ATLAS Higgs Search in the $H \rightarrow WW^*$ Decay Mode using 4.7 fb^{-1}

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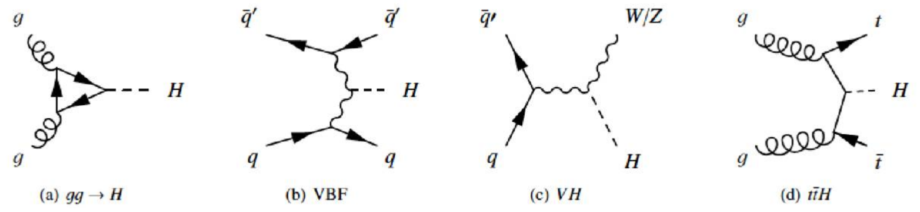
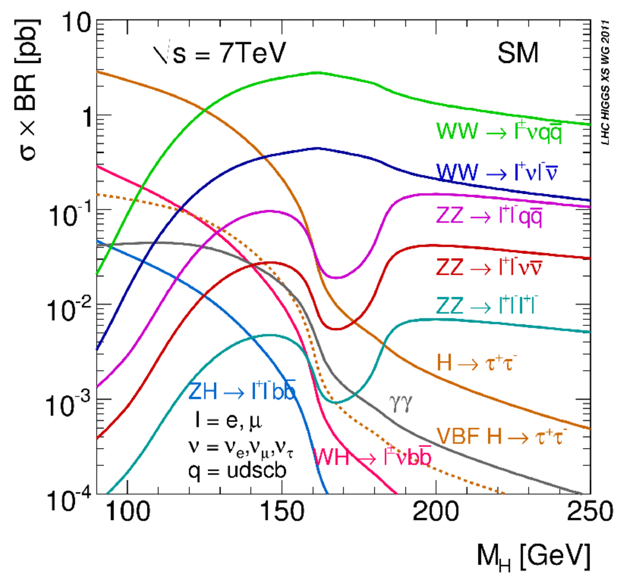
The existence of the Standard Model (SM) Higgs boson has been excluded at 95% confidence level over a broad mass range already. This poster summarizes the search in the WW^* decay channel at ATLAS, which is one of the most sensitive channels for 125 < m_H < 250 GeV.



The dominant production modes at the LHC are the gluon (via top loop) and vector boson fusion mechanisms. Considering the WW^* decay to leptons, this yields an event signature with exactly two leptons, missing E_T, and 0 – 2 jets. Because of the difficulty in creating a pure sample of τ leptons, only events with e and μ leptons are considered.

Since the SM Higgs is a scalar boson, the WW decay exhibits particular angular distributions. In particular, the $H \rightarrow WW^*$ events tend to have



leptons emitted at small angles, back-to-back with the $\nu\nu$ system. This allows Higgs events to be distinguished from continuum WW events, which are characterized by leptons separated at large angles.

The dilepton decay means that the Higgs mass cannot be fully reconstructed. Therefore, a shape fit to the transverse mass

$$m_T = \sqrt{(E_T^{\ell\ell} + E_T^{\rm miss})^2 - |\mathbf{p}_T^{\ell\ell} + \mathbf{p}_T^{\rm miss}|^2}$$

is performed, and instead of searching for a peak, we look for an excess of events over the background model.

