Design and expected performances of the large acceptance calorimeter for the HERD space mission.

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1 Summary

The High Energy cosmic-Radiation Detection (HERD) is a future space experiment which will be installed on the Chinas Space Station around 2027 . The main goal of the experiment is the measurement of cosmic rays up to energies which are not explored by the instruments currently operating in space, in particular protons with energies up to PeV, nuclei up to hundreds of TeV per nucleon and electrons up to tens of TeV. The instrument will consist of silicon charge detectors, anti-coincidence scintillators, scintillating fiber trackers, a transition radiation detector and a calorimeter (CALO). The latter is a homogeneous, deep, 3D segmented calorimeter made of about 7500 LYSO cubic crystals: thanks to this innovative design, it will achieve large acceptance, good energy resolution and excellent electron/proton discrimination. In order to increase both energy calibration capabilities and redundancy of the instrument, the LYSO scintillation light will be read-out by two independent systems: the first is made of wave-length shifting fibers coupled with imaged intensified CMOS cameras, and the second consists of photodiodes with different active areas connected to a custom front-end electronics. Both read-out systems are designed to have a large dynamic range, up to 10^7, and a low power consumption. The double read-out scheme will strongly improve both the calibration and trigger capabilities, which usually have large impact on the systematic errors of flux measurements. The design of the calorimeter is validated by several Monte Carlo simulations. The expected effective geometrical factor (GF), i.e. the GF multiplied by the selection efficiency, is larger than 2 m^2sr for electrons and 1 m^2sr for protons. In parallel,the energy resolution at 1 TeV is better than 2% and 30% for electrons and protons respectively. In order to validate the CALO performances obtained by MC simulations, tests with high energy beams are done. As an example, a prototype made of 5x5x20 LYSO cubes read-out with the WLS system was tested in 2017 at the CERN SPS, while the PD system was tested with several prototype made of hundreds CsI crystals. The energy resolution of both electrons and protons is consistent with the MC simulation predictions. Finally, a new calorimeter prototype including both WLSs and PDs is under construction and will be tested at the CERN SPS in November 2021.