

# First data from DAMPE space mission

**Paolo Bernardini**

**Università del Salento and INFN, Lecce, Italy  
(on behalf of DAMPE Collaboration)**

**Thanks to I. De Mitri**



# Physics goals



Dark Matter  
Particle Explorer

## High energy particle detection in space

- Study of electron and photon spectra
- Study of protons and nuclei: spectrum and composition
- High energy gamma ray astronomy
- Search for dark matter signatures in lepton spectra
- Looking for exotica and "unexpected"  
(e.m. counterparts of Gravitational Waves)

### Detection of

**electrons and gammas ( 10 GeV - 10 TeV )**

**protons and nuclei ( 50 GeV - 500 TeV )**

with excellent energy resolution, tracking precision  
and particle identification capabilities

# The collaboration



- **CHINA**

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

*Prof. Jin Chang*



- **ITALY**

- INFN Perugia and University of Perugia
- INFN Bari and University of Bari
- INFN Lecce and University of Salento

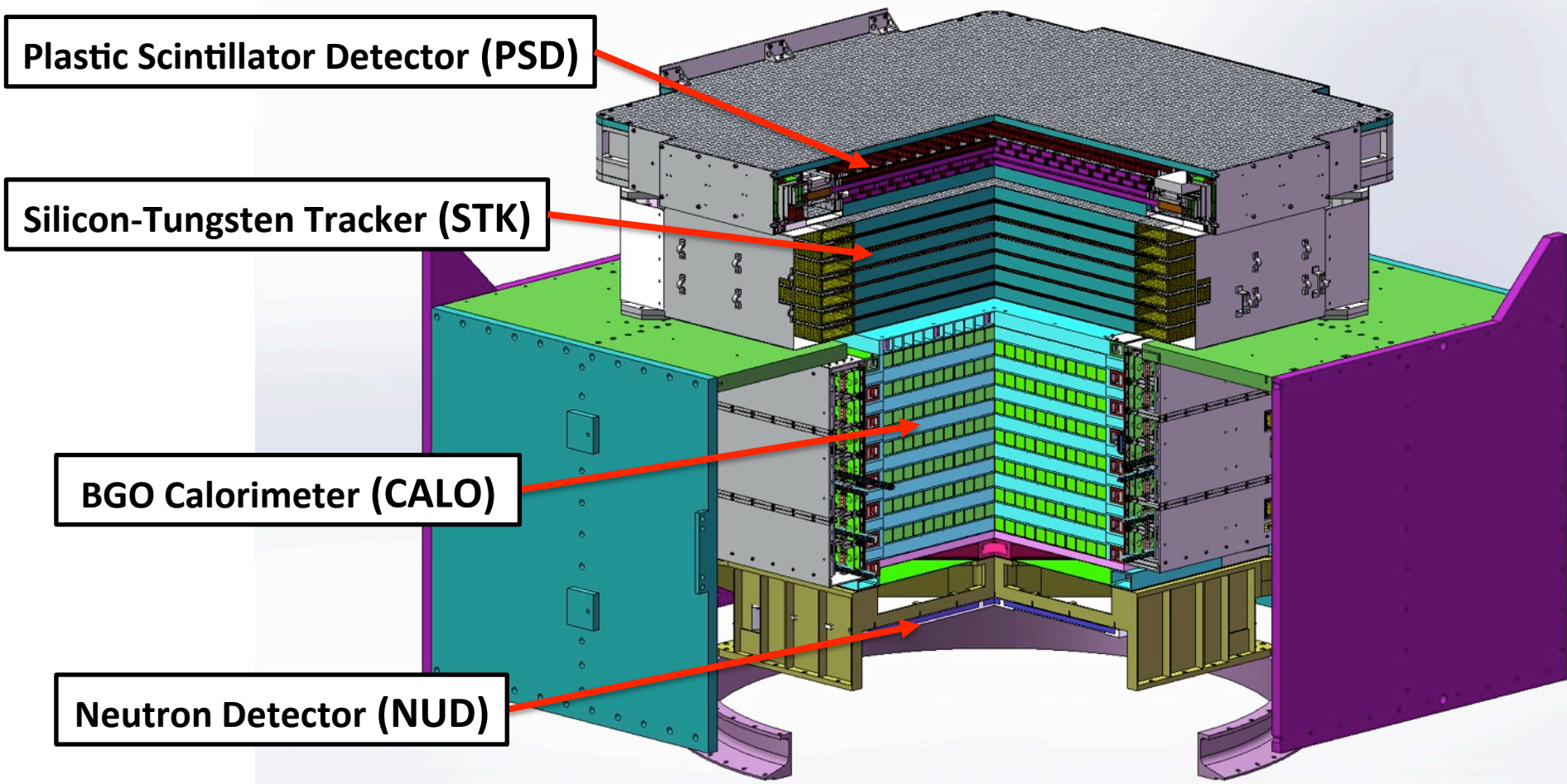


- **SWITZERLAND**

- University of Geneva



# The detector



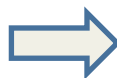
Plastic Scintillator Detector (PSD)

Silicon-Tungsten Tracker (STK)

BGO Calorimeter (CALO)

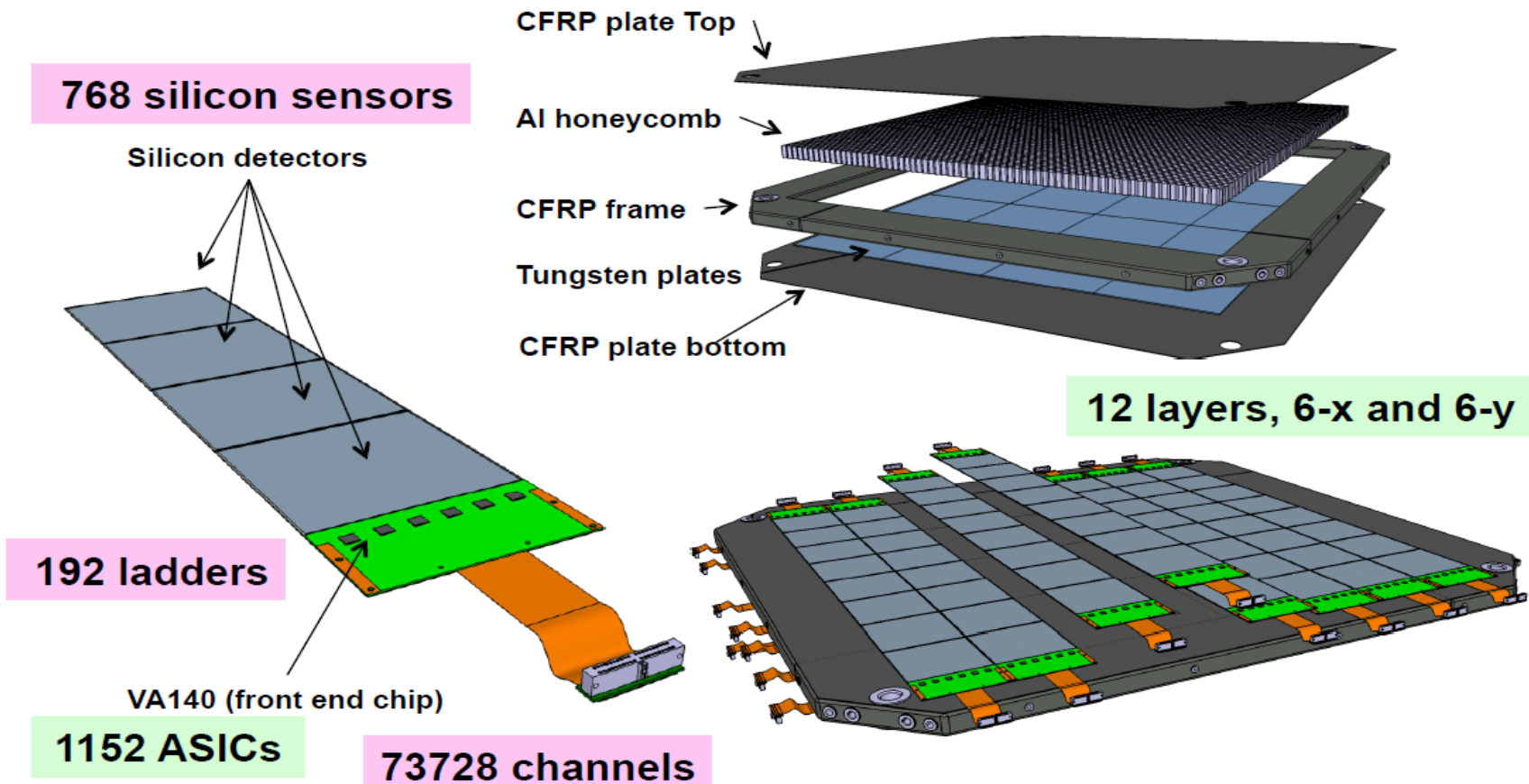
Neutron Detector (NUD)

- Charge measurement (  $dE/dx$  in PSD, STK and CALO)
- Tungsten converter (pair production)
- Precise tracking (silicon strips)
- Thick calorimeter (BGO bars)
- Hadron rejection (neutron detector)



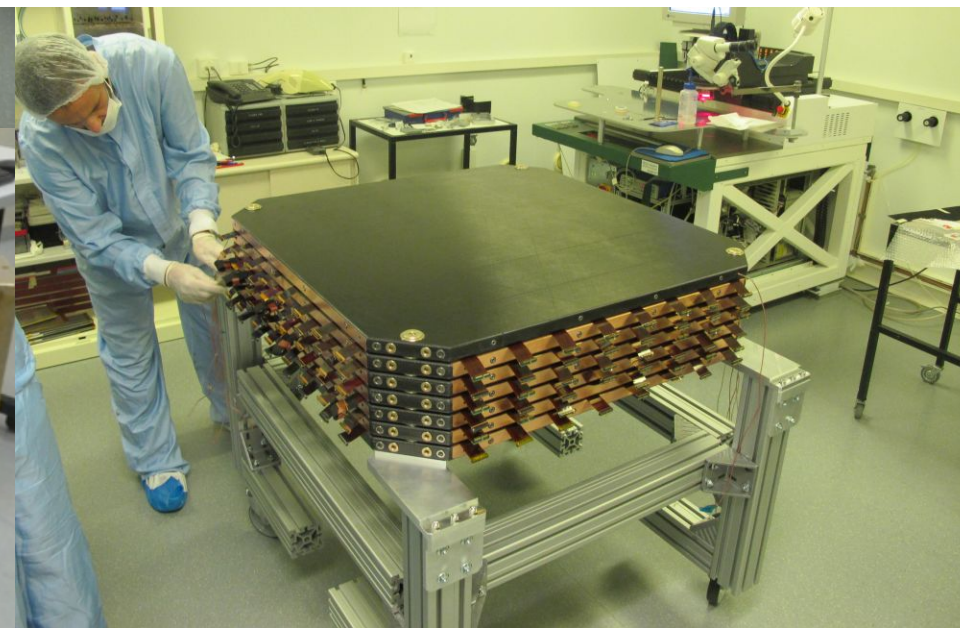
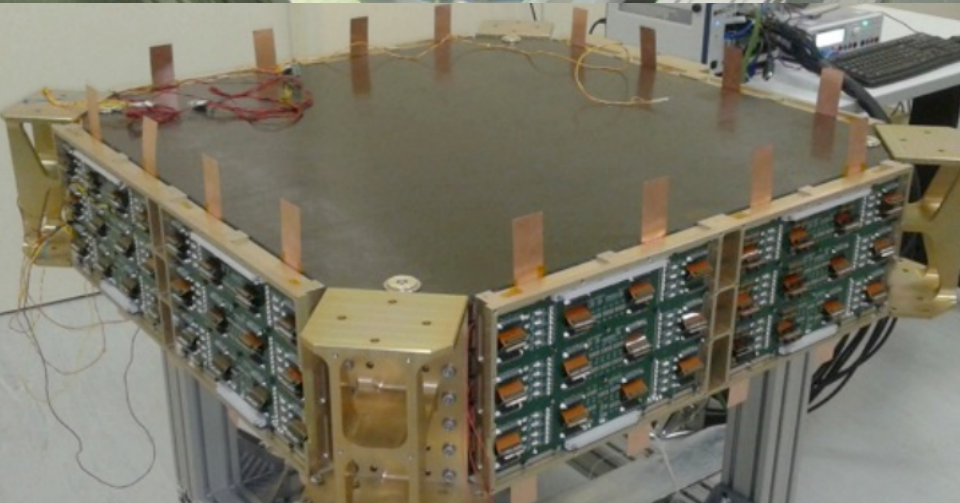
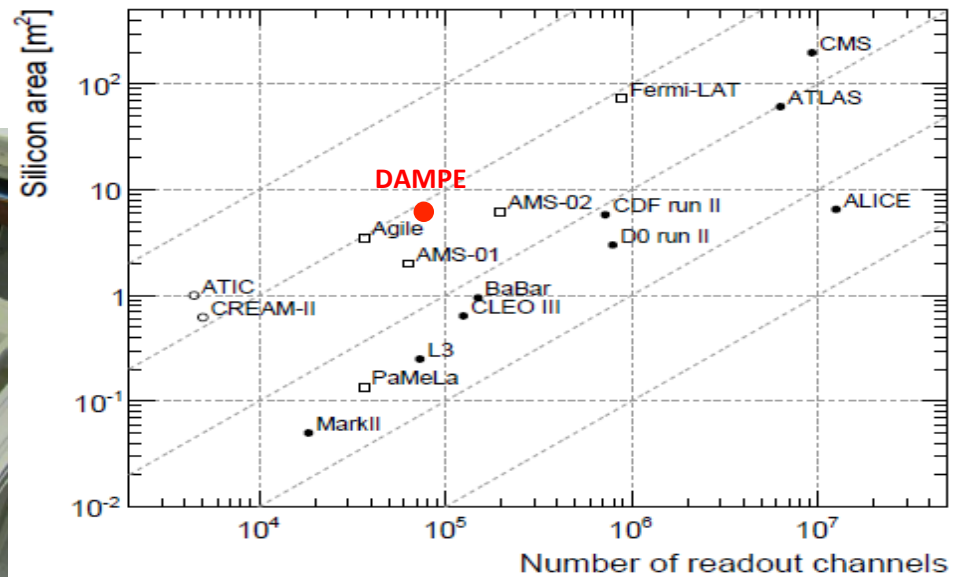
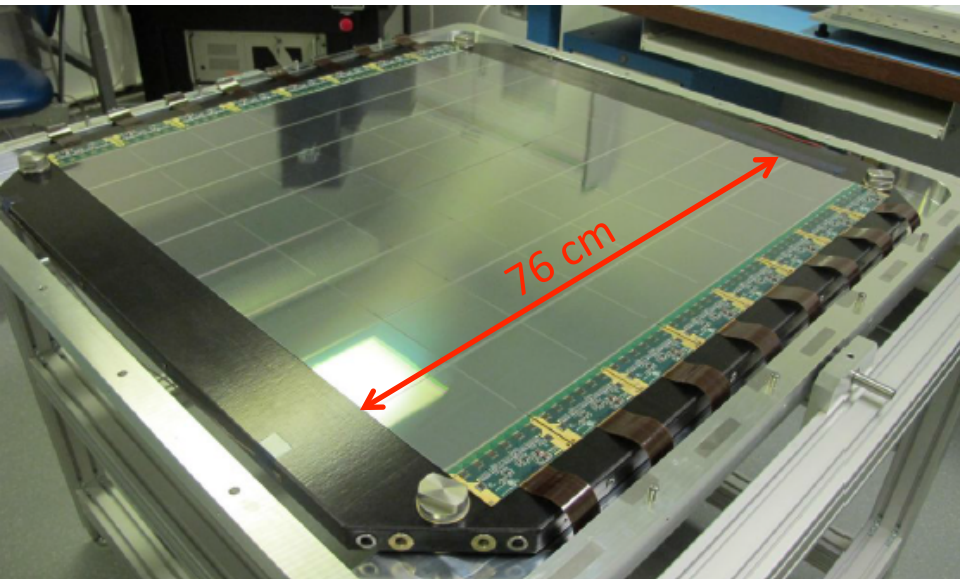
**telescope for high energy  
 $\gamma$ -ray, electron and cosmic ray**

