DPG 2018, Bochum

The CBM - MVD : Group Report

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On behalf of the CBM-MVD collaboration

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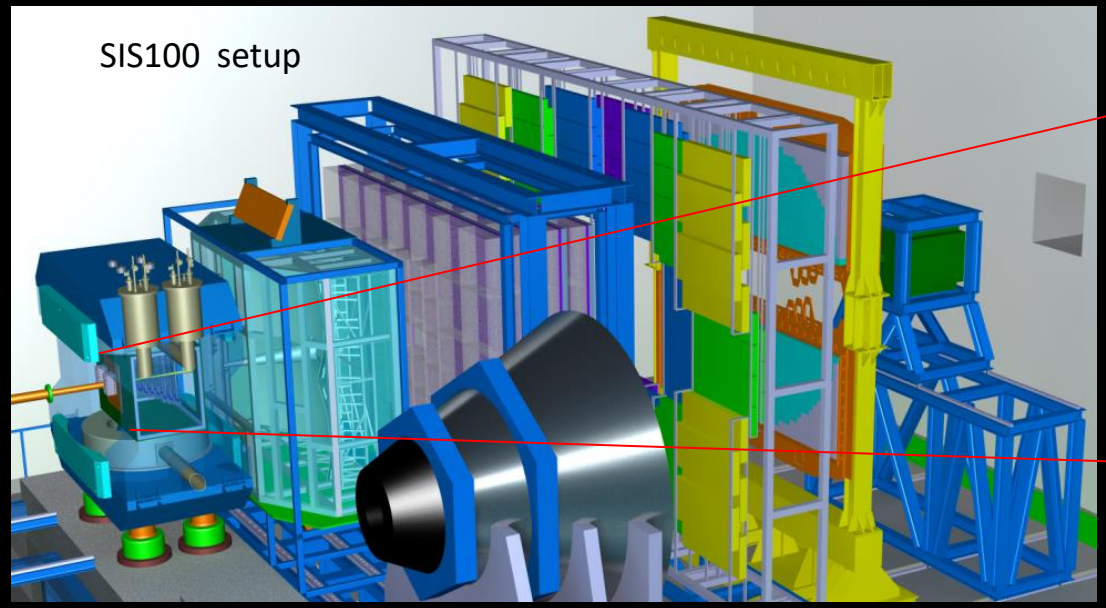
CBM

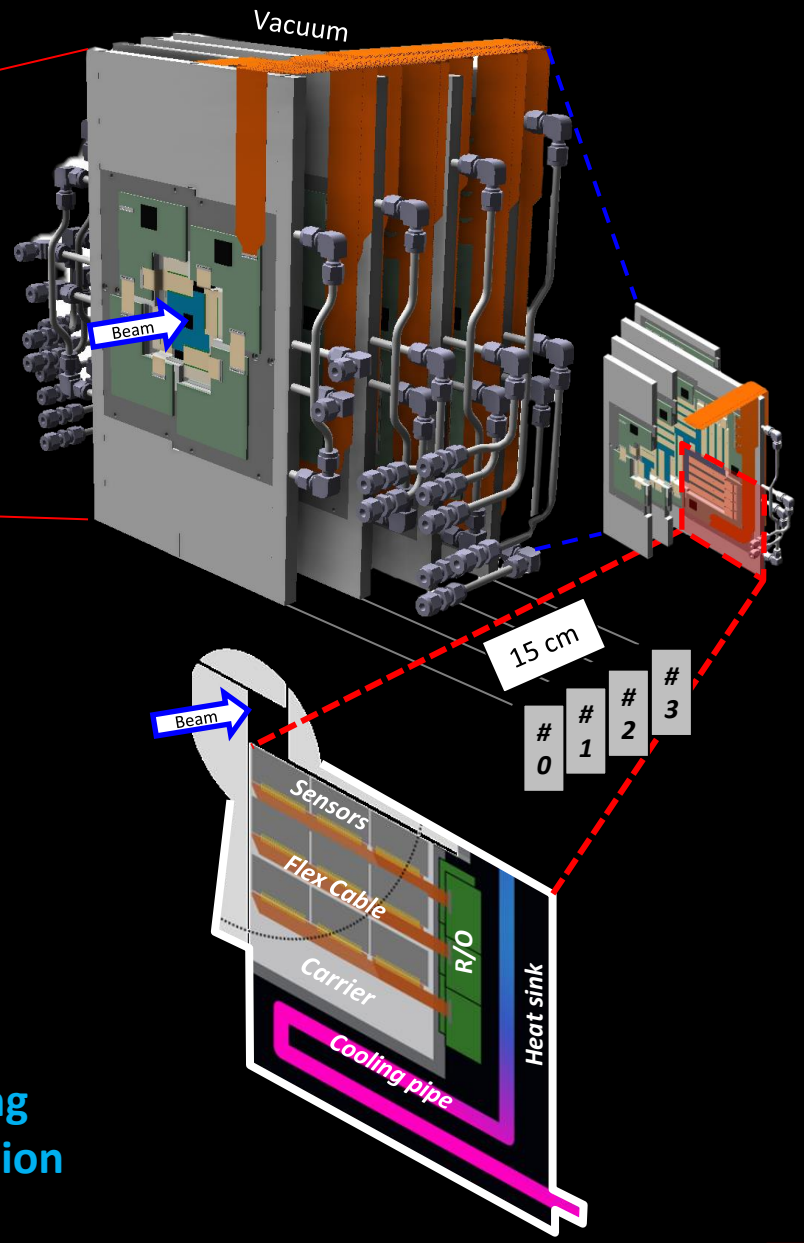
FAIR Facility for Antiproton and Ion Research in Europe GmbH

Outline

- The CBM-MVD: reminder
- Sensor development
- Radiation tolerance studies
- Detector integration
- Slow control
- Simulations
- Summary

