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Assembling Procedure for the Si Inner-Tracker

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1 Introduction

The LHCb Silicon Tracker consists of planar tracking stations made of Si microstrip detectors. The tracker is divided in two part : the *Trigger Tracker* (TT) and the IT detector, although both will be build up from Silicon sensors. The following document deals with the assembly of the Si ladders of the IT.

The total sensitive area of the IT will be approximately 4.14 m^2. The detectors will be grouped in 3 stations, each station consisting of 4 detector boxes above, below and on the left and right hand sides of the beam pipe. Each of these boxes contains 4 detection layers with vertical strips, strips at $\pm 5^\circ$ for stereo angles and, again, vertical strips. Each of the detection layers will in turn consist of 7 ladder of silicon sensor, each of these ladders being 11 or 22 cm long. This results in having 168 one-sensor ladders and 168 two-sensor ladders.

The each sensor will be of p-on-n Silicon and will have a sensitive area of 108×76 mm^2 and a thickness of $(320 \pm 20)\,\mu$m. The strip pitch will be $198\,\mu$m and their width is currently under study. We aim at a spatial resolution better than 70 μm.

This note describes the procedure adopted to assemble the sensors onto their support; the procedure that was chosen will allow to reliably build the ladders within a tight alignment tolerance. The description of the detectors and their front-end electronics as well as the detector boxes can be found elsewhere [1].

2 The detector ladder

The detector ladder consists of 1 or 2 Si strip sensors bonded together and to their readout Beetle chip mounted on a hybrid circuit. The sensors will be glued onto a carbon support frame of 400 μm thickness which will give to the ladder its mechanical stiffness. The ladder will be attached to a *balcony* that will provide the mechanical and thermal contact to a cooling plate in which a refrigerating fluid is circulating. The hybrid circuit will be in direct thermal contact with this balcony and not with the carbon support frame.

The precision of the Si-detector positioning and its reproducibility is of primordial importance for the detector. This precision and this reproducibility are ensured by two alignment pins (diameter : 1.5 mm) inserted in the balcony (see Figure 1 and Figure 2). These two alignment pins will also serve as position reference points for the ladder to a precision of much better than 10 μm.

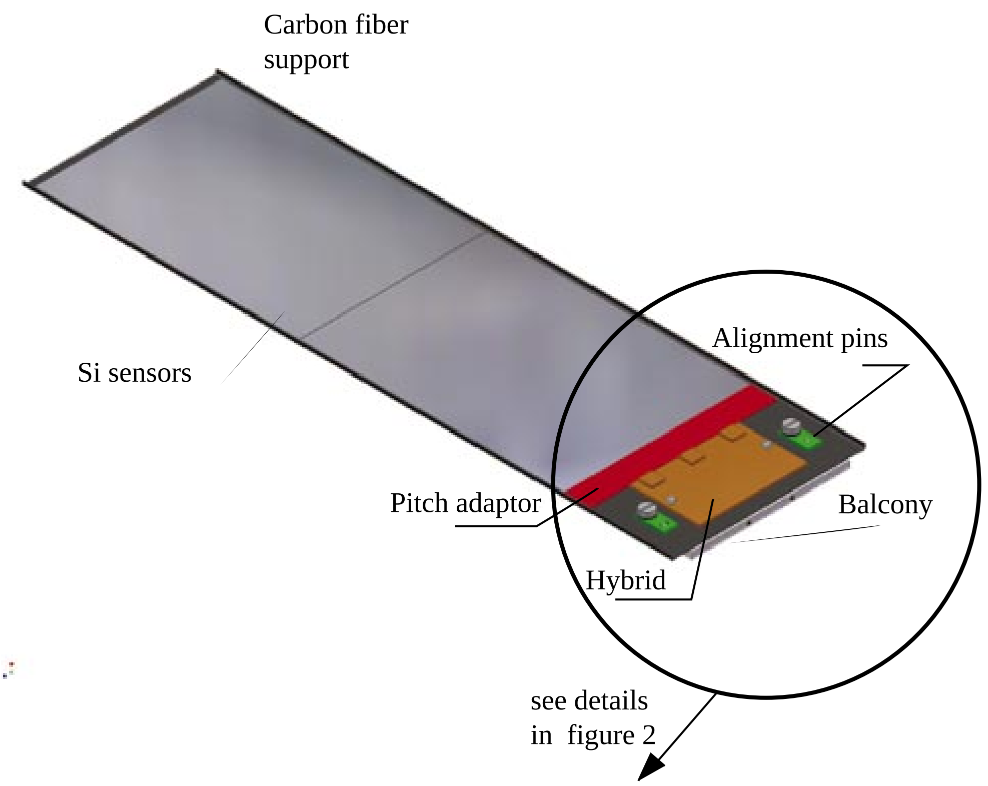

Figure 1: Layout of a 2 sensor-ladder.

