Particle Physics Division
Fachverband Teilchenphysik (T)

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Overview of Invited Talks and Sessions

Plenary and prize talks

See PV for details.

PV I	Tue	9:00– 9:45	PVa	**Physics-Informed AI for Image Reconstruction in PET** — •Andrew Reader
PV II	Wed	9:00– 9:45	PVa	**Recent physics highlights of experiments at the LHC** — •Wolfgang Wagner
PV III	Wed	19:30–21:30	PVp	**Geschüttelt, nicht gerührt! – James Bond im Visier der Physik** — •Metin Tolan
PV IV	Thu	9:00– 9:45	PVa	**Roadmap for Accelerator Development in Response to the 2020 Update of the European Strategy for Particle Physics** — •Michael Benedikt
PV V	Fri	9:00– 9:45	PVa	**On top of Dark Matter searches at the LHC** — •Priscilla Pani

Hauptvorträge (Invited Talks)

T 23.1	Tue	9:45–10:30	Tb	**Physics Beyond Colliders** — •Joerg Jaeckel, Various Physics Beyond Colliders Study Group
T 23.2	Tue	11:00–11:45	Tb	**Going the Extra Mile to Push the Frontier** — •Alexander Mann
T 23.3	Tue	11:45–12:30	Tb	**Cosmic Nucleosynthesis, a Multi-Messenger Challenge** — •Roland Diehl
T 48.1	Wed	9:45–10:30	Tb	**Moving ahead with flavor** — •Gudrun Hiller
T 48.2	Wed	11:00–11:45	Tb	**Highlights from the LHCb experiment** — •Michel De Cian
T 48.3	Wed	11:45–12:30	Tb	**Neutrino Oscillations: Status and Prospects** — •Alfons Weber
T 73.1	Thu	9:45–10:30	Tb	**The Higgs boson at the LHC: a glimpse under the peak** — •Matthias Schröder
T 73.2	Thu	11:00–11:45	Tb	**No Time to die? Scrutinizing the SM and other Top Stories** — •Reinhild Yvonne Peters
T 73.3	Thu	11:45–12:30	Tb	**New detector developments: The next challenges** — •Erika Garutti
T 99.1	Fri	9:45–10:30	Tb	**Probing the neutrino mass scale with the KATRIN experiment** — •Kathrin Valerius
T 99.2	Fri	11:00–11:45	Tb	**The quest for precise LHC predictions** — •Jonas Lindert
T 99.3	Fri	11:45–12:30	Tb	**European Strategy for Particle Physics: towards the next collider at CERN** — •Ursula Bassler

Eingeladende Vorträge (Invited Topical Talks)

T 24.1	Tue	14:00–14:30	Tc	**Cosmic Particles at Extreme Energies** — •Michael Unger
T 24.2	Tue	14:30–15:00	Tc	**IceCube Upgrade - The next level in precision neutrino physics at the South Pole** — •Lew Classen
T 24.3	Tue	15:00–15:30	Tc	**The NUCLEUS experiment - New physics with coherent neutrino-nucleus scattering** — •Raimund Strauss
T 25.1	Tue	14:00–14:30	Td	**A large Scintillating Fibre Tracker for the LHCb Upgrade** — •Xiaoxue Han
T 25.2	Tue	14:30–15:00	Td	**Assembling the flavour jigsaw (2021 edition)** — •Oscar Cata

T 25.3	Tue	15:00–15:30	Td	**Erste Physik mit "Full Event Interpretation" am Belle II Experiment** — •William Sutcliffe
T 49.1	Wed	14:00–14:30	Tc	**A walk through $H \to \tau\tau$ in the CMS experiment** — •Hale Sert
T 49.2	Wed	14:30–15:00	Tc	**Looking inside jets - jet substructure techniques and their application in ATLAS** — •Chris Malena Delitzsch
T 49.3	Wed	15:00–15:30	Tc	**Real-time track reconstruction with GPUs** — •Dorothea vom Bruch
T 50.1	Wed	14:00–14:30	Td	**Gamma-ray Propagation as a Probe for Cosmology and Fundamental Physics** — •Manuel Meyer
T 50.2	Wed	14:30–15:00	Td	**Results and Status of the XENON Dark Matter experiment** — •Michael Murra
T 50.3	Wed	15:00–15:30	Td	**Opportunistic direct search for axion Dark Matter** — •Babette Döbrich
T 74.1	Thu	14:00–14:30	Tc	**Searches for electroweak supersymmetry: highlights, coverage and limitations** — •Jeanette Miriam Lorenz
T 74.2	Thu	14:30–15:00	Tc	**To the top and beyond: top quarks as a probe of new interactions at the LHC** — •Katharina Behr
T 74.3	Thu	15:00–15:30	Tc	**Stress testing the Standard Model via vector-boson scattering at the LHC** — •Mathieu Pellen
T 75.1	Thu	14:00–14:30	Td	**Hunting dark matter on earth and in the sky** — •Kai Schmidt-Hoberg
T 75.2	Thu	14:30–15:00	Td	**Gravitational wave astronomy: highlights so far and future detectors** — •David S. Wu
T 75.3	Thu	15:00–15:30	Td	**Advanced Powering of Pixel and Tracking Detectors** — •Martin Lipinski

Invited talks of the joint symposium "Dark Matter" (SYDM)

See SYDM for the full program of the symposium.

SYDM 1.1	Mon	10:00–10:45	PVa	**New (and old) ideas on dark matter** — •Bjoern Malte Schaefer
SYDM 1.2	Mon	10:50–11:35	PVa	**Producing on Earth the missing matter of the Universe** — •Alexander Grohsjean
SYDM 1.3	Mon	11:40–12:25	PVa	**Detecting on Earth the missing matter of the Universe** — •Federica Petricca

Sessions

T 1.1–1.10	Mon	16:00–18:30	Ta	**QCD and electroweak interactions (theory)**
T 2.1–2.1	Mon	16:00–16:15	Tb	**Other Topics**
T 3.1–3.8	Mon	16:00–18:00	Tc	**Accelerator neutrino experiments**
T 4.1–4.8	Mon	16:00–18:00	Td	**Quark mixing and CP violation**
T 5.1–5.7	Mon	16:00–17:45	Te	**Higgs decay in fermions I**
T 6.1–6.10	Mon	16:00–18:30	Tf	**Flavour physics I**
T 7.1–7.10	Mon	16:00–18:30	Tg	**Flavour physics V**
T 8.1–8.10	Mon	16:00–18:30	Th	**Top quark production I**
T 9.1–9.9	Mon	16:00–18:15	Ti	**Associated Higgs production and Higgs quantum numbers I**
T 10.1–10.9	Mon	16:00–18:15	Tj	**Gaseous detectors**
T 11.1–11.7	Mon	16:00–17:45	Tk	**Search for Supersymmetry I**
T 12.1–12.9	Mon	16:00–18:20	Tl	**Search for New Particles I**
T 13.1–13.9	Mon	16:00–18:20	Tm	**Cosmic Rays I**
T 14.1–14.9	Mon	16:00–18:15	Tn	**Pixel detectors I**
T 15.1–15.10	Mon	16:00–18:30	To	**Experimental methods I**
T 16.1–16.9	Mon	16:00–18:15	Tp	**Cosmic Rays V**
T 17.1–17.10	Mon	16:00–18:35	Tq	**Neutrino Astronomy I**
T 18.1–18.9	Mon	16:00–18:20	Tr	**Neutrino physics without accelerators I**
T 19.1–19.8	Mon	16:00–18:05	Ts	**Detector systems I**
T 20.1–20.9	Mon	16:00–18:15	Tt	**DAQ, trigger and electronics I**
T 21.1–21.9	Mon	16:00–18:15	Tu	**Data analysis, Information technology I**
T 22.1–22.10	Mon	16:00–18:35	Tv	**Experimental techniques in astroparticle physics I**
T 23.1–23.3	Tue	9:45–12:30	Tb	**Hauptvorträge (Invited Talks) I**
T 24.1–24.3	Tue	14:00–15:30	Tc	**Eingeladene Vorträge (Invited Topical Talks) I**
T 25.1–25.3	Tue	14:00–15:30	Td	**Eingeladene Vorträge (Invited Topical Talks) II**
T 26.1–26.10	Tue	16:00–18:30	Ta	**Higgs physics (theory)**

T 27.1–27.7	Tue	16:00–17:45	Tb	**QCD I**
T 28.1–28.10	Tue	16:00–18:30	Tc	**Top quark production II**
T 29.1–29.8	Tue	16:00–18:05	Td	**Top quark decay and top properties I**
T 30.1–30.9	Tue	16:00–18:15	Te	**Higgs decay in fermions II**
T 31.1–31.10	Tue	16:00–18:30	Tf	**Flavour physics II**
T 32.1–32.10	Tue	16:00–18:30	Tg	**Flavour physics VI**
T 33.1–33.9	Tue	16:00–18:15	Th	**Cosmic Rays VI**
T 34.1–34.8	Tue	16:00–18:00	Ti	**Extended Higgs models I**
T 35.1–35.10	Tue	16:00–18:30	Tj	**Semiconductor Detectors - Radiation Hardness, New Materials and Concepts**
T 36.1–36.7	Tue	16:00–17:45	Tk	**Search for Supersymmetry II**
T 37.1–37.9	Tue	16:00–18:15	Tl	**Search for New Particles II**
T 38.1–38.10	Tue	16:00–18:30	Tm	**Data analysis, information technology II**
T 39.1–39.10	Tue	16:00–18:35	Tn	**Pixel Detectors II**
T 40.1–40.10	Tue	16:00–18:30	To	**Experimental methods II**
T 41.1–41.8	Tue	16:00–18:00	Tp	**DAQ, trigger and electronics II**
T 42.1–42.10	Tue	16:00–18:30	Tq	**Neutrino astronomy II**
T 43.1–43.10	Tue	16:00–18:30	Tr	**Neutrino physics without accelerators II**
T 44.1–44.10	Tue	16:00–18:35	Ts	**Neutrino physics without accelerators V**
T 45.1–45.10	Tue	16:00–18:30	Tt	**Searches for Dark Matter I**
T 46.1–46.10	Tue	16:00–18:30	Tu	**Cosmic Rays II**
T 47.1–47.10	Tue	16:00–18:30	Tv	**Experimental techniques in astroparticle physics II**
T 48.1–48.3	Wed	9:45–12:30	Tb	**Hauptvorträge (Invited Talks) II**
T 49.1–49.3	Wed	14:00–15:30	Tc	**Eingeladene Vorträge (Invited Topical Talks) III**
T 50.1–50.3	Wed	14:00–15:30	Td	**Eingeladene Vorträge (Invited Topical Talks) IV**
T 51.1–51.10	Wed	16:00–18:30	Ta	**BSM physics (theory)**
T 52.1–52.8	Wed	16:00–18:00	Tb	**Top quark decay and top properties II**
T 53.1–53.10	Wed	16:00–18:30	Tc	**Electroweak Interactions I**
T 54.1–54.10	Wed	16:00–18:30	Td	**Cosmic Rays III**
T 55.1–55.10	Wed	16:00–18:30	Te	**Bosonic and Rare Higgs decays**
T 56.1–56.10	Wed	16:00–18:30	Tf	**Flavour physics III**
T 57.1–57.8	Wed	16:00–18:00	Tg	**Calorimeters I**
T 58.1–58.9	Wed	16:00–18:25	Th	**Gamma astronomy I**
T 59.1–59.9	Wed	16:00–18:15	Ti	**Extended Higgs models II**
T 60.1–60.9	Wed	16:00–18:15	Tj	**Silicon Strip Detectors I**
T 61.1–61.9	Wed	16:00–18:15	Tk	**Search for New Particles III**
T 62.1–62.7	Wed	16:00–17:45	Tl	**Search for New Particles V**
T 63.1–63.8	Wed	16:00–18:00	Tm	**Detector Systems II**
T 64.1–64.9	Wed	16:00–18:15	Tn	**Pixel Detectors III**
T 65.1–65.10	Wed	16:00–18:30	To	**Experimental methods III**
T 66.1–66.9	Wed	16:00–18:15	Tp	**DAQ, trigger and electronics III**
T 67.1–67.10	Wed	16:00–18:30	Tq	**Neutrino astronomy III**
T 68.1–68.9	Wed	16:00–18:20	Tr	**Neutrino physics without accelerators III**
T 69.1–69.10	Wed	16:00–18:35	Ts	**Neutrino physics without accelerators VI**
T 70.1–70.10	Wed	16:00–18:30	Tt	**Searches for Dark Matter II**
T 71.1–71.9	Wed	16:00–18:15	Tu	**Data analysis, Information technology III**
T 72.1–72.10	Wed	16:00–18:30	Tv	**Experimental techniques in astroparticle physics III**
T 73.1–73.3	Thu	9:45–12:30	Tb	**Hauptvorträge (Invited Talks) III**
T 74.1–74.3	Thu	14:00–15:30	Tc	**Eingeladene Vorträge (Invited Topical Talks) V**
T 75.1–75.3	Thu	14:00–15:30	Td	**Eingeladene Vorträge (Invited Topical Talks) VI**
T 76.1–76.10	Thu	16:00–18:30	Ta	**Outreach Methods**
T 77.1–77.8	Thu	16:00–18:00	Tb	**QCD II**
T 78.1–78.9	Thu	16:00–18:15	Tc	**Electroweak Interactions II**
T 79.1–79.9	Thu	16:00–18:15	Td	**Top quark production III**
T 80.1–80.10	Thu	16:00–18:35	Te	**Cosmic Rays IV**
T 81.1–81.10	Thu	16:00–18:30	Tf	**Flavour physics IV**
T 82.1–82.9	Thu	16:00–18:15	Tg	**Calorimeters II**
T 83.1–83.10	Thu	16:00–18:35	Th	**Gamma astronomy II**
T 84.1–84.9	Thu	16:00–18:15	Ti	**Associated Higgs production and Higgs quantum numbers II**
T 85.1–85.8	Thu	16:00–18:00	Tj	**Silicon Strip Detectors II**
T 86.1–86.8	Thu	16:00–18:00	Tk	**Search for New Particles IV**

T 87.1–87.9	Thu	16:00–18:15	Tl	**Extended Higgs Models III**
T 88.1–88.9	Thu	16:00–18:15	Tm	**Detector Systems III**
T 89.1–89.8	Thu	16:00–18:00	Tn	**Pixel Detectors IV**
T 90.1–90.10	Thu	16:00–18:35	To	**Muon detectors**
T 91.1–91.6	Thu	16:00–17:30	Tp	**GRID computing**
T 92.1–92.10	Thu	16:00–18:30	Tq	**Neutrino astronomy IV**
T 93.1–93.10	Thu	16:00–18:30	Tr	**Neutrino physics without accelerators IV**
T 94.1–94.10	Thu	16:00–18:35	Ts	**Neutrino physics without accelerators VII**
T 95.1–95.10	Thu	16:00–18:30	Tt	**Searches for Dark Matter III**
T 96.1–96.7	Thu	16:00–17:45	Tu	**DAQ, Trigger and Electronics IV**
T 97.1–97.10	Thu	16:00–18:30	Tv	**Experimental techniques in astroparticle physics IV**
T 98	Thu	19:00–21:00	Ta	**General assembly - Particle Physics Division (for DPG members)**
T 99.1–99.3	Fri	9:45–12:30	Tb	**Hauptvorträge (Invited Talks) IV**

Annual General Assembly of the Particle Physics Division (for DPG members)

Thursday 19:00–21:00 Ta

- Report: Division Particle Physics and Section Matter and Cosmos
- Decision to be taken: Enlargement of DPG Section Matter and Cosmos (SMuK) by Division Plasma Physics?
- Election: chair and vice chair of Division Particle Physics for period June 1, 2021 - May 31, 2023.
- Decision to be taken: Future meeting venues (in particular in 2025)
- General Discussion: Format of spring meeting in 2021 and in the future
- AOB

T 1: QCD and electroweak interactions (theory)

Time: Monday 16:00–18:30 Location: Ta

T 1.1 Mon 16:00 Ta

Soft Gluon Resummation for the Associated Single Top and Higgs Production at the LHC — •Laura Moreno Valero[1], Anna Kulesza[1], and Vincent Theeuwes[2] — [1]Institut für Theoretische Physik, Westfälische Wilhelms Universität Münster, Deutschland — [2]Institut für Theoretische Physik, Georg-August-Universität Göttingen, Deutschland

Processes involving the Higgs boson and the top quark are of high interest in searches for BSM physics because they allow to directly measure the top Yukawa coupling. Although it has a relatively small cross section, the single top and Higgs production process $pp \to Htj$ is particularly sensitive to new physics, calling for precise theoretical predictions. For many processes at the LHC, a reduction of theoretical uncertainties can be achieved by means of resummation techniques, accounting for large logarithmic corrections, which originate from soft gluon emissions. In this talk, we discuss extending the precision with which theoretical predictions for the s-channel tHj production are known from NLO (next-to-leading order) to NLO+NLL (next-to-leading logarithmic matched to NLO) accuracy.

T 1.2 Mon 16:15 Ta

Soft gluon resummation for single leptoquark production at the LHC — •Fausto Frisenna, Anna Kulesza, and Daniel Schwartlaender — WWU, Institut für Theoretische Physik, Muenster, Germany

Leptoquarks provide one of the most promising explanations to the hints of lepton flavor non-universality in B decays. At the LHC, a single leptoquark can be directly produced together with a lepton in the final state. For TeV-scale leptoquarks, theoretical predictions can be improved by resumming large logarithmic corrections originating from soft gluon emissions. In this talk we discuss how to perform threshold resummation in Mellin space for single leptoquark production.

T 1.3 Mon 16:30 Ta

Automating the calculation of jet functions in SCET — Guido Bell, •Kevin Brune, Goutam Das, and Marcel Wald — Center for Particle Physics Siegen, Theoretische Physik 1, Universität Siegen

In pertubative QCD large logarithms can arise in the computation of collider observables. These logarithms can be resummed via factorization theorems within Soft-Collinear Effective Theory(SCET). The factorization theorems contain jet functions, which describe collinear interactions. In this talk I present a systematic framework for the computation of jet functions for generic observables. For this purpose we introduce a phase space parametrization which allows the factorization of universal singularities of jet functions. We have implemented this framework for different observables, by using the public code "pySecDec" to compute the next-to-leading order and part of the next-to-next-to-leading order jet function.

T 1.4 Mon 16:45 Ta

On the automated calculation of beam functions in Soft-Collinear Effective Theory — Guido Bell, Kevin Brune, Goutam Das, and •Marcel Wald — Center for Particle Physics Siegen, Theoretische Physik 1, Universität Siegen

Over the last decades, factorization theorems became an important method to tackle problems in perturbative QCD, especially within the framework of effective field theories. In Soft-Collinear Effective Theory, these factorization theorems include beam functions accounting for the initial-state collinear interactions. While these functions have been calculated case by case for different observables until now, we are investigating an automated approach for a general class of observables. For this, we study a general phase-space parameterization which factorizes the singularities of the beam function in an universal way. This approach has been implemented in the public code "pySecDec" in order to calculate the next-to-leading order and part of the next-to-next-to leading order beam function.

T 1.5 Mon 17:00 Ta

Investigation of Intrinsic kT and DY processes — •Mikel Mendizabal and Hannes Jung — DESY (Deutsches Elektronen-Synchrotron DESY), Hamburg, Germany

With Parton Branching (PB) we are able to describe the parton evolution in terms of transverse momentum dependent parton density functions (TMDs). We present an application of PB-TMDs to Drell-Yan (DY) production, where the PB-TMDs are matched to MC@NLO matrix element. We compare our predictions to a wide DY mass range (NuSea $\sqrt{s} = 38.8$ GeV, LHC $\sqrt{s} = 8, 13$ TeV), showing a good agreement with measurements. In addition, we study the role of non-perturbative effects in the PB approach at NLO, specifically, the role of the intrinsic, non-perturbative k_T distribution.

T 1.6 Mon 17:15 Ta

Charm quark mass effects to Upsilon decays — Matthias Steinhauser[1], Jan Piclum[2], Kay Schönwald[1], Matteo Fael[1], and •Manuel Egner[1] — [1]Karlsruher Institut für Technologie — [2]Universität Siegen

The decay of the $\Upsilon(1S)$ meson is described within non-relativistic QCD where an important building block is given by the matching coefficient of the vector current. We compute two-loop corrections to this quantity for bottom quarks including the dependence of the charm quark mass. Details to the calculation are provided. In the second part of the talk we will discuss the decay of the $\Upsilon(1S)$ meson into leptons including perturbative corrections up to order α_s^3. Full charm quark mass dependence is taken into account up to order α_s^2.

T 1.7 Mon 17:30 Ta

Heavy-quark hadro-production at next-to-leading-order in QCD and beyond. — •Yewon Yang and Sven-Olaf Moch — Universität Hamburg, Hamburg, Germany

Heavy-quark hadro-production is accessible to quantum chromodynamics (QCD) perturbation theory for heavy quark mass scales which are larger than the QCD scale. The talk reports on phenomenological results for heavy-quark pair production beyond next-to-leading-order (NLO) for the hard scattering in combination with modern parton distribution functions (PDFs).

Transverse momentum and rapidity distributions beyond NLO are obtained using single-particle inclusive kinematics where the threshold logarithms are resummed to derive approximate fixed-order perturbative corrections at next-to-next-to-leading-order (NNLO). For the total inclusive cross section, complete predictions at NNLO are used, which include also the contributions from the high energy limit. These complete predictions at NNLO for total cross section are compared with four different modern PDF sets in proton-proton collisions at 7, 8 and 13 TeV hadronic center-of-mass energy for the Large Hadron Collider.

T 1.8 Mon 17:45 Ta

Mixed NNLO QCD×electroweak corrections of $\mathcal{O}(N_f\alpha_s\alpha)$ to single-W/Z production at the LHC — •Jan Schwarz[1], Stefan Dittmaier[1], and Timo Schmidt[2] — [1]Albert-Ludwigs-Universität Freiburg — [2]Universität Würzburg

Owing to its clean experimental signature and its high cross section the Drell–Yan-like W/Z production is among the most important processes at the LHC. Drell–Yan-like processes can be used for a variety of applications, e.g., for detector calibration or measuring the W-boson mass and beyond that are also an important SM background for searches of new physics. On the theoretical side the $\mathcal{O}(\alpha_s\alpha)$ corrections seem to be the largest missing fixed order part, and in recent years it has been possible to get a handle on these corrections in the vicinity of the pole corresponding to the on-shell production of Drell–Yan-like W/Z bosons using, e.g., so-called pole approximations (PA). However, since new physics like the production of Z′ or W′ might show up for example in the tails of invariant mass spectra, the theoretical uncertainty on the SM background has to be controlled in these off-shell regions of phase space where the PA is not applicable. Therefore, a full off-shell calculation of the $\mathcal{O}(\alpha_s\alpha)$ corrections is desirable. In this talk we present results on the radiative corrections of order $\mathcal{O}(N_f\alpha_s\alpha)$ for the off-shell production of W or Z bosons at the LHC, where N_f is the number of fermion flavours. These corrections form a gauge-invariant part of the next-to-next-to-leading-order corrections of mixed QCD×EW type and include all diagrams at $\mathcal{O}(\alpha_s\alpha)$ with closed fermion loops.

T 1.9 Mon 18:00 Ta

Electroweak Corrections for W^+W^- Scattering — •Robert Franken — JMU Würzburg

Vector boson scattering (VBS) processes are a very good testing ground for the validity of the Standard Model (SM) and electroweak symmetry breaking in general. Over the last few years, Atlas and CMS have been able to measure the cross sections of VBS. To search for deviations, it is important to have precise predictions for VBS processes within the SM. Whilst only the QCD NLO predictions were available for some time, recently electroweak corrections have become available for the like-sign WW, WZ and ZZ scattering, and turned out to be at the the level of 15% for fiducial cross sections. In this talk we report on our efforts to calculate the NLO EW corrections to opposite sign WW scattering and the complete NLO corrections to the process $pp \to e^+\mu^-\nu_e\bar{\nu}_\mu jj$.

T 1.10 Mon 18:15 Ta

`ARGES` – **Advanced Renormalisation Group Equation Simplifier** — •Tom Steudtner[1,2] and Daniel Litim[2] — [1]Fakultät für Physik, TU Dortmund, Otto-Hahn-Str. 4, D-44221 Dortmund, Germany — [2]Department of Physics and Astronomy, University of Sussex, Brighton, BN19QH, United Kingdom

I will present `ARGES`, a Mathematica toolkit for obtaining perturbative renormalisation group equations in arbitrary four-dimensional QFTs. The framework exhibits several distinctive features from similar software: the computation is symbolic rather than numeric, input of unconventional scalar and Yukawa sectors is allowed, the evaluation and disentanglement of couplings is interactive and there are capabilities to inject algebraic simplification rules. I will give a conceptual and practical introduction, highlight differences to existing packages, and provide an outlook on applications.

T 2: Other Topics

Time: Monday 16:00–16:15 Location: Tb

T 2.1 Mon 16:00 Tb

A Particle Model that Yields a Bunch of Solutions — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

We will present a particle model which differs considerably from that used in present-day physics but yields important benefits compared to the latter.

The essential difference is that every fermion is considered to be made of two sub-particles which are massless and orbit each other at the speed of light. The mass of the overall particle is caused by the fundamental physical fact that every extended object inevitably has inertia.

The particle model is in no conflict with experimental results since this type of configuration has never been tested. The fairly simple formula for mass does not have any adjustable parameters, but it yields the mass of e.g. an electron to within 3*10**-6 of the measurement.

The model assumes that the constituents are bound by the strong force. The shape of the force field is such that the bond depends critically on the conformity of the particles' sizes. This explains why e.g. leptons and quarks do not interact noticeably through the strong force; and also why different types of quarks do not normally interact.

The model further allows the quantitative deduction of particle properties such as the Bohr magneton, the magnetic anomaly, the energy to frequency relation and the fine structure constant alpha, as well as the constancy of spin. And it provides the fundamental causes of special as well as general relativity.

Introductory information on: www.ag-physics.org/rmass

T 3: Accelerator neutrino experiments

Time: Monday 16:00–18:00 Location: Tc

T 3.1 Mon 16:00 Tc

Hydrogen-rich Gases for High Pressure Time Projection Chambers at Neutrino Beamlines — •Philip Hamacher-Baumann, Nick Thamm, Thomas Radermacher, and Stefan Roth — RWTH Aachen University - Physics Institute III B, Aachen, Germany

DUNE's near detector complex foresees a magnetized high-pressure gaseous time projection chamber (HPgTPC) as part of its detector suite. The gaseous active volume results in a very low detection threshold with high particle-identification power and large acceptance for tracking, especially for interactions on the gas itself. Neutrino interactions on hydrogen nuclei in the drift gas can be extracted with the transverse kinematic imbalance method to produce intra-nucleon-interaction-free neutrino samples. For design and development of a pressurized TPC, it is essential to quantify and validate electron swarm parameters, such as drift velocity or diffusion, to ensure performance at large detector scales. In this presentation, I will discuss how electron swarm parameters of drift gas mixtures perform at higher than atmospheric pressures. Additionally, a study of a choice of hydrogen-rich gas mixtures for consideration in HPgTPC is presented in addition to measurements in a test chamber. The results are assessed with respect to performance at 10 bar pressure in HPgTPC.

T 3.2 Mon 16:15 Tc

Status of the ESSνSB Target Station — •Tamer Tolba — Institut für Experimentalphysik, Universität Hamburg, Hamburg - Germany

In the quest to discover CP-violation in the leptonic sector, a crucial information has been obtained from reactor experiments demonstrating that the value of the third neutrino-mixing angle, θ_{13}, is higher than its previously defined standard value. In the light of this new finding, an urgent need has arisen to improve the detection sensitivity of the current long-baseline detectors, with a key modification to place the far detectors at the second, rather than the first, oscillation maximum.

The European Spallation Source Neutrino Super Beam (ESSνSB) aims at searching for CP-violation in the leptonic sector, at 5σ significance level in more than 60% of the leptonic Dirac CP violating phase range, and measuring the CP phase angle with high precision by setting the neutrino source-to-detector distance, the baseline, at the second oscillation maximum. Several technological challenges must be precisely studied and simulated before addressing the design of the ESSνSB detector. Among these, the finite element and physics simulations of the target station and the neutrino beam are considered to be highest priority at this phase of the ESSνSB project.

Here I will shed light on the current target station design physics and FEA simulation efforts of the ESSνSB WP4 working group.

T 3.3 Mon 16:30 Tc

A Highly Granular Electromagnetic Calorimeter Concept for the DUNE Near Detector — •Lorenz Emberger[1], Eldwan Brianne[2], and Frank Simon[1] — [1]Max-Planck-Institut für Physik — [2]DESY

The Near Detector (ND) of the Deep Underground Neutrino Experiment (DUNE) will play an important role in the search of CP violation in the neutrino sector. Additionally, as a standalone complex, it will be an excellent laboratory to study a wide range of neutrino interactions and BSM models. The ND design consists of three independent sub-detectors, placed downstream of the neutrino production target. One of these detectors, called ND-GAr, consists of a high pressure gaseous Argon Time Projection Chamber (TPC), surrounded by an electromagnetic calorimeter (ECAL) and a muon system. One key aspect of the ECAL is the reconstruction of neutral particles such as neutral pions and potentially neutrons. Together with the muon system, the ECAL also extends the detector's separation capability of muons and pions. We present a study of the detector system featuring a highly granular electromagnetic calorimeter inspired by the SiPM-on-Tile technology developed by the CALICE collaboration. We will introduce the detector design considerations, as well as the potential physics program. Additionally, we will touch on first ECAL perfor-

mance evaluations and the separation of muons and pions using a full GEANT4 detector simulation.

T 3.4 Mon 16:45 Tc

Scintillator material studies to reconstruct neutrons at the ECAL of DUNE Near Detector — •Asma Hadef, Antoine Laudrain, Volker Büscher, Lucia Masetti, and Sebastian Ritter — Johannes Gutenberg Universität, Mainz, Germany

The Deep Underground Neutrino Experiment (DUNE) seeks to revolutionize our understanding of neutrinos and their role in the universe. The DUNE near detector (ND) is located near the neutrino source and is a crucial part of a precision measurement of the CP violating phase. It needs to measure neutrino interactions with high detection efficiency, superior identification of charged and neutral particles and precise energy reconstruction. The electromagnetic calorimeter (ECAL) of the ND should be in particular sensitive to neutrons with energies of hundreds of MeV that interact inside the plastic scintillator or nearby. By precisely measuring the time and position of a neutron-induced hit, it is possible to determine the neutron kinetic energy via time of flight. In this talk, an experimental setup to study the scintillator material to identify neutron interaction with respect to the background by using pulse shape discrimination (PSD) with plastic scintillators and silicon photomultipliers (SiPMs) will be presented.

T 3.5 Mon 17:00 Tc

Dual Cherenkov/Scintillation Reconstruction in Water-based Liquid Scintillator — •Daniele Guffanti, Manuel Böhles, Nils Brast, Hans Steiger, and Michael Wurm — Institute of Physics and Excellence Cluster PRISMA, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany

One of the most intriguing possibilities for the next generation of neutrino experiments consists in large hybrid Cherenkov/Scintillation detectors, made possible by recent innovations in photodetection technologies and liquid scintillator chemistry such as Water-based Liquid Scintillators and Slow Scintillators. Being able to exploit both Cherenkov and Scintillation photons can bring significant improvements to the sensitivity of an experiment, enhancing energy and track reconstruction. This possibility is particularly interesting for hadronic interactions, which can be studied on an extracted beamline with a ton-scale experiment.

T 3.6 Mon 17:15 Tc

The ANNIE experiment — •Michael Nieslony, David Maksimovic, Daniele Guffanti, and Michael Wurm for the ANNIE-Collaboration — Johannes Gutenberg University, Mainz, Germany

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a Gadolinium doped water Cherenkov detector located in the Booster Neutrino Beam at Fermilab with the primary goal of measuring the final state neutron multiplicity of neutrino-nucleus interactions. ANNIE will make use of pioneering photodetectors called Large Area Picosecond Photodetectors (LAPPDs) with less than 100 picosecond time resolution to enhance its reconstruction capabilities and demonstrate the feasibility of this technology as a new tool in high energy physics. This talk will present an overview of recently taken ANNIE beam commissioning and calibration data and outline the framework for the upcoming neutron multiplicity analysis. Furthermore, additional future R&D efforts involving the use of the novel detection medium of water-based Liquid Scintillators will be briefly highlighted.

T 3.7 Mon 17:30 Tc

The T2K Near Detector Upgrade — Philip Hamacher-Baumann, Paula Nehm, Paolina Noll, Thomas Radermacher, Stefan Roth, David Smyczek, and •Nick Thamm — RWTH Aachen University - Physics Institute III B, Aachen, Germany

The Tokai to Kamioka (T2K) long baseline neutrino oscillation experiment is entering the next phase (T2K-II) with increased beam power of up to 1.3 MW. To match the reduced statistical uncertainty an upgrade of the near detector (ND280) is planned to increase the detector acceptance and therefore reduce the systematic uncertainties. In the upstream part a 3D fine-grained scintillator target, a time-of-flight system and two time projection chambers (TPCs) will be installed. These new High Angle TPCs (HATs) will cover the phase space of neutrino scattering with the final state lepton scattered at a large angle. Improved momentum resolution and particle identification will be achieved by using resistive bulk micromegas technology. Installation is scheduled for the year 2021 with first data taking starting in 2022. In this talk first tests of a prototype HAT including gas monitoring chambers will be presented.

T 3.8 Mon 17:45 Tc

Pattern Recognition Algorithm for the High Angle TPCs of the T2K Near Detector Upgrade — Philip Hamacher-Baumann, •Paula Nehm, Paolina Noll, Thomas Radermacher, Stefan Roth, David Smyczek, and Nick Thamm — RWTH Aachen University - Physics Institute III B, Aachen, Germany

The T2K near detector upgrade includes the addition of two High Angle Time projection chambers (HATs). They will increase the selection efficiency of leptons for scattering angles larger than ca. 40 degrees by achieving a full polar angle coverage for muons produced in CC events. For these HATs the reconstruction algorithm needs to be reworked. As a first step the pattern recognition algorithm of the already installed time projection chambers of the T2K near detector has been adapted for the new HATs. This as well as the readjustment of the parameters of the algorithm to the new geometry will be presented.

T 4: Quark mixing and CP violation

Time: Monday 16:00–18:00 Location: Td

T 4.1 Mon 16:00 Td

Reconstruction of tau lepton decay planes for analysing the Higgs CP at CMS — Mate Farkas[2], Olena Hluschenko[2], Wolfgang Lohman[1,2], Dennis Roy[2], Hale Sert[2], Sebastian Siebert[2], Achim Stahl[2], •Lucas Wiens[1,2], and Alexander Zotz[2] — [1]Deutsches Elektronen-Synchrotron (DESY), Hamburg — [2]III. Physikalisches Institut B, RWTH Aachen University, Germany

One of the three Sakharov conditions states that CP violation is needed to explain the matter-antimatter symmetry in our universe. In order to find more occurances of CP violation, the Higgs Boson is now being investigated, so one can find out whether or not it is the CP-even Higgs Boson of the Standard Model or if it is in a mixed state of CP-even and CP-odd and a gateway to new physics. This analysis uses the Run 2 data of 2017 collected by the CMS detector corresponding to an integrated luminosity of 41.5fb^{-1} in proton-proton collisions with a centre-of-mass energy of 13TeV. Selecting events with a Higgs Boson decaying into a pair of tau leptons, one will find that the tracks of the tau daughters do not intersect with the interaction point. The minimal distance of such a displaced track and the interaction point is called an impact parameter and can be used in conjunction with the daughter particles momentum to reconstruct the decay plane for each tau lepton. The angle between these two planes is sensitive to the Higgs CP and thus it is vital to select well reconstructed impact parameters.

T 4.2 Mon 16:15 Td

Time-dependent measurement of *CP* violation in $B_s^0 \to D_s^+ D_s^-$ and $B^0 \to D^+ D^-$ decays with the LHCb experiment — Louis Gerken, Philipp Ibis, and •Antje Mödden — Experimentelle Physik 5, TU Dortmund

To test the Standard Model of particle physics and search for New Physics, the LHCb experiment performs precision measurements, e.g. decay-time-dependent measurements of *CP* violation in decays of neutral B mesons.

In the topologically similar decays $B_s^0 \to D_s^+ D_s^-$ and $B^0 \to D^+ D^-$, the weak mixing phases ϕ_s and $\sin(2\beta)$ can be measured in the interference between the direct decay and the decay after $B^0_{(s)} - \bar{B}^0_{(s)}$ mixing. A decay-time-dependent analysis is performed with data corresponding to an integrated luminosity of 6 fb^{-1} recorded by the LHCb experiment from 2015 to 2018 at a centre-of-mass energy of 13 TeV.

The modelling of the decay-time-dependent efficiency, the calibration of the decay-time resolution, and the calibration of the Flavour Tagging will be presented in this talk.

T 4.3 Mon 16:30 Td

Measurement of CP violation in $B^0 \to \psi K^0_S$ decays with the LHCb detector using the full Run II data — Vukan Jevtic, Patrick Mackowiak, and •Gerwin Meier — Experimentelle Physik 5, TU Dortmund

The measurement of the CKM angle β is an important precision test of the Standard Model. The golden mode of this observable is $B^0 \to J/\psi K^0_S$, because of its domination by tree-level amplitudes. With new reconstruction types of the K^0_S and the combination of different decay channels it is possible to increase the statistical sensitivity to the most precise measurement of this quantity.

In this talk the current status of the CP violation measurement in the decays $B^0 \to J/\psi(\to \ell^+\ell^-)K^0_S(\to \pi^+\pi^-)$ with $\ell = e, \mu$ and $B^0 \to \psi(2S)(\to \mu^+\mu^-)K^0_S(\to \pi^+\pi^-)$ will be presented for the full LHCb Run II dataset, which corresponds to 6 fb^{-1}.

T 4.4 Mon 16:45 Td

Measurement of the B^0_s oscillation frequency Δm_s with $B^0_s \to D^-_s \pi^+$ decays at the LHCb experiment — •Quentin Führing and Kevin Heinicke — Experimentelle Physik 5, TU Dortmund

The $B^0_s - \overline{B}^0_s$ oscillation frequency Δm_s is equivalent to the mass difference of the B^0_s mass eigenstates. This frequency is an important Standard Model measurement in its own right, and a precise measurement is crucial for reducing the systematic uncertainties associated with time-dependent CP violation measurements in the $B^0_s - \overline{B}^0_s$ system.

At the LHCb experiment, the parameter Δm_s has previously been measured using data of $B^0_s \to D^-_s \pi^+$ decays, recorded in 2011, corresponding to an integrated luminosity of $\mathcal{L}_{\rm int} = 1.0 {\rm fb}^{-1}$. In this talk, an updated measurement of Δm_s is presented. The analysis uses an larger dataset, recorded with the LHCb experiment between 2015 and 2018, corresponding to an integrated luminosity of $\mathcal{L}_{\rm int} = 5.7 {\rm fb}^{-1}$.

T 4.5 Mon 17:00 Td

Measurement of CP violation in $B^0_s \to D^+_s D^-_s$ and $B^0 \to D^+ D^-$ decays with the LHCb experiment — •Louis Gerken, Philipp Ibis, and Antje Mödden — Experimentelle Physik 5, TU Dortmund

The LHCb experiment performs measurements of CP violation to test the Standard Model of particle physics. CP-violation parameters, such as $\phi_{\rm s}$ and $\sin(2\beta)$, can be measured in $b \to c\bar{c}s$ and $b \to c\bar{c}d$ transitions, respectively. These phases occur in the interference between the direct decay of the $B^0_{(s)}$ meson and the decay after mixing. In the topologically similar decays $B^0_s \to D^+_s D^-_s$ and $B^0 \to D^+ D^-$ a time-dependent measurement of CP violation can be performed.

In this talk, the selection of $B^0_s \to D^+_s D^-_s$ and $B^0 \to D^+ D^-$ candidates for these CP-violation measurements will be presented. The analysis uses data collected by the LHCb detector during 2015 to 2018 at a centre-of-mass energy of 13 TeV corresponding to an integrated luminosity of 6 fb^{-1}.

T 4.6 Mon 17:15 Td

Event reconstruction techniques in the context of a Higgs boson CP analysis in the di-tau lepton final state with the CMS experiment — Olena Hlushchenko, Sven Krausse, Wolfgang Lohmann, Dennis Roy, Hale Sert, Sebastian Siebert, Achim Stahl, and •Alexander Zotz — RWTH Aachen University - Physics Institute III B, Aachen, Germany

In 2020 the first measurement of the effective CP mixing angle in Higgs boson decay into two tau leptons has been performed by the CMS experiment. It was determined to be $(4 \pm 17)^\circ$ using the Run 2 data set of pp collisions of $137 fb^{-1}$ integrated luminosity. The mixing angle was extracted from a distribution of angles between the decay planes of the tau lepton decay products in the $H \to \tau\tau$ decay. In the case of hadronic tau lepton decays via the intermediate a_1 resonance the full tau lepton kinematics including its neutrino and furthermore its polarimetric vector can be reconstructed. Requiring both tau leptons to decay via a_1 mesons allows for the reconstruction of a CP sensitive observable with higher sensitivity. However the $a_1 a_1$ final state suffers from a small branching fraction and therefore these improvements have a neglible effect on the overall sensitivity once all final states are included. In this talk, an extension of the polarimetric vector method via the inclusion of final states with an a_1 decay on one side and a single charged lepton or hadron on the other side of the $H \to \tau\tau$ decay is presented. To reconstruct the event a kinematic fit with external constraints is used and the potential improvement on the measurement of the CP mixing angle is discussed.

T 4.7 Mon 17:30 Td

Background studies in B0 mixing to hadronic final states at the Belle 2 experiment — •Caspar Schmitt and Thibaud Thumair for the Belle II-Collaboration — Max Planck Institute for Physics, Munich, Germany

The Belle II experiment at the SuperKEKB electron-positron collider started taking data in 2018. In this talk, we will focus on time-dependent measurements for B mesons using the new Pixel Vertex Detector. The increased precision on the vertex reconstruction will help to better constrain the CKM sector of the Standard Model of particle physics.

After shortly reviewing the first Belle II time-dependent measurements on CP violation and the mixing frequency in the B0 system, we will illustrate the various improved techniques being developed to achieve a high precision measurement of the B0 mixing frequency. These notably include the understanding and modelling of backgrounds and the decay time resolution in fully hadronic B0 decays.

T 4.8 Mon 17:45 Td

Measurement of CP violation in $B^0_s \to J/\psi K^0_S$ decays at LHCb — •Vukan Jevtic, Patrick Mackowiak, and Gerwin Meier — Experimentelle Physik 5, TU Dortmund

With larger datasets collected by the LHCb detector and with the start of Belle II, future measurements of $\sin(2\beta)$ in the golden mode $B^0 \to J/\psi K^0_S$ will be systematically limited by penguin contributions. One way to constrain these contributions is through the measurement of CP-violation parameters in the closely related mode $B^0_s \to J/\psi K^0_S$, where the tree-level decay is Cabibbo suppressed and penguin contributions are significant. The higher oscillation frequency of the B^0_s meson and the lower branching fraction of this channel add to the challenges of this analysis, which uses the full Run II dataset collected by the LHCb experiment. In this talk the current status of the analysis will be presented.

T 5: Higgs decay in fermions I

Time: Monday 16:00–17:45 Location: Te

T 5.1 Mon 16:00 Te

Evidence for Higgs boson decays to muons — Tobias Kramer, Peter Schleper, •Oliver Rieger, and Torben Lange — Universität Hamburg

A search for Higgs boson decays to muons in the top quark-antiquark pair associated Higgs boson production is presented. The analysis serves as a part of a combined result based on four complementary analysis channels which address the ggH, VBF, VH, and $t\bar{t}$H Higgs boson production modes. The results are presented using proton-proton collision data at 13 TeV, corresponding to an integrated luminosity of 137 fb^{-1} recorded by the CMS experiment. After the definition of an exclusive $t\bar{t}$H production channel, events are classified into subcategories using boosted decision trees. The signal is extracted by a simultaneous fit to the dimuon mass distribution in all BDT-based subcategories, where the background is estimated directly from data. The combination of all four Higgs boson production channels observes an excess of events at $m_H = 125.38$ GeV with a significance of 3.0 standard deviations, where the expectation for the SM Higgs boson is 2.5. This result constitutes the first evidence for decays of the Higgs boson to second generation fermions.

T 5.2 Mon 16:15 Te

Measurement of the Higgs boson coupling to τ leptons using a multi-class neural network — •Frank Sauerburger,

Daniele Zanzi, Karsten Köneke, and Christian Weiser — Albert-Ludwigs-Universität Freiburg, Freiburg, Deutschland

A multivariate analysis using a multi-class neural network to measure the Standard Model coupling of the Higgs boson to τ leptons ($H \to \tau\tau$) is presented. The analysis focuses on the signal region enriched in vector-boson-fusion (VBF) events. The background is estimated with a combination of Monte Carlo simulation and data-driven methods. A neural network is trained on multiple event categories of the background and signal model and employed to select VBF-like events. The rejection of background events and signal events originating from the gluon-fusion Higgs production mechanism increases the sensitivity of the analysis by increasing the signal to background ratio and reducing the systematic uncertainties of the theoretical prediction. The analysis is performed using the full Run 2 dataset of proton-proton collisions at a center-of-mass energy $\sqrt{s} = 13\,\text{TeV}$ corresponding to an integrated luminosity of $139\,\text{fb}^{-1}$ recorded with ATLAS detector at the LHC between 2015 and 2018.

T 5.3 Mon 16:30 Te

Measurements of Simplified Template Cross Sections in the H→ $\tau\tau$ decay channel at the ATLAS experiment — •Fabian Becherer, David Hohn, Markus Schumacher, and Valerie Lang — Albert-Ludwigs-Universität Freiburg

The measurement of Simplified Template Cross Sections (STXS) is a strategy to study the Higgs boson at the LHC. The measurements of the signal strength μ and coupling modifiers κ used in Run 1 make use of assumptions, such as the Standard Model kinematics or extrapolating from the measured phase space to the global phase space. These assumptions introduce theoretical uncertainties on the determined results and dependencies on the underlying physics model. The STXS technique allows the reduction of theory dependencies in a systematic way, which are directly folded into the measurements. It provides more finely-grained measurements of cross sections in well-defined phase-space regions. These measurements will benefit from the global combination of the measurements in all decay channels and the higher cross section for the Higgs boson production at $\sqrt{s}$=13 TeV in Run 2. Furthermore, the common definition used by the ATLAS and CMS experiments will simplify a combination across them. This talk will focus on the optimization of the H→ $\tau\tau$ decay channel analysis strategy of the ATLAS experiment for the full Run 2 data set. These measurements form an important input to combined STXS results, in particular for vector boson fusion and high transverse momentum topologies.

T 5.4 Mon 16:45 Te

The $H \to \tau\tau$ couplings measurement as an example to validate fit models — •Michael Hübner, Philip Bechtle, Klaus Desch, and Christian Grefe — Universität Bonn

With increasing statistics of the pp collision data recorded by the ATLAS experiment at the LHC, the focus of measurements of known processes shifts more and more to precision measurements. Such an example is the measurement of the $H \to \tau\tau$ couplings in multiple phase space regions which can be interpreted in the Simplified Template Cross Section framework. This is an example of how fit models can grow more complex due to an increasing number of phase space regions and/or processes to consider.

This talk will introduce concepts of how to validate such complex fit models. Different individual steps of this validation process, each one involving elaborate statistical methods, will be discussed. Possible conclusions and interpretations of the results of these steps will be discussed.

T 5.5 Mon 17:00 Te

Optimization of neural networks considering systematic uncertainties — •Gessi Risto[1], Stefan Wunsch[1,2], Roger Wolf[1], and Guenter Quast[1] — [1]Karlsruhe Institute of Technology, Institute of Experimental Particle Physics, Karlsruhe, Germany — [2]CERN, Geneva, Switzerland

Machine learning based data analysis strategies have shown an improved performance for many measurements in high-energy physics. This work presents a novel method of neural network optimization based on binned Poisson likelihoods with nuisance parameters to integrate the influence of systematic uncertainties in the training objective. We show with simple examples using pseudo-experiments and examples from high-energy physics that such an analysis strategy can result in an optimal measurement, and demonstrate an application of this method on a reduced CMS dataset used for the machine learning based SM STXS analysis of the Higgs to two tau leptons channel of CMS.

T 5.6 Mon 17:15 Te

Search for resonant $HH \to 4\tau$ production with the ATLAS detector — •Dominik Weiss, Henrik Junkerkalefeld, Christian Grefe, Philip Bechtle, and Klaus Desch — Physikalisches Institut, Universität Bonn, Deutschland

Although with the discovery of the Higgs boson in 2012 all particles predicted by the Standard Model (SM) have been found, there are still a few SM parameters which have not been measured yet. The Higgs self-coupling strength, which actually has not been measured directly at all, is one of these parameters that is very sensitive to many extensions beyond the SM as well.

In this talk we will discuss the prospects of measuring the Higgs self-coupling in the 4τ final state and of using it to search for new beyond SM $X \to HH$ resonances . In order to increase the sensitivity of this measurement, several channels have to be combined. In addition to the ones already studied, the $HH \to 4\tau$ channel provides a unique final state with up to four hadronically decaying τ-leptons, which can be efficiently distinguished from most other SM background processes. Due to the very low cross section of HH production, a high selection efficiency is of utmost importance. A dedicated identification method for multi-tau events based on multiplied τ-lepton probabilities has been developed and tested on ATLAS Run 2 data. A measurement of the $ZZ \to 4\tau$ process is used to validate the identification of a signal with four true τ-leptons. An estimate of the largest background due to QCD jets misidentified as τ-lepton decay using combinatorial considerations of the reconstructed four τ-lepton charges will be discussed as well.

T 5.7 Mon 17:30 Te

Search for lepton-flavour violating decays of the Higgs boson using the symmetry method for background estimation with the ATLAS experiment at $\sqrt{s} = 13$ TeV — •Katharina Schleicher, Valerie Lang, and Markus Schumacher — University of Freiburg

The discovery of the Higgs boson opened the window to a variety of interesting probes to physics beyond the standard model (SM), including searches for lepton-flavour violating (LFV) Higgs-boson decays. These are predicted in several models, including supersymmetric extensions of the SM and general two-higgs-dublet models. In nature, LFV was already observed in form of neutrino oscillations. In this analysis the decays of $H \to e\tau$ and $H \to \mu\tau$ with leptonic τ-decays leading to $e\mu + 2\nu$ final states are considered. A central part of the analysis is the precise estimation of the SM backgrounds. Therefore, a data-driven method is used - the so-called symmetry method. It exploits two principles: First, SM backgrounds with prompt leptons are symmetric w.r.t. electrons and muons. And second, this symmetry is broken if the branching ratios of the two LFV decays are of different magnitude. The first principle implicates the challenge of restoring this symmetry since electrons and muons are experimentally different. The second principle is motivated by the upper limit on $\mu \to e\gamma$. To obtain the best possible sensitivity, a dedicated statistical model was developed and neural networks for classification are deployed. In this talk, an overview of the analysis using the LHC Run-2 dataset recorded with the ATLAS detector in p-p collisions at $\sqrt{s} = 13$ TeV is given.

T 6: Flavour physics I

Time: Monday 16:00–18:30 Location: Tf

T 6.1 Mon 16:00 Tf

Lepton universality and lepton flavor conservation tests with dineutrino modes — •Hector Gisbert, Rigo Bause, Marcel Golz, and Gudrun Hiller — TU Dortmund

$SU(2)_L$-invariance links charged dilepton $\bar{q}\,q'\,\bar{\ell}\,\ell$ and dineutrino $\bar{q}\,q'\,\bar{\nu}\,\nu$ couplings. This connection can be established using SMEFT and holds model-independently if only SM-like left-handed light neutrinos are present. It allows to perform complementary experimental tests of lepton universality and charged lepton flavor conservation with flavor-summed dineutrino observables. The phenomenological implications of this novel idea will be discussed in detail.

T 6.2 Mon 16:15 Tf

Search for the lepton flavour violating decay $\tau^- \to \mu^-\mu^+\mu^-$ with the LHCb experiment — •Rowina Caspary, Flavio Archilli, Giulia Frau, and Chishuai Wang for the LHCb-Collaboration — University of Heidelberg, Physikalisches Institut Heidelberg, Germany

Lepton flavour violationg (LFV) decays are within the Standard Model only possible by higher order diagrams including neutrino oscillation. Thus they are highly suppressed. However, some theories including beyond Standard Model phenomena predict branching fractions within an experimentally accessible range. The LHCb experiment is well equipped to search for these decays due to its excellent vertex and momentum resolution and its particle identification capabilities. An upper limit on the branching fraction of the LFV decay $\tau^- \to \mu^-\mu^+\mu^-$ has been measured by the LHCb experiment using data collected in the years 2011 and 2012. In this talk we present the expected sensitivity of the analysis exploiting the data taken in the years 2016 and 2018 and we will discuss improvements to the original analysis strategy.

T 6.3 Mon 16:30 Tf

A feasibility study for the search of lepton flavour violating decay $\tau^- \to \phi(K^+K^-)\mu^-$ at LHCb — •Chishuai Wang, Flavio Archilli, Rowina Caspary, and Giulia Frau for the LHCb-Collaboration — Physikalisches Institut, Heidelberg, Germany

The Lepton Flavour Violating (LFV) decays are highly suppressed in the Standard Model and only possible via higher order diagrams including neutrino oscillation. However, potential new physics models can significantly enhance their branching frations. For example, leptoquark hinted by some recent test of lepton univerisality might have significant contributions to the decay $\tau^- \to \phi(K^+K^-)\mu^-$. In this talk, we will present a feasibility study to search LFV decay $\tau^- \to \phi(K^+K^-)\mu^-$ based on the data collected by LHCb experiment during the years from 2016 to 2018. In LHCb, copious τ leptons are produced in the decays of $D_s^\pm$, $D^\pm$ and b-hadrons. This search is dominated by a background decay $D_s^+ \to \phi(K^+K^-)\mu^+\nu_\mu$ which is highly similar with the signal in decay topology.

T 6.4 Mon 16:45 Tf

First Results and Prospects for $\tau \to e + \alpha$(invisible) at Belle II — •Thomas Kraetzschmar for the Belle II-Collaboration — Max-Planck-Insitut für Physik (Werner-Heisenberg-Insitut), München, Deutschland

The Belle II experiment at SuperKEKB, an asymmetric e^+e^- collider, aims at a total integrated luminosity of 50 ab^{-1}, to pursue a rich program of Standard Model and Beyond the Standard Model physics. Until the end of 2020 and beginning of 2021 about 100 fb^{-1} were collected at the $\Upsilon(4S)$ resonance. This results in a sizeable sample of τ pairs, enabling detailed studies of Standard and Beyond the Standard Model measurements, including searches for Lepton Flavor Violating (LFV) decays. One of the first channels where competitive limits are expected is the $\tau \to e + \alpha$(invisible) process, where α is a Goldstone boson. Here, the currently best limit has been obtained by ARGUS with an integrated luminosity of 475 pb^{-1}. Belle II is expected to be able to improve on this result already with the data recorded. This contribution will discuss the expected reach of the measurements with the current data set, and the progress towards a new upper limit.

T 6.5 Mon 17:00 Tf

The pion light-cone distribution amplitude from the pion electromagnetic form factor — Shan Cheng[1], Alexander Khodjamirian[2], and •Aleksey Rusov[2] — [1]Hunan University, Changsha, China — [2]Universität Siegen, Germany

We suggest a new way of probing the pion light-cone distribution amplitude using the dispersion relation for the pion electromagnetic form factor. It relates the spacelike pion form factor, for which the QCD light-cone sum rule is used, with the timelike form factor obtained from the data. Adopting for the pion twist-2 distribution amplitude an ansatz with the first few Gegenbauer polynomials, it is possible to fit their coefficients $a_{2,4,6,\ldots}$ (Gegenbauer moments) from the dispersion relation. For the exploratory fit we use the data of the BaBar collaboration. The results definitely exclude the asymptotic shape of the twist-2 distribution amplitude, also the model with a single $a_2 \neq 0$ is disfavoured by the fit. Considering scenarios with $a_{n>2} \neq 0$, we find that the fitted values of the second and fourth Gegenbauer moments cover the intervals $a_2(1\mathrm{GeV}) = (0.22-0.33)$, $a_4(1\mathrm{GeV}) = (0.12-0.25)$. The higher moments starting from a_8 are consistent with zero, albeit with large uncertainties.

T 6.6 Mon 17:15 Tf

Search for $\pi^o \to$ *invisible* decays with the NA62 experiment — •Letizia Peruzzo — Johannes Gutenberg University, Mainz

The search for new physics beyond the Standard Model (SM) is one of the most active fields in particle physics. Complementary to direct searches for new processes at high-energy scale, rare or forbidden SM decays are investigated to look for deviations from the predictions. The NA62 experiment at the CERN SPS, designed for the measurement of the ultra-rare decay $K^+ \to \pi^+\nu\bar{\nu}$, investigates new-physics contributions in the kaon and pion sector. The highly efficient, hermetic photon-veto system makes NA62 a perfect apparatus for a high-sensitivity search for π^o decays into invisible particles. In a fraction of data collected by NA62 in 2017, about 8.4×10^9 π^o mesons have been tagged from the reconstruction of the second most-abundant K^+ decay, $K^+ \to \pi^+\pi^o(\gamma)$. The background rejection power for visible π^o decays, ranging from $\mathcal{O}(10^8)$ to $\mathcal{O}(10^9)$, is estimated by the combination of data-based studies and Monte Carlo simulations, a novel experimental technique with respect to that used in the most sensitive previous experimental result. The analysis is performed with the blind technique for a cut-based signal region. No signal is observed in excess of the expected background fluctuations. The resulting upper limit on the branching ratio, $\mathrm{BR}(\pi^o \to \mathit{invisible}) \leq 4.4 \times 10^{-9}$ at 90% confidence level, improves on the previous best limit by a factor of 60. As a by-product of the analysis, the decay $K^+ \to \pi^+X$ is investigated, where X is a neutral particle escaping detection with a mass in the range 0.110–0.155 GeV/c^2 and rest lifetime greater than 100 ps.

T 6.7 Mon 17:30 Tf

Evidence for the decay $K^+ \to \pi^+\nu\bar{\nu}$ from the NA62 experiment at CERN — •Radoslav Marchevski — JGU Mainz

The ultra-rare decay $K^+ \to \pi^+\nu\bar{\nu}$ benefits from a precisely predicted branching ratio in the SM of $(8.4 \pm 1.0) \times 10^{-11}$, being almost free from theoretical uncertainties, and most importantly of very high sensitivity to a variety of beyond-the-standard-model scenarios, making it one of the best candidates to reveal indirect effects of new physics in the flavour sector. The NA62 experiment at the CERN SPS, designed to measure the branching ratio of $K^+ \to \pi^+\nu\bar{\nu}$ with a decay-in-flight technique, collected data in 2016-2018. New results from the analysis of the 2018 data, the largest data set so far collected, will be presented. The result represents the most accurate measurement of this ultra-rare decay achieved so far. Future prospects and plans for further data taking starting in 2021 will also be presented.

T 6.8 Mon 17:45 Tf

Rare charm $c \to u\nu\bar{\nu}$ dineutrino null test for e^+e^-–machines — •Rigo Bause, Hector Gisbert, Marcel Golz, and Gudrun Hiller — TU Dortmund

Rare $|\Delta c| = |\Delta u| = 1$ transitions into dineutrinos are strongly GIM-suppressed and constitute excellent null tests of the standard model. While branching ratios of $c \to u\,\nu\bar{\nu}$ transitions are experimentally unconstrained, signals of new physics can be just around the corner.

Signatures of these modes, including $D \to P\,\nu\bar{\nu}$ or $D \to P^+P^-\,\nu\bar{\nu}$ with $P = \pi, K$, $\Lambda_c \to p\,\nu\bar{\nu}$, contain missing energy and are well suited for experimental searches at e^+e^-–facilities, such as BES III, Belle II

and future e^+e^-–colliders, such as the FCC-ee running at the Z.

Using current bounds on $c \to u\,\ell^+\ell^-$ transitions, model-independent upper limits on branching ratios assuming lepton universality and charged lepton flavour conservation are presented (arxiv:2010.02225). An observation in excess of these upper limits implies a breakdown of the corresponding symmetry.

T 6.9 Mon 18:00 Tf

Radiative three-body D-meson decays in and beyond the standard model — •Nico Adolph[1], Joachim Brod[2], and Gudrun Hiller[1] — [1]Technische Universität Dortmund, Dortmund, Deutschland — [2]University of Cincinnati, Cincinnati, USA

We study radiative charm decays $D \to P_1P_2\gamma$, $P_{1,2} = \pi, K$ in QCD factorization at leading order and within heavy hadron chiral perturbation theory. Branching ratios including resonance contributions are around $\sim 10^{-3}$ for the Cabibbo-favored modes into $K\pi\gamma$ and $\sim 10^{-5}$ for the singly Cabibbo-suppressed modes into $\pi^+\pi^-\gamma, K^+K^-\gamma$, and thus in reach of the flavor factories BES III and Belle II. Dalitz plots and forward-backward asymmetries reveal significant differences between the two QCD frameworks; such observables are therefore ideally suited for a data-driven identification of relevant decay mechanisms in the standard-model dominated $D \to K\pi\gamma$ decays. This increases the potential to probe new physics with the $D \to \pi^+\pi^-\gamma$ and $D \to K^+K^-\gamma$ decays, which are sensitive to enhanced dipole operators. CP asymmetries are useful to test the SM and look for new physics in neutral $|\Delta C| = 1$ transitions.

T 6.10 Mon 18:15 Tf

Search for D^* and D Mesons at Belle using hadronic tagging of B Mesons — •Maximilian Graf, Florian Bernlochner, Jochen Dingfelder, Michael Eliachevitch, Markus Prim, Wiliam Sutcliffe, and Maximilian Welsch for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, 53115 Bonn, Germany

Belle II is a next generation Super$B$-Factory located in Tsukuba in Japan, that recently started its first physics data taking period. One particular important result Belle II aims to measure is the CKM matrix element V_{cb}. One clean approach for such measurements involves hadronic tagging, where low yields are balanced by very clean samples. In this talk, I present the current status of measurements of semileptonic $B \to D^{(*)}\,\ell\bar{\nu}_\ell$ decays and their role in calibrating hadronic tagging efficiencies. In addition, I present first background subtracted spectra of the recoil parameter w and the relevant decay angles for the D^* final state.

T 7: Flavour physics V

Time: Monday 16:00–18:30 Location: Tg

T 7.1 Mon 16:00 Tg

Hadronically tagged $B \to D^{(*)}\ell\nu_\ell$ with Belle II — Florian Bernlochner[1], Racha Cheaib[2], Jochen Dingfelder[1], •Michael Eliachevitch[1], Max Graf[1], Markus Prim[1], William Sutcliffe[1], and Hannah M. Wakeling[3] for the Belle II-Collaboration — [1]Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn — [2]Deutsches Elektronen–Synchrotron, 22607 Hamburg, Germany — [3]McGill University, Montréal, Québec, H3A 2T8, Canada

The analysis of semileptonic B meson decays is one of the main pillars of the physics program of the Belle II experiment, since their theoretical cleanliness enables precise theoretical predictions which can be compared with measurements for tests of the Standard Model of particle physics. This talk presents early results and analysis plans for the $B \to D^{(*)}\ell\nu_\ell$ decay with ℓ denoting the light leptons e and μ. The other B meson originating from the $\Upsilon(4S)$ is fully reconstructed in hadronic decay modes via the *Full Event Interpretation* tagging algorithm, providing the full four-momentum of the signal B meson. Due to its high branching fraction and ease of reconstruction, this decay allows for early measurements on available Belle II data. A good understanding of this channel on observed data and discrepancies to simulated data is essential in the context of future measurements of the lepton flavour universality probing $R\left(D^{(*)}\right)$ observable, which measures the ratio of semitauonic $B \to D^{(*)}\tau\nu_\tau$ decays to the $B \to D^{(*)}\ell\nu_\ell$ channel as a normalization. Furthermore, it is of interest due to its sensitivity to the magnitude of the V_{cb} CKM matrix element.

T 7.2 Mon 16:15 Tg

Study on semileptonic $\mathrm{B} \to \mathrm{D}^{**}\ell\nu$ decays for a $\mathcal{R}(\mathrm{D}^{(*)})$ measurement at Belle — •Patrick Ecker[1], Felix Metzner[1], Florian Bernlochner[2], and Pablo Goldenzweig[1] — [1]Karlsruher Institut für Technologie — [2]Universität Bonn

Measuring the semileptonic ratio $\mathcal{R}(\mathrm{D}^{(*)})$ shows an over 3σ tension to the prediction of the standard model. This tension is still one of the most interesting open questions in flavor physics, which makes a more precise measurement of the ratio desirable. Nevertheless, the precision of the measurement is mainly limited by the insufficient knowledge about the $\mathrm{B} \to \mathrm{D}^{**}\ell\nu$ background decays.
This study uses the $711\mathrm{fb}^{-1}$ dataset provided by Belle to analyse the form factor modeling of these modes, as well as giving ratios of the branching fractions of the D^{**} decays to the $\mathrm{B} \to \mathrm{D}^{(*)}\ell\nu$ decays used in the $\mathcal{R}(\mathrm{D}^{(*)})$ analysis.

T 7.3 Mon 16:30 Tg

$R(D^{**})$ at Belle II with leptonic τ decays — Ariane Frey, •Noreen Rauls, and Benjamin Schwenker — II. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Deutschland

Semileptonic B meson decays to τ leptons are used to probe the standard model. This can be investigated in the rate of the semitauonic decay $B \to D^{**}\tau\nu$, which can be enhanced, for instance, by the presence of an additional charged Higgs boson.
$R(D^{**})$ is defined as the ratio of the branching ratio $B \to D^{**}\tau\nu$ by the averaged branching ratio of both light leptons $B \to D^{**}\ell\nu$ and is hence sensitive to new physics that couples differently to light and heavy leptons.
At the Belle II experiment, B mesons are always produced in pairs at the $\Upsilon(4S)$ resonance. One B meson is reconstructed using the B decay modes stated above. Here, the τ lepton is reconstructed in the leptonic mode. For the reconstruction of the other B meson the Full Event Interpretation (FEI) is chosen. The FEI algorithm reconstructs the other B meson using multivariate classifiers in various different hadronic decay modes.
This talk will present first studies on the reconstruction of the B meson decays used to extract $R(D^{**})$ conducted on Belle II Monte Carlo samples as well as an outlook on future plans.

T 7.4 Mon 16:45 Tg

Probing the $R(D^{(*)})$ discrepancy with the $B \to X\tau\nu$ channel at Belle II — Florian Bernlochner, Jochen Dingfelder, •Henrik Junkerkalefeld, and Peter Lewis for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

In the absence of direct evidence for new physical phenomena at the TeV scale, several measurements in the flavor sector are spotlighted that might be in tension with theoretical predictions. Of these flavor anomalies, excesses in the $R(D)$ and $R(D^*)$ ratios measured by multiple experiments have caused particularly large interest in recent years.

The new Belle II experiment in Japan enables a complementary test of these measurements. Due to the controlled production of $B\bar{B}$ pairs, the inclusive measurement of $B \to X\tau\nu$ becomes possible. Its measurement should contribute important information to the $R(D^{(*)})$ problem. Additionally, this channel should help constrain the currently unmeasured contribution of $B \to D^{**}\tau\nu$ decays.

In this talk, the general analysis strategy of the $B \to X\tau\nu$ branching fraction measurement is presented and first attempts to separate the signal from background are outlined.

T 7.5 Mon 17:00 Tg

Search for the decay $B_s^0 \to D^{*+}D^{*-}$ with the LHCb experiment — Sophie Hollit, Philipp Ibis, •Jan Langer, and Antje Mödden — Experimentelle Physik 5, TU Dortmund

At the LHCb experiment precise measurements are performed to

search for physics beyond the Standard Model. For this it is important to observe new decays and measure their branching ratio. Besides the primary aim of observing the decay $B_s^0 \to D^{*+}D^{*-}$, this analysis also aims to measure the branching ratio relative to the decay $B^0 \to D^{*+}D^{*-}$. By measuring the relative branching ratio, dominant systematic uncertainties can be cancelled.

In this talk, the current status of the analysis is presented, in which the full data set of the LHCb experiment is used corresponding to an integrated luminosity of $9\,\text{fb}^{-1}$.

T 7.6 Mon 17:15 Tg

Fully Inclusive Analysis of Untagged $B \to X_s\ell^+\ell^-$ Decays at Belle II — Thomas Kuhr, Sviatoslav Bilokin, and •Michail Moussine — Ludwig-Maximilians-Universität München

Semileptonic B meson decays to $X_s\ell^+\ell^-$, where X_s stands for a set of final state particles with non-vanishing total strangeness, are very rare because they are forbidden at tree level in the standard model (SM). They can occur through loop diagrams, where particles beyond the SM could contribute. Measurements of branching fractions or kinematic distributions are therefore sensitive to new physics.

The Belle II experiment at the SuperKEKB accelerator is well suited to study inclusive decays because of the clean environment with known initial conditions. However, a full reconstruction of the second B meson in $\Upsilon(4S) \to B\bar{B}$ events suffers from a low reconstruction efficiency. Feasibility studies of an untagged analysis, including optimizations of selection criteria, will be presented.

T 7.7 Mon 17:30 Tg

Testing Lepton Flavour Universality with $B_s \to \phi\ell^+\ell^-$ decays using LHCb data — Christoph Langenbruch, Stefan Schael, •Sebastian Schmitt, and Eluned Smith — I. Phys. Inst. B RWTH Aachen

In the Standard Model of Particle Physics (SM), $b \to s\ell^+\ell^-$ transitions are forbidden at tree-level and may only occur at the loop-level. The branching fractions of these so-called Flavour Changing Neutral Currents (FCNCs) can thus be significantly affected by New Physics (NP) beyond the SM. While in the SM, the coupling of the electro-weak gauge-bosons is Lepton Flavour Universal (LFU), this universality can be broken in NP scenarios. The ratios R_H, defined as the ratios of the branching fractions $\mathcal{B}\left(B \to H\mu^+\mu^-\right)$ and $\mathcal{B}\left(B \to He^+e^-\right)$, constitute precise tests of the SM. Recent measurements of R_K and $R_{K^{*0}}$ show tensions with the SM of 2.1 to 2.5 standard deviations (σ), complementary R_H measurements are therefore of great interest.

The LHCb detector, located at the Large Hadron Collider (LHC) at CERN, is optimised to study rare b-hadron decays. For this purpose LHCb features high trigger efficiencies, excellent track reconstruction and particle identification.

This talk summarises the status of the measurement R_ϕ, which benefits from the experimentally clean $B_s \to \phi\ell^+\ell^-$ decay. The analysis is using the full Run 1 and Run 2 dataset collected by LHCb that corresponds to $9\,\text{fb}^{-1}$ of integrated luminosity.

T 7.8 Mon 17:45 Tg

Branching fraction measurement of $B_s^0 \to \phi\mu^+\mu^-$ and search for $B_s^0 \to f_2'(1525)\mu^+\mu^-$ using LHCb data — •Sophie Kretzschmar, Christoph Langenbruch, and Eluned Smith — I. Physikalisches Institut B, RWTH, Aachen

The LHCb detector at CERN is an experiment optimised to study decays of b-quarks, which are produced copiously in the proton-proton collisions at the Large Hadron Collider (LHC). Flavour-changing neutral-current decays proceeding via $b \to s\ell\ell$ transitions are of particular interest since they occur only via higher order loop corrections in the Standard Model (SM), and thus can be significantly affected by new heavy particles beyond the SM.

One example of such a rare decay is $B_s^0 \to \phi\mu^+\mu^-$, which has been previously analysed by the LHCb collaboration using data taken in 2011 and 2012. The $B_s^0 \to \phi\mu^+\mu^-$ branching fraction was measured to be more than $3\,\sigma$ below the SM expectation. Now, an updated measurement is performed including the data taken by the LHCb experiment during 2015-2018, which will provide more insight on the nature of this discrepancy with the SM.

This talk presents the status of the updated measurement of the $B_s^0 \to \phi\mu^+\mu^-$ branching fraction using the full LHCb data sample. In addition, a search for the decay $B_s^0 \to f_2'(1525)\mu^+\mu^-$ will be presented.

T 7.9 Mon 18:00 Tg

Analysis of $B^0_{s,d} \to \mu^+\mu^-$ decays with the full LHCb dataset — Johannes Albrecht, •Maik Becker, and Titus Mombächer — Experimentelle Physik 5, TU Dortmund

The first observation of the decay $B_s^0 \to \mu^+\mu^-$ with a single experiment was reported by the LHCb collaboration in 2017 with a significance of 7.8σ using data corresponding to 4.4 fb^{-1} of integrated luminosity. The measurement demonstrated the excellent sensitivity of the LHCb experiment in this channel, but no deviations from the Standard Model predictions were found, introducing strong constraints to New Physics models. Since the uncertainty on the result is driven by statistical limitations, an analysis with a larger dataset and improved methods is performed, which may also allow for the first observation of the decay $B_d^0 \to \mu^+\mu^-$.

In this talk the ongoing measurement of $B^0_{s,d} \to \mu^+\mu^-$ with the full LHCb dataset corresponding to 9 fb^{-1} will be presented.

T 7.10 Mon 18:15 Tg

Non-local matrix elements in $B_{(s)} \to \{K^{(*)}, \phi\}\ell^+\ell^-$ — •Nico Gubernari[1], Danny van Dyk[2], and Javier Virto[3] — [1]Universitaet Siegen, Walter-Flex-Strasse 3, 57068 Siegen — [2]Technische Universitaet Muenchen, James-Franck-Strasse 1, 85758 Garching — [3]Universitat de Barcelona, Marti Franques 1, E08028 Barcelona, Catalunya

We revisit the theoretical predictions and the parametrization of non-local matrix elements in rare $\bar{B}_{(s)} \to \{\bar{K}^{(*)}, \phi\}\ell^+\ell^-$ and $\bar{B}_{(s)} \to \{\bar{K}^*, \phi\}\gamma$ decays. We improve upon the current state of these matrix elements in two ways. First, we recalculate the hadronic matrix elements needed at subleading power in the light-cone OPE using B-meson light-cone sum rules. Our analytical results supersede those in the literature. We discuss the origin of our improvements and provide numerical results for the processes under consideration. Second, we derive the first dispersive bound on the non-local matrix elements. It provides a parametric handle on the truncation error in extrapolations of the matrix elements to large timelike momentum transfer using the z expansion. We illustrate the power of the dispersive bound at the hand of a simple phenomenological application. As a side result of our work, we also provide numerical results for the $B_s \to \phi$ form factors from B-meson light-cone sum rules.

T 8: Top quark production I

Time: Monday 16:00–18:30 Location: Th

T 8.1 Mon 16:00 Th

Measurement of the Single-Top production cross section in the s-channel at $\sqrt{s}$=13 TeV with the ATLAS detector — •Ken Kreul — Humboldt Universität zu Berlin

The production of single top-quarks in electroweak processes (Single-Top) is an important part for the study of the Standard Model and possible extensions. Single-Top production is possible in three channels: t-channel, s-channel and via associated production of a W-boson. In proton-proton collisions at the Large Hadron Collider (LHC), the s-channel has the lowest production cross section and is dominated by many background processes. During the LHC run at 8 TeV, the s-channel was already observed with a significance of 3.2σ using the Matrix Element Method. In this method, the matrix elements for the most important signal and background processes are integrated over the available phase space to compute process likelihoods, which can then be combined to a discriminant. The method is now applied to current ATLAS data at $\sqrt{s}$=13 TeV to improve the previous result using the higher luminosity of up to 139 fb^{-1}.

T 8.2 Mon 16:15 Th

Measurement of the t-channel single top-quark production cross-section in proton-proton collisions at a centre-of-mass energy of 13 TeV with the ATLAS detector — Olga Bessidskaia Bylund, Dominic Hirschbühl, •Joshua Reidelstürz, Mohsen Rezaei Estabragh, and Wolfgang Wagner

— Bergische Universität Wuppertal, Wuppertal, Deutschland

The measurement of the single top-quark t-channel production cross sections σ_{tq} and $\sigma_{\bar{t}q}$ and their fraction R_t as well as the total cross section $\sigma_{tq,\bar{t}q}$ is presented. These measurements provide a precise test of the standard model and are sensitive to new-physics phenomena by probing the properties of the Wtb vertex and placing limits on the CKM matrix element $|V_{tb}|$. Data taken with the ATLAS detector from 2015 to 2018 corresponding to an integrated luminosity of $\mathcal{L} = 139\,\text{fb}^{-1}$ at a center-of-mass energy of 13 TeV is analyzed using corresponding samples of simulated events. Requirements are applied to the data selecting events with the signature expected for the signal process. To further enhance the separation between signal and background events a neural network is trained using the Monte Carlo simulated data combining several kinematic variables. The neural network output distribution is then used in a binned profile maximum likelihood fit including all systematic uncertainties to determine the cross sections.

T 8.3 Mon 16:30 Th

Sensitivity studies of differential cross-sections of t-channel single-top-quark production on physics beyond the standard model parameterised by effective field theories — •Mohsen Rezaei Estabragh[1], Wolfgang Wagner[1], Dominic Hirschbuehl[1], Joshua Aaron Reidelsturz[1], and Olga Bessidskaia Bylund[2] — [1]Bergische Universität Wuppertal, Wuppertal, Germany — [2]University of Paris-Saclay

Unique features of the top quark such as its large mass and its decay before hadronisation, providing access to spin information via its decay products, make the top quark a fascinating object of many high energy physics studies, including searches for physics beyond the standard model (BSM). The aim of this study is to consider the sensitivity of t-channel single top-quark production to BSM physics, parameterised in a model-independent way via higher dimension operators in the framework of effective field theory (EFT).

At leading order three EFT operators contribute to $t-channel$ single top-quark production. The presented study investigates the impact of these operators on differential production cross-sections. The operator $O_{\Phi q}^{(3)}$ modifies the magnitude of the Wtb vertex, while $O_{qq}^{(1,3)}$ affects angular distributions of top-quark production. The operator O_{tW} mainly impacts the decay of top quarks.

T 8.4 Mon 16:45 Th

Search for single production of top quarks in association with a photon with the ATLAS detector at $\sqrt{s} = 13$ TeV — •Björn Wendland, Johannes Erdmann, and Kevin Kröninger — TU Dortmund, Experimentelle Physik IV

Analyses of top quark production in association with a photon are important tests of the Standard Model as top quark properties with respect to the electroweak interaction such as the top quark charge or the structure of the top quark and photon vertex can be probed. Top quark pair production with a photon in leptonic final states was observed and investigated extensively by the ATLAS and CMS collaborations. No significant deviations from the Standard Model expectations were found by now.

With the rich datasets collected by the ATLAS and CMS experiments during Run 2 of the LHC programme, it is feasible to observe single production of top quarks in association with a photon. The CMS collaboration reported evidence corresponding to $4.4\,\sigma$ for this process using a partial Run 2 dataset.

In this talk, studies of t-channel single production of top quarks with a photon using the full Run 2 dataset collected by the ATLAS detector are presented. As the leptonic decay channel of the top quark is used in this analysis, the final state consists of either an electron or a muon, a jet containing B hadrons, missing transverse energy, a photon and an additional jet produced in forward direction.

T 8.5 Mon 17:00 Th

Differential Measurement of the Associated Production of a Single Top Quark and a Z Boson at the CMS Experiment — •David Walter, Abideh Jafari, and Nicolas Tonon — DESY, Hamburg, Germany

The top quark is the heaviest particle of the standard model (SM) and can be produced through strong interactions in top quark-antiquark pairs, or polarised as a single top quark (or antiquark) via the electroweak interaction. The associated production of a single top quark and a Z boson (pp $\rightarrow$ tZq) includes the tZ coupling as well as the coupling of three vector bosons (WWZ) and is therefore a unique process to study the couplings of heavy particles in the SM. As early as 2018, the CMS Collaboration observed the production of tZq in its final state with three leptons. It was found to be in agreement with the SM prediction.

In an ongoing analysis, a differential tZq cross section measurement is being carried out. This can give more detailed insight into the modeling of the process in the SM while some of the distributions are also sensitive to beyond-SM effects. The analysis makes use of 137 fb^{-1} of pp collision data, collected at the LHC with the CMS experiment at a center of mass energy of $\sqrt{s} = 13$ TeV. A full event reconstruction is performed and multivariate analysis techniques are exploited to isolate the signal from various background contributions. A maximum likelihood based unfolding is performed to extract the differential cross section at parton level and to correct for detector effects and hadronization effects.

T 8.6 Mon 17:15 Th

Measurement of the inclusive production cross sections of a top-quark pair in association with a Z boson at $\sqrt{s} = 13$ TeV in final states with three leptons using deep neural nets with the ATLAS detector — •Steffen Korn, Arnulf Quadt, Elizaveta Shabalina, and Knut Zoch — II. Physikalisches Institut, Georg-August-Universität Göttingen

Through the associated production of the $t\bar{t}Z$ process, the strength and structure of the coupling of the top quark and the Z boson can be measured which provides sensitivity to the top quark's weak isospin in the Standard Model (SM). The measurement of this fundamental parameter of the SM also serves as a probe to new physics beyond the SM. The process was first observed by CMS and first measured by ATLAS at $\sqrt{s} = 8$ TeV by considering $t\bar{t}W$ and $t\bar{t}Z$ processes simultaneously, and later measured with increased precision at $\sqrt{s} = 13$ TeV by both experiments. The effect of deep neural networks (DNN) on the sensitivity of a refined analysis using $139\,\text{fb}^{-1}$ is investigated and presented within a measurement of the inclusive cross section in $t\bar{t}Z$ final states. The analysis selects event with three charged leptons in proton-proton collisions data, taken between 2015 and 2018 with the ATLAS detector.

T 8.7 Mon 17:30 Th

Differential cross-section measurement of the tZq process with the ATLAS detector — •Nilima Akolkar and Ian Brock — Physikalisches Institut, Universität Bonn

The associated production of a single top-quark with a Z-boson (tZq) is a rare process that has been discovered by the CMS and ATLAS Collaborations. This process is of a special interest, as it allows to probe the couplings of the Z-boson to the quark sector and W-boson simultaneously.

This talk will focus on the differential cross-section measurement of the tZq production, analyzed in the trilepton decay channel. The data used were collected with the ATLAS detector during Run 2 of the LHC, corresponding to an integrated luminosity of 139 fb^{-1}. The differential cross-section is measured using unfolding and the preliminary results will be presented.

T 8.8 Mon 17:45 Th

Measurement of the tZq cross section in events with two leptons — •Federica Cecilia Colombina — Windmühlenweg 27, 22607 Hamburg, Germany

In the years 2016-2018 the CMS Experiment at CERN's Large Hadron Collider (LHC) recorded a large amount of proton-proton collision data at a centre-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 137 inverse fb. In this work, events in which a single top quark is produced in association with a Z-boson are investigated. Particular focus is on final states in which two leptons originate from the Z boson and the top quark decays hadronically. The discrimination between signal and backgrounds is optimized by testing different methods for the event reconstruction in conjunction with a Deep Neural Network (DNN). It is shown that the use of jet kinematics that are associated with the particles in the final state improves the performance over cases where the event reconstruction information is not used. A statistical fit is then performed to the DNN output, reaching an expected signal significance for tZq events of 2.4 standard deviations. Further optimization of the analysis, e.g. by use of additional control regions, is being studied.

T 8.9 Mon 18:00 Th

Measurement of highly boosted W-boson-associated single top quark production using the CMS detector — •Christopher Matthies, Paolo Gunnellini, Johannes Haller, Roman Kogler, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

A cross-section measurement of the associated production of a single top quark and a W boson (tW) in boosted ℓ+jets final states in pp collisions at $\sqrt{s} = 13\,\text{TeV}$ with the CMS experiment is presented. Boosted hadronic decays of both the W boson or the top quark are reconstructed as large-radius jets using the HOTVR algorithm for the first time. Deep learning techniques are employed to discriminate tW from top quark pair production and other background processes. It is shown that a measurement up to a transverse momentum of about 1 TeV of the top quark or associated W boson is feasible, extending the phase space covered by previous measurements considerably.

T 8.10 Mon 18:15 Th

Using Machine Learning Techniques to Probe the Interference Between tW and $t\bar{t}$ — •Federico G. Diaz Capriles and Ian C. Brock — Physikalisches Institut, Bonn

The production of two W-bosons in conjunction with two b-quarks ($WWbb$) is not only the signature of top-quark pair production ($t\bar{t}$) but also single top-quark production in association with a W-boson (tW) at the next-to-leading-order. The modeling difficulty of the interference between these two processes becomes a significant systematic uncertainty in a differential cross-section measurement.

A machine learning approach is used in order to study the interference in depth. The network is trained to pick out differences between a mixed Monte Carlo sample of tW and interference against a Monte Carlo sample of only tW. The resulting classifier is expected to differentiate between interference-like and tW-like events. This classification can aid in the scrutiny of the modeling of the interference-inclusive Monte Carlo.

T 9: Associated Higgs production and Higgs quantum numbers I

Time: Monday 16:00–18:15 Location: Ti

T 9.1 Mon 16:00 Ti

Simplified Template Cross Section Measurement of the Process $pp \to HW \to WWW \to l\nu l\nu l\nu$ with ATLAS — •Moritz Hesping, Volker Büscher, Ralf Gugel, Thomas Honig, Christian Schmitt, and Natalie Wieseotte — Johannes Gutenberg Universität Mainz

The measurement of the couplings of the Higgs boson is of great scientific interest, since it has the potential of testing possible extensions to the Standard Model. The decay of a Higgs boson into a pair of W bosons after production in association with a W boson is especially useful, since in this process the Higgs boson exclusively couples to W bosons.

As the total cross section of the process $pp \to HW \to WWW \to l\nu l\nu l\nu$ has previously been measured at the ATLAS detector using data from 2015 and 2016, the next step is now to extend this out to the scheme of Simplified Template Cross Sections (STXS), using the full run 2 dataset. The STXS mesurement of this process requires access to the transverse momentum of the associated W boson, which due to the presence of three neutrinos in the final state cannot be fully reconstructed. This talk details the analysis strategy used to enable a STXS measurement of the Higgs-W coupling.

T 9.2 Mon 16:15 Ti

Search for WH production at the CMS Experiment using Deep Learning Techniques — •Frederic Engelke — III. Physikalisches Institut A, RWTH Aachen University

The analysis of the associated production of a Higgs boson with a vector boson via Higgs-Strahlung provides a possibility to detect Beyond the Standardmodel (BSM) effects. For a full understanding, the VH production cross section has to be investigated very precisely.

This analysis is performed blinded in the WH $\to$ bb $\ell\nu$ final state producing an expected upper limit on σ_{WH}. A physics process multiclassification by a deep neural network is used for the enhancement of this analysis. The used simulations correspond to the data measured by the CMS detector in 2017 amounting to a luminosity of $\mathcal{L} = 41.2\ \text{fb}^{-1}$.

T 9.3 Mon 16:30 Ti

Towards a measurement of single top quark production in association with a Higgs boson (tH) in the ditau channel at ATLAS — •Tanja Holm and Ian C. Brock — Physikalisches Institut Universität Bonn

Single top quark production in association with a Higgs boson sometimes is referred to as the 'golden channel' of single top-quark processes due to the opportunities it gives in studying the couplings of the Higgs boson. Especially interesting is $\frac{C_F}{C_V}$ which results in the cross-section changing by almost one order of magnitude.
The production of a top quark in association with a Z boson has been discovered at ATLAS and CMS in the trilepton channel, considering the top quark and the Z boson to decay leptonically. Hence a promising channel for the tH search is the multilepton channel where the Higgs decays into two τ leptons. Given that each τ has a 64.6% probability to decay hadronically we search for events containing two hadronic τ decays and events containing one hadronic τ decay.
This talk will discuss the search for the tH production in the hadronic τ channels in ATLAS using the Run 2 data of the LHC.

T 9.4 Mon 16:45 Ti

Neural network development in the analysis of single top-quark production in association with a Higgs boson and light-quark at ATLAS — •Christian Kirfel, Ian Brock, and Tanja Holm — Physikalisches Institut Bonn

A measurement of the single top-quark production in association with a Higgs boson and a spectator light-quark (tHq) gives insight into the properties of not only the top quark but also the Higgs boson. The associated production is uniquely sensitive to the relative sign of the top quark-Higgs boson Yukawa coupling. Additionally, the ditau decay of the Higgs boson allows for a reconstruction of the Higgs mass.

The extraction of a signal is limited by the plethora of background processes with higher cross sections. This makes the usage of multivariate analysis methods a necessary choice.

A variety of new methods have been used to optimise the network, including an evolutionary optimisation process. In addition, the use of negative weights in the training has been investigated. Both the development and the results of a deep neural network for the separation of the tHq channel from its backgrounds are presented.

T 9.5 Mon 17:00 Ti

Associated production of a single top quark and a Higgs boson in the H$\to$ b$\bar{\text{b}}$ decay channel at the CMS experiment — Thorsten Chwalek, Nils Faltermann, •Marco Link, and Thomas Müller — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

The associated production of a single top quark and a Higgs boson (tH) is a still undiscovered Standard Model (SM) process with a production cross section of about one tenth of the production cross section of the associated production of a top quark pair and a Higgs boson (t$\bar{\text{t}}$H). In contrast to t$\bar{\text{t}}$H production, tH production is through interference also sensitive to the sign of the top-Higgs coupling.

This presentation focuses on the reconstruction of tHq, tHW, t$\bar{\text{t}}$ and t$\bar{\text{t}}$H events with a single lepton final state using boosted decision trees (BDT) and the results obtained from the combination of three channels (fully hadronic, single lepton and dilepton) with $137.2\,\text{fb}^{-1}$ of proton-proton collision data recorded at $\sqrt{s} = 13\,\text{TeV}$ by the CMS experiment from 2016 to 2018. These results include a limit on the SM tH production and measurements of the top-Higgs coupling, for a SM Higgs boson and for a mixture with a non-SM CP-odd Higgs boson.

T 9.6 Mon 17:15 Ti

Investigation of ttH(bb) Events with Very High Higgs Boson Momentum at ATLAS Detector — Lucia Masetti, Eftychia Tzovara, Alexander Basan, Andriani Panagi, Asma Hadef, and •Doga Elitez — Johannes Gutenberg Universität Mainz, Institut für Physik, Mainz, Germany

The coupling of the Higgs boson to the top quark is very sensitive to effects of the physics beyond the Standard Model (BSM) and the most favorable production mode for direct measurement of the top Yukawa coupling is the Higgs production in association with a pair of top quarks, $t\bar{t}H$. The decay to two bottom quarks ($H \to b\bar{b}$) has the largest branching fraction of about 58%.

This analysis aims at events in which one of the top quarks decays semi-leptonically and produces an electron or a muon plus several jets. The so-called ultra boosted topology targets events containing a Higgs boson produced at very high transverse momentum, which is contained in a single small-R jet. This topology is not included in the current high p_T (boosted) Higgs boson selection and requires a dedicated analysis. The challenges in terms of background rejection and the potential to increase the sensitivity above the current p_T range are presented in this talk.

T 9.7 Mon 17:30 Ti

STXS measurement of topquark-antiquark pair production in association with a Higgs boson at CMS — •Sebastian Wieland[1], Ulrich Husemann[1], Philip Keicher[1], Matthias Schröder[2], and Jan van der Linden[1] — [1]Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT) — [2]Universität Hamburg

Top quark-antiquark pair production in association with a Higgs boson offers a model-independent measurement of the top-Higgs Yukawa coupling. This is of great interest in order to precisely test the couplings of the Higgs boson to fermions predicted by the standard model. Since physics beyond the Standard Model may show in the spectrum of the transverse momentum of the Higgs boson, a joint effort of Higgs analyses in all channels is made in order to simplify and streamline potential combinations between measurements. In the context of these Simplified Template Cross Section (STXS) measurements the cross section is measured in common bins.

In this talk a multivariate STXS measurement in the semileptonic decay channel of the top quark-antiquark pair and the decay of the Higgs boson into a bottom quark-antiquark pair based on the full Run-2 dataset of the CMS experiment is presented.

T 9.8 Mon 17:45 Ti

Modelling studies of the $t\bar{t} + b\bar{b}$ background to the $t\bar{t}\,(H \to b\bar{b})$ analysis — •Stephen Eggebrecht, Andreas Kirchhoff, Arnulf Quadt, Elizaveta Shabalina, and Knut Zoch — II. Physikalisches Institut, Georg-August-Universität Göttingen

The measurement of the Yukawa coupling of the Higgs boson to the top quark is an important parameter of the Standard Model (SM). It could be used to either find deviations from the SM or to constrain BSM theories. To study this coupling, the production of a SM Higgs boson in association with a top-quark pair is used. The decay mode where the SM Higgs boson decays to bottom quarks has the highest branching ratio. Unfortunately, it suffers from a large $t\bar{t} + b\bar{b}$ background. It has a two times larger cross-section than the signal as well as similar kinematics. By reducing the modelling uncertainties of the $t\bar{t} + b\bar{b}$ background, a better sensitivity of the measurement can be achieved. For this purpose, four different Monte Carlo (MC) simulations are compared. All simulations have different generator tunes and parton distribution function (PDF) sets. Firstly, the kinematics of the additional b-jets are studied when the $t\bar{t} + b\bar{b}$ process is simulated in the 5-flavour scheme. Secondly, a comparison is made with $t\bar{t} + b\bar{b}$ kinematics simulated in the 4-flavour scheme, where the bottom quark is no longer treated as a massless particle. This treatment corresponds to the best available theoretical predictions and is expected to reduce the uncertainties on this background.

T 9.9 Mon 18:00 Ti

ANN based jet assignment in the simultaneous inclusive cross-section measurement of $t\bar{t}$+H/$t\bar{t}$+Z in the semileptonic channel targeting $b\bar{b}$ decays at the CMS experiment — •Lukas Armbruster, Ulrich Husemann, and Jan van der Linden — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

Higgs production in association with a top quark-antiquark pair ($t\bar{t}$+H) is one of the main Higgs production channels at the Large Hadron Collider (LHC). Additionally, the subsequent decay of the Higgs boson into a pair of bottom quarks (H→ $b\bar{b}$) is one of the most favored decay channels, due to the fact that b-jets are well distinguishable from other jet background (b-tagging).

This is why this study's focus is on the $t\bar{t}$+H decay chain. However, there occur some very similar processes, mainly the production of a Z boson in association with a top quark-antiquark pair ($t\bar{t}$+Z) and the associated production of bottom quarks with a pair of top quarks ($t\bar{t}$+$b\bar{b}$). Since these processes are very similar to the $t\bar{t}$+H → $b\bar{b}$ process, it is of vital importance to discriminate these from each other.

One essential step for the discrimination of these processes is the correct assignment of the occurring jets to a certain hypothesis (e.g. $b\bar{b}$ from Z boson) for any event. The jet assignment is quite challenging, since there are many (b-)jets in a single event and therefore numerous jet combinations are possible.

In this talk the strategy of jet assignment via Artificial Neural Networks (ANNs) is presented, in contrast to traditional χ^2-methods.

T 10: Gaseous detectors

Time: Monday 16:00–18:15 Location: Tj

T 10.1 Mon 16:00 Tj

A Cherenkov Position Micromegas — •Maximilian Rinnagel, Otmar Biebel, Maximilian Herrmann, Christoph Jagfeld, Felix Klitzner, Katrin Penski, Chrysostomos Valderanis, Fabian Vogel, and Ralf Hertenberger — LMU München

Detectors utilizing the Cherenkov effect have been well established for particle identification of charged particles in detector systems such as LHCb or HADES. In reverse it is possible to determine the momentum of a known particle by measuring the opening angle of the Cherenkov cone in thick Cherenkov media. Our goal with this 10x10 cm^2 prototype is a proof of principle using cosmic muons. A traversing muon creates around 700 Cherenkov photons in a 1-2 cm thick ulta-violet (UV) transparent LiF, CaF_2 or MgF_2 window with an optical refractive index around 1.5 in the UV range. The conversion to electrons happens in transmission in a photosensitive CsI layer at the bottom of the radiator. High voltage around -300 V, applied to a thin layer of Chromium in between the crystal and the CsI, forces the electrons into the drift region of a Micromegas, i.e. gaseous micro pattern detector, where the electrons are detected with excellent spatial resolution after gas-amplification in the anode-stage of the detector. Overall efficiencies of 7% seem possible at transparencies of 60% through the Chromium layer and conversion efficiencies around 12% in the CsI layer. Thus, good momentum resolution and spatial resolution of an incident muon particle will be achieved. We will present the detector design as well as studies concerning the transmission of the radiator material and the predicted photon yield.

T 10.2 Mon 16:15 Tj

Photon Detection by a Structured Cathode of a Micro-Pattern Gaseous Detector — •Katrin Penski, Otmar Biebel, Maximilian Herrmann, Ralf Hertenberger, Christoph Jagfeld, Felix Klitzner, Maximilian Rinnagel, Chrysostomos Valderanis, and Fabian Vogel — LMU München

Micro-Pattern Gaseous Detectors (MPGDs) are high-rate capable and show an extremely good spatial and temporal resolution. Nevertheless, due to the low density of the gas these detectors exhibit only a poor detection efficiency for electrically neutral particles. For photons the detection efficiency can be increased by using a solid converter cathode which is made of high-Z materials. Even higher efficiencies are obtained by stacking several tilted converter layers with large overlap inside a MPGD. In an interaction process electrons are created which have to be guided to the amplification and readout area for detection which is achieved by a specific designed electric field configuration. The tilted layers in combination with the electric guidance field act as structured cathode. In order to investigate the photon detection efficiency measurements are performed using a prototype structured cathode, a GEM detector and an ^{241}Am-source emitting 59.5 keV photons. These results are presented and compared to corresponding simulations regarding the electron guiding efficiency, the electron distribution as well

as the photon detection efficiency.

T 10.3 Mon 16:30 Tj

Developement of a low background GridPix detector for IAXO — •Tobias Schiffer, Klaus Desch, Markus Gruber, Jochen Kaminski, and Sebastian Schmidt — Physikalisches Institut, Universität Bonn

In the scope of the search for axions and axion like particles (Alps) with helioscopes, like the International Axion Obeservatory (IAXO) and its precurser BabyIAXO, detectors capable of measuring low energy X-rays down to the 200 eV range are necessary. For this purpose the GridPix detector is an appropriate solution, which has already been used successfully at CAST.

The GridPix is a MicroMegas like readout consisting of a pixelized readout ASIC (Timepix/Timepix3) with a perfectly aligned gas amplification stage on top of the ASIC. Due to the very high granularity this detector is capable of detecting single electrons allowing the measurement of low energy X-rays. To convert these X-rays into electrons a gas volume is built above the readout sealed with an X-ray entrance window.

For the goals of IAXO and BabyIAXO a very low background needs to be achived with the detector, therefore only a few radiopure materials are contemplable. Also, to get a good signal to noise ratio the X-ray entrance window needs to be as transparent as possible for the low energy X-rays, while still maintaining a barrier between the detector gas and the vacuum system in front. This is achived with an ultra thin (<200 nm) silicon nitride membrane.

The challenges and the status of the detector will be presented.

T 10.4 Mon 16:45 Tj

X ray reconstruction for IAXO using a Timepix 3 based InGrid — Ivor Fleck, •Jan Hahn, and Ulrich Werthenbach — Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen

We present a reconstruction algorithm for X ray photons in a gaseous volume instrumented with a Gridpix. The algorithm is based on the Cambridge Aachen algorithm for jet reconstruction. By recursive recombination, active pixels on the readout chip are combined to clusters based on their distance to each other, combining the closest pair until the minimal distance exceeds a threshold. Each pixel corresponds to one electron from the primary ionisation.These clusters are subjected to cuts to to reject background and noise. Several X ray energies are investigated using iron-55 and X ray fluorescence of aluminum, copper and rubidium to obtain an energy calibration for energies in the region of interest for solar axion searches between 1 and 14 keV. In addition, different cuts are investigated to separate signal and background. Unknown energies can be reconstructed by the number of hits assigned to the cluster and the calibration. The experimental setup operates in an 80:20 mixture of argon and carbon dioxide at room temperature and ambient pressure.

T 10.5 Mon 17:00 Tj

Commissioning of a Gas Monitoring Chamber for the T2K Near Detector Upgrade — Philip Hamacher-Baumann, Paula Nehm, Paolina Noll, Thomas Radermacher, Stefan Roth, •David Smyczek, and Nick Thamm — RWTH Aachen University - Physics Institute III B, Aachen, Germany

A pair of High Angle Time Projection Chambers (HATs) will be installed during the upgrade of the T2K near detector ND280. These HATs have the task to reconstruct particle tracks and energy loss at high scattering angles of the final state charged leptons. The new Gas Monitoring Chambers will continuously measure important electron drift parameters, especially drift velocity and gain. This data will be used in the calibration procedure to improve the resolution of the measurement of the specific ionisation dE/dx and to guarantee the long term stability of track reconstruction. The design, construction and commissioning of a first prototype is presented.

T 10.6 Mon 17:15 Tj

Boron based neutron Time Projection Chamber — •Divya Pal[1], Klaus Desch[1], Jochen Kaminski[1], Micheal Luperger[1], and Markus Köhli[1,2] — [1]Physikalisches Institut, Universität Bonn — [2]Physikalisches Institut, Universität Heidelberg

Thermal neutrons have widespread applications ranging from fundamental physics tests to neutron tomography, solid-state physics and medical physics, making their detection important. Thermal neutrons are traditionally detected with Helium-3 filled proportional counters. However, due to the supply shortage of Helium-3, leading to a rapid increase in its price, alternative detectors are sought.

In Bonn, the BOron DEtector with Light and Ionization Reconstruction (BODELAIRE) is being developed with the aim of providing high spatial and time resolution in thermal neutron detection. The BODELAIRE is based on the principle of a Time Projection Chamber (TPC) with thin layers of Boron-10 neutron converters placed perpendicular to a GridPix readout which will have Timepix3 as ASIC. The trigger is placed along the field cage and consists of multiple layers: Boron, scintillator and light readout. Thus, the working principle is that the conversion of the neutron with Boron-10 gives two tracks, one giving a trigger signal in the scintillator while the other leaves a track in the gas volume.

The concept and current development status of the BODELAIRE will be presented.

T 10.7 Mon 17:30 Tj

Tracking-TPC for a Belle II Upgrade — Florian Bernlochner, Jochen Dingfelder, Peter Lewis, •Andreas Löschcke Centeno, and Christian Wessel for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The central drift chamber (CDC) in the Belle II experiment will suffer from large cross-talk effects and high occupancy at full design luminosity of the SuperKEKB accelerator at KEK in Tsukuba, Japan.

In the context of a future upgrade of the Belle II tracking system, the viability of removing the CDC and replacing its outer region with a time projection chamber (TPC) is investigated. This upgrade scenario would see the silicon layers in the inner region being extended into the region not covered by the TPC.

The first-order and conceptual designs are simulated in the Belle II software. Of particular interest are the ion backflow characteristics and the event overlap in the TPC.

Due to the high design luminosity at Belle II there will be a large overlap in physics events due to the long drift time compared to the event rate.

Beam background contributions are dominant in the number of hits in the TPC volume. While a solid background rejection is part of tracking studies not conducted in this project, it is outlined here how the beam-induced background complicates tracking in the TPC.

T 10.8 Mon 17:45 Tj

A simple method to improve the position resolution — •Lucian Scharenberg[1,2], Jona Bortfeldt[3], Florian Brunbauer[1], Klaus Desch[2], Francisco Garcia[4], Marek Hracek[1,5], Djunes Janssens[1,6], Marta Lisowska[1,7], Michael Lupberger[2], Hans Muller[1], Hugo Natal da Luz[5], Eraldo Oliveri[1], Dorothea Pfeiffer[8,1], Heikki Pulkkinen[1,9], Leszek Ropelewski[1], Jerome Samarati[8,1], Miranda van Stenis[1], Antonija Utrobicic[1], and Rob Veenhof[1,10] — [1]CERN — [2]University of Bonn — [3]Ludwig Maximilian University of Munich — [4]Helsinki Institute of Physics — [5]Czech Technical University in Prague — [6]Free University of Brussels — [7]Wroclaw University of Science and Technology — [8]ESS — [9]VR Group — [10]Bursa Uludag University

During the development of position-sensitive particle detectors, significant efforts are spent on finding segmented readout electrodes that suit the experimental requirements. The centre-of-gravity method is a popular choice to then reconstruct the position of the incident radiation. However, the discretisation by the electrode causes an information loss, leading to inaccuracies in the position reconstruction.

We present the observed inaccuracies and a simple method that reduces them. Using imaging techniques, we show that the reduction is not the consequence of a smoothing effect. For these studies, we made use of a hardware feature from our readout electronics (VMM3a ASIC and RD51's Scalable Readout System) that allows us to gain more charge information. Afterwards, we present results with MIPs that confirm the improved position resolution.

T 10.9 Mon 18:00 Tj

Particle position reconstruction using a segmented GEM foil in a micro-structure gaseous detector — •Christoph Jagfeld, Otmar Biebel, Maximilian Herrmann, Ralf Hertenberger, Felix Klitzner, Katrin Penski, Maximilian Rinnagel, Chrysostomos Valderanis, and Fabian Vogel — LMU München

In Micromegas (Micro-MEsh GAseous Structures) detectors, a modern form of micro-pattern gaseous detectors, the signal is usually read out

via readout strips on the anode. The signal created at the mesh is usually neglected for the particle position reconstruction. By replacing the mesh with a GEM (Gas Electron Multiplier) foil, which is segmented into 0.5 mm broad readout strips on its side facing the anode readout strips, the particle position can be determined on the "mesh" as well. If the strips on the GEM foil are orientated perpendicular to the anode readout strips, a particle position can be reconstructed in two spatial coordinates without adding a second layer of readout strips on the anode. First measurements with the new GEM foil will be presented.

T 11: Search for Supersymmetry I

Time: Monday 16:00–17:45 Location: Tk

T 11.1 Mon 16:00 Tk

Analysis of the viable parameter space in the phenomenological MSSM using clustering algorithms with the ATLAS detector. — •Markus Eck and Jeanette Lorenz — Ludwig-Maximilians-Universität München

Supersymmetry (SUSY) is a theoretical framework extending the Standard Model of particle physics, potentially solving several of its shortcomings. In the search for supersymmetric particles with the ATLAS experiment at the LHC, typically, simplified models are considered, which contain a small number of parameters. These simplified models focus on specific SUSY production scenarios with very specific decays. Therefore, they may fail to capture effects that can result from the large number of competing production and decay processes present in more complete models. To resolve this, efforts are on-going to reinterpret searches for supersymmetric particles in the 19-parameter phenomenological MSSM (pMSSM).

This talk presents an analysis of the part of the pMSSM parameter space sensitive to electroweak supersymmetric particles. Models in this parameter space not excluded by the current ATLAS search program are analysed via clustering methods to find common properties. The gained insight will help to improve the future search program for supersymmetric particles.

T 11.2 Mon 16:15 Tk

Evaluating current LHC results in the pMSSM using MadAnalysis5 — •Malte Mrowietz, Sam Bein, and Peter Schleper — Universität Hamburg, Hamburg, Deutschland

The impact of 13 TeV LHC searches for supersymmetry on the minimal supersymmetric standard model (MSSM) is evaluated using MadAnalaysis5, in the context of the 19-parameter phenomenological MSSM (pMSSM). Complementarity and possible tension between the LHC data and results from dark matter, low energy physics, and implications of fine-tuning are examined.

T 11.3 Mon 16:30 Tk

Impact of fundamental MSSM parameters on the SUSY dark matter contribution — •Marten Berger[1], Sven Heinemeyer[2], Cheng Li[3], Gudrid Moortgat-Pick[1,3], Christian Schappacher[4,5], and Georg Weiglein[1,3] — [1]II. Institute of Theoretical Physics, University of Hamburg, Germany — [2]Instituto de Fisica Teorica, Madrid, Spain — [3]DESY, Hamburg, Germany — [4]Karlsruhe University, Karlsruhe, Germany — [5]KIT, Karlsruhe, Germany

The Minimal Supersymmetric Standard Model (MSSM) is one of the best motivated extensions of the Standard Model (SM): it is of high predictive power and can explain the main open questions of the SM. For instance, it offers a well-motivated cold dark matter candidate. A crucial question is therefore whether parameter sets within this model can explain the correct amount of relic density with its cold dark matter candidate. Since the mixing character can rapidly change depending on the actual parameter point and consequently has immediate influence on the relic density contribution it is necessary to include one-loop corrections in the calculations of the dark matter observables. In this talk we will discuss two classes of possible scenarios and the impact of the fundamental SUSY parameters on the resulting relic density.

T 11.4 Mon 16:45 Tk

Modelling Pair Production of Top Squarks with Decays via Tau Sleptons in the pMSSM — •Christoph Ames and Alexander Mann — Ludwig-Maximilians-Universität, Munich, Germany

The phenomenological Minimal Supersymmetric Standard Model (pMSSM) is a simplified supersymmetric model that allows for a systematic probing of its parameter space due to its heavily reduced number of parameters. This work focuses on the comparison of three simplified models in the context of the pMSSM, in which a stop decays via either a stau or a tau-sneutrino. The lightest supersymmetric particle is either a gravitino or a neutralino. These models are used to get an understanding of how different particle decays are influenced by the parameters of the pMSSM, and to find the boundaries for each model's phase space. Decay modes that compete with the simplified models are also studied to determine how to suppress them. These comparisons are performed using random samples of model points, which are configurations of particle masses and decay modes uniquely defined by sets of pMSSM parameter values. The phase space of the model generation has been adjusted to increase the likelihood that the model points will contain the simplified models, whilst still allowing for an uncompromising study.

T 11.5 Mon 17:00 Tk

Search for the production of a pair of stops in the all-hadronic tt+MET channel using the ATLAS detector — •Alvaro Lopez Solis — DESY-Zeuthen

Supersymmetry (SUSY) is an extension of the Standard Model associating to every fermion and boson known by now a scalar or fermion partner respectively, called superpartners. There are several phenomenological motivations of this extension, amongst which it is useful to cite three: it provides a natural solution to the Higgs mass hierarchy problem, whose diverging diagrams caused by fermionic loops are cancelled out by their corresponding superpartner-mediated loops; the provision of a cold dark matter candidate; and the gauge coupling unification at high energies.

Amongst all the versions of SUSY, I will focus on the one providing a minimal extension of the Standard Model, also called MSSM. In this theory, the top superpartner is crucial to the cancellation of the top corrections to the Higgs mass. In addition, naturalness arguments suggest that the superpartners of the third-generation quarks may present a mass of the order of TeV, meaning that they might be accessible by LHC collisions. In consequence, top partner search is a key point in the SUSY searches in ATLAS.

In this talk, I will present search for the production of a pair of top superpartners performed inside the ATLAS collaboration in the tt+MET channel. This search is focused on the all-hadronic decays of the top-quark, thus requiring no lepton in the final state.

T 11.6 Mon 17:15 Tk

New physics searches in tt+MET final states in pp collisions at 13 TeV with the ATLAS experiment — •Simran Gurdasani — Albert-Ludwigs-Universität Freiburg, Freiburg im Breisgau, Deutschland

This talk will report on preliminary results on a search for SUSY and Dark Matter particles with the ATLAS experiment at the LHC using 139 fb^{-1} of pp data at 13 TeV. The targeted signals are the productions of pairs of SUSY stop quarks and the production of DM candidates in associations with a pair of top quarks via a new scalar or pseudoscalar mediator, as predicted in DM simplified models or in 2HDM+a models. The search focuses on events with either an electron or a muon from the decay of one of the two top quarks. It will expand the reach of a previous similar analysis by adding a new sample of events using single lepton triggers and by deploying neural networks to reconstruct the momenta of the top quarks and to classify the signal and background events. The talk will give an overview of the physics motivation of the search and will report on the ongoing developments of the analysis.

T 11.7 Mon 17:30 Tk

Search for Supersymmetry in Leptonic Final States with the ATLAS Detector — •Marian Rendel, Michael Holzbock, Hubert Kroha, and Sandra Kortner — Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München)

Supersymmetry (SUSY) is one of the best studied extensions of the

Standard Model (SM) and as such the search for SUSY is a major part of the ATLAS physics program. A SUSY models with scalar partners of the SM leptons (sleptons) may address the muon g-2 anomaly, as well as provide a viable candidate for Dark matter, and are thus of particular interest. Due to their low production cross section and the high Standard Model (SM) background, the search for sleptons is challenging. This motivates to employ multivariate methods to distinguish between SUSY and the SM background. In this talk a search for sleptons in events with two same-flavor opposite-sign leptons and initial state radiation topology is presented which uses 139 fb^{-1} LHC proton-proton collision data collected by the ATLAS experiment during the years 2015 and 2018.

T 12: Search for New Particles I

Time: Monday 16:00–18:20 Location: Tl

Group Report T 12.1 Mon 16:00 Tl

Upcoming Experimental Axion Searches at DESY — •Aaron Spector — DESY, Hamburg, Germany

With the physics case for axions and axion-like particles growing ever stronger, DESY is now set to host three upcoming axion searches, ALPS II, a light shining through a wall experiment, BabyIAXO, a solar axion helioscope, and MADMAX, a dark matter haloscope. While the methods used in each of these experiments are different, all of them utilize the Sikivie effect where axions convert to photons in the presence of a DC magnetic field with a rate proportional to the coupling constant $g_{a\gamma\gamma}$. Since they rely on different assumptions about the source of the axions, these searches will target complementary regions of the axion-like particle parameter space where evidence indicates these particles could exist. Together, their results will offer a cohesive picture of $g_{a\gamma\gamma}$ and potentially identify the cause of a number of phenomena which cannot be explained by the standard model. This talk will introduce these experiments and their sensitivity curves, in addition to providing a status report and timeline for each of them.

T 12.2 Mon 16:20 Tl

Optical Design of the ALPS II experiment — •Todd Kozlowski for the ALPS-Collaboration — University of Florida, Gainesville, USA

Currently under construction at DESY, the Any Light Particle Search (ALPS II) experiment will search for laboratory-generated axions and axion-like particles via photon-axion coupling. The experiment exploits several optical techniques in order to improve sensitivity. Two 122-meter long optical resonators are enclosed within a string of HERA dipole magnets. The first of these resonators is used to amplify the power of a laser field circulating inside the strong magnetic field to generate axions. This Production Cavity (PC) leads to an increase in the axion flux rate which can be measured on the other side of a light-tight barrier. For detection, a second resonator - the Regeneration Cavity (RC) - improves the reconversion rate of axions to photons which are measured with a heterodyne interferometer.

The optical systems must be actively controlled to assure that the frequency of the light circulating inside the PC is simultaneously resonant with the RC, but without allowing any PC light into the RC which would contaminate the detection. Additionally, the experiment requires at least a 95% overlap between the eigenmodes of the PC circulating light and the RC. This talk will discuss these challenges and the designs which will soon be implemented to solve them to allow first data-taking before the end of 2021.

T 12.3 Mon 16:35 Tl

TES Detector for ALPS II — •Rikhav Shah[1], Katharina-Sophie Isleif[2], Friederike Januschek[2], Axel Lindner[2], and Matthias Schott[1] for the ALPS-Collaboration — [1]JGU Mainz — [2]DESY, Hamburg

The Any Light Particle Search II (ALPS II) is a light-shining-through-a-wall (LSW) experiment at DESY, Hamburg, attempting to detect axions and axion-like-particles (ALPs). ALPS II will convert photons into axions/ALPs in an optical cavity. After passing through an opaque, light-tight barrier, these particles enter another optical cavity. Here, they can reconvert to photons and be detected. The detection requires a sensor capable of observing the extremely low rates of $\mathcal{O}(10^{-5})$ Hz, necessitating a very low dark rate and high detection efficiency. This can be achieved by using a TES, a Transition Edge Sensor, which is a cryogenic calorimeter exploiting the drastic temperature dependence of a material's electrical resistance in its transition region. We present the setup of a TES detector for ALPS II, its current status, and the analysis and improvement of its backgrounds. The viability and outlook of such a detector for the ALPS II experiment will be discussed, including future steps to understand its backgrounds and measure the detection efficiency.

