The HERD space mission

Leandro Silveri
On behalf of the HERD collaboration

Gran Sasso Science Institute (GSSI) and INFN, L'Aquila, Italy

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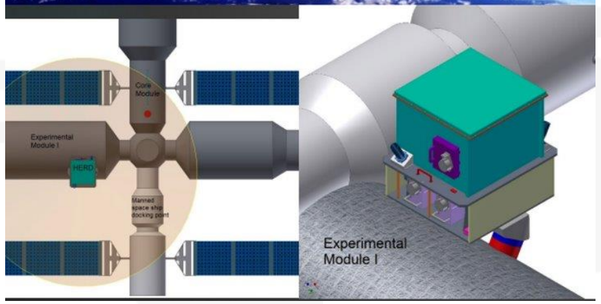
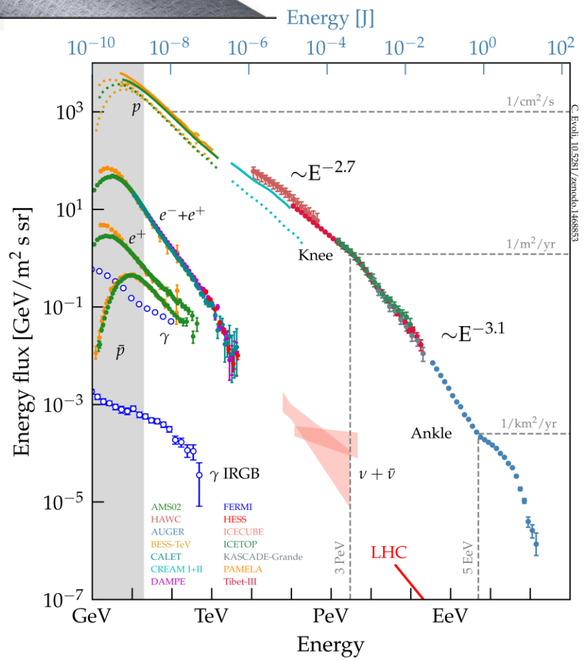
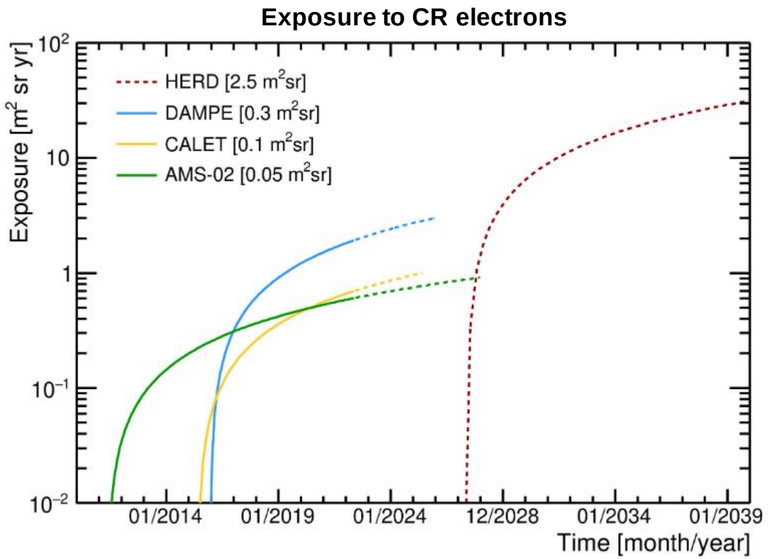
HERD Space Mission

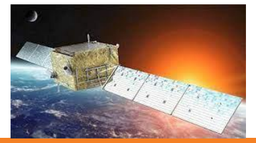




- Joint collaboration between Italy, Spain, Switzerland and China
- Particle detector to be installed onboard the Chinese Space Station
- Planned launch in 2027
- Scientific goals:
  - Direct measurement of Cosmic Ray energy spectrum up to the *knee* region (PeV scale)
  - Electron energy spectrum up to 10 TeV
  - Gamma monitor and full sky survey up to 100 TeV
  - Indirect dark matter searches

