ATLAS Search for the Charged MSSM Higgs Boson

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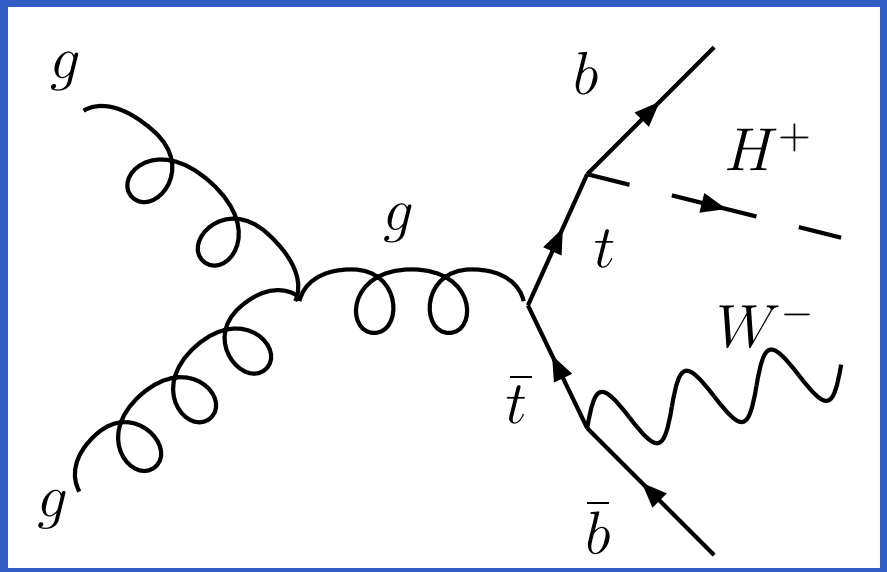
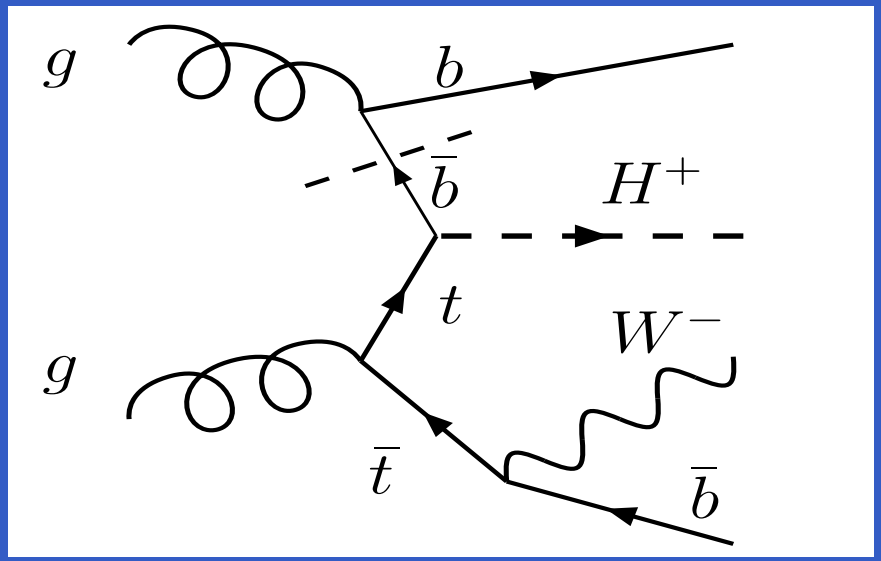
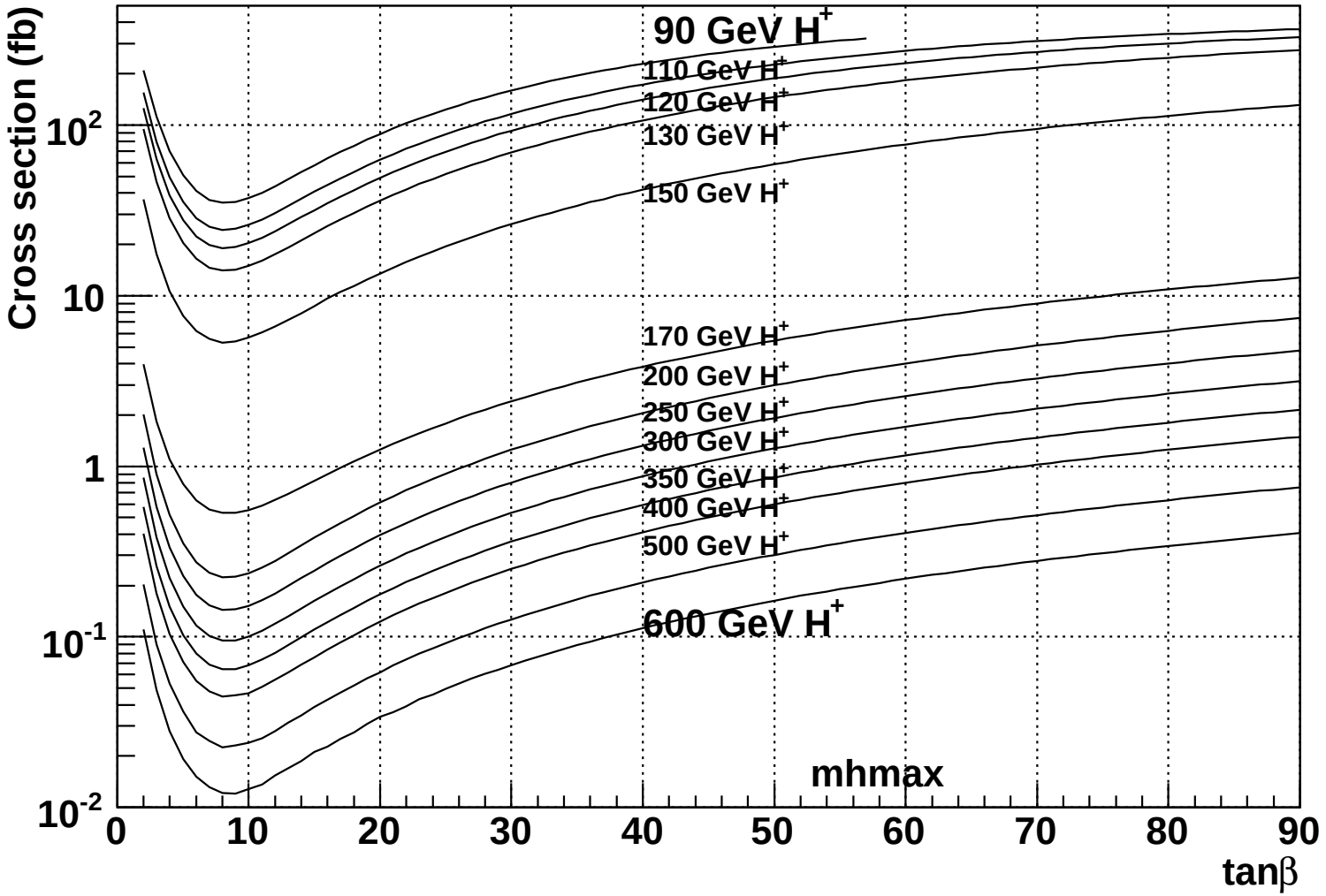
MSSM H^+ Production at the LHC





