Characterisation of the Plastic Scintillator Detector for HERD: 224

38th PhD cycle-Curriculum 5:Design,Performance and Simulation of not-imaging space-based detector

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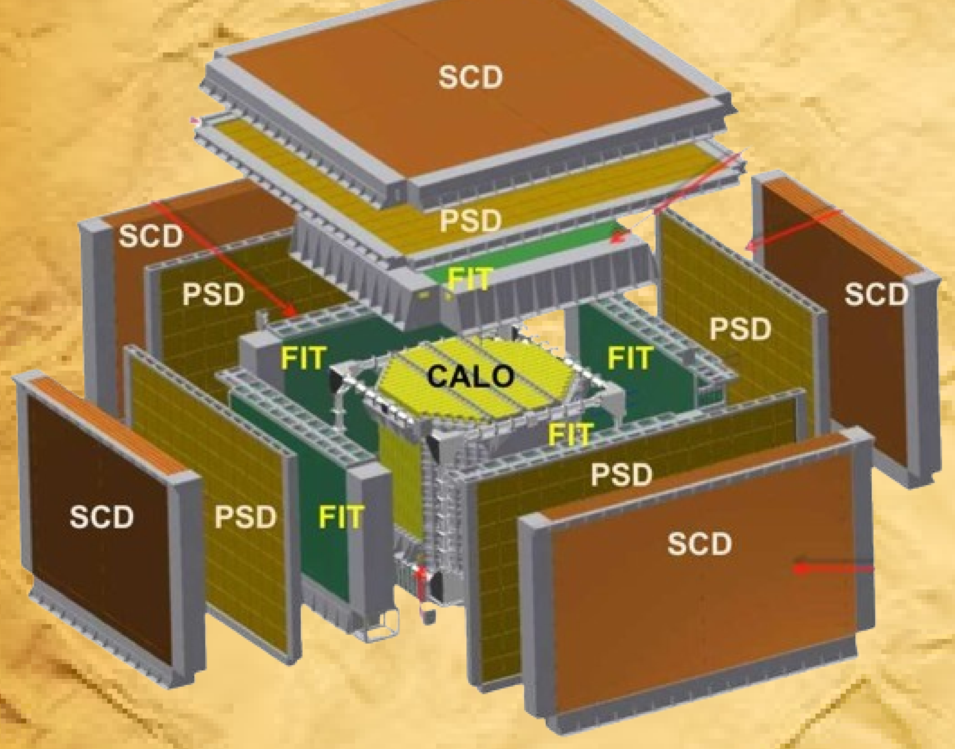
Introduction



1.HERD Payload

- The High Energy Cosmic Radiation Detection (HERD) facility is foreseen to be onboard China's Space Station in 2027 [1]
- Dedicated to the detection of Cosmic Rays (CRs) up to the knee region and gamma-rays greater than 100 MeV.
- Design requirements are: High Detection Efficiency, Broad Dynamic Range, and Optimal energy/charge Resolution
- The current HERD design is shown in Figure 1. It is composed of various sub detectors. My work is focused on the Plastic Scintillator Detector (PSD).
- In this poster I'll describe the characterisation process of the PSD readout electronics.

