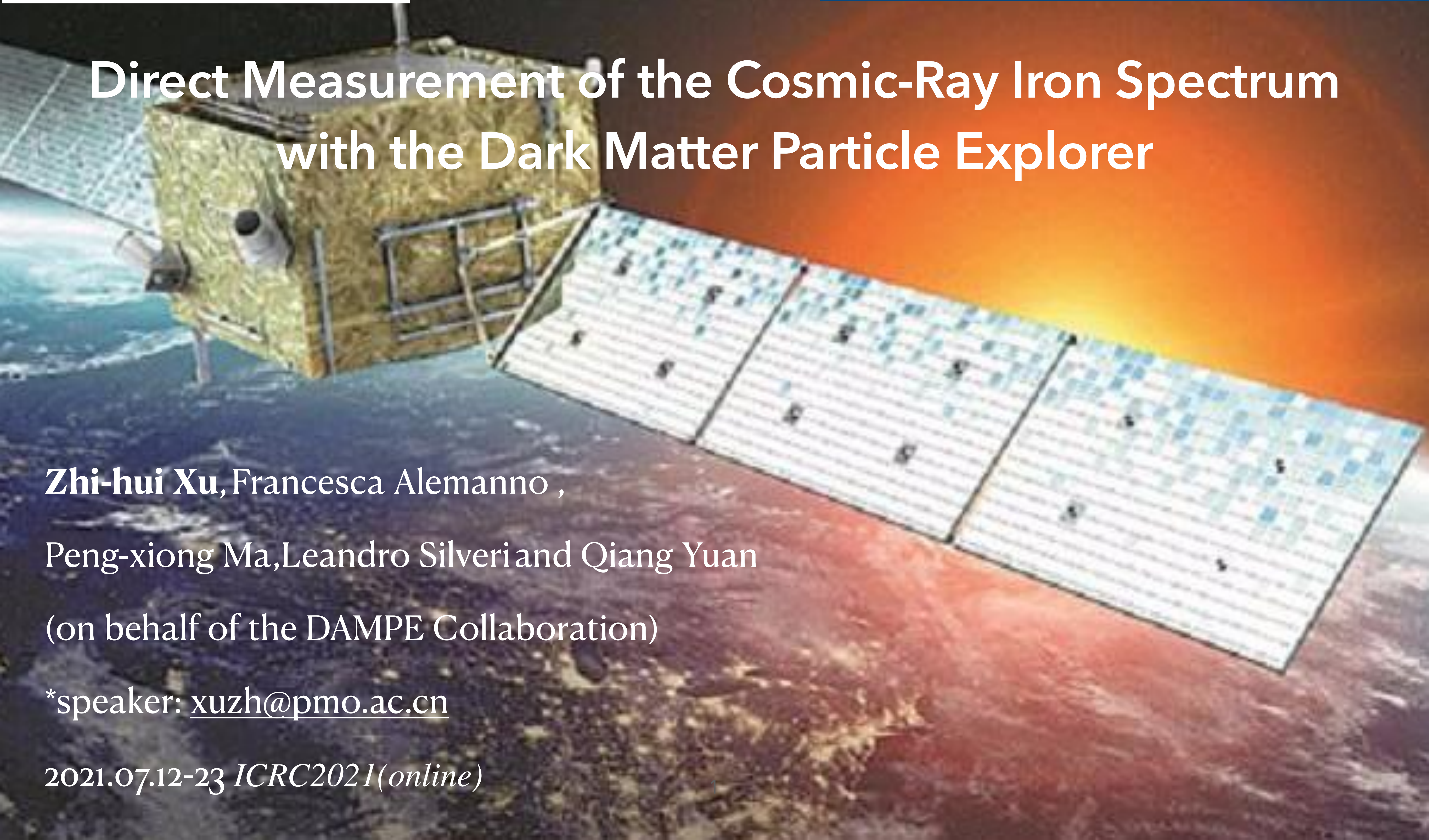
Direct Measurement of the Cosmic-Ray Iron Spectrum with the Dark Matter Particle Explorer



