The Plastic Scintillator Detector of the HERD space mission

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Executive Summary

Nowadays, Cosmic Ray (CR) detection remains in the forefront of intense research and is represented by a multitude of sophisticated experiments aiming towards the clarification of their origin, acceleration and propagation mechanisms in the Universe. Specifically for direct CR detection, forthcoming space–based experiments should incorporate requirements related to: increased geometric factors, extended mission duration, as well as high discrimination power in separating different cosmic radiation components. Combining the above–stated properties, will allow for a deeper understanding of the intricate features that constitute distinctive structures in CR spectra. In that regard, the High Energy cosmic-Radiation Detector (HERD) was proposed to address the aforementioned requirements, being one of the primary instruments to be installed on–board China's Space Station around 2027, with a planned duration of 5 to 10 years.

HERD will be capable of studying spectral features of various CR nuclei with optimal precision, up to the highest–achievable energies (considering space–borne instruments), while also providing insights on various topics concerning: gamma ray astronomy, throughout a broad energy range up to several TeV; the all-electron component and its fine structure up to 100 TeV, while distinguishing particles originating from astrophysical sources over possible dark matter annihilation products (due to inherent differences in both spectra), owing to its wide field–of–view (FoV).

One of HERD's prominent sub-detectors is the Plastic Scintillator Detector (PSD) and will be utilized as an anti–coincidence detector (discriminating incident photons from charged particles), while providing charge measurement of incoming cosmic–ray nuclei in a range up to iron. Practically, thin and light materials (*i.e.*, organic scintillators) can be an optimal choice regarding this task. Scintillator bars are readout by silicon photomultipliers (SiPMs) instead of conventional PMTs, due to recent technological developments that demonstrate: fast light signal detection; good sensitivity to low light yields; lower power consumption and robustness. Two designs are currently under investigation: long scintillator bars and square scintillator tiles. Said options are rigorously developed from hardware and software perspectives, in order to achieve a robust understanding of the various performance aspects and inherent detector effects that arise from both designs.

Main requirements of the PSD include: high detection efficiency, broad dynamic range, good energy resolution as well as optimal radiation hardness and overall detector robustness, necessitated by missions in space. Numerous configurations concerning tiles & bars have been constructed, validated and tested. In that sense, all setups were verified via a multitude of particles, ranging from: electrons, CR muons, protons and carbon nuclei in a wide energy range. Upcoming activities foresee a beam test campaign at CERN, where both prototypes will be characterized and thoroughly evaluated in order to provide insight about the optimal PSD layout.