Ladder Assembly for the Silicon Tracking System of the CBM Experiment at FAIR

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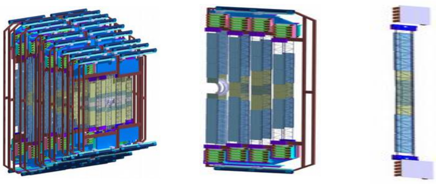
Introduction

The Compressed Baryonic Matter (CBM) experiment [1] is one of the major scientific pillars of the future Facility for Anti-proton and Ion Research (FAIR), which presently is under construction adjacent to GSI in Darmstadt, Germany. The main goal of the CBM experiment is to explore the Quantum Chromo Dynamics (QCD) phase diagram in the regions of high baryonic densities and moderate temperatures in the beam energy range of 2-45 AgeV for SIS-100.

The Silicon Tracking System (STS) is the core detector of the CBM experiment located inside the dipole magnet. The main task of STS is to reconstruct the tracks and measure the momentum of charged particles. The detector comprises of detector modules, based on double-sided silicon micro-strip sensors distributed on 8 tracking stations Fig 1(a). The stations are made from mechanical half units Fig 1(b) and the detector modules are mounted onto lightweight space frames with end supports, the "Carbon Fiber (CF) ladders" Fig 1(c).

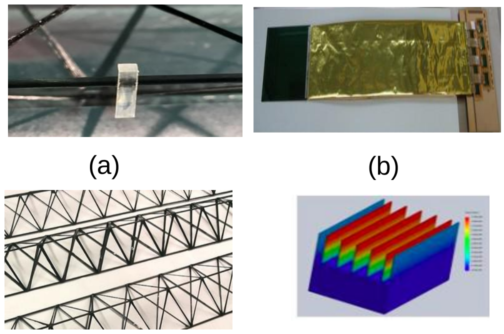


(a) (c)

Fig.1 STS Integration (a) 8 tracking stations (b) 18 half-units (c) 896 detector modules mounted on 106 ladders

CF ladder and its components

A CF ladder comprises two times five modules. The concept of the CF space frames was developed for the barrel geometry of the Inner Tracking System of the ALICE experiment and has been adapted to the use case in the CBM-STS. The main components of a STS ladder are CF space frames, legs of L shape made from fiberglass and modules comprising of Silicon double sided microstrip sensor, micro-cables and Front End Boards (FEBs) and FEB Box (Fig. 2).



(a) (b) (c) (d)

Fig. 2 (a) L-legs (b) Detector module (c) CF space frames (d) FEB Box

Feasibility test of adhesives

The integration of the STS ladder involves several kinds of adhesives. According to the particular application, different glues vary in their consistence from liquid to viscous, curing method (thermal or optical) and mechanical strength. These are required for mounting the sensors onto CF ladders and to glue the l-legs onto the CF ladder. A set of candidate adhesives: Araldite 2011, silicon glue CAF4, Epolite FH53313, Epotek 7110, Epotek 302-3M have been tested for their pull-off forces. It resulted in a minimal pull-off force of about 3.5-7 N in the case of softest (silicon) glue which was decided to be used for glueing modules to l-legs and Araldite-2011 glue having adhesive force of 21-40 N was proposed to be used to glue the l-legs to the ladder (Fig 3).

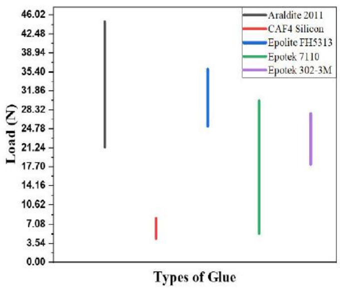


Fig.3 Ranges of the pull-off force for different adhesives for a single l-leg.

Assembling of ladder

A tool has been designed to study the feasibility and technique for handling the modules on CF ladders. The positioning of modules requires a precision better than ±100 µm. Using the tool, a prototype ladder has been assembled with 5 non- functional modules with two types of sensors, first two sensors have dimensions 6.2 x 6.2 cm^2 and last three have 6.2 x 12.4 cm^2. The complete process is divided into the following steps:

(I) **Mounting of ladder on the tool and gluing of L-legs on the ladder:** Ladder bearings are attached to the tool plate and CF ladder is then glued to the bearings. After mounting the ladder, l-legs are glued to it using Araldite-2011 glue. 4 l-legs are required to hold each sensor.

(II) **Positioning of modules on the ladder:** The modules are positioned onto module holder which consists of two parts: sensor holder which holds the sensor via vacuum and cable arm which holds the rest part of the module Fig 4. The sensors are positioned in respect to the supporting fixtures and glued sequentially on L-legs using CAF4 glue. The precision of positioning is given by the height of the tool and dowel pins.

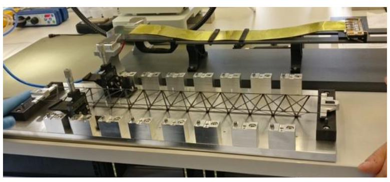


Fig. 4 Module holder holding the complete module with L-legs glued on the ladder

(III) **Optical survey of CF ladder using measurement table:** For the optical survey of the ladder, measurement table with movable camera is used with dimensions in X, Y and Z as 1100 mm, 800 mm, 170 mm respectively (Fig 5). The table is equipped with a movable camera. To measure the height of the object auto focus technique is used and to measure the marks on the sensors surface pattern recognition technique is used. The resolution of the measurement of the surface of the table was found to be ±10 µm.

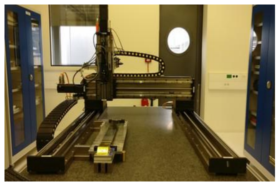


Fig. 5: Movable camera system equipped on the table for optical survey of ladder

After the measurement, the ladder is shifted to the C-frame using a specially designed transfer tool Fig 6

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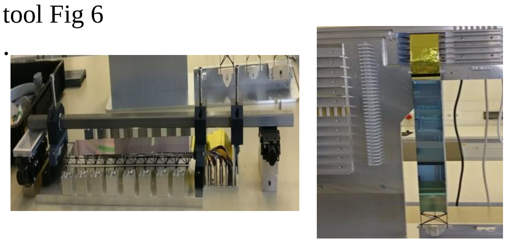

(a) (b)

Fig. 6 (a) Transfer tool holding the ladder (b) A prototype ladder assembled with 5 non – functional modules assembled onto the C-frame

Summary: Ladder assembly technique for the STS of the CBM experiment has been tested. This approach uses a streamlined set of precision tools where one by one modules are assembled to the CF ladder. So, the first non- functional ladder was assembled succesfully where the positioning of marks on the sensors was with in the limits. This technique will be used to produce the ladders of the STS for the mini-CBM experiment in 2018.

References

[1] http://www.fair-center.eu/for-users/experiments/cbm.html

[2] CBM Collaboration, Technical Design Report for the CBM Silicon Tracking System