The DArk Matter Particle Explorer (DAMPE) Status in Space

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On Behalf of DAMPE Collaboration

Outline

1. DArk Matter Particle Explorer
2. The Performance in Space
3. Summary

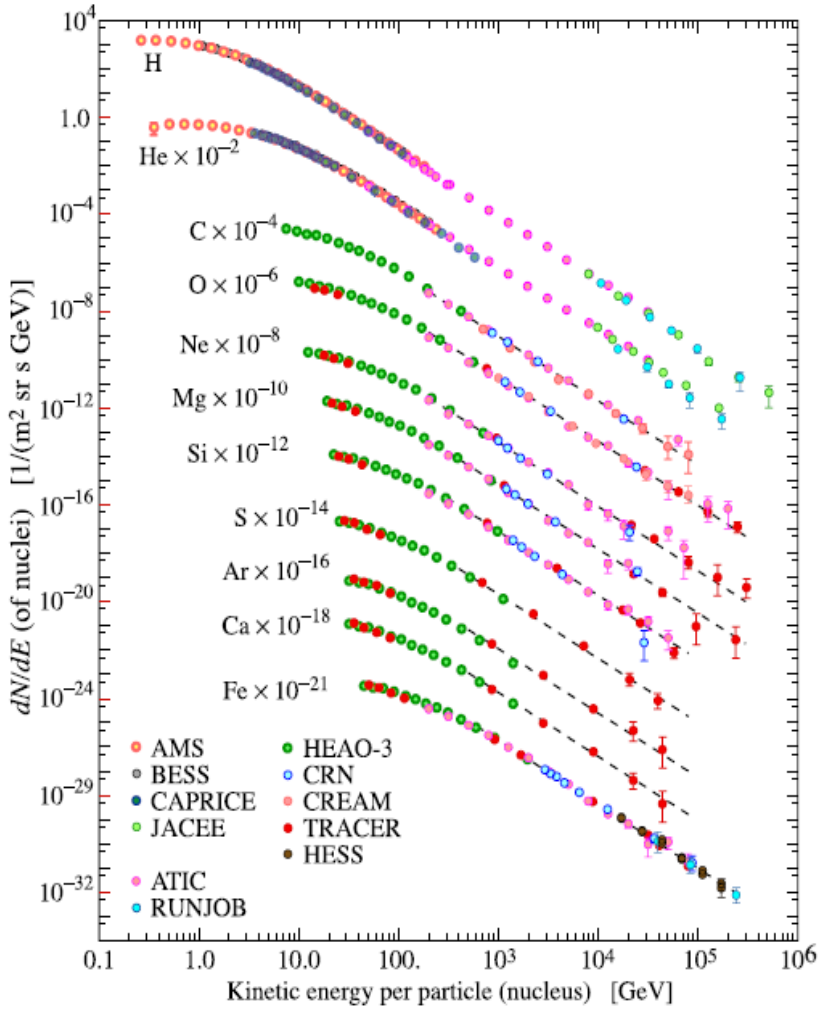
DAMPE Collaboration

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

- **ITALY**
  - INFN Perugia and University of Perugia
  - INFN Bari and University of Bari
  - INFN Lecce and University of Salento
  - GSSI and INFN - Laboratori Nazionali del Gran Sasso (LNGS)

- **SWITZERLAND**
  - University of Geneva

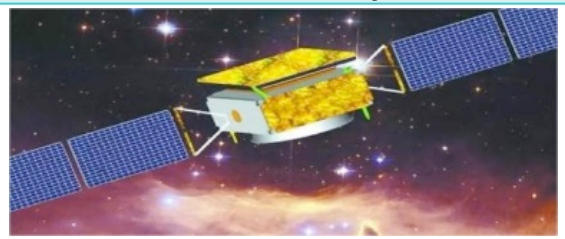
Scientific Objectives

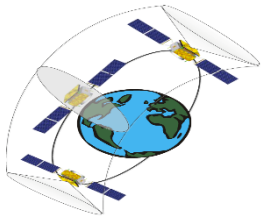


- Probing the nature of darkmatter
- Understanding the particle acceleration in astrophysical sources, and the propagation of cosmic rays in the Milky Way
- Studying the gamma-ray emission from Galactic and extragalactic sources.

DAMPE Detector

DArk Matter Particle Explorer Satellite





Altitude: 500 km

Inclination: 97.4065°

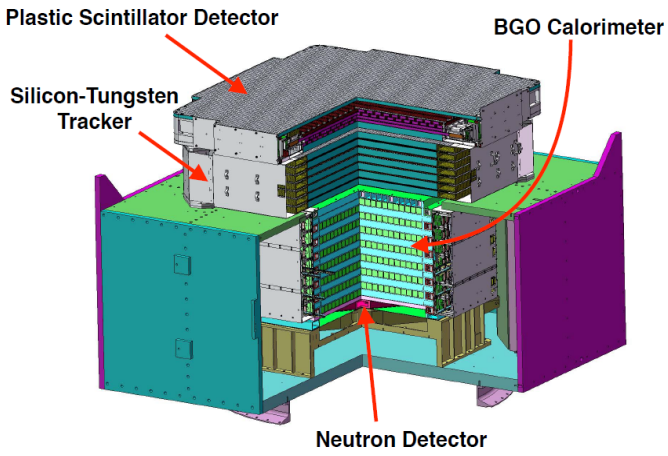
Period: 95 minutes

Orbit: sun-synchronous

Life： > 3 years

DArk Matter Particle Explorer Spectrum

- Plastic Scintillator Array
  - Response : Z=1~26
- Silicon Tracker
  - 12 layers Si-strip
- BGO Calorimeter
  - 14 layers , ~32X_0
- Neutron Detector
  - Plastic scintillator with Boron



Energy: 5 GeV – 10 TeV

Res: 1.5% @ 800 GeV ($e^{\pm}$)

Acc: 0.3 m^2 sr (for $e^{\pm}$)

