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for the ATLAS Collaboration

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Charged Higgs Prospects with ATLAS

Charged 2008
Uppsala, Sep 16, 2008

H^+ searches with ATLAS

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- **$m_{H+} < m_{top}$**: ttbar → bW bH^+
  - **Hadronic τ + jets:** $H^+ \to \tau(\to had)\nu$ W→qq'
  - **Hadronic τ + lepton:** $H^+ \to \tau(\to had)\nu$ W→lν
  - **Leptonic τ**: $H^+ \to \tau(\to lep)\nu$ W→qq'
  - **Hadronic H^+**: $H^+ \to cs$ W→lν
- **$m_{H+} > m_{top}$**: gg/gb → t[b]H^+
  - **tb mode**: $H^+ \to tb$ one W→qq', the other W→lν
  - **τν mode**: $H^+ \to \tau(\to had)\nu$ W→qq'
- H^+ production in or decay to **SUSY cascades** (e.g. $H^+ \to \chi^+\chi^0$)
- H^+ production with or decay to **bosons** (e.g. $H^+ \to Wh$; $qq' \to H^+A$)
- **Indirect searches**: ttbar and single top cross section measurements
- **Parameter Determination**: m_{H+}, tan β

H^+ searches with ATLAS

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- **$m_{H+} < m_{top}$**: ttbar → bW bH$^+$
  - **Hadronic τ + jets:** $H^+ \to \tau(\to had)\nu$ $W \to qq'$
  - **Hadronic τ + lepton:** $H^+ \to \tau(\to had)\nu$ $W \to l\nu$
  - **Leptonic τ**: $H^+ \to \tau(\to lep)\nu$ $W \to qq'$
  - **Hadronic H$^+$:** $H^+ \to cs$ $W \to l\nu$

updated

- **$m_{H+} > m_{top}$**: gg/gb → t[b]H$^+$
  - **tb mode:** $H^+ \to tb$ one $W \to qq'$, the other $W \to l\nu$
  - **τν mode:** $H^+ \to \tau(\to had)\nu$ $W \to qq'$

updated

- H$^+$ production in or decay to **SUSY cascades** (e.g. $H^+ \to \chi^+\chi^0$)
- H$^+$ production with or decay to **bosons** (e.g. $H^+ \to Wh$; $qq' \to H^+A$)
- **Indirect searches**: ttbar and single top cross section measurements
- **Parameter Determination:** m_{H+}, tan β

Outline

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1. **Introduction**
   1. The ATLAS Experiment
   2. Important tools in H^+ searches
   3. The ATLAS “CSC” efforts: H+ searches in a common framework
2. **$m_{H+} < m_{top}$**: ttbar $\rightarrow$ bW bH^+
   1. Hadronic τ + jets: $H^+ \rightarrow \tau(\rightarrow had)\nu$ $W \rightarrow qq'$
   2. Hadronic τ + lepton: $H^+ \rightarrow \tau(\rightarrow had)\nu$ $W \rightarrow l\nu$
   3. Leptonic τ : $H^+ \rightarrow \tau(\rightarrow lep)\nu$ $W \rightarrow qq'$
3. **$m_{H+} > m_{top}$**: gg/gb $\rightarrow$ t[b]H^+
   1. tb mode: $H^+ \rightarrow tb$ one $W \rightarrow qq'$, the other $W \rightarrow l\nu$
   2. $\tau\nu$ mode: $H^+ \rightarrow \tau(\rightarrow had)\nu$ $W \rightarrow qq'$
4. **Systematic Uncertainties** and **Combined Results**

1. Introduction

1.1 The ATLAS Experiment
1.2 Tools for H+ Searches
1.3 The ATLAS H+ “CSC Efforts”

2. H^+ in Top Quark Decays

3. H^+ in gg- & gb-fusion

4. Systematics & Results

ATLAS @ LHC

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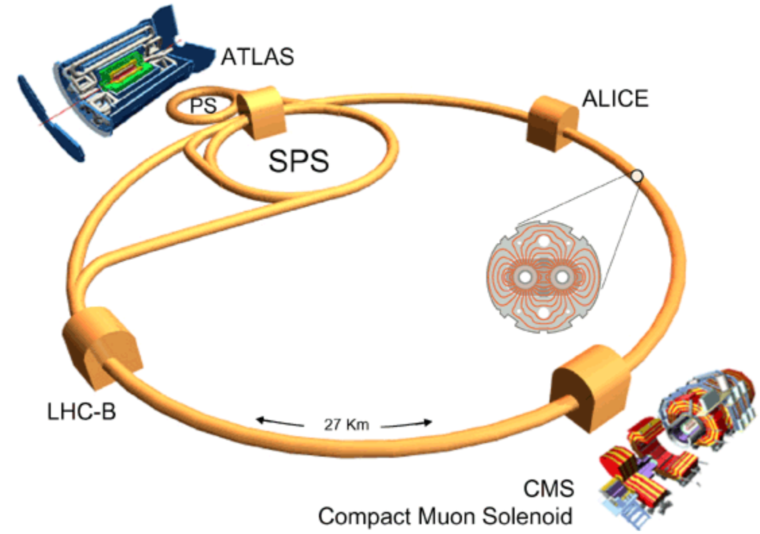
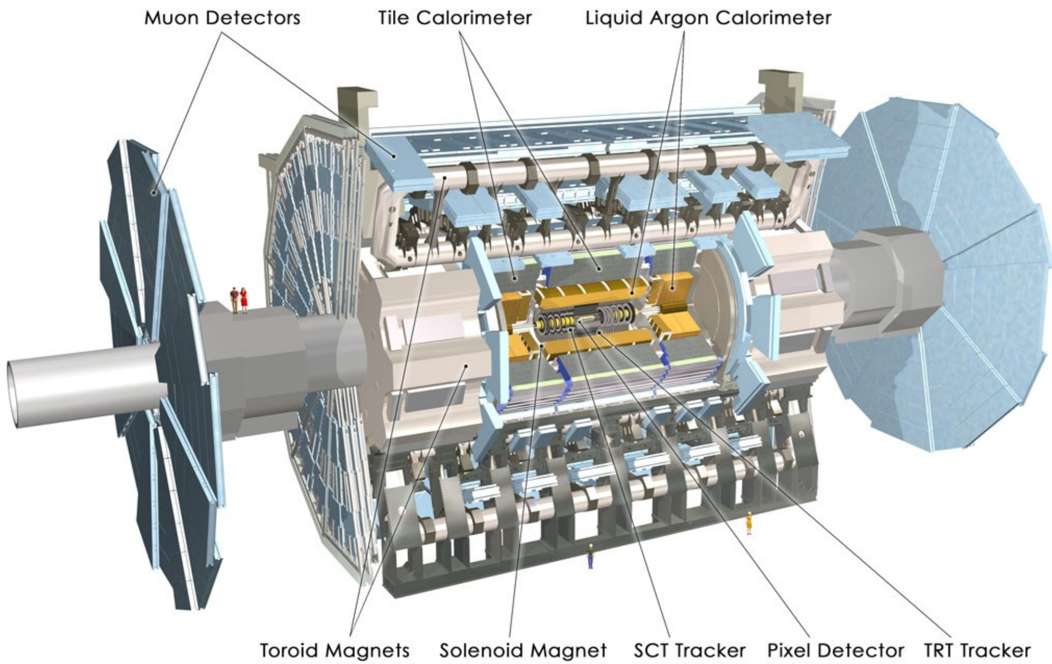
- **LHC**
  - pp-collisions at 14 TeV, 25ns spacing
  - reaching a new order of magnitude in energy and luminosity



- **ATLAS**
  - general-purpose detector
  - length: 46m; diameter: 25m; weight: 7000t
  - to record 200 events (out of 20*40M) every second



The Tools

- Charged Higgs searches would be impossible without any of the following tools and the people involved

- Excellent coverage in the following days – thus only pointers here:
  - **Trigger**:
    - Performance: Frank Winklmeier, Wednesday
    - For H^+: Chris Potter, Tuesday
    - Tau Trigger: Richard Brenner, Wednesday
  - **τ ID**: Aldo F. Saavedra, Wednesday
  - **b-tagging**: Giacinto Piacquadio, Thursday
  - and many others (**jet/missing energy; lepton ID; ...**)

The H^+ "CSC efforts"

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- Start: June 2006; now at the end of the publication process
- For the first time: **Simulation studies of all of the most promising H^+ channels** with
  - a **realistic detector simulation**
  - full consideration of all **trigger** levels
  - inclusion of dominating **systematic uncertainties**
  - in a **common framework** (simulation, reconstruction, analysis, tools, combination, ...)
- Aim: To get the machinery **ready for first data**
- More than 20 people from about a dozen of institutions directly involved

Parameters & Scenarios

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- ATLAS H^+ searches currently focus on the **MSSM** and on generic scenarios (**model-independent**)

- The figures in this talk are all for the MSSM scenario "**m_h-max**", unless marked otherwise:
  M_2 = 200 GeV M_3= 800 GeV μ = 200 GeV X_T = 2 TeV M_{SUSY} = 1 TeV

- **NLO calculations** used throughout;
  important SUSY corrections (Δ_b) considered (FeynHiggs, Tilman's code)
  → see Andre Sopczak's talk

- All results: based on the **H^+ trigger menu** (within the trigger bandwidth budget for $\mathcal{L}=10^{33}cm^{-2}s^{-1}$ = "low lumi" runs)
  → see Chris Potter's talk

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1. Introduction

2. H^+ in Top Quark Decays

2.1	Production and Decay	
2.2	Hadronic τ+jets:	$H^+ \rightarrow \tau(\rightarrow had)\nu, \quad W\rightarrow qq'$
2.3	Hadronic τ+lepton:	$H^+ \rightarrow \tau(\rightarrow had)\nu, \quad W\rightarrow l\nu$
2.4	Leptonic τ :	$H^+ \rightarrow \tau(\rightarrow lep)\nu, \quad W\rightarrow qq'$

3. H^+ in gg- & gb-fusion

4. Systematics & Results

H^+ in Top Quark Decays

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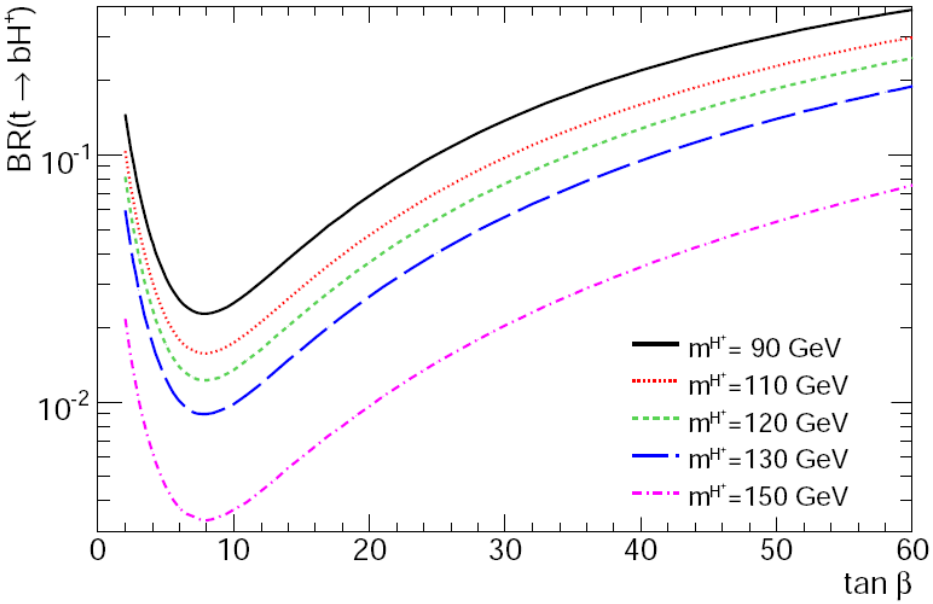
- H^+ lighter than the top quark

- Dominant **production** mode: **ttbar decays**, σ(ttbar)≈800pb

- **BR(t→bH^+)** depends on m_{H+} & tan β (typical: a few per cent) [and your favourite scenario...]

- Decay: **almost exclusively to τν;** for tan β<2, cs becomes sizable



Main channels of interest:

ttbar → bH^+ bW,

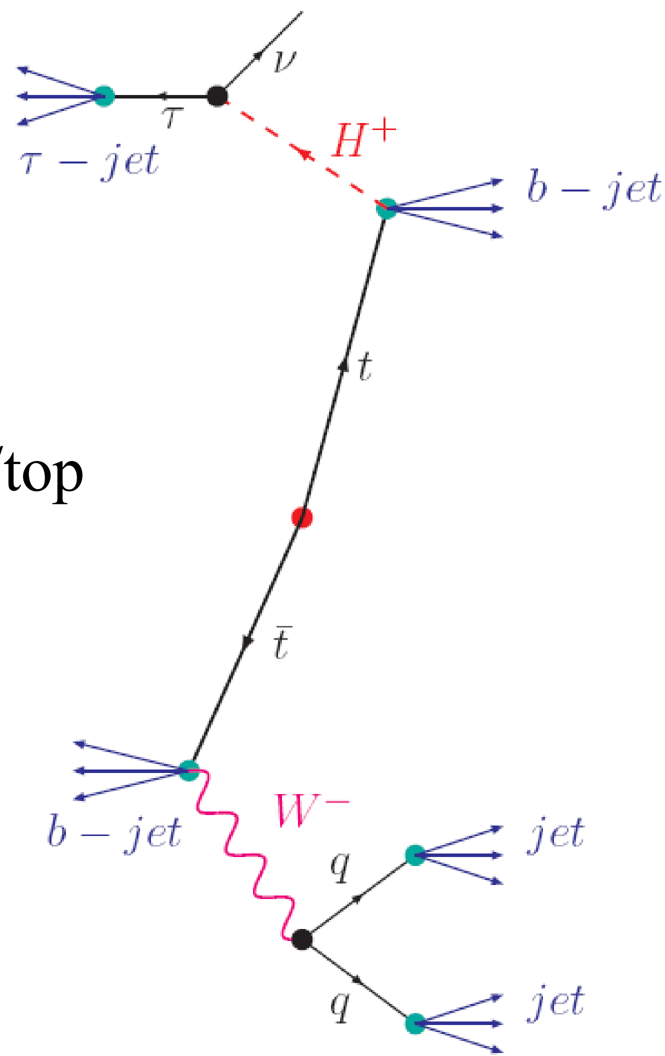
H^+ Decay	W Decay
τν, τ→had	qq
τν, τ→had	lν
τν, τ→lep	qq

The Hadronic τ+jets Mode

[see Elias Coniavitis' talk]

Signature:

- τ jet
- missing E_T
- 2 b jets
- hadronic W/top



Main Backgrounds:

