Search for heavy Higgs bosons A/H decaying to a top-quark pair in pp collisions with the ATLAS detector

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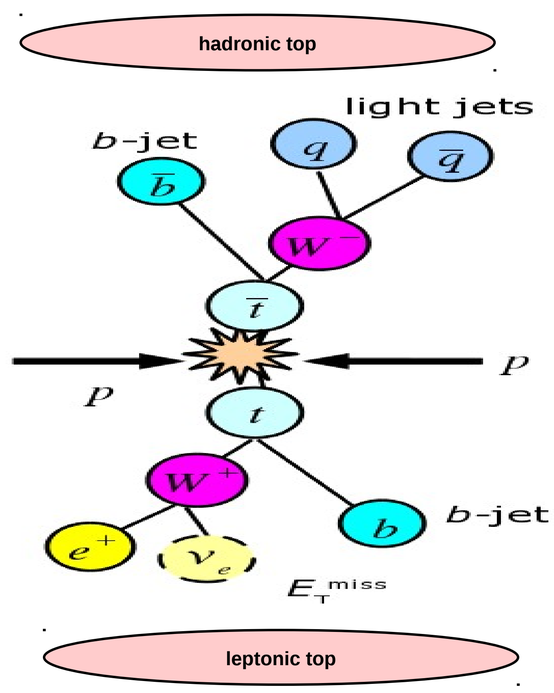
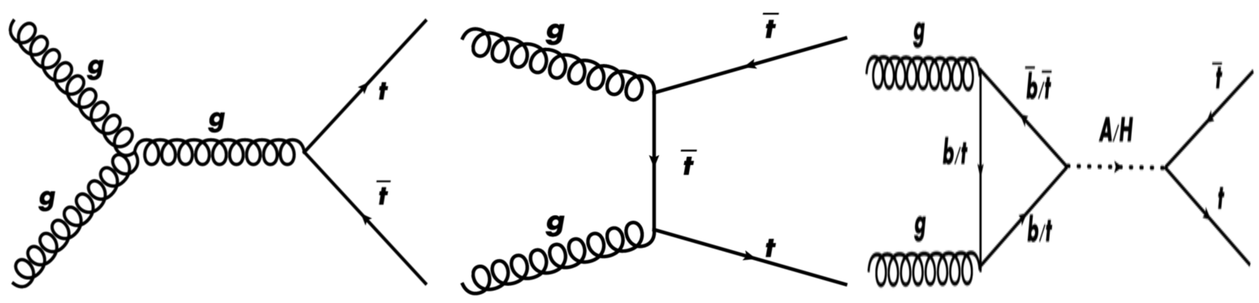
Generally Introduction

We present the search for a pseudoscalar (A) or scalar (H) heavy Higgs boson decaying into a top-quark pair ($t\bar{t}$) conducted in 20.3 fb−1 of data collected by the ATLAS detector at the Large Hadron Collider in proton--proton collisions at a centre-of-mass energy of √s=8 TeV. The analysis relies on the invariant mass spectrum of the $t\bar{t}$ pair in final states with an electron or muon, large missing transverse momentum, and at least four jets. The interference effects between the signal processes and gg→ $t\bar{t}$ production in the Standard Model, **which heavily distort the signal shape from a single peak to very complicated peak-dip (or even pure-dip) structures**, are taken into account. Exclusion limits are derived for two resonance masses (500 and 750 GeV), as a function of the parameter tanβ in the Two-Higgs-Doublet Models (2HDM).



