



# Study of discriminating variables for charged Higgs boson searches in $t\bar{t}$ with leptons at ATLAS<sup>[1]</sup>



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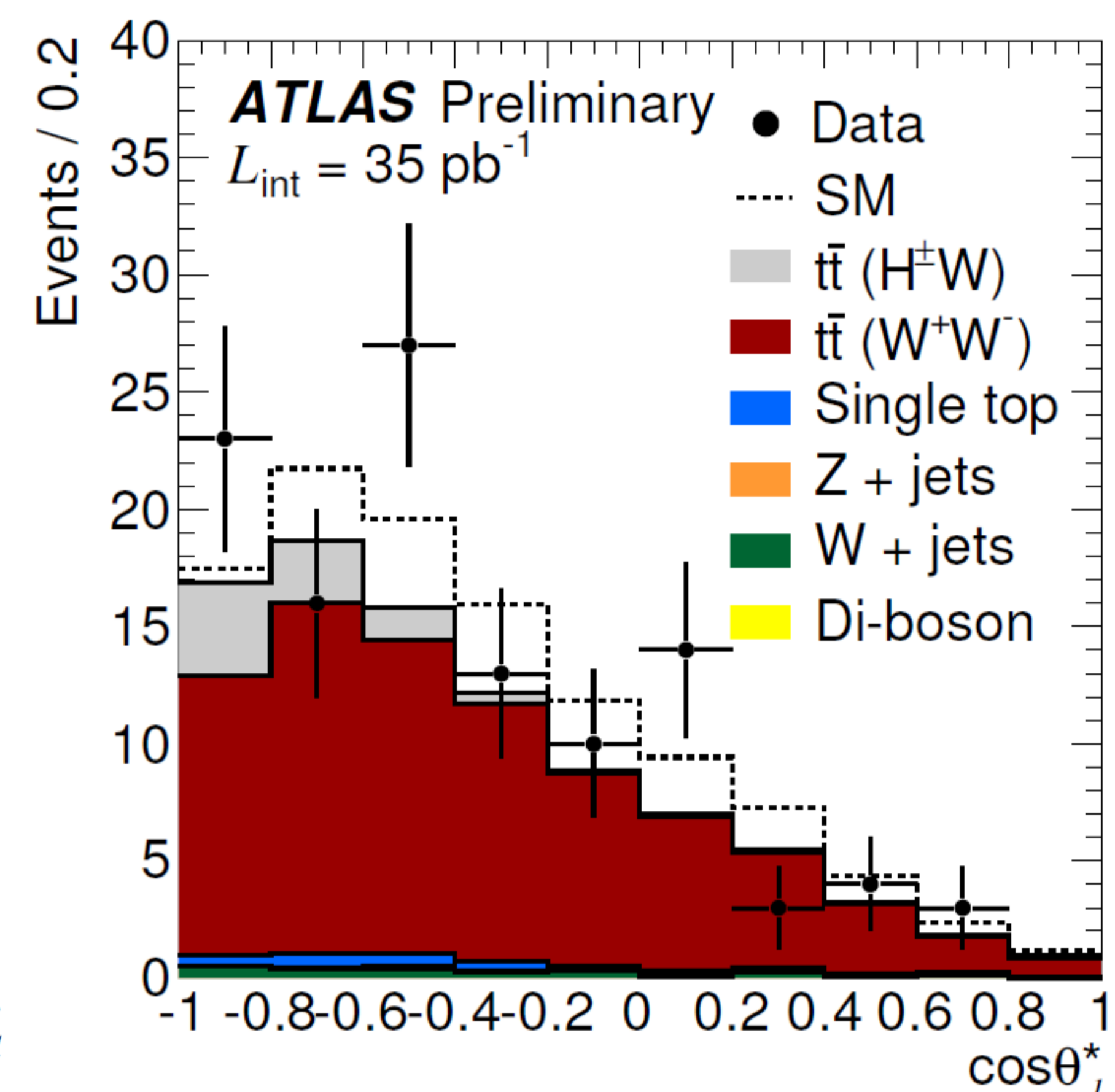
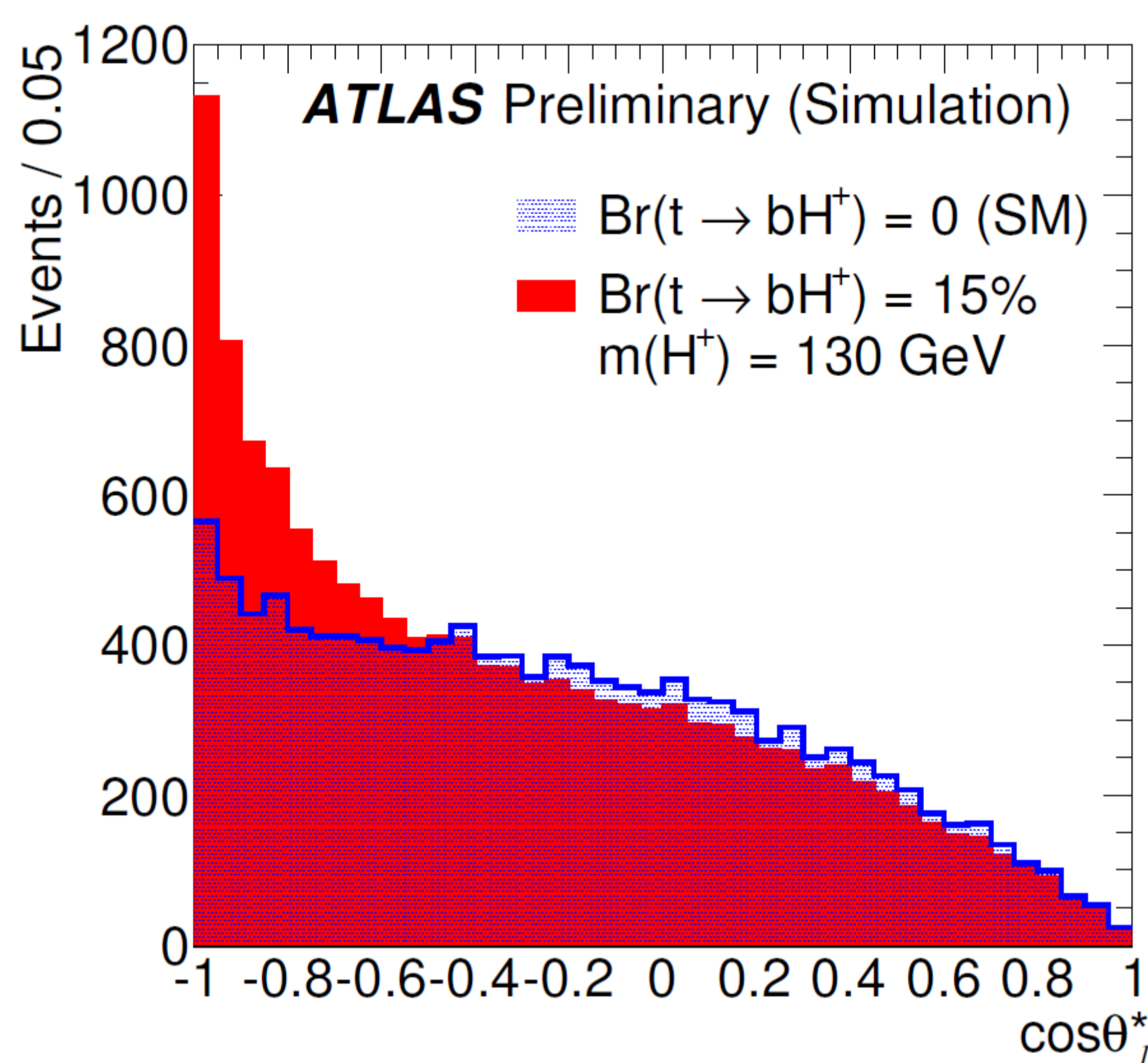
In several extensions of the Standard Model, the top quark can decay to a bottom quark and a light charged Higgs boson ( $m_{H^+} < m_{top}$ ) with a dominant decay mode to  $\tau\nu$ . We present novel transverse mass discriminating variables which can tell a lepton emerging from tau decays from a lepton produced in direct W decays. The new observables can help in the discovery of Charged Higgs bosons produced in top decays. These observables were validated with ATLAS 2010 data.

