Proton energy spectrum with the DAMPE experiment

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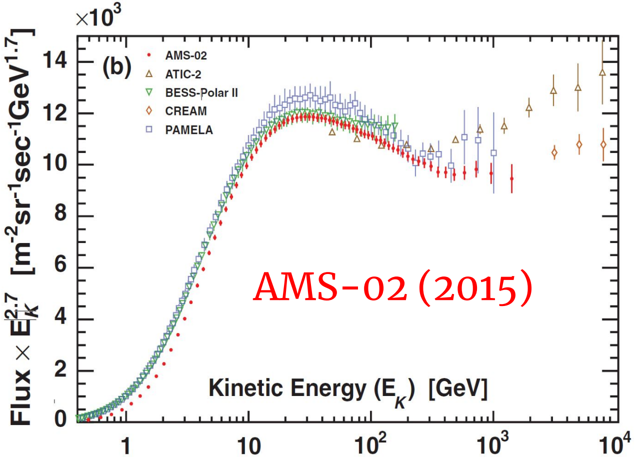
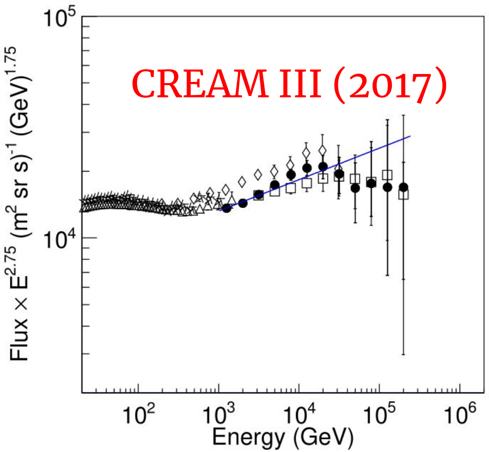
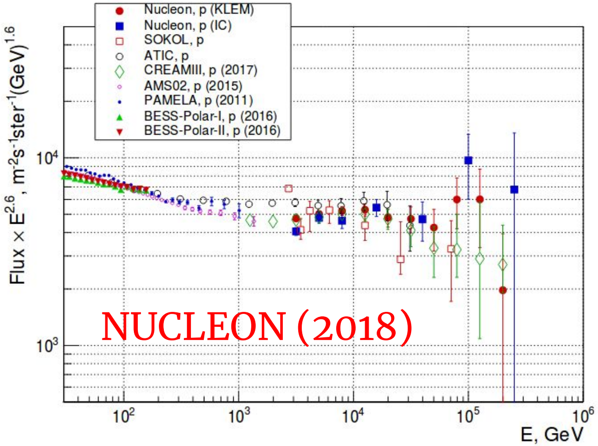
Outline

- **Overview of observed proton fluxes**
- **DAMPE Detector**
- **Analysis**
  - **Proton selection**
  - **Electron discrimination**
  - **Helium contamination**
  - **Selection Efficiencies**
  - **Preliminary Proton flux**
- **Summary**

