The Micro Vertex Detector of the CBM-Experiment

Tobias Tischler,
Institut für Kernphysik, Goethe-Universität Frankfurt, Deutschland,
for the CBM-MVD Collaboration

Quark Matter, Washington D.C., 2012
ID 13

Motivation

The fixed target experiment **Compressed Baryonic Matter** (CBM) will explore the nuclear phase diagram in the region of highest net-bayron densities at moderate temperatures. **Open charm** is one of the promising probes to access information on the medium created in the early phase of the relativistic heavy-ion collisions in this energy regime. Particles with **open charm** will be identified by reconstructing their secondary decay vertex with high precision. To do so, a **Micro Vertex Detector (MVD)** with ultra-low material budget is needed. The MVD comprises several planar stations positioned downstream (5 - 15 cm) the target. Moreover, it will operate in moderate vacuum and inside the magnetic field.

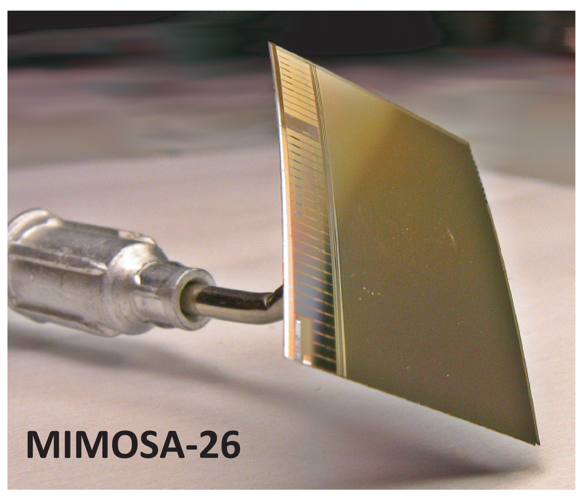
Micro Vertex Detector: requirements

• Number of stations	3 (4)	• Spatial resolution	< 5 µm	• Radiation tolerance	
• Inner acceptance	3° (polar)	• Sec. vtx. resolution	50 µm	ionizing	3 Mrad
• Outer acceptance	25° (polar)	• Read-out time/frame	30 µs	non-ionizing	< 10^{13} n_{eq}/cm^2
• x/X_0 (first station)	~0.3 %	• Sensor power dissipation	< 1 W/cm²	• Operation in moderate vacuum	
• x/X_0 (other stations)	~0.5 %			• Free streaming read-out system	

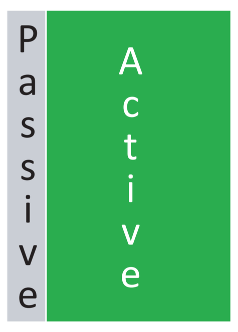
The concept of the MVD

Sensor technology

- CMOS Active Pixel Sensors [1]
- R&D ongoing
  to meet MVD requirements related to
  - radiation hardness
  - read-out time/frame
- Prototype sensor for the MVD
  - MIMOSA-26



Sensor area



MIMOSA-26 (prototype sensor)

- Developed at IPHC Strasbourg
- High granularity (pixel pitch 18.4 x 18.4 µm², 1152 x 576 pixels, 2 cm² active surface)
- Thickness: thinned to 50 µm
- Ionizing radiation tolerance @ 20 °C: 300 krad
- Non-ionizing radiation tolerance @ 20 °C: $3 \cdot 10^{13}$ neq/cm²
- Read-out time per frame 115,2 µs

