Search for a Standard Model Higgs Boson in the $H \rightarrow ZZ \rightarrow ll\nu\nu$ channel with the ATLAS detector

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4^{th} April 2012
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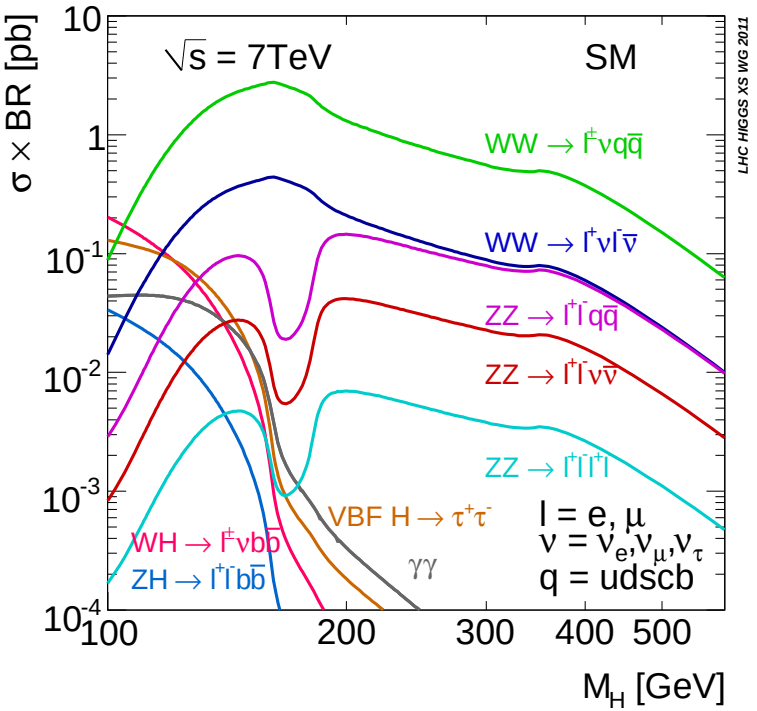
Outline

- Brief overview of analysis
- Discussion of backgrounds
- Limits
- Conclusion and outlook

- For more details see CONF note - https://cdsweb.cern.ch/record/1419469

Introduction

- At high mass ($m_H \geq 200$) dominated by WW/ZZ decay modes
  - $H \rightarrow ZZ \rightarrow llqq/llbb$
  - $H \rightarrow ZZ \rightarrow ll\nu\nu$
  - $H \rightarrow ZZ \rightarrow \nu\nu bb$
- Take advantage of higher branching ratios for $Z \rightarrow \nu\nu$ compared to $Z \rightarrow ll$



- Why look in the high mass range?
  - First direct search to be performed in this region
  - Many multi-higgs boson theories which need to be tested

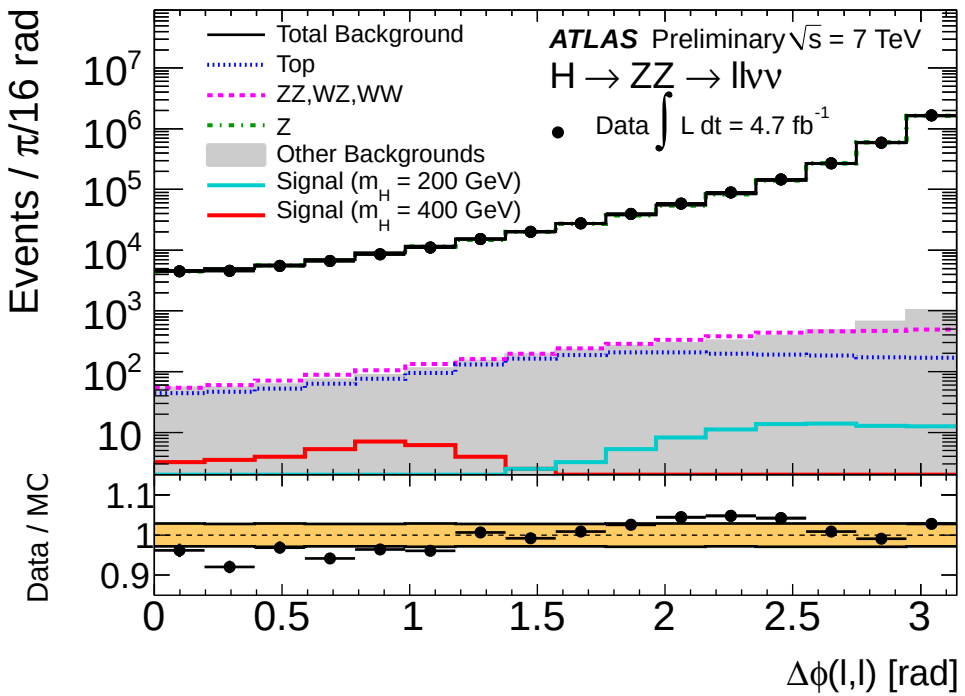
Event Selection (1)

