DPG 2019, München

MIMOSIS, a CMOS sensor for the CBM -

Michael DEVEAUX & Michal KOZIEL
On behalf of the CBM-MVD collaboration

koziel@physik.uni-frankfurt.de

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

IPHC Institut Pluridisciplinaire Hubert CURIEN STRASBOURG

CBM

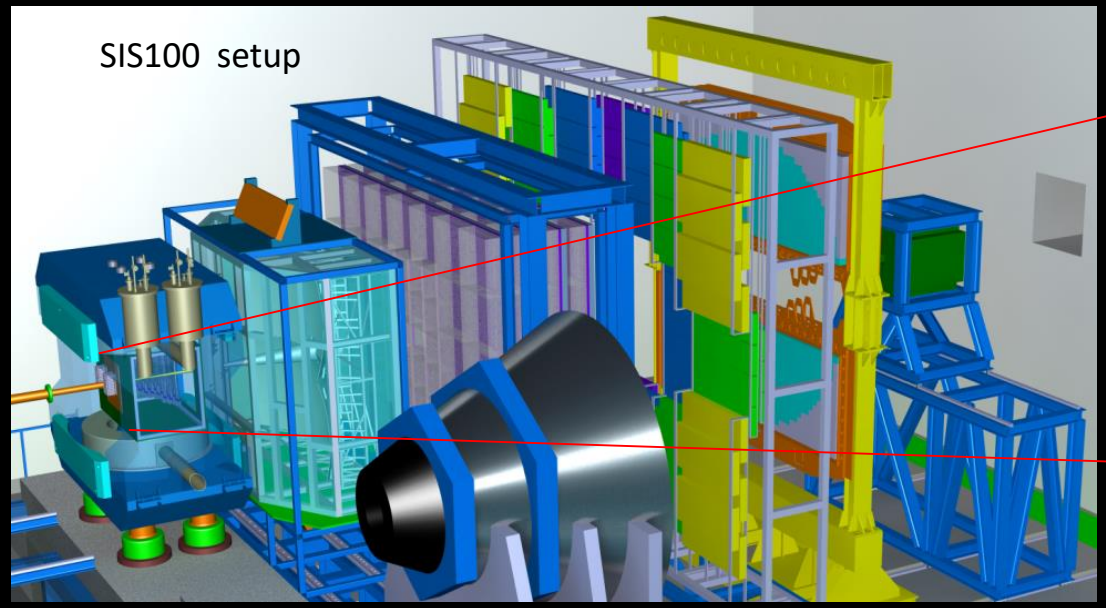
FAIR Facility for Antiproton and Ion Research in Europe GmbH

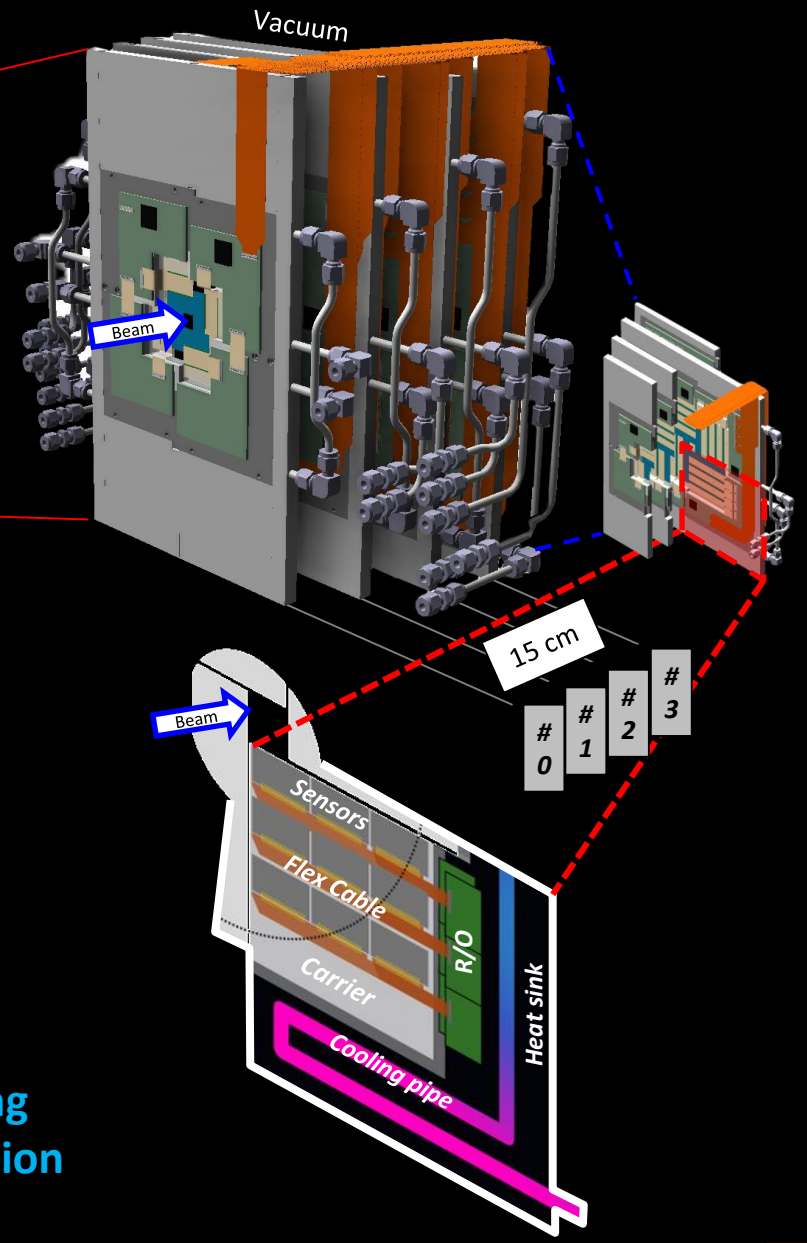
Bundesministerium für Bildung und Forschung

