Search for the Higgs boson in the WW decay channel with ATLAS using 4.7 fb^{-1} of data from 2011

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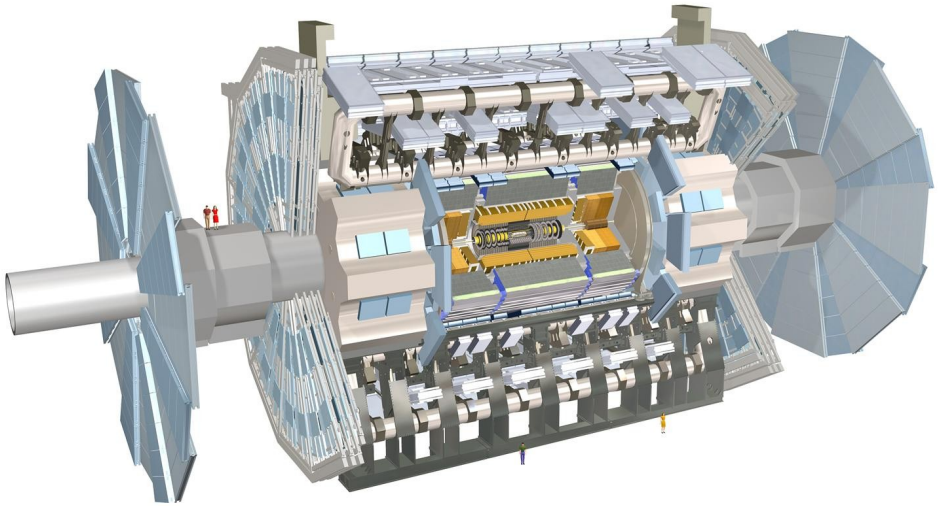
For the ATLAS Collaboration

Rencontres de Moriond 2012

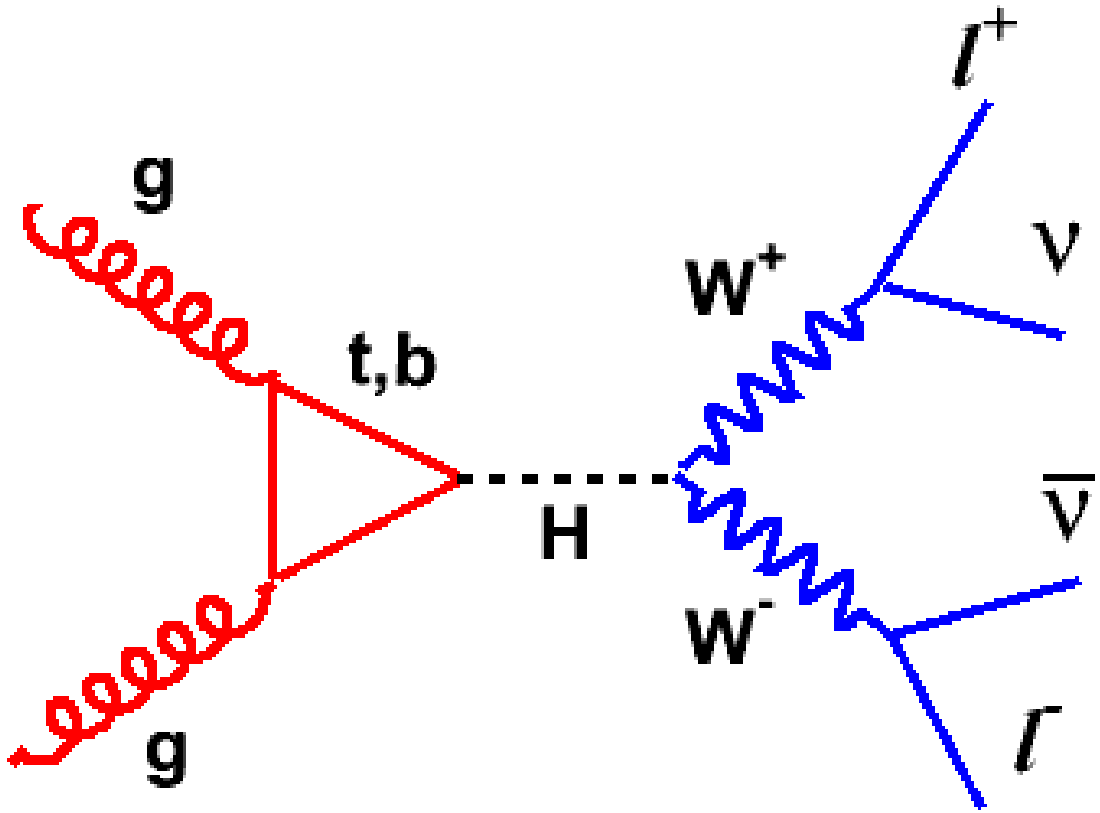


http://cdsweb.cern.ch/record/1429660

$H \rightarrow WW \rightarrow l^+ \nu l^- \nu$

Higgs production

Higgs decay

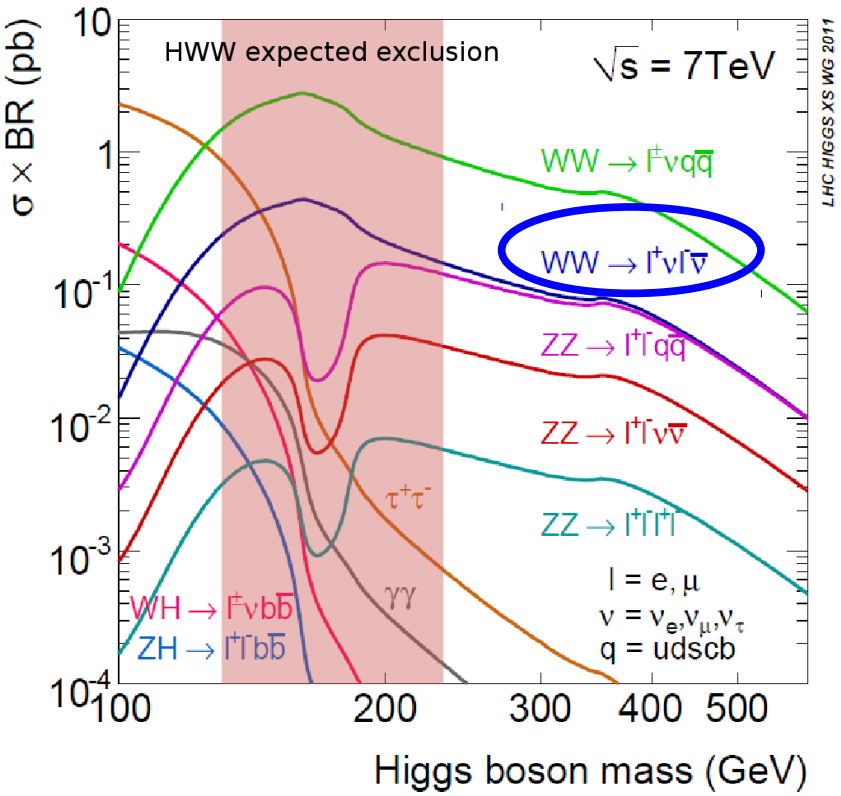


If $M_H < 2\ M_W$ one W is off shell

Why we search in $H \rightarrow WW \rightarrow l^+\nu l^-\nu$

- Large branching fraction for wide range of masses – Large window of sensitivity

- Expected sensitivity extends to low m_H (127 GeV with 4.7fb^{-1}). Competitive with $H \rightarrow \gamma\gamma$



Why is $H \rightarrow WW \rightarrow l^+\nu l^-\nu$ difficult?