- On chip discrimination and data sparsification
- Power dissipation < 1 W/cm²

- R&D ongoing
  - Final sensor: MIMOSIS-1

Electrical & mechanical integration

Customized electrical integration

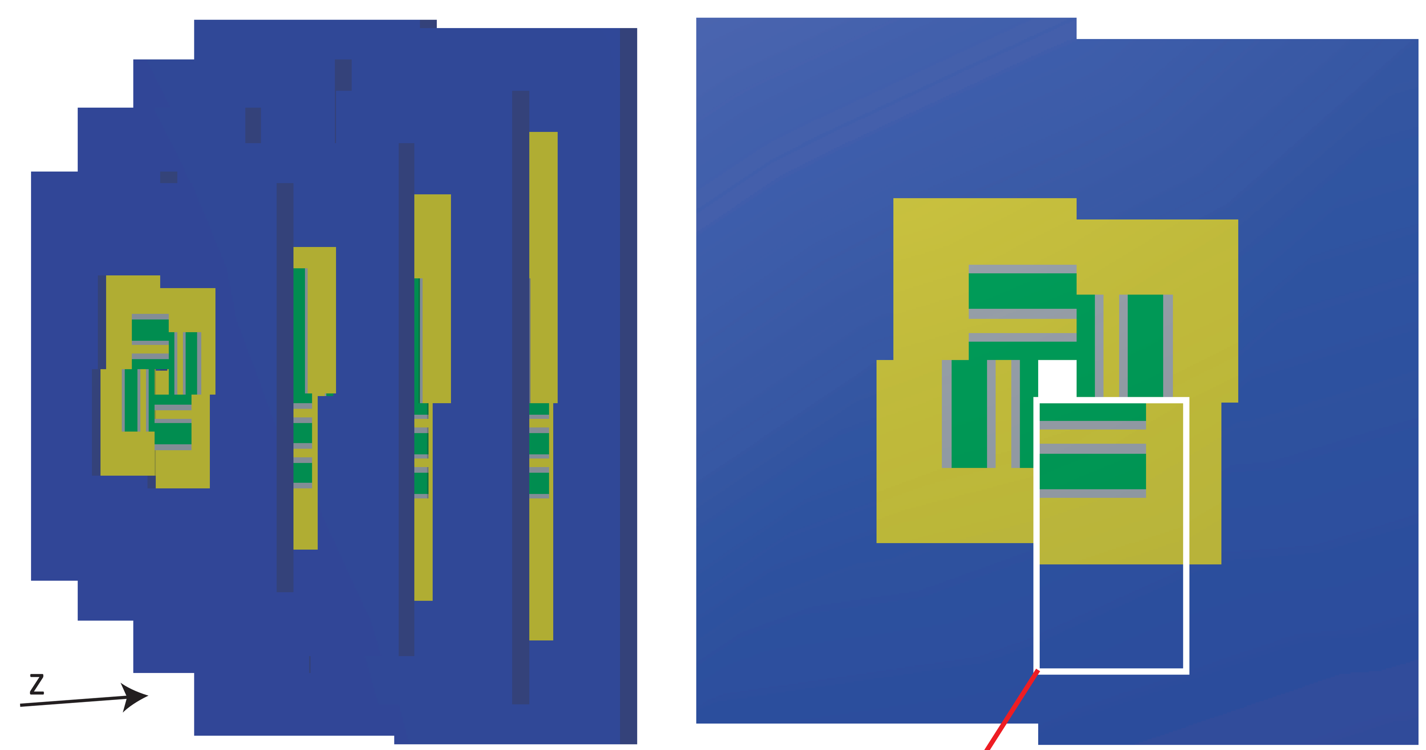
Inside high radiation environment
- Flexprint-cable [2] (FPC)
- Front-end boards
  - Impedance and noise filtering
  - Signal routing and distribution
    - Sensor-signal (LVDS)
    - Clock, reset, slow control (based on JTAG)
  - Power distribution

Outside high radiation environment
- Readout Controller
  - Based on HADES-TRB [3]
  - FPGA platforms to perform data sparsification
  - Slow control (synchronization, sensor settings)
  - Latch-up protection and handling
  - Optical outputs
  - Scalable

Mechanical integration

- **Sensor**:
  - Based on **CVD diamond** [4] (stiffness & excellent heat conductivity of > 1800 W/mK)
  - Heat evacuation via **heat sinks** (outside acceptance)
  - Tolerable temperature gradient over sensors surface of less than ΔT = 10 K at T = - 20 °C
  - Expected heat load < 1 W/cm² per Sensor
- **Front-end boards**:
  - Mounted on **heat sinks**
- **Operation in moderate vacuum**