We transpose these 2 reference points to the Carbon support via two precision holes whose drilling is as follows : two small aluminium plates will be first glued on the Carbon support and then the positioning holes will be precisely drilled through the ensemble allowing the above mentioned precision of better than 10 μm. The balcony will be tightened to the carbon support by two bearing screws (*vis à portée*).

3 Assembly procedure

For the positioning of the sensors and their transfer to the Carbon support, we will use vacuum jig. The position of the sensors relative to these jigs must reflect their position with respect to the alignment pins. The surface of all the mechanical pieces, which will be in contact with the sensors, will be in Teflon or coated with this material.

3.1 The Carbon support jig

This is the basic piece in which the positioning of the sensors relatively to the Carbon support will be made (Figure 3). This piece has two precise alignment pins of the same dimensions and at the same relative distances as the ones placed on the balcony. To ensure the relative positioning of the sensors with respect to these alignment pins, we rely on two dowels (diameter : 10 mm) placed on known positions relatively to the alignment pins; these dowels will be bought from the Sferax company and have a quoted

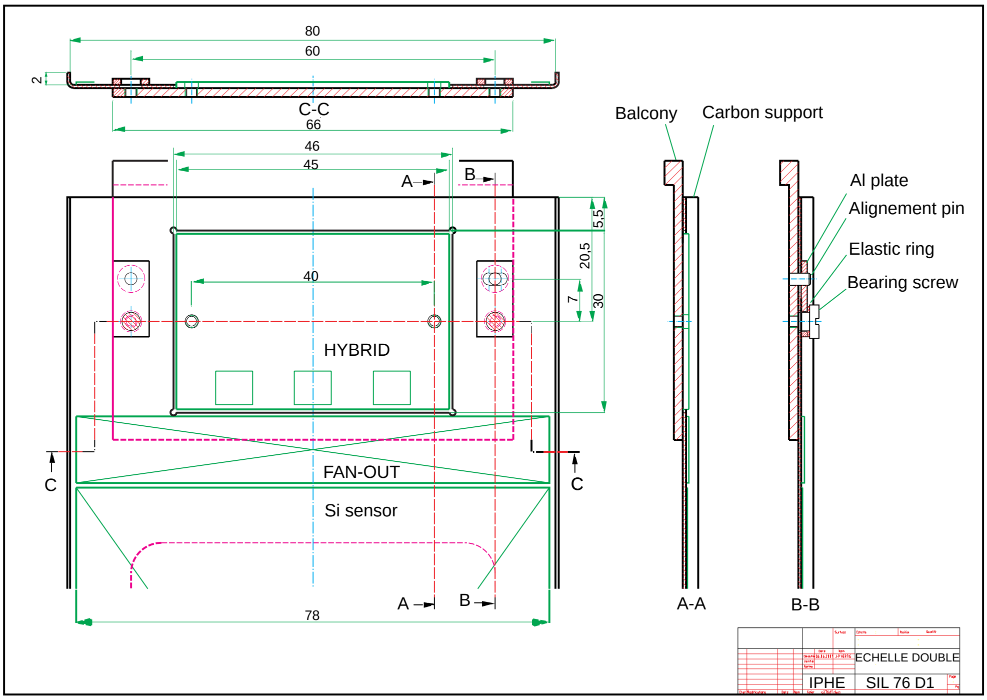

Figure 2: detailed drawing of the upper part of the Carbon support including the Al-Be balcony and the hybrid holding the Beetle chips.

tolerance of 2 μm. Their assembly must be precise to the micron level. All the transfers pieces (jigs) will therefore have Sferax linear ball bearing (feed-through) adjusted to these two dowels to a precision of 2 μm.

The carbon support will be placed on this jig, which will also serve as a gluing jig. The position of the carbon support is completely determined by inserting the alignment pins of the jig into the positioning holes. A clamp at the far end of the support will maintain the flatness of the support onto the jig during the glue dispensing if necessary.

3.2 Dispensing the glue onto the Carbon support

Several glues are being considered at this time; the glue will be spread onto the carbon support using a Techcon T83030 glue dispenser robot. We will study the variations of the glue thickness and width using different dispensing speed and needles. To ensure a good thermal contact between the Si and the carbon support, we will have to study the distribution of the glue on the support and its spreading once the Si sensor is placed on the support.

