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University of Science and Technology of China

Measurement of Iron Spectrum in Cosmic Rays with DAMPE

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Outline

- Motivation
- DAMPE Instrument
- Data sample
- Reconstruction and selections
- Template fit
- Systematic uncertainties
- Result : Iron flux

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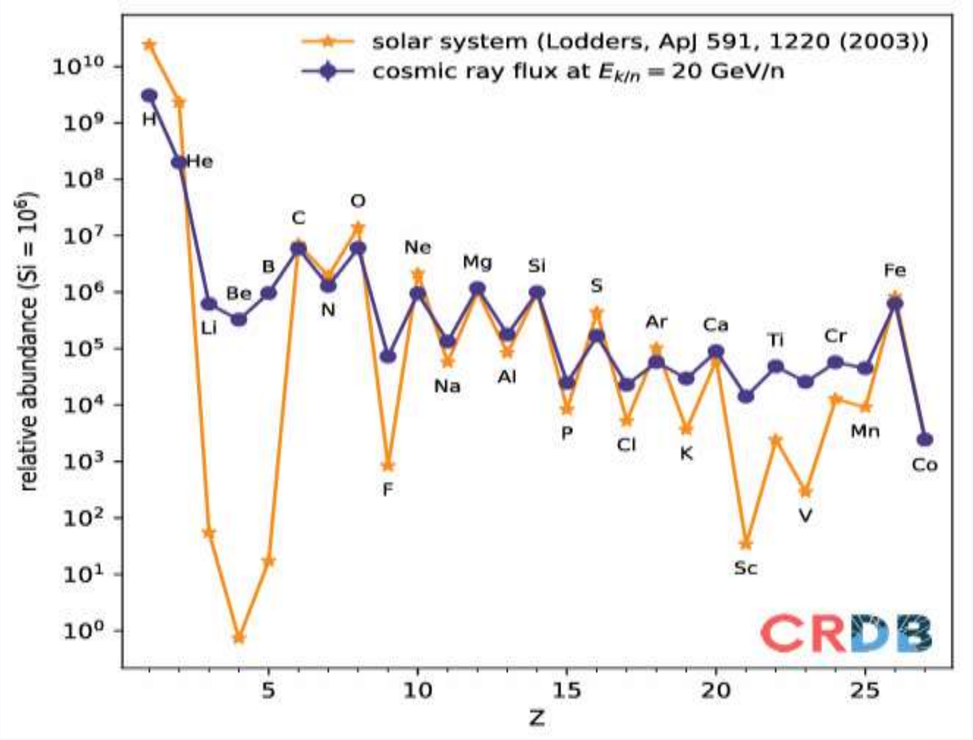
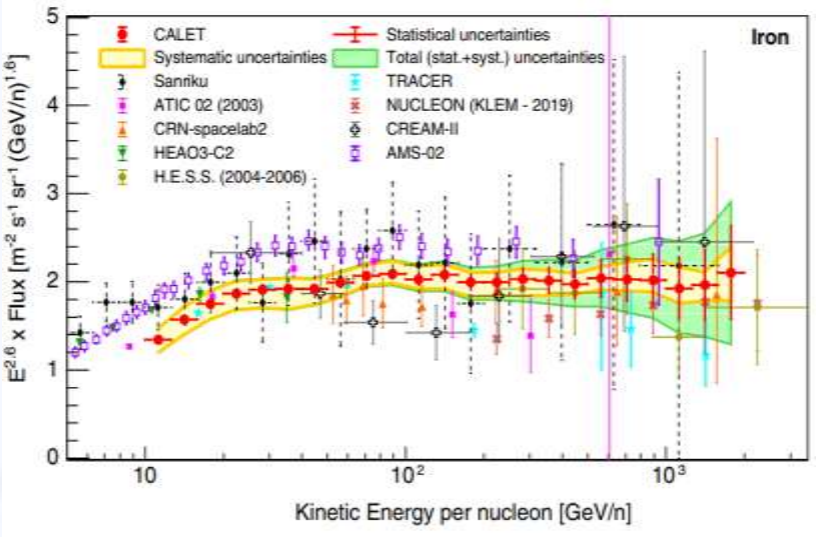
DAMPE

