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Cosmic Ray Helium spectrum measured by DAMPE

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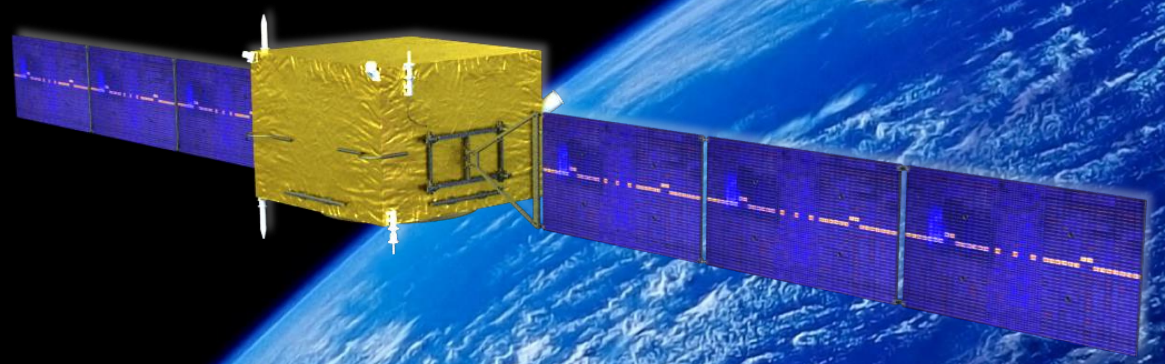
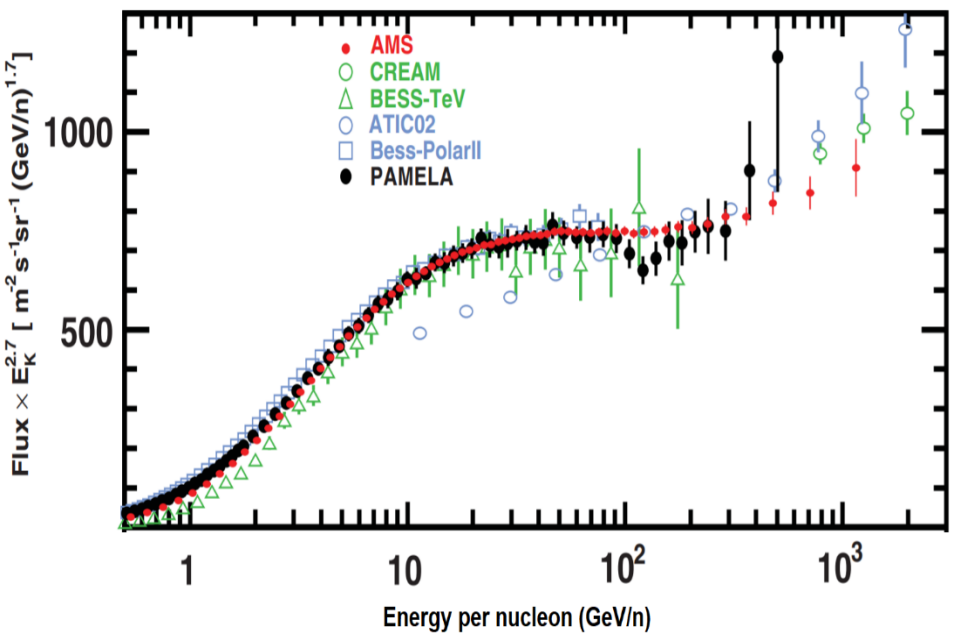
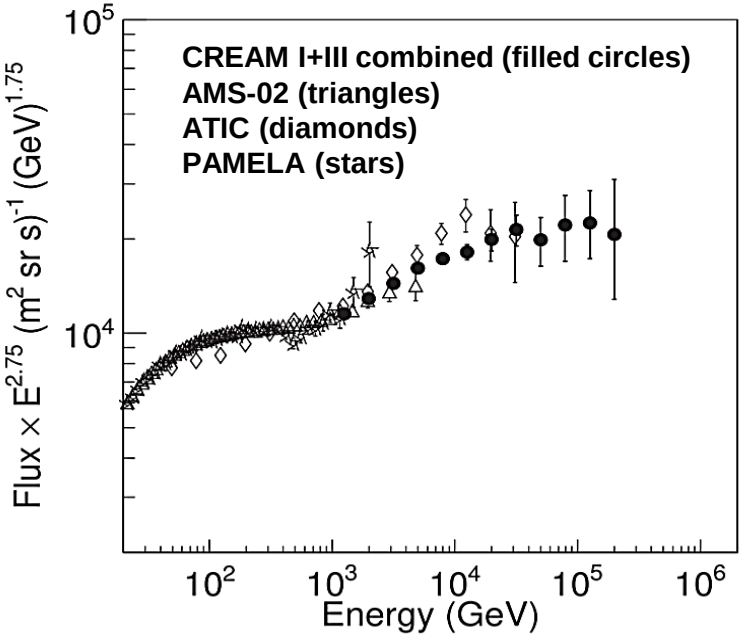