Overview of observed proton fluxes





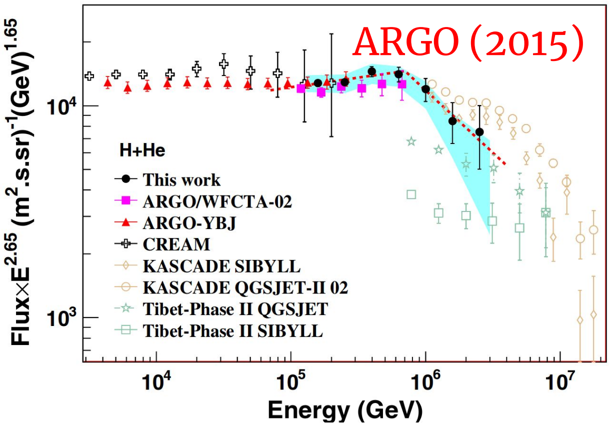


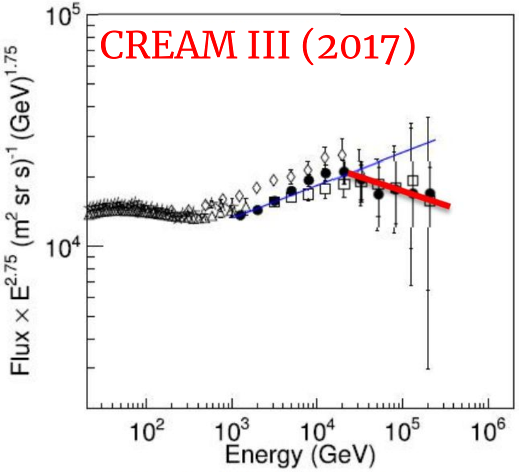
In all these measurements a spectral **hardening** has been observed at E ~ 200 GeV

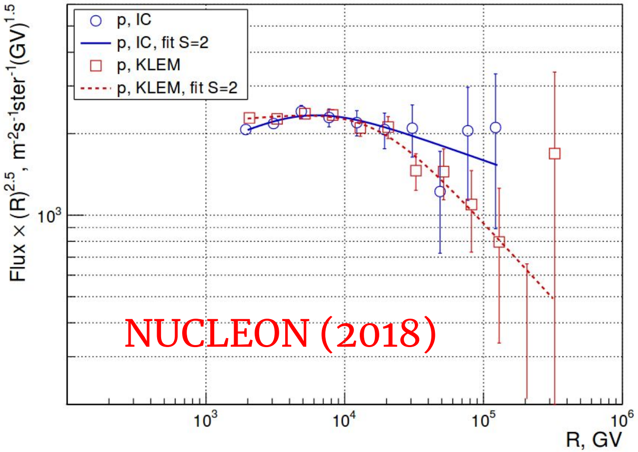
Due to:

- Unknown acceleration mechanisms?
- Propagation effects?
- Different Galactic sources?

Overview of observed proton fluxes (II)







Moreover some other experiments observed a spectral **softening** at E > 10 TeV

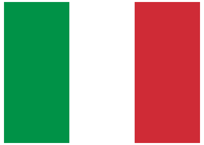
Again:

- Unknown acceleration mechanisms?
- Propagation effects?
- Different Galactic sources?

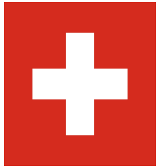
The DAMPE Collaboration

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

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



- SWITZERLAND
  - University of Geneva

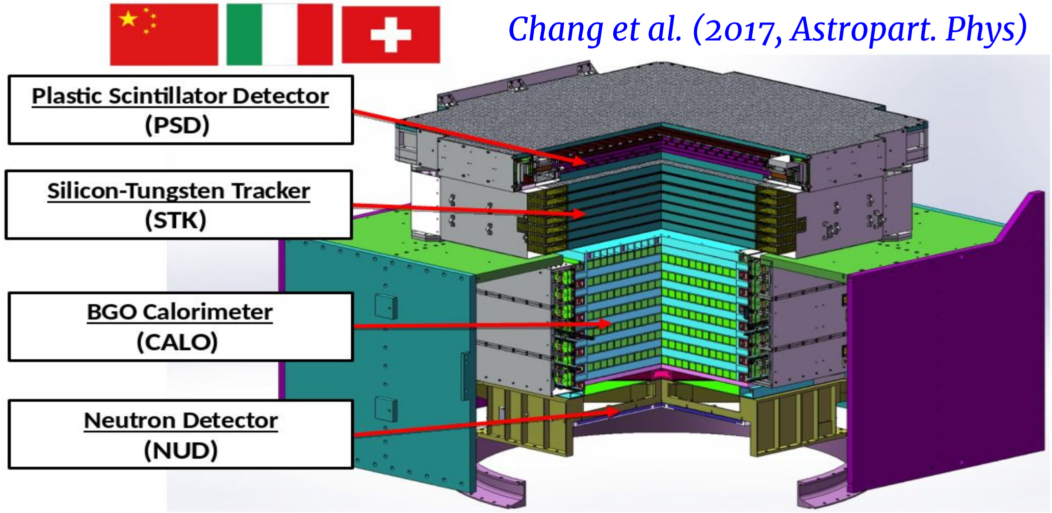


The Detector

The DAMPE (DArk Matter Particle Explorer) mission was launched on December 17, 2015.