The CBM-MVD: reminder



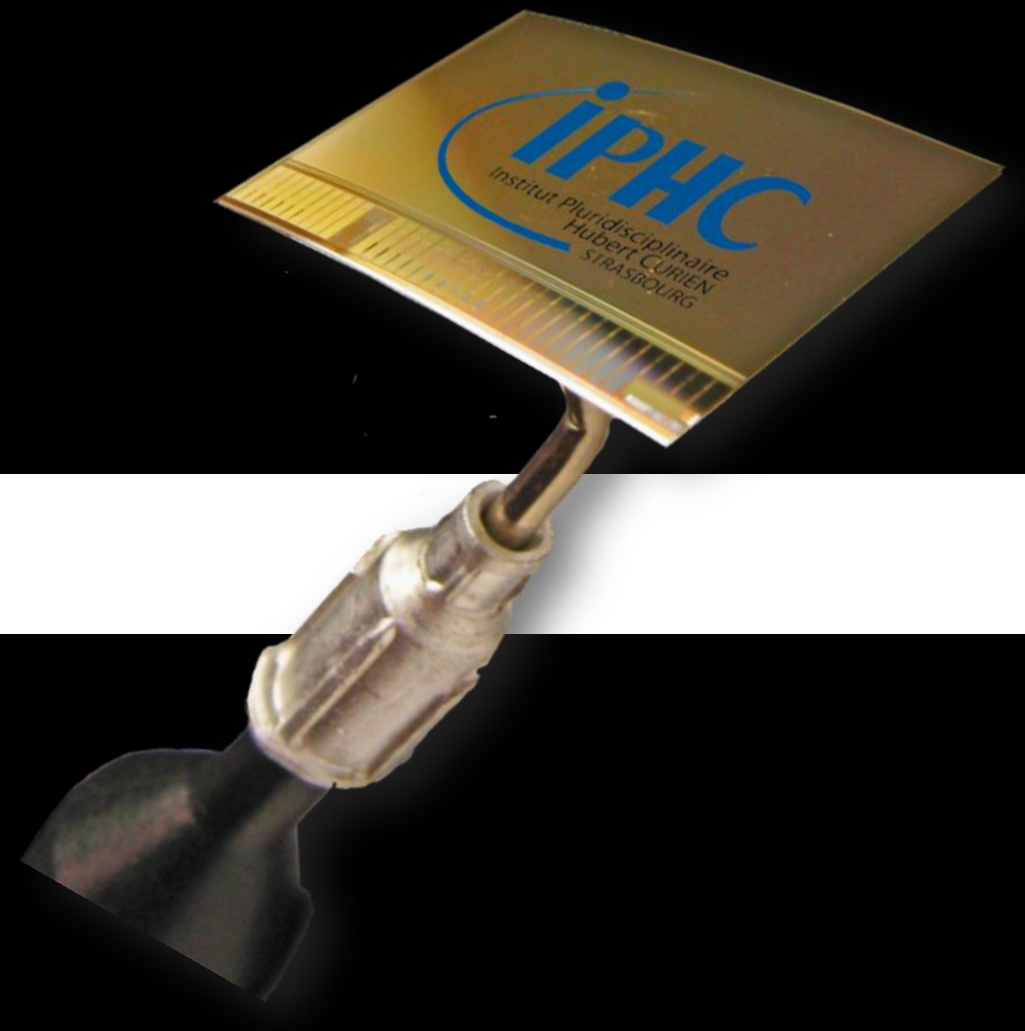


CBM-MVD :

- **Improve secondary vertex resolution (open charm)**
- **Tracking, focus low momentum particles**
- **Background rejection in di-electron measurements**

The MVD hosts highly granular silicon pixel sensors featuring low material budget, fast read-out, excellent spatial resolution and robustness to radiation environment.

Sensor development

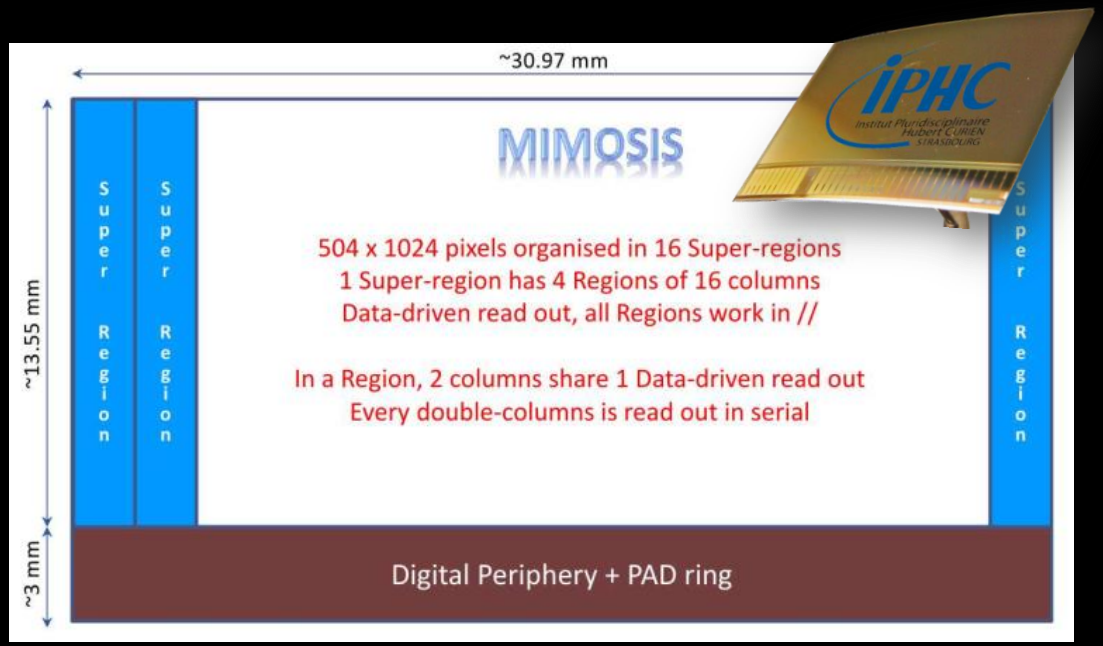


MIMOSIS CPS development

	ALICE-ITS (IB)	CBM-MVD 1st station
Radiation load TID	~270 krad	**3 Mrad @ -20 °C** / 1 Mrad @ +30 °C
Radiation load NIEL	~1.7x10^{12} n_{eq}/cm^2	**3x10^{13} n_{eq}/cm^2 @ -20 °C** , 1x10^{13} n_{eq}/cm^2 @ +30 °C
Peak hit rate	~1.25x10^4 /mm^2/s	**7x10^5 /mm^2/s** (x56 more than ITS)
Trigger	yes	no

There is no ready technical solution

The CBM-MVD sensor will be based on the ALPIDE asynchronous read-out but with entirely new digital circuitry (signal processing and transmission, slow control) and different in-pixel architecture.



Development plans (assuming rad. tol. does not turn into an issue**):**

- Small size pixel array -> MIMOSIS-0 ← Today

  Aims at selecting an optimum in-pixel architecture (AC vs. DC coupled pixels, performance of in-pixel amplifier and comparator) and studying the built-in priority encoder.

- 1st full-size prototype - submission 2018
- 2nd full-size prototype - submission 2019
- MIMOSIS - submission 2020