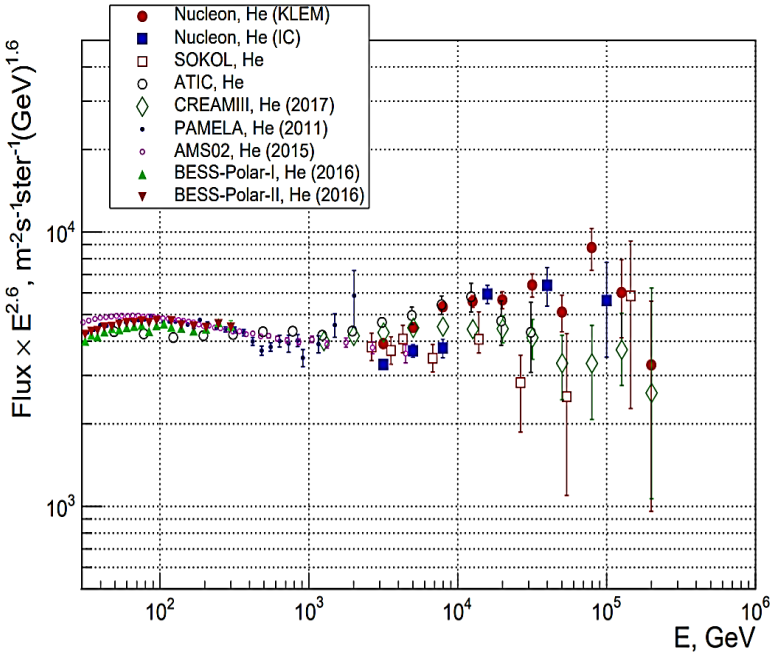
UNIVERSITÀ DEL SALENTO

INFN
Istituto Nazionale di Fisica Nucleare

Scientific framework







M. Aguilar *et al.* (AMS Collaboration) PRL 119 (2017)

Y.S. Yoon *et al.* (CREAM Collaboration) Astrophys. J. 839 (2017)

E. Atkin *et al.* (NUCLEON Collaboration) arXiv:1702.02352 (2018)

SPECTRAL HARDENING AT FEW HUNDREDS OF GeV/n

CRs coming from different galactic sources?

Different acceleration mechanisms that we should understand?

Different propagation effects?

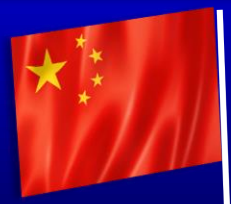
DAMPE Space mission

Satellite-borne particle detector prosed in the framework of the *Strategic Pioneer Program on Space Science, promoted by the Chinese Academy of Sciences (CAS).*

ALTITUDE: 500 km
PERIOD: 95 minutes
ORBIT: Sun-synchronous

SCIENTIFIC GOALS:

- Study of Cosmic Rays composition, origin and propagation
- Search for Dark Matter signatures in lepton and photon spectra
- High Energy Gamma-Ray Astronomy



- Purple Mountain Observatory
- University of Science and Technology
- Institute of High Energy Physics
- Institute of Modern Physics
- National Space Science Center

- INFN Lecce and University of Salento
- INFN Bari and University of Bari
- INFN Perugia and University of Perugia
- INFN LNGS and Gran Sasso Science Institute

- Geneva University

DAMPE detector

J. Chang et al., Astrop. Phys. 95 (2017) 6-24

PSD

- 2 planes with double layer configuration
- 82 bars of plastic scintillator

- CHARGE MEASUREMENT (Z<28, Z∝√E)
- γ-RAYS VETO

STK

- 6 planes with 2 single-sided silicon layers
- 3 thin tungsten layers (for γ conversion in e^+/e^-)

- TRACK RECONSTRUCTION
  - spatial resolution <70 μm for CR (θ_{inc}< 60°)
  - angular resolution ~0.2° for γ at 10 GeV
- CHARGE MEASUREMENT (Z ∝ √ADC)

