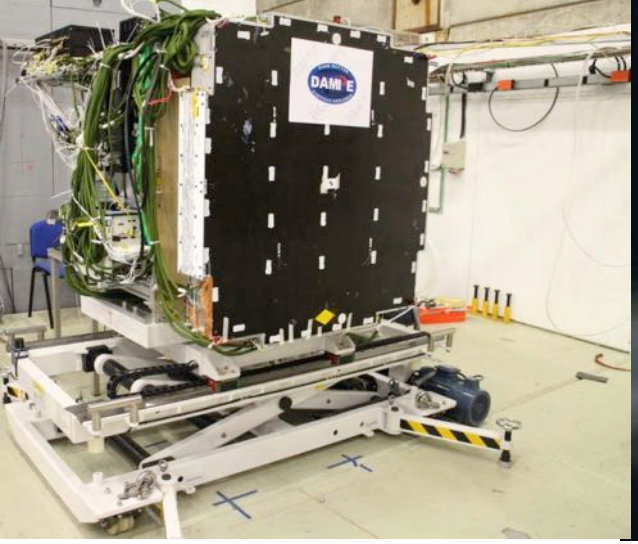


# DAMPE: first data from space


Ivan De Mitri

Università del Salento and INFN, Lecce, Italy

(on behalf of DAMPE collaboration)



**6th Roma International Conference on AstroParticle physics**
**June 22-24, 2016, Frascati (Rome)**

# The physics goals

## High energy particle detection in space

- Study of the cosmic electron and photon spectra
- Study of cosmic ray protons and nuclei: spectrum and composition
- High energy gamma ray astronomy
- Search for dark matter signatures in lepton spectra

**Detection of**
**10 GeV - 10 TeV e/γ**
**50 GeV - 500 TeV protons and nuclei**
**with excellent energy resolution , tracking precision and particle identification capabilities**

- Exotica and "unexpected" , e.g. GW e.m. counterpart in the FoV

# The collaboration

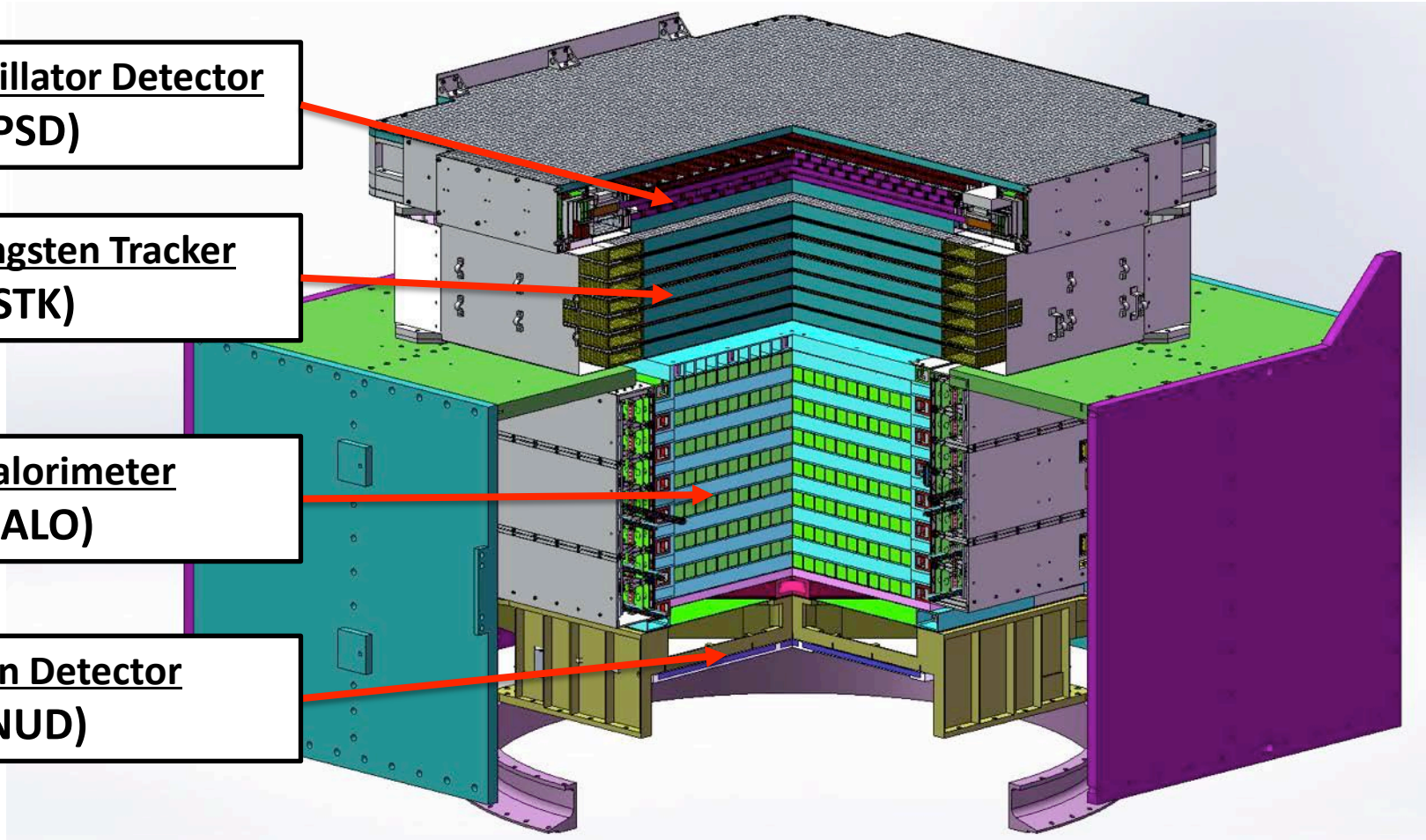
- **CHINA**
  - Purple Mountain Observatory, CAS, Nanjing
  - Institute of High Energy Physics, CAS, Beijing
  - National Space Science Center, CAS, Beijing
  - University of Science and Technology of China, Hefei
  - Institute of Modern Physics, CAS, Lanzhou

***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

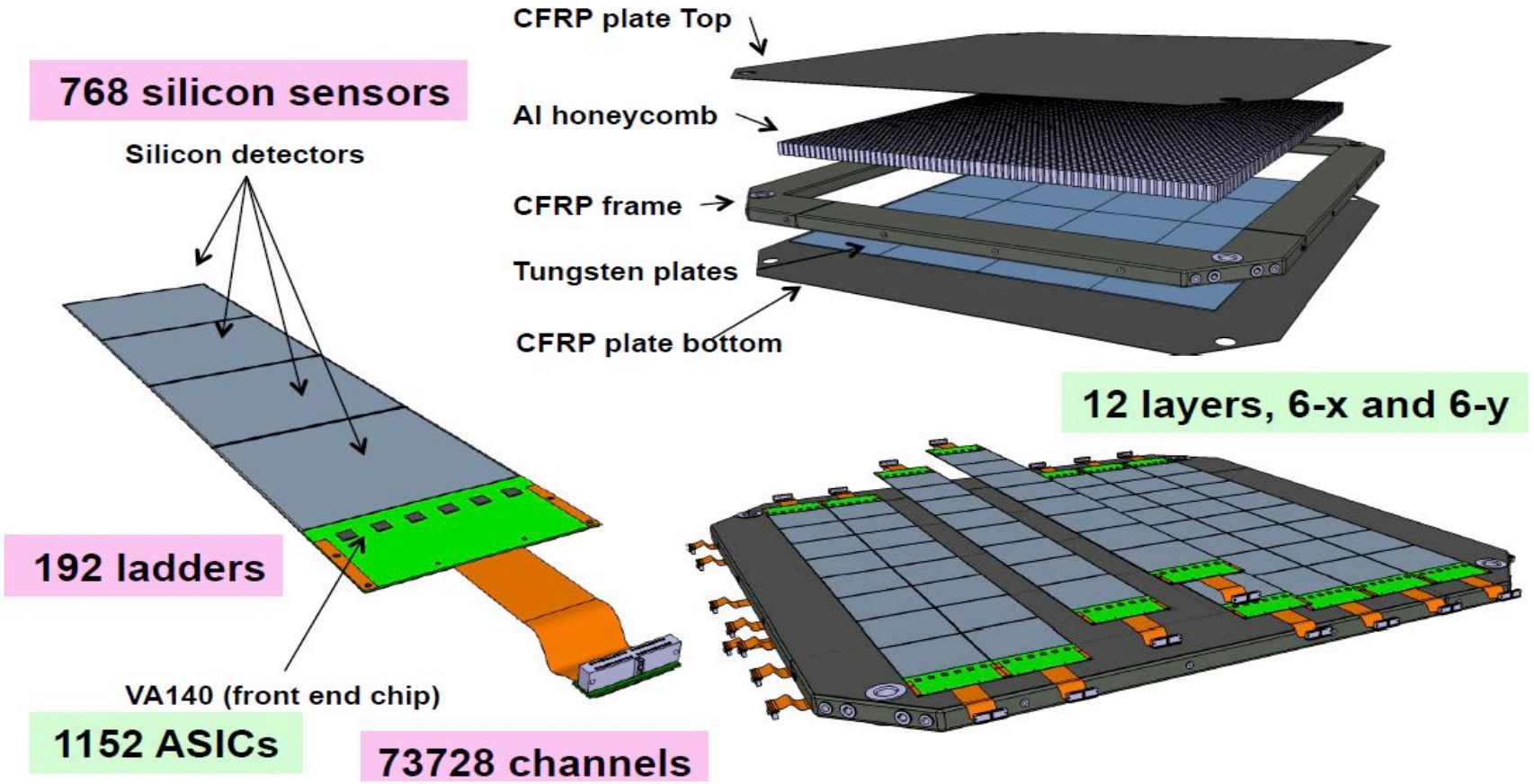
# The detector




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

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

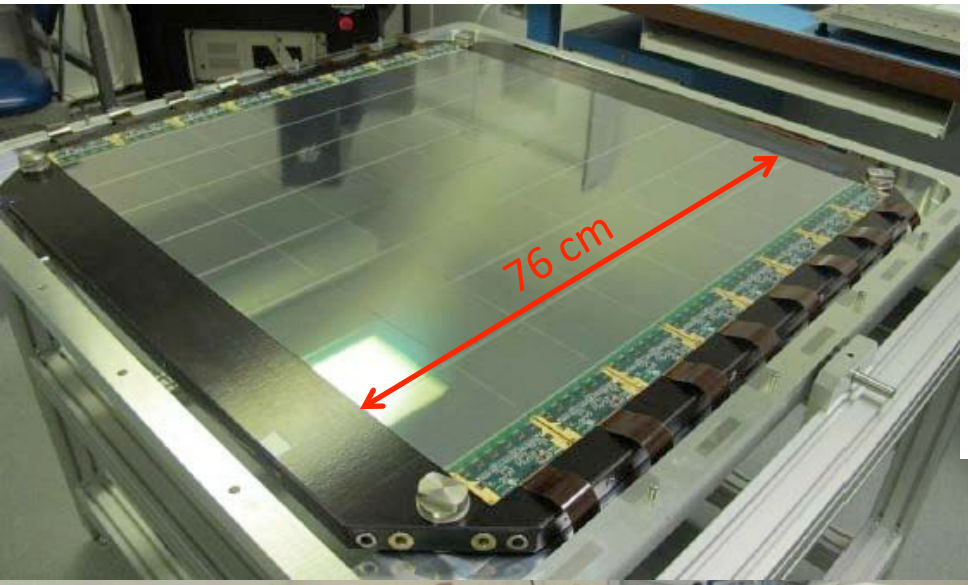
# The Silicon TracKer (STK)

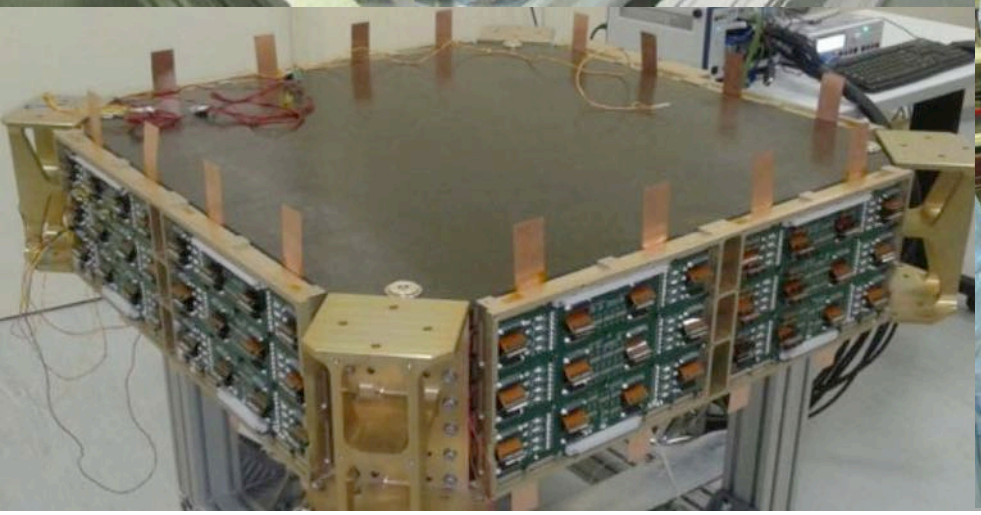


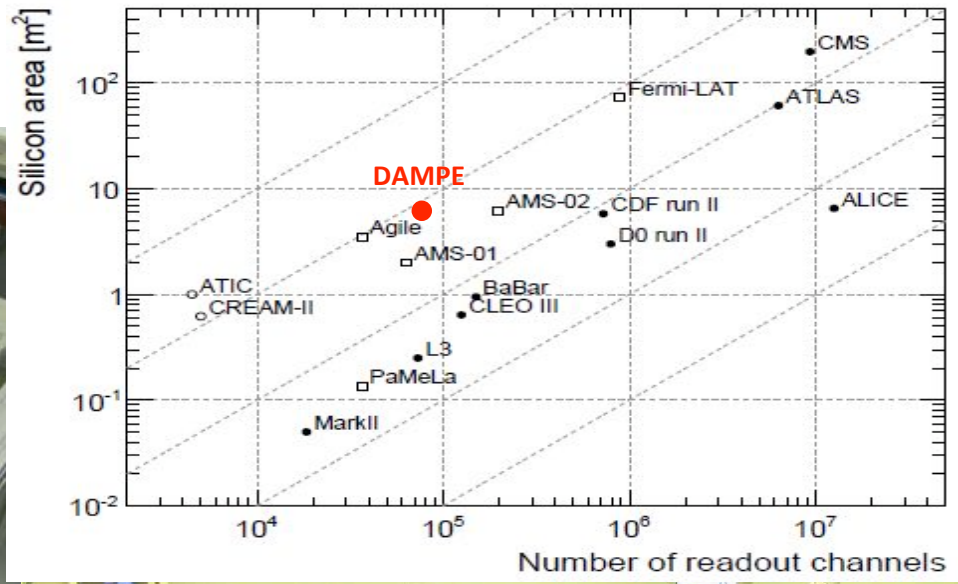

- 48 μm wide Si strips with 121 μm pitch
- (95 × 95 × 0.32 mm$^3$) Silicon Strip Detectors (SSD) with 768 strips
- One ladder composed by 4 Silicon Strip Detectors (SSD)
- 16 Ladders per layer (76 cm × 76 cm )
- 12 layers (6x + 6y)

