

Assembly and test of prototype scintillator tiles for the plastic scintillator detector of the High Energy Cosmic Radiation Detection (HERD) facility

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Introduction

The High Energy cosmic Radiation Detection (HERD) facility is an international space mission that will be operative on the Chinese Space Station currently being assembled (see Fig. 1) that will be operative by the end of 2027. The main goals of HERD are: the detection of precise cosmic ray spectrum and composition measurements up to the knee energy, precise cosmic electron/positron spectrum and measurements of anisotropy up to 10 TeV, high energy gamma-ray monitoring and survey, search for signals of dark matter annihilation products. The instrument will be surrounded by plastic scintillator detector (PSD), which will be used to discriminate charged from neutral particles in order to correctly identify gamma-rays and nuclei [1]. Currently two configurations are being studied for the PSD geometry, respectively based on scintillating bars and tiles. Several tests and R&D are ongoing; hereafter we will illustrate the tests based on the second option.



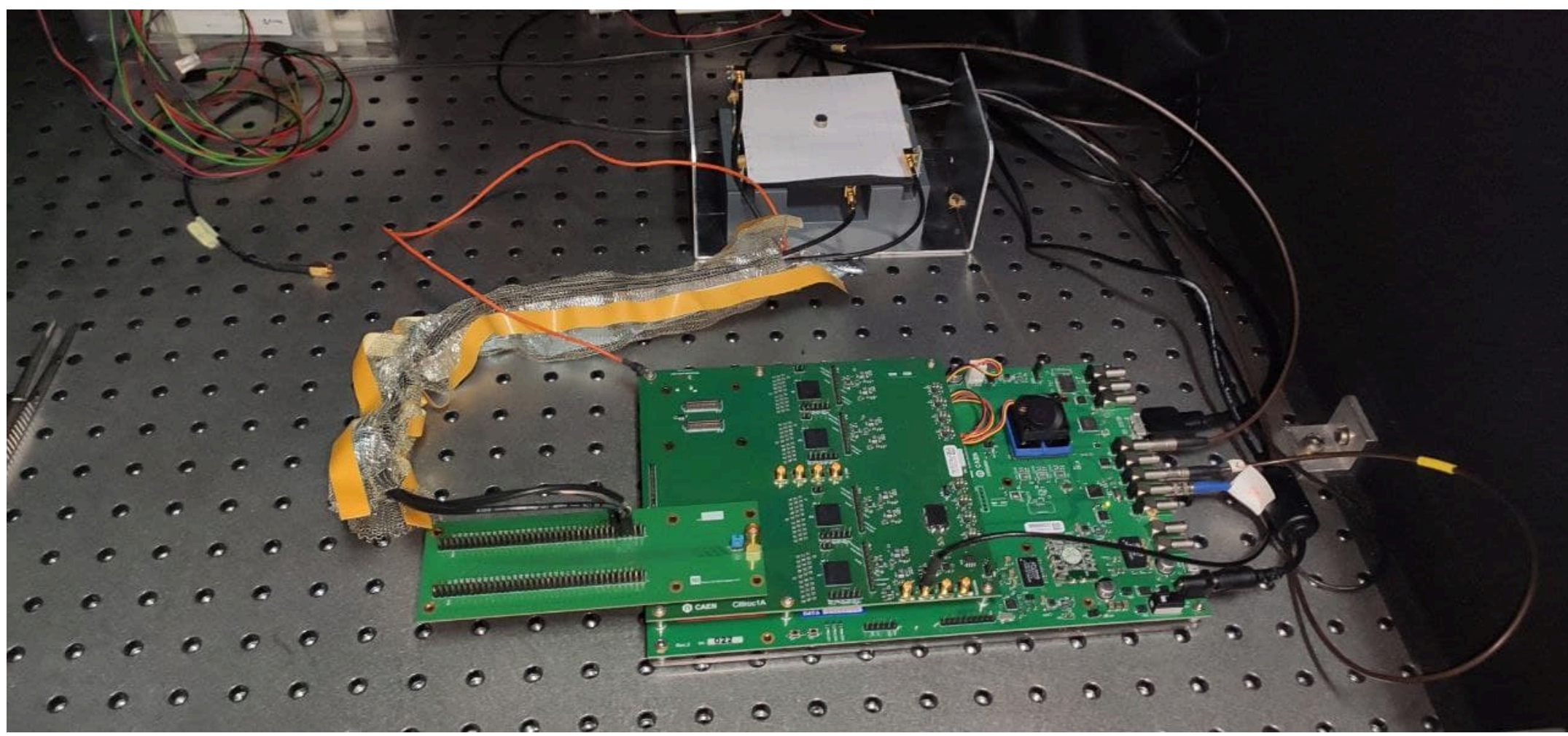
Fig. 1: Artist's view of the Chinese Space Station

