

Search for Diboson Production in the Lepton + MET + Jets Final State

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(for the ATLAS Collaboration)



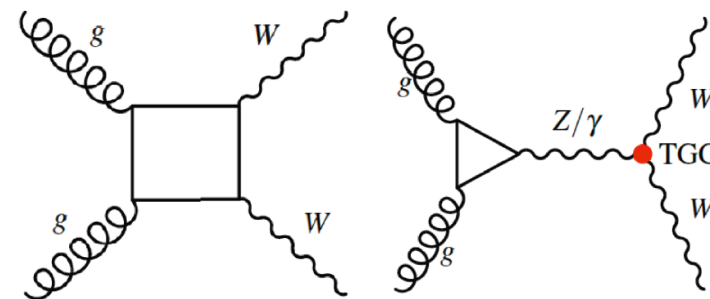
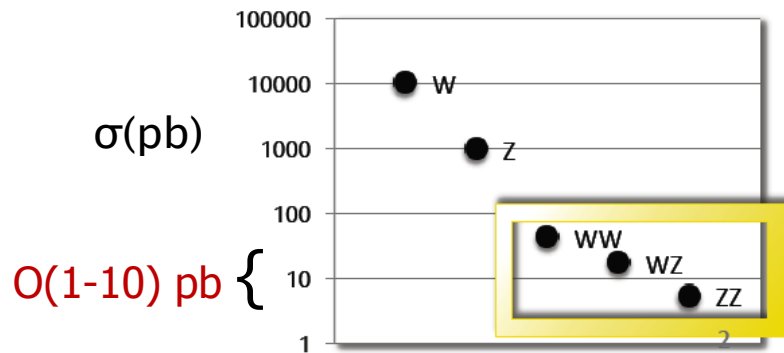
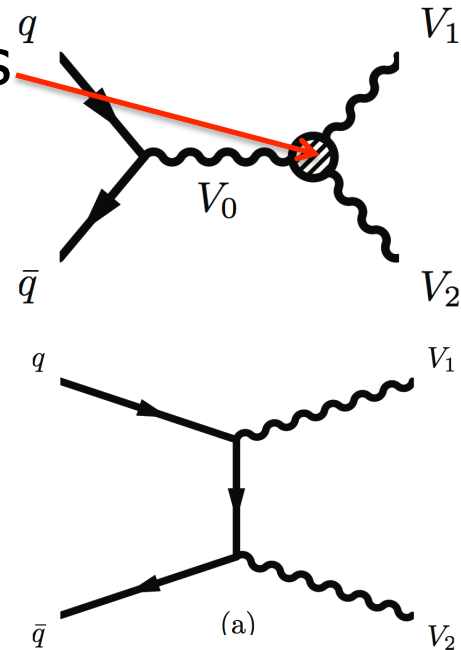


Dibosons @ Hadron Colliders



- Diboson production: gauge boson self couplings

- Couplings intimately related to gauge structure of the SM and electroweak symmetry breaking
- Sensitive probe of new phenomena
 - ❖ Higgs, SUSY, LED, technicolor, Higgsless, ...
- Important background to many searches
 - ❖ Higgs, SUSY, LED, technicolor, Higgsless, ...
- Demonstrate sensitivity to small cross section processes in the SM

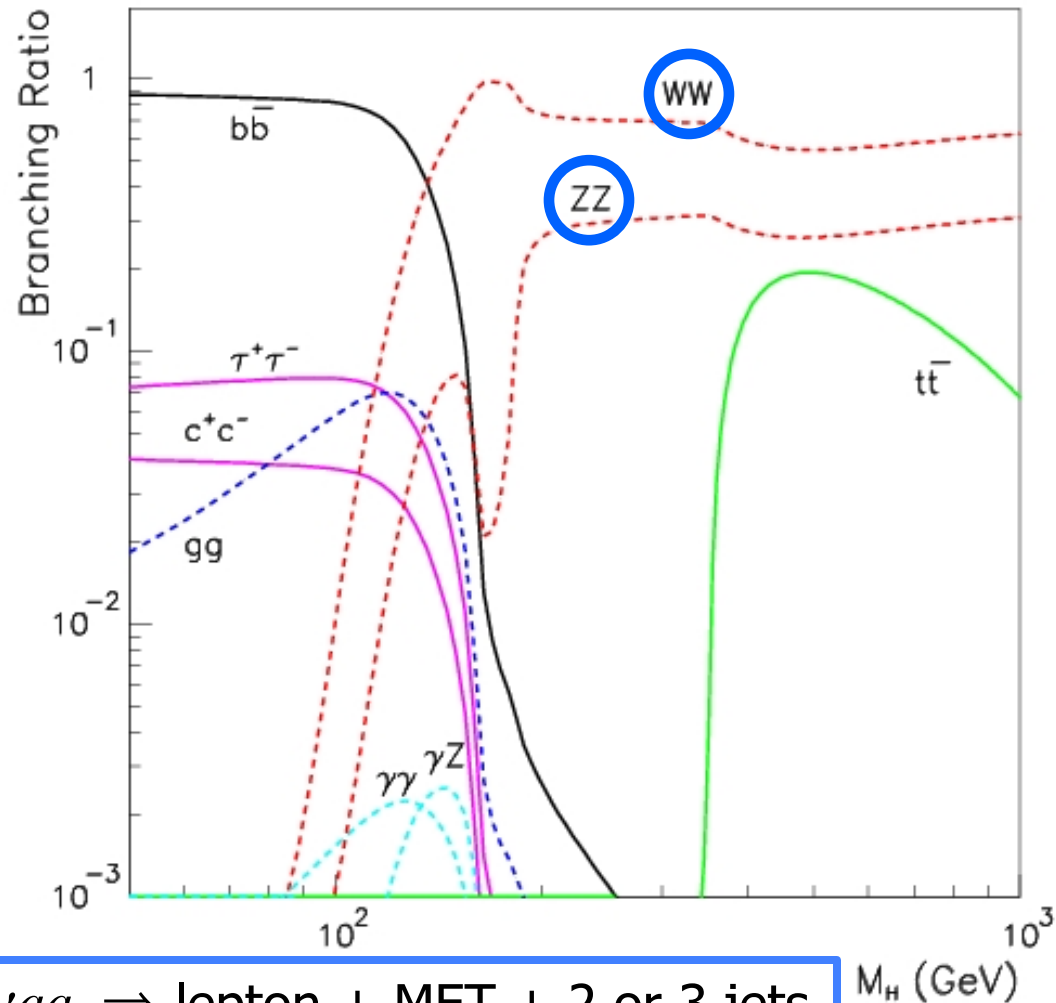




Dibosons in Higgs Search



- Dibosons play a central role in Higgs searches for $m_H > 135$ GeV
 - WW is the dominant decay channel
 - ❖ $H \rightarrow WW \rightarrow \ell\nu\ell\nu$
 - ❖ $H \rightarrow WW \rightarrow \ell\nu qq$
 - ZZ channels very clean
 - ❖ $H \rightarrow ZZ \rightarrow \ell\ell\ell\ell$
 - ❖ $H \rightarrow ZZ \rightarrow \ell\ell\nu\nu$
 - ❖ $H \rightarrow ZZ \rightarrow \ell\ell qq$



