Forum on Tracking Detector Mechanics. 30 .06 – 02.07 2014 DESY Hamburg

The MVD of the CBM experiment at FAIR: Selected Aspects of Mechanical Integration.

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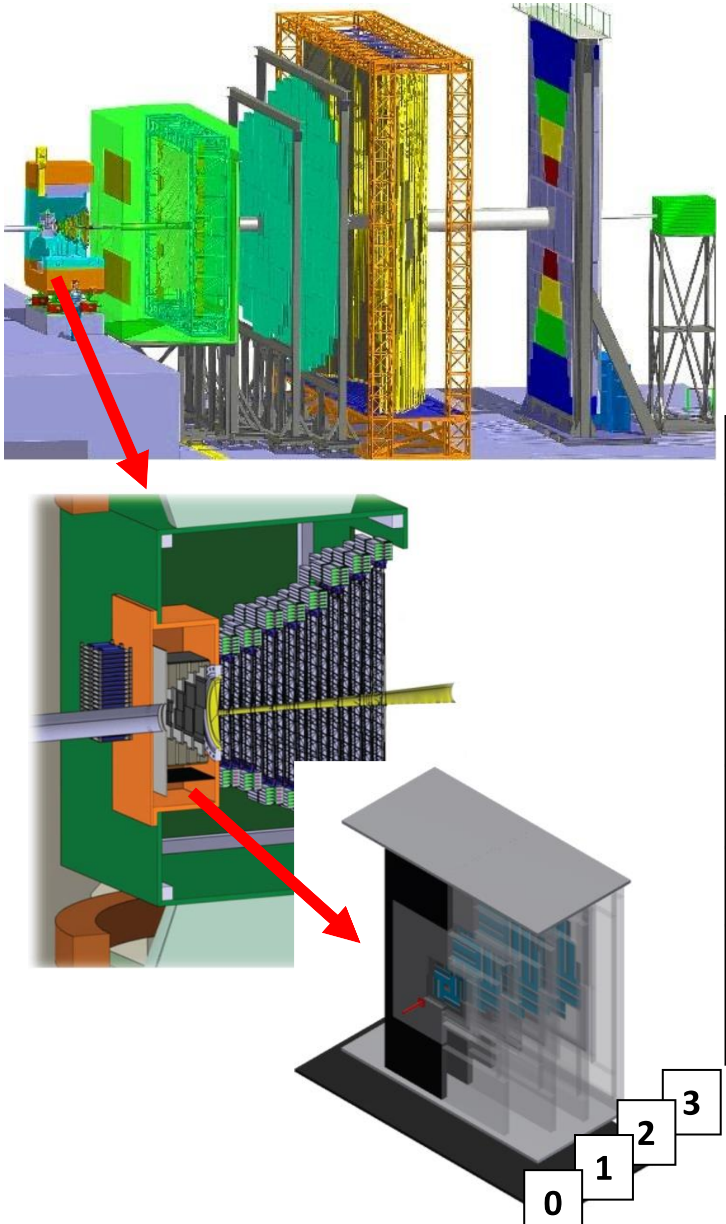
Outline:

- The Micro Vertex Detector for the CBM experiment: requirements
- Material budget
- R&D towards CBM-MVD and synergies with other experiments
    - Vacuum compatibility
    - Adhesives
    - Commissioning of ultra thin Si sensors
- Support materials
    - Thermal simulations
    - laboratory tests in preparation
- Outlook

The MVD – required performance



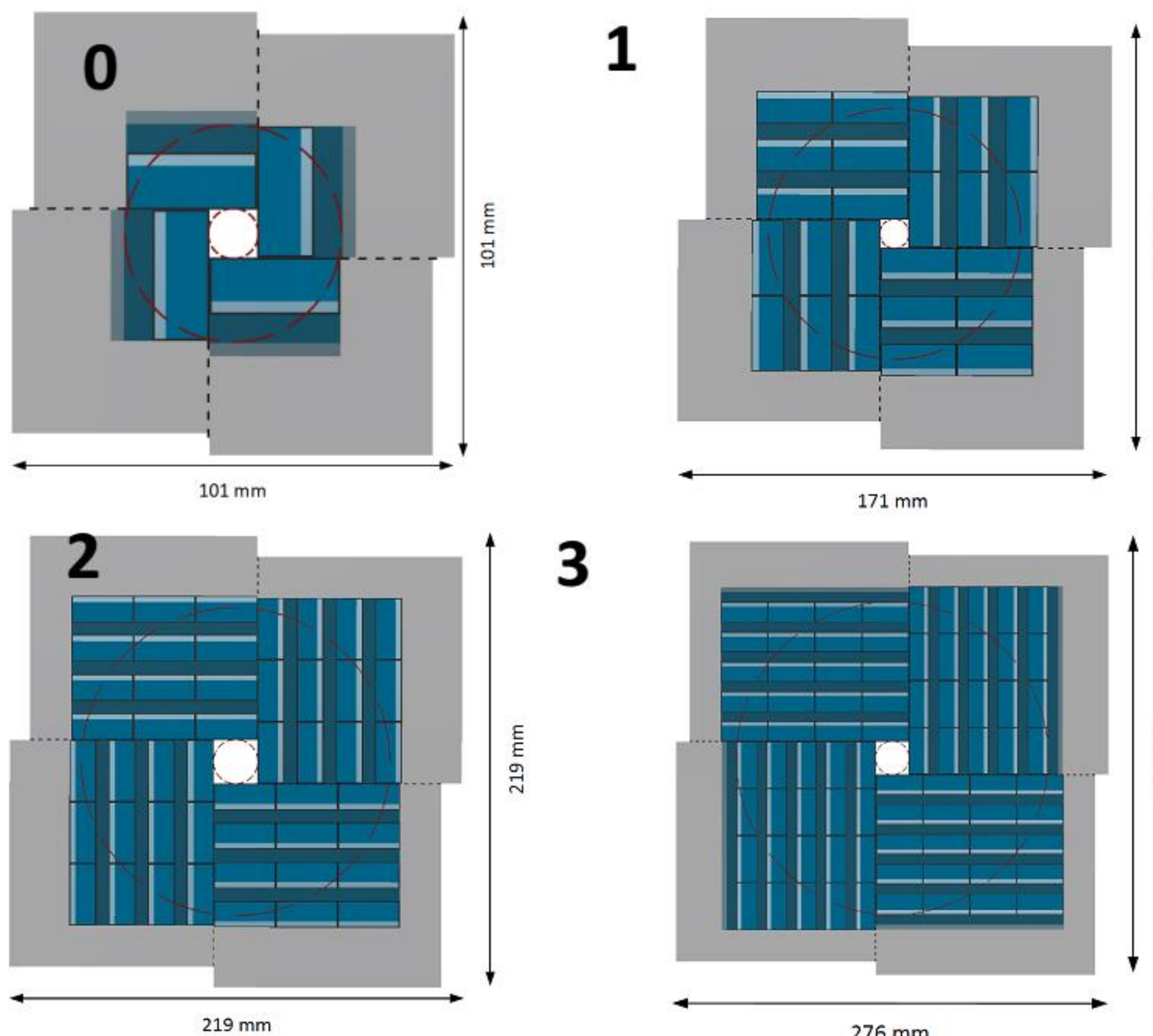
CBM-MVD will:

- **improve secondary vertex resolution**
- **host highly granular silicon pixel sensors featuring fast read-out, excellent spatial resolution and robustness to radiation environment.**

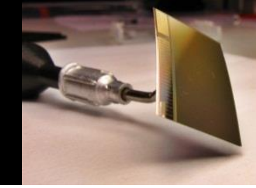
Required performances (SIS-100)	
Radiation tolerance	> $10^{13} n_{eq}/cm^2$ & >3 MRad
Read-out speed	>30 kframes/s => 500 Gbit/s/MVD, Free streaming
Intrinsic resolution	< 5 µm
Operation in vacuum and magnetic field	
„Light” support and cooling	Material budget (station 0) of ~ 0.3 % x/X_0

The MVD – stations

Stations 0 – 3, front view



Material budget



<u>Assumptions:</u>

Carrier: CVD diamond (150 μm)/ CF-TPG-CF (500 μm) (do we need CF reinforcment ?)