Outline

- The CBM-Micro Vertex Detector: reminder
- Why another CMOS Pixel Sensor ?
- MIMOSIS-0
  - Sensor architecture
  - Test setup
  - Test results
  - Radiation tolerance
- Summary

The CBM-MVD: reminder





CBM-MVD :

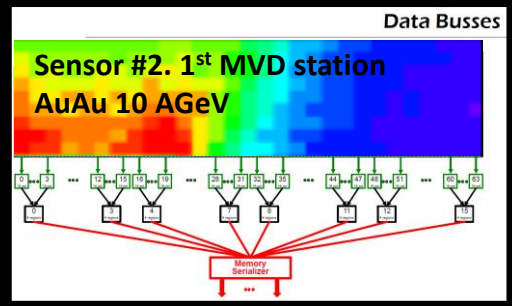
- **Improve secondary vertex resolution (open charm)**
- **Tracking, focus low momentum particles**
- **Background rejection in di-electron measurements**

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

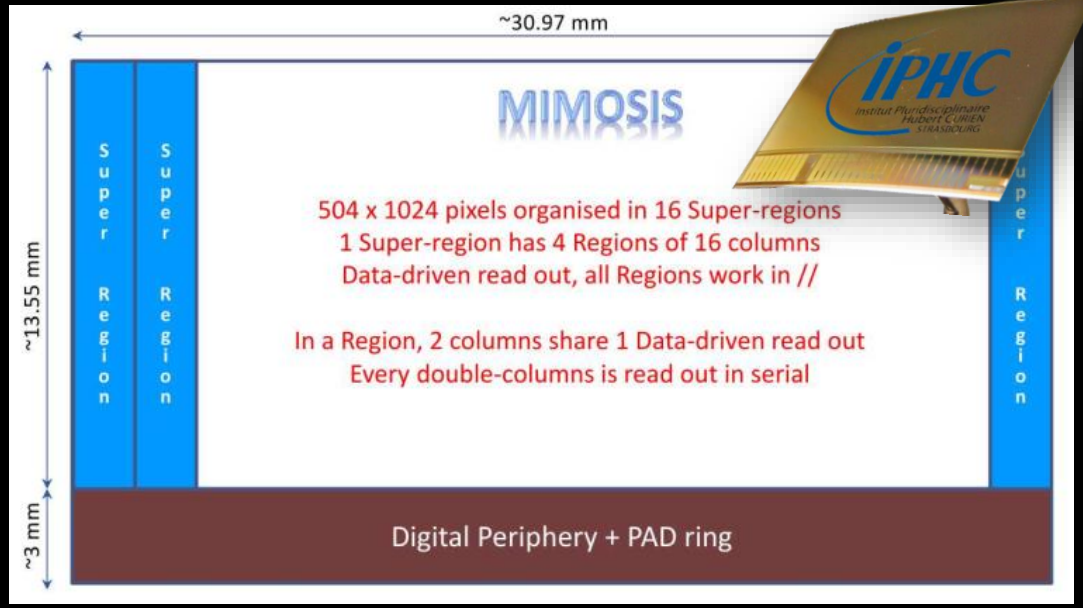
MIMOSIS CPS development

	ALICE-ITS (IB)	CBM-MVD 1st station
Radiation load TID	~270 krad	**3 Mrad**
Radiation load NIEL	~1.7×10^{12} n_{eq}/cm^2	**3×10^{13} n_{eq}/cm^2**
Power dissipation	50 mW/cm^2	**<300 mW/cm^2**
Operating temp.	T_{ROOM}	**-10 °C**
Peak hit rate	~1.25×10^{4} /mm^2/s	**7×10^{5} /mm^2/s** (x56 more than ITS)
Trigger	Yes	no