Two neutrinos in final state → no mass reconstruction. Signal is a broad excess of events

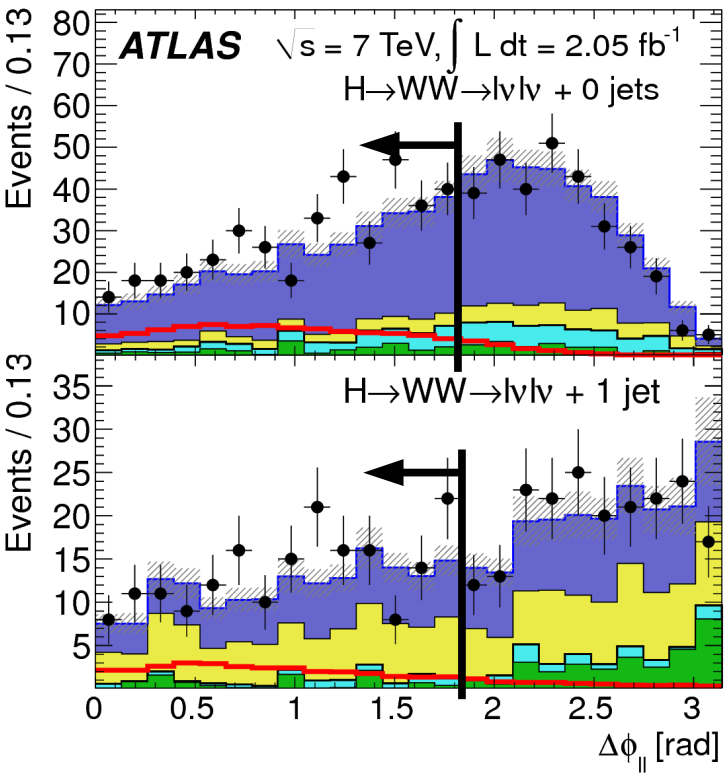
Must have confidence in background model to identify an emerging signal

How to select $H \rightarrow WW \rightarrow l^+\nu l^-\nu$

- Opposite-sign lepton pairs – ee μμ eμ
- Large missing transverse momentum from neutrinos
- Use 0 and 1 jet final states + 2 jet VBF (tag forward jets)

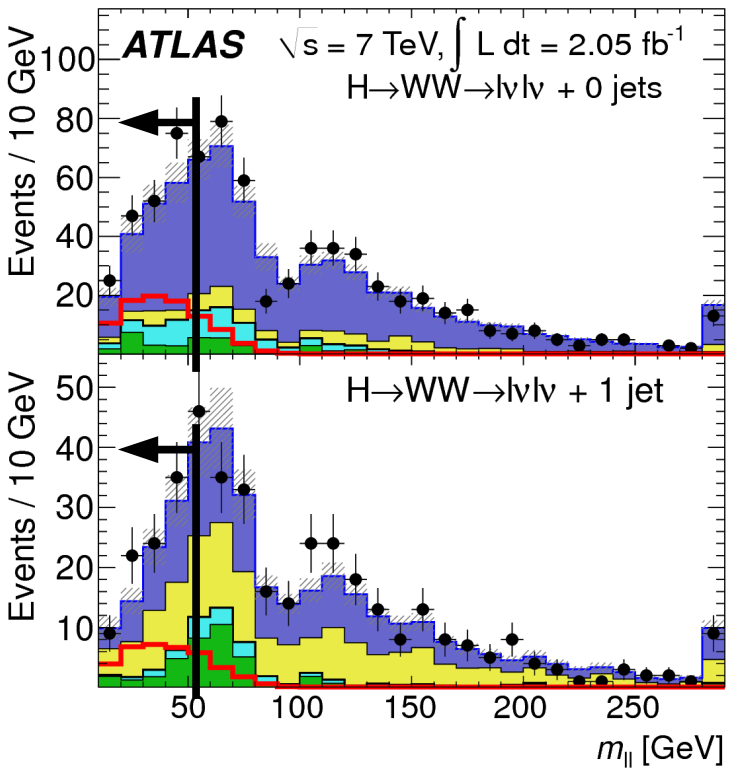
WW Spin correlation :

Require small $\Delta\varphi(l^+, l^-)$



Low m_H :

Require low $m(l^+, l^-)$



Backgrounds to $H \rightarrow WW \rightarrow l^+ \nu l^- \nu$

Use data-driven estimates for main backgrounds

W + jets	Z/γ* + jets
Reject with isolation, PID	Reject with met cut
10 % of Background	5% of Background
Extrapolate from inverted lepton PID control region	Normalize MC using Z control region

Top	WW
Reject with jet cuts	Reject with Δφ(l,l), m(l,l) cut
5% of Background	65 % of Background
Jet veto efficiency derived in b-tag control region	Normalize MC using high $m(l^+,l^-)$ control region

Remaining backgrounds from Di-Bosons are estimated using simulation

Final distributions

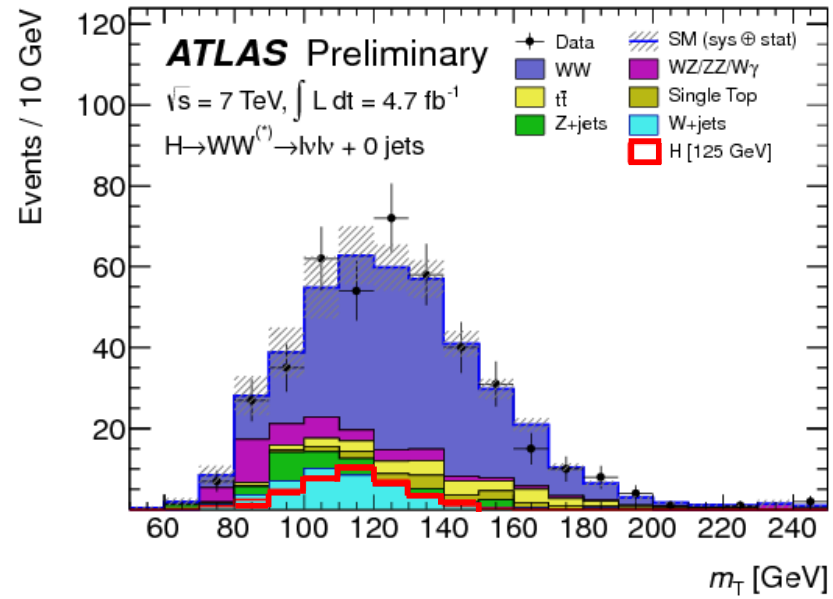
After all analysis cuts

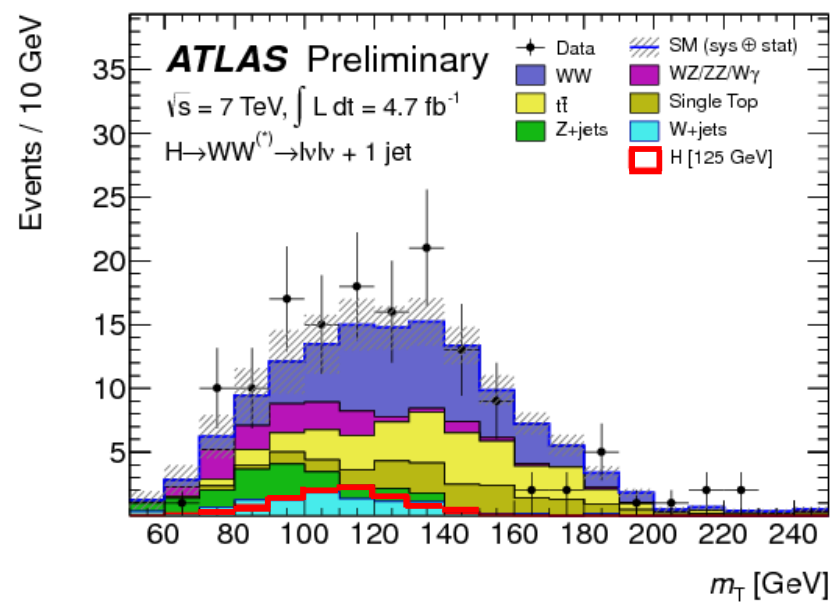
Transverse Mass (m_T) is a proxy for Higgs mass for WW channel

