

Searches for Minimal Supersymmetric Standard Model Higgs bosons H/A and for a Z' boson in the $\tau\tau$ final state at 13TeV with the ATLAS Detector

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BMBF-Forschungsschwerpunkt
ATLAS-EXPERIMENT

Physik bei höchsten Energien mit dem ATLAS-Experiment am LHC

FSP 103

ATLAS

Introduction

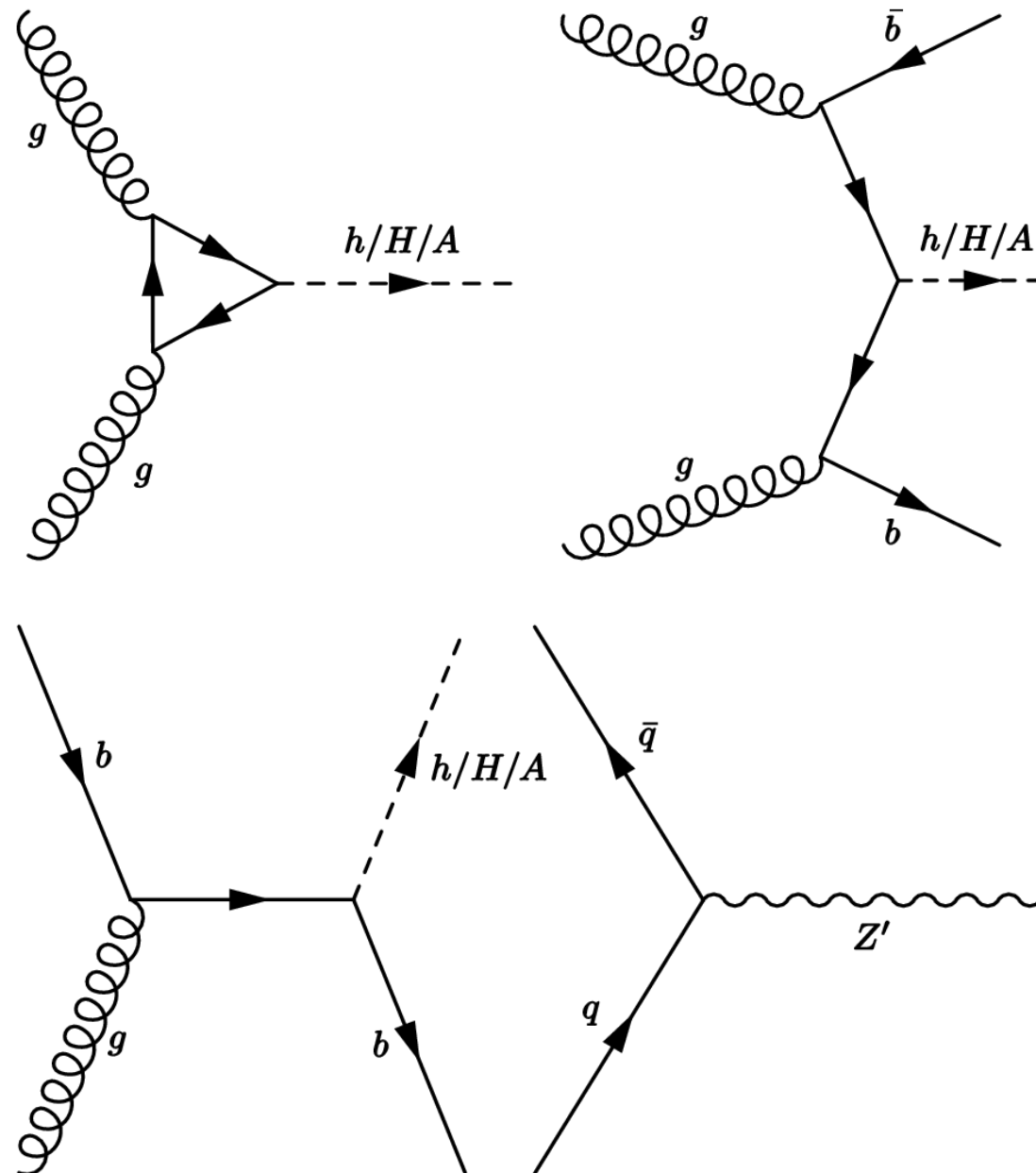
- Search for heavy neutral resonances decaying into a pair of taus
- Interpretation in various models of:

- **MSSM A/H:** latest public results with 13.2ifb at $\sqrt{s}=13\text{TeV}$

ATLAS-CONF-2016-085

- **Z' bosons:** latest public results with 3.2ifb at $\sqrt{s}=13\text{TeV}$

CERN-EP-2016-164



Analysis strategy



- Select two back-to-back tau decays of opposite charge

- Channels are complementary

	Muons	Electrons
$\tau_{\text{had}} \tau_{\text{had}}$	0	0
$\tau_{\mu} \tau_{\text{had}}$	1	0
$\tau_e \tau_{\text{had}}$	0	1

- Reconstructing total transverse mass:

$$m_{\text{T}}^{\text{tot}}(\tau_1, \tau_2, E_{\text{T}}^{\text{miss}}) = \sqrt{m_{\text{T}}^2(\tau_1, \tau_2) + m_{\text{T}}^2(\tau_1, E_{\text{T}}^{\text{miss}}) + m_{\text{T}}^2(\tau_2, E_{\text{T}}^{\text{miss}})}$$

Event Selection

$\tau_{\text{had}}\tau_{\text{had}}$ channel:

- 2 taus, no leptons
- Single tau trigger (tau80, tau125)
- Leading tau:
 - matches trigger
 - Jet BDT medium
- Subleading tau:
 - $p_{\text{T}} > 55 \text{ GeV}$ (65 GeV in b-tag category)
 - Jet BDT loose
- $\Delta\phi(\tau_1, \tau_2) > 2.7$
- Opposite charge

$\tau_{\text{lep}}\tau_{\text{had}}$ channel:

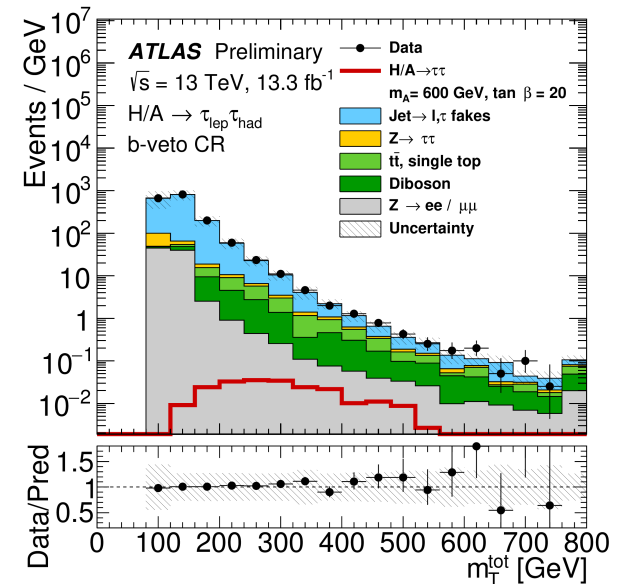
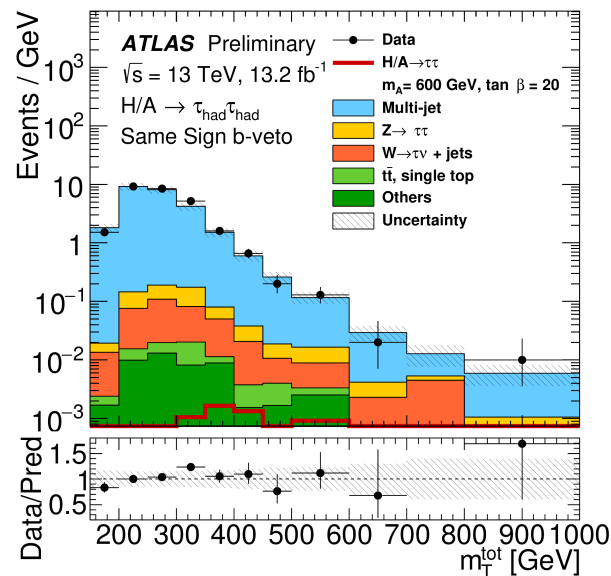
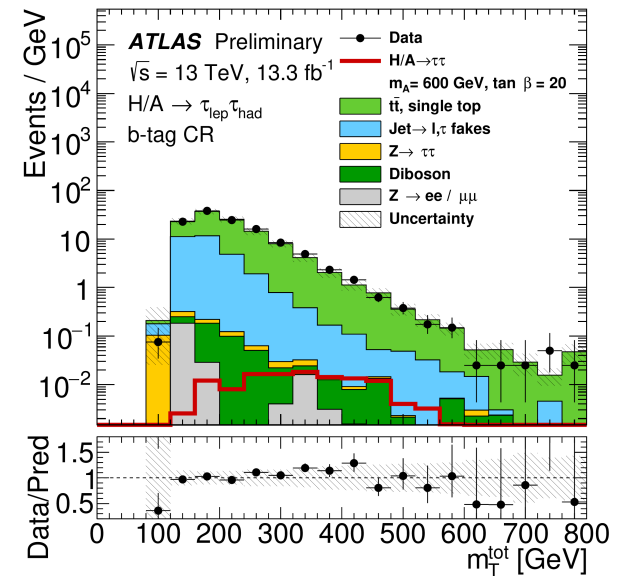
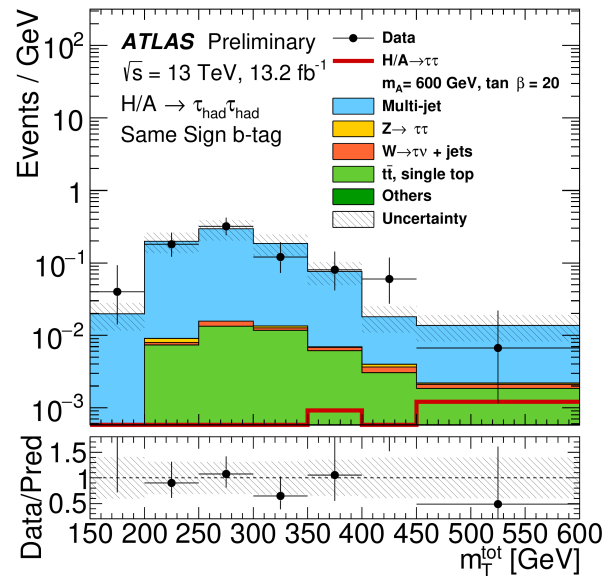
- 1 tau, 1 lepton
- Single lepton triggers and MET trigger
- Lepton $p_{\text{T}} > 30 \text{ GeV}$
- Tau $p_{\text{T}} > 25 \text{ GeV}$
- E-had channel:
 $80 < m(e, \tau_{\text{had}}) < 110 \text{ GeV}$
- Suppression of W+jets
 $m_{\text{T}}(\ell, E_{\text{T}}^{\text{miss}}) < 40 \text{ GeV}$, where
 $m_{\text{T}}(\ell, E_{\text{T}}^{\text{miss}}) \equiv \sqrt{2p_{\text{T}}(\ell)E_{\text{T}}^{\text{miss}}(1 - \cos \Delta\phi(\ell, E_{\text{T}}^{\text{miss}}))}$
- $\Delta\phi(\tau_{\text{lep}}, \tau_{\text{had}}) > 2.4$
- Opposite charge

Categories

- **B-tag**
 - At least one preselected b-tagged jet
 - Most sensitivity at high mass and b-associated production
- **B-veto**
 - No preselected b-tagged jet
 - Dominant at low mass
- **High MET category**
- **Inclusive b-tag category**
 - This region is only used for Z' interpretation and has no further selection
 - Very similar to the b-veto category, but without b-tagging uncertainties

