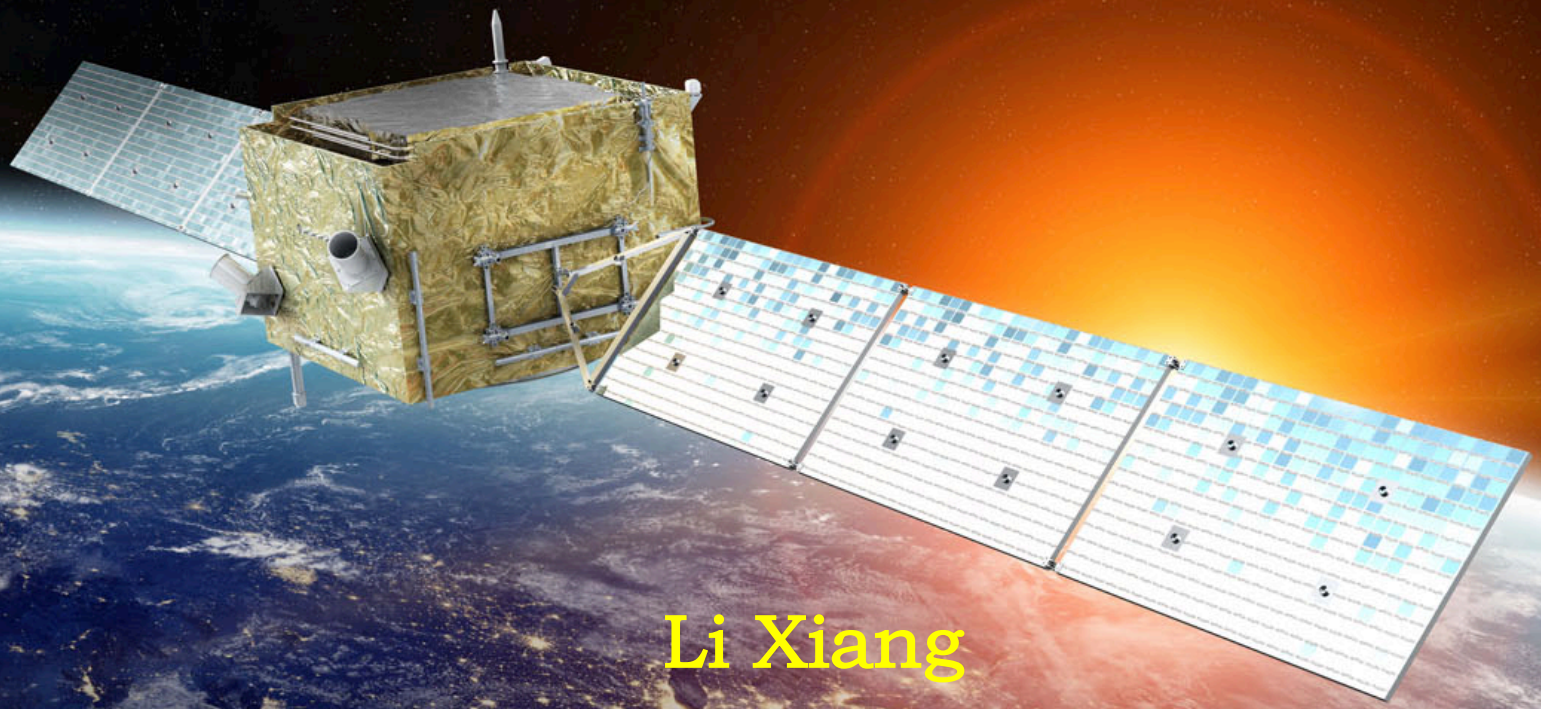
Key Laboratory of Dark Matter and Space Astronomy, CAS

53rd Moriond, La Thuile, 10-17 March 2018

DAMPE Mission and Its First Result



Li Xiang

Purple Mountain Observatory, CAS

(on behalf of the DAMPE collaboration)

The collaboration

- **PI of DAMPE: Jin Chang from PMO**

- **CHINA**
  - **Purple Mountain Observatory, CAS, Nanjing**
  - **University of Science and Technology of China, Hefei**
  - **Institute of High Energy Physics, CAS, Beijing**
  - **Institute of Modern Physics, CAS, Lanzhou**
  - **National Space Science Center, CAS, Beijing**

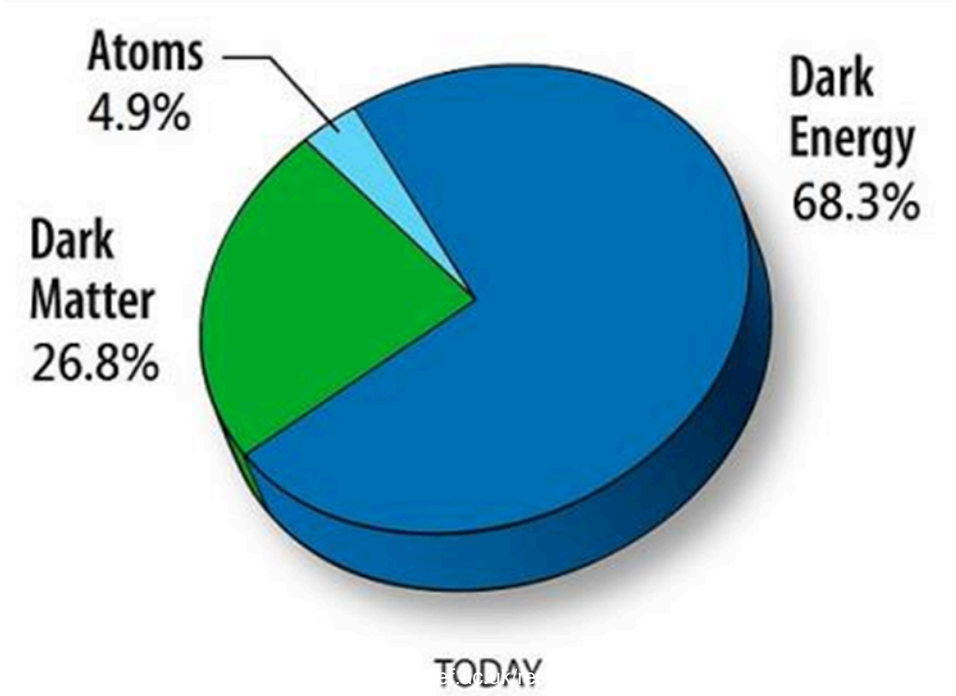
- **ITALY**
  - **INFN Perugia**
  - **INFN Bari**
  - **INFN Lecce**

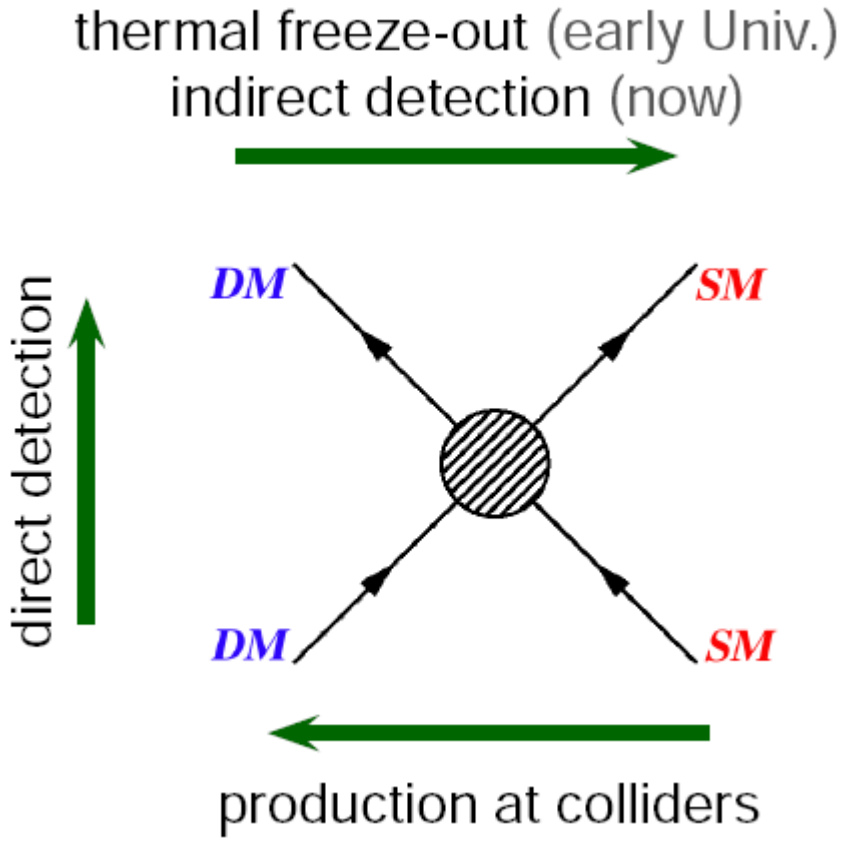
- **SWITZERLAND**
  - **University of Geneva**