The bias voltage being applied to the back plane of the sensor, this back plane will be passivated. Should this turn out to provide insufficient insulation with respect to the electrically conductive carbon support frame, an additional thin layer of insulating kapton can be glued in between the sensor and the support.

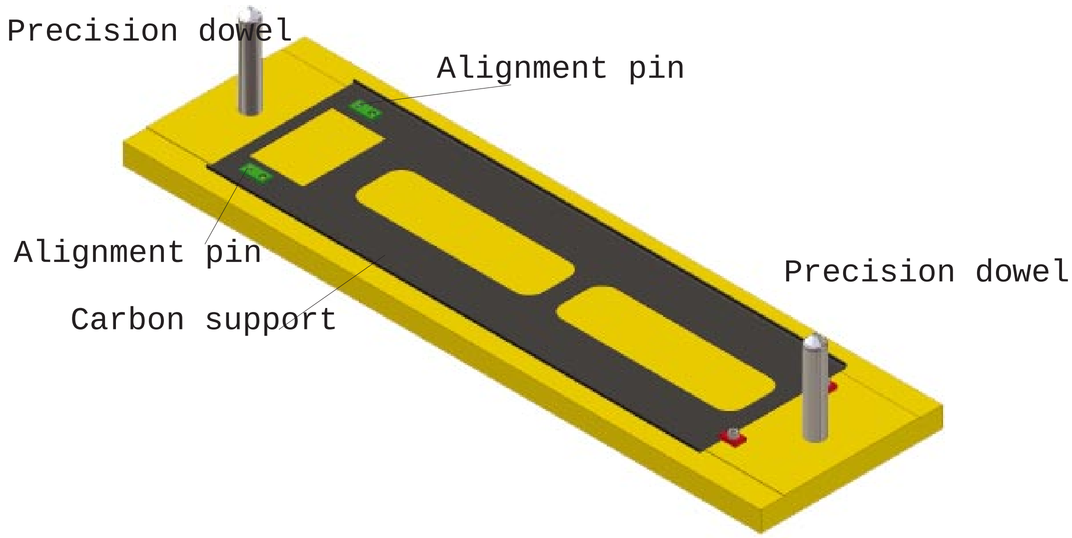

Figure 3: The Carbon support on its jig. This ensemble will be put on the glue dispenser robot

3.3 Positioning the sensors and the pitch adaptor

At this step, we rely on the precision of both the external dimensions of the Si sensors and the pitch adaptor. The dimensions of the sensors are guaranteed by the manufacturer to better than ± 20 μm (in fact, we have found that the dicing precision on the delivered prototypes is ± 3.5 μm round the dicing line) and we can require the precision on the dimensions of the pitch adaptor to meet the above-mentioned figures. The sensors will first be placed face up on a positioning jig and pushed against back and side stops which ensure their relative positions (see Figure 4). The principle of this positioning method is the one adopted by the Geneva University group participating to ATLAS for their outer forward Si tracker [2] and has already been successfully used for the large BTEM test module of the GLAST silicon tracker (see for instance [3]).

The positioning jigs have two dowels similar to the ones on the jig holding the carbon support. A vacuum holding is applied to the Si sensors at this moment. At this point, the sensors' positions will be checked and recorded using a X-Y table and a microscope equipped with CCD camera.

A transfer jig (Figure 4) with Sferax feed-through adjusted to the dowels will then be placed on top of the positioning jig, vacuum holding will be released on the positioning jig and applied to the transfer jig. This transfer jig is then placed on top of the Carbon support. Two micrometric stops (not shown on figure 4) ensure a precise height of the Si sensor relative to the upper surface of the Carbon support, thus controlling the glue thickness between the sensors and the carbon support.

During this operation, the pitch adaptor will be placed on its transfer jig and pushed against the back and side stops. Precision dowels on this positioning jig and feed-through on the transfer jig allow to bring the pitch adaptor to the sensor's transfer jig and to place it onto the Carbon support.

