Silicon Sensors for the Calibration of ATLAS Muon Chambers

F. Fiedler , O. Biebel , T. Christiansen , J. Dubbert , G. Duckeck , J. Elmsheuser , M. Erlebach , R. Hertenberger , J. Kennedy , R. Mameghani , D. Merkl , T. Nunnemann , M. Obermaier , F. Rauscher , H. Schachenmayr , D. Schaile , M. Schott , A. Staude , H. Steffens , R. Ströhmer , B. Ujvári [a], A. Varga , F. Vollmer , and C. Zupancic

[a] Marie Curie Fellow

For the ATLAS experiment at the future LHC collider at CERN, 88 muon chambers are constructed in collaboration between Dubna, MPI München, and LMU. To determine the positions of the four aluminium alignment platforms on each of the chambers, silicon detector systems have been developed and constructed at LMU [1]. This article describes their integration into the readout of the cosmic ray measurement facility and the data analysis.

Figure 1 shows the principle of the measurement. A cosmic ray muon passing through the setup traverses the silicon detector box mounted on an alignment platform. From the correlation between the muon trajectory in the chamber and the signal seen on the silicon sensor, the alignment platform position can be determined.

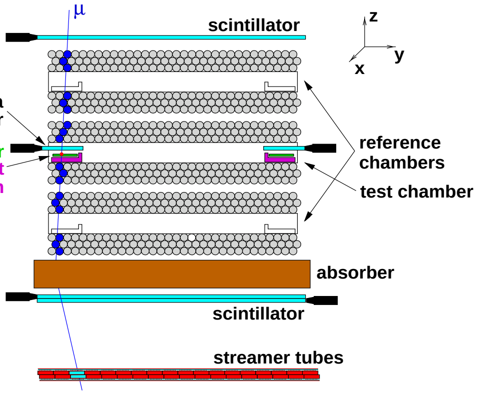

Fig. 1: A schematic drawing of the Cosmic Ray Test Facility with a muon traversing both the chambers and a silicon detector box.

The silicon strip signals are read out with VA2 [2] hybrids and passed via a repeater card to the digitization electronics, using V551 sequencer and V550 ADC boards.

Only a small fraction of cosmic rays traversing the cosmic ray measurement facility actually pass the silicon sensors. To limit the data volume and to ensure a reasonable trigger rate despite the dead-time for processing of the silicon strip signals, extra scintillators are installed above the silicon detector boxes. For regular event triggers, requiring signals in the upper and lower scintillator layers, no silicon detector data is processed. The silicon data is only read out, digitized, and stored with the event if one of these extra scintillators has a signal in coincidence with the scintillator bars vertically underneath it (in this case no signal from the upper scintillator layer is required to maximise the angular acceptance). Typical rates are 60 Hz for regular events and 1 Hz for events with silicon detector data.

The silicon detector data analysis proceeds by identifying noisy and dead strips, subtracting common mode noise and pedestal offsets, and forming clusters of adjacent strips with significant collected charge. Figure 2 shows a typical resulting distribution of cluster positions on a silicon sensor. The slight asymmetry is expected and is caused by the variation of the angular acceptance with the position on the detector.

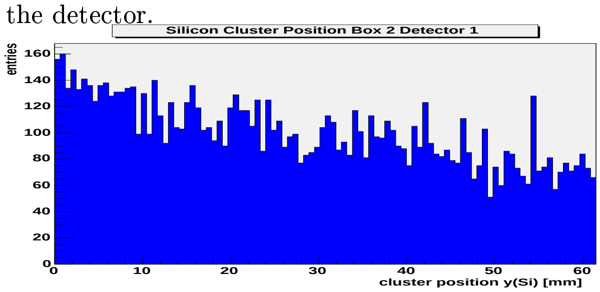

Fig. 2: Distribution of reconstructed cluster positions on a silicon detector.

To determine the position of the alignment platform, the muon trajectory is reconstructed in the test chamber. The difference $\Delta y(\text{track} - \text{cluster})$ of y positions measured in the muon chamber and on the silicon sensor is plotted in bins of the track inclination $m_y = \mathrm{d}y/\mathrm{d}z$ for a first estimate of the silicon sensor y and z position. For each m_y bin, the Δy distribution is fitted with a Gaussian. The mean values of the Gaussians as a function of m_y are fitted with a straight line, whose parameters yield corrections to the initial y and z position estimate. This procedure is iterated and yields stable results as shown in Figure 3 typically after 3 iterations.

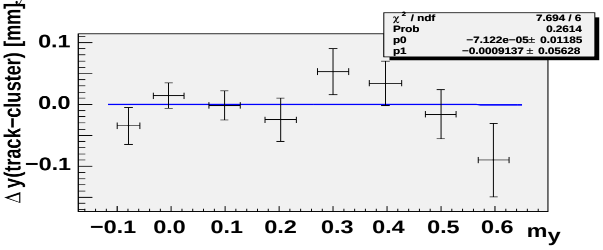

Fig. 3: The mean value of Gaussian fits to the Δy distributions measured in various m_y bins, fitted with a straight line as a function of m_y. The fit for the final iteration is shown.

In the example shown in Figure 3 the y position of the alignment platform has been determined with a *statistical* precision of 12 μm. These results will be calibrated with measurements of alignment platforms on chambers which have been scanned in an X-ray tomograph. The systematic uncertainty from positioning the sensors on the alignment platforms will be determined e.g. from data where the silicon sensors have been re-mounted several times.

References

[1] F. Fiedler *et al.*, Annual report 2003, p. 87
[2] http://www.ideas.no/products/ASICs/pdf/VA2S2.pdf