ . The main focus will be the physics of the so-called Hidden Portals, i.e. search for Dark Photons, Light scalars and pseudo-scalars, and Heavy Neutrinos. Another dedicated detector will allow the study of neutrino cross-sections and angular distributions.  $\nu_\tau$  deep inelastic scattering cross sections will be measured with a statistics 1000 times larger than currently available, with the extraction of the  $F_4$  and  $F_5$  structure functions, never measured so far and allow for new tests of lepton non-universality with sensitivity to BSM physics.

T 78.2 Mi 17:05 JUR 2

**Search for hidden particles at SHiP: impact of the vertex reconstruction** — MAXIMILIAN EHLERT, SANDRA GERLACH, •IEVGEN KOROL, HEIKO LACKER, PAUL ROSENAU, and PLAMENNA VENKOVA — Humboldt University, Berlin, Germany

A new general-purpose fixed-target facility, SHiP, is proposed at the CERN SPS 400 GeV accelerator complex. It aims to search for "hidden particles", such as Heavy Neutral Leptons (HNL), dark photons, axion-like particles etc. The principal background to the hidden-particle decay signals originates from neutrino- and muon-induced interactions, from muon combinatorial background, and from cosmic muons. The talk explains the offline reconstruction of signal events and the vertex and impact-parameter reconstruction, which plays an important role in the rejection of background events.

T 78.3 Mi 17:20 JUR 2

**The role of the Surround Background Tagger for the SHiP experiment** — MAXIMILIAN EHLERT, SANDRA GERLACH, IEVGEN KOROL, HEIKO LACKER, PAUL ROSENAU, and •PLAMENNA VENKOVA — Humboldt University, Berlin, Germany

SHiP, a new general-purpose fixed-target facility is proposed to be constructed at the CERN SPS accelerator complex. The goal is to dump  $2 \times 10^{20}$  protons of 400 GeV momentum on a molybdenum-tungsten target over a time of five years and to search for very weakly interacting long-lived particles with masses below  $\mathcal{O}(10)$  GeV, such as Heavy Neutral Leptons (HNLs). After stopping hadrons and filtering out muons, the HNLs can decay inside a 50 m long decay vessel, which is enclosed by a surround background tagger (SBT). The decay products of the HNLs are detected in a subsequent spectrometer. The talk discusses the role of the SBT to suppress background in the offline analysis.

T 78.4 Mi 17:35 JUR 2

**Searches for New Physics with the Mu3e Experiment** — •ANN-KATHRIN PERREVOORT for the Mu3e-Collaboration — Physikalisches Institut, Universität Heidelberg

The upcoming Mu3e experiment searches for physics beyond the Standard Model in the lepton-flavour violating decay  $\mu^+ \rightarrow e^+ e^+ e^-$  with a final sensitivity of one signal decay in  $10^{16}$  muon decays. For this purpose, the detector is designed to measure electron and positron tracks of low momenta with excellent precision while operating at very high muon stopping rates in the order of  $10^8 \frac{\mu}{s}$  up to  $10^9 \frac{\mu}{s}$ . The high number of observed muon decays combined with the excellent detector resolution opens up a window for New Physics searches beyond the  $\mu \rightarrow eee$  decay. Currently, two classes of such processes are under study. These are processes of the type  $\mu^+ \rightarrow e^+ X^0$  with  $X^0$  being a neutral light boson, as well as  $\mu^+ \rightarrow e^+ A \bar{\nu}_\mu \nu_e$ , where the  $A$  can either decay to an  $e^+ e^-$  pair or leave the detector unseen. An example of  $A$  could be a dark photon. Simulation studies estimating the sensitivity of the Mu3e experiment to these processes will be presented.

T 78.5 Mi 17:50 JUR 2

**Search for magnetic monopoles, utilizing luminescence light, with the IceCube detector\*** — •FREDERIK LAUBER for the IceCube-Collaboration — Bergische Universität Wuppertal

Magnetic monopoles are hypothetical particles predicted by many Beyond the Standard Model theories. They are carriers of single elementary magnetic charge. This work considers Intermediate Mass Monopoles which have been created shortly after the Big Bang. No recent search exists for the low relativistic range ( $0.1 - 0.5 c$ ) because of the predominant usage of Cherenkov light as a detection mechanism in current experiments. No Cherenkov light is produced in the considered velocity range. Still, highly ionizing particles such as magnetic monopoles produce luminescence light in water and ice. To detect luminescence light, a high effective detection volume, as provided by the IceCube detector, with a high sensitivity to light is needed.

An ongoing search in the low relativistic range, utilizing luminescence light for the first time as a detection method with the IceCube detector, is outlined. Signal simulation will be shown as well as a first comparison between data, taken with the new monopole filter of the IceCube detector, and background simulation. The first separating variables used in the search will be presented.

\* Gefördert durch die BMBF-Verbundforschung Astroteilchenphysik

T 78.6 Mi 18:05 JUR 2

**Search for heavy Majorana neutrinos in rare semileptonic B meson decays at the LHCb experiment** — •MERIEM BOUBDIR, ARNO HEISTER, CHRISTOPH LANGENBRUCH, and STEFAN SCHAEEL — I. Physikalisches Institut B, RWTH Aachen

It is an open question of particles physics whether Neutrinos are Dirac or Majorana fermions. Neutrinos of Majorana-type (meaning they are their own antiparticles) would induce lepton number violating (LNV) processes. An example would be B meson decays with two same-sign leptons in the final state.

The LHCb experiment is an ideal environment for the search for these striking signatures due to the large  $b\bar{b}$  production cross section. This talk presents an ongoing search for the LNV decay  $B^+ \rightarrow \mu^+ \mu^+ \pi^-$  using data collected by the LHCb experiment during the LHC Run 1 and 2. The analysis is extended by a search for the related decay  $B_c^+ \rightarrow \mu^+ \mu^+ \pi^-$ , which allows to probe Neutrino masses of up to  $\sim 6$  GeV. The selection of the signal modes and the suppression of possible backgrounds will be discussed. In addition, the expected limit on the branching fractions of the signal decays will be presented.

T 78.7 Mi 18:20 JUR 2

**Analysis of high mass lepton flavour violating processes with CMS** — •AARON HORNSCHILD, SÖREN ERDWEG, THOMAS HEBBEKER, ARND MEYER, and SWAGATA MUKHERJEE — III. Physikalisches Institut A, RWTH Aachen University

Lepton flavour violating processes are common in several models of physics beyond the Standard Model. Some models predict objects at the TeV mass scale that can decay into two standard model leptons of different flavour: electron + muon, muon + tau, or electron + tau.

The challenges in a search for such phenomena are to achieve a high mass resolution, good rejection of standard model backgrounds, and an efficient lepton identification at the same time.

The selection part of the analysis is presented, which is based on the 2016 CMS dataset corresponding to an integrated luminosity of  $36 \text{ fb}^{-1}$  at a center of mass energy of 13 TeV.

T 78.8 Mi 18:35 JUR 2

**Search for massive particles with flavour violating decays with CMS - interpretation of the results** — •SÖREN ERDWEG, THOMAS HEBBEKER, AARON HORNSCHILD, ARND MEYER, and SWAGATA MUKHERJEE — III. Physikalisches Institut A, RWTH Aachen University

Many models of physics beyond the standard model predict charged lepton flavour violation at scales within LHC reach: Quantum gravity at the TeV scale can lead to the production of quantum black holes (QBH). Also, new heavy  $Z'$  bosons can be produced via quark-quark interaction. Finally, allowing R-parity violation can permit resonant sneutrino production in SUSY scenarios.

In all these models, a resonance-like excess of events at high elec-

tron + muon invariant masses can appear, thus leading to a striking signature with low standard model background.

The interpretation part of the analysis is presented, which is based on the 2016 CMS dataset corresponding to an integrated luminosity of  $36 \text{ fb}^{-1}$  at a center of mass energy of 13 TeV.

T 78.9 Mi 18:50 JUR 2

**Search for disappearing tracks with the CMS experiment at 13 TeV** — PAUL ASMUS, TOBIAS KRAMER, •VIKTOR KUTZNER, PETER SCHLEPER, and BENEDIKT VORMWALD — Institut für Experimentalphysik, Universität Hamburg

The status of the search for long-lived charged BSM particles, which decay in the CMS detector and produce disappearing track signatures, is presented. A disappearing track signature is characterized by missing hits in the outer layers of the tracker with little or no energy deposited in the calorimeter. The findings are interpreted in the anomaly-mediated supersymmetry breaking model, which predicts a small mass splitting between the two lightest SUSY particles, giving rise to non-reconstructed soft leptons or hadrons. The search is further extended to consider pairs of tracks yielding a kinked track signature. First results of this extended search are presented using proton-proton collision data with  $\sqrt{s} = 13 \text{ TeV}$  collected by the CMS experiment in 2016.

## T 79: Suche nach Dunkler Materie 3 (Direkter Nachweis)

Zeit: Mittwoch 16:45–19:10

Raum: VSH 19

### Gruppenbericht

T 79.1 Mi 16:45 VSH 19

**Searching for low-mass Dark Matter with EDELWEISS** — •VALENTIN KOZLOV — Karlsruher Institut für Technologie, Institut für Experimentelle Kernphysik, Gaedestr. 1, 76128 Karlsruhe

The EDELWEISS experiment uses Germanium low-temperature detectors with heat and ionization readout for direct dark matter search. These advanced high-purity detectors are operated at 18 mK in a low-radioactivity environment of the Modane underground laboratory (LSM, France). Eight detectors with best energy resolutions were selected for low-mass WIMP analysis from a total set of 20 detectors operated in a long-term campaign. Boosted Decision Tree and likelihood approaches were used to analyze acquired data and show up to two orders of magnitude improvement with respect to the previous EDELWEISS-II low-mass WIMP search for  $7 \text{ GeV}/c^2$  WIMPs. The current R&D program concentrates on further improvements of ionization and heat baseline resolutions, and use of voltage-assisted heat amplification technique (so-called Neganov-Luke mode). Significant improvement in sensitivity can be realized with a moderate exposure of 350 kg.d at actual background conditions within the next 1-2 years. Beyond 2018 the already existing cooperation with SuperCDMS should lead to a common experimental infrastructure in SNO-LAB. Recent results, current R&D activities, sensitivity projections and the project towards the SNOLAB cryogenic facility will be discussed.

### Gruppenbericht

T 79.2 Mi 17:05 VSH 19

**Direct Dark Matter Search with CRESST III – Status & Perspectives** — •MICHAEL WILLERS for the CRESST-Collaboration — Physik-Department, Technische Universität München, D-85748 Garching, Germany

The CRESST experiment, located in the Gran Sasso underground laboratory (LNGS), Italy aims at the direct detection of dark matter (DM) particles. Scintillating  $\text{CaWO}_4$  crystals operated as cryogenic detectors are used as target material for DM-nucleus scattering. The simultaneous measurement of the heat signal from the  $\text{CaWO}_4$  crystal and the emitted scintillation light is used for particle identification. Due to its low nuclear recoil energy threshold the experiment is probing the low-mass region of the parameter space for spin-independent DM-nucleus scattering below  $\sim 5 \text{ GeV}/c^2$  with high sensitivity. Recent results obtained using a 300 g detector with a nuclear recoil energy threshold of 307 eV provide the world best limit for DM particle masses below  $1.7 \text{ GeV}/c^2$ .

The goal of the CRESST III experiment is to significantly improve the sensitivity for low-mass DM particles by using optimised cryogenic detector modules, each consisting of a 24 g  $\text{CaWO}_4$  target crystal and  $20 \times 20 \text{ mm}^2$  Silicon-on-Sapphire light detector. Phase 1 of the experiment operates 10 detector modules with a total target mass of 240 g and started taking data in August 2016. In this talk I will present the current status and future perspectives of the CRESST III experiment.

T 79.3 Mi 17:25 VSH 19

**Production of high-purity  $\text{CaWO}_4$  crystals for direct dark matter search with CRESST** — •ANDREA MÜNSTER for the CRESST-Collaboration — Physik-Department and Excellence Cluster Universe, Technische Universität München, D-85748 Garching

The direct dark matter search experiment CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) uses scintillating  $\text{CaWO}_4$  single crystals as targets to search for possible recoils of dark

matter particles. Since several years these  $\text{CaWO}_4$  crystals have been produced directly at the Technische Universität München (TUM) including the  $\text{CaWO}_4$  powder production from the raw materials  $\text{CaCO}_3$  and  $\text{WO}_3$ , the  $\text{CaWO}_4$  crystal growth via the Czochralski method as well as the after-growth treatment of the crystals. In CRESST-II Phase 2 (2013-2015), 4 TUM-grown crystals were operated in the experiment for the first time, showing the best radiopurities of all crystals installed. Therefore, in CRESST-III Phase 1 (started in summer 2016) mainly TUM-grown crystals have been included. The goal for the upcoming CRESST-III Phase 2 is a further improvement of the radiopurity. A method to chemically purify the raw materials was developed at TUM and will be presented together with first promising results. This research was supported by the DFG cluster of excellence "Origin and Structure of the Universe", by the Helmholtz Alliance for Astroparticle Physics, by the Maier-Leibnitz-Laboratorium (Garching) and by the BMBF.

T 79.4 Mi 17:40 VSH 19

**Characterization of the non-linearity of the light-yield at low energy deposition in  $\text{CaWO}_4$  crystals** — •ERIK LINDNER, XAVIER DEFAY, JEAN-CÔME LANFRANCHI, ALEXANDER LANGENKÄMPER, ELIZABETH MONDRAGON, ANDREA MÜNSTER, CORBINIAN OPPENHEIMER, TOBIAS ORTMANN, WALTER POTZEL, STEFAN SCHÖNERT, HONG HANH TRINH THI, ANDREAS ULRICH, STEPHAN WAWOCZNY, MICHAEL WILLERS, and ANDREAS ZÖLLER — Technische Universität München, Physik Department Lehrstuhl E15 und Excellence Cluster Universe, James-Frank-Straße 1, D-85748 Garching

The CRESST experiment uses scintillating  $\text{CaWO}_4$  single crystals as target material for direct dark matter search. A particle interaction in the crystal simultaneously produces heat and light. The light-yield, defined as the ratio of energy in the light channel compared to the phonon channel, can be used as discrimination parameter for different event classes. The light-yield shows a crystal dependent non-linear behaviour at low energy depositions in the crystal. The  $\text{CaWO}_4$  crystals of the current phase CRESST-III are mainly produced at the TUM. To investigate the energy dependence of the growth parameters, a coincident Compton scattering experiment is conducted. The experimental setup, the latest results, and future plans for the experiment will be presented. This research was supported by the DFG cluster of excellence "Origin and Structure of the Universe" and the Maier-Leibnitz-Laboratorium (Garching).

T 79.5 Mi 17:55 VSH 19

**Quenching Factor Measurements using the CRESST/ EURECA Neutron-Scattering-Facility** — •S. WAWOCZNY<sup>1</sup>, X. DEFAY<sup>1</sup>, J.-C. LANFRANCHI<sup>1</sup>, A. LANGENKÄMPER<sup>1</sup>, E. LINDNER<sup>1</sup>, A. MÜNSTER<sup>1</sup>, E. MONDRAGON<sup>1</sup>, L. OBERAUER<sup>1</sup>, C. OPPENHEIMER<sup>1</sup>, W. POTZEL<sup>1</sup>, S. SCHÖNERT<sup>1</sup>, T. ORTMANN<sup>1</sup>, R. STRAUSS<sup>2</sup>, M. WILLERS<sup>1</sup>, and A. ZÖLLER<sup>1</sup> — <sup>1</sup>Physik Department E15 und Excellence Cluster Universe, Technische Universität München, 85748 Garching — <sup>2</sup>Max-Planck-Institut für Physik, Föhringer Ring 6, 80805 München

The direct Dark Matter search experiment CRESST and the planned EURECA experiment use scintillating  $\text{CaWO}_4$  crystals as target for Dark Matter interactions. The scintillation light is measured in a separate cryogenic detector and enables the identification of nuclear recoils based on their distinct light yield. Especially in the search for low mass Dark Matter it is therefore necessary to precisely know the Quenching Factors (QF), describing the reduction of the light yield of nuclear re-

coils relative to electron recoils, and their energy dependencies at low recoil energies ( $< 100$  keV). The QFs of the target nuclei can be measured with high precision *in situ* at mK-temperatures with the CRESST Neutron-Scattering-Facility at the Maier-Leibnitz-Laboratory (MLL) by irradiating a dedicated cryogenic detector module with neutrons (11 MeV, from MLL accelerator). We present a new technique employed at the Neutron-Scattering-Facility as well as first promising results. This work was supported by the DFG cluster of excellence "Origin and Structure of the Universe" and the MLL (Garching).

T 79.6 Mi 18:10 VSH 19

**Purity control of the XENON1T gas inventory** — CONSTANZE HASTEROK, SEBASTIAN LINDEMANN, •VERONICA PIZZELLA, and HARDY SIMGEN for the XENON-Collaboration — Max-Planck-Institut für Kernphysik (MPIK), Saupfercheckweg 1, 69117, Heidelberg, Germany

The XENON1T experiment uses xenon nuclei as scattering target for dark matter particles. It employs a total of 3.5 tonnes of liquid xenon, from which 2 tonnes are in a Time Projection Chamber (TPC). For the success of the experiment, it is necessary to use xenon with low concentration impurities. The dangerous ones are: radioactive impurities such as Kr-85 and Rn-222, since they increase the background; electronegative molecules such as oxygen and water, since they lower the electron life-time and disrupt the well functioning of the TPC; helium, since it can harm the photomultipliers (PMTs). In this presentation, the measurements of the xenon inventory prior to filling the XENON1T detector for the first time will be discussed using the technique of gas chromatography. A dedicated measurement of the helium concentration will be introduced, and the results before and after a gas phase distillation of the xenon inventory will be illustrated.

T 79.7 Mi 18:25 VSH 19

**Krypton assay in xenon at the ppq level for XENON1T** — •LUISA HÖTZSCH, STEFFEN FORM, SEBASTIAN LINDEMANN, and HARDY SIMGEN for the XENON COLLABORATION — Max-Planck-Institut für Kernphysik (MPIK), Heidelberg, Germany

The XENON1T experiment aims for the detection of dark matter with a ton scale liquid xenon target for scattering events of Weakly Interacting Massive Particles (WIMPs), which represent one of the main candidates for particle dark matter. Due to the expected very low event rate of this process, ultra-low background conditions are required to reach the sensitivity necessary for WIMP detection. Among the most serious internal background contributions is the radioactive krypton isotope  $^{85}\text{Kr}$ , a  $\beta$ -emitter which is intrinsically present in commercially available xenon at the ppm or ppb level. However, krypton traces are successfully reduced from liquid xenon by cryogenic distillation. For the purpose of monitoring krypton concentrations in xenon, the XENON collaboration uses an off-line gas-chromatographic mass spectrometry

setup (RGMS), sensitive to krypton in xenon concentrations at the ppq (parts per quadrillion) level.

In this talk, the RGMS setup and its current status will be presented, as well as krypton in xenon measurement results from recent XENON1T samples.

T 79.8 Mi 18:40 VSH 19

**Monte Carlo simulations of a neutron veto for the XENONnT dark matter experiment** — •DIEGO RAMÍREZ GARCÍA for the XENON-Collaboration — Institut für Physik, Johannes Gutenberg-Universität Mainz

XENON1T is the first multi-ton dual-phase xenon time projection chamber (TPC) aiming for the direct detection of dark matter in the form of weakly interacting massive particles (WIMPs). With dark matter search already operative at the Laboratori Nazionali del Gran Sasso (LNGS), a spin-independent WIMP-nucleon cross section sensitivity of  $1.6 \cdot 10^{-47} \text{ cm}^2$  for WIMP masses of 40 GeV will be reached in an exposure of two years. With the goal of improving sensitivity by another order of magnitude, the infrastructure of the experiment has been designed for XENON1T to be rapidly upgraded to XENONnT, a detector already under development with a 35% larger photosensor coverage than its predecessor and containing about twice the mass of xenon.

With an improved self-shielding due to a larger TPC, it will be more effective to define a fiducial volume in which the external backgrounds can be reduced to a negligible level. In order to optimize this volume for the dark matter search, the possibility of developing a liquid scintillator neutron veto is now under study and Monte Carlo-based simulations have been performed to evaluate the potential decrease of nuclear recoil background from the detector materials.

T 79.9 Mi 18:55 VSH 19

**Search for Dark Matter at keV energies with the GERDA experiment** — •ROMAN HILLER for the GERDA-Collaboration — Universität Zürich

The GERDA experiment consists of an array of enriched  $^{76}\text{Ge}$ -detectors, surrounded by a liquid argon cryostat, which also acts as an active shielding. Located in the Laboratori Nazionali del Gran Sasso, an underground laboratory in Italy, it is shielded by 1400m of rock and after the careful selection of low background materials, it is one of the least radioactive places on earth. Its main goal is the detection of neutrinoless double beta decay, which would shed light on the nature and mass scale of the neutrino. However, its low background and high energy resolution make it a perfect environment to search also for other extremely rare processes. This study focuses on the capabilities of GERDA to detect narrow spectral lines at energies below 1 MeV to search for example for bosonic superweakly interacting massive particles, a dark matter candidate with keV scale mass.

## T 80: Neutrinophysik 6 (Szintillatorexperimente)

Zeit: Mittwoch 16:45–19:10

Raum: H 2

### Gruppenbericht

T 80.1 Mi 16:45 H 2

**Neutrino Physics with JUNO** — •HENNING REBBER for the JUNO-Collaboration — Universität Hamburg, Institut für Experimentalphysik

The Jiangmen Underground Neutrino Observatory (JUNO) is a next-generation neutrino experiment currently being built in the province Guangdong in the South of China. Below an overburden of  $\sim 1900$  m.w.e., 20 kt of liquid scintillator will be used to detect reactor antineutrinos from two power plants at a distance of  $\sim 53$  km. The primary goal is to determine the neutrino mass ordering from oscillation measurements. An energy resolution below 3% @ 1 MeV is intended to reach at least  $3\sigma$  significance. Furthermore, JUNO can improve the precision on solar oscillation parameters to below 1%, and allows for the measurement of neutrinos from Earth, Sun, and core-collapse supernovae. The start of data taking is planned for 2020. This talk will review the physics potential of JUNO, as well as the current status of design and construction. This work is funded by the DFG research unit JUNO.

### Gruppenbericht

T 80.2 Mi 17:05 H 2

**Topological track reconstruction in unsegmented multi-**

**kiloton liquid scintillator neutrino detectors** — FELIX BENCKWITZ<sup>1</sup>, CHRISTOPH GENSTER<sup>2</sup>, CAREN HAGNER<sup>1</sup>, DANIEL HARTWIG<sup>1</sup>, •SEBASTIAN LORENZ<sup>3</sup>, DAVID MEYHÖFER<sup>1</sup>, BJÖRN OPITZ<sup>1</sup>, HENNING REBBER<sup>1</sup>, MICHAELA SCHEVER<sup>2</sup>, HAUKE SCHMIDT<sup>1</sup>, ALEXANDER TIETZSCH<sup>4</sup>, KATHARINA VOSS<sup>1</sup>, BJÖRN WONSAK<sup>1</sup>, and MICHAEL WURM<sup>3</sup> — <sup>1</sup>Univ. Hamburg, Inst. für Experimentalphysik — <sup>2</sup>Forschungszentrum Jülich, Inst. für Kernphysik — <sup>3</sup>Johannes Gutenberg-Univ. Mainz, Inst. für Physik — <sup>4</sup>Eberhard Karls Univ. Tübingen, Physikalisches Inst.

The precise reconstruction of charged particle tracks in unsegmented liquid scintillator (LSc) neutrino detectors, e.g., from muons, is an important prerequisite for the efficient rejection of cosmogenic background events or the analysis of multi-GeV neutrino interactions. Topological information on such events, i.e., the reconstructed 3D density distribution of isotropically emitted scintillation photons, opens up new ways to accomplish these tasks. Especially future multi-kiloton LSc detectors will profit from improved (muon) track reconstruction possibilities, both regarding their low- and high-energy neutrino physics programs. Connected to the international JUNO project in China, a topological track reconstruction method for unsegmented LSc detectors is developed in Germany. Its application to simulated muon

events already showed that the particle's differential energy loss  $dE/dx$  is accessible. This talk summarizes recent developments and the current status of the reconstruction method.

T 80.3 Mi 17:25 H 2

**Status of the PALM Experiment for JUNO** — ●SABRINA PRUMMER<sup>1</sup>, JULIA SAWATZKI<sup>1</sup>, LOTHAR OBERAUER<sup>1</sup>, ANDREAS ULRICH<sup>2</sup>, HANS STEIGER<sup>1</sup>, MARIO SCHWARZ<sup>1</sup>, and PHILIPP LANDGRAF<sup>1</sup> — <sup>1</sup>TU München, E15, Physik-Dep, Garching — <sup>2</sup>TU München, E12, Physik-Dep, Garching

Status Update of the Precision Attenuation Length Measurement Setup

The planned JUNO detector is a 20kt liquid scintillator neutrino detector. Its primary goal is the determination of the neutrino mass hierarchy. This will be done by precision measurements of the reactor antineutrino survival probability. Due to the spherical detector's diameter of approx. 35.5 m, the optical parameters, especially the attenuation length, of the scintillator have to be known precisely and have to be very good to achieve the required energy resolution of 3%@1MeV. To determine one of the crucial optical parameters, the attenuation length, a new spectrometer experiment, called PALM, was built. Unless the commercially available spectrometers with light paths up to 10 cm, this spectrometer is able to measure light paths up to 2.8 m through the medium, making it possible to determine the attenuation length very precisely. This talk will give a status update on the commissioned PALM setup. This work is supported by the DFG cluster of excellence "Origin and Structure of the Universe" ([www.universe-cluster.de](http://www.universe-cluster.de)), the DFG research unit "JUNO" and the Maier-Leibniz-Laboratorium.

T 80.4 Mi 17:40 H 2

**Studies on muon track reconstruction with the JUNO liquid scintillator neutrino detector** — ●CHRISTOPH GENSTER and LIVIA LUDHOVA — Forschungszentrum Juelich, IKP-2

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kt liquid scintillator detector. Its main goal is the determination of the neutrino mass hierarchy with neutrinos from two nuclear power plants at 53 km baseline. Fast and effective muon tracking is essential for the veto of atmospheric muons and the detection of atmospheric muon neutrinos. An expected muon rate of 3 / second inside the detector makes a partial veto of volume along the track mandatory. To achieve this, JUNO features an outer water Cherenkov detector around its liquid scintillator central detector. Due to the isotropic emission of light, tracking in liquid scintillator is more difficult than in water. Results for muon tracking in those two subdetectors of JUNO are presented.

T 80.5 Mi 17:55 H 2

**Topological track reconstruction for Borexino** — ●BJÖRN OPITZ<sup>1</sup>, BJÖRN WONSAK<sup>1</sup>, DANIEL BICK<sup>1</sup>, SEBASTIAN LORENZ<sup>2</sup>, and MICHAEL WURM<sup>2</sup> — <sup>1</sup>Universität Hamburg, Institut für Experimentalphysik — <sup>2</sup>Johannes Gutenberg-Universität Mainz, Institut für Physik

In unsegmented liquid scintillator detectors like Borexino, signal and background events are recorded by measuring the scintillation light from charged particle interactions in the detector volume. A novel event reconstruction technique, currently being developed at several German institutes, allows an improved reconstruction of track topologies within the detector (see the overview talk by Sebastian Lorenz, Uni Mainz). In particular, particle showers induced by cosmic muons can be identified and analyzed. Up to now, the method has been implemented and used for Monte Carlo studies concerning the planned experiments LENA and JUNO. Adopting the reconstruction technique for Borexino allows the use of real data and a comparison with standard reconstruction methods for both neutrino and muon events. The current status of the implementation is presented.

T 80.6 Mi 18:10 H 2

**Improvement of Position Reconstruction in Borexino** — ●JOHANN MARTYN for the Borexino-Collaboration — Johannes Gutenberg-Universität Mainz

Borexino is measuring neutrinos through scintillation events in the

target volume, which are intrinsically undistinguishable from the radioactive background. Using time of flight of the scintillation light to reconstruct the position of the events it is possible to construct a fiducial volume which greatly suppresses the gamma background. Currently the neutrino interaction point in the Borexino detector is reconstructed with an uncertainty of 15cm at 1 MeV and shows systematic shifts at the edge of the detector. For the Borexino experiment this behaviour can be handled by using a fiducial volume, but for the upcoming search for sterile neutrinos in Borexino (SOX) it is important to use a maximal volume and thus to understand the systematic shifts close to the detector edge and if possible remove them and it is useful to have a position reconstruction as good as possible. This talk will present the improvements on the current position reconstruction algorithm of Borexino and describe the systematic shifts and their handling.

T 80.7 Mi 18:25 H 2

**Borexino Detector Studies with Background Components** — ●STEFAN WEINZ for the Borexino-Collaboration — Universität Mainz

The SOX experiment searches for sterile neutrinos by placing a radioactive  $\bar{\nu}_e$  source below the Borexino detector. Oscillations of active to sterile neutrinos are identified by a disappearance pattern of  $\bar{\nu}_e$  events within the detection volume. Sensitivity can be increased by enlarging the detection volume as much as possible towards the border of the inner vessel that holds the liquid scintillator. Here, light collection is deteriorating and spill-out effects of  $\gamma$ 's into the passive buffer region distort energy and spatial reconstruction.

This talk presents strategies for characterising this peripheral detector region by employing well-defined background events. For this data-driven approach cosmogenic neutron captures on hydrogen and  $\alpha$  decays of <sup>210</sup> are used, since both are mono-energetic events which allow for the energy response studies. Furthermore cosmogenic neutrons are useful messengers for detector response studies due to their isotropical distribution.

T 80.8 Mi 18:40 H 2

**Data Selection in the SOX experiment** — ●BIRGIT NEUMAIR for the Borexino-Collaboration — James-Franck-Straße 1, 85748 Garching bei München

In the last years, several neutrino oscillation experiments reported results not compatible within the 3-neutrino model, which hint at the existence of light sterile neutrinos. To test this hypothesis, the SOX (Short distance neutrino Oscillations in BoreXino) experiment will search for oscillations from active to sterile neutrinos by placing a (100-150) kCi <sup>144</sup>Ce -  $\bar{\nu}_e$  - source underneath the liquid scintillator detector Borexino. Oscillations will be observed via a reduction of the detected interaction rate of the  $\bar{\nu}_e$  and an oscillatory pattern as a function of the neutrino energy and travelled distance. In the talk the data selection will be presented.

The work is supported by the DFG cluster of excellence "Origin and Structure of the Universe".

T 80.9 Mi 18:55 H 2

**Vertex reconstruction in unsegmented liquid scintillator detectors** — CAREN HAGNER<sup>1</sup>, SEBASTIAN LORENZ<sup>2</sup>, ●DAVID MEYHÖFER<sup>1</sup>, HENNING REBBER<sup>1</sup>, and BJÖRN WONSAK<sup>1</sup> — <sup>1</sup>Univ. Hamburg, Inst. für Experimentalphysik — <sup>2</sup>Forschungszentrum Jülich, Inst. für Kernphysik

Large unsegmented liquid scintillator detectors play a key role in modern neutrino physics. Event start time and position are essential parameters for the MeV energy range and usually are determined with a vertex reconstruction. On the other hand, for events in the GeV range, vertex reconstructions have been neglected. But in the case of more sophisticated high energy track reconstructions a vertex determination can provide important initial parameters.

In this talk a vertex reconstruction applicable for MeV events and GeV events will be introduced. It was developed for the LENA detector, but can be used with any unsegmented liquid scintillator detector and no prior knowledge of the event is needed. The basic idea of this vertex reconstruction and preliminary results will be discussed.



## T 81: Neutrinophysik 7 (Doppelbetazerfall, sterile Neutrinos)

Zeit: Mittwoch 16:45–19:10

Raum: VSH 118

**Gruppenbericht**

T 81.1 Mi 16:45 VSH 118

**Background free search for neutrinoless double beta decay with GERDA Phase II** — ●CHRISTOPH WIESINGER for the GERDA-Collaboration — Physik-Department and Excellence Cluster Universe, Technische Universität München, James-Frank-Straße, 85748 Garching

An observation of neutrinoless double beta decay would allow to shed light onto the nature of neutrinos. GERDA (GERmanium Detector Array) is operating isotopically enriched high purity germanium detectors bare in liquid argon and is aiming to perform a background-free search for this process in  $^{76}\text{Ge}$ . A signal would manifest in a monoenergetic peak in the summed electron spectrum. GERDA is located at the Laboratori Nazionali del Gran Sasso (LNGS) of INFN in Italy and follows a staged approach. In Phase II 35.6 kg of enriched germanium detectors are operated. The application of active background rejection methods, such as a liquid argon scintillation light read-out and pulse shape discrimination of germanium detector signals, allowed to reduce the background index to the intended level of  $10^{-3}$  cts/(keV·kg·yr). In the first five month 10.8 kg·yr of exposure were accumulated. No signal has been found and together with data from Phase I a new limit for the neutrinoless double beta decay half-life of  $^{76}\text{Ge}$  of  $5.3 \cdot 10^{25}$  yr at 90% C.L. was established in June 2016. Phase II data taking is ongoing and will allow the exploration of half-lives in the  $10^{26}$  yr regime. The current status of the blinded data taking and an update on the background index will be presented. This work was partly funded by BMBF.

T 81.2 Mi 17:05 VSH 118

**Monte Carlo Geometry of GERDA Phase II** — ●JANINA HAKENMÜLLER for the GERDA-Collaboration — Max-Planck-Institut für Kernphysik (MPIK), Saupfercheckweg 1, 69117 Heidelberg, Germany

The GERDA experiment is looking for neutrinoless double beta decay in Germanium. GERDA Phase II consists of 40 germanium diodes enriched in  $^{76}\text{Ge}$  and operated in liquid argon. The setup is equipped with a liquid argon veto, meaning a light instrumentation registers energy depositions of background sources in liquid argon.

The geometry of the GERDA setup is implemented into a Monte Carlo (MC) simulation in MaGe, based on Geant4. It is used e.g. to simulate spectra of possible contaminations for the background model. For GERDA Phase II analysis this geometry has been updated to the current 7 string setup and will be shown in the talk. To check the accuracy of this implementation, a weekly calibration run with 3  $^{228}\text{Th}$  sources has been simulated. After a necessary optimization of the source positions a good agreement between MC and data was found for the integral count rate as well as the spectral shape.

Moreover, in the MC output of the simulations of the background contributions also the energy depositions in liquid argon are registered. By doing a cut on these energy depositions it can be tried to approximate the effect of the veto suppression in the MC. This comparison as well as the MC to data comparison of the  $^{228}\text{Th}$  calibration will be presented in the talk.

T 81.3 Mi 17:20 VSH 118

**Characterization of a segmented broad energy prototype Germanium detector** — ALLEN CALDWELL, IRIS ABT, BELA MAJOROVITS, ●XIANG LIU, CHRIS GOOCH, MARTIN SCHUSTER, and JINGLU MA — Max Planck Institut fuer Physik, Muenchen

High purity Germanium detector (HPGe) has been playing an important role in fundamental research, especially in the searches for neutrinoless double beta decay in  $\text{Ge}^{76}$  (GERDA, Majorana) and WIMP dark matter candidate (CDEX, CoGeNT). In both cases, background identification and reduction is very important and extremely challenging. A four-fold segmented broad energy (BEGe) prototype HPGe detector, SegBEGe, was designed at the Max Planck Institut fuer Physik (MPI) in Munich and fabricated at Canberra Lingolsheim (now Mirion Technologies (Canberra) SAS). Results from the characterization of this prototype SegBEGe are presented. Similar to a standard BEGe detector, it provides the information to distinguish so-called single-site and multi-site events through a standard pulse shape analysis. In addition, the mirror pulses recorded in segments without energy deposition make it possible to locate the energy deposition in the segment in between with a precision of up to mm. This could contribute to

background identification for the future ton-scale Germanium detector experiment.

**Gruppenbericht**

T 81.4 Mi 17:35 VSH 118

**Search for keV mass sterile neutrinos with the KATRIN experiment** — ●TOBIAS BODE for the KATRIN-Collaboration — Max-Planck-Institut für Physik, Munich, Germany

Sterile neutrino are a well-motivated extension of the Standard Model of Particle Physics. They are experimentally accessible via the mixing with the known active neutrinos.

A sterile neutrino with a mass of  $\mathcal{O}(\text{keV})$  is a promising dark matter candidate possibly solving the too big to fail and the cusp vs core problem. In addition to astrophysical searches by X-ray telescopes, several laboratory measurement have been proposed. One is the TRISTAN project pursued in the framework of KATRIN. The KATRIN (KArlsruhe TRitium Neutrino) experiment investigates the energy endpoint of the tritium beta-decay to determine the effective mass of the electron anti-neutrino with a precision of 200 meV (90% C.L.) after an effective data taking time of three years.

The signature of a sterile neutrino would be a kink-like structure in the tritium beta-decay spectrum originating from the mixing with the active neutrino states.

The TRISTAN project will proceed in two phases. Phase-0 will use the standard KATRIN setup. Whereas Phase-I will use a greatly improved detector system which will reduce systematics and allow a high count rate, increasing statistics. An overview of the two measurement phases and the respective experimental sensitivities will be given.

T 81.5 Mi 17:55 VSH 118

**Silicon drift detector prototypes for the keV-scale sterile neutrino search with TRISTAN** — ●KONRAD ALTENMÜLLER<sup>1,2</sup>, TOBIAS BODE<sup>3</sup>, OLIVIER GEVIN<sup>2</sup>, MARC KORZECZEK<sup>4</sup>, THIERRY LASSERRE<sup>2,5</sup>, OLIVIER LIMOUSIN<sup>2</sup>, DANIEL MAIER<sup>2</sup>, SUSANNE MERTENS<sup>3</sup>, and MARTIN SLEZAK<sup>3</sup> — <sup>1</sup>Physik Department, Technische Universität München — <sup>2</sup>CEA Saclay / IRFU, France — <sup>3</sup>Max-Planck-Institut für Physik, München — <sup>4</sup>IEKP, Karlsruher Institut für Technologie — <sup>5</sup>IAS, Technische Universität München

The TRISTAN project is an upgrade of the KATRIN experiment to search for the signature of keV-scale sterile neutrinos in the electron spectrum of tritium. Since the detector in the KATRIN setup is designed to count electrons within a controlled energy range rather than to do electron spectroscopy, a new detector and read-out system are needed. An array of up to 10 000 silicon drift detectors could meet the requirements of a few hundreds eV energy resolution and ultra-low electronics noise while handling a high electron flux at the same time. Prototypes of 7-pixel arrays with 20-30 nm deadlayer were produced in different designs by MPG Halbleiterlabor. In this talk the results of the characterization with a proven multichannel ASIC (IDeF-X by CEA), originally developed for spaceborne applications, and with an ultra-low noise ASIC by XGLab are presented; the achieved energy resolution, noise performance, and charge sharing characteristics are reported. Also the analysis methods and consequences for the final TRISTAN setup are discussed.

T 81.6 Mi 18:10 VSH 118

**Characterization of the detector dead layer for a sterile neutrino search with KATRIN** — ●TIM BRUNST for the KATRIN-Collaboration — Max-Planck-Institut für Physik, Munich, Germany

The KATRIN (Karlsruhe Tritium Neutrino) experiment investigates the energy endpoint of the tritium beta-decay to determine the effective mass of the electron anti-neutrino with a precision of 200 meV (@90CL) after an effective data taking time of three years.

The TRISTAN (Tritium Beta Decay to Search for Sterile Neutrinos) group aims to detect a sterile neutrino signature by measuring the entire tritium beta decay spectrum with an upgraded KATRIN system. One of the greatest challenges is to measure all electron energies in the decay spectrum up to the endpoint at 18.6 keV with a resolution  $< 300$  eV (FWHM). Since systematic effects (e.g. detector backscattering) lead to drastic modifications of the measured energy spectrum, a thin dead layer ( $< 30\text{nm}$ ) at the entrance window of the detector is crucial for achieving high sterile neutrino sensitivities. Several prototype detectors have been manufactured at the Halbleiterlabor of the

Max-Planck-Society in Munich. The dead layer thickness will be determined by a combined analysis of simulated and measured data with dedicated proton and electron sources.

This talk gives first simulation results and an overview of the planned experimental implementation of the dead layer characterization.

T 81.7 Mi 18:25 VSH 118

**Backscattering on the KATRIN rear wall as a systematic effect for a keV sterile neutrino search** — ●ELLEN FÖRSTNER for the KATRIN-Collaboration — KIT

The main goal of the Karlsruhe Tritium Neutrino experiment (KATRIN) is the determination of the effective electron anti-neutrino mass. The TRISTAN project of KATRIN focuses on a possible upgrade of KATRIN that would allow the search for sterile neutrinos up to the keV mass range. A keV-scale sterile neutrino would imprint itself as a kink-like distortion of the tritium beta decay spectrum. This signature is extremely small and therefore a very precise understanding of the theoretical and experimental systematic effects is necessary.

One systematic effect is caused by backscattering of beta-decay electrons on the gold rear wall of the KATRIN-setup. Backscattering of electrons causes an energy and angle change and hence significantly distorts the tritium beta decay spectrum.

The effect can be mitigated by the following countermeasures: 1) reduced magnetic field at the rear wall, 2) low-Z rear wall materials, 3) reduced tritium source strength. Using Kassiopeia and Geant4 Monte-Carlo simulations the influence of the rear wall on a keV-scale sterile neutrino search with KATRIN has been investigated and an optimized rear wall design has been developed. In this talk, the systematic effects related to the rear wall and the new mitigation techniques will be presented.

This work has been supported by BMBF (05A14VK2), KSETA and the Helmholtz Association.

T 81.8 Mi 18:40 VSH 118

**Impacts of magnetic traps in the source section of KATRIN on a sterile neutrino search** — ●FELIX KNAPP for the KATRIN-Collaboration — Karlsruhe Institute of Technology (KIT)

The main goal of the Karlsruhe Tritium Neutrino Experiment is the

determination of the effective electron neutrino mass by measuring the endpoint of the energy spectrum of tritium beta decay electrons. With the search for a sterile neutrino in the keV-mass regime, the physical reach of the experiment can be extended. A sterile keV-scale sterile neutrino would imprint itself as a kink-like distortion of the tritium beta decay spectrum. However, this signature is of a very small value and therefore a very precise understanding of systematic effects is necessary. One effect is the appearance of magnetic traps in the KATRIN source. The electrons start in the windowless gaseous tritium source at a magnetic field of 450 Gs. This field is however not completely homogeneous. Local field minima create magnetic traps for electrons starting with a large pitch angle. All trapped electrons will eventually escape via two mechanisms: 1) Due to the high gradient of the magnetic field in a trap the guidance of an electron along the field lines is not fully adiabatic, resulting in chaotic angle changes, allowing the electron to escape. 2) The electrons can scatter with tritium molecules. Hereby also their angle can be changed and the electron is able to escape. Escaped electrons, that reach the detector would distort the spectral shape and hence impact the sensitivity of a sterile neutrino search. This Talk gives an insight on this systematic effect and its impact on the sensitivity of KATRIN to a sterile neutrino in the keV-mass range.

T 81.9 Mi 18:55 VSH 118

**Search for sterile neutrinos with IceCube DeepCore** — ●ANDRII TERLIUK for the IceCube-Collaboration — DESY, Platanenallee 6, 15738 Zeuthen, Germany

Sterile neutrinos are a hypothetical neutrino species that could explain the tension between some accelerator, reactor and radiochemical neutrino experiments. They have no standard weak interactions. However, they can mix with the three standard neutrinos, resulting in a modification of the characteristic pattern of atmospheric neutrino oscillations. DeepCore is a densely instrumented region in the center of the IceCube Neutrino Observatory that has an energy threshold for neutrino detection about 10 GeV. We present the results of a search for an eV-scale sterile neutrino signal in the atmospheric neutrino oscillation pattern using three years of low-energy DeepCore data taken between 2011 and 2014.

## T 82: Neutrinoastronomie 3

Zeit: Mittwoch 16:45–18:50

Raum: H 1

### Gruppenbericht

T 82.1 Mi 16:45 H 1

**KM3NeT - Status und Perspektiven** — ●STEFAN GEISSELSÖDER für die ANTARES-KM3NeT-Erlangen-Kollaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg — ECAP

KM3NeT ist eine im Aufbau befindliche Forschungsinfrastruktur am Grund des Mittelmeeres. Die Hauptziele des Projekts, die Erforschung des Kosmos mit und der Eigenschaften von Neutrinos, werden mithilfe von zwei technisch identischen Wasser-Cherenkov-Detektoren ermöglicht. KM3NeT/ARCA, mit einem instrumentierten Volumen von etwa einem Kubikkilometer, wird gegenwärtig vor der Küste Siziliens in einer Wassertiefe von 3500m aufgebaut. Der Detektor wurde optimiert um die Quellen des Flusses hochenergetischer kosmischer Neutrinos zu entdecken, dessen Existenz inzwischen von IceCube nachgewiesen wurde. Dieselbe Technologie wird von KM3NeT/ORCA genutzt, welches vor der französischen Küste in einer Wassertiefe von 2500m aufgebaut wird. Durch Auswerten der energie- und zenitwinkelabhängigen Oszillationswahrscheinlichkeit niederenergetischer atmosphärischer Neutrinos soll die Massenhierarchie bestimmt und damit eine der wichtigsten offenen Fragen der Neutrinophysik beantwortet werden.

Der Vortrag gibt einen Überblick über den gegenwärtigen Status des Aufbaus, der bereits angelaufenen Datennahme sowie einen Ausblick auf einige der Analysen, die durch dieses Projekt in naher Zukunft ermöglicht werden. Der Fokus liegt auf den vielfältigen Beteiligungen der ECAP-Neutrinogruppe.

T 82.2 Mi 17:05 H 1

**Resolving the muon flux in KM3NeT/ARCA** — ●TIM STÜVEN for the ANTARES-KM3NeT-Erlangen-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

KM3NeT is an extensive undersea research infrastructure currently in Phase 1 of construction. KM3NeT/ARCA will be the instrument dedi-

cated to high-energy neutrino astronomy in Phase 2.0, and will consist of two 'blocks' at the KM3NeT Italy site off the coast of Sicily. The major goal of ARCA will be to study the origin of the high-energy astrophysical flux detected by IceCube.

The greatest fraction of events detected by ARCA will be down-going muons from the interactions of cosmic rays in the Earth's atmosphere. In addition, the conventional and prompt atmospheric neutrino flux, and the astrophysical flux, will generate incoming muons from all directions, with different energy dependencies. Studies aiming to identify the flavour composition of the astrophysical flux, and/or the magnitude of the prompt contribution, will need to simultaneously fit all these contributions. This talk will present the results of simulations of the muon flux expected at ARCA, and discuss in which regimes – of energy and direction – these contributions may be disentangled.

T 82.3 Mi 17:20 H 1

**Stacking point source search of low energy contribution at the HESE track positons** — ●THORBEN MENNE for the IceCube-Collaboration — TU Dortmund

The IceCube detector is a cubic kilometer sized neutrino telescope located at the South Pole. One main goal is to observe neutrinos originating from a single or multiple sources in the sky. Despite the discovery of multiple neutrinos of astrophysical origin no significant source of these high energy events has been found in a point source follow-up analysis yet. Also no significant clustering of lower energy neutrinos at a single point has been found in a search with 7 years of IceCube data. This analysis aims to find a signal from lower energy neutrinos originating from the positions of HESE track events with a stacking method. It is searched for combined spatial clustering of lower energy events at those source locations. The usual stacking likelihood approach is used which combines signal from all source positions. Because the HESE events and thus the source positions have a positional uncertainty due

to event reconstruction a slight modification in the fitting procedure is used. The positions are not kept fixed but are allowed to vary, using the full sky reconstruction likelihood landscape for each event as a prior to constrain the source positions around their original best fits.

T 82.4 Mi 17:35 H 1

**Search for neutrino point sources with an all-sky autocorrelation analysis in IceCube** — ●ANDREA TURCATI, STEFAN COENDERS, and ANNA BERNHARD for the IceCube-Collaboration — TUM, Munich, Germany

The IceCube Neutrino Observatory is a cubic kilometre scale neutrino telescope located in the Antarctic ice. Its full-sky field of view gives unique opportunities to study the neutrino emission from the Galactic and extragalactic sky. Recently, IceCube found the first signal of astrophysical neutrinos with energies up to the PeV scale, but the origin of these particles still remains unresolved. Given the observed flux, the absence of observations of bright point-sources is explainable with the presence of numerous weak sources. This scenario can be tested using autocorrelation methods. We present here the results of a two-point angular correlation analysis performed on seven years of IceCube data, taken between 2008 and 2015. The test is applied on the northern and southern skies separately, using the neutrino energy information to improve the effectiveness of the method. A dedicated additional analysis is also performed on the Cygnus Region: an active and massive star-forming complex situated in our galaxy.

T 82.5 Mi 17:50 H 1

**Search for High Energy Astrophysical Tau Neutrinos with IceCube** — ●MAXIMILIAN MEIER and MATHIS BÖRNER for the IceCube-Collaboration — TU Dortmund, Dortmund, Deutschland

The IceCube Neutrino Observatory at the South Pole is a Cherenkov detector designed to measure astrophysical neutrinos of all flavors. High energy tau neutrinos interacting inside the detector produce two cascades separated by the tau lepton decay length. At energies above 100 TeV the spatial separation can be resolved within the waveform of one IceCube optical module and identified as a double pulse signature. This work aims to select events with a cascade-like topology that contain at least one double pulse signature.

T 82.6 Mi 18:05 H 1

**Search for High-Energy Tau Neutrino Interactions in IceCube** — ●JULIANA STACHURSKA for the IceCube-Collaboration — DESY Zeuthen

The IceCube Neutrino Observatory at the South Pole detects Cherenkov light from charged particles produced in neutrino interactions. At the highest energies, the neutrino flux is of cosmic origin, with an expected flavor ratio of  $\nu_e:\nu_\mu:\nu_\tau$  of 1:1:1, but its astrophysical

sources are yet unknown. A measurement of the flavor ratio on Earth can provide important information to constrain sources and production mechanisms. But as of today, no high energy tau neutrino interaction has been identified in the IceCube data, leaving the  $\nu_\tau$  fraction of the cosmic neutrino flux largely unconstrained. This work aims at identifying high-energy tau neutrino interactions creating tau leptons with a mean decay length of 50m per PeV neutrino energy. Above energies of  $\sim 100$  TeV they produce a unique Double Bang signature with two cascades from the neutrino interaction and the subsequent tau decay that are potentially resolvable in IceCube.

