Cosmic and Final ATLAS Inner Detector – SCT tests

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***Abstract*–A combined cosmic run of the ATLAS SemiConductor (SCT) and Transition Radiator Tracker (TRT) has taken place successfully in May 2006, allowing to fully test both detectors before installation in the ATLAS cavern and the full operation chain: data acquisition, detector control and safety system, monitoring and offline reconstruction, alignment and analysis chains.**

I. Introduction

A combined cosmic run of the ATLAS SemiConductor tracker (SCT) with the Transition Radiator Tracker (TRT) took place at CERN in May 2006 in the SR1 building of the ATLAS experimental site.

There were many motivations for such a test. On the operational side, it would allow to gain experience on detector operation, test combined detector supply systems, commission and test combined readout and trigger and commission the offline software chain with real data. On the performance side, it would allow to test for the first time the 4 SCT barrels together and their synchronous operation with the TRT, check grounding and cross talk noise and collect cosmic rays for efficiency, tracking and alignment studies.

About ¼ of the SCT and 1/8 of the TRT were cabled and the connectivity was well verified afterwards, checking the pipe work pressure, power supplies and fibres (see Fig. 1). The procedure was proven to be very important for the installation down in the cavern that is taking place right now.

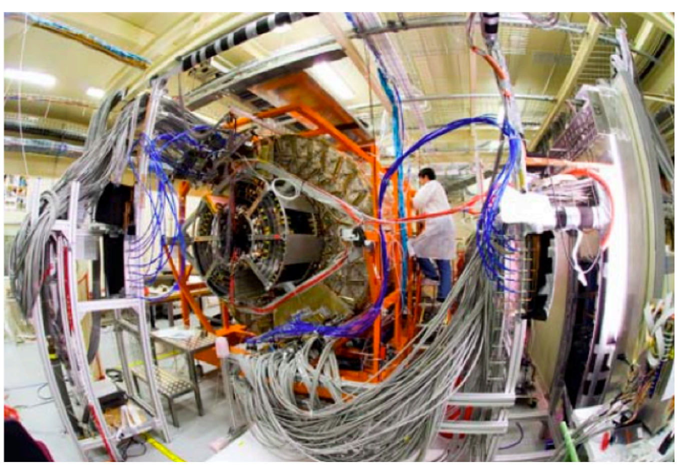

Fig. 1: Picture of the SCT and TRT barrel during the cabling process.

The trigger was provided by a set of scintillators at the top and bottom of the barrel and a third scintillator was installed under the concrete floor to get rid of very low energy particles. That was convenient because there was no magnetic field in the setup and therefore the tracking algorithms could not take material effects into account. Fig. 2 shows a schematic view of the full setup.

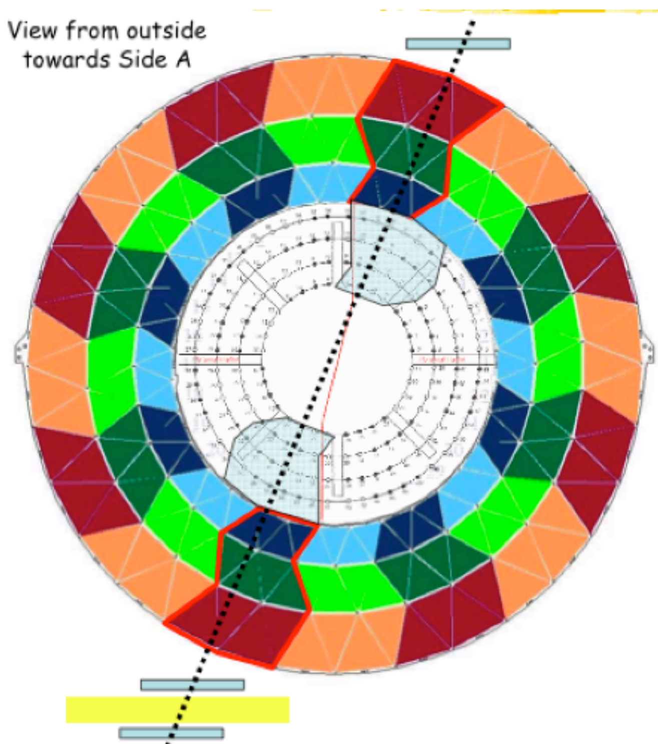

Fig. 2: Schematic view of the setup used for the cosmic ray combined run.

Calibrations were then performed to adjust the readout settings. Digital functions and analog performance were also verified.

II. Detector operation

In order to operate the detector there are three basic ingredients that are needed in the chain.

First the detector control system (DCS) in order to provide the monitoring of the cooling system, environmental and power supplies (which are in addition also controlled by the DCS system). Fig. 3 shows an example of the environmental temperature monitored during a normal day of running. A hardware based interlock safety system is also essential in order to stop the acquisition if required.

