Results from the Commissioning of the ATLAS Pixel Detector with Cosmics Data

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Abstract

The ATLAS pixel detector consists of three barrel layers and three disk-layers in the endcaps, comprising a total of 80 million pixel cells. Commissioning for the pixel detector has started in spring 2008. A representative selection of commissioning results is given.

Key words: ATLAS, Pixel, Commissioning

1. Introduction

The ATLAS pixel detector consists of 1744 individual modules, each comprising 46080 pixels of $50 \times 400 \mu\text{m}^2$ [1]. The connection between modules and off-detector electronics is made using a custom optical link. The detector was installed in the center of ATLAS in June 2007.

2. Commissioning in 2008

Commissioning of the pixel detector started in April 2008 when the electrical, optical, and cooling connections were finished. It was soon interrupted by a failure of the cooling system, to be restarted only in August with the adjustment of the operational parameters of the optical link followed by verification tests to determine the largest possible sample of modules to be included in a combined ATLAS data taking run. After the LHC incident the commissioning program was extended until the end of 2008 to refine the parameters of the optical links as well as to improve the module performance and to obtain a complete set of calibrations needed for offline data analysis.

3. Calibration Results

Optical link tuning

An automated tuning procedure is used to determine the optimal set of parameters in on-detector laser power, off-detector threshold and data sampling phase. Using this algorithm 96% of all links could be adjusted, the remaining ones needing some manual fine-tuning due to effects like large spread of laser power across one laser array.

Threshold and noise

The discriminator threshold for each pixel is adjusted to 4000 e^- . Figure 1 shows the threshold and noise distributions for 94% of all pixels, showing a threshold non-uniformity of 1%. The noise distribution peaks at 165 e^- .

Charge measurement

The charge measurement, using the time-over-threshold (TOT)

Figure 1: Top: Distribution of discriminator thresholds over 75 million pixels with an RMS of 40 e^- . Bottom: Distribution of single channel noise over 75 million pixels, peaking at 165 e^- .

method, is adjusted for every pixel to yield a TOT of 30 LHC bunch-crossing units (BX) for a charge deposition of 20 ke^- . Figure 2 shows the TOT distribution for 94% of all pixels, displaying a non-uniformity of only 2% in TOT.

4. Cosmic Data Taking

In the combined ATLAS and Inner Detector stand-alone cosmic runs a total of 450000 tracks were recorded with hits in the pixel detector. During the data taking 96% of all pixel modules were operational. The hit efficiency of the three barrel layers was measured to be around 99.8%, excluding known bad modules (see Figure 4). After masking noisy pixels accounting for less than 10^{-4} of all pixels an occupancy due to noise hits below

Figure 2: Distribution of TOT values over 75 million pixels with an RMS of 0.65 BX.

Figure 3: Correlation of TOT with injected charge. Color-coded is the number of pixels.

2×10^{-10} was measured, as shown in Figure 5. The data was used for alignment of the pixel detector, reducing the width of the distribution of track residuals for clusters with two hit pixels to $23.4 \mu\text{m}$ in the $50 \mu\text{m}$ pixel direction using charge interpolation between the clustered pixels (see Figure 6). Using the TOT calibration (Figure 3) the reconstructed charge for clusters associated to tracks was measured to be within 7% of the expected value.

5. Conclusions

The commissioning of the ATLAS pixel detector started in august 2008, achieving basic data taking readiness in time for the first LHC beams in september. After the LHC incident the commissioning program was extended until the end of 2008, concentrating on improving the detector efficiency through improvements in software and to refining the tuning of the parameters of the optical links. The commissioning phase was also used to successfully train about 40 non-expert detector operators for continued shift operation.

References

- [1] G. Aad et al., *ATLAS Pixel Detector Electronics and Sensors*. JINST 3 P07007, 2008

Figure 4: Hit efficiency of the three barrel layers measured using cosmic tracks. The hit efficiency is around 99.8%.

Figure 5: Noise occupancy after masking a fraction of about 10^{-4} pixels due to noise.

Figure 6: Comparison of track residual distributions for the nominal and the simulated perfect geometry, as well as with the aligned geometry as calculated using the cosmes data. The width of the latter distribution is $24 \mu\text{m}$.