T 82.7 Mi 18:20 H 1

**Measurement of atmospheric anti-neutrino/neutrino-ratio with Icecube** — ●DAVID KAPPESSER, SEBASTIAN BÖSER, GERALD KRÜCKEL, and LUTZ KÖPKE for the IceCube-Collaboration — Johannes Gutenberg-Universität, Mainz, Deutschland

Models on atmospheric neutrino flux suffer from a uncertainty of about 20% from modeling hadronic interactions. It is therefore interesting to measure parameters that may constrain this. Cherenkov detectors like IceCube in general can not differentiate between particles and antiparticles. However for charged current interactions where hadronic cascade and a sufficient fraction of the created leptons energy is contained, it is possible to measure the inelasticity from the energy deposition along the track. Particles and antiparticles experience different quark density functions in the nucleus, the cross section as a function of inelasticity differs. Selecting a pure sample of sufficiently contained events and fitting the Monte-Carlo event rate as a function of inelasticity to the data allows measuring the neutrino-antineutrino ratio.

T 82.8 Mi 18:35 H 1

**Neutrino mass determination using extragalactic supernovae** — ●MAIKE JUNG and SEBASTIAN BÖSER for the IceCube-Collaboration — JGU Mainz, Mainz, Germany

MICA, the Megaton Ice Cherenkov Array, is a hypothetical low energy extension for IceCube. With optimized optical modules and a much higher instrumentation density MICA could detect neutrinos down to an energy of 10 MeV, allowing the trigger on supernovae (SN) up to a distance of 10 Mpc. This will enable the observation of up to 1-4 SN per year, a significant improvement to the 1 per century rate of IceCube. Due to the mass of the neutrinos a time delay, especially of the lower energetic neutrinos, is expected. This causes a specific shift in the arrival time spectrum of these SN-neutrinos that also depends on the distance to the SN. This effect is more prominent the further away the detected SN, therefore the limits obtained from extragalactic SN detection with MICA will be a significant improvement to those from SN1987A. I present simulation results on how accurate the neutrino mass can be determined.

## T 83: Kosmische Strahlung 6

Zeit: Mittwoch 16:45–19:05

Raum: H 3

### Gruppenbericht

T 83.1 Mi 16:45 H 3

**Anisotropies in galactic cosmic rays with AMS-02** — ●IRIS GEBAUER, STEFAN ZEISSLER, MATTHIAS WEINREUTER, MAURA GRAZIANI, and FABIAN BINDEL — Karlsruher Institut für Technologie  
The Alpha Magnetic Spectrometer (AMS-02) on the International Space Station measures the fluxes of cosmic rays up to energies of a few TeV. A search for anisotropies in the arrival directions of protons, electrons and positrons was performed. The results are consistent with isotropy and no significant time dependence in the arrival directions of cosmic rays are observed. This talk will discuss the latest results from AMS-02 and their implications.

T 83.2 Mi 17:05 H 3

**Correlation between arrival directions and sources of cosmic ray positrons (AMS-02)** — ●MATTHIAS WEINREUTER and IRIS GEBAUER — KIT, Karlsruhe

Since the high-precision measurement of the cosmic ray positron component was published in 2014, the astrophysical community has yet to agree on the source of the positron population at kinetic energies above a few GeV. The two most popular explanations assume either an astrophysical acceleration mechanism around pulsar magnetospheres, or understand these positrons as a product of dark matter annihilation

processes; and it is currently believed that a clear distinction can be made by the analysis of the dipole anisotropy in positron flux. In particular, it is currently assumed that the pulsar hypothesis is falsifiable if the anisotropy of positrons relative to electrons lies below 1% (for energies 16 to 350 GeV). We demonstrate that the state of knowledge of close-by pulsars is sufficiently uncertain to construct various pulsar scenario explanations for the present AMS-02 measurement that show a significantly smaller degree of anisotropy. Moreover, the propagation of positrons throughout the local environment further increases the uncertainty in anisotropy prediction considerably.

T 83.3 Mi 17:20 H 3

**Cosmic ray anisotropy searches with AMS-02** — ●STEFAN ZEISSLER, IRIS GEBAUER, MAURA GRAZIANI, and FABIAN BINDEL — Karlsruher Institut für Technologie (KIT)

The Alpha Magnetic Spectrometer (AMS-02) is a state-of-the-art particle detector designed to operate as an external module on the International Space Station (ISS). In this unique space environment cosmic particles can be measured with high precision over an energy range from GeV up to TeV. The AMS collaboration provided precise measurements of the electron and positron fluxes, which indicate an additional source of positrons among the various cosmic particles. Possible

candidates for this source are local pulsars, a local source of positrons produced in proton-gas interactions or dark matter annihilation. In the first two cases a possible anisotropy in the electrons and positrons incoming direction at Earth might be detectable. To determine the level of isotropy the measured data is compared to reference maps, which simulate the measurement of an isotropic sky. A common choice of reference maps are proton count maps or shuffled maps, which redistribute measured incoming directions over the whole measuring time. Both choices lead to difficulties in the reconstruction of a marginal signal with a big expansion over the galactic sky as it would be the case for charged cosmic particles. We developed a method to construct reference maps based on fundamental detector characteristics such as the livetime and the geometric acceptance. Using this we are able to reconstruct the isotropic sky as it would be seen by the detector. We demonstrate the performance of the method using AMS-02 data.

T 83.4 Mi 17:35 H 3

**Antiproton Flux and Antiproton-to-Proton Flux Ratio Measured with the Alpha Magnetic Spectrometer on the ISS —**  
**•ANDREAS BACHLECHNER — RWTH Aachen University**

AMS-02 is a multi-purpose particle detector for cosmic rays onboard the International Space Station.

Due to the very small abundance of antiprotons in the cosmic radiation of about  $10^{-5}$  compared to protons a very precise particle identification is crucial. The methods to identify antiprotons in the cosmic-ray measurement of AMS-02 in different energy regions will be discussed.

The precision measurement of the antiproton flux by AMS-02 and the antiproton-to-proton flux ratio in primary cosmic rays in the absolute rigidity range from 1 to 450 GV based on  $3.49 \times 10^5$  antiproton events and  $2.42 \times 10^9$  proton events will be presented. The antiproton-to-proton flux ratio reaches a maximum at approximately 20 GV and is rigidity independent above 60.3 GV.

T 83.5 Mi 17:50 H 3

**Large Acceptance Analysis of Electrons and Positrons with AMS-02 —**  
**•FABIAN MACHATE — RWTH Aachen University, Deutschland**

The Alpha Magnetic Spectrometer (AMS-02) on the International Space Station performs precision measurements of cosmic rays in the GeV to TeV energy range. The published analyses of the electron and positron fluxes rely on the electromagnetic calorimeter (ECAL) for energy measurements and background rejection. The geometrical acceptance for the conventional analyses is restricted by the weight limitations for the calorimeter.

A new analysis procedure for electrons and positrons, which uses information from the Tracker to determine the energy scale and the Transition Radiation Detector (TRD) to reject the background, will be presented. This analysis increases the geometrical acceptance by a factor of  $\sim 6$ .

T 83.6 Mi 18:05 H 3

**Electron and Positron Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the International Space Station —**  
**•NIKOLAS ZIMMERMANN — RWTH Aachen University**

Precision measurements by the Alpha Magnetic Spectrometer on the International Space Station of the primary cosmic-ray electron flux in the range 0.5 to 700 GeV and the positron flux in the range 0.5 to 500 GeV are presented. The electron flux and the positron flux each require a description beyond a single power-law spectrum. Both the electron flux and the positron flux change their behavior at  $\sim 30$  GeV but the fluxes are significantly different in their magnitude and energy dependence. Between 20 and 200 GeV the positron spectral index is significantly harder than the electron spectral index. The results show, for the first time, that neither  $e^+$  nor  $e^-$  can be described by a single power law above 27.2 and 52.3 GeV, respectively. The determi-

nation of the differing behavior of the spectral indices versus energy is a new observation and provides important information on the origins of cosmic-ray electrons and positrons. The time dependence of the electron and positron fluxes will also be discussed.

T 83.7 Mi 18:20 H 3

**Verlängerte Messzeit für Fluoreszenzteleskope —**  
**•JOACHIM DEBATIN, MICHAEL UNGER, RALPH ENGEL und RADOMIR SMIDA für die Pierre Auger-Kollaboration — Institut für Kernphysik (IKP), Karlsruher Institut für Technologie (KIT), Karlsruhe, Deutschland**

Fluoreszenzteleskope werden benutzt um Luftschauder kosmischer Strahlung zu messen. Sie verbinden eine kalorimetrische Messung der Energie im Luftschauder mit der Möglichkeit die longitudinale Schauerentwicklung zu studieren. Fluoreszenzteleskope werden von den beiden größten Luftschauderexperimenten, dem Pierre-Auger-Observatorium und Telescope Array, benutzt um ihren Oberflächendetektor zu kalibrieren.

Eine Einschränkung von Fluoreszenzteleskopen ist jedoch, dass nur in klaren, mondlosen Nächten gemessen werden kann. Daraus ergibt sich typischerweise ein Messzeitanteil von ungefähr 15 %. Jeder einzelne, bei höchster Energie mit Fluoreszenzteleskopen gemessene Luftschauder ist dabei sehr wichtig für die Energiekalibration. Am Pierre-Auger-Observatorium wird derzeit daran gearbeitet den Messzeitanteil der Fluoreszenzteleskope zu erhöhen. Während ein erhöhtes Hintergrundlicht für den Nachweis von Schauern oberhalb  $10^{19}$  eV unproblematisch ist, kann dieses jedoch eine vorzeitige Alterung der Kamera-PMTs bewirken. Deshalb wird bei höherem Untergrundlicht mit niedrigerer Hochspannung an der Kamera des Teleskops gemessen. Studien am KIT haben bereits gezeigt, dass dies ohne Schäden an den benutzten Photomultipliern möglich ist. In diesem Vortrag wird der Einfluss auf die Apertur des Fluoreszenzdetektors diskutiert.

T 83.8 Mi 18:35 H 3

**Characterisation of 64 channel SiPM arrays for the SiECA project —**  
**•MAX RENSCHLER<sup>2</sup>, FRANCESCA BISCONTI<sup>1</sup>, ANDREAS HAUNGS<sup>1</sup>, THOMAS HUBER<sup>2</sup>, ALEXANDER MENSHIKOV<sup>3</sup>, and WILLIAM PAINTER<sup>1</sup> for the JEM-EUSO-Collaboration — <sup>1</sup>Institut für Kernphysik (IKP), KIT — <sup>2</sup>Institut für experimentelle Kernphysik (IEKP), KIT — <sup>3</sup>Institut für Prozessdatenverarbeitung und Elektronik (IPE), KIT**

To investigate the possibility of replacing conventional Multi Anode Photomultiplier Tubes (MAPMTs) with Silicon Photomultipliers (SiPMs), the 'Silicon Elementary Cell Add-on' (SiECA) is at the moment under development and in its final steps. The aim of SiECA is the detection of UHECRs with SiPMs within the frame of the 'Extreme Universe Space Observatory' (EUSO) pathfinder experiment 'EUSO-Super Pressure Balloon'. In this context, 64 channel SiPM arrays of the newest series manufactured by Hamamatsu have been studied and characterized. The motivation, the idea and the current status of SiECA will be presented and the results of our work on characterizing the newest 64 channel SiPM arrays will be discussed. With the focus on these particular studies, the talk will also give a short overview of the status of JEM-EUSO in general and of its other pathfinder studies.

T 83.9 Mi 18:50 H 3

**Mini-KASCADE electronics miniaturization —**  
**•CHRISTIAN TESCH, GÜNTER QUAST, ANDREAS HAUNGS, HARALD SCHIELER und BERND HOFFMANN — KIT IKP, Karlsruhe, Deutschland**

Mini-KASCADE is the attempt to provide a high-quality, mobile small scintillator array to detect cosmic ray air showers. In my master thesis I am recycling scintillators from the KASCADE experiment for such a small modular detector array. The main goal is to replace the currently used DAQ-rack from the KASCADE era with small DAQ-cards. Focusing on miniaturization and reducing the data per event in the DAQ chain as early as possible, the data rate should be low enough to use a small single-board computer to exchange events between the detectors and the master node, which then handles the data analysis.

## T 84: Gittereichtheorie

Convenor: C. Bogner, P. Maierhöfer

Zeit: Mittwoch 16:45–19:00

Raum: VSH 11

T 84.1 Mi 16:45 VSH 11

**Non-perturbative improvement and renormalization of quark bilinears in lattice QCD with three flavours** — ●FABIAN JOSWIG<sup>1</sup>, JOCHEN HEITGER<sup>1</sup>, ANASTASSIOS VLADIKAS<sup>2</sup>, and CHRISTIAN WITTEMEIER<sup>1</sup> — <sup>1</sup>Institut für Theoretische Physik, Universität Münster, Wilhelm-Klemm-Str. 9, 48149 Münster, Germany — <sup>2</sup>INFN, Sezione di Tor Vergata, c/o Dipartimento di Fisica, Università di Roma Tor Vergata, Via della Ricerca Scientifica 1, I-00133 Rome, Italy

We report on calculations in lattice QCD with 3 flavours of Wilson-clover fermions and the tree-level Symanzik-improved gauge action, in order to non-perturbatively determine the improvement coefficient and the renormalization factor of the vector current. The improvement and renormalization conditions are derived from massive Ward identities, using Schrödinger functional boundary conditions, which also offer a method to extract the ratio of the scalar to pseudoscalar renormalization constants. Our computations are done along a line of constant physics with couplings corresponding to lattice spacings of about 0.09 fm and below, relevant for phenomenological applications.

T 84.2 Mi 17:00 VSH 11

**Applying the generalized eigenvalue method to extract masses and decay constants in the  $D_s$ -meson system** — BENOIT BLOSSIER<sup>1</sup>, JOCHEN HEITGER<sup>2</sup>, and ●MATTHIAS POST<sup>2</sup> — <sup>1</sup>Laboratoire de Physique Théorique, Bâtiment 210, Université Paris XI, F-91405 Orsay Cedex, France — <sup>2</sup>Institut für Theoretische Physik, Universität Münster, Wilhelm-Klemm-Str. 9, 48149 Münster, Germany

We discuss the application of the generalized eigenvalue problem to lattice QCD determinations of energies and matrix elements in the pseudoscalar and vector meson channel of the charm-strange meson system. The computations employ CLS  $N_f = 2$  ensembles with the Wilson gauge action,  $O(a)$  improved Wilson-clover fermions and lattice spacings of about 0.065 and 0.05 fm. To extract the ground state masses and decay constants and to investigate effects from excited states, our analysis involves enlarged bases of interpolating fields, e.g., matrices of cross correlators defined via different iterations of Gaussian smearing or including terms with covariant derivatives. These techniques are also expected to be useful for studies of the phenomenologically interesting charmonium system.

T 84.3 Mi 17:15 VSH 11

**Lattice Simulations of QCD-like Theories at Finite Density** — ●PHILIPP SCIOR<sup>1</sup>, LORENZ VON SMEKAL<sup>2</sup>, and BJÖRN WELLEGHAUSEN<sup>2</sup> — <sup>1</sup>Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster — <sup>2</sup>Institut für Theoretische Physik, Justus-Liebig-Universität Gießen

We study QCD-like theories at finite density. In particular we investigate the cold and dense regime of the phase diagram where we expect to find the Silverblaze property realized as Bose-Einstein-condensation of diquarks or a first order liquid-gas transition depending on the gauge group of the theory. Part of our results are derived in the limit of heavy quark masses by using a three-dimensional Polyakov loop theory. This theory can be derived from the full QCD-like theory by a combined strong coupling and hopping expansion.

T 84.4 Mi 17:30 VSH 11

**Light Bound States in  $\mathcal{N}=1$  SU(2) SUSY Yang-Mills Theory** — SAJID ALI<sup>1</sup>, GEORG BERGNER<sup>2</sup>, ●HENNING GERBER<sup>1</sup>, PIETRO GIUDICE<sup>1</sup>, SIMON KUBERSKI<sup>1</sup>, ISTVAN MONTVAY<sup>3</sup>, GERNOT MÜNSTER<sup>1</sup>, PHILIPP SCIOR<sup>1</sup>, and STEFANO PIEMONTE<sup>4</sup> — <sup>1</sup>Universität Münster — <sup>2</sup>Universität Jena — <sup>3</sup>DESY Hamburg — <sup>4</sup>Universität Regensburg

Supersymmetry has been investigated for more than forty years. However, the non-perturbative nature of supersymmetric field theories is still largely unknown.

We study non-perturbative properties of  $\mathcal{N}=1$  supersymmetric Yang-Mills theory (SYM) within the lattice field theory approach using Monte Carlo simulations. Similar to QCD, SYM is confining and contains strongly bound states.

Applying the variational method together with different smearing techniques we extract masses of the lightest bound states such as gluino-gluon, glueball and mesonic states. As these states should form

supermultiplets, this study allows to check whether SYM remains supersymmetric also on the quantum level.

T 84.5 Mi 17:45 VSH 11

**Ward identities in  $\mathcal{N} = 1$  supersymmetric SU(3) Yang-Mills theory on the lattice** — ●SAJID ALI<sup>1</sup>, GERNOT MÜNSTER<sup>1</sup>, ISTVAN MONTVAY<sup>2</sup>, GEORG BERGNER<sup>4</sup>, PIETRO GIUDICE<sup>1</sup>, HENNING GERBER<sup>1</sup>, and STEFANO PIEMONTE<sup>3</sup> — <sup>1</sup>Institut für Theoretische Physik, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 9 D-48149 Münster. — <sup>2</sup>Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, D-22603 Hamburg. — <sup>3</sup>Universität Regensburg, Institute for Theoretical Physics, D-93040 Regensburg. — <sup>4</sup>Theoretisch-Physikalisches Institut Friedrich-Schiller-Universität Jena Max-Wien-Platz 1

The introduction of space-time lattice as a regulator of path integral breaks symmetries associated with continuous space-time i.e. Poincare invariance and supersymmetry. Due to non-zero bare gluino mass in the supersymmetric Yang-Mills theory the chiral symmetry is also broken. Provided that there are no SUSY-anomalies the lattice form of Ward identities can be used, by imposing that their continuum form should be recovered when removing the lattice regulator, to obtain chiral limit where the theory is characterized by massless gluinos.

T 84.6 Mi 18:00 VSH 11

**Lattice studies of the charmonium spectrum** — ●STEFANO PIEMONTE — University of Regensburg

Many experiments have found evidence of charmonium-like states that do not fit into conventional models of quark-antiquark mesons. Non-perturbative insight provided by lattice simulations is required to fully understand the properties of those states. The computation of single and multiparticle correlators is the main challenge of the numerical investigation of unstable states on the lattice. The phase shift and the properties of the resonance are then extracted from the finite volume energy levels. We present our analysis based on the distillation method and preliminary results for the charmonium states near the threshold.

T 84.7 Mi 18:15 VSH 11

**Near threshold charmed-strange meson states** — ●ANTONIO COX — Universitätsstraße 31 93053 Regensburg Deutschland

Early theoretical studies and lattice simulations predicted the scalar and axial-vector  $D_s$  charmed-strange mesons to be broad states lying above the thresholds,  $DK$  and  $D^*K$  respectively. Experiments found narrow states  $D_{s0}^*$  (2317) and  $D_{s1}$  (2460) below threshold. We present lattice results of a high statistics  $N_f = 2$  study with a lattice spacing of approximately 0.071 fm, taking explicitly into account the thresholds by including four quark operators. We find a lowering of the meson's masses relative to the two quark operator results. Two pion masses of 290 and 150 MeV with multiple volumes up to 4.5 fm were employed. The volume dependence of the resulting spectrum is investigated according to Luescher's formula.

T 84.8 Mi 18:30 VSH 11

**$\eta$  and  $\eta'$  masses and decay constants from lattice QCD** — ●JAKOB SIMETH, GUNNAR BALI, and SARA COLLINS — Universität Regensburg, D-93040 Regensburg

We present preliminary results for the masses and decay constants of the  $\eta$  and  $\eta'$  mesons from ab initio lattice QCD simulations.

The analysis is performed using the CLS  $N_f = 2 + 1$  ensembles, which cover a wide range of quark masses, lattice spacings and volumes and approach the physical point along two trajectories, one keeping the trace of the quark masses fixed and the other at constant strange quark mass.

One of the major challenges in these calculations are the large statistical fluctuations due to disconnected quark loops. We tackle these by employing a combination of noise reduction techniques which are tuned to achieve the optimal noise reduction per cost.

T 84.9 Mi 18:45 VSH 11

**Faster process integration and event generation with WHIZARD** — ●WOLFGANG KILIAN<sup>1</sup>, THORSTEN OHL<sup>2</sup>, JÜRGEN REUTER<sup>3</sup>, and SIMON BRASS<sup>1</sup> — <sup>1</sup>Department Physik, University of

Siegen, D-57068 Siegen, Germany — <sup>2</sup>Institut für Theoretische Physik und Astrophysik, University of Würzburg, D-97074 Würzburg, Germany — <sup>3</sup>Theory Group, DESY Hamburg, D-22603 Hamburg, Germany

Monte Carlo generators are committed to keep up with the rising complexity of collider experiments. Collider energies rising to new levels

make the simulation of processes with an increasing number of final state particles more and more time-consuming.

We describe a parallelisation ansatz using first-principle strategies provided by OpenMP and MPI for the Monte Carlo generator WHIZARD and show the gained speed up of WHIZARD for 2 → 6 benchmarking processes.

## T 85: QCD (Theorie)

Convenor: S. Borowka, P. Marquard (QCD), A. Huss (EW)

Zeit: Mittwoch 16:45–18:45

Raum: VSH 10

T 85.1 Mi 16:45 VSH 10

**Automated Numerical Evaluation of Multi Loop Amplitudes** — ●STEPHAN JAHN — Max-Planck-Institut für Physik, München — Technische Universität München

Amplitude calculations at higher orders in perturbation theory are a key ingredient for the success of the LHC programme and future colliders. Fully automated one-loop calculations are state of the art nowadays, while multi-loop calculations still require a lot of hand work. We present recent developments in GoSAM and SecDEC towards automated two-loop calculations.

T 85.2 Mi 17:00 VSH 10

**Towards NLO QCD radiative corrections for the associated production of heavy quarks and vector bosons** — ●FELIX RICHARD ANGER, VASILY SOTNIKOV, and HARALD ITA — Physikalisches Institut, Universität Freiburg

The production of vector bosons in association with heavy quarks constitutes an irreducible background to many processes relevant for the ongoing physics programme at the LHC, for both SM measurements and BSM searches.

In order to provide NLO QCD radiative corrections to these processes, we employ the framework of numerical generalized unitarity, where loop amplitudes are constructed by combining on-shell tree amplitudes. The latter are generated using a Berends-Giele recursion. Rational terms are obtained using an adaptation of the D-dimensional numerical unitarity approach within dimensional regularisation. Here we report our recent progress with the implementation of this process class.

T 85.3 Mi 17:15 VSH 10

**Five-loop quark mass and field anomalous dimensions for a general gauge group** — ●PETER MARQUARD — DESY, Zeuthen

We present analytical five-loop results for the quark mass and quark field anomalous dimensions, for a general gauge group and in the  $\overline{MS}$  scheme. We confirm the values known for the gauge group SU(3) from an independent calculation, and find full agreement with results available from large- $N_f$  studies.

T 85.4 Mi 17:30 VSH 10

**NLO QCD corrections to ZH + jet production** — ●MICHAEL SCHÜSSLER<sup>1</sup>, ROBIN ROTH<sup>1</sup>, DIETER ZEPPENFELD<sup>1</sup> und FRANCISCO CAMPANARIO<sup>2</sup> — <sup>1</sup>ITP, Karlsruher Institut für Technologie, Karlsruhe, Deutschland — <sup>2</sup>IFIC, University of Valencia, Paterna, Spain

The ZH process is an important contributor to the production of Higgs bosons, especially when considering decays to bottom quarks. To suppress backgrounds, the boosted phase space region is of interest which gets sizable contributions from additional jet radiation.

We discuss a fully differential calculation of ZH + jet production including leptonic decays of the Z boson at NLO QCD and its implementation in the Monte Carlo program VBFNLO. Furthermore we take a look at anomalous couplings in the EW part of the cross section.

T 85.5 Mi 17:45 VSH 10

**Resummation Improved Rapidity Spectrum for Gluon Fusion Higgs Production** — ●JOHANNES MICHEL<sup>1,2</sup>, MARKUS EBERT<sup>2</sup>, ANNA KULESZA<sup>1</sup>, and FRANK TACKMANN<sup>2</sup> — <sup>1</sup>Institute for Theoretical Physics, WWU Münster, Wilhelm-Klemm-Straße 9, D-48149 Münster, Germany — <sup>2</sup>Theory Group, Deutsches Elektronen-Synchrotron (DESY), Notkestraße 85, D-22607 Hamburg, Germany

The rapidity spectrum for gluon fusion Higgs production is an impor-

tant observable in upcoming precision measurements at the LHC. It also enters measurements of the production cross section through the fiducial acceptance. On the theory side, perturbative corrections to the spectrum contain large logarithms that can be resummed to all orders. We show how their resummation can be performed by RG evolution in a SCET-based framework, leading to the currently most precise predictions for the Higgs rapidity spectrum. Our formalism also applies to other color-singlet production processes.

T 85.6 Mi 18:00 VSH 10

**Soft gluon resummation for associated production of a massive boson with a top-antitop quark pair** — ANNA KULESZA<sup>1</sup>, LESZEK MOTYKA<sup>2</sup>, ●DANIEL SCHWARTLÄNDER<sup>1</sup>, TOMASZ STEBEL<sup>2</sup>, and VINCENT THEEUWES<sup>3</sup> — <sup>1</sup>Institute for Theoretical Physics, WWU Münster, D-48149 Münster, Germany — <sup>2</sup>Institute of Physics, Jagellonian University, S. Łojasiewicza 11, 30-348 Kraków, Poland — <sup>3</sup>Department of Physics, SUNY Buffalo, 261 Fronczak Hall, Buffalo, NY 14260-1500, USA

The measurements of associated production of a vector or a scalar boson with a top-antitop quark pair provide an important test for the Standard Model at the LHC. In particular these are the key processes to measure the top quark properties. Furthermore they are very relevant in searches for new physics, both as being directly sensitive to it and as providing an important background. While NNLO calculations for this particular type of 2 to 3 processes are currently out of reach, a class of corrections beyond NLO can be taken into account with the help of resummation methods. In this talk we consider an application of soft gluon resummation in Mellin space to these processes at hadron colliders and discuss numerical predictions for the LHC.

T 85.7 Mi 18:15 VSH 10

**Soft interactions in Herwig** — ●PATRICK KIRCHGAESSER, STEFAN GIESEKE, and FRASHER LOSHAJ — Institute for Theoretical Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany

In this talk we present a completely new model for soft interactions in the event-generator Herwig 7. The model includes diffractive scattering and a new model for soft particle production. We explain the theoretical background and discuss the implementation of the model. After a quick outline of the tuning procedure we present numerous results. The new model resolves a number of shortcomings of the old model.

T 85.8 Mi 18:30 VSH 10

**Parton-Shower Effects in QCD-VVjj Production with Leptonic Decays** — ●CHRISTOPHE THEISS and MICHAEL RAUCH — ITP/KIT, Karlsruhe, Deutschland

The production of vector bosons plus two jets is an important signature at the LHC. QCD Production, i.e. at  $\mathcal{O}(\alpha_s^2)$ , is the leading contribution to these processes. Also when studying electroweak production via vector-boson fusion (VBF), the corresponding QCD process is the main background and yields sizable contributions even after placing typical VBF cuts. Therefore, precise predictions for these processes are necessary.

In this talk, we present the combination of NLO QCD results with parton showers for VVjj processes, including leptonic decays as well as off-shell and non-resonant contributions. To that end, we have extended the NLO QCD implementation in VBFNLO to provide an interface to parton showers via the Binoth Les Houches Accord. We discuss some details of the implementation and show results when combining with the Herwig 7 event generator.

## T 86: Higgs Physik (Theorie) 2

Convenor: M. Wiesemann

Zeit: Mittwoch 16:45–18:15

Raum: VSH 06

T 86.1 Mi 16:45 VSH 06

**On the Renormalization of the 2HDM** — ●MARCEL KRAUSE — Karlsruher Institut für Technologie (KIT), Institut für Theoretische Physik (ITP), Wolfgang-Gaede-Str. 1, 76131 Karlsruhe

The Two-Higgs-Doublet Model (2HDM) is one of the simplest extensions of the Higgs sector of the Standard Model (SM) of particle physics. In order to investigate experimental data from particle colliders and to distinguish between different extensions of the SM, precise predictions for Higgs observables are required. This necessitates also the consideration of next-to-leading order (NLO) contributions to Higgs decays as well as their renormalization. Desirable properties of any renormalization scheme that is used in practice are process-independence, gauge-independence and numerical stability of the NLO contributions. Based on several exemplary Higgs decays within the 2HDM, we compare different renormalization schemes and propose a scheme which fulfills all three desirable properties. We pay special attention to the scalar mixing angle  $\alpha$  for the CP-even Higgs bosons and the mixing angle  $\beta$  for the CP-odd and charged Higgs bosons, as well as to the  $Z_2$ -symmetry-breaking mass term  $m_{12}$ .

T 86.2 Mi 17:00 VSH 06

**Strong First Order Electroweak Phase Transition in the CP-Conserving 2HDM Revisited** — ●PHILIPP BASLER<sup>1</sup>, MARCEL KRAUSE<sup>1</sup>, MARGARETE MÜHLEITNER<sup>1</sup>, JONAS WITTBRODT<sup>1,2</sup>, and ALEXANDER WLOTZKA<sup>1</sup> — <sup>1</sup>Karlsruher Institut für Technologie, ITP, Karlsruhe, Deutschland — <sup>2</sup>DESY, Hamburg, Deutschland

The generation of the observed matter-antimatter asymmetry in the universe through baryogenesis cannot be explained in the Standard Model. We therefore investigate the possibility of a strong first order phase transition in the 2-Higgs-Doublet Model (2HDM) after imposing theoretical and experimental constraints. We study the type I and II 2HDM where either of the two CP-even Higgs bosons can be the Standard Model-like Higgs boson. Our results show that there is a strong interplay between the requirement of a strong phase transition and collider phenomenology with testable implications for searches at the LHC.

T 86.3 Mi 17:15 VSH 06

**Full QCD and leading Yukawa two-loop corrections to the MSSM Higgs-boson spectrum** — SOPHIA BOROWKA<sup>1</sup>, ●SEBASTIAN PASSEHR<sup>2</sup>, and GEORG WEIGLEIN<sup>2</sup> — <sup>1</sup>CERN Theory Division, CH-1211, Geneva 23, Switzerland — <sup>2</sup>Deutsches Elektronensynchrotron DESY Notkestraße 85, D-22607 Hamburg, Germany

A high-precise prediction of the Higgs-boson mass spectrum in the MSSM is an essential ingredient to test the validity of the model. The Higgs sector of the MSSM consists of two doublet fields leading to five physical Higgs bosons.

I will present recent progress of new two-loop corrections to the Higgs masses in the MSSM with complex parameters. The new contributions contain the full lowest order QCD result including momentum dependence and gauge terms. Furthermore the leading Yukawa corrections are amended by taking into account possible complex parameters. The new results will become available through the public code FeynHiggs.

T 86.4 Mi 17:30 VSH 06

**Higgs-boson masses, mixing and decays in the NMSSM** — FLORIAN DOMINGO<sup>1,2</sup>, PETER DRECHSEL<sup>3</sup>, and ●SEBASTIAN PASSEHR<sup>4</sup> — <sup>1</sup>Instituto de Física Teórica (UAM/CSIC), Universidad Autónoma de Madrid, Cantoblanco, E-28049 Madrid, Spain — <sup>2</sup>Instituto de Física de Cantabria (CSIC-UC), E-39005 Santander, Spain — <sup>3</sup>II. Institute for Theoretical Physics, University of Hamburg,

D-22761 Hamburg, Germany — <sup>4</sup>Deutsches Elektronensynchrotron DESY, Notkestraße 85, D-22607 Hamburg, Germany

The Next-to-Minimal Supersymmetric Standard Model (NMSSM) catches increasing interest in particle physics due to its rich phenomenology. In addition to the two Higgs doublets of the MSSM a Higgs singlet enriches the particle spectrum leading to seven physical Higgs bosons. Precise predictions for the masses and mixing of these Higgs bosons is of foremost importance to validate the NMSSM. Different with respect to the MSSM is also the possibility for CP mixing in the Higgs sector at the tree level. Further constraints arise from the decays of these particles and the associated crosssections.

I will present the Higgs-boson mass spectrum for selected scenarios and explain the mixing of the Higgs bosons at higher orders in perturbation theory in the NMSSM with complex parameters. Furthermore I will report on the prediction of important decays. Finally a summary about the status of implementing all these results in the public code FeynHiggs will be given.

T 86.5 Mi 17:45 VSH 06

**Phenomenology of the 125 GeV Higgs boson in the N2HDM** — MARGARETE MÜHLEITNER<sup>1</sup>, MARCO O. P. SAMPAIO<sup>2</sup>, RUI SANTOS<sup>3,4</sup>, and ●JONAS WITTBRODT<sup>1,5</sup> — <sup>1</sup>ITP, KIT, 76128 Karlsruhe, Germany — <sup>2</sup>Departamento de Física, Universidade de Aveiro and CIDMA, 3810-183 Aveiro, Portugal — <sup>3</sup>ISEL, Instituto Politécnico de Lisboa, 1959-007 Lisboa, Portugal — <sup>4</sup>CFTC, Universidade de Lisboa, 1749-016 Lisboa, Portugal — <sup>5</sup>DESY, D-22607 Hamburg, Germany

The N2HDM is based on the CP-conserving 2HDM extended by a real scalar singlet field. Its enlarged parameter space and its fewer symmetry conditions as compared to supersymmetric models allow for an interesting phenomenology compatible with current experimental constraints. In this talk, we present the phenomenology of the 125 GeV Higgs boson in this model. We performed a large scan of the N2HDM parameter space which takes into account all applicable theoretical and experimental constraints. In the N2HDM the 125 GeV state can mix with the singlet field. We find that this singlet admixture can be sizeable despite the SM-like behaviour observed at the LHC. We show how the singlet admixture affects the coupling structure and signal strengths of the 125 GeV Higgs boson and analyse how to best constrain it experimentally. Like in the 2HDM, the N2HDM features a wrong-sign regime where the gauge and bottom quark couplings are of opposite sign. We discuss how the correct and wrong sign regimes can be distinguished through measurements of the 125 GeV Higgs properties.

T 86.6 Mi 18:00 VSH 06

**Light Higgs Branching Ratios in Constrained Next-to-Minimal Supersymmetry Scenarios Surveyed** — ●CONNY BESKIDT<sup>1</sup>, WIM DE BOER<sup>1</sup>, DMITRI KAZAKOV<sup>1,2</sup>, and STEFAN WAYAND<sup>1</sup> — <sup>1</sup>Karlsruhe Institute of Technology (IEKP) — <sup>2</sup>JINR, ITEP, Moscow, Russia

Within the rich particle spectrum of the next-to-minimal supersymmetric standard model (NMSSM) three scalar Higgs bosons are predicted. In many cases the second lightest Higgs represents the standard model (SM) Higgs mass with SM couplings and a mass of 125 GeV, so a light Higgs below 125 GeV is automatically generated. We provide a scan over the NMSSM parameter space for different specific NMSSM scenarios to show the allowed mass range and branching ratios of this singlet-like Higgs boson. By comparing the cross section times branching ratio with the ones of the SM-like Higgs boson, we give prospects for future searches at the LHC.

## T 87: Neutrinophysik (Theorie)

Convenor: W. Rodejohann

Zeit: Mittwoch 16:45–19:00

Raum: VSH 05

T 87.1 Mi 16:45 VSH 05

**Coherent Neutrino-Nucleus Scattering and new Neutrino Interactions** — ●XUNJIE XU, MANFRED LINDNER, and WERNER RODEJOHANN — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

We investigate the potential to probe new neutrino physics with future experiments measuring coherent neutrino-nucleus scattering. Experiments with high statistics should become feasible soon and allow to constrain parameters with unprecedented precision. Using a benchmark setup for a future experiment probing reactor neutrinos, we study the sensitivity on neutrino non-standard interactions and new exotic neutral currents (scalar, tensor, etc). Compared to Fermi interaction, percent and permille level strengths of the new interactions can be probed, superseding for some observables the limits from future neutrino oscillation experiments by up to two orders of magnitude.

T 87.2 Mi 17:00 VSH 05

**Discriminating sterile neutrinos and unitarity violation with CP invariants** — ●PHILIPP SICKING and HEINRICH PÄS — TU Dortmund

We present a new method to analyze upcoming results in the search for CP violating neutrino oscillations. The CP violating amplitudes  $\mathcal{A}_{\alpha\beta}^{kj}$  provide parametrization independent observables, which will be accessible by experiments soon. The strong prediction of a unique  $\mathcal{A}_{\alpha\beta}^{kj}$ , the Jarlskog invariant, in case of the standard three neutrino model does not hold in models with new physics beyond the Standard Model. Nevertheless there are still correlations among the amplitudes depending on the specific model. Due to these correlations it is possible to reject specific new physics model by determining only 3 of the CP violating amplitudes.

T 87.3 Mi 17:15 VSH 05

**Sizable NSI from the SU(2)<sub>L</sub> scalar doublet-singlet mixing and the implications in DUNE** — ●WEI-CHIH HUANG — Technische Universität Dortmund, Dortmund, Germany

We propose a novel and simple mechanism where sizable effects of non-standard interactions (NSI) in neutrino propagation are induced from the mixing between an electrophilic second Higgs doublet and a charged singlet. The mixing arises from a dimensionful coupling of the scalar doublet and singlet to the standard model Higgs boson. In light of the small mass, the light mass eigenstate from the doublet-singlet mixing can generate much larger NSI than those induced by the heavy eigenstate. We show that a sizable NSI ( $\sim 0.3$ ) can be attained without being excluded by a variety of experimental constraints. Furthermore, we demonstrate that NSI can mimic effects of the Dirac CP phase in the neutrino mixing matrix but they can potentially be disentangled by future long-baseline neutrino experiments, such as the Deep Underground Neutrino Experiment (DUNE).

T 87.4 Mi 17:30 VSH 05

**Charged-lepton decays from soft flavour violation in a two-Higgs doublet seesaw model** — ●ELKE AEIKENS<sup>1</sup>, WALTER GRIMUS<sup>1</sup>, and LUÍS LAVOURA<sup>2</sup> — <sup>1</sup>University of Vienna — <sup>2</sup>CFTP Lisboa

Extensions of the Standard Model with right-handed neutrinos  $\nu_R$  in the framework of the seesaw mechanism are popular to explain the smallness of the neutrino masses. In our model, we additionally allow a second Higgs doublet. And to avoid lepton flavour-changing neutral-scalar interactions at tree level, we impose lepton flavour violation solely in the non-flavour-diagonal Majorana mass matrix of the right-handed neutrinos whereas all Yukawa-coupling matrices are lepton flavour-diagonal. We show explicit in framework that the branching ratios of the charged-lepton decays  $\ell_1^- \rightarrow \ell_2^- \ell_3^+ \ell_3^-$  are close to their experimental upper bounds, while the branching ratios of other lepton flavour-changing decays, are invisible because they are suppressed by  $m_R^{-4}$ , where  $m_R$  is the seesaw scale. Considering the anomalous magnetic moment of the muon, in our model the contributions from the extra scalars can remove the discrepancy between its experimental and theoretical values.

T 87.5 Mi 17:45 VSH 05

**Testing neutrino mass generation at the GeV scale: experi-**

**mental reach versus theoretical predictions** — ●RASMUS WESTPHAL RASMUSSEN and WALTER WINTER — Desy, Platanenallee 6, 15738 Zeuthen

We discuss the parameter space reach of future experiments searching for sterile neutrinos at the GeV scale in terms of neutrino mass models with three generations. We investigate two classes of models: one tends to be partially within reach, whereas the other case yield more refined predictions. We also highlight the importance to measure the flavor-dependent couplings of the sterile neutrinos as a model discriminator, and we clarify the impact of assumptions frequently used in the literature to show the parameter space reach for the active-sterile mixings.

T 87.6 Mi 18:00 VSH 05

**Sterile neutrino searches at future electron-positron, proton-proton, and electron-proton colliders** — STEFAN ANTUSCH<sup>1,2</sup>, ●EROS CAZZATO<sup>1</sup>, and OLIVER FISCHER<sup>1</sup> — <sup>1</sup>Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland — <sup>2</sup>Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), Föhringer Ring 6, D-80805 München, Germany

Sterile neutrinos are among the most attractive extensions of the SM to generate the light neutrino masses observed in neutrino oscillation experiments. When the sterile neutrinos are subject to a protective symmetry, they can have Majorana masses around the electroweak scale and potentially large neutrino Yukawa couplings, which makes them testable at the planned Future Circular Colliders. In this talk I outline a systematic assessment of the signatures for sterile neutrino searches at electron-positron, proton-proton and electron-proton colliders. I present preliminary results on foreseeable sensitivities of the most promising signatures and compare the performance of the different collider types.

T 87.7 Mi 18:15 VSH 05

**From CP Phases to Yukawa Textures - Maximal Yukawa Hierarchies in Minimal Seesaw Models** — ●THOMAS RINK and KAI SCHMITZ — Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland

The type-I seesaw mechanism involving only two right-handed neutrinos represents a minimal model to account for the observed masses and mixings in the Standard Model neutrino sector. It features four real parameters that cannot be fully fixed by the current data: two CP-violating phases,  $\delta$  and  $\sigma$ , as well as one complex parameter,  $z$ , that is experimentally inaccessible at low energies. We perform a systematic scan over the complex  $z$  plane and study maximal hierarchies in the neutrino Yukawa matrix that are still consistent with observations for given values of  $\delta$  and  $\sigma$ . Our analysis generalizes previous studies of so-called texture zeros in the neutrino Yukawa matrix and demonstrates that relaxing this assumption significantly enlarges the range of possible Yukawa matrices. Allowing for small corrections, models with an approximate two-zero texture can be realized even in the case of a normally ordered light-neutrino mass spectrum, which is usually ruled out in this framework. For the inverted hierarchy, we further show that small perturbations can resurrect Yukawa textures which were inconsistent with observations. Our analysis is based on a novel *hierarchy parameter* that allows us to assess to what extent any given Yukawa matrix exhibits a certain flavor texture. Generalization of this parameter paves the way for similar studies in other neutrino mass models.

T 87.8 Mi 18:30 VSH 05

**Extra Dimensional Seesaw Mechanism** — ●MATHIAS BECKER — TU Dortmund, Deutschland

An extra dimensional model is presented where the brane is shifted away from the fixed points of the extra dimension and one right handed neutrino field is introduced.

The right handed neutrino is able to propagate in the extra dimension, thereby allowing for an extra dimensional seesaw mechanism.

It is investigated if this setup is capable of producing the observed neutrino masses and mixing. Additionally, some phenomenological consequences, e.g. rare lepton decays, are studied.



T 87.9 Mi 18:45 VSH 05

**Neutrino assisted GUT baryogenesis - revisited** — ●SINAN ZEISSNER — TU-Dortmund, Germany

Many GUT models conserve  $B - L$ . This results in heavy Higgs or gauge boson decays with  $\Delta(B + L) \neq 0$  but with  $\Delta(B - L) = 0$ . Since sphaleron processes violate  $B + L$  as well, such an asymmetry

will be washed out completely. We will revisit the idea to revive GUT baryogenesis where right-handed neutrinos wash out the  $L$  asymmetry before sphaleron processes can significantly wash out the original  $B + L$  asymmetry. This way a total washout of the initial baryon asymmetry can be prevented. At the same time one can explain the neutrino mass differences and to combine this idea with the scotogenic model to produce DM. (arXiv:1608.04354)

## T 88: Andere Gebiete der Theorie

Zeit: Mittwoch 16:45–18:30

Raum: H 4

T 88.1 Mi 16:45 H 4

**Particle Rest-Mass and Application: Free Neutron Decay** — ●MANFRED GEILHAUPT — Hessenfeld 10, 41844 Wegberg

The Standard Model (SM) describes the electron mass as resulting from a dimensionless Yukawa-coupling-constant. The Yukawa-Potential describes the interactions of e-, mu, tau, and their neutrinos with the Higgs field background. After diagonalization of the matrix, the particle masses are basically the product of an arbitrary Yukawa coupling times the Higgs field value (250 GeV). (Tod Gardiner) However, there is no theory ("flavor physics") that determines the Yukawa coupling constant for each lepton up to now.

Therefore we present a mass-formula for the restmass of a single, FREE electron, muon and tauon at REST, as well as for the two composite particles proton and neutron based on Einstein's Theory. This (pure) restmass is made from internal action only, so defined to be free from external interaction which of course, if present, has a contribution to mass. Application of the rest-mass generating mechanism is the minus beta-decay of a free neutron. The Feynman-Diagram is extended by the self-energy-levels of the components and includes the mediating W-Boson (external) action as a catalyst-particle.

T 88.2 Mi 17:00 H 4

**De Broglie's Wavelength of a Particle Has a Conflict** — ●ALBRECHT GIESE — Taxusweg 15, 22605 Hamburg

The postulation of matter waves by Louis de Broglie was a big step towards a new understanding in particle physics and of quantum mechanics. And his result that the wavelength of a particle is given by the particle's momentum was convincing at the first glance and seemed to be confirmed by experiments.

Unfortunately, however, de Broglie's deduction of the wavelength is based on an incorrect understanding of special relativity. And the dependence of the wavelength on momentum is neither Lorentz- nor even Galilei-invariant. It does not therefore reflect correct physics. Nevertheless, it was used by Schrödinger and by Dirac as an essential part of their wave functions.

We will explain how the problem occurred and why the results seem to be confirmed by experiments. And we will show what a correct solution would look like.

T 88.3 Mi 17:15 H 4

**The Origin of Mass - A Fundamental Mechanism** — ●ALBRECHT GIESE — Taxusweg 15, 22605 Hamburg

The origin of mass is one of the basic questions in our understanding of physics. The great attention being paid to the Higgs theory is an indication of it. However, the Higgs theory does not really work. Aside from its great complexity, the necessary Higgs field is contradicted by astronomical observations and the necessary Yukawa coupling needed to determine any actual mass is not provided by this theory. - On the other hand, there is a very fundamental solution for inertia based on classical physics. If two objects are bound to each other in such a way as to maintain a distance from each other, then this configuration necessarily has inertia, even if the two objects do not have any mass.

If this model is used to determine the mass of the electron, for example, then the results conform precisely to the actual measurements. For this evaluation, the size of the electron is determined by classical means from its magnetic moment. - This calculation also works for the other leptons, as well as for quarks. And it covers the relativistic behavior of mass, including Einstein's famous relation between mass and energy.

It can be shown that no other mechanism is needed in physics to explain inertia.

Further info: [www.ag-physics.org/rmass](http://www.ag-physics.org/rmass)

T 88.4 Mi 17:30 H 4

**The baryon octet in the light of the alpha/beta rule for exact calculation of particle masses.** — ●KARL OTTO GREULICH — Fritz-Lipmann Institut, Beutenbergstr.11, 07745 Jena

The baryon octet arranges eight prominent elementary particles (nucleons, Lambda, Sigma and Omega baryons) according to their strangeness "S" and their Isospin. In the present contribution it is shown that their masses can be calculated with an accuracy of better than 1 % by the equation:

$$m = m(\text{proton}) + 70,04 \text{ MeV}/c^2 (S^2 + 1,5)$$

For the neutral and charged Sigma baryon the additive term is 2 and 2,5. Here it is shown that the mass  $m_0 = 70,04 \text{ MeV}/c^2$  is predicted by simple equations for accurate calculation of particle masses (K.O. Greulich 2010 J Mod Phys, 1, 300-302), particularly by the alpha/beta rule (K.O. Greulich, 2016 DPG Spring meeting, Hamburg, T 99.4). This is exactly the mass of a fictive particle with the classical electron radius as de Broglie wavelength.

T 88.5 Mi 17:45 H 4

**Quo Vadis? Vanitas! Die 13,5 Leben der Planck'schen Konstante** — ●MORGUEN ROTWANG — Adam-Weisenhaupt-Boulevard 23, 53115 Bonn

Der Wunsch nach einer Großen Vereinheitlichten Theorie steht in antiproportionalem Verhältnis zum Erfolg eine ebensolche zu etablieren. Nicht Einstein, nicht Heisenberg gelang eine Konzeption und bis zum heutigen Tag stehen die Allgemeine Relativitätstheorie und die Quantenmechanik unvereinbar und scheinbar nachweisbar richtig nebeneinander. Die Antwort jedoch für dieses Dilemma liegt möglicherweise in der Planck-Konstante selbst, welche den als kontinuierlich angenommenen Raum, so auch die Zeit, in Einheiten der Wirkung von Raum x Zeit quantisiert. Dies ist der eigentliche fundamentale Baustein. Anhand der im Titel genannten Vielzahl an Beispielen für das Auftreten der Planckkonstanten in unterschiedlichsten Theorien und Konzeptionen wollen wir die Rolle der Wirkung in ihrem Fundamentalen Zusammenhang genauer hervorheben.

T 88.6 Mi 18:00 H 4

**A Fifth Generation of Quarks** — ●LELLO BOSCOVERDE — Institute for Theoretics, Dirnismanning

Considerable focus in theory has been given to the phenomenology of a fourth generation of quarks. And a considerable experimental effort was invested in searching for it. The resulting strong limits nearly rule out the existence of such an extra fourth generation. In light of this, we skip over the fourth generation and discuss the phenomenology of a *fifth* generation of quarks, highlighting the complete lack of experimental limits on its existence.

T 88.7 Mi 18:15 H 4

**The LHC signals and a "new physic".** — ●NORBERT SADLER — Wasserburger Str. 25a ; 85540 Haar

It can be shown that the respective proton-confinement of 2.5 GeV will be stimulated momentarily at around 62.68 GeV, percolates over the 57-dimensional object of the Exzeptional E8-group and will be emitted in the form of two jets with 125.72 GeV at collision of two protons equivalents of 0.9384 GeV in the LHC in total. The 57 dimensional objekt in conjunction with the confinement represents the postulated Higgs Boson and the E8-symmetry the Higgs field.

At doubling of the collision energy the confinements would be stimulated around the factor 6 to  $6 \times 125 \text{ GeV}$  in the first mode.

At fourfold increase of the collision energy the stimulation factor would already be 30.

This collision energy is however not realisable and therefore a "new

physic” of the future LHC signals can not be expected.