# The Silicon Tracker - 1



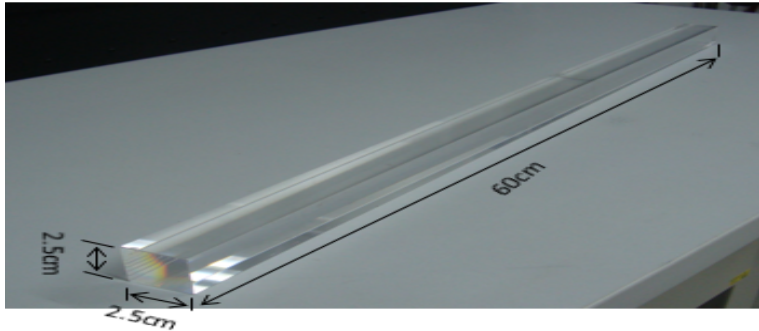
- 48  $\mu\text{m}$  wide Si strips with 121  $\mu\text{m}$  pitch
- (95  $\times$  95  $\times$  0.32 mm<sup>3</sup>) Silicon Strip Detectors (SSD) with 768 strips
- Analog Readout of each second strip: 384 channels / SSD
- 4 Silicon Strip Detectors (SSD) = 1 ladder
- 16 Ladders per layer (76  $\times$  76 cm<sup>2</sup>)

# The Silicon Tracker - 2

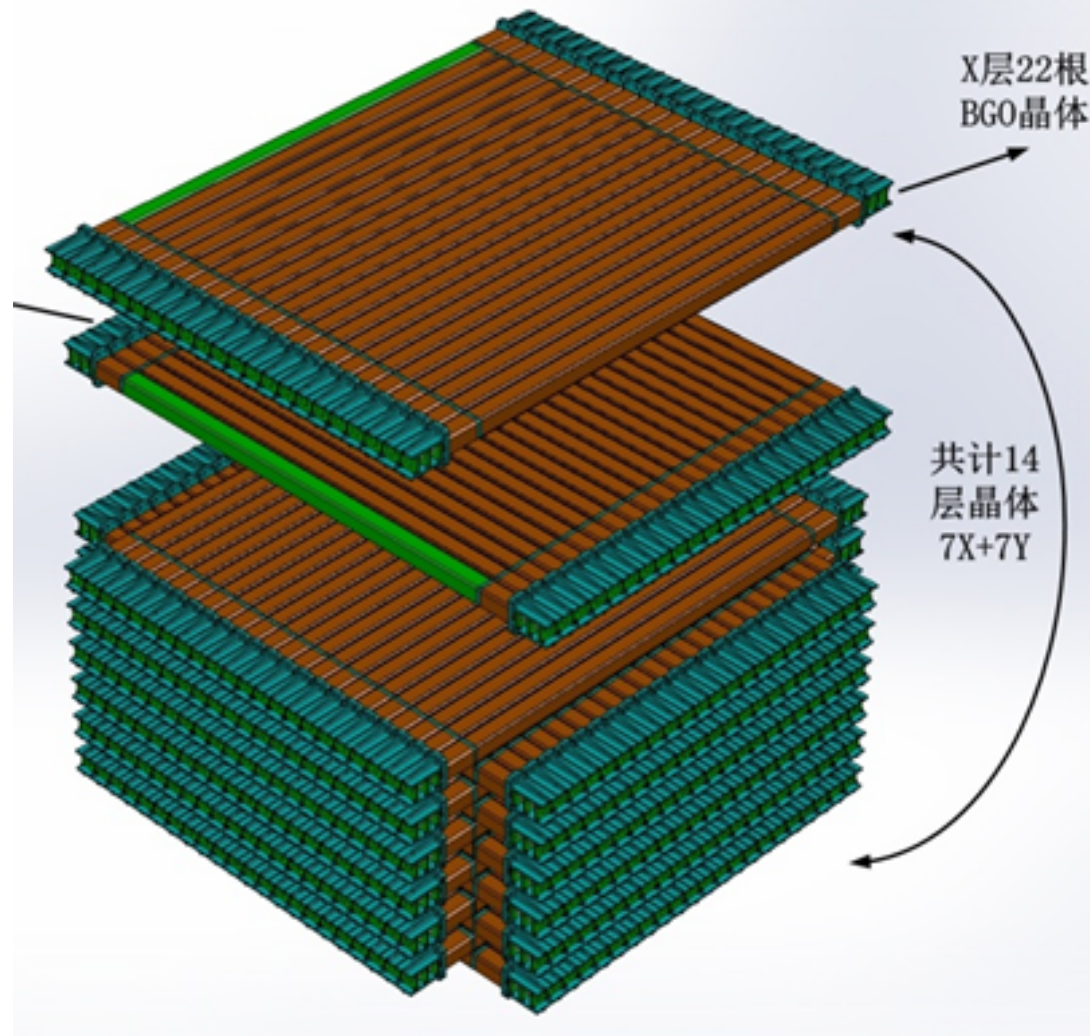


# The CALOrimeter - 1

- 14 layers of 22 BGO bars
  - BGO bar:  $2.5 \times 2.5 \times 60 \text{ cm}^3$
  - hodoscopic stacking alternate orthogonal layers
  - depth  $\sim 32X_0$

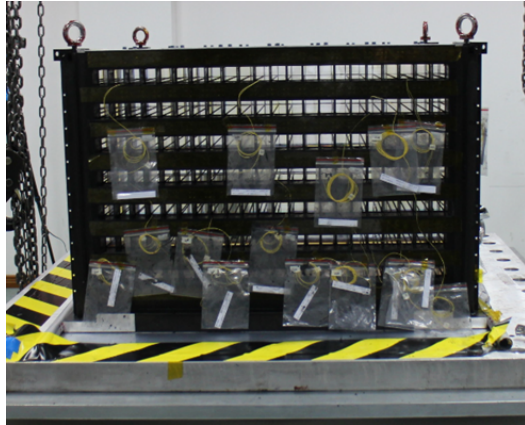


- PMTs coupled with each BGO crystal bar in two ends



- Front-end electronics attached to each side of the module

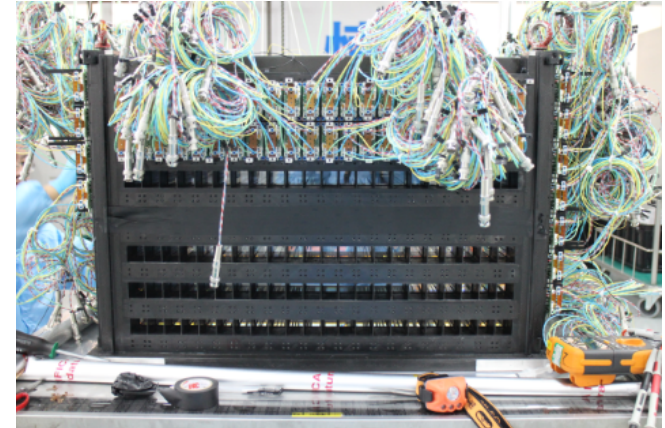
# The CALOrimeter - 2



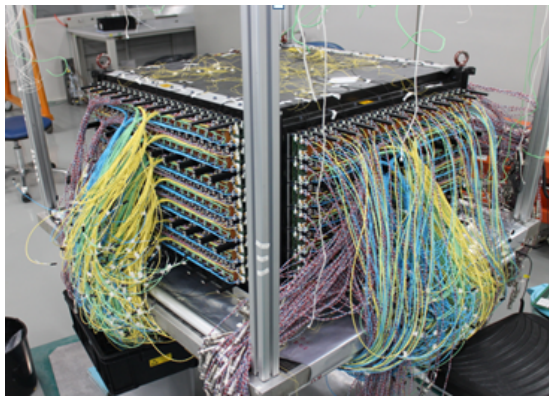
**Carbon fiber structure**



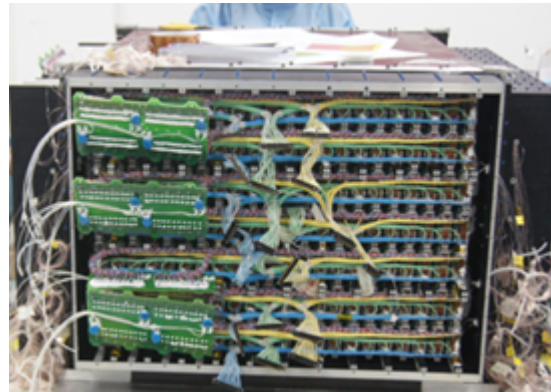
**BGO crystal installation**



**PMT installation**



**Cable arranging**



**Cable connector**

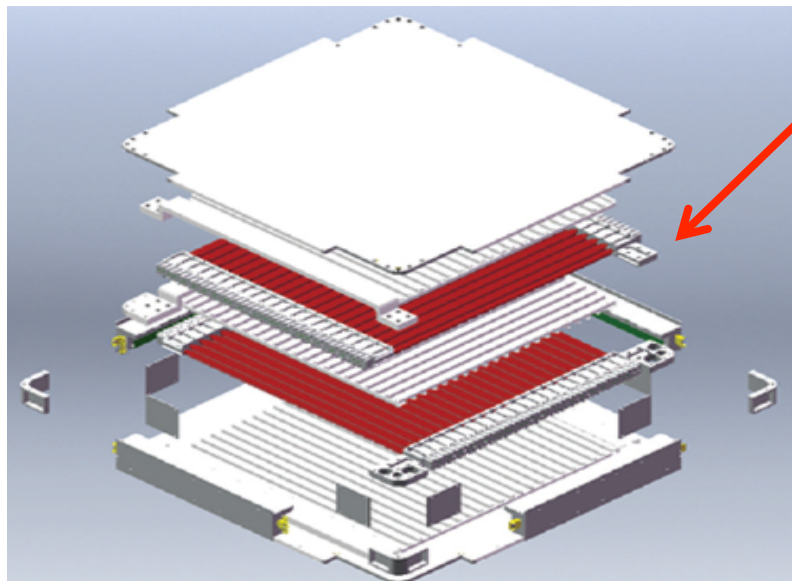


**BGO Calorimeter**

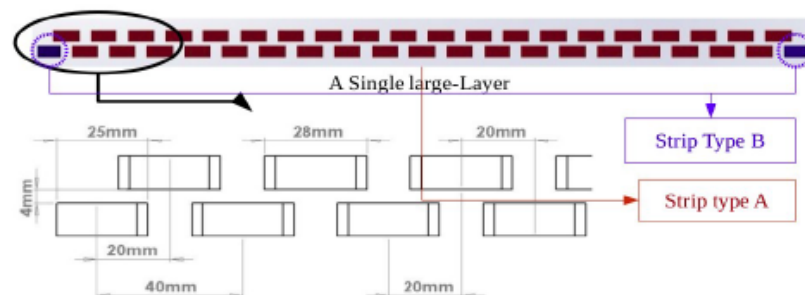


# PSD and NUD

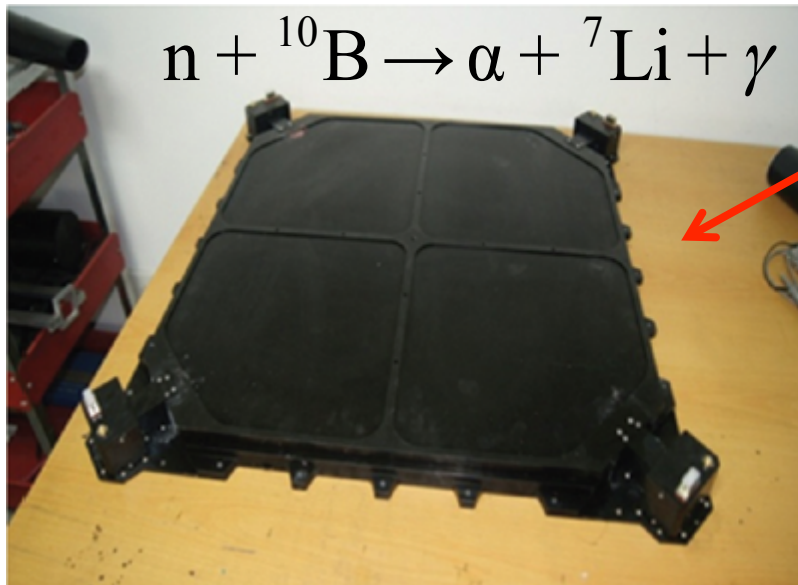
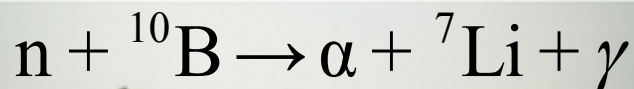
PSD



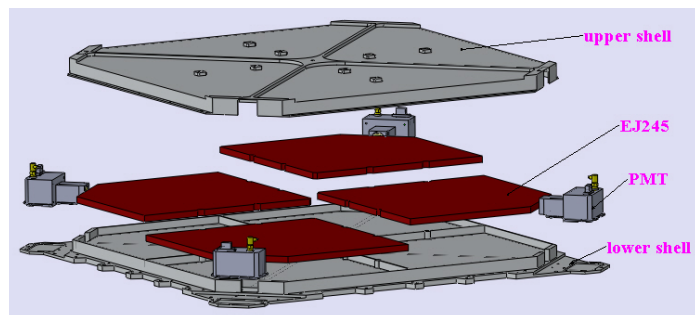
- scintillator strips (2.8 cm × 82 cm × 1 cm)
- staggered by 1.2 cm in a layer
- 82 cm × 82 cm layers
- 2 layers ( x and y )