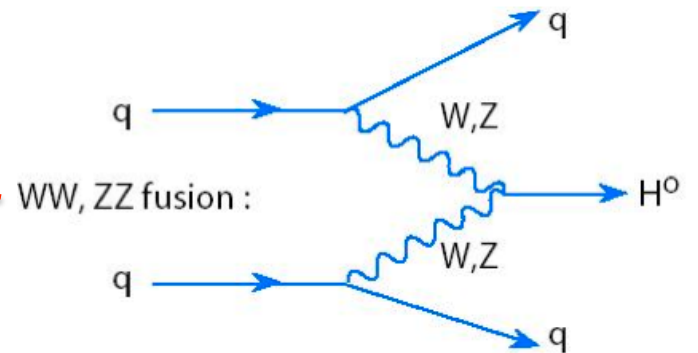
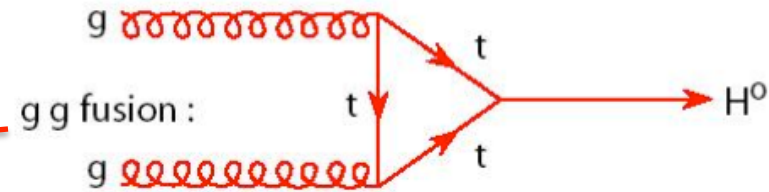
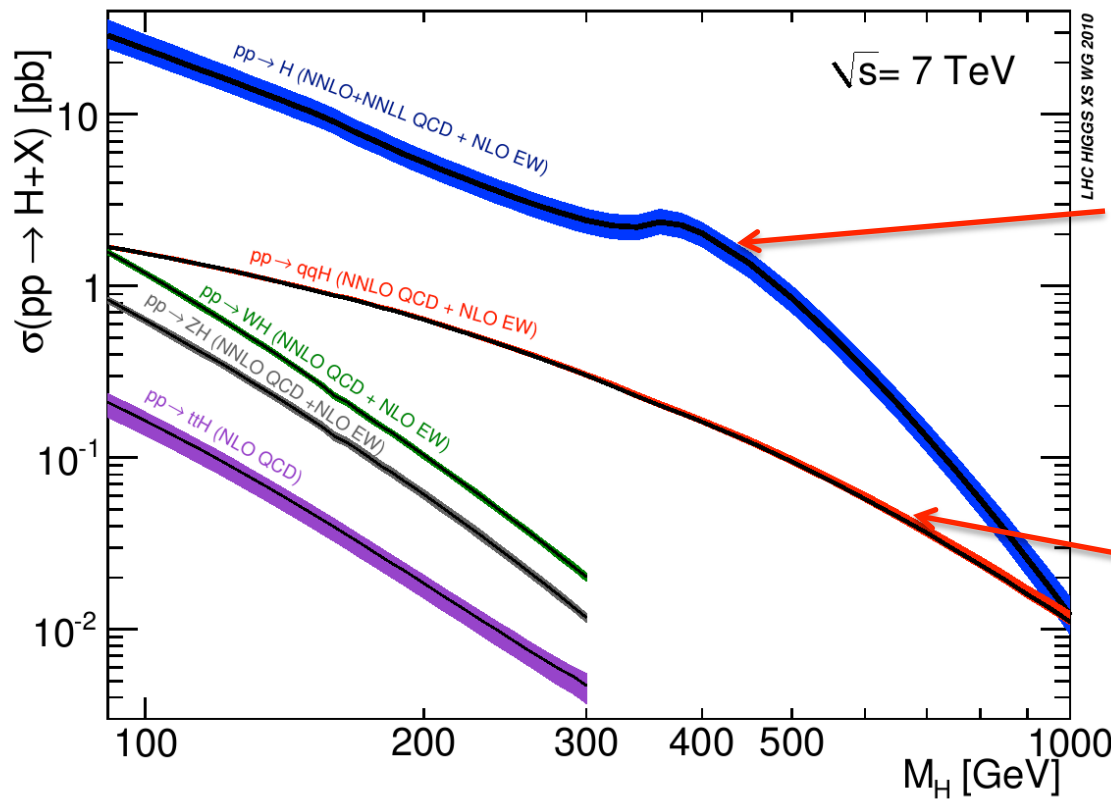
This talk focuses on $H \rightarrow WW \rightarrow \ell\nu qq \Rightarrow$ lepton + MET + 2 or 3 jets



Higgs Boson Production @ LHC



- Signal rates and theoretical uncertainties (m_f , m_r , PDF and α_s) from [arXiv:1101.0593 \[hep-ph\]](https://arxiv.org/abs/1101.0593)

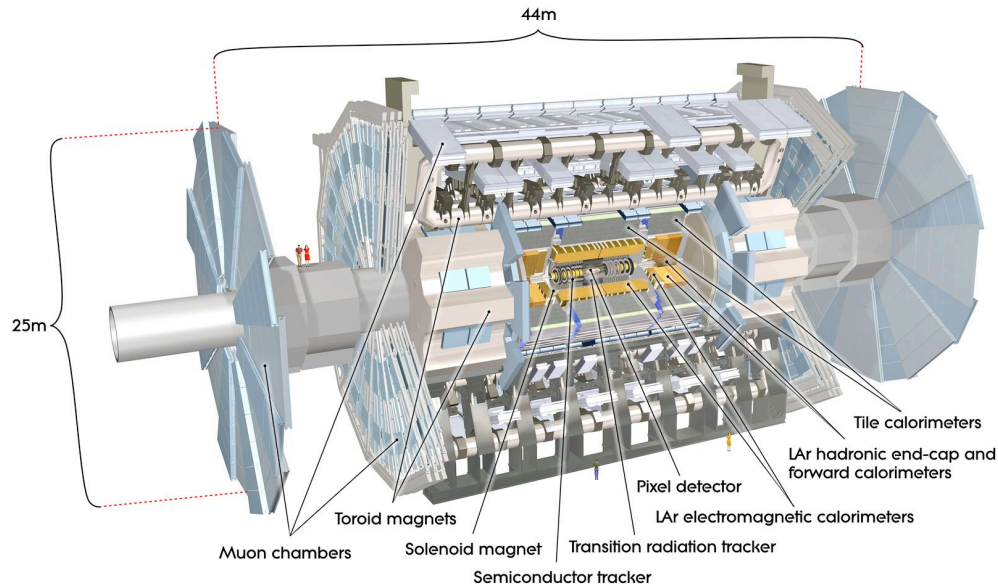
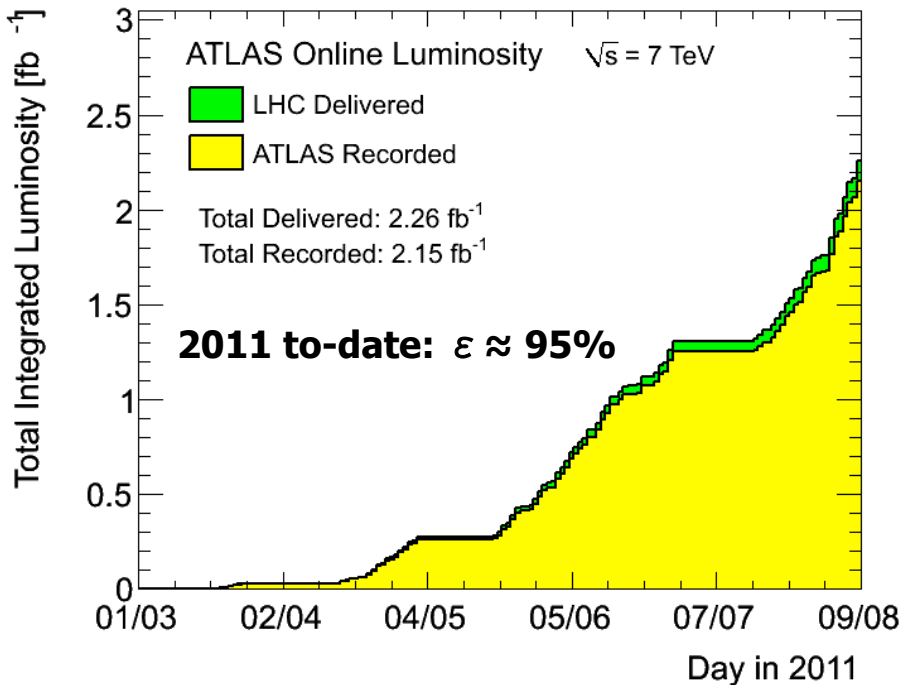




