SCT Barrel Module FDR Document

SCT Barrel Module : Interfaces

Abstract

This document defines and documents the interfaces and relationships between the SCT barrel modules and other SCT barrel components.

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1 SCOPE OF THE DOCUMENT

The document defines and documents the interfaces and relationships between the Barrel detector modules and the following items:

- Barrel module support brackets
- Barrel cooling units
- Barrel electrical harnesses
- Barrel DCS components

2 MECHANICAL INTERFACES TO THE BARRELS

The design of the four SCT barrels is described in the Final Design Report on ATLAS SCT Barrel Cylinder FDR / 2000-1.

The mechanical interfaces and the Z position of the modules are described in the detail drawings:

For cylinder 3: ATLISBB30012

For cylinder 4: ATLISBB40010

For cylinder 5: ATLISBB50008

For cylinder 6: ATLISBB60008

(These drawings are the machining drawings of the 4 cylinders that were prepared for the Invitation to tender for the SCT cylinders).

The R-φ position of the modules are defined in the Geometry drawings:

For Barrel 3: Geneva 252205P3C ATLISBB30001

For Barrel 4: Geneva 252210P3B ATLISBB40001

For Barrel 5: Geneva 252207P3B ATLISBB50001

For Barrel 6: Geneva 252212P3B ATLISBB60001

(These drawings have an earlier module separation of 2mm, which will soon be updated to the current value of 2.8mm).

2.1 SCT BARREL CYLINDERS

The overall SCT barrel envelope is defined in drawing RAL A1-TB-0049-158-01-F. However each of the four SCT barrels has also to be built within its own radial envelope, which are defined by:

	Inner radius (mm)	Outer radius (mm)	Overall outer radius (mm)
Barrel 3	260	284	323
Barrel 4	327	355	393
Barrel 5	397	427	464
Barrel 6	468	498	534
Thermal enclosure	540		549

2.2 SUPPORT BRACKETS

The CFRP support cylinders are equipped with small glued pads that are machined afterwards (see, for example, drawing ATLISBB30012). There are 32, 40, 48 or 56 rows of 12 pairs of pads spaced around and along the cylinder. The 'z' separation of the module physics centres is the same for all 4 barrels (see, for example, drawing ATLISBC0001). A barrel module will be mounted on a low-mass bracket which is screwed into the cylinder pads. The principles of the bracket can be seen in drawing Geneva 252575P1 (which is not up-to-date). Each barrel type requires 2 types of bracket shells for lower and upper modules, make a total of 8 different types for the whole SCT Barrel.

The positions of the support brackets are calculated to ensure sufficient clearance between modules. The layout is designed to result in a minimum separation of 1mm between the sensor surfaces of overlapping modules after all tolerances have been allowed for. This minimum separation is used for both mechanical and electrical reasons, as described in SCT-BM-FDR-4, section 4. The radial 'centre to centre' module separation is 2.8mm, nominal. The module thickness in this region is nominally 1.15mm (see section 1.3 below). Subtracting the required 1mm separation between sensor surfaces leaves a radial distance of 650 µm to accommodate the module tolerances and module non-planarity, and the bracket tilt tolerance (which gives movement at the end of a module amplified by a lever-arm effect). The division of the 650 µm is 250 µm for the bracket tolerance and 400 µm for the module tolerance and non-planarity.

2.3 MODULES

The module envelope is given in drawing RAL 1-TB-0059-522-00. The module parameters (without tolerance) are:

Thickness of module:

Region	*thickness [mm]*
Sensor	1.15
BeO facings	0.92
Hybrid surface	3.28
Highest component	6.28
ASICs	4.48
Wire-bonds	5.08
Stay-clear wire-bonds	7.08

The wrap-around part of the hybrid interconnect cable (SCT-BM-FDR-5.3) extends to reach a distance of between 40.0 mm from the module centre (for a perfect round shape at the wrap-around) and 41.22 mm maximum (for a perfect wedge shape at the wrap-around). The hybrid placement error of order 50 μm will add to these number.

