The ATLAS Pixel Detector with IBL

The ATLAS Pixel Detector consisted of:
- three barrel layers
- three disks on each side closing the barrel

The Insertable B-Layer (IBL) has been added at a radius of 3.3 cm in 2014 to improve tracking and vertex reconstruction performances.

The Pixel Detector is now ready to join the ATLAS data acquisition campaign starting in June 2015.

Calibration Analysis

The calibration analysis runs offline to:
- Classify the modules
- Test the Calibration results

The analysis is started by the user:
1. Takes in input the Scans histograms stored after the detector Calibration
2. Checks the scan and modules configurations from the Database
3. Compares the pixels response with the expectations
4. A map of the not properly responding pixels is generated for each module to mask them from the data taking

Threshold Analysis

The threshold value can be adjusted operating on the FE registers.

It corresponds to the minimum charge release for a hit to be considered ~3000 electrons (~20000 for a mip).

The noise has to be uniform and to not exceed ~400 electrons.

A threshold scan measures the occupancy at different injected charges. The typical outcome is an S-curve for each pixel.

The mean value of the S-curve is the threshold, the bending gives information regarding the noise.

The noise and the threshold distributions per module are stored in local disks.

Success or the failure of a threshold tuning can be assessed analysing a threshold scan.

The modules are then classified depending on their threshold and noise distributions.

Noisy pixels have to be excluded from the data taking.

TOT Analysis

The Time over Threshold is proportional to the particles charge release.

At fixed charge injection, the ToT depends on the threshold value and on the charge conversion.

- In FE-I3 8 bit are dedicated to the ToT, 4 in FE-I4
- The last bit is dedicated to the overflow (all ToT values greater than the maximum: 2^{n-2}=14)

High ToT values will correspond to high charge release but also to higher processing time.

The ToT analysis verifies that a ToT tuning succeeded and that a given charge corresponds to the expected ToT value for all the pixels within a module.

A typical charge-ToT curve is presented below for a FE-I4 (system test).

Bump Analysis

The bump bonds are metallic drops connecting the FE chip to the sensor.

Bumps can be merged or disconnected.

The bump analysis classifies the modules with respect to the bump bonds conditions.

The scans needed to perform the analysis are:
- Crosstalk scan
- Threshold scan
- Analog scan
- Analog scan with low injected charge

Test criteria:

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Crosstalk</th>
<th>Analog low charge</th>
<th>Analog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merged</td>
<td>---</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Dead</td>
<td>---</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Known good</td>
<td>x</td>
<td>x</td>
<td>---</td>
</tr>
<tr>
<td>Good</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Not good</td>
<td>x</td>
<td>x</td>
<td>---</td>
</tr>
</tbody>
</table>

Occupancy Analysis

The occupancy is the number of hits registered by the FE with respect to the number of charge injections.

It depends on a correct analog and digital FE response.

The algorithm identifies the number of pixels that present:
- Less hits than expected
- More hits than expected
- No hits

Depending on the defects, the module may be considered not reliable for data taking.

Above one stave from the system test, the modules are coloured depending on the extra hits.

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