ERuM FSP-T06

Compressed Baryonic Matter

CBM

MVD

SPONSORED BY THE
Federal Ministry of Education and Research

Si-D Kick-off Meeting

Al-metallisation of cvd-diamond carriers

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

The MVD Group – IKF, GSI, IPHC

January 28, 2025

IKF Institut für Kernphysik Frankfurt

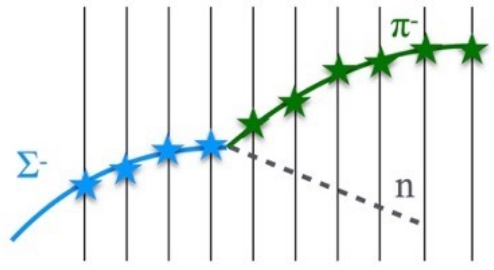
GSI

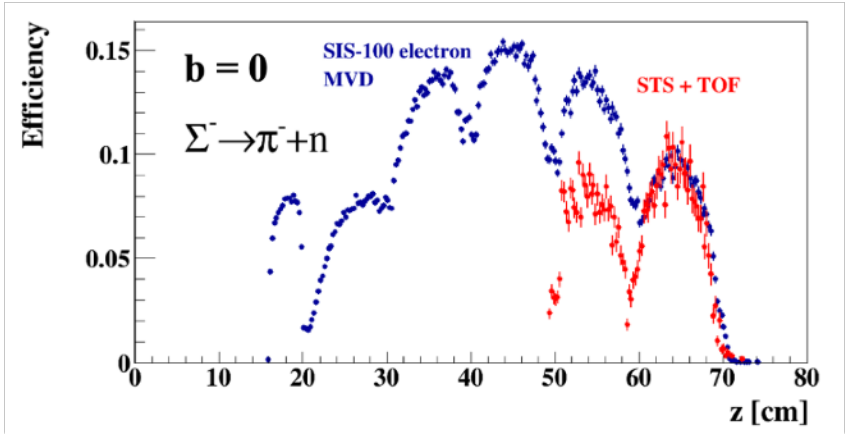
IPHC Institut Pluridisciplinaire Hubert CURIEN STRASBOURG

We Build a Detector System To Be Placed Here

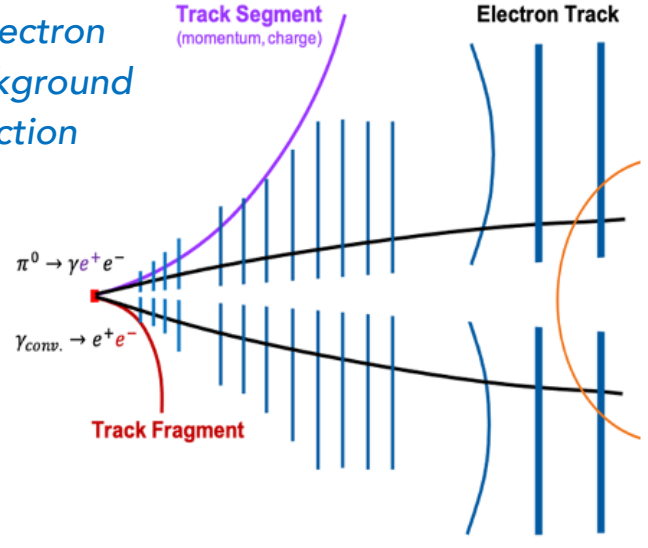
Physics Case of Micro-Vertex Detector w/o Charm