Preparing the MIMOSIS-0 test bench

Idea

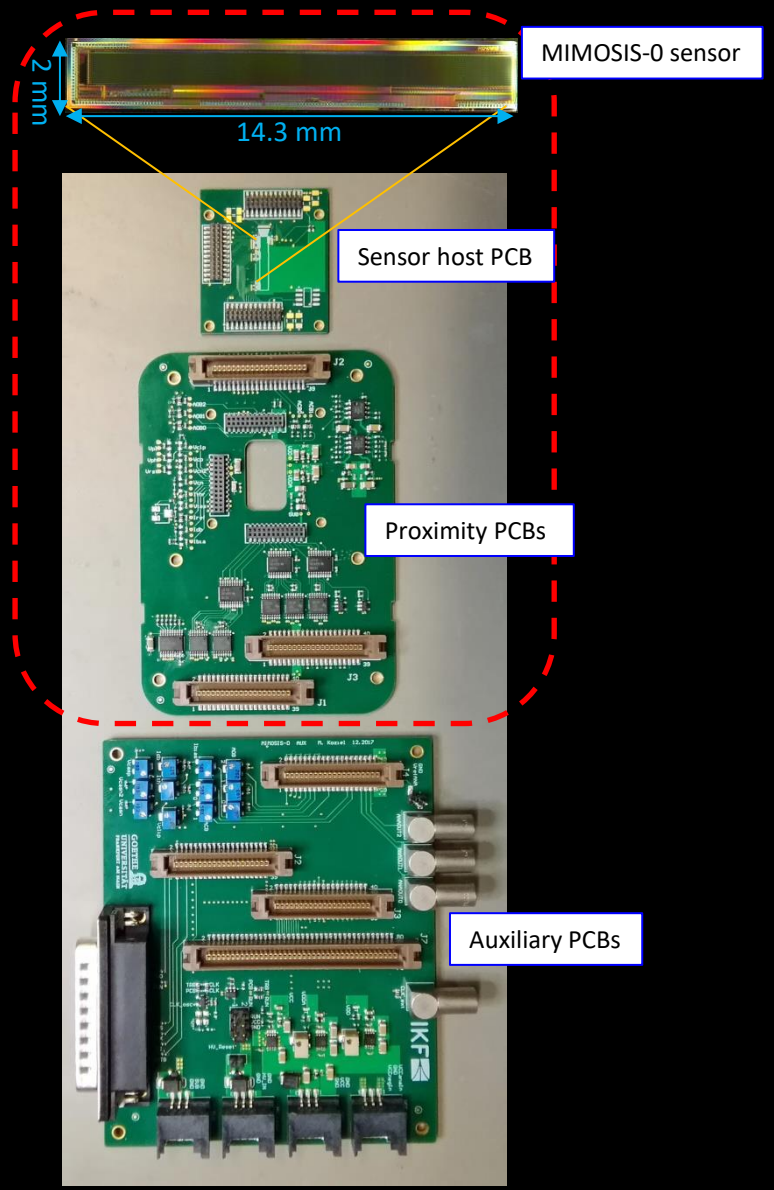
MIMOSIS

- LVDS buffers
- Voltage level converters
- Analog amplifiers

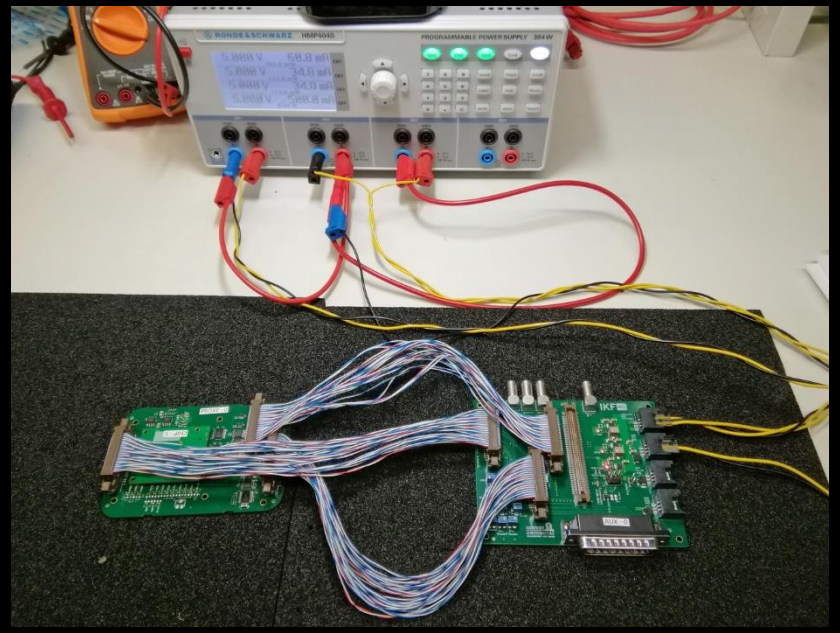
Climate chamber / dark box

- Connection to PC / TRBv2sc
- Voltage regulators
- Reference voltages

Implementation



Functional test

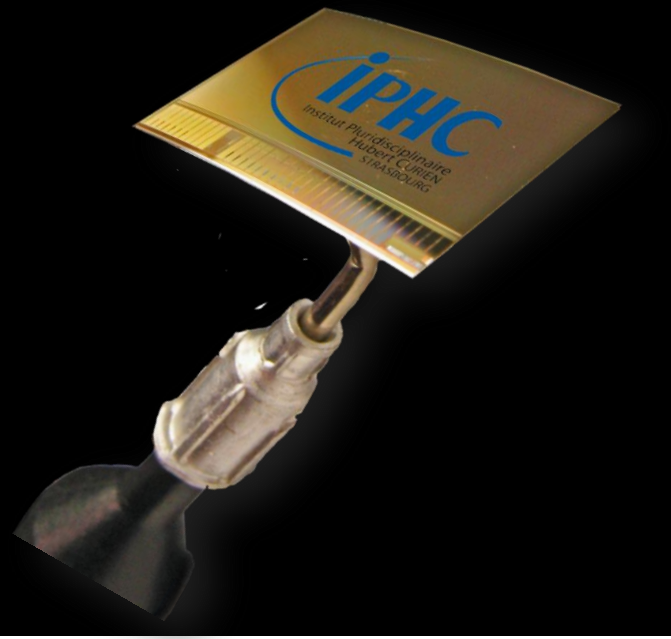


Accomplished:

- PCB design & production (50%)
- “smoke” & JTAG communication test => PASSED

To do list:

- PXI & TRB - based DAQ under development
- Priority encoder tests (IPHC)
- Radiation hardness tests (IKF/IPHC)

