T 89: Higgs Physics IX

Time: Friday 9:00–10:30 Location: KH 00.014

T 89.1 Fri 9:00 KH 00.014

Test of CP invariance in Higgs boson production via vector boson fusion at the HL-LHC exploiting the $H \to \tau\tau$ decay mode — •Daniel Bahner, Lorenzo Rossini, and Markus Schumacher — Albert-Ludwigs-Universität, Freiburg, Deutschland

The observed baryon asymmetry of the Universe can be accounted for only if the three Sakharov conditions are satisfied, one of which is the violation of CP invariance. However, the amount of CP violation predicted by the Standard Model is insufficient to generate the observed asymmetry through electroweak baryogenesis. Precision measurements of the Higgs boson therefore offer a promising avenue to search for additional sources of CP violation. In particular, the vector-boson fusion (VBF) production mode provides sensitivity to potential CP-violating contributions in the HVV coupling.

This talk focuses on VBF Higgs boson production followed by its decay into a pair of tau leptons. ATLAS published an analysis in 2025 that set the most stringent limits to date on the CP-violating coupling parameters in the HVV vertex using data collected from 2015 to 2018 corresponding to an integrated luminosity of $\mathcal{L}_{\text{int}} = 140\,\text{fb}^{-1}$. Building on that work, the extrapolation of the analysis to the High-Luminosity LHC dataset, corresponding to $\mathcal{L}_{\text{int}} = 3000\,\text{fb}^{-1}$ at $\sqrt{s} = 14$ TeV, will be discussed. The study performs a profile-likelihood fit to the CP-odd optimal observable to test CP invariance and to constrain the magnitude of possible new CP-violating interactions. Results from the published analysis, the extrapolation methodology, and the expected sensitivity to the coupling parameter at the HL-LHC will be presented.

T 89.2 Fri 9:15 KH 00.014

Measurements of $H \to \tau\tau$ CP properties at FCC-ee — •Sofia Giappichini[1], Markus Klute[1], Matteo Presilla[1], and Xunwu Zuo[2] — [1]Institute for Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany — [2]Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland

The Future Circular Collider (FCC-ee), a key pillar of the European Strategy for Particle Physics, offers unprecedented precision for studying the Higgs boson. The decay $H \to \tau\tau$ stands out due to its sizable branching ratio, clean experimental environment, and sensitivity to tau polarization, making it an ideal channel to probe the CP properties of the Yukawa couplings and search for signs of CP violation beyond the Standard Model. We highlight the prospects for measuring CP-odd components in the $H \to \tau\tau$ decays through angular and polarization observables in associated ZH production at a center-of-mass energy of 240 GeV within the Anomalous Coupling and the Effective Field Theory frameworks.

T 89.3 Fri 9:30 KH 00.014

Probing CP invariance in the decay $H \to \tau\tau$ at a future e^+e^- Linear Collider — •Lea Kuttler, Michael Böhler, and Markus Schumacher — Institute of Physics, Albert-Ludwigs-University Freiburg, Freiburg, Germany

Sources of CP violation (CPV) beyond the Standard Model (SM) are required to explain the baryon asymmetry observed in our universe (BAU). The Yukawa coupling of the Higgs boson to the tau lepton may deliver a sufficient source of CPV, which allows explaining the observed size of the BAU.

This analysis investigates the CP-nature of the $H\tau\tau$ Yukawa coupling, considering $ee \to ZH$ events at an e^+e^- linear collider, operating at $\sqrt{s} = 250\,\text{GeV}$, assuming an integrated luminosity of 2 ab^{-1} and e^-/e^+ beam polarizations of 80%/30%. Events are simulated for the International Large Detector concept.

In $H \to \tau\tau$ decays, the strength of CP violation can be parametrized by a single mixing angle ψ_τ. Two observables sensitive to ψ_τ are the azimuthal angle difference $\Delta\phi$ between the tau lepton polarimeter vectors and the matrix-element-based optimal observable $\mathcal{OO}$.

