CH±arged Higgs Searches at ATLAS

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on behalf of the ATLAS collaboration

Introduction

- In the Standard Model (SM), only 1 doublet of Higgs scalars is responsible for the electroweak symmetry breaking: there is only one neutral Higgs boson.

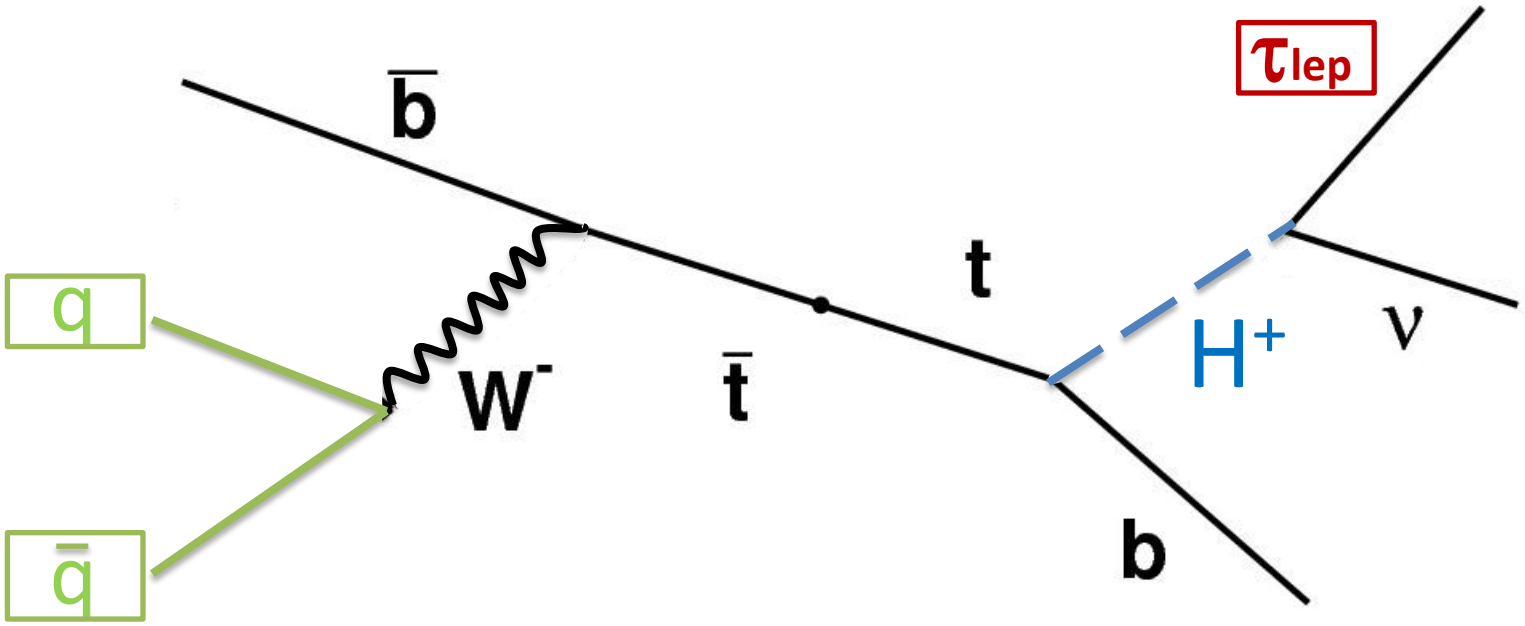
- Other so-called 2HDM models, such as the MSSM, predict the existence of 2 complex Higgs doublets... hence 5 physical states: H^+, H^-, h^0, H^0, A^0.

Introduction

- This talk will focus on the charged Higgs (following http://arxiv.org/pdf/1204.2760).
- With no decay to supersymmetric particles, $H^+ \rightarrow \tau\nu$ dominates below the $H^+ \rightarrow t\bar{b}$ threshold ($m_H < m_{top}$).
- The presented search is model independent.
- The decay $H^+ \rightarrow \tau\nu$ assumed to be 100%.
- This study focusses on a charged Higgs mass in the range of 90-160 GeV.