Zhi-hui Xu, Francesca Alemanno ,

Peng-xiong Ma, Leandro Silveri and Qiang Yuan

(on behalf of the DAMPE Collaboration)

*speaker: xuzh@pmo.ac.cn

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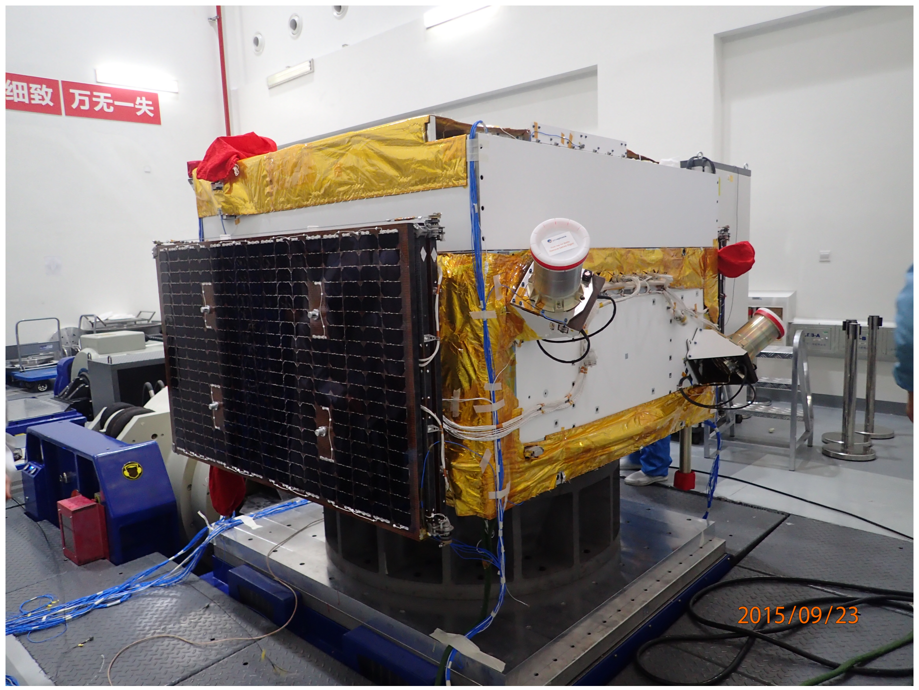
DAMPE Collaboration



DAMPE was successfully launched in a Sun-synchronous orbit on December 17^{th} 2015 from the Jiuquan Satellite Launch Center