- **ttbar**
- QCD
- single top
- W+jets

Basic Event Selection

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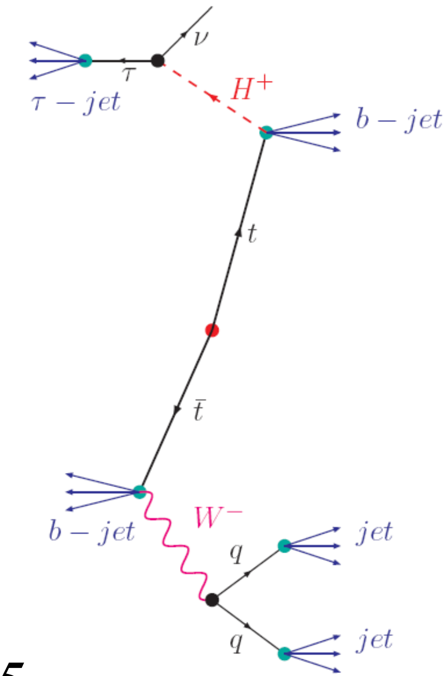
- **Trigger**: $\tau + E_T^{miss}$
  → main challenge for this channel; only about 10% trigger efficiency
- **Preselection**:
  - 1 τ jet, 2 b jets, 2 light jets
  - $E_T^{miss} > 30$ GeV
  - No isolated lepton
  - W and top reconstructued
  - 2 top quarks: p_T-ratio<2; angle in transverse plane>2.5



→**enhances the ttbar topology** (signal & background!); other backgrounds become negligible

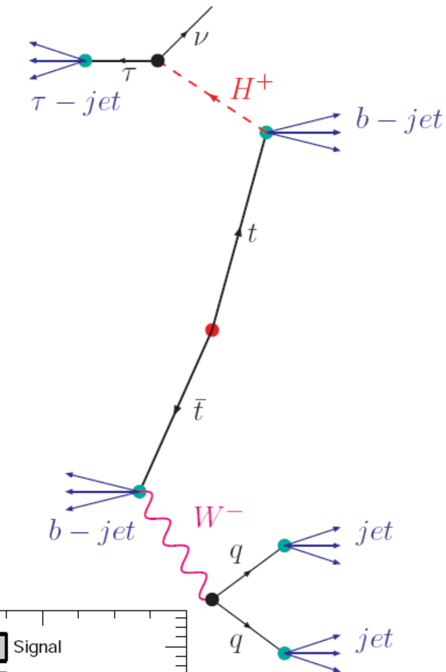
Efficiency after basic event selection:

Signal	ttbar≥1 lepton	QCD
0.4-0.5%	0.07%	<0.000 01%

Further Event Selection

- **Likelihood**
  - suppress SM ttbar
  - 7 variables

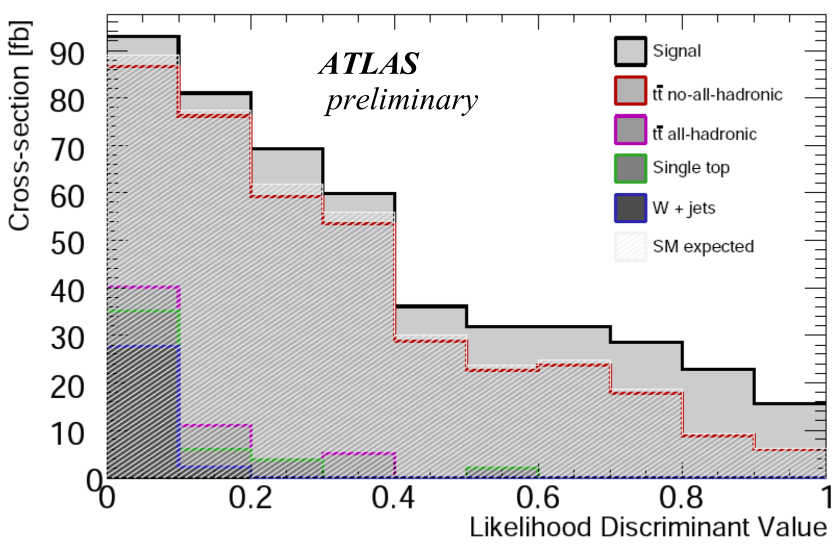
#	Likelihood Variables
1	p_T Ratio: τ track/τ jet
2	p_T Ratio: τ / b
3	angle(τ, E_t^{miss})
4	angle(H^+, b)
5	angle(τ, b)
6	mass(τ-b pair)
7	(#5)x(#6)



- Likelihood distribution for m_{H+}=130 GeV, tan β=20: **signal & background, stacked**

- m_{H+} < 140 GeV: Cut at LH>0.6; **efficiency**:

Signal	ttbar≥1 lepton
40-50%	15-20%



Results

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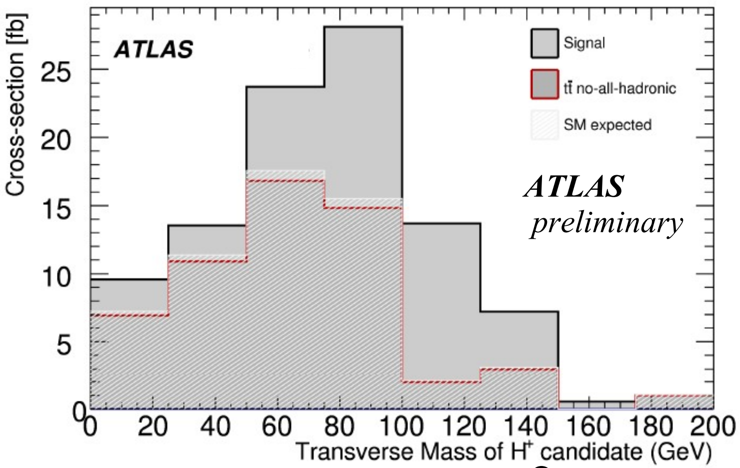
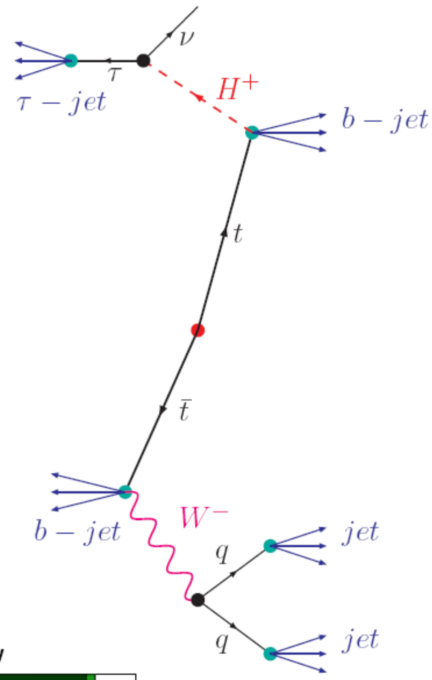
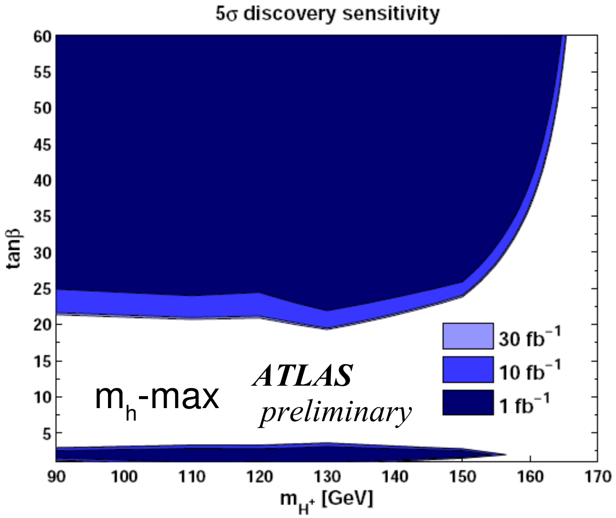
- **H^+ transverse mass**:

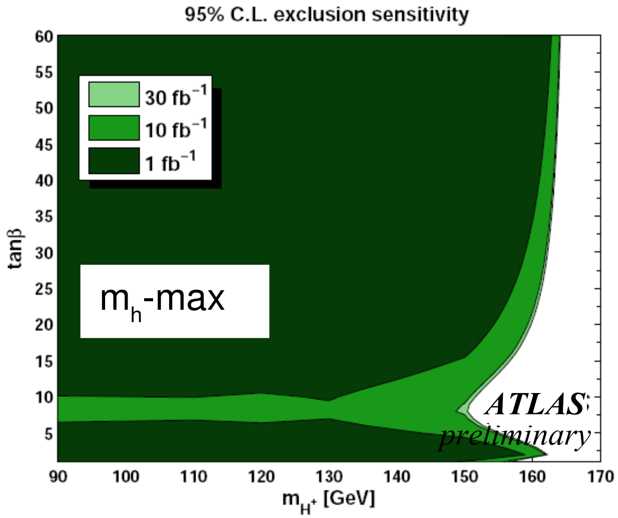


m_{H+}=130 GeV, tan β=20



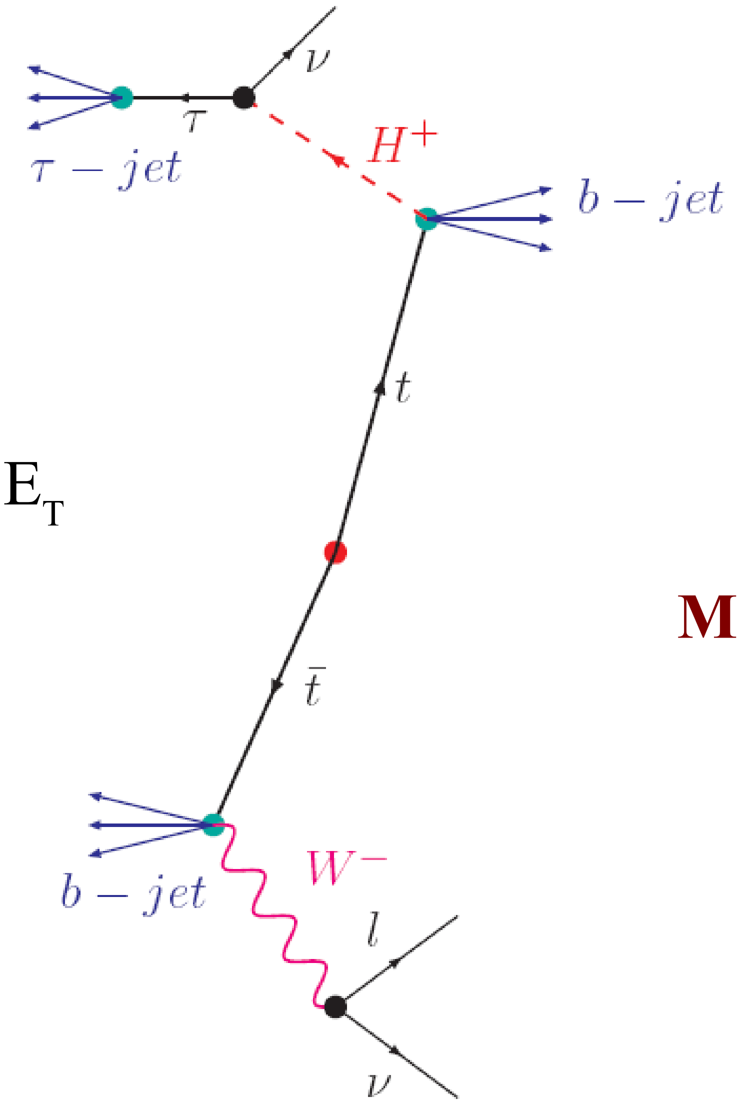
- **Sensitivity reach**:
most promising light H^+ channel





The Hadronic τ+lepton Mode

[see Thies Ehrich's talk]



Signature:

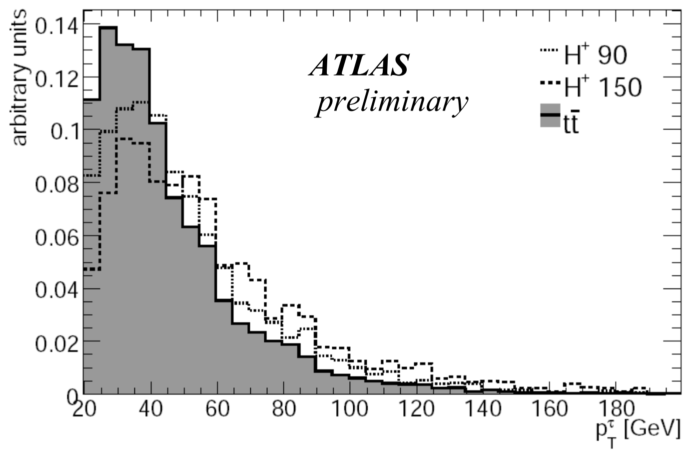
- lepton
- missing E_T
- τ jet
- 2 b jets

Main Backgrounds:

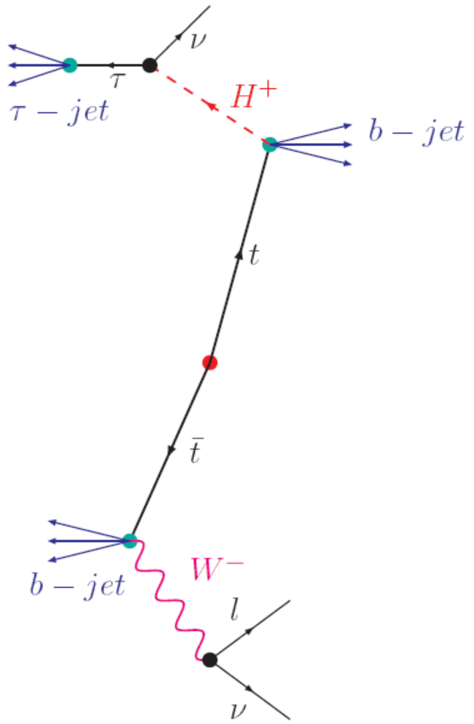
- **ttbar**
- single top
- W+jets

Event Selection

- **Trigger**: (lepton or τ)+E_T^{miss}
- **Selection Cuts**:
  - isolated lepton
  - ≥3 jets
    → ≥1 τ-tagged
    → ≥1 b-tagged
  - $q_l + q_\tau = 0$
  - E_T^{miss} >175 GeV