NUD

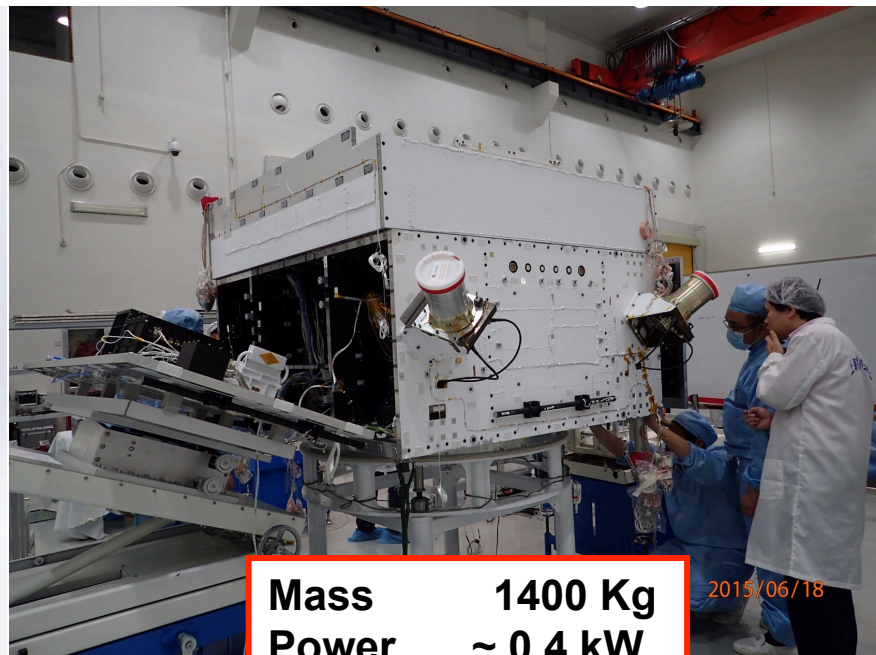
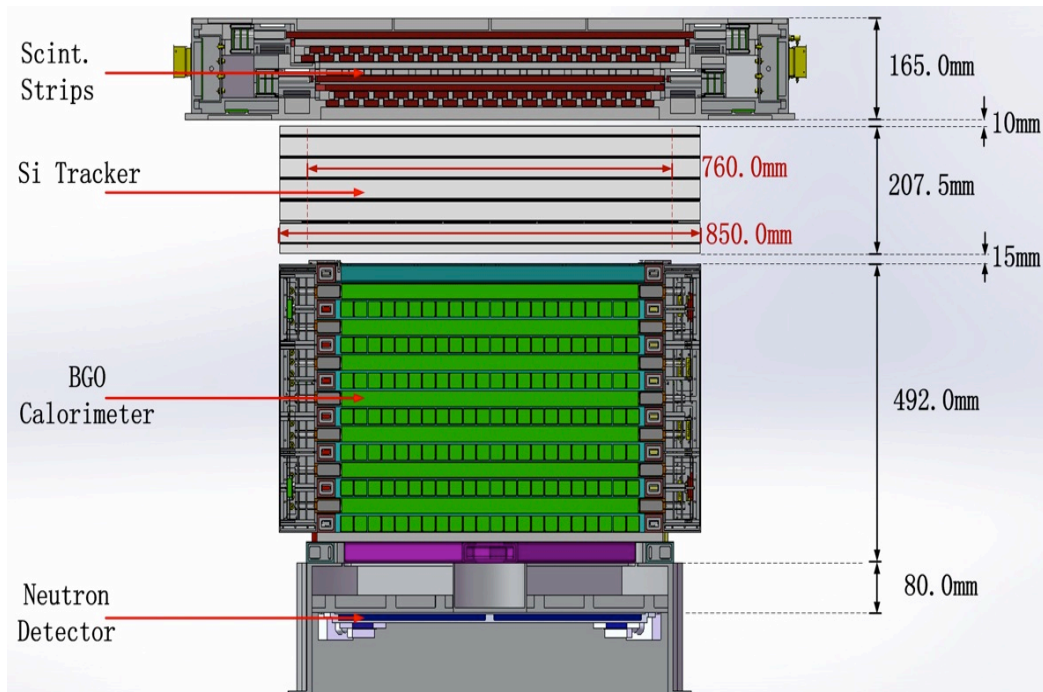


- 4 large area boron-doped plastic scintillators (30 cm × 30 cm × 1 cm)



# Comparison with AMS-02 and FERMI

	DAMPE	AMS-02	Fermi LAT
e/γ Energy res.@100 GeV (%)	<b>1.5</b>	3	10
e/γ Angular res.@100 GeV (°)	<b>0.1</b>	0.3	0.1
e/p discrimination	<b>10<sup>5</sup></b>	10 <sup>5</sup> - 10 <sup>6</sup>	10 <sup>3</sup>
Calorimeter thickness (X <sub>0</sub> )	<b>32</b>	17	8.6
Geometrical acceptance (m <sup>2</sup> sr)	<b>0.29</b>	0.09	1

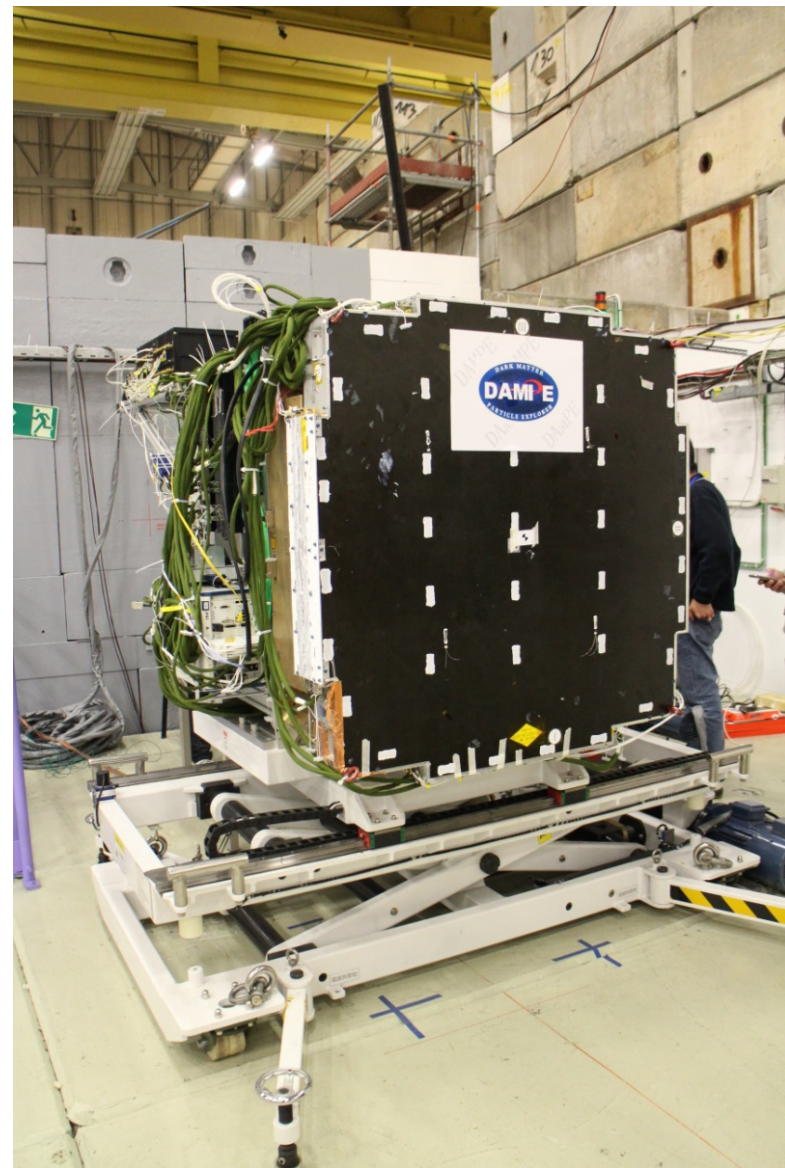


**Mass**      1400 Kg  
**Power**     ~ 0.4 kW  
**Lifetime**   > 3 years

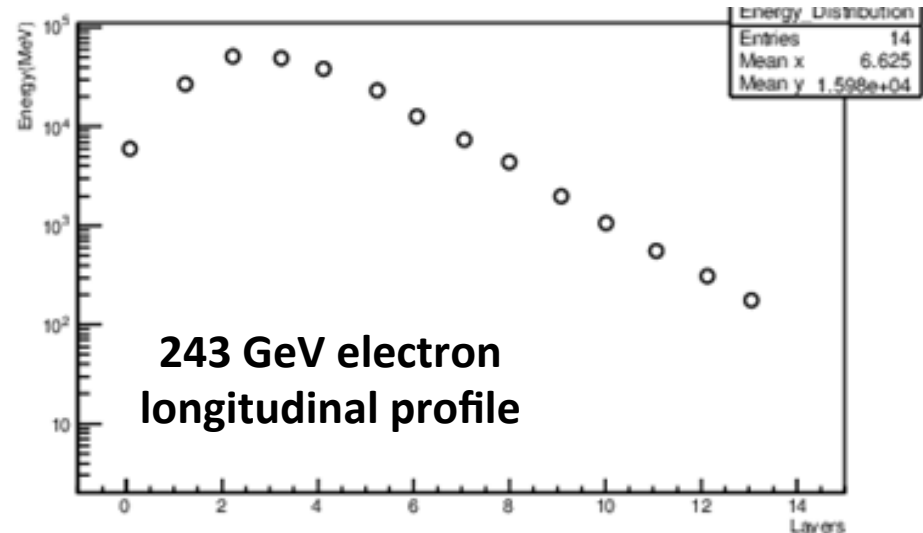
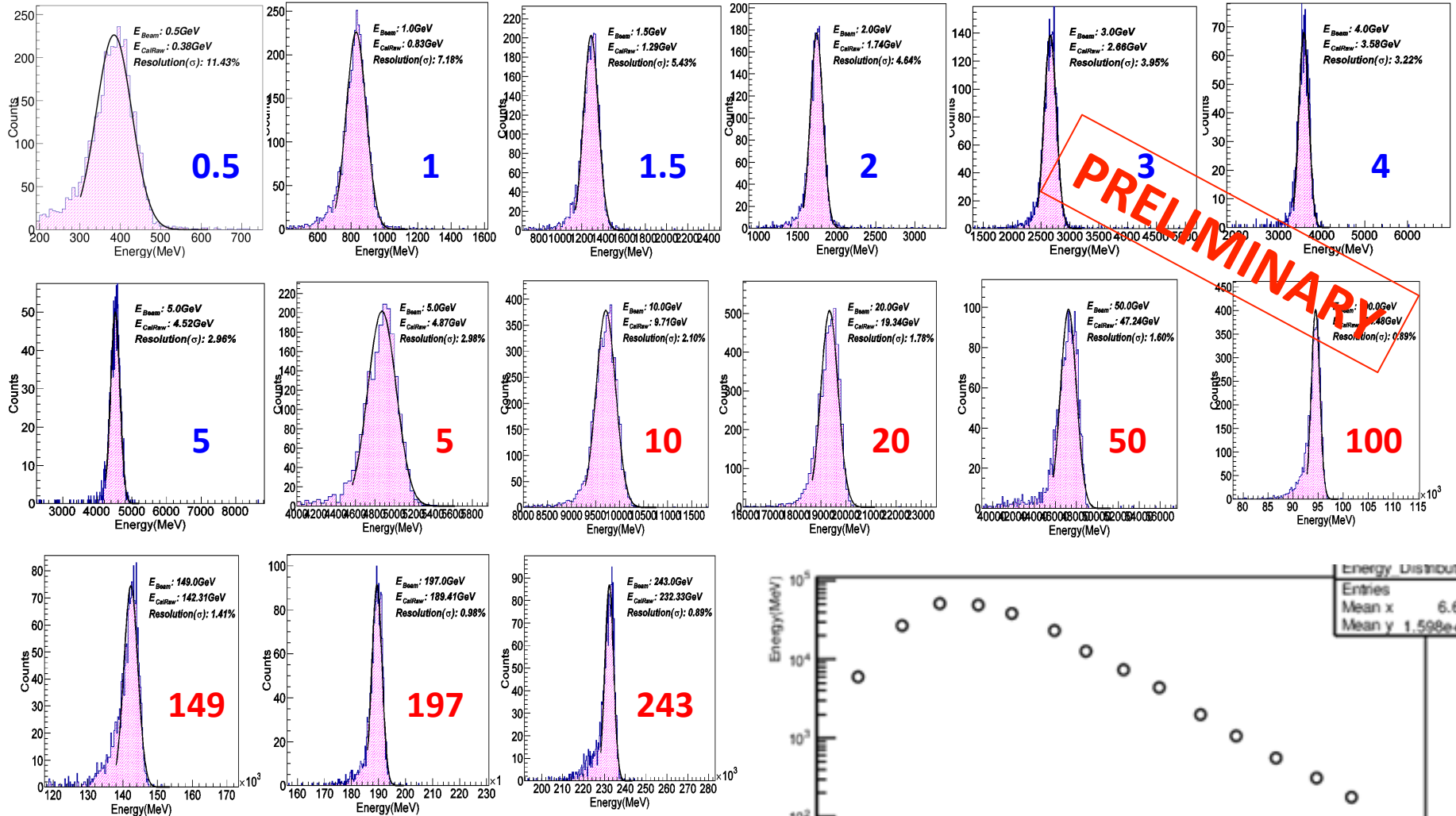
2015/06/18

# Test beam at CERN

- **14 days@PS, October 29 – November 11, 2014**
  - e @ 0.5, 1, 2, 3, 4, 5 GeV/c
  - p @ 3.5, 4, 5, 6, 8, 10 GeV/c
  - $\pi$  @ 3, 10 GeV/c
  - $\gamma$  @ 0.5-3 GeV/c
- **8 days@SPS, November 12 – 19, 2014**
  - e @ 5, 10, 20, 50, 100, 150, 200, 250 GeV/c
  - p @ 400 GeV/c (SPS primary beam)
  - $\gamma$  @ 3-20 GeV/c
  - $\mu$  @ 150 GeV/c
- **17 days@SPS, March 16 – April 1 2015**
  - Argon (and fragments): 30 – 40 – 75 A GeV/c
  - Protons: 30, 40 GeV/c
- **21 days@SPS, June 10 – July 1 2015**
  - p @ 400 GeV/c
  - e @ 20, 100, 150 GeV/c
  - $\gamma$  @ 50, 75, 150 GeV/c
  - $\mu$  @ 150 GeV/c
  - $\pi^+$  @ 10, 20, 50, 100 GeV/c
- **6 days@SPS, November 20-25 2015**
  - Pb (and fragments): 30 A GeV/c



# Test beam at CERN: electrons

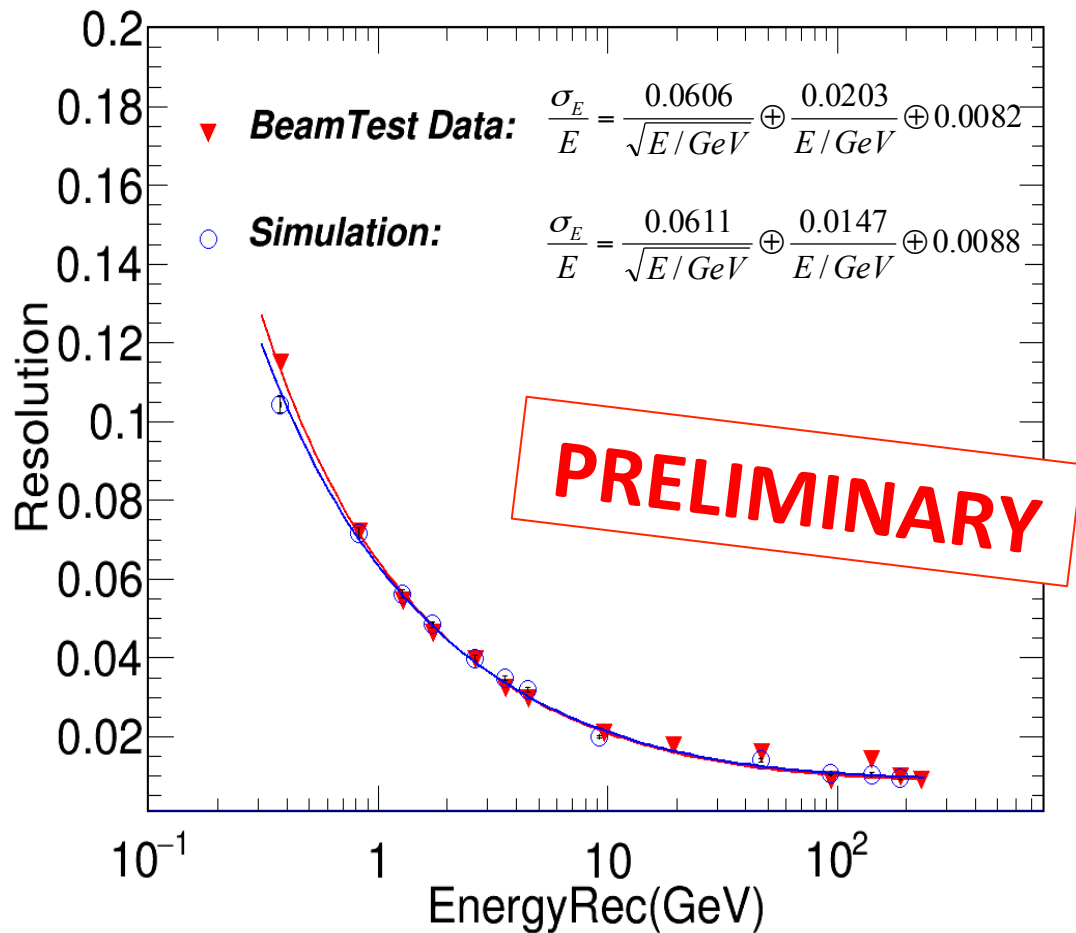
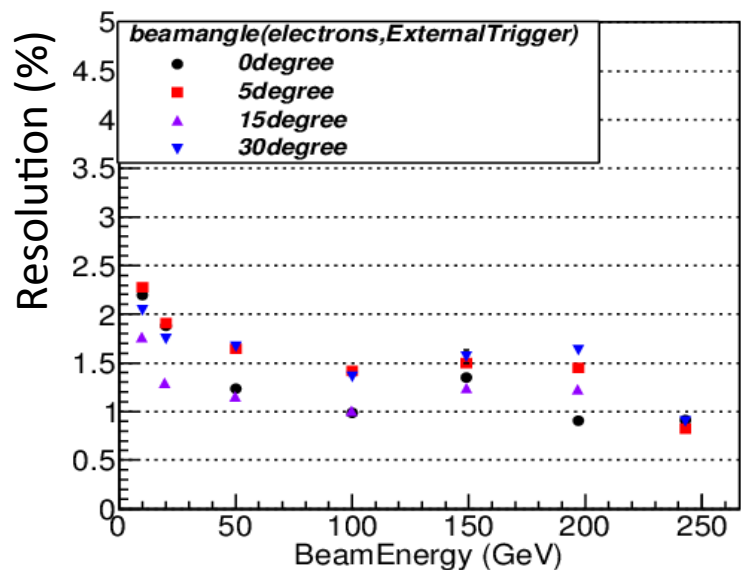
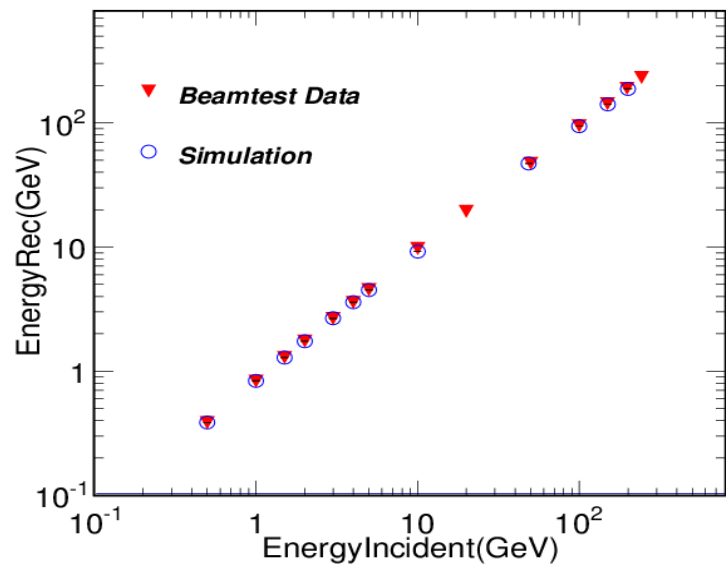