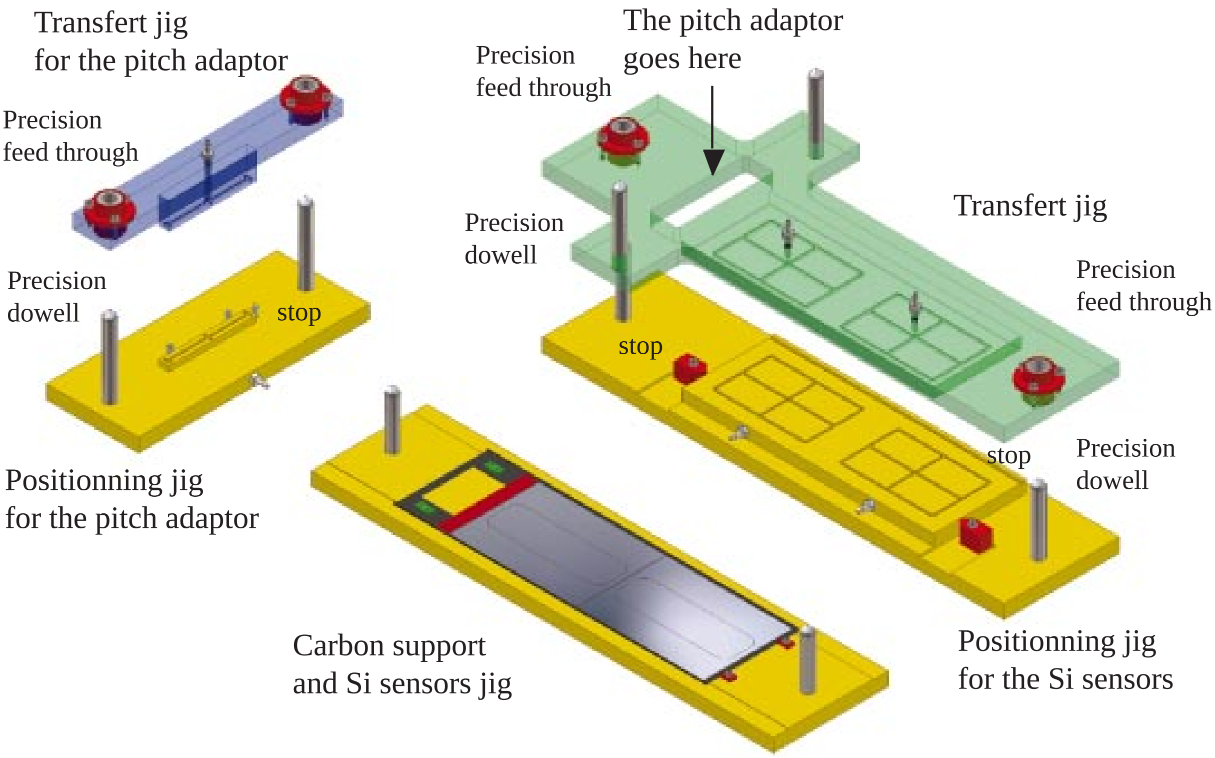

Figure 4: Drawing of the positioning and transfer jigs for the sensors and the pitch adaptor. The micrometric stops are not shown.

3.4 Joining the balcony and the Carbon support

The *balcony* with its positioning pins is put in a "mounting plate" (see Figure 5). The "mounting plate" will have two steps, the level which will be in contact with the Carbon support being approximately 60 μm higher than the level of the balcony; this difference accounts for a heat conducting paste thickness of $\sim$ 60 μm which will then be pasted on the upper face of the balcony. The Carbon support with its sensors will then be brought to match the positioning pins of the balcony; the tightening of the support to the balcony is then made with the two bearing screws mentioned earlier. To ensure a uniform pressure on the heat conducting paste, a loading piece has been designed to press on the Carbon support (see Figure 5) and will be removed prior to any further operations. To have a reproducible pressure load, dynamometric keys will be used to tighten this piece to the mounting plate.

3.5 Positioning the hybrid onto the Carbon support

At this point, the hybrid, which comprises the Beetle chip and its circuitry, has been glued onto a heat conductive substrate (e.g. AlN). The positioning of the hybrid ensemble on the Carbon support must be done under microscope : one has to align the bonding pads of the pitch adaptor to the bonding input pads on the Beetle chip side.