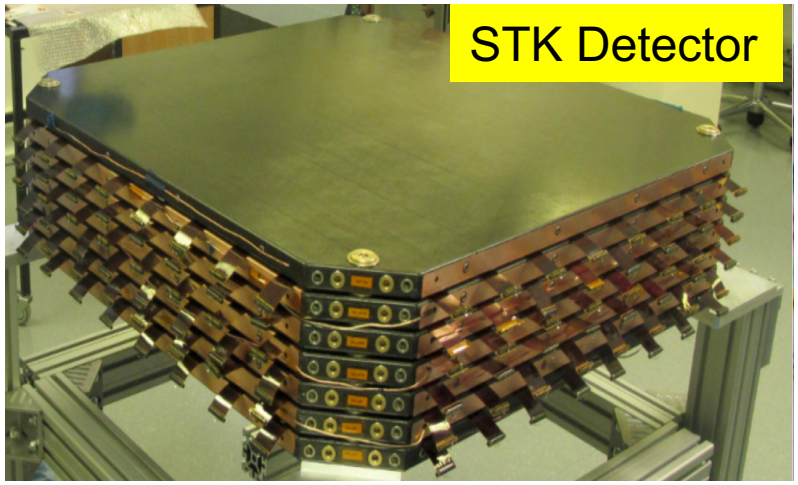
Ang: 0.1 degree @ 100 GeV

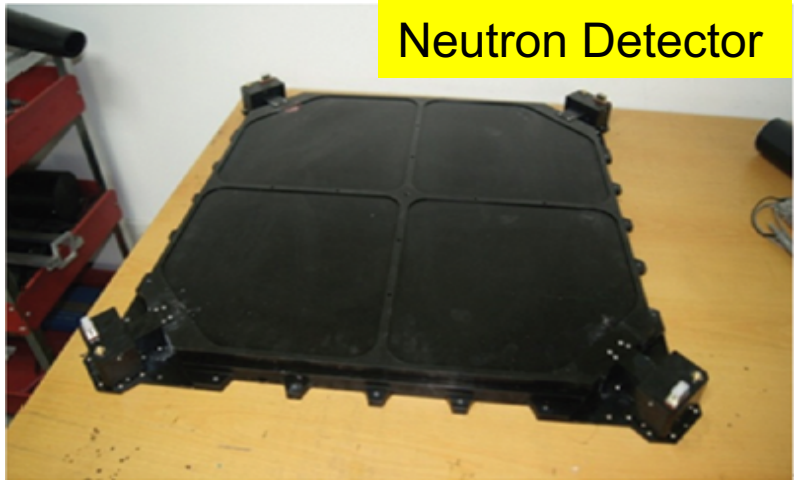
Weight: 1450 kg

Power: 300 W

Size: 1.2 m×1.2 m×1.0 m

DAMPE Detector



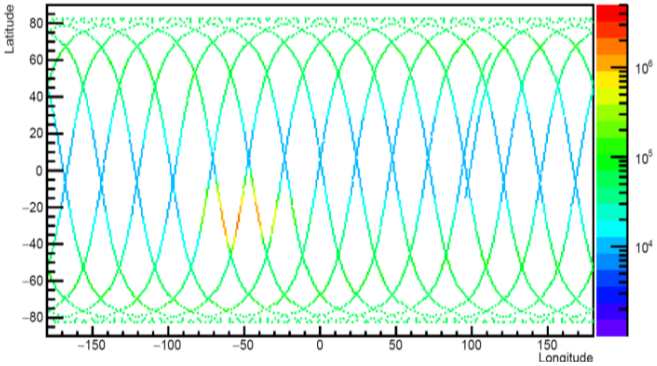


Jiuquan Satellite Launch Center, Gobi desert
12/17/2015, 08:12

Data Downlink

DAMPE Satellite

Satellite Orbit



- Trig-Rate: ~50 Hz
- 15 orbits/day
- 16 GB/d raw data

National Space Science Center, CAS

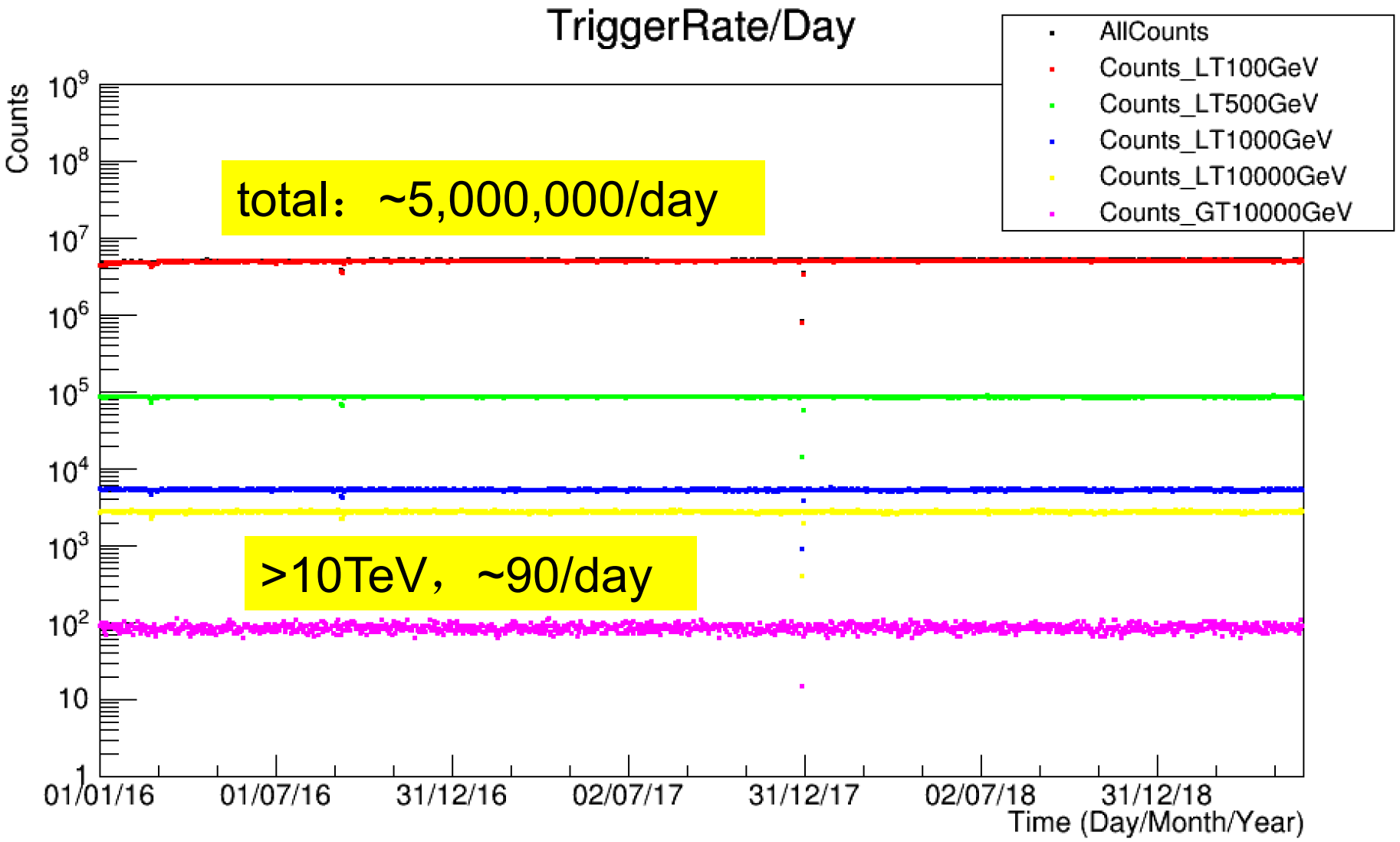
Purple Mountain Observatory, CAS

Ground Stations

Space Science Mission Operations Center

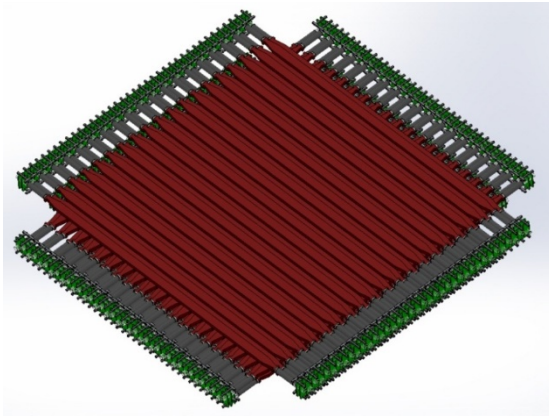
Space Science Data Analysis Center (China, Italy, Geneva)

Total Number of events per Day

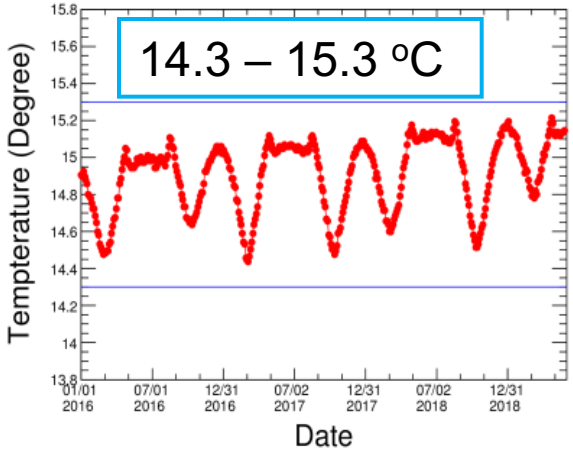


The Status of PSD Sub-detector

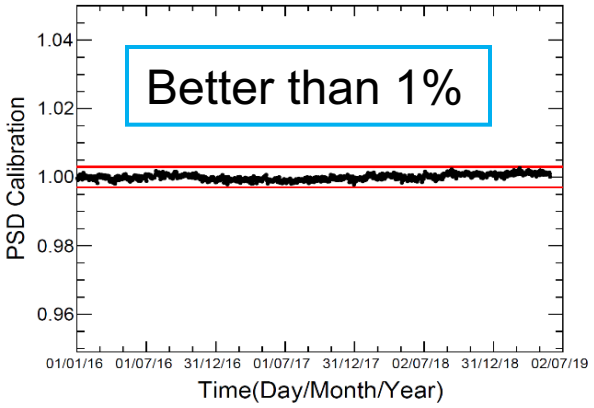
Plastic scintillator array

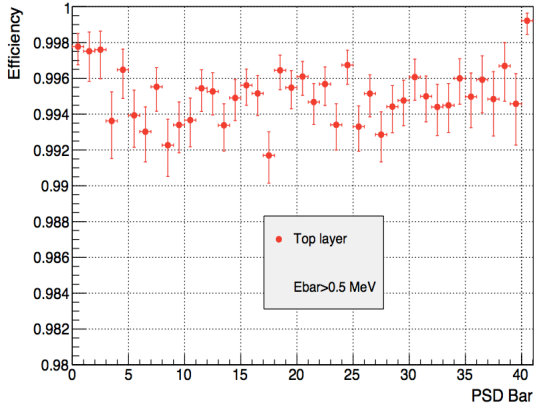


Ave. temperature since launch

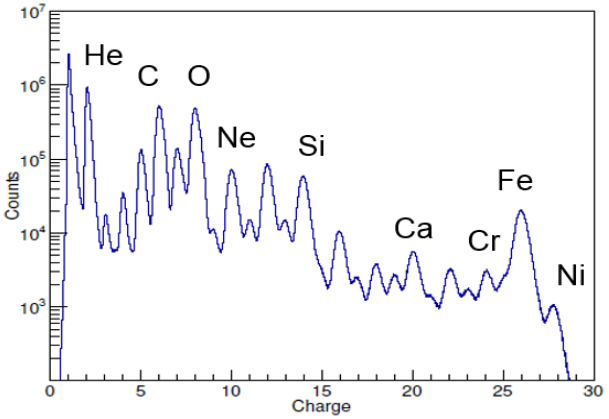


Noise stability





Efficiency of MIPs



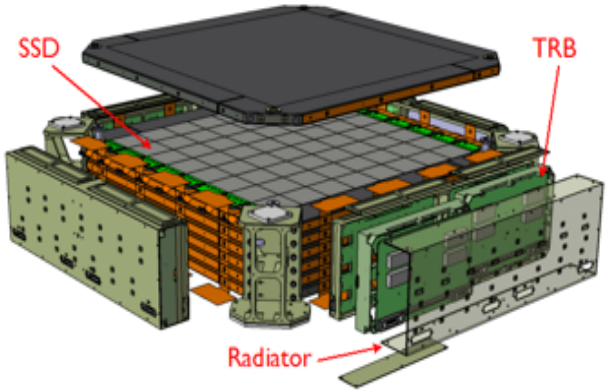
Charge measurement

- plastic scintillator strips were arranged with no visible joint.
- Eff：99.5% for MIPs
- σ_z/Z：~6%@Z=1
- The Nickle nuclide peak could be seen clearly