Background estimation

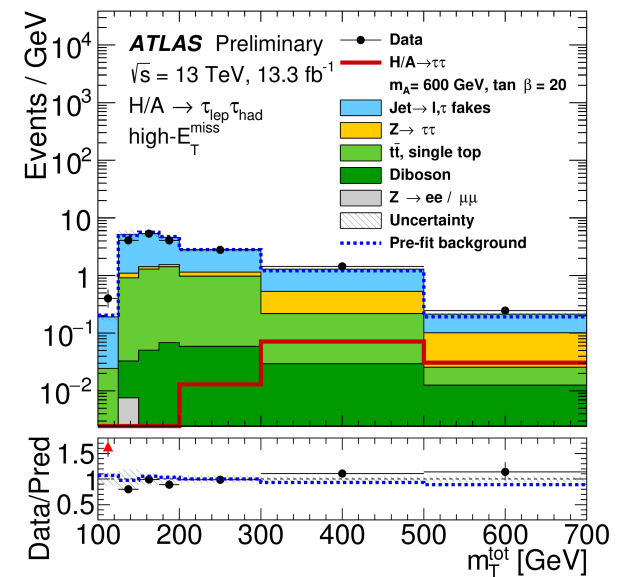
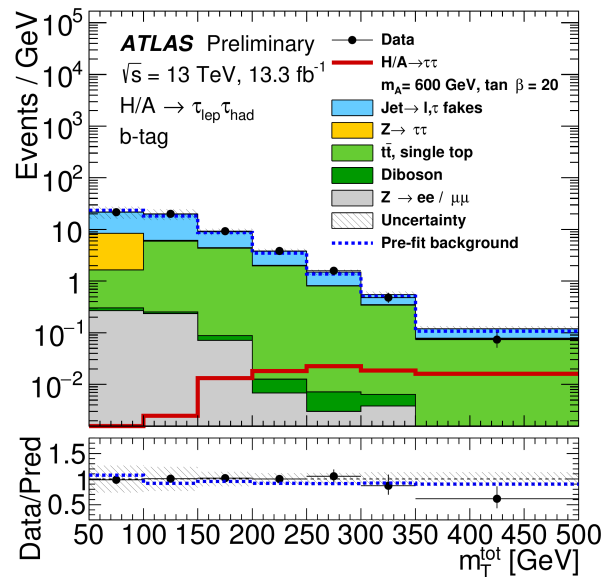
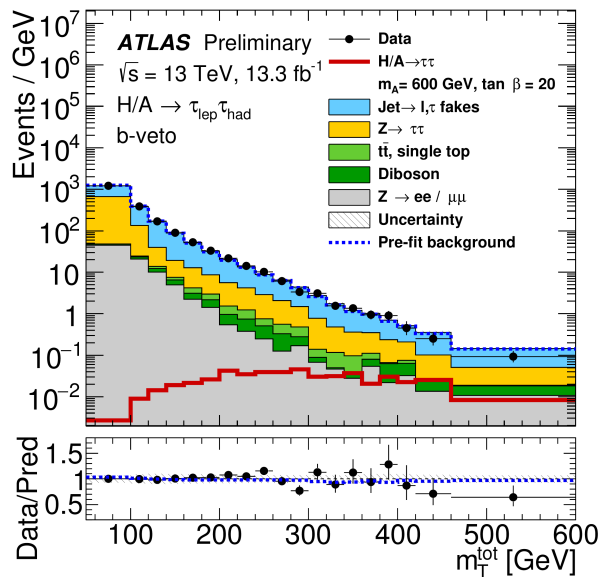
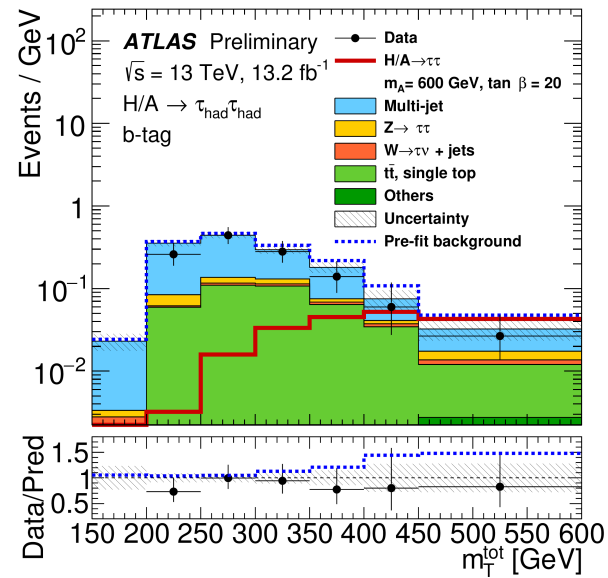
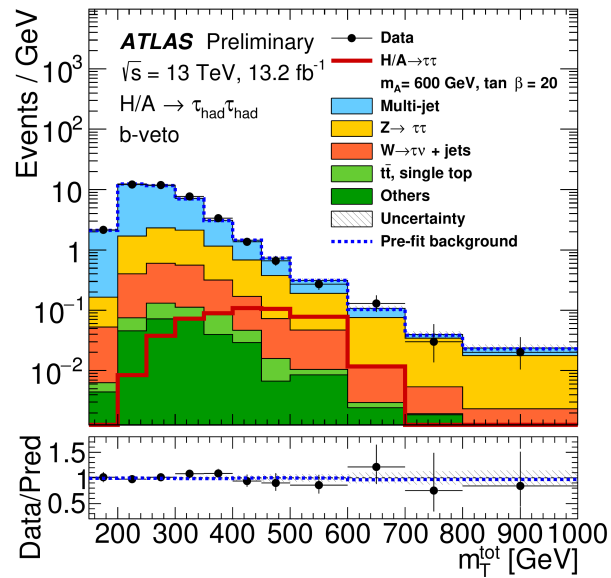
- Multi-jet background directly estimated from data
- Other jet \rightarrow τ fakes estimated from Simulation with data driven correction
- All true backgrounds estimated from simulation



