Admission to 3° PhD year of Technologies for Fundamental Research in Physics and Astrophysics

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curriculum: Electronics

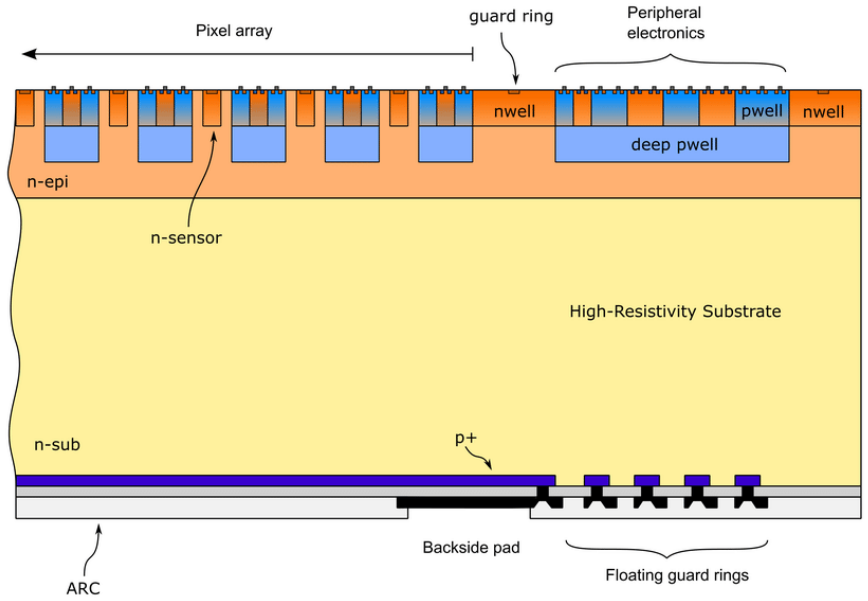
16/09/2025

UNIVERSITÀ DEGLI STUDI DI PADOVA

Dipartimento di Fisica e Astronomia Galileo Galilei

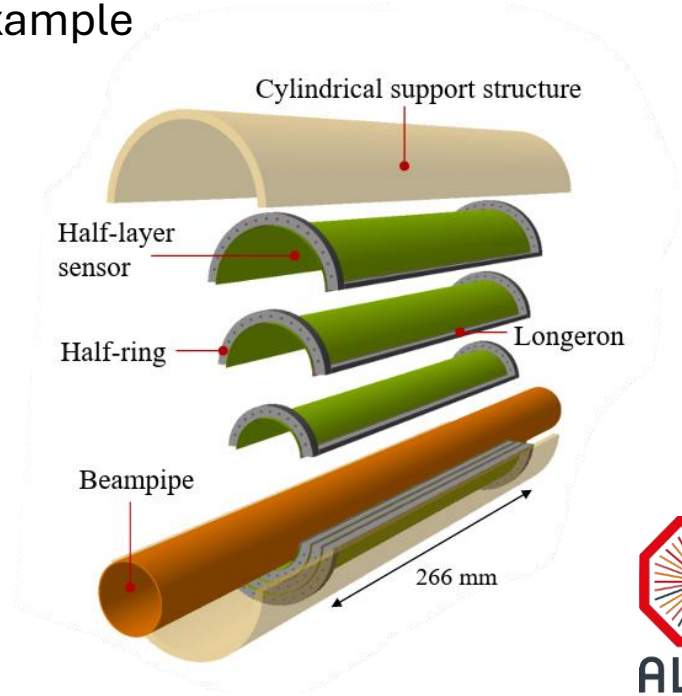
Research Topics: PhD Objectives

PhD general topic: development and characterization of novel CMOS **M**onolithic **A**ctive **P**ixel **S**ensors (MAPS) in 65 nm technology, exploiting stitching to realize single-die, ultra-large area sensors.