125 GeV Higgs signal shown

No significant excess observed

Fit m_T shape to extract limits



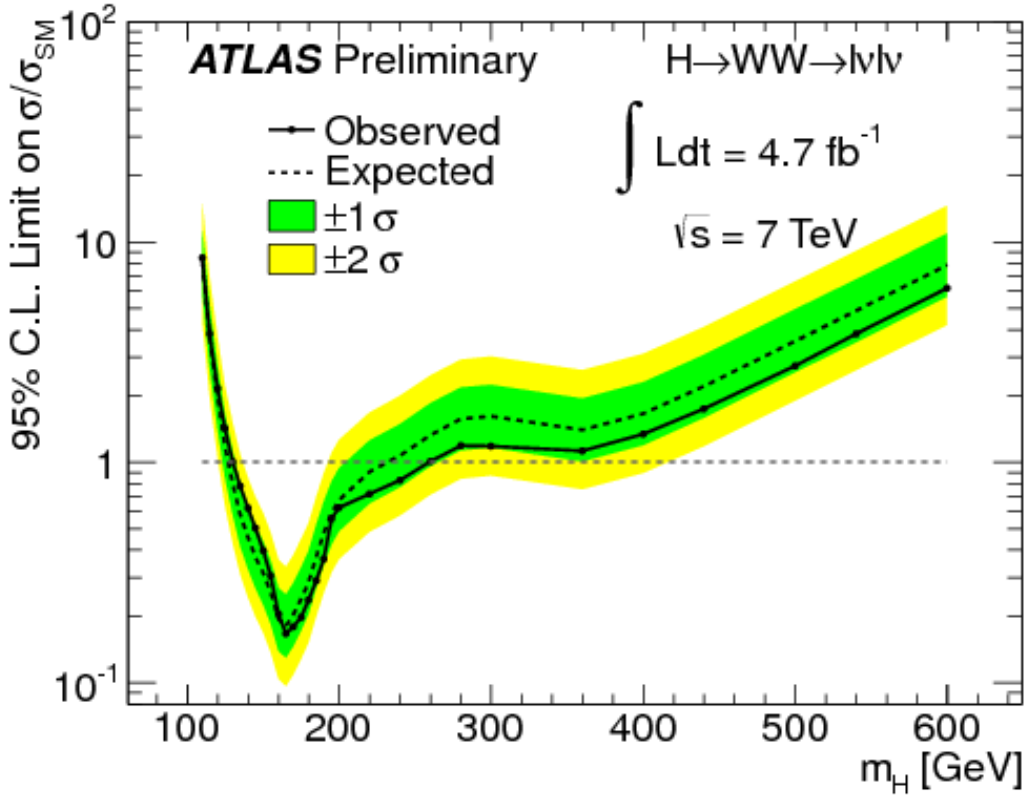


Limit results

Likelihood for each M_H in 9 channels (ee, mm, em) x (0 jet, 1 jet, 2 jet)

Expected 95% C.L. Exclusion : 127 GeV < m_H < 234 GeV

Observed 95% C.L. Exclusion : 130 GeV < m_H < 260 GeV



What's next for the Higgs search?

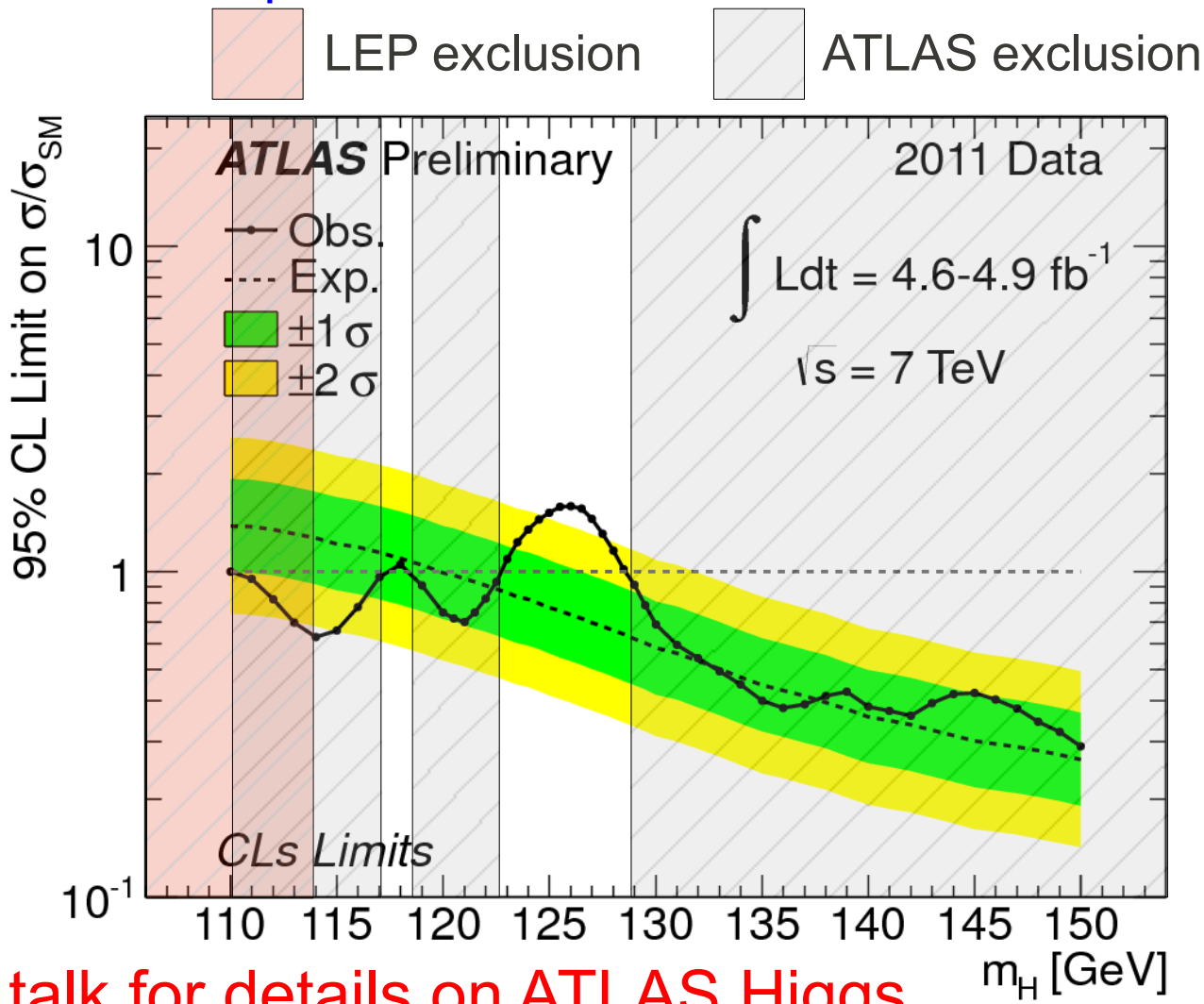
http://cdsweb.cern.ch/record/1429660

$H \rightarrow WW \rightarrow l^+\nu l^-\nu$ is one of the most sensitive Higgs search channels

