PhD Progress Report

"Year 1 Review and Year 2 Plans"

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Technologies for Fundamental Research in Physics and Astrophysics- Electronics curriculum

XXXIX Cycle

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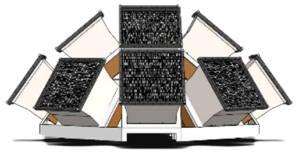
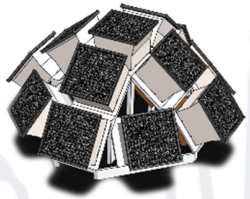
Research Topic and Objectives

- The research activity, carried at INAF/OAS Bologna Gamma-Ray Laboratory, will be mainly focused on the development of a **test equipment** for a new prototype of a **front-end electronics for Silicon Drift Detectors**, in the framework of an **high-energy astrophysics** experiment, and on its experimental characterization.
- The test equipment will be based on a commercial FPGA board (Xilinx Zynq 7200 platform), that will handle the configuration of the FEE ASICs and the event acquisition. Further activity will involve laboratory testing of the setup, with and without Silicon detectors, in order to characterise the FEE and the detector performance.
- The main topic of the PhD will revolve around the **LEM-X** (PNRR/NRRP EMM project) VEGA-2 ASIC and its TE testing activities.

Overall Planning and Timeline

- The Lunar Electromagnetic Monitor in X-rays (LEM-X) project aims at developing a large, permanent X-ray observatory on the Lunar surface, operating in the X-ray energy band (2–50 keV).
- Each LEM-X camera is equipped with four large-area Silicon Drift Detectors (SDDs) and is capable of monitoring and imaging the high-energy sky in a field-of-view larger than 2 steradians.





- The read-out (AFE) and ADC (DFE) ASICs design rely on the heritage of the VEGA, LYRA and ORION ASICs developed by PoliMi and UniPV in the framework of the ReDSoX collaboration (HERMES, +THESEUS)

*Astronaut not included

Research Activities (1st Year)

- Due to **unforeseen visa issues**, I was able to reach Bologna with **a significant delay of 7 months**. This delay impacted the timeline for the planned activities, particularly the hands-on testing and characterization work in the laboratory. However, I have since been fully engaged in catching up with the initial objectives and have made substantial progress.

- The first year research effort, besides a general familiarisation with laboratory procedures and facilities, focused on a **literature assessment** as well as **inspecting and testing an HERMES detector prototype and its front-end electronics**, which includes GAGG:Ce scintillator material read out by Silicon Drift Detectors for detection of X-ray event and Gamma event using a front-end electronics a custom-made ASIC(LYRA).

- The HERMES testing will provide valuable insights for two distinct and interconnected scientific endeavors, namely the HERMES and SISCO projects. I expect acquiring not just the necessary skills for my PhD Project but also the opportunity to collaborate with my colleagues in publishing the findings from these two initiatives.

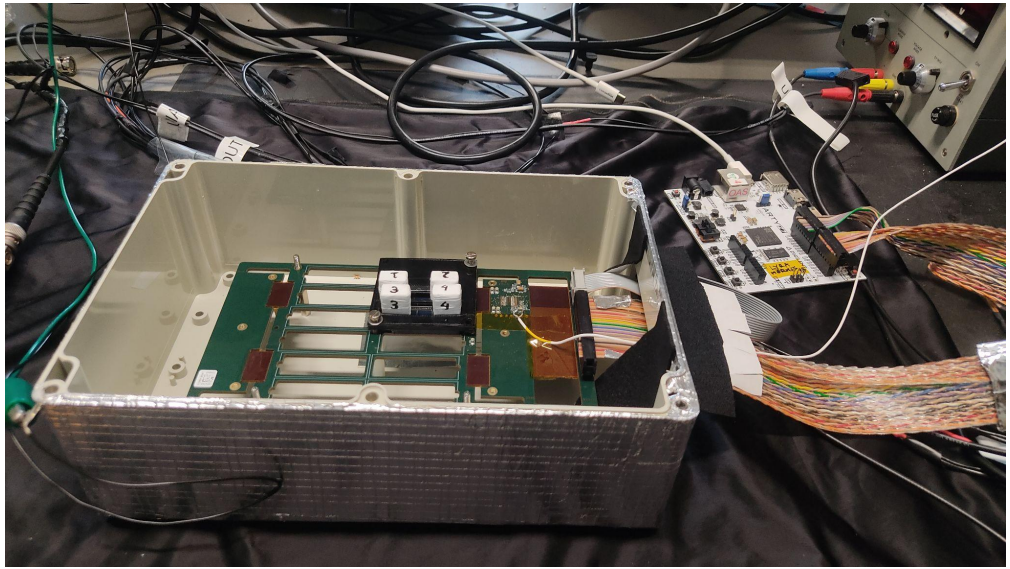
- The test equipment is based on a FPGA board (Xilinx Zynq 7200 platform), that handles the configuration of the LYRA ASICs (FEE ASICs) and the event acquisition. This is a platform similar to the one **foreseen for the LEM-X ASIC testing activities**.