Outline

- **Background**
- **DAMPE mission**
- **First Result**

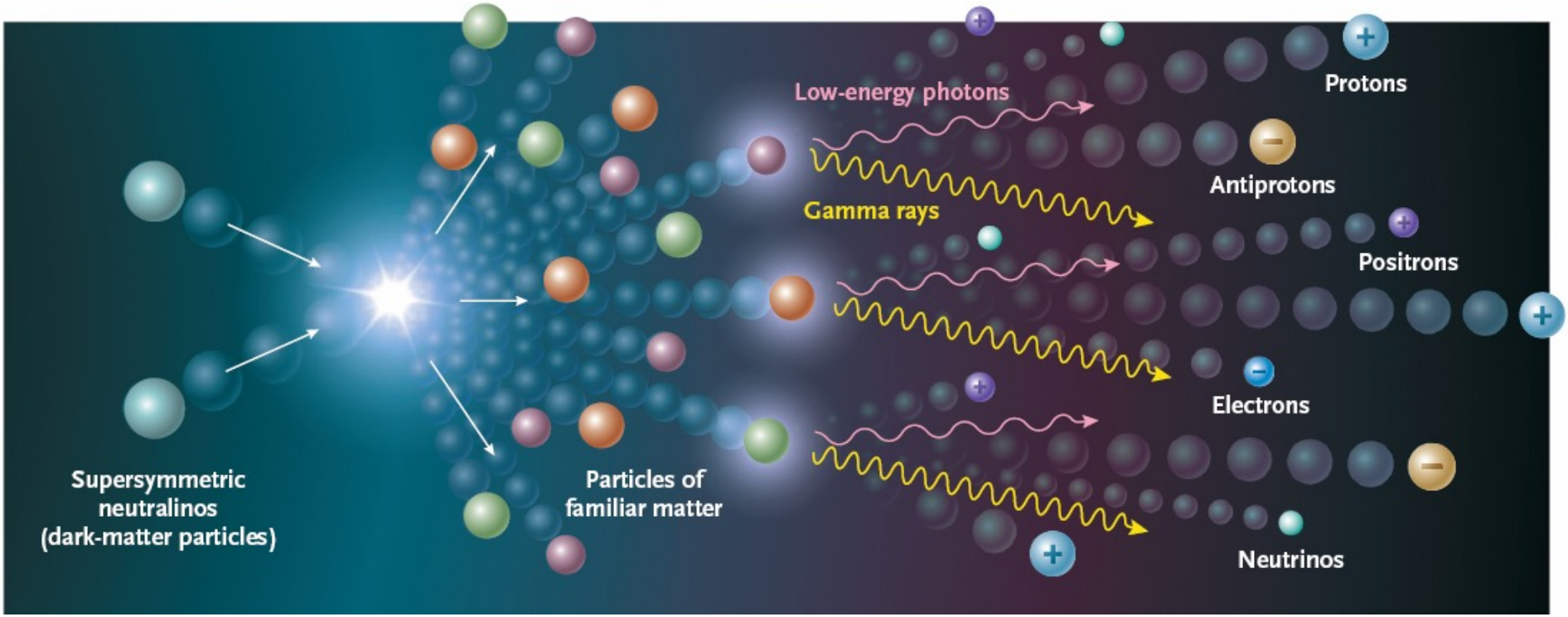
Dark matter





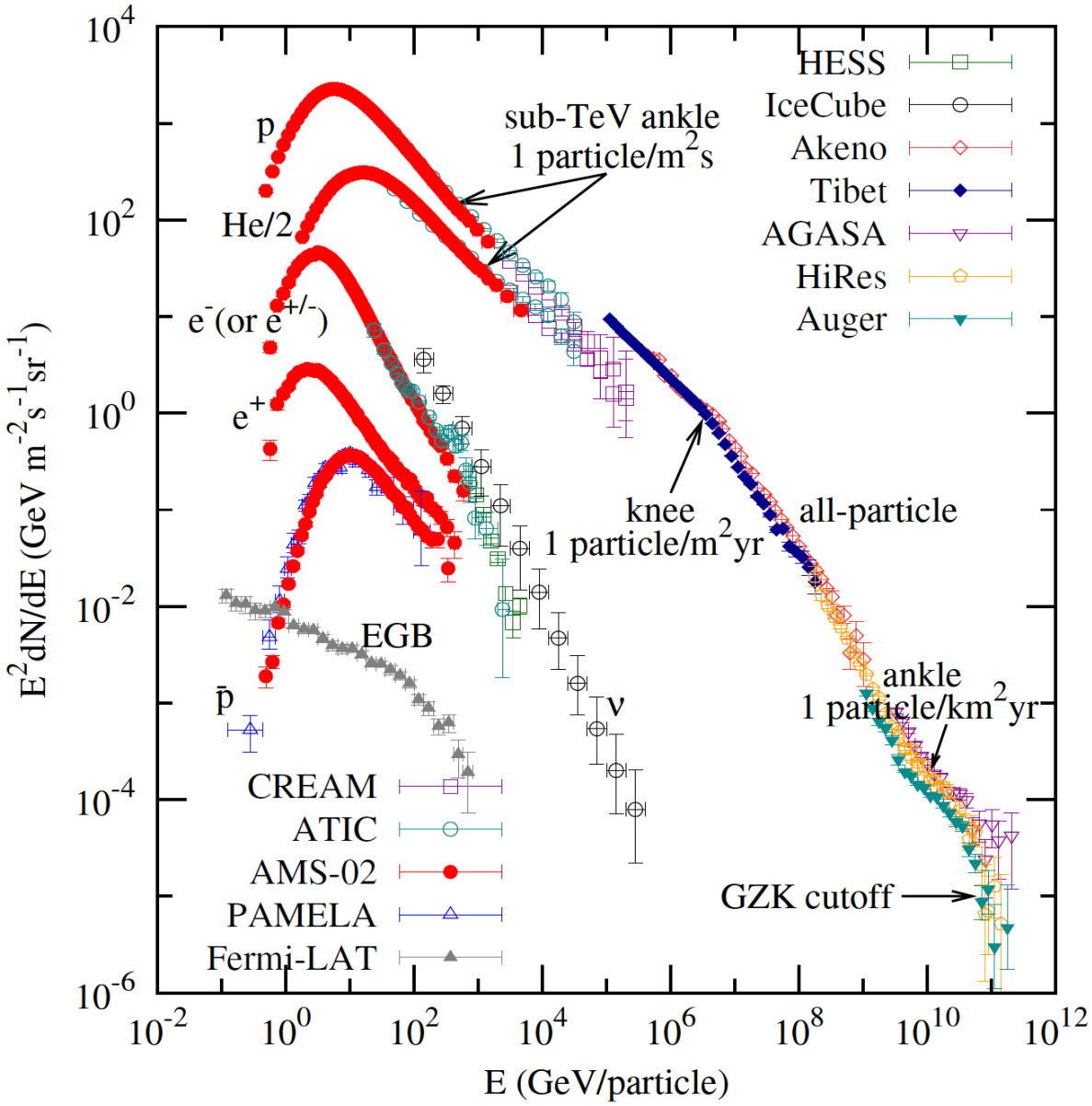
- Compelling astrophysical evidence for dark matter
- New particle or modified gravity?
- Three detection methods

Dark matter indirect detection



Dark matter particles may annihilate and then generate pairs of particles and anti-particles (gamma-rays, electrons/positrons, proton and antiprotons), see e.g., Bergström & Snellman 1988, Turner &Wilczek 1990

Dark matter indirect detection



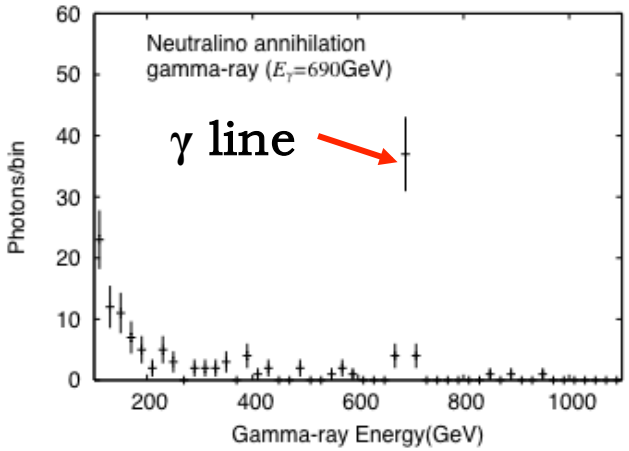
DM signal in anti-particles (AMS-02 like detectors): lower background

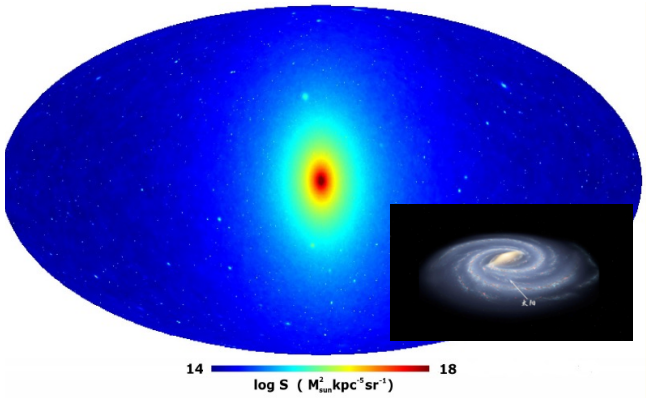
Electrons: relatively small contrast between the electron and positron flux

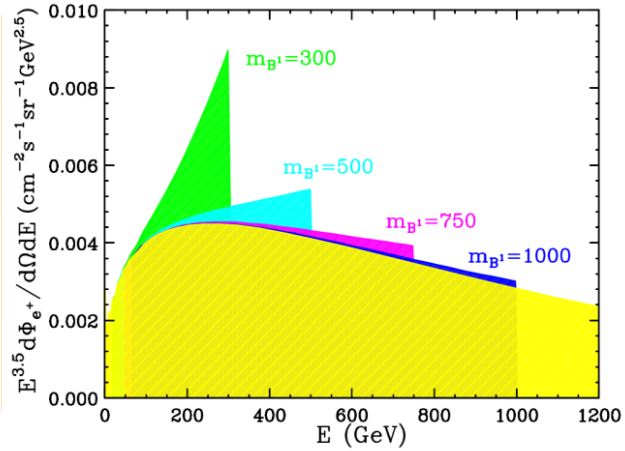
Gamma-rays and neutrinos: trace the source

Dark matter indirect detection

Possible DM signal in γ-rays and electrons



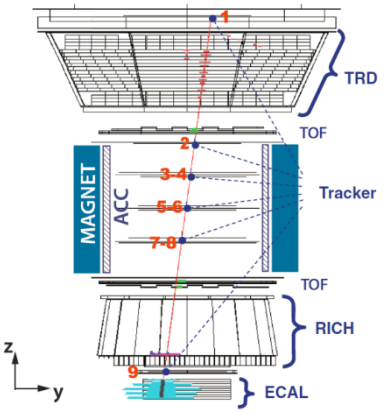


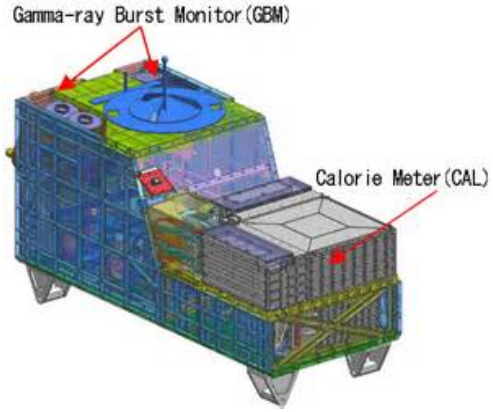


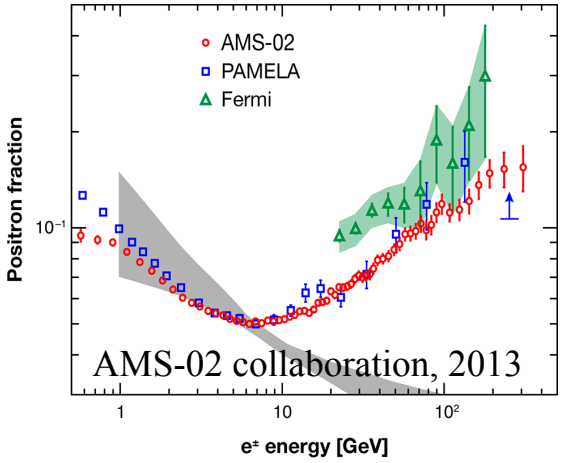
- The γ-ray line
- Continual γ-ray emission spatially correlated with the DM distribution
- Electrons with unusual spectrum

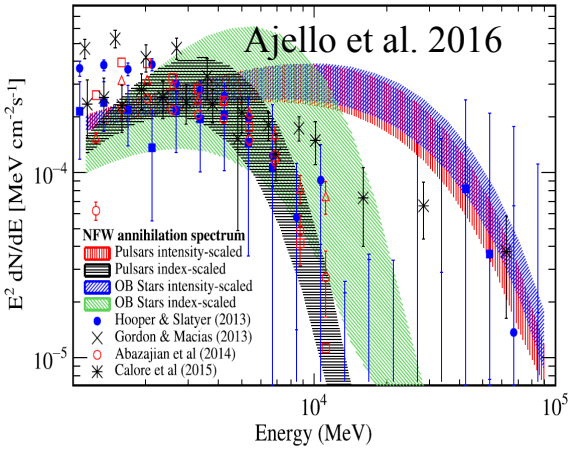
Dark matter indirect detection

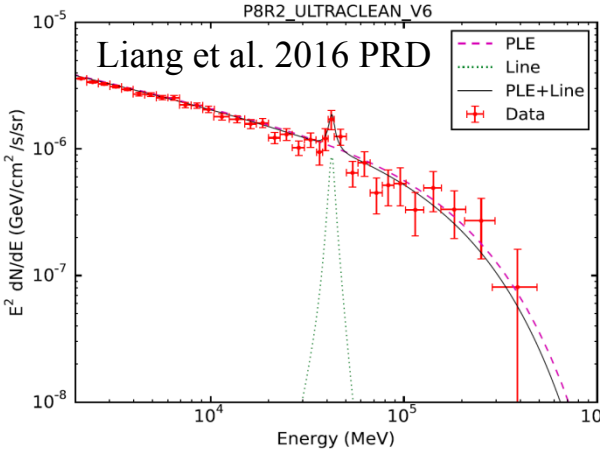
Some previous/current experiments and hints





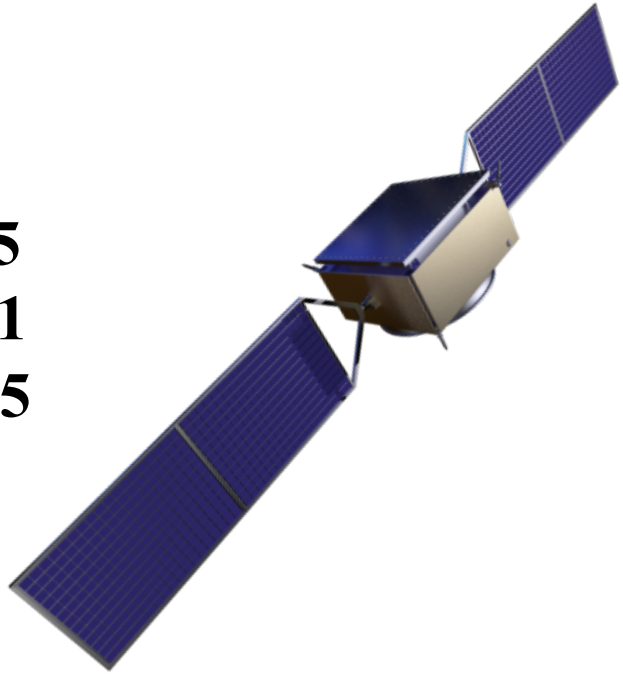






DArk Matter Particle Explorer

Proposed: 2005
Founded: 23 Dec. 2011
Launched: 17 Dec. 2015



悟空
Wukong

●Scientific objectives：
(a)Probing the nature of dark matter
(b)Understanding acceleration and propagation of cosmic rays
(c)Studying γ-ray emission from Galactic and extragalactic sources