T 12.4 Mon 16:50 Tl

Estimation of reconstruction and trigger efficiencies in search for ALPs in Higgs boson decays at the LHC with ATLAS — Bernard Brickwedde, Peter Krämer, Marten Mildeberger, Kristof Schmieden, Matthias Schott, and •Olivera Vujinovic — Johannes Gutenberg Universität Mainz

Some puzzling questions in particle physics, such as the strong CP problem or the discrepancy of the muon magnetic moment could be solved by introducing light scalar or pseudo-scalar axion-like particles (ALPs). ALPs may be produced at the Large Hadron Collider in Higgs decays. They further decay into a pair of photons ($H \to aa \to 4\gamma$). Depending on the ALP mass, the final photon-pairs will be reconstructed either as one (merged) photon or as two resolved photons. An artificial neural network (ANN) is used to identify merged photons amongst the immense background from prompt photons and π^0 from SM processes. Our analysis is using data collected at LHC within the ATLAS experiment. This talk will give an overview of the analysis's strategy to probe the ALP mass-coupling parameter space, including the preliminary estimations of the acceptance, reconstruction and trigger efficiencies using simulated Monte Carlo signal samples. The decay length of the ALPs is non-negligible and has a significant impact on the experimental acceptance, which will be discussed as well.

T 12.5 Mon 17:05 Tl

Single-Photon Detector Development at DESY — •Katharina-S. Isleif[1], Rikhav Shah[2], Friederike Januschek[1], Axel Lindner[1], Hartmut Grote[3], Dmitry Morozov[4], and Robert Hadfield[4] — [1]Deutsches Elektronen-Synchrotron — [2]Johannes Gutenberg Universität Mainz — [3]Cardiff University — [4]James Watt School of Engineering, University of Glasgow

In recent years, single-photon detector technologies have been continuously developed and improved. The advancement of photon-counting technologies has significantly contributed to scientific progress and enabled real-world quantum technology applications such as quantum key distribution. The performance of a single-photon detector can be quantified in terms of spectral range, dead time, dark count rate and detection efficiency, among others. The ALPS II axion-detection experiment, which is currently under construction at DESY in Hamburg, utilizes many of these properties, which we will highlight in this talk. We will demonstrate how single-photon detectors are characterized, what the current limitations of today's detectors are and we will give an outlook on the approaches we will study to undercut the given limitations to realize single-photon detectors with a rate of 10^{-5} counts per second and a detection efficiency of over 80% for 1064 nm photons. The goal is to eliminate spurious events at energies of 1.17 eV to below 1 event per day when the detector is connected to an experiment via optical fiber. Possible new detector structures will be addressed, such as a cryogenic dual on-chip transition edge sensor, and discuss low-noise optical interfaces and in-situ low-temperature optical filters.

T 12.6 Mon 17:20 Tl

Deriving limits on ALPs coupling to the SM Higgs boson in multiphoton events recorded at the LHC with ATLAS — Bernard Brickwedde, •Peter Krämer, Marten Mildeberger, Kristof Schmieden, Matthias Schott, and Olivera Vujinovic — Johannes Gutenberg Universität Mainz

Some puzzling questions in particle physics, such as the strong CP problem or the discrepancy of the muons magnetic moment could be solved by introducing light scalar or pseudo-scalar axion like particles (ALPs). Theoretic models allow a wide range of ALP-masses and couplings to SM particles such as the photon and the Higgs boson.

Therefore, parts of the ALPs parameter space could be investigated with collider experiments like the ATLAS experiment at the LHC.

In the present analysis we search for SM Higgs bosons decaying to a pair of ALPs further decaying to two photons each.

In this talk, it will be discussed how limits on the ALP parameters can be derived after selecting events with two, three or four photons in the final state.

T 12.7 Mon 17:35 Tl

Searching for ALPs in light-by-light scattering in pp collisions using AFP proton tagging with the ATLAS detector — Peter Bussey[1], Tomaš Chobola[2], Petr Dostál[2], Hussain Kitagawa[3], Artem Kravchenko[2], •Patrick Odagiu[4], André Sopczak[2], Junichi Tanaka[5], Gen Tateno[5], and Koji Terashi[5] — [1]University of Glasgow — [2]CTU in Prague — [3]Okayama University — [4]EPF Lausanne — [5]ICEPP University of Tokyo

The search for an Axion-Like-Particle (ALP) is being performed using about 20 fb^{-1} data recorded with the ATLAS experiment and the ATLAS Forward Proton (AFP) detector in 2017. The AFP detector is positioned symmetrically at approximately 220 m away from the interaction point near the beam pipe and is used to measure the kinematics of surviving protons. The high-mass diphoton spectrum is studied to search for an ALP mediated by light-by-light scattering. The investigated mass range is between 0.1 TeV and 2 TeV ALP with a typical coupling $g = 1\,\mathrm{TeV}^{-1}$. Data containing photon information and AFP containers are prepared. A blinding strategy is established, along with the next steps in this search.

T 12.8 Mon 17:50 Tl

Search for off-shell ALPs in ATLAS — •Vincent Goumarre — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

An Axion Like Particle (ALP) is a Dark Matter candidate, but its expected small mass makes it difficult to detect in resonance searches at the LHC. However, it is possible to search for ALPs as off-shell mediators in s-channel processes (Phys. Rev. Lett. 124, 051802 (2020)). We report results based on ATLAS measurements of differential cross-section of pp->Zγ and pp->WW production. This study leads to new constraints on the allowed parameter space in the context of an effective field theory model for ALPs with mass smaller than 100 GeV.

T 12.9 Mon 18:05 Tl

LHC Constraints on Axion-Like Particles and Their Coupling to Top Quarks — •Henrik Jabusch, Ksenia de Leo, Paolo Gunnellini, Johannes Haller, Roman Kogler, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

We investigate the possibility of axion-like particle (ALP) production at the LHC. At high-energy proton-proton collisions, ALPs could arise as off-shell mediators. Employing a model-independent effective field theory approach with ALP couplings to gluons and top quarks, ALPs lead to non-resonant signatures modifying the shape of the invariant mass distribution of the $t\bar{t}$ system.

We reinterpret a search by CMS for resonant $t\bar{t}$ production in the lepton+jets final state, based on 35.9 fb^{-1} of 13 TeV data. While the analysis is not optimized for non-resonant production, it allows us to study constraints on the ALP-top quark coupling for the first time.

T 13: Cosmic Rays I

Time: Monday 16:00–18:20 Location: Tm

Group Report T 13.1 Mon 16:00 Tm

The Pierre Auger Observatory – Status, Results, Prospects* — •Michael Schimp for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal

The Pierre Auger Observatory is the world's largest observatory for ultra-high energy cosmic rays (UHECRs), covering an instrumented area of 3000 km^2. Its 1660 Surface Detector (SD) stations and 27 Fluorescence Detector (FD) telescopes are designed to collect data of unprecedented statistics and quality.

Recent results have revealed new features in the energy spectrum of UHECRs, while their mass composition is best described as mixed with increasing primary particle masses towards the highest energies. Additionally, several significant large- and medium-scale anisotropies have been established. Searches for neutrinos and photons have yielded the most significant constraints on their fluxes in a substantial energy and directional range. Furthermore, the data indicate that there are significantly more muons produced in air showers than expected in state-of-the-art simulations. About 1600 elves, lightning-related luminous events in the ionosphere, have been detected with the FD, making it a unique contributor to high-energy atmospheric physics research.

An upgrade of the Pierre Auger Observatory, called AugerPrime, is nearing completion. It will add scintillation and radio detectors together with improved electronics to the SD stations. AugerPrime will improve particle identification and therefore enhance the overall UHECR mass composition sensitivity for the full-duty-cycle SD.

**Supported by BMBF Verbundforschung Astroteilchenphysik*

T 13.2 Mon 16:20 Tm

Performance of the surface detector calibration of the Pierre Auger Observatory — •Alexander Streich, David Schmidt, Darko Veberic, Markus Roth, and Ralph Engel for the Pierre Auger-Collaboration — Karlsruher Institut für Technologie (KIT), Karlsruhe, Deutschland

After more than a decade since the start of its data acquisition, the Pierre Auger Observatory is undergoing a major upgrade phase, the so-called AugerPrime upgrade. This phase includes, among other things, the installation of a variety of new detector components and the replacement of the electronics boards of all the 1660 Surface Detector stations. With the accompanying changes of hardware and software, the adaptation of the calibration procedures of the different detectors and devices becomes essential. This presentation focuses on the analysis of the calibration performance of both, the currently implemented algorithms of the non-upgraded Surface Detector stations, as well as the modifications and optimizations applied to these algorithms to match the changes in the data. In addition, we provide a short overview on the current status of the AugerPrime upgrade.

T 13.3 Mon 16:35 Tm

Improved reconstruction of events recorded by the surface detector of the Pierre Auger Observatory — •Quentin Luce for the Pierre Auger-Collaboration — Karlsruhe Institute for Technologie, Karslruhe, Germany

For the last fifteen years, the Surface Detector of the Pierre Auger Observatory is continuously recording, at ground level, the footprint of Extensive Air Showers initiated by Ultra-High Energy Cosmic-Rays. Each triggered Water-Cherenkov detector participating in an event, provides two information: the time at which the first particles of the shower hit the detector and the signal produced by all the particles going through it. While from the timing information the arrival direction of cosmic-rays is reconstructed, its energy is estimated, using the signal information, with the reconstruction of the lateral profile and the determination of the shower size $S(1000)$. With increase of statistics and the evolution of our knowledge, this reconstruction procedure is improving. The latest developments of the algorithms, i.e. correction of the azimuthal asymmetries, improvements of the lateral profile, used to reconstruct the properties of the cosmic-rays and the resolution associated to these developments are described in this presentation.

T 13.4 Mon 16:50 Tm

Correction of the asymmetry of the signal measured by the surface detector of the Pierre Auger Observatory — •Quentin Luce for the Pierre Auger-Collaboration — Karlsruhe Institute für Technologie, Karslruhe, Germany

For the last fifteen years, the Surface Detector (SD) of the Pierre Auger Observatory is continuously recording the footprint of Extensive Air Showers (EAS) initiated by Ultra-High Energy Cosmic-Rays at ground level. To reconstruct most accurately as possible the lateral profile of the EAS recorded, the asymmetry of the signal measured by the water-Cherenkov detectors has to be corrected. The correction applied is first derived from simulated data sets, from which the true arrival direction and thus the position of each detectors in the shower-plane is known. In addition to the SD, 27 fluorescence telescopes are deployed looking over the SD. Thus a sub-set of events can be reconstructed by two independent procedures. Thanks to this hybrid design, the use of

simulated data sets is complemented by a study of hybrid events to optimize the correction, specially with an addition of a scaling factor of the muonic component of the EAS. This addition takes into account the discrepancies between measured and simulated data on the number of muons published in the litterature.

T 13.5 Mon 17:05 Tm

Propagation of core uncertainties in subordinate surface detector reconstructions at the Pierre Auger Observatory — •Tobias Schulz, David Schmidt, Quentin Luce, Darko Veberič, and Markus Roth for the Pierre Auger-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany

A better understanding of ultra-high-energy cosmic rays is one of the goals of the AugerPrime upgrade at the Pierre Auger Observatory. Together with the existing Water Cherenkov Detectors, Surface Scintillation Detectors are currently being deployed to measure air showers induced by cosmic rays. The measured signals of these detectors are samples of the shower footprint at ground and are also dependent on the distance to the shower axis.

The shower geometry reconstructed from measurements of the Water Cherenkov Detectors of the surface detector array is commonly used in subsequent steps of event reconstruction, especially those pertaining to subordinate detectors, such as the scintillator detectors. An uncertainty on the reconstructed position of the shower core translates into uncertainties in the position of each station relative to the true location of the core. The uncertainties of the core position may therefore influence the results of shower reconstructions of other detector measurements and thus should be propagated into the subsequent reconstruction procedures. Here, we present a method of propagating core uncertainties and the resulting impact on the reconstruction of the shower size with the Surface Scintillation Detector.

T 13.6 Mon 17:20 Tm

A new end-to-end calibration of the fluorescence detector of the Pierre Auger Observatory — •Christoph Schäfer for the Pierre Auger-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology (KIT)

A crucial part of the Pierre Auger Observatory is the fluorescence detector composed of 27 large-aperture wide-angle Schmidt telescopes. In the past, the absolute calibration of these fluorescence telescopes was performed with a large-diameter light-source, which illumines the whole aperture of one telescope at once, roughly once every three years, while a relative calibration is performed every night. In this contribution a new technique for an absolute end-to-end calibration of the fluorescence telescopes is presented. This new technique employs a calibrated portable Lambertian light-source which scans across the aperture of each telescope. The analysis of the readout of the PMT camera at each position of the light source provides an absolute calibration of the telescope. We will give a brief overview of this novel calibration method and its current status, as well as preliminary results from the measurement campaigns performed so far.

T 13.7 Mon 17:35 Tm

Measurement of laser tracks from the Aeolus satellite with the Pierre Auger Observatory — •Felix Knapp for the Pierre Auger-Collaboration — Karlsruher Institut für Technologie

The Pierre Auger Observatory is the world's largest experiment for the observation of ultrahigh-energy cosmic rays. These cosmic-ray particles initiate extensive air showers in the atmosphere that can be studied via the measurement of secondary particle densities with surface detectors or by the observation of the light induced by a shower along its trajectory through the atmosphere with fluorescence telescopes.

Aeolus is a satellite operated by the ESA. It uses an UV-laser pointed towards Earth to measure the flow of air in the atmosphere. This laser beam traverses the Pierre Auger Observatory several times throughout the year. Light that scatters off the laser beam produces tracks in the atmosphere that trigger the fluorescence telescopes of the observatory.

In this talk we will give an overview of the reconstructed laser shots and the possibility of utilizing them for a study of aerosols over the Observatory.

T 13.8 Mon 17:50 Tm

Calibration of the Underground Muon Detector in the Pierre Auger Observatory — •Marina Scornavacche[1,2], Federico Sanchez[1], Juan Manuel Figueira[1], Markus Roth[2], and Ana Martina Botti[1,2] for the Pierre Auger-Collaboration — [1]Instituto de Tecnologias en Deteccion y Astroparticulas, Comision Nacional de Energia Atomica, Buenos Aires, Argentina — [2]Institut für Astroteilchenphysik, Karlsruher Institut für Technologie, Karlsruhe, Deutschland

The Pierre Auger Observatory was designed to answer the key questions about the origin and composition of ultra-high energy cosmic rays. One of the most sensitive observables to the mass composition is the muon content of the air showers. The Underground Muon Detector (UMD) is optimized to perform a direct measurement of this component in the ankle-region of the energy spectrum and has two complementary ways to estimate the number of muons: counting mode and integrator mode. In case of the integrator mode, the output signal is based on the total signal charge and the number of muons can be estimated by dividing this signal by the mean charge of a single muon. In this work, we show how to calibrate the integrator on simulations to obtain the mean charge left by a single muon. In order to compare with UMD field data, simulations of a single muon were performed following the distributions on energy and zenith angle of the atmospheric muons. The simulated muons were also asked to satisfy the same condition of recontruction that is requested (for the binary channel) in the field. We will report on the status and recent developments.

T 13.9 Mon 18:05 Tm

Measurement of the ultrahigh-energy cosmic-ray composition using a Markov Chain Monte Carlo approach — •Olena Tkachenko for the Pierre Auger-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Germany

To understand the nature and to constrain the possible astrophysical sources of ultrahigh-energy cosmic rays (UHECRs) the determination of the mass composition is essential. One of the most sensitive observables to the cosmic-ray mass composition is the depth of atmospheric shower maximum, $X_{\max}$. The fractions of different mass groups can be estimated by comparing the $X_{\max}$ distributions, as measured by the Fluorescence Detector of the Pierre Auger Observatory, to the predictions obtained from air shower simulations.

In this talk we present an estimate of the mass composition from the $X_{\max}$ distribution with the Markov Chain Monte Carlo methods (MCMC). We test the performance of the algorithm on the simulated data with different benchmark mass composition scenarios and study the statistical properties of the outcome. Furthermore, we fit real data from the Pierre Auger Observatory and compare the estimated fractions with the previous results. The most important advantage of the MCMC mass composition analysis is the possibility to sample from the posterior distribution of the composition fractions. We will present the example applications like the average rigidity of cosmic rays as a function of energy.

T 14: Pixel detectors I

Time: Monday 16:00–18:15 Location: Tn

T 14.1 Mon 16:00 Tn

Development of MAPS in 65nm CMOS Imaging Technology — •Adriana Simancas, Simon Spannagel, Anastasiia Velyka, and Lennart Huth — Deutsches Elektronen-Synchrotron, Hamburg, Deutschland

Monolithic CMOS sensors have found their way through imaging technologies into High Energy Physics thanks to its multiple advantages in particle detection. Their main characteristic is the integration of the sensor and the readout in a single chip, which provides a reduction in production effort, costs and material. As part of the next generation of silicon pixel sensors that are usually employed as tracker and vertex detectors, a 65 nm CMOS sensor is being investigated at DESY. Device simulations (TCAD) are needed to develop the understanding of this technology and to obtain inputs for Monte Carlo simulations (Allpix^2). The outcomes of these simulations can give an important insight into performance parameters of the sensor, which will be tested in experiments later on. This contribution will present the latest developments

and simulation results of a 65 nm CMOS sensor.

T 14.2 Mon 16:15 Tn

Development of a Monolithic Pixel Sensor with sub-nanosecond Time Resolution in BiCMOS — Heiko Augustin[1], Ivan Peric[2], André Schöning[1], and •Benjamin Weinläder[1] — [1]Physikalisches Institut, Universität Heidelberg — [2]IPE, Karlsruher Institut für Technologie

In the field of particle physics, High Voltage Monolithic Active Pixel Sensors (HV-MAPS) are promising candidates to fulfil the high demands on spatial and time resolution of modern detectors. The Mu3e experiment with its development of the MuPix sensor has strongly driven this technology in recent years. By using a 180 nm HV-CMOS technology, a typical time resolution in the order of 5 ns was achieved. To improve this further, the combination of HV-MAPS with a BiCMOS process opens up further possibilities, which was proven in the scope of the TT-PET project at the university of Geneva (Y. Bandi *et al.* 2018 **JINST** 13 C01007).

Following this concept and based on the experience with developing the MuPix a subsequent R&D project was started, with the ambition to achieve a time resolution in the sub-nanosecond regime. For this purpose the BiCMOS technology SG13S from IHP is used, which offers great advantages for high-frequency circuits. Using Cadence Virtuoso® a small pixel layout with a size of $25 \times 25\,\mu\mathrm{m}^2$ was designed. Simulations with a signal corresponding to a MIP showed high performance with a ToA Jitter of $\sigma_{ToA} = 86\,\mathrm{ps}$ and an $ENC = 205\,\mathrm{e}^-$.

T 14.3 Mon 16:30 Tn

Study of current, capacity and thermal runaway of hadron-irradiated silicon sensors — Ingo Bloch[1], Heiko Lacker[2], •Felix Riemer[2], and Christian Scharf[2] — [1]Deutsches Elektronen-Synchrotron DESY — [2]Humboldt-Universität zu Berlin

Silicon sensors are widely used in HEP experiments for particle tracking and calorimetry. One of the problems silicon detectors are facing is the increase of leakage current due to radiation damage. Leakage currents generate considerable heat for large detectors. At the same time, the leakage current increases with increasing sensor temperature. Therefore, catastrophic thermal runaway can occur with accumulated radiation damage during service if the cooling performance falls short of the demands. In order to estimate the effects, capacitance and current of irradiated silicon diodes have been measured as a function of particle fluence, temperature, bias voltage, cooling power, and for different pad areas. The diodes were irradiated with 70 MeV/c protons and 1 MeV/c neutrons to equivalent fluences between 1E13 cm^{-2} and 5E16 cm^{-2}. A parametrization to describe the reverse current of highly irradiated silicon sensors and an analytical model for thermal runaway were used to estimate the critical parameters. A setup was built to confront the model with measurements within its validity range. Runaway was achieved and the existing analytical model was tuned using experimental data. The results can be applied to estimate the change of the heating power of silicon sensors in harsh radiation environments and the cooling infrastructure which is necessary to prevent thermal runaway in future ATLAS operation and other future detectors.

T 14.4 Mon 16:45 Tn

Evolution of currents in irradiated DEPFET sensors — •Marike Schwickardi[1], Ariane Frey[1], Benjamin Schwenker[1], Botho Paschen[2], Georgio Giakoustidis[2], and Harrison Schreeck[1] — [1]II. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Deutschland — [2]Physikalisches Institut Uni Bonn, Nußallee 12, 53115 Bonn

The Belle II experiment at the Japanese Super B-factory SuperKEKB has started data taking in early 2019, the peak luminosity will be ramped up to $8{\cdot}10^{35}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, which is 40 times higher than the previous luminosity at the Belle experiment, which was therefore upgraded with a new DEpleted P-channel Field Effect Transistor (DEPFET) based silicon pixel detector (PXD) for vertex detection. The silicon bulk, on which the field-effect transistors form the individual pixels, is biased by different voltages enabling bulk depletion, charge collection and charge removal.

Due to the much harsher environment, the radiation hardness of the equipped sensors in the PXD has to be well understood and is investigated. Especially, since during operation in the Belle II environment with only small neutron fluences, an increase in the bulk depletion current could be observed. Therefore, x-ray irradiation studies were conducted to investigate the current behaviour of the sensors. This talk will present observations on the sensor performance during an irradiation campaign with doses of up to 18.5 Mrad in the silicon oxide.

T 14.5 Mon 17:00 Tn

Characterization of a depleted monolithic active pixel sensor in 180 nm TowerJazz technology — Ivan Berdalovic[2], •Christian Bespin[1], Ivan Caicedo Sierra[1], Tomasz Hemperek[1], Toko Hirono[1], Fabian Hügging[1], Hans Krüger[1], Thanusan Kugathasan[2], Cesar Augusto Marin Tobon[2], Konstantinos Moustakas[1], Heinz Pernegger[2], Walter Snoeys[2], Tianyang Wang[1], Norbert Wermes[1], and Jochen Dingfelder[1] — [1]Physikalisches Institut, Universität Bonn — [2]CERN, Genf

The high-luminosity upgrade of the LHC (HL-LHC) imposes new requirements on the detectors. With the availability of highly resistive silicon in commercial CMOS processes, there are ongoing efforts to build depleted monolithic active pixel sensors (DMAPS) for high energy particle detectors. TJ-MonoPix is a prototype of such a pixel sensor in 180 nm TowerJazz technology. It is designed for usage in high-radiation environments such as the HL-LHC. The pixels with a small collection electrode design and pixel pitch of 36 um * 40 um are read out using a column-drain readout architecture.

In this talk, results from measurements with radioactive sources and in test beams will be presented. Furthermore, an overview of the ongoing work towards a future chip in this CMOS technology will be shown.

T 14.6 Mon 17:15 Tn

Inter-pixel resistance measurements of passive CMOS sensors — •Sinuo Zhang, David-Leon Pohl, Tomasz Hemperek, and Jochen Dingfelder — Physikalisches Institut, University of Bonn, Nussallee 12, 53115 Bonn, Germany

Using commercial CMOS chip fabrication lines, the so-called "passive CMOS" pixel and strip sensors have become an interesting alternative to standard planer sensors. To achieve and maintain a high spatial resolution for operating in HEP experiment facilities with high radiation levels, it is important to understand how the resistance between electrodes changes after irradiation for various implant geometries. We present results on the measurements of the inter-pixel resistance of n-on-p passive CMOS sensor test-structures fabricated in the LFoundry 150nm CMOS technology. The inter-pixel resistance of two types of test-structures: 1) p-stop isolation and 2) field plate between pixel implants, were evaluated by fitting the current-voltage behavior between a single pixel and the surrounding pixels. Results from the samples after 14MeV proton irradiation reveal a drop of the inter-pixel resistance for both types of the structures, with respect to the un-irradiated samples. An improvement of the inter-pixel resistance has been observed after applying appropriate voltages on the inter-pixel field plate.

T 14.7 Mon 17:30 Tn

Radiation hardness and development of a large electrode DMAPS design in a 150 nm CMOS process — •Ivan Caicedo, Christian Bespin, Jochen Dingfelder, Tomasz Hemperek, Toko Hirono, Fabian Hügging, Hans Krüger, Piotr Rymaszewski, Tianyang Wang, and Norbert Wermes — Physikalisches Institut, Universität Bonn. Bonn, Germany.

Monolithic CMOS active pixel sensors in depleted substrates (DMAPS) are an attractive development for pixel tracker systems in high-rate collider experiments. The radiation tolerance of these devices is enhanced through technology add-ons and careful design, which allow them to be biased with large voltages and collect charge through drift in highly resistive silicon bulks.

LF-Monopix1 is the first DMAPS with a fully functional column-drain readout architecture. It was designed in a 150 nm CMOS process that made it possible to place and isolate each pixel's front-end circuitry within a charge collection electrode of a size comparable to the pixel area. This talk will summarize the chip performance and focus on its radiation hardness. Measurements on irradiated samples showed an in-time detection efficiency of $\sim 97\%$ after a NIEL dose of $1 \times 10^{15} n_{eq}/cm^2$. In addition, their gain did not degrade and their noise increased by 25% after a TID dose of 100 MRad from X-rays.

In the end, an overview and initial test results of the new prototype chip LF-Monopix2 with increased column length, reduced pixel pitch and design changes motivated by measurement results will be given.

T 14.8 Mon 17:45 Tn

CAD Simulation and Testbeam characterization studies of High-Voltage Monolithic Active Pixel Sensors — •Annie Meneses Gonzalez on behalf of the HV-MAPS consortium

— Physikalisches Institut, Universität Heidelberg

Modern particle physics experiments set high requirements on the sensor technologies for their tracking detectors. High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) are ideal for tracking low momentum particles at very high rates. This technology has been chosen as the baseline for the Mu3e Pixel Tracker and is under study for application in future detectors for PANDA, P2, CLIC, and LHCb.

In this talk, an HV-MAPS engineering run developed within the HV-MAPS consortium will be presented. The results include sensors manufactured by TSI Semiconductors, implemented in a commercial 180-nm High-Voltage CMOS process, with different pixel sizes and in-pixel electronic. Technology Computer Aided Design (TCAD) simulations and testbeam campaigns at DESY are used to characterize the sensors, aiming for a comprehensive understanding of their characteristics

T 14.9 Mon 18:00 Tn

Radiation tolerant small-pixel passive CMOS sensors with RD53A readout — •Yannick Dieter, Michael Daas, Tomasz Hemperek, Fabian Hügging, Jens Janssen, Hans Krüger, David-Leon Pohl, Tianyang Wang, Norbert Wermes, Pascal Wolf, and Jochen Dingfelder — Physikalisches Institut der Universität Bonn

With the HL-LHC upgrade of the ATLAS detector, the surface of the ATLAS pixel detector will increase from 2 m^2 to approximately 13 m^2. Therefore, commercial CMOS processing lines offering high production throughput at comparatively low costs represent an attractive option for such large-area detectors. Further benefits originate from multiple metal layers, metal-insulator-metal capacitors, and polysilicon layers which offer enhanced sensor designs through additional routing options.

Thinned, small-pixel passive CMOS sensors in 150 nm technology offered by LFoundry were manufactured and assembled to hybrid pixel modules using the RD53A readout chip.

The sensors were characterized, before and after irradiation to fluences of $5\times10^{15}n_{eq}/cm^2$ and $1\times10^{16}n_{eq}/cm^2$, in the laboratory and also using a minimum ionising electron beam. Their performance in terms of noise and hit-detection efficiency equals that of conventional planar pixel sensors. Special emphasis will be put on the results after a fluence of $1\times10^{16}n_{eq}/cm^2$ yielding a hit-detection efficiency of approximately 99 %.

T 15: Experimental methods I

Time: Monday 16:00–18:30 Location: To

T 15.1 Mon 16:00 To

Simulation of background reduction in KATRIN via induced de-excitation of Rydberg atoms with terahertz radiation — •Enrico Ellinger for the KATRIN-Collaboration — University of Wuppertal

A major background in the neutrino mass experiment KATRIN is supposed to originate from the ionization of Rydberg atoms within the main spectrometer (MS) volume. In Rydberg atoms one or more electrons have a high principal quantum number n resulting in a large orbital radius and long decay periods in the ms range. Once produced by radioactive processes in the surface of the MS vessel wall the neutral Rydberg atoms can travel through the whole MS before they get ionized by thermal radiation and finally accelerated towards the main detector producing the background. Terahertz radiation can be used to stimulate $\Delta n = \pm1$ transitions to states from where spontaneous de-excitation to ground state is faster (μs range). This approach was pioneered by the anti-hydrogen community at CERN. However, due to the very different environment in comparison to atomic trap experiments the feasibility at KATRIN must be examined. This study is presented as well as the first draft of an experimental set-up for testing this new method.

T 15.2 Mon 16:15 To

Investigating the reduction in Rydberg Background — •Shivani Ramachandran for the KATRIN-Collaboration — Bergische Universitaet Wuppertal, Wuppertal, Germany

The KArlsruhe TRItium Neutrino experiment (KATRIN) is aimed at measuring the effective mass of the electron-antineutrino with a sensitivity of 0.2 eV/c2. This will be achieved by inspecting the endpoint of the beta-electron spectrum of Tritium. There are many known contributors to the background in the measured signal of the KATRIN experiment. The most dominant background source are the electrons produced by thermal ionization of Rydberg atoms which are highly excited atoms with large principal quantum numbers. In this talk the methods of de-excitation of the Rydberg atoms will be discussed and a mechanism for the same to the ground state in the KATRIN main spectrometer will also be investigated. THz and or microwave radiation allows for stimulated de-excitation hence reducing the lifetime of Rydberg atoms. This approach was pioneered by the anti-hydrogen community at CERN. The irradiative power needed for de-excitation and its efficiency will also be studied.

T 15.3 Mon 16:30 To

Angular selective detection of electrons with a microchannel plate detector — •Patrick Oelpmann, Kevin Gauda, Volker Hannen, Tim König, Alexey Lokhov, Hans-Werner Ortjohann, and Christian Weinheimer — Institut für Kernphysik, Münster, Deutschland

The Karlsruhe Tritium Neutrino Experiment (KATRIN) aims at determining the electron neutrino mass with a sensitivity of $0.2\,eV/c^2$ from a precision measurement of the tritium β-decay spectrum. The analysis of the first science run allowed to set a new upper limit of $1.1\,eV/c^2$ at 90 % confidence level.

To reach the target sensitivity an ultra-low background is a key requirement. However, currently the background in KATRIN exceeds its design value, creating demand for new techniques of background reduction. To this end, several background suppression methods have been proposed or have already been implemented. A promising idea is to make use of the different angular distribution of electrons produced in tritium β-decay compared to those produced by the dominant background mechanism, which is ionization of Rydberg states in the volume of the KATRIN main spectrometer. The talk will focus on first tests of angular selective detection of electrons with microchannel plate detectors.

This project is supported by BMBF under contract number 05A20PMA.

T 15.4 Mon 16:45 To

VAE-WGAN and Fast simulation of Electromagnetic Calorimeter Responses — •Jubna Irakkathil Jabbar[2], Günter Quast[2], Florian Bernlochner[1], and Pablo Goldenzweig[2] — [1]University of Bonn, Germany — [2]Karlsruhe Institute of Technology, Germany.

The simulation of particle showers in electromagnetic calorimeters with high precision is a computationally expensive and time consuming process. Fast simulation of particle showers using generative models have been suggested to significantly save computational resources.In this study, the energy responses of electromagnetic calorimeter for electrons and pion showers are used to train a deep learning generative model.The model is a combination of Wasserstein GAN and Variational Autoencoder.Once the model is trained, the generator of the model is used to generate particle shower simulations providing noise vectors as input.The generated particle showers are cross-checked with the Geant4 showers using various observables.

T 15.5 Mon 17:00 To

The Acoustic Module for the IceCube Upgrade — •Christoph Günther, Jürgen Borowka, Dirk Heinen, Andreas Nöll, Maximilian Scharf, Lars Steffen Weinstock, Christopher Wiebusch, and Simon Zierke for the IceCube-Collaboration — RWTH Aachen University - Physics Institute III B, Aachen, Germany

One major goal of the IceCube Upgrade is improved calibration by deploying additional calibration devices in the center of IceCube. Amongst these devices are ten stand-alone Acoustic Modules, capable of receiving and sending acoustic signals. By trilateration, these will provide a position calibration of the sensor strings with a resolution of about 10 cm. Additionally, glaciological measurements of the

acoustic ice properties are planned. In view of the future IceCube-Gen2 detector, this system will provide an important proof of principle for the reliable position determination on distance scales of a few hundred meters. The design of the modules and the status of the development are presented in this talk.

T 15.6 Mon 17:15 To

Ppm precise high voltage: Advanced post regulation and absolute calibration — •Caroline Rodenbeck[1], Thomas Thümmler[2], and Sascha Wüstling[3] — [1]Institut für Kernphysik, WWU Münster — [2]IKP, Karlsruher Institut für Technologie — [3]IPE, Karlsruher Institut für Technologie

The Karlsruhe Tritium Neutrino (KATRIN) has started data taking to determine the neutrino mass using tritium beta decay spectroscopy. Use of a MAC-E filter type spectrometer enables a precise measurement of the spectrum's endpoint region. For KATRIN to reach its neutrino mass sensitivity target of $0.2\,\mathrm{eV/c^2}$ (90% C.L.), the spectrometer's retarding potential needs to be stable within 60 mV. This requires the system that creates the retarding potential as well as the system that measures it to be stable within 3 ppm at -18.6 kV on a wide range of time scales, from several months down to 1 μs (1 MHz).

Measuring the retarding potential at the ppm level is done using custom-built high-voltage dividers. Their stability has been proven with a variety of calibration methods over more than a decade. More recently, an absolute calibration technique with 1 ppm precision is being used to perform on-site calibrations. The advanced post regulation system – a feedback loop between the post regulation and one of the precision high-voltage dividers – stabilizes the high voltage on a sub-ppm level for time scales down to 1 us.

The talk presents the absolute calibration method and the advanced post regulation system. This project is supported by BMBF under contract number 05A20PMA and HGF.

T 15.7 Mon 17:30 To

Compton Scanner Messungen an Germaniumdetektoren — •Felix Hagemann für die GeDet-Kollaboration — Max-Planck-Institut für Physik, München

In der Grundlagenforschung werden Germaniumdetektoren z.B. bei der Suche nach neutrinolosem Doppelbetazerfall oder dunkler Materie verwendet. In vielen dieser Experimente ist das bestmögliche Verständnis der Physik und der Pulsentstehung in diesen Detektoren essentiell. Seit Mitte 2019 betreibt die GeDet Gruppe am Max-Planck-Institut für Physik einen Compton Scanner zur Untersuchung von Germaniumdetektoren. In diesem vollständig automatisierten Aufbau wird der zu untersuchende Detektor mit 662 keV Photonen einer kollimierten Caesiumquelle bestrahlt. Im Germanium Compton gestreute Photonen werden in einer nahe platzierten CdZnTe Kamera absorbiert. Mit Hilfe der jeweils deponierten Energien und der Position des gestreuten Photons in der Kamera kann die jeweilige Position der Streuung im Germanium rekonstruiert werden. Die gemessenen Pulsformen können so ihren Entstehungspunkten zugeordnet werden. Das ermöglicht, die Signale über das gesamte Volumen hinweg kontrolliert auf Einflüsse von Kristallachsen, Betriebsspannung und Temperatur zu untersuchen. Dies kann im Vergleich mit Simulationsergebnissen dabei helfen, Ladungsträgerbeweglichkeiten und Raumladungsdichten in Germaniumdetektoren besser zu verstehen. Erste Ergebnisse für einen vierfach segmentierten p-Typ Broad Energy Germaniumdetektor werden präsentiert und mit Simulationen des Softwarepakets `SolidStateDetectors.jl` verglichen.

T 15.8 Mon 17:45 To

Gas cooling of test masses for future gravitational-wave observatories — Christoph Reinhardt[1], •Alexander Franke[2], Jörn Schaffran[1], Roman Schnabel[2], and Axel Lindner[1] — [1]Deutsches Elektronen Synchrotron (DESY), 22607 Hamburg, Germany — [2]Institut für Laserphysik und Zentrum für Optische Quantentechnologien der Universität Hamburg, Hamburg, Germany

Recent observations made with Advanced LIGO and Advanced Virgo have initiated the era of gravitational-wave astronomy. The number of events detected by current observatories is partially limited by noise arising from temperature-induced position fluctuations of the test mass mirror surfaces used for probing space time dynamics. Future gravitational-wave observatories address this limitation by using cryogenically cooled test masses; current approaches for continuously removing heat (resulting from absorbed laser light) rely on black-body radiation or conduction through suspension fibers.

We investigate cooling via helium gas impinging on the test mass in the free molecular flow regime and develop a relation between gas-induced cooling power and corresponding added observatory strain noise. The application of our analytical models and numerical simulations is presented with regard to the conceptual design of the Einstein Telescope.

T 15.9 Mon 18:00 To

LUXE: A new experiment to study non-perturbative QED in e^--LASER and γ-LASER collisions — Oleksandr Borysov[1], Maryna Borysova[1], John Hallford[1,2], Beate Heinemann[1,3], Louis Helary[1], Marius Hoffmann[1], •Ruth Jacobs[1], Jenny List[1], Rajendra Prasad[1], and Matthew Wing[1,2] — [1]Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany — [2]University College London, London, United Kingdom — [3]Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

The LUXE experiment (LASER Und XFEL Experiment) is a new experiment in planning at DESY Hamburg using the electron beam of the European XFEL. LUXE is intended to study collisions between a high-intensity optical LASER and 16.5 GeV electrons from the XFEL electron beam, as well as collisions between the optical LASER and high-energy secondary photons. The physics objective of LUXE are processes of Quantum Electrodynamics (QED) at the strong-field frontier, where the electromagnetic field of the LASER is above the Schwinger limit. In this regime, QED is non-perturbative. This manifests itself in the creation of physical electron-positron pairs from the QED vacuum, similar to Hawking radiation from black holes. LUXE intends to measure the positron production rate in an unprecedented LASER intensity regime. This group report gives an overview of the LUXE experimental setup and its context within the field of high-intensity particle physics. The foreseen detector systems and their sensitivity are presented. Finally, the prospects of a modified LUXE setup for studying BSM physics are discussed.

T 15.10 Mon 18:15 To

Surface cleaning for background reduction and its influence on liquid xenon TPC performance — •Natascha Rupp[1], Dominick Cichon[1], Florian Joerg[1], Teresa Marrodan Undagoitia[1], and Stefan Bruenner[2] — [1]Max-Planck-Institut fuer Kernphysik, Heidelberg — [2]NIKHEF, Amsterdam

One main challenge in the direct detection of dark matter particles with liquid xenon TPCs (Time Projection Chambers) is the background reduction to a minimal rate. The plate-out of Rn222 daughters on the surfaces in contact with the liquid xenon can cause background events. We investigated different cleaning procedures that mitigate this background source. In order to apply them in future TPCs like DARWIN it has to be verified that they don't affect the xenon purity which strongly influences the signal production and hence the discrimination power of signal and background. This talk presents different cleaning procedures for PTFE and shows results of the xenon purity evolution after applying a strong nitric acid treatment to the PTFE surface of a TPC.

T 16: Cosmic Rays V

Time: Monday 16:00–18:15 Location: Tp

T 16.1 Mon 16:00 Tp

Turbulence level dependent investigation of the cosmic ray diffusion coefficient — •Leander Schlegel[1,2], Patrick Reichherzer[1,2,3], Julia Becker Tjus[1,2], Lukas Merten[4], Antonius Frie[1,2], Björn Eichmann[1,2], Moritz Püschel[5], and Ellen Zweibel[6] — [1]RuhrUniversity Bochum, Theoretical Physics IV — [2]Ruhr Astroparticle and Plasma Physics (RAPP) Center — [3]Irfu, CEA Paris-Saclay — [4]Institute for Astro-& Particle Physics, University of Innsbruck — [5]Dutch Institute for Fundamental Energy Research, 5612 AJ Eindhoven, The Netherlands — [6]Department of Astronomy & Physics, University of WisconsinMadison

Understanding the transport of energetic cosmic rays belongs to the

most challenging topics in astrophysics. The complicated evolution of the cosmic-ray distribution can be modeled mathematically by a diffusive process in the limit of large times. Consequently, diffusion is of fundamental importance in the transport of cosmic rays through turbulence. We show that at turbulence levels b/B above 5% of the total magnetic field, the approximation of an energy dependence E^(1/3) as predicted for a Kolmogorov spectrum within Quasi-Linear Theory does not hold. Different energy regimes also lead to specific diffusive behaviour, especially for low energies magnetic mirroring could have a relevant influence on the diffusion. Using a gridless synthetic turbulence model, we therefore investigate the diffusion coefficients behaviour in more detail dependent on E and b/B.

T 16.2 Mon 16:15 Tp

Diffusion of cosmic rays in plasmoids of AGN jets - implications for multimessenger predictions — •Marcel Schroller, Julia Becker-Tjus, Mario Hoerbe, Ilja Jaroschewski, and Patrick Reichherzer — Ruhr-University Bochum,44780 Bochum, Germany

Active Galactic Nuclei (AGN), and the accompanied AGN jets, are one of the most fascinating and luminous objects in the observable Universe. Both the active cores and their jets are candidates for the engine of cosmic rays and neutrinos with the highest energies measured at Earth. A deep understanding of the processes related to jets will not only fuel the field of high energy cosmic rays, it will give insights in fundamental plasma, astro, and particle physics. The physical and mathematical modelling of an AGN jet is challenging, with ambiguous signatures that need to be understand by numerical simulations of cosmic-ray transport and interaction. Based on the work of Hoerbe et al. (MNRAS 2020), a simulation framework for hadronic constituents and their interactions inside of a plasmoid, propagating along the AGN jet axis, was made. The final goal of the simulation is to give predictions in context of multimessenger astrophysics. This talk will answer one of the preceding questions, namely at which point the propagation of cosmic rays inside the plasmoid is diffusive or ballistic. The solution of the telegraph equation in this context will be presented and analysed, alongside a scheme for the classification of different astrophysical regions. A first excerpt of the results will be given, as well as a run time analysis of the full 24-dimensional parameter space of the setup.

T 16.3 Mon 16:30 Tp

Propagation in the Galactic magnetic field: Effects on the spectrum, composition, and anisotropy of Galactic and extragalactic cosmic rays * — •Alex Kääpä, Eric Mayotte, and Karl-Heinz Kampert — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal

In the energy range signifying the transition from Galactic to extragalactic cosmic rays (GCRs and EGCRs), current cosmic ray source and propagation models fail to describe the observed flux above PeV energies. This is partly due to the complicated effects the Galactic magnetic field (GMF) imposes on both GCRs and EGCRs, as the propagation regime of cosmic rays in the GMF transitions from diffusive to ballistic. At the lowest rigidities, near the end of the diffusive regime, GCRs are trapped in, and EGCRs are effectively shielded from the Galaxy. At intermediate rigidities, the EGCRs that reach the Galaxy and the GCRs are concentrated in the Galactic plane where they propagate diffusively. At highest rigidities, particles are hardly affected by the GMF. In this talk, we present the consequences of these propagation effects on the spectrum, composition, and anisotropy of both GCRs and EGCRs based on CRPropa simulation. Special focus will given on how these results may help elucidate the missing predicted flux in the transition region.

**Supported by the BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A17PX1).*

T 16.4 Mon 16:45 Tp

When heavy ions meet cosmic rays : potential impact of QGP formation on the muon puzzle — •Tanguy Pierog[1], Sebastien Baur[2], Hans Dembinski[3], Matias Perlin[1], Ralf Ulrich[1], and Klaus Werner[4] — [1]KIT, IAP, Karlsruhe, Germany — [2]Université Libre de Bruxelles, Belgium — [3]Experimentelle Physik 5, TU Dortmund — [4]SUBATECH, Nantes, France

The deficit of muons in the simulation of extensive air showers is a long standing problem and the origin of large uncertainties in the reconstruction of the mass of the high energy primary cosmic rays. Hadronic interaction models, re-tuned after early LHC data, have a more consistent description of the muon content among them but still disagree with data. Collective hadronization due to the formation of a quark gluon plasma (QGP) has already been studied as a possible cause for a larger production of muons under extreme conditions (rare, very central nuclear interactions), but without real success. However, in the view of the most recent LHC data, a collective hadronization phase might not be limited to such extreme conditions. And because of its different ratio of electromagnetic to hadronic energy, a QGP may have the properties to solve the muon puzzle. It is demonstrated using a theoretical approach and tested in a realistic way by the modification of hadronic model spectra in CONEX to mimic the production of a QGP also in not so extreme conditions with a possible large impact on air shower physics.

T 16.5 Mon 17:00 Tp

Status of air shower simulation for GRAND — •Chao Zhang, Tim Huege, Tanguy Pierog, Markus Roth, Andreas Haungs, Frank Schroeder, and Ralph Engel for the GRAND-Collaboration — Institut fuer Astroteilchenphysik, Karlsruher Institut fuer Technologie-Campus Nord, Post-fach 3640, 76021 Karlsruhe, Germany

GRAND is a proposed project to measure ultra-high-energy air showers with a 200,000 km ^{2} array of radio antennas distributed in mountainous areas. It will be able to detect cosmic ray, gamma-ray, and neutrino primaries in the energy range beyond 10^{17} eV with unprecedented sensitivity and thereby opening a window to study the origin of the ultra-high-energy cosmic rays. Further more, it will play an important role in the multi-messenger era.

In this talk, we will present simulation work aimed at GRAND-Proto300, a prototype of GRAND, covering an area of 300 km ^{2}, for which construction will start in 2021. This presentation will include a study of the atmospheric models applicable to different candidate sites, the methods we have implemented to prepare an air shower library, upgrades of CORSIKA for the simulation of upward going neutrinos for GRAND, and the investigation of a signal model derived from CoREAS simulations.

T 16.6 Mon 17:15 Tp

Efficiency and aperture estimation of the Tunka-Rex array — •Vladimir Lenok for the Tunka-Rex-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Germany

Sparse digital-antenna arrays are a promising technique for the future large-scale observatories of cosmic rays and neutrinos. However, estimation of the efficiency of these instruments is challenging. The efficiency depends on the zenith and azimuth angles. Monte-Carlo simulations of the radio emission of cosmic-ray air showers, which are usually the main tool in assessment of an instrument performance, are computationally intensive. We developed a phenomenological model for the estimation of the detection efficiency. The model is based on a parametrization of the air-shower radio footprint and includes a probabilistic treatment of both, the signal detection by an individual antenna and the shower detection. Currently, the model is under validation against Monte-Carlo simulations and the observational data of the Tunka-133 air-Cherenkov array. We use the model in application to the Tunka-Rex instrument — a radio-antenna array operated on the site of TAIGA (the Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy). However, the developed model can be applied to any radio antenna array. In the talk we will present the recent updates of the model development and the results of the validation.

T 16.7 Mon 17:30 Tp

Towards the Energy Spectrum of Cosmic-Rays using Atmospheric Stopping Muons in IceCube — •Janina Bolles for the IceCube-Collaboration — TU Dortmund, Germany

In the IceCube neutrino observatory the main type of detected events are muons being produced by cosmic-ray particles interacting with the earth's atmosphere. In the context of neutrino analyses these muons are the dominating background, though in case of cosmic-ray physics the energy losses of the muons within the detector can be used as an indicator to reconstruct the cosmic-ray energy spectrum.

In this work muon events stopping inside the detector are selected, due to the possibility to reconstruct the range to the muons stopping point as a proxy for its energy. This approach takes advantage of the high statistics of atmospheric muons, so strict cuts on the reconstruction can be applied to obtain an event sample of single muons with high resolution. The reconstructed range of the muons can later be used to estimate the cosmic ray energy spectrum. This talk covers the early stage of the analysis and an overview over the analysis methods

and goals is given.

T 16.8 Mon 17:45 Tp

Towards an Energy Spectrum Using the Depth Dependence of Stopping Atmospheric Muons in IceCube — •Lucas Witthaus for the IceCube-Collaboration — Technische Universität Dortmund

The IceCube Neutrino Observatory, located in the Antarctic ice sheet near the geographic South Pole, is meant to detect neutrinos with energys up to a few PeV. However, the majority of recorded events in IceCube is caused by muons from atmospheric air showers. Those events pose as background for neutrino observations, but are particulary suitable to study the underlying cosmic ray spectrum.

This work aims to reconstruct the muon energy spectrum from the depth-dependence of the stopping muon events. The propagation length of these muons is a direct proxy to their surface energy. First steps towards such a data set using deep neural networks and machine learning techniques are presented.

T 16.9 Mon 18:00 Tp

Calibration of the Data Acquisition System of the IceCube Surface Array Enhancement — •Ömer Nuhoglu, Andreas Haungs, Bernd Hoffmann, Marie Oehler, and Andreas Weindl for the IceCube-Collaboration — KIT, Karlsruhe, Germany

IceTop, the surface array of the IceCube Neutrino Observatory, will be enhanced with hybrid stations within the current footprint, which will increase the detection sensitivity of cosmic rays significantly. Each station consists of eight scintillation detectors and three radio antennas, which are read out by a custom designed central hybrid data acquisition system (DAQ). The detectors consist of organic scintillators, wavelength shifting optical fibers and silicon photomultipliers (SiPM). The analog signals of the SiPM are integrated and digitized inside the detectors and then transferred to the central DAQ.

Since the signal of the SiPM depends on the applied voltage and the temperature, calibration measurements are needed to ensure the stability of the voltage and the reliability of the temperature sensor in the detector. Additionally, the integration of the SiPM signals needs to be characterized. In this contribution the methods and results of these calibration measurements will be presented.

T 17: Neutrino Astronomy I

Time: Monday 16:00–18:35 Location: Tq

Group Report T 17.1 Mon 16:00 Tq

KM3NeT: Status, results and science goals — •Matthias Bissinger for the ANTARES-KM3NeT-Erlangen-Collaboration — Erlangen Centre for Astroparticle Physics, Erwin-Rommel-Str. 1, 91058 Erlangen, Germany

The research infrastructure KM3NeT is currently under construction off shores of France and Italy. The two main objectives of KM3NeT are investigating fundamental aspects of neutrino physics as well as the discovery and analysis of the most powerful cosmic accelerators via their neutrino signal. The deep-sea Cherenkov detectors, ORCA and ARCA, consist of technically identical detector modules but with different instrumentation densities. KM3NeT/ORCA will allow us to determine the oscillation probabilities of GeV-scale neutrinos produced in Earth's atmosphere and thus to constrain the neutrino mass hierarchy. KM3NeT/ARCA's instrumented sea volume of one cubic kilometer is much larger compared to ORCA. ARCA will detect neutrinos of energies from TeV to beyond PeV and thus of galactic origin and way beyond. Combined with the existing neutrino telescopes KM3NeT will complete our neutrino field of view to the full sky. The talk will summarise the current construction status of KM3NeT, the results achieved by investigating the data recorded over the past years, and the scientific discovery potential of the upcoming years.

T 17.2 Mon 16:20 Tq

Studying optical water properties with atmospheric muon events in KM3NeT/ORCA — •Martin Schneider for the ANTARES-KM3NeT-Erlangen-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

The KM3NeT neutrino detectors are currently under construction in the deep Mediterranean Sea. ORCA, the low-energy part of KM3NeT, is an underwater Cherenkov neutrino detector featuring a dense configuration of optical modules designed for the measurement of atmospheric neutrinos down to the low GeV energy regime. A very large sample of atmospheric muon events has already been recorded and can be used to study the detector performance. Located in a deep-sea environment, the detector performance depends on the optical water properties.

In this talk, atmospheric muon events are used to study the optical water properties with the ORCA detector. The focus is on the comparison between data and Monte-Carlo simulations with respect to the attenuation length.

T 17.3 Mon 16:35 Tq

Modeling Deep-Sea Bioluminescence — •Stephan Meighen-Berger[1] and Li Ruohan[2] — [1]Technische Universität München, James-Franck-Straße, 85748, Garching — [2]Ludwig-Maximilians-Universität München, Schellingstraße 4, 80799, München

We present a new modeling framework for simulating deep-sea organisms and their luminescence which is detectable by neutrino detectors, such as KM3Net, Antares, and P-ONE. This bioluminescence light is a unique background for deep-sea instruments, due to the emission spectra covering the expected Cherenkov peak. The emission itself is predominantly caused by the organisms' defensive response to turbulences caused by detectors' super-structures. Designed for a broad range of Reynold's numbers, the framework employs Monte Carlo methods to model individual organisms. It provides methods to solve the underlying Navier-Stokes equation, using Streamline Upwind Petrov Galerkin Method in the velocity equation to avoid instabilities. In this talk, we present the framework, lessons learned from this new exact modeling scheme, and unique signatures that can be used to identify the organisms, bridging the gap between physics and biology.

T 17.4 Mon 16:50 Tq

The Pacific Ocean Neutrino Experiment: site qualification — •Immacolata Carmen Rea and Christian Fruck — TUM Physics Department, Munich, Germany

The Pacific Ocean Neutrino Experiment (P-ONE) is a collaboration of Ocean Networks Canada (ONC), the Technical University of Munich (TUM), Germany, and other US and Canadian universities, with the goal of building a large volume neutrino telescope at 2600 m depth in the Cascadia Basin site (a heavily sedimented abyssal plain region 300 km west from Vancouver Island in the northern Pacific Ocean). Two pathfinder experiments have already been deployed there: STRAW (STRings for Absorption length in Water) in 2018 and STRAW-b in 2020. The main purpose of both is the optical qualification of the site placing a special focus on the absorption and scattering length measure and on the light background, mainly caused by bioluminescence phenomena.

STRAW is composed by a two strings array equipped with pulsed light sources, 3 POCAMs (Precise Optical CAlibration Modules) that are also under development for IceCube upgrade, and with custom developed light sensors, 5 sDOMs (STRAW digital Optical Modules). With this setup the light attenuation has been probed on different baselines and background rates have been recorded in several sensors over almost 2 years. We present the preliminary results of this first pathfinder mission and discuss the implications for a future neutrino telescope at this site.

T 17.5 Mon 17:05 Tq

The Pacific Ocean Neutrino Experiment: STRAW-b as a pathfinder — •Eva Laura Winter, Christian Spannfellner, and Elisa Resconi — Technische Universität München, Germany

The Pacific Ocean Neutrino Experiment (P-ONE) is a collaboration of Ocean Networks Canada (ONC), the Technical University Munich (TUM) and other Canadian/German institutes with the aim of building a large-scale neutrino telescope in the Northeast Pacific Ocean. Two pathfinders have been developed and successfully deployed, as part of the NEPTUNE observatory, established by ONC, at Cascadia Basin, which will also host P-ONE. The first pathfinder STRAW

(STRings for Absorption length in Water) was deployed in June 2018 and has measured the optical properties of the deep Pacific Ocean. Moreover, it is also monitoring the in-situ background rates due to K40 decay and bioluminescence. Subsequently, the second pathfinder STRAW-b, deployed in September 2020, aims to further characterize the deployment site. For this, it is equipped with six specialized modules, two LiDARs, three spectrometers and one muon tracker. The talk covers technical details and will give an overlook of preliminary results of the pathfinders.

T 17.6 Mon 17:20 Tq

The Pacific Ocean Neutrino Experiment: the prototype line — Elisa Resconi and •Christian Spannfellner — Technische Universität München

The Pacific Ocean Neutrino Experiment (P-ONE) is a Canadian/German initiative, which aims to construct a new large volume astrophysical neutrino detector in the Northeast Pacific Ocean. P-ONE strives to complement the sky coverage of the existing or under development neutrino telescopes, as such it will be part of the NEPTUNE observatory, established by Oceans Networks Canada (ONC). This deepsea infrastructure provides power and data streams for various experiments. At the Cascadia Basin node, which will host P-ONE, two pathfinders were already initiated to characterize the site. The P-ONE prototype line, currently in its early concept phase, is planned as the successor of the pathfinders and will be the first installment of the P-ONE detector. The line will be comprised of P-ONE Digital Optical Receivers (P-DOR) to detect the emerging Cherenkov radiation and P-ONE Calibration Modules (P-CAL) to provide in-situ calibration. We will present the concepts of the planned optical sensors and calibration modules and give an outlook on the entire mooring.

T 17.7 Mon 17:35 Tq

PLEnuM: Prospects of a planetary neutrino observatory system — •Matthias Huber and Elisa Resconi — Technische Universität München, Fakultät für Physik, James-Franck-Str. 1, 85748 Garching, Deutschland

High-energy neutrinos, arriving at the Earth from the farthest reaches of the cosmos have long been thought to hold the key to resolving the cosmic ray riddle. While the first compelling evidence for a correlation between high-energy neutrinos and the blazar TXS 0506+056 was found in 2018, no sources of these neutrinos have been discovered yet. To bring rapid improvements in the sensitivity of cosmic neutrino studies, we propose to launch the Planetary Neutrino Monitoring System (PLEnuM). The concept of PLEnuM is based on the vision to operate a global-scale neutrino telescope network, integrating all neutrino telescopes in progress (KM3NeT, GVD, P-ONE, IceCube). By means of this collaboration, every direction of the Universe becomes observable with local improvements of the sensitivity of factors up to ~160 compared to IceCube. In this talk, I will outline the prospects of cosmic neutrino source searches on the basis of PLEnuM.

T 17.8 Mon 17:50 Tq

Development of an in-situ calibration device of ice properties for high-energy neutrino radio detectors in Antarctica — •Jakob Beise — Uppsala Universitet, Uppsala, Sweden — Humboldt Universität, Berlin, Germany

High-energy neutrino astronomy has become a powerful tool to explore the most extreme environments in our universe. High energy neutrinos ($E>10^{16.5}$ eV) are detected most efficiently via the Askaryan effect in ice, where a particle cascade induced by the neutrino interaction produces coherent radio emission. There are several pilot radio arrays at the moment, among them ARIANNA at the Ross Ice Shelf. In order to reconstruct the neutrino energy with high precision, the snow accumulation must be monitored in real time. Therefore, one ARIANNA station was extended with a radio emitter that allows the measurement of the snow accumulation with unprecedented precision. I will present 14 months of measured data that I analyzed using traditional and deep-learning techniques. Furthermore, I show how the measurement setup can be extended to also measure the change of the index-of-refraction with depth, another property relevant for reconstruction of the neutrino direction and energy.

T 17.9 Mon 18:05 Tq

Seasonal Variations of the Atmospheric Neutrino Flux Measured by IceCube — •Hannah Erpenbeck, Jakob Böttcher, Philipp Fürst, Simon Hauser, Jöran Stettner, and Christopher Wiebusch for the IceCube-Collaboration — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Atmospheric muon neutrinos measured by the IceCube Neutrino Observatory originate from charged meson decays in cosmic-ray-induced air showers. The meson production and decay depend on the local atmospheric conditions. Therefore, one expects a correlation between the atmospheric temperature and the observed atmospheric neutrino flux. We have analyzed almost 6 years of IceCube neutrino data in conjunction with global atmospheric temperature profiles measured by the Atmospheric Infrared Sounder (AIRS) on the AQUA satellite, and the correlation is observed with high significance. In this talk, we present a binned χ^2 and an unbinned likelihood analysis of the correlation with focus on systematic checks of the results.

T 17.10 Mon 18:20 Tq

Seasonal Variations of the Unfolded Atmospheric Neutrino Energy Spectrum with IceCube — •Karolin Hymon and Tim Ruhe for the IceCube-Collaboration — TU Dortmund

The IceCube Neutrino Observatory is a detector array at the South Pole, with the central aim of studying high energy neutrinos of astrophysical origin. The majority of the detected neutrinos, however, are atmospheric neutrinos, caused by cosmic ray interactions in the atmosphere. The rate of atmospheric neutrinos undergoes a seasonal variation with indications that the rate changes with the temperature in the stratosphere. Possible implication of this variation on the shape of the atmospheric neutrino spectrum have not been studied so far. This talk will focus on the investigation of possible shape changes of the atmospheric neutrino spectrum, which will be analyzed using the Dortmund Spectrum Estimation Algorithm (DSEA).

T 18: Neutrino physics without accelerators I

Time: Monday 16:00–18:20 Location: Tr

Group Report T 18.1 Mon 16:00 Tr

The Project 8 neutrino mass experiment: First tritium results and future prospects — •Christine Claessens and Sebastian Böser for the Project 8-Collaboration — PRISMA+ Cluster of Excellence, JGU Mainz

The Project 8 collaboration aims for a direct measurement of the absolute neutrino mass scale from the distortion of the tritium decay spectrum near the endpoint. To this end, the collaboration has successfully established Cyclotron Radiation Emission Spectroscopy (CRES), a frequency-based approach for measuring differential beta decay spectra. By making use of the advantages of the CRES technique, Project 8 intends to overcome the statistical and systematic limitations of current-generation direct neutrino mass measurement methods and achieve a final sensitivity of 40 meV. To meet this goal, the collaboration has divided the development of the experiment into four phases with Phase II data collection completed in 2020. In this contribution I will report on the status and prospects of the Project 8 experiment, presenting the results of the first tritium spectrum recorded with the Phase II CRES prototype setup and providing an overview of systematic effects and plans to address them in the future Phases III and IV.

T 18.2 Mon 16:20 Tr

Real-time event reconstruction in the Project 8 Phase III Free Space CRES Demonstrator — •Florian Thomas and Sebastian Böser for the Project 8-Collaboration — PRISMA+ Cluster of Excellence, JGU Mainz

The Project 8 collaboration aims at measuring the absolute neutrino mass with a sensitivity of 40 meV in a tritium endpoint measurement using the recently demonstrated technique of Cyclotron Radiation Emission Spectroscopy (CRES).

In the upcoming Phase III of the experiment CRES will be demonstrated in free space instead of a closed waveguide for the first time.

The free space cyclotron radiation emitted by tritium beta decay electrons in a background magnetic field is detected by an array of antennas. For the required sampling frequency a raw data rate of ∼60 GB/s is expected, which quickly exhausts today's permanent storage capacities. Therefore, most of the event reconstruction has to proceed in real-time. This talk presents beamforming as a proposed reconstruction technique as well as the implementation plans for real-time computing and triggering.

T 18.3 Mon 16:35 Tr

Absolute energy scale of the KATRIN experiment — •Manuel Klein and Rudolf Sack for the KATRIN-Collaboration — Karlsruhe Institute of Technology (KIT), IAP, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

The KArlsruhe TRItium Neutrino (KATRIN) experiment performs a model-independent measurement of the electron neutrino mass. It is designed for a neutrino mass sensitivity of 0.2 eV (90% CL) after three full years of measurement time. KATRIN measures near the endpoint of the tritium beta-decay spectrum with a MAC-E filter, which relies on Magnetic Adiabatic Collimation of the beta electrons and an Electrostatic retarding potential: at the main spectrometer, the high voltage of about −18.6 kV is monitored with a precision of 2 ppm, and in the the tritium source, the electron start potential is provided by a weakly-ionised plasma created from the self-ionising source gas.

For the neutrino mass analysis, the endpoint is fitted from the high voltage of the main spectrometer as one of four free parameters. Nevertheless, the absolute energy scale is also relevant: a) in order to compare with the Q value of tritium, which serves as a precision benchmark for the retardation energy scale and b) because any time-dependence of the energy scale induces a broadening of the measured spectrum, which has to be considered in the analysis. A key aspect here is the effective electron start potential in the strongly-magnetised source plasma. This contribution shows that the systematic effect from drifts of the energy scale is not negligible but well within the uncertainty budget.

Supported by BMBF (Ø05A17VK2) and the Helmholtz Association.

T 18.4 Mon 16:50 Tr

Lorentz invariance violation (LV) at the KATRIN experiment — •Johannes Wickles for the KATRIN-Collaboration — Max-Planck-Institut für Physik, München

The **KA**rlsruhe **TRI**tium **N**eutrino (KATRIN) experiment uses the MAC-E filter principle to determine the mass of the neutrino in the beta-decay of Tritium. Besides measuring the neutrino mass, KATRIN offers insights into physics beyond the Standard Model. The violation of Lorentz invariance (LV) would manifest itself as a temporal oscillation of the spectral endpoint with siderial time. In this contribution first sensitivity studies based on MC data are presented. We will illustrate the analysis method and the impact of systematic uncertainties. The sensitivity of the first neutrino mass data set and the final KATRIN experiment will be presented.

T 18.5 Mon 17:05 Tr

Background reduction with the shifted analyzing plane configuration in KATRIN — •Alexey Lokhov for the KATRIN-Collaboration — University of Muenster, 48149 Muenster, Germany — Institute for Nuclear Research RAS, 117312, Moscow, Russia

To measure the effective electron antineutrino mass mv with a sensitivity of 0.2 eV/c2 the KATRIN experiment requires the level of background of about 10 mcps. One of the sources of the background electrons are the Rydberg atoms, created in the decay of Po-210, entering the spectrometer and ionized by thermal radiation. This yields low-energy electrons, almost uniformly distributed over the vessel volume.

We present here a technique to reduce this volume-dependent background of the KATRIN main spectrometer by using a specific configuration of the electromagnetic fields (so called shifted analyzing plane with a reduced fluxtube), that effectively decreases the volume of the fluxtube of electrons while preserving the energy resolution and allowing for the required neutrino mass sensitivity. The dedicated tests, which were performed recently, investigated the background reduction in this configuration and studied the EM fields at the shifted analyzing plane by calibration measurements using the Kr-83m conversion electrons and electron gun as reference sources.

T 18.6 Mon 17:20 Tr

Atomic hydrogen beam monitor for Project 8 — •Christian Matthe and Sebastian Böser for the Project 8-Collaboration — PRISMA+ Cluster of Excellence, JGU Mainz

The Project 8 collaboration aims to determine the absolute neutrino mass to a precision of 40 meV by measuring the tritium decay spectrum around the endpoint energy. For this level of precision it is necessary to use atomic tritium, since molecular tritium sensitivity is limited by the final molecular state distribution to about 100 meV. We anticipate using an atomic tritium flux of $\approx 10^{19}$atoms/s from the source to inject a beam with $\approx 10^{15}$atoms/s of the proper state and temperature into the detection volume.

For monitoring this beam, we envision a detector that uses a wire with a micrometer-scale diameter intersecting the beam on which a small fraction of the beam's hydrogen atoms recombine into molecules. The energy released heats the wire and produces a measurable change in its resistance. Using either a grid of wires or a sweep with a single wire the beam profile could be determined. Thanks to the wires' minimal area, such a detector is suitable for both development work and for online monitoring in the final experiment. In this talk I will present first results from such a detector designed for the Mainz atomic hydrogen setup.

T 18.7 Mon 17:35 Tr

Atom-Source Development for Project 8 — •Alec Lindman, Sebastian Böser, and Christian Matthe for the Project 8-Collaboration — PRISMA+ Cluster of Excellence, JGU Mainz

The Project 8 experiment will make a direct measurement with sensitivity to much of the unexplored range of neutrino masses. Past experiments used molecular tritium, which has an unavoidable energy smearing from its final states. Project 8 will use atomic tritium to reach $m_\beta \leq 40$ meV. This requires $\mathcal{O}(10^{20})$ tritium atoms held at ∼60 mK in a several-cubic-meter magnetic trap. The efficiencies of cooling the atoms and their trapped lifetime require, coincidentally, $>10^{20}$ atoms/s from the source. Phase III of Project 8 includes building a smaller Atomic Tritium Demonstrator to confirm solutions are ready to produce, cool, and trap atomic tritium at a scale suitable for the final Phase IV experiment.

This talk will discuss experiments at JGU Mainz to develop a cold, high-flux atom source. Our tests extend to a hydrogen flow of 20 sccm, some 40 times the previously-published values for this type of source. Highlights include improved understanding of atom transport in the test stand, automated analysis of large datasets, measurements of the atom-beam profile, and a redesign that boosted the atomic signal 100-fold. Upgrades to the test stand and its instrumentation are underway to definitively determine whether the present atom source provides sufficient atomic flux. Designs for a higher-output source, if needed, and the cooling and trapping stages are in progress and will be installed on the test stand in due course.

T 18.8 Mon 17:50 Tr

Magnetic Trap Design for the Project 8 Free Space CRES Demonstrator — •René Reimann and Martin Fertl for the Project 8-Collaboration — PRISMA+ Cluster of Excellence, JGU Mainz

The existence of non-zero neutrino masses is well established, however their absolute values are a major open question in particle physics. The most direct way to measure the neutrino mass is through a measurement of the spectral endpoint region for a low-energy beta decaying isotope, e.g. tritium. A new technique called Cyclotron Radiation Emission Spectroscopy (CRES) has been demonstrated by the Project 8 collaboration with krypton or molecular tritium confined in a section of a microwave guide. To collect sufficient statistics to reach a neutrino mass sensitivity of 40 meV requires to leave the confined space within a microwave guide and detect the feeble microwave signal in free-space by observing the volume with a set of antennas. All major challenges for a full-scale neutrino mass experiment will be investigated in the coming phase. A key component of the free-space CRES demonstrator is a magnetic trap to confine electrons in a region superimposed on to the homogeneous ∼ 1 T magnetic background field provided by an MRI magnetic. In this talk, we will present the design of the magnetic electron trap, characteristic parameters, and relationships to other key components of the free-space CRES demonstrator.

T 18.9 Mon 18:05 Tr

Characterization and First Integration of the TRISTAN Detector — •Korbinian Urban for the KATRIN-Collaboration — Max Planck Institut for Physics, Föhringer Ring 6, D-80805 München

The TRISTAN project aims at detecting a keV sterile neutrino sig-

nature by measuring the entire tritium beta-decay spectrum with an upgraded detector for the KATRIN experiment. To obtain a high sensitivity to the sterile neutrino mixing angle, a strong activity of the KATRIN source and as follows a high electron rate at the detector is necessary. At the same time excellent spectroscopic properties, like energy resolution and linearity, are important. To meet these challenging requirements a novel multi-pixel silicon drift detector and read-out are being developed to handle rates up to 100 kcps with an energy resolution of 300 eV (FWHM) at 20 keV.

In the last year, the first devices of the new TRISTAN detector became available. This talk addresses the characterization of seven-pixel TRISTAN detectors with X-ray sources and will show details of the first integration of a 47-pixel module in the Monitor Spectrometer at the KATRIN site.

This work is supported by the Max Planck society and the TU Munich ("Chair for Dark Matter, Susanne Mertens")

T 19: Detector systems I

Time: Monday 16:00–18:05 Location: Ts

Group Report T 19.1 Mon 16:00 Ts

The Mu2e experiment at Fermilab — •Stefan E. Müller, Anna Ferrari, Oliver Knodel, and Reuven Rachamin for the Mu2e-Collaboration — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The Mu2e experiment, currently under construction at the Fermi National Accelerator Laboratory near Chicago, will search for the neutrinoless conversion of muons to electrons in the field of an aluminum nucleus. In the Standard Model, this process, which violates charged lepton flavor, is highly suppressed and therefore undetectable. However, scenarios for physics beyond the Standard Model predict small but observable rates. The Mu2e experiment aims for a sensitivity four orders of magnitude better than existing experiments. This is achieved by a rigorous control of all backgrounds that could mimic the monoenergetic conversion electron.

At the Helmholtz-Zentrum Dresden-Rossendorf, we use the ELBE radiation facility to study radiation hardness and performance of components for the Mu2e calorimeter and the detector that will monitor the rate of stopped muons in the aluminum target. Additionally, Monte Carlo simulations are performed for both the pion production target and the muon stopping target.

In the presentation, the design and status of the Mu2e experiment and its detectors will be presented, and results from the ELBE beamtimes and the simulation studies will be given.

T 19.2 Mon 16:20 Ts

Status update of the Mu3e Tile Detector — Konrad Briggl, •Hannah Klingenmeyer, Yonathan Munwes, Wei Shen, Tiancheng Zhong, and Hans-Christian Schultz-Coulon — Kirchhoff-Institut für Physik, Universität Heidelberg

The Mu3e experiment, which will be installed at the Paul Scherrer Institute (PSI) in Switzerland, is designed to search for the lepton-flavour violating decay $\mu \to eee$ with a target sensitivity of 10^{-16}. In order to determine the vertex of the three decay electrons, precise space and time measurements are required. Dedicated tracking and timing detectors are being developed for this purpose. One of the timing systems is the Mu3e Tile Detector, which allows precise timing of individual electrons with a resolution below 100 ps.

The Mu3e Tile Detector, which is currently in the pre-production phase, uses plastic scintillator tiles and silicon photomultipliers that are read out by the MuTRiG ASIC, also developed in Heidelberg. In this talk, a comprehensive overview of the current detector status is given; details on the pre-production process and first performance tests of the detector prototype are presented. In particular, the production steps, the developed production tools, and quality assurance are discussed.

T 19.3 Mon 16:35 Ts

A camera alignment system for the Mu3e experiment — •Goran Stanic for the Mu3e-Collaboration — Johannes Gutenberg University Mainz

The Mu3e experiment is going to be conducted at PSI in Switzerland and it aims at finding or excluding the lepton flavour violating decay $\mu \to eee$ at branching fractions above 10^{-16}. The Mu3e detector consists of a tracking detector built from thin high-voltage monolithic active pixel sensors (HV-MAPS) complemented by scintillating fibers and tiles for precise timing measurement. One of the main challenges of the experiment lies in precise alignment of detector elements. In order to achieve the best possible momentum resolution a track based alignment programme will be utilised. Track-based alignment can however not resolve so-called weak modes, deformations of the detector that produce tracks of equal quality. The aim of this work is to correct for the weak modes by designing and developing a high precision camera based alignment system that monitors the detector position from the outside. The system will consist of multiple infrared cameras which will observe each other and the detector set-up. The main goal is to drive the camera measurement precision to be comparable to the size of the individual tracking detector pixels, which is at $80\mu m$.

T 19.4 Mon 16:50 Ts

A 2D pixelated stilbene scintillator detector array for simultaneous radiography with fast neutrons and gammas — Ilya Aleshin, •Nina Höflich, and Oliver Pooth — III. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen

The Neutron Detectors group at the Physics Institute III B develops pixelated detectors for fast neutron imaging applications with compact neutron sources such as Americium-Beryllium sources or neutron generators. The detectors use specialized scintillators such as stilbene that enable to distinguish neutron and gamma induced signals via pulse shape discrimination. Therefore, these detectors allow for a simultaneous investigation of objects with neutrons and gammas.
In this talk, recently published results (arXiv: 2010:01870) obtained with our 16-pixel detector prototype will be presented. This prototype consists of 16 stilbene cuboids of size $5 \times 5 \times 25\,\mathrm{mm}^3$ coupled to a 4×4 SiPM array. The prototype was tested with a D-D neutron generator at the Paul Scherrer Institute in Switzerland, that emits neutrons between 2.3 and 2.8 MeV energy. Attenuating samples with different composition and thickness were placed between the generator and the 16-pixel detector. The neutron attenuation in dependence of material and thickness was studied and fast neutron macroscopic cross sections were calculated and compared to the expected ones. Geant4 simulations were used to study deviations. The detection efficiency for D-D neutrons was measured to be around 10%.

T 19.5 Mon 17:05 Ts

Gamma spectroscopy of an Americium-Beryllium source with a High Purity Germanium detector in a neutron radiography setup — •Ilya Aleshin, Nina Höflich, and Oliver Pooth — III. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen

The neutron radiography group at the Physics Institute III B, RWTH Aachen University, develops a multi-pixel detector for fast neutron radiography.

The purpose of fast neutron radiography is to resolve structures in heterogeneous test objects that cannot be well investigated by X-ray radiography. As a neutron source, 2 Americium-Beryllium radioactive sources (16.5 GBq and 16.9 GBq) are used. These sources produce neutrons as well as gamma-rays. For neutron detection, the organic scintillator stilbene ($C_{14}H_{12}$) is used. This scitntillator allows to distinguish neutron- and gamma-induced signals via their pulse shape.

For the sake of future analyses like for example the prompt gamma neutron activation analysis, which explores the characteristic gamma rays produced by interaction of fast neutrons with matter, precise gamma spectra of the radiography setup (and especially of the Americium-Beryllium sources) are necessary. This talk will focus on the measurement of this spectra with a High Purity Germanium detector and on the spectra themselves. The mode of operation of such a Germanium detector, the positions of this detector with respect to the Americium-Beryllium sources during measurements and the spectra themselves will be presented in this talk.

T 19.6 Mon 17:20 Ts

Tracking of charged particles using an FE-I4B pixel telescope and moving emulsion films — •Nikolaus Owtscharenko[1], Markus Cristinziani[1], Vadim Kostyukhin[2], Christopher Betancourt[3], Fabian Hügging[4], Jens Janssen[4], David-Leon Pohl[4], Antonia Di Crescenzo[5], and Antonio Iuliano[5] — [1]Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen — [2]University of Sheffield — [3]Universität Zürich — [4]Physikalisches Institut, Universität Bonn — [5]Sezione INFN di Napoli

The SHiP collaboration proposes a general purpose fixed-target experiment to search for hidden particles at the new beam-dump facility at CERN SPS. To estimate the charm production cross section in the experiment, which includes hadronic cascade production, several dedicated measurements have been proposed. A first run was performed in summer 2018. Protons from SPS interacted with a thick multilayer target, interleaved with tracking emulsion films. While the emulsion detector offered high spatial resolution, it did not provide timing information. For full event reconstruction a 6-plane telescope made of ATLAS IBL double-chip modules was assembled and placed downstream of the target to provide a high timing resolution. An occupancy limit on the emulsion films made a movement of the target during and in between spills necessary. The matching of track candidates reconstructed in the moving emulsion detector with those reconstructed in the fixed pixel detector is presented.

T 19.7 Mon 17:35 Ts

A low-background Silicon Drift Detector system for IAXO — •Thibaut Houdy[1,2] and Susanne Mertens[1,2] — [1]Max-Planck-Institut für Physik, Föhringer Ring 6, D-80805 München, Germany — [2]Physik-Department, Technische Universität München, D-85747 Garching, Germany

The nature of dark matter is among the most challenging question of modern physics. Axions are invoked to solve the strong CP problem and are dark matter candidates. IAXO is the new generation helioscope, designed to discover solar axions by measuring x-rays induced by axion-photon conversion. The requirement for the detector to reach an extremely low background level below 10 keV is very challenging.

The TRISTAN project is developing a new detection system using silicon drift detector (SDD) for upgrading the KATRIN experiment and search for keV sterile neutrino. We propose to use this unique technology as an x-ray detector for the IAXO experiment. A first prototype detector revealed excellent spectroscopic quality, matching each IAXO requirements however the required background level remains to be demonstrated.

A dedicated test-bench have been built to assess the intrinsic background level. This includes simulations of the expected external background, design of the shields, determination of the natural radioactivity of detector board and front-end electronics. In this talk, first results of measurements in the Munich shallow underground laboratory will be reported. Secondly, conceptual design studies of the final detector system, meeting the required background level, will be presented.

T 19.8 Mon 17:50 Ts

Development of the Detector Control System for the ATLAS ITk-Pixel Demonstrator — •Andrés Melo, Jason Veatch, and Stan Lai — II. Physikaliches Institut, Georg-August-Universität Göttingen

The High-Luminosity LHC Upgrade will allow the ATLAS experiment to collect an order of magnitude more data than Run 3. Since the new Inner Tracker (ITk) must cope with this increased occupancy, bandwidth and radiation damage, a sophisticated prototype, called the ITk-Demonstrator, has been built. The ITk-Demonstrator allows the investigation and proof-of-principle for the ITk to be established, with powering, data acquisition, and the Detector Control System (DCS) to be tested in detail.

This talk discusses the tests of the DCS system planned for the ITk and tested with the Demonstrator. Among the technical issues tested were CANMoPs, a package that communicates with a CAN protocol interface, and the serial power protection chips (PSPP) of the Demonstrator. Furthermore, the user interface of the power supply (Wiener PL512) is being redesigned. Among other things, a migration from the Siemens program WinCC for supervisory control and data acquisition from version 3.15 to 3.16 was investigated. This allows the program to run on a Linux operating system, removing the dependence on MS Windows.

T 20: DAQ, trigger and electronics I

Time: Monday 16:00–18:15 Location: Tt

T 20.1 Mon 16:00 Tt

Prototyping Serial Powering with RD53A — •Florian Hinterkeuser, Klaus Desch, Matthias Hamer, Fabian Hügging, Hans Krüger, and Charlotte Perry — Physikalisches Institut, Universität Bonn

The high luminosity upgrade for the Large Hadron Collider at CERN requires a complete redesign of the current inner detectors of ATLAS and CMS. These new inner detectors will consist of all-silicon tracking detectors. A serial powering scheme has been chosen as baseline for the pixel detector to cope with the higher number of modules and the higher power consumption of the new front-end chip, spatial constraints and the need to minimize the tracker's material budget.

This new powering scheme provides challenges for the electrical and mechanical design. In order to verify this new powering scheme and its implications on the detector integration, efforts are ongoing to set up a prototype for serial powering using modules based on the RD53A chip, a half-size prototype for the new Pixel front-end chip, developed by the RD53 collaboration. In particular, a serial powering stave consisting of up to 8 RD53A quad chip modules has been set up in Bonn.

First results from the ongoing activities with RD53A chips are presented. Emphasis is put on the electrical characterization of an RD53A serial powering chain, using representative services and power supplies. The setup, measurement goals and characterization of the serial powering chain will be discussed.

T 20.2 Mon 16:15 Tt

Entwicklung automatischer Qualitätstests für den RD51 VMM3a Hybrid — •Finn Jaekel, Michael Lupberger, Patrick Schwäbig und Jochen Kaminski — Physikalisches Institut Universität Bonn

Das Scalable Readout System der RD51 Kollaboration ist ein vielseitiges Auslesesystem, das in großen Bereichen der Entwicklung von gasgefüllten Detektoren verwendet wird. Es unterstützt verschiedene Front-End Chips, wie z.B. Timepix, VFAT oder APV25 und beinhaltet die komplette Auslesekette zur Übertragung von Daten zwischen Detektor und Computer. Bis vor kurzem wurde hierfür häufig der APV25 ASIC benutzt. Da dieser nun aber nicht mehr hergestellt wird, wurde ein neuer Front End Chip, der VMM (entwickelt für das ATLAS New Small Wheel upgrade)ASIC- entwickelt, in das Scalable Readout System implementiert.

Das Projekt befindet sich momentan in der Übergangsphase von der Entwicklung zur Massenproduktion. Es gibt bereits großes Interesse an dem Auslesesystem zur Verwendung für zukünftige Experimente und Forschungsprojekte. Insbesondere das Front-End board mit dem VMM chip, genannt Hybrid, von dem große Stückzahlen produziert werden, bedarf einer automatisierten Qualitätskontrolle.

In diesem Vortrag wird das im vergangenen Jahr entwickelte Testsystem vorgestellt, und erste Ergebnisse präsentiert.

T 20.3 Mon 16:30 Tt

Firmware development for the Scalable Readout System (SRS) with VMM3a — •Patrick Schwäbig, Finn Jaekel, Jochen Kaminski, and Michael Lupberger — Physikalisches Institut, Universität Bonn

The Scalable Readout System which was developed within the RD51 collaboration is a flexible readout system which can be used with various front-end chips and is scalable from a few channels to many thousand channels.

As a future-oriented technology the VMM front-end chip (ASIC) has been chosen as a successor for the so far prevailing APV25 for innovations in gaseous detector development. Originally developed for the New Small Wheel Upgrade of the ATLAS detector the VMM offers features like continuous readout, low electronic noise and neighbor-enabling logic, which are required to fulfill future demands e.g. for use

in the NMX instrument at the European Spallation Source (ESS).

The VMM ASIC has been implemented in recent years in the SRS and was tested in various projects. Additional improvements and enhancements are in ongoing development.

The talk will focus on the progression of the firmware of the FPGA responsible for the VMM readout. Improvements of the readout speed and the necessary adaptions to the VMM readout process will be presented.

T 20.4 Mon 16:45 Tt

Timing Studies of KLauS6: A Low Power ASIC for Silicon Photomultiplier Charge Readout with Precise Timing — •Erik Warttman and Konrad Briggl for the CALICE-D-Collaboration — Kirchhoff-Institut für Physik, Universität Heidelberg

The scintillator-based high-granular calorimeters developed within the CALICE collaboration require sophisticated front-end readout electronics, providing precise charge and time measurements of the generated Silicon-Photomultiplier (SiPM) signals, while minimizing the power consumption. The KLauS ASIC has been developed for this application, targeting low-gain SiPMs with large dynamic range. In the recent version KLauS6, a Phase Locked Loop (PLL) driven TDC has been integrated. This enables precise time measurements with 200ps time binning. The chip has been characterized using SiPMs with and without scintillating tiles. The characterization procedures and the results from lab and testbeam measurements with a particular focus on timing will be presented.

T 20.5 Mon 17:00 Tt

Towards a Level 1 Single Track Z Trigger in the Belle II Experiment — •Felix Meggendorfer[1,3], Steffen Baehr[2], Christian Kiesling[1,4], Sebastian Skambraks[1,4], and Kai Lukas Unger[2] for the Belle II-Collaboration — [1]Max-Planck-Institut für Physik — [2]Karlsruher Institut für Technologie — [3]Technische Universität München — [4]Ludwig-Maximilians-Universität München

The Neurotrigger is a Level 1 track trigger within the drift chamber in the Belle II Experiment, which uses a neural network for the z vertex estimation. Since it ran stable in the last run period of 2020, we managed to improve the delta z resolution by using real data for the network training. We now aim for an unprescaled single track trigger operation from 2021 on. This will lead to a much better sensitivity for low multiplicity events, which is important for the discovery of new physics, for example in the sectors of tau lepton flavor violation or dark matter searches.

T 20.6 Mon 17:15 Tt

Modular and scalable Timepix3 readout system — Klaus Desch, •Markus Gruber, Thomasz Hemperek, Jochen Kaminski, Leonie Richarz, and Tobias Schiffer — Physikalisches Institut, Universität Bonn, Nußallee 12, 53115 Bonn

With the highly granular pixel ASIC Timepix3 several different detectors can be built by combining it either with a bump bonded sensor or with a photolithographically postprocessed MicroMegas gas amplification stage (InGrid). With these combinations quite different applications like beam telescopes, X-Ray detectors and neutron TPCs can be realized.

For the detectors to be built with this ASIC that range from single chip to multichip designs and from low- to high-rate applications a modular and scalable readout and control system is needed which can efficiently adapt the different scenarios. The firmware and software are based on the basil framework and as readout system several FPGA boards are supported including the Scalable Readout System (SRS) which offers scalability in low to medium rate multichip applications. Besides the capability of different detector designs the system offers optional monitoring interfaces for different detector parameters.

In this talk I will present the readout and control system and how it scales for the applications. Furthermore, I will show how the modular approach enables several different detector designs and offers the needed functionality like calibration, equalization, readout and monitoring.

T 20.7 Mon 17:30 Tt

Software trigger optimization for the OSIRIS pre-detector of JUNO — •Runxuan Liu[1,2], Philipp Kampmann[1], Kai Loo[3], Livia Ludhova[1,2], Alexandre Göttel[1,2], Mariam Rifai[1,2], Giulio Settanta[1], and Cornelius Vollbrecht[1,2] — [1]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [3]Johannes Gutenberg-Universität Mainz, Institute for Physics, Staudingerweg 7, 55128 Mainz

JUNO is a 20 kt liquid scintillator detector under construction in Jiangmen, China, whose goal is to determine the neutrino mass hierarchy. Its data taking is expected to start in 2022. In order to meet the stringent requirements on the radiopurity of the liquid scintillator, the OSIRIS pre-detector is being designed to monitor the liquid scintillator during the several months of filling the large volume of JUNO. OSIRIS will contain 20 ton of scintillator and will be equipped with 76 20-inch PMTs. The data acquisition system will have no global hardware trigger: instead, each PMT will provide a data-stream composed of the digitized PMT pulses, each containing a time stamp. Based on the latter, dedicated software will organize these data streams into events. This talk will discuss the optimization of the event trigger conditions, for the inner liquid scintillator detector as well as outer water Cherenkov detector, considering the expected rates of different radio-active contaminations, cosmogenic muons, and the PMT dark rates.

T 20.8 Mon 17:45 Tt

Development towards an active Muon Veto System for the IAXO Experiment — •Shivani Shivani, Elisa Ruiz Chóliz, and Matthias Schott — Johannes Gutenberg-University Mainz

A ray tracing code has been developed to simulate photons generated by muons passing through scintillator coupled with SiPMs. The code models the rectangular geometry of detector and optical properties of the scintillator. This work concentrates on simulating photon transportation in a scintillator detector. A preliminary study comparing the experimental and stimulated efficiencies of the detector are presented.

T 20.9 Mon 18:00 Tt

Optimizations and Upgrades to the SuperCDMS SNOLAB L1 Trigger System — •Hanno Meyer zu Theenhausen, Lea Burmeister, Fatema Thasrawala, Matthew Wilson, Alexander Zaytsev, and Belina von Krosigk — Universität Hamburg

The SuperCDMS SNOLAB dark matter search experiment targets sensitivity toward nuclear- and electron-recoil interactions with deposited energies as low as a few eV. This puts requirements on the resolution, efficiency, noise rejection, and throughput capacity of the employed trigger system. To accomplish this, the SuperCDMS trigger system is implemented on an FPGA on custom-hardware detector readout cards. Using a multi-modular architecture, input waveforms from the detector channels are downsampled, filtered, and subjected to a flexible threshold- and trigger logic. The filtering step is achieved via an FIR filter of which the coefficients resemble a time-domain optimal filter. This presentation gives an overview about the trigger system and reports on parameter optimizations regarding the downsampling and FIR filtering modules. Finally an outlook is given on a near future upgrade involving noise correlations between individual input channels, as well as a far future upgrade about triggering using an FPGA-level neural network.

T 21: Data analysis, Information technology I

Time: Monday 16:00–18:15 Location: Tu

T 21.1 Mon 16:00 Tu

Anomaly searches for new physics based on generative classifiers — •Sven Bollweg and Gregor Kasieczka — Universität Hamburg, Germany

There exist strong hints for the existence of physics beyond the standard model (BSM). Many models for BSM physics have been investigated but none of these could be observed in data so far. Another strategy are model-independent searches. The idea is that events originating from BSM processes differ from events originating from SM processes. Without applying any knowledge of possible BSM processes, it can be used to search for anomalous events.

To search for anomalies, we use a generative classifier (GC) based on invertible neural networks. A GC learns the likelihood of the input data. The likelihood can be used either for classification or anomaly detection. In the ideal case, anomalous events are less likely than all the other events if we train the GC on SM events. We show a first attempt to apply this method in the context of searching for new physics with the CMS experiment in the dijet final state. We investigate different input representations and anomaly scores based on the likelihood.

T 21.2 Mon 16:15 Tu

Searching for new physics with anomaly detection — •Manuel Sommerhalder[1], Tobias Lösche[1], Gregor Kasieczka[1], David Shih[2], and Anna Hallin[2] — [1]Universität Hamburg — [2]Rutgers University

Most analyses looking for new physics, such as beyond Standard Model searches at the LHC, rely on a specific signal hypothesis for selecting relevant data points. However, recently there is an increased interest in developing model-independent selection criteria with the aim of generically gaining sensitivity to unthought-of phenomena. A potential solution to this problem lies in anomaly detection, which consists of various techniques that quantify how anomalous each data point (or group of data points) is with respect to the entire data set, thus yielding an additional measure to identify signal candidates.

We present our recent developments in using anomaly detection to search for new physics via the concrete example of resonance searches at the LHC. The primary focus is our application of Anomaly Detection with Density Estimation (ANODE) using normalizing flows. Building up on the previous state-of-the-art performance achieved by ANODE, we highlight further advancements to improve its performance and useability.

T 21.3 Mon 16:30 Tu

Utilization of GPUs in the training of neural networks — Günter Quast, Roger Wolf, Janek Bechtel, Sebastian Brommer, Rene Caspart, Ralf Schmieder, Felix Heyen, Gessi Risto, Andrew Issac, and •Tim Voigtländer — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

Machine learning has become a commonly used technique in recent particle physics analyses. As machine learning algorithms become more refined and the neural networks used in recent analyses have become more complex, the usage of specialized computing resources needs to be explored, in order to ensure a reasonable turnaround cycle, especially for the training of the networks. In this talk the utilization of a cluster of GPUs used to accelerate the training process is shown by the example of the multilayer neural networks used in the CMS Higgs $\rightarrow \tau\tau$ analysis.

T 21.4 Mon 16:45 Tu

Improved energy resolution via super-resolution — Johannes Erdmann, Florian Mentzel, Olaf Nackenhorst, and •Aaron van der Graaf — TU Dortmund, Experimentelle Physik IV

In high energy particle physics, detectors with a good energy resolution are essential for the precision of measurements. One possibility to improve the energy resolution are detector upgrades. Another approach is to artificially enhance the energy resolution by using super-resolution (SR) algorithms. SR algorithms learn to upscale low resolution data to high resolution data. The SR algorithms that are used in this work are based on generative adversarial networks (GANs). By training GANs with simulation-based high resolution and low resolution data, they have been shown to learn the complex correlations between low and high resolution data. After the training, GANs can then upscale the low resolution data. In this presentation, preliminary results are presented.

T 21.5 Mon 17:00 Tu

Decoding γ-showers: Physics in the Latent Space of a BIB-AE Generative Network — •Erik Buhmann — Institut für Experimentalphysik, Universität Hamburg

With future collider experiments' vast data collection capabilities and limited computing resources, interest in using generative neural networks for fast simulation of collider events is growing. In our previous study the Bounded Information Bottleneck Autoencoder (BIB-AE) showed state-of-the-art generation accuracy for photon showers in a high-granularity calorimeter, precisely modelling various global differential shower distributions. In this work we investigate how the BIB-AE encodes these physics information in the latent space for different model configurations. Our understanding of this latent space encoding allows us to propose methods to further optimize the generation performance of the BIB-AE model, namely specific hyperparameter optimization and an altered latent space sampling. In particular we were able to improve the modelling of the shower shape along the particle incident axis.

T 21.6 Mon 17:15 Tu

Hadronic Shower Separation in Five Dimensions using Machine Learning Methods — •Jack Rolph, Gregor Kasieczka, and Erika Garutti — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

Accurate clustering of hadronic energy depositions plays a critical role in the particle flow approach proposed for future linear colliders. The highly-granular CALICE Analogue Hadronic Calorimeter prototype (AHCAL), designed with this task in mind, is distinguishable due to its ability to measure the development of a hadron shower in time as well as space. The benefit of time as an additional observable to the clustering of the simulated energy depositions of a charged and 'faked' neutral hadron observed with the AHCAL was studied using several state-of-the-art neural network architectures. These neural networks were optimised using simulations of perfect and expected operating time resolutions. As a control, networks with the same architectures were also trained without time. The clustering performance of each network relative to the control was then assessed over a range of possible operating time resolutions. For all studied networks and resolutions, the improvement in energy resolution due to time was found to be minor to negligible using these existing methods.

T 21.7 Mon 17:30 Tu

Applications of Graph Neural Networks in Liquid Scintillator Neutrino Detectors — •Alexandros Tsagkarakis, Markus Bachlechner, Thilo Birkenfeld, Philipp Soldin, Achim Stahl, and Christopher Wiebusch — III. Physikalisches Institut B, RWTH Aachen University

In neutrino physics, liquid scintillator detectors like Double Chooz and JUNO are utilized to measure the elements of the Pontecorvo-Maki-Nakagawa-Sakata matrix or to determine the sign of the mass difference Δm^2_{31} of the neutrino mass hierarchy. The main channel for the detection of neutrinos is the Inverse Beta Decay with protons in the detector medium, resulting in a positron and a neutron. Those initiate a prompt signal from the positron and a delayed signal from the neutron. On the other hand electrons from various sources, such as the decay of 9Li and 8He atoms, produce similar signatures, which cause a significant amount of background and hence challenges to achieve the above goals. Therefore, we apply machine learning algorithms for energy and vertex reconstruction or direct electron-positron discrimination to reduce this background. The geometry of the experiments can be well mapped in a Graph Neural Network. In this talk, we present the implementation and the first results of the aforementioned tasks.

T 21.8 Mon 17:45 Tu

Online Event Selection using GPUs for the Mu3e experiment — •Valentin Henkys for the Mu3e-Collaboration — Johannes Gutenberg University Mainz

The Mu3e experiment searches for physics beyond the Standard Model using the lepton flavour violating decay $\mu^+ \rightarrow e^+e^-e^+$. Observing the decay products of $1 \cdot 10^8 \mu/s$ results in a data rate of 80Gbps. An online algorithm for graphics processing units (GPU) is presented, reducing the data rate with the Mu3e filter farm by a factor of over 100, to bring it below 100MBps. The filter farm consists of 12 PCs running this algorithm on one GPU each.

The algorithm is divided into three parts. The first step selects possible event candidates using simple and fast geometric selection criteria, reducing the candidates to under 2.5% of the initial set. These are then used in the second step, reconstructing the helical tracks of the electrons and positrons. Finally these tracks are used to reconstruct the event vertex. To fulfill the high performance requirements, fast geometric considerations are used instead of a full vertex fit.

The algorithm is able to reduce the data rate by a factor of over 100 while keeping 98% of the events found by the offline algorithm.

T 21.9 Mon 18:00 Tu

Muon Track Reconstruction in Liquid Scintillators with Graph Neural Networks — •Rosmarie Wirth — Hamburg University, Hamburg, Germany

Large liquid scintillation detectors are successfully used to observe the neutrino oscillation parameters by detecting reactor neutrinos. A main, hard to identify background are cosmogenics. These are ^{9}Li and ^{8}He atoms, which are produced in showers along cosmic muon tracks. While decaying the cosmogenics mimic the inverse β-decay, which is the detection process to identify reactor neutrinos. While muon vetos are a straight forward method to reduce this background, they create a lot of dead time. With the JUNO experiment 15.7 % reactor neutrino events are predicted to be missed, due to the muon veto. A superior muon track and shower reconstruction method, could improve the data taking of JUNO and comparable experiments tremendously. Classical and machine learning approaches are being developed for JUNO.

The here presented work studies the use of Graph Neural Networks to reconstruct muon tracks and corresponding showers. Graph Neural Networks provide the option to include the geometrical detector setup to improve the reconstruction. On TOY Monte Carlo Data showers in the detector volume could be located with an accuracy of $\pm 0.22 \pm 0.14$ m. Additionally results on a voxelwise photon emission distribution are presented.

T 22: Experimental techniques in astroparticle physics I

Time: Monday 16:00–18:35 Location: Tv

Group Report T 22.1 Mon 16:00 Tv

The IceCube Upgrade Project — •Martin Rongen for the IceCube-Collaboration — Johannes Gutenberg Universität Mainz, Institut für Physik

The IceCube Neutrino Observatory instruments about 1 km^3 of deep, glacial ice at the geographic South Pole with 5160 photomultipliers to detect Cherenkov light of charged relativistic particles. Exact models of the optical properties of the natural ice are crucial since their shortcomings are a major source of systematic uncertainty in physics analyses.

Following IceCube's recent success in the discovery of an astrophysical neutrino flux, strong indications for the first neutrino point sources, and competitive measurements of neutrino oscillation parameters, the detector is now set to be upgraded. This IceCube Upgrade will consist of seven new strings to be deployed near the center of the existing IceCube array in 2022/23.

In addition to a further 700 novel optical sensors (of various designs including variants with a segmented photocathode and enhanced-UV sensitivity), enabling world-leading neutrino oscillation physics, the Upgrade strings will include unique calibration devices designed to improve the understanding of the ice. The refined calibration resulting from the Upgrade will be applied to the entire archival IceCube data set, improving in particular point source sensitivities. This talk will give an overview of the IceCube Upgrade project including its instrumentation and will detail how we anticipate the improved calibration to impact physics results.

T 22.2 Mon 16:20 Tv

Hole Ice, Cables, and Non-Spherical Detector Modules in Light-Propagation Simulations for the IceCube Experiment — •Sebastian Fiedlschuster for the IceCube-Collaboration — Erlangen Centre for Astroparticle Physics, Erwin-Rommel-Str. 1, 91054 Erlangen

IceCube is a neutrino observatory located at Earth's South Pole that uses glacial ice as detector medium where particles from neutrino interactions produce Cherenkov light as they move through the ice. The light is then detected by an array of photo detectors deployed within the ice.

Aiming to improve detector calibration for the current IceCube detector as well as for the upcoming detector upgrade, a modified ray-tracing algorithm based on IceCube photon-propagation software is used to account for regions of different optical properties in light-propagation simulations. Of particular interest are the drill-hole regions (*hole ice*) of the detector medium, opaque cables of the detector instrumentation as well as light-sensitive detector modules of different shapes. This talk will outline the simulation method and present current and future applications.

T 22.3 Mon 16:35 Tv

Trilateration-based Geometry Calibration of the IceCube Detector — •Matthias Boddenberg[1], Christian Haack[3], Saskia Philippen[1], Martin Rongen[2], and Christopher Wiebusch[1] for the IceCube-Collaboration — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]Johannes Gutenberg-Universität Mainz — [3]TU München

The IceCube Neutrino Observatory detects charged particles by measuring their Cherenkov light using photomultipliers embedded in the deep Antarctic ice at the South Pole. Reconstruction of the particle directions relies on arrival times of Cherenkov photons at the position of these photomultipliers. Their currently assumed positions are only accurate to about a meter. Goal of this work is improving the calibration of these sensor positions. For this, we measure the transit times of light emitted from LEDs within the sensor modules and received by neighboring sensors. From these transit times the sensor distances can be derived using models for the light propagation in ice. In this talk, we present a novel method for calibrating the detector geometry based on the trilateration of these distances within a global likelihood analysis.

T 22.4 Mon 16:50 Tv

Comparison of directional reconstruction algorithms for muons using the Moon shadow in IceCube — •Sebastian Schindler, Thorsten Glüsenkamp, and Gisela Anton for the IceCube-Collaboration — Erlangen Centre for Astroparticle Physics (ECAP), University Erlangen-Nürnberg, Germany

IceCube is a cubic-kilometer-sized neutrino observatory located at the Geographic South Pole. In IceCube, arrival directions of muon neutrinos are determined from resulting muon tracks in the detector. Atmospheric muons, which originate from cosmic rays, produce a similar signature in the detector, and can therefore be used to test directional reconstruction algorithms. The Moon acts as a calibration source for directional reconstructions using atmospheric muons, by producing an easy-to-observe localized reduction of the mostly uniform cosmic-ray flux.

The directional accuracy of two new muon-reconstruction algorithms is tested by using the abundant flux of cosmic rays in a Moon analysis. One reconstruction is a further development of the currently best reconstruction used in IceCube, and the other is a machine-learning-based approach. The results of the accuracy comparison with the currently best reconstruction will be presented.

T 22.5 Mon 17:05 Tv

The mDOM - a multi-PMT optical module for the IceCube Upgrade — •Martin Antonio Unland Elorrieta for the IceCube-Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, Münster

The IceCube detector at the South Pole, currently the largest neutrino observatory worldwide, is being upgraded with seven new strings. New sensors with increased sensitivity have been developed for this project, the IceCube Upgrade. More than half of the modules installed will be Multi-PMT Digital Optical Modules (mDOMs), which feature 24 isotropically aligned photomultipliers (PMTs) in a pressure vessel. This design provides, among other things, an effective photosensitive area more than twice that of IceCube's current optical sensor, near-uniform angular coverage, and the ability to exploit local coincidence between PMTs of the same module. The presentation provides an overview of the module design.

T 22.6 Mon 17:20 Tv

Analyzing PMT characterization measurements for the IceCube mDOM with the python/numpy-based package PeeEmTee — •Jonas Reubelt and Judith Schneider for the IceCube-Collaboration — ECAP, Universität Erlangen-Nürnberg

Photomultiplier tubes (PMTs) are frequently used as high-sensitivity light sensors in modern physics detectors like IceCube. Precision measurements employing PMTs require a detailed understanding of the sensors' behavior in low-light-level environments. The PeeEmTee package (https://github.com/JonasReubelt/PeeEmTee) provides functionalities fundamental for PMT characterization under such conditions.

Concept and functionality of the package will be presented in the context of recent PMT characterization measurements for the IceCube mDOM.

T 22.7 Mon 17:35 Tv

Test der Linearität der Photomultiplier für das mDOM des IceCube Upgrades — •Charlotte Benning, Lasse Halve und Christopher Wiebusch für die IceCube-Kollaboration — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Das IceCube Upgrade wird das aktuelle IceCube Neutrino Observatorium um sieben zusätzliche Instrumentenstränge erweitern. Mehr als 400 multiple-PMT Digital Optical Modules [mDOM] mit jeweils 24 3" Photomultiplier Tubes [PMT] werden eingesetzt. Vor der Integration in die Module müssen die mehr als 10.000 neuen PMTs auf Einhaltung der Herstelleranforderungen geprüft und kalibriert werden. Eine dieser Anforderungen an die PMTs ist die Linearität der Ladungsantwort von 90% bei bis zu 100 instantanen Photoelektronen. In diesem Vortrag wird das Prinzip der Messung der Linearität durch Variationen der Lichtintensität sowie vorbereitende Messungen für die Massentests vorgestellt.

T 22.8 Mon 17:50 Tv

First light of the PMT characterisation facility for the IceCube mDOM at the TU Dortmund — •Johannes Werthebach for the IceCube-Collaboration — TU Dortmund

The IceCube Neutrino Observatory measured the first astrophysical high-energy neutrino flux back in 2013. One substantial part of the upcoming low energy expansion is the multi-PMT optical module, mDOM. It consists of 24 3-inch PMTs spherically arranged within the mDOM. To provide a consistent signal quality more than 10.000 PMTs need to be tested and characterised before they are installed into the mDOM.

A large scale testing facility is build in Aachen and Dortmund. To provide a fast and reliable solution 98 PMTs can be characterised in a single test cycle at temperatures as low as -20°C. The setup and first measurements from the site at the TU Dortmund are presented.

T 22.9 Mon 18:05 Tv

Characterization of the analog front-end of the mDOM for the IceCube Upgrade at different temperatures — •Judith Schneider — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

In the framework of a planned upgrade of the IceCube Neutrino Observatory and a next-generation neutrino telescope at the South Pole, new optical modules are being developed, which are expected to significantly increase the detector sensitivity. One of such concepts is the multi-PMT Digital Optical Module (mDOM) which features 24 three-inch PMTs inside a pressure vessel resulting in a homogeneous directional sensitivity. An interacting neutrino creates secondary particles producing Cherenkov light which is detected by the PMTs. The PMT signal is processed by an analog front-end (AFE). All 24 channels are digitized separately with a 125 MSPS ADC. We present characterization measurements of the AFE of the mDOM for the IceCube Upgrade at different temperatures including -40°C as a proof of concept.

T 22.10 Mon 18:20 Tv

Calibration LEDs for the IceCube Upgrade mDOM Modules — •Theodoros Manoussos, Sebastian Böser, and Martin Rongen for the IceCube-Collaboration — Institut für Physik, JGU Mainz

The IceCube Neutrino Observatory detects charged particles by measuring their Cherenkov light using photomultipliers embedded in the deep Antarctic ice at the South Pole. The IceCube Upgrade is planned to be deployed in the 2022/2023 Antarctic summer and will include about 700 new multi-PMT digital optical modules (mDOM). Each of those will be equipped with LEDs (mDOM flashers), two daisy chains with five LEDs each. The upgraded flasher system aims for the better understanding of the optical properties of the glacial ice and therefore plays an essential role to further reduce the systematic uncertainties in IceCube. In this talk the design, production and testing of this flasher system is presented.

T 23: Hauptvorträge (Invited Talks) I

Time: Tuesday 9:45–12:30 Location: Tb

Invited Talk T 23.1 Tue 9:45 Tb

Physics Beyond Colliders — •Joerg Jaeckel[1] and Various Physics Beyond Colliders Study Group[2] — [1]ITP Heidelberg, Heidelberg, Germany — [2]Various

Physics Beyond Colliders is a study group mandated by CERN management to explore the options for future experiments complementary to those at colliders. In this talks we consider the experiments discussed in this context over the last few years with a particular focus on the fundamental physics questions that they could explore and hopefully answer.

Coffee Break 30 min

Invited Talk T 23.2 Tue 11:00 Tb

Going the Extra Mile to Push the Frontier — •Alexander Mann — Ludwig-Maximilians-Universität München

With the completion of the Run-2 dataset, a major checkpoint in the LHC physics program has been reached. For several years, this dataset will be the largest ever taken at the high-energy frontier and enable searches for physics beyond the Standard Model to explore new regions of phase space.

The wealth of data increases the sensitivity to the many models already under consideration, but the more important boost typically arises from new and refined analysis techniques that allow more challenging scenarios to be tackled, which are characterized by small cross sections or low signal acceptance or require dedicated reconstruction algorithms. With the Run-2 dataset many new and interesting models can be studied for the first time — in this presentation, we will look at the overall status of the LHC searches and at the highlights from some selected recent results in detail.

Invited Talk T 23.3 Tue 11:45 Tb

Cosmic Nucleosynthesis, a Multi-Messenger Challenge — •Roland Diehl — Max Planck Institut für extraterrestrische Physik, Garching, Germany

The origin of cosmic elements and isotopes is one of the fundamental questions in astrophysics. Identifying signatures clearly attributed to specific atomic or nuclear species is the main tool of the associated astronomy, and commonly applied to starlight. In stellar explosions, gas however is highly ionized and not in thermal equilibrium, making identifications more challenging. Moreover, nucleosynthesis in stars and explosions occurs through reactions among often unstable isotopes, and elemental information is ambiguous. In this talk, we review the astronomical messengers towards an understanding of cosmic nucleosynthesis, in their diversity. Observations of cosmic nucleosynthesis, direct and less direct, in gaseous and solid materials will be compared. The decay of unstable isotopes that are ejected from such sources provides a new tool from gamma-ray spectroscopy; more-common optical spectra, but also stardust or cosmic ray compositions within the solar system can be analysed with high precision, but are also offset in time and space from the nucleosynthesis event. We will discuss how these multiple messengers of cosmic nucleosynthesis complement each other, addressing specific events such as the kilonova/gravitational-wave event GW170817, and examples of core-collapse and type Ia supernovae.

T 24: Eingeladene Vorträge (Invited Topical Talks) I

Time: Tuesday 14:00–15:30 Location: Tc

Invited Topical Talk T 24.1 Tue 14:00 Tc
Cosmic Particles at Extreme Energies — •Michael Unger — Karlsruhe Institute of Technology, Karlsruhe, Germany

Cosmic rays are the highest energy messengers of astrophysical phenomena in the Universe. The sources of these particles are unknown and it is one of the great puzzles of modern astrophysics how they are accelerated to macroscopic energies of >10^20 eV. In this talk I will highlight recent experimental results on ultrahigh-energy cosmic rays and discuss their implications on our understanding of the physics and astrophysics at extreme energies.

Invited Topical Talk T 24.2 Tue 14:30 Tc
IceCube Upgrade - The next level in precision neutrino physics at the South Pole — •Lew Classen — WWU Münster, Münster, Germany

Following the discovery of cosmic high energy neutrinos, a competitive measurement of neutrino oscillation parameters and a strong indication for the first neutrino point source, plans for extensions of the IceCube neutrino telescope have matured. IceCube Upgrade, a next-generation low-energy neutrino detector, will be installed in the 2022/23 Antarctic summer season and consist of about 700 novel optical sensors as well as state-of-the-art calibration devices distributed along seven strings located in the central region of the existing array. This upgrade will significantly enhance IceCube's capabilities to measure oscillation parameters. In particular, it will allow for measuring tau neutrino appearance in the atmospheric neutrino flux to unprecedented precision. Providing a test for the unitarity of the neutrino mixing matrix, this result will be a sensitive probe for physics beyond the standard model. The enhanced understanding of the detection medium and sensor response will also reduce IceCube's systematic uncertainties, allowing to revisit more than ten years of archival data with an improved directional and spatial resolution. In addition to its compelling science case, IceCube Upgrade will also pave the path towards IceCube-Gen2, the upcoming next-generation high-energy neutrino telescope at the South Pole. The presentation will address the R&D activities towards the Upgrade as well as the resulting physics potential.

Invited Topical Talk T 24.3 Tue 15:00 Tc
The NUCLEUS experiment - New physics with coherent neutrino-nucleus scattering — •Raimund Strauss — Technische Universität München

The detection of coherent-neutrino nucleus scattering (CEvNS) opens a new window to study the fundamental properties of neutrinos and to probe physics beyond the Standard Model of Particle Physics. NUCLEUS is a novel cryogenic neutrino experiment at a nuclear power reactor which allows for precision measurements of CEvNS at unprecedentedly low energies. It is based on recently demonstrated ultra-low threshold cryogenic detectors with nuclear-recoil energy thresholds in the 10eV regime. Accessing these energies enables to fully exploit the strongly enhanced cross section of CEvNS which leads to a miniaturization of neutrino detectors. NUCLEUS is fully funded and will be installed at a new experimental site in between the two 4GW reactor cores of the CHOOZ nuclear power plant in France. In this talk, I will present recent results from a prototype detector as well as the physics program of NUCLEUS, and give an overview of the growing field of CEvNS.

T 25: Eingeladene Vorträge (Invited Topical Talks) II

Time: Tuesday 14:00–15:30 Location: Td

Invited Topical Talk T 25.1 Tue 14:00 Td
A large Scintillating Fibre Tracker for the LHCb Upgrade — •Xiaoxue Han — Physikalisches Institut, Universität Heidelberg,Heidelberg, Germany

The LHCb detector at the Large Hadron Collider (LHC) is undergoing a major upgrade during the long shutdown 2019/2020 in order to collect data at an instantaneous luminosity of up to 2*1033 cm-2s-1.The higher detector occupancy and higher radiation level require the replacement of the current downstream tracking stations by a Scintillating Fibre (SciFi) Tracker. The SciFi Tracker comprises plastic scintillating fibres, read out by state-of-the-art multi-channel Silicon Photomultiplier (SiPM) arrays. The detector design, studies of the radiation hardness of scintillating fibres and the SiPM arrays, the customized PACIFIC ASIC, the front-end electronics, the test beam performance of the detector slice and the current detector assembly and commissioning status are described.

Invited Topical Talk T 25.2 Tue 14:30 Td
Assembling the flavour jigsaw (2021 edition) — •Oscar Cata — Theoretische Physik 1, Universität Siegen, Walter-Flex-Str. 3, D57068 Siegen

I will discuss the status of the different flavour puzzles that we are currently facing in particle physics, taking into account the most recent experimental data. I will also report on the most compelling theoretical ideas to tackle them. In particular, I will comment on the current status of low-TeV leptoquarks, which in the last years have attracted increasing attention. Such new-physics extensions strongly correlate quark and lepton interactions and carry a number of genuine new-physics predictions that can be tested in future experimental searches. Interestingly, in light of some of these predictions, new insights on the different flavour puzzles might be just lurking around the corner.

Invited Topical Talk T 25.3 Tue 15:00 Td
Erste Physik mit "Full Event Interpretation" am Belle II Experiment — •William Sutcliffe — University of Bonn, Bonn, Germany

Das Belle II Experiment in Japan hat 2018 seinen Betrieb aufgenommen und wurde gebaut um bei den höchsten Luminositäten im sauberen Produktionsprozess von e^+e^--Annihilation eine große Anzahl von produzierten B-Mesonen aufzuzeichnen. Durch Untersuchungen der anschließenden B-Mesonen-Zerfälle können eine Vielzahl von Präzisionstests des Standardmodells durchgeführt werden um so direkt oder indirekt nach neuartigen Physikprozessen zu suchen. Angesichts der herausfordernden Natur vieler dieser Messungen wird oft eine spezielle Technik, die als Tag-Seiten-Rekonstruktion bekannt ist, verwendet, bei der eines der beiden B-Mesonen aus dem jeweiligen Ereignis in vielen exklusiven Zerfallskanälen rekonstruiert wird. Mit diesem Ansatz lassen sich kinematische Eigenschaften und den sog. Flavor des zweiten B-Mesons rekonstruieren oder eingrenzen. In diesem Vortrag präsentiere ich erste Messungen von Belle II mit den 2019 und 2020 aufgezeichneten Kollisionsdaten, die mit dem Belle-II-Algorithmus für Tag-Seiten-Rekonstruktion, der sog. "Full Event Interpretation" (FEI), durchgeführt wurden. Der FEI-Algorithmus wird einen Beitrag bei der Realisierung des Belle II-Physikprogramms spielen und uns Messungen von herausfordernden Endzustände ermöglichen.