Motivation

- Iron provides a favorable condition to understand cosmic ray origin and propagation
  - Most abundant heavy nuclei beyond Si
  - Contamination from spallation of heavier elements is negligible





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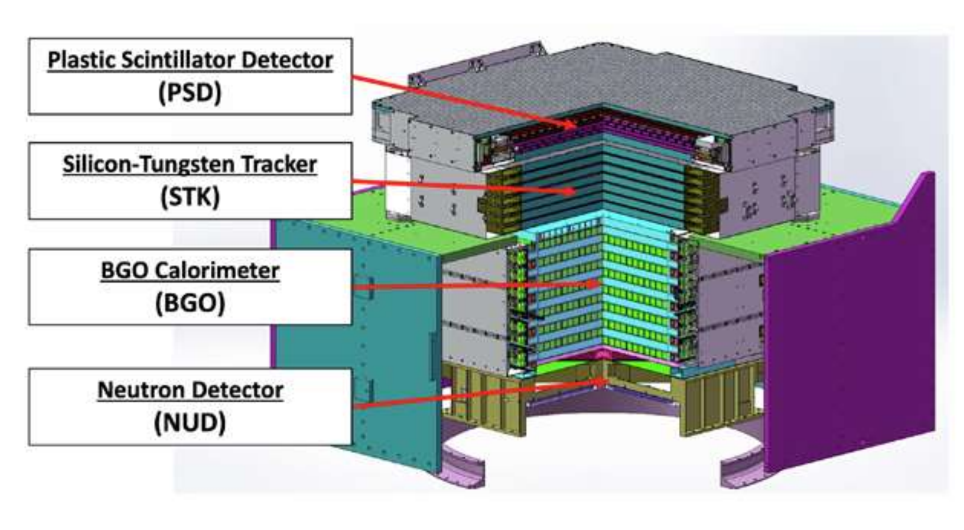
- Previous measurements on iron flux follow single power law (**SPL**) above hundred GeV/n
- DAMPE has capability to extend the measurement of Iron to higher energy with high statistics

The DArk Matter Particle Explorer



DAMPE main goals
- Dark Matter indirect detection
- Origins and propagations of CRs
- High Energy γ astronomy

Orbit information
- Sun-synchronous Orbit
- Altitude: ~500 km
- Inclination: ~97 deg
- Launch Data: Dec.17th,2015

DAMPE sub-detectors
- PSD : Charge measurement and anticoincidence of γ
- STK : Tracking and additional charge measurement
- BGO : Energy measurement and e/p discrimination
- NUD : Further e/p discrimination