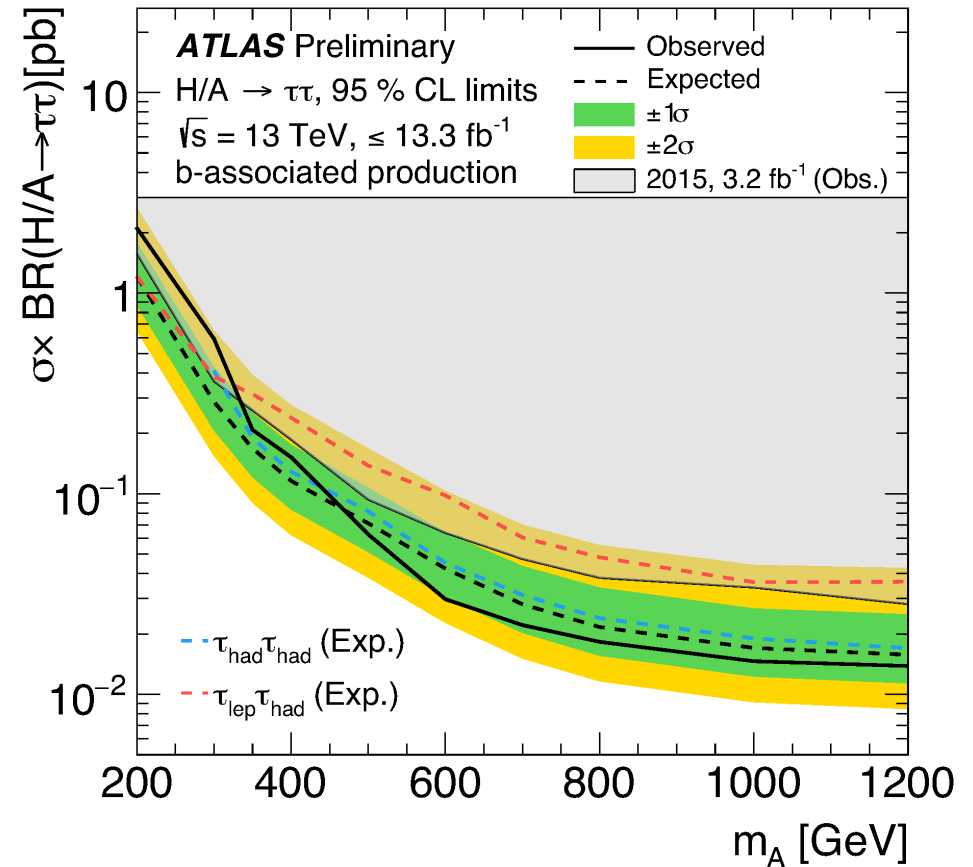
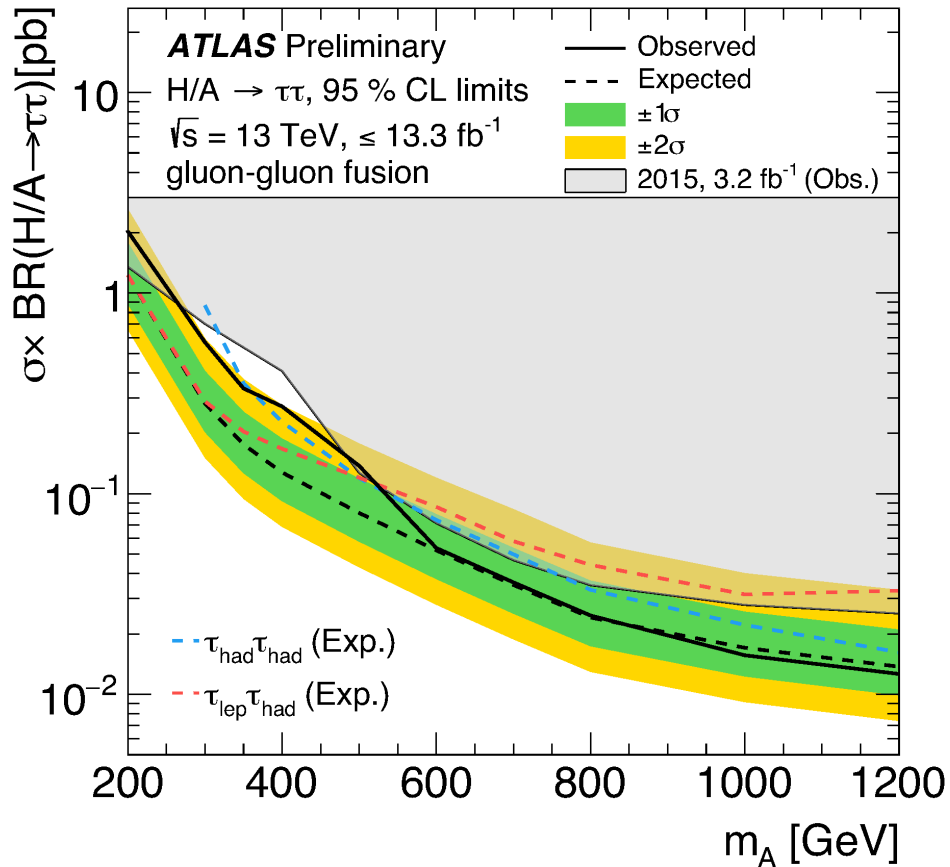
Systematic uncertainties

Source of uncertainty	F_- (%)	F_+ (%)
$t\bar{t}$ background parton shower model	-21	+39
$\tau_{\text{had-vis}}$ energy scale, detector modelling	-10	+12
r_{MJ} estimation b -veto region ($\tau_\mu \tau_{\text{had}}$)	- 5	+ 6
r_{MJ} estimation b -veto region ($\tau_e \tau_{\text{had}}$)	- 2.3	+ 3.0
bbH signal cross-section uncertainty	- 3.8	+ 1.6
Multi-jet background ($\tau_{\text{had}} \tau_{\text{had}}$)	- 2.2	+ 2.6
Jet-to- $\tau_{\text{had-vis}}$ fake rate b -veto region ($\tau_{\text{lep}} \tau_{\text{had}}$)	- 1.3	+ 2.9
$\tau_{\text{had-vis}}$ energy scale, in-situ calibration	- 1.4	+ 1.1
r_{MJ} estimation high- $E_{\text{T}}^{\text{miss}}$ region ($\tau_\mu \tau_{\text{had}}$)	- 1.4	+ 1.0
τ trigger (2016)	- 0.5	+ 1.3
Statistics (data and simulation)	-48	+25