It operates on a sun-synchronous orbit permanently oriented to the zenith

Chang et al. (2017, Astropart. Phys)

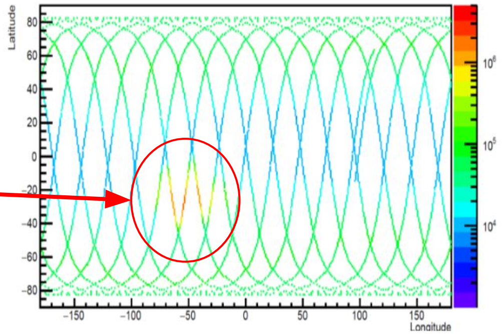


The Detector is composed by:

- 2 layers of **Plastic Scintillator Detector (PSD)** for charge measurement and γ- ray veto
- 6 layers of **Silicon-Tungsten Tracker (STK)** for a precise tracking (spatial resolution ~50 µm) and γ converter
- 14 layers of BGO that compose the **Calorimeter (CALO)**: almost 100% of the energy of electrons and photons is deposited in the calorimeter (~31 X_0)
- 1 layer of **Neutron Detector (NUD)** for hadron rejection

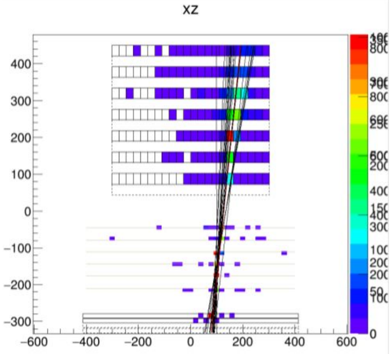
Proton selection

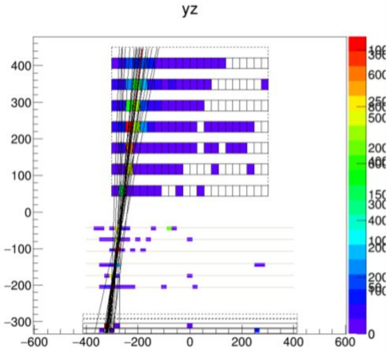
Data collected since January 1, 2016 up to December 31, 2017



The following requests are applied (pre-selection):

- SAA events excluded
- Track geometrically contained in the detector
- E_{dep} > 20 GeV (in BGO crystals)

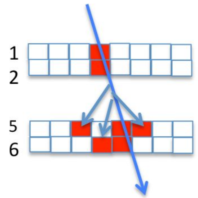




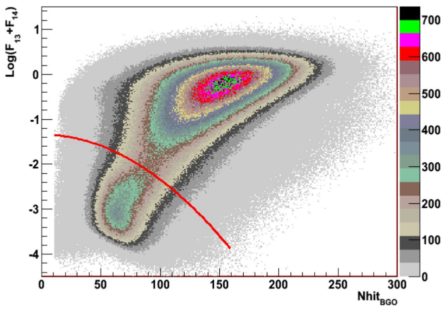
Proton selection (II)

In addition, the following requests have to be satisfied:

- Events have to satisfy the High Energy Trigger (HET) requirement (Energy deposited in the first 4 layers of BGO > 10 MIP)
- A signal in both PSD views
- Shower shape in BGO



- Selected track crossing a fired PSD strip
- Agreement between PSD-energy according to the track (Etrack) and maximum energy (Emax) in both PSD-layers
- Matching of track with BGO max in first 2 BGO-layers
- Rejection of electron events