Further Information: [www.cosmology-harmonics-mundi.com](http://www.cosmology-harmonics-mundi.com)

## T 89: Experimentelle Methoden 3

Zeit: Mittwoch 16:45–19:00

Raum: JUR 253

T 89.1 Mi 16:45 JUR 253

**Optimierung der Zeitauflösung eines endoskopischen TOF-PET-Systems** — •OLE BRANDT, BASTIAN LUNOW, MILAN ZVOLSKY und ERIKA GARUTTI — Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

Im Rahmen des EndoTOFPET-US-Projekts wird ein neuartiges multimodales Gerät zur Ultraschall-Endoskopie und Positronen-Emissions-Tomographie (PET) von Prostata- und Pankreas-Karzinomen entwickelt. Das Gerät besteht aus einem miniaturisierten PET-Kopf, installiert auf einem kommerziellen Ultraschall-Endoskop und einer externen Detektor-Platte, die in unmittelbarer Nähe zum Körper positioniert wird. Dieses nutzt die Flugzeit (TOF)-Information der detektierten Photonen, um Untergrund von naheliegenden Organen zu unterdrücken. Dazu soll eine Koinzidenz-Zeitauflösung von unter 300 ps FWHM erreicht werden. Die Detektion der Photonen erfolgt mittels Szintillationskristallen, ausgelesen durch Silizium-Photomultiplier (SiPM). Die Verarbeitung der SiPM-Signale erfolgt durch den STiC-Chip (SiPM Timing Chip, Uni Heidelberg). Dieser nutzt die time-over-threshold-Methode, um Energie- und Zeitinformation der eintreffenden Photonen zu extrahieren. Um die bestmögliche Zeitauflösung des Systems zu erreichen, werden die relevanten Parameter des Chips sowie die angelegte Bias-Spannung optimiert.

T 89.2 Mi 17:00 JUR 253

**Track Based Alignment for the Mu3e Detector** — •ULRICH HARTENSTEIN for the Mu3e-Collaboration — JGU Mainz

The Mu3e experiment searches for the lepton flavor violating decay  $\mu \rightarrow e^+ e^- e^+$  with a sensitivity goal for the branching fraction of better than  $10^{-16}$ . This process is heavily suppressed in the standard model of particle physics ( $BR < 10^{-50}$ ) which makes an observation of this decay a clear indication of new physics. For track reconstruction, four barrel shaped layers consisting of about 3000 high-voltage monolithic active pixel sensors (HV-MAPS) are used. The position, orientation and possible deformations of these sensors must be known to greater precision than the assembly tolerances. A track based alignment via the General Broken Lines fit and the Millepede-II algorithm will be used to achieve this precision in the final detector.

The talk will discuss preparations for aligning the detector using a detailed simulation. A set of alignment parameters that not only describe the position and rotation but also deformations of individual pixel sensors will be introduced. An alignment for these kind of parameters is - due to the very thin ( $50\mu m$ ) pixel sensors - essential for the Mu3e detector.

T 89.3 Mi 17:15 JUR 253

**Photon rejection for the  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  measurement and search for the  $\pi^0 \rightarrow$  invisible decay at the NA62 experiment** — •LETIZIA PERUZZO — Johannes Gutenberg University Mainz

In June 2015 the NA62 experiment at CERN began its physics data taking with the aim to collect in three years around 100  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  events and measure the branching ratio with a precision about 10%. Well predicted inside the Standard Model,  $Br(K^+ \rightarrow \pi^+ \nu \bar{\nu}) = (9.11 \pm 0.72) \cdot 10^{-11}$ , this decay is closely related to the CKM matrix elements  $|V_{td}|$  and  $|V_{ts}|$  and any deviation from the theoretical  $Br$  could open many scenarios of physics beyond the Standard Model. The suppression of the main  $K^+$  decays, which have  $Br$  several order of magnitude higher than the  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  signal, is the primary task of NA62. In particular two types of decays are very crucial to suppress:  $K^+ \rightarrow \mu^+ \nu$  and  $K^+ \rightarrow \pi^+ \pi^0$ . For this reason good particle identification and photon veto systems are needed for the experiment. A directly spin-off of the  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  measurement is the search for the  $\pi^0 \rightarrow$  invisible decay where the  $\pi^0$  comes from  $K^+ \rightarrow \pi^+ \pi^0$  events. The same signature of  $\pi^0 \rightarrow$  invisible with respect the  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  signal allows to perform the two measurements using the same dataset and analysis pillars. This talk describes the NA62 photon rejection performance reached in the 2016 run and the perspective for the measurement of  $\pi^0 \rightarrow$  invisible.

T 89.4 Mi 17:30 JUR 253

**Comparison of Methods to analyze Crosstalk of Silicon Photomultipliers** — •LUKAS MADERER, PATRICK HUFSCHEIDT, JUDITH SCHNEIDER, MICHAEL WAGENPFEIL, TOBIAS ZIEGLER, and THILO MICHEL — ECAP Uni Erlangen

Silicon Photomultipliers are devices for detection of low light intensities. An important parameter when characterizing these devices is the probability for correlated avalanches. Especially Crosstalk can be a problem for single photon measurements. Since there are multiple methods of analyzing Crosstalk present in literature leading to different results, we compare several of them based on the same data. One method measures the probability that a Crosstalk occurs, while the other one focuses on the mean number of Crosstalk events per initial avalanche. The first method yields to a linear dependency on the overvoltage, the second one to a quadratic dependency.

T 89.5 Mi 17:45 JUR 253

**Instrumentation of the Guard Ring Electrode of Coplanar-Grid CdZnTe Detectors for the COBRA Experiment** — •JAN-HENDRIK ARLING for the COBRA-Collaboration — TU Dortmund, Experimentelle Physik IV, Dortmund — now at Deutsches Elektronen-Synchrotron DESY, Hamburg

A novel method to suppress alpha induced background in the COBRA experiment is presented here. The experiment's aim is to search for neutrinoless double beta-decay ( $0\nu\beta\beta$ ) using CdZnTe semiconductor detectors with a coplanar-grid (CPG) readout. The next phase of COBRA will be the installation of the extended demonstrator (XDEM) consisting of CdZnTe detectors with a volume of  $(2 \times 2 \times 1.5) \text{ cm}^3$  and applying an adjusted coplanar quad-grid (CPqG) readout. The CPqG anodes are surrounded by an outer electrode called guard ring. It is used to reduce leakage currents as well as to increase the homogeneity of the weighting potential. In the standard case, the guard ring is left on a floating potential. Recent results from laboratory measurements showed that setting the charge-collecting ground potential to it can lead to a great suppression of alpha induced events in the order of 99.9%. Current recorded physics data indicate that the main background contribution is due to alpha contaminations on the detector surfaces. Therefore, the instrumentation and readout of the guard ring electrode can be highly beneficial in terms of background reduction for the COBRA experiment.

T 89.6 Mi 18:00 JUR 253

**Muon Pion Separation for the  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  Measurement at the NA62 Experiment** — •RICCARDO ALIBERTI — Johannes Gutenberg University Mainz

The ambitious goal of the NA62 experiment is to achieve a direct measurement of the  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  branching ratio with an accuracy around 10%. This decay has a theoretical BR of  $0.85 \times 10^{-10}$  with a single track detectable: the  $\pi^+$ .

The main decay channels of charged kaons have rates several orders of magnitude larger than those for the signal. For this reason the presence of a very efficient veto system to reject background events is mandatory.

The discrimination between muons and pions represents one of the central topics for the measurement of the  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  decay. This talk presents the latest results on the muon pion separation achieved in the NA62 2016 run.

T 89.7 Mi 18:15 JUR 253

**Pulse Shape Discrimination mit dem DRS4 Evaluation Board** — JOHN KETTLER<sup>2</sup>, OLIVER POOTH<sup>1</sup>, ACHIM STAHL<sup>1</sup>, SIMON WEINGARTEN<sup>1</sup> und •CHRISTIAN DZIWO<sup>1</sup> — <sup>1</sup>III. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen — <sup>2</sup>NET, RWTH Aachen University, Elisabethstr. 16, D-52056 Aachen

In Zusammenarbeit mit dem Institut für Nukleare Entsorgung und Techniktransfer (NET) entwickelt das III. Physikalisches Institut B ein Detektorkonzept zur Tomographie mit schnellen Neutronen. Im Detektor werden szintillierende Kristalle und Silizium-Photomultiplier

(SiPM) verwendet. Die Auslese erfolgt über den FPGA des DRS4 Evaluation Boards (Paul Scherrer Institute), eine programmierbare Ringspeicher-ADC Einheit. Die Herausforderung liegt in der Unterscheidung zwischen Neutronen- und Photonsignalen. Derzeit wird offline eine Analyse der Pulsform (Pulse-Shape-Discrimination) durchgeführt. Dazu müssen die einzelnen Pulse vollständige zeitintensiv überprüft werden.

Ziel dieser Arbeit ist es, die Pulse-Shape-Discrimination in die FPGA-Logik des DRS4 Evaluation Boards zu integrieren um die zu sendende Datenmenge zu reduzieren, dabei die aufwendige Offline-Analyse zu ersetzen und die maximale Ausleserate zu steigern. In einer weiteren Ausbaustufe soll die Möglichkeit eruiert werden, das Kamera-Bild einer Kamera aus Silbenkristallen mit vier mal vier Pixeln ebenfalls online auf dem DRS4 Board zu erstellen.

T 89.8 Mi 18:30 JUR 253

**Momentum transfer reconstruction for the P2 Experiment** — ●ALEXEY TYUKIN for the P2-Collaboration — Institute for Nuclear Physics, Johannes Gutenberg University, Mainz

The P2 experiment at the future MESA accelerator in Mainz is designed to determine the Weinberg angle, a core parameter of the weak force, with great precision. It will require measuring a parity violating asymmetry of elastically scattered electrons from a liquid hydrogen target for different beam polarisations, which depends heavily on the momentum transfer  $Q^2$ . Therefore a reconstruction of the electron tracks in the inhomogeneous magnetic field of the P2 detector is essential. For this, the detector will have four tracking planes of thin high voltage monolithic active pixel sensors (HV-MAPS).

In this talk the method of  $Q^2$  reconstruction will be shown. A Geant4 simulation is used to produce electron tracks and hits in the detection planes. For track reconstruction the General Broken Lines fit is used, which requires propagating seed parameters to all planes in order to determine a good approximation of the real parameters at the first plane, which can then be extrapolated back to the target. The prop-

agation is done by solving the equation of motion numerically with a Runge-Kutta method. In each step also the track parameter error matrix needs to be calculated by the Bugge-Myrheim method. Systematical effects producing offsets in the reconstructed values must be kept under control. The average  $Q^2$  value of  $0.006 \text{ GeV}^2/c^2$  can be reconstructed with about 4% uncertainty for a single event, leading to a high overall precision due to large electron rates in the experiment.

T 89.9 Mi 18:45 JUR 253

**Parameterization-based tracking for the P2 experiment** — ●IURI SOROKIN for the P2-Collaboration — Prisma Excellence Cluster — Institute for Nuclear Physics, JGU Mainz

The P2 experiment in Mainz aims to determine the weak mixing angle  $\theta_W$  at low momentum transfer by measuring the parity-violating asymmetry of elastic electron-proton scattering. In order to achieve an unprecedented measurement accuracy within the planned 10 000 hours of data taking, the experiment has to run at event rates on the order of  $10^{11}$  per second. Whereas the tracking system is not required to operate at the full beam rate, every attempt is made to achieve the highest possible rate capability.

At the full beam rate every reconstruction frame (45 ns long) will contain about 800 signal tracks, and 16 000 background hits from Bremsstrahlung photons. In order to cope with the extreme combinatorial background on-line, a parameterization-based tracking is considered as a possible solution. The idea is to determine the optimal hit search windows in every tracking plane for every possible positions of hits in the previous planes. Currently, the position and the size of the hit search windows are expressed as polynomial functions of hit coordinates. The coefficients of the polynomials are evaluated from a sample of reference tracks, reconstructed with a simple, exhaustive-search tracking in low-rate data.

The implementation, as well as the estimated performance of the parameterization-based tracking is going to be presented.

## T 90: Experimentelle Techniken der Astroteilchenphysik 5

Zeit: Mittwoch 16:45–19:00

Raum: S 9

T 90.1 Mi 16:45 S 9

**Untersuchungen der Lumineszenz Eigenschaften von Wasser und Eis** — ●SARAH PIEPER — Bergische Universität Wuppertal

Lumineszenz von Wasser und Eis wird als eine neue Methode erforscht, um Spuren von stark ionisierenden Teilchen mit niedrig-relativistischen Geschwindigkeiten ( $0.1c - 0.5c$ ) mit Wasser-Cherenkov Detektoren nachzuweisen. Bisher können diese Teilchen nicht durch andere Methoden an Neutrino-Teleskopen detektiert werden. Aufgrund ihrer Größe, erreicht man mit Neutrino-Teleskopen im Vergleich zu anderen Teilchen-Detektoren momentan jedoch die beste Sensitivität für seltene oder noch nicht entdeckte Teilchen.

Die charakteristischen Parameter der Lumineszenz von Wasser und Eis, wie die Effizienz, die Lebensdauer der angeregten Zustände sowie das Wellenlängen-Spektrum, werden für die Detektion und die Interpretation der Ergebnisse benötigt. Aufgrund dessen werden diese Parameter und ihre Temperaturabhängigkeit untersucht. Dazu wird reines Wasser mithilfe radioaktiver Quellen in verschiedenen Temperaturbereichen angeregt und die Lumineszenz Eigenschaften über die Analyse der Rate von Einzelphotonen bestimmt. Vorgestellt wird der aktuelle Stand dieser Untersuchungen.

T 90.2 Mi 17:00 S 9

**Measuring the optical properties of the IceCube drill holes** — ●MARTIN RONGEN for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen

IceCube instruments about  $1 \text{ km}^3$  of deep ice below the South Pole with 5160 digital optical modules (DOMs) to register the Cherenkov light of charged particles. As the detector operates in a natural medium, a good understanding of its optical properties is crucial to the understanding of systematic uncertainties at analysis level. While the optical properties of the natural ice in-between drill holes are well understood, the properties of the refrozen drill holes still pose a challenge. By comparing the detected light pattern of photons emitted from calibration LEDs, situated in each DOM, to an extensive set of photon propagation simulations, the optical properties of the drill holes can be

constrained. The method as well as the derived ice model modifications are presented and compared to previous investigations.

T 90.3 Mi 17:15 S 9

**Entwicklung einer Sonde zur Untersuchung der Propagation von UV-Licht in Eis im SPICECore Bohrloch** — ●JANNES BROSTEAN-KAISER — Desy Zeuthen

In der Erweiterung Gen2 des Neutrino-Teleskops IceCube ist eine Möglichkeit zur Sensitivitätsverbesserung eine Erweiterung des detektierbaren Wellenlängenbereichs in das Ultraviolette durch neue Module wie etwa dem Wellenlängenschiebenden Optischen Modul (WOM). Das SPICECore UV Calibration Device ist eine Sonde zur Vermessung von ultraviolettem Licht in Eis. Die Messungen dienen der Untersuchung des Potentials der Gen2 Erweiterung. Die Sonde besteht aus einem UV-Licht emittierenden Teil und drei durch Spiegel abgetrennten PMMA-Zylindern. Die Zylinder sind mit wellenlängenschiebender Farbe beschichtet und werden mit je einem Photomultiplier an beiden Enden ausgelesen. Die Sonde wird in das mit Estisol-140 gefüllte SPICECore Loch auf eine Tiefe von etwa 1750 m gelassen. Dort wird Licht in den Wellenlängen 250 nm und 370 nm ausgesandt und die Zeitverteilung des zurückgestreuten Lichts gemessen. Aus dieser Verteilung können die Absorptions- und Streukoeffizienten ermittelt und mit Simulationen verglichen werden. Aufbau und Methode einer solchen Sonde, sowie erste Tests werden hier präsentiert.

T 90.4 Mi 17:30 S 9

**A Precision Optical Calibration Module for IceCube-Gen2** — ●ANTONIO BECERRA ESTEBAN, MICHAEL BÖHMER, ANDREAS GÄRTNER, ROMAN GERNHÄUSER, FELIX HENNINGSEN, KILIAN HOLZAPFEL, KAI KRINGS, LASZLO PAPPAS, IRENE SORIANO, and ELISA RESCONI for the IceCube-Collaboration — TUM (ECP), München, Deutschland

A self-calibrated, homogeneous, multiwavelength calibration module for a precise measurement of the energy scale and resolution of IceCube-Gen2 is presented. This is obtained by creating an isotropic, in-situ calibrated light pulse of a few nanoseconds length inside the IceCube-Gen2 detector. The Pulse imitates a high-Energetic neutrino event

that in combination with the in-situ calibration will reduce the systematic uncertainties to a target value of 1

T 90.5 Mi 17:45 S 9

**Testing the POCAM Prototype in the Gigaton Volume Detector (GVD) of Lake Baikal** — ●ANTONIO BECERRA ESTEBAN, MICHAEL BÖHMER, ANDREAS GÄRTNER, ROMAN GERNHÄUSER, FELIX HENNINGSSEN, KILIAN HOLZAPFEL, KAI KRINGS, LASZLO PAPPS, IRENE SORANO, and ELISA RESCONI for the IceCube-Collaboration — TUM (ECP), München, Deutschland

The first working prototype of the Precision Optical Calibration Module (POCAM) is going to be deployed in the Baikal Gigaton Volume Detector (GVD) in early 2017. The POCAM is an isotropic nanosecond light pulser, designated for high-precision calibration of systematic uncertainties in the IceCube-Gen2 Upgrade. In collaboration with the Baikal-GVD team the goal of this deployment is two folded: from one side we intend to test the functionalities of the POCAM under realistic conditions, on the other hand we aim to contribute to the calibration of the GVD detector. We will report the development of the prototype, including component selection and testing environment together with the preparations for the GVD deployment.

T 90.6 Mi 18:00 S 9

**Multi-PMT optische Module für IceCube-Gen2** — ●LEW CLASSEN<sup>1</sup>, ALEXANDER KAPPES<sup>1</sup>, TIMO KARG<sup>2</sup>, RAFFAELA BUSSE<sup>1</sup>, FLORIAN TRITTMACK<sup>1</sup> und MARTIN ANTONIO UNLAND ELORRIETA<sup>1</sup> für die IceCube-Kollaboration — <sup>1</sup>Institut für Kernphysik, Westfälische Wilhelms-Universität Münster — <sup>2</sup>DESY, Zeuthen

Nach der erstmaligen Messung eines hochenergetischen astrophysikalischen Neutrinoflusses durch IceCube, wird momentan intensiv an den Planungen zur nächsten Generation eines Neutrino-Observatoriums am Südpol, IceCube-Gen2, gearbeitet. Eine wesentliche Steigerung der Sensitivität von IceCube-Gen2 wird dabei von neuen optischen Sensoren erwartet. Eines der vielversprechendsten Designs ist hierbei das sogenannte multi-PMT-Modul. Optische Module nach diesem Konstruktionsprinzip bestehen aus einer Anordnung mehrerer kleiner Photomultiplier innerhalb eines transparenten Druckkörpers, was einige Vorteile gegenüber dem konventionellen Design mit einem großen PMT bietet, darunter eine vergrößerte effektive Fläche, eine gleichmäßige Raumwinkelabdeckung sowie intrinsische Richtungssensitivität. Für die Verwendung innerhalb der IceCube-Infrastruktur im tiefen Eis am Südpol wurde das bewährte multi-PMT-Design des KM3NeT-Detektors adaptiert sowie in einigen Punkten verbessert.

In dem Vortrag werden das Modulkonzept sowie der aktuelle Stand der Entwicklungsarbeiten vorgestellt.

T 90.7 Mi 18:15 S 9

**Untersuchungen zur Dunkelrate durch radioaktive Zerfälle in Multi-PMT Optischen Modulen (mDOM)** — ●MARTIN ANTONIO UNLAND ELORRIETA, LEW CLASSEN und ALEXANDER KAPPES für die IceCube-Kollaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster

Im Rahmen der sich in der Planung befindlichen nächsten Generation des Neutrino-Observatoriums am Südpol, IceCube-Gen2, werden neue

optische Module entwickelt, von denen eine signifikante Steigerung der Detektorsensitivität erwartet wird. Ein sehr vielversprechendes Design ist hier das mDOM, welches über 24 3"-große Photomultiplier (PMTs) anstatt des bisherigen einzelnen 10"-PMTs verfügt. Das mDOM bietet u. a. eine größere effektive Fläche und Informationen über die Ankunftsrichtung der Photonen, sowie die Möglichkeit für Koinzidenzen zwischen PMTs innerhalb eines mDOM-Moduls. Dabei stellt der durch das Modul selber verursachte Untergrund in den Photomultipliern eine intrinsische Herausforderung für die Auswertung echter Signale dar. Eine Quelle dieses Untergrunds ist Cherenkov- und Szintillationslicht, das durch radioaktive Zerfälle im Glas des Druckkörpers entsteht. Zu dessen Charakterisierung wurden auf Geant4 basierende Simulationen der Zerfälle der im Glas enthaltenen radioaktiven Nuklide durchgeführt und mit Messungen verglichen. Der Vortrag präsentiert die bisherigen Erkenntnisse.

T 90.8 Mi 18:30 S 9

**Track resolutions for the IceCube Gen2 High Energy Array comparing the multi-PMT optical module to the standard IceCube optical module** — ●THOMAS KITTLER for the IceCube-Collaboration — Erlangen Centre for Astroparticle Physics, Erlangen, Germany

The IceCube neutrino observatory, located at the South Pole, is a neutrino telescope which successfully operates in its current form since 2011. An extension of the existing detector with an increase of the instrumented volume up to 10 km<sup>3</sup>, called "IceCube Gen2", is subject of current research. Apart from the increased volume, new optical modules, which are the basic detection units of the detector, are being investigated. One of these new modules is the so called multi PMT digital optical module (mDOM), which contains 24 3" PMTs per pressure sphere instead of a single 10" PMT as in the current IceCube array. In this talk the angular resolutions of tracks obtained with Gen2 detectors, one equipped with mDOMs and one equipped with standard IceCube DOMs, will be compared and discussed.

T 90.9 Mi 18:45 S 9

**Sensitivity of multi-PMT optical modules to MeV supernova neutrinos in South Pole ice.** — ●CRISTIAN JESÚS LOZANO MARISCAL and ALEXANDER KAPPES for the IceCube-Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster

Within the efforts for the next generation neutrino observatory at the South Pole, IceCube-Gen2, new optical modules like the multi-PMT optical module (mDOM) are being developed, which are expected to significantly increase the detector sensitivity to high energy astrophysical neutrinos. On the other hand, neutrinos from core-collapse supernovae with energies as low as few MeVs can reveal a detailed picture of the events that accompany the collapse of the core and verify and enhance our picture of these powerful explosions. With its unique features like local coincidences and information on the arrival direction of detected photons, the mDOM may allow for event-by-event detection of MeV neutrinos with a single module while at the same time keeping the background sufficiently low. The talk presents the results of initial studies concerning the detection efficiency of mDOMs for MeV neutrinos and the potential of a corresponding detector to detect extragalactic supernovae.

## T 91: Streifendetektoren 2 (gemeinsam mit HK)

Zeit: Mittwoch 16:45–19:00

Raum: F 102

T 91.1 Mi 16:45 F 102

**Bau von 2S-Modul-Prototypen für das Phase-2-Upgrade des CMS-Trackers** — LUTZ FELD, WACLAW KARPINSKI, KATJA KLEIN, MARIUS PREUTEN, MAX RAUCH, ●NICOLAS RÖWERT und MICHAEL WLOCHAL — RWTH Aachen, 1. Physikalisches Institut B

Im Rahmen des Phase-2-Upgrades von CMS am LHC (CERN) wird der derzeitige Siliziumspurdetektor (Tracker) ausgetauscht werden, voraussichtlich ab dem Jahr 2023. Im neuen Tracker werden u.A. etwa 8000 Stück der neuartigen 2S-Siliziumstreifenmodule eingesetzt werden.

Das Grundgerüst eines 2S-Moduls besteht aus zwei ca. 10 cm × 10 cm großen Siliziumstreifensensoren, die auf zwei Abstandshalter (Spacer) aus einem Aluminium-Kohlefaser-Verbundmaterial geklebt sind. Die Klebeschichtdicken sollen aus thermischen Gründen 20 µm oder weni-

ger betragen und die Sensoren müssen gegenüber den Spacern gegen Hochspannung isoliert sein. Für den Winkel zwischen den beiden Streifensensoren wird eine Toleranz von 400 µrad verlangt. Es wird ein auf einer mechanischen Vorrichtung basierendes Verfahren zum Bau von 2S-Modulen vorgestellt und die Ergebnisse vom Bau erster Prototypen werden diskutiert.

T 91.2 Mi 17:00 F 102

**Wirebonding auf den 2S Modulen des Outer Trackers für das Phase-2-Upgrade des CMS Experiments** — LUTZ FELD<sup>1</sup>, KATJA KLEIN<sup>1</sup>, OLIVER POOTH<sup>2</sup> und ●TIM ZIEMONS<sup>2</sup> — <sup>1</sup>I. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen — <sup>2</sup>III. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen

Vor dem Start des HL-LHC müssen am CMS-Detektor aufgrund von

Strahlenschäden und den bevorstehenden höheren Luminositäten Upgrades vorgenommen werden. Im sogenannten Phase-2-Upgrade des CMS-Detektors werden viele Subdetektoren durch solche mit moderneren Technologien ersetzt. Dazu zählt auch der neue Silizium Outer Tracker, in dem sogenannte PS Module (pixel and strips) und 2S Module (strips and strips) Signale liefern sollen, die in den Level-1 Trigger integriert werden.

Ein 2S Modul besteht aus zwei Silizium-Streifen Sensoren, die durch Wire-Bonds mit der Ausleseelektronik verbunden werden. Im Vortrag werden die 2S Module im Hinblick auf Machbarkeit der Wire-Bonds vorgestellt und erste Schritte in Richtung des Bondings bei einer Massenproduktion diskutiert. Die Optimierung der Bondqualität und der Schutz vor Beschädigung der Bondverbindungen sind wichtig, um die Lebensdauer der Detektormodule zu maximieren.

T 91.3 Mi 17:15 F 102

**A high resolution tracker for (p,2p) reactions** — ●LUKAS WERNER for the TUM-RIKEN-p2p-Collaboration — Technical University of Munich

Models of the r-process predict a strong influence of fission barrier heights on the distribution of r-process nuclei, mainly through termination of the r-process and simultaneously by a recycling of the fission products, refueling the r-process with neutron rich, medium mass nuclei.

The (p,2p)-reaction in inverse kinematics allows for the study of fission barrier heights for even the most exotic, experimentally available nuclei. For this purpose a missing mass spectroscopy of the reaction has to be performed. A silicon tracker system has been developed using highly segmented, thin silicon detectors with an APV25 based low noise readout. Tests of the system have been performed at the HIMAC facility in Japan, using a stable 16-O beam at energies of  $E=290$  MeV/u.

Even at a readout speed of up to 100 kiloevents per second the experimental resolution of a vertex reconstruction is in excellent agreement with expectations from Geant4 simulations.

Supported by BMBF 05P15WOFNA (Germany) and Outstanding Individual Research Grant (Japan).

T 91.4 Mi 17:30 F 102

**Test-beam results of an unirradiated and an irradiated module for the ATLAS ITk Strip detector** — ●EDOARDO ROSSI — DESY, Hamburg, Germany

Starting in 2022, the LHC will be upgraded to the High Luminosity-LHC which will have a luminosity almost five times larger than the present luminosity. In order to cope with the higher radiation level and with the higher pile up, the ATLAS experiment needs a complete replacement of the current tracking system with an all silicon detector, the Inner Tracker (ITk).

The ITk strip detector will be subject to a radiation more than one order of magnitude higher than the maximum radiation fluence expected for the SCT, the current strip detector. For this reason, new radiation-hard sensors and front-end chips will be used and are now under development. Among other measurements, a test-beam campaign is on going to determine the performance of the new modules at the end of the lifetime of the HL-LHC. Some strict requirements are set on the performance to provide efficient pattern recognition and track reconstruction and to fulfill the needs of the physics program.

In this presentation, test-beam results obtained with unirradiated and proton-irradiated prototype barrel modules are compared. The measurements were performed at DESY and CERN. The main focus is on the degradation of the efficiency, collected charge and noise occupancy after irradiation.

T 91.5 Mi 17:45 F 102

**Long Term Annealing Studies on ATLAS12 Sensors** — ●LEENA DIEHL, RICCARDO MORI, MARC HAUSER, SUSANNE KÜHN, ULRICH PARZEFALL, INES MESSMER, and KARL JAKOBS — Albert-Ludwigs-Universität Freiburg

Non-ionizing energy loss (NIEL) causes damage to silicon particle detectors, resulting for p-type sensors in an increased effective doping concentration, growing depletion voltage and leakage current. Defects in the lattice are mobile with an exponential temperature dependence.

Therefore, a long-term study of damage parameters is performed as a function of time at Room Temperature and 60°C, using irradiated p-type sensors up to a fluence of  $2e15 n_{eq}/cm^2$ . Measurements include the charge collection and leakage current behavior, the scaling factor between the two temperatures and the behavior of the effective doping

concentration. A strong deviation from the conventional scaling factor is found.

T 91.6 Mi 18:00 F 102

**Cold IV measurements of highly irradiated silicon strip detectors** — ●SVEN MÄGDEFESSEL<sup>1</sup>, EVA SICKING<sup>1,2</sup>, ULRICH PARZEFALL<sup>1</sup>, and KARL JAKOBS<sup>1</sup> — <sup>1</sup>Albert-Ludwigs-Universität Freiburg, Germany — <sup>2</sup>now at CERN, Switzerland

Highly irradiated silicon strip detectors show a strong increase of the leakage current. Thus an intense cooling is necessary to perform an IV measurement. On the one hand it has to be ensured that the detector is kept at the lowered temperature and on the other hand the heat being produced by the leakage current has to be removed.

We present a actively cooled and temperature stabilized setup which provides temperatures down to -40°C for detectors up to 8" size. Furthermore we show the latest results of planar and 3D silicon strip detectors.

T 91.7 Mi 18:15 F 102

**Electrical quality assurance of silicon microstrip sensors for the CBM experiment** — ●IAROSLAV PANASENKO for the CBM-Collaboration — Physikalisches Institut, Universität Tübingen, Germany — Institute for Nuclear Research, Kiev, Ukraine

The CBM experiment at FAIR will investigate the properties of nuclear matter at extreme conditions created in ultrarelativistic heavy-ion collisions. Its core detector — the Silicon Tracking System (STS) — will determine the momentum of charged particles from beam-target interactions.

The STS will be constructed from about 900 double-sided silicon microstrip sensors with 58  $\mu m$  pitch and a total area of about 4 m<sup>2</sup> with all together 2.1 million channels will be read out.

In this talk the electrical quality assurance of double-sided silicon microstrip sensors will be discussed. For this purpose dedicated equipment including a custom-built probe station has been set up in the clean room at Tübingen University. Results of the electrical characterization of prototype microstrip sensors CBM06 will be presented, which include basic checks like current-voltage and capacitance-voltage measurements, as well as specific tests like coupling and interstrip capacitances.

Work supported by BMBF under grant 05P12VTFCE.

T 91.8 Mi 18:30 F 102

**Optical quality assurance procedures for the sensors of the CBM Silicon Tracking System** — ●EVGENY LAVRIK for the CBM-Collaboration — Physikalisches Institut der Universität Tübingen, Tübingen, Deutschland

The Compressed Baryonic Matter (CBM) experiment at FAIR aims to study the properties of nuclear matter at high net-baryon densities. The Silicon Tracking System is the key detector to reconstruct charged particle tracks created in heavy-ion interactions. In order to assure the quality of more than 1000 silicon sensors including spares, highly efficient and highly automated procedures need to be developed.

In this contribution we report on the optical quality assurance setup built at the University of Tübingen and the progress in the development preparing for the mass inspection of the silicon sensors arriving from the manufacturers in 2017. We will as well as summarize the results and experience obtained from inspecting prototype sensors.

This work was supported by grant BMBF-05P16VTFCE1

T 91.9 Mi 18:45 F 102

**DC-DC Powered Silicon Microstrip Modules for the CMS Phase-II Tracker** — LUTZ FELD, WACLAW KARPINSKI, KATJA KLEIN, ●MARIUS PREUTEN, and MAX RAUCH — I. Physikalisches Institut B - RWTH Aachen

To prepare the CMS experiment for the High Luminosity LHC and its planned instantaneous luminosity of  $5 \cdot 10^{34} cm^{-2}s^{-1}$  the CMS Silicon Tracker will be replaced in the Long Shutdown 3 (around 2025). The new Tracker will comprise about 15000 conceptually new modules: Two identical vertically spaced silicon microstrip sensors are integrated into a single module and read out by the same front-end chip. The displacement of the hits between both sensors - caused by the bending of charged particle tracks within the 3.8 T magnetic field - can be used to infer a lower bound on the pT of the track within a single module. In order to satisfy the increased power demand of the new front-end electronics at minimal material budget an on-board DC-DC converter scheme was chosen. These converters, the high voltage circuit and the

electro-optical conversion are merged into a single PCB (Service Hybrid) and are an integral part of the new tracker modules. First full size module prototypes have been produced and are currently tested.

Results on the electrical performance during system tests including a Service Hybrid, will be presented in this talk.

## T 92: Strahlenschäden (gemeinsam mit HK)

Zeit: Mittwoch 16:45–19:00

Raum: F 234

T 92.1 Mi 16:45 F 234

**Proton-energy dependent damage to Si sensors** — ●ELENA DONEGANI, ECKHART FRETWURST, and ERIKA GARUTTI — University of Hamburg

Silicon bulk damage is the limiting factor of detector lifetime for future HL-LHC experiments. Nowadays, the knowledge of radiation-induced bulk defects and their effects on the sensor properties are especially limited after proton irradiation. Therefore, 200 $\mu$ m silicon pad-sensors (n- and p-type bulk materials; FTH, MC and dd-FZ) were irradiated with 23 MeV, 188 MeV and 23 GeV protons (with  $\Phi_{neq} \leq 3 \cdot 10^{14} \text{ cm}^{-2}$ ). I-V, C-V-f and TSC measurements were performed at subsequent annealing steps at 353K. In particular, the main experimental challenges will be addressed regarding the TSC filling temperature (at T=10K) and filling forward current ( $I \approx 1 \text{ mA}$ ). The TSC spectra are analyzed with a revisited SRH statistics, modified to account for defect clusters after hadron irradiation.

A proton-energy dependent introduction of defects is found, except for deep cluster-related defects. Shallow defects are present in different concentrations according to the material type. A correlation is notable between the leakage current and the concentrations of three deep defects (the V2, E5 and H(220K) defects). Other defects affect the space charge, with positive contributions from e.g. the E(30K) and BiOI defects, or negative contributions from deep acceptors (namely the H(116K), H(140K) and the H(152K)).

This information will be exploited as input for a physics-based and measurement-driven radiation damage model.

T 92.2 Mi 17:00 F 234

**X-ray dose and electric field dependence of oxide charges at the Si-SiO<sub>2</sub> interface of high-ohmic Si** — ●IOANNIS KOPSALIS, ECKHART FRETWURST, ERIKA GARUTTI, ROBERT KLANNER, and JOERN SCHWANDT — Institute for Experimental Physics, Hamburg University, Luruper Chaussee 149, D-22761 Hamburg, Germany

The surface radiation damage of the Si-SiO<sub>2</sub> system on high-ohmic Si has been investigated. Circular p- and n-MOSFETs biased to an electric field of about 500 kV/cm at the Si-SiO<sub>2</sub> interface, have been irradiated up to an X-ray dose of about 17 kGy(SiO<sub>2</sub>). From the measured drain-source current the change of oxide charge density during irradiation has been determined. Cycling the gate voltage before and after irradiation the oxide charge density  $N_{ox}$ , the interface traps  $N_{it}$  and the charging and discharging of border traps as function of X-ray dose and field direction has been determined. The study has been performed for two field directions at an electric field of 500 kV/cm, which according to TCAD simulations is the maximum field at the Si-SiO<sub>2</sub> interface in segmented sensors under normal operation.

The  $N_{ox}$  increases and decreases as function of dose depending on the field direction in the SiO<sub>2</sub>. An increase of  $N_{it}$  has been observed for all the conditions. The observations predict that the position dependence of the electric field at the Si-SiO<sub>2</sub> interface in segmented silicon sensors will result in a non-uniform oxide charge density due to surface damage. The results presented can be used to improve simulations of the surface radiation damage of silicon sensors.

T 92.3 Mi 17:15 F 234

**Studies of radiation field impact on microstrip sensors for the CBM Silicon Tracking System** — ●LEVENIA MOMOT<sup>1,2,3</sup>, OLGA BERTINI<sup>2</sup>, MAKSYM TEKLIHYN<sup>3,4</sup>, ANTON LYMANETS<sup>2,3</sup>, HANNA MALYGINA<sup>1,2,3</sup>, JOHANN HEUSER<sup>2</sup>, and CHRISTIAN STURM<sup>2</sup> for the CBM-Collaboration — <sup>1</sup>Goethe-Universität, Frankfurt — <sup>2</sup>GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — <sup>3</sup>KINR, Kyiv Institute for Nuclear Research, Kyiv, Ukraine — <sup>4</sup>FAIR, Facility for Antiproton and Ion Research, Darmstadt, Germany

The Silicon Tracking System (STS) is the main tracking detector of CBM experiment. Located in the dipole magnet, reconstructs tracks and determines momentum of charged particles originating from beam-target interactions. The response of double-sided silicon micro-strip

sensors to hits is very depended on the radiation load on the detector, which is expected to reach  $10^{14} \text{ 1 MeV } n_{eq}/\text{cm}^2$ . It is vital to maintain signal-to-noise ratio at the level of  $\approx 10$  to keep 98% hit reconstruction efficiency after irradiation up to the CBM lifetime dose. Results of testing newest prototypes of sensors from two different vendors to fluences between  $10^{13}$  and  $2 \times 10^{14} \text{ } n_{eq}/\text{cm}^2$  will be reviewed. Thus the total effect of the different radiation doses on the signal-to-noise ratio will be presented.

Supported by HIC for FAIR and HGS-HIRE.

T 92.4 Mi 17:30 F 234

**Characterization and calibration of radiation-damaged double-sided silicon strip detectors** — ●LEVENT KAYA<sup>1</sup>, ANDREAS VOGT<sup>1</sup>, PETER REITER<sup>1</sup>, BENEDIKT BIRKENBACH<sup>1</sup>, ROUVEN HIRSCH<sup>1</sup>, CHRISTIAN STAHL<sup>2</sup>, and NORBERT PIETRALLA<sup>2</sup> — <sup>1</sup>Institut für Kernphysik, Universität zu Köln — <sup>2</sup>Institut für Kernphysik, Technische Universität Darmstadt

Double-sided silicon strip detectors (DSSSD) are commonly used for event-by-event identification of charged particles as well as the reconstruction of particle trajectories in nuclear physics experiments with stable and radioactive beams. Individual pixel segments are given by intersecting areas of both p- and n-doped front- and backside segments resulting in a high detector granularity. Typically, charged particles do not homogeneously illuminate the detector surface during in-beam experiments. Consequently, radiation damages of the detector are distributed non-uniformly. Position-dependent incomplete charge collection due to radiation damage limits the performance and lifetime of the detectors; the response of different channels may vary drastically. Position-resolved charge-collection losses for front- and back-side segments were investigated for an in-beam experiment and by performing radioactive source measurements. A novel position-resolved calibration method for radiation-damaged DSSSDs, based on mutual consistency of p-side and n-side charges, was developed. It yields a significant enhancement of the energy resolution and the performance of radiation-damaged parts of the detector. Supported by Bonn-Cologne Graduate School for Physics and Astronomy (BCGS).

T 92.5 Mi 17:45 F 234

**Applikations- und Bestrahlungsstudien für die Wire-Bond-Enkapsulierung in zukünftigen Siliziumsensormodulen des CMS Spurdetektors** — TOBIAS BARVICH, FELIX BOEGELSBACHER, ALEXANDER DIERLAMM, ●STEFAN MAIER und PIA STECK — Institut für Experimentelle Kernphysik (IEKP), KIT

Für das Phase-II-Upgrade des CMS-Spurdetektors werden sowohl Siliziumpixel-, als auch Streifensensoren in einer Modulbauweise eingesetzt. Die Wire-Bond-Verbindungen zwischen Siliziumsensoren und Auslesechips sollen hierbei durch eine Einkapsulierung geschützt werden. Neben den herkömmlichen Voraussetzungen wie Temperaturbeständigkeit, hohe Strahlungslänge und Strahlenhärte muss das verwendete Material die richtige Viskosität besitzen. Diese muss in einem Bereich liegen der einerseits ein leichtes Benetzen der Bonddrähte ermöglicht, andererseits aber ein Verlaufen auf darunter liegende Modulkomponenten verhindert. Am Karlsruher Institut für Technologie wird mit Hilfe eines selbst entwickelten halbautomatischen Roboters die Applikation und Eigenschaften der Materialien untersucht. Der Vortrag gibt Einblicke in eine Auswahl an Materialien, deren Eigenschaften und Applikationsmöglichkeiten.

T 92.6 Mi 18:00 F 234

**Dark Current of Neutron Irradiated SiPMs** — ●SVENJA NADINE SONDER<sup>1</sup>, MATTEO CENTIS VIGNALI<sup>1,2</sup>, ERIKA GARUTTI<sup>1</sup>, ROBERT KLANNER<sup>1</sup>, and JÖRN SCHWANDT<sup>1</sup> — <sup>1</sup>Institut für Experimentalphysik, Universität Hamburg, Germany — <sup>2</sup>CERN, Geneva, Switzerland

Silicon photomultipliers (SiPMs) have become popular as photon detectors in high-energy physics and many other fields due to their excellent performance. One major limitation, especially for the use in

colliders, is the radiation damage by hadrons. In this talk, SiPMs with 3484 pixels of  $15 \times 15 \mu\text{m}^2$  produced by the company KETEK have been irradiated with reactor neutrons to different fluences up to  $10^{12} \text{ n}_{\text{eq}}/\text{cm}^2$  (1 MeV equivalent neutrons). Current-voltage measurements have been performed at different temperatures between  $-30^\circ\text{C}$  and  $+30^\circ\text{C}$ . To better understand the generation of the dark current, parameters like the breakdown voltage and the activation energy given by the Arrhenius model have been investigated. A parameterization, which describes the temperature and dose dependence of the current-voltage results within 5%, is presented.

T 92.7 Mi 18:15 F 234

**Study of GEM ageing effects for the ALICE TPC Upgrade** — ●MICHAEL JUNG<sup>1</sup>, HARALD APPELSHÄUSER<sup>1</sup>, CHILO GARABADOS<sup>2</sup>, and RENATO NEGRAO DE OLIVEIRA<sup>3</sup> for the ALICE-Collaboration — <sup>1</sup>IKF - Goethe-Universität Frankfurt — <sup>2</sup>GSI - Helmholtzzentrum für Schwerionenforschung — <sup>3</sup>Universidade de Sao Paulo

Long-term measurements with a quadruple stack of Gas Electron Multipliers (GEMs) at relatively high gain (about 15,000) were performed to investigate the ageing effects of GEMs in Ar-CO<sub>2</sub> (70-30). The GEM stack was irradiated with a high-rate <sup>55</sup>Fe source to simulate the dose of the upgraded ALICE Time Projection Chamber (TPC) at the LHC during RUN3 with a Pb-Pb interaction rate of about 50 kHz. Also the outgassing effects of different materials, such as Vetronite, Araldite 2011 and Polyamide on the energy resolution and the gain were studied. During all measurements the temperature and the ambient pressure were measured to discriminate between a change of the environment conditions and a degradation of the detector properties. One phenomenon observed was that the kapton in the GEM holes was etched, so that the double conical shape of the holes got lost.

T 92.8 Mi 18:30 F 234

**Radiation Tolerance of a Fully Depleted CMOS Monolithic Active Pixel Sensor** — ●TOBIAS BUS, MICHAEL DEVEAUX, and BENJAMIN LINNIK for the CBM-MVD-Collaboration — Goethe-Universität Frankfurt

CMOS Monolithic Active Pixel Sensors (MAPS) are considered as the technology of choice for the micro vertex detector (MVD) of the CBM experiment. We aim to adapt the radiation tolerance of the technology to the needs of CBM.

The tolerance of MAPS to non-ionizing radiation damage can be improved by means of depleting the active volume of the sensors. This technologically difficult approach could be realized with a novel sensor prototype named Pipper-2. The tolerance of this prototype to non-ionizing radiation hardness of the sensors was tested for doses of up to  $5 \cdot 10^{14} \frac{\text{n}_{\text{eq}}}{\text{cm}^2}$ . First results of the test will be shown and discussed.

\*This work has been supported by BMBF (05P15RFFC1), GSI and HIC for FAIR.

T 92.9 Mi 18:45 F 234

**Einsatzmöglichkeiten von synthetischem Graphit in zukünftigen Spurdetektoren** — TOBIAS BARVICH, CONNY BESKIDT, WIM DE BOER, ALEXANDER DIERLAMM und ●STEFAN MAIER — Institut für Experimentelle Kernphysik (IEKP), KIT

Die Anforderungen an die verwendeten Materialien in zukünftige Spurdetektoren wie dem des CMS Phase-II-Upgrades sind sehr hoch. Die Verwendung von synthetischem Graphit in Form von Klebefolien hätten in solchen Experimenten viele Vorteile. Es ermöglicht einen präzisen und leichten Bau während es gleichzeitig mit seiner hohen Wärmeleitfähigkeit für die Kühlung der Komponenten sorgt. Mit einer PET Schutzschicht ist es zusätzlich als elektrische Isolation zwischen Hochspannungspotentialen geeignet. Am Karlsruher Institut für Technologie werden die Eigenschaften und Einsatzmöglichkeiten des Materials untersucht. Der Vortrag gibt Einblicke in Simulationen und Tests mit synthetischem Graphit.

## T 93: Detektorsysteme 3 (Kalorimeter, Myonsysteme)

Zeit: Mittwoch 16:45–19:00

Raum: JUR 372

T 93.1 Mi 16:45 JUR 372

**Monte Carlo Simulations and Investigation of the Muon-induced Background of the DLB** — ●MARCEL GERHARDT, CLAUS GÖSSLING, KEVIN KRÖNINGER, and CHRISTIAN NITSCH — TU Dortmund, Physik EIV, D-44221 Dortmund

The Dortmund Low Background Facility (DLB) is a low-background gamma-ray spectrometry system built at ground level. It uses a high-purity germanium detector with a relative efficiency of 60%, which is set up within an artificial overburden. This overburden consists of a massive outer shielding made of barite concrete and cast iron, corresponding to ten meters of water equivalent. It houses a multi-layer lead castle to shield against environmental radioactivities and uses borated polyethylene as a neutron absorber. Additionally, an active muon veto is installed to reduce the cosmic-induced muon contributions to the spectrum.

The remarkably low background level of the DLB allows radio-purity screening measurements for material preselection and the detection of radionuclides with short half-lives for activation analysis, with sensitivities well below the Bq/kg-level, which is comparable to laboratories located underground.

In this talk the recently completed muon veto of the DLB is presented and estimations of the influence of the residual muonic contribution to the background spectrum using Monte Carlo simulations are given. These are most likely induced by the inefficiency of the used thin plastic scintillators. Therefore, most of them will be replaced by thicker plastic scintillators with a larger sensitive area.

T 93.2 Mi 17:00 JUR 372

**Analysis of CERN 2015 Test Beam data of the CALICE Analog Hadronic Calorimeter technological prototype** — ●AMBRA PROVENZA for the CALICE-D-Collaboration — DESY — Hamburg University

The goal of the CALICE Collaboration is to develop calorimeters for a future  $e^+e^-$  linear collider.

The Analog Hadronic Calorimeter (AHCAL) is a high granularity calorimeter, developed to use the Particle Flow method, to reach a

good jet energy resolution. The AHCAL technological prototype, scalable to a full collider detector, is composed of  $3 \times 3 \text{ cm}^2$  scintillator tiles read out by Silicon Photomultipliers.

During the year 2015 two periods of test beams at CERN have been performed, to validate the detector calibration with muon and electron beams and to study the shower evolution with hadron beams. In fact a very important and new feature of this prototype is the possibility to have time information of the hits in the detector. The talk will start with an overview of the AHCAL technological prototype and its development.

It will then focus on the analysis of the test beam data taken at CERN with a steel absorber structure. In particular a detailed look into the electrons data will be presented. Due to the well known physics of electromagnetic showers, this analysis allows us to understand the behaviour and the performance of the prototype.

This analysis will also allow the validation of the prototype implementation in the Monte Carlo simulation.

T 93.3 Mi 17:15 JUR 372

**Time Measurements with the CALICE Analog Hadronic Calorimeter** — ●CHRISTIAN GRAF for the CALICE-D-Collaboration — Max-Planck-Institut für Physik, München, Deutschland

The Particle Flow concept (PFA) gives a possibility to enhance the jet energy resolution of multi purpose detectors at future  $e^+e^-$  colliders as ILC or CLIC. One requirement for a detector that is optimized for the Particle Flow approach is a calorimeter with a high spatial resolution.

The CALICE Collaboration is developing concepts of highly granular calorimeters. For this purpose, prototypes with different technologies are designed and investigated in various test-beam campaigns. One of these detector concepts is the Analog Hadronic Calorimeter (AHCAL), which is based on scintillators and Silicon Photomultipliers. The signals are processed by an ASIC that provides the signal amplitude as well as a time measurement. The time information may help to improve the performance of the Particle Flow algorithm, enhance the energy reconstruction and reduce the background. Furthermore, the time structure of hadronic showers can be investigated.



This talk presents an analysis of the time measurements taken in a test-beam run at CERN. Emphasize will be put on the time calibration.

T 93.4 Mi 17:30 JUR 372

**Myonen nahe an Jets - Nachweiseffizienz und Unterdrückung von Untergrund durch Sekundärzerfälle am ATLAS-Detektor im LHC-Run-2** — ●JOHANNES JUNGGEURTH, NICOLAS KÖHLER, HUBERT KROHA und OLIVER KORTNER — Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München

Endzustände mit kollimierten Jets und Myonen sind bei vielen Suchen nach neuer Physik jenseits des Standardmodells ein charakteristisches Element des Endzustandes. Für diese Analysen ist eine genaue Kenntnis der Nachweiseffizienz von Myonen nahe an Jets erforderlich. Da bei der Selektion oftmals die Kriterien an die Isolierung der Objekte abgeschwächt werden, um die Akzeptanz nicht zu verringern, können Untergrundbeiträge von  $B$ -,  $K$ - oder  $\pi$ -Meson Zerfällen nicht mehr vernachlässigt werden. Um diesen Untergrund zu minimieren werden die Stoßparameter als diskriminierende Variablen verwendet. Der Vortrag diskutiert sowohl die Messung der Nachweiseffizienz von Myonen nahe an Jets als auch die Messung der Effizienz der Schnitte auf die Stoßparameterigenschaften mit Hilfe einer *Tag&Probe*-Messung.

T 93.5 Mi 17:45 JUR 372

**Hadronic energy reconstruction in the CALICE combined calorimeter** — ●YASMINE ISRAELI for the CALICE-D-Collaboration — Max Planck Institute for Physics, Munich, Germany

The CALICE collaboration develops high granularity calorimeters for future linear electron-positron colliders, ILC and CLIC. These calorimeters aim at detailed reconstruction of the beam interaction final states.

