Integration Concept of the CBM Micro Vertex Detector

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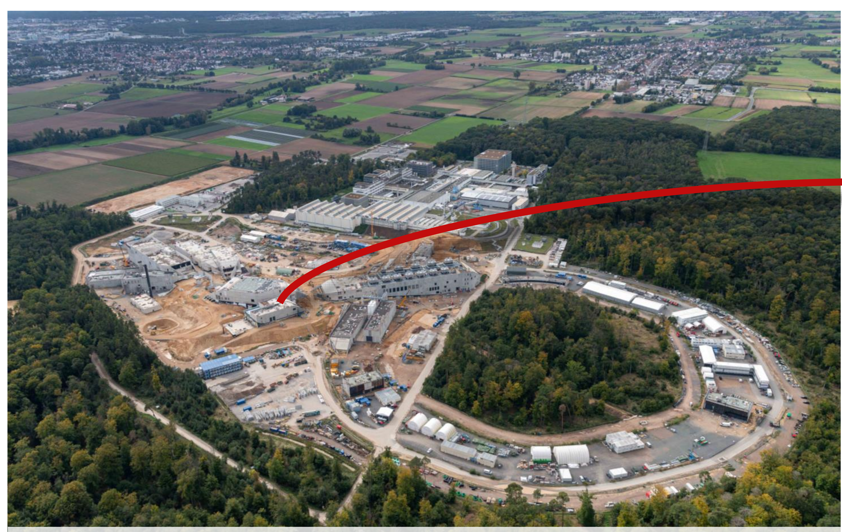
The Compressed Baryonic Matter Experiment at FAIR

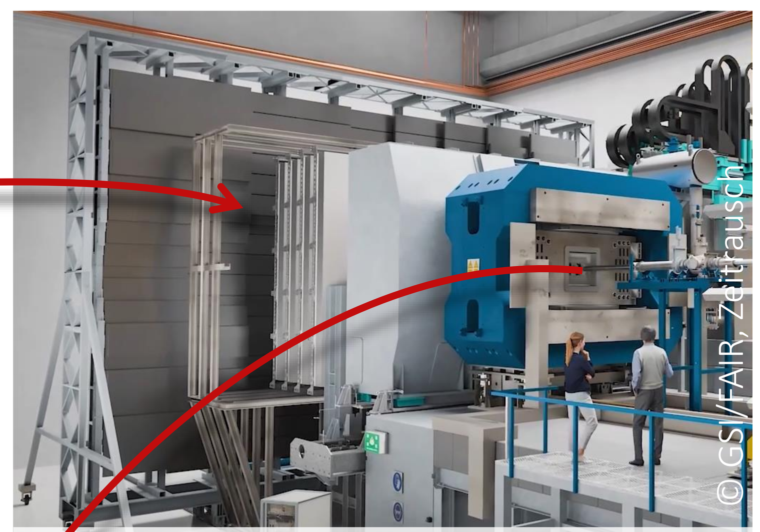
CBM at FAIR & Its CMOS MAPS-based Micro Vertex Detector

Compressed Baryonic Matter (CBM)

Fixed-Target heavy ion experiment at FAIR
≤ 10^7 reactions/s at $\sqrt{s_{NN}}$ = 2.9 – 4.9 GeV
High μ_B, moderate T
Electron and Muon Setup
Multi-differential measurements , rare probes
Trigger-less free-streaming readout
Online event selection, 4-D event reconstruction



FAIR construction site (09/24)



CBM detector (CAD render)

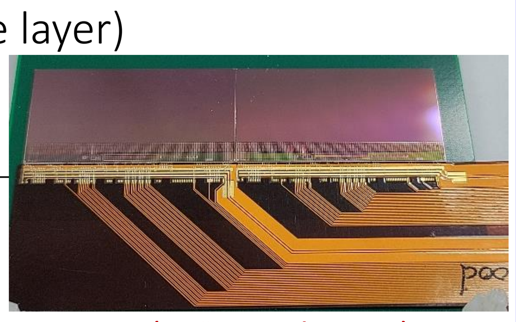
Micro Vertex Detector (MVD)