Delta=electron dominated



There is no ready technical solution



Road map towards MIMOSIS:

Today

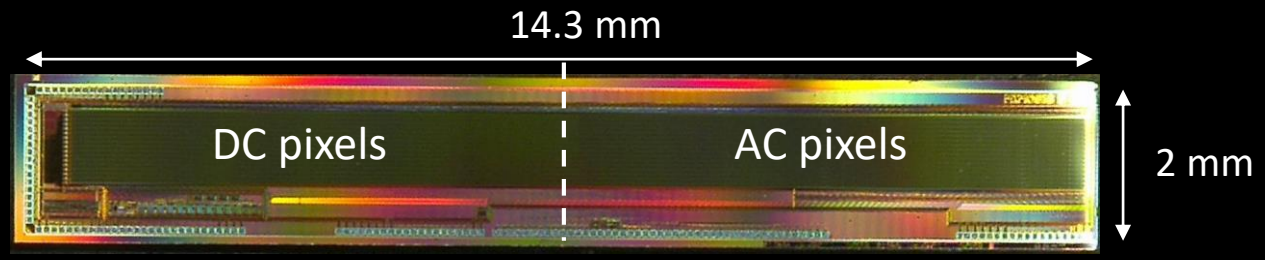
- Small size pixel array -> MIMOSIS-0
  Aims at selecting an optimum in-pixel architecture (AC vs. DC coupled pixels, performance of in-pixel amplifier and comparator) and studying the built-in priority encoder.

- 1st full-size prototype - submission 2019
- 2nd full-size prototype - submission 2020
- MIMOSIS - submission 2021

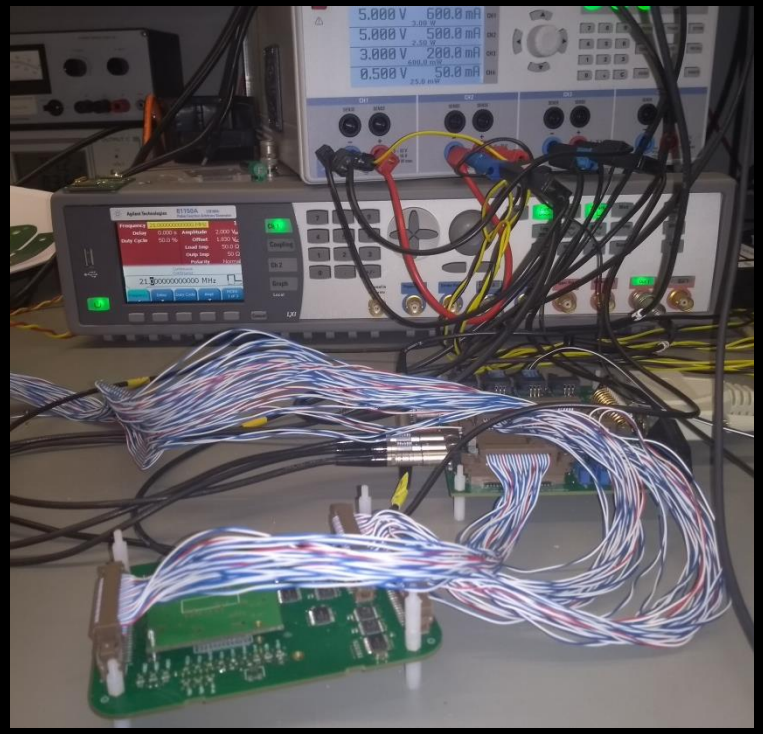
The CBM-MVD sensor will be based on the ALPIDE asynchronous read-out but with entirely new digital circuitry (signal processing and