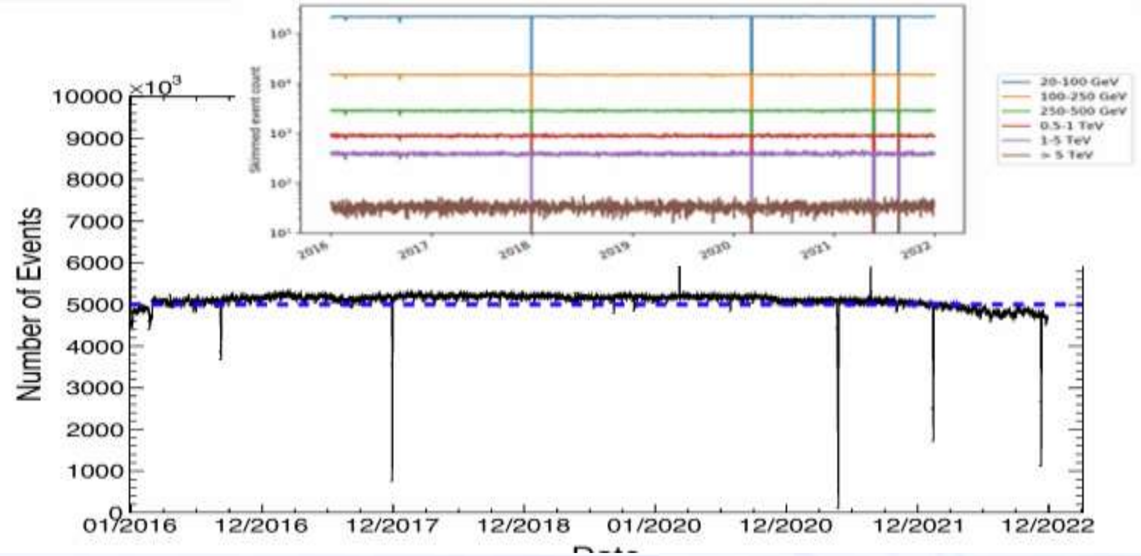
Data Sample

Flight Data

- 7 years : 2016. 01.01~ 2022. 12.31
- Live Time : 1.68×10^{8}s
    1. Dead time of the instrument is excluded
    2. Data in South Atlantic Anomaly (**SAA**) region is excluded
    3. Data during 2017.09 Solar Flare is excluded

Simulation

- Geant4.10.5.p02(FTFP_BERT)



Reconstruction and Selections

1.Not in SAA

2.High Energy Trigger

3.Fiducial : Machine-Learning based STK track

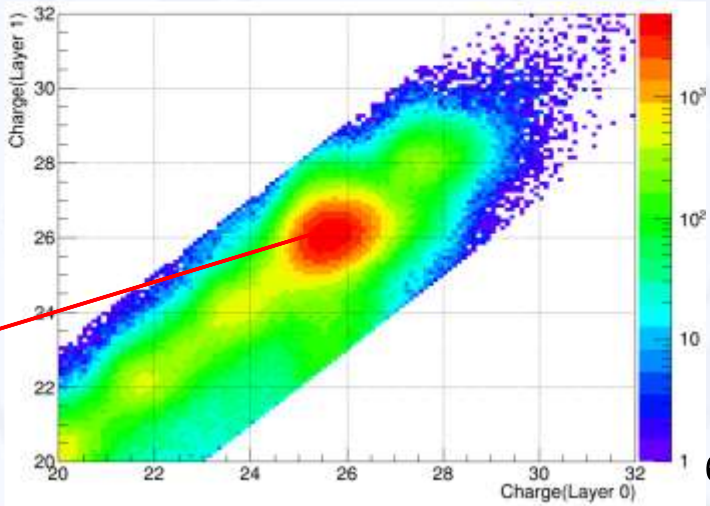
- STK track should be fully contained in (PSD + STK +BGO)
- Angle between STK and BGO Track < 15 deg
- Average distance from energy center is less than 25 mm at first 4 layers of BGO
- Track pass through the max energy bar or the bar near the max energy bar in PSD Layer 0 & 1

4.BGO :

- E_{dep} > 100 GeV
- ID of strip with max deposited energy is not at the edge of BGO

5.PSD :