ARCADIA

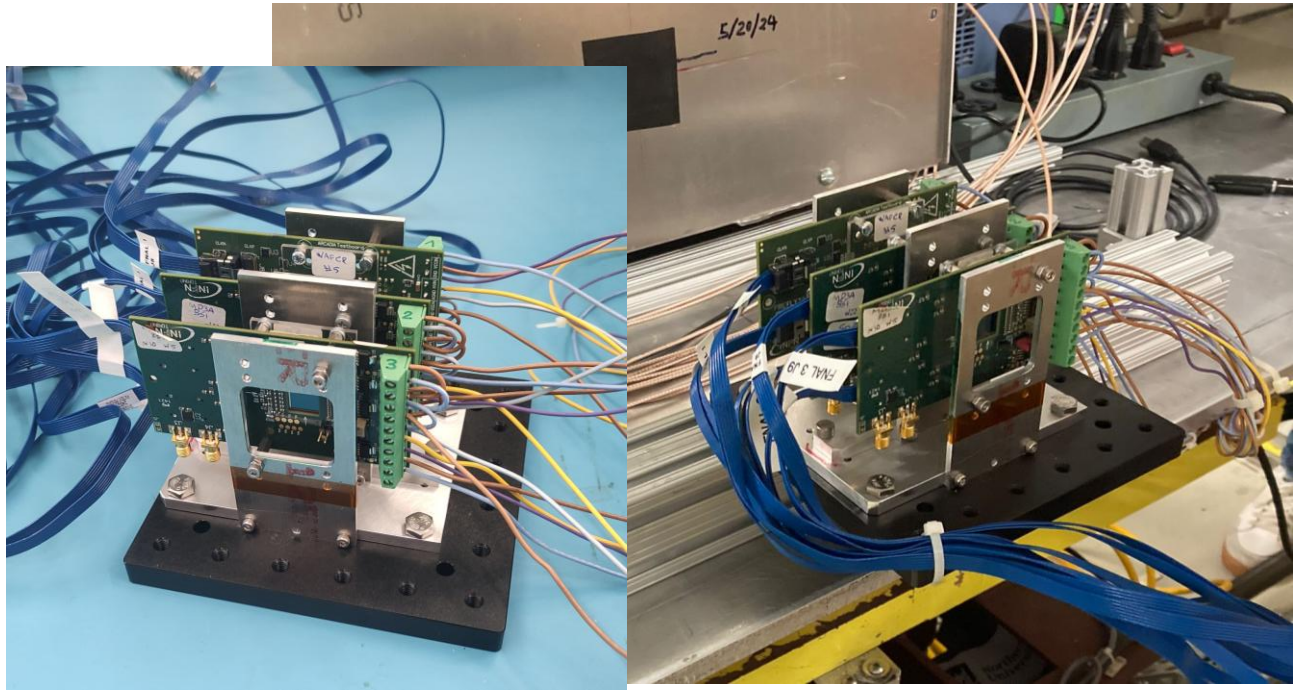
MAPS are used in HEP experiments for tracking applications for example



ALICE

Research Activities: ARCADIA test beam

Test beam at FNAL with 120 GeV proton beam done in June-July of 2024



- Commissioning of the telescope
- Developing the acquisition software to control 3 devices
- Testing with cosmic rays

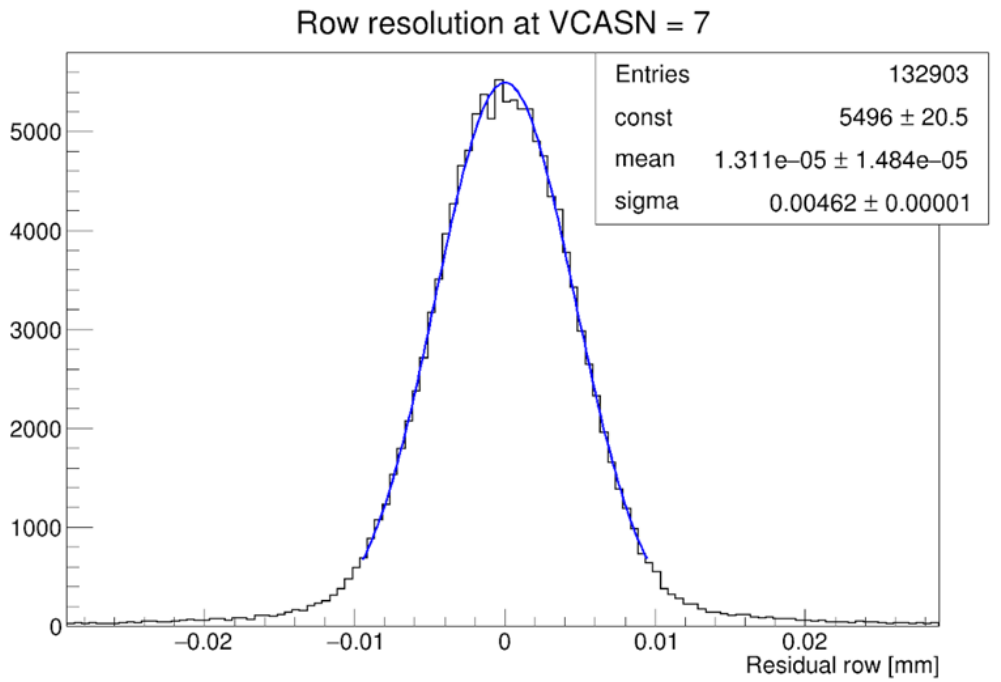
Scans done during the test beam:

- over different threshold values
- varying frontend parameters
- varying bias voltage
- Threshold scan with tilted DUT: 7.5°, -15° and 15°

Research Activities: ARCADIA test beam

Data analysis was carried out using non-standard tool for test beam measurements, like for example Corryvreckan framework

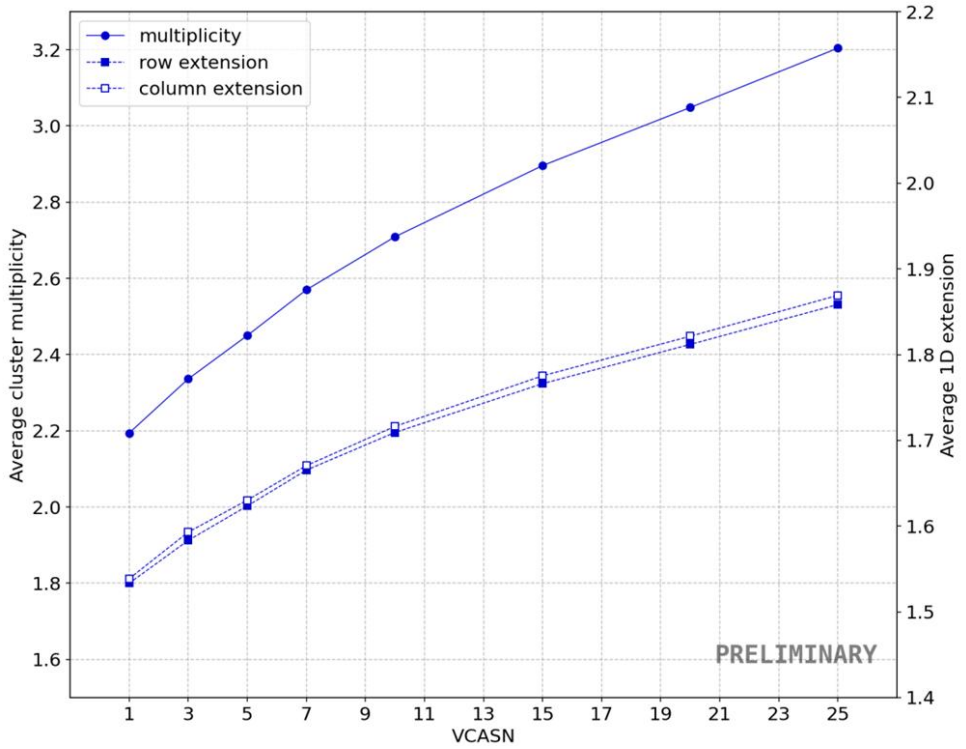
- Raw data packets → clusters for each plane
- Cluster sync in time since no trigger system was used
- Alignment corrections of two external planes and then DUT
- Analysis of residuals and efficiency using aligned cluster coordinates