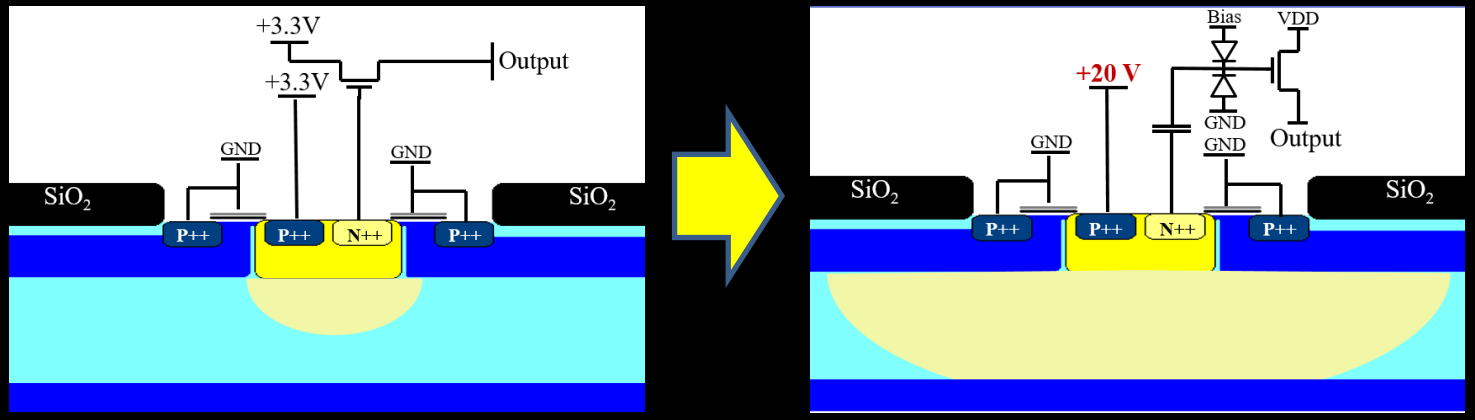


Radiation tolerance studies

Tobias Bus „News on Rad Hardness studies for the CBM MVD “

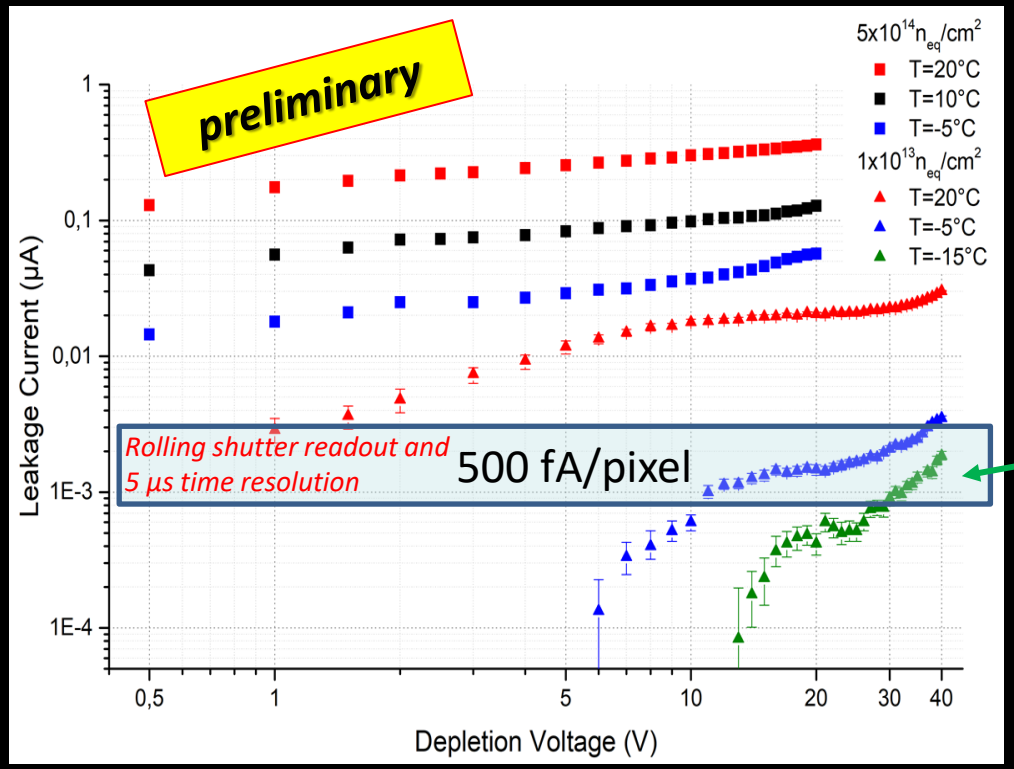
Mon, Feb 26 2018, 17:45-18:00, HK 14.4

Sensor development: Fully depleted CMOS (Pipper-2)



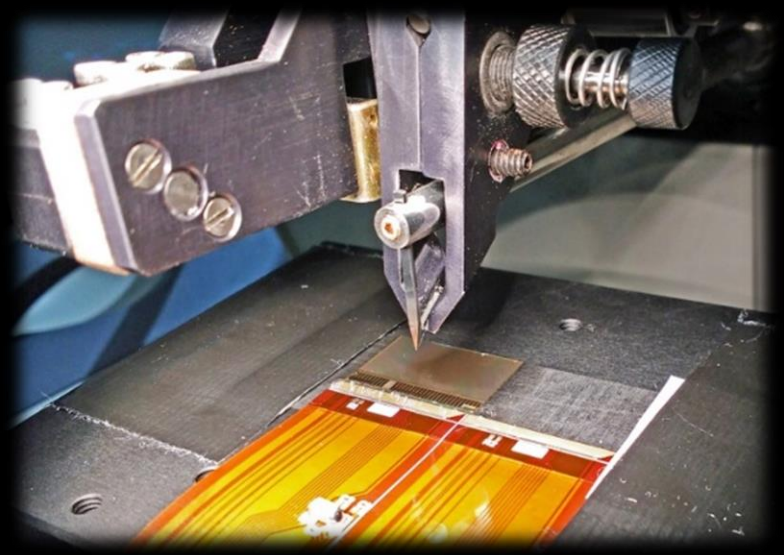
DPG-2017: Sensor seems fully depleted after 10-20 V.

Radiation tolerance ?



Implication to CBM-MVD:
Radiation tolerance > $10^{14} n_{eq}/cm^2$ is possible but:

- a cooling concept able to keep the sensors at the temperature < -60 °C (power & material budget)
- the in-pixel readout needs to be much faster

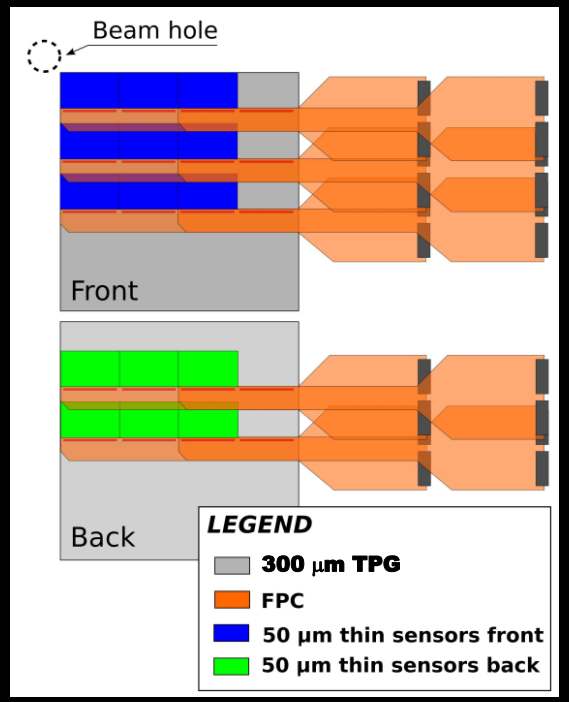


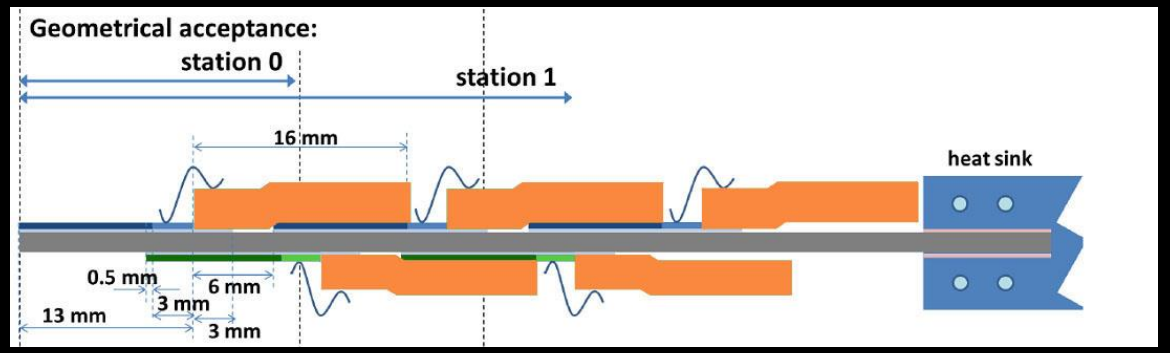
Detector integration

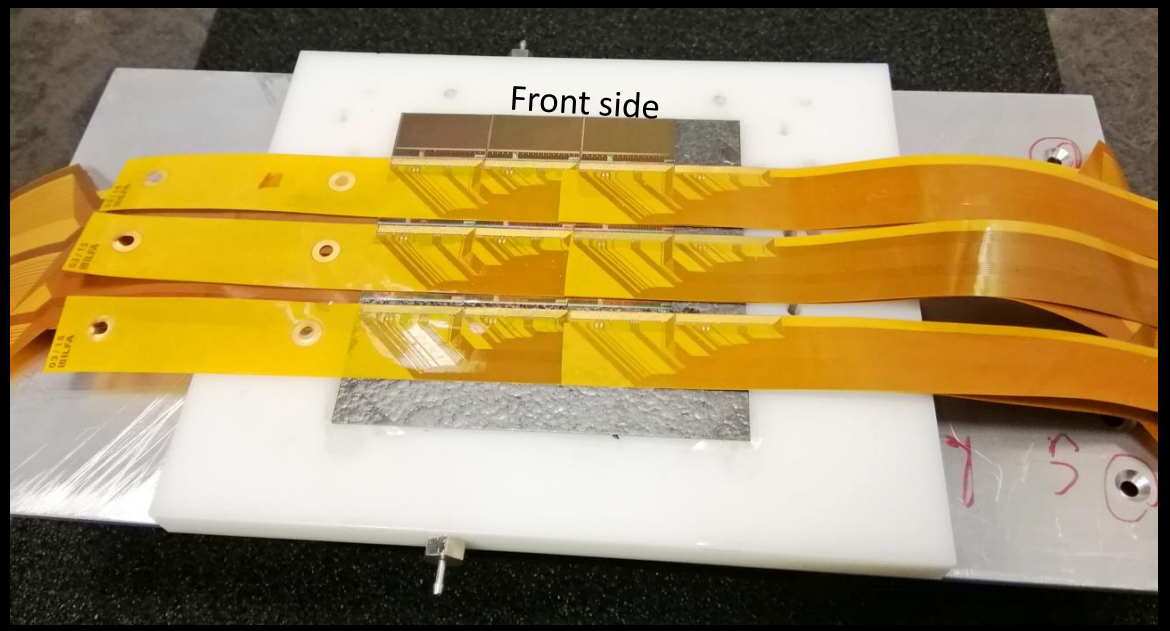
Michal Koziel „PRESTO Yield -> this talk“

