Radiation Tolerance of CMOS Sensors

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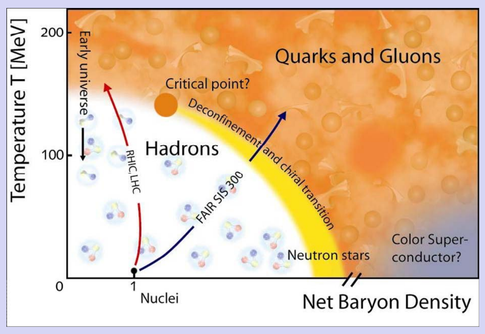
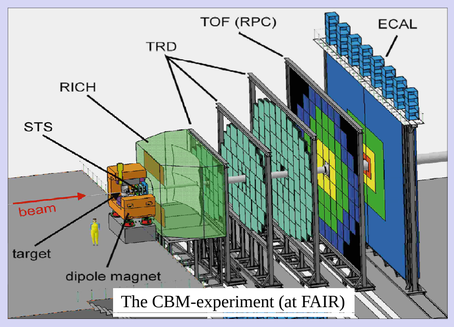
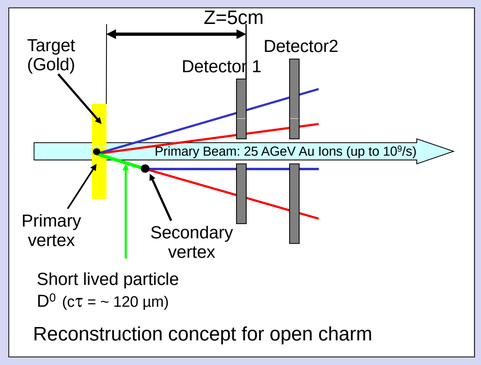
The Heavy Ion Experiment CBM





The Compressed Baryonic Matter (CBM) experiment at FAIR will explore the nuclear phase diagram in the region of highest net-baryon densities at moderate temperatures. One of the promising probes is open charm which will be identified by reconstructing their secondary vertex with 50 µm precision.

The Task

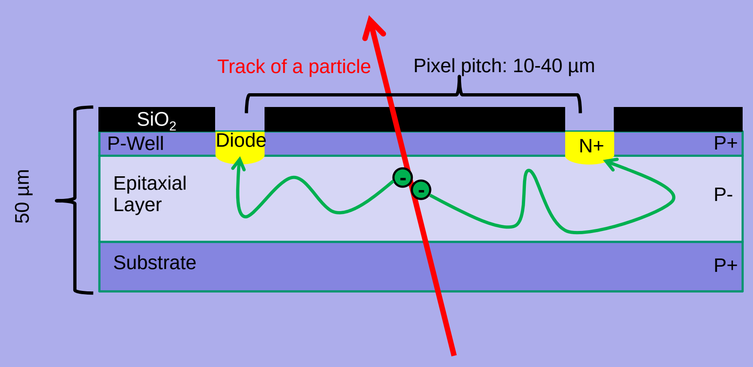


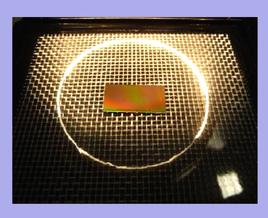
Sensor requirements for CBM@SIS-100:

- 5 µm spatial resolution
- 0.05 % X_0 material budget (sensor only)
- 30 µs time resolution
- Power dissipation: ~350 mW/cm²
- Ionizing radiation tolerance: **1-3 Mrad**
- Non-ionizing radiation tolerance: **10^{13} n_{eq}/cm²**

CMOS Monolithic Active Pixel Sensors (MAPS)

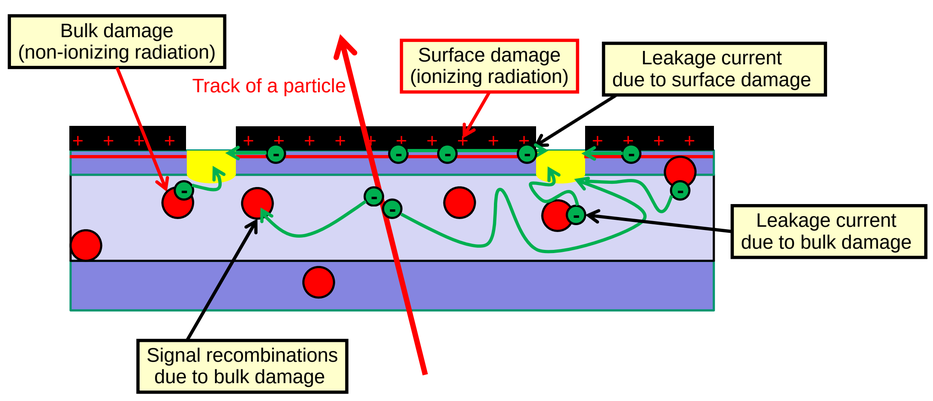
MAPS are pixel sensors for charged particle tracking. Their small pitch of 10 – 40 µm and 50 µm thickness provides excellent spatial resolution of a few µm.



