ATLAS Internal Note
INDET-NO-draft
16 March, 1999

Report on Feasibility of 0^o Tilt Angle in the SCT Barrel

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Abstract

In the base-line SCT barrel design, individual silicon modules a mounted on brackets with a tilt angle of approximately 10^o with respect to the tangent. This design was motivated by, and well adapted to, the TDR baseline of centre-tap barrel modules using n-on-n silicon sensors. Following the change of baseline to p-on-n detectors, the consequence on the engineering design of a 0^o tilt angle has been studied. It is concluded that significant design changes are consequent to any significant change of the tilt angle.

1.0 Introduction

The TDR SCT layout [1] assumed the existence of n-on-n silicon detectors. To minimise the Lorentz deviation of charge transport towards the n-strips, a tilt angle of the order 10^o for the barrel modules was chosen. The existing barrel layout, and to a large extent the barrel module design, was developed with this tilt angle in mind, and the exact tilt angle of the modules was imposed by mechanical and overlap constraints.

Subsequent to the TDR, a p-on-n detector design was chosen for the SCT. In this case, a reduced tilt angle is desirable. At the same time, a study by S. Snow [2] emphasised the importance of correlated module alignment errors in the azimuthal and radial directions. The SCT Steering Group therefore requested a study of the minimal engineering changes required, in the case of barrel module placement with 0^o tilt angle.

In this short note, we first note the existing design. We then describe possible module mounting designs assuming no change to the module design. We conclude that substantial engineering development is required. The second possibility is to develop a completely new design for the barrel structure (and module design). It is concluded that this is a possible course of action.

2.0 Existing Module and Barrel Layout

Figure 1 shows an azimuth view of the SCT Barrel 3 (inner barrel) and Figure 2 shows the same view for Barrel 6 (outer radius) [3]. On each Figure, the centre-tap barrel module design is shown. The layout, motivated as noted above by the requirement of a tilt angle of the order of 10^o, has the following characteristics (constraints):

- The centre-tap module design was chosen to minimise the electronic noise (that is the load capacitance of the front-end input). Given that a longitudinal cooling pipe is used by the SCT, the need for a cooling contact at the side of the module is evident. That is, the width of the module is larger than the active silicon width. In order to ensure full coverage of the silicon active area, either a tile or castellated module placement is required in the azimuthal direction, and a castellated longitudinal mounting of the modules is required (only a castellated module placement ensures in principle a fixed radius for strips in z).
- The azimuthal tile mounting has a minimal angle defined by the separation between adjacent module rows, and by the azimuthal overlap specification. The existing design of ~10^o was chosen as a good compromise. This value has been re-visited. By using thinner brackets (which are submitted for prototyping but which may reduce stability), and by reducing the clearance between modules, this value may be reduced slightly (~ 1^o) on at least some barrels.
- The tile assembly - whether the modules are mounted directly on the barrel brackets or are mounted on a stave - allows space for cable attachment.
- Because of the radial variation in the existing layout (tile), within one module, the radial uncertainty of any strip must be controlled. In the tile arrangement, it is feasible (and planned) to provide this control via a 3 point mounting using the azimuthally adjacent bracket [3].

Using the existing module design, it is evident that the dual specifications of module overlap and 0^o tilt angle are incompatible with an azimuthal tile assembly.