Daniela Mijatovic „Thermal Charaterization of CBM-MVD prototypes “
Mon, Feb 26 2018, 15:15-15:30, HK 7.5

PRESTO yield







YIELD

Poor statistics

Back side:
2 - malfunctioning
4 - working

Front side:
3 - malfunctioning
6 - working

Malfunctioning sensors:

- **Category (A)**: 3 sensors exhibiting the problem with reference voltages
- **Category (B)**: 2 not fully working devices

PRESTO yield

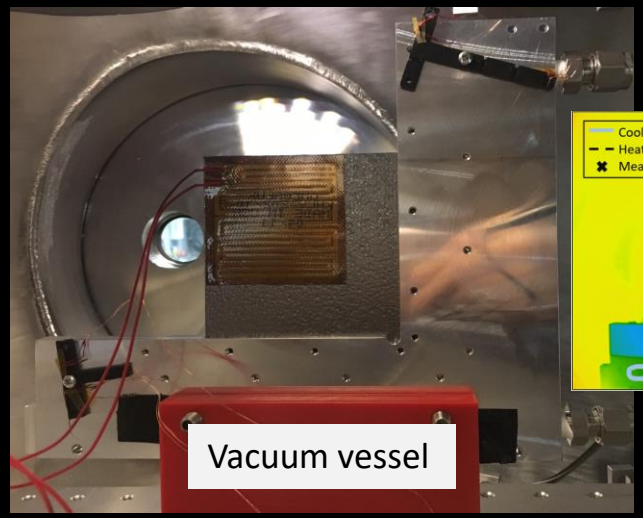
Yield issues – possible candidates and future plans:

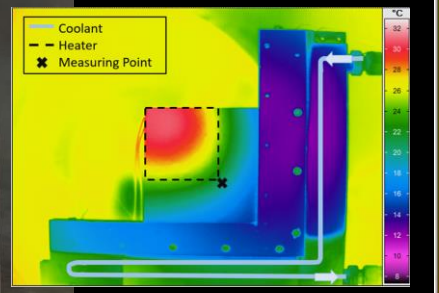
- ESD problem – pads delivering reference voltages not protected
  - No climate control system
    - Summer relative humidity - weather dependent
    - Winter relative humidity - below 30% (assumed to be highly risky according to industry standards).
- Wire bonding quality to examined during destructive pull tests
- Re-visit assembly process and jigs
- Create PRESTO-II based on the lessons learned. Use 50% of thin (50 µm) and 50% of thick (300 µm) sensors.

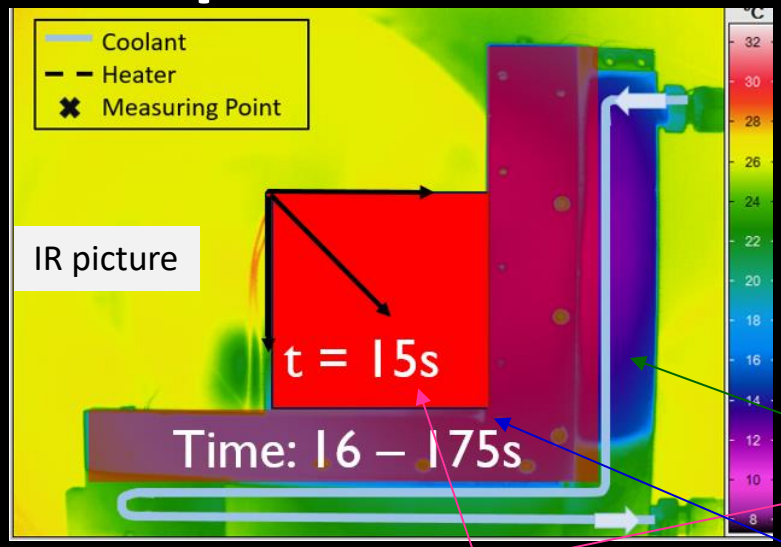
Understanding of the yield of the PRESTO module is ongoing. The outcome may not be directly transferrable to the yield we may achieve with future MIMOSIS sensors (different CMOS process, full ESD protection.

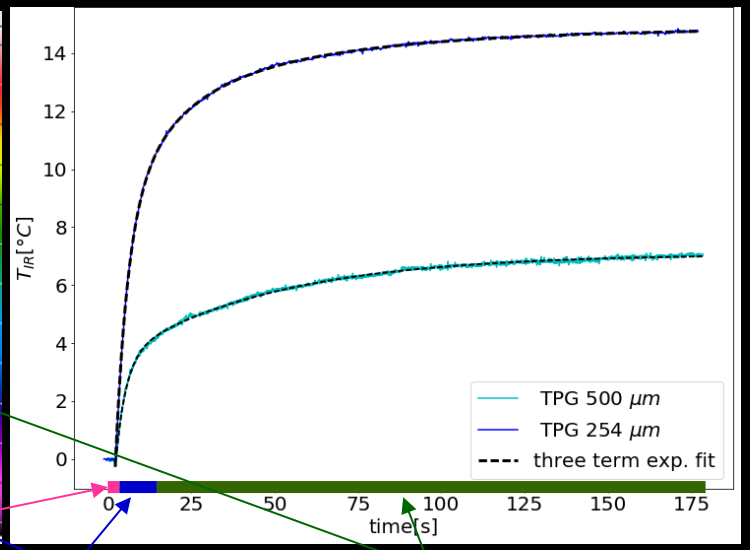
Verification of the cooling concept and materials

Performance of TPG carriers:







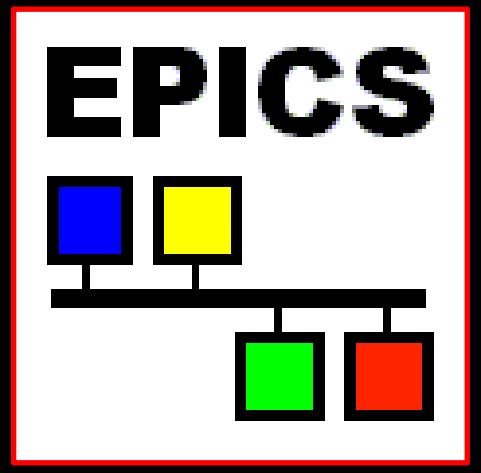


$$T(t) = T_{End} - T_0 * \exp\left(-\frac{time}{\tau_{carrier}}\right) - T_{contact} * \exp\left(-\frac{time}{\tau_{contact}}\right) - T_{HS} * \exp\left(-\frac{time}{\tau_{slow}}\right)$$

Preparation for 24/7 PRESTO run in the vacuum chamber:

- Many parameters influences the measurements.
  - Create a calibration module: TPG + sensor dummy + Pt100 sensors and used for reference measurement and calibration
  - Reflections from IR window (rings) do not allow for better precision than ± 1.5 °C without calibration.