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

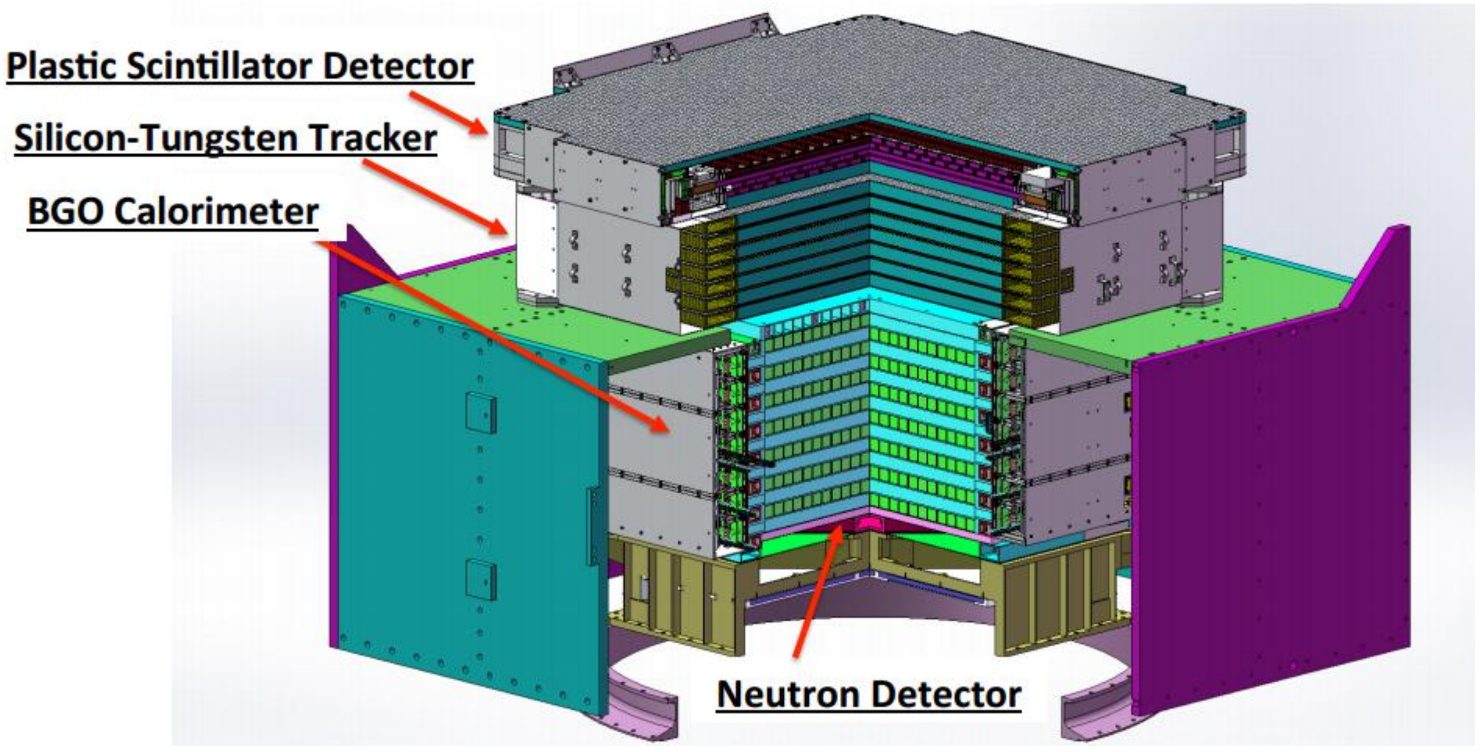
SWITZERLAND

- University of Geneva

main objectives of the DAMPE mission

- **Study of Cosmic Ray composition, origin and propagation**
- **Dark matter searches**
- **High-energy gamma-ray astronomy**

DAMPE Instrument



Charge measurement (dE/dx in PSD, STK and BGO)

Gamma-ray converting and tracking (STK and BGO)

Precise energy measurement (BGO)

Electron-hadron separation (BGO and NUD)

Data Sample

- Flight Data Sample:

  Jan.1st 2016 to Dec.31th 2020

- Live Time

  1.20155e+08s

- MC Data

  Sc45:10GeV-100TeV:(Geant4.10.5.p02 (FTFP_BERT))

  Ti46&Ti47&Ti48: 10GeV-100TeV:(Geant4.10.5.p02 (FTFP_BERT))

  V49&V50&V51:10GeV-100TeV :(Geant4.10.5.p02 (FTFP_BERT))

  Cr50&Cr51&Cr52: 10GeV-100TeV :(Geant4.10.5.p02 (FTFP_BERT))

  Mn53&Mn54&Mn55: 10GeV-100TeV :(Geant4.10.5.p02 (FTFP_BERT))

  Fe56:10GeV-100TeV: Quenching(Geant4.10.5.p02 (FTFP_BERT))