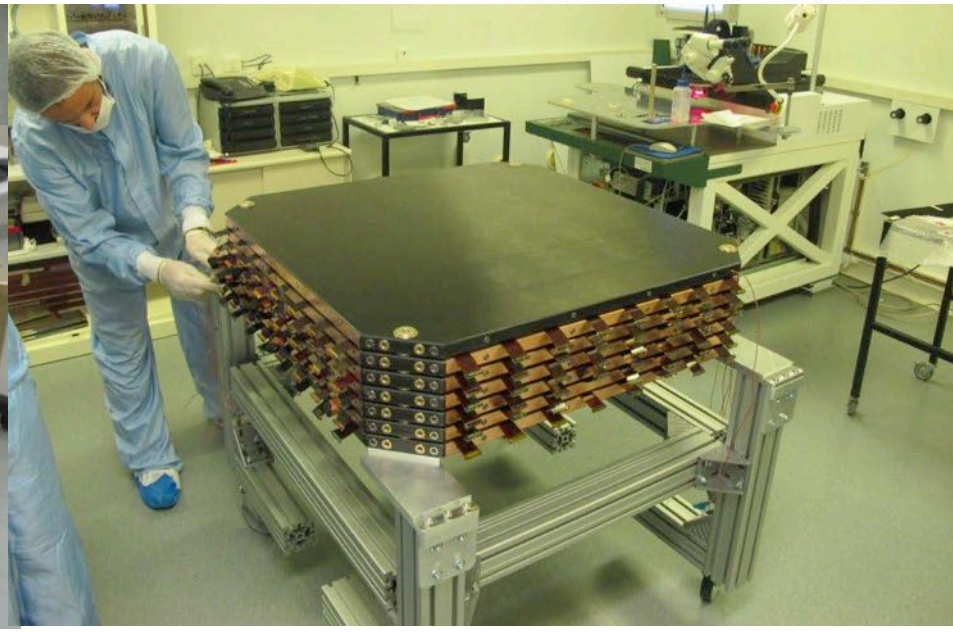
Analog Readout of each second strip:
384 channels / SSD- Ladder
Charge sharing

# The Silicon TracKer (STK) - 2



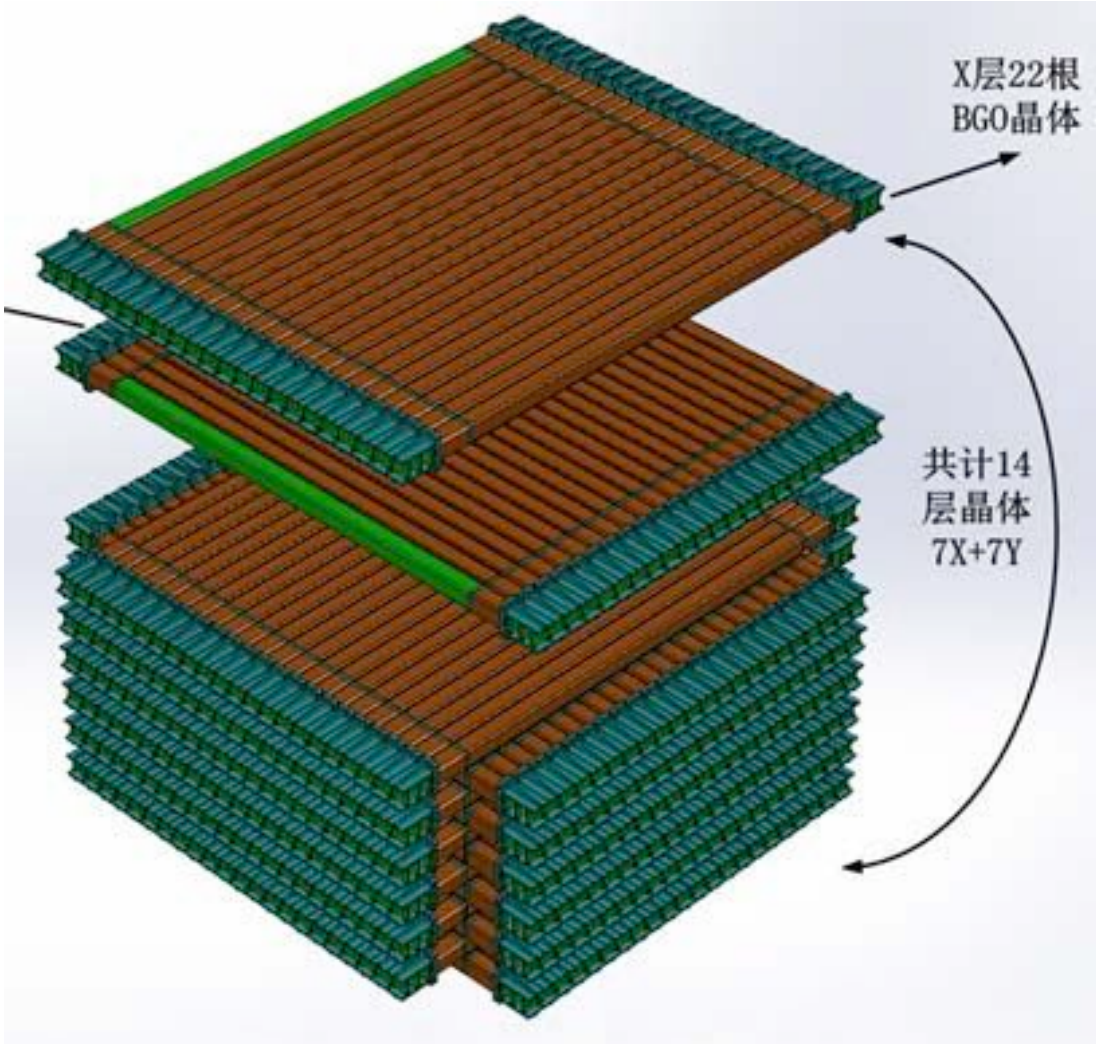





# The CALOrimeter

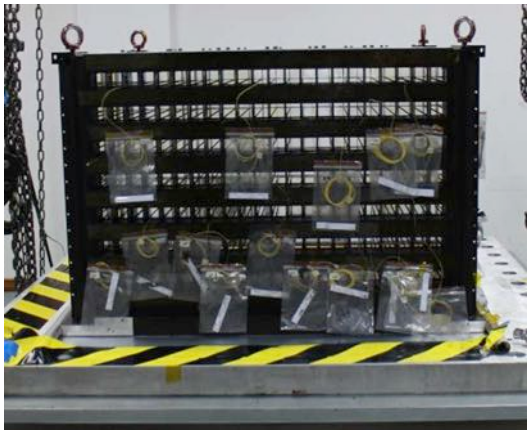
- 14 layers of 22 BGO bars
  - Dimension of BGO bar: $2.5 \times 2.5 \times 60\ cm^3$
  - 14 hodoscopic stacking alternating orthogonal layers
  - depth ~$32X_0$
- Two PMTs coupled with each BGO crystal bar in two ends
- Electronics boards attached to each side of module





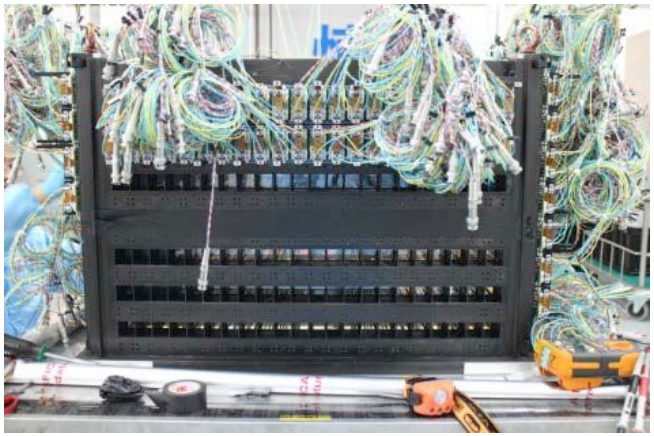
308 bars
616 PMTs

# The CALOrimeter -2

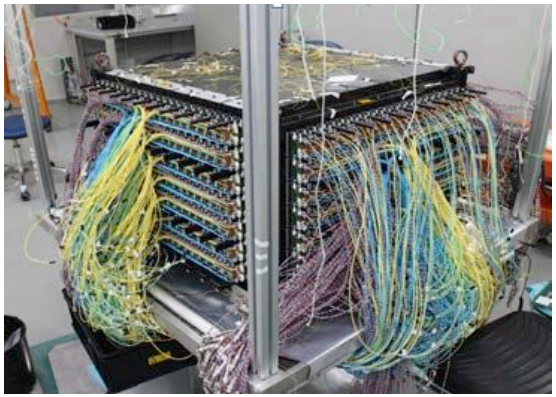


Carbon Fiber Structure

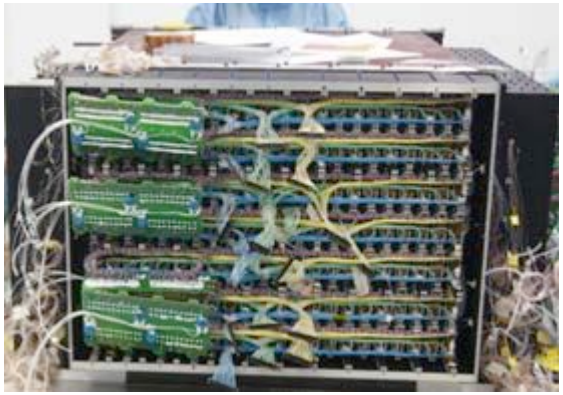
BGO crystal installation



PMT installation



Cable arranging

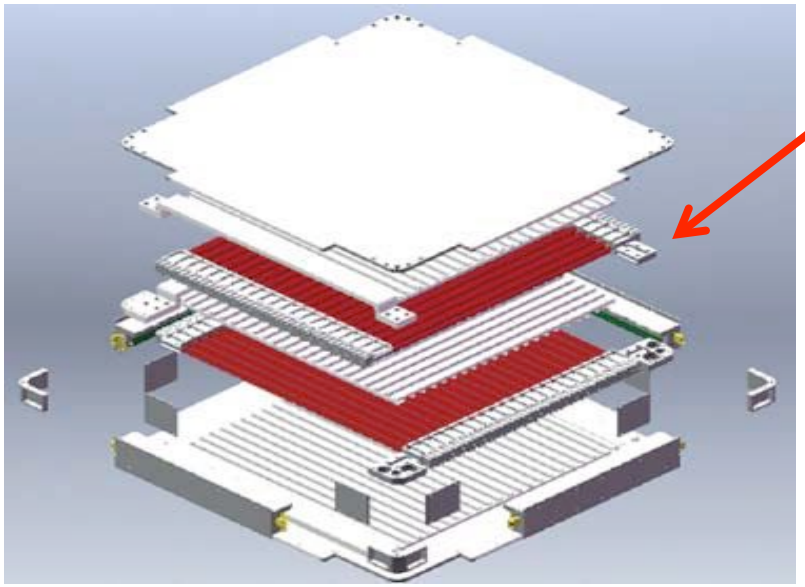


Cable connector

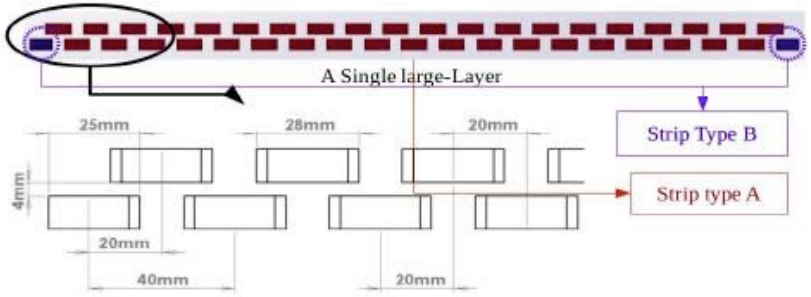
BGO Cal

# The PSD and the NUD

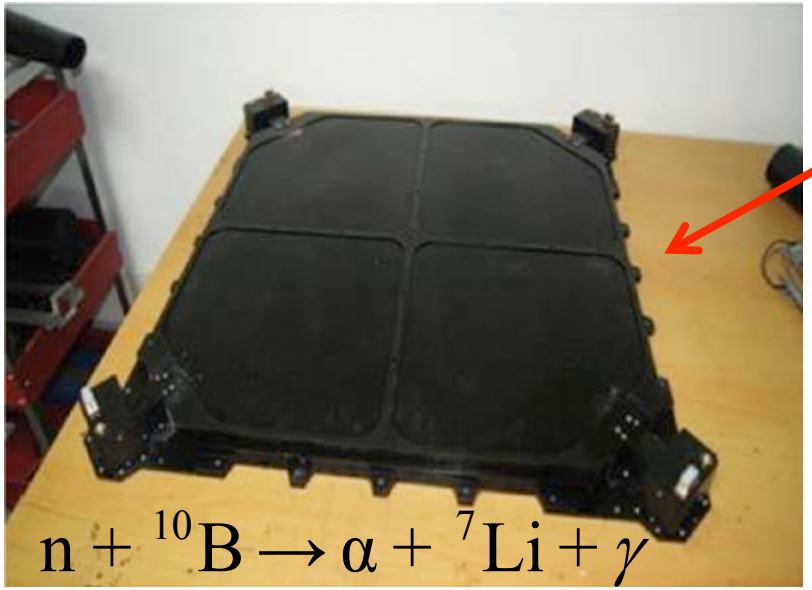
**PSD**



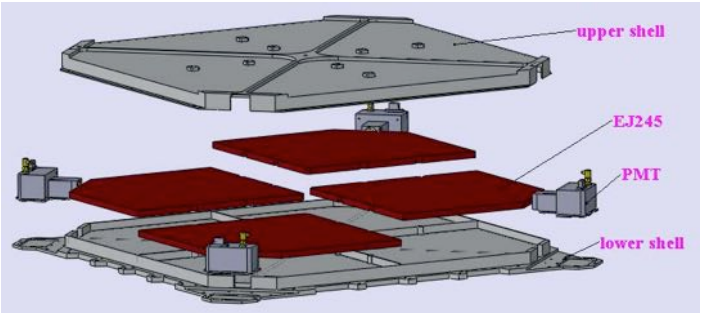
- 1.0 cm thick ,2.8cm wide and 82.0 cm long scintillator strips
- staggered by 0.8 cm in a layer
- 82 cm × 82 cm layers
- 2 layers ( x and y )




**NUD**

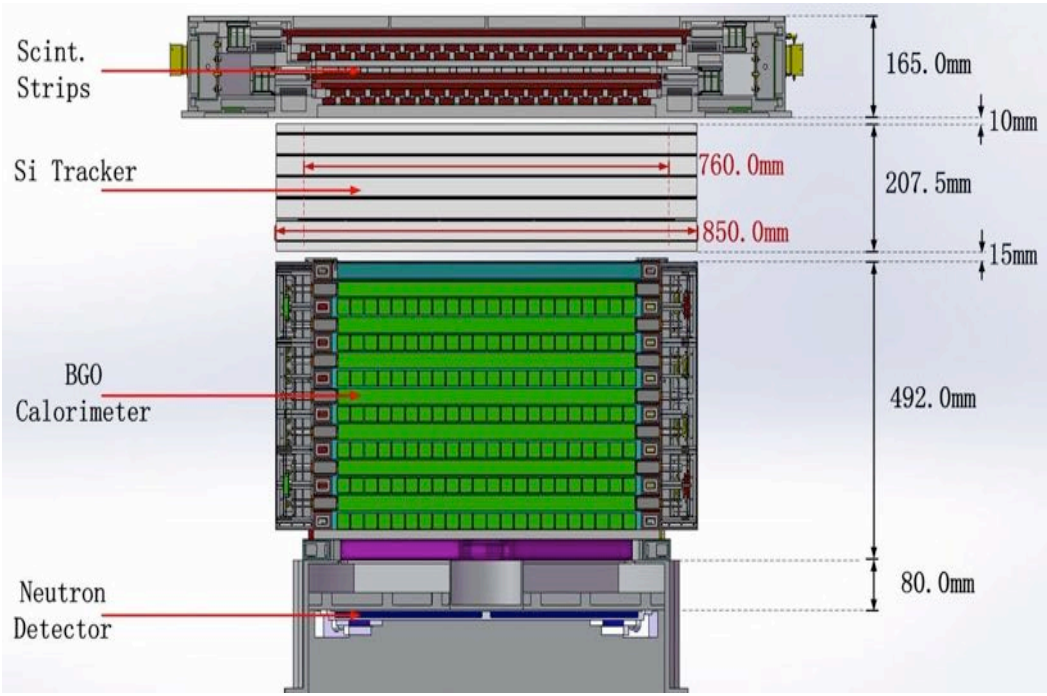


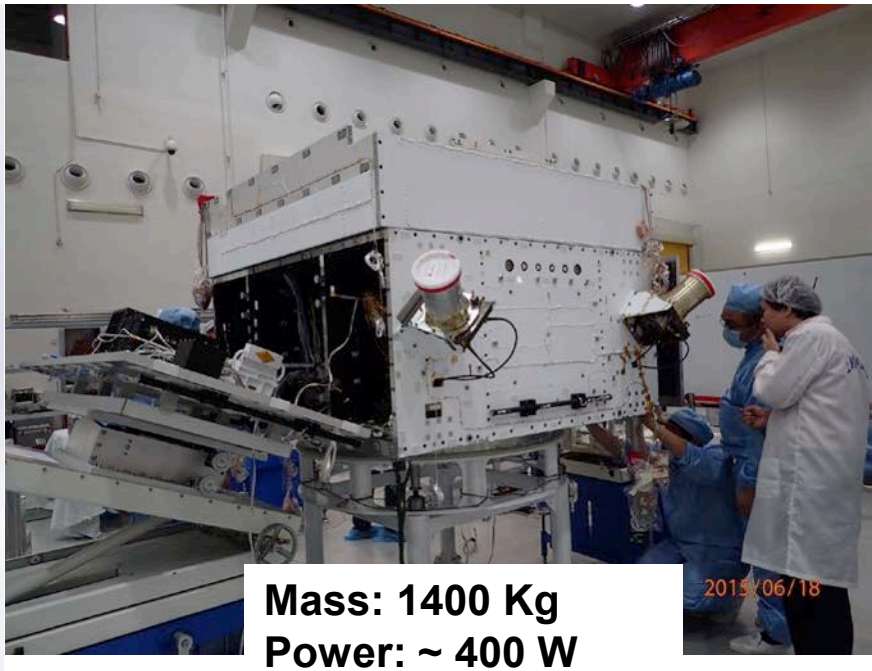

- 4 large area boron-doped plastic scintillators ( 30 cm × 30 cm × 1 cm)