T 26: Higgs physics (theory)

Time: Tuesday 16:00–18:30 Location: Ta

T 26.1 Tue 16:00 Ta

Parton-shower effects in Higgs production via Vector-Boson Fusion — Barbara Jäger[1], Alexander Karlberg[2], Simon Plätzer[3], •Johannes Scheller[1], and Marco Zaro[4] — [1]Institute for Theoretical Physics, University of Tübingen, Germany — [2]Rudolf Peierls Centre for Theoretical Physics, University of Oxford, United Kingdom — [3]Particle Physics, Faculty of Physics, and Erwin Schrödinger Institute for Mathematics and Physics, University of Vienna, Austria — [4]INFN Sezione di Milano & TifLab, Italy

We present a systematic investigation of parton-shower and matching uncertainties of perturbative origin for Higgs-boson production via vector-boson fusion. To this end we employ different generators at next-to-leading order QCD accuracy matched with shower Monte Carlo programs, `PYTHIA8`, and `HERWIG7`, and a next-to-next-to-leading order QCD calculation. We thoroughly analyse the intrinsic sources of uncertainty within each generator, and then compare predictions among the different tools using the respective recommended setups. Within typical vector-boson fusion cuts, the resulting uncertainties on observables that are accurate to next-to-leading order are at the 10% level for rates and even smaller for shapes. For observables sensitive to extra radiation effects uncertainties of about 20% are found. We conclude that for vector-boson fusion processes an assessment of the uncertainties associated with simulation at next-to-leading order matched to parton showers based only on the variation of renormalisation, factorisation and shower scales systematically underestimates their true size.

T 26.2 Tue 16:15 Ta

Gauge-invariant description of the Higgs resonance and its phenomenological implications — •René Sondenheimer and Axel Maas — Institute of Physics, NAWI Graz, University of Graz, Universitätsplatz 5, A-8010 Graz, Austria

We investigate the phenomenological consequences of a strict gauge-invariant formulation of the Higgs particle. This requires a description of the observable scalar particle in terms of a bound state structure. Although this seems to be at odds with the common treatment of electroweak particle physics at first glance, the properties of the bound state can be described in a perturbative fashion due to the Fröhlich-Morchio-Strocchi (FMS) framework. In particular a relation between the bound-state Higgs and the elementary Higgs field is obtained within 't Hooft gauges such that the main quantitative properties of the conventional description reappear in leading order of the FMS expansion. In particular the pole structure of the elementary and the bound-state propagator coincide to all orders in a perturbative expansion. However, slight deviations of scattering amplitudes containing off-shell Higgs contributions can be caused by the internal bound state structure which will be discussed.

T 26.3 Tue 16:30 Ta

Effective Field Theory interpretations in Higgs boson pair production studies — •Christina Dimitriadi — Physikalisches Institut Universität Bonn, Germany — Uppsala University, Sweden

After the discovery of the Higgs boson in 2012, searching for the simultaneous production of two Higgs bosons (di-Higgs) in proton-proton collisions would enable us to establish evidence of the Higgs boson self-coupling which is directly linked to the shape of the Higgs potential.

Interpretations in Effective Field Theories (EFT) can be beneficial as they provide new physics contributions in a model-independent way. Two different approaches are popular in di-Higgs, the Higgs EFT (HEFT), which is described by the Electroweak Chiral Lagrangian and the Standard Model EFT (SMEFT), where the SM Lagrangian is extended to higher mass dimensions. Theorists have provided an analytical parametrisation for the total cross-section and the m_{hh} distribution as a function of the anomalous Higgs couplings including NLO corrections, and weights have been produced and made available. Some intermediate results will be presented concerning HEFT reweighting validation studies.

T 26.4 Tue 16:45 Ta

Probing standard-model Higgs substructures using tops and weak gauge bosons — •Axel Maas — University of Graz, Graz, Austria

Manifest gauge-invariance requires that observable states in the standard-model are described by composite operators, which involve additional (valence) Higgs contributions beyond perturbation theory. This field-theoretical effects has been supported in various lattice simulations, including for fermions. With current available and future experimental facilities it starts to become possible to probe this. This will be explored in this talk.

It will be shown how such a valence Higgs contribution can show up in production of final states like ttbar(Z) at both future lepton and future and current hadron colliders. Especially at the LHC this has been found to be compatible with run 2 data. The effect is expected to be much more substantial at the FCC-hh. Such a substructure can also affect precision observables, e.g. anomalous couplings, both of the Higgs and of the weak gauge bosons. It is therefore a natural candidate for an investigation at the ILC.

T 26.5 Tue 17:00 Ta

Investigating triple Higgs production in and beyond the SM at proton-proton colliders. — •Gilberto Tetlalmatzi-Xolocotzi[1], Andreas Papaefstathiou[2], Tania Robens[3], and Marco Zaro[4] — [1]University of Siegen, Walter-Flex-Str. 3, 57068 Siegen — [2]Higgs Centre for Theoretical Physics, University of Edinburgh, Peter Guthrie Tait Road, Edinburgh EH9 3FD, UK. — [3]Ruder Bokovic Institute, Bijenicka cesta 54, 10000 Zagreb, Croatia — [4]Tif Lab, Dipartimento di Fisica, Università di Milano and INFN, Sezione di Milano, 20133 Milano, Italy

In this talk we will discuss the production of three Higgs bosons in the LHC and at a proton-proton collider running at a centre-of-mass energy of 100 TeV. We will argue that the seemingly challenging 6-botton jets final state is a very good candidate to investigate triple Higgs production within and beyond the SM in proton-proton colliders.

In particular we will consider three different scenarios: one in which the triple and quartic Higgs boson self-couplings are not affected by new physics phenomena besides the Standard Model (SM) and in addition, we will explore two possible SM extensions by one and two new scalars. We will show that a 100 TeV machine can impose competitive constraints on the quartic coupling in the SM-like scenario. In the case of the scalar extensions of the SM, we will show that large significances can be obtained in the LHC and the 100 TeV collider while obeying current theoretical and experimental constraints including a first order electroweak phase transition.

T 26.6 Tue 17:15 Ta

Two-Loop Higgs Boson Masses in the CP-Violating NMSSM — Nhung Dao[3], •Martin Gabelmann[1], Margarete Mühlleitner[1], and Heidi Rzehak[2] — [1]KIT, Karlsruhe, Germany — [2]Uni Freiburg, Germany — [3]ICISE, Vietnam

Imposing supersymmetry inevitably connects a theories Higgs-, gauge- and Yukawa-sector. Therefore, the discovery of a 125 GeV Higgs boson at the LHC puts tight constraints on parameter spaces of supersymmetric models which need to predict the correct Higgs boson mass.
The importance of higher-order corrections in this game cannot be overemphasised: in the minimally supersymmetric SM (MSSM), loop-corrections are known to be $\mathcal{O}(40\%)$ of the tree-level Higgs boson mass prediction.

In this talk, we report on recent progress in Higgs boson mass predictions at two-loop accuracy $\mathcal{O}\left((\alpha_\lambda + \alpha_\kappa + \alpha_t)^2\right)$ in the CP-violating NMSSM. We introduce the imposed renormalization schemes which combine minimal subtraction as well as on-shell conditions and discuss the size of the resulting scheme uncertainty. Furthermore, we discuss the appearance of infra-red (IR) divergences as well as three different IR-restoring methods in a subset of the two-loop tadpole- and selfenergy-diagrams. Finally, we compare size of the new two-loop corrections relative to the previously calculated $\mathcal{O}\left(\alpha_t(\alpha_s + \alpha_t)\right)$ contributions.

T 26.7 Tue 17:30 Ta

Calculations of one-loop corrections to decays for charged Higgs bosons in NMSSM — Thi Nhung Dao[1], Margarete Mühlleitner[2], Shruti Patel[2,3], and •Kodai Sakurai[2,4] —

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Despite the discovery of the Higgs boson with a mass of 125 GeV, the structure of the Higgs sector remains unknown. In light of the current situation that a second Higgs boson has not been discovered, indirect searches of such a new particle through observables for Higgs bosons are more and more important. This requires accurate theoretical predictions for such observables in order to compare them with the precision measurements in experiments. In this study, we calculated the full one-loop corrections to the decay widths for various charged Higgs boson decays in the framework of Next-to-Minimal Supersymmetric Model (NMSSM) with CP violation. In this talk, we discuss the impact of the NLO corrections for the branching ratio of each decay mode in a wide range of parameter space that is compatible with the experimental constraints.

T 26.8 Tue 17:45 Ta

A Two-Higgs-Doublet Variant of the Standard*Model*Axion*Seesaw*Higgs-Portal-Inflation Model — •Michael Matlis, Andreas Ringwald, and Gudrid Moortgat-Pick — Deutsches Elektronen-Synchrotron DESY, Theory Group, D-22603 Hamburg, Germany

The Standard Model (SM) suffers from five shortcomings: Dark Matter, Neutrino masses and mixing, Baryon asymmetry, Strong CP-Problem and Inflation. The latter is regarded as the seeds for structure formation. In this contribution, we introduce the 2hdSMASH (Two-Higgs-Doublet SM*Axion*Seesaw*Higgs-Portal-Inflation) model which aims at giving a complete and unified picture of the universe evolution from the inflationary epoch to today. In particular, we focus on parameter constraints for scalar masses and on the inflationary constraint for perturbative unitarity and provide an outlook for further collider phenomenology in 2hdSMASH.

T 26.9 Tue 18:00 Ta

Beyond the Standard Model Higgs bosons in the reach of the LHC — •Thomas Biekoetter[1], Alexander Grohsjean[1], Sven Heinemeyer[2], Victor Lozano[1], Christian Schwanenberger[1], and Georg Weiglein[1] — [1]DESY, Hamburg, Germany — [2]IFT, Madrid, Spain

Many extensions of the Standard Model (SM) contain additional Higgs bosons heavier than the Higgs boson at 125GeV. However, there is also the possibility of beyond the SM (BSM) Higgs bosons with masses below 125 GeV. In both cases there is room left for a discovery during the upcoming (HL)-LHC runs. Moreover, it is an interesting question whether there are hints for such BSM Higgs bosons already in the currently existing data. We interpret different collider excesses below the TeV scale in terms of scalar and pseudoscalar resonances in the N2HDM and the the NMSSM. We demonstrate for both models which of the excesses can be realized simultaneously, while still accommodating a SM-like Higgs boson at 125GeV and being in agreement with the other relevant theoretical and experimental constraints. We finally discuss how the scenarios can be probed in the near future.

T 26.10 Tue 18:15 Ta

Theoretical constraints on multi-Higgs scalar potentials: the [illegible] 331 model — •Margherita Ghezzi — Institut für Theoretische Physik, Eberhard Karls Universität Tübingen, Tübingen, Deutschland

Extensions of the Standard Model presenting a multi-Higgs potential are subject to a set of theoretical constraints in order to be physically viable. This talk reviews these constraints for the case of a general extension of the Standard Model that encompasses a $SU(3)_c \times SU(3)_L \times U(1)_X$ gauge symmetry. In this respect, the boundedness from below is analysed to identify the correct criteria for obtaining the physical minima of the Higgs parameter space. Furthermore, perturbativity and unitarity bounds are discussed in light of the exact diagonalisation of the scalar fields. Altogether, these constraints provide a restriction of the parameter space to be taken into account prior to any further experimental study.

T 27: QCD I

Time: Tuesday 16:00–17:45 Location: Tb

T 27.1 Tue 16:00 Tb

Measurement of inclusive jet cross-section with different size parameters at $\sqrt{s}$ =13 TeV in the ATLAS experiment — •Fernando Del Rio — Kirchhoff Institute for Physics

Jets are the experimental evidence of the fundamental particles governed by quantum chromodynamics (QCD), quark and gluons; their study brings valuable insight into both the physics of the Standard Model and the searches for new physics. A jet can be though in terms of a set of particles coming from a single original particle, or, in terms of measurement, a set of energy deposits in a detector. On the particle-level, the process by which a jet is formed involves hadronization, a non-perturbative phenomenon that cannot be explained from first principles. On the measurement-level a size parameter (radius or R) must be set for the anti-k_t algorithm used to define jets. In the ATLAS experiments the default value for R is 0.4. In this ongoing work which uses 43 fb^{-1} of data from the LHC, we plan to measure the cross-section of jets that have different radii (0.2 and 0.6) to gain insight of the non-perturbative processes involved in jet formation. With this goal, in-situ calibrations have been derived for the different R, a trigger strategy has been worked out and their resolution has been determined with an in-situ method.

T 27.2 Tue 16:15 Tb

Measurement of di-jet event cross sections in pp collisions at $\sqrt{s}$ = 13 TeV with CMS 2016 data — •Luis Ignacio Estevez Banos, Armando Bermudez Martinez, Patrick Connor, and Hannes Jung — DESY Hamburg

A measurement of multi-differential cross-sections for QCD di-jet events production in pp collisions at a centre-of-mass energy of 13 TeV will be presented. The analysed data set was recorded with the CMS detector during 2016, corresponding to an integrated luminosity of about 36 fb-1. The multiplicity is measured triple-differentially as a function of the $\Delta\phi_{1,2}$ separation between leading and subleading jets and p_T of the leading jet. The transverse momenta of the leading four jets are also measured.

This talk will give an overview of the analysis starting with the event selection and the applied corrections to data and MC and finally the cross-section unfolding procedure. The data measured will be compared to MC predictions.

T 27.3 Tue 16:30 Tb

Low mass Drell-Yan measurement in p-p collision at $\sqrt{s}$ = 13 TeV using the ATLAS detector at the LHC — •Alessandro Guida — DESY, Hamburg

High energy physics experiments are performed at the Large Hadron Collider at CERN colliding bunches of protons at energies up to 13 TeV. The ATLAS experiment, with its multipurpose detector, studies the products of these collisions and compares the experimental measurements with the predictions of the Standard Model. This talk presents the study of the process $Z/\gamma^* \to \mu\mu$ at low invariant mass of the di-muon pair, in the region between 7 GeV and 60 GeV, below the the Z boson resonance mass peak (m_Z = 91.2 GeV). The single and double differential cross sections $d\sigma/dm_{\mu\mu}$, $d^2\sigma/dm_{\mu\mu}\, d|y_{\mu\mu}|$ and $d^2\sigma/dm_{\mu\mu}\, dp_T^{Z/\gamma^*}$ of the process are measured in 13 TeV proton-proton collisions at the LHC, using the ATLAS detector. The measurement explores an extreme region of the phase space and is sensitive to resummation results in the theoretical prediction (a calculation that, in some particular kinematics conditions, is valid at each perturbative order). The analysis exploits the good resolution of the ATLAS detector in reconstructing low momentum muons. The main difficulties come instead from the high background component that enters in the event selection, the triggering of events and the modelling of some key physical quantities.

The main features of the analysis, the studies done to overcome the

main challenges, as well as the first results and comparison to theory predictions are presented in the talk.

T 27.4 Tue 16:45 Tb

Search for contact interactions with inclusive jet production at the LHC at 13 TeV — •Toni Mäkelä and Katerina Lipka — Notkestraße 85, 22607 Hamburg, Germany

In this work, inclusive jet production cross sections and triple-differential cross sections of top quark-antiquark pair production at the LHC at a center of mass energy of 13 TeV are used together with data of inclusive deep inelastic scattering to extract the parton distributions of the proton and the strong coupling constant. In an additional analysis of the same data, the standard model cross section is extended with effective couplings for 4-quark contact interactions. In particular, left-handed vector-like or axial-vector like colour-singlet exchanges are considered. These would correspond to beyond-the-standard model scenarios with quark substructure, Z' or extra dimensions. For the first time, the Wilson coefficients of contact interactions are extracted simultaneously with the standard model parameters using the LHC data.

T 27.5 Tue 17:00 Tb

Impact of differential dijet data on PDF and strong coupling fits at NNLO — •Jakob Stark and Klaus Rabbertz — Karlsruhe Institute of Technology

Influence of triple differential dijet cross sections at $\sqrt{s} = 8\,\text{TeV}$ on fitted PDFs is studied. Inclusion of jet data into PDF fits mainly has impact on the gluon PDF. Compared to previous PDF fits of the CMS collaboration with dijet data included, this is done for the first time with NNLO theory calculations, that only became available in the last few years. By comparing PDF fits at NLO to NNLO one finds, that at NNLO the scale dependency and scale uncertainties of the resulting PDFs decrease significantly, which matches the expected behavior.

In addition, simultaneous fits of the PDFs and the strong coupling constant are presented. Here the results exhibit significantly smaller scale uncertainties at NNLO. The central fit results for $\alpha_s(M_z)$ are, as expected, somewhat smaller at NNLO than at NLO.

At last, a double differential dijet cross section measurement at $\sqrt{s} = 7\,\text{TeV}$ is included into the PDF fits as well. While at NLO both dijet measurements lead to slightly different results, at NNLO these differences decrease drastically, such that a combined fit can be performed including both dijet datasets in a consistent way.

T 27.6 Tue 17:15 Tb

Jet Mass Calibration — •Steffen Albrecht, Andreas Hinzmann, Dennis Schwarz, and Roman Kogler — Universität Hamburg

In this talk, a technique for calibrating the mass of (fat) jets will be presented. In the analysis of hadronic final states, the resolution and the scale of the jet mass can be an important source for the systematic uncertainties. Therefore an improvement of its measurement will benefit many of these analyses.

Using scales of jet constituents of different categories (e.g. charged hadronic, neutral hadronic) as nuisance parameters in a template fit of the jet mass in several regions to data, one can learn about their influence on the jet mass shape and normalisation. The presented analysis takes processes with W+jets as well as hadronic $t\bar{t}$ systems in the final states into account. In addition, only events are considered in which the bosons have a large transverse momentum and thus produce strongly collimated decay products which are reconstructed as single fat jets.

T 27.7 Tue 17:30 Tb

Pileup mitigation in CMS — •Ksenia de Leo, Anna Benecke, Johannes Haller, Andreas Hinzmann, Roman Kogler, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

The high instantaneous luminosity reached by the LHC during Run-2 leads to an increased number of additional collisions in each bunch crossing (pileup). An important experimental challenge is the separation of particles produced in the interaction of interest from those resulting from pileup interactions.

This talk will present studies of the Pile Up Per Particle Identification (PUPPI) technique to mitigate effects from pileup on the object reconstruction in the CMS detector. The algorithm will be described together with challenges in its application. In addition, the optimisation of the algorithm for the final reconstruction of Run-2 data will be presented in detail.

T 28: Top quark production II

Time: Tuesday 16:00–18:30 Location: Tc

T 28.1 Tue 16:00 Tc

Measurements of differential cross sections for $t\bar{t}$ production at $\sqrt{s} = 13$ TeV with the CMS experiment — Maria Aldaya, Olaf Behnke, •Henriette Petersen, Mykola Savitskyi, Rafael Sosa, and Sebastian Wuchterl — Deutsches Elektronen Synchrotron (DESY)

Precision tests of the Standard Model are of utmost importance in particle physics, not only in order to test existing theories but also to probe the realm of new physics. The top quark is of particular interest in this context, as its heavy mass can link it to production- and decay-modes of new processes at higher energy scales. In this talk measurements of differential cross sections for $t\bar{t}$ production at $\sqrt{s} = 13$ TeV will be presented. The analysis is based on data obtained with the CMS experiment during 2016, 2017 and 2018 in Run 2 of the LHC, corresponding to an integrated luminosity of 137 fb^{-1}. In this period of time more than 100 million pp collisions with a $t\bar{t}$ pair in the final state have occurred, and therefore, Run 2 facilitates unprecedented precision in measurements of kinematic spectra and topologies in these events. The analysis is performed using the dileptonic decay channel. We perform differential measurements of the $t\bar{t}$ production cross section in bins of kinematic properties of the visible decay products, $t\bar{t}$ system and top quark. In this talk the general analysis strategy will be presented. This includes an overview of the event selection, kinematic reconstruction of the $t\bar{t}$ system, cross section unfolding procedure and results for full Run 2 differential cross sections compared to MC predictions based on NLO QCD models matched to parton showers.

T 28.2 Tue 16:15 Tc

Measurement and EFT interpretation of the $t\bar{t}$ cross section in the boosted lepton+jets channel with the ATLAS detector at $\sqrt{s} = 13\,\text{TeV}$ — Johannes Erdmann, Kevin Kröninger, and •Kevin Sedlaczek — TU Dortmund University, Dortmund, Germany

Physics beyond the Standard Model (SM) can, in absence of resonances, be investigated in a model-independent way by using effective field theory (EFT) approaches. Without assumption of the underlying theory, effects of potential new particles at a low energy scale can be quantified by higher dimension expansions of the SM Lagrangian at a much higher energy scale.

At the LHC, physics in the top sector is entering a phase of precision measurements combined with very accurate predictions. Meanwhile, many theories beyond the SM predict deviations in the top couplings or new interactions coupling to the top quark. These aspects combined make model-independent measurements in the top sector a very attractive way to test the SM for deviations arising from new physics at higher energy scales.

In this talk, studies on a differential $t\bar{t}$ cross-section measurement are shown. The analysis is performed in the boosted lepton + jets channel on the full Run 2 dataset taken with the ATLAS detector at $\sqrt{s} = 13$ TeV. The EFT framework is used to derive bounds on the contributions of new physics via two EFT operators. The choice of variables for the unfolded differential distributions on basis of their sensitivity to the EFT operators as well as first simulation-based studies are presented.

T 28.3 Tue 16:30 Tc

Measurement of the $t\bar{t}$ production cross-section in the lepton+jets channel at $\sqrt{s} = 13$ TeV with the ATLAS experiment — •Baida Achkar[1], Tomas Dado[1,2], Jacopo Magro[3], Kevin Moor[1], Clara Nellist[1,4], Marcel Niemeyer[1], Arnulf Quadt[1], Leonid Serkin[5], and Elizaveta Shabalina[1] — [1]II. Physikalisches Institut, Georg-August-Universität Göttingen — [2]now at: Technische-Universität Dortmund — [3]Università di Udine/INFN — [4]now at:

Radboud University Nijmegen/Nikhef — [5]ICTP Trieste/INFN

Studies of top-quark production and decays provide a precise probe of the Standard Model (SM) as well as its extensions. At the CERN Large Hadron Collider, top quarks are primarily produced in quark–antiquark pairs ($t\bar{t}$) and form an important background in many searches for physics beyond the SM. This talk reports ATLAS measurements of the $t\bar{t}$ cross-sections in the full phase space (inclusive) and in a phase space close to the experimental measurement range (fiducial) at $\sqrt{s}$ = 13 TeV, using the full pp data set collected during 2015–2018 which corresponds to an integrated luminosity of $\mathcal{L} = 139$ fb^{-1}. Events with exactly one charged lepton and four or more jets in the final state, with at least one jet containing b-hadrons are used to measure the $t\bar{t}$ cross-section through a profile-likelihood fit to data of the distributions of discriminating variables in three non-overlapping regions. The $t\bar{t}$ fiducial cross-section is measured with a precision of 4.3% to be: $\sigma_{\text{fid}} = 110.7 \pm 4.8$ pb. The inclusive cross-section is measured with a precision of 4.6% to be: $\sigma_{\text{inc}} = 830 \pm 38$ pb. Results agree with the theoretical calculations at NNLO in QCD.

T 28.4 Tue 16:45 Tc

Systematic-aware top-quark pair reconstruction with deep learning — Tomas Dado, Johannes Erdmann, •Lars Kolk, and Olaf Nackenhorst — TU Dortmund University

The top quark plays a unique role in the Standard Model of particle physics as it is the most massive of all known elementary particles. Due to its large Yukawa coupling, a precise measurement of its properties is crucial in order to search for hints for physics beyond the Standard Model. Since the average lifetime of a top quark is smaller than the hadronisation timescale, it decays before it can form a bound state.

In the Standard Model, the top quark almost exclusively decays into a bottom quark and a W-boson. The W-boson can then either decay into a charged lepton and its respective neutrino or into an up- and a down-type quark. In this work, $t\bar{t}$ production with one charged lepton in the final state is studied, which results in four jets, two of which are b-jets, at leading order. In order to calculate the four momenta of the top quarks, the detected jets must be assigned to the final state particles of the hard scattering process, using the kinematic properties of the decay products. This process is called $t\bar{t}$ reconstruction.

Deep Neural Network (DNN) have shown to outperform commonly used algorithms in $t\bar{t}$ reconstruction with one charged lepton in the final state (J. Erdmann et al 2019 JINST14 P11015). In this work, the DNN approach is modified in order to minimise the impact of modelling uncertainties, which many top quark analyses suffer from. Initial studies of the top quark reconstruction using DNNs using Monte Carlo simulated samples are presented.

T 28.5 Tue 17:00 Tc

Jet activity measurement in top pair productions in dilepton channel with the ATLAS experiment — •Matthieu Robin — DESY, Zeuthen

The subject of this talk is the $t\bar{t}$ + $jets$ measurement with the ATLAS detector.

This measurement allows to challenge the understanding of physics phenomena described by a robust theory (QCD), thus providing the necessary feedback to theorists to fine-tune the approximations and parameters used to perform the simulations of these phenomena and continue to further improve the precision one can reach. Achieving precision is indeed important for other analyses regarding the understanding and rejection of their QCD background (e.g.: $t\bar{t}H(H \to b\bar{b})$).

This study uses the full LHC run II dataset of 139 fb^{-1} to improve the results in statistically limited regions as well as method to better estimate and/or reject our signal backgrounds such as fake lepton background and pile-up jets. In this talk updated data/MC comparisons will be shown using updated b-tagging and jet reconstruction algorithms with some unfolded results and an emphasis on PU study that I performed with the help of the $t\bar{t}$ + $jets$ analysis team of ATLAS.

T 28.6 Tue 17:15 Tc

Measurement of the dileptonic $t\bar{t}$ differential cross section in a BSM phase space at CMS — Lutz Feld, •Danilo Meuser, Johannes Schulz, and Marius Teroerde — I. Physikalisches Institut B, RWTH Aachen University

Measurements of the $t\bar{t}$ production cross section yield important precision tests of the Standard Model (SM), while also probing scenarios for physics beyond the SM (BSM). Although the dileptonic channel has the lowest branching ratio of all $t\bar{t}$ decay channels, its sensitivity is large due to small contributions from other SM processes.

This analysis aims to measure the $t\bar{t}$ cross section in a phase space where additional contributions from BSM scenarios could be present. It is based on the data set recorded by CMS in the years 2016 to 2018 at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 137.2 fb^{-1}. The BSM scenarios considered include supersymmetric and dark matter models, where, similarly to the dileptonic $t\bar{t}$ channel, two leptons, b jets and undetected particles are produced. Unlike previous measurements, where the differential cross sections were mainly measured as a function of kinematic variables of the leptons or top quarks, this analysis focuses on observables related to the neutrinos, like the missing transverse momentum and the angular distance between the missing transverse momentum and the nearest lepton, to separate BSM from SM $t\bar{t}$ events.

T 28.7 Tue 17:30 Tc

Constraining Effective Field Theory with $t\bar{t}\gamma$ events using ATLAS data at $\sqrt{s}$ = 13 TeV — •Binish Batool, Carmen Diez Pardos, and Ivor Fleck — Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen

The study of the production cross section of top anti-top quark pairs in association with a photon ($t\bar{t}\gamma$) probes the electroweak coupling of top quark and photon. The ATLAS detector at the Large Hadron Collider (LHC) has recorded data at the centre-of-mass energy of $\sqrt{s}$ = 13 TeV in Run 2, corresponding to an integrated luminosity of 139 fb^{-1}, which provides an opportunity to search for possible deviations from the Standard Model. These deviations can be interpreted in the context of model independent approaches, such as Effective Field Theories. The production cross section of $t\bar{t}\gamma$ is expected to be sensitive to three dimension-six operators, namely O_{tG}, O_{tB} and O_{tW}. In this talk, the sensitivity of the total and differential $t\bar{t}\gamma$ cross sections to those three operators is investigated and expected limits for the full Run 2 data from ATLAS at $\sqrt{s}$ = 13 TeV are provided.

T 28.8 Tue 17:45 Tc

Determination of Background from Misreconstructed Electrons in $t\bar{t}\gamma$ topologies with the ATLAS detector — Ivor Fleck, •Buddhadeb Mondal, and Carmen Diez Pardos — Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen

An effort is ongoing on measuring inclusive and differential cross-sections of the $t\bar{t}\gamma$ production in pp collision at $\sqrt{s}$ = 13 TeV with 139 fb^{-1} data collected by the ATLAS detector at CERN. One of the background sources comes from the misidentification of electrons as photons ($e \to \gamma$ fake). This happens mainly due to tracking inefficiency or failure to find a match between inner detector track and electromagnetic cluster. The $e \to \gamma$ fakes are not well described by Monte Carlo simulations. In this talk, a method to estimate the $e \to \gamma$ fake based on data using a "tag and probe" approach with $Z \to e^+e^-$ events will be presented.

T 28.9 Tue 18:00 Tc

Measurement of $t\bar{t} + \gamma$ production with full Run 2 data — •Andreas Kirchhoff, Arnulf Quadt, Elizaveta Shabalina, and Knut Zoch — II. Physikalisches Institut, Georg-August-Universität Göttingen

The optimal way to measure the top-photon coupling and later interpret it within an EFT-framework would be an e^+e^- collider with sufficient energy. As such a collider does not exist, another possibility to measure it is the production of $t\bar{t}$ pairs in association with a photon. Unfortunately, most of such photons will come from the decay products of the top quarks and hence have nothing to do with the top-photon coupling. In contrast, photons produced in the production of the $t\bar{t}$ pair mostly originate from the top quark (beside a small contribution from ISR). The separation of photons originating from production and decay is tried for the first time in this ATLAS analysis. In this talk, the status of the currently ongoing full Run 2 analysis of the $t\bar{t} + \gamma$ process will be presented with some first studies that use deep neural networks to enhance the sensitivity to the top-photon coupling.

T 28.10 Tue 18:15 Tc

Measurement of multi-differential cross sections for the production of top quark pairs plus additional jets in pp collisions at sqrt(s)=13TeV. — •Rafael Eduardo Sosa Ricardo, Maria Aldaya, Olaf Behnke, Henriette Petersen, Mykola Savitskyi, and Sebastian Wuchterl — DESY

Measurements of multi-differential cross sections for top quark pair ($t\bar{t}$) production in pp collisions at a center-of-mass energy of 13 TeV using events containing two opposite-sign leptons will be presented. The analyzed dataset was recorded with the CMS detector in during the years 2016, 2017 and 2018, corresponding to an integrated luminosity of $137fb^{-1}$. The $t\bar{t}$ cross sections are measured double and triple-differentially as a function of the $t\bar{t}$ system kinematics, the top quark, and of additional jets in the event.

This talk comprises an overview of the analysis starting with the event selection, kinematic reconstruction of the $t\bar{t}$ system, and the cross section unfolding procedure. First cross section results will be compared to MC predictions based on NLO QCD matched to parton showers.

T 29: Top quark decay and top properties I

Time: Tuesday 16:00–18:05 Location: Td

Group Report T 29.1 Tue 16:00 Td

Top quark mass measurements at the University of Hamburg with CMS — Christoph Garbers, Johannes Haller, Roman Kogler, Johannes Lange, Alexander Paasch, Peter Schleper, •Dennis Schwarz, and Hartmut Stadie — Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Being the heaviest particle that we know of, the top quark is of special interest in the Standard Model of particle physics. Its mass plays a crucial role in quantum loop corrections to the Higgs boson mass, and precise measurements of this fundamental parameter provide important tests of the theory. Ambiguities in the top quark mass scheme arise from the use of non-perturbative parton shower models in direct measurements that could be resolved by new analysis strategies.

In this talk, efforts of the CMS group of the University of Hamburg in the area of top quark mass measurements are presented, which include the most precise single direct measurement to date and an alternative approach using the jet mass of boosted hadronic top quark decays.

T 29.2 Tue 16:20 Td

Measurement of the top quark pole mass using $t\bar{t}$+1 jet events with the CMS experiment — Matteo Defranchis, Katerina Lipka, and •Sebastian Wuchterl — DESY, Hamburg

The top quark is the most massive elementary particle known. Its mass, m_t, is a fundamental parameter of the Standard Model (SM), and its value needs to be determined experimentally. Therefore, a precision measurement of m_t, together with the masses of the W and Higgs bosons, allows for stringent tests of self-consistency of the SM. Furthermore, the value and the uncertainty of m_t are driving predictions for the energy dependence of the Higgs quartic coupling, which determines the stability of the electroweak vacuum. In proton-proton collisions at the LHC, top quark-antiquark ($t\bar{t}$) pair production can be used to extract m_t in different renormalization schemes.

In this work, the pole mass of the top quark is measured using events in which the $t\bar{t}$ pair is produced in association with one additional jet. This analysis is performed using proton-proton collision data collected by the CMS experiment at the LHC in 2016-2018 with $\sqrt{s} = 13$ TeV, corresponding to a total integrated luminosity of 137 fb^{-1}. Events with two opposite sign leptons in the final state are analyzed to measure the normalized differential cross section as a function of the inverse of the invariant mass of the $t\bar{t}$+1 jet system. This observable has been chosen due to strongest sensitivity to m_t at the threshold of the $t\bar{t}$ pair production.

T 29.3 Tue 16:35 Td

Measurement of the jet mass in decays of boosted top quarks using the full Run-2 dataset of the CMS detector — •Alexander Paasch, Johannes Haller, Roman Kogler, and Dennis Schwarz — Institut für Experimentalphysik, Universität Hamburg

Hadronic decays of boosted top quarks result in single large-radius jets. The mass of the jets is sensitive to the top quark mass. At the LHC, it is commonly used as a discriminator against jets originating from light quarks and gluons. For this reason, a measurement of the jet mass of boosted top quark decays is of special interest for both, studies of the Standard Model and searches for new physics.
In this talk, a measurement of the jet mass is presented using the full Run-2 dataset of the CMS experiment corresponding to a significantly larger statistics than an earlier result. In addition, the two dominant systematic uncertainties, namely the uncertainties related to final state radiation and the jet energy scale, are significantly reduced by measurements in dedicated control regions.

T 29.4 Tue 16:50 Td

A nuisance parameter fit for the top quark mass measurement — •Christoph Garbers, Peter Schleper, and Hartmut Stadie — Universität Hamburg, Hamburg, Germany

The top quark is the heaviest known particle in the standard model. It plays a crucial role in consistency checks of the Standard Model and in search for new physics.
In the $t\bar{t}$ to lepton+jets channel a top quark mass of 172.25±0.63 GeV was measured. With the $35.9fb^{-1}$ data recorded by CMS in 2016 this measurement was limited by systematic uncertainties, especially the correction of jet energies and the description of color reconnection in simulation.
A method to improve this measurement by inserting systematic uncertainties as nuisance parameters into a profiled likelihood fit with multiple additional observables will be presented.

T 29.5 Tue 17:05 Td

Measurement of the top quark mass in single top quark enriched events — •Soureek Mitra[1], Thomas Müller[1], Tariq Aziz[2], Sashi Dugad[2], Ravindrbabu Karnam[2], Mintu Kumar[2], and Gagan Mohanty[2] — [1]Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany — [2]Tata Institute of Fundamental Research (TIFR), Mumbai, India

The mass of the top quark (m_t) is one of the important parameters of the standard model (SM) of particle physics. It has the largest contribution to the radiative correction of the Higgs boson self-coupling among the SM particles; thus it is directly related to the stability of the electroweak vacuum. A measurement of m_t is presented in a sample enriched with single top quark events produced in the t channel, using 35.9 fb^{-1} of proton-proton collision data recorded at $\sqrt{s} = 13$ TeV by the CMS experiment in 2016. Candidate events are selected by requiring an isolated charged lepton (muon or electron), exactly two jets, and large missing transverse momentum. One of the jets is identified to originate from a bottom quark, whereas the other stems from the hadronization of a light-flavour quark. A multivariate discriminant is designed to separate signal from backgrounds and the selection criterion on the discriminant output is optimized to ensure an event sample with high signal purity. The masses of top quark and antiquark are measured separately based on the charge of the lepton in the final state, and their ratio and difference are determined as a test of the CPT invariance.

T 29.6 Tue 17:20 Td

Measurement of top quark charge asymmetry in $t\bar{t}\gamma$ production in the ATLAS experiment — Ivor Fleck, Carmen Diez Pardos, and •Amartya Rej — Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen

The top quarks and anti-top quarks produced via initial quarks at the LHC are emitted in slightly different directions depending on their charge, referred to as charge asymmetry (A_c). The asymmetry is due to QCD interference contributions at next-to-leading order accuracy and it is sensitive to New Physics models. Such asymmetry was observed at the Tevatron experiment, where quark anti-quark ($q\bar{q}$) annihilation was the dominant mode of $t\bar{t}$ production. The asymmetry is diluted at the LHC owing to the very large fraction of gluon fusion initiated $t\bar{t}$ production. However, recently its evidence has been found by the ATLAS experiment.

In $t\bar{t}$ production associated with a photon ($t\bar{t}\gamma$), the fraction of top quark pairs produced via $q\bar{q}$ annihilation increases compared to $t\bar{t}$ production and also leading order QED interference contributes to the charge asymmetry. Hence a larger value of charge asymmetry is

expected to be found in this process with higher sensitivity to New Physics models. Still, this process has a tiny cross-section compared to $t\bar{t}$ production, one of the dominant background processes. Thus the background discrimination becomes challenging. In this presentation, the ongoing effort for the charge asymmetry measurement in $t\bar{t}\gamma$ production in the ATLAS experiment will be presented highlighting the analysis methods and related challenges.

T 29.7 Tue 17:35 Td

Top-antitop energy asymmetry in jet-associated top-quark pair production at ATLAS — •Alexander Basan[1], Asma Hadef[1], Lucia Masetti[1], Eftychia Tzovara[1], and Susanne Westhoff[2] — [1]Universität Mainz — [2]Universität Heidelberg

The top quark is particularly well suited to probe the standard model (SM) and many extensions thereof at the electroweak symmetry-breaking scale and beyond.

At hadron colliders, the $t\bar{t}$ production is symmetric at leading order perturbation theory under the exchange of the top- and anti-top-quark, while interferences at higher orders create an asymmetry. This charge asymmetry can provide sensitive probes for many models beyond the standard model like massive color-octet states, extra dimensions, flavor violating gauge bosons and axigluons. Within the framework of effective field theories (EFT), the charge asymmetry is especially sensitive to four-quark operators and one operator that modifies the top-gluon interaction.

In inclusive jet-associated top-quark pair production the asymmetry arises already at leading order in quark-gluon interactions. Furthermore, the $t\bar{t}j$ final state allows the definition of a new observable, the energy asymmetry, expressed in terms of the distribution of the energy difference $E_t - E_{\bar{t}}$.

This talk presents the measurement strategy in lepton+jets events with a high p_T hadronically decaying top quark at ATLAS with a center of mass energy of $\sqrt{s} = 13\,\text{TeV}$ as well as expected sensitivities to the Wilson coefficients.

T 29.8 Tue 17:50 Td

Measurement of helicity fractions of W bosons decaying from top quarks in dileptonic $t\bar{t}$ events at $\sqrt{s} = 13$ TeV with the ATLAS detector. — Tomas Dado[1,2], Thomas Peiffer[1], •Ishan Pokharel[1], Arnulf Quadt[1], Elizaveta Shabalina[1], and Knut Zoch[1] — [1]II. Physikalisches Institut, Georg-August-Universität Göttingen — [2]now at: Technische Universität Dortmund

Due to the large difference between the top and b-quark masses, the W boson in the Wtb vertex is heavily polarised. A measurement of three helicity fractions of W bosons from top-quark decays is presented. They are extracted from the differential distribution of the observable $cos\theta^*$, defined as the angle between the charged lepton and the top quark in the W boson rest frame. The reconstructed $cos\theta^*$, distribution in the dilepton channel of $t\bar{t}$ events is unfolded to parton level. Event reconstruction is performed using the neutrino weighting algorithm, owing to the fact that two neutrinos need to be reconstructed from one measurement of missing transverse energy. The helicity fractions are extracted from the fit of the unfolded $cos\theta^*$ differential distribution to an analytical function that relates the observable to the helicity fractions of the W boson. The fractions are constrained to unity in the fit via Lagrange multiplier.

T 30: Higgs decay in fermions II

Time: Tuesday 16:00–18:15 Location: Te

T 30.1 Tue 16:00 Te

Reconstruction of b- and c- jets at e^+e^- Higgs Factories with ParticleFlow detectors — •Yasser Radkhorrami[1,2] and Jenny List[1] — [1]DESY, Hamburg — [2]University of Hamburg, Hamburg

The Higgs boson decay modes to heavy b and c quarks are crucial for the Higgs physics studies. The presence of semileptonic decays in the jets originating from b and c quarks causes missing energy due to the undetectable neutrinos. A correction for the missing neutrino momenta can be derived from the decay kinematics up to a two-fold ambiguity. The correct solution can be identified by a kinematic fit, which exploits the well-known initial state at an e^-e^+ collider by adjusting the measured quantities within their uncertainties to fulfill the kinematic constraints. The ParticleFlow concept, based on the reconstruction of individual particles in a jet allows understanding the individual jet-level uncertainties at an unprecedented level. The modeling of the jet uncertainties and the resulting fit performance will be discussed for the example of the ILD detector. Applied to $H \to b\bar{b}/c\bar{c}$ events, the combination of the neutrino correction with the kinematic fit improves the Higgs mass reconstruction significantly, both in terms of resolution and peak position.

T 30.2 Tue 16:15 Te

Search for standard model Higgs boson decaying into a charm quark-antiquark pair with the CMS experiment — •Luca Mastrolorenzo, Alexander Schmidt, Andrey Pozdnyakov, Xavier Coubez, Andrzej Novak, Spandan Mondal, and Alena Dodonova — RWTH, Aachen, Germany

In this talk, the search for a standard model Higgs boson decaying into a charm quark-antiquark pair with the data collected by the CMS experiment during the 2016 data-taking period is presented. The search targets Higgs boson production in association with a vector boson (Z,W). To maximally enhance the analysis sensitivity and fully exploit the topology of the Higgs boson decay, two strategies are followed. In the first one, targeting lower vector boson transverse momentum, the Higgs boson candidate is reconstructed via two resolved jets arising from the two charm quarks from the Higgs boson decay. A second strategy identifies the case where the two charm quark jets from the Higgs boson decay merge to form a single jet, which generally only occurs when the vector boson has higher transverse momentum. One of the crucial aspects of the analysis is represented by the capability to correctly identify jets originating from charm quarks. To reach this goal, charm-taggers based on advanced machine learning algorithms have been deployed. The result achieved in this analysis represents the most stringent limit on the Higgs decay to charm quark-antiquark pair production cross-section to-date.

T 30.3 Tue 16:30 Te

Search for decays of boosted Higgs bosons to pairs of charm quarks with the CMS Experiment — •Andrzej Novak, Luca Mastrolorenzo, Xavier Coubez, Spadan Mondal, and Andrey Pozdnyakov — RWTH Aachen

The Higgs boson decay into charm quarks has the highest branching fraction of the yet unobserved decays. Moreover, it is predicted to be the strongest coupling to the second generation of fermions which as of now remains unconfirmed. This talk presents a search for the Higgs boson in the gluon fusion production mode with high Lorentz boosts, decaying to a pair of charm quarks. The analysis is modeled on a previous analysis of decays to pairs of bottom quarks and is enabled by recent developments in deep learning based tools for jet identification in such topologies. Probing this channel is not only important for completeness, but it could also be sensitive to potential beyond Standard Model corrections.

T 30.4 Tue 16:45 Te

Full Run2 analysis of Higgs boson decay to b-quarks in CMS — •hessamoddin kaveh — DESY, Hamburg, Germany

After the discovery of the 125 GeV Higgs boson in July 2012, the data collected at the LHC in 2016 and 2017 facilitated the discovery of the Higgs boson also in its decays into b-quarks. By now, the focus has shifted to measuring this decay channel at further improved precision. A measurement of the properties of the Higgs boson produced in association with vector bosons and decaying into a pair of b-quarks (VH(bb)) is presented. The full data of pp collisions recorded by the CMS experiment during Run 2 is reported. The focus of the talk is on the mass cross-check analysis in comparison to the DNN-based approach, statistical and systematic power of the analysis, improving the analysis methods such as kinematical reconstruction and optimization.

T 30.5 Tue 17:00 Te

$H \to b\bar{b}$ Tagger Calibration in $Z \to b\bar{b}$+jet events — •Shubham Bansal, Jochen Dingfelder, and Tatjana Lenz — Physikalisches Institut, Universität Bonn

Within the ATLAS collaboration, the most recent algorithm to separate boosted $H \to b\bar{b}$ decays from dominant backgrounds like multijets and jets originating from hadronically decaying top-quarks, employs an algorithm based on a feed-forward neural network. In boosted $H \to b\bar{b}$ decays, the b-quark fragmentation products are reconstructed using a large-R ($R = 1.0$) jet containing variable-radius subjets. The neural network algorithm combines flavor discriminants from up to three subjets inside the large-R jet and discriminates boosted Higgs from the dominant backgrounds. Since these algorithms are optimized and evaluated in simulation only, they need to be calibrated in data in an environment with b-jets that are close to each other. This talk presents the developments of the $H \to b\bar{b}$ tagger calibration in $Z \to b\bar{b}$+jet events with the ATLAS experiment.

T 30.6 Tue 17:15 Te

Search for heavy neutral Higgs bosons decaying into a pair of b quarks — •Paul Asmuss — DESY Hamburg

With the discovery of the Higgs boson in 2012, a milestone in particle physics was reached. The precision measurements that followed indicate that the found particle agrees with the Standard Model predictions. Nevertheless, there is still room for theories beyond the Standard Model including an extended Higgs sector. Examples for such theories are Supersymmetry or general Two Higgs Doublet models. Not only feature these models additional Higgs bosons but they also allow for a significantly enhanced coupling of the Higgs boson to b quarks.This analysis targets heavy neutral Higgs bosons decaying into two b quarks and produced in association with one or two additional b quarks. The final state is thus fully hadronic. A mass range from 300 GeV to 1.6 TeV is investigated based on data collected in 2017 with the CMS detector at the LHC at a center-of-mass energy of 13 TeV. First results are shown.

T 30.7 Tue 17:30 Te

Search for Higgs-boson pair production in the $bb\ell\ell$+$\mathbf{E_T^{miss}}$ final state with the ATLAS detector — •Benjamin Rottler, Benoit Roland, and Markus Schumacher — Albert-Ludwigs-Universität Freiburg

The determination of the triple Higgs-boson self-coupling λ is one of the key goals of the physics program at current and future colliders. It will allow to reconstruct the Higgs potential. The self-coupling can be accessed via non-resonant Higgs-boson pair production, which can happen at the LHC via the destructively interfering top-loop and Higgs self-interaction diagrams. The data can also be analyzed to probe resonant Higgs-boson pair production in a search for new heavy particles.

The goal of this analysis is to measure the cross-section of the non-resonant Higgs-boson pair production σ_{HH} using the full Run-2 dataset collected by the ATLAS experiment, corresponding to an integrated luminosity of $\sim$140 fb^{-1} at $\sqrt{s} = 13$ TeV. This is done by considering the $bb\ell\ell$+$E_{\mathrm{T}}^{\mathrm{miss}}$ final state, which combines the high branching ratio of the $H \to bb$ decay and the good efficiency of lepton triggers. Our focus is on a combined search for the $HH \to bb(WW \to 2\ell 2\nu)$, $HH \to bb(\tau\tau \to 2\ell 4\nu)$ and $HH \to bb(ZZ \to 2\ell 2\nu)$ processes.

A multi-class deep neural network (NN) is used to separate signal and background processes on top of a loose preselection. In this talk, I will focus on modern technologies used to optimize the NN architecture, like Bayesian hyperparameter optimization and input feature ranking algorithms, as well as on the statistical analysis which makes use of the shape of the NN output distribution to extract σ_{HH}.

T 30.8 Tue 17:45 Te

Search for pair production of Higgs bosons decaying to $b\bar{b}\tau^+\tau^-$ with the ATLAS detector — •Christopher Deutsch, Jochen Dingfelder, and Tatjana Lenz — Physikalisches Institut, Bonn, Germany

The discovery of the Higgs boson and the measurement of its properties confirming the Standard Model (SM) is a major step towards the understanding of electroweak symmetry breaking. As a result, the potential of the Higgs field, and therefore the trilinear self-coupling of the Higgs boson, is precisely predicted in the SM. It can be probed by measuring the cross section of Higgs boson pair production, offering an additional test of the SM. In the SM such measurements are difficult due to the destructive interference of processes containing the self-coupling and processes with Yukawa couplings to top quarks, leading to a small production cross section at the Large Hadron Collider (LHC). An enhancement would indicate the presence of physics beyond the Standard Model (BSM), since heavy resonances decaying into pairs of Higgs bosons are predicted by several BSM models.

A search for non-resonant and resonant Higgs boson pair production in the $b\bar{b}\tau^+\tau^-$ channel is presented. This channel is one of the most sensitive for probing the Higgs self-coupling. The talk will focus on the subchannel with two hadronically decaying tau leptons. New developments towards the analysis of the $\sim 139\,\mathrm{fb}^{-1}$ dataset collected by the ATLAS experiment in Run 2 of the LHC are presented. These include improvements in object selection with new particle identification algorithms and using multivariate methods for signal selection.

T 30.9 Tue 18:00 Te

Search for ZZ/ZH events in the 4b final state — •Roman Küsters, Tatjana Lenz, and Jochen Dingfelder — Rheinische Friedrichs-Wilhelms-Universität Bonn

One of the primary physics goals at the LHC is to measure the Higgs self-coupling and to determine the shape of the Higgs potential. The Higgs self-coupling can be directly measured in the di-Higgs (HH) production channel. Thus a search for the HH production is one of the important goals at the LHC. The HH->4b decay mode has the highest branching ratio and is thus one of the main search channels. The current sensitivity to HH is about 6.9 times the Standard Model cross section. The idea is to use the ZZ and ZH channels with a higher production cross section to validate the HH analysis. This talk presents the search for ZZ and ZH production in the 4b final state at a center-of-mass energy of 13 TeV collected with the ATLAS detector in 2015-2018 and how it can be used to validate the HH->4b analysis.

T 31: Flavour physics II

Time: Tuesday 16:00–18:30 Location: Tf

T 31.1 Tue 16:00 Tf

Search for lepton-flavour violating decays in the charm system at the LHCb experiment — •Daniel Unverzagt — Physikalisches Institut Heidelberg, Heidelberg, Germany

Decays of hadrons that violate the conservation of the lepton flavour number are forbidden within the standard model, but might be generated in many theories that go beyond. This talk summarises recent results on lepton-flavour violating decays in the charm system at the LHCb experiment. The focus will be on existing searches for two- and three-body decay topologies of neutral and charged charm mesons. Furthermore, plans and prospects to extend the program to four-body decays in the near future are presented.

T 31.2 Tue 16:15 Tf

Extrapolation of flavour tagging calibrations to high transverse momenta — Arnulf Quadt, Elizaveta Shabalina, and •Sreelakshmi Sindhu — II. Physikalisches Institut, Georg-August-Universität Göttingen

Identifying jets containing heavy-flavour hadrons can be very beneficial for a variety of analyses and this can be done using flavour tagging algorithms. Currently, these algorithms are calibrated by matching their performance on data to simulation. However, for jets with transverse momenta greater than a few hundred GeV, these calibrations do not exist due to statistical limitations. Flavour-tagging information for jets with high transverse momenta can be quite useful for analyses such as searches for heavy resonances. Hence, a Monte Carlo based extrapolation is done on the data based flavour tagging calibrations to extend these up to 3 TeV. The extrapolation uncertainties are calculated by propagating the relevant modelling, tracking and jet uncertainties through the tagging algorithm. In this talk, the extrapolation procedure will be explained. The results for extrapolation of b, c and light jets will be presented for the b-tagging algorithm that was used for the analysis of the Run 2 data by the ATLAS Collaboration.

T 31.3 Tue 16:30 Tf

Extending the Full Event Interpretation to the Y(5S) system at Belle — •Moritz Bauer and Pablo Goldenzweig — Karlsruhe

Institute of Technology, Karlsruhe, Germany

The Belle experiment has, in addition to the data collected at the $\Upsilon(4S)$ resonance, also collected 121 fb^{-1} of data at the $\Upsilon(5S)$ resonance. The decay products of this resonance include B_s mesons which present interesting channels to test the standard model. Until now, it has not been possible to apply Belle II's new B meson tagging algorithm, the Full Event Interpretation (FEI), to the $\Upsilon(5S)$ dataset. This exclusive tagging algorithm uses O(10k) decay channels to recombine final-state particles to B mesons.

This talk presents the development and validation of the FEI at the $\Upsilon(5S)$ resonance.

T 31.4 Tue 16:45 Tf

Test of isospin symmetry by measuring $\Upsilon(4S) \to B^0\overline{B^0}$ — •Pascal Schmolz and Thomas Kuhr — Ludwig-Maximilians-Universität München

In contrast to hadron colliders, B-factories allow for the determination of absolute branching fractions. The *Belle* experiment as well as its successor, *Belle II*, examine decays of the $\Upsilon(4S)$ to pairs of either neutral or charged B mesons. The calculation of the production rate for B mesons is often based on the assumption of strong isospin symmetry, i.e. charged and neutral pairs would be produced with the same probability. Quark masses and electromagnetic interaction, however, are responsible for slightly breaking isospin symmetry. In most of the previous measurements of $f_{00} = Br(\Upsilon(4S) \to B^0\overline{B^0})$ isospin is assumed. We present an analysis that bypasses this bias with a sophisticated method, first applied by the *BABAR* collaboration for such a measurement, that avoids any assumption on isospin.

T 31.5 Tue 17:00 Tf

Theory status of the lifetime ratio $\tau(B_s)/\tau(B_d)$ — Daniel King[1], Alexander Lenz[2], Maria Laura Piscopo[2], Thomas Rauh[3], and •Aleksey Rusov[2] — [1]IPPP, University of Durham, UK — [2]Universität Siegen, Germany — [3]University of Bern, Switzerland

The precise determination of the lifetime ratios of heavy hadrons plays a crucial role both for the accurate test of the Heavy Quark Expansion in the Standard Model and for the search of New Physics which may be hidden in the invisible decays of heavy hadrons. In this talk, I plan to overview the current theoretical status of the lifetime ratio $\tau(B_s)/\tau(B_d)$ in the light of recent determination of important Darwin operator contribution to non-leptonic decays of heavy hadrons and of s-quark mass corrections to the corresponding dimension-6 Bag parameters obtained in the framework of HQET Sum Rules.

T 31.6 Tue 17:15 Tf

Measurement of the time-integrated mixing parameter χ_d with dilepton tagging using semileptonic B decays at the Belle II experiment — Florian Bernlochner, Jochen Dingfelder, •Stephan Duell, and Peter Lewis for the Belle II-Collaboration — Rheinische Friedrich-Wilhelms-Universität Bonn

We present the current status of an analysis of inclusive semileptonic B decays with electrons in the final state and an early dataset of about 36.4fb^{-1} of integrated luminosity, which was recorded by the Belle II experiment in 2019 and 2020. The analysis aims to measure the time-integrated mixing parameter of the neutral B meson, χ_d, by exploiting the charge-flavour correlation between the B meson and the electron in inclusive semileptonic $B \to Xe\nu_e$ decays. A double tag strategy is employed where two electron candidates are reconstructed and the prompt semileptonic contribution is determined by a fit to the lepton momentum spectrum. The resulting yields can be separated into same-sign and opposite-sign events, which allows the direct determination of χ_d. The current status of the analysis will be presented in this talk.

T 31.7 Tue 17:30 Tf

NNLO QCD corrections to B_s mixing — •Marvin Gerlach, Ulrich Nierste, Vladyslav Shtabovenko, and Matthias Steinhauser — Institut für Theoretische Teilchenphysik, Karlsruhe Institute of Technology (KIT), Wolfgang-Gaede Straße 1, 76128 Karlsruhe, Germany

Since late 1980s, when the mixing of neutral B-mesons was first observed at DESY, B-$\bar{B}$ systems are an ever growing field of interest. The experimental as well as the theoretical progress in the recent 20 years enables precise determination of key parameters, such as the width difference $\Delta\Gamma_s$ between B_s and $\bar{B}_s$. The experimental uncertainty of this quantity only amounts to a few percent. The precision of the theoretical prediction, on the other hand, is currently limited by perturbative uncertainties. In this talk we give a short overview of the perturbative corrections to $\Delta\Gamma_s$, including QCD corrections to contributions with effective current-current and penguin operators in the framework of Heavy Quark Expansion (HQE).

T 31.8 Tue 17:45 Tf

CP Violation in Three-body B Decays: A Model Ansatz — •Kevin Olschewsky[1], Thomas Mannel[1], and Keri Vos[2] — [1]Center for Particle Physics Siegen, Theoretische Physik 1, Universität Siegen — [2]Faculty of Science and Engineering, Maastricht University

The mechanism of CP violation remains one of the puzzles in particle physics. Key to understanding this phenomenon are nonleptonic B decays, especially multibody decays which exhibit large CP asymmetries in various regions of phase space. A full QCD-based theoretical description of these decays is still missing, requiring the use of models to fit the data.

We suggest a model ansatz which reflects the underlying physics and the known mechanism of CP violation via the CKM matrix. In addition, since CP violation is driven by the interference between amplitudes with and without valence charm quarks, we argue that the opening of the open-charm threshold may play an important role in generating CP violation in the high invariant mass region. We present a natural extension of the isobar model to incorporate these effects and suggest using it to analyse nonleptonic three-body B decay data.

T 31.9 Tue 18:00 Tf

QCD Sum Rules for Parameters of the B-meson Distribution Amplitudes — •Muslem Rahimi and Marcel Wald — Theoretische Physik 1, Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Germany

We obtain new estimates for the parameters λ_E^2, λ_H^2 and their ratio $\mathcal{R} = \lambda_E^2/\lambda_H^2$, which appear in the second moments of the B-meson light-cone distribution amplitudes defined in the heavy-quark effective field theory.

The computation is based on two-point QCD sum rules for the diagonal correlation function and includes all contributions up to mass dimension seven in the operator-product expansion. For the ratio we get $\mathcal{R} = (0.1 \pm 0.1)$ with $\lambda_E^2 = (0.01 \pm 0.01)\,\mathrm{GeV}^2$ and $\lambda_H^2 = (0.11 \pm 0.02)\,\mathrm{GeV}^2$.

T 31.10 Tue 18:15 Tf

QED effects and factorization in charmless B decays — Martin Beneke[1], Philipp Böer[1], •Jan-Niklas Toelstede[1], and Keri Vos[2] — [1]Technical University of Munich — [2]Maastricht University

In the heavy-quark limit, hadronic matrix elements of B-meson decays into two light charmless final-state mesons factorize to all orders in the strong coupling into universal hadronic quantities (form factors and light-cone distribution amplitudes) as well as process-dependent hard-scattering kernels. Within the framework of Soft-Collinear Effective Theory, we generalize the QCD factorization to include QED corrections and show that it retains its QCD form. However, the presence of electrically charged final state mesons requires to introduce modified hadronic functions that become process-dependent to a certain extent as soft photons do not decouple completely. It further leads to interesting and qualitatively new features, in particular regarding the renormalization group of these objects, that will be discussed in this presentation, as well as the size of QED corrections on selected observables for πK final states.

T 32: Flavour physics VI

Time: Tuesday 16:00–18:30 Location: Tg

T 32.1 Tue 16:00 Tg

Angular analysis of $B_s^0 \to \phi\mu^+\mu^-$ decays — •Marcel Materok, Christoph Langenbruch, and Eluned Smith — I. Physikalisches Institut B, RWTH Aachen University

The LHCb experiment at the LHC is dedicated to the search for new phenomena beyond the Standard Model (SM) through precision measurements of heavy flavour decays. Rare semileptonic $b \to s\ell^+\ell^-$ decays are particularly interesting as they constitute flavour-changing neutral currents that are forbidden at tree-level in the SM and are only allowed at loop-level. Theses processes are thus rare and are sensitive to the effects of new, heavy particles beyond the SM.

The rare decay $B_s^0 \to \phi\mu^+\mu^-$ has been previously analysed by the LHCb collaboration using data taken in 2011 and 2012, during Run 1 of the LHC. Further studies of this mode are particularly motivated by recent tensions with SM predictions seen in other rare $b \to s\ell^+\ell^-$ processes.

This talk will give an overview of the measurement of the angular observables in the $B_s^0 \to \phi\mu^+\mu^-$ decay using LHCb data collected during Run 1 and 2.

T 32.2 Tue 16:15 Tg

Calibration of Belle II hadronic tagging on Belle data — Florian Bernlochner[4], Thomas Kuhr[1,2], •Kilian Lieret[1,2], Felix Metzner[3], and Markus Prim[4] — [1]Ludwig Maximilian Universität — [2]Excellence Cluster Origins — [3]Karlsruhe Institute of Technology — [4]Rheinische Friedrich-Wilhelms-Universität Bonn

The Belle II experiment at the SuperKEKB accelerator observes pairs of B mesons. As the center of mass energy is known, the kinematics of one B meson (the signal B) are determined if the other B meson (the tag B) is fully reconstructed.

The tag B meson can be reconstructed in different channels and using different techniques. This analysis considers hadronic B decays reconstructed with the FEI (Full Event Interpretation), an algorithm relying heavily on machine learning techniques.

Because imperfections in the MC simulation may result in a different tag B reconstruction efficiency than in real data, the FEI must be calibrated. By considering a well known decay mode on the signal side (here inclusive $B \longrightarrow X\ell\nu$), calibration weights can be calculated.

The calibration is performed for the full Belle dataset of $710\,\mathrm{fb}^{-1}$, which has been converted in order to be analyzed with the Belle II software framework. The results of the calibration will be first used for an update of Belle results for $B \longrightarrow D^{(*)}\ell\nu_\ell$ decays that profit from the improved Belle II reconstruction software.

T 32.3 Tue 16:30 Tg

Rare baryonic decays at LHCb — Johannes Albrecht, Maik Becker, •Vitalii Lisovskyi, and Janina Nicolini — TU Dortmund

Flavour-changing neutral-current $b \to s\ell^+\ell^-$ transitions are forbidden at tree level in the Standard Model, and can only occur at loop level. Therefore, they are rare and sensitive to potential New Physics effects.

A number of tensions has been observed in the recent years in such rare decays of mesons containing a b quark ("beauty mesons"). Beauty baryons offer complementary probes owing to their non-zero spin. Baryonic decays often have orthogonal experimental and theoretical challenges, compared to mesonic transitions. LHCb has actively explored the rare decays of the Λ_b baryon, performing angular analyses and lepton universality tests. Decays of other beauty baryons, such as Ξ_b or Ω_b, may offer complementary observables, and are currently being explored. This talk presents an overview of the LHCb physics programme with rare baryonic decays, including recent results and future prospects.

T 32.4 Tue 16:45 Tg

Search for the rare decay $\Omega_b^- \to \Omega^-\mu^-\mu^+$ at the LHCb experiment — Johannes Albrecht, Vitalii Lisovskyi, and •Janina Nicolini — Technische Universität Dortmund

At the LHCb experiment several $b \to s\ell\ell$ transitions, such as $B \to K\ell\ell$ or $B \to K^*\ell\ell$, have been studied. They show tensions towards the Standard Model predictions in several observables, such as lepton universality ratios (R_K, R_{K^*}) or angular observables. While the differential branching fractions for mesonic and baryonic decays differ, most of the measurements have been focused on mesons and the Λ_b baryon. To clarify the nature of the tensions seen for the Λ_b decays, it is important to study $b \to s\ell\ell$ transitions for other weakly decaying baryons as well.

Therefore the primary aim of this analysis is to observe the decay $\Omega_b^- \to \Omega^-\mu^-\mu^+$. If successful, the branching ratio relative to the decay $\Omega_b^- \to \Omega^- J/\Psi(\to \mu^-\mu^+)$ will be measured.

The used data set corresponds to an integrated luminosity of $6\,\mathrm{fb}^{-1}$, which has been taken with the LHCb experiment from 2015 to 2018. In this talk the current status of the analysis is presented.

T 32.5 Tue 17:00 Tg

Search for the rare decay $\mathrm{B}^+ \to \ell^+\nu_\ell\gamma$ with the Full Event Interpretation at the Belle II experiment — •Laura Frank and Pablo Goldenzweig — Karlsruher Institut für Technologie

Since challenging questions in flavour physics still remain open and indicate possible unrevealed New Physics, the experimental determination of CKM matrix elements and related parameters are of great importance. The e^+e^- collider experiment Belle II at the SuperKEKB accelerator in Japan produces charged and neutral B-meson pairs whose decays offer a great variety of analyses including the rare decay $B^+ \to \ell^+\nu_\ell\gamma$. Although no B-factory has yet to observe this decay, the existing measurements provide an important limit on the first inverse momentum λ_B of the light-cone distribution amplitude (LCDA) of the B-meson.

We present preliminary studies of the first search for $B^+ \to \ell^+\nu_\ell\gamma$ decays at Belle II, where the signal decay is combined with the exclusively reconstructed tag side provided by the Full Event Interpretation tagging algorithm.

T 32.6 Tue 17:15 Tg

Search for the lepton flavour violating decays $B^+ \to K^+e^\pm\mu^\mp$ with the full dataset of the LHCb experiment — Johannes Albrecht, •Alexander Battig, and Elena Dall'Occo — Technische Universität Dortmund

The conservation of lepton flavour in interactions of charged leptons is an important prediction of the Standard Model of particle physics, making searches for lepton flavour violating decays of B mesons an interesting probe for New Physics. In addition, hints of lepton non-universality in $b \to sll$ transitions (R_{K^+}, $R_{K^{*0}}$) imply the violation of lepton flavour conservation. Due to the abundance of produced B-mesons and ability to precisely study them, the LHCb experiment provides an ideal environment for searches for lepton flavour violating decays of B-mesons.

In this talk, the search for the lepton flavour violating decays $B^+ \to K^+e^\pm\mu^\mp$ with the LHCb experiment is presented. The analysed data set has been recorded during Run 1 and Run 2 of the LHC and corresponds to an integrated luminosity of $9.1\,\mathrm{fb}^{-1}$.

T 32.7 Tue 17:30 Tg

Search for new physics in $B \to D^{(*)}\tau\nu$ decays — Thomas Kuhr, Thomas Lück, and •Liang Qiao — Ludwig-Maximilians-Universität, München

The decays $B \to D^{(*)}\tau\nu$ are one of the few cases where a significant deviation from the standard model prediction was observed in the experiment. Therefore it is essential to study these decays in as much detail as possible. The expected huge dataset and the sophisticated analysis tools at Belle II will open new analysis techniques to investigate possible violations of lepton universality using Monte Carlo simulations as well as the reconstruction of B mesons. Ideas of an inclusive reconstruction of the second B meson in $Y(4S) \to B\bar{B}$ events will be presented.

T 32.8 Tue 17:45 Tg

Search for a long-lived particle in b to s transitions at Belle II — •Sascha Dreyer — DESY Belle II

The Belle II experiment at the asymmetric e+ e- SuperKEKB collider in Tsukuba, Japan allows to perform studies in the B-physics sector as well searches for dark sectors.

A hypothetical new long-lived particle, e.g. a scalar particle that mixes with the Standard Model Higgs boson, could serve as a portal to dark sectors. This particle could be produced in B meson decays

via b to s quark transitions and decay to pairs of charged Standard Model particles. In the scalar portal case, small mixing angles result in a long lifetime on detector scales. The displaced vertex signature can be reconstructed within the tracking detectors.

This talk gives an overview of the search for a new long-lived particle at Belle II, including the reconstruction and selection of signal candidates.

T 32.9 Tue 18:00 Tg

Search for the lepton flavour violating decay $B^0 \to \tau^\pm \ell^\mp$ — Thomas Kuhr, Thomas Lück, and •Nathalie Eberlein — Ludwig-Maximilians-Universität, München

Lepton flavour is conserved in the Standard Model, but violated in many new physics models. An observation of the $B^0 \to \tau^\pm \ell^\mp$ decay, where $\ell = e/\mu$, would be a clear sign for new physics.

At B factories one can determine the kinematics of the signal B meson by fully reconstructing the accompanying B meson in $e^+e^- \to \Upsilon(4S) \to BB$ events. In the rest frame of the signal B meson the mono-energetic lepton provides a clean signature to identify the signal $B^0 \to \tau^\pm \ell^\mp$ decays.

This talk presents the current status of the search for $B^0 \to \tau^\pm \ell^\mp$ decays with Belle data using the Full Event Interpretation algorithm for the reconstruction of the accompanying B meson.

T 32.10 Tue 18:15 Tg

Search for the lepton flavour violating decays $B^0 \to K^*(892)^0 \mu^\pm e^\mp$ and $B_s^0 \to \phi(1020)\mu^\pm e^\mp$ — •Jan-Marc Basels, Andreas Güth, Christoph Langenbruch, and Stefan Schael for the LHCb-Collaboration — I. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany

The conservation of lepton flavour in interactions involving charged leptons is a central property of the Standard Model (SM). Thus, every discovery of lepton flavour violation (LFV) would simultaneously be a discovery of new physics.

Designed to study the decays of heavy flavour hadrons, the LHCb detector at the Large Hadron Collider (LHC) at CERN allows for the search for LFV in $b \to s\ell^+\ell'^-$ transitions of B-mesons with unprecedented sensitivity. An additional motivation for such searches arises by recent tests of lepton flavour universality (LFU) in rare $b \to s\ell^+\ell^-$ decays, which have shown tensions with the SM prediction. Any discovery of lepton flavour non-universality would generally imply the existence of LFV.

This talk presents the status of a search for the LFV decays $B^0 \to K^*(892)^0 \mu^\pm e^\mp$ and $B_s^0 \to \phi(1020)\mu^\pm e^\mp$, based on a dataset taken with the LHCb detector during Run 1 and Run 2 of the LHC that corresponds to an integrated luminosity of $9.1\,\text{fb}^{-1}$. Particular focus is placed on the study and control of backgrounds and the determination of expected upper limits on the signal branching fraction.

T 33: Cosmic Rays VI

Time: Tuesday 16:00–18:15 Location: Th

T 33.1 Tue 16:00 Th

The hybrid detector stations of the IceCube surface array enhancement — •Thomas Huber for the IceCube-Collaboration — Institut für Astroteilchenphysik (IAP), Karlsruher Institut für Technologie (KIT)

The IceCube Collaboration foresees to upgrade IceTop, the present surface array, with scintillation detectors augmented by radio antennas. As one of several goals the detectors will be used to measure and mitigate the effects of snow accumulation on the IceTop tanks: The increasing energy threshold and efficiency loss are nowadays the sources of the largest systematic uncertainties in shower reconstruction and mass composition analysis. In addition, the enhancement will provide useful experience for the development of next generation (IceCube-Gen2) neutrino detectors.
A full prototype hybrid station was installed near the center of the IceTop array. The station features custom-designed DAQ electronics and consists of three radio antennas, sensitive in the MHz region and eight scintillation detectors, each having an active area of 1.5 m^2 plastic scintillators, coupled via wavelength-shifting fiber and read out by a Silicon Photomultiplier (SiPM).
In this talk the DAQ and detector R&D decisions, the calibration methods and the performance are reviewed and results from more than three years of operation of the hybrid station are shown. Several thousand air-shower events have been measured in coincidence with IceTop. In addition, the future plans for instrumenting the whole IceTop surface with scintillation detectors and radio antennas will be presented.

T 33.2 Tue 16:15 Th

Studying the Energy-Dependent Cosmic-Ray Moon and Sun Shadow with IceCube Data. — •Johan Wulff, Frederik Tenholt, and Julia Tjus for the IceCube-Collaboration — Ruhr-Universität Bochum

Measuring the temporal variation of the Cosmic-Ray Sun shadow has proven to be a useful tool for assessing solar magnetic field models.

By comparing seven years of IceCube data with the Solar Cycle and magnetic field models, the relationship between the solar activity and the strength of the Cosmic-Ray Sun shadow was investigated in a recent publication (Aartsen et al, accepted for Publication in PRD). Furthermore, two different models of the coronal magnetic field were tested by modelling cosmic-ray propagation in the solar magnetic field and comparing the predicted Sun shadow to the measured one.

In this work, an event-based energy reconstruction was introduced in the analysis of the 7-year data set. This allows for an investigation of the energy dependence of both shadows. Furhtermore, magnetic field effects of the Sun shadow can be investigated at different energies and an energy-dependent pointing can be studied with the Cosmic-Ray Moon shadow.

In this talk, various approaches at an event-based energy reconstruction using machine-learning techniques will be discussed with respect to their performance on the IceCube Cosmic-Ray Moon and Sun shadow data.

T 33.3 Tue 16:30 Th

Simulation study of the IceCube-Gen2 Surface Array — •Mark Weyrauch, Agnieszka Leszczynska, Frank Schröder, and Andreas Haungs for the IceCube-Collaboration — Karlsruhe Institute of Technology (KIT), Institute for Astroparticle Physics (IAP), Karlsruhe, Germany

The IceCube Neutrino Observatory at the South Pole consists of an in-ice array and a surface array, IceTop. IceTop is comprised of 162 ice-Cherenkov tanks distributed over $1\,\text{km}^2$ and is currently getting enhanced by scintillator panels and radio antennas.

IceCube-Gen2 is a planned extension of the IceCube detector, which will increase its science capabilities in many aspects. IceTop has proven to be a very valuable component of IceCube, providing among others measurements of the cosmic-ray (CR) spectrum and mass composition as well as the discrimination of CR induced background for the in-ice array. Consequently, IceCube-Gen2 will feature a surface array, too. The IceCube-Gen2 surface array will also consist of scintillator panels and radio antennas distributed over an array of $\sim 8\,\text{km}^2$, extending the range of CR measurements towards higher energies and improving veto as well as multi-messenger capabilities of the observatory. In order to quantify the science capabilities, a first simulation study of the IceCube-Gen2 surface array has been performed. In this talk I will present the results of this study.

T 33.4 Tue 16:45 Th

Low-Energy Cosmic Ray Composition Spectra with IceCube and IceTop in Synergy — •Julian Saffer for the IceCube-Collaboration — Institute of Experimental Particle Physics, Karlsruhe Institute of Technology (KIT)

IceTop is the surface component of the IceCube South Pole Neutrino Observatory and dedicated to the indirect detection of cosmic rays (CRs). The recent implementation of a new trigger that only requires 2 of IceTop's 6 central infill stations hit by a CR-induced shower allowed to reduce the primary energy threshold for the detection of low-energy CRs from 1.6 PeV to 250 TeV. This lead to a narrowing of the gap between direct and indirect CR measurements and coverage of the entire 'knee' region of the spectrum. [M. G. Aartsen et al. (IceCube Collaboration) Phys. Rev. D 102, 122001]

This talk presents the concept and performance of this new filter/trigger combination as well as reconstruction results for shower position, zenith angle and primary energy from Monte Carlo simulations and experimental data. Additionally, plans towards an enhancement of the machine learning techniques used for the determination of direction, primary energy and mass-composition of CRs are discussed. This will include the combination of the surface signals with the corresponding tracks of high-energetic muons within the deep in-ice detector.

T 33.5 Tue 17:00 Th

Muon studies with the IceTop surface array — •Donghwa Kang for the IceCube-Collaboration — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie

IceTop is the surface component of the IceCube Neutrino Observatory at the geographical South Pole. It is designed to measure the air showers of cosmic rays in the energy range from PeV up to EeV. In general, it is reasonable to assume that the muon signal becomes significant for a large distance from the shower axis, since they are overwhelmed by the signal from electromagnetic components close to the shower axis. Considering the charge signal distribution, the a muon parameter was defined and reconstructed, which is the sum of the charge signals divided by the total number of tanks and the area of the tanks at a fixed distance from the shower axis. In this talk the estimated muon parameter based on the charge distribution will be presented and its use for energy determination and composition reconstruction of primary cosmic rays discussed.

T 33.6 Tue 17:15 Th

Studies and comparison of charge signals measured by IceTop — •Sally-Ann Browne for the IceCube-Collaboration — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie (KIT)

IceTop is the surface array of the IceCube Neutrino Observatory and one of its missions is the detection of air showers initiated by cosmic rays. IceTop consists of 81 stations with two ice-Cherenkov tanks, each, which can be operated in either 'Hard Local Coincidence' (HLC) mode or 'Soft Local Coincidence' (SLC) mode. In HLC mode, signals are read out only if two neighboring tanks are triggered simultaneously. In SLC mode, the signal is recorded when one single tank is triggered. The latter becomes more likely with increasing distance to the air shower core. Thus, most SLC signals occur in the region where the muon component dominates the air shower. Therefore, by studying SLC signals one can obtain relevant information about the muon content and thereby also about the primary particle of detected air showers. In this talk, I will illustrate the characteristics of SLC signals and explain some challenges of studying them. In addition, I will give examples of ongoing studies in which Monte-Carlo-simulated SLC signals are being compared with real data from IceTop.

T 33.7 Tue 17:30 Th

Design and Calibration of the Surface Radio Antennas of the Prototype Station for the planned IceTop Enhancement — •Roxanne Turcotte for the IceCube-Collaboration — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie (KIT)

The IceTop array, located at the surface of the IceCube Neutrino Observatory, is currently used as a veto for the in-ice neutrino detection as well as a cosmic-ray detector. Over the years, snow accumulated on the IceTop detector which has reduced the sensitivity and resolution. In order to improve the detector, an enhancement of IceTop is planned in the next few years which consists of an array of scintillator panels and radio antennas. Upgrading IceTop with surface radio antennas will improve the measurement accuracy and the field-of-view for the detection of cosmic rays. This in turn will lead to a better resolution of the energy and the depth of shower maximum (X_{max}) in the second knee region of the cosmic-ray energy spectrum. Radio measurements combined with particle measurements will also enable a better estimation for the mass of the cosmic ray. In January 2020, a prototype station comprising three antennas and eight scintillators was deployed at the South Pole. In this talk, I will focus on the functioning of the radio hardware of this station: the mechanical installation, the electronic chain and its calibration. I will also give a small overview about the performance of the improved final hardware for the planned full-scale deployment.

T 33.8 Tue 17:45 Th

First radio measurements of cosmic air showers with the prototype station of the IceCube surface enhancement — •Hrvoje Dujmovic for the IceCube-Collaboration — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie (KIT)

IceTop, the surface array of the IceCube Neutrino Observatory, currently consists of 162 ice-Cherenkov tanks distributed over an area of $1\,\mathrm{km}^2$. IceTop is used for cosmic-ray air shower detection and as a veto for the in-ice neutrino detector. The science case of IceTop will be greatly improved by complementing the existing detectors with an array of radio antennas and scintillator panels. The IceTop enhancement array will cover the same footprint as IceTop and will consist of 32 stations. One such station, consisting of 3 radio antennas and 8 scintillator panels, was deployed in January 2020.

In this talk, we will present the results from the radio measurements with the prototype station. We will introduce the event selection and basic reconstruction of the first identified air shower events, as well as compare the data to the predictions from Monte Carlo simulations.

The results obtained from the prototype station will help us to better understand the full capabilities and physics potential of IceCube's surface enhancement.

T 33.9 Tue 18:00 Th

Development of a scintillation and radio hybrid detector station at the South Pole — •Marie Oehler — KIT, Karlsruhe, Germany

The IceCube Observatory is a cubic-kilometer neutrino detector installed in the ice at the geographic South Pole. To increase the efficiency of detecting astrophysical neutrinos the upgrade IceCube-Gen2 is under development. To also boost the sensitivity of the surface array, IceTop, an enhancement consisting of a hybrid scintillation-detector and radio-antenna array is planned.

An optimized prototype station, consisting of eight scintillation detectors and three radio antennas, was deployed in January 2020. Both, scintillation detectors and radio antennas, are read out by a central hybrid data acquisition system (DAQ), researched, developed and built by a cooperation of DESY, UW-Madison and KIT. The scintillation detectors transfer digitized integrated signals to the DAQ to minimize the amount of transmitted data and trigger the radio antennas. The radio waveforms are transferred as analog signals to the central DAQ and are digitized and read out, when triggered by the scintillation detectors. In this contribution the enhanced prototype station and its DAQ will be presented and first measurement results will be shown.

T 34: Extended Higgs models I

Time: Tuesday 16:00–18:00 Location: Ti

T 34.1 Tue 16:00 Ti

Suche nach unsichtbaren Zerfällen des Higgs-Bosons in Ereignissen mit einem hadronisch zerfallenden Vektorboson mit dem ATLAS-Detektor — •Johannes Balz, Volker Büscher, Andreas Reiss und Duc Bao Ta — Institut für Physik, Johannes Gutenberg-Universität Mainz

Eines der gegenwärtig größten Ziele für das ATLAS Experiment ist neben der präzisen Vermessung des Standardmodells (SM) die Suche nach Physik jenseits des SM.

In diesem Vortrag geht es um die Suche nach unsichtbaren Zerfällen des Higgs-Bosons jenseits des Standardmodells. Beim untersuchten Kanal wird das Higgs-Boson über die assoziierte Produktion mit einem Vektorboson erzeugt, wobei das beteiligte Vektorboson im weiteren Verlauf hadronisch zerfällt und das Higgs-Boson in für den Detektor unsichtbare Teilchen, zum Beispiel Dunkle Materie, zerfällt. Daher werden Ereignisse mit hohem fehlendem Transversalimpuls und einem großflächigen Jet selektiert, der als W/Z-Jet klassifiziert ist. Dadurch kann der Hauptuntergrund $Z \to \nu\nu$ bereits stark unterdrückt werden. Eine weitere Untergrundunterdrückung ist mithilfe von Jetsubstrukturvariablen der W/Z- und der Quark-Gluon-Klassifizierung möglich.

Im Vortrag wird der aktuelle Stand der Analyse bei einer Schwer-

punktsenergie von $\sqrt{s}$=13 TeV vorgestellt.

T 34.2 Tue 16:15 Ti

Identification of highly boosted W and Z Bosons with the ATLAS detector — Johannes Balz, Volker Büscher, •Kira Köhler, Christian Schmitt, and Duc Bao Ta — Johannes Gutenberg-Universität Mainz

The ATLAS detector at the LHC is used for the search for invisible decays of the Higgs Boson beyond those predicted by the Standard Model in the associated production channel. The signature in this search is a high momentum large-area jet from the hadronically decaying W/Z recoiling against the invisible decay products of the Higgs Boson. The large-area jet can be distinguished from a background jet due to the particular structure given by the hadronic W/Z decays.

This identification is conventionally done by applying cuts on jet observables from the calorimeter. By using a Neural Network and additional observables from the high resolution tracking detector it was possible to significantly improve the identification of W/Z - jets with high transverse momenta in the multi-TeV region. This talk will give an overview of the new identification method and a comparison to the cut-based identification tool.

T 34.3 Tue 16:30 Ti

Exotic Higgs Decays: ATLAS Analysis of Asymmetric Higgs Decays to Two Light Scalars — •Judith Höfer, Claudia Seitz, Rickard Ström, Priscilla Pani, and Beate Heinemann — DESY, Hamburg, Germany

Extensions of the SM Higgs sector featuring one or several singlet scalar fields are realised in many BMS models. While several searches have been performed targeting decays of the SM Higgs boson to two light scalars of the same mass, the asymmetric decay to two new spin-zero particles of different mass is largely unexplored. The successive decays of these particles can give rise to spectacular high-multiplicity collider signatures, including so-called cascade decays, where the heavier of the scalars decays into the lighter one.

The talk discusses the progress of an analysis studying these asymmetric decays with the ATLAS experiment at the Large Hadron Collider, CERN. The analysis focuses on the VH production mode and the channel where the scalars decay to b-quarks, resulting in a challenging low-pT jet final state. These signatures profit largely from the experiences gained with the equivalent symmetric analysis and motivate the use of novel reconstruction techniques.

T 34.4 Tue 16:45 Ti

Search for heavy Higgs bosons decaying to top quark pairs using the CMS experiment — Afiq Anuar, Alexander Grohsjean, •Jonas Rübenach, Dominic Stafford, and Christian Schwanenberger — DESY, Hamburg, Germany

A key ingredient in shedding light on dark matter and the validity of proposed supersymmetric theories, such as the minimal supersymmetric standard model, is the existence of additional Higgs bosons. Using data collected by CMS at the LHC at $\sqrt{s}$ = 13TeV, corresponding to a luminosity of 137 fb^{-1}, a search is performed for scalar and pseudoscalar, electrically neutral bosons decaying predominantly to top quark pairs, which are assumed to further decay dileptonically. The challenges connected to this particular search, such as interference with the standard model background and unknown quantities resulting from neutrino momenta, are tackled by a full reconstruction of the top quark system and the utilization of multi-dimensional distributions arising from mass and spin information.

T 34.5 Tue 17:00 Ti

Search for heavy Higgs bosons in the Z+$t\bar{t}$ final state — •Yannick Fischer, Ksenia de Leo, Johannes Haller, Roman Kogler, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

Since its discovery in 2012 the properties of the Higgs boson at 125 GeV have been subject of various analyses. Within the uncertainties all results suggest a standard model like behaviour. However, the observed boson might well be part of an extended Higgs sector, which is predicted in various scenarios of new physics beyond the standard model. Two Higgs Doublet Models (2HDM) provide a generic description of the phenomology arising in models with a second Higgs doublet. In this talk we will investigate the hypothetical decay chain A → ZH with H → $t\bar{t}$, where H is a CP even and A a CP odd heavy Higgs boson. This channel has not yet been studied at the LHC. We will give a phenomenological overview of the expected branching ratios depending on the free parameters of the model. Furthermore, first studies of the properties of the signal events are presented.

T 34.6 Tue 17:15 Ti

Search for additional Higgs bosons decaying to a pair of W bosons in the semi-leptonic final state with the CMS detector using full Run 2 data — Olena Hlushchenko, Sven Krausse, Wolfgang Lohmann, Dennis Roy, Hale Sert, •Sebastian Siebert, Achim Stahl, and Alexander Zotz — RWTH Aachen University - Physics Institute III B, Aachen, Germany

During Run 2 of the LHC, an integrated luminosity of 137 fb^{-1} at $\sqrt{s}$ = 13 TeV was recorded by the CMS detector. Apart from measuring properties of known particles more precisely, it is also expected that new particles might be discovered with such a large dataset. Additional heavy Higgs bosons are predicted by many theories beyond the standard model. The high mass $H \to WW$ analysis investigates gluon-gluon fusion and vector-boson fusion as Higgs production mechanisms. The analysis aims to find Higgs boson like resonances in the mass region from 115 GeV/c^2 to 5000 GeV/c^2 or set exclusion limits in the context of two-Higgs-doublet and in different MSSM benchmark scenarios. This talk presents the status and future plans related to the semi-leptonic channel.

T 34.7 Tue 17:30 Ti

Search for additional Higgs bosons decaying into W^+W^- in the di-leptonic final state with CMS using full Run 2 data — Olena Hlushchenko, Sven Krausse, Wolfgang Lohmann, •Dennis Roy, Hale Sert, Sebastian Siebert, Achim Stahl, and Alexander Zotz — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Using proton-proton collision data, corresponding to an integrated luminosity of 137.1 fb^{-1} recorded by CMS during Run 2, searches for new particles are performed with unprecedented sensitivity. The high mass $H \to WW$ analysis aims to search for resonances at masses up to 5 TeV. Their origin might be an additional Higgs boson, such as one expected in extended Higgs sectors, e.g. the Two Higgs Doublet Model (THDM) and a more specific case, the Minimal Supersymmetric Standard Model (MSSM). In case no signal is found, new limits on THDM and MSSM scenarios are set. This analysis is performed in the semi-leptonic and the di-leptonic final state. The status of the full Run 2 analysis in the di-leptonic final state is presented in this talk.

T 34.8 Tue 17:45 Ti

Generator level study of di-Higgs decaying to the $b\bar{b}\tau^+\tau^-$ final state — •Anjali Krishnan, André Schöning, and Tamasi Kar — Physikalisches Institut, Universität Heidelberg

In the search for new physics, the understanding of the Higgs field plays an important role. Measurement of the different coupling constants associated with the Higgs field is crucial to answer some of the very fundamental questions in particle physics. One such coupling constant is the C_{2V} coupling constant, that measures the coupling between a pair of vector bosons and a pair of Higgs. The C_{2V} can be uniquely determined in the process of di-Higgs production via Vector Boson Fusion (VBF).

This talk aims to present a generator level study to optimise the sensitivity to measure C_{2V} in the process of di-Higgs decaying to $b\bar{b}\tau^+\tau^-$ via VBF for the High Luminosity LHC phase-II upgrade scenario. The $b\bar{b}\tau^+\tau^-$ final state in di-Higgs production is particularly interesting because it can be triggered using various trigger objects compared to other decay channels, allowing for a wide phase space coverage. Various kinematic distributions, for instance, the transverse momentum, invariant mass, eta for this decay channel will be presented for a range of C_{2V} values with an integrated luminosity of $300 fb^{-1}$.

T 35: Semiconductor Detectors - Radiation Hardness, New Materials and Concepts

Time: Tuesday 16:00–18:30 Location: Tj

T 35.1 Tue 16:00 Tj

Untersuchung der durch aufeinanderfolgende Laserpulse gemessenen Signale in bestrahlten Siliziumsensoren — •Leena Diehl, Riccardo Mori, Marc Hauser, Dennis Sperrlich, Ulrich Parzefall und Liv Wiik-Fuchs — Universität Freiburg, Deutschland

Während Untersuchungen zur Signalzusammensetzung in Silizium-Streifensensoren, die bestrahlt und bis zum Auftreten von Ladungsvervielfachung annealed wurden, wurde beobachtet, dass zuvor kreierte freie Ladungsträger Auswirkungen auf den Sensor haben. Es wurde daraus gefolgert, dass die erzeugten freien Ladungsträger die vorhandene elektrische Feldverteilung verändern.

Der Einfluss von aufeinander folgenden Laserpulsen wurde daraufhin mithilfe von Edge- und Top- Transient Current Technique untersucht. Dabei wurde eine signifikante Abnahme der gemessenen gesammelten Ladung beobachtet. Abnahme und Veränderungen zeigten Abhängigkeiten von der Laserintensität, des zeitlichen Abstands der Laserpulse, der Messtemperatur und der Bestrahlungsdosis der Sensoren.

In dieser Studie wird untersucht wie Trapping und De-Trapping und die damit einhergehende Veränderung des elektrischen Feldes die beobachtete Abnahme erklären kann.

T 35.2 Tue 16:15 Tj

Einfluss von grossen passivierten Oberflächen auf BEGe Detektoren — •Martin Schuster für die GeDet-Kollaboration — Max-Planck-Institute for Physics

Germaniumdetektoren kommen in einer Vielzahl von Experimenten weltweit zum Einsatz. Beispielsweise werden Broad Energy Germanium (BEGe) Detektoren bei der Suche nach neutrinolosen Doppelbetazerfällen genutzt. Ein genaues Verständnis der Detektoren ist dabei von großer Bedeutung. In der GeDet (Germanium Detektor Entwicklung) Gruppe am MPI für Physik werden Germaniumdetektoren genau untersucht. Die nicht kontaktierten Flächen werden zu ihrem Schutz oft passiviert. Solche passivierten Oberflächen beeinflussen jedoch die Drift der Ladungsträger in einer Schicht unterhalb der Oberfläche und reduzieren das effektiv nutzbare Volumen. Die Tiefe der Einflusszonen und deren Temperaturabhängigkeit wurden untersucht und die Ergebnisse werden vorgestellt. Dazu wurde ein vierfach segmentierter n-Typ BEGe Detektor in mehreren Scans mit einer kollimierten ^{133}Barium-Quelle bestrahlt. Die Temperatur konnte mittels eines elektrisch gekühlten Kryostaten kontrolliert über etwa 30 K variiert werden. Die Daten werden mit Simulationen verglichen, die dem Verständnis der Phänomene dienen.

T 35.3 Tue 16:30 Tj

Charge collection depth profile of pad diodes — •Mohammadtaghi Hajheidari[1], Erika Garutti[1], Joern Schwandt[1], and Aliakbar Ebrahimi[2] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland — [2]Paul Scherrer Institute, Villigen, Switzerland

The charge collection of two 150 μm thick n^+pp^+ pad diodes has been scanned along the diode thickness using a 4.2 GeV electron beam at DESY II beam test facility. The electron beam enters from the sensor edge and its position along the edge was reconstructed by three planes of a EUDET-type telescope.

The diodes have an area of 25 mm^2 and a p-doping concentration of 4×10^{12} cm^{-3}. The measurements were performed at -20 °C for bias voltages up to $V_{bias} = 800$ V. One diode was not irradiated while the other one was irradiated with 23 MeV protons to a 1 MeV neutron equivalent fluence of $\Phi_{eq} = 2 \times 10^{15}$ cm^{-2}. For the non-irradiated diode, the charge profile is uniform as a function of the depth. For the irradiated diode, the charge profile is non-uniform and it changes with the applied bias voltage.

In this presentation, the online alignment and the measurement procedures, as well as preliminary results are presented. The results can be used to obtain an electric field depth profile, needed in simulations of charge collection in diodes and segmented silicon sensors.

T 35.4 Tue 16:45 Tj

TPA-TCT: Two Photon Absorption - Transient Current Technique — •Moritz Wiehe[1,2], Marcos Fernandez Garcia[1,3], Michael Moll[1], Raul Montero[4], F.R. Palomo[5], and Ivan Vila[3] — [1]CERN, Route du Meyrin 285, CH-1211 Genève 23, Switzerland — [2]Albert-Ludwigs-Universität Freiburg, Physikalisches Institut, Hermann-Herder-Str. 3, 79104 Freiburg, Germany — [3]Instituto de Física de Cantabria (CSIC-UC), Avda. los Castros s/n, E-39005 Santander, Spain — [4]UPV/EHU, Sarriena, s/n- 48940 Leioa-Bizkaia, Spain — [5]Escuela Técnica Superior de Ingenieros, US, Avda. de los Descubrimientos s/n, 41092, Isla de la Cartuja, Sevilla, Spain

The Transient Current Technique (TCT) is a very important tool for characterization of unirradiated and irradiated silicon detectors. In recent years a novel method, the Two Photon Absorption - Transient Current Technique (TPA-TCT), based on the charge carrier generation by absorption of two photons, was developed. TPA-TCT proved to be very useful in 3D characterization of silicon devices with unprecedented spatial resolution. Currently the first compact TPA-TCT setup is under development at CERN. After a revision of the laser system, commissioning is now in the final stage. The current status of the setup and first measurements are presented.

T 35.5 Tue 17:00 Tj

Bestrahlungsstudien im Zuge der CMS Phase-2 Outer Tracker Sensorproduktion — •Jan-Ole Müller-Gosewisch, Tobias Barvich, Alexander Dierlamm, Ronja Fischer, Ulrich Husemann, Stefan Maier, Thomas Müller, Marius Neufeld, Andreas Nürnberg, Hans Jürgen Simonis, Julian Stanulla, Pia Steck und Thomas Vetter — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

Der Large Hadron Collider (LHC) in Genf wird innerhalb dieses Jahrzehnts ausgebaut, sodass die Luminosität um einen Faktor fünf ansteigt. Um den neuen Anforderungen zu genügen, wird der CMS-Detektor in der sogenannten Phase-2 ausgebaut. Insbesondere der CMS-Spurdetektor muss einer deutlich erhöhten Strahlenbelastung widerstehen können. Nachdem ein finales Sensordesign entwickelt wurde, läuft aktuell die Produktion der Sensoren an. Im Zuge dieser muss die hohe Sensorqualität über die Dauer von einigen Jahren gewährleistet werden können.

Dieser Vortrag stellt die laufenden Tests zur Strahlenhärte der Sensoren vor. Zunächst wird näher auf die Strategie der Qualitätssicherung eingegangen. Dann werden erste Bestrahlungen und Messungen des finalen Materials präsentiert und die Ergebnisse diskutiert.

T 35.6 Tue 17:15 Tj

Iterative Bestrahlungsstudien von Siliziumstreifensensoren — •Umut Elicabuk[1], Tobias Barvich[1], Alexander Dierlamm[1], Ulrich Goerlach[2], Ulrich Husemann[1], Stefan Maier[1], Thomas Müller[1], Marius Neufeld[1], Andreas Nürnberg[1], Hans Jürgen Simonis[1], Julian Stanulla[1] und Pia Steck[1] — [1]Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT) — [2]Institut Pluridisciplinaire Hubert CURIEN (IPHC), Strasbourg

Im Rahmen des Phase-2-Upgrades des zukünftigen CMS-Spurdetektors ist geplant, Siliziumstreifensensoren zur Rekonstruktion der Spuren geladener Teilchen zu verwenden. Aufgrund der hohen Strahlenbelastung ist ein Detektormaterial notwendig, das eine hohe Strahlenhärte aufweist.

Während des Betriebs werden fortlaufend Strahlenschäden im Detektormaterial akkumuliert. Bisherige Studien konnten dieses Bestrahlungsszenario nur in sehr groben Schritten abbilden.

Das ETP untersucht in Zusammenarbeit mit dem IPHC die Sensorcharakteristiken von Siliziumstreifensensoren im Rahmen einer fein aufgelösten Bestrahlungsstudie. Zu diesem Zweck wird eine neuartige Messstation entworfen, die sowohl eine Bestrahlung des Sensors mit Protonen, als auch die Messung verschiedener Sensorparameter direkt in der Strahllinie ermöglichen soll.

Der Vortrag gibt einen Einblick in den verwendeten Messaufbau, untersuchte Sensorcharakteristiken und das geplante Vorgehen.

T 35.7 Tue 17:30 Tj

Boron removal effect in silicon sensors — •Chuan Liao, Erika Garutti, Joern Schwandt, Eckhart Fretwurst, and Annika Vauth — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

Silicon detectors are widely used devices for radiation detection. In

high energy physics experiments, for example in the inner region of hadron collider experiments, radiation can induce damage in silicon materials. Depending on the type of radiation, the main effect is so-called displacement damage. In the frame of the CERN RD50 collaboration the acceptor removal effect in Low Gain Avalanche Detectors (LGADs) is investigated. The suspected cause is the displacement of substitutional Boron (Bs), being negatively charged, by incident particles or other recoil atoms into an interstitial position (Bi). This is followed by Bi migration and being captured by Oxygen atoms and forming complex defects of interstitial Boron and interstitial Oxygen (BiOi) with positive charge. This is the boron removal effect. For lower radiation fluence, this has one main consequence: The maximum electric field at a given reverse bias will decrease, causing a decrease of the LGAD gain. In this presentation, the setup of experiments for investigating boron removal effect is presented including C-V, I-V, and Thermally stimulated current (TSC). And several properties of BiOi defect given by measured results have also been shown including activation energy, capture cross-section, defect concentration, annealing behavior as well as generation rate of BiOi.

T 35.8 Tue 17:45 Tj

Effects of gamma radiation on DEPFET pixel sensors for the Belle II experiment — Jochen Dingfelder[1], Ariane Frey[2], •Georgios Giakoustidis[1], Botho Paschen[1], Harrison Schreeck[2], Benjamin Schwenker[2], and Marike Schwickardi[2] for the Belle II-Collaboration — [1]University of Bonn, Germany — [2]University of Göttingen, Germany

For the Belle II experiment at KEK (Tsukuba, Japan) the KEKB accelerator was upgraded to deliver e^+e^- collisions at a center of mass energy of $E_{CM} = 10.58\ GeV$ with an instantaneous luminosity of $8 \cdot 10^{35}\ cm^{-2}s^{-1}$. As the innermost part of the Belle II detector, the PiXel Detector (PXD), based on DEpleted P-channel Field Effect Transistor (DEPFET) technology, is most exposed to radiation from the accelerator. Prototypes as well as a module from the final Belle II production batch were irradiated with X-rays to doses up to 20 $Mrad$, corresponding to the expected lifetime exposure. The performance of the DEPFET sensors and front-end electronics will be presented and the results of two recent campaigns will be compared to previous results.

T 35.9 Tue 18:00 Tj

Aufbau eines Messstandes zur Messung schneller Siliziumsensoren — •Christina Schwemmbauer[1], Leena Diehl[1], Marc Hauser[1], Gregor Kramberger[2], Ulrich Parzefall[1], Dennis Sperlich[1] und Liv Wiik-Fuchs[1] — [1]Albert-Ludwigs Universität Freiburg — [2]Josef-Stefan Institut Ljubljana, Slowenien

Im Hinblick auf fortschreitende Detektor- und Beschleunigertechnologien, wie dem HL-LHC, werden immer höhere Luminositäten und damit mehr Teilchenkollisionen erreicht. Um bei mehr als hundert gleichzeitigen Teilchenkollisionen die einzelnen Vertices separieren zu können, ist außer der Ortsinformation auch die präzisere Zeitauflösung der Spurdetektoren ein limitierender Faktor. Deshalb ist die Entwicklung von Siliziumsensoren, die den Anspruch einer Zeitauflösung im Picosekundenbereich erfüllen können, ein wichtiger Schwerpunkt der aktuellen Forschung.

Bei der Charakterisierung dieser neuartigen Sensoren ist es daher wesentlich, die Zeitauflösung verschiedenster Sensoren schnell und unkompliziert unter Laborbedingungen messen zu können. Mit diesem Ziel wird ein Messstand aufgebaut, der auch bei den für bestrahlte Sensoren benötigten niedrigen Temperaturen funktionabel ist.

In diesem Vortrag wird der prinzipielle Aufbau einer solchen Messstation erläutert und erste Messergebnisse verschiedener Siliziumsensoren unter unterschiedlichen Bedingungen werden vorgestellt.

T 35.10 Tue 18:15 Tj

Simulation von Germaniumdetektoren mit SolidStateDetectors.jl — •Lukas Hauertmann für die GeDet-Kollaboration — MPI für Physik, München, Deutschland

Germaniumdetektoren kommen in Experimenten mit niedrigem Untergrund zum Einsatz. So, z.B., in den beiden abgeschlossenen Experimenten GERDA und MAJORANA, die nach neutrinolosem doppelten Betazerfall suchten. In der nächsten Generation solcher Suchen soll die Masse und damit die Anzahl der Detektoren erhöht und der Untergrund noch weiter reduziert werden. Um dazu beizutragen, wurde in der GeDet (Germaniumdetektor Entwicklung) Gruppe am MPI für Physik eine neue Software, „SolidStateDetectors.jl“ (SSD), zur 3d Simulation solcher Detektoren entwickelt. Diese hilft, Germaniumdetektoren besser zu verstehen und mehr Untergrundereignisse als solche zu identifizieren. In diesem Vortrag werden die unterschiedlichen Schritte der Simulation demonstriert und parallel dazu die Funktionsweise eines Germaniumdetektors erklärt.

T 36: Search for Supersymmetry II

Time: Tuesday 16:00–17:45 Location: Tk

T 36.1 Tue 16:00 Tk

Search for disappearing tracks with the CMS experiment at $\sqrt{s} = 13$ TeV — •Viktor Kutzner[1], Samuel Bein[1], Seh Wok Lee[2], Sang-Il Pak[2], Peter Schleper[1], Sezen Sekmen[2], and Alexandra Tews[1] — [1]Institute for Experimental Physics, Hamburg University, Luruper Chaussee 149, D-22761 Hamburg, Germany — [2]Kyungpook National University, Daegu, South Korea

Long-lived particles are often predicted in theories with a small mass splitting between the two lightest particles, for example a chargino and a neutralino in supersymmetry. Given a sufficiently small mass splitting in the range of $m_\pi \lesssim \Delta m \lesssim 200$ MeV, the chargino is expected to decay in the CMS tracker volume into soft non-reconstructed leptons or hadrons and a lightest supersymmetric particle, leaving a short track that then seems to disappear. This signature is characterized by missing hits in the outer layers of the tracker with little or no energy deposited in the calorimeter. In addition to events with one or more disappearings tracks, events with an additional lepton are considered as well to account for a second very long-lived chargino, which decays outside the tracker volume. For both topologies events with additional b-quark jets are investigated to account for gluino-/squark-associated chargino production. Data-driven methods are used to determine the dominant backgrounds arising from prompt leptons and fake tracks. Results are presented using proton-proton collision data with $\sqrt{s} = 13$ TeV collected with the CMS experiment during Run-2.

T 36.2 Tue 16:15 Tk

Search for compressed mass-spectrum long-lived particles using short disappearing tracks with the ATLAS experiment — •Paul Gessinger and Stefan Tapprogge — Johannes Gutenberg-Universität Mainz

In certain Supersymmetry scenarios, the lightest neutralino $\tilde{\chi}_1^0$ and charginos $\tilde{\chi}_1^\pm$ can become nearly degenerate in mass. At mass splittings as low as $\Delta m(\tilde{\chi}_1^\pm, \tilde{\chi}_1^0) \approx 100$ MeV, the chargino obtains lifetimes of $\mathcal{O}(1$ ns), which allows it to reach sensitive parts of the ATLAS experiment, before decaying, mostly to a neutralino leaving the detector without interacting, and a low momentum charged pion that is difficult to detect. This causes the chargino track to *disappear*.

The tracking systems and reconstruction algorithms of the ATLAS detector are designed to efficiently detect and reconstruct charged particles crossing all silicon sensor layers. Using specialized reconstruction techniques, it is possible to reconstruct short *tracklets*, which arise only from hits in the silicon Pixel detector. Previous ATLAS analyses used tracklets consisting of at least 4 Pixel hits and no hits in the silicon strip detector as disappearing track signatures to search for the aforementioned scenarios in LHC *pp*-collisions at 13 TeV.

This talk presents first results from the inclusion of short tracklets with only 3 hits. The analysis carried out in the context of a *pure-higgsino* signal scenario, featuring very short lifetimes. Background characteristics of this new tracklet type are evaluated, and signal efficiency is discussed. Expected sensitivity in the form of upper signal strength limits and mass exclusion limits is shown.

T 36.3 Tue 16:30 Tk

Search for Mono-Top Signatures in Compressed SUSY Scenarios in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS Detector — •Paola Arrubarrena and Alexander Mann — Ludwig-Maximilians-Universität München

Supersymmetry (SUSY) is an extension of the Standard Model (SM) of particle physics which predicts a supersymmetric partner for each particle in the SM. A distinctive mono-top signature is present in Natural SUSY scenarios when the scalar top-quark ($\tilde{t}$) and higgsinos ($\tilde{h}$) are almost mass degenerate and their decay products are too soft to be detected. The mono-top signature is the SUSY counterpart of the $t\bar{t}H$ process, $pp \to t\tilde{t}\tilde{h}$. This model can have a measurable production rate due to the large top Yukawa coupling, leading to a characteristic final state with a single top quark and missing transverse momentum. A strategy to discriminate the mono-top signal from the dominant backgrounds in the hadronic channel is presented.

T 36.4 Tue 16:45 Tk

Search for Higgsino production in SUSY scenarios with a compressed mass spectrum — •Yuval Nissan[1], Sam Bein[1], Peter Schleper[1], and Gudrid Moortgat-Pick[2] — [1]Institut für Experimentalphysik, Universität Hamburg — [2]Institute of Theoretical Physics, DESY

A search for leptonic decays of Higgsino-like neutralinos in the case of a compressed mass spectrum using a track, a reconstructed lepton and missing transverse momentum is presented. We consider the case of a second-lightest neutralino decaying into a dark matter candidate - lightest neutralino - and two leptons via an off-shell Z boson. In the case of a very small mass differences between the neutralinos, the leptons produced are very soft, making it very difficult to reconstruct them at CMS. We consider a case where one of the leptons is reconstructed by a track, and the other as a reconstructed lepton of opposite charge. Signals of different mass splitting are probed and interpreted within a set of simplified models. Multivariate discriminants are employed in the event- and object-level selection, and their performance is studied.

T 36.5 Tue 17:00 Tk

Search for Compressed Higgsinos in events with two oppositely charged soft and displaced leptons at the CMS experiment — •Alexandra Tews — Universität Hamburg, Hamburg, Deutschland

A variety of supersymmetric extensions of the Standard Model lead to light Higgsinos with compressed mass spectra and correspondingly large lifetime.

In case of pair production of Higgsino-like electroweakinos, e.g. $\chi_1^{\pm}, \chi_2^0$, the decay of the second neutralino through an off-shell Z boson can lead to a pair of same-flavor opposite-sign leptons. These leptons can have very low momentum if the mass spectrum of the SUSY particles is sufficiently compressed (nearly degenerate).

Searches for SUSY in events with two low-momentum opposite-sign leptons are particularly sensitive to such SUSY models. Scenarios with compressed Higgsinos with a mass splitting below 2 GeV with the CMS experiment are studied. We exploit new reconstruction and vertexing techniques for oppositely charged displaced lepton tracks with very low momenta of order of a few hundred MeV.

T 36.6 Tue 17:15 Tk

Search for Higgsinos in final states with a low-momentum, displaced track at the CMS experiment — Samuel Bein, Viktor Kutzner, Yuval Nissan, Peter Schleper, Alexandra Tews, and •Moritz Wolf — Universität Hamburg

Many supersymmetric extensions to the Standard Model predict the three lightest electroweakinos, χ_2^0, $\chi_1^{\pm}$, χ_1^0, to be Higgsino-like with similar masses around the electroweak scale. The lightest chargino and the second-lightest neutralino can be pair-produced and decay to the lightest neutralino. To search for these particles, the best strategy depends on the differences between their masses. For $\Delta m(\chi_2^0, \chi_1^0) > \mathcal{O}(1\,\text{GeV})$ lepton pairs from the decay of the second-lightest neutralino leave an experimentally distinct signature, whereas $\Delta m(\chi_1^{\pm}, \chi_1^0) \lesssim 0.3\,\text{GeV}$ can lead to the chargino giving rise to a disappearing track. However, mass splittings in the range of $\Delta m(\chi_1^{\pm}, \chi_1^0) = 0.3 - 1.0\,\text{GeV}$ are still unexplored by either of those methods.

This study describes how a mono-jet analysis can be made more sensitive to Higgsinos with mass splittings in the latter range by requiring a slightly displaced track with low momentum in the event corresponding to a pion originating from the chargino decay.

T 36.7 Tue 17:30 Tk

Reinterpreting a search for electroweakinos in the phenomenological MSSM with the ATLAS detector. — •Eric Schanet and Jeanette Lorenz — Ludwig-Maximilians-Universität München

Supersymmetry is a popular extension of the Standard Model of Particle Physics (SM), providing a solution to several open questions of the SM. At the LHC, searches for supersymmetry (SUSY) are traditionally interpreted in simplified models containing a very limited number of free parameters. Although very useful for covering a wide range of phenomena, this methods fails to capture more complex effects resulting from a larger set of parameters and the influence of different production and decay processes. Thus, it is of high interest to interpret SUSY searches in more complete and realistic supersymmetric models.

In this talk efforts to reinterpret a search for electroweakinos in the phenomenological MSSM (pMSSM)—a 19-dimensional supersymmetric model space—are presented. In order to cope with the high dimensionality of the pMSSM, a method for computationally efficient but still reliable analysis approximations is introduced, and illustrated on exemplary SUSY searches. Relying on full likelihoods of the respective searches, these approximations are not only crucial for reinterpretations in high-dimensional model spaces, but also serve as useful tools for theorists wishing to incorporate results from ATLAS SUSY searches in their work. Finally, results from a preliminary scan in the pMSSM are presented and discussed.

T 37: Search for New Particles II

Time: Tuesday 16:00–18:15 Location: Tl

T 37.1 Tue 16:00 Tl

Model Unspecific Search in CMS (MUSiC) - Overview — •Saranya Samik Ghosh, Thomas Hebbeker, Arnd Meyer, and Lorenzo Vigilante — III. Physikalisches Institut A, RWTH Aachen, 52074 Aachen, Germany

The Model Unspecific Search in CMS (MUSiC) is a long-term project aiming to search for new physics beyond the standard model (BSM) by searching for significant deviations from the standard model (SM) expectation in LHC data. Kinematic distributions of the data are compared with the SM expectation in hundreds of different final states using an automated procedure with a minimum of additional assumptions, and in particular without optimization for specific models beyond the SM. In this presentation, the general method and its current implementation will be discussed, pointing out limitations and applications beyond the original scope, as well as methods used for validation and benchmarking.

T 37.2 Tue 16:15 Tl

Model Unspecific Search in CMS (MUSiC) - Results — •Lorenzo Vigilante, Arnd Meyer, Saranya Samik Ghosh, and Thomas Hebbeker — III. Physikalisches Institut A, RWTH Aachen, 52074 Aachen, Germany

The CMS experiment has been collecting data during proton-proton collisions at a center of mass energy of 13 TeV during Run 2 of the CERN LHC. This presents a unique opportunity to search for new physics phenomena beyond the Standard Model. 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 search for new physics at CMS in several hundred final states that are not all covered by dedicated analyses. This talk extends the previous introductory talk and presents the results of the MUSiC analysis using 35.9 fb^{-1} of data recorded by the CMS detector at the LHC during proton-proton collisions at a center of mass energy of 13 TeV. The overall agreement between the CMS data and simulation of the Standard Model is evaluated and most significant deviations are studied.

T 37.3 Tue 16:30 Tl

Resonant Single BSM Particle Production at the LHC using Lepton PDFs — •Jonas Botz, Saurabh Nangia, Yong Sheng Koay, Philip Bechtle, Klaus Desch, Herbert Dreiner, and Manuel Drees — Physikalisches Institut der Rheinischen-Friedrich-Wilhelms-Universität Bonn

Many new physics scenarios require particles (leptoquarks) that couple to a vertex at which both leptons and quarks interact. Indeed, leptoquark searches have received considerable interest at the LHC. Recently, however, a new search strategy has been proposed. Combining QCD and QED effects, there is a non-zero probability to find leptons with a certain momentum inside the proton, described by the lepton parton distribution functions (PDFs). Such PDFs have recently been calculated for the first time. This allows us to study resonant leptoquark production at the LHC. In the following phenomenological study, a search strategy is analysed for resonant leptoquark production at the LHC using the one lepton and one jet final state. After identifying the most relevant backgrounds and discussing cuts, parameter space diagrams of minimal leptoquark models are shown to demonstrate the LHC sensitivity.

T 37.4 Tue 16:45 Tl

Machine Learning Based Dijet Anomaly Search — Lukas Judith, Gregor Kasieczka, •Tobias Lösche, and Manuel Sommerhalder — Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

The search for particles and phenomena beyond the Standard Model (BSM) is a crucial part of the current LHC physics program. Although considerable effort has been put into the investigation of BSM physics at the LHC as well as other experiments, no evidence has been found so far. A major disadvantage of many current searches is their reliance on specific signal and background models. Since it is not feasible to cover all possible BSM models with a dedicated search and the unexplored regions of the LHC phase space are vast, it is necessary to develop novel model-independent anomaly detection methods, which can be directly trained on and applied to data.

One proposed method for model-independent anomaly detection is ANODE. It uses density estimation based on normalizing flows to learn the densities in signal and background regions and has achieved state-of-the-art results in a recent community study. We present the first application of ANODE for a search for new physics with the CMS experiment in the dijet final state.

T 37.5 Tue 17:00 Tl

Search for new particles in events with four top quarks at the ATLAS detector — •Alicia Wongel[1], Krisztian Peters[1], Philipp Gadow[1], Xingguo Li[1], Christopher Pollard[1], James Ferrando[1], Loic Valery[1], Nedaa-Alexandra Asbah[2], Elise Le Boulicaut[3], Mark Kruse[3], Ashutosh Kotwal[3], Katherine Pachal[3], Sourav Sen[3], Samuel Calvet[4], William Barbe[4], Qin Yang[5], and Masahiro Morii[2] — [1]DESY Hamburg — [2]Harvard University — [3]Duke University, Department of Physics — [4]Laboratoire de Physique de Clermont-Ferrand (LPC), Universite Clermont Auvergne — [5]University of Manchester

A novel search for anomalous production of four-top-quark events is presented. It offers a unique way to probe top-philic resonances (Z') which can only be produced in association with top quarks ($t\bar{t}Z' \to t\bar{t}t\bar{t}$) and thus are inaccessible by conventional searches. The Run 2 LHC proton-proton collision data recorded with the ATLAS detector is used in the search to select events with exactly one reconstructed lepton. This selection ensures high signal acceptance while suppressing multijet process events. Furthermore, the particular configuration where the resonance decays fully hadronically is investigated. A potential signal would manifest itself as a localized excess over the steeply falling mass spectrum of the two top quarks with the highest momentum which are reconstructed in their hadronic decay mode ($m_{t\bar{t}}$). In this talk, an overview of the analysis strategy is given, highlighting the data-driven background estimation.