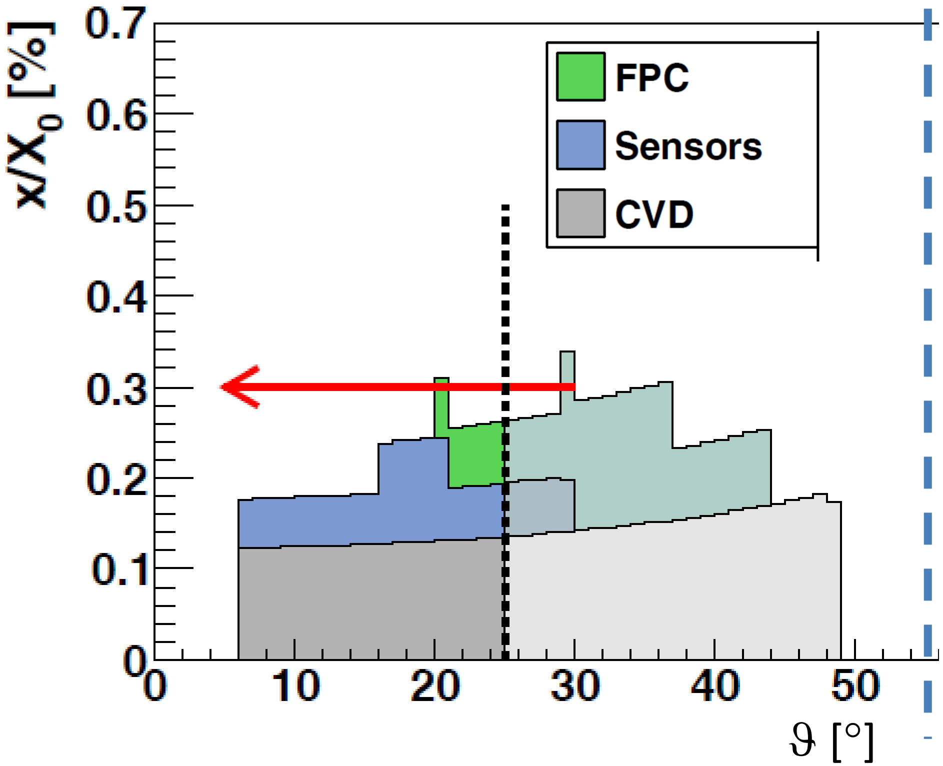
Sensors: 50 μm Si

FPC: Cu traces , 1 layer, 1 cable / 2 sensors, material budget of 0.06% x/X_0

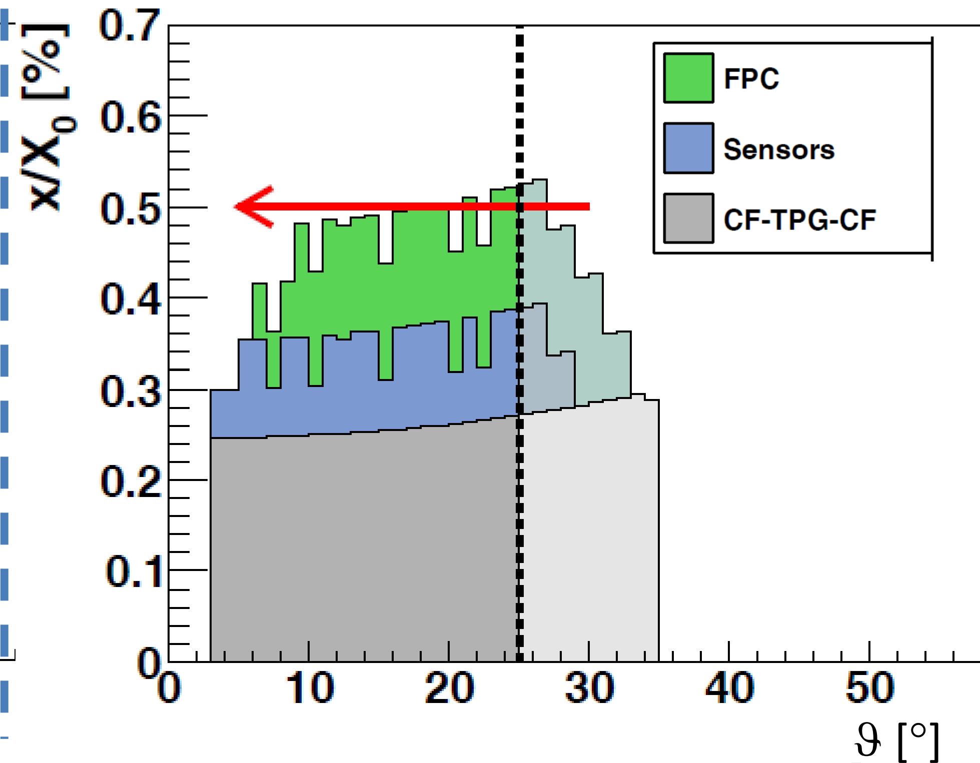
No encapsulation for wire bonds yet

Glue: 10-30 μm epoxy-based (not shown in the figures)

Station 0



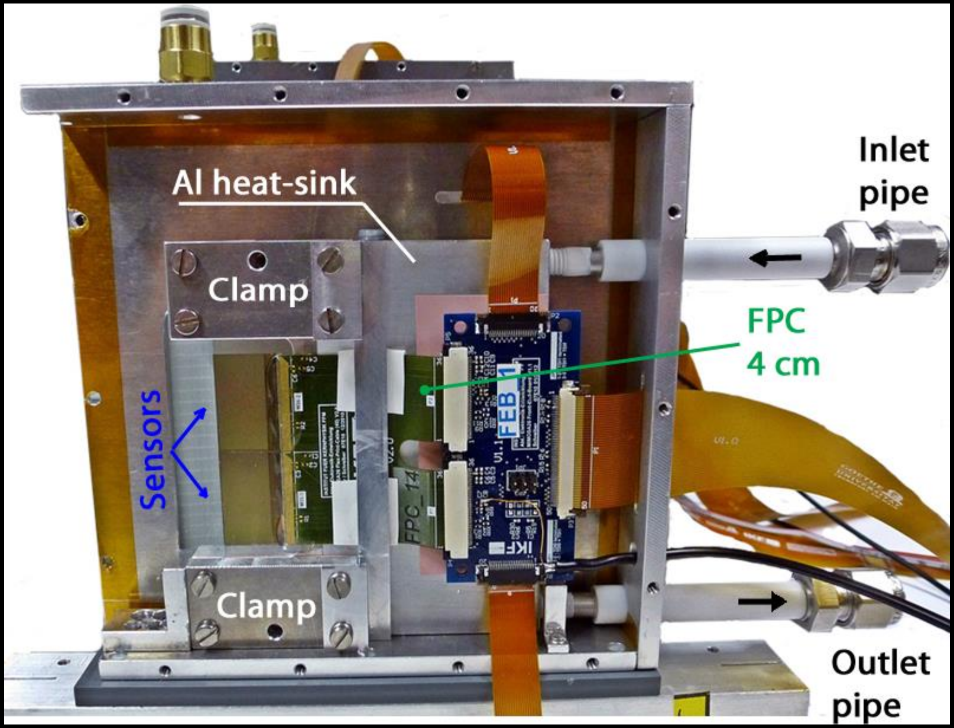
Station 3



CBM-MVD requirements and synergies

Requirements	Possible scenario @CBM	Synergy with:
Radiation tolerant and fast sensors	CMOS pixel sensors: 50 µm thin MAPS from IPHC-Strasbourg	ALICE ITS upgrade
Low material budget	CVD Diamond CF-TPG-CF Low viscosity epoxy Al based FPC	PANDA luminosity det, CERN (d'Oliveira), RAL, STAR-HFT, CBM-STS
Vacuum compatibility	Dispensing methods Feed-throughs Movement/mechanics	PANDA luminosity det, LHCb-VELO