BGO

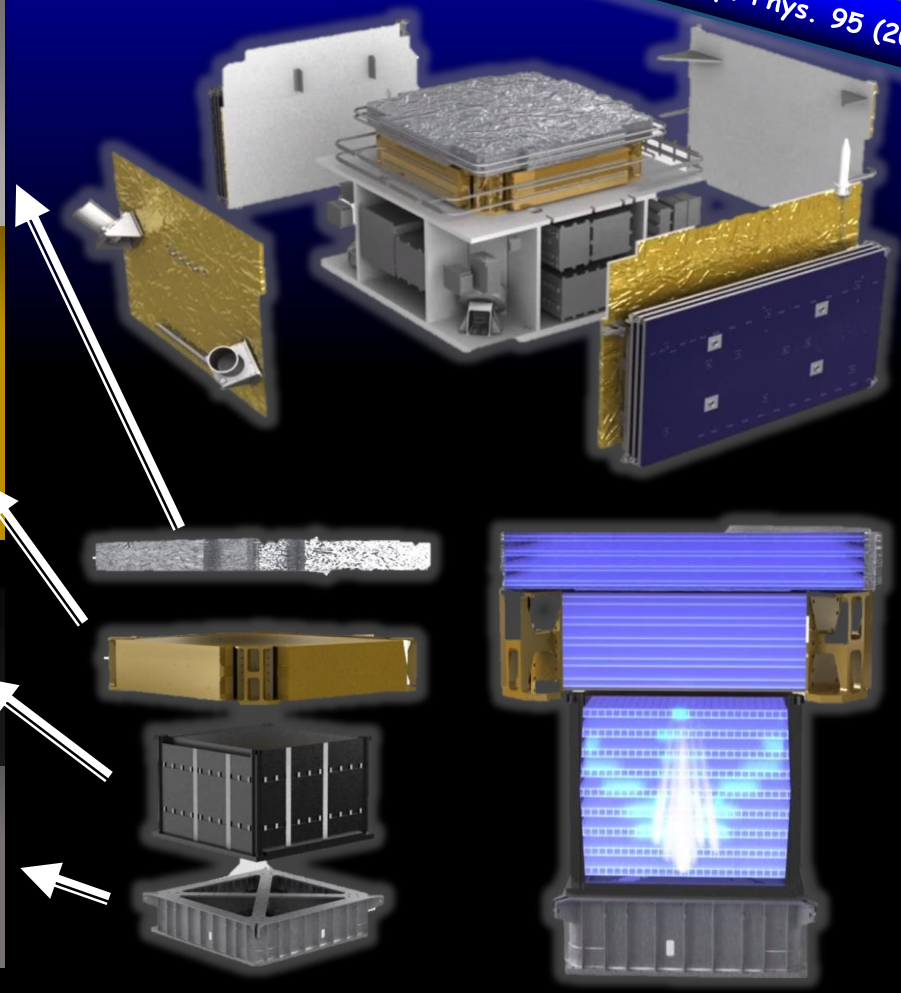
- 14 layers, each one with 22 bars of $Bi_3Ge_4O_{12}$,~32 X_0

- ENERGY MEASUREMENT
  - 1 GeV - 10 TeV for electrons and γ
  - 50 GeV - 100 TeV for nuclei

NUD

- 1 layer, 4 boron-doped plastic scintillators

- detection of neutrons generated in the BGO for hadron/e.m. showers discrimination



Event selection - (1)

DATA SAMPLE: 39 months of Flight-data

Dead time

South Atlantic Anomaly (SAA) (~4.5% of O.T.)

On-orbit calibration (~1.5% of O.T.)

Instrumental dead time (~18.5% of O.T.)