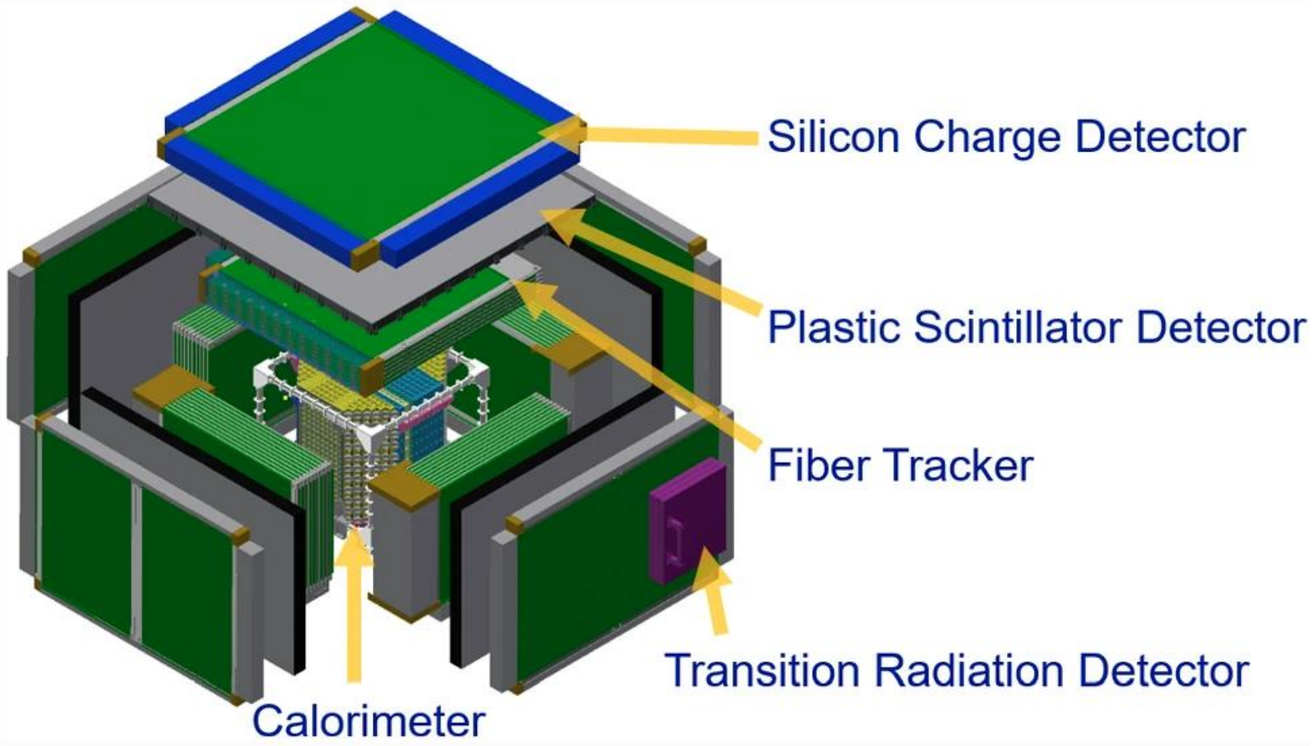
Expected Performances






	HERD	DAMPE	CALET	AMS-02	Fermi LAT
e/γ Energy res.@100 GeV (%)	<1	<1.5	2	3	10
e/γ Angular res.@100 GeV (deg.)	< 0.1	<0.2	0.2	0.3	0.1
e/p discrimination	$>10^6$	$>10^5$	10^5	10^5 - 10^6	10^3
Calorimeter thickness (X_0)	55	32	27	17	8.6
Geometrical accep. (m^2sr)	>3	0.3	0.12	0.09	1

Preliminary Design



The use of **5 sensitive faces** increases significantly the detector acceptance without dramatically affecting the size

