Charged Higgs searches in ATLAS

Updates on Light and Heavy Charged Higgs

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Light Charged Higgs: "Ratio Method"

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Search for charged Higgs bosons through the violation of lepton universality in $t\bar{t}$ events using pp collision data at $\sqrt{s} = 7$ TeV with the ATLAS experiment

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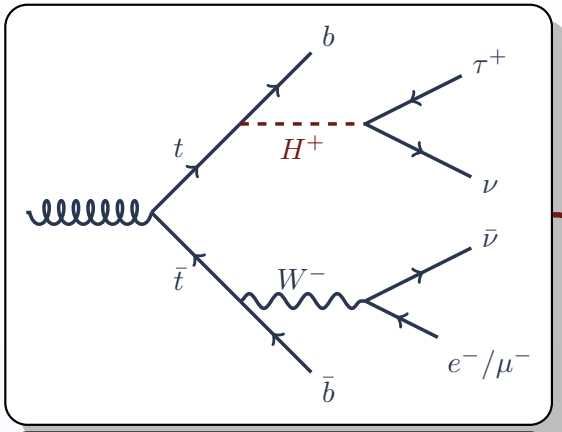
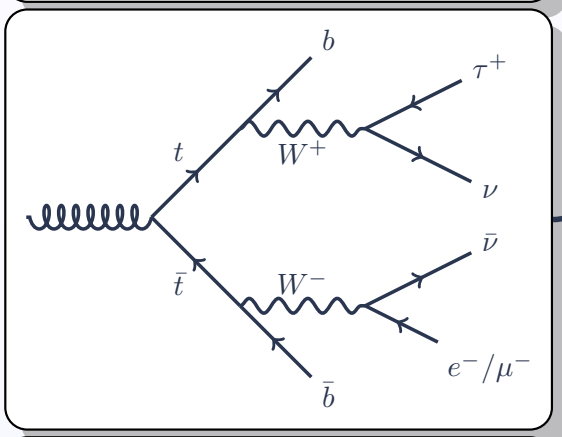
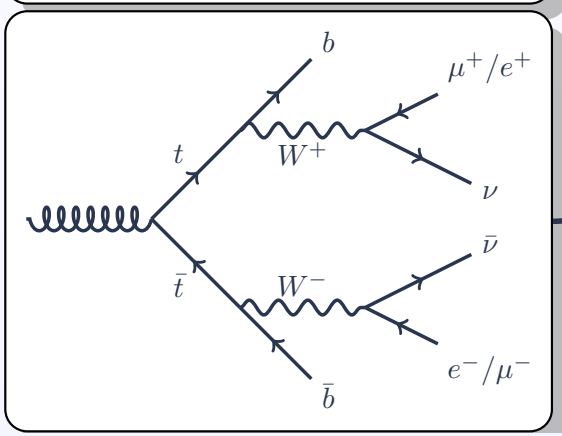
The ATLAS collaboration