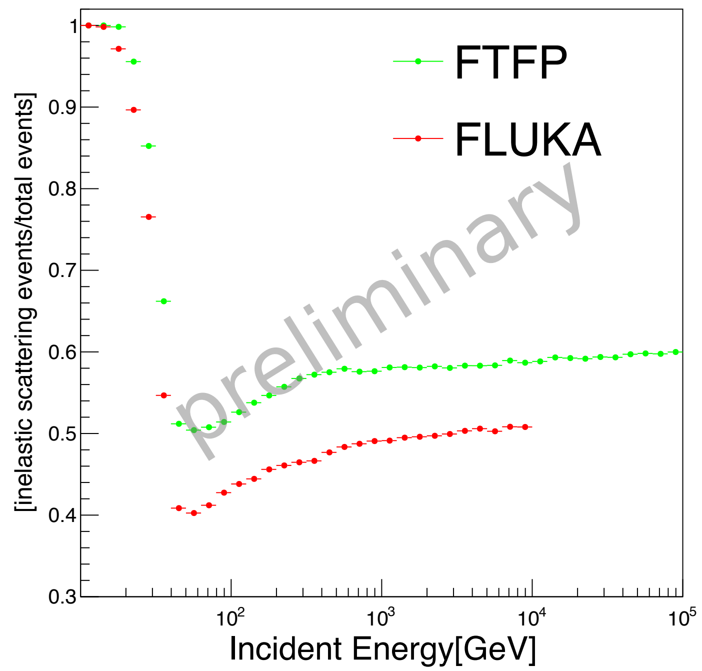
PreSelection

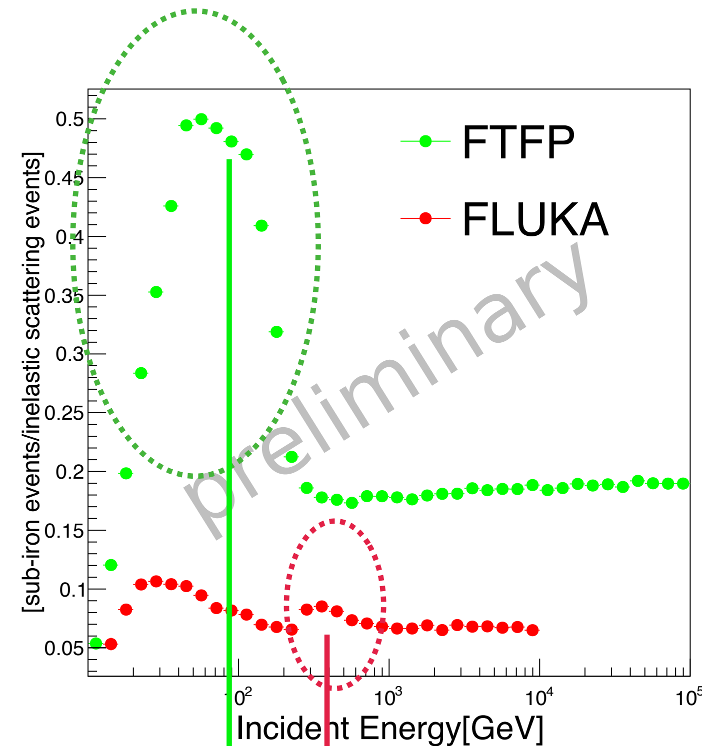
- **SAA Exclusion**
- **Has STK Tracker**
- **Tracer Selection (STK tracker):**
    - HitPoints >= 8
    - PASS MaxEnergy PSD
    - chi2/ndf < 50
    - Max Energy
- **Geometry CUT : PSD top && BGO top && bottle**
- **PSD selection** ：
    - PASS two layers
    - PASS the Max_Energy PSD Bar for each layer
    - for the same Layer:
        - Z1 > 10 || Z2 > 10
        - if(abs(Z1-Z2)/max(Z1,Z2)<0.1); —> Z=(Z1+Z2)/2
        - else Z = max(Z1,Z2)
- **HET(Hight Energy Trigger)**

Fragmentation of iron

Probability of total inelastic scattering (in PSD)