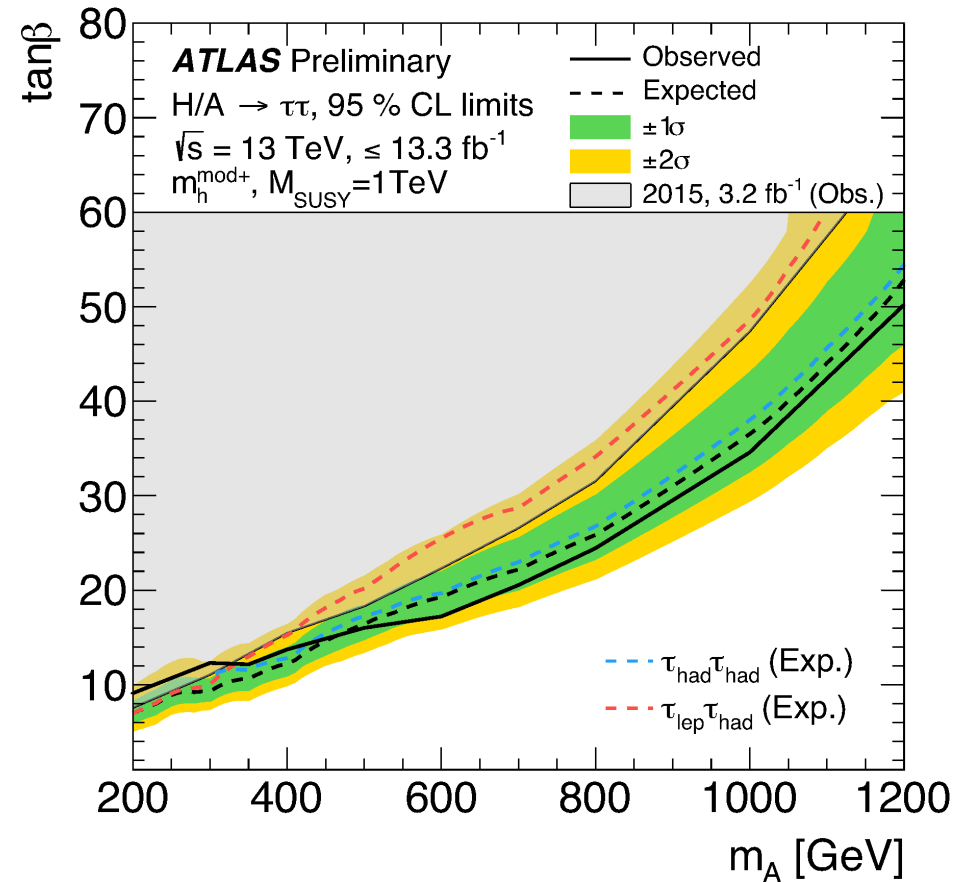
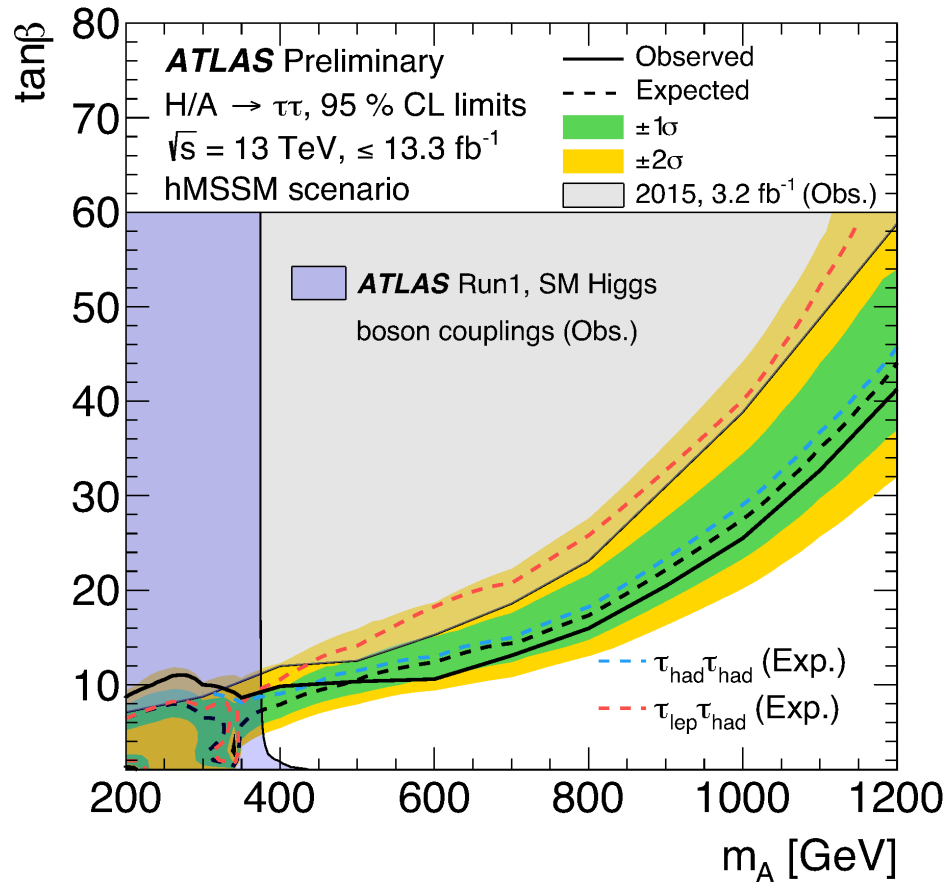
MSSM A/H Signal region