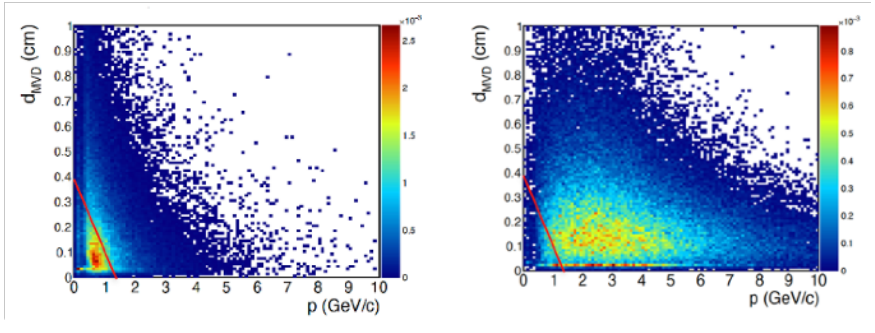
Hyperon decay using missing mass method





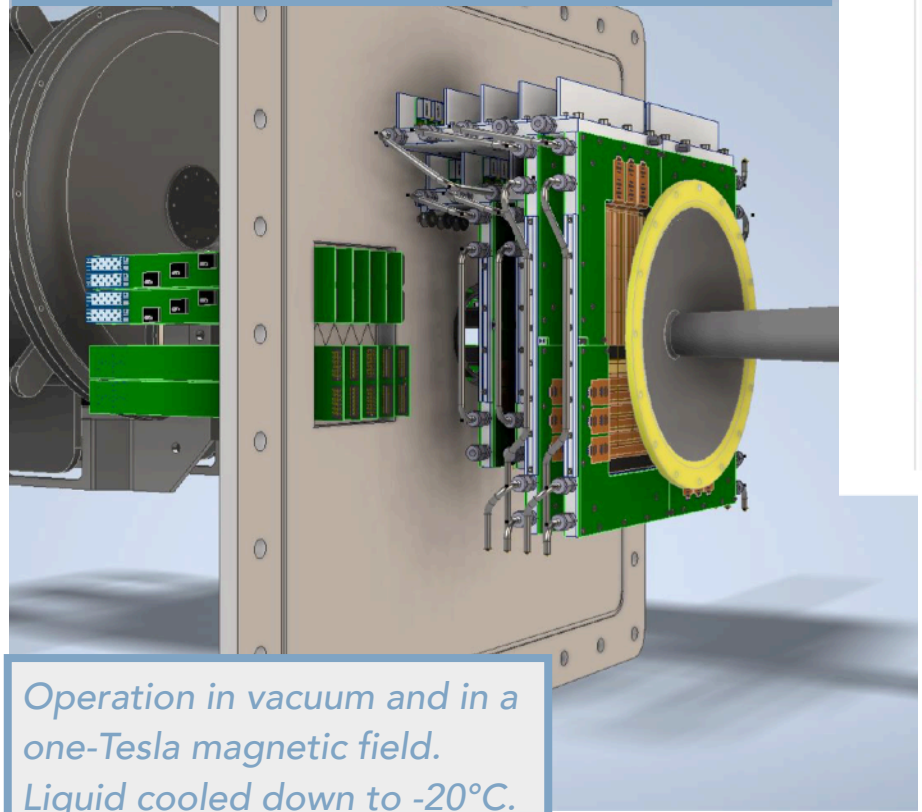
Dielectron background rejection



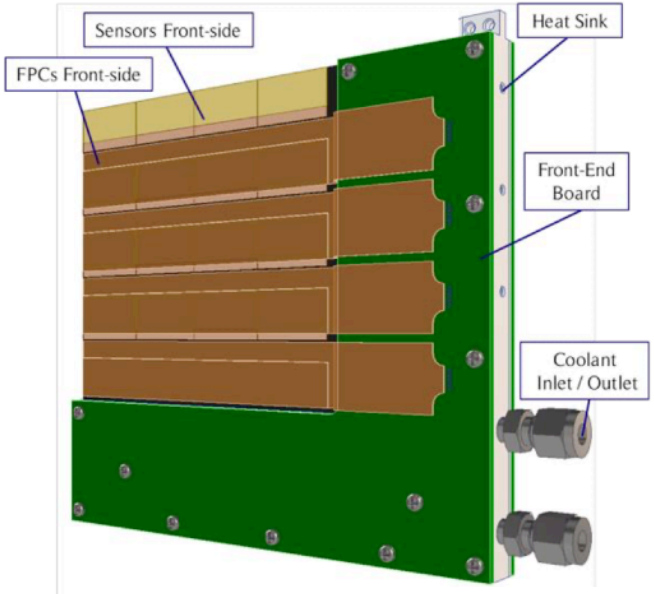


MVD in a nutshell

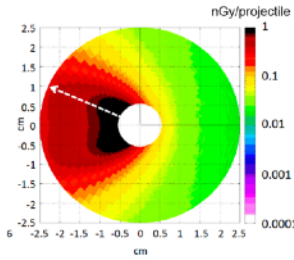
Four stations of MIMOSIS (CPS) sensors with 100% fill factor positioned close to the target

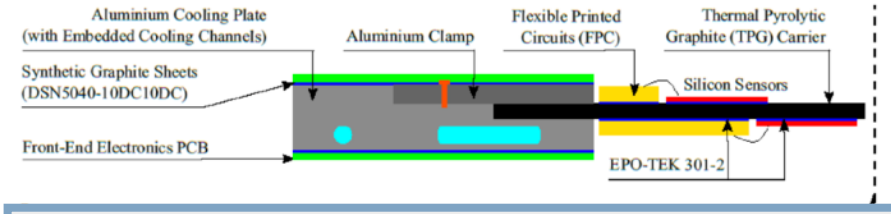


Operation in vacuum and in a one-Tesla magnetic field.
Liquid cooled down to -20°C.



Enhanced track reconstruction efficiency for tracks with low-momentum and factor ten improved vertex resolution over STS alone.



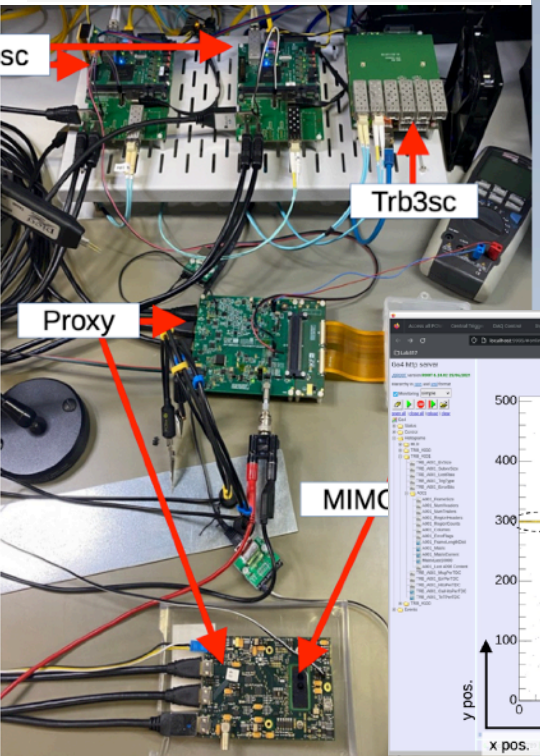


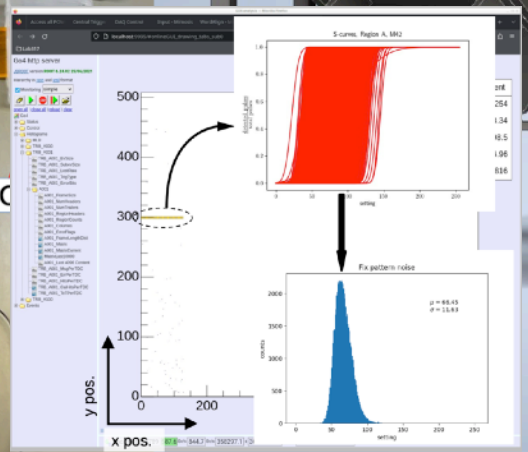
70 % heat extracted laterally, $0.2 - 0.5\ \% X_0$/station.
288 sensors, 148 M pixel, 200 kfps, 5 μm precision.

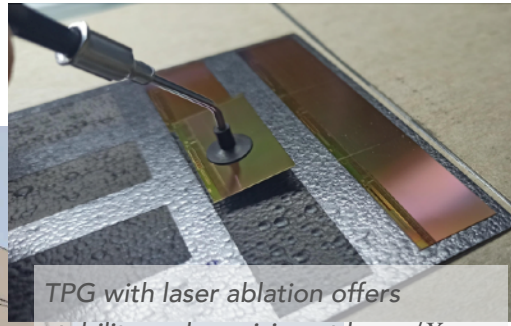
MVD – Integration Concept Fully Developed

Major challenge: heat evacuation with minimal material budget and maximum stability