A prototype consisting of three sampling calorimeters, a SiW electromagnetic calorimeter, a scintillator steel hadronic calorimeter and a tail catcher, was tested with hadronic beams at CERN as well as at Fermilab. Due to the sub detectors different geometry, three different calibration factors are being used for the energy reconstruction. These factors are obtained via the use of a  $\chi^2$  minimization on data. Furthermore, in order to improve the calorimeter energy and to compensate for the different energy deposit of hadronic and electromagnetic showers resolution, software compensation methods are implemented. This contribution presents the energy reconstruction and resolution for the full calorimeter system with and without software compensation.

T 93.6 Mi 18:00 JUR 372

**Performance tests of GEM chambers for the CMS detector at CERN** — ●HENNING KELLER, THOMAS HEBBEKER, CARSTEN HEIDEMANN, and KERSTIN HOEPFNER — III. Physikalisches Institut A, RWTH Aachen University

Gas electron multiplier detectors (GEMs) belong to the category of Micro-Pattern Gas Detectors. They are part of the foreseen upgrade of the CMS muon system targeting the high-luminosity phase of the LHC. In the forward region, large-area GEM chambers will be installed in order to be able to handle high particle rates and increase the geometrical acceptance for physics searches. A special challenge concerning the chamber production is the necessary large (square meter) size to be fabricated with high uniformity and efficiency. Before integration into CMS, the performance parameters of the GEM chambers have to be verified by undergoing several tests. One of the sites performing these tests is located at Aachen. This talk gives an introduction of the design of GEM detectors and discusses the status and results of the performance tests.

T 93.7 Mi 18:15 JUR 372

**Betrachtung von Elektronenschauern in einem Hadronen-Kalorimeter-Prototypen für einen zukünftigen Linearbeschleuniger** — ●ANNA ROSMANITZ für die CALICE-D-Kollaboration — Institut für Physik, Johannes Gutenberg-Universität Mainz

Die CALICE-Kollaboration entwickelt Kalorimeter für zukünftige Linearbeschleuniger wie das ILC. Diese Kalorimeter sollen möglichst hochgranular sein, um die Anwendung von Particle Flow Algorithmen zu ermöglichen und so die Rekonstruktion von Jets und die Identifikation einzelner Teilchen zu verbessern. Im ILC sollen Elektronen und Positronen in Trains von 1 ms beschleunigt werden, die von strahllosen Zeiten von 199 ns unterbrochen werden. Deswegen soll auch das Auslesesystem nicht durchgängig betrieben werden, sondern es soll das sogenannte Powerpulsing verwendet werden, bei dem nicht benötigte Komponenten des Detektors auf inaktiv geschaltet werden. Dadurch können z.B. die Kühlsysteme und der Energieverbrauch im Detektor minimiert werden.

Ein von CALICE entwickelter hadronischer Kalorimeterprototyp wurde 2016 erstmals in einem Testbeam am DESY mit Elektronenstrahlen unterschiedlicher Energien mit Powerpulsing verwendet. In diesem Vortrag wird die Analyse dieser Daten vorgestellt, wobei die Schauerform und der Einfluss des Powerpulsing untersucht werden.

T 93.8 Mi 18:30 JUR 372

**Test and Installation of New sMDT Chambers in the ATLAS Muon Spectrometer** — ●ERIC TAKASUGI, KORBINIAN SCHMIDT-SOMMERFELD, OLIVER KORTNER, and HUBERT KROHA — Max-Planck-Institut für Physik, München, Deutschland

In the ATLAS muon spectrometer, Monitored Drift Tube chambers (MDTs) are used for precise tracking measurements. In order to increase the geometric acceptance and rate capability, new chambers were designed and constructed in Munich, then installed in ATLAS over the past few months. The new chambers have a drift tube diameter of 15 mm (compared to 30 mm of the other MDTs) and are therefore called sMDT chambers. This presentation reports on the results of quality assurance tests both during and after construction, as well as the commissioning and installation of the chambers at the ATLAS detector.

T 93.9 Mi 18:45 JUR 372

**Light yield characterization of single channels for the AHCAL** — ●SAIVA HUCK for the CALICE-D-Collaboration — Universität Hamburg

The light yield of the active single channels for the Analog Hadron Calorimeter (AHCAL) was characterized and compared.

The AHCAL is a highly granular prototype hadron calorimeter with 8 million single channels designed by the collaboration Calorimeter for Linear Collider Experiment (CALICE) for the International Linear Collider (ILC). One channel consists of a  $29.60 \times 29.60 \times 2.98 \text{ mm}^3$  plastic scintillator tile which is wrapped in reflective material and read out via a Silicon Photomultiplier (SiPM).

The light yield of scintillator tiles from different producers, wrapped in different materials and read out by SiPMs from 3 producers was measured as function of SiPM voltage using electrons from a  $^{90}\text{Sr}$  source at the Institute for Experimental Physics of the University of Hamburg. The results were evaluated with respect to the requirements of the ILC.

A number of combinations were found which fulfill the light yield goal of the CALICE collaboration and can be used in the AHCAL prototype.

## T 94: Pixeldetektoren 4

Zeit: Mittwoch 16:45–19:05

Raum: VSH 116

T 94.1 Mi 16:45 VSH 116

**Gated mode operation of large DEPFET pixel modules for the Belle II Pixel Detector** — ●FELIX MÜLLER<sup>1</sup>, CHRISTIAN KIESLING<sup>1</sup>, PHILIPP PHILIPP<sup>1</sup>, HANS-GÜNTHER MOSER<sup>1</sup>, LADISLAV ANDRICEK<sup>2</sup>, CHRISTIAN KOFFMANE<sup>2</sup>, JELENA NINKOVIC<sup>2</sup>, RAINER RICHTER<sup>2</sup>, and ANDREAS WASSATSCH<sup>2</sup> for the Belle II-Collaboration — <sup>1</sup>Max-Planck-Institut für Physik, München — <sup>2</sup>Halbleiterlabor der

Max-Planck-Gesellschaft, München

DEPFET pixel detectors offer excellent signal to noise ratio, resolution and low power consumption with very little material budget. They will be used at Belle II and are a candidate for an ILC vertex detector. The modules were fully characterized and the operation voltages and control sequences of the ASICs were investigated and optimized.

Due to the rolling shutter read-out the DEPFET modules have integra-



tion times in the order of  $20\,\mu\text{s}$ , which can create problems in applications with temporary high background at SuperKEKB, e.g. during the top-up injection of bunches which will create large backgrounds every ten microseconds for about a few ms. In order to get rid of this background, we study a new operation mode, which allows a gated or shutter controlled operation of the detector. This operation mode makes the detector blind for short time interval of about 1 microsecond in which background is expected to pass the detector, whereas the charge of the previous signals will not be removed. Simulations and successful lab tests with large DEPFET matrices will be presented.

T 94.2 Mi 17:00 VSH 116

**Charge calibration for the read-out chip of the ATLAS Insertable B-Layer** — JOERN GROSSE-KNETTER, ARNULF QUADT, and ●PAOLO SABATINI — II. Physikalisches Institut, Georg-August-Universität Göttingen

The Insertable B-Layer (IBL) is the innermost layer of the ATLAS Pixel detector, composed of 14 staves located around the beam pipe at a distance of about 33 mm, hosting about 12 million hybrid-silicon pixels. A new generation of Front End chips (FE-I4) was developed exclusively for this component, in order to sustain the challenging hit rate and radiation dose. The insertion of this layer improves the performance on secondary vertex recognition (b-tagging) maintaining the total material budget of the detector low.

Being the innermost layer requires a high position resolution, which is improved by algorithms exploiting the measured charge in each pixel of the cluster induced by a crossing particle. This information is obtained, for each pixel, by measuring the Time-over-Threshold (ToT) of the measured signal, expected to be proportional to the deposited charge. That makes the ToT-to-charge calibration important for track position reconstruction and it requires an automatic test and tuning procedure, aimed to ensure the correct charge measurement for each pixel of the detector. This calibration, performed via on-chip charge injection, depends on two conversion factors known to limited precision from wafer probing. New improved calibration ideas based on production and operation data will be presented.

T 94.3 Mi 17:15 VSH 116

**Charakterisierung finaler Demonstrationsmodule für den Belle II-Pixelvertexdetektor** — JOCHEN DINGFELDER, LEONARD GERMIC, HANS KRÜGER, ●BARBARA LEIBROCK, FLORIAN LÜTTICKE, CARLOS MARINAS, BOTHO PASCHEN und NORBERT WERMES für die Belle II-Kollaboration — Universität Bonn, Physikalisches Institut

Im Jahr 2017 wird die Aufrüstung des KEKB-Beschleunigers in Japan fertiggestellt werden. SuperKEKB wird asymmetrische e+e-Kollisionen bei etwa 40-mal höherer Luminosität liefern. Um die höhere Ereignisrate ausnutzen zu können, wird derzeit ein Upgrade des Belle-Detektors zu Belle II durchgeführt. Als wichtiger Teil des Detektor-Upgrades wird ein neuer zweilagiger, auf DEPFET-Technologie basierender Pixeldetektor als innerster Subdetektor hinzugefügt. Die DEPFET-Pixelmatrix besteht aus p-FETs mit einem zusätzlichen internen Gate und vollständig verarmtem Siliziumbulk. Die im Sensor generierten Elektronen driften ins interne Gate und modulieren den Transistorstrom. Die Transistorströme der Pixel werden mit Hilfe des Drain Current Digitizer (DCD) Chips ausgelesen und in digitale Signale umgewandelt. Diese werden im Data Handling Processor (DHP) Chip weiterverarbeitet, in dem eine erste Datenreduktion vorgenommen wird. Um die zuverlässige Zusammenarbeit der unterschiedlichen Komponenten zu gewährleisten, werden sie zunächst mit Demonstrationsmodulen getestet, die ein funktional vollständiges Matrix- und Komponentensystem enthalten. In diesem Vortrag werden Messungen zur systematischen Charakterisierung und Optimierung der aktuellen Version der Demonstrationsmodule vorgestellt.

T 94.4 Mi 17:30 VSH 116

**Pixel Readout Chip for ATLAS HL-LHC Hybrid Pixels in 65nm CMOS Technology** — TOMASZ HEMPEREK, TETSUICHI KISHISHITA, HANS KRÜGER, ●PIOTR RYMASZEWSKI, MARCO VOGT, TIANYANG WANG, and NORBERT WERMES — University of Bonn, Bonn, Germany

The LHC High Luminosity upgrade will result in a significant change of environment in which particle detectors are going to operate, especially for devices very close to the interaction point like pixel detector electronics. Due to similar requirements in terms of pixel size ( $50\,\mu\text{m} \times 50\,\mu\text{m}$ ), hit rate ( $3 \frac{\text{GHz}}{\text{cm}^2}$ ), and radiation tolerance (500Mrad) ATLAS and CMS are developing together a pixel readout chip in 65nm CMOS technology to cope with this challenge. This collaboration,

named RD53, started in 2013 and is now close to submitting a first large scale prototype. In this talk the chip overview will be presented, which includes the design flow, read-out concept and the development of specialized IP blocks. Issues arising from the very high radiation tolerance requirement will be discussed. A large focus will be given to the parts designed by our group.

T 94.5 Mi 17:45 VSH 116

**FE65-P2: A prototype pixel readout chip in 65nm technology for HL-LHC upgrades** — REBECCA CARNEY<sup>2</sup>, MARKUS CRISTINZIANI<sup>1</sup>, MAURICIO GARCIA-SCIVERES<sup>2</sup>, DARIO GNANI<sup>2</sup>, ●CARLO ALBERTO GOTTARDO<sup>1</sup>, TIMON HEIM<sup>2</sup>, TOMASZ HEMPEREK<sup>1</sup>, LASHKAR KASHIF<sup>3</sup>, HANS KRÜGER<sup>1</sup>, ABDERREZAK MEKKAOU<sup>2</sup>, VERONICA WALLAGEN<sup>2</sup>, and NORBERT WERMES<sup>1</sup> — <sup>1</sup>Physikalisches Institut, Universität Bonn — <sup>2</sup>Lawrence Berkeley National Lab, Berkeley, CA, USA — <sup>3</sup>University of Wisconsin-Madison, Madison, WI, USA

The High-Lumi LHC upgrade of the trackers of the ATLAS and CMS experiments is a challenging benchmark for silicon detector technology. High rate, radiation hardness, low noise and low power consumption are the main concerns the detector design has to deal with.

The FE65-P2 pixel readout test chip has been developed by the RD53 collaboration with the goal of demonstrating small ( $50\,\mu\text{m}$  pitch) pixel performance and validating its layout scheme in 65 nm technology. The layout design, dubbed "analog island in a digital sea" is characterized by analog front-end blocks shared by four pixels and surrounded by synthesized digital logic and it nominally operates down to a threshold of 500 electrons.

A description of the readout chip and total ionizing dose (TID) radiation hardness test will be presented.

Several parameters of the chip have been measured during x-ray irradiation up to a dose of 45 Mrad showing both expected and unexpected features.

T 94.6 Mi 18:00 VSH 116

**65 nm Pixel Readout-Chip Verification and Characterization Environment for the High-Luminosity Upgrade of the ATLAS Detector within the RD53 Collaboration** — VIACHESLAV FILIMONOV, TOMASZ HEMPEREK, FABIAN HÜGGING, JENS JANSSEN, HANS KRÜGER, DAVID-LEON POHL, PIOTR RYMASZEWSKI, ●MARCO VOGT, JOCHEN DINGFELDER, and NORBERT WERMES — Physikalisches Institut der Universität Bonn

With the LHC High Luminosity upgrade, multiple new challenges will arise for the involved particle detector systems.

Due to significantly increased hit rates, new readout chips with highly complex digital architectures will have to deliver drastically increased data rates and ensure unprecedented radiation tolerance, especially close to the interaction point.

The collaboration "RD53" was formed to approach these challenges, by designing a pixel readout chip in a 65 nm CMOS process, suitable for the inner layers of both the ATLAS and the CMS experiment.

In order to verify the digital design and to characterize the prototype chips, a test and data acquisition environment consisting of software frameworks and custom hardware is currently being developed in Bonn. One important aspect is the ability to use the same Verilog/Python framework for the hardware as well as during the design verification process.

The concept and status of this test environment will be presented, as well as a summary about the new hybrid pixel readout chip.

T 94.7 Mi 18:15 VSH 116

**Characterization of readout circuitry in a demonstrator chip of depleted CMOS active sensors** — ●TOKO HIRONO, TOMASZ HEMPEREK, FABIAN HÜGGING, PIOTR RYMASZEWSKI, TIANYANG WANG, and NORBERT WERMES — Physikalisches Institut, Universität Bonn

Depleted CMOS active sensors (DMAPS) in commercial multi-well CMOS technologies are an attractive detector choice for high-energy particle physics experiments, such as in the ATLAS High Luminosity Large Hadron Collider (HL-LHC). Since charge collection by drift is mandatory for such a harsh radiation environment, the application of high bias voltage to high resistive sensor material is needed. A demonstrator of a DMAPS (LFCPIX) has been fabricated in LFoundry 150nm CMOS process on a substrate with a resistivity of  $>2\,\text{k}\Omega\cdot\text{cm}$ . The chip size is  $10\,\text{mm} \times 10\,\text{mm}$  and the pixel size is  $50\,\mu\text{m} \times 250\,\mu\text{m}$ . ATLAS HL-LHC requires high time resolution of 25 ns and a total ionizing dose (TID) for the outer layers of ATLAS pixel detector is estimated as high as 50 Mrad. Ten flavors of readout circuitry

are implemented in LFCPIX to investigate the timing performances and the radiation hardness. In the presentation, the characteristics of each readout flavors measured with electrical test pulses, radio active sources and 2.5 GeV electron beam will be shown.

**Gruppenbericht** T 94.8 Mi 18:30 VSH 116

**A Thin Silicon Pixel Tracker for the Mu3e Experiment** — ●ADRIAN HERKERT for the Mu3e-Collaboration — Physikalisches Institut Heidelberg

The Mu3e experiment will search for the charged lepton flavor violating decay  $\mu \rightarrow eee$ , which is suppressed to unobservable levels in the Standard Model. The aim is to either discover it, which would be a clear sign of new physics, or to exclude it above a branching ratio of  $10^{-16}$  at 90% CL. To achieve that, the world's highest intensity muon beam is required, which will be available at the Paul Scherrer Institute (PSI) in Switzerland. The experiment is based on low energy muons being stopped on a target and decaying at rest, which results in decay electrons with energies  $\leq 53$  MeV. Backgrounds can be suppressed by very precise momentum, vertex and timing measurements. Due to the electrons' low energies, the vertex and momentum resolution are dominated by multiple scattering, which makes a low material budget in the active detector region crucial for the experiment. The other basic requirement is the capability of dealing with muon decay rates of about  $10^9 \frac{1}{s}$ . A barrel shaped detector system has been designed which consists of four layers of high-voltage monolithic active pixel sensors (HV-MAPS) in a 1T solenoid magnet for tracking and a combination of scintillating fibers and tiles for additional timing measurements.

After a general overview of the Mu3e experiment, this talk will focus on the pixel tracker including the sensors, readout scheme, mechanics and cooling. Performance results of the last sensor prototype, the MuPix7, will be presented.

T 94.9 Mi 18:50 VSH 116

**Readout of the Mu3e pixel detector** — ●SEBASTIAN DITTMEIER for the Mu3e-Collaboration — Physikalisches Institut, Universität Heidelberg

The Mu3e experiment searches for the charged lepton flavor violating decay  $\mu^+ \rightarrow e^+e^-e^+$  with a target sensitivity of one in  $10^{16}$  decays. The Mu3e detector consists of an ultra-thin silicon pixel tracking detector using the HV-MAPS (High Voltage Monolithic Active Pixel Sensor) technology to measure the momentum of the decay products, and scintillating fibres and tiles for precise timing.

This talk covers the readout components of the pixel detector. The pixel sensors send their hit information untriggered via fast serial data links to FPGAs located on the frontend boards where the data is time sorted. Via fast optical links, this data is sent to the switching boards where the data from several detector segments is merged into time slices of the full detector and provided to the computing nodes that perform online event reconstruction and filtering based on graphics processing units.

A prototype of the frontend board including the FPGA and optical transceivers has been produced and evaluated. Results of these studies will be presented.

## T 95: Pixeldetektoren 5

Zeit: Mittwoch 16:45–18:50

Raum: S 2

**Gruppenbericht** T 95.1 Mi 16:45 S 2

**Die Belle II Software** — ●MARTIN RITTER und THOMAS KUHR für die Belle II-Kollaboration — Ludwig-Maximilians-Universität München

Belle II ist ein B-Fabrik-Experiment, das 50-mal mehr Daten aufzeichnen wird als das Vorgängerexperiment Belle. Der durch die hohe Luminosität des SuperKEKB-Beschleunigers verursachte Okkupanzgrad erfordert grundlegende Verbesserungen des Detektors. Konsequenterweise müssen auch Simulations-, Rekonstruktions- und Analysesoftware tiefgreifend überarbeitet werden. Der größte Teil der Software wurde von Grund auf neu entwickelt, um Erfahrungen von Belle und anderen Experimenten sowie neue Technologien einfließen lassen zu können. Die erwartete große Menge an gemessenen und simulierten Ereignissen erfordert ein sehr hohes Maß an Zuverlässigkeit und Reproduzierbarkeit. Verschiedene Technologien, Werkzeuge und organisatorische Maßnahmen werden eingesetzt, um die Leistungsfähigkeit der Software während der Entwicklung zu bestimmen und überwachen.

T 95.2 Mi 17:05 S 2

**Precision Luminosity of LHC Proton-Proton Collisions at 13 TeV Using Hit-Counting with TPX Pixel Devices** — ●ANDRE SOPCZAK<sup>1</sup>, BABAR ALI<sup>1</sup>, THANAWAT ASAWATAVONVANICH<sup>1</sup>, JAKUB BEGERA<sup>1</sup>, BENEDIKT BERGMANN<sup>1</sup>, THOMAS BILLOUD<sup>2</sup>, PETR BURIAN<sup>1</sup>, DAVIDE CAFORIO<sup>1</sup>, IVAN CAICEDO<sup>1</sup>, ERIK HEIJNE<sup>1</sup>, JOSEF JANECEK<sup>1</sup>, CLAUDE LEROY<sup>2</sup>, PETR MANEK<sup>1</sup>, KAZUYA MOCHIZUKI<sup>2</sup>, YESID MORA<sup>1</sup>, JOSEF PACIK<sup>1</sup>, COSTA PAPADATOS<sup>2</sup>, MICHAL PLATKEVIC<sup>1</sup>, STEPAN POLANSKY<sup>1</sup>, STANISLAV POSPISIL<sup>1</sup>, MICHAL SUK<sup>1</sup>, and ZDENEK SVOBODA<sup>1</sup> — <sup>1</sup>IEAP CTU in Prague — <sup>2</sup>University of Montreal

A network of Timepix (TPX) devices installed in the ATLAS cavern measures the LHC luminosity as a function of time as a stand-alone system. The data were recorded from 13 TeV proton-proton collisions in 2015. Using two TPX devices, the number of hits created by particles passing the pixel matrices was counted. A van der Meer scan of the LHC beams was analysed using bunch-integrated luminosity averages over the different bunch profiles for an approximate absolute luminosity normalization. It is demonstrated that the TPX network has the capability to measure the reduction of LHC luminosity with precision. Comparative studies were performed among four sensors (two sensors in each TPX device) and the relative short-term precision of the luminosity measurement was determined to be 0.1% for 10s time intervals. The internal long-term time stability of the measurements was below

0.5% for the data-taking period.

T 95.3 Mi 17:20 S 2

**Test beam results of ATLAS DBM pCVD diamond detectors using a novel threshold tuning method** — ●JENS JANSSEN, FABIAN HÜGGING, DAVID-LEON POHL, and NORBERT WERMES — Physikalisches Institut, Universität Bonn

The ATLAS Diamond Beam Monitor (DBM) is the first diamond pixel tracking detector in a high-energy physics experiment. The test beam data, which was taken at the CERN SPS with a 120 GeV/c pion beam in 2015/2016, covers a large active area of polycrystalline chemical vapour deposited (pCVD) diamond. A novel threshold tuning method was developed and tested which is based on counting noise hits and allows for tuning to very low thresholds. Efficiency measurements show the advantage of the novel threshold tuning method.

T 95.4 Mi 17:35 S 2

**Implementation of radiation damage into CMS Phase II Tracker Digitizer** — ●CAROLINE NIEMEYER, ERIKA GARUTTI, and ADRIAN PERIEANU — Institute of Experimental Physics, University of Hamburg

The present simulation of the CMS pixel detector has been developed using test beam data from non-irradiated sensors. It assumes 100 percent charge collection and takes into account charge diffusion and the Lorentz angle. Radiation damage is simulated by just scaling the signal height by a fluence dependent charge-collection efficiency. From the analysis of the Pixel Phase I test beam data it is expected however that irradiation causes charge sharing between neighboring pixels, leading to a larger cluster size and possibly affecting the hit resolution, which needs to be considered to achieve a realistic description of the signal and noise in the CMS pixel detector during the High Luminosity LHC period. This knowledge has to be implemented into the Digitizer package of the CMS software in order to parametrize the response of the Phase II Pixel upgrade to a higher granular level. The status of this new radiation damage implementation in the CMS Digitizer is presented.

T 95.5 Mi 17:50 S 2

**A Scintillating Fibre Detector for Radiation Therapy** — ●LUKAS RENNER — Universität Heidelberg, Heidelberg, Deutschland

A prototype detector using plastic scintillating fibres for monitoring the position, width and intensity of proton and ion beams at the

Heidelberg Ionenstrahl Therapiezentrum (HIT) is presented. The requirements are a position resolution better than 0.200 mm in two dimensions, with an integration time less than 200 microseconds and a minimal deadtime. Additionally there are constraints on the material budget to reduce multiple scattering. The prototype detector consists of two planes of scintillating fibers with 0.250 mm diameter that have been arranged into ribbons of six layers. The optical signal is readout with Hamamatsu S11865-64 photodiode arrays. We will report on results of test beam measurements using protons, helium, carbon and oxygen ions with energies ranging between 48 MeV/u and 430 MeV/u and intensities from 2E6 particles/s up to 2E9 particles/s, depending on the particle species.

T 95.6 Mi 18:05 S 2

**Testbeam-Analysen für unbestrahlte Pixelsensoren** — SILKE ALTENHEINER<sup>1</sup>, KAROLA DETTE<sup>1,2</sup>, SASCHA DUNGS<sup>1</sup>, ANDREAS GISEN<sup>1</sup>, CLAUD GÖSSLING<sup>1</sup>, MARIUS GROTHE<sup>1</sup>, REINER KLINGENBERG<sup>1</sup>, KEVIN KRÖNINGER<sup>1</sup>, ●RAPHAEL MICHALLEK<sup>1</sup> und MAREIKE WEERS<sup>1</sup> — <sup>1</sup>TU Dortmund, Experimentelle Physik IV — <sup>2</sup>CERN

Die innersten Pixeldetektoren des ATLAS-Experiments sind aufgrund der Luminosität des LHCs einer hohen Strahlenbelastung ausgesetzt. Diese führt zu Schäden in der Gitterstruktur des Halbleitermaterials der Sensoren, wodurch deren Detektionseffizienz über die Betriebsdauer herabgesetzt wird. Die Auswirkungen dieser Schäden auf die Detektionseigenschaften sind nicht nur durch die Strahlungseigenschaften, sondern auch durch das Design der Sensoren gegeben.

Aus diesem Grund wurden unterschiedliche Designprototypen in Testbeams vermessen und anschließend analysiert um eine ideale Struktur zu erhalten, welche für zukünftige Pixeldetektoren eine hohe Effizienz zu Beginn und während der Detektorlebensdauer gewährleistet.

T 95.7 Mi 18:20 S 2

**Entwicklung und Test eines Kontroll-Chip für eine Serielle Stromversorgungskette im ATLAS Pixeldetektor Upgrade** — ●NIKLAUS LEHMANN<sup>1</sup>, MICHAEL KARAGOUNIS<sup>2</sup>, SUSANNE KERSTEN<sup>1</sup> und CHRISTIAN ZEITNITZ<sup>1</sup> — <sup>1</sup>Bergische Universität Wuppertal — <sup>2</sup>FH Dortmund

Für das geplante Upgrade des LHC zum HL-LHC (High Luminosity

Large Hadron Collider) ist als innerste Komponente ein neuer Pixel-detektor für das ATLAS Experiment geplant. Eine serielle Stromversorgung ist für die Pixelmodule vorgesehen um die Anzahl der Versorgungsleitungen zu reduzieren. Dies benötigt zum sicheren Betrieb ein völlig neues Detektor-Kontroll-System (DCS), welches zur Zeit unter anderem an der Bergischen Universität Wuppertal entwickelt wird. Ein ASIC ist vorgesehen, welcher parallel zu jedem Modul in der seriellen Stromversorgungskette eingebaut wird. Zusammen mit anderen Parametern wie Temperatur überwacht dieser DCS Chip die Modulspannung und kann bei Bedarf das Modul überbrücken und dadurch ausschalten. Ein neuer Prototyp für diesen Chip wurde im November 2016 submitiert. Dieser wird im Frühjahr 2017 erwartet. Die Entwicklung und ersten Tests von diesem Chip werden präsentiert.

T 95.8 Mi 18:35 S 2

**Characterization of a new 65 nm Shunt-LDO Regulator** — MATTHIAS HAMER<sup>1</sup>, ●FLORIAN HINTERKEUSER<sup>1</sup>, FABIAN HÜGGING<sup>1</sup>, MICHAEL KARAGOUNIS<sup>2</sup>, NORBERT WERMES<sup>1</sup> und KLAUS DESCH<sup>1</sup> — <sup>1</sup>Universität Bonn — <sup>2</sup>Fachhochschule Dortmund

The high luminosity upgrade for the Large Hadron Collider at CERN requires a complete overhaul of the ATLAS detector. The current tracking detector will be replaced by an all-silicon tracking detector, the ITk. It will occupy the same volume as the current ATLAS tracker and will cover a significantly larger phase space.

The new ITk pixel detector will consist of multichip modules produced in 65 nm CMOS technology. In order to optimize the performance of the new tracker, the material budget has to be minimized. A parallel powering scheme, as used in the current pixel detector, is not feasible due to the increased number of modules. In order to reduce the material budget as well as voltage drops on the supply cables, a serial powering scheme has been proposed.

In this scheme, modules are powered in series and supplied by a constant current source, reducing the voltage drop on the cables as well as the material used. On module level, several front-end chips are powered in parallel. The supply voltages for the digital and analog parts of these readout chips are generated by on-chip Shunt-LDO regulators.

This talk will present the properties of a first regulator prototype produced in 65 nm CMOS technology to be used in the future readout chip for the ITk pixel detector.

## T 96: Trigger und DAQ 2

Zeit: Mittwoch 16:45–18:45

Raum: VSH 17

T 96.1 Mi 16:45 VSH 17

**Optimization of the ATLAS (s)MDT readout electronics for high counting rates** — OLIVER KORTNER, HUBERT KROHA, SEBASTIAN NOWAK, CLEMENS SCHMID, and ●KORBINIAN SCHMIDT-SOMMERFELD — Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), Föhringer Ring 6, 80805 München

In the ATLAS muon spectrometer, Monitored Drift Tube (MDT) chambers are used for precise muon track measurement. For the high background rates expected at HL-LHC, which are mainly due to neutrons and photons produced by interactions of the proton collision products in the detector and shielding, new small-diameter muon drift tube (sMDT)-chambers with half the drift tube diameter of the MDT-chambers and ten times higher rate capability have been developed. The standard MDT readout electronics uses bipolar shaping which causes a deterioration of signal pulses by preceding background hits, leading to losses in muon efficiency and drift tube spatial resolution. In order to mitigate these so-called signal pile-up effects, new readout electronics with active baseline restoration (BLR) is under development. Discrete multi channel prototype electronics with BLR functionality has been tested in the Gamma Irradiation Facility at CERN under high  $\gamma$ -irradiation rates. Results of the measurements will be presented.

T 96.2 Mi 17:00 VSH 17

**Die TREX Module für das ATLAS Triggersystem** — ●VICTOR ANDREI — Kirchhoff-Institut für Physik, Im Neuenheimer Feld 227, D-69120 Heidelberg

Im Rahmen der zweiten Upgrade Phase wird der "ATLAS-Level-1-Kalorimeter-Trigger" (L1Calo) mit drei neuen digitalen "Feature-

Extractor" Systemen (FEX) erweitert. Während das "Liquid-Argon" Kalorimeter die Trigger Daten digital über optische Fasern an die FEX Systeme senden wird, wird das Tile Kalorimeter weiter analoge Signale zu dem L1Calo Preprozessor System schicken. Der Preprozessor digitalisiert die eingehenden Signale und bestimmt die zugehörige Transveralenergie und Strahlkreuzung.

Um diese digitalisierten Tile Daten an die FEX Systeme zu übertragen, werden neue "Tile Rear Extension" (TREX) Module entwickelt. Die TREX Module werden in dem Preprozessor System installiert, um die Daten zu empfangen, zu formatieren und über optische Fasern an die FEX Systeme zu senden. Um die Funktionalität des Triggers während der Inbetriebnahme der neuen FEX Systeme zu garantieren, müssen die TREX Module zusätzlich die Ergebnisse des Preprozessors den bisherigen Prozessoren zur Verfügung stellen. Außerdem werden die TREX Module Event-Daten sowie gemessene Temperatur und Betriebsspannungen an die ATLAS DAQ und DCS Systeme weiterleiten.

Die TREX Module sind sehr komplexe PCBs, mit modernsten FPGAs und Hochgeschwindigkeitstransceivern für Datenübertragungsraten bis zu 14 Gbps. Die ersten Testergebnisse mit dem Prototypmodul werden präsentiert.

T 96.3 Mi 17:15 VSH 17

**Systemtest der LATOME-Firmware des ATLAS Flüssigargon-Kalorimeters im Rahmen des Phase-I-Upgrades** — ●YVES BIANCA, RAINER HENTGES und ARNO STRAESSNER — Institut für Kern- und Teilchenphysik, TU Dresden

In einer zweijährigen Pause in den Jahren 2019-2020 soll am LHC das geplante Phase-I-Upgrade durchgeführt werden. Das Ziel ist es, die Luminosität zu erhöhen und somit die Leistungsfähigkeit des Beschleunigers zu steigern.

Hierfür ist es notwendig, die Teilchendetektoren an die gestiegenen Anforderungen anzupassen. Die Flüssigargon-Kalorimeter des ATLAS-Detektors werden im Rahmen dieser Umstellung eine höhere Granularität des Triggersystems (sog. Super-Cells) erhalten. Die Vorverarbeitung der digitalisierten Rohdaten für die erste Triggerstufe (Level-1) übernehmen hierbei die LDPB-Elektronikkarten (LAr Digital Processing Blades). Durch die Notwendigkeit, sowohl die Signalvorverarbeitung als auch die Kalibrierparameter dynamisch zu prozessieren und steuern zu können, finden FPGAs auf sogenannten LATOME-Trägerkarten innerhalb der LDPB Verwendung. Die sich derzeit in der Entwicklung befindliche LATOME-Firmware muss entwicklungsbegleitend anhand eines Teststands verifiziert werden. Es werden der Aufbau, die Inbetriebnahme des benötigten Prüfstands sowie die ersten Ergebnisse des Systemtests der LATOME-Firmware unter realen Bedingungen vorgestellt.

T 96.4 Mi 17:30 VSH 17

**TARGET, A Digitizing and Trigger ASIC for the Cherenkov Telescope Array** — DAVID JANKOWSKY<sup>1</sup>, ADRIAN ZINK<sup>1</sup>, MANUEL KRAUS<sup>1</sup>, ●JACKY CATALANO<sup>1</sup>, MANUEL LOOS<sup>1</sup>, JOHANNES SCHÄFER<sup>1</sup>, STEFAN FUNK<sup>1</sup>, LUIGI TIBALDO<sup>2</sup>, GARY VARNER<sup>3</sup>, and THE CTA CONSORTIUM<sup>4</sup> — <sup>1</sup>Erlangen Centre for Astroparticle Physics (ECAP) — <sup>2</sup>Max-Planck-Institut für Kernphysik, Heidelberg — <sup>3</sup>Department of Physics and Astronomy, University of Hawaii — <sup>4</sup>Full consortium author list at <http://cta-observatory.org>

The future ground-based gamma-ray experiment Cherenkov Telescope Array (CTA) features multiple types of imaging atmospheric Cherenkov telescopes. To be affordable, camera concepts for these telescopes have to feature low cost per channel while achieving the desired scientific goals. We present the concept of the TeV Array Readout Electronics with GSa/s sampling and Event Trigger (TARGET) ASIC, envisaged to be used in the cameras of various CTA telescopes. In the newest version of this readout concept the sampling and trigger parts are split into two ASICs, TARGET C (TC) and T5TEA, both providing 16 parallel input channels. TC features a tunable sampling rate (typ. 1 GSa/s), a 16k sample deep buffer for each channel and on-demand digitization and transmission of waveforms with typical spans of  $\sim 100$  ns. T5TEA provides 4 LVDS trigger outputs and can generate a pedestal voltage independently for each channel. The trigger decision is based on the analog sum of 4 adjacent channels, the associated threshold can be set by the user. We show preliminary results of the characterization and testing of TC and T5TEA.

T 96.5 Mi 17:45 VSH 17

**The Digital Control Unit of the Highly-Integrated Receiver Chip for JUNO** — ●PAVITHRA MURALIDHARAN for the JUNO-Collaboration — Forschungszentrum Jülich GmbH, Jülich, Germany

The Jiangmen Underground Observatory (JUNO) is a multi-purpose underground experiment based on a 20000 ton liquid scintillator to measure neutrino interactions. The primary objective is the determination of the neutrino mass hierarchy by observing reactor neutrinos. The detection system must provide good timing and a continuous charge measurement of the signals delivered by around 18000 20 inch photomultipliers (PMTs) with a high quantum efficiency. To reduce cabling effort and improve power dissipation, the signal acquisition receiver chain is integrated into the PMT housing, creating an intelligent PMT. The digitization is performed in a fast analog to digital converter (ADC) with the receiver frontend integrated so that no external components are required. With a powerful digital part included into the

receiver chip, effective data reduction and compression methods are employed as well as automatic regulation of baseline drifts. The concept and design of the digital part will be shown with a focus on the data processing path.

T 96.6 Mi 18:00 VSH 17

**A Highly-Integrated Receiver Chip for the JUNO Experiment** — ●ANDRÉ ZAMBANINI for the JUNO-Collaboration — Forschungszentrum Jülich GmbH, Jülich, Germany

The Jiangmen Underground Observatory (JUNO) is a planned neutrino experiment currently being built in Jiangmen, China, with a baseline of 53 km to two nuclear reactors and an expected data taking start in 2020. It is a multi-purpose detector with its main goal to determine the neutrino mass hierarchy. The neutrinos will be measured with a detector based on a sphere filled with 20 kton of liquid scintillator. The light emitted from the scintillator is observed by 18000 large (20 inch) photomultipliers (PMTs) and 34000 small (3 inch) PMTs. The former are designed as intelligent units with their control and readout embedded into the casing. To digitize the signals with a sampling rate of 1 Gsamples/s, a highly-integrated solution is under development - called Vulcan - that includes the analog to digital converter (ADC) and the analog frontend without the need for external components. After digitization, the digital part of Vulcan prepares the data stream for further data management in an FPGA. An overview of the concept and design of Vulcan will be presented along with measurements of the first prototype.

T 96.7 Mi 18:15 VSH 17

**Development of intelligent Photomultipliers for the JUNO Detector** — ●FLORIAN LENZ, JOCHEN STEINMANN, and ACHIM STAHL — III Physikalisches Institut B

The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose neutrino experiment currently build next to Jiangmen (China) with the primary goal to measure the neutrino mass hierarchy. The 20-thousand-ton liquid scintillator detector is therefore build 50km away from two nuclear power plants in South China. Due to the size of the detector it was decided to use a new concept for the readout - a fast ADC combined with a FPGA for a low-level reconstruction mounted on the base will convert the PMTs into intelligent sensors. The design and the functionality of the iPMTs will be explained with a focus on the power supply and challenges during the design.

T 96.8 Mi 18:30 VSH 17

**Spurfindung im SciFi-Tracker des LHCb-Experimentes mit Grafikkarten** — HOLGER STEVENS und ●JULIAN SURMANN — Experimentelle Physik 5, TU Dortmund

Im Zuge des LHCb-Upgrades im Jahr 2019 werden die bisherigen Tracking-Stationen durch den SciFi-Tracker ersetzt. Dieser besteht aus szintillierenden Fasern mit einem Durchmesser von 0,25 mm, die zu Matten verklebt werden. Der aktuelle Hardware-Trigger wird während des Upgrades durch einen reinen Software-Trigger ersetzt. Daher muss die Leistungsfähigkeit der Rechnerfarm erhöht werden. Eine Möglichkeit ist die Integration von Grafikkarten. Diese ermöglichen die parallele Ausführung von Prozessen, in denen z.B. jeweils ein unabhängiger Spurkandidat untersucht wird.

An der TU Dortmund werden Tracking-Algorithmen entwickelt, die die neue Architektur möglichst effizient nutzen. In diesem Vortrag werden aktuelle Erkenntnisse und Ergebnisse vorgestellt.

## T 97: Hauptvorträge 3

Zeit: Donnerstag 8:30–10:30

Raum: H 1

### Hauptvortrag

T 97.1 Do 8:30 H 1

**Die Akte Higgs - Fünf Jahre Higgsphysik am LHC** — ●ROGER WOLF — Karlsruhe Inst. für Technologie (KIT)

Vor nunmehr fast fünf Jahren führte die Entdeckung des Higgs Bosons zur derzeitigen Vervollständigung des Standardmodells (SM). Was wissen wir seitdem über die Eigenschaften dieses bemerkenswerten Teilchens? Welche Erkenntnisse hat uns die vollständige Analyse der LHC run-1 Datennahmeperiode und das erste Jahr des LHC run-2 gebracht? Ist das bisher beobachtete Higgs Boson wirklich nur dieses eine Higgs Boson des SM oder hält der LHC run-2 nach seinem fullminanten Start

2016 die Entdeckung noch weiterer Higgs Bosonen für uns bereit? Dieser Vortrag versucht einen Überblick über den Status Quo des Higgs-sektors zu geben, wie wir ihn heute kennen.

### Hauptvortrag

T 97.2 Do 9:10 H 1

**Neutrinos: wer seid ihr – und wenn ja, wie viele?** — ●SEBASTIAN BÖSER — PRISMA, Universität Mainz

Während die Eigenschaften der meisten Elementarteilchen sehr gut bekannt sind, bietet der Neutrinosektor eine ganze Reihe offener Fragen. Bereits die Beobachtung der Neutrinooszillationen erzwingt eine Erweiterung des Standardmodells, um die Neutrinomassen zu erklä-

ren. Im gleichen Zuge wird auch die Einführung *steriler* Neutrinos plausibel, die nicht direkt mit Materie wechselwirken, sondern lediglich über diese Oszillationseffekte zu beobachten sind. Ergebnisse aus verschiedensten Beschleuniger- und Reaktor-Experimenten lassen sich dabei mit der Einführung leichter steriler Neutrinos mit Massen im eV-Bereich erklären. Die weitreichenden Konsequenzen dieser Erweiterungen motivieren ein breites Programm neuer Suchen nach sterilen Neutrinos; nicht nur an Beschleuniger- und Reaktorexperimenten, sondern auch mit atmosphärischen Neutrinos und radioaktiven Quellen.

**Hauptvortrag** T 97.3 Do 9:50 H 1  
**New results from LHCb** — ●MIKA VESTERINEN for the LHCb-

Collaboration — Physikalisches Institut, Heidelberg, Germany

The LHCb experiment is designed to make precise studies of the properties of beauty and charm hadrons. Many of these properties are sensitive to the effects of possible new particles that appear in physics beyond the Standard Model. LHCb recorded a large dataset during Run-I of the LHC (2010-2012) with pp collisions at center-of-mass energies of 7 and 8 TeV. During 2015-2016, LHCb recorded data at the higher energy of 13 TeV. LHCb has also collected a large dataset of PbPb, pPb, Pbp collisions, and further data in a fixed target mode with noble gas targets. The latest results from LHCb are presented and their implications are discussed.

## T 98: Eingeladene Vorträge 3

Zeit: Donnerstag 14:00–16:15

Raum: H 1

**Eingeladener Vortrag** T 98.1 Do 14:00 H 1  
**Exploring the LHC flavour anomalies** — ●LARS HOFER — Universität de Barcelona

Semileptonic B decays are highly sensitive to Physics beyond the Standard Model. Therefore it is quite intriguing that LHCb has found several tensions in these channels, yielding a combined significance of more than  $4\sigma$ . I will discuss the current status of global analyses of the data and contrast explanations in terms of non-perturbative hadronic effects with solutions via high-scale New Physics.

**Eingeladener Vortrag** T 98.2 Do 14:27 H 1  
**Semileptonic  $b$ -decays: Preparing theory predictions for the era of high-luminosity experiments** — ●DANNY VAN DYK — Universität Zürich, Winterthurerstrasse 190, 8057 Zürich, Schweiz

Semileptonic decays of  $b$ -hadrons comprise an important set of probes for physics beyond the Standard Model. In order to fully use the existing and upcoming measurements from the B factory experiments, the LHC, and future high-luminosity experiments, theoretical inputs for hadronic matrix elements in semileptonic decays must be available with high precision. I will present a choice of approaches that are successful in reducing the theory uncertainties of these matrix elements. The impact of these reduced theory uncertainties on Standard Model predictions, as well as constraints on models beyond the Standard-Model, will also be discussed.

**Eingeladener Vortrag** T 98.3 Do 14:54 H 1  
**Physics Prospects at Belle II** — ●DANIEL GREENWALD — Technische Universität München

The Belle II experiment, a major upgrade of the Belle experiment, will run at the SuperKEKB asymmetric-energy  $e^+e^-$  collider at the KEK laboratory in Japan. SuperKEKB is an upgrade of the KEKB collider and will run at approximately forty-times higher luminosity than its predecessor. Belle II aims to collect data from  $50 \text{ ab}^{-1}$  of integrated luminosity—fifty times more than its predecessor. This data set will provide unprecedented precision in B, D, and  $\tau$  decays and allow for searches for rare decays and signs of physics beyond the standard model. We will present some of the physics prospects of the Belle II experiment.

**Eingeladener Vortrag** T 98.4 Do 15:21 H 1

**Studies towards optimisation of a highly granular calorimeter for future linear collider detectors** — ●HUONG LAN TRAN for the CALICE-D-Collaboration — Deutsches Elektronen Synchrotron DESY

The Particle Flow approach to calorimetry requires highly granular calorimeters and sophisticated software in order to reconstruct and identify individual particles in complex event topologies. The high calorimeter granularity can also provide a discrimination of the electromagnetic sub-showers in hadron showers. This discrimination can be utilised in an offline weighting scheme, the so-called software compensation technique, to reduce the fluctuation of the calorimeter response due to the electromagnetic sub-showers and therefore improves the energy resolution for single particles. The improvement in the single particle energy resolution can then lead to a better jet energy resolution. This talk will give a detailed description of the software compensation technique and its implementation in Particle Flow reconstruction. The impact of software compensation on the choice of optimal transverse granularity for the Analogue Hadronic Calorimeter (AHCAL) option of the International Large Detector (ILD) concept is also discussed.

**Eingeladener Vortrag** T 98.5 Do 15:48 H 1  
**The CMS Tracker Upgrades – Pushing the Limits** — ●BENEDIKT VORMWALD — Institute of Experimental Physics, Luruper Chaussee 149, 22761 Hamburg

During the extended year end technical stop 2016/2017 of the LHC, the CMS collaboration is installing a completely new pixel detector (Phase 1) as LHC is going to exceed the design luminosity of the old detector of  $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ . The new detector will feature higher tracking efficiency and lower mass with four barrel layers and three forward/backward disks to provide a 4-hit coverage up to absolute pseudo-rapidities of 2.5.

For the high luminosity phase of the LHC starting around 2026, CMS will replace the entire silicon tracking system by new silicon strip and pixel detectors (Phase 2). The upgraded systems need to be able to cope with an instantaneous luminosity of up to  $7 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  for a total of  $3000 \text{ fb}^{-1}$  in order to maintain the physics reach. Intense R&D activities are ongoing in order to define the final design of both subsystems.

In this talk, I will present the features and installation status of the Phase-1 pixel detector and discuss current developments and novel technologies and concepts of the Phase-2 tracker upgrade.

## T 99: Eingeladene Vorträge 4

Zeit: Donnerstag 14:00–16:15

Raum: H 3

**Eingeladener Vortrag** T 99.1 Do 14:00 H 3  
**Photons at ultra-high energies - a new window to the universe** — ●DANIEL KUEMPEL — III. Physikalisches Institut A, RWTH Aachen University

The observation of ultra-high energy photons with energies  $> 100 \text{ PeV}$  would extend the observed electromagnetic spectrum to highest energies and open a new window to the universe, with possible impact on astrophysics, particle physics, cosmology and fundamental physics. Current and planned air shower experiments, particularly the Pierre

Auger Observatory, offer an unprecedented opportunity to search for such photons and to complement efforts of multi-messenger observations of the universe. In this talk I will summarize motivation, achievements, and prospects of the search for ultra-high energy photons.

**Eingeladener Vortrag** T 99.2 Do 14:27 H 3  
**First results from TAIGA HiSCORE** — ●MARTIN TLUCZYKONT — Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

TAIGA is implementing a new, unique observation method, based on a combination of the imaging air Cherenkov telescope (IACT) technique, and the HiSCORE concept (shower front sampling or timing technique). TAIGA aims at opening up the so far only poorly explored gamma-ray energy regime from few 10s of TeV to several 100 TeV. This energy range is particularly important to spectrally resolve the cutoff regime of the long-sought Pevatrons, the cosmic-ray PeV accelerators. TAIGA currently consists of an array of 28 wide angle (0.6 sr) air Cherenkov timing stations distributed over an area of 0.25 km<sup>2</sup>, and an IACT with a diameter of 4.75 m and a field of view of 10°. Further 17 stations are currently in deployment, and a second IACT is planned in the next two years. Data from one observation season with the first stage of the experiment are available for comparison to simulations. In this presentation, these comparisons, first results, and a serendipitous discovery of a pulsed laser on-board the international space station will be addressed.

**Eingeladener Vortrag** T 99.3 Do 14:54 H 3  
**Suche nach neuen Phänomenen mit Jet Substruktur Methoden und hochenergetischen Topquarks beim ATLAS Experiment** — ●CHRISTOPH ANDERS — Physikalisches Institut, Universität Heidelberg

Das Topquark als schwerstes bekanntes Teilchen und seine damit verbundene starke Kopplung an das Higgs-Boson spielen eine zentrale Rolle in vielen Erweiterungen des Standardmodells. Die erhöhte LHC Schwerpunktsenergie von 13 TeV erlaubt die Suche nach Anzeichen neuer Phänomene auf der TeV-Skala in den von ATLAS in 2015 und 2016 aufgezeichneten  $pp$ -Kollisionsdaten. Bei entsprechend hohen zu erwartenden Impulsen lassen sich hadronisch zerfallende Topquarks in einem Jet mit grossem Radiusparameter rekonstruieren, wobei von Gluonen und leichten Quarks induzierte Jetuntergründe mit Hilfe von

Jet Substruktur Methoden unterdrückt werden können.

Exemplarisch werden einige Analysen, die diese neuen experimentellen Methoden und Suchen nach neuen Phänomenen mit Topquarks verbinden, wie beispielsweise in Topquarkpaare zerfallende schwere Resonanzen, vorgestellt.

**Eingeladener Vortrag** T 99.4 Do 15:21 H 3  
**Exotic Hadrons with Hidden Charm** — ●SEBASTIAN NEUBERT for the LHCb-Collaboration — Physikalisches Institut Heidelberg, INF226, 69120 Heidelberg

The spectrum of confined systems of strongly interacting particles, especially those containing charm quarks, is ripe with surprise. The latest generation of experiments is expanding a series of discoveries and precision studies of new exotic resonances in the meson sector and lately in the baryon sector as well. This talk will review the status of the spectroscopy of these enigmatic hadrons with hidden charm and discuss recent experimental results from the pentaquark candidates to the evidence for multiflavor states.

**Eingeladener Vortrag** T 99.5 Do 15:48 H 3  
**QCD measurements at the CMS experiment** — ●PAOLO GUNNELINI — DESY, Notkestrasse 85, 22607 Hamburg

Jets, which are the signatures of quarks and gluons in a detector, can be described by Quantum Chromodynamics (QCD) in terms of parton-parton scattering. Jets are abundantly produced at the high energy scales reached by the Large Hadron Collider. Measurements of inclusive jets, dijets and multijets can be used to test perturbative QCD predictions and to constrain parton distribution functions. Various jet measurements performed with the CMS experiment in proton-proton collisions are presented and their interpretation in view of the current theoretical models is shown.

