Status of the vertex detector program of the CBM experiment at FAIR

PM2018 - 14th Pisa Meeting on Advanced Detectors

Philipp Klaus‡ for the CBM-MVD collaboration

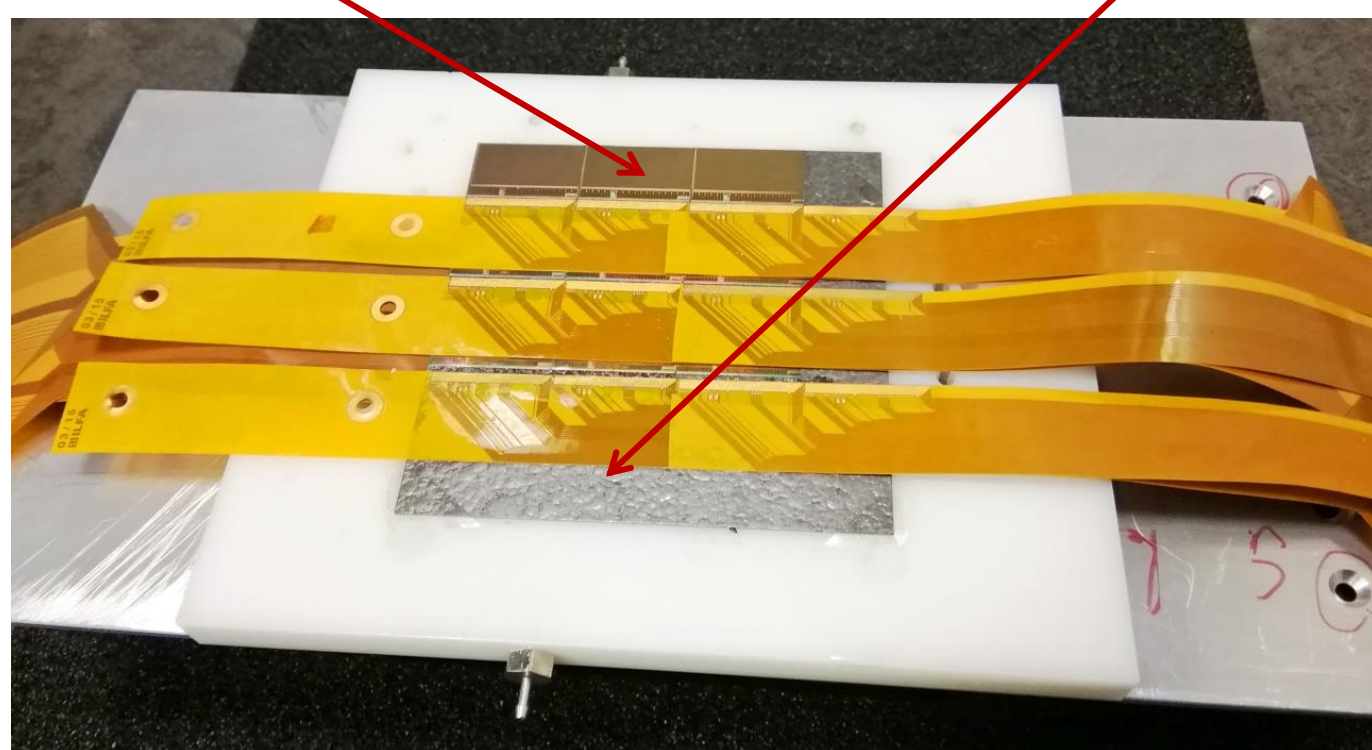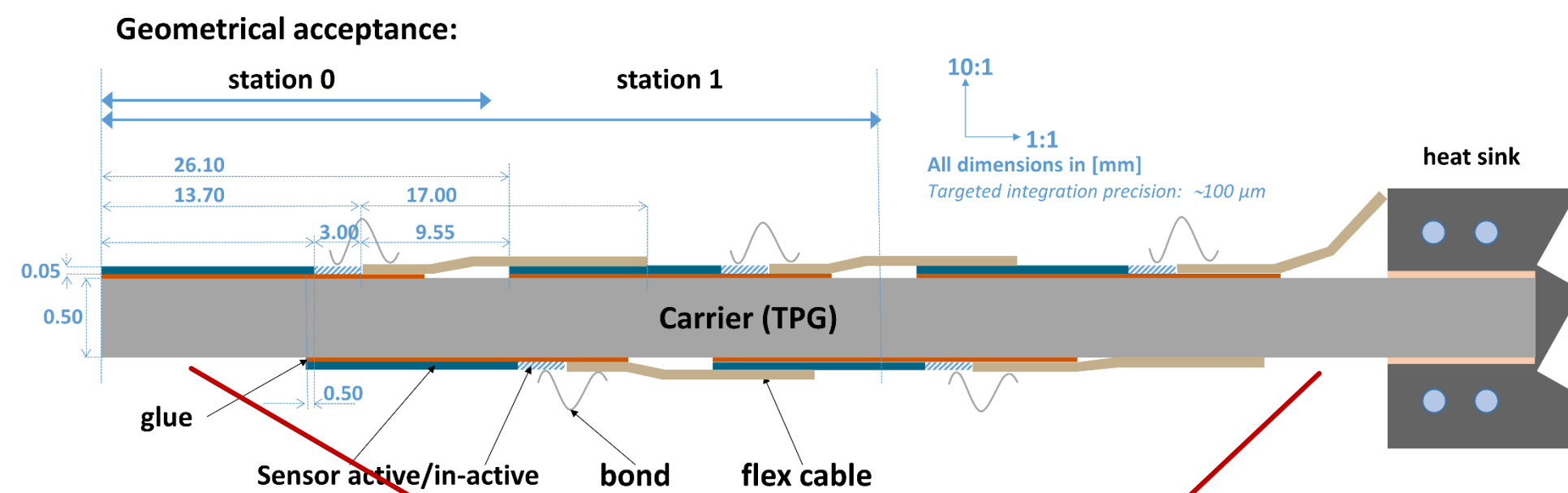Work supported by BMBF (05P15RFFC1), HIC for FAIR and GSI