TRB based fast read-out system for sensor commissioning





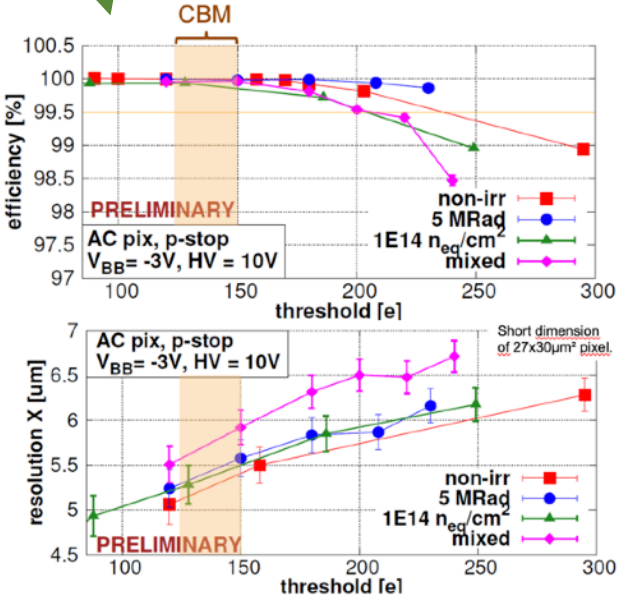


TPG with laser ablation offers stability and precision at low x/X_0

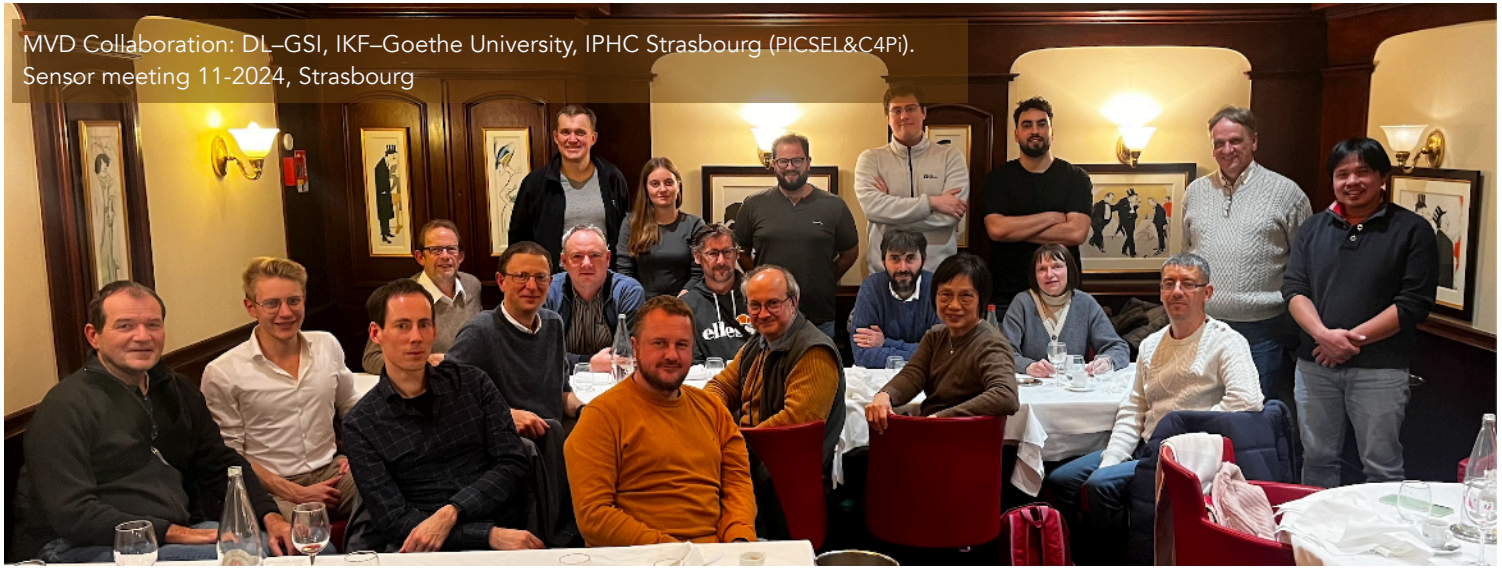
Efficient heat exchange with customised cooling sink

The Long Way to the Right Sensor

- Considered: SoI, DepFET, CPS (MIMOSA)
- MIMOSA-28 ("ULTIMATE") first CPS in heavy-ion experiment,
- ALPIDE – ITS-II first TOWERJazz in HI-Exp.
- MIMOSA Performance gain (2001 – today) – first for fix-target
  - Ionizing radiation: $100\,\mathrm{krad} \rightarrow 10\,\mathrm{Mrad}$
  - Non-ionizing rad.: $(3 \cdot 10^{11} \rightarrow 3 \cdot 10^{13})\,\mathrm{n_{eq}/cm^2}$
  - Frame readout time: $100\,\mu s \rightarrow 5\,\mu s$
- Challenge for CBM-MVD
  - High local hit densities (< few tracks/mm2)
  - Strong load variation over active area of a sensor
  - Verify anticipated radiation hardness for MIMOSIS



Excellent Team Work all Time


MVD Collaboration: DL–GSI, IKF–Goethe University, IPHC Strasbourg (PICSEL&C4Pi).
Sensor meeting 11-2024, Strasbourg


2017 Collaboration Meeting

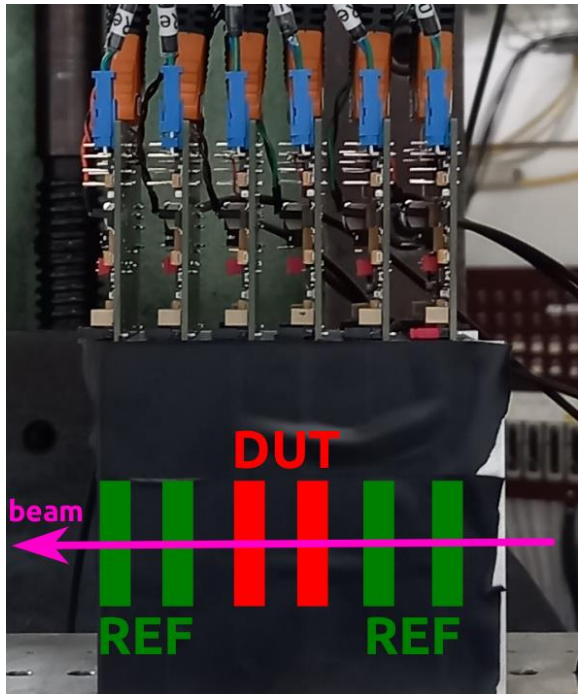

2022 St. Odile MVD Retreat

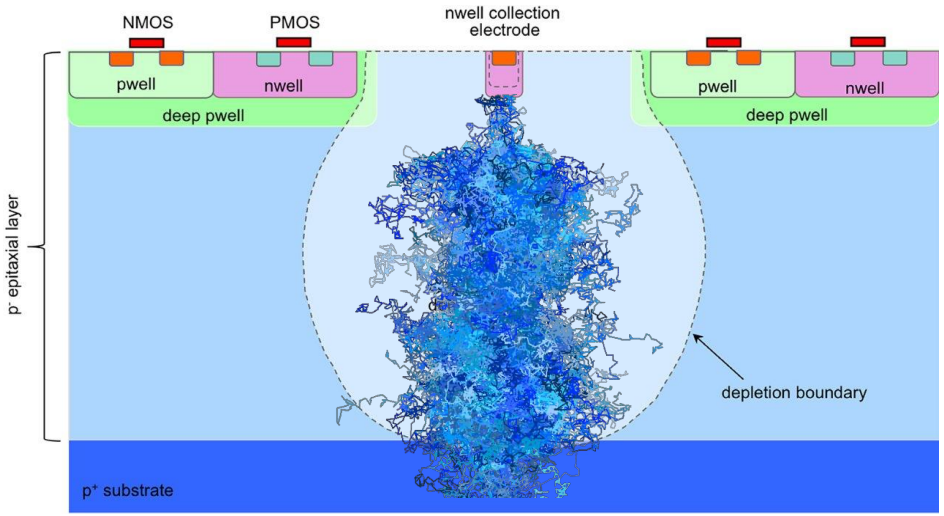

2023 CBM Collaboration Meeting

Hasan Darwish
PhD candidate: 2021-ongoing
Goethe University Frankfurt & University of Strasbourg

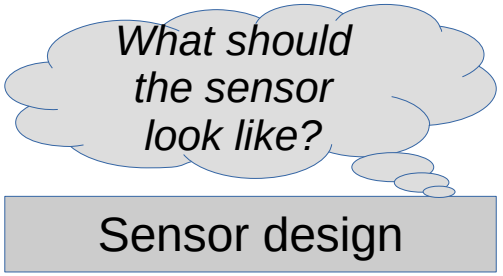
- **Contribution in the data analysis for the different beam tests of MIMOSIS-1/2.1 @ DESY, COSY and CERN**
  - **Evaluating the sensor performance:**
    - **Spatial resolution**
    - **Detection efficiency**
    - **Radiation hardness**
    - **dE/dx**

