

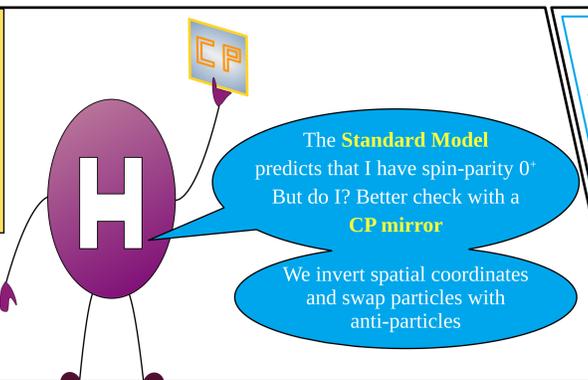
The Higgs through the looking glass.

Measurement of the CP quantum number of the Higgs boson in $H \rightarrow \tau\tau$ decays

Andrea Cardini (DESY) on behalf of the CMS collaboration

CP-violation in the Higgs couplings is investigated in:

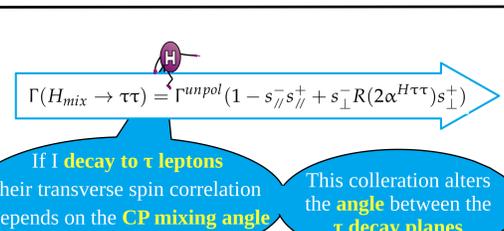
- HVV couplings
- Yukawa coupling:
 - Production via $t\bar{t}H$ and ggH
 - Decays into τ leptons



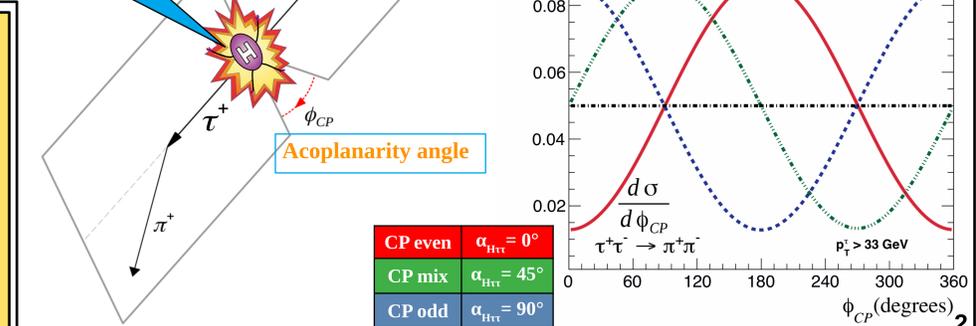
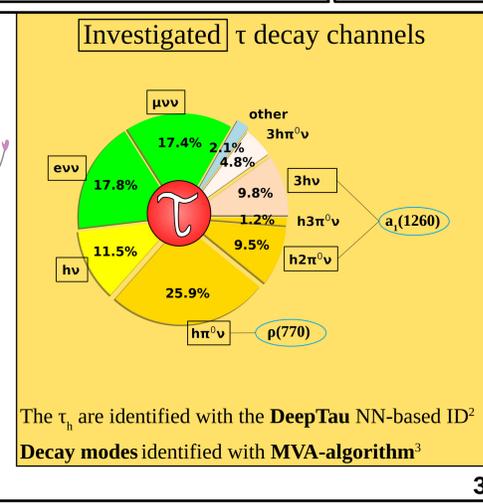
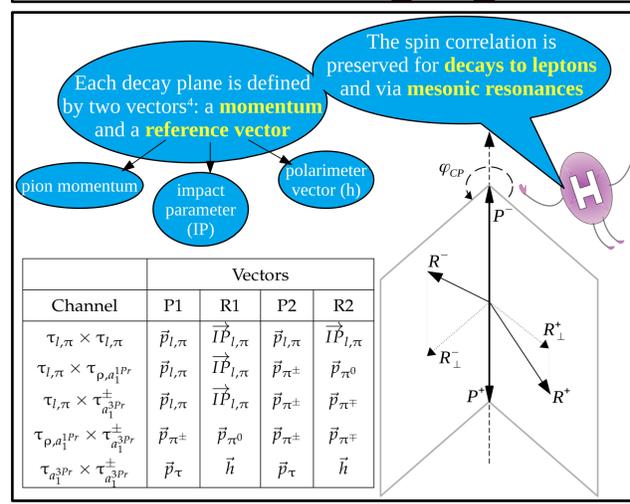
CP mixing angle