4 planar layers at z = 8 – 20 cm
2.5 – 25° azimuthal acceptance
In vacuum, mounted to ´front flange´
Inside 1 T·m magnet dipole field
≈ 0.15 m² area, 288 sensors, 150M pixels
CMOS MAPS (MIMOSIS; TJ180 nm)
≈ 0.3% – 0.5% X_0 per layer

Electrical Integration

Sensor FPC (R&D phase)

Power, Bias, SC, Data connection
Baseline: 12 µm Cu-traces (ILFA)
≈ 0.05 % X_0 (single layer)
2 sensors per FPC
R&D on Al FPCs



Front-End Board – FEB (R&D phase)

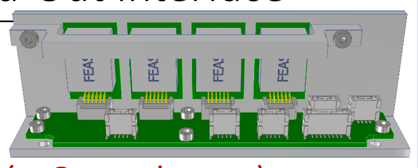
GBT-SCA for SC
Power, Bias, SC, Data interface

Data FPC (R&D phase)

Clock, Data connection
3 layers, 18 µm Cu-traces

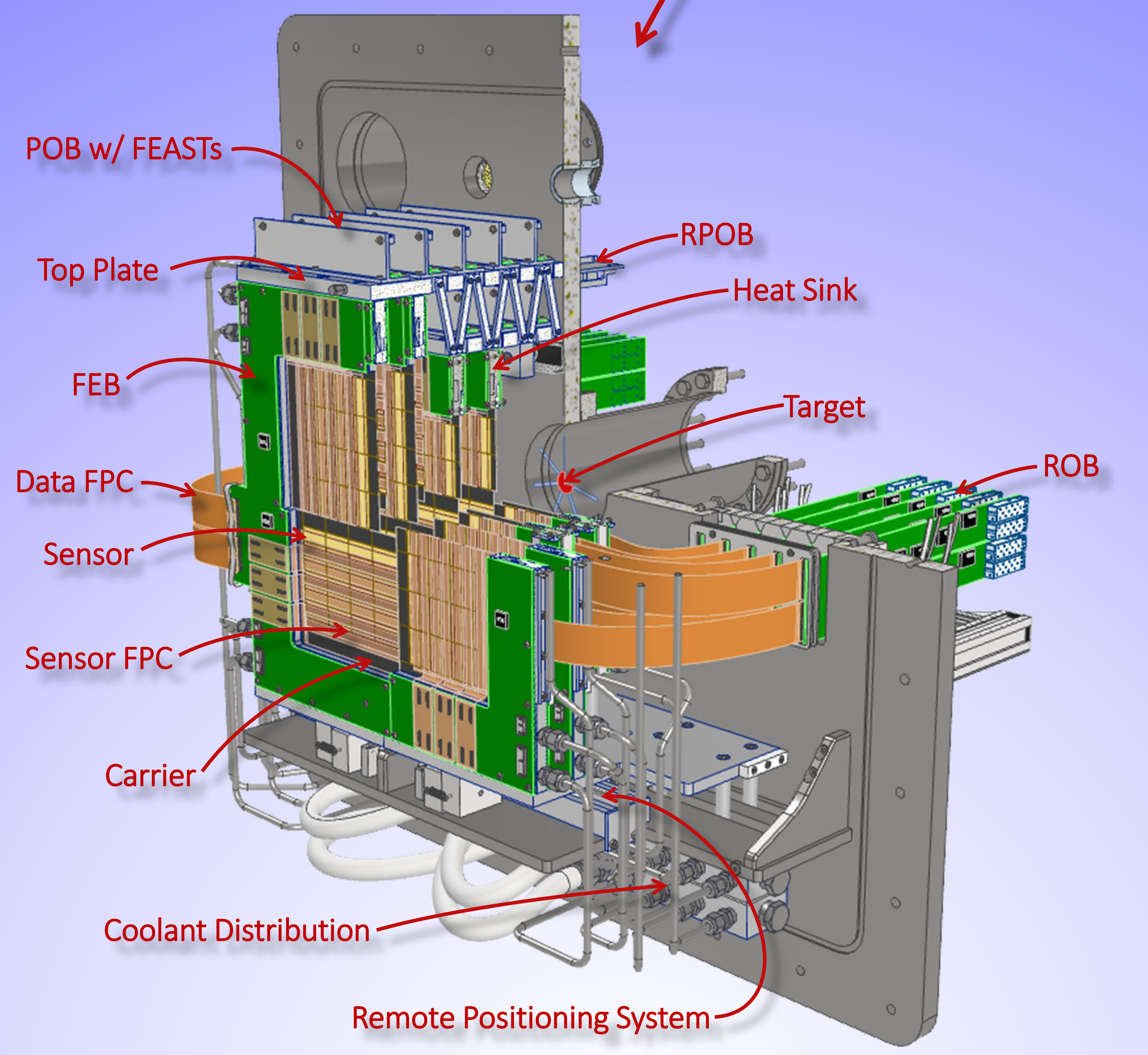
Read-Out Board – ROB (Design Phase)

