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CBM Silicon Tracking System integration: from module production to ladder assembly

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The Silicon Tracking System (STS) is the core detector of the Compressed Baryonic Matter (CBM) experiment at the future FAIR facility. It is located inside of a 1 Tm dipole magnet to achieve a momentum resolution of 2% for charged particles. The functional building block of STS is a module consisting of double-sided silicon micro-strip sensor connected via microcables to front-end electronics located outside of the detector's physics acceptance of 25°[1]. Self-triggering read-out electronics based on the STS-XYTER ASIC is used, which is capable of acquiring data at collision rates of upto 10 MHz. The system comprises of low-mass detector modules, distributed on 8 tracking stations with a material budget of 1-2% X_0 per station. The stations are made from mechanical half-units onto which ultra-light carbon fiber support structures, or ladders, are mounted which hold the sensors. The positioning of modules after mounting them on the ladder is expected to be in the order of 100 µm.

This contribution aims to provide an overview on the module assembly procedure and how modules are integrated on to the ladders along with the challenges faced during the integration. These techniques have been successfully demonstrated in the ongoing FAIR Phase-0 Programme of mini-CBM, where 11 such modules were successfully installed. Additional assemblies have also been made for various test setups.

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1. Assembly of modules for STS : handling to production readiness

A STS module comprises of a double-sided silicon micro-strip sensor connected via signal and power transmission micro-cables to the two front-end electronics boards (FEBs) to read out the p- and n-sides of the sensor. There are 4 different sizes of silicon sensors, 22 mm, 42 mm, 62 mm, 124 mm with the width of 62 mm. Before the assembly of a module, each sensor has been electrically and optically inspected along with the quality controlled tests of Application Specified Integrated Circuits (ASICs), Low DropOut (LDO) voltage regulators, microcables and front-end boards. The basic steps to assemble a module are as follows, with some recent modifications applied to the order described in [2]:

1. Micro-cables are fixed on a tool by vacuum, aligned and TAB-bonded to the ASICs; then the bonds are protected by glue.
2. The so formed chip-cables are bonded to the front-end board, for the p- and the n-side read-out. The ASICS are glued into the boards using Epotek E4110 glue and the electrical connections are created through wire-bonding. This is followed by communication and functionality tests.
3. The other end of the chip-cables are connected to the sensor. This is done in several steps for the even/odd sub-cables, and for the p- and n-sides.
4. After further functionality tests are passed, layers stretching over the micro-cables are glued on either side.
5. As the last step of module assembly, FEBs are glued to the cooling T-shelves using Stycast 2850 FT with 23 LV catalyst as the thermally conducting interface material to dissipate the heat from front-end electronics. The resulting module is shown in Fig. 1.

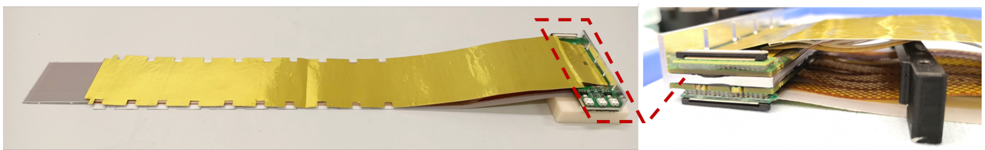


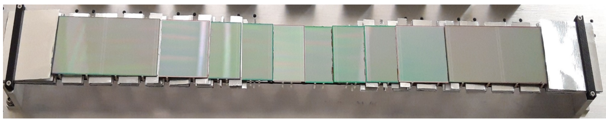
Figure 1: Fully assembled STS module (left) and detailed view of FEBs attached to a cooling shelve (right).

After the production of each module, they are stored in ESD protected boxes until the further testing. Each module's performance is tested in a specially designed module test box before it is transported to the ladder integration step.

2. Precise mounting of modules on ultra-light support structures: Ladder

The carbon fiber ladders designed for STS act as support structures for the sensors. The sensors are glued onto the ladder with small L-shaped glass fiber objects "L-legs". The main goal of ladder assembly is to ensure a precise and reproducible sensor placement with 100 μm precision. In order to achieve this, a well-defined assembly technique has been designed and tested.

To test for the handling of the tools, several half-ladders have been assembled and optically inspected for the resulting mounting precision. The longest STS ladder can have maximum of 10 modules, therefore, a ladder was built with 10 non-functional modules as shown in Fig. 2. This is the first full-size ladder assembled, to get acquainted with the precise module mounting procedure. First, the two central modules are assembled one after the other since the tools are designed in such a way that both the modules sit on the same positioning block. Afterwards, modules are assembled in parallel on both the left and right sides. Each module remains in the tool held under vacuum for 24 hours because of the curing time of CAF4, used to glue the sensors on L-legs.



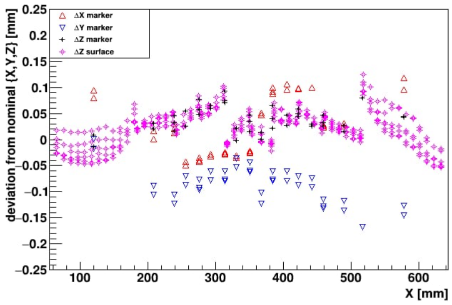


Figure 2: Ladder with mechanical dummy modules (left) and measured deviation from the nominal position of the sensors mounted on the ladder (right).

For the mechanical survey of sensor positions on the ladder, a camera-based proximity-focus measurement setup on a granite table with XYZ motor stage is used [3]. The 3-D position of the sensors is determined from alignment marks on their surface. In the plot shown in Fig. 2, the deviation of markers from their nominal position (in x,y,z) has been plotted. All the sensors are within the required precision of 100 μm. All survey data of the ladders to be assembled will be saved in a database to be available for detector alignment. After getting the experience with dummy modules, several half-ladders with functional modules are also built and tested.

3. Summary and Outlook

The procedure for module assembly and mounting them onto the ladder after the functionality tests, has been finalised. A full ladder (with dummy modules) and several half-ladders (comprising functional modules) were realized. The mounting precision of modules on ladders is achievable within the precision of 100 µm. Also, half ladders equipped with functional modules has been tested under the heavy-ion beam at FAIR Phase-0 Programme of mini-CBM. All the final components of the detector have been delivered and is now ready for the pre-series production.

References

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