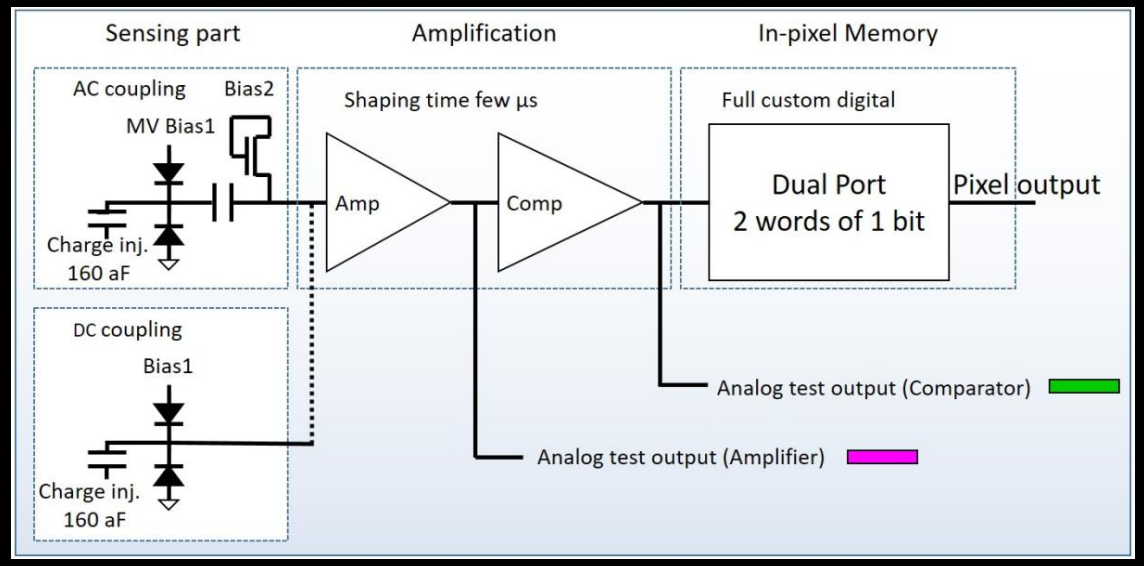
1st prototype => MIMOSIS-0 sensor

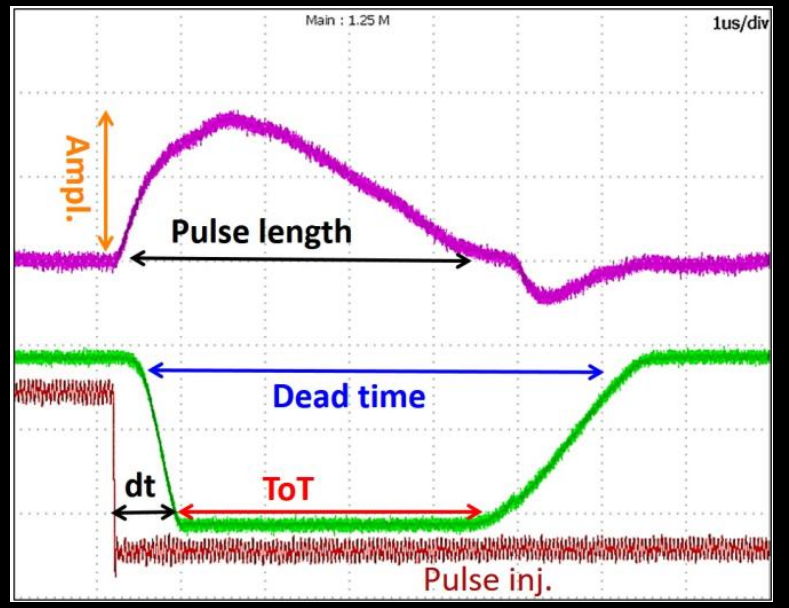
Aims at selecting an optimum in-pixel architecture (AC vs. DC coupled pixels, performance of in-pixel amplifier and comparator) and studying the built-in priority encoder.



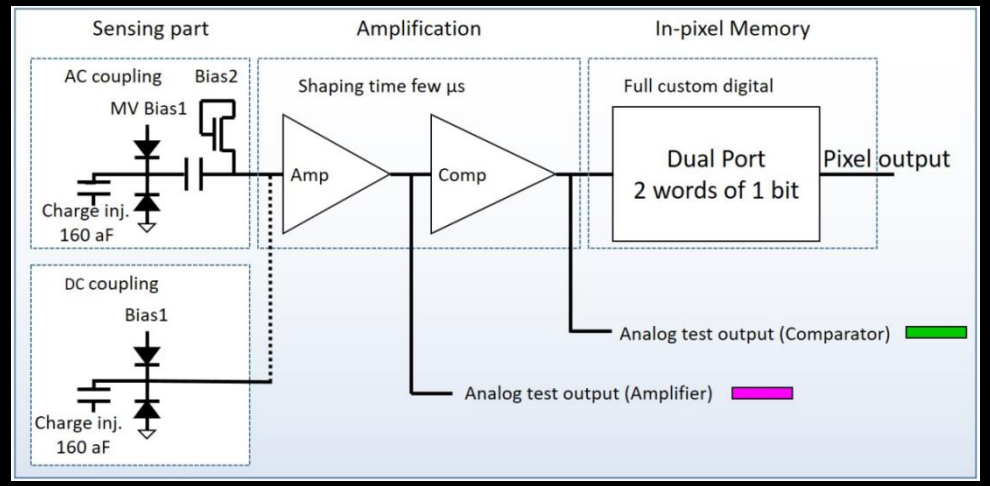
- Pixel size: 26.88 x 30.24 µm
- EPI type / thickness: HR / 18 µm
- 13 8-bit DACs
- 16 col x 54 rows => 16128 pixels

