Measurement of the Z boson production cross-section at $\sqrt{s} = 13$ TeV at LHCb

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Event Selection

Integrated luminosity of dataset: 294 ± 11 pb⁻¹

Fiducial requirements:
- Oppositely charged lepton pairs (e⁺e⁻ or μ⁺μ⁻)
- Both leptons within LHCb acceptance ($2 ≤ \eta ≤ 4.5$)
- Transverse momentum of each lepton: $p_T > 20$ GeV
- Dilepton invariant mass: $60 < m_{ll} < 120$ GeV

Measurements corrected to the Born level in QED

Overall, 43,643 $Z \rightarrow \mu\mu$ and 16,395 $Z \rightarrow ee$ candidates selected

Results

Cross-sections are determined from data using: $\sigma_{Z \rightarrow ll} = \frac{(N - N_{BKG})}{(e \times L \times A)}$

Efficiencies are calculated from data using tag-and-probe methods. Unfolding and FSR corrections are found with MC

The measured cross-section is: $\sigma_{Z \rightarrow \mu\mu} = 194.3 \pm 0.9 \pm 3.6 \pm 7.6$ pb

The uncertainties are due to the size of the dataset, systematic effects and the luminosity determination respectively

The measurements are in very good agreement with NNLO predictions

With more data and a reduction in luminosity uncertainty, LHCb results will significantly constrain the PDFs

Comparisons of theoretical and measured cross-sections as functions of $p_T$, $y$ and $\Phi^*$ show no significant deviations

Uncertainties

<table>
<thead>
<tr>
<th>Source</th>
<th>$\Delta \sigma_\mu^Z$ [%]</th>
<th>$\Delta \sigma_\mu^T$ [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical</td>
<td>0.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Reconstruction efficiencies</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Purity</td>
<td>0.2</td>
<td>0.5</td>
</tr>
<tr>
<td>FSR</td>
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<td>0.2</td>
</tr>
<tr>
<td>Total systematic (excl. lumin.)</td>
<td>2.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Luminosity</td>
<td>3.9</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Motivation

LHC process cross-sections are given by the partonic cross-section convolved with the parton distribution function of colliding protons:

$$\sigma_{x,Q^2} = \sum_{a,b} \int dx_1 dx_2 f_a(x_1,Q^2)f_b(x_2,Q^2) \times \hat{\sigma}(x_1,x_2,Q^2)$$

- Measured cross-section: benchmark test of the Standard Model
- PDFs: LHCb provides constraints in a unique $x$-$Q^2$ region
- Partonic cross-section: very well known

Backgrounds

Heavy flavour hadron decays (data) , $Z \rightarrow \tau\tau$ decays (MC) , $t\bar{t}$ decays (MC) , WW decays (MC) , misidentified hadrons (data)

Overall purities: $\rho_{\mu\mu} = (99.2 \pm 0.2)\%$, $\rho_{ee} = (92.2 \pm 0.5)\%$

Reference:

Presented at the poster session of the 129th LHCC Meeting, 22nd February 2017 at CERN