$$\cos\theta_l^*$$

Discriminates between direct and indirect leptons

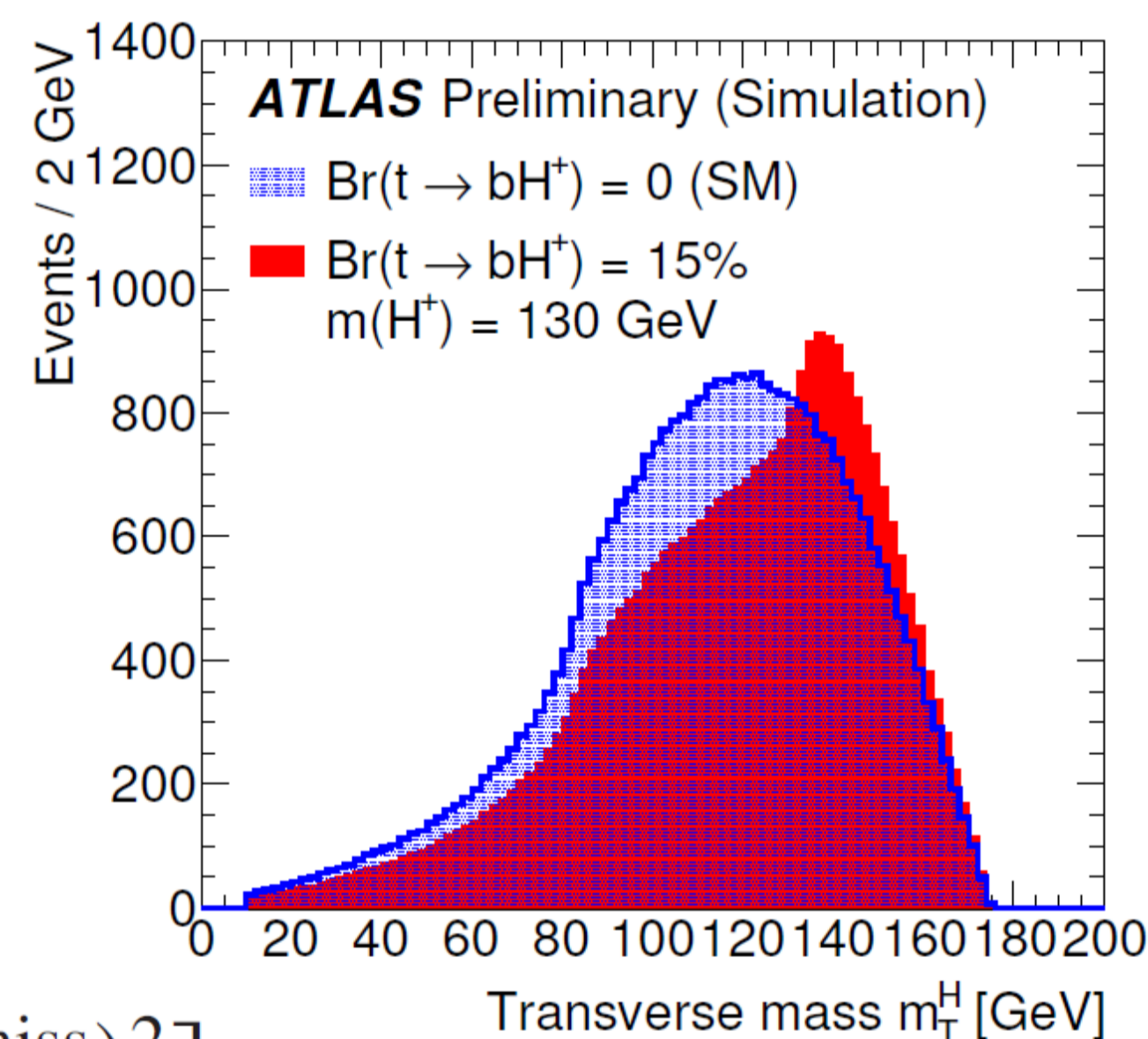
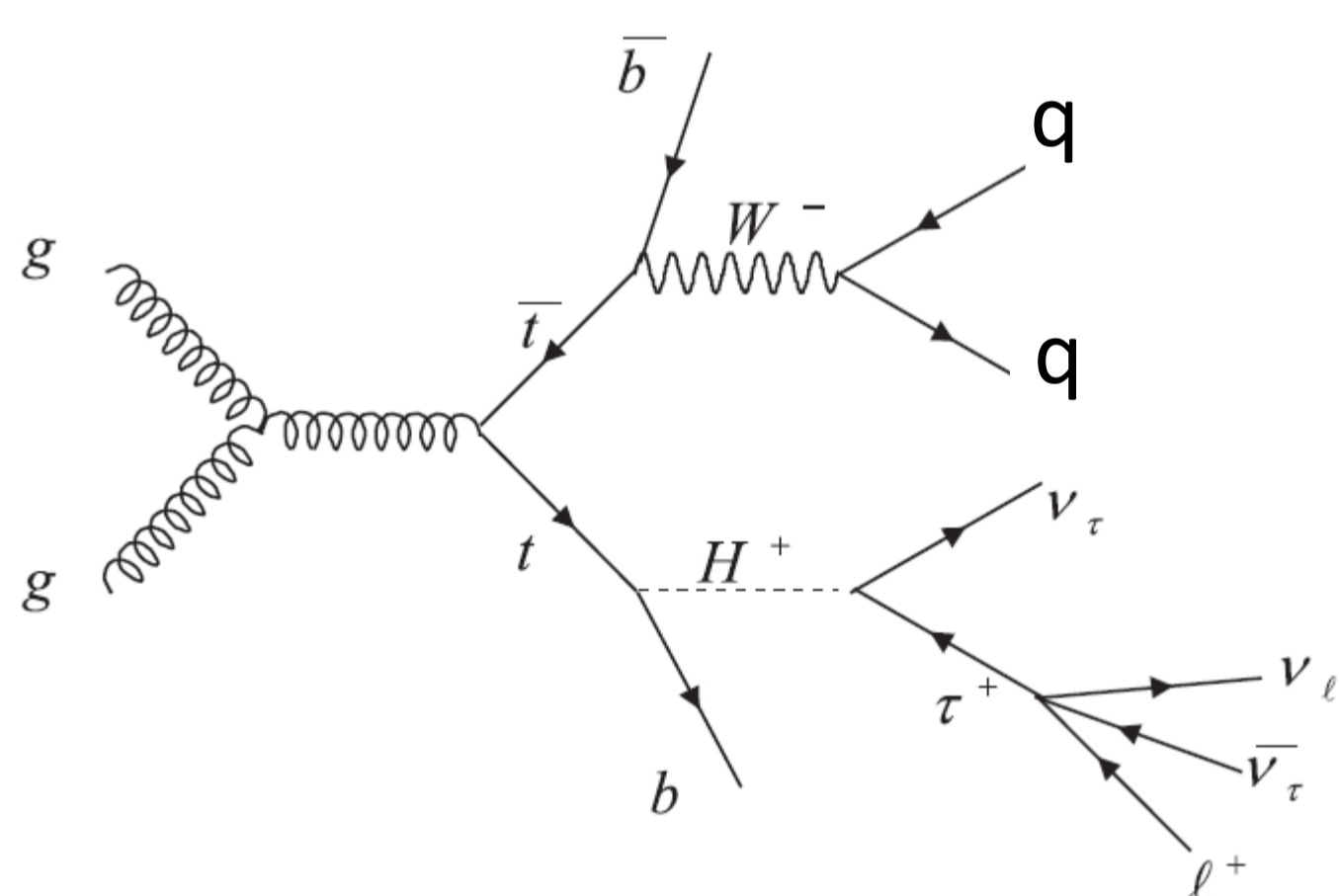
$$\cos\theta_l^* = \frac{2m_{bl}^2}{m_{top}^2 - m_W^2} - 1 \simeq \frac{4p^b \cdot p^l}{m_{top}^2 - m_W^2} - 1$$