# Comparison with AMS-02 and FERMI

| | DAMPE | AMS-02 | Fermi LAT |
|---|---|---|---|
| e/γ Energy res.@100 GeV (%) | **1.5** | 3 | 10 |
| e/γ Angular res.@100 GeV (°) | 0.1 | 0.3 | 0.1 |
| e/p discrimination | $10^5$ | $10^5$ - $10^6$ | $10^3$ |
| Calorimeter thickness ($X_0$) | **32** | 17 | 8.6 |
| Geometrical accep. ($m^2sr$) | **0.29** | 0.09 | 1 |

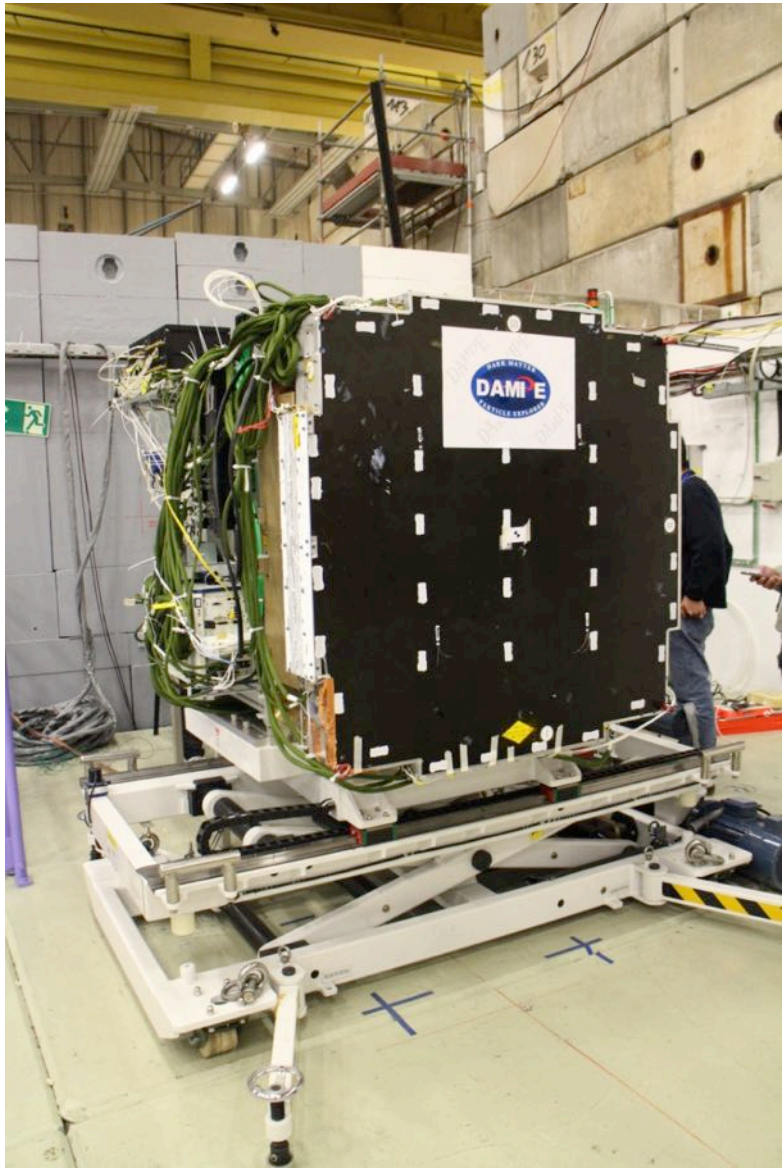


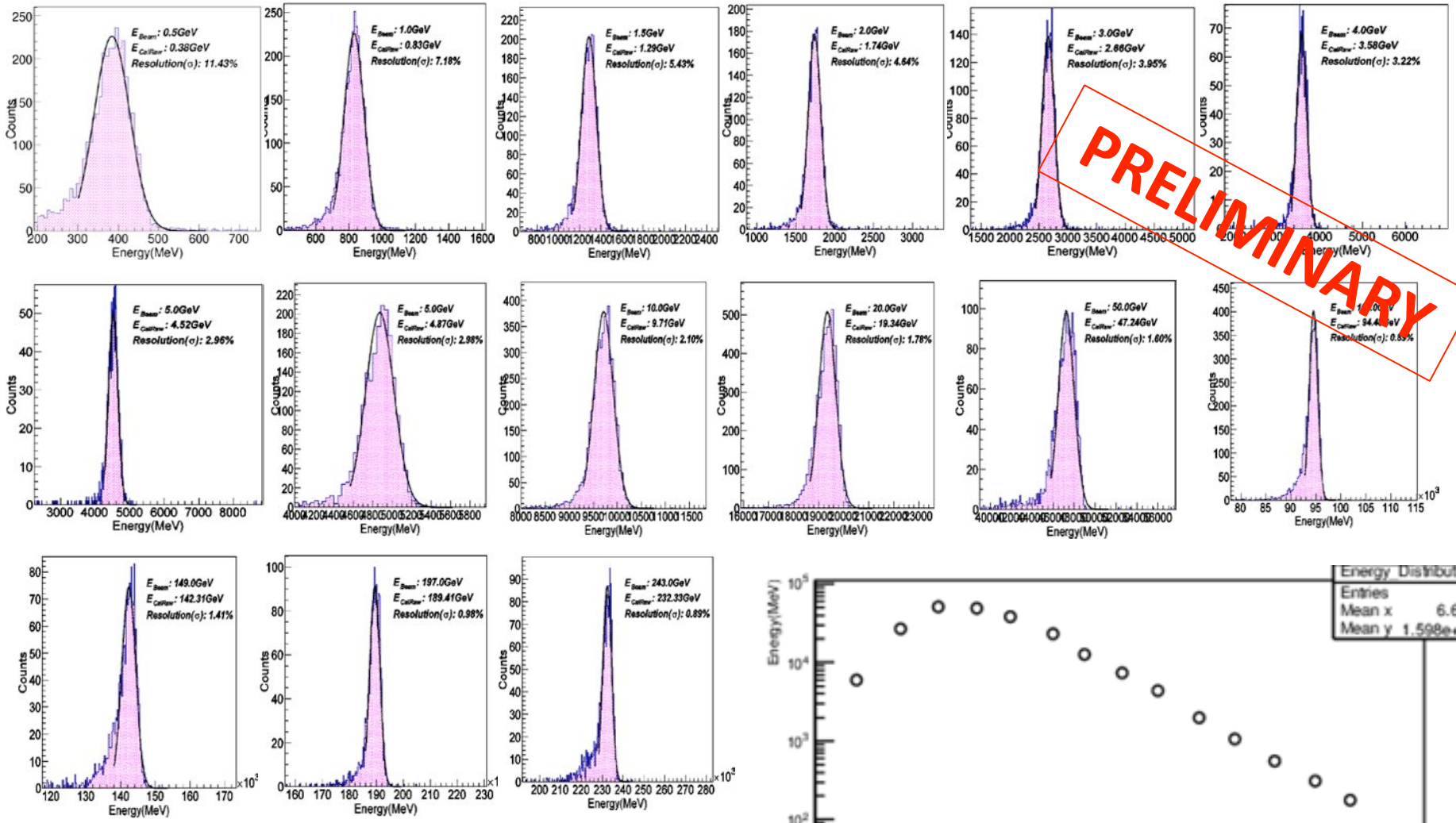

**Mass: 1400 Kg**
**Power: ~ 400 W**
**Livetime: > 3 years**

# Test beam activity at CERN

- 14days@PS，29/10-11/11 2014
  - e @ 0.5GeV/c, 1GeV/c, 2GeV/c, 3GeV/c, 4GeV/c, 5GeV/c
  - p @ 3.5GeV/c, 4GeV/c, 5GeV/c, 6GeV/c, 8GeV/c, 10GeV/c
  - π-@ 3GeV/c, 10GeV/c
  - γ @ 0.5-3GeV/c
- 8days@SPS，12/11-19/11 2014
  - e @ 5GeV/c, 10GeV/c, 20GeV/c, 50GeV/c, 100GeV/c, 150GeV/c, 200GeV/c, 250GeV/c
  - p @ 400GeV/c (SPS primary beam)
  - γ @ 3-20GeV/c
  - μ @ 150GeV/c,
- 17days@SPS，16/3-1/4 2015
  - Fragments：66.67-88.89-166.67GeV/c
  - Argon：30A- 40A- 75AGeV/c
  - Proton：30GeV/c，40GeV/c
- 21days@SPS，10/6-1/7 2015
  - Primary Proton: 400GeV/c
  - Electrons @ 20, 100, 150 GeV/c
  - γ @ 50, 75 , 150 GeV/c
  - μ @ 150 GeV /c
  - π+ @10, 20, 50, 100 GeV/c
- 10days@SPS, 11/11-20/11 2015
  - -- Pb 30AGeV/c (and fragments) (HERD)
- 6days@SPS, 20/11-25/11 2015
  - -- Pb 030 AGeV/c (and fragments)



# Test beam activity at CERN: electrons




**Electrons**

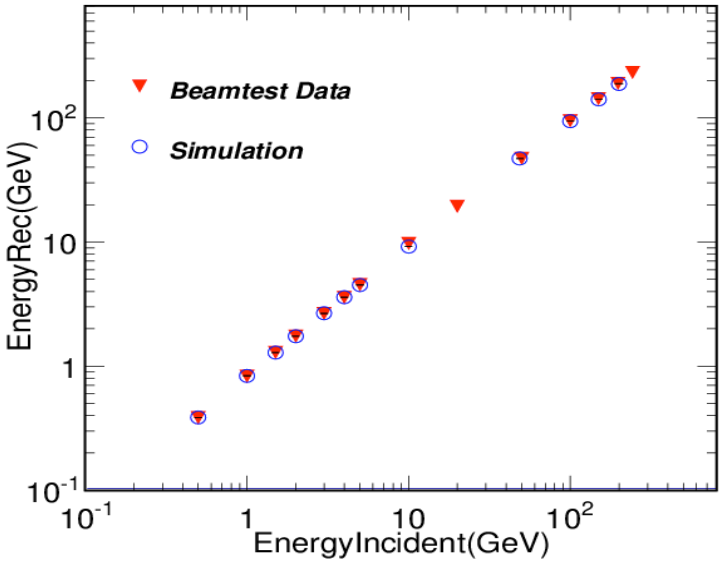
0.5, 1, 1.5, 2, 3, 4, 5 GeV @ PS

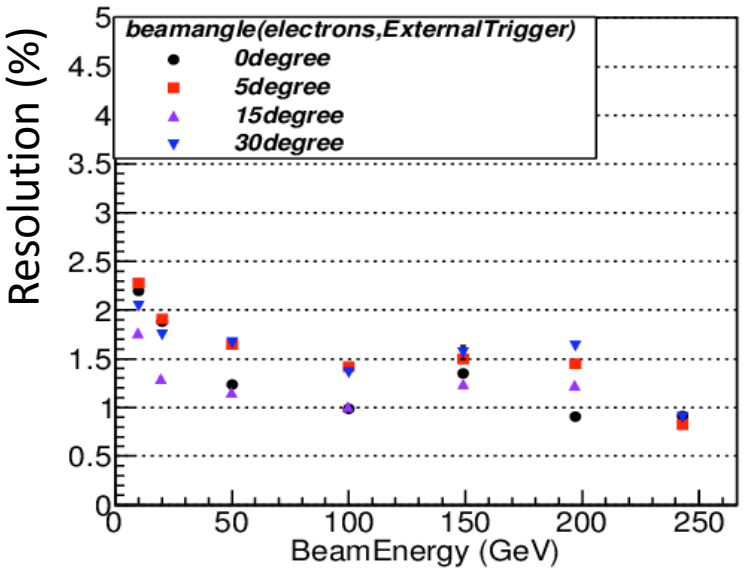
5, 10, 20, 50, 100, 149, 197, 243 GeV @ SPS