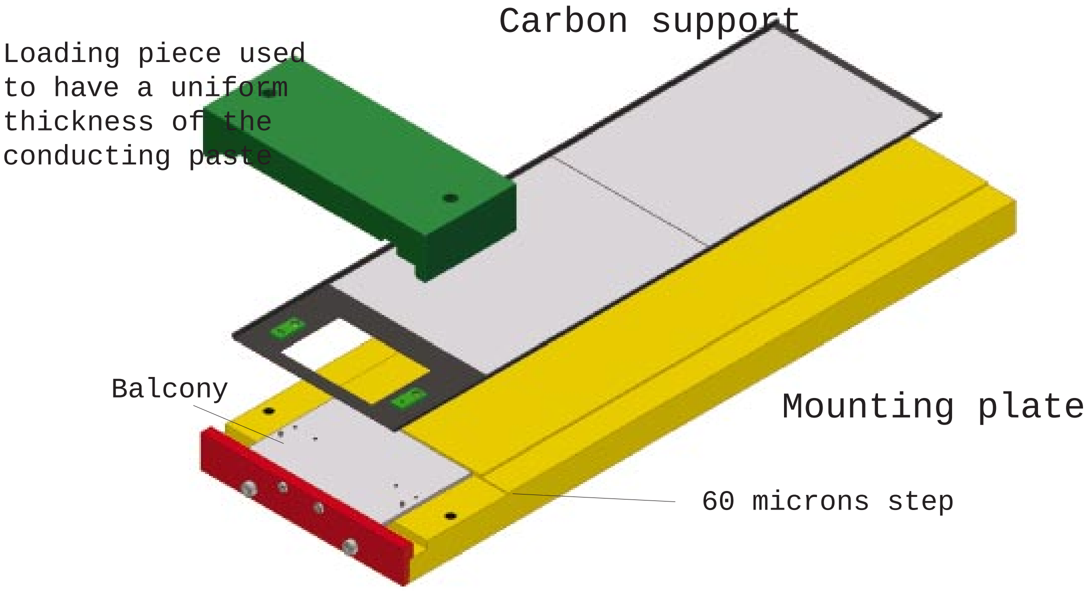

Figure 5: Drawing of the positioning of the Carbon support and the balcony.

This metrology checking under the microscope will also allow to record for each ladder the position of the sensors relative to the alignment pins on the balcony.

Once the hybrid ensemble is fixed, a couple of grounding "bridges" will be put between the Carbon support and the balcony; the ladder is then ready for the bonding. The "mounting plate" can be used for this purpose.

4 Production rate

The duration of the bonding of a 2-sensor ladder is estimated to be less than half a day. We think that the most time consuming operations will be the various checks : bonding checks, electronics tests after the bondings, bonding corrections, etc... We estimate that these tests can take from half a day to a whole day for a single ladder, but can be done in parallel for two ladders. The total time for the assembling of the ladders will then be around 35 weeks. This estimation, however, needs to be validated and this will be the main of our objectives for the near future.

5 Résumé of the assembly sequences

The successive steps in the ladder assembly are the following :

1. The Carbon support is placed on the *positioning jigs*
2. This jig is moved to the *glue dispenser robot* where lines of glue are delivered.
3. In the mean time, we will place the sensors in position by sliding them against two stops.

4. The sensors are lifted up by the *transfer jig.*
5. The sensors are positioned onto the Carbon support.
6. The *balcony* is placed in the *mounting plate.*
7. Thermal conductive paste is spread on the *balcony.*
8. The Carbon support with the sensors glued on it is put on the *balcony* and *mounting plate.*
9. The Carbon support and the balcony are pressed together.
10. The hybrid will be positioned with respect to the sensors; this operation will done under the microscope.
11. The ladder is ready for bonding.

6 Equipments and tools

The main equipment needed for this assembling is composed of :

- A glue dispenser robot to spread the araldite onto the Carbon support. Studies must be done in order to have good glue coverage and a glue layer as thin and constant as possible.
- A metrology facility. In Lausanne, we will build such a machine from X - Y computer controlled movements (Newport Cie). Microscopes with CCD cameras will also be available.
- Automatic bonding machines must be available.
- Detector storage places with controlled humidity and temperature must be built.

Most of the assembling jigs which will be used in the detector assembling will be made from *Alplan* , an Aluminium alloy which has much less stresses and is much more stable when machined than the usual Anticorrodal. The temperature coefficient for this Aluminium alloy is not of great importance, as the jigs will be used in clean rooms where temperature is controlled to 1 degree. The parts of the jigs, which will be in contact with the sensors, will be made of Teflon. The jigs to be used are relatively simple pieces and multiple sets of these jigs will be built in our workshops.

7 Conclusion

In the "Inner Tracker group", we have decided to have the position reference points for a ladder on the balcony, which will be tightly connected to the "back bone" of the detector box, i.e. the cooling plate. To satisfy this starting requirement, we have designed a whole tooling system, which transposes these reference points from the balcony to a pair of precision dowels. The use of these dowels has shown to be quite valid for the ATLAS SCT and we expect them to give a precision of the order of $\pm 20\,\mu$m in our experiment.

References

[1] "The Silicon Inner Tracker for LHCb"
Olaf Steinkamp, LHCb Note 2002-019

[2] "Status Report on the Construction of Mechanical Outer Forward Module Prototypes for the SCT"
CERN and the University of Geneva.

[3] "The assembly of the silicon tracker for the GLAST beam test engineering model"
P. Allport et al., Nucl. Inst. and Meth. **A466** (2001) 376 - 382.