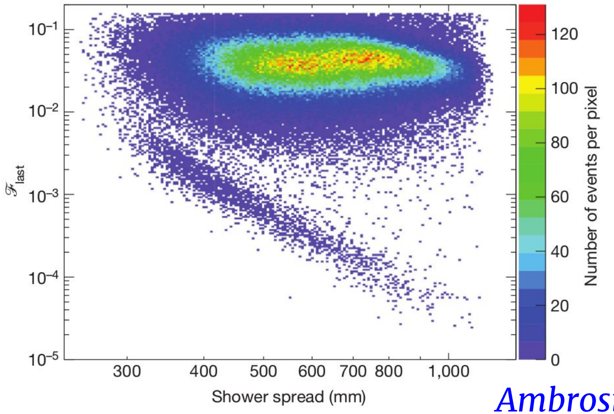


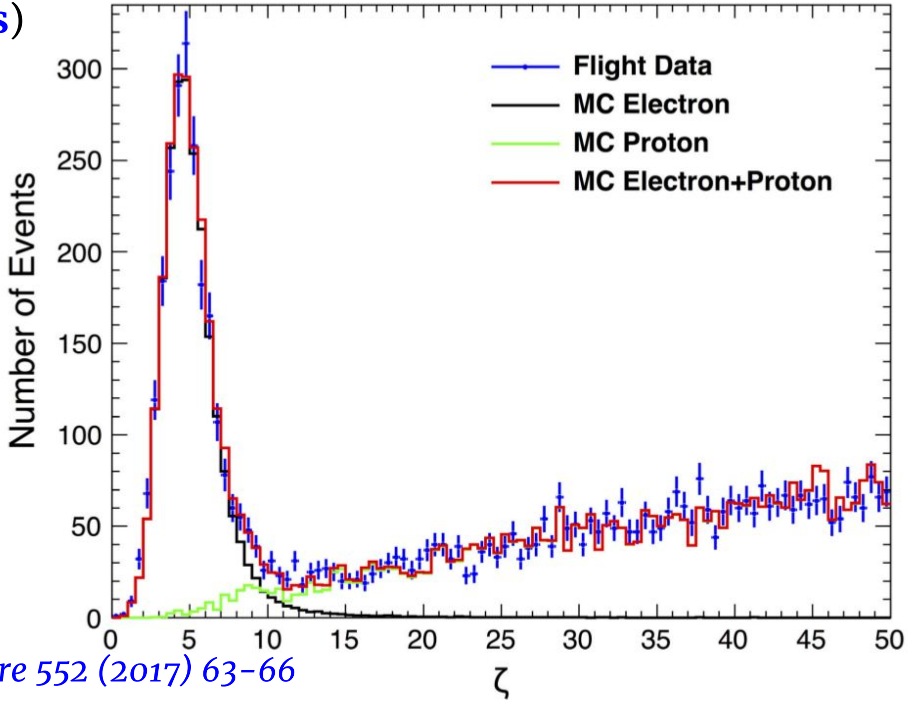
- Charge selection obtained studying the PSD-energy distribution ($Z^2 \propto E$)

Electron discrimination

The electron/proton discrimination method is based on pattern recognition that exploits the topological differences of the shower shape between hadronic and electromagnetic particles in the calorimeter (**rejection > 99.99% of protons**)

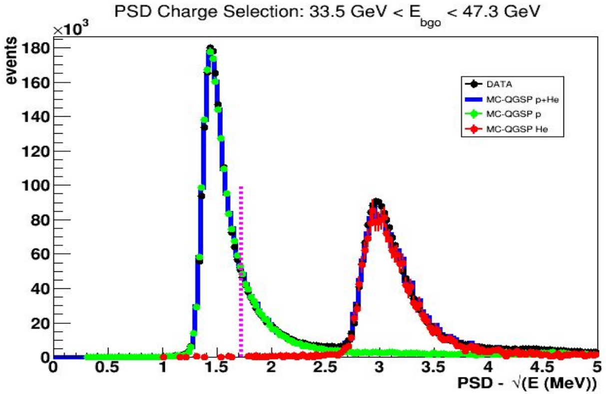
$$\boxed{\zeta = \frac{E_{dep,last}}{E_{dep,tot}} \times \left(\frac{\sum_i r.m.s._i}{mm}\right)^4 \times (8 \cdot 10^{-6})}$$