## Electrons

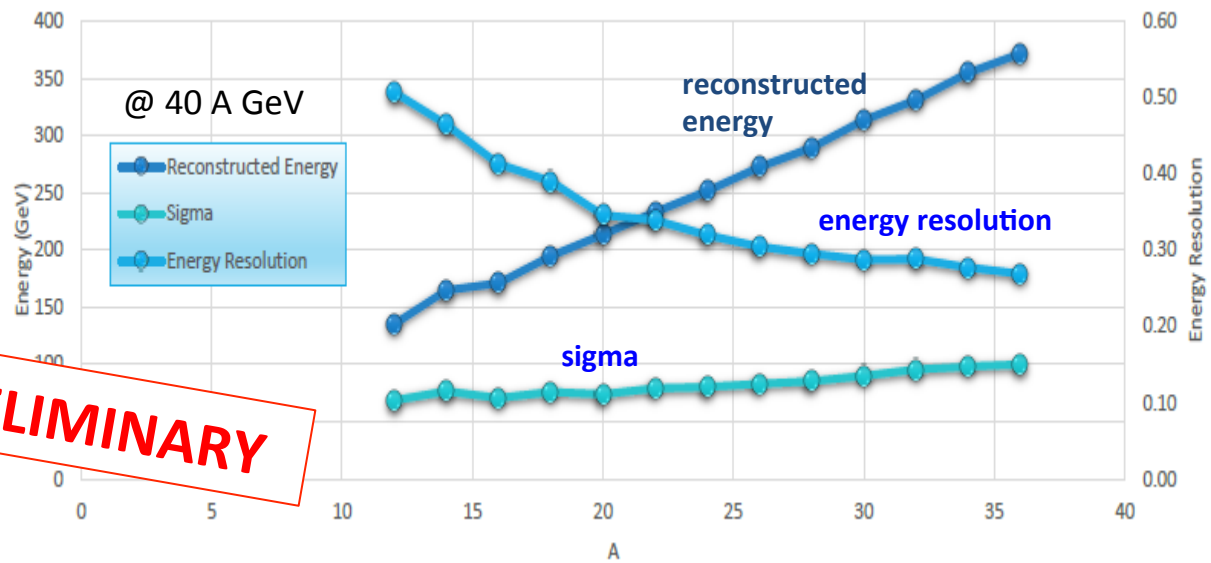
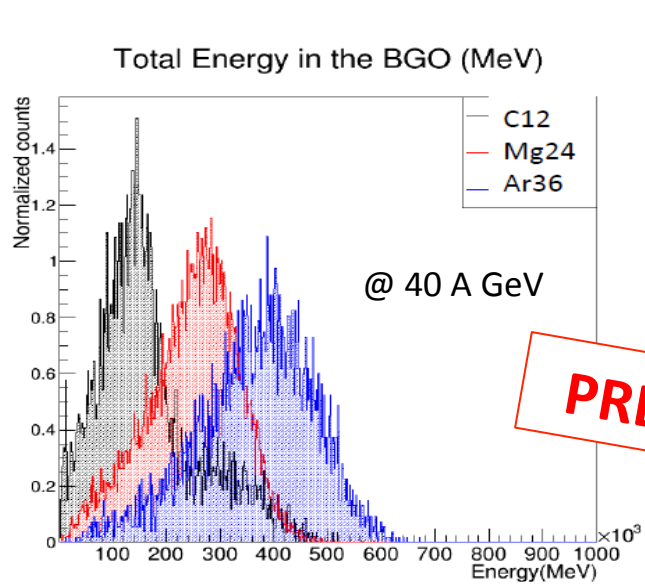
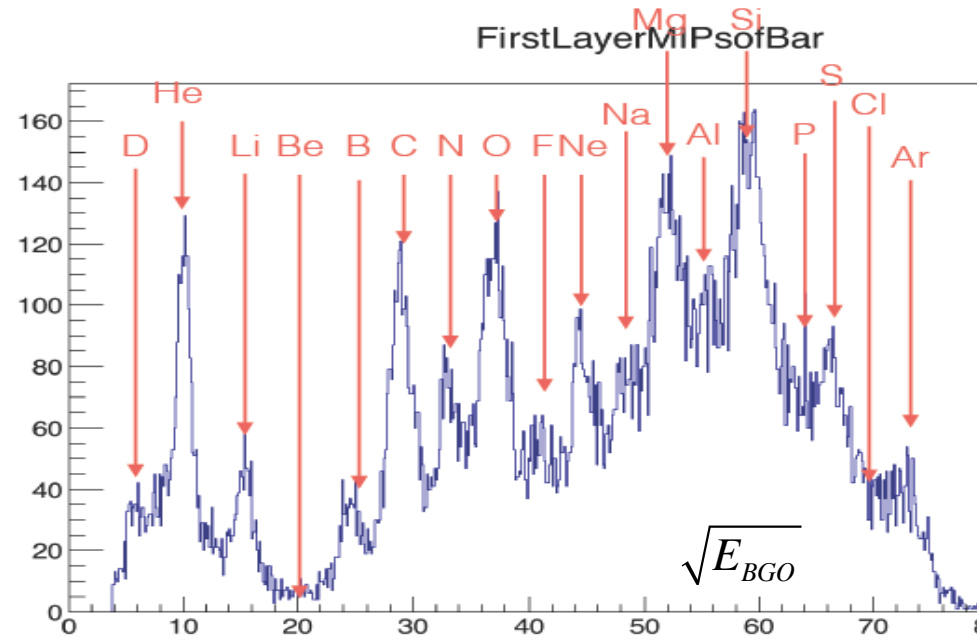
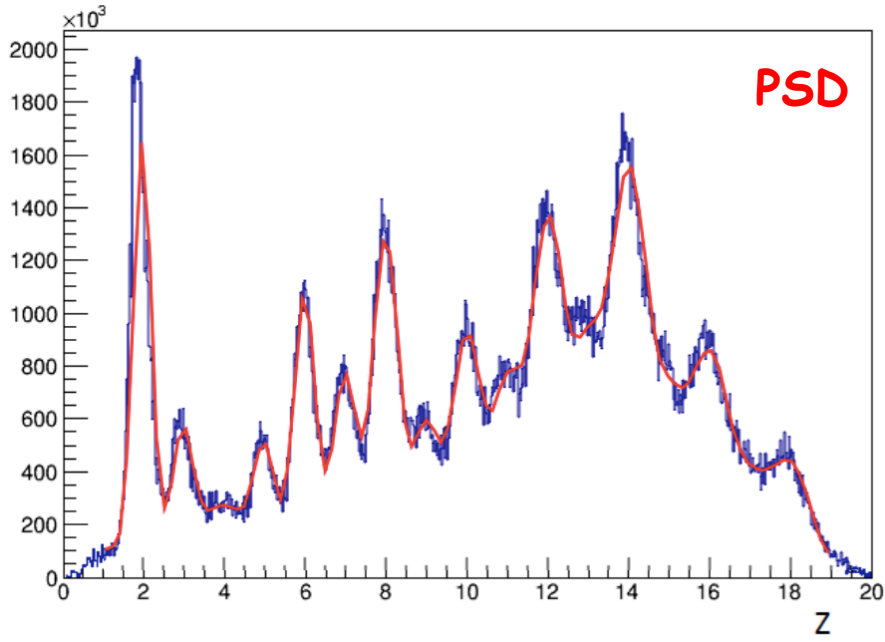
0.5, 1, 1.5, 2, 3, 4, 5 GeV @ PS

5, 10, 20, 50, 100, 149, 197, 243 GeV @ SPS

# Test beam at CERN: electrons



# Test beam at CERN: Ar and fragments (A/Z=2)



**PRELIMINARY**

# The launch: Dec 17th 2015, 0:12 UTC



Jiuquan Satellite Launch Center  
Gobi desert

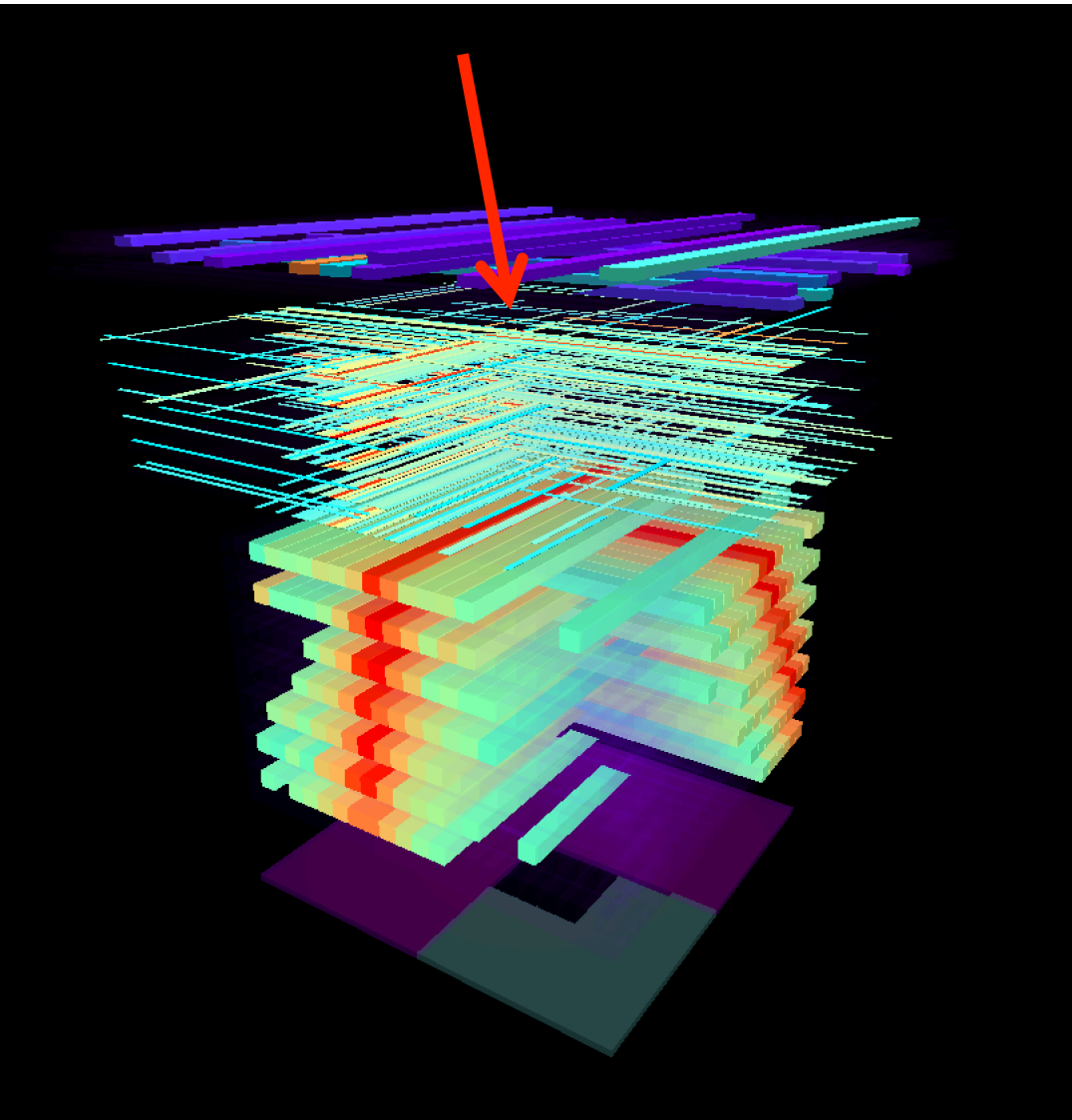
Orbit: Sun synchronous  
Altitude: 500 km  
Period: 1.5 hours

DAMPE → WUKONG ( 悟空 )



# December 24, 2015: HV on

## 330 GeV electron



**Z-X View**      **Z-Y View**

69.6  
34.8  
0.0 MeV

16038  
2311  
332  
47  
5  
0 ADC

1.71e+04  
5.78e+03  
1.96e+03  
662  
223  
75  
24.7  
7.72  
1.95  
0 MeV

<< First   < Previous   4911   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):  
../display/20151224\_2A/DAMPE\_OBS\_20151224B012559\_RECO5000.root

