

T 100: Higgs 4 (coupling to taus, CP, rare decays)

Time: Thursday 16:00–18:00

Location: Geb. 30.41: HS 2

T 100.1 Thu 16:00 Geb. 30.41: HS 2

H → $\tau\tau$ cross-section measurement in the VBF production mode with focus on the non- τ background — ●LENA HERMANN, CHRISTIAN GREFE, PHILIP BECHTLE, and KLAUS DESCH — Physikalisches Institut, University of Bonn

Precision measurements of the Higgs boson properties are promising to show evidence of physics beyond the Standard Model. One aspect of interest is the Yukawa-interaction which can be directly investigated by a cross-section measurement in the di- τ final state.

Differential measurements in the vector-boson fusion production mode are performed in a binned maximum-likelihood fit of the di- τ mass in various p_T^H and m_{jj} bins using the "Simplified Template Cross Section" framework (STXS). The main backgrounds of this analysis are, besides $Z \rightarrow \tau\tau$ events, misidentified τ leptons – so called *Fakes*. This background has a non-negligible impact on the final sensitivity and is therefore a central topic in developing strategies to improve the measurement. Apart from introducing a more accurate reconstruction of misidentified tau leptons, effort has been made to define fake reduced signal regions and to stabilize the fit setup by decreasing statistical uncertainties on the shape of the background in question.

This presentation will discuss several studies related to the fake estimate. These include strategies applied in the current analysis as well as promising ideas for future fit setups which are already validated in preparatory studies. In addition, fit results will be presented to probe the Standard Model prediction in the vector-boson fusion production mode.

T 100.2 Thu 16:15 Geb. 30.41: HS 2

The $\tau\tau$ background estimation with the τ -embedding method of CMS — ●CHRISTIAN WINTER, SEBASTIAN BROMMER, ARTUR GOTTMANN, ROGER WOLF, and GÜNTER QUAST — ETP, Karlsruhe Institute of Technology, Karlsruhe, Germany

In $H \rightarrow \tau\tau$ analyses a major source of background are genuine tau leptons, mostly originating from $Z \rightarrow \tau\tau$ decays. The τ -embedding method is a method to estimate this background from data, by replacing muons in a selected-event in data with simulated τ -decays. This talk will explain this method and gives an outlook of how this method will be improved further.

T 100.3 Thu 16:30 Geb. 30.41: HS 2

Test of CP invariance in Higgs boson production via vector boson fusion exploiting the $H \rightarrow \tau_{\text{had}}\tau_{\text{had}}$ decay mode — ●DANIEL BAHNER, Ö. OĞUL ÖNCEL, and MARKUS SCHUMACHER — Physikalisches Institut, Freiburg, Deutschland

Violation of CP invariance is one of the Sakharov conditions to explain the observed baryon asymmetry in our universe (BAU). While CP violation is already realized in the Standard Model via CKM matrix, it is not sufficient to explain the observed magnitude of BAU. The discovery of the Higgs boson has opened a new window to search for additional sources of CP violation. The vector-boson fusion (VBF) production of the Higgs boson is one of them. Here, it is possible to probe CP-violating contributions to the HVV vertex.

In this talk, the subsequent Higgs boson decay into two hadronically decaying tau leptons is considered. The dominant background process in this decay channel is the irreducible $Z \rightarrow \tau\tau$ process. A data-driven Fake Factor method is used to estimate the sizeable contribution from events in which jets are misidentified as hadronically decaying tau leptons. A neural network is exploited to discriminate signal from background processes.

CP-odd observables are used in a profile-likelihood fit to perform a test of CP invariance and to constrain the strength of new CP-violating interactions. The talk will discuss the analysis strategy, CP-odd observables, and first results including systematic uncertainties based on $\sqrt{s} = 13$ TeV proton-proton collision data collected by the ATLAS detector corresponding to $\mathcal{L}_{\text{int}} = 140 \text{ fb}^{-1}$.

T 100.4 Thu 16:45 Geb. 30.41: HS 2

Measurement of the CP properties of the Higgs boson in the decay into tau leptons with the Run 3 data of the CMS experiment — ●STEPAN ZAKHAROV, ALEXEI RASPEREZA, ELISABETTA GALLO, and ANDREA CARDINI — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

The Standard Model (SM) Higgs boson is predicted to be CP-even. Measurements from Run 2 data at the LHC have excluded a purely CP-odd state at 3 standard deviations. However, experimental results up to now do not exclude the possibility for the Higgs boson to be a mixture of a CP-even and a CP-odd state. The analysis of the Run 3 combined with the Run 2 data collected by the CMS experiment will allow to elucidate the CP nature of the SM Higgs boson. The Run 3 analysis is developed by exploiting observables sensitive to CP in the decay of the Higgs boson to a pair of tau leptons using the Columnflow approach. This talk will cover the strategy of the analysis: starting from the theoretical motivation, discussing the main steps, and presenting the first data and Monte Carlo comparisons for some observables with the 2022 dataset.