MSSM A/H Limits

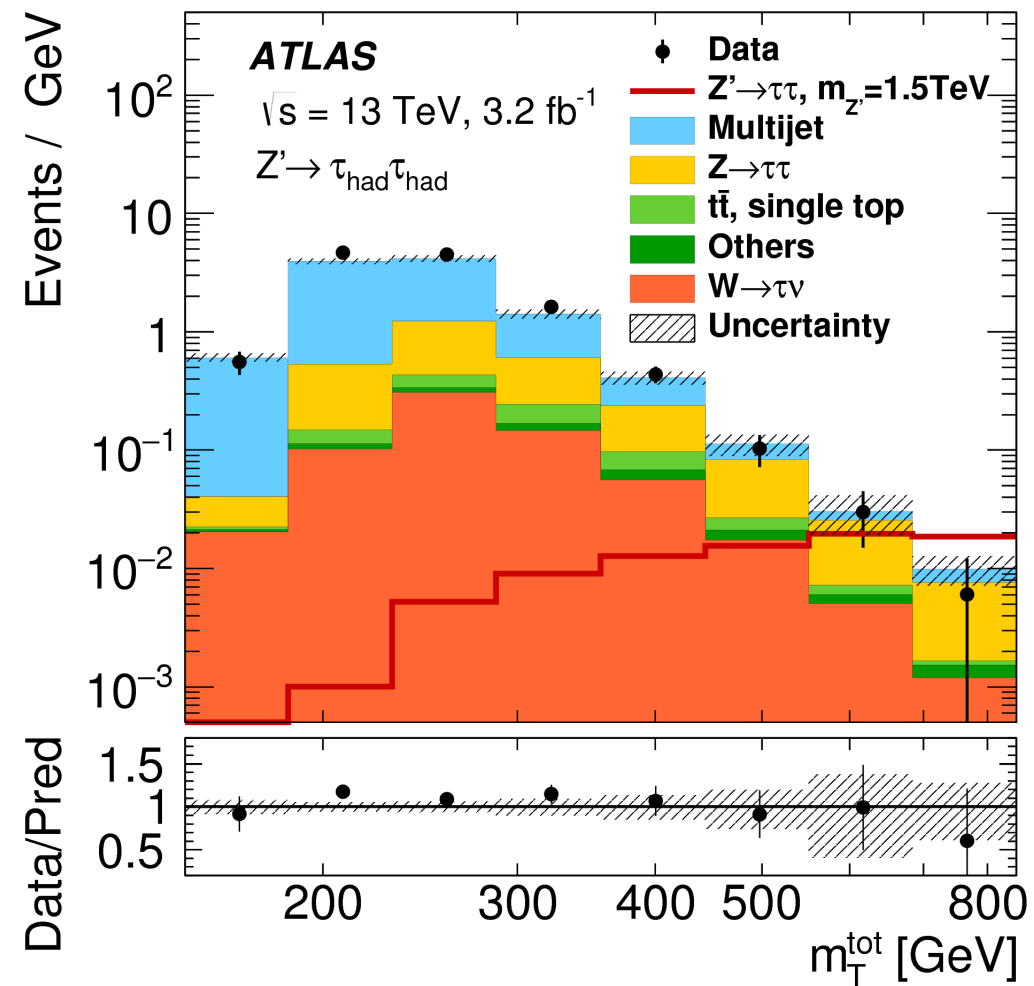
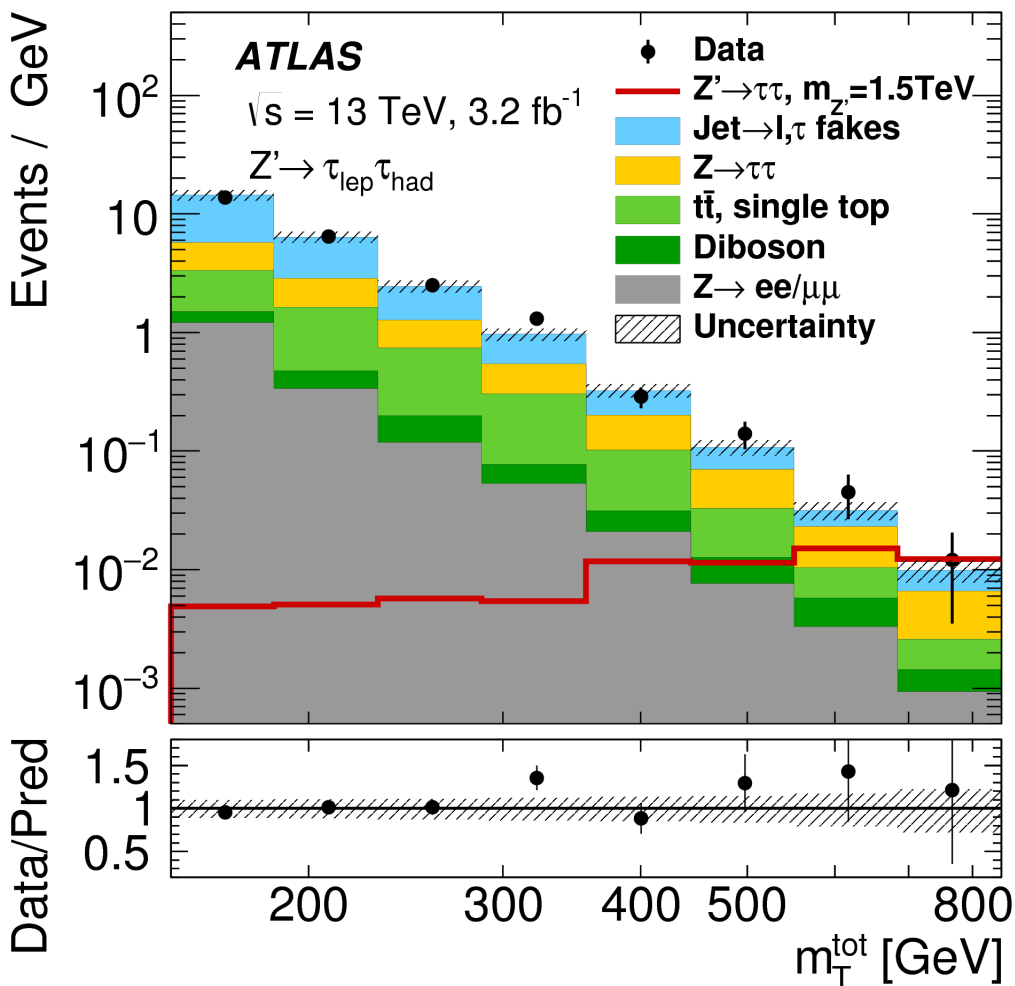