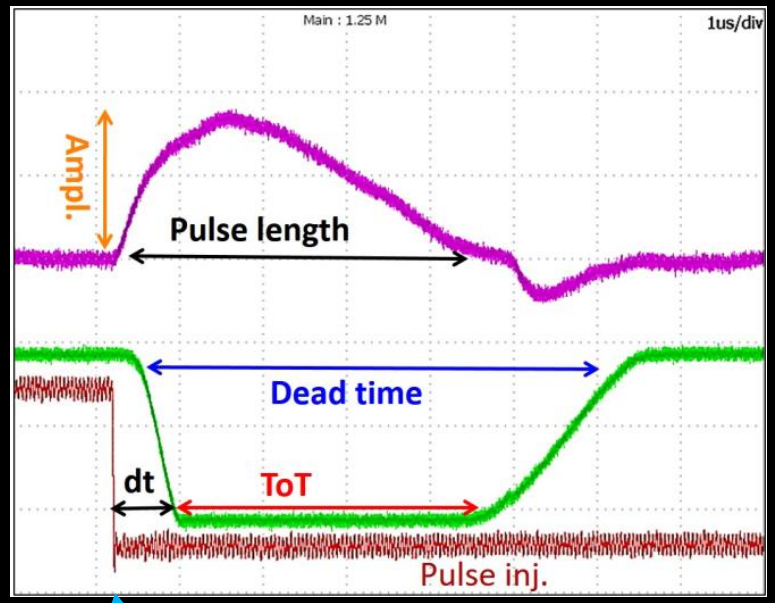




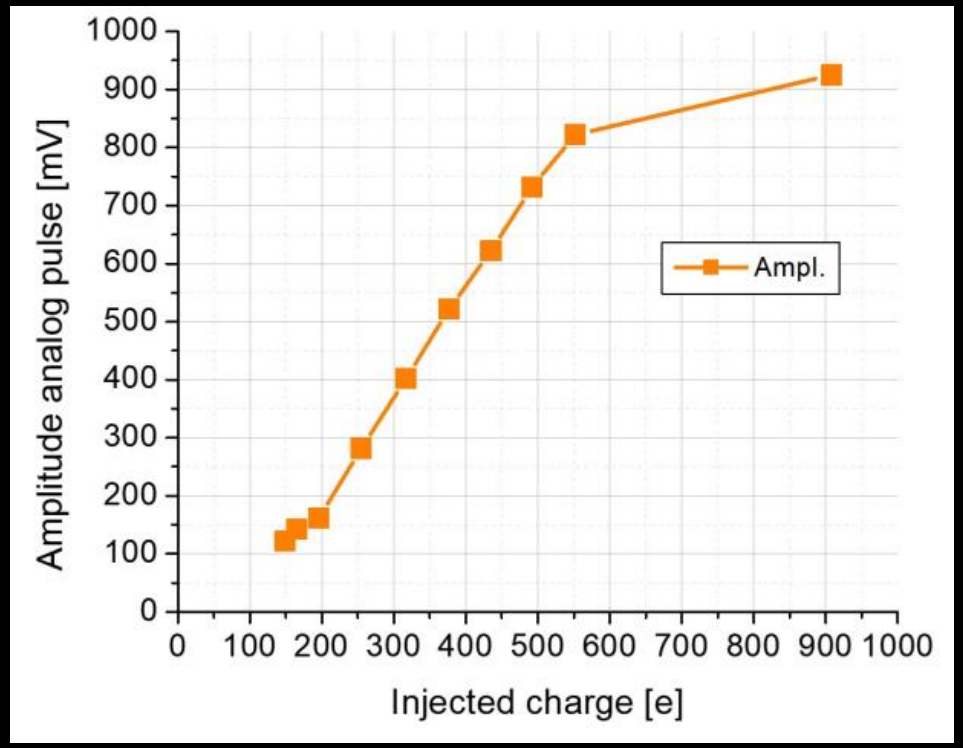


Properties of the amplification chain





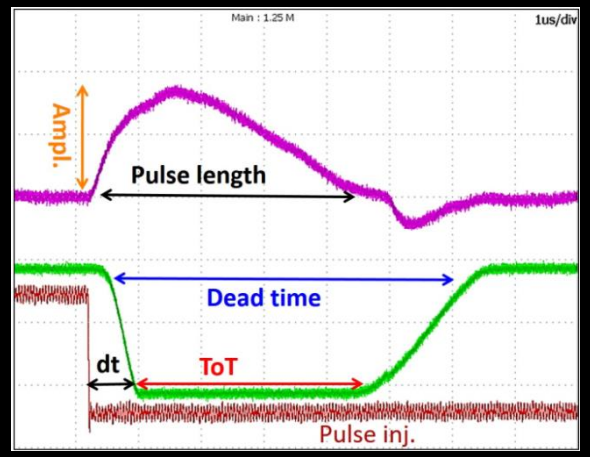
injection

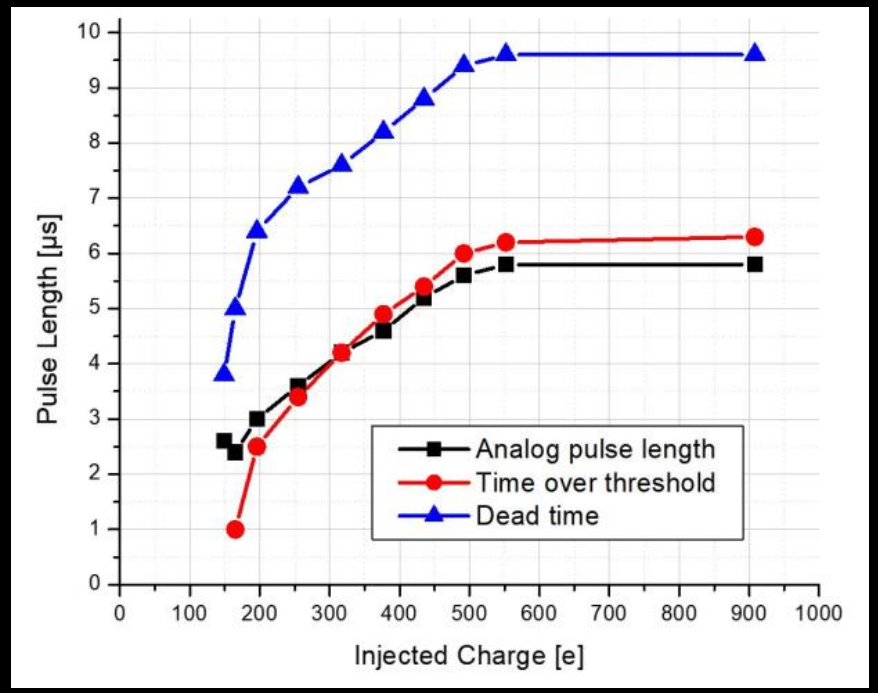


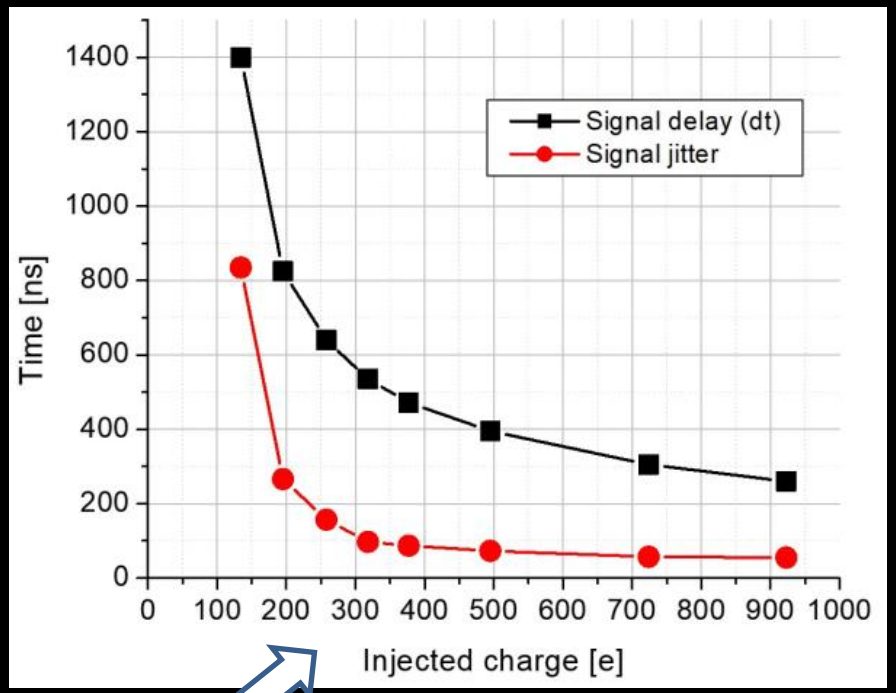
- The amplifier is found linear in a range between roughly 150 *e* and 600 *e*. Below this value, the gain is reduced, which complicates choosing substantially lower thresholds independently of the noise.
- Above 600 *e*, the amplifier is intentionally saturated in order restrict the pulse duration.