Event Number:  
4911

Time Point:  
01:28:17.746, 24/12/2015

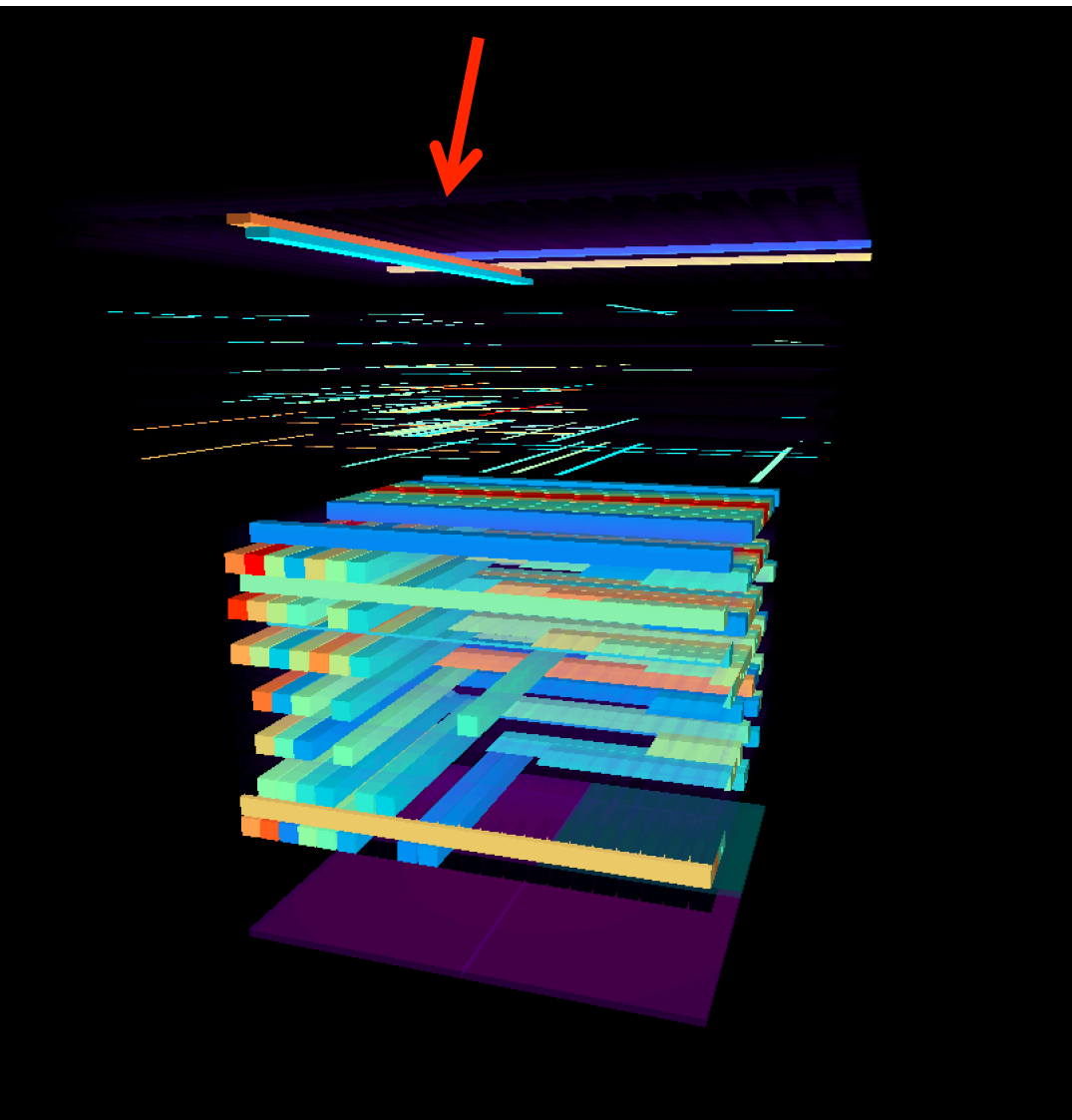
Total Energy:  
328.276531 GeV

Direction:  
Theta: 31.3 deg, Phi: -13.0 deg




# December 24, 2015: HV on

## 12 GeV proton



**Z-X View**      **Z-Y View**



2.5 MeV  
0.0 MeV  
4792 ADC  
879 ADC  
160 ADC  
28 ADC  
4 ADC  
0 ADC

1.31e+03 MeV  
591 MeV  
266 MeV  
119 MeV  
53.1 MeV  
23.3 MeV  
9.96 MeV  
3.93 MeV  
1.22 MeV  
0 MeV  
10.0 MeV

<< First   < Previous   160   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):  
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Event Number:  
160

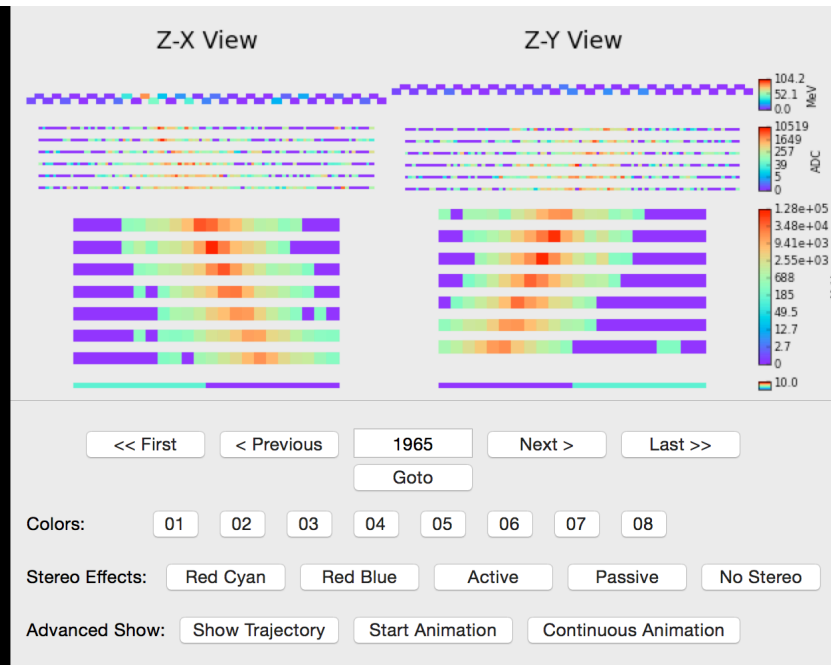
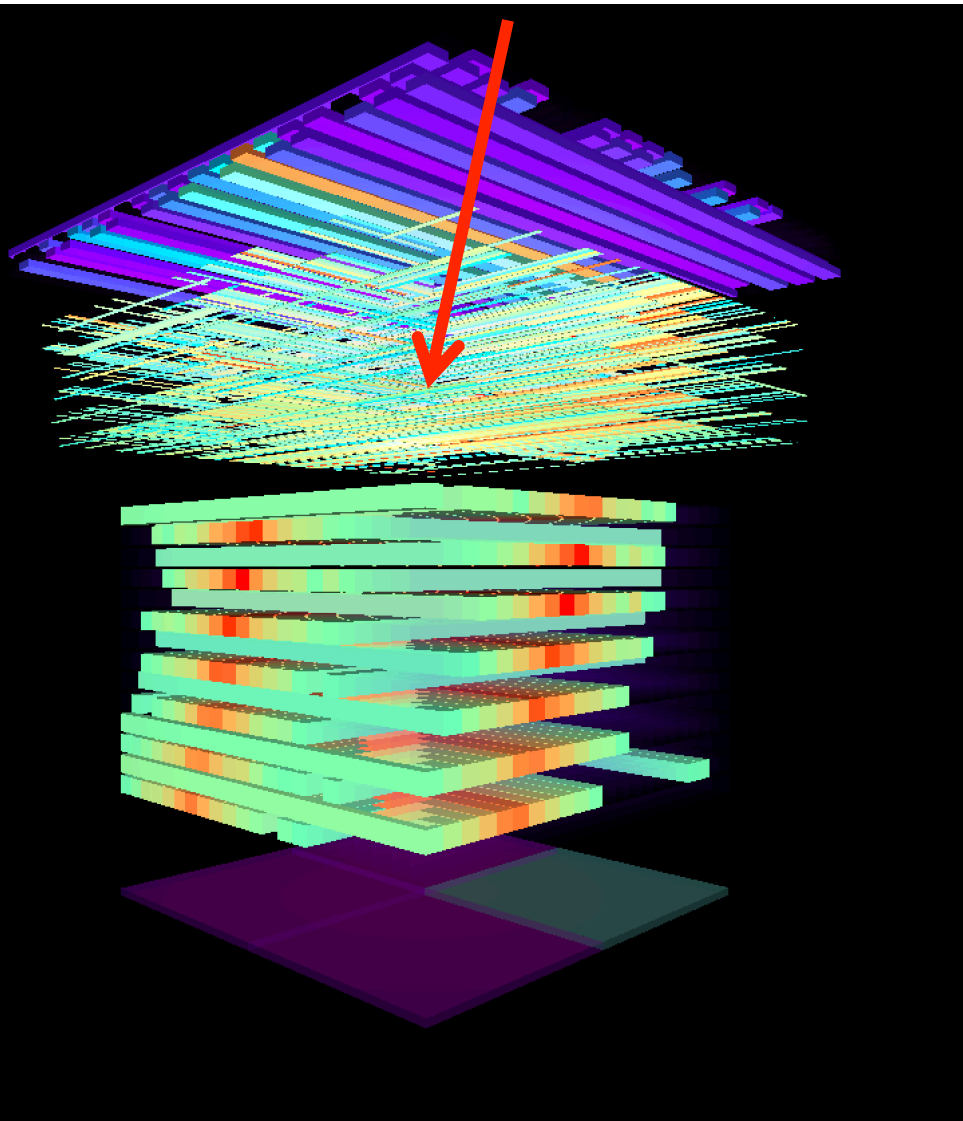
Time Point:  
01:26:05.040, 24/12/2015

Total Energy:  
12.452557 GeV

Direction:  
Theta: 44.6 deg, Phi: -91.2 deg

# December 24, 2015: HV on

## 1.3 TeV carbon



File Name(s):  
../display/20151224\_2A/DAMPE\_OBS\_20151224B012559\_RECO5000.root

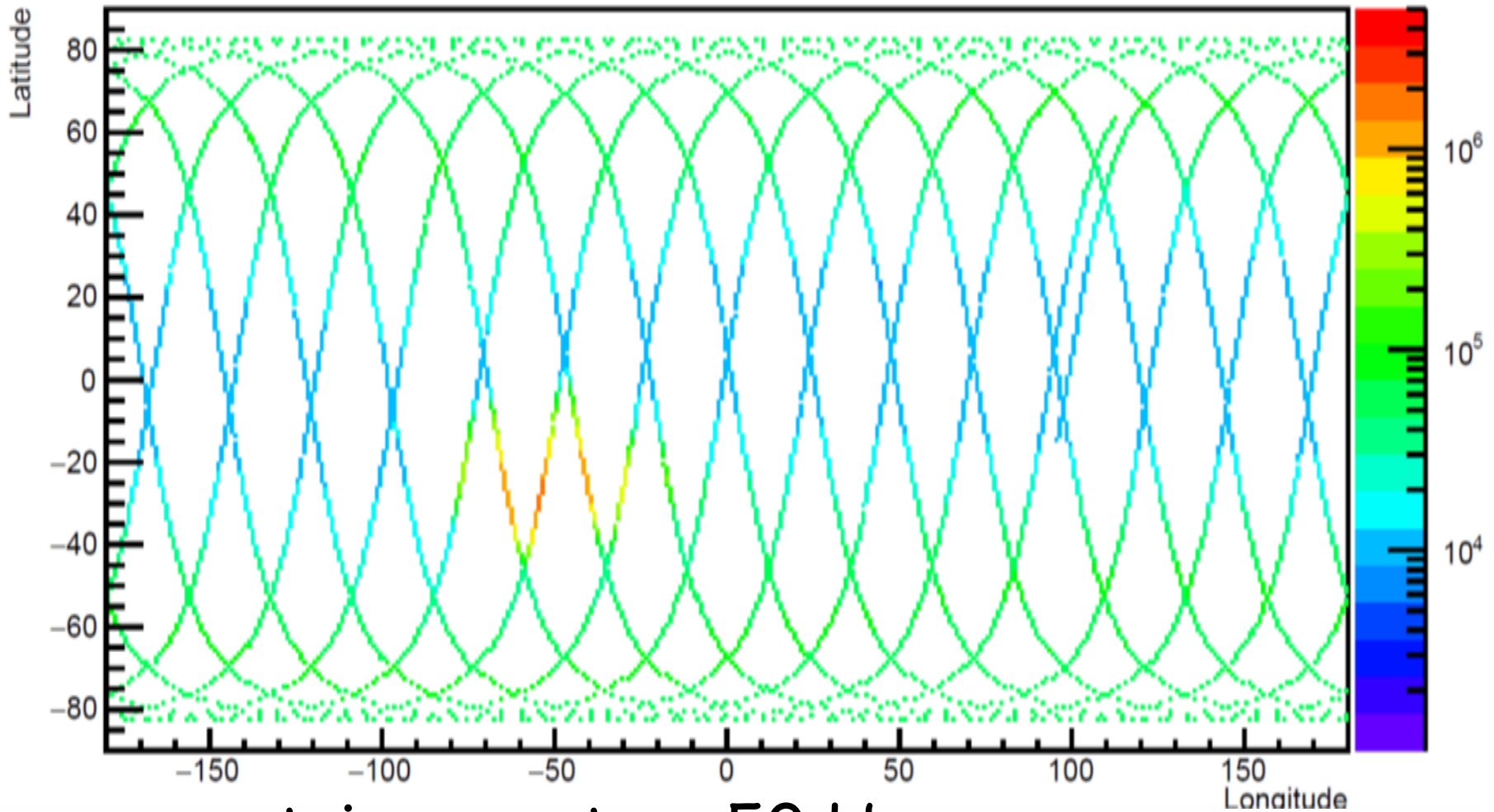
Event Number:  
1965

Time Point:  
01:26:56.936, 24/12/2015

Total Energy:  
1306.882750 GeV

Direction:  
Theta: 26.8 deg,   Phi: -45.9 deg

# Trigger rate in orbit

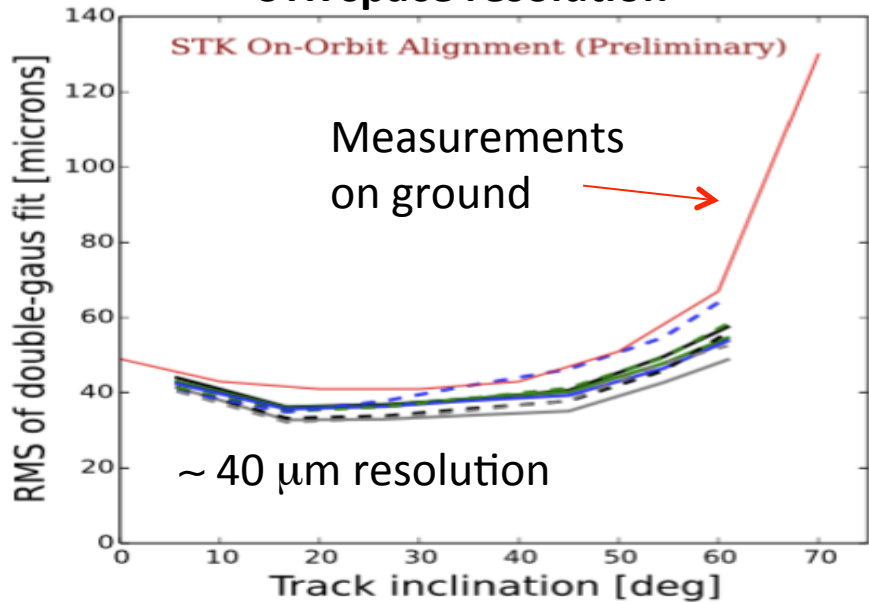


average trigger rate:  $\sim 50$  Hz

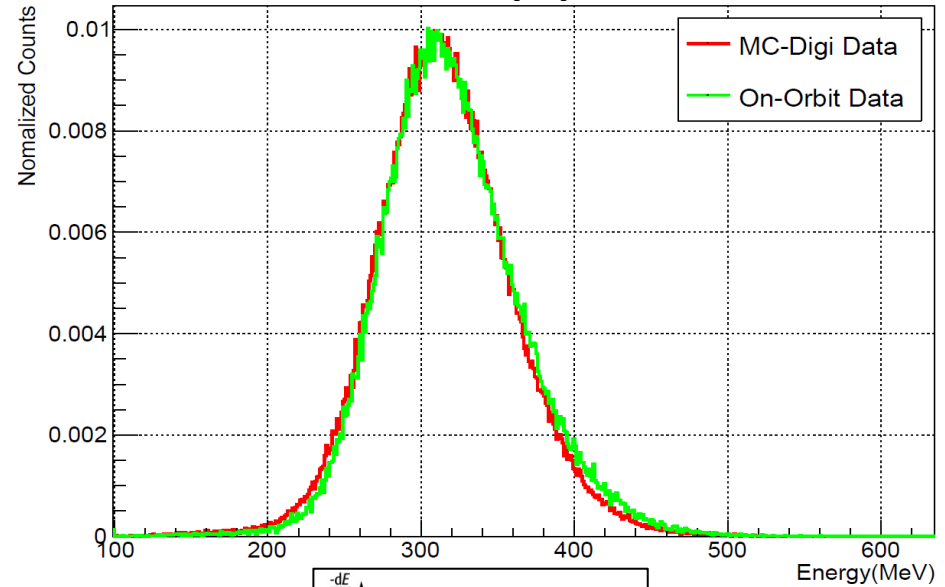
$\rightarrow 100$  GB/day on ground (about 4 M events)