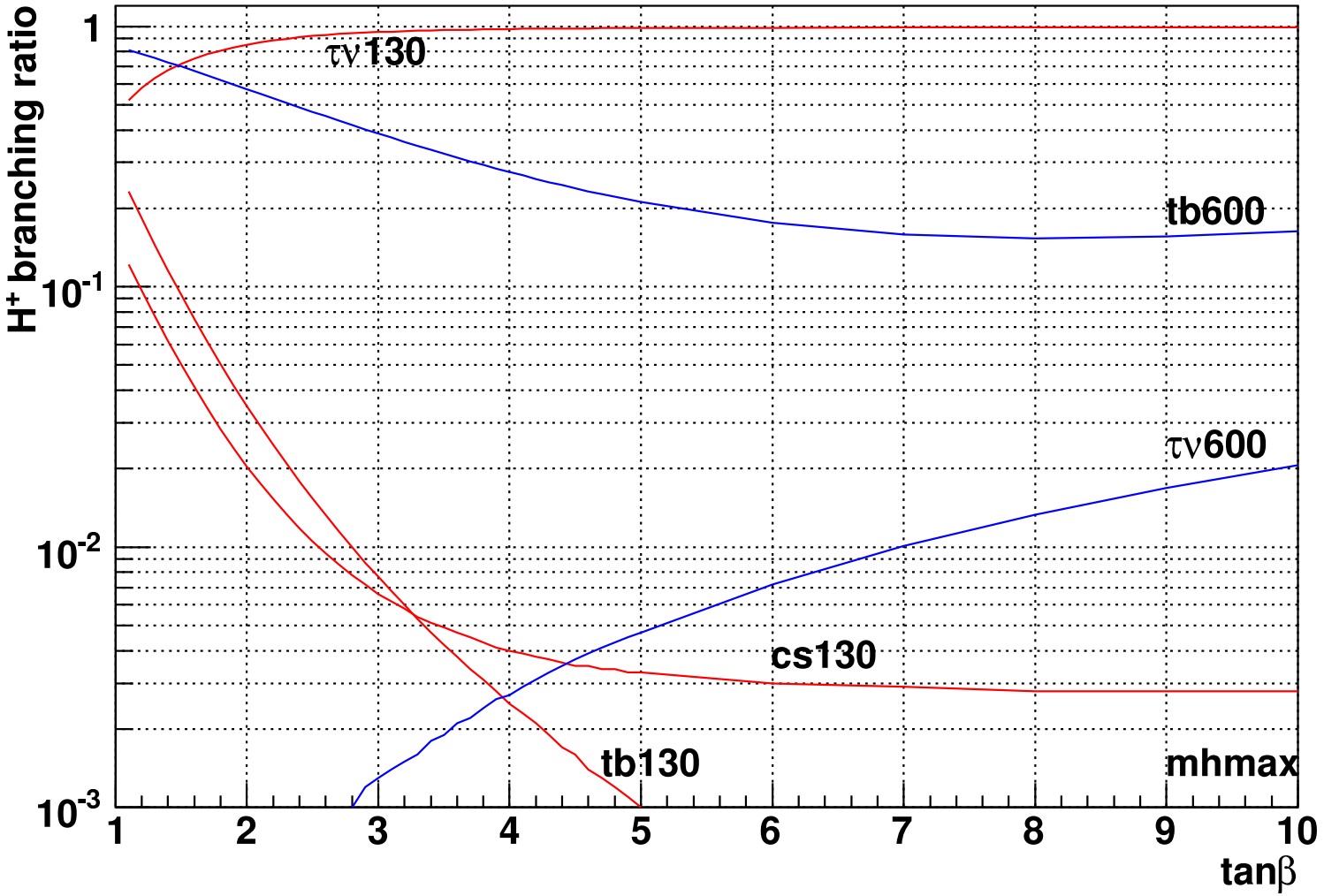
- For the *light* charged Higgs boson ($m_{H^+} < m_{top}$) in the MSSM:
  - dominant production mode is from top decay $t \to bH^+$ (left) and
  - dominant decay is $H^\pm \to \tau\nu$.
- For the *heavy* charged Higgs boson ($m_{H^+} > m_{top}$) in the MSSM:
  - dominant production modes are $gg \to tbH^+$ and $gb \to tH^+$ (right).
  - dominant decays are $H^\pm \to t\bar{b}$ and $H^\pm \to \tau\nu$.
- These modes were chosen for study with full detector simulation for the ATLAS Computing System Commissioning (CSC).

MSSM Cross Sections for LHC H^+ Production ($m_h - max$)



For these plots (FeynHiggs 2.6.2) and hereafter, we assume the $m_h - max$ scenario: $m_t = 175$ GeV, $\mu = 0.2$ TeV, $M_{SUSY} = 1$ TeV, $A_t = 2$ TeV $+\mu/\tan\beta$, $M_2 = 0.2$ TeV and $M_3 = 0.8$ TeV.