- Data
  - Run over full 2011 ATLAS dataset, which corresponds to 4.7 fb^{-1}
- Triggers
  - Single lepton triggers with lowest p_T threshold
- Leptons
  - Isolated muon(electron) with $p_T > 20$ GeV, $|\eta| < 2.5(2.47)$
  - Remove electron if $\Delta R_{e,\mu} < 0.2$ or if $0.2 \leq \Delta R_{e,j} < 0.4$
  - Remove muon if $\Delta R_{\mu,j} < 0.4$
- Jets
  - AntiKt clustering algorithm with $\Delta R = 0.4$
  - Jet (b-jet) $p_T > 25(20)$ GeV, $|\eta| < 2.5$
  - Remove jet if $\Delta R_{e,j} < 0.4$
- Missing Energy
  - E_T^{miss} is reconstructed from all objects after appropriate callibration has been applied

Event selection (2)

- 76 GeV $< m_{ll} <$ 106 GeV and exactly 2 oppositely charged leptons (third lepton threshold at $p_T > 10$ GeV)
- Reject events with a b-jet
- Split into high mass $m_H \geq 280$ GeV and low mass selection

- Low m_H:
  - $E_T^{\text{miss}} > 66$ GeV
  - $\Delta\Phi_{Jet,MET} > 0.15$
  - $1 < \Delta\Phi_{ll} < 2.64$
- High m_H:
  - $E_T^{\text{miss}} > 82$ GeV
  - $\Delta\Phi_{Jet,MET} > 0.5$
  - $\Delta\Phi_{ll} < 2.25$
  - $\Delta\Phi_{Z,MET} > 1$



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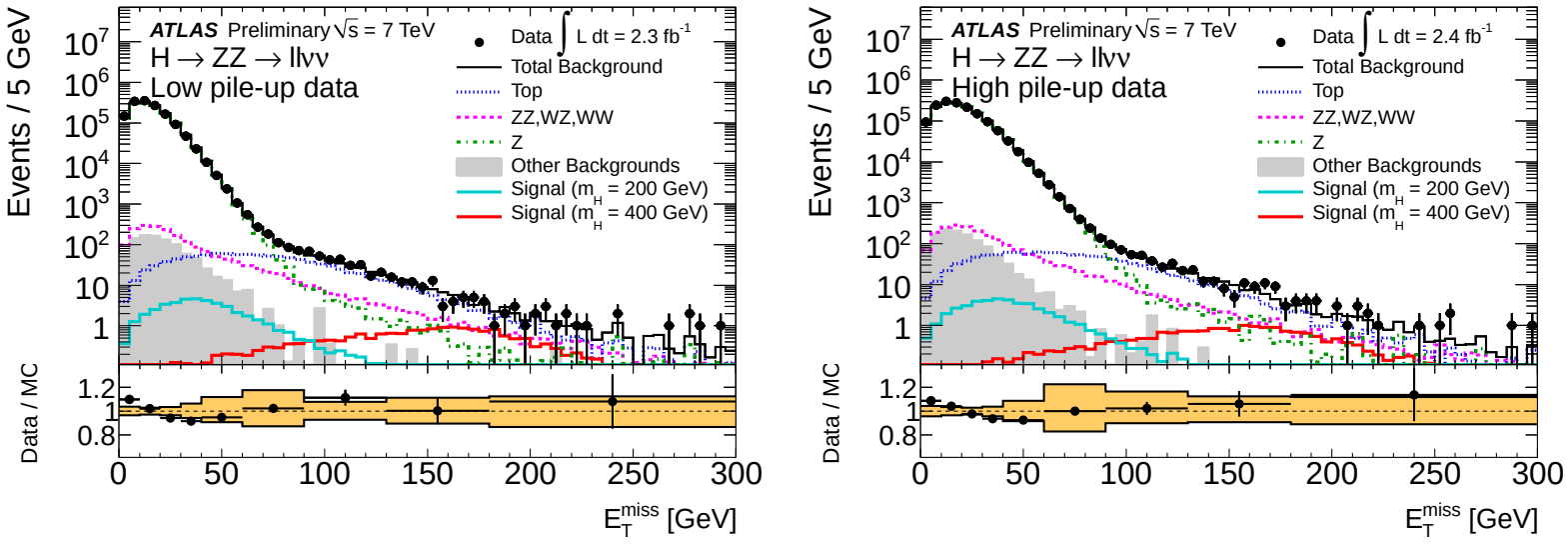
Missing Energy