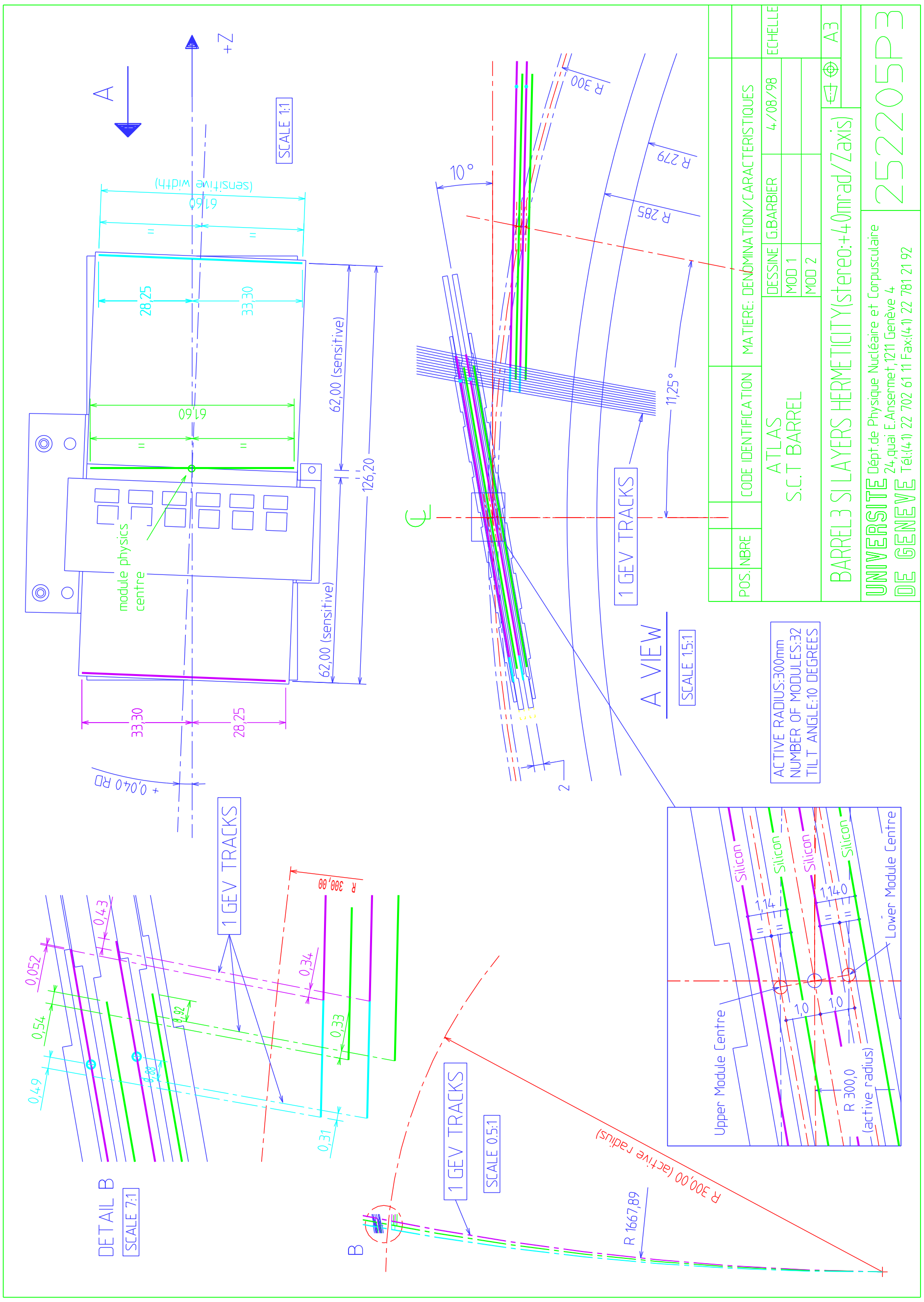

FIGURE 1. Module design and azimuthal position of modules on SCT barrel 3.