# On-orbit performances

## STK space resolution

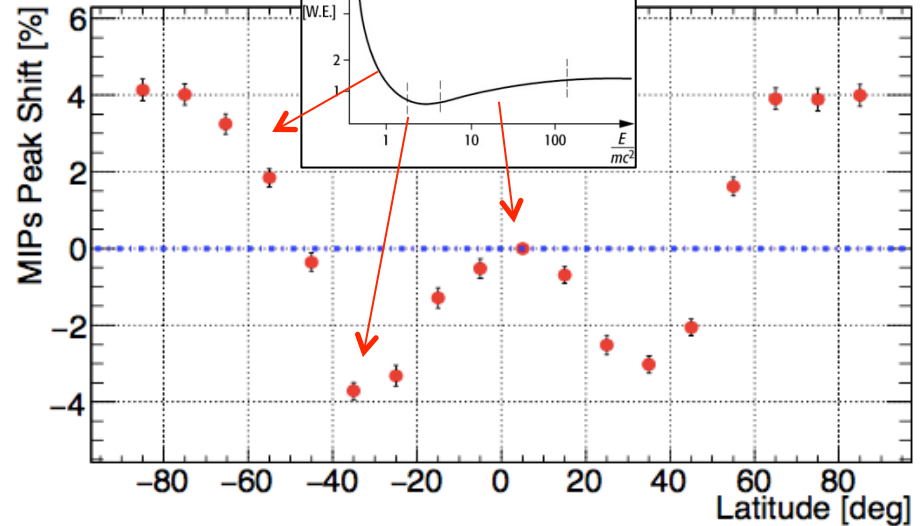
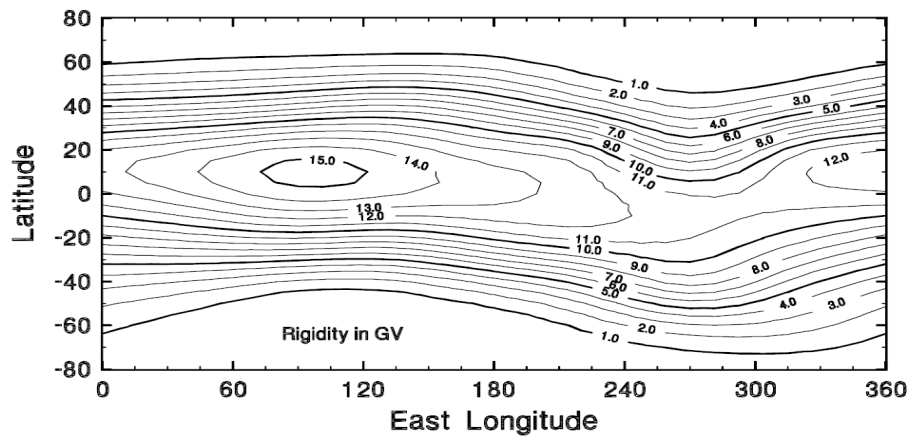


## BGO "mip" peak



## VERTICAL CUTOFF RIGIDITIES AT 450 KM

Tsyganenko model  $K_p = 0$

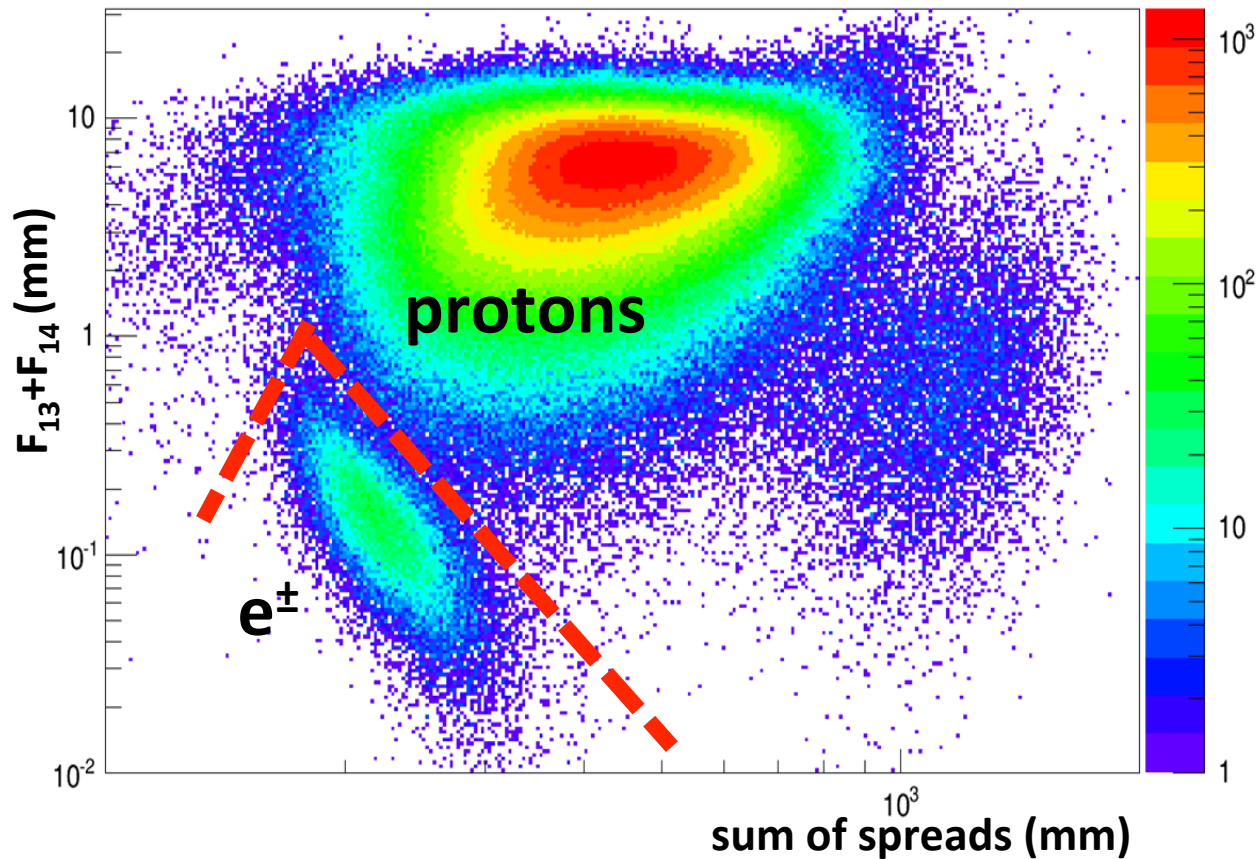
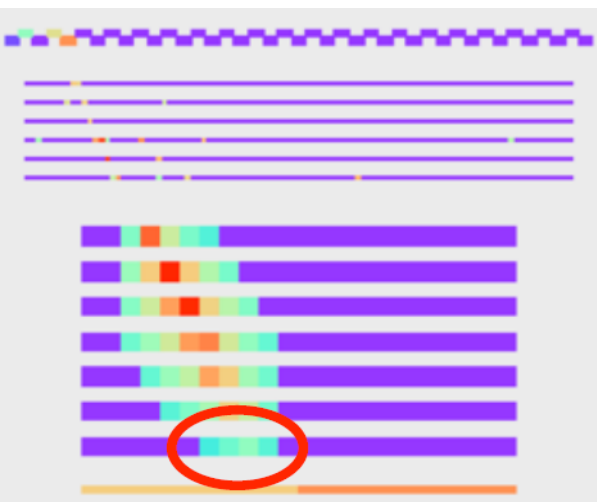


# Electron identification

Possible “shape parameter”  
( $i$ , index of BGO layer)

$$F_i = \text{spread}_i \times \frac{E_i}{E_{tot}}$$

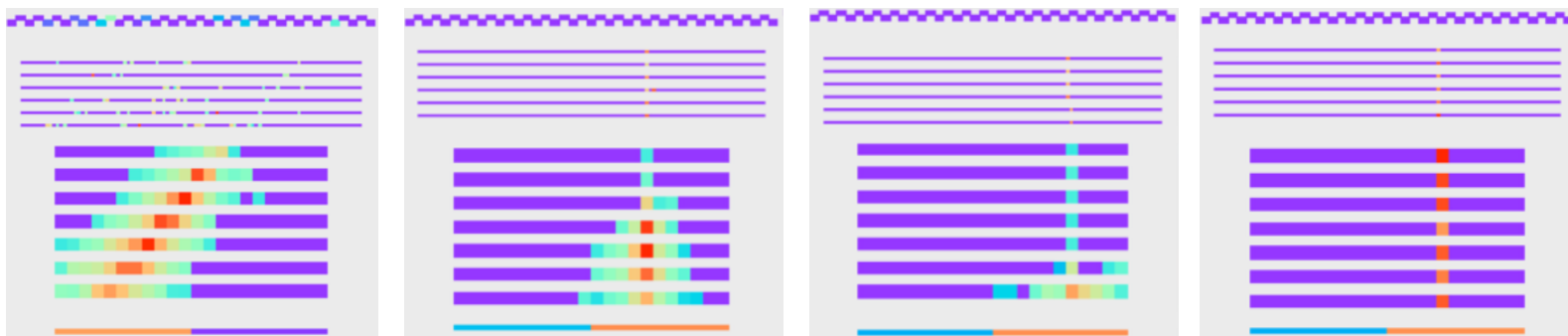
Rejection power  $> 10^5$



Electrons  
and  
positrons

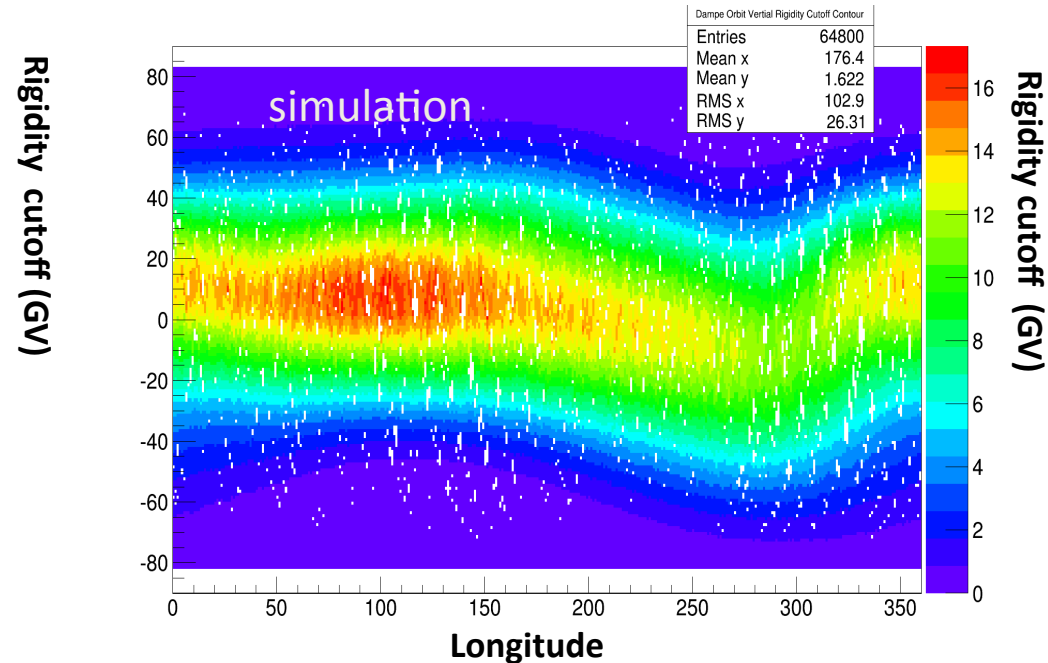
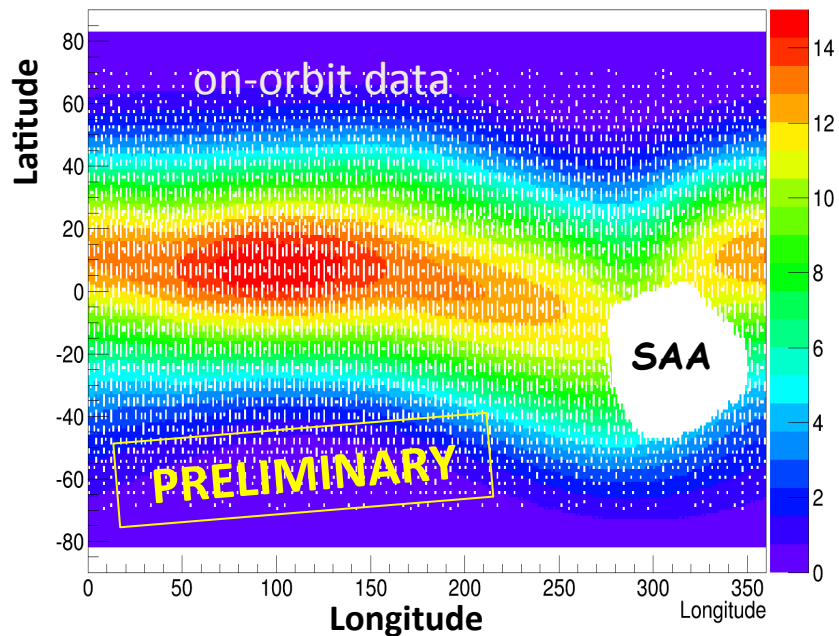
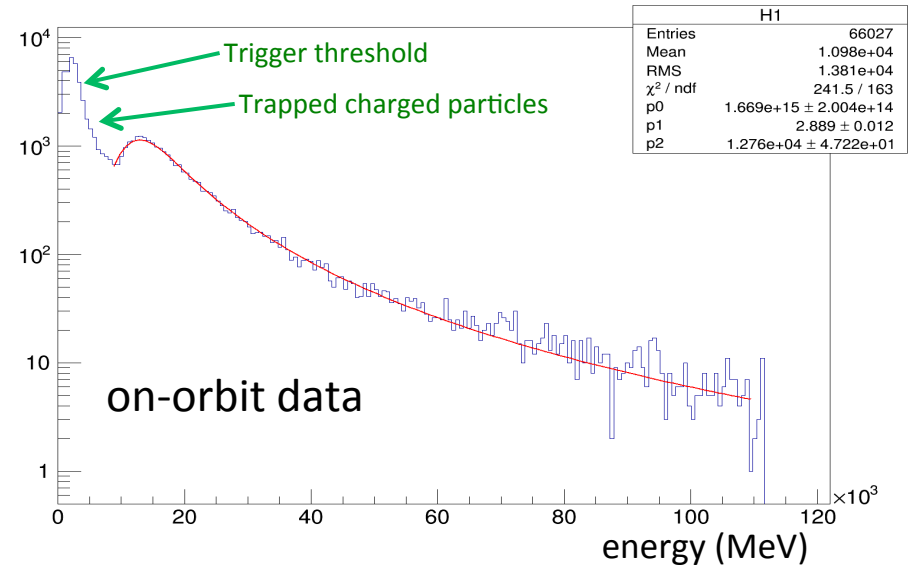


