T 99: Di-Higgs 3 (bbWW)

Time: Thursday 16:00–17:30 Location: Geb. 30.41: HS 1

T 99.1 Thu 16:00 Geb. 30.41: HS 1

Search for non-resonant Higgs boson pair production in dilepton final states of the bbWW decay mode at CMS — Matteo Bonanomi, Mathis Frahm, Johannes Haller, Viacheslav Kosterin, •Lara Markus, Janek Möls, Alexander Paasch, and Matthias Schröder — Insitut für Experimentalphysik, Universität Hamburg

The trilinear coupling of the Higgs boson is related to the shape of the Higgs potential, which makes it a crucial parameter of the Standard Model. The shape can be directly probed by measuring the cross-section of Higgs boson pair production.

In this talk, studies towards a search are presented for non-resonant pair production of Higgs bosons decaying into a b quark anti-quark pair and two W bosons, with subsequent decays of the W bosons into leptons and neutrinos. The analysis strategy is developed using simulated proton-proton collision data at 13 TeV center-of-mass energy at the CMS experiment. The analysis is implemented in a columnar-based framework 'columnflow'.

T 99.2 Thu 16:15 Geb. 30.41: HS 1

Conceptualization and Development of a Boosted Analysis for Run-3 for Higgs boson pair production in the 1-lepton $bbWW^*$ final state — •Lina Buschmann, Kira Abeling, and Stan Lai — II. Physikalisches Institut, Georg-August-Universität Göttingen

Since the discovery of the Higgs boson in 2012, many studies have been performed to test its properties against Standard Model (SM) predictions. In particular, a direct measurement of the Higgs self-coupling is important to characterise the Higgs potential.

Furthermore, it is known that there must be physics beyond the SM (BSM). Many BSM theories predict additional, highly massive narrow-width scalars, X, which can resonantly decay to two Higgs bosons, H, enhancing the di-Higgs cross section. Since the mass of X is not predicted by theory in this approach, a wide range of masses, m_X, is considered, resulting in various decay topologies.

In this talk, the development of a Run-3 analysis, based on the Run-2 analysis, for HH production in the boosted $b\bar{b}WW^*$ decay channel with the one lepton final state is discussed. Since only large resonant masses are considered, the jets from the W boson decay and the $b\bar{b}$ decay cannot be resolved completely. This yields a boosted topology and the decay products being collected in two back-to-back large-R jets, where the lepton overlaps with the W_{had} jet. This channel offers a fairly high branching ratio with a moderate amount of background, dominated by $t\bar{t}$ events with at least one leptonic top decay.

T 99.3 Thu 16:30 Geb. 30.41: HS 1

Search for non-resonant Higgs boson pair production in the boosted lepton+jets final state of the bbWW decay mode at CMS — Matteo Bonanomi, Mathis Frahm, Johannes Haller, Viacheslav Kosterin, Lara Markus, •Janek Möls, Alexander Paasch, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

The Higgs potential is a largely unexplored area of the Higgs mechanism. One important parameter for this potential is the Higgs boson self-coupling, since it is related to the shape of the potential. Measuring the cross section of Higgs boson pair production (HH) allows probing this parameter directly. The small HH production cross section in the Standard Model of just 33 fb at 13 TeV center-of-mass energy makes the experimental observation challenging. Analyzing the Run 3 data of the LHC detectors promises a further leap in sensitivity.

In this talk, preparatory studies towards a search for non-resonant HH production in the lepton+jets final states of the bbWW decay mode with Run 3 data of the CMS detector at the LHC are presented. Particular emphasis is placed on the impact of a separation between the resolved and boosted phase space for the Higgs boson candidates decaying into two bottom quarks.

T 99.4 Thu 16:45 Geb. 30.41: HS 1

Employing Matrix Elements with Neural Networks to Search for Higgs Self-coupling — •Christoph Ames, Otmar Biebel, Lars Linden, Celine Stauch, Edis Hrustanbegovic, Stefanie Götz, Lukas Von Stumpfeldt, and Youn Jun Cho — Ludwigs-Maximilians-Universität, München

The Higgs boson was discovered in 2012 as predicted by the Standard Model (SM); however not all of its predicted couplings have been measured. One such coupling is the Higgs self-coupling, in which a Higgs boson decays into two further Higgs bosons. By integrating over all possible initial states and by using the details of the end state, the matrix element method evaluates the weight (likelihood) of an event for the specific production cross section. In this work, machine learning is combined with the matrix element method to search for $HH \to b\bar{b}W^+W^-$ using simulated data. A neural network is trained to calculate the matrix element weight of an event and to use this to determine whether the event contains a signal or a background decay.

T 99.5 Thu 17:00 Geb. 30.41: HS 1

Employing Matrix Elements in the Search for Higgs Self-coupling — Christoph Ames, Otmar Biebel, Lars Linden, Celine Stauch, and •Edis Hrustanbegovic — Ludwigs-Maximilians-Universität, München

The Higgs boson is one of the most complex and least understood parts of the Standard Model. Even though it cleared up a lot of the questions this model posed, some of the predictions that came with it have yet to be proven by measurement. One of these predictions being the Higgs self-coupling. This coupling is especially difficult to measure, since it has a very small cross section along with background reactions that are far more common. Using the C++ software package MoMEMta the probability of a measurement aligning with the process $H \to HH \to (b\bar{b})(W^+W^-) \to (b\bar{b})((l\nu)(q'\bar{q}))$ can be calculated to determine if this decay took place, or if it is a background process. This is done by using the matrix element method, in which for the wave functions the measured particles and jets are being used to compute the cross section of the investigated process. Since the momenta of the initial partons are unknown, MoMEMta employs energy and momentum conservation to substitute the momenta of the initial partons and up to two more particles. However, the necessary Jacobian is not available for the considered HH process which, therefore, needs to be constructed from the available processes in the MoMEMta package. The challenges and the result of this implementation will be presented in this talk.

T 99.6 Thu 17:15 Geb. 30.41: HS 1

Separating $t\bar{t}$ and HH end states using neural networks — •Youn Jun Cho, Christoph Ames, Stephanie Goetz, Edis Hrustanbegovic, Lars Linden, Celine Stauch, Lukas von Stumpfeldt, and Otmar Biebel — Ludwig-Maximilian University of Munich

Immense research has been conducted on the Higgs Boson since its discovery. However, the sheer amount of background events in high energy particle colliders complicate the study of its physical properties. Research on the Higgs self interactions is no exception. The corresponding cross section is small compared to many competing processes with similar final states. For example, the Higgs self interactions and the top anti-top quark pair decays can have equivalent final states, e.g. $b\bar{b}W^+W^-$, but the cross sections are roughly 30 femtobarns and 1 microbarns, respectively, such that the top anti-top quark distributions reach into those of the Higgs pair production. To separate these two, Pytorch neural networks were applied onto the data simulated with the MCatNLO+Herwig event generator. Given a reasonable computation time, MCatNLO+Herwig could not generate enough top background events to train the neural network. Therefore, certain features of these data beyond kinematics were modified in order to generate sufficient training data. Overall, the neural network was effective in separating the two end states.