- $|Q_0 - Q_1| < 3$



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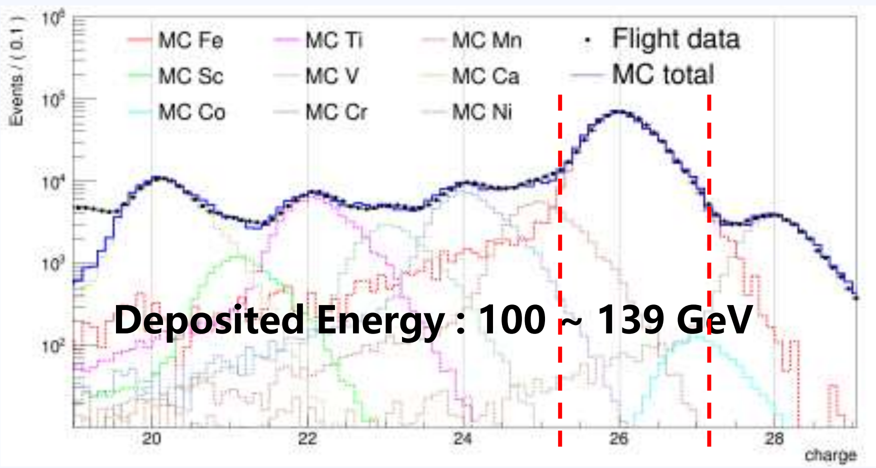
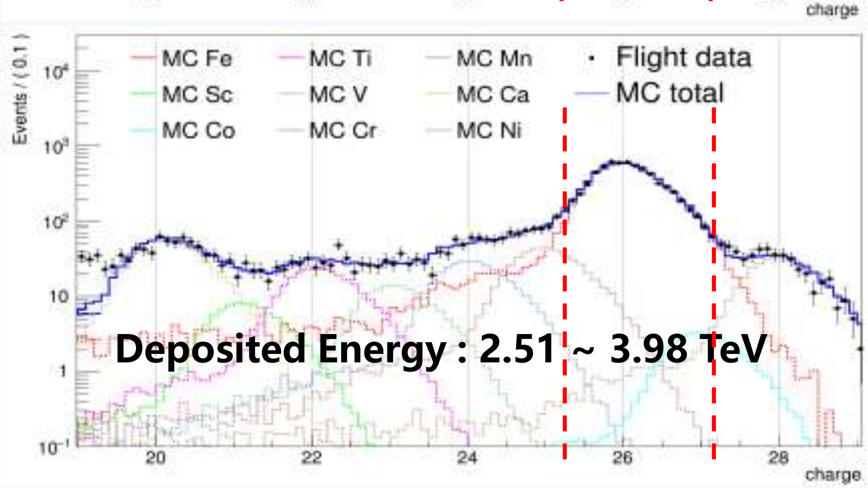
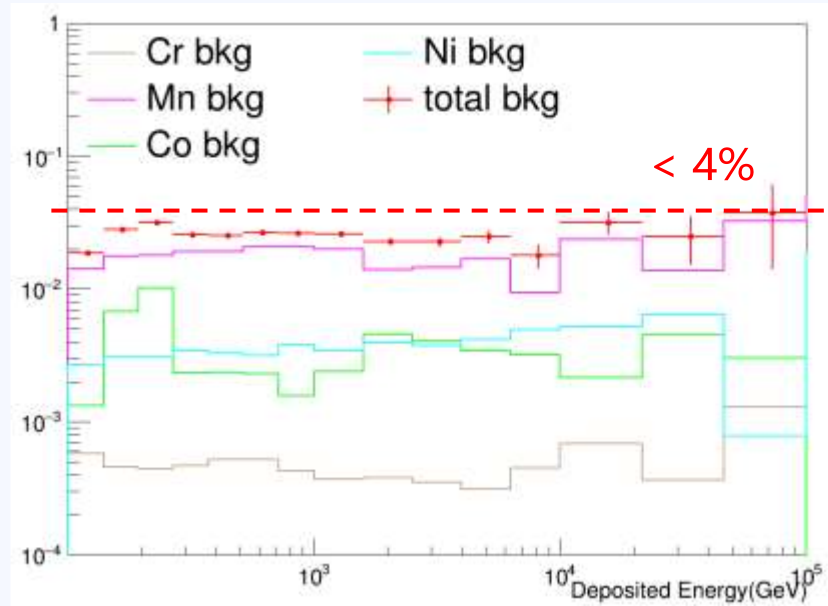
Template Fit

- Template Fit : Charge selection window [25.5, 27.2]