Decay Modes

- Lepton + jets

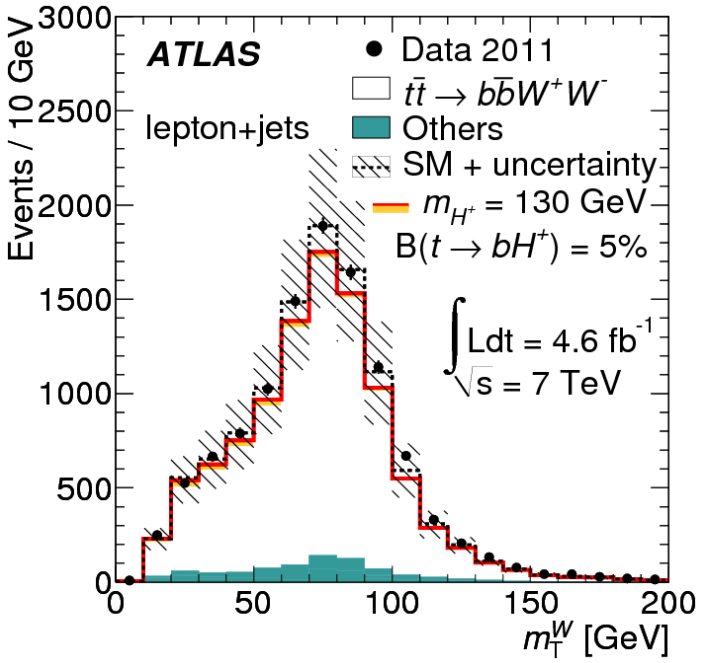


Lepton + jets

- **1** isolated **e/μ** with $p_T > 25/20$ GeV and **0 τhad** with $p_T > 20$ GeV.
- **≥4 jets** with $p_T > 20$ GeV and exactly 2 of them are b jets.
- E_T^{miss}
  - $E_T^{miss} > 40$ GeV if $|\phi_{l,miss}| \geq \pi/6$
  - $E_T^{miss} \times |\sin(\phi_{l,miss})| > 20$ GeV if $|\phi_{l,miss}| < \pi/6$.
- Building hadronic top ($\chi^2 < 5$):

$$\chi^2 = \frac{(m_{jjb} - m_{top})^2}{\sigma_{top}^2} + \frac{(m_{jj} - m_W)^2}{\sigma_W^2}$$

- Backgrounds with misidentified leptons are estimated from data.
- $m_T^W < 60$ GeV.



$$m_T^W = \sqrt{2p_T^l E_T^{miss}(1 - \cos\phi_{l,miss})}$$

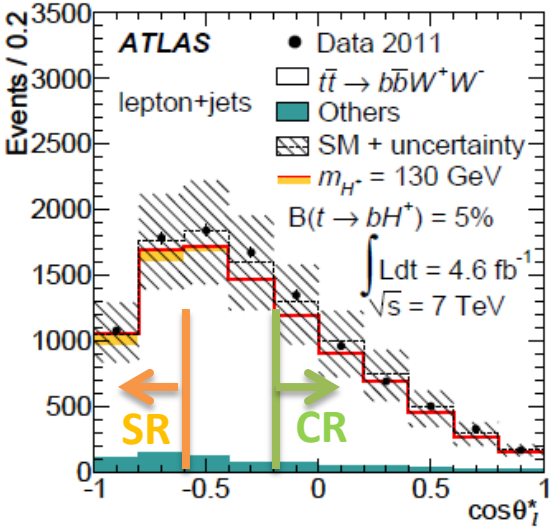
Lepton + jets

- m_{bl} – the invariant mass of the b jet and the charged lepton:

$$\cos\theta_l^* = \frac{2m_{bl}^2}{m_{\text{top}}^2 - m_W^2} - 1 \simeq \frac{4\,p^b \cdot p^l}{m_{\text{top}}^2 - m_W^2} - 1$$