Experimental setup and Measurements (PSD test)

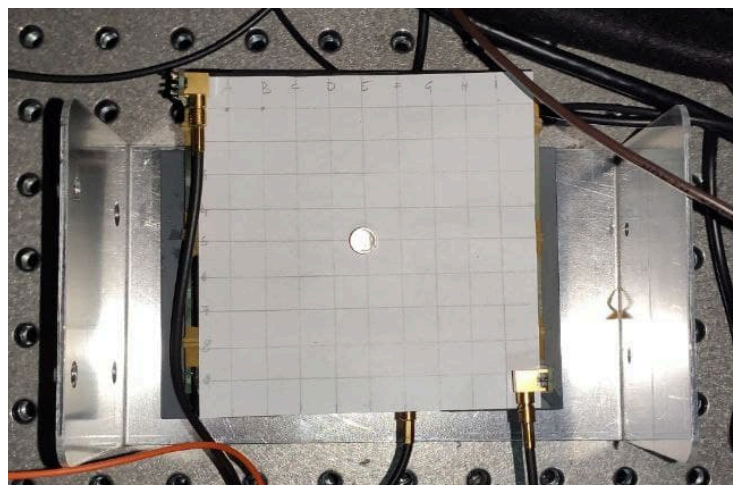
We have used a 10x10x0.5 cm³ BC – 404 tile equipped with 3 PCB with Hamamatsu Silicon Photomultipliers (SiPMs):

- 2 PCB equipped with 3 SiPMs 3x3mm² (15µm cell) S14160-3015ps
 - Ch17 on one side and Ch18 on the top
- 1 PCB equipped with 3 SiPM 1x1mm² (15µm cell) S14160-1315ps
 - Ch16 on one side

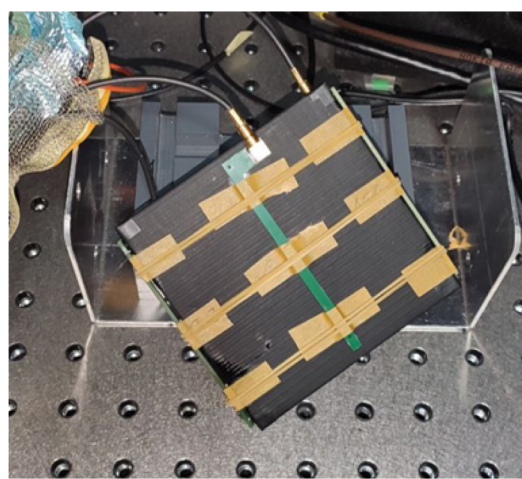
The signals have been acquired with the CAEN DT5550W [3] board based on the CITIROC ASIC [4]. The entire setup was placed in a dark box, see Fig. 2a). We have performed a test with a radioactive ⁹⁰Sr source (see Fig. 2b, 2c) moving the source with 1cm steps both in X and Y, as is illustrated in Fig. 2a) and a test with cosmic-rays.



a)



b)



c)

Fig. 2: a) Picture of the experimental setup b) ⁹⁰Sr radioactive beta-particle source placed on PSD, c) 3 PCB placed on the PSD are visible, 1 on the top and the others on the two opposite sides .

Analysis and Results

- We triggered on the PCB equipped with S14160-1315ps both in the cosmic-ray and ⁹⁰Sr source tests

Cosmic-ray test results

- In Fig. 3 are shown the spectra for top (ch18) and side (ch17) PCB. The SiPMs on the top side seems to collect 1/3 of the light on the one of the side.

⁹⁰Sr source test results

Fig 4 shows the distribution for top (ch18) and side(ch17) SiPMs, placing the source in the position (4,3) cm.

In Fig. 5 and 6 are shown the mean value of the measured spectra for top SiPMs and side SiPMs respectively. The number of photons increases when the source position is close to the SiPMs. Side SiPMs shows a better uniformity response respect to the top ones.

