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Design and Electronics of the CBM Micro-Vertex-Detector

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Reconstructing Open-Charm Particles with the CBM-Experiment requires an ultra-light Micro Vertex Detector (MVD) using CMOS Monolithic Active Pixel Sensors. These sensors have unique properties concerning spatial resolution, radiation hardness, and material budget. A full read-out chain was designed and prototyped, comprising a multi-purpose FPGA platform and specialized front-end electronics. A commercially available very thin single-layer flex cable will be used as electrical connections to the sensors. We are going to give an overview on the detector concept for the MVD including our latest results from building a full sized prototype of one quadrant.

Summary

The Compressed Baryonic Matter (CBM) experiment will be located at the SIS100/300 heavy ion synchrotron of the FAIR facility in Darmstadt. The fixed target experiment will study the phase diagram of nuclear matter in the region of highest net baryon densities by means of rare probes like di-electrons and open charm. The Micro Vertex Detector (MVD) in close proximity to the target will allow to reconstruct open charm particles by measuring their decay topology. In addition, the MVD will help to reject electrons generated in $\gamma \rightarrow e^+ + e^-$ conversions and such reduce the background of the di-electrons.

To fulfill its task, the four stations of the MVD have to combine an ultra-light material budget (0.3% X_0 for the first and 0.5% X_0 for subsequent stations) with a spatial hit resolution of ~ 5 μm. Moreover, vacuum operation and a high rate capability for 100 kHz Au+Au collisions are required.

Being placed only 5 cm away from the target, the sensors have to endure $\sim 10^{13}$ n_{eq}/cm^2 non-ionizing and 3 Mrad ionizing radiation. These requirements can be met by CMOS Monolithic Active Pixel Sensors (MAPS). The strict material budget constraints require special care also with respect to support and cooling materials as well as electrical connections. The latter contribute significantly to the material budget of the stations. Therefore, the material budget of those cables was minimized by pushing commercial copper technology to its limits and a material budget of 0.05% X_0 was reached. Carriers made of industrial CVD diamond or thermal pyrolytic graphite (TPG) will be employed as support structures.

As the final sensors are not yet available, the MVD is being prototyped based on the MIMOSA-26AHR sensor, which was developed by the PICSEL group of the IPHC Strasbourg. A total of 15 sensors will be placed on both sides of the carrier, forming a full quadrant of one station of the final vertex detector.

All supply electronics for the sensors are placed on a so-called converter board, located at about 50˜cm distance from the sensors. Therefore, it is supplemented by a passive front-end board dedicated to voltage stabilization and filtering.
In addition to remote controlled power supplies, signal switches and drivers, the converter boards feature an ADC section
to monitor the sensors' momentary electrical parameters.
The read-out and control system employs the TRB3-FPGA-board, which was initially
developed for HADES and is now used by several experimental groups at FAIR and other institutes.

The firmware and software of the fully scalable prototype
include error recognition, status monitors and the necessary
slow and fast control features for controlling a full size detector system.

The contribution introduces the concept of the
readout system of the MVD and discusses our solutions for matching the
demanding constraints of the physics mission of the CBM experiment.

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