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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: **AJAY SHARMA**
Cycle and a.a.: **XXXIX Cycle**
Supervisor: **Riccardo Campana, Enrico Virgilli**

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

The project main objective is to develop, test, and characterize front-end electronics for Silicon Drift Detectors (SDDs) in the framework of the LEM-X and TASTE space missions. The VEGA2/NOVA ASIC and related FPGA-based test equipment form the basis of the testing work, which aims to enable accurate readout and calibration of X and gamma-ray experiments for high-energy astrophysics missions in the energy range 2–50 keV (LEM-X) between 2 keV and several MeVs (TASTE).

→ **During the second year, the focus was on preparing and characterizing a prototype and testing breadboard systems as a part of the Beyond HERMES project.**

Activities carried out during the second year:

1. **Board preparation and power setup:** Cleaning and inspection, fixing BOM issues, safe LV/HV configuration, and design of custom 3D protective covers.
2. **ASIC + detector integration:** Bonding of FBK-fabricated SDDs to the VEGA2 boards, with inspection and validation of correct HV operation.
3. **Signal characterization:** Measurement of rise times and amplitudes across shaping times, noise vs shaping time studies with MCA, and stretcher chain testing.
4. **Performance evaluation:** Demonstrated linear dynamic range up to ~63 keV, and calibration of Am-241 and Fe-55 spectra.
5. **Scintillator mechanical coupling and testing of the gamma-ray branch:** First tests with GAGG:Ce crystals (preliminary light yield $\approx 16 \text{ e}^-/\text{keV}$).
6. **Difficulties encountered & mitigations implemented:**
 - **Bonding failures & short circuits** due to Kapton cover proximity → mitigated by redesigning taller 3D covers (>4 mm) and optimizing safety limits power supply current.
 - **Test equipment bug solving (e.g., timing issues in handling of the output multiplexer** causing phantom signals → fixed by increasing the End-of-Channel (EOC) delay.)
 - **Mechanical issues in the crystal/SDD coupling**, e.g., stress on scintillator modules leading to SDD cracks → addressed through holder redesign and reduced pressure.



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

1. High Energy Particle Detectors in Space (2,5 CFUs)
2. Gaseous Detectors for Experimental Particle Physics (2,5 CFUs)
3. Design of Readout IC for Particle Detectors (2,5 CFUs)
4. Programmable system on Chip (SoC) for data acquisition and processing (4 CFUs)
5. Fundamental of FPGA-based digital (2.5 CFUs)

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

1. Workshop on Electronics for physics experiments and applications INFN Turin
2. Gran Sasso Hands-on 2025 - PhD summer school on experimental astroparticle physics
3. Educational and Training Course on "Radiation Protection in Workplaces"
4. Italian Language Course PRE-A1

• **List of published papers/proceedings**

- P. Calabretto, ..., A. Sharma et al., "Advanced readout logic for the XGIS instrument: discriminating X-ray and gamma-ray photons from background and particles", Particles, submitted (2025) [peer-reviewed proceeding of the ASAPP2025 conference]
- F. Ceraudo, ..., A. Sharma et al., "The LEM-X all-sky monitor: first results of the detector prototype" Particles, in preparation (2025) [peer-reviewed proceeding of the ASAPP2025 conference]
- G. Della Casa, ..., A. Sharma et al., "The Large Area Detector for future spectral-timing space missions" Particles, in preparation (2025) [peer-reviewed proceeding of the ASAPP2025 conference]
- A. Sharma et al. "Design and development of a test equipment for Silicon Drift Detectors" (in preparation)

• **Thesis title (even temporary)**

Design of test equipment and characterization of front-end electronics for high-energy astrophysics space missions

Date, September 21, 2025

Signature

Ajay Sharma

Seen, the supervisor

Pranab