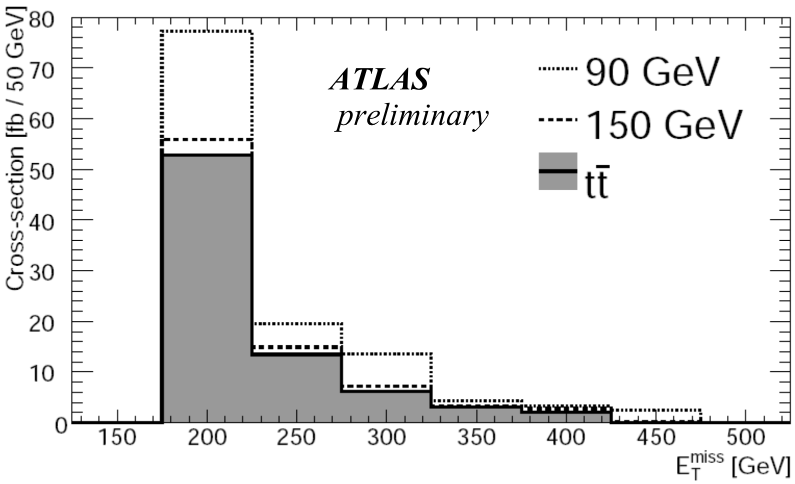


Tau Transverse Momentum

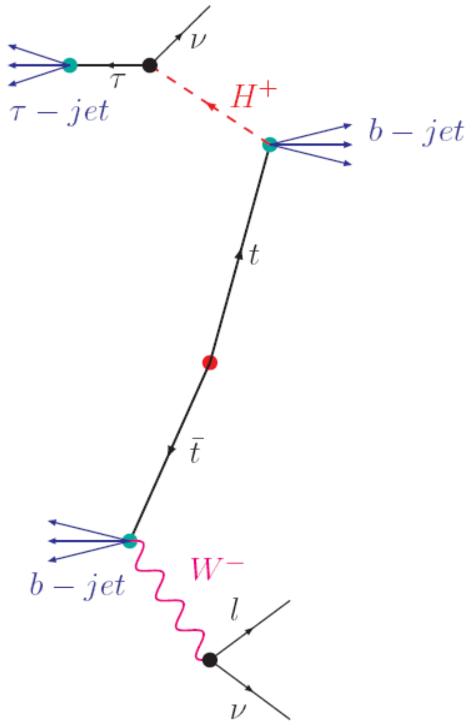


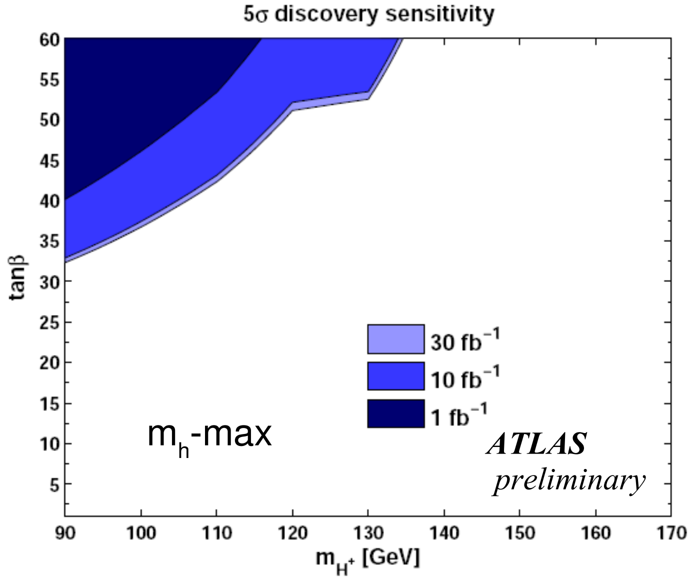
- neutrinos from multiple sources =>
  no mass reconstruction possible for the H^+ (nor for the W or top)

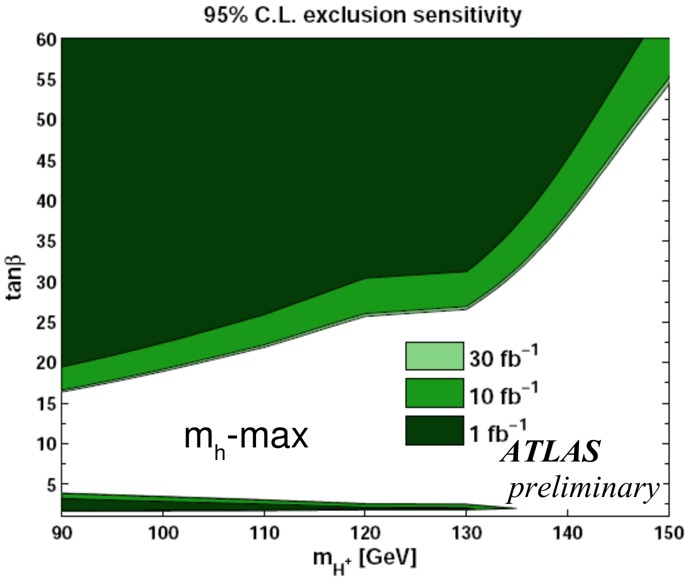
Results



E_T^{miss} distribution after all cuts, tan β=20
→clear excess only for light H^+



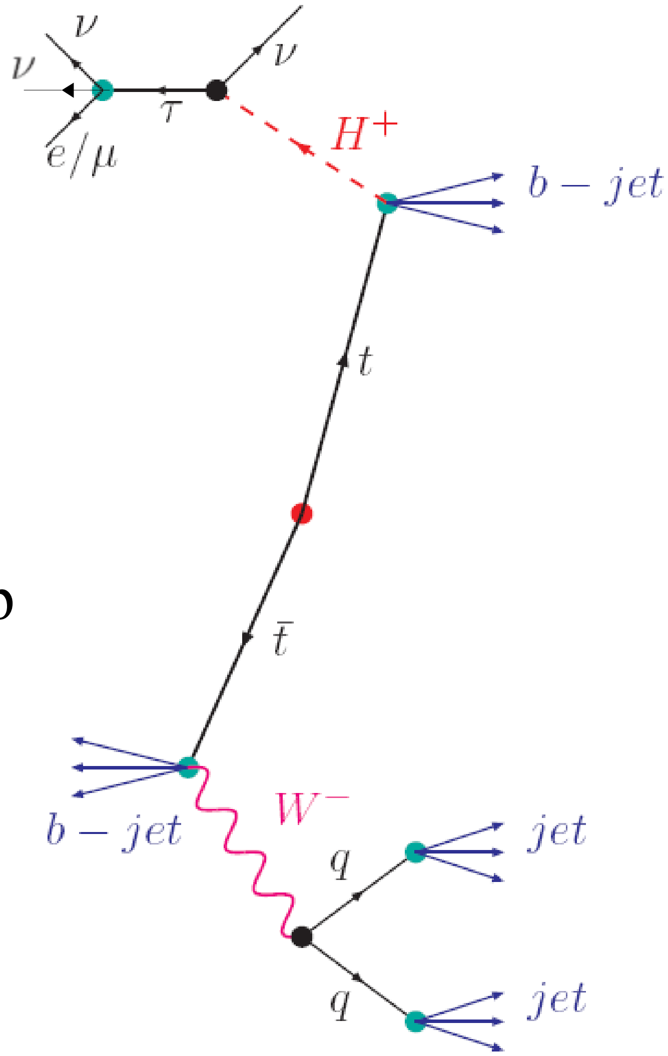




Discovery and Exclusion reach

- large uncertainties from JES

The Leptonic τ Mode



Signature:
- lepton
- missing E_T
- 2 b jets
- hadronic W/top

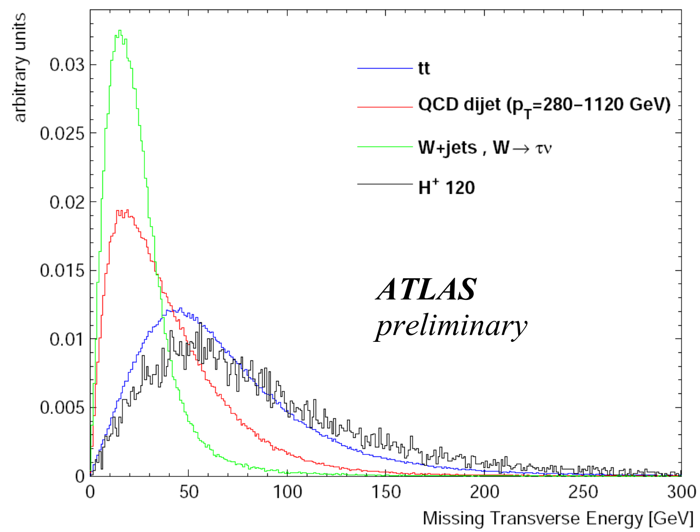
in Backgrounds:
- **ttbar**
- W+jets
- QCD

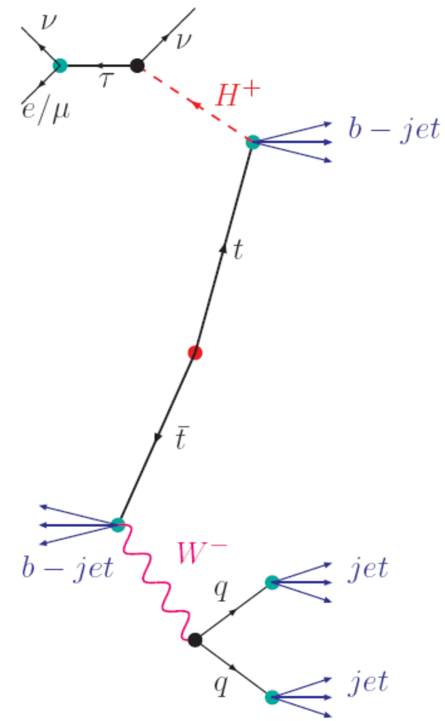
Basic Event Selection

Trigger: lepton + missing energy OR high missing energy

Preselection:

- 1 lepton
- High missing transverse energy: >120 GeV
- ≥4 jets
  ≥2 of them b-tagged





After preselection, all backgrounds are negligible compared to ttbar → **selection efficiency**:

	Signal	ttbar≥1 lepton
Trigger	40-55%	45%
Preselection	2-3%	1%

Further Event Selection

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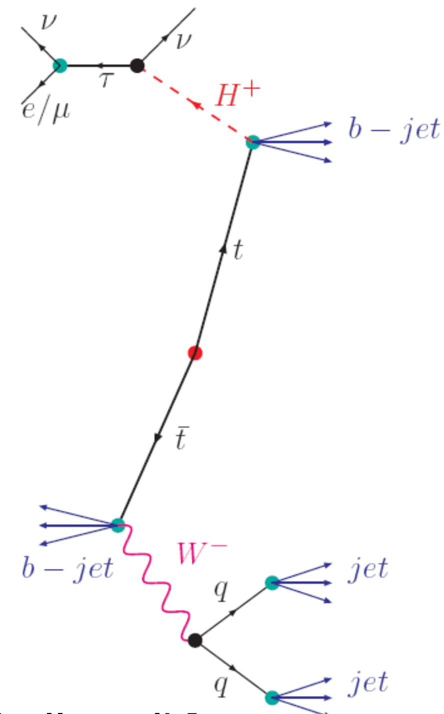


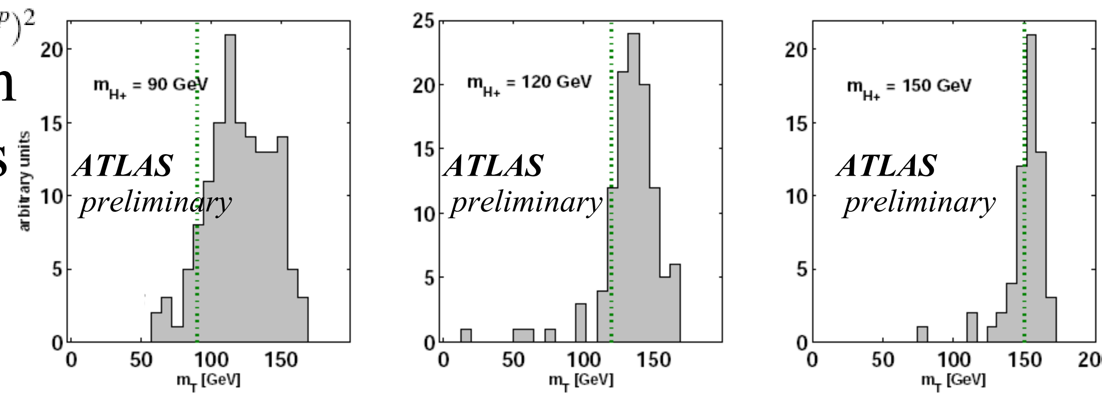
- **Reconstruct hadronic top quark**:
  - select dijet closest to W mass
  - assign the two b jets to the W and H^+
    $\rightarrow$likelihood [b charge; angle (b,lepton) & (b,W)]
  - cut on m_{top}
- Cut on the **decay angle** $\cos\psi = \frac{2m^2_{\ell b}}{m^2_{top} - m^2_W} - 1 < -0.8$

  Cut on **m(lepton,E_T^{miss})** < 60 GeV

  $\rightarrow$ suppress events with $W\rightarrow l\nu$. For those:
  ψ = angle (top, lepton) and $m = m_T^W$
- Novel **generalized transverse mass** definition [see Ofer Vitell's talk]

$$(m_T^{H^+})^2 = (\sqrt{m^2_{top} + (\vec{p}_T^{\,lep} + \vec{p}_T^{\,b} + \vec{p}_T^{\,miss})^2} - p_T^b)^2 - (\vec{p}_T^{\,miss} + \vec{p}_T^{\,lep})^2$$