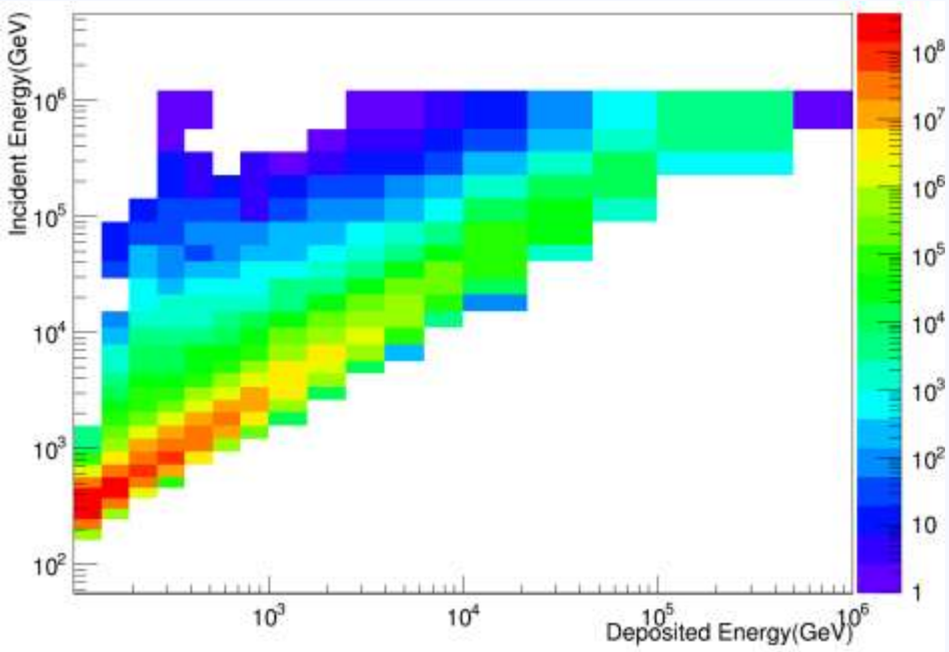
- Mn is the main source of the background
- Total contamination from other nuclei is less than 4%

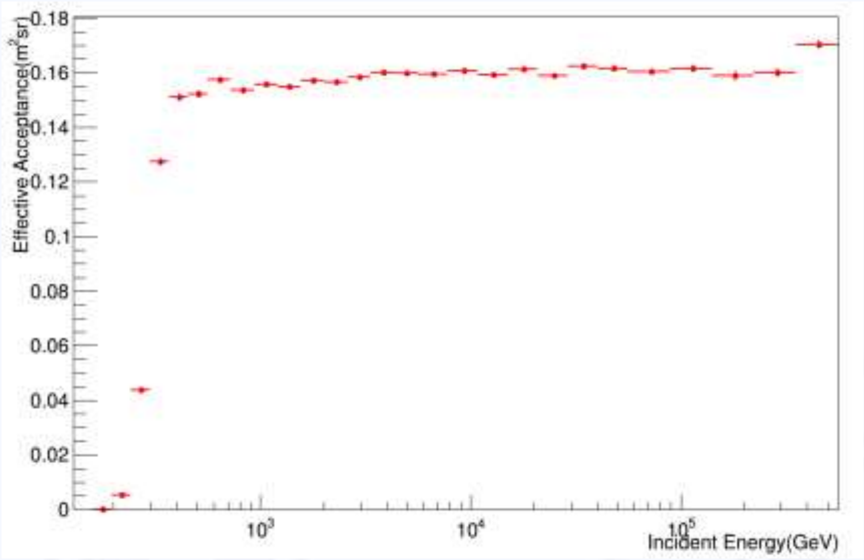
Unfold and Effective Acceptance

Bayesian Unfolding Method

$$N_{inc,i} = \sum M_{ij} N_{obs,j}$$

- M_{ij} : response matrix
- $N_{obs,j}$: Events in jth deposited energy bin
- $N_{inc,i}$: Events in ith incident energy bin