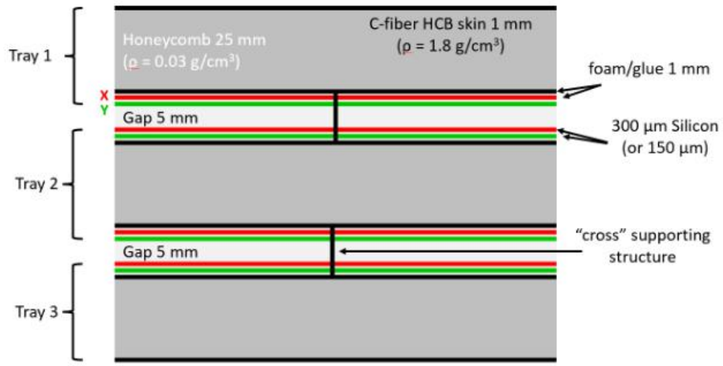
- **SCD** -> charge measurement
- **PSD** -> photon anticoincidence and charge measurement
- **FIT** -> tracking system
- **TRD** -> calibration of response for TeV protons
- **CALO** -> energy measurement and shower imaging (LYSO cubes)

Silicon Charge Detector (SCD)

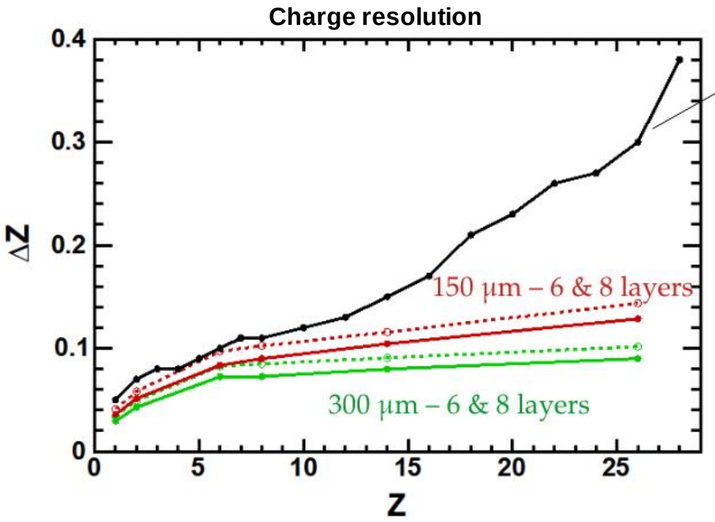
Silicon microstrip detector for precise charge measurement

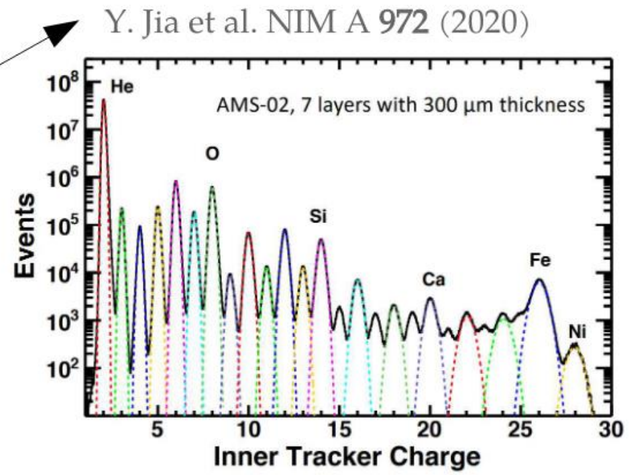
- Z resolution < 0.1 c.u. @ Z = 1
- Z resolution < 0.2 c.u. @ Z = 6

- Z minimum range 1 – 26



Schematic of preliminary SCD design

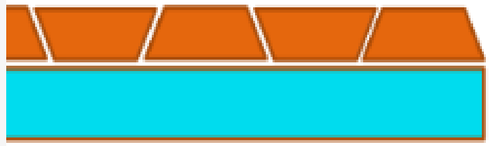


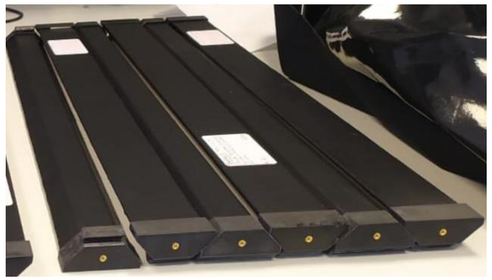


Plastic Scintillator Detector (PSD)

