Impact parameters resolutions in $\sqrt{s}=13$ TeV pp interactions measured with ATLAS at the LHC

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ATLAS detector

- is a particle physics experiment for pp, pA and AA collisions investigated for energies 0.9 - 14 TeV at the Large Hadron Collider at CERN
- covers almost the whole solid angle around the collision point with layers of tracking detectors, calorimeters and muon chambers
- for our measurements the tracking devices and the trigger system are of particular importance
Introduction

- The distributions are corrected for detector effects and are presented as inclusive-inelastic distributions, in a well-defined fiducial region.
- These distributions are compared to particle level Monte Carlo (MC) predictions.
Motivation

- The motivation of these study are analysis of transverse, $d_0$, and longitudinal, $z_0\left(sin\Theta\right)$, Impact Parameters (IP) distributions within the Inner Detector for Selected, Primaries and Secondary (electrons and non-electrons) tracks with the aim of characterizing the resolution, alignment and material budget in dependent from $\eta$, $p_T$ and $n_{sel}$

- The comparison of Monte-Carlo predictions for IP distributions with Experimental results are good source of information for verification of ATLAS Geo Model for Inner Detector.

- Impact parameters are one of the most important criterion for reconstructed track selection.
Impact parameters $d_0$ and $z_0(\sin \Theta)$

$d_0$ - the signed distance to the z-axis

$z_0(\sin \Theta)$ - the z-coordinate of the track at the point of closest approach to the global z-axis

**Figure 6.4:** Illustration of the perigee parameters of a track in the transverse plane (left) and RZ-plane (right), as defined in the global ATLAS tracking frame.
Track distribution for $d_0$ parameter

Run 2 for pp at 13 TeV

Run 1 for pp 0.9 – 8 TeV
Convolution of Gaussian with Gaussian for $\sigma(d_0)$ and $\sigma(z_0 \sin \Theta)$

$$P_{IP \otimes BS} = \frac{C}{\sqrt{2\pi(\sigma_{IP}^2 + \sigma_{BS}^2)}} e^{- \frac{(x-(\mu_{IP}+\mu_{BS}))^2}{2(\sigma_{IP}^2 + \sigma_{BS}^2)}}$$

- The beam spot resolution for $\sigma_{BS}(d_0) = \sigma_{BS}$
- The beam spot resolution for $\sigma_{BS}(z_0) = \sigma_{BS} \cotg \Theta$
- The beam spot resolution for $\sigma_{BS}(z_0 \sin \Theta) = \sigma_{BS} \cos \Theta$
- $C$ – normalization parameter
- $\sigma_{IP}$ and $\mu_{IP}$ - resolution and average of the IP
- $\sigma_{BS}$ and $\mu_{BS}$ - resolution and average for beam spot
Resolution in dependence from $\eta$ for $d_0$ at 13 TeV

Reprocessing. Average of IP $d_0$

Deconvolution. Resolution of IP $d_0$
Resolution in dependence from $p_T$ for $d_0$ at 13 TeV.

Reprocessing. Average of IP d0

Deconvolution. Resolution of IP d0
Charged-particle multiplicities at $\sqrt{s}=13$ TeV

- Results of our investigation for impact parameters are included in these distributions.
- Absolutely new energy
Conclusion

- Impact parameters resolution are very important for correct track selection.
- IP resolution is twice better for Run2 than for Run1 geometry. It means that background from secondary tracks are smaller.
- The IP d0 and z0 sinΘ resolutions for experimental data are in good agreement with MC prediction.
- The IP d0 and z0 sinΘ averages for experimental data are in good agreement with MC predictions.
Thank you for your attention
BACKUP SLIDES
Selection of tracks

**Selection cuts at 13 TeV**

- Select only well-defined tracks,
- Select a primary vertex to reduce error in IP.

<table>
<thead>
<tr>
<th>Cut parameter</th>
<th>Cut value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_T$</td>
<td>$&gt; 0.5 \text{ GeV/c}$</td>
</tr>
<tr>
<td>$</td>
<td>\eta</td>
</tr>
<tr>
<td>Number of Silicon hits</td>
<td>$\geq 6$</td>
</tr>
<tr>
<td>Number of Pixel hits</td>
<td>$\geq 1$</td>
</tr>
<tr>
<td>Number of b-layer hits</td>
<td>$&gt; 0$</td>
</tr>
<tr>
<td>Number of tracks in PV</td>
<td>$&gt; 1$</td>
</tr>
<tr>
<td>Number of PVs</td>
<td>$= 1$</td>
</tr>
<tr>
<td>Number tracks in PV</td>
<td>$\geq 2$</td>
</tr>
<tr>
<td>Track Probability for $p_T&gt;10 \text{ GeV}$</td>
<td>$\geq 0.01$</td>
</tr>
</tbody>
</table>
Track distribution for $z_0(\sin \Theta)$ parameter

Run 2

Run 1
Resolution in dependence from $n_{sel}$ for $d_0$

Reprocessing. Average of IP d0

Deconvolution. Resolution of IP d0

**ATLAS Internal**

- $\sqrt{s} = 13$ TeV
- $n_{sel} \geq 1$
- $p_T > 500$ MeV
- $|\eta| < 2.5$
Resolution in dependence from $\eta$ for $z_0(s\sin\Theta)$

Reprocessing. Average of IP $z_0\sin\Theta$

Deconvolution. Resolution of IP $z_0\sin\Theta$
Resolution in dependence from $p_T$ for $z_0(\sin\Theta)$

Reprocessing. Average of IP $z_0\sin\Theta$

Deconvolution. Resolution of IP $z_0\sin\Theta$
Resolution in dependence from $n_{sel}$ for $z_0(\sin\Theta)$

Reprocessing. Average of IP $z_0\sin\Theta$:

- $\sqrt{s} = 13$ TeV
- $n_{sel} \geq 1$
- $p_T > 500$ MeV
- $|\eta| < 2.5$

Deconvolution. Resolution of IP $z_0\sin\Theta$:

- $\sqrt{s} = 13$ TeV
- $n_{sel} \geq 1$
- $p_T > 500$ MeV
- $|\eta| < 2.5$