Search for CP-odd $t\bar{t}H$ production in the single-lepton $H \to b\bar{b}$ decay channel

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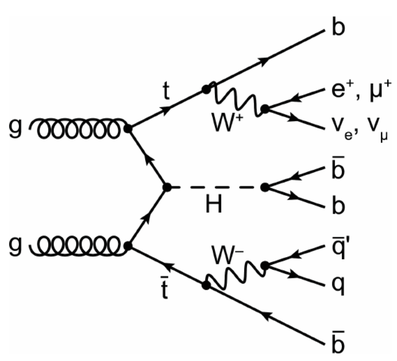
Introduction

- The SM Higgs boson is a scalar with no CP-violating interactions.
- The CP properties of the top quark Yukawa interaction can be directly probed through $t\bar{t}H$ and tH processes.



- Top Yukawa interaction was parametrised as

$$\mathcal{L}_{t\bar{t}H} = -k_t' y_t \phi \bar{\psi}(\cos\alpha + i\gamma_5 \sin\alpha)\psi$$

- Pure CP-even (CP-odd) coupling correspond to $\alpha = 0°$ ($90°$).

Event Selection

- Events divided according to jet and b-tag multiplicity.
- 70% b-tagging efficiency.
- Signal-depleted regions used to constrain backgrounds from data.

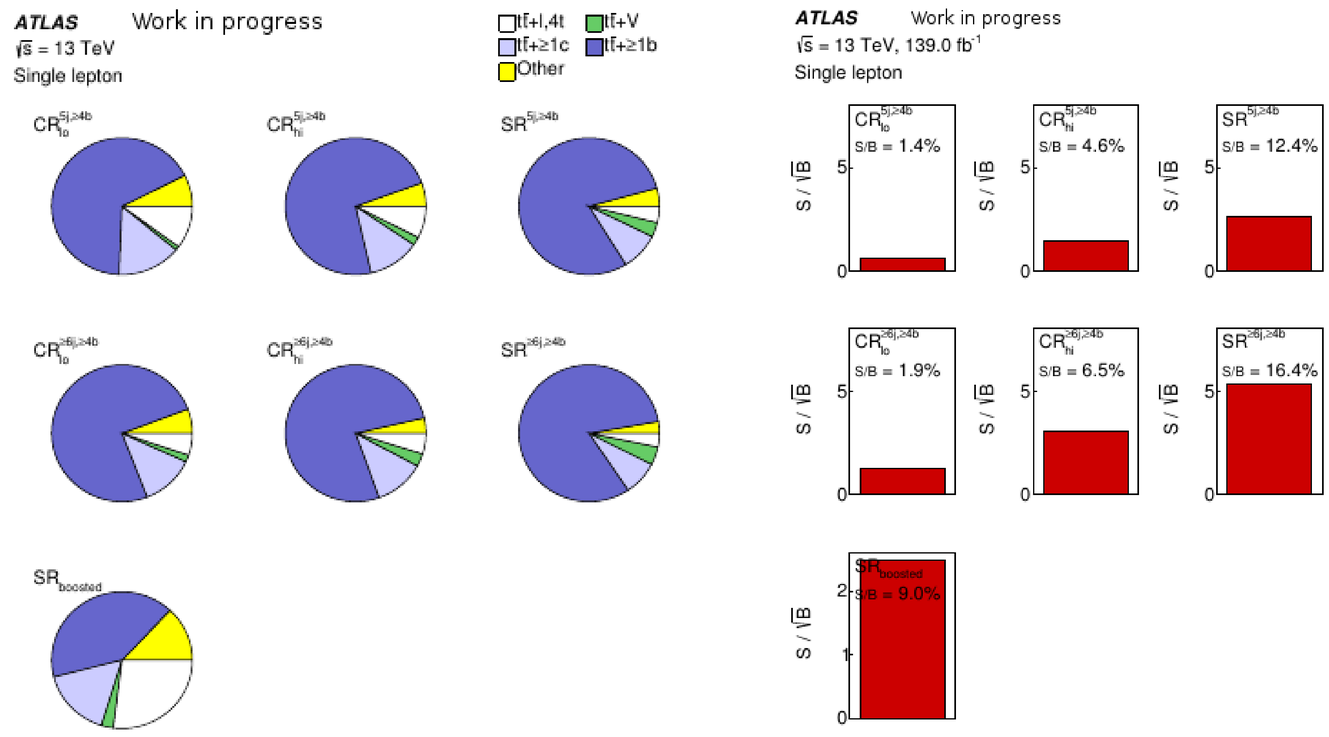
Region	Leptons	Jets	B-tag	Higgs candidates
$SR_{inc}^{\geqslant 6j \geqslant 4b}$	$= 1$	$\geqslant 6$	$\geqslant 4$	-
$SR_{inc}^{\geqslant 5j \geqslant 4b}$		$= 5$		-
$SR_{boosted}$		$\geqslant 4$	-	$\geqslant 1$

- **Boosted Higgs Candidate:**
  - Large-R jet with $p_T > 300$ GeV and $m \in (100 - 140)$ GeV, containing two b-tagged jets.