GBTx, SCA, VTTx, VTRx
30 uplinks per ROB (844 links total)
Connects Common Read-Out Interface



Power Boards – POB (R&D phase)

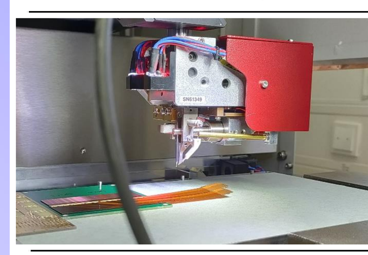
PCBs w/ 4, 5, or 6 FEASTMP
Sensor and ROB powering
Liquid/Air cooled (in-/outside vacuum)



Mechanical Integration

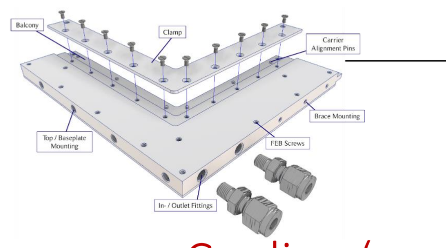
Carrier (ready for pre-production)

Thermal Pyrolytic Graphite (TPG)
≈ 0.2 % X_0 (380 µm), >1500$_{xy}$ W/mK
Mechanical support and cooling
Cut and µ-structured with laser ablation
Parylene-C coating + plasma activation



Double-sided Integration

Full coverage of geometric acceptance
Double-sided wire-bonding (25 µm Al)
EpoTek 301-2 low-viscosity epoxy (sensors)
3M™ Tape 9461P (FPCs)



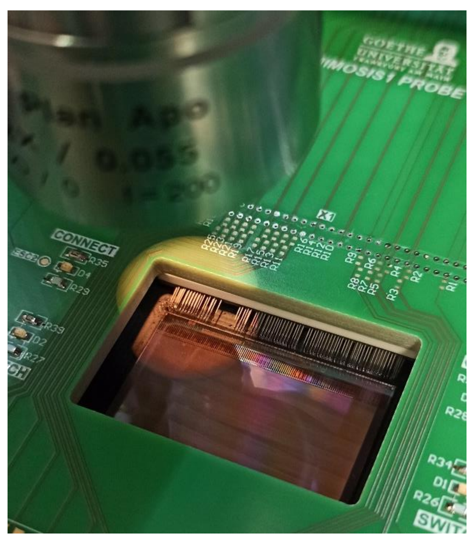
Cooling (ready for pre-production)

Conductive inside, active outside acceptance
Mono-phase liquid 3M™ Novec 649 (≈ –20 °C)
Heat sinks: integration jigs and detector frame
Upstream electronics air cooled

Remote Positioning System

Safe position 5 cm lateral displacement
Two independent, rigid half-detectors
Pneumatic motor, rail system
Adjustable end stops

MIMOSIS CMOS MAPS



↑ *Thinned MIMOSIS* →

QA (Probe Testing)

Analog and digital power	Data output mode
Back bias sweep	DAC scan
Register addressing, crosstalk, r&w	Analog scan (pulsing)
	Threshold scan (S-curves)
Chip ID	Dead, noisy pixels

Dedicated Talk on MIMOSIS Design and Performance in Beam (COSY, DESY, CERN)