Vacuum compatibility

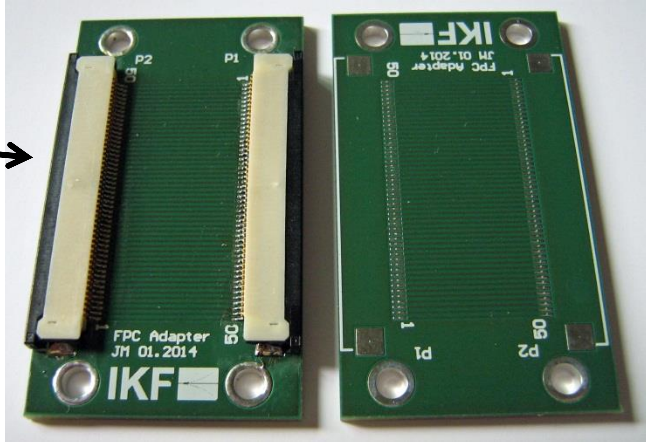


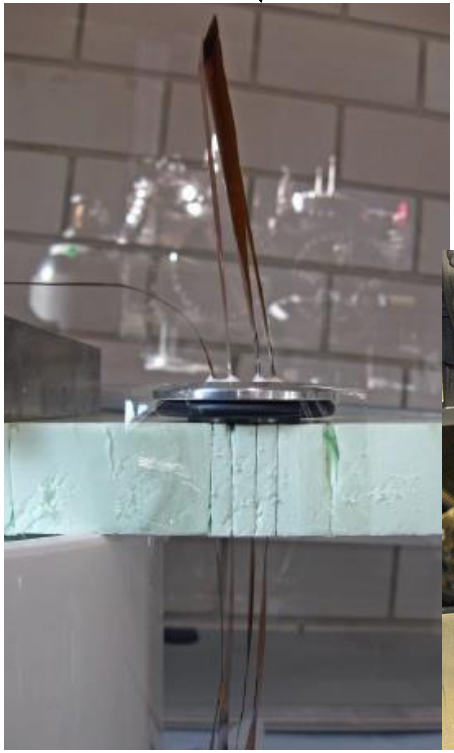
of the CBM-MVD prototype addressed with telescope station.

Vacuum tests: feed-through

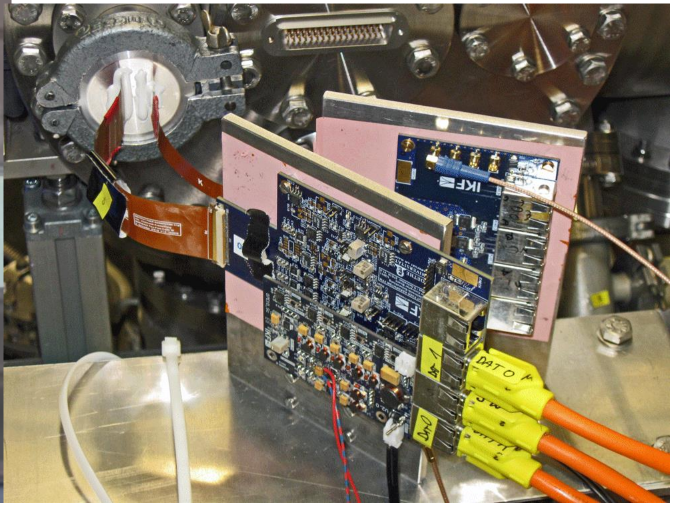
Scenarios:

- easy plug/unplug devices -> dedicated feed-throughs with connectors (FPC)
- minimize no. connections





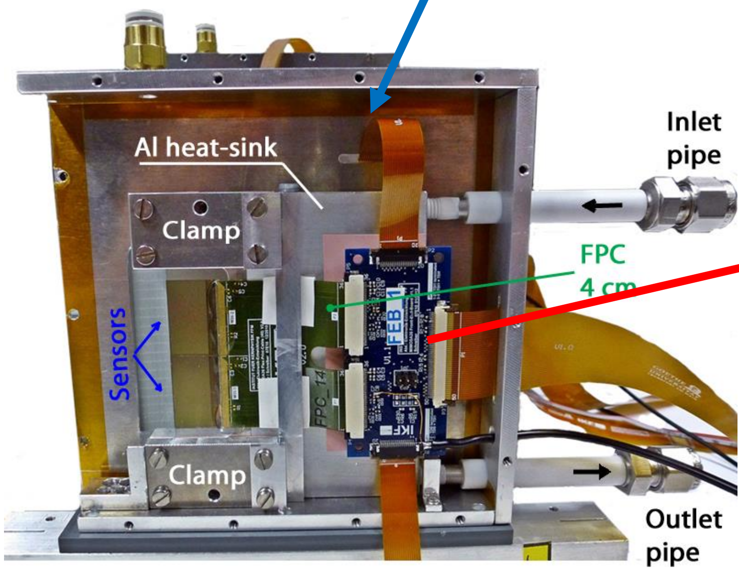
Done at IKF

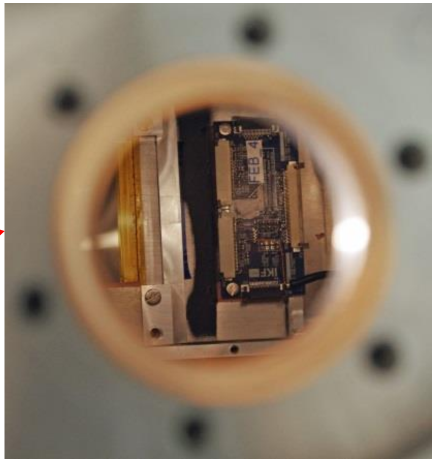


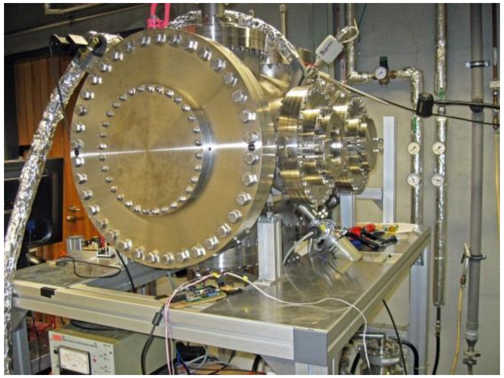
Any experience with making high-density vacuum feed-throughs for differential signals + power supply **?**

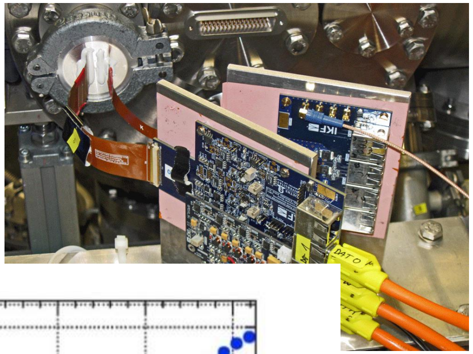
Vacuum test: Telescope station

[M. Koziel et al., Nucl.Instrum.Meth. A732 (2013) pp.515-518]