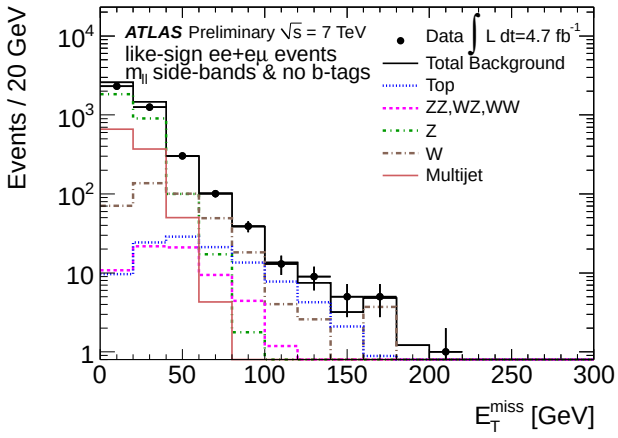


[1]

- Shown above on the left(right) is the E_T^{miss} distributions for events with low (high) pile up.
- The average number of interactions per bunch crossing was 6 for the low region, and 12 for the high region.
- Can see the degradation in the resolution of the E_T^{miss} with higher pile-up conditions.
- But still very good agreement in both periods.

Backgrounds - W and WZ

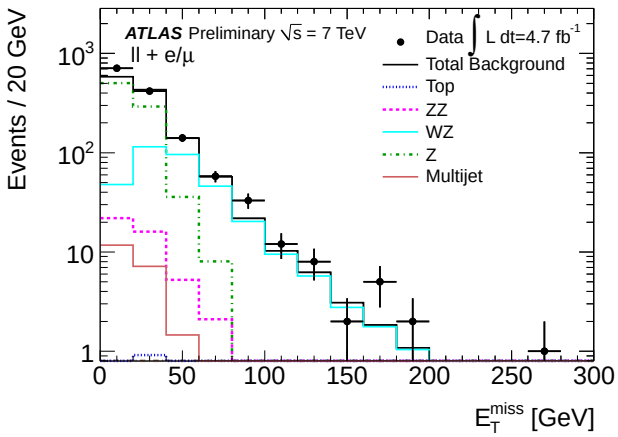
W background:



[1]

- Can pass selection due to fake electrons
- Look for like-sign lepton pairs in events in m_{ll} sidebands and without b-jets
- W normalistaion is taken from this distribution

WZ background:



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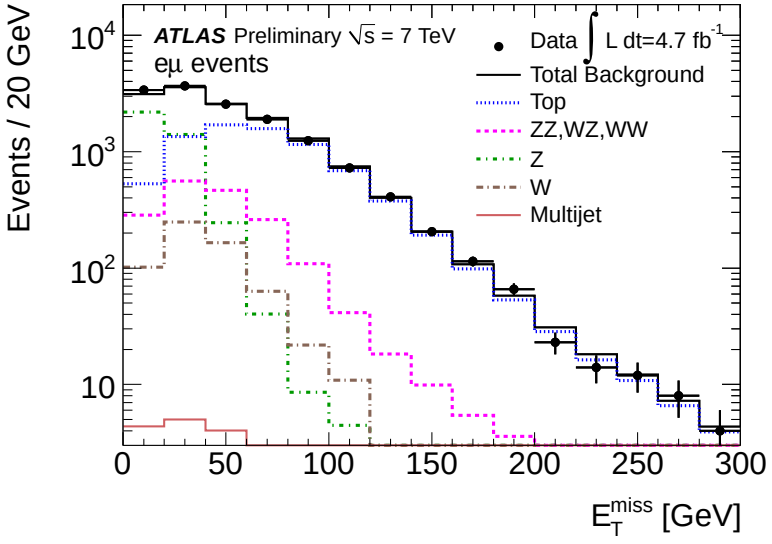
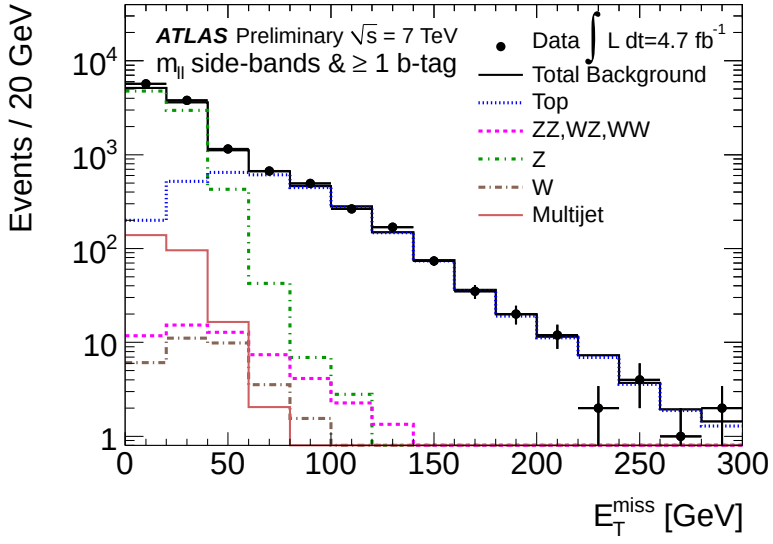
- Look at events with a third lepton
- Good agreement with data and MC
- WZ background is taken from MC