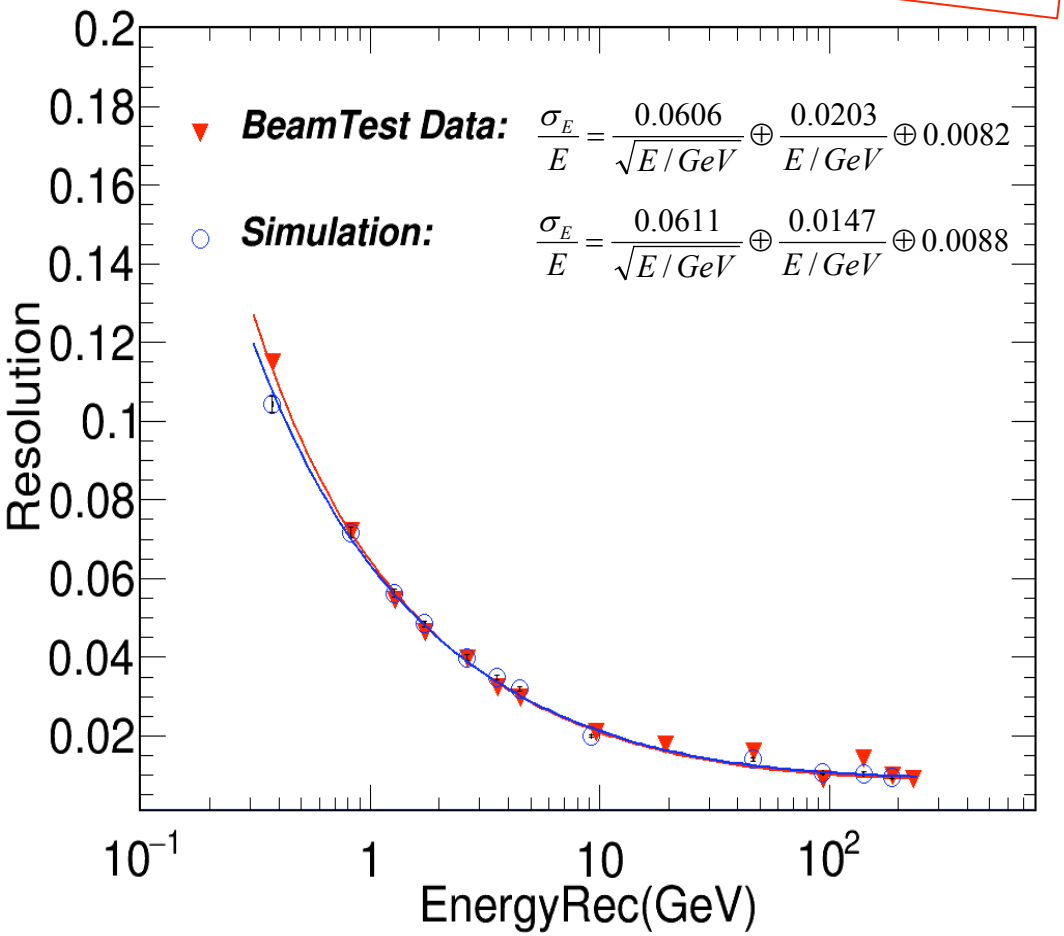

243 GeV Electron
Longitudinal profile

# Test beam activity at CERN: electrons

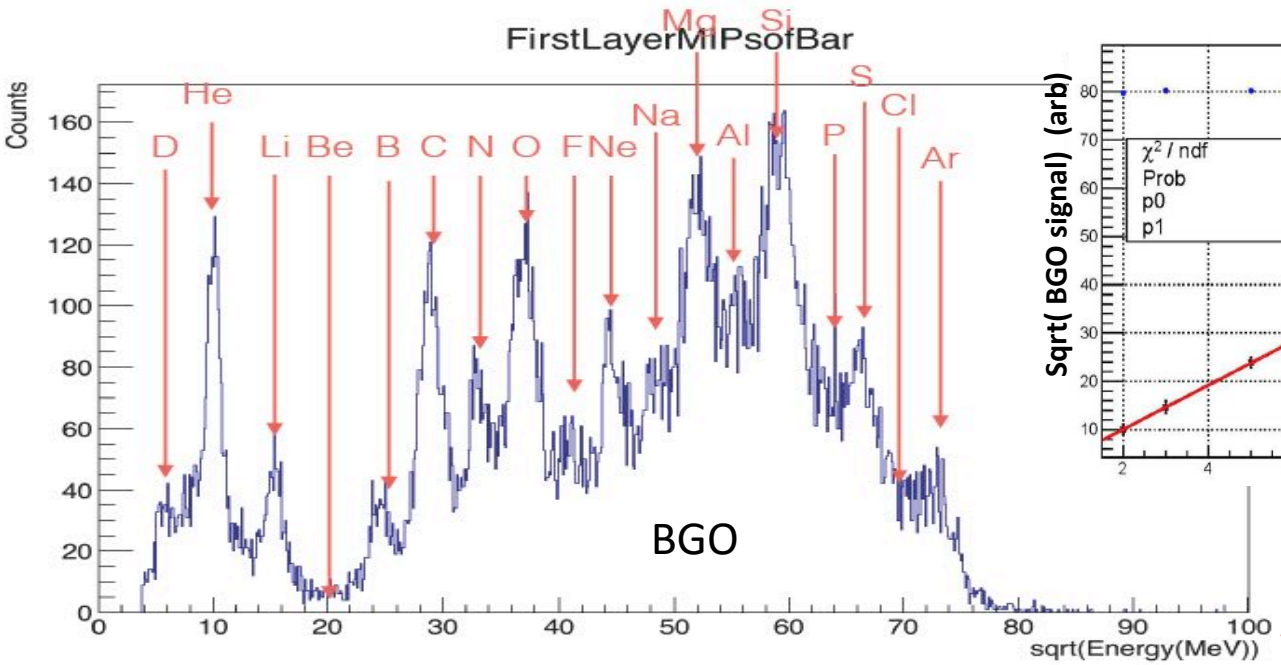


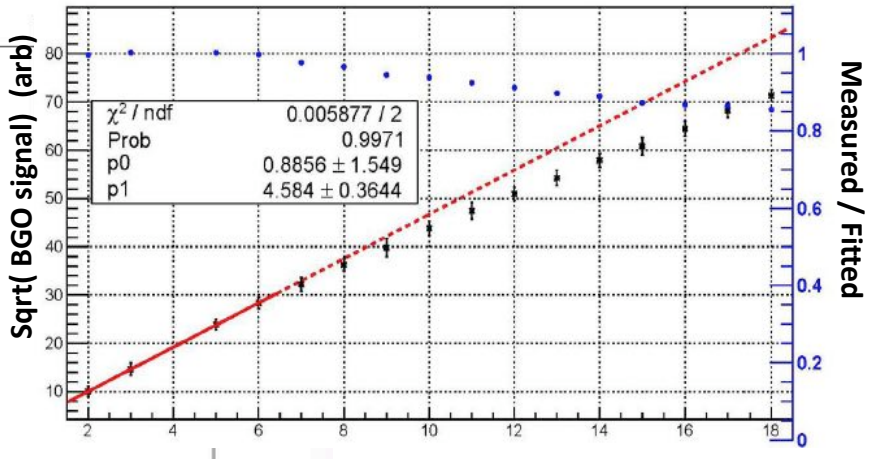




PRELIMINARY

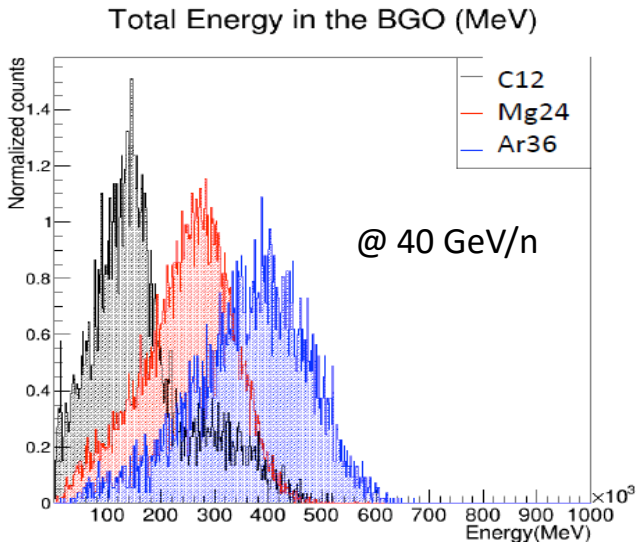


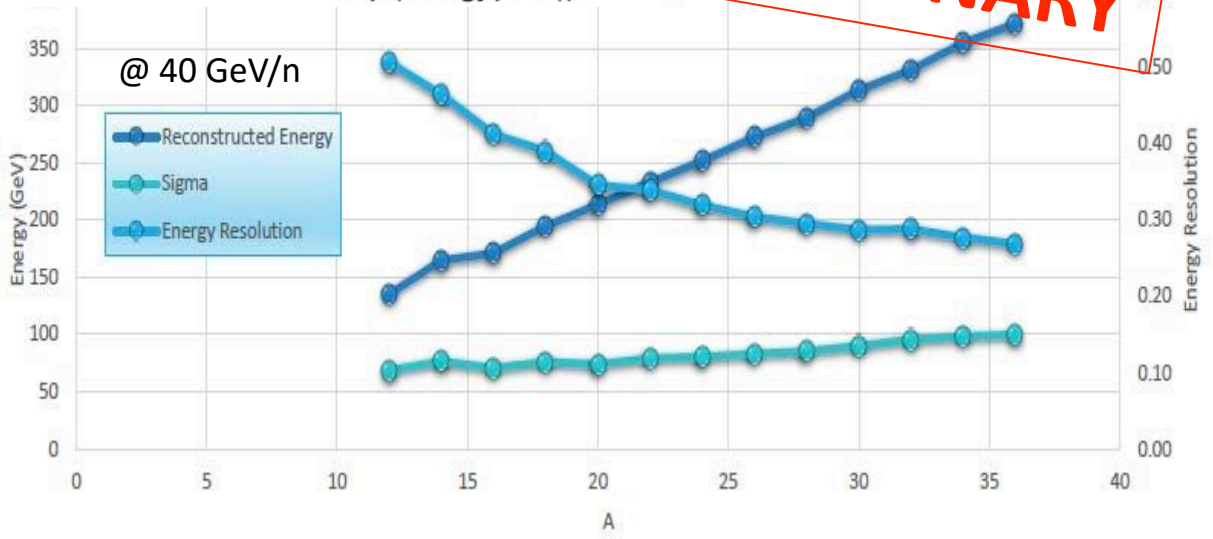
# Test beam activity at CERN: ions




PRELIMINARY



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

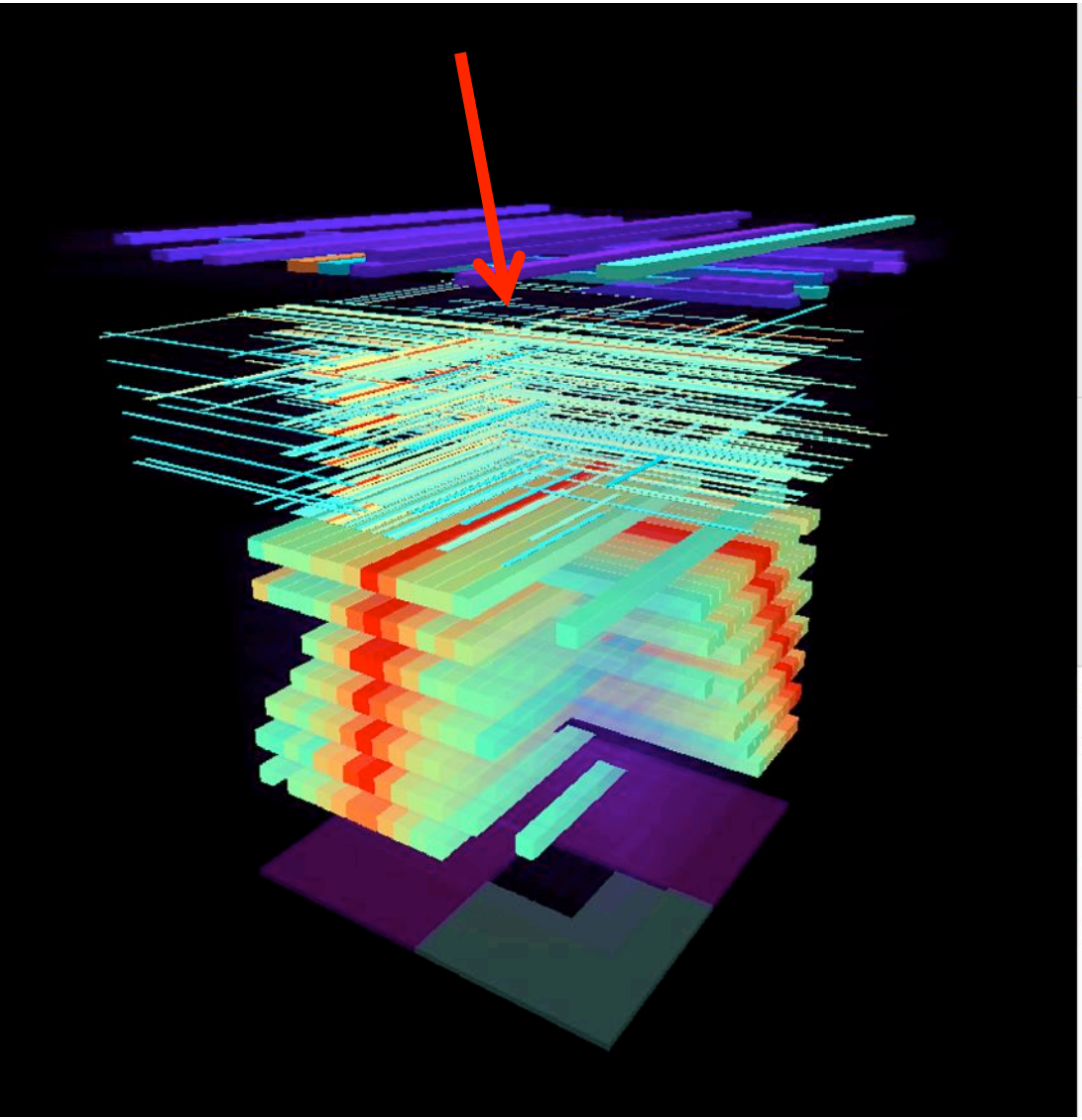
Jiuquan Satellite Launch Center
Gobi desert