Combine WW and 11 other channels (right)

We will "close the gap" with the 2012 data

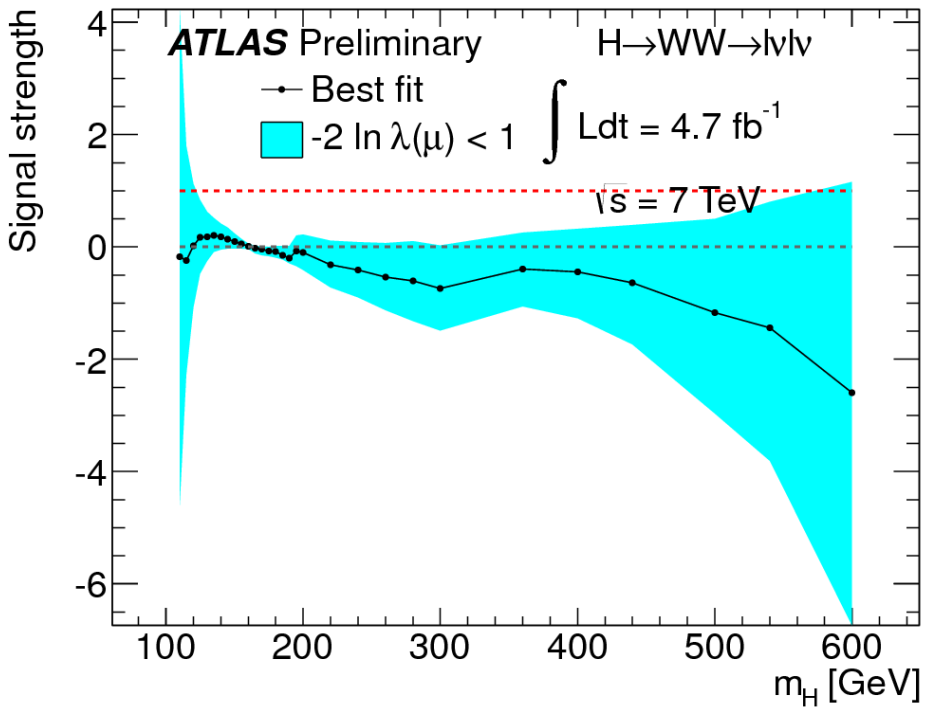
Expect discovery or exclusion this year!