T 37.6 Tue 17:15 Tl

Searching for high-mass resonances decaying to $\tau\nu$ in pp-colisions at $\sqrt{s} = 13$ TeV with the Run-2 data of the ATLAS detector — •Christos Vergis and Jochen Dingfelder — University of Bonn, Bonn, Germany

Several theories Beyond the Standard Model predict the presence of new heavy charged gauge bosons (W') that could be produced at the LHC. The leptonic decays of the W' result in a high-p_{T} lepton and large missing momentum from the undetected neutrino. Although for models with universal lepton couplings the searches for $W' \to (e/\mu)\nu$ are more sensitive than $W' \to \tau\nu$, the latter is motivated by models that predict preferential W' couplings to the third generation of fermions.

This talk will present the latest results from the search for heavy resonances decaying to a tau lepton and a neutrino, in events where the tau lepton decays hadronically, using data collected during 2015-2018 pp-collisions at $\sqrt{s} = 13$ TeV by the ATLAS detector at the LHC. Recent updates to the background estimation and analysis strategy will be discussed. Exclusion limits on the W' masses in the Sequential Standard Model and models with preferential couplings to the third generation of fermions will be given. Finally, model-independent upper limits on the production cross-section times branching ratio for mono-tau signatures at ATLAS will be shown.

Following the increase in luminosity as well as upgrades in the tau reconstruction algorithms and analysis strategy, the reach of the search is significantly improved compared to the 36.1 fb^{-1} ATLAS results.

T 37.7 Tue 17:30 Tl

Search for heavy resonances decaying to ZH in the H→WW→4q/H→cc channel at CMS — •Andrea Malara, Paolo Gunnellini, Johannes Haller, Roman Kogler, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany

A search for new heavy particles decaying to a Higgs boson and a Z boson is presented. The analysis is performed on the dataset recorded by the CMS experiment in proton−proton collisions at a centre-of-mass energy of 13 TeV during Run-2, corresponding to an integrated luminosity of 137.2 fb^{-1}. The focus is set on the H→WW→4q/H→cc final states. Expected exclusion limits on the production cross section are reported using a combination of the leptonic Z decay modes.

T 37.8 Tue 17:45 Tl

Search for singly produced excited bottom quarks decaying to tW with the CMS experiment — •Alexander Fröhlich, Johannes Haller, Roman Kogler, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

We present a search for a singly produced excited bottom quark (b*) in data of pp-collisions at $\sqrt{s} = 13$ TeV recorded with the CMS detector. The search is performed in the tW decay channel, where the top quark decays hadronically, while the W boson decays into a lepton and a neutrino.

The reconstruction and identification of the top quark is done with the Heavy Object Tagger with Variable R (HOTVR). The stable performance of this algorithm allows for a high signal sensitivity over a wide range of b* masses. Data driven methods are used to estimate standard model background contributions from misidentified objects.

T 37.9 Tue 18:00 Tl

Lowering the dijet resonance mass threshold for a trigger-level analysis in ATLAS — Falk Bartels and •Hagen Tockhorn — Kirchhoff-Institut für Physik, Heidelberg, Deutschland

The search for sub-TeV dijet resonances at the LHC is statistically limited due to the reduced readout rate of lower p_T jet triggers. The ATLAS trigger-level analysis covers this part of the spectrum by recording a strongly reduced set of event-level information processed by the High Level Trigger for all events passing the seeding Level-1 trigger. This has so far allowed for lowering the minimal detectable dijet resonance mass from ≈1 TeV to 450 GeV.

To further lower this threshold, a novel approach for defining the signal region is presented. Selecting the efficient phase space of the jet trigger based on the dijet mass instead of the leading jet p_T can yield significantly lower mass thresholds. Additionally, the potential of including even lower p_T Level-1 triggers is investigated.

T 38: Data analysis, information technology II

Time: Tuesday 16:00–18:30 Location: Tm

T 38.1 Tue 16:00 Tm

Composition Study of Cosmic Rays with IceCube Observatory using Graph Neural Networks — •Paras Koundal for the IceCube-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Germany

Concealed deep under the South Pole Antarctic Ice, the IceCube Observatory is a large-scale physics detector used to capture high-energy particles from cosmic events and provide us with new insights into their fundamental behaviour. Besides its principle usage and merits in neutrino astronomy, IceCube is also used for cosmic-ray detection.

The information about the cosmic-ray induced high-energy muons detected primarily in the in-ice part of the IceCube detector and the induced electromagnetic component, detected at the corresponding surface array called IceTop, has proven to be useful for cosmic-ray studies. However, their composition analysis are still prone to large systematic uncertainties. There is a significant dependence of expected particle-flux and primary-particle mass on the hadronic-interaction model one chooses to interpret the air-shower measurements. This talk discusses the ongoing progress made to establish a consistent framework using full event-signal information, for an improved cosmic-ray spectrum analysis in the transition region from Galactic to extragalactic sources, using advanced techniques in Graph Neural Networks. This is a significant progress over the previous analysis which relied primarily on signal information from IceTop. This will help establish IceCube as a unique three-dimensional cosmic-ray detector, providing improved sensitivities for detailed physics analysis.

T 38.2 Tue 16:15 Tm

Deep-Learning-Based Reconstruction of Cosmic-Ray Properties From Extensive Air Shower Measurements — Martin Erdmann, Jonas Glombitza, Berenika Idaszek, and •Niklas Langner — III. Physikalisches Institut A, RWTH Aachen University

Ultra-high-energy cosmic rays colliding with the Earth's atmosphere lead to the formation of extensive air showers. At the Pierre Auger Observatory, showers are measured using the surface detector (SD) on ground and the fluorescence detector (FD) observing the sky above. The depth of shower maximum, directly measurable by the FD, is of particular interest due to its connection to the cosmic-ray mass.

Currently thriving in the field of machine learning, deep neural networks which consist of hundreds of thousands of parameters can be trained to exploit complex data and extract information otherwise hard to access. While such networks are able to achieve remarkable precision, understanding their working principle is challenging due to the large number of parameters. Using deep learning, the depth of shower maximum can be extracted from SD observations.

We present our network to extract properties of air showers by analyzing the signal of water Cherenkov detectors. It utilizes recurrent long short-term memory layers and hexagonal convolutions. The technical setup and method is explained. We investigate the reasoning of the trained network by visualizing inputs relevant for the network's decision. We show the performance of our method using simulations and discuss the incorporation of additional scintillator detectors which are part of the upgrade program of the Pierre Auger Observatory.

T 38.3 Tue 16:30 Tm

Using a conditional Invertible Neural Network to determine the parameters of ultra-high-energy cosmic ray sources — Teresa Bister, Martin Erdmann, and •Josina Schulte — III. Physikalisches Institut A, RWTH Aachen University

The usage of modern machine learning techniques is growing with immense speed and new advanced methods for physics analysis are developed. Often, the task is to estimate the physical parameters of a model, using only a set of measurements without the possibility to formulate an explicit inverse function. Traditionally, the full posterior parameter distributions can be approximated using the Markov Chain Monte Carlo (MCMC) method. This is useful to uncover correlations and to estimate the parameter uncertainties. However, posterior sampling is generally computationally expensive and slow. A new alternative technique, based on Deep Learning, is a so-called conditional Invertible Neural Network. Here, the network implicitly learns the posterior distributions from a large set of training data, whereby a specific loss function ensures convergence. The basic functionality and possibilites of this technique, applied on an example from astroparticle physics, will be presented in this talk. Here, the observable is the binned energy spectrum of ultra-high-energy cosmic rays on Earth. The free parameters of the astrophysical model define the acceleration process at the origin sites, which are currently still unknown. We show that it is possible to find posterior distributions of the free model parameters with the network and compare them to the ones using the classic MCMC method.

T 38.4 Tue 16:45 Tm

Muon bundle reconstruction with KM3NeT/ORCA using graph convolutional networks — •Stefan Reck for the ANTARES-KM3NeT-Erlangen-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

KM3NeT/ORCA is a water-Cherenkov neutrino detector, currently under construction in the Mediterranean Sea at a sea depth of 2450 meters. The project's main goal is the determination of the neutrino mass hierarchy by measuring the energy- and zenith-angle-resolved oscillation probabilities of atmospheric neutrinos traversing the Earth.

Deep Learning techniques provide promising methods to analyse the signatures induced by the particles traversing the detector. Despite being in an early stage of construction, the data taken so far already provide large statistics to investigate the signatures from atmospheric muons. This talk will cover a deep-learning based approach using graph convolutional networks to reconstruct atmospheric muon bundles, and results on both simulations and data will be presented. Furthermore, the performances are compared to the ones of classical approaches, showing good agreement.

T 38.5 Tue 17:00 Tm

CNN classification and regression for ANTARES — •Nicole Geisselbrecht for the ANTARES-KM3NeT-Erlangen-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

ANTARES is the largest undersea neutrino detector, installed in the Mediterranean Sea, and is primarily sensitive to neutrinos in the TeV-PeV energy range. Data taking with the telescope has been continuous since 2008. One of the central goals of ANTARES, next to searches for neutrino signals from point, transient, and extended sources, is an independent detection and investigation of the diffuse cosmic neutrino flux discovered by IceCube. The suppression of backgrounds, in particular of atmospheric muons, is essential to further increase the sensitivity of the data analysis.
The contribution reports on the design and application of deep Convolutional Neural Networks to ANTARES telescope data. Data preprocessing concepts, image generation, and performance investigations of an event-topology classifier as well as first studies with energy regression will be presented.

T 38.6 Tue 17:15 Tm

graFEI: Full Event Interpretation using Graph Neural Networks at Belle II — •Lea Reuter[1], James Kahn[2], Ilias Tsaklidis[3], and Pablo Goldenzweig[1] — [1]Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT) — [2]Steinbuch Centre for Computing (SCC), Karlsruher Institut für Technologie (KIT) — [3]Physikalisches Institut, Universität Bonn, Germany

At the Belle II experiment, flavor physics and charge parity violation are investigated at the $\Upsilon(4S)$ resonance. By colliding electrons and positrons, the Belle II experiment ensures a clean collision environment, where the initial state is fully defined. Neutrinos or other missing particles that cannot be directly detected, can therefore be identified using conservation laws. To analyse such processes, it is necessary to reconstruct the full $\Upsilon(4S)$ decay process.

The currently used Full Event Interpretation algorithm utilises Boosted Decision Trees to reconstruct the decay processes step-wise, and is therefore heavily dependent on the previous steps. The decays must be explicitly defined, which restricts the branching fraction coverage of the algorithm.

Recent works have explored Graph Neural Network approaches, since a natural representation of a decay process is a tree graph. Given their success, this work explores their application to Belle II and integrating them into the analysis software framework. Ultimately, the aim

is to apply the Graph Neural Network approach to the measurement of missing energy decays.

T 38.7 Tue 17:30 Tm

Pixel Detector Background Generation using Generative Adversarial Networks at Belle II — •Hosein Hashemi[1], Thomas Kuhr[2], Martin Ritter[3], Nikolai Hartman[4], and Matei Srebre[5] — [1]Ludwig-Maximilians-Universität München — [2]Ludwig-Maximilians-Universität München — [3]Ludwig-Maximilians-Universität München — [4]Ludwig-Maximilians-Universität München — [5]Ludwig-Maximilians-Universität München

The pixel detector (PXD) is an essential part of the Belle II detector recording particle positions. Data from the PXD and other sensors allow us to reconstruct particle tracks and decay vertices. The effect of background hits on track reconstruction is simulated by adding measured or simulated background hit patterns to the hits produced by simulated signal particles. This model requires a large set of statistically independent PXD background noise samples to avoid the systematic bias of reconstructed tracks. However, data from the fine-grained PXD requires a substantial amount of storage. As an efficient way of producing background noise, we explore the idea of an on-demand PXD background generator using conditional Generative Adversarial Networks (GANs), adapted by the number of PXD sensors in order to both increase the image fidelity and produce sensor-dependent PXD hit maps.

T 38.8 Tue 17:45 Tm

GANplifying Event Samples — Anja Butter[1], •Sascha Diefenbacher[2], Gregor Kasieczka[2], Benjamin Nachman[3], and Tilman Plehn[1] — [1]Institut für Theoretische Physik, Universität Heidelberg, Deutschland — [2]Institut für Experimentalphysik, Universität Hamburg, Deutschland — [3]Physics Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA

Generative machine learning models have been successfully used in order to speed up or augment many simulation tasks in particle physics, ranging from event generation to fast calorimeter simulation to many more. This indicates that generative models have great potential to become a mainstay in many simulation chains. One question that still needs to be addressed, however, is whether the data produced by a generative model can offer increased precision compared to the data the model was originally trained on. In other words, can one meaningfully draw more samples from a generative model than the ones it was trained with. We explore this using a simplified model and demonstrate that generative models indeed have the capability to amplify data sets.

T 38.9 Tue 18:00 Tm

Fast Simulation of High Granularity Calorimeters with Deep Generative Models — •Peter McKeown — DESY, Hamburg, Germany

Simulation is a key corner stone of modern high energy physics experiments- not only to characterise and optimise the design of detectors, but also to investigate the compatibility of experimental observations and theoretical models. Monte Carlo techniques provide a powerful method to build simulation tools, however these simulations require a large amount of compute time and will prove to be a major bottleneck at the high luminosity phase of the LHC and for future colliders. A particularly time consuming part of simulation involves calorimeter showers, which require a large number of computations to be performed to account for the many interactions that occur.

Deep generative models provide a promising solution to reduce the computing time for such simulations. Recent work in our group has demonstrated the ability to reproduce physically realistic showers in highly granular calorimeters with a high degree of fidelity. While this work focused on the specific case of a particle entering orthogonally to the calorimeter face, in order for such a simulation scheme to be used in practice, arbitrary angles of incidence must be incorporated and correctly simulated. This talk will describe the principles of using generative networks for accurate particle shower simulations and then focus on the efforts of adding conditioning on the particle incident angle.

T 38.10 Tue 18:15 Tm

Optimization of Selective Background Monte Carlo Simulation with Graph Neural Networks at Belle II — •Boyang Yu, Thomas Kuhr, and Nikolai Hartmann — Ludwig-Maximilians-Universität München

When measuring rare processes such as $B \to K^{(*)}\nu\bar{\nu}$ or $B \to l\nu\gamma$, a huge luminosity is required, which means a large number of simulations are necessary to determine signal efficiencies and background contributions. However, this process demands high computation costs while most of the simulated data, in particular in case of background, are discarded by the event selection. Thus filters using neural networks are introduced after the Monte Carlo event generation to speed up the following processes of detector simulation and reconstruction.

In this work, we study optimizations of the performance of neural networks by implementing different architectures with graph neural networks based on moderner libraries and validate them on large datasets. Efficiency, accuracy, ROC curves and AUC values are considered as major criteria.

T 39: Pixel Detectors II

Time: Tuesday 16:00–18:35 Location: Tn

Group Report T 39.1 Tue 16:00 Tn

A timing layer for EUDET-type beam telescopes — •Annika Vauth[1], Erika Garutti[1], Ingrid-Maria Gregor[2,3], Keerthi Nakkalil[2], Jörn Schwandt[1], and Simon Spannagel[2] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland — [2]Deutsches Elektronen-Synchrotron, Notkestraße 85, 22607 Hamburg, Deutschland — [3]Universität Bonn, 53012 Bonn, Deutschland

EUDET-type silicon pixel telescopes are widely used as test beam infrastructure to provide precision reference tracking for detector development, for example at the DESY II test beam facility. They each feature six tracking planes equipped with Mimosa26 sensors.

Experiments at future facilities demand excellent time and space resolution to be combined in a single detector. The R&D on these novel detectors requires the availability of a new reference system at test beams that is also capable of precise time resolution. Within the research program of the Cluster of Excellence Quantum Universe, our group will equip the existing telescopes with an additional plane providing timing resolution in the order of tens of picoseconds.

In this contribution, the short- and mid-term plans for such an upgrade will be presented: The timing layer will use LGADs bump-bonded to a dedicated readout chip and integrated in the already vastly used EUDAQ2. In the first stage the Timepix4 chip will be used, which will allow a resolution on the order of nanoseconds.

T 39.2 Tue 16:20 Tn

Testing and Characterization of RD53A Quad Modules — •Lars Schall, Michael Daas, Fabian Hügging, David-Leon Pohl, and Jochen Dingfelder — Physikalisches Institut, University of Bonn, Germany

The increased data rate and radiation level expected for the High-Luminosity upgrade of the Large Hadron Collider (LHC) demands the ATLAS Experiment to upgrade its detector systems. To maintain an excellent tracking performance in the high occupancy environment and cope with the increased total radiation fluence the improved Inner Tracker (ITk) will consist of all-silicon detectors. The ITk will be built largely of quad modules. As part of the ITk preproduction program RD53A quad modules are assembled and tested. The RD53A readout chip is a half-size prototype for testing purposes only, developed by the RD53 collaboration. Four RD53A readout chips interconnected with one large sensor tile yield a quad module.

First results from the ongoing tests and characterizations of RD53A quad modules are presented. Special emphasis is put on electrical tests and tuning procedures of digital quad modules. Further measurements procedures for RD53A quad modules with sensors will be discussed.

T 39.3 Tue 16:35 Tn

Radiation Damage Measurements of the Hybrid Pixel Readout Chip RD53A — •Marco Vogt, Jochen Dingfelder, Flo-

rian Hinterkeuser, Tomasz Hemperek, Fabian Hügging, Hans Krüger, Konstantinos Moustakas, Piotr Rymaszewski, Mark Standke, and Norbert Wermes — Physikalisches Institut der Universität Bonn

After the phase-2 upgrade of the LHC at CERN, the instantaneous luminosity will be increased by a factor of ~7. New detector systems are required which are able to deliver hit information at drastically increased data rates and cope with unprecedented radiation levels of almost 1 Grad.

The RD53 collaboration will provide the pixel readout chips for the innermost tracking detector layers of both ATLAS and CMS. The half- and full-scale prototype chips RD53A and ITkPixV1 have been manufactured in a 65 nm CMOS process.

Irradiation campaigns with X-rays and radioactive sources indicate that the radiation damage of RD53A is significantly dose rate dependent. It is therefore necessary to improve the radiation models to further optimize the design and make better predictions about the degradation of detector performance during its lifetime, prior to the submission of the final production chip.

In this contribution, the ongoing low-dose-rate irradiation campaigns and their results will be presented.

T 39.4 Tue 16:50 Tn

Characterization of RD53A modules using x-ray fluorescence — •Sascha Dungs[1,2], Kevin Kröninger[1], Susanne Kühn[2], Lingxin Meng[2], and Heinz Pernegger[2] — [1]TU Dortmund, Experimental Physics IV — [2]CERN

As part of the Phase-II upgrade of the ATLAS detector, the current tracking detector will be replaced by an all-silicon detector, the Inner Tracker (ITk). For this, a new generation of silicon hybrid pixel modules are currently being developed. There are different techniques to investigate the properties of these modules. X-ray fluorescence can be used for energy calibration. An x-ray source is pointing on a target material, which leads to emission of photons with monochromatic energy. By using various target materials a wide energy range can be evaluated.

In this talk, results of x-ray fluorescence measurements of unirradiated and irradiated planar pixel modules with RD53A readout chips will be presented.

T 39.5 Tue 17:05 Tn

A study of the LHCb mighty tracker concept for upgrade 2 — •Hannah Schmitz, Klaas Padeken, and Sebastian Neubert for the LHCb-Collaboration — Rheinische Friedrich-Wilhelms Universität Bonn

After the HL-LHC upgrade in long shutdown 4 the instantaneous luminosity of the HL-LHC is up to $1.5 \cdot 10^{34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ at point 8. Therefore, the LHCb tracking system has to be upgraded. The three tracking stations of its downstream tracking spectrometer are thus studied with focus on a hybrid detector technology, where silicon pixels and scintillating fibres are installed in one module. This is known as the mighty tracker.
During long shutdown 3 (upgrade 1b) the inner part ($3.9\,\mathrm{m}^2$) of the tracking stations is planned to be replaced by a silicon pixel detector, surrounded by scintillating fibres in the outer part, to cover the region of highest particle density. The pixels are based on HV-CMOS technology and have a size up to $100\,\mu\mathrm{m} \times 500\,\mu\mathrm{m}$. In upgrade 2 the silicon part is planned to be expanded up to a size of $18.1\,\mathrm{m}^2$ in total.
This presentation covers first results of the mighty pixel studies and plans for the mighty tracking detector.

T 39.6 Tue 17:20 Tn

Design and cooling of the tracking detector of the P2 experiment — •Michail Kravchenko for the P2-Collaboration — PRISMA+ Cluster of Excellence and Institute of Nuclear Physics, Johannes Gutenberg University Mainz

The P2 Experiment aims to measure the weak mixing angle $sin^2\theta_w$ at low momentum transfer Q^2 by measuring the parity violating asymmetry in elastic electron-proton scattering. It will be carried out at the Mainz Energy-recovering Superconducting Accelerator (MESA), which will provide a 150 μA beam of alternatingly polarized 150 MeV electrons with excellent beam stability. 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 High Voltage Monolithic Active Pixel Sensors (HV-MAPS) made of silicon thinned to 50 μm. HV-MAPS allow reducing the material budget to a minimum by integrating the readout on the sensor substrate. The tracking detector modules will be cooled by the gas flow, and helium is selected as a coolant. The current state of the P2 tracking detector design development and of the results of the computational fluid dynamics (CFD) simulation for evaluating the cooling efficiency are presented.

T 39.7 Tue 17:35 Tn

The development and first measurements of a laboratory readout system for the DEPFET pixel detector module — •Patrick Ahlburg, Florian Bernlochner, Jochen Dingfelder, Tomasz Hemperek, Hans Krüger, Botho Paschen, and Norbert Wermes — University of Bonn

The DEPFET PiXel Detector (PXD) is successfully operated in the innermost layers of the Belle II experiment at the SuperKEKB e^+e^- collider in Japan. The PXD-DAQ is optimized for the requirements of a full scale detector operating in Belle II. In this talk, the development of a laboratory readout system (BDAQ-PXD) for a single PXD module is shown. BDAQ-PXD is intended as an easily accessible lab test system for irradiation- and test-beam setups using a custom designed readout board (BDAQ53). The lab test system will help gather information about the behavior of DEPFET pixel detector modules in dedicated tests. The implementation of the firmware and the first measurements with the system in a test-beam conducted at DESY are presented in this talk.

T 39.8 Tue 17:50 Tn

Irradiation burst study of Belle II PXD module components — Jochen Dingfelder[1], Georgios Giakoustidis[1], Martin Hensel[2], Matthias Hoek[3], Florian Lütticke[1], Botho Paschen[1], •Jannes Schmitz[1], and Marike Schwickardi[4] for the Belle II-Collaboration — [1]University of Bonn, Germany — [2]HLL of Max-Planck-Society, Munich, Germany — [3]University of Mainz, Germany — [4]University of Göttingen, Germany

The Belle II detector started recording collision data in spring 2019. During physics runs in 2019 and 2020, unexpected irradiation burst events occurred, which exposed the inner detectors and especially the PXD (PiXel Detector) to unwanted levels of prompt irradiation. Dedicated measurement campaigns were carried out at the Mainz Microtron (MAMI), which aimed to reproduce the observed effects of irradiation bursts on the PXD in Belle II. To this end, a focused high intensity (800 nA) pencil beam of 855 MeV electrons was used to irradiate full system demonstrators in several spatially confined fiducial regions. In this talk, the results of these campaigns will be presented and compared to the observed impact of the irradiation bursts on the PXD modules installed inside Belle II.

T 39.9 Tue 18:05 Tn

Commissioning and Time Resolution Studies of a Timepix3 Tracking Plane in the DESY II test beam facility — •Keerthi Nakkalil[1], Annika Vauth[2,3], Ingrid Gregor[4,1], and Simon Spannagel[5] — [1]University of Bonn, Bonn, Germany — [2]DESY, Hamburg, Germany — [3]University of Hamburg, Germany — [4]DESY, Hamburg, Germany — [5]DESY, Hamburg, Germany

Test beam infrastructure plays an indispensable role in the R&D and prototyping of key detector technologies. At the DESY II test beam facility, the EUDET-telescopes based on the Mimosa26 monolithic active pixel sensors (MAPS) has been a workhorse for detector developments providing unparalleled tracking resolution for the test beams for over a decade. Our goal is to integrate Timepix3 tracking planes into the existing telescope at the DESY II test beam facility to perform track time-stamping at the nanosecond scale.

In this talk, the results of the studies undertaken to understand the general characteristics of the Timepix3 ASIC such as noise performance, threshold, and gain dispersion will be presented. Furthermore, the tracking resolution studies performed at the test beam facility will also be shown.

T 39.10 Tue 18:20 Tn

Mu3e inner tracker prototyping — •Thomas Rudzki for the Mu3e-Collaboration — Physikalisches Institut, Universität Heidelberg

The Mu3e experiment searches for the lepton flavour violating decay $\mu \to eee$ with an ultimate aimed sensitivity of 1 event in 10^{16} decays. This goal can only be achieved by reducing the material budget per tracking layer to $X/X_0 \approx 0.1$ %. High-Voltage Monolithic Ac-

tive Pixel Sensors (HV-MAPS) which are thinned to 50 μm serve as sensors. Gaseous helium is chosen as coolant.

This talks presents the results of recent prototyping which verified that such an ultra-thin tracker can be constructed for the inner tracker. The construction and commission of this prototype were used to establish the quality assurance procedure for the final production. In addition, the helium cooling system was tested by heating the prototype with the nominal heat load.

T 40: Experimental methods II

Time: Tuesday 16:00–18:30 Location: To

T 40.1 Tue 16:00 To

Track reconstruction for the Mu3e experiment — •Alexandr Kozlinskiy for the Mu3e-Collaboration — Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, Johann-Joachim-Becher-Weg 45, 55128 Mainz, Germany

The *Mu3e* experiment will search for the lepton flavour violating decay $\mu^+ \to e^+e^-e^+$ with the aim to reach a branching ratio sensitivity of 10^{-16}. The first phase the experiment will be performed at an existing beam line providing 10^8 muons per second at the Paul-Scherrer Institute (Switzerland) which will allow to reach a sensitivity for the branching fraction of 10^{-15}. The muons will stop on a target and decay at rest. The decay products (positrons and electrons) with energies below 53 MeV are measured by a tracking detector consisting of two double layers of 50 μm thin High-Voltage Monolithic Active Pixel Sensors (HV-MAPS). The high granularity of the pixel detector with a pixel size of 80×80 μm allows for a precise track reconstruction in the high occupancy environment of the *Mu3e* experiment. The *Mu3e* track reconstruction uses a novel fit algorithm that in the simplest case takes into account only the uncertainty due to multiple scattering, which allows fast online tracking on a GPU based filter farm. The implementation of the 3-dimensional multiple scattering fit based on hit triplets is described. An extension of the fit that takes into account energy losses and pixel size is used for offline track reconstruction. The algorithm and performance of the offline track reconstruction based on a full Geant4 simulation of the *Mu3e* detector are presented.

T 40.2 Tue 16:15 To

Status and outlook of the CMS fast Monte Carlo simulation chain (FastSim) — •Samuel Bein — Universitaet Hamburg, Hamburg, Germany

The High Luminosity LHC is expected to deliver a total integrated luminosity of 3 fb^{-1} to the CMS detector by the end of the next decade, a data set roughly 30 times larger than that obtained before the current date. This significant ramp up will enhance the importance of fast Monte Carlo simulation programs, both to satisfy computing budget requirements, and to provide analysis teams with accurate simulated event samples in a timely manner. The CMS experiment plans to develop its existing fast simulation program (FastSim), a factor of 10 faster than the Geant4-based full simulation, in order to fulfill a larger fraction of the collaboration's needs. The current performance of FastSim is highlighted, and the status of various developments, including the use of generative models to improve the accuracy of high-level physics observables, is discussed.

T 40.3 Tue 16:30 To

Direct-photon plus jets production in Powheg — •Yanwen Hong, Thomas Peiffer, Arnulf Quadt, and Elizaveta Shabalina — II. Physikalisches Institut, Georg-August-Universität Göttingen

Photons and photons-plus-jets production play an important role in high-energy collisions. Theoretical predictions for final-state photon production in pp, pPb, and PbPb collisions have been available at leading order (LO) and next-to-leading-order (NLO), and have been implemented in Monte Carlo generators like Sherpa. For direct-photon production, NLO samples are available only with the Sherpa generator and have been shown to provide a good description of data. An alternative sample, generated using the matrix element Monte Carlo generator Powheg, would help to provide an estimate of the systematic uncertainties in the modelling and to have a better understanding of these final states. The talk covers the following. A setup at NLO using the Powheg direct-photon process is studied. Configuration for di-photon plus jets samples with MadGraph5 interfaced with Pythia8 at NLO using the FxFx merging scheme is prepared, and a validation against the Sherpa setup and unfolded data using Rivet is performed. Finally, the effects of changing certain MC parameters and merging scale variations are studied.

T 40.4 Tue 16:45 To

Track reconstruction with ACTS — Florian Bernlochner, Jochen Dingfelder, and •Ralf Farkas for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The reconstruction of trajectories of charged particles is a crucial task for most HEP experiments. The ACTS (A Common Tracking Software) aims to be a generic, framework and experiment-independent toolkit for track reconstruction, initially started from the ATLAS tracking software. My talk will summarize recent developments of a Combinatorial Kalman Filter (CKF) for the ACTS project, and the possibilities of integrating ACTS with the Belle II software framework.

T 40.5 Tue 17:00 To

Studies of parameter uncertainty correction methods in unbinned maximum likelihood fits to events weighted by the SPlot technique — Peter Buchholz, Mazuza Ghneimat, •Tim-Philip Hücking, Iskander Ibragimov, and Wolfgang Walkowiak — Universität Siegen, Siegen, Deutschland

The sPlot technique is used in HEP to e.g. separate signal and background events in control variable distributions on a statistical basis. This separation is achieved by applying sWeights as event weights. The sWeights are calculated based on a discriminating variable fit. In case of fitting the sWeighted distributions using an unbinned maximum likelihood approach, the covariance matrix, defined as the inverse Hessian matrix of the likelihood function, needs to be corrected.

Uncertainty correction methods proposed by Eadie et al. and Langenbruch are studied, utilizing RooFit. The studies are based on pseudo experiments employing a simple statistical model. The uncertainty correction method proposed by Eadie et al. is found to be sufficient only in few cases. Langenbruch proposed two uncertainty correction methods: The first one accounts for the presence of the sWeights in the fit and the second one additionally for the uncertainties of the sWeights. This second method is found to work best.

For certain distributions of the control variable, fits to sWeighted distributions may still show some problematic behavior, as observed for the case of two Gaussian distributions.

T 40.6 Tue 17:15 To

Estimating the fake lepton contribution in the framework of Bayesian statistics — Johannes Erdmann, Cornelius Grunwald, Kevin Kröninger, Salvatore La Cagnina, and •Lars Röhrig — TU Dortmund, Experimentelle Physik IV

In a particle detector, the signature of prompt leptons like electrons and muons can be faked by other objects, such as jets or non-prompt leptons from hadron decays. Huge amounts of simulated events would be needed to estimate the fake lepton background contribution due to the small fake probability, thus data-driven techniques like the matrix method are commonly used instead. The method is based on the definition of two identification criteria, referred to as loose and tight and the probabilities of a real or fake lepton to pass either one of these criteria.

Known limitations of the classical matrix method are the possible prediction of negative fake rates and the approximation of Poisson distributed counting rates as Gaussian distributions. A Bayesian approach is presented, facing these restrictions and leading to a stable fake rate estimation in cases, in which the classical matrix method has limited validity. Several studies and comparisons to alternative methods are presented.

T 40.7 Tue 17:30 To

Neural network background estimation for Higgs boson pairs decaying to $b\bar{b}b\bar{b}$ final state — •Marta Czurylo and André Schöning — Physikalisches Institut Universität Heidelberg

Monte Carlo (MC) simulations and data-driven techniques are commonly used for the background estimation in ATLAS analyses. An advantage of data-driven methods over more traditional MC simulations is observed when MC is unreliable, for example, in case of QCD processes.

One of such techniques is background reweighting from control to signal regions which is firstly discussed in general. A novel approach uses neural network machinery for the reweighting. The idea and preliminary performance of the neural network reweighting are presented for the Vector Boson Fusion production of Higgs boson pairs decaying to $b\bar{b}b\bar{b}$ final state. The studies are performed based on ATLAS datasets collected between 2016 and 2018 with total integrated luminosity of $126.7 fb^{-1}$.

T 40.8 Tue 17:45 To

Combinatorial Kalman Filter for the Belle II Experiment — Florian Bernlochner[1], Jochen Dingfelder[1], Alexander Glazov[2], Simon Kurz[2], and •Christian Wessel[1] for the Belle II-Collaboration — [1]Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, Bonn — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg

Kalman filters are a widely used tool in HEP to identify charged particle trajectories with a high efficiency and purity. The Belle II Combinatorial Kalman Filter (CKF) implementation is instrumental in achieving the physics goals of the experiment and is successfully being used in first emerging physics measurements. In this talk, I will summarize the key elements of the CKF implementation, show first results with data and give an outlook on future optimizations and extensions we have been working on.

T 40.9 Tue 18:00 To

Performance and calibration of the semileptonic Full Event Interpretation at Belle II — Florian Bernlochner, Jochen Dingfelder, Peter Lewis, •Alina Manthei, and William Sutcliffe for the Belle II-Collaboration — Physikalisches Institut, Universität Bonn, Germany

The Belle II experiment is located at the SuperKEKB collider in Japan, where electrons and positrons collide at the $\Upsilon(4S)$ resonance to produce $B\overline{B}$ pairs. The analysis of the decays of these B mesons allows for precise tests of the Standard Model. In order to investigate properties of B meson decays with missing energy as precisely as possible, one relies on the accurate reconstruction of the second B meson in the event. For this purpose, a reconstruction algorithm has been developed, named the Full Event Interpretation (FEI). As not all of the features of the detector are modelled precisely by Monte Carlo simulation, differences in efficiencies of the FEI in data and MC may occur. Therefore, a careful calibration of the tagging efficiency is required to account for such mismatches in efficiencies. In this talk, the strategy for obtaining such a calibration in a data-driven way for semileptonically tagged events is presented and first results are shown.

T 40.10 Tue 18:15 To

Hadronic Tagging at the Belle II experiment — Florian Bernlochner, Lu Cao, Jochen Dingfelder, Maximilian Graf, •Gianna Mönig, William Sutcliffe, and Ilias Tsaklidis for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The Belle II experiment, located at the SuperKEKB accelerator complex in Japan, recently started its first physics runs. Belle II aims to record B meson-pairs at unprecedented luminosities produced through electron-positron annihilation at the $\Upsilon(4S)$ resonance.

One key experimental method to carry out measurements with missing final state particles, such as neutrinos, is the reconstruction of one of the two B mesons in fully hadronic decay modes. The clean laboratory of electron-positron annihilation in combination with this approach allows one to infer flavor and momentum of the other B meson in the event. This method is called "hadronic tagging" and Belle II employs a machine learning based algorithm called the Full Event Interpretation (FEI) for an efficient reconstruction.

In this presentation, I review the current status and efficiency of hadronic tagging with early Belle II data. In addition, I present promising extensions that rely on the semi-inclusive reconstruction of the tag-side B meson or graph networks that are under study and summarize the calibration strategy of the tagging efficiency that was developed.

T 41: DAQ, trigger and electronics II

Time: Tuesday 16:00–18:00 Location: Tp

T 41.1 Tue 16:00 Tp

Particle Track Fitting in Hardware for the ATLAS Phase II Update — •Joachim Zinsser, Sebastian Dittmeier, and André Schöning — Physikalisches Institut, Universität Heidelberg, Deutschland

Due to the planned increase in luminosity during the ATLAS Phase II Upgrade, it is necessary to filter interesting events more efficiently. It is planned to install a filter based on the particle tracks, which, have to be evaluated in real time. The parameters of the helix-shaped trajectories can be approximated linearly.

This task is well suited for an implementation in hardware since, on the one hand, it requires only basic arithmetics and comparisons, and, on the other hand, it can be implemented in a highly parallel hardware architecture, e.g. by exploiting FPGAs.

The *Hardware Track Trigger* (HTT) group of ATLAS-TDAQ decided to follow an approach that utilizes a database of simulated trajectories. The Track-Fitter is implemented on the *Intel Stratix 10* with an integrated *High Bandwidth Memory* (HBM) for storing the constants for the linear fit of the parameters. The FPGA will be mounted on a mezzanine board that connects it to a group of *Associate Memory ASICs* that store the simulated trajectories.

This talk will focus on the way in which the fit parameters are calculated within the FPGA-logic.

T 41.2 Tue 16:15 Tp

Towards SLDO characterisation in ITkPixV1 — •Charlotte Perry, Florian Hinterkeuser, Matthias Hamer, Hans Krüger, Fabian Hügging, and Klaus Desch — Physikalisches Institut der Universität Bonn

At the high luminosity upgrade of the LHC at CERN the ATLAS Inner Detector (ID) will be replaced by an all-silicon inner tracker (ITk) consisting of an inner pixel and an outer strip detector. Compared to the current pixel detector, the upgrade will cover a significantly larger phase space while featuring a smaller pixel size.

In order to optimise the material budget, considering the increased current consumption per chip and the significantly higher number of readout chips in the upgraded pixel detector, a serial power scheme of modules had been chosen. In this scheme, a chain of modules is connected in series and supplied with a constant current. The readout chip supply voltage is generated from this constant current by on-chip Shunt-LDO (SLDO) regulators.

The SLDO is an integral part of this kind of powering scheme. It has been extensively tested with several generations of test chips, advancing its design towards the implementation in the first full size readout chip for the upgraded ATLAS pixel detector, the ITkPixV1 readout chip. In this presentation, a first characterisation of the SLDO in the ITkPixV1 is given.

T 41.3 Tue 16:30 Tp

Scan Automated Testing for the ATLAS Pixel Detector — Marcello Bindi[1], Tobias Bisanz[2], Arnulf Quadt[1], and •Christian Scheulen[1] — [1]II. Physikalisches Institut, Georg-August Universität Göttingen — [2]CERN, Geneva, Switzerland

The ATLAS Pixel detector data acquisition system (DAQ) is distributed over several different physical components, such as front-end detector modules, read-out drivers, and PCs for operating and calibrating the detector. As a result, time-consuming manual tests are currently required to ensure the correct operation of the entire system after software or firmware changes in any component.

To simplify software validation and free up manpower, a suite of automated tests is being developed for deployment in the DAQ software's continuous integration system on GitLab. Fully automated testing is only possible without involvement of the detector modules, whose operation requires some degree of manual supervision. Therefore, emulated detector responses are used for tests of readout-chain components

under exclusion of the detector modules themselves.

This talk will present the initial stages of scan automated testing development, consisting of the fundamental test infrastructure and the first emulated scan tests for software validation.

T 41.4 Tue 16:45 Tp

b-jet triggers in ATLAS Run-3 — •Christian Nass[1], Tatjana Lenz[1], Jochen Dingfelder[1], and Carlo Schiavi[2] — [1]Physikalisches Institut, Universität Bonn, Germany — [2]Dipartimento di Fisica, Università di Genova, Genova, Italy

In high energy particle physics b-quarks play an important role for numerous reasons, e.g. 3rd generation particle, long lifetime, large couplings to top-quark and Higgs Boson. The latter point is crucial for many top-quark and Higgs analyses. Some of these analysis like $HH \to bbbb$, ttH or $bH \to bbb$ have fully hadronic final states. The challenge is to select these events out of the overwhelming QCD background. Since not all events can be recorded, this has to be done in real-time. Therefore a lot of effort has been put in developing algorithms to discriminate b-quark initiated jets from c-quark, light-quark and gluon initiated jets by utilising the b-quark properties. These algorithms form the b-jet triggers and have to be fast and efficient in order to keep the p_{T}-threshold as low as possible.

This talk will present the b-jet trigger code structure for ATLAS in Run-3 as well as its validation.

T 41.5 Tue 17:00 Tp

Jet algorithm performance studies of the Phase-1 upgrade of the ATLAS Level-1 Calorimeter Trigger — •Lisa Marie Baltes — Kirchhoff-Institute for Physics, University Heidelberg, Germany

The ATLAS Level-1 Calorimeter Trigger (L1Calo) identifies events containing objects such as electrons, photons, tau leptons, jets and missing transverse energy and therefore plays an important role in the data taking process of the ATLAS detector. In order to address the challenges introduced by the increased luminosity of the Large Hadron Collider in Run 3, the L1Calo Phase-1 upgrade includes several hardware and software-based updates. Within the new system, the granularity of the data from the electromagnetic calorimeter being sent to the L1Calo trigger is increased by a factor of 10. Instead of using trigger tower information, the trigger readout in Run 3 consists of so-called supercells. Several new trigger algorithms, which are implemented via FPGAs, are developed to maintain a good trigger performance even in high pile-up conditions. In order to evaluate the rates of these Run 3 algorithms, Run 2 data is used by merging the offline cells into Run 3 supercells. This can be cross-checked using Monte Carlo simulations. This talk motivates the use of the supercell emulation and shows preliminary results of the jet algorithm performance studies.

T 41.6 Tue 17:15 Tp

A FPC for the ATLAS High Granularity Timing Detector Demonstrator — •Marisol Robles Manzano[1], Peter Bernhard[2], Andrea Brogna[2], Atila Kurt[2], Karl-Heinz Geib[1], Lucia Masetti[1], Binh Pham[2], and Quirin Weitzel[2] — [1]Institut für Physik, Johannes-Gütenberg Universität Mainz — [2]PRISMA$^+$ Detector Lab, Johannes-Gütenberg Universität Mainz

The ATLAS detector requires upgrades to exploit the physics potential of new HL-LHC, where the large increase of pile-up interactions is a main challenge. The High-Granularity Timing Detector (HGTD) will be built in order to mitigate the effects of pile-up in the ATLAS forward region, providing a time resolution of about 30 ps per track. A 2x4 cm^2 Low Gain Avalanche Detector (LGAD sensor) bump-bonded to two ASICs and glued to a flexible PCB, make up the so-called module, the HGTD basic unit. The active area consists of 2-doubled-sided disks per end-cap and is surrounded by the Peripheral Electronics Boards (PEB). A Flexible Printed Circuit (Flex tail) serves as connection between a module and the PEB: power, communication signals and HV bias. A demonstrator is proposed to test the functionality and assembly of a subset of components of the full detector such as electronics, sensors and the cooling system as part of the R&D phase. A Flex tail prototype is planned to be tested during the demonstrator activities. An overall description of the demonstrator activities with emphasis on the Flex tail is presented.

T 41.7 Tue 17:30 Tp

Development of a DC-DC converter for powering the Mu3e detector — •Sophie Gagneur for the Mu3e-Collaboration — Institute of Nuclear Physics, Johannes Gutenberg University Mainz

The Mu3e experiment under construction at the Paul Scherrer Institute, Switzerland, aims to search for the lepton flavour violating decay of a muon into one electron and two positrons with an ultimate sensitivity of one in 1016 muon decays.

The detector for the Mu3e experiment consists of High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) combined with scintillating tiles and fibres. The detector ASICs need a supply voltage of around 2V. This voltage is generated from the 20V external supply via switching DC-DC converters. These buck converters must be able to operate within a magnetic field and provide a constant output voltage with a ripple of less than 10mV to guarantee a proper operation of the pixel sensors and timing detectors. A first version of the converter has been successfully tested in the laboratory and with a prototype pixel sensor. The second version of the Mu3e DC-DC converter has been designed and produced based on the findings from these tests. The innovations in the design of these converters include an improved output filter, a temperature interlock and a current sense measurement.

T 41.8 Tue 17:45 Tp

Large Area Avlanache Photodiode gain optimization — •Kim Tabea Giebenhain — Justus-Liebig-Universität, Gießen, Deutschland

The PANDA EMC, a calorimeter with high energy resolution, is an extremely important factor in reconstruction and particle identification, especially in the lower energy range. Its PWO-II crystals are read out with two Large Area Avalanche Photodiodes. Since the energy resolution and the noise of the LAAPDs depend on the bias voltage a study was done to find the optimal bias voltage in a range between 10 MeV and 2 GeV, using a single LAAPD and the APFEL ASIC preamplifiers. In order to simulate signals a LED-Pulser, planned for an online monitoring system, was used. Those light-pulser measurements indicate, that especially for energies below 1 GeV the energy resolution can be vastly improved by using much higher amplification than a standart gain of 150.

T 42: Neutrino astronomy II

Time: Tuesday 16:00–18:30 Location: Tq

T 42.1 Tue 16:00 Tq

Muon Deflection Angle Study with IceCube — •Pascal Gutjahr, Mirco Hünnefeld, and Wolfgang Rhode — TU Dortmund, Experimentelle Physik Vb

Neutrino detectors, such as IceCube, utilize muons resulting from charged current muon-neutrino interactions to infer the direction of the primary neutrino. These muons may travel several kilometers before entering the detector. Along this track, the muon may be deflected though interactions with the surrounding medium. Due to their high energies of hundreds of GeV to PeV, the muons are highly Lorentz boosted, resulting in small deflection angles. The deflection along the track is therefore assumed to be negligible for IceCube. However, these small deflection angles may accumulate over long distances.

A study is presented that investigates the impact of accumulated deflections along the muon track by introducing a scaling factor for bremsstrahlung interactions. This study focuses on the one hand on the possibility to measure this scaling factor with IceCube. On the other hand, the opening angle between the incoming and outgoing muon is studied as a function of scaling factor, energy and propagated distance via Monte Carlo simulation.

T 42.2 Tue 16:15 Tq

Studies of systematic uncertainty effects on IceCube's real-time angular uncertainty — •Cristina Lagunas Gualda for the IceCube-Collaboration — DESY Zeuthen

Sources of astrophysical neutrinos can be potentially discovered

through the detection of neutrinos in coincidence with electromagnetic or gravitational waves. Real-time alerts generated by IceCube play an important role in this search since they act as a trigger for follow-up observations with instruments sensitive to other wavelengths.

Once a high-energy event is detected by the IceCube real-time program, a sophisticated and time-consuming method is run in order to calculate an accurate localization. To investigate the effect of systematic uncertainties on the uncertainty estimate of the location, we simulate a set of high-energy events with a wide range of directions for different ice model realizations. This makes use of a novel simulation tool, which allows the treatment of systematic uncertainties with multiple and continuously varied nuisance parameters. Then those events are reconstructed using various reconstruction methods. The aim of this study is to include systematic uncertainties in a robust way in the real-time direction and error estimates.

T 42.3 Tue 16:30 Tq

Precision self-monitoring calibration module for the IceCube Upgrade — •Tobias Pertl and Felix Henningsen — Technische Universität München

The IceCube detector is a large-volume neutrino detector embedded in the Antarctic ice at the geographic South Pole. As the detector has been online for over a decade, advancements in hardware and an increased scientific focus on oscillation and high-energy physics as well as re-calibration of the detector have driven the IceCube Upgrade. This upgrade encompasses a detector expansion with seven new densely instrumented strings focussed on low-energy physics. A novel type of precision optical calibration module – or POCAM – for large-volume detectors has been developed and will be deployed throughout the instrumented volume of the IceCube Upgrade. We report on the design and extended performance of the POCAM instrument as well as calibration procedures.

T 42.4 Tue 16:45 Tq

Redesigning the IceCube processing pipeline with deep learning — •Christian Haack and Theo Glauch for the IceCube-Collaboration — TU München

The IceCube Neutrino Observatory is a cubic-kilometer sized neutrino detector located at the geographic South Pole. The main background for neutrino searches are atmospheric muons, induced by cosmic-ray air showers. IceCube employs multiple levels of software filters, involving various event reconstructions, to reduce the atmospheric muon background and classify the events based on their topology. While this pipeline has enabled many scientific breakthroughs, such as the measurement of the diffuse astrophysical neutrino flux and the detection of the first high-energy neutrino point source, many of its components have been in place for more than ten years. This makes the filtering pipepline increasingly challenging to maintain. Additionally, detector extensions, such as the IceCube Upgrade, are difficult to incorporate in the existing filtering systems. However, recent developments in deep-learning based filtering and reconstruction algorithms have the potential to drastically simplify the filtering pipeline. In this talk, we will outline how a deep-learning based filtering system for IceCube might look like.

T 42.5 Tue 17:00 Tq

Machine Learning-based Cascade Event Selection for IceCube — •Mirco Hünnefeld for the IceCube-Collaboration — TU Dortmund, Germany

IceCube is a neutrino detector located at the geographic South Pole, instrumenting a cubic kilometer of glacial ice. Neutrino interactions are detected via Cherenkov radiation of charged secondary particles. The two main detection channels consist of tracks, induced by charged current muon-neutrino interactions, and cascade events, which are almost spherical energy depositions. Although the selection and angular reconstruction of cascades is challenging, these events enhance IceCube's capabilities to probe the southern neutrino sky. In this talk, a machine learning-based cascade event selection is presented. The event selection utilizes a series of convolutional neural networks and boosted decision trees for classification and reconstruction tasks. In addition, a novel reconstruction method based on a hybrid approach of maximum-likelihood estimation and generative neural networks is employed. The presented event selection improves upon the performance of previous selections, while greatly reducing the necessary computation time, enabling the application in real-time.

T 42.6 Tue 17:15 Tq

Unfolding the neutrino energy spectrum from three years of IceCube data — •Leonora Kardum — Technische Universität Dortmund

Precise unfolding techniques are crucial for determining the diffuse astrophysical neutrino flux from the low statistic data of the higher energy region. Here presented is a rigorous approach to muon neutrino sample cleaning achieving higher purity than previous methods, combined with a novel approach to rebin the observable space with the goal of attaining substantial statistics in all regions. A comprehensive unfolding approach is presented for the purpose of determining the neutrino distribution in the whole zenith area of interest aimed at analyzing three years of IceCube IC86 data.

T 42.7 Tue 17:30 Tq

Perspectives of a Global Fit of IceCube's Astrophysical Neutrino Data — •Erik Ganster[1], Jakob Böttcher[1], Philipp Fürst[1], Christian Haack[2], Jöran Stettner[1], and Christopher Wiebusch[1] for the IceCube-Collaboration — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]TU München - Experimental Physics with Cosmic Particles

The IceCube Neutrino Observatory has observed a flux of high-energy astrophysical neutrinos since 2013. This observation has been confirmed in multiple complementary detection channels such as high-energy starting events (HESE), cascades, and through-going muon tracks. This diffuse flux is typically modelled by power-law energy spectra. However, the measured flux properties differ between these different observations. We report on the status of a combined global analysis of all high-energy neutrino data from IceCube which is currently being prepared. Studies of the sensitivity of this 'global fit' for measuring the flux properties will be shown.

T 42.8 Tue 17:45 Tq

Neutrino-blazar correlations: Striving for the big picture — •Martina Karl[1,2] and Matthias Huber[2] for the IceCube-Collaboration — [1]Max-Planck-Institut für Physik, Föhringer Ring 6, 80805München, Deutschland — [2]Technische Universität München, Fakultät für Physik, James-Franck-Str. 1, 85748 Garching, Deutschland

The IceCube neutrino observatory experienced remarkable success in the field of neutrino astronomy since its completion. Besides the discovery of a diffuse astrophysical high-energy neutrino flux, IceCube found evidence for a correlation between high-energy neutrinos and the blazar TXS 0506+056 in 2018. Blazars, being a subclass of active galactic nuclei and consequently one of the most powerful objects in the universe are one of the most promising source candidates of high-energy neutrinos.

In this talk, we will present a correlation study between high-energy neutrinos measured with the IceCube neutrino detector and different classes of blazars. This study aims to provide the deepest understanding of the neutrino-blazar correlation that is accessible by means of current measurements.

T 42.9 Tue 18:00 Tq

The followup of IceCube alerts: Search for high-energetic neutrino sources — •Anna Schubert[1] and Martina Karl[1,2] for the IceCube-Collaboration — [1]Technische Universität München, Fakultät für Physik, James-Franck-Str. 1, 85748 Garching, Deutschland — [2]Max-Planck-Institut für Physik, Föhringer Ring 6, 80805 München, Deutschland

IceCube is a cubic-kilometer scale neutrino detector instrumenting a gigaton of ice at the geographic South Pole in Antarctica. On average, 8 track-like high energetic neutrino events with a high probability of being of astrophysical origin are detected per year. The bright appearance of these events in the detector allows for a good pointing to their origin. In this talk we present a search for the production sites of these cosmic neutrinos and hence also of the closely connected high-energy cosmic-rays. We use IceCube's high-statistics, neutrino-induced through-going muon samples to search for sources specifically in the vicinity of the arrival directions of the single most high-energetic events. The analysis searches for both, steady sources as well as for sources that only temporarily produce neutrinos.

T 42.10 Tue 18:15 Tq

Stacking Point Source Search for a Neutrino Contribution at HESE and EHE Positions with IceCube Data — •Johannes Kollek[1], Jan Soedingrekso[1], and Alexander Sandrock[1,2] for

the IceCube-Collaboration — [1]TU Dortmund, Dortmund, Germany — [2]Now at National Research Nuclear University MEPhI, 115409 Moscow, Russia

Neutrino point source searches could help understanding cosmic ray acceleration. With past all-sky searches in IceCube not revealing any point sources so far, a higher sensitivity can be achieved with time-dependent stacking searches on predefined source positions. A previous analysis on high energy starting event (HESE) positions with different non-overlapping time windows issued no significant lower-energy excess. The analysis is repeated also using the positions of extremely high energy events (EHE) and extended to additionally test overlapping time windows. This talk covers the early stage of the analysis and gives an overview over the analysis methods and goals.

T 43: Neutrino physics without accelerators II

Time: Tuesday 16:00–18:30 Location: Tr

T 43.1 Tue 16:00 Tr

Column Density Determination for the KATRIN Neutrino Mass Measurement — Fabian Block[1], •Christoph Köhler[2], and Alexander Marsteller[1] for the KATRIN-Collaboration — [1]Karlsruhe Institute of Technology — [2]Technical University of Munich/Max Planck Institute for Physics

The KATRIN experiment aims to model-independently probe the effective electron anti-neutrino mass with a sensitivity of 0.2 eV (90% C.L.) by investigating the endpoint region of the tritium beta decay spectrum. To achieve this goal the gas quantity of the windowless gaseous tritium source, characterized by the column density, has to be known with great accuracy.
This contribution describes the principle of measuring the column density with an angular resolved photoelectron source. Moreover, we report on the monitoring accuracy of the column density achieved with dedicated activity monitoring devices in 5 and 7 weeks long neutrino mass measurement campaigns of KATRIN. The influence of the column density uncertainty on the neutrino mass determination is then discussed in light of KATRIN's world-leading direct upper limit on the neutrino mass and the ongoing further data-taking.
This work is supported by the Technical University of Munich, the Max Planck Society, the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), the GRK 1694, and the Helmholtz Young Investigator Group (VH-NG-1055).

T 43.2 Tue 16:15 Tr

Towards a better understanding of KATRIN's global magnetic field for neutrino mass measurements — Jan Behrens and •Fabian Block for the KATRIN-Collaboration — Institute for Astroparticle Physics and Institute of Experimental Particle Physics, Karlsruhe Institute of Technology

The KATRIN experiment aims to determine the effective electron anti-neutrino mass with a sensitivity of 0.2 eV (90% C.L.) by investigating the endpoint region of the tritium decay spectrum. The experimental setup of KATRIN consists of a high-luminosity windowless gaseous tritium source, from which the beta electrons are adiabatically guided in a magnetic flux tube to the spectrometer and detector section, which measures the integrated beta decay spectrum.
The global magnetic field in KATRIN's experimental setup plays a crucial role in the experiment's response function. To avoid a bias on the neutrino mass measurement, the magnetic field needs to be known with high accuracy. We present in this talk techniques to determine the magnetic fields in the source and spectrometer sections in KATRIN. Additionally, the influence of the magnetic field uncertainty on the neutrino mass determination is discussed in light of KATRIN's first neutrino mass results and the on-going further data-taking.
This work is supported by the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), the GRK 1694, and the Helmholtz Young Investigator Group (VH-NG-1055).

T 43.3 Tue 16:30 Tr

KATRIN neutrino mass results from the second science run — Wonqook Choi, Stephanie Hickford, and •Leonard Köllenberger for the KATRIN-Collaboration — Institute for Astroparticle Physics and Institute of Experimental Particle Physics, Karlsruhe Institute of Technology

The KATRIN collaboration aims to determine the neutrino mass with a sensitivity of $0.2\,\mathrm{eV/c^2}$ (90 % CL). This will be achieved by measuring the endpoint region of the tritium β-electron spectrum. The first four-week KATRIN science run was taken in Spring 2019, and yielded a neutrino mass limit of $m_\nu \leq 1.1\,\mathrm{eV}$ 90 % CL).

The second KATRIN science run was taken in Autumn 2019. This measurement data was taken over seven weeks with a substantially higher tritium column density in the source, leading to approximately twice the statistics collected compared to the first KATRIN science run. One of the neutrino mass analyses of this data was performed using the `KASPER` software framework including systematics via free parameters with constraints. This analysis and the neutrino mass results will be presented in this talk.
This work is supported by the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Young Investigator Group (VH-NG-1055).

T 43.4 Tue 16:45 Tr

Precision measurement of the energy loss of e^--T_2 scattering in the source of KATRIN — •Lutz Schimpf for the KATRIN-Collaboration — ETP, Karlsruhe Institute of Technology (KIT)

The **Ka**rlsruhe **Tri**tium **N**eutrino experiment (KATRIN) is targeted to measure the effective neutrino mass $m(\nu_e)$ with a sensitivity of 0.2 eV at 90 % CL. In order to determine the neutrino mass, an integrated β-decay spectrum close to the endpoint is measured and a fit to the data comprising $m(\nu_e)$ as a free parameter is performed. A number of systematic effects on the measured spectrum need to be taken into account in the spectral analysis. One of these is the energy loss of the β-electrons from inelastic scatterings with the source gas. The probability distribution of the energy losses of 18.6 keV electrons scattering off molecular tritium can be determined in-situ with KATRIN by using a pulsed monoenergetic source of photoelectrons, allowing for time-of-flight spectroscopy. The measurement is analysed by fitting a newly developed, semi-empirical energy-loss model to a combined data set of integral and differential spectra. With this measurement and analysis technique, an analytical description of the energy loss function with unprecedented precision is obtained. In this contribution, the latest analysis results will be presented and discussed in the context of the neutrino-mass systematics budget of KATRIN.
This work is supported by the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), and the Helmholtz Alliance for Astroparticle Physics (HAP).

T 43.5 Tue 17:00 Tr

Analysis of New KATRIN Neutrino Mass Data using Monte Carlo Propagation — •Christian Karl[1,2], Susanne Mertens[1,2], and Martin Slezák[1] — [1]Max-Planck-Institut für Physik — [2]Technische Universität München

The KATRIN experiment is designed to measure the effective electron anti-neutrino mass by investigating the energy spectrum of tritium beta-decay. Here we will focus on the second data taking phase which took place in autumn 2019. For this period, the source activity was set to about 84 % of the nominal value and around 4.2 million electrons were collected in the region of interest. This corresponds to an improval of the statistical uncertainty of about a factor of three compared to the first measurement phase published in 2019.

This talk presents one of the analysis strategies pursued which is based upon Monte Carlo propagation of uncertainties. After briefly describing the model and systematics treatment we will present the sensitivity on MC-data and prospectively also our results on the unblinded data set including an updated confidence interval using the sensitivity limit method of Lokhov and Tkachov.

T 43.6 Tue 17:15 Tr

Spectrocopy of Kr-83m Conversion Electron Lines for Plasma Investigations at KATRIN — •Matthias Böttcher — WWU Münster

The Karlsruher Tritium Neutrino Experiment (KATRIN) aims at measuring the effective electron neutrino mass with the unprecedented sensitivity of 0.2 eV by measuring the energy spectrum of tritium β-decay electrons. The non-zero neutrino mass established in oscillation experiments introduces a change of the shape of the electron spectrum near the endpoint energy. The first neutrino mass result published by the KATRIN experiment gives a new upper limit of 1.1 eV (90 % C.L.). To improve on this limit, a detailed analysis of systematic effects in the tritium source and the main spectrometer is required. One of the tools to assess systematic uncertainties in KATRIN is the use of Krypton-83m as a calibration source, which provides mono-energetic conversion electrons. Gaseous ^{83m}Kr can be injected into KATRIN's windowless gaseous tritium source (WGTS), and can be used, among others, to study the effect of inhomogeneities in the tritium plasma. In this talk, the spectroscopy of ^{83m}Kr for investigating plasma inhomogeneities is presented.

This work is supported by BMBF under contract number 05A20PMA.

T 43.7 Tue 17:30 Tr

GNN-based reconstruction of low-energy IceCube events — Martin Ha Minh and •Janus Gurth for the IceCube-Collaboration — Technische Universität München

The IceCube Neutrino Observatory is a cubic kilometer scale neutrino detector embedded in the antarctic ice of the South Pole. So far it has been providing globally competitive results in neutrino oscillation physics, such as constraints on atmospheric oscillation parameters or eV-scale sterile neutrinos.

The sparseness of observed charge in the detector for low-energy events, and the irregular detector geometry, have always been a challenge in reconstructing the detected neutrino's parameters of interest. This problem is exacerbated by the planned IceCube Upgrade, which introduces seven new detector strings with novel detector modules. Doing so will increase the detection rate of low-energy events to further constrain neutrino oscillation physics. Here we introduce a novel reconstruction algorithm based on Graph Neural Networks, which we use to reconstruct neutrino events at speeds magnitudes faster than the traditional algorithms, while providing comparable resolution.

T 43.8 Tue 17:45 Tr

Likelihood-free inference for low-energy reconstruction in IceCube DeepCore — •Jan Weldert[1], Philipp Eller[2], and Sebastian Böser[1] for the IceCube-Collaboration — [1]JGU, Mainz, Germany — [2]TUM, Munich, Germany

DeepCore, the low energy extension of the IceCube neutrino observatory at the geographic South Pole, detects neutrinos at a rate on the order of mHz resulting in unprecedentedly large event samples. Reconstructing the latest generation of these samples ($\sim$300.000 νs) is currently computationally expensive ($\sim$40s per event). In addition, the employed max. LLH method includes simplifications in the photon propagation in ice which limit the reconstruction accuracy but are hard to overcome in the current approach.

Machine learning techniques can solve problems at a tremendous speed. But they also come with disadvantages, e.g. most will just give you a point estimation without any information about the uncertainty. Likelihood-free inference is a possibility to combine the speed of neural networks with a likelihood-based approach, which is very well understood. The main idea is to let a network learn a function proportional to the likelihood, which can then be used for a max. LLH reconstruction. While this is slower than a pure deep learning approach, it offers the possibility to perform likelihood scans for error estimation or test coverage.

In my talk I will present the application of likelihood-free inference to the reconstruction of low-energy events in IceCube-DeepCore. We achieve speed-ups up to a factor of 100 at comparable resolutions.

T 43.9 Tue 18:00 Tr

Search for non-standard neutrino interactions with 8 years of IceCube DeepCore data — •Elisa Lohfink and Sebastian Böser for the IceCube-Collaboration — Institut für Physik, JGU Mainz, Deutschland

Non-standard neutrino interactions (NSI) are well motivated and result in a change of the potential that neutrinos encounter when traversing matter, hence altering their oscillation patterns. This signature can be probed using high-statistics neutrino experiments such as IceCube and its low-energy extension DeepCore which detect atmospheric neutrinos after propagating through matter at baselines up to the Earth diameter. The event selection that this search is based on includes 8 years of IceCube-DeepCore data, containing all neutrino flavors. It reaches from the few-GeV DeepCore energy threshold up to several hundred GeV and constitutes a significant increase in statistics with respect to previous searches. In addition, the treatment of systematic uncertainties, background rejection and event reconstruction have been improved substantially. This sample allows us to probe not only NSI in the μ-τ sector, as is commonly done, but also those involving the electron flavor.

T 43.10 Tue 18:15 Tr

A neutrino oscillation probability package for KM3NeT/ORCA — •Johannes Schumann for the ANTARES-KM3NeT-Erlangen-Collaboration — ECAP, Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, 91058 Erlangen

A crucial part for the prediction of neutrino event rates is the flavour transition probability based on the phenomenon of neutrino oscillations. The computation time of those transition probabilities depends on the oscillation model and the sampled resolution of the propagation path. Thus, neutrino oscillation software is required to implement different oscillation model features at a high level of computational performance. A neutrino oscillation probability package (https://github.com/KM3NeT/Neurthino.jl) using the programming language Julia has been developed for use in the data processing chain of the KM3NeT/ORCA neutrino telescope. The package is based on an n-flavour oscillation model and capable of neutrino propagation through earth. The main features of Neurthino.jl will be outlined and a performance comparison to other commonly used oscillation software packages will be presented.

T 44: Neutrino physics without accelerators V

Time: Tuesday 16:00–18:35 Location: Ts

Group Report T 44.1 Tue 16:00 Ts

Prospects, Design and Status of JUNO — •Hans Steiger on behalf of the JUNO Collaboration — Cluster of Excellence PRISMA+, Johannes Gutenberg University Mainz (JGU), Staudingerweg 9, D-55128 Mainz

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton multi-purpose liquid scintillator detector currently being built in a dedicated underground laboratory in Jiangmen (PR China). Data taking is expected to start in 2021. JUNO's main physics goal is the determination of the neutrino mass ordering using electron anti-neutrinos from two nuclear power plants at a baseline of about 53 km. JUNO aims for an unprecedented energy resolution of 3% at 1 MeV for the central detector, to be able to determine the mass ordering with 3 - 4 σ significance within six years of operation. Besides this fundamental aim, JUNO will have a very rich physics program. It includes the measurement (at a sub-percent level) of the solar neutrino oscillation parameters, the detection of low-energy neutrinos coming from galactic core-collapse supernovae, the first measurement of the diffuse supernova neutrino background, the detection of neutrinos coming from the Sun, the Earth and the Earth's atmosphere. Moreover, JUNO will be sensitive to searches for nucleon decays and neutrinos resulting from dark matter annihilation in the Sun. In this talk JUNO's design, physics prospects as well as the status of its construction will be presented, together with a short excursion into its rich R&D program.

T 44.2 Tue 16:20 Ts

Relative Light Yield Determination for the Future Neutrino Experiments JUNO and THEIA — •David

Dörflinger[1], Lothar Oberauer[1], Hans Steiger[1,2], Raphael Stock[1], Konstantin Schweizer[1], Ulrike Fahrendholz[1], Stefan Schoppmann[3], Ludwig Wallner[1], Matthias Mayer[1], Sebastian Zwickel[1], and Andreas Steiger[1] — [1]Technische Universität München (TUM), Physik-Department, James-Franck-Straße 1, 85748 Garching bei München — [2]Institute of Physics and Excellence Cluster PRISMA+, Johannes Gutenberg-Universität (JGU) Mainz, Staudingerweg 9, 55099 Mainz — [3]University of California, Department of Physics, Berkeley, CA 94720-7300, USA and Lawrence Berkeley National Laboratory, Berkeley, CA 94720-8153, USA

The Jiangmen Underground Neutrino Observatory (JUNO) aims to detect neutrinos using 20 kton of organic liquid scintillator (LS) based on LAB (Linear AlkylBenzene). The THEIA experiment, which is currently being designed, has similar scientific goals but will additionally measure long baseline neutrinos. Therefore, it will take a different approach on the detector design and is expected to use 100 kt of a water based liquid scintillator (WbLS). Still, in order to understand the detector response, a precise knowledge of the used liquid scintillator's light yield is needed. In this talk a way to measure the relative light yield of a given LS sample will be presented. This work is supported by the Bundesministerium für Bildung und Forschung (BMBF) for THEIA (Verbundprojekt 05H2018: R&D Detectors and Scintillators) and the DFG Research Unit JUNO (FOR2319).

T 44.3 Tue 16:35 Ts

Muon veto restriction with Topological Track Reconstruction in JUNO — •David Meyhöfer, Henning Rebber, Malte Stender, and Björn Wonsak — Institut für Experimentalphysik, Universität Hamburg, Germany

The main signal at Jiangmen Underground Neutrino Observatory (JUNO) is the inverse beta decay (IBD) and the muon veto has the largest impact on IBD efficiency. Therefore an improvement of the muon veto strategy can yield more active volume, which in turn will enable more signal in the same time or the same signal in less measurement time. This talk will focus on the reduction of dead volume in JUNO with the restriction of muon vetoes to points of interest along muon tracks. This method is enabled by the reconstruction capabilities of the topological track reconstruction approach, which can determine shower positions along muon tracks.

T 44.4 Tue 16:50 Ts

On the road to THEIA: current status of the Mainz WbLS test cell — •Manuel Böhles, Nils Brast, Daniele Guffanti, Hans Steiger, and Michael Wurm — Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany

The detection of neutrinos using water-based liquid scintillators (WbLS) is a promising method in the field of detector development. Its strength lies in combining high-resolution energy determination with a low energy threshold through the use of scintillation light and in the directional reconstruction with the help of Cherenkov radiation. The spectrum of potential applications is broad, ranging from long-baseline oscillation studies to the measurement of low-energy solar neutrinos. The key point of this new technique is the discrimination between scintillation and Cherenkov photons, which can be achieved by exploiting the different chromatic features, time behaviour and angular emission. In order to characterise this innovative medium and to prove whether scintillation and Cherenkov radiation can be distinguished, our group is building a test cell (15l) equipped with fast photomultipliers that can provide useful insights towards a new generation of detectors. In addition, complementary ultrafast photodetection systems (SiPM array, LAPPD) can be investigated in future studies. This work is supported by the BMBF Verbundprojekt 05H2018: R&D Detectors and Scintillators.

T 44.5 Tue 17:05 Ts

Application of the Topological Track Reconstruction to an idealised water-based liquid scintillator detector as study for Theia — Caren Hagner, David Meyhöfer, Henning Rebber, •Malte Stender, and Björn Wonsak — Universität Hamburg, Institut für Experimentalphysik

The Topological Track Reconstruction (TTR) was developed for unsegmented liquid scintillator detectors like JUNO and performs well in reconstructing track and point-like events in pure liquid scintillator. A next step is the application of the TTR to water-Cherenkov detectors like ANNIE and, in view of Theia, also to water-based liquid scintillator to exploit the advantages of both scintillation and Cherenkov light. Scintillation yields a high number of photons for determining the dE/dx, whereas Cherenkov light gives a handle for the particle identification via its event signature and a more precise event topology due to better time information. Furthermore, a high potential lies in the usage of newly developed photodetectors to max out the reconstruction's performance. The Large Area Picosecond Photodetectors (LAPPDs) feature a good spatial resolution of $\sim 1\,\mathrm{mm}$ and an excellent time resolution of $\sim 0.1\,\mathrm{ns}$ compared to the few nanoseconds PMTs typically achieve.
This contribution introduces the basic principles of the TTR and the application of the TTR to an idealised detector, which features a maximum coverage with LAPPDs and an active volume of water-based liquid scintillator. Therefore, also the detector simulation and the first results of the TTR are shown. This work is supported by the BMBF.

T 44.6 Tue 17:20 Ts

Implications of a fine structure in the reactor neutrino spectrum for JUNO — David Blum, Lukas Bieger, Marc Breisch, Jessica Eck, •Tobias Heinz, Benedict Kaiser, Frieder Kohler, Tobias Lachenmaier, Axel Müller, Tobias Sterr, Alexander Tietzsch, and Jan Züfle — Physikalisches Institut, Eberhard Karls Universität Tübingen

With the main goal to determine the neutrino mass hierarchy, the Jiangmen Underground Neutrino Observatory (JUNO) is currently constructed in the Guangdong province in southern China. To determine which mass hierarchy is realized in nature, JUNO measures the reactor neutrino spectrum from two nuclear power plants located in a distance of around 53 km. One crucial aspect is the precise knowledge of the emitted reactor neutrino spectrum. In the last years, new predictions of the spectrum revealed the possible existence of a spectral fine structure which can only be observed with the unprecedented energy resolution the JUNO detector will have. This talk will present studies on possible implications of the fine structure in the reactor neutrino spectrum for the sensitivity of the mass hierarchy determination with JUNO. This work is supported by the Deutsche Forschungsgemeinschaft.

T 44.7 Tue 17:35 Ts

Results from and Prospects for the PMT Mass Testing Container System for JUNO — •Alexander Tietzsch[1], Lukas Bieger[1], David Blum[1], Marc Breisch[1], Jessica Eck[1], Caren Hagner[2], Tobias Heinz[1], Benedict Kaiser[1], Frieder Kohler[1], Tobias Lachenmaier[1], David Meyhöfer[2], Axel Müller[1], Henning Rebber[2], Tobias Sterr[1], Björn Wonsak[2], and Jan Züfle[1] — [1]Physikalisches Institut, Eberhard Karls Universität Tübingen — [2]Institut für Experimentalphysik, Universität Hamburg

The Jiangmen Underground Neutrino Observatory (JUNO) experiment will be a new neutrino oscillation experiment, which is currently under construction and starting in the next years, with main goal of determining the neutrino mass ordering from the oscillation pattern. Therefore a high energy resolution of 3% @ 1 MeV is required, for whose realization up to 20'000 20-inch photomultiplier tubes (PMTs) will be used in JUNO. All of these PMTs have to fulfil dedicated quality requirements for several key characteristics (dark rate, PDE, peak-to-valley ratio etc.) for which a PMT mass testing facility using commercial shipping containers has been developed. This PMT testing container system is running successfully for more than 3 years now and all 20'000 PMTs have been tested and characterized at least once. In this talk we report about the progress in PMT testing, show selected results on the PMT performance and accuracies of the testing facility and will discuss prospects for the container system and the ongoing PMT characterization campaign for JUNO. This work is supported by the Deutsche Forschungsgemeinschaft.

T 44.8 Tue 17:50 Ts

JUNO's sensitivity for indirect dark matter search — •David Blum, Lukas Bieger, Marc Breisch, Jessica Eck, Tobias Heinz, Benedict Kaiser, Frieder Kohler, Tobias Lachenmaier, Axel Müller, Tobias Sterr, Alexander Tietzsch, and Jan Züfle — Eberhard Karls Universität Tübingen

The Jiangmen Underground Neutrino Observatory (JUNO) is a multipurpose 20 kton liquid scintillator neutrino detector currently under construction in southern China. Due to the size and the excellent energy resolution (3% @ 1 MeV) of the detector, JUNO is sensitive to a potential neutrino flux produced by dark matter self-annihilation in the Milky Way. The expected neutrino signals from dark matter self-annihilation and the relevant backgrounds in the energy range from

10 MeV to 100 MeV are investigated. Moreover, effective background suppression is realized by a detailed pulse shape discrimination analysis. Results of a sensitivity study on the dark matter self-annihilation cross section based on a Bayesian analysis are presented in this talk. This work is supported by the Deutsche Forschungsgemeinschaft.

T 44.9 Tue 18:05 Ts

Reconstruction of the atmospheric neutrinos energy spectrum with JUNO — •Giulio Settanta[1], Alexandre Göttel[1,2], Philipp Kampmann[1], Runxuan Liu[1,2], Livia Ludhova[1,2], Luca Pelicci[1,2], Mariam Rifai[1,2], and Cornelius Vollbrecht[1,2] for the JUNO-Collaboration — [1]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

The atmospheric neutrino flux represents a continuous source that can be exploited to infer properties about Cosmic Rays and neutrino oscillation physics. The JUNO observatory, a 20 kt liquid scintillator (LS) currently under construction in China, will be able to detect the atmospheric flux, given the large fiducial volume and the excellent energy resolution. In this work, potential JUNO measurements in the field of atmospheric neutrinos are evaluated. A sample of Monte Carlo events has been generated from theoretical models of the atmospheric neutrino flux, through the Genie software. The events have been processed by a full Geant4- based simulation, which propagates all the particles and the light inside the detector. The different time evolution of light on the PMTs allows to discriminate the flavor of the primary neutrinos. A probabilistic unfolding method has been used, in order to infer the primary neutrino energy spectrum by looking at the detector output. Thanks to the LS low energy threshold and resolution, JUNO will be particularly sensitive in the range (100-1000) MeV, where neutrino-induced events can be fully contained within the instrumented volume.

T 44.10 Tue 18:20 Ts

Measuring the Fluorescence Time Profile of the JUNO Scintillator with Gamma and Neutron Excitation — •Matthias Raphael Stock[1], Hans Th. J. Steiger[1,2], Lothar Oberauer[1], David Dörflinger[1], Ulrike Fahrendholz[1], Konstantin Schweizer[1], Andreas Steiger[1], and Ludwig Wallner[1] — [1]Physik-Department, Technische Universität München (TUM), James-Franck-Straße 1, 85748 Garching bei München — [2]Cluster of Excellence PRISMA+, Johannes Gutenberg University Mainz (JGU), Staudingerweg 9, D-55128 Mainz

Major science goals of the Jiangmen Underground Neutrino Observatory (JUNO) in China are the determination of the neutrino mass ordering and precise measurements of the oscillation parameters as well as the search for proton decay and the detection of the diffuse supernova neutrino background. THEIA is a planned 100 kt detector using a water-based liquid scintillator (WbLS) and has a broad science program, e.g., investigating long-baseline neutrino physics. Therefore, we evaluate the pulse shape discrimination performance of liquid scintillators (LSs) using excitation by gamma radiation inducing recoil electrons as well as a pulsed neutron beam inducing recoil protons. We developed an experimental setup to characterize the time distribution of light emission for different and novel LS mixtures. We present the fluorescence time profiles of the JUNO LS, obtained during two beam times at the Maier-Leibnitz-Laboratorium. This work is supported by the DFG Research Unit "JUNO"(FOR 2319) and by the BMBF (Verbundprojekt 05H2018: R&D Detectors and Scintillators).

T 45: Searches for Dark Matter I

Time: Tuesday 16:00–18:30 Location: Tt

T 45.1 Tue 16:00 Tt

Sub-GeV WIMP search with a SuperCDMS R&D device — •Alexander Zaytsev, Lea Burmeister, Hanno Meyer zu Theenhausen, Fatema Thasrawala, Matthew Willson, and Belina von Krosigk — Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

The SuperCDMS experiment is an underground cryogenic direct dark matter search experiment with a potential to discover WIMPs or alternative light dark matter candidates. During the SuperCDMS R&D program, a surface run with a gram-scale silicon detector was performed. Offline optimal filter triggering applied to these data allowed for an extremely low analysis threshold of 9.2 eV, opening the possibility to probe new parameter space in the low-mass region. We present preliminary results for the dark matter nuclear recoil exclusion limit obtained with the data collected during this run.

T 45.2 Tue 16:15 Tt

Charakterisierung von SuperCDMS Hintergrund Spektren in HVeV-Detektor Daten — •Lea Burmeister, Hanno Meyer zu Theenhausen, Fatema Thasrawala, Matthew Wilson, Alexander Zaytsev und Belina von Krosigk — Universität Hamburg

SuperCDMS ist ein Experiment zur direkten Suche nach dunkler Materie. Ziel ist es die Interaktion zwischen dunkler Materie, z. B. WIMPs, und Silizium- oder Germanium-Detektoren bei ca. 15mK nachzuweisen. Vorbereitend werden R&D-Detektoren genutzt, bestehend aus 0.93g Silizium. Mögliche Ereignisse werden als Phononensignal detektiert, welches durch den Neganov-Luke-Effekt verstärkt wird. Mit einem dieser R&D-Detektoren wurden Daten sowohl an der Erdoberfläche als auch 100m unter der Erde genommen. In diesem Vortrag geht es um die Charakterisierung und den Vergleich der Hintergrundspektren ober- und unterhalb der Erdoberfläche.

T 45.3 Tue 16:30 Tt

Na-22 source study in the SuperCDMS experiment — •Fatema Khozema Thasrawala, Alexander Zaytsev, Hanno Meyer zu Theenhausen, Lea Burmeister, Matthew Wilson, and Belina Von Krosigk — University of Hamburg

The SuperCDMS experiment focuses on searching for WIMPs and light dark matter particles. SuperCDMS detectors are designed with the primary function of detecting the minute crystal lattice vibrations (phonons) and ionization (charge) generated within the crystal by low-mass dark matter particles and elastic collisions between crystal nuclei or electrons. An applied bias voltage across the detector amplifies event signals and allows for low-energy collisions to be measured. An analysis is underway to investigate the effects a radioactive source has on the events observed. One of the sources studied was sodium-22 with an activity of 4.6uCi which was placed near the detector. We present preliminary results about this study performed using the radioactive source at various bias voltages applied to the detector.

T 45.4 Tue 16:45 Tt

Investigation of coating methods for radon background reduction in liquid xenon experiments — •Mona Piotter, Hardy Simgen, and Florian Jörg for the XENON-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg

Several cosmological and astrophysical observations hint that a large fraction of the energy density of today's universe is present in the form of non-luminous matter. One candidate for this so-called dark matter is the WIMP (weakly interacting massive particle). Liquid xenon detectors are being used to search for their rare interactions with baryonic matter for which a very low background is necessary. The biggest source of background in these experiments originates from radon. To reduce this background, studies are carried out to examine the radon mitigation properties of surface coatings applied by electrodeposition. Previous investigations already showed that electrodeposited copper layers can offer a significant reduction in radon emanation. The various parameters of this coating method have now been systematically analyzed, with the focus being placed on the surface current density. The results of these investigations will be discussed during the talk.

T 45.5 Tue 17:00 Tt

XENONnT Rn222 budget — •Joaquim Palacio Navarro for the XENON-Collaboration — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117, Heidelberg, Germany

XENONnt operates a 5.9 ton liquid xenon (LXe) Time Projection Chamber (TPC) to probe WIMP cross sections down to $1.5{\cdot}10^{-48}\mathrm{cm}^2$ at 90% confidence level for a 50 GeV particle. Such a low background experiment can only be achieved by the combination of shielding from external radiation plus mitigation of the effects from internal detector

materials. Among the dominant contributions is emanation of ^{222}Rn, produced by the decay of residual ^{226}Ra present in nearly all materials. Once released, ^{222}Rn may reach the LXe target, inducing low-energetic background events within the sensitive volume. Long-lived daughters ^{222}Rn, can end up located at TPC walls and, due to partial signal lost, can mimic a typical WIMP signal.

Direct ^{222}Rn emanation measurements are hence, very important to prevent higher emanating materials to end up being, directly or indirectly, in contact with the LXe. Even more, a deep understanding of the location from the different ^{222}Rn sources within the system is crucial to define potential mitigation strategies during operation. Through very low-background techniques and the usage of alpha detectors, as proportional counters or radon monitors, we are sensitive to the different alphas produced through the decay chain of emanated ^{222}Rn. In this talk I show the most up-to-date XENONnT ^{222}Rn mapping and present preliminary results on the achieved radon concentration in LXe.

T 45.6 Tue 17:15 Tt

Strax and Straxen: Streaming analysis for xenon experiments — •Daniel Wenz for the XENON-Collaboration — Institut für Physik & Exzellenzcluster PRISMA, J. Gutenberg-Universität Mainz, 55099 Mainz, Germany

Over the last decades noble liquid time projection chambers (TPCs) have become one of the forefront technologies for the search in WIMP dark matter. As the detector increases in size, so do the amount of data and data-rates, leading to higher demands on the analysis software. The "streaming analysis for xenon experiments" (strax) is a software package used by the XENON collaboration. It provides a framework for signal processing, data storage and reduction as well as corrections handling for noble liquid TPCs. The software is written in Python and relies heavily on the SciPy-stack. The data itself is organized in a tabular format utilizing a combination of numpy structured arrays and numba for high performances. This approach allows live online processing of the data with throughputs of 60 MB raw / sec / core. Strax is an open source project and is used by a couple of smaller liquid xenon TPCs such as XAMS and XEBRA. It is also test by the nEXO Experiment for their MC simulations. In this talk we will explain the working principle and infrastructure provided by strax. We will show how a complex processing streamline can be build up via so called strax plugins based on XENON-collaborations open source package called straxen.

T 45.7 Tue 17:30 Tt

Update on the XENONnT Gd-loaded water Cherenkov neutron veto — •Daniel Wenz for the XENON-Collaboration — Institut für Physik & Exzellenzcluster PRISMA, J. Gutenberg-Universität Mainz, 55099 Mainz, Germany

For several years, the XENON1T experiment has been the most sensitive Dark Matter experiment for WIMP-nucleon coupling at masses above 6 GeV/c2. Following this success, an upgraded experiment XENONnT with a larger and more sensitive liquid xenon time projection chamber has been constructed and is currently being commissioned at the Laboratori Nazionali del Gran Sasso in Italy. The new experiment aims at a sensitivity improvement of more than one order of magnitude. To achieve this ambitious goal, the intrinsic neutron background of the detector must be reduced as well. Neutrons are capable of mimicking a WIMP signal by undergoing single-scatter nuclear recoils, escaping the sensitive volume without interacting a second time. To suppress this background, XENONnT will be equipped with a neutron veto system based on the novel principle of a gadolinium-loaded water Cherenkov detector, as has been developed for the Sk-Gd upgrade of the Super-Kamiokande experiment. The predicted neutron tagging efficiency for the XENONnT system reaches 84%, sufficient to render the remaining neutron background insignificant. In this talk we present an overview of the neutron veto system as well as its commissioning status.

T 45.8 Tue 17:45 Tt

A 4 cylinder radon-free magnetically coupled piston pump for the XENONnT experiment — •Philipp Schulte, Denny Schulte, Christian Huhmann, Michael Murra, and Christian Weinheimer for the XENON-Collaboration — Institut für Kernphysik WWU, Münster, Germany

Since commercially available pumps often exhibit electronegative contamination from lubricants on internal components and cannot meet the requirements on radiopurity of low background noble gas experiments especially w.r.t. radon emanation, a special type of pump has been developed for the XENON1T dark matter project (E. Brown et al., EPJ C78 (2018) 604). The design uses a magnetic piston in a hermically sealed cylinder that is magnetically coupled to an outer set of permanent magnets, which are moved up and down. All materials, essentially stainless steel, copper and special high density plastic for the inner pistion sealings are selected for low radioactivity.

In order to further increase the performance for the usage in the high flux radon removal system of the subsequent XENONnT, the design was extended to a four cylinder magnetically coupled piston pump being used as compressors for a kind of heat pump. Moreover, these four-pump were synchronized in operation to a phase shifted movement such that fluctuations in pressure and flow are reduced to a minimum.

This talk is about the design of this type of pump, as well as the optimization and synchronization of the pump extension.

The project is funded by BMBF under contract 05A17PM2 and 05A20PM1.

T 45.9 Tue 18:00 Tt

The ultra-low energy calibration based on a diluted ^{37}Ar source at the XENON experiment — •Matteo Alfonsi for the XENON-Collaboration — Institut für Physik & Exzellenzcluster PRISMA+, JGU Mainz, 55099 Mainz, Germany

The XENONnT experiment for direct Dark Matter detection is currently under commissioning. It is the upgrade of the XENON1T experiment and more than 20 times better sensitivity is expected from the three times larger target mass and the six times smaller background. The calibration of the detector response for ton-scale xenon Time Projection Chambers relies mostly on the dilution of gaseous radioisotopes such as ^{83m}Kr and ^{220}Rn into the liquid xenon. A novel calibration possibility based on the injection of the gaseous ^{37}Ar isotope and the subsequent active removal by cryogenic distillation has been demonstrated at the end of the XENON1T operation. This radioactive source has been produced with high purity by neutron capture in the TRIGA research reactor in Mainz, and its decay by electron capture (causing an X-ray and Auger electrons cascade) provided two unprecedented ultra-low energy calibration lines at 2.8 keV and 270 eV, which were crucial to validate the detector response model for several XENON1T results. Due to the relatively long decay time of the ^{37}Ar, 35.0 days, the proof of the cryogenic distillation active removal method has been the key for the consideration of this technique during the XENONnT operation.

This talk reports the results of the XENON1T calibration test and describe the new ^{37}Ar injection system installed in XENONnT.

T 45.10 Tue 18:15 Tt

A cage for Dark Matter: XENONnT electric field design — •Francesco Toschi — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

The XENONnT experiment is the next phase of the XENON project and aims at the direct detection of dark matter via WIMP-nucleus scattering. Its dual-phase Time Projection Chamber (TPC) filled with 5.9 ton of liquid Xenon allows position reconstruction and interaction-type discrimination, necessary for WIMP detection. The applied electric field plays a crucial role in its detection capabilities: uniformity in the drift field means homogeneous response in the full active volume, while high intensity fields in the liquid-gas interface are needed for electron extraction and proportional signal production. Numerical simulations are important both to optimize the design of the detector and to have a better understanding of the expected signals.

This talk will focus on the field shaping elements of the TPC and how the electric field simulations drove their design.

T 46: Cosmic Rays II

Time: Tuesday 16:00–18:30 Location: Tu

T 46.1 Tue 16:00 Tu

Composition Measurements with AugerPrime using Deep Learning* — Sonja Schröder and •Julian Rautenberg for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal, Germany

The AugerPrime upgrade of the Pierre Auger Observatory in Argentina will enhance the precision of primary particle composition measurements made by the Surface Detector. This will be achieved using the different response of the Water Cherenkov Detector (WCD) and the Surface Scintillator Detector (SSD) to the electromagnetic and muonic component of the extensive air shower.
With the deployment of AugerPrime ongoing, the cosmic ray composition sensitivity of the upgrade can already be probed using simulations and modern machine learning techniques. In this presentation, a Deep Learning approach is shown to be able to reconstruct the depth of shower maximum, X_{max}, a mass sensitive observable, on an event-by-event basis. For this, a combination of deep convolutional neural networks is used to process information simultaneously from both WCD and SSD signals, obtained from full AugerPrime detector simulations using a mixed composition of protons, helium, oxygen, and iron. The increase in sensitivity gained through the addition of the SSD, as well as the end estimated mass bias and resolution will be presented.
**Supported by the BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A17PX1).*

T 46.2 Tue 16:15 Tu

Towards the Determination of the UHECR Composition using Deep Learning and the Surface Detector of the Pierre Auger Observatory — Martin Erdmann, •Jonas Glombitza, Berenika Idaszek, and Niklas Langner — III. Physikalisches Institut A, RWTH Aachen University

Ultra-high energy cosmic rays (UHECRs) are the most energetic particles found in nature. When propagating within the Earth's atmosphere, they induce extensive air showers which can be measured by cosmic-ray observatories. The Pierre Auger Observatory features a surface detector (SD) which is overlooked by 27 fluorescence telescopes. The reconstruction of event-by-event information sensitive to the cosmic-ray mass is a challenging task and so far, mainly based on fluorescence observations with a duty cycle of about 15%.

Recently, deep learning-based algorithms have shown to be extraordinary successful across many domains. Applying these algorithms to surface-detector data allows for an event-by-event estimation of the cosmic-ray mass, exploiting the 100% duty cycle of the SD [1].

In this contribution we present a deep neural network, designed to exploit the symmetries of the SD and suited to the real operation-conditions at the Pierre Auger Observatory. We evaluate the performance of the method and introduce a calibration of the algorithm using Auger hybrid data. Finally, we estimate the expected accuracy of the method to determine the UHECR composition at the highest energies with unprecedented statistics.

[1] arXiv:2101/02946

T 46.3 Tue 16:30 Tu

Paving the way to an event-by-event level estimation of the masses of UHECRs with AugerPrime and Air Shower Universality — •Max Stadelmaier, Markus Roth, Darko Veberic, and David Schmidt for the Pierre Auger-Collaboration — Institut für Astroteilchnphysik KIT, Karlsurhe, Germany

Reconstructing the primary masses of ultra high-energetic cosmic rays (UHECRs) on event level can give insight into a manifold of open questions in astrophysics, for instance identifying individual sources or source regions. A reconstruction based on Air Shower Universality allows the determination of the relative muon content, R_μ, and the atmospheric depth of the shower maximum, X_{max}, of an extensive air shower with data collected only from a surface detector. Both these observables can be linked to the mass of the cosmic ray. The upgraded surface detector of the Pierre Auger Observatory, *AugerPrime*, will allow an accurate reconstruction of these mass sensitive observables on an event level. We present the principles of Air Shower Universality as well as first results based on simulations to reconstruct the relative muon content of extensive air showers produced by ultra high-energetic cosmic rays using AugerPrime.

T 46.4 Tue 16:45 Tu

Determination of the muon deficit in air shower simulations using SD-AERA hybrid events detected with the Pierre Auger Observatory* — •Marvin Gottowik and Julian Rautenberg for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal

The number of muons in extensive air showers is underpredicted by all current generation hadronic interaction models. For the first time, this muon deficit is determined using hybrid events that have been detected with the Auger Engineering Radio Array (AERA) and the Surface Detector (SD) of the Pierre Auger Observatory. Using a subset of 31 high quality events with primary energies between 6 EeV and 20 EeV and zenith angles between 60° and 80°, that have been detected in more than 6 years of operation, a muon deficit of up to 40 % is found assuming a pure proton composition. Assuming a mixed composition of protons and iron reduces the deficit to about 15 %. The analysis is limited by low statistics due to the small area of AERA of only 17 km^2 and by the high energy threshold originating from the SD reconstruction. Statistics will be increased by the Radio Upgrade of Auger which will measure thousands of events with energies up to 100 EeV. This will allow for the study of the mean number of muons, as well as their intrinsic spread, with vastly increased statistics and allowing for in-depth tests of hadronic interactions at energies much higher than those accessible with current accelerators.
**Supported by the BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A17PX1/05A20PX1)*

T 46.5 Tue 17:00 Tu

Analysis of photon-like air showers measured by the Pierre Auger Observatory — •Jannis Pawlowsky for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal

The Pierre Auger Observatory is the largest experiment measuring ultra high energy cosmic rays. It has sensitivity to the primary particle type from the differences in the way showers develop. This leads to the Pierre Auger Observatory presently being the most sensitive detector for photons and neutrinos at energies above the EeV range. For the search of photons, the 12 years of the Surface Detector data was used. The detectors are able to discriminate the electromagnetic and hadronic shower component by the shape of the measured time traces and by the lateral particle density distribution of the air shower. These observables are combined in a principal component analysis (PCA) resulting in a photon-like parameter. In this, the distributions for hadrons and photons are well separated. Photon candidates have been selected by applying a PCA threshold corresponding to a 50% photon detection efficiency. Applied to the full dataset, 13 candidates in the tail of the data-distribution were found.
To test a hadron hypothesis, events with highly energetic π^0 secondaries have been simulated and analysed. Results for the characterization of these photon-like hadronic showers and the probability to be misinterpreted as photon candidates are presented.
**Supported by the BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A17PX1/05A20PX1).*

T 46.6 Tue 17:15 Tu

Search for ultra-high energy photons with the AugerPrime upgrade of the Pierre Auger Observatory — •Paulo Ferreira, Thomas Bretz, and Thomas Hebbeker for the Pierre Auger-Collaboration — III. Physikalisches Institut A, RWTH Aachen University

The Pierre Auger Observatory, the world's largest experiment for the detection of ultra-high energy cosmic rays, consists of an array of 1660 water Cherenkov detectors and 27 fluorescence telescopes, allowing for a hybrid reconstruction of air showers. An air shower detected by the observatory can have its origin in nuclei, but also in very energetic photons. Analyzing the photon flux is crucial to understand the flux suppression of cosmic rays above 50 EeV. No photon-induced air shower has yet been detected by the Pierre Auger Collaboration. While recent studies allowed for better upper limits for the photon flux at ultra-high energies, they are constrained by the current discrimination power between different types of primary particles. AugerPrime, an on-going upgrade of the Pierre Auger Observatory, brings, among

other improvements, an additional scintillator detector to be installed on top of each water Cherenkov detector station. Since the scintillator's signals are mostly dominated by the electromagnetic part of the shower and the water Cherenkov detectors by the muonic one, their combination offers a better characterization of the shower. Through this, new variables which increase the sensitivity to primary photons are aimed at. As such, a new analysis strategy exploiting the additional information obtained using AugerPrime has been developed.

T 46.7 Tue 17:30 Tu

Testing the Pierre Auger Observatory Starburst Galaxy and Active Galactic Nuclei Correlation Result with CRpropa Simulations — •Wilson Namasaka for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal, Germany.

Intermediate scale anisotropies in the distribution of UHECR arrival directions can be associated with two prominent classes of extragalactic gamma-ray sources detected by Fermi-LAT. In the most recent study, a correlation between the arrival directions of cosmic rays at energies above 38 EeV for starburst galaxies (SBG) and above 39 EeV for active galactic nuclei (AGN) was reported by the Pierre Auger Collaboration with a significance against isotropy at 4.5σ and 3.1σ, respectively. In the study, the observed gamma ray luminosity was used as a proxy for cosmic ray luminosity. The cosmic ray excess models for these sources used an angular smearing parameter to fit the observed arrival direction distribution in an optimization scan. The goal of this research is to investigate the viability of this angular smearing using CRPropa simulation and test whether the results of the Pierre Auger Observatory can be reproduced by the deflections expected due to galactic and extragalactic magnetic fields. For this test, the five strongest gamma-ray sources in both the Fermi-LAT AGN and SBG catalogs have been selected based on flux weight. Simulations of these sources including extragalactic and galactic magnetic fields are hereby discussed. The preliminary angular smearing found in these simulations are presented. *Supported by the DAAD Ref No. 91653888.

T 46.8 Tue 17:45 Tu

Fitting a model of the ultra-high-energy cosmic ray universe — •Teresa Bister, Martin Erdmann, Josina Schulte, and Marcus Wirtz for the Pierre Auger-Collaboration — III. Physikalisches Institut A, RWTH Aachen University

The Pierre Auger Collaboration performed a fit of the measured energy spectrum and shower depth distribution, using an astrophysical model of a homogeneous source distribution. Later, measurements showed that the arrival directions of ultra-high-energy cosmic rays are in better agreement with the positions and fluxes of catalogs of starburst galaxies and active galactic nuclei compared to isotropy.

Here, a combination of both analyses is presented, utilizing all three complementary measurements simultaneously. For that, a three-dimensional universe model containing a nearby source population as well as a homogeneous background is built and its parameters are adapted with a combined fit of energy spectrum, shower depth distribution and arrival directions using an MCMC method. A rigidity dependent symmetric magnetic field smearing is used and its size is adapted by the fit along with the magnitude of the anisotropic fraction induced by propagation effects. Additionally, the element fractions and spectral parameters of the cosmic ray sources are fitted. We use CRPropa3 to simulate data resembling measurements of the Pierre Auger Observatory to show that the fit is able to determine the correct best-fit parameters. Additionally, we use a likelihood ratio to demonstrate the method's ability to significantly discriminate between the catalogs of starburst galaxies and active galactic nuclei.

T 46.9 Tue 18:00 Tu

Studies of Lorentz Violation using Air Shower Data — •Fabian Duenkel, Marcus Niechciol und Markus Risse — Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen

Due to their extremely high energies, cosmic rays are ideally suited to search for new physics, for example violations of Lorentz invariance. Isotropic, nonbirefringent Lorentz violation is considered in the following, specializing to the case of a photon velocity which is larger than the maximum attainable velocity of standard Dirac fermions. Earth-based bounds on this type of Lorentz violation have been determined before by observations of TeV gamma rays. The approach to test Lorentz invariance presented here is based on the measurement of extensive air showers induced by cosmic-ray particles in the Earth's atmosphere. Lorentz-violating processes can have a large impact on the longitudinal shower development of air showers, for example reducing the average atmospheric depth of the shower maximum Xmax. For showers with high primary energies, this change is significantly larger than the average resolution of current air-shower experiments. This can be used to obtain new bounds on this type of Lorentz violation, which can be further improved by taking into account further shower observables.

This work is supported by the Deutsche Forschungsgemeinschaft (DFG).

T 46.10 Tue 18:15 Tu

A Simulation study of the performance of the AugerPrime Radio Detector — •Felix Schlüter for the Pierre Auger-Collaboration — Institut für Astroteilchenphysik, Karlsruhe, Deutschland

The AugerPrime Radio Detector will pioneer the detection of ultra-high energy cosmic rays with energies of up to 10^{20} eV with the aid of the world's largest, 3000 km^2 array of radio antennas. The detection of highly inclined air showers with radio antennas in coincidence with the Auger water-Cherenkov detector array provides highly complementary information yielding a strong sensitivity to the mass of the primary cosmic rays. Measuring the mass of cosmic rays at the highest energies is the key challenge in the quest after their origin. I will present first results of an end-to-end simulation study of the performance of the Auger Radio Detector. The study features a newly developed reconstruction model for the radio-emission induced footprint of inclined air showers. Based on the achieved performance, the potential to discriminate between proton and iron primaries will be presented.

T 47: Experimental techniques in astroparticle physics II

Time: Tuesday 16:00–18:30 Location: Tv

T 47.1 Tue 16:00 Tv

Studies on the hole ice characterization with mDOM LED flashers in IceCube Upgrade — •Cristian Jesús Lozano Mariscal and Alexander Kappes for the IceCube-Collaboration — Institut für Kernphysik, WWU Münster

For the upgrade of the IceCube neutrino telescope seven additional strings equipped with new optical modules will be installed in the center of DeepCore, the current low energy extension of the detector. The upgrade is not only aimed at extending IceCube's capabilities to detect low-energy neutrinos, but also to improve the current calibration of the existing IceCube detector by installing new calibration equipment. One such device consists of up to twelve LEDs which are built into the optical sensors and generate nanoseconds-long flashes of light. One goal is to characterize the dust column that forms when the hole ice refreezes after the module is deployed, which is currently one of the largest sources of systematic uncertainty in IceCube. The talk presents initial studies on the dust column characterization using the LEDs in the mDOM module, one of the major optical sensors of IceCube Upgrade.

T 47.2 Tue 16:15 Tv

Geant4 studies on the impact of the harness on the sensitivity of the mDOM — •Moritz Schlechtriem, Alexander Kappes, and Lew Classen for the IceCube-Collaboration — Institut für Kernphysik, WWU Münster, Münster

The IceCube neutrino telescope at the South Pole uses optical sensors to detect Cherenkov radiation emitted by charged secondary particles produced in neutrino interactions. For a precise reconstruction of the neutrino properties, a detailed characterization of the detector performance is mandatory. With seven additional closely spaced strings, the IceCube Upgrade will not only significantly enhance IceCube's capabilities at low energies but also improve the calibration of the detector at all energies. More than half of its sensors will be multi-PMT Dig-

ital Optical Modules (mDOMs). The mDOM features a more than doubled effective photosensitive area compared to the sensors in the current detector as well as intrinsic directional sensitivity and nearly isotropic acceptance. In this paper, the impact of the mDOM harness on the photon sensitivity of the module is investigated using a detailed Geant4 simulation of the module.

T 47.3 Tue 16:30 Tv

The wavelength-shifting optical module (WOM) - first prototype — •Sebastian Böser for the IceCube-Collaboration — PRISMA+ / Institut für Physik, Johannes Gutenberg-Universität, Staudinger Weg 7, 55099 Mainz

The sensitivity and energy threshold of neutrino telescopes is mainly driven by the deployed photocathode area. The wavelength-shifting optical module (WOM) uses a novel approach to enhance the photon collection area while keeping the noise rate constant. Combining wavelength-shifting and light-guiding techniques, abundantly generated UV photons in the Cherenkov process are converted in a coated tube and guided to conventional PMTs at the ends. With a conversion efficiency of close to 100%, the efficiency is dominated by absorption and scattering processes in propagation. On quartz tubes with 55mm diameter photon collection efficiencies of 40% can be achieved over length larger than 60cm length.

I will report on the design and performance of a first prototype that was developed in the context of the STRAWb mission to explore the Cascadian basin as a neutrino telescope site. First in-situ results from the prototype deployed at a depth of 2539m will be presented.

T 47.4 Tue 16:45 Tv

Optimization and decision-making for the outer pressure vessel of the IceCube-Upgrade WOM — •Nick Jannis Schmeisser for the IceCube-Collaboration — Bergische Universität Wuppertal (BUW), FK 4 - Astroparticle Physics, Gaußstr. 20, 42119 Wuppertal

In 2023/24 the IceCube Neutrino Observatory is going to be enhanced by the IceCube Upgrade. Therefore over 700 new photosensors are planned to be deployed in addition to the old IceCube detector. This deployment will contain the Wavelength-shifting Optical Module (WOM) among other sensors. The WOM's goal is to achieve a large photosensitive area combined with an improved signal to noise ratio and UV-sensitivity via wavelength shifting and light guiding techniques. A combination of wavelength-shifting dies allows to effectively capture photons below 400nm that are abundantly generated in the Cherenkov process and reemit them close to the peak sensitivity of PMTs at 450nm. The lower edge of the sensitivity is typically given by the housing of the module. To reach this goal the pressure vessel of the WOM needs to fulfill different requirements for example to ensure most of the photons hitting the sensitive area get detected. Also the pressure resistance needs to be taken into account so that the WOM resists the pressure inside the ice. This presentation discusses these key points in the development of the pressure vessel. Especially the decision-making on which glass to use while considering the transmission in the critical sensitive area between 250 nm and 400 nm is going to be presented.

T 47.5 Tue 17:00 Tv

Performance of the IceAct Imaging Air Cherenkov Telescopes at the South Pole — •Franziska Maria Tischbein[1], Thomas Bretz[2], Giang Do[2], Frank Maslowski[2], Yuriy Popovych[1], Florian Rehbein[2], Merlin Schaufel[1], and Christopher Wiebusch[1] for the IceCube-Collaboration — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]RWTH Aachen University - Physics Institute III A, Aachen, Germany

IceAct telescopes are compact Imaging Air Cherenkov Telescopes (IACTs) that are used to observe cosmic-ray showers in coincidence with the IceCube Neutrino Observatory. With a hybrid observation it is possible to calibrate the surface and in-ice components of IceCube. Furthermore, the primary particle identification of IceTop can be improved and potentially a veto for atmospheric neutrinos in IceCube can be provided. In January 2019, two new IceAct telescopes, with different camera and DAQ design, were installed at a distance of 220m close to the center of the IceTop surface array. This talk will present the different steps to understand the data and compare the performances of the telescopes in this configuration.

T 47.6 Tue 17:15 Tv

IceAct Project status - SiPM based Imaging Air-Cherenkov Telescopes for IceCube — •Merlin Schaufel[2], Thomas Bretz[1], Giang Do[1], Frank Maslowski[1], Yuriy Popovych[2], Florian Rehbein[1], Jonas Reimann[2], Franziska Tischbein[2], and Christopher Wiebusch[2] for the IceCube-Collaboration — [1]RWTH Aachen University - Physics Institute III A, Aachen, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

IceAct is a proposed surface array of cost-effective Imaging Air-Cherenkov telescopes above IceCube for the hybrid detection of Air-Showers. Starting January 2019, two IceAct telescope demonstrators featuring 61 SiPM pixels and improved optics operate in the center of the IceTop surface detector at the geographic South Pole. Combining information from these telescopes and IceCube, it is possible to test the performance in primary particle discrimination, energy calibration, and veto capabilities. We present the status and prospects of the project and first results from coincident and stereoscopic data taken during the antarctic winter 2019/2020.

T 47.7 Tue 17:30 Tv

Application of graph neural networks to classification and reconstruction tasks in KM3NeT — •Daniel Guderian and Alexander Kappes for the KM3NeT-Collaboration — WWU Münster

The KM3NeT neutrino telescope consists of a network of large-volume Cherenkov detectors at the bottom of the Mediterranean Sea, destined to search for neutrino interactions in water. With its two different sites, ORCA and ARCA, specializing in lower and higher neutrino energies, respectively, it aims at studying physics spanning from the determination of the neutrino mass hierarchy to detection of neutrinos from astrophysical objects. Currently under construction, data from the first deployed detector units, each holding 18 optical modules for the Cherenkov light detection, is available for analysis.

This talk presents results from studies on event classification and reconstruction for the ORCA detector, consisting of four detector units, based on graph neural networks.

T 47.8 Tue 17:45 Tv

Liquid Scintillator Light Response Nonlinearity Determination in the Context of the JUNO Experiment — •Konstantin Schweizer[1], Lothar Oberauer[1], Raphael Stock[1], David Dörflinger[1], Ulrike Fahrendholz[1], Julia Sawatzki[1], Sebastian Zwickel[1], Matthias Mayer[1], Hans Steiger[2], Andreas Steiger[1], and Ludwig Wallner[1] — [1]Technische Universität München (TUM), Physik-Department, James-Franck-Str., 85748 Garching, Deutschland — [2]PRISMA$^+$ Cluster of Excellence, Johannes Gutenberg-Universität (JGU) Mainz, 55099 Mainz, Deutschland

Many current and future neutrino experiments use liquid scintillators as their target material. The energy information of the neutrino interaction is one of the most important observed quantities. However the light yield of charged particles depositing energy in the scintillator follows a nonlinear behaviour. This talk will show the importance of the knowledge of the scintillator nonlinearity for neutrino experiments, in particular for the JUNO experiment which aims to determine the neutrino mass ordering. An experiment has been set up to measure the nonlinearity of the light yield of low energy electron events with a low threshold of approximately 10 keV. The talk will present recent developments and the current status of the experiment. This work is supported by the DFG Research Unit "JUNO" (FOR 2319).

T 47.9 Tue 18:00 Tv

Calibrating OSIRIS: A 20-ton radioactivity monitor for JUNO — •Alexandre Sébastien Göttel[1,2], Philipp Kampmann[1], Runxuan Liu[1,2], Livia Ludhova[1,2], Luca Pelicci[1,2], Mariam Rifai[1,2], Giulio Settanta[1], and Cornelius Vollbrecht[1,2] — [1]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kt liquid scintillator reactor neutrino experiment being built in the Guangdong province in China. JUNO is a multi-purpose experiment with a wide range of applications in neutrino physics, ranging from a mass-hierarchy determination to solar, geo, and atmospheric neutrino measurements, to detecting supernovae, etc.. For many of these applications it is imperative to closely monitor the radiopurity of the liquid scintillator during the several months it will take to fill the detector. The Online Scintillator Internal Radioactivity Investigation System (OSIRIS), a 20-ton liquid scintillator detector, is being developed for this purpose and will be built in Jiangmen in 2021. In order for the

OSIRIS pre-detector to achieve its goals a rigorous calibration is necessary. This calibration will consist of the lowering of radioactive sources, as well as a fast-pulsed LED, directly inside of the liquid scintillator using a fully automated and sealed calibration unit which was previously used in the Daya Bay experiment. In this talk the methods used for this calibration are discussed, as well as how they were optimized beforehand using a GEANT4-based Monte Carlo simulation.

T 47.10 Tue 18:15 Tv

Radon Monitoring in gaseous Nitrogen used for the Filling of the Central Detector of JUNO and OSIRIS — •Hans Steiger[1,2], Lothar Oberauer[1], Matthias Raphael Stock[1], and Philipp Landgraf[1] — [1]Physik-Department, Technische Universität München (TUM), James-Franck-Straße 1, 85748 Garching bei München — [2]Cluster of Excellence PRISMA+, Johannes Gutenberg University Mainz (JGU), Staudingerweg 9, D-55128 Mainz

The planned JUNO (Jiangmen 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 as well as for the filling of OSIRIS (Online Scintillator Internal Radioactivity Investigation System) with LS pressurized nitrogen will be used. To avoid a contamination of the LS with ^{222}Rn, its content in the nitrogen gas will be monitored. In this talk the status of a prototype radon monitoring system based on a large volume (50 l) proportional chamber operated in pure nitrogen will be presented as well as pulse shape analysis techniques applied for efficient background reduction. This work is supported by the DFG research unit "JUNO" (FOR2319) and the Maier-Leibnitz-Laboratorium (MLL).

T 48: Hauptvorträge (Invited Talks) II

Time: Wednesday 9:45–12:30 Location: Tb

Invited Talk T 48.1 Wed 9:45 Tb

Moving ahead with flavor — •Gudrun Hiller — Fakultaet Physik. TU Dortmund, Germany

The standard model has passed an enormous amount of tests. We report on present challenges posed by flavor for physics in and beyond the Standard model, and discuss directions to go ahead: Improving the precision frontier and understanding of the standard model background, multi-observables methods and fits, new directions in model building, and joint efforts from theory, phenomenology and experimental communities. We highlight the progress and persistent puzzles from the flavor sector.

Coffee Break 30 min

Invited Talk T 48.2 Wed 11:00 Tb

Highlights from the LHCb experiment — •Michel De Cian — EPFL, Lausanne, Switzerland

In the last years, the LHCb experiment observed intriguing deviations from Standard Model predictions in charged-current and neutral-current b-hadron decays, commonly known as "flavour anomalies". They might hint to physics beyond the Standard Model. In this talk I will review the state of these anomalies, present the latest results and also highlight other key results by the LHCb collaboration of the last months.

Invited Talk T 48.3 Wed 11:45 Tb

Neutrino Oscillations: Status and Prospects — •Alfons Weber — University of Oxford, Oxford, UK — UKRI/STFC Rutherford Appelton Laboratory, Didcot, UK

The Nobel Prize in Physics 2015 was awarded to Kajita and McDonald "for the discovery of neutrino oscillations, which shows that neutrinos have mass." It was the recognition of important work and the solution to the so-call atmospheric and solar neutrino anomalies, which puzzled physicists for a decade. We have now moved on and start to develop a good understanding of the neutrino flavour sector. Diverse experiments studying neutrinos from the sun, reactors, cosmic rays and accelerators have given us insight of the mass and flavour structure of neutrinos. This presentation will summarise the current state of the field and highlight what we stil do not know and future experiments that will lead the area of precision neutrino physics and shed light on the question, whether the CP symmetry is violated in the neutrino sector.

T 49: Eingeladene Vorträge (Invited Topical Talks) III

Time: Wednesday 14:00–15:30 Location: Tc

Invited Topical Talk T 49.1 Wed 14:00 Tc

A walk through $H \to \tau\tau$ in the CMS experiment — •Hale Sert — RWTH Aachen University, Experimental Physics Institute 3B, Aachen, Germany

The direct coupling of Higgs bosons to fermions is the necessary probe to understand the mass generation of the fermions. The tau lepton decay of the Higgs boson, with the second largest branching ratio, was the first one observed in combination of the CMS and ATLAS data collected at $\sqrt{s}$ =7 TeV and $\sqrt{s}$ =8 TeV. The first observation by the CMS experiment was achieved after inclusion of the 2016 data with $\mathcal{L}$ =35.9 fb^{-1} at $\sqrt{s}$ =13 TeV. Since then, $H \to \tau\tau$ has been observed in various production modes. Cross sections, the signal strength μ, defined as the ratio of the observed cross section to the Standard Model expectation, and the couplings to bosons and fermions, κ_v and κ_f, have been determined, and found in agreement with the predictions of the Standard Model. This decay has been recently used to investigate the CP structure in the Yukawa coupling. In parallel, the heavier Higgs bosons decaying in tau leptons have been searched in several channels. This talk will guide you through the progress from the discovery of $H \to \tau\tau$ to up-to-date results obtained in Run 2 data with $\mathcal{L}$ =137 fb^{-1} collected at $\sqrt{s}$ =13 TeV in the CMS experiment.

Invited Topical Talk T 49.2 Wed 14:30 Tc

Looking inside jets - jet substructure techniques and their application in ATLAS — •Chris Malena Delitzsch — University of Arizona, Tucson, USA

The unprecedented center-of-mass energy of the proton-proton collisions at the Large Hadron Collider enables the production of hadronically decaying particles such as W/Z/H bosons and top quarks with a transverse momentum much larger than their rest mass, resulting in the collimation of their decay products. To enhance the sensitivity to new physics and the precision of Standard Model measurements at high transverse momenta, many different jet substructure techniques have been developed and established over the past years that take advantage of the different radiation patterns within the jet depending on the initiating particle. This talk describes the state of the art substructure and tagging techniques and their applications in physics analyses in ATLAS and highlights the challenges of the jet substructure field.

Invited Topical Talk T 49.3 Wed 15:00 Tc

Real-time track reconstruction with GPUs — •Dorothea vom Bruch — Aix Marseille Univ, CNRS/IN2P3, CPPM, Marseille, France

As the instantaneous luminosity of high energy physics (HEP) experiments increases, so does the data rate produced. To process these data streams in real time, available computing hardware has to be exploited optimally. In addition, increasingly more global event information is needed for efficient data selection, such as the reconstruction of charged particle trajectories at the earliest possible stages of the selection chain. I will discuss how the multi-core architecture of graphics processing units (GPUs) is used in several HEP experiments to cope with the computing challenge of particle reconstruction in real-time.