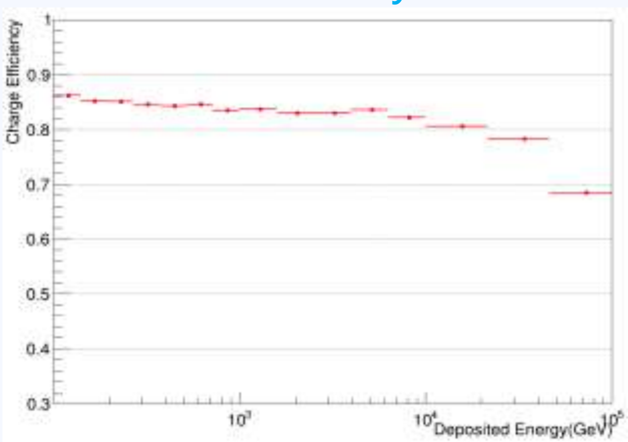
Effective Acceptance

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

- A_{gen} : Geometrical factor of MC
- $N_{gen,i}$: Events generated
- $N_{pass,i}$: Events passing the selections

Systematic Uncertainties (1)

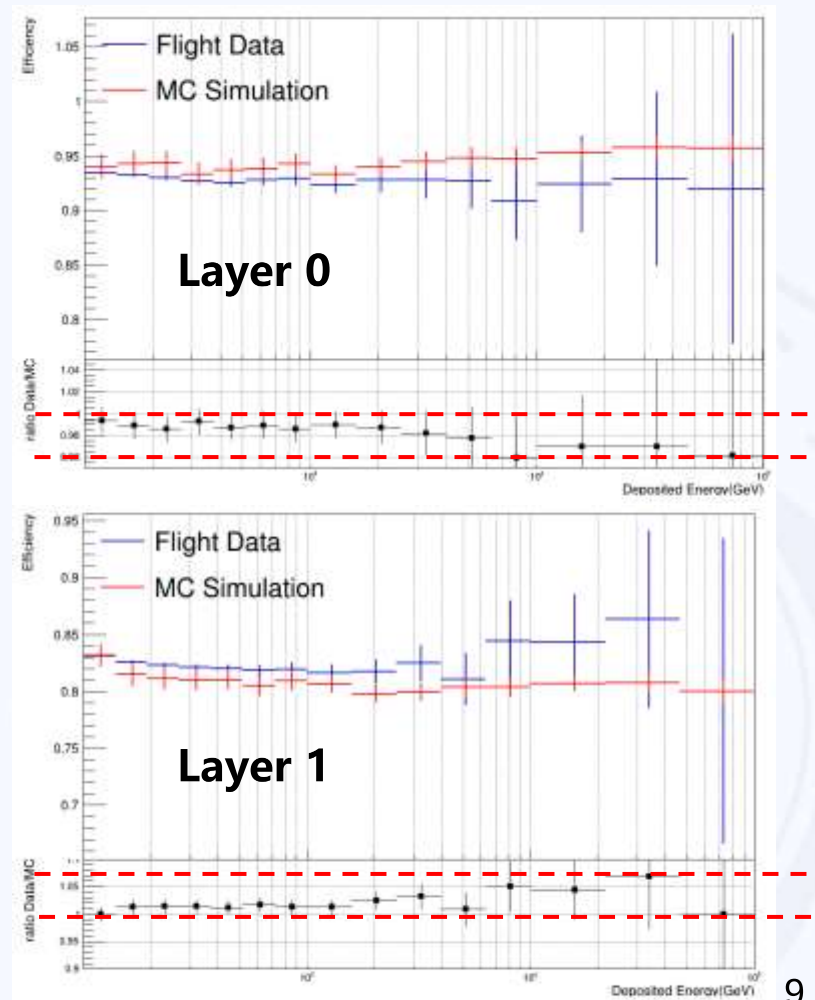
Energy dependent Charge Selection Efficiency



1.Uncertainty estimation

$$\epsilon_i = \frac{N_{Layer_0\&Layer_1}}{N_{Layer_i}}$$

- ϵ_i : Charge efficiency of PSD layer i , $i = 0{,}1$
- $N_{Layer_0\&Layer_1}$: Events passing the Selections of layer 0 and layer 1
- N_{Layer_i} : Events passing layer i
- Layer 0 : MC/Data difference **<4%**
- Layer 1 : MC/Data difference **<7%**