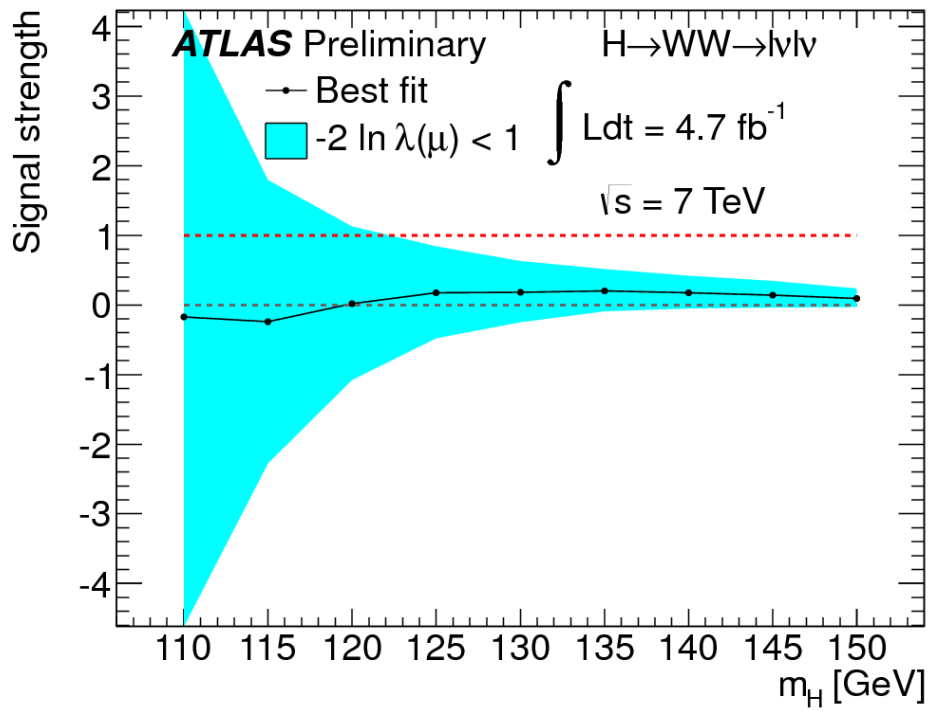


See Sandra Kortner's talk for details on ATLAS Higgs combination results

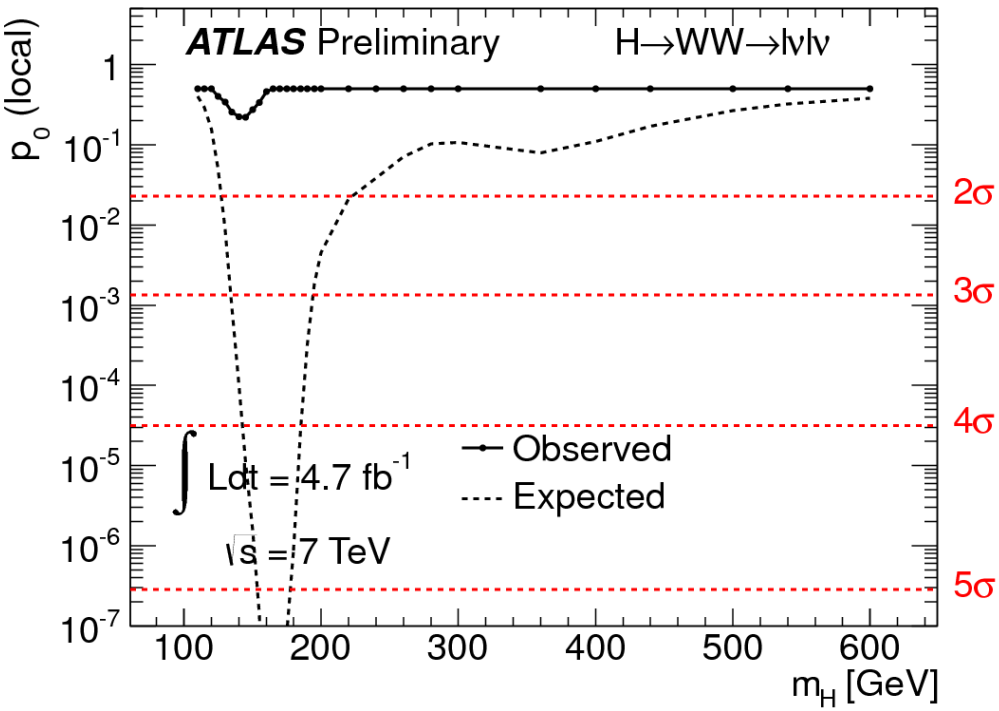
Backup

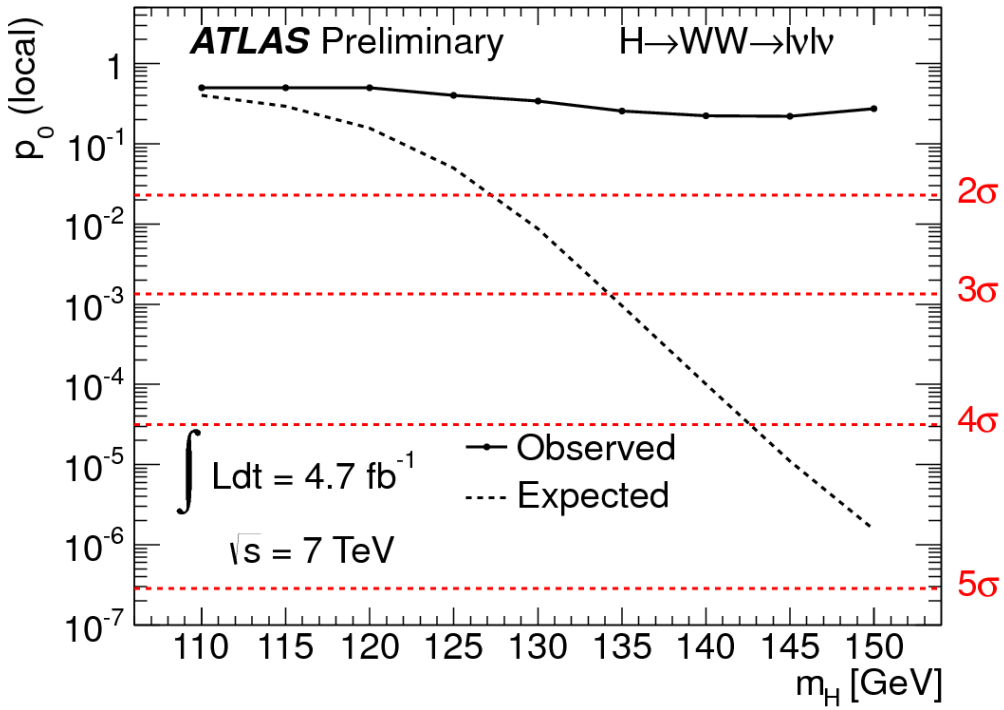
Signal Strength





P_0 Plots


ATLAS Preliminary
H→WW→lνlν
p0 (local)
1
10-1
10-2
10-3
10-4
10-5
10-6
10-7
2σ
3σ
4σ
5σ
∫ Ldt = 4.7 fb-1
√s = 7 TeV
Observed
Expected
100
200
300
400
500
600
mH [GeV]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1
10-1
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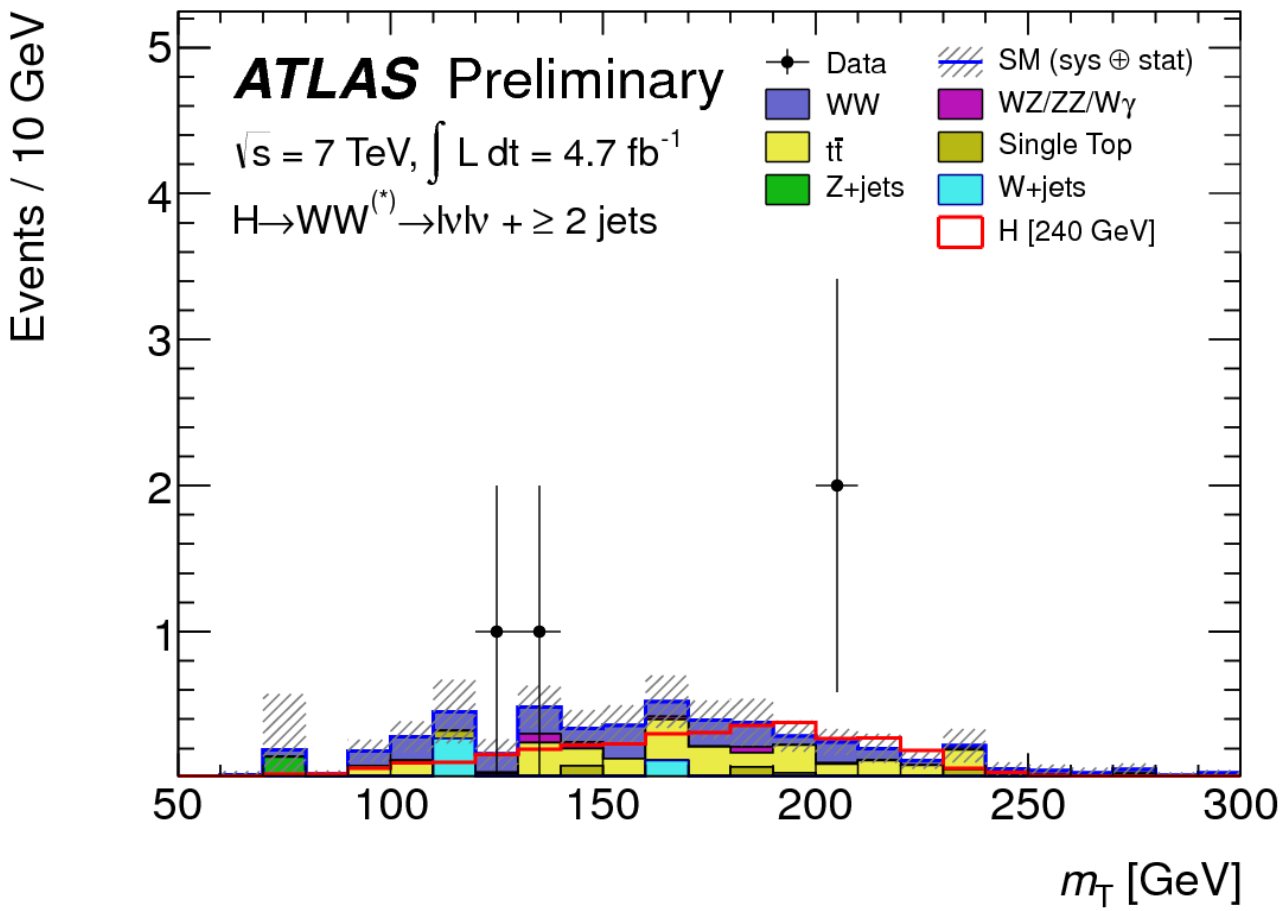
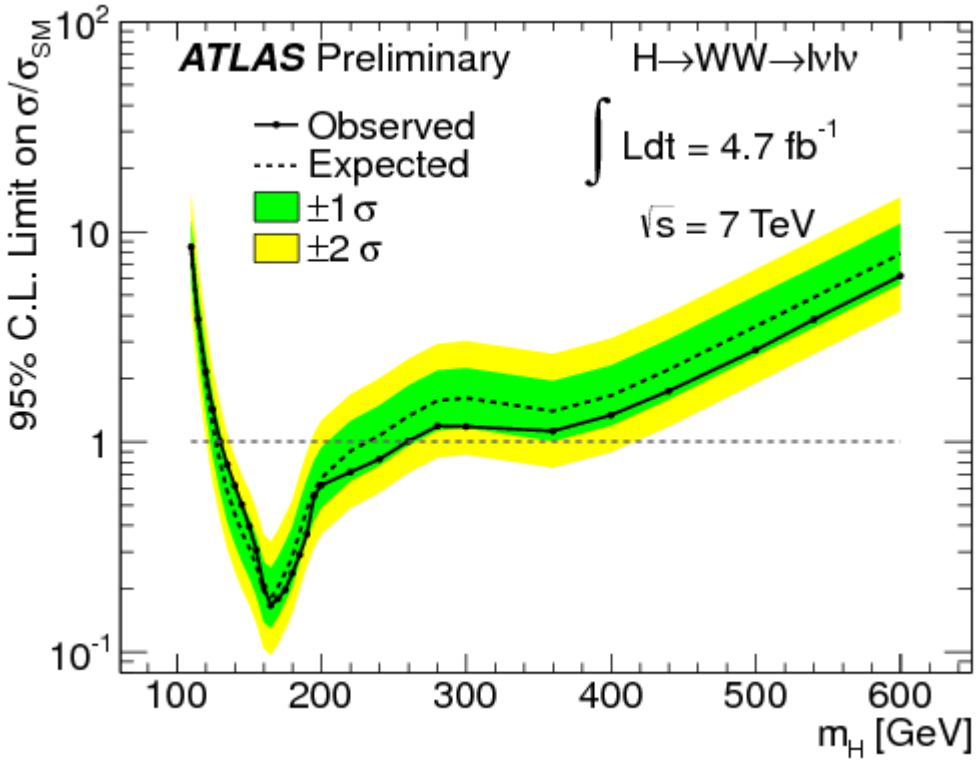
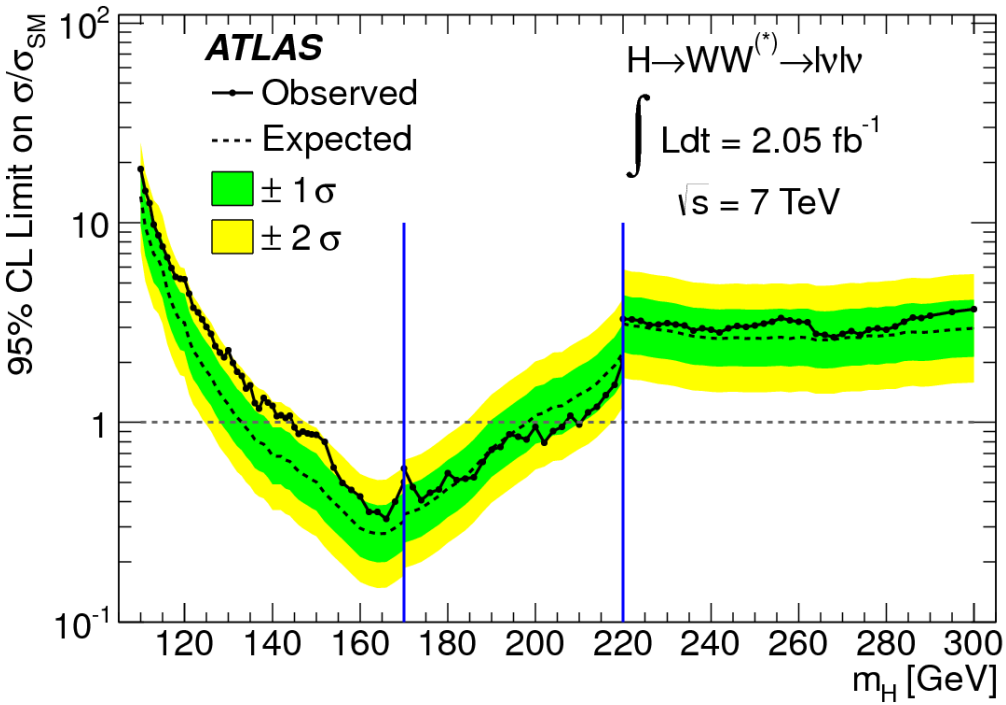
10-6
10-7
2σ
3σ
4σ
5σ
∫ Ldt = 4.7 fb-1
√s = 7 TeV
Observed
Expected
110
115
120
125
130
135
140
145
150
mH [GeV]