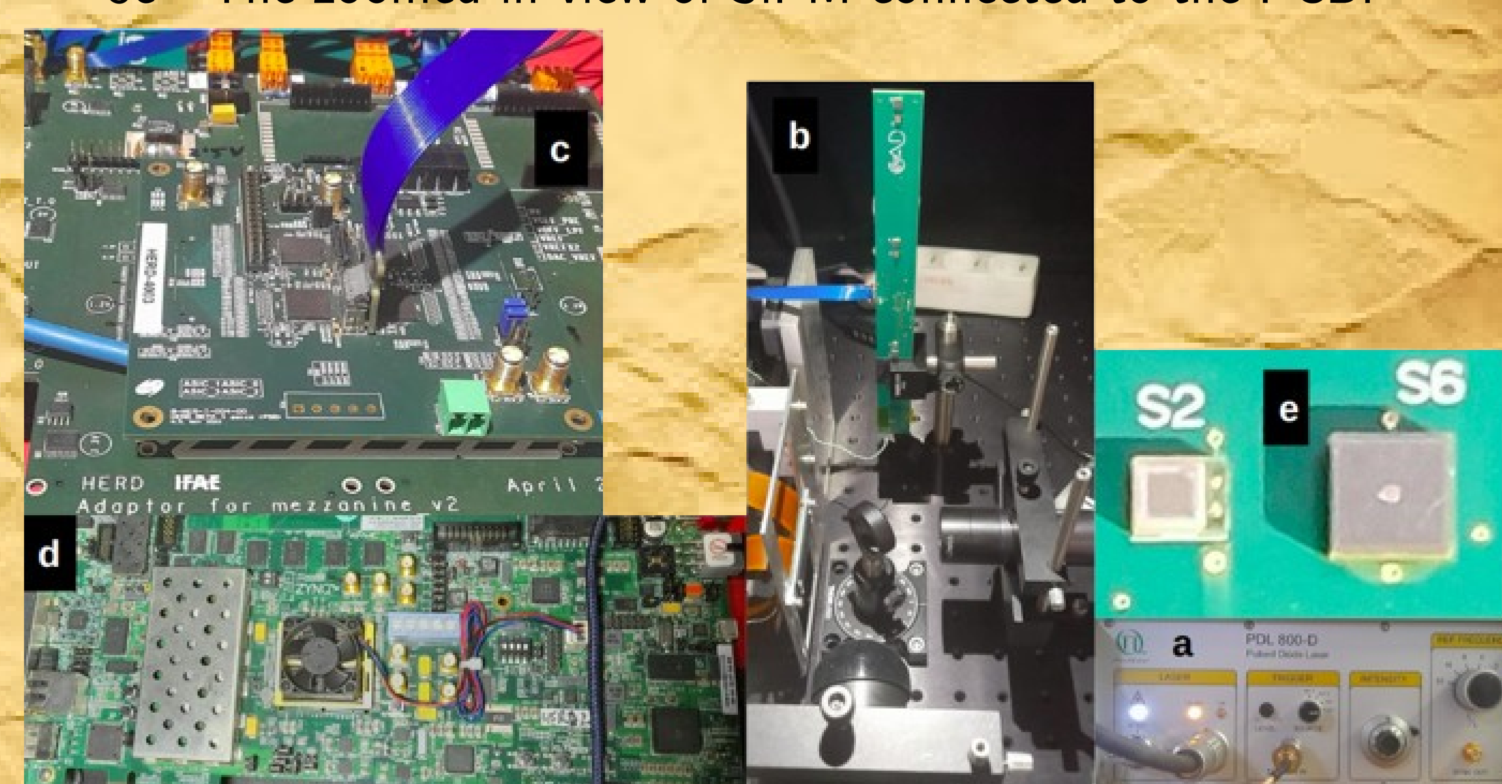
The PSD

2. The Scintillator bar

- The (PSD) is dedicated to photon tagging and precise charge measurement of incoming CRs from proton to iron [1].
- The current design of the PSD utilises 2 orthogonally arranged layers of scintillator bars as shown in Figure 2.
- Each bar will be read out with 4 low Z and 4 high Z Silicom Photomulpliers (SiPMs) placed along its longer side.
- 1 set of SiPM are optimised to detect low Z charges and another set is optimised to detect high Z charges.
- The SiPMs we are using are manufactured by Hamamatsu. The high Z model is S14160-3050HS and the low Z model is S14160-1315.