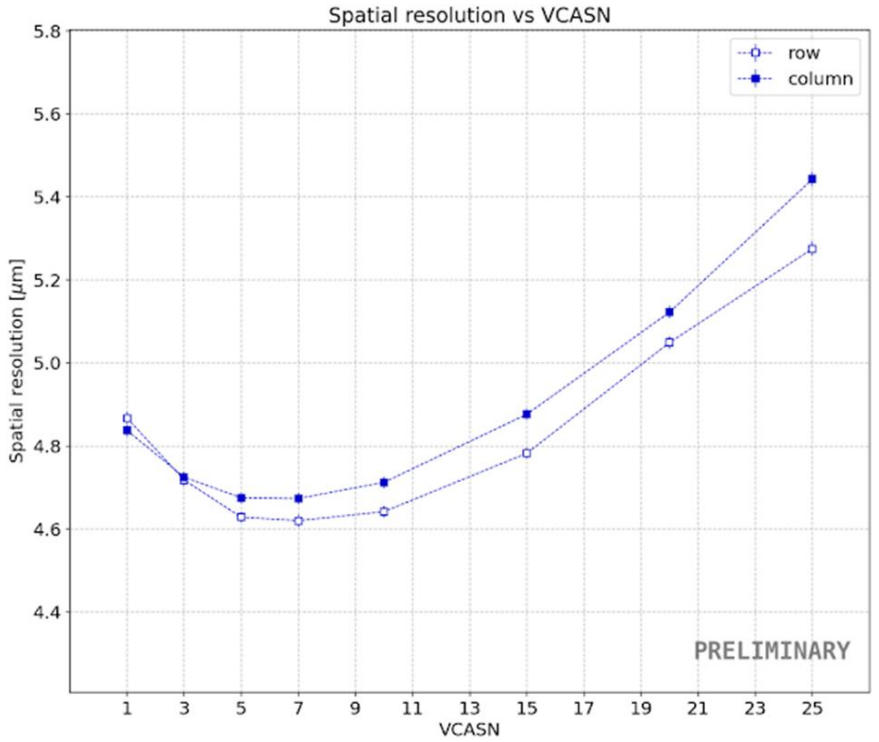


4.6 µm of spatial resolution

Research Activities: ARCADIA test beam

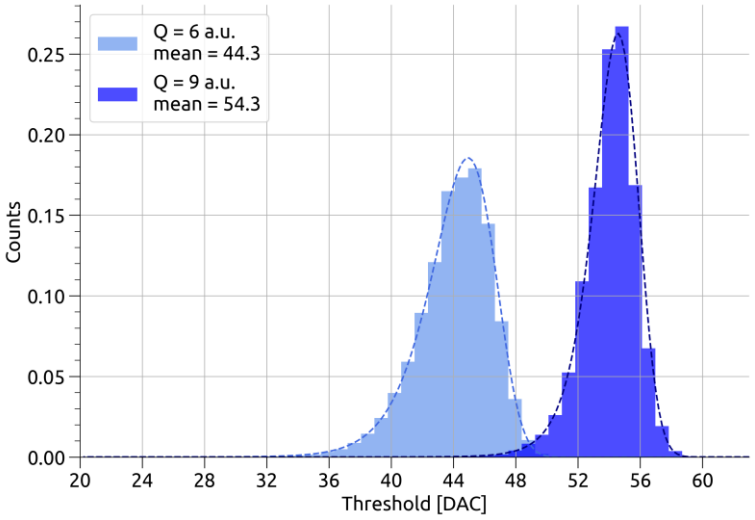
Data analysis was carried out using non-standard tool for test beam measurements, like for example Corryvreckan framework