$$p^b \cdot p^l = 2E_b E_l (1 - \cos\theta_{bl}) = 4E_b E_l \sin^2(\theta_{bl}/2)$$



## Charged Higgs Transverse Mass – Semileptonic channel

Discriminates between H and W



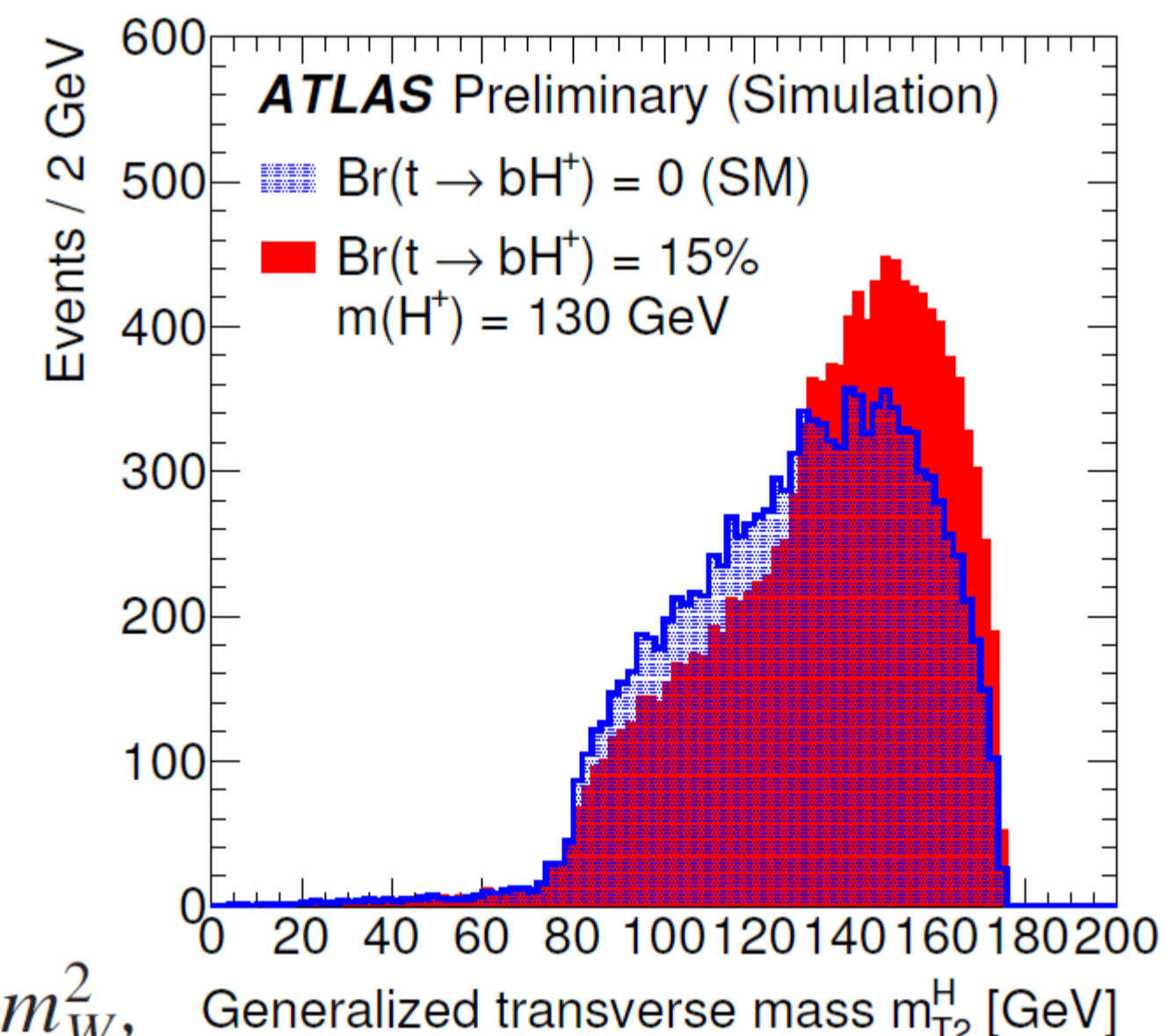
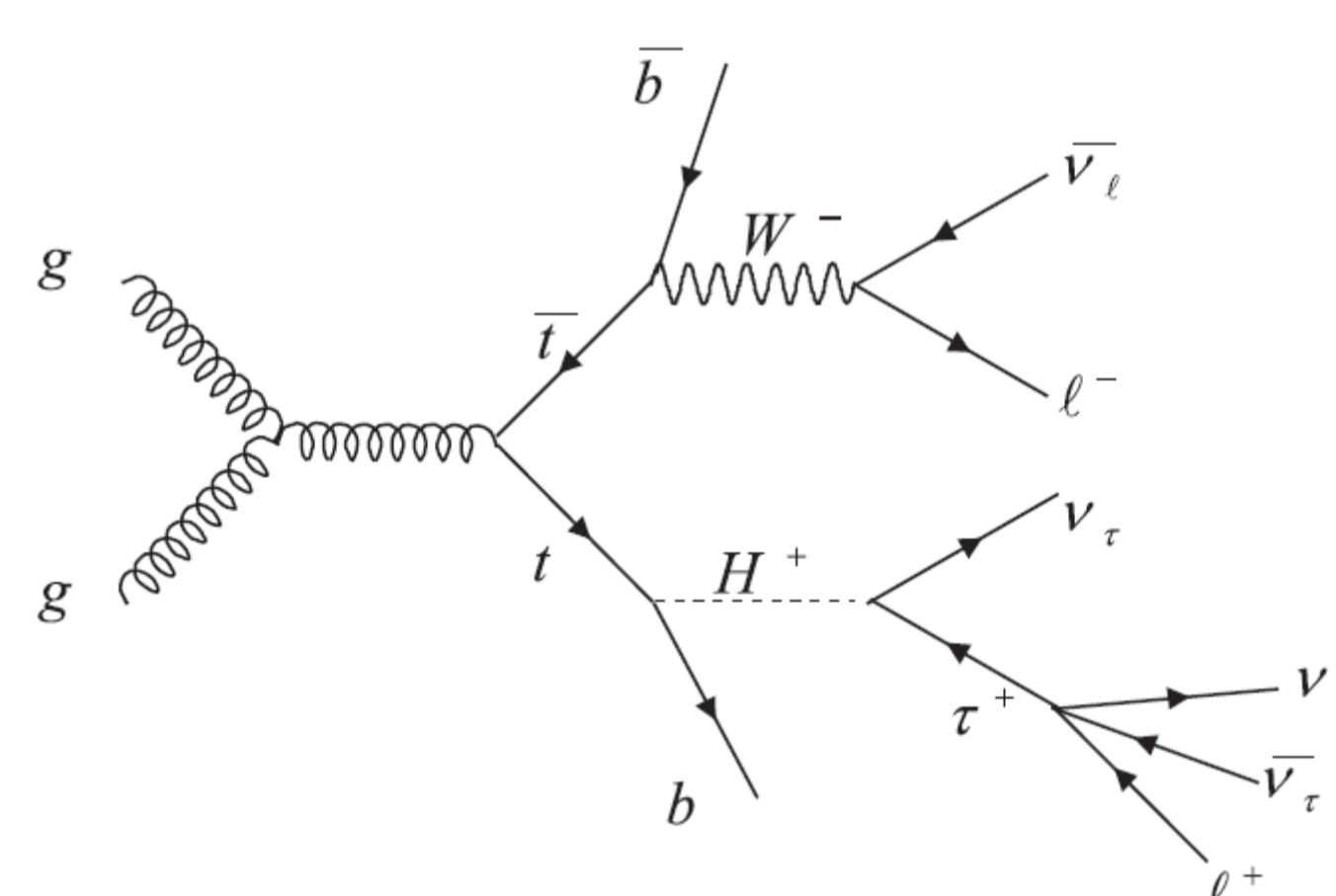
$$(m_T^H)^2 = \max_{\{p_T^{\text{miss}} + p_T^{\ell} + p_T^b = m_{top}^2\}} [(p^{\ell} + p^{\text{miss}})^2]$$