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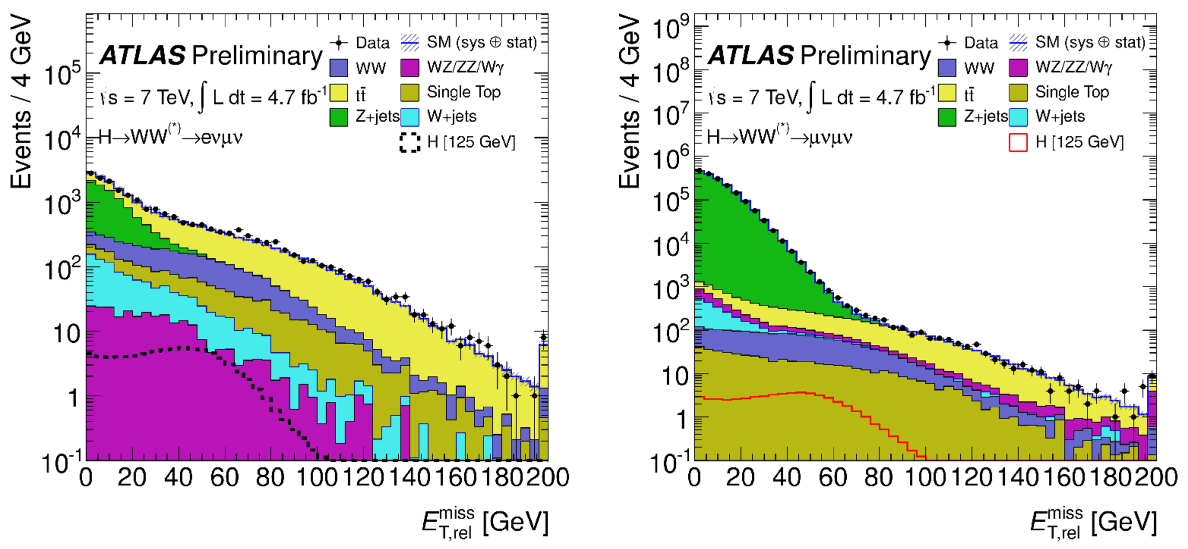
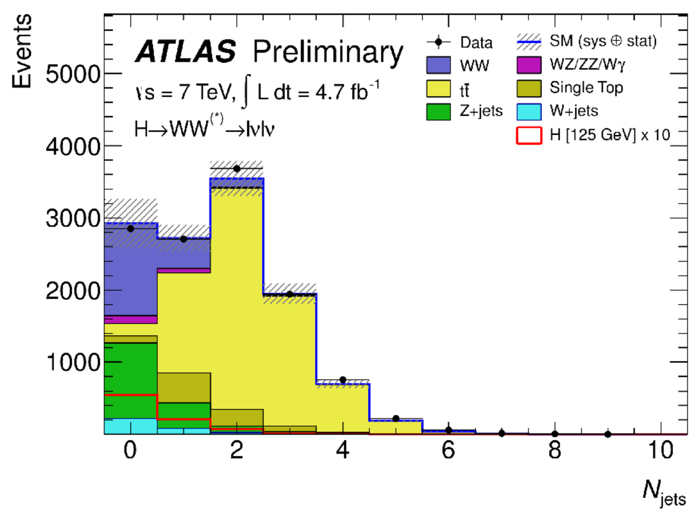
Events with oppositely charged, isolated, high p_T (25 and 15 GeV for leading and sub-leading, respectively) leptons are selected. Various object identification criteria are applied to ensure that sources of fake leptons are severely reduced.

In order to limit the contribution from Drell-Yan backgrounds in the same-flavour (ee and $\mu\mu$) samples, a cut is placed on the dilepton mass, excluding a 15 GeV window around the Z pole and a lower bound > 12 GeV. The Drell-Yan and QCD multi-jet background are both further reduced with cuts on

$$E_{\rm T,rel}^{\rm miss} = E_{\rm T}^{\rm miss} \sin \Delta\phi_{\rm min}$$

Jets are defined in this analysis with p_T > 25 GeV and η < 4.5. The analysis is divided into 0,1 & 2 jet bins, and further into ee, $\mu\mu$ & $e\mu$ and channels.





Different background and signal processes are dominant in the various jet bins, so the selection cuts are specific to each bin.

0 jet	1 jet	2 jet
$p_T^{\ell\ell} > 30(45)$	$N_{b-tag} = 0$	$\eta(j_1) \cdot \eta(j_2) < 0$
	$p_T^{total} < 30$	$\Delta\eta(j_1, j_2) > 3.8$
	$\lvert m_{\tau\tau} - m_Z \rvert > 25$	$m_{jj} > 500$
		(+ 1 jet cuts ...)