- **Contribution to building a charge transport model for detector-level simulations of the CBM-MVD**
  - **CBMRoot + allpix-squared**





Effectively running sensors in the CBM experiment – My research focus



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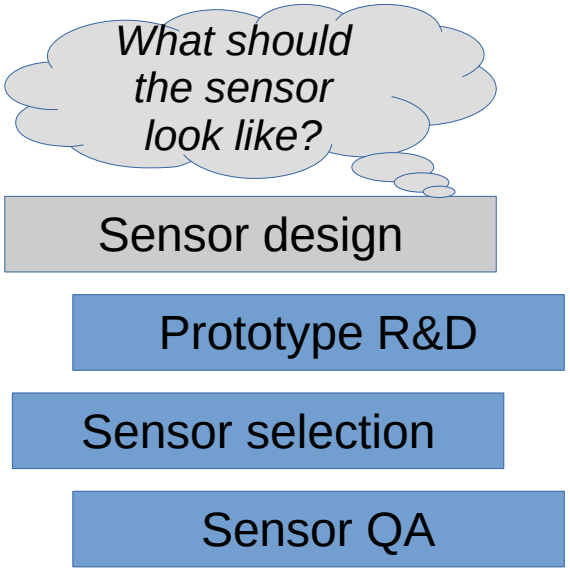

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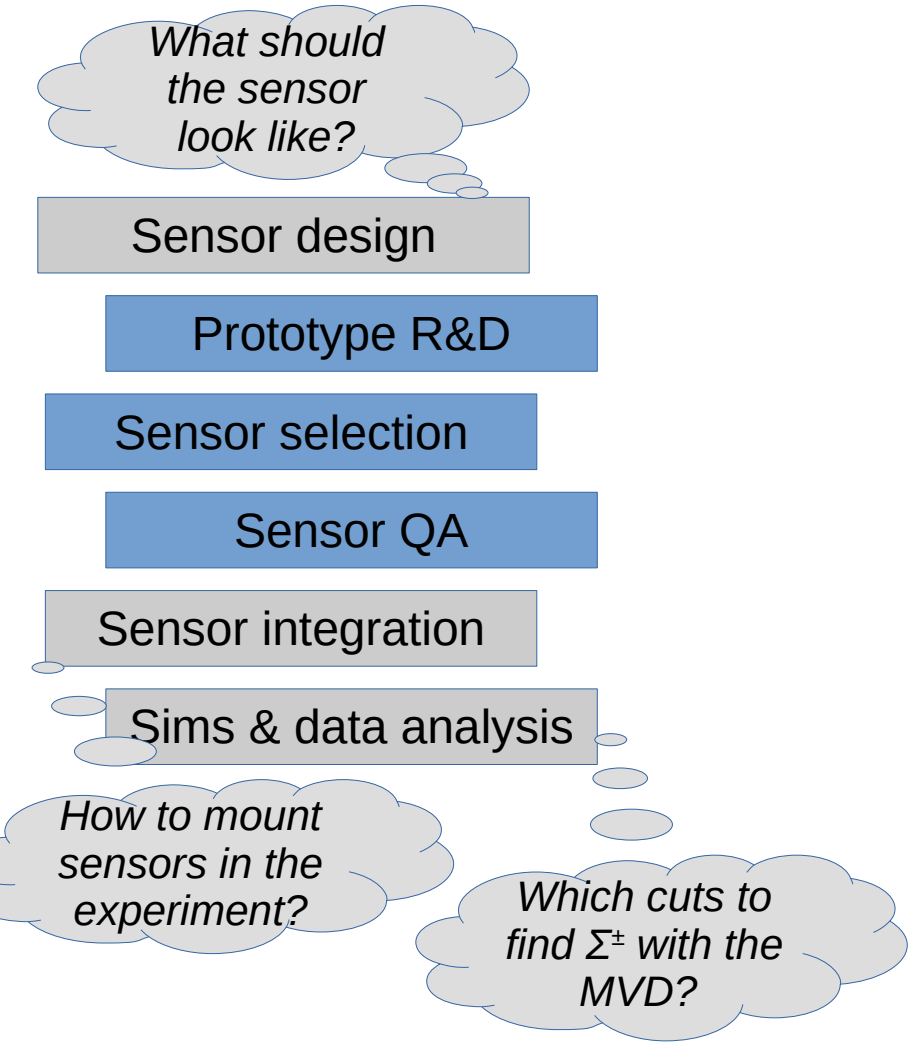