LHC Delivers, ATLAS Collects



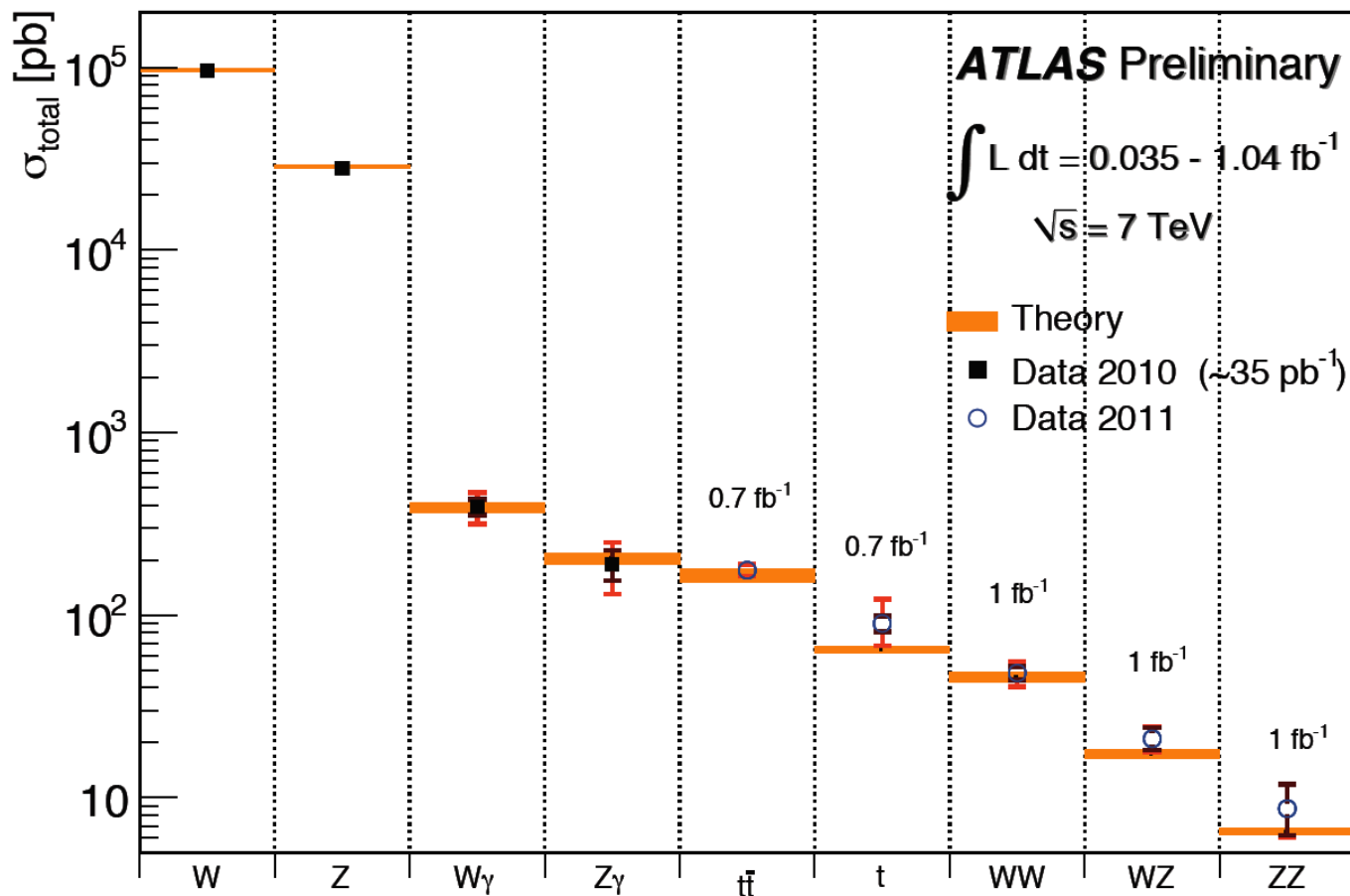
- Data collected in 2011 (pp collisions at $\sqrt{s} = 7$ TeV)
 - Peak luminosity $L_{inst} = 2.11 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$
 - Mean number of interactions per bunch crossing $\mu = 5.7$
 - $\Delta L / L = \pm 3.7\%$ (2011, preliminary)



1.04 pb⁻¹ used for results in this talk



ATLAS Diboson Measurements



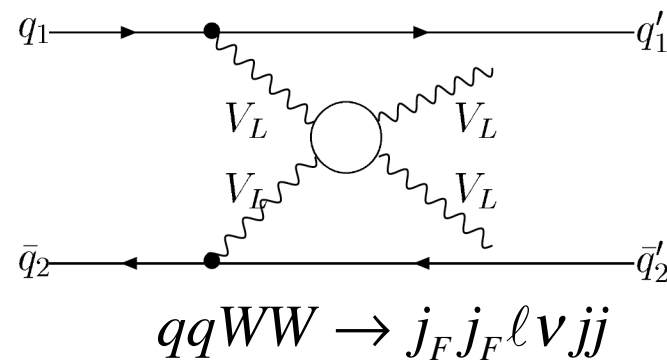
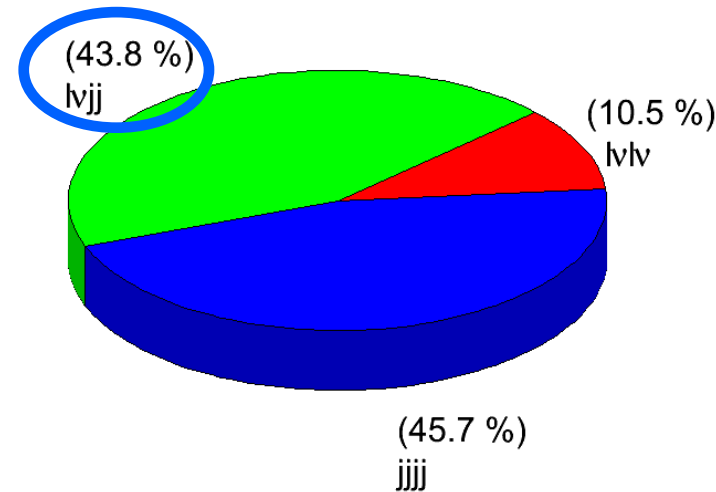
- Single boson and diboson cross section measurements in the leptonic decay channels



Lepton + MET + Jets Motivation



- **WW** dominant Higgs decay channel for $M_H > 135$ GeV
 - $lvlv$ dominates our Higgs sensitivity for $135 < M_H < 200$ GeV
 - $lvqq$ dominates WW sensitivity for $240 < M_H < 600$ GeV due to:
 - ❖ Larger W branching fraction
 - ❖ Dominant background (W+jets) falls off rapidly with increasing $M(lvjj)$
 - ❖ Full Higgs mass reconstruction
 - $lvqq$ complements ZZ channels with comparable sensitivity
 - **Weak Boson Fusion** (WBF) in $lvqq$ channel a stepping stone to **Weak Boson Scattering** (WBS) for deep study of EWSB





Analysis Overview



- Select events with one high- p_T e/μ , 2 or 3 jets, and large MET
- $M(l\nu jj)$ to discriminate signal and background: $M(l\nu) = M(W)$

- **Objection selection**

- ❖ Lepton: $p_T > 30$ GeV, $|\eta| < 2.5$
- ❖ Jet: $E_T > 25$ GeV, $|\eta| < 4.5$
- ❖ "Neutrino": MET > 30 GeV

- **Event selection / categorization**

- ❖ $71 < M(jj) < 91$ GeV
- ❖ Require real $p_{\nu,z}$ solution
- ❖ Separate categorization for H+0j and H+1j