As the Higgs mass increases, the W's become more boosted, and the leptons are emitted more back-to-back. Thus, selection criteria are optimized for various mass hypotheses. For the masses > 300 GeV, no additional cuts are applied.`

$m_H < 200$	$200 \leq m_H \leq 300$
$\Delta\phi(\ell,\ell) < 1.8,\ m_{\ell\ell} < 50$	$m_{\ell\ell} < 150$

0 & 1-jet selections for different mass hypotheses

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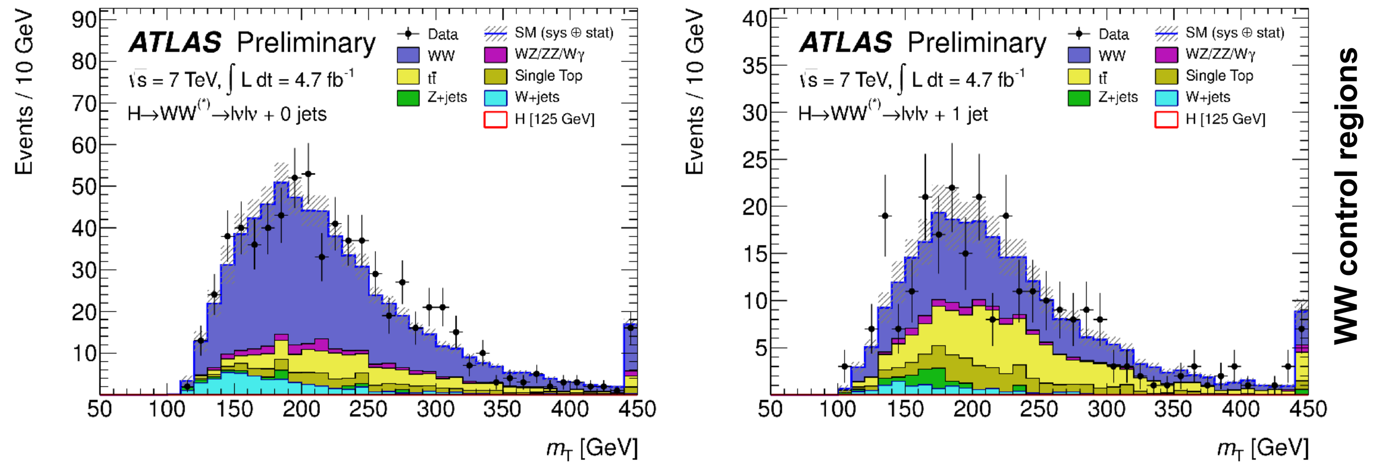
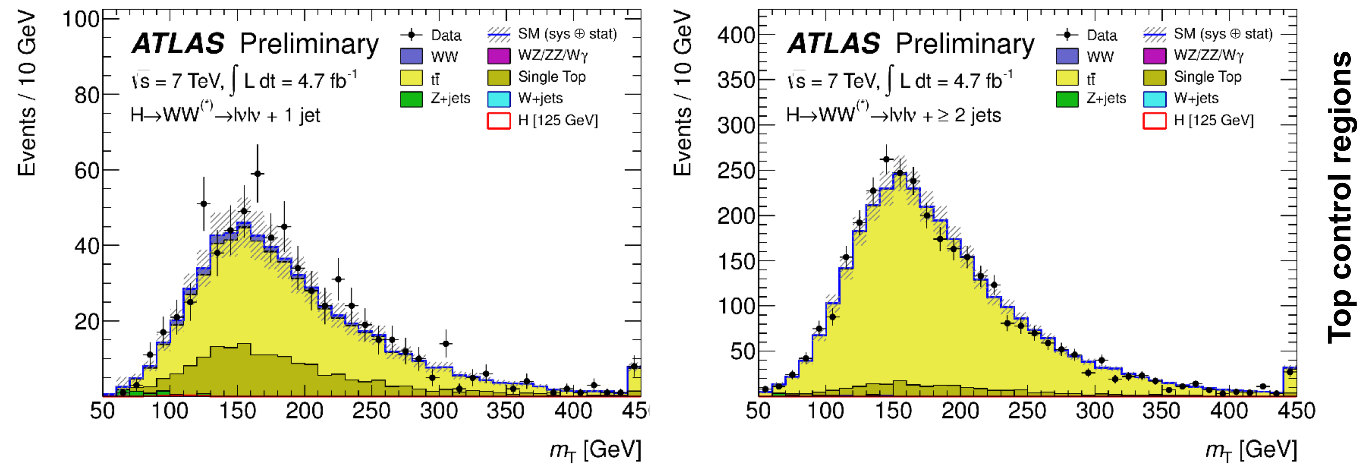
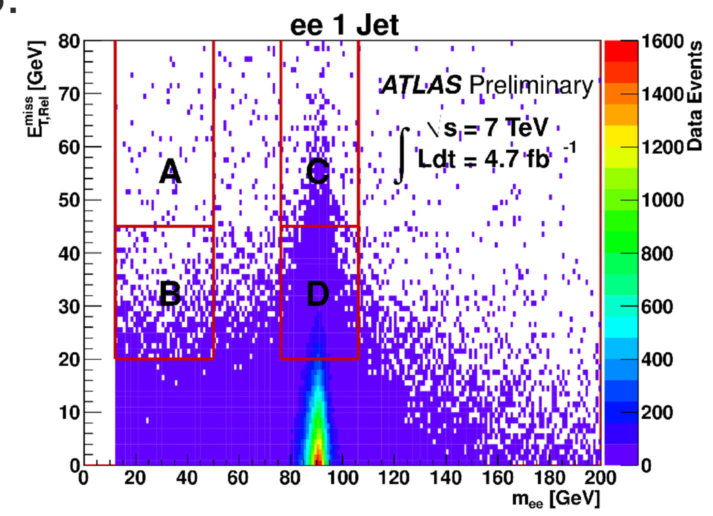
In order to constrain and validate the models for the backgrounds, various control samples are used. For the continuum WW background, reversing the m_{ll} cut can be used for low m_H hypotheses. Using an extrapolation factor derived from simulations, the WW contribution after all selection criteria applied can be set in situ with this control sample.