The Ratio Method: Introduction



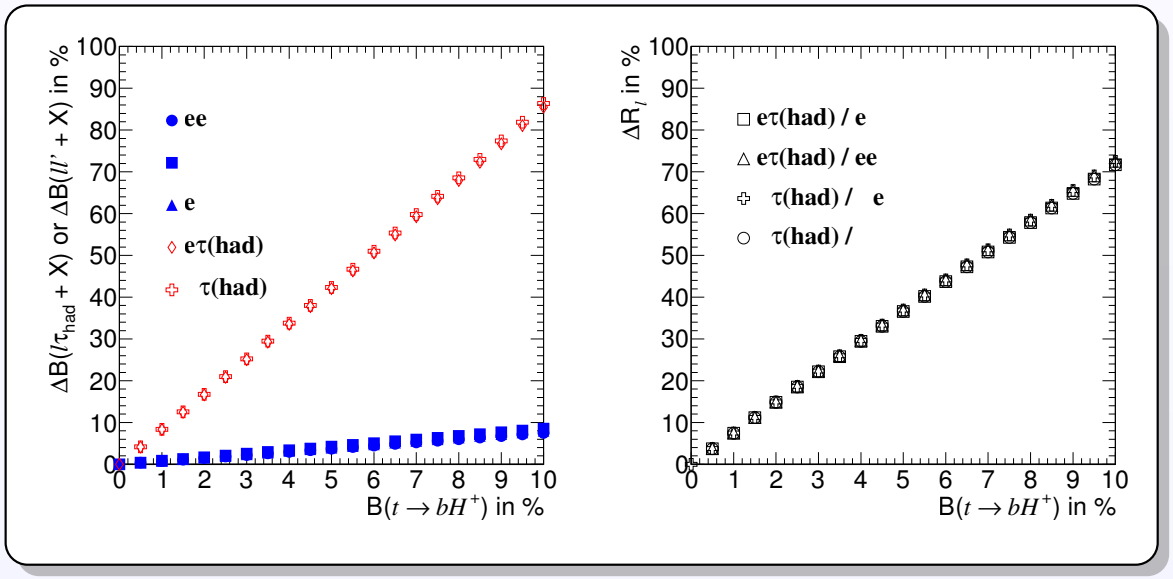




A test of lepton universality in top decays

- Can offer improved sensitivity over direct direct searches, especially in the difficult region close to the W mass.
- The idea is to look for an apparent increase in $\mathcal{B}(t \to X \to \tau\nu)$ by measuring the ratios:

$$\frac{\mathcal{N}\ (t\bar{t} \to b\bar{b} + \mu\tau_{had} + N\nu)}{\mathcal{N}\ (t\bar{t} \to b\bar{b} + \mu e + N\nu)}\ ,\ \frac{\mathcal{N}(t\bar{t} \to b\bar{b} + e\tau_{had} + N\nu)}{\mathcal{N}(t\bar{t} \to b\bar{b} + e\mu + N\nu}\ .$$



Analysis Outline

Event Selection

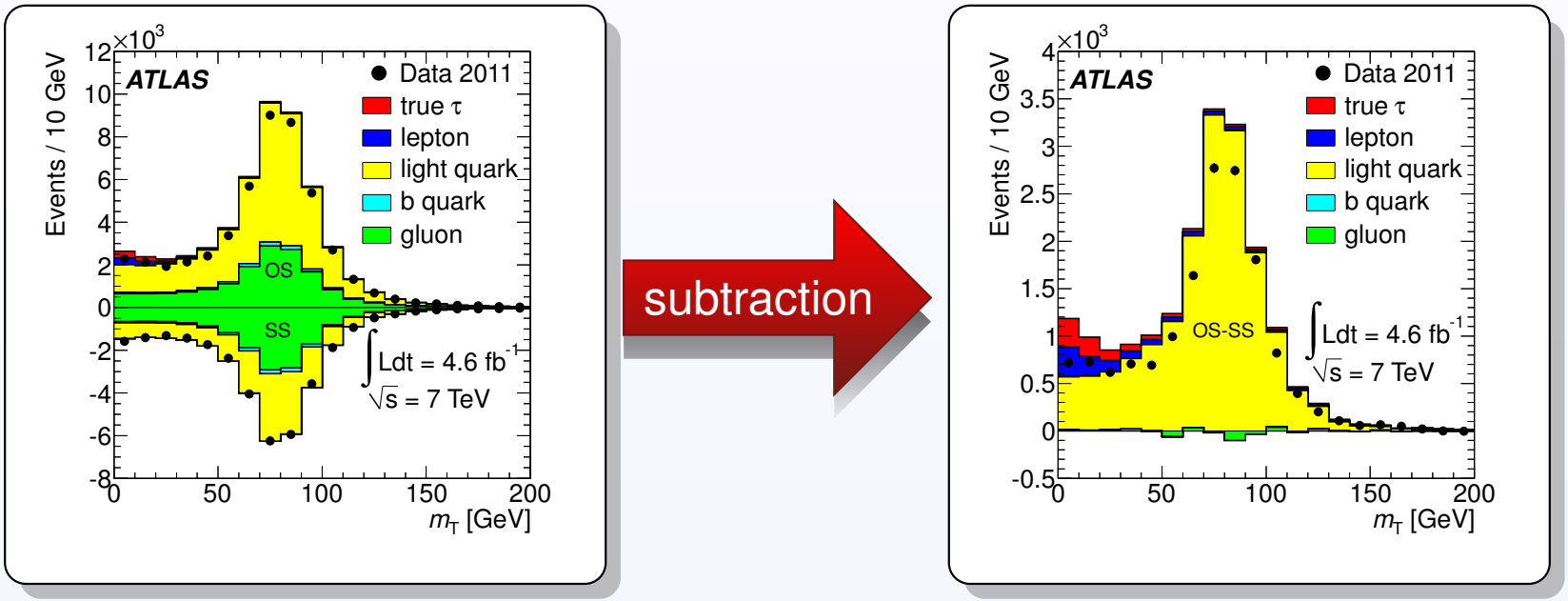
- Single lepton trigger.
- Exactly one electron (muon) having $E_{\mathrm{T}}(p_{\mathrm{T}}) > 25$ GeV and matched to trigger.
- At least two jets having $p_{\mathrm{T}} > 20$ GeV and $|\eta| < 2.4$, including exactly two b-tags.
- Either exactly one τ jet with $p_{\mathrm{T}} > 25$ GeV and $|\eta| < 2.3$ with no additional charged lepton, or exactly one muon (electron with E_{T} or p_{T} above 25 GeV.
- ${E_{\mathrm{T}}}^{miss} > 40$ GeV.
- Require that the transverse mass m_{T2}^{H} which corresponds to a lower bound on the boson (W or H^{+}) is well defined in the event.