$$(m_T^H)^2 = \left( \sqrt{m_{top}^2 + (\vec{p}_T^{\ell} + \vec{p}_T^b + \vec{p}_T^{\text{miss}})^2} - p_T^b \right)^2 - (\vec{p}_T^{\ell} + \vec{p}_T^{\text{miss}})^2$$

The transverse Higgs mass has a threshold at  $m_{H^+}$

## Generalized Charged Higgs Transverse Mass Dileptonic channel

Discriminates between H and W



$$(p^{H^+} + p^b)^2 = m_{top}^2, \quad (p^{\ell^-} + p^{\bar{\nu}_{\ell}})^2 = m_W^2,$$

$$(p^{\ell^-} + p^{\bar{\nu}_{\ell}} + p^b)^2 = m_{top}^2, \quad (p^{\bar{\nu}_{\ell}})^2 = 0,$$

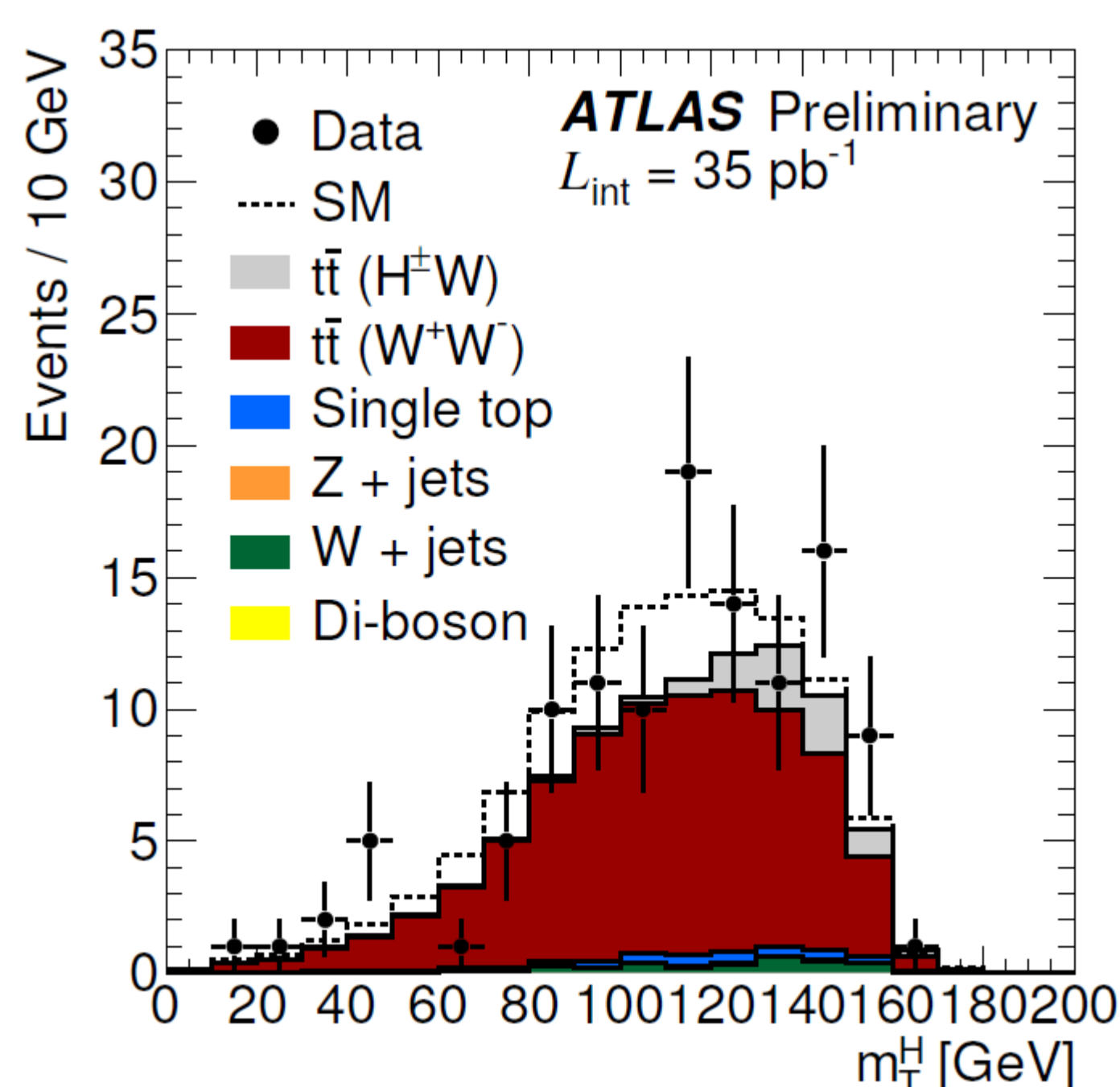
$$\vec{p}_T^{H^+} - \vec{p}_T^{\ell^-} + \vec{p}_T^{\bar{\nu}_{\ell}} = \vec{p}_T^{\text{miss}}$$

$$(m_T^H(\vec{p}_T^{H^+}))^2 = (\sqrt{m_{top}^2 + (\vec{p}_T^{H^+} + \vec{p}_T^b)^2} - p_T^b)^2 - (\vec{p}_T^{H^+})^2$$