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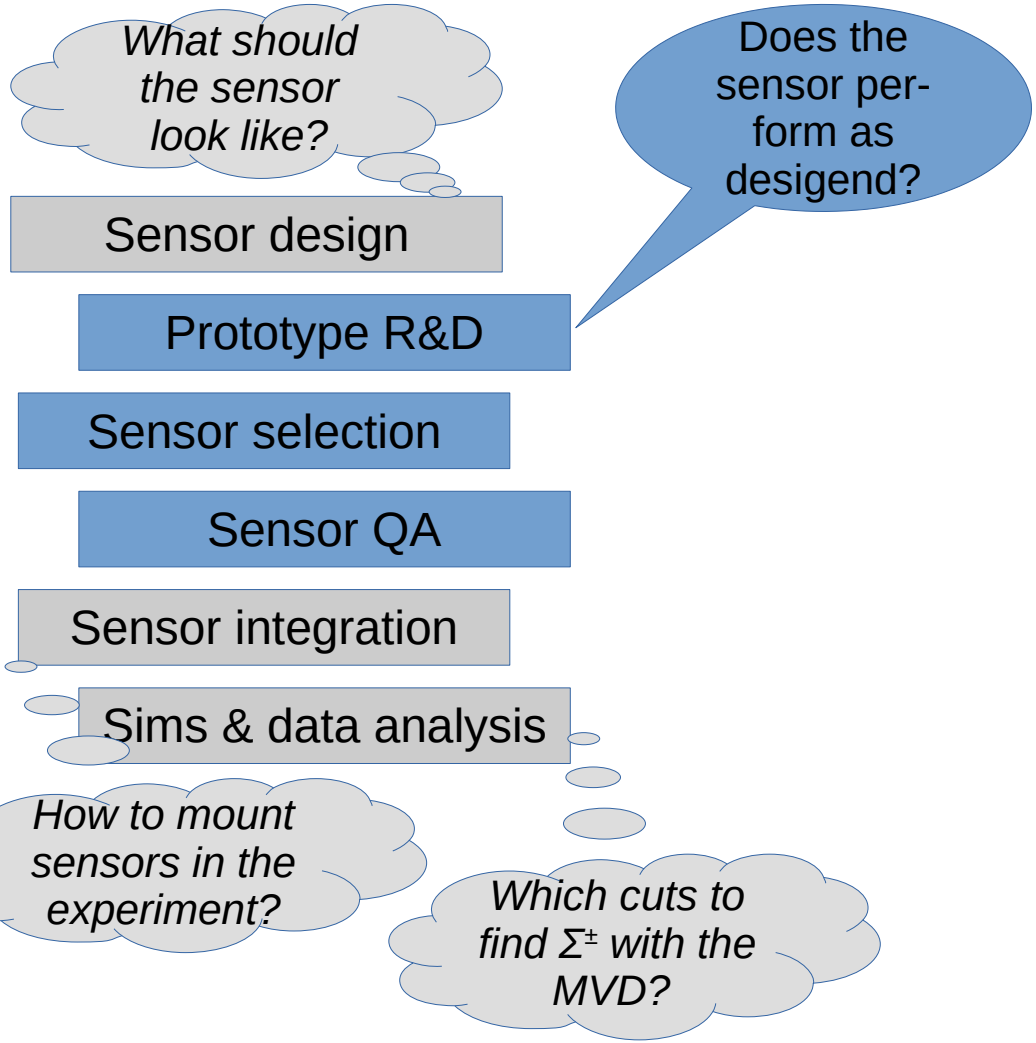
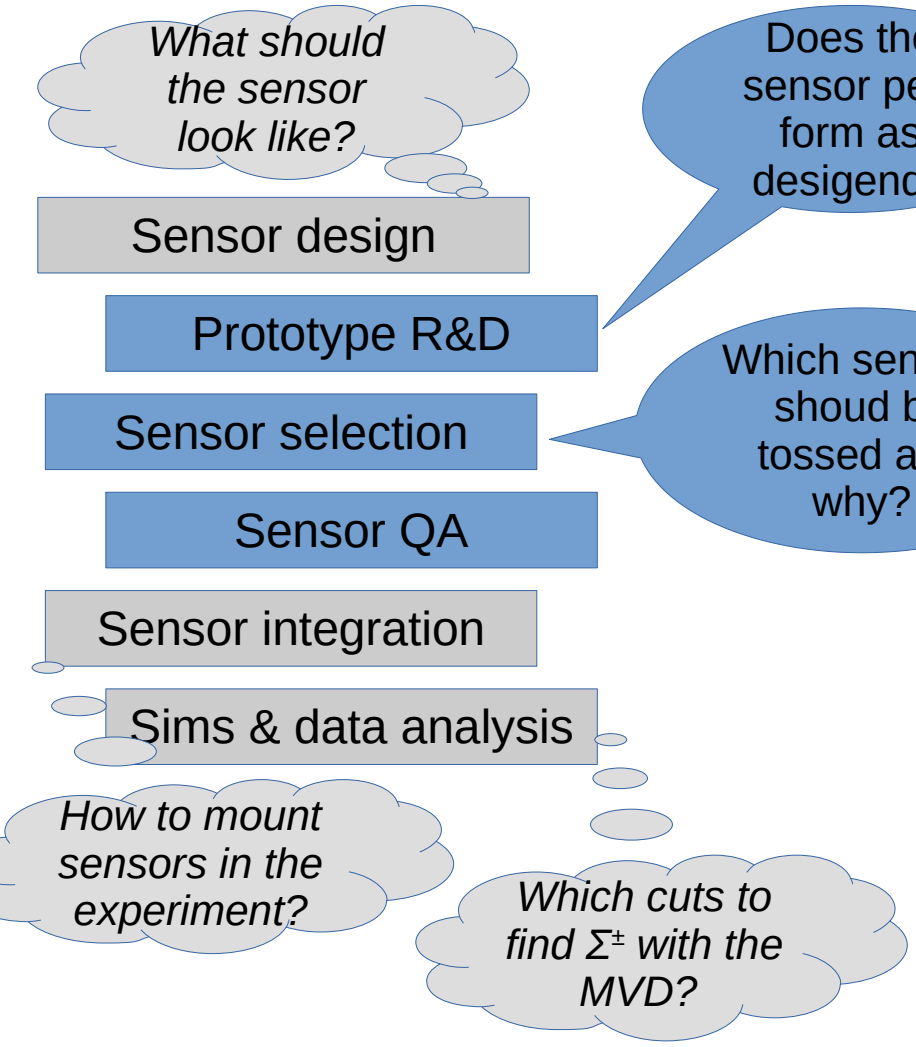


Does the sensor function generally?
How about after irradiation (5 MRad & 10^{14} n_{eq}/cm^2)?

- Behavior of components on the sensor
- Pixel response as expected?
- Any weak spots overlooked? Tied closely to the following points

Effectively running sensors in the CBM experiment – My research focus



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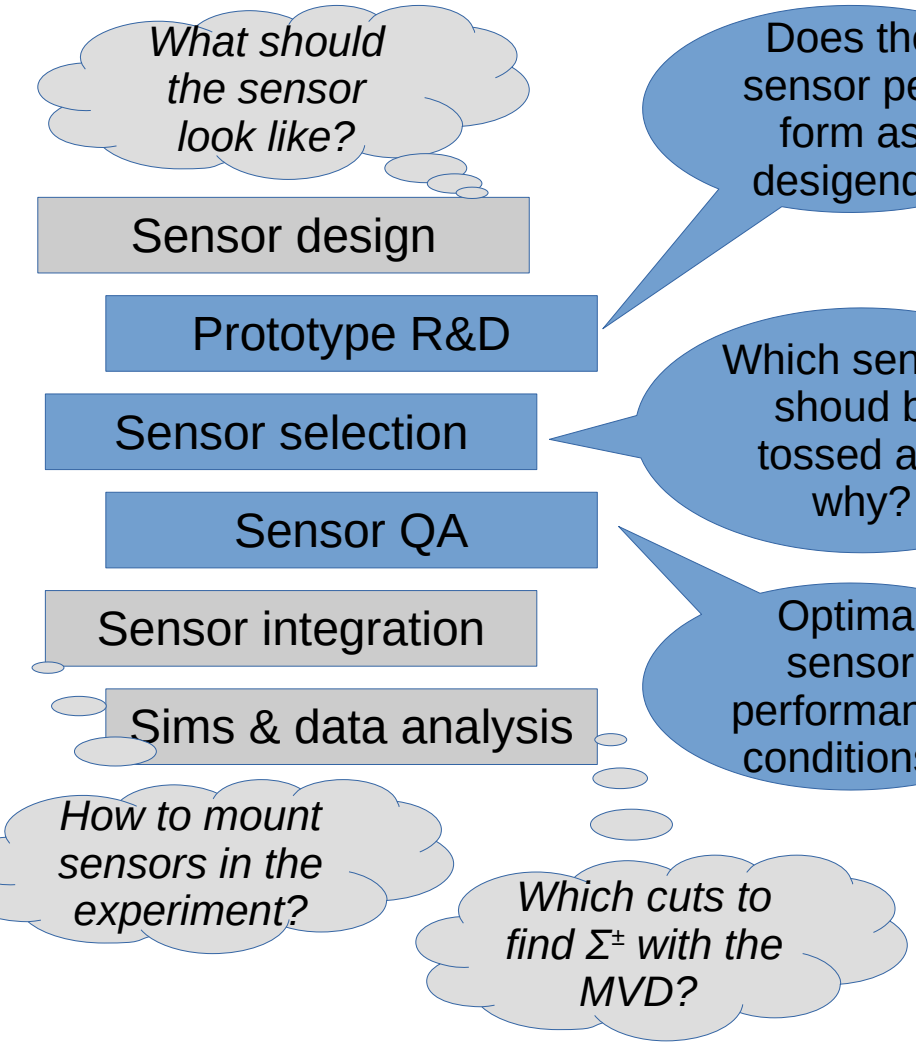
Lab and beam tests with H. Darwish

What are the tests a sensor must pass such considered for use? Max-min deviation?