T 50: Eingeladene Vorträge (Invited Topical Talks) IV

Time: Wednesday 14:00–15:30 Location: Td

Invited Topical Talk T 50.1 Wed 14:00 Td

Gamma-ray Propagation as a Probe for Cosmology and Fundamental Physics — •Manuel Meyer — Erlangen Center for Astroparticle Physics, Erwin-Rommel-Str. 1, 91058 Erlangen, Germany

Observations of gamma rays produced in active galactic nuclei – the most powerful persistent sources in the Universe – offer the unique opportunity to study a range of open questions in cosmology and fundamental physics. In particular, gamma-ray observations can constrain the interaction of photons with axion-like particles as well as the strength of intergalactic magnetic fields. Such fields are thought to act as a seed for magnetic fields ubiquitously observed in galaxies and galaxy clusters. In this talk, I will review how current and future gamma-ray observatories enable us to study these phenomena.

Invited Topical Talk T 50.2 Wed 14:30 Td

Results and Status of the XENON Dark Matter experiment — •Michael Murra — Institut für Kernphysik (WWU Münster), Münster, Germany

The XENON1T experiment for the direct detection of dark matter with a dual phase time projection chamber (TPC) utilized 3.2 t of liquid xenon. With its 1 (t×yr) data, it sets the most stringent limits on the spin-independent scattering cross section of Weakly Interacting Massive Particles (WIMP) on nucleons for nearly the complete range of WIMP masses above 120 MeV/c^2.

The unprecedented low electronic recoil (ER) background allows for other physics searches as well. One example is the first observation of the two-neutrino double electron capture in Xe-124 with a half-live of 1.8×10^{22} yr, the longest decay ever measured directly. Furthermore, an energy excess at low energies in the ER spectrum was found: Possible origins can come from new particles like axions, a neutrino magnetic moment or from the decay of trace amounts of tritium within the xenon.

The next-generation experiment XENONnT, with 8.4 t of xenon, will not only become one order of magnitude more sensitive to WIMP nucleon interactions, it will also be able to clarify the origin of this low energy excess.

This talk will summarize the most important results from XENON1T and their physics context, and give an update on the XENONnT status, with emphasis on the radon removal system to reach the required xenon radio-purity.

Invited Topical Talk T 50.3 Wed 15:00 Td

Opportunistic direct search for axion Dark Matter — •Babette Döbrich — CERN

The last decade has witnessed a large increase of new direct searches for an old candidate for constituting Dark Matter: the axion. The aim of the talk is to convey the reasons for the growing interest in the Dark Matter axion. In addition, the talk will give a rough overview of the corresponding experimental landscape. As a concrete example, opportunistic searches for axion Dark Matter at existing (and proposed) dipole magnets using custom-made radio-frequency structures are presented, along with initial experimental results of these efforts.

T 51: BSM physics (theory)

Time: Wednesday 16:00–18:30 Location: Ta

T 51.1 Wed 16:00 Ta

Testing the 2HDMS — •Steven Paasch[1], Cheng Li[1], Gudrid Moortgat-Pick[1,2], Sven Heinemeyer[3], and Florian Lika[2] — [1]Deutsches Elektronen-Synchroton — [2]Universität Hamburg — [3]Instituto de Física Teórica (UAM/CSIC), Universidad Autónoma de Madrid Cantoblanco

The 2HDMS is based on the CP-conserving 2HDM extended by a complex singlet field. We impose an additional Z3 symmetry on the potential. This leads to a Higgs-sector similar to the Next-to-Minimal Supersymmetric SM (NMSSM), while having fewer symmetry conditions compared to supersymmetric models. We introduce the theoretical background of this model and set it up for phenomenological studies. For this we study theoretical constraints including tree-level perturbative unitarity, boundedness from below conditions and vacuum stability constraints. Furthermore we look at experimental constraints from direct searches for BSM Higgs bosons at colliders. This defines the basis for our study on the 96 GeV excesses at CMS and LEP.

T 51.2 Wed 16:15 Ta

Standard Model Extensions from Asymptotic Safety with Higgs and Flavor Portals — Gudrun Hiller[1], Clara Hormigos-Feliu[2], Daniel Litim[3], and •Tom Steudtner[1,3] — [1]Fakultät Physik, TU Dortmund, Otto-Hahn-Str.4, D-44221 Dortmund, Germany — [2]INFN, Sezione di Roma P.le A. Moro, 2, I-00185 Roma, Italy — [3]Department of Physics and Astronomy, University of Sussex, Brighton, BN19QH, United Kingdom

I present a study of several SM extensions which are free of Landau poles and instabilities until the Planck scale, stabilise the Higgs sector, and allow to accommodate discrepancies of lepton anomalous magnetic moments.

Our models feature a singlet matrix scalar field, three generations of vectorlike leptons, and direct links to the Higgs and flavor sectors via new Yukawa and portal couplings.

I will highlight properties the renormalisation group evolution, important phenomenological implications and some aspects of collider searches.

T 51.3 Wed 16:30 Ta

Top and Beauty synergies in SMEFT-fits at present and future colliders — Stefan Bissmann, •Cornelius Grunwald, Gudrun Hiller, and Kevin Kröninger — TU Dortmund, Fakultät Physik, Deutschland

The Standard Model Effective Field Theory (SMEFT) has become an established framework for searching physics beyond the Standard Model. Combining observables from top-quark and B physics has recently been shown to be a promising approach for improving constraints within SMEFT. In this talk, we present studies on the combination of measurements from top-quark and B physics in fits of SMEFT Wilson coefficients. We combine observables from top-quark pair production and decay processes with $Z \to b\bar{b}$ and $b \to s$ transitions. We point out how the individual datasets allow to probe different sets of Wilson coefficients and how a combined fit to current top-quark and B data improves the constraints. We also demonstrate the influence of future measurements on the results of our fits by considering future projections for measurements from HL-LHC, Belle II and CLIC.

T 51.4 Wed 16:45 Ta

Towards constraining triple gluon operators through tops — •Prasham Jain[1], Debjyoti Bardhan[2], Diptimoy Ghosh[3], and Arun Thalapillil[4] — [1]Albert-Ludwigs-Universität Freiburg, Physikalisches Institut, Hermann-Herder-Straße 3, D-79104 Freiburg, Germany — [2]Department of Physics, Ben-Gurion University of the Negev, Beer Sheva 8410501, Israel — [3]Indian Institute of Science Education and Research, Homi Bhabha road, Pashan, Pune 411008, India — [4]Indian Institute of Science Education and Research, Homi Bhabha road, Pashan, Pune 411008, India

Effective field theory techniques provide important tools to probe for physics beyond the Standard Model in a relatively model-independent way. In this talk, the CP-even dimension-6 purely gluonic operator is revisited to investigate the possible constraints on it by studying its effect on top-pair production at the LHC, in particular the high p_T and $m_{t\bar{t}}$ tails of the distribution. Cut-based analysis reveals that the scale of New Physics when this operator alone contributes to the production process is greater than 3.6 TeV at 95% C.L., which is a much stronger bound compared to the bound of 850 GeV obtained from Run-I data using the same channel. This is reinforced by an analysis using Machine Learning techniques. This study complements similar studies

that have focussed on other collider channels to study this operator.

T 51.5 Wed 17:00 Ta

Vector-boson scattering - concrete model realization versus EFT — •Jannis Lang, Stefan Liebler, Heiko Schäfer-Siebert, and Dieter Zeppenfeld — Institute for Theoretical Physics, Karlsruhe Institute of Technology (KIT), 76128 Karlsruhe, Germany

We consider a concrete UV complete model with additional fermions and scalars being multiplets under $SU(2)_L$ in the $SU(2)_L$ limit of the Standard Model. We derive its impact on vector-boson scattering, both in the full model as well as in terms of an effective field theory (EFT). The validity of the plain EFT and unitarized versions in comparison to the full model is examined, and the impact for experimental analyses bounding EFT operators is pointed out.

T 51.6 Wed 17:15 Ta

Dark Matter and nature of Electroweak Phase Transition in the Inert Doublet Model — •Sven Fabian[1], Florian Goertz[1], and Yun Jiang[2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]TianQin Research Center for Gravitational Physics & School of Physics and Astronomy, Zhuhai, P.R. China

In this talk, we will provide a comprehensive analysis of the prospect to realize Dark Matter (DM) and to enhance the Electroweak Phase Transition (EWPhT) in the Inert Doublet Model. Taking the latest constraints from collider physics and direct-detection experiments into account, we will investigate the possibility of a strong first-order EWPhT via one or two steps in combination with a significant amount of the measured DM abundance both in the low-mass and in the high-mass regime, exploring also new regions of parameter space. We will find that the low-mass regime leads to a parameter space providing a significant DM abundance as well as to a strong first-order EWPhT either via one or two steps. On the contrary, the high-mass regime either gives rise to a significant amount of DM or to a strong first-order EWPhT, the latter being necessary for explaining the present baryon-antibaryon asymmetry.

T 51.7 Wed 17:30 Ta

Direct Detection of Dark Matter: Precision Predictions in a Simplified Model Framework — •Christoph Borschensky, Gabriele Coniglio, Barbara Jäger, Josef Jochum, and Vincent Schipperges — Eberhard Karls Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen

In my talk, I will present a calculation of the next-to-leading order QCD corrections for the scattering of dark matter particles off nucleons in the framework of simplified models with s- and t-channel mediators. These results are matched to the Wilson coefficients and operators of an effective field theory that is generally used for the presentation of experimental results on spin-independent and spin-dependent direct detection rates.

Detailed phenomenological studies illustrate the complementary reach of collider searches for dark matter and the direct detection experiments CRESST and XENON. In the case of cancellation effects in the tree-level contributions, one-loop corrections can have a particularly large impact on exclusion limits in the case of combined $s+t$-channel models.

T 51.8 Wed 17:45 Ta

Absolute neutrino mass as the missing link to the dark sector — •Sybrand Zeinstra[1], Thede de Boer[1], Michael Klasen[1], and Caroline Rodenbeck[2] — [1]Institut für Theoretische Physik, WWU Münster — [2]Institut für Kernphysik, WWU Münster

With the KATRIN experiment, the determination of the absolute neutrino mass scale down to cosmologically favored values has come into reach. We show that this measurement provides the missing link between the Standard Model and the dark sector in scotogenic models, where the suppression of the neutrino masses is economically explained by their only indirect coupling to the Higgs field. We determine the linear relation between the electron neutrino mass and the scalar coupling λ_5 associated with the dark neutral scalar mass splitting to be $\lambda_5 = 3.1 \times 10^{-9} m_{\nu_e}/\text{eV}$. This relation then induces correlations among the DM and new scalar masses and their Yukawa couplings. Together, KATRIN and future lepton flavor violation experiments can then probe the fermion DM parameter space, irrespective of the neutrino mass hierarchy and CP phase.

T 51.9 Wed 18:00 Ta

Probing radiative seesaw models with neutrinos from the sun at IceCube — •Thede de Boer[1], Sybrand Zeinstra[1], Raffaela Busse[2], Michael Klasen[1], and Alexander Kappes[2] — [1]Institut für Theoretische Physik, WWU Münster — [2]Institut für Kernphysik, WWU Münster

Dark matter scattering off of nuclei in the sun and subsequent DM self-annihilations can lead to an enhanced neutrino flux which is in principle detectable at IceCube. We study possible event rates considering a radiative seesaw model containing scalar triplet and singlet-doublet fermion dark matter candidates. In the case of scalar dark matter, the absence of a spin dependent scattering on nuclei results in a low capture rate in the Sun, which is reflected in an event rate of less than one event per year. For singlet-doublet fermion dark matter there exists a spin dependent scattering process next to the spin independent one, allowing for higher event rates. Due to a correlation between both processes, the stringent limits on the spin dependent cross section set by XENON1T exclude most points detectable at IceCube.

T 51.10 Wed 18:15 Ta

Gravitational waves from collapsing domain walls in a 2HDM + complex singlet — •Luis Hellmich — DESY, Hamburg, Germany

I investigate the possibility of domain wall formation in a 2HDM + complex singlet with a discrete $\mathbb{Z}_2$- and an additional $\mathbb{Z}_3$-symmetry. Spontaneous breaking of the discrete symmetries at the elctroweak phase transition leads to the formation of domain walls, which may collapse sufficiently fast, if there exists a bias term in the potential to break the symmetries explicitly. The gravitational waves (GW) produced by these collapsing domain walls are analyzed, taking into account a combination of constraining collider and cosmological data. The resulting GW spectra are compared to limits of current and future GW detectors.

T 52: Top quark decay and top properties II

Time: Wednesday 16:00–18:00 Location: Tb

T 52.1 Wed 16:00 Tb

Measurement of observables sensitive to color reconnection effects in $t\bar{t}$ dilepton events — Dominic Hirschbuehl, Wolfgang Wagner, and •Shayma Wahdan — Bergische Universität Wuppertal

The color reconnection (CR) modelling uncertainty could become one of the dominant sources of systematic uncertainties in the top mass determination. Ongoing top-quark mass analyses use the PYTHIA 8 MC generator for parton showering and hadronization. PYTHIA 8 comes with several alternative CR models which should be explored to estimate the CR modelling uncertainty. At the same time, the models should be confronted with collision data to test their validity. Only models which are in agreement with data in general are suitable to define the corresponding modelling uncertainty. This analysis presents a measurement of three of the most discriminating observables between these models in $t\bar{t}$ dilepton events. The sensitive observables use tracks associated to the vertex of the hard scattering (primary vertex). The selected tracks are diluted with pile-up tracks and tracks of secondary particles. Therefore, a procedure is developed for correcting the pile-up contribution. After the correction the observables are unfolded to the particle-level and the unfolded spectrum is compared to the different CR models.

T 52.2 Wed 16:15 Tb

Improving the Heavy Object Tagger with Variable R with soft-drop grooming — •Anna Albrecht, Johannes Haller, Roman Kogler, Christopher Matthies, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

The Heavy Object Tagger with Variable R (HOTVR) is an algorithm for the clustering and identification of boosted, hadronically decaying, heavy particles in high energy particle collisions. The central feature

of the HOTVR algorithm is a variable distance parameter R that decreases with increasing transverse momentum p_T of the jet.

In this study, the original mass-jump grooming of HOTVR is replaced by the soft-drop criterion, that results in a jet grooming with a rejection criterion based on a single proximity scale. Subjets are defined through a mass criterion, such that the algorithm can perform clustering, grooming and subjet finding in a single sequence. As a result, the top tagging performance is improved in comparison to the original tagger.

T 52.3 Wed 16:30 Tb

Study of fake tau leptons in rare top quark production processes using deep neural networks — •Chris M. Staude and Ian C. Brock — Physikalisches Institut, Universität Bonn

Fake tau leptons in Higgs and Z boson decays arise mainly from jets as well as from electrons that mimic the signature of a hadronically decaying tau lepton. QCD events can sometimes appear to be tau lepton decays. This problem is magnified as the cross-section of such QCD events is orders of magnitude higher than our desired production.

In this work, rare top quark production processes where a single top quark is produced in association with a Z boson as well as the associated production with a Higgs boson are investigated.

Deep Neural Networks (DNNs) are used to discriminate real from fake tau leptons using fully labelled simulated events. However, the simulations are often not perfect or have sufficient statistics. Therefore a new method called CWoLa (Classification Without Labels) is also used to differentiate between real and fake tau leptons using only mixtures of events instead of true labels. The classifier is trained on the enriched with fakes $t\bar{t}$ data and compared to the optimal classifier in the fully-supervised case.

T 52.4 Wed 16:45 Tb

Search for FCNC in strong interactions with the ATLAS detector — •Gunnar Jäkel, Wolfgang Wagner, and Dominic Hirschbühl — Bergische Universität Wuppertal

Flavor changing neutral currents (FCNC) are forbidden at tree level and highly suppressed at higher orders in the standard model. In some new physics models leading order contributions could enhance cross sections for FCNC processes by many orders of magnitude. A search for direct top quark production is presented. In this process a u(c)-quark interacts with a gluon and produces a top quark. Different cuts and neural networks are studied to increase the sensitivity of the search.

T 52.5 Wed 17:00 Tb

Search for flavour-changing photon interactions in top-quark production and decay at $\sqrt{s} = 13$ TeV with the ATLAS experiment — Tomas Dado, Johannes Erdmann, •Benedikt Gocke, Florian Mausolf, and Olaf Nackenhorst — TU Dortmund, Lehrstuhl für Experimentelle Physik IV

In the Standard Model of particle physics, flavour-changing neutral currents (FCNC) are forbidden at tree level and are highly suppressed by the GIM mechanism at higher orders of perturbation theory. However, several extensions of the Standard Model predict larger branching ratios for FCNC processes.
One possible process with an FCNC includes a top quark that interacts with an up-type quark and a photon ($tq\gamma$ coupling with $q = u, c$). A distinction is made between the production mode, in which a single top quark is produced via an FCNC interaction, and the decay mode, in which one of the top quarks of a $t\bar{t}$ system decays through an FCNC interaction.
Improvements of an ATLAS search that focused on the production mode with a partial Run-2 dataset (Phys. Lett. B 800 (2019) 135082) are shown. These include in particular, that decay and production mode are considered in the optimisation of the analysis, the full Run-2 data is used, and the background estimations are revisited.

T 52.6 Wed 17:15 Tb

Neural network optimisation in the search for flavour-changing neutral currents in processes with a top quark and a photon at the ATLAS experiment — Tomas Dado, Johannes Erdmann, Benedikt Gocke, •Florian Mausolf, and Olaf Nackenhorst — Experimentelle Physik IV, TU Dortmund, Germany

A search for flavour-changing neutral currents (FCNC) in processes with a top quark and a photon is presented. In the Standard Model (SM) of particle physics these processes are highly suppressed, so that an observation would be a direct hint to physics beyond the SM. Proton-proton collision data taken with the ATLAS detector at a centre-of-mass energy of $\sqrt{s} = 13\,\text{TeV}$ are used. The signal region targets two possible signal modes, the FCNC production of a single top quark and the decay of a top quark via an FCNC process.

A neural network is used to maximise the separation between signal events and the SM background. Two different network architectures are tested: A binary classifier that discriminates between signal and background, and a multiclass network that evaluates if events originate from the production mode, the decay mode or a background process. Studies for the optimisation of the neural networks as well as the resulting expected upper limits on the signal strength are presented.

T 52.7 Wed 17:30 Tb

Search for FCNC-couplings between the top-quark and the Higgs-boson in multilepton final states — •Marvin Geyik, Oliver Thielmann, and Wolfgang Wagner — Bergische Universität Wuppertal

Flavor-changing neutral current interactions are strongly suppressed in the Standard Model. Still, some extensions of the Standard Model predict tree-level FCNC-couplings between the top quark, other up-type quarks and neutral bosons, including the Higgs boson. These anomalous couplings can be parameterised in the framework of effective field theories (EFT). The presented analysis searches for the production of a single top-quark in association with a Higgs boson and for top-quark-antiquark production with one of the top quarks decaying to an up quark or a charm quark and a Higgs boson. Higgs decays to WW*, ZZ* and two taus leading to leptonic final states are considered in the event selection. Two analysis channels are defined: one with two leptons (electrons or muons) of the same electric charge and a second channel with three leptons. The sensitivity of the analysis in setting limits to relevant coefficients of EFT operators will be presented.

T 52.8 Wed 17:45 Tb

Search for flavour-changing neutral current couplings between the top-quark and the Higgs boson in the $H \to b\bar{b}$ decay channel with the ATLAS detector at the LHC — •Oliver Thielmann, Geoffrey Gilles, and Wolfgang Wagner — Bergische Universität Wuppertal

A search for flavour-changing neutral current (FCNC) couplings between the top-quark and the Higgs boson in the $H \to b\bar{b}$ decay channel is presented. The search for FCNC couplings in the top-quark-Higgs-boson sector is a promising search for a theory beyond the SM. Proton-proton collision data produced by the LHC at a centre-of-mass energy of $\sqrt{s} = 13TeV$ and collected by the ATLAS experiment during 2015, 2016, 2017 and 2018, and corresponding to an integrated luminosity of $139fb^{-}1$, are used. Data is analysed in three different final states, characterised by one isolated electron or muon, missing transverse energy and three, four or more than five jets where three of them are identified as b-jets. A machine learning analysis based on neural networks is conducted to improve the discrimination between the signal and the backgrounds. Preliminary results on the expected signal cross section exclusion limits are derived using the CLs method. Further interpretation is performed in the context of an effective field theory for FCNC where additional exclusion limits on the qtH effective coupling are derived.

T 53: Electroweak Interactions I

Time: Wednesday 16:00–18:30 Location: Tc

T 53.1 Wed 16:00 Tc

Measuring lepton universality, mass and width of the W-boson with the ATLAS detector — Lennart Adam[2], Nassim Ainouz[1], Philip Bechtle[1], Klaus Desch[1], Oleh Kivernyk[1], Jakub Kremer[2], •Philipp König[1], and Matthias Schott[2] — [1]Rheinische-Friedrich-Wilhelms-Universität Bonn — [2]Johannes Gutenberg-Universität Mainz

In 2017, the ATLAS collaboration measured the W-boson mass using *pp*-collision data taken at $\sqrt{s} = 7$ TeV in 2010, resulting in the most precise single measurement with a precision of 19 MeV. We present a revised analysis of the same dataset, improving the fit methods and including a measurement of the width of the W-boson. A precise measurement of these quantities and a test of lepton universality in the decay of the W-boson represent an excellent precision test of the Standard Model (SM).

A deviation of the branching fraction $BR(W \to \tau\nu)$ from the SM prediction would be an indicator for new physics coupling predominantly to heavier particles. Experimentally, it is preferable to measure the ratio of the branching ratios of the tau lepton decay into light leptons compared to the direct W decay into light leptons. However, it implies that numerator and denominator only differ in kinematic distributions from which the result is extracted in a fit. The most important observables for the fitting procedure will be discussed as well as possibilities increasing the sensitivity of the measurement. Finally, the expected sensitivity will be compared to previous measurements by other experiments.

T 53.2 Wed 16:15 Tc

Polarized same-sign W boson scattering at the CMS experiment — Thorsten Chwalek[1], Nils Faltermann[1], Abideh Jafari[2], Thomas Müller[1], and •Komal Tauqeer[1] — [1]Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT) — [2]Deutsches Elektronen-Synchrotron (DESY), Hamburg

Polarized vector boson scattering (VBS) provides an opportunity for testing the Higgs mechanism in the electroweak sector of the standard model. At the LHC, the scattering of the weak gauge bosons can reveal the actual process by which they get their masses. In particular, the longitudinal polarized state of these bosons can reveal new information about the Goldstone bosons of the electroweak symmetry breaking sector.

The most promising VBS channel for this type of study is same-sign WW scattering, which has a good balance between signal and backgrounds. In particular, the dileptonic decay channel provides a larger cross section than the fully leptonic decay channel; however, this channel faces large background contributions from V + jets process.

To increase the signal sensitivity and to identify the W boson decaying into hadrons along with its charge and polarization, our study aims for advancements in the boosted W-jet tagging techniques via jet substructure variables.

T 53.3 Wed 16:30 Tc

Estimation of non-prompt lepton background in same-sign WW production at 13 TeV with ATLAS detector — •Shalu Solomon — Albert-Ludwigs University of Freiburg, Freiburg, Germany

The production of same-sign W boson pair via vector boson scattering is one of the pivotal processes to experimentally probe the electroweak symmetry breaking mechanism. The analysis of 2015-2016 ATLAS data at $\sqrt{s} = 13$ TeV resulted in the observation of the process with the signal significance of 6.5 σ. With the entire Run 2 data set, corresponding to an integrated luminosity of 139 fb^{-1}, the signal event yield has increased approximately by a factor of 4, which gives the potential for the first differential cross-section measurement of this process. The final state consisting of two prompt leptons of the same electric charge, two neutrinos and two forward jets is considered. The second-largest background source, non-prompt lepton background, arises due to leptons from heavy-flavour hadron decays and jets misidentified as electrons, passing the lepton selection criteria. A data-driven technique, called fake factor method, is used to estimate this background. The fake factors are extracted from a jet-enriched sample kinematically close to the signal region. The performance of this background in various validation regions and the estimation in the signal region are presented.

T 53.4 Wed 16:45 Tc

ATLAS measurement of photon induced WW production in pp collisions — •Filip Nechansky — DESY, Zeuthen

The LHC is currently the largest hadron collider, where strong interaction between the colliding protons or ions results in a production of large number of energetic particles. Under special circumstances, however, there can be an interaction of the electromagnetic fields of the colliding particles, resulting in high energetic photon-photon interactions. These are characterized by a clean final state driven mainly by the electroweak force and provide an important probe of the electroweak sector.

This talk reports on the recent observation of the two photon interaction producing a WW final state measured by the ATLAS detector at the LHC. This process is identified by the presence of two leptons and no additional activity in the proximity of the interaction vertex. Beside the signal isolation, the estimation of the dominant backgrounds is discussed as well.

T 53.5 Wed 17:00 Tc

Data-driven estimation of the non-prompt background in same charged $W^{\pm}W^{\pm}$ boson scattering within the ATLAS experiment — •Max Stange, Michael Kobel, Joany Manjarres, and Carsten Bittrich — IKTP, TU Dresden, Germany

The scattering of electroweak vector bosons offers a unique opportunity to study the electroweak sector of the Standard Model of particle physics, the Higgs mechanism, and furthermore physics beyond the Standard Model. One of the cleanest channel to investigate vector boson scattering at the LHC is the scattering of same charged $W^{\pm}$ bosons. In the previous publications largest experimental uncertainty of the measurement, was coming from the data-driven estimation of misidentified leptons (non-prompt leptons).

This study aims to improve the data-driven method used so far to estimate this non-prompt background. The method is adapted to use a new dilepton control region and thoroughly tested with Monte Carlo simulated events. This dilepton control region is kinematically closer to the signal region than the dijet control region used in the previous publications. The data studied in this thesis were measured with the ATLAS experiment at a collision energy of 13 TeV with an integrated luminosity of 138.7 fb^{-1}.

To validate the data-driven method using data the low dijet invariant mass validation region is used, which is kinematically very close to the signal region. The data in this validation region is sufficiently well modeled by the data-driven method, making this method a valuable alternative to the one currently in use by the $W^{\pm}W^{\pm}jj$-EW analysis.

T 53.6 Wed 17:15 Tc

Data-driven methods for the estimation of the non-prompt lepton background for the W^+W^- measurement with the ATLAS detector — •José Antonio Fernández Pretel — Albert-Ludwigs Universität Freiburg, Freiburg im Breisgau, Deutschland

Fiducial and differential cross sections of W^+W^- pair production are key measurements to test self-couplings predicted by the electroweak sector of the Standard Model, but also to validate QCD corrections and to accurately estimate important background contributions to other measurements such as Higgs boson decays into W boson pairs. Single W boson production in association with jets can contribute to the selected W^+W^- candidate events when an associated jet is misreconstructed as a lepton. These are referred to as "non-prompt" or "fake" leptons. Due to the production cross section of W+jet, orders of magnitude larger than diboson W^+W^-, these contributions become an important background for this measurement, corresponding to about 10

T 53.7 Wed 17:30 Tc

Search for anomalous couplings in the hadronic decay channel of Vector Boson Scattering at the LHC — Steffen Albrecht[1], Thomas Müller[2], and •Max Neukum[2] — [1]Institut für Experimentalphysik, Universität Hamburg — [2]Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

Vector boson scattering (VBS) is at the LHC the dominating processes to investigate the quartic vertex of electroweak theory and the cross section is ultimately determined by the Higgs boson. New physics in the Higgs sector may thus alter the cross section noticeably even if it is currently out of reach of direct measurements.

Deviations of couplings at high energies are formulated in an effective field theory, a bottom-up approach, which parametrizes a multitude of explicit theories. Limits on introduced parameters allow to draw conclusions regarding the strength and energy scale of new physics.

This presentation describes the search for anomalous couplings in the hadronic decay channel of VBS at a center-of-mass energy of 13 TeV. Jet substructure techniques are used to distinguish between signal and background events and a three-dimensional fit supresses contributions from QCD events.

T 53.8 Wed 17:45 Tc

Measurement of the charged-current Drell-Yan differential cross-section at high transverse masses at $\sqrt{s} = 13\,\text{TeV}$ with the ATLAS detector — Frank Ellinghaus, •Frederic Schröder, and Christian Zeitnitz — Bergische Universität Wuppertal

The charged-current Drell-Yan (DY) cross-section is measured for the leptonic decay of the W boson $W \to l\nu$ with $l = e, \mu$. While the cross-section at the peak of the W boson mass is known very well, the measurement of the differential cross-section for transverse masses up to $\mathcal{O}(1\,\text{TeV})$ is measured for the first time. In addition, the double-differential cross-section will be measured as a function of the transverse mass of the W boson and the pseudorapidity of the lepton.
The charged-current DY can be used to constrain the density function that describes the partonic content of the proton and to measure fundamental parameters of the Standard Model. In particular, the high m_T^W region of the charged-current DY allows probing new physics by constraining effective field theory parameters, because these parameters are sensitive to small deviations in the cross-section with respect to the theory prediction.
An overview of the analysis including the fake lepton background estimation based on the matrix method as well as the unfolding procedure will be presented. The data has been taken at the ATLAS experiment based on pp-collisions at a center-of-mass energy of $\sqrt{s} = 13\,\text{TeV}$ at the LHC.

T 53.9 Wed 18:00 Tc

Determination of angular coefficients of the Z boson production at ATLAS — •Julian Fischer and Stefan Tapprogge — Institut für Physik, Johannes Gutenberg-Universität, Mainz

A better understanding of QCD production processes at hadron colliders is a key aspect for theoretical predictions of perturbative QCD at higher accuracy and thus allows for more precise measurements of Standard Model parameters and background estimations for searches. This contribution focusses on the measurement of angular coefficients that are used to describe the differential cross section of the Z boson production and subsequent decay into leptons in the 'Collins-Soper-frame'. These angular coefficients allow to probe in detail QCD contributions in Z production processes. Two of the coefficients can also be used to make inferences about the weak mixing angle. For the measurement the full Run 2 ATLAS dataset with an integrated luminosity of $L \approx 139\,\text{fb}^{-1}$ at $\sqrt{s} = 13\,\text{TeV}$ is used, which increases the statistical accuracy significantly at a higher centre-of-mass energy than previous analyses. Major challenges of the measurement and uncertainties are discussed and insights into the expected precision of the measurement will be shown.

T 53.10 Wed 18:15 Tc

Measurement of $Z\gamma\gamma$ production in pp collisions at $\sqrt{s} = 13\,\text{TeV}$ with the ATLAS detector — •Philipp Ott — Kirchhoff-Institute for Physics, Heidelberg University

The simultaneous production of three electroweak gauge bosons is a rare process predicted by the Standard Model of Particle Physics (SM). The theory predictions of the electroweak sector of the SM can be validated by measuring the cross section of the aforementioned process. The analysis presented in this talk aims to measure the simultaneous production of a Z boson and two photons ($Z\gamma\gamma$). In order to determine the cross section of this process, it is crucial to separate signal events from events arising through background processes mimicking the signal topology. The most dominant background is the production of non-prompt photons within jets. Due to the abundance of hadronic activity in the ATLAS detector, such processes have a non-negligible contribution to the total number of events selected in the signal region. A data-driven method is used to determine the non-prompt photon production by exploiting variations in the shape of the energy deposited in the proximity of photons. Templates describing the different energy behavior are used in a maximum likelihood estimation to measure the amount of prompt and non-prompt photon events in the signal region.

After giving a general introduction about the $Z\gamma\gamma$ analysis, highlighting the motivation and challenges of the measurement, an overview of the data-driven method used to determine the dominant background process is presented.

T 54: Cosmic Rays III

Time: Wednesday 16:00–18:30 Location: Td

T 54.1 Wed 16:00 Td

Follow-Up Search for UHE Photons after Gravitational Wave Events with the Pierre Auger Observatory — •Philip Ruehl, Marcus Niechciol, and Markus Risse — Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen

With the first detection of a gravitational wave (GW) event by the Advanced LIGO detectors in September 2015 a new window to multimessenger astronomy has been opened. The origin of this event has later been identified as the merger of a binary black hole system. Since then, multiple gravitational wave events have been observed from different sources. Possibly, these transient objects could be sources of ultra-high-energy (UHE) cosmic rays. This can be tested by multimessenger observations. Unlike charged particles, neutral messengers like neutrinos and photons carry information about the direction and the time of their production site making them ideal tools for multimessenger astronomy. While in classical scenarios photons can interact with the cosmic microwave background such that a measurable UHE photon fraction would only be expected from nearby sources, a UHE photon detection from a distant source could point towards new physics.
To extend the search window of the Pierre Auger Observatory, in addition to the established follow-up neutrino search now also a follow-up photon search is being developed. In this contribution, the first approach towards a search for UHE photons from GW sources using the surface detector of the Pierre Auger Observatory will be presented.
Gefördert durch BMBF-Verbundforschung.

T 54.2 Wed 16:15 Td

Follow-up of the ANITA observation of up-going high energy showers with the Fluorescence Detector of the Pierre Auger Observatory* — •Ioana Alexandra Caracas for the Pierre Auger-Collaboration — Bergische University Wuppertal, Gaußstraße 20, Wuppertal, Germany

The ANITA observations of two upgoing cosmic ray like showers with energies of $\simeq 0.6$ EeV remain unexplained. Because the Pierre Auger Observatory also has sensitivity to these phenomena, a follow up search of these events is performed. With 14 years of Fluorescence Detector(FD) data available, the post-selection exposure of the FD to upgoing showers exceeds that of ANITA by at least a factor of 10 as indicated by Monte Carlo studies. Therefore a search with the FD should be able to either confirm or significantly constrain ANITA's observations.

Simulations of up-going extensive air showers with elevation angles of more than 20 degrees above the horizon with primary energies between $10^{16.5}$ - $10^{18.5}$ eV have been performed using CONEX. The detector response to these events is further simulated using the Auger software framework. Additionally, a large isotropic sample of downgoing and horizontal cosmic ray showers was simulated as background. Preliminary results of the detector response and sensitivity to both cosmic ray and tau leptons induced air showers scenario will be presented and discussed.

**Supported by BMBF Verbundforschung Astroteilchenphysik 05A17PX1 and 05A20PX1*

T 54.3 Wed 16:30 Td

The 320 EeV Fly*s Eye event: a key messenger or a statistical oddity? — •Thomas Fitoussi[1,2], Gustavo Medina-Tanco[2], and Juan-Carlos D'Olivo[2] — [1]Karlsruhe Institute of Technology, Institut für Kernphysik, Karlsruhe, Germany — [2]Instituto de Ciencas Nucleares, Universidad Nacional Autónoma de México, México, D.F., México

Almost three decades ago, the Fly's Eye experiment recorded the most energetic cosmic-ray ever observed. With an energy of 320 EeV, this event is well beyond the suppression region of the ultra-high energy cosmic rays (UHECR) spectrum. Modern and larger observatories, with an exposure up to 60 times larger, have never observed an event with even remotely comparable energy. Thus, if the energy of the Fly's Eye event was indeed well measured, as strongly suggested by the data, then it remains a great mystery. At such high energies, the Universe is very opaque to electromagnetic interacting particles and therefore its source must be relatively close. Using numerical simulations for the propagation of protons and nuclei, we reexamine the problem by testing different possibilities for the nature of the primary, the injection spectrum and the location of the source. Based on these calculations, we show that the most feasible scenario corresponds to a nearby ($\sim 2-3$ Mpc) bursting source of heavy nuclei in the northern sky, which injected a hard spectrum ($\gamma \leq 1.5$) with an energy cut-off between 300 and 1000 EeV. Such scheme generates a significant probability for the observation of one event by Fly's Eye combined with a null result of Telescope Array at the same energy.

T 54.4 Wed 16:45 Td

Muon deficit in air shower simulations estimated from AGASA muon measurements — •Flavia Gesualdi[1,2], Alberto Daniel Supanitsky[1], and Alberto Etchegoyen[1] — [1]Instituto de Tecnologías en Detección y Astropartículas (CNEA, CONICET, UNSAM), Centro Atómico Constituyentes, B1650KNA San Martín, Buenos Aires, Argentina — [2]Karlsruhe Institute of Technology, Institute for Astroparticle Physics (IAP), 76021 Karlsruhe, Germany

Understanding the origin of ultra-high energy cosmic rays is still a challenge. The composition profile as a function of primary energy is a key information to elucidate the origin of these very energetic particles. The most sensitive observables to the mass composition are the atmospheric depth of the shower maximum and the muon content of the showers. In this work, direct measurements of the muon density at 1000 m from the shower axis observed by the Akeno Giant Air Shower Array (AGASA) are analysed. The selected events have zenith angles $\theta \leq 36^\circ$ and energies in the range $18.83 \leq \log_{10}(E_R/\mathrm{eV}) \leq 19.46$. These are compared to the predictions corresponding to proton, iron, and mixed composition scenarios obtained by using the high energy hadronic interaction models EPOS-LHC, Sibyll2.3c, and QGSJetII-04. A muon deficit in air shower simulations is observed: The muon density obtained from AGASA data is greater than the one obtained in the mixed composition scenario by a factor of $1.49 \pm 0.11\,(\mathrm{stat}) \pm 0.17\,(\mathrm{syst})$, $1.54 \pm 0.12\,(\mathrm{stat}) \pm 0.18\,(\mathrm{syst})$, and $1.66 \pm 0.13\,(\mathrm{stat}) \pm 0.20\,(\mathrm{syst})$ for EPOS-LHC, Sibyll2.3c, and QGSJetII-04, respectively.

T 54.5 Wed 17:00 Td

Time-dependent antiproton to proton ratio with the AMS-02 experiment — •Sichen Li — I. Physikalisches Institut B, RWTH, Aachen, Germany

The Alpha Magnetic Spectrometer (AMS-02) on the International Space Station has been performing precision measurements of cosmic rays in the GeV to TeV energy range since 2011. The study of the time dependence of the antiproton-to-proton ratio ($\frac{\overline{p}}{p}$), and its comparison to the electron-to-positron ratio, allows important insights into the physics of the heliospheric modulation of cosmic rays. I will present the analysis method developed to derive the $\frac{\overline{p}}{p}$ ratio with a time resolution of six months.

T 54.6 Wed 17:15 Td

Analysis of the isotopic composition of cosmic-ray Lithium with AMS-02 — •Manbing Li — I. Physikalisches Institut B RWTH Aachen, Sommerfeldstraße 14

AMS-02 is a multi-purpose magnetic spectrometer designed for precise measurements of cosmic-ray fluxes above Earths atmosphere. The isotopic composition of cosmic-ray nuclei is of great interest since it directly reflects processes related to cosmic-ray propagation through the Galaxy. In more than nine years of data taking, AMS-02 has collected the largest available dataset on the fluxes of cosmic-ray nuclei. The Ring Imaging Cherenkov detector of AMS-02 provides particle velocity measurements with a resolution better than 0.1%. Together with the rigidity measurement provided by the silicon tracker, the mass of a particle can be derived. I will present an analysis method based on template fits to determine the lithium isotope ratio.

T 54.7 Wed 17:30 Td

Search for heavy antimatter with AMS — •Robin Sonnabend — 1. Physikalisches Institut B, RWTH Aachen, Aachen

The Alpha Magnetic Spectrometer (AMS-02) on the International Space Station has been performing precision measurements of cosmic rays in the GeV to TeV energy range since 2011. The search for heavy antimatter (Z>=2) requires advanced methods for the suppression of instrumental background which arises from the mis-reconstruction of the charge sign. I will present a multivariate analysis designed to achieve this goal.

T 54.8 Wed 17:45 Td

Daily Electron Fluxes with AMS-02 — •Fabian Machate — 1. Physikalisches Institut B, RWTH Aachen University

The Alpha Magnetic Spectrometer (AMS-02) on the International Space Station has been performing precision measurements of cosmic rays in the GeV to TeV energy range since 2011. The time variation in the fluxes of electrons and positrons, caused by heliospheric modulation that varies with solar activity, has so far only been observed with monthly time resolution.

Now, an analysis to derive a daily flux of electrons with AMS-02 has been developed. It increases the acceptance by a factor of five, by including events outside the electromagnetic calorimeter. The new method allows the study of short-term variations in the electron flux, such as Forbush decreases.

T 54.9 Wed 18:00 Td

Measurement of the cosmic ray spectrum with the HAWC's Eye hybrid detector at the HAWC observatory. — •Frank Maslowski for the HAWC's Eye-Collaboration — Physics Institue III A, RWTH Aachen, Germany

HAWC's Eye is a compact imaging air Cherenkov telescope, which aims to improve energy and angular resolution of the High Altitude Water Cherenkov (HAWC) observatory. The HAWC observatory is a ground based air-shower array located in the Mexican state of Puebla, dedicated to the messurement of TeV gamma rays. When primary cosmic ray particles interact with the atmosphere they create extensive air showers, which in turn create Cherenkov light. These two components are messured by the two detectors. The good reconstruction of the core position by HAWC combined with the imaging capabilities of the telescope enables triangulation of the shower. From the data taken during one of the first hybrid observation campaigns, a cosmic ray spectrum above a few TeV has been derived.

T 54.10 Wed 18:15 Td

Proton Energy Reconstruction with the MAGIC Experiment — •Alicia Fattorini and Lena Linhoff for the MAGIC-Collaboration — TU Dortmund, Germany

MAGIC is a stereoscopic telescope system located on Roque de los Muchachos (2200 m a.s.l.) on La Palma, Canary Islands. The two Imaging Air Cherenkov Telescopes (IACTs) were built for the detection of gamma-ray sources at energies between 20 GeV and 100 TeV. The background of measurements with IACTs consists mainly of protons and heavier nuclei such as helium and iron. The signal-to-background ratio is typically 1:10000, leading to large statistics of hadrons. In this work, the energies of the primary protons are estimated. The proton energies are reconstructed with a random forest trained and tested on Monte Carlo simulations of protons. The performance of the energy reconstruction of protons and the instrument response of the telescopes are shown.

T 55: Bosonic and Rare Higgs decays

Time: Wednesday 16:00–18:30 Location: Te

T 55.1 Wed 16:00 Te

Background Modelling in the ATLAS $H \to \gamma\gamma$ Differential Cross Section Analysis — •Nils Gillwald — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Since its discovery in 2012, efforts to measure the Higgs boson properties as precisely as possible are ongoing in order to probe the Standard Model of particle physics and look for potential deviations from its predictions. Differential cross section measurements are an important part of these efforts. They aim at providing model-independent differential measurements of different kinematic and event observables, offering access to e.g. properties of perturbative QCD, the spin and CP nature of the Higgs boson, bottom and charm Yukawa couplings and potential new heavy particles coupling to the Higgs boson. This talk focuses on an analysis in the $H \to \gamma\gamma$ decay channel, using the full Run-2 data set taken between 2015 and 2018.

The general measurement strategy uses a signal and background fit to data to extract signal and background yields, which are then unfolded to particle level. For this fit, a functional form describing the background distribution needs to be determined. This is done based on Monte Carlo simulated templates. The potential bias on the measurement due to the choice of the background model is the largest systematic uncertainty in the fit procedure. This uncertainty is called the *spurious signal* uncertainty.

In this talk, the $H \to \gamma\gamma$ differential cross-section analysis is discussed with an emphasis on the background modelling strategy and the resulting spurious signal estimate.

T 55.2 Wed 16:15 Te

Measurement of $H \to WW^*$ Decays in the $\ell\nu qq$ Final State with a Large-R Jet — •Johannes Hinze, Karsten Köneke, and Benedict Winter — Universität Freiburg

The talk presents a study of $H \to WW^*$ decays at large transverse momenta ($p_{\mathrm{T},H} > 200$ GeV) with one leptonic ($W \to \mu\nu$ or $W \to e\nu$) and one hadronic W boson decay, where the experimental signature of the hadronic W boson decay is a large-R jet. The lepton provides means to efficiently trigger event candidates and to eliminate background events in particular from multijet events. Further background events, primarily from W+jets events, can be suppressed via W-boson taggers for large-R jets. The measurement benefits from the larger branching fraction in comparison with $\ell\nu\ell\nu$ final states, and from the reduced background levels for large transverse momenta. The measurement will contribute significantly in an area of the phase space that is considered particularly sensitive to possible BSM effects.

T 55.3 Wed 16:30 Te

Combination of Higgs boson measurements using Simplified Template Cross Sections at the ATLAS experiment — •Joshua Clercx — Hamburg University, Hamburg, Germany — DESY, Hamburg, Germany

Experimental measurements of certain high energy physics parameters could show deviations from the theoretical predictions, which would indicate the existence of physics beyond the standard model (BSM). Depending on where these deviations are found, it also gives some insight into which BSM physics theories are interesting to further investigate. Measurements in the Higgs sector are especially interesting, as there are many opportunities to detect BSM effects here. The most precise measurements in the Higgs sector are obtained by combining measurements of cross sections of different Higgs boson production processes in several Higgs boson decays. This is typically done in the Simplified Template Cross Sections (STXS) framework: measurements of cross sections of mutually exclusive regions of phase space, defined per production process, are combined. What will be presented is the most recent combination from the summer of 2020, which is based on analyses of 13 TeV data.

T 55.4 Wed 16:45 Te

New limit on the Higgs-to-invisible branching fraction based on a combination of ATLAS searches at $\sqrt{s} = 7$, 8 and 13 TeV — •Philipp Mogg — Ludwigs-Maximilians-Universität München

In the Standard Model the Higgs-to-invisible branching fraction is very small, hence, current experiments are not expected so be sensitive to it. However, many extensions of the Standard Model suggest a significantly higher branching ratio, as e.g. Higgs-portal models, where the Higgs boson acts as a mediator between dark matter and ordinary matter. This contribution presents a novel combination by the ATLAS collaboration of different searches sensitive to invisible Higgs decays. Together with the LHC Run 1 search results, the present combination obtains the currently best direct limit on the Higgs-to-invisible branching fraction. The talk will highlight the analyses entering the combination, as well as the interpretations made, as in particular in Higgs-portal dark matter models.

T 55.5 Wed 17:00 Te

Di-higgs physics with the CMS experiment in multilepton final states - Motivation and results — •Torben Lange, Tobias Kramer, Oliver Rieger, and Peter Schleper — Institut für Experimentalphysik, Universität Hamburg

With the conclusion of the LHC Run 2 data taking period an unprecidented amount of high energy collision data is now available. The dataset consists of 137 fb^{-1} recorded by the CMS experiment at a center of mass energy of $\sqrt{s} = 13$ TeV. This allows for the study of rare processes including the production of two SM higgs bosons either with our without the so far unmeasured trilinear di-higgs self coupling or BSM physics. The presented analysis is the first CMS search for di-higgs processes in the multilepton final states motivated by $h \to WW$ and $h \to \tau\tau$ decays. It aims at providing limits on the trilinear higgs self coupling as well as various cross section limits for BSM scenarios featuring either EFT modified couplings or heavy resonances decaying into higgs bosons. This talk focuses on the theoretical motivation and projected results of the presented analysis. There is a second talk focusing on the experimental methodology.

T 55.6 Wed 17:15 Te

Di-Higgs physics with the CMS experiment in multilepton final states - Experimental methodology — •Tobias Kramer, Torben Lange, Oliver Rieger, and Peter Schleper — Institut für Experimentalphysik, Universität Hamburg

The first CMS analysis searching for di-Higgs events in multilepton final states is presented. The full LHC Run 2 dataset corresponding to 137 fb^{-1} recorded by the CMS experiment at a center of mass energy of $\sqrt{s} = 13$ TeV is used. Several scenarios for producing events with two SM Higgs bosons are considered, such as the decay of heavy resonances as well as non-resonant production via the SM as well as EFT modified couplings. The targeted Higgs decays are $h \to WW$ and $h \to \tau\tau$ leading to various multilepton final states. The analysis aims at providing limits on the yet to be discovered trilinear Higgs self coupling as well as cross section limits for different BSM scenarios. This talk focuses on the experimental challenges. There is a second talk about the theoretical motivation and projected results.

T 55.7 Wed 17:30 Te

Search for pair-produced Higgs bosons decaying to W bosons and bottom quarks at CMS — •Mathis Frahm, Johannes Haller, Matthias Schröder, Dennis Schwarz, and Roman Kogler — Institut für Experimentalphysik, Universität Hamburg

The Higgs boson self-coupling is an important parameter of the Standard Model, since it is related to the shape of the Higgs potential. At the LHC, this parameter can be probed by measuring the Higgs boson pair production cross section. In the Standard Model, HH production occurs in processes that include the Higgs-boson self-coupling and in processes that include a fermion loop. Due to destructive interference of these two contributions, the resulting production cross-section is small, amounting to only 33 fb at the LHC.

In this talk, studies of the properties and the reconstruction of the signal are presented, focusing on the decay channel of two W bosons and two bottom quarks, where one W boson decays leptonically and the other one hadronically.

T 55.8 Wed 17:45 Te

Search for non-resonant di-Higgs production in the decay channel bbWW with one leptonically decaying W boson with the CMS experiment. — Martin Erdmann, Peter Fackeldey, Benjamin Fischer, and •Dennis Noll — III. Physikalisches Institut A - RWTH Aachen University

A measurement of the di-Higgs production can directly determine the trilinear Higgs coupling and probe the structure of the Higgs potential.

We present a search for Higgs boson pair production with one Higgs boson decaying into b quarks and the other one decaying into W bosons, with one W boson decaying leptonically. The search works in different kinematic regions (resolved or boosted Higgs decays) and on different flavours of the final state lepton (electron or muon).

The core of the analysis is a Neural Network driven Physics Process Multi-classification using a specialised physics motivated architecture, the Lorentz-Boost Network (LBN), in conjunction with a Residual Neural Network.

Expected limits, based on simulations corresponding to the Full Run 2 dataset, are presented.

T 55.9 Wed 18:00 Te

Search for non-resonant di-Higgs production in the decay channel bbWW with two leptonically decaying W boson with the CMS experiment — Martin Erdmann, •Peter Fackeldey, Benjamin Fischer, and Dennis Noll — III. Physikalisches Institut A - RWTH Aachen University

A measurement of the di-Higgs boson production constitutes a direct test of the electroweak symmetry breaking in the standard model of particle physics (SM). The coupling strength between three Higgs bosons (self-coupling) determines the shape of the Higgs potential and thus the vacuum stability of the universe. The cross section of the di-Higgs boson production is about a factor of thousand smaller in comparison to a single SM Higgs boson, making it a highly challenging statistically search.

The expected sensitivity for the HH→bbWW($l\nu l\nu$) final state is shown corresponding to Run II data.

T 55.10 Wed 18:15 Te

Search for Di-Higgs production in the $bb\gamma\gamma$ final state with the ATLAS detector — •Florian Beisiegel, Jochen Dingfelder, and Tatjana Lenz — Physikalisches Institut, Universität Bonn

The discovery of the Higgs boson in 2012 was a great success of modern particle physics since it served as a proof of the Higgs mechanism introduced in 1964. One focus of the current particle physics experiments at the LHC is the measurement of the Higgs properties, such as its coupling strengths to fundamental particles. In addition to the coupling of the Higgs boson to fermions and gauge bosons, the Higgs mechanism also predicts a Higgs self-coupling. The triple-Higgs self-coupling can be measured in the di-Higgs production channel (non-resonant production). Di-Higgs analyses also facilitate the search for new heavy particles that decay to two Higgs bosons (resonant production).

This talk presents a search for Di-Higgs production in the $bb\gamma\gamma$ final state using 139 fb^{-1} of proton-proton collisions at 13 TeV recorded with the ATLAS detector. The analysis aims to measure the non-resonant SM HH production cross section and the Higgs boson self-coupling as well as search for resonant di-Higgs production. The focus is put on studies to improve the limits on the non-resonant SM production cross-section using a 2D fit in the $m_{\gamma\gamma}$ and m_{bb} variables.

T 56: Flavour physics III

Time: Wednesday 16:00–18:30 Location: Tf

T 56.1 Wed 16:00 Tf

Contribution of the Darwin operator to non-leptonic decays of heavy quarks — •Maria Laura Piscopo, Aleksey Rusov, and Alexander Lenz — Center for Particle Physics Siegen, Theoretische Physik 1, Universität Siegen

We compute the Darwin operator contribution ($1/m_b^3$ correction) to the width of the inclusive non-leptonic decay of a B meson (B^+, B_d or B_s), stemming from the quark flavour-changing transition $b \to q_1\bar{q}_2 q_3$, where $q_1, q_2 = u, c$ and $q_3 = d, s$. The key ideas of the computation are the local expansion of the quark propagator in the external gluon field including terms with a covariant derivative of the gluon field strength tensor and the standard technique of the Heavy Quark Expansion (HQE). We confirm the previously known expressions of the $1/m_b^3$ contributions to the semi-leptonic decay $b \to q_1\ell\bar{\nu}_\ell$, with $\ell = e, \mu, \tau$ and of the $1/m_b^2$ contributions to the non-leptonic modes. We find that this new term can give a sizeable correction of about $-4\,\%$ to the non-leptonic decay width of a B meson. For B_d and B_s mesons this turns out to be the dominant correction to the free b-quark decay, while for the B^+ meson the Darwin term gives the second most important correction - roughly 1/2 to 1/3 of the phase space enhanced Pauli interference contribution. Due to the tiny experimental uncertainties in lifetime measurements the incorporation of the Darwin term contribution is crucial for precision tests of the Standard Model.

T 56.2 Wed 16:15 Tf

Investigation of $B \to \mu\nu$ with inclusive tagging at Belle II — Florian Bernlochner, Jochen Dingfelder, Svenja Granderath, •Daniel Jacobi, and Peter Lewis for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

$B\overline{B}$ meson pairs are the dominant decay products of the $\Upsilon(4S)$ resonance, which is produced in large amounts in e^+e^- collisions at the SuperKEKB collider in Japan, and their decays are measured by the Belle II experiment. Leptonic B meson decays, such as the investigated $B \to \mu\nu$ decay, are highly suppressed, both due to Cabibbo-Kobayashi-Maskawa matrix element V_{ub} and helicity arguments. In a two-body decay like $B \to \mu\nu$, the muon momentum is exactly known in the rest frame of the signal-side B meson. By boosting the signal-side muon into that frame, a better signal resolution and improved sensitivity can thus be achieved compared to the center-of-mass frame. This requires a high-precision boost vector, which can be determined by studying the rest of the event that contains the decay products of the second B meson. This indirectly reconstructs the signal-side B meson kinematics, since in the center-of-mass frame of the e^+e^- collision the B mesons are produced with equal energy and equal but opposite momentum. This talk will discuss the current status of the analysis and possible approaches toward improving the sensitivity of measuring $B \to \mu\nu$ at Belle II.

T 56.3 Wed 16:30 Tf

QCD factorization of the four-lepton decay $B^- \to \ell\bar{\nu}_\ell\ell'\bar{\ell}'$ — Martin Beneke[1], Philipp Boer[1], •Panagiotis Rigatos[1], and Keri Vos[2] — [1]Technical University of Munich — [2]Maastricht University

The radiative decay $B^- \to \gamma\ell\bar{\nu}_\ell$ has been extensively studied in the context of QCD factorization, when the energy of the photon is large compared to the scale of strong interaction $\Lambda_{\rm QCD}$. The branching ratio of this decay depends strongly on the first inverse moment of the B meson light-cone distribution amplitude (LCDA), an important, poorly constrained, non-pertubative parameter for the QCD factorization of other hadronic decays. In this work we consider the same decay with an off-shell photon which further decays into a lepton pair ($\ell, \ell' = e, \mu$), resulting in the exclusive four lepton decay $B^- \to \ell\bar{\nu}_\ell\gamma^* \to \ell\bar{\nu}_\ell\ell'\bar{\ell}'$. We investigate whether these decays retain sensitivity on λ_B and provide decay rate estimates for the case of identical and non-identical leptons.

T 56.4 Wed 16:45 Tf

Measurement of the photon energy spectrum in the fully-inclusive hadronic-tagged $B \to X_s\gamma$ decays at the Belle II experiment — •Henrikas Svidras — DESY, Notkestraße 85, 22607 Hamburg, Germany

Belle II is an experiment at the next-generation B factory SuperKEKB located at KEK in Tsukuba, Japan. It aims to probe heavy flavour physics at a higher precision than its predecessors, namely BaBar and Belle. The goal is to collect 50 ab^{-1} of data during its run: more than 50 times that of Belle. One of the particularly promising decay channels to study is the inclusive radiative $B \to X_s\gamma$ decay, where X_s denotes any possible decay products containing an s quark and γ is a high-energetic photon. This decay can provide constraints for beyond-SM theories, for example by measuring CP asymmetries, and be used to extract important parameters such as the b quark mass. The analysis presented in this talk focuses on the hadronic-tagged fully-inclusive approach, where one of the daughter B mesons of the $\Upsilon(4S) \to B\bar{B}$ decays into hadrons. The extraction of the photon energy spectrum of the $B \to X_s\gamma$ is one of the goals of the analysis. The talk presents an overview of the aspects and challenges of this measurement at Belle II.

T 56.5 Wed 17:00 Tf

Towards completion of the four-body contributions to $\bar{B} \to X_s\gamma$ — •Lars-Thorben Moos and Tobias Huber — Center for Particle Physics Siegen, Theoretische Physik 1, Universität Siegen

The inlusive radiative $\bar{B} \to X_s\gamma$ decay constitutes an important pillar in the indirect search for new physics and allows to constrain the parameter space of many models.

In this talk we present the ongoing efforts in the computation of four-body contributions to the process $\bar{B} \to X_s\gamma$, namely those of $b \to s\bar{q}q\gamma$ at NLO in the strong coupling and the necessary complementing 5-particle cuts of the gluon-bremsstrahlung $b \to s\bar{q}q\gamma + g$.

Although these corrections are expected to be small, this computation formally completes the NLO contributions to $\bar{B} \to X_s\gamma$.

Since the anomalous dimensions are already computed to a sufficient order, the main tasks are the systematic generation of the 1-loop amplitude, the automation of the phase space integration, the infrared-regularization and finally the renormalization of the diagrams including the operator mixing.

The results obtained so far are shown and the further structure of the calculation is outlined.

T 56.6 Wed 17:15 Tf

Measurement of inclusive $B \to X_u\ell\nu$ decay with hadronic tagging at Belle — Forian Bernlochner, •Lu Cao, William Sutcliffe, and Raynette van Tonder for the Belle-Collaboration — Physikalisches Institut, Universität Bonn, Germany

Precise measurement of the CKM matrix element $|V_{ub}|$ permits a stringent test of the Standard Model (SM) of particle physics through its role of constraining the apex of the unitarity triangle. The sizeable tension between the exclusive and inclusive determinations of $|V_{ub}|$ is limiting the precision of this test, which evoked many investigations in the past decades. With the full data set of the Belle experiment comprising 772 million $B\bar{B}$ pairs, we measure partial branching fractions in three phase-space regions covering about 31% to 86% of the accessible $B \to X_u\ell\nu$ phase-space. The $|V_{ub}|$ value is extracted based on a two-dimensional fit of the hadronic mass spectrum and the four-momentum transfer squared distribution in the phase-space of $E_\ell^B > 1$ GeV. In addition, the unfolded differential distributions of the key kinematic variables will be provided for the first time, which are crucial for future model-independent determinations of $|V_{ub}|$.

T 56.7 Wed 17:30 Tf

The differential B-meson semi-leptonic width at NLO — Thomas Mannel, •Daniel Moreno, and Alexei A. Pivovarov — NN, Center for Particle Physics Siegen, Theoretische Physik 1, Universität Siegen

In this talk we present a new approach based on Heavy Quark Effective Theory (HQET) to compute the B-meson semi-leptonic decay width differential in the lepton pair energy. The key feature is the use of the spectral representation of the leptonic loop. The new setup allows for a systematic computation of corrections and the possibility to compute moments of the distribution with lepton energy cuts. We develop our method for the computation of α_s corrections, which requires the computation of the imaginary part of two loop integrals with two masses.

T 56.8 Wed 17:45 Tf

Measurement of the q^2 moments in semi-leptonic B meson decays at Belle II — Jochen Dingfelder, Florian Bernlochner, and •Maximilian Welsch — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The determination of inclusive $|V_{cb}|$ from $b \to c\ell\nu$ decays relies on the Heavy Quark Expansion (HQE) involving coefficients and associated non-perturbative matrix elements, which can be expressed in terms of a number of expansion parameters. The moments of the kinematic distribution of the decay can be computed in a similar manner and are dependent on the same HQE parameters. Consequently, measurements of such moments can be used to better constrain the expansion parameters and, thereby, more precisely determine $|V_{cb}|$. In this talk, we present the first measurement of the q^2 moments of $B \to X_c\ell\nu$ decays with $74\,\text{fb}^{-1}$ of Belle II data. The q^2 moments of the $b \to c\ell\nu$ transition are particularly powerful for constraining the HQE expansion as they can be expressed in terms of a reduced set of non-perturbative parameters due to reparametrization invariance.

T 56.9 Wed 18:00 Tf

Tagged analysis of $B \to \pi\ell\nu$ at Belle — Florian Bernlochner, Jochen Dingfelder, •Jonathan Grumke, and Peter Lewis for the Belle-Collaboration — Physikalisches Institut, Bonn, Germany

We study the exclusive semileptonic decay $B \to \pi\ell\nu$, where ℓ is an electron or muon, with the Belle experiment at KEK in Tsukuba, Japan. From 1999 to 2010 Belle collected events from electron-positron collisions at a center-of-mass energy corresponding to the mass of the $\Upsilon(4S)$ resonance which almost always decays into a pair of B mesons. Events are tagged by fully reconstructing one B meson in a hadronic decay mode using the Full Event Interpretation algorithm. The remaining unassigned tracks are used to reconstruct the signal side B meson from a pion and lepton candidate. The hadronic B tagging allows for a precise reconstruction of the kinematics of the signal B meson and therefore a good signal-to-background ratio, but requires a large data set due to its small efficiency. In this talk, the general analysis strategy and status of the tagged $B \to \pi\ell\nu$ analysis is presented.

T 56.10 Wed 18:15 Tf

Untagged Analysis of $B \to \pi\ell\bar{\nu}_\ell$ using Early Belle II Data — Florian Bernlochner, Jochen Dingfelder, •Svenja Granderath, and Peter Lewis for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

A discrepancy between the results of exclusive and inclusive measurements of the CKM matrix element $|V_{ub}|$ persists. The charmless semileptonic decay $B \to \pi\ell\bar{\nu}_\ell$ is one of the most accessible and powerful channels for determining $|V_{ub}|$ in exclusive modes. Using data from the Belle II experiment, a new precision measurement of $|V_{ub}|$ will become possible. In preparation for this, an untagged measurement method for extracting $B \to \pi\ell\bar{\nu}_\ell$ events is developed using early Belle II data. Lepton and pion candidates are combined to form $B \to \pi\ell\bar{\nu}_\ell$ candidates. In order to increase the signal purity, a boosted decision tree is employed to suppress continuum and other backgrounds. This talk will discuss the current status of the analysis and present an outlook on the precision of future Belle II $|V_{ub}|$ measurements.

T 57: Calorimeters I

Time: Wednesday 16:00–18:00 Location: Tg

T 57.1 Wed 16:00 Tg

Even π-er: High Fidelity Simulation of Pion Showers with High Speed — •Sascha Diefenbacher — Institut für Experimentalphysik, Universität Hamburg, Deutschland

Simulations of particle collisions play an irreplaceable part in particle physics analyses. A significant part of the time required for these simulations has to be dedicated to modeling particle showers. As collider luminosities continue to increase, the demand for simulated data, and thereby the required simulation time, increases with it. It is therefore imperative that we find ways to speed up these costly simulations. In previous works we managed to show that generative machine learning models can be used to simulate electromagnetic photon showers significantly faster than classical simulations methods. Building on this success we now attempt to extend our generative setups to simulate pion showers. Compared to the electromagnetic showers these pion showers feature significantly more variance in their structure, which presents an additional challenge for the generative models. We present ongoing results using a Generative Adversarial Network (GAN), a Wasserstein GAN (WGAN) and a Bounded Information Bottleneck Autoencoder (BIB-AE).

T 57.2 Wed 16:15 Tg

Performance of neutron irradiated SiPM for the CMS HGCAL — •Carmen Victoria Villalba Petro, Erika Garutti, and Joern Schwandt — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

The CMS Collaboration has proposed a high granularity calorimeter (HGCAL) to replace the endcap calorimeter as part of the HL-LHC up-

grade. In the region covered by plastic scintillators a fluence of 8x10^{13} n_{eq}/cm^2 is expected. Operating SiPMs in this high radiation environment increases dark count rate and correlated noise, making it not possible to detect single photons anymore. Candidate SiPMs are MPPC S14160-9766 (8480 pixels) and S14160-9768 (17520 pixels), both with pixel size 15μm. The aim of this study is to characterize Light Yield (LY) and Signal-to-Noise Ratio (SNR) of a plastic scintillator tile coupled to the SiPM in response to a MIP. SNR has been calculated as the ratio between the MIP integrated charge and the standard deviation of the pedestal. For LY the MIP integrated charge is normalized to the SiPM gain obtained with low intensity laser light illumination. It is presented a method to record charge spectra illuminating the SiPMs by a pulsed laser and using a beta source. To characterise effects before and after irradiation the analysis of the charge-voltage measurements are performed at different temperatures, irradiation fluences and integration gate lengths. It has been observed that the noise increases and the charge collection efficiency decreases with fluence. Both effects are mitigated by reducing the temperature. To obtain a maximum in SNR gate length and bias voltage can be optimized.

T 57.3 Wed 16:30 Tg

Investigation of neutron-induced radiation damage on SiPMs — •Laura Büttgen, Erika Garutti, and Jörn Schwandt — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

Silicon Photomultipliers are photosensors employed in many HEP detectors. Their radiation hardness is subject of intense investigation. For the upgrade of the CMS detector SiPMs should be exposed to fluences up to 5×10^{13} cm^{-2} in the High Granularity Calorimeter (HGCAL) and up to 2×10^{14} cm^{-2} in the barrel timing layer. In this study twenty SiPMs from Hamamatsu with the serial number S14160-9766 and S14160-9768 were characterized and the effects of neutron irradiation with different fluences were analyzed. For the analysis current-voltage measurements, capacitance-frequency-voltage measurements and charge-voltage measurements have been performed.

Due to irradiation an increase of six orders of magnitude of dark current was found after irradiation. Furthermore an evidence of the decrease of the photodetection efficiency after irradiation will be presented. The quantification of the reduction is still subject of investigation and may depend on the effect of self-heating of the SiPM. As self-heating effects one describes the increase of temperature induced in the SiPM pixels by high currents, for instance due to high frequency dark noise, or light detection. Variations in temperature lead to a shift in the breakdown voltage, which if not corrected causes a change of all SiPM performance parameters. This effect is also described and first measurements are attempted to quantify it.

T 57.4 Wed 16:45 Tg

The new fast calorimeter simulation of the ATLAS detector — •Joshua Beirer[1,2], Michael Duehrssen[1], and Stan Lai[2] — [1]CERN — [2]Georg-August-Universität Göttingen

The simulation of physics processes is one of the most essential tools for all types of measurements and searches at hadron colliders. However, the production of simulated events is a highly CPU intensive task and the limited amount of Monte Carlo (MC) events is already one of the largest sources of systematic uncertainties in many ATLAS physics analyses. The main bottleneck of the simulation is the detailed detector simulation with Geant4, for which most of the simulation time is needed to simulate the calorimeter response. In order to increase the amount of produced MC events, ATLAS has successfully employed a fast calorimeter simulation (FastCaloSim) during Run 1 and 2 of the LHC. FastCaloSim parametrizes the energy response of particles in the calorimeter cells, taking into account the lateral shower profile and the correlation between the energy depositions in the various layers of the calorimeter. In recent years, an improved version of FastCaloSim has been developed, which uses machine learning techniques such as principal component analysis and neural networks, and has been shown to considerably improve the simulation while reducing the required CPU time per simulated event.

In this talk, an overview of the new fast simulation of the ATLAS calorimeter, which is planned to be deployed imminently, will be given. Not only will recent developments be discussed, but future possible improvements will also be outlined.

T 57.5 Wed 17:00 Tg

Artificial Neural Networks for the Energy Reconstruction of ATLAS Liquid-Argon Calorimeter Signals — •Anne-Sophie Berthold, Nick Fritzsche, Wolfgang Mader, Arno Straessner, and Johann Christoph Voigt — Institut für Kern- und Teilchenphysik, Dresden, Deutschland

Starting in 2027, the enhanced performance of the High-Luminosity LHC will increase the number of particle collisions in the ATLAS detector significantly. The Phase-II upgrade of the detector aims to cope with that. Since up to 200 pile-up events will emerge within one bunch crossing, one important part of this upgrade will be the processing of the Liquid-Argon Calorimeter signals. It has been shown that the conventional signal processing, which applies an optimal filtering algorithm, will loose its performance due to the increase of overlapping signals and a trigger scheme with trigger accept signals in each LHC bunch crossing. That is why more sophisticated algorithms such as neural networks come into focus. This talk will deal with the development and performance of convolutional neural networks, which on the one hand aim to detect signals and reconstruct their energy under various conditions, and on the other hand need to satisfy resource restrictions.

T 57.6 Wed 17:15 Tg

Beam Tests of the first CMS HGCAL Tilemodule prototypes — •Malinda de Silva, Mathias Reinecke, Ole Bach, Katja Krüger, and Felix Sefkow — Deutsches Elektronen-Synchrotron (DESY)

For the HL-LHC phase, the calorimeter endcap of the CMS detector will be upgraded with a High Granularity Calorimeter (HGCAL), a sampling calorimeter which will use silicon sensors as well as scintillator tiles read out by silicon photomultiplier (SiPMs) as active material (SiPM-on-tile). The complete HGCAL will be operated at -30 °C. The SiPMs will be used in areas where the expected radiation dose during the lifetime of the detector is up to 5x10^13 neq/cm^2. The design of the SiPM-on-tile part is inspired by the CALICE AHCAL.

The basic detector unit in the SiPM-on-tile part is the tile module, consisting of a PCB with one or two HGCROC ASICs, reading out up to 96 tiles with SiPMs. The first functional tile module prototypes have been constructed with HGCROC2 ASICs and SiPMs which are candidates for the HGCAL production. They have undergone beam tests at DESY and Fermilab, investigating the interplay of the components and evaluating the performance with several scintillator tile types. The first test with irradiated SiPMs was also performed. We will report on these tests, which were all performed in 2020, and the work still to come using beams.

T 57.7 Wed 17:30 Tg

New concept for a calorimeter with shower direction reconstruction — •Matei Climescu, Phi Chau, and Rainer Wanke for the SHiP-SBT-Collaboration — Universität Mainz

The SplitCAL is a mixed electromagnetic-hadronic calorimeter designed to provide both energy reconstruction through regular layers and shower direction information through high-precision layers. This can be used for fixed target experiments which require high geometrical precision. The development needs to account for low rates but large dynamic range. The technology, the performance and the challenges are presented here.

T 57.8 Wed 17:45 Tg

Particle identification using boosted decision trees for the CALICE highly granular SiPM-on tile calorimeter. — •Vladimir Bocharnikov for the CALICE-D-Collaboration — DESY, Hamburg — NRNU MEPhI Moscow, Russia

The Analog Hadron Calorimeter (AHCAL) is a highly granular SiPM-on-tile sampling calorimeter developed by the CALICE collaboration for future e^+e^- colliders such as the International Linear Collider (ILC) or the Compact Linear Collider (CLIC). The AHCAL technological prototype consists of 39 active layers alternating with 1.72 cm steel absorber plates. Each active layer is equipped with 576 3×3 cm^2 scintillator tiles with individual readout by silicon photomultipliers. The prototype was tested with muon, electron and pion beams at the CERN SPS facilities in 2018. The high granularity provides detailed spatial information about energy depositions of particles in the detector material that can be used for the event characterisation. We perform a gradient boosted decision tree method to classify events according to incoming particle type. Monte-Carlo simulations were used to train and test the classification model. In this contribution, the particle identification method, its efficiency in simulations and the results of data purification will be discussed.

T 58: Gamma astronomy I

Time: Wednesday 16:00–18:25 Location: Th

Group Report T 58.1 Wed 16:00 Th

The MAGIC gamma-ray telescopes: Highlights and recent developments — •Moritz Hütten for the MAGIC-Collaboration — Max-Planck-Institut für Physik, München, Germany

MAGIC is a stereoscopic system of two imaging-atmospheric Cherenkov telescopes located on the Canary island of La Palma. MAGIC is measuring very-high-energy (VHE) gamma rays in the range from $\sim$ 20 GeV to 100 TeV from to date more than 70 astrophysical sources of Galactic and extragalactic origin, up to distances of redshift $\sim$ 1. During the last years, the instrumental performance was enhanced by several upgrades. In this report, we present recent highlights of the diverse science programme: Galactic observations of the Geminga and Crab pulsars above 20 GeV and of the Crab Nebula up to 100 TeV; the measurement of the extragalactic background light and multi-wavelength observations of AGN flares; and fundamental physics searches for Lorentz Invariance Violation and combined searches for Dark Matter. A special focus will be drawn on MAGIC's transient programme with multiple recent results, including the discussion of GRB190114C, the first gamma-ray burst found to emit photons at TeV energies.

T 58.2 Wed 16:20 Th

The Intermittently Extreme Behaviour of the High-peaked BL Lac Type Blazar 1ES 2344+514 — •Axel Arbet-Engels[1], Daniela Dorner[2], and Marina Manganaro for the FACT and MAGIC Collaborations[3] — [1]ETH Zürich, Switzerland — [2]Universität Würzburg, Würzburg, Germany — [3]University of Rijeka, Rijeka, Croatia

MAGIC and FACT investigate the very-high-energy (E>100GeV) gamma rays emitted by BL Lac type objects, which are active galactic nuclei with a relativistic jet pointing towards the observer. Past observations have revealed that the VHE emitting BL Lac type object 1ES2344+514 shows strong flux variability and the spectral energy distribution shifts towards unusually high energies during active states. Previous studies show that the synchrotron component could reach a peak frequency above 1 keV during some past flares, making it a member of the extreme high-peaked BL Lac family. We present results of a dense multi-wavelength observing campaign during a flaring event of 1ES2344+514 in August 2016. The VHE flux measured by MAGIC and FACT is comparable to the historical maximum observed in 1995 by Whipple. The X-ray spectrum is hard with a shift of the synchrotron peak frequency by more than an order of magnitude with respect to low activity states, implying an intermittent extreme high-peaked BL Lac behaviour. Combining multi-wavelength observations, we obtain an unprecedented characterisation of the inverse Compton component during a flare. We interpret the emission within a leptonic and hadronic scenario.

T 58.3 Wed 16:35 Th

Analyses of Neutrino Follow-Up Observations of IC171106 and IC190922 with MAGIC — •Hendrik Bökenkamp for the MAGIC-Collaboration — TU Dortmund, Experimentelle Physik Vb, Deutschland

One of the long-standing questions in astroparticle physics is the origin of the measured cosmic neutrino flux. In order to understand physical processes of neutrino sources, it is crucial to find correlations to other cosmic messengers like gamma-rays. In the framework of multi-messenger programs, the MAGIC telescopes are doing the follow-up of neutrino alerts by IceCube. The two Cherenkov telescopes are measuring very high energy (VHE) gamma-rays in the range between 20 GeV and 100 TeV and are located in the Canary Island of La Palma.

In 2017 it was the very first time that VHE gamma-rays were observed by MAGIC coincidently with a neutrino from IceCube. Both, the gamma-rays and the neutrino could be assigned to the the blazar TXS 0506+056.

Two of the follow-up observations with MAGIC in recent years are presented here. MAGIC data from the neutrino alerts IC190922 and IC171106A are analyzed to extract source information by using the MAGIC analysis software `MARS`. With this procedure the significance of these sources is presented.

T 58.4 Wed 16:50 Th

The MAM telescope subsystem of MAGIC as a monitor for atmospheric transmission — •Marine Pihet, Jürgen Besenrieder, and Razmik Mirzoyan for the MAGIC-Collaboration — Max Planck Institute for Physics, Munich

Monitoring of atmospheric transmission is a crucial part for the measurement and analysis of data from Imaging Atmospheric Cherenkov Telescopes like the MAGIC telescopes, located at the Roque de los Muchachos European Northern Observatory on the Canary Island of La Palma. It is especially important when searching for PeVatron candidate sources emitting gamma rays above 10TeV by using the very large zenith angle (VLZA) observation technique. The latter significantly increases the collection area and as a result increases the detection rate of gamma rays by the MAGIC telescopes at the highest energies. In this report, we present the current work on the MAGIC Atmosphere Minion (MAM) telescope as an optical subsystem of MAGIC for atmospheric monitoring. It includes a 5-inch and an 11-inch optical telescope with a CMOS and a CCD camera respectively, a filter wheel, and a spectrograph, attached to the 11-inch. All these are mounted on a precision drive system and enclosed in the 2.5 m size high-quality dome from Baader, located just next to the MAGIC-I telescope. We developed a concept for photometric measurements of transmission with MAM at VLZA using aperture photometry and tested it in November 2020. Results from the photometric calibration of the subsystem and recent progress are presented, along with the planned work on improvements and anticipated long term goals.

T 58.5 Wed 17:05 Th

Automated analysis of MAGIC Sum-Trigger-II data — •Jan Lukas Schubert, Simone Mender, and Lena Linhoff for the MAGIC-Collaboration — Technische Universität Dortmund

The MAGIC telescopes are a stereoscopic system of Imaging Air Cherenkov Telescopes. They are used for the detection of gamma-ray sources at energies between tens of GeV and tens of TeV. With Sum-Trigger-II, data with a threshold as low as ~25 GeV can be taken. This data requires a special analysis adapted to the low energies. The aim of this work is to integrate the automated analysis of Sum-Trigger-II data in the automated analysis AutoMAGIC. This will reduce the human interaction needed and enable completely reproducible results.

Later, the automatization of the analysis of Sum-Trigger-II data could be used to compute some standard cleaning thresholds for different conditions for a special cleaning algorithm used in the analysis of Sum-Trigger-II data.

T 58.6 Wed 17:20 Th

Multiwavelength Analysis of NGC1275/3C84 — •Lena Linhoff — TU Dortmund, Dortmund, Germany

The radio galaxy 3C 84 is a well studied source of radio emission and was detected as misaligned blazar NGC 1275 also in the very high-energy regime by gamma-ray detectors like MAGIC and FermiLAT. Unless the innermost structure of 3C 84 can be resolved with radio observations at 43 GHz, the mechanisms producing gamma-ray emission are still not fully understood. A necessary step to understand the production of high-energy photons, is to localize the emission region of gamma-rays in the central region of the source. For this aim, we use calculations of the optical depth within the broad line region to constrain the origin of the gamma-ray emission. In this talk we place our results in the context of theoretical models and other multi-wavelength analysis results.

Group Report T 58.7 Wed 17:35 Th

Performance of the CTA Large Size Telescope — •Martin Will for the CTA-Collaboration — Max-Planck-Institut für Physik, München

The Large Size Telescope (LST) is the largest of the several sizes of telescopes that will comprise the Cherenkov Telescope Array (CTA). With its reflective surface of 23 meters in diameter, the LST is optimized to detect gamma rays in the energy range between 20 and 200 GeV. The use of lightweight materials to construct the telescope is crucial for fast repositioning and follow-up of transients. In 2019, operations of the LST prototype on the Canary island of La Palma started as part of the telescope commissioning. In this presentation, some results on the performance evaluation as well as some prelimi-

nary data on the Crab Nebula and pulsar gamma-ray sources will be presented.

T 58.8 Wed 17:55 Th

Data Volume Reduction for the LST Prototype — •Jonas Hackfeld for the CTA-Collaboration — Institute for theoretical physics IV, Ruhr-University Bochum, Germany

The prototype of the Large Size Telescope (LST) of the Cherenkov Telescope Array (CTA), which is going to be the next-generation gamma-ray observatory, was inaugurated in October 2018 and has already observed several bright gamma-ray sources during its commissioning phase. For the next years, in addition to 3 more LSTs, several Medium Size Telescopes (MST) are planned, which together will form the northern array CTA-N. Due to the locally limited data transfer rates and the technical and economic effort to store data quantities of 100 PByte/year permanently over a planned duration of 30 years, a low level data volume reduction is inevitable. In addition to lossless compression methods for volume reduction, there are lossy methods such as pixel selection. In this process, the pixels with signal are isolated from the background, so that the physics are impacted as minimally as possible during subsequent reconstruction. In this talk, pixel selection algorithms and their impact on higher data level analysis will be presented.

T 58.9 Wed 18:10 Th

Crab Nebula Observations with the LST prototype — •Lukas Nickel für die CTA-Kollaboration — TU Dortmund

The lowest energy range of the Cherenkov Telescope Array, which is going to be the next-generation gamma-ray observatory, will be covered by the Large-Sized Telescope (LST). The prototype of the LST was inaugurated in October 2018 on the Canary Islands of La Palma and has since performed observations of bright gamma-ray sources as part of the commissioning process. In this talk, high-level results of Crab Nebula observations will be presented using the package for gamma-ray astronomy gammapy and the recently reworked code for the generation of the instrument response function pyirf.

T 59: Extended Higgs models II

Time: Wednesday 16:00–18:15 Location: Ti

T 59.1 Wed 16:00 Ti

Search for additional Higgs bosons in $H \to h_S(bb)h(\tau\tau)$ decays in the context of the NMSSM with CMS Run-2 data — •Felix Heyen, Ralf Schmieder, Janek Bechtel, Tim Voigtländer, Günter Quast, Roger Wolf, Sebastian Brommer, and Maximilian Burkhart — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

In the next-to-minimal supersymmetric extension of the Standard Model (NMSSM), modifications to the SM Higgs sector lead to a total of seven Higgs bosons. The decay of a heavy scalar Higgs boson (H) into a light scalar (h_S) and an SM-like Higgs boson (h) is a very promising signature to search for this extension, which has not been addressed by experiments so far. This talk discusses the physics motivation of the NMSSM and introduces the search for such a decay in the $h \to \tau\tau$ and $h_S(bb)$ partonic final state.

T 59.2 Wed 16:15 Ti

Event selection optimization in the $X \to SH \to b\bar{b}WW$ analysis with $\sqrt{s} = 13$ TeV ATLAS data — •Naman Kumar Bhalla, Kira Abeling, Jason Veatch, and Stan Lai — II. Physikaliches Institut, Georg-August-Universität Göttingen

Pair production of the Higgs boson, H, offers a direct measurement of the Higgs potential and is hence a crucial probe for the nature of the Standard Model. Additionally, many Beyond Standard Model scenarios predict heavy resonances, X, with a possible decay to a pair of Higgs bosons. Furthermore, theories such as the "Two Real Scalar Singlet" extension of the Standard model, predict a possible decay of X into another scalar, S, along with a Higgs Boson. The Higgs boson can further decay into a pair of b-quarks while S, with sufficient mass, can decay into a pair of on-shell W bosons. Here, the case where one W boson decays hadronically and the other W boson decays leptonically is considered.

Depending on the relation between the masses of the two additional scalars, m_X and m_S, the kinematic properties of the final state products may differ significantly from $X \to HH \to b\bar{b}WW^*$ decays. Hence, the methods used for event selection such as the classification of the jets observed from the hadronic decay of the W boson and those from the decay of the Higgs boson to a pair of b-quarks are investigated and re-optimized for the $X \to SH$ topology. This talk presents studies performed to optimize such event selection techniques.

T 59.3 Wed 16:30 Ti

Search for $H \to h_S(bb)h(\tau\tau)$ decays with CMS Run-2 data, using NN multi-classification — •Ralf Schmieder, Felix Heyen, Tim Voigtländer, Günter Quast, Roger Wolf, Janek Bechtel, Sebastian Brommer, and Maximilian Burkhart — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

The decay $H \to h_S(bb)h(\tau\tau)$ of a heavy scalar Higgs boson (H) into a light scalar (h_S) and an SM-like Higgs boson (h) is one of the most promising search channels for an next-to-minimal supersymmetric (NMSSM) extension of the SM. This talk summarizes the technical details of the analysis to search for such a decay in the $h \to \tau\tau$ and $h_S(bb)$ partonic final state, using a multiclass neural network categorization. The main challenge arises from training the neural network to a variety of different decay signatures given by the two unconstrained mass parameters of the model.

T 59.4 Wed 16:45 Ti

Constraints on Higgs $\mathcal{CP}$-properties in the Higgs Characterization model from HiggsSignals — •Marco Menen, Tobias Klingl, Tim Stefaniak, Henning Bahl, Philip Bechtle, and Klaus Desch — Rheinische Friedrich-Wilhelms-Universität Bonn

Following the discovery of a Standard Model (SM) like Higgs boson in 2012, many of it's properties are by now determined with high precision from measurements by the ATLAS and CMS experiments. This includes that it is not a pure $\mathcal{CP}$-odd state. However, a possible $\mathcal{CP}$-mixing of the Higgs Boson or a complex $\mathcal{CP}$-structure of it's couplings to individual particles are still allowed.

Many theories of physics beyond the SM (BSM) allow or motivate the introduction of CP violation in the Higgs sector. This can be described within concrete models, such as Supersymmetry or the 2-Higgs-Doublet model, or in different frameworks of effective models. In this talk, the Higgs Characterization (HC) model is presented. It introduces either a global mixing angle α between the two $\mathcal{CP}$ states and/or individual $\mathcal{CP}$-even and $\mathcal{CP}$-odd couplings of the Higgs Boson to SM particles, partly due to BSM higher-dimensional operators.

The programs HiggsBounds and HiggsSignals are used to calculate couplings, rates and limits on additional states, and compare them to available data from the 7, 8 and 13 TeV runs of the LHC at CERN via a statistical χ^2 test. To find constraints on the new parameters of the HC model, a Markov Chain Monte Carlo approach is used and its performance is evaluated against other techniques. The fit results for different realizations of the HC model are presented.

T 59.5 Wed 17:00 Ti

Combined measurements of Effective Field Theories with the ATLAS Experiment — •Carsten Burgard — DESY, Hamburg

The LHC experiments have so far not been able to present discoveries of new physics beyond the Standard Model (SM), be it in the form of Supersymmetry, additional Higgs bosons or other new exotic particles. At present, deeper investigations of the collected data in the form of precision measurements of the most elusive parts of the SM are one of the most promising paths to success in discovering physics beyond the SM. Many analyses in the Higgs sector are progressing from discovery to precision measurement as the dataset grows. Additional statistical precision beyond that can be gained by combining data from different individual analyses, usually focused on specific decay modes. For the measurement of Higgs boson production sections and decay ratios such combinations are well-established, both within ATLAS and across experiments, but a more exciting prospect is the ability to directly measure Wilson coefficients of Effective Field theories from LHC data. A combined simultaneous fit of Wilson coefficients to a subset of ATLAS Higgs data has recently been published. Such a combina-

tion could conceivably incorporate not only Higgs boson data, but also measurements of other SM particles and even other experiments. Novel techniques for these types of measurements need to be developed, such as the use of principal component analyses to identify sensitive directions within an EFT model of the measured data, or the combination of unfolded differential fiducial measurements with results using the simplified template cross section method.

T 59.6 Wed 17:15 Ti

A 96 GeV Higgs Boson in the 2HDMS — •Cheng Li[1,2], Steven Paasch[1,2], Gudrid Moortgat-Pick[1,2], and Sven Heinemeyer[3,4,5] — [1]DESY, Notkestrasse 85, 22607 Hamburg, Germany — [2]II. Institut für Theoretische Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Instituto de Física Teórica (UAM/CSIC), Universidad Autónoma de Madrid, Cantoblanco, 28049, Madrid, Spain — [4]Campus of International Excellence UAM+CSIC, Cantoblanco, 28049, Madrid, Spain — [5]Instituto de Física de Cantabria (CSIC-UC), 39005, Santander, Spain

CMS reported a $\sim 3\sigma$ excess at ~ 96 GeV in the $pp \to H \to \gamma\gamma$ channel. In the same mass range a $\sim 2\sigma$ excess in the $e^+e^- \to ZH, H \to b\bar{b}$ channel has been reported at LEP as well. We interpret the experimental excesses as the lightest Higgs boson in the Two-Higgs-Doublet Model with a complex singlet (2HDMS) with type II Yukawa structure. We demonstrate the the model can fit both excess simultaneously, while being in agreement with all other existing theoretical and experimental constraints. In this talk, we will present the scan of parameter space of 2HDMS and discuss the "best fit" points from the scan. Furthermore, we will also study the experimental uncertainties of specific Higgs couplings that can be obtained at the future International Linear Collider (ILC) with 250 GeV center-of-mass energy.

T 59.7 Wed 17:30 Ti

Influence of Higgs potential parameters on Dark Matter observables in a Two Higgs Doublet Model with a complex singlet — Juhi Dutta, Gudrid Moortgat-Pick, and •Merle Schreiber — II. Institute for Theoretical Physics, University Hamburg, Hamburg, Germany

Since the Standard Model of particle physics (SM) cannot explain the Dark Matter (DM) observed in the Universe, it is interesting to look at extensions of the SM, which include a DM candidate. An interesting new physics candidate is the Two Higgs Doublet Model (THDM) with an additional complex singlet, which provides a DM candidate that has a mass and interacts weakly with the Higgs doublets.

In this talk I will explore how the Higgs potential parameters of a THDM with a complex singlet influence DM observables, specifically the DM relic density and the cross section of direct detection processes. This is in order to understand how to find a parameter configuration that matches the experimental observations available and then make predictions on how to potentially observe this model in experiments and distinguish it form other extensions of the SM.

T 59.8 Wed 17:45 Ti

Search for charged Higgs bosons in $H^+ \to Wh \to qqbb$ decay channel — •Shubham Bansal, Jochen Dingfelder, and Tatjana Lenz — Physikalisches Institut, Universität Bonn

The observation of a heavy charged scalar particle (H^+) would clearly indicate physics beyond the Standard Model. Charged Higgs bosons are predicted by several non-minimal Higgs scenarios, one of which is the two-Higgs-Doublet Model (2HDM). The H^+ production mechanism and decay modes at the tree level depend on its mass (m_{H^+}) and two parameters namely, α, the mixing angle between the neutral CP-even Higgs bosons, and tanβ, the ratio of the vacuum expectation values of the two Higgs doublets.

For $m_{H^+} > m_t + m_b$, the leading production mode of H^+ at the LHC is the associated production with a top and a bottom quark via $gg \to tbH^+$, and in the alignment limit for 2HDM when cos $(\beta-\alpha) \approx 0$, the dominant decay mode is $H^+ \to tb$. Nevertheless, it is possible to attain sizable branching ratios for $H^+ \to Wh$ in the 2HDM scenarios where the 125 GeV Higgs is the heaviest CP-even scalar, and in a few other scenarios such as the N2HDM and the Georgi-Machacek (GM) model. This talk focuses on the first studies of the $H^+ \to Wh \to qqbb$ decay channel in ATLAS Run-2 data.

T 59.9 Wed 18:00 Ti

Search for a low mass charged Higgs decaying to cs — •Christian Nass, Tatjana Lenz, and Jochen Dingfelder — Physikalisches Institut, Universität Bonn, Deutschland

In the Standard Model (SM) electroweak symmetry breaking (EWSB) is introduced by a single complex scalar field. The consequence is the prediction of a scalar, neutrally charged particle, the Higgs Boson, which was discovered in 2012 at the LHC. The simplest extension of the SM is to introduce EWSB through two complex scalar fields. This theory is called two Higgs doublet model (2HDM) and is very prominent because it offers opportunity to include additional CP-violation in the SM, which is needed for explaining baryogenesis. It features 3 neutral and 2 charged Bosons. Observation of such a charged scalar would be a striking signal for physics beyond the SM.

In the low mass region, i.e. $m_H^{\pm} < m_t$, the dominant production mode is by a $t\bar{t}$ pair with one t-quark decaying to $H^{\pm}b$. It is advised by several theory papers to search for $H^p m \to cs$ decays in the low mass region. Compared to previous analyses the sensitivity is expected to be higher, because statistics is higher, b-tagging and other techniques improved, and the introduction of new tools, i.e. c-tagging or multivariate analysis techniques. This search in Run-2 ATLAS data at 13 TeV will be presented.

T 60: Silicon Strip Detectors I

Time: Wednesday 16:00–18:15 Location: Tj

T 60.1 Wed 16:00 Tj

Track Reconstruction with the FASER detector with ACTS — Florian Bernlochner, Jochen Dingfelder, Markus Prim, and •Tobias Böckh — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The Faser (ForwArd Search ExpeRiment) experiment is located 480m downstream from the ATLAS interaction point at the LHC and is designed to search for light, weakly interacting particles. One of the main goals is the search for a massive dark photon that decays into two charged particles. This requires a good hit resolution and tracking performance to effectively separate the two closely-spaced, oppositely-charged tracks. In this talk, we will summarize the track reconstruction of FASER, which is based on the experiment-independent toolkit for charged particle track reconstruction ACTS. We will also show first results of the hit resolution with cosmic data and briefly recap the status of the experiment.

T 60.2 Wed 16:15 Tj

Charakterisierung passiver CMOS Sensoren — Marta Baselga[1], Leena Diehl[2], Ingrid-Maria Gregor[1,3], Tomasz Hemperek[3], •Jan Cedric Hönig[2], Ulrich Parzefall[2], Arturo Rodriguez[2], Surabhi Sharma[1], Dennis Sperlich[2], Tianyang Wang[3] und Liv Wiik-Fuchs[1] — [1]Deutsches Elektronen-Synchrotron DESY — [2]Hermann Herder Str.3 — [3]Rheinische Friedrich-Wilhelms-Universität Bonn

Ein Trend in zukünftigen Experimenten der Hochenergiephysik ist es, immer größere Teile des Detektors aus Silizium zu fertigen. Das macht Siliziumsensoren zu einem der größten Kostenpunkte für die Experimente. Ein Weg die Kosten für den Detektor zu senken ist die Nutzung von CMOS Produktionsstraßen, die für die Produktion von Wafern in großen Mengen ausgelegt sind. In diesem Vortrag werden Labormessungen erster Prototypen für passive CMOS Streifensensoren vorgestellt. Es wurden drei Sensortypen, mit Streifenlängen zwischen 2 und 4 cm, auf einem 150 Mikrometer dicken Wafer von LFoundry verwirklicht. Die Sensoren wurden aus einzelnen Elementen durch stitching zu einer Einheit zusammengefasst. Stitching erlaubt es, unter Verwendung von in der Industrie üblichen Masken Strukturen beliebiger Größe auf dem Wafer zu verwirklichen. Ein Hauptanliegen der Studie war die Charakterisierung von Auswirkungen des stitchings auf die Funktionalität der Streifensensoren. Zu diesem Zweck wurden die Sensoren elektrisch charakterisiert. Ferner wurden durch ortsaufgelöste Messungen mit einem Laser, die Konfiguration des elektrischen Feldes und die

Ladungssammlung untersucht.

T 60.3 Wed 16:30 Tj

Charge collection measurements of passive CMOS strip sensors — Marta Baselga[1], Leena Diehl[2], Ingrid-Maria Gregor[1,3], Tomasz Hemperek[3], Jan Cedric Hönig[2], Ulrich Parzefall[2], •Arturo Rodriguez[2], Surabhi Sharma[1], Dennis Sperlich[2], Tianyang Wang[3], and Liv Wiik-Fuchs[1] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]Physikalisches Institut Albert-Ludwigs-Universität Freiburg, Freiburg im Breisgrau, Germany — [3]Universität Bonn, Bonn, Germany

An increasing trend towards full silicon trackers in future high energy physics experiments provokes the need to cover increasingly large areas with silicon detectors. As a consequence, detector designs that utilize cost-effective production processes are becoming more critical. Employing CMOS production lines for strip sensors allow large and high-resistive wafers at low cost, making them a prime candidate for future large scale silicon trackers. The present contribution presents the first laboratory charge collection measurements using a beta source of novel passive unirradiated CMOS silicon strip sensors developed within the market survey for phase two upgrade of the ATLAS detector. The study contains three different strip flavors fabricated by LFoundry on a 150 μm thick wafer with a passive CMOS 150 nm process. The strip sensors have a length of up to 4 cm, formed by the stitching of individual elements. A primary focus was position-dependent measurements to understand the impact of stitching on the functionality of the sensors.

T 60.4 Wed 16:45 Tj

Testbeam studies of passive CMOS strip sensors — Marta Baselga[1], Leena Diehl[2], Ingrid-Maria Gregor[1,3], Tomasz Hemperek[3], Jan Cedric Hönig[2], Ulrich Parzefall[2], Arturo Rodriguez[2], •Surabhi Sharma[1], Dennis Sperlich[2], Tianyang Wang[3], and Liv Wiik-Fuchs[2] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg — [2]Physikalisches Institut Albert-Ludwigs-Universität Freiburg, Freiburg im Breisgrau — [3]Universität Bonn, Bonn, Germany

Future particle physics experiments are motivated by the increase in luminosity and thus the need for intelligent tracking detectors. The next generation tracking detectors are mostly all silicon detectors and thus finding a cost effective solution to maximise the output is important. A recent R&D project is using CMOS technology for silicon strip sensors, which allows large and high-resistive wafers at low cost, making them a prime candidate. Also since CMOS is the commercially fabricated process it provides the advantage of easier production. In this contribution, the test beam measurements at DESY test beam facilities of novel passive unirradiated CMOS silicon strip sensors developed by the ATLAS Collaboration are presented. The sensor is processed by LFoundry on a 150 μm thick wafer, employing a 150 nm CMOS technology and has three different strips design to study. The strip sensors are designed in two different lengths, formed by stitching of individual reticles. The main focus of this test beam measurement is to study the charge collection by the sensor and examine the performance of the stitching.

T 60.5 Wed 17:00 Tj

Characterisation of long-term operation of silicon strip sensors before and after neutron irradiation — •Jonas Lönker, Kevin Kröninger, and Jens Weingarten — TU Dortmund, Experimentelle Physik IV

In order to utilise silicon sensors in tracking detectors for high energy particle physics, their operation needs to be stable and reproducible over long periods of time. This includes, amongst other parameters, the leakage current, the Charge Collection Efficiency (CCE) and the inter-strip capacitance C_{int}.
Presented are results obtained in long-term laboratory measurements on sensors with the same area of roughly 1 cm^2 but different designs regarding their layout and thickness. Between single scans, the sensor is being biased at a constant voltage for a defined period of time. A subset of samples was irradiated with neutrons up to fluences of 5×10^{15} n$_{eq}$ cm^{-2} at the Jožef Stefan Institute in Ljubljana.
The data indicates a shift of C_{int} observed during such consecutive measurements.

T 60.6 Wed 17:15 Tj

Investigation of irradiated silicon strip sensors using the Transient Current Technique — •Nicky Potters[1], Christian Scharf[2], Heiko Lacker[2], and Ingo Bloch[3] — [1]Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany — [2]Humboldt-Universität zu Berlin, Berlin, Germany — [3]Deutsches Elektronen-Synchrotron (DESY), Zeuthen, Germany

A new edge-TCT setup has been built and commissioned at DESY Zeuthen. The setup allows for charge injection at defined depths or at the surfaces of silicon sensors in order to study the detector response (e.g. its charge collection properties).
ATLAS ITk mini strip sensors from the ATLAS17LS prototyping submission have been investigated using red and infrared laser light with 100 ps pulse width and a minimum beam diameter of $\omega_0 = 7$ μm. The current induced by the injected carriers is measured. Information on the electric field can be extracted from the measurements as a function of the position in the sensors.
The sensors were irradiated with 70 MeV/c protons to equivalent fluences from $1.0{\cdot}10^{13}$ cm^2 to $1.3{\cdot}10^{16}$ cm^2 and with 1 MeV neutrons from $4.0 \cdot 10^{14}$ cm^2 to $5.0 \cdot 10^{16}$ cm^2. The position-dependent electric field has been determined by using a novel method of fitting the edge-TCT data. Results of the commissioning of the setup using non-irradiated strip sensors as well as measurements of irradiated strip sensors will be presented.

T 60.7 Wed 17:30 Tj

Strahltest von Siliziumsensormodulen mit bestrahlten Sensoren für das CMS-Experiment — •Roland Koppenhöfer, Tobias Barvich, Justus Braach, Alexander Dierlamm, Ulrich Husemann, Stefan Maier, Thomas Müller, Marius Neufeld, Andreas Nürnberg, Hans Jürgen Simonis, Julian Stanulla, Pia Steck und Florian Wittig — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

Im Rahmen des Phase-2-Upgrades des CMS-Experiments wird der gesamte CMS-Spurdetektor ausgetauscht. Der neue äußere CMS-Spurdetektor wird aus zwei verschiedenartigen Siliziumsensormodulen bestehen (PS- und 2S-Module). Die während der Detektorlaufzeit entstehenden Strahlenschäden verändern die Ladungserzeugung in den Siliziumsensoren. Um zu gewährleisten, dass während der kompletten Laufzeit des CMS-Experimentes das Ladungssignal ausreichend hoch ist um die Detektormodule effizient auslesen zu können, wurde ein 2S-Modul mit bestrahlten Sensoren gebaut und bei einem Strahltest am Deutschen Elektronen-Synchrotron vermessen. Der Vortrag stellt die in diesem Strahltest erzielten Ergebnisse vor.

T 60.8 Wed 17:45 Tj

Hochratenstudien der Auslesekette von 2S-Modulen für das Phase-2 Upgrade des CMS-Experiments — •Alexander Droll, Tobias Barvich, Alexander Dierlamm, Ulrich Husemann, Stefan Maier, Thomas Müller, Jan-Ole Müller-Gosewisch, Marius Neufeld, Andreas Nürnberg, Hans Jürgen Simonis, Julian Stanulla und Pia Steck — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

Das Phase-2 Upgrade des CMS-Experiments beinhaltet den Austausch des kompletten Spurdetektors. Der neue Spurdetektor wird aus zwei verschiedenen Modultypen bestehen (2S- und PS-Module). Da aus Bandbreitengründen nicht alle Trefferinformationen ausgelesen werden können, muss eine Triggerentscheidung getroffen werden. Der zukünftige Spurdetektor stellt Informationen für diese Entscheidung bereit, indem Teilchen mit großem Transversalimpuls bereits auf Modulebene identifiziert werden.

Der KARATE-Teststand (KArlsruhe high RAte TEst) wurde entwickelt um die Auslesekette von 2S-Modulen mit hohen Triggerraten zu untersuchen. Der Aufbau erlaubt die Injektion von definierbaren Pulsen bei 40 MHz in die analogen Eingänge von 48 Auslesekanälen. Da bekannt ist, welche Pulse injiziert wurden, erlaubt dies Effizienzstudien der kompletten Auslesekette unter möglichst realen Bedingungen mit der Möglichkeit, auch extreme Bedingungen zu testen. Der Vortrag stellt den Aufbau und erste Ergebnisse der Hochratentests vor.

T 60.9 Wed 18:00 Tj

Test Beam Analysis of a Silicon-Strip Module for the CMS Phase-II Tracker Upgrade — •Chun Cheng — DESY, Hamburg, Germany

The foreseen Large Hadron Collider upgrade is expected to deliver an integrated luminosity that is one order of magnitude larger after 2027. Rare processes and new phenomena may be observed in this high lu-

minosity era. The Phase-II Outer Tracker upgrade of the CMS experiment is required to surmount higher radiation and increased event rate. Transverse momentum (PT) discrimination is introduced in the design and will contribute to the Level-1 Trigger. A CMS silicon strip module with PT discrimi- nation concept was built by the DESY Outer Tracker group and has undergone a test beam experiment at the test beam DESY facility.

The talk will mainly focus on DESY 2S module production, sensor studies, data acquisi- tion scheme and give a summary of the results from the recent test beam measurements.

T 61: Search for New Particles III

Time: Wednesday 16:00–18:15 Location: Tk

T 61.1 Wed 16:00 Tk

Search for heavy resonances decaying into ZH with Z→νν and H→WW→4q at CMS — •Tom Sokolinski, Johannes Haller, Roman Kogler, Andrea Malara, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

A search for new heavy particles decaying into a Higgs and a Z boson is presented. The analysis is performed on the dataset recorded by the CMS experiment in proton-proton collisions at a centre-of-mass energy of 13 TeV in the years 2016-2018, corresponding to an integrated luminosity of 137.2 fb^{-1}.

The final state resulting from Z→νν and H→WW→4q decays is analysed. Expected upper exclusion limits on the production cross section of the new resonance are derived.

T 61.2 Wed 16:15 Tk

Search for high mass lepton flavour violating processes with CMS — •Sebastian Wiedenbeck, Thomas Hebbeker, Arnd Meyer, and Swagata Mukherjee — III. Physikalisches Institut A, RWTH Aachen University

Lepton flavour is a conserved quantity in the standard model of particle physics, but it does not follow from an underlying symmetry. Neutrino oscillations imply that lepton flavour is not conserved in the neutral sector. Lepton flavour violating processes are common in several models of physics beyond the standard model (e.g. supersymmetry with R-parity violation, black hole production, and leptoquarks). Some models predict objects at the TeV mass scale that can decay into two standard model leptons of different flavours: 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 efficient lepton identification at the same time. The status of the analysis is presented, based on the latest CMS data taken in Run 2.

T 61.3 Wed 16:30 Tk

A multi-dimensional search for new heavy resonances decaying to boosted WW, WZ, ZZ, WH or ZH boson pairs in the all jets final state at 13 TeV — •Irene Zoi[1], Anna Benecke[1], Andreas Hinzmann[1], Robin Aggleton[1], and Daniela Schaefer[2] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland — [2]KIT

The standard model (SM), the best to date description of elementary particles and their interactions, still has open questions, such as the hierarchy problem. In the attempt to solve this issue, extensions of the SM predict the existence of new massive resonances. Here a search for such resonances decaying to two bosons (WW, WZ, ZZ, WH or ZH), where the vector bosons decay hadronically and the Higgs boson decays into pairs of bottom quarks is presented. Multiple resonance production modes are investigated, for the first time also vector-boson fusion is considered in this search. The analysis is performed on data corresponding to an integrated luminosity of 137.2 fb^{-1} recorded with the CMS experiment at the LHC at a centre-of-mass energy of 13 TeV. The signal extraction method is based on a three-dimensional maximum likelihood fit of the dijet invariant mass and the mass of both jets. This approach has proven to increase the sensitivity and to be applicable to a diverse set of final states. As the search is focused on heavy resonances, the decay products of each boson are expected to be collimated into one single jet, substructure techniques are exploited to significantly reduce the SM background. Improvements in boson tagging techniques and sensitivity estimates will be presented.

T 61.4 Wed 16:45 Tk

A search for pair production of excited top quarks t^* at CMS — •Finn Labe, Paolo Gunnellini, Johannes Haller, Anastasia Karavdina, Roman Kogler, Andrea Malara, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

A search for pair production of excited top quarks t^* in the decay channel $t^*t^* \to tgtg$ is presented. The search is performed in the boosted lepton + jets final state using data collected from proton-proton collisions at a center-of-mass energy of 13 TeV during Run-2 of the CMS experiment, corresponding to 137 fb^{-1} of data. After a preselection, a deep neural network is used for discrimination of signal from background. The network inputs have been decorrelated from the sum of all jet momenta H_T, which is used to set expected exclusion limits. This approach is compared to the usage of the reconstructed t^* mass and yields promising results over the full mass range analyzed.

T 61.5 Wed 17:00 Tk

Observation of an excess at 30 GeV in the opposite sign di-muon spectra of $\mathrm{Z} \to b\bar{b} + \mathrm{X}$ events recorded by the ALEPH experiment at LEP — •Arno Heister — Hergenrath, Belgium

The re-analysis of the archived data recorded at the Z^0 resonance by the ALEPH experiment at LEP during the years 1992-1995 shows an excess in the opposite sign di-muon mass spectra at 30.40 ± 0.46 GeV in events containing b quarks. The excess has a natural width of 1.78 ± 1.14 GeV. The di-muon excess has a local significance around 5 σ ($\mathrm{Z}_{\mathrm{asym}}$), depending on the background model used. The significances for background models based on a kernel density approximation stay close to 3 σ ($\mathrm{Z}_{\mathrm{freq,\ lee}}$), when including a look elsewhere effect. Another method to obtain a significance value results in at least 2.6 σ (Z_{Bi}). A compatible, but smaller excess is visible in the opposite di-electron mass spectrum as well. Several experiments have data samples that include the di-lepton mass region discussed here. The excess described in the paper arXiv:1610.06536 may be present in data of other experiments at LEP, the Tevatron and the LHC. Former members of the L3 collaboration as well as the ATLAS and CMS collaborations have published the result of their searches for this excess. The L3 data and the CMS data shows a noteworthy excess. The ATLAS experiment did not find anything in its data, yet.

T 61.6 Wed 17:15 Tk

Search for resonant WZ production with the ATLAS detector at the LHC — •Abhishek Nag, Joany Manjarres, and Michael Kobel — Institut für Kern und Teilchenphysik, Technische Universität Dresden

In the Standard Model (SM) the low mass of the Higgs boson leads to hierarchy and naturalness problems and therefore there is a need for physics beyond SM. Heavy resonance decays provide simple ways to discover new physics and particles. The search for a resonance decaying into dibosons, such as WZ, is a model-independent powerful probe for physics beyond the SM.

In this talk I will present the details of the search for resonant WZ production decaying into fully leptonic final state with the ATLAS detector at the LHC with the full Run-2 dataset. The focus of the talk will be on the improvements and optimization of the analysis selection. Parametrization of Heavy Vector Triplet Lagrangians and the Georgi-Machacek Model are used to optimize and interpret the search results.

T 61.7 Wed 17:30 Tk

Search for new physics in the τ+MET final state with CMS — •Christoph Schuler, Kerstin Hoepfner, Thomas Hebbeker, and Swagata Mukherjee — III. Physikalisches Institut A, RWTH Aachen University

A search for new physics in the τ + missing transverse energy (MET) channel is presented based on proton-proton collisions measured with the CMS detector at the LHC, using the full Run-II CMS data set recorded at a center of mass energy of 13 TeV. The analysis strategy is discussed and the results are interpreted in the context of various

models predicting enhancements to the Standard Model in the high mass region.

T 61.8 Wed 17:45 Tk

Search for long-lived particles decays in the CMS muon system — •Jörg Schindler[1], Lisa Benato[1], Gregor Kasieczka[1], Cristián Peña[2], Christina Wang[3], and Si Xie[3] — [1]Universität Hamburg, Germany — [2]Fermilab, USA — [3]Caltech, USA

Traditionally, searches for new physics at the LHC focused on already established objects, like photons, leptons, jets or missing energy. A different approach is to look for signatures in the detector which up until now were not considered. One example are long-lived particles, which can have a large lifetime leading to macroscopic flight distances ranging from a few micrometers up to several kilometers. Such particles are for example predicted by twin Higgs models, where a dark sector mirroring the Standard Model (SM) particles is introduced. The Higgs boson mixes with its dark partner, acting as a mediator between the SM and dark sector and therefore can decay into non-SM particles. These non-SM particles are the long-lived neutral scalars π_ν, which later decay back into SM particles - in this case assumed to be predominantly b quarks.

In this talk a search for long-lived particles decaying in the CMS muon system is presented. These signatures can be observed with close to no background, but require the development of new reconstruction and analysis tools.

The status of the current search for LLPs with decays in the muon system is shown, using data collected by the CMS detector in run 2.

T 61.9 Wed 18:00 Tk

Searches for long-lived particles produced in Higgs decays with b-quark like signature — •Melanie Eich, Lisa Benato, Gregor Kasieczka, Karla Pena, and Joerg Schindler — Institut für Experimentalphysik, Universität Hamburg

Beyond Standard Model (BSM) theories including neutral, long-lived particles (LLP) can solve the hierarchy problem. In these theories, a mirror version of SM gauge groups exists alongside additional fermions. SM and mirror particles are connected via a discrete symmetry. In our analysis the Higgs boson is assumed to be the mediator between the two groups, because it mixes with its mirror partner. We further assume Higgs boson decays into a pair of long-lived neutral scalars π_ν.

We show results for the case that each π_ν decays into two b-quarks, with π_ν lifetimes measured as $c \cdot \tau$ in the order of up to a few millimetres. Such a lifetime results in a displaced vertex (DV), mimicking a b-quark like signature. The search for such π_ν requires new analysis techniques to distinguish between decay products coming from DV and background events. We present a comparison of different reconstruction techniques including machine learning methods and show the achievable sensitivity to twin Higgs production as a function of the mass and lifetime of the π_ν. In this talk an overview of the analysis and its current status and results will be presented, using data recorded with the CMS detector in Run2.

T 62: Search for New Particles V

Time: Wednesday 16:00–17:45 Location: Tl

T 62.1 Wed 16:00 Tl

Development of a new trigger for exotic particle searches with IceCube — •Timo Stürwald for the IceCube-Collaboration — Bergische Universität Wuppertal, Deutschland

The IceCube Neutrino Observatory is a km^3 scale Cherenkov light detector that also searches for signatures of particles beyond the standard model. The upcoming IceCube-Gen2 will improve the sensitivity for these searches due to an increased detection volume. The better sensitivity allows for the detection of faint signatures of exotic particles including Magnetic Monopoles, Q-Balls and Nuclearites which directly or indirectly produce light. In this talk we present the development of a new trigger that combines and improves searches for exotic particles from sub-relativistic to relativistic speeds. This new trigger includes the analysis of isolated single hits that so far are not included in any IceCube trigger.

T 62.2 Wed 16:15 Tl

Search for Sub-Relativistic Magnetic Monopoles in IceCube — •Christian Dappen, Jakob Böttcher, Sukeerthi Dharani, and Christopher Wiebusch for the IceCube-Collaboration — RWTH Aachen University - Physics Institute III B, Aachen, Germany

The IceCube Neutrino Observatory detects high energy atmospheric neutrinos through their interaction in the Antarctic ice while also searching for more exotic particles such as magnetic monopoles. These hypothetical particles are predicted by Grand Unified Theories to originate from the very early universe. For masses on the GUT-scale (10^{14} - 10^{17} GeV) those monopoles would move at subrelativistic speeds ($\beta < 10^{-2}$) through IceCube. A subrelativistic monopole in matter may catalyze nucleon decays via the Rubakov-Callan effect. This results in Cherenkov light from small particle showers along the trajectory of the monopole separated by centimeters to meters. This pattern is recognised by a dedicated Slow Particle Trigger in the detector. Simulated monopole signal and a data-driven background simulation are used to train a multivariate machine learning algorithm separating signal from background events. A first level Boosted Decision Tree is used to reject most of the background and further levels can perform a finer separation on the remaining events to achieve a final selection.

T 62.3 Wed 16:30 Tl

Sterile neutrino and exotics searches with the KATRIN experiment — Wonqook Choi, Stephanie Hickford, Leonard Köllenberger, and •Marco Wetter for the KATRIN-Collaboration — Institute for Astroparticle Physics and Institute of Experimental Particle Physics, Karlsruhe Institute of Technology

The KATRIN collaboration aims to determine the neutrino mass with a sensitivity of $0.2\,\mathrm{eV/c^2}$ (90 % CL). This will be achieved by measuring the endpoint region of the tritium β-electron spectrum. Using this same measurement data searches for physics beyond the standard model, including eV-scale sterile neutrinos, right handed currents, and other exotic particles, can be performed.

The second KATRIN science run was taken in Autumn 2019. A sensitivity study for eV-scale sterile neutrinos using Monte Carlo equivalent to this high-statistics data set will be presented. Furthermore, an outlook will be given on analyses searching for physics beyond the standard model in the KATRIN data. This includes a search for right-handed currents and possible non V-A modifications to weak interactions.

This work is supported by the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Young Investigator Group (VH-NG-1055).

T 62.4 Wed 16:45 Tl

Search for new physics at NA62: beam line simulation for background studies — •Simone Schuchmann — Johannes Gutenberg University Mainz

The NA62 experiment challenges the Standard Model with measurements of rare charged kaon decays from a secondary charged kaon beam. In addition, searches for dark matter and exotic particles as well as high precision measurements of various kaon decays are performed. Not only the standard proton-on-target technique for secondary beam particle production is employed but also dumping of the proton beam upstream the detector region. Especially for these additional research targets the precise knowledge of the beam induced background is essential.

The background is produced by the decay of secondary beam particles and by beam interactions with material before reaching the detector. It is dominated by muons though careful measures to sweep them out of the detector acceptance were taken by the beam line design. In beam dump mode, the proton-on-material interaction is the main source for possible dark matter particle production as well as for secondary particle background. A simulation framework was developed which incorporates the detailed description of the NA62 detector using the GEANT4 software and the full secondary beam line employing the BDSIM software. In this contribution, the results of background sim-

ulation studies will be presented and an outlook for further possible measurements will be given.

