PhD course of National Interest in Technologies for Fundamental Research in Physics and Astrophysics

# Annual report

**Name and surname:** Alessandra Zingaretti
**Cycle and a.a.:** 40th cycle 2024-2025 a.a.
**Supervisor:** Serena Mattiazzo

- **Research activity carried out during the year**

The aim of the research project is to study and characterize the performance of different Monolithic Active Pixel Sensors (MAPS) developed by different collaboration groups for application at future colliders.

During the 1st year the activity carried out was focused on the characterization of the first prototypes, designed for the Inner Tracking System 3 upgrade of the A Large Ion Collider Experiment (ALICE) at CERN. I tested the babyMOSS chip, that is a single Repeated Sensor Unit (RSU), i.e. the building block of the MOnolithic Stictched Sensor (MOSS), which will be composed of 10 RSUs stitched together. The characterization procedure is based on performance assessment through test pulses, parameter scans, and measurements with radioactive sources such as $^{55}$Fe or fluorescence X-rays for calibration purposes. The measurements with $^{55}$Fe are performed by placing the radioactive source above the chip and acquiring a spectrum exploiting the Time over Threshold (ToT) technique. For fluorescence X-rays, the setup includes an X-ray tube and targets of different materials to obtain spectra with energy peaks at different values, to characterize a wider energy range to calibrate the response of the chip. Unfortunately, having only one chip to test in the laboratory limited the possibility to directly compare the performance between different prototypes. Useful feedback on the issues encountered was provided by other groups in the collaboration.

Besides the laboratory activity, I contributed to the analysis of datasets taken at a test beam with 120 GeV protons (made during July 2024). The setup used during the test beam was a telescope made of two tracking planes and one device under test. All the three sensors are MAPS developed by the ARCADIA (Advanced Readout CMOS Architectures with Depleted

Integrated sensor Arrays) collaboration (in which many INFN Sections participate). The analysis carried out aims at establishing the performance characteristics of the sensor, such as the detection efficiency (~ 99%) and the spatial resolution (~ 5 µm).

- **List of attended courses and passed exams**

Attended courses:

Design of readout integrated circuits for particle detectors (2.5 ECTS, online)

Structured Light: from principles to modern applications (3 ECTS, in presence)

Fundamental of FPGA-based digital design (2.5 ECTS, online)

Methodologies and techniques for the analysis of experimental data (2 ECTS, online)

Attended and passed exams:

Numerical Simulation of Electronic Devices with TCAD (2.5 ECTS, in presence)

- **List of attended conferences, workshops and schools, with mention of the presented talks**

Conferences:

- "FCC Italy&France" (4-6 November 2024, Venezia)
- "ALICE Italia meeting" (16-18 December 2024, Brescia)
- "ELMA workshop" (10-11 September 2025, Trieste)

Workshops:

- "IFD 2025 – INFN Workshop on Future Detectors" (17-19 March 2025, Sestri Levante)
  - **Talk:** "ARCADIA fully depleted MAPS sensor first test-beam results"
- "TECH-FPA PhD Retreat 2025" (17-21 February 2025, L'Aquila)

Schools:

- "MAPS Academy" (23-30 July 2025, Tsukuba, Japan)



Next:

- "SIF – 111° Congresso Nazionale" (21-26 September 2025, Palermo)
  - **Talk:** "Tracking performance of the ARCADIA fully depleted MAPS"

- **List of published papers/proceedings**
  - *Σ+ production in pp collisions at √s=13 TeV*, ALICE Collaboration, http://arxiv.org/abs/arXiv:2508.20808
  - *First direct access to the ρ0p interaction via correlation studies at the LHC*, ALICE Collaboration, http://arxiv.org/abs/arXiv:2508.09867
  - *Multiplicity dependence of $\Xi^{+}_{c}$ and $\Xi^{0}_{c}$ production in pp collisions at √s=13 TeV*, ALICE Collaboration, http://arxiv.org/abs/arXiv:2508.09867
  - *$\Sigma^{-}\pm$ production in pp and p–Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV with ALICE*, ALICE Collaboration, http://arxiv.org/abs/arXiv:2507.13183
  - *Multiplicity dependence of $f_0$(980) production in pp collisions at √s= 13 TeV*, ALICE Collaboration, http://arxiv.org/abs/arXiv:2507.19347
  - *The IDEA detector concept for FCC-ee*, The IDEA Study Group, https://arxiv.org/abs/2502.21223
- **Thesis title (even temporary)**

"Development of pixel detectors in CMOS technology for applications at future colliders"

**Date,** 05/09/2025 **Signature** Alessandra Fingaretti

**Seen, the supervisor**

Serena Mattiazzo