m_T distribution for 2 jet analysis



Compare to 2 fb^{-1} results





Exclusion regions :

Expected : 127 GeV < m_H < 234 GeV

Observed : 130 GeV < m_H < 260 GeV

Expected : 134 GeV < m_H < 200 GeV

Observed : 145 GeV < m_H < 206 GeV

Changes since 2 fb^{-1} publication

Analysis changes :

Extend analysis up to M_H = 600 GeV (does not affect low M_H limits)

Add VBF channel – Improves expected limit (a few GeV at low M_H and 10 GeV at high M_H)

Fit M_T shape in limit extraction – Improves limit by 10 – 20 %

Analysis changes :

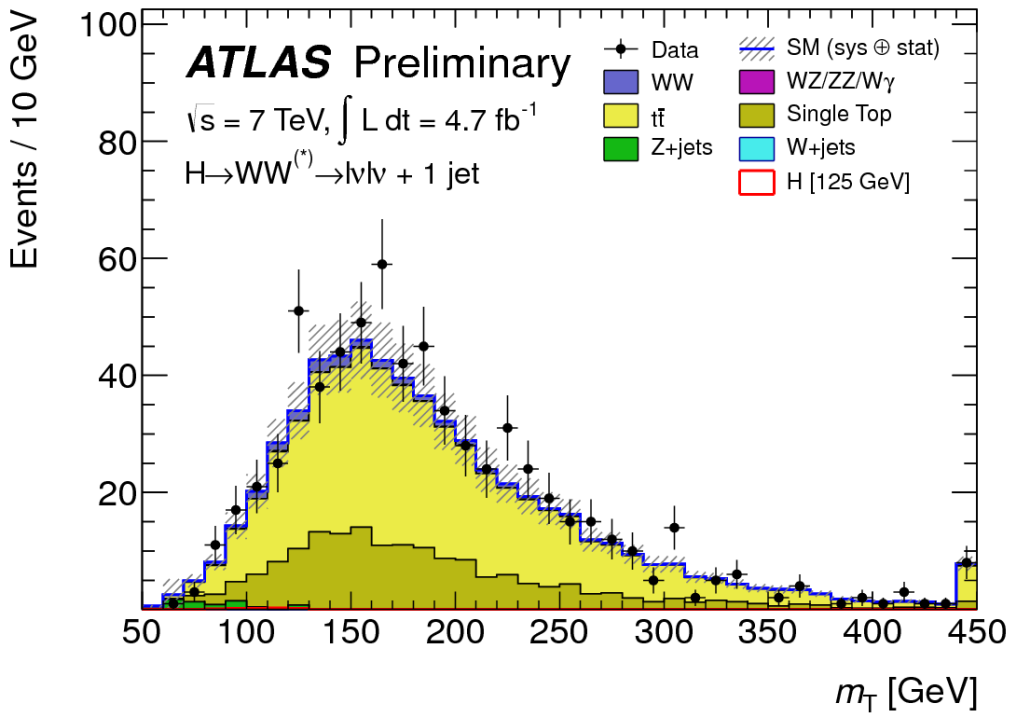
Improved background determination :