- IR camera software is not dedicated for a long-time observations. Optionally, equip PRESTO with a PT100 sensor for constant temperature monitoring.



Slow control

Philipp Klaus **„Towards an EPICS based Detector Control System for the CBM Micro Vertex Detector “**

Mon, Feb 26 2018, 15:00-15:15, HK 7.4

Slow control with EPICS for PRESTO and beyond

Areas of control

Powering
LV power supplies, voltmeters

Cooling
Setpoint, circulation

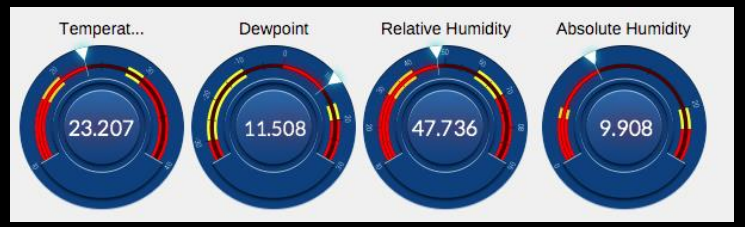
Vacuum
Pressure Gauges, Valves

Environmental
Temperature , humidity

Safety
Hardware interlocks, latch-up protection, emergency shutdown

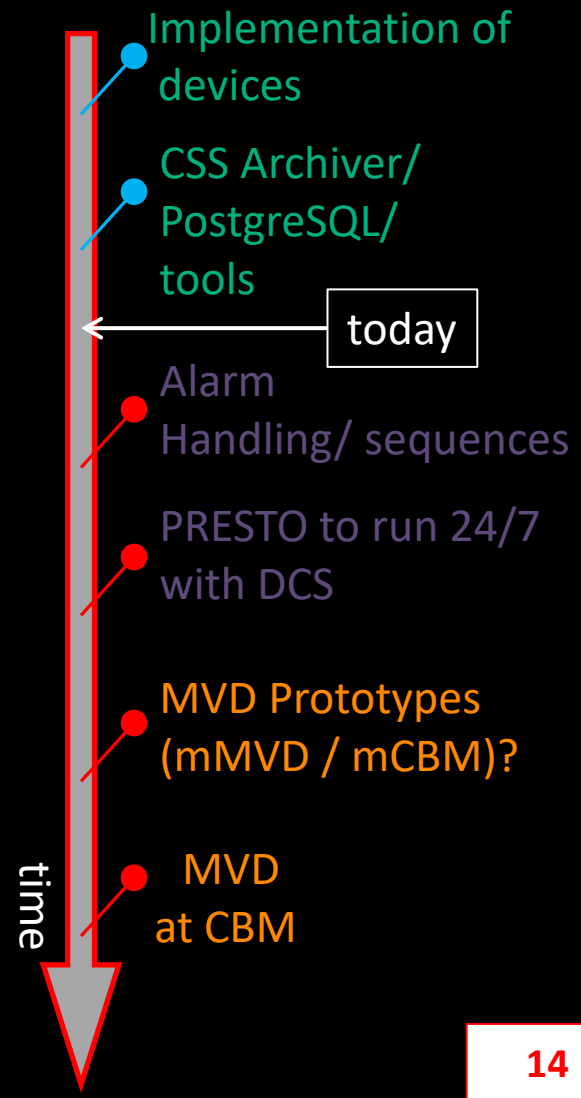
User interfaces

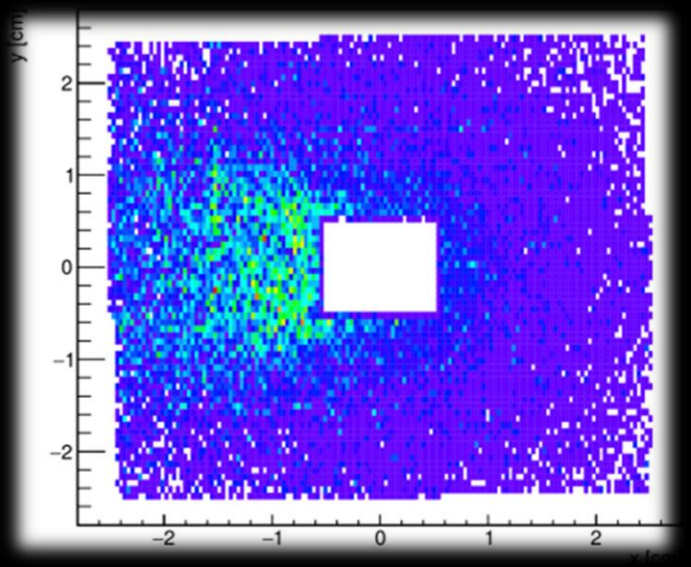
- CS-Studio
  - For full-fledged system control
  - Locally accessible (read/write access)
- Web GUI
  - Dashboard-like
  - For quick status information
  - Remotely accessible (read-only!)
  - “Mobile First” Approach



