T 28: Higgs-Zerfälle in Fermionen I

Zeit: Dienstag 16:00–18:35 Raum: H04

Gruppenbericht T 28.1 Di 16:00 H04

Higgs physics in the $\tau\tau$ final state — Janek Bechtel, Sebastian Brommer, Maximilian Burkart, Artur Gottmann, Guenter Quast, Roger Wolf, •Sebastian Wozniewski, and Stefan Wunsch — Karlsruhe Institute of Technology, Karlsruhe, Germany

The $\tau\tau$ final state allows for highly relevant investigations the Higgs sector in the context of the standard model (SM) and models beyond the SM, like the MSSM. This talk summarizes recent milestones on the way to an LHC Run II legacy result in Higgs to $\tau\tau$ analyses of CMS, both in the SM and MSSM context. The focus is on the ongoing SM analysis based on a machine-learning approach, published developments of the τ-embedding technique and the ongoing efforts in searches for additional heavy Higgs bosons in the MSSM and general 2HDMs.

T 28.2 Di 16:20 H04

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

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 $\sim 140\,\mathrm{fb}^{-1}$ 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 28.3 Di 16:35 H04

Observation of $H \to b\bar{b}$ decay with the CMS experiment — •Luca Mastrolorenzo and Alexander Schmidt — RWTH Aachen University - III. Physikalisches Institut A

The first observation of the Higgs boson decay into a bottom and antibottom quarks by the ATLAS and CMS Collaboration in summer 2018 represents a discovery of major importance towards the characterization of the Yukawa couplings. Even though this decay channel is the one with the highest predicted branching fraction, the detection of such events is extremely challenging at a hadron collider environment because the overwhelming production of hadronic jets from QCD events. In order to maximise the sensitivity to the $H \to b\bar{b}$ signal, sophisticated analysis techniques have been deployed relying on the exploitation of Deep Neural Networks along the whole analysis chain. In this talk, the CMS observation of the $H \to b\bar{b}$ decay will be presented focussing on the analysis of the data collected by the experiment during the 2017 Run of the LHC and targeting the identification of events where a Higgs boson is produced in association with a vector boson.

T 28.4 Di 16:50 H04

Search for Higgs-boson pair production in the $bb\tau_{\mathbf{lep}}\tau_{\mathbf{lep}}$ decay channel with the ATLAS detector — •Benjamin Rottler, Kathrin Becker, 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 measured via non-resonant Higgs-boson pair production, which can happen at the LHC via the destructively interfering top-loop and Higgs self-interaction diagrams. Furthermore, this process is sensitive to new heavy particles.

The goal of this analysis is to measure the cross-section of the non-resonant Higgs-boson pair production using the full Run-2 dataset corresponding to an integrated luminosity of $\sim$140 fb^{-1} at $\sqrt{s} = 13$ TeV. This is done via the $HH \to bb\tau\tau$ process, which combines the high branching ratio of the $H \to bb$ decay and the good trigger efficiency of the $H \to \tau\tau$ decay. Our focus is the study of the $HH \to bb(\tau\tau \to 2\ell 4\nu)$ decay channel, which has not been investigated so far. We expect this decay channel to give a sizeable contribution to the sensitivity of the measurement due to the highly efficient lepton triggers and the different topologies of the signal and background processes. Our plan is to incorporate modern machine learning technologies like deep neural networks (DNNs) in the analysis.

T 28.5 Di 17:05 H04

Search for a SM Higgs boson decaying to a pair of muons in associated production with a gauge boson — •Tobias Kramer, Oliver Rieger, and Peter Schleper — Institut für Experimentalphysik, Universität Hamburg

A search for the Standard Model Higgs boson decaying to a pair of muons is presented. The focus of this analysis is on Higgs production in association with W and Z bosons. The full Run 2 data collected at the CMS experiment from 2016-2018 at a center of mass energy of $\sqrt{s} = 13$ TeV are used. Events with at least two oppositely charged muons as well as at least one additional lepton, supposedly originating from the gauge boson, are selected. This selection reduces the dominant Drell Yan background events as they do not contain a prompt third lepton. Because of the low signal yields in these Higgs decay channels, it is important to achieve a high signal efficiency while suppressing background contributions. Studies to this end are presented, including final state radiation photon recovery and multivariate prompt lepton identification.

T 28.6 Di 17:20 H04

Constraints on the Higgs self-coupling from searches for Higgs boson pairs in the $b\bar{b}\tau^+\tau^-$ final state with the ATLAS detector and prospects at the High-Luminosity LHC — •Petar Bokan[1,2], Stan Lai[1], Arnaud Ferrari[2], and Jason Veatch[1] — [1]University of Göttingen — [2]Uppsala University

After the discovery of the Higgs boson, the ultimate test of the electroweak symmetry breaking is to establish Higgs self-coupling by searching for pairs of Higgs bosons.

A search for non-resonant Higgs boson pair production in the $b\bar{b}\tau^+\tau^-$ channel is presented for 36.1 fb^{-1} of $\sqrt{s} = 13$ TeV data recorded at the ATLAS experiment at the Large Hadron Collider (LHC). The analysis considers the semi-leptonic and fully hadronic di-τ final states. The observed (expected) upper limit on the non-resonant Higgs boson pair production cross-section times branching ratio corresponds to 12.7 (14.8) times the predicted Standard Model cross-section. The ratio of the Higgs boson self-coupling to its Standard Model expectation, κ_λ, is observed (expected) to be constrained at 95% confidence level to $-7.3 < \kappa_\lambda < 15.7$ ($-8.8 < \kappa_\lambda < 16.7$).