T 62.5 Wed 17:00 Tl

Prospects for a Dark Photon Search Expermiment at the ELSA Electron Accelerator — Philip Bechtle, Klaus Desch, Oliver Freyermuth, Matthias Hamer, •Jan-Eric Heinrichs, and Martin Schürmann — Rheinische Friedrich-Wilhemls-Universität Bonn

The true nature of Dark Matter (DM) has long been of interest for scientists worldwide. Previous searches have so far been unsuccessful in finding proposed DM particles. A promising and not well explored parameter space of light DM particles up to 1 GeV remains to be subjected to intense experimental testing. Mainly two approaches are investigated by the community: Beam dump and single particle-tracking fixed-target experiments, respectively. In the latter case, single electrons with a narrow energy spectrum are extracted from a storage ring or linear accelerator and tracked individually in front and behind a target, yielding sensitivity to Bremsstrahlung of invisible particles

This talks highlights the future prospects of a fixed target experiment aimed at detecting particles from one of the simplest light DM models - Dark Photons. The underlying theory and the resulting experimental challenges and strategy will be explained. The possibility of building a corresponding experiment at the ELSA electron accelerator in Bonn is highlighted. First steps towards a Geant4 simulation, including pixel based tracking with a Kalman Filter, have been taken and will be presented.

T 62.6 Wed 17:15 Tl

Including heavy spin effects in the investigation of $\bar{b}\bar{b}ud$ tetraquark candidates with lattice QCD static potentials — •Andre C. Zimermmane-Santos[1,2], Jakob Hoffmann[2], and Marc Wagner[2] — [1]Deutsches Elektronen-Synchrotron - DESY, Hamburg, Germany — [2]Institut für Theoretische Physik, Goethe Universität, Frankfurt am Main, Germany

The study of exotic hadrons composed of four or more valence quarks is very challenging, both from theoretical and experimental perspectives. In this context, the particular class of states composed of two heavy antiquarks, $\bar{b}\bar{b}$, and two light quarks, ud is a promising system in the search for tetraquark candidates.

In this talk, I present an approach to investigate such a system in the Born-Oppenheimer approximation using lattice-QCD static potentials. In the static limit, spins of the heavy particles are irrelevant. To go beyond that limit, we have developed a formalism to include $\bar{b}\bar{b}$-spin corrections for arbitrary angular momentum. I will discuss and apply it in the context of a possibly existing $\bar{b}\bar{b}ud$ resonance with quantum numbers $I(J^P) = 0(1^-)$.

T 62.7 Wed 17:30 Tl

Study of the X(3915) at Belle — •Yaroslav Kulii[1], Thomas Kuhr[1], and Boris Grube[2] — [1]Ludwig-Maximilians-Universität München — [2]Technische Universität München

Many of the charmonium states, which consist of a charm and anticharm quark, have been found and studied experimentally. Detailed theoretical predictions of the charmonium excitation spectrum agree well with the experimental data.

However, in recent years experiments discovered a growing number of charmonium-like states that do not fit into the predicted charm-anticharm excitation spectrum. One such state is X(3915). It has been discovered by the BaBaR and Belle collaborations in the reaction $e^+e^- \to e^+e^-X(3915) \to e^+e^-J/\psi\omega$, where the final-state electron and positron were not detected. The analysis of projections of angular distributions preferred the $J^{PC} = 0^{++}$ hypothesis, but other quantum numbers, in particular $J^{PC} = 2^{++}$, could not be excluded.

Because of this the $X(3915)$ was initially identified as the $\chi_{c0}(2P)$ charmonium state, although its mass and decay width were not in good agreement with the theory predictions. Following the Belle discovery of the $X^*(3860)$, which agrees much better with the $\chi_{c0}(2P)$ hypothesis, opinions shifted towards interpreting the X(3915) as an exotic state. It could be, for example, a meson molecule or a so-called hybrid meson.

We will present the current state of affairs as well as the research prospects of studying the X(3915) in its $J/\psi\omega$ decay using Belle and, in the future, Belle II data.

T 63: Detector Systems II

Time: Wednesday 16:00–18:00 Location: Tm

T 63.1 Wed 16:00 Tm

Transverse momentum discriminating silicon modules for the Phase-II Upgrade of the CMS Outer Tracker — •Younes Otarid — Deutsches Elektronen-Sychrotron DESY, Hamburg, Germany

The Large Hadron Collider (LHC) will undergo a major High Luminosity upgrade with the goal of delivering a peak instantaneous luminosity of about $5 - 7.5 \times 10^{34} cm^{-2} s^{-1}$ by 2027. In order for the CMS experiment to cope with the higher radiation levels and data rates, the current CMS Silicon Outer Tracker will be replaced. The upgraded Outer Tracker will introduce a new module concept, made of two vertically stacked silicon sensors, which will exploit the strong magnetic field inside the CMS detector to select high transverse momentum particles locally and send the corresponding information to the triggering system.
This talk will focus on one of the two foreseen designs, the Pixel-Strip (PS) module, as well as the developments related to the module assembly and testing, covering the topics of momentum discriminating module design, DAQ system and automated assembly.

T 63.2 Wed 16:15 Tm

Development of a radiation monitoring system for satellite application — •Fabian Abo, Marius Hötting, Kevin Kröninger, and Jens Weingarten — Technische Universität Dortmund, Lehrstuhl für Experimentelle Physik IV

The use of commercial electronics components in satellites is increasing. Therefore, the understanding and investigation of radiation induced damages are inevitable. The *Lehrstuhl für Experimentelle Physik IV* at Technische Universität Dortmund is developing a radiation monitoring system based on Commercial-of-the-shelf (COTS) semiconductor components. The main principle is to detect and monitor the radiation induced damages. Nevertheless, the device is able to detect multiple particle types, store information about the accumulated dose and detect Single Event Effects (SEE) which could lead to a Bitflip as well as severe failure of electronical devices on board.
However, the radiation monitoring device has to operate within a defined bandwidth and a limited power usage to be useful as an additional payload.
In this talk we will present the results of temperature and radiation induced changes of different MOSFETS and diodes characteristics.

T 63.3 Wed 16:30 Tm

The intelligent PMTs for OSIRIS — Feng Gao[1], Achim Stahl[1], •Jochen Steinmann[1], Cornelius Vollbrecht[1,2], and Christian Wysotzki[1] — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]Forschungszentrum Jülich GmbH, Nuclear Physics Institute IKP-2, Jülich, Germany

The Online Scintillator Internal Radioactivity Investigation System (OSIRIS) allows an on the fly radiopurity measurement of the scintillator during filling of the JUNO detector. It consists of a 20 ton liquid scintillator target monitored by 76 intelligent photomultiplier tubes (iPMTs).

In the novel approach of the iPMT, all electronics required for the PMT operation are directly attached to its back. It includes an FPGA for control of the PMT and processing of the data. This reduces analog signal cable length to the absolute minimum and creates a very scalable system.

Each iPMT is connected via a single standard CAT5 Ethernet cable to the backend, where the cable is splitted into a synchronisation signal and the Ethernet part. The Ethernet wires are connected to a Power over Ethernet switch to supply the whole iPMT and integrate it into the DAQ and slow-control network.

This talk presents the concept of the iPMT and its realisation within OSIRIS.

T 63.4 Wed 16:45 Tm

Potting of the intelligent PMTs for OSIRIS — •Feng Gao, Achim Stahl, Jochen Steinmann, Cornelius Vollbrecht, and Christian Wysotzki for the JUNO-Collaboration — RWTH university, Aachen, Germany

For OSIRIS 76 intelligent PMTs (iPMTs) will be used inside pure water as light detectors. All readout electronics are mounted at the backside of the PMT. Compared with a traditional PMT readout, a pure digital signal will be sent from the iPMT to the back-end electronics, so that the PMT signal can be transmitted lossless.

The electronics soldered on the PMT are immersed within oil inside a cylindrical stainless steel shell. Heat, generated by the electronics, is transferred via oil and stainless steel to the cooled water pool. This way the electronics are kept at a stable temperature. In order to prevent the electronics from being exposed to pure water, potting is required.

The solution and process of the potting will be presented in this talk.

T 63.5 Wed 17:00 Tm

Performance of the intelligent PMTs for OSIRIS — •Christian Wysotzki[1], Feng Gao[1], Achim Stahl[1], Jochen Steinmann[1], and Cornelius Vollbrecht[1,2] — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]Institut für Kernphysik, Forschungszentrum Jülich, Jülich 52428, Germany

OSIRIS (Online Scintillator Internal Radioactivity Investigation System) is a standalone 20-ton liquid scintillator detector. As a subsystem of the JUNO experiment, it provides surveillance of the liquid scintillator quality with respect to the radiopurity.

OSIRIS uses 76 20-inch PMTs as detector units and harnesses a novel approach of readout. The analog signal digitization is located on the backend of the PMT. Additionally, each PMT has signal processing resources consisting of an FPGA plus processor combination. This allows the implementation of high-speed algorithms directly on the back of the PMT, denoted as "intelligence".

Performance results of a prototype system will be presented in this talk.

T 63.6 Wed 17:15 Tm

Radiopurity treatment of the intelligent PMTs for OSIRIS — •Cornelius Vollbrecht[1,2], Feng Gao[2], Livia Ludhova[1,2], Achim Stahl[2], Jochen Steinmann[2], and Christian Wysotzki[2] — [1]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

The Jiangmen Underground Neutrino Observatory (JUNO), currently under construction in Southern China, is expected to yield new insights regarding the mass hierarchy of neutrinos. In order to reach the design sensitivity for detecting reactor and solar neutrinos, a radiopure liquid scintillator is required.

The Online Scintillator Internal Radioactivity Investigation System (OSIRIS) allows an on-line quality evaluation of the scintillator during filling of the JUNO detector. It features a 20 ton liquid scintillator target monitored by 76 intelligent photomultiplier tubes (iPMTs).

Because contamination with radioactive isotopes might prevent OSIRIS to reach its target sensitivity, the detector has to be cleaned prior to installation. For removing potential production residues from the iPMTs, a cleaning procedure has been developed. In this talk, the construction of the facility using ultra pure water at RWTH Aachen University will be presented.

T 63.7 Wed 17:30 Tm

A novel neutron imaging detector based on neutron sensitive MCP on Timepix3 Readout — •Saime Gürbüz[1], Jochen Kaminski[1], Markus Gruber[1], Markus Köhli[1,2], Michael Lupberger[1], and Klaus Desch[1] — [1]Physikalisches Institut, Universität Bonn — [2]Physikalisches Institut, Universität Heidelberg

Neutron imaging is a method to research materials non-invasively. In the University of Bonn, we are developing a state-of-art neutron imaging detector with a high spatial resolution.

As a neutron converter, we use a B(10) and Gd enriched Microchannel plate detector (MCP). The MCP has been studied with cold and thermal neutrons for neutron imaging and it already showed very promising results in means of neutron detection efficiency and spatial resolution. Our aim is to design a novel detector which will combine the efficiency of the MCP with a good time and spatial resolution readout system.

The detector readout is achieved by 4 Timepix3 AISCs. The Timepix3 is an upgraded version of Timepix with additional features of package based readout and better timing resolution of upto 1.5 ns. With the help of the new readout technique, it has less counting losses. It can simultaneously record arrival time and time over threshold. A Timepix3 can achieve good timing resolution and spatial resolution at the same time.

In this talk, we will present the concept and the current status of the first prototype of the neutron sensitive MCP on a Timepix3 readout.

T 63.8 Wed 17:45 Tm

Production of low-background poly(ethylene naphthalate) as a self-vetoing structural material for LEGEND-200 — •Felix Fischer for the PEN-Collaboration — Max-Planck-Institut für Physik, 80805 Munich, Germany

Poly(ethylene naphthalate), PEN, is a widely used industrial polyester which intrinsically scintillates in the blue wavelength region. Measurements have established a high intrinsic radio purity. This has sparked interest in the material for use in low-background experiments. The entire process from commercially available PEN pellets to an optically active support-structure for the next generation $0\nu\beta\beta$-search experiment LEGEND-200 is presented. In addition, new measurements on radiopurity are presented as well as first characterisation studies important for the performance in a low-background experiment.

T 64: Pixel Detectors III

Time: Wednesday 16:00–18:15 Location: Tn

T 64.1 Wed 16:00 Tn

A Very Large HV-MAPS Tracking Telescope — •David Maximilian Immig for the Mu3e-Collaboration — Physikalisches Institut Universität Heidelberg

The MuPix-telescope is an evolving tracking telescope with very high rate capabilities that makes use of the most recent high-voltage monolithic active pixel sensor (HV-MAPS).
In the nominal setup, a DUT is sandwiched between three tracking layers of 100 μm thin HV-MAPS chips, at present MuPix10, complemented by scintillating tiles for additional time information. MuPix10 is a completely monolithic sensor with an active area of about 20 mm×20 mm, manufactured in the 180 nm HV-CMOS process at TSI Semiconductors with a pixel size of 80 μm×80 μm. Its trigger-less readout uses a column-drain architecture with on-chip zero suppression. 8b/10b encoded hit data is sent off the chip by three serial links with up to 1.6 Gbit/s each.
In the context of pixel sensor R&D this telescope is used to investigate efficiency, time resolution, and noise behaviour of different MuPix-like sensors. In this talk, the telescope concept is introduced. Highlights of several test beam campaigns at DESY and PSI will be presented which have been performed using a MuPix10-telescope.

T 64.2 Wed 16:15 Tn

The tracking detector of the P2 experiment at the MESA accelerator — •Lars Steffen Weinstock for the P2-Collaboration — PRISMA+ Cluster of Excellence and Institute of Nuclear Physics, Johannes Gutenberg University Mainz

The Mainz Energy-recovering Superconducting Accelerator (MESA) will begin its operation in 2024. One of the experiments planned at MESA is P2. The goal of P2 is to determine the electroweak mixing angle with unprecedented precision at low energy scales by measuring the parity violating asymmetry in proton-electron scattering at low momentum. A key parameter for the analysis, the electron momentum transfer during scattering, is measured by the P2 tracker, which is placed inside the 0.6 T solenoid spectrometer. The tracker consists of eight identical modules utilising a total of 5000 novel High Voltage

Monolithic Active Pixel Sensors (HV-MAPS) for precise track reconstruction. The event rate is expected to be 0.1 THz; This, in combination with the high number of readout channels, poses challenging requirements to the tracker front-end with regards to radiation hardness and data acquisition rate. This talk will give an overview of the P2 tracker, the requirements driving its design, and the current state of development.

T 64.3 Wed 16:30 Tn

Usability of the track reconstruction framework Corryvreckan for testbeam data and proton therapy — •Christopher Krause, Valerie Hohm, Jens Weingarten, and Kevin Kröninger — TU Dortmund, Dortmund, Deutschland

Pixel sensors with a high efficiency are necessary in the Inner Tracker of the ATLAS experiment for accurate track measurements and analysis. To measure the sensor's efficiency, an electron beam at the testbeam facility at DESY is used for irradiation. The generic framework EUTelescope was used for track reconstruction in the last years.

A new track reconstruction software, Corryvreckan, was published in 2017 with the intention of equally good track reconstruction capability, while also reducing external dependencies. It bears great similarity in its modular structure with the simulation software Allpix^2, creating a good compatibility between the two frameworks. The different implemented modules in Corryvreckan ensure its usability for track reconstruction and analysis in complex environments.

Further applications of track reconstruction with pixel sensors are investigated at TU Dortmund with regard to proton computed tomography. A comparison of reconstructed testbeam data with the EUTelescope and Corryvreckan software is presented in this talk, as well as the performance of Corryvreckan with low-energy protons used in proton therapy. The protons are simulated with Allpix^2.

T 64.4 Wed 16:45 Tn

Pixel front-end masking and its impact on tracking — Marcello Bindi, Jörn Grosse-Knetter, •Andreas Kirchhoff, and Arnulf Quadt — II. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Germany

During Run 2 of the LHC, the ATLAS tracking software masked non-working pixel modules for offline reconstruction. The masking itself is applied if a module does not receive hits (because it is inactive). To improve track reconstruction the number of holes should be reduced. Holes are defined as intersections of reconstructed tracks with sensitive detector elements that did not result in a hit. They are estimated by comparing the hits-on-track with the intersected modules. Inactive modules for example are excluded from the hole definition. As a consequence, a masked module is treated in the track reconstruction as if it received always a hit.

The aim of the ATLAS tracking group for Run 3 is to increase the granularity of the masking (moving from module to single front-ends) in order to reduce the number of pixel holes and increase the tracking efficiency. Hit maps collected at the end of each run were chosen as input of the new front-end masking mechanism. A new data base (DB) scheme was developed in order to integrate the module and the front-end masking information. This scheme will be presented in this talk together with the first studies that quantify the effect of the new masking on the track reconstruction efficiency.

T 64.5 Wed 17:00 Tn

Development of a Hybrid Pixel Detector Tracker for a Light Dark Matter Experiment at ELSA — Philip Bechtle, Klaus Desch, Markus Gruber, Matthias Hamer, Jochen Kaminski, •Leonie Richarz, and Tobias Schiffer — Physikalisches Institut, Universität Bonn, Nußallee 12, 53115 Bonn

Light Dark Matter Experiments based on dark bremsstrahlung are promising approaches to solve the mystery of unobserved dark matter in our universe. In these experiments an electron beam is shot onto a thin target, where aside from normal bremsstrahlung also possibly dark bremsstrahlung could be observed.

Due to the low signal cross-section in the parameter space where these experiments are typically sensitive, a large number of electrons on target is required. At the same time, for the reconstruction of single electron-target interactions a low number of such interactions per recorded event is advantageous. The electron stretcher accelerator (ELSA) in Bonn could provide both, as a very low number of electrons can be extracted at a high rate. A candidate for reconstructing the tracks of individual electrons in such a setup (and identifying dark bremsstrahlung via the momentum loss) is an ultrafast hybrid pixel detector. As a first step towards such a tracker, a setup using hybrid pixel modules with the Timepix3 ASIC is developed, providing spatial coordinates and timing information at a high readout rate.

In this talk the ongoing preparations of a first testbeam with such a detector will be presented, including elements of the development of the required readout system.

T 64.6 Wed 17:15 Tn

Software development for the ITk-Pixel module read-out and test system "BDAQ" — •Rafael Gonçalves Gama, Ali Skaf, Jörn Grosse-Knetter, Jörn Lange, and Arnulf Quadt — II. Physikalisches Institut, Georg-August-Universität Göttingen

The Inner Tracker (ITk) is a new all-silicon detector which will replace the current ATLAS tracking system during the Phase II upgrade. The ITk innermost layers are composed by pixel modules, which comprise a new sensor and a new front-end chip, designed to cope with the challenging demands of the HL-LHC environment. This work consists of adding support for the BDAQ hardware platform to the ITk DAQ software. The BDAQ hardware is an affordable, yet powerful, FPGA-based electronics board designed by the University of Bonn for test and characterization of the new ITk front-end and upcoming generation chips. The work presented here enables the operation of this hardware in a centralized environment. Therefore, one can ensure that the same software, including the production-database interface, will be used during all the quality control steps throughout the prototyping, (pre-)production, construction and operation phases of the ITk. A new software library, based on the original BDAQ software package, was written to allow the hardware integration into the ITk DAQ software. A summary of the development process, as well as results of the BDAQ hardware integration, will be presented.

T 64.7 Wed 17:30 Tn

ITk-pixel prototype module assembly and testing — Baida Achkar, Sascha Böhlken, Raffael Gama, Jörn Grosse-Knetter, Tim Kanngiesser, Jörn Lange, •Silke Möbius, Arnulf Quadt, and Rüdiger Widera — II. Physikalisches Institut, Georg-August-Universität Göttingen

For the upgrade of the LHC to the High-Luminosity-LHC, the ATLAS tracking detector will be replaced with a pure silicon detector, the Inner Tracker (ITk), as the higher luminosity asks for radiation hard components that can deal with higher occupancies and radiation. Given the close proximity to the interaction point, the environment is especially challenging for the pixel detector, which is planned to feature 3D and planar radiation hard sensors and a new readout chip, allowing a faster and reliable readout of the sensors.

In order to characterize and test ITk-pixel prototype modules with the RD53A, a protoype chip, up to 200 modules are built and tested at several institutes. At a later stage, these modules will be integrated in a larger structure, a so-called demonstrator, to test the system functionalities.

Göttingen is responsible for the development of the core part of the tooling, needed for the gluing of the flex PCB in the assembly of the module and is involved in the assembly and testing itself.

This talk will give an overview over the ITk-pixel module building efforts and qualification measurements performed so far and also sketch the electrical tests performed in Göttingen.

T 64.8 Wed 17:45 Tn

Position resolution with 25 μm pitch pixel sensors — •Irene Zoi[1], Aliakbar Ebrahim[3], Finn Feindt[1], Erika Garutti[1], Mohammadtaghi Hajheidari[1], Andreas Hinzmann[1], Caroline Niemeyer[1], Daniel Pitzl[2], Jörn Schwandt[1], and Georg Steinbrück[1] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland — [2]Deutsches Elektronen-Synchrotron, Notkestraße 85, 22607 Hamburg, Deutschland — [3]PSI, Forschungsstrasse 111, 5232 Villigen PSI, Schweiz

The pixel pitch for vertex detectors has constantly been reduced to cope with the experiments' necessities of achieving higher position resolution and maintaining low occupancy per channel. The spatial resolution takes advantage of a decreased pixel size but several factors, as radiation hardness, need to be considered in developing new prototypes. In the frame of the Phase-2 upgrade for the CMS pixel detector, the position resolution of 25 μm planar sensors has been investigated and compared to other existing measurements with various pitch size.

In this talk, the definition of resolution will be discussed as well as its significant dependence on the tracks selection criteria and the

employed reference tracking system. For these measurements, three parallel planes of sensors have been used to achieve the necessary precision. The results are compared to what is obtained using a conventional test beam telescope. The dependence of the position resolution on the relative inclination between the incoming beam trajectory and the sensor is also presented.

T 64.9 Wed 18:00 Tn

Timing Study and Optimization of ATLASPix3 a full-scale HV-MAPS Prototype — H. Augustin[1], F. Ehrler[2], D.M. Immig[1], •D. Kim[1], L. Mandok[1], L.O.S Noethe[3], I. Perić[2], M. Prathapan[2], T.T. Rudzki[1], R. Schimassek[1], A. Schöning[1], and A. Weber[1,2] for the Mu3e-Collaboration — [1]Physikalisches Institut Universität Heidelberg — [2]Karlsruher Institut für Technologie — [3]Paul Scherrer Institut

For the high luminosity upgrade at the Large Hadron Collider (HL-LHC), ATLAS will replace its tracking system. The instantaneous luminosity, that increases by 5-7 times with respect to the current LHC value, causes challenges in terms of radiation tolerance and readout speed. For this upgrade, the Inner Detector will be replaced by an all-silicon tracking detector, the Inner Tracker (ITk).

As a candidate for the outermost pixel layer, the ATLASPix3 was developed. It is a full scale prototype designed in an 180 nm HV-CMOS process by TSI. The pixel size is 150 μm x 50 μm, resulting in an active matrix consisting of 132 x 372 pixels with a total active area of 19.8 mm x 18.6 mm.

This presentation focuses on the study and optimization of the time resolution of ATLASPix3. As a result of these measurements, a configuration is found which leads to an efficiency of 99.6 % with an uncorrected time resolution of 7.7 ns. After offline correction, this value can be improved to 4.5 ns.

T 65: Experimental methods III

Time: Wednesday 16:00–18:30 Location: To

T 65.1 Wed 16:00 To

Performance of Top-quark Tagging using Unified Flow Object Jets — •Christof Sauer and André Schöning — Physikalisches Institut Universität Heidelberg, Deutschland

Algorithms that identify boosted hadronically decaying objects are used in a variety of physics analyses. The improvements of such *taggers* have a significant impact on the sensitivity of searches beyond the Standard Model (SM), but also allow for more precise SM measurements. Jets reconstructed from *Unified Flow Object* (UFO) are going to be the new baseline for large-R(= 1.0) jets due to their improved mass and substructure variable resolutions compared to jets built from other objects like, e.g., topological clusters, pFlow or TCCs.

The results shown in this talk are based on the optimization of two different taggers utilizing UFO jets that identify top quarks and reject QCD jets. A simple comparison of various jet substructure variables – in combination with a one-sided mass cut – has been performed to select a list of well discriminating variables for the new UFO jet collection. However, it was shown in earlier analyses that Deep Neural Networks (DNN) for top identification *significantly* outperform simple cut-based taggers that cut on two to three variables; hence, their usage is the primary consolidated recommendation for the upcoming release.

Finally, a comparison of both taggers (cut- and DNN-based) using UFOs as well as their performance improvement with respect to the previous baseline, i.e. LCTopo, will be presented along with an outlook regarding upcoming tagger concepts involving UFO jets.

T 65.2 Wed 16:15 To

Light flavour mistag calibration for ATLAS b-jet identification algorithms — •Angela Burger — Oklahoma State University, United States

Many analyses in ATLAS rely on the identification of jets containing b-hadrons (b-jets) with high efficiency while rejecting more than 99% of non-b-jets. Identification algorithms, called b-taggers, exploit b-hadron properties such as their long lifetime, their high mass, and high decay multiplicity. Recently developed ATLAS b-taggers using neural networks are expected to outperform previous b-taggers by a factor of two in terms of light jet rejection. Nevertheless, contributions from light jet mistags can be non-negligible in certain analyses phase spaces. It is therefore important to precisely measure the mistag rate of the light jets in both data and simulation to correct the corresponding rate in simulation. Due to the high light jet rejection of the b-taggers, the mistag rate cannot be measured directly but rather by means of a modified tagger, designed to decrease the b-jet efficiency while leaving the light jet response unchanged. This so-called "negative tag method" has been improved recently: uncertainties are reduced by constraining non-light flavour contribution with a data-driven method and the dominant systematic uncertainty has been reduced significantly, from 10-60% to 5-35% due to improved inner detector modeling. The method and a selection of results released recently to the ATLAS collaboration using pp collisions at $\sqrt{s} = 13$ TeV will be presented.

T 65.3 Wed 16:30 To

Data-driven corrections to shower shape variables for photon identification with the ATLAS detector — •Jan Lukas Späh, Björn Wendland, and Johannes Erdmann — TU Dortmund, Experimentelle Physik IV

Measurements of Standard Model processes, searches for new particles or processes forbidden in the Standard Model with photons in the final state play an important role in the physics programme of the ATLAS experiment. At hadron colliders, studies of photons are particularly challenging as large background contributions arise from jets, which can be misidentified as photons. This requires a method of identification providing high efficiency for genuine photons while ensuring an excellent background rejection for misreconstructed objects. By now, this method relies on rectangular cuts on so-called shower shape variables, which capture relevant information about the shape and evolution of the electromagnetic shower and the possible leakage into the hadronic calorimeter.

Monte Carlo samples with accurate simulations of the electromagnetic showers are required to interpret measurements with photons consistently. However, residual mismodelling, especially in the distributions of the shower shape variables, is observed. Therefore, these simulated distributions are corrected with a data-driven approach.

In this talk, studies of one-dimensional correction methods with the full Run-2 dataset are discussed and new approaches to improve these methods are presented.

T 65.4 Wed 16:45 To

Derivation of Custom b-Tagging Working Points — Arnulf Quadt, Elizaveta Shabalina, and •Yusong Tian — II. Physikalisches Institut, Georg-August-Universität Göttingen

The identification of jet flavours plays an important role in experimental particle physics research. It aims at identifying jets initiated by b, c and light hadrons. b-tagging is the centre of flavour tagging, due to the distinct features of b-jets. In many analyses, selecting a suitable b-tagging working point for jet selection is often one of the first steps. Currently there are four working points centrally provided by the ATLAS flavour tagging group, corresponding to the efficiency of 60%, 70%, 77% and 85%. However, some analyses could benefit from having non-standard working points. The work to automate the flavour tagging workflow from ntuple production to calibration is ongoing, and providing flexible working point definitions is one link of the chain. This talk presents the framework that allows a user to derive custom working points, and defines different working point profiles (fixed cut, flat efficiency, hybrid and flat rejection).

T 65.5 Wed 17:00 To

Non-collision Backgrounds in ATLAS — •Sergio Grancagnolo — Humboldt-Universität zu Berlin

Understanding events from proton interactions with residual gas in the beam pipe, with collimators, or from cosmic rays is of primary importance to evaluate backgrounds on non-conventional physics signatures, usually based on the primary interaction point. As an example, tracks not pointing to it, out-of-time energy deposits, or displaced decay vertices might come from signals released by long-living heavy particles, introduced by several extensions of the standard model. Last improve-

ments in the characterization of backgrounds not coming from beam collisions will be illustrated.

T 65.6 Wed 17:15 To

Performance of forward electrons in the ATLAS experiment — •Manuel Hohmann and Stefan Tapprogge — Institut für Physik, Johannes Gutenberg-Universtät, Mainz

Electrons are important objects both for the search for new physics and for precision measurements. In some cases, such as the determination of the effective weak mixing angle, the additional use of forward electrons ($2.5 < |\eta| < 4.9$) can provide a large gain in sensitivity and accuracy. To achieve such a gain, it is necessary to better understand the reconstructed and identified forward electrons and their performance, such as their identification efficiency and energy calibration. However, this is challenging because the forward region does not have a tracking system, so only calorimeter information is available. In this contribution, the analysis strategies used to obtain information on forward electrons are discussed and the status of current studies is presented. For the studies, a sample of forward electrons is selected by the tag-and-probe method using data from *pp* collisions in the ATLAS experiment collected at $\sqrt{s} = 13$ TeV, corresponding to an integrated luminosity of 139 fb^{-1}.

T 65.7 Wed 17:30 To

Impact Parameter Resolution Studies in the ATLAS detector — •Supriya Sinha — DESY, Zeuthen

For many physics studies in ATLAS, b-quark identification emerges to be a very crucial component of the analysis. This is particularly useful in studies involving the selection of pure top quark samples, search for new physics, studying the Standard Model, etc.

The Impact Parameter (IP) is defined as the distance of closest approach of a track to the Primary Vertex (PV). It is the key-ingredient for discriminating the tracks originating from the PV, from the ones originating from displaced vertices, e.g. from decays of b-hadrons. Precise measurement of the IP of charged particle tracks and correct modelling in simulation is fundamental for b-tagging performance.

The resolution of the IP is effected by many factors: intrinsic single hit resolution, multiple scattering inside the detector material, etc. These are difficult to simulate and hence, the track IP reconstruction performance in Monte Carlo (MC) may need additional tuning to reproduce the data precisely. However, the track IP resolution is contaminated by the PV resolution, which has to be eliminated to get the intrinsic (unfolded) IP resolution of the track. This talk shows the comparison of IP resolution for data and MC for different years. In addition, the comparison is done for different track qualities defined for the b-tagging purposes.

T 65.8 Wed 17:45 To

Improving truth smearing for tau leptons at the ATLAS detector — •Daniel Buchin and Alexander Mann — Ludwig-Maximilians-Universität München

Searches for physics beyond the Standard Model (SM) rely on Monte-Carlo simulations of the signal process to identify an excess with respect to the SM background. This simulation consists of two steps: the physical process itself (truth level) and the detector response (reconstruction level). For some large-scale studies of models beyond the SM, e.g. a scan of the parameter space of the phenomenological Minimal Supersymmetric SM, a full simulation of the supersymmetric processes of each model point is not feasible. To skip the reconstruction-level simulation, smearing functions are used to make truth-level objects resemble reconstruction-level objects as accurately as possible.

In this study, we are looking at ways to improve the accuracy of the truth smearing of tau leptons. To achieve this, we predict the efficiency of the tau reconstruction and identification using a Boosted Decision Tree (BDT) based on truth level variables. This efficiency parametrization can then be used to smear truth level objects.

T 65.9 Wed 18:00 To

Prospects of fast timing detectors for particle identification at future Higgs factories — •Bohdan Dudar[1,2], Rémi Ete[1], and Jenny List[1] — [1]DESY, Hamburg, Germany — [2]Hamburg University, Germany

Future e^+e^- colliders are excellent tools to probe fundamental physics beyond Standard Model via Higgs and electroweak precision measurements.

Modern silicon detectors are able to measure time-of-arrival with high precision of O(10 ps). This can be used to measure the time-of-flight (TOF) of the particles and improve their identification.

We develop reconstruction and calibration algorithms based on TOF information to separate $\pi^{\pm}$, $K^{\pm}$, p, $\bar{p}$ particles at future Higgs factory detectors. Furthermore, we study how to implement fast timing silicon layers in the tracking and/or calorimeter systems, in order to derive requirements on the time resolution. As an example case, the ILD detector concept is studied.

The $K^{\pm}$ mass measurement is a simple benchmark to test the performance of TOF algorithm. A precision at the level of 10 keV can be expected, which would significantly improve the knowledge of the $K^{\pm}$ mass.

T 65.10 Wed 18:15 To

Observation of an inactive region in irradiated silicon diodes — •Oscar Murzewitz, Erika Garutti, Mohammadtaghi Hajheidari, Robert Klanner, and Jörn Schwandt — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

The Transient Current Technique (TCT) is used to investigate the response of silicon diodes. Electron-hole pairs are generated close to the surface by illuminating the diode with two sources: either a pulsed red-light laser or α-particles. These charge carriers drift in the electric field and induce transient currents on the diodes electrodes. The charge collection of a diode is determined by integrating these transients.

In this work, n^+pp^+ diodes irradiated with 23 MeV protons up until a 1 MeV equivalent neutron fluence of 1.2×10^{16} cm^{-2} are examined. The measurements are done at -20°C up to a bias voltage of 800 V. TCT observations show evidences for a region with zero charge collection at the n^+p interface. The thickness of this inactive region is determined by comparing charge collection measurements with the two sources. This talk presents the results for three diodes irradiated with varying degrees of fluence.

T 66: DAQ, trigger and electronics III

Time: Wednesday 16:00–18:15 Location: Tp

T 66.1 Wed 16:00 Tp

Power Distribution in the Mu3e Experiment — •Lucas Sebastian Binn for the Mu3e-Collaboration — PRISMA+ Cluster of Excellence and Institute of Nuclear Physics, Johannes Gutenberg University Mainz

The Mu3e experiment at PSI searches for new physics utilizing the lepton-flavor-violating decay of a positive muon into two positrons and one electron. The detector consists of a lightweight tracker built from high-voltage monolithic active pixel sensors complemented by scintillating tiles and fibres for precise timing measurements. Powering of the pixel sensors and scintillating detector poses unique challenges, requiring voltages in the range of 2.0V to 3.3V and currents of up to 21A per power partition. The experiment will supply these by using DC-DC converters placed as close as possible to the consumers inside the detector's magnet. The converters step-down 20V, produced by external commercial power supplies, to the required voltages. In the final experiment, 16 converters will be mounted together in one crate. A first prototype crate has been designed and produced, providing space for four board and using an external controller. To allow high-current operation, a custom water-cooling solution has been designed and is currently being tested.

T 66.2 Wed 16:15 Tp

Firmware and Synchronisation of the First Layer in the Mu3e DAQ System — •Martin Müller for the Mu3e-Collaboration — Institute for Nuclear Physics, JGU Mainz

The Mu3e experiment will search for the lepton flavour violating decay $\mu^+ \to e^+e^-e^+$ and is aiming for a sensitivity of one in 10^{16} muon

decays. Since this decay is highly suppressed in the Standard Model to a branching ratio of below $\mathcal{O}(10^{-54})$, an observation would be a clear sign for new physics.

In the Mu3e detector, four layers of silicon pixel sensors will be used to track electrons and positrons and a time resolution of $\mathcal{O}(100$ ps) will be provided by scintillating tile and fibre detectors. The overall detector is expected to produce a data rate from 80 Gbit/s (Phase I) to 1 Tbit/s (Phase II), which will be processed in a three-layer, triggerless DAQ system using FPGAs and a GPU filter farm for online event selection.

The first layer of the DAQ system consists of 114 FPGA boards inside the 1T solenoid magnet responsible for configuration, data readout and synchronisation of the three detector types. The talk will discuss the firmware for these boards and the implementation of the clock and reset distribution in the Mu3e DAQ system.

T 66.3 Wed 16:30 Tp

Hit synchronisation in the Mu3e DAQ — •Marius Köppel for the Mu3e-Collaboration — PRISMA+ Cluster of Excellence and Institute of Nuclear Physics, Johannes Gutenberg University, Mainz Germany

The Mu3e experiment at the Paul Scherrer Institute searches for the decay $\mu^+ \to e^+e^+e^-$. This decay violates lepton flavour conservation - any observation would be a clear indication for Physics Beyond the Standard Model. The Mu3e experiment aims for an ultimate sensitivity of one in 10^{16} μ decays. To this end, more than one billion μ tracks per second need to be detected and reconstructed.

Since the corresponding data of about 1TB/s cannot be saved to disk, a trigger-less online readout system is required which is able to sort, align and analyze the data while running. A farm with PCs equipped with powerful graphics processing units (GPUs) will perform the data reduction. The talk presents the ongoing integration of the sub detectors into the Field Programmable Gate Array (FPGA) based readout system and the hit synchronisation between different parts of the detector.

T 66.4 Wed 16:45 Tp

Tile Rear Extension (TREX) Modul — •Damir Rassloff and Tigran Mkrtchyan — Kirchhoff-Institut für Physik, Heidelberg

During the phase-I upgrade of the ATLAS experiment, the Level-1 Calorimeter (L1Calo) trigger system is also undergoing a series of improvements. For the identification of isolated particles and jets the upgraded L1Calo trigger system is using new subsystems so called feature extractors (FEXes). The FEXes directly receive digitized data from the LAr Calorimeter. The Tile Calorimeter, on the other hand still send analog data to the L1Calo PreProcessor subsystem. In order to provide digitized hadronic transverse energy results at the LHC clock frequency from the Tile Calorimeter to the FEXes, the PreProcessor is being extended with new Tile Rear Extension (TREX) modules. The modules send the data to the FEX processors via optical fibers operating at 11.2 Gbps, while also maintaining the data path to the legacy L1Calo processors via electrical cables. This talk discusses the design, the different data paths and the monitoring of the TREX modules.

T 66.5 Wed 17:00 Tp

Entwicklung von algorithmischer Firmware für den Ausbau des ATLAS Level-1 Jet/Energiesummen-Triggers — Volker Büscher, Ralf Gugel, Christian Kahra, 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 dies für eine effiziente Selektion von Ereignissen zu nutzen, muss das existierende System ausgebaut werden. Bei einer Datenrate von 40 MHz muss in der ersten Triggerstufe eine Entscheidung innerhalb von 2.5 μs getroffen werden.

Der jet Feature EXtractor, kurz jFEX, bildet eine Neuerung für den Ausbau des ATLAS Level-1 Triggers. Ab 2022 wird jFEX in erster Linie für die Identifikation von Jet-Kandidaten und zur Berechnung von Energiesummen eingesetzt. Pro Modul ist eine Eingangsbreite von bis zu 2.7 Tb/s erforderlich, die sich auf 4 Xilinx UltraScale+ FPGAs verteilt. Für die dort laufenden Algorithmen stehen maximal 125 ns an Berechnungszeit zur Verfügung. Aus diesem Grund müssen diese eine hochparallele Struktur aufweisen.

In diesem Vortrag wird der aktuelle Stand der Algorithmen-Implementierung vorgestellt.

T 66.6 Wed 17:15 Tp

Demonstrator for ATLAS LAr Phase-II readout chain — •Markus Helbig, Rainer Hentges, and Arno Straessner — Institut für Kern- und Teilchenphysik, TU Dresden, Germany

A demonstrator for the readout chain of the Phase-II upgrade of the ATLAS Liquid Argon Calorimeters is being set up at the TU Dresden. This talk will give an overview of the source part of the setup representing the transmission of data from the detector Front-End Boards to the counting room.

For this purpose, dedicated VHDL firmware for the Xilinx VC707 FPGA Evaluation Kit was implemented to emulate the output of twelve on-detector ADCs of the calorimeters. The raw data are serialized by the lpGBT ASIC (Low Power GigaBit Transceiver) designed by CERN and transmitted to the off-detector backend via optical fiber at 10 Gigabit per second using the CERN Versatile Link PLUS (VL+) module. The two aforementioned components are part of a custom PCB, developed by B. Deng et al. [1] who previously showed the suitability of those components for the ATLAS LAr calorimeter readout. Finally, the backend consists of an Intel Stratix-10 FPGA development kit running parts of the Liquid Argon Signal Processor (LASP) firmware in order to receive and decode the data. Results from data integrity tests and experience with the setup will be presented.

[1] B. Deng et al., Design and hardware evaluation of the optical-link system for the ATLAS Liquid Argon Calorimeter Phase-II Upgrade, Nucl. Instrum. Methods Phys. Res., A 981 (2020) 164495

T 66.7 Wed 17:30 Tp

First level EM trigger algorithms in the ATLAS forward region for the HL-LHC — •Julian Fischer and Stefan Tapprogge — Institut für Physik, Johannes Gutenberg-Universtät, Mainz

The High-Luminosity Large Hadron Collider (HL-LHC) at CERN is a planned upgrade of the Large Hadron Collider (LHC) that will increase its instantaneous luminosity of up to a factor of five in *pp*-collisions. In order to exploit the full potential of the HL-LHC the first level trigger of the ATLAS experiment will have to efficiently find electromagnetic objects in the forward region, corresponding to pseudorapidity ranges of $|\eta| > 2.5$. A dedicated 'forward Feature EXtractor' (fFEX) is in development for the high-luminosity upgrade to trigger jets as well as electromagnetic objects in the ATLAS forward region making use of the full granularity of the calorimeters. Dedicated hardware modules with FPGAs are to be developed to cover both forward directions of the detector in order to process the large amount of data delivered by the HL-LHC. This contribution will highlight the development of candidate algorithms that are designed to trigger electromagnetic objects on the fFEX modules. Performance studies will be shown and different concepts investigated to tackle the challenging geometries in this particular detector region while considering the restrictions imposed by the firmware implementation.

T 66.8 Wed 17:45 Tp

Development of an FPGA Implementation of Convolutional Neural Networks for Signal Processing for the Liquid-Argon Calorimeter at ATLAS — Anne-Sophie Berthold, Nick Fritzsche, Rainer Hentges, Arno Straessner, and •Johann Christoph Voigt — TU Dresden, Germany

With the planned Phase 2 upgrade of the ATLAS detector at LHC, the number of proton-proton collisions occuring at the same time will increase significantly. This leads to higher requirements for the data processing, since the rate of detected particles in one detector cell will increase. New machine learning solutions are under development to better reconstruct the energy deposited in the calorimeter and its timing information than the current optimal filter approach.

Here an implementation of convolutional neural networks for FPGA hardware is introduced. The network architecture is flexible and can be configured directly from the model files after network training. It is optimized regarding signal delay and resource usage. Especially the efficient use of the digital signal processors used for multiplications is crucial, since their availability is the limiting factor for network size. Respective performance and resource usage results are presented. The current status of the time division multiplexing, which is necessary to handle the high number of detector readout channels and process multiple input streams per network, is shown.

T 66.9 Wed 18:00 Tp

Evaluation einer netzwerkbasierten Detektorauslese unter Nutzung neuer Netzwerktechnoligien — •Carsten Dülsen, Tobias Flick, Wolfgang Wagner und Marius Wensing — Bergische Universität Wuppertal

Mit steigender Komplexität und höherem Auflösungsvermögen von kommenden Detektorsystemen wie dem ATLAS ITk Pixel Detektor steigt auch die zu übertragende Datenmenge weiter an. Während FPGA-basierte Auslesekomponenten die notwendigen Datenraten problemlos unterstützen, stellt die Schnittstelle zwischen FPGA und Auslesesoftware meist eine Engstelle dar. Für die Übertragung von Auslesedaten vom FPGA zur Auslese-Software wird ein Ansatz vorgestellt, bei dem die Daten über ein kommerzielles Netzwerk mittels Standardprotokollen versendet werden. Dazu wurde ein 100 GbE Netzwerk-Stack im FPGA umgesetzt. Um die Komplexität des FPGA-Systems zu reduzieren, soll die Übertragung ohne erneutes Versenden der Daten auskommen, damit auf eine Zwischenspeicherung verzichtet werden kann. Diese Strategie setzt eine Reduzierung des Paketverlustes auf ein Minimum voraus. Das Zusammenspiel von Hardware und Software wurde untersucht und das Übertragungssystem auf die Vermeidung von Paketverlusten optimiert. Auf der Software-Seite wird in diesem Zusammenhang eine eXpress Data Path (XDP) genannte Technik erprobt und ihre Eignung für die Reduzierung von Übertragungsverlusten untersucht.

T 67: Neutrino astronomy III

Time: Wednesday 16:00–18:30 Location: Tq

T 67.1 Wed 16:00 Tq

A new and improved IceCube point-source analysis — Chiara Bellenghi[1], Theo Glauch[1], Christian Haack[1], •Tomas Kontrimas[1], Hans Niederhausen[1], Martin Wolf[1], and Rene Reimann[2] for the IceCube-Collaboration — [1]Technische Universität München — [2]RWTH Aachen

The IceCube Neutrino Observatory is a one cubic kilometer neutrino telescope deployed deep in the Antarctic ice at the South Pole. The general aim of IceCube is to investigate high energy astrophysical phenomena by studying the corresponding high energy neutrino signal. One of the main goals is to identify the sources of the diffuse astrophysical neutrino flux, that IceCube discovered in 2012. We present a new method to search for neutrino point-sources that improves the accuracy of the likelihood function description in the low energy regime, where the usual Gaussian approximation of IceCube's point spread function breaks down. The new method includes multidimensional kernel density estimation (KDE) based probability density functions, angular error estimates using a boosted decision tree (BDT) classifier, and a new deep neural network (DNN) energy estimator. In this talk we will present the final performance estimates of the improved analysis.

T 67.2 Wed 16:15 Tq

The SkyLLH framework for IceCube point-source search — •Tomas Kontrimas and Martin Wolf for the IceCube-Collaboration — Technische Universität München

The hypothesis tests with unbinned log-likelihood (LLH) functions are a common technique used in multi-messenger astronomy, including IceCube's neutrino point-source searches. We present the general Python-based tool "SkyLLH", which provides a modular framework for implementing and executing log-likelihood functions to perform data analyses with recorded multi-messenger astronomy data from multiple experiments. Specific SkyLLH framework features for a new and improved IceCube point-source analysis are highlighted, including the support for kernel density estimation (KDE) based probability density functions. In addition, the future development goals of the SkyLLH framework as a common analysis tool for the multi-messenger community will be discussed.

T 67.3 Wed 16:30 Tq

Constraining populations of astrophysical neutrino sources with IceCube — •Chiara Bellenghi — Technische Universität München, Physik-Department, James-Franck-Str. 1, 85748 Garching

The IceCube neutrino telescope has provided precise measurements of the diffuse flux of high-energy astrophysical neutrinos. However, the sources of this signal have not been identified yet. The effort to identify point-like neutrino sources recently resulted in the development of a new analysis method that improves the accuracy of the search in the low-energy regime. In addition to the point-source search, the sky can also be tested for a significant excess of events from a population of sub-threshold sources. Such a signal from multiple weaker sources would be missed by analyses aiming at pointing only to the most significant one. The presentation will focus on the performance of this "hotspot population analysis".

T 67.4 Wed 16:45 Tq

Future Sensitivity of the Astrophysical Neutrino Flux Measurement in IceCube: Improved Energy Estimation and Uncertainties — •Philipp Fürst[1], Jakob Böttcher[1], Erik Ganster[1], Christian Haack[2], Jöran Stettner[1], and Christopher Wiebusch[1] for the IceCube-Collaboration — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]TU München

The IceCube Neutrino Observatory has measured a diffuse flux of high-energy astrophysical neutrinos in multiple detection channels. We focus on the channel of neutrino-induced muon tracks where the astrophysical signal is measured by an excess of high-energy events above the background of atmospheric neutrinos. The uncertainty of such a measurement depends on the systematic uncertainties of the detector and background predictions, and particularly on the resolution of the energy estimate of the muon in the detector. Several methods for the energy estimation already exist - here, we present a new energy estimator with increased resolution which is based on a combination of these previous estimation methods. We present possible sensitivity gains from increasing the energy resolution and compare them to the influence of the other systematic uncertainties. Combining all this information with increased detector livetime, we give an outlook towards feasible future sensitivity gains.

T 67.5 Wed 17:00 Tq

Search of BSM Particle STau in IceCube — •Jan-Henrik Schmidt-Dencker, Stephan Meighen-Berger, Christian Haack, and Elisa Resconi for the IceCube-Collaboration — Technische Universität München

The supersymmetric partner of the Tau lepton, the STau, appears in some models as the next-to lightest and therefore a long-lived particle. In this scenario its signature is a long-dim minimally ionizing track when travelling through the IceCube detector. The STau tracks, independent of their primary energy, seem like low energy muons for the detector and will appear as an excess on the muon tracks by atmospheric neutrinos. In our analysis we focus on the region around the horizon as we expect the ratio between STau signal and atmospheric muons to be best there. We then calculate the sensitivity to constrain the mass of the STau using the IceCube detector.

T 67.6 Wed 17:15 Tq

Investigation of the Neutrino Emission from Supermassive Black Hole Mergers and Starburst Galaxies — •Ilja Jaroschewski[1], Julia Becker Tjus[1], and Peter L. Biermann[2,3,4,5] — [1]Theoretische Physik IV, Ruhr-Universität Bochum — [2]MPI for Radioastr., Bonn — [3]Dept. of Phys., Karlsruhe Inst. for Tech. — [4]Dept. of Phys. & Astron., Univ. Alabama, Tuscaloosa, AL, USA — [5]Dept. of Phys. & Astron., Univ. Bonn

The first detection of non-terrestrial, high-energy neutrinos by IceCube in 2013 as well as the high-probability association of such a neutrino to the blazar TXS 0506+056 in 2017 are fundamental achievements in neutrino astronomy. Along with the successful detection of gravitational waves in September 2015 by LIGO and the clear identification of the binary neutron star merger GW170817, these detections opened both new branches in multi-messenger astrophysics. With over a dozen binary black hole mergers already documented and more to come, there are strong indications that supermassive black holes in galaxy centers also merge and have had at least one merger in their lifetime.

Such a merger is almost always accompanied by a change of the jet

direction leading to interactions of the jet with molecular clouds and therefore neutrino productions.

In this work, the connection between the radiated gravitational wave energy of supermassive black hole mergers and the diffuse astrophysical neutrino flux that is measured by IceCube is investigated. It is estimated whether these mergers contribute to the diffuse neutrino flux and how much starburst galaxies can contribute.

T 67.7 Wed 17:30 Tq

Die Suche nach versteckten Supernovae mit dem IceCube Neutrinoteleskop — •Alexander Fritz und Lutz Köpke für die IceCube-Kollaboration — Institut für Physik, JGU Mainz, Deutschland

IceCube ist mit 1 km^3 das weltweit größte Neutrinoteleskop und nimmt am Südpol Daten rund um die Uhr mit mehr als 99 % Verfügbarkeit. Im Falle einer Supernova messen die 5160 optischen Module einen Überschuss in der Rauschrate, welche sonst durch das Dunkelrauschen dominiert wird, und bieten die beste Zeitauflösung der Neutrinolichtkurve für galaktische Supernovae. Rund ein Drittel der Supernovae in benachbarten Galaxien könnten durch Staub mit optischen Methoden unerkannt bleiben, ähnliches gilt für Supernovae, die in schwarzen Löchern enden. Erste Ergebnisse zur Bestimmung einer oberen Grenze auf die Rate galaktischer Supernovae anhand von 11 Jahren IceCube-Daten werden präsentiert. Das effektive Volumen für einen Stern mit 20 Sonnnenmassen ist in 10 kpc Enfernung zwei Größenordnungen höher als das von Super-Kamiokande. Für die leichtesten möglichen Vorläufersterne sind die effektiven Volumina vergleichbar. Zudem wird eine Suche nach möglichen periodischen Signalen - versteckt in der IceCube-Dunkelrauschrate - mit Hilfe der Lomb-Scargle Transformation demonstriert.

T 67.8 Wed 17:45 Tq

Mean Supernova Neutrino Energy Reconstruction with IceCube — •David Kappesser and Lutz Köpke for the IceCube-Collaboration — Johannes Gutenberg-Universität, Mainz

The IceCube Neutrino Observatory is capable of detecting supernova neutrinos with energies around 10 MeV by observing a significant excess in the overall raw rate of the detector above noise rate. This method allows for a particularly precise measurement of the supernova neutrino lightcurve. Due to IceCube's sparse Instrumentation with Digital Optical Modules (DOMs), only in rare cases, more than one Cherenkov photon is detected per supernova neutrino interaction. Still, the number of coincidences is sufficiently large in order to estimate the average neutrino energy by analyzing the energy dependent rate increase of coincidences between neighbouring DOMs. A Geant4 based Monte Carlo was developed and tested to calibrate and evaluate such a measurement. Further Geant4 simulations were used to study the passage of positrons through ice, their production of secondary particles, and the Cherenkov photons being emitted. I will present a Likelihood approach for the analysis of this simulated data and to account for the different combinations of noise and supernova signal events leading to coincidences in the detector.

T 67.9 Wed 18:00 Tq

Particle identification by high resolution convolutional neural networks for the DSNB detection in next generation neutrino experiments — •David Maksimovic, Michael Nieslony, and Michael Wurm — Johannes Gutenberg-Universität, Mainz, DE

An important physics goal of next generation neutrino experiments is the search for the Diffuse Supernova Neutrino Background (DSNB), which is an isotropic neutrino signal composed of all the supernova explosions that occurred throughout the observable universe. Through the addition of Gadolinium to water Cherenkov detectors, many of the single-event backgrounds that were problematic in earlier analyses can be suppressed, generating a possible detection window from 10 to 30 MeV. Within this window, neutral current (NC) events of atmospheric neutrinos are the main remaining background. This talk presents the application of convolutional neural networks (CNN) for the identification and rejection of such atmospheric NC background events in future DSNB searches. The developed CNNs show very promising results and could prove to be of high relevance for measuring this signal in next generation neutrino experiments.

T 67.10 Wed 18:15 Tq

Ordinal Classification in DSEA — •Jan Philipp Jäkel — Technische Universität Dortmund

DSEA+, or Dortmund Spectrum Estimation Algorithm, is an improved version of the original DSEA algorithm built for unfolding energy distributions in the area of neutrino astronomy. It interprets deconvolution as a multinomial classification problem enabling reconstruction of binned spectra. Several classification models can be embedded for this purpose, but all of them treat the energy bins and their associated reconstructed values as unrelated quantities, leading to loss of generality. The need for ordinal classification arises, that preserves the ordinal inherent nature of the energy spectra. In this talk, we propose a built on version of DSEA+ utilizing this approach with the result of refined reconstruction and the capability of inspecting probability distributions of individual events detected.

T 68: Neutrino physics without accelerators III

Time: Wednesday 16:00–18:20 Location: Tr

Group Report T 68.1 Wed 16:00 Tr

Search for Neutrinoless Double-Beta Decay with LEGEND-200 — •Michael Willers for the LEGEND-Collaboration — Max-Planck-Institut für Physik, Föhringer Ring 6, D-80805 München.

The **L**arge **E**nriched **G**ermanium **E**xperiment for **N**eutrinoless $\beta\beta$ **D**ecay (LEGEND) is a proposed ton-scale ^{76}Ge-based neutrinoless double-beta decay experimental program with discovery potential at a half-life greater than 10^{28} years.

The first 200-kg phase (LEGEND-200) is currently under construction at the Gran Sasso underground laboratory (Laboratori Nazionale del Gran Sasso, LNGS, Italy) and commissioning of the experiment is scheduled to start in 2021. With a background index in the signal region of interest around $Q_{\beta\beta} = 2039$ keV of $2 \cdot 10^{-4}$ cts/(kev kg yr) and a data-taking period of 5 years, LEGEND-200 is expected to achieve a half-life sensitivity of 10^{27} years. In this contribution, results from a first integration test (the so-called *Post-GERDA Test*) conducted in summer of 2020 as well as the current status of the experiment will be presented.

This work is supported in part by the Max-Planck Society, the German Federal Ministry for Education and Research (BMBF) and the German Research Foundation (DFG) via the *SFB1258* and the cluster of excellence *ORIGINS*.

T 68.2 Wed 16:20 Tr

Usage of PEN as self-vetoing structural material in the LEGEND-1000 experiment — •Luis Manzanillas Velez for the PEN-Collaboration — Max-Planck-Institut für Physik

PEN is an industrial polyester plastic interesting for the physics community as a new type of wavelength shifting plastic scintillator. Recently, PEN structures with good radiopurity and attenuation length have been successfully produced using the injection compression moulding technology. This opens the possibility for usage of PEN as optically active structural components in low-background experiments such as the LEGEND experiment. The ongoing R&D on PEN will be outlined with focus on the evaluation of the optical properties PEN. In addition, the ongoing efforts for application of PEN in the LEGEND-1000 experiment will be presented.

T 68.3 Wed 16:35 Tr

The cosmic muon induced background in LEGEND-1000 — •Moritz Neuberger, Luigi Pertoldi, Stefan Schönert, and Christoph Wiesinger — Physik-Department, Technische Universität München, Garching

In-situ production of long-lived isotopes by cosmic muon interactions may generate a non-negligible background for deep underground rare event searches. Depending on the depth, this might limit the sensitivity of next generation experiments, if no additional background identification techniques are implemented. One of those experiments is the LEGEND-1000 experiment (Large Enriched Germanium Experiment

for Neutrinoless double beta Decay). Previous Monte Carlo studies identified the delayed decay of $^{77(m)}$Ge as dominant cosmogenic background in the search for neutrinoless double beta decay of ^{76}Ge [1]. Studies of this depth-dependent background, with special focus on the current LEGEND-200 site are carried out. Various background mitigation strategies, including different geometries, xenon doping and active rejection cuts are under study to increase the virtual depth.

[1] C. Wiesinger et al., Eur.Phys.J.C 78 (2018) 7, 597

T 68.4 Wed 16:50 Tr

The Large Enriched Germanium Experiment for Neutrinoless double beta Decay - LEGEND-1000 — •Christoph Wiesinger for the LEGEND-Collaboration — Physik-Department, Technische Universität München, Garching

Hidden by their tiny mass, neutrinos may carry a profound secret with far-reaching consequences for both particle physics and cosmology. Given zero electric charge and no color, they may be Majorana particles - fermions which are their own anti-particles. Double beta decay offers a unique probe for this hypothesis. Finding no neutrinos, but solely two electrons carrying the full decay energy, would prove lepton number non-conservation and reveal the Majorana character of neutrinos. The superb spectroscopic performance of high-purity germanium detectors provides exceptional discovery potential for the mono-energetic peak and separates it from the standard-model allowed continuum. Event topology information and outstanding intrinsic radiopurity allow for an ultra-low background level. Following the initial 200-kg phase, LEGEND-1000 will expand the reach of current neutrinoless double beta decay experiments by two orders of magnitude, beyond 10^{28} years of half-life, probing the full parameter space spanned by the inverted ordering scenario. The status of the LEGEND experimental program, as well as the requirements and challenges for the ton-scale phase will be covered in this talk. This work has been supported in part by the German Federal Ministry for Education and Research (BMBF), the German Research Foundation (DFG) via the SFB1258 and the Max Planck Society (MPG).

T 68.5 Wed 17:05 Tr

Pulse Shape Analysis in GERDA — •Vikas Bothe for the GERDA-Collaboration — MPIK Heidelberg

The GERDA experiment searches for the neutrinoless double- beta decay of ^{76}Ge using enriched high purity Germanium diodes as a source as well as a detector. For such a rare event search, the sensitivity of the experiment can be improved by employing active background suppression techniques. The time-profile analysis of the signals, called pulse shape analysis (PSA), generated by energy deposits within the detectors is employed to discriminate signal and background events. The PSA can highly reject background events like alpha particles and Compton scattered photons while preserving a high signal efficiency for $2\nu\beta\beta$-like events.

In Phase II, GERDA operated 44.2 kg HPGe detectors which included 6 semi-coaxial detectors, 5 inverted coaxial detectors, and 30 point-contact BEGe detectors. Different pulse shape analysis techniques were employed for these three types of detectors due to their different geometries. I will discuss the results from the pulse shape analysis of these detectors after the final data unblinding from May 2020.

T 68.6 Wed 17:20 Tr

Statistical methods for the final data analysis of GERDA — •Lolian Shtembari[1], Allen Caldwell[1], Matteo Agostini[2], and Oliver Schulz[1] for the GERDA-Collaboration — [1]Max Planck Institute for Physics, Munich, Germany — [2]Department of Physics and Astronomy, University College London, London, UK

The GERmanium Detector Array (GERDA) experiment investigated the Majorana nature of neutrinos by searching for the lepton-number-violating neutrinoless double-β ($0\nu\beta\beta$) decay of 76Ge. We present the statistical analysis of the data collected during all of GERDA's operational time. Through Bayesian Hierarchical modelling we investigated some challenging key aspects in the search for rare-processes: evaluating the discovery potential power, the limit setting power on the signal rate and the goodness of fit of the background for models with data sets consisting of a small number of events. The topics selected include the systematic variations in the results due to the choice of fit models. Order statistics and the Bayes factor are used as tools to study the background goodness of fit and the signal discovery potential.

T 68.7 Wed 17:35 Tr

Investigating the background of Ge neutrino experiments by ^{76}Ge(n,p)^{76}Ga reaction studies — •Hans Hoffmann[1], Marie Pichotta[1], Konrad Schmidt[2], Steffen Turkat[1], Birgit Zatschler[1], and Kai Zuber[1] — [1]TU Dresden IKTP, Dresden, Deutschland — [2]HZDR, Dresden, Deutschland

Several neutrino experiments, e.g. GERDA, are searching for the neutrinoless double beta decay of ^{76}Ge. The discovery of this extremely rare process with an expected Q-value of 2039 keV would prove the Majorana character of neutrinos and consequently physics beyond Standard Model. For an explicit identification of a signal caused by the neutrinoless double beta decay a precise understanding of the background components is crucial.

Previous work indicates gamma rays from the decay of ^{76}Ga in the region of interest (ROI) which can be produced by neutrons via (n,p)-reactions with ^{76}Ge and therefore contribute to the background in the ROI. For the investigation of this potential background an enriched Ge-sample is activated by neutrons from a DT generator located at the Helmholtz-Zentrum Dresden-Rossendorf (HZDR). Experimental procedure and preliminary works will be presented. This project is supported by BMBF (05A17OD1).

T 68.8 Wed 17:50 Tr

Simulation of the liquid argon veto system in Gerda and beyond — •Luigi Pertoldi[1,2] and Christoph Wiesinger[1] for the GERDA-Collaboration — [1]Physik-Department, Technische Universität München, Garching — [2]INFN Padova, 35131 Padua, Italy

Liquid argon (LAr) is widely employed in physics experiments as an active detector medium, thanks to its scintillation properties. In the Gerda experiment, LAr has served the three-fold role of cooling liquid for germanium detectors, passive and active shield against backgrounds. This technology choice has proven to be an effective background suppression strategy for Gerda to search for neutrinoless double-beta decay ($0\nu\beta\beta$) of ^{76}Ge in a background-free regime. In order to characterize the LAr veto system, a Monte Carlo framework has been developed to simulate the propagation of scintillation photons in the experimental setup and determine the expected veto condition for various event types. Data from special calibration runs is used to compensate for unknown optical parameters and effectively tune the simulation. Based on these expectations, a full background model of physics data has been obtained. This model provides insights on the background composition in the region of interest for the $0\nu\beta\beta$ search and is a fundamental input to exotic physics searches in the full energy range. In this talk, I will review the tools and the techniques developed to model the Gerda LAr veto system and present preliminary results. This work has been supported in part by the Italian Ministry of University and Research (MIUR), the Istituto Nazionale di Fisica Nucleare (INFN), BMBF and DFG via the SFB1258.

T 68.9 Wed 18:05 Tr

Search for 0νECEC of ^{36}Ar in GERDA Phase II — •Michele Korosec, Elisabetta Bossio, and Christoph Wiesinger for the GERDA-Collaboration — Physik-Department, Technische Universität München, Garching

The main objective of the GERmanium Detector Array (GERDA) experiment at the Laboratori Nazionali del Gran Sasso (LNGS, Italy) is to prove the Majorana nature of neutrinos through the discovery of the lepton-violating neutrinoless double-beta decay of ^{76}Ge. Similarly, an ^{36}Ar atom can capture two electrons in a process called neutrinoless double electron capture (0νECEC) which likewise can be studied in the GERDA experiment.

The GERDA Phase I analysis of 0νECEC in ^{36}Ar resulted in the current best lower limit for the half-life of $T_{1/2} > 3.6 \times 10^{21}$ years [1] for this process. The introduction of the liquid argon veto system in Phase II allowed for a significant background reduction compared to Phase I. Additionally, Phase II of the experiment offers more than four times the exposure.

According to a preliminary estimate, the Phase II sensitivity will double the Phase I result. The current status quo on the analysis of 0νECEC of ^{36}Ar in GERDA Phase II will be presented in this contribution. This work has been supported in part by the German Federal Ministry for Education and Research (BMBF) and the German Research Foundation (DFG) via the SFB1258.

[1] GERDA Collaboration, Eur.Phys.J.C 76 (2016) 12, 652

T 69: Neutrino physics without accelerators VI

Time: Wednesday 16:00–18:35 Location: Ts

Group Report T 69.1 Wed 16:00 Ts

First constraints on coherent elastic neutrino nucleus scattering by CONUS — •Thomas Hugle for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik (MPIK), Heidelberg, Germany

The CONUS experiment, located in Brokdorf, Germany, at one of the most powerful nuclear power plants in the world, aims at the detection of elastic neutrino nucleus scattering in the fully coherent regime below 10 MeV neutrino energy. This talk will describe the experimental setup of the four CONUS germanium detectors with a very low energy threshold in an elaborate shield at 17 m distance from the 3.9 GW thermal power generating reactor core. A first full spectral analysis of 248.7 kg·d reactor on and 58.8 kg·d reactor off (background) data will be presented, including all relevant systematic uncertainties and a complete Monte Carlo description of the background. This data set allows to place the current best limit on the coherent elastic scattering of reactor antineutrinos.

T 69.2 Wed 16:20 Ts

Quenching factor measurements for keV range nuclear recoils in germanium — •Aurélie Bonhomme for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik, 69117 Heidelberg

Coherent elastic neutrino-nucleus scattering (CEvNS) and Dark Matter search experiments are looking for nuclear recoils induced by neutrinos or Weakly Interacting Massive Particles. Their interpretation crucially relies on the understanding of the stopping process of the recoiling ion in the detecting media. In particular for detectors measuring ionization yields, such as high-purity germanium detectors (HPGe), it is of primary importance to know which fraction of the initial energy goes into ionization, while the rest is being dissipated as heat. This quantity, commonly called quenching factor, suffers from large uncertainties in the keV range - the region of interest for reactor-based CEvNS experiments like CONUS.

Recently, a dedicated quenching measurement was carried out by the CONUS group of MPIK in cooperation with the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig, Germany. It is expected that the results will significantly reduce the dominant uncertainty of the signal prediction of currently running CEvNS experiments using HPGe detectors. For this measurement, collimated monoenergetic neutron beams obtained via Li(p,n) reactions were used to probe nuclear recoils energies between 0.8 and 6 keV in a thin HPGe target. In this talk, the experimental setup and preliminary insights into the data will be presented.

T 69.3 Wed 16:35 Ts

The CONUS experiment - SM and BSM opportunities with recent and future data — •Thomas Rink for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik (MPIK), Heidelberg, Deutschland

The discovery of coherent elastic neutrino nucleus scattering (CEνNS) by the COHERENT experiment in 2017 set the stage for new opportunities within and beyond the Standard Model's neutrino sector. In 2020, the CONUS experiment located at the nuclear power plant in Brokdorf (Germany) was able to set the world's best limit in the challenging fully coherent regime at reactor site. In particular, the application of ultra-low threshold, high-purity Germanium detectors within a sophisticated shielding design in close vicinity to a nuclear reactor core describes the next milestone towards high-statistic neutrino physics. Moreover, the acquired and future CONUS data sets allow further investigations of yet undetected neutrino channels and properties such as neutrino magnetic moments and non-standard neutrino-quark interactions. Sensitivities to the Weinberg angle at MeV-scale and the reactor's antineutrino spectrum persist as well. Measurements at reactor site not only complement CEνNS investigations with neutrino beams, but might also affect other branches like dark matter or supernova physics. This talk gives an overview of the rich CEνNS phenomenology that can be addressed with recent and future experiments while highlighting the unique possibilities of the CONUS concept at nuclear power plants.

T 69.4 Wed 16:50 Ts

Background decomposition of the CONUS Experiment — •Janina Hakenmüller for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The CONUS experiment uses four low energy threshold high-purity Germanium (Ge) spectrometers to look for coherent elastic neutrino nucleus scattering (CEνNS) at the nuclear power plant of Brokdorf, Germany, which provides a high antineutrino flux with energies below 10 MeV. A successful background suppression is crucial to the success of the experiment. It is achieved with an elaborated shell-like shield design including an active muon veto. The latter provides reduction of cosmic radiation, as at the nuclear power plant only an overburden of 24 m w.e. is available. The background composition and its reduction through the shield is studied with Monte Carlo (MC) simulations with the Geant4-based framework MaGe. Any potential reactor correlated background at the location of the experiment was examined in a dedicated measurement and simulation campaign. In the talk, it will be shown that the contribution is negligible within the shield. A full description of the remaining non-reactor correlated background components inside the shield within the region of interest for CEνNS below 1 keV$_{ee}$ will be presented. Special attention is paid to time-dependent backgrounds such as the decay of cosmogenically activated isotopes and airborne radon. An outlook on possibilities to further suppress the remaining background will be given.

T 69.5 Wed 17:05 Ts

Development and operation of the OSIRIS prototype — •Oliver Pilarczyk, Wilfried Depnering, Heike Enzmann, Paul Hackspacher, Artur Meinusch, Kai Loo, Hans Steiger, Eric Theisen, and Michael Wurm — Institut für Physik, JGU Mainz

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kt liquid scintillator experiment currently under construction in Jiangmen (China). Its main scientific goal is to determine the neutrino mass ordering by measuring antielectron neutrinos from two nearby nuclear power plants at a distance of ~53 km. To achieve this goal the liquid scintillator has to go through several purification plants on site to make sure it meets the optical and radiopurity requirements.

The 20m* OSIRIS pre-detector is the last device behind these purification plants. Its task is to monitor the radiopurity of the purified scintillator before it is filled in the JUNO detector. OSIRIS is expected to be operated in a continuous mode, which means that the scintillator will be filled from the top and drained from the bottom into the main JUNO detector. To make sure every batch of the scintillator stays about 24 h inside the OSIRIS detector a temperature gradient will be established in the detection volume to help stratification of the liquid scintillator inside. This talk presents the prototype of the OSIRIS detector as developed and operated in Mainz as well as the results from the experiment. Furthermore a study on the sensitivity of the OSIRIS detector to U/Th contamination levels of the scintillator will be shown. The development is funded by the DFG Research Unit 'JUNO' (FOR2319) and the Cluster of Excellence PRISMA+.

T 69.6 Wed 17:20 Ts

Online analysis for the OSIRIS pre-detector of JUNO — •Philipp Kampmann[1], Runxuan Liu[1,2], Kai Loo[3], Livia Ludhova[1,2], Alexandre Göttel[1,2], Luca Pelicci[1,2], Mariam Rifai[1,2], Giulio Settanta[1], and Cornelius Vollbrecht[1,2] — [1]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [3]Johannes Gutenberg-Universität Mainz, Institute for Physics and EC PRISMA+, Mainz, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton liquid scintillator experiment currently under construction in the vicinity of the Pearl River Delta in Southern China. The data-taking is expected to start in 2022. JUNO aims to address a vast variety of physics goals in a broad range of energies. Its main focus lies on the determination of the Neutrino Mass Ordering measuring the oscillated reactor electron anti-neutrino spectrum from two adjacent nuclear power plants. Such measurements in the low-energy regime are affected and would suffer from high unexpected radioactive contaminations in the liquid scintillator. To ensure these strict limits, the OSIRIS pre-detector is designed to monitor the radioactivity of the liquid scintillator during the filling process of the JUNO detector. It

holds 18 tons of scintillator and is instrumented via 76 large 20-inch PMTs. To provide an early warning of such a highly contaminated scintillator, the data from the OSIRIS detector needs to be evaluated in real-time. The corresponding online monitor software and analysis will be presented in this talk.

T 69.7 Wed 17:35 Ts

Vertex-Rekonstruktion für den JUNO-Vordetektor OSIRIS — •Artur Meinusch, Wilfried Depnering, Heike Enzmann, Paul Hackspacher, Kai Loo, Oliver Pilarczyk, Hans Steiger, Eric Theisen und Michael Wurm — Johannes Gutenberg-Universität Mainz, Institute of Physics and EC PRISMA$^+$, Staudingerweg 7, 55128 Mainz

Das Jiangmen Underground Neutrino Observatory (JUNO) ist ein Neutrino-Experiment, welches mehrere aktuelle Fragen zu Neutrino-Oszillationen klären soll, z.B. die Neutrino-Massenhierarchie, aber auch Sonnen-, Supernova- und Geo-Neutrinos beobachten soll. Die radioaktive Reinheit des Flüssigszintillators ist sehr wichtig für die Empfindlichkeit des Detektors. Um das Funktionieren der Reinigungsanlagen während der Befüllung des JUNO-Detektors zu gewährleisten, wurde der „Online Scintillator Internal Radioactivity Investigation System“ OSIRIS-Vordetektor entwickelt. Seine Aufgabe ist es, die intrinsische Kontamination über die Zerfälle der radioaktiven Isotope im Szintillator zu messen. Die angepeilte Empfindlichkeit von OSIRIS beträgt 10^{-16} Gramm U/Th pro Gramm Szintillator. Die Analyse stützt sich auf die Verwendung eines ausgezeichneten Referenzvolumens und die räumliche Koinzidenz von Bi-Po-Zerfällen. In diesem Vortrag werden verschiedene Rekonstruktionsalgorithmen vorgestellt, die zu diesem Zweck entwickelt wurden. Diese Arbeit wird von der DFG-Forschergruppe „JUNO“ (FOR2319) und dem Exzellenzcluster PRISMA$^+$ unterstützt.

T 69.8 Wed 17:50 Ts

Timing Calibration of the OSIRIS detector — •Tobias Sterr, Lukas Bieger, David Blum, Marc Breisch, Jessica Eck, Tobias Heinz, Benedict Kaiser, Frieder Kohler, Tobias Lachenmaier, Axel Müller, Alexandert Tietzsch, and Jan Züfle — Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20kt liquid scintillator (LS) detector currently under construction near Kaiping in southern China. Since this detector will feature an energy resolution of 3% @ 1MeV, the radiopurity of the liquid scintillator is of high importance. For monitoring the very low background rate introduced by radio impurities of the LS filling, the OSIRIS (Online Scintillator Internal Radioactivity Investigation System) pre-detector is introduced. To enable OSIRIS to measure impurities of up to 10-16g/g of Uranium and Thorium, a good event reconstruction and control of external backgrounds is important. Therefore, a precise calibration of the timing of the PMT array of OSIRIS is necessary. This talk will present an overview on the concept, the hardware and accompanying simulations of the timing calibration system of OSIRIS, which is based on 24 diffused light injection points driven by a pico-second pulsed Laser. This work is supported by the DFG (Deutsche Forschungsgemeinschaft).

T 69.9 Wed 18:05 Ts

Development of the muon veto system for the OSIRIS pre-detector of JUNO — •Axel Müller, Lukas Bieger, David Blum, Marc Breisch, Jessica Eck, Tobias Heinz, Benedict Kaiser, Frieder Kohler, Tobias Lachenmaier, Tobias Sterr, Alexander Tietzsch, and Jan Züfle — Eberhard Karls Universität Tübingen

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20-kton liquid scintillator next-generation neutrino detector currently under construction in southern China. Besides the main goal of determining the neutrino mass ordering, a broad range of neutrino sources will be investigated. For the monitoring of the liquid scintillator contamination levels during the filling process, the OSIRIS pre-detector is being designed, a 20-ton liquid scintillator detector installed in the scintillator filling line. Secondary neutrons and isotopes from cosmic muons are a severe background source, which affect the OSIRIS sensitivity limits. To reject this background source a Cherenkov muon veto was developed, for which the water volume around the target volume will be instrumented with additional PMTs. Their arrangement and the optical properties of the detector surfaces were optimized based on simulations to maximize the detection of Cherenkov photons from muons and thus increasing the muon detection efficiency. In this talk the requirements on the muon veto sensitivity, the design of the veto system and its expected performance will be reported. This work is supported by the Deutsche Forschungsgemeinschaft.

T 69.10 Wed 18:20 Ts

Status update on AURORA — •Wilfried Depnering, Michael Wurm, Heike Enzmann, Paul Hackspacher, Kai Loo, Artur Meinusch, Oliver Pilarczyk, Hans Steiger, and Eric Theisen for the JUNO-Collaboration — Johannes Gutenberg University, Mainz, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a reactor antineutrino experiment which aims to determine the neutrino mass ordering. In order to reach that goal, an energy resolution of 3% @ 1 MeV and percent-level understanding of energy-scale non-linearities are crucial prerequisites. Therefore, the transparency of the liquid scintillator (LS) has to be sufficiently high (attenuation length $L \geq 20\,\mathrm{m}$ @ 430 nm) and remain stable during the whole operation time.

One device for in-situ monitoring of the optical LS quality is AURORA (**A** **U**nit for **R**esearching **O**n-line the LS t**RA**nsparency) inside the central detector of JUNO. Tiltable, blue laser beams are used to measure the optical attenuation of the LS allowing the detection of aging or other potential effects on LS transparency over time.

This talk presents the current status of AURORA. The development is funded by the DFG Research Unit "JUNO"(FOR2319) and the Cluster of Excellence PRISMA$^+$.

T 70: Searches for Dark Matter II

Time: Wednesday 16:00–18:30 Location: Tt

T 70.1 Wed 16:00 Tt

The DARWIN full diameter test platform — •Florian Tönnies — Albert-Ludwigs-Universität Freiburg, Deutschland

In the last two decades liquid xenon TPCs have proven to be a very successful tool in the search for WIMP dark matter and other science channels. The detectors became bigger with every generation and the next generation and probably the final evolution stage of xenon TPCs for dark matter search will be DARWIN, which is planned to emply 50 tons of xenon. As it is almost twice the height and diameter of its direct predecessors currently under commissioning, its hardware components needs adequate testing at this new scale. For this purpose the DARWIN full-diameter test facility PANCAKE was developed and is being set up in Freiburg. We present it's unique features, design challenges, subsystems and first test results.

T 70.2 Wed 16:15 Tt

Modelling muon-induced background for the DARWIN observatory — •Jose Cuenca-García for the DARWIN-Collaboration — Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT)

The goal of the DARWIN experiment is to become the most powerful WIMP dark matter (DM) detector using tens of tonnes of liquid Xenon as a target inside a sensitive time projection chamber. Although DM experiments are placed deep underground in order to be shielded from the cosmic radiation, muon-induced secondaries, especially neutrons are a relevant contribution to the background. These neutrons are produced by muons via direct spallation of nuclei or by the electromagnetic cascades generated when the muon passes through the rock, the shielding materials or the detector system itself. Since the energy of neutrons can be of the order of several GeV, they can deeply penetrate various materials before being stopped. The study of the muon-induced neutrons is therefore a key part for the design of the vetos around the detector. We present here detailed 3-dim full-chain Geant4 simulations of muons with their interactions producing the neutrons and other potential background sources for the DARWIN science program and estimate how much they can contribute to the

total background of various physics channels.

T 70.3 Wed 16:30 Tt

A New Radon Emanation Chamber for the Radiopurity Assay of DARWIN — •Daniel Baur — University of Freiburg, Freiburg, Germany

Liquid xenon-based experiments are currently leading the search for WIMP dark matter. Their electronic recoil background in the energy region of interest is dominated by the naked (i.e. not accompanied by the coincident emission of a gamma-ray) beta decays of 214Pb, a progeny of 222Rn which is emanated from all material surfaces. Consequently, the assessment of 222Rn emanation is mandatory for the success of next-generation dark matter experiments with multi-ton xenon targets such as DARWIN. The 222Rn surface emanation can be measured directly with a radon emanation chamber, where the daughters of 222Rn are collected electrostatically on a silicon PIN diode and the subsequent alpha decays are detected. We report on a new suchlike detector for the radiopurity assay of DARWIN, currently being commissioned in Freiburg.

T 70.4 Wed 16:45 Tt

Towards a hermetic TPC for the DARWIN experiment — •Julia Dierle — Albert-Ludwigs-Universität, Freiburg, Germany

With its ambitious sensitivity to rare WIMP-nucleus interaction, the DARWIN experiment has to significantly exceed the already very low target-intrinsic background rates achieved by the currently leading dark matter experiments. These are dominated by radon which is constantly emanated from all detector surfaces. The concept of a hermetic TPC could complement approaches like radon distillation, material selection and surface treatment and contribute towards the goal of a radon-induced background rate of 0.1 μBq/kg. The hermetic TPC minimizes the surface being in direct contact with the active xenon target volume which must thus be enclosed in an almost liquid- and gas-tight shell. We report on the status and the first run of such a hermetic TPC prototype.

T 70.5 Wed 17:00 Tt

Optimizing Disk Positions for MADMAX — •Jacob Egge for the MADMAX-Collaboration — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

The **MA**gnetized **D**isk and **M**irror **A**xion e**X**periment is an upcoming dark matter experiment which will search for axions, a promising dark matter candidate. It relies on the conversion of axions from the galactic dark matter halo to detectable photons in a strong magnetic field. Dielectric disks placed inside the magnetic field each emit converted photons and boost the tenuous axion signal by coherent interference and resonances between disks. The spacing of disks determines this frequency-dependent boost and finding the optimal configuration for a given frequency range is a non-trivial task.

The position and orientation of up to 80 disks in the final full-scale experiment and 20 disks in the prototype experiment must be considered. As with any high-dimensional optimization, a brute force approach quickly becomes unpractical. This talk outlines a method that greatly reduces dimensionality and complexity of the problem by exploiting correlations between disk positions. This not only significantly speeds up optimization but also yields insights into the electromagnetic behavior of the disks.

Deviations from perfectly flat dielectric disks deteriorate the boost of the axion signal. First results on compensation by re-optimizing disk positions and subsequent relaxation of disk flatness requirements are presented as well.

T 70.6 Wed 17:15 Tt

Characterisation of dielectric materials for the MADMAX booster. — •Dominik Breitmoser for the MADMAX-Collaboration — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

The axion is a hypothetical low mass particle which is a prominent candidate for cold dark matter. The **MA**gentized **D**isc and **M**irror **A**xion e**X**periment is an experiment designed for its detection. MADMAX utilizes the axion photon conversion at dielectric surfaces in a strong magnetic field. Through constructive interference and resonance effects, the combination of several dielectric disks can boost the axion photon conversion sufficiently to make it detectable, requiring a material with high dielectric constant ε and low dielectric losses.

One of the favoured materials is Lanthanum Aluminate with $\varepsilon \approx 24$ available in small wafers. The MADMAX dielectric disks need to have a size of 1.25 m in diameter (0.3 m for the prototype). Thus, the disks need to be glued from hexagonal tiles using a cryo-compatible adhesive like Stycast Blue. Characterisation of these materials is performed by measurements with a Split-Post Dielectric Resonator in a cryostat at 10 GHz.

In this talk, this technique and its limitations are explained. Results of the dielectric loss and ε for these materials at several temperatures will be shown.

T 70.7 Wed 17:30 Tt

The MADMAX prototype booster system — •Christoph Krieger for the MADMAX-Collaboration — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

The axion is a viable and natural candidate for (cold) dark matter. The theoretically favored mass range for the discovery of axions, 40 to 400 μeV, can be ivestigated using a dielectric haloscope. The **MA**gentized **D**isc and **M**irror **A**xion e**X**periment is based on this approach, utilizing the axion photon conversion at dielectric surfaces in a strong magnetic field. By combining many surfaces, the conversion can be boosted significantly using constructive interference and resonances.

To prototype the MADMAX booster system, a small booster with twenty dielectric discs of 300 mm diameter is foreseen. These discs have to be (re-)positioned in situ with micrometer precision inside a large magnetic field and a cryogenic environment. The prototype system will be commissioned in a dedicated cryostat at the University of Hamburg and later operated at CERN inside the MORPURGO magnet for a first axion search with a dielectric haloscope.

In this presentation, the concept of the MADMAX prototype and especially the development of the booster will be presented, showing the recent status of the production of tiled discs as well as studies on the first prototype of the drive system.

T 70.8 Wed 17:45 Tt

Investigation of dielectric loss (tanδ) of low-loss materials for the axion dark matter search experiment, MADMAX — •Erdem Oez for the MADMAX-Collaboration — RWTH, Aachen, Germany

In the presence of dark matter axions a dielectric material submerged in a magnetic field emits microwaves. The magnetized disk and mirror axion (MADMAX) experiment plans to use multiple ($\sim$ 80) large ($\sim$ 1 mm thick, $\sim$ 1.25 m diameter) dielectric disks to enhance the microwave signal. In order to further maximize generated signal, low-loss (tan$\delta < 10^{-4}$) materials such as Sapphire (Al2O3) or Lanthanum Aluminate (LaAlO3) need to be used as disk materials. In this talk we present a very sensitive resonator cavity method, measurements and results for investigation of dielectric properties of these materials.

T 70.9 Wed 18:00 Tt

Tuneable (HT)S RADES cavity prototype — •Jessica Golm for the RADES-Collaboration — European Organization for Nuclear Research (CERN), Geneva , Switzerland — Friedrich Schiller University Jena, Jena, Germany

The RADES (Relic Axion Detector Exploratory Setup) project has the goal of directly searching for axion dark matter above the 30 μeV scale employing custom-made microwave filters in magnetic fields, in particular exploiting existing accelerator dipole magnets. Our existing setup comprises an array of small microwave cavities connected by rectangular irises. The size of the unit cavity determines the main resonant frequency, while connecting a large number of cavities provides a large detection volume. The next step of the project is the development of superconducting cavities which resonate in the range of 8 to 9 GHz and have high quality factors in magnetic fields of up to 14 T. Suitable materials for this applications are high temperature superconductors (HTS) or Nb3Sn. A microwave cavity has been optimized to facilitate superconducting coating which fits in the bore of available high-field accelerator magnets at CERN. Such cavities can be used in multi-tesla magnetic fields and have a higher sensitivity compared to copper coated cavities of the same type. In addition, the new prototype is cut vertically along the electrical field lines which allows a tuning range of 600 MHz by adjusting the separation of the two halves. The present status of this program is described.

T 70.10 Wed 18:15 Tt

New method to search for axion-like particles demonstrated

with polarized beam at the COSY storage ring — •Swathi Karanth for the JEDI-Collaboration — Marian Smoluchowski Institute of Physics, Jagiellonian University, Cracow, Poland

The axion was originally proposed to explain the small size of CP violation in quantum chromodynamics. If sufficiently abundant, it might be a candidate for dark-matter in the universe. Axions or axion-like particles (ALPs), when coupled with gluons, induce an oscillating Electric Dipole Moment (EDM) along the nucleon's spin direction. This can be used in an experiment to search for axions or ALPs using charged particles in a storage ring.

In spring of 2019, at the Cooler Synchrotron (COSY) in Jülich, we performed a first test experiment to search for ALPs using an in-plane polarized deuteron beam with a momentum of 0.97 GeV/c. At resonance between the spin precession frequency of deuterons and the EDM oscillation frequency there will be an accumulation of the polarization out of the ring plane. Since the axion frequency is unknown, the momentum of the beam was ramped to search for a vertical polarization jump that would occur when the resonance is crossed. At COSY, four beam bunches with different polarization directions were used to make sure that no resonance was missed because of the unknown relative phase between the polarization precession and the EDM oscillations. We scanned a frequency window of about a 1-kHz width around the spin precession frequency of 121 kHz. This talk will describe the experiment and show preliminary results.

T 71: Data analysis, Information technology III

Time: Wednesday 16:00–18:15 Location: Tu

T 71.1 Wed 16:00 Tu

Usage of neural networks in photon identification in ATLAS — •Florian Kirfel and Oleh Kivernyk — Physikalisches Institut der Universität Bonn

Optimal photon identification in ATLAS analyses plays an important role in precise measurements of Higgs boson properties and in the search for new particles.

Currently photons are selected using a set of cuts on calorimeter variables which describe the shape of electromagnetic showers. These cuts were optimized using Monte Carlo simulations of photons and jets. Due to the simulations not being ideal, the selection efficiencies must be corrected to match data. The efficiency measurement in data is not simple and requires assumptions about some shower shape variables, i.e. that they are independent of the isolation of the photon candidate.

Artificial neural networks are employed to improve the current photon identification. Decorrelation of the neural network output from the isolation variable results in an improvement of the efficiency measurement in data.

T 71.2 Wed 16:15 Tu

Studies of modern machine learning methods for tau lepton identification with the CMS detector — •Andrew Issac[1], Günter Quast[1], Roger Wolf[1], Stefan Wunsch[1,2], and Sebastian Brommer[1] — [1]Karlsruhe Institute of Technology, Institute of Experimental Particle Physics, Karlsruhe, Germany — [2]CERN, Geneva, Switzerland

High-energy physics particle reconstruction algorithms are a perfect playground for modern machine learning methods due to the vast amount of data and complex learning tasks. The tau lepton identification is an interesting field to explore new neural network models such as graph-based networks and benchmark them against existing approaches, e.g., a deep convolutional model currently used by CMS.

T 71.3 Wed 16:30 Tu

Adversarial Neural Network-based shape calibrations of observables for jet-tagging at CMS — Martin Erdmann[1], •Benjamin Fischer[1], Jan Middendorf[1], Dennis Noll[1], Yannik Alexander Rath[1], Marcel Rieger[2], Erwin Rudi[1], and David Josef Schmidt[1] — [1]III. Physikalisches Institut A, RWTH Aachen University — [2]CERN

Scale factors are commonly used in HEP to improve shape agreement between distributions of data and simulation. The choice of the underlying model for such corrections is of great importance, but often requires a lot of manual tuning e.g. of bin sizes or fitted functions. This can be alleviated through the use of neural networks and their inherent powerful data modeling capabilities.

We present a novel and generalized method for producing shape changing scale factors using adversarial neural networks. This method is investigated in the context of the bottom-quark jet-tagging algorithms within the CMS experiment. The scale factor of each jet is produced by the primary network using the jet's variables. The second network, the adversary, aims to differentiate between data and rescaled simulation events and facilitates the training of the former. An additional third network is used for normalization preservation with respect to correlated variables.

We present the conceptual design and resulting scale factors in comparison to the previously applied methods.

T 71.4 Wed 16:45 Tu

AI-safety for jet flavour tagging at the CMS experiment — Xavier Coubez[1,2], Nikolas Frediani[1], Spandan Mondal[1], Andrzej Novak[1], Alexander Schmidt[1], and •Annika Stein[1] — [1]RWTH Aachen University, Germany — [2]Brown University, USA

Besides traditional Machine Learning techniques, Deep Learning has gained popularity in High Energy Physics in general. At the CMS experiment in particular, jet identification algorithms use Deep Neural Networks to classify the quark flavour from which the jet originates. The tagger learns to discriminate between heavy flavour quarks and light quarks.

The aim of AI safety studies is to test how susceptible neural networks are when mismodeling occurs in the simulation or when adversarial attacks are applied to the input data. Subtle mismodelings could be invisible to typical validation methods. In this talk, several methods to manipulate the input data and the impact on the performance of the tagging algorithm will be shown.

T 71.5 Wed 17:00 Tu

Charm jet identification and discriminator calibration with the CMS experiment — •Spandan Mondal[1], Xavier Coubez[1,2], Alena Dodonova[1], Luca Mastrolorenzo[1], Andrzej Novak[1], Andrey Pozdnyakov[1], and Alexander Schmidt[1] — [1]RWTH Aachen University, Germany — [2]Brown University, USA

Identification of charm-quark-initiated jets at the LHC is especially challenging. Over the past few years, usage of advanced deep learning based algorithms has enabled several CMS analyses to efficiently discriminate charm jets simultaneously from bottom and light jets. The charm probability scores yielded by such charm tagging algorithms can play a powerful role when used as inputs to a machine learning based signal-background discriminating algorithm. However, as jet identification algorithms are trained strictly on simulated jets, a direct usage of charm tagger output values requires calibrating the entire output probability distributions using real jets reconstructed from CMS data. This talk focuses on charm jet identification algorithms in CMS as well as the calibration of their output discriminator values using flavour-enriched selections of jets in data.

T 71.6 Wed 17:15 Tu

Performance Studies of the Integration of a Deep-Impact-Parameter-Setsbased Tagger for the ATLAS Experiment b-Tagging Algorithm — •Alexander Froch, Manuel Guth, and Andrea Knue — Albert-Ludwigs Universität Freiburg, Experimentelle Teilchenphysik AG Herten

The identification of the origin of a jet produced in a high-energy collision is an important task and is crucial for most analyses performed at the ATLAS experiment. Different multivariate techniques are used and combined to determine the jet origin. One of these techniques is the Deep Impact Parameter Sets (DIPS) tagger.

The DIPS tagger is a deep neural network based on the Deep Sets architecture. It uses track information of the particles inside the clustered jets for classification. It is part of a new tagging algorithm currently developed in ATLAS. The algorithm itself can distinguish between different jet origins, like light, charm or bottom jets. A good performance was already observed for a training using $t\bar{t}$ events. For further improvement in the high p_T region, jets from Z' decays are included in the training.

The performance of this training will be shown along with the impact of the hyper-parameter optimization studies.

T 71.7 Wed 17:30 Tu

Training of an extended b-tagging algorithm with deep neural networks. — •Thea Engler, Manuel Guth, Gregor Herten, and Andrea Knue — Uni Freiburg, Deutschland

The search for the $t\bar{t}H(H \to b\bar{b})$ signal provides direct access to the top-Higgs Yukawa coupling. This channel has four b-jets in the final state and is suffering from large physics background, which makes b-tagging a crucial tool for this analysis. The irreducible $t\bar{t} + b\bar{b}$ background has the same final-state particles as the signal process. In this background process, a radiated gluon splits into a b-quark pair. If these b-hadrons are close to each other, they can be reconstructed as one single jet (bb-jet). The irreducible background $t\bar{t} + b\bar{b}$ can be better rejected if these bb-jets can be classified. Accordingly, an extended b-tagging algorithm is prepared, based on the ATLAS recommended b-tagger, with an additional classification category for bb-jets. To prepare the extended b-tagging algorithm, the importance of balanced input classes in the training of deep neural networks is studied. The studied approaches are implemented in the extended bb-tagger and a first training is presented.

T 71.8 Wed 17:45 Tu

Treating Uncertainties with Bayesian Neural Networks in a $t\bar{t}H$ Measurement — •Nikita Shadskiy and Ulrich Husemann — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

In the Standard Model of particle physics, fermions couple to the Higgs boson via a Yukawa-type coupling with a strength proportional to their mass. The top quark is the heaviest known fermion and, therefore, has the strongest coupling to the Higgs boson.

One of the processes to investigate this coupling is the associated $t\bar{t}H$ production in which the Higgs boson decays into a $b\bar{b}$ pair. This signal process has a much smaller cross section than the challenging background processes like $t\bar{t}$+jets production. Especially $t\bar{t}$+$b\bar{b}$ events are very signal-like. A common approach to separating this signal from the backgrounds is to use artificial neural networks.
Neural networks usually do not take into account uncertainties. In contrast, Bayesian neural networks use weight distributions instead of single weight values. This not only prevents overfitting but also allows to obtain an uncertainty estimate on the predictions of the neural network. In this talk it is investigated how this feature of Bayesian neural networks can be used in a $t\bar{t}H(b\bar{b})$ measurement.

T 71.9 Wed 18:00 Tu

Improvement of the jet-parton assignment in $t\bar{t}H(b\bar{b})$ events using machine-learning techniques — •Daniel Bahner, Andrea Knue, and Gregor Herten — Albert-Ludwigs-University, Freiburg, Germany

The associated production of a Higgs boson and a top quark pair allows to directly measure the Higgs-top Yukawa coupling, which can be sensitive to Beyond Standard Model physics. In the studies presented, the process of interest is the semileptonic decay of the $t\bar{t}$ pair accompanied by a $b\bar{b}$ pair resulting from the most prominent Higgs decay. In this topology, four b-jets and two light jets are expected. This Higgs decay channel suffers from irreducible background due to $t\bar{t} + b\bar{b}$ production. Furthermore, the full reconstruction of this final state proves difficult because of the ambiguities in assigning the jets to their original parton.

In the latest publication, a Boosted Decision Tree was used for the jet-parton assignment. In the studies presented, a Deep Neural Network is used that has been previously trained in the scope of a master thesis. Optimization studies of the network architecture and the impact of using the new ATLAS b-tagging algorithm DL1r will be shown.

T 72: Experimental techniques in astroparticle physics III

Time: Wednesday 16:00–18:30 Location: Tv

T 72.1 Wed 16:00 Tv

PMT afterpulse studies in XENONnT — •Luisa Hötzsch for the XENON-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg

The XENONnT detector is the next generation direct dark matter detector in the XENON experiment series, utilizing in total 8.4 tonnes of xenon in a dual-phase liquid xenon time projection chamber. The scintillation light produced by particle interactions in the xenon target is detected by 494 Hamamatsu R11410-21 photomultiplier tubes (PMTs), chosen for their high quantum efficiency and low intrinsic radioactivity. One of the main PMT-intrinsic backgrounds is the effect of ion afterpulsing. Due to their typically short delay times of up to only a few microseconds, afterpulses can seriously impact the data quality in rare event searches. In particular, increasing afterpulse rates caused by a gradual vacuum degradation in the PMT can induce time-dependent background effects. In this talk I will present studies on the ion afterpulses in the XENONnT PMTs, using in-situ LED data taken during the XENONnT commissioning phase, as well as the afterpulse monitoring tools developed for future science data runs of XENONnT.

T 72.2 Wed 16:15 Tv

Radon removal system for the XENONnT experiment — •Denny Schulte, Michael Murra, Christian Huhmann, Philipp Schulte, and Christian Weinheimer for the XENON-Collaboration — Westfählische Wilhelms Universität, Münster, Germany

The direct dark matter search experiment XENONnT, located at Laboratori Nazionali del Gran Sasso, uses 8.3 tonnes of liquid xenon aiming for the direct detection of the Weakly Interacting Massive Particle (WIMP) and the search for other very rare processes. Intrinsic radioactive isotopes within the liquid xenon like Kr-85 and Rn-222 create the dominant electronic recoil background of the experiment and cannot be reduced by shielding or fiducialisation. A proven removal technique is cryogenic distillation using the different vapor pressures of krypton, radon and xenon. While the krypton removal can be done once before the detector is filled, radon is continously emanating from detector components. Therefore, a novel radon removal system based on an efficient thermodynamic concept ensuring a high xenon throughput has been developed and is now under commissioning at the XENONnT experiment.

This talk will zoom in on the thermodynamic idea and design along with first characterization measurements.

The project is funded by BMBF under contract 05A17PM2 and 05A20PM1.

T 72.3 Wed 16:30 Tv

Measuring xenon scintillation light transmission through PTFE — •Dominick Cichon[1], Guillaume Eurin[1,2], Florian Jörg[1], Teresa Marrodán Undagoitia[1], and Natascha Rupp[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]IRFU, CEA/Saclay, France

Xenon has proven itself to be a well-suited target material to be used in detectors searching for rare events predicted by new physics. This is because of its properties, which include a high stopping power and the availability of both scintillation and charge signal channels. The latter allows for effective particle discrimination.

Detectors which utilize liquid xenon (LXe), such as LXe time projection chambers (TPCs), commonly use polytetrafluoroethylene (PTFE) to maximize the collection of scintillation photons and to optically decouple the intended sensitive volume from other detector regions. The reason is PTFE's high reflectivity at xenon's peak emission wavelength.

For rare event searches, the amount of PTFE used for the purposes mentioned above should be as small as possible in order to reduce the material budget and the accompanying radiogenic background. Furthermore, some detector applications necessitate the attenuation of the scintillation signal because of photosensor constraints. Motivated by these considerations, this talk presents measurements of the transmittance of PTFE for xenon scintillation light, both in gaseous and in liquid xenon. The results can be applied to estimate the amount of PTFE needed for optical decoupling and to construct xenon scintillation light attenuators made out of PTFE.

T 72.4 Wed 16:45 Tv

Offline xenon purity monitoring combining APIMS and gas

chromatography — •Veronica Pizzella and Hardy Simgen — Max-Planck-Institut für Kernphysik, Heidelberg

Dual-phase xenon TPCs are among the most sensitive detectors for Dark Matter in direct searches. For the success of these experiments, it is necessary to use xenon with low concentration impurities. Two classes of impurities are of concern: radioactive impurities such as Kr-85 and H-3, since they increase the background; electronegative molecules such as oxygen, since they reduce the amount of electrons in the TPC. In this presentation, an offline purity monitor is presented using the technique of Atmospheric Pressure Ionization Mass Spectrometry (APIMS), with a commercial APIX dQ from Thermo Fisher and a custom-designed chromatography setup. The presented system is able to detect chemical impurities at the sub-ppb level. The calibration of the system and some results are presented.

T 72.5 Wed 17:00 Tv

Transmission of VUV light through PTFE — •Lutz Althueser[1], Sebastian Lindemann[2], Michael Murra[1], Marc Schumann[2], Christian Wittweg[1], and Christian Weinheimer[1] — [1]Institut für Kernphysik, WWU Münster, Germany — [2]Physikalisches Institut, Universität Freiburg, Germany

Polytetrafluoroethylene (PTFE, Teflon^{TM}) is commonly used in liquid xenon (LXe) based detectors to optimize the xenon scintillation light collection and to reduce the radioactive background rate from detector materials. The active LXe volume of such detectors is encapsulated in PTFE due to its high reflectance for VUV LXe scintillation light with peak emission at 178 nm. The thickness of these PTFE detector components specifies the reflectance, transmission and material radioactivity introduced into the detector.
The talk will present VUV transmission measurements for PTFE samples of various thicknesses in vacuum as well as in gaseous xenon using collimated light at a wavelength of 178 nm [1]. The Kubelka and Munk model will be introduced and applied to describe the light transmission over the full range of PTFE thicknesses.
The work of the author is supported by DFG through the Research Training Group "GRK 2149: Strong and Weak Interactions - from Hadrons to Dark Matter", by BMBF under contract 05A20PM1 and by ERC grant No. 724320 (ULTIMATE).
[1] L. Althueser et al., JINST 15 (2020) P12021

T 72.6 Wed 17:15 Tv

Production and characterization of a ^{226}Ra implanted stainless steel radon source — •Florian Jörg[1], Hardy Simgen[1], and Guillaume Eurin[1,2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Present Address: IRFU, CEA, Université Paris-Saclay, F-91191 Gif-sur-Yvette, France

Future liquid xenon detectors require unprecedented low levels of intrinsic radioactive backgrounds. Particularly, ^{222}Rn represents a background source threatening the design goals for the experiments sensitivity. Therefore extensive radon screening campaigns as well as studies on novel approaches for radon mitigation need to be carried out. Both of which crucially depend on infrastructure allowing to measure radon at very low activities. For the correct quantification of detection efficiencies as well as radon mitigation factors, reliable sources of known and stable radon emanation are necessary.

A new approach to produce clean and dry radon sources by implantation of ^{226}Ra ions into stainless steel has been investigated. In a proof of principle study, two 4 cm^2 large stainless steel plates have been implanted in collaboration with the ISOLDE facility located at CERN. Results from a first characterization of the sources will be presented. Measurements using electrostatic radon monitors and miniaturized proportional counters showed a ^{222}Rn emanation rate of about 2 Bq for each sample. Additional measurements using HPGe screening, alpha spectroscopy as well as measurements of their radon emanation rate at varying temperatures and pressures were carried out.

T 72.7 Wed 17:30 Tv

Modeling the response of non-uniform SiPM arrays — •Christoph Wiesinger, Patrick Krause, Stefan Schönert, and Mario Schwarz — Physik-Department, Technische Universität München, Garching

With typical silicon photomultipliers (SiPMs) having a photo-sensitive area of $O(1)$ cm^2, large-scale installations of > 1 m^2 photo coverage still represent a technical challenge. The usual workaround is to use light guides, e.g. optical fibers, and/or a common read-out of multiple SiPMs in a parallel array configuration. As it is not necessarily granted that each device features equal response, non-uniformities have to be considered an additional source of non-linearity. An analytical response model providing a continuous description of SiPM array spectra, containing on-top optical crosstalk and afterpulsing, has been developed. Its application is intended for the upcoming LEGEND experiment, where secondary event information is provided by scintillation light read-out at liquid argon temperatures.

T 72.8 Wed 17:45 Tv

Measurement of Cherenkov light in Water-based Liquid Scintillators — •Dorina Carolin Zundel, Michael Wurm, and Hans Theodor Josef Steiger — Johannes Gutenberg-Universität Mainz, Institute of Physics, Staudingerweg 7, 55128 Mainz

The SCHLYP detector (Scintillation Cherenkov Light Yield Prism) is a newly developed laboratory setup, used to distinguish between scintillation and Cherenkov light in (Water-based) liquid scintillator samples. The setup uses the geometrical advantages of a hollow prism as a detector, equipped with three ultra-fast photomultipliers (PMTs), on each side. The PMTs have a rise time of 1ns and a transit time spread of 200ps. The prism is filled with a scintillator based on a variety of novel solvents (e.g., LAB (Linear AlkylBenzene), DIN (di-isopropyl naphthalene)), on which photons from a close ^{137}Cs source scatter. A fast scintillation detector based on an anorganic crystal or a plastic scintillator is placed at a distance to detect backscattered events. Due to the directionality of Cherenkov light, the two PMTs opposite to the source are able to detect Cherenkov and scintillation light, while the last PMT is only able to detect scintillation light. Analyzing the coincident events from all four PMTs, the amount of light detected by the PMTs facing the source is higher, which indicates a simultaneous detection of scintillation and Cherenkov light. In this talk the first setup and the analysis of measured data will be presented as well as a new and improved setup. This work is supported by the Bundesministerium für Bildung und Forschung (Verbundprojekt 05H2018: R&D Detectors and Scintillators).

T 72.9 Wed 18:00 Tv

Quantitative Long-Term Monitoring of the Gas Composition in the KATRIN Experiment Using Raman Spectroscopy — •Genrich Zeller — Karlsruhe Institute of Technology

The Karlsruhe Tritium Neutrino (KATRIN) experiment aims at measuring the effective electron neutrino mass with a sensitivity of 0.2 eV/c^2 (90% C.L.) by investigating the energy spectrum of tritium beta-electrons near the kinematic endpoint of 18.6 keV. Analysis of the first neutrino mass data from 2019 set the known neutrino mass limit to 1.1 eV. This achievement was made possible, because most of the system components met, or even surpassed, the requirements during long-term operation. One important component is the laser Raman (LARA) system, which provides continuous high-precision information on the composition and tritium purity of the gas in the experiment's windowless gaseous tritium source (WGTS). In this talk, the performance and achievements of the LARA system are presented. The concentrations c_x for all six hydrogen isotopologues were monitored simultaneously, with a measurement precision of the order 10^{-3} throughout the complete KATRIN data taking. From these, the tritium purity, ϵ_T, is derived with precision of $<10^{-3}$ and trueness of $< 3 \cdot 10^{-3}$, fulfilling and surpassing the requirements for KATRIN. *This work is supported by the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Young Investigator Group (VH-NG-1055).*

T 72.10 Wed 18:15 Tv

KWISP - Latest results on the chameleon hunt at the CAST experiment at CERN — •Justin Baier — Uni Freiburg

The KWISP (Kinetic Weakly Interacting Slim Particle) detector is part of the CAST experiment at CERN exploring the dark sector. It utilizes an ultra-sensitive opto-mechanical force sensor for the search for solar chameleons. Chameleons are hypothetical scalar particles postulated as dark energy candidates, which have a direct coupling to matter depending on the local density. Considering these characteristics a flux of solar chameleons hitting a solid surface at grazing incidence will, under certain conditions, reflect and exert the equivalent of a radiation pressure. To exploit this trait the KWISP sensor consists of a thin and rigid dielectric membrane placed inside a resonant optical cavity. The latest results will be presented in this talk.

T 73: Hauptvorträge (Invited Talks) III

Time: Thursday 9:45–12:30 Location: Tb

Invited Talk T 73.1 Thu 9:45 Tb
The Higgs boson at the LHC: a glimpse under the peak — •Matthias Schröder — Universität Hamburg

In the Standard Model (SM) of particle physics, the Higgs boson is deeply related to the mechanism that creates the masses of elementary particles and, as such, has very characteristic properties, which are different from any other known particle. The large data samples collected during the LHC Run 2 from 2015 to 2018, together with new analysis techniques, allow measurements of Higgs boson production and properties at unprecedented precision. These cover various production and decay channels and include more and more differential measurements. The results play a crucial role in probing the SM and provide a unique window to discover new physics.

In this presentation, I will review the status of Higgs boson measurements by the ATLAS and CMS collaborations and discuss their interpretation within and beyond the SM. Furthermore, I will outline prospects for future measurements at the upcoming LHC Run 3 and at the High-Luminosity LHC.

Coffee Break 30 min

Invited Talk T 73.2 Thu 11:00 Tb
No Time to die? Scrutinizing the SM and other Top Stories — •Reinhild Yvonne Peters — The University of Manchester, Manchester, UK

Technically, the standard model of particle physics has been completed with the discovery of the Higgs boson in 2012. However, the success of the standard model can not hide the fact that new physics beyond the standard model must exist. With the ever-increasing data sample provided by the LHC, precision studies of the standard model are used to challenge its predictions. In my talk, a selection of results from the LHC experiments are presented, in which the standard model is being scrutinised. This includes measurements of the strong and electroweak forces, as well as property measurements of the heaviest known elementary particle, the top quark.

Invited Talk T 73.3 Thu 11:45 Tb
New detector developments: The next challenges — •Erika Garutti — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

Progress in experimental high energy physics crucially depends on advances in detector technologies. Ahead of us is an exciting decade for fundamental research on detectors to fully exploit the possibilities offered by future facilities.

What are the demands of the next generation detector systems? What are the challenges we need to solve? And what are the emerging ideas for novel detectors? I will present recent developments and trends, with a primary focus on accelerator-based experiments. Applications in other fields will also be discussed.

T 74: Eingeladene Vorträge (Invited Topical Talks) V

Time: Thursday 14:00–15:30 Location: Tc

Invited Topical Talk T 74.1 Thu 14:00 Tc
Searches for electroweak supersymmetry: highlights, coverage and limitations — •Jeanette Miriam Lorenz — LMU Muenchen, Germany

Supersymmetry is an appealing extension beyond the Standard Model, which could provide e.g. a particle candidate for Dark Matter. Both the ATLAS and the CMS experiments at the Large Hadron Collider, CERN, carry out a comprehensive search program, addressing several complementary signatures of supersymmetric particles. Searches for the supersymmetric partners of the electroweak gauge bosons (charginos and neutralinos) and leptons (sleptons) are particularly challenging due to low cross sections and possibly low-energetic decay products. The increasing data statistics as well as improvements in the technical methods allow some of these searches to be done for the first time at the LHC. Recent highlights of these searches will be presented along with the assumptions made in the interpretation of the results. Although these searches have not resulted in a discovery yet, there are several ways how supersymmetry could hide, which guide us to new directions in future searches.

Invited Topical Talk T 74.2 Thu 14:30 Tc
To the top and beyond: top quarks as a probe of new interactions at the LHC — •Katharina Behr — DESY

As the heaviest known elementary particle with a close to unity Yukawa coupling to the Higgs field, the top quark plays a special role in the Standard Model and in searches for new particles and interactions, which are often predicted to couple preferentially to the third quark generation. Searches targeting the complex detector signatures of single or multiple top quarks aim, for example, to shed light on dark matter or probe the existence of additional Higgs bosons. I will review the strategies of searches involving top quarks or hypothetical top partners on LHC data from proton-proton collisions at $\sqrt{s} = 13$ TeV, highlighting new analysis and reconstruction techniques.

Invited Topical Talk T 74.3 Thu 15:00 Tc
Stress testing the Standard Model via vector-boson scattering at the LHC — •Mathieu Pellen — Physikalisches Institut, Freiburg, Germany

Vector-boson scattering (VBS) processes have just started to be measured at the Large Hadron Collider (LHC). This is particularly exciting because this class of processes has been thought to be a possible window to new physics. But VBS is also interesting in its own right because it probes the Standard Model in extreme phase-space regions at high energy. The measurement of such processes is particularly challenging due to their low rates and large background. In this talk, I review necessary theoretical inputs to perform such measurements.

T 75: Eingeladene Vorträge (Invited Topical Talks) VI

Time: Thursday 14:00–15:30 Location: Td

Invited Topical Talk T 75.1 Thu 14:00 Td
Hunting dark matter on earth and in the sky — •Kai Schmidt-Hoberg — DESY

I will discuss recent developments in dark matter research with a particlar focus on light dark matter. After a quick overview I will concentrate on complementary search strategies including astrophysical as well as collider based experiments with a particular focus on the complementarity between different searches.

Invited Topical Talk T 75.2 Thu 14:30 Td
Gravitational wave astronomy: highlights so far and future detectors — •David S. Wu — Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Hannover, Germany

The first three observation runs from the advanced (2nd) generation of gravitational wave detectors (GWDs) have opened the doors to the era of gravitational wave astronomy and provided fantastic and partly unexpected scientific results. Upgrades to the current detectors and especially planned future ground-based GWDs such as the Einstein Telescope and Cosmic Explorer will improve the sensitivity limitations of the current detectors by more than an order of magnitude. This in-

creased sensitivity of future GWDs will open a scientific treasure trove and help answer some of the important open questions of cosmology and astrophysics.

Invited Topical Talk T 75.3 Thu 15:00 Td

Advanced Powering of Pixel and Tracking Detectors — •Martin Lipinski — I. Physikalisches Institut B, RWTH Aachen University, Germany

Modern pixel and tracking detectors like the ones foreseen in the upgrades of the LHC experiments require novel power systems. On the one hand, an increasing number of active channels as well as higher data rates lead to a larger power consumption of the detectors. On the other hand, the supply voltages must decrease due to smaller technology nodes used for the frontend electronics. Advanced powering schemes are required to avoid large cable losses and to keep the material budget small.

In this talk, two different powering concepts, based on DC-DC conversion and based on serial powering, will be discussed. The implementation of both schemes in the future Phase-2 upgrades of the ATLAS and CMS silicon tracking detectors will be presented. In addition, the experience gained from the use of DC-DC converters in the CMS Phase-1 pixel detector will be reported.

T 76: Outreach Methods

Time: Thursday 16:00–18:30 Location: Ta

T 76.1 Thu 16:00 Ta

Die Woche der Teilchenwelt - eine Entdeckungsreise vom Urknall bis in die Welt der Elementarteilchen — •Lisa Johnsen und Uta Bilow für die Netzwerk Teilchenwelt-Kollaboration — Netzwerk Teilchenwelt, Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden

Woher kommt unser Universum? Welche Geheimnisse birgt der Kosmos? Gemeinsam mit Forscher*innen konnte die interessierte Öffentlichkeit vom 02.-08.11.2020 in der *Woche der Teilchenwelt* Antworten auf diese Fragen finden.

Per Videokonferenz öffneten bundesweit Forschungseinrichtungen mit virtuellen Rundgängen, öffentlichen Vorträgen, Masterclasses@home, einem Science Slam und vielen anderen spannenden digitalen Veranstaltungen ihre Türen. So konnte sich die Öffentlichkeit über Erkenntnisse, Forschungsmethoden in der Grundlagenforschung und offene Fragen in der Teilchen- und Astroteilchenphysik sowie der Hadronen- und Kernphysik informieren.

Organisiert wurde die Aktionswoche von Netzwerk Teilchenwelt zum 10-jährigen Bestehen des Netzwerks. Außerdem floss die Woche in das Jubiläumsprogramm der DPG zu deren 175-Jahre-Jubiläum ein. Gefördert wurde die Veranstaltungsreihe von der Wilhelm und Else Heraeus-Stiftung.