MSSM H^+ Branching Ratios ($m_h - max$)



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Signal Channels and Trigger Objects

Production and Decay	Branching Ratio	Studied	Trigger Objects
$t\bar{t} \rightarrow 2bW_{lep}\tau_{lep}\nu$	0.076	NO	j,b, e, mu, E_T^{miss}
$t\bar{t} \rightarrow 2bW_{lep}\tau_{had}\nu$	0.140	YES	j,b, e, mu, tau, E_T^{miss}
$t\bar{t} \rightarrow 2bW_{had}\tau_{lep}\nu$	0.276	YES	j,b, e,mu,E_T^{miss}
$t\bar{t} \rightarrow 2bW_{had}\tau_{had}\nu$	0.508	YES	j,b, tau,E_T^{miss}
$tbH^+ \rightarrow 4bW_{lep}W_{lep}$	0.046	NO	j,b, e,mu,E_T^{miss}
$tbH^+ \rightarrow 4bW_{lep}W_{had}$	0.338	YES	j,b, e,mu,E_T^{miss}
$tbH^+ \rightarrow 4bW_{had}W_{had}$	0.611	NO	j,b
$tbH^+ \rightarrow 2bW_{lep}\tau_{lep}\nu$	0.076	NO	j,b,e,mu,E_T^{miss}
$tbH^+ \rightarrow 2bW_{lep}\tau_{had}\nu$	0.140	NO	j,b,e,mu,tau,E_T^{miss}
$tbH^+ \rightarrow 2bW_{had}\tau_{lep}\nu$	0.276	NO	j,b,e,mu,E_T^{miss}
$tbH^+ \rightarrow 2bW_{had}\tau_{had}\nu$	0.508	YES	j,b,tau,E_T^{miss}

ATLAS H^+ Trigger Menu

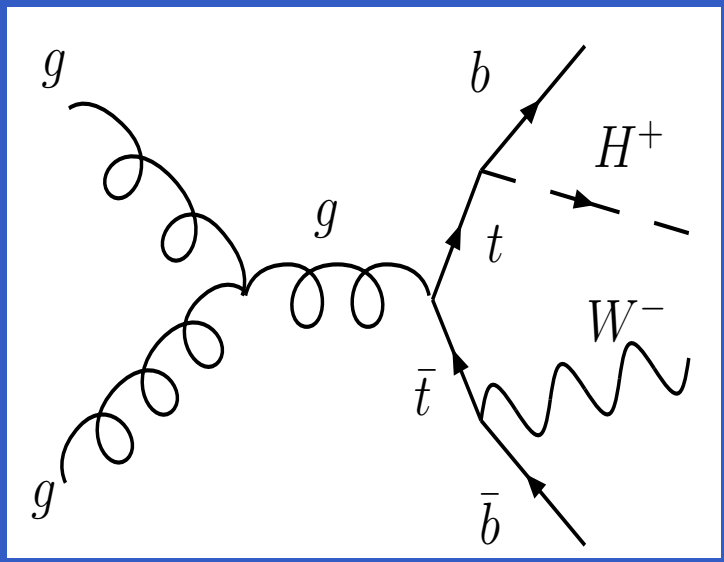
- 10^{31} Menu: xe70 OR e25i tight OR mu20 OR tau20i+xe30 OR tau15i+xe20+3j18
- $10^{33}A$ Menu: xe80 OR e55 OR mu40 OR tau35i+xe50 OR tau35i+xe40+3j18
- $10^{33}B$ Menu: xe80 OR e25i+xe30 OR mu20+xe30 OR tau35i+xe50 OR tau35i+xe40+3j18

Light H^+ Search Strategy

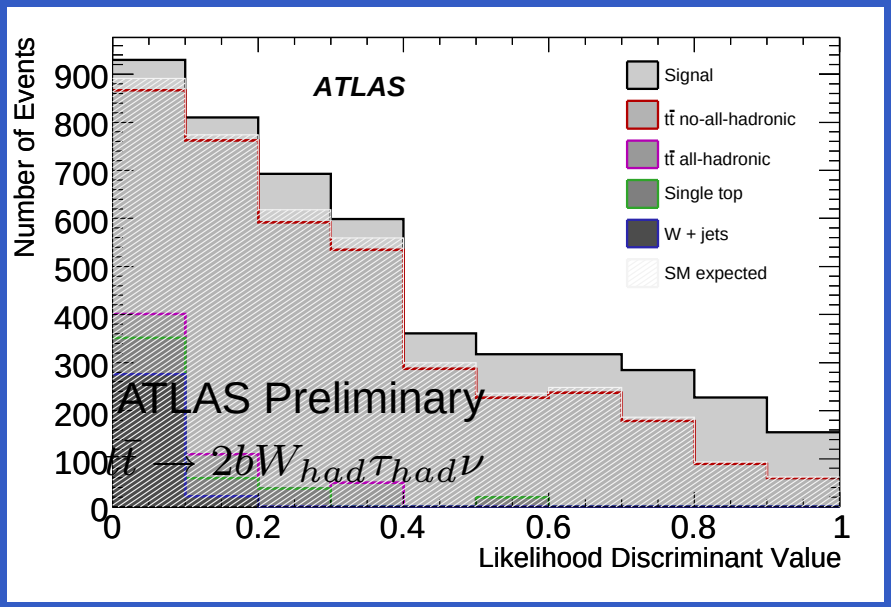
Channel	Signal ($m_{H^+} = 120$ GeV)	$t\bar{t}$	W+jets	QCD
$t\bar{t} \to 2bW_{lep}\tau_{had}\nu$	36.4 fb	32.1 fb	negl.	negl.
$t\bar{t} \to 2bW_{had}\tau_{lep}\nu$	23 fb	144 fb	<80 fb	<50 fb
$t\bar{t} \to 2bW_{had}\tau_{had}\nu$	23 fb	78 fb	negl.	negl.

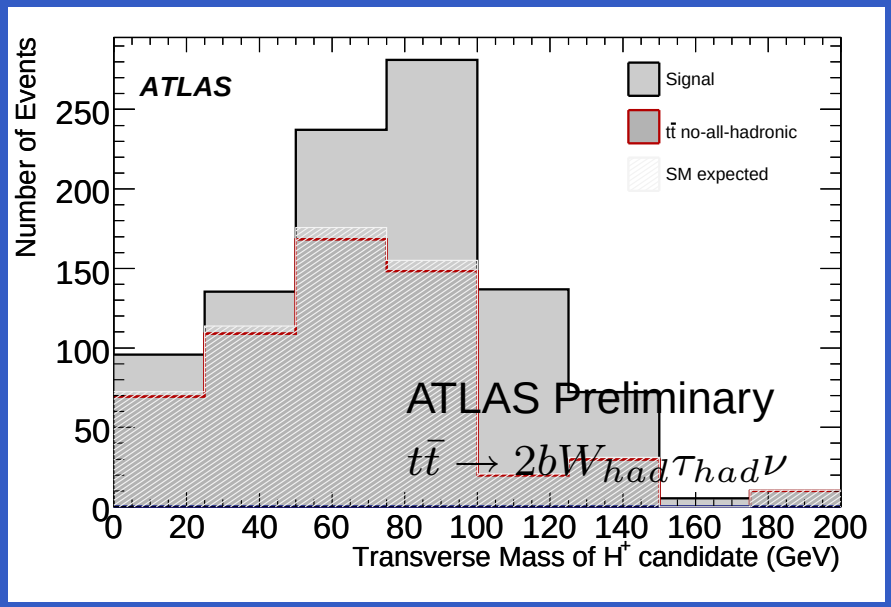
Preliminary expected yields after full event selection for the light H^+ search channels. Results are for $\tan\beta = 20$ and $m_{H^+} = 120$ GeV, though $90 < m_{H^+} < 150$ GeV were studied.