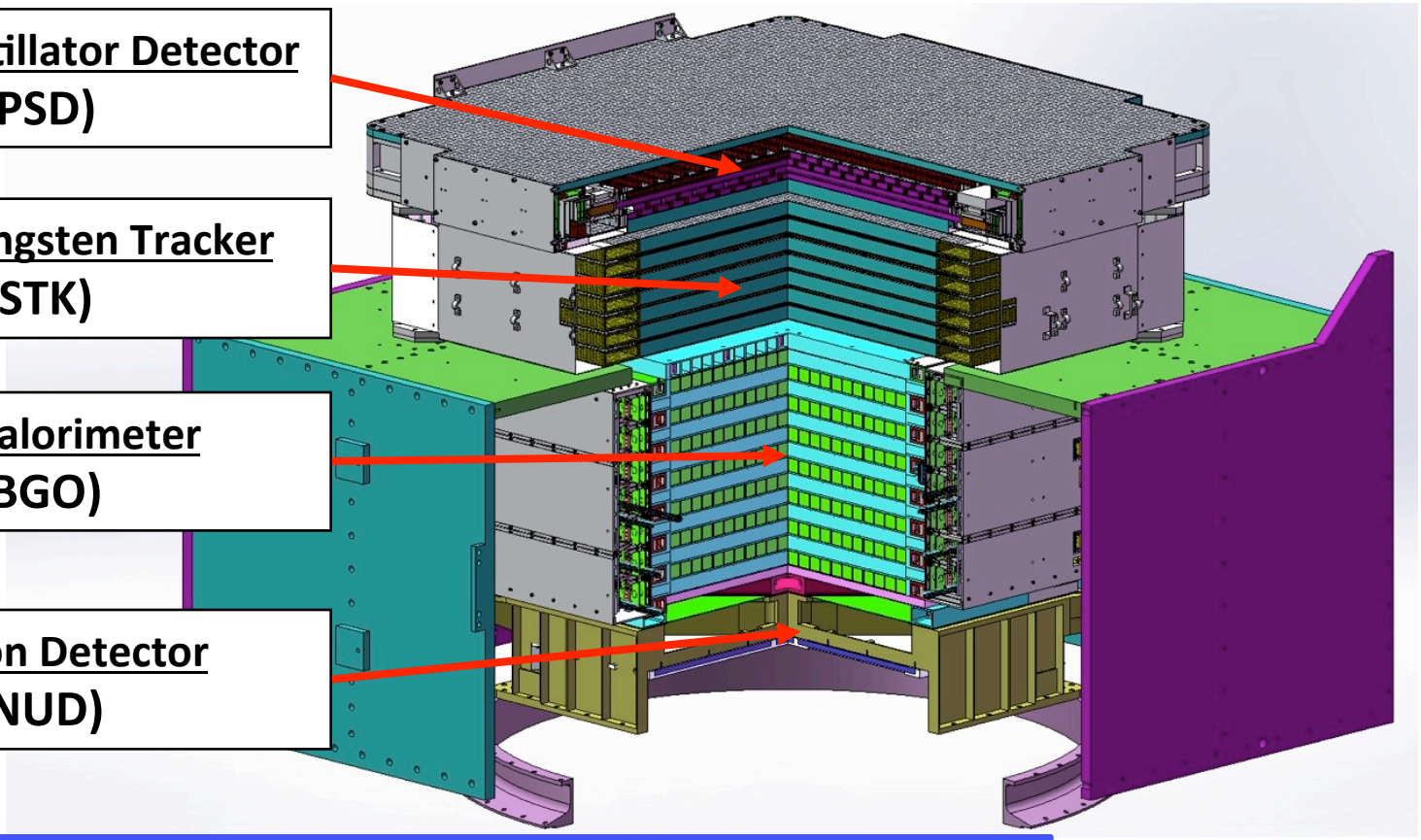
The payload

Plastic Scintillator Detector (PSD)

Silicon-Tungsten Tracker (STK)

BGO Calorimeter (BGO)

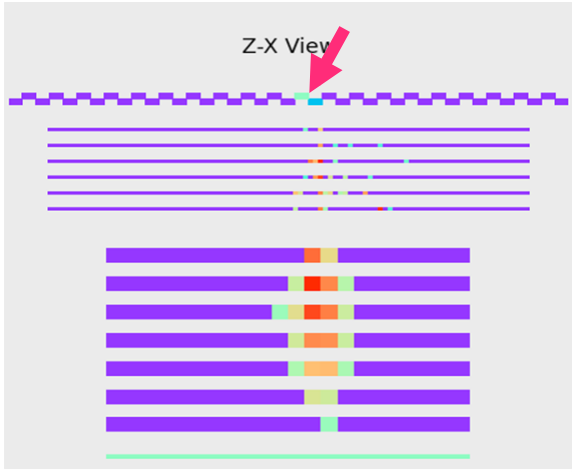
Neutron Detector (NUD)

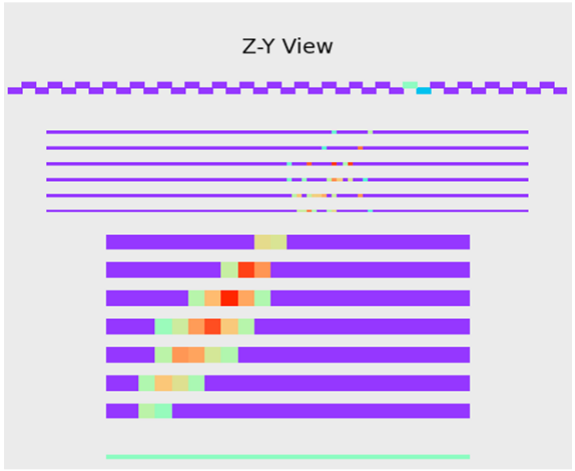


- Charge measurement (dE/dx in PSD, STK and BGO)
- Pair production and tracking (STK and BGO)
- Precise energy measurement (BGO bars)
- Hadron rejection (BGO and neutron detector)

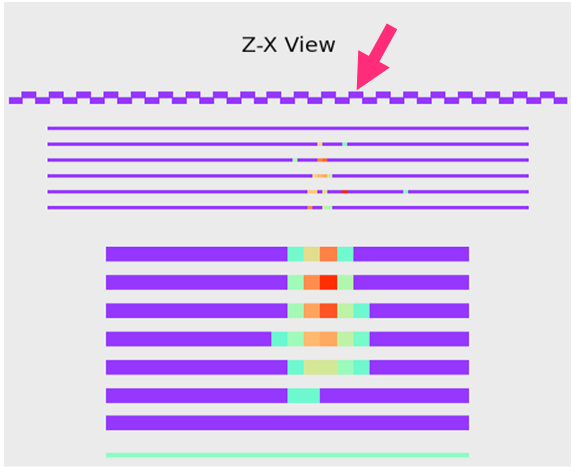
Signals for different particles

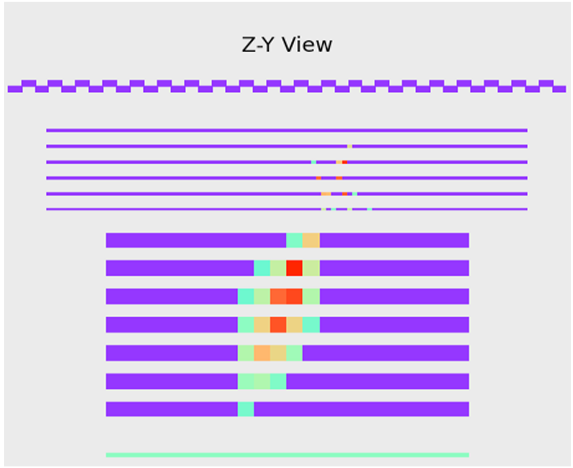
electron



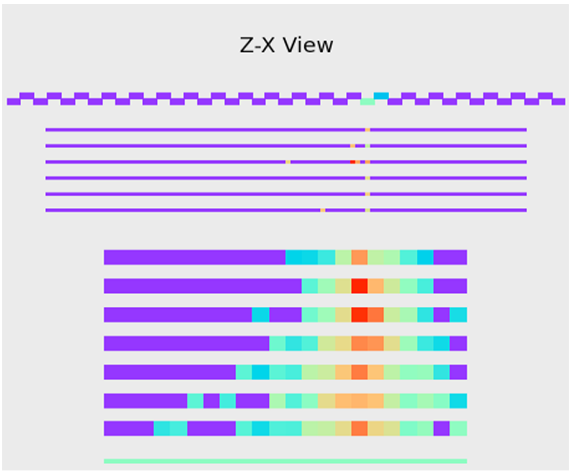


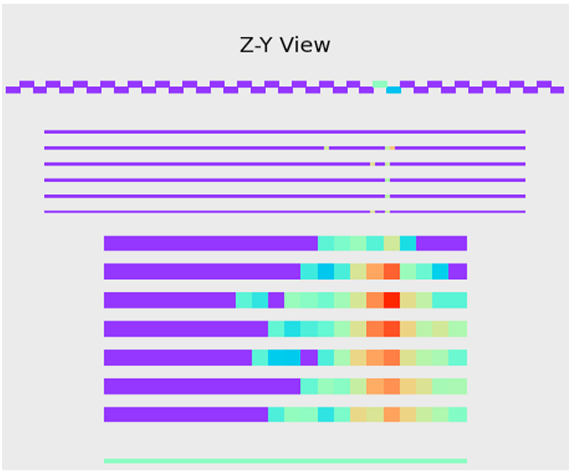
gamma



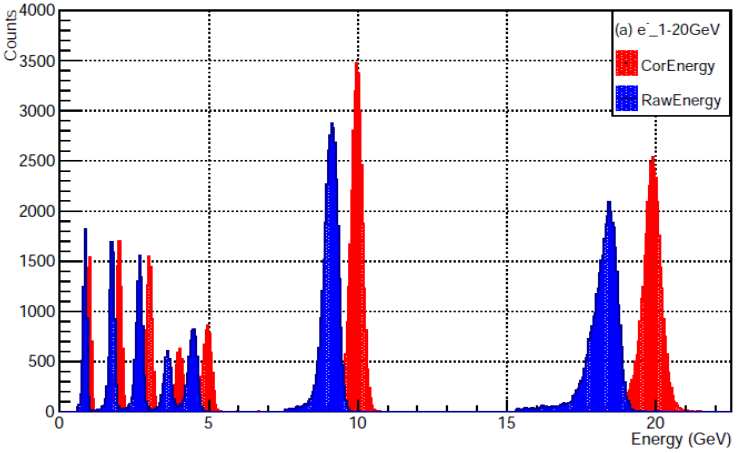


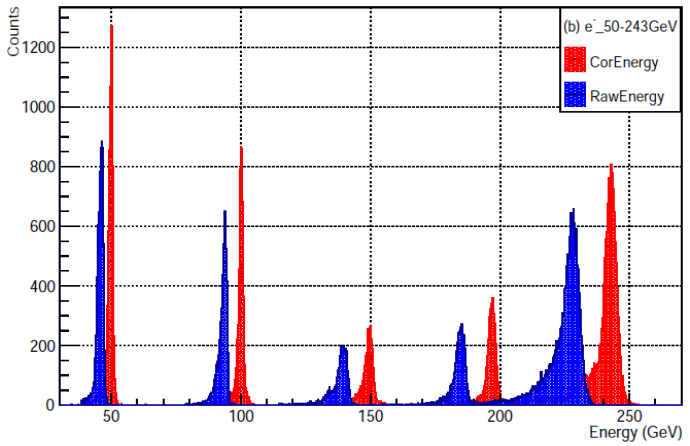
proton

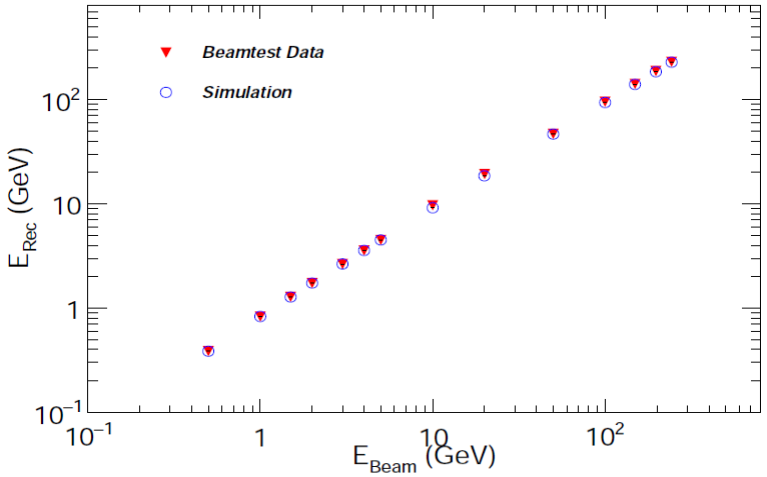




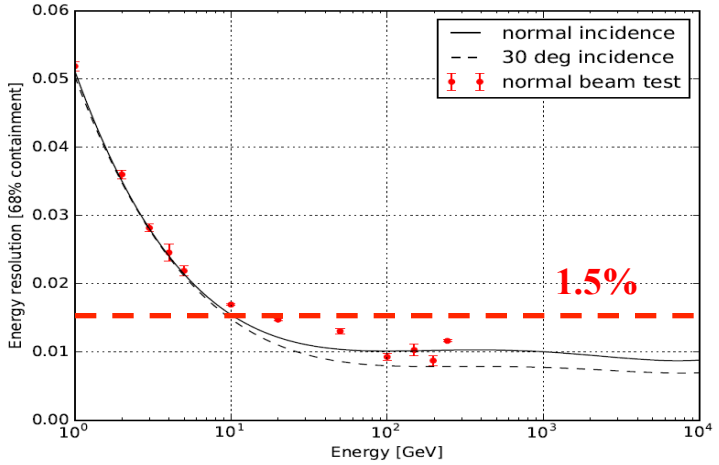
Beam test @ CERN







Energy linearity of electrons



Energy resolution of electrons

(Chang et al. [DAMPE collaboration] 2017 Astropart. Phys.)