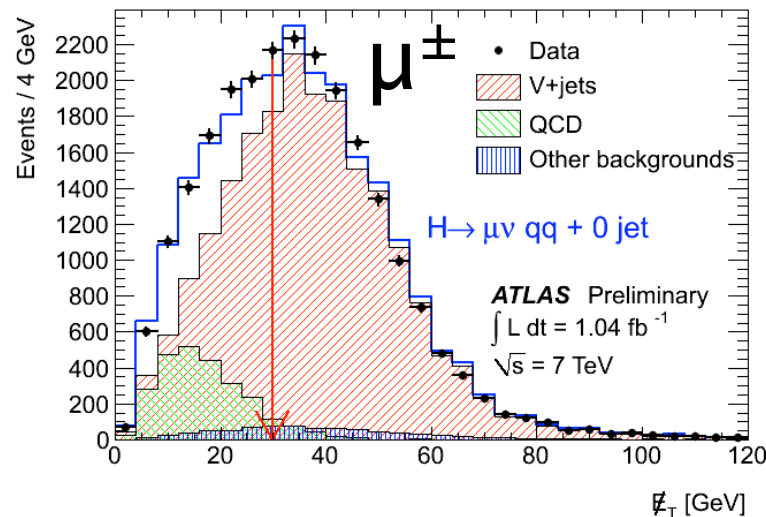
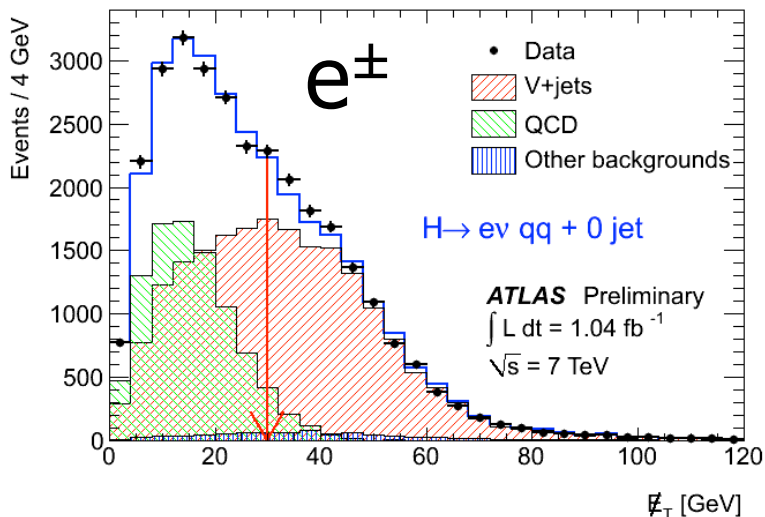
- **Data-driven background**

- **Signal modeled by POWHEG + PYTHIA**

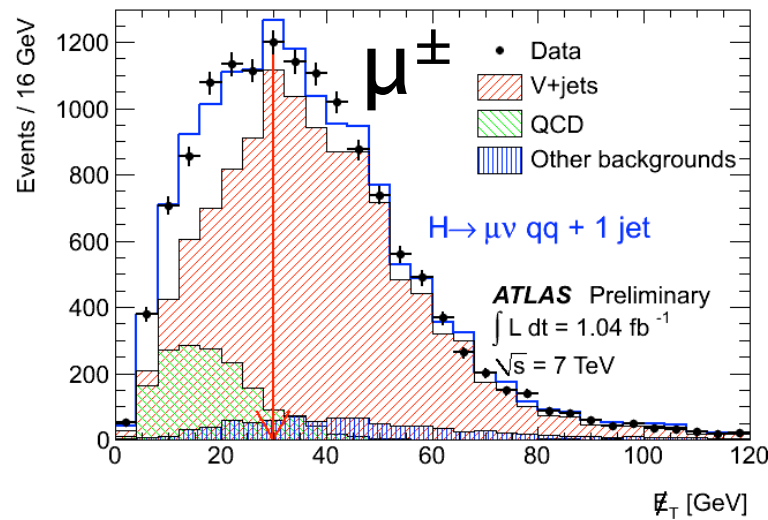
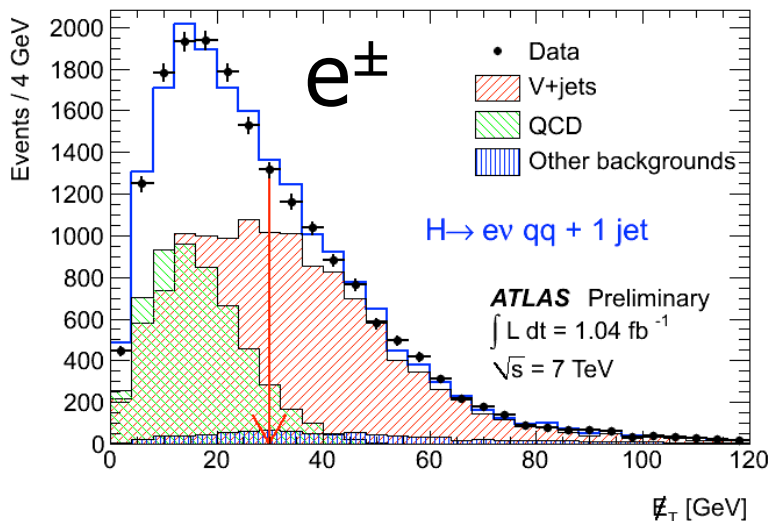
m_H [GeV]	$\sigma(gg \rightarrow H)$ [pb]	$\sigma(qq \rightarrow H)$ [pb]	BR($H \rightarrow \ell^\pm \nu jj$)
300	2.4 ± 0.4	$0.30^{+0.014}_{-0.008}$	0.202
400	$2.0^{+0.31}_{-0.34}$	$0.162^{+0.010}_{-0.005}$	0.170
500	0.85 ± 0.15	$0.095^{+0.0068}_{-0.0032}$	0.160
600	$0.33^{+0.063}_{-0.058}$	$0.058^{+0.005}_{-0.002}$	0.164



Data-Driven QCD Estimates



H + 0 j



H + 1 j



Yields after MET Fits



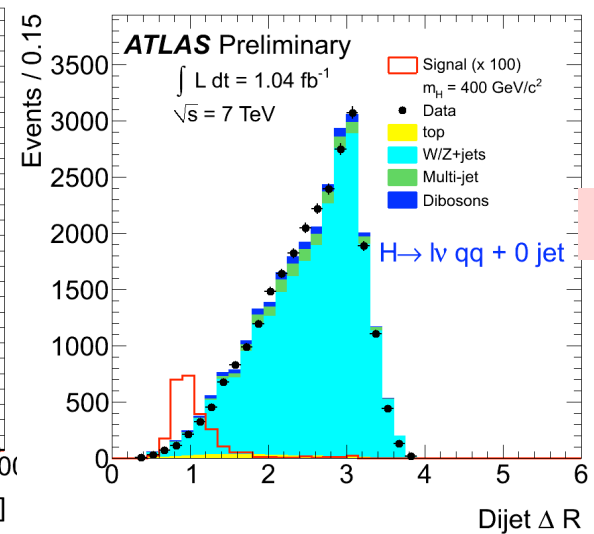
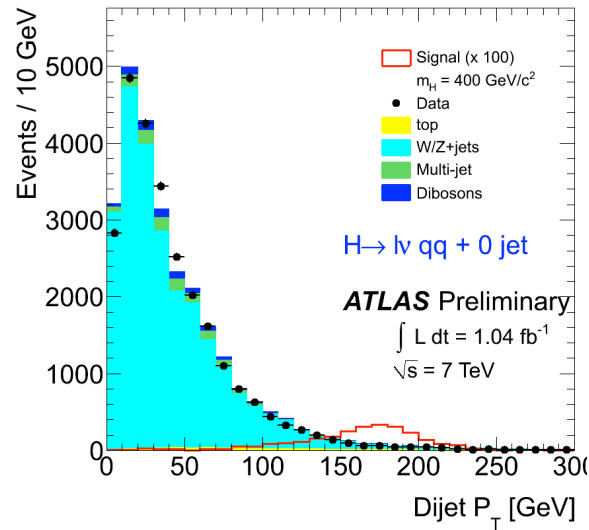
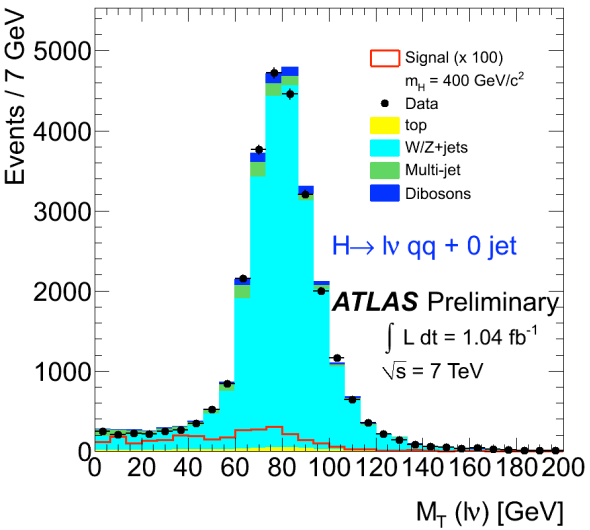
- Expected and observed yields after MET fit
 - Real $M(l\nu jj)$ solution requirement not applied

