$Z \rightarrow \tau\tau$ production in the forward region, $\sqrt{s}=7$ TeV
• Cross-section definition
• Event selection
• Efficiencies
• Results
• Conclusions

LHCb-PAPER-2012-029(*)

* preliminary
1. Cross-section definition
2. Event selection
3. Efficiencies etc.
4. Results
5. Conclusions

\[ \sigma_{pp \to Z \to \tau\tau} = \frac{\sum_{i=1}^{N} 1/\epsilon_{rec}^i - \sum_{j=1}^{N_{source}} N_{bkg}^j}{L \cdot A \cdot B \cdot \epsilon_{sel}} < 1.0/\epsilon_{rec}^j } \]

60 < \text{M}_{\tau\tau} < 120

2 < \eta_{\tau} < 4.5

p_{T\tau} > 20

\tau_{\mu} \tau_{\mu}, \tau_{e} \tau_{\mu}, \tau_{\mu} \tau_{h}, \tau_{e} \tau_{h}
2. Event selection

\[ \sigma_{pp \rightarrow Z \rightarrow \tau\tau} = \frac{\sum_{i=1}^{N} 1/\epsilon_{\text{rec}}^{i} - \sum_{j=1}^{N_{\text{source}}} N_{\text{bkg}}^{j} < 1/\epsilon_{\text{rec}}^{j}}{L \cdot A \cdot B \cdot \epsilon_{\text{sel}}} \]
Trigger:
- Single $\mu$, $p_T > 10$ GeV
- Single $e$, $p_T > 15$ GeV

Muon / electron:
- $2.0 < \eta < 4.5$
- $p_T > 20$ (5) GeV

Hadron:
- One prong
- $2.25 < \eta < 3.75$
- $p_T > 5$ GeV

Backgrounds considered:
- Electroweak (DY, WW, W/Z+jet, top)
- Hadronic (jet production)

Selection:
- Back-to-back: $\Delta\phi > 2.7$
- Isolated: $l_{PT} < 2(1)$ GeV
  $(\tau_\mu \tau_h, \tau_e \tau_h)$
- Lifetime: $IPS > 9$ (0)
  $(\tau_\mu \tau_e)$
- Unbalanced in $p_T$: $A_{PT} > 0.3$
  $(\tau_\mu \tau_\mu$ only)
<table>
<thead>
<tr>
<th>Source</th>
<th>Shape ((\mathbb{M}_{\tau\tau}))</th>
<th>Normalisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drell Yan (Z)</td>
<td>data (anticut IPS)</td>
<td>data ((80&lt;\mathbb{M}_{\mu\mu}&lt;100))</td>
</tr>
<tr>
<td>WW</td>
<td>simulation</td>
<td>simulation</td>
</tr>
<tr>
<td>W,Z + jet (EWK)</td>
<td>simulation</td>
<td>data ((\text{fitted os:ss,ss}))</td>
</tr>
<tr>
<td>Top production</td>
<td>simulation</td>
<td>simulation</td>
</tr>
<tr>
<td>Jet production (QCD)</td>
<td>data (anticut (\text{I}_{\text{PT}}))</td>
<td>data ((\text{fitted os:ss,ss}))</td>
</tr>
</tbody>
</table>

1. Cross-section definition
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4. Results
5. Conclusions
1. Cross-section definition
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**Channel**

<table>
<thead>
<tr>
<th></th>
<th>$\tau_\mu \tau_\mu$</th>
<th>$\tau_\mu \tau_e$</th>
<th>$\tau_e \tau_\mu$</th>
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<tbody>
<tr>
<td>No. observed</td>
<td>124</td>
<td>421</td>
<td>155</td>
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<tr>
<td>Background</td>
<td>42</td>
<td>130</td>
<td>57</td>
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<tr>
<td>Signal</td>
<td>82</td>
<td>291</td>
<td>98</td>
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</table>
1. Cross-section definition
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**Channel**

<table>
<thead>
<tr>
<th></th>
<th>$\tau_\mu \tau_h$</th>
<th>$\tau_e \tau_h$</th>
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<tr>
<td>No. observed</td>
<td>189</td>
<td>101</td>
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<tr>
<td>Background</td>
<td>53</td>
<td>37</td>
</tr>
<tr>
<td>Signal</td>
<td>136</td>
<td>66</td>
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</table>
Reconstruction efficiency:
- Trigger: data, tag and probe.
- Tracking: data, tag and probe (e, μ); data + simulation (had)
- Identification: data, tag and probe (e, μ); min. bias data (had)
1. Cross-section definition
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Luminosity:

$\sigma_{pp \rightarrow Z \rightarrow \tau \tau} = \frac{\sum_{i=1}^{N} 1/\epsilon_{\text{rec}}^i - \sum_{j=1}^{N_{\text{source}}} N_{\text{bkg}}^j < 1./\epsilon_{\text{rec}} >^j}{L \cdot A \cdot B \cdot \epsilon_{\text{sel}}}$

Luminosity:

$1.03 \pm 0.04 \text{ fb}^{-1}$ ($\mu$ triggers)
$0.96 \pm 0.03 \text{ fb}^{-1}$ (e triggers)
Acceptance:
Simulation
Pythia8, Herwig++, Powheg(NLO)
Branching fractions:
From PDG
44% of final states covered in this analysis.
Selection efficiency:
Simulation, calibrated to data where possible.
### Systematic errors

<table>
<thead>
<tr>
<th>Uncertainty (%)</th>
<th>$\tau_\mu \tau_\mu$</th>
<th>$\tau_\mu \tau_e$</th>
<th>$\tau_e \tau_\mu$</th>
<th>$\tau_\mu \tau_h$</th>
<th>$\tau_e \tau_h$</th>
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<tbody>
<tr>
<td>Acceptance</td>
<td>1.5</td>
<td>1.6</td>
<td>1.3</td>
<td>1.1</td>
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<tr>
<td>Branching fractions</td>
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<td>0.4</td>
<td>0.4</td>
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<tr>
<td>$N_{bkg}$</td>
<td><strong>10.0</strong></td>
<td>1.8</td>
<td>3.4</td>
<td>0.6</td>
<td>1.3</td>
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<td><strong>4.7</strong></td>
<td>2.1</td>
<td><strong>6.2</strong></td>
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<td>2.4</td>
<td><strong>4.7</strong></td>
<td>2.6</td>
<td>4.5</td>
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<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
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</tr>
</tbody>
</table>

**Statistically dominated.**

Sys: Z-$\rightarrow \mu\mu$ background ($\tau_\mu \tau_\mu$), electron track and trigger efficiency.
Agreement with NNLO
Agreement between channels
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Systematic errors
LHCb
LHCb vs. ATLAS, CMS


(courtesy P. Ilten). LHCb compares well with others.
Z-$\tau\tau$ production cross-section measured in forward region
Currently statistically dominated
Results in agreement with NNLO and Z-$\mu\mu$
Combined measurement competitive with Z-$\mu\mu$ precision