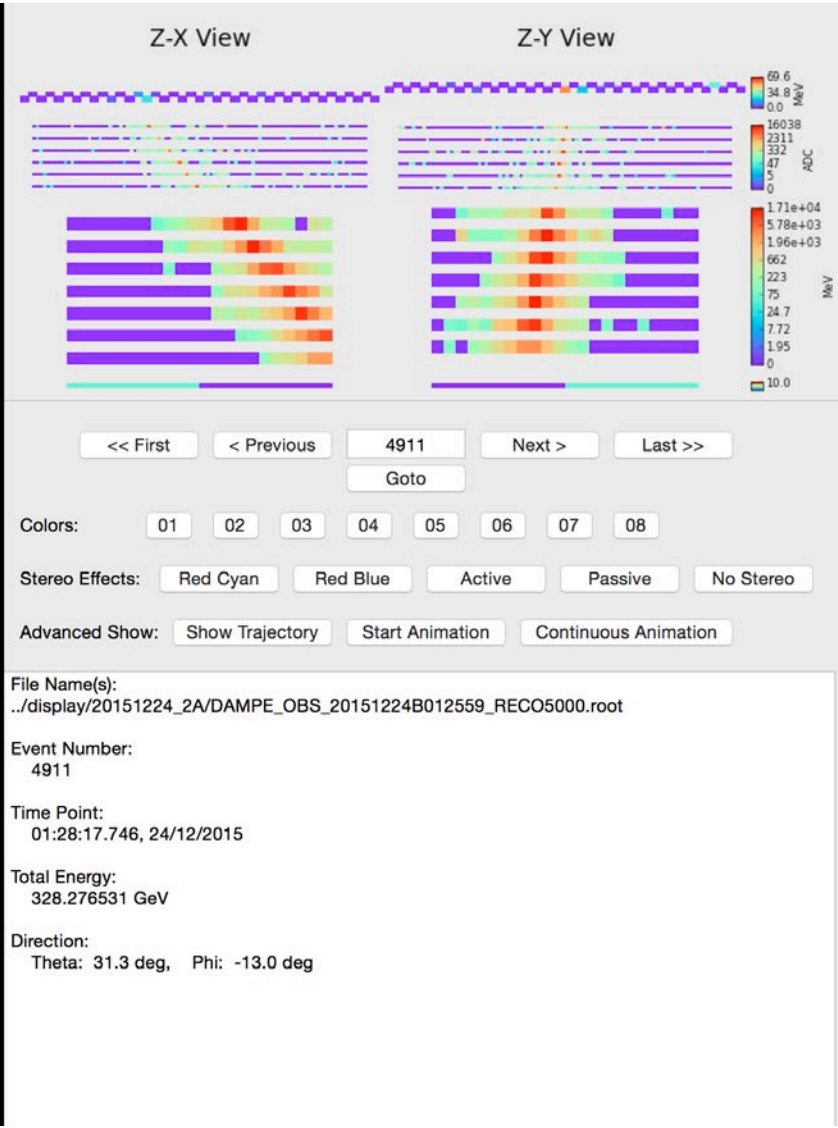
Orbit: sun syncronous , 500km

DAMPE → WUKONG

# Dec 24th 2015: HV on

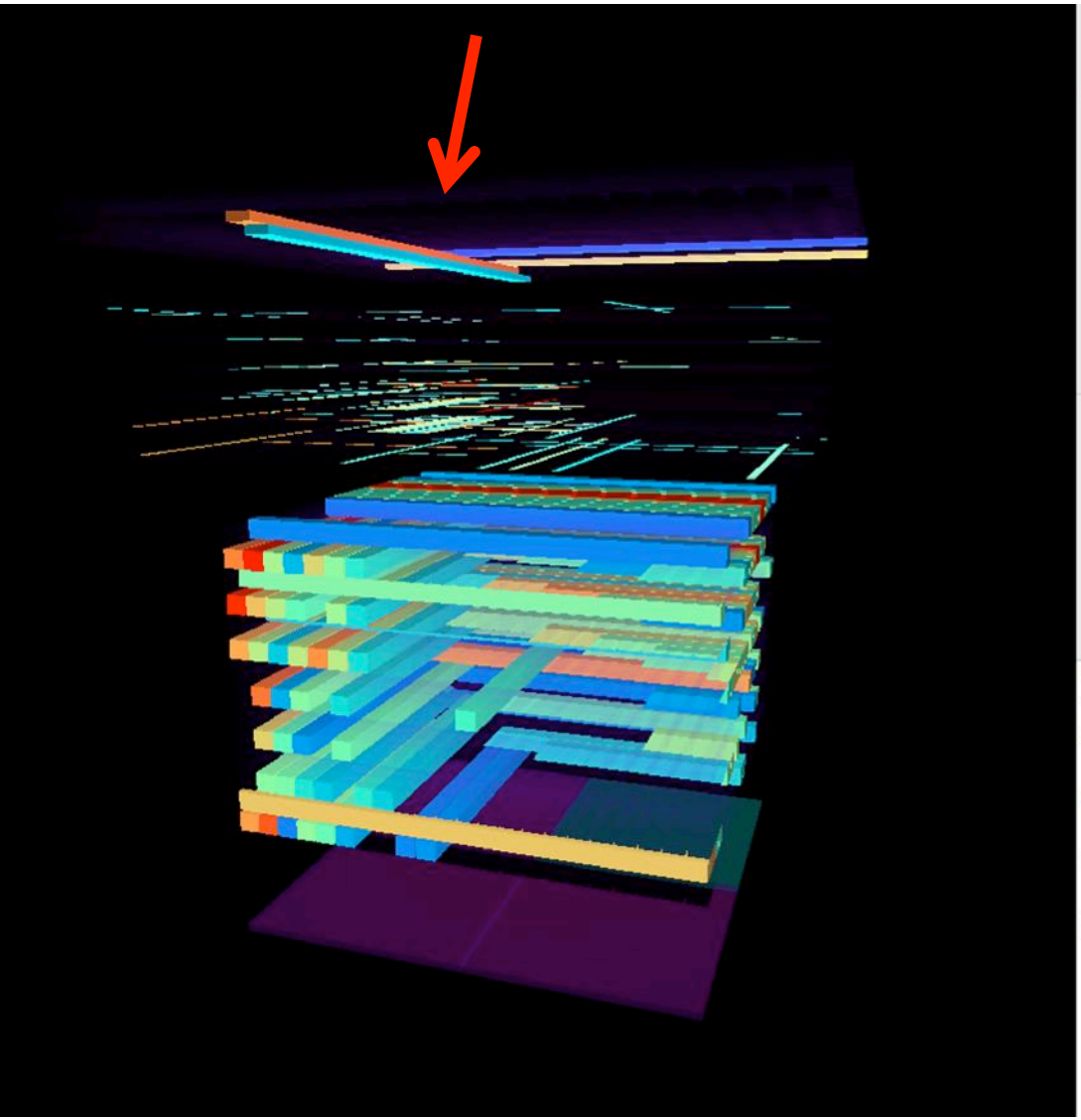
## 330 GeV electron





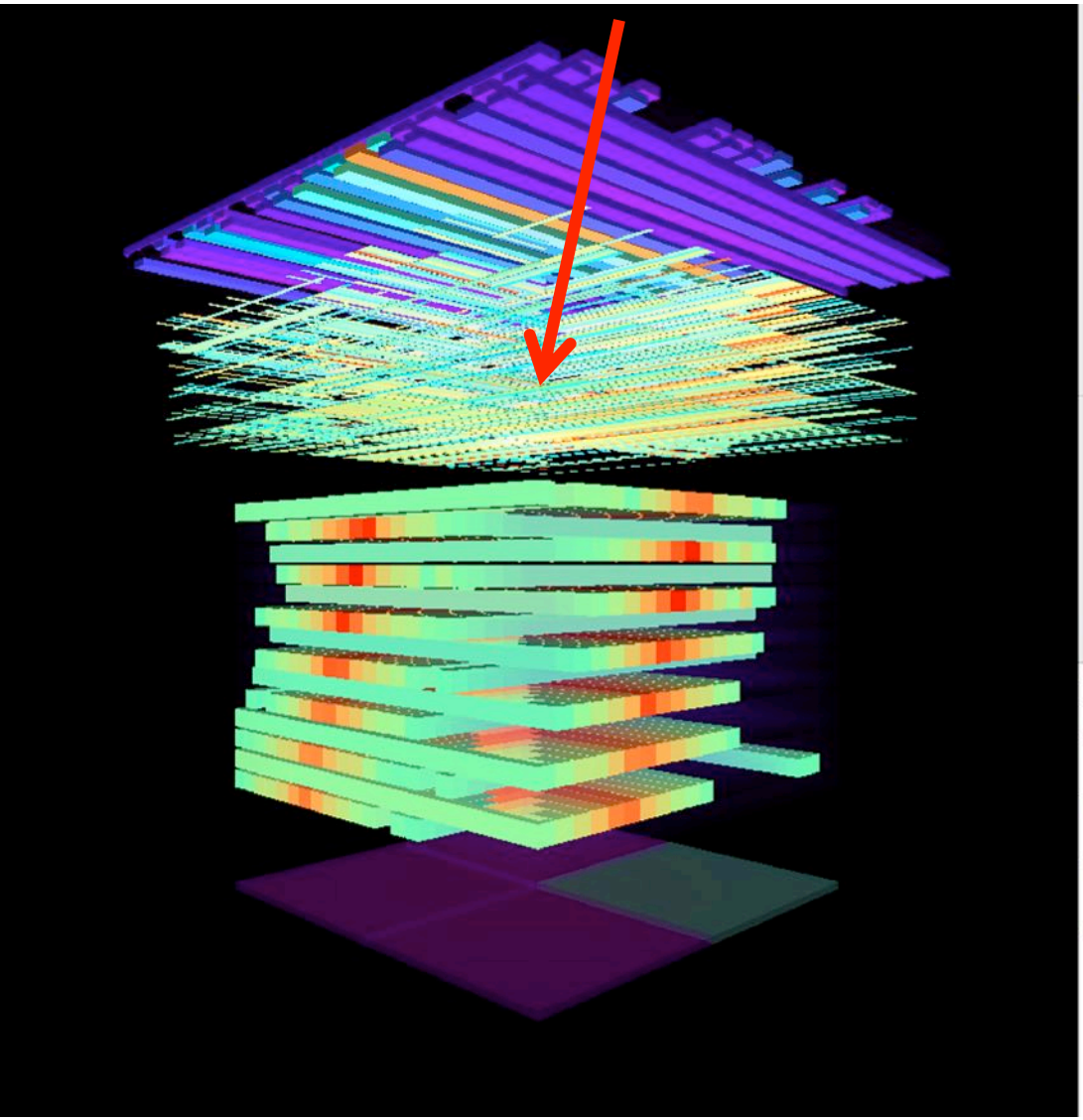
# Dec 24th 2015: HV on

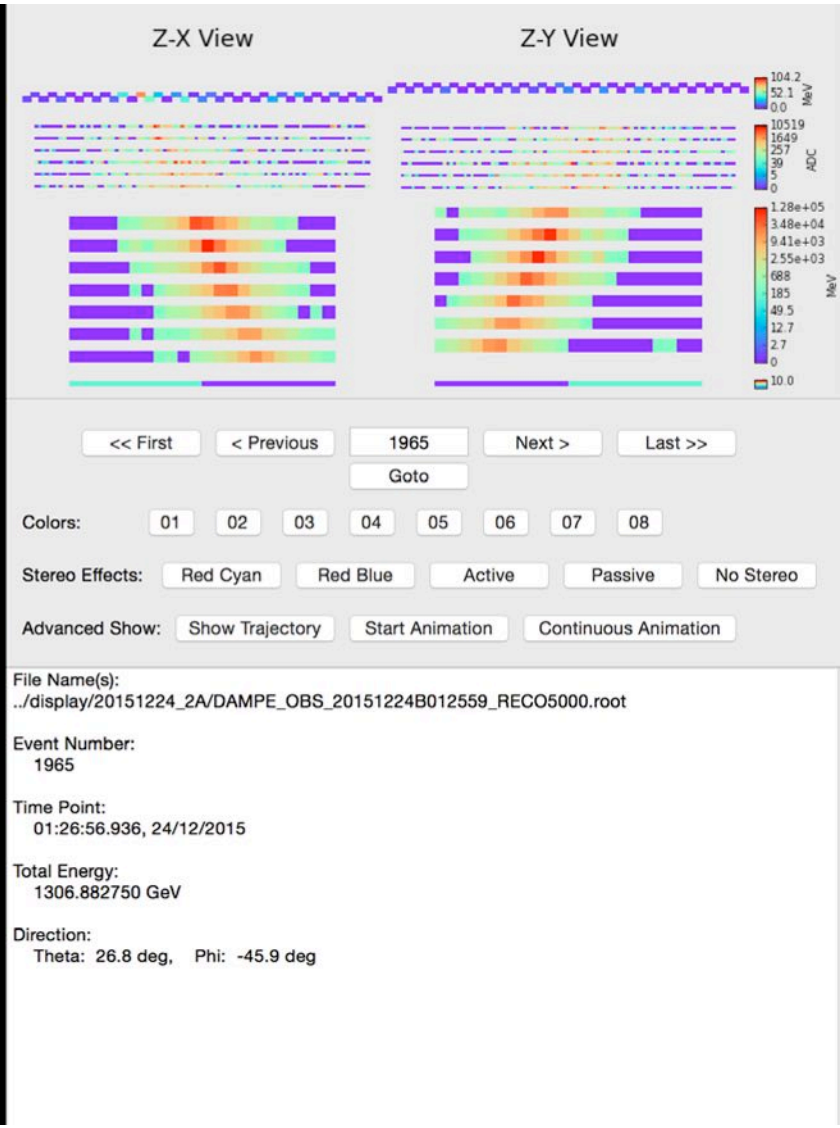
## 12 GeV proton



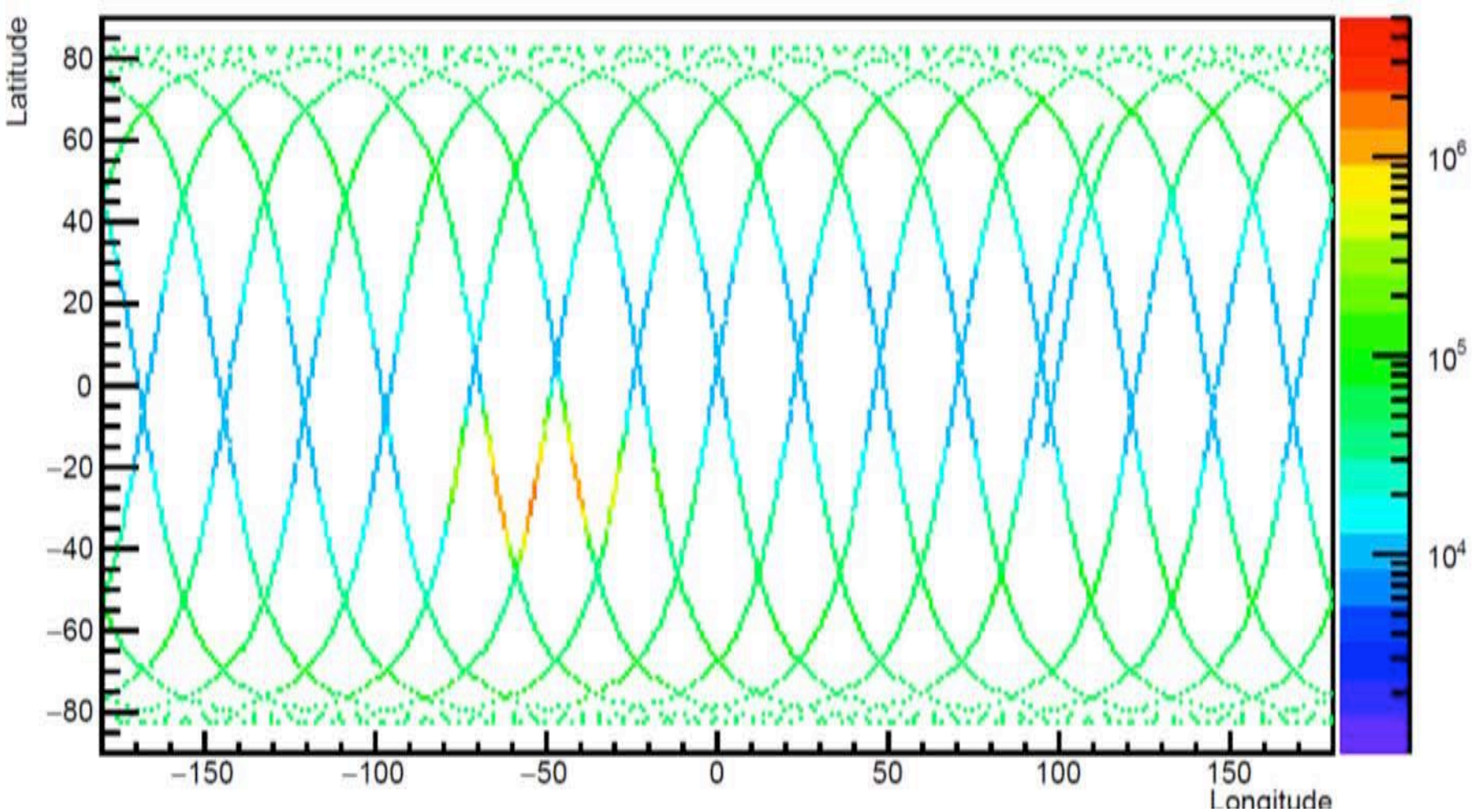
# Dec 24th 2015: HV on

## 1.3 TeV carbon





# Trigger rate in orbit

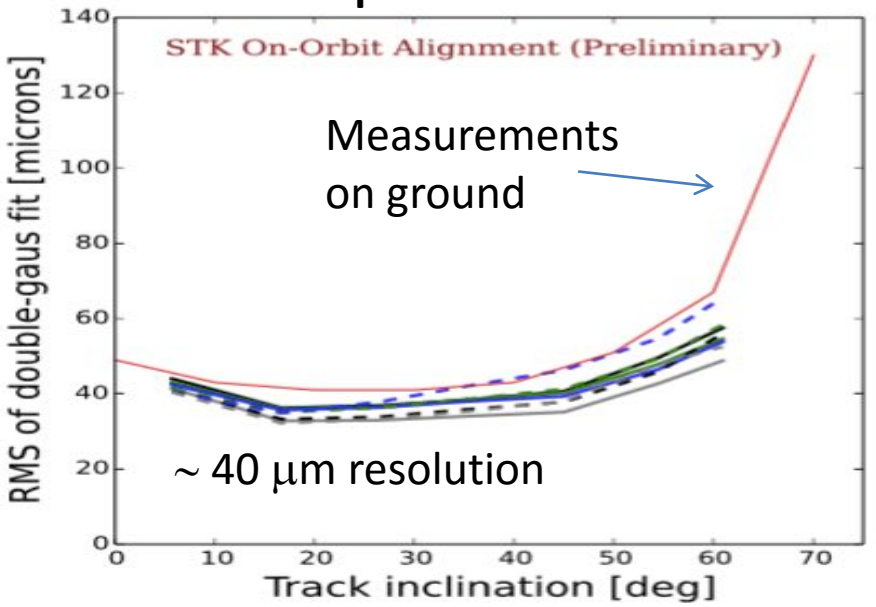



~50 Hz average trigger rate

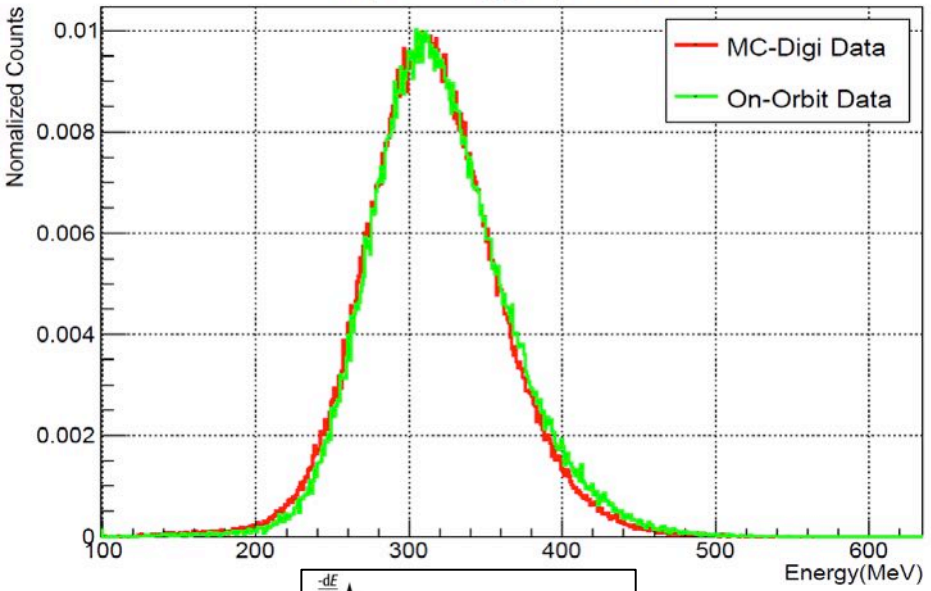
→100GB/day on ground (about 4 M events)

