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Thermal Management of the CBM-FAIR's Silicon Tracking System (STS) –Concept and Demonstrators

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The Silicon Tracking System (STS) is the core tracking subdetector of the CBM experiment at the under-construction FAIR facility in Darmstadt, Germany. The STS is tasked to provide track reconstruction (> 95%) and momentum determination (< 2%) of charged particles from the beam-target interactions (Au-Au $\sqrt{s_{NN}}$ = 2.9 - 4.9 GeV). The STS comprises of 876 double-sided microstrip silicon sensors which are distributed across 8 tracking layers. The silicon sensors are mechanically held by light-weight carbon fibre ladders, whereas the front-end electronics are placed outside the physics aperture to ensure a low material budget of $0.3\% - 2\% X_0$ per layer. The silicon sensors and the front-end electronics will operate in a range of -10 $\cdots$0°C to neutralise the radiation damage caused by the non-ionising dose of 10^{14} n_{eq} (1MeV)/cm^2 accumulated during the detector's lifetime.

The first part of this contribution will describe the corresponding cooling concepts. This will include: [1] sensor cooling concept based on impinging cold air jets to remove the sensor power dissipation of 6 mW/cm^2 at -10°C, [2] sensor thermal runaway calculations and their verification by CFD simulations and, [3] CFD and thermal simulations of the 3M NOVEC 649 based electronics cooling concept tasked to eventually remove 40 kW of power dissipation.

The second part of this contribution will focus on the experimental verification of the cooling concepts. This will include: [1] the construction and commissioning of the STS thermal demonstrator, [2] characterization of the thermal enclosure properties, in terms of its leak tightness and thermal isolation and, [3] interplay between the silicon sensor and electronics cooling to converge to the optimal operational conditions.

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