Horizon 2020
European Union Funding
for Research & Innovation

PAN
Penetrating Particle Analyzer

Development of a Penetrating particle ANalyzer for high energy radiation measurements in deep space and interplanetary missions

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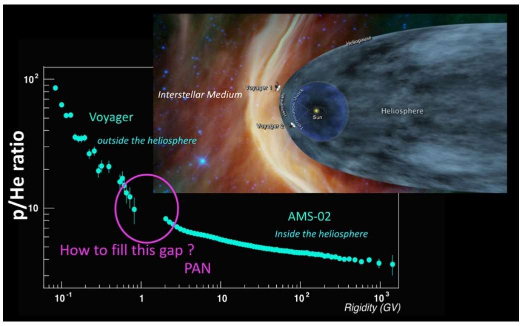
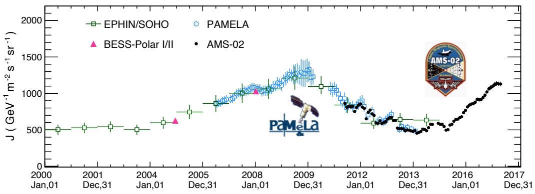
INFN Sez. di Perugia





Cosmic ray physics: fill an in situ observation gap of **galactic cosmic rays** (GCRs) in the GeV region in deep space

→understanding of the origin of the GCRs and their interplay with solar activities

→antimatter searches

Solar physics: provide precise information on solar energetic particles

→study the physical process of solar events, in particular those producing intensive flux of energetic particles.

Space weather:

→improve **space weather models** from the energetic particle perspective

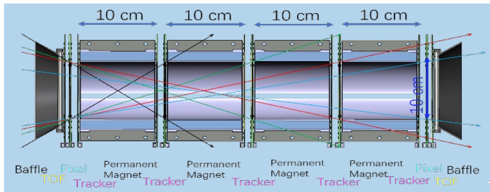
Planetary science:

→develop a full picture of the **radiation environment of a planet**, in particular as a **potential habitat.**

Deep space travel: Penetrating particles are difficult to shield. PAN can **monitor the flux and composition of penetrating particles during a space voyage**. PAN can become a standard on-board instrument for deep space travel.

→ after AMS: no monitoring at supra-GeV energies…
no instrument covering e^+, e^-, p, He, C, O, ...
→ after PAMELA no monitoring at sub-GeV energies...

PAN Instrument



- *Tracker:*

five silicon modules will provide excellent rigidity resolutions, particle direction measurement with an angular resolution of 0.2 deg, a trigger and the measurement of Z

- *The Magnet:*

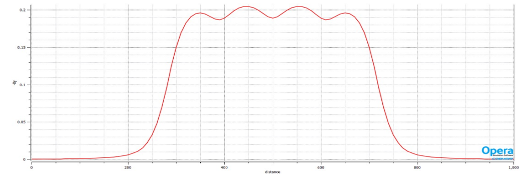
four permanent magnet sectors with a 0.2 T magnetic field. Each sector will be 10 cm long with diameter of 10 cm

- *TOF detectors:*

made of plastic scintillator readout by SiPM. Will provide a trigger, particle counter (max. ~10 MHz), charge measurement (Z = 1 -26), and time measurement (< 100 ps)

- *Pixel Detector:*

made by two modules providing Time of Arrival (ToA) and Time over Threshold (ToT) measurement, will avoid measurement degradation for high rate solar events and at lower rate solar events. Gives one extra 3D point

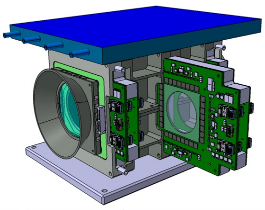


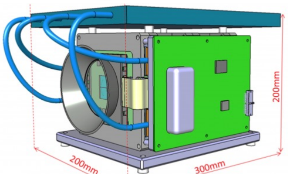
Mini.PAN Demonstrator

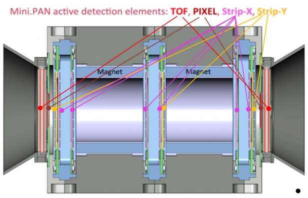
Mini.PAN is funded by European Commission as a technology demonstrator

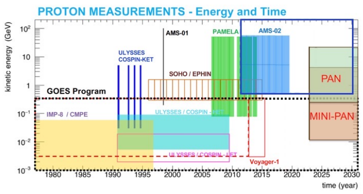
- Max 8 kg
- 20 W
- 2 Sectors with smaller dimensions with the same instrumentation (ToF, pixel, strip)
- Mini.PAN is suitable for space weather and planetary radiation measurements

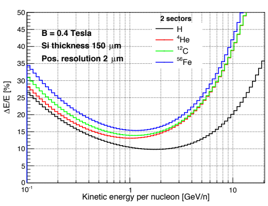
- We are actively looking for flight opportunities (from 2023):
  - Lunar Gateway
  - CubeSat missions
  - Jupiter radiation belt exploration
  - European Large Logistic Lander (EL3) for Moon exploration



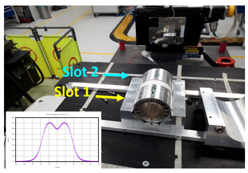




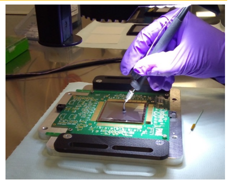




- GF: ~6.3 or 2.1 cm^{2}sr (x2 for isotropic sources, for crossing 1 or 2 sectors)
- Energy resolution for 1-sector acceptance same as PAN (<20% for protons of 0.2 – 2 GeV)
  - shorter sector length compensated by stronger B field

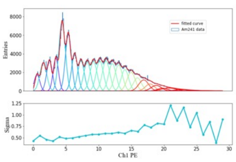


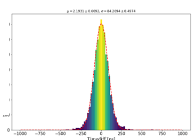
Magnet 2 permanent magnet Halbach arrays, each f = 5 cm, L = 5 cm, provide a dipole magnetic field of ~0.4 T, magnet weight ~2 kg



μstrips 2 Strip-X with 25 μm pitch,32 VA1140, 2048 chs; 1 Strip-Y with 500 μm pitch, VATA GT7.2, 128 chs

Pixels Timepix 3 quad detector
Challenge: Power consumption (currently: 5.5 W → goal: 2.5 W)





ToF Scintillator: EJ-230;
SiPMs: HPK-S13360-6050 for Time, HPK-S13360-6075/6025 for Energy;
ASIC: TRIROC (Time), CITIROC (Energy) from WEEROC

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