T 76.2 Thu 16:15 Ta

Masterclass@home: Ein Online-Angebot zur Teilchenphysik — Philipp Bielefeldt, •Dominik Köhler und Barbara Valeriani-Kaminski für die Netzwerk Teilchenwelt-Kollaboration — Rheinische Friedrich-Wilhelms-Universität Bonn, Germany

Das Netzwerk Teilchenwelt ist ein Zusammenschluss von deutschen Universitäten und Forschungseinrichtungen, die sich für die Vermittlung von Teilchenphysik an Schulen engagieren. In einem mehrstufigen Programm können interessierte Schülerinnen und Schüler den Aufbau der Materie lernen als auch einen Einblick über das Physikstudium, die Arbeit und das Vorgehen von Physikerinnen und Physikern gewinnen. Das Konzept baut auf die Masterclasses auf: Dort werden größere Gruppen, wie z. B. Schulklassen, von erfahrenen Vermittlerinnen und Vermittlern angeleitet, um einfache Analysen von Daten aktueller Experimente durchzuführen.

Aufgrund der weltweiten Pandemie und der Hygienevorschriften konnten diese Veranstaltungen im letzten Jahr nicht wie gewohnt an den Schulen oder den Universitäten durchgeführt werden. Um den Schülerinnen und Schülern dennoch die Gelegenheit zu bieten, Einblicke in die Teilchenphysik zu erhalten, hat die Universität Bonn das neue Konzept der Masterclass@home entwickelt, bei der die Vorträge, Gruppenarbeiten und Analysen online stattfinden. In diesem Vortrag wird auf die verwendeten Programme, notwendigen Änderungen und neue Möglichkeiten gegenüber der Masterclasses eingegangen, Vor- und Nachteile erläutert sowie die Reaktionen der Schülerinnen und Schüler präsentiert.

T 76.3 Thu 16:30 Ta

Masterclasses@Home: der ATLAS-Z Pfad – ein Erfahrungsbericht — •Kira Abeling und Stan Lai — II. Physikalisches Institut, Georg-August-Universität Göttingen

Im Rahmen der Corona-Pandemie, waren wir gezwungen neue – hauptsächlich virtuelle – Wege zu gehen. Ein Konzept, das dabei entwickelt wurde, sind die Masterclasses@Home, bei denen die Schüler*innen von Zuhause aus über Videokonferenz mit uns, den Vermittler*innen des Netzwerks Teilchenwelt, eine Masterclass komplett online durchführen – inklusive Datenanalyse.

In diesem Vortrag werden Ideen zu virtuellen Spielen vorgestellt, die im Rahmen der Masterclasses@Home für den ATLAS-Z Pfad an der Uni Göttingen gesammelt, testweise umgesetzt und evaluiert wurden. Zudem werden allgemeine Erfahrungen – gute sowie verbesserungswürdige – präsentiert, die auch anderen Standorten bei der Durchführung der (International) Masterclasses@Home helfen können.

T 76.4 Thu 16:45 Ta

Astroparticle Physics Online Masterclass built on the KASCADE Cosmic Ray Data Centre — •Victoria Tokareva, Katrin Link, Andreas Haungs, Jurgen Wochele, Doris Wochele, Frank Polgart, Donghwa Kang, Olena Tkachenko, and Paras Kundal for the Netzwerk Teilchenwelt-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany

The global pandemic of 2020 caused our group to explore our opportunities in organizing online outreach events to teach pupils and share our knowledge without spatial limitations. As part of these efforts, we developed an online masterclass built on the KASCADE Cosmic Ray Data Centre and gained first practical experience during the International Cosmic Day. Students at the age of 14-19 years from a school in Villach, Austria, took part in lectures on cosmic ray physics and data analysis and then consolidated the acquired skills in a hands-on part. By performing particle mass composition analysis on KASCADE data, the participants gained experience in using the KCDC platform, working in the JupyterHub environment, preprocessing data from a real astroparticle physics experiment, programming Python and performing exploratory data analysis. The talk will describe the content of the masterclass such as the analysis performed and the results obtained, as well as the choice of implementation tools (such as platform, programming language and libraries) and organizational aspects of the event.

T 76.5 Thu 17:00 Ta

A Modern Arduino Approach for Advanced Physics Laboratories in the Time of COVID — •Shawn Zaleski, Thomas Hebbeker, and Kerstin Hoepfner — III Physikalisches Institut A,RWTH Aachen University, Aachen, Germany

Entering 2021, COVID-19 still threatens to require remote laboratory operation, and new longer-term solutions need to be developed to for students to do this. Many kits have been developed for the introductory level during 2020. However, very little has been developed for the advanced physics laboratory. We have developed a kit that allows advanced lab students to perform a set of mini-experiments using PYTHON, a Raspberry Pi, Arduinos, and Arduino compatible sensors. Students are permitted to take the kit home and only need to provide a few common items, e.g. a ruler, to perform the experiment.

This experiment serves as a nice introduction to microcontrollers. The overarching goal is for students to gain familiarity with the Raspberry Pi, Arduino, and it's sensors by performing basic experiments inwhich the physics is well known and the students learn how to acquire data with these microcontrollers. Students perform mini-experiments from basic kinematics to determining Planck's constant and using a Geiger-Mueller counter. Students use analog-to-digital converters(ADCs), digit-to-analog converters (DACs), accelerometers, and more complex sensors.

We give details on the different mini-experiments that the students

perform. We also discuss some of the learning outcomes as well as how the experiment can easily be performed at the university or at home.

T 76.6 Thu 17:15 Ta

Computer-Kurs auf Basis von Jupyter Notebooks zur Higgs-Entdeckung als Masterkurs für Fortgeschrittene — •Artur Monsch[1] und Günter Quast[2] — [1]Fakultät für Physik, Karlsruher Institut für Technologie, Karlsruhe — [2]Institut für Experimentelle Teilchenphysik, Karlsruher Institut für Technologie, Karlsruhe

Vorgestellt wird ein an unterschiedliche Kompetenzstufen anpassbares, an die CMS Masterclass anknüpfendes, Konzept, dass es Schülerinnen und Schülern ermöglicht im Rahmen eines, als *jupyter-Notebooks* ausgelegten, Computer-Kurses die spannende Geschichte der Entdeckung des Higgs-Bosons nachzuempfinden. Dazu werden aufbereitete Originaldaten aus dem CERN Open Data Portal verwendet.

Der Arbeit mit Event-Displays zur Erklärung von Aufbau und Funktionsweise des Detektors folgend werden Grundkonzepte der Rekonstruktion und der Selektion der seltenen Signalereignisse vermittelt. Die Basis der anschließenden Datenauswertung bildet die Verteilung der invarianten Massen im 'goldenen Zerfallskanal' $H \to ZZ \to 4\ell$, anhand derer auch die Frage untersucht wird, inwieweit der bei einer Masse von $125\,\mathrm{GeV}/c^2$ beobachtete Überschuss an Ereignissen statistisch signifikant ist. Gerade die zur statistischen Datenauswertung gewonnenen Erkenntnisse und Methoden sind für Themenbereiche außerhalb der Teilchenphysik relevant und anwendbar.

T 76.7 Thu 17:30 Ta

Virtuelle Führungen am KATRIN-Experiment — •Manuel Klein, Kathrin Valerius, Leonard Köllenberger und Katrin Link — Karlsruher Institut für Technology (KIT), IAP, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

Das KArlsruher TRItium Neutrino (KATRIN) Experiment dient der Messung der Neutrinomasse anhand des Tritium-Betaspektrums. Hierzu wird neben einer leuchtstarken Tritiumquelle eine 70 Meter lange Beamline mit einem 20 Meter langen Hauptspektrometer benötigt. Technologische Herausforderungen sind neben der Handhabung des Tritiums beispielsweise die kryogene Pumpstrecke und das Ultrahochvakuum im Hauptspektrometer.

Um KATRIN der Öffentlichkeit und Schülerinnen und Schülern zugänglich zu machen, werden Führungen am Experiment angeboten. Während der Corona-Pandemie 2020 war dies jedoch nicht möglich. Deswegen wurde eine virtuelle Führung konzipiert: Ein Video der Beamline wurde mit dem Handy erstellt und mit Archivaufnahmen vom Transport und Aufbau des Experiments kombiniert. Die rund 40 minütige Tour wird live kommentiert und folgt auf eine Einführung über Neutrinos und KATRIN. Anlässe für die Führung waren u.a. die Woche der Teilchenwelt des Netzwerks Teilchenwelt und die Karlsruher Nacht der Wissenschaft. In diesem Vortag werden wir sowohl auf den Inhalt der Führung, als auch auf die technische Umsetzung und erste Rückmeldungen der Teilnehmer eingehen.

Unterstützt vom BMBF (Ø05A17VK2), der Helmholtz-Hochschul-Nachwuchsgruppe VH-NG-1055 und der Helmholtz Gemeinschaft.

T 76.8 Thu 17:45 Ta

3D und Virtual-Reality-Umgebung zur Vermittlung von Grundlagenforschung am Beispiel des ALICE-Detektors am CERN-LHC — •Christian Klein-Bösing[1], Philipp Bhatty[2], Stefan Heusler[3] und Reinhard Schulz-Schaeffer[2] für die Netzwerk Teilchenwelt-Kollaboration — [1]Institut für Kernphysik, WWU Münster, Germany — [2]Department Design, HAW Hamburg, Germany — [3]Institut für Didaktik der Physik, WWU Münster, Germany

Detektoren in der Elementarteilchenphysik, wie der ALICE-Detektor am LHC, können in der Regel der breiten Öffentlichkeit nur an Hand von Bildern oder Filmen präsentiert werden. Die Darstellung in einer Echtzeit-3D-Umgebung, wie einer Virtual-Reality- und Web3D-Applikation, ermöglicht hingegen direkt die Größe des Experimentes erfahrbar zu machen, aber auch neue, virtuelle Handlungsräume und Handlungsoptionen zu erforschen und zielgruppengerecht einzusetzen.

Die Entwicklung einer solchen Web3D-Lernumgebung sowie einer VR- Lernapplikation, inklusive der empirischen Bewertung verschiedener Darstellungsoptionen, der Gestaltung von Nutzerinteraktion und interaktiver Lernaufgaben, erfordert eine enge Kooperation zwischen Grundlagenforschung in der Elementarteilchenphysik, der Didaktik der Physik und der Wissenschaftsillustration.

Wir präsentieren den aktuellen Entwicklungsstatus basierend auf einer interaktiven Visualisierung des ALICE-Detektors in VR und Web-3D.

T 76.9 Thu 18:00 Ta

Streubretter - Ein mechanisches Analogon zu Fixed-Target Experimenten — •Stephan Aulenbacher[1], Wiebke Kött[2] und Achim Denig[1] für die Netzwerk Teilchenwelt-Kollaboration — [1]Institut für Kernphysik, Mainz, Deutschland — [2]Institut für Physik, Mainz, Deutschland

Streuexperimente wie sie an Beschleuniger-Anlagen durchgeführt werden, sind für Menschen ohne physikalischen Hintergrund nur schwer zu begreifen. Wie kann das Beschießen eines Materials mit Teilchen Aufschluss über die Struktur der Materie geben? Um diese Frage der Öffentlichkeit zugänglich zu machen, wurde an der Johannes Gutenberg-Universität Mainz ein mechanisches Analogon zu solchen Experimenten entwickelt. Kleine Stahlkugeln werden an einer geometrischen Form gestreut, welche nach dem Streuprozess durch Lichtschranken rollen, um den Streuwinkel zu detektieren. Auf Basis der so entstehenden Histogramme kann die geometrische Gestalt des Streuzentrums identifiziert werden. Das Experiment kann sowohl in Schülerversuchen als auch als Demonstrationsobjekt in öffentlichen Vorträgen genutzt werden. Einfache geometrische Strukturen wie ein Dreieck bis hin zum 3D gedruckten 1/r-Potential können als Streuzentrum eingesetzt werden. Als didaktische Hilfsmittel stehen den Experimentatoren interaktive Simulationen Tools zur Verfügung. In diesem Vortrag werden die Bauweise sowie das didaktische Konzept der Streubretter vorgestellt. Außerdem werden die Grenzen des mechanischen Analogons, der durch die Streubretter gegeben ist, erörtert.

T 76.10 Thu 18:15 Ta

Feynman-Rhombino und Quark-Tower – Die Elementarteilchenphysik spielend entdecken — •Philipp Lindenau[1], Sebastian Fabianski[2] und Otmar Winkler[3] für die Netzwerk Teilchenwelt-Kollaboration — [1]Technische Universität Dresden — [2]Ehrenfried-Walther-von-Tschirnhaus-Gymnasium Dresden — [3]Sächsisches Landesgymnasium Sankt Afra, Meißen

Spiele bieten eine gute Möglichkeit, um schulische Bildungsinhalte in interessante und motivierende Lernszenarien zu integrieren oder durch subtile Kontextualisierung Interesse zu erzeugen. Im Rahmen von Netzwerk Teilchenwelt wurden deshalb zwei Spiele entwickelt, die Spielmechaniken bekannter Gesellschaftsspiele nutzen, um Fachinhalte der Elementarteilchenphysik zu festigen bzw. aufzugreifen.

"Feynman-Rhombino" ist ein dominoartiges Spiel, mit dem die Grundregeln der fundamentalen Wechselwirkungen des Standardmodells der Teilchenphysik gefestigt werden können. Die Spielenden fügen dabei reihum Spielsteine (Rhombinos) nach den Regeln für Feynman-Diagramme zusammen. Zielgruppe sind dabei Schülerinnen und Schüler der Sekundarstufe II.

Eine deutlich niederschwelligere Annäherung an die Teilchenphysik bietet das Spiel "Quark-Tower". Aufgrund der einfachen Regeln kann es ohne teilchenphysikalisches Vorwissen gespielt werden. Dadurch eignet es sich besonders für Zwecke der Wissenschaftskommunikation. Das Spielkonzept basiert auf dem Spiel "Jenga", wobei die Spielzüge dadurch eingeschränkt sind, dass Quarks (bunte Spielsteine) zu farbneutralen Protonen und Neutronen zusammengefügt werden müssen.

T 77: QCD II

Time: Thursday 16:00–18:00 Location: Tb

T 77.1 Thu 16:00 Tb

Measurement of inclusive jet production in deep inelastic scattering using ZEUS data — •Florian Lorkowski — DESY, Hamburg, Germany

The cross sections of deep inelastic scattering processes at electron-proton colliders are a well established tool to test perturbative QCD predictions. They can also be used to determine theory parameters, such as the strong coupling constant or the parton distribution functions of the proton.

In this talk, a measurement of inclusive jet cross sections in neutral current deep inelastic scattering using the ZEUS detector at the HERA collider is presented. The data was taken in the years 2003 to 2007 at a center of mass energy of 318 GeV and corresponds to an integrated luminosity of $372\,\mathrm{pb}^{-1}$. Massless jets, reconstructed using the $k_\perp$-algorithm in the Breit frame, are measured as a function of the squared momentum transfer Q^2 and the transverse momentum of the jets in the Breit reference frame $p_{\perp,\mathrm{Breit}}$, in a range of $125\,\mathrm{GeV}^2 < Q^2 < 15000\,\mathrm{GeV}^2$ and $p_{\perp,\mathrm{Breit}} > 7\,\mathrm{GeV}$. The measured cross sections are compared to previous measurements.

T 77.2 Thu 16:15 Tb

Event shape analysis in deep-inelastic $e^{\pm}p$ scattering — •Johannes Hessler, Daniel Britzger, Stefan Kluth, and Andrii Verbytskiy — Max Planck Institut für Physik, München

Event shape observables are sensitive to the strong coupling constant α_s and parton distribution functions (PDFs). A new measurement of the 1-jettiness observable τ_1^b in neutral-current deep-inelastic scattering will be performed. Data from the H1 experiment at the HERA electron-proton collider at DESY will be used. The data was taken in the years 2003 to 2007. It includes electron-proton and positron-proton scattering. Due to momentum conservation τ_1^b has an analogy to the observable thrust. Precise theoretical calculations are available for τ_1^b. The observable is defined in the Breit frame. Only the hadronic final state in the current hemisphere contributes. A triple differential measurement in the observables τ_1^b, x_{Bj} (momentum fraction of the scattered parton) and Q^2 (virtuality of the exchanged boson) will be performed. The sensitivity to the strong coupling constant α_s and to proton PDFs are explored. In the talk preliminary results for the triple-differential cross section measurement will be presented.

T 77.3 Thu 16:30 Tb

Measurements of the total charm and beauty cross sections with the CMS detector — •Josry Metwally, Nur Zulaiha Jomhari, and Achim Geiser — DESY, Hamburg, Germany

The aim of this project is the determination of the total cross section for inclusive charm and beauty production at the LHC with different center-of-mass energies down to very low transverse momentum, and the comparison with QCD predictions in next-to-next-leading order of perturbation theory. The measurement of the cross sections for the production of heavy quarks at the LHC are one important test of QCD, and can, as has already happened in the case of top production, be used for a measurement of the quark masses.

Other experiments as ATLAS and ALICE covered only small fractions of the available phase space while the LHCb experiment fully covered the forward region, $2.0 < y < 4.5$. For this project, we measure cross sections in the full phase space complementary to LHCb of prompt D mesons, and D mesons from b hadron decays through the decays $B \to D^* X \to D^0 \pi_s X \to K\pi\pi_s X$ and $B \to D^0 X \to K\pi X$. One of the challenges is the separation of prompt D mesons and D mesons from b hadron decays near the production threshold. In this talk, the details of this separation and the resulting cross sections will be presented.

T 77.4 Thu 16:45 Tb

First Belle II results on charmless B-decays and prospects — •Oskar Tittel, Markus Reif, Benedikt Wach, and Hans-Günther Moser for the Belle II-Collaboration — Max-Planck-Institut für Physik, München, Deutschland

In early 2019 the Belle II experiment at the SuperKEKB electron-positron collider started taking data on the $\Upsilon(4S)$ resonance. The expected large yields of charmless B decays at Belle II will enable significant advancements in the understanding of quark dynamics, including a world-leading determination of the CKM phase α/ϕ_2, and a conclusive understanding of the so-called K-π CP-puzzle. Using an early sample of 34.6 fb^{-1} recorded until mid-2020, we report on first measurements of branching ratio and direct CP violation of charmless B decays. The new results are compatible with the current state of knowledge and the ongoing data taking looks promising to deliver the most precise measurements on this field.

T 77.5 Thu 17:00 Tb

LHCb for astroparticle physics: Inclusive production of prompt charged particles — Johannes Albrecht[1], •Julian Boelhauve[1], Hans Dembinski[1], Michael Schmelling[2], and Bernhard Spaan[1] — [1]TU Dortmund University, Dortmund, Germany — [2]Max Planck Institute for Nuclear Physics, Heidelberg, Germany

A long-standing issue in the field of cosmic-ray research is the discrepancy in the number of muons produced in high-energy air showers between observations and simulations, referred to as the Muon Puzzle. Precision measurements of hadron production in the forward region need to be performed to validate and improve the hadronic-interaction models used in air-shower simulations and to solve the Muon Puzzle. For the achievement of these goals, measuring the differential cross-section of inclusive production of prompt charged long-lived particles as a function of transverse momentum and pseudorapidity has key importance.

An analysis in which this differential cross-section is determined based on a trigger-unbiased data sample of proton-proton collisions recorded with the LHCb experiment at a centre-of-mass energy of 13 TeV is presented in this talk. In particular, the efficiency determination and the construction of proxies that enable a data-adjusted quantification of the backgrounds are described.

T 77.6 Thu 17:15 Tb

Reconstruction of missing momentum in $\Lambda_b \to \Lambda_c \bar{D}^{*0} K$ decays — •Mindaugas Sarpis for the LHCb-Collaboration — University of Bonn, Bonn, Germany

Charmonium-pentaquarks, P_c, were observed by LHCb in 2015 and 2019 as resonances in the $J/\psi p$ final state from $\Lambda_b \to J/\psi p K^-$ decays. The nature of these resonances is not yet fully understood, but their proximity to the $\Sigma_c \bar{D}^{*0}$ thresholds motivate 'molecular' pentaquark models. These models predict large branching fractions of $P_c \to \Lambda_c \bar{D}^{*0}$ decays. There is a large sample of $\Lambda_b \to \Lambda_c \bar{D}^{*0} K$ decays in the LHCb data acquired during Run 1 and Run 2 of the LHC, however the low-momentum π^0 or γ from the decay $\bar{D}^{*0} \to \bar{D}^0 \pi^0/\gamma$ are difficult to reconstruct. Instead, the four-momentum of the $\bar{D}^{*0}$ is found from a kinematic over-constraint method called Extended Cone Closure, which is the main topic of this talk.

T 77.7 Thu 17:30 Tb

Search for pentaquark states in $\Lambda_b^0 \to \Sigma_c^{++(*)} D^- K^-$ — •Abhay Mehta[1], Nicola Skidmore[2], and Sebastian Neubert[1] — [1]Helmholtz Institute for Radiation and Nuclear Physics, University of Bonn, Germany — [2]University of Manchester, United Kingdom

In 2015, LHCb first observed exotic hadronic objects consisting of five quarks [1]. So far, evidence for these pentaquarks has only been seen in the $J/\Psi p$ decay and their nature is still obscure. (Non)-evidence in further decay processes is crucial to distinguish between the numerous theoretical models of pentaquarks. Hadronic molecular models, in particular, predict a strong coupling to the decay into $\Sigma_c^{++(*)} D^-$. This study uses the Run 1 and Run 2 dataset from the LHCb detector at the LHC.

The talk will cover preliminary selections and fits on the data in the given decay channel.

[1] Roel Aaij et al. "Observation of $J/\Psi p$ Resonances Consistent with Pentaquark States in $\Lambda_b^0 \to J/\Psi K^- p$ Decays". In:Phys. Rev. Lett.115 (2015),p. 072001.

T 77.8 Thu 17:45 Tb

LHCb for astroparticle physics: The Muon Puzzle in air showers and its connection to the LHC — •Hans Dembinski[1], Julian Boelhauve[1], Johannes Albrecht[1], Bernhard Spaan[1], and Michael Schmelling[2] — [1]Experimentelle Physik 5, TU Dortmund — [2]Max Planck Institut für Kernphysik, Heidelberg

The Muon Puzzle is a central issue for the ground-based observation of astroparticles. It refers to a lack of muons produced in simulated air showers initiated by cosmic rays in comparison to measurements. Progress has been made in recent years to confirm the muon discrepancy with high significance and to theoretically trace its origin to features of hadron-nuclear interactions in air showers (most muons are produced at the end of a hadronic cascade). Air shower simulations use state-of-the-art hadronic models tuned to the latest LHC data, which cover hadron production at mid-rapidity in great detail. The tuning does not solve the puzzle, which suggests "missing physics" in these models regarding the forward production of light hadron in high-energy hadron-nucleus collisions, which dominate the evolution of air showers but are not sufficiently studied at the LHC.

We will review evidence for the Muon Puzzle, the connection between muon production in air showers and hadron production, and which measurements at the LHC have the potential to solve the puzzle. The focus will be placed on the unique opportunities offered by LHCb measurements of proton-nucleus collisions. Running the LHC

with oxygen beams to study proton-oxygen collisions is of key importance to achieve these goals.

T 78: Electroweak Interactions II

Time: Thursday 16:00–18:15 Location: Tc

T 78.1 Thu 16:00 Tc

Isolating systematic effects with beam polarisation at e^+e^- colliders — •Jakob Beyer[1,2] and Jenny List[1] — [1]DESY Hamburg — [2]Universität Hamburg

Future high-energy e^+e^- colliders will provide some of the most precise tests of the Standard Model. Statistical uncertainties are expected to improve by orders of magnitude over current measurements. This provides a new challenge in accurately assessing and minimizing systematic uncertainties. Beam polarisation may hold a unique potential to isolate and determine the size of systematic effects. So far, studies have mainly focused on the statistical improvements from beam polarisation. This study aims to assess the impact on systematic uncertainties. A combined fit of precision observables, such as cross-sections, asymmetries and anomalous gauge couplings, together with systematic effects is performed on 2-fermion and 4-fermion final-states. Different setups of available beam polarisations and luminosities are tested with and without systematic effects. The dependence of the uncertainties and correlations for the varying setups informs the relevance of beam polarisation for isolating systematic effects. Effects observed for this analysis may qualitatively apply to other analyses as well. Future collider efforts can use this knowledge in their design studies to maximize their physics potential.

T 78.2 Thu 16:15 Tc

Test of the universality of tau and muon lepton couplings in W boson decays with the ATLAS detector — •Nicolas Köhler — CERN, Meyrin, Schweiz

The universality of the lepton couplings to the electroweak gauge bosons is one of the fundamental axioms of the Standard Model (SM) of particle physics. At LEP, the branching fractions of the W boson into charged leptons have been precisely measured, however, the uncertainty on the ratio of $\mathcal{BR}(W \to \tau\nu)/\mathcal{BR}(W \to \mu\nu)$ still remains at approximately 2.4%. The PDG combined measurement of $\mathcal{BR}(W \to \tau\nu)/\mathcal{BR}(W \to \mu\nu)$ shows a 2.7σ deviation from the SM prediction, motivating an independent measurement of this ratio at the LHC. ATLAS recently performed a measurement of this quantity using 139 fb^{-1} of pp collision data recorded during LHC Run 2. To obtain a large unbiased sample of W bosons, di-leptonic $t\bar{t}$ events are selected. Muons originating from W bosons and those originating from an intermediate tau lepton are distinguished through the muon transverse impact parameter and the muon transverse momentum spectra. The result is in agreement with a universal coupling as postulated in the SM and the measurement is the most precise one to date.

T 78.3 Thu 16:30 Tc

Measurement of aτ at the ATLAS Experiment — •Birte Sauer, Jakub Kremer, and Matthias Schott — Johannes Gutenberg-Unitersity Mainz

The anomalous magnetic moment, being the difference to the value predicted by Dirac's theory, is used since long to probe the limits of the Standard Model. Both the electronic and muonic anomalous magnetic moment have been studied to a great extent, while the anomalous magnetic moment of tau lepton is missing a precise measurement. The short lifetime of tauons makes it experimentally challenging to measure their properties. This talk discusses the sensitivity of the $\gamma\gamma \to \tau\tau$ process in ultraperipheral Pb+Pb collisions on the anomalous magnetic (aτ) and electric (dτ) moments of τ lepton at the LHC. We also present preliminary results on this measurement using the di-muon final state with data collected by the ATLAS detector with a special focus on the relevant detector performance.

T 78.4 Thu 16:45 Tc

Search for Lepton flavor Violation in Tau leptons — •Marton Nemeth-Csoka, Felix Meggendorfer, and Christian Kiesling — Max-Planck-Institut für Physik

With the start of data taking using the Belle II detector at the SuperKEKB electron-positron collider a new era in searches for New Physics is on the horizon.

We report here on plans and first Monte Carlo studies to search for lepton flavor violation (LFV) in tau leptons. In particular, we investigate the decay $\tau- > l\ \pi^0$, which is highly forbidden in the Standard Model, but could possibly become observable in certain scenarios of New Physics. Using the improved detector capabilities of Belle II, estimates of the efficiency and backgrounds for the above LFV decay are presented.

T 78.5 Thu 17:00 Tc

The muX experiment at the Paul Scherrer Institute — •Frederik Wauters — PRISMA+ Cluster of Excellence and Institute of Nuclear Physics, Johannes Gutenberg University Mainz

When a negative muon comes to rest in matter, an exotic atom is quickly formed. During the formation process, muonic X-rays, which can have energies up to several MeV, are emitted until the 1s orbital is reached. The muon wave function in the lower orbits has a large overlap with the nucleus, making this system an excellent laboratory to study short range interactions between the muon and the atomic nucleus. The muX project at the Paul Scherrer Institute is performing muonic X-ray measurements on medium and high-Z nuclei, thereby fully exploiting the coverage and multiplicity of a full high-purity germanium array in combination with muon, electron and neutron detectors. A new technique was developed utilizing transfer reaction in a H2/D2 gas cell to stop a standard muon beam in a few ug of target material. The physics program is focusing on atomic parity violation (APV). A measurement of the charge radius of 226Ra will serve as an important input for an upcoming APV experiment with Ra in a Paul trap. We are also pursuing measuring APV directly in muonic atoms in the 2s-1s transition. As a short term goal, we want to significantly improve the signal to noise for this low intensity transition. In this talk I will present the preliminary results of the 2017, 2018, and 2019 experimental campaigns.

T 78.6 Thu 17:15 Tc

Search for $B \to K^{(*)}\nu\bar{\nu}$ at the Belle II experiment with machine learning techniques — •Cyrille Praz — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

The Belle II experiment, located in Tsukuba, Japan along the SuperKEKB e^+e^- collider, has started to collect data in 2018 and offers many opportunities to improve our understanding of the B-meson decays. In particular, the $B \to K^{(*)}\nu\bar{\nu}$ decay has not been observed yet, it can be computed with accuracy in the Standard Model and is sensitive to new physics models. This presentation gives a brief overview of a novel approach to search for this decay and focuses on the machine learning techniques that are used to reject the background and select the signal.

T 78.7 Thu 17:30 Tc

Measurement of the Branching Fractions and Differential Kinematic Distributions of $B^{+/0} \to XJ/\psi$ with Hadronic Tagging — Florian Bernlochner[1], William Sutcliffe[1], Sviat Bilokin[2], Thomas Khur[2], and •Martin Angelsmark[1] for the Belle II-Collaboration — [1]Physikalisches Institut der Rheinischen, Friedrich-Wilhelms-Universität Bonn, 53115 Bonn, Germany — [2]Fakultät für Physik, Ludwig Maximilians University Munich, D-80539 München, Germany

We measure for the first time the individual branching fractions of $B^+ \to XJ/\psi$ and $B^0 \to XJ/\psi$ to be X and Y, respectively, using hadronic tagging in 74 fb^{-1} of Belle II data. In addition, the employment of hadronic tagging allows for a novel determination of the differential distributions of the mass of the X system, the helicity angle for the decay and the momentum magnitudes of the J/ψ and X in the B rest frame. These fully inclusive measurements of $B \to XJ/\psi$ represent an important benchmark towards a fully inclusive analysis of $B \to X_s\ell\ell$ with tag-side reconstruction.

T 78.8 Thu 17:45 Tc

Bremsstrahlung Measurements for the LUXE Experiment — •Marius Hoffmann[1], Ruth Jacobs[1], Louis Helary[1], and Beate

Heinemann[1,2] — [1]DESY, Hamburg — [2]Universität Freiburg

While Quantum Electrodynamics has been tested with a superb precision in the perturbative regime, there is a regime of very strong fields where it becomes non-perturbative and which has not yet been explored experimentally. The LUXE (Laser Und European XFEL-) Experiment aims to use the high-quality electron beam of the XFEL accelerator to probe this strong-field regime. Colliding high energy photons produced via bremsstrahlung (photon-photon mode) with a high intensity laser leads to field strengths above the Schwinger limit. This opens up the possibility to measure nonlinear Breit-Wheeler pair production, a process that takes place also in nature, for example around heavy astronomic objects, or in future particle colliders.

To create photon-photon collisions, the electrons from the XFEL beam are converted to high energy photons via bremsstrahlung in a target foil. A good understanding of this process, which has not been studied in detail at the energy scale relevant for LUXE before, is therefore necessary. To achieve this understanding testbeam experiments and simulations thereof are performed. The testbeam experiment presented aims to analyse the properties of a bremsstrahlung photon beam produced at the DESY testbeam.

After a short introduction to the LUXE experiment, this talk focuses on those testbeam experiments conducted to analyse high-energy bremsstrahlung properties.

T 78.9 Thu 18:00 Tc

Measuring the 2s-1s transition in Muonic atoms — •Nilesh Deokar — Johannes Gutenberg University of Mainz, Germany

2s-1s muonic X-rays are a potential observable to study Atomic Parity Violation (APV) in muonic atoms. Muonic X-rays are produced when negative muons are stopped in matter and cascade down the different energy levels of an atom. To detect the 2s-1s X-rays, a krypton target (2018) and a zinc target (2019) were placed in a negative muon beam from the piE1 beamline at the Paul Scherrer Institute, Switzerland. The targets were surrounded by High Purity Germanium (HPGe) detectors on two sides which detected the outgoing muonic X-rays. The beam momenta ranged from around 28 MeV/c (for krypton) and 33 MeV/c to 35 MeV/c (for zinc) during the run. The 2s-1s transition in krypton corresponds to an energy value of ~2222 keV which in zinc is ~1640 keV. These transitions are overshadowed by background transitions and also the X-rays scattered between the HPGe detectors which give rise to satellite peaks. X-ray-X-ray coincidences can help to suppress this background. The analysis of the data acquired revolves around separating the 2s-1s transitions from the background. A clear observation of the 2s-1s transition opens up to the possibility for an APV experiment with muonic atoms.

T 79: Top quark production III

Time: Thursday 16:00–18:15 Location: Td

T 79.1 Thu 16:00 Td

Studies of $t\bar{t}$ production with additional heavy flavour jets in p-p collision with the ATLAS detector — •Lucas Klein, Mahsana Haleem, and Raimund Ströhmer — Julius-Maximilians-Universität Würzburg

The production of $t\bar{t}$-pairs with additional jets provides a strong test of quantum chromodynamics (QCD) predictions at high orders. Furthermore, this represents as a significant background to rare SM processes (e.g. $t\bar{t}H$, $t\bar{t}t\bar{t}$), as well as to processes beyond the standard model. The additional jets consisting of b-quarks originating from gluon splitting are particularly interesting in constraining uncertainties in the prediction of the process.

In this talk, we will show studies of $t\bar{t}$-pair production with additional b-jets in the dileptonic top decay channel using full Run 2 ATLAS data from proton-proton collision at $\sqrt{s} = 13\,\text{TeV}$. Events are chosen by requiring an oppositely-charged $e\mu$-pair and at least two b-jets in the final state as a baseline selection. The backgrounds originating from $t\bar{t}$ events with additional light- or c-flavour jets ($t\bar{t}l$, $t\bar{t}c$) misidentified as b-jets in exclusive 3 b-tagged jet and ≥ 4 b-tagged jet regions are estimated using a data-driven method. The additional jet multiplicity and various kinematic distributions in the $t\bar{t}$ predictions will be compared to the data at the particle-level in ≥ 3 b-jet and ≥ 4 b-jet regions.

T 79.2 Thu 16:15 Td

Differential measurement of the $t\bar{t} + b\bar{b}$ cross section in the lepton+jet channel at the CMS experiment — •Jan van der Linden[1], Ulrich Husemann[1], Emanuel Pfeffer[1], and Matthias Schröder[2] — [1]Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT) — [2]Universität Hamburg

The associated production of bottom quarks with a pair of top quarks ($t\bar{t} + b\bar{b}$) is an important irreducible background for searches of Higgs boson production in association with a pair of top quarks ($t\bar{t}+H$). Due to the large mass difference between the light bottom quarks and the heavy top quarks, the modeling of the $t\bar{t}+b\bar{b}$ process is very challenging and is still today associated with large uncertainties. Past measurements of the inclusive cross section of that process also showed discrepancies between the predicted and measured cross sections, which can be attributed to the challenging modeling. Furthermore, different Monte Carlo simulation methods show significant differences in the modeling of this process.

Hence a measurement of the inclusive, as well as differential, cross section of $t\bar{t} + b\bar{b}$ production is performed at the CMS experiment in the lepton+jet decay channel of the $t\bar{t}$ system. The measurement will provide an important input for the development and tuning of future Monte Carlo generators, to describe the physics of the $t\bar{t} + b\bar{b}$ process more accurately.

In this talk an overview of the ongoing analysis, targeting the full Run-2 period of the LHC, is given.

T 79.3 Thu 16:30 Td

Assignment methods for b jets in $t\bar{t}$+$b\bar{b}$ processes in the lepton+jets channel at the CMS experiment. — •Emanuel Pfeffer, Ulrich Husemann, and Jan van der Linden — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

The associated production of bottom quarks with a top quark-antiquark pair is a large irreducible background in measurements of $t\bar{t}H$ in $H \to b\bar{b}$ decays at the Large Hadron Collider which are important to test the Standard Model and to constrain Physics beyond the Standard Model. Additionally, the process itself is of particular interest due to its multiscale QCD nature. In order to better understand the process, the b jets must be assigned to their origin. In the final state of a $t\bar{t}$+$b\bar{b}$ event it is unknown which b jets originate from top quark decays and which b jets are not associated with the top quarks. Therefore, the question should be answered: Which methods allow for an assignment of the b jets to their origin and how accurate is the assignment? The talk gives an overview of different strategies to assign the b jets and evaluates the accuracies of the methods. These methods range from straightforward observables to sophisticated reconstructions with deep neural networks.

T 79.4 Thu 16:45 Td

Differential measurement of ttbar in association with a photon — •Beatriz Lopes, Alessia Saggio, and Abideh Jafari — DESY, Hambueg, Germany

Precision measurements of top quark production provide a test ground for the Standard Model (SM) predictions and for phenomena beyond the SM.

In this context, the production of $t\bar{t}$ in association with a photon is an important process. It is sensitive to the electroweak top-photon coupling, which can be constrained by cross-section measurements. The results can also be interpreted in the context of Effective Field Theory, where new physics scenarios that predict modifications to the $t - \gamma$ interaction can be constrained.

In this talk, I will present several differential cross-section measurements of this process in the dilepton channel, using lepton, photon and top variables. This measurement is based on data collected by the CMS experiment at the LHC during the full Run 2 (2016-2018).

T 79.5 Thu 17:00 Td

Z boson reconstruction in $t\bar{t}Z$ final states with four charged leptons using deep neural networks at 13 TeV with the

ATLAS detector — Steffen Korn, Arnulf Quadt, •Tomke Schröer, Elizaveta Shabalina, and Knut Zoch — II. Physikalisches Institut, Georg-August-Universität Göttingen

The production of a top quark in association with a Z boson gives access to the electroweak coupling between the top quark and the Z boson, which provides sensitivity to the third component of the top-quark's weak isospin. In the tetralepton channel, the Z boson and both top quarks decay leptonically. This channel is of major interest as it comes with a high signal purity. In this talk, the application of a deep neural network for the reconstruction of the Z boson is presented. The reconstruction includes the correct assignment of the leptons originating from the Z boson and the origin of the Z boson itself. This is an important aspect since it provides access to the t–Z system. When the Z boson is emitted by one of the top quarks, the structure and strength of the coupling between the top quark and the Z boson can be probed within the framework of the Standard Model Effective Field Theory (SMEFT). Deviations from the Standard Model (SM) prediction would indicate physics beyond the SM.

T 79.6 Thu 17:15 Td

Measurement of the $t\bar{t}Z$ production cross section in the dilepton channel with ATLAS — Otmar Biebel[1], •Florian Fischer[1], and Thomas McCarthy[2] — [1]Ludwig-Maximilians-Universität, München — [2]Max-Planck-Institut für Physik, München

In the Standard Model of Particle Physics, the coupling of the Z boson to top quarks is precisely predicted via the weak interaction. As its value is experimentally not yet well constrained, several possible extensions of the Standard Model predicting modifications to this coupling could not be ruled out nor confirmed so far. Therefore a more accurate understanding of electroweak processes could significantly benefit from a precise measurement of this coupling at the LHC.

A process that is particularly sensitive to this coupling is the associated production of top-antitop quark pairs with a Z boson. Analyses targeting final states with three or four leptons offer the benefit of a very high signal purity. However, they suffer from low branching ratios. In contrast, the dileptonic channel currently being considered targets events in which the Z boson decays leptonically but the $t\bar{t}$ system decays to a fully hadronic final state.

Multivariate techniques are employed to improve the discrimination between signal events and the two dominant backgrounds: the production of top-antitop quark pairs, and the associated production of Z bosons with jets. For the work presented in this talk, LHC Run 2 data collected by the ATLAS detector between 2015 and 2018 at a centre-of-mass energy of 13 TeV, as well as simulated data normalised to an integrated luminosity of 139 fb^{-1}, have been used.

T 79.7 Thu 17:30 Td

Calibration of the prompt lepton veto in a cross-section measurement of top-quark pair production in association with a W boson — •Marcel Niemeyer, Arnulf Quadt, Elizaveta Shabalina, and Knut Zoch — II. Physikalisches Institut, Georg-August-Universität Göttingen

The top-quark pair production in association with a W boson is an important background to processes like $t\bar{t}H$ or 4-tops production. Due to higher order electroweak corrections, the process is difficult to model. In consequence, a mismodelling of $t\bar{t}W$ has been observed in previous analyses. Thus, it is of high importance to increase our understanding of it. The analysis is performed in the multi-lepton channel, i.e. 2ℓ (same-sign) and 3ℓ, with a significant contribution from fake backgrounds. To suppress them, a prompt lepton veto is used. Its improvement and calibration will be discussed in this talk.

T 79.8 Thu 17:45 Td

Evidence for $t\bar{t}t\bar{t}$ production in same-sign dilepton and multilepton final states at the LHC with the ATLAS detector using the full Run-2 dataset — Vakhtang Ananiashvili[1], •Ö. Oğul Öncel[1], Niklas Werner Schwan[1], and Markus Cristinziani[2] — [1]Physikalisches Institut, Universität Bonn — [2]Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen

Production of $t\bar{t}t\bar{t}$ in proton–proton collisions is a rare process predicted by the Standard Model with an expected cross section at $\sqrt{s}$=13 TeV of around 0.01 pb. Many BSM theories, such as Top Compositeness and 2HDM, predict an enhancement of the $t\bar{t}t\bar{t}$ cross section. In addition, $t\bar{t}t\bar{t}$ can also be used to measure the top-quark Yukawa coupling, another important quantity for probing new physics.

The recently established evidence for this process in the same-sign dilepton and multilepton channels using ATLAS data collected at the LHC during 2015–2018 with 139.4 fb^{-1} integrated luminosity and at a centre-of-mass energy of 13 TeV, is presented. The main challenges are the small cross section, irreducible backgrounds from the $t\bar{t}Z$, $t\bar{t}H$, and $t\bar{t}W$ processes, as well as sizeable backgrounds due to charge misidentification and photon conversion.

T 79.9 Thu 18:00 Td

Studies on the reconstruction of multiple top quarks in the $t\bar{t}t\bar{t}$ production in same-sign dilepton final states using Boosted Decision Trees with the ATLAS detector — Vakhtang Ananiashvili[1], Peter Johannes Falke[1], •Ö. Oğul Öncel[1], Niklas Werner Schwan[1], and Markus Cristinziani[2] — [1]Physikalisches Institut, Universität Bonn — [2]Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen

Recently, ATLAS has established the evidence for the $t\bar{t}t\bar{t}$ process in the same-sign dilepton and multilepton channels, using data collected at the LHC during 2015–2018 with 139.4 fb^{-1} integrated luminosity and at a centre-of-mass energy of 13 TeV.

The analysis is impacted particularly from large $t\bar{t}Z$, $t\bar{t}H$, and $t\bar{t}W$ backgrounds, as well as small but persistent $t\bar{t}t$ background. This talk presents studies made on the reconstruction of multiple top-quarks in the same-sign dilepton final states of the $t\bar{t}t\bar{t}$ process. The $t\bar{t}t\bar{t}$ process presents significant challenges for top-quark reconstruction in both, hadronic and leptonic decay modes due to the large number of jets, inflating the possible number of combinations, as well as multiple neutrinos in the event that cannot be reconstructed by the detector.

Boosted Decision Trees are employed to reconstruct top-quarks based on an object-level training, in which all possible combinations in an event are evaluated and assigned a score. The performance of the reconstruction is investigated by comparison to Monte-Carlo truth information, and its impact on the analysis sensitivity is evaluated by using this additional information in the statistical analysis.

T 80: Cosmic Rays IV

Time: Thursday 16:00–18:35 Location: Te

Group Report T 80.1 Thu 16:00 Te

Status of the CORSIKA 8 Project — •Ralf Ulrich for the CORSIKA 8-Collaboration — Institute for Astroparticle Physics, KIT

It is the goal of the CORSIKA 8 project to create a novel framework for astroparticle physics to simulate and describe high-energy particle cascades in matter. While solidly founded on the legacy of the fortran version of CORSIKA, this new framework will provide high flexibility, modularity, and is opening new opportunities for research in the intersection of astroparticle-, astro-, particle-, nuclear-physics – and beyond. The CORSIKA 8 framework is implemented as a modern C++ high-performance computing code, with the main goal to provide best achievable physics performance. The recent progress of the CORSIKA 8 framework is described, the current capabilities are presented, and the roadmap to a first production release is outlined.

T 80.2 Thu 16:20 Te

Random number generation in massivelly parallel platforms for CORSIKA8 — •Antonio Augusto Alves Junior, Anton Poctarev, and Ralf Ulrich — IAP - KIT, Karlsruhe, Germany

Advances of the generation of high quality random numbers in CORSIKA8, which is being developed in modern C++17 and is designed to run on multi-thread modern processors and accelerators, are discussed.

The aspects associated with the generation of high quality random numbers on massively parallel platforms, like multi-core CPUs and GPUs, are reviewed in depth, with particular emphasis on the deployment of counter-based engines.

Detailed performance measurements for the available counter-based algorithms are provided, as well as detailed comparisons with conventional designs. Finally, the design choices and integration into COR-

SIKA 8 are presented, together with some cascade simulation examples.

T 80.3 Thu 16:35 Te

Radio emission simulations using CORSIKA 8 — •Nikos Karastathis[1], Remy Prechelt[2], and Tim Huege[1,3] for the CORSIKA 8-Collaboration — [1]Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]Department of Physics and Astronomy, University of Hawaii-Manoa, Hawaii, USA — [3]Astrophysical Institute, Vrije Universiteit Brussel, Brussels, Belgium

For years, CORSIKA has served the scientific community as one of the leading simulation tools for air showers. Simulations of the radio emission from air showers are made possible within this context using the CoREAS extension. Given that the current code rests upon the monolithic structure of FORTRAN77, a complete reimplementation of CORSIKA 8 that is based on a modular and more flexible C++ design is an ongoing project. Part of this effort is to include radio-emission calculations as an integral part of the program.

In this talk, I will present the current state of the software design and how a reimplementation of CoREAS fits into CORSIKA 8 by taking advantage of its features. This design makes radio calculations more general, giving the freedom to choose different formalisms for the radio-emission calculations, such as the Endpoint or ZHS formalisms, and in the future accommodating more complex interaction media. Our first radio simulations using CORSIKA 8 will be presented.

T 80.4 Thu 16:50 Te

Millicharged Particles in Cosmic Ray Air Showers — Anatoli Fedynitch[1], Ralf Ulrich[2], Tanguy Pierog[2], Max Reininghaus[2], Antonio Augusto Alves Jr[2], and •Maria Pokrandt[2] for the CORSIKA 8-Collaboration — [1]Tokyo University, ICRR — [2]Institut for Astroparticle Physics, KIT

Despite its widely appreciated success, there are open questions in the Standard Model (SM) such as potential dark matter particles, the neutrino masses or the anomalous magnetic moment of the muon. Some theories extending the SM suggest the existence of millicharged particles (MCPs) with just a fraction of an electron charge. Such particles are experimentally poorly constraint in the quite interesting mass range from about 1 to 100GeV. Cosmic air showers abundantly produce particles of such energies and are therefore an interesting opportunity to look for the existence of MCPs. In this work, MCPs in the GeV regime are implemented in the powerful air shower simulation tool MCEq (Matrix Cascade Equations) and first results are derived from the resulting simulations. The goal is to obtain competitive exclusion limits for MCPs in that particular mass range.

T 80.5 Thu 17:05 Te

EAS genealogy for muon production — Tanguy Pierog[1], •Maximilian Reininghaus[1,2], and Ralf Ulrich[1] — [1]Institut für Astroteilchenphysik, KIT, Karlsruhe — [2]Instituto de Tecnologías en Detección y Astropartículas (CNEA, CONICET, UNSAM), Buenos Aires

Measurements of the muon content of extensive air showers at the highest energies show large discrepancies compared to simulations. This so-called muon puzzle is commonly attributed to a lack of understanding of the hadronic interactions in the shower development. Furthermore, measurements of the fluctuations of muon numbers suggest that the discrepancy is likely a cumulative effect of interactions of all energies in the cascade.

With the newly developed "history" extension of the air shower simulation code CORSIKA 8 we are able to relate interactions happening at any intermediate stage in the cascade to the final-state muons. With this technique we study "muon-number weighted" particle distributions of hadronic interactions in order to quantify the relevance of different phase space regions for muon production.

T 80.6 Thu 17:20 Te

Prediction of cosmic ray signatures on Earth from nearby supernova explosions — •Jonathan Heil — Ruhr-University Bochum, Germany

Supernova remnants are among the most promising candidates for the production of a large component of the cosmic-ray flux at Earth. However, even more than 100 years after the detection of cosmic rays, the exact contribution to the luminosity of cosmic rays from SNRs is could not be fully quantified yet. In this contribution, we present a simulation performed with the CRPropa transport framework, in which particles are propagated from sources in the Galaxy to Earth for different source parameters like luminosity, activity time and position. The goal is to map the influence of nearby supernova remnants on the diffusive cosmic ray flux and to extend the simulated cosmic ray energy range to low energies. In this talk, the simulation setup will be presented together with first results.

T 80.7 Thu 17:35 Te

Recent developments for the high-energy lepton and photon propagator PROPOSAL — •Jean-Marco Alameddine[1], Jan Soedingrekso[1], Alexander Sandrock[2], and Maximilian Sackel[1] — [1]TU Dortmund University — [2]National Research Nuclear University MEPhI

The precise simulation of high-energy particles is a major task for many analyses in astroparticle physics. PROPOSAL is a Monte Carlo software, usable in both C++ and python, providing an easy to use and customizable environment to simulate high-energy muons, taus, electrons, positrons and photons. Its functionalities allow finding an adequate trade-off between simulation precision and performance.

In this talk, the recent developments of PROPOSAL are presented, including the implementation of electron, positron and photon propagation as well as a major code restructuring towards a more modular software. This provides the possibility to extract individual components of the propagation routine of PROPOSAL to be used in external frameworks or analyses. One application example is the air shower simulation framework CORSIKA 8, where it will be possible to use PROPOSAL as an electromagnetic interaction model.

T 80.8 Thu 17:50 Te

Distributed simulation of extensive air showers with Geant4 — Kai-Thomas Brinkmann, Hans-Georg Zaunick, and •Daniel Treffenstädt — Justus-Liebig-Universität Gießen

This talk presents an approach to simulating extensive air showers caused by ultra high energy cosmic radiation in earths atmosphere with Geant4. The scope is to simulate the interaction of extensive air showers with an array of plastic scintillator detectors distributed in a loose formation within an area of few square kilometers. The main area of interest thereby is to determine the signature of a shower event specific to the timing of individual detecor events with respect to each other. This simulation however requires a high level of precision and tracking of all individual particles produced in the shower, which causes a high CPU runtime impact. An approach to reduce the total runtime of each simulation by distributing the simulation on a large number of calculation nodes is investigated.

T 80.9 Thu 18:05 Te

The air shower arrays at the South Pole — •Agnieszka Leszczyńska, Mark Weyrauch, and Fiona Ellwanger for the IceCube-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Germany

The IceTop air-shower array, detecting cosmic rays in the PeV–EeV energy range, will be enhanced with scintillation detectors and radio antennas. Due to their better sensitivity to the electromagnetic component of the air showers, those will, together with the IceTop Cherenkov tanks, help to improve the measurement of the cosmic ray mass and energy. A denser sampling of the area will lower the energy threshold to cover the knee region of the cosmic ray spectrum. A similar array is planned to be also deployed within the surface footprint of the next generation of the IceCube experiment, IceCube-Gen2. A larger exposure of the IceCube-Gen2 surface array will allow for studying higher energy cosmic-rays and, at the same time, will serve as an additional veto of the atmospheric background for the down-going astrophysical neutrinos. Recent simulation results as well as the prospects for these new surface arrays will be discussed.

T 80.10 Thu 18:20 Te

Cosmic muon induced neutron measurement with the MINIDEX experiment — •Xiang Liu, Iris Abt, Bela Majorovits, Oliver Schulz, Christopher Gooch, Anton Empl, and Raphael Kneissl for the GeDet-Collaboration — Max Planck Institute for Physics, Föhringer Ring 6, Munich D-80805, Germany

Cosmic-ray muon induced neutrons are an important source of background in low-background experiments searching for rare phenomena, like neutrinoless double beta decay or dark matter. These neutrons can generate radioactive isotopes in the shielding materials or in the detector itself, creating background which can not be easily removed

by a cosmic muon veto, due to the time delay. The Muon-Induced Neutron Indirect Detection EXperiment, MINIDEX, running in the shallow undergound laboratory at the University of Tuebingen, measures the production of muon-induced neutrons in a variety of high-Z materials. Recently, the experiment has been upgraded to measure the neutron production not only from through-going muons but also from stopped muons. The design of the experiment and the upgrade are presented as well as selected results.

T 81: Flavour physics IV

Time: Thursday 16:00–18:30 Location: Tf

T 81.1 Thu 16:00 Tf

Angular analysis of the decay $B^0 \to K^{*0}\mu^+\mu^-$ — •Leon Carus, Thomas Oeser, Eluned Smith, and Christoph Langenbruch — 1. Physikalisches Institut B, RWTH Aachen, Germany

In the past few years there has been increasing interest in $b \to s\ell\ell$ processes, due to the emergence of several intriguing tensions between measured observables and SM predictions. Of particular interest is the study of angular distributions of such decays, where measurements of angular observables can offer detailed insight on the nature of potential new physics models. A previous measurement of the angular distribution of $B^0 \to K^{*0}(\to K^+\pi^-)\mu^+\mu^-$ decays at LHCb, using data collected during Run 1 and 2016, found a tension at the level of 3 standard deviations with the Standard Model. This talk will present the current status of the update of this angular analysis, including LHCb data collected during 2017 and 2018.

T 81.2 Thu 16:15 Tf

Angular analysis of the $B^+ \to K^{*+}\mu^+\mu^-$ decay — Martino Borsato[1], Michel De Cian[2], •David Gerick[1], and Renata Kopecna[1] for the LHCb-Collaboration — [1]Physikalisches Institut, Universität Heidelberg — [2]EPFL, Lausanne

In this talk the angular analysis of the $B^+ \to K^{*+}\mu^+\mu^-$ decay with the subsequent decays $K^{*+} \to K^0_S\pi^+$ and $K^0_S \to \pi^+\pi^-$ is presented. The full data set collected by the LHCb experiment during the first two periods of pp collisions at the Large Hadron Collider in the years 2011 – 2018 is used. In total, 737 ± 34 signal candidates are selected. A four-dimensional maximum-likelihood fit is used to extract two sets of angular observables in ten different intervals of the invariant dimuon mass squared, q^2. The fit uses angular folds of the differential decay rate to stabilize the fit and random re-sampling of the data to obtain the correlations between all angular observables.
For most observables and in most q^2 intervals the resulting values are compatible with Standard Model predictions. However, most prominently the CP-averaged angular observables $A_{\rm FB}$ (P_2) and S_5 (P'_5) show significant discrepancies in the q^2 region below the J/ψ resonance. This pattern of deviation is coherent with previous measurements in the isospin-partner decay of the B^0 meson.

T 81.3 Thu 16:30 Tf

Inclusive tagging search for $B^\pm \to K^\pm\nu\bar{\nu}$ at the Belle II experiment, with focus on a novel validation procedure. — •Filippo Dattola — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

The experimental measurement of the rare, flavour-changing neutral current decay $B^\pm \to K^\pm\nu\bar{\nu}$ represents a powerful probe allowing to test the validity of the Standard Model and the possible existence of physics beyond it. Predicted with high level of accuracy by the Standard Model, the decay has not been experimentally observed yet. A search for the decay is performed by means of an inclusive tagging technique applied to a data sample, collected by the Belle II experiment at the $\Upsilon(4S)$ resonance mass, corresponding to an integrated luminosity of 63 fb^{-1}. Particular focus in this talk will be given to a novel approach that enables to validate the inclusive tagging technique on the $B^\pm \to J/\psi K^\pm$ control channel by modifying the reconstructed events in order to reproduce the topology and the kinematics of the $B^\pm \to K^\pm\nu\bar{\nu}$ events of interest.

T 81.4 Thu 16:45 Tf

Test of lepton flavour universality with $b \to s\ell\ell$ decays at the LHCb experiment — Johannes Albrecht, Vitalii Lisovskyi, and •Alex Seuthe — Technische Universität Dortmund

Current measurements of the LHCb experiment hint to deviations from Standard Model predictions in tests of lepton flavour universality. Examples for this are the measurements of $R_{K^{*0}}$ and R_K, the ratios of the branching fractions of the decays $B^0 \to K^{*0}\mu^+\mu^-$ and $B^0 \to K^{*0}e^+e^-$, and $B^+ \to K^+\mu^+\mu^-$ and $B^+ \to K^+e^+e^-$, respectively. For conclusive results the measurements have to include the full LHCb dataset. In this talk the updated simultaneous measurement of $R_{K^{*0}}$ and R_K, which is currently under preparation, is presented.

T 81.5 Thu 17:00 Tf

Search for the $B \to K^*\nu\bar{\nu}$ decay at Belle II — •Jiyong Jeong and Thomas Kuhr — Ludwig-Maximilians-Universität München

The rare decay $B \to K^*\nu\bar{\nu}$ is a flavor-changing neutral current process, which is suppressed in the standard model and thus sensitive to new physics contributions. We search for this decay in $\Upsilon(4S)$ events produced at the SuperKEKB e^+e^- collider. B mesons are collected and reconstructed from $\Upsilon(4S) \to B\bar{B}$ decays. The K^* is reconstructed in the Belle II detector from its daughter kaon and pion particles. The missing energy and momentum of the neutrinos is inferred from the reconstructed second B meson in the event and the known beam energies. Monte-Carlo simulated data is applied to optimize the separation between signal and background and to estimate the sensitivity of the search.

T 81.6 Thu 17:15 Tf

Measurement of the ratio $R_{K^{*0}}$ using Run 1 + 2 data of the LHCb experiment — •Stephan Escher, Christoph Langenbruch, Stefan Schael, Sebastian Schmitt, and Eluned Smith — RWTH Aachen (Germany)

In the Standard Model (SM) of particle physics flavour-changing neutral-current processes are forbidden at tree-level and can only occur in electroweak loop diagrams. Therefore, $b \to s$ transitions are rare and sensitive to heavy particles beyond the SM. In the SM the coupling of gauge bosons to leptons are independent of their flavour, which is known as lepton flavour universality (LFU). Thus, the $R_{K^{*0}}$ ratio, defined as $R_{K^{*0}} = \mathcal{B}(B^0 \to K^{*0}\mu^+\mu^-)/\mathcal{B}(B^0 \to K^{*0}e^+e^-)$, is predicted to be unity in the SM (neglecting lepton mass effects). The existence of new particles, that couple differently to electrons and muons, could influence the $R_{K^{*0}}$ ratio significantly and lead to deviations from unity.

To this date, the most precise measurement of $R_{K^{*0}}$ is performed by the LHCb collaboration using Run 1 data showing a deviation of $2.4 - 2.5$ standard deviations (σ) from the SM expectations.

This talk will present the updated $R_{K^{*0}}$ analysis using the combined Run 1 and 2 LHCb data sample, which is currently in LHCb review. Particular emphasis will be on the validation of fit yields and efficiencies of the control channel as well as on rare mode fits and sensitivities.

T 81.7 Thu 17:30 Tf

Measurement of the ratio $R_{K\pi\pi}$ with the LHCb experiment — Christoph Langenbruch, •Johannes Heuel, and Stefan Schael — I. Physikalisches Institut B, RWTH Aachen University

In the Standard Model (SM) of particle physics, the coupling of electroweak gauge bosons to all leptons is universal. Stringent tests of this Lepton Flavour Universality (LFU) are possible by measuring ratios of rare $b \to s\ell\ell$ decays with different leptons in the final state. These decays are loop-suppressed in the SM and therefore sensitive to new heavy particles beyond the SM.

The LHCb experiment is ideally suited for the study of rare b hadron decays due to its large acceptance, the high trigger efficiencies and the excellent tracking and particle identification. Recent measurements of $b \to s\ell\ell$ ratios published by the LHCb Collaboration show tensions with the SM predictions of up to 2.5 standard deviations. Therefore, further studies of LFU tests using other rare B decay channels are crucial.

The current status of the ongoing measurement of the ratio $R_{K\pi\pi}$ of the branching fractions of the decays $B^+ \to K^+\pi^+\pi^-\mu^+\mu^-$ and $B^+ \to K^+\pi^+\pi^-e^+e^-$ is presented. The measurement is experimentally challenging as the hadronic system is measured inclusively.

T 81.8 Thu 17:45 Tf

Final state hadron multiplicity of charmless semileptonic B-decays at Belle — Florian Bernlochner, Jochen Dingfelder, •Alexander Ermakov, and Peter Lewis for the Belle-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, 53115 Bonn, Germany

The Belle experiment dataset with an integrated luminosity of 711 fb^{-1} from e^+e^- collisions allows the investigation of charmless semileptonic B-decays and their properties. These decays are interesting, because they give access to the modulus of the CKM-matrix element V_{ub}, when combined with theory predictions. Inclusive and exclusive measurements of these decays yield different values of the modulus of V_{ub}. Measurements at different experiments agree on this persistent tension at the 3σ level. A large source of systematic uncertainties for these types of decays can be related to the modeling of the final state hadron multiplicity. As the reconstruction and selection efficiencies of these decays depend upon the final state hadron multiplicity the related uncertainty can be reduced, if the analysis incorporates the final state hadron multiplicity dependency explicitly. Resonant and non-resonant signal contributions can thus be studied simultaneously. The talk describes the selection of $B \to X_u \ell \nu$ decays, the variables used for signal selection and background suppression, the different signal subsamples, the impact of incorporating the final state hadron multiplicity as an extraction variable as well as the systematic uncertainties on the determination of the branching fraction of charmless semileptonic B-decays.

T 81.9 Thu 18:00 Tf

Search for the $B^0 \to D^0 \bar{D}^0$ decay with the LHCb experiment. — •JONAH BLANK and SOPHIE HOLLITT — Experimentelle Physik 5, TU Dortmund

With precise measurements of B meson decays the LHCb experiment can test the integrity of the Standard Model of particle physics. Especially $B \to D\,D$ are interesting to examine CP violation and further constrain the unitarity triangle. While decays to charged $D^{\pm}$ mesons have already been found and well measured, the $B \to D^0 \bar{D}^0$ decay channel has not yet been observed by any experiment.

In this analysis, data collected by the LHCb experiment at $\sqrt{s} = 7, 8$ and 13 TeV corresponding to 9 fb^{-1} is used to search for the $B^0 \to D^0 \bar{D}^0$ decay channel. The $B^0 \to \bar{D}^0 \pi^+ \pi^-$ decay channel is used as a normalisation mode to control high theory uncertainties. The current status of the analysis will be presented.

T 81.10 Thu 18:15 Tf

Untagged $\overline{B}^0 \to D^{*+} \ell^- \overline{\nu}_\ell$ studies with Belle II — Florian Bernlochner, Lu Cao, Jochen Dingfelder, and •Chaoyi Lyu for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, 53115 Bonn, Germany

The precise determination of the CKM matrix element $|V_{cb}|$ and semileptonic form factors in B meson decays are important for carrying out precision tests of the flavour sector of the Standard Model and to search for new physics. The decay of $\overline{B}^0 \to D^{*+} \ell^- \overline{\nu}_\ell$ is particularly well suited to determine $|V_{cb}|$ due to its large branching fraction, small backgrounds and the availability of lattice data to describe the form factors. In this talk, I will present the current status of establishing an untagged measurement of the $\overline{B}^0 \to D^{*+} \ell^- \overline{\nu}_\ell$ branching fraction and form factors using early Belle II data. In addition, I will report on the status of the determination of the slow pion reconstruction efficiency using fully hadronic B-meson decays.

T 82: Calorimeters II

Time: Thursday 16:00–18:15 Location: Tg

T 82.1 Thu 16:00 Tg

Test beam results of the Megatile prototype for the CALICE AHCAL — •Anna Rosmanitz for the CALICE-D-Collaboration — Johannes Gutenberg-Universität Mainz

The CALICE collaboration develops several highly granular calorimeter concepts for a future e^+e^- collider, that are specialised for Particle Flow Algorithms.

The current design for the AHCAL consists of small, seperately produced scintillator tiles with a size of 3x3 cm^2 read out by silicon photomultipliers (SiPM). They are separately wrapped in reflective foil and glued to the boards. In total, the AHCAL is going to have 8 million channels.

To facilitate the assembly process, the Megatile, a structured scintillator plate, was developed at the University of Mainz. Its advantage is that larger sections of 12x12 channels are produced at once with the channels separated by tilted trenches filled with reflective TiO_2.

Different prototypes of the Megatile have been tested in test beams at DESY with electrons. This talk presents the light yield and cross talk results from this analysis.

T 82.2 Thu 16:15 Tg

Test Beam Study of CALICE Scintillator Tiles — •Fabian Hummer, Frank Simon, Ivan Popov, and Lorenz Emberger for the CALICE-D-Collaboration — Max-Planck-Institut für Physik

One of the main design drivers at future energy-frontier e^+e^- colliders is the precise determination of the energy of particle jets. This is achieved with detector designs optimized for the particle flow paradigm. CALICE is an R&D collaboration focused on the development of highly granular calorimeters optimized to aid this paradigm by providing high spatial resolution. The Analogue Hadronic Calorimeter (AHCAL) is one of the detector concepts based on the SiPM-on-Tile technology, using scintillating tiles read out by Silicon Photomultipliers. A key aspect of the recently completed technological prototype is the capability for single-cell time stamping on the nanosecond level to enhance the particle separation and background rejection capability. To investigate the intrinsic time resolution of this technology, a modular test beam setup has been designed and tested at DESY in October 2020. In this setup four scintillator tiles arranged as a "beam telescope" are read out by precise digitizers, allowing detailed studies of the time structure of the detector response. We have investigated different scintillator materials and tile arrangements. In this contribution we will introduce the setup, outline the calibration procedure and report on the achievable time resolutions.

T 82.3 Thu 16:30 Tg

Easing the assembly of the CALICE high-granularity Analogue Hadronic Calorimeter: an application of the Megatile concept — •Antoine Laudrain for the CALICE-D-Collaboration — Johannes Gutenberg Universität, Mainz, Germany

The CALICE collaboration is developing a high-granularity Analogue Hadronic Calorimeter (AHCal), designed for future experiments at lepton colliders. The current design includes around 8 million scintillator tiles, individually wrapped in a reflective foil and glued on a board, and read out by silicon photomultipliers (SiPM). After the successful assembly of a 22000-channel technological prototype (tested in beams at CERN in 2018), a new mechanical design easing the assembly is being developed.

The new concept relies on Megatiles, a large plate of scintillator housing 12x12 channels. The channels are separated by optical trenches filled with a glue-TiO2 mixture, ensuring both the mechanical robustness and the optical isolation. Several prototypes have been built and continuously tested in a cosmic-ray test stand at the University of Mainz. The performances are competitive compared to the original design. The latest developments presented in this talk improve the performance of edge channels and reduce the optical cross-talk between neighbouring channels.

T 82.4 Thu 16:45 Tg

Pandora Particle Flow Algorithm Studies on CALICE AHCAL 2018 Prototype Test Beam Data — •Daniel Heuchel for the CALICE-D-Collaboration — DESY, Hamburg, Germany

The CALICE collaboration is developing highly granular calorimeters for a future e^+e^- collider, like ILC or CLIC. To achieve the desired jet energy resolution of 3-4% for jet energies between 40-500 GeV in such an experiment the Pandora Particle Flow Algorithm (PandoraPFA) can be used. The basic concept of PandoraPFA is to use the energy measurement of the sub-detector providing the best resolution for each individual particle. This means that charged particles are measured

by the tracker, neutral particles by the calorimeters. For this pattern recognition framework high granularity in the calorimeter systems is crucial to correctly assign particle tracks to shower clusters and efficiently separate charged and neutral particles.
The current Analog Hadronic Calorimeter (AHCAL) technological prototype features 38 active layers with a total of 21888 channels each consisting of a 3x3cm^2 scintillating tile read-out by a Silicon Photomultiplier (SiPM). Three test beam periods at the SPS CERN have been performed in 2018 to proof the scalability to a full collider detector and to measure different particles for detailed shower analysis.
In this contribution, we will present first results of the application of PandoraPFA to AHCAL data. Focusing on the case of single particle reconstruction and the separation of a neutral hadron in the vicinity of a charged one, we are validating the simulated algorithm performance with test beam data.

T 82.5 Thu 17:00 Tg

Analysis of shower shapes recorded with the CALICE AHCAL in 2018 Test Beam Data — •Olin Pinto for the CALICE-D-Collaboration — Deutsches Elektronen-Synchrotron DESY

The analog hadron calorimeter prototype is a highly granular calorimeter based on steel absorbers and $30 \times 30 \times 3$ mm^3 scintillator tiles read out by Silicon Photomultipliers (SiPM), developed by the CALICE collaboration. It has acquired sizeable datasets with precise five-dimensional information on electromagnetic and hadronic showers in two test-beam periods at the CERN SPS beam test facility The unprecedented granularity of the detector provides detailed information about the properties of electromagnetic and hadronic showers, which helps to constrain shower models through comparisons with model calculations. Results on longitudinal and lateral shower profiles compared to GEANT4 shower models will be discussed which were measured for electrons and pions in the energy range between 10 and 200GeV. A shower parametrization is used on both longitudinal and lateral shower profiles and a comparison is performed with a variety of different hadronic shower models which can provide input for further development of these models.

T 82.6 Thu 17:15 Tg

Simulation of ALP reconstruction for the SHiP experiment — •Phi Chau, Matei Climescu, and Rainer Wanke — Johannes Gutenberg-Universität, Institut für Physik, Mainz, Germany

So-called Axion-Like Particles (ALPs) are Dark Matter candidates. Various experimental approaches are foreseen to search for evidence of its existence. At the SHiP experiment the SPS 400 GeV proton beam could produce ALPs by interaction with a target material and subsequent decays of the produced particles. These ALPs would be boosted in longitudinal direction and may decay into two photons. The photon pair would be detected by the sampling calorimeter of the experiment, which consists of 50 layers of active material, each separated via lead absorber layers. High precision layers (2-3x) are supposed to support the track reconstruction and improve the angular resolution of photon showers while the other layers, consisting of scintillators with SiPM readout, measure the deposited energy. In this contribution results of simulation studies for determination of the calorimeter design's suitability for ALPs detection and its efficiency are presented. The focus of these studies is put on an ALP mass range of 0.1-1.5 GeV. Also, the performance of the detector in terms of photon energy resolution is determined.

T 82.7 Thu 17:30 Tg

Neural network based pulse shape analysis with the Belle II electromagnetic calorimeter — •Stella Katharina Wermuth — DESY, Hamburg, Deutschland

The Belle II experiment, located at the SuperKEKB e^+e^- collider in Japan, uses pulse shape analysis techniques to distinguish electromagnetically and hadronically interacting particles within the CsI(Tl) electromagnetic calorimeter. The pulse shapes from the particle-dependent scintillation response are nominally analyzed with a multi-template offline fit to measure the fraction of scintillation emission produced by hadrons. This fitting method allows for the determination of the total deposited energy, the total scintillation emission by hadrons, and the time of energy deposit. This presentation reports on a new approach to extract the total deposited energy, and the hadronic component of the scintillation emission from the pulse shapes using machine learning techniques. For this, a neural network is trained on pulse shapes produced in crystals from calorimeter clusters from simulated photons and pions, and is employed as a multivariate regression tool. I will show the comparison between the performance of the neural network and the performance of the current fitting method. The neural network shows an improvement in the total and hadron energy resolution, and robustness towards fluctuations in photon pile-up from beam backgrounds.

T 82.8 Thu 17:45 Tg

Particle identification with the Belle II calorimeter using machine learning — •Abtin Narimani Charan for the Belle II-Collaboration — Deutsches Elektronen-Synchrotron DESY, Hamburg

The Belle II experiment, located at the asymmetric SuperKEKB e^+e^- collider in Tsukuba, Japan, performs studies of B-physics and searches for new physics at the luminosity frontier. The Belle II electromagnetic calorimeter is constructed from 8736 CsI(Tl) scintillator crystals. It is designed to measure the energy deposited by charged and neutral particles. The electromagnetic calorimeter also provides important contributions to the Belle II particle identification system. Identification of low-momentum muons and pions is crucial in the electromagnetic calorimeter if they do not reach the outer muon detector.

This talk presents an application of a convolutional neural network to separate muons and pions. The granularity of the calorimeter crystals provides 5x5 and 7x7 pixel images of calorimeter clusters which are used as inputs to the neural network. The performance of the network is investigated with data control samples of muons and pions. Finally, comparisons of the neural network approach with conventional methods and with a BDT using shower-shapes are presented.

T 82.9 Thu 18:00 Tg

First studies of pulse-shape analysis in pure CsI at Belle II. — •Munira Khan for the Belle II-Collaboration — DESY BELLE II

The Belle II electromagnetic calorimeter is the first high energy physics detector to implement pulse shape discrimination in CsI(Tl) crystals, as new method to improve particle identification. Different particles produce a different scintillation response in the crystals. By analysing these pulse shapes, electromagnetically and hadronically interacting particles can be distinguished. This technique has been demonstrated in the first data from the Belle II experiment and included in the particle identification.

Pure CsI has a faster scintillation time, is more resistant against radiation damage from high beam backgrounds, and is therefore an interesting calorimeter material for future high intensity colliders or a potential upgrade of Belle II. This talk will report on a test-bench setup for pure CsI crystals at DESY and simulation studies with GEANT. The goal of this project is to perform investigation into a pulse-shape analysis with this scintillator material and compare it to the well-characterised CsI(Tl).

T 83: Gamma astronomy II

Time: Thursday 16:00–18:35 Location: Th

Group Report T 83.1 Thu 16:00 Th

FACT - Highlights from Unbiased Monitoring at Very High Energies — •Daniela Dorner[1] and Thomas Bretz[2,3] for the FACT-Collaboration — [1]Universität Würzburg, Germany — [2]ETH Zürich, Schweiz — [3]RWTH Aachen, Germany

The First G-APD Cherenkov Telescope (FACT) has been monitoring bright sources at TeV energies for more than eight years, collecting a total of more than 14700 hours of physics data. The duty cycle is maximized and gaps in the light curves are minimized using semiconductor photosensors. In combination with an unbiased observing strategy, this yields an unprecedented data sample and allows for systematic studies of source variability. In addition, many multi-wavelength observations are triggered or carried out in the context of multi-instrument campaigns. Those are crucial to interpret the origin of the TeV gamma-ray emission. The presentation will summarize results from the past years

on the blazars Mrk 501, Mrk 421, 1ES 1959+650 and 1ES 2344+514.

T 83.2 Thu 16:20 Th

Variability Analysis of *Fermi*-LAT and FACT blazar light curves — •Sarah Wagner, Daniela Dorner, and Karl Mannheim for the FACT-Collaboration — Julius-Maximilians-Universität Würzburg

Blazars are active galactic nuclei with a relativistic outflow directed closely towards our line of sight showing rapidly variable non-thermal continuum emission. We present a flare analysis of blazar light curves observed with *Fermi*-LAT and FACT in order to better understand the physical processes that give rise to the observed variability. Based on Bayesian blocks and the HOP algorithm, the asymmetries of flux rise and decay time are studied.

T 83.3 Thu 16:35 Th

FACT - Analysis of Flux Distributions of the Blazars Mrk 421 and Mrk 501 — •Laura Eisenberger for the FACT-Collaboration — University of Würzburg

The blazars Mrk 421 and Mrk 501 are the brightest known astrophysical sources at TeV energies. Active Galactic Nuclei (AGN) viewed along the jet axis, known as blazars, show extremely variable gamma-ray emission which so far defies a compelling physical interpretation.

Theoretical models predict non-thermal emission due to particle acceleration at shock waves travelling down an initially relativistic jet. Doppler boosting of the emission from the fastest shocks results in high-amplitude flux states, while the multiple shocks from the decelerated jet further downstream produce an apparently steady baseline emission with weaker Doppler boosting. Studying the shape of flux distributions on time scales from minutes to years and investigating its temporal evolution provides crucial information for testing this scenario.

FACT, the First G-APD Cherenkov Telescope, has been designed for long-term and continuous monitoring in the very-high-energy regime. Here, we present results of our analysis of FACT data acquired during 786 nights (1882 hours in total) for Mrk 421 and 896 nights (1725 hours in total) for Mrk 501.

T 83.4 Thu 16:50 Th

Long-term Studies of the Blazar Mrk 421 in the Multi-Wavelength Context — •Bernd Schleicher for the FACT-Collaboration — University of Würzburg, Institute for Theoretical Physics and Astrophysics

The blazar Mrk 421 is one of the brightest sources in very-high-energy (VHE) gamma rays. The origin of such gamma rays is still under debate but several models predict correlation between different wavelengths. Therefore, regular multi-wavelength (MWL) campaigns have been carried out, since 2009. Based on this extensive data sample, variability is studied on different time scales from minutes to years. At VHE, the source is regularly monitored by MAGIC and FACT. Combining the data from these two telescopes, both the short time scales (excellent sensitivity of MAGIC) and long time scales (dense monitoring by FACT) can be studied in detail. Studying 5.5 years of FACT light curves combined with MWL data show a correlation between VHE and X-ray with a lag < 0.6 days and a correlation between GeV gamma-ray and radio data with a lag of 43 days. A study of two years of data including both MAGIC and FACT in the VHE also shows a significant correlation between X-ray and VHE. The highest variability was found in X-rays and VHE in both studies. The analysis of further MWL observations is ongoing.

T 83.5 Thu 17:05 Th

Detection of new Misaligned Active Galactic Nuclei in the Fermi-LAT Fourth Source Catalog using machine learning techniques — •Luca Deval[1,2], Fiorenza Donato[3], and Mattia Di Mauro[3] — [1]Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]Physics Department-Torino University, Turin, Italy — [3]Physics Department, Torino University, and Istituto Nazionale di Fisica Nucleare, Sezione di Torino, Torino,Italy

Active galactic nuclei (AGN) are the most luminous and abundant objects in the gamma-ray sky. AGN with jets misaligned along the line-of-sight (MAGN) appear fainter than the brighter blazars, but are expected more numerous. Fermi Large Area Telescope (LAT) detected 40 MAGN compared to 1943 blazars.

The aim of this study is to identify new MAGN candidates in the blazars of uncertain type (BCUs) listed in the Fermi-LAT 10-years Source Catalog using an artificial neural network (ANN). The statistical tests applied to the trained ANN reveals that a classification with machine learning techniques is feasible with high accuracy and precision. The trained ANN has been applied to the 1120 BCUs which have been classified into 655 BL Lacs and 314 Flat Spectrum Radio Quasars (FSRQs). Among the re-classified BCUs, the possible MAGN candidates have been determined by applying thresholds on the spectral index, variability index and gamma-ray luminosity.

Our results led to 36 possible MAGN candidates, which respect the main physical properties of the 40 MAGN already listed in the Fourth Fermi Catalog.

T 83.6 Thu 17:20 Th

Event classification in Compton-Pair telescopes using Convolutional Networks — •Jan Lommler and Uwe Oberlack — Johannes Gutenberg-Universität Mainz

Low to medium energy gamma rays are shielded by the Earth's atmosphere and cannot be measured with on-ground facilities. Satellite based gamma-ray astronomy relies on Compton scatter and Pair creation as measurement channels. Among the biggest challenges are the poor signal to background ratio due to low signal fluxes from cosmic sources and the high background rates even in the comparatively moderate environment of Low Earth Orbits. An efficient event tagging reduces signal losses by preventing type-mismatching applications of reconstruction algorithms (e.g. performing a Compton reconstruction on a Pair event) and signal pollution (distinguishing events originating from background sources). We explore the feasibility of Deep Convolutional Neural Nets in the context of event classification for Compton-Pair telescopes on the example of the e-ASTROGAM design proposal.

T 83.7 Thu 17:35 Th

Colibri - The coincidence library for real-time inquiry for multi-messenger astrophysics — •Patrick Reichherzer[1,2,3], Fabian Schüssler[3], Julia Tjus[1,2], Anke Yusafzai[4], and Atilla Alkan[3] — [1]Ruhr-University Bochum, Theoretical Physics IV — [2]Ruhr Astroparticle and Plasma Physics (RAPP) Center — [3]Irfu, CEA Paris-Saclay — [4]ECAP, FAU Erlangen-Nuremberg

Flares of known stable astronomical sources and transient sources can occur on different timescales, from only a few seconds to several days. The discovery potential of both serendipitous observations and multi-messenger and multi-wavelength follow-up observations could be maximized with a tool which allows for quickly acquiring an overview over both stable sources and transient events in the relevant phase space. We here present COincidence LIBrary for Real-time Inquiry (Colibri), a comprehensive tool for this task.

Colibri evaluates incoming VOEvent messages of astronomical observations in real time, stores them in the database and filters them by user specified criteria in the context of known sources from various catalogs. Colibri's architecture comprises a RESTful API, a real-time database, a cloud-based alert system and a website as well as apps for iOS and Android as clients for users. The clients provide a graphical representation with a summary of the relevant data to allow for the fast identification of changes in observed sky regions, and for analyses of those. In this contribution, the key features of Colibri are presented. Current and possible future implementations of Colibri will be discussed.

T 83.8 Thu 17:50 Th

COMCUBE: Exploring the violent Universe with CubeSat Technology — •Jan Lommler for the COMCUBE-Collaboration — Johannes Gutenberg-Universität Mainz

Gamma Ray Bursts are a window into some of the most energetic processes in the Universe. Due to the energy range of the emitted electro-magnetic radiation, measurements have to be performed in space by a network of either dedicated observatories like SWIFT and POLAR or piggy-back detectors mounted on other observatories like Fermi GBM. Most detectors only allow the measurement of the burst's energy-spectrum and time evolution, missing out on polarization of the incident photons.Using Compton scattering as main detection channel, Cubesats offer the opportunity to setup a network of small-scale dedicated detectors at relatively low cost that are able to pinpoint GRBs, measure their spectra and temporal evolution while obtaining polarization information. In this talk we want present the detector concept of COMCUBE and report basic performance estimates.

T 83.9 Thu 18:05 Th

Performance analysis of the Cherenkov telescope HAWC's

Eye in a hybrid setup with HAWC — •Florian Rehbein for the HAWC's Eye-Collaboration — Physics Institute III A, RWTH Aachen, Germany

The compact imaging air-Cherenkov telescope HAWC's Eye was developed to operate with the High-Altitude Water Cherenkov Gamma-Ray Observatory (HAWC), which is an extensive air shower array located in the state of Puebla, Mexico. The hybrid observation improves the energy and angular resolution significantly. This approach is very promising not only for the HAWC observatory but also for future experiments such as the Southern Wide-field Gamma-ray Observatory (SWGO). A full detector simulation of multiple HAWC's Eye telescopes in a hybrid setup with HAWC has been set up. A simply hybrid reconstruction with one or more HAWC's Eye telescopes shows an improvement of the angular and energy resolution above 10 TeV.

T 83.10 Thu 18:20 Th

Implications of turbulence dependent diffusion on cosmic ray spectra — •Julien Dörner, Julia Tjus, and Patrick Reichherzer — RAPP-Center at Ruhr University Bochum, Bochum, Germany

The propagtion of cosmic rays can be described by diffusive motion in most galactic enviroments. Therfore, a detailed knowlege of the diffusion tensor is necessary. Recent analyses of the energy dependence of the diffusion tensor show a function of the turbulence level b/B, i.e. $\kappa_i \propto E^{\gamma_i}$ with $\gamma_i = \gamma_i(b/B)$, where $i \in \{\parallel, \perp\}$. (Reichherzer et al, MNRAS 498:5051-5064 (2020))
In this talk we show the implication of this turbulence-dependent diffusion on the radial dependence of the cosmic-ray spectral index and the transition between parallel and perpendicular component. Finally, we interpret the cosmic-ray gradient detected by Fermi in the light of these findings.

T 84: Associated Higgs production and Higgs quantum numbers II

Time: Thursday 16:00–18:15 Location: Ti

T 84.1 Thu 16:00 Ti

Reconstruction of advanced neural network approaches for $t\bar{t}H$ and development towards tH event analysis — Nazim Huseynov[1], Lars Kolk[2], André Sopczak[3], Petr Urban[3], and •Cyrus Walther[2] — [1]JINR Dubna — [2]TU Dortmund — [3]CTU in Prague

The reconstruction of $t\bar{t}H$ events is performed using advanced machine learning approaches. The focus is on the Higgs boson mass reconstruction. The study is first based on generated truth information. The analysis is further developed towards the tH production process. Different neural network architectures are applied and the performance is tested. Optimizations of the machine learning algorithms are performed. The precision of the Higgs boson mass reconstruction is compared between the $t\bar{t}H$ and tH production processes. The aim is to apply the developed algorithms on a data set based on full ATLAS detector simulation.

T 84.2 Thu 16:15 Ti

Fake-Rate Determination for the ttH and ttW Production with a Signature of Two Same Electric Charge Light Leptons Associated with a Tau Using the ATLAS Detector at the LHC — Nello Bruscino[1], Arthur Chomont[1], Simonetta Gentile[1], Nazim Huseynov[2], Georgiy Ivannikov[3], Santu Mondal[3], and •André Sopczak[3] — [1]Università di Roma, Sapienza & INFN — [2]JINR Dubna — [3]CTU in Prague

After the discovery of a Higgs Boson, the measurements of fits 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 Yukawa coupling is large and can probe for physics beyond the Standard Model. The analysis is based on data taken by the ATLAS experiment recorded from 13 TeV proton-proton collisions. The ttH and ttW production was analyzed in various final states. The focus of this presentation is on the fake rate determination in the final state with two light leptons of same electric charge and one hadronically decaying tau lepton..

T 84.3 Thu 16:30 Ti

Measurement of the $t\bar{t}H$ production cross-section with $H \to b\bar{b}$ in the boosted topology with the ATLAS detector — •Eftychia Tzovara, Lucia Masetti, Doga Elitez, Asma Hadef, Andriani Panagi, and Alexander Basan — JGU Mainz, Germany

Studying the coupling of the Higgs boson to the top quark is of particular interest, since it could be sensitive to effects of physics beyond the SM. The Higgs production in association with a top-quark pair is the most favorable for a direct measurement of the top Yukawa coupling. The decay to a b-quark pair has the largest branching fraction. This analysis aims at events in which one of the top quarks decays semileptonically, producing an electron or a muon. In the single-lepton channel, the boosted topology, targets events with a Higgs and/or a hadronically decaying top produced at high transverse momentum.

Due to the highly complex final state and the large SM backgrounds, the reconstruction of the Higgs becomes a complicated task. As a result, measuring the signal strength in this process is challenging. The ultimate goal is to constrain the background events of the boosted channel in order to maximise the statistical significance of the measurement. For this purpose, multivariate techniques are used to discriminate between signal and background events, in particular from $t\bar{t}$ + jets production. In this talk, the challenges of this decay channel and the suppression of the background processes will be discussed. Finally, the measurement of the $t\bar{t}H(b\bar{b})$ cross-section, using the full LHC run-2 data, as well as further improvements on the boosted channel, will be presented.

T 84.4 Thu 16:45 Ti

Measurement of the top-Higgs coupling in the H → bb̄ final state at the CMS experiment — •Philip Keicher[1], Ulrich Husemann[1], Matthias Schröder[2], Jan van der Linden[1], and Sebastian Wieland[1] — [1]Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT) — [2]Universität Hamburg

The production of the Higgs boson in association with a top quark-antiquark pair enables the direct measurement of the top-Higgs coupling, which is modeled to be a Yukawa-type coupling in the standard model of particle physics (SM). This production channel is expected to be sensitive to many models beyond the SM. Therefore, its measurement is a good test of the SM and of great importance to the theory community.

In this talk, an analysis is presented where the top quark-antiquark pair decays semileptonically and the Higgs boson decays into a bottom quark-antiquark pair. This entails a discussion of the analysis strategy, which is based on a classification using neural networks, as well as the most dominant background processes and systematic uncertainties. Finally, the presentation will cover the current status of the evaluation of the full Run-II data set collected at the CMS experiment.

T 84.5 Thu 17:00 Ti

Improvements of the MVA classifiers for the $t\bar{t}H(b\bar{b})$ analysis in the dilepton channel with full Run2 data in the CMS experiment — •Angela Giraldi — CMS DESY, Hamburg, Germany

In the Standard Model (SM), the Higgs boson couples to fermions with a Yukawa-type interaction and a strength proportional to the fermion mass. The associated production of a Higgs boson with a top-quark pair ($t\bar{t}H$) is therefore the best direct probe of the top-Higgs Yukawa coupling, a vital element to verify the SM nature of the Higgs boson. In the SM, the Higgs boson decays into b-quark-antiquark pair with the largest branching fraction, and is thus experimentally attractive as a final state. The dominant background contributions arise from $t\bar{t}$+jets production, and in particular the $t\bar{t}b\bar{b}$ background is irreducible with respect to $t\bar{t}H, H \to b\bar{b}$. To better enhance the sensitivity, the signal is extracted exploiting multivariate analysis (MVA) techniques.

This talk focuses on the analysis of the $t\bar{t}H, H \to b\bar{b}$ process in final states with two leptons using proton-proton data collected by the CMS experiment at the LHC during 2016-2018 at $\sqrt{s} = 13$ TeV. The possibility to critically increase the sensitivity to the $t\bar{t}H$ signal is investigated using machine learning approaches. Detailed studies on the optimization and performance of MVA discriminants trained using Artificial Neural Networks are presented for the first time in this final

state.

T 84.6 Thu 17:15 Ti

Improvements for POWHEG+Pythia8 tt+bb NLO Monte Carlo predictions — •Lars Ferencz and Judith Katzy — DESY, Hamburg, Germany

Measurements of tt+H production in the H → bb channel are strongly affected by theoretical uncertainties introduced by the irreducible tt+bb background. In order to reduce these uncertainties, it is important to work on improving predictions for these backgrounds. In this talk studies are presented focussing on improvements for tt+bb focussing on several different aspects of the simulation.
Studies of the scale used in the Matrix Element calculation, different parton shower and matching settings for POWHEG and Pythia8 are compared to theoretical predictions and data.

T 84.7 Thu 17:30 Ti

Associated production of two Higgs bosons with a top quark-antiquark pair in the CMS experiment — •Ellen Sarauer, Ulrich Husemann, and Philip Keicher — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

To investigate predictions of the Standard Model of Particle Physics, the Higgs boson and its coupling to fermions are of great interest. After the discovery of the associated production of a Higgs boson with a top quark-antiquark pair, further studies in this field provide new physical insights. The associated production of two Higgs bosons with a top quark-antiquark pair allows the direct measurement of the top-Higgs-coupling, as well as the triple Higgs coupling.

The presentation is about a multivariate analysis focusing on the final state with a single lepton and the Higgs bosons decaying into bottom quark-antiquark pairs. The main topics are the analysis strategy, the most important background processes and systematic uncertainties. Additionally, an introduction is given to the multivariate classification technique with neural networks to distinguish between signal and background processes. The study of the associated production of two Higgs bosons with a top quark-antiquark pair is based on the simulated CMS dataset of 2017.

T 84.8 Thu 17:45 Ti

Messung der HZZ-Tensor-Kopplung in $pp \to H \to ZZ^* \to 4\ell$ - Zerfällen mit dem ATLAS-Detektor — •Verena Walbrecht, Sandra Kortner, Oliver Kortner und Hubert Kroha — Max-Planck-Institut für Physik

Ein wichtiger Zerfallsprozess für die Messung der Eigenschaften des Higgs-Bosons ist der Zerfall in zwei Z-Bosonen, die jeweils in ein e^+e^-- oder $\mu^+\mu^-$-Paar zerfallen, $pp \to H \to ZZ^* \to 4\ell$. Im Standardmodell wird das Higgs-Boson als Spin-0-Teilchen mit positiver CP-Quantenzahl vorhergesagt. Diese Hypothese wird auch von den Run-1-Daten des LHC bevorzugt. Dabei sind kleine Beimischungen anomaler, möglicherweise auch CP-verletzender Kopplungen mit geänderter Tensorstruktur nicht ausgeschlossen.
Solche Abweichungen vom Standardmodell können unter anderem im Rahmen effektiver Feldtheorien (EFT) beschrieben werden, in denen die Standardmodell-Lagrangedichte durch weitere Operatoren höherer Dimensionen erweitert wird. In diesem Vortrag werden die Messungen der Produktions- und Zerfallseigenschaften des Higgs-Bosons im Kanal $pp \to H \to ZZ^* \to 4\ell$ vorgestellt und im Rahmen einer effektiven Feldtheorie interpretiert, um die EFT-Parameterwerte einzuschränken. Die Messungen basieren auf dem vollen Run-2-Datensatz des ATLAS-Detektors.

T 84.9 Thu 18:00 Ti

Analysis of the CP structure of the Higgs boson in $\tau\tau$ decays — Andrea Cardini, •Oleg Filatov, Elisabetta Gallo, Alexei Raspereza, and Merijn van de Klundert — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

The Standard Model (SM) predicts the existence of a CP-even Higgs boson. Measuring the CP quantum number of the Higgs boson is therefore useful to confirm the prediction of the SM and search for evidences pointing to new physics. The study of bosonic decays of the Higgs boson has already excluded a CP odd Higgs, however direct measurement of a mixing angle between a CP-even and a CP-odd state has not been performed yet.

The H to $\tau\tau$ decay at tree level is sensitive to the CP parity of the Higgs boson and offers a possible measurement of the CP mixing angle. The decay planes of the two τ leptons are reconstructed using their decay products and the corresponding acoplanarity angle between the planes is used to estimate the CP mixing angle.

We present the first measurement of the CP structure of the Yukawa coupling between Higgs boson and τ leptons. The measurement is based on Run II data corresponding to an integrated luminosity of 137 fb^{-1} and collected by the CMS experiment in proton-proton collisions at the LHC.

T 85: Silicon Strip Detectors II

Time: Thursday 16:00–18:00 Location: Tj

T 85.1 Thu 16:00 Tj

Development of a GUI for a test stand for silicon detector modules of CMS 2S modules for the Phase-2 Upgrade of the CMS Tracker — •Anna Becker, Lutz Feld, Waclaw Karpinski, Katja Klein, Martin Lipinski, Alexander Pauls, Nicolas Röwert, and Michael Wlochal — 1. Physikalisches Institut B, RWTH Aachen

The CMS Collaboration is developing so-called 2S modules for the second phase of the CMS tracker upgrade. This upgrade will enable the CMS experiment to utilize the high luminosity provided by the future HL-LHC. One of the module assembly centres is RWTH Aachen, where 1000 2S modules will be built. During the production, a test stand based on a probe station is needed to monitor the quality of the silicon sensors in between the various assembly steps. To simplify, secure and accelerate the workflow a GUI for this test stand has been developed. After each assembly step various control measurements are performed. This GUI enables a user-friendly automatization, especially of the sensor's leakage current measurement and its surface inspection. Moreover, various environmental conditions are monitored to guarantee constant measurement conditions. Both the GUI itself and selected measurement results of 2S modules built at RWTH Aachen are presented.

T 85.2 Thu 16:15 Tj

A Test Card for Service Hybrids of CMS silicon strip modules — Christian Dziwok[2], Lutz Feld[1], Waclaw Karpinski[1], Katja Klein[1], Martin Lipinski[1], Daniel Louis[1], •Alexander Pauls[1], Oliver Pooth[2], Michael Wlochal[1], and Tim Ziemons[2] — [1]1. Physikalisches Institut B, RWTH Aachen — [2]3. Physikalisches Institut B, RWTH Aachen

The CMS Collaboration is developing silicon strip modules for the second phase of the CMS tracker upgrade. This upgrade will enable the CMS experiment to utilize the high luminosity provided by the future HL-LHC. The modules' Service Hybrids are responsible for the high and low voltage distribution on the module and the data transmission via optical links to the back-end electronics. During the production a test system for roughly 20,000 Service Hybrids will be needed. The design of a test card compatible with a common infrastructure for CMS hybrid qualification during series production is presented. It features a USB controlled micro controller for slow control monitoring, control and readout. The hybrid's e-links are tested via a connected FC7 advanced mezzanine card, while the test card provides the necessary buffers and level translators. Measurement results of the commissioning are presented.

T 85.3 Thu 16:30 Tj

The Coldbox for Thermal Testing of ATLAS ITk Modules — Sören Ahrens, Sergio Diez Cornell, Ruchi Gupta, Torsten Külper, and •Jonas Neundorf — Deutsches Elektronen-Synchrotron, Notkestraße 85, 22607 Hamburg

During the upcoming Long Shutdown 3 of the Large Hadron Collider, the ATLAS experiment will receive a new tracking detector. As part of the quality control process, the new Detector modules will have to undergo tests both at -35 °C and +40 °C. This ensures that they do

not only function well at the operating temperature of the detector, but are also able to operate under a variety of conditions. DESY is developing a dedicated test setup called "coldbox" for this. This talk will introduce the setup, show it's thermal performance and briefly introduce the testing procedure.

T 85.4 Thu 16:45 Tj

Myonenhodoskop aus Siliziumsensormodulen für das CMS-Experiment — •Lea Stockmeier, Tobias Barvich, Alexander Dierlamm, Ulrich Husemann, Roland Koppenhöfer, Stefan Maier, Thomas Müller, Marius Neufeld, Andreas Nürnberg, Hans Jürgen Simonis, Julian Stanulla und Pia Steck — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

Im Rahmen des Phase-2-Upgrades werden in den zukünftigen äußeren CMS-Spurdetektor neuartige Siliziumsensormodule eingebaut. Jedes Modul besteht aus zwei Sensorschichten, die je nach Lage im Detektor entweder aus Pixel- oder Streifensensoren bestehen. Module mit zwei Schichten aus Streifensensoren heißen 2S-Module.

Im Rahmen der Prototyp-Phase der 2S-Module werden diese in einem Hodoskop aus drei übereinander angeordneten 2S-Modulen getestet. Durch das Triggern mit Szintillatoren auf kosmische Myonen können die Module synchron ausgelesen und Auflösungsstudien durchgeführt werden. Außerdem wird das Modulverhalten unter verschiedenen Einfallswinkeln der Myonen analysiert. Der Vortrag stellt die Ergebnisse der Messungen mit diesem Hodoskop vor.

T 85.5 Thu 17:00 Tj

Qualitätskontrolle von Siliziumsensoren für das Phase-2-Upgrade des CMS-Experiments — •Florian Wittig, Tobias Barvich, Alexander Dierlamm, Ulrich Husemann, Roland Koppenhöfer, Stefan Maier, Thomas Müller, Jan-Ole Müller-Gosewisch, Marius Neufeld, Andreas Nürnberg, Hans Jürgen Simonis, Julian Stanulla und Pia Steck — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

Im Rahmen des Phase-2-Upgrades des CMS-Experiments wird der äußere Spurdetektor komplett ausgetauscht. Im neuen Spurdetektor kommen drei unterschiedliche Varianten von Siliziumsensoren zum Einsatz. 2S-Sensoren, mit einer Fläche von $10\times10\,\mathrm{cm}^2$, die in 2032 Streifen der Länge 5 cm segmentiert sind, sowie die halb so großen PSs-Sensoren mit insgesamt 1920 Streifen der halben Länge. Die dritte Sensorvariante, die PSp-Sensoren, bildet mit etwa 30.000 Makropixeln mit 1,5 mm Länge, verteilt auf einer Fläche von $5\times10\,\mathrm{cm}^2$, einen Kompromiss zwischen Streifen- und Pixelsensoren. Die Serienproduktion der Sensoren hat Mitte 2020 begonnen und wird bis in das Jahr 2024 andauern. Innerhalb dieses Zeitraums werden insgesamt etwa 30.000 Sensoren produziert. Die Qualitätssicherung der Sensoren ist hierbei von großer Bedeutung, um deren uneingeschränkte Funktionalität im Detektor zu gewährleisten.
Dieser Vortrag gibt einen Überblick über die Qualitätskontrolle der Streifensensoren während der Serienproduktion. Es wird das allgemeine Vorgehen beschrieben und erste Messergebnisse diskutiert.

T 85.6 Thu 17:15 Tj

Beam test of 2S module prototypes for the Phase-2 CMS Outer Tracker — Christian Dziwok[2], Lutz Feld[1], Katja Klein[1], Martin Lipinski[1], Alexander Pauls[1], Oliver Pooth[2], Nicolas Röwert[1], and •Tim Ziemons[2] — [1]I. Physikalisches Institut B, RWTH Aachen University — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

The CMS detector will be upgraded in the Phase-2 Upgrade for the operation at the HL-LHC. Among others, the silicon tracking system will be completely replaced by a new system providing an extended acceptance, an improved granularity and the feature to include tracking information into the level-1 trigger. The new Outer Tracker will consist of 2S modules with two strip sensors and PS modules with a macro-pixel sensor and a strip sensor, specialized detector modules with onboard p_T discrimination.

The functionality of current generation prototype 2S modules has been tested at the test beam facility at DESY Hamburg in November 2019. With a 4 GeV electron beam, various studies are performed like efficiency scans at different positions of the module or at varying inclination angles to mimic different p_T particles. In this talk, efficiency studies are presented.

T 85.7 Thu 17:30 Tj

Beam test with the final readout scheme of Phase-2 CMS Outer Tracker 2S prototype modules — •Christian Dziwok[2], Lutz Feld[1], Katja Klein[1], Martin Lipinski[1], Alexander Pauls[1], Oliver Pooth[2], Nicolas Röwert[1], and Tim Ziemons[2] — [1]I. Physikalisches Institut B, RWTH Aachen University — [2]III. Physikalisches Institut B, RWTH Aachen University

For the upcoming Phase-2 Upgrade for the operation of CMS at the HL-LHC a new silicon tracker design will be implemented. With extended acceptance and giving additional input of track p_T to the level-1 trigger, the new Outer Tracker will consist of 2S modules with two coplanar strip sensors and PS modules with a macro-pixel sensor and a strip sensor. Therefore, for these specialized detector modules the pT information of a track is already available online. Based on cluster size and position in a module's sensors and its sensor spacing, a first pT trigger information is generated in its front-end ASIC and then constantly streamed to the back end at bunch crossing rate.

The final front-end ASIC CBC 3.1 was used alongside the concentrator ASIC CIC v1 and the serializer- and slow control ASICs GBTx and SCA without additional interface card for the first time. This final readout scheme of 2S modules has been tested with two modules at once at the test beam facility of DESY Hamburg using a 4 GeV electron beam and the DATURA telescope. This talk will showcase the efficiency of the new p_T discrimination mechanism and the test on synchronicity of modules.

T 85.8 Thu 17:45 Tj

Loading and testing of strip silicon modules for the ATLAS ITk upgrade phase2 — •Alessia Renardi, Sergio Diez Cornell, and Ruchi Gupta — DESY, Hamburg, Germany

The upgrade of the central tracking system of the ATLAS experiment is required for the operation at the High Luminosity LHC (HL-LHC) starting in the middle of 2027. It needs to be completely replaced for the Phase II upgrade due to increased radiation environment, detector occupancy and trigger rate, as well as aging and radiation damage of the existing inner detector. The most basic unit, a module, of the new Inner Tracker (ITk) strip detector consists of a single silicon sensor, one or two flex hybrid circuit boards where the read-out chips are located, and a power-board. For the ATLAS ITk strip End-cap six flavors of modules have been designed, different in shape and structure. All of them are glued on both sides of a low-mass carbon-fibre support structures with embedded CO2 cooling, so-called petal core. A semi-electrical petal was built at DESY-Hamburg: semi-electrical modules have been produced in different institutes of the ITk strip collaboration and glued on a petal core using an automatized procedure. The glue is dispensed on the local support structure and the pattern was investigated in order to aim for a good glue coverage as well as the required thickness and sensor flatness. The whole procedure will be shown explaining how the robot is able to pick and place every single module and glue it on the petal core. The talk includes the results of the electrical quality control test too.

T 86: Search for New Particles IV

Time: Thursday 16:00–18:00 Location: Tk

T 86.1 Thu 16:00 Tk

Limit setting in the current search for displaced heavy neutral leptons with the ATLAS detector using the full integrated LHC Run 2 luminosity — •Christian Appelt and Heiko Lacker — Humboldt University, Berlin, Germany

The existence of right-handed neutrinos with Majorana masses below the electroweak energy scale can address ongoing problems of neutrino masses, matter-antimatter asymmetry of the universe, and dark matter. In this talk, we present limit-setting methods, as applied in the current search for heavy neutral leptons using the full LHC Run 2 luminosity of 139 / fb. The heavy neutral leptons are produced in

leptonic decays of on-shell W bosons formed in 13 TeV pp collisions at the LHC. We focus on unique displaced signatures captured by the ATLAS detector, characterized by a prompt lepton originating from the W boson decay and a secondary vertex displaced in the radial direction by 4-300 mm from the beamline. The expected limit results are given as exclusion contours in the heavy neutral lepton coupling strength versus mass plane.

T 86.2 Thu 16:15 Tk

Search for long-lived particle decays in the CMS tracker — Lisa Benato, Melanie Eich, Gregor Kasieczka, •Karla Peña, and Jörg Schindler — Institut für Experimentalphysik, Universität Hamburg

Higgs-portal models propose the existence of a dark sector, neutral under all Standard Model (SM) gauge groups. Interaction between the dark sector and the SM is mediated solely by the Higgs boson, which mixes with its dark partner. As a consequence of this, the Higgs boson is predicted to decay also in the dark sector. Scenarios are considered where the Higgs boson decays into a pair of dark long-lived particles (LLPs), each of which travels a macroscopic distance before decaying back to a pair of SM particles—predominantly b quarks.

Decays occurring within the CMS tracking system result on displaced-vertex signatures, which can be observed with almost no background from the SM. However, as conventional tracking and vertex finding algorithms are optimized for prompt decays, these signatures are challenging to find and advanced reconstruction techniques are required. Studies of machine-learning methods for displaced-vertex reconstruction will be discussed and compared to a benchmark analysis, where information from displaced tracks is used to tag jets resulting from LLP decays. The status of a search for LLPs is presented, using data collected by the CMS detector in pp collisions at $\sqrt{s} = 13$ GeV.

T 86.3 Thu 16:30 Tk

Search for displaced decays of massive particles in multijet events with the ATLAS detector — •Emily Thompson — DESY, Hamburg, Germany

The existence of long-lived particles (LLPs) is a common feature in many theories beyond the Standard Model. For example, models with small couplings (i.e. R-parity-violating supersymmetry) and models allowing for decays via highly virtual intermediate states (i.e. Split supersymmetry) predict the presence of LLPs. With lifetimes ranging from picoseconds to nanoseconds, massive LLPs could decay to several electrically charged particles in the inner tracking volume of the ATLAS detector, allowing for the reconstruction of a displaced secondary vertex

In this talk, an inclusive search for new long-lived massive particles leaving a displaced vertex signature in the ATLAS inner detector in multijet events with 139 fb^{-1} of data collected at $\sqrt{s} = 13$ TeV is presented. As there are no Standard Model particles which give rise to high-mass displaced vertices, the backgrounds stem from various instrumental and algorithmic effects. A data-driven technique to estimate the dominant source of background is presented.

T 86.4 Thu 16:45 Tk

Search for pair-produced leptoquarks decaying into quarks of the third and leptons of the first or second generation with the ATLAS experiment at $\sqrt{s} = 13\,\text{TeV}$ — •Volker Austrup and Frank Ellinghaus — Bergische Universität Wuppertal

Motivated by similarities between the quark and lepton sectors in the Standard Model, leptoquarks (LQs) are hypothetical bosons that are assumed to couple to quarks and leptons at the same time. First proposed in the 1980s, the initial model includes couplings only within one generation. However, hints at flavor anomalies recently observed by various experiments such as LHCb, BaBar, and Belle have sparked interest in extended models with LQs coupling to quarks and leptons of different generations.
In this talk, a search for up- ($q = 2/3\,\text{e}$) and down-type ($q = -1/3\,\text{e}$) LQs decaying into quarks of the third and leptons of the first or second generation is presented. The focus of this analysis is on final states with exactly one lepton and large amounts of missing transverse energy. Neural networks (NNs) are applied to ensure good separation between signal and background processes over a wide range of the parameter space. The NN output is subsequently used as the discriminating variable in a profile-likelihood fit in control and signal regions. Expected lower limits on the signal mass are obtained from the fit results as a function of the LQ branching ratio into charged and uncharged leptons. The analysis shown is based on pp-collision data at a centre-of-mass energy of $\sqrt{s} = 13\,\text{TeV}$ measured by the ATLAS experiment at the LHC between 2015 and 2018.

T 86.5 Thu 17:00 Tk

Leptoquark production in a single τ, charm/bottom and met final state at the ATLAS detector — •Patrick Bauer, Philip Bechtle, and Klaus Desch — Physikalisches Institut Bonn

At B-factories, anomalies were observed in decays of the B-hadrons into $\text{D}^{(*)}$ and $\text{K}^{(*)}$, which are consistent with the hypothesis of contributions from Leptoquarks in the high GeV to low TeV range.

Therefore, the direct search for leptoquarks (LQ) got once again in focus at high energy collider experiments. So far most searches aimed at the pair-production via strong interaction, as it is enables a almost model independent approach and is for LQ-masses below 1 TeV expected to be dominating.
However for LQ masses well above 1 TeV the single production mode becomes more relevant. The analysis presented this talk, offers the most direct approach for a search of LQ signature related to the $\text{B} \to \text{D}^{(*)}\tau\nu$ anomaly, as it incorporates essentially the same couplings. Furthermore the process to be investigated could be mediated by a U_1-vector LQ, which is presently widely discussed among theorists, as preferred solution to B-anomalies.It could explain the two observed anomalies within one model. The talk will motivate the analysis and present the ongoing search for vector LQ in single and pair production in final states with one τ, bottom or charm jet and large met.

T 86.6 Thu 17:15 Tk

Vector-Leptoquark Interpretation of the Search for Top Squarks with Decays via Tau Sleptons — •Kyeong Ro Lee and Alexander Mann — Ludwig-Maximilians-Universität, Munich, Germany

Leptoquarks are bosons predicted by various extensions of the Standard Model. Carrying non-zero baryon and lepton numbers, they can decay into a quark-lepton pair and can explain similarities between the lepton and the quark sector of the Standard Model, as well as hints of lepton-flavor universality violation observed in physics of B mesons. Supersymmetry (SUSY) is a framework of theories extending the Standard Model by introducing an additional symmetry between bosons and fermions. If leptoquarks coupling to third-generation fermions (i.e. top and bottom quarks, tau leptons and neutrinos) exist, pair production of such leptoquarks at the LHC would show similar final states as pair-produced top squarks (the SUSY partner of the top quark). More specifically, pair-produced leptoquarks decaying into bottom-tau or top-neutrino pairs will leave similar signatures as pair-produced top squarks decaying via tau sleptons (the SUSY partner of the tau lepton). Thus the search for this SUSY model can be reinterpreted as a search for leptoquarks. In addition to the existing interpretation for scalar (spin-0) leptoquarks, we here look at vector (spin-1) leptoquarks using data taken by the ATLAS detector.

T 86.7 Thu 17:30 Tk

Sensitivity of the SHiP experiment to dark photons decaying to a pair of charged particles — •Atakan Tuğberk Akmete — Johannes Gutenberg-Universität, Mainz, Germany

SHiP is a planned fixed-target experiment that aims to search directly or indirectly for electrically neutral, feebly interacting, hidden particles with masses below $\mathcal{O}(10)$ GeV. It plans to collect 2×10^{20} protons on target with a 400 GeV SPS proton beam in 5 years of running. The hidden particles should have renormalizable interactions with SM fields through small dimensionless coupling operators, so-called portals. According to their spin, each portal refers to a different mediator. One of the most critical portals is the vector portal since all three fundamental forces interact through vector bosons. The kinetic mixing model of the vector portal has a mediator that mixes with the $U(1)$ photon by a coupling ε. This mediator is known as dark photon and has a mass of $\text{m}_{\gamma^\text{D}}$. It is the lightest particle of the hidden sector; therefore, it could decay into fermion pairs. In this talk, recent research on the SHiP experiment's sensitivity to dark photons decaying to a pair of charged particles is presented. Our exclusion contours claim a unique sensitivity for $\text{m}_{\gamma^\text{D}}$ ranging between 0.7 and 3 GeV, and ε^2 ranging between 10^{-11} and 10^{-17}.

T 86.8 Thu 17:45 Tk

Results of the Muon Flux and Spectrum Measurement for the SHiP Experiment — •Stefan Bieschke, Caren Hagner, and Daniel Bick — Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

The SHiP experiment is a proposed beam dump experiment dedicated for the Search for Hidden Particles. Utilizing the 400 GeV proton beam of CERN's SPS at a high intensity, it can explore physics beyond the standard model at the intensity frontier. A large number of protons on target, however, is accompanied by a huge amount of muons emerging from the target which would enter the detector's acceptance and render the observation of hidden particle decays impossible. A magnetic shield is foreseen to deflect the muons away from the detector, which is optimized using a particle simulation. Due to the complex interactions in a dense proton beam dump, an experimental verification of the simulation was considered necessary. In 2018, a replica of the proton target was used in the SPS beam to verify the simulated flux and spectrum. The experimental setup and the results of the data analysis will be presented.

T 87: Extended Higgs Models III

Time: Thursday 16:00–18:15 Location: Tl

T 87.1 Thu 16:00 Tl

Search for invisible Higgs boson decays with vector boson fusion signatures with the ATLAS detector using an integrated luminosity of 139 fb^*1 — •Pablo Rivadeneira — DESY, Hamburg

Several Beyond Standard Models consider the Higgs boson as the mediator between the Standard Model and Dark Matter. At the LHC, it is possible to probe these Higgs portal Dark Matter models searching for the production of Dark Matter through large values of missing transverse energy generated by the DM particles escaping the detector. Using 139fb^-1 of pp collision at a center-of-mass energy of 13 TeV recorded by the ATLAS detector, a search for Higgs bosons produced via vector boson fusion and subsequently decay into invisible particles was developed. The observed number of events was found to be in agreement with the background expectation from the Standard Model. Observed and expected upper limits on the branching fraction of Higgs boson decaying to invisible were derived to be at 0.13 at 95% confidence level. These results were used to set limits on the scattering cross-section of weakly interacting massive particles and nucleons. The invisible decays of additional scalar bosons with masses from 50 GeV up to 1TeV were also studied, and upper limits on the cross section times branching fraction were evaluated to be 0.97 pb for a scalar boson of a mass of 50 GeV, which falls with increasing mass to become 0.12 pb at a mass of 1TeV.

T 87.2 Thu 16:15 Tl

Identification of Collinear Photons in the Context of a search for anomalous Higgs Boson Decays — Bernard Brickwedde, Peter Krämer, •Marten Mildeberger, Kristof Schmieden, Matthias Schott, and Olivera Vujinovic — Johannes Gutenberg Universität Mainz

New physics models that predict couplings of axion-like-particles (ALPs) to the Higgs boson could explain the famous discrepancy between experimental value and measurement of the muon anomalous magnetic moment $(g-2)_\mu$. These models assume an ALPs decay into highly collinear photons. Hence special photon reconstruction algorithms have to be developed in order to distinguish $H \to aa \to \gamma\gamma\gamma\gamma$ from normal $H \to \gamma\gamma$ signatures. In this talk, the performance of a neural network based approach for the photon identification and reconstruction will be presented.

T 87.3 Thu 16:30 Tl

Search for charged Higgs bosons in $H^+ \to W^+h$ decays to a merged event topology with the ATLAS detector — •Patrick Bongratz, Dominik Duda, Simon Grewe, Sandra Kortner, and Hubert Kroha — Max-Planck-Institut für Physik, München

Various theories predicting an extended Higgs sector predict also the existence of at least one set of charged Higgs bosons. The main production mode of these new particles depends on their mass. For charged Higgs boson masses larger than the sum of the top and the bottom quark mass, the dominant production mode is expected to be in association with a top quark and a bottom quark.

In the alignment limit of the two Higgs-Doublet model (2HDM), heavy charged Higgs bosons with $m(H^+) > m(t) + m(b)$ decay almost exclusively via $H^+ \to tb$. However, in other models such as the N2HDM or in Higgs-triplet models e.g. the Georgi-Machacek model, significant branching ratios of $H^+ \to W^+h$ are possible. The latter decay mode has so far been covered neither by ATLAS nor CMS.

We present first studies on the search for heavy charged Higgs bosons decaying via $H^+ \to W^+h$ in final states with at least one large-R jet, one charged lepton and missing transverse momentum.