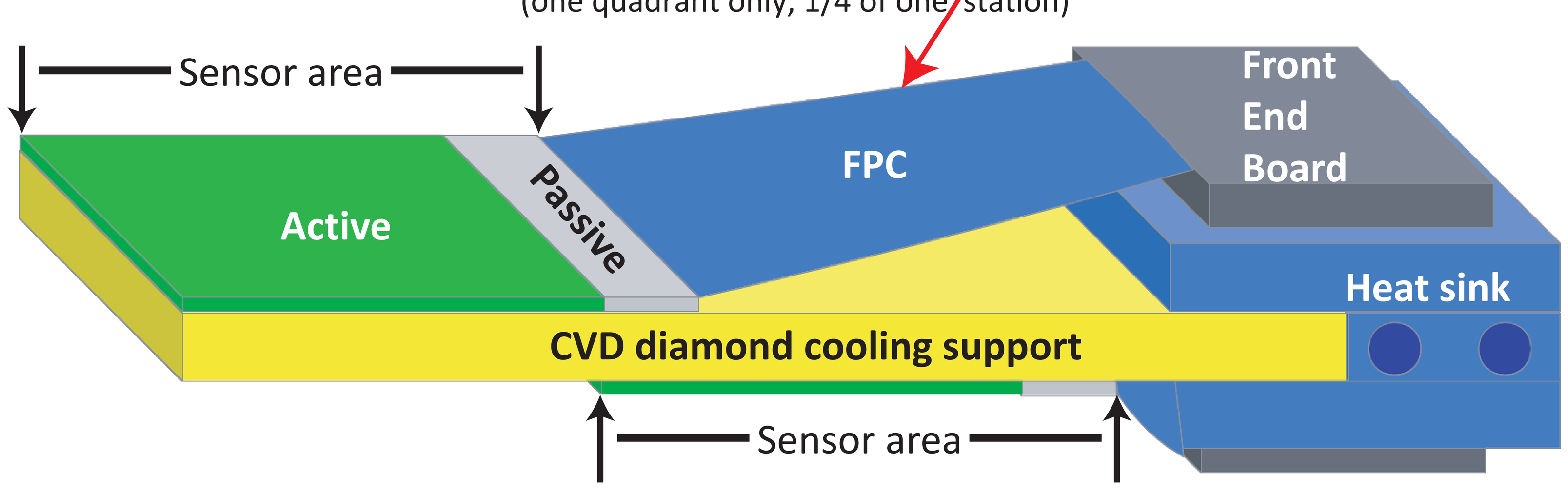
CAD model of the MVD



Side view of the MVD stations   Front view of the first MVD station

Sketch of the MVD

(one quadrant only, 1/4 of one station)



Currently the MVD prototype for SIS-100 is being set up for a test beam at CERN SPS (π, 120 GeV).

The MVD prototype will be equipped with
- 4 sensors (one quadrant, 1/4 of a station) glued on CVD diamond
- DAQ system with a scalable read-out chain

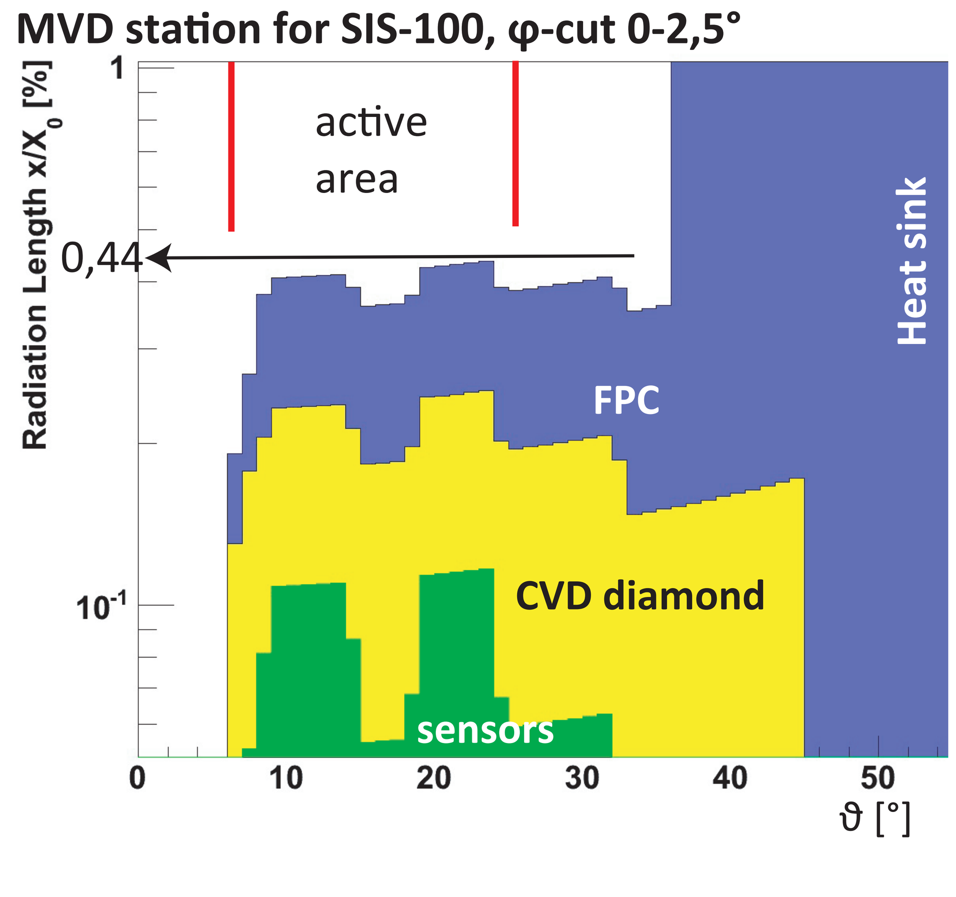
Challenge

Minimal material budget of the single detector stations including

- Sensors (**50 µm thin, 0.05 % X_0**)
- Electrical services (FPC, **Cu-traces, 0.0861 % X_0**)
- Support (carrying and cooling)
  - CVD Diamond (**150 µm thick, 0.12 % X_0**)

- Total material budget
  0.44 % X_0 (on Cu-traces based FPCs)
- Reduction of the material budget (active area) by factor 2 expected by using Al based FPCs
- Development of FPC based on aluminum traces is ongoing

Evaluation of the material budget for the first MVD station for SIS-100, φ-cut 0-2,5°



References

[1] MIMOSA-26, DOI: 10.1016/j.nima.2010.03.043.
[2] C. Schrader et. al, GSI Scientific Report 2011, PHN-NQM-CBM-04.
[3] HADES TRB, J Michel et al 2011 JINST 6 C12056
[4] CVD diamond, diamond materials, Freiburg, Germany.