- Development of criteria and test protocols

Effectively running sensors in the CBM experiment – My research focus



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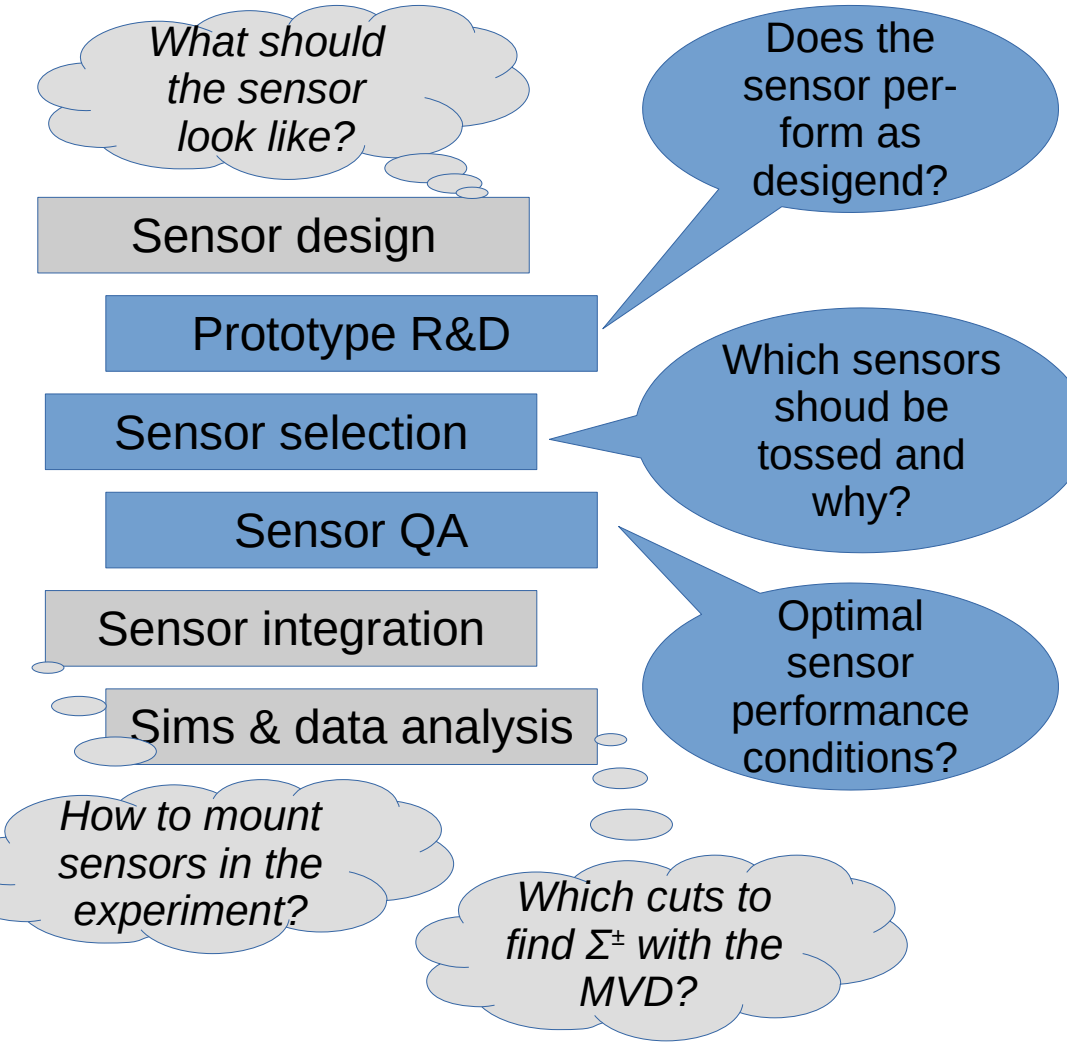
Based on prev. experience & probe testing with F. Matejcek

How should the sensor be operated?

- Tuning of...
  - Biasing of the sensor
  - Biasing of the amplification-discrimination line
  - Questions on coping with SEE

Effectively running sensors in the CBM experiment – My research focus



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What are the tests a sensor must pass such considered for use? Max-min deviation?

Based on prev. experience &
probe testing with F. Matejcek

Which biases (top and back bias) should be used?
Which SEE protections are necessary?

•

Based on prev. experience &
dedicated beam tests
with F. Matejcek & B. Gutsche

Franz Matejcek: Turning Concepts into Reality

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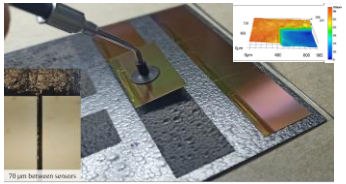
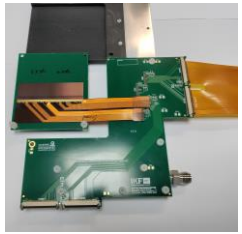
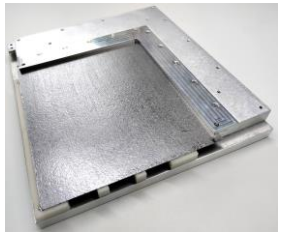
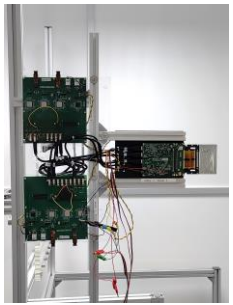
Mechanics

- Integration optimization w/ high-precision tools
- Laser vaporization cutting and surface ablation
- Design and validation of detector mechanics
- Design and testing of jigs, assembly tools, …
- mMVD for mCBM









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- Probe Testing (wafer and die)
- Wire Bonding (manual, automatic)
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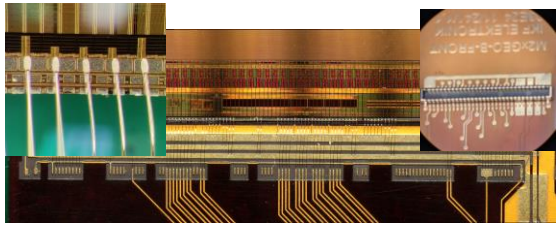

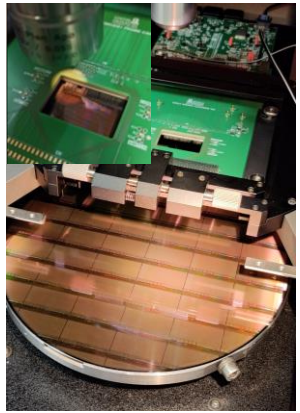

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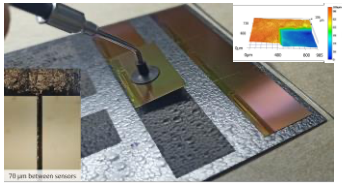