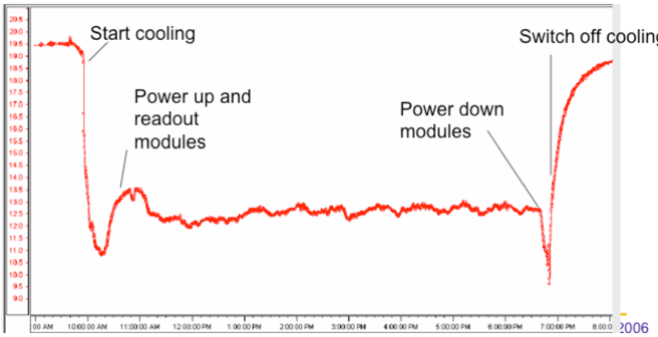

Fig. 3: Result of the monitoring of the environmental temperature in a normal day of running, done by the DCS system.

Second, the data acquisition chain (DAQ) that would give as an output the raw data byte stream file. A lot of experience was gained in the DAQ for both modes of running (calibration and physics mode) and specific tools were developed to time in the detectors and understand possible synchronization problems.

The third element is the software reconstruction and monitoring chains that are needed to provide event displays and a detailed monitoring of the detector performance. An example of an event display in which a comic ray track is reconstructed is shown in Fig. 4.

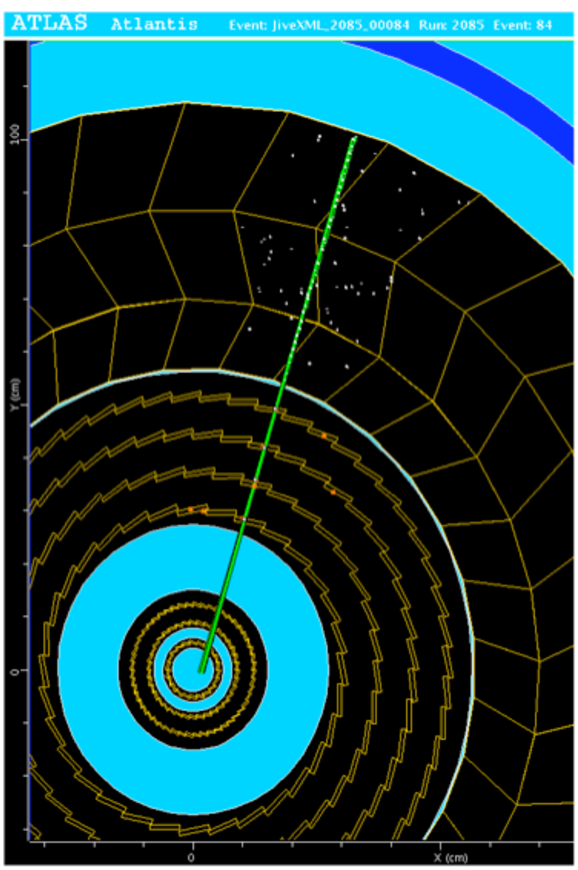

Fig 4: Event display of cosmic ray reconstructed track going through both SCT and TRT systems. The hits produced in the detectors are also displayed.

III. Data analysis

The offline reconstruction software was used to analyse both noise and cosmic runs, providing prompt feedback to the detector performance.

Concerning the noise studies, the noise was tested for many different conditions: varying the trigger rate from 5 Hz to 50 KHz, for different thresholds, having the TRT on and off, with the heaters on, off and switching between the two states, several grounding schemes and while the TRT was being readout. No increase of noise was observed in any of the configurations tested. As an example, Fig. 5 shows the SCT module noise occupancy distribution for two different grounding schemes, being the difference between the two distributions negligible.

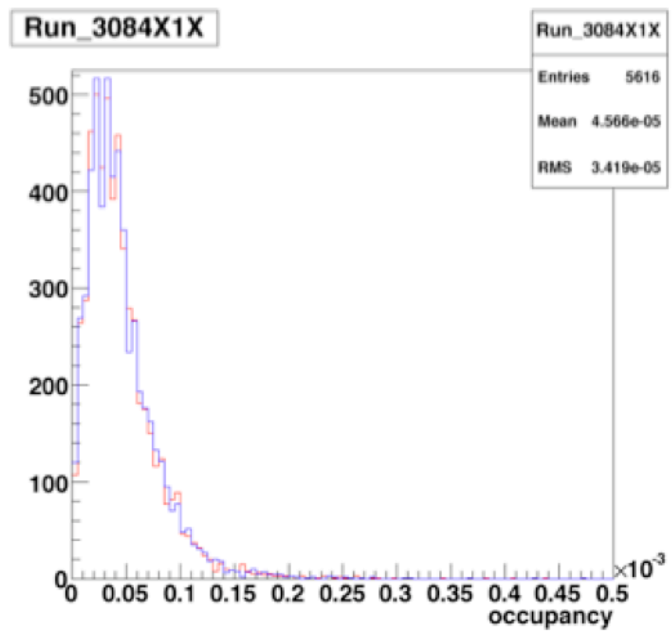

Fig. 5: Distribution of the SCT module noise occupancy distribution for two different grounding schemes.

