The **ARCADIA** Depleted Monolithic Active Pixel: characterization and prospects for high precision tracking systems at future colliders

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Future tracker detectors

The main requirements for vertex detectors and trackers of experiments at future colliders are **high momentum** and **spatial resolution,** and to perform **non perturbative** measurements.

Monolithic **A**ctive **P**ixel **S**ensors **(MAPS)** have recently gained interest for inner trackers and vertex detectors, because of their features:

small pixel pitch ✓ thin, bent and stitched sensors ✓
low power, material budget, production costs ✓

MAPS-based ePIC barrel vertex end endcap detectors at the Electron-Ion Collider EIC (BNL)

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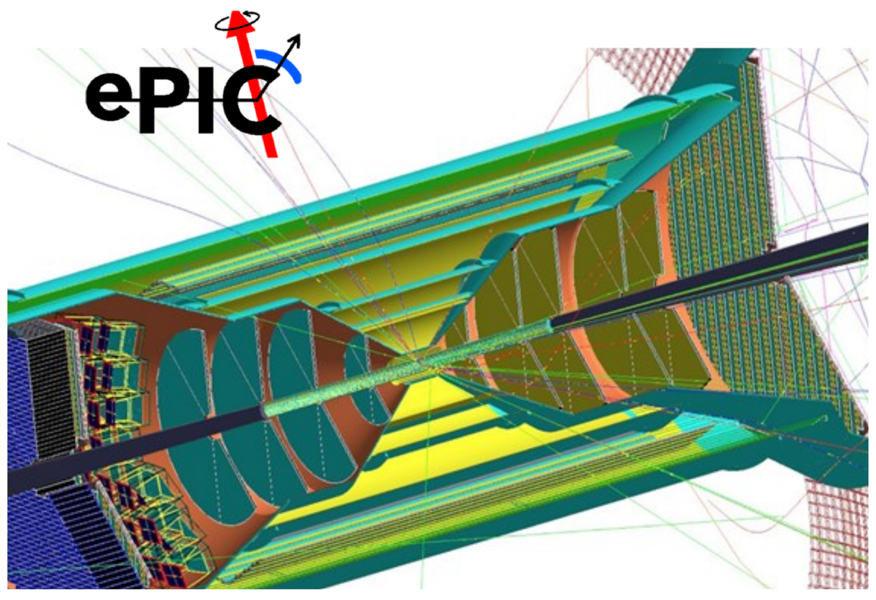
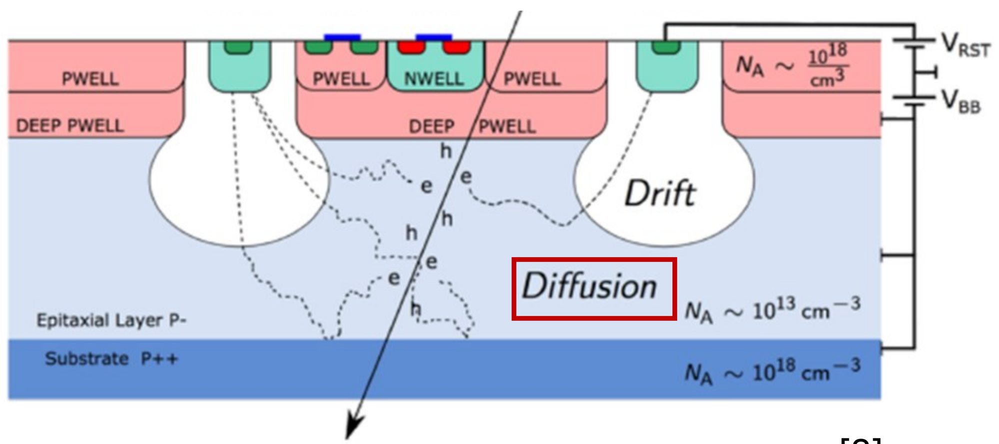
Next generation 65-nm reticle-size bent MAPS



[1]

Typical MAPS cross section



[2]

MAPS drawbacks:

Charge is collected mainly by diffusion

⇩

slow collection x

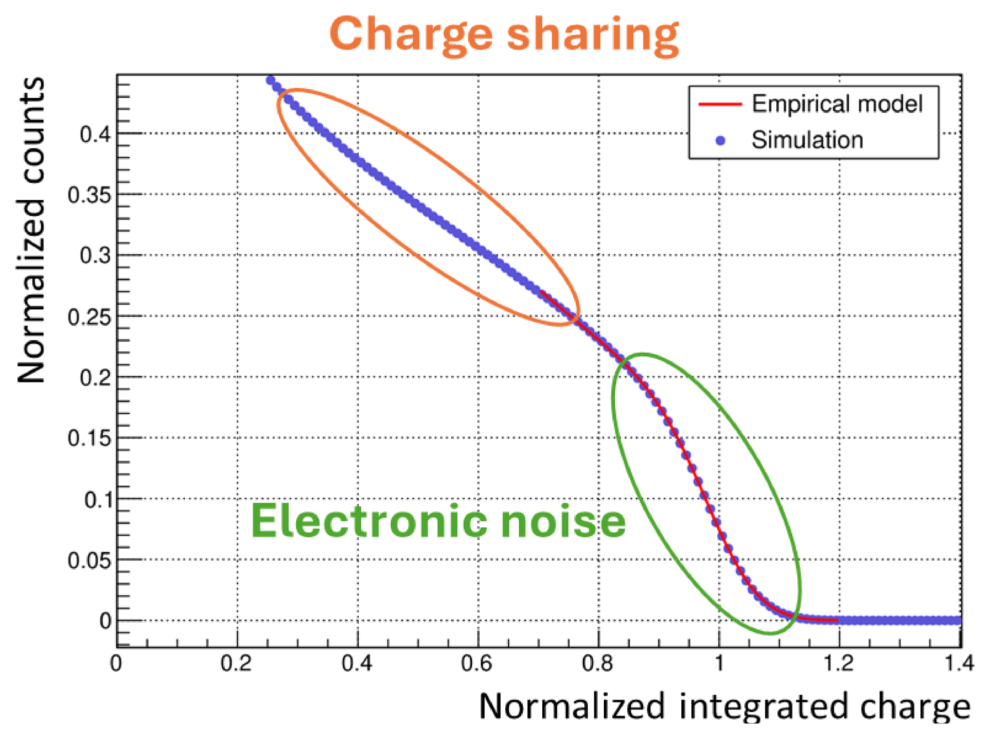
low radiation hardness x

Sensor characterization: exploiting X-rays

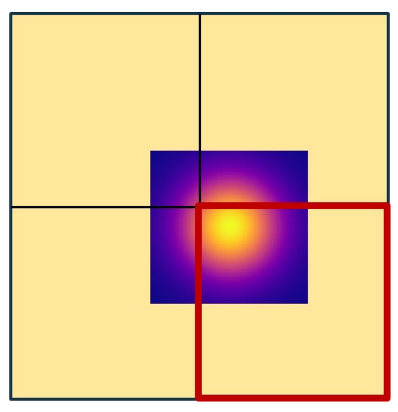
One of the possible characterization studies of digital MAPS is related to threshold calibration.

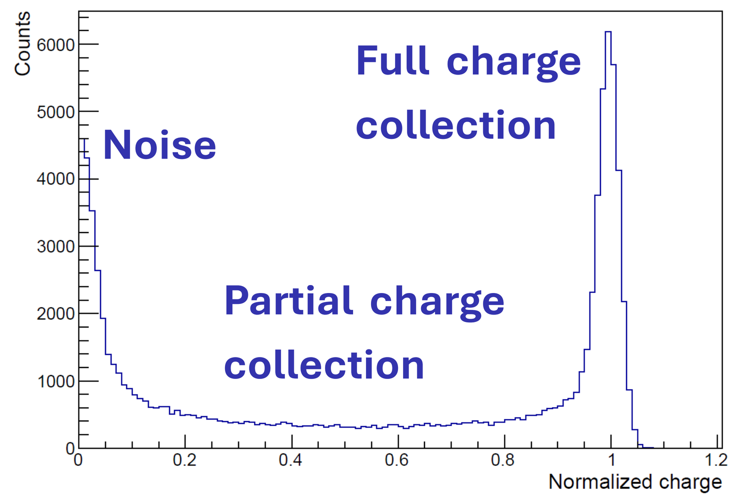
The standard way is based on analog injection, however a different approach is to use **monochromatic X-ray sources**, performing measurements varying the pixel threshold → S-curve.

The **S-curve** shape, obtained with analog injection, depends only on the pixel electronic noise. However, when the S-curve is acquired with a monochromatic source, an additional linear contribution arises due to charge sharing effects.



A MonteCarlo simulation has been developed to study geometrical charge sharing among pixels and to extract estimations on the charge sharing and noise contributions.





Analog simulated pixel spectrum

ARCADIA

The drawbacks mentioned above can be partially overcome by recent **Depleted MAPS (DMAPS)** in which the depleted region is extended to the full silicon substrate.

