T 45: Higgs Physics V (HH and Trilinear Coupling)

Time: Wednesday 16:15–18:15 Location: ZHG104

T 45.1 Wed 16:15 ZHG104

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

Interactions involving multiple Higgs bosons in the final state are yet to be observed. The di-Higgs production via gluon-gluon fusion and vector-boson fusion processes at the LHC provides a unique opportunity to study those properties and test the predictions of the Standard Model for the Higgs boson self-couplings. Thanks to a good balance of signal yield and signal purity, di-Higgs boson production with one Higgs boson decaying into two b-quarks and one into two tau leptons is one of the best channels to measure the Higgs boson self-couplings. In the $HH \to bb\tau\tau$ analysis, the second largest background is the $t\bar{t}$ fake-$\tau_{\text{had-vis}}$ process, where at least one quark- or gluon-initiated jet is misidentified as a visible tau lepton, $\tau_{\text{had-vis}}$. This background is estimated via a data-driven scale-factor method in the search for non-resonant $HH \to bb\tau_{\text{had}}\tau_{\text{had}}$ decays at the ATLAS experiment. In the talk, I will present the scale factor method for the analysis of the Run 2 and partial Run 3 datasets.

T 45.2 Wed 16:30 ZHG104

Fake-τ background estimation for the Atlas $HH \to bb\tau\tau$ analysis — •Philipp Rincke[1,2], Stan Lai[1], and Arnaud Ferrari[2] — [1]II. Physikalisches Institut, Georg-August-Universität Göttingen, Deutschland — [2]Department of Physics and Astronomy, Uppsala University, Sweden

The $HH \to bb\tau\tau$ analysis has the highest expected sensitivity to the Standard Model (SM) Higgs boson pair production signal based on the legacy Run 2 results. Several SM processes contribute to this final state as backgrounds. One of the most important backgrounds consists of processes where quark- and gluon-initiated jets are mis-identified as hadronically decaying τ leptons (fake-τ leptons), which are difficult to model precisely with simulations. A better description of these backgrounds can be achieved using data-driven methods, such as the Fake Factor method.

This talk will present the Fake Factor method which is under development for the Run 2 + Run 3 analysis to model the QCD multijet background in the $bb\tau\tau$ channel. The method relies on creating a fake-τ enriched template of events by inverting the τ lepton identification criteria. This template is then re-weighted using Fake Factors derived in control regions to model the QCD multijet background in the signal region, for which the current fake-τ background and uncertainty estimates will be shown.

T 45.3 Wed 16:45 ZHG104

Background estimation for the di-Higgs process $HH \to \bar{b}b\tau^-\tau^+$ with Run3 data from the CMS experiment — •Ana Andrade, Nathan Prouvost, Bogdan Wiederspan, Marcel Rieger, Philip Keicher, Anas Haddad, Tobias Kramer, and Peter Schleper — University of Hamburg, Hamburg, Germany

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 observed. One way to probe its existence is through double Higgs boson production, where one Higgs boson directly couples to two final state Higgs bosons. The predicted cross-section of such a decay depends on the self-coupling strength and can therefore be probed with experimental data.

Since double Higgs boson production has a cross-section several orders of magnitude smaller than that of background processes, the efforts to observe the self-coupling are heavily limited by statistics. The channel $HH \to \bar{b}b\tau^-\tau^+$ is a promising target for such analyses as it offers a good compromise between sufficient statistics and reasonable background contamination. A major challenge in background estimation stems from multi-jet events, as these are notoriously difficult to simulate. In this talk, I will present techniques to model background processes in such analyses, with Run 3 data.

T 45.4 Wed 17:00 ZHG104

Morphing Di-Higgs processes — Ana Andrade, Anas Haddad, Philip Keicher, Tobias Kramer, •Nathan Prouvost, Marcel Rieger, Peter Schleper, and Bogdan Wiederspan — Universität Hamburg

The Standard Model of particle physics is currently the most successful theory describing our understanding of elementary particles and their interactions.

Currently, the investigation of the parameters of the Higgs mechanism is of utmost interest for tests of the predictions of the Standard Model. The trilinear higgs coupling is one such parameter. One of the challenges in the statistical interpretations of these measurements is the correct parametrisation of the distributions of the discriminating observable as a function of the coupling coefficients.

