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.