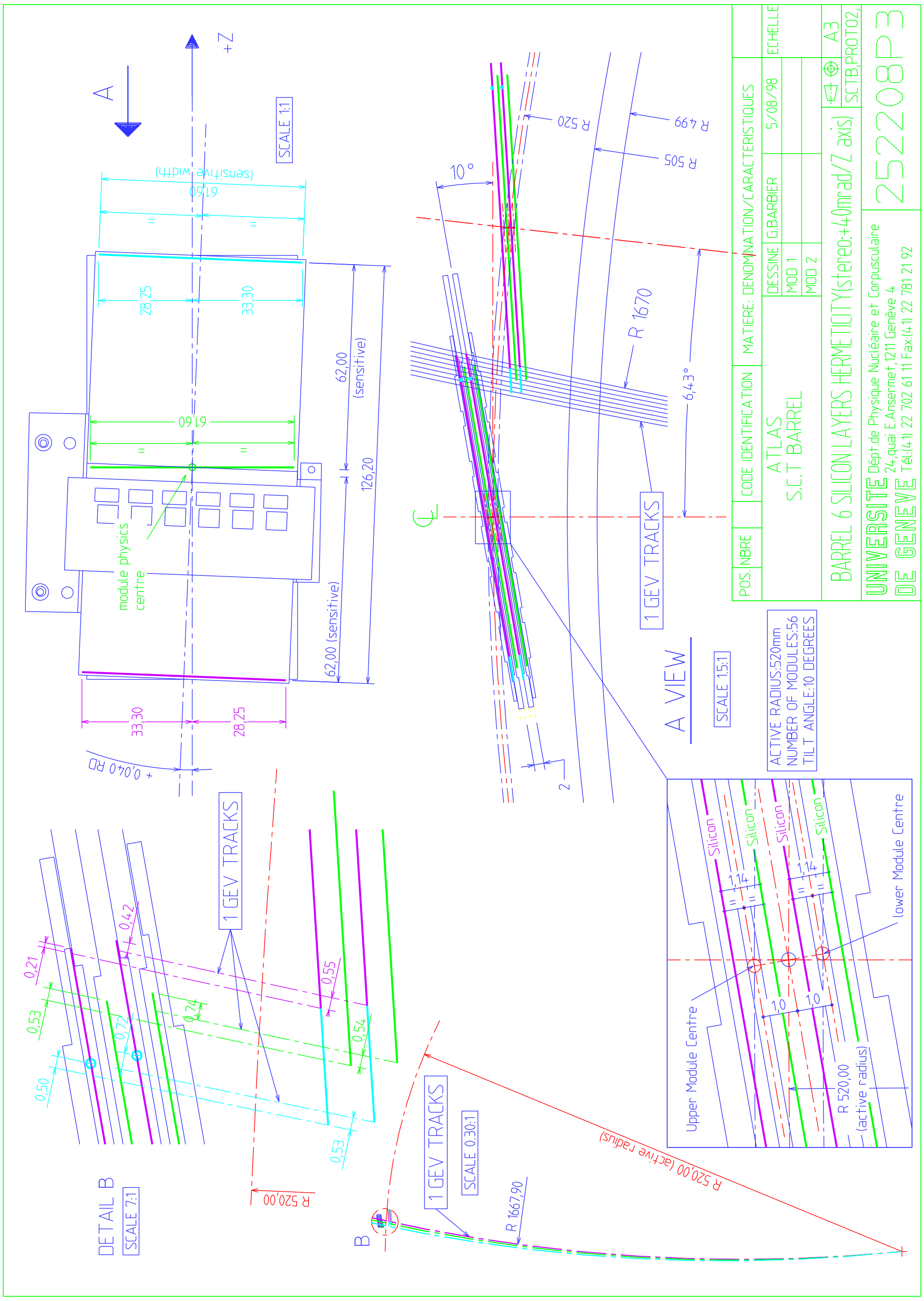

FIGURE 2. Module design and azimuthal position of modules on SCT barrel 6

3.0 Minimal changes to the barrel and module design.

With the present design of barrel modules, there is no alternative to the castellated longitudinal mounting of modules in a given row (in order to maintain the existing specifications on hit precision). However, a castellated azimuthal scheme could be envisioned. We have studied two possible castellated designs that are briefly summarised below.

3.1 Direct mounting of modules.

Figure 3 shows an azimuthal slice, in which castellated modules are supported by a T-shaped bracket. This design retains three key elements of the baseline layout - a direct module mounting on the barrel, a 3 point module mounting to retain dimensional stability, and an opto-electric harness similar to that being designed for the baseline tiled structure.

This design has the following consequences:

- The radial separation of adjacent modules is increased, necessitating an increased detector overlap.
- The brackets are more complex and heavier, with a long lever arm if 3-point module mounting is to be retained (with possibly less dimensional stability).
- During assembly, the lower module rows must be installed, before adding the brackets and cooling pipes from an upper row of modules. In addition, cable harnesses must be connected to the upper modules while the lower modules are in place. This operation would be extremely delicate.

An extended design and prototype phase using this solution would introduce a significant delay in the SCT schedule (estimated by one of us (EP) to be at least 6 months). This is clearly not a solution which is conceptually attractive.