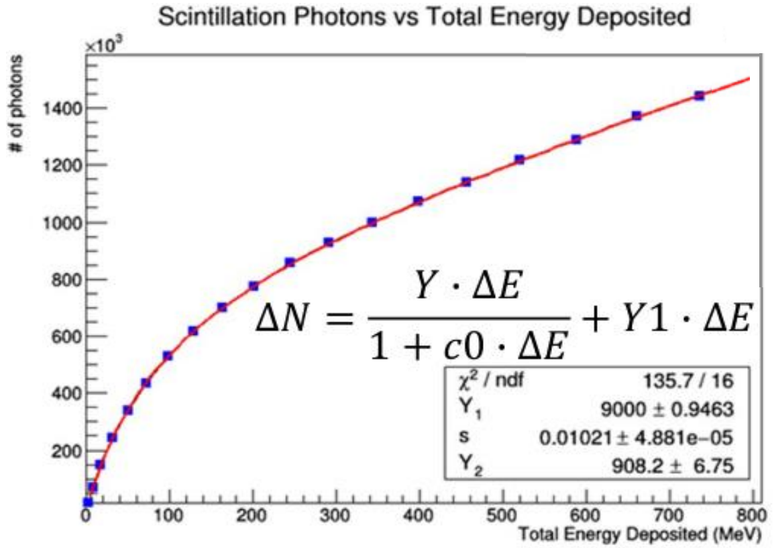
4 layers of PS bars readout by SiPMs, used for *γ* anticoincidence and charge measurements

- Veto efficiency > 99.5% (+/-90°)
- Z resolution < 0.2 c.u @ Z= 2, < 0.3 c.u @ Z = 6
- Veto delay < 150 ns