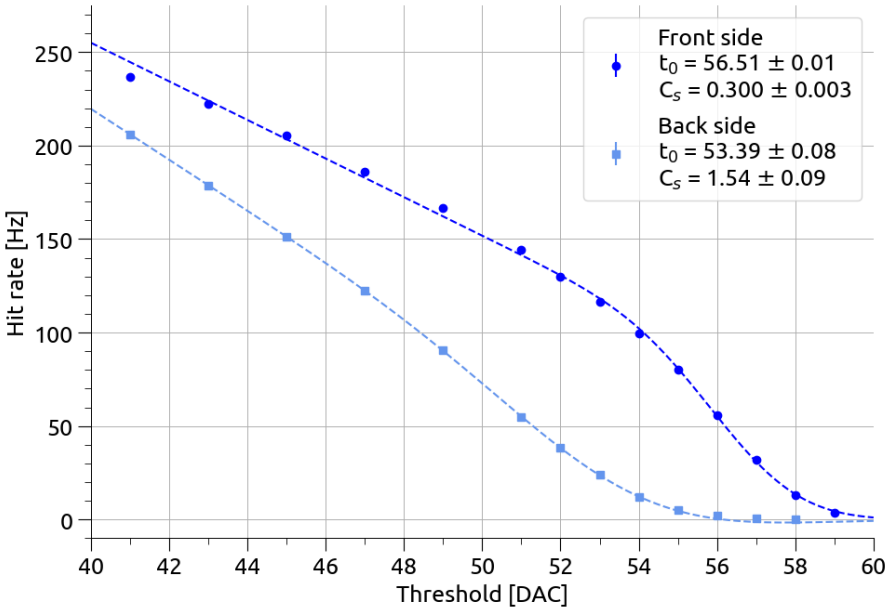


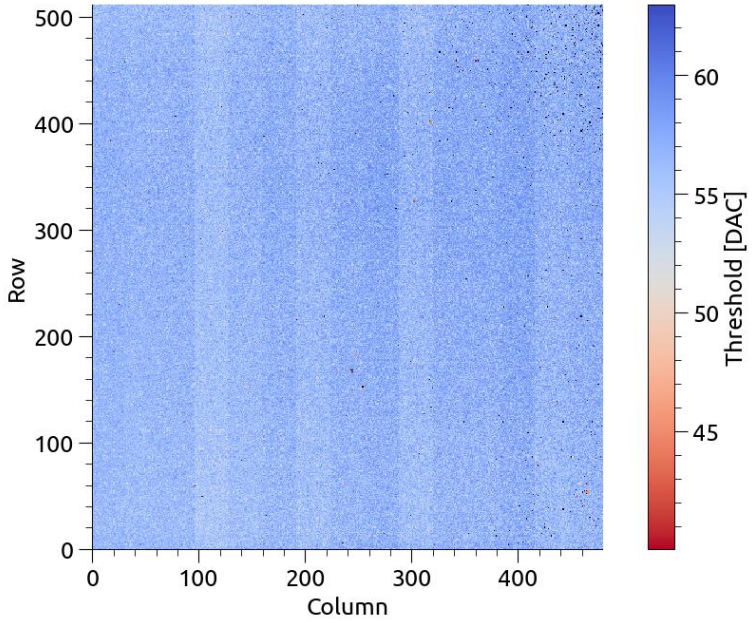
Results of cluster extension and multiplicity are good also for tilted DUT data

Research Activities: ARCADIA characterization



Threshold distribution obtained from s-curve fit of test pulse threshold scan



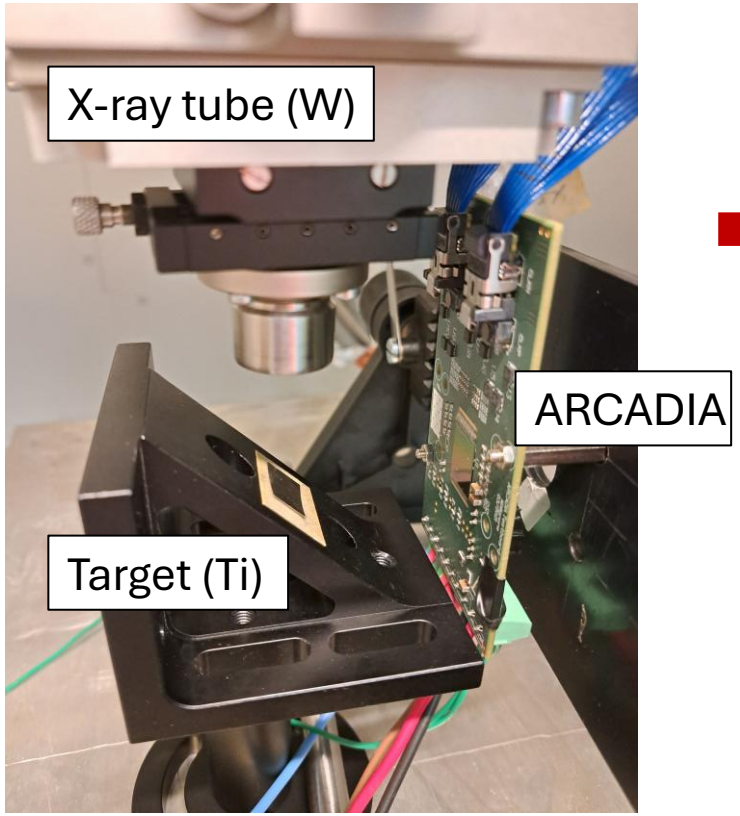


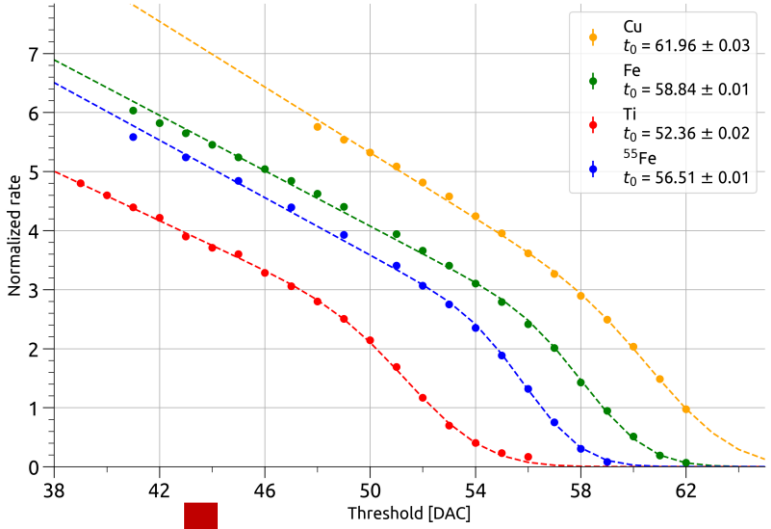
Threshold heatmap: entries are given by s-curve fit of threshold scan measurements with ^{55}Fe (1640 e^-)