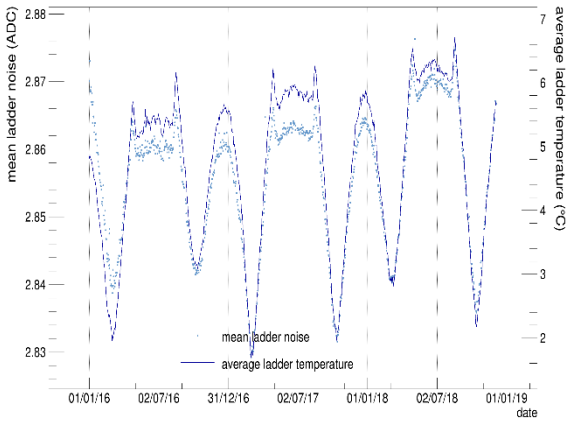
More details could be seen in PoS(2019)063 and PoS(2019)615

The Status of STK Sub-detector

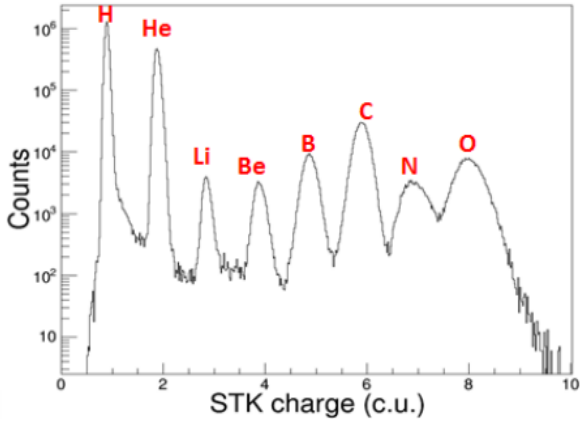
Silicon Tungsten-Tracker



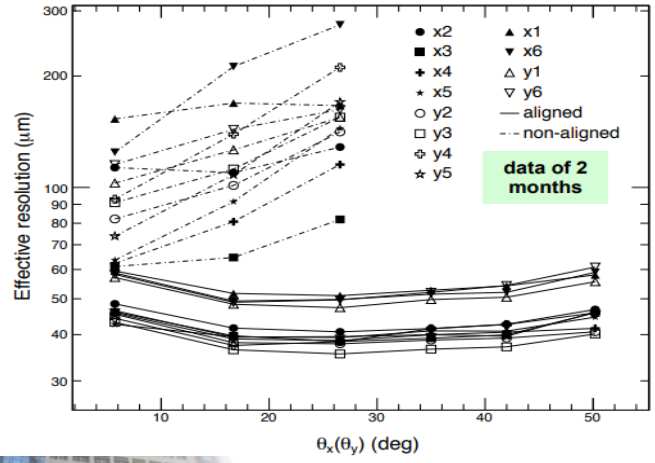
Ave. temp/noise evolution



Charge measurement



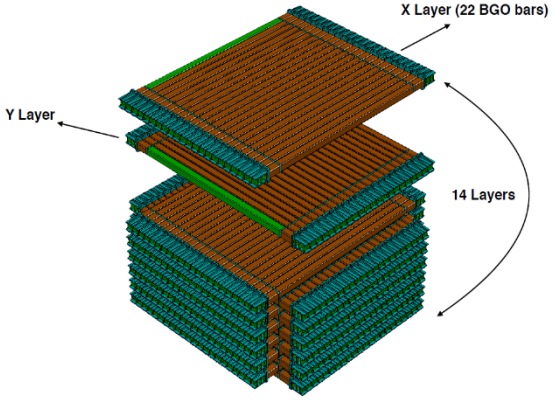
spatial resolution



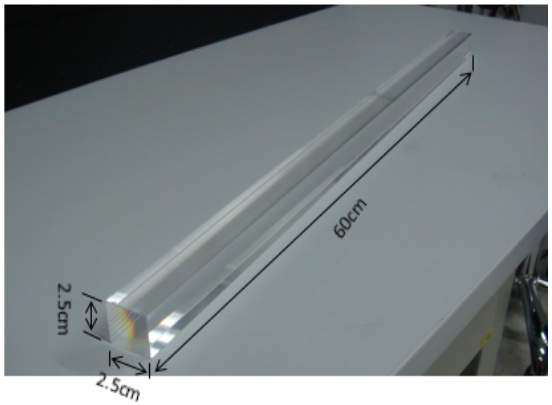
- 12 layers silicon strips to measure the track of charged particles, and 3 tungsten plates to convert γ-rays to $e^{\pm}$
- Temp： 0 – 8 °C cyclical variation
- σ_z/Z： ~5% @ Z=1
- Spatial Res： better than 60 um after alignment

The Status of BGO Calorimeter

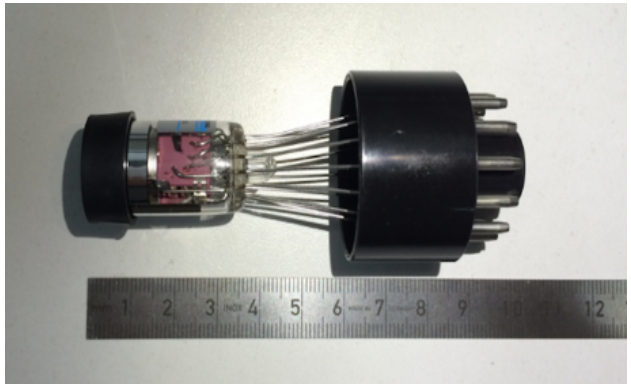
BGO Calorimeter

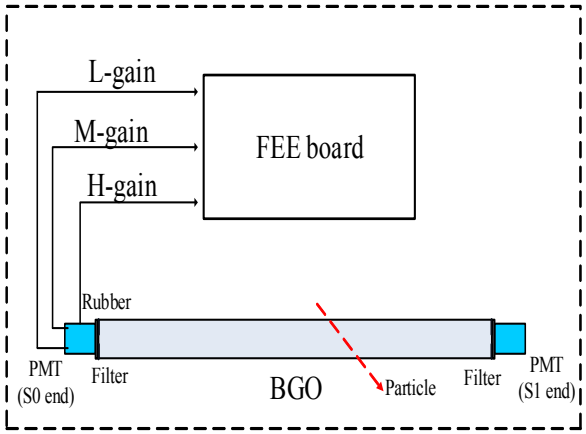


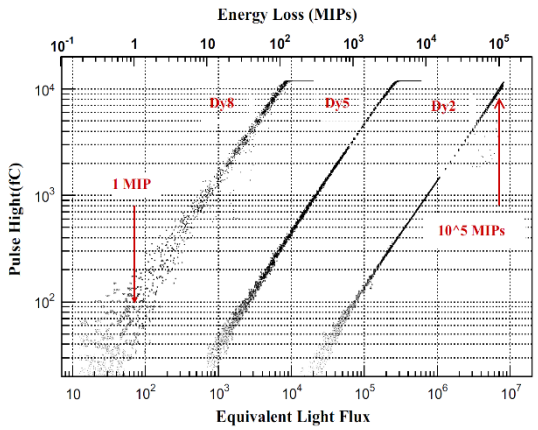
308 BGO bars



616 PMTs





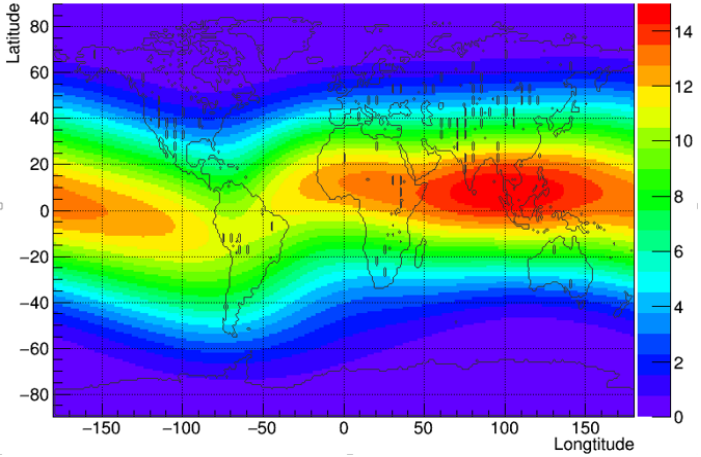


- Total absorption
  - Good energy resolution
- 3-D imaging
  - excellent shower topology reconstruction for PID
- Large radiation length
  - TeV-events PID