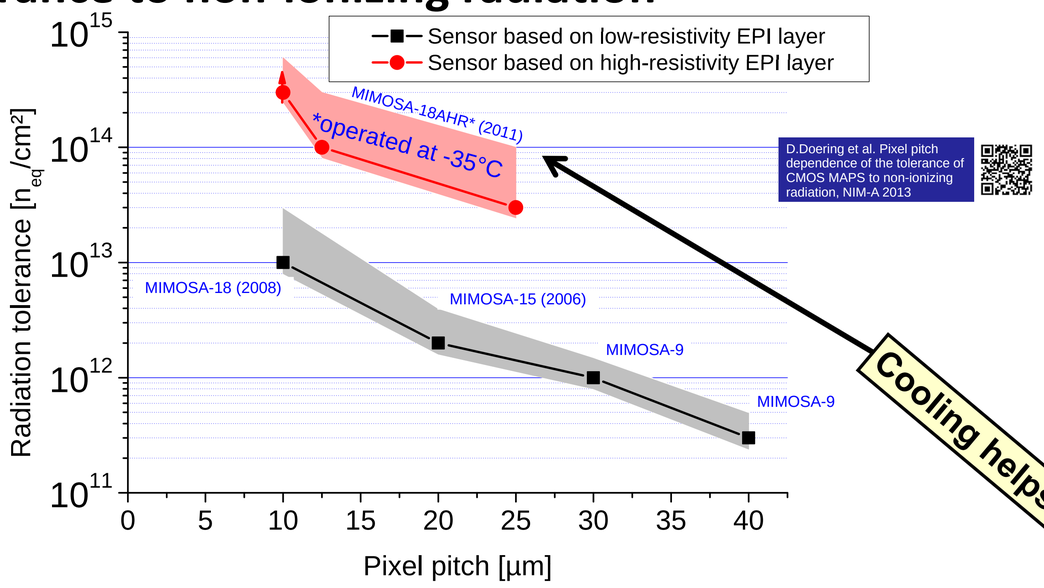


The (P++, P, P++) doping of the MAPS sensor generates a potential minimum in the region of the epitaxial layer. Impinging particles excite electrons which diffuse within this region until they are collected by the P-Epi/N-Well diode.