Expected performance

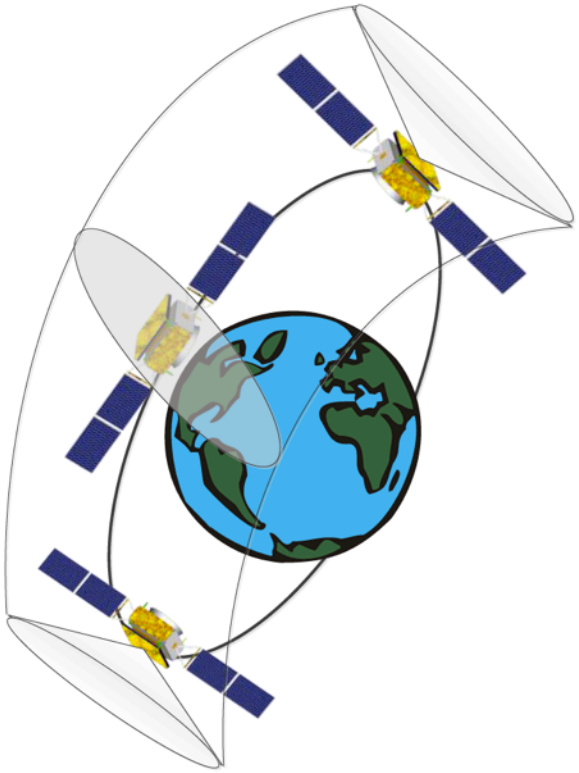
Parameter	Value
Energy range of gamma-rays/electrons	5 GeV to 10 TeV
Energy resolution(electron and gamma)	1.5% at 800 GeV
Energy range of protons/heavy nuclei	50 GeV to 500 TeV
Energy resolution of protons	40% at 800 GeV
Eff. area at normal incidence (gamma)	1100 cm^2 at 100 GeV
Geometric factor for electrons	0.3 m^2 sr above 30 GeV
Photon angular resolution	0.1 degree at 100 GeV
Field of View	1.0 sr

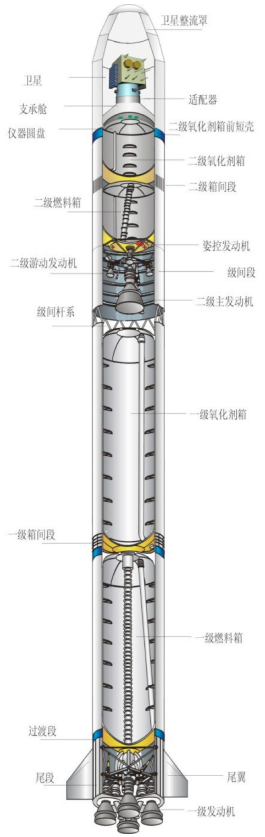
(Chang et al. [DAMPE collaboration] 2017 Astropart. Phys.)

DAMPE mission

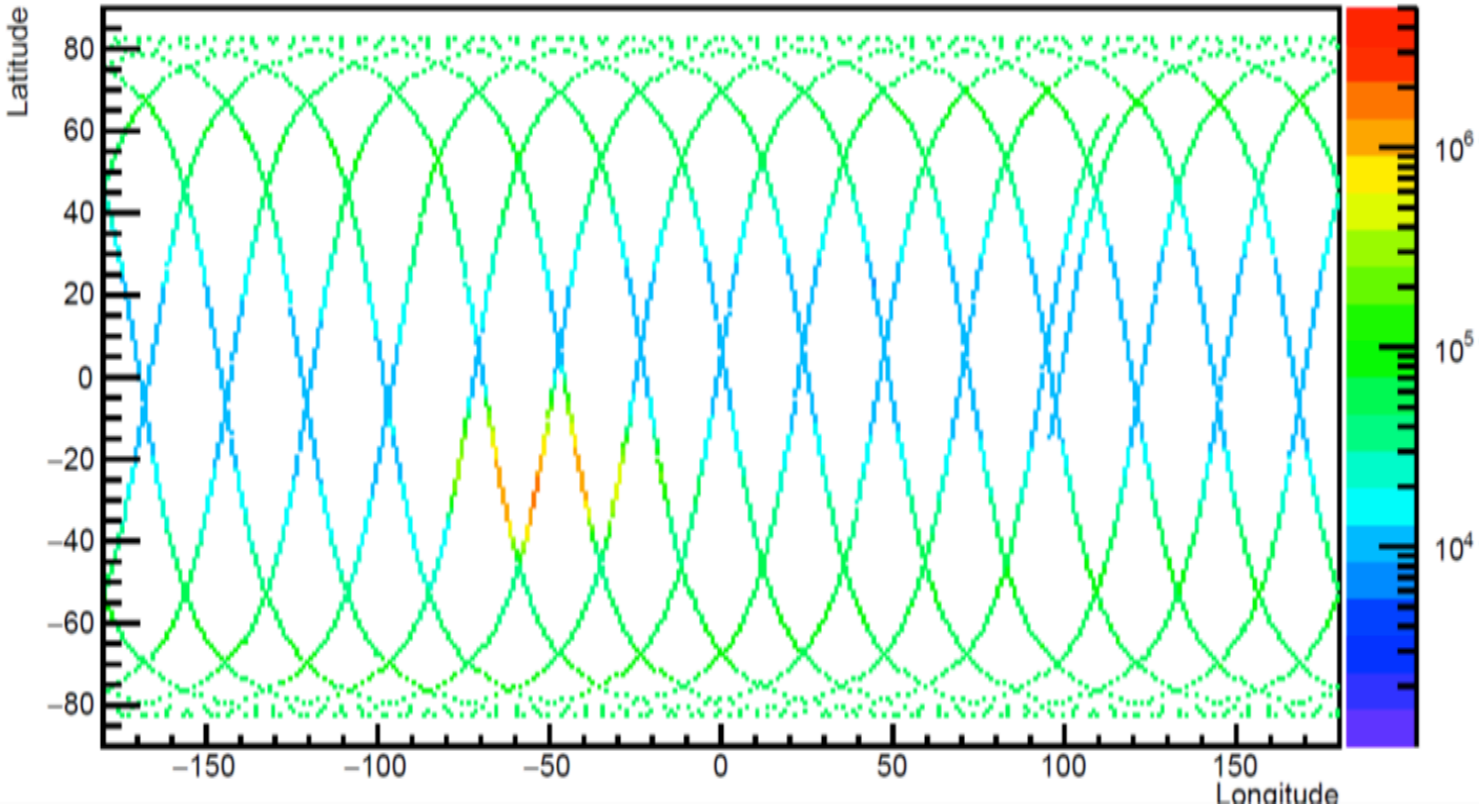
- **Launch: December 17th 2015, CZ-2D rocket**
  - **Total weight ~1850 kg, power consumption ~640 W**
    - **Scientific payload ~1400 kg, ~400 W**
  - **Lifetime > 3 year**

- **Altitude: 500 km**
- **Inclination: 97.4065°**
- **Period: 95 minutes**
- **Orbit: sun-synchronous**
- **16 GB/day downlink**





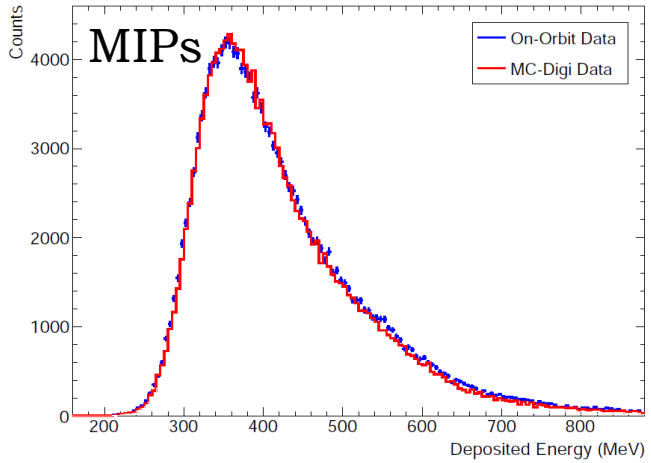
On-orbit trigger rate

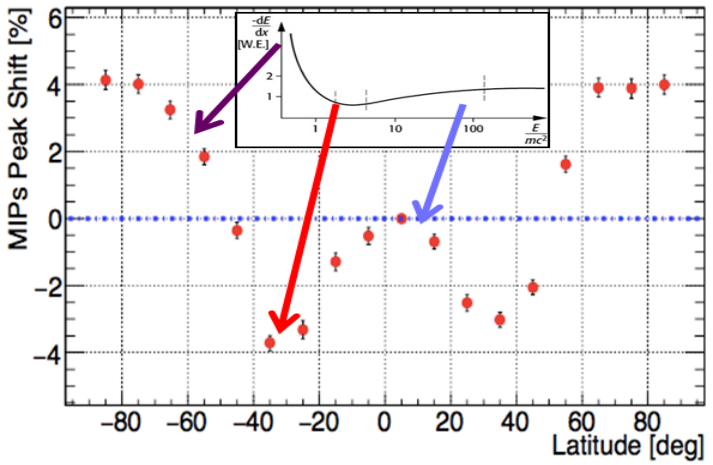


~60 Hz average trigger rate

→100GB (H.L.)/day on ground (about 5 M events)