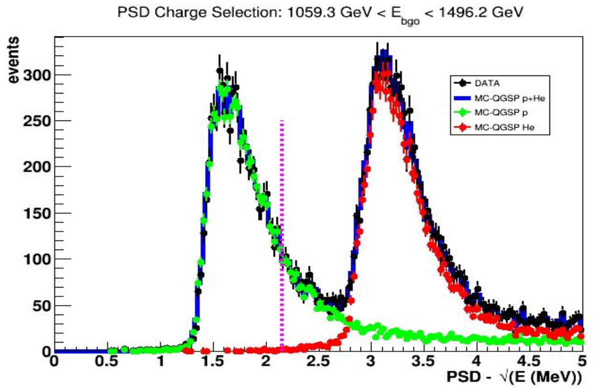


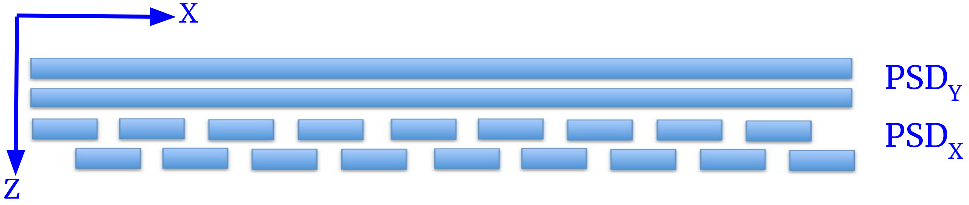


Ambrosi et al. Nature 552 (2017) 63–66

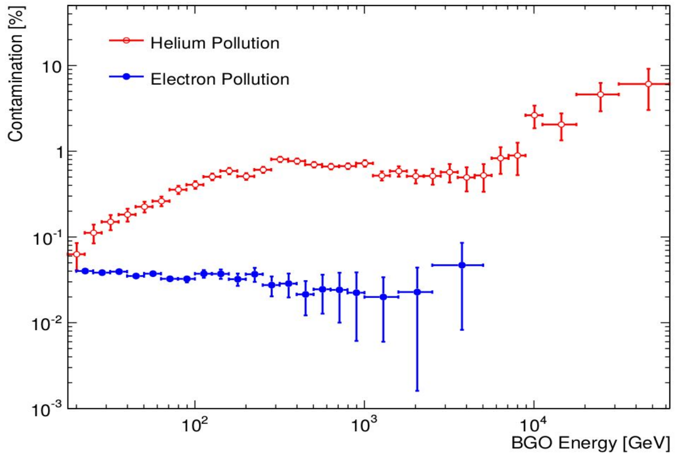
Helium Contamination







Helium pollution is less than 1% up to E~10 TeV



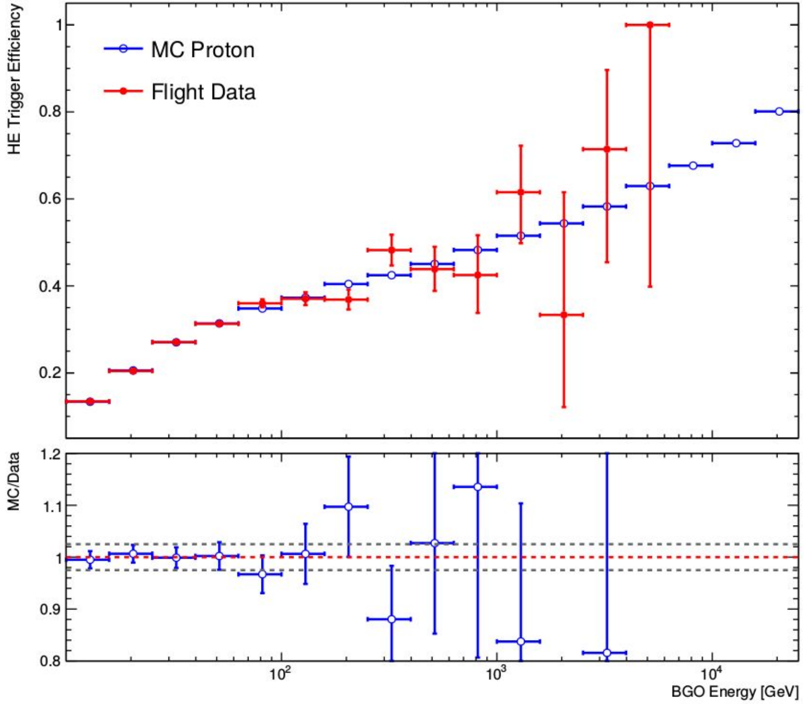
High Energy Trigger Efficiency

$$\varepsilon_{HET} = \frac{N_{HET \| UNBT}}{N_{UNBT}}$$

Estimated with the ***Unbias trigger*** sample

Unbias trigger: pre-scaled by 1/512 at low latitudes and 1/2048 at high latitudes