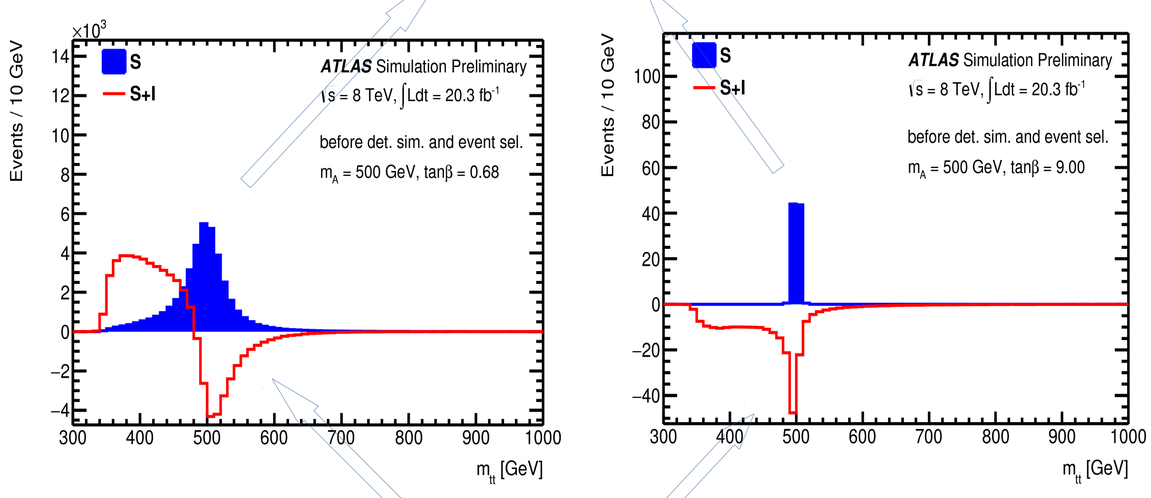
Physics Motivation

A/H→$t\bar{t}$ is very important for high Higgs boson mass regions (above $2m_t$). It would be the only channel could be sensitive to low tanβ (at high mass). This analysis is the first LHC search of A/H→$t\bar{t}$ with the interference effects properly considered and treated.
The right three plots are the Feynman diagrams of the processes generated in MadGraph5 aMC@NLO for this analysis: left and middle, the SM tt background, and right is the pseudo-scalar or scalar signal gg→ A/H → $t\bar{t}$.



Challenging of the Search

Normal searches (bump-hunter)



What we are looking for

Signal + Interference Generation

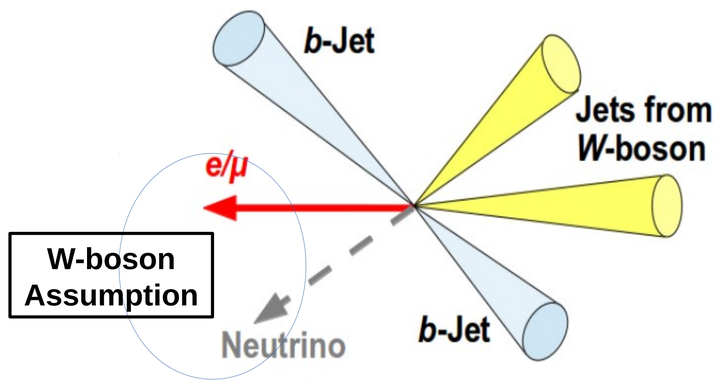
- It is not realistic to generate/produce A/H→$t\bar{t}$ + SM $t\bar{t}$ + interference
  - imagine we would need to generate (+ simulate and reconstruct) a whole SM ttbar dataset for each signal point
- The quick way (**direct**): change the MadGraph code to remove the SM ttbar matrix-element; then just generate A/H + interference [I]
  - there is another reweighting way being studied for Run-II
- The **In-direct way**: subtraction between the follow two samples [II]:
  (a) g g > t t~/ h QED=99 QCD=99 (SM $t\bar{t}$ + A/H + interference)
  (b) g g > t t~ (SM $t\bar{t}$)
- Compare distributions between [I] and [II] (very nice agreement), as a kind of validation of approach-[I] which was finally used in generation.