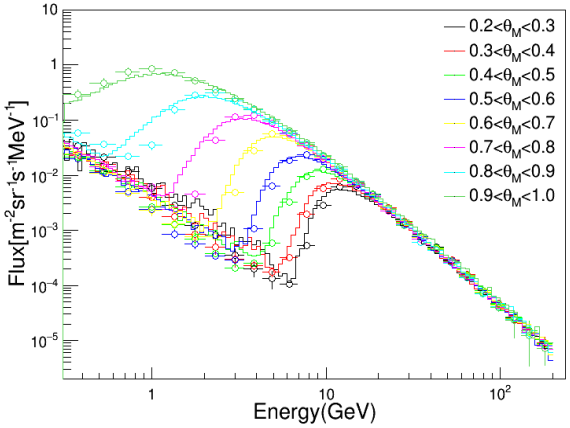
Three dynodes output could cover high dynamic range from ~ 10 MeV to ~2 TeV.

Calibration of BGO Calorimeter

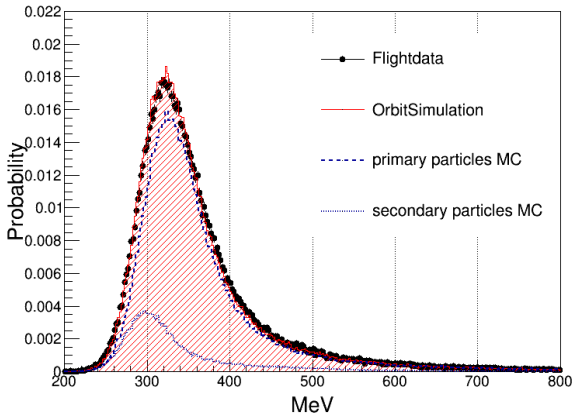
Geomagnetic rigidity cutoff

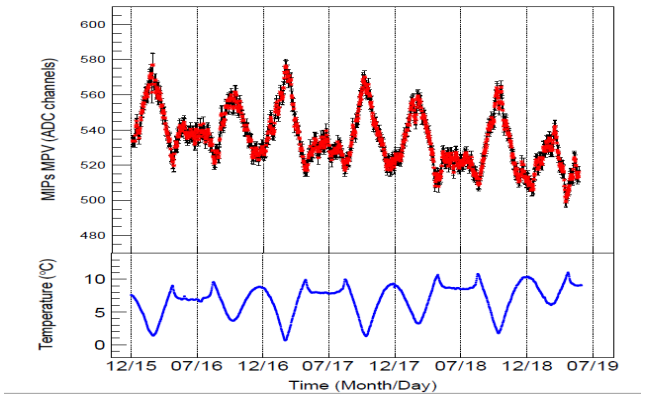


Proton differential flux

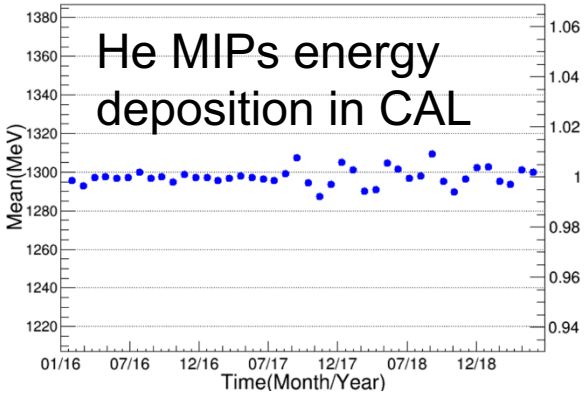


Energy Scale using MIPs





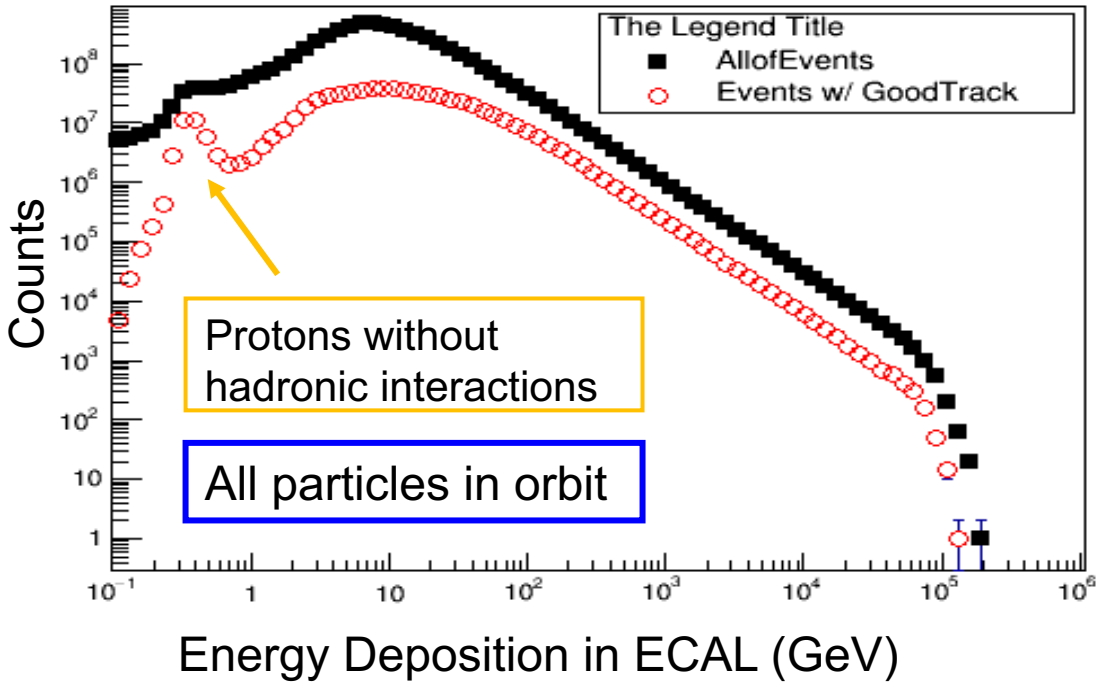
MIPs amplitude vs. time before temp. correction



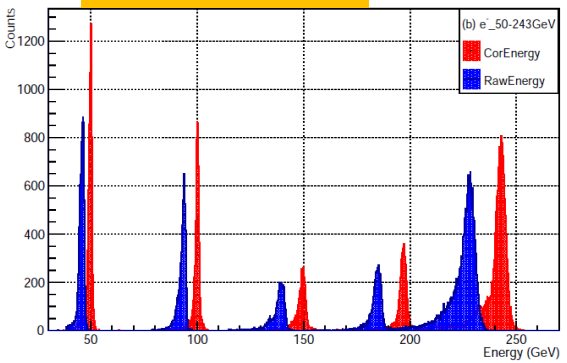
MIPs amplitude vs. time after temp. correction

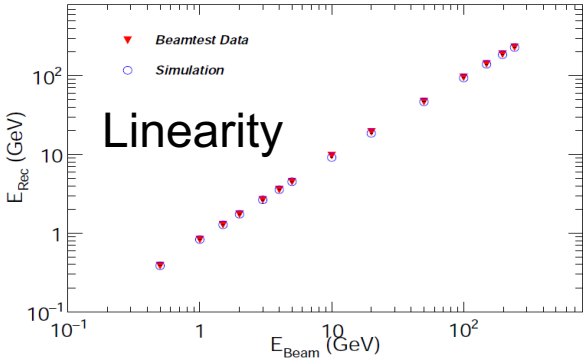
- low geomagnetic latitude the rigidity cutoff is above 10 GV
- Temp: 0 – 15 ºC
- Stability: < 1% after temperature correction