Systematic uncertainty ~ 2.5%

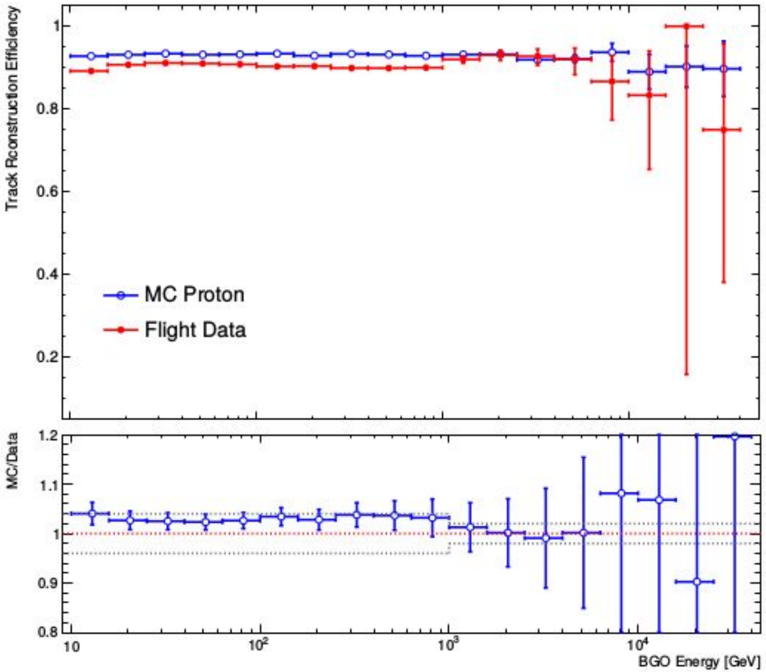


Track reconstruction efficiency

$$\varepsilon_{track} = \frac{N_{track\|BGOtrack}}{N_{BGOtrack}}$$

The track efficiency is estimated using a proton sample selected by an independent charge selection based on the reconstructed shower axis in the calorimeter

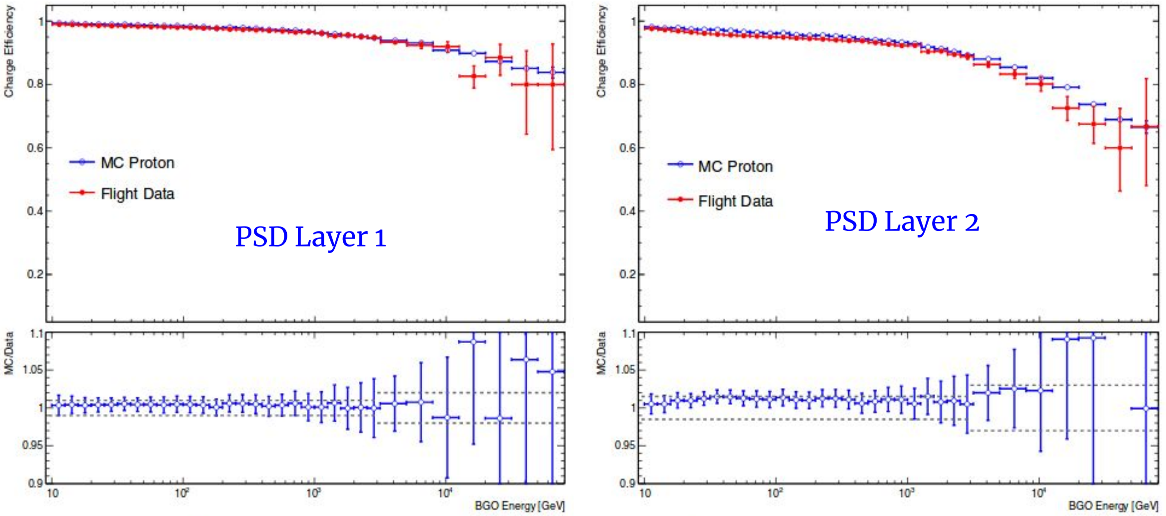
Systematic uncertainty ~ 4%



Charge selection efficiency

The charge selection efficiency is estimated independently for each PSD layer with the help of STK
A proton sample is selected with the charge measurement in PSD layer 1 (or 2) and the first layer of STK

