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Lightweight Thermal Management Strategies for the Silicon Detectors of CBM at FAIR

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The Compressed Baryonic Matter Experiment (CBM) at the Facility for Antiproton and Ion Research (FAIR) is a fixed-target spectrometer designed to explore the high-density regime of the QCD phase diagram at √sN N = 2.9 - 4.9 GeV (Au-Au collisions) with interaction rates reaching 10 MHz. The Inner Tracker is compromised of the Micro Vertex Detector (MVD) and the Silicon Tracking System (STS) housed inside a superconducting dipole magnet.
The first part of this contribution pertains to the CBM-MVD which uses CMOS MAPS for its four detection planes, offering high spatial (~ 5 μm) and time (~ 5 μs) resolution, with good radiation tolerance (~ 5 MRad, ~ 7 × 1013 neq/cm2). The MVD sensors will operate in vacuum at ≈ 0◦C by mechanically supporting them on Thermal Pyrolytic Graphite carriers (TPG, ~ 1500 W/m·K), conducting the heat to actively cooled heat sinks (3MTM NOVECTM 649) outside the physics aperture to ensure a material budget of 0.3% − 0.5% X0 per plane. There will be special focus on the preparation of TPG carriers which feature pros (thermal conductivity, price) and cons (surface quality, softness). Solutions developed during prototyping will be presented, recommending employing TPG in high-precision vertex trackers.
The second part of this contribution pertains to the CBM-STS which uses double-sided silicon micro-strip sensors for its eight detection planes, offering high track reconstruction efficiency (> 95%) and momentum resolution (< 2%). The silicon sensors are mechanically held by light-weight carbon fibre ladders, while the electronics along with its cooling are placed outside the physics aperture to provide a material budget of 0.3% − 2% X0 per plane. The STS sensors will operate at ≈ 10◦C to mitigate the radiation damage of 1 × 1014 neq/cm2. There will be special focus on the thermal management strategy of using liquid-assisted air cooling. This approach involves cooling silicon sensors with impinging cold air jets to remove the sensor power dissipation (~ 54 mW/cm2), while the 40 kW power dissipation from electronics is cooled with liquid 3MTM NOVECTM 649. Detailed experimental investigation will be presented verifying the cooling concept with a realistic STS thermal demonstrator.

Collaboration

CBM

Role of Submitter

I am the presenter

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