Search for A→ZH→lltt̄ with the ATLAS detector

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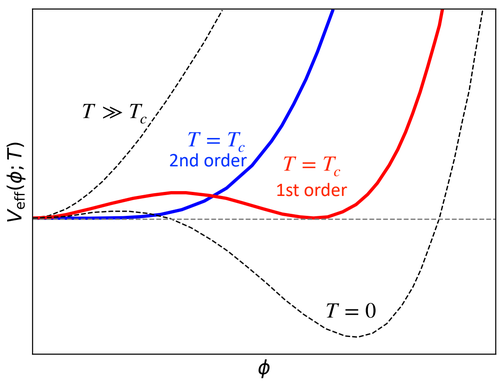
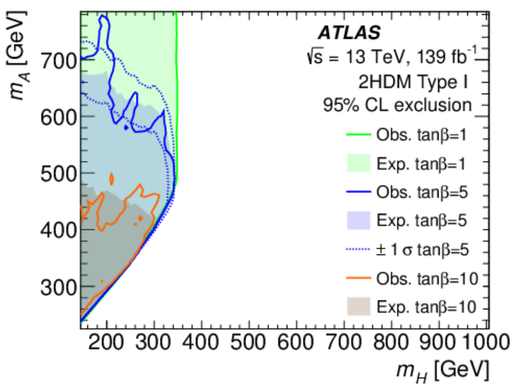
Motivation

A large matter-antimatter asymmetry is observed in the universe. For the generation of this asymmetry (baryogenesis) the Sakharov conditions need to be fulfilled: 1) C/CP violation, 2) baryon number violation, 3) interactions out of equilibrium. While SM fulfils these conditions, it cannot reproduce the observed asymmetry with m_h=125 GeV.

⇒baryogenesis requires new physics



One of the simplest viable models for baryogenesis is the 2 Higgs Doublet Model (2HDM). In these models baryogenesis can occur through a **1st order phase transition if there is a large splitting between the scalar masses**.
A previous search was done in the llbb̄ final state, **probing only the region with m_H < 350 GeV.**

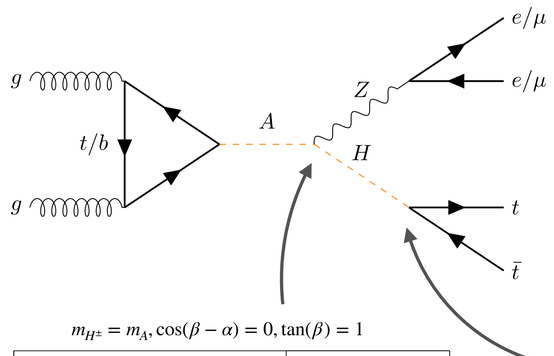


Goals:

- ➡ **Search for heavy scalars with large mass splitting**
- ➡ **Extend the mass region to** $m_H \geq 350GeV$

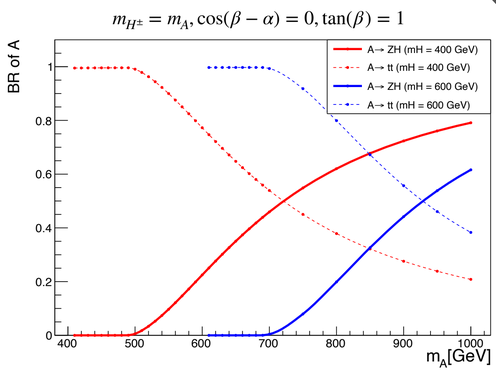
Signature of 2HDM's

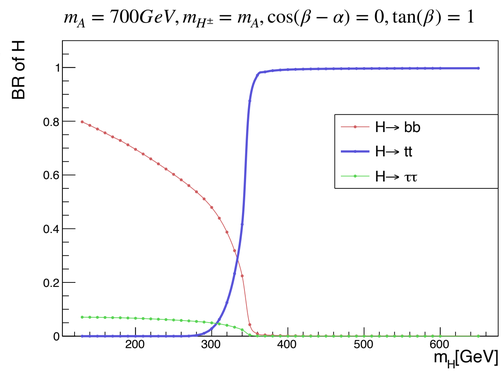
Due to the second Higgs doublet in 2HDM's 5 physical spin 0 states occur: two neutral CP even (h,H), two charged (H^{+-}) and one neutral CP odd (A) state.



We search for A→ZH→lltt̄ because :

- H → tt̄ is dominant for m_H>350 GeV
- A → ZH dominates for high mass splittings ($m_A \geq m_H + \nu$)





Search for: semi-leptonic top decays (high BR & low background) and Z decays to leptons.