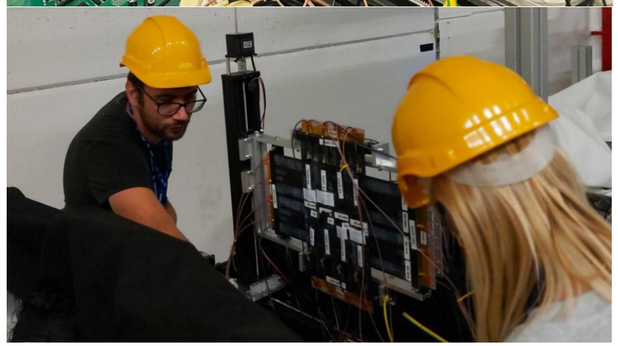




Trapezoidal bar shape helps increasing the hermeticity of the PSD layer



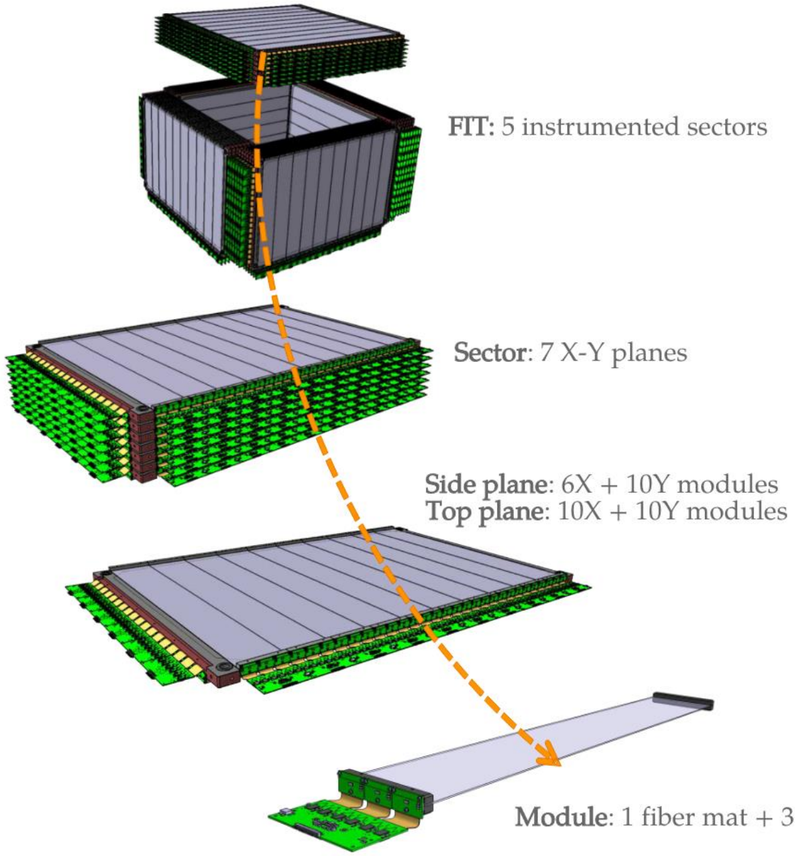
G4 Simulations
by C. Altomare



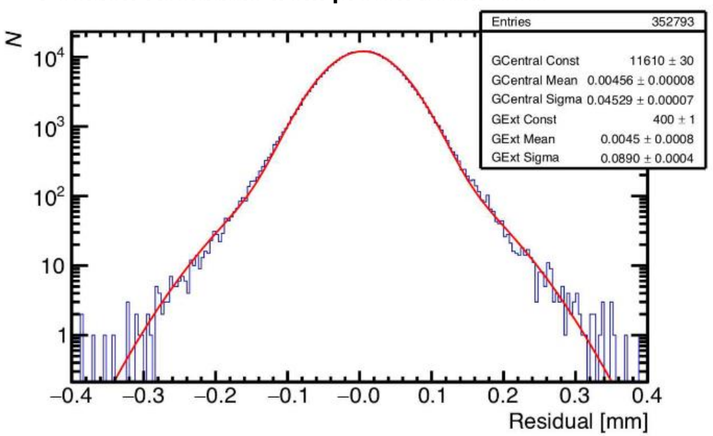
FIber Tracker (FIT)

Track reconstruction of the impinging particles by using scintillating fibers readout by SiPMs

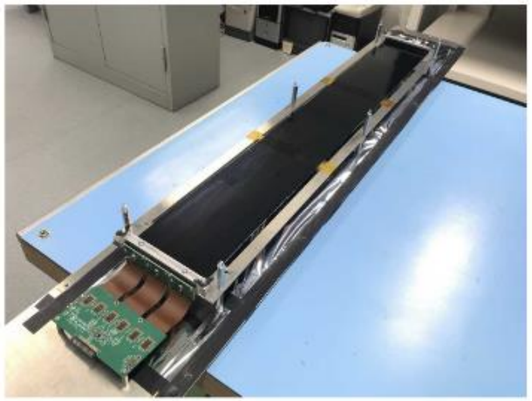
- Angular resolution < 0.6° @ 1GeV, 0° inc. angle
- Coverage ratio > 80%
- Z resolution < 0.3 c.u. @Z=2



Position Residuals from proton beam tests



Spatial resolution = (45.0 ± 0.1) μm



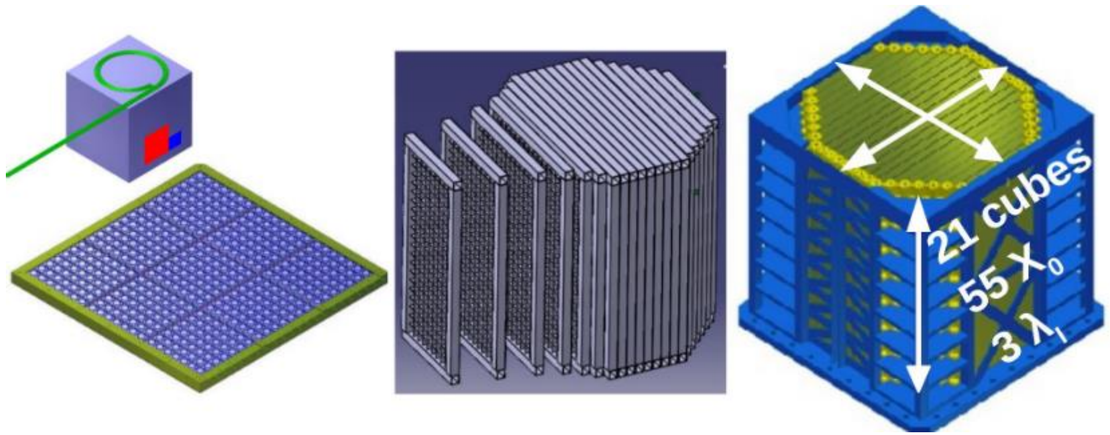
Picture of the FIT prototype

CALOrimeter (CALO)