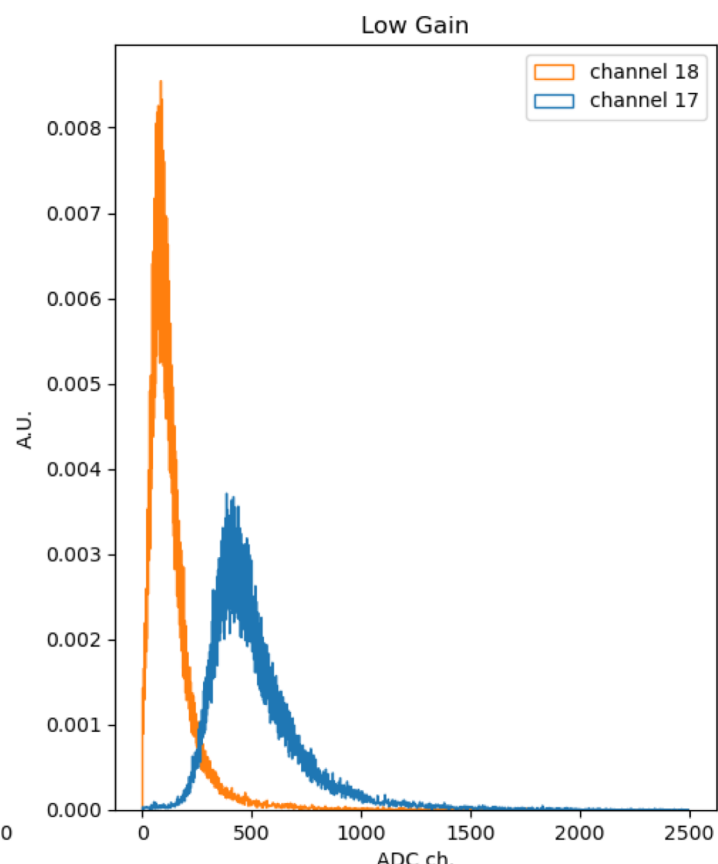


Fig. 3: Cosmic-rays distributions.

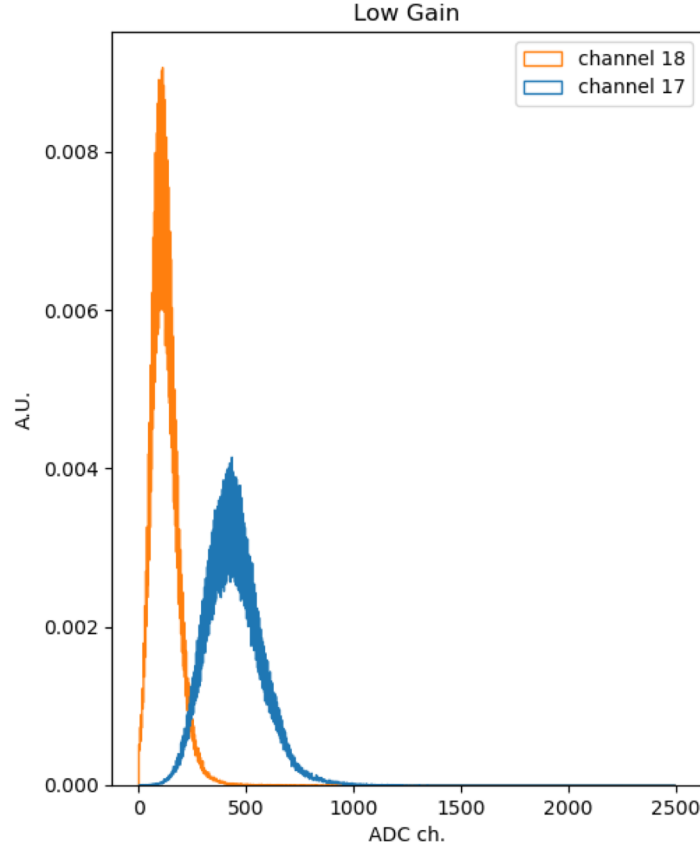


Fig. 4: ⁹⁰Sr radioactive source distributions.