Backgrounds - Top

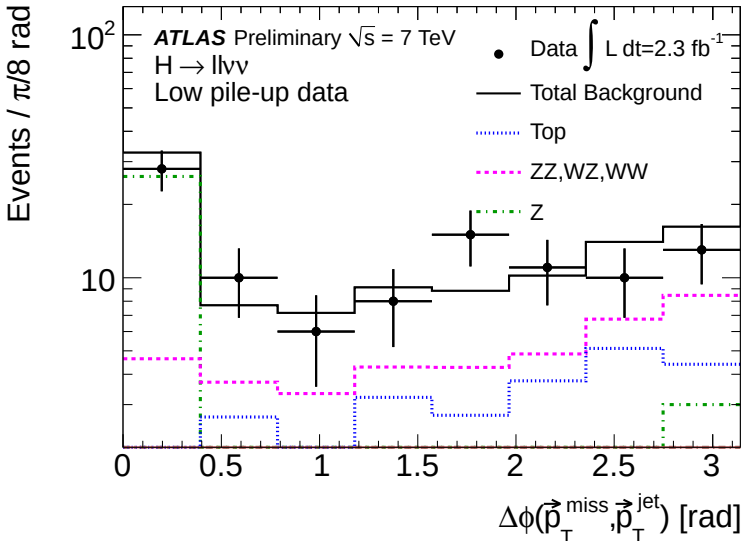


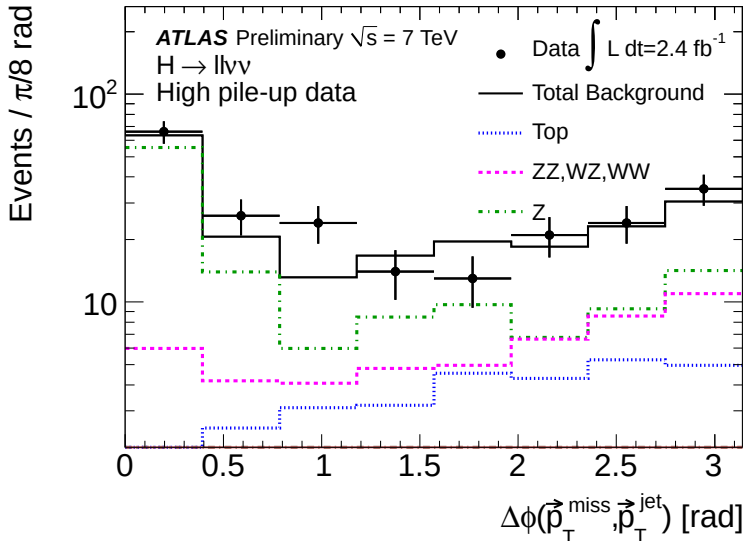


[1]

- Electron-muon pairs with $E_T^{\text{miss}} > 66$ GeV (left)
- Events in m_{ll} sidebands and with b-jets for both ee and $\mu\mu$ pairs (right)
- Agreement well within errors so the top background is taken from MC

Backgrounds - $Z + jets$





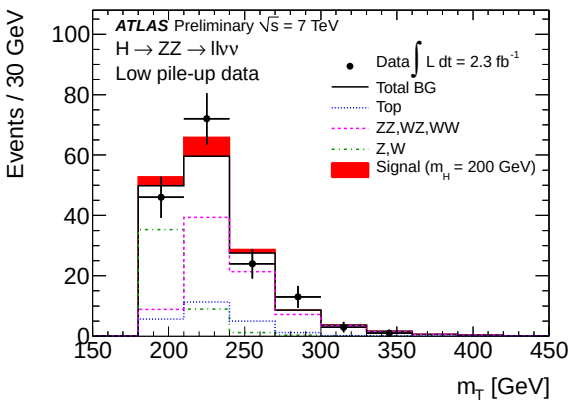
[1]

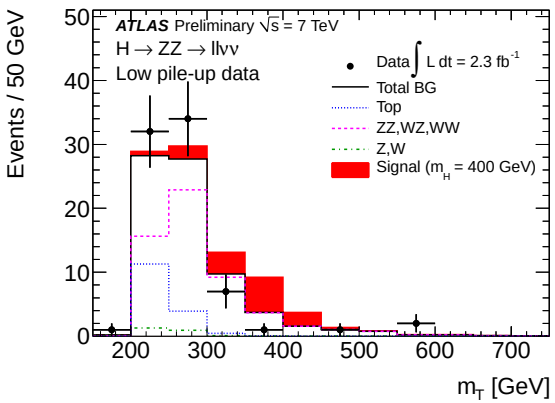
- $\Delta\Phi_{Jet,MET}$ after the $E_T^{\text{miss}} > 88$ GeV cut
- $Z + jets$ background dominant at low $\Delta\Phi_{Jet,MET}$
- Agreement within uncertainties across entire range