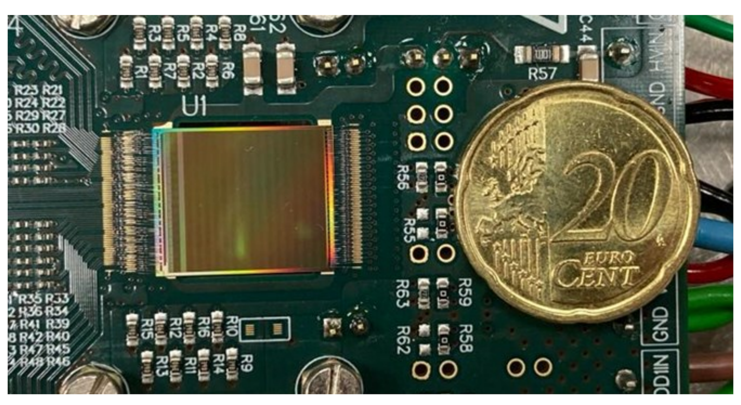
In this way, charge is collected mainly by drift.

⇩

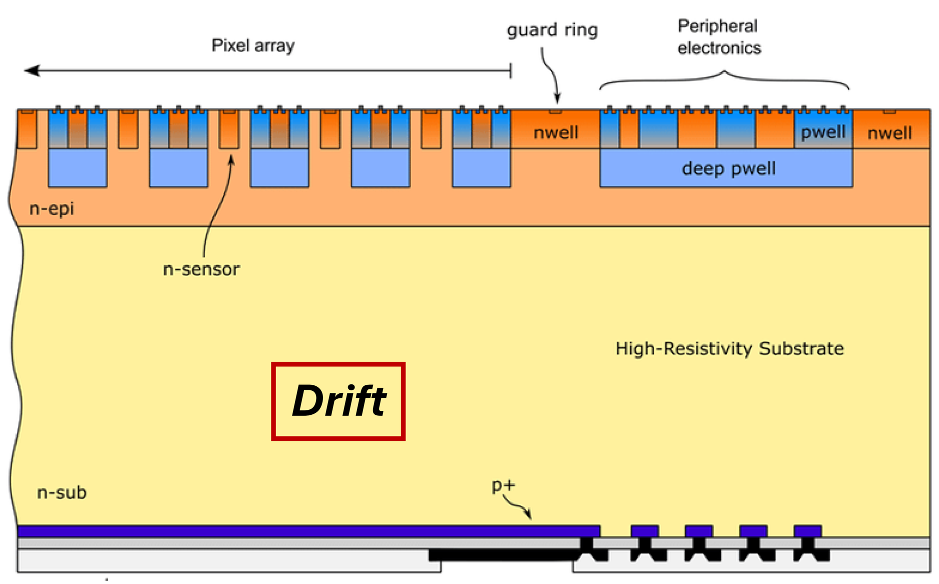
Faster and more efficient collection ✓

Improved radiation hardness ✓

An example is the **ARCADIA** chip (MD3), a 512x512 pixel array, with an active area of 1.28×1.28 cm^2. It has been fully designed and manufactured by the INFN Arcadia collaboration and LFoundry.



Technology	CIS 110 nm
Pixel pitch	25 µm
Power consumption	O(10 mW/cm^2)
Readout	Digital

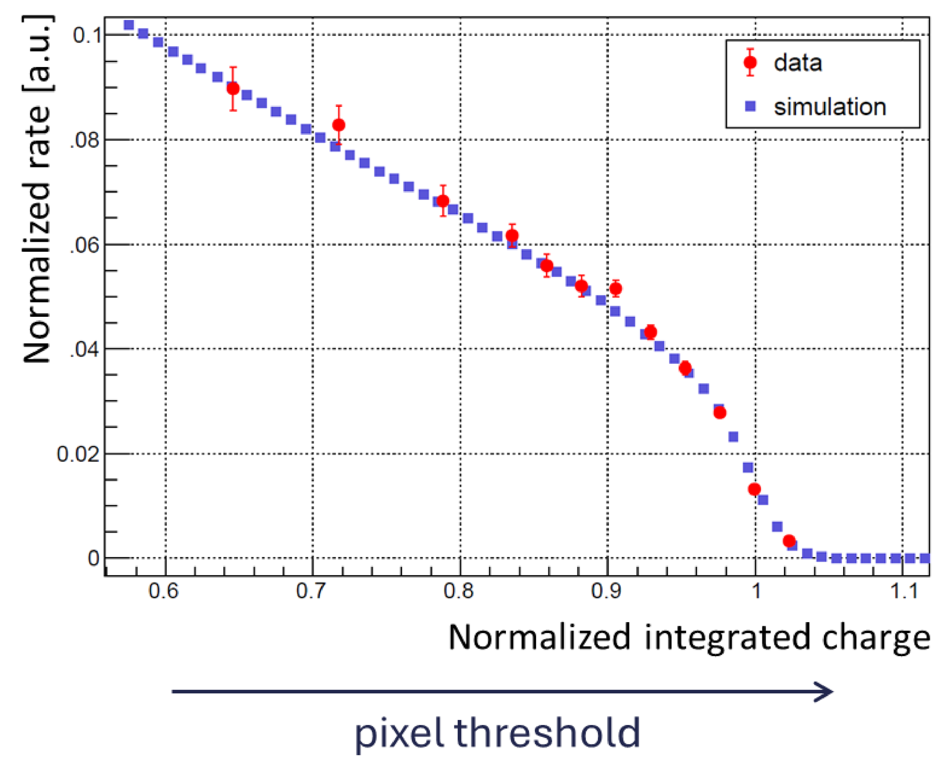


[3]