## T 100: Higgs-Boson 8 (BSM-Zerfälle)

Zeit: Donnerstag 16:45–19:05

Raum: JUR 3

**Gruppenbericht** T 100.1 Do 16:45 JUR 3  
**Search for Higgs bosons decaying into pairs of  $\tau$ -leptons in the context of the MSSM** — ARTUR AKHMETSHIN, ●RENÉ CASPART, ANDREW GILBERT, GÜNTER QUAST, ROGER WOLF, and SEBASTIAN WOZNIEWSKI — Institut für Experimentelle Kernphysik, Karlsruher Institut für Technologie (KIT)

The discovery of a Higgs Boson at the LHC in the year 2012 was an important milestone in the field of particle physics. However the question remains if additional Higgs bosons which for example are predicted in the Minimal Supersymmetric Standard Model exist. With the restart of the LHC in 2015 at an increased center of mass energy of 13 TeV the reach of searches for these Higgs bosons is increased significantly.

The search for additional heavy neutral Higgs bosons decaying into a pair of  $\tau$ -leptons is the most sensitive one in a large class of extensions of the Standard Model. In this talk the search for these Higgs bosons using data recorded by the CMS experiment at 13 TeV will be shown.

T 100.2 Do 17:05 JUR 3  
**Search for Neutral MSSM Higgs Bosons  $H/A \rightarrow \tau_l \tau_h$  at ATLAS** — ●VERENA MUCKHOFF, WILLIAM DAVEY, and JOCHEN DINGFELDER — Physikalisches Institut Universität Bonn

The Minimal Supersymmetric Standard Model (MSSM) is an extension of the Standard Model (SM) that is able to address problems of the SM such as the hierarchy problem, gauge coupling unification and the existence of dark matter. Its Higgs Sector consists of two charged,  $H^\pm$ , and three neutral Higgs bosons,  $h$ ,  $H$ ,  $A$ . For a large parameter space (large  $\tan\beta$ ), the couplings of  $H$  and  $A$  to down-type fermions are enhanced with respect to the SM, resulting in increased branching fractions to  $\tau$  leptons and  $b$ -quarks. This has motivated a variety of searches of MSSM Higgs bosons decaying into  $\tau\tau$  final states.

In this talk, a search for neutral MSSM Higgs Bosons decaying into a  $\tau$  lepton pair is presented in the channel where one  $\tau$  decays leptonically, the other  $\tau$  decays hadronically, respectively. The final selection is split into a  $b$ -tagged and a  $b$ -veto region to optimize the sensitivity for different production processes (e.g.  $b$ -associated production).

In this talk, the results of the current update of the  $H \rightarrow \tau\tau$  analysis based on 36.47 fb<sup>-1</sup> proton-proton collision data collected with the ATLAS detector in 2015 and 2016 at a centre-of-mass energy of  $\sqrt{s} =$

13 TeV are presented. The focus will be on the background estimation.

T 100.3 Do 17:20 JUR 3  
**Sensitivity enhancement for the MSSM analysis in the  $H \rightarrow \tau\tau$  channel** — RENÉ CASPART, ANDREW GILBERT, GÜNTER QUAST, ROGER WOLF, and ●SEBASTIAN WOZNIEWSKI — Institut für Experimentelle Kernphysik, Karlsruhe, Germany

In 2012 a Higgs boson was discovered at the LHC which represents an important contribution to the Standard Model. But is it the only one? For example the Minimal Supersymmetric Standard Model (MSSM) predicts the existence of four further Higgs bosons. Therefore searches are performed across a broad mass range for these particles.

The analysis referred to in this talk is looking for additional heavy neutral Higgs Bosons decaying into  $\tau$  pairs. The talk deals with the sensitivity enhancement for this analysis involving Boosted Decision Trees as a machine learning method.

T 100.4 Do 17:35 JUR 3  
**BDT based search for neutral MSSM Higgs bosons in the fully hadronic  $\tau$ -pair final state with ATLAS** — ●MAX MÄRKER, DIRK DUSCHINGER, WOLFGANG MADER, LORENZ HAUSWALD, ARNO STRAESSNER, and SEBASTIAN WAHRMUND — IKTP TU Dresden, Dresden, Germany

The Minimal Supersymmetric Standard Model (MSSM) extends the Higgs sector with an additional doublet leading to the prediction of five Higgs bosons, two charged and three neutral bosons. At tree level the Higgs sector is fully described by the mass of the CP-odd Higgs boson,  $m_A$ , and the ratio of the vacuum expectation values of the two Higgs doublets,  $\tan\beta$ . At large values of  $\tan\beta$  the couplings to  $b$  quarks or  $\tau$  leptons are significantly enhanced.

In this talk, a new multivariate analysis based on boosted decision trees (BDT) in the search for heavy, neutral Higgs bosons in the fully hadronic  $H \rightarrow \tau^+ \tau^-$  channel is presented. The dominant background processes are QCD multi-jet, Drell-Yan and  $W$ +jets production. To separate the signal from these backgrounds, two independent event categories are introduced, and the description of the multi-jet background is taken directly from data. Using the BDT analysis, an improved expected signal significance is observed when compared to a

traditional cut-based analysis.

T 100.5 Do 17:50 JUR 3

**Search for BSM  $H \rightarrow \tau\tau$  in the dihadronic decay channel with ATLAS** — ●LINO GERLACH, MICHEL JANUS, and STAN LAI — II. Physikalisches Institut, Georg-August-Universität Göttingen

In 2012, a scalar boson was found at CERN that is consistent with the properties of the Higgs boson predicted by the Standard Model of particle physics. Some theories, in particular supersymmetric models, also predict the existence of additional heavier neutral Higgs bosons. The decays of these hypothetical particles to a pair of  $\tau$  leptons can have higher branching ratios compared to decays to other leptons because of the high mass of the  $\tau$  lepton and additional effects of two-Higgs-doublet models that can enhance the coupling to the third generation of leptons.

In this talk, some details of the search for  $H \rightarrow \tau\tau$  in the dihadronic channel will be presented. Data is taken at the ATLAS experiment with a centre-of-mass energy of  $\sqrt{s} = 13$  TeV. Special emphasis will be put on the mass reconstruction algorithms used and the calculation of so-called fake rates. These describe the probability of a jet to be falsely identified as a hadronically decaying  $\tau$  lepton and are a crucial ingredient in estimating the background.

T 100.6 Do 18:05 JUR 3

**Search for Minimal Supersymmetric Standard Model Higgs bosons  $H/A$  and for a  $Z'$  boson in the  $\tau\tau$  final state at  $\sqrt{s} = 13$  TeV with the ATLAS Detector** — ●DIRK DUSCHINGER, LORENZ HAUSWALD, WOLFGANG MADER, and ARNO STRAESSNER — Institut fuer Kern und Teilchenphysik, TU-Dresden

Searches for new heavy resonances decaying to tau-lepton pairs are both theoretically and experimentally well motivated. Extensions of the Standard Model often include additional particles, such as the Minimal Supersymmetric Standard Model (MSSM) introducing new heavy neutral higgs bosons  $A$  and  $H$ . Many other models commonly include heavy neutral  $Z'$  bosons, some of them predicting preferred couplings to third-generation fermions.

The search for high-mass resonances decaying into  $\tau^+\tau^-$  final states with the ATLAS detector is presented. The data were recorded in proton-proton collisions at  $\sqrt{s} = 13$  TeV produced by the Large Hadron Collider. The  $\tau_{\text{had}}\tau_{\text{had}}$ ,  $\tau_{\mu}\tau_{\text{had}}$  and  $\tau_e\tau_{\text{had}}$  channels are analyzed. The results are interpreted for the MSSM in the hMSSM and  $m_h^{\text{mod}}$  scenarios. Theories including  $Z'$  bosons are studied in the sequential standard model as well as in the non-universal G(221) model.

T 100.7 Do 18:20 JUR 3

**Search for massive (pseudo)scalar states  $A/H$  decaying to  $t\bar{t}$  with interference at the ATLAS experiment** — KATHARINA BEHR, ●YU-HENG CHEN, KLAUS MÖNIG, and JIKE WANG — DESY, Germany

The search for new neutral TeV scale (pseudo)scalar particles is well-

motivated by a wide range of theories beyond the Standard Model (BSM) which include an extra Higgs doublet such as the Minimal Supersymmetric Standard Model (MSSM). Final states with a top-antitop-quark pair ( $t\bar{t}$ ) provide good sensitivity especially for low values of  $\tan\beta$  (the ratio of the vacuum expectation values of the two Higgs fields), a parameter range that is not accessible by most searches in other final states.

However, strong interference effects between the signal and the Standard Model  $t\bar{t}$  background distort the signal shape from a simple Breit-Wigner peak to a peak-dip structure and reduce the sensitivity of established search strategies for  $t\bar{t}$  resonances; therefore, a new strategy has to be adopted. We present the first search with interference effects taken into consideration. We describe the search strategies adopted for the analyses of proton-proton collisions at  $\sqrt{s} = 8$  TeV and 13 TeV. The results are interpreted in terms of a type-II 2HDM model.

T 100.8 Do 18:35 JUR 3

**Optimierung einer Suche nach geladenen Higgs-Bosonen mit dem ATLAS-Experiment hinsichtlich des b-Tagging-Arbeitspunktes** — ●SEBASTIAN BANNMANN, HEIKO LACKER, JANET DIETRICH und FRANCESCO PERI — Humboldt Universität, Berlin, Deutschland

Geladene Higgs-Bosonen,  $H^\pm$ , treten in verschiedenen Erweiterungen des Standardmodells auf. Bei großen  $H^\pm$ -Massen ist der dominante Produktionsprozeß am Large Hadron Collider  $pp \rightarrow H^\pm b\bar{b}$  und der dominante Zerfall  $H^\pm \rightarrow t\bar{b}$ .

Der Vortrag diskutiert die Optimierung einer bereits existierenden ATLAS-Datenanalyse bei einer Proton-Proton-Schwerpunktsenergie von 13 TeV, die Endzustände mit einem Lepton und hoher (b-)Jet-Multiplizität verwendet, hinsichtlich der Wahl des besten b-Tagging-Arbeitspunktes für den Massenbereich zwischen 250 und 2000 GeV mit Hilfe simulierter Ereignisse.

T 100.9 Do 18:50 JUR 3

**Developments in the search for a heavy charged Higgs boson** — ●FRANCESCO PERI, HEIKO LACKER, and JANET DIETRICH — HU-Berlin

Many Beyond-the-Standard Model (BSM) scenarios predict charged Higgs bosons ( $H^\pm$ ). In particular, an additional Higgs doublet naturally appears in the Minimal Supersymmetric Standard Model (MSSM). The production mechanisms and decays of such particles strongly depend on their mass. This presentation focuses on heavy charged Higgs bosons, with a mass larger than the top-quark mass, whose predicted production cross section at the Large Hadron Collider is not negligible. In this case, the dominant production mode is in association with a top quark, while the decay is into a top-bottom pair. In this talk, the current status of a search for  $tbH^\pm$  production with the ATLAS experiment is presented. The latest public results are summarised, showing upper limits on the production cross section times the decay branching fraction, and proposing possible improvements.

## T 101: Top Quark 5 (Eigenschaften)

Zeit: Donnerstag 16:45–19:00

Raum: JUR 4

T 101.1 Do 16:45 JUR 4

**Measurements of top quark spin observables in  $t\bar{t}$  events using dilepton final states in  $\sqrt{s} = 8$  TeV  $pp$  collisions with the ATLAS detector** — ●ROGER NARANJO<sup>1</sup>, RALPH SCHAEFER<sup>1</sup>, CECILE DETERRE<sup>1</sup>, JAMES HOWARTH<sup>2</sup>, and YVONNE PETERS<sup>2</sup> — <sup>1</sup>DESY, Hamburg, Germany — <sup>2</sup>University of Manchester, Manchester, England.

Measurements of top quark spin observables in  $t\bar{t}$  events are presented based on 20.2 fb<sup>-1</sup> of  $\sqrt{s} = 8$  TeV proton-proton collisions recorded with the ATLAS detector at the LHC. The analysis is performed in the dilepton final state, characterised by the presence of two isolated leptons (electrons or muons). There are 15 observables, each sensitive to a different coefficient of the spin density matrix of  $t\bar{t}$  production, which are measured independently. Ten of these observables are measured for the first time. All of them are corrected for detector resolution and acceptance effects back to the parton and stable-particle levels. The measured values of the observables at parton level are compared to Standard Model predictions at next-to-leading order in QCD. The corrected distributions at stable-particle level are presented and the

means of the distributions are compared to Monte Carlo predictions. No significant deviation from the Standard Model is observed for any observable.

T 101.2 Do 17:00 JUR 4

**Status of the top quark mass measurement in fully hadronic  $t\bar{t}$  decays with the CMS experiment at  $\sqrt{s} = 13$  TeV** — CHRISTOPH GARBERS, NATALIA KOVALCHUK, ●JOHANNES LANGE, PETER SCHLEPER, HARTMUT STADIE, and FRED STÖBER — Institut für Experimentalphysik, Universität Hamburg

The top quark is the heaviest known elementary particle and its mass is an important parameter of the standard model (SM) of particle physics. In conjunction with the W and Higgs boson masses and other precision observables, it provides a self-consistency check of the SM and is responsible for the largest part of higher-order corrections to the Higgs boson mass.

At the LHC, top quarks are mainly produced in pairs and the fully hadronic decays have the largest branching fraction. The final state consisting of six jets, two of which initiated by b-quarks, is experimen-

tally challenging. To reconstruct the complete  $t\bar{t}$  system, a kinematic fit is employed, by means of which also background is suppressed. The top quark mass can be extracted using an ideogram method.

At  $\sqrt{s} = 7$  TeV and 8 TeV the top quark mass has been determined with this method using data recorded with the CMS detector. In this talk the progress of the analysis for the LHC Run II at  $\sqrt{s} = 13$  TeV is presented.

T 101.3 Do 17:15 JUR 4

**Measurement of the Top Quark Mass in the Muon+Jets Final State at  $\sqrt{s} = 13$  TeV in 2015 data** — ●CHRISTOPH GARBERS, NATALIA KOVALCHUK, JOHANNES LANGE, PETER SCHLEPER, HARTMUT STADIE, FRED STÖBER, MARKUS SEIDEL und ANDRE SCHMALFELD — Universität Hamburg, Hamburg, Germany

The top quark is the heaviest known particle in the standard model. The precise measurement of its properties is mandatory for a more accurate knowledge of the standard model of particle physics and a important indicator for new physics searches. We present a measurement of the top quark mass using a sample of  $t\bar{t}$  candidate events with a muon and at least four jets in the final state, collected by CMS in pp collisions at  $\sqrt{s} = 13$  TeV at the LHC in 2015. The candidate events are selected from data corresponding to an integrated luminosity of  $2.2 \text{ fb}^{-1}$ . For each event the mass of the top quark candidates is reconstructed from a kinematic fit of the decay products to a  $t\bar{t}$  hypothesis. The top quark mass is determined with a template method. Simultaneously a jet energy scale factor (JSF) is estimated from the invariant mass of the W boson candidate. The combination of the in situ JSF with jet energy corrections out of  $\gamma/W$  events reduces systematic uncertainties.

T 101.4 Do 17:30 JUR 4

**Measurement of the top-quark  $\overline{M_S}$  and pole masses with  $2.2 \text{ fb}^{-1}$  at  $\sqrt{s} = 13$  TeV** — ●MATTEO DEFRANCHIS<sup>1</sup>, KATERINA LIPKA<sup>1</sup>, JAN KIESELER<sup>2</sup>, and SVEN-OLAF MOCH<sup>3</sup> — <sup>1</sup>DESY, Hamburg, Germany — <sup>2</sup>CERN, Geneva, Switzerland — <sup>3</sup>Universität Hamburg, Hamburg, Germany

A measurement of the top-quark  $\overline{M_S}$  and pole masses is performed using proton-proton collisions data recorded by the CMS detector during 2015 data taking at the centre-of-mass energy of 13 TeV, corresponding to an integrated luminosity of  $2.2 \text{ fb}^{-1}$ . A binned-likelihood fit to multi-differential distributions of final state observables is performed to constrain systematic uncertainties *in situ* and to extract the visible  $t\bar{t}$  production cross section. The top-quark Monte Carlo mass is treated as a nuisance parameter in the fit, and the observed  $t\bar{t}$  cross section is compared to theory predictions at next-to-next-to-leading order in order to extract the top-quark mass in a well-defined renormalization scheme.

T 101.5 Do 17:45 JUR 4

**Measurement of additional-jet activity in top-quark pair events at 13 TeV at ATLAS** — ●AKANKSHA VISHWAKARMA — DESY Zeuthen, Germany

Measurements of additional-jet activity in top-quark pair events produced in proton-proton collisions at a centre-of-mass energy of 13 TeV collected by the ATLAS experiment are presented. Events are chosen in dilepton channel by requiring an opposite-charge  $e\mu$  pair and two b-tagged jets in the final state. Studies on kinematic distributions of final state leptons and jets, for example additional-jets multiplicity,  $p_T$  spectra of heavy flavor and light jets, angular separations between objects, are performed. Data are compared to different Monte-Carlo predictions for some observables like additional-jet multiplicity and transverse momentum,  $p_T$  to test the QCD modelling in these predictions. Measurements are corrected for detector effects and presented as particle-level distributions.

T 101.6 Do 18:00 JUR 4

**Abschätzung der Untergrundprozesse für die Suche nach FCNCs in der Produktion von Single-Top-Quarks am ATLAS-Experiment bei  $\sqrt{s} = 13$  TeV** — ●LENNART RUSTIGE, GREGOR GESSNER, DIANE CINCA, JOHANNES ERDMANN und KEVIN KRÖNINGER — TU Dortmund, Experimentelle Physik IV

Die Suche nach Flavour Changing Neutral Currents (FCNCs) bietet eine Möglichkeit Vorhersagen des Standardmodells bzw. von BSM-

Modellen zu überprüfen. Der Grund dafür ist, dass der Wirkungsquerschnitt für solche Prozesse aufgrund des GIM-Mechanismus im Standardmodell stark unterdrückt ist, in verschiedenen BSM-Modellen aber Größenordnungen erreicht, auf die das ATLAS-Experiment bereits jetzt sensitiv ist bzw. am Ende der Datennahme in LHC-Run 2 sein wird.

In diesem Vortrag wird eine Untergrundabschätzung eines FCNC-Prozesses, der Single-Top-Quark-Produktion mit einem Photon ( $tq\gamma$ -Vertex), beschrieben. Im Rahmen solcher Untergrundabschätzung für Prozesse mit Photonen im Endzustand spielen Photon-Fake-Raten eine wichtige Rolle, da die Fehlrekonstruktion von Elektronen oder Hadronen als Photon dazu führen können, dass auch Prozesse die kein echtes Photon im Endzustand besitzen zum Untergrund beitragen. Deshalb wird in diesem Vortrag insbesondere auf die Anwendung einer datenbasierten Abschätzung der Elektron-zu-Photon-Fake-Rate eingegangen. Für diese Untersuchung werden Daten des ATLAS-Experiments der Jahre 2015 und 2016 bei einer Schwerpunktsenergie von  $\sqrt{s} = 13$  TeV verwendet.

T 101.7 Do 18:15 JUR 4

**Messung von differentiellen Wirkungsquerschnitten von geboosteten  $t\bar{t}$  Ereignissen im Run 2 des ATLAS Experiments** — ●MELANIE SCHEPP, SABRINA GROH und LUCIA MASETTI — Universität Mainz

Im Run 2 des LHC wurde die Produktionsrate von  $t\bar{t}$  Paare durch die Steigerung der Schwerpunktsenergie signifikant erhöht. Diese erhöhte Produktionsrate zusammen mit der gesteigerten integrierten Luminosität erlaubt eine genauere Vermessung der differentiellen Wirkungsquerschnitte als Funktion verschiedener kinematischer Variablen. Die genaue Kenntnis dieser Wirkungsquerschnitte ermöglicht Tests der perturbativen QCD und die genauere Bestimmung der Partonverteilungsfunktionen. Ausserdem sagen viele Erweiterungen des Standardmodells neue Prozesse voraus, die insbesondere in Zerfällen von Top-Antitop Paaren messbar sein sollten.

In diesem Vortrag wird die Analyse zur Bestimmung der differentiellen Wirkungsquerschnitten von  $t\bar{t}$  Ereignissen mit kollimierten (geboosteten) Zerfallprodukten im Lepton+Jets Kanals präsentiert.

T 101.8 Do 18:30 JUR 4

**Messung des Wirkungsquerschnittes der  $t\bar{t}Z$ -Produktion im 4-Leptonen-Endzustand mit dem ATLAS-Experiment** — KATHARINA BIERWAGEN, VOLKER BÜSCHER und ●ALEXANDRA SCHULTE — Institut für Physik, Mainz

Die Messung der  $t\bar{t}Z$ -Produktion ist ein wichtiger Test des Standardmodells und kann verwendet werden, um die Kopplung zwischen einem Top-Quark und einem Z-Boson zu messen. Bis jetzt wurde die Kopplung noch nicht direkt gemessen. Ein erster Meilenstein auf diesem Weg ist die Beobachtung der  $t\bar{t}Z$ -Produktion.

Der Wirkungsquerschnitt der  $t\bar{t}Z$ -Produktion bei einer Schwerpunktsenergie von 13 TeV wurde bereits mit einer integrierten Luminosität von  $3,3 \text{ fb}^{-1}$  im Jahre 2016 gemessen. Der aktuelle Datensatz von  $36 \text{ fb}^{-1}$  verspricht jedoch eine wesentliche Verbesserung der Sensitivität, da die Messung statistisch limitiert ist.

In diesem Vortrag wird der aktuelle Stand der  $t\bar{t}Z$ -Analyse im 4-Leptonen-Endzustand vorgestellt. Der Fokus liegt auf der Bestimmung des Fakelepton-Untergrundes und dem Fit in Signal- und Kontrollregionen. Charakteristisch für den 4-Leptonen-Kanal sind niedrige Raten bei einem sehr guten Signal-zu-Untergrund-Verhältnis.

T 101.9 Do 18:45 JUR 4

**Estimation of the "hadron-fake" background for  $t\bar{t}\gamma$  production in  $pp$  collision with the ATLAS experiment** — ●SARA GHASEMI, IVOR FLECK, and YICHEN LI — Universität Siegen, Department für Physik, D-57068 Siegen, Germany

The pair production of Top quarks with an associated photon is of particular interest, as it provides the opportunity to study the electroweak couplings of the Top quark.

In the  $t\bar{t}\gamma$  analysis, a template fit is used to estimate the fraction of signal events in the observed data. The major background contribution comes from the hadrons misidentified as photons; the so-called "hadron-fakes". Templates are extracted for the prompt photons and the hadron-fakes, separately. In this presentation, the hadron-fake template determination from control samples in data is presented.



## T 102: Flavourphysik 3

Zeit: Donnerstag 16:45–19:00

Raum: JUR 490

T 102.1 Do 16:45 JUR 490

**Beobachtung und Analyse des Zerfalls  $\bar{B}_s^0 \rightarrow \Lambda \bar{p} K^+$  mit den Run-I-Daten des LHCb-Detektors** — ●CHRISTIAN VOSS — I. Physikalisches Institut B, RWTH-Aachen

Im Gegensatz zu den  $\bar{B}^0$ ,  $B^-$  und  $B_c^-$  Mesonen wurde für das  $\bar{B}_s^0$ -Meson bisher kein Zerfall in einen Endzustand mit einem Paar von Baryonen beobachtet. Aufgrund der hohen Produktionsrate für  $b\bar{b}$ -Paare ist es möglich mit den Daten des LHCb-Experimentes nach solchen Zerfällen zu suchen. Präzise Studien dieser Zerfälle dienen zum besseren Verständnis der QCD bei niedrigen Energien und der Produktion von Baryonen.

Im Vortrag wird die erste Beobachtung eines  $\bar{B}_s^0$ -Zerfalls in Baryonen vorgestellt. Als Normierungskanal dient der Zerfall  $\bar{B}^0 \rightarrow \Lambda \bar{p} \pi^+$ . Neben der Messung des Verzweungsverhältnisses wurden die Dalitz-Plots beider Zerfälle studiert. Dabei zeigt sich die aus anderen baryonischen  $B$ -Zerfällen bekannte ausgeprägte Anreicherung nahe der Schwelle der invarianten Baryon-Antibaryon-Masse. Desweiteren wurde die Winkelverteilung des Baryon-Antibaryon-Paares untersucht und die Polarisation der  $\Lambda$ -Baryonen bestimmt.

T 102.2 Do 17:00 JUR 490

**Messung des Verzweungsverhältnisses des Zerfalls  $B_s^0 \rightarrow K_S^0 K_S^0$  mit dem LHCb-Experiment** — MORITZ DEMMER, SEBASTIAN JÄGER, TIMON SCHMELZER und ●LEONARD WOLLENBERG für die LHCb-Kollaboration — Experimentelle Physik 5, TU Dortmund

Der Zerfall  $B_s^0 \rightarrow K_S^0 K_S^0$  findet im Standardmodell der Teilchenphysik mit dem  $b \rightarrow s \bar{d} d$  Übergang statt und wird in führender Ordnung durch ein sogenanntes Pinguindigramm beschrieben. Abweichungen von dem erwarteten Verzweungsverhältnis von  $BR(B_s^0 \rightarrow K_S^0 K_S^0) \approx 20 \cdot 10^{-6}$  könnten Hinweise auf Physik jenseits des Standardmodells enthalten. Dieses geringe Verzweungsverhältnis stellt zusammen mit dem rein hadronisch rekonstruierten Endzustand des  $K_S^0$  in zwei geladene Pionen und den neutralen Zwischenzuständen eine große Herausforderung dar.

Bisher wurde das Verzweungsverhältnis nur vom Belle-Experiment bestimmt. In diesem Vortrag soll die Suche nach dem Zerfall  $B_s^0 \rightarrow K_S^0 K_S^0$  mit dem LHCb-Experiment beschrieben werden. Eine Besonderheit dieser Analyse ist die Aufteilung der Daten nach Massenauflösung der  $K_S^0$ -Masse, die sich sowohl aus ihrer Langlebigkeit als auch dem physikalischen Aufbau des LHCb-Experimentes ergeben. Die verwendeten Daten entsprechen einer integrierten Luminosität von  $5 \text{ fb}^{-1}$ .

T 102.3 Do 17:15 JUR 490

**Untersuchung der Zerfälle  $B_s^0 \rightarrow K_S^0 h^\pm h'^\mp$  und  $B^\pm \rightarrow K_S^0 K_S^0 h^\pm$  als Normierungskanal der Verzweungsverhältnismessung in  $B_s^0 \rightarrow K_S^0 K_S^0$  mit dem LHCb Experiment** — MORITZ DEMMER, ●SEBASTIAN JÄGER, TIMON SCHMELZER und LEONARD WOLLENBERG für die LHCb-Kollaboration — Experimentelle Physik 5, TU Dortmund

Das Verzweungsverhältnis des Zerfalls  $B_s^0 \rightarrow K_S^0 K_S^0$  soll mit dem LHCb Detektor bestimmt werden. Die Zerfälle  $B_s^0 \rightarrow K_S^0 h^\pm h'^\mp$  und  $B^\pm \rightarrow K_S^0 K_S^0 h^\pm$  mit  $h = K, \pi$  werden als Normierungskanäle dieses Zerfalls untersucht, da sie eine höhere Zerfallsbreite besitzen. Weiterhin können damit Effizienzen bestimmt und Unsicherheiten aus der Hadronisierung vermieden werden. Da es sich um rein hadronische Zerfallskanäle handelt, ist die Rekonstruktion der Zerfälle experimentell herausfordernd. Zusätzlich unterscheidet sich die Massenauflösung der  $K_S^0$ -Mesonen durch ihre lange Lebenszeit, sodass diese in zwei separaten Kategorien untersucht werden müssen.

Das Verzweungsverhältnis des Zerfalls  $B_s^0 \rightarrow K_S^0 h^\pm h'^\mp$  wurde bereits 2013 mit dem LHCb Experiment gemessen, während der Zerfall  $B^\pm \rightarrow K_S^0 K_S^0 h^\pm$  bisher noch nicht untersucht wurde. In dieser Analyse werden diese Kanäle mit einem Datensatz entsprechend einer integrierten Luminosität von  $5 \text{ fb}^{-1}$  untersucht. Der aktuelle Stand der Analyse wird in diesem Vortrag präsentiert.

T 102.4 Do 17:30 JUR 490

**Background studies of  $B \rightarrow K^{(*)} \nu \bar{\nu}$  decays at Belle I** — ●JAMES KAHN and THOMAS KUHR — Ludwig-Maximilians-Universität München

The  $B \rightarrow K^{(*)} \nu \bar{\nu}$  decays provide theoretically clean, experimentally measurable instances of the flavour changing neutral current process  $b \rightarrow s \nu \bar{\nu}$ , which presents an excellent opportunity to investigate physics beyond the standard model. The missing energies of the two neutrinos make the measurement experimentally challenging and require the reconstruction of the spectator  $B$  meson in  $e^+ e^- \rightarrow \Upsilon(4S) \rightarrow B \bar{B}$  events. Observation of the  $B \rightarrow K^{(*)} \nu \bar{\nu}$  decays will only become possible with the large data set that will be collected at the upgraded Belle II detector at the SuperKEKB accelerator in Tsukuba, Japan. A challenge of this decay analysis will be the understanding and suppression of the backgrounds. This talk presents a status update on the ongoing analysis and progress of the development of new techniques to identify and simulate background events in sufficient volumes for statistical analysis.

T 102.5 Do 17:45 JUR 490

**Search for  $B^\pm \rightarrow l^\pm \gamma$  at Belle with the Belle II analysis software** — ●ANTONIO YUSTA ESPLÁ, MARTIN RITTER, and THOMAS KUHR — Universe Cluster, Garching bei München, Bayern

Belle II is a next generation experiment designed to study  $e^+ e^-$  collisions at the SuperKEKB accelerator in Tsukuba, Japan. The upgrade of the accelerator will increase the luminosity compared to its predecessor by a factor of 40 allowing the Belle II experiment to search for New Physics with unprecedented precision. A milestone for Belle II is the validation of the new and improved data analysis software with the dataset acquired by its predecessor experiment Belle. In particular, the decays  $B^\pm \rightarrow l^\pm \gamma$  with  $l^\pm = e^\pm, \mu^\pm$  are being searched for as lepton number violation (LNV) would be a clear sign of New Physics.

T 102.6 Do 18:00 JUR 490

**Suche nach dem Lepton Flavor verletzenden Zerfall  $B^0 \rightarrow \tau^\pm + e^\mp$  und  $B^0 \rightarrow \tau^\pm + \mu^\mp$**  — ●PHILIPP MEYER, THOMAS KUHR und MARTIN RITTER — LMU München

Die Lepton Flavor Verletzung (LFV) wurde in Neutrino Oszillationen beobachtet, jedoch nicht in Prozessen mit geladenen Leptonen. Die Lepton Flavor Verletzung wird in einigen Theorien jenseits des Standardmodells vorhergesagt und dessen Beobachtung wäre ein klares Zeichen für neue Physik. Dieser Vortrag wird die Suche nach  $B^0 \rightarrow \tau^\pm + e^\mp$  und  $B^0 \rightarrow \tau^\pm + \mu^\mp$  am Belle Experiment vorstellen. Die Analyse verwendet das basf2 Software framework der Belle II Kollaboration und beruht auf der vollständigen Rekonstruktion des zweiten B Mesons in  $Y(4S) \rightarrow B^0 \bar{B}^0$  Events.

T 102.7 Do 18:15 JUR 490

**Erste Studien von inklusiven  $B \rightarrow X \ell \nu_\ell$  Zerfällen für Phase-II des Belle II Experiments** — FLORIAN BERNLOCHNER, JOCHEN DINGFELDER und ●STEPHAN DUELL — Rheinische Friedrich-Wilhelms-Universität Bonn

Im Sommer 2017 wird das Belle II Experiment seine ersten Kollisionen produzieren. Geplant ist die Aufzeichnung von zwei Datensätzen: Rund  $40 \text{ fb}^{-1}$  an  $e^+ e^- \rightarrow \Upsilon(4S) \rightarrow B \bar{B}$  sowie  $40 \text{ fb}^{-1}$  von  $e^+ e^- \rightarrow \Upsilon(6S) \rightarrow B_{(*)}^{(*)} \bar{B}_{(*)}^{(*)}$  Ereignissen. Die während Phase-II des Belle II-Starts aufgenommenen Daten dienen insbesondere der Charakterisierung der Leistungsfähigkeit des Belle II Detektors. Zur Untersuchung von Leptonidentifikation und Trackrekonstruktion sind inklusive  $B \rightarrow X \ell \nu_\ell$  Zerfälle gut geeignet, da man aufgrund des hohen Verzweungsverhältnisses von 20% für Elektronen und Myonen kombiniert bereits für kleine Datensätze auf eine ausreichende Anzahl an Zerfällen zurückgreifen kann. In diesem Vortrag werden die geplanten Phase-II-Messungen und der Stand der ersten Vorstudien vorgestellt.

T 102.8 Do 18:30 JUR 490

**The secondary vertex finding algorithm with the ATLAS detector** — NELLO BRUSCINO, JULIEN CAUDRON, MARKUS CRISTINZIANI, MAZUZA GHNEIMAT, CARLO ALBERTO GOTTARDO, ●SEBASTIAN HEER, VADIM KOSTYUKHIN, ANDREA SCIANDRA, and KAVEN YAU WONG — Physikalisches Institut, Universität Bonn

The ability to identify jets with  $b$ -hadrons is essential for many physics analyses at the LHC. In ATLAS there are several algorithms available to tag jets induced by  $b$ -hadrons. The secondary vertex finding algorithm uses the information of the secondary decay vertex of the  $b$ -hadron. As  $b$ -hadrons have a sufficiently long lifetime, the distance

to the primary vertex can be resolved in the detector. The secondary vertex finder is able to reconstruct one or more secondary vertices in a jet, depending on the physics problem.

This talk will describe the algorithm and the information that can be exploited from reconstructing secondary vertices. This information is fed to the higher-level  $b$ -tagging algorithms in ATLAS. The major updates of the algorithm, that lead to an improved performance are shown and compared to the LHC Run 1.

T 102.9 Do 18:45 JUR 490

**Kalibration des hadronischen und des semileptonischen Markierungsseitenalgorithmus für das Belle II-Experiment** — ●JUDITH SCHWAB, THOMAS HAUTH, MARTIN HECK, PABLO GOLDENZWEIG und THOMAS KECK — IEKP, KIT, Karlsruhe

Das Belle II-Experiment am japanischen Forschungszentrum KEK

ist ein geplantes Experiment am  $e^+e^-$ -Beschleuniger, SuperKEKB. Dieser wird auf der Schwerpunktsenergie der  $\Upsilon(4S)$ -Resonanz laufen und B-Mesonen-Paare produzieren. Zur Untersuchung seltener Zerfälle wird eines der B-Mesonen als 'Markierungs-B-Meson' und eines als 'Signal-B-Meson' verwendet. Die Rekonstruktionseffizienz der Markierungsseite ist eine wichtige Größe in der Analyse. Durch Unsicherheiten in der Simulation ist diese in Monte-Carlo-Daten und echten Daten unterschiedlich. Um die Kalibrationsfaktoren für die Markierungsseitenkanäle zu ermitteln, werden gut bekannte Signalkanäle in den verschiedenen Markierungsseitenkanälen betrachtet und der Unterschied zwischen Daten und Monte-Carlo ermittelt. Die hier beschriebene Kalibration spielt eine entscheidende Rolle bei der Messung seltener B-Mesonen-Zerfälle, die auf eine hadronische oder semileptonische Markierungsseite angewiesen sind.

## T 103: Suche nach Supersymmetrie 5

Zeit: Donnerstag 16:45–19:00

Raum: JUR 498

T 103.1 Do 16:45 JUR 498

**Search for resonant slepton production in R-parity violating SUSY scenarios with CMS** — ●PHILIPP MILLET, THOMAS HEBBEKER, ARND MEYER, and SEBASTIAN THÜER — III. Physikalisches Institut A, RWTH Aachen University

Supersymmetric models with R-parity violation can allow the resonant production of sleptons in proton proton collisions. These processes violate lepton number conservation and are not present in conventional SUSY scenarios, where R-parity is conserved.

A search for resonant production of second generation sleptons ( $\tilde{\mu}$ ,  $\tilde{\nu}_\mu$ ) with two same-sign muons and at least two jets in the final state is presented. One muon is expected to be produced directly in the decay of the slepton, while the other muon and at least two jets are produced in the subsequent decay of a neutralino or chargino originating from the resonantly produced slepton.

The analysis is based on the 2016 dataset of proton proton collisions recorded with the CMS detector at a centre-of-mass energy of 13 TeV.

T 103.2 Do 17:00 JUR 498

**Search for supersymmetry in dileptonic final states with jets with the JZB method at CMS using Run II data** — ●MARIUS TEROERDE, LUTZ FELD, and CHRISTIAN SCHOMAKERS — 1. Physikalisches Institut B, RWTH Aachen University

Supersymmetry (SUSY) is a popular extension of the standard model of particle physics, as it would solve a variety of problems in particle physics. In the model considered in the presented analysis, a possible final state contains jets as well as the stable lightest supersymmetric particle (LSP), which is produced together with a leptonically decaying Z boson. Thus, the signal is characterized by two same-flavor opposite-sign leptons, missing transverse energy (MET) and the presence of two or more jets. An important background for this search is the Drell-Yan process with additional jets, as it has a similar event topology. In contrast to SUSY events, Drell-Yan events only contain instrumental MET. Therefore, the variable "jet-Z balance" (JZB), which takes the transverse momentum of the Z boson and the hadronic recoil into account, is distributed differently for Drell-Yan and SUSY events. This allows the definition of a signal depleted control region which is used to predict the Drell-Yan background. The JZB method was successfully used in several analyses at  $\sqrt{s} = 7 - 8$  TeV.

This talk shows the application of the method on data taken in 2015 and 2016 in two separate searches for supersymmetry.

T 103.3 Do 17:15 JUR 498

**Suche nach Supersymmetrie mit versetzten Leptonpaaren beim ATLAS-Experiment am LHC** — ●DOMINIK KRAUSS, ZINONAS ZINONOS und HUBERT KROHA — Max-Planck-Institut für Physik, München

Supersymmetrie nahe der TeV-Skala ist eine elegante Möglichkeit, um das Hierarchieproblem zu lösen und die geringe Masse des Higgs-Bosons zu erklären. Die meisten Suchen nach Supersymmetrie am LHC konzentrieren sich auf den Fall, dass das leichteste supersymmetrische Teilchen (LSP) stabil und die anderen supersymmetrischen Teilchen kurzlebig sind. In dieser Analyse werden beide Annahmen fallen gelassen und der Fall betrachtet, bei dem das LSP rein leptonisch zerfällt

und seine Lebensdauer im Bereich von Pikosekunden bis Nanosekunden liegt, so dass der Zerfall als sekundärer Vertex im Innerdetektor rekonstruiert werden kann. In diesem Vortrag wird die Strategie zur Abschätzung des Untergrunds behandelt sowie die zu erwartende Sensitivität des ATLAS-Experiments auf ausgewählte Signalmodele.

T 103.4 Do 17:30 JUR 498

**Data-driven background estimates in searches for supersymmetry in final states with two same-sign leptons or three leptons, jets and  $E_T^{\text{miss}}$  with the ATLAS detector** — ●PETER TORNAMBÉ and FABIO CARDILLO — Albert-Ludwigs Universität Freiburg

A search for supersymmetric phenomena in final states with two leptons with the same electric charge or three leptons, jets and missing transverse energy  $E_T^{\text{miss}}$  is presented. The production of same-sign lepton pairs or three leptons is only induced by rare Standard Model processes with very small cross-sections. The search thus profits from little background and has a good exclusion potential in compressed SUSY spectra and in scenarios where the R-parity is violated, and no stable SUSY particles are produced. Except from the prompt production of same-sign lepton pairs, the main sources for SM processes contaminating the signal regions are fake-leptons and leptons with a charge mis-identification. While background originating from prompt same-sign lepton sources is estimated with simulated Monte Carlo events, the non-prompt sources are addressed with data-driven techniques. Within this talk, the current analysis strategy in Run-II will be presented focusing on the methods used for the background estimation and sensitivity optimisation. But also the latest results obtained during the 2015 and 2016 data-taking will be shown.

T 103.5 Do 17:45 JUR 498

**A search for supersymmetry at 13 TeV with two same-sign leptons or three leptons at the ATLAS detector - Latest analysis results and statistical interpretations** — ●FABIO CARDILLO and PETER TORNAMBÉ — Albert-Ludwigs Universität Freiburg

Supersymmetry (SUSY) is one of the most studied theories to extend the Standard Model. In R-Parity conserving (RPC) models, the lightest supersymmetric particle (LSP), which is typically the lightest neutralino  $\tilde{\chi}_1^0$ , is stable. In scenarios which allow a violation of the R-Parity (RPV), no stable SUSY particles are produced.

In this talk a search for supersymmetry in final states with two leptons of the same electric charge or three leptons, jets and  $E_T^{\text{miss}}$  is presented. While the same-sign signature is present in many SUSY scenarios, Standard Model processes leading to such events have very small cross-sections. Therefore, this analysis benefits from a small background in the signal regions leading to a good sensitivity especially in SUSY scenarios with compressed mass spectra.

This search was performed with the data recorded with the ATLAS detector during the years 2015 and 2016 corresponding to a total integrated luminosity of  $13.2 \text{ fb}^{-1}$ . The sensitivity to a big variety of supersymmetric models is illustrated by the interpretation of the results in the context of several SUSY benchmark scenarios. No significant excess above the Standard Model prediction is observed. The results can be used to set model-independent limits to new physics signals as well as deriving limits on the masses of the superpartners in different SUSY scenarios.

T 103.6 Do 18:00 JUR 498

**Search for Supersymmetry in final states with two opposite-sign same-flavor leptons, jets, and  $p_T^{miss}$  in pp collisions at  $\sqrt{s} = 13$  TeV with the CMS experiment** — ●CHRISTIAN SCHOMAKERS, CHRISTIAN AUTERMANN, LUTZ FELD, and MARIUS TEROERDE — 1. Physikalisches Institut B, RWTH Aachen University

One of the main purposes of the LHC is the search for new physics which is predicted by theories such as Supersymmetry (SUSY) and is necessary to solve several problems of the standard model. Cascade decays of SUSY particles often yield final states with hadronic activity and missing transverse energy. Signatures including leptons are of particular interest since standard model background processes are suppressed by this selection and can be predicted with good accuracy.

The invariant dilepton mass distribution can provide further information on possible decays of SUSY particles e.g. the mass difference between particles in the decay chain.

This talk covers the CMS SUSY dilepton edge search on the full dataset of 2016. Improvements with respect to previous searches have been made to cope with the large background statistics and the sensitivity to certain SUSY models was increased significantly.

T 103.7 Do 18:15 JUR 498

**Datenorientierte Untergrundbestimmung für die Suche nach Supersymmetrie in multileptonischen Endzuständen mit dem ATLAS-Detektor** — ●STEFAN MASCHKE, MICHAEL FLOWERDEW und HUBERT KROHA — Max-Planck-Institut für Physik, München, Deutschland

Supersymmetrie ist eine der beliebtesten Erweiterungen des Standardmodells welche unter anderem das Hierarchieproblem lösen kann. Sie sagt zu allen Standardmodellteilchen supersymmetrische Partner vorher, von denen bislang jedoch keines bei Collider-Experimenten nachgewiesen werden konnte. 2015 ist der LHC mit Proton-Proton Kollisionen bei einer Schwerpunktsenergie von  $\sqrt{s} = 13$  TeV wieder in Betrieb gegangen, und die Suche nach supersymmetrischen Teilchen wurde fortgesetzt.

Supersymmetrische Modelle mit Verletzung der R-Parität erlauben den Zerfall der leichtesten supersymmetrischen Teilchen in Leptonen. Die Signatur von vier oder mehr Leptonen im Endzustand hat einen

besonders geringen Untergrund und eignet sich daher sehr gut zum Nachweis oder Ausschluss R-paritätsverletzender supersymmetrischer Modelle.

In diesem Vortrag wird die datenorientierte Bestimmung reduzierbarer Untergründe in dem vier-Lepton-Endzustand vorgestellt.

T 103.8 Do 18:30 JUR 498

**Search for gluino-pair decays into multileptonic final states with the ATLAS detector** — ●MARIAN RENDEL, HUBERT KROHA, ZINONAS ZINONOS, and JOHANNES JUNGGEURTH — Max Planck Institut für Physik

The search for supersymmetry (SUSY) is an important goal of the ATLAS physics program. If R-parity is conserved, the lightest supersymmetric particle is stable, leading to signatures with large missing transverse momentum. The high cross-section for strong production modes in proton-proton collisions at the Large Hadron Collider and the low background contributions in events with four or more leptons and high jet multiplicity makes the search of such final SUSY states very interesting. This talk presents the optimization of the event selection of models involving four-lepton signatures from gluino-pair decays.

T 103.9 Do 18:45 JUR 498

**Searches for R-parity violating Supersymmetry in multileptonic final states** — ●JOHANNES JUNGGEURTH, ZINONAS ZINONOS, and HUBERT KROHA — Max-Planck-Institut für Physik

Supersymmetry is one of the most extensively tested theories in the physics programme of the Large Hadron Collider (LHC). If the discrete R-parity symmetry is conserved, the lightest supersymmetric particle (LSP) is stable, thus providing a dark-matter candidate. However, R-parity may be violated allowing the LSP to decay into Standard Model (SM) particles. Multileptonic final states provide an excellent signature to probe such supersymmetric scenarios due to the low SM background. In this talk, a search for events with at least four isolated charged leptons is presented which uses LHC proton-proton collision data collected by the ATLAS detector. The results are interpreted in terms of the visible cross-section for such new physics final states and in terms of various supersymmetric models with R-parity violation.

## T 104: Suche nach neuen Teilchen 5

Zeit: Donnerstag 16:45–19:00

Raum: JUR 2

T 104.1 Do 16:45 JUR 2

**Search for a heavy resonance  $Z'$  decaying into  $T't$  at  $\sqrt{s} = 13$  TeV with the CMS experiment** — ●ANNA BENECKE, JOHANNES HALLER, ANDREAS HINZMANN, and ROMAN KOGLER — Institut für Experimentalphysik, Universität Hamburg

Many models of physics beyond the Standard Model predict vector-like quarks ( $T'$ ) and a new heavy gauge boson ( $Z'$ ). While decays of the  $Z'$  and  $T'$  into Standard Model particles have been already studied, no experimental results for the decay  $Z' \rightarrow tT'$  with  $T' \rightarrow Ht, Zt$  are available so far. In this talk a search for a heavy spin-1 resonance  $Z'$  decaying into  $T't$  at  $\sqrt{s} = 13$  TeV with the CMS experiment is presented. Two decays of the  $T'$  quark to third generation Standard Model quarks are considered:  $T' \rightarrow Ht$  and  $T' \rightarrow Zt$ .

Due to the large mass of the  $T'$  the  $H$  and  $Z$  bosons receive a large Lorentz boost and the decay products of the bosons appear as a single merged jet. Jet substructure techniques are used to identify these jets. The performance of the taggers is evaluated by measurements of the efficiency and the mistag rate. Sidebands are used to test the simulation of the Standard Model backgrounds in this search. The reconstruction of the  $Z'$  mass is done with a  $\chi^2$  method, and the distribution obtained is used to test for deviations from Standard Model predictions.

T 104.2 Do 17:00 JUR 2

**Kinematic fits in  $t\bar{t}$  resonance searches** — ●MELANIE EICH, JOHANNES HALLER, ROMAN KOGLER, and ANASTASIA KARAVDINA — Institut für Experimentalphysik, Universität Hamburg

Many extensions of the Standard Model predict new massive gauge bosons ( $Z'$ ) with an enhanced coupling to top quarks. The experimental signature of such a new boson decaying into a top-quark pair is a resonant structure in the invariant mass of the  $t\bar{t}$  system. While previous searches focussed on high mass resonances with boosted sig-

natures, an extension to low mass resonances with resolved topologies is performed in this work.

In this talk the status of the  $Z' \rightarrow t\bar{t}$  search in the lepton+jets channel is presented, using data recorded with the CMS experiment in 2016. A kinematic fit tool is employed, which improves the reconstruction of  $W$  bosons and top quarks using measured final state objects, such as jets and leptons. The effect on the resolution of the invariant mass of the  $t\bar{t}$  system is studied and compared to previous reconstruction techniques.

T 104.3 Do 17:15 JUR 2

**Search for heavy resonances decaying to a neutrino and a tau lepton using hadronic tau decays at ATLAS** — ●CHRISTOS VERGIS, WILLIAM DAVEY, and JOCHEN DINGFELDER — Physikalisches Institut, Nussallee 12, Bonn

Many models beyond the Standard Model predict the existence of new heavy, charged ( $W'$ ) and neutral ( $Z'$ ) gauge bosons. In case of leptonic  $W'$  decays, the signature in the detector is a high- $p_T$  lepton and large missing transverse energy from the emitted neutrino. Although searches for  $W' \rightarrow (e/\mu)\nu$  are more sensitive than  $W' \rightarrow \tau\nu$  for a universal coupling to leptons, decays with a tau lepton are well suited to investigate models in which the  $W'$  bosons couple predominantly to third generation fermions.

This talk presents preparations of a search for  $W' \rightarrow \tau\nu$  decays with a hadronically decaying tau lepton, using 2015 and 2016 pp-collision data at a center-of-mass energy of  $\sqrt{s} = 13$  TeV collected with the ATLAS detector at the Large Hadron Collider. The expected limits to the cross-sections are derived from simulation considering a Sequential Standard Model scenario, where the  $W'$  bosons have the same couplings as the Standard Model  $W$  bosons.

T 104.4 Do 17:30 JUR 2

**Search for a new heavy resonance in the decay channel  $V' \rightarrow VH \rightarrow l\nu/l\bar{\nu}\nu + b\bar{b}$  with the ATLAS experiment** — ●RUTH JACOBS, ALESSANDRA BETTI, GÖTZ GAYCKEN, VADIM KOSTYUKHIN, TATJANA LENZ, ALEXANDER MELZER, ELISABETH SCHOPF, ECKHARD VON TÖRNE, and NORBERT WERMES — Physikalisches Institut, Universität Bonn

One of the aims of the LHC Run-2 is the search for BSM physics. Many BSM models predict heavy resonances with masses in the TeV range. Some of these resonances are predicted to decay into a SM Higgs boson and a massive electroweak boson  $V = W, Z$ . A search for new heavy resonances in the decay mode  $V' \rightarrow VH \rightarrow l\nu/l\bar{\nu}\nu + b\bar{b}$  using data collected with the ATLAS detector in 13 TeV  $pp$ -collisions is presented. The resonance search is performed by studying the invariant mass distribution of the reconstructed  $VH$  system and testing for a localized excess. The talk will focus on the decay channel  $Z' \rightarrow ZH \rightarrow \nu\nu + b\bar{b}$  ("0-lepton channel"), presenting studies on the SM background suppression and the optimization of the statistical model used to obtain upper limits on the resonance cross section. In addition, the statistical combination of the search results in the individual lepton channels into a combined  $V'$  cross section limit is discussed.