‡ klaus@physik.uni-frankfurt.de

Prototyping

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• double-sided integration of 50 μm thin CMOS sensors onto dedicated materials (CVD-diamond / TPG), • assembly yield, • slow control, • cooling concept, • flex-print cable performance, • selection and use of adhesive, • vacuum compatibility
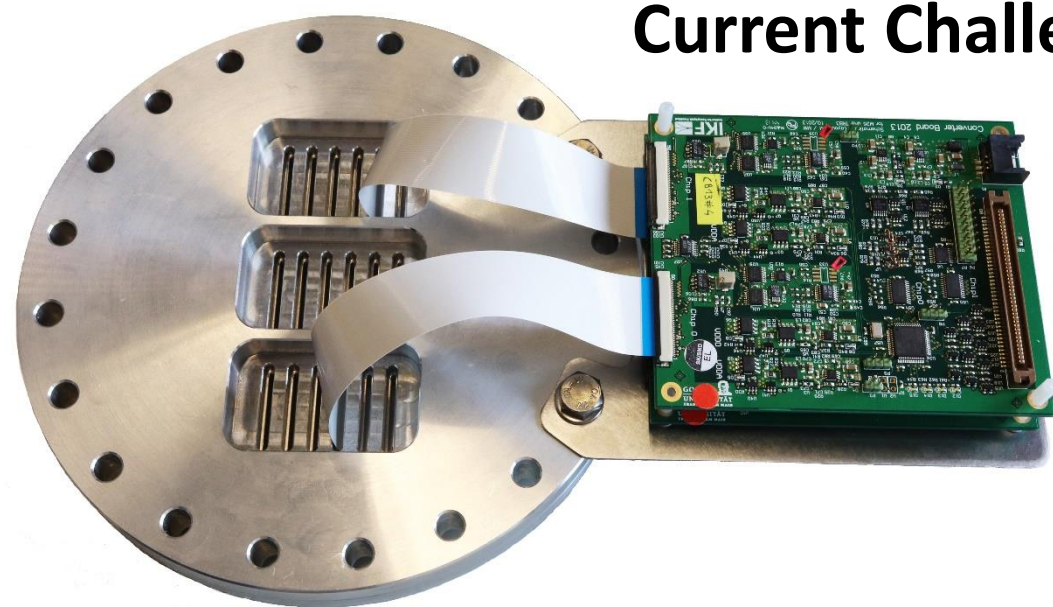
Geometrical acceptance:

station 0   station 1

26.10
13.70   17.00
3.00   9.55
0.05
0.50

Carrier (TPG)