Specifications

31.15 x 17.25 mm², 1024 x 504 pixels
70 (50) µm thick with 50 (25) µm epi-layer
AC and DC pixels, Std. (ALPIDE) and p-Stop epi
Back bias up to 6 V, HV up to 20 V
20 (80) MHz/cm² mean (peak)
Priority encoding, on-matrix clustering

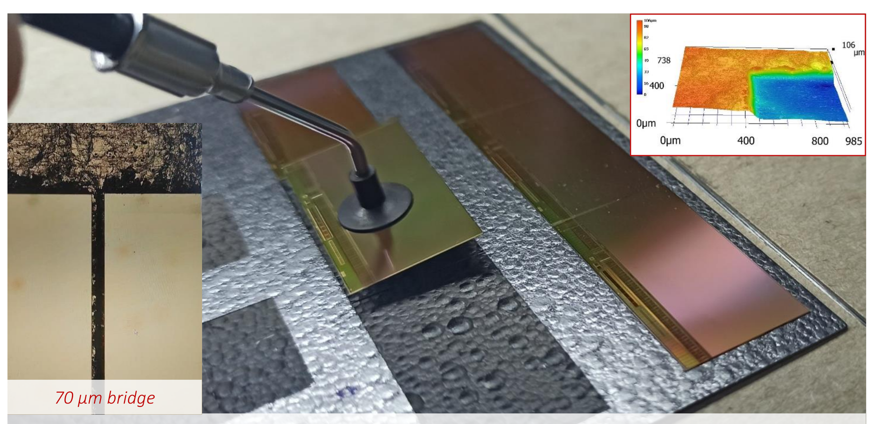
Performance

Power density p ≪ 75 mW/cm²
GMDT ≳ 80 e, efficiency ≫ 99 %
σ_{xy} = 6 µm (σ_z= 70 µm), t_{frame}= 5 µs
MIMOSIS-2.1: Irradiation campaign ongoing
MIMOSIS-2.1: No LU for LET ≲ 50 MeV cm²/mg (preliminary)
MIMOSIS-1: In specs up to 10^{14} n_{eq}/cm², 5 Mrad (preliminary)

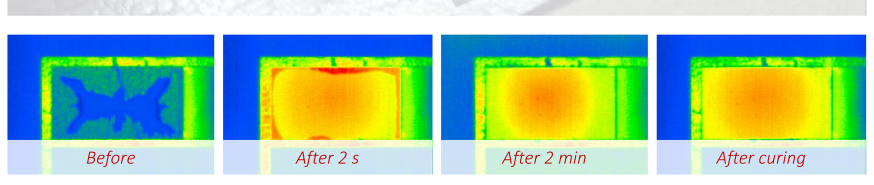
Aspects of Integration

Sensor Integration

Jigless; µ-structured carrier
→ laser-ablated pockets (´hatches´)
Mechanical & thermal connection Sensor/Carrier
Mechanical connection FPC/Carrier
Electrical connection: Full-automatic wire-bonding



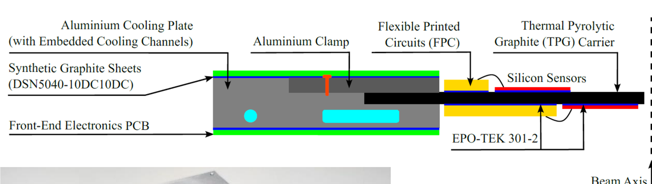
Thinned MIMOSIS in TPG hatches



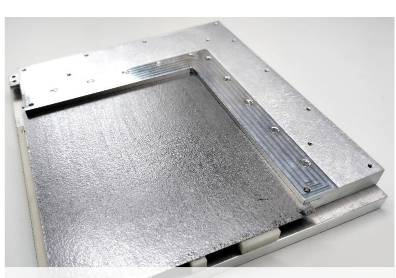
Optimized gluing pattern (EpoTek 301-2)

Double-sided Integration

Concept validated in R&D phase
Dedicated support jig
QA + reworkability to ensure yield