FTFP > FLUKA





Probability:

iron ➔ sub-iron(Z=21-25)

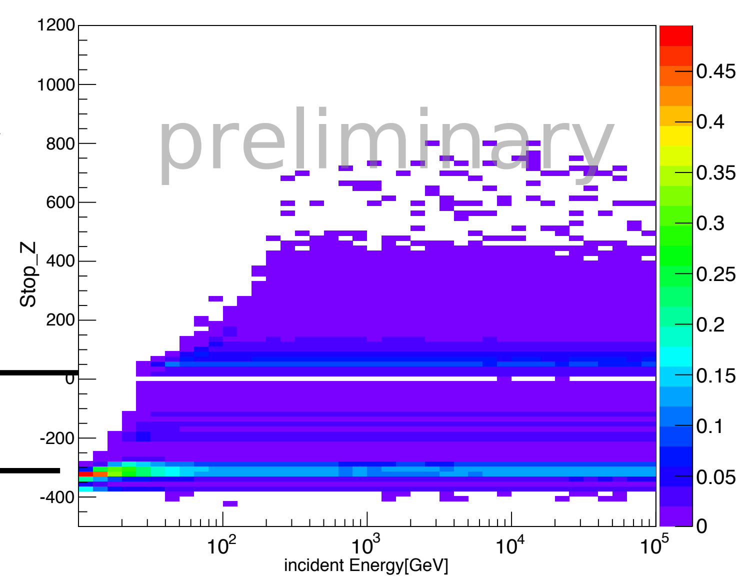
(in PSD)

FTFP has peak (20-200GeV)