50-200 µm **fully depleted (DMAPS) active substrate**

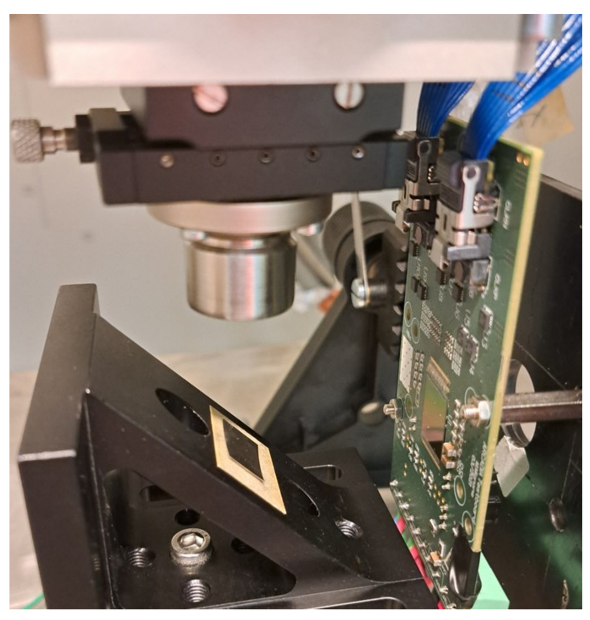
S-curve measurements and comparison with simulation

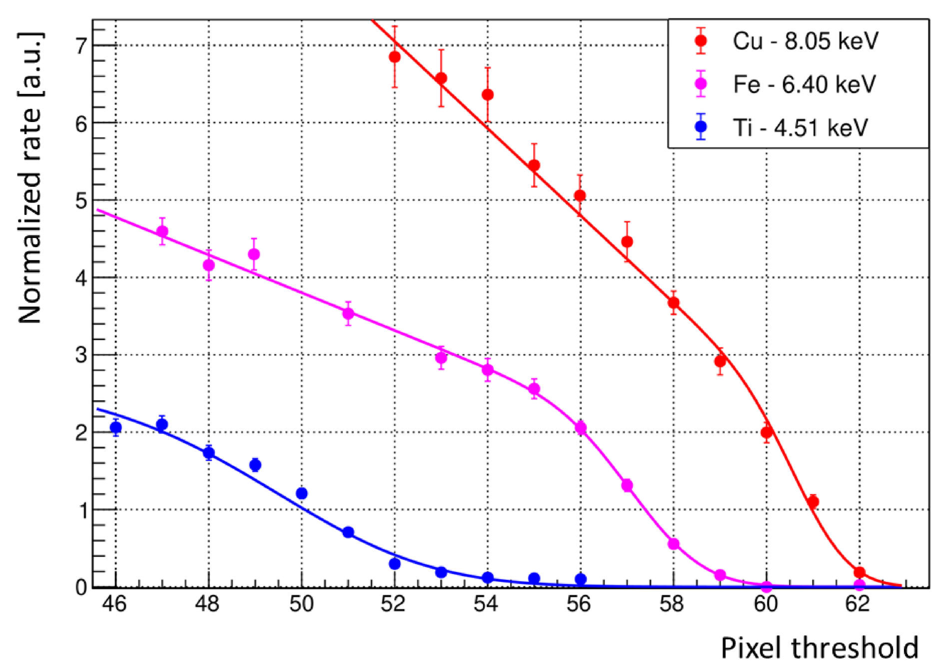
Measurements have been performed with ^{55}**Fe** source (~ 5.9 keV): single pixel hit rate at different values of threshold is compared with simulation.



Ongoing work

To study the response at different energies, it is possible to perform measurements with **X-ray fluorescence**, obtained using a primary X-ray beam and different target materials.





[1] D. Elia, Update on Silicon Tracker, EIC_NET National Meeting (2023)
[2] ALICE Collaboration, Letter of intent for ALICE 3: A next-generation heavy-ion experiment at the LHC (2022)
[3] T. Corradino et Al., Design and Characterization of Backside Termination Structures for Thick Fully-Depleted MAPS, Sensors, 21 (2021)