Conceptual design of mechanics for the CBM Silicon Tracking System

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The mechanics of the STS was designed in accordance with the requirements of the CBM experiment, with the extensive use of the experience gained in creating similar installations for other experiments, including ALICE at LHC. The tracker consists of eight stations of silicon detectors positioned along the beam axis. A general view of the tracker is shown in Fig. 1.

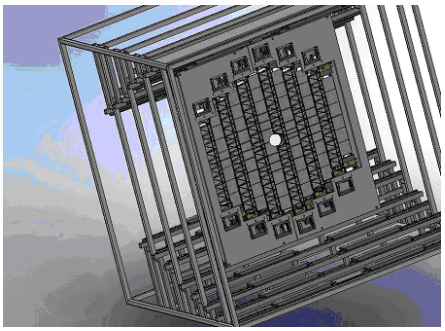

Figure 1: Front view of the tracker with detector station 4

The detectors used in the tracking system are either single double-sided silicon strip detectors or, at the periphery of the stations, complex detectors composed of two or three daisy-chained sensors. Single or composite detectors connected to the end cap electronics with analogue cables make up detector modules, which can be tested separately and stored as spares. The modules are mounted on lightweight space frames with end supports to form ladders. The supporting structure of the ladder is a three-edged space frame made of the M55JB high-modulus carbon fiber impregnated with a hot polymerization epoxy binder. Depending on the station number and on the ladder position, the lengths of the frames vary from 280 mm to 1060 mm. The frames were optimized in calculations using the ANSYS software package. Their mass can be minimized by placing them vertically to reduce the gravitation sagging. The calculated specific mass of the frames is 14 g / 1000 mm. An optimized version of the ladder is shown in Fig. 2.

The fabrication technique for the production of lightweight carbon-fiber space frames is based on a one-cycle polymerization process at 125°C in a metallic mold. The ladders are assembled with the use of a dedicated machine. They are mounted on flat bearing plates made of carbon plastic. The accurate positioning of the ladders with minimum stress is ensured by pins with ruby spheres. A block of ladders is shown in Fig. 3-left. The stations are built from these blocks.

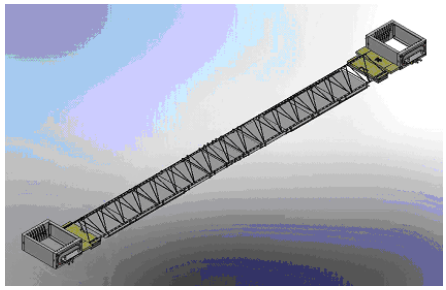

Figure 2: Optimized version of the ladder (without cables and front-end electronics)

The eight stations of the tracking system are arranged in four two-station modules. The main supporting unit of the module is a rectangular frame made of carbon composite tubes. Each frame is equipped with a precision linear bearing and two carriages joined together by a U-shaped bar thus forming a movable block. This block can be moved along the rail of a linear bearing and even outside of the module with the use of a supplementary rail. The U-shaped bars have landing pins for precision mounting of the ladders. The stations in the module are placed 110 mm apart, but the two-station modules themselves are placed 200 mm apart, which makes it possible to freely place on the vertical tubes of the main supporting frame such service components as fittings, electrical and optical connectors and manifolds of the liquid cooling system. The frames with the linear bearings provide accurate relative positioning of the stations. A half station is shown in Fig. 3-right.

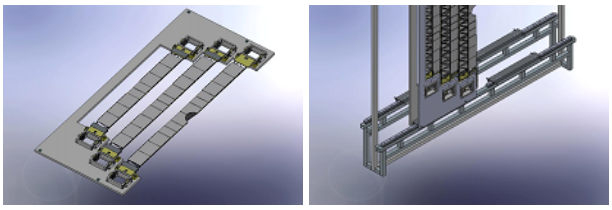

Figure 3: (Left) A block of ladders. (Right) Half-station of a two-station module with two blocks mounted.

The design presented above provides

- accurate mounting/replacement of ladder blocks using a removable supplementary rail,
- realization of detector overlaps in the vertical plane by slightly shifted front and rear blocks,
- possible movement of blocks to the sides during beam tuning to avoid radiation damage to the detectors.