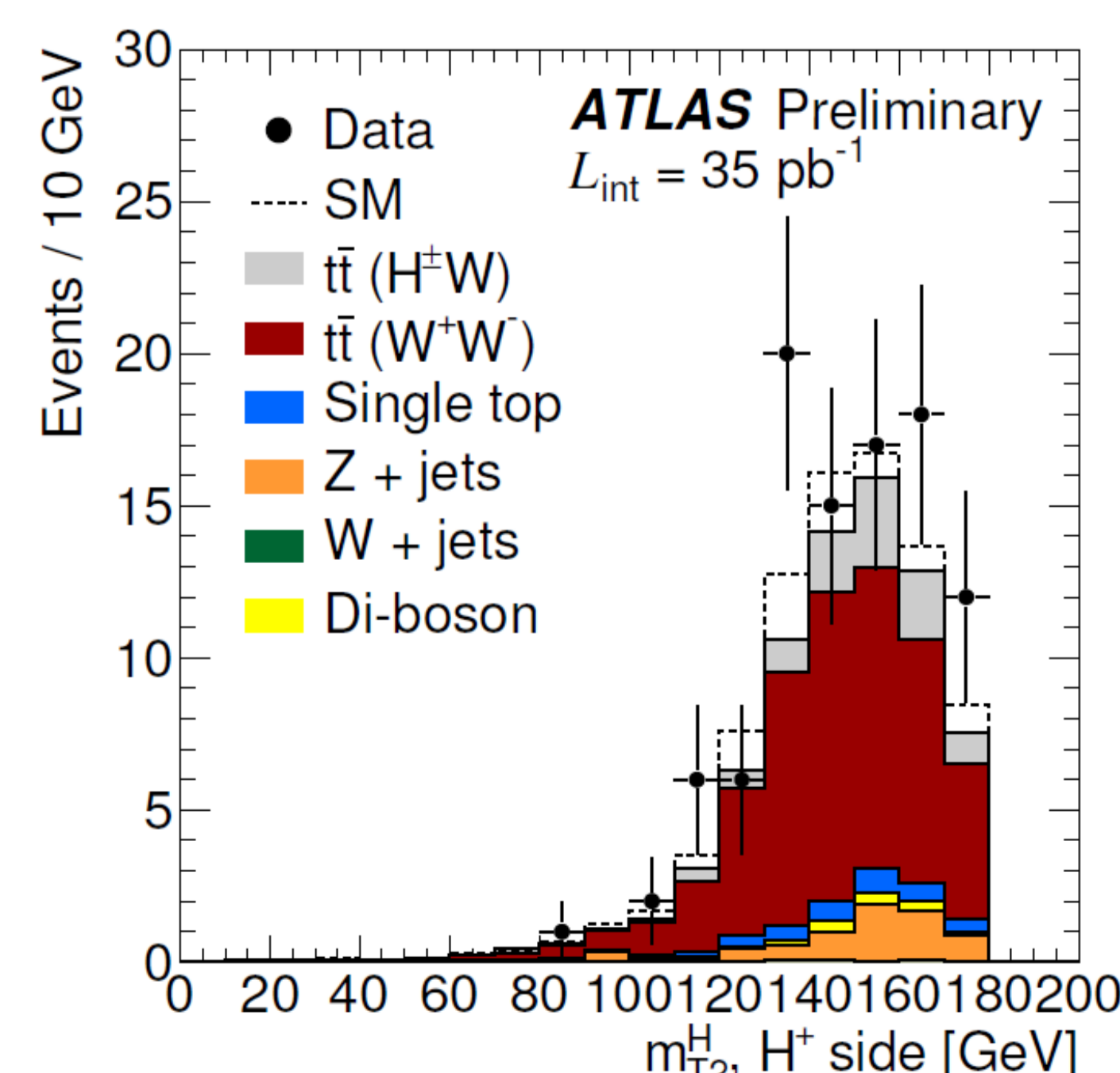
$$m_{T2}^H = \max_{\{\text{constraints}\}} [m_T^H(\vec{p}_T^H)],$$

The transverse Higgs mass has a threshold at  $m_{H^+}$

## Reconstruction of $M_T^H$



## Reconstruction of $M_{T2}^H$



1. The ATLAS Collaboration, *Study of discriminating variables for Charged Higgs boson searches in  $t\bar{t}$  events with leptons, using 35  $pb^{-1}$  of data from the ATLAS detector*, ATLAS-CONF-2011-018.

2. E.Gross and O.Vitells, *Transverse mass observables for charged Higgs boson searches at hadron colliders*, Phys. Rev. **D81** (2010) 055010.