MSSM A/H Limits



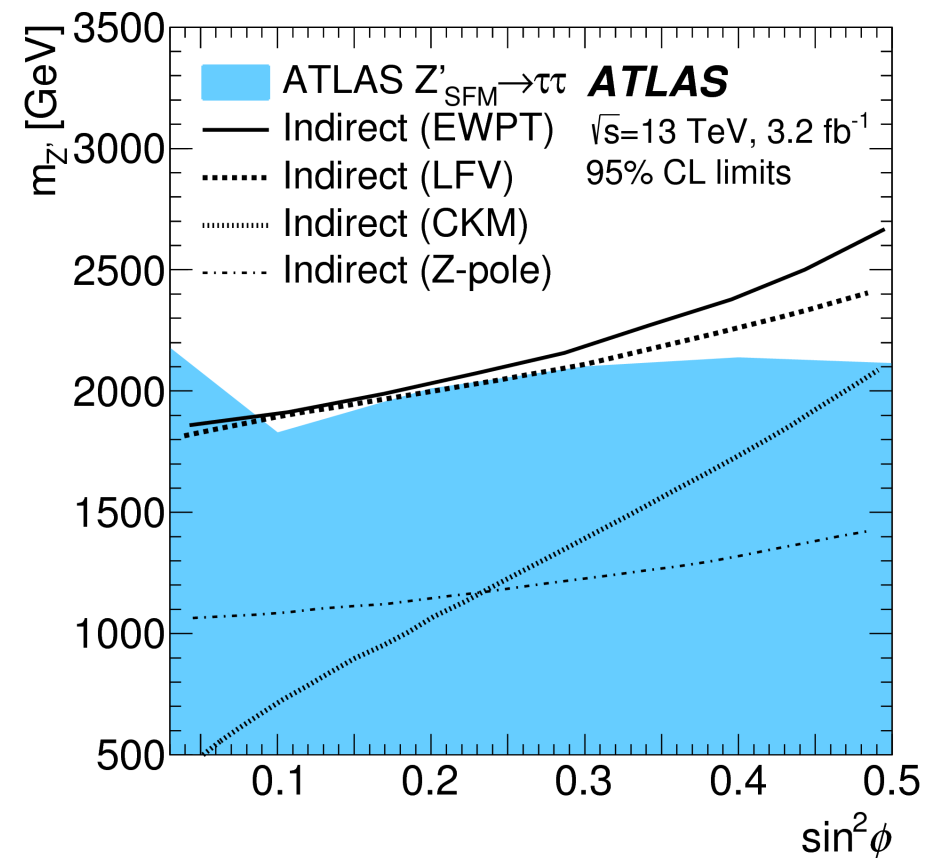
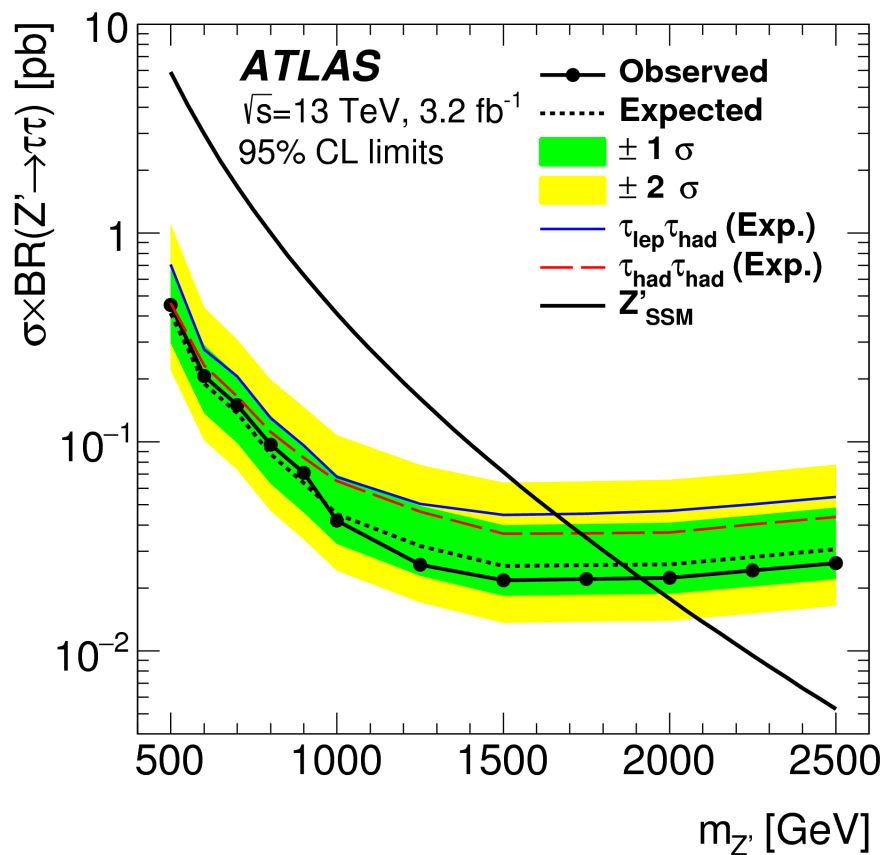
Z' signal region

- Inclusive in number of b-tagged jets
- Measurement considered 2015 data only



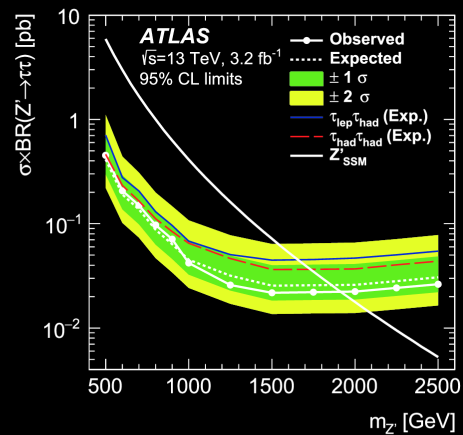
Z' limits

- Observed lower limit on the Z' mass is 1.90 TeV
- SFM model with different couplings between the first two and the third generation
- Limits