We assume the capacity of the charge injection system to amouts precisely its nominal value of C = 160 aF

Properties of the amplification chain





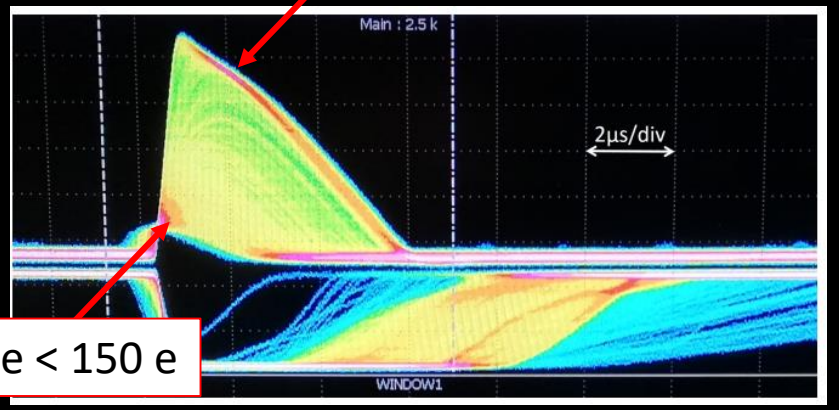


- The precise values vary by few 100 ns depending on the individual pixel and depend on the detailed settings of the eight current and voltage sources, which steer the pixels.
- Due to space constraints, all pixels share common voltage sources => an individual tuning of the pixels is not feasible.

