	ATLAS SCT Barrel Module FDR/2001				
SCT-BM-FDR-1	*Institute Document No.*	*Created :*		*Page*	
		Modified:	15/05/01	*Rev. No.*	

SCT Barrel Module FDR Document

SCT Barrel Module: Final Design Review INTRODUCTION AND OVERVIEW

Abstract

This document provides the introduction and overview to the Final Design Review (FDR) for the ATLAS SCT Barrel Module. It explains the role of the SCT within the ATLAS Inner Detector, gives the structure of the review and comments on relevant areas which are not topics of detailed study for this review but which are documented elsewhere.

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1 SCOPE OF THE DOCUMENT

This document provides the introduction and overview to the Final Design Review (FDR) for the ATLAS SCT Barrel Module. It explains the role of the SCT within the ATLAS Inner Detector and then gives the document agenda of the review. This is followed by a brief account of the Barrel Module, and reference to its integration in to an assembled structure. Status reports are then given for those items of direct association with the Barrel Module implementation, but which are not addressed further in this review. These include : power supplies, detector control system, the cooling system, the readout data-links and off-detector electronics, and the survey and alignment projects.

2 INNER DETECTOR INSTRUMENTATION

The Semiconductor Tracker (SCT) combines with the pixel detector within it, and the gaseous/polypropylene foil transition radiation tracker surrounding it, to form the Inner Detector (ID) tracking scheme of ATLAS. The overall ID is 2.3m in diameter and 7m in length. Its main requirements are:

- the precision tracking of charged particles
- using ionising detection devices that are capable of 40MHz bunch crossing identification
- and that can tolerate large radiation doses, both intrinsically and to their in-situ electronics,
- and that are constructed with minimal material
- within a complete ID that has inclusive capability of electron identification.

The ID has both barrel and endcap regions. This FDR covers only the SCT modules of the barrel region. The SCT endcap modules have, by necessity, a different design, and will be the subject of their own future FDR.

3 THE FINAL DESIGN REVIEW (FDR) DOCUMENTS

Barrel Module Project Plan: SCT-BM-FDR-2

This defines the cluster concept for module production, explains the logistics of component supply, and the responsibilities for assembly on to barrels and assembly at CERN. It emphasises the role of this FDR in the planned execution of the baseboard and hybrid production projects, and discusses site facilities and commissioning, and finally provides the overall production schedule.

The Barrel Module Interfaces: SCT-BM-FDR-3

This validates and documents all the interfaces between the barrel modules and their support brackets, cooling units, electrical harnesses and the overall detector control systems.

Requirements and Specifications of Barrel Modules: SCT-BM-FDR-4

This details the specifications and the general requirements of the barrel modules: electrical, mechanical, thermal, material constraints, and the geometrical envelope, and provides relevant technical drawings and thermal FEA results. The radiation lengths of the separate components and of the whole module are tabulated.

Details of Barrel Module Components: SCT-BM-FDR-5

This document describes all aspects of the Barrel Module components and their quality assurance, discusses the silicon detector and ASIC projects in depth, and pays particular attention to the technical specification, production and QA in the baseboard and hybrid projects, both of which are seeking approval to place production orders.

Module Assembly: SCT-BM-FDR-6

This explains the procedures for module assembly, from initial components through to the final tested module. It also explains the cluster strategy for assembly and appends documentation of the procedures at each cluster site. There is also a section on the boxes needed for safe testing and transport of modules.

Module QA: SCT-BM-FDR-7

This discusses the QA for modules during the full-scale production period. It explains monitoring procedures for mechanical and electrical performance both during the assembly sequence and after construction is complete. It also considers how product sampling tests through irradiation, beam tests and source measurements will ensure the overall high quality throughout the project.

Mechanical and Thermal Performance of Modules: SCT-BM-FDR-8

The metrology and thermal results are presented for modules produced in the current pre-series, including some constructed specially for thermal studies, and these are compared and shown to be satisfactory either by direct comparison with required specifications or finite element calculations.

Electrical Performance of Modules: SCT-BM-FDR-9

This summarises the electrical performance of barrel modules read out by front-end binary ASICs that have come from process runs of ABCD2T, ABCD3T and the current ABCD3T-A versions of the SCT chip. The detailed performance of noise occupancy and extracted noise are shown pre- and post-irradiation as well as tracking efficiency, charge collection and spatial resolution from test beams. Finally, encouraging and successful first results from a 10-module system test are used to demonstrate that the Barrel Module project can expect to now move to the production phase.

