T 47: Higgs Physics V

Time: Wednesday 16:15–18:15 Location: KH 00.014

T 47.1 Wed 16:15 KH 00.014

Top-Yukawa- and Light-Quark-Induced Electroweak Corrections in Higgs Pair Production — Arunima Bhattacharya[1], Francisco Campanario[1], •Sauro Carlotti[2], Jamie Chang[3], Javier Mazzitelli[3], Milada Margarete Mühlleitner[2], Jonathan Ronca[4], and Michael Spira[3] — [1]University of Valencia-CSIC, Spain — [2]Karlsruher Institut für Technologie, Germany — [3]Paul Scherrer Institut, Switzerland — [4]University of Padua, Italy

Since the discovery of the Higgs boson in 2012, the measurements of the Higgs self coupling remains a major challenge for current and future experiments in particle physics. Current projections for the trilinear coupling measurements at HL-LHC, and next generation of colliders, require the experimental precision to be matched by theory predictions. This necessitates besides the QCD corrections, which are found to be large, also the electroweak corrections (EW). The NLO corrections involve evaluation of two-loop Feynman diagrams. The EW corrections are a true challenge for the numerical solution of the two-loop integrals due to the presence of many different mass scales, such as the gauge boson, bottom, top quark, and Higgs boson masses. Additional challenges arise from numerical instabilities near virtual thresholds, which require a careful treatment. In my talk, I will present results for the EW corrections induced by the top Yukawa coupling, including contributions from light-quark loops, without using any reduction techniques to master integrals. All calculations are performed with fully symbolic masses while maintaining a manageable code size, enabling future studies of parametric and mass-scheme/scale uncertainties.

T 47.2 Wed 16:30 KH 00.014

Search for non-resonant Higgs boson pair production in $\mathrm{bb}\tau\tau$ **final states with the CMS experiment** — •Simon Daigler, Jan Voss, Nikita Shadskyi, Artur Gottmann, Roger Wolf, and Markus Klute — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technol-ogy (KIT)

Our preparation of a search for non-resonant Higgs boson pair production in $\mathrm{bb}\tau\tau$ final states is presented. A first setup of the analysis is based on the well-understood data of the LHC Run-2, of the year 2018, which have been completely re-reconstructed by the CMS Collaboration. The $\mathrm{e}\tau_\mathrm{h}$, $\mu\tau_\mathrm{h}$, and $\tau_\mathrm{h}\tau_\mathrm{h}$ final states are analysed. Event classification is based on neural network multi-class classification. The sensitivity is compared to a previous publication of CMS.

T 47.3 Wed 16:45 KH 00.014

Status of the $HH \to \bar{b}b\tau^-\tau^+$ **anaylsis with the CMS experiment with Run 3 data** — •Ana Andrade, Bogdan Wiederspan, Nathan Prouvost, Marcel Rieger, Moritz Wolf, Tobias Kramer, Quintus Diepholz, Benjamin Le, Jonah Fischer, and Peter Schleper — University of Hamburg

The shape of the Higgs potential plays a crucial role in our understanding of vacuum stability. The potential is directly dependent on the Higgs boson self-coupling which, despite continuous efforts, has yet to be experimentally determined. One way to probe its existence is through double Higgs boson production, where one Higgs boson can directly decay into two Higgs bosons. The predicted cross-section of such a decay depends on the self-coupling strength and can therefore be probed with experimental data. The $\bar{b}b\tau^-\tau^+$ final state is a promising candidate to perform such a search, as it offers a good compromise between sufficient statistics and reasonably low background contamination.

This talk summarizes the current status of the $HH \to \bar{b}b\tau^-\tau^+$ analysis with Run 3 data recorded by the CMS experiment at a center-of-mass energy of $\sqrt{s} = 13.6$ TeV. The techniques employed in background estimation, signal extraction, and statistical inference will be discussed, amongst other developments. Particularly, we will present recent work in the discriminator network which enhances the search sensitivity.

T 47.4 Wed 17:00 KH 00.014

Statistical analysis for the $HH \to b\bar{b}\tau^+\tau^-$ **analysis with the ATLAS detector** — •Pim Bijl, Karl Jakobs, Brian Moser, Benedict Winter, and Yingjie Wei — University of Freiburg, Freiburg im Breisgau, Germany

Di-Higgs production at the Large Hadron Collider (LHC) allows to directly measure the Higgs boson self-coupling and, in turn, the shape of the Higgs potential. This talk will present studies performed for the statistical analysis used to measure or establish limits on the di-Higgs signal strength in the $HH \to b\bar{b}\tau^+\tau^-$ decay channel, using the combined LHC Run 2 and partial Run 3 datasets of up to 191 fb^{-1} collected by the ATLAS experiment. This decay channel has one of the largest branching ratios of di-Higgs decays and provides a clean decay signature. Because di-Higgs production is expected to be a very small signal, the statistical analysis makes use of pseudo-experiments which serve to validate results of the analysis.

