Study of Charge Clusters in the ATLAS SCT

Cristina Oropeza Barrera, Craig Buttar

I. Introduction

ATLAS is the largest particle detector ever constructed. At its centre lies the **Inner Detector** whose purpose is to provide robust pattern recognition, accurately measure the momentum of charged particles and their trajectories and to identify primary and secondary vertices.

The SCT is divided in 4 barrel layers and 9 discs in each of its two endcap regions. An **SCT module** consists of two pairs of single-sided p-in-n silicon microstrip sensors glued back-to-back with a 40 mrad stereo rotation angle. The sensors are 285 µm thick and are fully depleted at about 65V. However, to reduce noise and to cope with the LHC clock of 25 ns, the operation voltage is set to 150V [1].

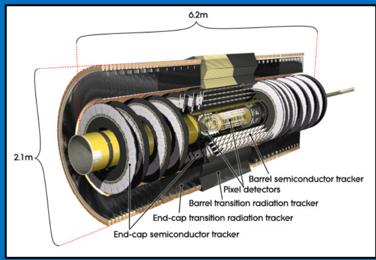


Figure 1. 3D schematic view of the Inner Detector.

II. Depletion Depth

Depletion Depth => active volume of the sensor

Importance: the depletion depth is an important parameter to monitor since it affects the hit efficiency and spatial resolution of the SCT modules. This study can be carried out throughout the whole SCT life (radiation damage => greater depletion voltage of about 350 V).

Two methods were used to extract the depletion depth from cosmic-ray data:

A) Track Depth Approach

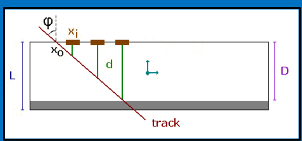


Figure 2: Schematic view of a particle crossing an SCT sensor.

The track depth is given by:

$$d = \frac{x_i - x_0}{\tan\varphi}$$

x_0 = entry point

x_i = local position of strip

φ = incidence angle

It is calculated for every strip in every cluster and stored in a histogram which is then fitted with this error function [2]:

$$f(D_f - x) = 1 - \frac{a}{2} Erfc\left(\frac{D_f - x}{b\sqrt{2}}\right)$$

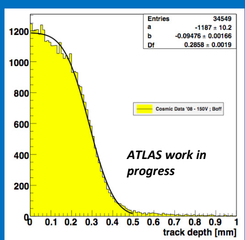


Figure 3. Example of a track depth fit using cosmic data (B-field off; 150 V)

For cosmic-ray data taken with the solenoid magnetic field off (150V and 50V), this method gives results consistent with the expected values.

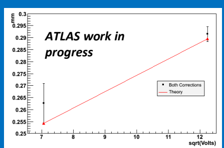


Figure 4. Depletion depth as a function of sqrt(voltage) for cosmic runs without the solenoid magnetic field

Below depletion voltage:

$$D \propto \sqrt{V_{bias}}$$

B) Fit to Slope Approach

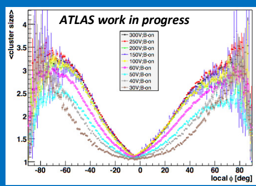


Figure 6. Average cluster size as a function of the local incidence angle at different bias voltages.

The average cluster size as a function of the local incidence angle changes as the bias voltage decreases: slope is an indirect measurement of how depleted the sensors are.

This method is particularly useful for data with the magnetic field on, since the geometrical track depth method doesn't take into account the effect of the Lorentz force on the charge liberated by the incoming particle.

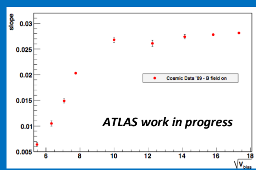
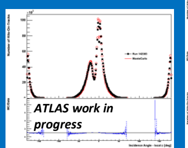


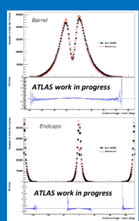
Figure 7. Slope as a function of the sqrt(voltage). The slope stays flat for voltages above the depletion one and falls rapidly below it.

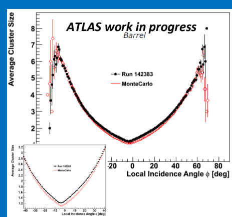
III. Data/MC Comparison

Some plots comparing 900 GeV data and MonteCarlo (see caption at the bottom right). Overall there is good agreement, however a 5% difference in the mean number of strips hit has been observed. This indicates that SCT digitisation model needs tuning.

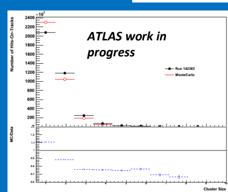


(a)





(b)



(c)

Figure 8. (a) Local incidence angle phi for all tracks, tracks in the barrel and in the endcaps. Overall good agreement. (b) Average cluster size as a function of the incidence angle. Discrepancies around the minimum. (c) Cluster size distribution. Significant differences. MC produces more single-strip clusters.

IV. Summary/Future Work

- The depletion depth has been studied in great detail using different methods for cosmic-ray data with and without the magnetic field => implement code to monitor this quantity.
- A first comparison of 900 GeV collision data and MC simulation shows discrepancies in the cluster size => Tune SCT digitisation model.

References:

[1] ATLAS Collaboration and G. Aad et al. The ATLAS Experiment at the CERN Large Hadron Collider, JINST, 3:S08003,2008.

[2] P.Behera, T.Lari and A.L.Schorlemmer. Measurement of the Lorentz angle and depletion depth in the ATLAS Pixel Detector with cosmic rays data, ATL- COM-INDET-2010-041.