The $t\bar{t}$ background in the 0-jet bin is normalized using a jet veto probability that is derived from a single b-tagged sample. In the 1 and 2-jet bins, a control region is derived by reversing the b-tag veto.



The Drell-Yan contribution in the ee and $\mu\mu$ channels is normalized in data using a side-band technique known as the ABCD method. The Z background in signal region A is derived from the ratio C/D multiplied by the amount measured in region B.



A different control region for the $Z \rightarrow \tau\tau$ background is used.

The W+jet(s) is derived fully from data. Events are selected that contain one lepton with loosened selection criteria. This sample is dominated by W+jet(s) events where one jet or heavy-flavour decay has faked a prompt lepton. A fake probability for these leptons is then derived from an independent dijet sample and is applied to the selected W+jet(s) candidate events.

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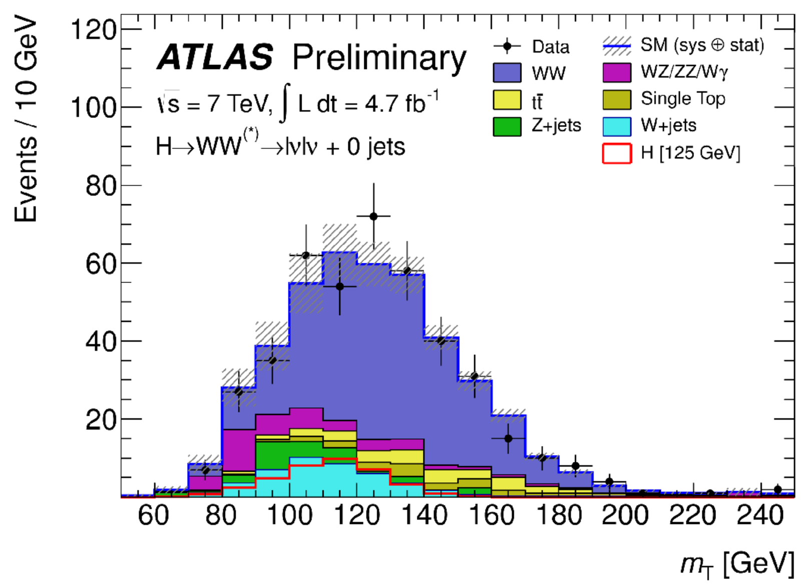
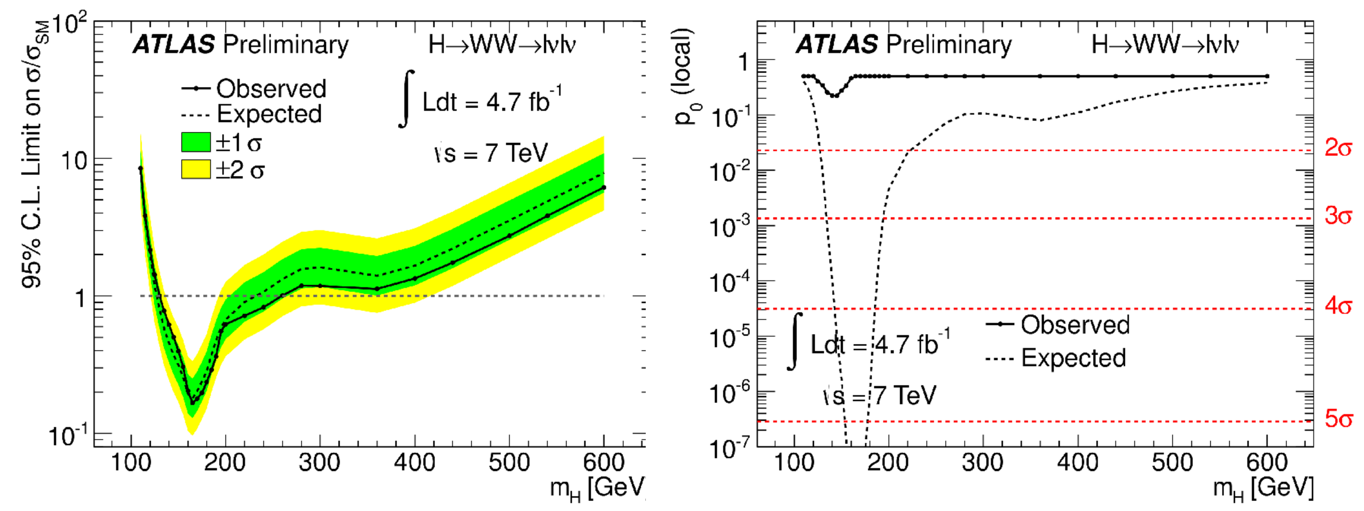
The full treatment of systematic uncertainties is described in the reference below. The dominant sources arise from W+jet(s) normalization, jet energy scale and b-tagging efficiency. After full event selection in each of the nine separate sub-channels, an excess of events is searched for in the m_T distributions (below).