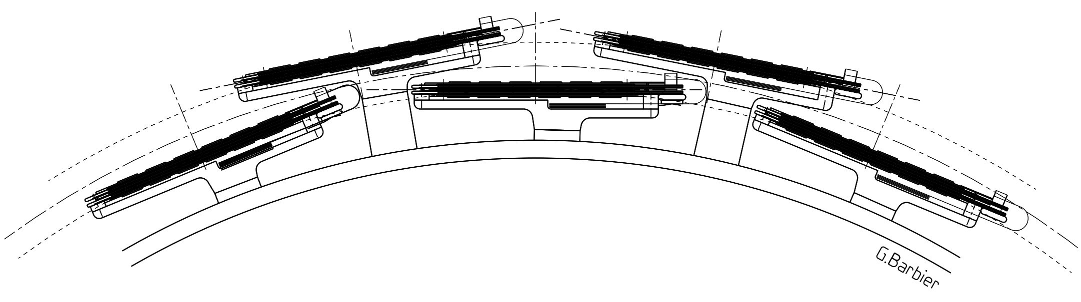

FIGURE 3. Possible bracket mounting on carbon fibre cylinder for castellated rows.

3.2 Modules on staves.

Figure 4 indicates an alternative mounting scheme, in which the T-shaped mounting brackets are replaced by a rectangular stave, as in designs proposed by RAL. This solution would have the following consequences as compared with the scheme of Section 3.1.

- The material budget would be further augmented.

- There is some question of whether the module separation must be further increased, to allow space for the cable connection to modules, over the full barrel length. On the other hand, in this case, the cable harness could be pre-assembled. Brackets mounted on the stave are still required for the cooling tubes.
- The stability assured by 3-point module mounting is only possible with respect to the stave, and the dimensional stability of the stave itself remains a concern.
- Stave fixations would be required in this design to be via holes drilled in the carbon fibre shell.

From an assembly viewpoint, this solution appears less risky than that described in Section 3.1. However, a longer design and prototype period would be required, without guarantee of success. In particular, major design work would be required for the stave itself, and for the stable module fixations.

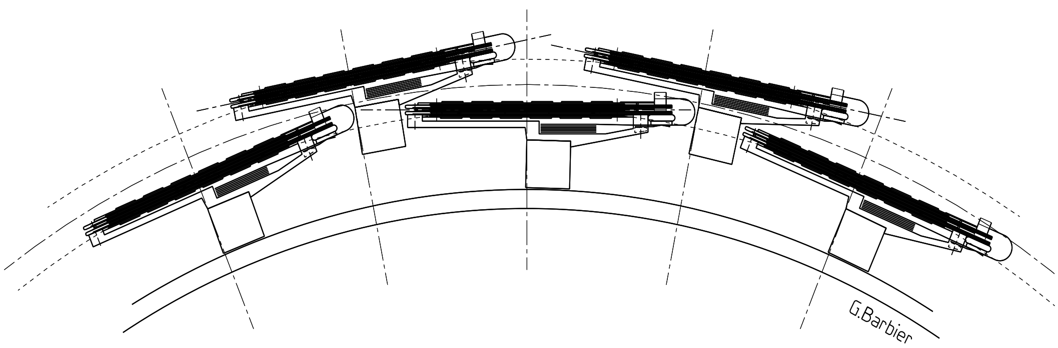

FIGURE 4. Possible stave mounting on carbon fibre cylinder for castellated rows

4.0 A new structure and module design.

This option lies outside the mandate of the request made by SCT Steering Group. An essential constraint on existing designs is that of module overlap. In our view, the most natural design which retains 0^{o} tilt angle would be to abandon Φ-overlaps, and to maintain the track recognition capability by the construction of an additional barrel. In this case, of course, azimuthal module gaps must be minimised, implying a module width determined by the active silicon width. The preferred module design would be therefore be end-tap, with unclear consequences on the cooling scheme, and on the existing castellated longitudinal overlap.

A solution of this type may be achievable, and may be competitive in both cost and performance with the existing base-line design. It requires, however, an extended R&D and prototype cycle for both the structure and module design, with a delay to construction of both the modules and the mechanical support which would certainly exceed one year.

5.0 Summary

We conclude that with consequences on

- the material budget,
- the ease of assembly and maintenance, and
- possible delays to the construction schedule,

a revised barrel structure which allows module assembly with 0^{o} tilt angle might be achievable. Such a revised structure would not be conceptually attractive.

More radical structural changes may permit 0^{o} module assembly in a more elegant way, but would necessitate substantial engineering re-designs of both the barrel structure and the barrel module design.

References

[1] ATLAS Inner Detector Technical Design Report, April 1997, CERN/LHCC/97-16,17

[2] S. Snow, Dimensional tolerances of the SCT module.

[3] See http://mpej.unige.ch/physics.html, click on 'mechanics'