4. A BARREL MODULE

The Barrel Module, shown in Figure 1, is the focus of this review, and some of its basic features, properties and specifications are briefly summarised here:

- particle-induced ionization within high-resistivity n-type silicon wafers processed with p-strip implant diodes, provide the signals to on-board ASICs with binary readout functionality.

- the module itself has minimum mass, is radiation hard in its overall functionality, to the levels anticipated after 10 years of ATLAS operation, and is robust and efficient both mechanically and thermally.

- for tracking, the rφ position resolution per SCT layer (i.e. from two measurements per module) is aimed to be around 17μm, with the SCT instrumentation covering a rapidity range of ±2.5 with four cylindrical layers in the barrel and nine layers of disks in each end-cap.
- the total area of such silicon microstrip coverage is $61m^2$, where the silicon detectors have implants with 80μm pitch and an effective active strip length of 124mm. In total there are 768 readout strips on each side of a module and each is capacitively coupled to a metal strip through an oxide layer.

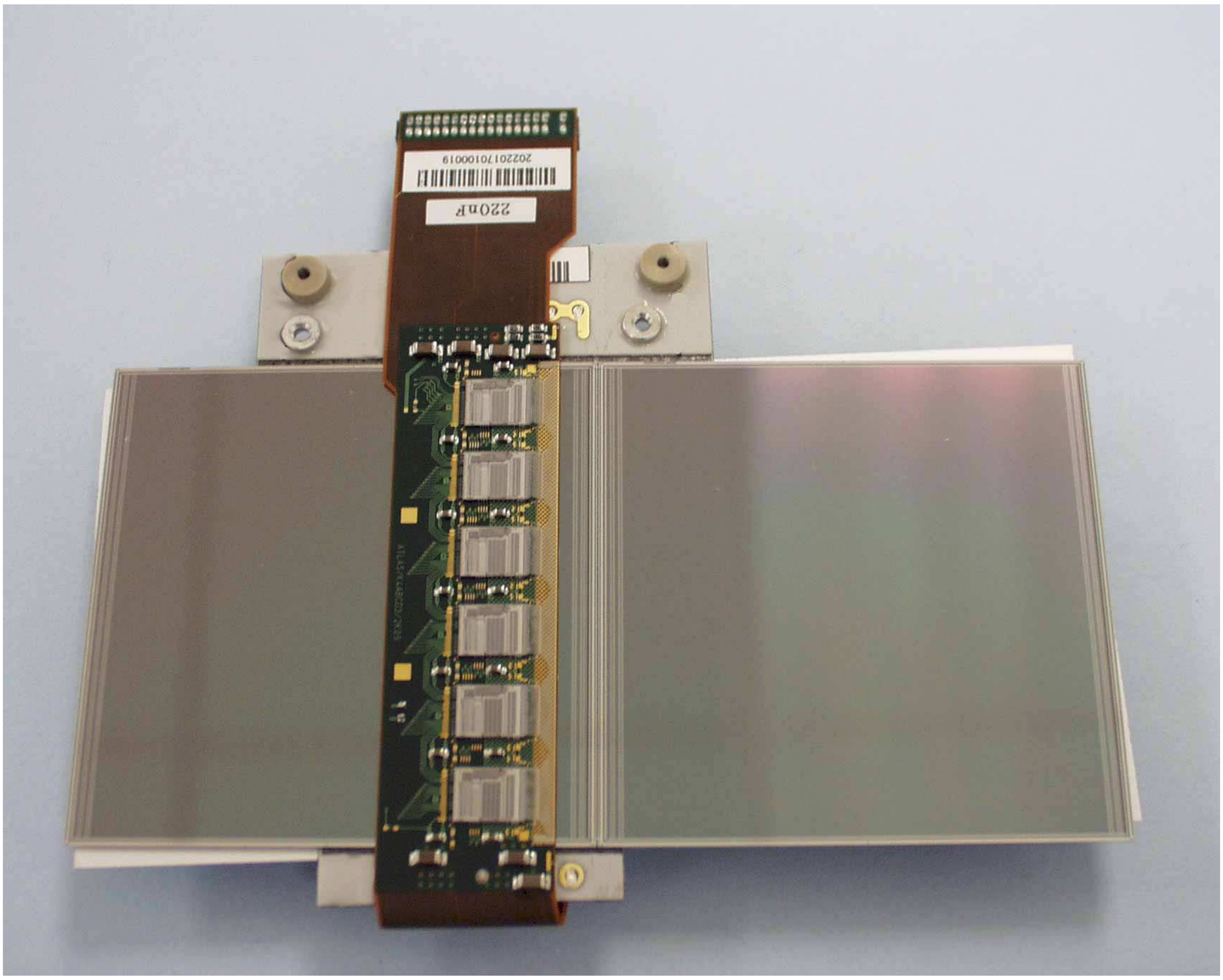

Figure 1: Barrel Module, showing two inter-bonded silicon detectors, with a wrap-around hybrid and 6 of the 12 front-end ASICs, with the hybrid pigtail leaving the module above the region of the beryllia-faced baseboard that interfaces directly to the external cooling pipe.