glue   0.50

Sensor active/in-active   bond   flex cable

10:1
1:1
All dimensions in [mm]
Targeted integration precision: ~100 μm

heat sink

Beam

Prototype 2 based on 500 μm thin TPG support

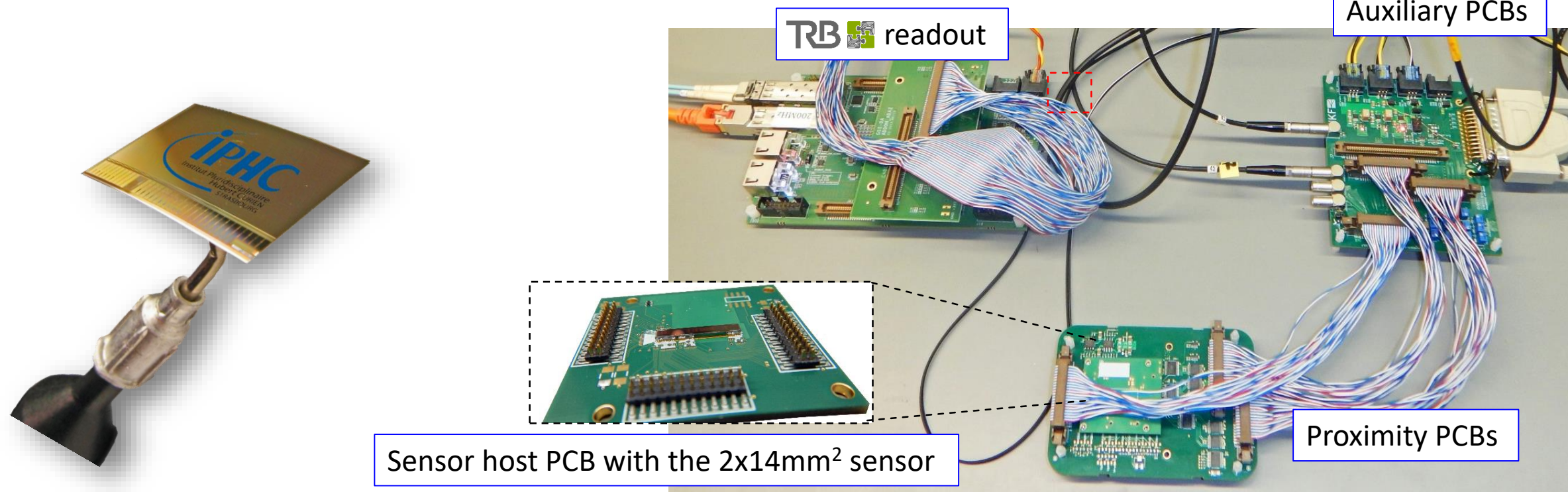## Vacuum Operation

Achieved:
• In-vacuum temperature measurements (IR & Pt100)
• Vacuum-compatible integration onto TPG carriers

Current Challenge:
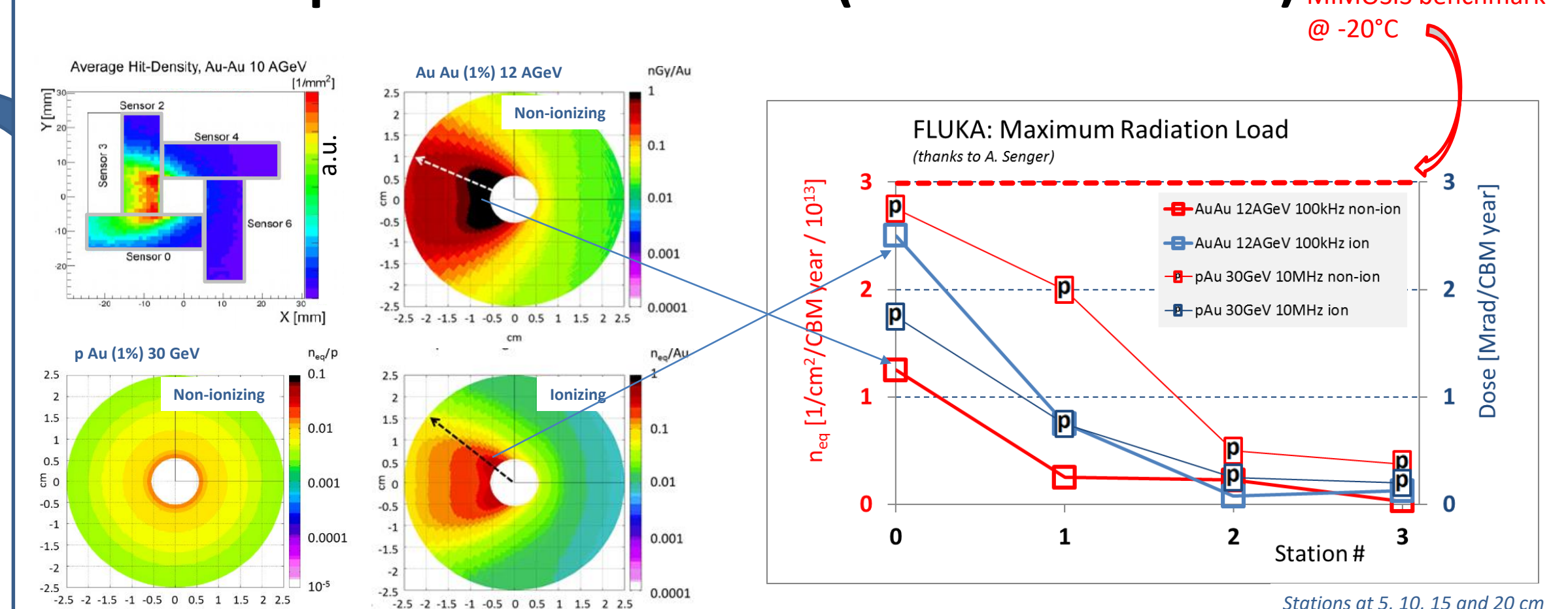
Custom feedthrough for flat flex data cables