$\rightarrow$ allows $m_T(H^+)$ reconstruction in the presence of 3 neutrinos

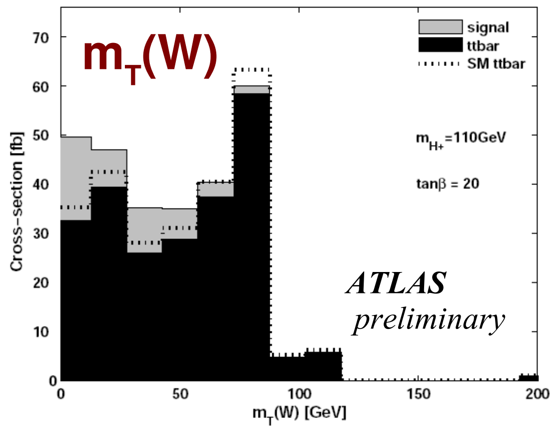


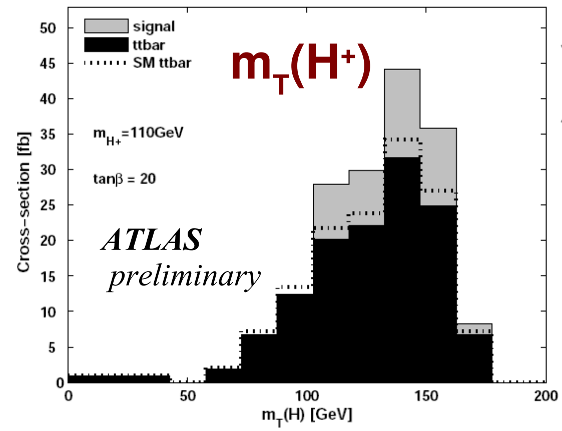
Further event selection efficiency

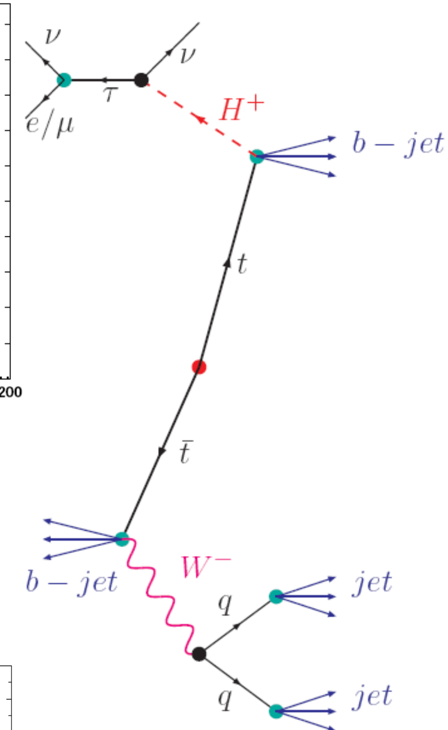
Signal	ttbar≥1 lepton
20-30%	7%

Results

cross section in fb, m_{H+}=110 GeV, tan β=20

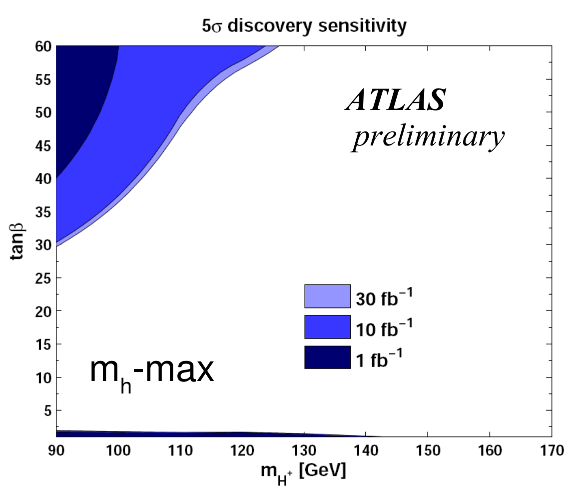


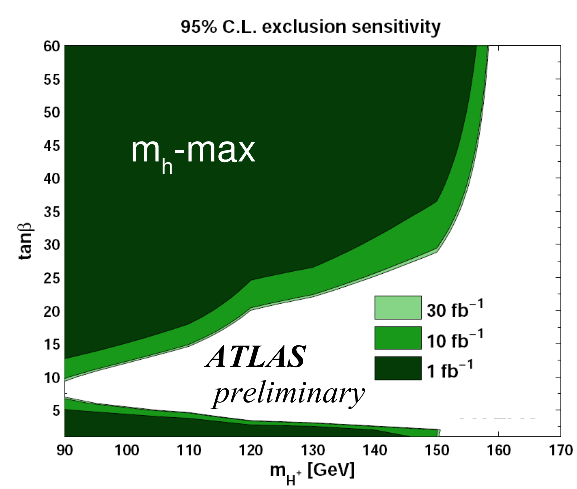




- Significance calculated from shape of $m_T(W)$ or $m_T(H^+)$

Discovery and exclusion reach





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1. Introduction
2. H^+ in Top Quark Decays

3. H^+ in gg- & gb-fusion

- 3.1 Production and Decay
- 3.2 tb mode
- 3.3 $\tau\nu$ mode

4. Systematics & Results

H^+ in gg- and gb-fusion

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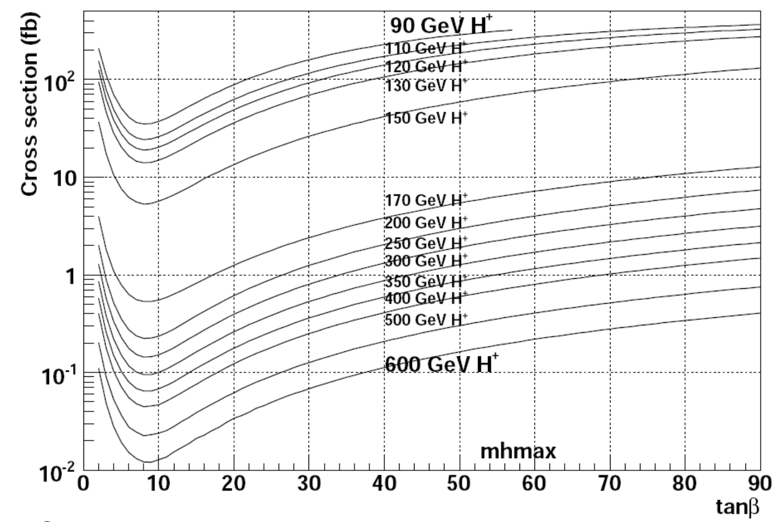
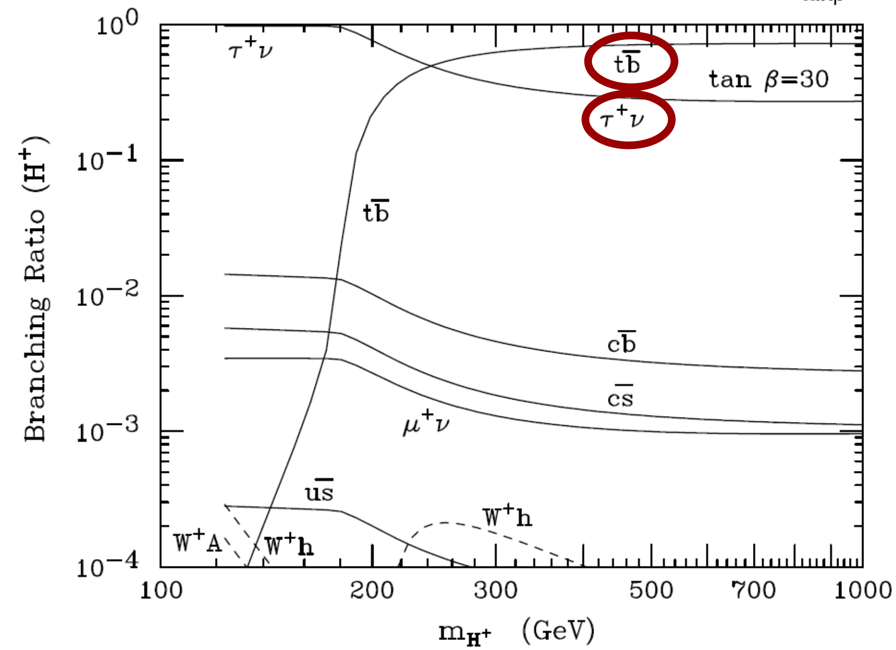
- For H^+ heavier than top quark:
- Dominant **production** mode (MSSM):
  gg→tbH$^+$, gb→tH$^+$
  → twin processes; overlap can be handled with generator Matchig
- **Decay**: **tb** dominates, **τν** sizeable

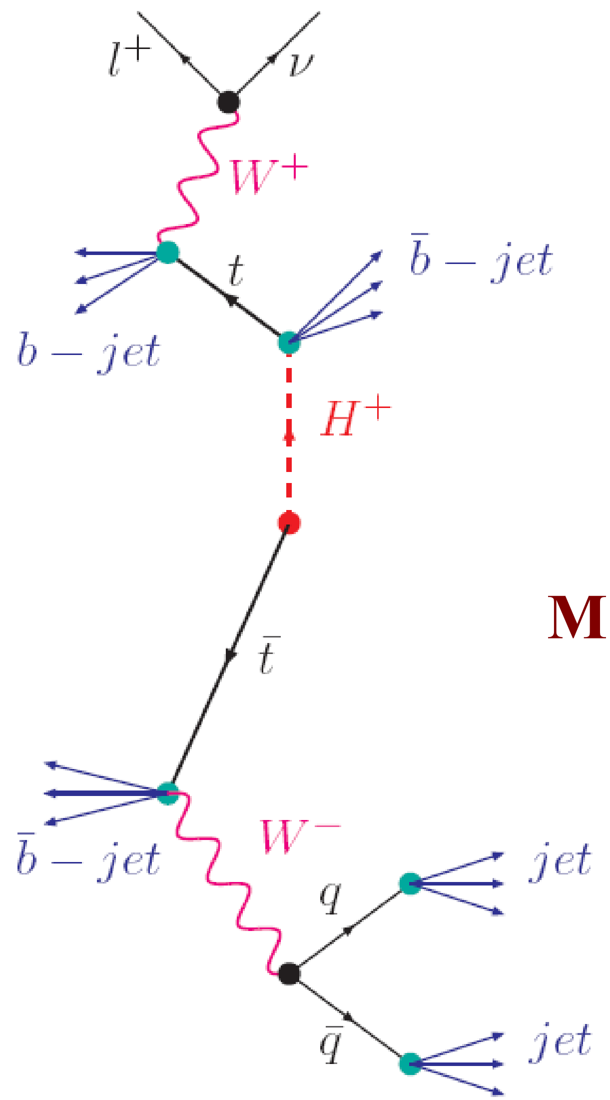
Main channels of interest:
gg/gb → bW [b]H$^+$

H^+ Decay	W Decay
tb	lν & qq (2 Ws)
τν, τ→had	qq





The $H^+ \rightarrow tb$ Mode



Signature:

- 3-4 b jets
- lepton
- 2 W, 2 top

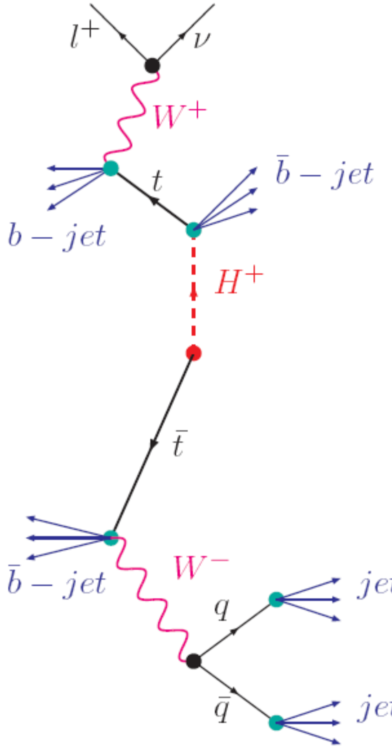
Main Backgrounds:

- ttbar+b, ttbar+bbbar
- **ttbar+jet(s)**

Basic Event Selection

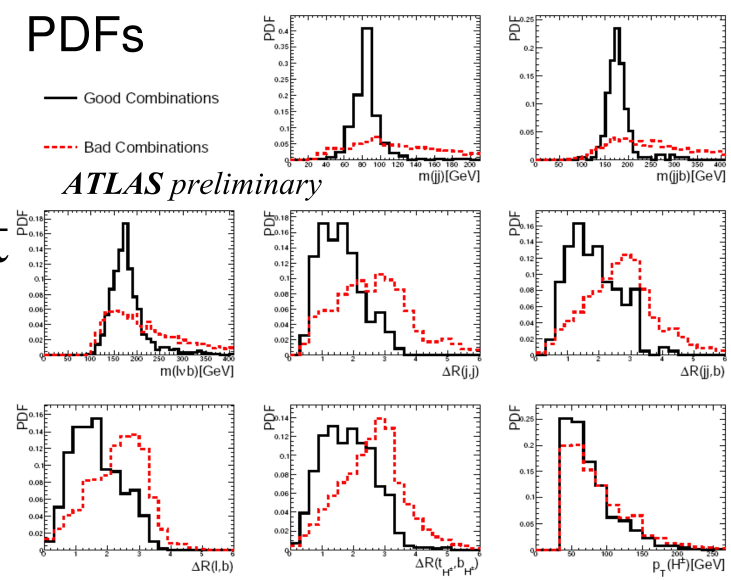
- **Trigger**: (τ or lepton)+E_T^{miss}
- **Preselection**:
  - 1 isolated lepton
  - ≥5 jets
    ≥3 of them b-tagged
  - Leptonic W reconstructed
- **Selection efficiency**:

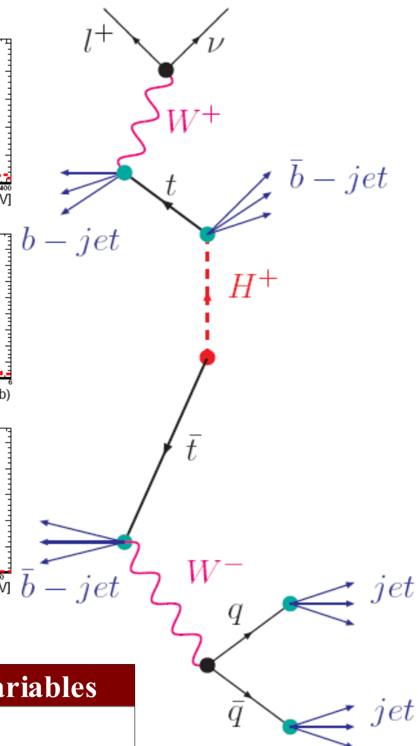
Signal	ttbar+jets	ttbar+bbar
2-9%	1%	6%



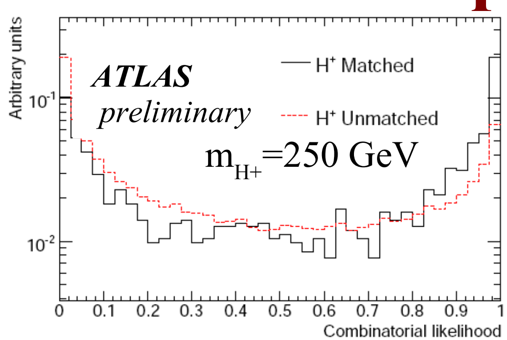
Further Event Selection

- **Combinatorial likelihood**
  - based on 8 variables
  - best combination is kept
  - cut: LH>0.7





- **Likelihood output**:



#	LH Variables
1	m_{jj}
2	m_{jjb}
3	$m_{l\nu b}$
4	p_T (b^{H+})
5	angle(j,j)
6	angle(jj,b)
7	angle(lepton,b)
8	angle(b^{H+},t^{H+})

b^{H+}, t^{H+}: b, t from H+ decay

- Requirement of **4 b jets**

	Signal	ttbar+jets	ttbar+bbar
LH	90%	84%	90%
4b	10-15%	4%	15%

Results

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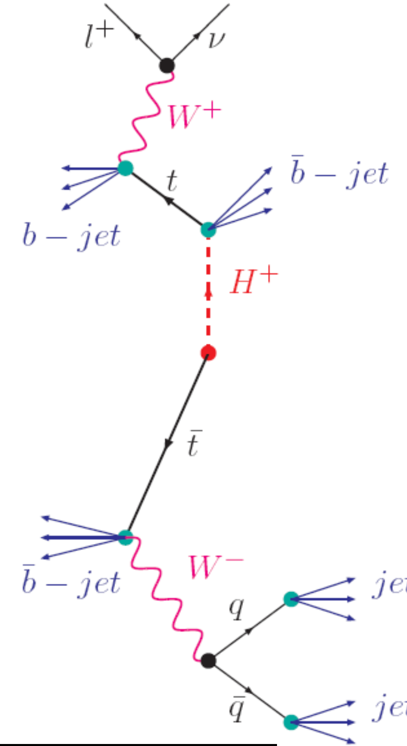
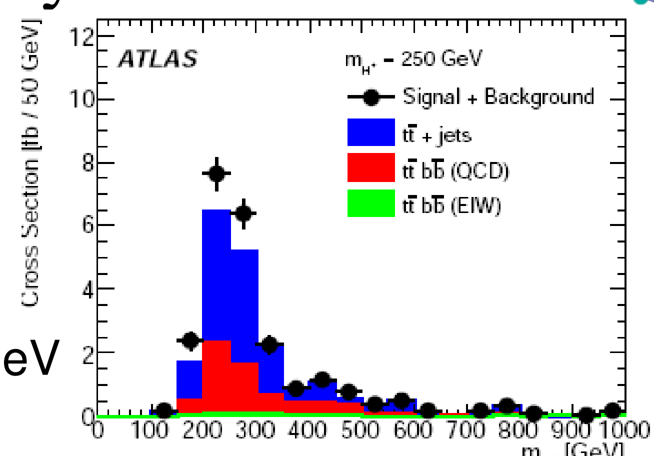


- Finally, a **selection likelihood** is defined
  - aim: suppress ttbar+jets
  - larger background samples are needed for a performing likelihood
- **No H^+ sensitivity on its own** (MSSM!)... but:
  - Contributes to combined H^+ sensitivity
  - Hope for improvement with a future selection likelihood

m_{H+}=250 GeV
tan β=70



The $H^+ \rightarrow \tau\nu$ Mode

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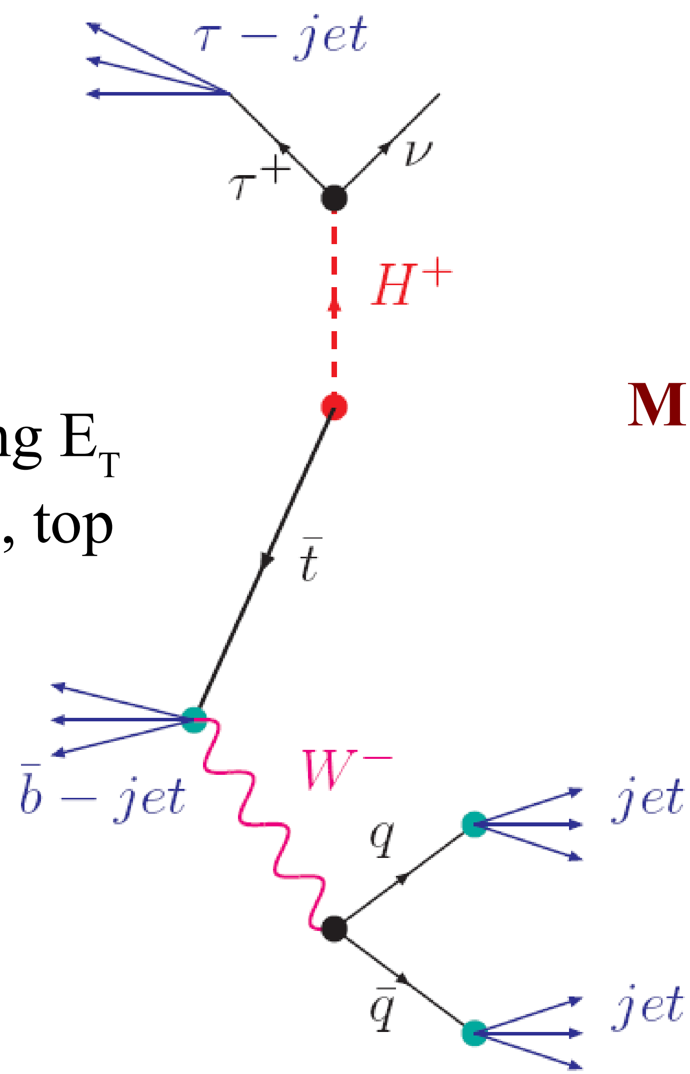
Signature:

- hard τ jet
- large missing E_T
- hadronic W, top
- 1-2 b jets



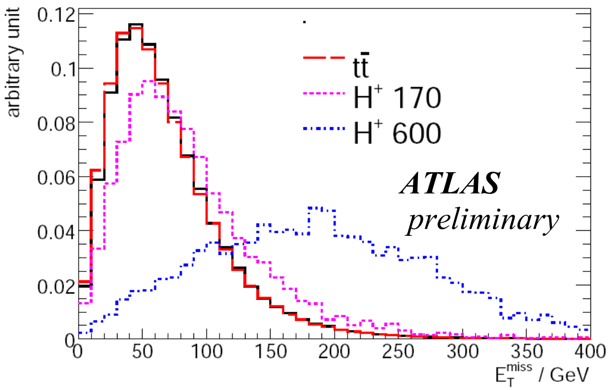
Main Backgrounds:

- **ttbar**
- single top
- W+jets
- QCD

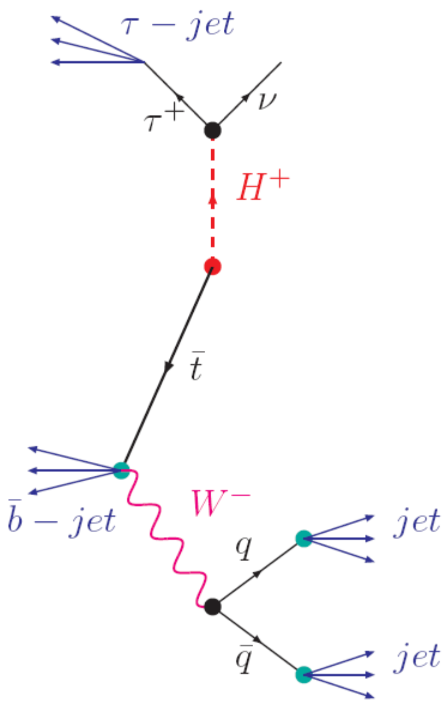
Basic Event Selection

- **Trigger**: τ jet + missing energy

- **Preselection**:
  - E_T^{miss} >50 GeV
  - ≥4 jets, of which
    - 1 b-tagged
    - 1 τ-tagged
  - veto on isolated leptons
  - W & top reconstructed



Missing Transverse energy



- After preselection, all backgrounds are negligible compared to ttbar
  → **selection efficiency**:

Signal	ttbar≥1 lepton
1-2%	0.04%

Further Event Selection

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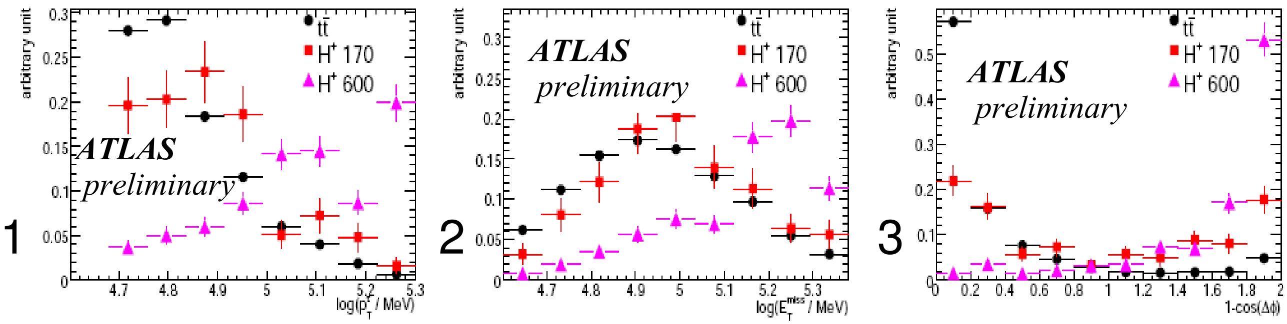
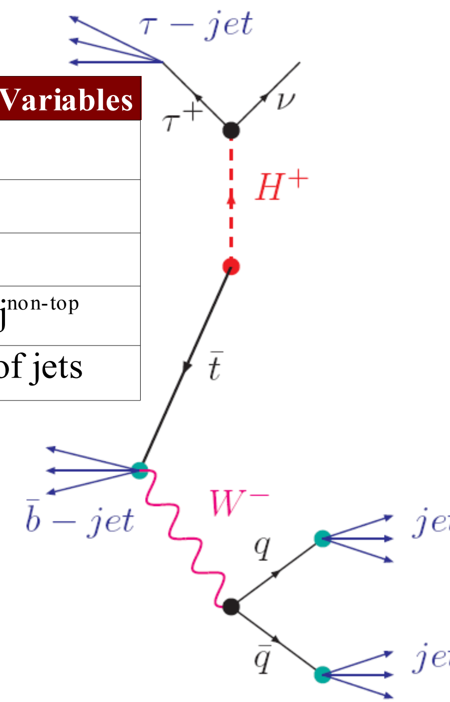
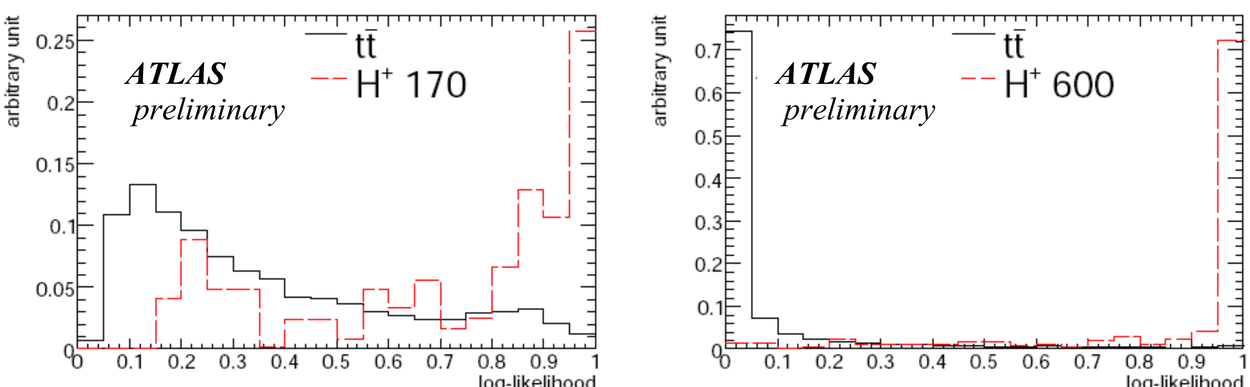
Likelihood based on 5 variables



Input Variables (pdf)

#	Likelihood Variables
1	p_T(τ jet)
2	E_T(miss)
3	angle(τ,ν)
4	p_T ratio: $\tau/j^{\text{non-top}}$
5	sum of p_T of jets





Log-Likelihood

Signal	ttbar≥1 lepton
25-80%	1-2%

LH Efficiency

Large performance difference depending on m_{H+}

Cut on **LH>0.9** (high m_{H+}: 0.95)

Results

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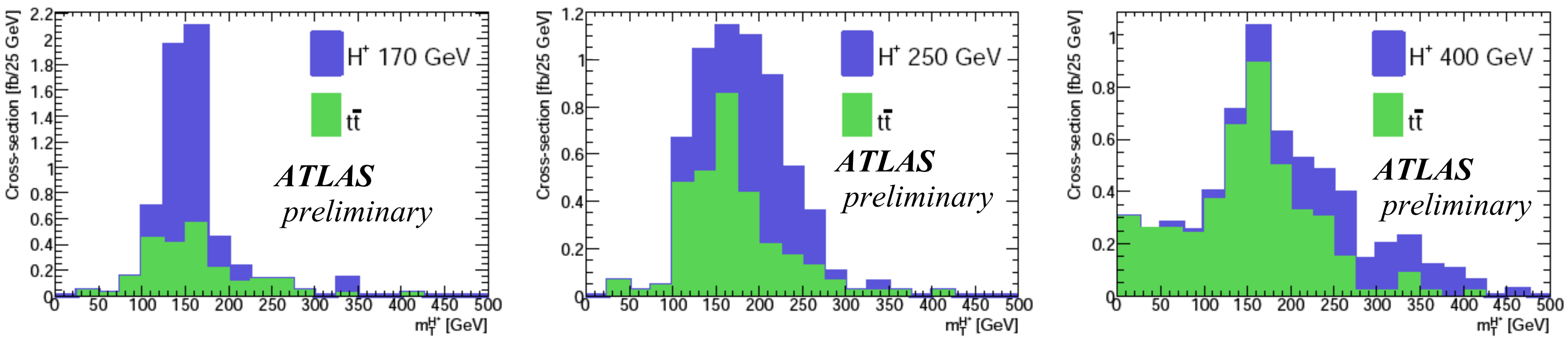
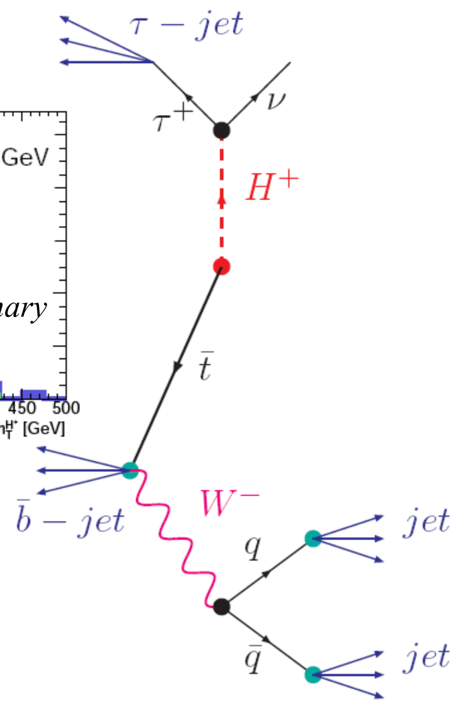
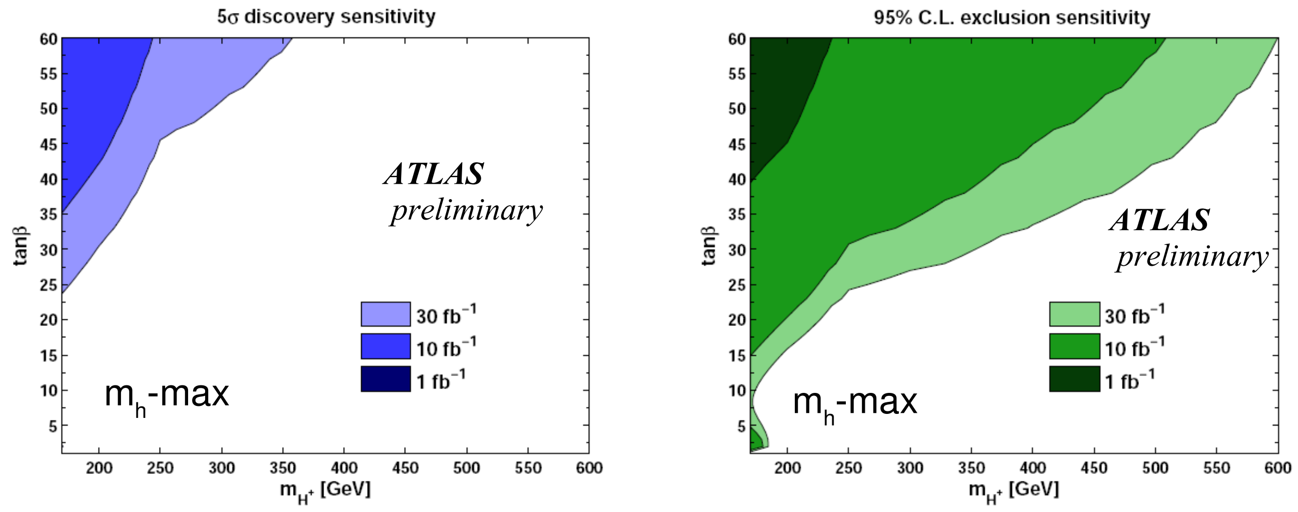
- **$m_T(H^+)$** after all cuts, tan β=35.