Check it out for yourself
https://presto.site

Timeline





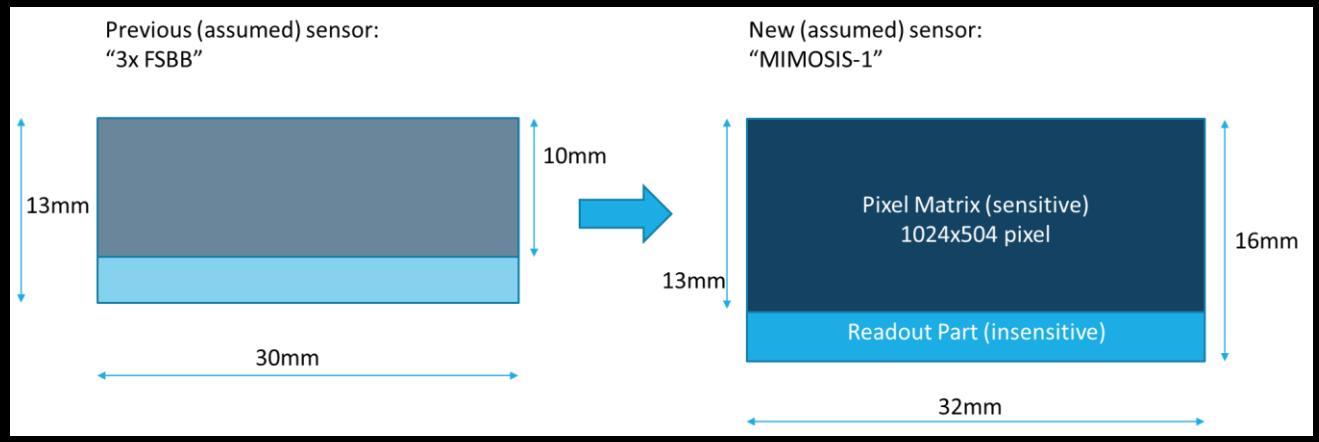
Simulations

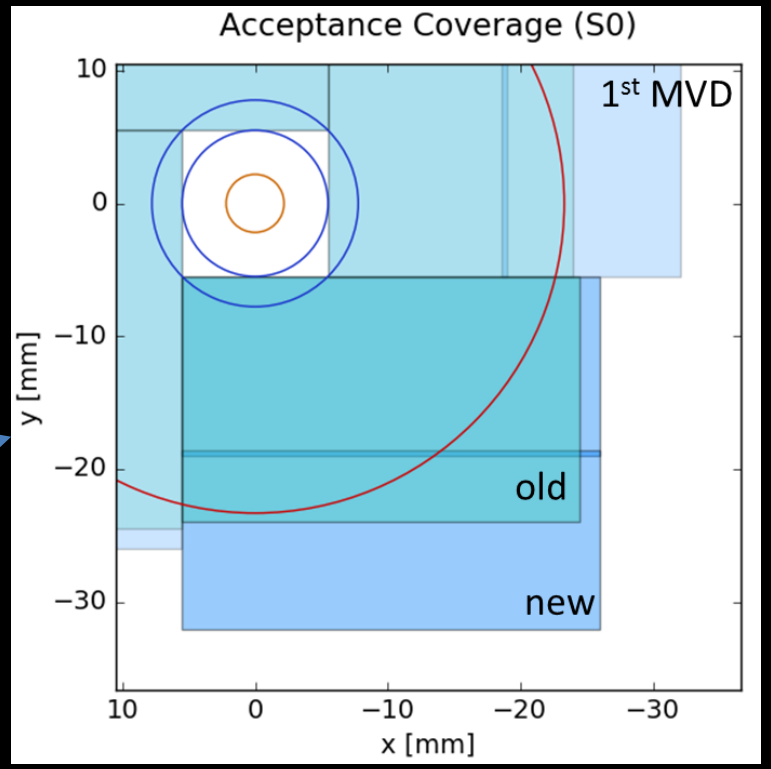
Philipp Sitzmann **„Updates on the Micro Vertex Detector Geometry for the CBM - Experiment “**

Mon, Feb 26 2018, 17:30-17:45, HK 14.3

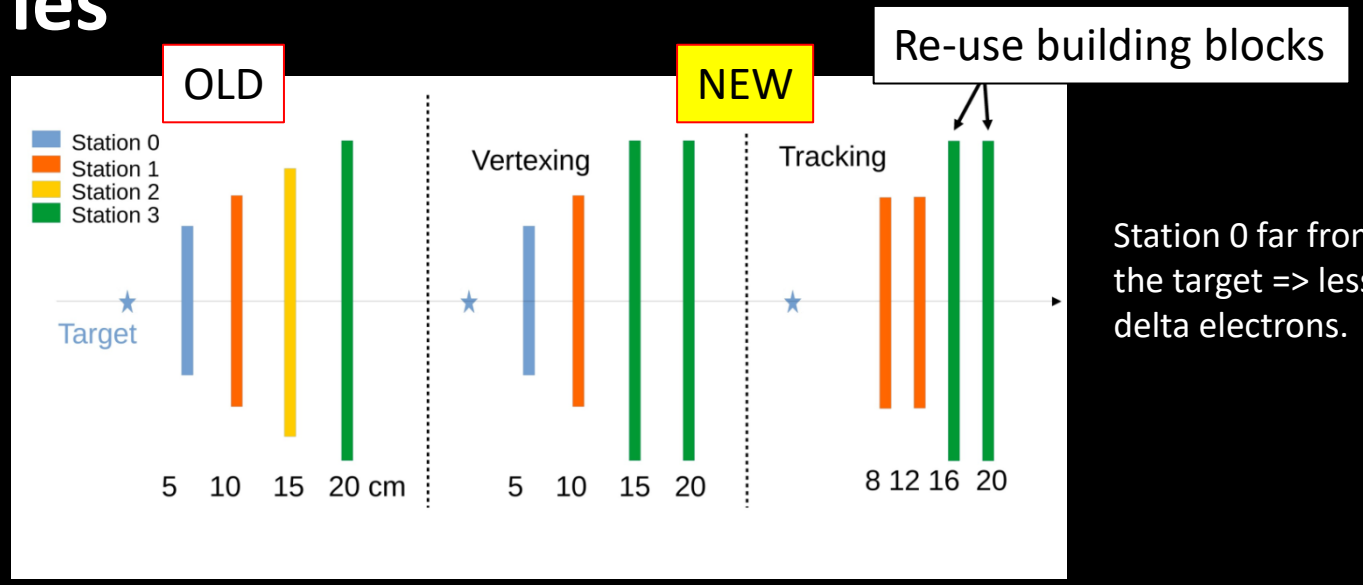
MIMOSIS based CBM-MVD geometry

- **MIMOSIS: new sensor geometry**
  - Allows for a larger geometrical acceptance per station
  - Re-do station layouts
- **Scripted geometry instead of Cad2Root (DPG 2017)**
- Lateral station dimensions might slightly change, might effect target chamber dimensions
- status: include/transfer new geos to CBM-CAD



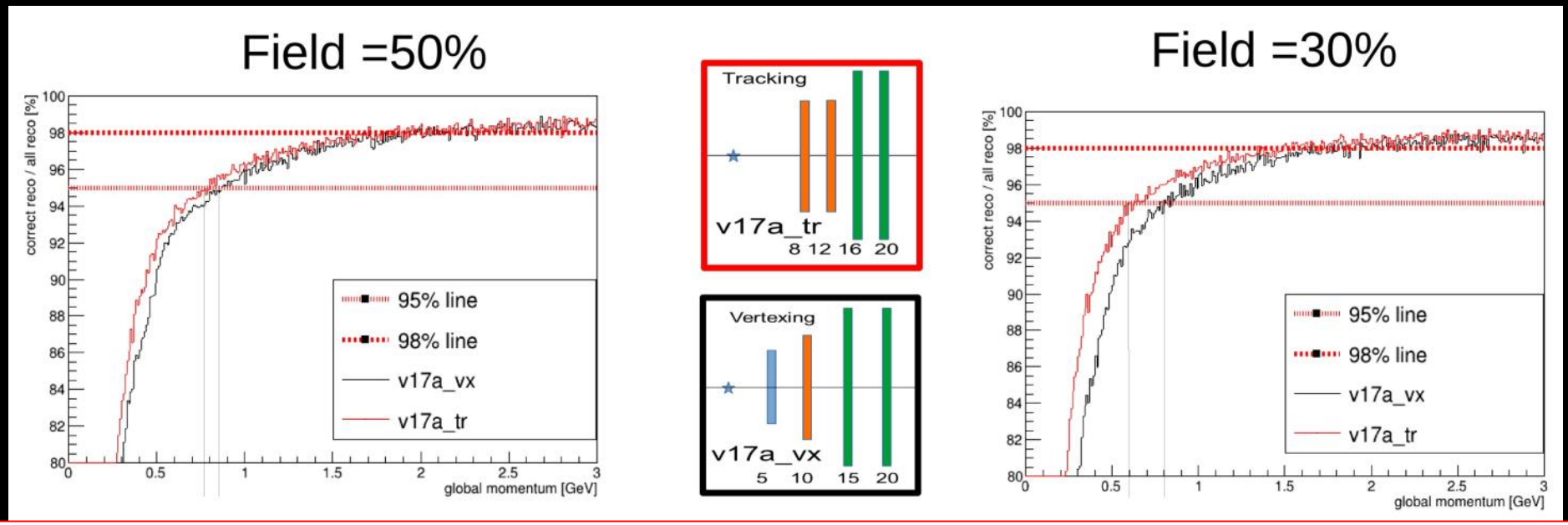


New MVD geometries



Station 0 far from the target => less delta electrons.

preliminary



The MVD extends tracking capability of the CBM experiment system towards low momenta, which is relevant for SIS100 instead of SIS300 physics and for background suppression in general.

