Cluster charge distributions in Barrel Pixel Read Out Chips

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Pixel detector components

Barrel layer

A module

Barrel → Half Shell → Layer → Ladder → Module

↑

Pixel

↓

Endcap → Half Cylinder → Half Disk → Blade → Panel → Module

↓

ROC

↑

http://grid.kfki.hu/twiki/bin/view/CMS/DetectorComponents
Pixel detector components (Barrel)

A ladder consists of 8 modules along the Barrel.
A module has either 8 or 16 readout chips (ROC) arranged in a $1 \times 8$ (for half-ladders) or $2 \times 8$ (for full-ladders) configuration.
A readout chip (ROC) is an array of $80 \times 52$ pixels, each of size $100 \, \mu m \times 150 \, \mu m$. 
Method

• Ionizing particle creates electron-whole pairs.
• Signal is converted and amplified by the ROCs.
• Hit clusters = overall collection of hit pixels.
• Select hit clusters associated to Reconstructed Trajectory Hits in the Barrel.
• Look at cluster charge distribution per Read Out Chip for these clusters.

Dataset

• Dataset:
  - /MinimumBias/Run2010B-Dec22ReReco
• CMSSW version:
  - CMSSW_3_8_6
• Lumi selection from JSON files:
  - Cert_136033-149442_7TeV_Dec22ReReco_Collisions10_JSON.txt
Fitting per ROC

- Use normalized cluster charge, i.e. cluster charge corrected by the incident angle of the trajectory, so that all tracks appear to enter perpendicularly to the detector.
- The cluster charge distribution is a superposition of smeared Landau distributions.
- Fit with a Landau+Gaussian in two steps:
  - **First**: fit with L+G with some reasonable parameters/limits,
  - **Second**: constrain the mean of the Gaussian to be within ~1 sigma of the Landau MPV fit and fit again.

\[ \chi^2, \text{Ndof: 19} \]
Fit results

• In general Gaussian behavior of the Mean fits of ROCs.
• Shift of the Mean average between the Layer 1 and Layer 2,3 is clearly visible in the average of the Mean.
• The width seems to be compatible between the Layers.

<table>
<thead>
<tr>
<th></th>
<th>σ</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>1.59</td>
<td>22.2</td>
</tr>
<tr>
<td>L2</td>
<td>1.55</td>
<td>21.8</td>
</tr>
<tr>
<td>L3</td>
<td>1.64</td>
<td>21.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>1 σ int.</th>
<th>2 σ int.</th>
<th>3 σ int.</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>68.4%</td>
<td>94.7%</td>
<td>99.4%</td>
</tr>
<tr>
<td>L2</td>
<td>68.6%</td>
<td>94.3%</td>
<td>98.8%</td>
</tr>
<tr>
<td>L3</td>
<td>69.4%</td>
<td>93.2%</td>
<td>98.6%</td>
</tr>
</tbody>
</table>
## ROC quality

<table>
<thead>
<tr>
<th>σ interval</th>
<th>Good</th>
<th>OK</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2 - 3</td>
<td>&gt; 3</td>
</tr>
<tr>
<td>&lt;=3</td>
<td>2</td>
<td>3 - 10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Mean error</td>
<td>&lt; Mean</td>
<td>&lt; Mean</td>
<td>&gt; Mean</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>χ²/N dof</th>
<th>Good</th>
<th>OK</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=3</td>
<td>145</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>&gt;10</td>
<td>145</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>&gt; 3σ</td>
<td>145</td>
<td>18</td>
<td>12</td>
</tr>
</tbody>
</table>
Fit results - MPV of Landau

Layer 1

Layer 2

Layer 3
Fit results - Significance

Layer 1

Layer 3

Layer 2

- Significance: 
  $|\text{MPV Fit} - \text{MPV Mean}| / \text{Sigma}$
Tail of the cluster charge distributions

- Observation: bad ROCs have something going on in the tails
- Look at the tail of the cluster charge distribution
- Plot the fraction of the charge in the tails w.r.t. the total charge per ROC
Fraction of entries in lower tail of the cluster charge distributions

Layer 1

Layer 2

Layer 3

- The modules became visible
- But some full or half modules are pronounced in Layers 2 and 3
Impact of Time Delay on Landau MPV mean (2011 MinBias Run)

• Using the mean MPV of all ROCs per BPix layer.
• At the correct timing the average cluster charge MPV is expected to be at maximum.
• Timing of all 3 layers consistent with each other.
• Uncertainties are the standard errors on the MPV mean fits.
Conclusions

- ROC quality monitoring in Barrel Pixel
- Fit cluster charge distribution from multi-pixel RecHits associated to track segments per ROC
- Mainly Gaussian distribution of cluster charge mean
- ~ 1 % Bad ROCs, dominated by > 3 sigma cases

Tasks:
- Impact of HV bias on cluster charge distribution
- Bad ROC into prompt calibration loop
- FED error propagation