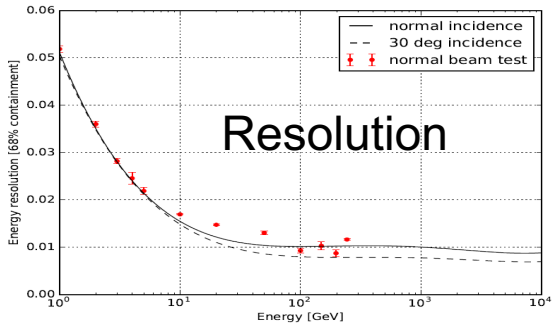
Energy Reconstruction



Beam Data

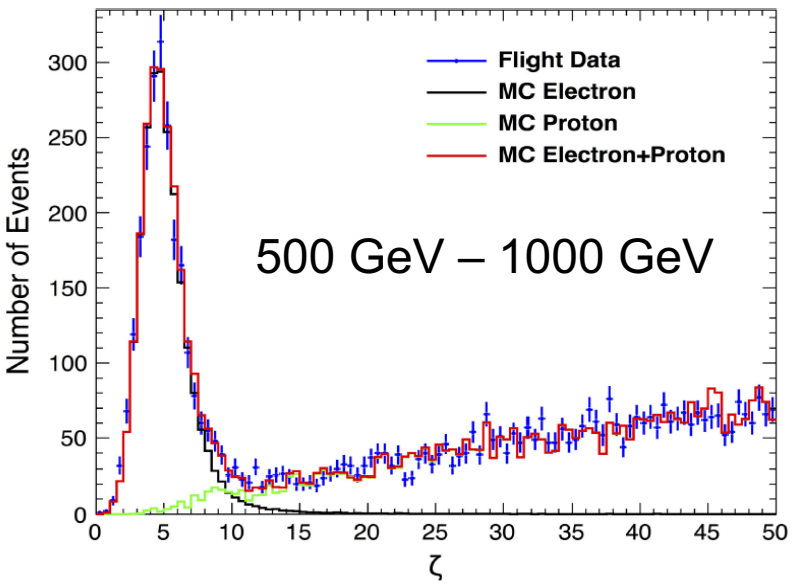


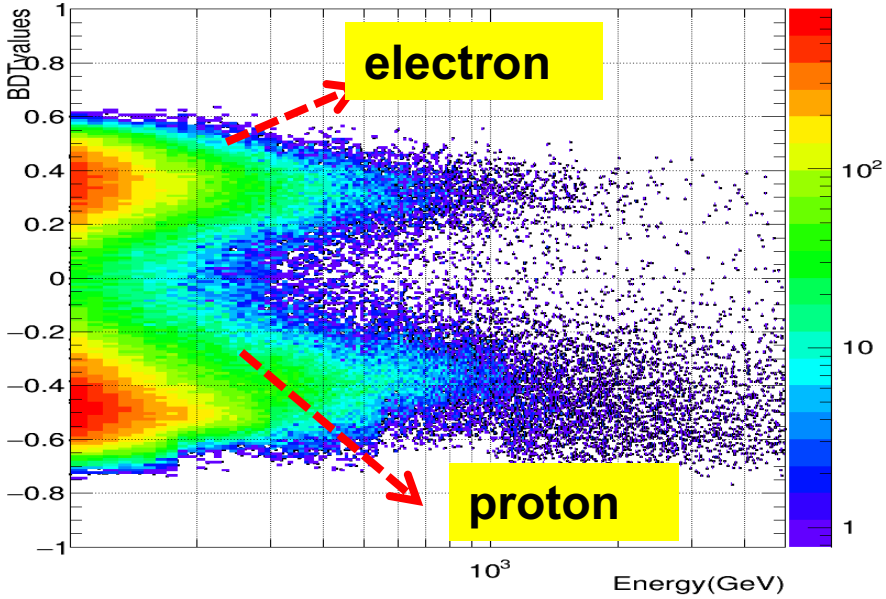




- Beam test results show the energy linearity is better than 1% and energy resolution is about 1% while energy above 200 GeV
- In orbit, the energy measurements have been carried out up to 100 TeV without correction

Particle Identification





Classical method:

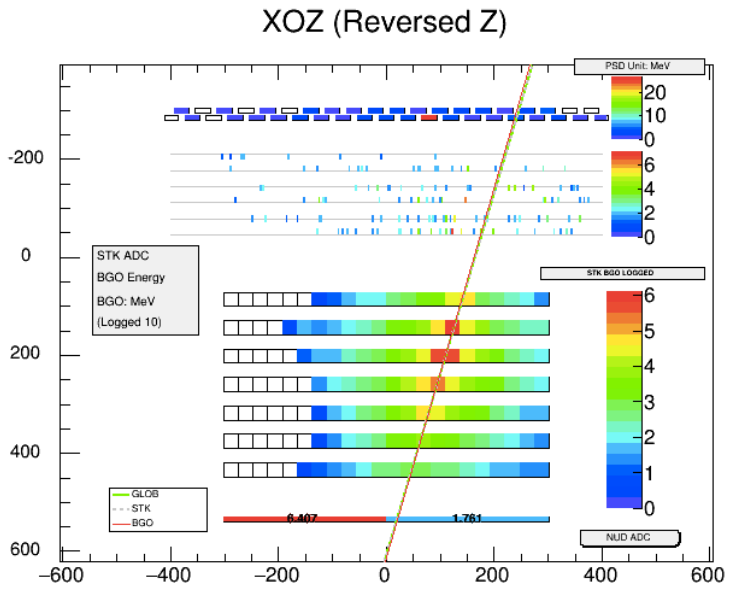
ζ, a separation parameter to describe the shower topology in the calorimeter, was used to identify particles.

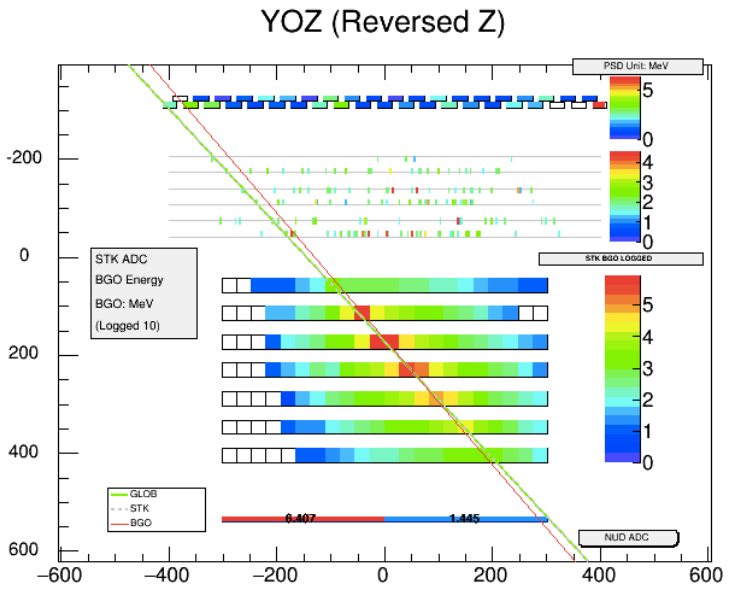
$$\zeta = \mathcal{F}_{\text{last}} \times (\Sigma_i \text{RMS}_i/\text{mm})^4/(8 \times 10^6)$$

Boosted Decision Tree:

a multi-variate analysis method which includes ~20 variables to describe shower shape, was also used to the PID work

Electron and Positron Candidate

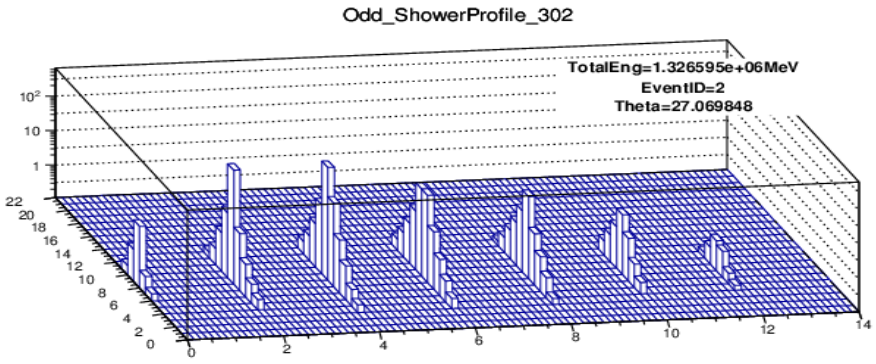


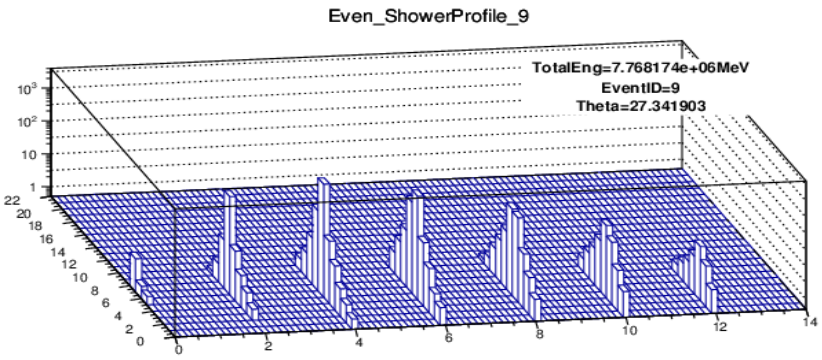


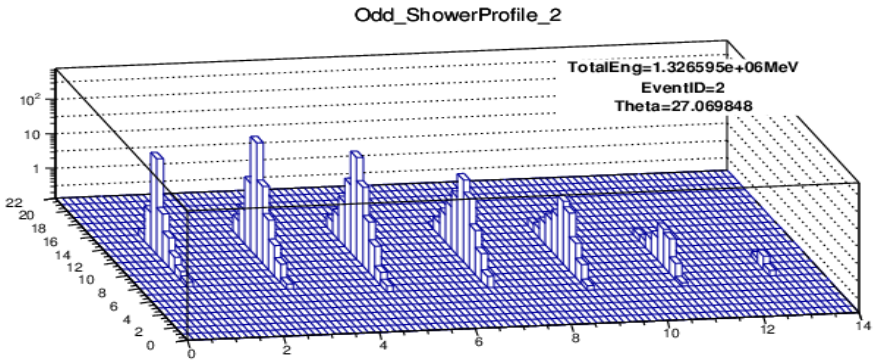
- There are many fired strips in the PSD because of the albedo effect
- The calorimeter should give the seeds to STK in order to reconstruct precision tracker information
- About 250 BGO crystals are fired in Calorimeter for TeV $e^{\pm}$ candidate
- The shower max position is at ~4-5 layer (~ 7-10 X_0)