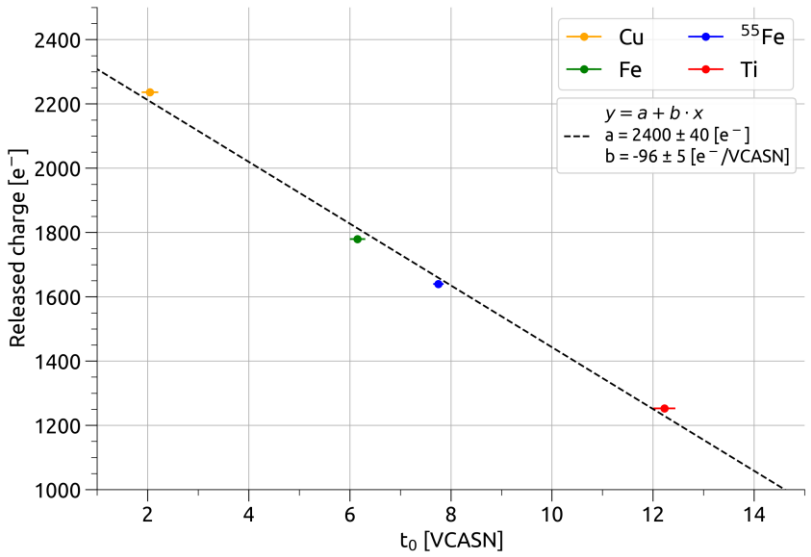
Comparison of the s-curve obtained with front- and back-side illumination with ^{55}Fe. Therefore, threshold corresponding to the same number of generated electrons, is lower by 2 DAC units for the backside case.

Research Activities: ARCADIA characterization

Fluorescence: extract monochromatic X-rays using a target







Research Activities: ARCADIA characterization

Università degli Studi di Padova

Dipartimento di Fisica e Astronomia Galileo Galilei

Current status of the ARCADIA characterization work:

- FNAL test beam data analysis is completed, except for the tilted DUT data
- Laboratory characterization measurements include:
  - Threshold scan using test pulse injections
  - Threshold scan to study chip uniformity response with ^{55}Fe
  - Energy calibration using fluorescence X-ray setup
  - Charge collection efficiency with IR laser

The first paper with lab characterization measurements is almost completed and a second paper on the FNAL test beam is planned

Characterization of ARCADIA FD-MAPS

[No Title]

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Abstract: Monolithic Active Pixel Sensors (MAPS) achieved widespread use in several scientific, industrial, space, and medical applications. The ARCADIA MAPS sensor, developed by an INFN collaboration, further extends MAPS performance by embodying a fully-depleted sensing volume across the entire device. This contribution details the characterization of the ARCADIA sensor, reporting reference data for charge collection efficiency, energy resolution, and response uniformity.