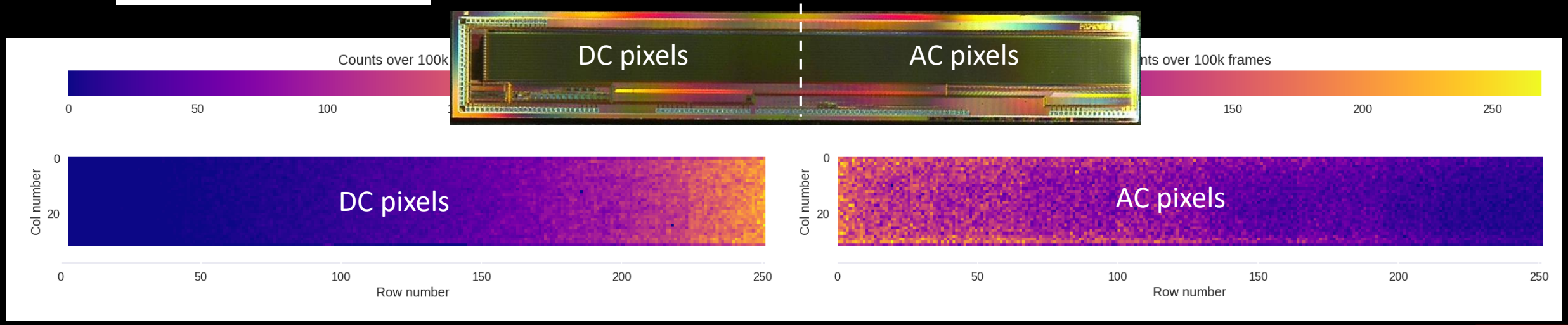
- Time walk (variation of the delay as function of the signal amplitude) of ~ 1.4 µs and a jitter of 0.85 µs, observed for the minimum charge injected.
- Still modest signal of > 300 *e* ENC => the time resolution might already be as good as 0.6 µs, …and may allow for further frame time reduction for limited occupancies.

Sensitivity to radioactive source

Tests with 55-Fe source



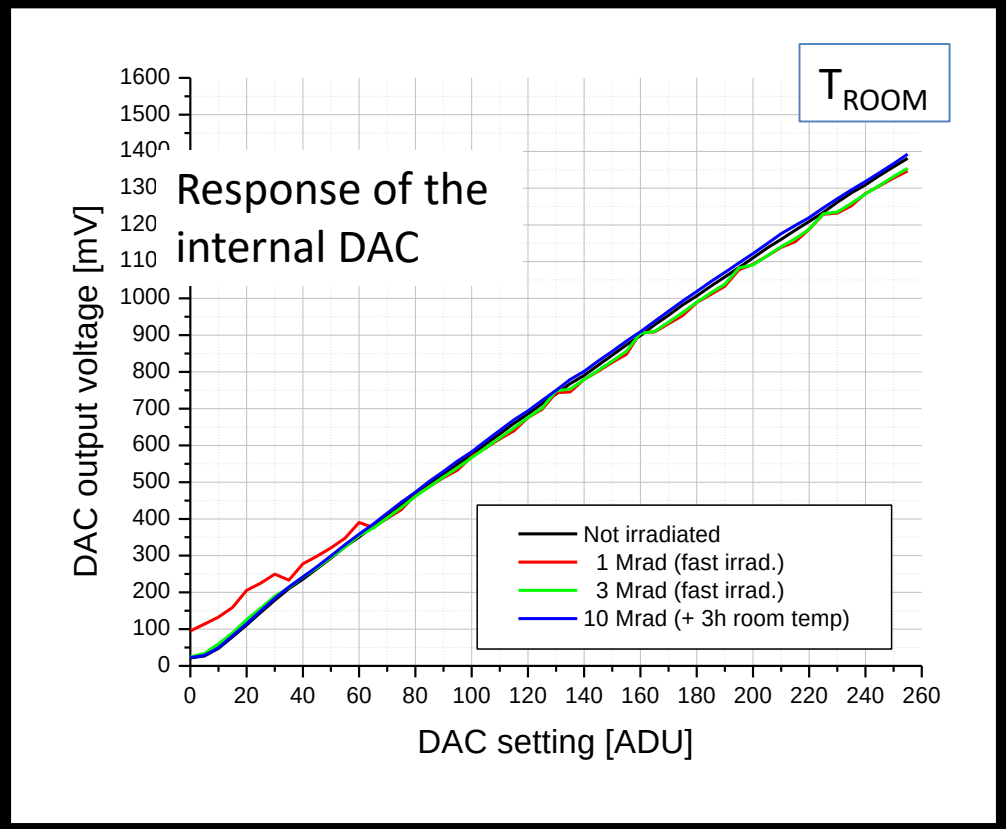
- In many cases, the 1640 *e* generated by the photon exceed the saturation limit of the pixel.
- Number of entries with low signal charge related to hits occurring far from the collection diode.