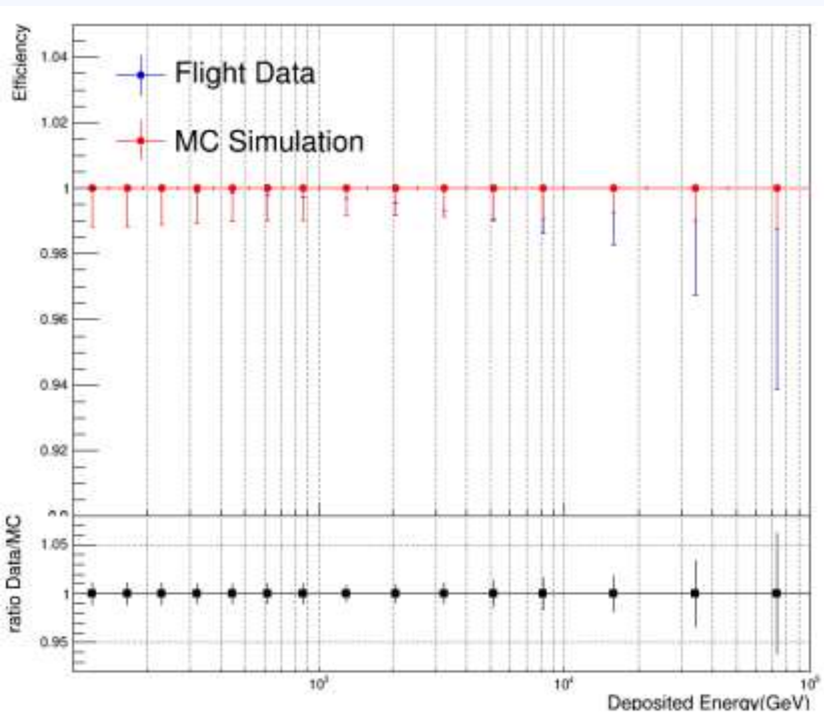


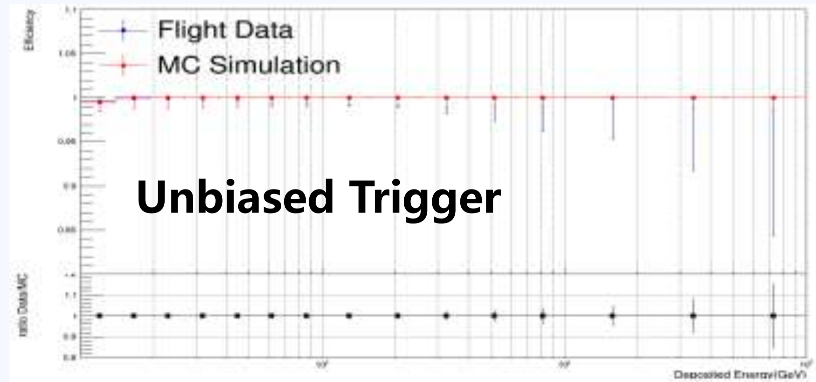
Systematic Uncertainties (2)

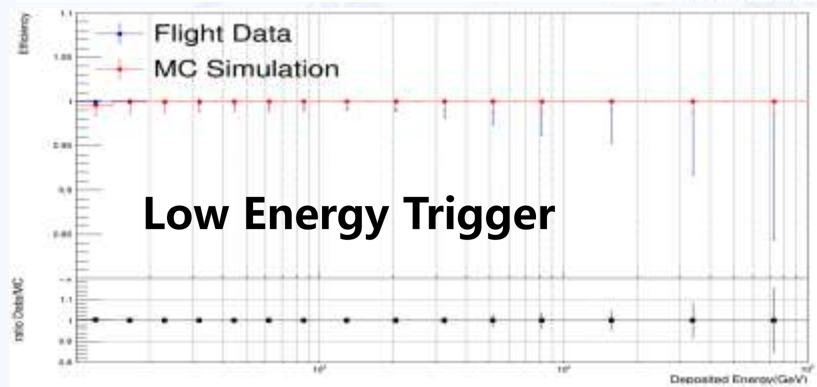
2.Track Efficiency

$$\epsilon_{track} = \frac{N_{STK\&BGO}}{N_{BGO}}$$

- $N_{STK\&BGO}$: Iron Events with both STK and BGO track.
- N_{BGO} : Iron Events with BGO track
- MC/Data difference **< 0.01%**