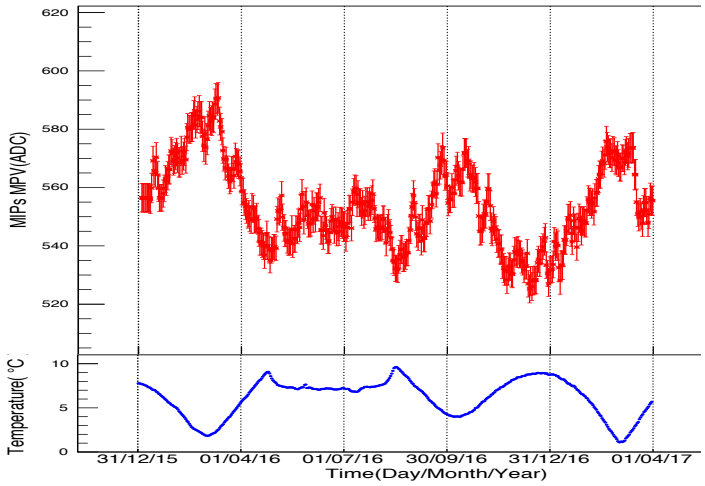
BGO on-orbit calibration: MIPs

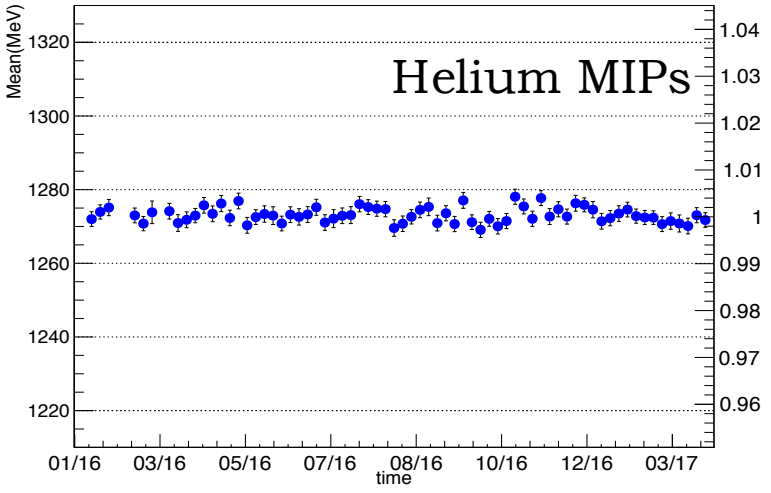




Before temperature correction

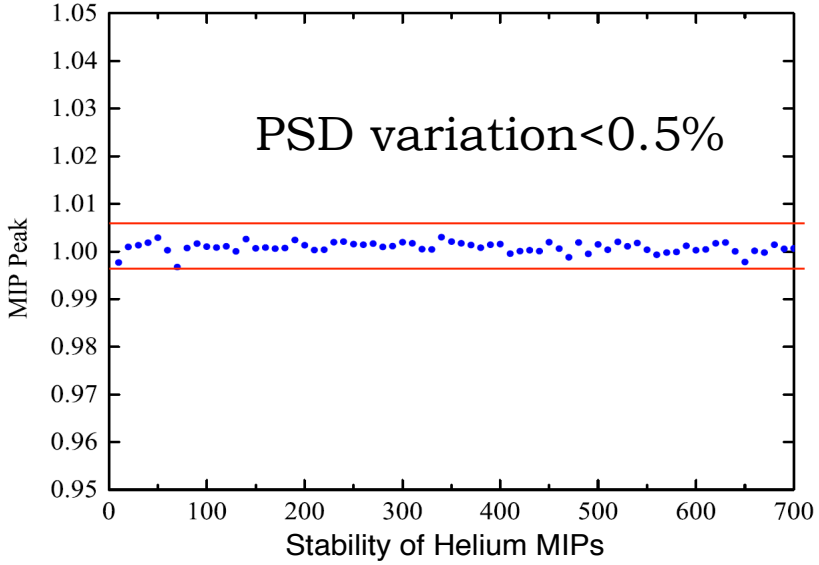
After temperature correction

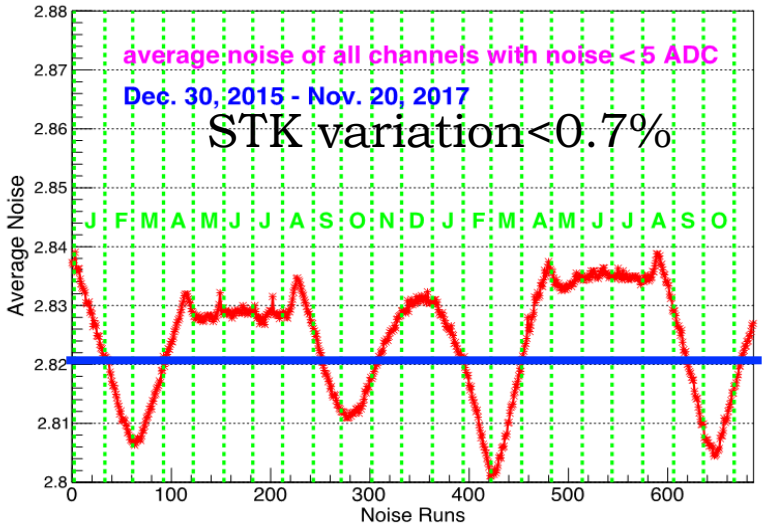


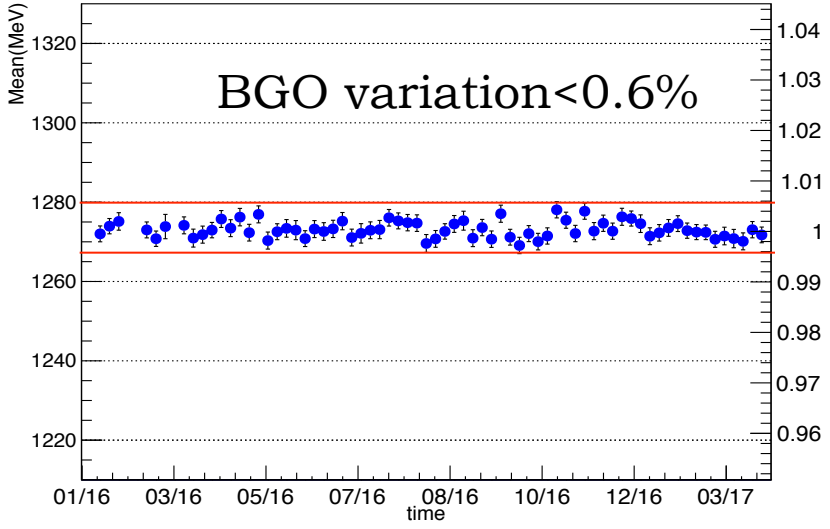


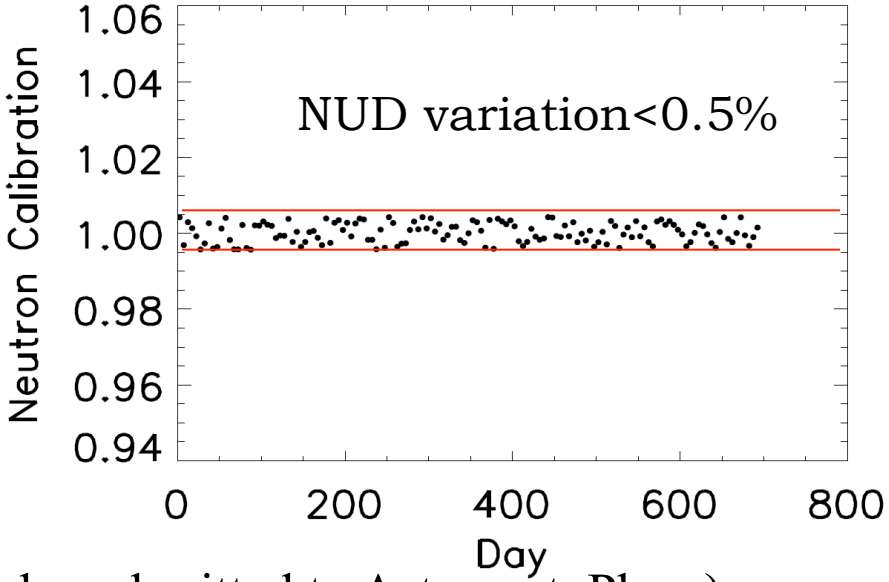
(DAMPE collaboration. 2018, to be submitted to Astropart. Phys.)

Satbility of on-orbit performance



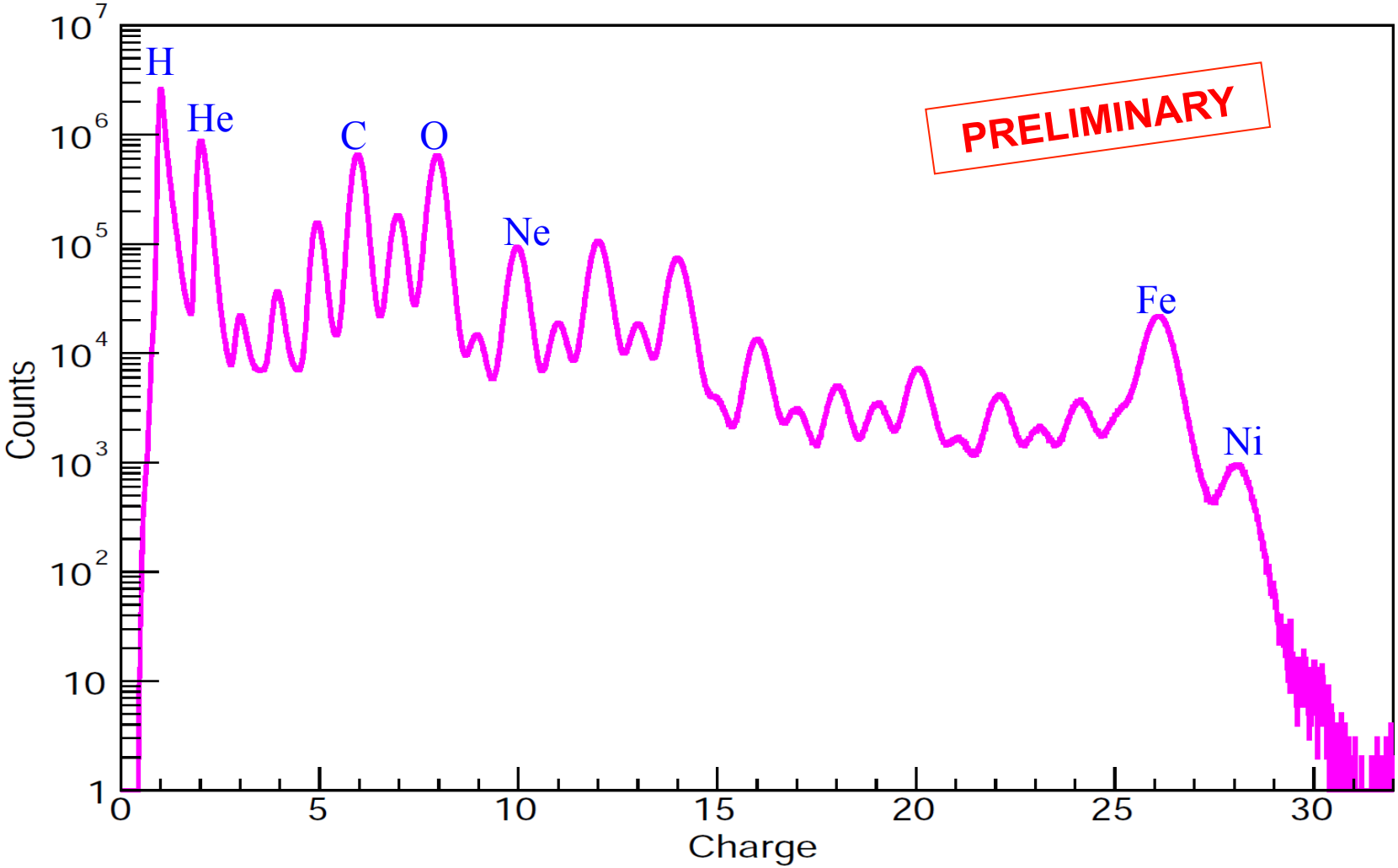






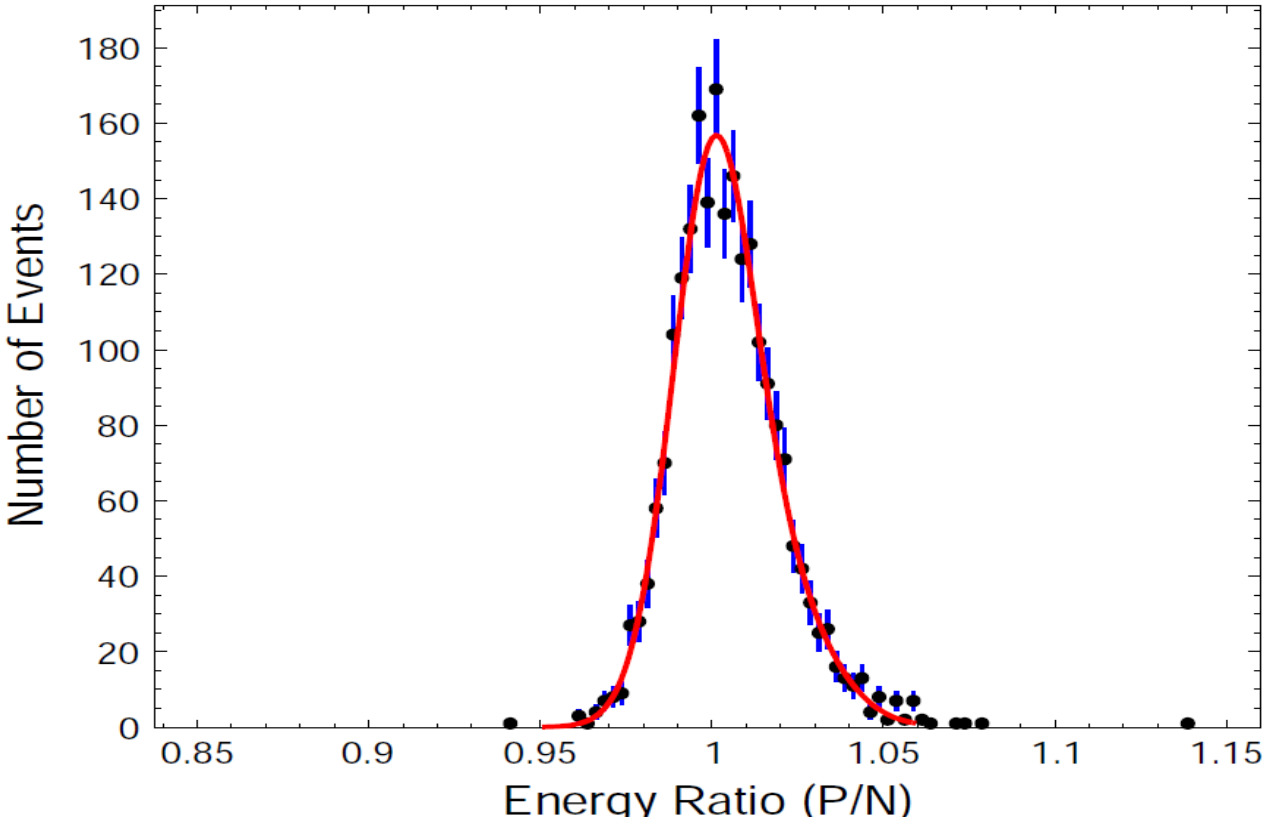
(DAMPE collaboration. 2018, to be submitted to Astropart. Phys.)