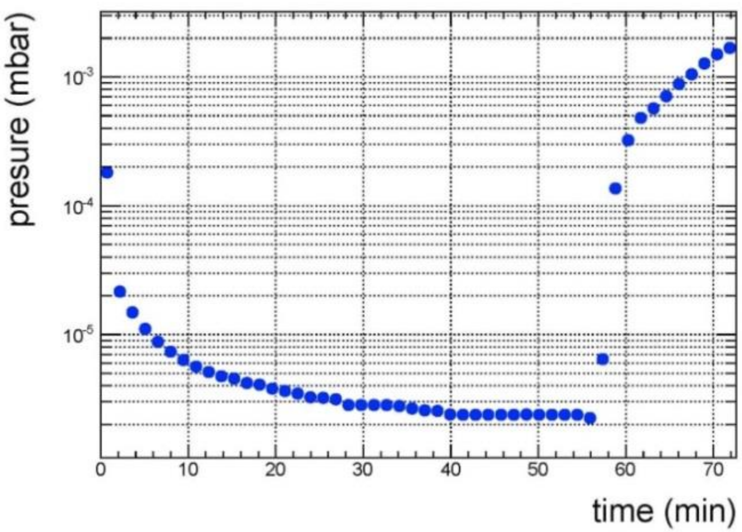




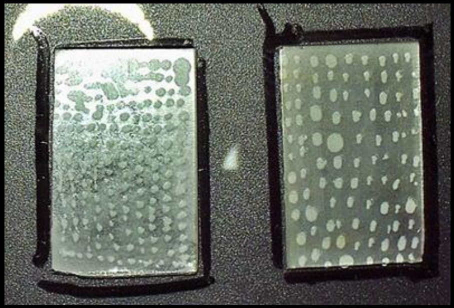




- Single-sided module employing two 50 µm thin MIMOSA-26 sensors integrated onto a 200 µm thin CVD Diamond support
- Liquid cooling for sensors: +15 °C
- Operated for several days in vacuum
- Out-gassing studies
- Pressure $2*10^{-6}$ mbar reached (same as without module)



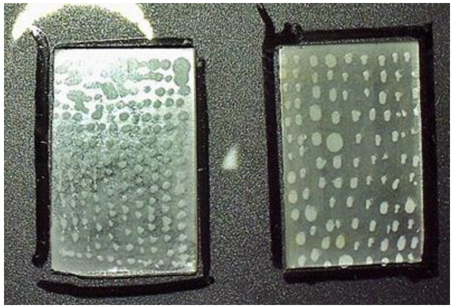
Glue



Glue choice

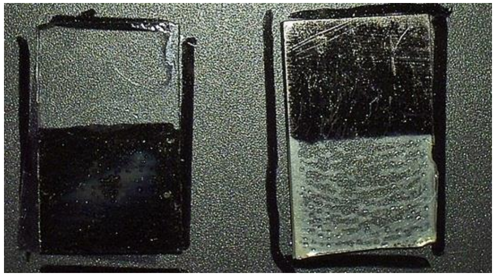
Glue requirements	Epoxy based	Silicone based
Radiation tolerant	Yes	Limited
Easy to rework	No*	Yes
Low material budget	Thin layer easy	Thicker layer
Strong	Yes	Medium
Low outgassing	Yes	No
Soft at -20 °C	No*	Yes
High thermal conductivity*	No	No

Thor Labs S-10



High viscosity

Epotecny E505



Medium viscosity

Epotecny E501

Low viscosity

Used for MVD prototype

Custom-made glue from RAL

Glue requirements	RAL 247
Radiation tolerant	Studies ongoing
Easy to rework	Yes
Low material budget	Yes
Strong enough	Studies ongoing
Low outgassing	Yes
Soft at -20 °C	Yes
High thermal conductivity*	No

Development at the Rutherford Appleton Laboratory (RAL)
Synergy with the ATLAS expreiment

Irradiation @ KIT Karlsruhe Institute of Technology, JÜLICH FORSCHUNGSZENTRUM

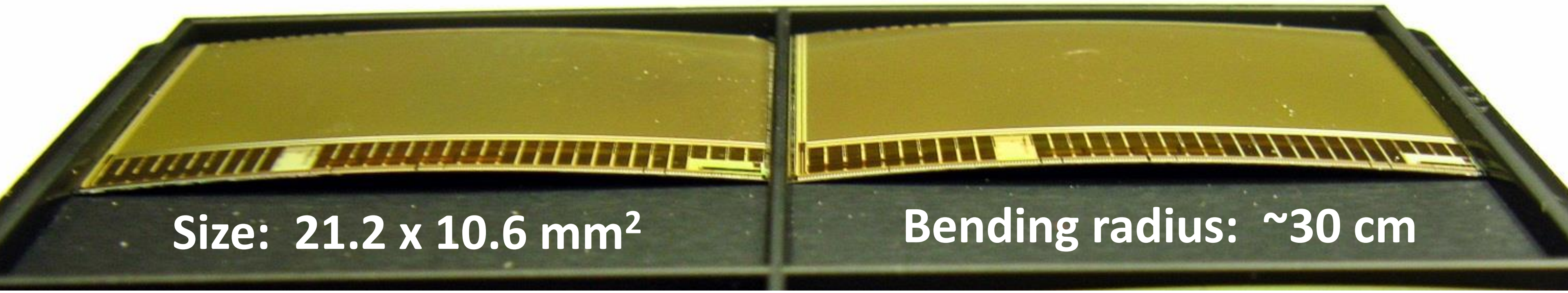
Science & Technology Facilities Council
Rutherford Appleton Laboratory

More on Wednesday 9:45 by Simon Canfer
„Studies of Adhesives for HL-LHC Tracking Detectors”

Sensor commissioning

Probe card test of ultra-thin sensors

Precursor of CBM-MVD sensor (used in the MVD prototype)
MIMOSA-26 CMOS sensor
Thickness: ~50 µm



Future CBM-MVD sensor:
Thickness: ~50 µm
Size 30x10 mm^2

Mass production →

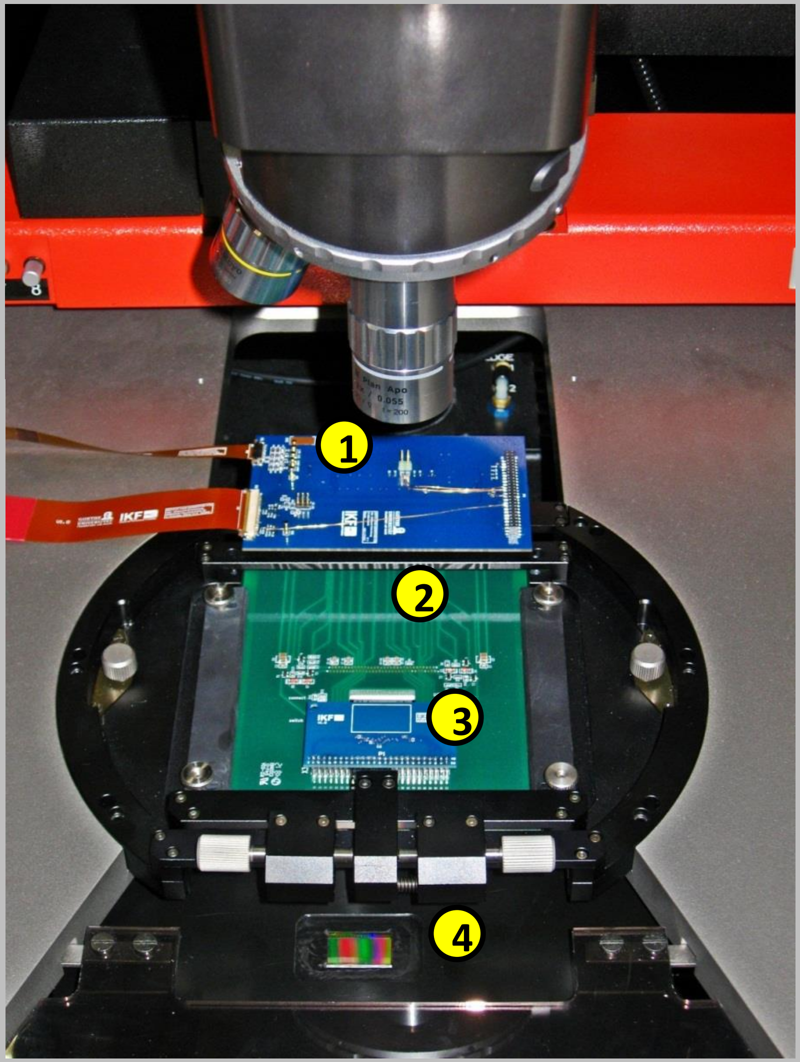
- Quality control before assembly
- Probe tests

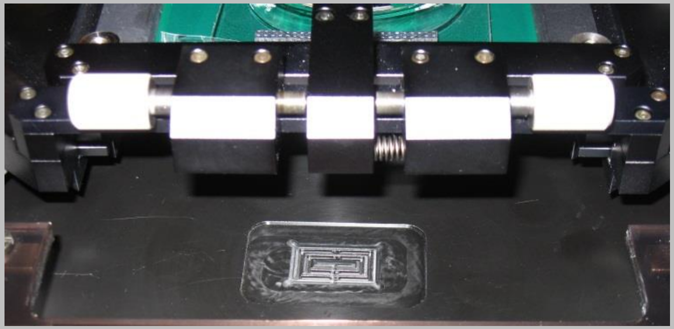
...but HOW ?!