Experimental Set-Up

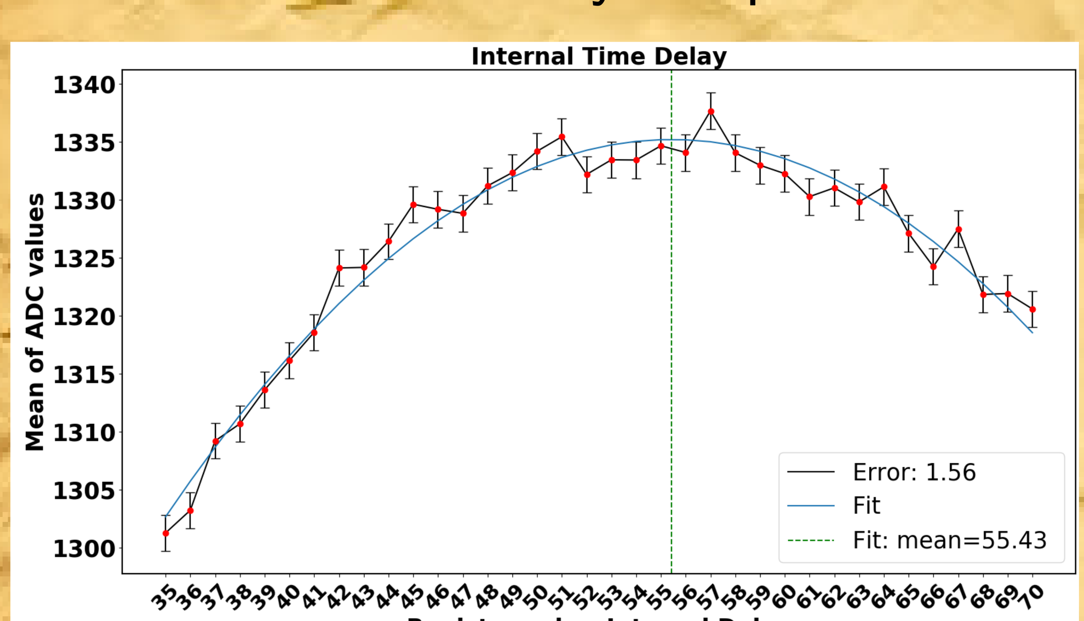
- The current design proposes a front-end electronics board equipped with Beta - Application-Specific Integrated Circuits (ASICs), as shown in Figure 3 [2].
- The subplots in Figure 3 refers to the different components of the setup as described below:
- 3a - LED pulsed laser as the light-source.
- 3b - The green vertical bar is the Printed Circuit Board (PCB) with the SiPMs. The blue cable on the left side of the bar is connected to the PSD-Board shown in 3c. On the right side of the bar is the light from LED and in the middle is the dichroic mirror splitting the light to PSD and FIT (FIber Tracker - another sub-detector of HERD).
- 3c - The 4 black squares on the PSD board are the 4 ASICs. Each ASIC has 16 readout channels.
- 3d - The Field programmable Gate Array (FPGA) board of the PSD.
- 3e - The zoomed-in view of SiPM connected to the PCB.