On-orbit performance: Charge measurement by PSD



(H, Fe)=(0.12, 0.28)e

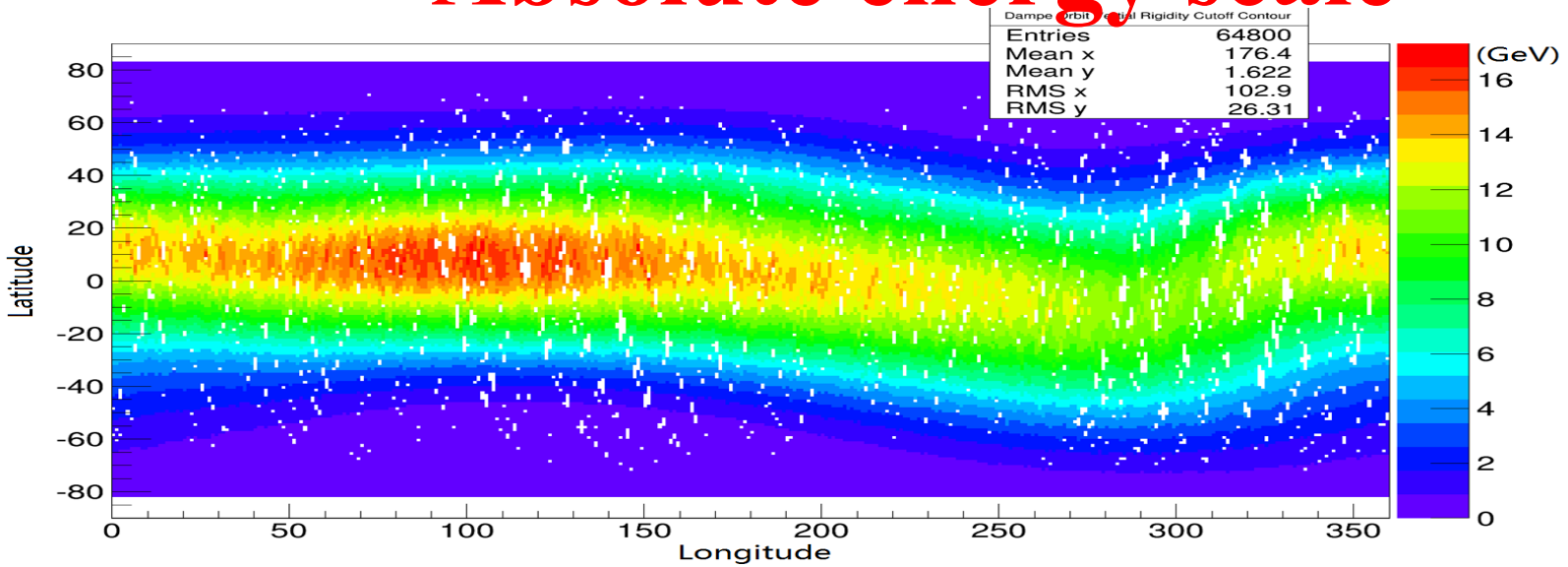
On-orbit performance: energy measurement by BGO

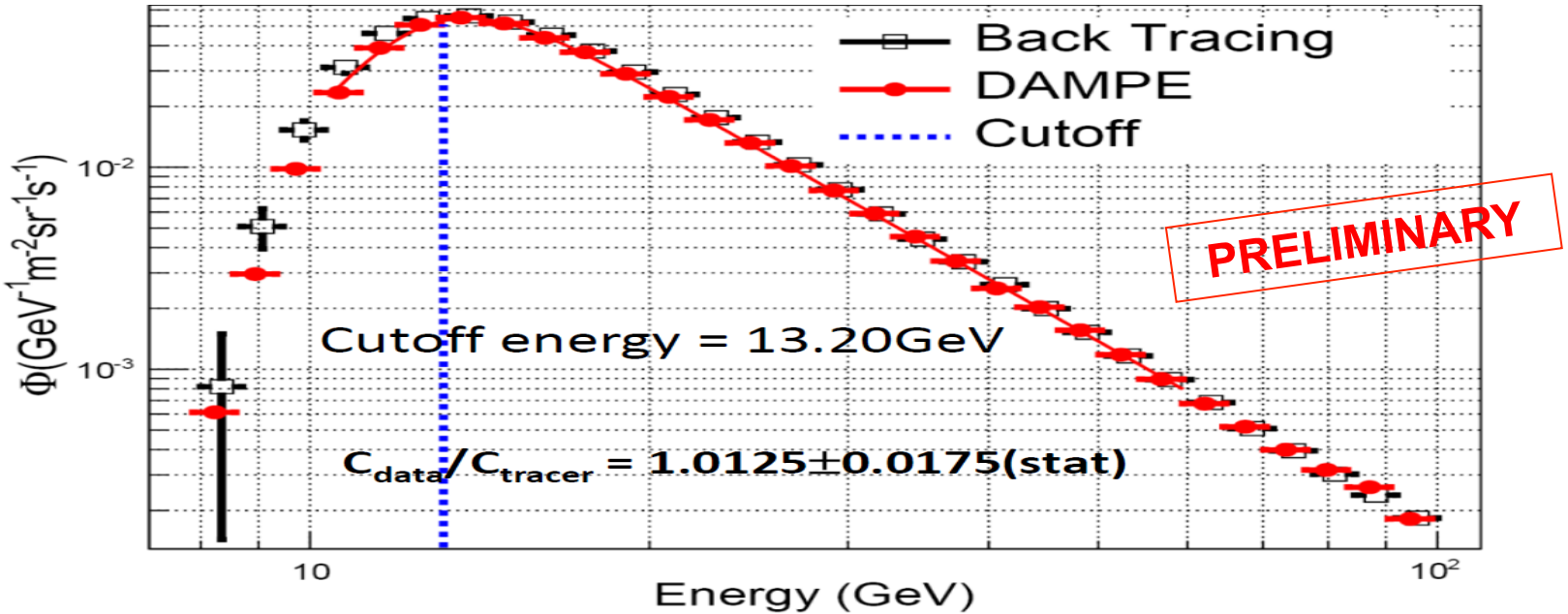


The ratio of the energies reconstructed with positive and negative side readout data of BGO crystals, for CRE candidates with deposit energy of 0.5-1.0 TeV

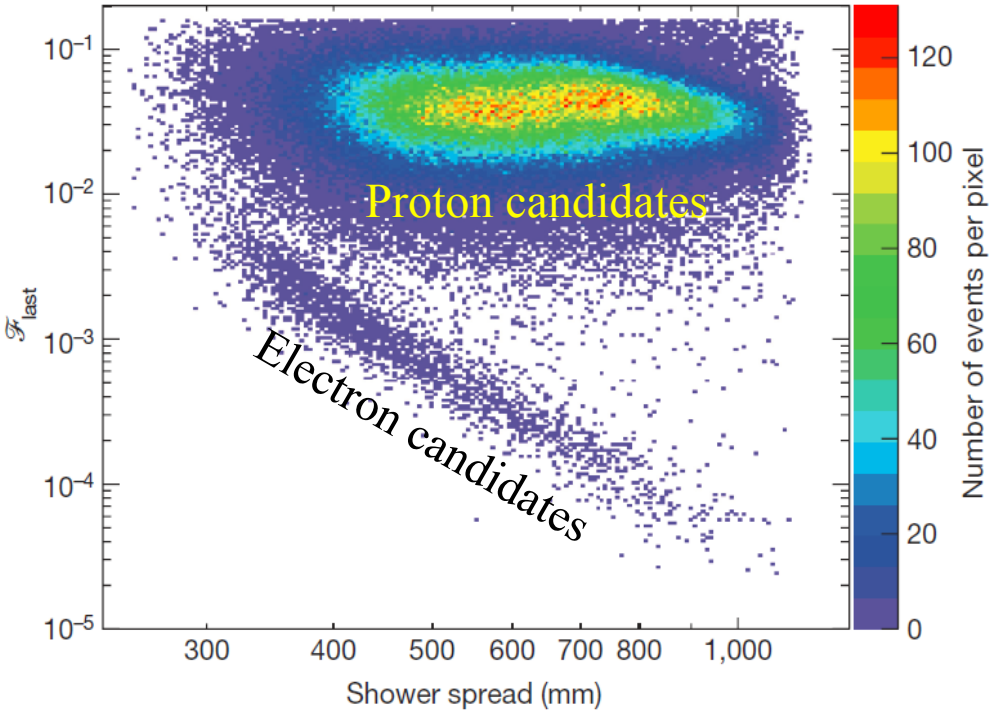
(DAMPE collaboration. 2017, Nature, 552, 63)

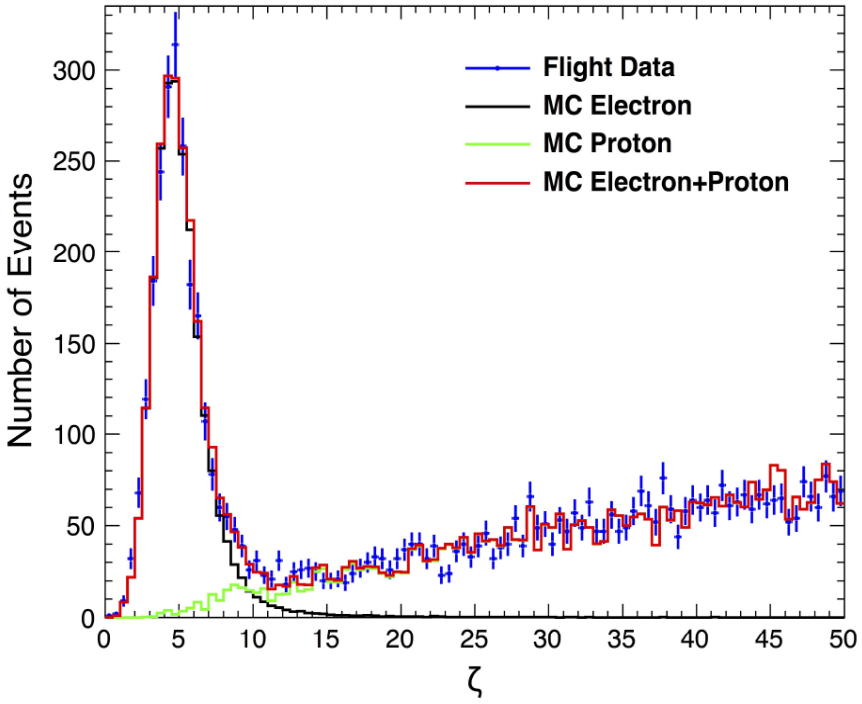
On-orbit performance: Absolute energy scale





On-orbit performance: e/p separation

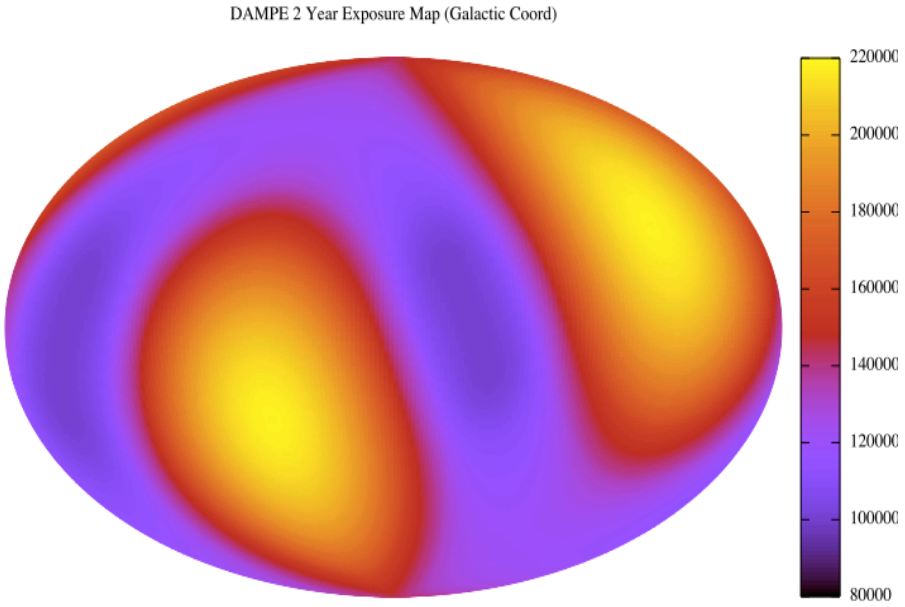


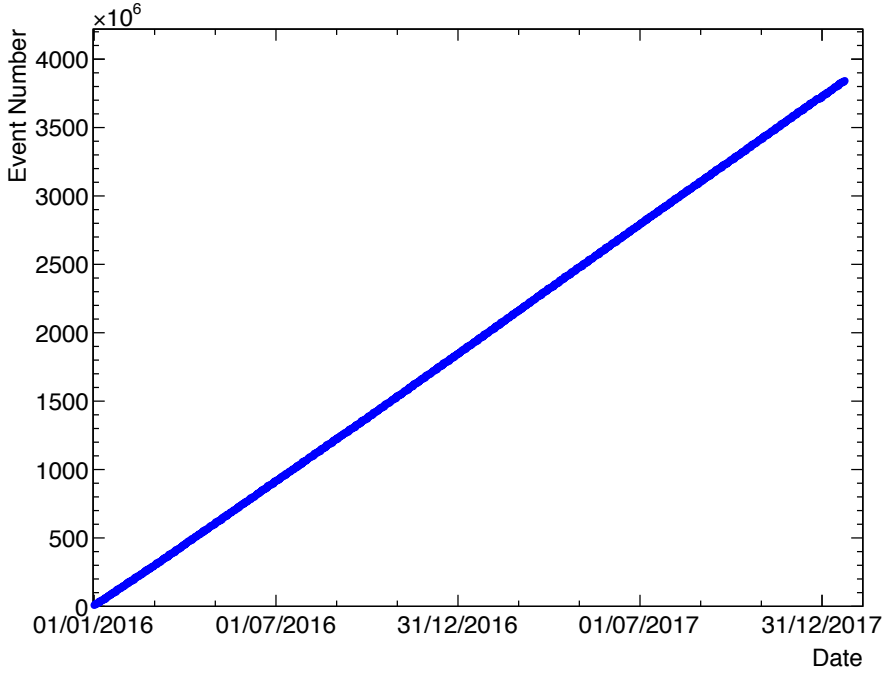


For events with deposit energy of 0.5-1.0 TeV; the proton contamination fraction is found to be <3% below 1TeV and <6% in the energy range of 1-2 TeV.