5. THE BARREL STRUCTURES AND ASSEMBLY

The barrel modules are supported on carbon fibre cylinders through attachment to brackets that are located by precision inserts in the cylinders. The diode implants and readout strips on one side of the module are along the axis of the cylinders, and on the other side at a 40mr stereo angle to provide the longitudinal coordinate. Alternate barrels have stereo u-v orientation (ie ± 40mr). Adjacent modules are overlapped longitudinally each end, requiring that they are staggered in radius by 2.8mm. A tilt angle near 10^0 (different for each of the barrels) allows adjacent rows of modules to be overlapped, hence providing an hermetic detector coverage. More details of the barrels and the assembly procedures are provided in the documentation of their Final Design Reviews, where ATL-IS-AP-0002 is the top-level assembly document, ATL-IS-AP-0032 describes the module mounting procedure, and ATL-IS-AP-0027 gives a description of the assembly facilities.

6. THE POWER SUPPLIES and DETECTOR CONTROL SYSTEM (DCS)

The operation of the module requires low voltage supplies for the ASIC analogue and control functions, and for associated temperature control readout and for components on the opto harness. A high voltage system provides the bias for depleting the silicon strip detectors. All the supplies are interfaced to the ATLAS DCS for the safe operation of the complete SCT. The details and reference documents for the SCT Power Supplies are available in http://www-hep.fzu.cz/Atlas/WorkingGroups/Projects/MSGC.html. The DCS is detailed in the documentation dcsfdr.pdf on EDMS, within the document ATL-IS-ES-0011.

7 THE COOLING SYSTEM

This is an important item for the overall satisfactory operation of the Barrel Module, and was comprehensively reviewed in ATC-IC-MT-0001 in June 2000. Its properties and performance will not be covered further in this review. It is based upon an evaporative fluid cooling scheme developed for this project. This provides fluid that circulates through blocks that interface directly to the barrel modules, at temperatures down to -30^0C. This is sufficient for safe operation of the barrel modules in all expected powering and radiation-damaged conditions at any point over the planned ten year lifetime of the detector. The implications on the thermal management of the SCT and the consequent module performance are given in detail in the appropriate sections of the ATLAS TC review.

8. THE READOUT SYSTEM

The front-end ASICs, the ABCD3T-A chips, are situated directly on the module and their specifications are described in SCT-BM-FDR-5.4. Their electrical output, in the form of binary data, is passed from the module via links to the ReadOut Drivers (ROD)s. There are two streams of 40 Mbits/s data from each module with each link reading out the data from one side of an SCT module. In the event of a link failure, the data can be re-routed through the other link. The 40 MHz bunch crossing (BC) clock and the L1 trigger and all fast and slow commands (TTC data) are also transferred from the RODs to the modules. A BiPhase mark encoding is used to send a 40 Mbits/s data stream down the same fibre as the 40 MHz BC clock. The system is based on optical links and the initial scheme was described in the Inner Detector TDR, and the LEDs described there have now been replaced by VCSELs. The module is interfaced to the readout chain through the opto harness and this is referenced in SCT-BM-FDR-5.3. The ROD has been through a series of review updates, but its basic requirements are those given in the original specification document: http://www-wisconsin.cern.ch/~atlas/off-detector/ROD/doc/1996-09-OffDet-Requirements.txt.

9. THE ALIGNMENT AND SURVEY

In ATLAS, the SCT will be within a nitrogen environment to ensure that the modules are in the optimum conditions for long-term operation of silicon devices; it is also the environment in which the properties and long-term behaviour of modules have been studied and qualified. There will be an initial comprehensive X-ray survey of the modules on the barrels, and the alignment will subsequently be tracked through a Frequency Scanning Interferometry (FSI) system developed for this purpose, and by particle tracks. The macro-assembly of the modules and their alignment are topics covered by the Final Design Review that precedes this review and details can be found in its documentation, where the alignment and X-ray overviews are given respectively in ATL-IS-ES-0026 and ATL-IS-EN-0004, and the structure is described in ATL-IS-ES-0010.