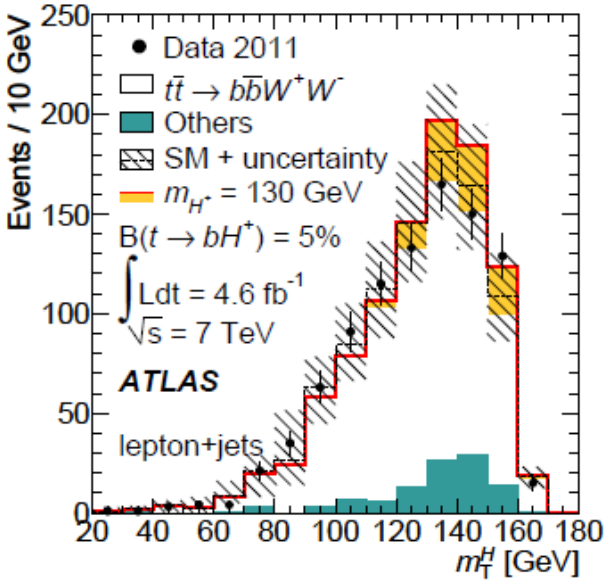
- Higgs transverse mass:

$$(m_{\text{T}}^H)^2 = \left(\sqrt{m_{\text{top}}^2 + (\vec{p_{\text{T}}}^{\,l} + \vec{p_{\text{T}}}^{\,b} + \vec{p_{\text{T}}}^{\,\text{miss}})^2} - p_{\text{T}}^b\right)^2 - \left(\vec{p_{\text{T}}}^{\,l} + \vec{p_{\text{T}}}^{\,\text{miss}}\right)^2$$



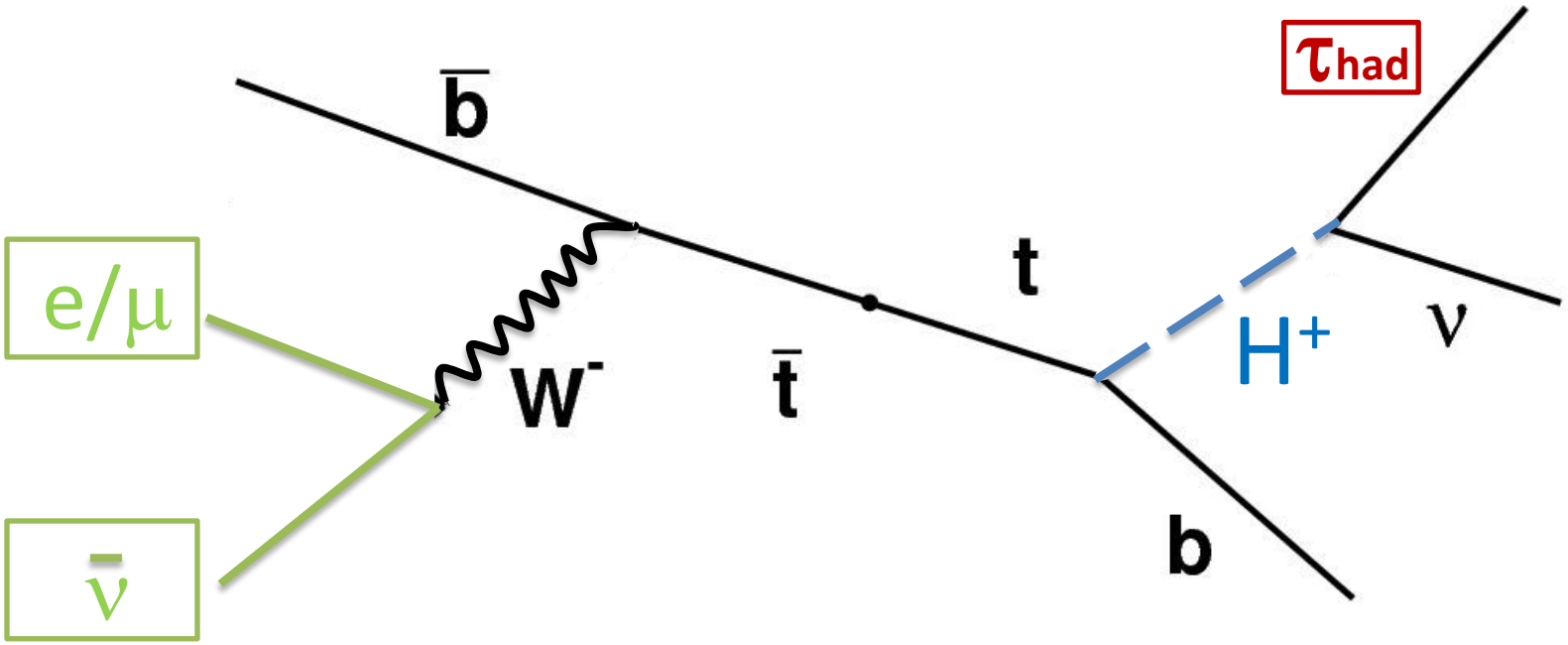
- Yields for signal with B(t→bH⁺)=5%:

All SM backgrounds	940	± 22	± 150
Data	933		
$t \to bH^+$ (130 GeV)	120	± 4	± 25
Signal+background	990	± 21	± 140



Decay Modes

- TauHad + lepton

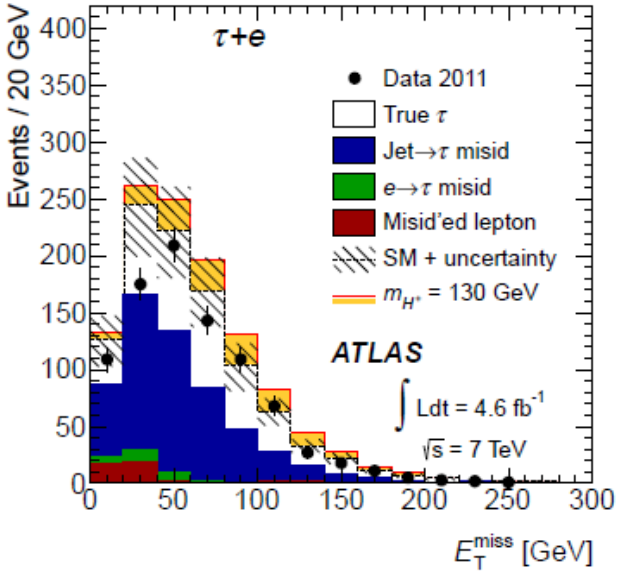


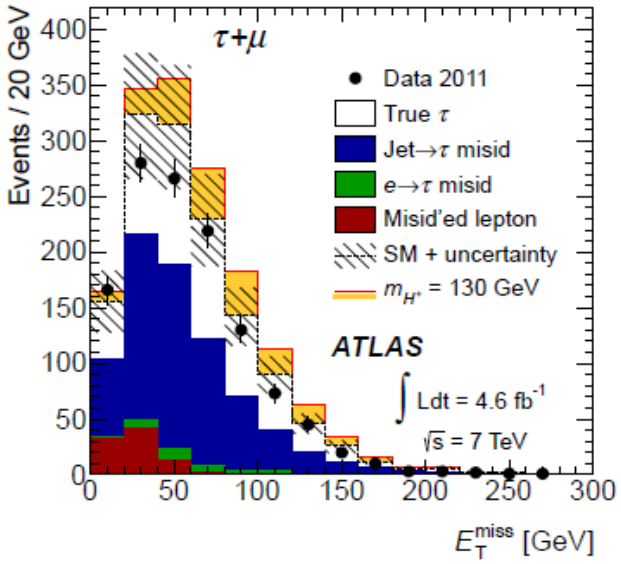
Tau + lepton

- **1** isolated **e/μ** with $p_T > 25/20$ GeV and **1 τhad** with $p_T > 20$ GeV.
- **≥2 jets** with $p_T > 20$ GeV and ≥ 1 of the jets is a b jet.
- Σp_Ttracks > 100 GeV.
- Yields for signal with B(t→bH⁺)=5% for τ+e (first) and τ+μ (second):

$\sum$ SM	$1010 \pm 30 \pm 110$
Data	880
$t \to bH^+$ (130 GeV)	$220 \pm 6 \pm 29$
Signal+background	$1160 \pm 30 \pm 100$