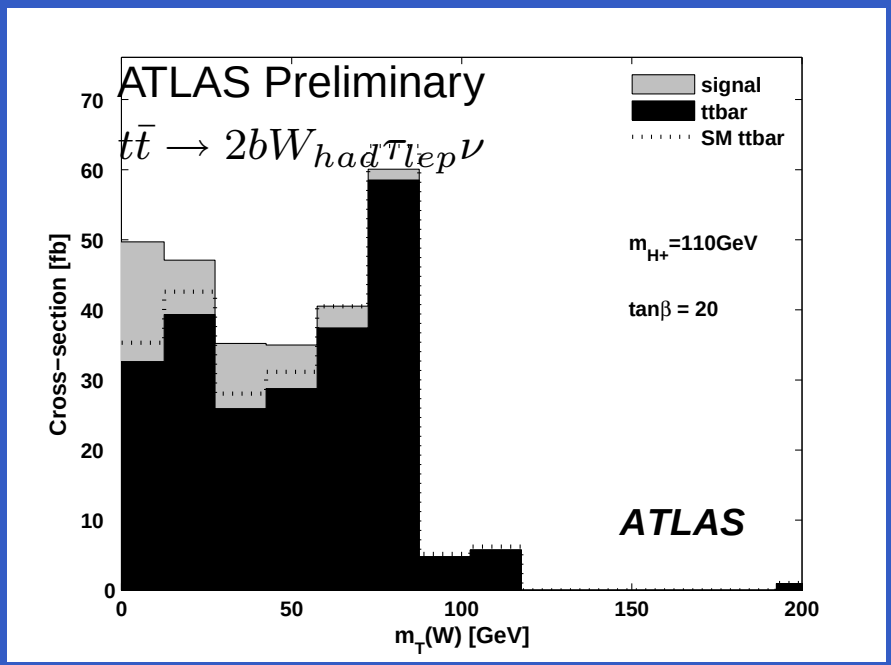
- All three analyses require:
  - E_T^{miss}, 2 or more jets and 1 or 2 b-tags
  - W and top reconstructed masses consistent with measured values
  - likelihood and transverse H^+ mass consistent with signal.
- The $t\bar{t} \to 2bW_{had}\tau_{had}\nu$ and $t\bar{t} \to 2bW_{lep}\tau_{had}\nu$ analysis requires one hadronic τ-jet.
- The $t\bar{t} \to 2bW_{lep}\tau_{had}\nu$ and $t\bar{t} \to 2bW_{had}\tau_{lep}\nu$ analyses require one $\ell = e, \mu$.