Event yields after full event selection and 0.75 (0.6) $m_H < m_T < m_H$ for 125 (240) GeV mass hypotheses

		Signal	WW	$WZ/ZZ/W\gamma$	$t\bar{t}$	$tW/tb/tqb$	Z/γ^* + jets	W + jets	Total Bkg.	Obs.
0-jet	m_H = 125 GeV	25 ± 7	110 ± 12	12 ± 3	7 ± 2	5 ± 2	13 ± 8	27 ± 16	173 ± 22	174
	m_H = 240 GeV	60 ± 17	432 ± 49	24 ± 3	68 ± 15	39 ± 9	8 ± 2	36 ± 24	607 ± 63	629
1-jet	m_H = 125 GeV	6 ± 2	18 ± 3	6 ± 3	7 ± 2	4 ± 2	6 ± 1	5 ± 3	45 ± 7	56
	m_H = 240 GeV	23 ± 9	99 ± 22	8 ± 1	73 ± 27	35 ± 19	6 ± 2	7 ± 7	229 ± 55	232
2-jet	m_H = 125 GeV	0.4 ± 0.2	0.3 ± 0.2	negl.	0.2 ± 0.1	negl.	0.0 ± 0.1	negl.	0.5 ± 0.2	0
	m_H = 240 GeV	2.5 ± 0.6	1.1 ± 0.7	0.1 ± 0.1	2.6 ± 1.3	0.3 ± 0.3	negl.	0.1 ± 0.1	4.2 ± 1.7	2

These distributions are combined with the various control regions in a profile likelihood fit with a signal strength parameter μ. The systematic uncertainties are included as nuisance parameters, and the CL_s method is used to set limits on the signal strength parameter (shown below in units of σ_{SM}). The expected exclusion ranges at 95% confidence level are 127 < m_H < 234. A Standard Model Higgs boson with mass 130 < m_H < 260 is excluded by this analysis.



Further Reading:

- https://cdsweb.cern.ch/record/1429660
- https://cdsweb.cern.ch/record/1430033
- http://arxiv.org/abs/1112.2577