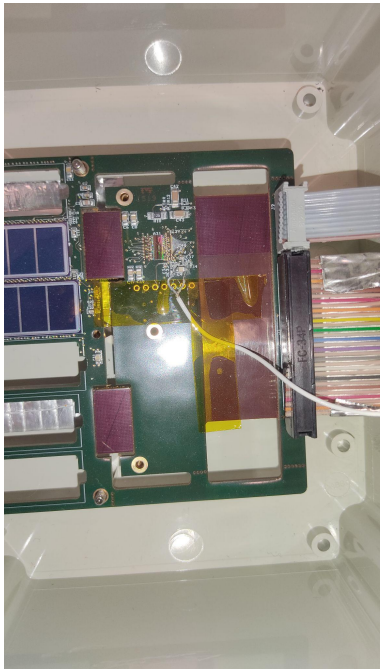
Achievements and Progress

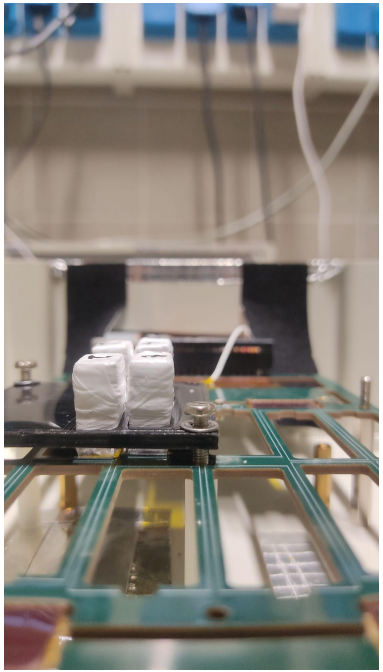
- After thoroughly inspecting each ASIC connection, we have successfully **calibrated and tested the LYRA ASIC board**. We have already begun gathering data at room temperature, and in the meanwhile we in the process of writing the initial data analysis codes. Once done with we evaluate its ability to perform in various climatic conditions using the climatic chamber.

- By the end of the first year**, the aim is to have finished a complete sequence of data acquisition and calibration at several temperatures with the LYRA ASICs to have a well-developed tested "training" prototype and to start testing and debugging of the LEM-X ASIC testing boards.**

Achievements and Progress







Research Activities (2nd Year)

Planned Research Activities for the 2nd Year

- In the second year, the primary focus will be on the debugging and testing phases of the LEM-X ASIC and TE prototype.
- The electronic boards have already been designed and are in production
- The ASIC has been produced and is being delivered
- Planned steps:
  - Test/debug of the PCB board
  - Development of the Test Equipment (FPGA firmware, PC client software)
  - Test of the ASIC functionality and performance
  - Test of the ASIC+SDD full system

Courses and Training Activities

1. Photodetection: Scintillators and Silicon Photomultipliers.
2. High-Energy Particle Physics Detectors In Space.
3. Cosmic radiations and radiation hardness assessments.
4. Programmable System on Chip (SoC) for data acquisition and processing.
5. Gaseous Detectors for Experimental Particle Physics.
6. Design of read out integrated circuits for particle detectors.

Additionally, I am eager to engage in **additional educational activities**:
Activity-8 (Activities at research facilities-Physics with Accelerators),
Activity-9 (Activities at research facilities-Astroparticle Physics),
Activity-10 (Seminar-Nuclear Safety Applied to Basic Physics Research Facilities)

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A special and heartfelt thanks to the University of Padua for providing the opportunity to be a part of this esteemed institution.

Thank You

Any Questions?