This contribution demonstrates the use of these observables to constrain ψ_τ at a future e^+e^- linear collider using the decay modes $\tau \to \rho\nu$ and $\pi\nu$ and compares their sensitivity. In this context, methods for fully reconstructing the tau leptons and for identifying hadronic tau decays are presented.

T 89.4 Fri 9:45 KH 00.014

Future collider perspective on Higgs CP violation — •Yuyang Zhang[1,3], Aidan Robson[1], Christoph Englert[2], Andrew Pilkington[2], Jay Nesbitt[1], Jenny List[3], and Junping Tian[4] — [1]U of Glasgow, Glasgow, UK — [2]U of Manchester, Manchester, UK — [3]DESY, Hamburg, Germany — [4]U of Tokyo, Tokyo, Japan

Future Higgs factories based on electron-positron colliders are expected to provide unprecedented precision in the measurement of Higgs boson properties, offering a new window for the discovery of physics beyond the Standard Model. In particular, the observation of CP-violation in Higgs interactions would serve as an important indication for electroweak baryogenesis.

In this work, we study the sensitivity to CP-violating Higgs couplings at future Higgs factories within the framework of the SM Effective Field Theory. We focus on Higgs production via the Higgsstrahlung process at $\sqrt{s}$=250 GeV and top-quark-associated Higgs production at $\sqrt{s}$=550 GeV at a linear collider facility with polarised beams.

The introduction of machine-learning techniques benefits the analysis in two ways. By constructing observables to discriminate between the CP-even and CP-odd contributions we demonstrate that the interference introduced by dimension-six operators can lead to sensitivity to CP-violating Higgs interactions. We also enhance sensitivity through improved reconstruction techniques. The use of polarised beams further increases the CP-sensitive interference contributions. Overall, the sensitivity obtained at a linear collider becomes comparable to that expected at circular colliders with higher luminosity.

T 89.5 Fri 10:00 KH 00.014

Impact of polarized beams for Electroweak and Higgs Physics — •Gudrid Moortgat-Pick[1,2], Cheng Li[4], Jayita Lahiri[5], and Juhi Dutta[3] — [1]University of Hamburg — [2]Deutsches Elektronen Synchrotron — [3]IMSc Chennai — [4]SYSU, Guangzhou — [5]Krakow University

Polarized beams are substantial to achieve the precision requirements in the electroweak and Higgs sector. Mmost of the future high-energy lepton collider designs offer the availability of beam polarization. In this talk we summarize the polarization-related results for different Beyond the Standard Models Extensions (MSSM, 2HDMS, inflation models) and discuss CP-violating effects, flavour aspects, high precision electroweak observables and Higgs couplings.

T 89.6 Fri 10:15 KH 00.014

Study of CP-violation in extended Higgs sectors at a Gamma-Gamma collider — •Muriel Blenck[1], Gudrid Moortgat-Pick[1,2], Marten Berger[1], and Ayoade Sotona[1] — [1]II. Institut für Theoretische Physik, Universität Hamburg, Luruper Chaussee 149, Hamburg — [2]Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, Hamburg

A $\gamma\gamma$ collider offers a rich Higgs physics program at relatively low center of mass energies. The polarisation of the photon beams, which are obtained via Compton backscattering, are controlled by the incident laser and can reach high levels. This allows the study of CP-violating effects in extended Higgs sectors by constructing CP-odd observables that have higher sensitivity to CP-violating effects when transverse or longitudinal polarisation is used. The SM predicts the Higgs boson to be scalar-even particle, but BSM models like the 2HDM and 2HDMS allow an admixture of CP-even and CP-odd states, which could introduce additional CP-violating effects that would help explain the large baryon-antibaryon asyymetry in the universe. In this talk we present the possibility to use a $\gamma\gamma$ collider to measure these effects and determine the CP-mixing angle in the extended Higgs sectors.