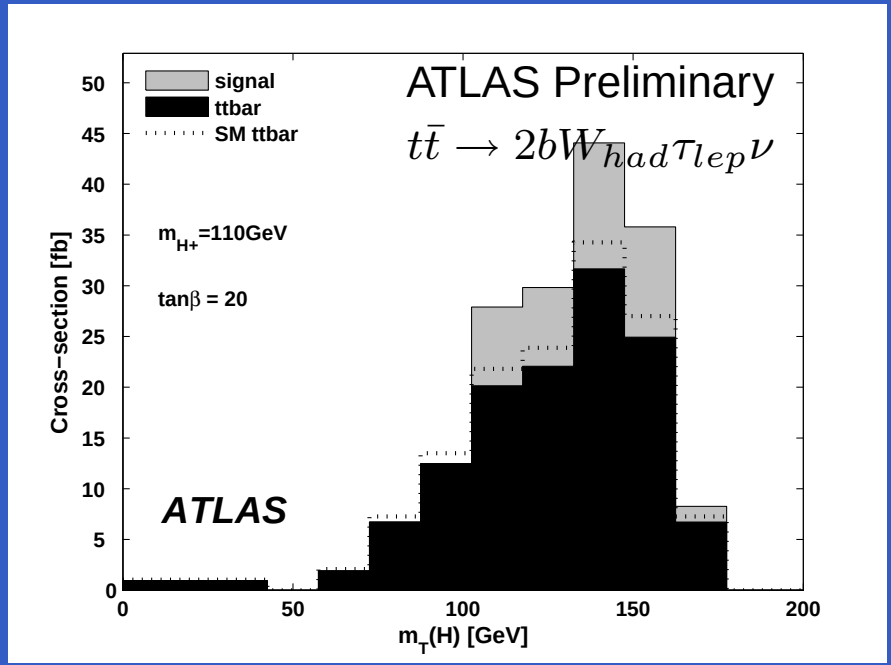


Light $H^+ \to \tau\nu$: $m_{H^+} = 130$ GeV, $\tan\beta = 20$, and 10 fb^{-1}









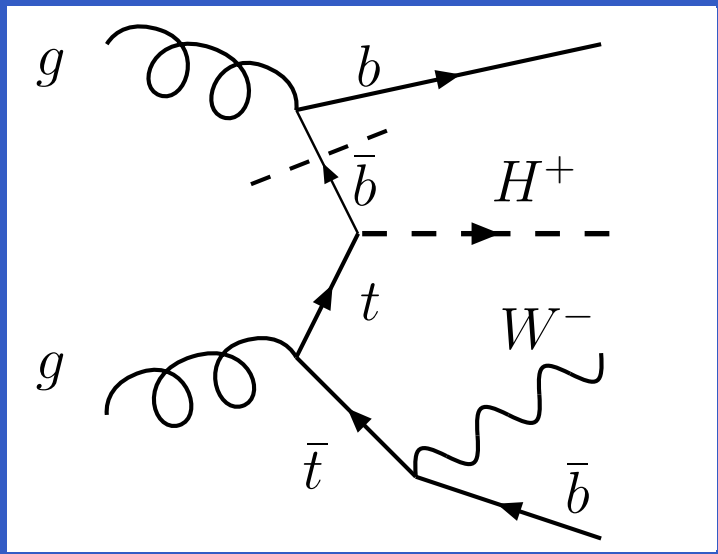
Heavy $H^+ \to tb$ Search Strategy

Channel	Signal	$t\bar{t}$+jets	$t\bar{t}b\bar{b}$ QCD	$t\bar{t}b\bar{b}$ EW
$tbH^+_{200} \to 4bW_{lep}W_{had}$	0.21 fb	21.0 fb	12.2 fb	1.05 fb
$tbH^+_{400} \to 4bW_{lep}W_{had}$	0.34 fb	15.9 fb	8.91 fb	1.05 fb
$tbH^+_{600} \to 4bW_{lep}W_{had}$	0.24 fb	19.8 fb	10.5 fb	1.21 fb

Preliminary expected yields after full signal $H^+ \to tb$ selection assuming $\tan\beta = 35$ and $m_{H^+} = 200, 400, 600$ GeV.

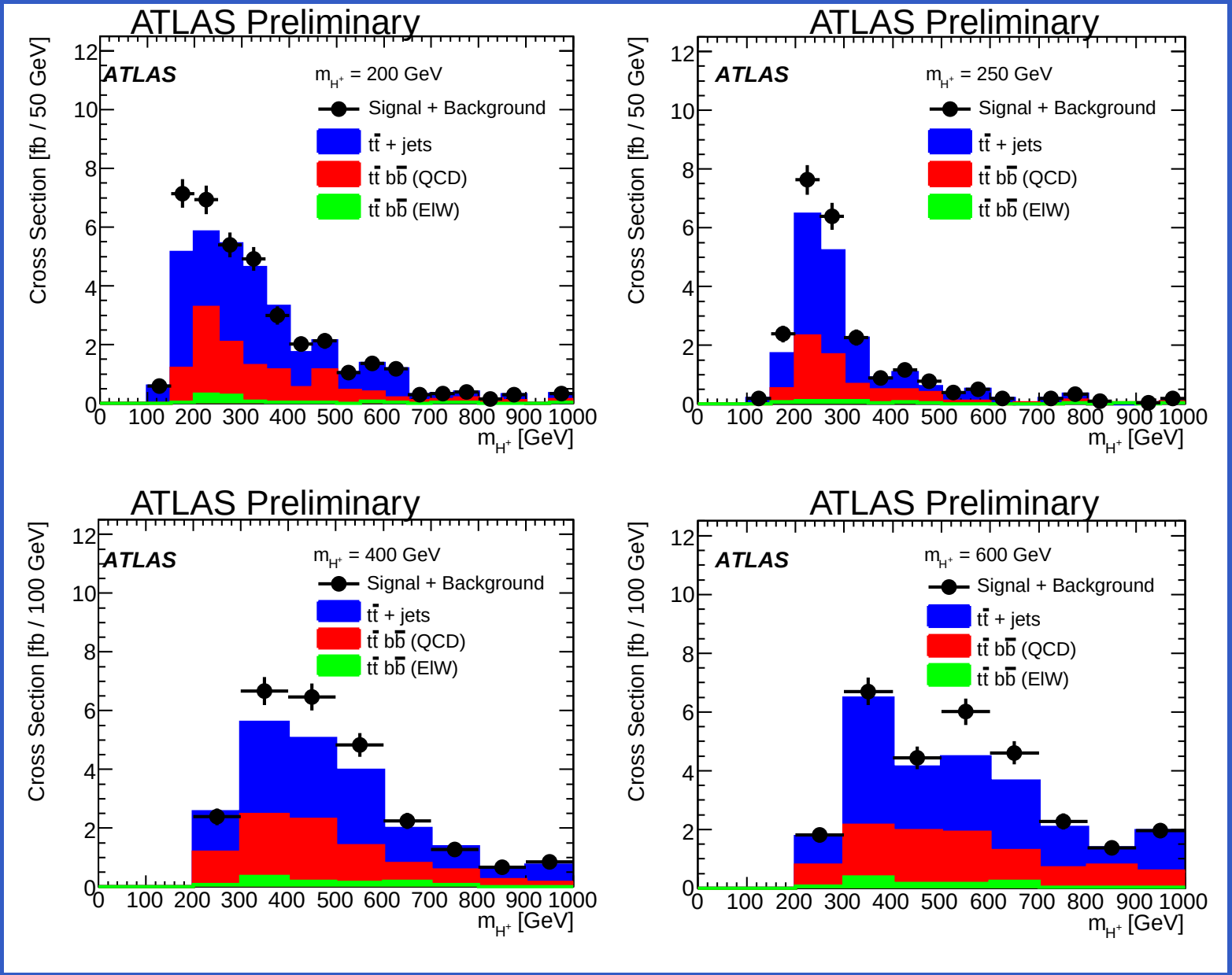
The $tbH^+ \to 4bW_{lep}W_{had}$ analysis requires:

- 1 $\ell = e, \mu$, >4jets, >3 b-tags
- likelihood for correct combination of jets
- W and top reconstructed masses consistent with measured values
- a likelihood for background suppression



Heavy $H^+ \to tb$ Results

$\tan\beta$ is chosen so that pure statistical significance is 5.