$$\mathcal{L}_{Y,\tau} = -\frac{m_\tau}{v} \bar{\tau}(\kappa_\tau + i\gamma^5 \tilde{\kappa}_\tau) H \tau$$

$$\kappa_\tau = \sqrt{\mu^{\tau\tau}} \cos(\alpha^{H\tau\tau})$$

$$\tilde{\kappa}_\tau = \sqrt{\mu^{\tau\tau}} \sin(\alpha^{H\tau\tau})$$


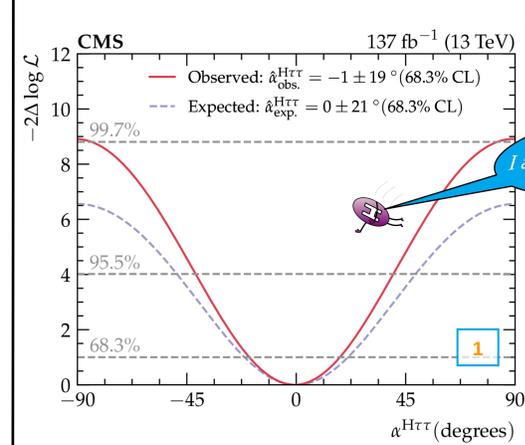
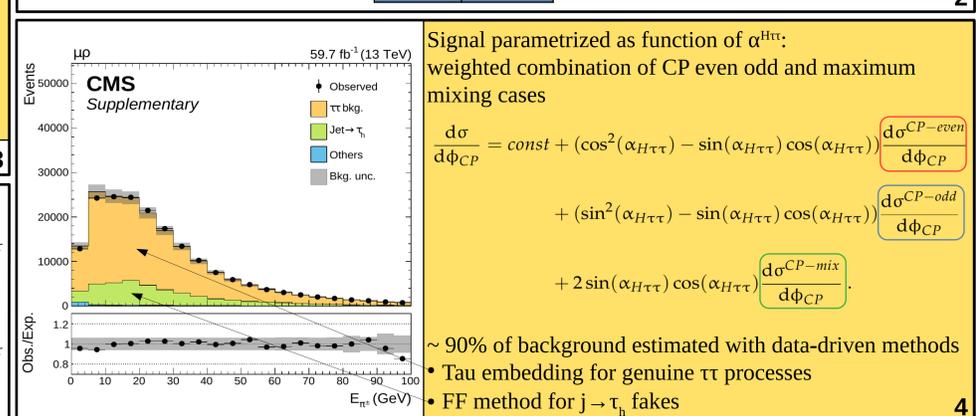
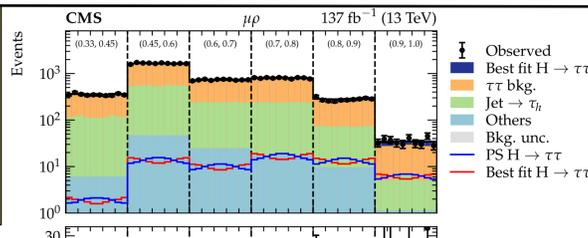
The cross-section of the $H \rightarrow \tau\tau$ process has a **sinusoidal shape**

$$\frac{d\sigma}{d\phi_{CP}} \propto \text{const} - \cos(\phi_{CP} - 2\alpha^{H\tau\tau})$$


CP mixing angle measured with simultaneous fit for signal and background models over **full Run 2**