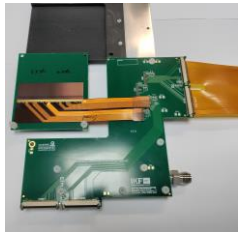

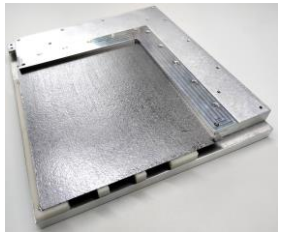

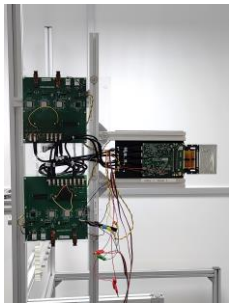

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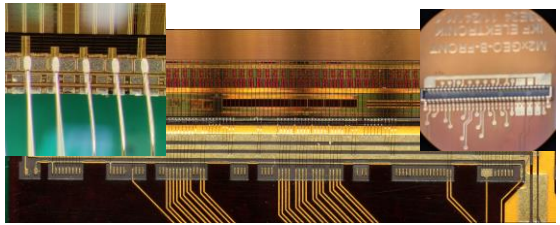
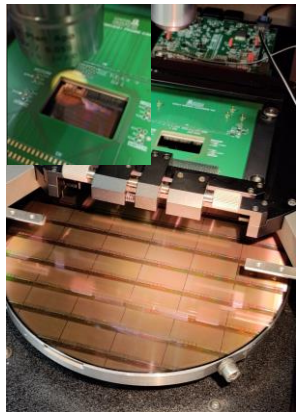
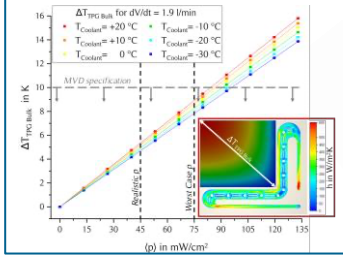
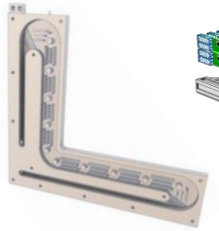


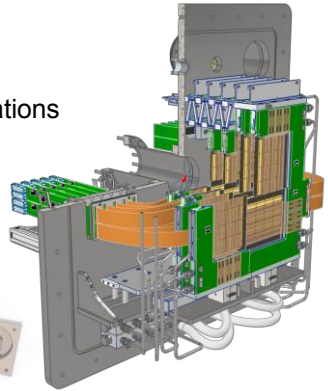


CAD Design and FEA Simulations

- CAD of detector
- Fluid, thermal, and mechanical simulations







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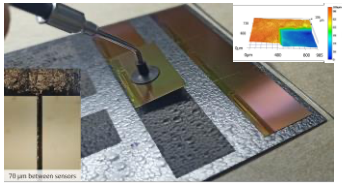
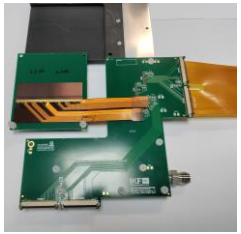
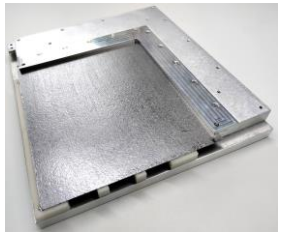
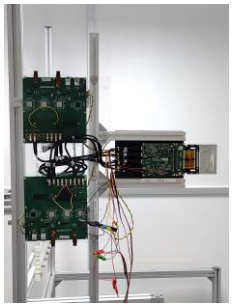


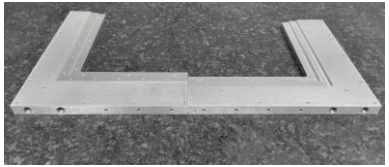


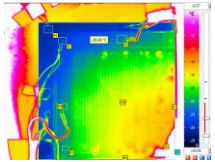




Thermal Performance

- Validation of high-performance material TPG
- Design and validation of Heat Sinks





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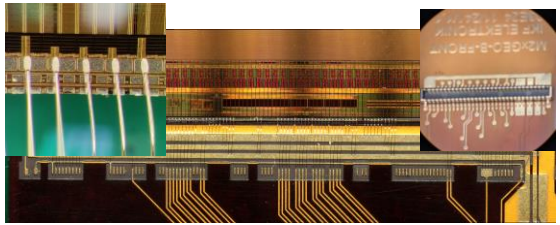

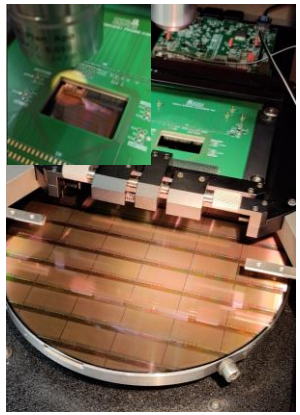

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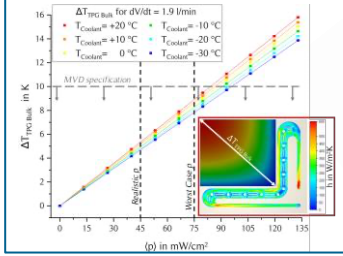
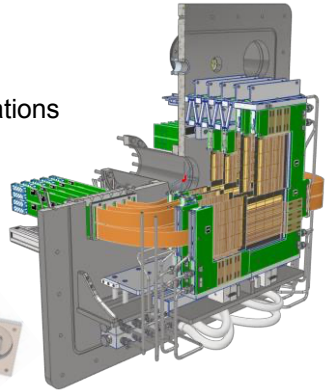
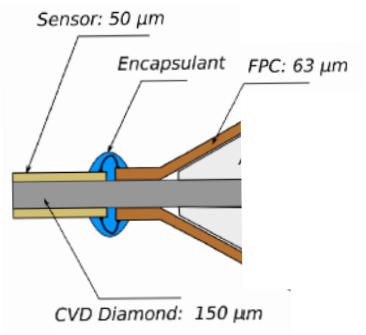


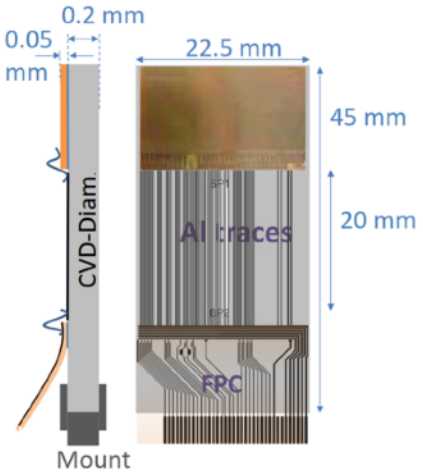


Multifunctional Integration of Pixel Sensors on pCVD Diamond Carriers

Eva-dhidho Taka, Goethe-Universität Frankfurt, AG Prof.Dr. Stroth

Expand functionalities of pCVD diamond carrier:
- Heat dissipation
- Mechanical mounting
- Housing of electrical lines