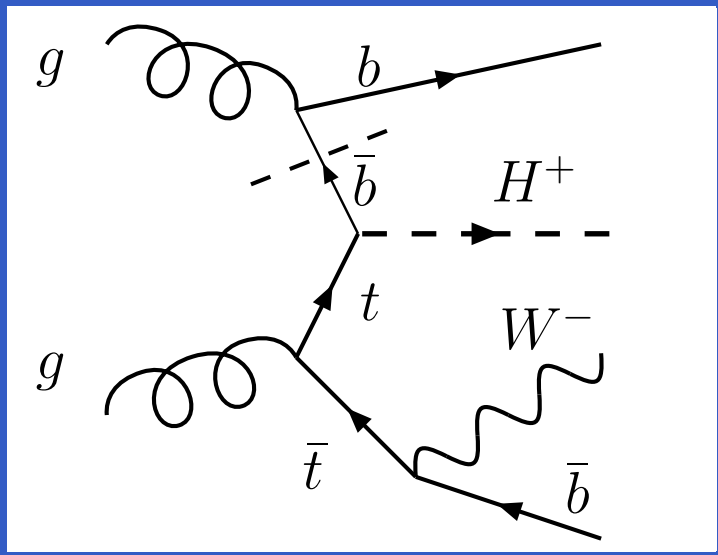
Heavy $H^+ \to \tau\nu$ Search Strategy

Channel	Signal	$t\bar{t}$	QCD	W+jets
$tbH^+_{200} \to 2bW_{had}\tau_{had}\nu$	3.8 fb	2.0 fb	negl.	negl.
$tbH^+_{400} \to 2bW_{had}\tau_{had}\nu$	0.35	0.33 fb	negl.	negl.
$tbH^+_{600} \to 2bW_{had}\tau_{had}\nu$	0.058	0.15 fb	negl.	negl.

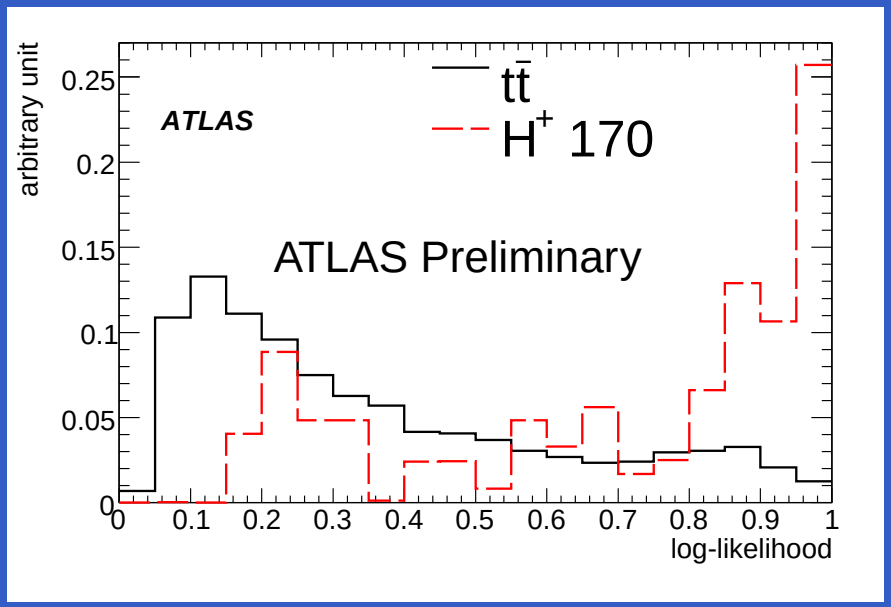
Preliminary expected yields after full signal $H^+ \to \tau\nu$ selection assuming $\tan\beta = 35$ and $m_{H^+} = 200, 400, 600$ GeV.

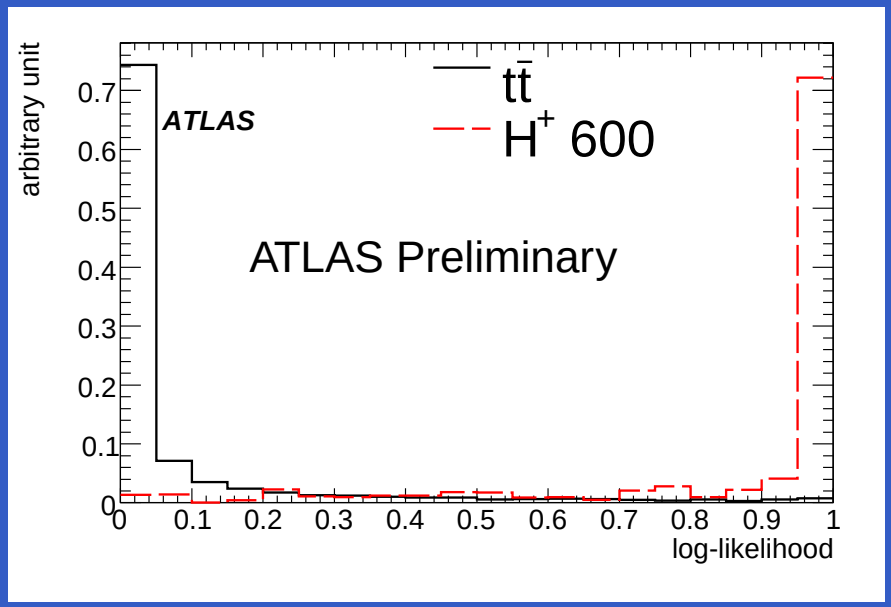
The $tbH^+ \to 2bW_{had}\tau_{had}$ requires:

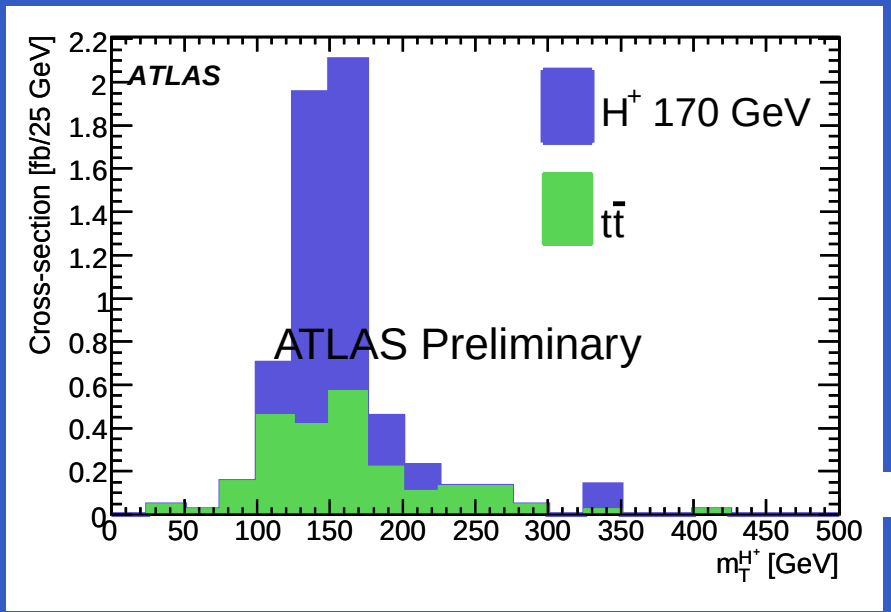
- one τ-jet, three or more jets, one b-jet, E_T^{miss}, a lepton veto
- W and top reconstructed masses consistent with measured values
- transverse mass and likelihood consistent with signal.