Furthermore the sensitivity is extrapolated to a 14 TeV center-of-mass energy and 3000 fb^{-1}, which is the target integrated luminosity of the High-Luminosity LHC. Various extrapolation assumptions are presented in this talk.

T 28.7 Di 17:35 H04

Search for lepton-flavour violating decays of the Higgs-boson using the asymmetry method with the ATLAS experiment at $\sqrt{s} = 13$ TeV — •Katharina Schleicher, Kathrin Becker, and Markus Schumacher — Albert-Ludwigs-Universität Freiburg

After the discovery of the Higgs boson the search for lepton-flavour violating (LFV) couplings is an interesting topic. These are predicted in several models, including supersymmetric extensions of the standard model (SM) and in general two-higgs-dublet models. In nature, LFV was already observed in form of neutrino oscillations.

Possible LFV decays in the Higgs-sector are $H \to e\mu$, $H \to \tau e$ and $H \to \tau\mu$. In this analysis only the decays of $H \to \tau e$ and $H \to \tau\mu$ with leptonic τ-decays leading to $e\mu + X$ final states are considered. For background estimation the asymmetry method is utilized. It exploits two principles: First, SM backgrounds with prompt leptons are

symmetric with respect to a replacement of electrons with muons and vice versa. And second, this symmetry is broken when assuming that the branching ratios of the two considered LFV decays are of different magnitude.

One challenge of the analysis is to maintain this symmetry despite the experimental differences of electrons and muons. Another challenge is to enhance the sensitivity. Therefore, a dedicated statistical model and a multivariate analysis are developed.

The analysis is performed on data recorded in proton-proton collisions with the ATLAS detector at $\sqrt{s} = 13$ TeV.

T 28.8 Di 17:50 H04

Constraining Higgs CP properties using $H \to \tau\tau$ decays — •Alina Manthei, Peter Wagner, Maike Hansen, Christian Grefe, Philip Bechtle, and Klaus Desch — Physikalisches Institut Universität Bonn

In 2012, the discovery of a resonance featuring properties consistent with those of the Higgs boson affirmed the theory of the Higgs mechanism, an essential component of the Standard Model of Particle Physics. The latter predicts the Higgs boson to be CP even. Although measurements revealed that the Higgs cannot be fully CP odd, the existence of a CP-mixed Higgs cannot be ruled out, which can be considered as an indication of physics beyond the Standard Model. Only in the case of the coupling to fermions, it is possible to define a model-independent observable that allows to distinguish between the different CP scenarios. Due to the large QCD background in the channel $H \to b\bar{b}$, this analysis makes use of the decay to τ leptons, the next to heaviest fermionic decay products of the Higgs boson. Due to the short lifetime of the τ, it immediately decays further so that only its decay products can be detected. By examining the decay of the τ lepton to only one charged prong, an angle between the two decay planes of the τs can be defined, an observable that serves to determine the CP phase in the coupling of the Higgs to the two τs. Via the measurement of this angle, the transverse spin correlations can be studied and a mixing angle between the CP even and CP odd states can be extracted. The state of the measurement descibed above will be presented and an outlook towards further steps will be given.

T 28.9 Di 18:05 H04

Test of CP invariance in vector-boson fusion production of the Higgs boson using $H \to \tau_{lep}\tau_{lep}$ decays at $\sqrt{s} = 13$ TeV with the ATLAS detector — Kathrin Becker, •Alena Lösle, and Markus Schumacher — Physikalisches Institut, Universität Freiburg

Violation of CP invariance is one of the Sakharov conditions to explain the observed baryon asymmetry in our universe. While CP violation is already realised in the Standard Model via the CKM matrix, it is not sufficient to explain the amount of observed baryon asymmetry. Hence, it is interesting to search for new sources of CP violation in the Higgs sector. The vector-boson fusion production allows to investigate the CP structure of the Higgs-boson coupling to electroweak gauge bosons and to test CP invariance in this interaction.
The analysis discussed in this talk is performed in the $H \to \tau_{lep}\tau_{lep}$ decay channel and uses the CP-odd *Optimal Observable*. First combined results with the semi-leptonic and fully-hadronic finally state based on data taken by the ATLAS detector at $\sqrt{s} = 13$ TeV corresponding to an integrated luminosity of 36.1 fb^{-1} are presented.

T 28.10 Di 18:20 H04

Measurement of $H \to \tau_{\text{had}}\tau_{\text{had}}$ at $\sqrt{s} = 13$ TeV with the ATLAS Experiment — •Timo Dreyer, Stan Lai, and Michel Janus — Georg-August-Universität Göttingen

The $H \to \tau\tau$ process is currently the only observed leptonic decay channel of the Higgs boson at the LHC. The ATLAS experiment performed a cut based analysis in this decay channel on 36.1 fb^{-1} of data collected in 2015 and 2016 at $\sqrt{s} = 13$ TeV, measuring the cross section times branching ratio for $pp \to H \to \tau\tau$.

The process is divided in sub-channels according to the decay of the τ-leptons into lighter leptons or hadrons. The Higgs production cross sections for the gluon gluon fusion and vector boson fusion production modes are extracted from a maximum likelihood fit to data on the distribution of the reconstructed mass $m_{\tau\tau}$ from the two τ-leptons.

This talk will discuss the recently published ATLAS results with a focus on the di-hadronic sub-channel and give an outlook for the analysis on the full 13 TeV dataset