Search for the Higgs boson in the $H \rightarrow WW \rightarrow ℓνℓν$ channel in ATLAS

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On behalf of ATLAS Higgs

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Status

- Analysis uses 1.04 fb$^{-1}$ of 7 TeV LHC data
- Search range between 110 and 240 GeV
- Most sensitive in the range 160-170 GeV
  - Large $H \rightarrow WW$ branching ratio
  - Good S/B due to clean dilepton signature
Event Selections

- Search for high $E_T$ opposite sign dilepton events
  \[ E_{T,rel} > 40 \text{ (25) GeV for } ee, \mu\mu (e\mu) \]

- Analysis is split by jet multiplicity
  - Jets required to have $p_T > 25 \text{ GeV}, |\eta| < 4.5$ (anti-$k_T$ R=0.4)
  - Dilepton $p_T$ cut in zero-jet to suppress Drell-Yan
  - B-veto in one-jet analysis to reject $t\bar{t}$ + single top
Two selection criteria optimized for low mass and high mass, with a cutoff at 170 GeV

- $M_{\ell\ell} < 50$ or 65 GeV for low and high mass
- $\Delta\phi(\ell_1, \ell_2) < 1.3$ or 1.8 for low and high mass
Mass Distributions

- Transverse Mass distribution for zero-jet (left) and one-jet (right) after all selections
  - Sliding mass cut as final selection: $0.75 \times M_H < M_T < M_H$
\[
L(\mu, \tilde{\theta}) = \prod_{\ell = ee, e\mu, \mu\mu} \prod_{j = 0, 1} P^{SR}(N_{\ell j} | \mu s_{\ell j} + \alpha_{\ell j}^{WW} N_{e\mu, j}^{WW} + \delta_1^{\ell} \alpha_{\ell}^{top} N_{\ell, 1j}^{top} + \sum_k b_{\ell jk}) \\
 \left[ P^{CR_{WW}}(N_{\ell j} | \mu s_{\ell j} + \gamma_{\ell j}^{WW} N_{e\mu, j}^{WW} + \delta_1^{\ell} \beta_{\ell, 1j}^{top} N_{e\mu}^{top} + \sum_k b_{\ell jk}) \\
 P^{CR_{top}}(N_{\ell j} | \mu s_{\ell j} + \delta_1^{\ell} \gamma_{\ell, 1j}^{top} N_{e\mu}^{top} + \sum_k b_{\ell jk}) \times \prod_i G(\theta_i) \right]
\]

- \(\alpha\) terms describe background extrapolation into signal region
- \(\beta\) terms describe extrapolation between control regions
### Event Rates

<table>
<thead>
<tr>
<th>$m_H$ (GeV)</th>
<th>Lepton Flavors</th>
<th>Nominal</th>
<th>$\mu=0$</th>
<th>$\mu=1$</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 H+0j</td>
<td>$ee$</td>
<td>3.1</td>
<td>4.7</td>
<td>5.7</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>$e\mu$</td>
<td>10.6</td>
<td>17.2</td>
<td>20.8</td>
<td>10.4</td>
</tr>
<tr>
<td></td>
<td>$\mu\mu$</td>
<td>6.8</td>
<td>10.9</td>
<td>13.4</td>
<td>6.7</td>
</tr>
<tr>
<td>150 H+1j</td>
<td>$ee$</td>
<td>0.94</td>
<td>2.2</td>
<td>2.3</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>$e\mu$</td>
<td>4.0</td>
<td>9.0</td>
<td>8.8</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>$\mu\mu$</td>
<td>2.3</td>
<td>4.0</td>
<td>4.2</td>
<td>2.5</td>
</tr>
<tr>
<td>180 H+0j</td>
<td>$ee$</td>
<td>4.2</td>
<td>6.3</td>
<td>6.8</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>$e\mu$</td>
<td>11.8</td>
<td>19.1</td>
<td>20.9</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td>$\mu\mu$</td>
<td>7.8</td>
<td>13.5</td>
<td>14.7</td>
<td>7.4</td>
</tr>
<tr>
<td>180 H+1j</td>
<td>$ee$</td>
<td>1.60</td>
<td>4.9</td>
<td>4.9</td>
<td>1.44</td>
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<tr>
<td></td>
<td>$e\mu$</td>
<td>5.5</td>
<td>14.6</td>
<td>12.3</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>$\mu\mu$</td>
<td>3.4</td>
<td>6.5</td>
<td>6.4</td>
<td>3.1</td>
</tr>
</tbody>
</table>

- **Expected and best fit signal, background rates**
  - Nominal expectation before fit
  - Post-fit assuming $\mu=0$
  - Post-fit assuming $\mu=1$
• Observed 95% CL exclusion with CLs: 158-186 GeV

• Expected exclusion: 142-186 GeV
p-values, significance

• $>2\sigma$ excess between 126-158 GeV. The largest is $2.7\sigma$ at 130 GeV

• Right plot shows background-only p-value
Summary

- $H \rightarrow WW \rightarrow \ell\nu\ell\nu$ analysis done with $1.04 \text{ fb}^{-1}$
- 95% CL exclusion region between 158-186 GeV
- Slight excess above background observed in low mass region
Backup
Background Estimation

- Data-driven estimates for Drell-Yan, W+jets, and top in 0-jet
  - Drell-Yan is scaled by a $E_T$ mis-modelling factor derived from events in Z window
  - W+jets estimated by deriving fake factor from a control region with loosened lepton ID
  - Top in 0-jet applies a jet veto survival probability scale factor derived from a b-tagged control region
Limit by jet bin

\[ H \to WW^{(*)} \to l\nu l\nu + 0j \]
\[ \int Ldt = 1.04 \text{ fb}^{-1} \]
\[ \sqrt{s} = 7 \text{ TeV} \]

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\[ \sqrt{s} = 7 \text{ TeV} \]
Significance by jet bin

**ATLAS Preliminary**

- **H → WW**(*) → ℓνℓν + 0j
- Observed
- Expected

- ± 1σ
- ± 2σ

\[ \sqrt{s} = 7 \text{ TeV} \]

\[ \int L dt = 1.04 \text{ fb}^{-1} \]

**Statistical significance**

\[ \text{Observed} - \text{Expected} \]

\[ M_H \text{ [GeV]} \]

\[ 120 \ 140 \ 160 \ 180 \ 200 \ 220 \ 240 \]

\[ 0 \ 2 \ 4 \ 6 \ 8 \ 10 \]

\[ \text{Statistical significance} \]

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