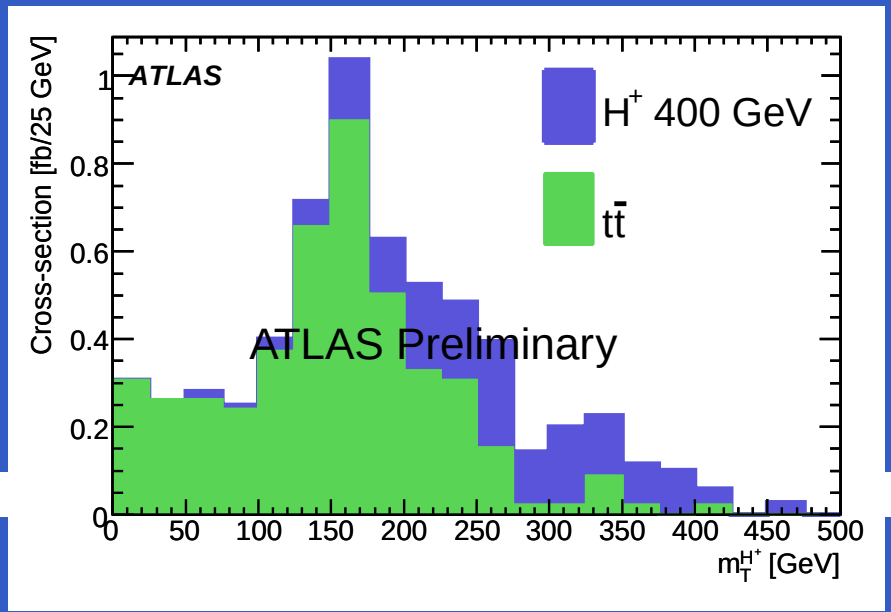


Heavy $H^+ \to \tau\nu$ Results for $\tan\beta = 35$







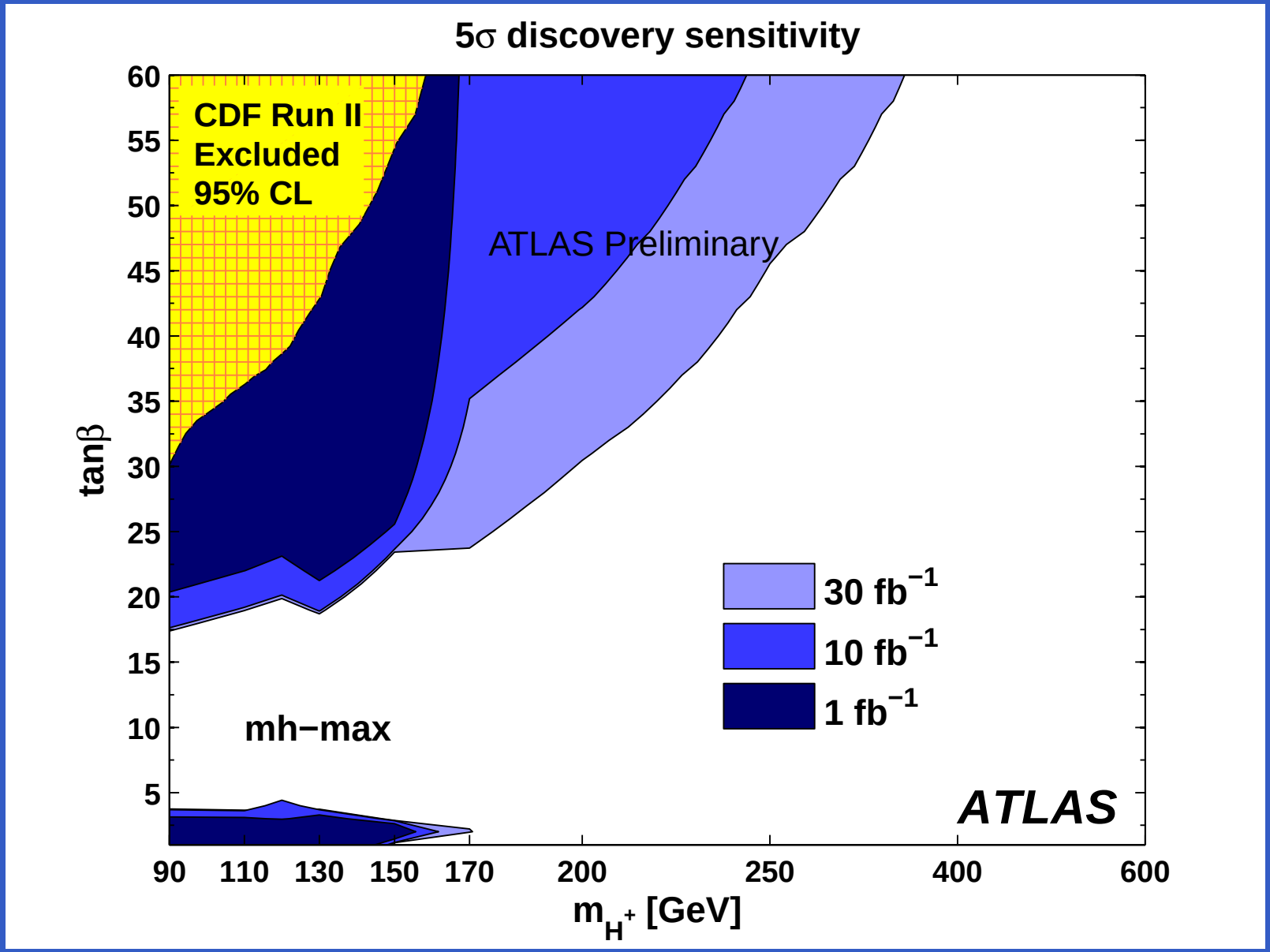


Expected Systematic Uncertainties

Uncertainty	Light H^+ Signal	Light H^+ Background	Heavy H^+ Signal	Heavy H^+ Background
Luminosity	± 3 %	± 3 %	± 3 %	± 3 %
τ-jet E Resolution	± 2 %	± 2 %	± 2 %	± 2 %
τ-jet E Scale	± 5 %	± 5 %	± 5 %	± 5 %
τ-jet Efficiency	± 5 %	± 5 %	± 5 %	± 5 %
Jet E Resolution	-9 %	$+7$ %	-12 %	-3 %
Jet E Scale	-13 %	± 11 %	$+4$ %, -31 %	$+15$ %, -18 %
b-tag Efficiency	± 2 %	± 7 %	± 7 %	± 3 %
b-tag Rejection	± 10 %	± 10 %	± 10 %	± 10 %