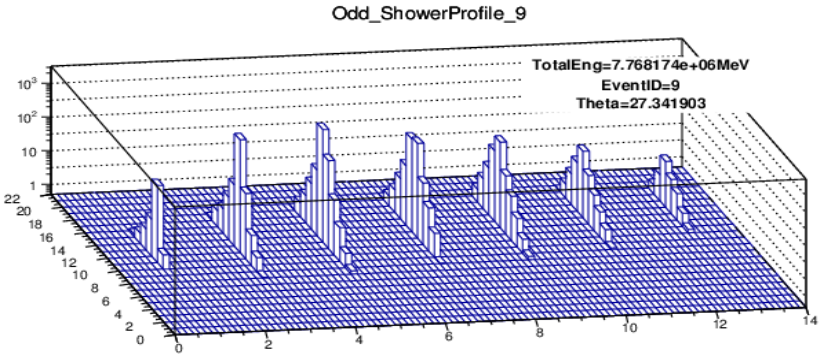
1.3 TeV

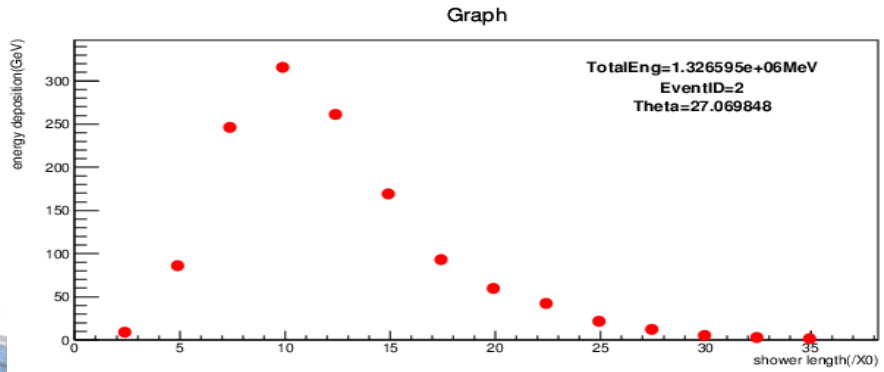
7.8 TeV

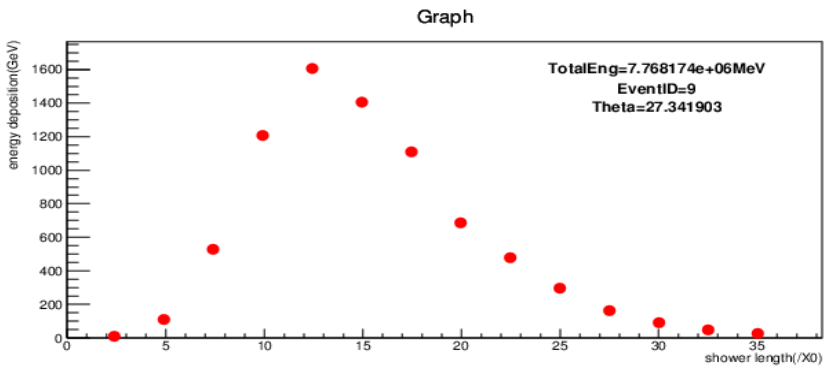

Odd_ShowerProfile_302
TotalEng=1.326595e+06MeV
EventID=2
Theta=27.069848

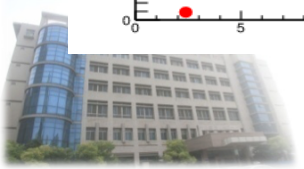

Even_ShowerProfile_9
TotalEng=7.768174e+06MeV
EventID=9
Theta=27.341903


Odd_ShowerProfile_2
TotalEng=1.326595e+06MeV
EventID=2
Theta=27.069848

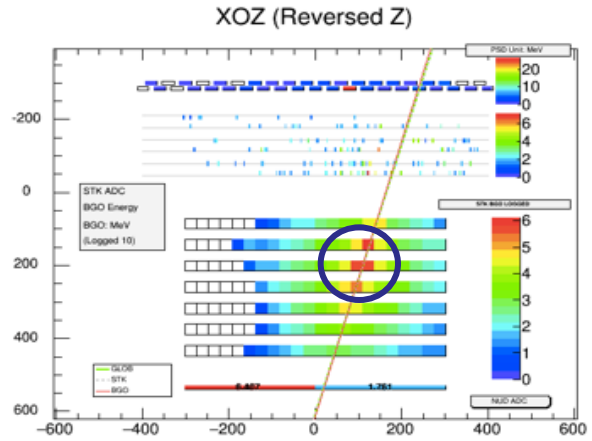

Odd_ShowerProfile_9
TotalEng=7.768174e+06MeV
EventID=9
Theta=27.341903


Graph
TotalEng=1.326595e+06MeV
EventID=2
Theta=27.069848
energy deposition(GeV)
shower length(/X0)


Graph
TotalEng=7.768174e+06MeV
EventID=9
Theta=27.341903
energy deposition(GeV)
shower length(/X0)