7500 LYSO crystal cubes array
55 X_0 radiation length

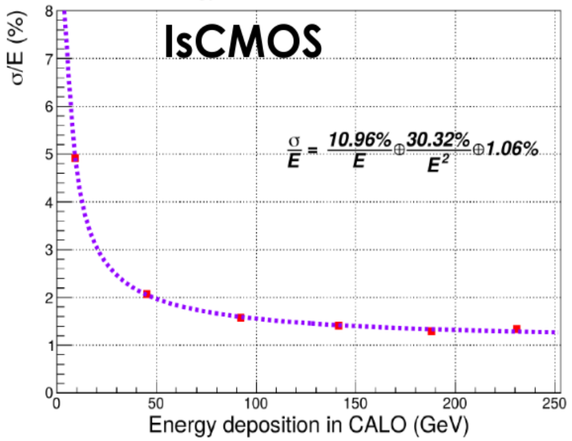
- **Energy resolution:**
  - 1% electrons and γ
  - 20% protons
- **Energy range:**
  - 10 GeV – 100 TeV electrons and γ
  - 30 GeV – PeV protons and nuclei

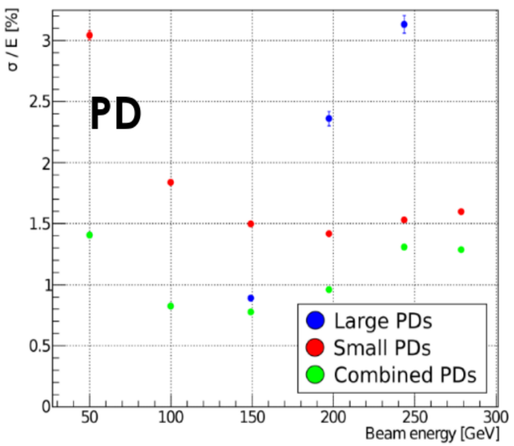
CALO preliminary design, schematic view



Dual readout (IsCMOS and PD) to increase the range, crosscalibrate and reduce the systematics