Process	Events in 1.04 fb^{-1}
W/Z + jets	38080 ± 1170
QCD Multi-jets	2027 ± 43
Top	1330 ± 270
Dibosons	1180 ± 240
Total Expected Background	42600 ± 1200
Observed	41687
Expected Signal ($m_H=400 \text{ GeV}$)	58 ± 15

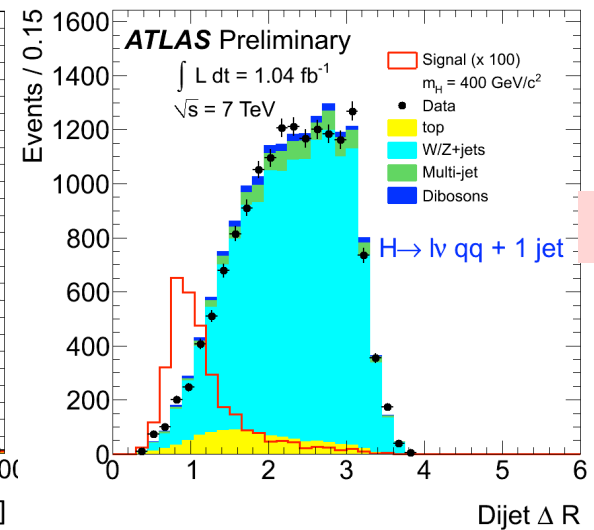
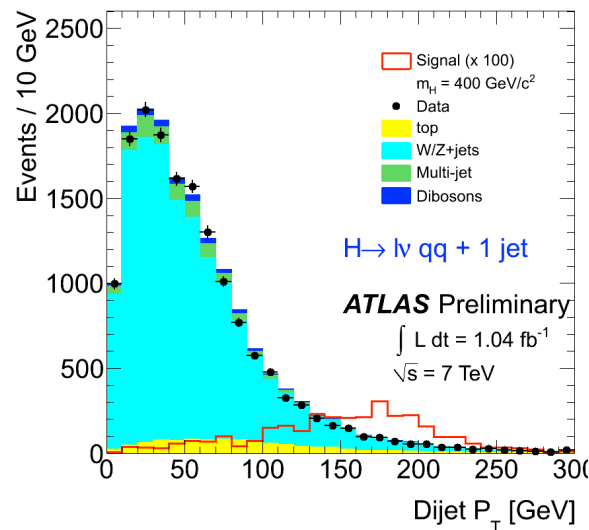
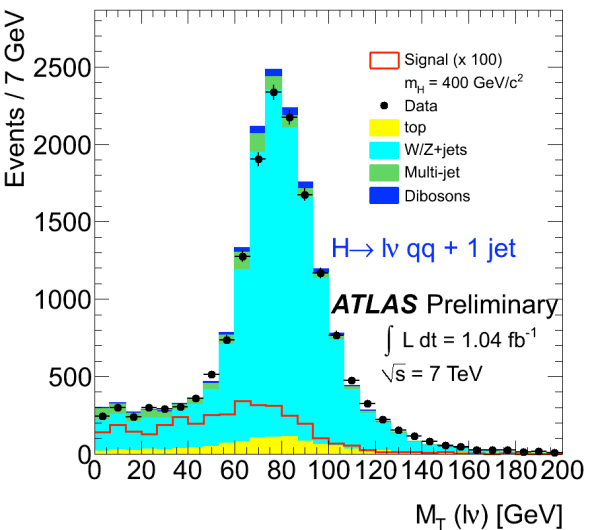
- Good agreement with expectations



Some Kinematic Distributions



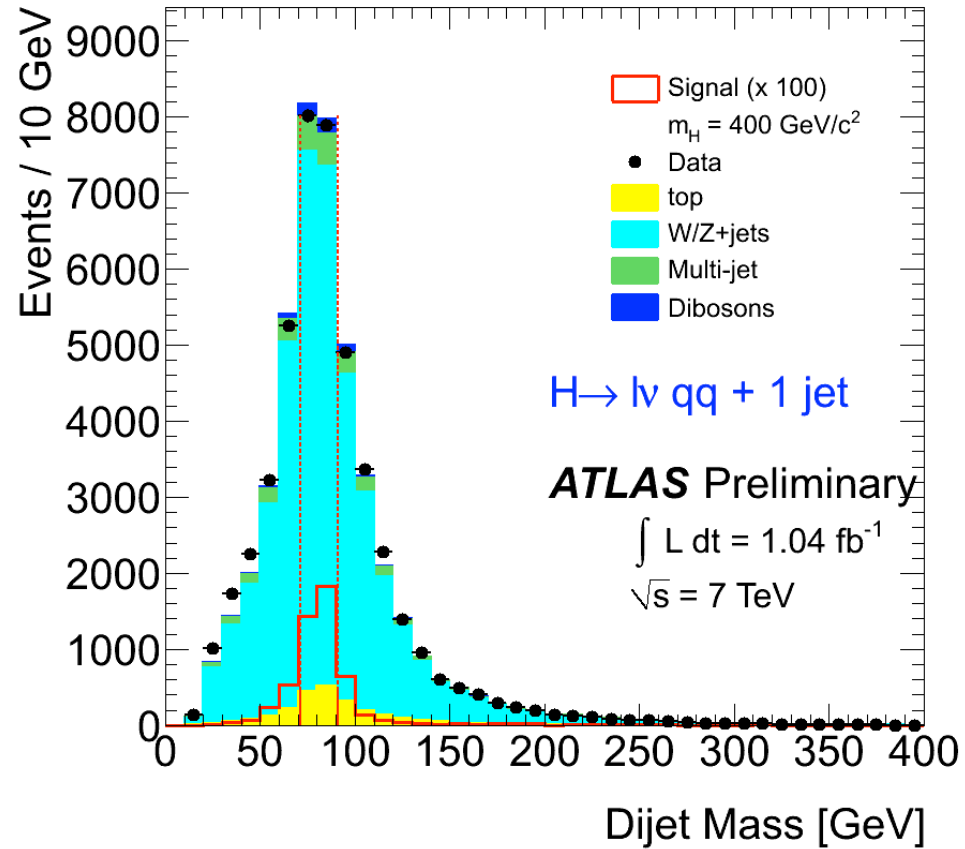
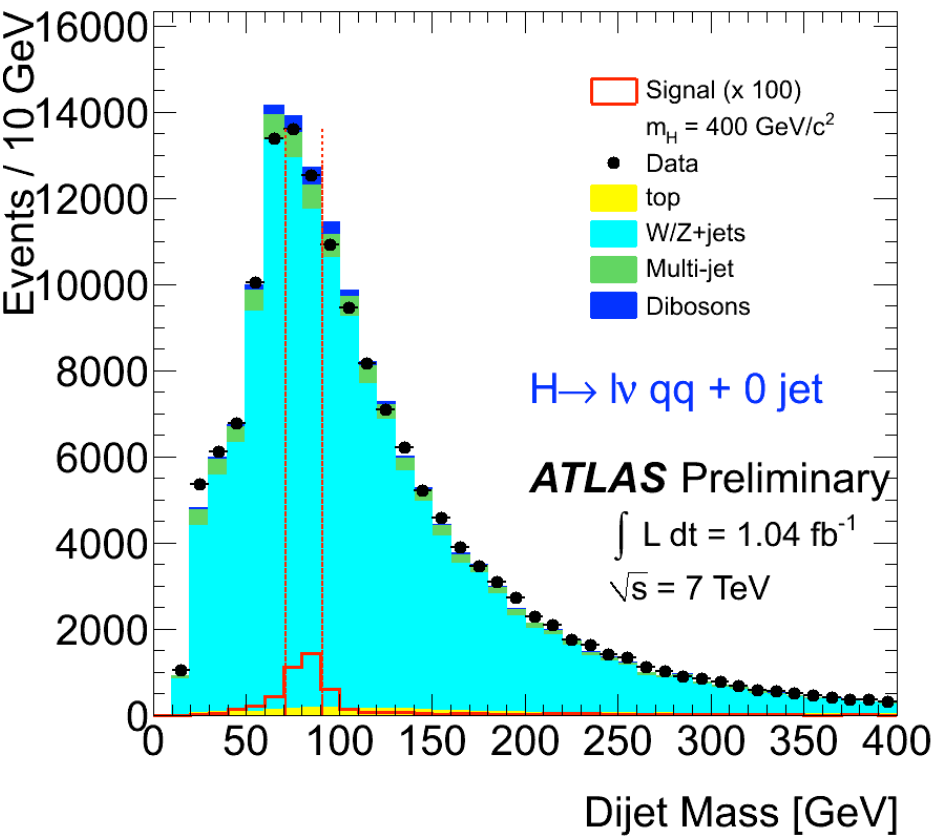
H + 0 j