Systematic uncertainty ~ 2%



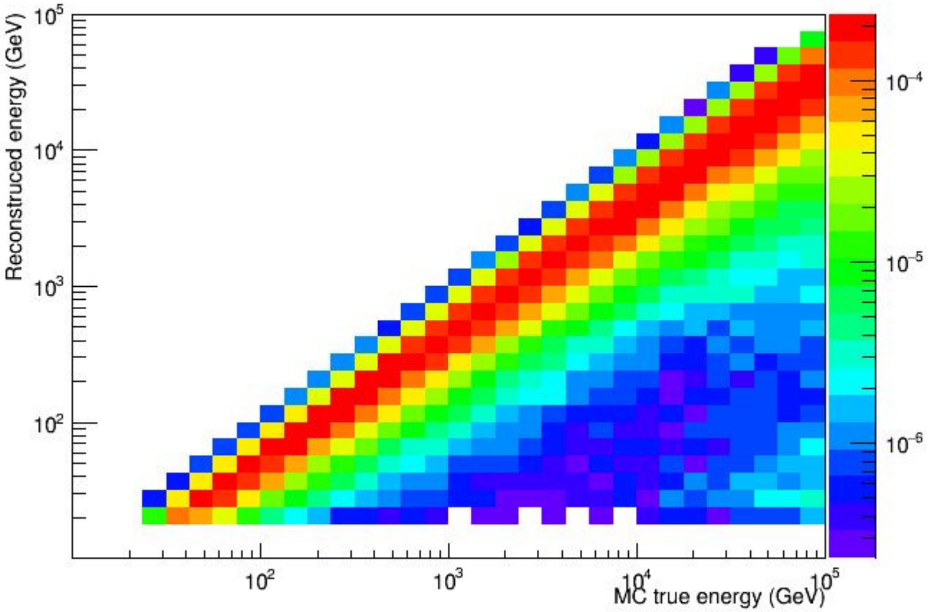
Energy response matrix

$$\boxed{N_{dep,i} = \sum_i M_{ij} N_{pri,j}}$$

The ratio E_{dep}/E_{tru} is between:

- ~0.45 at E = 100 GeV
- ~0.35 at E = 100 TeV

For this reason an unfolding procedure has been applied (*G. D'Agostini, N. I.M. A,362, 487-498, (1995)*)