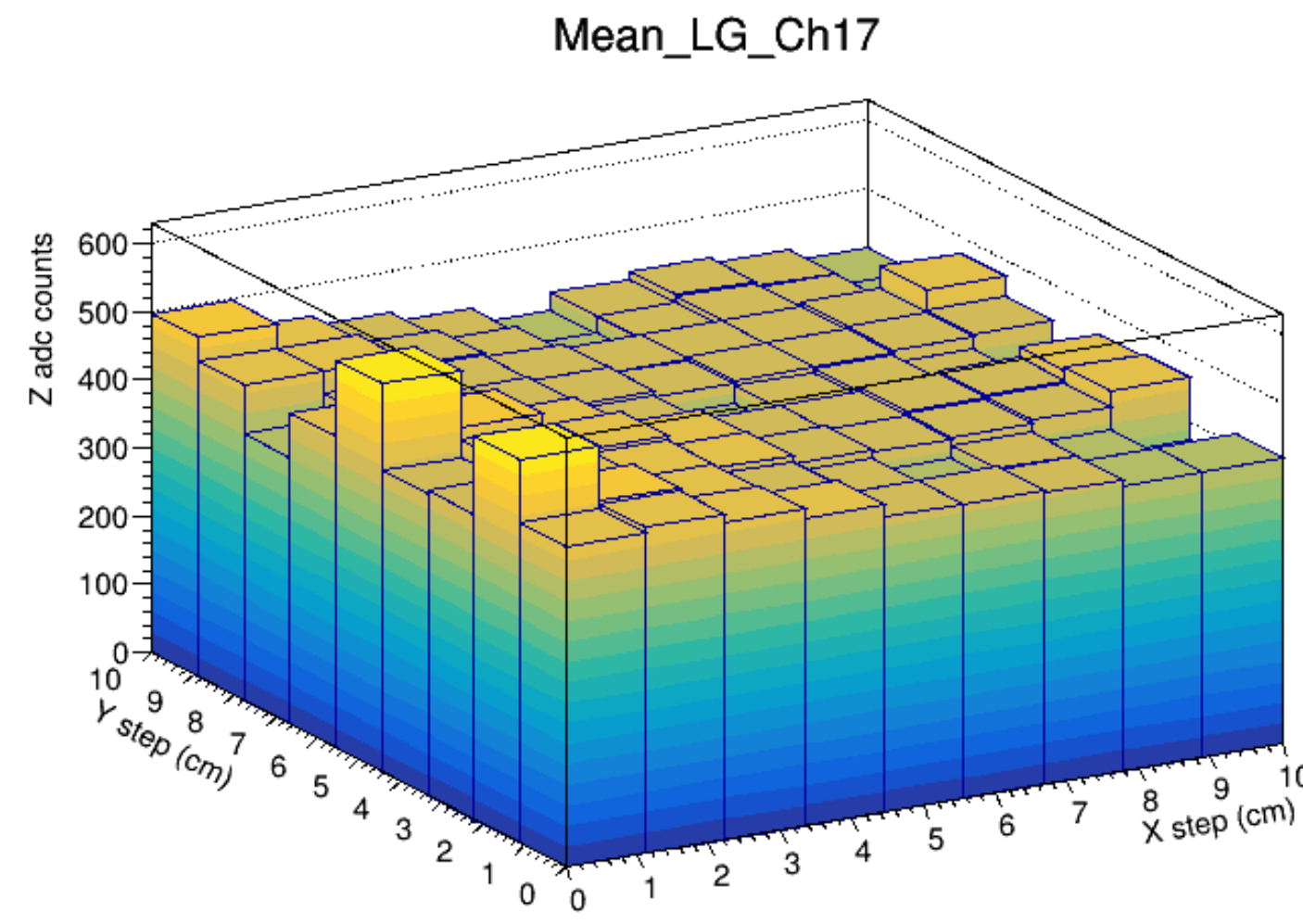


Fig. 5: Photon count map for the channel 17 in the low gain case, placing the source on the left side.

