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System Integration Issues with the Silicon Tracker of the CBM Experiment at FAIR

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The Compressed Baryonic Matter (CBM) experiment at FAIR is a heavy-ion physics experiment, conceived for high-rate beam-target interactions to allow for the exploration of the phase diagram of strongly interacting matter at highest net baryonic matter densities. The FAIR facility is currently under construction. The CBM detectors are close to desigh finish and the start of series assembly. Beam delivery to the CBM experiment is foreseen from 2024 on.
The Silicon Tracking System (STS) is the central CBM detector for charged-particle identification and momentum measurement. As a consequence of the CBM physics program, its key performance requirements are (a) resolving charged-particle multiplicities of up to 1000 in heavy-ion collisions at up to 11 GeV/nucleon projectile energy, (b) pile-up free track measurement at collision rates between 0.1 and 10 MHz, (c) momentum resolution in a 1 Tm dipole magnetic field of better than 2%, and (d) capabilities for the identification of particle decays, e.g. with strangeness content. A low-mass detector is of particular importance as the particle momenta are low when compared with those at LHC. At the same time a large aperture and standalone track reconstruction capability keeping up with the high interaction rates must be achieved. The STS design chosen comprises 8 tracking stations equipped with a total of about 900 double-sided silicon micro strip sensors. The detector's functional building blocks are low-mass modules consisting of a sensor spaced by ultra-thin read-out cables from its read-out electronics that is placed outside of the physics aperture. A total of close to two million channels will be read out with self-triggering electronics, streaming time-stamped data to a computing farm where on-line event formation and analysis is performed.
At the Forum we will address a number of issues that we have with the system integration of the STS, along with approaches made. Module assembly has been achieved using tape-automated bonding of micro cables to double-sided sensors and read-out ASICs. Two cable materials and related interconnect techniques are being explored. About 20 module variants, i.e. combinations of sensor strip and microcable lengths, are required due to the forward geometry of the experiment. Signal-to-noise is an issue in particular with the longest modules. First full modules with longest cables have been assembled and mounted onto carbon fiber support ladders. Optical survey has been developed for sensor quality assurance and ladder metrology. Some of the ladders have been installed and operated in the miniSTS detector of the miniCBM experiment at GSI-SIS18, allowing to test mechanical and functional aspects of the full detector. The thermal management of read-out and powering electronics has to be capable of removing dissipation of about 40 kW through a liquid cooling system. The silicon sensors have to withstand an integrated particle fluence of 10^{14} n/cm^2 (1 MeV equivalent) and will be cooled to below -5 deg. C with a flow of nitrogen gas to suppress leakage currents. Electronics and sensor cooling are addressed with a separate "thermal"demonstrator, currently under construction, focusing on thermal interfaces, wall insulations and feed-throughs for the various services, as well as proving the liquid and gas cooling approach.

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