Energy resolution from electron beam test

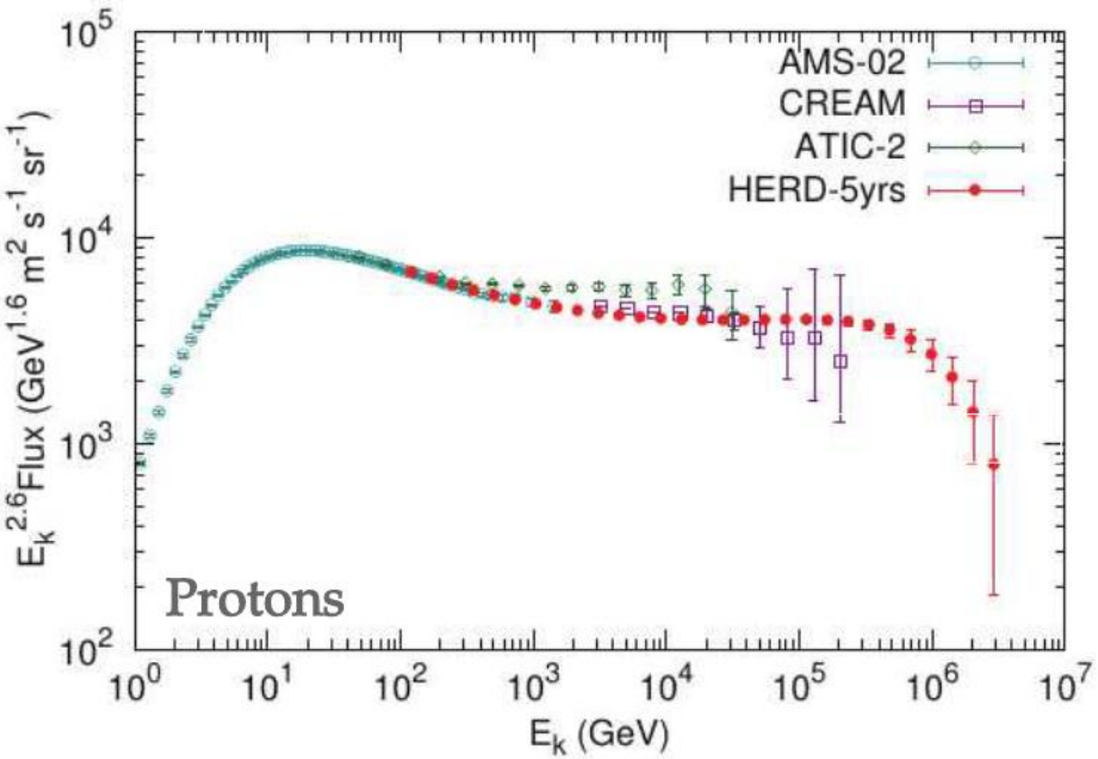


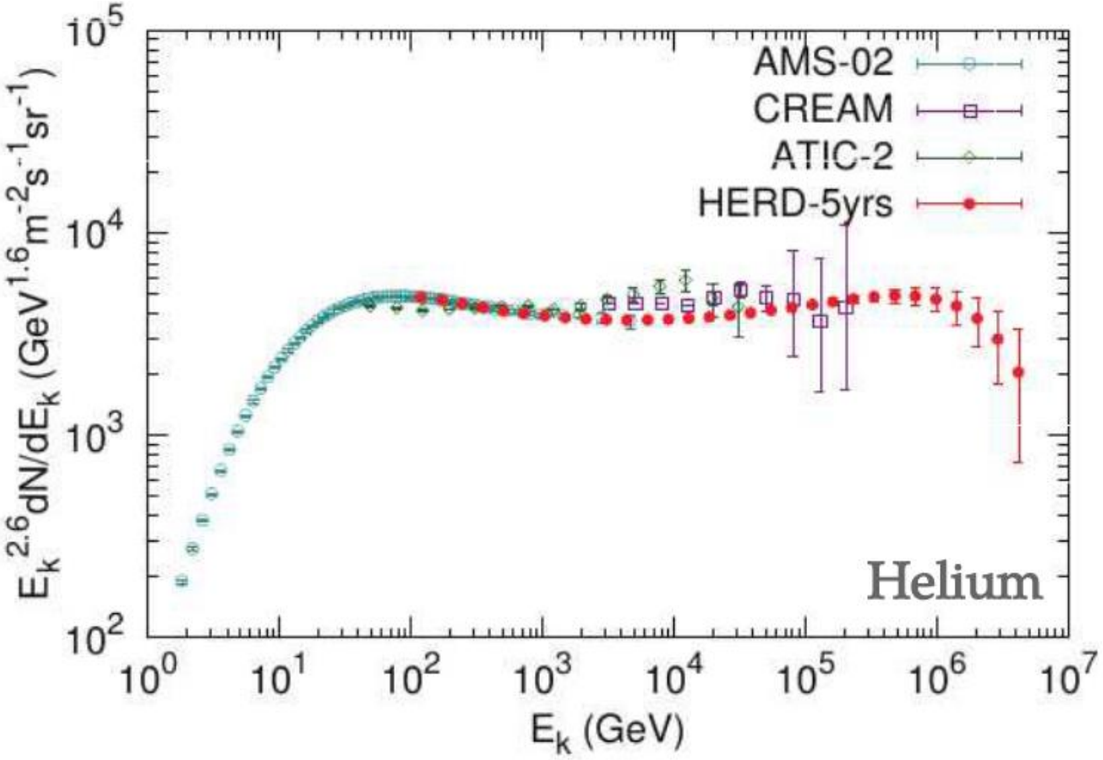


Outlooks on CR nuclei

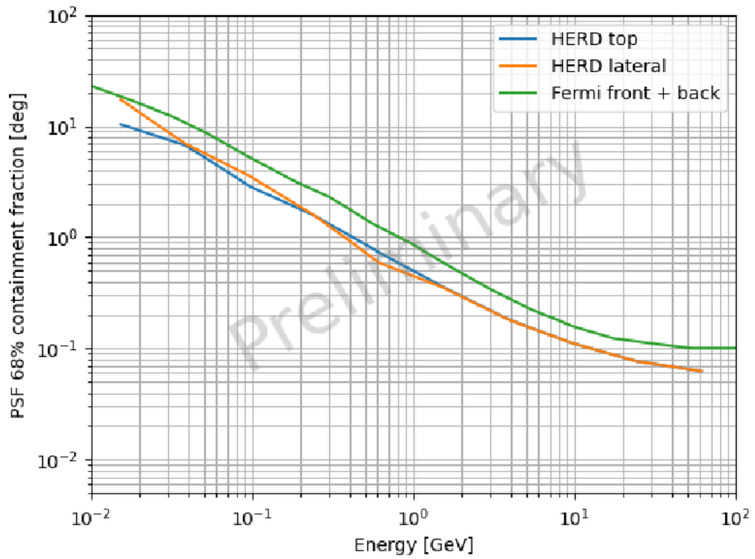
After 5 years of data taking:

- **Direct observation** of protons and helium at the knee of their spectra
- **Increased statistics** in the overall energy range of previous experiments





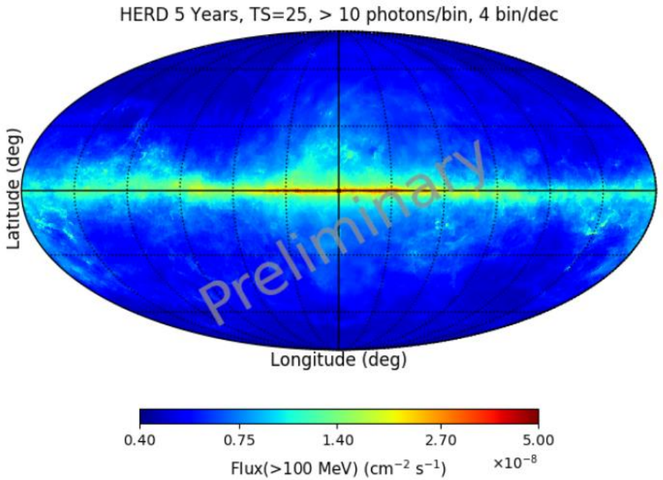
Outlooks on γ astronomy

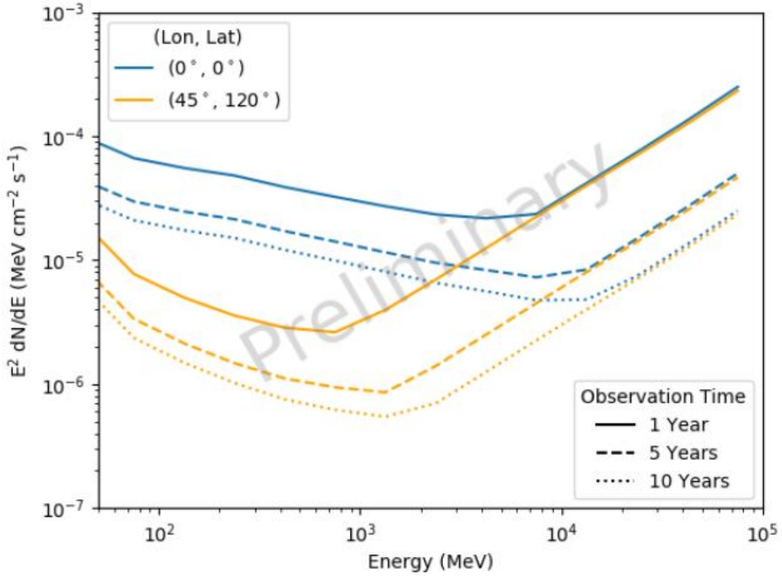


PSF of top and lateral face
Compared with Fermi-LAT PSF

(L. Fariña et al., PoS ICRC 2021, 651)

5 years Sky Map for E > 100 MeV





Differential sensitivity to point-like sources

Using its very large FoV and Energy coverage, HERD can produce alerts for MultiMessenger astronomy, and study **transient phenomena**, also combining data with CTA and LHAASO

Summary

- The goals and the performances that can be reached by the HERD Space Mission
- How the preliminary design of the HERD subdetectors modules look like
- Some outlooks on the science that can be made with HERD
- We are working on the detector optimization using data from simulations, test beam and cosmic-ray muons