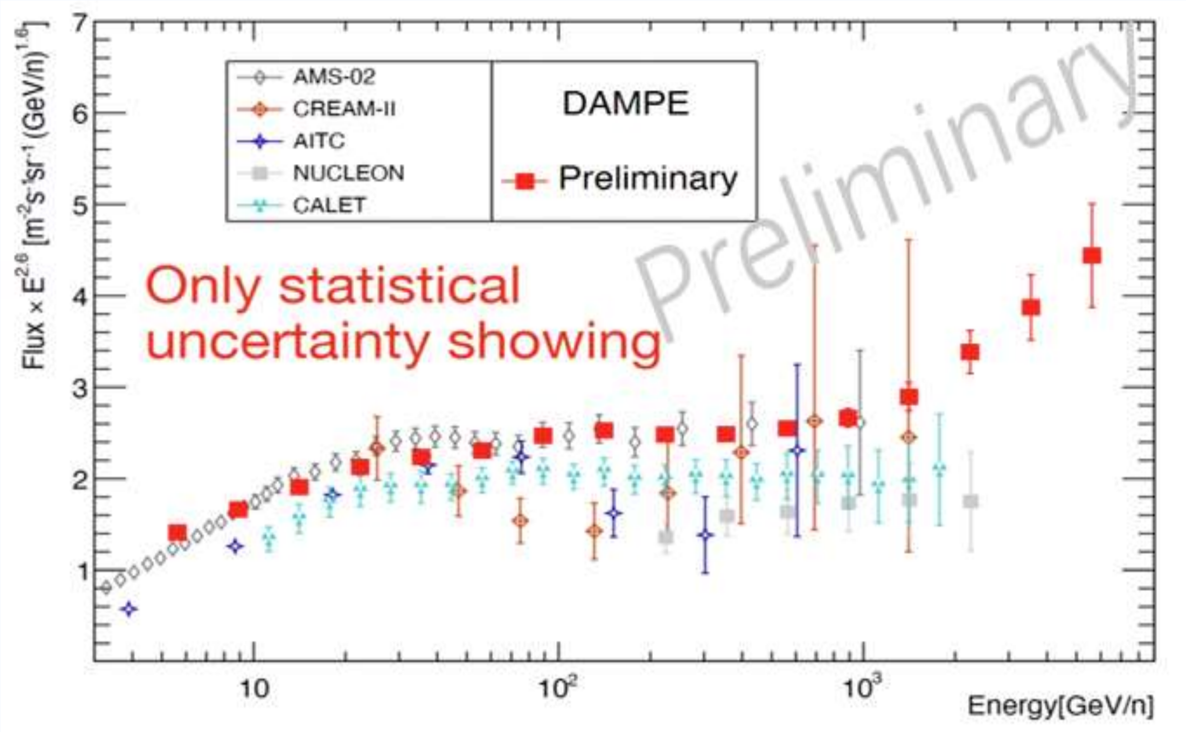
3.Trigger Efficiency

$$\epsilon_{HET} = \frac{N_{HET\&OT}}{N_{OT}}$$

- Unbiased trigger : MC/Data difference **< 0.1%**
- Low energy trigger : **< 0.4%**

DAMPE Iron Spectrum

- Flux calculation : $\phi(E_i, E_i + \Delta E_i) = \frac{\Delta N_i}{\Delta E_i A_{eff,i} \Delta T}$



- Conclusion : DAMPE observed a hardening of the iron spectrum at **several hundred GeV/n**

Summary

- Seven years of DAMPE data are analyzed for Iron flux
- Preliminary analysis has yielded the iron flux up to 10 TeV/n, which is roughly consistent with result of AMS and observed spectral hardening at several hundred GeV/n
- With further refinement and more data , the measurement of iron flux can be extended up to tens of TeV/n in the near future

Thank you !