T 47.5 Wed 17:15 KH 00.014

Neural network classifier strategy for optimal Higgs boson self-coupling sensitivity in the CMS $HH \to bb\tau\tau$ **analysis** — Ana Andrade, •Benjamin Le, Bogdan Wiederspan, Marcel Rieger, Moritz Jonas Wolf, Nathan Prouvost, Peter Scleper, and Tobias Kramer — University of Hamburg

The Standard Model (SM) of particle physics remains one of the most accurate theories describing the universes matter and its fundamental interactions at the smallest scales. One prediction that is yet to be fully tested is the self-interaction of the Higgs boson, characterized by the trilinear coupling strength λ, which gives rise to the shape of the Higgs potential. Typical analysis strategies involve neural networks for signal-background classification, often trained with simulated signal events following the SM prediction for λ. However, in case the actual value of λ deviates from the SM expectation, kinematic properties are subject to change and therefore, rendering the choice of λ used during training suboptimal. This talk summarizes a study that addresses this challenge by exploring different neural network strategies, enhancing the sensitivity to a wide range of hypothetical self-coupling values.

T 47.6 Wed 17:30 KH 00.014

Searching for Higgs boson pair production in the $HH \to bb\tau\tau$ **channel with the ATLAS experiment** — •Katharina Häussler, Karl Jakobs, Brian Moser, Yingjie Wei, Christian Weiser, and Benedict Winter — University of Freiburg

The Standard Model (SM) predicts final states with multiple Higgs bosons, which have yet to be observed experimentally, to occur in proton-proton collisions at the LHC. The production of Higgs boson pairs is interesting especially because it provides a direct test of triple Higgs boson self-interactions. The $bb\tau\tau$ final state presents a good compromise between expected signal yields and background contamination, making it one of the golden channels to explore this phenomenon.

This talk presents the current ATLAS $HH \to bb\tau\tau$ analysis with a focus on the estimation of the background stemming from Z bosons produced in association with heavy flavour jets, which is a major background for the analysis.

T 47.7 Wed 17:45 KH 00.014

Estimation of the Background from $t\bar{t}$ **Events with Misidentified Tau Leptons in the Search for Di-Higgs Production in the** $bb\tau_\mathrm{had}\tau_\mathrm{had}$ **Channel with the ATLAS Detector** — •Baktash Amini, Brian Moser, Yingjie Wei, Christian Weiser, Benedict Tobias Winter, and Karl Jakobs — Albert-Ludwigs-Universität Freiburg

Interactions involving multiple Higgs bosons in the final state are yet to be observed. Higgs boson pair production via gluon-gluon fusion or vector-boson fusion involves tri-linear couplings of Higgs bosons providing a unique opportunity to observe the self-coupling at the LHC and to test the Standard Model. Thanks to a good balance of signal yields and signal purity, di-Higgs boson production with one Higgs boson decaying into two b-quarks and the other into two tau leptons is one of the best channels to observe this process. The second-largest background in the $HH \to bb\tau\tau$ analysis is top pair production, where at least one quark- or gluon-initiated jet is misidentified as a hadronic tau decay. This background is estimated via a data-driven scale-factor method. The talk presents this method for the analysis of the ATLAS Run 2 and partial Run 3 datasets.

T 47.8 Wed 18:00 KH 00.014

Studies for validating the CMS Run-3 HH $\rightarrow b\bar{b}\gamma\gamma$ analysis with ZZ $\rightarrow b\bar{b}e^{+}e^{-}$ events — Johannes Erdmann, •Lea Jakubowski, and Nitish Kumar — III. Physikalisches Institut A, RWTH Aachen University

Since its discovery, the properties of the Higgs boson have been the subject of extensive study. Of particular interest is the structure of the Higgs potential, which can be constrained by measuring the trilinear Higgs self-coupling. This coupling can be accessed via Higgs boson pair production. However, owing to the small predicted production cross-section relative to the background processes, it has yet to be observed experimentally.

A particularly promising channel for probing this interaction is the HH $\rightarrow b\bar{b}\gamma\gamma$ decay. Its sensitivity arises from the large branching fraction of H $\rightarrow b\bar{b}$, combined with the low background rates and excellent mass resolution achievable in the H $\rightarrow \gamma\gamma$ final state.

This talk presents studies for validating the CMS Run-3 nonresonant HH $\rightarrow b\bar{b}\gamma\gamma$ analysis via a well-understood Standard Model process with a similar final-state topology. The validation channel, ZZ $\rightarrow b\bar{b}e^{+}e^{-}$, is chosen due to its significantly higher cross-section compared to di-Higgs production and the similar detector signatures of electrons and photons, which yield a final-state signature closely mirroring HH $\rightarrow b\bar{b}\gamma\gamma$. By employing an analysis strategy analogous to that of the HH $\rightarrow b\bar{b}\gamma\gamma$ search, we perform studies toward a cross-section measurement of ZZ $\rightarrow b\bar{b}e^{+}e^{-}$ that aims to provide a robust validation and benchmark for the di-Higgs analysis.