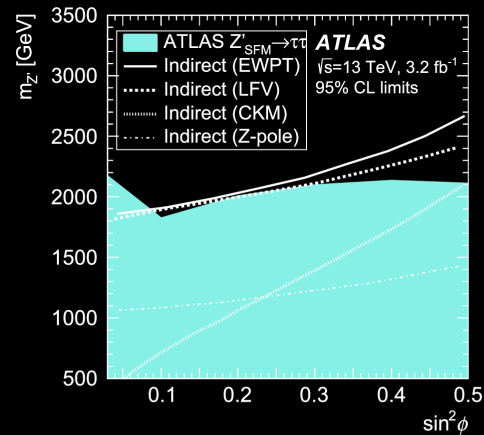




Particles and Fields



(a) Z'_{SSM} scenario



(b) Z'_{SFM} scenario

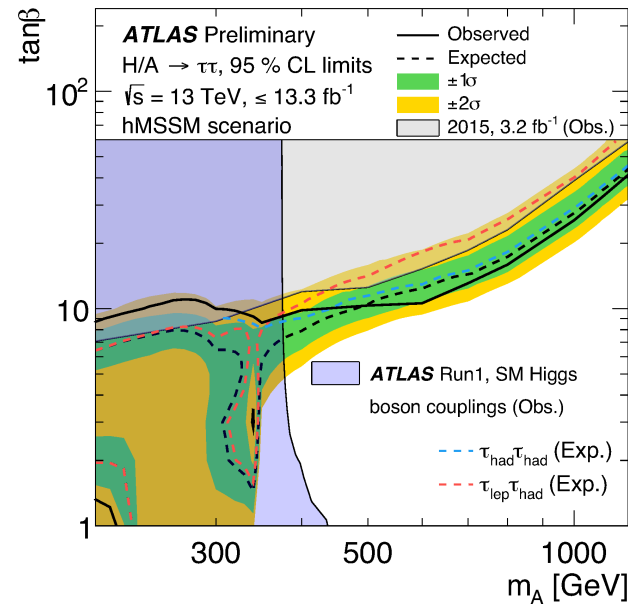
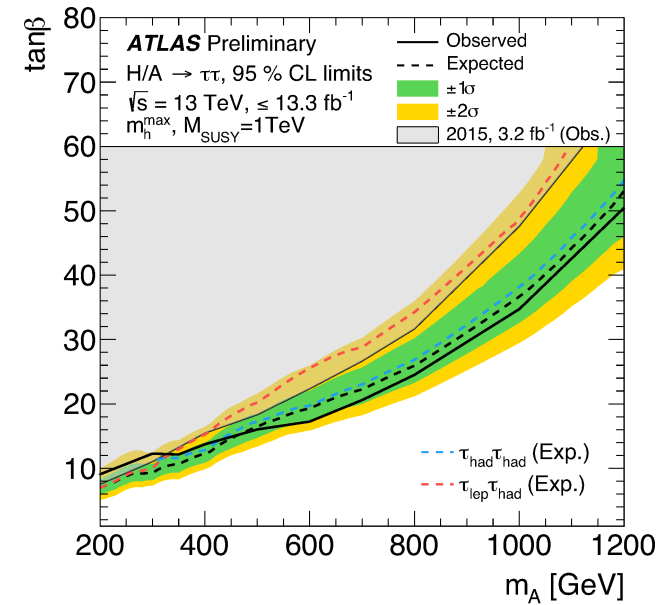
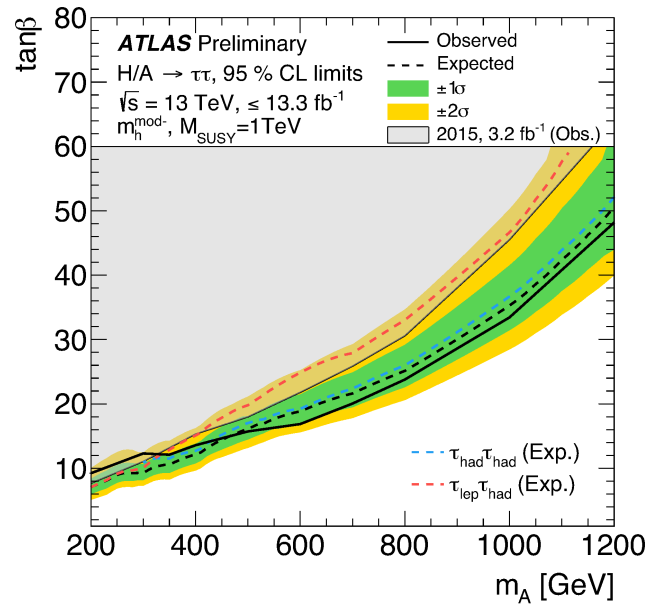
The 95% CL upper limit on the cross section times branching fraction for a $Z' \rightarrow \tau\tau$ in **a** the Sequential Standard Model and 95% CL exclusion on **b** the Strong Flavour Model parameter space, overlaid with indirect limits at 95% CL from fits to electroweak precision measurements, lepton flavour violation, CKM unitarity and Z-pole measurements. From the ATLAS Collaboration: Search for Minimal Supersymmetric Standard Model Higgs bosons H/A and for a Z' boson in the $\tau\tau$ final state produced in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS Detector.

Summary

- ATLAS search for heavy neutral resonances with di-tau final states was quite productive since start of the run2 data taking
- Unfortunately no new physics observed so far
- But limits have been set on various models on MSSM A/H and Z' bosons
- New results with 36fb are on they way
 - So stay tuned

BACKUP

Additional MSSM A/H limits



Z' model acceptance studies