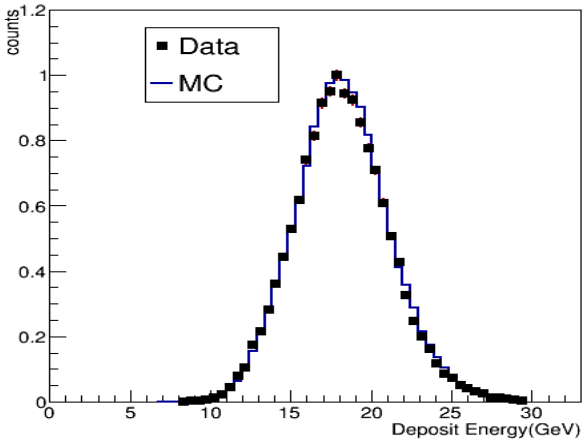


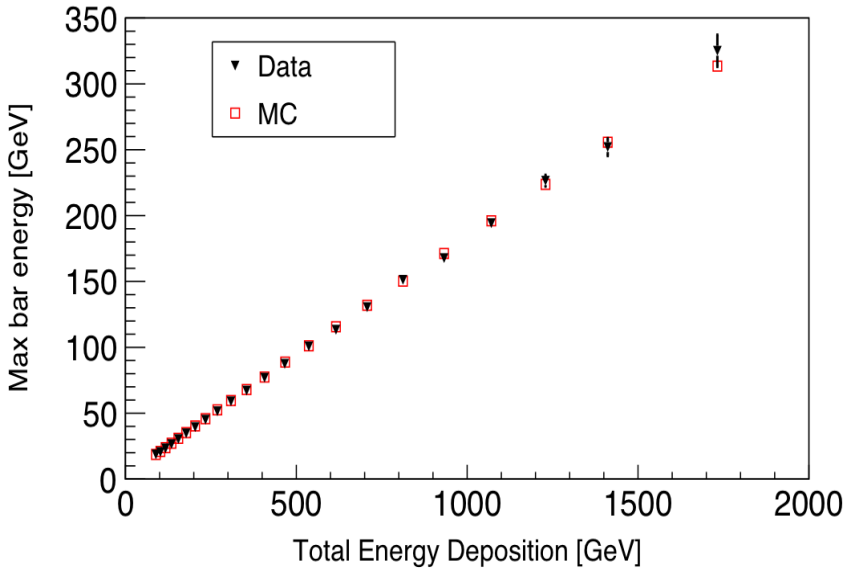
Energy Linearity



Select the "hottest" crystal

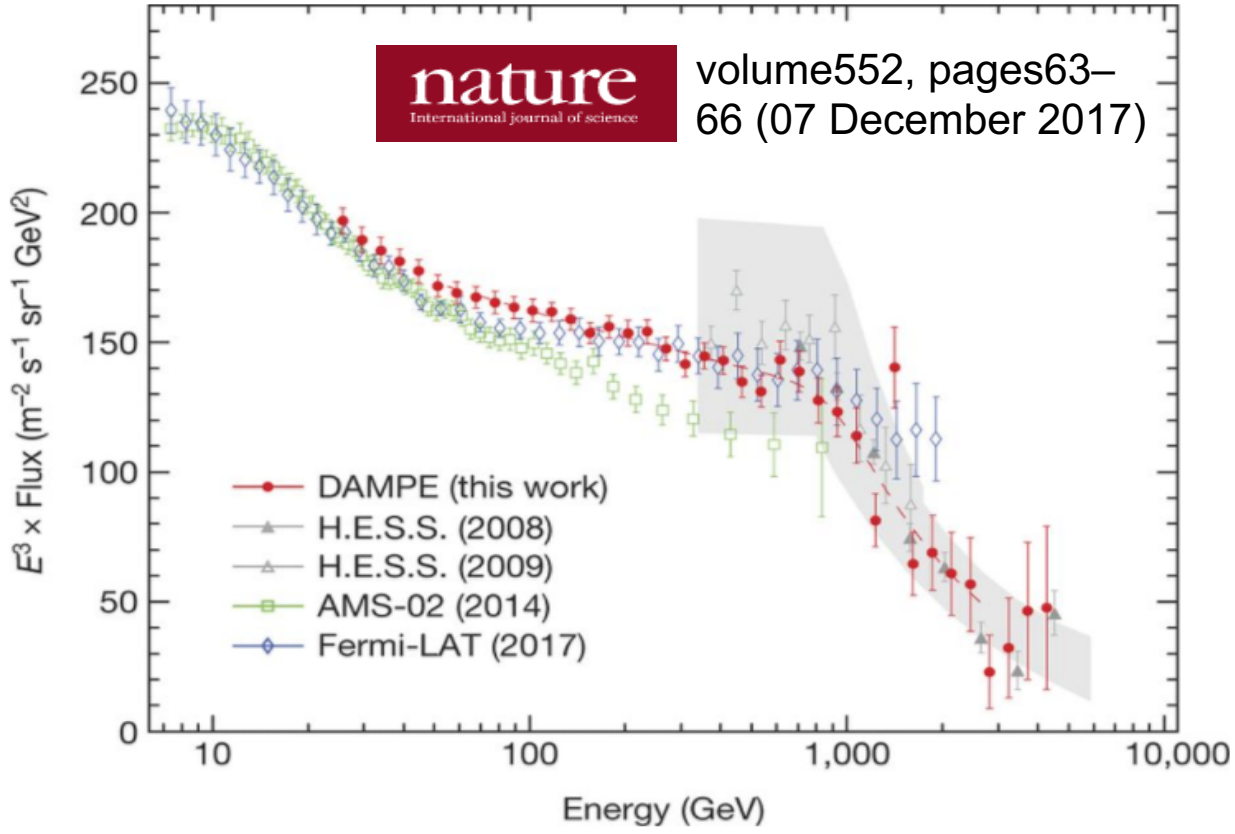
[95-105 GeV]





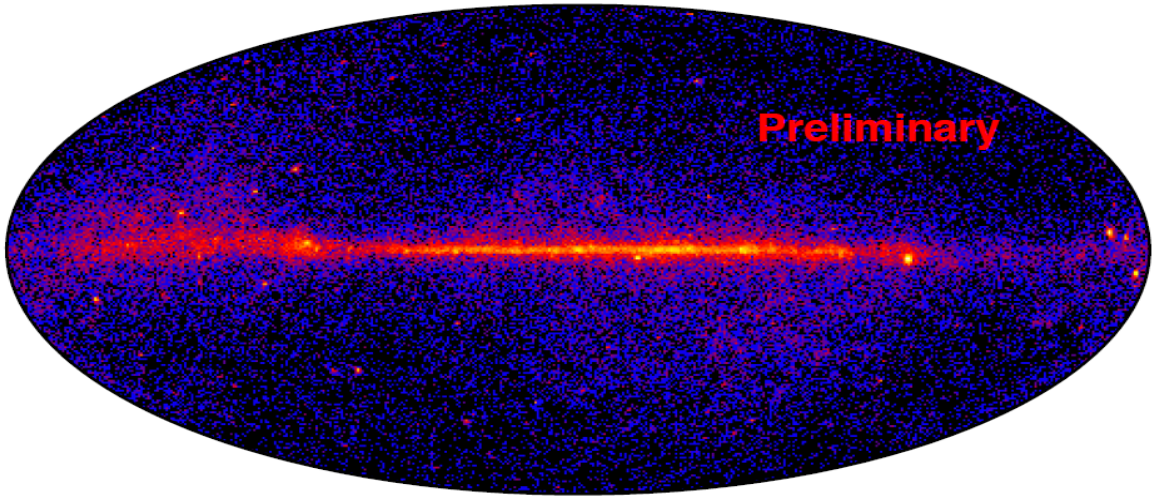
- For the energy deposition of shower max crystal, data and MC are in good agreement up to TeV range
- About 20% percent of the total energy deposit in the "hottest" crystal
- No fluorescence saturation effect was found in BGO crystal up to TeV EM shower

$e^{\pm}$ spectrum

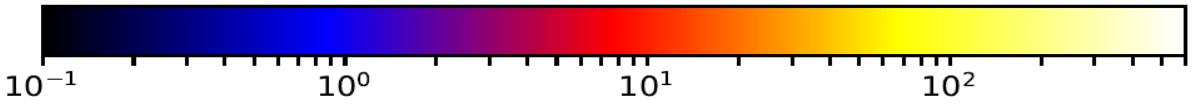


- Electrons and positrons from 20 GeV to 5 TeV
- Direct detection of a spectral break at ~0.9 TeV
- With the spectral index changing from γ = 3.1 to 3.9

Gamma Skymap



More details could be seen in PoS(2019)576



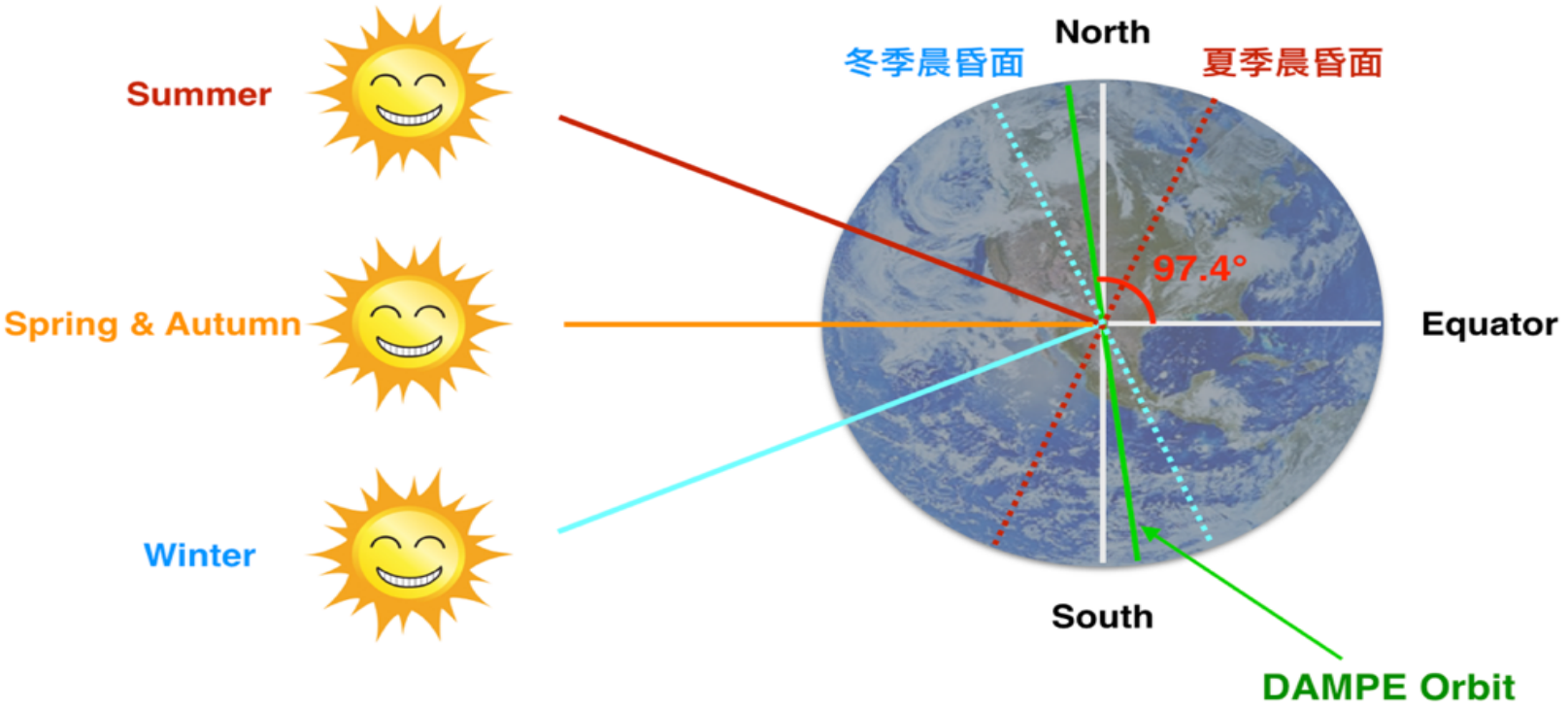
- Particle Identification ☑
- Track Reconstruction ☑
- Energy Reconstruction ☑

