HERD space mission:
Probing the Galactic Cosmic Ray frontier

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The space mission

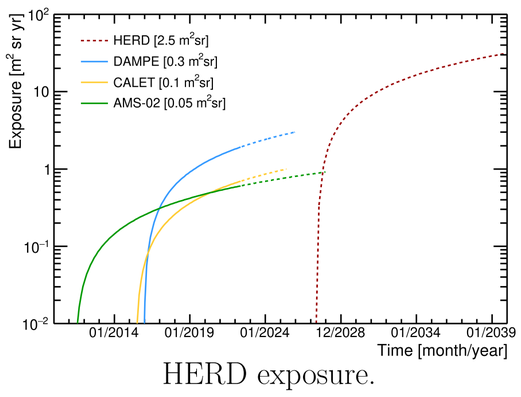
- High Energy cosmic-Radiation Detection (HERD)
- Planned for launch in 2027 and to be on board of the Chinese Space Station (CSS):
  - circular LEO orbit inclined at 42°
  - at an altitude of $\sim$ 340 - 450 km
  - lifetime >10 yr

Main features

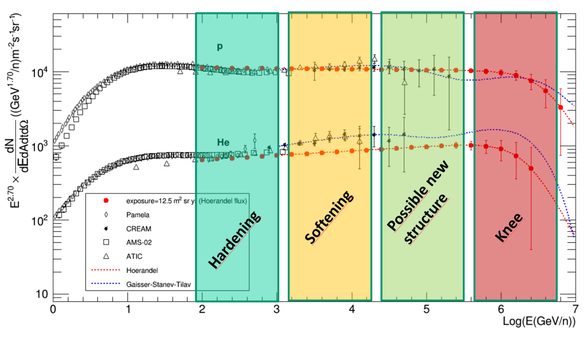
Payload mass	$<$ 4t
Power consumption	$<$ 1.5 kW
FOV	$\pm$ 70°
Calorimeter	55 X_0 ($\sim 3\ \lambda_I$)
Geometric acceptance	$\sim 3\ m^2 sr$
Detection	0.5 GeV - 100 TeV (γ) 10 GeV - 100 TeV (e) 30 GeV - 3 PeV (p/nuclei)
Energy resolution	1 % at 200 GeV (e/γ) $\sim$ 20% at 100 GeV - 1 PeV (nuclei)

Scientific goals

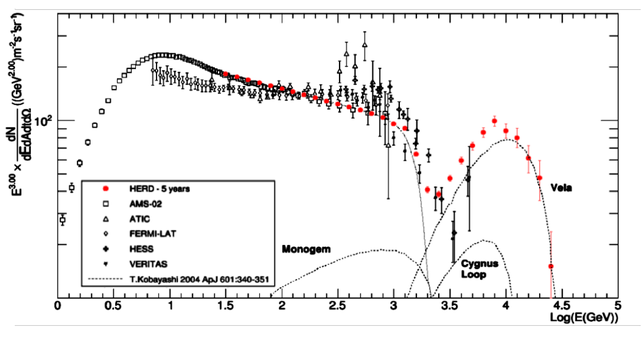
- Measure the cosmic rays spectra and composition up to the *knee*.
- Study the electron spectra up to tens of TeV.
- Perform γ-ray astronomy and transient studies.
- Indirect dark matter search.



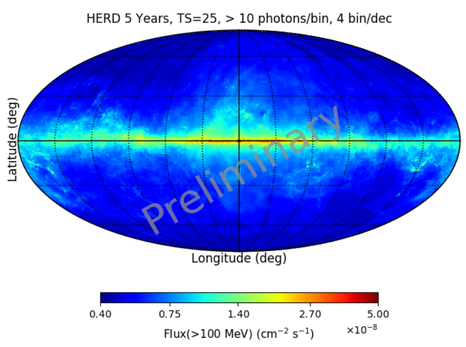
HERD exposure.



Expected HERD results for p and He spectra.



Expected HERD results on the e^+e^- spectrum.

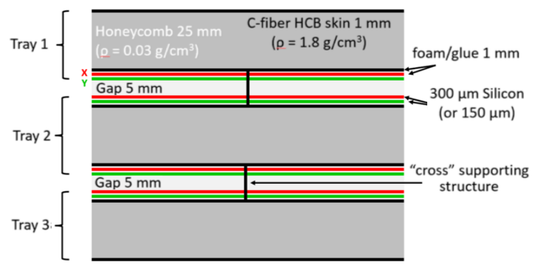


Expected HERD 5-year-sky-map.

The detector

SCD (Silicon Charge Detector)

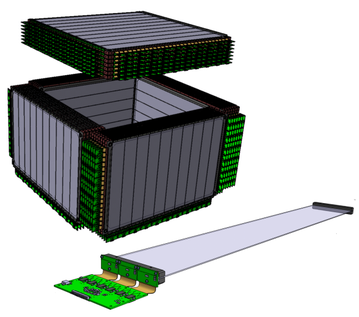
- For charge measurement up to Z=28.
- Outermost detector: less systematics due to particle fragmentation.
- Highly segmented: prevent back-scattering effects.



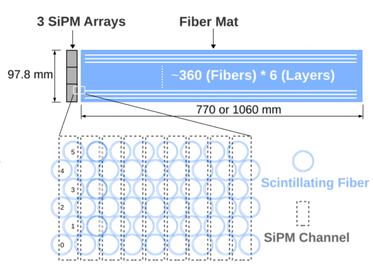
SCD configuration.