Protons  
and  
nuclei



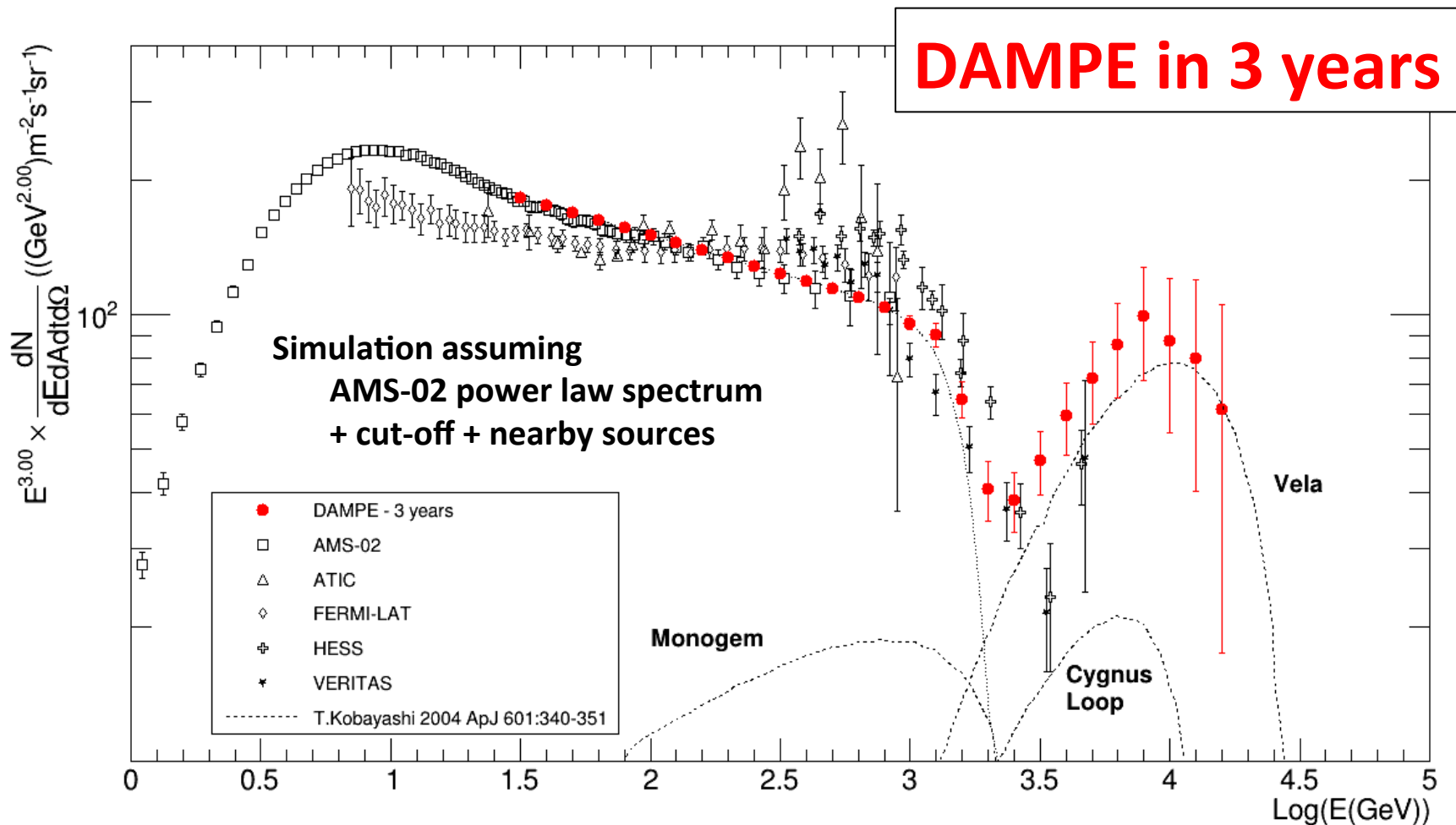
# On-orbit energy calibration

Measurement of  $e^\pm$  rigidity cutoff  
with 1 month statistics



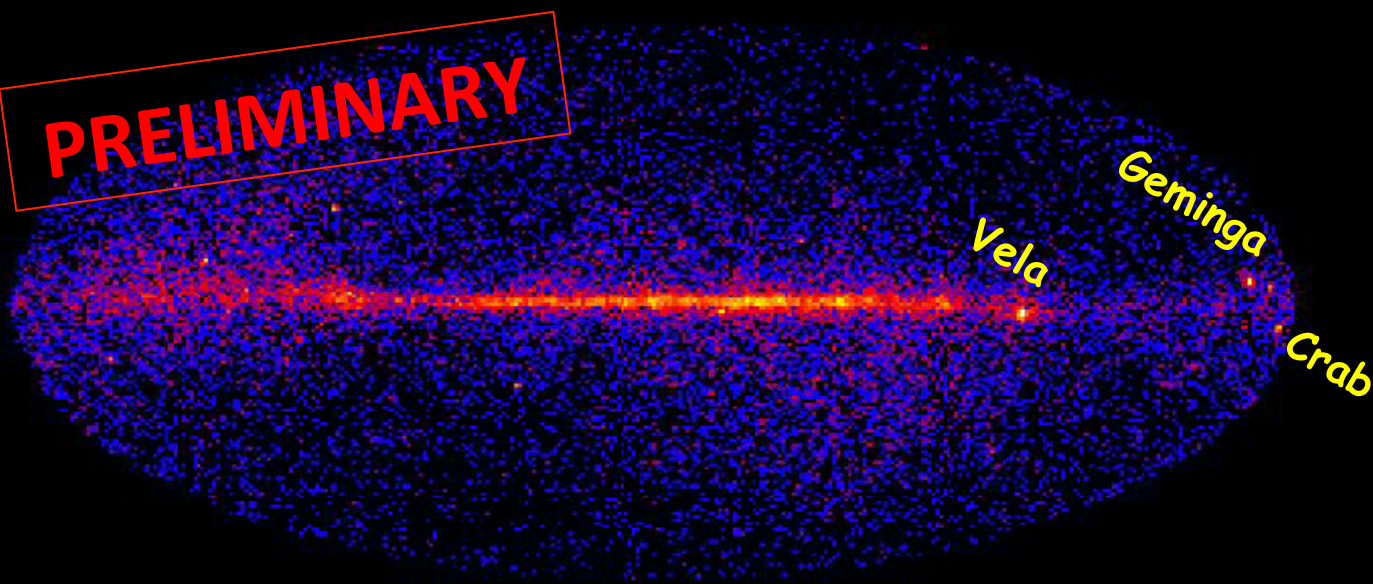
# All-electron spectrum

- Measure the all-electron flux up to about 10 TeV
- Measure with high accuracy the sub-TeV region and the possible cut-off around 1 TeV
- Detect structures in the spectrum due to nearby sources and/or DM induced excesses
- Detect anisotropies at high energy



# Photons

**PRELIMINARY**

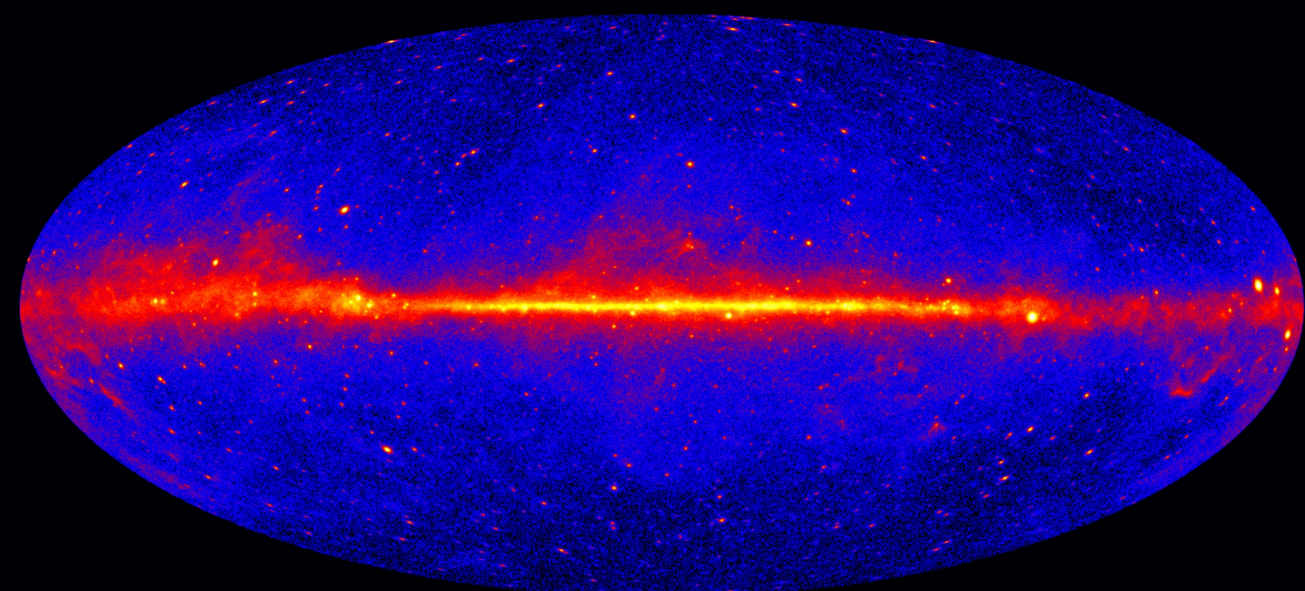


**DAMPE 165 days**

$E > 1 \text{ GeV}$

Counts /  $(0.5^\circ)^2$

$\sigma_\theta \approx 0.2^\circ$  @ 3 GeV

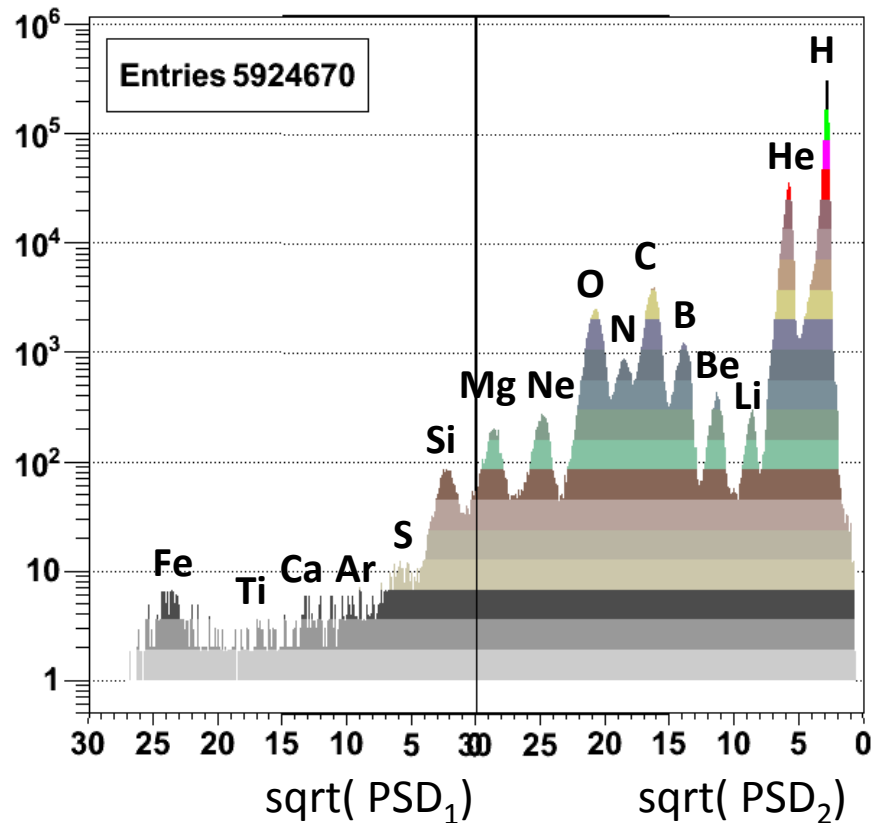
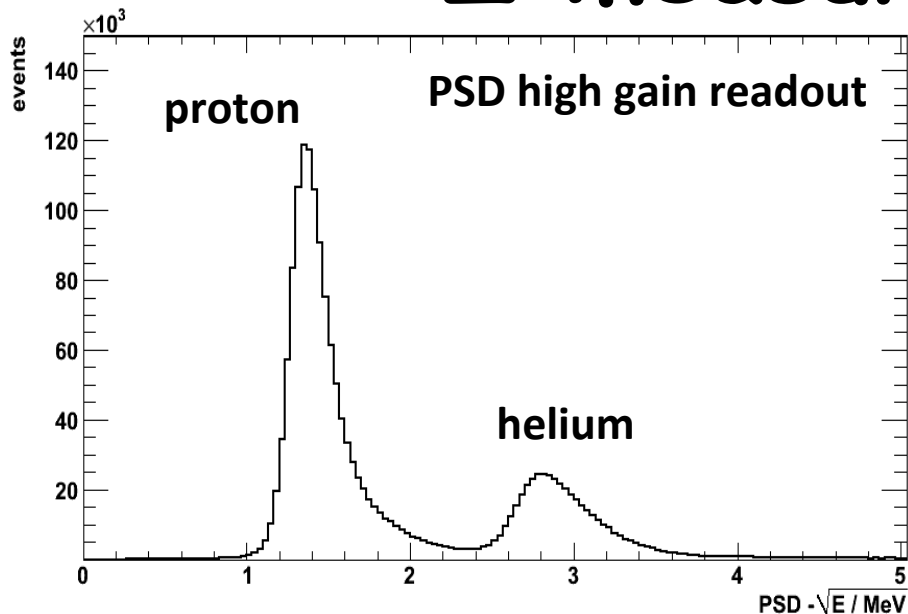