T 87.4 Thu 16:45 Tl

Search for a light CP-odd Higgs boson decaying into a pair of taus with ATLAS — •Xynia-Magdalena Sonntag, Tom Kresse, Wolfgang Mader, and Arno Straessner — IKTP, Dresden, Germany

Even though theoretical predictions of the SM are corresponding to experimental results to an incredible degree, there are still some phenomena unexplained, for example the deviation of the measured anomalous magnetic moment of the muon from SM calculations. This deviation could be explained by the flavor-aligned two-Higgs-doublet model (2HDM). The introduction of a second Higgs doublet leads to four additional Higgs bosons, one of which being CP-odd and electrically neutral. Parameters of interest in this model are the mass of the CP-odd Higgs boson and the couplings to charged leptons and up type quarks.

In this talk, the search for such a light CP-odd Higgs boson produced via gluon fusion and decaying into a pair of tau leptons is presented, looking at final states with one electron and one muon. The mass range of the CP-odd Higgs boson analyzed lies between 40 GeV and 90 GeV. The search is based on Monte Carlo simulations and data to Monte Carlo comparisons in background control regions using 139 fb^{-1} of data collected by the ATLAS experiment at 13 TeV. Results will be presented, focussing on a refined event selection optimized according to the expected limit for the production of such a CP-odd Higgs boson.

T 87.5 Thu 17:00 Tl

A search for resonances decaying into a Higgs boson and a new particle X with the ATLAS detector — •Nicola de Biase[1,2], Vincenzo Canale[2], Francesco Conventi[2], Francesco Cirotto[2], Silvia Auricchio[2], and Antonio Giannini[2] — [1]DESY Hamburg — [2]Università Federico II e sezione INFN di Napoli

Several theories beyond the Standard Model (SM) are theoretically well motivated and predict the existence of high mass particles that are likely to produce a Higgs boson when decaying.

In this talk, a search for a new narrow resonance Y at the TeV scale, decaying into a Higgs boson and a new boson (X), with a completely hadronic $XH \to q\bar{q}'b\bar{b}$ final state is presented. The search uses data from proton-proton collisions at a center of mass energy $\sqrt{s} = 13$ TeV and corresponding to a 139 fb^{-1} integrated luminosity, collected by the ATLAS experiment at CERN.

The X boson decay can have two different signatures: for low momenta of the X, the quarks $q\bar{q}'$ hadronize into a pair of well separated jets, while for high momenta they merge into a single large radius jet.

A new tagging algorithm, based on a feed forward Deep Neural Network, is used to identify the Higgs decay.

A set of signal hypotheses, characterized by two continuous parameters, the masses of the new particles, is investigated. A machine learning algorithm (parametrized Deep Neural Network) that takes into account this dependence is used to enhance the discovery sensitivity for new signals over SM background processes.

T 87.6 Thu 17:15 Tl

Optimization of the Search for New Physics in boosted $HH \to b\bar{b}\tau^+\tau^-$ Decays in ATLAS — •Merle Schröder, David Kirchmeier, Wolfgang Mader, and Arno Straessner — IKTP, Dresden, Germany

In searches for physics beyond the Standard Model the resonant production of two Higgs bosons plays an important role. The decay into the $b\bar{b}\tau^+\tau^-$ final state is especially promising. While on the one hand, the decay of the Higgs boson into two b quarks has a high branching ratio, on the other hand, the signal from the decay into two τ leptons can be well distinguished from the multi-jet background whilst maintaining a large enough branching ratio. However, the reconstruction of

highly boosted di-tau final states from decays of high-mass resonaces above 1 TeV is challenging. Therefore, dedicated algorithms for reconstruction and identification have been developed in the past. The optimization of the analysis and the resulting improvements using the full Run-2 dataset of 139 fb^{-1} will be shown in this talk.

T 87.7 Thu 17:30 Tl

Search for charged Higgs bosons in $H^+ \to Wh \to l\nu bb$ decays with resolved event topology with the ATLAS detector — Patrick Bongratz, Dominik Duda, •Simon Grewe, Sandra Kortner, and Hubert Kroha — Max-Planck-Institut für Physik, München

Various theories predicting an extended Higgs sector predict also the existence of at least one set of charged Higgs bosons. The main production mode of these new particles depends on their mass. For charged Higgs boson masses larger than the sum of the top and the bottom quark mass, the dominant production mode is expected to be in association with a top quark and a bottom quark (tbH^+).

In the alignment limit of the two Higgs-Doublet model (2HDM), heavy charged Higgs bosons with m(H^+)>m(t)+m(b) decay almost exclusively via $H^+ \to tb$. However, in other models such as the N2HDM or in Higgs triplet models e.g Georgi-Machacek model, significant branching ratios for $H^+ \to W^+h$ are possible. The latter decay mode has so far been covered neither by ATLAS nor CMS.

We present first studies on the search for $H^+ \to W^+h \to \ell\nu bb$ decays in final states with the resolved topology containing four or more, well separated jets, one charged lepton and missing transverse momentum. Boosted decision trees (BDTs) are used to solve the jet combinatorics, thus reconstructing the charged Higgs boson decay.

T 87.8 Thu 17:45 Tl

Search for Dark Matter produced in association with a Standard Model Higgs boson decaying to b-quarks with 139 fb^{-1} of pp collision data with the ATLAS detector — •Janik von Ahnen — DESY, Hamburg, Germany

Many extensions of the Standard Model predict the production of Dark Matter in association with Higgs bosons. This search examines the final state of missing transverse momentum accompanied by a $b\bar{b}$ pair coming from a Higgs boson decay. For this matter proton-proton collision data is used which is produced at 13 TeV centre-of-mass energy and recorded by the ATLAS experiment at the LHC, amounting to an integrated luminosity of 139 fb^{-1}. The increase in integrated luminosity in conjunction with many analysis optimizations result in a better sensitivity in comparison to previous iterations. No significant deviations from the Standard Model are observed and the results are interpreted in the context of the 2-Higgs doublet models with an additional vector or pseudoscalar mediator.

T 87.9 Thu 18:00 Tl

Exploring the 0L channel in the search for dark matter produced in association with a single top quark — •Paul Moder[1], Claudia Seitz[1], Ben Brüers[2], and Alvaro Lopez Solis[2] — [1]DESY Hamburg — [2]DESY Zeuthen

While the Standard Model (SM) is very effective in describing most of the observations in particle physics, there are still effects that remain unexplained. One of these mysteries is the existence of dark matter (DM) in the universe although it is assumed to make up around 80% of the existing matter. With the construction of the LHC and the discovery of the Higgs boson in 2012, completing the SM, a lot of searches were focused on possible final states with DM, which can only be detected indirectly through missing transverse energy. One particular scenario of interest is a model where a mediator is added to the 2 Higgs doublet model (2HDM). The 2HDM assumes a second Higgs doublet in addition to the one in the SM, resulting in a total of five Higgs bosons. The additional mediator couples both to the 2HDM and the DM sector, making it possible to create dark matter at the LHC. A number of final states is explored in this model, one of them containing a top quark, a W-boson and dark matter. This final state was previously explored in two analysis channels, one with 1 lepton and one with 2 leptons in the final state. This talk presents a new, orthogonal 0 lepton channel in the same final state and will focus on its challenges and possiblities, discuss a preliminary signal region and compare its sensitivity to the already existing analysis.

T 88: Detector Systems III

Time: Thursday 16:00–18:15 Location: Tm

T 88.1 Thu 16:00 Tm

A Scintillator Based Background and Beam Abort System for SuperKEKB — •Ivan Popov, Hendrik Windel, Thomas Kraetzschmar, and Frank Simon — Max Planck Institute for Physics

The asymmetric-energy collider SuperKEKB started its physics operation in March 2019. The usage of a nano-beam scheme will enable collisions of electrons and positrons at record-breaking luminosities, but requires continuous particle injections at a rate of 50 Hz. These injections result in periods of high backgrounds, which can negatively affect the operation of Belle II subdetectors. In order to monitor and mitigate such backgrounds, the CLAWS detector system, consisting of scintillator tiles read out by silicon photomultipliers, is in operation in various forms since 2016. Beginning with the first physics run in 2019, 32 sensor modules have been distributed along the final focusing magnets. Over the course of SuperKEKB's run time in 2020 the sensors have been proven to reliably and consistently observe disturbances in the particle beam which can result in catastrophically high backgrounds and quenches of the final focusing magnets. An upgrade of the electronics and the DAQ together with the implementation of a smart trigger logic enables the generation of a beam abort trigger within 400 ns after the occurrence of excessive background, thus ensuring the safe operation of the experiment. The CLAWS system is currently undergoing the necessary upgrades, which will enable its use as a beam abort system and will be operational in time for SuperKEKB's 2021 run time. In this report, the development and early results of the CLAWS system upgrade are discussed.

T 88.2 Thu 16:15 Tm

Open-source tools for a robust and versatile slow control system — •Jaron Grigat — Albert-Ludwigs-Universität Freiburg

Most experiments are equipped with a number of auxiliary sensors to keep track of the experiment's conditions and ensure a secure and stable operation. The slow control system monitors these parameters; the name refers to the relatively low rate at which the values have to be tracked. We present a slow control system developed as an open-source solution for small- to medium-size experiments. Based on the successful operation of the system in three different experiments in the field of direct Dark Matter search, we show how the modular design of the software allows an easy adaptation of the system to new experimental setups.

T 88.3 Thu 16:30 Tm

The LumiTracker detector — Johannes Albrecht, •Elena Dall'Occo, David Rolf, and Dirk Wiedner — Experimentelle Physik 5, TU Dortmund

The LumiTracker is a newly proposed detector upstream of the LHCb interaction point. It consists of a mini telescope based on silicon pixel detectors with the main goals of providing a real-time estimate of luminosity and contributing to its offline measurement. The luminosity measurement is based on reconstructing and counting tracks, exploiting the linearity with luminosity. Simulation studies show that a precision of 1% is achievable over an integration time of 5 seconds for an average number of pp interactions per bunch crossing of 7.6. In addition, such a solution would allow to measure the longitudinal profile of the luminous region with an expected resolution per track of a few millimetres.

In this talk, the feasibility studies, the LumiTracker projected performance and the detector specifications within the global framework of the LHCb detector are presented.

T 88.4 Thu 16:45 Tm

Upgrade of the LHCb Beam Condition Monitor — •Martin Bieker, Holger Stevens, and Dirk Wiedner — Experimentelle Physik 5, TU Dortmund

The LHCb experiment is a single-arm forward spectrometer at the LHC and it focuses on measurements in the b and c quark sector. Due to its unique geometry, featuring a sensitive tracking system located as close as 3.5 mm to the LHC beams, the detector is at risk of damage from adverse beam conditions. For this reason, the particle flux is monitored near the beampipe by 8 diamond sensors in a circular arrangement at either side of and close to the interaction point.

This so-called Beam Conditions Monitor (BCM) successfully protected the LHCb detector during Run I and Run II of the LHC. However, at the end of Run II in 2018 indications of possible ageing effects in the diamond sensors were observed. The system is being overhauled and will receive new diamond sensors and a new back-end electronics matching the LHCb upgrade standards.

This talk will give an overview of the activities linked to the development of the new BCM system. Both the status of the readout architecture and the characterisation of diamond sensors for use in the upgrade BCM system will be covered.

T 88.5 Thu 17:00 Tm

Techniques and challenges for aligning LHCb's Scintillating Fibre Tracker — •Sophie Hollitt — Experimentelle Physik 5, TU Dortmund, Dortmund, Germany

LHCb's new Scintillating Fibre Tracker (SciFi) is currently being commissioned for the next LHC data run beginning later this year. Correctly calibrating the existing LHCb alignment algorithms with respect to the SciFi's geometry will be crucial for the SciFi to reach its full potential during operation.

The selection of alignment constraints and degrees of freedom for the different parts of the SciFi at different scales provides a particular challenge. In this talk, the current status of the alignment will be discussed in relation to this challenge.

T 88.6 Thu 17:15 Tm

Commissioning of the LHCb Scintillating Fibre Tracker — Sebastian Bachmann, Daniel Berninghoff, Xiaoxue Han, Blake Leverington, Ulrich Uwer, and •Lukas Witola — Universität Heidelberg, Heidelberg, Deutschland

The LHCb detector is currently undergoing a major upgrade. The modifications will enable the detector to operate at an increased instantaneous luminosity and to read out data at the LHC bunch crossing rate of 40 MHz. The new operating conditions require the replacement of the complete tracking system. The main tracking stations will be replaced by the SciFi Tracker, a large high granular scintillating fibre tracker readout by arrays of silicon photomultipliers (SiPMs). A custom ASIC is used to digitise the SiPM signals at 40 MHz. Further digital electronics perform clustering and data-compression before the data is sent via optical links to the DAQ system.
The detector modules together with the readout electronics and all services are mounted on so-called C-Frames. The serial assembly and commissioning of frames is currently ongoing at the LHCb CERN site. The talk will give an overview of the detector and present experiences from the serial production and the latest commissioning results.

T 88.7 Thu 17:30 Tm

The SHiP Experiment - Surround Background Tagger (SBT) — •Patrick Deucher for the SHiP-SBT-Collaboration — Johannes Gutenberg Universität, Mainz, Germany

SHiP is a proposed, general-purpose fixed target experiment at the SPS accelerator of the CERN Facility. Data collection is aimed to start in 2027 focusing on the identification of Hidden Sector Particles, such as Heavy Neutral Leptons and light dark matter, and further investigation concerning tau neutrinos. When the high-intensity 400 GeV/c proton beam impinges on the hybrid target, heavy mesons and other weakly interacting particles of masses below 10 GeV/c* are created which can potentially decay into the particles of interest. After a hadron absorber and an active muon shield, the beam traverses through a vacuum vessel, where the particles are expected to decay. The products are then detected by a magnetic spectrometer and a calorimeter. To discriminate against external particle interactions, the vessel is enveloped by the Surround Background Tagger (SBT). The SBT is divided into segments and utilizes liquid scintillator and Wavelength Shifting Optical Modules (WOM) connected to SiPMs to identify throughgoing particles. In 2018/19, we have performed test beam measurements with a prototype detector cell at CERN PS and DESY. This contribution gives a general overview on the SBT and results from the past test beams.

T 88.8 Thu 17:45 Tm

Rekonstruktionsfähigkeit von Orts-/Richtungsinformation in einem Flüssigszintillatordetektor mit Hilfe von SiPM-Ringarray-Auslese wellenlängenschiebender Module — •Joscha Hanel für die SHiP-SBT-Kollaboration — Humboldt-Universität zu Berlin

SHiP ist ein vorgeschlagenes Beam-Dump-Experiment in der CERN SPS North Area mit dem Ziel, nach sogenannten Hidden Particles (Search for Hidden Particles, SHiP) zu suchen. Proton-Proton-Kollisionen mit dem 400GeV-SPS-Protonenstrahl auf ein fixiertes Target könnten schwach wechselwirkende neue Teilchen mit einer Masse zwischen 0,1 und 10GeV erzeugen. Hadronen aus diesen Kollisionen werden absorbiert, Myonen durch ein Magnetsystem abgelenkt. Dadurch bleiben nur Neutrinos und andere neutrale Teilchen übrig, um im 50m langen Zerfallsvolumen zu zerfallen. Dieses Volumen wird von Szintillationsflüssigkeit (Surround Background Tagger, SBT) umgeben, um Untergrundereignisse, die durch Myonen und Neutrinowechselwirkungen erzeugt werden, zu identifizieren. Die Szintillationsphotonen können durch wellenlängenschiebende optische Module detektiert werden, die an ringförmige Arrays von Silizium-Photomultipliern (SiPMs) gekoppelt sind. Dieser Vortrag zeigt Ergebnisse einer Testbeam-Messung, die mit einem Prototyp einer SBT-Zelle in der DESY electron test-beam facility durchgeführt wurde. Der Fokus bei der Analyse liegt auf der Frage, ob es möglich ist, Informationen zur Trajektorie durchquerender Teilchen aus Mustern der SiPM-Antwort über das ringförmige Array zu rekonstruieren.

T 88.9 Thu 18:00 Tm

Verbesserung der Lichtausbeute durch Verwendung eines transparenzverbesserten Flüssigszintillators für den SHiP-SBT — •Max Zacharias für die SHiP-SBT-Kollaboration — Humboldt-Universität zu Berlin, Berlin, Germany

SHiP ist ein vorgeschlagenes Beam-Dump-Experiment in der CERN-SPS North Area mit dem Ziel, nach sogenannten Hidden Particles (Search for Hidden Particles, SHiP) zu suchen. Proton-Proton-Kollisionen mit dem 400 GeV-SPS-Protonenstrahl auf ein fixiertes Target könnten schwach wechselwirkende neue Teilchen mit einer Masse zwischen 0,1 und 10 GeV erzeugen. Hadronen aus diesen Kollisionen werden absorbiert, Myonen durch ein Magnetsystem abgelenkt. Dadurch bleiben nur Neutrinos und andere neutrale Teilchen übrig, um im 50 m langen Zerfallsvolumen zu zerfallen. Dieses Volumen wird von Szintillationsflüssigkeit (Surrounding Background Tagger, SBT) umgeben, um Untergrundereignisse, die durch Myonen- und Neutrinowechselwirkungen erzeugt werden, zu identifizieren. Die Szintillationsphotonen können durch wellenlängenschiebende optische Module detektiert werden, die an ringförmige Arrays von Silizium-Photomultipliern (SiPMs) gekoppelt sind. Die Lichtausbeute und somit auch die Photonen-Detektions-Effizienz des Detektors können durch eine Reinigung des verwendeten LAB-PPO Flüssigszintillators, welche die Transparenz des Szintillators verbessert, erhöht werden. In diesem Vortrag wird die Zunahme der Lichtausbeute in einem Testdetektor bei der Messung kosmischer Myonen nach einem Austausch durch einen gereinigten Szintillator dargestellt.

T 89: Pixel Detectors IV

Time: Thursday 16:00–18:00 Location: Tn

T 89.1 Thu 16:00 Tn

Spatial Hit Resolution of Planar Pixel Sensors for the CMS Phase 2 Upgrade — •Finn Feindt[1], Aliakbar Ebrahimi[3], Erika Garutti[1], Mohammadtaghi Hajheidari[1], Caroline Niemeyer[1], Daniel Pitzl[2], Georg Steinbrück[1], Jörn Schwandt[1], and Irene Zoi[1] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland — [2]Deutsches Elektronen-Synchrotron, Notkestraße 85, 22607 Hamburg, Deutschland — [3]Paul Scherrer Institut, Forschungsstrasse 111, 5232 Villigen

PSI, Schweiz

For the High Luminosity upgrade of the Large Hadron Collider (HL-LHC), the CMS Pixel Detector will be upgraded to withstand 1 MeV neutron equivalent fluences ϕ_{eq} of up to 2.3×10^{16} cm^{-2} at a distance of 2.8 cm from the beam, corresponding to an integrated luminosity of 3000 fb^{-1}. It has to enable tracking and vertex finding in an environment of high track multiplicity with up to 200 proton-proton collisions per bunch crossing. Planar n^{+}-p pixel sensors prototypes with pixel sizes of 50×50 μm^2 or 25×100 μm^2 and an active thickness of 150 μm were investigated and their spatial hit resolution was measured in the DESY II test beam. The investigated sensors were irradiated with protons or neutrons, to fluences up to $\phi_{eq} = 7 \times 10^{15}$ cm^{-2}. The spatial hit resolution is studied as a function of the track angle and charge pixel threshold. It is compared for different fluences ϕ_{eq} and sensors with different layouts of the pixel implants. The results of this study serve as input to the final decision on the layout of planar pixel sensors for the HL-LHC upgrade of CMS.

T 89.2 Thu 16:15 Tn

Qualification of the Hybridization Process for the ATLAS ITk Module Production — •Michael Daas, Tomasz Hemperek, Florian Hinterkeuser, Fabian Hügging, Hans Krüger, David-Leon Pohl, Lars Schall, Mark Standke, Marco Vogt, Norbert Wermes, and Jochen Dingfelder — Physikalisches Institut der Universität Bonn

The Large Hadron Collider (LHC) at CERN will be upgraded for higher luminosities in 2025. The increased luminosity poses new demanding requirements for its detectors. Alongside the accelerator, the ATLAS experiment and all its subdetectors will be upgraded as well.

This talk gives an overview of the qualification process for the hybridization of the pixel detector modules for the upgraded ATLAS Inner Tracker (ITk). This part of the ITk preproduction program is based on the RD53A readout ASIC prototype, developed by the RD53 collaboration.

In the scope of the Hybridization Market Survey (MS), hybrid double chip modules consisting of two RD53A readout chips interconnected with a single, larger sensor tile via high-density, fine-pitch bump bonding have been produced by several vendors. A comprehensive measurement program, consisting of physical and electrical tests, measurements with radioactive sources, as well as thermal stress testing has been conducted in order to assess the quality of the different hybridization processes and vendors. Finally, recommendations for the suitability of all examined vendor combinations have been put forward.

T 89.3 Thu 16:30 Tn

High Rate Studies on 2S-Modules for the CMS Tracker Upgrade — •Christina Klauda[1], Tobias Barvich[1], Alexander Dierlamm[1], Ulrich Goerlach[2], Ulrich Husemann[1], Stefan Maier[1], Thomas Müller[1], Marius Neufeld[1], Andreas Nürnberg[1], Rudolf Schimassek[1], Hans Jürgen Simonis[1], Julian Stanulla[1], and Pia Steck[1] — [1]Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT) — [2]Institut Pluridisciplinaire Hubert Curien (IPHC)

Starting in 2027 the luminosity of the LHC will be strongly increased. This high luminosity requires the Phase 2 Upgrade of the CMS experiment with improved properties for the new detector components. The outer region of the silicon tracker will consist of so-called 2S Modules. The modules have to meet the requirement of readout trigger rates of up to 750 kHz.

To guarantee a triggered readout at a sufficient rate the 2S Modules will be tested at a dedicated beamline. The setup will be placed at the Cyrcé cyclotron of the IPHC in Strasbourg. Here a bunched proton beam at a frequency of 42.5 MHz is produced, a value close to the bunch crossing rate of 40 MHz at LHC. As a reference for the efficiency measurements a beam telescope setup is necessary. The sensor used for the telescope is the ATLASPix3, which is supposed to reach the required readout rates of at least 750 kHz.

This presentation will briefly introduce the monolithic ATLASPix3 sensor, the telescope setup developed for testing the 2S Modules, and will present the first results.

T 89.4 Thu 16:45 Tn

The next ATLAS Hybrid Detector Readout Chip ITkPix - Performance and Quantitative Analysis — •Mark Standke, Michael Daas, Yannick Dieter, Tomasz Hemperek, Florian Hinterkeuser, Fabian Hügging, Hans Krüger, David-Leon Pohl, Lars Schall, Marco Vogt, Jochen Dingfelder, and Norbert Wermes — PI Bonn - Nussallee 12, 53115 Bonn

ITkPixV1.1 is the first working full-scale 65 nm hybrid pixel-detector read out prototype developed by the RD53 collaboration. Hybrid pixel detectors are micro electronic devices, which are soldered together at pixel level. The two separate entities are used for highly efficient and fast charge sensing (sensor), of the charge carriers from ionizing radiation, while the second chip is used to read out the deposited charge (read out chip). ITkPix consists of more than one billion transistors with high triplication ratio in order to cope with high particle and therefore radiation densities at the heart of ATLAS. The chips will be located as close as possible to the interaction point to optimize impact parameter resolution. ITkPix features a single low power, low noise analog front-end to ensure high readout speeds and low detection thresholds. A failure of such chips at the heart of ATLAS is assumed to be hard to correct. Therefore, thorough testing is necessary. For this purpose, Bonn has developed a fast and versatile simulation, testing and analysis environment, making small- and large-scale testing for ITkPix possible. This talk will give an overview over the testing environment, while summarizing the latest findings and performance of ATLAS's future inner tracker performance driver, ITkPix.

T 89.5 Thu 17:00 Tn

Pixel track reconstruction for the Phase-2 CMS tracker — •Elias Paknejad[1], Alexander Schmidt[1], Xavier Coubez[1], and Adriano Di Florio[2] — [1]RWTH Aachen University, Physics Institute III A, Aachen, Germany — [2]University of Bari, Department of Physics, Bari, Italy

The new geometry of the Phase-2 CMS detector and the high data rates collected by its pixel tracker require significant improvements in the track reconstruction algorithms in order to cope with the conditions at the High-Luminosity LHC. The algorithms are being adapted to run on Graphics Processing Units (GPUs) in addition to the traditional CPU implementations.

In this presentation, the customized track reconstruction algorithms and results of the first performance studies are presented. The results show that the high pile-up conditions at the HL-LHC represent significant challenges in particular in the online trigger system, such that further improvements are necessary in the future.

T 89.6 Thu 17:15 Tn

ATLAS ITk-Pixel read-out systems with FELIX and lpGBT — Jörn Grosse-Knetter, Arnulf Quadt, and •Ali Skaf — II. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Germany

The ATLAS Phase II upgrade ITk-Pixel read-out chain is based on the use of ITkSoftware commanding the ITkPix front-end (FE) chips through FPGA off-detector communication boards, called FELIX and high-speed transceiver chips called lpGBT. This work describes the road-map, and the relevant intermediate steps, enabling the achievement of the final system. An lpGBT FPGA full-featured emulator using a Xilinx Ultrascale+ KCU116 development board is used as an alternative to the real lpGBT ASIC, included in the CERN VLDB+ boards or other prototypes of the final Pixel optoboards.

Waiting for the ITkPix, modules with the prototype FE RD53A were used. These modules are connected either to the lpGBT emulator implemented in a KCU116 with a mezzanine board, or to the lpGBT ASIC (e.g. VLDB+), through a special Breakout Board, which was also designed in-house. Furthermore, in order to configure lpGBT ASIC or Emulator, a Java GUI application was also developed using an existing USB-I2C dongle. All these developments aim, in particular, at the operation of and test measurements with an RD53A demonstrator, a small prototype system containing about 100 FEs, on the way to the target ITk-Pixel full-scale readout system. Details of the different system components are given, along with the different experimentation setups that were tested.

T 89.7 Thu 17:30 Tn

Bump bond stress tests with ITk-Pixel-style daisy-chain modules through thermal cycling — •Steffen Korn, Jörn Grosse-Knetter, and Arnulf Quadt — II. Physikalisches Institut, Georg-August-Universität Göttingen

For the upgrade of the LHC to the HL-LHC, the Inner Detector will be replaced by the fully silicon-based Inner Tracker Detector (ITk). The pixel detector of the ITk uses hybrid modules where sensor and readout chips are connected by bump bonds. Early ITk module prototypes highlighted these bump bond connections as a possible point

of failure in future ITk Pixel modules when exposed to thermally induced stress. In order to investigate this issue, daisy chain modules with realistic bump bond pitch and modules with read-out-chips were tested before and during exposure to thermal stress through cycling in a thermal shock chamber using a dedicated in-situ method in Goettingen. The results of these tests using different modules with different assembly options are presented in this talk.

T 89.8 Thu 17:45 Tn

Characterization of Prototype Pixel Sensors for the CMS Inner Tracker at the High-Luminosity LHC — •Anna Liisa Puchert[1], Aliakbar Ebrahimi[2], Finn Feindt[1], Erika Garutti[1], Mohammadtaghi Hajheidari[1], Daniel Pitzl[3], Peter Schleper[1], Jörn Schwandt[1], Georg Steinbrueck[1], and Irene Zoi[1] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland — [2]Paul Scherrer Institut, Villingen, Switzerland — [3]Deutsches Elektronen-Synchrotron DESY, Notkestrasse 85, 22607 Hamburg

During the shutdown from 2025 to 2027 (LS3), the Large Hadron Collider (LHC) will undergo an upgrade. The luminosity will be increased to up to 7.5×10^{35} $\mathrm{cm}^{-2}\mathrm{s}^{-1}$. Consequently, the data rate as well as the particle flux through the detector will be increased. The silicon tracker of the CMS experiment will therefore need to be completely replaced. The sensors for the CMS Inner Tracker (IT) will have to fulfil stringent requirements, including high efficiency for hit detection ($>$ 99 %) and excellent spatial resolution till the end of their lifetime. We report on performance measurements on prototype sensors. For this purpose, some of the sensors were irradiated to simulate the radiation after a certain runtime. The tests for efficiency and spatial resolution were performed at the DESY II test beam in Hamburg. Even after an irradiation of 2.1×10^{16} $\mathrm{n_{eq}/cm^2}$, which approximately corresponds to the expected particle flux after 3000 fb^{-1} for the first layer, the tested sensors still meet the requirements in terms of efficiency and resolution at bias voltages below 800 V.

T 90: Muon detectors

Time: Thursday 16:00–18:35 Location: To

Group Report T 90.1 Thu 16:00 To

Commissioning of the new small-diameter Monitored Drift Tube detectors for the Phase-1 Upgrade of the ATLAS muon spectrometer — •Elena Voevodina, Gregor Hieronymus Eberwein, Oliver Kortner, Hubert Kroha, Daniel Soyk, Patrick Rieck, and Marian Rendel — Max Planck Institute for Physics, Munich, Germany

The Muon Drift Tube chambers provide very precise and reliable muon tracking and momentum measurement in the ATLAS muon spectrometer. Already in Run 2 of the LHC they have to cope with very high background counting rates up to 500 Hz/cm2 in the inner endcap layers. At High-Luminosity LHC, the background rates are expected to increase by almost a factor of 10. New small (15 mm)-diameter Muon Drift Tube detectors have been developed for upgrades of the muon system. They provide about an order of magnitude higher rate capability and allow for the installation of additional new triplet-RPC trigger chambers in the barrel inner layer of the muon detector for HL-LHC. A pilot project for the barrel inner layer upgrade is underway during the 2019/21 LHC shutdown. Several sMDT chambers have already been installed and operated in the ATLAS detector. The detailed studies of the muon detection efficiency and muon track resolution have been carried out after the assembling of the sMDT detectors in MPI and repeated at CERN after the integration with the new RPC detectors. The author will describe the detector design, the quality assurance and certification path, as well as will present the status of sMDT detectors installation and commissioning in the ATLAS experiment.

T 90.2 Thu 16:20 To

CMS Drift Tube Chambers : Upgrade activities during LHC long shutdown II — •Archana Sharma, Thomas Hebbeker, Kerstin Hoepfner, Hans Reithler, and Saranya Ghosh — III. Physikalisches Institut A, RWTH Aachen Universtity

To sustain and extend its discovery potential, the Large Hadron Collider (LHC) will undergo a major upgrade in the coming years, referred to as High Luminosity LHC (HL-LHC), aimed to increase its instantaneous and integrated luminosity respectively by a factor of five and ten beyond the original design value. After delivering an integrated luminosity of more than 160 fb-1 until the end of Run 2, at the beginning of 2019, LHC has been shutdown for two years (LS2) in order to get its accelerator-chain and detectors upgraded for the HL-LHC phase. During this LS2, the CMS experiment aims to upgrade its electronics and detector performance to improve the data taking and a precise reconstruction of all the particles in high pile-up conditions of HL-LHC. The Drift Tube (DT) chambers are one of the important parts of the CMS muon system responsible for identifying, measuring and triggering on muons by the precise measurement of their position. This talk summarises the ongoing activities and plans related to the upgrade activities of the DT chambers.

T 90.3 Thu 16:35 To

Performance of Muon Drift Tube Detectors and Fast Readout Electronics at Very High Counting Rates — Hubert Kroha, Oliver Kortner, Elena Voevodina, and •Gregor Eberwein — Max-Planck-Institute for Physics, Munich, Germany

Small-diameter Drift Tube (sMDT) detectors with 15 mm tube diameter have proven to be excellent candidates for precision muon tracking detectors in experiments at future hadron colliders like HL-LHC and FCC-hh where unprecedented high background rate capabilities are required. sMDT chambers are currently being installed in the inner barrel layer of the ATLAS muon spectrometer. The rate capability of the sMDT drift tubes in terms of muon detection efficiency and spatial resolution is limited by the performance of the readout electronics. Simulations show, that the addition of active baseline restoration circuits in the front-end electronics chips in order to suppress signal-pile-up effects at high counting rates leads to significant improvement of both efficiency and resolution. To confirm these expectations, extensive tests using sMDT prototype chambers have been conducted at the CERN Gamma Irradiation Facility. Chambers equipped with readout chips with improved pulse shaping and discrete readout circuits with baseline restoring functionality have been tested. Results of both simulation and test will be presented. They provide guidelines for the design of a new sMDT readout chip for operation at very high counting rates.

T 90.4 Thu 16:50 To

The CMS Muon upgrade and the impact of GEM etching techniques on detector performance — •Francesco Ivone, Thomas Hebbeker, Kerstin Hoepfner, Henning Keller, Giovanni Mocellin, and Shawn Zaleski — III. Physikalisches Institut A, RWTH Aachen University

The LHC will undergo a major upgrade to deliver ten times more pp-collisions in the next two decades, which has been named High-Luminosity LHC (HL-LHC). To cope with the higher event rates and with the increased radiation doses, the Compact Muon Solenoid (CMS) experiment will undergo several upgrades including the installation of an additional set of muon detectors based on the Gas Electron Multipliers (GEM) technology. Triple-GEM detectors have already been installed in the CMS endcap stations named GE1/1 during Long Shutdown 2, while two more stations, GE2/1 and GE0, will adopt the same technology during subsequent shutdowns. The GEM foils, the core of GEM-based detectors, are currently produced with either double-mask or single-mask etching. Despite being an effective method, GEM hole asymmetry is observed in single mask compared to double mask. The effect of the hole asymmetry on the detector performance has been studied with a twofold approach. On one hand experimental data have been collected using GEM foils with different hole geometries, on the other hand detailed simulations have been performed matching the experimental set-up conditions. This talk gives an introduction to GEM detectors in CMS and describes a study to assess the impact of the GEM hole asymmetry on the detector performance.

T 90.5 Thu 17:05 To

Muon reconstruction efficiency evaluation with the ATLAS detector at the LHC using J/ψ and Υ resonances — •Noemi

Cavalli — INFN and Università di Bologna, Italy - TU Dortmund, Germany

This work is carried out within the Muon Combined Performance group of the ATLAS Experiment at the LHC. Muon reconstruction efficiencies are measured using data collected by the detector. $J/\psi \longrightarrow \mu\mu$ events are employed and the "Tag and Probe method" is used. The ratio between the reconstruction efficiency obtained from the data and from simulated J/ψ samples is then evaluated. This ratio is called "Scale Factor" and it is provided to the ATLAS Collaboration to correct simulated muon samples employed in physics analyses. In particular, the Scale Factor systematic uncertainty associated to the fit model choice has been improved by using Monte Carlo samples with real background events injected on the simulated samples to test the fit performance.

In the second part of the work the reconstruction efficiency and Scale Factor evaluation has been extended to $\Upsilon \longrightarrow \mu\mu$ events. The Υ resonance has never been exploited by the ATLAS Collaboration to get muon reconstruction efficiencies and its implementation would be complementary to the other standard candles used so far. A dedicated strategy for Υ events has been developed, starting from the one employed for the J/ψ meson. The state of the art and the outlook on future developments is presented.

T 90.6 Thu 17:20 To

Trigger Performance Studies with a small-strip Thin Gap Chamber quadruplet — •Ksenia Solovieva, Jose Antonio Fernandez Pretel, Vladislavs Plesanovs, Patrick Scholer, and Ulrich Landgraf — Albert-Ludwigs University, Freiburg, Germany

The ongoing ATLAS detector upgrade includes the implementation of the New Small Wheels as part of the Muon Spectrometer. One of its detector technologies is the small-strip Thin Gap Chamber (sTGC), used for improved triggering and tracking in a higher particle rate environment. The sTGC detector readout is segmented into strips and pads, which play a key role in the trigger chain. For the purpose of investigating the sTGC pad trigger performance, a quadruplet was set up in a cosmic muon test stand in Freiburg and read out with the final ATLAS NSW readout system. This presentation discusses the goals and challenges of the setup, as well as presenting the prospective results of the trigger studies.

T 90.7 Thu 17:35 To

Alignment reconstruction of Micromegas quadruplets — •Fabian Vogel, Otmar Biebel, Maximilian Herrmann, Ralf Hertenberger, Christoph Jagfeld, Felix Klitzner, Katrin Penski, Maximilian Rinnagel, and Chrysostomos Valderanis — LMU München

For the upcoming New Small Wheel upgrade of the ATLAS detector Micromegas quadruplets will be implemented as muon tracking detectors. These gaseous detectors are optimized for the detection of minimum ionizing particles. They contain a metallic micromesh to divide the gas volume into a drift and an amplification region. The anode on the bottom of the detector contains parallel readout strips on a printed circuit board (PCB) for one dimensional readout. Each of the four detector layers is built from three individual PCBs glued side-by-side on either side of the readout panel. The alignment of a quadruplet made from two readout panels with four layers of PCBs, for each individual layer, as well as the alignment of these layers with respect to each other is investigated. Studies of those quadruplets in the cosmic ray facility of the LMU are compared to optical precision inspections using dedicated markers on the PCBs. New measuring techniques have been developed and integrated in the series production of the modules. Results of the comparison will be presented.

T 90.8 Thu 17:50 To

Construction of new small-diameter Monitored Drift Tube (sMDT) chambers for the HL-LHC upgrade of the ATLAS Muonspectrometer — •Marian Rendel, Patrick Rieck, Verena Walbrecht, Oliver Kortner, and Hubert Kroha — Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München

In order to improve the muon trigger efficiency of the ATLAS muon spectrometer for the high luminosity upgrade of the Large Hadron Collider (HL-LHC), the precision tracking Monitored Drift Tube (MDT) chambers in the inner barrel layer will be replaced by integrated stations combining new thin-gap RPC trigger chambers with new small-diameter Monitored Drift Tube (sMDT) chambers. The sMDT chambers are designed to meet the very tight space constraints in the detector and to provide an order of magnitude higher background rate capability compared to the current detectors.

The sMDT chambers have to provide a sense wire positioning accuracy of better than 20 μm. The assembly procedures and the results of the measurements of the geometry of prototype chambers and of the first chambers of the serial production are discussed.

T 90.9 Thu 18:05 To

Construction of new small diameter Monitored Drift Tube (sMDT) chambers for the ATLAS muon spectrometer at the HL-LHC — •Verena Walbrecht, Marian Rendel, Patrick Rieck, Oliver Kortner, Sandra Kortner, and Hubert Kroha — Max-Planck-Institut für Physik

In order to improve the muon trigger efficiency of the ATLAS muon spectrometer for the high-luminosity upgrade of the Large Hadron Collider (HL-LHC), the precision tracking Monitored Drift Tube (MDT) chambers in the inner barrel layer will be replaced by integrated stations combining new thin-gap RPC trigger chambers with new small-diameter Monitored Drift Tube (sMDT) chambers. The sMDT chambers are designed to meet the very tight space constraints in the detector and to provide an order of magnitude higher background rate capability compared to the current detectors.
In this talk, the results of measurements of the geometry, the tests, and the performance of the chambers are discussed.

T 90.10 Thu 18:20 To

Development of a tester hardware tool for new-read electronic cards of the MDT detectors of the ATLAS muon spectrometer for the Phase-II upgrade — •Mathias Modlmayr, Gia Khoriauli, and Raimund Ströhmer — University of Würzburg

The monitored drift tube detectors (MDT) are part of the ATLAS muon spectrometer. The MDT segments (chambers) are read-out with on-chamber mezzanine cards. The cards are equipped with signal amplifier-shaper-discriminator and time to digital converter chips. For the LHC Phase-II upgrade, these cards are planned to be replaced with the new mezzanine cards currently being developed. The new MDT read-out is essential to cope with the increased particle rates at the High-Luminosity LHC. Moreover, the MDT will be part of the ATLAS hardware-based trigger system. Therefore, one of the new requirements to the new mezzanine cards is to operate in a triggerless read-out mode as well as to keep a triggered read-out mode as an option.

We develop a hardware tool, which will be used in the quality mass tests of the new mezzanine cards. The main goal of the tool is to test all functionalities and the stability of the new mezzanine cards and certify them. Also, efficiencies, noise rates, crosstalk, resolution and linearity of time measurements and some more characteristics of the mezzanine cards will be measured and documented in a dedicated database. The current status of the development of the tester tool and the test procedures are presented.

T 91: GRID computing

Time: Thursday 16:00–17:30 Location: Tp

T 91.1 Thu 16:00 Tp

Opportunistic cloud computing for German HEP — •R. Florian von Cube, René Caspart, Max Fischer, Manuel Giffels, Eileen Kühn, Günter Quast, and Matthias J. Schnepf — Karlsruhe Institute of Technology

For on-demand usage of resources not dedicated to HEP, KIT develops the resource management system COBalD/TARDIS. It allows for dynamic integration of resources temporarily made available from different providers. Those might be e.g. university HPC clusters, shared science computing centers or commercial cloud providers.

By using modern virtualization and containerization technologies,

such as Docker or Singularity, heterogeneous resources can be used transparently by experiments e.g. for Monte-Carlo-production and end-user analysis.

In this contribution we introduce COBalD/TARDIS and present recent successes with exemplary setups.

T 91.2 Thu 16:15 Tp

Job Shaping with HammerCloud ATLAS — •Michael Böhler, David Hohn, and Markus Schumacher — Albert-Ludwigs-Universität, Freiburg, Deutschland

The functionality of the compute sites of the Worldwide LHC Computing Grid for the ATLAS and CMS experiments is verified by a large number of experiment specific test jobs. These jobs are steered, controlled and monitored by the HammerCloud testing infrastructure. HammerCloud ATLAS runs different functional tests, continuously checking the site status by representative MC simulation and analysis jobs. If these test jobs fail, the site is automatically excluded from central ATLAS job brokerage system: only test jobs will be send to the site until the test results succeed again. The auto-exclusion mechanism increases the success rate of the user jobs by only allowing job brokerage to healthy sites.

The aim of Job Shaping, which is discussed in this talk, is to speed up auto-exclude and re-include decisions made by HammerCloud. This is to be achieved by dynamically adjusting the frequency of test jobs based on latest test job results. Dedicated visualizations are developed to provide intelligible information. Additionally, specialized debug test jobs can be sent to problematic sites to identify root causes of problems like failing or missing test job results. The additional information of the debug jobs will provide more detailed data in order to help problem solving and identifying failure patterns. Therefore new test templates are developed which focus on testing specific components of the site functionality.

T 91.3 Thu 16:30 Tp

Benchmarking of GRID resources using the HammerCloud service — Michael Böhler, •David Hohn, Benoît Roland, Benjamin Rottler, and Markus Schumacher — Albert-Ludwigs-Universität Freiburg

The high luminosity LHC is a major upgrade to the current accelerator and will provide an order of magnitude more high energy physics data in the coming decades than exists now. To enable the analysis of this wealth of data the computing resources need to follow suit and be upgraded as well.

Reliable performance information is the foundation for planning of upgrade efforts as well as efficient operation of the complex computing systems. To this end, benchmarks provide essential insight. This talk will present fast benchmarks of CPUs which can enable prompt matching between available and required resources, as is mandatory to incorporate opportunistic and heterogeneous resources.

The benchmarks are performed by the HammerCloud service within the ATLAS GRID computing network. This constitutes an extension of the HammerCloud use cases from functional to additional performance testing.

T 91.4 Thu 16:45 Tp

Performance monitoring of the opportunistic resource NEMO at ATLAS-BFG — Michael Böhler, Anton J. Gamel, •Stefan Kroboth, Benoit Roland, Benjamin Rottler, and Markus Schumacher — Albert-Ludwigs-Universität Freiburg

The workload of computing clusters is typically unpredictable and tends to alternate between over- and under-utilization of the available resources. The software COBalD/TARDIS provides an easy way to opportunistically make under-utilized resources of one cluster available to another cluster. Fine-tuning of the involved software infrastructure to optimize efficiency and user experience needs to be performed in a production environment and is therefore difficult without continuous monitoring of logs and meaningful metrics. In this work we present the current situation at Freiburg University where resources of the NEMO cluster are used to extend the WLCG-Tier-2/3 cluster ATLAS-BFG in an opportunistic fashion using COBalD/TARDIS. The talk covers the tools involved in the collection and analysis of logs and metrics acquired from different sources within the ATLAS-BFG and opportunistic NEMO. Examples of how the aggregation of logs and the monitoring of metrics aids decision-making are shown. Besides fine-tuning of the involved tools, this setup can also be used to detect problems and anomalies early on. It furthermore serves as a basis for the future development of an accounting system for compute infrastructure which involves opportunistically integrated resources.

T 91.5 Thu 17:00 Tp

Performance gain in HEP workflows via coordinated caches in heterogenous distributed systems — Rene Caspart, Tabea Fessenbecker, Max Fischer, Manuel Giffels, Christoph Heidecker, •Maximilian Horzela, Eileen Kühn, Günter Quast, and Paul Skopnik — Karlsruhe Institute of Technology

The steadily increasing demand on compute resources due to an explosively growing amount of data and demand for simulations for analysis purposes particularly in the context of the High Luminosity LHC can only be covered by harnessing novel computing concepts.

Besides the integration of additional resources, a promising approach to meet the need for resources is to improve the efficiencies of the workflows. In the HEP community these are often limited by the I/O bandwidth. Nevertheless, to utilize the full available computational capacities of distributed computational systems, aiming for optimal efficiency, coordinated caching solutions in combination with data-locality aware batch systems can provide a significant contribution.

This talk outlines basic concepts and visions for coordinated caching solutions in heterogeneous distributed batch systems.

T 91.6 Thu 17:15 Tp

Implementation and benchmarking of a caching solution in the ATLAS Freiburg environment — Michael Böhler, Anton Gamel, Stefan Kroboth, •Dirk Sammel, and Markus Schumacher — Albert-Ludwigs-Universität Freiburg

The near future of particle physics will be an era of high luminosity: the High Luminosity Large Hadron Collider (HL-LHC), which is expected to be operational in 2027, will enable the collection of data corresponding to a total luminosity of around 3000 fb^{-1} by the ATLAS experiment. In addition to this data, a large number of simulated events will be needed by a multitude of analyses. This results in the requirement for huge amounts of disk space. In order to cope with these enhanced storage requirements, scenarios with fewer, but larger storage sites and several compute sites without long-term storage are discussed.

Therefore, caching solutions are being developed. In this approach, the required data is transferred from external storage sites and then stored on local cache spaces. This enables fast access if the data is subsequently needed. The data is automatically deleted if it is not used for some predefined amount of time.

In this talk, the implementation of a caching setup, Disk-Caching-On-The-Fly (DCOTF), in the ATLAS Freiburg environment and the development of a benchmark that mimics a typical user-analysis are presented. The results of the benchmark testing the performance in Freiburg, especially in comparison to non-cached data access, are discussed.

T 92: Neutrino astronomy IV

Time: Thursday 16:00–18:30 Location: Tq

T 92.1 Thu 16:00 Tq

Search for the DSNB in JUNO: Development of new Methods for Background Event Identification — •Matthias Mayer[1], Lothar Oberauer[1], Raphael Stock[1], Hans Steiger[2], Julia Sawatzki[1], Konstantin Schweizer[1], Ulrike Fahrendholz[1], David Dörflinger[1], Sebastian Zwickel[1], and Ludwig Wallner[1] for the JUNO-Collaboration — [1]Physik-Department, TU München, James-Frank-Str. 1, 85748 Garching b. München, Deutschland — [2]**PRISMA**$^+$ Cluster of Excellence, Staudingerweg 9, 55128 Mainz, Deutschland

The diffuse supernova neutrino background (DSNB) describes the total relic neutrino flux from past core-collapse supernovae over the entire visible universe. It is expected to be observable at the Jiangmen Un-

derground Neutrino Observatory (JUNO), a 20 kton liquid scintillator detector currently in construction near Jiangmen, China. The detection channel to measure the DSNB signal at JUNO is the inverse beta decay (IBD). Besides irreducible background sources to the DSNB signal in the form of IBD events caused either by atmospheric or reactor electron anti-neutrinos, there are non-IBD background events. Those events can be discriminated applying the method of pulse shape discrimination (PSD). In this talk, I discuss the identification of neutron-induced background events and reactions due to atmospheric neutrinos of all flavours. This talk investigates how different PSD techniques can be used to discriminate IBD signal events against these two non-IBD event sources. This work is supported by the DFG within the project MO3 of the SFB1258.

T 92.2 Thu 16:15 Tq

Reconstruction and selection of Supernova burst neutrinos in JUNO — •Thilo Birkenfeld, Achim Stahl, and Christopher Wiebusch — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Since the detection of neutrinos emitted by the supernova SN 1987A, no neutrinos from other supernovae have been observed to date. The Jiangmen Underground Neutrino Observatory (JUNO) will be capable of measuring the neutrino burst from a galactic supernova explosion. High statistics, a low detection threshold, and an excellent energy resolution will strongly constrain the details of the neutrino-driven supernova mechanism. JUNO will be sensitive to signals from all neutrino flavors via different detection channels. These comprise of the inverse beta decay, elastic scattering on protons and electrons, and various interactions with carbon. Separating these channels is challenging but crucial for flavor dependent analyses of the supernova burst. We present preliminary results of an event classification based on a full detector simulation including energy and vertex reconstruction.

T 92.3 Thu 16:30 Tq

Development of the comprehensive analysis tools for the Supernova neutrino detectors — •Vsevolod Orekhov and Michael Wurm — Institute of Physics and Cluster of Excellence PRISMA+, JGU Mainz, Germany

A galactic Supernova explosion is a unique neutrino source: detecting the neutrinos from deep inside the star will help us understand both the physics of the core collapse and properties of the neutrino themselves. If a SN neutrino burst arrived at Earth today, it would be detected by a variety of ton to kiloton scale neutrino detectors based on different technologies and target media. A full understanding of the observed signals can only be obtained by a combined analysis of the different interaction channels. This contribution presents an analysis framework developed to combine and fit the neutrino spectra from different detectors assuming a common flavour-dependent neutrino signal. We start the development from the six channels available on hydrogen, carbon and electrons that are available in large liquid scintillator detectors like JUNO. From there, the framework will be extended to include other detector types.

T 92.4 Thu 16:45 Tq

Solar Neutrinos in JUNO — •Sebastian Zwickel, Lothar Oberauer, David Dörflinger, Ulrike Fahrendholz, Matthias Mayer, Julia Sawatzki, Konstantin Schweizer, and Raphael Stock — TU München (TUM), Physik Department, James-Franck-Straße 1, 85748 Garching b. München

The detection of solar neutrinos can give deep insights in the understanding of the underlying processes in the sun and tests of the standard model. This is one of the scientific goals of the upcoming Jiangmen Underground Neutrino Observatory (JUNO), a 20 kt liquid scintillator detector. Its low-energy threshold, high energy resolution and large target mass make it a suitable candidate for high precision measurements. This talk will give an overview over the signal signature and relevant background sources including their potential suppression.

This work is based on past data analysis of solar neutrinos in the successful Borexino experiment and is supported by the DFG project number 284839683.

T 92.5 Thu 17:00 Tq

Solar neutrino physics below 2 MeV with Juno — •Luca Pelicci[1,2], Alexandre Göttel[1,2], Philipp Kampmann[1], Runxuan Liu[1,2], Livia Ludhova[1,2], Mariam Rifai[1,2], Giulio Settanta[1], and Cornelius Vollbrecht[1,2] for the JUNO-Collaboration — [1]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

The Juno observatory, currently under construction in Jiangmen (China), is a 20 kt liquid scintillator detector. Thanks to the large fiducial volume, and thus the high statistics collectable, and excellent energy resolution, it represents a compelling opportunity for the detection of solar neutrinos. In order to be able to extract solar neutrino fluxes once data taking has started, a multivariate fitting strategy will be adopted to disentangle neutrino signals from backgrounds present in the detector. The key steps of the analysis is the estimation of signal and background rates and Monte Carlo PDF production including detector response function. The main aspects used to produce such distributions and their exploitation within the fitting procedure are explained in the following presentation. Depending on the level of contaminants within the detector, it will be possible to extract neutrino fluxes more accurately. For this reason, sensitivity studies conducted under varying background scenarios are presented.

T 92.6 Thu 17:15 Tq

A Simulation Model for Solar Atmopheric Neutrinos — •Kruteesh Desai and Stephan Meighen-Berger — TU München, Müunchen, Deutschland

We introduce a new Solar Atmospheric Neutrino Simulation Model. Solar atmospheric neutrinos are produced in cascades initiated by cosmic rays in the solar atmosphere. The model is based on the principles of cascade equations, widely studied for Earth's atmosphere. This provides a flexible environment to study the impact of solar, primary, and interaction models. The simulation model includes all relevant particles for the production of neutrinos, with the option to extend to other interacting particles. This could in turn be applied to the study of neutrinos produced due to dark matter. The Solar model used here is based on Helioseismic observations from the GOLF instrument onboard the SOHO satellite. This allows differentiating between fluxes generated in low and high impact parameter scenarios. These fluxes are expected to differ due to the rapidly varying density profile of the Sun. We present the different components of the simulation model and the resulting neutrino fluxes, as well as example applications for experiments, such as IceCube.

T 92.7 Thu 17:30 Tq

Prospects for the Detection of Solar Neutrinos in DARWIN via Elastic Electron Scattering — •Shayne Reichard for the DARWIN-Collaboration — Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT) — Physik-Institut, University of Zurich

The DARWIN observatory, a proposed experiment that would utilize tens of tonnes of liquid xenon to directly detect dark matter, will additionally exhibit sensitivity to solar neutrinos via elastic electron scattering. DARWIN will have the potential to measure the fluxes of five solar neutrino components: *pp*, ^{7}Be, ^{13}N, ^{15}O and *pep*. A high-statistics observation of *pp* neutrinos would allow us to infer the values of the weak mixing angle, $\sin^2\theta_w$, and the electron-type neutrino survival probability, P_e, in the electron recoil energy region from a few keV up to 200 keV. Such measurements would be the first at these low energies. An observation of *pp* and ^{7}Be neutrinos would constrain the neutrino-inferred solar luminosity down to 0.2%. A combination of all flux measurements would distinguish between the high (GS98) and low metallicity (AGS09) solar models with 2.1-2.5σ significance, independent of external measurements from other experiments or a measurement of ^{8}B neutrinos through coherent elastic neutrino-nucleus scattering in DARWIN. Finally, the neutrino capture process on ^{131}Xe may be observable with a target depleted of ^{136}Xe. We present results of detailed calculations based on the anticipated properties of the DARWIN detector.

T 92.8 Thu 17:45 Tq

Directional reconstruction of solar ^{7}Be neutrinos in Borexino — •Johann Martyn for the Borexino-Collaboration — Johannes Gutenberg-Universität Mainz

The Borexino detector is a liquid scintillator detector with a high radiopurity and a light yield of ≈ 12000 photons/MeV with the main goal of measuring the entire spectrum of solar neutrinos from very low energies (>150 keV). While the method of using the directional information of Čerenkov photons is readily used to discriminate between signal and background in water based detectors on an event-by-event basis this cannot be done in Borexino due to its large scintillation light

yield and a relative fast scintillation time. In this talk we present a novel approach of directional analysis where the PMT hit patterns are summed up for a large number of events and plotted versus the angle of the known position of the sun and the direction of the photons given by the reconstructed event vertex and the PMT position. We use the ^{7}Be neutrino energy region to investigate if it is possible to use this cumulative method to distinguish between directional neutrino signal and isotropic radioactive background.

This work is supported by the Cluster of Excellence PRISMA+.

T 92.9 Thu 18:00 Tq

Search for ultra-high energy neutrinos from binary black hole mergers* — •Michael Schimp for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal

The Surface Detector of the Pierre Auger Observatory is able to distinguish extensive air showers induced by ultra-high energy neutrinos (UHE neutrinos; $E_\nu > 0.1$ EeV) from those induced by atomic nuclei, provided that they are highly inclined (zenith angles from 60° to 95°). While its sensitivity to a diffuse UHE neutrino flux is comparable to IceCube's, the dependences on the direction and flavor are very different. For instance, the Pierre Auger Observatory is the only operational instrument sensitive to UHE neutrinos from the Northern Hemisphere. Close to the horizon, the effective area is much enhanced, leading to unrivaled instantaneous UHE neutrino sensitivities for searches following up transient sources in this part of the sky.

Binary black hole (BBH) mergers are among the most recently discovered classes of astrophysical objects, but have not yet been successfully observed by any other means than gravitational waves. Using the 3D sky localization probability distributions of the BBH mergers published so far, and the assumption of a universal time-dependent luminosity, a combined search for UHE neutrinos emitted by the BBH mergers is performed. We present constraints on the time-dependent luminosity for the exemplary hypothesis of an emission lasting for 24 hours beginning at the time of the merger.

**Supported by BMBF Verbundforschung Astroteilchenphysik (Projects 05A17PX1 and 05A20PX1)*

T 92.10 Thu 18:15 Tq

Performance of new triggers used for neutrino detection at the Pierre Auger Observatory* — •Srijan Sehgal for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Germany

The Pierre Auger Observatory, currently the world's largest cosmic ray detector, can also be used to identify highly inclined ($60° < \theta < 95°$ where θ is the zenith angle) neutrino induced extensive air showers by using its Surface Detector (SD). In 2013, two new SD triggers – time-over-threshold-deconvolved (ToTd) and multiplicity of positive steps (MoPS) – were installed to reduce the energy threshold of the SD and increase the trigger efficiency for neutrino induced air showers.

This talk presents an overview of the performance of the new triggers on neutrino simulations ($60° < \theta < 75°$; shower energy $< 10^{19}$eV) simulated using CORSIKA with detector simulations and signal reconstruction performed using the Auger software framework. Quantities such as zenith angle, shower energy, and slant depths are investigated to gauge performance.

**Gefördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A17PX1 und 05A20PX1)*

T 93: Neutrino physics without accelerators IV

Time: Thursday 16:00–18:30 Location: Tr

T 93.1 Thu 16:00 Tr

Charge-carrier collective motion in germanium detectors for $\beta\beta$-decay searches — •Tommaso Comellato, Matteo Agostini, and Stefan Schönert — Physik-Department, Technische Universität München, Garching

The state-of-the-art technology in germanium crystals allows the production of detector blanks with lengths and diameters of 10 cm, and a level of impurities in the range of 10^{10} atoms/cm^3. Such crystals can be converted into High Purity Germanium (HPGe) detectors. In such devices, the time structure of the signal can be used to discriminate the topology of the energy deposition. This is exploited in the search for neutrinoless double beta decay ($0\nu\beta\beta$) of ^{76}Ge, where HPGe detectors enriched in ^{76}Ge are used simultaneously as source and detector (Gerda, Legend). In the effort to enlarge the detector dimensions, new geometries such as the Inverted Coaxial have been recently developed [1]. In this new type of detectors the time needed to collect charge carriers is much larger than the detectors used in the current $0\nu\beta\beta$ experiments. Longer collection times lead to the observation of subleading effects in the signal formation due to the self-interaction of the charge-carriers' clusters during their migration. In this talk I will present the impacts that such effects have on signal shape and on pulse shape discrimination performance, as we describe in [2]. This work has been supported in part by the ERC (Grant agr. No. 786430 - GemX) and by the SFB1258 funded by the DFG.

[1] R. J. Cooper et al., Nucl. Instrum. Meth. A665 (2011) 25
[2] T. Comellato et al., arXiv: 2007.12910 (2020)

T 93.2 Thu 16:15 Tr

Search for light exotic fermions in double beta decay — •Elisabetta Bossio[1], Matteo Agostini[1,2], Alejandro Ibarra[1], and Xabier Marcano[1] — [1]Physik-Department, Technische Universität München, Garching, Germany — [2]Department of Physics and Astronomy, University College London, UK

Double beta decay is predicted in the Standard Model with the emission of two active neutrinos. Models in which light exotic fermions are emitted, replacing one or both the neutrinos in the final state, could be tested through the search for spectral distortions in the electron spectrum with respect to the Standard Model expectations.

In this contribution, the discovery potential of selected neutrinoless double beta decay experiments will be presented, under two concrete scenarios: the single production of a light sterile neutrino in double beta decay and the pair production of light Z_2-odd fermions. It will be shown that future searches allow to test for the first time a new part of the parameter space at the MeV-mass scale[1]. This work has been supported in part by the German Federal Ministry for Education and Research (BMBF) and the German Research Foundation (DFG) via the SFB1258.

[1]M. Agostini, E. Bossio, A. Ibarra, X. Marcano, arXiv:2012.09281

T 93.3 Thu 16:30 Tr

Detection prospects for the double-beta decays of ^{124}Xe — •Christian Wittweg[1], Brian Lenardo[2], Alexander Fieguth[2], and Christian Weinheimer[1] — [1]Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, 48151 Münster, Germany — [2]Physics Department, Stanford University, Stanford, CA 94305, USA

The isotope ^{124}Xe is exceedingly rare and long-lived. Still, its slow neutrinoless double-beta decays could be a key to understanding the mass and nature of the neutrino as well as the dominance of matter over antimatter in the Universe. Its double-beta decays with neutrinos could provide constraints for nuclear matrix element calculations in the neutron-poor region of the nuclear chart [C. Wittweg et al., EPJ C 80 (2020) 1161]. What makes ^{124}Xe special among double-beta emitters is the theoretical possibility of three different neutrinoless decay modes – either via double-electron capture in a nuclear resonance, or involving the emission of one or two positrons. Together with the observation of neutrinoless double-beta decays in other isotopes, ^{124}Xe could also allow to disentangle the underlying decay mechanism. The talk will introduce the neutrinoless and two-neutrino decays of ^{124}Xe and discuss the detection prospects with upcoming experiments such as XENONnT, nEXO and DARWIN.

The work of the reporting author is supported by DFG through the research training group GRK2149 *Strong and weak interactions - from hadrons to dark matter.*

T 93.4 Thu 16:45 Tr

Sensitivity of the DARWIN observatory to the neutrinoless double beta decay of ^{136}Xe — •Fabian Kuger for the DARWIN-Collaboration — Albert-Ludwigs-Universität, Freiburg, Germany

The DARWIN observatory is a proposed next-generation experiment to search for particle dark matter and other rare processes of nuclear or

astrophysical origin. Its time projection chamber will instrument 40 t of natural liquid xenon containing about 3.6 t of ^{136}Xe. The combination of ultra low background levels, very good energy resolution and large target mass predestines DARWIN to search for the neutrinoless double beta decay of ^{136}Xe.

We present a Monte Carlo simulation study of the background and event topologies resulting in a projected half-life sensitivity of 2.4×10^{27} yr after 10 yr of DARWIN operation, a comparable science reach to dedicated double beta decay experiments using xenon targets enriched in ^{136}Xe.

T 93.5 Thu 17:00 Tr

Background characterization for the COBRA experiment — •Juliane Volkmer — IKTP, TU Dresden

In 2011 the COBRA demonstrator was built with the objective of investigating the practicability of using CdZnTe semiconductor crystals for the investigation of double beta decays.
The CdZnTe crystals contain nine isotopes capable of different $\beta\beta$ decay modes, can be operated at room temperature and are commercially available. Additionally, the versatile detector material offers the possibility of investigating physics besides the $\beta\beta$ decay, like a potential quenching of g_A in nuclear processes – by measuring the spectrum shape of the strongly forbidden ^{113}Cd β decay – and exotic $\beta^+\beta^+$ decay modes.
One of the main challenges of investigating such extremely rare processes is the detector's background, potentially occurring at much higher rates than the searched-for signal itself. The background can be reduced by using ultra-pure materials and great care during the experiment's construction, a shielding system, as well as analysis cuts on the data.
However, a certain fraction of the background still passes through the shielding and survives the analysis cuts. For this remaining background it is important that it is well understood and characterized.
In this talk an overview of the background present for the COBRA demonstrator is given. The focus lies especially on the results of investigating the background with the help of coincidence analyses.

T 93.6 Thu 17:15 Tr

Measurement of the neutrino mixing angle θ_{13} with the Double Chooz experiment — •Philipp Soldin, Markus Bachlechner, Lars Heuermann, Achim Stahl, and Christopher Wiebusch — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Double Chooz is a reactor neutrino disappearance experiment that was operating between 2011 until the end of 2017. Its main purpose was the precise measurement of the neutrino mixing angle θ_{13}. The experimental setup consisted of two identical liquid scintillator detectors at average baselines of about 400 m and 1 km to two nuclear reactor cores in Chooz, France. The neutrinos were detected by measuring the signature of the inverse beta decay (IBD), which consists of a prompt positron annihilation and a delayed neutron capture signal. We perform a measurement of θ_{13} using a Poisson based likelihood fit of the energy dependent flux of the two detectors. This requires the consideration of the simultaneous measurement of the energy dependent neutrino rates in two detectors, all relevant backgrounds and systematic uncertainties, resulting in more than 300 partly correlated model parameters. In this talk we present the challenging fit method and the experimental result from the full data set of Double Chooz.

T 93.7 Thu 17:30 Tr

Likelihood-based searches of sterile neutrino signals in Double Chooz. — •Lars Heuermann, Markus Bachlechner, Philipp Soldin, Achim Stahl, and Christopher Wiebusch — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Double Chooz is a reactor neutrino disappearance experiment with the main goal to measure the neutrino oscillation. The setup consists of two identical detectors at baselines of 1050 m and 400 m, optimized for the neutrino mixing angle θ_{13}. Additional, hypothetical sterile neutrino flavours, which do not participate in weak interactions, still might contribute to anti-electron-neutrino disappearance and thus could be measurable in Double Chooz. In this search, we test the data in a maximum likelihood analysis with respect to the parameters of a model with one additional sterile neutrino flavour (3+1 model). A particular challenge is that Wilks' theorem is not fulfilled and the parameter scan is computationally expensive. An initial analysis has been performed with a subset of the data. Here we extend the analysis to the full available data set. We will present the analysis method, study of systematic uncertainties and conclude with upper exclusion boundaries for the sterile mixing parameters Δm^2_{41} and $\sin^2(2\theta_{14})$ through likelihood based scans.

T 93.8 Thu 17:45 Tr

Vertex Reconstruction using Graph Convolutional Networks in Double Chooz — •Markus Bachlechner, Thilo Birkenfeld, Philipp Soldin, Achim Stahl, Alexandros Tsagkarakis, and Christopher Wiebusch — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Double Chooz is a reactor anti-neutrino disappearance experiment, which took data from 2011 until the end of 2017. The main purpose was the precise measurement of the neutrino mixing angle θ_{13} with two identical liquid scintillator detectors. Neutrinos are detected via the signature of the inverse beta decay (IBD), which is characterized by a prompt signal from a positron and a delayed signal from neutron capture. The random association of uncorrelated events caused by natural radioactivity and the β-n decay of ^{9}Li produced by atmospheric muons are two major backgrounds. The discriminations between signal and background are based on either the spatial distance between the prompt and delayed like events or the proximity to a preceding muon track. A precise vertex reconstruction is thus important for reducing the background and improving the measurement of θ_{13}. In this talk an approach via Graph Convolutional Networks (GCNs), which can adapt to the complex geometry and specific physical features of the detector, is presented. By using such versatile deep learning technique, the current maximum likelihood based reconstruction is outperformed.

T 93.9 Thu 18:00 Tr

The Taishan Antineutrino Observatory — •Hans Steiger — Cluster of Excellence PRISMA+, Johannes Gutenberg University Mainz (JGU), Staudingerweg 9, D-55128 Mainz

The TAO (Taishan Antineutrino Observatory) detector is aiming for a measurement of the reactor neutrino spectrum at very low distances ($<$ 30 m) to the core with a groundbreaking resolution better than 2 % at 1 MeV. The TAO experiment will realize the unprecedented neutrino detection rate of about 2000 per day, which is approximately 30 times the rate in the JUNO main detector. In order to achieve its goals, TAO is relying on yet to be developed, cutting-edge technology, both in photosensor and liquid scintillator (LS) development which is expected to have an impact on future neutrino and Dark Matter detectors. In this talk TAO's design, physics prospects as well as the status of its construction will be presented, together with a short excursion into its rich R&D program with a special focus on the German contribution to the development of the novel gadolinium-loaded liquid scintillator. This work is supported by the Cluster of Excellence PRISMA+ at the Johannes Gutenberg University in Mainz.

T 93.10 Thu 18:15 Tr

Looking for sterile neutrinos and new physics using the solar ^{8}B neutrino spectrum — •Simon Appel, Lothar Oberauer, and Birgit Neumair — Physik Department, TU München

Solar ^{8}B neutrinos are detected via elastic scattering on electrons in large radiopure detectors. The expected upturn in the survival probability of solar ^{8}B neutrinos is still not detected. Current generation detectors struggle with several challenges. Cosmic muons produce radiogenic isotopes that mimic the ^{8}B neutrino shape. Especially the long lived ^{10}C and ^{11}Be isotopes are problematic. External gamma background limits the fiducial volume. Future detectors may improve these limitations. Besides the MSW effect there is more physics beyond the standard model that could affect the neutrino survival probability. Light sterile neutrinos $\Delta m^2_{01} \simeq (0.7 - 2) \cdot 10^{-7}\text{eV}^2$ and flavour changing ν_e-ν_τ interactions affect the survival probability in the same energy region as the MSW effect. This talks focuses on the ability of future detector generations exploring this parameter space.

T 94: Neutrino physics without accelerators VII

Time: Thursday 16:00–18:35 Location: Ts

Group Report T 94.1 Thu 16:00 Ts

Measurement of *pp* chain and CNO cycle solar neutrinos with Borexino — •Ömer Penek[1,2], Alexandre Goettel[1,2], Sindhujha Kumaran[1,2], Livia Ludhova[1,2], Luca Pelicci[1,2], Giulio Settanta[1], and Apeksha Singhal[1,2] for the Borexino-Collaboration — [1]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

The Borexino detector, located at the Laboratori Nazionali del Gran Sasso in Italy, is a liquid scintillator detector with a primary goal to measure solar neutrinos. The *pp* fusion chain has been measured in Borexino with an outstanding precision through the detection of *pp*, *pep*, ^{7}Be, and ^{8}B neutrinos in Borexino Phase-II, namely the data-taking period from December 2011 until May 2016. The observation of neutrinos from the CNO cycle has been achieved recently by the Borexino collaboration for the first time since its prediction in the 1930s by Bethe and Weizsäcker. This measurement is challenging due to the high correlation with the ^{210}Bi isotope and the *pep* neutrino signal present in the liquid scintillator. In the so-called Borexino Phase-III, namely the data-taking period from July 2016 until February 2020, the upper limit on the ^{210}Bi rate has been determined through the tagging of alphas from ^{210}Po, which is the decay product of ^{210}Bi. This talk is dedicated to the Borexino solar neutrino analysis with a focus on the observation of CNO neutrinos.

T 94.2 Thu 16:20 Ts

^{210}Bi upper limit for the direct evidence of CNO solar neutrinos with Borexino — •Sindhujha Kumaran[1,2], Alexandre Göttel[1,2], Livia Ludhova[1,2], Luca Pelicci[1,2], Ömer Penek[1,2], Giulio Settanta[1], and Apeksha Singhal[1,2] for the Borexino-Collaboration — [1]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

Borexino is a liquid scintillator detector located at the Laboratori Nazionale del Gran Sasso, Italy with the main goal to measure solar neutrinos. The experiment recently provided the first direct experimental evidence of CNO-cycle neutrinos in the Sun. The intrinsic ^{210}Bi is an important background for this analysis due to its similar spectral shape to that of CNO neutrinos. ^{210}Bi β^- decays to ^{210}Po, which then α decays to stable ^{206}Pb. Ideally, ^{210}Bi should be in secular equilibrium with ^{210}Po and ^{210}Po can be distinguished through an event-by-event basis via pulse shape discrimination techniques. Until mid-2016, additional ^{210}Po was brought from peripheral sources to the detector's fiducial volume via the convective motions of the scintillator, triggered by seasonal temperature changes. However, the thermal insulation performed in 2015-16 has thermally stabilized the detector, achieving low levels of convection in the innermost region and making it possible to measure ^{210}Bi via ^{210}Po. This talk will present the strategy and the methods used to extract the ^{210}Bi upper limit in Phase-III (Jul 2016- Feb 2020) of the experiment via the analysis of ^{210}Po in the cleanest region of the detector called the Low Polonium Field.

T 94.3 Thu 16:35 Ts

Strategy used in CNO solar neutrinos analysis with the Borexino Experiment — •Apeksha Singhal[1,2], Alexandre Göttel[1,2], Sindhujha Kumaran[1,2], Livia Ludhova[1,2], Luca Pelicci[1,2], Ömer Penek[1,2], and Giulio Settanta[1] for the Borexino-Collaboration — [1]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

The Borexino Detector, an ultra-pure liquid scintillator located at the Laboratori Nazionali del Gran Sasso, Italy has detected the neutrinos from CNO cycle in the Sun for the first time in history. The challenges faced in the analysis of CNO neutrinos are the low rate of CNO neutrinos and degeneracy of spectral shape of CNO neutrinos to that of Bi-210 background and pep solar neutrinos. This talk describes the optimization of Monte Carlo simulation in order to perform spectral fit of data and determination of constraints like C-11 shift in energy scale and Bi-210 constraint model parameters.

T 94.4 Thu 16:50 Ts

Development of an attenuation length monitor for JUNO — •Heike Enzmann, Michael Wurm, Wilfried Depnering, Paul Hackspacher, Oliver Pilarczyk, Artur Meinusch, Kai Loo, Hans Steiger, and Eric Theisen — Johannes Gutenberg - Universität, Institute of Physics, Mainz, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is currently under construction in China. Its 20 kt liquid scintillator (LS) detector is designed to determine the neutrino mass hierarchy via a precision measurement of the survival probabilities of electron antineutrinos in reactor neutrino oscillations. The filling of the detector with LS will commence late in 2021.

Excellent transparency of the LS is required to maximize the collection of scintillation light in order to reach the required measurement precision. Thus, several purity monitors will be installed as part of the filling system to test each batch of LS prior to its insertion into the Central Detector. This talk covers the development and testing of an attenuation length monitor for LS quality control. The monitor will measure the attenuation length using a laser. The measurement will be done over two different lengths of LS to reduce systematic effects. This work is supported by DFG research unit "JUNO" (FOR2319) and the Cluster of Excellence PRISMA+.

T 94.5 Thu 17:05 Ts

The Design of the DAQ-software for OSIRIS — •Kai Loo[1], Runxuan Liu[2,3], and Michael Wurm[1] — [1]Johannes Gutenberg-Universität Mainz, Institute for Physics and EC PRISMA+, Staudingerweg 7, 55128 Mainz — [2]Institut für Kernphysik, Forschungszentrum Jülich, 52428 Jülich — [3]III. Physikalisches Institut B, RWTH Aachen University

The Jiangmen Underground Neutrino Observatory (JUNO), under construction in southern China, will determine the neutrino mass hierarchy (MH) by observing neutrinos from nuclear reactors at the distance of 53 km. To reach the desired sensitivity ($> 3\sigma$) for MH, the radiopurity of the different detector components plays a crucial role. To ensure the purity of the 20 kt liquid scintillator (LS) target of JUNO, the Online Scintillator Internal Radioactivity Investigation System (OSIRIS) will be constructed. It will monitor the radiopurity of the LS during its production and the filling phase of the central detector of JUNO. The OSIRIS detector will utilize the novel concept of intelligent-PMT i.e. the necessary electronics will be mounted at the back of the PMT. Each iPMT will then act as an individual self-triggering digitizer. Due to the asynchronous data flow from the iPMT system and of the order of 15 kHz dark count rate per PMT, this chosen approach requires a triggering and physical event building in software level. This talk will report the design, progress and status of the DAQ software for OSIRIS. This work is supported by the DFG Research Unit *JUNO* (FOR2319) and the Cluster of Excellence PRISMA$^+$.

T 94.6 Thu 17:20 Ts

Reconstruction of atmospheric neutrino events with JUNO — •Mariam Rifai[1,2], Giulio Settanta[1], Livia Ludhova[1,2], Alexandre GöttelI[1,2], Philipp Kampmann[1], Runxuan liu[1,2], Cornelius Vollbrecht[1,2], and Luca Pelicci[1,2] for the JUNO-Collaboration — [1]Forschungszentrum Jülich GmbH, Nuclear Physics Institute IKP-2, Jülich, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

The ordering of the neutrino masses is one of the fundamental open questions in the field of neutrino physics. The Jiangmen Underground Neutrino Observatory (JUNO) is a multipurpose liquid scintillator-based experiment with a target mass of 20 kt. It aims to determine the neutrino mass hierarchy with at least 3σ significance, through a measurement of the oscillation pattern of reactor neutrinos over 53 km baseline.

The sensitivity of JUNO to the mass ordering could be enhanced through the atmospheric neutrino channel. As one of the largest LS detectors, JUNO might be able to measure with high precision the atmospheric neutrino events and their oscillation parameters at MeV-scale as well at GeV-scale. This work represents the current methods used in the reconstruction of atmospheric neutrinos with JUNO.

T 94.7 Thu 17:35 Ts

Instrumentation of the OSIRIS liquid handling system — •Eric Theisen[1], Wilfried Depnering[1], Heike Enzmann[1], Paul

Hackspacher[1], Kai Loo[1], Artur Meinusch[1], Oliver Pilarczyk[1], Hans Steiger[1,2], and Michael Wurm[1] — [1]Johannes Gutenberg-Universität Mainz, Institute of Physics and Cluster of Excellence PRISMA$^+$, Staudingerweg 7, 55128 Mainz — [2]Physik-Department, Technische Universität München (TUM), James-Franck-Straße 1, 85748 Garching bei München

The Jiangmen Underground Neutrino Observatory (JUNO) located in southern China is currently beeing contructed for future investigations of the neutrino mass hierarchy. It will observe anti-neutrinos created in nuclear reactors in a distance of about 50 km. In order to achieve the desired sensitivity, it is important to monitor precisely the radioactivity of JUNO's liquid scintillator target. For this purpose the 20-ton predetector OSIRIS (Online Scintillator Internal Radioactivity Investigation System) has been devised to monitor the radiopurity of the liquid scintillator before the filling of the JUNO main detector. To ensure a smooth operation of OSIRIS, numerous sensors of different types will provide precise knowledge of the filling levels, gas pressures and temperatures in each vessel of the liquid handling system. In this talk the concept for the OSIRIS liquid handling instrumentation and the sensor system design will be reported. This work has been supported by the DFG Research Unit "JUNO" (FOR2319) and the Cluster of Excellence PRISMA$^+$.

T 94.8 Thu 17:50 Ts

A liquid organic TPC for monitoring nuclear waste repositories — Malte Göttsche[1], Thomas Radermacher[2], Stefan Roth[2], and •Georg Schwefer[1] — [1]RWTH Aachen University - AICES Graduate School, Aachen, Germany — [2]RWTH Aachen University - Physics Institute III B, Aachen, Germany

In neutrino physics, the low energy region below 5 MeV is of great interest, e.g. for the investigation of solar neutrinos and geo-neutrinos. This energy regime is also crucial for the newly envisioned application of monitoring underground repositories of radioactive waste by measuring the antineutrino emissions produced by β-decaying isotopes present in the waste. To this end, we are investigating a detector design using a time projection chamber (TPC) based on a room-temperature organic liquid for precision measurements of low energy neutrinos. In this presentation, the results from first simulation studies on the reconstruction of low-energy antineutrinos in a liquid organic TPC and on the expected signal rates from nuclear waste repositories are discussed.

T 94.9 Thu 18:05 Ts

Current Status of the TRISTAN Project — •Daniel Siegmann for the KATRIN-Collaboration — Max-Planck Institute for Physics, Munich, Germany

The TRISTAN (TRitium Invetigations of STerile to Active Neutrino mixing) project aims to search for the signature of a keV sterile neutrino in the tritium beta decay spectra by upgrading the detector system of the KATRIN experiment. This extension of the experiment will be performed after its neutrino mass survey.

To reach a high sensitivity to the sterile neutrino mixing angle the strong activity of the KATRIN tritium source is required. The resulting high electron rate is one of the greatest challenges for the TRISTAN project. It will be approached by distributing the rate among 3500 pixels, resulting in count rates of 100 kcps per pixel. To resolve the kink-like signature of the keV sterile neutrino signal the detector needs to maintain an excellent energy resolution of 300 eV (FWHM) at 20 keV and a low energy threshold.

This year the first TRISTAN detector module was integrated into the Monitor Spectrometer of the KATRIN Experiment to investigate the overall detector performance and validate its design. The outcomes of this milestone as well as the upcoming steps for TRISTAN Project will be presented in this talk.

This work is supported by the Max Planck society and the TU Munich ("Chair for Dark Matter, Susanne Mertens").

T 94.10 Thu 18:20 Ts

Upgrade of the PoLiDe-setup for ortho-positronium lifetime and formation probability measurements in liquid scintillators — •Ulrike Fahrendholz[1], Lothar Oberauer[1], Hans Theodor Josef Steiger[1,2], Matthias Raphael Stock[1], Oliver Dötterl[1], Mario Schwarz[1], Konstantin Schweizer[1], David Dörflinger[1], and Ludwig Wallner[1] — [1]Physik-Department, Technische Universität München (TUM), James-Franck-Str. 1, 85748 Garching bei München — [2]Cluster of Excellence PRISMA+, Johannes Gutenberg-Universität (JGU) Mainz, Staudingerweg 9, 55099 Mainz

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kt liquid scintillator (LS) multi-purpose neutrino detector built in a dedicated underground laboratory in Jiangmen (China). The main detection channel for determination of the neutrino mass ordering is the Inverse Beta Decay (IBD), where a neutron and a positron are produced. The positron*s direction and energy are resolved by measuring its scintillation light followed by the two 511 keV gammas resulting from the annihilation with an electron. Formation ortho-positronium delays the annihilation signal, leading to an overall distorted pulse shape in the detector. For better understanding of this process, the existing setup for Positronium Lifetime Determination (PoLiDe) has been upgraded to achieve more accurate values for the lifetime and formation probability of ortho-positronium in the LS. This work is supported by the DFG Research Unit *JUNO* (FOR2319) and the Maier-Leibnitz-Laboratorium (MLL).

T 95: Searches for Dark Matter III

Time: Thursday 16:00–18:30 Location: Tt

T 95.1 Thu 16:00 Tt

New measurement of the photoelectric absorption cross section near the silicon band gap for dark matter searches — •Matthew Wilson[1,2] and Belina von Krosigk[1] — [1]Universität Hamburg, Hamburg, Deutschland — [2]University of Toronto, Toronto, Canada

Cryogenic silicon as a detection medium is used for various direct dark matter search experiments. Many of these experiments are sensitive to low-mass dark matter candidates that rely directly or indirectly on the temperature-dependent photoelectric absorption cross section of silicon near the band gap. While this cross section data from the literature is lacking, previous dark matter search experiments have attempted to estimate this parameter by extrapolating it from higher temperature measurements. However, discrepancies in the underlying literature data have resulted in dominating systematic uncertainties on dark matter limits. This presentation shows the results of using a novel technique to make a direct, low-temperature measurement of the photoelectric absorption cross section of silicon at energies near the band gap, and discusses the effect this new measurement has on the exclusion limits from various dark matter candidates.

T 95.2 Thu 16:15 Tt

Loop corrections to the power spectrum for massive neutrino cosmologies — Mathias Garny and •Petter Taule — Technical University of Munich

Mapping out the large-scale structure of the Universe is becoming a leading probe for precision cosmology. Current and near future surveys are expected to achieve unprecedented precision, and correspondingly a solid theoretical understanding is required in order to extract valuable information. Considerable efforts have been devoted in the recent years to model the weakly non-linear regime using perturbative methods. In this talk, I will describe an algorithm for computing loop corrections to the matter power spectrum that can be applied to a wide range of extended cosmological models, due to its capability of fully capturing time- and scale-dependence of the underlying fluid dynamics. I apply this framework to quantify the effect of massive neutrinos on the growth of structure, using a two-component fluid model for CDM+baryons and massive neutrinos. Finally, I compare the matter power spectrum at 2-loop in the presence of massive neutrinos obtained from this framework with simplified treatments that only take neutrinos into account linearly.

T 95.3 Thu 16:30 Tt

Constraints to the scotogenic dark matter model from indirect detection with neutrinos — •Raffaela Busse[1], Thede de Boer[2], Alexander Kappes[1], Michael Klasen[2], and Sybrand Zeinstra[2] — [1]Institut für Kernphysik, WWU Münster — [2]Institut für Theoretische Physik, WWU Münster

As our solar system moves through the galactic halo, dark matter can be captured gravitationally in large celestial bodies, leading to a local over-density and therefore an increased neutrino flux upon annihilation. Here we present a study of neutrino signals from scalar WIMP annihilations in the Sun in the framework of the scotogenic minimal dark matter model, which extends the Standard Model by a scalar doublet and a fermion singlet with three generations. The scotogenic model is studied by means of two parameter scans for the IceCube South Pole Neutrino Observatory in its current IC86 configuration. One scan exploits the entire parameter space whereas for the other coannihilations between the scalar and fermions are enforced allowing for higher event rates. The scan results are compared to several experimental limits in order to identify viable points within the model that can produce a detectable neutrino flux in IceCube, and therefore could be used to constrain the scotogenic parameter space with a future IceCube data analysis.

T 95.4 Thu 16:45 Tt

Exploiting W-tagging in a tW+MET signature Dark Matter search with the ATLAS experiment — •Ben Brüers, Paul Moder, Priscilla Pani, Claudia Seitz, and Alvaro Lopez Solis — DESY, Hamburg and Zeuthen, Germany

Dark Matter (DM) remains one of the unrevealed mysteries of the universe. Even though it constitutes $\sim 80\%$ of the matter, considerably little is known about DM, despite it significantly influences the dynamics of galaxies and the expansion of the universe. The search for DM at colliders, probing mainly a particle nature of the unknown matter, marks an important pillar in exploring all possible realisations of DM. From the variety of DM models, this talk will present a search for DM with the ATLAS experiment, where the DM is coupled to the Standard Model (SM) via a pseudo-scalar mediator that is added to a two-Higgs-doublet model (2HDM+a). Being enhanced by a diagram in which a charged Higgs-boson H^+ decays into the mediator and a W-boson, the associated production of DM with a W-boson and a top-quark is considered. The DM leaves a signature of missing transverse energy (MET) in the detector. For heavy H^+, the W-boson is boosted, meaning that if decaying hadronically, the two jets from its decay are merged into one large-radius jet. Since after preselection only few boosted W bosons are expected from the backgrounds, tagging boosted W's appears efficient to distinguish signal and backgrounds. The talk will introduce W-tagging techniques and their performance. Furthermore some first results of the application of W-tagging in the tW+MET analysis will be shown.

T 95.5 Thu 17:00 Tt

Sensitivity of LHC Measurements to Two Higgs Doublet Models with a Pseudoscalar Mediator — •Martin Habedank[1] and Priscilla Pani[2] — [1]Institut für Physik, Humboldt-Universität zu Berlin — [2]Deutsches Elektronen-Synchrotron (DESY)

In the past few years, two Higgs doublet models with a pseudoscalar mediator that couples to Dark Matter have gained increased attention as they offer a fairly minimal route to address the problem of Dark Matter and at the same avoid constraints from direct detection experiments. While they have been repeatedly probed in the LHC search programme, the sensitivity of existing LHC precision measurements to those models is not as well-explored. A study striving to fill that gap has been conducted, employing the Contur toolkit (https://hepcedar.gitlab.io/contur-webpage/) to compare the new physics predictions to LHC measurements. This method offers the additional advantage of allowing to deviate from the commonly addressed benchmark scenarios by broadening the considered parameter ranges. In this talk, the results of that study will be summarised, pointing out the differences to LHC search combinations and lessons to be learned.

T 95.6 Thu 17:15 Tt

Detector-corrected Dark Matter search in topologies with missing energy and jets with the ATLAS detector — •Sebastian Mario Weber — Kirchhoff-Institut für Physik, Heidelberg, Deutschland

A powerful signature for dark matter production at the Large Hadron Collider is large missing transverse energy (MET) from the dark matter particles in association with one or more energetic jets. A Standard Model (SM) process with a similar signature is the Z boson decaying to neutrinos ($Z \to \nu\nu + jets$).

A measurement of this process is performed by selecting events with energetic jets and MET as well as events which are selected to enhance vector-boson fusion processes. To allow for later comparisons of the measurement with models for physics beyond the SM, detector effects are removed from the data using an iterative unfolding procedure. Experimental and theoretical uncertainties are constrained using a set of control regions. These control regions are based on different boson mediated processes, which ensures a high degree of correlation of the uncertainties between the different regions. A search for deviations from the SM is then performed on the detector-corrected results.

In this talk new results on the signal and control regions are presented.

T 95.7 Thu 17:30 Tt

Search for Dark Matter in hadronic mono-top signatures at CMS — •Michael Wassmer, Ulrich Husemann, and Sebastian Wieland — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

A common approach to Dark Matter searches at colliders is to search for deviations in the distribution of missing transverse momentum because of the invisible nature of Dark Matter. Events with large missing transverse momentum in association with a Standard Model particle provide a clear signature to search for the aforementioned deviations. This signature is often referred to as the mono-X signature. In this talk, an analysis searching for hadronic mono-top signatures, targeting a phase space with large missing transverse momentum in association with a hadronically decaying top quark, is presented. First, a motivation for the mono-top signature and an introduction to the underlying simplified model are given. Then, the analysis strategy is presented. As a conclusion, the current status of the analysis is shown.

T 95.8 Thu 17:45 Tt

Towards a combination of searches for dark matter produced in association with a single top quark or a top quark pair in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector — •Marianna Liberatore — Deutsches Elektronen-Synchrotron DESY, Hamburg and Zeuthen, Germany

Astrophysical observations have provided compelling evidence for the existence of a non-baryonic component of the universe known as Dark Matter (DM). The nature of DM is not well established, but it is often considered to be a Weakly Interacting Massive Particle, characterised by weak-scale interactions with the Standard Model (SM) particles.

A motivation to DM searches at the Large Hadron Collider, and in particular in the ATLAS experiment, is the especially promising possibility that interactions between ordinary matter and DM are mediated by new spin-0 particles that extend the SM with a potential dark sector, to which DM particles belong. Similarly to the Higgs boson, these new mediators interact strongest with the heaviest particles via Yukawa-type couplings, making them more prone to associated production with heavy-flavour quarks.

To test those models, two recently released search channels are considered within ATLAS: DM with top quark pairs[1] or a single top quark[2], with a focus on the two charged leptons final states. Preliminary work aimed at a statistical combination of these two results in more realistic simplified models will be presented in this talk.

[1] ATLAS-CONF-2020-046
[2] arXiv:2011.09308

T 95.9 Thu 18:00 Tt

Detector corrected Dark Matter search with jets and missing transverse energy with the ATLAS experiment — •Martin Klassen — Kirchhoff-Institut für Physik, Heidelberg

Dark Matter (DM) could reveal itself within the ATLAS detector as a signature of missing transverse energy (MET) accompanied by at least one energetic jet. These jets can either originate from initial or final state radiation or can be relics from vector-boson-fusion (VBF) production leading to two distinct signal regions. An irreducible background results from Standard Model (SM) processes for which the Z boson decays into a pair of neutrinos. Hence, a DM search can be performed by studying deviations from the SM prediction of the cross-sections of those measured invisible Z bosons decays. Experimental and theoretical uncertainties are constrained by dedicated control. The result of the measurement is corrected for detector effects. To search for new physics, the detector-correction signal region and control regions are simultaneously fit to the data, including all systematic uncertainties. Multiple observables such as MET, the invariant mass as well as the difference between the azimuthal angle of the two jets with the largest transverse momenta in the VBF phase space are included in this fit. This talk discusses the simultaneous fit and limiting setting for new

physics models.

T 95.10 Thu 18:15 Tt

Searching for Dark Matter in top quark production with the CMS experiment — Danyer Perez Adan, Afiq Anuar, Alexander Grohsjean, Jonas Rübenach, Christian Schwanenberger, •Dominic Stafford, and Nicole Stefanov — DESY, Hamburg, Germany

Astronomical observations provide strong evidence that a large proportion of the matter in the universe is "Dark Matter" (DM) not described in the Standard Model (SM) of particle physics. Furthermore, many cosmological models suggest Dark Matter should couple to the SM on the 100 GeV scale, and hence may be produced at the LHC, appearing as missing transverse momentum. We present a search for Dark Matter produced in association with top quarks in the dileptonic channel, with an interaction via a spin-0 mediator. However, the dileptonic channel also includes missing transverse momentum in the SM process due to the presence of neutrinos, and so we introduce novel variables and machine learning techniques to separate signal from background.

This search, which uses the full Run 2 dataset and will be part of the CMS combination across all ttbar final states, is also the first in the dilepton channel to include the single top + DM process, which can greatly aid sensitivity to the highest mediator masses in the search.

T 96: DAQ, Trigger and Electronics IV

Time: Thursday 16:00–17:45 Location: Tu

T 96.1 Thu 16:00 Tu

The phase-II upgrade of the first-level muon trigger for the ATLAS experiment at the HL-LHC — •Davide Cieri, Markus Fras, Oliver Kortner, Sandra Kortner, Hubert Kroha, and Robert Richter — Max-Planck-Institut für Physik, Munich, Germany

The first-level muon trigger of the ATLAS experiment will be upgraded to operate at the HL-LHC. The selectivity of the current system is limited by the moderate spatial resolution of RPC and TGC trigger chambers. The Monitored Drift Tube (MDT) chambers, currently used for the precision tracking, will be therefore included to improve the transverse momentum resolution and the redundancy. In the upgraded muon trigger system, the MDT trigger processors will receive MDT hits from the detectors and match them to the trigger candidates from the trigger chambers. Matching MDT hits are then used to improve the momentum resolution, by forming track segments and combining them for the determination of the transverse momentum.

An ATCA–based hardware demonstrator of the MDT trigger processor has been produced, comprising two powerful FPGA devices and a large number of state-of-the-art optical links. A description of the algorithms for the MDT track reconstruction is presented together with the evaluation of the needed trigger processor resources. The achieved trigger performance allows for the reconstruction of muon tracks within the allocated $1\mu s$ latency, with a momentum resolution of $\sim 6\%$ and a trigger efficiency above 95% for 20 GeV muons, reducing the trigger rate of $\sim 70\%$.

T 96.2 Thu 16:15 Tu

Development of calibration procedures for NSW Micromegas readout electronics — •Vladislavs Plesanovs, Stephanie Zimmermann, Gregor Herten, and Ulrich Landgraf — University of Freiburg

During the current LS2 at CERN, ATLAS muon spectrometer will be upgraded by exchanging one of its inner end-caps. The aim is to have extra input to the L1 muon trigger system to cope with expected rate and lower fake-muon trigger rate significantly. For this purpose the New Small Wheel (NSW) will consist of two complementary detector technologies: sTGC (trigger) and Micromegas (tracking). Data readout from these detectors will be conducted by dedicated front-end electronics.

Before physics data taking, a calibration of the readout electronics and signal conversion from digital units to physical values are required. The first procedure sets a global threshold above the noise in the readout chip level and adjusts it individually for each of /approx 2 million channels. The second calibration procedure converts input charge from ADC counts to Coulombs and TAC ADC to nanoseconds for further data processing.

The presentation focuses on the developed procedures, and their integration into ATLAS TDAQ software, which involves interplay with novel readout and TTC infrastructure like FELIX and ALTI. Also challenges that were tackled during development stage together with calibration results from on-detector front-ends will be presented.

T 96.3 Thu 16:30 Tu

Hardware Demonstrator of the MDT Trigger Processor for the ATLAS HL-LHC Upgrade — •Davide Cieri, Markus Fras, Oliver Kortner, Sandra Kortner, Hubert Kroha, and Robert Richter — Max-Planck-Institut für Physik, Munich, Germany

The novel MDT Trigger Processor (MDTTP) is a fundamental part of the upgrade of the first-level (L0) muon trigger of the ATLAS experiment at the HL-LHC. The new system will be responsible for refining the muon track candidate measurements using for the first time at L0 the precision tracking information from Monitored Drift Tube (MDT) chambers in addition to the trigger chamber information. The system will also transmit the MDT hit data to the data acquisition (DAQ) system in the event of a trigger accept. A total of 64 MDTTP boards will be installed in ATLAS, one for each MDT trigger sector. The design of the MDTTP is highly challenging, requiring a high number of optical links and high-performance processing units.

In this talk, the recently designed and assembled hardware demonstrator of MDTTP will be presented. The demonstrator consists of modular ATCA blade, composed by two modules: the Service Module responsible for the powering and the infrastructure; and the Command Module, which performs the trigger and DAQ processing. The Command Module mounts two powerful FPGA devices, which run the trigger and DAQ algorithms. In addition, the system employs eight 12-channel bidirectional optical tranciever modules with a link speed up to 25 Gbps, which are fundamental to provide communication with other components of the muon trigger system.

T 96.4 Thu 16:45 Tu

Performance of new Amplifier-Shaper-Discriminator chips for the ATLAS high-luminosity upgrade — Sergey Abovyan[1], Varuzhan Danielyan[1], Markus Fras[1], Oliver Kortner[1], Hubert Kroha[1], Robert Richter[1], •Simeon Simeonov[1], and Chrysostomos Valderanis[2] — [1]MPI für Physik, München, Bayern — [2]LMU, München, Bayern

The front-end electronics of the ATLAS muon drift-tube chambers will be upgraded in the experiment's phase-II upgrade to comply with the new trigger and read-out scheme at the HL-LHC. A new amplifier shaper discriminator chip was developed in 130 nm Global Foundries technology for this upgrade. A preproduction of 7500 chips was launched in 2019 and tested in 2020. The presentation will summarize the functionality of the new ASD chip, the test set-up and testing procedure as well as the test results which show a production yield of 93%. Based on the successful test of the preproduction chip the serial production of 80,000 chips was carried out in fall 2020.

T 96.5 Thu 17:00 Tu

Ongoing upgrade activities for the CMS DT system — •Dmitry Eliseev, Thomas Hebbeker, and Markus Merschmeyer — III. Physics Institute A, RWTH Aachen University

The Drift Tube (DT) system is a muon detection system located in the barrel region of the Compact Muon Solenoid (CMS) experiment. The DT system is a combination of numerous gas detector cells (DT cells) grouped within bigger units (DT chambers). In preparation for the LHC's High-Luminosity phase a number of upgrades are taking place for the DT system. Although the core hardware of the DT chambers will remain the same for the High-Luminosity phase, numerous improvements are provided for the DT signal acquisition chain. The upgrade involves replacing particular components in the data acquisition chain, as well as an essential change to the structure of this chain. These improvements result in a higher acquisition rate and a more advanced triggering.

This talk covers particular upgrade activities for the DT system: new structure of the DT acquisition chain, design and operation of the

involved components. Special focus is given to the design of the On-Board DT (OBDT) electronics, located in a dedicated compartment of each DT chamber. The OBDT acquires multiple parallel signals from front-end circuits of every DT cell of the chamber. The OBDTs are then sending the data containing the full information of the muon hits from the DT chambers to the trigger and DAQ systems.

Current status of the upgrade activities, functional tests, hard- and software verification tests are covered in the talk as well.

T 96.6 Thu 17:15 Tu

Downstream tracking in the first stage of the upgraded LHCb trigger system — •Lukas Calefice[1,2], Johannes Albrecht[1], and Vladimir Gligorov[2] — [1]Experimentelle Physik 5, Technische Universität Dortmund — [2]Sorbonne Université, LPNHE/CNRS, Paris

The LHCb experiment is undergoing a major upgrade that will allow data taking at a five times higher instantaneous luminosity during the next run of the LHC. The upgrade equips the LHCb detector with a complete set of new tracking detectors to deal with the higher occupancy in the detector and increased radiation damage. Furtermore, the first hardware-based trigger stage will be removed. The LHCb trigger system is therefore redesigned to be able to process the higher data rate and make decisions in real time by moving to a GPU-based solution for a partial online event reconstruction in the first trigger stage.

Decay modes involving particles decaying downstream of the vertex locator can be found throughout the entire LHCb physics program. Particular interest evolved in very rare decays of kaons and the extension of $b \to sll$ transitions to the baryon sector. Enabling a downstream tracking in the first stage of the upgraded trigger system will show a large impact on the efficiencies of these modes.

This talk will cover the GPU implementation of the downstream tracking algorithm and give an outlook focusing on the implications for rare beauty and strange hadron decays.

T 96.7 Thu 17:30 Tu

Real-time reconstruction for the LHCb upgrade — •Peilian Li for the LHCb-Collaboration — Heidelberg University, Heidelberg, Germany

In 2022, the upgraded LHCb experiment will begin data taking with an instantaneous luminosity increased by a factor of five, from $4{\times}10^{32}$ to $2 \times 10^{33}\ cm^{-1}s^{-1}$. The lowest level trigger in previous runs, a hardware-based trigger will be removed, requiring the first stage of the software trigger to process events at the non-empty LHC bunch-crossing rate of 30 MHz instead of the previous rate of 1 MHz. To cope with the unprecedentedly high event rate, an offline-quality real-time reconstruction is implemented in the second stage of the software trigger, with the integration of a real-time alignment and calibration. Thus the analysis will be performed on physics objects produced directly at the trigger level. This gives fast access to the data without the need for reprocessing and allows to store only objects relevant for specific analysis, which in turn significantly reduces the size of the stored events.

In this talk, we present an overview of the LHCb trigger to be used during Run 3 and its performance.

T 97: Experimental techniques in astroparticle physics IV

Time: Thursday 16:00–18:30 Location: Tv

T 97.1 Thu 16:00 Tv

Characterization of Wavelength Shifters for Rare-Event Search Experiments at Low Temperatures — •Andreas Leonhardt[1], Gabriela R. Araujo[2], Patrick Krause[1], Laszlo Papp[1], Tina R. Pollmann[3], Stefan Schönert[1], and Andreas Ulrich[1] — [1]Physik Department, Technische Universität München, Garching, Germany — [2]Physik-Institut, Universität Zürich, Zurich, Switzerland — [3]Nikhef National Institute for Subatomic Physic, University of Amsterdam, Amsterdam, Netherlands

Rare-event search experiments commonly use liquid argon (LAr) as target or instrumented shielding medium. Particle interactions in LAr produce vacuum-ultraviolet (VUV) light flashes with a peak at 128 nm. To enable commercially available photodetectors to detect the scintillation light, it has to be shifted to longer wavelengths. The characterization of wavelength shifting materials is difficult due to the low LAr scintillation wavelength that requires VUV optics in vacuum, and due to the low temperatures the sample must have so that the results are relevant to operation in LAr. We present the wavelength-shifting efficiencies of common wavelength-shifters measured at 128 nm excitation, and the custom fluorometer built to make these measurements. The fluorometer consists of a high-intensity deuterium light source coupled to a VUV monochromator and vacuum-tight sample chamber. Both the wavelength-integrated and wavelength-resolved fluorescence yield can be measured. We also describe an ongoing upgrade of the setup that will enable the samples to be cooled to LAr temperature.

T 97.2 Thu 16:15 Tv

Towards Detecting Terrestrial Gamma-Ray Flashes with the Pierre Auger Observatory — •Martin Schimassek, Darko Veberič, and Ralph Engel for the Pierre Auger-Collaboration — Karlsruhe Institute of Technology

Terrestrial gamma-ray flashes (TGFs) are short bursts of MeV gamma-rays originating from within thunderstorms. TGFs were discovered by satellite experiments nearly two decades ago. To this day the detection of the same phenomena on the ground still remains challenging. The attenuation of gamma-rays near the ground is large, thus limiting the detection range. In addition, the statistics is very limited, as covering sufficiently large areas with sensitive instruments is expensive.

However, cosmic-ray observatories, like the Pierre Auger Observatory, have sensitive detectors deployed over large areas opening up the possibility of observing these events. For cosmic-ray observatories, the difficulty in measuring TGFs is the design of the data-taking system that is not targeted towards working in thunderstorm conditions and detecting long lasting gamma-ray emission.

In this contribution, we summarize the current abilities of the Pierre Auger Observatory to take data during thunderstorms and comment on the observations of candidate events obtained so far. Additionally, we highlight the possibilities for future improvements both on the existing hardware and on the upgraded electronics that is currently deployed.

T 97.3 Thu 16:30 Tv

Performance analysis of new PMTs and light guide systems at the Fluorescence Detector of the Pierre Auger Observatory — •Urs Grosse-Rhode for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Deutschland

The Fluorescence Telescopes at the Pierre Auger Observatory are used to measure the fluorescence light produced by extensive air showers. Each camera of the telescopes consists of 440 PMTs in the focal plane of a 12m* mirror. To study the performance of a new generation of PMTs, one camera has been partially equipped with two new PMT types and an new light guide system. Different PMT types and their performances will be compared. The analysis uses a reference calibration executed at the camera and laser shots which are fired into the atmosphere at low inclination passing by the telescopes. Also the recently launched Aeolus satellite introduced a new opportunity, providing laser shots into the Observatorys field of view, which trigger the Fluorescence Telescopes. An overview of the used methods for the fluorescence detectors performance analysis as well as results from the aeolus analysis will be presented. *Gefördert durch die BMBF Verbundforschung Astroteilchenphysik(Vorhaben 05A17PX1)*

T 97.4 Thu 16:45 Tv

Absolute calibration of the light source for the end-to-end calibration of the Fluorescence Detector of the Pierre Auger Observatory* — •Tobias Heibges — Bergische Universität Wuppertal, Gaußstraße 20 42119, Wuppertal, Deutschland

The accuracy of the cosmic ray energy reconstruction by the Fluorescence Detectors is the most crucial part of the hybrid detection method used at the Pierre Auger Observatory. Because of this the absolute calibration of the Fluorescence Telescopes is vitally important, since it determines the energy scale of the Observatory. The previous calibration method was carried out infrequently, due to its difficulty and high manpower requirements. To address this issue, a new XY-Scanner cal-

ibration system is being installed. It consists of a small isotropic light source, which is scanned across the front of the telescope and emits short light pulses at several known locations.

To calibrate the telescope with these light pulses, an exact measurement of the emitted intensity and angular profile of each pulse is needed. For this purpose a calibration test bench was designed, combining the measurements of a calibrated photo-diode and a photomultiplier tube. With the addition of precision rotation and translation stages it now also allows for angular profile measurements. An uncertainty of $< 4\%$ has been achieved with potential for further reductionsin the near future. The setup, operation and analysis of data takenfrom this bench are the main focus of this talk.

Supported by the BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A17PX1 und 05A20PX1).

T 97.5 Thu 17:00 Tv

Absolute energy calibration of the Fluorescence Detectors at the Pierre Auger Observatory with a roving laser system* — •Alina Nasr Esfahani for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, Wuppertal, Germany

The Fluorescence Detector (FD) of the Pierre Auger Observatory provides a nearly model independent measurement of the energy of primary cosmic rays. This FD energy measurement is used to calibrate the energy reconstruction of the Surface Detector. The precision of the FD energy calibration therefore factors into the systematic uncertainties of practically all scientific results from the Observatory. A precise calibration can be achieved by firing a laser with known energy output in front of the FD telescopes. The advantage of such a method is that the camera response to the laser closely mimics its response to a real cosmic ray shower in a way which can not be duplicated by other calibration techniques. Thorough work has been put into the design of the system and its components. The important aspects of mean energy, wavelength and stability have been tested with simulations. Special care has also been given with regard to the de-polarization of the beam to ensure a reliable correlation between output energy and directional light yield. Additionally a telescope mount is used to steer the laser to allow for inclined shots. This talk will focus on the design requirements of a roving laser system and outline plans for measurement campaigns.
**Supported by the BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A20PX1).*

T 97.6 Thu 17:15 Tv

Calibration of the Auger Radio Detector using the Galactic Emission — •Max Büsken for the Pierre Auger-Collaboration — Institut für Experimentelle Teilchenphysik, Karlsruher Institut für Technologie

The Pierre Auger Observatory is the largest ground-based experiment for the detection of cosmic rays up to the highest energies. These cosmic rays initiate extensive air showers, whose properties are measured by several different detectors. Among other things there is particular interest in determining the mass composition of the primary particles. New radio antennas will be installed on each of the surface detector stations as part of the AugerPrime upgrade. This will expand mass composition studies to air showers with high inclinations of zenith angles beyond 70°.

An absolute calibration of the deployed antennas is necessary in order to exploit the maximum potential of the new radio detector. In this talk I will explain the procedure to apply the absolute calibration by using the most dominant background signal, which is the emission by our own galaxy, the Milky Way. The comparison of noise traces in the antennas with the expected background signal from simulations allows for the determination of frequency dependent calibration factors. The treatment of sources of uncertainties will be presented in this talk as well.

T 97.7 Thu 17:30 Tv

A simulation study for application of the Forward Folding Method to data of the Radio Detector of AugerPrime — •Sara Martinelli for the Pierre Auger-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology

The Radio Detector of AugerPrime - the Pierre Auger Observatory's upgrade - will allow to increase the sky coverage for composition sensitive measurements of showers having energies up to 10^{20} eV. Combining the radiation energy estimated through the radio-event reconstruction and the muon number obtained through the Auger water-Cherenkov detector array will enable the mass composition studies for inclined showers beyond 60°.

My presentation will address the so-called *Forward Folding*, a 3D electric-field vector reconstruction-method for radio signals, which is based on the fit of the voltage traces by an analytic signal model. The application of the previously developed method will be evaluated for inclined showers in the 30-80 MHz frequency band. During the talk, the potential improvement of the estimation of the uncertainties on the radiation energy obtainable by employing *Forward Folding* will be discussed, too. The latter, strongly relies on the recovery of the vertical component of the electric-field, which is typically most affected by noise.

T 97.8 Thu 17:45 Tv

The LEGEND Liquid Argon Monitoring Apparatus (LLAMA) — •Mario Schwarz, Patrick Krause, Laszlo Papp, and Stefan Schönert — Physik-Department, Technische Universität München, Garching

Large volume liquid argon (LAr) scintillation detectors require a precise assessment of key optical parameters for rigid signal predictions and proper data interpretation. Considering neutrinoless double beta decay experiments, both the state-of-the-art GERDA experiment as well as the next-generation LEGEND 200 and 1000 detectors use LAr scintillation light read-out as part of their active veto system. Modeling the LAr veto efficiency requires knowledge of the optical parameters in LAr, which depend on the actual impurity concentrations in the liquid. To this end, a dedicated setup has been designed for in-situ measurements of the light yield, the triplet lifetime and the attenuation length valid for the 128 nm primary emission wavelength. The setup will monitor the LAr in the LEGEND 200 cryostat, where it resides permanently. Ahead of its successful installation in the cryostat, in the scope of a one-time measurement campaign, LLAMA measured optical properties of the LAr in GERDA.

An overview of LLAMA and preliminary results of the measurements in the GERDA cryostat are presented as well as data obtained at TUM. The work has been supported in part by the German Federal Ministry for Education and Research (BMBF) Verbundforschung.

T 97.9 Thu 18:00 Tv

Liquid Argon Purification for LEGEND-200 — •Christoph Vogl[1], Malgorzata Haranczykl[2], Patrick Krause[1], Tomasz Mroz[2], Laszlo Papp[1], Stefan Schönert[1], and Grzegorz Zuzel[2] — [1]Physik Department, Technische Universität München, Garching — [2]Institute of Physics, Jagiellonian University, Krakow, Poland

Experiments searching for rare events frequently use liquid argon (LAr) as scintillating detection medium. The first phase of the Large Enriched Germanium Experiment for Neutrinoless double beta Decay (LEGEND), L200, is currently being commissioned. Up to 200 kg of bare germanium detectors will be deployed in LAr. The LAr will serve as cooling medium as well as passive shielding and will be instrumented to serve as a detector by itself. The instrumentation is composed of light guiding fibers connected to silicon photomultipliers detecting scintillation light. The scintillation properties of LAr are worsened by electronegative impurities in the argon such as oxygen, water and nitrogen due to quenching and absorption processes. To reduce the amount of impurities, a pre-loading liquid-phase argon purification system was designed and is currently being tested and commissioned. In this talk, the current status of the system is presented. This work has been supported in part by the German Federal Ministry for Education and Research (BMBF).

T 97.10 Thu 18:15 Tv

Background Rejection with the Liquid Argon Instrumentation of LEGEND-200 — •Patrick Krause[1], Maria Fomina[2], Konstantin Gusev[2], Jozsef Janiscko-Csathy[1,3], Stefan Schönert[1], Mario Schwarz[1], Egor Shevchik[2], and Christoph Wiesinger[1] — [1]Physik-Department, Technische Universität München, Garching — [2]Joint Institute for Nuclear Research, Dubna, Russia — [3]now at Semilab Semiconductor Physics Laboratory Co. Ltd., Budapest, Hungary

The LEGEND Collaboration aims to develop a phased, ^{76}Ge-based double-beta decay experimental program with discovery potential at a half-life beyond 10^{28} years. The first Phase, LEGEND-200, targets a discovery potential of 10^{27} years by aiming at a background index of $2 \cdot 10^{-4}$ cts/(keV·kg·yr). Based on the success in GERDA a liquid argon (LAr) detector system will be deployed. It will offer secondary event information which will allow the identification of background events. The system utilizes the property of LAr to scintillate upon the interaction with ionizing radiation. The emitted vacuum ultraviolet

light is shifted to the optical spectrum and read out by silicon photomultipliers mounted at the end of optical fibers. The design of the LEGEND-200 LAr instrumentation will be presented and discussed with special emphasis on what was learned from the GERDA LAr instrumentation. This work has been supported in part by the BMBF Verbundforschung (05A20WO2).

T 98: General assembly - Particle Physics Division (for DPG members)

Time: Thursday 19:00–21:00 Location: Ta

General Assembly - Mitgliederversammlung

T 99: Hauptvorträge (Invited Talks) IV

Time: Friday 9:45–12:30 Location: Tb

Invited Talk T 99.1 Fri 9:45 Tb

Probing the neutrino mass scale with the KATRIN experiment — •Kathrin Valerius — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany

Precision measurements of the kinematics of weak decays offer a direct and nearly model-independent approach to probe the absolute neutrino mass scale. The KArlsruhe TRItium Neutrino experiment (KATRIN) is searching for the minute imprint of the neutrino mass in the endpoint region of the tritium beta-decay spectrum. KATRIN employs a high-intensity gaseous molecular tritium source and a high-resolution electrostatic filter with magnetic adiabatic collimation to target a neutrino-mass sensitivity of $0.2\,\mathrm{eV/c^2}$, thus improving on previous experiments by an order of magnitude, after five years of data-taking.

With just its first science run, KATRIN has tightened previous direct neutrino mass bounds by about a factor of two, yielding a new upper limit of $1.1\,\mathrm{eV/c^2}$ (90% CL), and has begun to address further science channels such as the direct search for light sterile neutrinos. As larger data sets are collected and further improvements in terms of signal-to-background ratio and systematics are being achieved, KATRIN is continuing along its path towards sub-eV neutrino-mass sensitivity and the exploration of interesting BSM physics cases.

Coffee Break 30 min

Invited Talk T 99.2 Fri 11:00 Tb

The quest for precise LHC predictions — •Jonas Lindert — University of Sussex, Brighton, UK

The continuous improvement of statistics and experimental systematics at the Large Hadron Collider permits to challenge the Standard Model (SM) of particle physics at steadily increasing levels of energy and precision. In this context, the uncertainty of theoretical predictions starts to play a decisive role in many areas of the physics program at the LHC. This provides a strong motivation to push theoretical predictions towards more complex processes and higher perturbative orders including both QCD and electroweak corrections.

In this talk, I will summarise the current status of SM probes and will introduce several related theoretical challenges. I will briefly review the recent progress in perturbative calculations at the precision frontier, followed by a discussion of crucial applications to Higgs physics, EW physics, top-quark physics and to background predictions in new-physics searches at the LHC.

Invited Talk T 99.3 Fri 11:45 Tb

European Strategy for Particle Physics: towards the next collider at CERN — •Ursula Bassler — IN2P3 - CNRS, Paris, France

In June 2020, CERN Council updated for the third time the European Strategy of Particle Physics after 2 years of preparatory work by the particle physics community from all over the world and scientific leaders from the CERN member states. After the publication of the Strategy, newspaper headlines reported prominently on the possible construction of a 100km Collider as CERN's next flagship project. Yet, the implementation of such a project requires in-depth feasibility studies in various areas before a possible approval. This presentation aims to work out the nuances in the Strategy Paper, the physics questions discussed to converge to the Strategy and the challenges ahead of a future collider project at CERN. Some emphasis will also be given to transvers considerations of the field, such as Education and Public Engagement, Early Careers, Diversity, Sustainability and Technology Transfer.