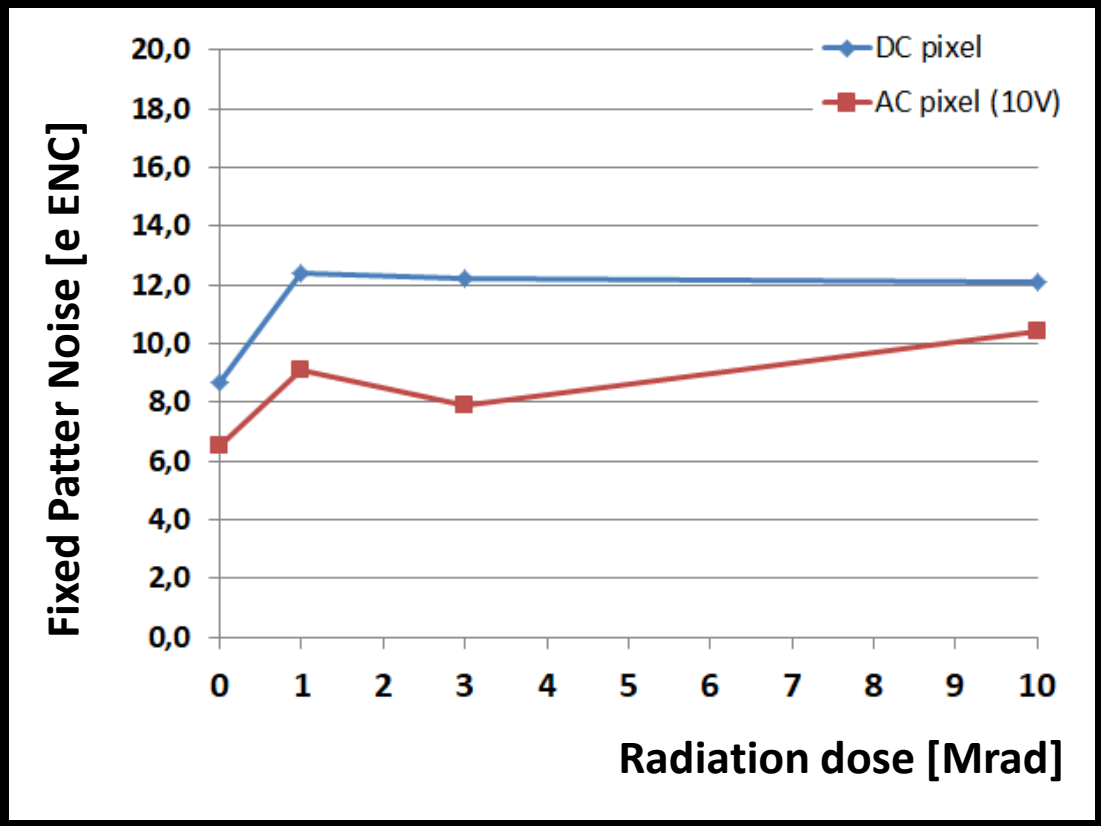


Radiation tolerance studies

- X-Ray tube used thanks to KIT Karlsruhe
- Tolerance to ionizing radiation addressed
- Focus:
  - internal DACs
  - in-pixel circuitry

PRELIMINARY





Summary and outlook

- CMOS Pixel Sensor for CBM Micro Vertex Detector is being developed

- The 1st prototype shown a successful integration of
  - Pixels hosting AC and DC coupled preamplifiers
  - Priority encoder
  - Slow control units

- The pulse shapes and lengths => it is conceptually suited to reach a ~ 1 µs time resolution (ambitioned 5 µs) in combination with a dead time of ~ 10 µs. Digital part to be adapted/tested.

- MIMOSIS-0 is currently being tested for its radiation tolerance
  - Preliminarily results have been presented
  - To do:
    - Leakage current measurements
    - The FPN and thermal noise will be studied in detail
    - AC vs. DC pixel ? => which pixel type for the upcoming submission

- First reticle size prototype is being prepared for a submission - mid 2019.