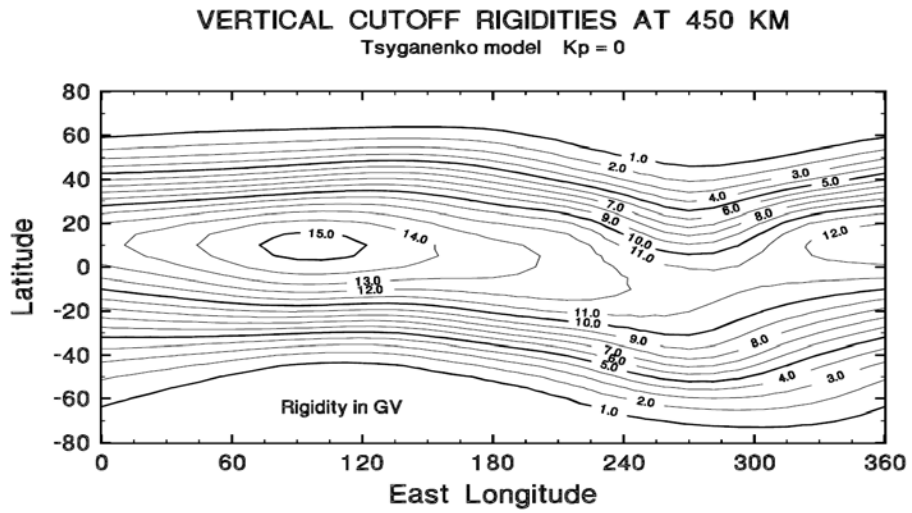
# Some on-orbit performance plot

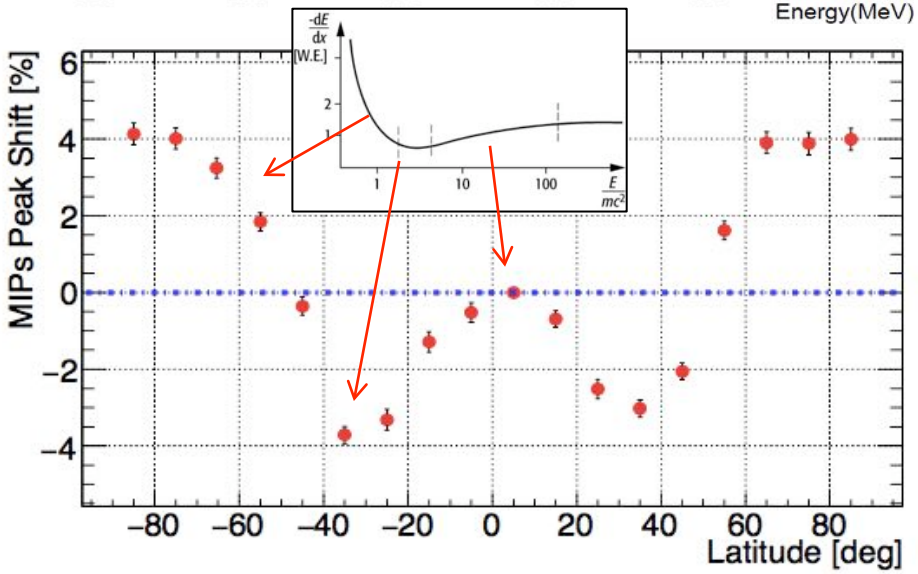
**STK space resolution**




**BGO "mip"peak**



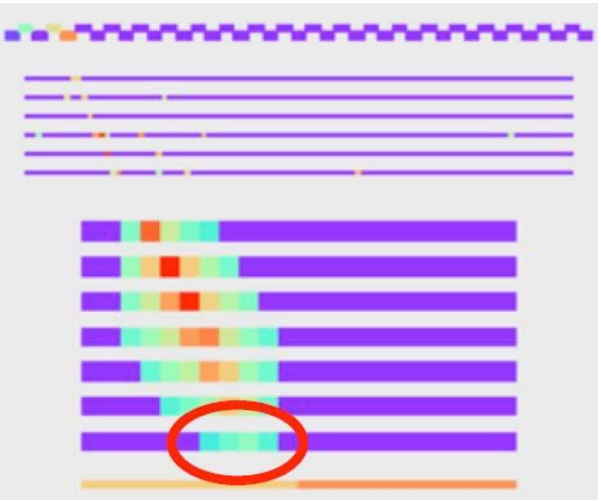



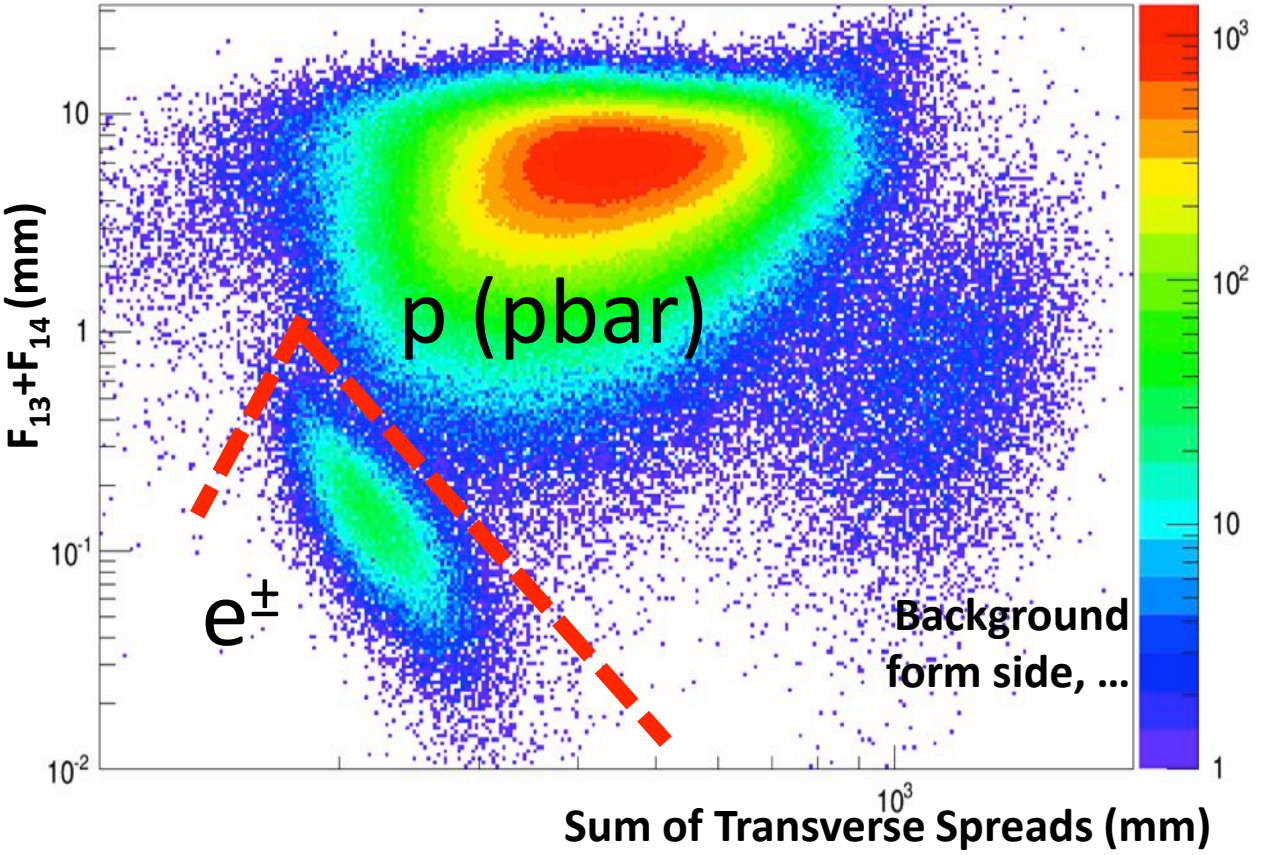
# Electron indentification

One possible "shape parameter"