T 104.5 Do 17:45 JUR 2

**Search for  $W'$  decays taking into account interference effects with  $pp$ -collisions at  $\sqrt{s} = 13$  TeV in the ATLAS experiment** — ●PAUL GESSINGER and STEFAN TAPPROGGE — Johannes Gutenberg-Universität Mainz

As part of the search for new physics, the electronic decay of new heavy charged gauge bosons,  $W' \rightarrow e\nu$ , can be looked for in  $pp$ -collisions at  $\sqrt{s} = 13$  TeV in the ATLAS experiment at the LHC. Events with a lepton of high transverse momentum and high missing transverse energy are selected. If no significant excess is observed, statistical methods can be employed to calculate a lower limit on the mass of a hypothetical  $W'$  particle. Narrow resonance signal templates are used, either taking into account interference with the background processes, or neglecting it. Interference effects modify the overall signal shape and can thus impact the limit obtained. The results of both approaches will be presented and discussed.

T 104.6 Do 18:00 JUR 2

**Search for new physics in the dilepton channel with ATLAS using proton-proton collisions at  $\sqrt{s} = 13$  TeV** — ●SIMON SCHMITZ, STEFAN TAPPROGGE, and MARKUS ZINSER — Johannes Gutenberg-Universität Mainz, Institut für Physik

Decays with two leptons in the final state are considered to be one of the most promising processes to find new physics. Well understood backgrounds as well as high signal efficiencies lead to an excellent sensitivity to models beyond the Standard Model predicting a narrow resonance (for example a  $Z'$  boson) decaying into two leptons. The search is performed with final states consisting either of two electrons or two muons. The results are based on an integrated luminosity of  $36.5 \text{ fb}^{-1}$  of proton-proton collision data at  $\sqrt{s} = 13$  TeV recorded with the ATLAS detector in 2015 and 2016.

This talk presents the analysis details with a focus on the determination of the background arising from QCD processes. This background is essential to know in the dielectron channel and can not be estimated by Monte Carlo simulation. Finally the status of the analysis in both channels will be shown. Furthermore an approach to express the results of the analysis in a model-independent way allowing a comparison to a wide variety of models is presented.

T 104.7 Do 18:15 JUR 2

**A data-driven QCD background estimate in ATLAS searches for heavy  $Wh$  resonances in the final state  $l\nu b\bar{b}$**  — ●ANDREAS HÖNLE, SANDRA KORTNER, HUBERT KROHA, and FELIX MÜLLER — Max-Planck-Institut für Physik

Many extensions of the Standard Model (SM) predict the existence of heavy resonances that decay into boson pairs. A promising channel is the decay of a heavy  $W'$  resonance into a charged SM vector boson  $W$  and the SM Higgs boson  $h$ , followed by a semi-leptonic decay into the final state  $l\nu b\bar{b}$ . Multijet background, originating from QCD processes, is difficult to describe with Monte Carlo simulations and is thus particularly challenging to model. In this talk, two data-driven methods to estimate this background are presented: the Template Method and the ABCD method.

T 104.8 Do 18:30 JUR 2

**Model-Independent Limits on the Production Cross Section of Diboson Resonances with the CMS-Detector at  $\sqrt{s} = 13$  TeV** — MATTHIAS MOZER, THOMAS MÜLLER, and ●DANIELA SCHÄFER — Institut für Experimentelle Kernphysik/KIT

Due to the multitude of theoretical models describing physics beyond the standard model, only a fraction of the existing models can be considered by a dedicated analysis by one of the experimental groups at the LHC. In this talk we present a framework which provides a model-independent interpretation of two CMS resonance searches in the diboson channel.

As a first step towards this goal, model-independent limits on the production cross section of diboson resonances with semileptonic or hadronic final states are extracted. For this, data collected by the CMS detector at a center of mass energy of  $\sqrt{s} = 13$  TeV corresponding to an integrated luminosity of  $2.3(2.7) \text{ fb}^{-1}$  are analyzed. Based on these limits we provide a ready-to-use framework, which enables theorists to calculate the approximate signal yield predictions of their theories. As a proof-of-concept the provided framework is applied to a Randall-Sundrum model.

T 104.9 Do 18:45 JUR 2

**Suche nach  $X \rightarrow t\bar{t}$  Resonanzen mittels der Methode *Buckets of tops* im ATLAS Experiment** — ●MATHIS KOLB, CHRISTOPH ANDERS, DANILO FERREIRA DE LIMA und ANDRÉ SCHÖNING — Physikalisches Institut, Universität Heidelberg, Deutschland

In Modellen für neue Physik koppeln neue schwere Teilchen häufig an Top Quarks. Daher stellt die Suche nach Resonanzen im invarianten Massenspektrum von Top Quark Paaren ein vielversprechendes Mittel dar, um Erweiterungen des Standardmodells zu testen. Dieser Vortrag behandelt die Suche nach solchen schweren Resonanzen mit den in 2016 aufgezeichneten Proton-Proton ATLAS Daten, wobei beide Top Quarks hadronisch zerfallen. Die Analyse konzentriert sich auf eine Verbesserung der Sensitivität bei niedrigen Ditol Massen unterhalb von 1 TeV.

Zur Rekonstruktion des Top Quark Paar Systems wird die Methode *Buckets of tops*, wie in JHEP 08 (2013) 086 vorgeschlagen, verwendet. Die Methode eignet sich insbesondere für moderate transversale Impulse der Top Quarks im Bereich  $p_T = 100 - 400 \text{ GeV}$ . So bietet sie die Möglichkeit Methoden, die auf Substruktur großer R-Jets basieren, zu ergänzen. Es werden anti- $k_T$  ( $R = 0.4$ ) Jets in drei *Buckets* aufgeteilt. Diese entsprechen den beiden Top Quarks und der weiteren hadronischen Aktivität.

Die größten Untergründe, bestehend aus Standardmodell Top Quark Paaren und QCD Multijets, werden mittels Kontrollregionen in Daten abgeschätzt und validiert. Die Daten werden analysiert und entsprechende Ergebnisse werden präsentiert.

## T 105: Suche nach neuen Teilchen 6

Zeit: Donnerstag 16:45–19:00

Raum: JUR 5

T 105.1 Do 16:45 JUR 5

**Energy loss calibration for a search for heavy, (meta-)stable, charged particles at CMS** — ●PAUL ASMUS, TOBIAS KRAMER, VIKTOR KUTZNER, PETER SCHLEPER, and BENEDIKT VORMWALD — Universität Hamburg

Many theories beyond the Standard Model predict new, long-lived particles. CMS performs a search for these kind of heavy, (meta-)stable, charged particles. Their momentum to mass ratio is often small, lead-

ing to enhanced energy loss in material. One of the main observables in this search is the measured  $dE/dx$  in the silicon tracker. In this talk, a calibration scheme for the more than 80000 read-out chips is presented which allows to use both tracker subsystems, the pixel and the strip detector, for discriminating between new heavy particles and Standard Model background. First results using data collected during LHC Run-2 at a center of mass energy of  $\sqrt{s} = 13 \text{ TeV}$  will be shown.

T 105.2 Do 17:00 JUR 5

**Calibration of the ATLAS Tile Calorimeter and the implications for the search for heavy charged long-lived particles** — ●MICHAEL ADERSBERGER and SASCHA MEHLHASE — Ludwig-Maximilians Universität München

Heavy charged long-lived particles are a promising but challenging type of particles predicted in many extensions of the Standard Model (SM). The high mass together with the long lifetime lead to a distinct signature in the detector. In this search only lifetimes allowing for a direct interaction with at least the hadronic tile calorimeter are considered, called Stable Massive Particles (SMPs). SMPs are expected to have a velocity significantly lower than the speed-of-light. The main observables for SMPs are long time-of-flight and high specific energy loss measurements together with a high momentum, as no particles in the SM are produced at the Large Hadron Collider (LHC) able to traverse the full (or at least a large fraction) detector with low velocities. The main background for this analysis is therefore detector mis-measurements. Hence it is essential to have a deep understanding of the measurements of the main observables in the corresponding detector components. A detailed description of the time-of-flight calibration of the ATLAS Tile Calorimeter together with the search for SMPs with the ATLAS detector at a center-of-mass energy of 13 TeV will be presented in this talk.

T 105.3 Do 17:15 JUR 5

**Calibration of the ATLAS Muon Spectrometer for time-of-flight measurements targeting searches for long-lived particles** — ●JOCHEN JENS HEINRICH and SASCHA MEHLHASE — Ludwig-Maximilians-Universität, München, Deutschland

Many theories beyond the Standard Model predict the existence of new long-lived heavy charged particles that can be produced in LHC proton-proton collisions at  $\sqrt{s} = 13$  TeV. If their lifetimes are large enough to enable them to traverse large parts of the detector before decaying, we speak of stable massive particles (SMPs). SMPs do not form extensive showers in the calorimeters and therefore present the signature of a muon-like particle that propagates with velocities much slower than the speed of light. A direct search for SMPs can be conducted, where the signature is largely model independent with only a small instrumental background. It also expands coverage in new-particle searches, as it is an orthogonal approach to generic missing-energy based searches for new physics. SMPs are identified by determining their velocity via measurement of their anomalous ionisation energy losses in the inner tracker and time-of-flight measurements carried out in the calorimeter and muon system. All involved subsystems require extensive calibration. The status of a search effort for stable supersymmetric particles in the dataset collected in 2015 and 2016 corresponding to  $36.5\text{fb}^{-1}$  is presented. Special emphasis is given to the timing calibration process of the Muon Spectrometer, which involves a series of dedicated corrections that account for time-dependent effects as well as disparities between individual detector components.

T 105.4 Do 17:30 JUR 5

**Improved mass reconstruction of large-radius jets with the ATLAS detector using tracker and calorimeter information** — ●FABRIZIO NAPOLITANO and OLEG BRANDT — Kirchhoff-Institut für Physik (KIP), Heidelberg, Germany

The invariant mass of large-radius jets is a powerful observable to identify hadronic decays of top quarks, W, Z, and Higgs bosons at very high transverse momenta of about 0.5 TeV and above; these decays are an important aspect of the physics potential of the ATLAS detector at the LHC. The track-assisted subjet mass belongs to a series of novel techniques developed to increase the precision of large-radius jet mass reconstruction by improving its resolution at very high transverse momenta. The information from the calorimeter and the tracker is combined on a subjet-by-subjet basis, resulting in an improved performance. The performance of this variable is presented and compared to the traditional calorimeter-based jet mass definition and other observables.

T 105.5 Do 17:45 JUR 5

**Dedicated Energy Calibration of Trigger Jets for the Dijet Trigger Level Analysis with the ATLAS Detector** — ●HANNO MEYER ZU THEENHAUSEN — Universität Heidelberg

In the search for particles, which could mediate between the standard model sector and the dark matter sector, a large unexcluded parameter space is represented by small mediator masses, both from the

cosmological as well as the particle physics point of view. In ATLAS and CMS at the Large Hadron Collider the sensitivity to mediators at small masses is limited by the data-archiving rate. As a result, their limits obtained from searches for low-mass resonances in the dijet mass spectrum are not competitive with those determined at the Tevatron and SPS. To circumvent this limitation, the dijet trigger level analysis (TLA) at ATLAS uses only the jet information from the trigger system, which can be recorded at higher event rates. The challenge of using trigger-based jet information is to achieve a similar performance of jet calibration as in the offline reconstruction, despite the lack of information e.g. from the tracking detectors. This talk reports on a dedicated derivation of a calorimeter based global sequential calibration scheme to be applied to the trigger-based jets, which improves jet energy resolution and reduces jet energy scale uncertainties.

T 105.6 Do 18:00 JUR 5

**Triggerlose Suche nach neuer Physik in Dijet-Ereignissen mit dem topologischen Prozessor des ATLAS Level-1 Triggers** — ●SEBASTIAN ARTZ, VOLKER BÜSCHER, CHRISTIAN SCHMITT, FRANK FIEDLER und JOHANNES DAMP — Johannes Gutenberg-Universität, Mainz

Im Large Hadron Collider am CERN werden Protonen bei einer Schwerpunktsenergie von 13 GeV zur Kollision gebracht. Entstehen dabei neue Teilchen, welche als Resonanz direkt produziert werden, zerfallen diese in Jets und sind somit als Erhöhung im Spektrum der invarianten Masse der Jets sichtbar.

Für Massen unterhalb  $\approx 1$  TeV werden Jet-Trigger benötigt, die mit hohen Raten feuern und deshalb nur mit hohen Prescale-Faktoren betrieben werden können, wodurch hier ein erheblicher Sensitivitätsverlust entsteht. Auf den FPGAs des topologischen Prozessors, welcher Teil der ersten Triggerstufe des ATLAS-Detektors ist, können jedoch die invarianten Massen aller Kollisionsereignisse ohne Einsatz eines Triggers betrachtet werden. So ist es im Gegensatz zur Offlineanalyse möglich das gesamte Spektrum mit voller Statistik zu analysieren. Inhalt dieses Vortrages ist sowohl die Analyse des Dijetspektrums als auch die Entwicklung der erforderlichen Firmware.

T 105.7 Do 18:15 JUR 5

**Search for new physics in events with one lepton and high missing transverse energy with the ATLAS detector** — ●HOLGER HERR and STEFAN TAPPROGGE — Johannes Gutenberg Universität Mainz

Extensions of the Standard Model (SM) predict new massive charged spin-1 gauge bosons decaying amongst others into a lepton and a neutrino. The existence of such a particle would lead to an excess of data in the tail of the transverse mass distribution. In 2015 and 2016 the LHC collided protons at a center of mass energy of 13 TeV. Data corresponding to an integrated luminosity of  $36.5/\text{fb}$  has been recorded by the ATLAS experiment and is analysed searching for such a new heavy gauge boson. Results of this search will be presented.

T 105.8 Do 18:30 JUR 5

**Search for new heavy vector bosons in the  $e+\text{MET}$  final state** — ●SEBASTIAN WIEDENBECK, THOMAS HEBBEKER, KERSTIN HOEPFNER, KLAAS PADEKEN, FABIAN BISPINCK, and MARCEL MATEROK — III. Physikalisches Institut A, RWTH Aachen University

Many BSM models predict new heavy vector bosons. CMS has been searching for such bosons taking guidance from the sequential standard model (SSM). Using the full CMS data set of the 2016 runs at  $\sqrt{s} = 13$  TeV, the signature consisting of a high  $p_T$  electron + missing transverse energy (MET) due to a neutrino was investigated. The reconstruction of high  $p_T$  objects is challenging because of their low statistics. The strategy and results of this analysis are presented in the context of the SSM along with other interpretations.

T 105.9 Do 18:45 JUR 5

**Search for new heavy vector bosons in the  $\tau + \text{MET}$  final state** — ●MARCEL MATEROK, THOMAS HEBBEKER, KERSTIN HOEPFNER, and SWAGATA MUKHERJEE — III. Physikalisches Institut A, RWTH Aachen University

A search for new physics in the  $\tau +$  missing transverse energy (MET) channel is presented based on proton-proton collisions measured with the CMS detector at the LHC, using the full 2016 CMS data set recorded at a center of mass energy of  $\sqrt{s} = 13$  TeV. The tau channel is of theoretical interest in particular for models with enhanced couplings or larger branching fraction to fermions of the third generation.

The analysis strategy is discussed and the results are interpreted in the context of a new heavy charged vector boson,  $W'$ , described by the Se-

quential Standard Model (SSM) and other models with non-universal couplings.

## T 106: Suche nach Dunkler Materie 4

Zeit: Donnerstag 16:45–18:55

Raum: VSH 19

### Gruppenbericht

T 106.1 Do 16:45 VSH 19

**Why the Fermi GeV gamma-ray excess cannot be explained by dark matter annihilation** — ●WIM DE BOER, IRIS GEBAUER, ALEXANDER NEUMANN, and PETER L. BIERMANN — Karlsruhe Institut of Technology (KIT), Karlsruhe, Germany

The "GeV-excess" of the diffuse gamma-rays in the halo is studied with a template fit based on energy spectra for each possible process of gamma-ray emission. Such a fit allows to determine the background and signal simultaneously, leading to a reliable background determination even in the Galactic Disk, largely independent of propagation models or gas distributions. We find evidence that the "excess", characterised by a gamma-ray spectrum peaking at 2 GeV, is related to the propagation inside Molecular Clouds (MCs), which show this excess, as is apparent from the Central Molecular Zone.

We find that the "excess" has the same morphology as the column density of MCs, as was apparent from the comparison with the CO maps from the Planck satellite. These CO maps are tracers from MCs and happen to lead to an emissivity resembling a typical dark matter profile. However, outside the Galactic Bar the Molecular Clouds and the observed "excess" in the Galactic Disk abruptly show a decrease, so the excess cannot originate from a process surrounding spherically the Galactic Center.

T 106.2 Do 17:05 VSH 19

**Search for Right-Handed Neutrinos from Dark Matter Annihilation with Fermi-LAT and H.E.S.S. Telescopes** — ●MIGUEL D. CAMPOS, FARINALDO S. QUEIROZ, and CARLOS E. YAGUNA — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The best strategy for indirect detection of dark matter depends entirely on its annihilation processes. In this work we discuss a model independent probe for dark matter annihilations into right-handed neutrinos in the GeV–TeV mass range, using data from Fermi-LAT and H.E.S.S. telescopes coming from 6 years observation of dwarf spheroidal galaxies and 10 years of the galactic center respectively. We exclude the thermal annihilation cross section for dark matter masses below 200 GeV for right-handed tau neutrinos final state.

T 106.3 Do 17:20 VSH 19

**Search for Decaying Dark Matter with Astrophysical Muon Neutrinos Measured by IceCube** — ●JÖRAN STETTNER, THEO GLAUCH, CHRISTIAN HAACK, RENÉ REIMANN, LEIF RÄDEL, SEBASTIAN SCHOENEN, and CHRISTOPHER WIEBUSCH for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen

The discovery of astrophysical neutrinos up to PeV energies by IceCube has triggered intense interest in possible explanations of their origin. One possibility besides astrophysical sources is a top-down scenario, namely the decay of a dark matter particle with mass of the order of PeV. We present an analysis of 6 years (2009–14) of muon neutrino events observed by IceCube from the northern hemisphere. In a three-dimensional template fit of energy and direction, the components contributing to the total neutrino flux are disentangled. These are atmospheric neutrinos, an isotropic astrophysical flux following a power-law energy spectrum and a flux from decaying dark matter. The dark matter signal would exhibit a clear signature in the arrival directions due to the shape of the galactic dark matter halo and in the energy spectrum. Results of the fit are constraints on the dark matter parameters, namely on the mass and lifetime of the DM-particle.

### Gruppenbericht

T 106.4 Do 17:35 VSH 19

**Status des ALPS Experiments** — ●KLAUS ZENKER für die ALPS-II-Kollaboration — DESY, Notkestrasse 85, 22607 Hamburg

Die Natur der dunklen Materie ist bis heute nicht erschlossen. Verschiedene Erweiterungen des Standardmodells der Teilchenphysik beinhalten Teilchen die Bestandteil der dunklen Materie sein könnten. Speziell axionartige Teilchen erfreuen sich zunehmender Popularität, da sie nicht nur das Rätsel der dunklen Materie lösen könnten, sondern

auch andere beobachtete Phänomäne im Universum erklären könnten. Dazu zählen die beobachtete, aber nicht erwartete, scheinbare Transparenz des Universums für Photonen mit Energien grösser als 1 TeV oder unverstandene Energieverluste in unterschiedlichen Sternarten.

Das *Any Light Particle Search Experiment* (ALPS) wird die Möglichkeit der direkten Erzeugung und des anschließenden Nachweises von axionartigen Teilchen und *Weakly Interacting Slim Particles* (WISPs) im Allgemeinen bieten. Dazu werden Photonen auf eine undurchlässige Wand gestrahlt. Falls WISPs existieren besteht die Möglichkeit, dass sich Photonen vor der Wand in diese umwandeln, WISPs die Wand durchdringen und hinter der Wand wieder in Photonen konvertieren. Die zu erwartende Rate an konvertierten Photonen ist äußerst gering. Die nachweisbare Photonenrate wird  $< 10^{-3} \text{ s}^{-1}$  sein. Das für die Konversion von axionartigen Teilchen notwendige Magnetfeld wird durch Magnete aus dem HERA Beschleuniger am DESY erzeugt. Zur Maximierung der Konversionswahrscheinlichkeit werden optische Techniken von Gravitationswelleninterferometern genutzt. Im Vortrag wird der aktuelle Stand zur Vorbereitung des ALPS Experiments vorgestellt.

T 106.5 Do 17:55 VSH 19

**Search for chameleons with an InGrid based X-ray detector at the CAST experiment** — KLAUS DESCH, JOCHEN KAMINSKI, ●CHRISTOPH KRIEGER, TOBIAS SCHIFFER, and SEBASTIAN SCHMIDT — Physikalisches Institut, Universität Bonn, Nußallee 12, 53115 Bonn

The CERN Axion Solar Telescope (CAST) searches for axions and also other exotic particles emerging from the Sun. Chameleons, for example, are part of Dark Energy theories. Like Axions they can be converted into soft X-ray photons in a high magnetic field and should result in an X-ray spectrum peaking below 1 keV. Because of their low energy and weak coupling, detectors with low energy threshold and low background rates are mandatory.

Both requirements are met by an X-ray detector based on the combination of a Micromegas gas amplification stage with a highly integrated pixel chip which allows to make full use of the Micromegas structure's granularity. It has been demonstrated that these devices can detect even single electrons. Thus, allowing for a topological background suppression as well as for detection of low energy X-ray photons.

After the detection threshold had been evaluated to be low enough to allow for the detection of the carbon  $K_\alpha$  line at 277 eV, the detector was mounted at one of CAST's X-ray telescopes in 2014. During data taking until end of 2015 background rates of less than  $10^{-4} \text{ /keV/cm}^2\text{/s}$  have been achieved below 2 keV. Preliminary results of the chameleon analysis and possibly an improved limit for solar chameleons will be presented as well as prospects for improvements followed in the development of a new detector for 2016.

T 106.6 Do 18:10 VSH 19

**Artificial Neural Networks as event classifiers for an InGrid detector at CAST** — KLAUS DESCH, JOCHEN KAMINSKI, CHRISTOPH KRIEGER, TOBIAS SCHIFFER, and ●SEBASTIAN SCHMIDT — Physikalisches Institut der Universität Bonn, Deutschland

The CERN Axion Solar Telescope is a helioscope experiment at CERN searching for solar axions and chameleons. In the magnetic field of a decommissioned LHC prototype dipole magnet the particles are reconverted to photons via the inverse Primakoff effect. The resulting photons are in the low X-ray regime. A low conversion probability means the data is dominated by background events. Thus, methods to differentiate between background and real X-ray events need to be very efficient, providing a very high background suppression, but still retain high signal efficiency.

In 2014 and 2015 a gaseous detector based on a single InGrid was deployed. A likelihood method was used in our analysis of this data. In this talk an approach using Convolutional Neural Networks (CNNs) will be presented. These are widely used in commercial applications, e.g. for image classification. CNNs allow to use the raw individual frames as inputs, without any need for preprocessing.

The talk will briefly cover the basics of Artificial Neural Networks (ANNs), compare the usage of standard ANNs in particle physics with

a CNN, explain the implementation and present some preliminary results.

T 106.7 Do 18:25 VSH 19

### Suche nach Dunkler Materie in Ereignissen mit fehlender transversaler Energie und Jets beim ATLAS Experiment —

•ANDREAS D. REISS, JOHANNES BALZ, KATHARINA BIERWAGEN, VOLKER BÜSCHER, KATHARINA JACOBI, MANUEL LORNATUS und JAN SCHÄFFER — Johannes Gutenberg-Universität, Mainz, Deutschland

Dunkle Materie konnte bisher nur indirekt durch die Auswirkungen der Gravitation im Kosmos beobachtet werden.

Durch die Datennahme mit dem Large Hadron Collider in 2015 und 2016 mit einer Schwerpunktsenergie von 13 TeV wurden direkte Suchen nach Dunkler Materie in Proton-Proton-Kollisionen unter Abstrahlung von Quarks oder Gluonen im Anfangszustand ermöglicht.

Die hier vorgestellte Analyse befasst sich mit der Produktion von Dunkler Materie unter Beobachtung von einem oder mehreren Jets und fehlender transversaler Energie beim ATLAS-Experiment. Bislang wurde hierbei ausschließlich die fehlende transversale Energie als Diskriminante zwischen Signal und Untergrund verwendet. Weitere topologischen Variablen werden studiert indem Formunterschiede in Multijetereignissen ausgenutzt werden, welche aufgrund von unterschiedlichen Produktionsmechanismen von Signal und Untergrund existieren. Diese konnten verwendet werden, um die Sensitivität der Analyse zu verbessern.

T 106.8 Do 18:40 VSH 19

### WIMP search at the International Linear Collider —

•MORITZ HABERMEHL<sup>1,2</sup> and JENNY LIST<sup>1</sup> — <sup>1</sup>Deutsches Elektronen-Synchrotron DESY, Notkestrasse 85, 22607 Hamburg — <sup>2</sup>Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

The International Linear Collider (ILC) is a planned electron-positron collider with  $\sqrt{s}$  tunable from 250 to 500 GeV, with a possible upgrade to 1 TeV. Besides precision measurements of the Higgs boson its physics goals comprise searches for physics beyond the Standard Model, e.g. searches for Dark Matter.

This collider search assumes the production of WIMPs in pairs. They are not visible in the detector but the energy carried away can be observed via an additional ("tag") particle. Photon emission from the initial state leads to the almost model independent signature:  $e^+e^- \rightarrow \chi\chi\gamma$ . As this analysis tests couplings between WIMPs and leptons it is complementary to analogous searches at the LHC and direct detection. A precise study is facilitated by the clean environment of lepton colliders with small systematics of electroweak backgrounds.

While the conceptual feasibility and the sensitivity reach of the ILC have been shown in the past, this talk focusses on the treatment of the main reducible Standard Model background: Radiative Bhabha scattering  $e^+e^- \rightarrow e^+e^-\gamma$  mimics the signal if the leptons are undetected. Hence the best possible hermeticity of the detector, especially in the forward region, is one of the key requirements on the detector design.

## T 107: Neutrinoophysik 8

Zeit: Donnerstag 16:45–18:45

Raum: H 2

T 107.1 Do 16:45 H 2

### Testing the Neutrino Mass Ordering Using 4 Years of IceCube/DeepCore Data — •MARTIN LEUERMANN, MARIUS WALLRAFF, and CHRISTOPHER WIEBUSCH for the IceCube-Collaboration — III. Physikalisches Institut B, RWTH Aachen University, Germany

The measurement of the Neutrino Mass Ordering (NMO), i.e. the ordering of the three neutrino mass eigenstates, is one of the major goals of many future neutrino experiments. One strategy is to measure matter effects in the oscillation pattern of atmospheric neutrinos as e.g. proposed for the PINGU extension of the IceCube Neutrino Observatory. Already, the currently running IceCube/Deepcore detector can explore this type of measurement – however, with lower significance.

We present a three dimensional likelihood analysis based on 4 years of IceCube data searching for indications of the NMO with a data sample reaching to energies below 10GeV and improved reconstruction techniques.

T 107.2 Do 17:00 H 2

### Computational and statistical aspects of neutrino mass ordering studies with very-large-volume neutrino telescopes —

•THOMAS EHRHARDT and SEBASTIAN BÖSER for the IceCube-Collaboration — Institut für Physik, Universität Mainz

Very-large-volume neutrino telescopes (VLvNTs) have the potential to determine the neutrino mass ordering (NMO) via a measurement of the flux of atmospheric neutrinos in the GeV energy range. Their sensitivity is brought about by an asymmetry in the oscillation pattern of Earth-crossing neutrinos. In combination with flux and cross-section differences between neutrinos and anti-neutrinos, this results in a few-percent net imprint of the NMO on the measured spectra, which can only be resolved unambiguously with megaton-scale detectors. In this talk, we highlight some computational and statistical challenges emerging from the high-statistics nature of the experiment, and introduce a fast detector simulation framework in which they are addressed.

T 107.3 Do 17:15 H 2

### A muon veto for the measurement of the downgoing neutrino flux with KM3NeT/ORCA — •MARCO VOLKERT, JANNIK HOFESTÄDT, and THOMAS EBERL — ECAP, Universität Erlangen-Nürnberg, 91058 Erlangen

By measuring the energy- and zenith-dependent oscillation probabilities of atmospheric neutrinos passing through Earth, it is possible to determine the hitherto unknown neutrino mass hierarchy. With this aim, the underwater Cherenkov detector ORCA is being built by the KM3NeT Collaboration in the Mediterranean deep sea.

The atmospheric muon flux entering the detector from the direction of the water surface is the main background for the detection of neutrinos. On the one hand, incorrectly reconstructed tracks of atmospheric muons distort the measurement of the upgoing atmospheric neutrino flux passing through Earth. On the other hand, this background crucially complicates the measurement of the downgoing atmospheric neutrino flux from above, which could be used for reducing the systematic uncertainties of the mass hierarchy measurement.

This talk presents a veto strategy for atmospheric muons developed for the determination of the downgoing atmospheric neutrino flux. A atmospheric muon contamination of about 1% remains, while an effective mass for neutrinos of roughly 1.75 Mton for neutrino energies above 10 GeV is achieved. Furthermore, an investigation to which precision the atmospheric neutrino flux parameters can be determined is presented.

T 107.4 Do 17:30 H 2

### Measurement of neutrino interactions in gaseous argon with T2K — •LUKAS KOCH and STEFAN ROTH — RWTH Aachen University

The T2K near-detector, ND280, employs three large argon gas TPCs (Time Projection Chambers) for particle tracking and identification. The gas inside the TPCs can be used as an active target to study the neutrino interactions in great detail. The low density of the gas leads to very low track energy thresholds, allowing the reconstruction of very low momentum tracks, e.g. protons with kinetic energies down to  $\mathcal{O}(1 \text{ MeV})$ . Since different nuclear interaction models vary considerably in their predictions of those low momentum track multiplicities, this makes neutrino interactions on gases a powerful probe to test those models.

The TPCs operate with an argon-based gas mixture (95% by volume) and have been exposed to the T2K neutrino beam since the beginning of the experiment in 2010. Due to the low total mass of the gas, neutrino argon interactions happen only rarely, compared to the surrounding scintillator-based detectors. We expect about 600 such events in the recorded data so far (about 300 in the fiducial volume). We are able to separate those events from the background and thus demonstrate the viability of using gaseous argon as a target for a neutrino beam. This enables us to do a cross-section measurement on gaseous argon, the first measurement of this kind. All previous neutrino cross-section measurements on argon were performed in liquid argon TPCs.

T 107.5 Do 17:45 H 2

### Current studies on solar neutrinos with Borexino — •ZARA



BAGDASARIAN for the Borexino-Collaboration — Forschungszentrum Jülich, Jülich, Germany

Borexino is located at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy with the primary goal of detecting solar neutrinos, particularly those below 2 MeV with unprecedentedly high sensitivity. Its technical distinctive feature is the ultra low radioactive background of the inner scintillating core, which is the basis of the outstanding achievements obtained by the experiment. During the Phase I (2007-2010), Borexino precisely measured the flux of  ${}^7\text{Be}$  solar neutrinos, ruled out any significant day-night asymmetry of their interaction rate, made the first direct observation of the pep neutrinos, and set the best available upper limit on the flux of solar neutrinos produced in the CNO cycle (carbon, nitrogen, oxygen). The data gathered starting from 2011 (Phase II), characterized by even lower background than Phase I, is currently under detailed investigation. In order to update the previously published results, the fit on the whole energy spectrum of the Phase II data is performed, obtaining simultaneously all solar neutrino components.

T 107.6 Do 18:00 H 2

**Cosmic Muon Modulation Analyses with Borexino** — ●DOMINIK JESCHKE — Technische Universität München

The Borexino Experiment is situated at the Laboratori Nazionali del Gran Sasso and aims for the measurement of low energetic solar neutrinos. Even though the cosmic muon flux is reduced by a factor  $10^6$  due to the 3800 mwe. of rock overburden at the experimental side, a residual cosmic muon flux of  $(3.41 \pm 0.01) \cdot 10^{-4} \text{m}^{-2}\text{s}^{-1}$  with a mean energy of 270 GeV is still present. These muons are detected by a highly efficient muon veto.

Most of the cosmic muons reaching the detector are produced in the decay of pions that originate from collisions of the primary cosmic radiation with atoms of the atmosphere. Since only pions that decay in flight without undergoing any interactions before produce muons with enough energy to reach the detector, a seasonal modulation of the cosmic muon flux is expected due to density changes in the atmosphere that alter the mean free path of the pions.

In this talk, an analysis of the cosmic muon flux based on almost 10 years of data from the Borexino experiment is presented. Besides the seasonal modulation, other periods are searched for and their significance is checked with the help of a Lomb-Scargle periodogram.

This work is funded by the DFG.

T 107.7 Do 18:15 H 2

**A new approach to identify cosmogenic  ${}^{11}\text{C}$  burst in Borexino** — ●ALESSIO PORCELLI for the Borexino-Collaboration — Johannes

Gutenberg Universität, Mainz

Borexino is a liquid scintillator detector sited underground in the Laboratori Nazionali del Gran Sasso. Its physics program is centred in the study of solar neutrinos, in particular from the Beryllium, pp, pep and CNO fusion reactions. With the start of the phase II, the aim is to improve the pep and CNO results. The background sources are mainly radioisotopes induced by muons in the detector, in particular  ${}^{11}\text{C}$  cosmogenics produced in muon spallation from  ${}^{12}\text{C}$  nuclei with emission of neutrons. The physics of this process is not very well understood, therefore carbon isotopes are not easy to predict. The Borexino analysis approach to deal with them, called Three Fold Coincidence (TFC), relies on time and space coincidence of muons, neutrons and  ${}^{11}\text{C}$ , vetoing volumes where those associated signatures occurred.

The work presented is a new approach to identify  ${}^{11}\text{C}$  events produced in “bursts”, i.e. by the same muon, entirely based on their correlations in time and space, without using  $\mu$  and  $n$  signals. This cannot fully substitute the TFC technique, but in combination is expected to reduce the vetoed volumes, increasing the data statistics of the neutrino measurements. Moreover, it might be used to better identify  ${}^{11}\text{C}$  samples to improve the study of the physics of their production.

T 107.8 Do 18:30 H 2

**Update on the 8B analysis with the Borexino detector** — ●SIMON APPEL for the Borexino-Collaboration — simon.appel@ph.tum.de

Borexino is a liquid scintillator based real-time neutrino detector with a target mass of 278t, located at the Laboratori Nazionali del Gran Sasso. Due to its low energy threshold of 100\*keV, Borexino was able to perform the first real-time measurement of  ${}^7\text{Be}$  and pp neutrinos. Furthermore it is also sensitive to 8B neutrinos, which is main topic of this talk. The 8B analysis is limited to a lower energy threshold of 3\*MeV by external gamma background. As the expected event rate is in the order of only 0.2-0.3 counts per day, it is crucial to have a profound knowledge of the different background sources. Especially radio-isotopes produced by muons are a major source of background for this analysis. To veto these events one has to identify cosmic muons crossing Borexino, which is realized with a water cherenkov veto in the outer detector and a pulse shape analysis in the inner detector. A time cut after each muon reduces background induced by cosmogenically produced radio-isotopes. In the presented analysis it was possible to suppress all the backgrounds to a negligible value. This allows to detect solar 8B neutrinos in Borexino and thus makes it possible to confirm the MSW-LMA solution. This talk will give an update on this analysis within the Borexino detector framework. This work is funded by the DFG and the Exzellenzcluster Universe Munich.

## T 108: Neutrinophysik 9 (sterile Neutrinos)

Zeit: Donnerstag 16:45–19:10

Raum: VSH 118

### Gruppenbericht

T 108.1 Do 16:45 VSH 118

**Search for eV Sterile Neutrinos – The Stereo Experiment** — ●JULIA HASER, HELENA ALMAZÁN, CHRISTIAN BUCK, MANFRED LINDNER, CHRISTIAN ROCA, and STEFAN SCHOPPMANN — Max-Planck-Institut für Kernphysik, Heidelberg

In the recent past major milestones in neutrino physics were accomplished at nuclear reactors: the smallest neutrino mixing angle  $\theta_{13}$  was determined with high precision and the emitted antineutrino spectrum was measured with unprecedented resolution. However, two anomalies – related to the absolute flux and the spectral shape – have yet to be solved. The flux anomaly is known as reactor antineutrino anomaly and could be caused by the existence of a light sterile neutrino participating in the neutrino oscillation phenomenon. Introducing a sterile eigenstate implies the presence of a fourth mass eigenstate and global fits favor  $\sin^2 2\theta = 0.09$  and  $\Delta m^2 = 1.8 \text{eV}^2$  as oscillation parameters. The Stereo experiment was built to finally solve this puzzle. It is one of the first running experiments built to search for eV sterile neutrinos and takes data since end of 2016 at ILL Grenoble (France). At a short baseline of 10 meters it measures the antineutrino flux and spectrum emitted by a compact research reactor. The segmentation of the detector in six target cells allows for independent measurements of the neutrino spectrum at multiple baselines. An active-sterile flavor oscillation could be unambiguously detected, as it distorts the spectral shape of each cell’s measurement differently.

This talk will give an overview of the Stereo experiment, including details on the detector design, detection principle and the current status.

### Gruppenbericht

T 108.2 Do 17:05 VSH 118

**Short Distance Neutrino Oscillations with SOX** — ●STEFAN WEINZ for the Borexino-Collaboration — Uni Mainz

The Borexino detector has convincingly shown its outstanding performances in the low energy regime and is therefore an ideal tool to perform a state of the art source-based experiment for testing the long-standing hypothesis of a fourth sterile neutrino species with  $\approx 2 \text{eV}$  mass, as suggested by several anomalies accumulated over the past three decades in source-, reactor-, and accelerator-based experiments. The SOX project aims at successively deploying two intense radioactive sources, made of Cerium (antineutrino) and Chromium (neutrino), respectively, in a dedicated pit located beneath the detector. The existence of such an  $\approx 2 \text{eV}$  sterile neutrino would then show up as an unambiguous spatial and energy distortion in the count rate of neutrinos interacting within the active detector volume. This article reports on the latest developments about the first phase of the SOX experiment, namely CeSOX, and gives a realistic projection of CeSOX sensitivity to light sterile neutrinos in a simple (3+1) model.

T 108.3 Do 17:25 VSH 118

**Sterile neutrino search at the keV mass scale with TRISTAN**



— TOBIAS BODE<sup>1</sup>, TIM BRUNST<sup>1</sup>, KAI DOLDE<sup>2</sup>, ELLEN FÖRSTNER<sup>3</sup>, ANTON HUBER<sup>3</sup>, FELIX KNAPP<sup>3</sup>, MARC KORZECZEK<sup>3</sup>, THIERRY LASSERRE<sup>4</sup>, SUSANNE MERTENS<sup>1</sup>, DAVID RADFORD<sup>5</sup>, and •MARTIN SLEZÁK<sup>1</sup> for the KATRIN-Collaboration — <sup>1</sup>Max Planck Institute for Physics, München, Germany — <sup>2</sup>University of Heidelberg, Germany — <sup>3</sup>Karlsruhe Institute of Technology, Germany — <sup>4</sup>Saclay Nuclear Research Center, France — <sup>5</sup>Oak Ridge National Laboratory, USA

Almost all experimental results in neutrino physics are consistent with the picture of three active weakly-interacting neutrinos. Nevertheless, several neutrino oscillation experiments and some cosmological observations indicate a possible existence of additional sterile neutrino states. The TRISTAN project is a planned modification of the KATRIN experiment that will allow to extend the physics reach to search for a keV-scale, mostly sterile, neutrino mass state. The signature of a such a state would be a miniscule kink-like distortion of the tritium beta-spectrum. Precise modelling and understanding of the spectrum over the whole energy range is required to reach the necessary experimental sensitivity needed for observation of such a distortion. In this talk, the project and in particular new analysis and modeling approaches will be presented.

T 108.4 Do 17:40 VSH 118

**KATRIN Sensitivity on Right-Handed Currents with Light Sterile Neutrinos** — •NICHOLAS STEINBRINK for the KATRIN-Collaboration — Institut für Kernphysik, WWU Münster

The KATRIN experiment aims to determine the absolute neutrino mass by measuring the endpoint of the Tritium beta spectrum. As a large-scale experiment with a sharp energy resolution, high source luminosity and low background it may also be capable of testing certain theories of neutrino interactions beyond the standard model (SM). An example of a non-SM interaction are right-handed currents mediated by right-handed W bosons in the left-right symmetric model (LRSM). In this extension of the SM, an additional  $SU(2)_R$  symmetry in the high-energy limit, which naturally predicts sterile neutrinos and the seesaw mechanism. In tritium  $\beta$  decay, interference between left- and right-handed currents thus leads to slightly modified kinematics, which enhances or suppresses certain regions near the endpoint of the beta spectrum. In this work, the sensitivity of KATRIN to right-handed currents is estimated for the scenario of a sterile neutrino with a mass of some eV. This has been performed with a Bayesian analysis using Markov Chain Monte Carlo (MCMC). The sensitivity and parameter correlations are further discussed under the hypothetical premise of a constrained tritium Q-value and with respect to the lack of knowledge about the sterile neutrino mass. The results are compared with current experimental limits on right-handed weak bosons.

This work is partly funded by BMBF under contract no. 05A11PM2 and by the DFG GRK 2149.

T 108.5 Do 17:55 VSH 118

**Systematic effects at the detector section of KATRIN and their impact to a sterile neutrino search** — •MARC KORZECZEK for the KATRIN-Collaboration — <sup>2</sup>Institute of Experimental Nuclear Physics (IEKP), Karlsruhe Institute of Technology (KIT), Wolfgang-Gaede-Str. 1, 76131 Karlsruhe, Germany

The KATRIN (KArlsruhe TRitium Neutrino Experiment) investigates energy endpoint of the tritium beta-decay to determine the effective mass of the electron anti-neutrino with a precision of 200 meV (@90CL) after an effective data taking time of three years. A possible future extension of KATRIN is the search for a sterile neutrino signature in the tritium beta-decay. Such a search requires to measure the whole energy spectrum of tritium beta-decay and thus requires a redesign of the detector section, as the total rate at the detector is increased by several orders of magnitude. Moreover systematic effects, such as detector backscattering and the detector deadlayer, which lead to drastic modifications of the measured energy spectrum, have to be investigated and modeled in order to achieve high sterile neutrino sensitivities. This talk discusses the impact of such systematics and shows the status of the modeling approaches.

T 108.6 Do 18:10 VSH 118

**Calibration studies with a  $^{68}\text{Ge}$ - $^{68}\text{Ga}$   $\beta^+$  source in the SOX experiment** — •MICHAEL NIESLONY for the Borexino-Collaboration — Johannes Gutenberg-Universität Mainz

Several experiments showed anomalous behavior in the neutrino sector which could be explained by the existence of a 4th, sterile neutrino with mass in the eV range. The existing 3 neutrino generations would

then be able to oscillate into the sterile state, enabling the appearance of new oscillation phenomena at short baselines. The aim of the SOX experiment (Short distance Oscillations in Borexino) is to test this hypothesis by placing a  $^{144}\text{Ce}$ - $^{144}\text{Pr}$  antineutrino source below the Borexino detector located deep underground in the Gran Sasso laboratories. SOX will search not only for a rate reduction in inverse beta decays induced by active antineutrinos but also for the presence of an oscillation pattern in space and energy related to the prompt positron signals.

This talk will present plans and the current status of the calibration campaign with a  $^{68}\text{Ga}$ - $^{68}\text{Ge}$   $\beta^+$  source that will be essential to assess the detector response to the neutrino-induced positrons and the connected systematic uncertainties. A calibration source design and an optimized scheme of calibration points will be outlined.

T 108.7 Do 18:25 VSH 118

**Calibration and energy scale reconstruction in the Stereo experiment** — •CHRISTIAN ROCA, HELENA ALMAZAN, CHRISTIAN BUCK, JULIA HASER, MANFRED LINDNER, and STEFAN SCHOPPMANN — Max-Planck-Institut für Kernphysik Heidelberg

The Stereo experiment, running since November 2016 at the ILL Grenoble, aims to test the hypothesis of sterile neutrinos as a possible cause of the reactor antineutrino anomaly at short baselines. The detector is divided in two main volumes each filled with liquid scintillator. The central volume is segmented in six independent cells corresponding to the neutrino target (NT). Its scintillator is doped with gadolinium to enhance the detection of the correlated neutrino signal produced by the inverse beta decay. Surrounding the NT there is the outer crown (OC) volume, optimized to capture escaping gammas originating from interactions in the NT.

The energy deposited in the detector is measured as scintillation light that is collected by a set of photomultiplier tubes. The readout charge signals are linked to visible energy by a non-linear energy scale. To determine such energy scale and to monitor the detector stability, several gamma and neutron sources are deployed by means of three different calibration systems: an internal set of tubes located within the NT cells, a single tube underneath the detector to introduce sources below the NT and OC, and a rail system optimized for OC calibration.

The calibration runs performed provided Stereo with a better understanding of the detector response and an energy scale reconstruction that will be presented in this talk.

T 108.8 Do 18:40 VSH 118

**Pulse Shape Discrimination in the STEREO Neutrino Experiment** — •STEFAN SCHOPPMANN, HELENA ALMAZÁN, CHRISTIAN BUCK, JULIA HASER, MANFRED LINDNER, and CHRISTIAN ROCA — Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany

The STEREO experiment is an antineutrino disappearance experiment located at the ILL research reactor in Grenoble, France. Its goal is to test the sterile neutrino hypothesis via oscillations. The detector has a segmented design, to measure the relative effect of neutrino oscillations at six different baselines between 9 and 11 metres. Neutrinos are detected in six Gd-loaded liquid scintillator volumes by the inverse beta decay reaction (IBD). In this reaction, an antineutrino capture by a proton yields a positron, giving a prompt energy deposition and annihilation signal, and a neutron, giving a delayed capture signal after thermalisation.

Due to its proximity to the reactor a significant flux of neutrons reaches the detector. In addition, atmospheric muons produce neutrons via spallation. Neutrons can mimic IBDs as they generate prompt proton recoils followed by their delayed capture. However, the scintillator deexcitation time differs for a proton recoil and a positron or gamma event. Thus, it is possible to distinguish both types of particle signals by analysing the time shape of their scintillation pulses.

This contribution will present in-situ and laboratory measurements of pulse shapes for gamma and neutron events. A strategy for background rejection using scintillation pulse shape will be described and its performance reviewed.

T 108.9 Do 18:55 VSH 118

**Background conditions of the first run period of the sterile neutrino search with STEREO** — •FELIX KANDZIA — Institut Laue Langevin, Grenoble, France

Light sterile neutrinos are currently a topic of high interest in neutrino physics. One indication of their possible contribution to neutrino oscillations is the Reactor Antineutrino Anomaly, which unveiled a deficit of about 6% between predicted and observed neutrino fluxes in short

baseline reactor experiments. The corresponding new oscillation parameters, obtained from global fits to reactor and beam experiments, result for electron antineutrinos from reactors (1 to 10 MeV) in oscillation lengths of a few meters. As a consequence several very short baseline oscillation experiments at reactors are currently in preparation or have already started.

The STEREO collaboration has commissioned a detector at about 10 m distance from the compact fuel element of the research reactor

of the Institut Laue Langevin, Grenoble, France, in November 2016 and is continuously taking data since then. The STEREO detector is installed on ground level in the experimental hall of the reactor building. Nearby neutron beam experiments and cosmic radiation result in challenging background conditions which were compensated by passive and active shielding. In this talk the background situation of the first run period of STEREO will be presented as well as methods employed for background reduction in the data analysis.

## T 109: Kosmische Strahlung 7

Zeit: Donnerstag 16:45–19:05

Raum: H 3

### Gruppenbericht

T 109.1 Do 16:45 H 3

**Measurement of forward particle production with CMS to better constrain extensive air shower simulations** — •RALF ULRICH, SEBASTIAN BAUR, HAUKE WOEHRMANN, MELIKE AKBIYIK, and ALAA KUOTB — Karlsruhe Institut of Technology, Germany

Recent measurements of very-forward hadronic particle production in particular also at 13TeV center-of-mass energy measured with the CMS experiment at the CERN LHC are reported. The CASTOR calorimeter is used to determine for the first time the forward energy distributions as well as jets and rapidity gaps. The data is corrected for detector effect and is compared to model predictions. The performance of the models used for the simulation of extensive air showers is reviewed and the impact of recent model-tunings is shown.

T 109.2 Do 17:05 H 3

**Collider input to heavy quark contribution for air shower MonteCarlos** — •JAN DOERSCH, WOLFGANG RHODE, DOMINIK ELSÄSSER, and DOMINIK BAACK — TU Dortmund University, Germany

One of the most decisive breakthroughs for astroparticle physics in recent years has been the detection of cosmic high energy neutrinos with the IceCube detector. This cosmic flux is evident as an excess over the atmospheric neutrino component at high and very high energies.

For the next steps, including more sensitive searches for discrete neutrino source populations, an even more stringent characterization of the hard atmospheric contribution from prompt neutrino production due to the decay of heavier mesons is desirable. The aim of the presented work is to improve the understanding of this prompt atmospheric neutrino component by including existing and possible future measurements of heavy quark production with the LHCb detector in air shower MonteCarlo simulations.

T 109.3 Do 17:20 H 3

**Cosmic ray propagation around the Sun** — •MIKE KROLL<sup>1</sup>, JULIA BECKER-TJUS<sup>1</sup>, PAOLO DESIATI<sup>2</sup>, and FREDERICK TENHOLT<sup>1</sup> — <sup>1</sup>Ruhr-Universität Bochum, Bochum, Deutschland — <sup>2</sup>University of Wisconsin-Madison, Madison, USA

The Sun shadow can be measured with the IceCube detector and varies in depth corresponding to the magnetic field. Hence, we are given a possibility to understand cosmic ray propagation in the magnetic field of the Sun, for which a sufficiently good modelling is necessary. We investigate the field with its temporal deviations in strength and orientation. In times of low solar activity, the field can be approximated by a dipole structure. During higher activities, however, the field becomes increasingly inhomogeneous, especially in regions near the solar surface. These regions are spatially constrained and can reach magnetic field strengths of up to 50 Gauss. In this work, we simulate protons with energies up to  $E_{p,max} = 40$  TeV. This energy is the median energy of those cosmic rays that are used in IceCube's Sun shadow analysis. Its data allows to determine the Sun shadow at different times in the solar cycle and compare the results to our simulation. We obtain solar magnetic field data within the PFSS model from the GONG data archive.