Pre-Selection

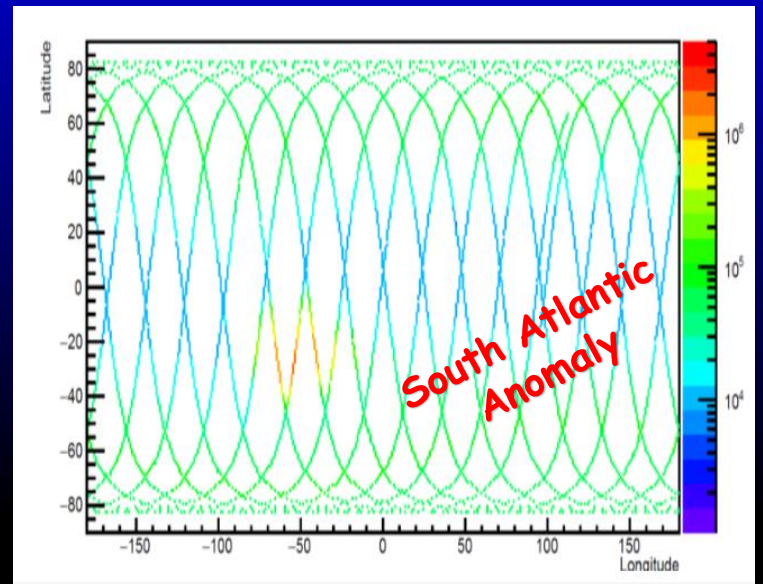
South Atlantic Anomaly events excluded

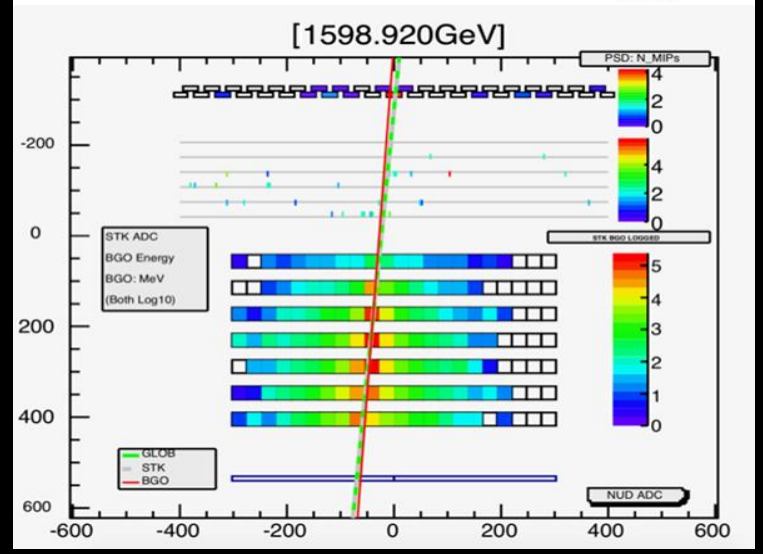
E_{dep} > 20 GeV inside the BGO calorimeter

$N_{STKTrack} \geq 1$ & full containment of the track

match STK track direction/hit position on the fired PSD bars

match STK track direction/BGO shower direction





Event selection - (2)

E_{dep} > 10MIPs in first 3 BGO Layers
&&
E_{dep} > 2 MIPs in 4th BGO Layer

(1 MIP_{BGO} = 23 MeV)

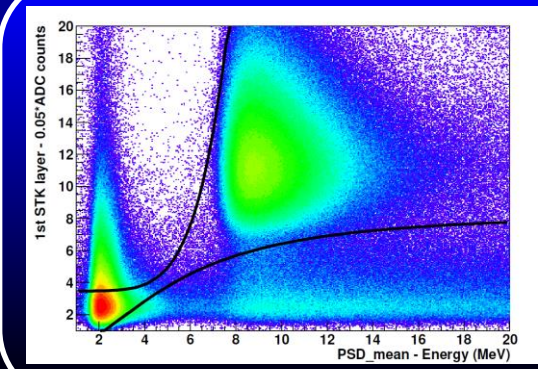
High Energy Trigger activation

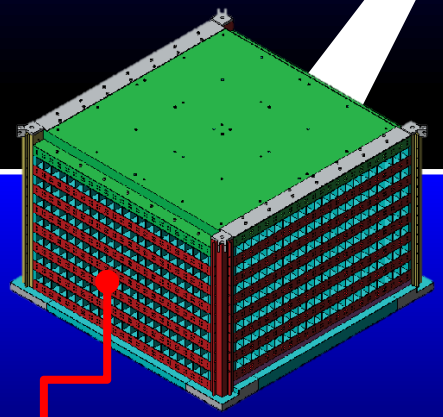
Top-down development of the shower in the BGO

Charge measurement agreement in both PSD views

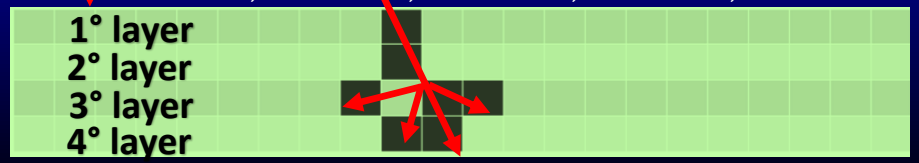
Charge measurement agreement in PSD and STK 1st layer