- **Discovery/Exclusion reach**:



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1. Introduction
2. H^+ in Top Quark Decays
3. H^+ in gg- & gb-fusion

4. Systematics & Results

4.1 Dominating Systematic Uncertainties
4.2 ttbar control samples
4.3 Combined Results

Systematic Uncertainties

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- **Theoretical** (σ, BR): ≈20%
- **Experimental**: 30-40%, JES dominates
- Removes almost all H^+ sensitivity → discovery potential depends on how well **background** can be extracted **from data**

Table 11: Effects of systematic uncertainties for all channels under investigation. The numbers are given in terms of percentage changes in cross-section. The channels are: 1: $t\bar{t} \to bH^+bW \to b\tau(had)\nu bqq$ (see Section 3.1), 2: $t\bar{t} \to bH^+bW \to b\tau(lep)\nu bqq$ (see Section 3.2), 3: $t\bar{t} \to bH^+bW \to b\tau(had)\nu b\ell\nu$ (see Section 3.3), 4: $gg/gb \to t[b]H^+ \to bqq[b]\tau(had)\nu$ (see Section 4.1) and 5: $gg/gb \to t[b]H^+ \to t[b]tb \to bW[b]bWb \to b\ell\nu[b]bqqb$ (see Section 4.2).

ATLAS preliminary

Uncertainty	Value	1 S	1 B	2 S	2 B	3 S	3 B	4 S	4 B	5 S	5 B
τ E Resolution	$0.45 \times \sqrt{E}$	-2	+3	-	-	+8	-3	-4	-1	-	-
τ E Scale	-5%	-2	+5	-	-	0	-9	-15	-21	-	-
	$+5\%$	-5	-5	-	-	+8	+1	+4	+28	-	-
τ-tag Efficiency	$\pm5\%$	-5	-2	-	-	-8	-1	-8	-5	-	-
Jet E Resolution	$0.45\sqrt{E}, \vert\eta\vert < 3.2$ $0.63\sqrt{E}, \vert\eta\vert > 3.2$	-2	-3	-8	+5	+8	+3	-12	-3	-2	-4
Jet E Scale	$+7(15)\%, \vert\eta\vert < (>) 3.2$	-9	+12	+29	+22	+35	+19	+4	-18	+9	+8
	$-7(15)\%, \vert\eta\vert < (>) 3.2$	-5	-5	-21	-12	-19	-17	-31	+15	-8	-6
b-tag Efficiency	$\pm5\% \varepsilon_{btag}$	0	-14	+4	-6	0	-3	-7	+3	-8	-10
b-tag Rejection	-10%	-7	+10	0	+1	0	0	-2	-3	-4	+6
	+10%	+7	-2	0	0	0	-1	-3	-1	0	-5
μ E Resolution	$0.011/P_T \oplus 0.00017$	0	0	-4	+1	0	+1	0	0	-4	-5
μ E Scale	-1%	0	0	0	+1	+4	-1	0	0	-4	-6
	+1%	0	0	-4	-1	0	0	0	0	+4	+7
μ Efficiency	$\pm1\%$	0	0	0	-1	0	0	0	-2	-2	-1
e E Resolution	$0.0073 \times E_T$	0	0	0	0	0	-1	0	0	-4	-4
e E Scale	-0.5%	0	0	0	+1	0	-1	0	0	-4	-5
	+0.5%	0	0	0	-1	+4	-1	0	0	+4	+6
e Efficiency	$\pm0.2\%$	0	0	0	0	0	0	0	0	0	-1
Luminosity	-3%	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3
	+3%	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3

ttbar control samples

[see Trevor Vickey's talk]

- The **principle** - in a nut shell:
  - **collect** pure samples of e.g. **ttbar→bqq bμν** events **from data**
  - **replace** the **muon** with a simulated **tau lepton**
  - **use these events** instead of MC for background estimation
- Tests indicate: a **precision of ~10%** in observables is achievable

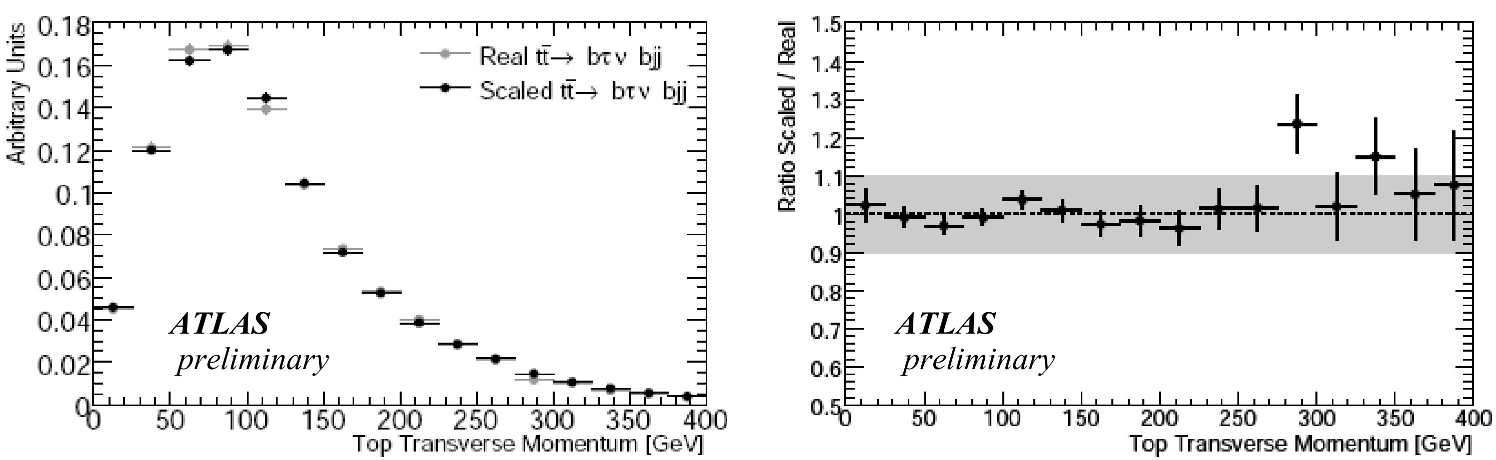
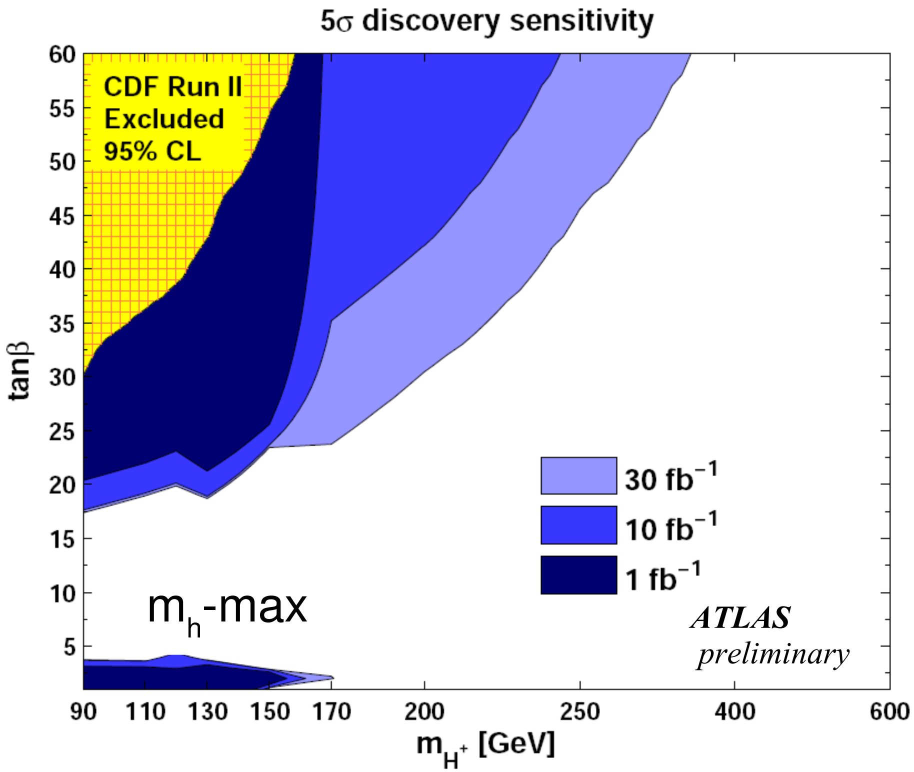
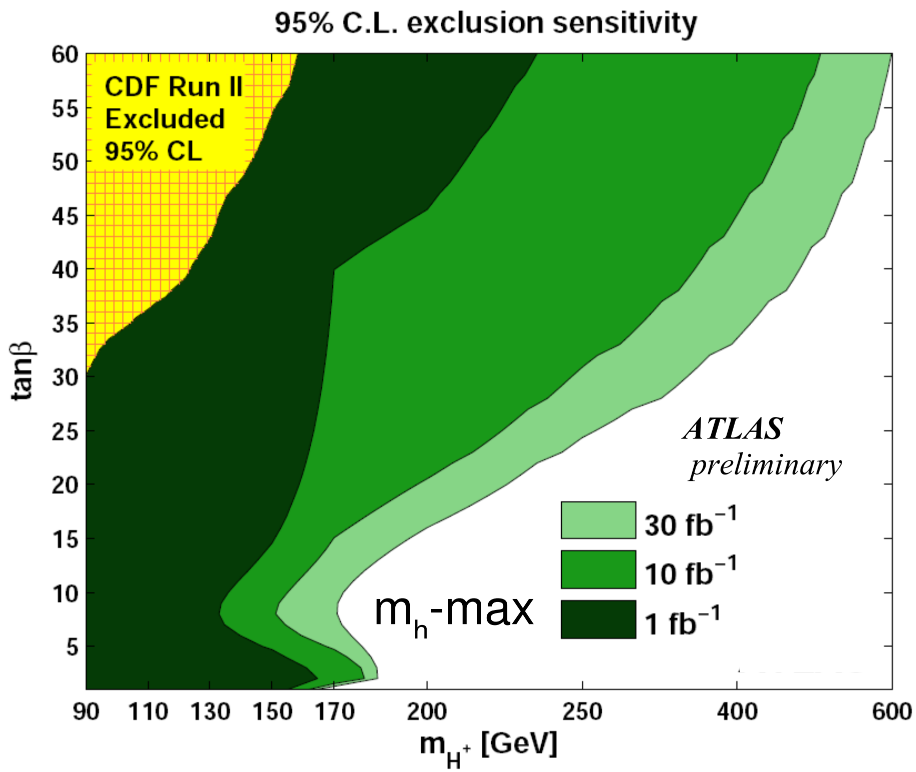


Figure 16: $t\bar{t} \to b\tau(had)\nu bqq$: Left: $t \to b\tau(had)\nu$ momentum, both for the real and the scaled $t\bar{t}$ events. Right: The corresponding bin-by-bin ratio. The gray band represents $\pm 10\%$ around a ratio of 1.