H + 1 j



Dijet Invariant Mass



Signal selection: [71, 91] GeV

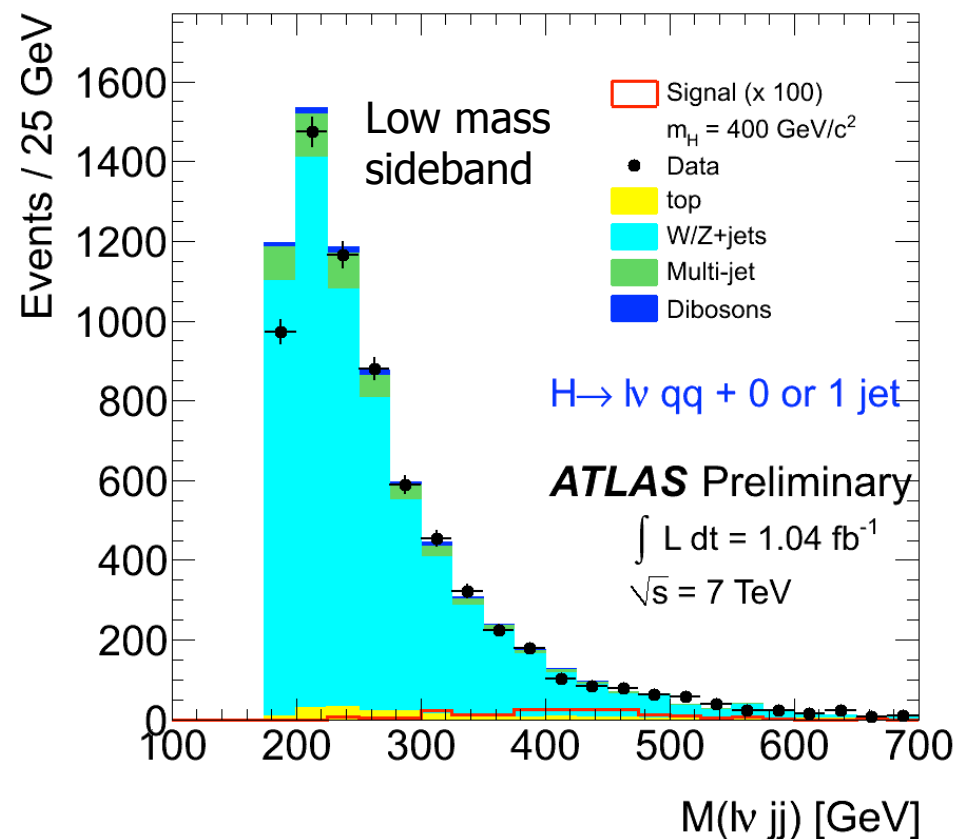
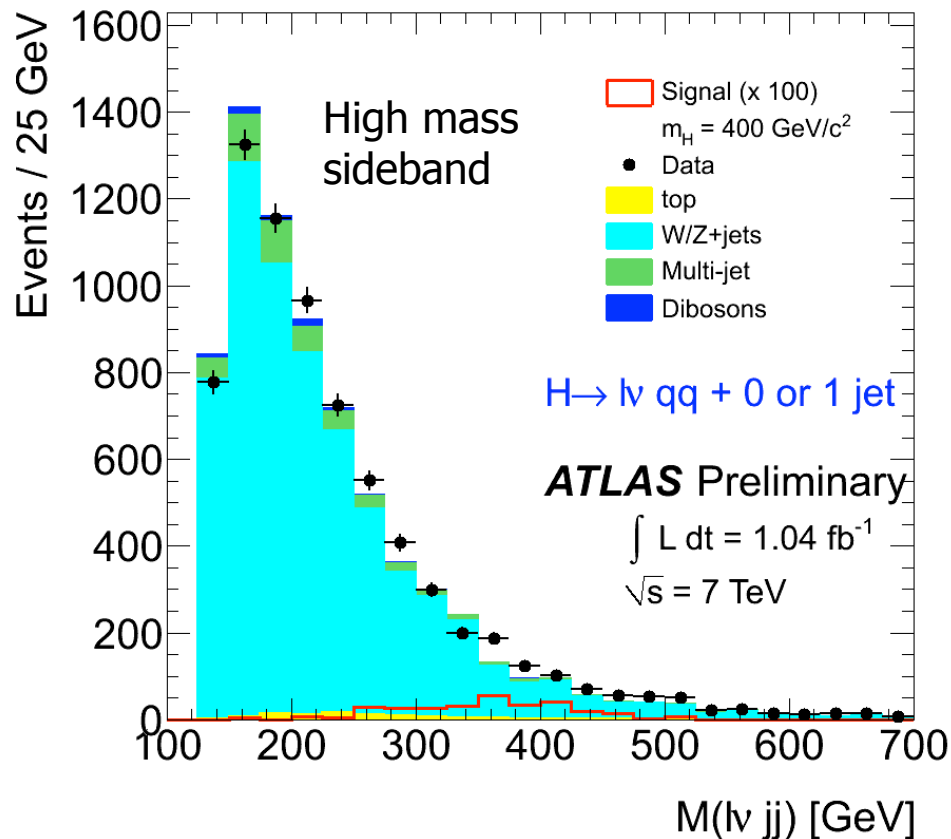
Sideband selections: [50, 60] GeV (low sideband) and [100, 110] (high sideband)