Radiation damage in MAPS

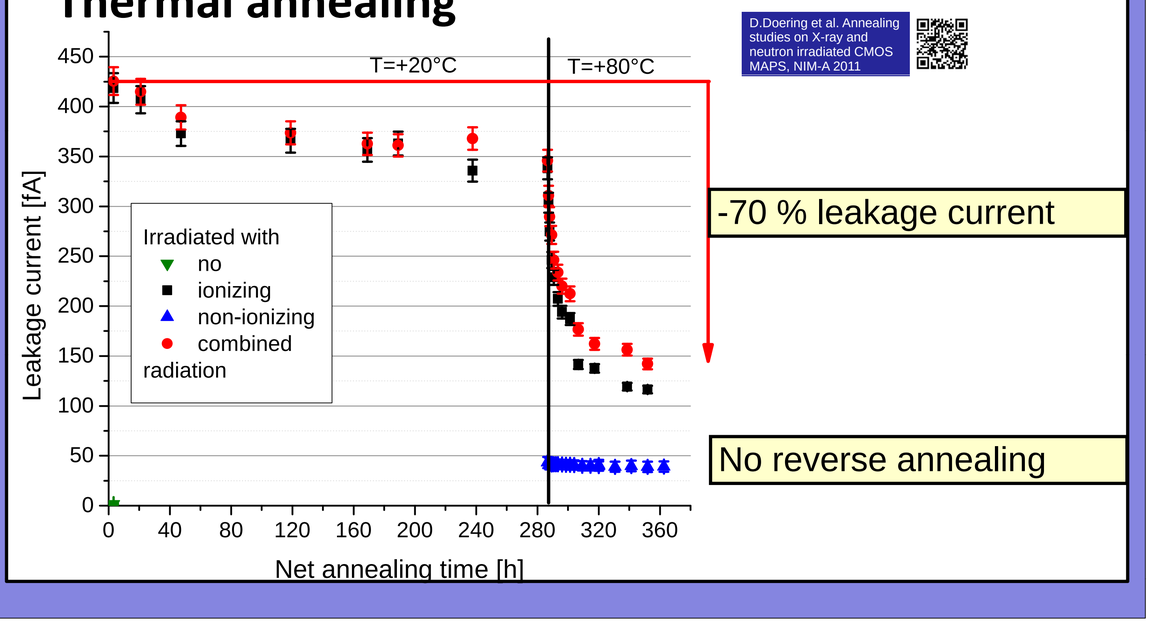


Tolerance to non-ionizing radiation

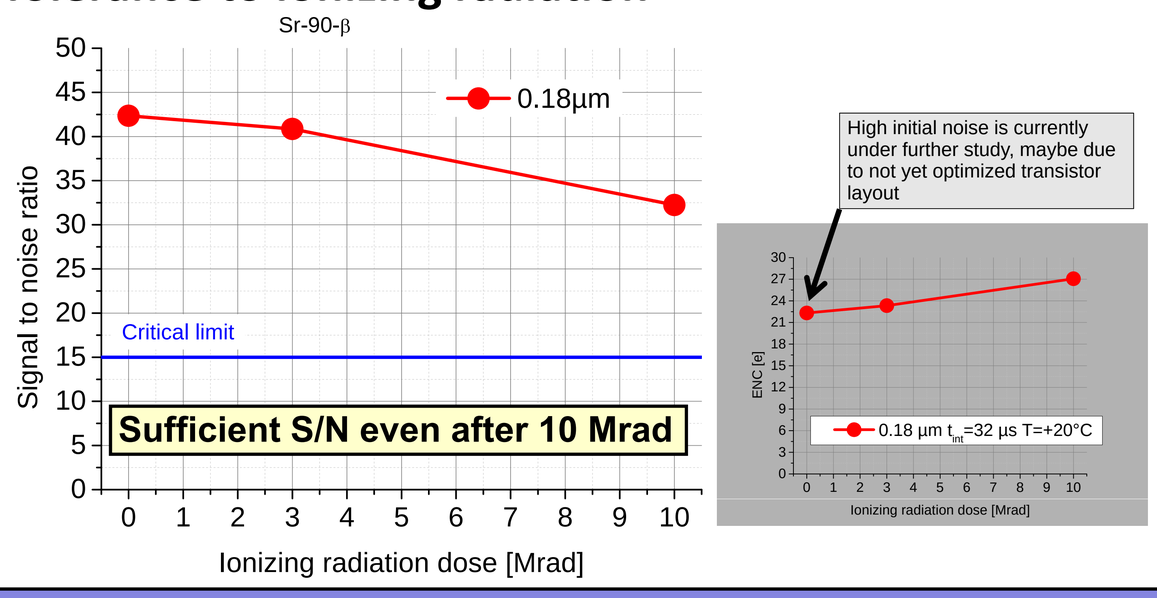


Improved non-ionizing rad. tol.: High-resistivity and/or smaller pitch

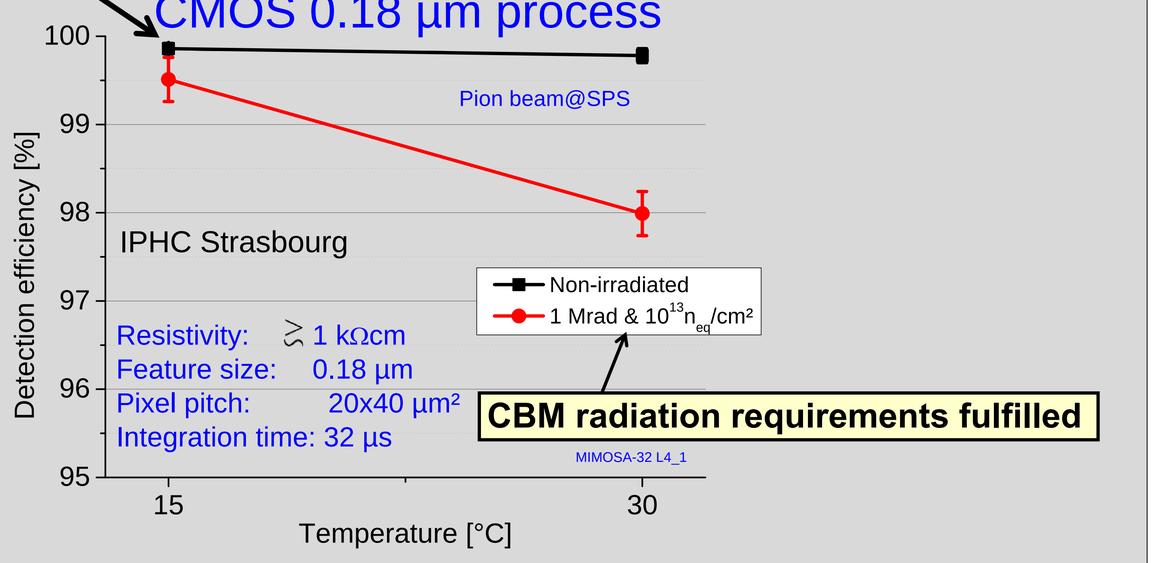
Thermal annealing



Tolerance to ionizing radiation



Performance in beam



Excellent detection efficiency of >99.5% despite of irradiation

Conclusion: MAPS based on a **0.18 µm**-CMOS process with a (**1 kΩcm) high-resistivity** epi-layer provide the radiation hardness needed for the next generation Heavy Ion experiments.

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