Background estimates

- Misidentified electrons and muons: Identification probailities measured in control samples; parametrized by pseudorapidity, distance to nearest jet and p_{T} of the leading jet; applied to events with tight and loose (loosened isolation/id requirements) leptons.
- Misidentified taus: Misidentification rates for electrons measured using $Z \rightarrow ee$ events, misidentification rates for jets measured in W+>2 jets events.xs
- Everything else from simulation.

OS-SS procedure for reduced uncertainties

- All common systematics cancel in the ratio between the $l + \tau$ and $l + l'$ channels.
- Only τ and l' systematics should remain, most importantly: jets faking taus (46% of identified taus).
- Misidentification rates differ between light quarks, heavy quarks, and gluons. Relative fractions of these contributions are not well known.
- To reduce the associated uncertainty, subtract Same Sign (SS) events from Opposite Sign (OS) events, using relative charge of the lepton and τ candidate.
- Heavy quark and gluon contributions cancel! (Plots are made in a control region.)



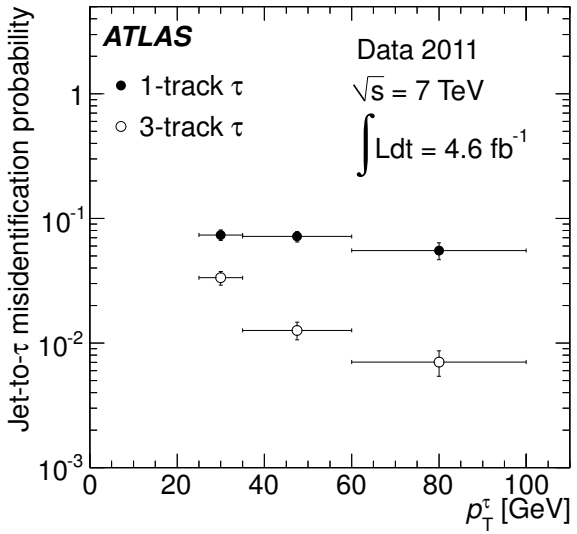
Data driven estimation of jets misidentified as taus

