Associated Higgs Boson Top-Quark production channel $\bar{t}tH \rightarrow l^\pm l^\pm + \tau_{\text{had}}$ at $\sqrt{s} = 13$ TeV with the ATLAS experiment

Babar Ali, on behalf of the ATLAS collaboration

**Motivation**

- $\bar{t}tH$ production allows direct measurement of Yukawa coupling of the top quark.
- The $2l + 1\tau_{\text{had}}$ channel sensitive to $\bar{t}tH$ via $H \rightarrow \tau\tau, WW^*, ZZ^*$.
- Luminosity presented is 13.2 fb$^{-1}$ at $\sqrt{s} = 13$ TeV recorded by the ATLAS experiment during 2015 and 2016.

### Higgs decay mode in $2l + 1\tau_{\text{had}}$ SR

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>$\tau\tau$</th>
<th>$WW^*$</th>
<th>$ZZ^*$</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>51%</td>
<td>46%</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

### $t\bar{t}H \rightarrow 2l + 1\tau_{\text{had}}$ channel

The final state is selected by the following requirements:

- Two light leptons (electrons or muons) of same charge.
- One hadronically decaying $\tau$, opposite charge to leptons.
- At least 4 jets of which at least one b-tagged jet.

Main backgrounds:

- Irreducible: $t\bar{t}V, VV$; produce real, isolated same-sign leptons.
- Reducible: $t\bar{t}$ produces at least one fake or non-prompt lepton.

### Results

- The expected signal, background yields and observed data.

<table>
<thead>
<tr>
<th>$2l + 1\tau_{\text{had}}$</th>
<th>$t\bar{t}W$</th>
<th>$t\bar{t}(Z/\gamma')$</th>
<th>Diboson</th>
<th>Non-prompt leptons</th>
<th>Charge misreconstruction</th>
<th>Other</th>
<th>Total background</th>
<th>$t\bar{t}H$ (SM)</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>259 events</td>
<td>0.8 ± 0.4</td>
<td>1.6 ± 0.4</td>
<td>0.20 ± 0.15</td>
<td>1.3 ± 1.2</td>
<td>0.24 ± 0.03</td>
<td>0.63 ± 0.15</td>
<td>4.8 ± 1.4</td>
<td>1.43 ± 0.31</td>
<td>14</td>
</tr>
</tbody>
</table>

**Best Fit** $\mu = \frac{\sigma_{\bar{t}tH}}{\sigma_{\bar{t}tH}^{SM}} = 2.5^{+1.3}_{-1.1}$

### Fake background estimation

- A two-dimensional side-band data-driven method. (ABCD method)

\[
N_{\text{fake}}^A = \frac{N_{\text{Data-MC}}^C}{N_{\text{Data-MC}}^D} N_{\text{Data-MC}}^B
\]

- The events with non-prompt or fake objects in the signal region (SR) is estimated from data yields in region B, C and D as:

### Candidate event display

2l + 1$\tau_{\text{had}}$ signal region events

- The expected signal, background yields and observed data.

- The best fit value of $t\bar{t}H$ signal, using maximum likelihood fit to observed data.