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

Annual report

Name and surname: Camilla Forza
Cycle and a.a.: XL Cycle, a.a. 2024/2025
Supervisors: Gianmaria Collazuol, Alberto Gola

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

The aim of the project is to study and characterize NUV-BSI SiPMs, currently under development at FBK, for use in large-area detectors. The primary application will be in the context of the second upgrade of the Hyper-K near detector. I will also keep some service tasks for the T2K collaboration.
To further my academic training on gaseous detectors, I attended the 2024 DRD1 School at CERN. While I was at CERN (three weeks), I had the opportunity to immediately apply what I was learning by collaborating on the development of a setup to study signal formation in a new Thick-GEM–like detector incorporating two micro-mesh layers and operating with the T2K gas mixture. This setup was then moved to LNL and it is still under optimization. For the T2K collaboration, I spent a total of two months in Tokai (J-PARC, Japan), where the near detector is located. There, I trained for TPC expert shifts, performed expert on-call shifts, and participated in two collaboration meetings (November and March). I also contributed to the renovation of the TPC data quality programs, both for the existing TPCs and for the new ones installed as part of the ND280 upgrade.
Alongside my T2K service tasks, I began working on a project for the Hyper-Kamiokande detector (the far detector for T2K), within the Hyper-K Padova group. Since the group is involved in the PMT electronics working group, a pressure vessel was developed to test the underwater units (UUs) of the electronics at 11 bar. I contributed both to building the prototype and to developing the electronics for sensors readout and water pump control. This project is now in its final stages. A total of six vessels will be produced: three will be installed at CERN and used during the UU testing phase after assembly, while the other three will carry out the same validation measurements in Japan, after the shipment, before installation in the Hyper-Kamiokande cavern.
In the second part of the semester, I moved to Trento to begin working on the NUV BSI-SiPM project at FBK under the supervision of Alberto Gola. I delved into the fundamentals of SiPM devices and their characterization, complementing my training by attending the course *Photodetection: Scintillators and Silicon Photomultipliers*. During my time at FBK, I gained hands-on experience with all stages of new device characterization (DCR, PDE, IV curves, SPTR, and more).
One of the most critical challenges faced by the group was the accident that occurred at CERN in Building 182, which was the planned construction site for the test vessel. As a result, we had to relocate all activities to LNL, since CERN closed the building for investigation. This unexpected move significantly slowed down progress and impacted the project schedule. Another challenge I faced in the second half of the year was the transition from gaseous detectors to SiPMs. This required substantial study, and the courses I attended proved to be very helpful in supporting this learning process.

- **List of attended courses and passed exams**
  - Photodetection: Scintillators and Silicon Photomultipliers (in May)
  - Solid state detectors (In September)

- **List of attended conferences, workshops and schools, with mention of the presented talks**
  - DRD1 School on Gaseous Detectors 27/11-6/12/2024, CERN
  - Tech-FPA PhD Retreat 2025, L'Aquila
  - Open Symposium on the European Strategy for Particle Physics, 23-27/06/2025, Venice

    In this conference I was part of the LOC Staff.
  - XXI International Workshop on Neutrino Telescopes 29/09-03/10/2025, Padova

    An abstract has been accepted for this conference.

- **List of published papers/proceedings**

Proceedings:

- D. D'Ago (INFN, Padua), G. Collazuol (INFN, Padua and Padua U.), M. Feltre (INFN, Padua and Padua U.), C. Forza (INFN, Padua and Padua U.), D. Henaff (INFN, Padua and Padua U.) et al. Preliminary measurement of ion drift velocity in T2K gas mixture, *JINST*, 20(04):C04006, 2025.

TPC group:

- D. Attié (IRFU, Saclay), P. Billoir (LPNHE, Paris), G. Bortolato (Padua U., Astron. Dept. and INFN, Padua), S. Bolognesi (IRFU, Saclay), N.F. Calabria (Bari Polytechnic and INFN, Bari) et al. Characterization of the electronic noise in the readout of resistive Micromegas in the high-angle Time Projection Chambers of the T2K experiment*, Nucl. Instrum. Meth. A,* 1081:170803, Jan 2026.

T2K Collaboration:

- K. Abe *et al.* (The T2K Collaboration). First measurement of neutron capture multiplicity in neutrino-oxygen neutral-current quasi-elastic-like interactions using an accelerator neutrino beam, *Phys. Rev. D*, 112(3):032003, 2025.
- K. Abe *et al.* (The T2K Collaboration). Testing T2K's Bayesian constraints with priors in alternate parameterisations, *arXiv:2507.02101 [hep-ex]*, 2025.

- K. Abe *et al.* (The T2K Collaboration). Results from the T2K experiment on neutrino mixing including a new far detector μ-like sample, *arXiv:2506.05889 [hep-ex]*, 2025.
- K. Abe *et al.* (The T2K Collaboration). Signal selection and model-independent extraction of the neutrino neutral-current single π^+ cross section with the T2K experiment, *arXiv:2503.06843 [hep-ex]*, 2025.
  Accepted for publication in PRL and PRD.
- K. Abe *et al.* (The T2K Collaboration). First differential measurement of the single π^+ production cross section in neutrino neutral-current scattering, *arXiv:2503.06849 [hep-ex]*, 2025.
- K. Abe *et al.* (The T2K Collaboration). First Measurement of the Electron Neutrino Charged-Current Pion Production Cross Section on Carbon with the T2K Near Detector, *arXiv:2505.00516 [hep-ex]*, 2025.

- **Thesis title (even temporary)**

  Study and Characterization of Silicon Photomultipliers with Applications to Large Area Radiation Detectors.

Date, 25/08/2025 **Signature** Camilla Jari

Seen, the supervisors Giannaria Collazuol