(DAMPE collaboration. 2017, Nature, 552, 63)

Summary of current data



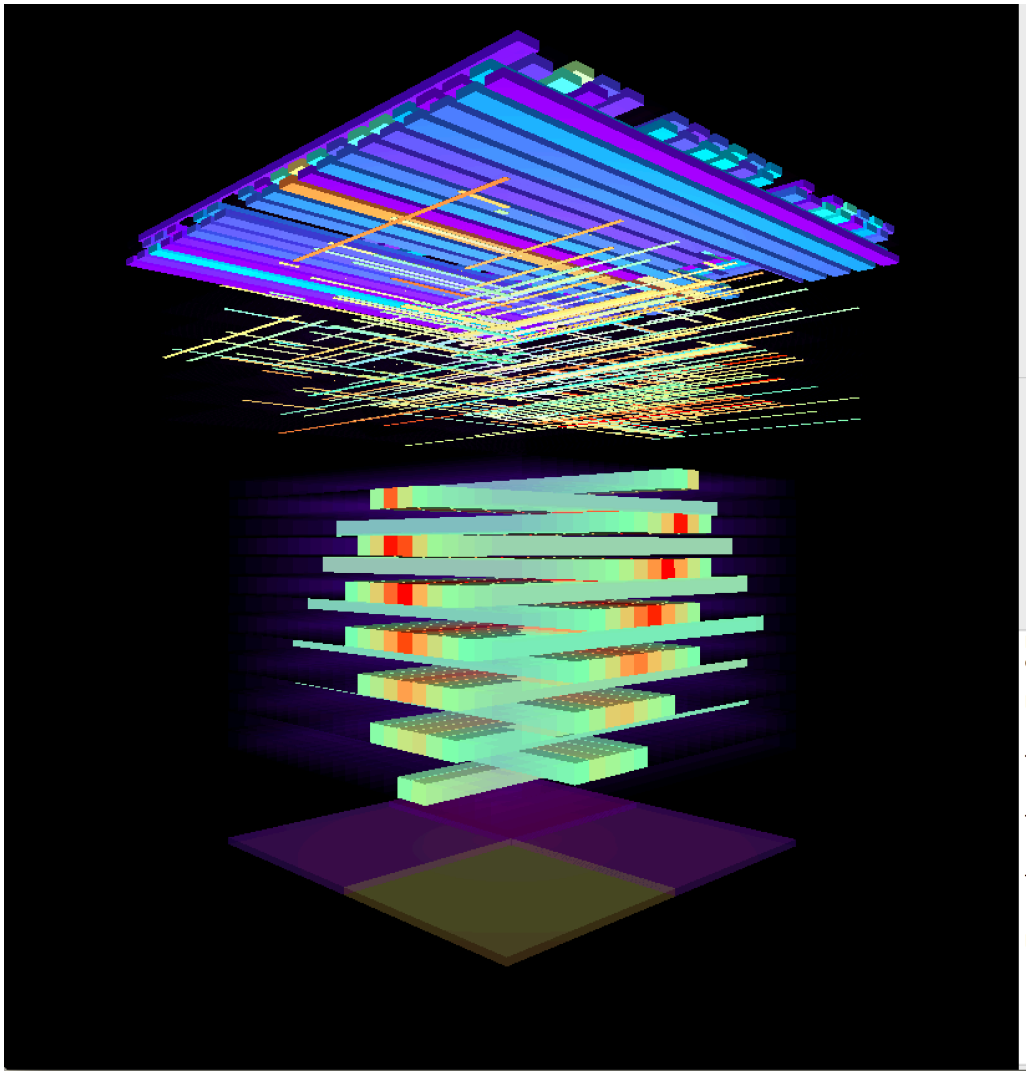


Full sky survey: 4 times

3.7 billion CRs (~5 million/day)

up to the end of 2017

Event: ~5 TeV electron candidate



<< First | < Previous | 525 | Next > | Last >>

Goto

Colors: 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08

Stereo Effects: Red Cyan | Red Blue | Active | Passive | No Stereo

Advanced Show: Show Trajectory | Start Animation | Continuous Animation

File Name(s):
electron_above500GeV.root

Event Number:
525

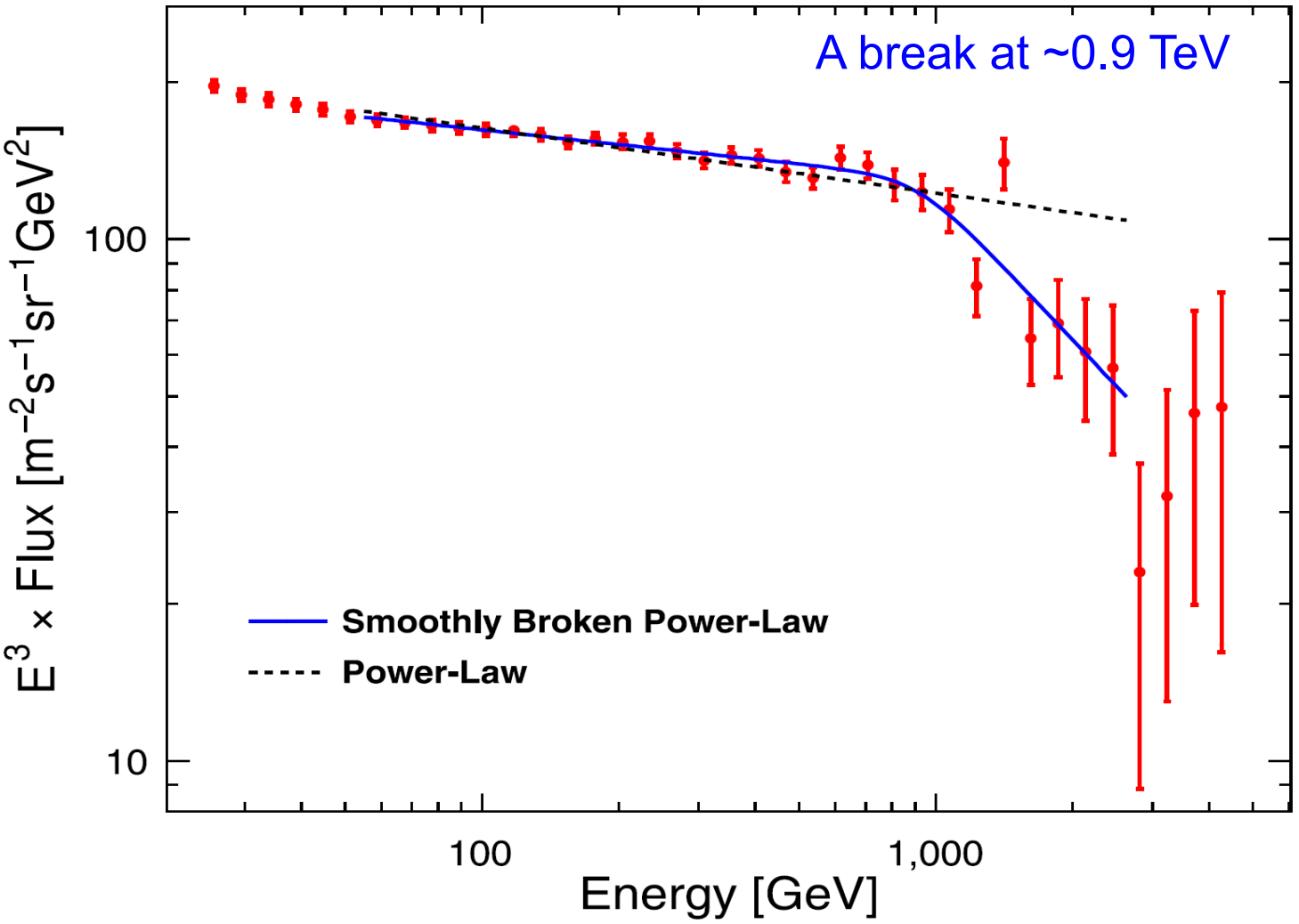
Time Point:
09:06:04.660, 27/04/2016

Total Energy:
4731.992000 GeV

Track Status:
Has BGO Track: Yes. Has Global Track: Yes.

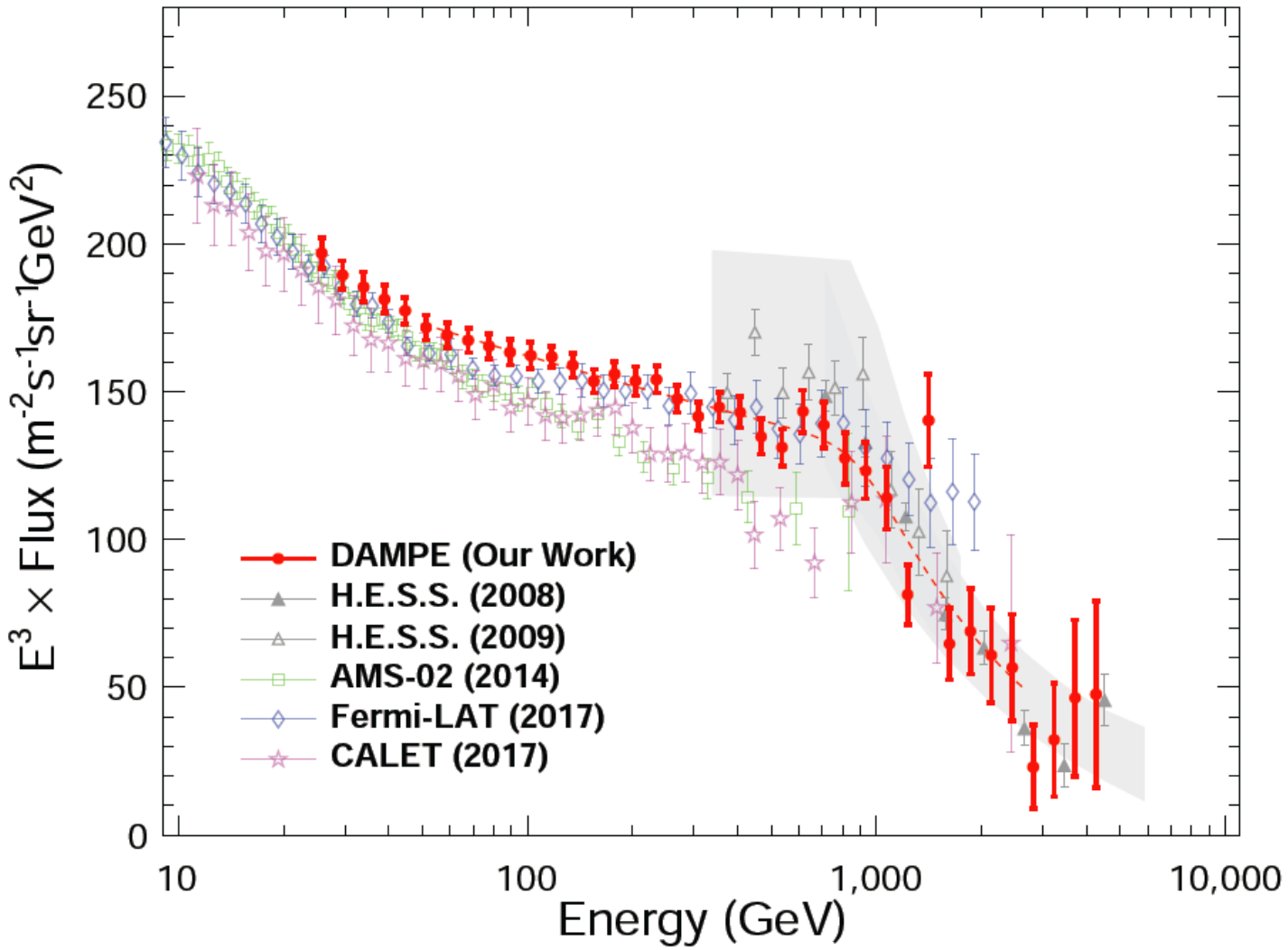
Direction:
Theta: 29.3 deg, Phi: -103.4 deg

First result: CRE spectrum



(DAMPE collaboration, 2017, Nature, 552, 63)

Some high energy CRE spectra



Error bars: systematic and statistical uncertainties added in quadrature for direct measurements. For H.E.S.S the grey band represents its systematic errors apart from the approximately 15% energy scale uncertainty.