The Micro Vertex Detector (MVD)
for the CBM experiment at GSI/FAIR

• Secondary vertex determination (several 10 μm scale), background rejection in di-electron spectroscopy, reconstruction of weak decays
• Vacuum/magnetic field operation
• 2 setups with 4 stations at:
  - 5, 10, 15 & 20 (vertexing)
  - 8, 12, 16 & 20 (tracking) cm downstream the target
• ~300 CMOS sensors (power dissipation 200 to 350 mW/cm²)
• Radiation tolerance: $>10^{13} n_{eq}/cm^2$ & >1 Mrad (ionizing)
• x/X_0 goal: < 0.5% (1st station: 0.3%) → dedicated low-mass flex cables

Quadrant (smallest functional unit):

• CVD Diamond / TPG carrier for heat transfer
• CMOS pixel sensors: 50 μm thin, 150 mW/cm², 5 to 10 μs per frame
• Aluminum heat-sink (actively cooled)

Beam

Sensors
Flex Cable
Carrier
R/O
Heat sink
Cooling pipe

Anisotropic Load on Sensors (Hits & Radiation)

MIMOSIS benchmark @ -20 °C

Average Hit-Density, Au-Au 10 AGeV

Au Au (1%) 12 AGeV   Non-ionizing

p Au (1%) 30 GeV   Non-ionizing

Ionizing

FLUKA: Maximum Radiation Load
(thanks to A. Senger)

- AuAu 12AGeV 100kHz non-ion
- AuAu 12 AGeV 100kHz ion
- pAu 30GeV 10MHz non-ion
- pAu 30GeV 10MHz ion

Station #

Stations at 5, 10, 15 and 20 cm

Sensor Development / MIMOSIS-0 Testing

TRB readout

Auxiliary PCBs

Sensor host PCB with the 2x14mm² sensor

Proximity PCBs

Focus: AC vs DC in-pixel architecture performance, priority encoder, amplification, radiation tolerance

	ALICE-ITS (IB)	CBM-MVD 1st station (vertexing)
Radiation load TID	~270 krad	**3 Mrad @ -20 °C** / 1 Mrad @ +30 °C
Radiation load NIEL	~1.7×10^{12} n_{eq}/cm^2	**3×10^{13} n_{eq}/cm^2 @ -20 °C** , 1×10^{13} n_{eq}/cm^2 @ +30 °C
Peak hit rate	~1.25×10^4 /mm²/s	**7×10^5 /mm²/s**
Trigger	yes	no

MIMOSIS specifications:
• Spatial resolution ~ 5 μm (driven by open charm in pA collisions)
• Read-out time 5-10 μs
• Power consumption: < 200 mW/cm² in stations 2 & 3; < 350 mW/cm² in 1st & 2nd station
• Data rate capability: average ~ 160 Mbits/cm²/s; peak ~ 1.6 Gbits/cm²/s
• Fake hit rate: at detector installation: . 10⁻⁵; with full radiation load: . 10⁻⁴

Detector Control

• Made for 24/7 operation of the detector
• Task: save operation for machine and users
• Based on EPICS v3.15 and Docker
• User interfaces: Web Dashboard and CS-Studio

EPICS

Control   Cooling System ON/OFF:

Current State   BathTemperatureMom: ExternalTemperatureMom:

C.S.S control system studio

DASHBOARD   Home   PV Overviews   OViews   IKF

Cooling

Current Heat Bath Temperature 14.98 °C
Cooling Setpoint Temperature 15.00 °C
Coolant Flow Towards Detector (PRESTO Inlet) 0.999 l/min

Low Voltage

Output State (Channel 1) OFF
Output State (Channel 2) ON
Output State (Channel 3) ON

Huber CC-405   Vacuum Feedthrough   PRESTO Heatsink

Host   docker

EPICS IOC

eth1: 172.19.0.12

5064, 5065

docker bridge

eth0: 10.1.1.2

5064, 5065

external EPICS network