T 109.4 Do 17:35 H 3

**Recognizing patterns in the arrival directions of ultra-high energy cosmic rays using deep neural networks** — •MARCUS WIRTZ, MARTIN ERDMANN, JONAS GLOMBITZ, GERO MÜLLER, and DAVID WALZ — III. Physikalisches Institut A, RWTH Aachen University, Deutschland

Where the accelerating sites of ultra-high energy cosmic rays are located remains an unanswered research question, since overdensities in

the cosmic-ray arrival distribution on small and intermediate angular scales are still largely compatible with isotropic expectations. However, hints for potential point sources may be provided by cosmic-ray deflection in the coherent component of the galactic magnetic field, which forms characteristic patterns in the arrival distribution. We present a method based on deep neural networks that attempts to identify these patterns and to uncover even complex source hypotheses.

T 109.5 Do 17:50 H 3

**Eine iterative Methode zur Bestimmung von Ladung und Quellrichtung von ultra-hochenergetischer kosmischer Strahlung mit Hilfe eines galaktischen Magnetfeldspektrometers** — •MARTIN URBAN, MARTIN ERDMANN, GERO MÜLLER und MARCUS WIRTZ — III. Physikalisches Institut A, RWTH Aachen University, Deutschland

Die Bestimmung der Ladung ultra-hochenergetischer kosmischer Strahlung ist ein wichtiger Schritt um ihre Quellen im Universum zu finden. Magnetische Felder und insbesondere das starke galaktische magnetische Feld lenken die Teilchen entsprechend ihrer Ladung auf ihrem Weg von der Quelle zur Erde ab. Parametrisierungen des galaktischen Magnetfelds basierend auf auf Faraday-Rotationsmessungen erlauben eine Bestimmung der Ankunftsrichtung auf der Erde. Wir präsentieren eine iterative Methode, bei der wir den galaktischen Spektrometereffekt ausnutzen, um die Ladung der Teilchen und mögliche Quellrichtungen zu bestimmen.

T 109.6 Do 18:05 H 3

**Speed up CORSIKA** — •DOMINIK BAACK for the FACT-Collaboration — Technische Universität Dortmund, Dortmund, Germany

For modern physics experiments, simulations are an essential part for the analysis of measured data. With increasing precision of those experiments, more and more simulated data are needed. To reduce the large amount of required calculation time, different approaches are possible. One possibility are experiment specific adjustments of simulation to reduce the number of not measurable particle and events.

In gamma-ray astronomy, it is common to use the software package CORSIKA for the simulation of cosmic-ray induced air showers. Two new modules have been developed to allow for an efficient customization of the simulation. Both modules are designed as an API to configure the simulation precisely to a specific experiment. The first module enables the user to modify and remove particles during the calculation of the air shower. The second module enables sending and receiving of arbitrary data to an external server, which is programmed to analyze incoming data from multiple simulations running in parallel. The server can send specific commands to CORSIKA to discard a calculating event or request the simulation of certain particle.

First studies for FACT showed, that these developments reduce the calculation time and memory space by more than 30% each. In this talk, the developed modules will be introduced and results of the optimization using the example of some selected use cases will be presented.

T 109.7 Do 18:20 H 3

**Cosmogenic Neutrinos Challenge the Proton Dip Model** — •JONAS HEINZE<sup>1</sup>, DENISE BONCIOLI<sup>1</sup>, BUSTAMANTE MAURICIO<sup>2</sup>, and WINTER WALTER<sup>1</sup> — <sup>1</sup>Deutsches Elektronen-Synchrotron (DESY), Platanenallee 6, 15738 Zeuthen, Germany — <sup>2</sup>Center for Cosmology and AstroParticle Physics (CCAPP), The Ohio State University, Columbus, OH 43210, USA

We fit the recent UHECR spectrum measurements from the Telescope Array experiment under the assumption of pure proton composition, as assumed by the proton dip model.

We present a full scan of the three main physical model parameters of UHECR-injection: source redshift evolution, injected maximal proton energy and spectral power-law index. We discuss how the result qualitatively changes compared to earlier two-parameter fits in the literature: a mild preference for a maximal energy cutoff at the sources instead of the Greisen-Zatsepin-Kuzmin (GZK) cutoff, hard injection spectra, and strong source evolution.

We show that the predicted neutrino flux exceeds the IceCube limit for any parameter combination. As a result, the proton dip model is challenged at more than 95% C.L. This is strong evidence against the dip-model independent of mass composition measurements.

T 109.8 Do 18:35 H 3

**Galactic extension of CRPropa3** — •LUKAS MERTEN and JULIA TJUS — Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Ruhr-Universität Bochum, Institut für Theoretische Physik IV/Plasma-Astroteilchenphysik, Germany

The propagation of charged cosmic rays through the Galactic environment influences all aspects of the observation at Earth. Energy spectrum, composition and anisotropy are changed due to deflections in magnetic fields and interactions with the interstellar medium. Today the transport is simulated with different simulation methods either based on the solution of a transport equation (multi-particle picture) or a solution of an equation of motion (single-particle picture).

We present a method to solve the transport equation using stochastic differential equations. This is possible since Ito's Lemma shows that a parabolic partial differential equation (like the Parker transport equation) is equivalent to a corresponding set of stochastic differential equations. This technique is used e.g. in heliospheric transport problems.

We developed a new module for the publicly available CRPropa3 software which performs the propagation of pseudo particles which

trace the phase space. The code is able to handle anisotropic diffusion tensors in realistic magnetic background fields as e.g. the regular component of the JF12 field. The validation of the code and first examples are shown.

T 109.9 Do 18:50 H 3

**Einfluss von Lorentz-Verletzung im Photon-Sektor auf ausgedehnte Luftschauer** — FRANS R. KLINKHAMER<sup>1</sup>, •MARCUS NIECHCIOL<sup>2</sup> und MARKUS RISSE<sup>2</sup> — <sup>1</sup>Institut für Theoretische Physik, Karlsruher Institut für Technologie (KIT) — <sup>2</sup>Department Physik, Universität Siegen

Aufgrund ihrer extrem hohen Teilchenenergien (bis zu  $10^{20}$  eV) eignet sich die kosmische Strahlung bestens für die Suche nach Verletzungen der Lorentz-Invarianz. Bisher wurden untere Grenzen auf den Parameter  $\kappa < 0$ , der im Rahmen der Standard Model Extension (SME) isotrope, nicht-doppelbrechende Lorentz-Verletzung im Photon-Sektor beschreibt, mit Hilfe von Messungen aus dem Bereich der TeV-Gamma-Astronomie bestimmt. In dem Beitrag wird ein neuer Zugang zur Bestimmung einer unteren Grenze auf  $\kappa$  vorgestellt, der auf der Messung von Luftschauern basiert, die von Teilchen der kosmischen Strahlung in der Atmosphäre induziert werden. Hierzu wurde der Einfluss von Lorentz-verletzenden Prozessen (z.B. Photon-Zerfall) auf die longitudinale Entwicklung von Luftschauern, insbesondere auf die atmosphärische Tiefe des Schauermaximums  $X_{\max}$ , untersucht. Dabei werden zum einen ein analytisches Modell, basierend auf dem klassischen Heitler-Modell zur Beschreibung elektromagnetischer Kaskaden, zum anderen aber auch Monte-Carlo-Simulationen, basierend auf dem um Lorentz-verletzende Prozesse erweiterten CONEX-Code, verwendet. Es zeigt sich, dass  $\langle X_{\max} \rangle$  für Schauer mit Primärenergien oberhalb von  $10^{18}$  eV um einen Betrag verringert wird, der weit oberhalb der Auflösung aktueller Luftschauer-Experimente liegt.

## T 110: Topical Workshop: Gravitational Waves and Particle Physics

Convenor: T. Konstandin, P. Schwaller

Zeit: Donnerstag 16:45–18:45

Raum: H 4

**Eingeladener Vortrag** T 110.1 Do 16:45 H 4  
**Gravitational waves from cosmological phase transitions** — •GERALDINE SERVANT — DESY and U. Hamburg

Strong first-order cosmological phase transitions produce a stochastic gravitational wave background. We discuss the resulting contributions from bubble collisions, magnetohydrodynamic turbulence, and sound waves, and estimate the total corresponding signal predicted in gravitational waves. We demonstrate that LISA is able to probe many well-motivated scenarios beyond the Standard Model of particle physics predicting strong first-order cosmological phase transitions in the early Universe.

**Eingeladener Vortrag** T 110.2 Do 17:15 H 4  
**Bubble wall dynamics - from friction to runaway** — •DIETRICH BÖDEKER — Bielefeld

In a first order electroweak phase transition bubbles of Higgs phase expand into the symmetric phase. Particles hitting a bubble wall cause friction and slow down the expansion. In some models this can be insufficient to compensate the pressure difference between the two phases. Then the bubble wall accelerates indefinitely, it 'runs away'. When two such bubbles collide, they can produce a large gravitational wave signal. The particles hitting the wall can emit radiation, causing additional friction which can prevent runaway.

**Eingeladener Vortrag** T 110.3 Do 17:45 H 4  
**The string soundscape at gravitational wave detectors** —

•SVEN KRIPPENDORF — Rudolf Peierls Centre for Theoretical Physics, University of Oxford, 1 Keble Road, Oxford, OX1 3NP, UK

We argue that gravitational wave signals due to collisions of ultra-relativistic bubble walls may be common in string theory. This occurs due to a process of post-inflationary vacuum decay via quantum tunnelling within warped throats. Though we study a specific string construction, we argue that our conclusions are more general. Many such transitions could have occurred in the post-inflationary Universe, as a large number of throats with exponentially different mass scales can be present in the string landscape, leading to several signals of widely different frequencies - a soundscape connected to the landscape of vacua. Detectors such as aLIGO, LISA, and observations with SKA and EPTA (pulsar timing) have the sensitivity to detect such signals. A distribution of primordial black holes is also a consequence, though reliable estimates of masses and their abundance require dedicated numerical simulations, as do the fine details of the gravitational wave spectrum due to the unusual nature of both the bubble walls and transition.

**Eingeladener Vortrag** T 110.4 Do 18:15 H 4  
**Probing Dark Sectors at Gravitational Wave Detectors and Elsewhere** — •JOERG JAECKEL<sup>1</sup>, VALYA KHOZE<sup>2</sup>, and MICHAEL SPANNOWSKY<sup>2</sup> — <sup>1</sup>ITP Heidelberg — <sup>2</sup>IPPP Durham

In this talk we will briefly motivate the existence of dark sectors. We will then look at different ways to explore dark sectors. Special attention is devoted to the opportunities provided by gravitational wave detectors.

## T 111: Experimentelle Methoden 4 (Rekonstruktion)

Zeit: Donnerstag 16:45–19:00

Raum: JUR 253

T 111.1 Do 16:45 JUR 253

**Identification of Hadronically Decaying Tau Leptons at the ATLAS experiment** — ●CHRISTOPHER DEUTSCH, WILLIAM DAVEY, and JOCHEN DINGFELDER — Physikalisches Institut, Universität Bonn

The tau lepton is the heaviest lepton in the Standard Model and an important probe of physics at high energy scales, such as Higgs physics and physics beyond the Standard Model. Hadronic decays make up approximately two-thirds of the total branching ratio of tau decays and play an important part in the physics programme of the ATLAS experiment.

Jets originating from quarks or gluons, which are more abundant than tau leptons due to the large multijet production cross section at the LHC, can mimic hadronic tau decays. At the ATLAS experiment an identification algorithm based on multivariate methods utilizing track and shower shape variables is used to discriminate hadronically decaying taus from jets.

This talk is concerned with the latest developments of the tau identification for ATLAS Run II data including measures to improve the rejection of jets while maintaining a robust algorithm suitable for different physics analyses. The focus lies on an improved input variable selection and a systematic investigation and optimization of multivariate methods for tau identification.

T 111.2 Do 17:00 JUR 253

**Latest status of the tau lepton decay mode classification at ATLAS** — PHILIP BECHTLE, KLAUS DESCH, ●LARA SCHILDGEN, and PETER WAGNER — University of Bonn

Due to its short lifetime, the tau lepton decays before reaching the detectors and can only be reconstructed by its decay products. For Run II, one integral part of the particle flow based tau reconstruction in ATLAS will be the decay mode classification algorithm *PanTau*.

The tau decay mode classification algorithm *PanTau* exploits information from the topology of the reconstructed tau decay products. It is based on particle flow techniques which combine the track measurements of charged tau decay products in the tracking detectors with the energy information from the calorimeters to provide reconstructed  $\pi^0$  candidates. Decay mode specific discriminating variables are constructed which are exploited in a Boosted Decision Tree based algorithm. Using this method, *PanTau* allows for a classification of the individual tau decay modes. Taking into account the additional information on the tau decay mode, the tau energy resolution and spatial resolution are significantly improved.

The talk summarizes the status of the *PanTau* development and presents the tau reconstruction performance using the latest algorithm tuning.

T 111.3 Do 17:15 JUR 253

**Track classification in hadronic tau decays** — ●RICHARD HARTMANN, DIRK DUSCHINGER, WOLFGANG MADER, and ARNO STRAESSNER — IKTP, TU Dresden

Tau leptons often play an important role in searches for new physics, not only because the Higgs decay probability into tau leptons is magnitudes larger than that for decays into muons or electrons, but also physics beyond the standard model can introduce enhanced couplings to tau leptons. However, their short lifetime makes it hard to detect tau leptons directly. In fact, tau decays in the ATLAS detector at the LHC often take place before any detector component. The majority of that decays are those into hadrons and additional neutrinos, where the hadronic constituents are most often 1 or 3 charged pions plus additional neutral pions. The classification of hadronic tau decays plays a crucial role in ATLAS tau reconstruction in terms of rejection against QCD jets and electrons.

Several changes have been applied to the LHC and the ATLAS detector during the first long shutdown phase. This requires a revision of the track selection criteria applied for hadronic tau decays. Improvements of the track selection are presented with focus on the efficiency to reconstruct the correct number of tracks for each hadronic tau decay. By using multivariate techniques, attempts are to obtain best separation of tracks from hadronic tau decays and tracks from pile-up, conversions, underlying event, etc. For this purpose track quality criteria as a function of the transverse momentum of the tau decay are considered.

T 111.4 Do 17:30 JUR 253

**A new energy reconstruction of hadronic Tau Leptons using at ATLAS** — ●TOBIAS KLINGL, PETER WAGNER, PHILIP BECHTLE, and KLAUS DESCH — Universität Bonn

Final states with hadronically decaying tau leptons play an important role in many measurements and searches of the ATLAS Collaboration already during Run 1 of the Large Hadron Collider. With the discovery of the Higgs boson, one of the crucial measurements in Run 2 will be the Higgs CP mixing angle via spin effects in  $H \rightarrow \tau\tau$ . This requires a good discrimination between the number of charged and neutral pions in the  $\tau$  decay. The Run 1 reconstruction, however, solely differentiates tau decay modes by the number of charged pions, using calorimeter information only. To this end, the Run 2 reconstruction identifies charged pions by their tracks in the tracking system while using energy deposits in the calorimeter to reconstruct neutral pions. For energies below  $E \approx 140$  GeV the good momentum resolution of the tracker yield to very good energy resolution of the new reconstruction. However, for energies rising above this threshold the calorimeter-based resolution improves over degrading track resolution. To achieve a smooth transition from the new reconstruction (low energies) to the Run 1 reconstruction (high energies) the corresponding energies are weighted by their respective core  $E_T$  resolutions after calibrating the mean of both distributions to zero. To handle non-Gaussian tails in the new reconstruction the Run 1  $E_T$  is picked if the two reconstructed energy values are incompatible to each another.

T 111.5 Do 17:45 JUR 253

**Recent developments in reconstruction of neutral pions in tau decays at ATLAS** — ●SIMON BLANKE, BENEDICT WINTER, WILLIAM DAVEY, and JOCHEN DINGFELDER — Physikalisches Institut Universität Bonn

Hadronic decays of tau leptons are intensively studied at the LHC, since they are important signatures e.g. of Higgs boson decays or Supersymmetry. Dedicated techniques have been developed to reconstruct the hadronic decay products in tau decays and are being commissioned for use in physics analysis. They will help improving the 4-momentum reconstruction by using particle flow methods. They will also improve the sensitivity to tau polarization, which is beneficial for physics analysis to study the properties of e.g. the Higgs boson or potentially other new particles. Two-thirds of the hadronic tau decays involve neutral pions. Thus the reconstruction and identification of neutral pions is of key importance for the tau decay reconstruction.

The neutral pion reconstruction algorithm determines the energy deposited by charged hadrons in the electromagnetic calorimeter and subtracts it. The remaining neutral pion candidate clusters are identified by utilizing variables sensitive to their shape in the calorimeter.

T 111.6 Do 18:00 JUR 253

**Measurement of the  $\tau$ -lepton trigger efficiency with  $t\bar{t}$ -events with a tag-and-probe method with the ATLAS experiment at  $\sqrt{s} = 13$  TeV** — ●KATHARINA SCHLEICHER, DUC BAO TA, and MARKUS SCHUMACHER — Albert-Ludwigs-Universität Freiburg

The study of final states containing hadronically-decaying  $\tau$ -leptons plays an important role in investigating Standard Model as well as beyond Standard Model processes. To select such final states the ATLAS experiment uses dedicated  $\tau$ -lepton identification and reconstruction algorithms already at the trigger level with very similar algorithms as for the offline analysis. The measurement of the trigger efficiency and the determination of MC-to-data correction factors has been performed so far using a tag-and-probe method using  $Z \rightarrow \tau\tau$  events. In order to complement the current method and to reach a higher transverse  $\tau$ -lepton momentum range top-quark-pair events are utilised. Final states with two  $b$ -quarks, neutrinos, a  $\mu$ -lepton (tag) and a hadronically decaying  $\tau$ -lepton (probe) are investigated in the analysis presented here. The measurement has been performed on the full 2016 Run-2 data set in proton-proton collisions ( $L = 33.3$  fb $^{-1}$ ) taken with the ATLAS detector at  $\sqrt{s} = 13$  TeV.

T 111.7 Do 18:15 JUR 253

**Verbesserung der Jet-Unsicherheiten mit der Rtrk-Methode** — ●ALEXANDER MELZER, ALESSANDRA BETTI, GÖTZ GAYCKEN, STEPHAN HAGEBÖCK, RUTH JACOBS, VADIM KOSTYUKHIN, TATJA

NA LENZ, ELISABETH SCHOPF, ECKHARD VON TÖRNE und NORBERT WERMES — Physikalisches Institut, Universität Bonn, Deutschland

Mit Beginn von Run2 wurde die Schwerpunktsenergie des LHC fast verdoppelt. Dies erhöht nicht nur den Wirkungsquerschnitt vieler Prozesse, sondern führt auch zu Endzustandsteilchen mit höheren transversalen Impulsen. Die klassischen Kalibrationsmethoden sind bei hochenergetischen Jets nicht mehr anwendbar. Dabei profitieren allen Analysen von einer präzisen Messung der Masse und des Impulses sowie von dem Wissen um die Unsicherheiten dieser Größen. In diesem Vortrag wird die Rtrk-Methode für die Bestimmung der Jet-Unsicherheiten vorgestellt. Rtrk ist ein komplementärer Ansatz zu den herkömmlichen Methoden, der anstelle von Photonen oder anderer Jets die Informationen von Teilchenspuren aus dem inneren Detektor zur Hilfe nimmt. Zudem ermöglicht diese Methode es Unsicherheiten auf Substruktur-Variablen von Jets zu bestimmen, die sonst unzugänglich bleiben. Diese Variablen werden bei der Rekonstruktion von hadronisch zerfallenden W-, Z-, H-Boson-Jets und Top-Quark-Jets eingesetzt. Die gezeigten Ergebnisse basieren auf Daten, die in den Jahren 2015 und 2016 mit dem ATLAS-Detektor am LHC gesammelt wurden.

T 111.8 Do 18:30 JUR 253

**Extrapolation of in-situ calibrations of large-radius jets to high  $p_T$  at ATLAS** — ●EFTYCHIA TZOVARA, LUCIA MASETTI, and SABRINA GROH — Institute of Physics, University of Mainz

Data-based, so called "in-situ", methods are used to correct the jet energy and mass calibrations and to determine their systematic uncertainties. A new technique for extracting the jet mass scale and resolution from resonance decays (e.g. W/Z, H, top) reconstructed in a single large-radius jet, is the "forward-folding" method. It is used to ex-

tract the relative difference in the jet mass response between data and simulation, by using non-parametric shapes for both the particle-level distribution and the response function, derived from the simulation. In order to use this method to set a systematic uncertainty on the jet mass scale and jet mass resolution for beyond Standard Model searches, an extrapolation to higher  $p_T$  regions is necessary.

Monte Carlo simulations can be used to extrapolate the large-radius jet forward-folding result from the phase space region where it is performed, to regions that are inaccessible to the measurement in data. However, since the extraction of the jet mass scale and resolution from a hadronic resonance requires the particle-level spectrum as input, its precision is limited by the corresponding modeling uncertainties. In this talk, methods to extrapolate large-radius jet calibrations to high  $p_T$  and to determine their uncertainties, with data collected by the ATLAS experiment at the center-of-mass energy of 13 TeV, are presented.

T 111.9 Do 18:45 JUR 253

**Verbesserung der Auflösung von Jets gemessen mit dem ATLAS Detektor mithilfe der globalen sequentiellen Kalibration (GSC)** — ●VINCENT KITALI<sup>1</sup> und KRISZTIAN PETERS<sup>2</sup> — <sup>1</sup>DESY, Hamburg — <sup>2</sup>DESY, Hamburg

Das Vorbereiten von Jets mit gut rekonstruierter Energieskala und Energieauflösung ist essentiell für die Arbeit vieler Analysegruppen in der ATLAS Kollaboration. Die globale sequentielle Kalibration (GSC) ist ein Verfahren, das ausgezeichnet dafür geeignet ist, die Detektorantwort auf die Jetmessung auszugleichen, um die Auflösung zu verbessern.

Ergebnisse der aktuellen Auflösungsverbesserung werden im Hinblick auf verschiedene Jet-Kollektionen vorgestellt.

## T 112: Experimentelle Techniken der Astroteilchenphysik 6

Zeit: Donnerstag 16:45–19:00

Raum: S 9

T 112.1 Do 16:45 S 9

**Bestimmung der Messgenauigkeit des KATRIN Laser Raman Systems** — ●GENRICH ZELLER, SEBASTIAN FISCHER, MAGNUS SCHLÖSSER und HENDRIK SEITZ-MOSKALIUK für die KATRIN-Kollaboration — Karlsruher Institut für Technologie, Deutschland

Das Karlsruhe Tritium Neutrino (KATRIN) Experiment hat das Ziel die Neutrinomasse mit einer Sensitivität von 200 meV/c<sup>2</sup> (90% C.L.) zu messen. Dazu wird das Tritium-Betaspektrum im Bereich des kinematischen Endpunkts genau vermessen. Die Tritiumreinheit  $\epsilon_T$  in der Tritiumquelle ist ein wichtiger Parameter für die Neutrinomassenmessung, der mithilfe eines Laser Raman (LARA) Systems gemessen wird. Die Kalibrierung zur Verwendung als quantitative Methode, beruht auf der Verwendung eines optischen Referenzmaterials, das bei Laserbestrahlung ein zertifiziertes Spektrum erzeugt.

Die Quantifizierung der Messunsicherheiten ist bisher nur für den Nominalbetrieb mit hoher Tritiumreinheit  $\epsilon_T > 95\%$  erfolgt. Im Zuge der Inbetriebnahme wird das KATRIN Experiment jedoch mit reduzierter Tritiumreinheit betrieben. In diesen Vorexperimenten ist es sehr wichtig die Gaszusammensetzung der Quelle auch während dieser Zeit genau messen zu können. Daher muss die Genauigkeit der LARA-Messung auch für die Inbetriebnahme bestimmt werden. Im Vortrag wird das Kalibrierungsverfahren erklärt und diskutiert, wie sich die Unsicherheiten der Kalibrierung und die Gaszusammensetzung auf die Genauigkeit der Messung der Tritiumreinheit auswirken. Gefördert durch das BMBF unter dem Kennzeichen 05A14VK2 und die Helmholtzgemeinschaft.

T 112.2 Do 17:00 S 9

**Monitoring high electron fluxes using PIN diodes** — ●ENRICO ELLINGER — Bergische Universität Wuppertal

The Forward Beam Monitor (FBM) will be used in KATRIN to monitor the relative intensity of the electron beam produced by the tritium source with a precision of 0.1%. Furthermore, beta spectra are taken for additional analysis. At the measuring position high fluxes of up to  $10^6 \frac{e}{s \cdot mm^2}$  with relatively low energies of maximum 18.6 keV are expected. Such measurements make great demands on the detector which consists of a PIN diode, a transimpedance amplifier and a digital pulse processor. The long term stability of such measurements is strongly influenced by temperature changes as well as internal and external

noise sources. In particular, the high event rate close to the detection threshold leads to systematic errors in case of detector drifts.

The dead layer of the Hamamatsu PIN diodes influences the measurements because the electrons lose energy passing through it. Therefore, the thickness of the dead layer and possible changes over time need to be estimated. Electron sources were used to determine the effective dead layer thickness and simulations have been performed and compared to the measurement results. Furthermore, an ultra high vacuum manipulator enables the FBM to perform all measurements along the whole flux tube with a positioning precision of better than 0.1 mm. The current status and latest results will be presented.

T 112.3 Do 17:15 S 9

**Time-Focusing-Time-of-Flight Methods for the KATRIN Experiment** — ●ALEXANDER FULST for the KATRIN-Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität, Münster

The Karlsruhe Tritium Neutrino (KATRIN) experiment aims at a direct and model independent determination of the electron antineutrino mass with a sensitivity of 0.2 eV/c<sup>2</sup>.

Investigations have shown that the standard statistical sensitivity of the experiment of  $\sigma_{\text{stat}}(m_{\nu_e}^2) = 0.018 \text{ eV}^2/\text{c}^4$  can be improved by up to a factor of 5 in the ideal case using Time-of-Flight (ToF) methods. This improvement is possible because the flight time of an electron depends on its kinetic energy, enabling the measurement of a differential spectrum compared to the integrated spectrum measured by the MAC-E filter in the standard mode. However, the actual benefit is dependent on the method used for the flight time determination. While there are different options available this talk focuses on the Time-Focusing-Time-of-Flight method and some results of the achievable sensitivity are presented.

This work is supported under BMBF contract number 05A14PMA.

T 112.4 Do 17:30 S 9

**Performance of the upgraded MAGIC LIDAR system** — ●CHRISTIAN FRUCK<sup>1</sup>, DOMINIK MÜLLER<sup>1</sup>, MARTIN WILL<sup>2</sup>, MARKUS GAUG<sup>3</sup>, RAZMIK MIRZOYAN<sup>1</sup>, and MASAHIRO TESHIMA<sup>1</sup> for the MAGIC-Collaboration — <sup>1</sup>Max-Planck-Institut für Physik, München, Germany — <sup>2</sup>Instituto de Astrofísica de Canarias, La Laguna (Tenerife), Spain — <sup>3</sup>Universitat Autònoma de Barcelona, Barcelona, Spain

Since 2011 MAGIC observations are supported by dedicated, continuous and pointed measurements from a single wavelength micro-power LIDAR system for measuring the transmission of the atmosphere in the observed direction. Transmission information is now available by default for data quality selection and can be used for spectral corrections. The old LIDAR system was optimized for low and medium zenith distance (Zd) operation and to minimize the impact on MAGIC observations by using a pulse energy of only  $5\mu\text{J}$ . As MAGIC is now also regularly conducting observations at  $\text{Zd} > 45^\circ$  and in order to further improve the overall accuracy of the system, several components including laser, detector and readout have been upgraded in two steps during the past two years. During this talk I will summarize all modifications and highlight the performance of the upgraded system.

T 112.5 Do 17:45 S 9

**Radon Monitoring in gaseous Nitrogen used for the Filling of the Central Detector of JUNO** — ●PHILIPP LANDGRAF, HANS STEIGER, LOTHAR OBERAUER, SABRINA PRUMMER, MARIO SCHWARZ, ANDREAS ULRICH, and JULIA SAWATZKI — Technische Universität München, Physik Department, Lehrstuhl für experimentelle Astroteilchenphysik, James-Franck-Str. 1, 85748 Garching bei München

The planned JUNO (Jinangmen Underground Neutrino Observatory) Detector will use 20 kt of liquid scintillator (LS) based on LAB (Linear AlkylBenzene) as neutrino target within an acrylic sphere with a diameter of 35.4 m. For the filling of this sphere with LS pressurized gaseous nitrogen will be used. To avoid a contamination of the LS with  $^{222}\text{Rn}$ , it's content in the nitrogen gas will be monitored. In this talk the status of a prototype radon monitoring system based on a proportional chamber developed at Technische Universität München is presented. This work is supported by the DFG Cluster of Excellence "Origin and Structure of the Universe", the DFG research unit "JUNO" and the Maier-Leibniz-Laboratorium.

T 112.6 Do 18:00 S 9

**Positronium Lifetime Determination in Linear Alkylbenzene based Scintillator for JUNO** — ●MARIO SCHWARZ, HANS STEIGER, SABRINA PRUMMER, LOTHAR OBERAUER, PHILIPP LANDGRAF, MARC TIPPMMANN, and JULIA SAWATZKI — Technische Universität München, Physik Department, Lehrstuhl für experimentelle Astroteilchenphysik, James-Franck-Str. 1, 85748 Garching bei München

The planned JUNO (Jinangmen Underground Neutrino Observatory) Detector will use 20 kt of liquid scintillator (LS) based on LAB (Linear AlkylBenzene) as neutrino target. Reactor antineutrino interactions will be detected by means of inverse beta decay with the emission of a positron and analysis of the resulting luminescent light. An experimental setup for a lifetime determination of positronium formed in LAB is currently being developed in Munich. In this talk an overview of the setup is presented as well as first results from Monte-Carlo-Simulations and measurements. This work is supported by the DFG Cluster of Excellence "Origin and Structure of the Universe", the DFG research unit "JUNO" and the Maier-Leibniz-Laboratorium.

T 112.7 Do 18:15 S 9

**Monitoring Systems for the Filling of the Central Detector of JUNO** — ●HANS STEIGER, LOTHAR OBERAUER, ANDREAS ULRICH, PHILIPP LANDGRAF, SABRINA PRUMMER, JULIA SAWATZKI, and MARIO SCHWARZ — Technische Universität München, Physik Department, Lehrstuhl für experimentelle Astroteilchenphysik, James-Franck-Str. 1, 85748 Garching bei München

In the planned JUNO (Jinangmen Underground Neutrino Observatory) Detector 20 kt of liquid scintillator (LS) will be used as neutrino

target. A 120 mm thin highly transparent acrylic hollow sphere stores the target in a water tank. Slightly different filling levels in the tank and the sphere during the filling of these volumes could cause fatal damage of the detector. Therefore precise monitoring of the hydrostatic and gas pressure in both volumes as well as controlling the mechanical stress on the acrylic is necessary. Also the filling levels in the water tank and the sphere has to be monitored. For this tasks first concepts and developments carried out in Munich are presented in this talk. This work is supported by the DFG Cluster of Excellence "Origin and Structure of the Universe", the DFG research unit "JUNO" and the Maier-Leibniz-Laboratorium.

T 112.8 Do 18:30 S 9

**Erste Messungen des AugerPrime Engineering Arrays\*** — ●SVEN QUERCHFELD für die Pierre Auger-Kollaboration — Bergische Universität Wuppertal

Für das Upgrade des Pierre-Auger-Observatoriums in Argentinien werden die vorhandenen 1660 Wasser-Cherenkov-Detektoren zusätzlich mit Szintillatoren ausgestattet. Diese werden auf den bestehenden Stationen installiert und ermöglichen für die Messung von Luftschauern eine bessere Separation des Signals zwischen elektromagnetischer und myonischer Komponente. Die Szintillationszähler besitzen eine Fläche von  $3,8\text{ m}^2$  und sind mit wellenlängenschiebenden Fasern durchzogen, welche zusammengeführt über einen Photosensor ausgelesen werden. Insgesamt 12 Prototypen wurden im September 2016 im Detektorfeld installiert.

In diesem Vortrag werden die ersten Ergebnisse der Prototypenmessung vorgestellt. Hierbei wird insbesondere auf die Nutzung von Photomultipliern (PMTs) als Photosensor eingegangen und deren Verhalten im Feld sowie Voruntersuchungen im Labor vorgestellt. Dies umfasst unter anderem die Temperaturstabilität der Signale sowie einen Vergleich zwischen einer aktiven Hochspannungserzeugung auf der PMT-Base und einem passiven Spannungsteiler mit separatem Hochspannungsmodul.

\*Gefördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A14PX1).

T 112.9 Do 18:45 S 9

**Der Aachen Muon Detector: Ein Myon-Detektor Konzept für den Nachweis kosmischer Strahlung** — ●CHRISTINE PETERS, THOMAS BRETZ, THOMAS HEBBEKER, JULIAN KEMP, MARKUS LAUSCHER, LUKAS MIDDENDORF, TIM NIGGEMANN und JOHANNES SCHUMACHER für die Pierre Auger-Kollaboration — III. Physikalisches Institut A, RWTH Aachen University

Das Pierre Auger Observatorium verwendet erfolgreich zwei sich ergänzende Methoden zum Nachweis ausgedehnter Luftschauer. Damit ist es unter anderem möglich, auf die Energie und Ankunftsrichtung des ursprünglichen Teilchens zu schließen. Besonders Myonen, die im Verlauf des Luftschauers entstehen, tragen Informationen über die Masse des Primärteilchens, sowie über die hadronischen Wechselwirkungen bei den höchsten Energien. Daher wird der Oberflächendetektor des Pierre Auger Observatoriums erweitert, um eine separate Bestimmung der Myonen-Anzahl im Luftschauer zu ermöglichen. Dies erlaubt nicht nur eine bessere Messung der chemischen Zusammensetzung der Primärteilchen, sondern auch ein tieferes Verständnis der Entwicklung des Luftschauers. Der Aachen Muon Detector (AMD) ist eine mögliche Option zur präzisen Bestimmung der Myonen-Anzahl. Zwei Prototypen befinden sich gerade im Aufbau. Der Detektor basiert auf Szintillatorkacheln, die jeweils mit einem Silizium-Photomultiplier (SiPM) ausgelesen werden. Um die Performance des Detektors genau zu untersuchen, wurden zahlreiche Monte-Carlo-Studien, sowie dedizierte Messungen des gesamten Detektors und einzelner Teilkomponenten durchgeführt. In diesem Vortrag präsentieren wir deren Ergebnisse.

## T 113: Gasgefüllte Detektoren 3 (gemeinsam mit HK)

Zeit: Donnerstag 16:45–19:00

Raum: F 102

### Gruppenbericht

T 113.1 Do 16:45 F 102

**Detectors and instrumentation for the fast-developing MAGIX experiment at MESA** — ●SABATO STEFANO CAIAZZA for the MAGIX-Collaboration — KPH Institute, Johannes-Joachim-Becher-Weg 45, Mainz, Deutschland

Within the next decade a new experiment will be built and will start to

be operated at the Institut für Kernphysik at the University of Mainz, exploiting the powerful electron beam of the new MESA accelerator. MAGIX aims to be a versatile apparatus which can be used to perform a broad set of experiments at the precision frontier including, but not limited to new measurements of the proton radius, searches for dark sector particles in the MeV range and high-precision nuclear cross-section measurements. To achieve this goal all the components

of the setup have to be designed and developed to the limits of the current state-of-the-art and often beyond those. In this talk I will give you an overview of the challenges we face in the development of our experiment and on the most interesting solutions we are developing to overcome them, focusing in particular on the GEM based focal plane detectors and the open jet target.

T 113.2 Do 17:15 F 102

**ROPPERI - Auslese einer Zeitprojektionskammer mit GEMs, Pads und Timepix** — •ULRICH EINHAUS für die LCTPC-Deutschland-Kollaboration — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg — Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

Für den International Large Detector (ILD) am geplanten International Linear Collider (ILC) ist als Spurdetektor eine Zeitprojektionskammer (TPC) vorgesehen. Zur Auslese des Gasvolumens gibt es verschiedene mögliche Mikrostruktur-Gasdetektoren (MPGDs). Dieser Vortrag beschäftigt sich mit einer neuen Kombination von Ausleseelementen: Die Verstärkung der Elektronen geschieht mittels Gas-Elektron-Vervielfachern (GEMs), die Auslese mit Pads der Größenordnung mm oder kleiner und die Digitalisierung durch hochintegrierte Timepix-Chips. Kleinere Pads als bisher erlauben die Auflösung von bis zu einzelnen Elektronenclustern und reichen an die Auflösungsgrenze von GEMs heran. Es werden Simulationen der Auslese vorgestellt, insbesondere in Hinblick auf Auflösung in Impuls und  $dE/dx$  in Abhängigkeit von der Padgröße. Sie werden verglichen mit Messungen eines ersten Prototypen. Eine mögliche Weiterentwicklung wird diskutiert.

T 113.3 Do 17:30 F 102

**Prototype of GEM based readout chamber for the upgrade of the Time Projection Chamber of ALICE** — •THOMAS THEODOR RUDZKI für die ALICE-Collaboration — Research Division and ExtreMe Matter Institute, GSI Helmholtzzentrum für Schwerionenforschung, Planckstr. 1, 64291 Darmstadt — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

The Time Projection Chamber (TPC) of ALICE is its most important tracking detector. In its present implementation, it can handle a trigger rate up to 3 kHz. Starting from 2021, the ALICE experiment will record Pb-Pb collisions at 50 kHz making an upgrade of the TPC indispensable. For this purpose, the current multi-wire proportional chambers will be replaced by new ones equipped with GEM foils.

Recently, the first two Outer ReadOut Chambers (OROC) were assembled in Bucharest and at GSI, Darmstadt. Both OROCs were subject to extensive tests.

The talk will give an introduction to the new design of the OROC and its components and present results of performance tests. The focus lies on the results of the validation tests carried out with the first OROC assembled at GSI, in particular the gas tightness and the performance of the chamber under ionising radiation in terms of gain uniformity and stability.

In the end, a brief outlook of upcoming tests like a testbeam and the regular production of OROCs will be given.

T 113.4 Do 17:45 F 102

**Design of a Gas Monitoring Chamber for High Pressure Applications** — •PHILIP HAMACHER-BAUMANN, LUKAS KOCH, THOMAS RADERMACHER, STEFAN ROTH, and JOCHEN STEINMANN — Physikalisches Institut IIIB, RWTH Aachen University

Currently, High Pressure Time Projection Chambers (HP-TPC) are intensely discussed in the neutrino detector community. Employing operation pressures of up to 10 bar comes with new challenges for detector construction and gas quality monitoring. This necessitates new gas monitoring chambers, capable of measuring drift and gain properties in such a high pressure regime. This talk presents the design of such a system, operable at pressures between 1 bar and 10 bar.

T 113.5 Do 18:00 F 102

**Study of single-mask GEM foil performance for the upgrade of the ALICE TPC** — •HENDRIK SCHULTE, ESTHER BARTSCH, RAINER RENFORDT, and HARALD APPELSHÄUSER für die ALICE-Collaboration — Institut für Kernphysik, Goethe-Universität Frankfurt

In the LHC RUN 3 period the interaction rate of Pb-Pb collisions will be increased to 50 kHz. To accommodate the higher rates the Time Projection Chamber (TPC) of ALICE has to be upgraded. In this upgrade the Multiwire Proportional Chambers of the TPC's readout system will

be replaced by quadruple Gas Electron Multiplier (GEM) stacks that can be operated in continuous mode. However, to prevent space-charge distortions in the drift volume the backflow of positive ions has to be kept below 1%. At the same time a reasonable energy resolution has to be maintained to preserve the good particle identification capability of the TPC.

So far GEMs have been produced in two different ways. While the GEM foils used in previous tests were produced with the so-called double-mask technique, the GEMs for the final readout chambers will be mass-produced with the so-called single-mask technique.

A dedicated test detector for the characterization of quadruple GEM stacks was set up at the IKF in Frankfurt. The performance of single-mask GEM foils for different voltage settings, also in comparison with double-mask GEM foils, will be presented.

Supported by BMBF and the Helmholtz Association.

T 113.6 Do 18:15 F 102

**Discharge studies with single- and multi-GEM structures** — •PIOTR GASIK, LAURA FABIETTI, and ANDREAS MATHIS — TU München, Physik Department E62, Excellence Cluster "Universe", Garching

The demands of a new generation of experiments in hadron physics require a substantial further advancement of gaseous detectors. Novel devices must handle the high luminosities planned for future hadron and electron colliders as well as meet the requirements of large experiments such as the substantial increase in active detector area. Among the new innovative detector techniques, the Gas Electron Multiplier (GEM) has become a widely used technology for high-rate experiments and is also foreseen for future large-area detectors (e.g. ALICE, CMS, sPHENIX).

The key parameters for a long-term operation of GEM-based detectors in the harsh environment of high-rate experiments are radiation hardness, ageing resistance and stability against electrical discharges. Therefore, a comprehensive understanding of the discharge mechanism is mandatory to assure a stable operation of the detector.

We report on discharge probability studies in single- and multi-GEM structures in Ar- and Ne-based gas mixtures. Our experimental findings are compared to the outcome of the GEANT simulations.

This research was supported by the DFG cluster of excellence "Origin and Structure of the Universe".

T 113.7 Do 18:30 F 102

**Erweiterung des Würzburger Höhenstrahlungsmessstandes zur Messung des Effekts von Sauerstoff und Gasfeuchte auf das Verhalten von MicroMeGas-Detektoren** — •THORBEN SWIRSKI, RAIMUND STRÖHMER und GIOVANNI SIRAGUSA — Universität Würzburg

Die Universität Würzburg betreibt einen Messstand zur Messung kosmischer Myonen, der im Jahr 2016 mit Elektronik zum Betrieb von MicroMeGas-Detektoren ausgestattet wurde.

Dieser Messstand soll nun dazu benutzt werden, den Einfluss von Gasunreinheiten, vor allem Sauerstoff und Gasfeuchte, auf die Detektoren systematisch und quantitativ zu vermessen. Der Vortrag stellt den momentanen Stand der Einrichtung zum Betrieb der MicroMeGas-Detektoren, sowie die bereits durchgeführten Änderungen an der Elektronik und notwendigen Änderungen und Anforderungen für Gaszufuhr und Gaskontrolle vor. Unter anderem werden Systeme zur Steuerung und Kontrolle des Sauerstoffgehaltes und des Wassergehaltes im Bereich von wenigen Promille benötigt, da ein Effekt schon bei kleinen Konzentrationen auftritt. Zusätzlich werden Simulationen mit Garfield++ und Magboltz vorgestellt, die einen Eindruck über den zu erwartenden Effekt ermöglichen.

T 113.8 Do 18:45 F 102

**Konzepte zur Umsetzung einer Druckkammer für Micromegas-Detektoren zur Messung von Gasverstärkungsprozessen bei variablem Druck** — •ROBIN BOSCHUIS, RAIMUND STRÖHMER und THORBEN SWIRSKI — Universität Würzburg

Die Eigenschaften eines Micromegas-Detektors hängen von der Stärke des elektrischen Feldes, der Größe der Verstärkungsregion sowie des Gasdruckes ab. Da eine systematische Variation des Abstands schwierig ist, wird an der Universität Würzburg ein Aufbau entwickelt, in dem der Druck und das elektrische Feld variiert werden können.

In diesem Vortrag werden die Konzepte zur Anfertigung eines Druckgefäßes für einen Micromegas-Detektor vorgestellt. Zur Beschreibung des Verhaltens des Detektors werden Simulationsstudien unter Zuhilfenahme des Programms Garfield++ angefertigt, mit dem sich Halbleiter-

und Gasdetektoren und die zugrunde liegenden Prozesse simulieren lassen. Die geplante Kammer soll in Zukunft sowohl mit Unter- als auch

Überdruck betrieben werden können.

## T 114: Pixeldetektoren 6 (gemeinsam mit HK)

Zeit: Donnerstag 16:45–19:00

Raum: F 073

### Gruppenbericht

T 114.1 Do 16:45 F 073

**The CBM-MVD: Group Report** — ●MICHAL KOZIEL for the CBM-MVD-Collaboration — Goethe-Universität Frankfurt

The Compressed Baryonic Matter Experiment (CBM) is one of the core experiments of the future FAIR facility. It will explore the phase diagram of strongly interacting matter in the regime of high net baryon densities with numerous probes, among them open charm. The Micro Vertex Detector (MVD) will contribute to the secondary vertex determination on a 10  $\mu\text{m}$  scale, background rejection in dielectron spectroscopy and reconstruction of weak decays of multi-strange baryons. The detector comprises up to four stations placed next to the target in the vacuum. The stations are populated with 50  $\mu\text{m}$  thin, highly-granular customized Monolithic Active Pixel Sensors, featuring a spatial resolution of  $<5 \mu\text{m}$ , a readout speed of less than 10  $\mu\text{s}/\text{frame}$ , a radiation tolerance of  $>10^{13} \text{ n}_{\text{eq}}/\text{cm}^2$  and 3 Mrad. This contribution will summarize recent activities towards constructing the MVD, that involve in particular: CMOS sensor development, characterization and read-out, integration and cooling aspects as well as MVD performance simulations.

\*This work has been supported by BMBF (05P15RFFC1), GSI and HIC for FAIR.

T 114.2 Do 17:15 F 073

**Passive CMOS pixel sensors as large area alternatives for HL-LHC trackers** — ●IVAN DARIO CAICEDO SIERRA<sup>1</sup>, JOCHEN DINGFELDER<sup>1</sup>, TOMASZ HEMPEREK<sup>1</sup>, TOKO HIRONO<sup>1</sup>, FABIAN HÜGGING<sup>1</sup>, JENS JANSSEN<sup>1</sup>, HANS KRÜGER<sup>2</sup>, ANNA MACCHIOLO<sup>1</sup>, DAVID-LEON POHL<sup>1</sup>, and NORBERT WERMES<sup>1</sup> — <sup>1</sup>Physikalisches Institut der Universität Bonn — <sup>2</sup>Max-Planck-Institut für Physik in München

The large area and intensity requirements of the inner tracking detector for the High Luminosity upgrade of the Large Hadron Collider call for detector developments at an affordable cost for mass production. In this talk, we present a passive CMOS sensor as a suitable option for new hybrid pixel detector designs which could fulfill the aforementioned demands.

The devices under test were n-in-p backside biased sensor prototypes in 150 nm LFoundry CMOS technology with a thickness of 100 and 300  $\mu\text{m}$ . Each sensor has both AC- and DC- coupled pixel regions, bump bonded to the ATLAS FE-I4 chip.

Results from measurements with these sensors show noise levels, leakage current and charge collection efficiency -before and after irradiation- comparable to those of the current ATLAS-IBL planar sensors.

T 114.3 Do 17:30 F 073

**Development of radiation-hard 3D pixel sensors for the HL-LHC** — ●JÖRN LANGE, EMANUELE CAVALLARO, FABIAN FÖRSTER, SEBASTIAN GRINSTEIN, IVAN LOPEZ PAZ, MARIA MANNA, STEFANO TERZO, and DAVID VAZQUEZ FURELOS — IFAE Barcelona, Spain

3D silicon detectors, with cylindrical electrodes that penetrate the sensor bulk perpendicular to the surface, present a radiation-hard sensor technology. Due to a reduced electrode distance, trapping is less and the operational voltage and power dissipation after heavy irradiation is significantly lower than for planar devices. During the last years, the 3D technology has matured and 3D pixel detectors are already used in HEP detectors where superior radiation hardness is key: the ATLAS IBL and the ATLAS Forward Proton detector.

For the High-Luminosity upgrade of the Large Hadron Collider (HL-LHC), the radiation-hardness requirements are even more demanding with fluences up to  $1\text{--}2 \times 10^{16} \text{ n}_{\text{eq}}/\text{cm}^2$  for the innermost pixel layers of the ATLAS and CMS experiments. Moreover, for occupancy reasons, smaller pixel sizes of  $50 \times 50$  or  $25 \times 100 \mu\text{m}^2$  are planned.

In this work, the suitability of 3D pixel sensors for the HL-LHC innermost pixel layers is studied. Firstly, the radiation hardness of the already existing IBL/AFP generation is investigated up to HL-LHC fluences. Secondly, a new dedicated HL-LHC generation of 3D sensors

is developed and tested, which is designed for the smaller pixel sizes and to even further improve the radiation hardness with smaller electrode distances. Laboratory and beam test results of 3D pixel detectors before and after irradiation will be presented.

T 114.4 Do 17:45 F 073

**Design studies on the MimoSIS pixel sensor for the CBM-MVD** — ●PHILIPP SITZMANN for the CBM-MVD-Collaboration — Goethe-Universität Frankfurt

The Compressed Baryonic Matter experiment at FAIR (CBM) is a dedicated fix-target experiment design to explore the QCD phase diagram in the region of high net-baryon density. One of the main physics goals is the reconstruction of short living Open Charm Mesons and Multi-Strange Hyperons. The Micro Vertex Detector (MVD) is designed to significantly increase the secondary vertex resolution and to boost near vertex tracking and reconstruction of low-momentum tracks. This detector will be equipped with CMOS Pixel Sensors developed at IPHC Strasbourg. A new generation of the sensor (MimoSIS) is developed with an improved readout aiming at a much faster readout speed below 10  $\mu\text{s}/\text{frame}$ . The internal readout concept and its corresponding limitations to the occupancy is simulated in the CBM-Root Framework and tested assuming the expected beam intensities and fluctuations.

This work will present the newest results on required internal bandwidth, limitations and resulting design guidelines for the employment of the new MimoSIS sensor in the CBM-MVD.

This work has been supported by BMBF (05P15RFFC1), GSI, HIC for FAIR and HGS-HIRE.

T 114.5 Do 18:00 F 073

**Edge effects of radiation damaged silicon pad diodes** — ●BENEDICT TOHERMES, ECKHART FRETWURST, ERIKA GARUTTI, MICHAEL HUFSCHEIDT, ROBERT KLANNER, and JÖRN SCHWANDT — Institut für Experimentalphysik, Universität Hamburg

Edge effects for square p+n silicon pad diodes fabricated on high-ohmic silicon are investigated. Using capacitance-voltage measurements of two pad diodes with different areas and 320  $\mu\text{m}$  thickness, the planar and the edge contributions to the diode capacitance are determined. For the non-irradiated pad diodes the doping profile is determined. The results with and without edge corrections differ significantly. Without edge correction the value of the bulk doping determined increases by up to 30 % over the depth of the diode, with edge correction it is uniform within  $\pm 1.5 \%$ , which agrees with expectation.