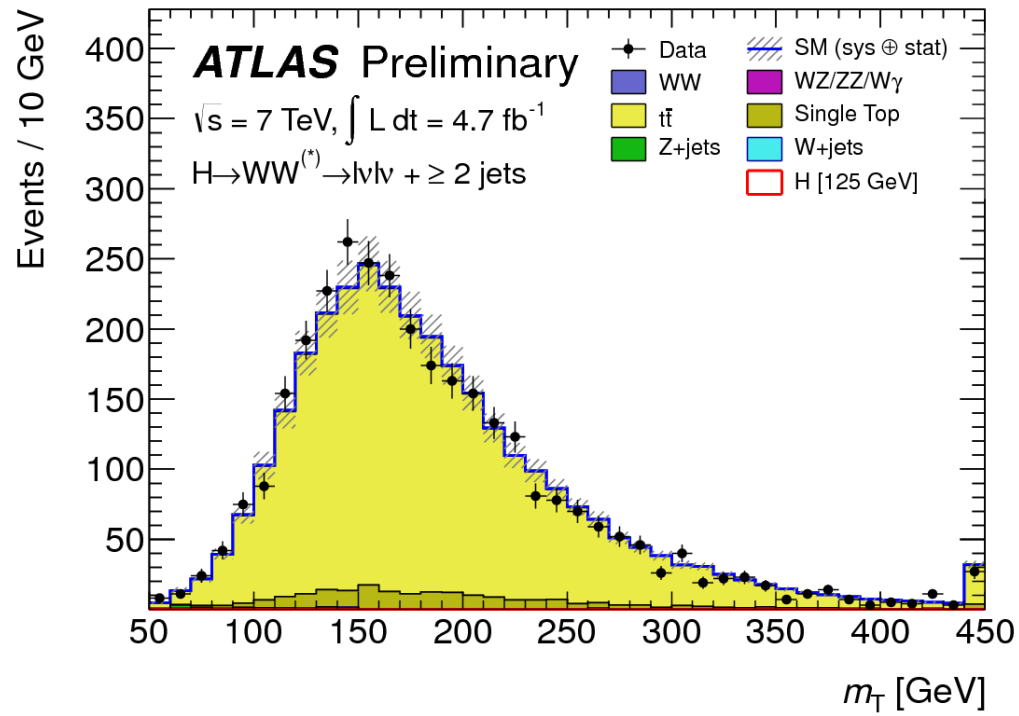
Wγ* - Studies to better understand contribution

DY – Study different methods for extrapolating from Z peak

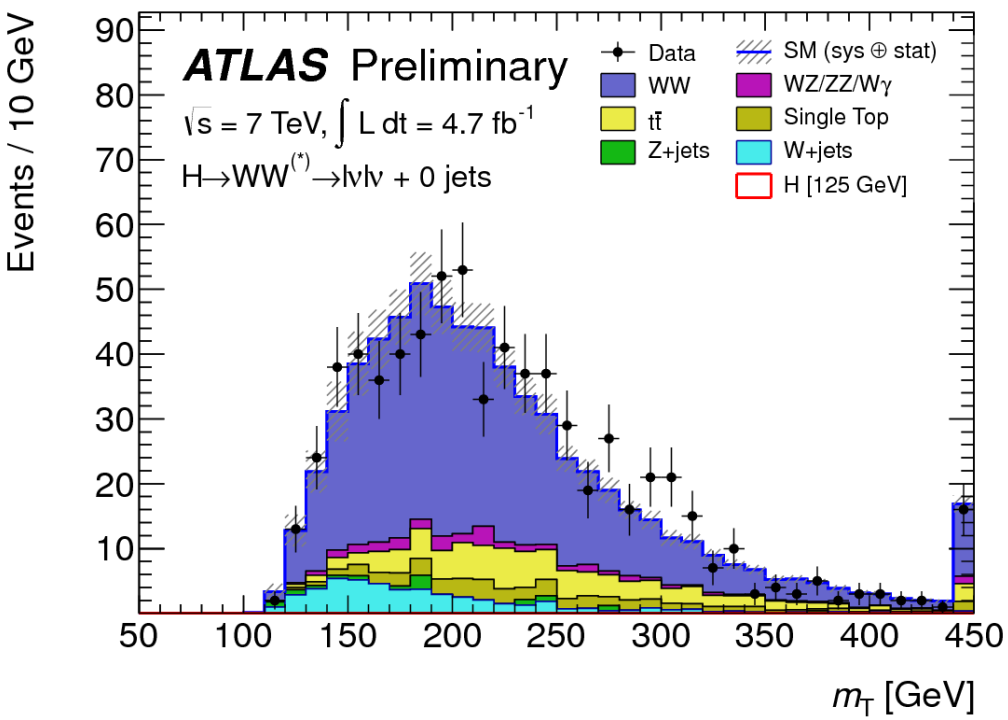
Conditions changes :
Increased Pileup
Increase trigger thresholds