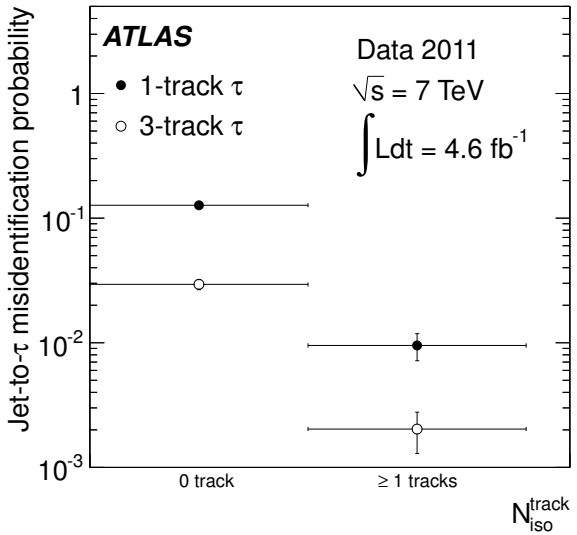
The rate at which light-quark jets are misidentified as taus is derived in a region enriched with W + >2 jets events in data and binned in number of associated tracks, $p_{\mathrm{T}}{}^{\tau}$ and number of tracks in $0.2<\Delta R<0.4$. To remove contributions of gluons and heavy flavour jets, the OS-SS subtraction is applied. Simulated events with tau candidates originating from jets in the signal region are then weighted using the measured misidentification probabilities.

$W+ > 2$ jets selection

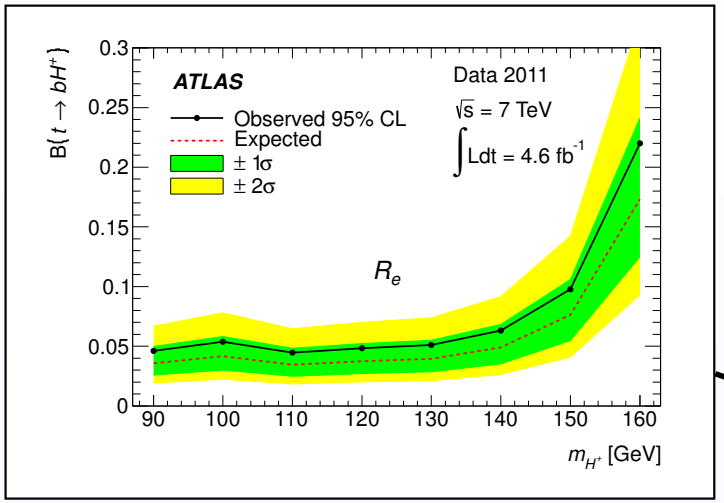
1. Exactly one electron (muon) with $E_{\mathrm{T}}(p_{\mathrm{T}}) > 25$ GeV.
2. At least one τ candidate.
3. At least two jets in addition to the τ candidate(s).
4. No b-tagged jets.
5. $E_{\mathrm{T}}{}^{miss} > 40$ GeV.
6. $m_T = \sqrt{2p_{\mathrm{T}}^{l} E_{\mathrm{T}}^{miss}(1 - \cos\Delta\phi_{l,miss})} > 30$ GeV

✓ Track multiplicity scale factors are also derived in the control region and applied to the simulated events.