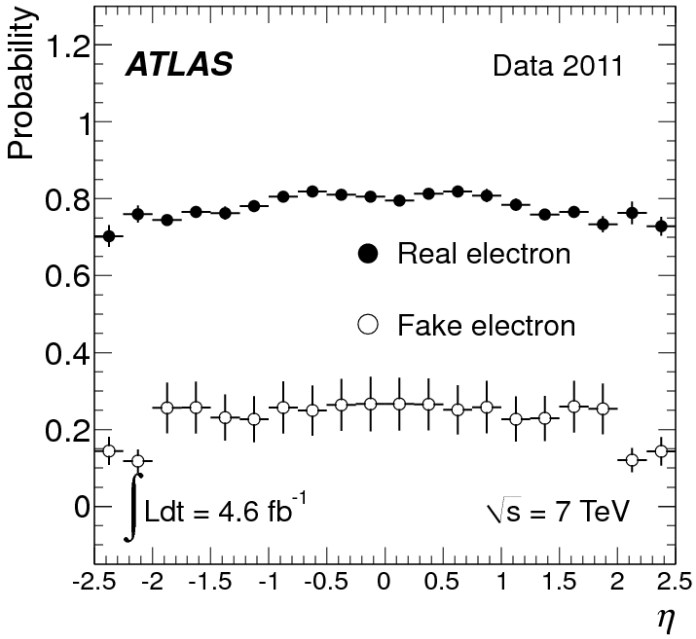
$\sum$ SM	$1360 \pm 30 \pm 140$
Data	1219
$t \to bH^+$ (130 GeV)	$310 \pm 7 \pm 39$
Signal+background	$1570 \pm 30 \pm 130$





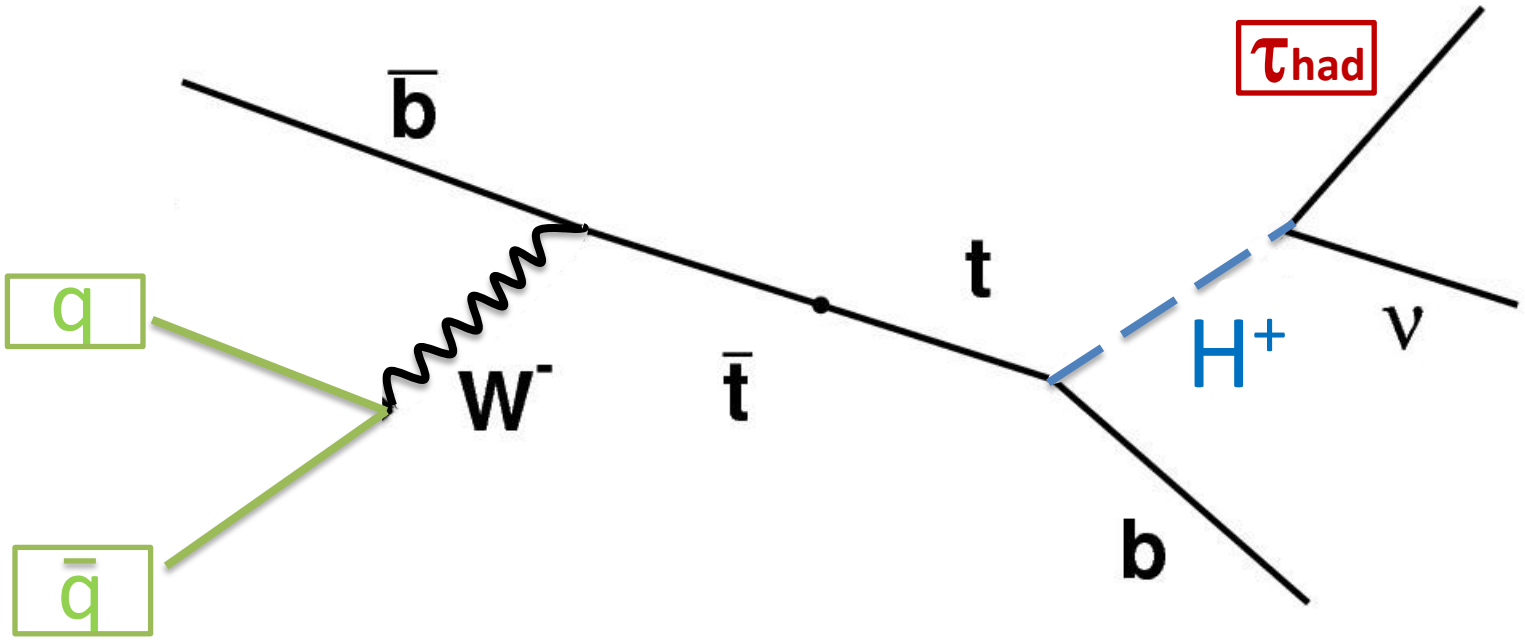
Tau + lepton

- Data driven methods:
- Backgrounds with misidentified leptons are estimated from data as in lepton + jets.
- Backgrounds with electrons misidentified as τ jets from Z→ee.
- Backgrounds with jets misidentified as τ jets from W+jets, this is evaluated separately for τ candidates with 1 or 3 associated tracks.
  - This misidentification probability is applied to simulated SM backgrounds fulfilling all requirements except the τ identification.