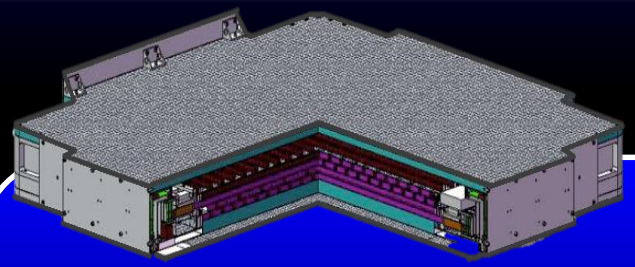
Charge Selection



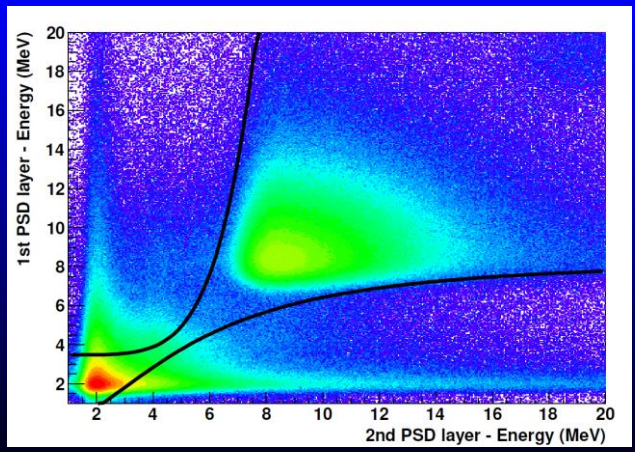


$$E_{BGO,1} + E_{BGO,2} < E_{BGO,3} + E_{BGO,4}$$

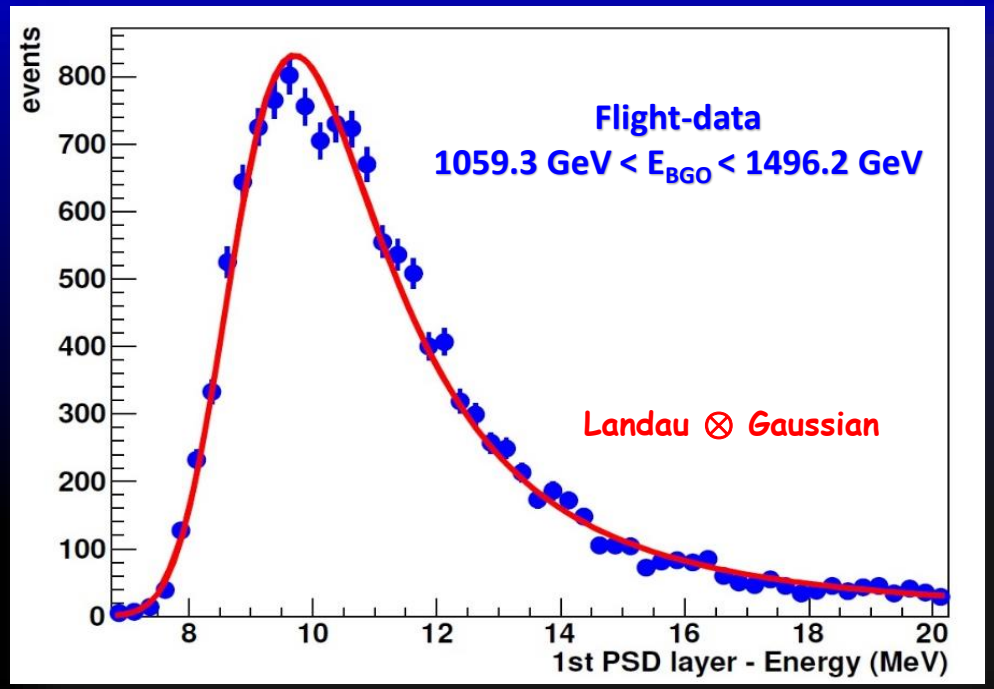




1st layer
2nd layer



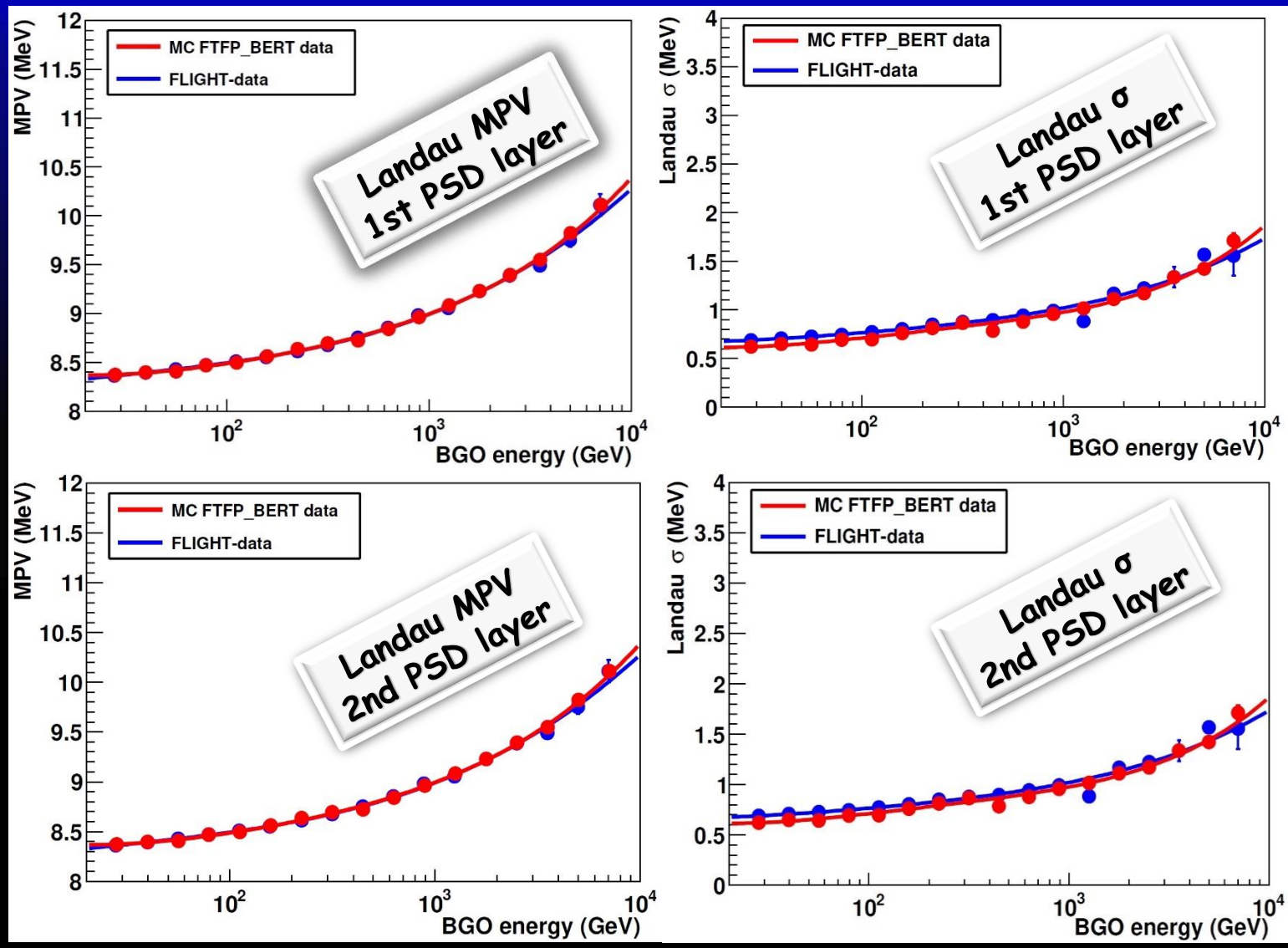
Charge Selection