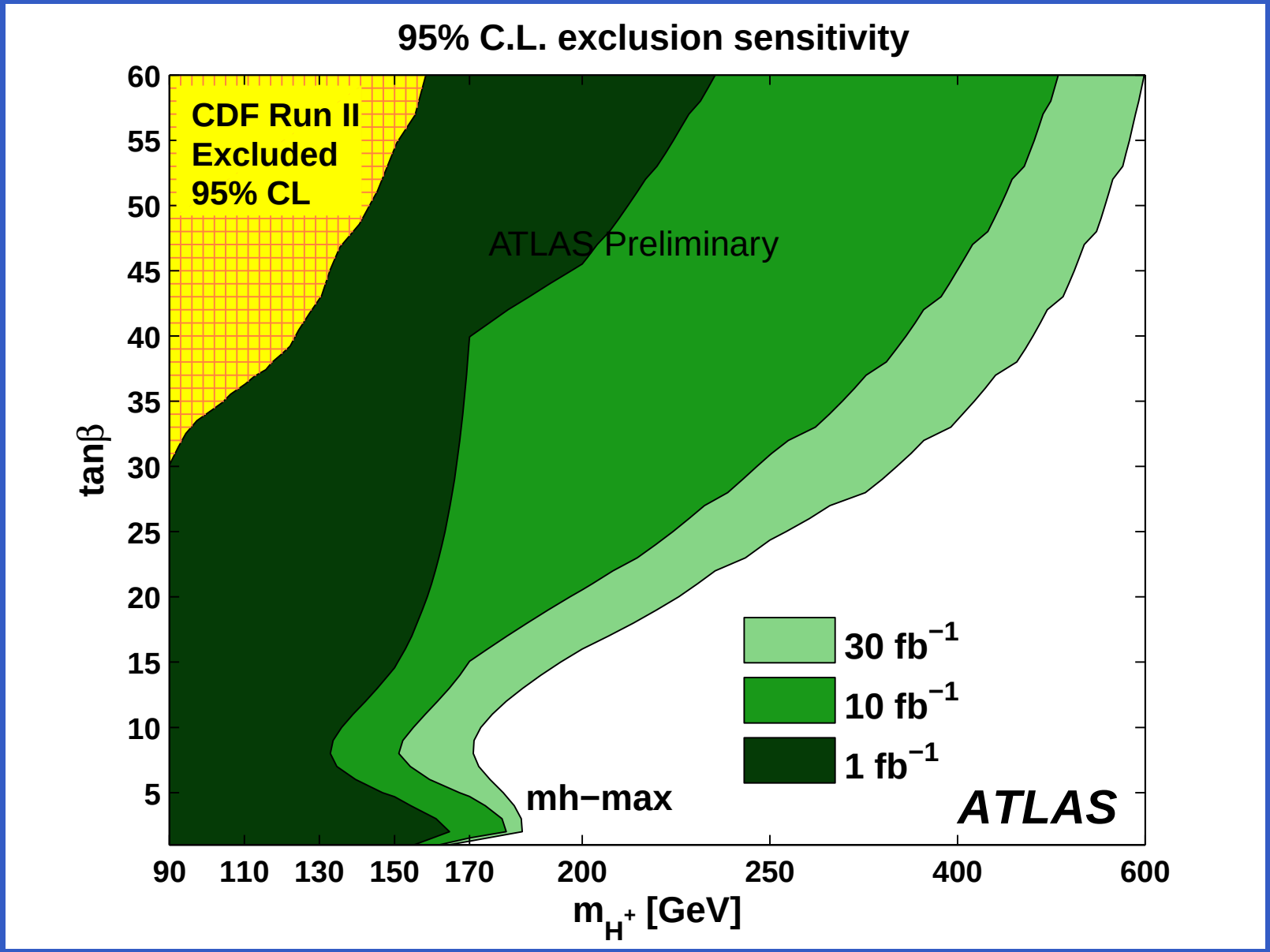
- Dominant expected systematic uncertainties for the light and heavy $H^+ \to \tau\nu$ analyses, assuming 30 fb^{-1}.
- These are pure systematics without any side bands or control samples. We believe we can control the background systematics at O(10%) level with the $t\bar{t}$ control samples.
- Signal theoretical uncertainties are <5% for $H^+ \to \tau\nu$ in the MSSM.

ATLAS MSSM H^+ Discovery Potential ($m_h - max$)



ATLAS MSSM H^+ discovery potential for 1, 10 and 30 fb^{-1}

ATLAS MSSM H^+ Exclusion Potential ($m_h - max$)



ATLAS MSSM H^+ exclusion potential for 1, 10 and 30 fb^{-1}

Conclusions

- For the light H^+ ($m_{H^+} < m_{top}$), the ATLAS discovery potential covers all but a small band at intermediate $\tan\beta$ in the $m_{H^+} - \tan\beta$ plane but 95% CL exclusion potential covers all $\tan\beta$ after 30 fb^{-1}.
- The light H^+ discovery potential in the current analysis is mainly limited by the finite simulation sample size.
- For the heavy H^+ ($m_{H^+} > m_{top}$), the ATLAS discovery potential covers a broad region in the $m_{H^+} - \tan\beta$ plane but 95% CL exclusion potential covers considerably more after only 30 fb^{-1}.
- After 30 fb^{-1}, the LHC luminosity profile will enable larger coverage in the $m_{H^+} - \tan\beta$ plane.
- The discovery and exclusion potential for both light and heavy H^+ depends critically on the $H^+ \to \tau_{had}\nu$ channel.
- The $H^+ \to \tau_{had}\nu$ channel in the current analysis depends on the tau35i+xe40+3j20 (hadronic tau, E_T^{miss}, three jets) triggers, though other triggers are currently under study. Measuring the efficiency of this trigger in data will be challenging.