Background Model

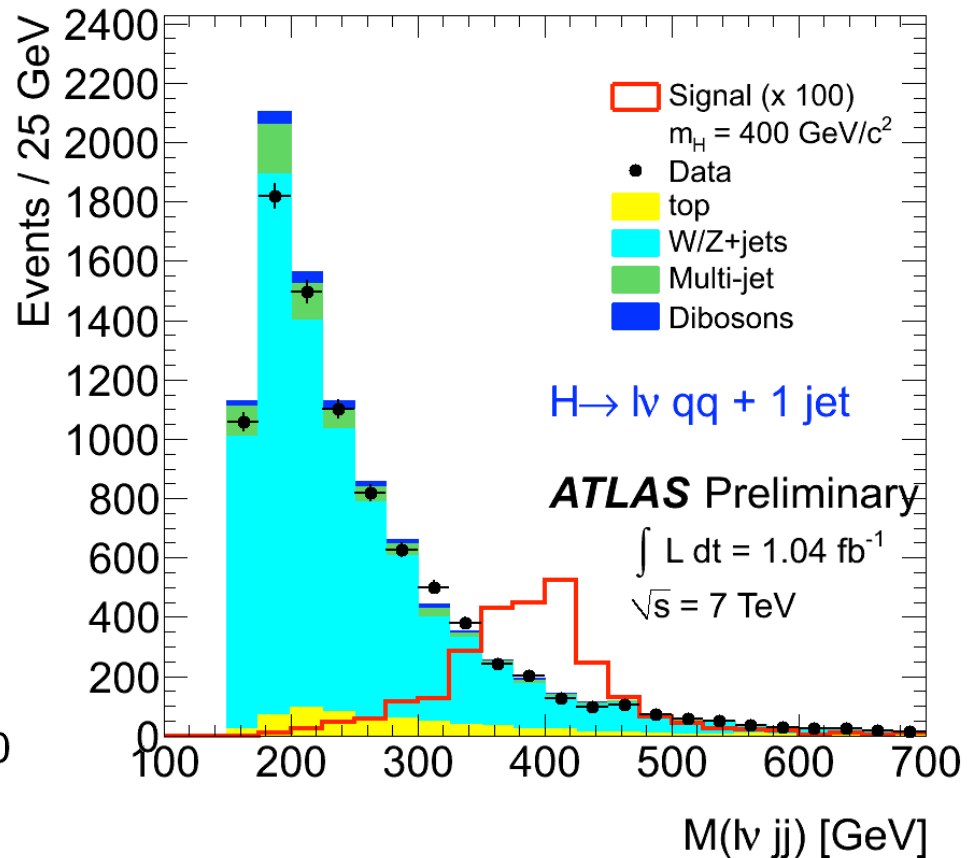
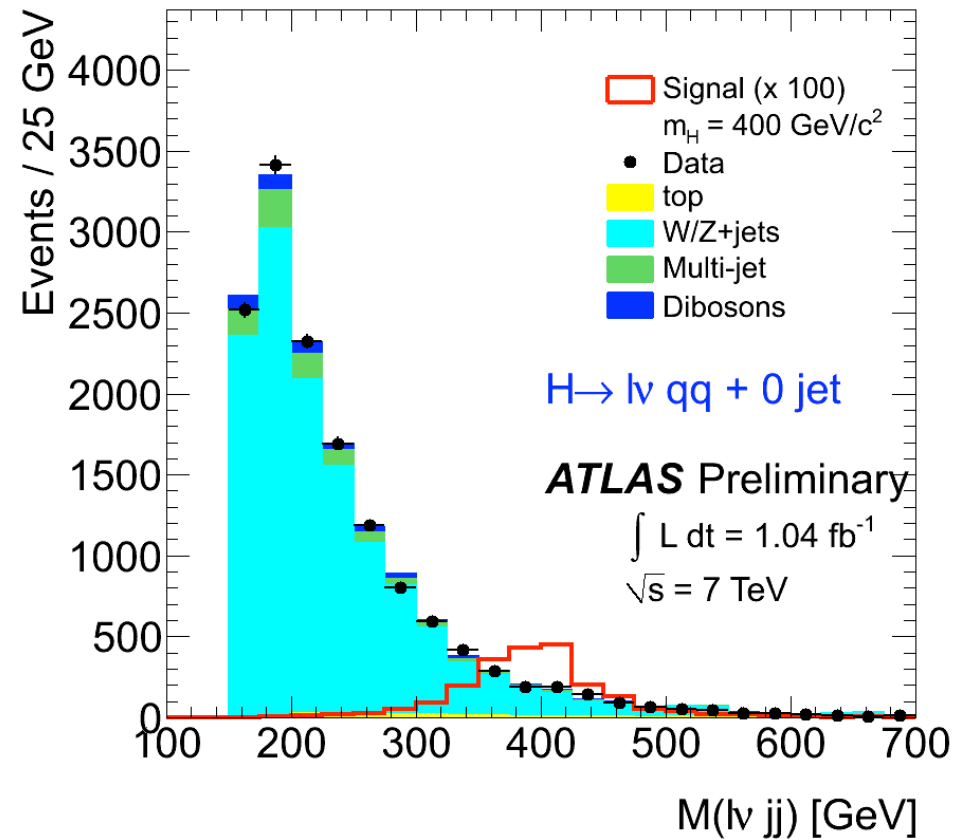


- Double-exponential model, well-motivated by MC and validated in $M(jj)$ sidebands of the W boson