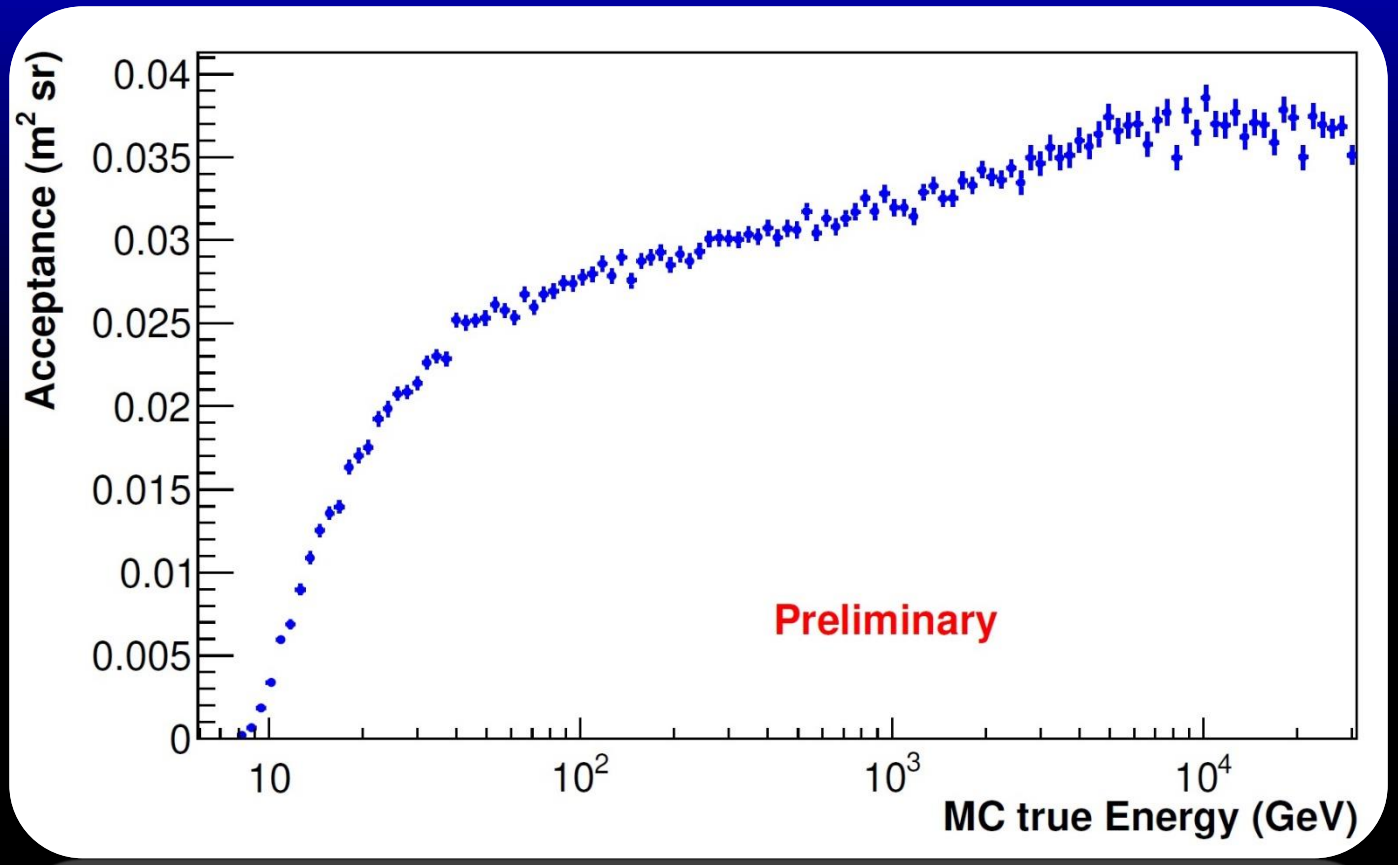
CHARGE SELECTION:

$$\mathbf{MPV} - 2\sigma < \mathbf{E_{PSD}} < \mathbf{MPV} + 4\sigma$$

with $\sigma = \sqrt{\sigma^2_{Landau} + \sigma^2_{Gaussian}}$



Acceptance



$$A_{eff,i} = A_{gen} \frac{N_{pass,i}}{N_{gen,i}}$$

- A_{gen} : geometrical factor used in MC simulation of an isotropic CR Helium nuclei flux generated above a sphere with R=1.0 m
- $N_{pass,i}$: number of events selected by the the analysis, in a given i-bin of primary energy
- $N_{gen,i}$: total number of generated events in the i-bin of primary energy