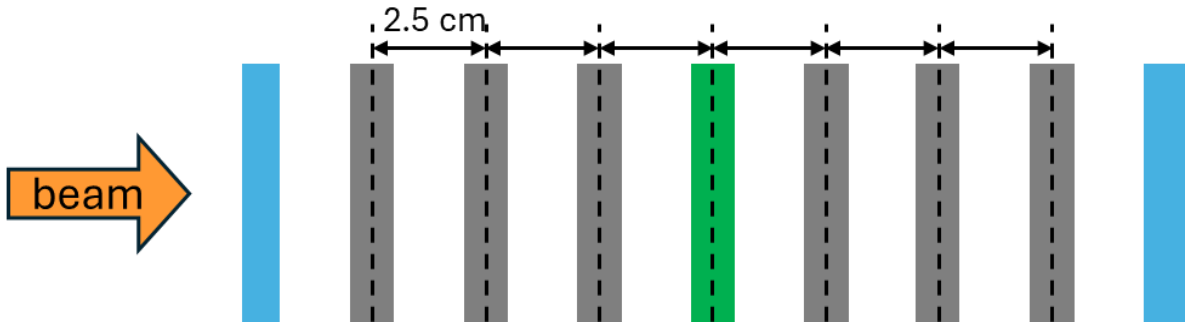
Research Activities: ALICE

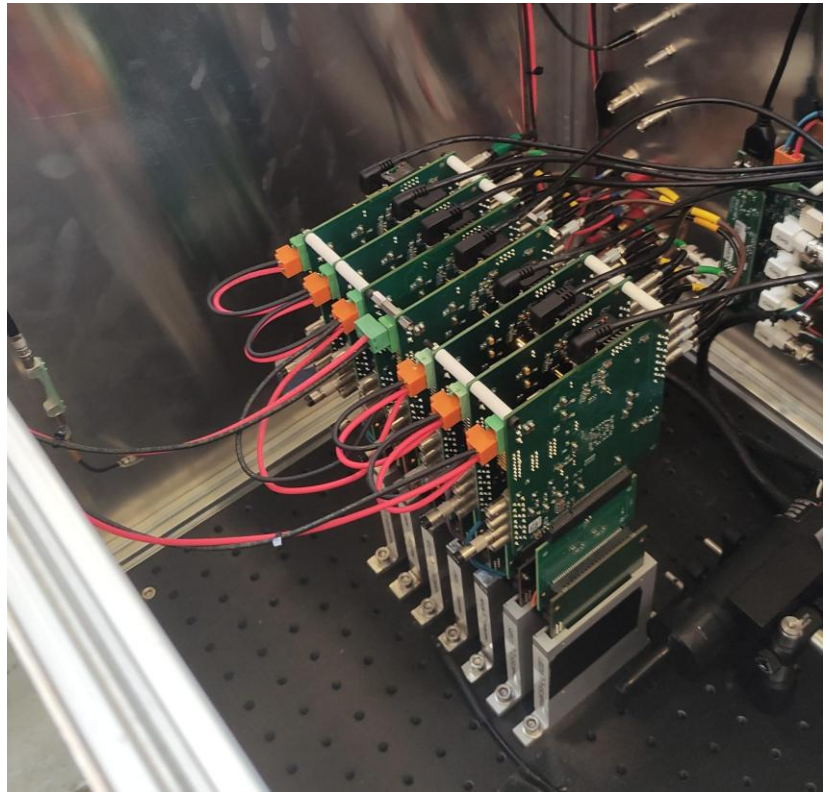
ALICE collaboration planned an upgrade of its Inner Tracking System (ITS3) using **stitched sensors**

Participation to lab activities and test beam at PS at CERN. Three DUTs tested, one non-irradiated and two irradiated ones

The telescope used is fully constituted of babyMOSS chips

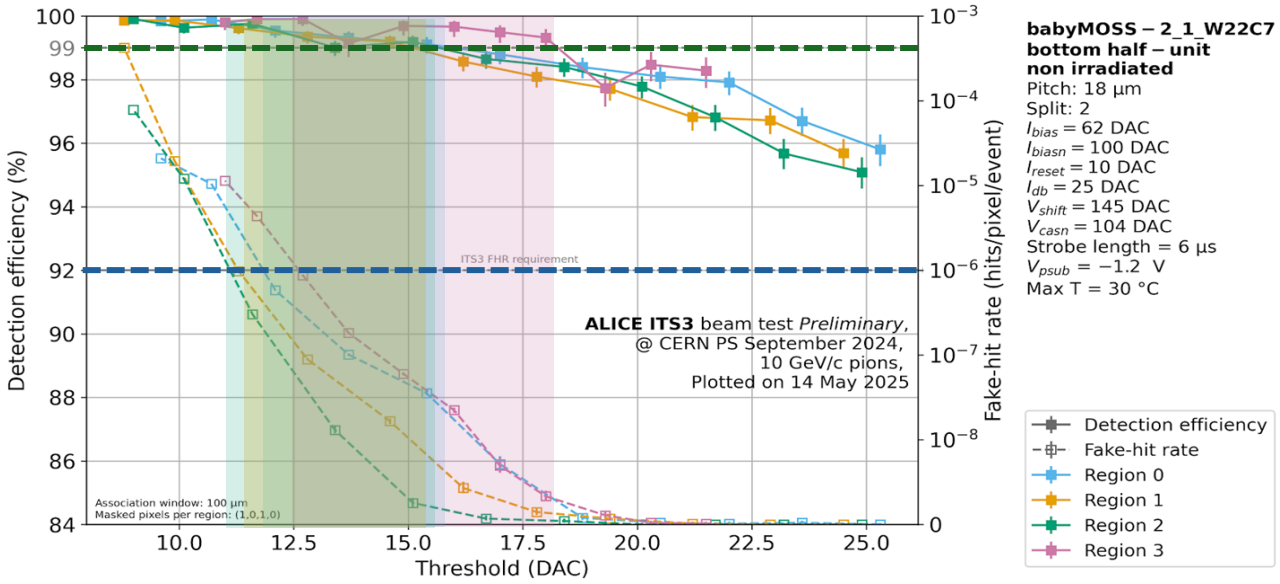
- 6 **babyMOSS tracking planes**
- 1 **babyMOSS DUT**
- 2 **scintillators** coupled to PMTs to generate trigger signal