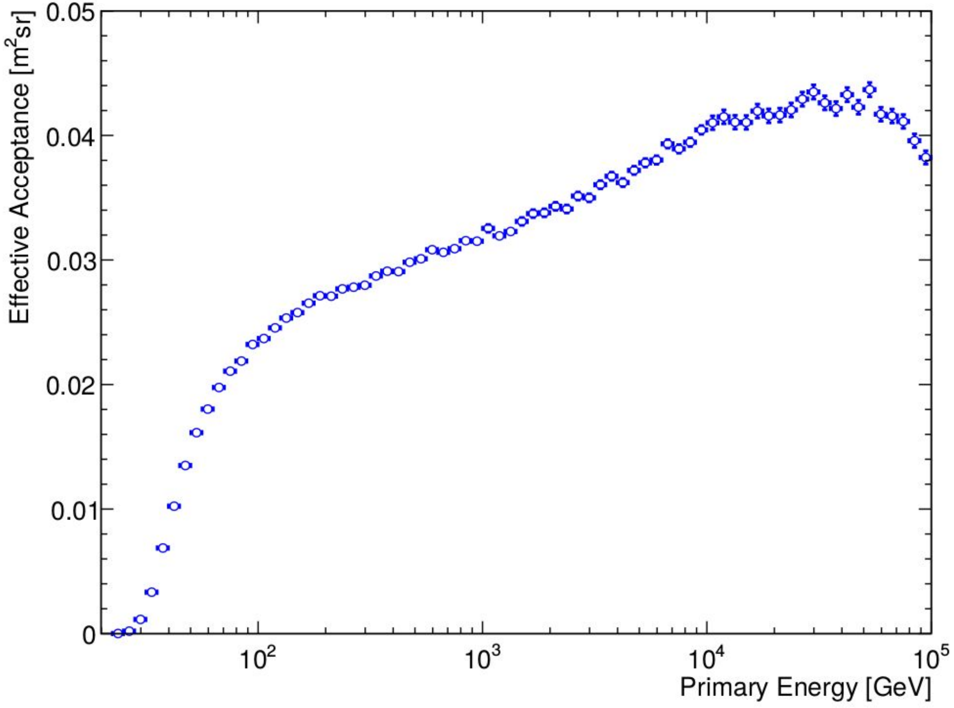


Acceptance

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

The acceptance is evaluated using an MC sample of protons to which the same cuts applied to the on-orbit data have been applied

$$\sigma_{effacc} = \sqrt{\sigma^2_{HET} + \sigma^2_{track} + \sigma^2_{charge}} \approx 5.5\%$$

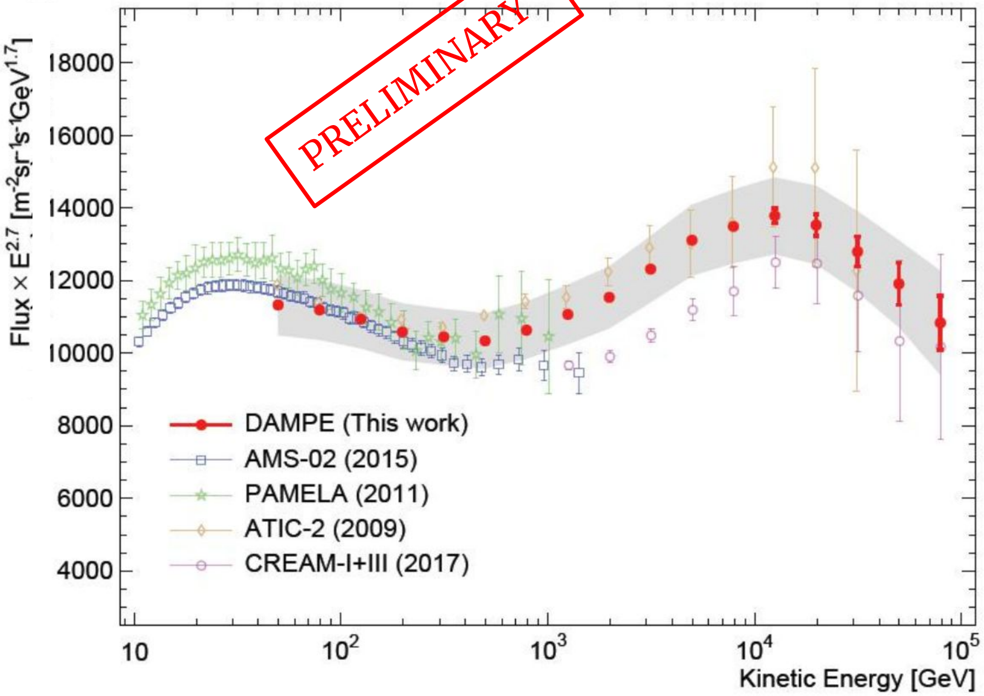


Proton Flux

2 years of data collection (January 1, 2016 to December 31, 2017)

The gray band takes in account the systematic uncertainties described above

- Spectral hardening at E ~ 200 GeV
- Exponential cut-off at E ~ 80 TeV



Summary

- DAMPE is working in a stable data taking since December 17, 2015
- A preliminary proton flux has been measured between 50 GeV - 100 TeV
- The flux is compatible with that measured by AMS-02, CREAM, PAMELA,... and confirm the presence of an hardening at energy E ~ 200 GeV
- Moreover a softening at energy E ~ 80 TeV has been observed
- The evaluation of the systematic uncertainties in ongoing


THANK YOU FOR YOUR ATTENTION