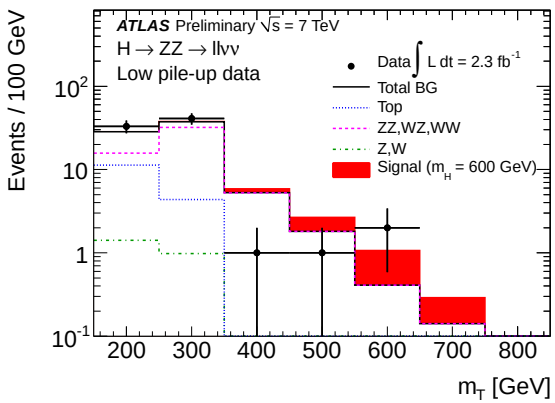
m_T distributions

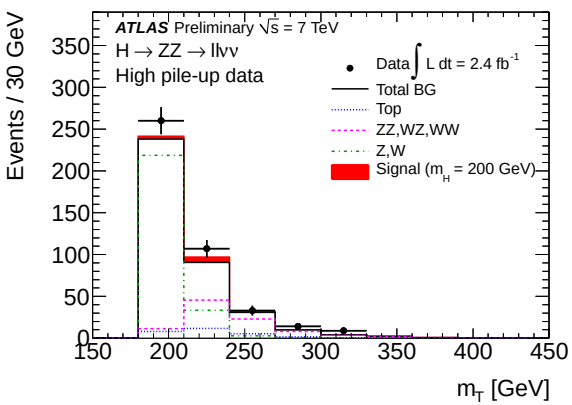
$$m_T^2 \equiv \left[\sqrt{m_Z^2 + |\vec{P}_T^{ll}|^2} + \sqrt{m_Z^2 + |\vec{P}_T^{miss}|^2}\right]^2 - \left[\vec{P}_T^{ll} + \vec{P}_T^{miss}\right]^2$$

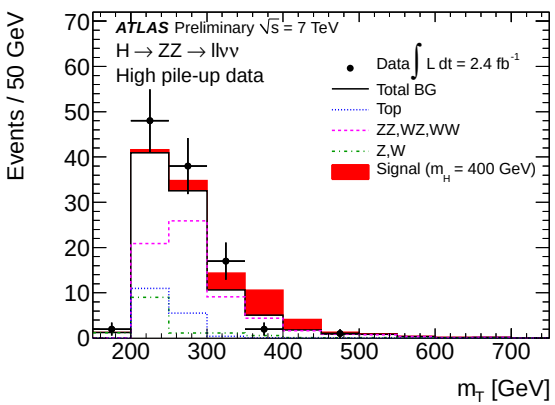
- Limits based on the m_T distributions after full selection, separated into high and low pile up regions and $ee\nu\nu$ and $\mu\mu\nu\nu$ channels to maximise sensitivity