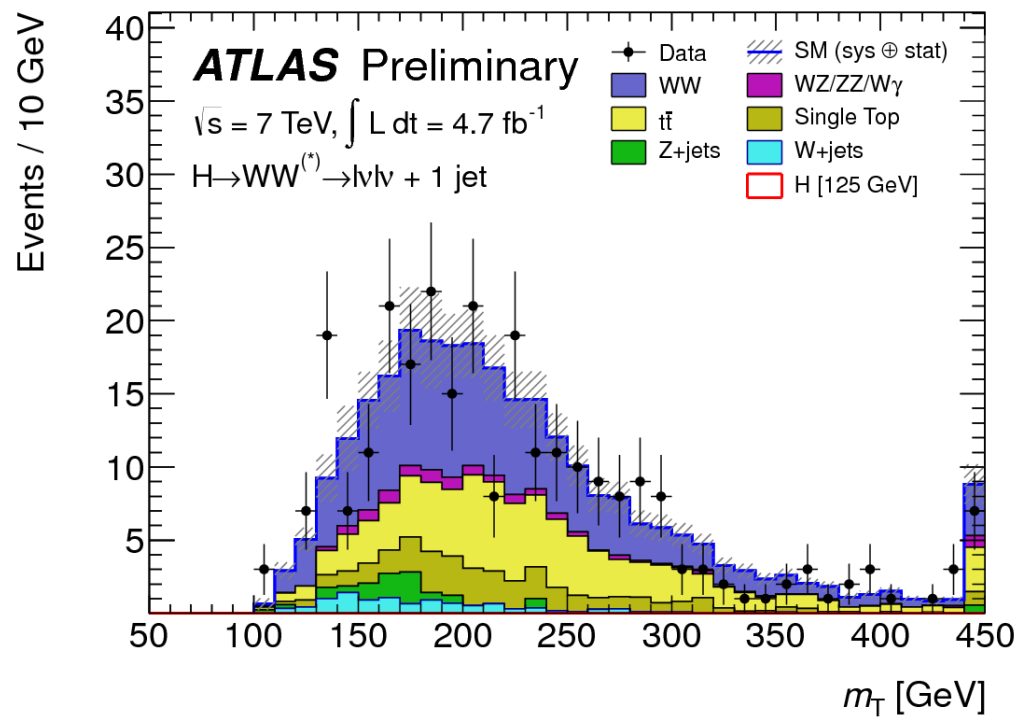
Top control region





WW control region

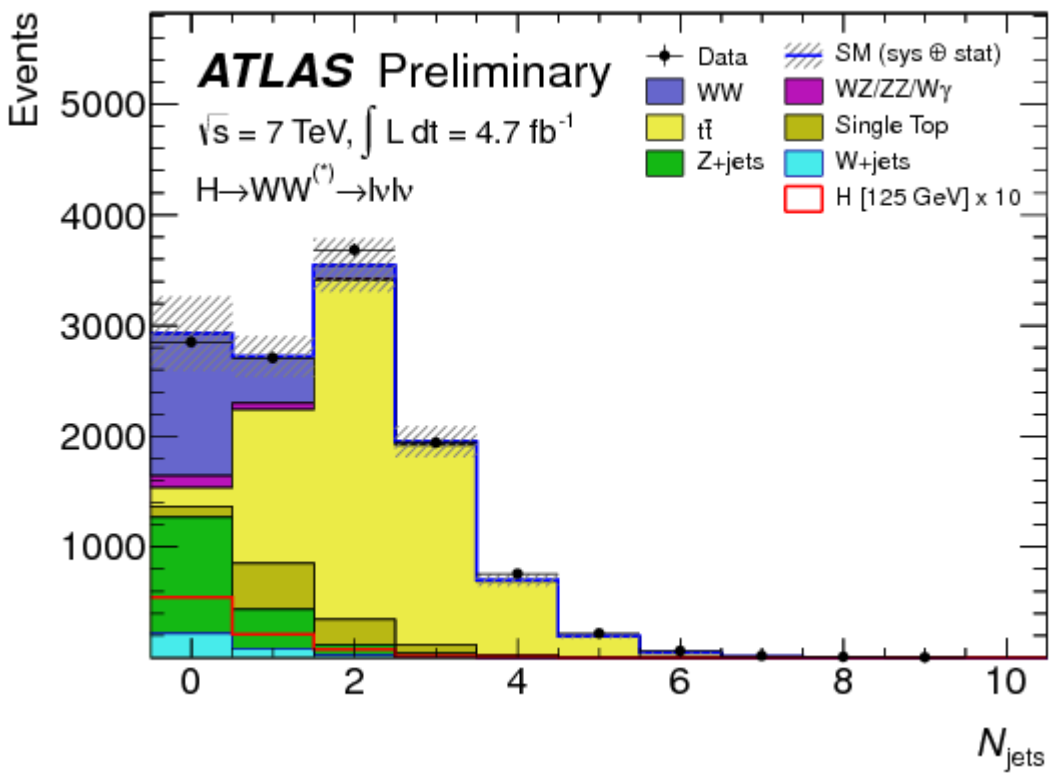




Jet multiplicity

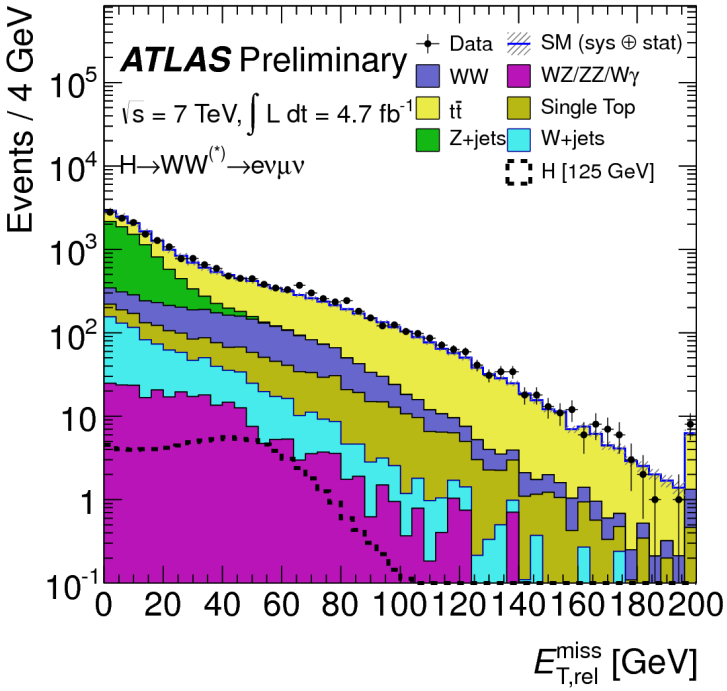
- VBF analysis in 2 jet bin to remove top background

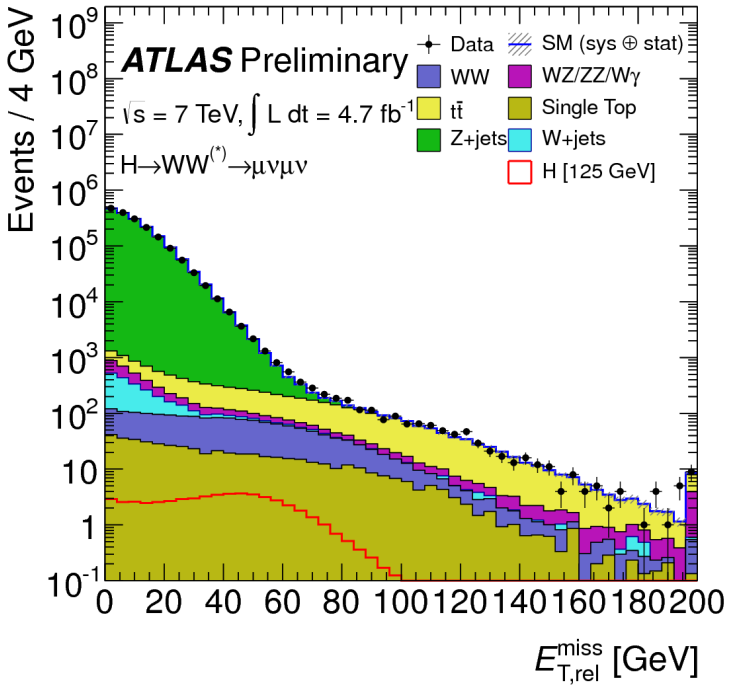
- While the VBF channel cannot exclude the Higgs alone, it does contribute to the combined limit

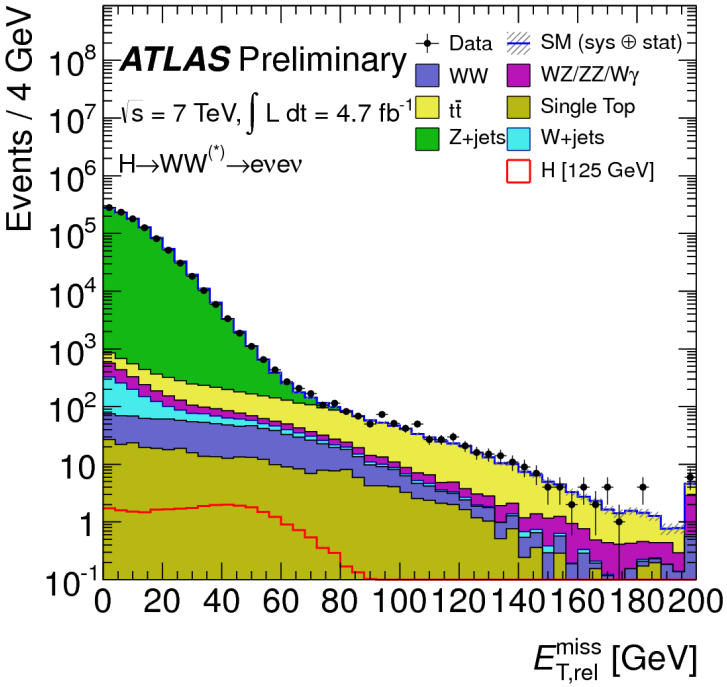


Missing Energy Distributions

Missing Energy distributions for the eμ (top right), ee (bottom left), μμ (bottom right) channels. The cut removes a majority of Z+jets events







Other Backgrounds

WZ + ZZ – Small backgrounds. Estimate from Simulation

Single Top – Included in the Top background. Differences in b-jet kinematics shown to be negligible

Wγ* - Important at low mass. Background estimate currently from Monte Carlo. Data driven methods are being developed.

Full combined limit plot