Contribution ID: **10** Type: **not specified**

CP-sensitive simplified template cross-sections for ttH

Monday, 9 June 2025 13:00 (1 hour)

The CP (Charge-Parity) structure of the Higgs boson is a fundamental property of the Standard Model of particle physics, and a precise measurement of this property is essential to understanding whether the Higgs mechanism accommodates new sources of CP violation beyond the Standard Model. To date, this structure has not yet been constrained with high precision.

One of the most promising avenues for probing CP violation in the Higgs sector is the Yukawa coupling between the Higgs boson and a top, something accessible probing, for example, the production of a top anti-top pair together with an Higgs. This process can be directly studied at the Large Hadron Collider (LHC). In such studies, the nature of the interaction—whether it is CP-even (as predicted by the Standard Model), CP-odd, or a mixture—can be inferred from the kinematic properties of the final state particles.

Multivariate analysis (MVA) techniques, such as boosted decision trees (BDTs) or deep neural networks (DNNs), are commonly employed in current experimental analyses to discriminate between CP-even and CP-odd components. However, these methods are typically optimized for specific benchmark signal models, making reinterpretation and statistical combinations across different analyses or future datasets challenging. To address these limitations, we propose a CP-sensitive extension of the Simplified Template Cross Section (STXS) framework, which is a structured approach developed by the LHC Higgs Cross Section Working Group to define Higgs measurements in exclusive kinematic bins. This framework provides a common language for comparing theoretical predictions and experimental results.

Focusing on multiple Higgs decay channels (e.g., Higgs in two photons pair, Higgs in a bottom anti-bottom pair, etc.), we perform a detailed study of CP-sensitive observables, evaluating their potential to discriminate different CP hypotheses. The observables considered include:
– The pseudorapidity difference between the top and anti-top quarks (delta eta of the top-antitop pair), which captures the forward-backward topology of the event.
– A variable called b 2, which is a kinematic function constructed from the top-antitop quarks momenta and encodes angular information sensitive to CP-mixing.
– The Collins-Soper angle, defined in the rest frame of the Higgs-top system, which has shown high sensitivity to the CP properties of the interaction.

We propose extending the existing STXS binning in the transverse momentum of the Higgs boson with an additional dimension based on one of the CP-sensitive variables like the one mentioned above. This two-dimensional binning provides a simple yet powerful alternative to MVA-based discriminants.

Our study demonstrates that such a selection offers near-optimal sensitivity to the CP-mixing angle in the top Yukawa coupling, especially for an integrated luminosity of 300 inverse femtobar, which corresponds to the expected dataset at the end of LHC Run 3. Furthermore, projections to 3000 inverse femtobar, corresponding to the High-Luminosity LHC (HL-LHC) era, suggest that this extended STXS scheme could further enhance the sensitivity and interpretability of Higgs CP studies across different decay channels and experiments.

Presenter: CARNELLI, Alberto (CNRS/IN2P3, LAPP, France)