Probe card test of ultra-thin sensors

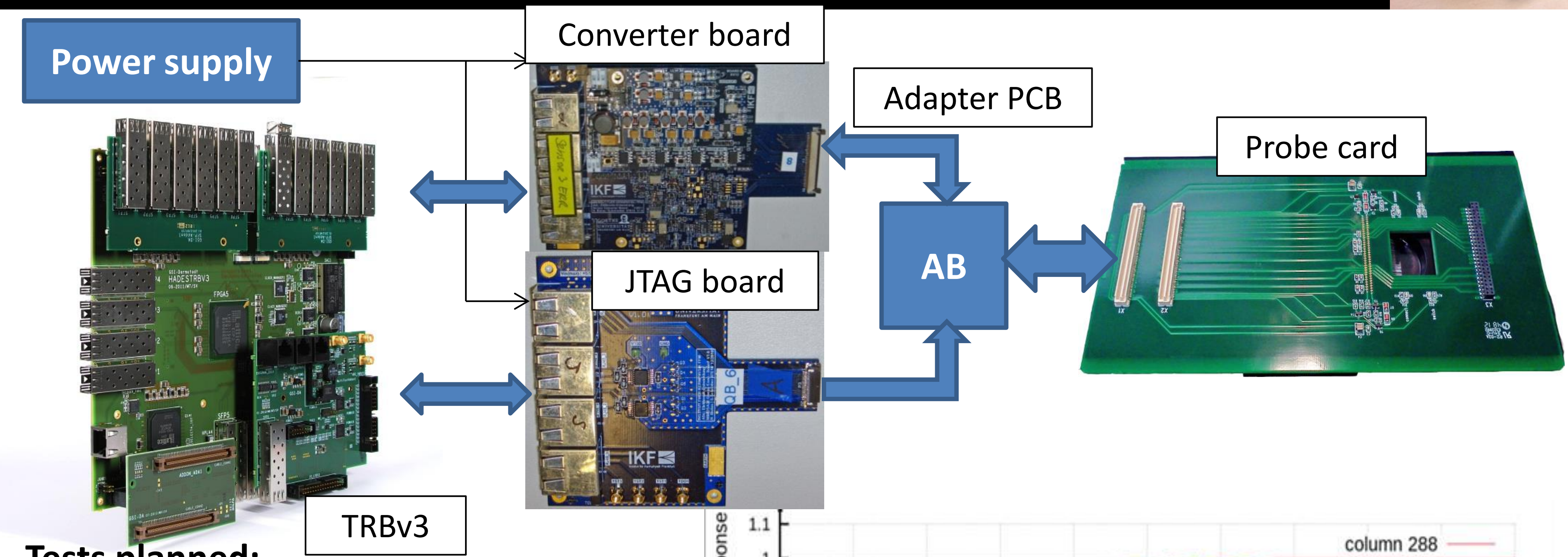
- Located in a dedicate cleanroom (ISO-6) at IKF.
- Suss MicroTec PA-200 probe station is employed.
- Probe station is located inside a light and electromagnetic tight box.

1. Adapter board
2. Probe card head, HTT-Dresden (65 tungsten needles, minimum pitch of 100 μm)
3. Test board
4. Chuck adapter with multi-channel underpressure holding



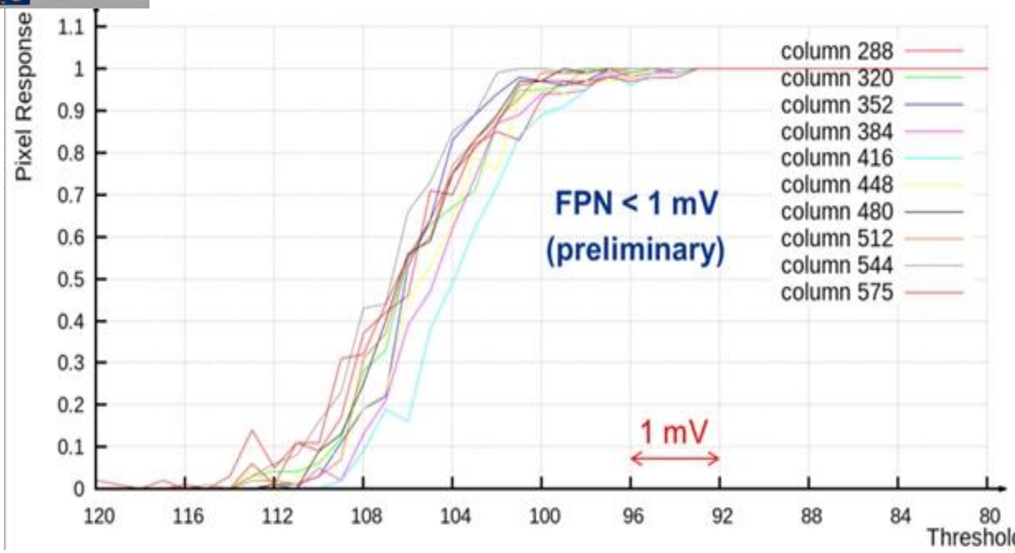


Probe card test of ultra-thin sensors



Tests planned:

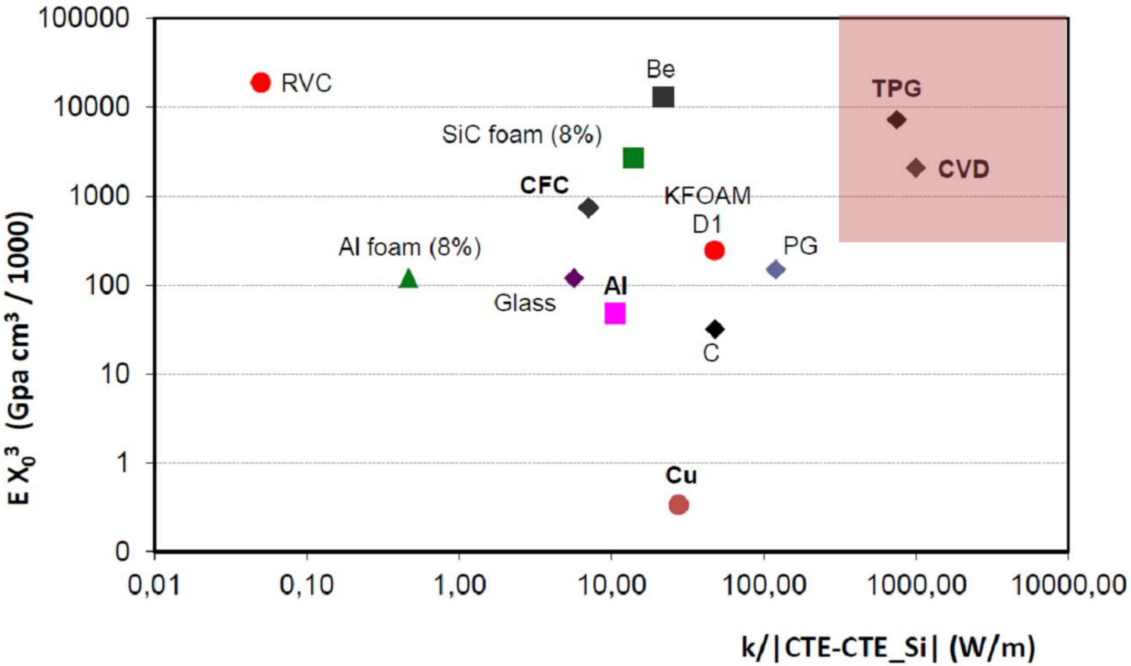
- „Smoke test"
- Sensor behaviour and response to JTAG signal
- Check of programming registers
- Dead pixels (tests with pulsing light or radioactive source)
- Hot pixels
- S-curves (noise information)