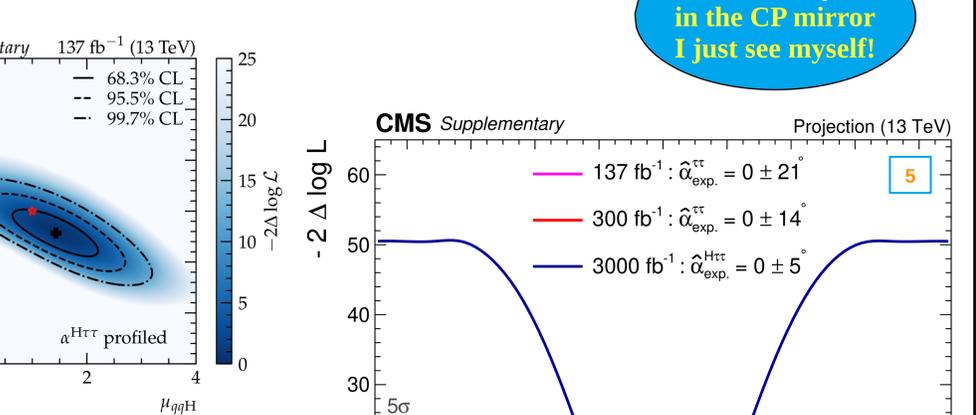
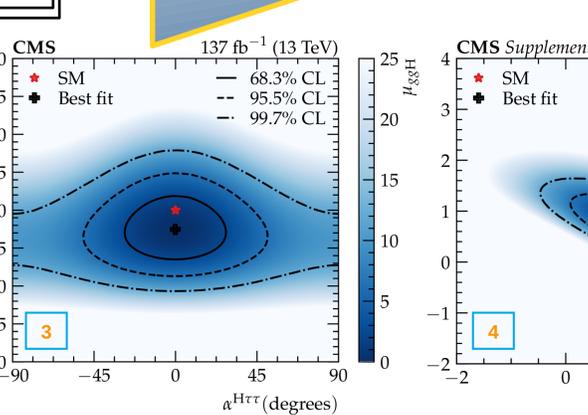
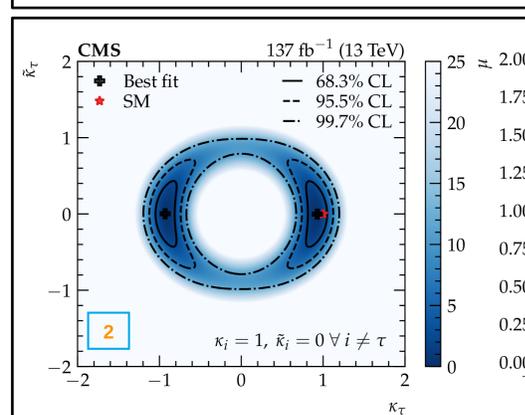
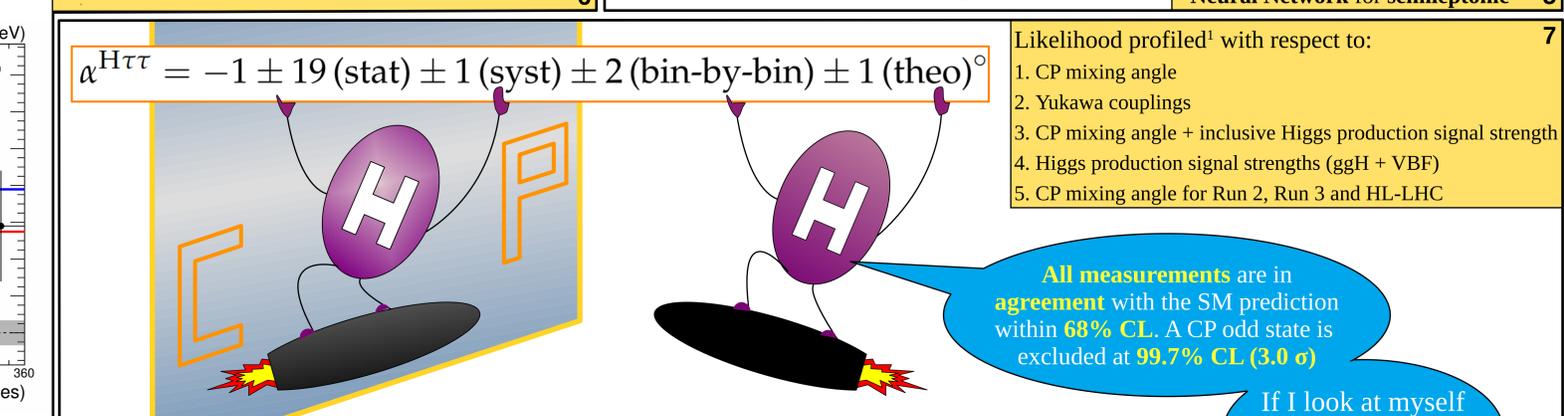
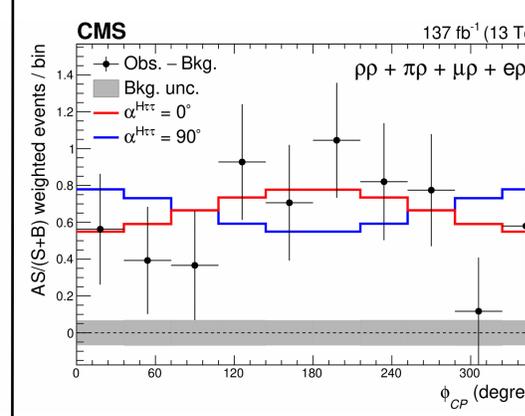
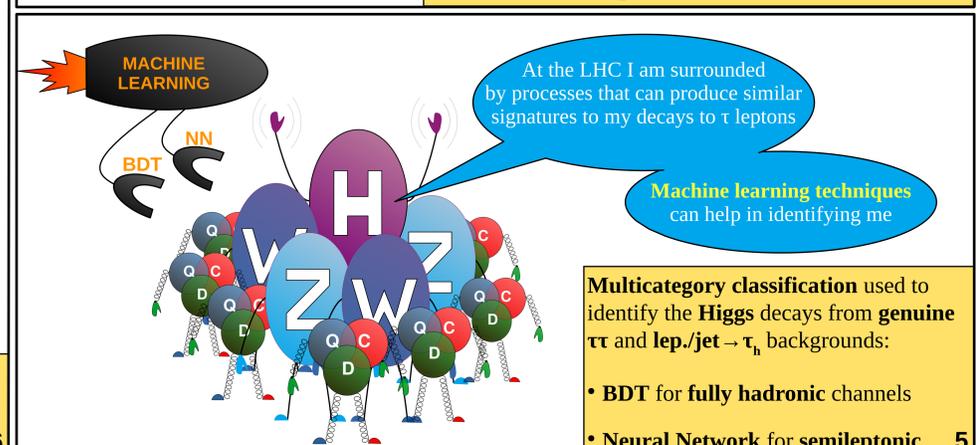
Fit performed with

- NN/BDT score for ML background categories
- Acoplanarity angle distributions in bins of NN/BDT score for **higgs** category \rightarrow **split by decay mode**



Exclusion for CP-odd hypothesis:

> Observed (exp.) significance = **3.0 σ** (2.6 σ)



References.

- CMS-HIG-20-006: "Analysis of the CP structure of the Yukawa coupling between the Higgs boson and τ leptons in proton-proton collisions at $\sqrt{s} = 13$ TeV"
- CMS-DP-2019-033: "Performance of the DeepTau algorithm for the discrimination of taus against jets, electron, and muons"
- CMS-DP-2020-041: "Identification of hadronic tau decay channels using multivariate analysis (MVA decay mode)"
- Andrea Cardini: "Measurement of the CP properties of the Higgs boson in its decays to τ leptons with the CMS experiment"