FIT (FIber Tracker)

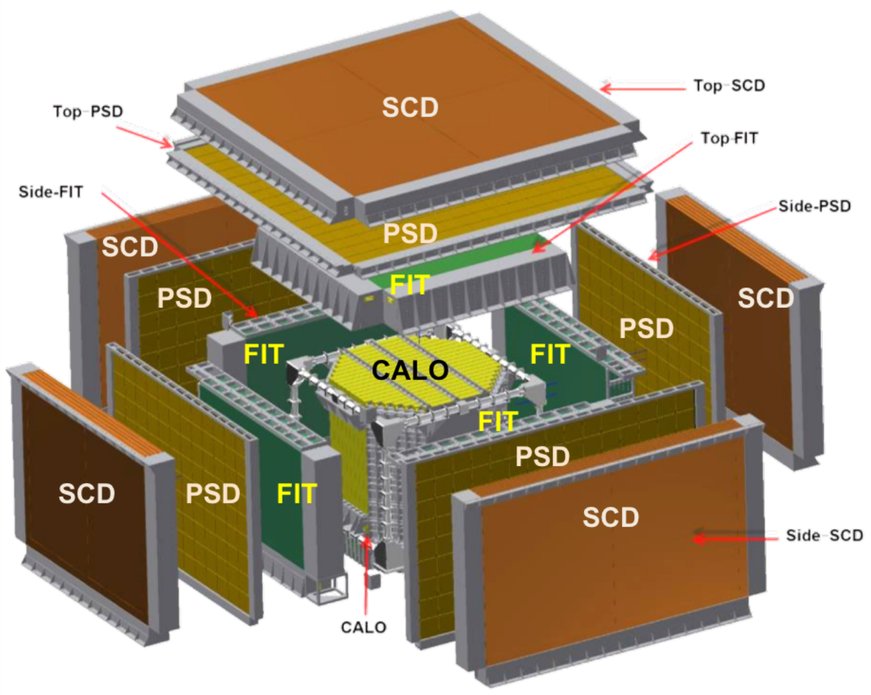
- For charged particles track reconstruction and conversion of γ to electron/positron pairs.
- Ongoing simulations and lab tests to study the performances
  - estimated spatial resolution of 45 μm
  - mean single hit detection efficiency of 99.6%



Scheme of the FIT 5 sectors and of a module.

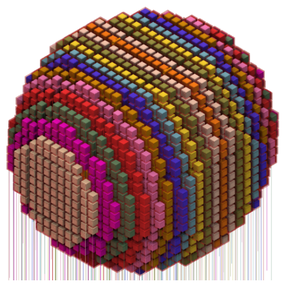


FIT Fiber mat.



CALOrimeter

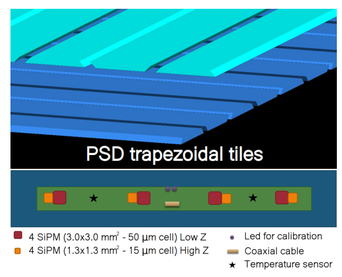
- 3D imaging calorimeter of 7500 LYSO crystals ($3 \times 3 \times 3$ cm^3).
- Isotropic and homogeneous: large acceptance and good energy resolution.
- Highly segmented: good e/p separation.
- Double read-out system: cross-calibration
  - Wavelength shifting fibers (WLS) coupled to image Intensified scientific CMOS (IsCMOS) cameras, and to Photo-Multiplier Tubes (PMTs)
  - Photo-diode (PD) connected to the HIDRA custom front-end electronics chips



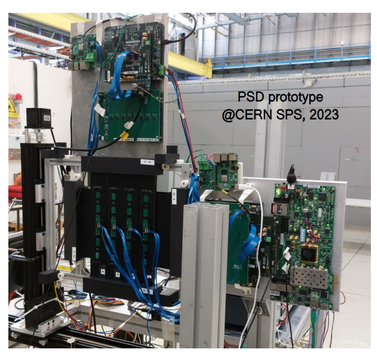
CALO LYSO crystal array (top) and single crystal double read-out systems (bottom).

PSD (Plastic Scintillator Detector)

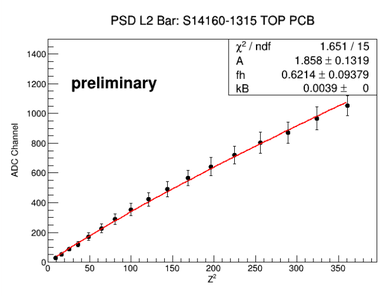
- For anti-coincidence for γ ID and charge measurement up to Z = 26.
- Requirements
  - high detection efficiency (>99.98%)
  - wide dynamic range in nuclei ID
  - highly segmented
- For all 5 sectors: 2 double X-Y layers of scintillating tiles, each readout by multiple SiPMs
- Test beam campaigns at CERN and CNAO to
  - study the uniformity response of light collection,
  - evaluate nuclei ID performances,
  - optimise SiPM-based readout.



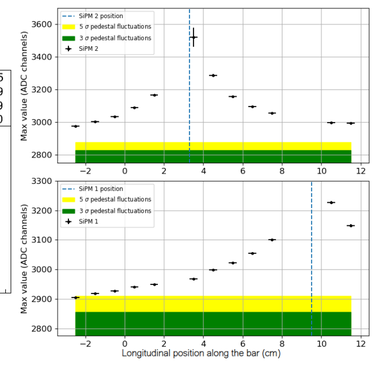
PSD layers disposition view (top) and a Printed Circuit Board (PCB) housing the SiPMs (bottom).



PSD prototype used at CERN SPS beam test.



PSD prototype quenching effects test.



PSD prototype attenuation test.