T 100.5 Thu 17:00 Geb. 30.41: HS 2

Comparison of the sensitivity of different CP-odd observables for testing CP-invariance in the Vector-Boson-Fusion production of the Higgs-Boson — ●LEA KUTTLER, LORENZO ROSSINI, and MARKUS SCHUMACHER — Albert-Ludwigs-Universität Freiburg

The observed baryon asymmetry in our universe (BAU) can be explained if the three Sakharov conditions, including the violation of CP-invariance, are met. However, the amount of CP-violation predicted by the Standard Model, via the CKM-matrix, is insufficient to explain the BAU. Hence, it is instructive 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 HVV and to test its CP invariance.

The strength of the new CP-violating interactions can be constrained by maximum-likelihood fits to the distribution of CP-odd-observables. In this talk, the sensitivity of different CP-odd observables exploiting the $H \rightarrow \tau_{\text{had}}\tau_{\text{had}}$ decay mode are compared by determining the expected length of the confidence intervals for the CP-violating coupling strength. The comparison includes both, newly constructed machine learning observables and traditional ones, such as the azimuthal angle difference of the tagging jets and the optimal observable.

The sensitivities are derived from simulated events corresponding to the data set collected with the ATLAS detector during Run-2 of the LHC at a center of mass energy of 13 TeV.

T 100.6 Thu 17:15 Geb. 30.41: HS 2

Classifying the CP properties of the ggH coupling in H+2j production — HENNING BAHL¹, ELINA FUCHS^{2,3}, MARC HANNIG², and ●MARCO MENEN^{2,3} — ¹Ruprecht Karls Universität, Heidelberg, Deutschland — ²Leibniz Universität, Hannover, Deutschland — ³Physikalisch-Technische Bundesanstalt, Braunschweig, Deutschland

The Higgs-gluon interaction is crucial for LHC phenomenology. To improve the constraints on the CP structure of this coupling, in this talk I will investigate Higgs production with two jets using machine learning. In particular, the CP sensitivity of the so far neglected phase space region that differs from the typical vector boson fusion-like kinematics is exploited. The presented results suggest that significant improvements in current experimental limits are possible. In the talk I also discuss the most relevant observables and how CP violation in the Higgs-gluon interaction can be disentangled from CP violation in the interaction between the Higgs boson and massive vector bosons. Assuming the absence of CP-violating Higgs interactions with coloured beyond-the-Standard-Model states, the projected limits on a CP-violating top-Yukawa coupling are stronger than more direct probes like top-associated Higgs production and limits from a global fit.

T 100.7 Thu 17:30 Geb. 30.41: HS 2

Steering towards an H → $\mu\mu$ analysis of the LHC Run III Data with the CMS Experiment — ●ERIK HETTWER BENITEZ — Karlsruhe Institute of Technology

Measuring the coupling of the Higgs Boson (H) to the second generation fermions is an important milestone of the LHC physics program. Evidence for $H \rightarrow \mu\mu$ has been established by CMS in 2021 analysing LHC Run II data from 2016, 2017 and 2018, resulting in a signal significance of 3.0 standard deviations. This talk gives an overview of our first steps towards an $H \rightarrow \mu\mu$ analysis with LHC Run III data.

T 100.8 Thu 17:45 Geb. 30.41: HS 2
Searches for Exclusive Higgs and Vector Boson Decays to a Meson and a Photon at ATLAS — ●ROBERT WARD — Universität Hamburg

In the Standard Model (SM) the mass generation of fermions is implemented through Yukawa couplings to the Higgs boson. Experimental evidence exists for the Higgs boson couplings to second and third generation leptons through its decay to muon and tau pairs, but for quarks direct evidence exists only for the third-generation couplings. Direct searches for inclusive decays of the Higgs boson to lighter quarks are challenging due to large QCD backgrounds at the LHC.

With their distinct experimental signature, radiative decays of the

Higgs boson to a meson and a photon may offer an alternative probe of quark Yukawa couplings. Moreover, these decays provide an opportunity to investigate physics beyond-the-SM, where significantly modified branching fractions from the SM expectation are predicted, as well as the existence of potential quark-flavour-violating couplings of the Higgs and Z bosons. This talk will summarise searches for rare exclusive Higgs boson decays to a meson and a photon performed by the ATLAS experiment using the $\sqrt{s} = 13$ TeV dataset, along with searches for related decays of the massive vector bosons. These searches use dedicated triggers which were in operation throughout Run 2 of the LHC, as well as novel non-parametric data-driven techniques to model the backgrounds.