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UNIVERSITÀ
DEGLI STUDI
DI PADOVA

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

Annual report

Name and surname: Isabella Sofia

Cycle and a.a.: XL cycle, A.A. 2024-2025

Supervisor: Prof. Andrea Chiavassa

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

The project is part of the Cherenkov Telescope Array collaboration and focuses on developing the silicon photomultiplier-based camera for the Small-Sized Telescopes (SST) of the observatory. The design of the Cherenkov Camera has been finalized, and the assembling and testing of the first detector has been the main focus of the SST Camera group.

During the first year, the project aimed to assemble and test the first quarter of camera (QCAM), i.e. eight out of thirty-two modules, each consisting of a 64-pixels Silicon Photomultiplier (SiPM) array and the readout electronics. Such a device was tested in a dark room to ensure its overall functionality and to study its response under different conditions. Indeed, after an initial 'health' check on all pixels, several tests were performed on QCAM: for example, the dynamic range of the device was studied by illuminating it with different levels of uniform light, allowing the study of the linearity and saturation in the device's response and the variation of the pulse shape parameters (FWHM, time and height of the pulse, rise time); the gain of the SiPMs can also be extracted at very low illuminations. The trigger system of QCAM was tested, for example measuring the trigger rate at different thresholds and under different conditions, like different simulated Night Sky Background (NSB) levels and different trigger coincidence levels.

The student actively participated in every assembly step and measurement, and then focused on testing the camera's current trigger system, developing ad hoc test routines to perform tasks such as the trigger threshold scan previously mentioned. This task, together with all other tests that were performed, required the understanding of both hardware and software systems, aided by frequent confrontation and collaboration with the respective developers.

The student also took part in the on-telescope campaign of QCAM, when the device was mounted on an ASTRI telescope at Observatorio del Teide (Tenerife) and underwent on-sky observations. This served as a first observation experience as operator and allowed the student to repeat all tests on the trigger system with on-sky data runs. As an example, ad hoc trigger threshold scans were performed and repeated under different Night Sky Background conditions and telescope pointings. Indeed, at least one trigger threshold scan was performed every night for every targeted cosmic source, while other dedicated runs aimed to study the trigger rate behaviour at different zenith angles.

Other trigger-related characteristics are also being studied by looking at the waveforms in the recorded events: for example, the distribution across the camera of the second-brightest superpixel, i.e. the group of 4 pixels that triggered the event, can help in assessing the trigger uniformity.



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The part of hardware work regarding the SST camera was carried out during a six-month abroad period at Max-Planck-Institute for Nuclear Physics in Heidelberg, while the analysis of data continues remotely from Turin.

During this first year, the student also began to familiarize with the Large-Sized Telescopes (LST) research group, particularly with the working group that focuses on the development and maintenance of the Calibration Box (CaliBox), a device used on-telescope to illuminate and calibrate the Cherenkov Camera every night of observation. Such a device is equipped with a laser, several optical components – such as neutral density filters, splitters and diffusers – and a monitoring sensor (silicon photomultiplier): together they allow to uniformly illuminate the LST camera with different light levels.

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

- Project Management in science (passed)
- New technologies for Cherenkov Telescopes (passed)
- Photodetection: scintillators and silicon photomultipliers (passed)
- Statistical methods and techniques for data analysis (in particle and astroparticle physics) (attended)

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

- LST General Meeting in Rome, Italy, 18-22 November 2024
- TECH-FPA PhD Retreat 2025 in L'Aquila, Italy, 17-21 February 2025
- XXXIII Bonaudi-Chiavassa school on particle detectors in Cogne, Italy, 23-27 June 2025

● **List of published papers/proceedings**

None

● **Thesis title (even temporary)**

Development and characterization of the silicon photomultiplier-based Cherenkov camera for the Small-Sized Telescopes of CTAO

Date: 10/09/2025

Signature

Seen, the supervisor



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