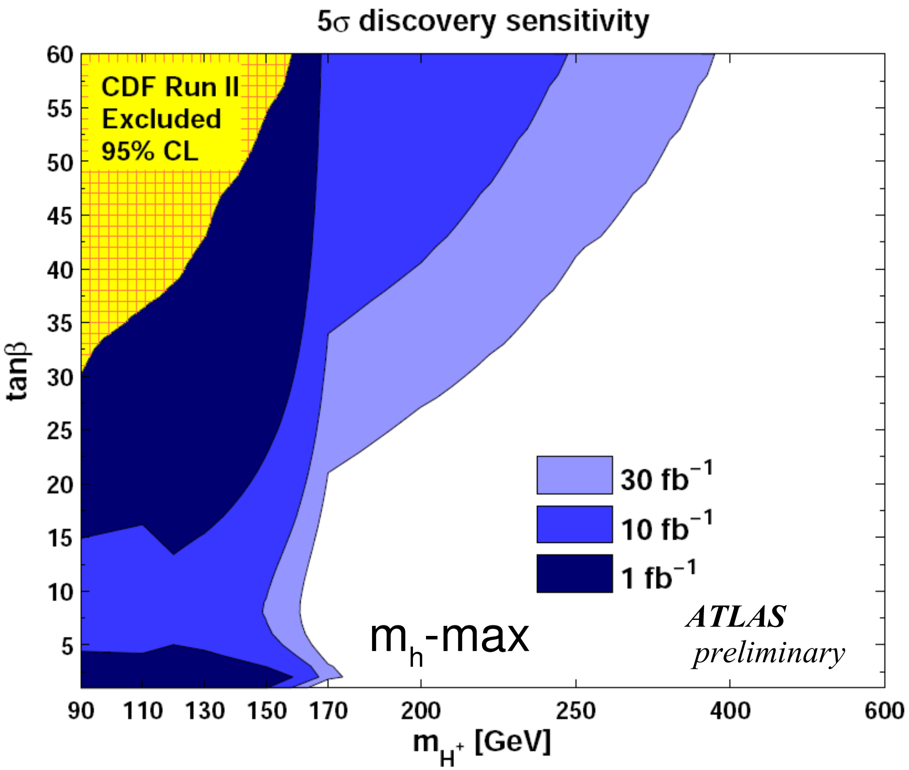
Combined Results: m_h-max

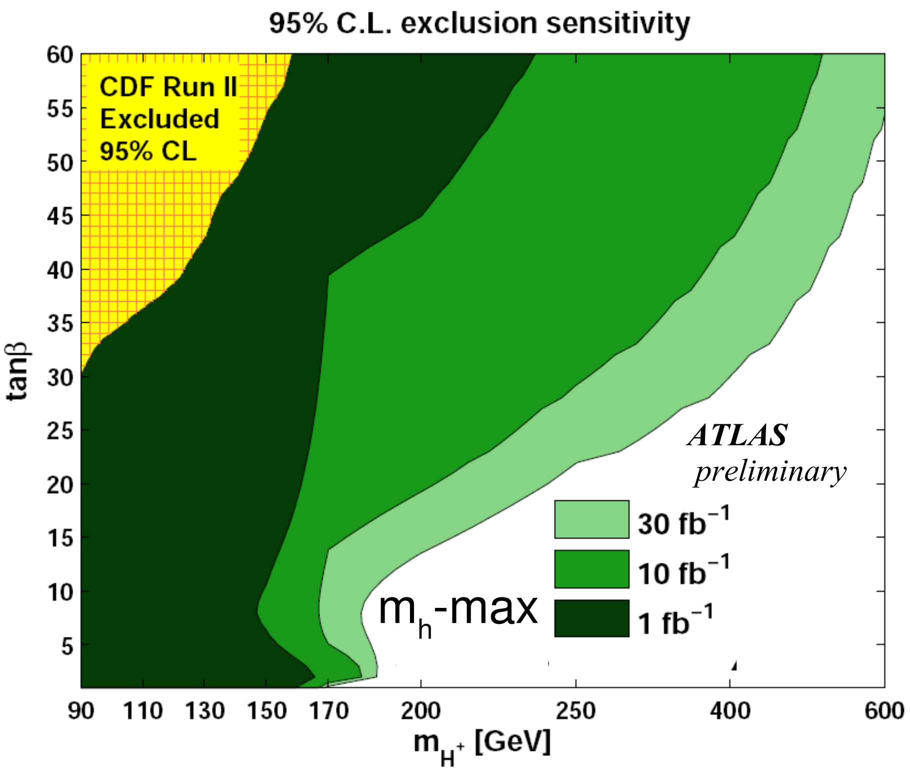




- Combination of all channels using **Profile Likelihood**→see Ofer Vitells' talk
- Including dominant **systematic and statistical uncertainties**
- **Light H^+**: gap for **intermediate tan β** (discovery); **heavy H^+** difficult
- 1 fb^{-1} corresponds to ~1 month at low luminosity; but:
  studies require understanding of **high-level objects**→1 fb^{-1} ≠ first 1 fb^{-1} !

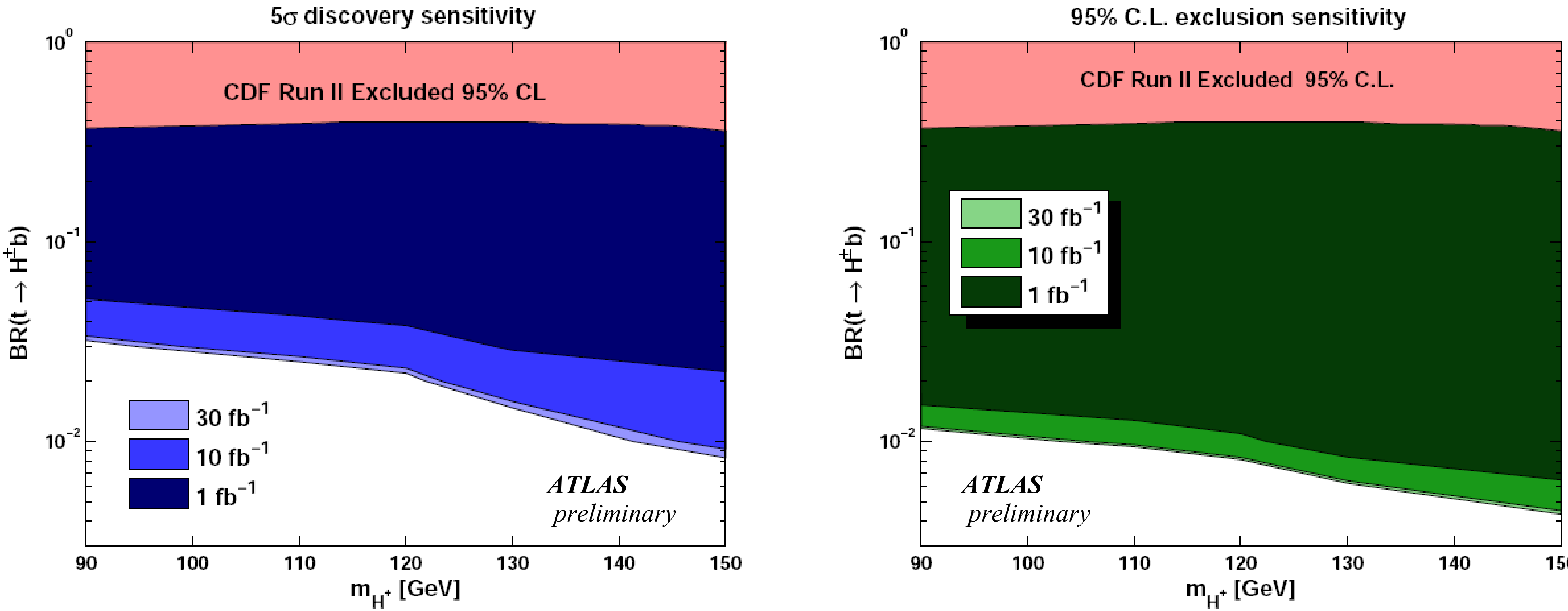
Simulation Statistics





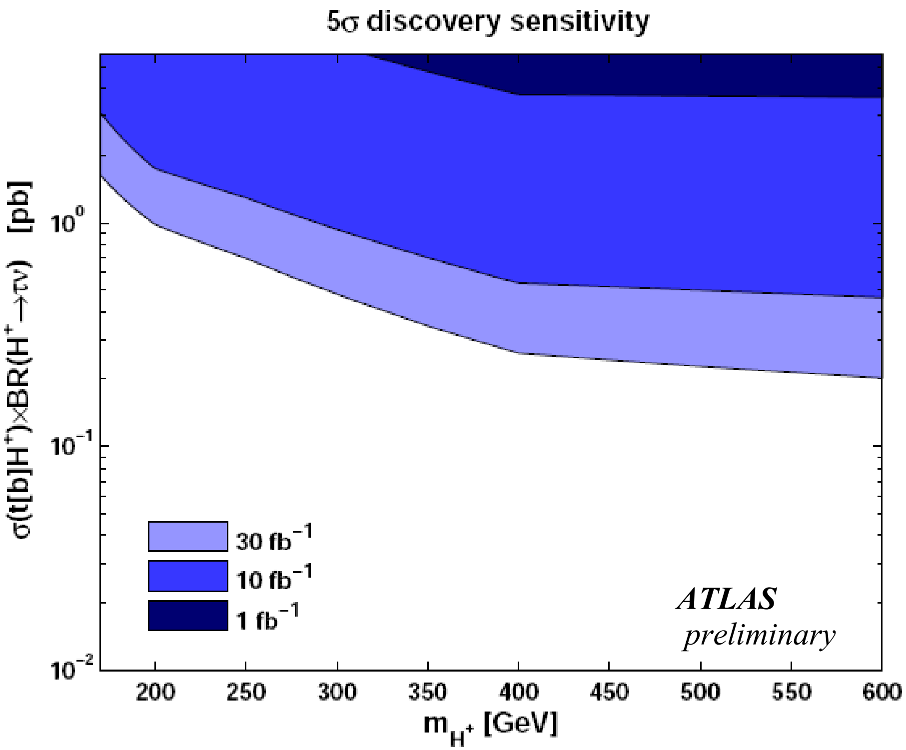
- Discovery contour when assuming an infinite number of simulated events → i.e. **neglecting uncertainty of finite MC statistics**
- **Hope that tan β gap can be closed** by a large MC production → main problem is ttbar; ≈20M events would be optimal

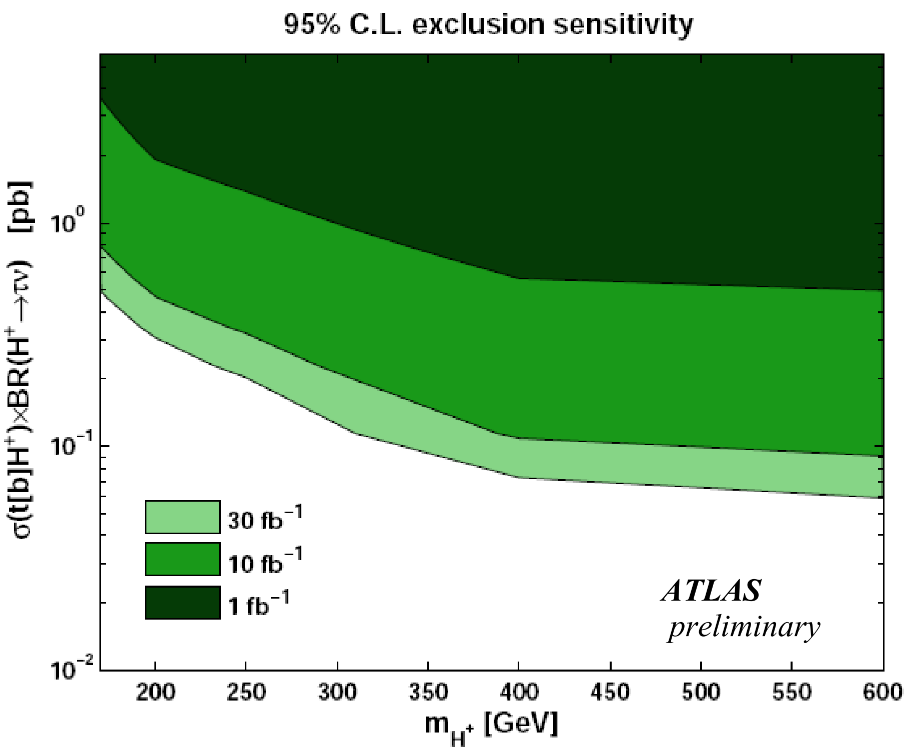
Model-independent: $t \to bH^+$



- **Sensitivity in terms of BR($t \to bH^+$)** - independently of physics model
- BR($H^+ \to \tau\nu$)=1 is assumed
- A **light H^+ can be excluded for BR($t \to bH^+$)>1%** with $10 fb^{-1}$

Model-independent: σ x BR





- Sensitivity in terms of **$\sigma(t[b]H^+)$ x BR($H^+ \rightarrow \tau\nu$)**
- Sensitivity for a cross section O(0.1pb)

ATLAS Collaboration,
Expected Performance of the ATLAS Experiment, Detector, Trigger and Physics,
Section: Charged Higgs Boson Searches,
CERN-OPEN-2008-020, Geneva, 2008, to appear.

Conclusions & Outlook

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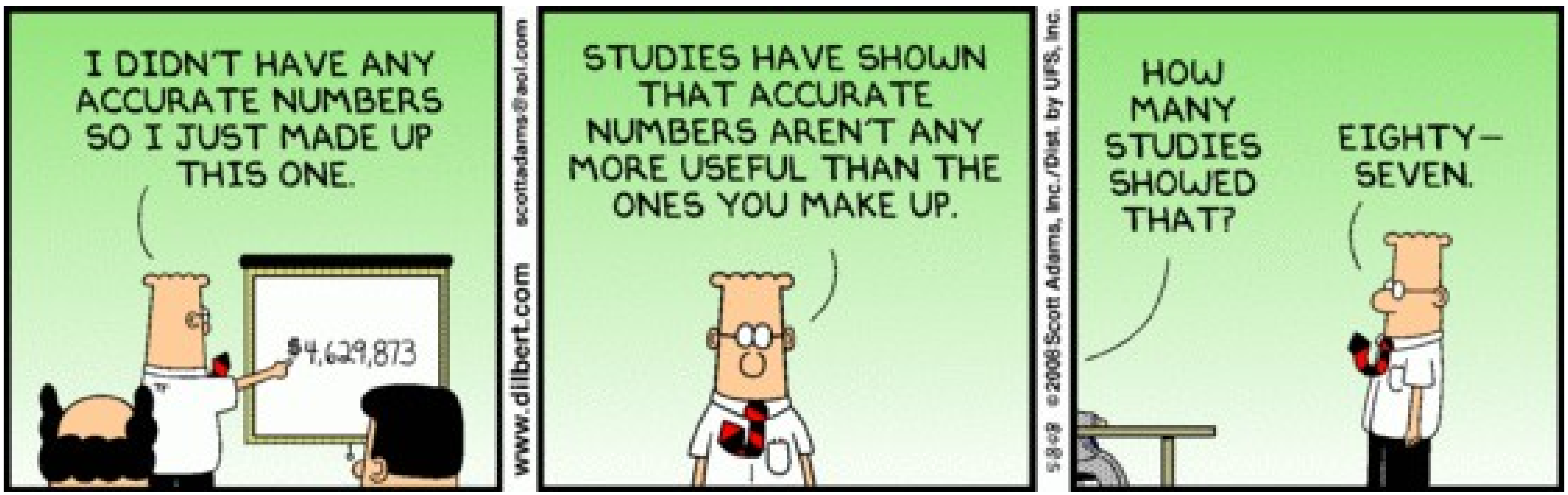
- An update on charged Higgs searches with ATLAS has been presented
- For the MSSM, $\mathbf{m_{H+} < m_t}$, the **charged Higgs boson can be excluded** with a few years of low luminosity data.
  - For **discovery**, there is currently a **gap** for intermediate tan β. There is good reason to believe that we will be able to fill it.
- **Heavy H^+ sensitivity only for large tan β**.
  - Discovery: (m_{H+} [GeV], tan β) from (m_t, 25) to (350, 60)
  - Exclusion: (m_t, 10) to (600, 60)
- Detector calibration and analysis tools refinement is the main challenge for the nearer future.
- **A very exciting time is waiting for us...**

Thank you.


I DIDN'T HAVE ANY ACCURATE NUMBERS SO I JUST MADE UP THIS ONE.
$4,629,873
www.dilbert.com
scottadams@aol.com
STUDIES HAVE SHOWN THAT ACCURATE NUMBERS AREN'T ANY MORE USEFUL THAN THE ONES YOU MAKE UP.
© 2008 Scott Adams, Inc./Dist. by UFS, Inc.
HOW MANY STUDIES SHOWED THAT?
EIGHTY-SEVEN.