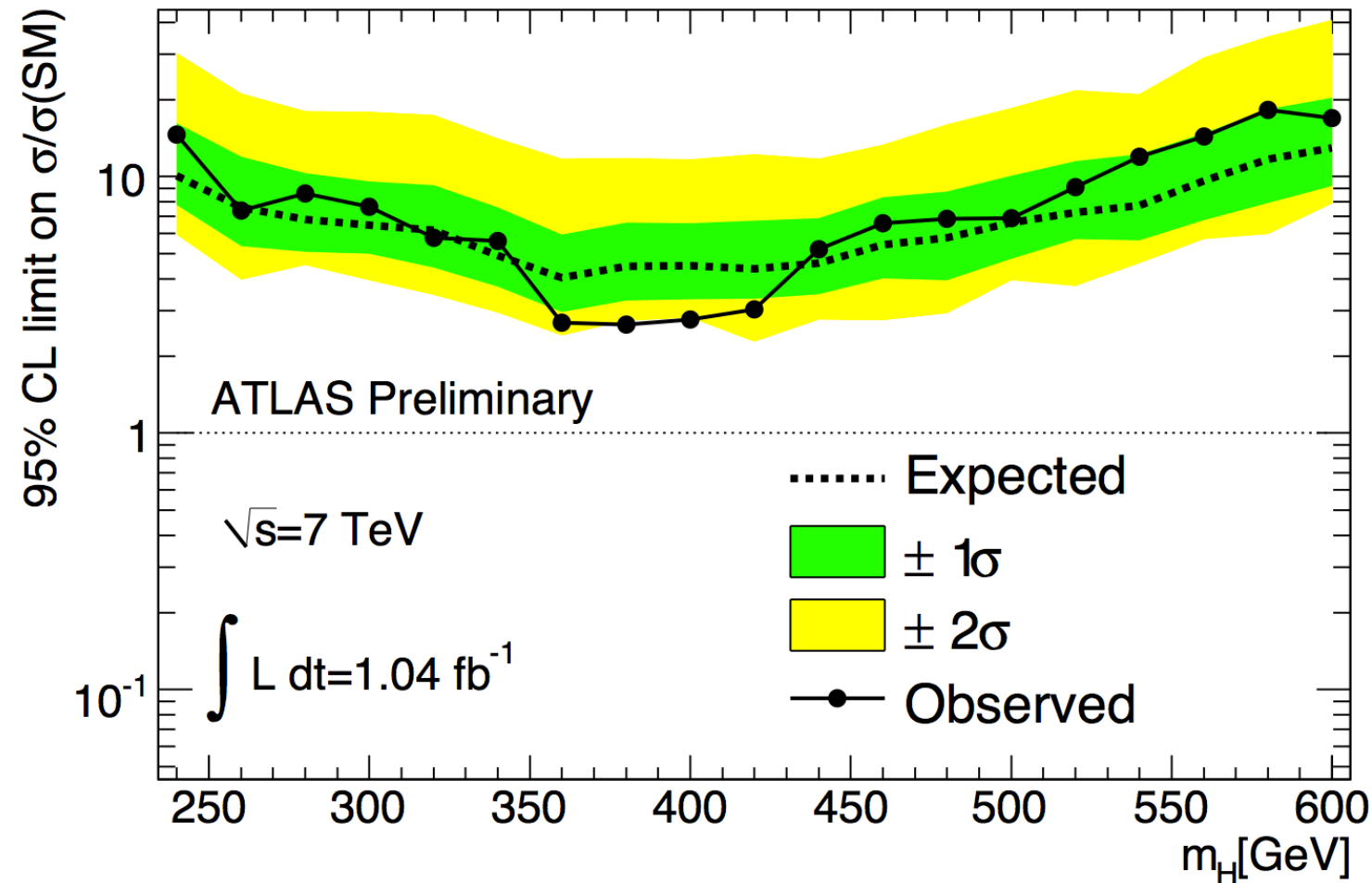
M(lvjj) Distributions



- No evidence for a resonance in the M(lvjj) spectrum



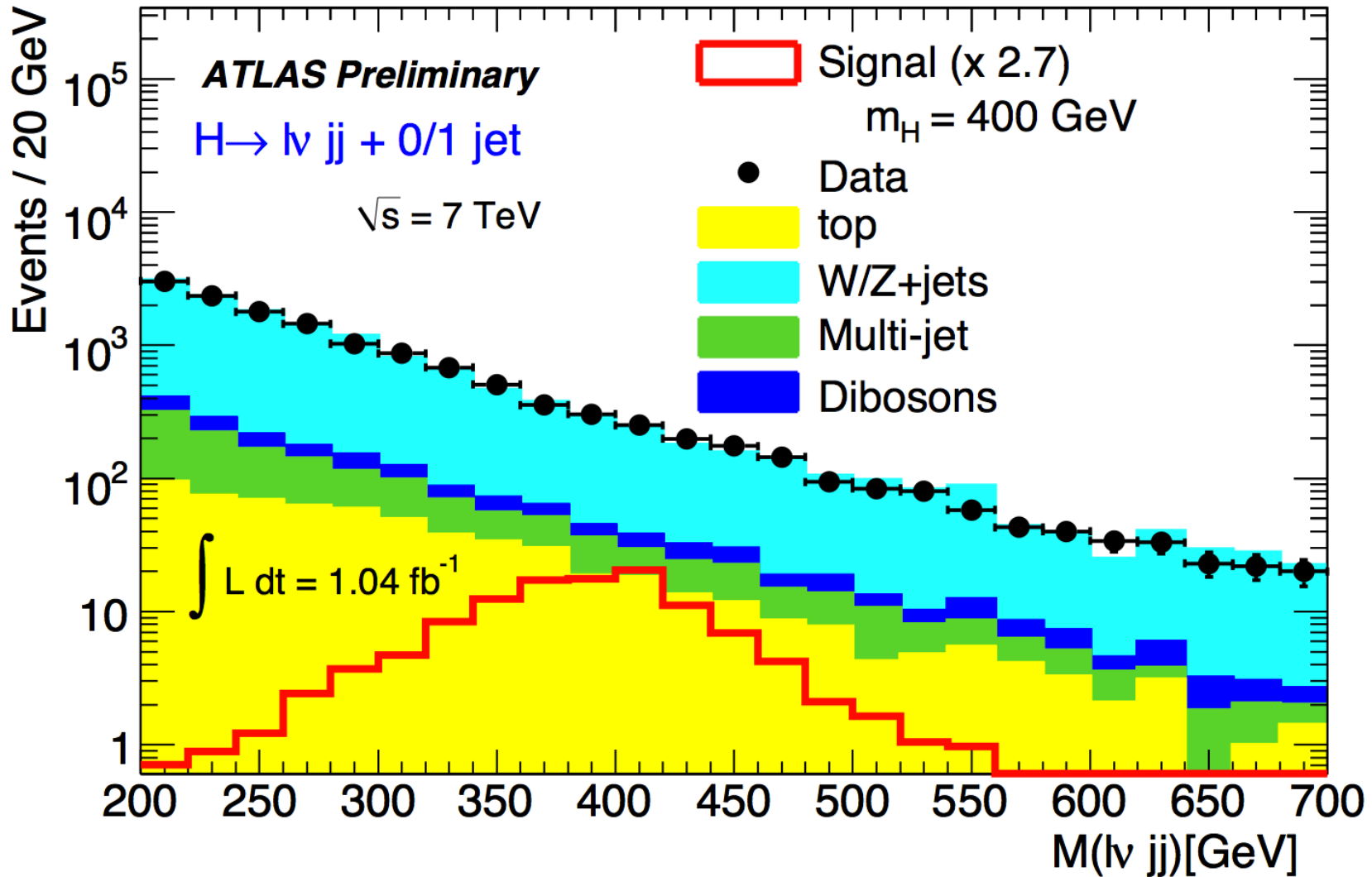
Cross Section Limits



95% C.L. limits
@ 400 GeV:
 $\sigma < 3.1\text{ pb}$
($2.7 \times \text{SM}$)

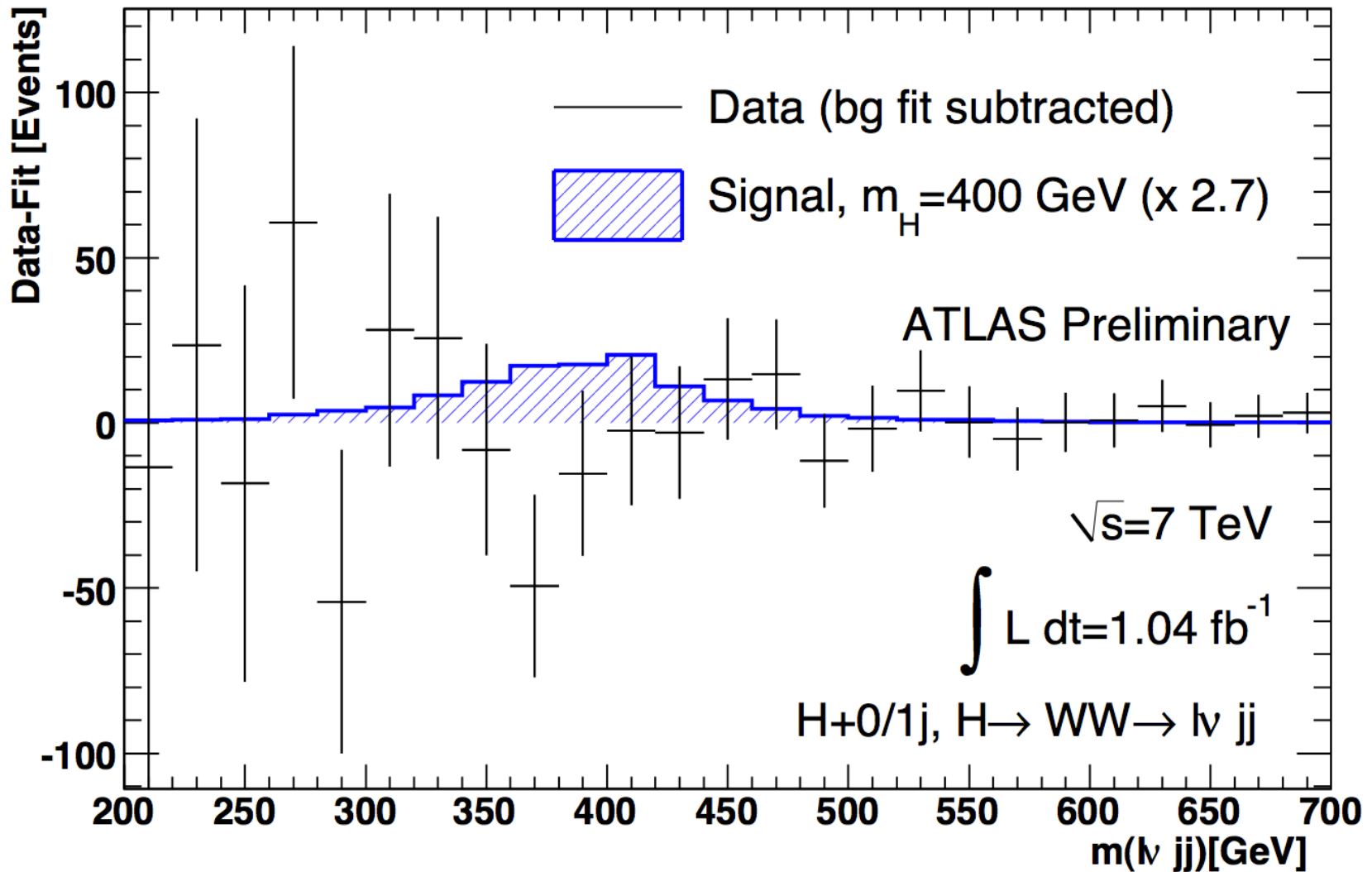


M(lvjj) Distribution





Background-Subtracted $M(l\nu jj)$





Summary



- **Diboson production** provides a sensitive probe of the Higgs and new physics
- Channels involving a **$W \rightarrow qq'$ decay** play an important role in the searches, especially at large diboson invariant mass
- We searched for **Higgs production** in the **lepton + MET + 2 or 3 jet** final state and place limits on the production
- Many improvements anticipated
 - Better pileup suppression
 - Weak boson fusion
 - Charm tagging
 - Multivariate techniques
 - More data!