Summary

The detector

- Large geometric factor instrument (0.3 m^2 sr for electrons)
- Precision Si-W tracker (40μm , 0.2°)
- Thick calorimeter (32 X_0 , σ_E/E better than 1.5% above 50 GeV for e/γ , (20~35)% for hadrons)
- "Mutiple" charge measurements (0.1-0.3 e resolution)
- e/p rejection power ~10^5 (topology alone, higher with neutron detector)

Launch and performances

- Succesfully launched on Dec 17, 2015
- On orbit operation steady and with high efficiencies
- The first CRE spectrum has been published in Dec. 2017
- More results will be released in the future

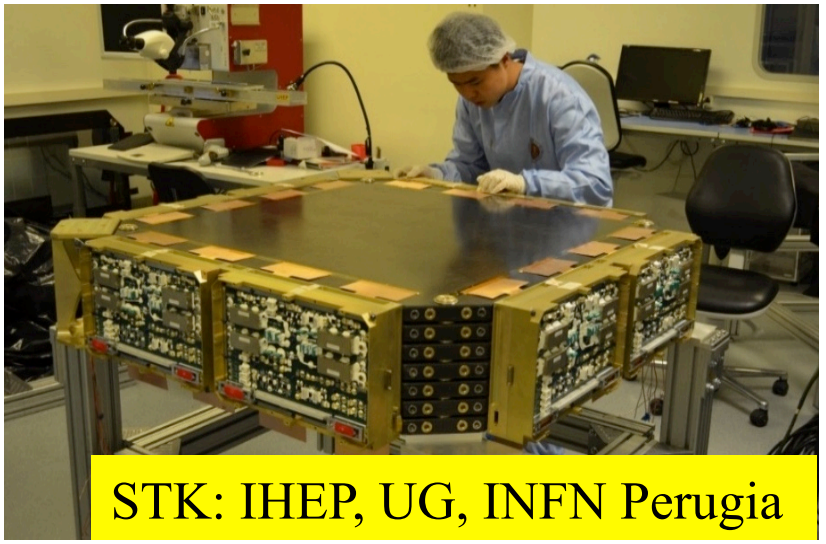
Some members and partners

Thank you for your attention!

Back up

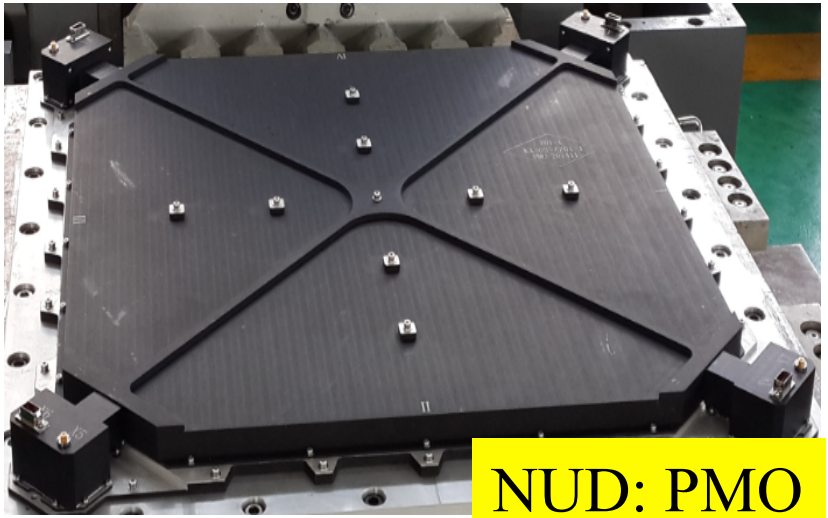
Flight Model: four sub-detectors

PSD: IMP



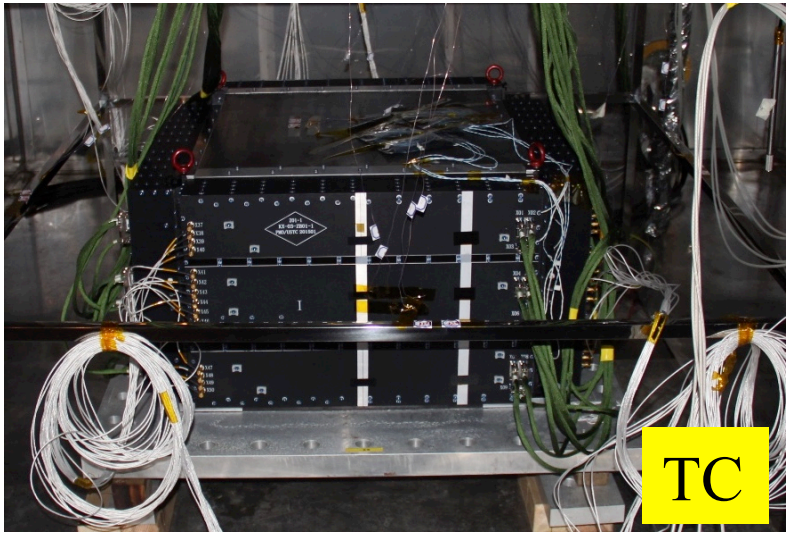
STK: IHEP, UG, INFN Perugia

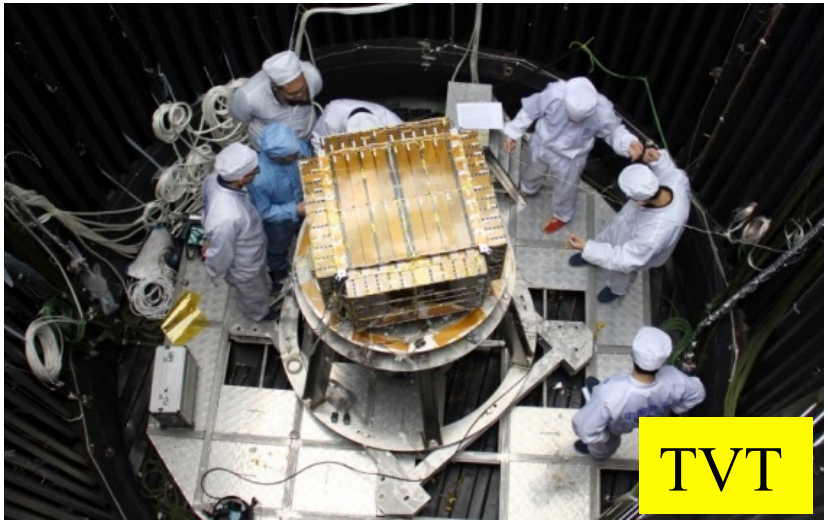
BGO: USTC & PMO

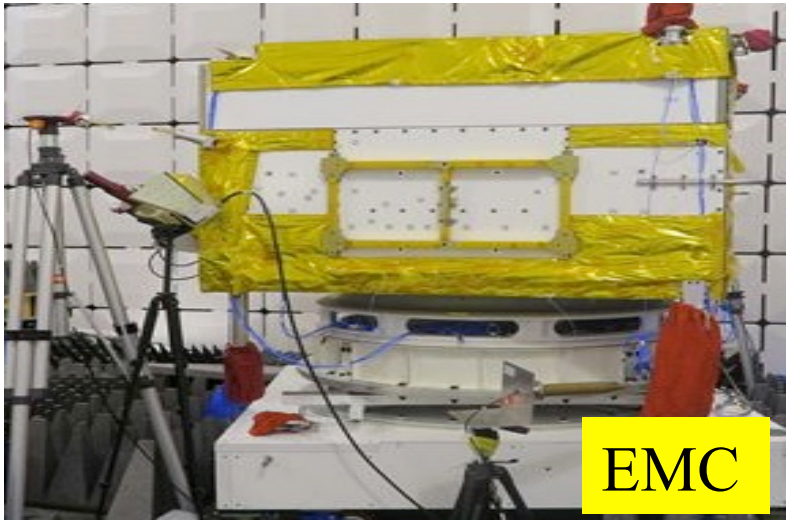


NUD: PMO

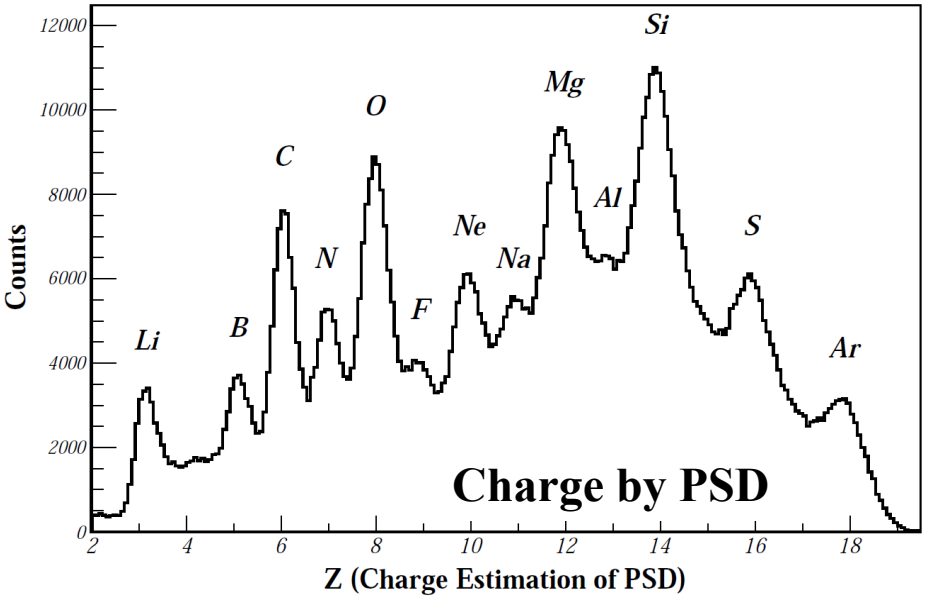
Flight model: environmental tests

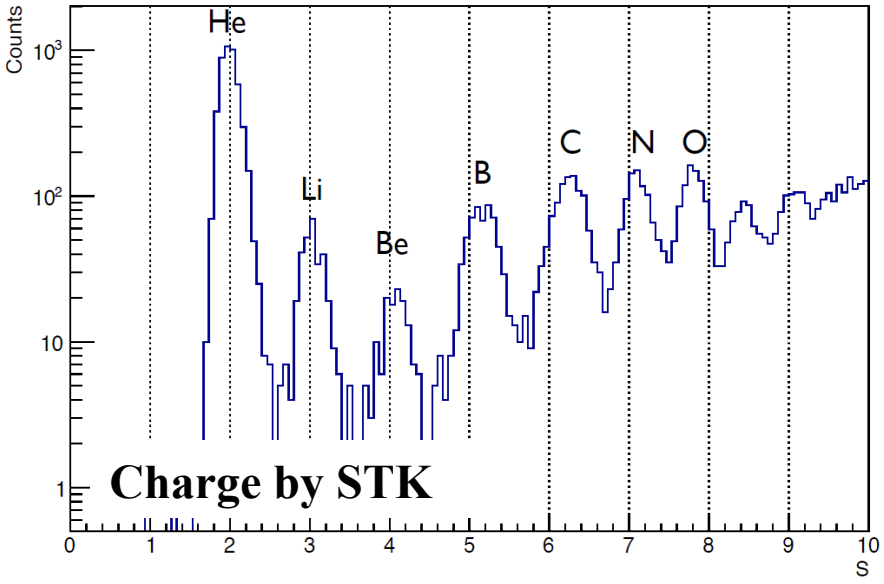






Beam test @ CERN





(Chang et al. [DAMPE collaboration] 2017 Astropart. Phys.)

METHODS

Discrimination between electrons and protons. The method of electron selection in this work relies on the differences in the development of showers initiated by protons and electrons[23,31,32]. The procedure is as follows. First, we search for events passing through the entire BGO calorimeter. We select events with hit positions from −28.5 cm to 28.5 cm for the top layer and −28 cm to 28 cm for the bottom layer (each BGO bar lies between −30 cm and 30 cm). Second, we calculate the shower spread, expressed by the energy-weighted root-mean-square value of hit positions in the calorimeter. The root-mean-square value of the ith layer is calculated as:

$$\mathrm{RMS}_i = \sqrt{\frac{\sum_j (x_{j,i} - x_{\mathrm{c},i})^2 E_{j,i}}{\sum_j E_{j,i}}} \tag{1}$$

where $x_{j,i}$ and $E_{j,i}$ are the coordinates and deposited energy of the jth bar in the ith layer, and $x_{\mathrm{c},i}$ is the coordinate of the shower centre of the ith layer. Figure 1 shows the deposited energy fraction in the last BGO layer ($\mathcal{F}_{\mathrm{last}}$) versus the total root-mean-square value of all 14 BGO layers (that is, $\sum_i \mathrm{RMS}_i$). We can see that electrons are well separated from protons. Note that in Fig. 1 and Extended Data Fig. 1, heavy ions have already been effectively removed by selection through the plastic scintillator detector, on the basis of the charge measurement.

For a better evaluation of the electron/proton discrimination capabilities, we introduce a dimensionless variable, ζ, defined as

$$\zeta = \mathcal{F}_{\mathrm{last}} \times (\Sigma_i \mathrm{RMS}_i/\mathrm{mm})^4/(8 \times 10^6) \tag{2}$$