Object and Selections

- Exactly 1 tight electron or muon, with pT>25 GeV, |η| <2.5. MET> 20 GeV, MET + mTW >60 GeV.
- ≥ 1 b-tagged jets, 70% b-tagging working point
- Six exclusive signal regions
  - e+jets and μ+jets channels
  - Three b-tagging categories: both top-quark candidates have matching b-jet, or only hadronic/leptonic top-quark candidate has matching b-jet

Event Reconstruction

- W-mass constraint to give out the neutrino pz
- Kinematic chi2 fit to reconstruct $t\bar{t}$ system



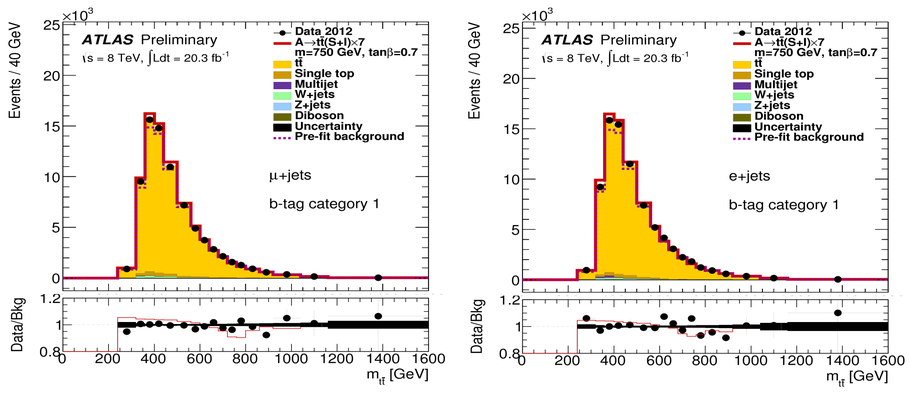
Statistics Treatment

- Change the ROOT to allow negative values of the pdf
- A dedicated interference term in the fitting model:

$$\mu \cdot S + \sqrt{\mu} \cdot I + B = \sqrt{\mu} \cdot (S + I) + (\mu - \sqrt{\mu}) \cdot S + B$$

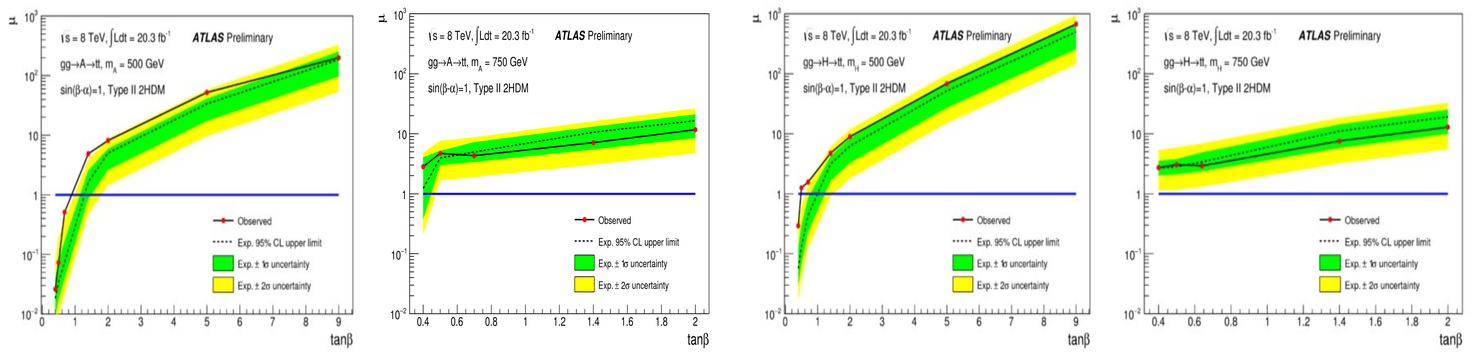
Final Post-fit plots

- Shown are the two most sensitive categories



Exclusion Limit Plots

- The left two plots are of the particle A; the right two plots are of the particle H.



Reference: ATLAS-CONF-2016-073