Backup Slides

Some Simplifications

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- p. 15: the assumed ttbar cross section: 833pb
- p. 18, 31: the true variables used for the likelihood are in fact transformations of the ones given [e.g. angle→1-cos(angle)]. Also, for obvious reasons, some of the angles can only be defined in the transverse plane. See the note for details.
- p. 24: The b and τ jet are required to be one of the four hardest jets in the event
- p. 25: The statement about φ is valid in the approximation $m_b=0$ for the W rest frame
- Selection cuts (general): typically a minimum p_T is required, e.g. "3 jets with $p_T>30$ GeV"
  For simplicity, these are only given if they are exceptional (beyond typical requirements), e.g. $E_T^{miss}>120$ GeV.
- Trigger (general): additional jet item usually omitted. Triggers incl. thresholds:
  xE80 e55 mu40 e22i_xE30 mu20_xE30
  xE50_L1_TAU30 xE40_3j20_L1_TAU30

Other ATLAS Studies

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- The studies shown so far have all been updated since 2006
- For completeness, the following slides show the (unchanged) status of other ATLAS studies
- All of them have been obtained with by simulation with a parametrized detector response

m_{H+} determination with $H^+ \rightarrow t\,b$

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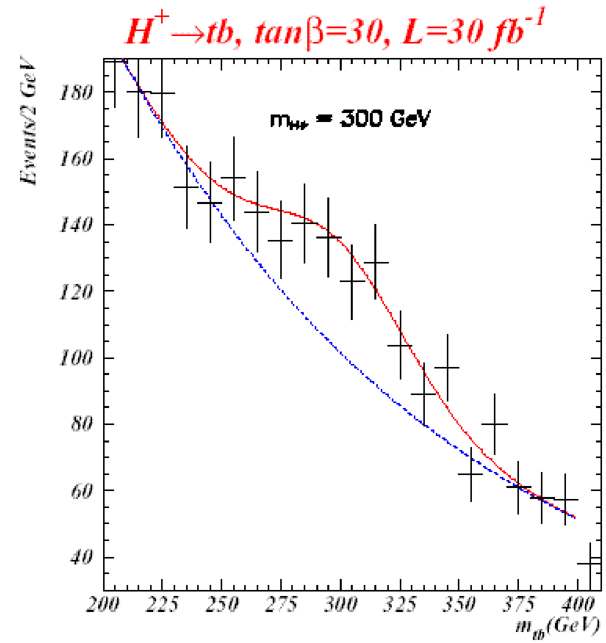
- In the tb channel the full invariant mass can be reconstructed but the channel suffers from the large irreducibel background and also from signal combinatorial background.
- It is possible to extract the mass using a likelihood method or by fitting the signal and background.
- One assumes that the background shape and normalisation can be found be fitting outside the signal region
- A Gaussian shape is assumed for the signal and an exponential for the background.
- Results show the precision on the mass determination from the likelihood and the fitting methods are comparable.



$m_{H^\pm}$ (GeV)	Likelihood		Fit	
	$< m >$	δm	$< m >$	δm
225.9	226.9	1.8		
271.1	270.1	10.1	271.0	10.3
317.8	320.2	11.3	316.4	11.5
365.4	365.4	12.1	363.8	12.5
413.5	417.4	17.6	412.6	17.9
462.1	465.9	24.1	460.4	24.4

(Slide from B. Mohn)

M_{H+} determination with $H^+ \rightarrow \tau\,\upsilon$

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Both below and above M_{top} the $H^+ \rightarrow \tau\,\upsilon$ decay channel is the most sensitive channel for a charged Higgs discovery.

However the decay mode does not allow for the observation of a resonance peak above the background, and only the transverse mass can be detected.

A maximum likelihood method is used both below and above Mtop to extract the mass.

Precision down to a few % can be acheived.

HIGH MASS

$m_{H^\pm}$ (GeV)	Statistics only		With systematics	
	$\langle m \rangle$	δm	$\langle m \rangle$	δm
225.9	226.4	1.7	225.9	1.7
271.1	271.1	2.0	270.9	2.3
317.8	318.3	3.0	319.9	3.5
365.4	365.7	4.6	365.2	4.7
413.5	413.8	4.5	414.9	4.7
462.1	462.6	6.0	460.8	6.3
510.9	511.9	7.4	511.7	9.2

LOW MASS

Generated $H^\pm$ mass (GeV)	Reconstructed $H^\pm$ mass (GeV)	Statistical error (GeV)	Systematic error (GeV)	Rel. precision $\Delta M/M$ (%)
127.0	128.4	1.1	3.6	2.8
138.6	141.1	1.0	5.1	3.6
145.0	142.1	0.8	3.5	2.4

(Slide from B. Mohn)

$H+ \rightarrow Wh/WH$

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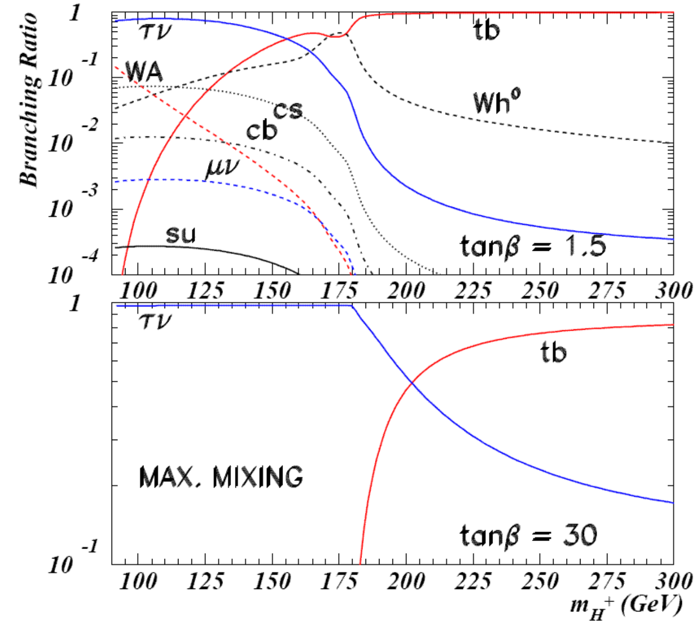
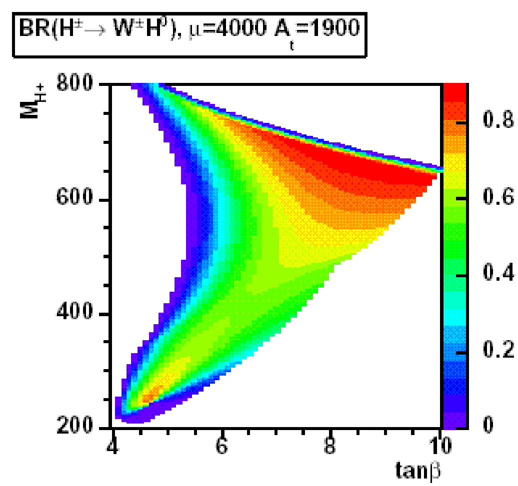
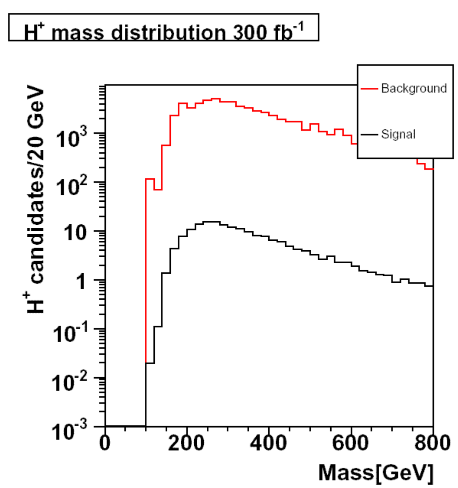
- Searches involving decays to neutral Higgs bosons (h^0, H^0) have also been performed with ATLAS.
- In ATL-PHYS-99-025 (Assamagan) it was showed that despite good mass reconstruction and ttbar supression the discovery potential of the channel ($H^+ \rightarrow Wh^0$, $h^0 \rightarrow bb$) is limited by the low signal rate.
- In ATL-PHYS-PUB-2005-017 (Mohn et al.) a large mass splitting MSSM scenario is assumer in which $M_{H+} >> M_{H0}$ opening the $H^+ \rightarrow WH^0$ decay channel.
- Despite large branching ratio the signal is found to be too much background like and impossible to extract.







(Slide from B. Mohn)

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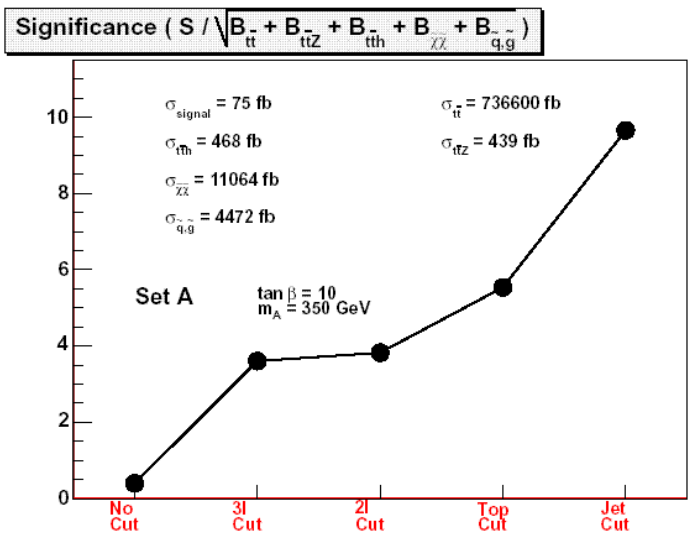
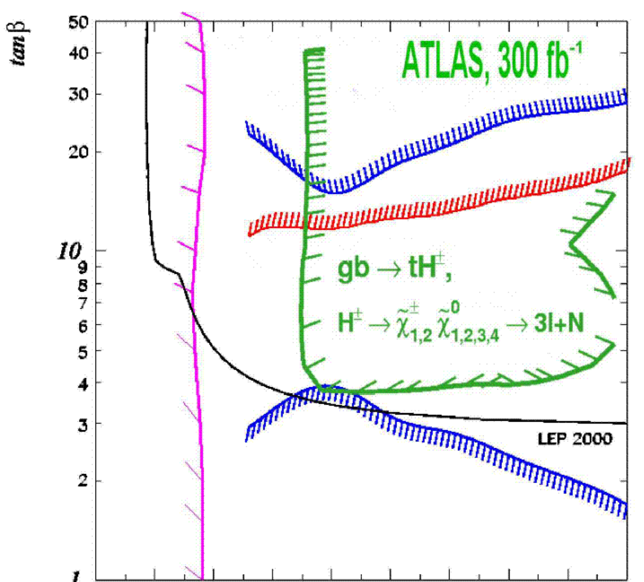
Charged Higgs in chargino-neutralino decay



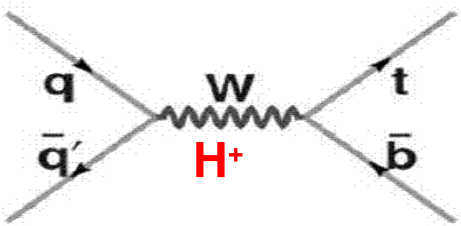


(Slide from B. Mohn)

- Selection efficiencies between 1% and 23% is obtained depending on tanβ and M_{H+}.
- A discovery potential is calculated by linear extrapolation between the simulated points, and is shown in the lower left figure.
- The left edge follows the limiting edge of the BR($H^+ \rightarrow \chi+ \chi0$) while the right and lower edge follow the pattern of the NLO signal x-sec.
- Since no discriminating signature is found, the search is done as a counting experiment, hence relying on that the various backgrounds are measured through other channels.
- Many more MSSM points must be investigated before general conclusions can be made, but as a preliminary result the study shows that for a specific MSSM point charged higgs through SUSY decays may be detected with ATLAS.

Single Top sensitivity to the existence of H+

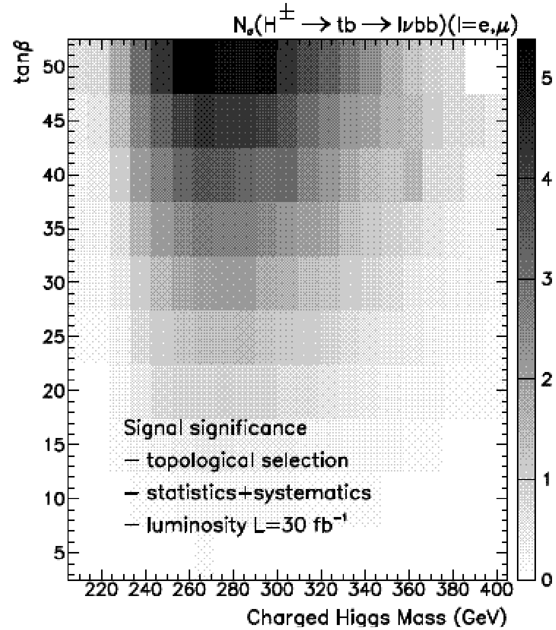
- Above the M_{top} the $H^+ \rightarrow tb$ decay becomes domiant, and the single top S-channel becomes competative discovery channel with the $gb \rightarrow tH^+$.

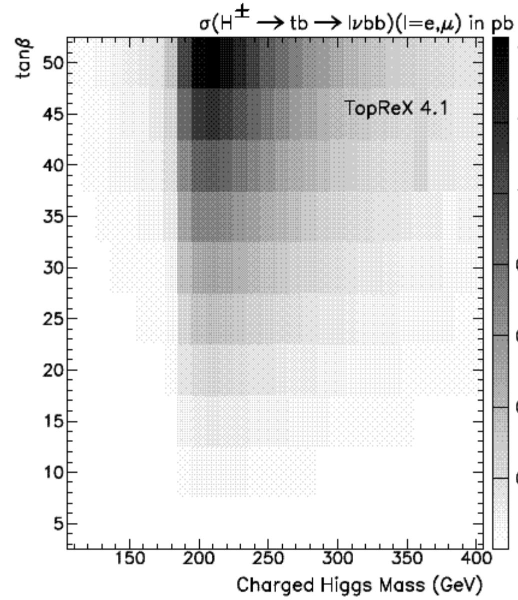


- The contribution from a charged Higgs boson can be as large as 2/3 of the SM S-channel for high tanβ and masses above 200 GeV. (top right plot.)

- In ATL-PHYS-2006-003 (Lucotte & Chevallier) this sensitivity was investigated by applying the same set of cuts as in the S-channel analysis.

- A 5 sigma sensitivity seems possible only for high tanβ and $M_{H+} \sim 250$ GeV. It is though expected that these results could be improved by cuts using the specific properties of the charged Higgs.





(Slide from B. Mohn)