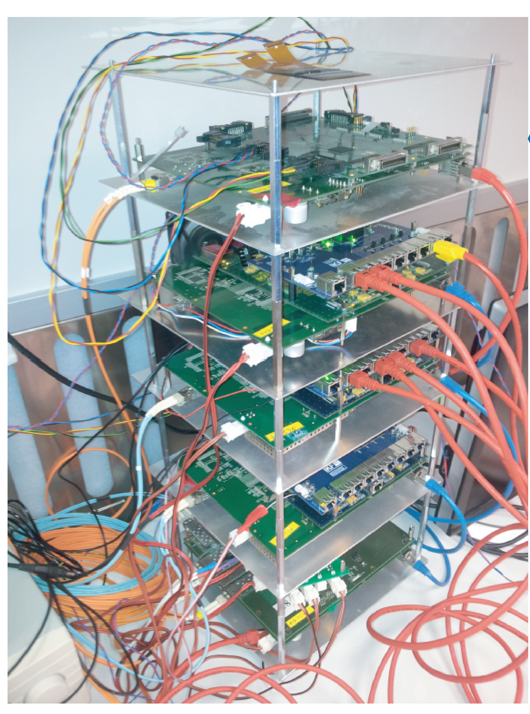
Contact: tischler@physik.uni-frankfurt.de

Status of the MVD Prototype

Test status

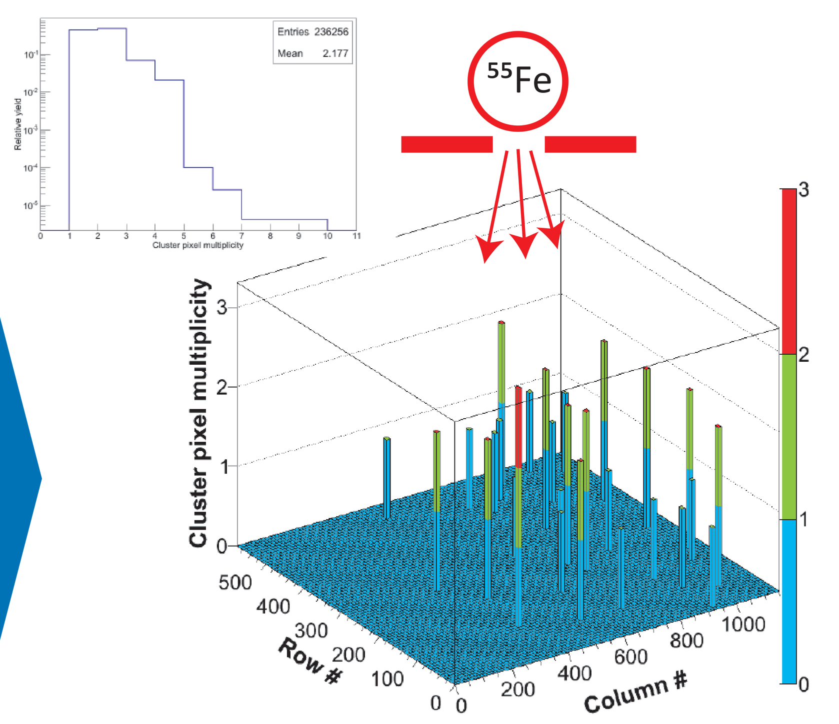
Hardware	Optimization
DAQ system	Firmware
Cables	Settings
Sensors	First test in laboratory
Ready	Ongoing

Reference modules, each equipped with two MIMOSA-26 sensors and read-out cables are currently examined for the upcoming tests with high-energy particle beams.



The data readout is performed with a prototype of a scalable DAQ system based on the HADES TRB2 (later: TRB3). It is following the requirements of the final MVD.

The sensors have been exposed to X-rays from a ^{55}Fe-source.
The plot depicts cluster positions summed over several frames, the z-axis represents the corresponding cluster pixel multiplicity, taken in binary mode. The insert exhibits the distribution of the cluster pixel multiplicity.



supported by BMBF (06FY9099I), GSI Helmholtzzentrum für Schwerionenforschung, HIC for FAIR, H-QM Research School, ULISI (EU-FP7)

H-QM Helmholtz Research School Quark Matter Studies · HIC for FAIR Helmholtz International Center · IKF Institut für Kernphysik Frankfurt · GSI · IPHC