This talk summarizes a study on this topic based on a search for Di-Higgs production in the $bb\tau\tau$ final state at the CMS experiment.

T 45.5 Wed 17:15 ZHG104

Streamlined Optimization Studies in the Search for Di-Higgs Boson Production in the $b\bar{b}\tau^+\tau^-$ channel at the ATLAS experiment — •Steffen Ludwig, Benedict Winter, Yingjie Wei, Christian Weiser, and Karl Jakobs — University of Freiburg, Institute of Physics, Freiburg im Breisgau, Germany

The Higgs boson has been studied at the Large Hadron Collider at CERN over the last decade with ever-increasing precision. However, one key quantity of electroweak symmetry breaking, the strength of the trilinear Higgs boson coupling, has not yet been observed due to the small Higgs pair production cross-section. A deviation of the coupling strength from the value predicted by the Standard Model would constitute an observation of new physics.

I will discuss prospects for improving the sensitivity of searches for the non-resonant production of Higgs boson pairs in the $HH \to b\bar{b}\tau^+\tau^-$ channel by using Graph Neural Networks. The study is based on the latest measurement with the Run 2 dataset using $140\,\text{fb}^{-1}$ of proton-proton collisions at a center-of-mass energy of 13 TeV, recorded by the ATLAS detector at CERN.

To study the benefits of Graph Neural Networks and transformer models on parts of the analysis, I developed an automatization and orchestration tool, called grid-pipeline, to conduct the existing analysis and its derivatives. The tool's versatility enables the elementarization of complex computing workflows and the combination of resources from multiple computing sites. This allows for a significantly improved analysis optimization workflow and reduces the turn-around time.

T 45.6 Wed 17:30 ZHG104

Analysis for Run3 in the $HHH \to b\bar{b}b\bar{b}\tau\bar{\tau}$ channel with the CMS Experiment — •Thanh Tan Nguyen, Philip Keicher, Marcel Rieger, Nathan Prouvost, Ana Andrade, Bogdan Widerspan, Tobias Kramer, and Peter Schleper — University Hamburg, Hamburg, Germany

Understanding the Higgs mechanism is currently one of the largest fields of research at the LHC. One factor in this endeavor is the measurement of the Higgs self-coupling, which defines the shape of its potential. The sensitivity to this parameter of the standard model increases with the multiplicity of Higgs bosons. This analysis focuses on the triple Higgs production at LHC, which is sensitive to both the triple and quartic self-coupling. Here, the final state of four bottom quarks and two tau leptons is chosen; it*s a compromise between high branching ratio and clearer distinction of the decay products. The current status of this analysis is presented in this talk, with a particular focus on studies on the analysis phase space definition and the derivation of discriminating observables

T 45.7 Wed 17:45 ZHG104

Search for Higgs Boson Pair Production in Multi-Lepton Final States with the ATLAS Detector — Anamika Aggarwal, Volker Büscher, Christian Schmitt, •Niklas Schmitt, and Duc Bao Ta — Johannes Gutenberg-University, Mainz

After the discovery of the Higgs boson in 2012 at the LHC, many of its properties have already been determined precisely using 139 fb^{-1} of proton-proton collisions at $\sqrt{s} = 13$ TeV. However, one of the biggest challenges in this field remains the measurement of the coupling of the Higgs boson to itself. It allows for a deep insight into the real shape of

the Higgs potential and hence has a big impact on the understanding of fundamental interactions not only at the electroweak scale. In order to constrain the trilinear self-coupling, the Di-Higgs production cross section is measured. While decay modes including b-quarks typically have larger branching fractions, leptonic final states are generally much cleaner and have less SM background. Accordingly, probing this channel as a complement to $b\bar{b}$ analyses will be very promising.

This talk will give an overview about the analysis strategy, which relies on neural networks to distinguish the signal processes from the sum of all SM backgrounds. In addition, preparations for the Run 2 + partial Run 3 analysis, based on a combined dataset of about 300 fb^{-1}, will be presented, as well as a first look at Run 3 data and comparisons to Monte Carlo.

T 45.8 Wed 18:00 ZHG104

HH Analysis with Multileptons Using Run-2 ATLAS Data — •Elizaveta Denisova and Andre Sopczak — Czech Technical University in Prague

The latest results with Run-2 ATLAS data are presented for the search HH in the multilepton channel.