Analysis Strategy

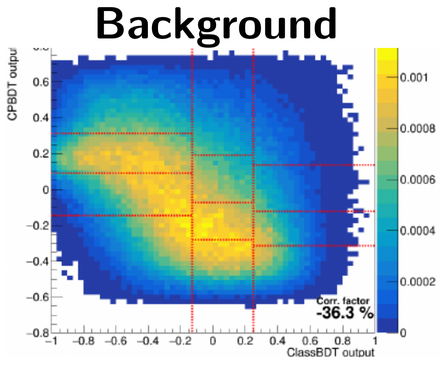
- One BDT is trained to separate signal from background.
- Inclusive signal regions are divided according to the output of the classification BDTs as control region or signal region depending on the signal-to-background ratio.

Background composition

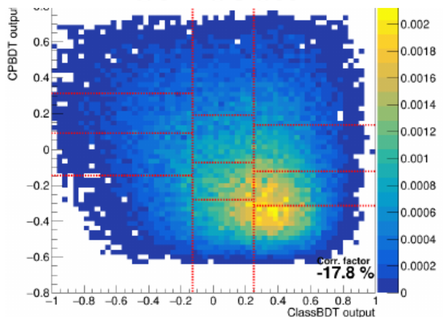


- Another BDT is trained to distinguish CP-even from CP-odd $t\bar{t}H$ events.
- Lab-frame observables and angular variables calculated in specific frames can be used to discriminate between CP scenarios [1, 2].
- In the inclusive signal regions, the CP BDT is used as input to the fit. In the boosted channel, the classification BDT is used.

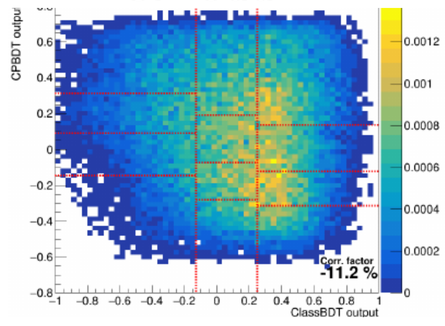
Background



CP-even



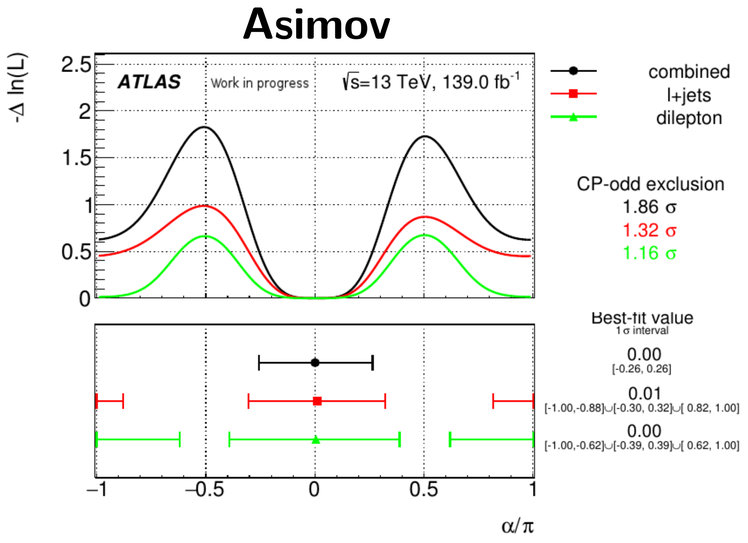
CP-odd



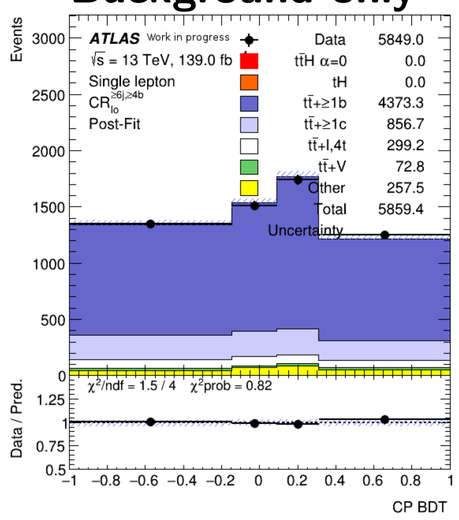
Measurement of the CP-Mixing Angle

- Analysis based on a binned likelihood $\mathcal{L}(\alpha, k_t', \theta)$.
- Number of events in a given bin depends on α, on k_t' and on the set of nuisance parameters θ.
- Parameters are allowed to vary, the best-fit α and k_t' maximise the likelihood.
- 0.26π ($47°$) expected uncertainty on the signal.
- Good agreement with the background model.

Asimov



Background-only



Contributions

- tH signal parameterization as function of the mixing angle α and the coupling strength κ_t'.
- Background-only fit to evaluate the efficacy of the background model.

References

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