Edge corrections are determined both for non-irradiated diodes and for diodes irradiated to a fluence of  $2.4 \cdot 10^{15} \text{ n}_{\text{eq}}/\text{cm}^2$  with 24 GeV/c protons. The edge correction for irradiated diodes is found to be larger than for non-irradiated ones.

T 114.6 Do 18:15 F 073

**Optimierung der Sensorparameter von Makropixelsensoren für das Phase II Upgrade des CMS-Trackers** — ALEXANDER DIERLAMM, THOMAS MÜLLER, ●DANIEL SCHELL und FLORIAN WITTING — Institut für Experimentelle Kernphysik (IEKP), KIT

Um die erhöhte Datenmenge während der Hochluminositätsphase des Large Hadron Colliders (LHC) verarbeiten zu können, werden für den Spurdetektor des CMS Experiments sogenannte „pT-Module“ entwickelt, welche Teilchen mit hohem und geringem Transversalimpuls zuverlässig separieren können. Dadurch können Ereignisse mit nieder-energetischen Teilchen verworfen und somit die effektive Datenrate reduziert werden. Eines dieser neuen Module ist das sogenannte PS-Modul welches aus einem Makro(P)ixel- und einem (S)treifensensor aufgebaut ist. Während die äußeren Dimensionen sowie die Anzahl der Pixel des Makropixelsensors durch die Moduldimension bzw. den Auslesechips bereits festgelegt sind, müssen Details wie die Peripherie weiter optimiert werden. Ein kritischer Punkt ist hierbei die sogenannte Punch-Through Struktur, welche es unter anderem erlaubt den Sensor vor dem Bump-Bonden der Auslesechips auf mögliche Defekte zu überprüfen. Gleichzeitig soll diese Struktur als Schutz des Auslesechips dienen, indem sie hohe Ströme an der Front-End Elektronik des Chips



vorbeileitet. Um diese und weitere Anforderungen zu erfüllen, nutzt die Outer-Tracker Sensorgruppe verschiedene Mess- und Simulationsprogramme um einen optimierten Parametersatz für den zukünftigen Makropixelsensor zu finden, welche in diesem Vortrag vorgestellt werden.

T 114.7 Do 18:30 F 073

**Finalizing the CBM-MVD Geometry: CAD and Simulation** — ●PHILIPP KLAUS for the CBM-MVD-Collaboration — Goethe-Universität, Frankfurt

The Compressed Baryonic Matter experiment (CBM) at FAIR is a dedicated fix-target experiment designed to explore the QCD phase diagram in the region of high net-baryon density. The talk will review the concluding studies on the geometry of its Micro Vertex Detector (MVD) comprising up to four planar stations equipped with monolithic active pixel sensors close to the target. In order to perform optimally in different physics cases, tweaking the station positioning for each case is considered. In addition, recent updates of the sensor dimensions require small changes to the detector geometry.

In this process, it became evident that improved procedures and tools are required to keep mechanical integration models (CAD) and detector simulation models in sync. This contribution will discuss es-

tablished methods and their advantages/disadvantages.

\*This work has been supported by BMBF (05P15RFFC1), GSI and HIC for FAIR.

T 114.8 Do 18:45 F 073

**Serial Powering Pixel Stave Prototype for the ATLAS ITk upgrade** — ●VIACHESLAV FILIMONOV, LAURA GONELLA, FABIAN HÜGGING, and NORBERT WERMES — University of Bonn, Bonn, Germany

ATLAS ITk is a new inner tracker that will be built for the Phase II upgrade in order to meet the requirements of increased Luminosity.

One of the main challenges for the ATLAS ITk Phase II Pixel upgrade is low mass efficient power distribution to power detector modules. This requires a powering scheme alternative to the parallel (direct) powering which is currently used. Serial powering scheme has been chosen as the baseline for the ITk pixel system.

The talk will focus on a serially powered pixel stave prototype which has been built with all the components that are needed for current distribution, data transmission, bypassing and redundancy in order to prove the feasibility of implementing serial powering scheme in the ITk. Detailed investigations of the electrical performance of the detector prototype equipped with FE-I4 quad modules will be shown.

## T 115: Kalorimeter (gemeinsam mit HK)

Zeit: Donnerstag 16:45–19:05

Raum: F 234

### Gruppenbericht

T 115.1 Do 16:45 F 234

**Final Design and Construction of the EMC for the PANDA Experiment** — ●MIRIAM KÜMMEL for the PANDA-Collaboration — Institut für Experimentalphysik I, Ruhr-Universität Bochum

The PANDA experiment is a key experiment at the future accelerator facility FAIR, under construction in Darmstadt, Germany. Open questions in hadron physics will be addressed by studying collisions of an antiproton beam with a fixed target at antiproton momenta between 1.5 GeV/c and 15 GeV/c.

An electromagnetic calorimeter (EMC) is used to determine the energy of electrons, positrons and photons. This information is essential to fully reconstruct the 4-momenta of all collision products. The homogeneous calorimeter is equipped with lead tungstate scintillation crystals, which were chosen due to their fast signal decay time, compactness as well as radiation hardness. The EMC is subdivided into a barrel part and two endcaps. The forward endcap will be exposed to the highest hit rates and radiation dose which puts very high demands on the performance of this subdetector. To increase the light yield, the electromagnetic calorimeter will be operated at -25°C.

This talk will provide an overview of the final design and construction status of the EMC. The mechanical support structure, the cooling system, the assembly of calorimeter subunits, the matching of crystals, photosensors and preamplifiers to achieve a homogeneous signal yield, the signal digitization as well as environmental and optical monitoring systems will be presented.

This project is supported by the BMBF.

T 115.2 Do 17:15 F 234

**Studies on 2015 testbeam data of a highly granular hadron calorimeter prototype** — ●SASCHA KRAUSE for the CALICE-D-Collaboration — Institut für Physik, Johannes Gutenberg-Universität Mainz, Germany

An Analog Hadronic Calorimeter (AHCAL) is being developed within the CALICE collaboration for the planned International Linear Collider (ILC). To achieve the required energy resolution for jets, the Particle Flow Algorithm has been proposed for the event reconstruction. One major requirement for this algorithm is a highly granular calorimeter. Therefore, about 8 million detector units consisting of scintillator tiles and silicon photomultipliers (SiPMs) will be installed in the final HCAL design. During a CERN SPS testbeam in 2015, data with a prototype consisting of up to 11 layers of HCAL Base Units (HBU) was collected using muon, electron and pion beams. A special feature was the first automatically assembled HBU including 144 scintillator tiles and surface mounted SiPMs. After several calibration steps and event selections, the testbeam data can be compared to a MC simulation of the prototype. First results of this comparison will be presented, testing the performance of the prototype.

### Gruppenbericht

T 115.3 Do 17:30 F 234

**Sensors for the CMS High Granularity Calorimeter** — ●ANDREAS MAIER — CERN, Genf, Schweiz

The Particle Flow Algorithm (PFA) is increasingly used in particle physics as a powerful tool to improve jet energy resolution. Recent technology advances allow to fully exploit PFA by combining precise tracking with fine-grained calorimetry. The CMS experiment is currently developing high granularity calorimeter endcaps for its HL-LHC upgrade (CMS HGCAL). The electromagnetic part, as well as the first layers of the hadronic part, foresees silicon sensors as the active material. This technology is similar to the silicon-based ECAL developed in the framework of the Linear Collider by the CALICE collaboration. In this talk the current status of the HGCAL silicon sensor development is presented. First results of single diode measurements are shown, as well as tests of full 6-inch hexagonal sensor wafers with 135 cells in the laboratory and in beam tests.

T 115.4 Do 17:50 F 234

**The CMS High-Granularity Endcap Calorimeter: Test Beam and Sensor Tests at CERN** — MARTIN ERDMANN<sup>1</sup>, ●THORBEN QUAST<sup>1,2</sup>, and EVA SICKING<sup>2</sup> — <sup>1</sup>Physics Institute IIIA, RWTH Aachen, Germany — <sup>2</sup>CERN, Geneva, Switzerland

Fine-grained calorimetry has been explored for future e<sup>+</sup>e<sup>-</sup> experiments at ILC and CLIC for several years. CMS is developing high-granularity endcap calorimeters (HGCAL) for its HL-LHC upgrade. After a quick overview to the CMS HGCAL project, the talk summarises results from silicon sensor testing and test beam experiments carried out at CERN in 2016. In this context, an energy reconstruction approach based on convolutional deep neural networks is presented to assess the image-like character of the recorded data. Its application for the HGCAL is evaluated and compared to standard energy reconstruction algorithms.

T 115.5 Do 18:05 F 234

**The crystal Zero Degree Detector at BESIII** — ACHIM DENIG<sup>1</sup>, PETER DREXLER<sup>1</sup>, ●BRICE GARILLON<sup>1</sup>, LEONARD KOCH<sup>2</sup>, WOLFGANG KÜHN<sup>2</sup>, SÖREN LANGE<sup>2</sup>, WERNER LAUTH<sup>1</sup>, YUTIE LIANG<sup>2</sup>, TORBEN RATHMANN<sup>1</sup>, and CHRISTOPH REDMER<sup>1</sup> for the BESIII-Collaboration — <sup>1</sup>Johannes Gutenberg Universität Mainz — <sup>2</sup>Justus-Liebig-Universität Gießen

The BESIII experiment based at the BEPCII e<sup>+</sup>e<sup>-</sup> collider (Beijing, China) is investigating physics in the charm- $\tau$  region. Processes in which the particles emission peaks towards small polar angles, such as photons from initial state radiation (ISR) or scattered leptons from  $\gamma\gamma$  collisions, are detected with limited efficiency.

In order to improve their detections, we propose two small calorimeters placed at the very forward/backward angles. Each detector is com-

posed of two arrays of 4x3 rectangular-shaped scintillating LYSO crystals, separated by a gap. The scintillation light will be collected by silicon photomultipliers (SiPMs) and the signals will be digitized using sampling Analog-to-Digital Converters (ADC).

In this contribution, we present a performance study of the detectors, based on a Geant4 simulation of BESIII, as well as the results from the tests of the LYSO crystals and the read-out electronics using radioactive sources and electron beams at the MAMI accelerator.

This work is supported by the DFG under contract No. CRC 1044.

T 115.6 Do 18:20 F 234

**Automatic assembly and test of CALICE second generation SMD readout boards** — ●PHI CHAU for the CALICE-D-Collaboration — Johannes Gutenberg-Universität Mainz

The CALICE collaboration is developing an analog hadronic sampling calorimeter (AHCAL) for the International Linear Collider (ILC) using scintillator with silicon photomultiplier (SiPM) readout. Due to an optimization of the design for particle flow algorithm, small detection units are necessary. This leads to a high number of channels for the AHCAL (in total around 8.000.000) which represents a challenge for the construction and calibration in a suitable time window. To assure a fast assembly of the detection units the design of the readout board are optimized for an automatic assembly process. This presentation will show the automatic assembly of this optimized second generation readout boards (6 boards x 144 channels) and the very good performances of these boards measured in an integrated cosmic ray test stand. Also preparations for the 2017 assembly run of a large number of readout boards (with around 20.000 channels) are shown.

T 115.7 Do 18:35 F 234

**Response of a prototype for the PANDA barrel EMC to tagged photons in an energy range from 50 MeV to 800 MeV** — ●BENJAMIN WOHLFAHRT<sup>1</sup>, KAI-THOMAS BRINKMANN<sup>1</sup>, STEFAN DIEHL<sup>1</sup>, CHRISTOPHER HAHN<sup>1</sup>, MARKUS MORITZ<sup>1</sup>, RAINER NOVOTNY<sup>1</sup>, CHRISTOPH ROSENBAUM<sup>1</sup>, ANDREA WILMS<sup>2</sup>, and HANS-GEORG ZAUNICK<sup>1</sup> for the PANDA-Collaboration — <sup>1</sup>II. Physikalisches Institut, Justus Liebig Universität Gießen — <sup>2</sup>GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt

The PANDA experiment will investigate physics in the strongly interacting regime via antiproton - proton annihilations. The PANDA detector will comprise a target spectrometer as well as a dedicated forward spectrometer. In the target region, a barrel-shaped electromagnetic calorimeter with end-caps on both sides will be used. It will play a major role by detecting photons utilizing about 15500 PbWO<sub>4</sub> crystals. A subsection of the barrel EMC has been implemented as a prototype, consisting of 120 crystals of which each is read out by two independent Avalanche Photo Diodes. To ensure that the Barrel-EMC fulfills all requirements, the response of this prototype has been tested with tagged photons in an energy range from 50 MeV to 800 MeV at the MAMI-facility in Mainz. This contribution will report about the energy resolution achieved with a 5x5 array of crystals within the prototype and will compare different calibration studies. In addition, the matching procedure of the two APDs for each crystal and their cross-calibration will be discussed. \*The Project is supported by BMBF, GSI and HIC for FAIR

T 115.8 Do 18:50 F 234

**Megatile studies and development for the mass assembly of a highly granular hadron calorimeter** — ●YONG LIU for the CALICE-D-Collaboration — Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany

A large technological prototype of a highly granular sampling hadron calorimeter (HCAL) based on scintillator tiles and silicon photomultipliers (SiPMs) is being developed within the CALICE collaboration. We have developed a novel design of scintillator tiles directly coupled to surface-mounted SiPMs, which addresses the challenge from automated mass assembly of around 8 million channels of the final HCAL detector. This design has been realized in 7 HCAL readout boards with a total of 1008 channels have been successfully built via mass assembly, and this design has been adopted as the baseline design for the large prototype construction. To further simplify mass assembly, various designs based on large scintillator plates with embedded structures for optical segmentation ("megatiles") have been developed. Simulation studies as well as prototype developments and measurements will be presented in detail.

## T 116: Detektorsysteme 4

Zeit: Donnerstag 16:45–19:05

Raum: VSH 17

### Gruppenbericht

T 116.1 Do 16:45 VSH 17

**Track reconstruction for the Mu3e experiment** — ●ALEXANDR KOZLINSKIY — Kernphysik Institut, Johannes Gutenberg-Universität Mainz

The *Mu3e* experiment is designed to search for the lepton flavour violating decay  $\mu^+ \rightarrow e^+ e^- e^+$ . To reach phase I sensitivity of  $5 \cdot 10^{-15}$ , the experiment will be performed at the  $\pi E5$  beam line at the Paul-Scherrer Institute (Switzerland) providing  $10^8$  muons per second. The muons with a momentum of about 28 MeV/c are stopped and decay at rest on a target that is placed inside two double layers of 50  $\mu\text{m}$  thin pixel sensors with a pixel size of  $80 \times 80 \mu\text{m}^2$ . Timing information is provided by three layers of scintillating fibres, placed just before the outer double layers, and a scintillating tile detector. To improve momentum resolution, the detector geometry allows to record hits when particles bend back in the 1 T magnetic field. A fast track reconstruction is needed to cope with the high occupancy environment, reaching 100 tracks per reconstruction frame of 50 ns. The track reconstruction uses a novel fit algorithm that only takes into account the multiple scattering uncertainty and neglects detector resolution, allowing fast online reconstruction on a graphics processor (GPU) based filter farm. The implementation and performance of offline track reconstruction and the use of timing information from fibre and tile detector are presented.

T 116.2 Do 17:05 VSH 17

**Jet reconstruction and performance using a Particle Flow algorithm in ATLAS** — IAN BROCK, IRINA CIOARA, MAIKE HANSEN, ●REGINA MOLES-VALLS, and RUI ZHANG — University of Bonn

Jets are a key ingredient in many ATLAS physics analyses. Therefore, a good jet reconstruction and calibration is essential to improve the measurements of the properties of the known particles, as well as to

facilitate the search of new particles.

During the Run 1 of the LHC, the ATLAS analyses used jets built only from topological clusters of calorimeter cells (topo-clusters) or only from tracks. The particle flow algorithm introduces a new approach by combining tracking and calorimeter information. This algorithm replaces the calorimeter topo-clusters associated to charged hadrons by their momenta measured in the inner detector.

The performance of particle flow jets compared with those jets reconstructed from calorimeter energy deposits alone, shows improvements in the transverse momentum and angular resolution, as well as a reduction of the pile-up contribution. The particle flow algorithm is one of the jet collections in ATLAS for the LHC Run 2 analyses.

T 116.3 Do 17:20 VSH 17

**Computertomographie mit einem CMS Phase I Pixeldetektor** — ERIKA GARUTTI<sup>1</sup>, MATTEO CENTIS VIGNALI<sup>2</sup>, MILAN ZVOLSKY<sup>1</sup> und ●SEVERIN DIEDERICH<sup>1</sup> — <sup>1</sup>Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg — <sup>2</sup>CERN

Ein CMS Phase I Einzelchip Pixeldetektor und eine PHYWE XR 4.0 Röntgenmaschine wurden verwendet, um einen Mikro-Computertomographen zu entwickeln. Der hybride Silizium-Pixeldetektor ermöglicht es, sowohl die Intensität, als auch die Energie der einfallenden Röntgenphotonen zu messen. Die gemessene Photonenenergie ermöglicht es, Algorithmen für spektrale Computertomographie zu studieren. Ein Programm wurde entwickelt, welches tomografische Bilder aus den aufgenommenen Daten rekonstruiert. Die Parameter des Systems, wie z.B. die Spannung und der Strom der Röntgenröhre, sowie die Messzeit, wurden optimiert und mehrere Korrekturen wurden angewandt, um die Bildqualität zu verbessern. Die Qualität der rekonstruierten tomografischen Bilder wurde durch einfache Phantome abgeschätzt. Die Leistungsfähigkeit des Systems wurde durch die Aufnahmen von Bildern kleiner Insekten validiert.

T 116.4 Do 17:35 VSH 17

**Signal Characterization in Two-Dimensional Floating Strip Micromegas Detectors** — ●FELIX KLITZNER, OTMAR BIEBEL, JONATHAN BORTFELDT, BERNHARD FLIERL, PHILIPP LOESEL, RALPH MUELLER, MAXIMILIAN HERRMANN, and RALF HERTENBERGER — Ludwigs-Maximilians-Universität München

Floating strip Micromegas detectors with one-dimensional readout strips are high-rate capable particle detectors with excellent spatial and temporal resolution, allowing single particle tracking for particle fluxes up to 7 MHz/cm<sup>2</sup>. A floating strip Micromegas detector collects the amplified ionization charge on copper anode strips with high ohmic contact to high voltage, so called floating strips. The charge signal is read out by readout strips, separated by a thin Kapton layer from the anode strips. This scheme makes the detector robust against discharges between the micro-mesh and the floating anode strips, induced by strongly ionizing particles. A novel two-dimensional readout has been realized with two layers of readout strips, parallel and perpendicular to the floating strips. Different designs of the two-dimensional floating strip anode have been investigated, where readout strip width and order of both readout layers on the PCB have been varied. We present results from characterizing measurements using a 20 MeV proton beam and 5.9 keV photons from an <sup>55</sup>Fe-source, recorded with APV25 front-end boards. Detailed simulations have been set up to understand the signal formation on the two readout layers, as differences with respect to the signal polarity, duration and height are observed on the parallel and perpendicular strip layer.

T 116.5 Do 17:50 VSH 17

**Reducing the systematic uncertainty of the integrated luminosity at the CMS experiment** — ●JOSCHA KNOLLE and ANDREAS B. MEYER — DESY, Hamburg, Germany

The integrated luminosity for a given dataset of the CMS experiment is computed from the event rate measurements of certain detectors, the luminosity monitors. Its uncertainty is a dominant systematic uncertainty in many cross section measurements.

A series of Van der Meer (VdM) scans is performed to calibrate the luminosity monitors. During a VdM scan, the colliding beams are scanned in steps across one another in opposite directions in the transverse plane of the detector. From the measurement of event rates in the luminosity monitors, the calibration constants for the conversion of the measured event rate to instantaneous luminosity can be determined.

In my talk, I will present studies towards the reduction of the systematic uncertainty of the integrated luminosity for the data collected in 2015 and 2016 at the CMS experiment.

T 116.6 Do 18:05 VSH 17

**FANGS, A radiation monitoring detector system for the Beast II experiment of Belle II** — PATRICK AHLBURG, JOCHEN DINGFELDER, ANDREAS EYRING, VIACHESLAV FILIMONOV, ●NANDITA KHETAN, HANS KRUGER, CARLOS MARINAS, LAURA MARI, DAVID .L POHL, and NORBERT WERMES — University of Bonn

The upgrade from KEKB to SuperKEKB is expected to lead to an increase of a factor of 40 in luminosity compared with KEKB. This requires the Belle II detector components, in particular the vertex detector close to the interaction point, to be sufficiently radiation-tolerant to cope with the higher event rates and background radiation. BEAST II, a dedicated detector system to study background radiation and also help in machine commissioning will be employed in Phase 2, which is expected to start at the beginning of 2018. This experiment will measure the expected radiation dose for the inner detectors and therefore ensure a radiation safe environment for the final vertex detector system.

FANGS (FE-I4 ATLAS Near Gamma Sensors), a part of the BEAST II detector system dedicated to radiation monitoring, based on ATLAS-IBL front-end electronics and planar silicon sensors is currently being developed and characterized for this purpose. FANGS is sensitive to low KeV X-rays and can operate at high particle rates. This talk will discuss the development of the FANGS modules and their integration in the BEAST II experiment.

T 116.7 Do 18:20 VSH 17

**CLAWS Phase 2: Beam background monitoring in the commissioning of SuperKEKB** — ●DANIEL HEUCHEL, MIROSLAV GABRIEL, HENDRIK WINDEL, NAOMI VAN DER KOLK, and FRANK SIMON — Max Planck Institute for Physics

The SuperKEKB accelerator in Tsukuba, Japan, is currently undergoing an extensive commissioning campaign, split in three phases. During the second phase, which is starting at the end of 2017, the inner part of Belle II will be replaced by a detector system called Beam Exorcism for a Stable Experiment II (BEAST II), specifically designed to measure background levels at the interaction point (IP) for different operation parameters of the accelerator.

One of the subsystems of this commissioning detector are the scintillation Light And Waveform Sensors (CLAWS), consisting of two ladders with 8 small scintillator tiles, each individually read out by a silicon photomultiplier. The main focus of CLAWS is to study the time evolution of background originating from the continuous top-off injection of the accelerator. Thus, the system features sub-ns time resolution combined with continuous sampling over millisecond time scales. In this contribution, we will present the overall setup and design of the CLAWS phase 2 modules and discuss the performance of the detector elements. Furthermore, first results from a common integration and beam test, scheduled for February 2017 at DESY, will be discussed.

T 116.8 Do 18:35 VSH 17

**Leistungsfähigkeit der Spurfundung mit dem Siliziumstreifendetektor des Belle II-Experiments** — THOMAS HAUTH<sup>1</sup>, MARTIN HECK<sup>1</sup>, JAKOB LETTENBICHER<sup>2</sup>, FELIX METZNER<sup>1</sup>, EUGENIO PAOLONI<sup>3</sup> und ●JONAS WAGNER<sup>1</sup> — <sup>1</sup>IEKP, KIT, Karlsruhe — <sup>2</sup>HEPHY, Wien — <sup>3</sup>INFN, Pisa

Das sich momentan in Tsukuba, Japan im Bau befindliche Belle II-Experiment wird einen modernen Siliziumstreifendetektor aufweisen, welcher eine eigenständige Spurrekonstruktion erlauben wird. Diese wird ergänzend zur Spurrekonstruktion auf Basis der Driftkammer des Belle II-Detektors eingesetzt werden. Insbesondere wird es möglich sein niederenergetische Teilchen, welche die Driftkammer nicht erreichen und eine besondere Beeinflussung durch Vielfachstreuung im Material erfahren, zu vermessen. Diese Streuung und die komplexe Geometrie des vierlagigen Siliziumstreifendetektors, sowie die erhöhte Ereignisrate und der hohe Untergrund erschweren die Spurrekonstruktion.

In diesem Vortrag sollen erste Einblicke in die Leistungsfähigkeit des Spurfundungsalgorithmus geliefert werden, der diese Aufgabe für ein breites Impulsspektrum mit einer hohen Effizienz und angemessener Laufzeit bewältigt.

T 116.9 Do 18:50 VSH 17

**Spurfundung mit dem Siliziumstreifendetektor des Belle II-Experiments** — THOMAS HAUTH<sup>1</sup>, MARTIN HECK<sup>1</sup>, JAKOB LETTENBICHLER<sup>2</sup>, ●FELIX METZNER<sup>1</sup>, EUGENIO PAOLONI<sup>3</sup> und JONAS WAGNER<sup>1</sup> — <sup>1</sup>IEKP, KIT, Karlsruhe — <sup>2</sup>HEPHY, Wien — <sup>3</sup>INFN, Pisa

Das sich momentan in Tsukuba, Japan im Bau befindliche Belle II-Experiment wird einen modernen Siliziumstreifendetektor mit einer komplexen Geometrie aufweisen. Dieser erlaubt eine eigenständige Spurrekonstruktion, welche ergänzend zur Spurrekonstruktion auf Basis der Driftkammer des Belle II-Detektors eingesetzt werden kann. Weiterhin wird die Vermessung niederenergetischer Teilchen, welche die Driftkammer nicht erreichen, ermöglicht.

Der für diesen Siliziumstreifendetektor entwickelte Spurfundungsalgorithmus muss die Spuren physikalisch interessanter Teilchen auch unter den Umständen der im Vergleich zum Vorgängerexperiment erhöhten Ereignis- und Untergrundsrate mit hoher Effizienz identifizieren können. Eine besondere Herausforderung ergibt sich hierbei aus der vierlagigen Detektorgeometrie, die keinerlei Symmetrien aufweist. Für niederenergetische Teilchen wird die Spurrekonstruktion zusätzlich durch die Vielfachstreuung die diese im Material erfahren erschwert.

In diesem Vortrag wird eine knappe Übersicht dieses Spurfundungsalgorithmus gegeben. Im Speziellen wird die Simulationsdatengetriebene Lösung für die Miteinbeziehung der unregelmäßigen Detektorgeometrie erläutert.

## T 117: Myondetektoren 2

Zeit: Donnerstag 16:45–18:35

Raum: VSH 06

## Gruppenbericht

T 117.1 Do 16:45 VSH 06

**Construction and Quality Assurance of Large Area Resistive Strip Micromegas for the Upgrade of the ATLAS Muon Spectrometer** — ●RALF HERTENBERGER<sup>1</sup>, OTMAR BIEBEL<sup>1</sup>, BERNHARD FLIERL<sup>1</sup>, MAXIMILIAN HERRMANN<sup>1</sup>, FELIX KLITZNER<sup>1</sup>, PHILIPP LÖSEL<sup>1</sup>, RALPH MÜLLER<sup>1</sup>, CHRYSOSTOMOS VALDERANIS<sup>1</sup>, and ANDRÉ ZIBELL<sup>2</sup> — <sup>1</sup>LMU München — <sup>2</sup>JMU Würzburg

To cope with the increasing luminosity of LHC intrinsically high-rate capable resistive strip Micromegas detectors of 2-3 m<sup>2</sup> size will replace in 2019 the present tracking detectors of the innermost stations of the ATLAS muon endcap system.

In order to retain 15% transverse momentum resolution for 1 TeV muons, a challenging mechanical precision is required for each of the eight planes of the assembled double-quadruplets, with an alignment of the readout strips at the level of 30  $\mu\text{m}$  along the precision coordinate and 80  $\mu\text{m}$  perpendicular to the plane and with a single plane spatial resolution better than 100  $\mu\text{m}$  at a rate capability up to 15 kHz/cm<sup>2</sup>.

Several PCB boards with micro readout strips need to be joined and precisely aligned to form a full readout plane. The precision in the alignment is reached either with precision mechanical holes or by optical masks, both referenced to the readout strips. Methods to confirm the precision of components and assembly are based on precise optical devices and X-ray or cosmic muon investigations.

We will report on the construction procedures for Micromegas quadruplets, on results from quality control, on assembly and calibration methods.

T 117.2 Do 17:05 VSH 06

**Printing high ohmic resistors for two-dimensional Floating Strip Micromegas Detectors** — ●ISABEL FRANK<sup>1</sup>, OTMAR BIEBEL<sup>1</sup>, BERNHARD FLIERL<sup>1</sup>, MAXIMILIAN HERRMANN<sup>1</sup>, RALF HERTENBERGER<sup>1</sup>, FELIX KLITZNER<sup>1</sup>, PHILIPP LÖSEL<sup>1</sup>, RALPH MÜLLER<sup>1</sup>, CHRYSOSTOMOS VALDERANIS<sup>1</sup>, and ANDRÉ ZIBELL<sup>2</sup> — <sup>1</sup>LMU München, Germany — <sup>2</sup>JMU Würzburg, Germany

Micromegas detectors are gaseous high-rate capable particle detectors with excellent spatial and temporal resolution. Single particle tracking is possible for particle fluxes up to 7 MHz/cm<sup>2</sup>. Different to the standard Micromegas design, floating strip Micromegas use anode strips which are on a floating electrical potential due to high ohmic contact to the HV supply. The charge signal is coupled to readout strips which are separated by a thin kapton layer from the floating anode strips. A two-dimensional floating strip Micromegas detector was built with an active area of 19.2 x 19.2 cm<sup>2</sup> and adjustable drift region height. The floating strips require individual high ohmic contact to high voltage. We present a method to connect reliably the floating strips individually to common high voltage using high atomic polymer resistive paste with a screen printing method. Results from characterizing measurements of the resistances and from tests of the detector using 5.9 keV photons from a <sup>55</sup>Fe source are presented.

T 117.3 Do 17:20 VSH 06

**Grossflächige Mikrogitter für ATLAS Micromegas Detektoren** — ●ANDRÉ ZIBELL und RAIMUND STRÖHMER — Julius-Maximilians-Universität Würzburg

Im Zuge der zweiten langen Wartungspause des LHC Beschleunigers 2019/2020 werden die 'Small Wheel' Myonkammern des ATLAS Detektors unter anderem gegen grossflächige und hochratenfeste Micromegas Detektoren ausgetauscht. Die Gesamtmenge dieser Detektoren ist in vier unterschiedliche Modultypen aufgeteilt, deren Serienproduktion 2017 beginnt.

Eine der Schlüsselkomponenten dieser Detektortechnologie sind vollflächige Edelstahl-Mikrogitter. Am Standort Würzburg werden für einen der vier Modultypen die 128 nötigen, je etwa 3 Quadratmeter grossen Mikrogitter auf Transferrahmen gespannt, und im Anschluss auf die Detektormodule umgeklebt.

Es werden die Entwicklung und der Aufbau der nötigen Infrastruktur vorgestellt, sowie die Ergebnisse der Modul- und frühen Serienproduktion hinsichtlich Homogenität der mechanischen Spannung, Stabilität, Verfahren und Ausbeute präsentiert. Die von ATLAS vorgegebenen Anforderungen wurden bereits bei den ersten Testgittern erfüllt.

T 117.4 Do 17:35 VSH 06

**Effects of humidity on the gas gain in MicroMegas detectors** — ●THORWALD KLAPDOR-KLEINGROTHAUS, STEPHANIE ZIMMERMANN, and ULRICH LANDGRAF — Universität Freiburg

The Micro Mesh Gaseous Detectors (MicroMegas, MM) are planar and high-rate capable detectors with a very good spatial resolution. In the recent years the MM technology was intensively studied in view of replacing the innermost station of the ATLAS endcap muon spectrometer in the next long LHC shutdown in 2019/20 by a new detector assembly known as the New Small Wheel (NSW) Upgrade. The two New Small Wheels will use the MicroMegas technology as well as STGC's for triggering and track reconstruction. In this context small MicroMegas prototypes (10x10cm) were developed, to study their performance and their behavior. The presented work uses a cosmic muon test setup with two of these prototypes in combination with a scalable readout system. Influences on the detector performance caused by variations in the pressure of the operation gas or by changes in the humidity at the low ppm level are investigated. These parameters will impact the later design of detector slow control system at the New Small Wheel in ATLAS. The results of the first measurements and corresponding simulation studies are presented.

T 117.5 Do 17:50 VSH 06

**Characterization tests of Micromegas with elongated pillars** — ●OURANIA SIDIROPOULOU — CERN and University of Würzburg

Micromegas are micro-pattern gaseous detectors which are more and more widely used in physics experiments. Micromegas are parallel-plate chambers where the amplification region is separated from the conversion region by a thin metallic micro-mesh. The width of the amplification region is defined by regularly spaced insulating pillars.

The pillars are made by photo-lithography from a uniform layer of photoimageable coverlay; its thickness defines the amplification gap. Since pillars produce a dead area and a perturbation of the electric field in the region nearby, the design of the pillar pattern is an important parameter. Moreover it has been observed that the attachment of small pillars to the anode plane of the detector is a critical factor for industrially produced large-size anode boards.

In this talk, a resistive micromegas detector built with a new pillar pattern with elongated shapes with length between few mm up to 10 cm will be presented. The detector features readout strips with a width of 250  $\mu\text{m}$  and a pitch of 400  $\mu\text{m}$ . The pillars extend in the direction orthogonal to the readout strips and are 200  $\mu\text{m}$  wide. The larger surface of the pillars allows for a better adhesion to the readout structure and a more uniform amplification gap.

After the motivation of the new proposed structure, the presentation focuses on the characterization of the detector. Results on gain measurements, electron mesh transparency, ion back-flow, efficiency, spatial resolution and tracking performance are presented.

T 117.6 Do 18:05 VSH 06

**Studies on Discharge Behaviour in Thick-GEMs** — ●BERNHARD FLIERL<sup>1</sup>, OTMAR BIEBEL<sup>1</sup>, THEO GOLDFUSS<sup>1</sup>, RALF HERTENBERGER<sup>1</sup>, PHILIPP LÖSEL<sup>1</sup>, and ANDRÉ ZIBELL<sup>2</sup> — <sup>1</sup>Ludwig-Maximilians-Universität München — <sup>2</sup>Julius-Maximilians-Universität Würzburg

Gaseous Electron Multipliers (GEMs) have shown great performance in different applications. Their intrinsic high rate capability might be lowered in hostile environment, where strongly ionizing particles occur simultaneously to minimum ionizing particles to be detected. Very high charge deposition creates discharges, which are in general harmless for the GEM, but create dead time until the initial voltages are recreated. Here the discharge characteristics of Thick-GEMs made from 1 mm PCB-Material and 35  $\mu\text{m}$  copper cladding in contrast to standard GEMs of 50  $\mu\text{m}$  Kapton with 5  $\mu\text{m}$  copper cladding is studied and different approaches of discharge prevention are discussed. An optical read-out is used to locate and count artificially induced discharges, which lead to a visible spark. We present results of characterization with different drift gases by measurements with cosmic muons and an  $\alpha$ -source in order to trigger discharges by high local energy deposition of 5.5 MeV. The main focus is on the minimization of the effects of a discharge, e.g. minimization of voltage drop on the GEM-electrodes and dead time after a discharge.

T 117.7 Do 18:20 VSH 06

**Precision Studies with Resistive Strip Micromegas and their Dependence on Detector Size** — ●PHILIPP LÖSEL<sup>1</sup>, OTMAR BIEBEL<sup>1</sup>, BERNHARD FLIERL<sup>1</sup>, MAXIMILIAN HERRMANN<sup>1</sup>, RALF HERTENBERGER<sup>1</sup>, FELIX KLITZNER<sup>1</sup>, RALPH MÜLLER<sup>1</sup>, and ANDRE ZIBELL<sup>2</sup> — <sup>1</sup>LMU München, Germany — <sup>2</sup>JMU Würzburg, Germany

Currently square-meter sized Micromegas are of big interest for many particle physics experiments. Smaller Micromegas are used often as reference detectors for testbeam setups. They have been intensively investigated in particle beams under background irradiation and with cosmic muons. Micromegas have excellent spatial resolution below 100  $\mu\text{m}$  for perpendicular incident of the traversing particle. Additionally Micromegas allow for angle reconstruction in a single plane with an angu-

lar resolution of up to 2° depending on the drift field. The achievable resolution is limited for measurements with cosmic muons due to increased multiple scattering at lower energies.

We will present a comparison of the spatial resolution, angular resolution, efficiency and signal shape effects of square-meter sized resistive strip Micromegas in comparison with (10 × 10) cm<sup>2</sup> versions in particle beams as well as in measurements with cosmic muons. The Micromegas were exposed to 120 GeV pions at the H6 beam-line at SPS/CERN, where the test Micromegas were investigated in a telescope, consisting of four reference Micromegas. Measurements with cosmic muons were performed in the Cosmic Ray Facility at LMU Munich with two high precision Monitored Drift Tube chambers for reference tracking and three small Micromegas for comparison.

## T 118: Trigger und DAQ 3

Zeit: Donnerstag 16:45–18:20

Raum: VSH 05

### Gruppenbericht

T 118.1 Do 16:45 VSH 05

**BonnDAQ - DAQ Software for the Belle II Pixel Detector** — JOCHEN DINGFELDER, ●FLORIAN LÜTTICKE, CARLOS MARINAS, and NORBERT WERMES for the Belle II-Collaboration — Physikalisches Institut, Rheinische Friedrich-Wilhelms Universität Bonn

The future Belle II experiment at the SuperKEKB accelerator will feature 2 layers of ultra-thin DEPFET pixel detectors, consisting of multiple modules. A DEPFET is a P-channel Field Effect Transistor on a fully Depleted bulk. Collected charge drifts into a potential minimum below the transistor gate, thus modulating the drain current. The readout current is digitized and zero suppressed on the module by multiple Application Specific Integrated Circuits (ASICs). The data is read out by the DHH (Data Handling Hybrid), an FPGA based readout system, which processes the data of several modules for further backend electronic during the experiment. For test data taking in lab setups, during beam tests and during local calibration runs in the final experiment, data can be transmitted directly to a computer by the DHH using the User Datagram Protocol (UDP). For receiving, checking and storing data the BonnDAQ software was developed. It features redistribution of data to Data Quality Monitoring (DQM) modules, an interface to the Belle II slow control system, lossless online data compression and integration into the EUDAQ Data Acquisition framework. Both C++ and Python modules are available for reading stored files as well as receiving live data. In this talk, the design choices and first performance measurements of the software are discussed and example results from its operation are presented.

T 118.2 Do 17:05 VSH 05

**The Data Handling Processor of the Belle II DEPFET Detector** — ●LEONARD GERMIC, TOMASZ HEMPEREK, HANS KRÜGER, CARLOS MARINAS, JOCHEN DINGFELDER, and NORBERT WERMES for the Belle II-Collaboration — Universität Bonn

A two layer highly granular DEPFET pixel detector will be operated as the innermost subsystem of the Belle II experiment, at the new Japanese super flavor factory (SuperKEKB). Such a finely segmented system will allow to improve the vertex reconstruction in such ultra high luminosity environment but, at the same time, the raw data stream generated by the 8 million pixel detector will exceed the capability of real-time processing due to its high frame rate, considering the limited material budget and strict space constraints. For this reason a new ASIC, the Data Handling Processor (DHP) is designed to provide data processing at the level of the front-end electronics, such as zero-suppression and common mode correction. Additional feature of the Data Handling Processor is the control block, providing control signals for the on-module ASICs used in the pixel detector. In this contribution, the description of the latest chip revision in TSMC 65 nm technology together with the latest test results of the interface functionality tests are presented.

T 118.3 Do 17:20 VSH 05

**DAQ Test System for CMS Tracker Upgrade Phase 2** — THOMAS EICHHORN, ●MYKYTA HARANKO, and ANDREAS MUSSGILLER — DESY, Hamburg, Germany

For the upcoming high-luminosity phase of the LHC, the tracking detector of the CMS experiment has to be upgraded. Two types of detector modules are foreseen to be used for the outer tracker regions: so-

called 2S and PS modules. Each module type consists of two semiconductor sensors with corresponding front-end electronics for the readout.

For the future module production at DESY, testing infrastructure is being developed, based on the FC7 board. The FC7 is a  $\mu\text{TCA}$ -compatible Advanced Mezzanine Card for generic data acquisition and control applications. Developed by Imperial College London and built around the Xilinx Kintex 7 FPGA, the FC7 provides a large array of configurable I/O ports, primarily delivered by on-board FPGA Mezzanine Card (FMC) headers, which give the opportunity to establish an optical or electrical interface between the FC7 and the front-end electronics of the CMS tracker's modules.

This talk will present the development status of the FC7 firmware and very first test results.

T 118.4 Do 17:35 VSH 05

**Entwicklungen zur Datenauslese des ATLAS Inner Tracker** — GERHARD BRANDT, ●ERIC BUSCHMANN, JÖRN GROSSE-KNETTER und ARNULF QUADT — Georg-August-Universität Göttingen

Die erhöhte Luminosität des Large Hadron Colliders (LHC) nach dem geplanten Upgrade zum High Luminosity LHC (HL-LHC) stellt hohe Anforderungen an die Detektor- und Auslesesysteme. Für den ATLAS Detektor am LHC ist hierfür ein vollständiges Ersetzen des jetzigen Inner Detector durch einen vollständig halbleiterbasierten Inner Tracker (ITk) bestehend aus Pixel- und Streifensensoren geplant. Dabei ist eine Strahlenhärte für Fluenzen über 10<sup>16</sup> neq/cm<sup>2</sup> erforderlich, wofür neue Komponenten wie GBTx und RD53 entwickelt werden. Besonders die Auslese der innersten Pixellagen stellt eine Herausforderung dar und benötigt eine Übertragungsrate von einigen Gb/s pro Modul. Die RCE (Reconfigurable Cluster Element) Plattform integriert ARM Prozessoren mit FPGAs und findet als Test- und Entwicklungsplattform für das ATLAS Upgrade Verwendung. Der aktuelle Stand der Entwicklungen wird vorgestellt.

T 118.5 Do 17:50 VSH 05

**Enhanced Bunch Crossing Identification for Saturated Pulses in the ATLAS Level-1 Calorimeter Trigger** — ●CLAIRE ANTEL — Kirchhoff-Institut für Physik, Heidelberg

The ATLAS Level-1 Trigger system is designed to perform an ultrafast analysis of a collision provided by the Large Hadron Collider (LHC) in order to decide within 2.5 microseconds whether to keep the event for further processing. The ATLAS Level-1 Calorimeter Trigger participates in this decision by processing calorimeter-based information from the detector. The preprocessing of the signals includes the identification of the correct bunch crossing (BCID) in which the collision took place; failure to do so will lead to events being irrevocably lost.

In view of the increased collision energy in Run II, a new BCID algorithm was commissioned in the Level-1 Calorimeter Trigger that targets saturated pulses. The algorithm is based on new capabilities offered by hardware upgrades in the calorimeter trigger, namely the implementation of new multi-chip modules that have a 80 MHz digitisation rate - twice that of the previous system. The inputs of the algorithm are the 80 MHz digitised samples on the rising edge of the pulse. Thus in order to tune the algorithm, the pulse shapes of signals from physics collision events were studied, using special runs with 80 MHz readout.

The algorithm was commissioned throughout 2016 and enabled towards the end of the year's proton physics data taking period. Presented here is the commissioning as well as the initial performance of the new saturated BCID algorithm.

T 118.6 Do 18:05 VSH 05

**FPGA-basierte Spurrekonstruktion für den Ausbau des Experiments CMS (Phase II)** — CHRISTIAN AMSTUTZ, MATTHIAS BALZER, BENJAMIN OLDENBURG, OLIVER SANDER, THOMAS SCHUH und MARC WEBER — KIT - Karlsruhe Institute of Technology (DE)

CMS entwickelt für den Hoch-Luminositätsbetrieb ab 2026 einen vollständig neuen auf "pT-Modulen" aufbauenden äußeren Spurdetektor.

Dieser wird Treffer von Primärteilchen mit einem Transversalimpuls über  $3\text{ GeV}/c$  selektieren und mit der Kollisionsrate des LHC von 40 MHz und einer resultierenden Datenrate von 50 TBit/s auslesen können. Um die Ereignisrate von CMS trotz erhöhter Luminosität zu erhalten, ist es zwingend notwendig bereits in der ersten Ereignisselektion Spurdaten zu verwenden. Dazu müssen die Treffer des äußeren Spurdetektors innerhalb von 4 ns zu Spuren rekonstruiert werden. Solch eine auf Teilchenspuren gestützte erste Triggerstufe stellt ein absolutes Novum für ein Hochenergiephysikexperiment dar. Das Systemkonzept, die Architektur, die zugrundeliegenden Algorithmen wie die Hough-Transformation zur Spurfundung werden eingeführt und Ergebnisse eines Demonstrators, welcher ein voll funktionsfähiges und skalierbares Segment des Gesamtsystems darstellt, werden präsentiert.

## T 119: Hauptvorträge 4

Zeit: Freitag 8:45–10:45

Raum: H 1

### Hauptvortrag

T 119.1 Fr 8:45 H 1

**Dem Standardmodell auf den Zahn gefühlt: Neue Resultate vom Top-Quark** — BORIS LEMMER — II. Physikalisches Institut, Georg-August-Universität Göttingen

Ein präziser Test des Standardmodells und die Suche nach Abweichungen gehören zu den wichtigsten Vorhaben der Elementarteilchenphysik. Das Top-Quark spielt hierbei als schwerstes bekanntes Elementarteilchen eine besondere Rolle. Durch seine sehr kurze Lebensdauer zerfällt es noch vor einer möglichen Hadronisation. Dies ermöglicht es, experimentell einen guten Zugang zu den Eigenschaften und Wechselwirkungen eines freien Quarks zu erhalten. Seine große Masse von etwa 173 GeV führt zu einer starken Kopplung an neue Teilchen, die aus möglichen Erweiterungen des Standardmodells hervorgehen, zum anderen auch an eine starke Yukawa-Kopplung an das Higgs-Boson des Standardmodells. Die an den Beschleunigern Tevatron und LHC erhobenen Daten erlauben Präzisionsmessungen der Eigenschaften und Wechselwirkungen des Top-Quarks bei verschiedenen Schwerpunktsenergien. Die neuesten Ergebnisse von Top-Quark assoziierten Tests des Standardmodells und der Suche nach möglichen Erweiterungen werden vorgestellt.

### Hauptvortrag

T 119.2 Fr 9:25 H 1

**Suche nach neuer Physik am LHC** — ROMAN KOGLER — Universität Hamburg, Institut für Experimentalphysik

Als Ergebnis der sehr erfolgreichen Datennahme am LHC in den Jahren 2015 und 2016 steht den LHC Kollaborationen der bisher größte Datensatz für Analysen zur Verfügung. Durch die Steigerung der Schwerpunktsenergie von 8 auf 13 TeV für Proton-Proton Kollisionen

besitzen diese Daten eine bis dato unerreichte Sensitivität auf Prozesse neuer Physik.

In diesem Vortrag wird ein Überblick gegeben über die Ergebnisse der Suche nach neuer Physik am LHC. Es wird gezeigt, wie die genaue Kenntnis möglicher Signalprozesse, präzise Vorhersagen und Messungen des Standardmodell-Untergrundes und neue Analyseansätze ausgenutzt werden, um nach Effekten neuer Physik bei den höchsten bisher erreichten Skalen zu suchen.

### Hauptvortrag

T 119.3 Fr 10:05 H 1

**The quest for Axions and Axion-like particles** — JAVIER REDONDO — Zaragoza University, Spain — Max Planck Institut für Physik, München, Germany

The QCD axion and its related axion-like particles appear in well motivated extensions of the standard model and could account for a number of unexplained phenomena, most importantly the absence of CP violation in the strong interactions and the nature of dark matter. The last years have witnessed a growing interest of the experimental verification of these hypothetical particles. Because of their small mass and tiny interactions with ordinary matter, one requires experimental techniques quite different from the usual high energy particle experiments. We will review motivation and hints for the existence of these particles with a particular emphasis on the experimental quest to detect them. Some techniques (solar axions, photon regeneration, dark matter MW cavity experiments) have already reached the level of maturity to develop into large scale projects (IAXO, ALPS, ADMX, CAPP) while recent proposals (CASPER, MADMAX) promise to cover many of the gaps left in parameter space.

## T 120: Hauptvorträge 5

Zeit: Freitag 11:15–13:15

Raum: H 1

### Hauptvortrag

T 120.1 Fr 11:15 H 1

**From Multi-Wavelength to Multi-Messenger Astrophysics: a success story** — STEFAN FUNK — Erlangen Centre for Astroparticle Physics (ECAP), FAU Erlangen, Germany

The Universe is home to exotic phenomena that can be directly linked to fundamental physics. Mergers of black holes produce gravitational waves that allow us to address fundamental physics in strong gravity, shocks in Supernova remnants or jets of black holes produce high-energy particles arriving here in the form of cosmic rays and dark matter leaves potential signatures through annihilation or decay. All these processes typically release enormous amounts of energy in the form of either photons from radio to gamma rays or of elementary particles.

In particular the recent discoveries of astrophysical neutrinos and gravitational waves are promising to open a window on the exploration of the high-energy Universe. Combining neutrino with photon observations promises to help solve the long-standing question of the origin of cosmic rays. Finding electromagnetic counterparts of transient gravitational wave events as possibly witnessed by the Fermi satellite will provide important insight into the nature of progenitor objects and into fundamental aspects of gravity. Indirect searches for dark matter are

probing deeper into possible annihilation cross sections. All these new probes of the Universe signal the dawn of Multi-Messenger astronomy in the quest for understanding fundamental aspects of our Universe. In this talk I will review the status of the field and give a perspective on future developments.

### Hauptvortrag

T 120.2 Fr 11:55 H 1

**The Belle II Experiment** — CARLOS MARINAS — University of Bonn

The Belle II experiment at the asymmetric  $e^+e^-$  SuperKEKB collider is a major upgrade of the Belle experiment, which ran at the KEKB collider at the KEK laboratory in Japan. The design luminosity of SuperKEKB is  $8 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$ , which is about 40 times higher than that of KEKB. Commissioning of the main ring of SuperKEKB has started in February 2016 and Belle II is expected to accumulate an integrated luminosity of  $50 \text{ ab}^{-1}$  well within the next decade. The experiment will focus on searches for new physics beyond the Standard Model via high precision measurements of heavy flavor and searches for rare signals. To reach these goals, the accelerator, detector, electronics, software, and computing systems are all being substantially upgraded. In this talk we present the status of the accelerator and of

the different Belle II sub-detector upgrades.

**Hauptvortrag**

T 120.3 Fr 12:35 H 1

**Beyond the Standard Model: status and remaining hopes —**

•CHRISTOPHE GROJEAN — DESY Hamburg — Humboldt-Universität zu Berlin

The Standard Model is a triumph of the combination of the two pillars of twentieth-century physics: quantum mechanics and special relativity. While it offers a remarkably accurate description of the matter we are made of, it fails to describe 95% of the matter and energy the

Universe is made of. Furthermore, its theoretical structure stumbles upon troubling problems seemingly calling for delicate tunings of its input parameters. Building upon these deficiencies, theorists have devised ultra-violet completions of the Standard Model featuring new particles and new interactions or going beyond the boundaries of our usual 4D space-time. The quest for these new phenomena beyond the Standard Model is an active field of research that requires intense collaborations between the LHC experimentalists and the theorists. In this talk, I shall review what has been learnt from the LHC and what could still be revealed.