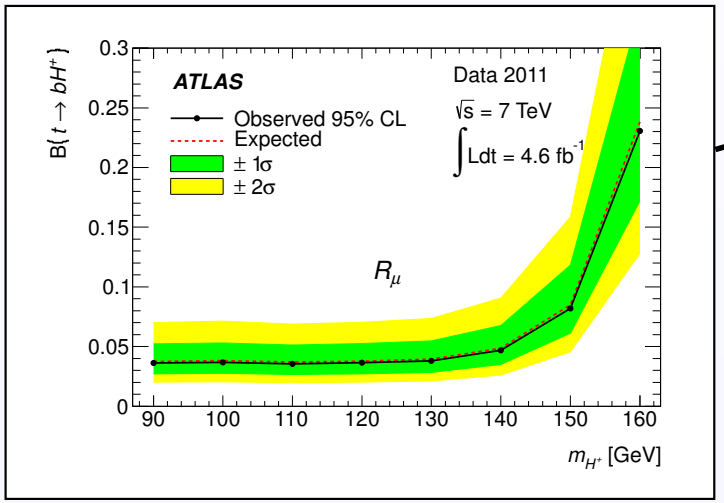




Exclusion limits

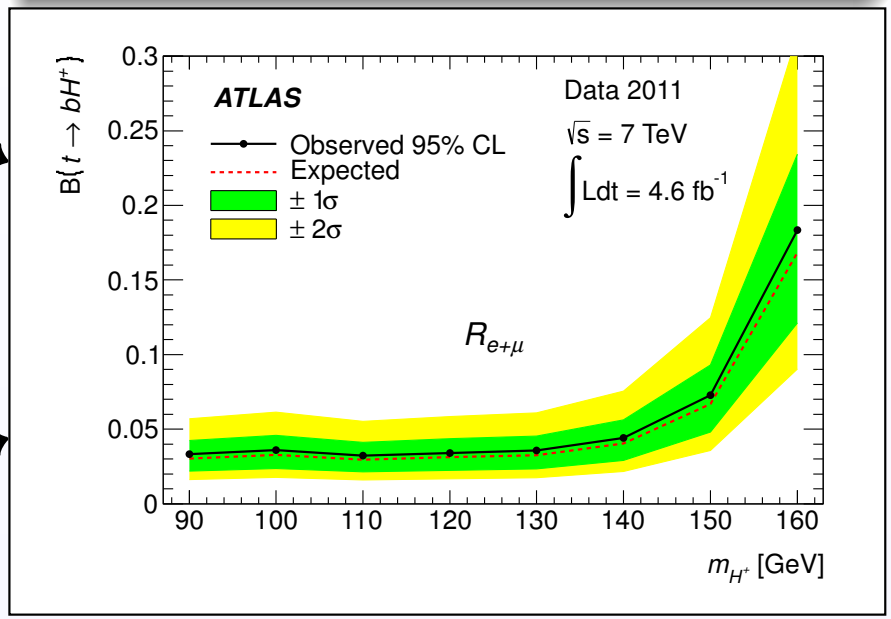


electron channel



muon channel

Exclusion limits are set on the branching fraction $\mathcal{B}(t \to bH^+)$ at 95% confidence level using the CL_S technique and a profile likelihood ratio with R_e and R_μ as the discriminating variables.