The front edge of the wrap-around is at x=4.2 mm, and the back edge at x=27.2 mm in the module coordinate system, which has its origin at the geometrical centre of the four sensors. The hybrid placement error of order 50 μm will add to the numbers.

The location of the hybrid connector can be specified by the location of pins number 1 and 35, which are at (x,y) = (3.612, -69.451) mm and (25.197, -69.883) mm, respectively, in the module coordinate system.

The error in the pigtail connector position is introduced by the error in the hybrid placement, connector (pin) play, and the soldering error, which are of order of 100 μm, 100 μm, and 200 μm, respectively, thus of order 500 μm in total. Note that the pigtail cable part is flexible and can absorb the errors as long as the mating connector is shorter.

Each module is fastened by 2 points on the bracket, screwed on pads, and by a third mounting point situated on one pad of the adjacent row of pads (see drawing Geneva 252552P0). The position of the modules on each barrel is defined according to geometry drawings (section 2).

Drawing ATLISBB0011 shows the details of the module mounting on the bracket and the 3rd mounting point on an opposing bracket. The lower-face contact with the cooling block is also shown. The module mounting accuracy is achieved by the use of precision set screws locating on the internal bore of a circular and a slotted aluminium washer, both mounted on the upper, cooled facing of the baseboard. Both the diameters of the screws and the holes in the washers are controlled to better than 10 μm. To ensure consistency, all drawings show this assembly method. Prototyping work has revealed that the same precision can be achieved by machining precision holes and slots directly into the epoxy in-fill of the baseboard assembly. These precision holes have been shown to be stable with temperature and they offer a cost reduction and also a small material reduction. An upgrade to this alternative scheme will therefore be followed. The conceptual drawing of a hand-held mounting/handling tool to be available for handling modules without washers is shown in http://atlas.kek.jp/~unno/si_mod/Jigs/ModulePicker2frame.pdf.

The mounting of modules to the cylinder brackets is accomplished using a robot. Document ATL-IS-ES-0022 "ATLAS SCT – Barrel Module Mounting Robot Specification" describes the mechanical specification of the Barrel module mounting robot and the procedure and equipment to be used to mount and remove modules.

The document, ATL-IS-AP-0032 "ATLAS SCT – Module Mounting/Removal Procedure" describes the procedure and equipment to be used to mount the module on the barrels. It also provides an overview of the complete system and contains references to further more detailed documentation.

The Barrel module dimensions are detailed in the '500 series' drawings 107761. The interfaces to the brackets are formed by the four beryllium oxide (beryllia) facings that are epoxy-fused to the VHCPG thermal substrate to form the Barrel module baseboard. This item is detailed in SCT-BM-FDR-5.2.

2.4 COOLING SYSTEM

Cooling tubes run along the axis of the cylinders and are held by clips against the modules. By arrangement, four adjacent cooling tubes become known as a cooling unit. The four tubes in each cooling unit are split into pairs, in each pair the two adjacent tubes connect together in series. Fine bore capillary tubes deliver the evaporative fluid to each pair of tubes. An exhaust manifold connects the two pairs together to make a cooling unit, see drawing RAL TD-1006-610 and TD-1006-990. The required precision of assembly is also defined in this drawing.

Cooling units are relatively decoupled from the CFRP cylinder in the sense that they are fixed to it via removable brackets bolted in the castellated flanges at either end of each barrel. The fixed end is on the inlet/outlet side of the cooling unit, the other end being allowed to slide to avoid stresses induced by CTE mismatches to be transmitted to the support structure.

The cooling pipes form the critical thermal interface between coolant and module. This interface is formed, by Dow Corning 340 thermal grease, between the cooling block and the cooled, lower beryllia facing of the baseboard. The choice of this thermal grease has been motivated by past experience and by laboratory tests. Further details are contained in the following documents:

- ATLAS Internal Note INDET-NO-177 Radiation hardness of thermal compound
- ATLAS Internal Note INDET-NO-166 Status report on modules cooling and mechanics.
- CMS-TN/94-248 Testing of radiation effects on thermal conductivity of a thermal grease.
- MEE-12-92-289 (LANL) Evaluation of available thermal greases

2.5 ELECTRICAL HARNESSES

The interface between the modules and the opto-harness is fully described in SCT-BM-FDR-3-Appendix 1.