$$F_i = Spread_i \times \frac{E_i}{E_{tot}}$$

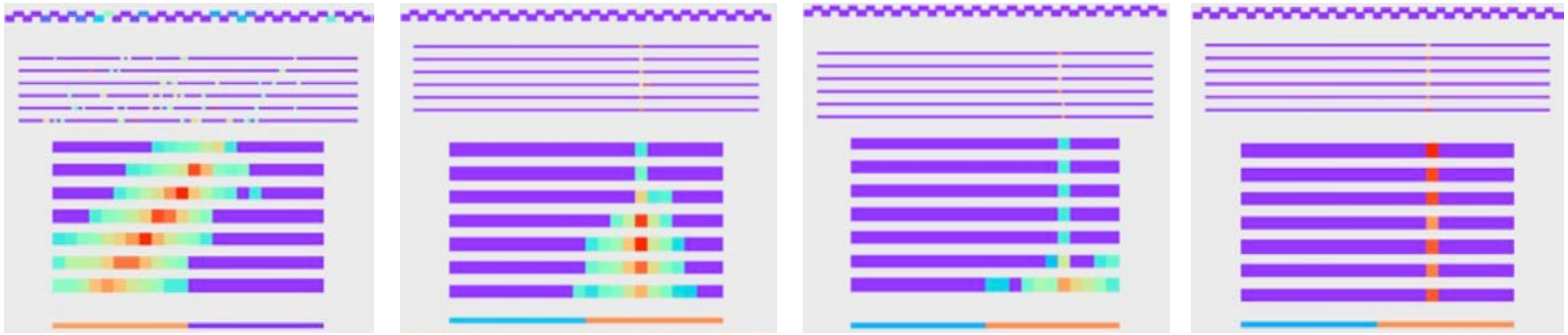
Rejection power > $10^5$





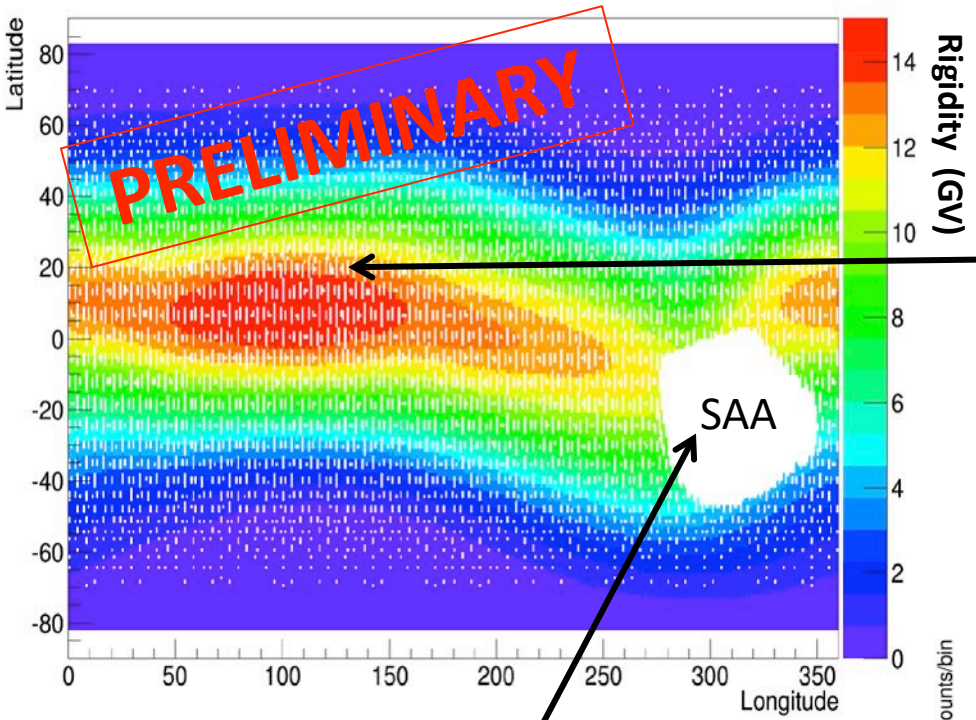

**Electrons and positrons**

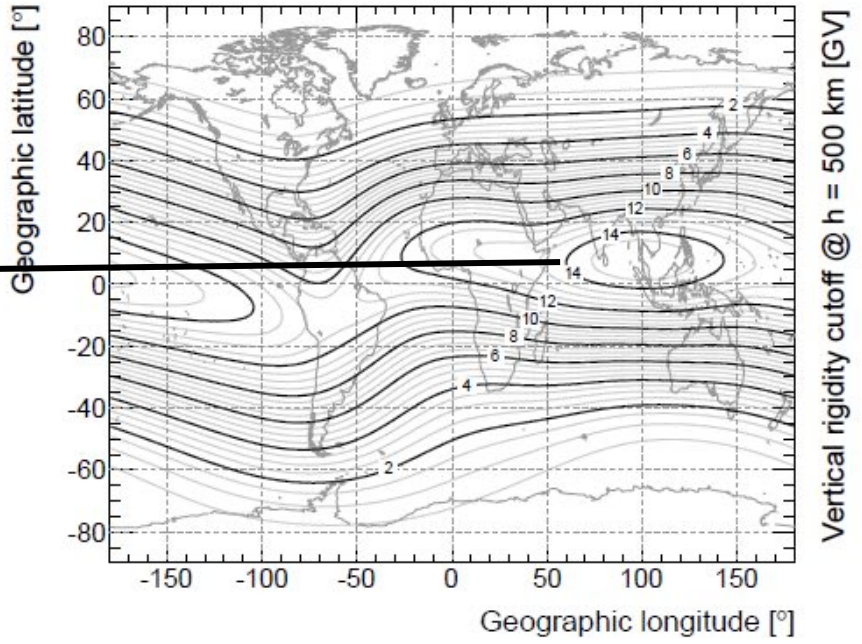
**Protons and nuclei**

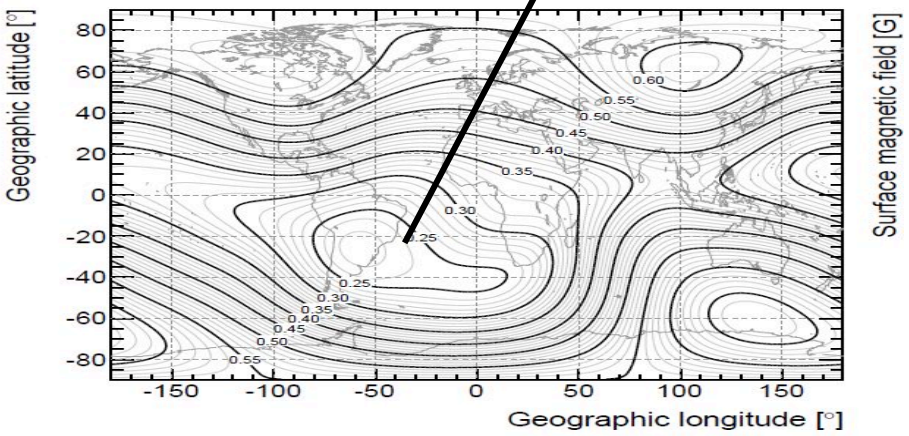


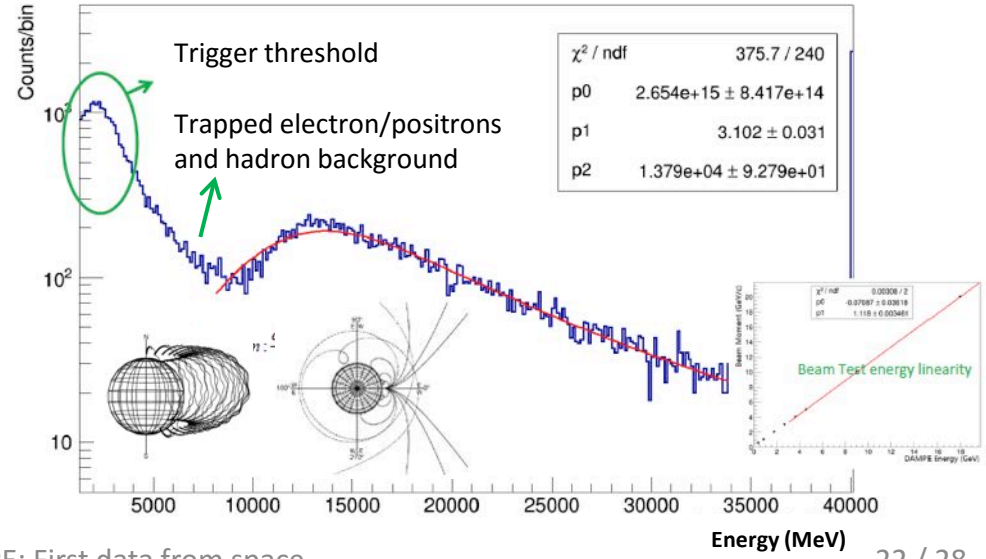
# On-orbit energy calibration

## $e^{\pm}$ rigidity cutoff with 1 month statistics



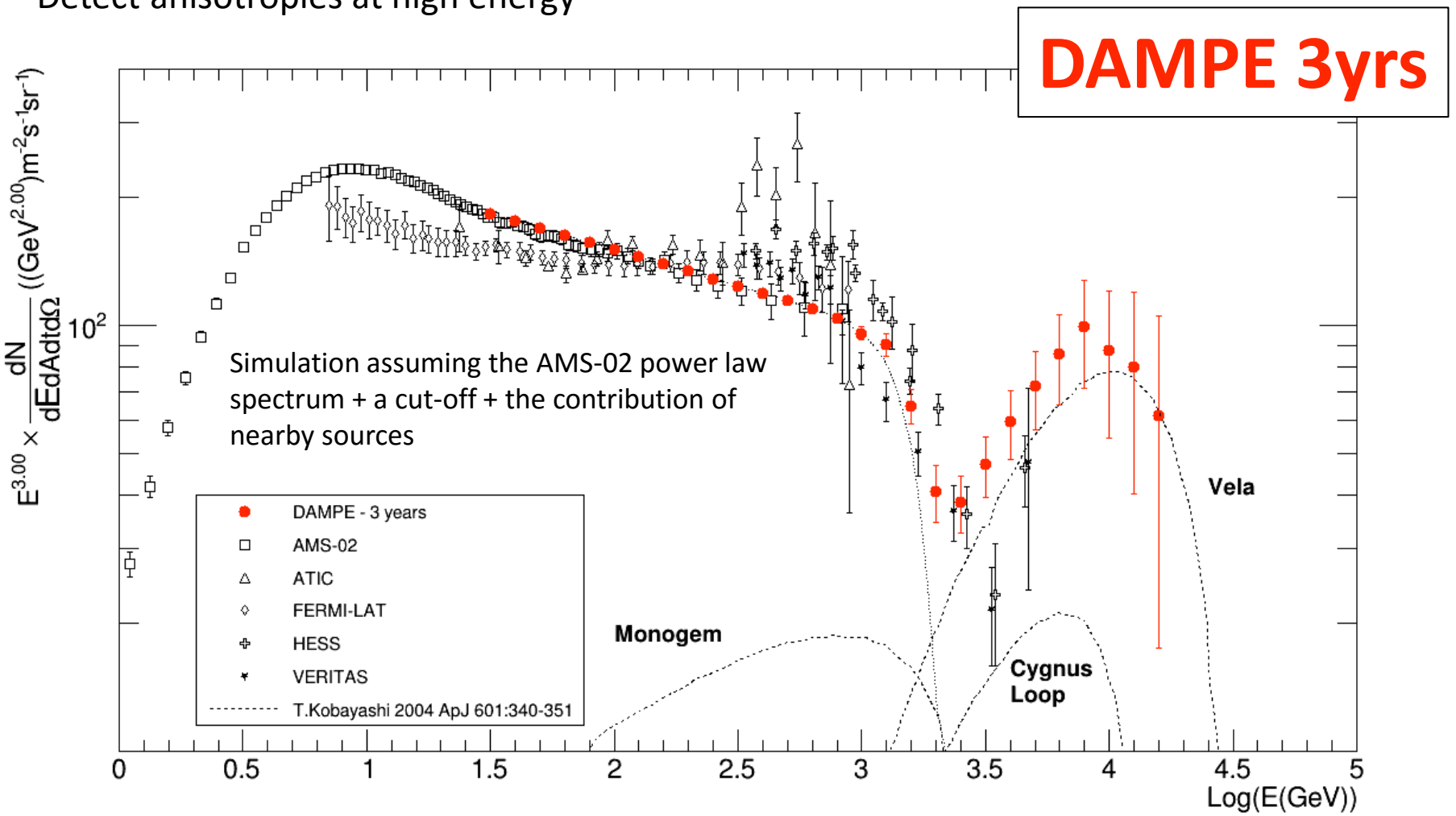



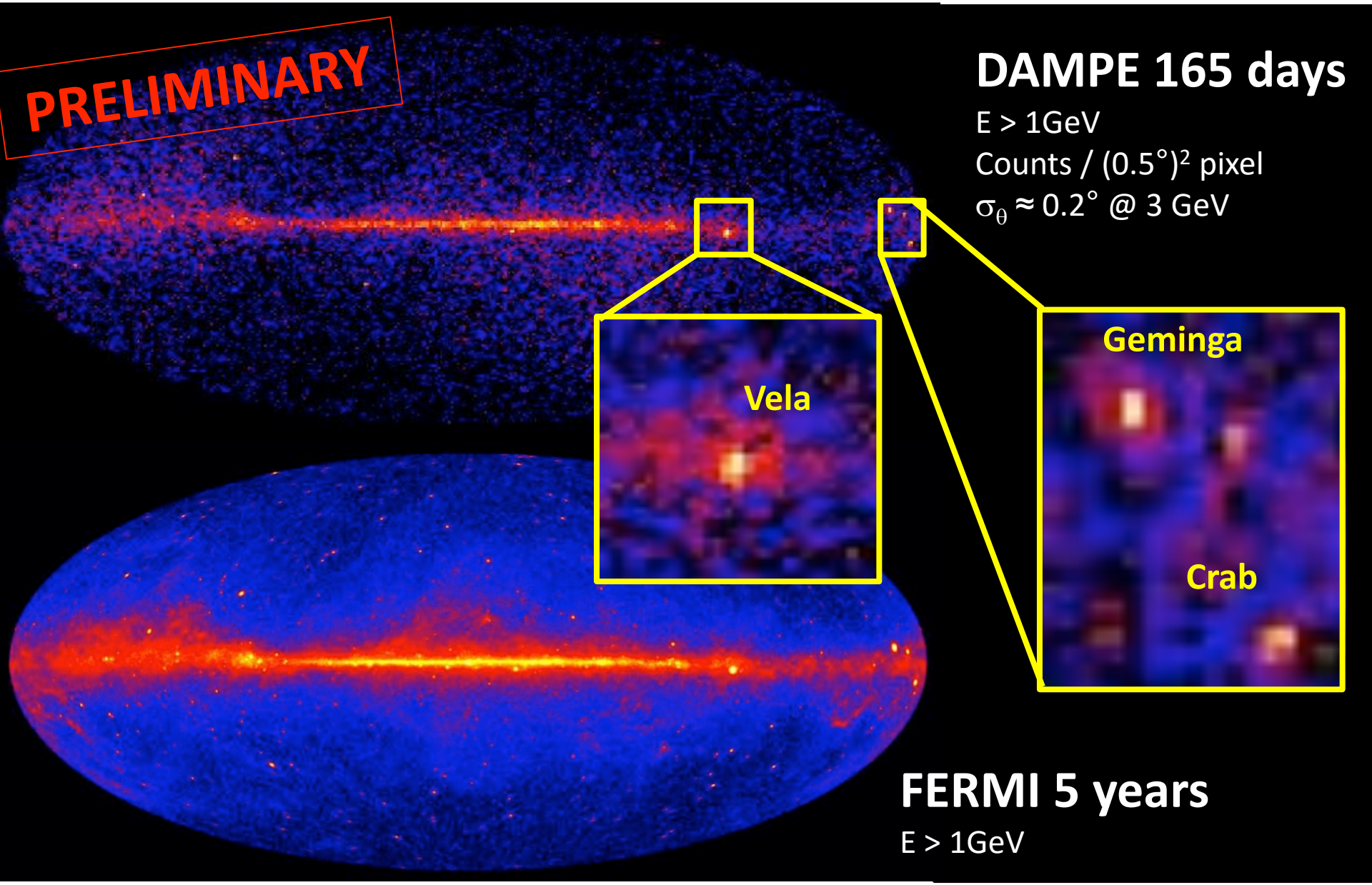



# All-electron spectrum

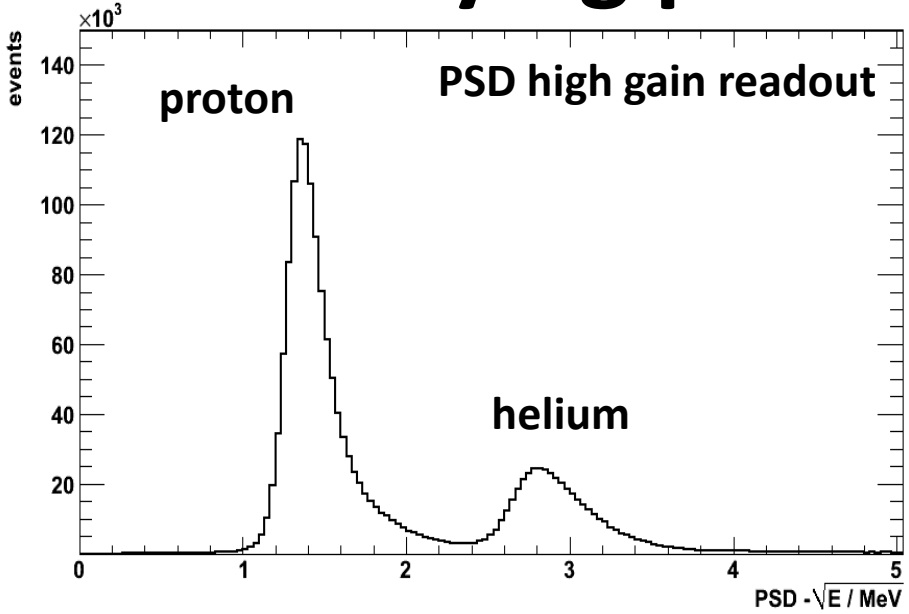
- Measure the all-electron flux up to about 10TeV
- Measure with high accuracy the sub-TeV region and the possible cut-off around one TeV
- Detect structures in the spectrum due to nearby sources and/or DM induced excesses
- Detect anisotropies at high energy

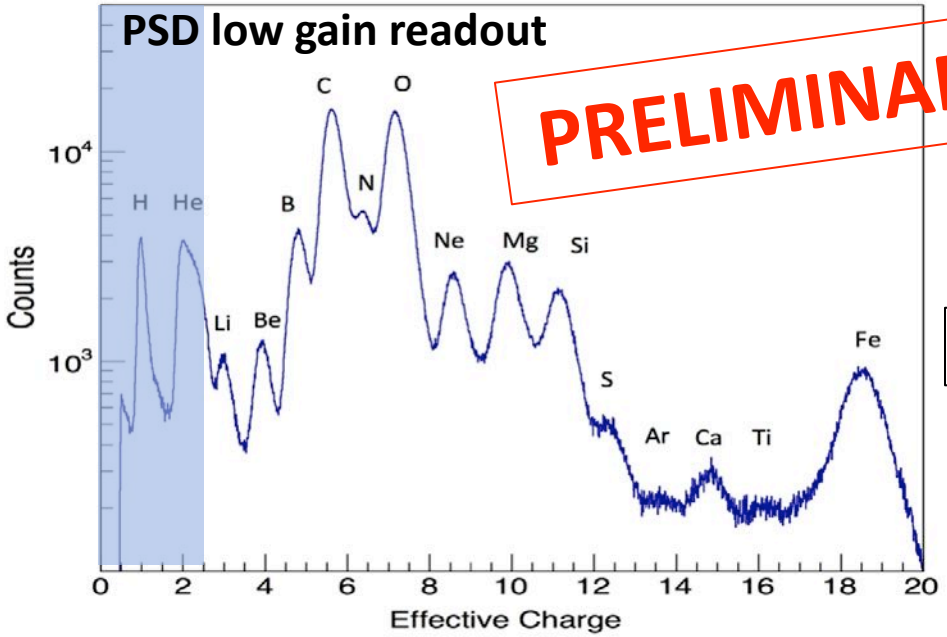


# Photons

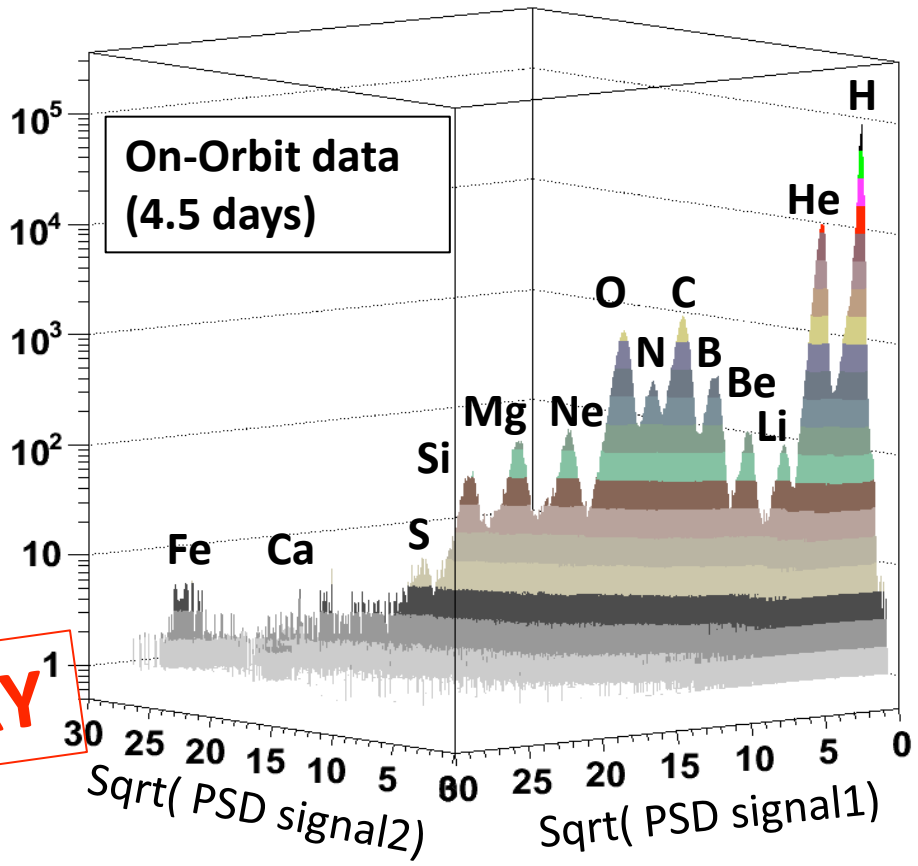

PRELIMINARY
DAMPE 165 days
E > 1GeV
Counts / (0.5°)² pixel
$\sigma_\theta \approx 0.2°$ @ 3 GeV
Vela
Geminga
Crab
FERMI 5 years
E > 1GeV

