# The ATLAS SCT Forward System Test

Paul Dervan

*On behalf of the ATLAS SCT Collaboration*

***Abstract*— The details of the ATLAS SCT system test are described in detail. Up to 6 forward silicon microstrip modules have been tested on the system and shown to performance well within specifications. Different grounding and shielding configurations have been tried and compared.**

***Index Terms*— ATLAS, SCT, silicon, grounding.**

## I. Introduction

ATLAS [1] is one of the two multipurpose detectors for new physics at the Large Hadron Collider (LHC) at CERN. The ATLAS Semiconductor Tracker (SCT) [2], [3] consists of two parts, the barrel section and the the forward. The forward part is built up of 9 wheels on each side of the barrel. Onto which are placed 3 types of silicon microstrip detector modules (inner, middle and outer) giving an $\eta$ coverage of 1.4 to 2.5.

The outer and middle modules are made from four wedge shaped sensors, glued in pairs on either side of a thermally highly conductive baseplate (the inner from two sensors). The second pair are rotated 40 mrad in the $\phi$ plane relative to the first pair. The sensors are p-in-n silicon wafers with 768 strips per measuring plane. Each module is equipped with a hybrid holding twelve binary ABCD read-out chips [4], six on each side. Each chip provides high-gain (50mV/fC) fast-shaping (20ns peaking time) binary read-out of 128 channels. Each module subtends an angle larger than required, to allow for a reasonable number of overlapping strips to ensure hermiticity. The outer ring is covered by 52 modules which have an active strip length of 121.1mm, the middle by 40 modules of active length 116.7 and the inner by 40 modules of active length 72mm.

The aim of the forward system test is to investigate the effect of pickup, crosstalk and common mode noise as functions of module location, grounding and neighbour module configuration, for as many modules (readout simultaneously) as possible in the final geometrical configuration of an SCT forward disk.

### A. The Forward System Test

The electrical forward system test uses a 90° sector of a forward disk equipped with a cooling system (outer, middle, and inner cooling circuits), all necessary services for the detector modules in any location on the sector, Fig. 1. The readout system is capable of reading out and controlling upto 12 modules. The aim is to progressively populate the sector with fully functional modules. The final sector will have 4 consecutive modules per cooling ring as this will be a fully populated environment for each geometrically different position on a disk in terms of nearest neighbour modules and services.

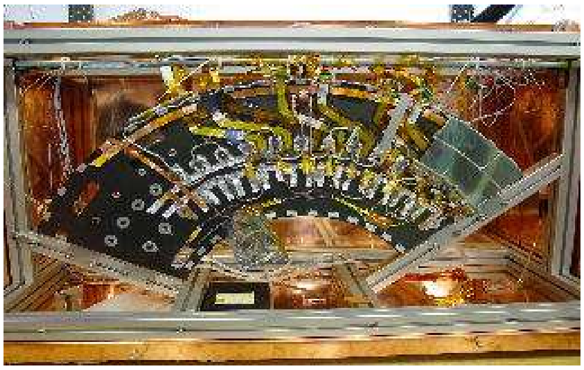

Fig. 1. Picture of the test sector and it's services. The three modules can be seen on the right hand side of the disk.

The modules are readout using a VME-based system that consists of four parts. Two parts, Cloac and Slog generate clock, command and trigger signals, another, Mustard, decodes the data received from the modules. All three are connected to an opto-transceiver, Optif, to transform the clock and command from electrical into optical and the received data from optical into electrical signals.

The digital and analogue voltages are supplied to the modules by the following chain. A 30m cable running from the low/high voltage power supplies in the VME crate to patch panel 2 (PPF2). Then a low mass kapton tape with 100 $\mu$m copper traces, carries the biases from PPF2 to patch panel 1 (PPF1). Low mass kapton tape with 50 $\mu$m thick aluminium traces, carries the biases from PPF1 to patch panel 0 PPF0. Then the "wiggly" kapton tape carries the biases from PPF0 onto the detector module. Optical fibres/pluggins are used to carry the command signal from the OPTIF (in the VME crate) to the detector module. And carry the data back from the detector to the DAQ.

### B. Grounding and Shielding

Three types of grounding schemes have been evaluated on the test sector. Common to all three schemes are the following:

- Continuous shielding of all cables and tapes (aluminium foil).
- Common mode chokes at PPF2 (to filter out noise from the power supplies.
- Capacitors connecting all lines to the shield at PPF1.

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P. Dervan is with Sheffield University.

- The sector is enclosed in a solid copper box ("thermal enclosure").
- Interconnecting foil rings on the disk, at the outer radius and at each ring of the cooling blocks.
- The thermal enclosure, support frame, disk skins, foil rings, cable shield and cooling circuits all connected together near PPF0.

The detailed specifics of the three grounding schemes are given below:

*1) "Shunt Shields In":* This scheme is based on the implementation of a shunt shield that would keep the module isolated from the cooling system. The shunt shield is implemented on the hybrid in two places. At the mounting point, to the cooling block, the shunt shield is implemented as an insulator/conductor/insulator sandwich incorporated in the hybrid. The conductor layer is electrically connected to module ground. At the detector side, the TPG in the module spine is isolated from the detector back planes and connected via a 47nF capacitor to AGND close to the connector.