2.6 DCS COMPONENTS

An SCT barrel module will contain two thermal sensors on the electrical hybrid, to monitor the temperature at one point on each 6-chip side of each module during operation.

3 THERMAL INTERFACES

The cooling of the modules is provided by the upper face of a cooling pipe running underneath the beryllia cooling facings of the modules. Thermal contact between the modules and cooling tubes takes place over an area of about 420mm^2. The cooling block entirely encapsulates the tube, so making use of the entire diameter. This is achieved by having the block in two halves, the block having a split line along the axis of the diameter. The block is joined to the tube by copper-plating the aluminium block making it possible to use conventional solder and non corrosive flux. The lower face of the tube provides cooling for the opto-package. Two spring clips compress the module, cooling tube and opto-package together. A thermal grease layer between each component enhances the thermal contact. The grease to be used is Dow Corning 340 which has demonstrated both good thermal conduction and high radiation tolerance.

There are twelve modules in each row. Every second module has an increased radial dimension of 2.8 mm to allow the overlap between adjacent modules. This will be achieved through use of a stepped CuNi cooling tube. The aluminium cooling block will be joined to the surface of the tube by solder. The aluminium block is copper plated to make possible the use of conventional solder.

4 ELECTRICAL INTERFACES

The three module mounting points are made of insulating material. The cooling tubes are made of electrically conductive material. They are isolated from the modules and opto-packages whose parts, in contact with the tubes, are made of insulating material. The option of two alternative grounding schemes is kept open, as it cannot be confirmed that the baseline scheme will work satisfactorily until it is are tested in a practical situation. Until such time as this practical test takes place, the cooling block design must be able to cater for both possibilities.

The baseline design has a shunt shield that exists in the form of a glue layer and aluminium foil on top of the cooling block. This scheme incorporates a wire that connects the foil to the dogleg making the module isolated from the cooling system but grounded to the electrical harness. If this scheme should fail then the foil will be employed to connect back to the cooling block making the shunt shield (glue layer and foil) redundant

The foil in the shunt shield will be no thicker than 200 µm. The thickness of the glue layer is yet to be determined.

The cylinder is equipped with patches of conductive material near each module to allow for a connection of each module to the CFRP structure and for pipe grounding connections.

The cable harness has an insulating kapton cover layer over its conductive tracks. No further insulation is required for the harness between itself and the CFRP cylinders or harness clamps.

5 ASSEMBLY

The overall procedure for assembly of the cooling units, harnesses, other services and detector modules is described in the barrel assembly procedure, RAL ATL-IS-AP-0002.

The main electronic parts of a module are four silicon detectors and a hybrid that interfaces to ASICs and provides the electrical readout. It is essential that the module connector, found at the end of the hybrid, mates with the dog-leg connector. The position of the connector on the module is defined in drawing A1-TB-0059-520-01 (the precision of this positioning is to be such that connection and disconnection can be made without damage to either a module or connector). The adopted scheme locates each dog-leg connector with reference to the hybrid connector on an individual basis. This is achieved by a jig that references the position of the module connector to the mounting points on the module baseboard. Once set, the jig is then offered to the mounting points on the bracket and the dog-leg connector is then located by the jig. A feature in the dog-leg allows two screws to pass through it, tightening these screws onto the bracket sets its final position.

It is proposed that the connection at patch-panel PPB1 is made by soldering six low mass tapes to a printed circuit board having a MOLEX 240 pin board-to-board connector. This assembly must first be routed underneath cooling manifolds and past further structures at the end of the cylinders. The assembly has a cross section of 26mm by 6mm and details of the low mass cables can be found at; http://www-f9.ijs.si/~cindro/low_mass.html.

The cooling unit is a fragile and precise assembly and must be supported at all times. A temporary structure will span between each of the brackets that will eventually support the cooling unit on the cylinder. The temporary structure can then be removed once the cooling unit is set in its final position. At the time of mounting the cooling units to the cylinder there will be no modules in place, dummy modules and spring clips will support the cooling tube along its axis.