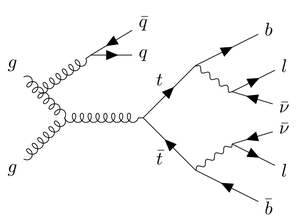
Event Selection and Backgrounds

Signature of process

- exactly 3 leptons (at least 1 Opposite Sign Same Flavour pair)
- at least 4 jets
- at least 2 b-jets

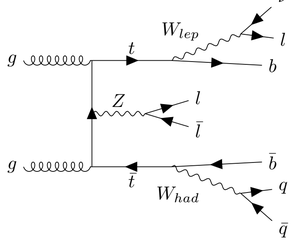
Dominant Backgrounds

top-pair + fake lepton



- low rate, but cross section >200 higher than other bkgs
- $m_{jj} \neq m_W$, $m_{ll} \neq m_Z$

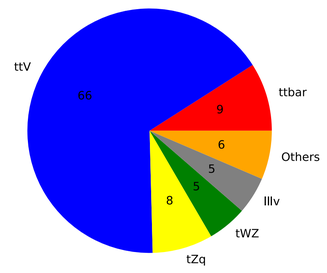
ttZ



- irreducible
- softer leptons, different topology

Different background composition in different final states.

This can be exploited to constrain tt̄ in the fit



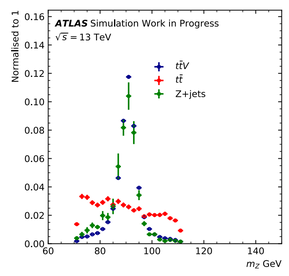
Top candidate reconstruction:

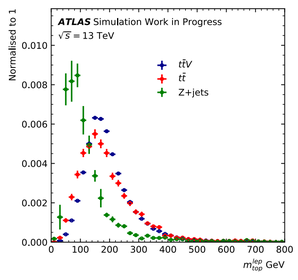
- t_{lep}: W_{lep} with closest b-jet
- t_{had}: W_{had} with remaining b-jet

Optimisation

Simple cut based analysis and multi-variate analysis are explored

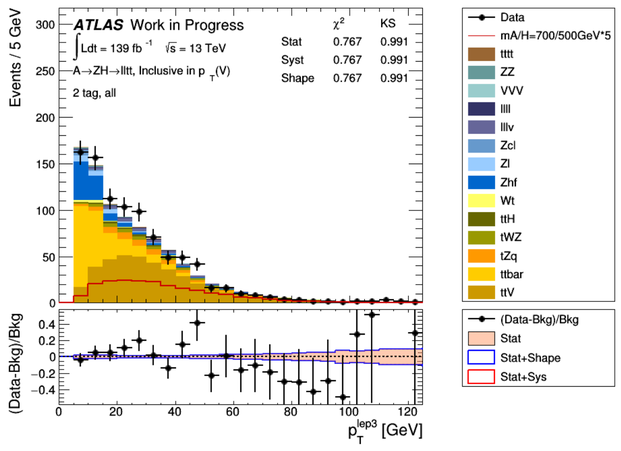
Exploit different variables to discriminate signal from background



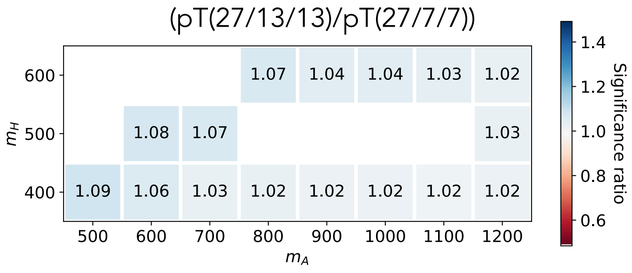


optimisations

- cut on p_T of 3 leptons
- m_Z window cut
- lepton identification/isolation cut
- $t\bar{t}$ reconstruction
- Binning in m_H



increase of significance to default values (pT(27/13/13)/pT(27/7/7))