# Identifying protons and nuclei



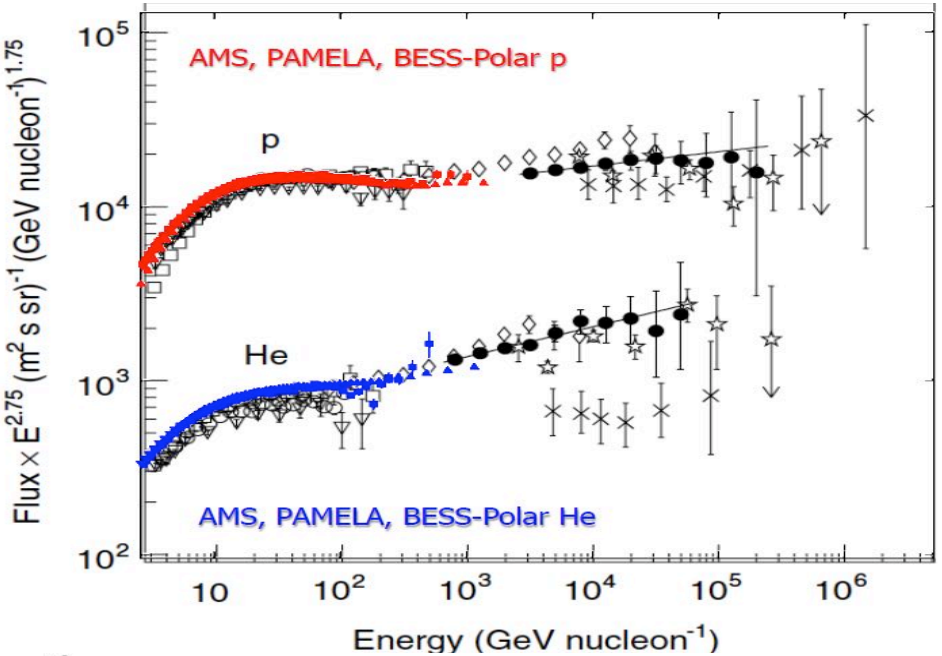

PRELIMINARY

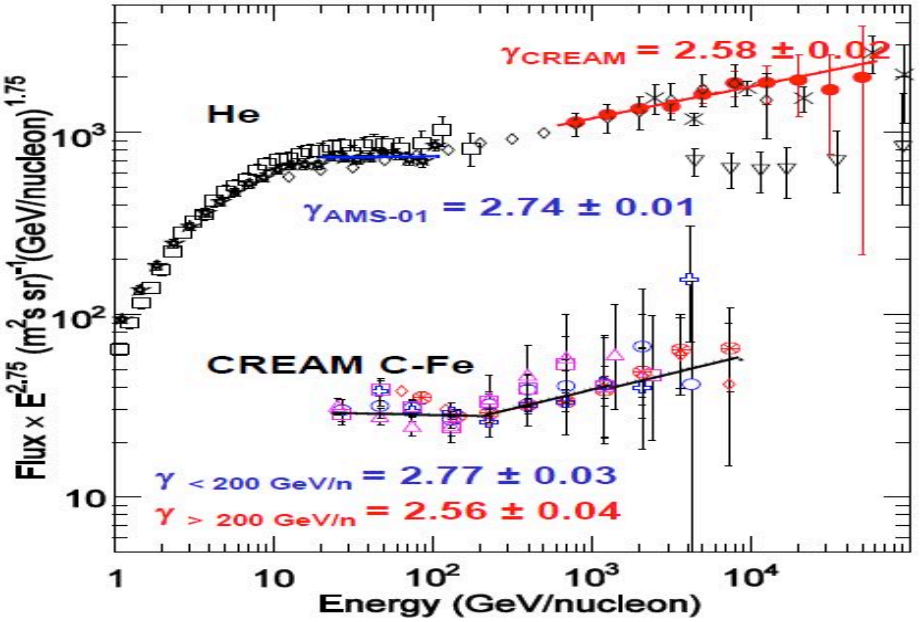


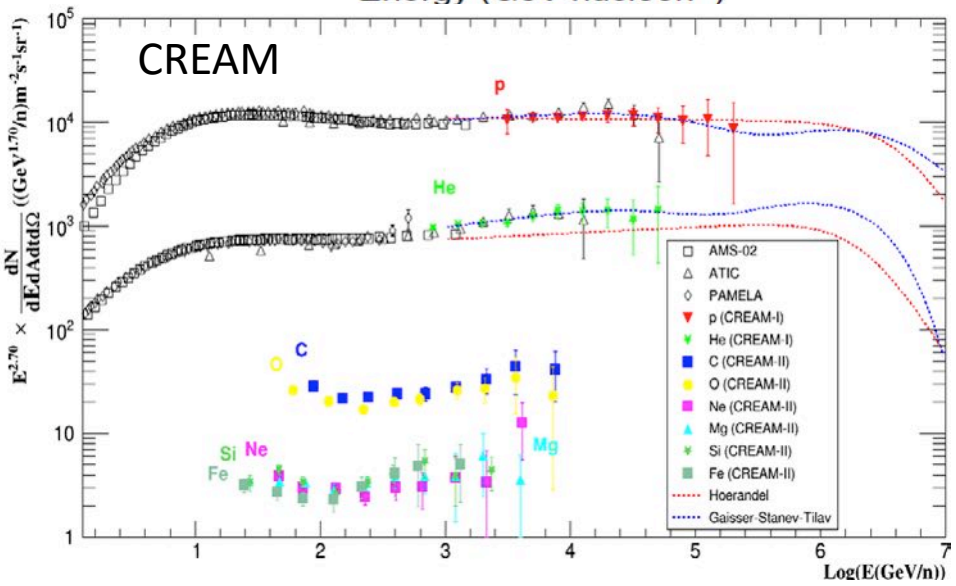

**Charge resolution ~ 0.2-0.3 e depending on Z**

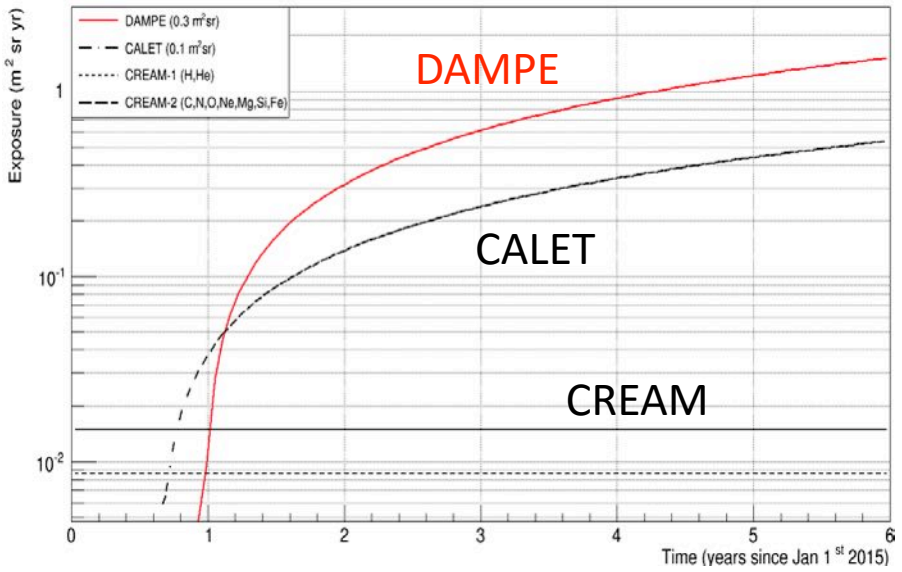
**Charge measurement also given by STK and (with lower precision) by the BGO bars**

# Protons and nuclei spectra

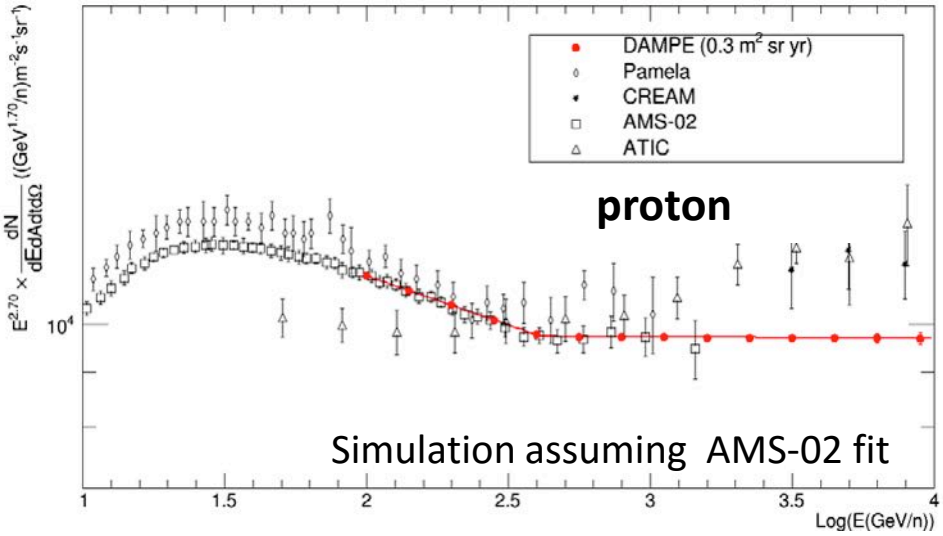


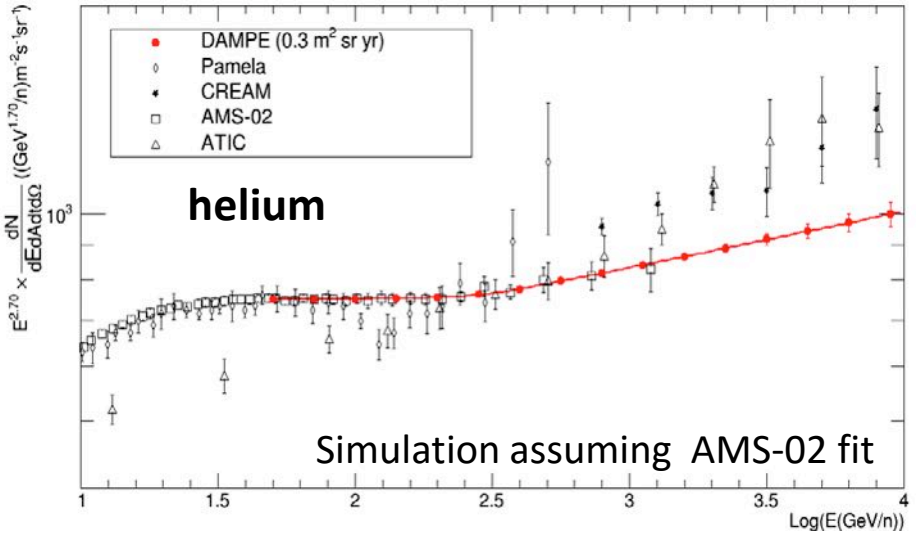



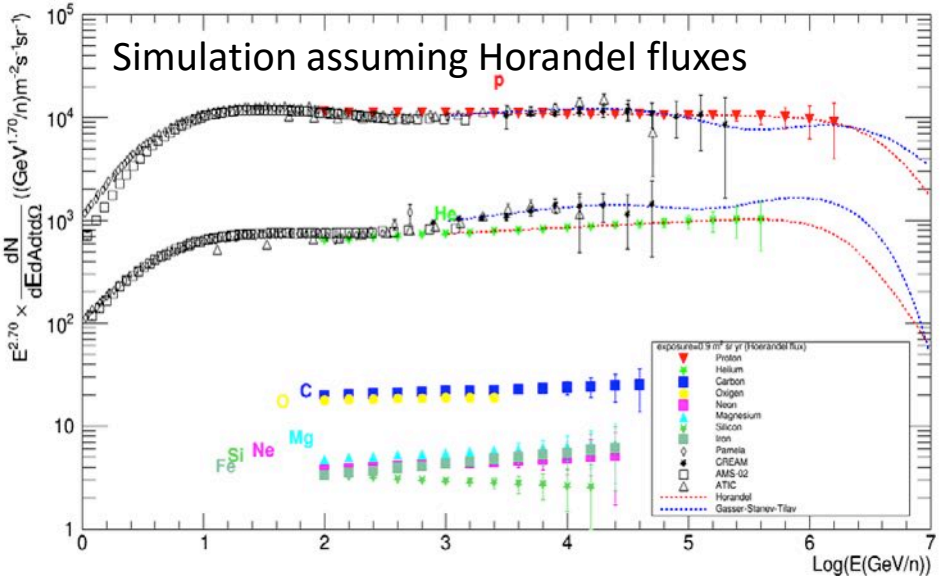



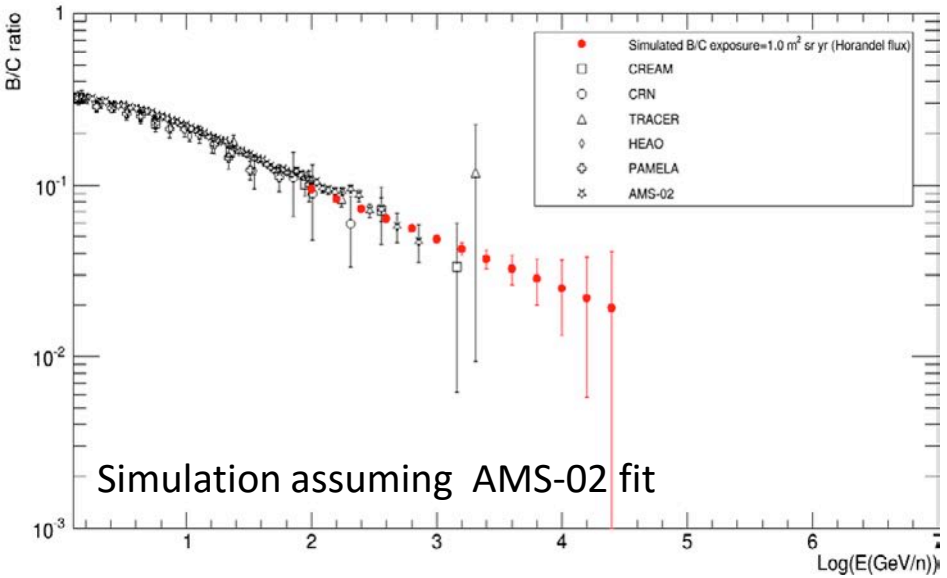



# Protons and nuclei: DAMPE 3years



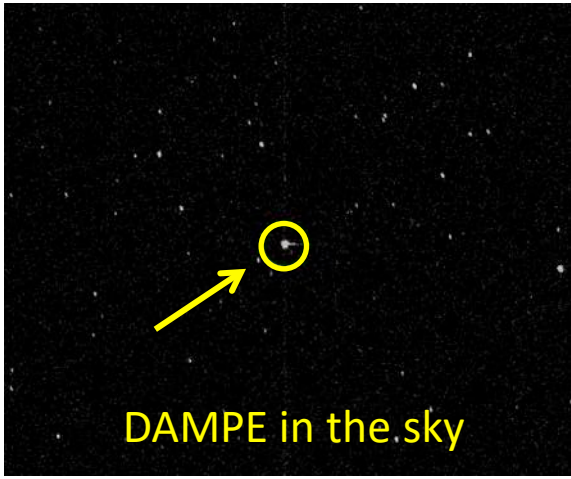
# Summary

**The detector**

- Large geometric factor instrument (0.3 $m^2$ sr for p and nuclei)
- Precision Si-W tracker (40μm , 0.2°)
- Thick calorimeter (32 $X_0$ , $\sigma_E/E$ better than 1% above 50 GeV for e/γ , ~35% for hadrons)
- "Mutiple" charge measurements (0.2-0.3 e resolution)
- e/p rejection power > $10^5$ (topology alone, plus neutron detector)

**Launch and performances**

- Succesfull launch on dec 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 photon map




**Physics goals**

- Study of the cosmic electron and photon spectra
- Study of electron anisotropy and nearby sources contribution
- Study of cosmic ray protons and nuclei: 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