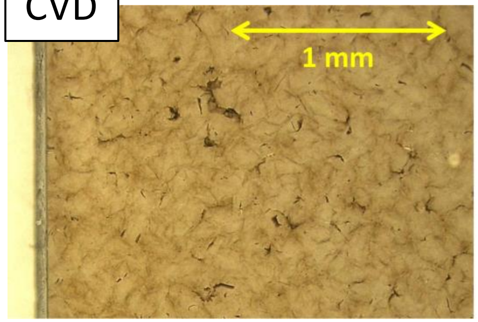
Probe tests of 50 µm thin CMOS sensors can be done with standard probe cards !

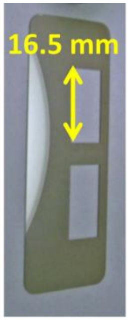
Support materials

Support materials considered

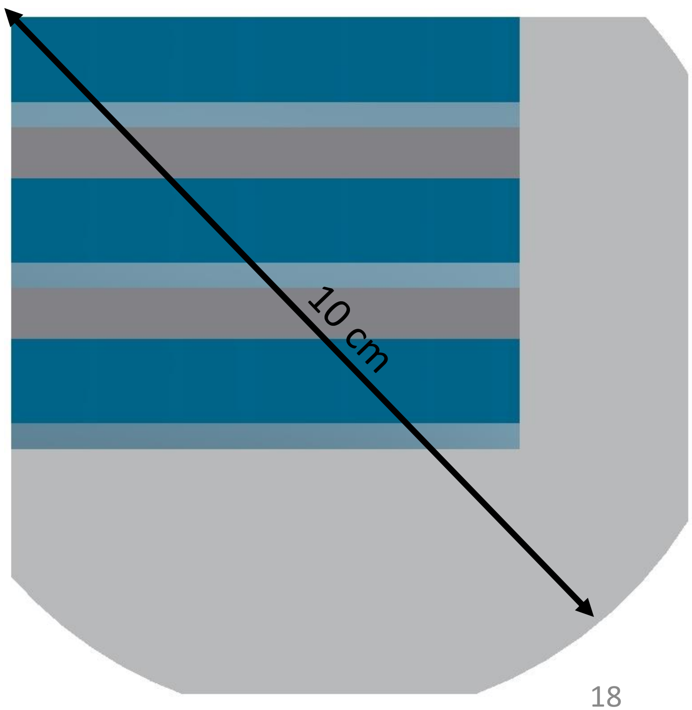


CVD

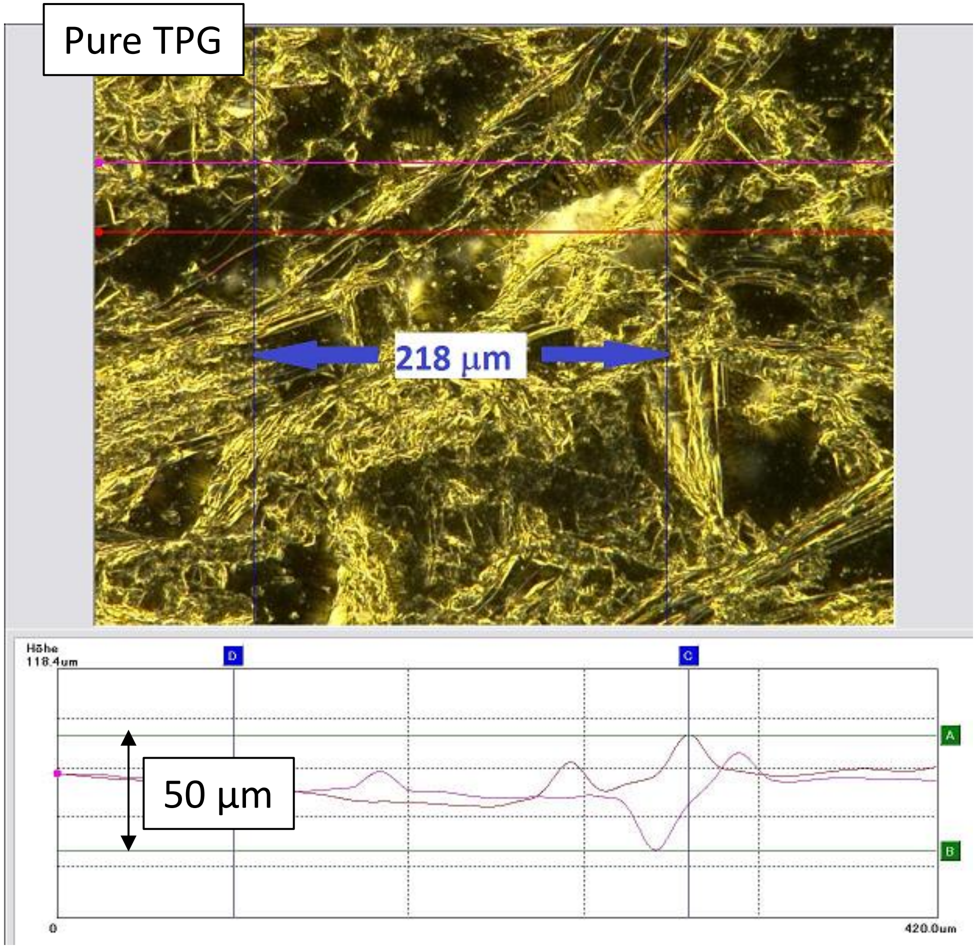




…but not larger than 8 cm diameter

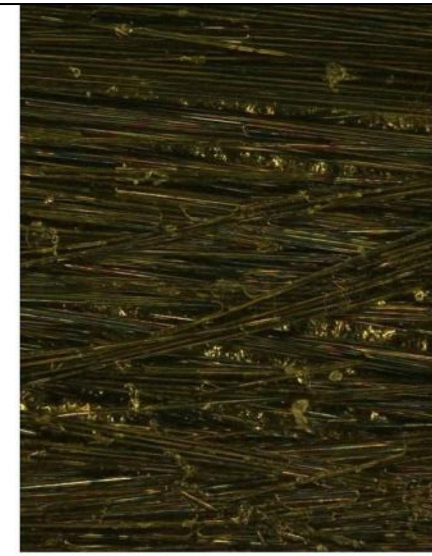


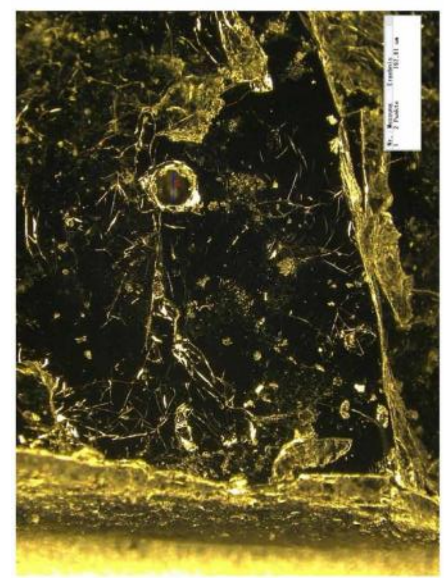
Support materials considered



v.s.