Details of other grounding and shielding are given here:

- The cable shield is AC-tied to the VME ground.
- The cable shielding stops at the thermal enclosure.
- All the modules DGNDs are connected to the shield at PPF0.

*2) "Shunt Shields Shorted":* This scheme tries to minimise high frequency voltage differences between modules and adjacent structures. The module ground is DC connected to the cooling block so that the modules' power returns are shorted to the cooling circuit at the mounting point.

Details of other grounding and shielding are given here:

- The cable shield is AC-tied to DGND at the VME crate.
- The cable shielding continues all the way to PPF0.
- All the modules DGNDs are connected to the cooling circuit.

*3) "Double Short":* This scheme is a combination of both of the above.

- As the "Shunt Shields Shorted"
- But also with DGND tied together at PPF0.

### *C. Sector setup*

Three modules have been tested on the test sector. All three were outer modules (K5-400, k5-303 and k5-402), Fig. 2. They were placed on the right side of the sector. From left to right they are k5-400, k5-303 and k5-402. The middle module, k5-303, was on a low cooling block, and the other two were on high ones. This allows the overlapping of modules, for charge particle tracking. Also, the power tapes ran underneath k5-400 and k5-303, but not under k5-402.

The grounding schemes were tested by injecting noise (usually a 6MHz, 10V peak-to-peak, sine wave), via a coil about a ferrite ring onto the low mass tapes between PPF1 and PPF2, and onto the cooling circuit. Multiple tests were carried out to check the results were consistent.

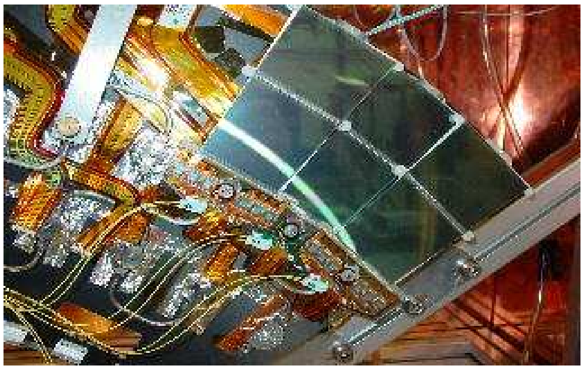

Fig. 2. The three modules used on the test sector. From left to right they are k5-400, k5-303 and k5-402.

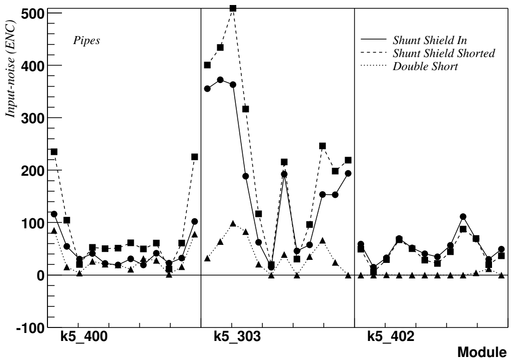


Fig. 3. Noise injection onto the pipes

### *D. Results*

The modules were characterised individually on the test sector and then tested together to see if the proximity of other modules affected their performance, for example noise pickup or crosstalk. No additional noise was observed when all three modules were tested together. Also, the performance of the modules with respect to noise pickup was exactly the same for all three grounding schemes when no noise was injected into the system.

When noise was injected onto the cooling pipes the "Shunt Shield In" and "Shunt Shield Shorted" scheme performed almost the same, Fig. 3. But the "Double Short" scheme performed better in rejecting the noise. Also of interest was that the noise pickup was largest on the lower, k5-303, module.

When noise was injected onto the power tapes the "Shunt Shield Shorted" scheme was the worst for picking up noise, Fig. 4. And again the "Double Short" scheme performed the best in rejecting the noise.

The modules were also moved around on the test sector to check if the pickup was module dependent or position dependent. It turned out it was position dependent. The middle (lower) position was always more susceptible to noise pickup. This was probably due to it's closer proximity to the power tapes and the cooling circuit.

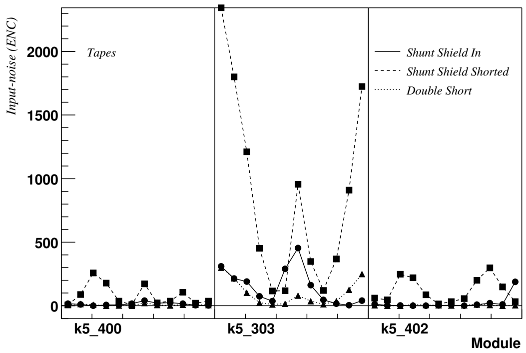


Fig. 4. Noise injection onto the tapes

## II. Conclusion

A prototype of a quarter of a forward SCT disk has been made with all the services. Three modules have been tested on this sector and noise injection studies have been performed to study three types of grounding and shielding schemes. The best for rejecting noise pick-up was the “Double Short” scheme. The noise pickup was also found to be position dependent but module independent.

The test sector is being up-graded so that further tests can be carried out with more forward modules of different types (middle and inner). At present 6 modules can be readout, 2 outer, 1 middle and 3 inner. Noise injection studies are in the process of being done.

## References

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