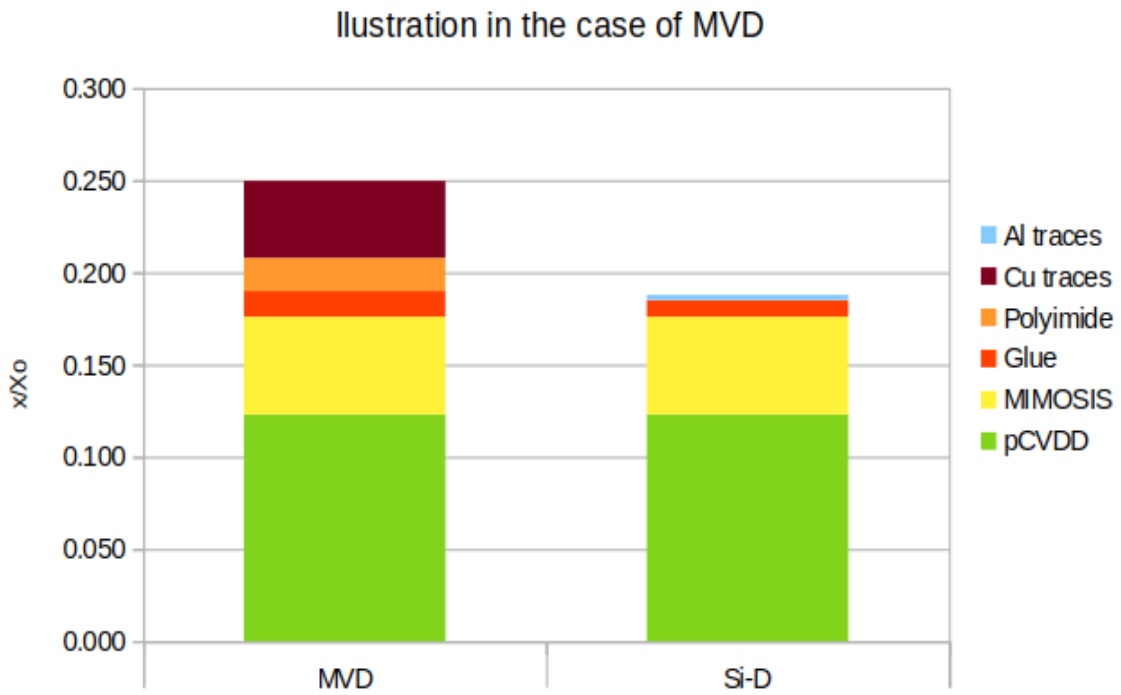


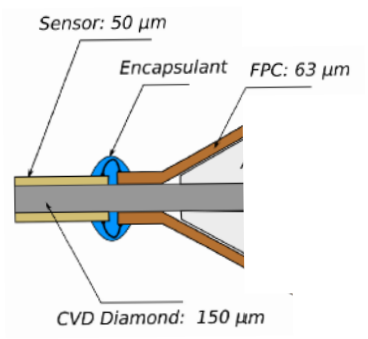
Multifunctional Integration of Pixel Sensors on pCVD Diamond Carriers

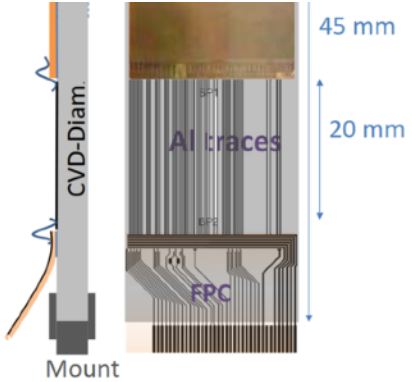
Eva-dhidho Taka, Goethe-Universität Frankfurt, AG Prof.Dr. Stroth

Expand functionalities of pCVD diamond carrier:

- Heat dissipation
- Mechanical mounting
- Housing of electrical lines







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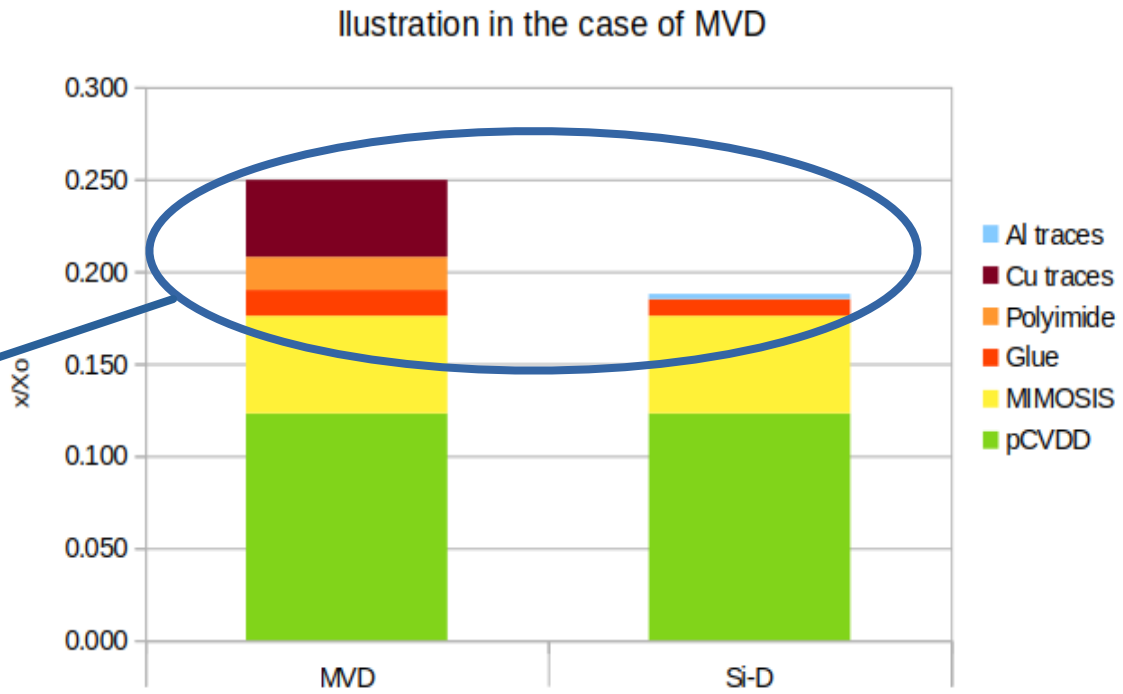
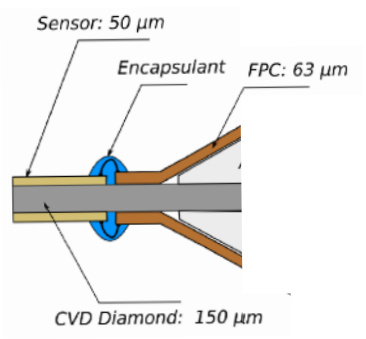
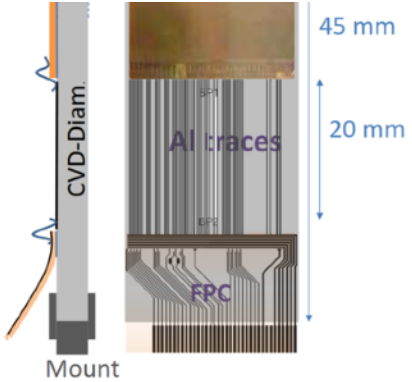
80% reduction of top part,
25% reduction overall







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Steps

- Photolithographic printing of Al traces
- Quality assessment

The project is part of the Si-D consortium