Reinforced TPG -> CF-TPG-CF



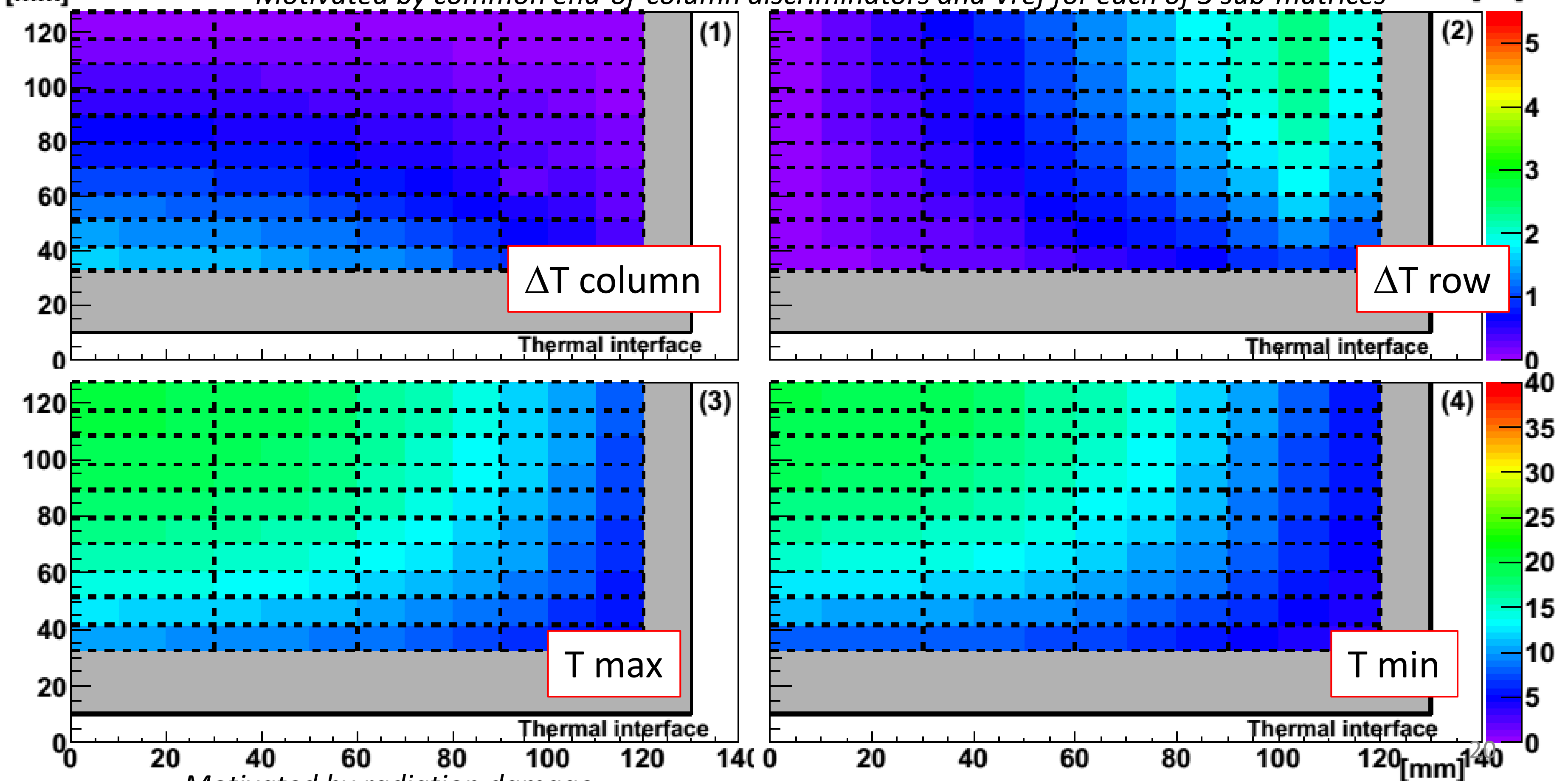


What can we gain from CF-TPG-CF sandwich developed by for the CMS upgrade ?

Thermal simulations

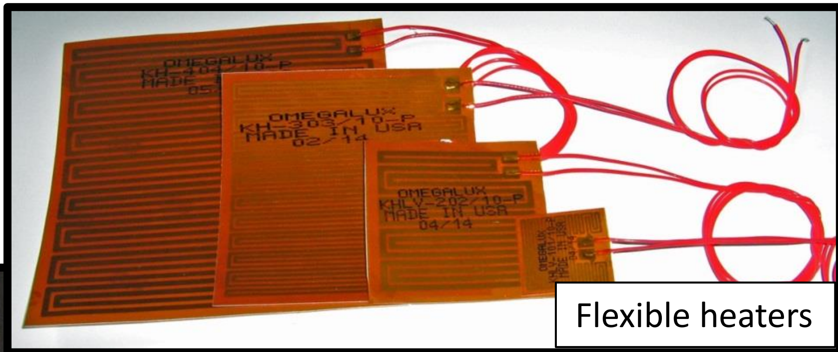
- Station 3
- Pure TPG 380 µm
- Expected power consumption of aboutr 185 mW/cm^2
- $T_{interface}$ = -20°C

Motivated by common end-of-column discriminators and Vref for each of 3 sub-matrices

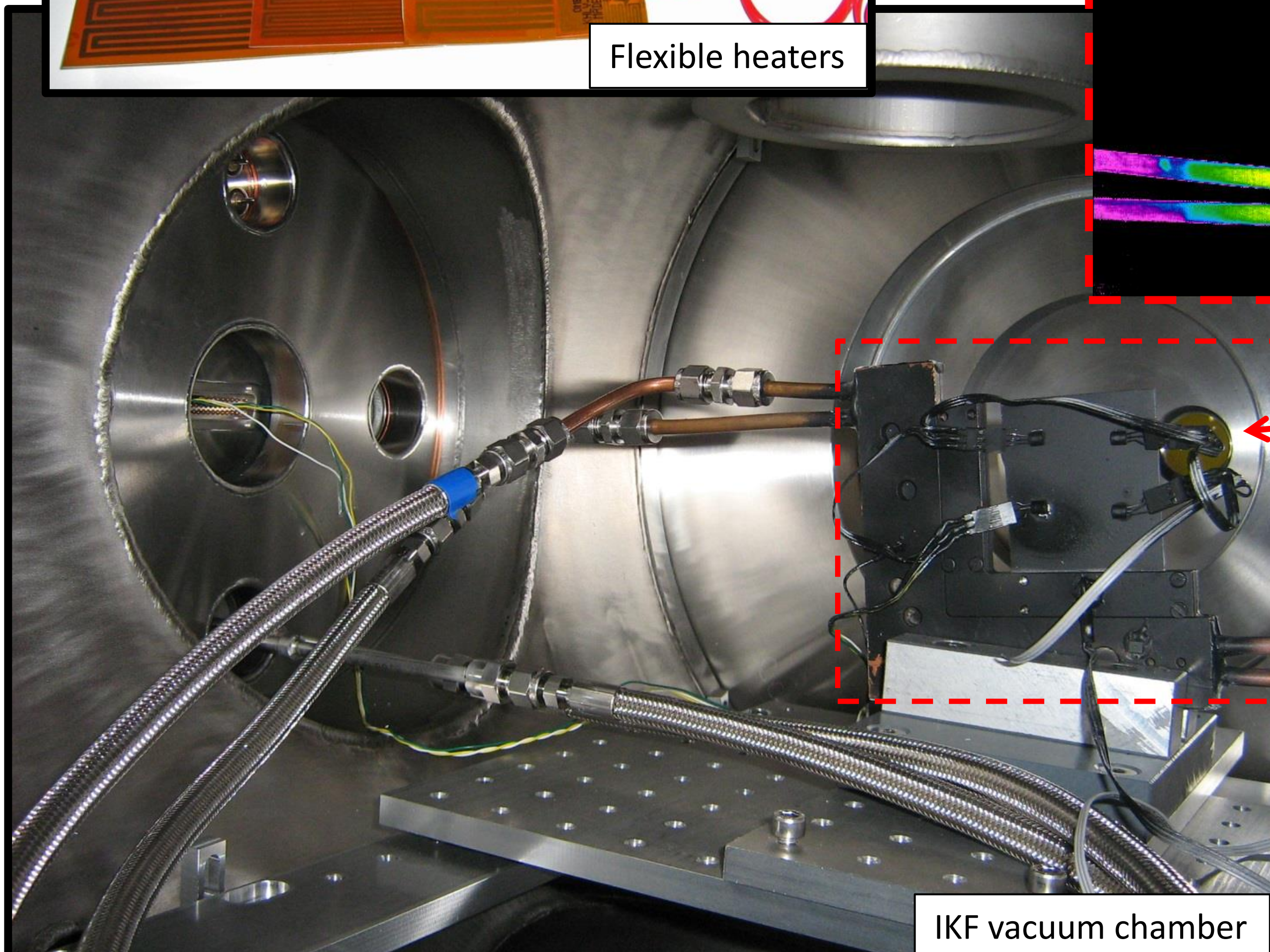


Motivated by radiation damage.