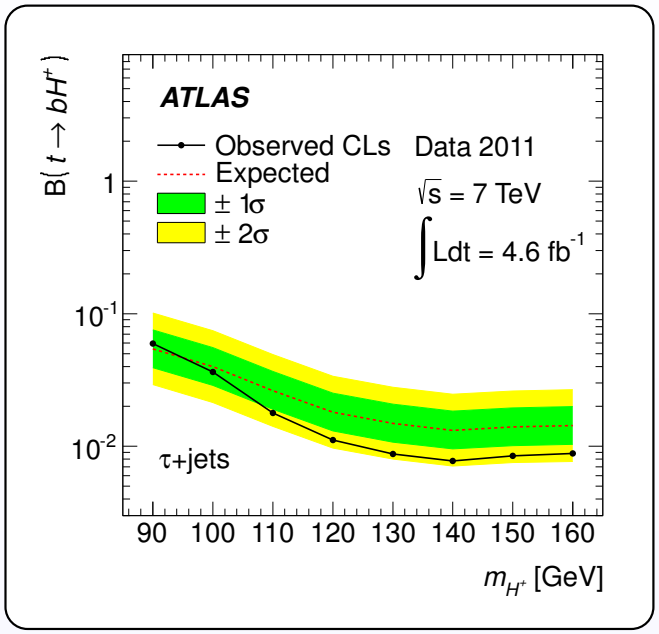
combination

➠ **Upper limit of 3.2%-4.5% in the mass range 90-140 GeV.**

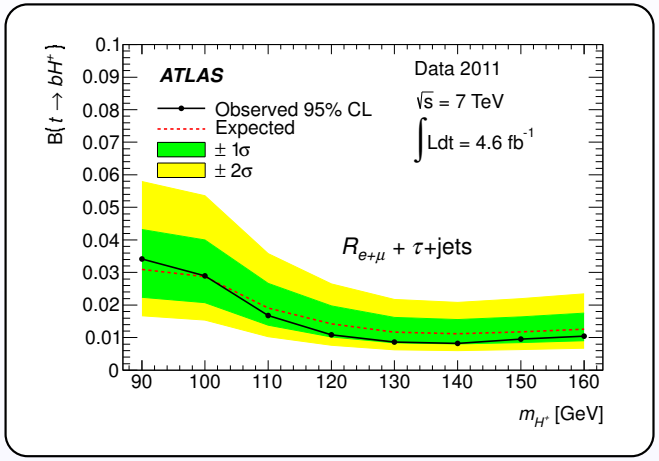
Major uncertainties: τ ID - real (3.3%) and misid. (4.2%)), $t\bar{t}$ modelling (5.7%), ISR/FSR (3.7%).

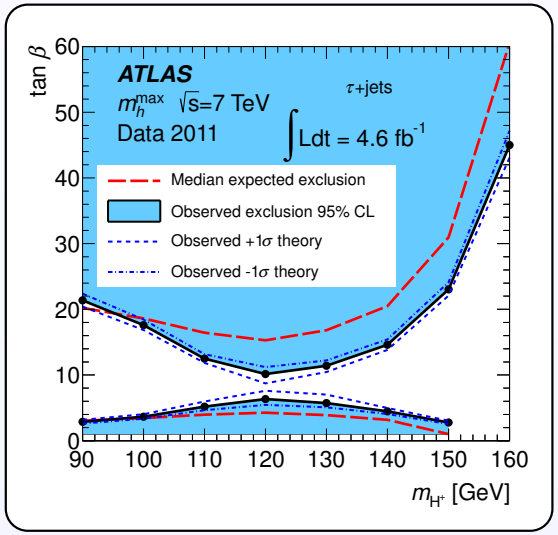
Combination with direct search

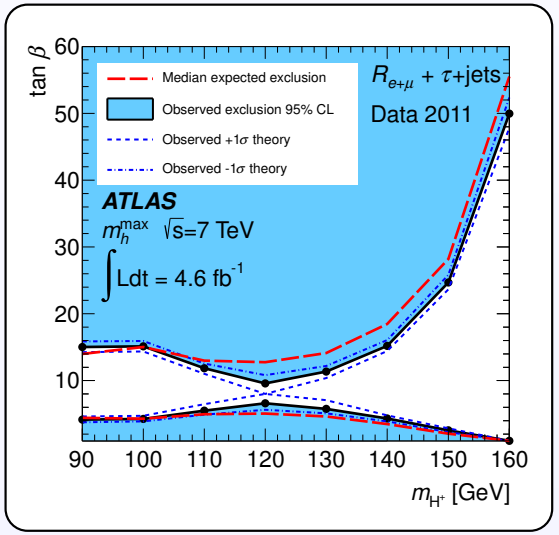
$\tau + jets$



$\tau + jets$ + ratio method





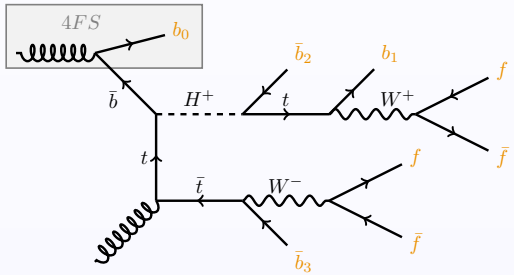


Heavy Charged Higgs

Ongoing work

$H^+ \to tb$

- Very complicated final state with 3 or 4 b-jets.
- Currently working on event reconstruction using BDTs and/or kinematic fitting.



$H^+ \to \tau\nu$

- Here the H^+ is produced in association with a top quark.
- Analysis just starting, we are looking to adapt the ratio method to case of a heavy H^+ and/or use some shape information for discrimination.
- Currently working on updating the data driven estimation of misidentified taus.