SUMMARY:

- Wide range of activities towards the CBM-MVD
- The CBM-MVD sensor development on a good track, MIMOSIS-0 under tests
- Fully depleted CMOS sensors have a potential to operate at radiation doses > 10^{14} n^{eq}/cm^2 but they require to be operated at T < -60 °C …which challenges the current cooling concept, and asks for putting emphasis on MIMOSIS power dissipation and in-pixel architecture optimization.
- PRESTO yield is under studies => conclusions => PRESTO-II production
- Developed test-stand for thermal material characterization. It will be used to in-vacuum thermal studies of the PRESTO module controlled by state of the art EPICS DCS.
- New MVD geometries simulated with CBM-ROOT
- ***All Information gained => TDR concluded in 2018***

The MVD team, 2018

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CBM

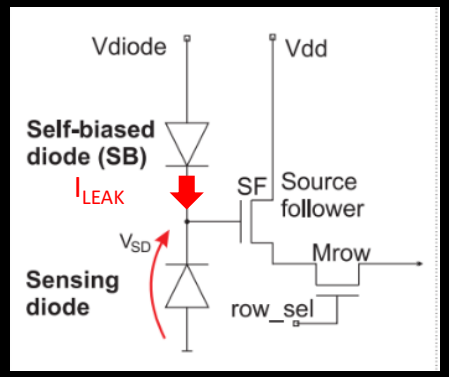
Thank you for your attention…

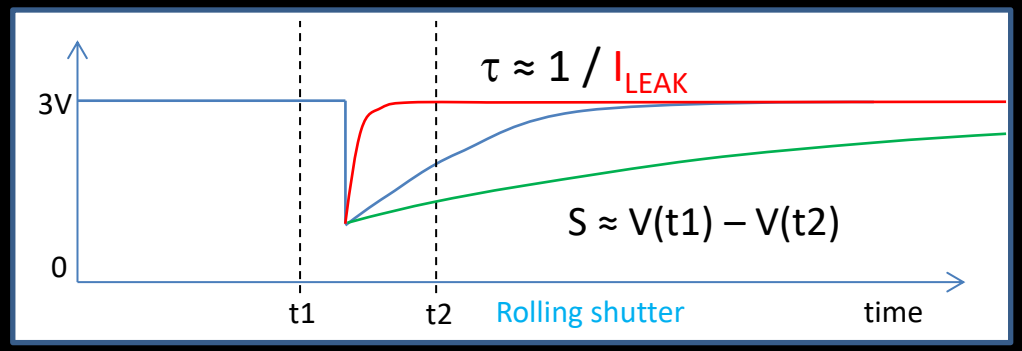
BACKUP

MimoSIS performances:

- 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 stations 0 & 1
- 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}

Sensor development: Fully depleted CMOS (Pipper-2)





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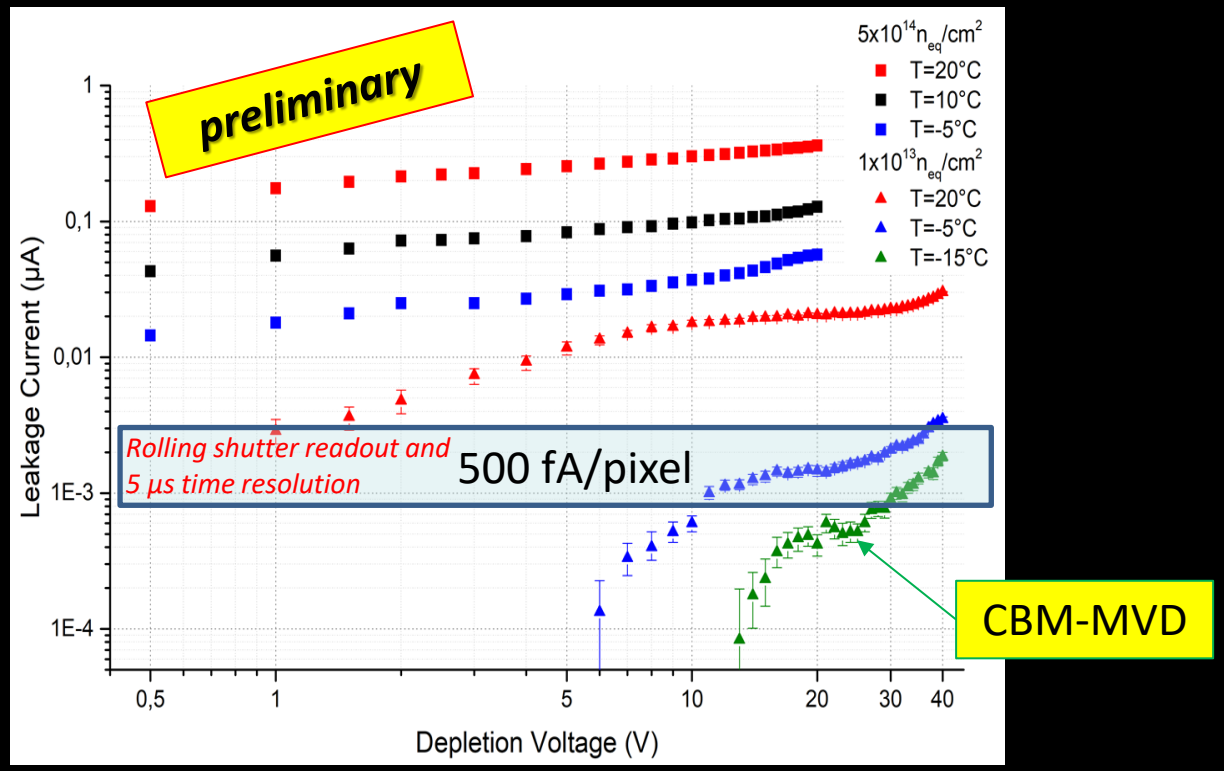

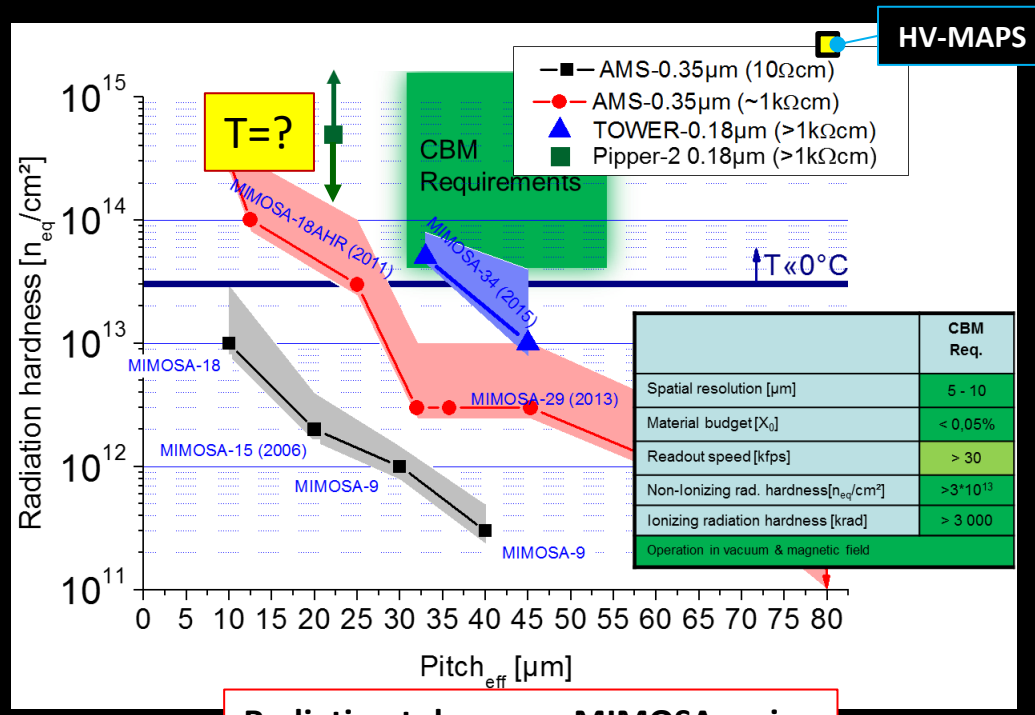

Radiation tolerance: MIMOSA series