Decay Modes

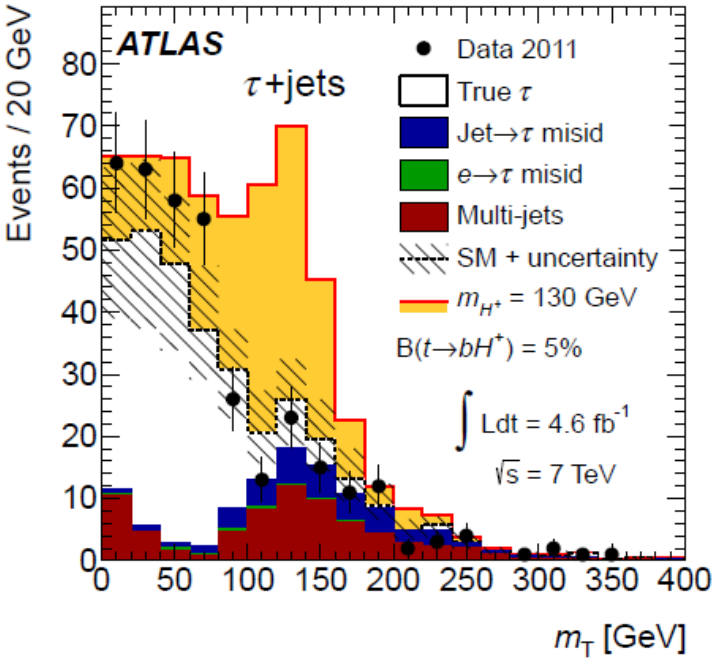
- TauHad + jets



Tau + jets

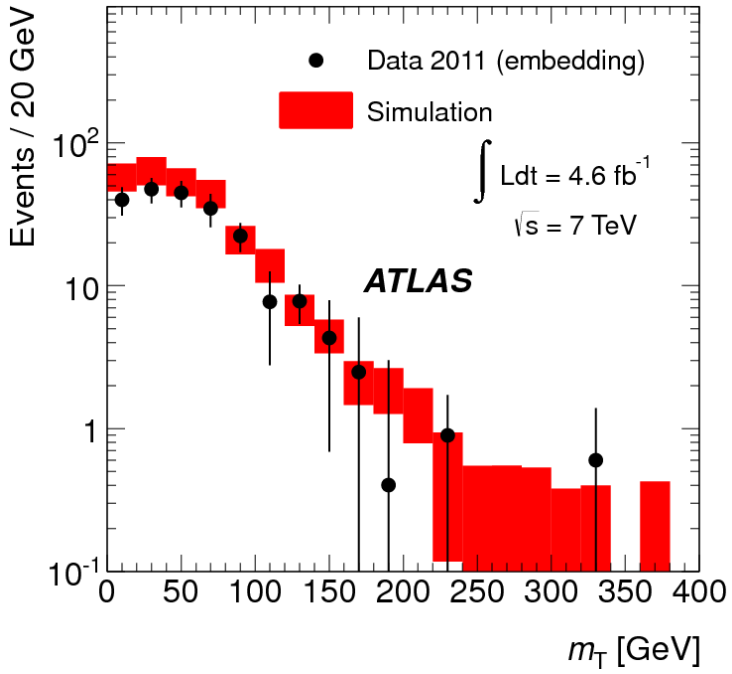
- **1 τhad** with $p_T > 40$ GeV and **0 e/μ** with $p_T > 20/15$ GeV.
- **≥4 jets** with $p_T > 20$ GeV and ≥1 of the jets is a b jet.
- $E_T^{miss} > 65$ GeV.
- $$\frac{E_T^{miss}}{0.5\ \text{GeV}^{1/2} \cdot \sqrt{\sum p_T}} > 13$$
- Building hadronic top: Combining jjb with highest p_T^{jjb} $m_{jjb} \in |120\text{-}240|$ GeV.
- Higgs transverse mass:

$$m_T = \sqrt{2 p_T^{\tau} E_T^{miss} (1 - \cos \phi_{\tau,miss})}$$



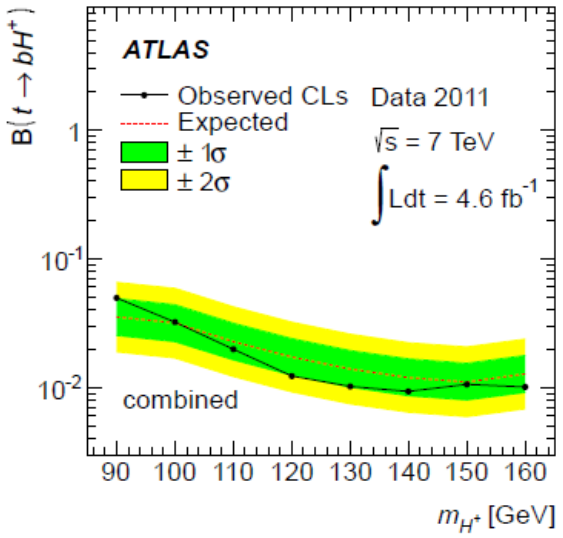
Tau + jets

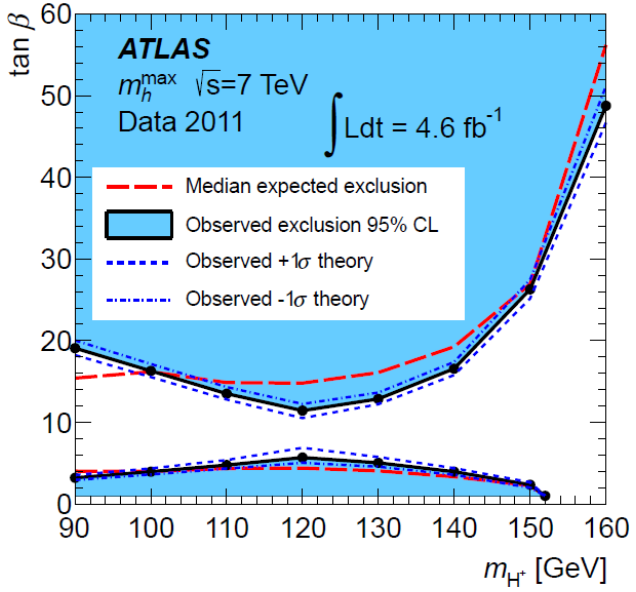
- Data driven methods:
- Background with multiple jets estimated by fitting its E_T^{miss} to data by using two shapes, multi jet model and sum of other processes.
- Backgrounds with electrons / jets misidentified as τ jets estimated as in the τ + lepton channel.
- The embedding method is used to estimate the backgrounds which contain correctly reconstructed τ jets by using a control sample of $t\bar{t}$-like μ+jets events and replacing the muon with a simulated hadronically decaying τ lepton.



Combined Results

- Expected and observed 95% CL exclusion limits on B(t → bH$^+$) for charged Higgs boson production from top quark decays as a function of $m_{H^\pm}$, assuming B(H$^+$ → τν) = 100%.
- Exclusion limits in the context of the m_h^{max} scenario of the MSSM on tan β (after relaxing the B(H$^+$ → τν) = 100% assumption).





Summary

- With 4.6 fb^{-1}, ATLAS searched for the light ($m_{H^{\pm}} < m_{top}$) charged Higgs in 3 different channels.
- Upper limits (95% CL) on $B(t \rightarrow bH^{+})$ between 5% and 1% were obtained.
- Interpretation in m_h^{max}, values of tan β above 12–26 and between 1 and 2-6 can be excluded in the mass range
  90 GeV < $m_{H^{\pm}}$ < 150 GeV.

THANK YOU
FOR YOUR ATTENTION

Back Up

Decay Mode: Lepton + jets

- The event selection is performed with loose and tight lepton definitions.
- The fake lepton originates mainly from QCD.
- The number of events with fake leptons (mainly from QCD) passing the tight criteria is estimated as:

$$N_{fake}^{tight} = \frac{f}{r-f}(rN^{loose} - N^{tight})$$

- r and f are the rates at which a real or fake loose lepton is identified as a tight lepton
  - r and f are measured in data using Z →ll and events with one lepton and low E_T^{miss} , respectively.
  - r and f are parametrised as functions of various relevant observables.

Tau + jets

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Signal+background	$540 \pm 13 \pm 85$