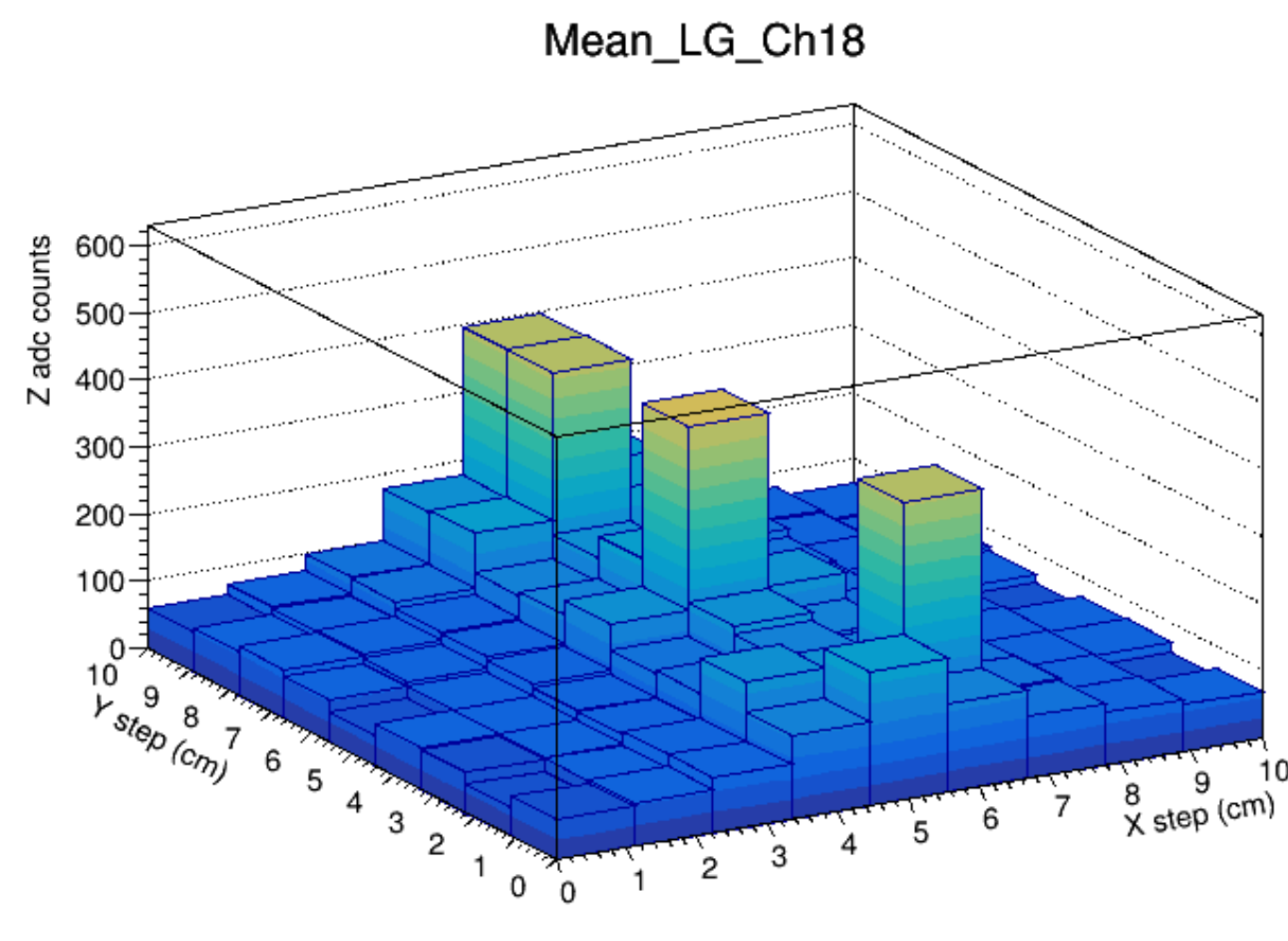


Fig. 6: Photon count map for the channel 18 in the low gain case, placing the source on the top.

Conclusions & future perspectives

- The HERD collaboration is an international space mission.
- The PSD needs to have a very high detection efficiency for the charged cosmic rays, which represent the main background for the identification of gamma rays, and a very great capability in identifying charged nuclei.
- The aim is to reach the best particle identification performances based on the choice of the best PSD geometry and on the optimization of the electronics.
- The future HERD space mission will employ Silicon Photomultipliers (SiPMs) instead of classical Photomultiplier tubes to read out the scintillator light emission in order to exploit their smaller sizes and lower power consumption.

References

[1] Yongwei Dong et al., PoS, 36th International Cosmic Ray Conference .ICRC 2019, Julay 24th – August 1st, 2019, Madison Wi, USA.
[2] <https://www.weeroc.com/my-weeroc/download-center/citiroc-1a/16-citiroc1a-datasheet-v2-5/file>
[3] <https://www.caen.it/products/dt5550w/>