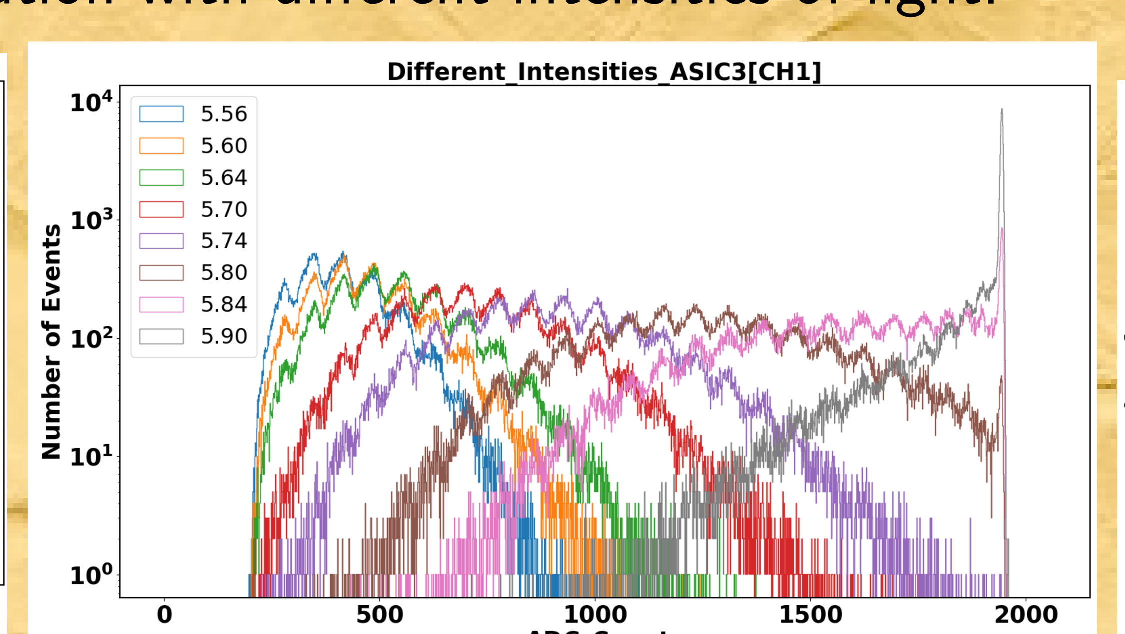
3. Laboratory setup of the PSD

Characterisation of the SiPMs

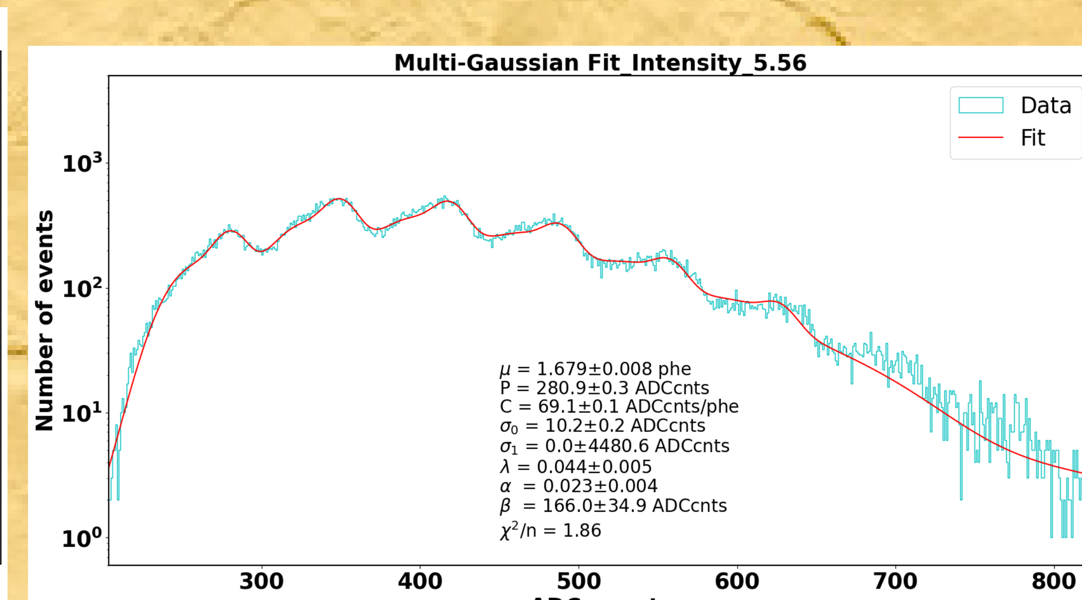
- The goal for the characterisation of the SiPMs and the electronic readout response is to calibrate the system and evaluate how many photoelectrons are produced by a MIP (Minimum Ionising Particle). This calibration is crucial for the upcoming test beam at CERN scheduled for 2024/2025.
- The response optimization process involves fine-tuning several parameters, including operating voltages, gains, delay times of each ASIC, the offset voltage and the threshold level of the trigger.
- Figure 4 is the Internal Delay Scan. It is the time between when the light is pulsed and when the signal is probed. 1 register value = 20ns. A Gaussian is fitted to find the optimal time delay to probe the signal at the maximum of the shaping time.
- Figure 5 shows the photoelectron peaks at the different intensities of light in arbitrary units(a.u) for 10000 events for the bias-voltage 39.5V.
- Figure 6 is the multi-gaussian fitting of one of the light intensities (5.6) shown in Figure 5. The various fitted parameters will help us understand statistically the peak distribution with different intensities of light.



4. Internal Delay Scan



5. Photoelectron peaks at different intensities



6. Multi-gaussian fit for intensity 5.6a.u

Ongoing work and Conclusion

- In addition to this hardware project, I'm also using the HERD Software simulation tool in order to study the hermeticity and the backsplash for PSD.
- The simulation tool uses Monte-Carlo simulations within the Geant4 framework and is coded in C++ language.
- The required number of CFUs necessary for this PhD program have been obtained.

Acknowledgements

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References

1. D. Kyratzis, *The Plastic Scintillator Detector of the HERD space mission*
2. A. Sanmukh, *Low-power SiPM readout BETA ASIC for space applications*