**FERMI 5 years**

$E > 1 \text{ GeV}$

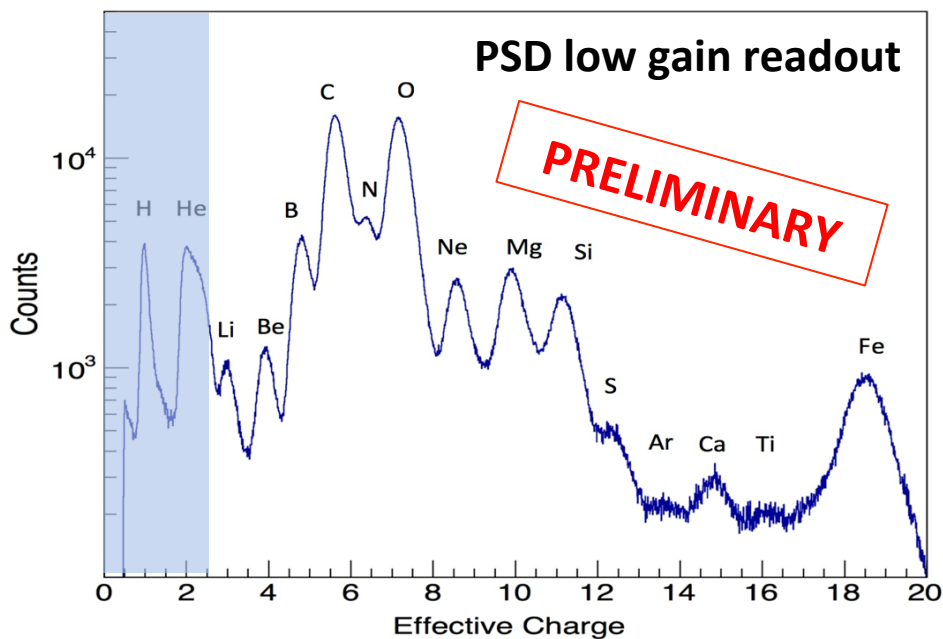


# Z measurement

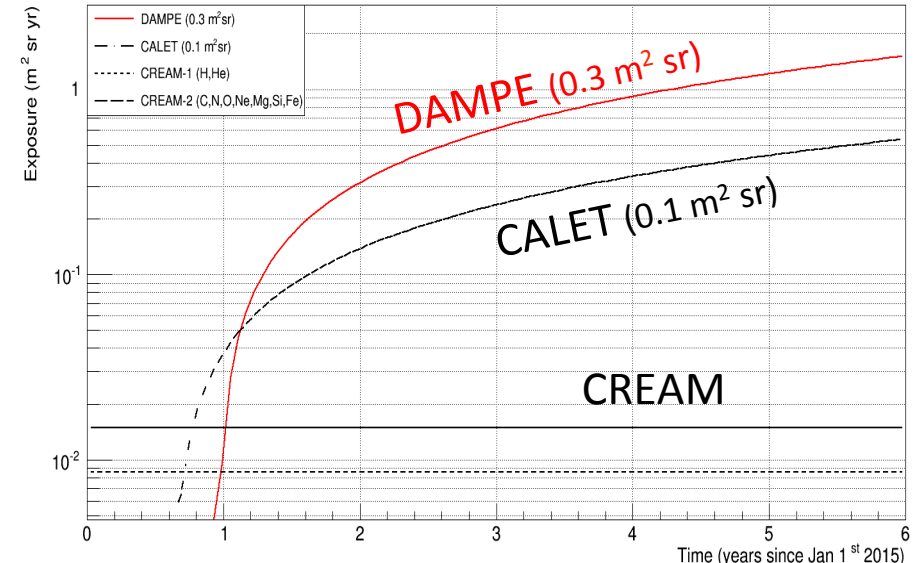
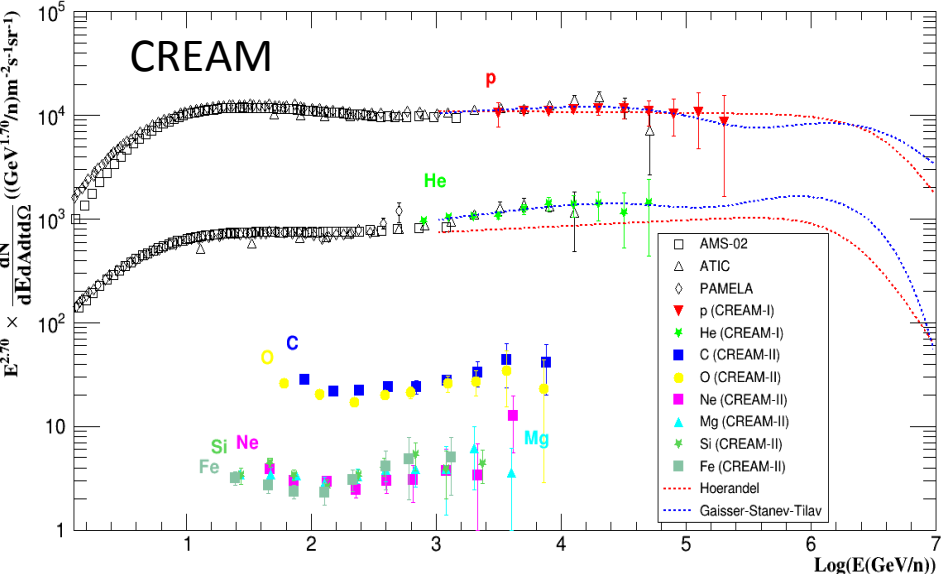
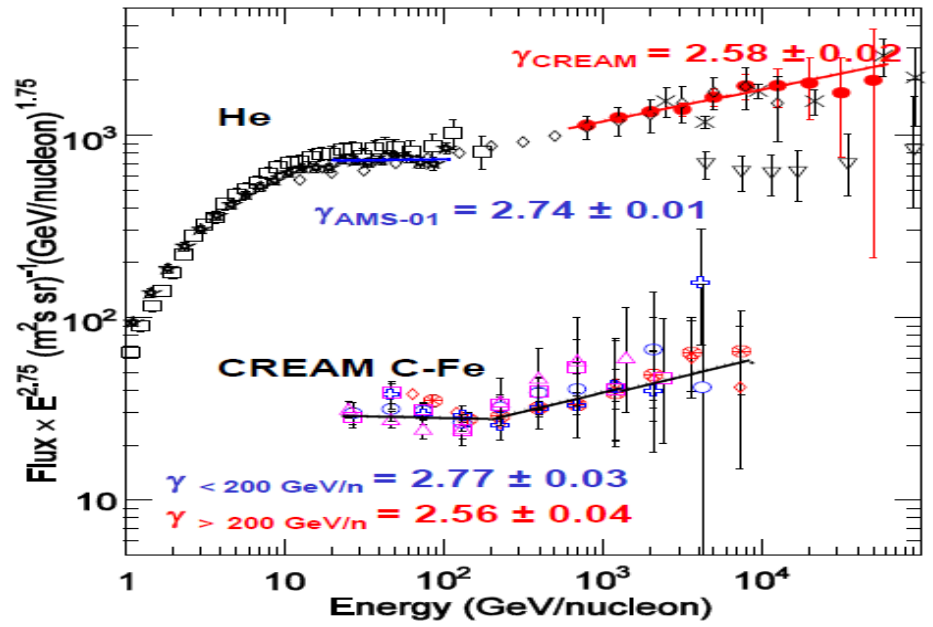
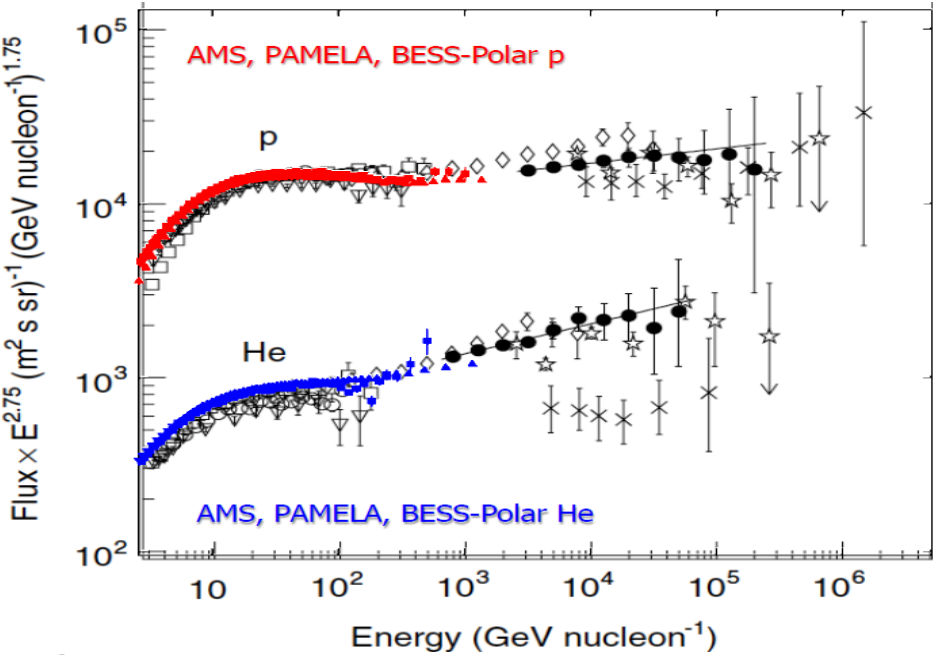


Charge resolution  $\sim 0.2- 0.3$  depending on Z

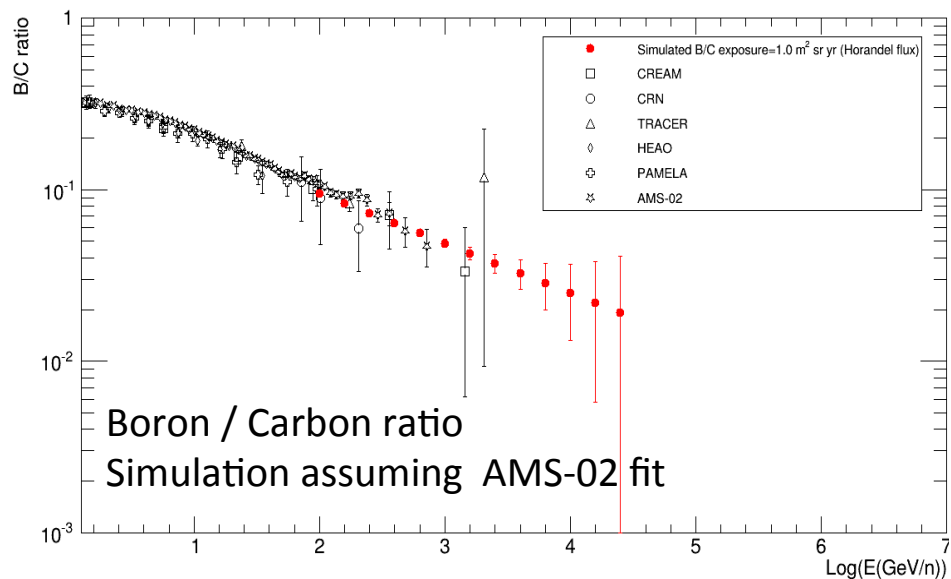
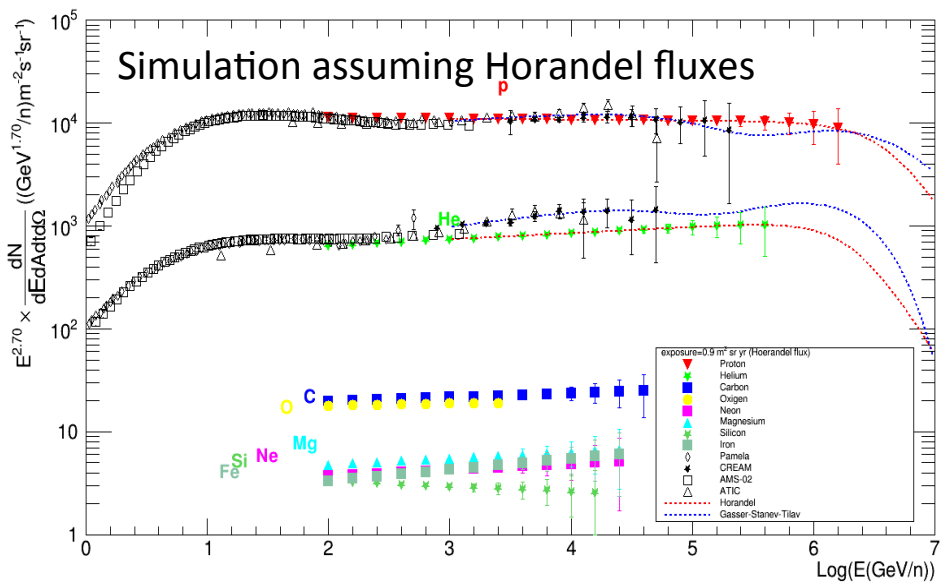
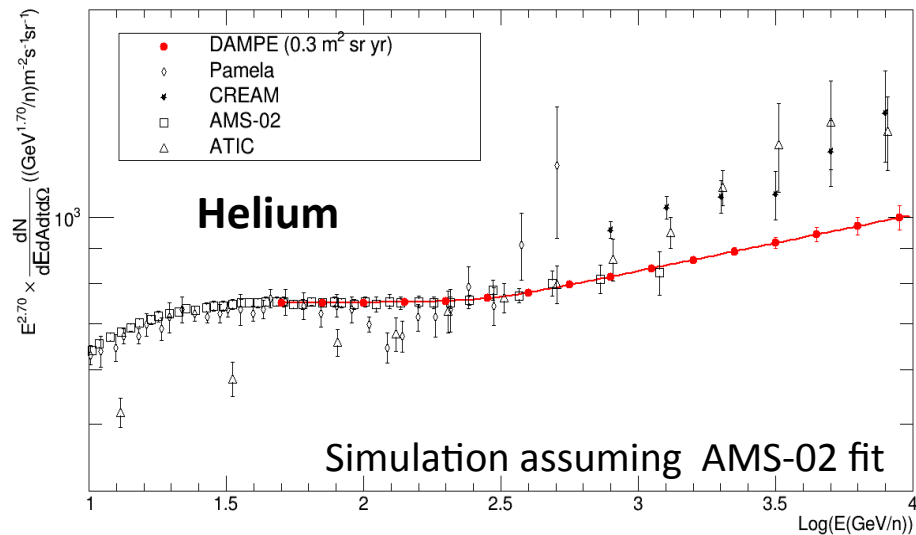
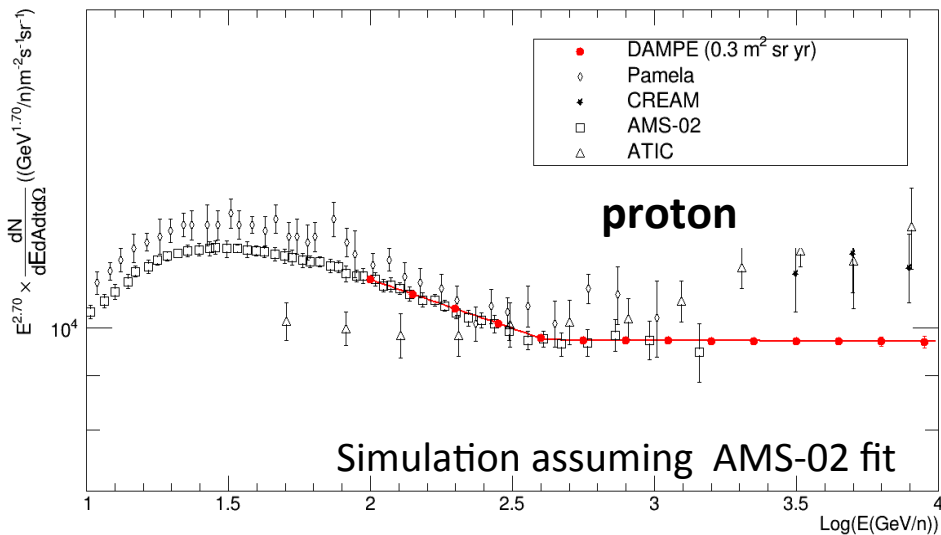
Charge measurement also given by STK and (with lower precision) by the BGO bars



# Protons and nuclei spectra



# Protons and nuclei: DAMPE 3 years



# Summary

## The detector

- Large geometric factor instrument ( $0.3 \text{ m}^2 \text{ sr}$  for p and nuclei)
- Precision Si-W tracker ( $40 \text{ } \mu\text{m}$ ,  $0.2^\circ$  resolution)
- Thick calorimeter ( $32 X_0$ ,  $\sigma_E/E$  better than 1% above 50 GeV for  $e/\gamma$ ,  $\sim 35\%$  for hadrons)
- “Multiple” charge measurements ( $0.2\text{-}0.3 \text{ e}$  resolution)
- $e/p$  rejection power  $> 10^5$  (topology alone, plus neutron detector)

## Launch and performances

- Successful launch on December 17, 2015
- On orbit operation steady and with high efficiencies
- Absolute energy calibration by using the geomagnetic cut-off
- Absolute pointing cross check by use of the gamma map

## Physics goals

- Study of the cosmic electron and photon spectra
- Search for electron anisotropy and nearby sources contribution
- Protons and nuclei: measurement of spectrum and composition
- Precise measurement of CR discrepant hardenings and spectral indexes
- High energy gamma ray astronomy
- Search for dark matter signatures in lepton spectra
- The “unexpected”: GW electromagnetic follow up in FoV