It was also observed that the calibration done with capacitance correction provided less spread in the modules noise occupancy and therefore that was the calibration used in most of the cosmic ray runs.

The offline reconstruction chain and the different alignment and calibration methods were verified for the first time with real cosmic events, allowing a detailed verification of the detector performance.

Fig. 6 and 7 show the distribution of the SCT residuals in one of the layers before and after alignment. Note that residuals are broader than the expected detector resolution (~ 23 microns) due to the fact that the tracking algorithms cannot take material effects into account. The alignment corrections cannot directly be applied to reconstruct the future LHC data since the detector slightly moves while being installed inside the ATLAS calorimeters in the cavern. However, it proofs that the alignment procedure can work with cosmic tracks so that it can be performed again with the detector in the final position in the ATLAS pit.

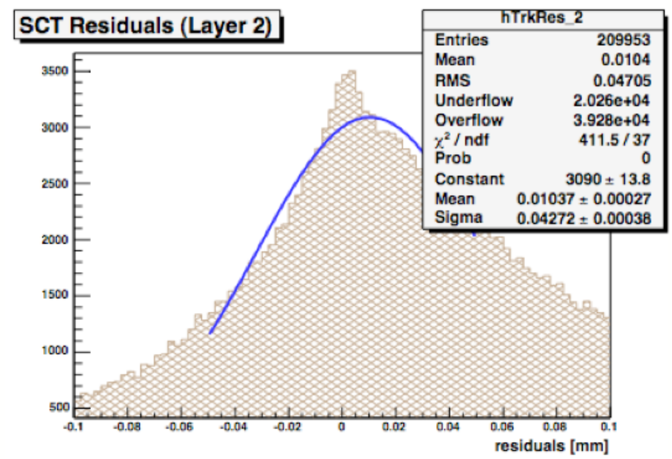

Fig. 6: SCT residuals with the as built geometry before applying any alignment corrections.

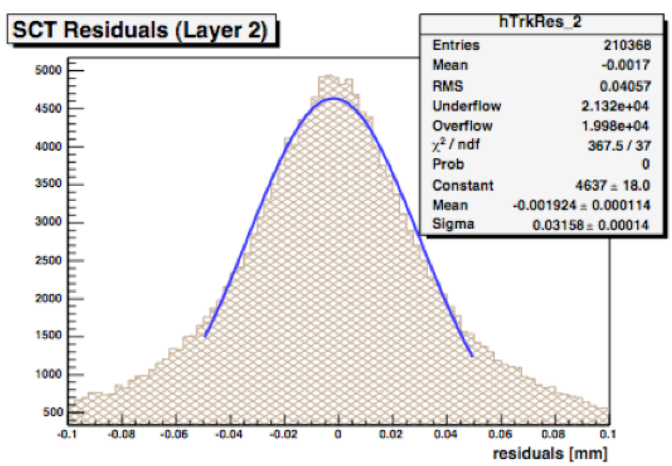

Fig. 7: SCT residuals obtained after alignment.

Concerning the detector performance, the analysis showed that the SCT was well within specifications. Fig. 8 shows as an example the SCT module side efficiencies for one of the four layers.

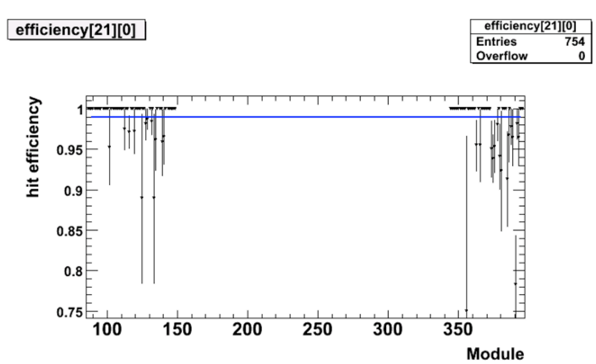

Fig. 8: SCT module side efficiencies for those modules contained in layer 0.

IV. CONCLUSIONS

A big step towards the commissioning of the Inner Detector has been accomplished by the combined test with SCT and TRT barrels. Full DAQ, DCS, monitoring and offline chains have been successfully tested. The good performance of the detector has been verified.

REFERENCES

[1] Inner Detector Technical Design report, CERN/LHCC/97-17.