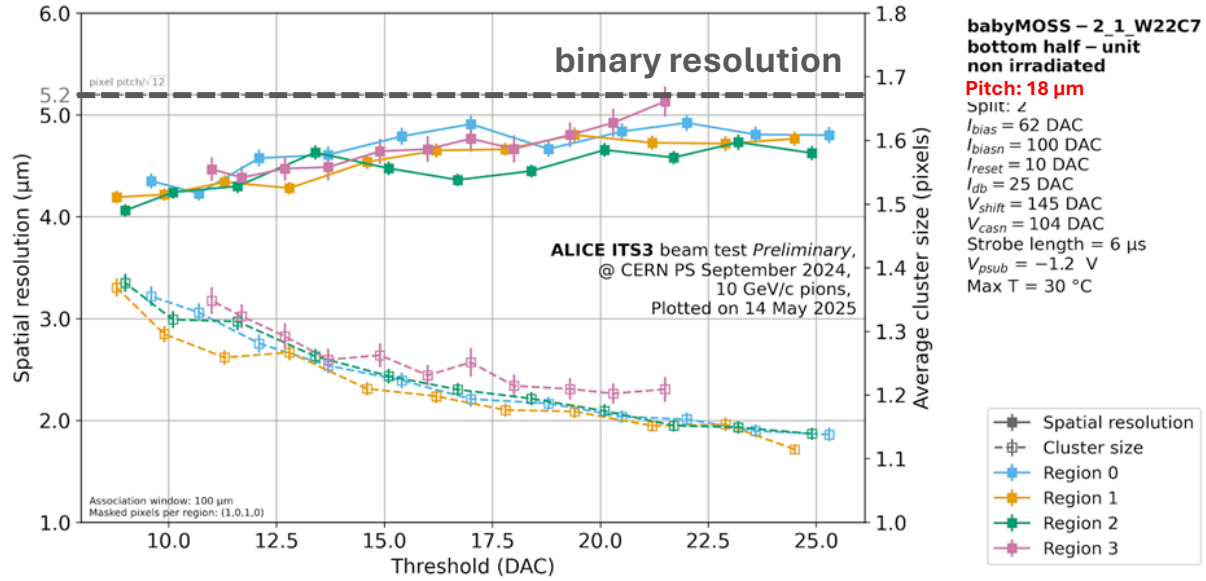
Telescope with 6 reference baby-MOSS

Research Activities: ALICE



ITS3 requirements

Efficiency	**> 99 %**
FHR	**< 10^{-6}** hits/pixel/event



$$\text{Binary pixel resolution} = \frac{18\ \mu m}{\sqrt{12}} = 5.2\ \mu\text{m}$$

ALICE Italia meeting in Brescia 16-18 December 2024. I presented a talk on the results of the PS test beam with babyMOSS chip: *Results of test beam campaign on baby-MOSS with MOSS-RAISER telescope at CERN PS*

PLANNED ACTIVITIES FOR 3° YEAR

ALICE Collaboration:

- Service work activity: ITS2 data analysis to study cluster size/shape
- Contribute to the development of the DAQ software for the MOSAIX test system

ARCADIA:

- Complete data analysis of Fermilab test beam and write a paper also on those measurements/results
- Develop a telescope using multiple ARCADIA tracking planes, using standard frameworks for data acquisition and data analysis. The aim is to have a final tracking system that can be used to test different devices

Exams, schools and conferences

First year: exams and schools

- Embedded design with FPGA: exam passed on June 11th
- Machine Learning for Physics: exam done on May 14th of 2025
- ESC Efficient Scientific Computing School from October 14th to October 24th → school with final examination passed as exam

Second year: exams and schools

- Design of readout integrated circuits for particle detectors → planned to do the exam by the end of the year
- ISOTDAQ – International School of Trigger and Data AcQuisition. School attended in Vilnius from June 17th to June 26th of 2025

Future conferences

- 111° Congresso Nazionale SIF, 22-26 September 2025. Oral presentation on *Characterization of stitched prototypes chip for the ALICE ITS3 upgrade*
- IEEE NSS MIC RTSD in Yokohama, 1-8 November 2025. Oral presentation on *Fully Depleted MAPS in 110nm CIS technology for particle tracking and X-ray detection*