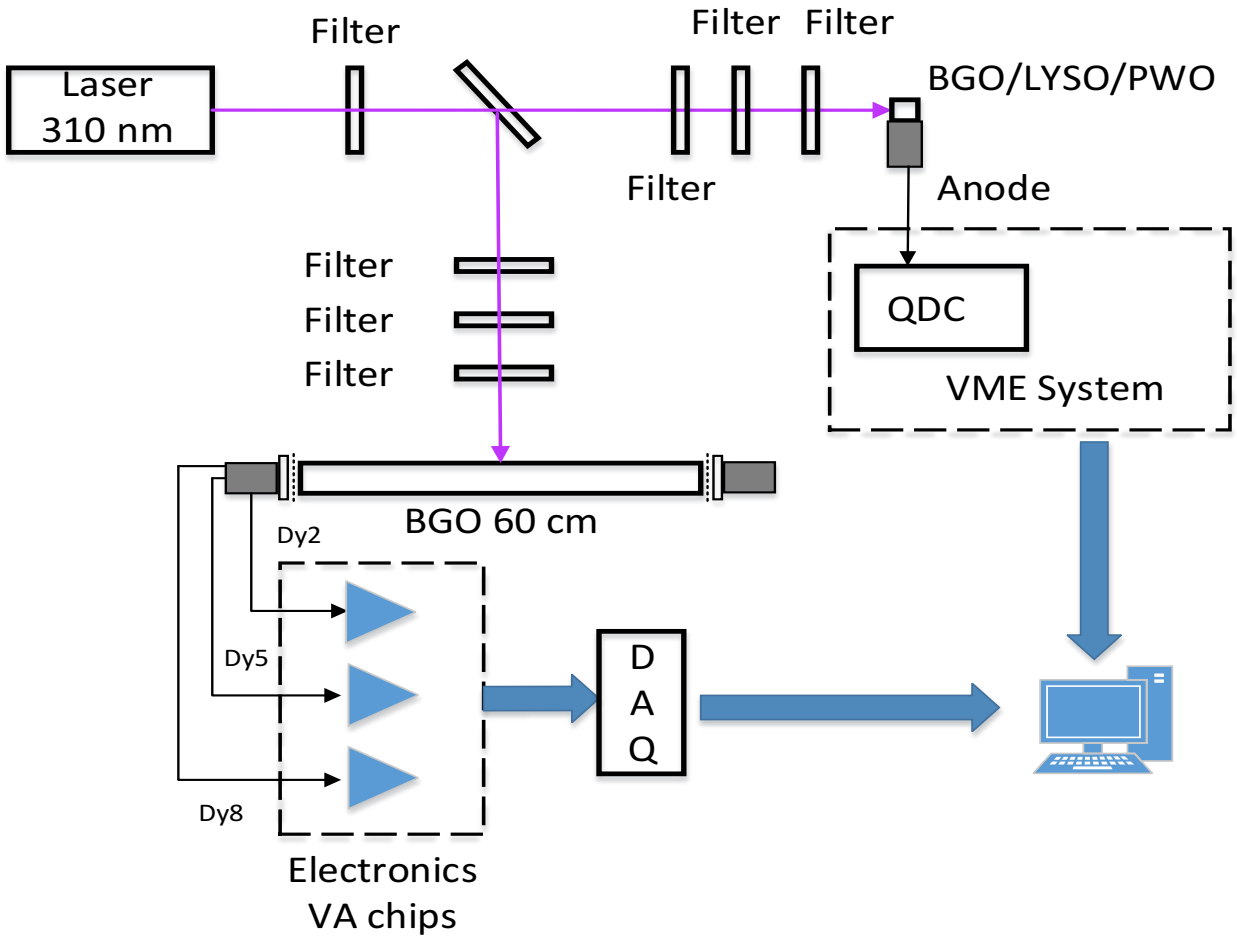
Summary

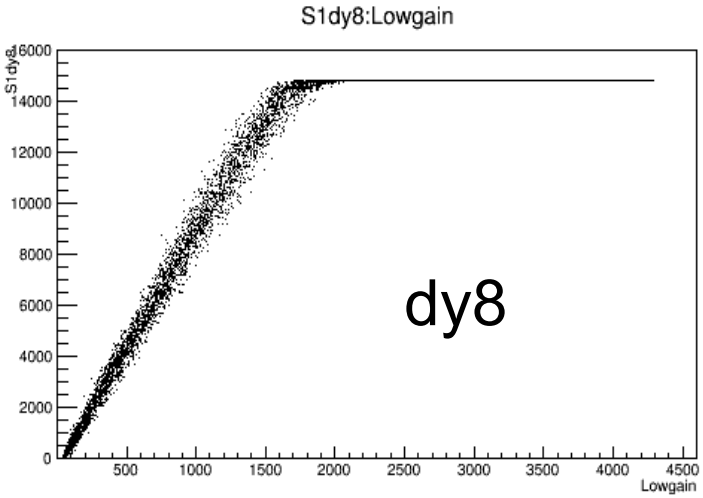
- DAMPE has successfully worked in space for more than 43 months since launched in Dec.17, 2015.
- All of the sub-detectors have worked stably and performed well
  - PSD: provides an excellent charge resolution: ~ 6%@Z=1, ~1%@Z=26
  - STK: a very good spatial resolution (< 60 um) could supply precision tracks
  - BGO calorimeter: the key sub-detector of DAMPE provides high precision energy reconstruction (~1% @ TeV) and strong particle separation power (10^5)
- We hope that DAMPE could continue to operate steadily in space and provide more high quality cosmic-ray data

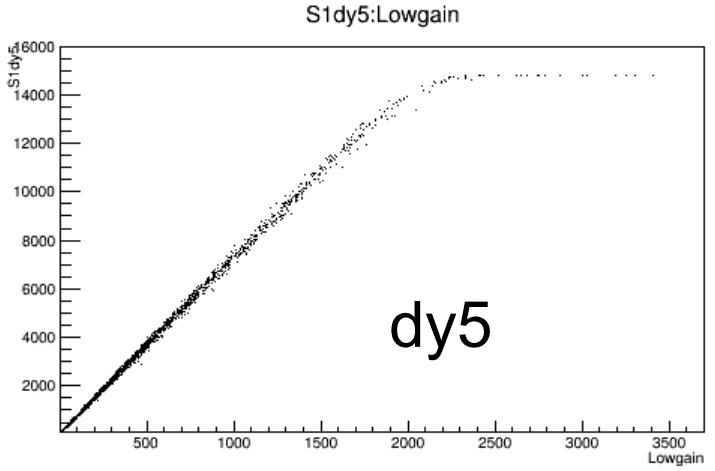
“立足常规，着眼新奇！”

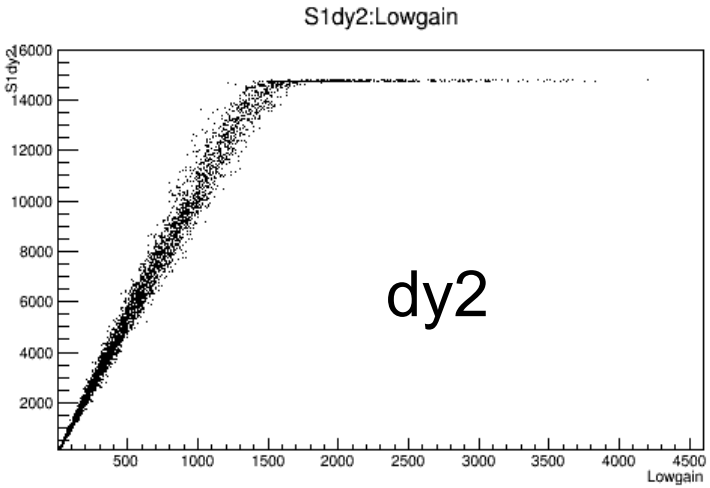
THANKS


Summer
Spring & Autumn
Winter
North
冬季晨昏面
夏季晨昏面
97.4°
Equator
South
DAMPE Orbit


Laser
310 nm
Filter
Filter
Filter
Filter
BGO/LYSO/PWO
Anode
Filter
Filter
Filter
QDC
VME System
BGO 60 cm
Dy2
Dy5
Dy8
D
A
Q
Electronics
VA chips


S1dy8:Lowgain
S1dy8
Lowgain
dy8


S1dy5:Lowgain
S1dy5
Lowgain
dy5


S1dy2:Lowgain
S1dy2
Lowgain
dy2