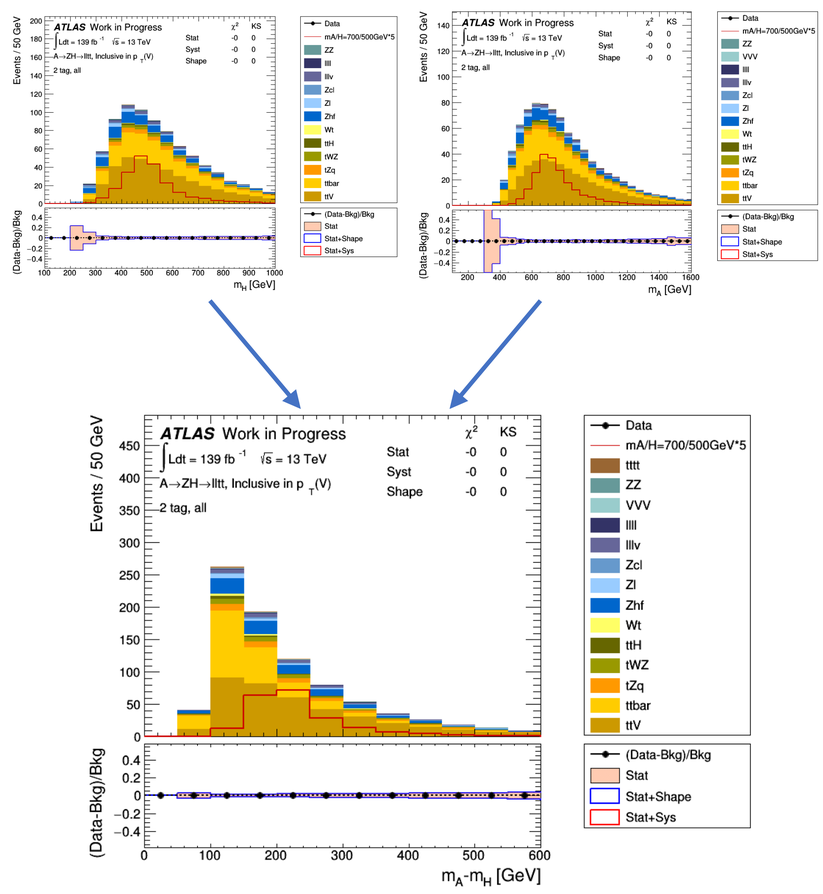
Fitting

If signal is present, a resonant peak in m_H & m_A distribution is expected.

Use binned profile likelihood fit to data to obtain upper limits on cross-section for different signal hypotheses.

Two strategies under study:

1) fitting m_A in bins of m_H
2) fitting m_A-m_H



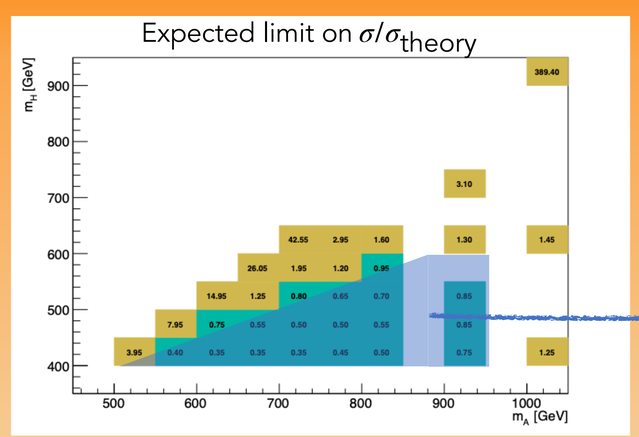
Preliminary results & outlook

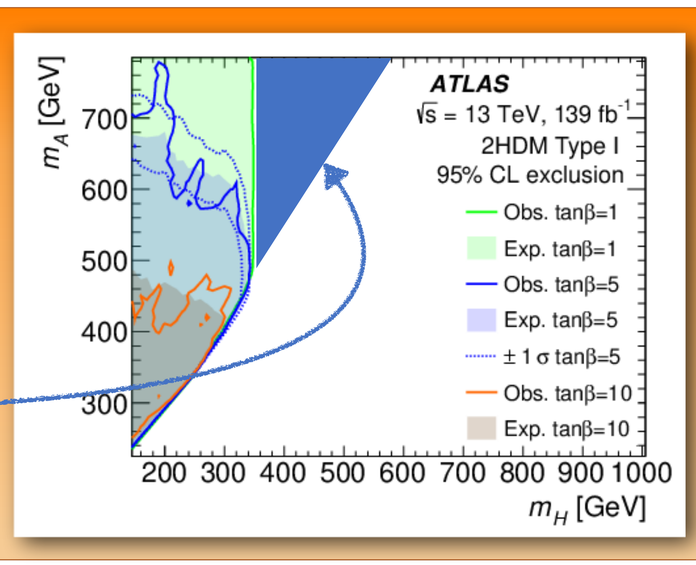
Preliminary results indicate that the expected sensitivity will extend from:

- $550 \lesssim m_A \lesssim 900$ GeV for $m_H \sim 2m_{top}$
- $350 \lesssim m_H \lesssim 550$ GeV for $m_A \sim 900$ GeV

This will allow to **probe a parameter region that has so far not been explored at the LHC.**

Expected limit on σ/σ_{theory}





Literature: arXiv:2011.05639 arXiv:1807.07734

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