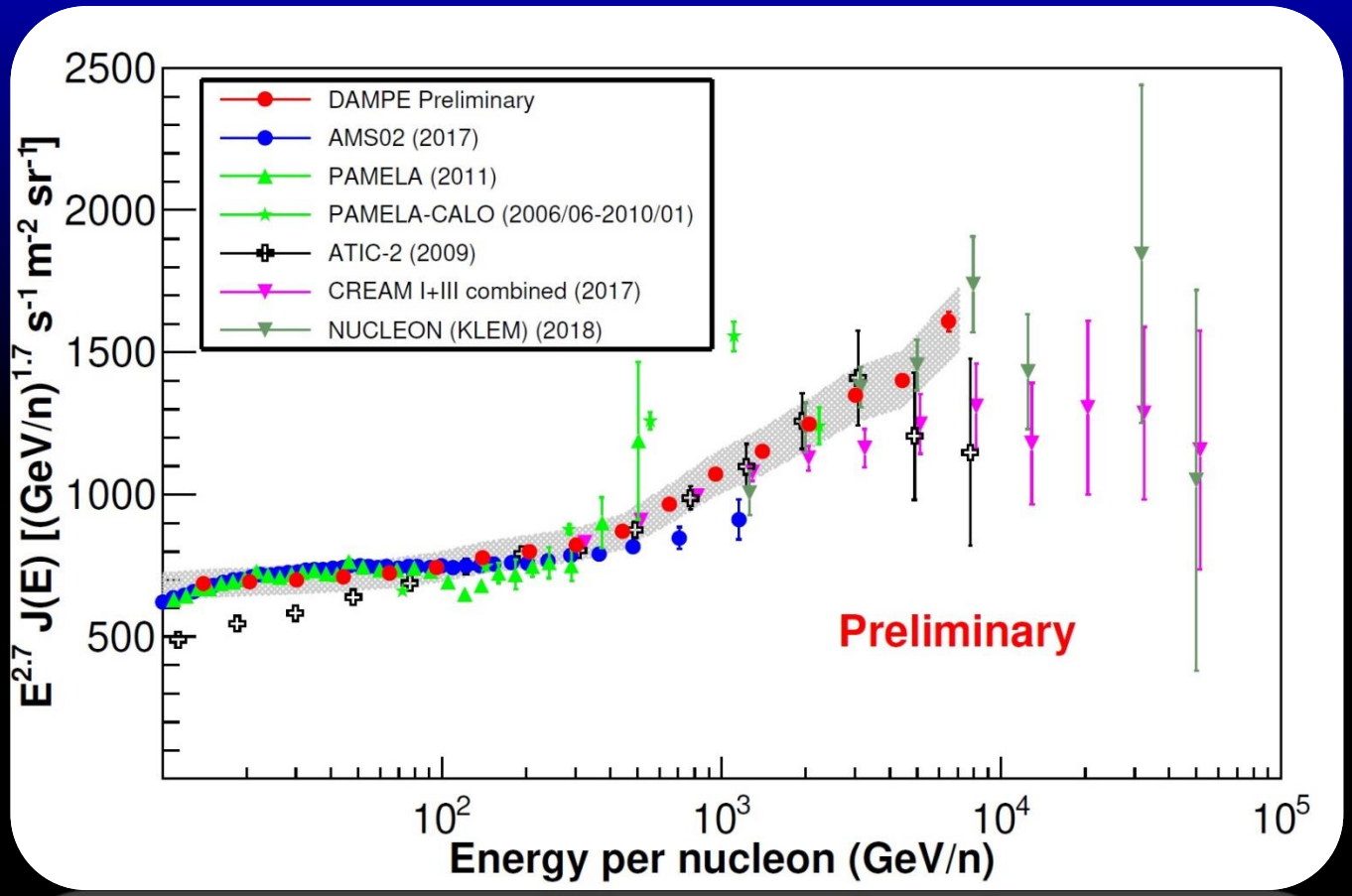
Preliminary Helium Flux

Preliminary Helium flux measurement provided by DAMPE, compared with latest results by other experiments.

Grey band :

$$\sigma_{sys} = \sqrt{\sigma_{HET}^2 + \sigma_{Track}^2 + \sigma_{Charge}^2 + \sigma_{bg}^2} \cong 7\ \%$$

- ~ 5% HET efficiency
- ~ 3% Track reconstruction
- ~ 4% Charge reconstruction
- ~ 3% of proton contamination



CONCLUSIONS

1. The DAMPE detector is stably collecting data since Dec. 17, 2015.
2. The preliminary measurement of Cosmic Ray Helium spectrum has been measured up to the energy of about 7 TeV/nucleon.
3. DAMPE measurement confirms the presence of a spectral hardening observed by previous experiments at hundreds of GeV.
4. The analysis is going on with the goal of a complete evaluation of the total systematics which affects the measurement.
5. The Helium spectrum measurement at higher energies will be provided very soon by the DAMPE collaboration.

BACKUP

Spectral Hardening

Fit of the Helium flux performed with a Smoothly Broken Power-Law (SBPL) in the energy range [40 GeV/n- 3 TeV/n].

Fit

$$\Phi(\mathrm{E}) = \Phi_0 \left(\frac{E}{TeV}\right)^{-\gamma} \left[1 + \left(\frac{E}{E_b}\right)^{1/\omega}\right]^{-\Delta\gamma\cdot\omega}$$

$$E_b = (339 \pm 14)\ GeV/n$$