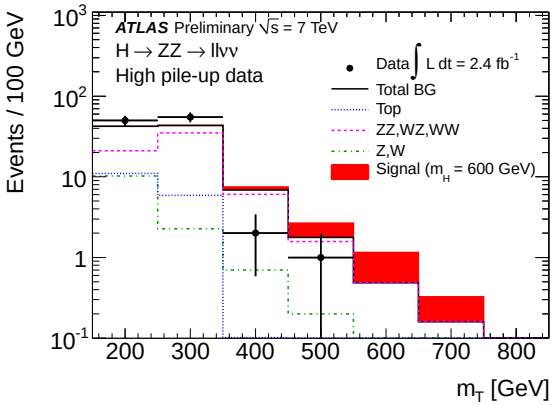






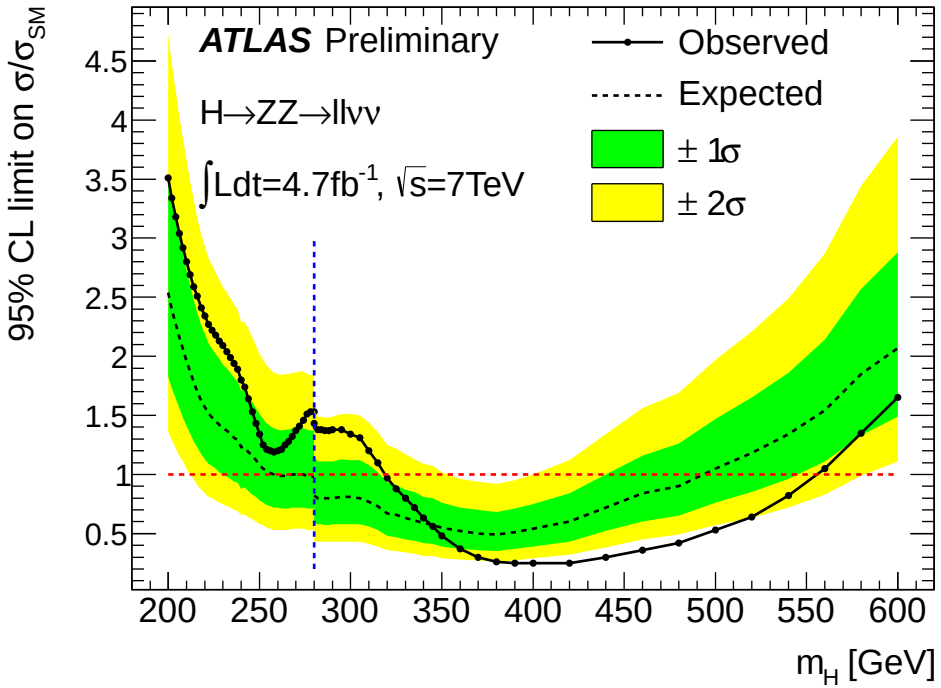






[1]

Limits

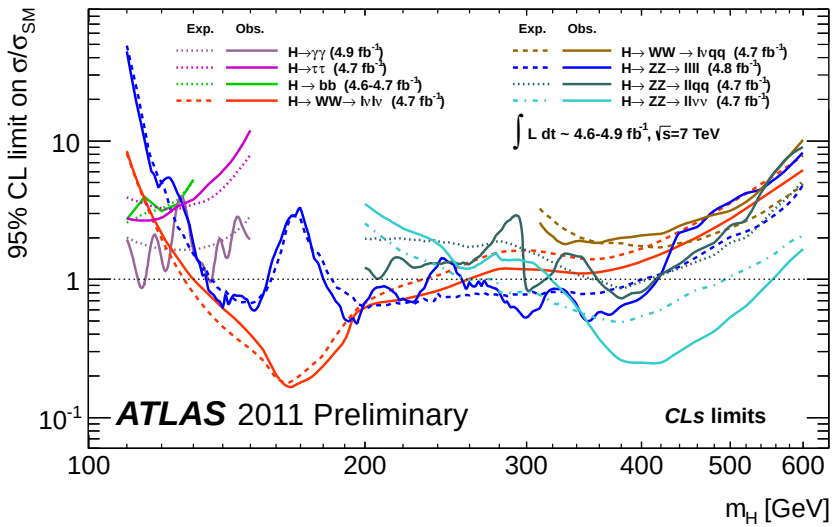


[1]

- A SM Higgs boson is excluded in the region $320 - 560$ GeV at 95% confidence level with this channel alone
- The expected exclusion for this channel is $260 - 520$ GeV
- No excess is observed, the smallest p_0 value is 0.05, seen at $M_H = 280$ GeV

Conclusions and Outlook

- I have presented the ATLAS search results for the $H \longrightarrow ZZ \longrightarrow ll\nu\nu$ for the full 2011 dataset.
- SM Higgs excluded from 320 – 560 GeV in this channel alone
- This channel contributes to the combined ATLAS Higgs boson search



[2]

- With 2012 data we will aim to push this search to even higher masses

[1] https://cdsweb.cern.ch/record/1419469 [2] https://arxiv.org/abs/1202.1408

Backups...

Data and MC Samples

- Data
  - Ran over full 2011 dataset $\rightarrow$ 4.7 fb^{-1}
- Signal samples:
  - $H \rightarrow ZZ \rightarrow ll\nu\nu, H \rightarrow ZZ \rightarrow llqq, H \rightarrow ZZ \rightarrow llll, H \rightarrow WW \rightarrow l\nu l\nu$
  - Signal is combination of all of these channels, POWHEG
- Background samples (MC11c)
  - Z/W+jets - ALPGEN
  - Top - $t\bar{t}$ and single top - MC@NLO
  - Diboson - MC@NLO
  - QCD - Pythia(B)