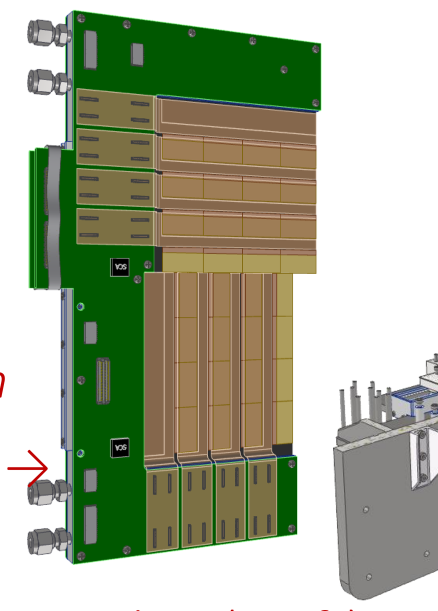


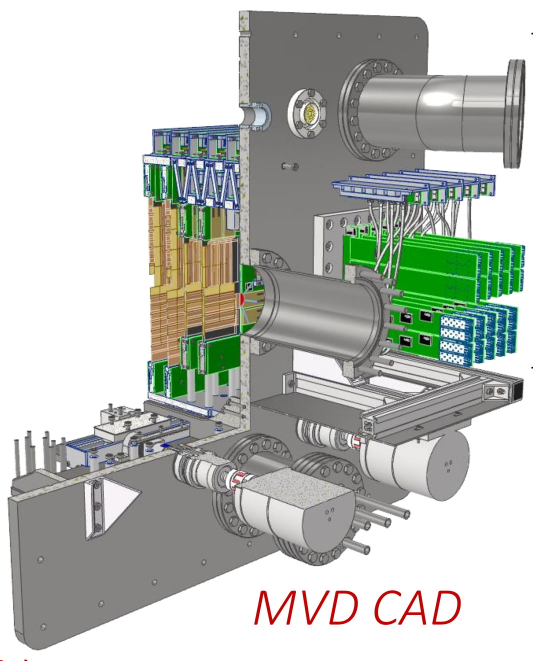
↑ *Cross-section*



Integration jig

Half-Station →





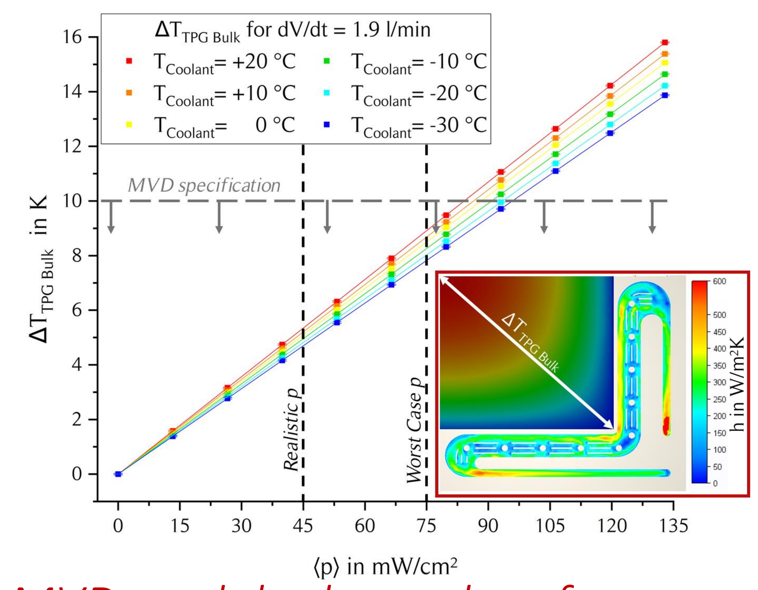
MVD CAD

Sensor Integration Flow (Draft)

Initial QA	Metrology
Carrier cutting & hatching	FPC gluing (QA)
Coating (QA), plasma activation	Wire bonding (row-by-row, QA)
Assembly of carrier & FEB in heat sink	Electrical characterization
FPC tape gluing (QA, rework)	Mounting to Half-Stations
Sensor gluing (QA, rework)	Final QA, storage

Detector Integration

Mounting and Remote Positioning System
LV distribution
Readout system
Cooling system
Detector control system (EPICS)
Assembly optimized w/ full-scale prototype



MVD module thermal performance

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