Validation of thermal simulations

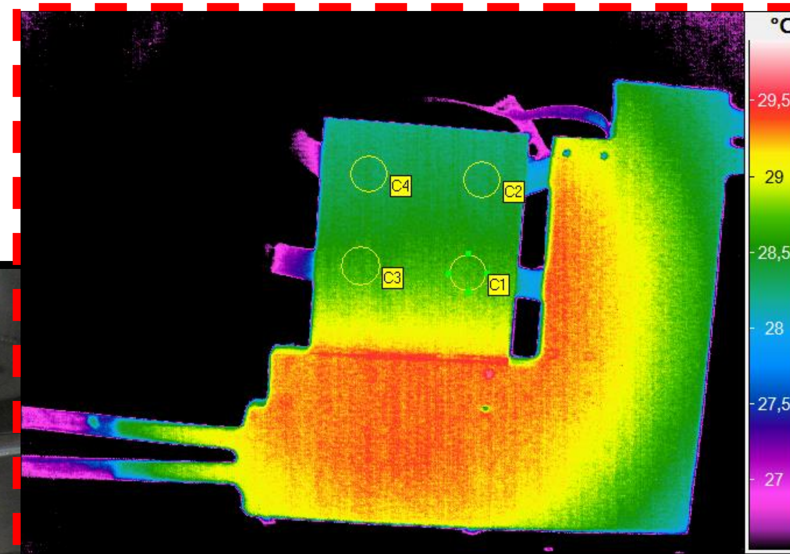


Flexible heaters



IKF vacuum chamber

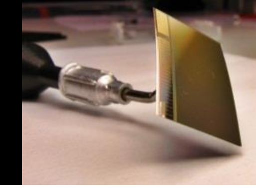
IR view-port



- Temperature range of -20°C ± 10°C
- Power consumption up to 300 mW/cm^2

So far :
Swagelok + silicone oil
-> …is leaking

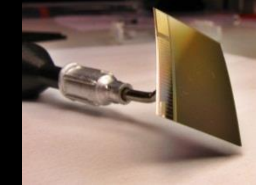
Open issues

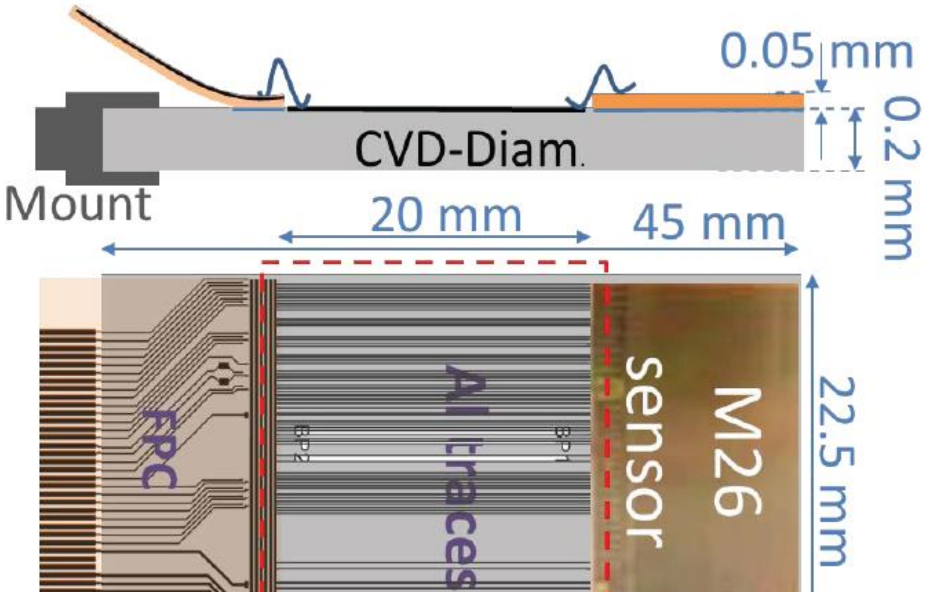


- CVD diamond size – max diameter of CVD wafer 8 cm so far (we try 10 cm with DiamondMaterilas but risky)
  - ElementSix offers 10 cm CVD but 500 µm thick
- CF-TPG-CF or TPG ? Pure TPG for station 1-3 ordered from
- High-density vacuum feed-throughs (differential signals & power)
- Movement inside vacuum and magnetic field
- Al based FPCs
- Metrology – ALICE/ATLAS/CMS ? Is CERN opened for external/CERN recognized experiments ?

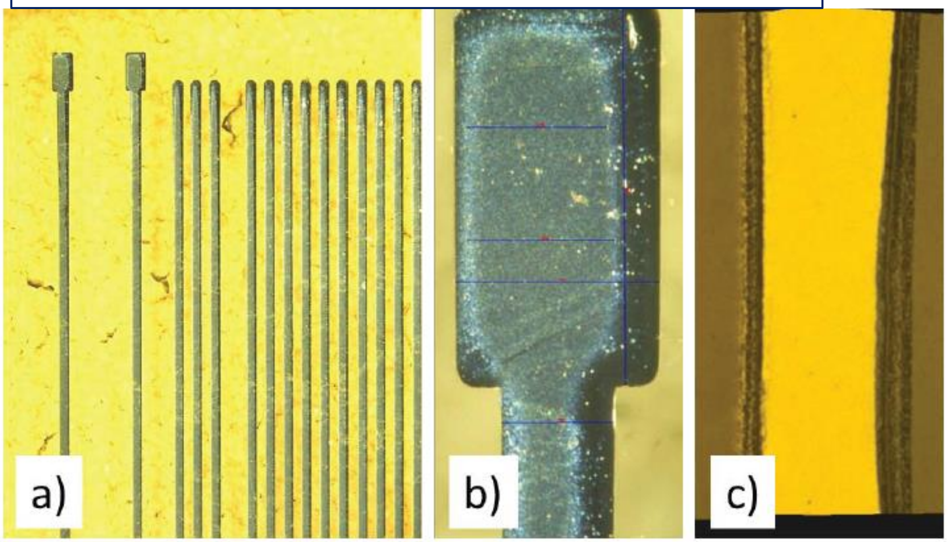
Thank you for your attention...

????





Together with Hochschule RheinMain and GSI



Cables are material budget… -> Try to avoid cables ?

Idea: Put Al traces directly on the CVD diamond carrier required for cooling and mechanical support.

Results:

- Thickness: 2 (2.8) mm , feature sizes: 50…100 mm
- Litho: Chemical wet etching, lift-off
- Interim results:
  - Pull tests: **sufficient adhesion** of Al-traces
  - Electrical characterization (4-terminal sensing, wire bonding): Al thickness homogeneity depends on the technique applied (best: lift-off), **specific. resistance of Al-traces can be factors (x3) higher compared to bulk aluminum**, to be adjusted by sputtering process. Relevant regarding layout of traces!
- Next steps**:**
  - **Improve uniformity and thickness** (up to 5 μm) of Al traces
  - **Decrease the specific resistance**
  - Demonstrate M26 r/o