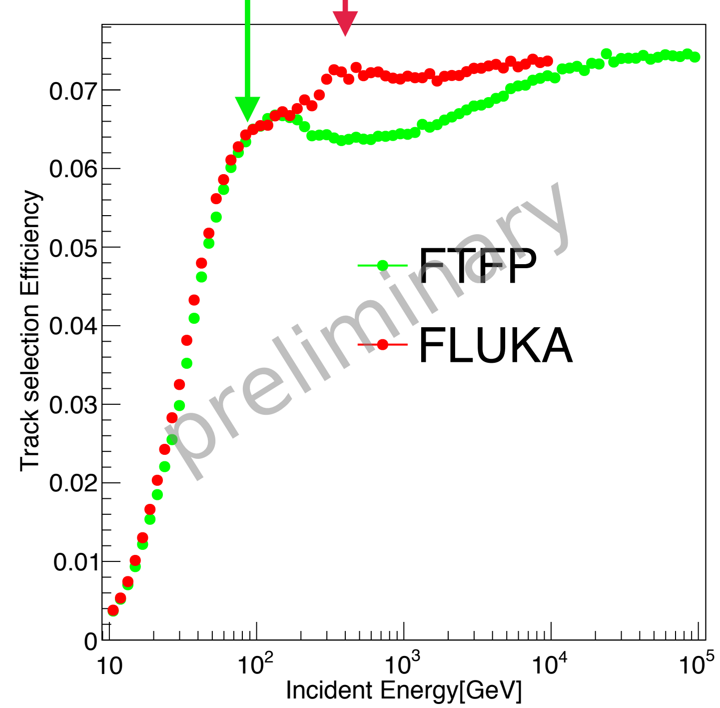
Iron Stop position in DAMPE

BGO

PSD



Low Energy: iron can not reach BGO

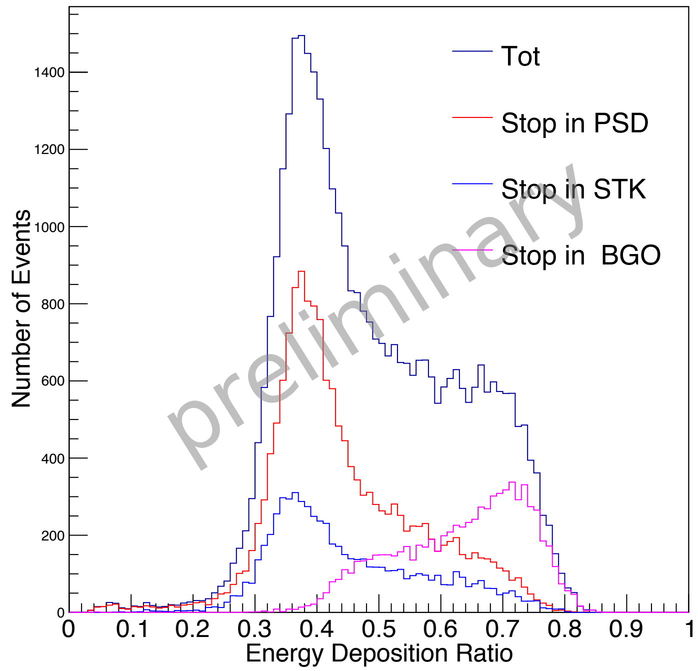


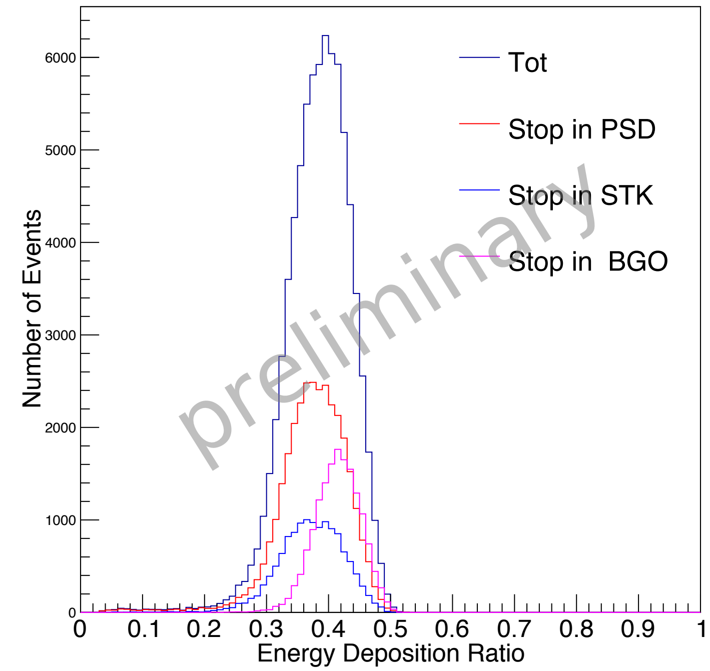
Track selection efficiency

Fragmented to sub-iron has bigger probability to reconstruct track

Quenching of iron

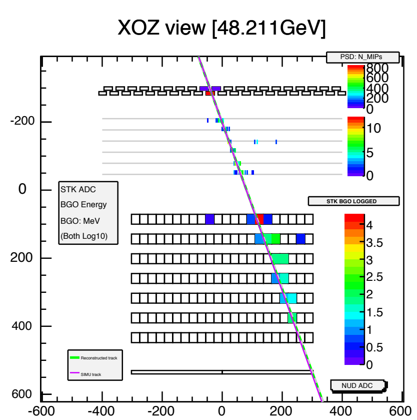
FTFP
no-quenching

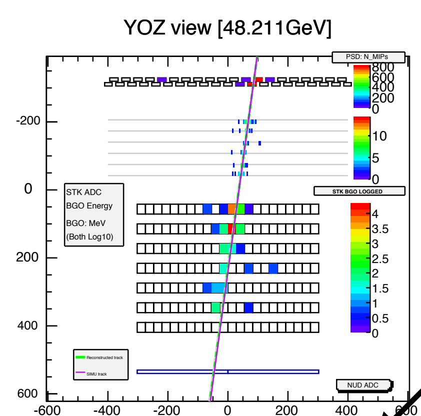




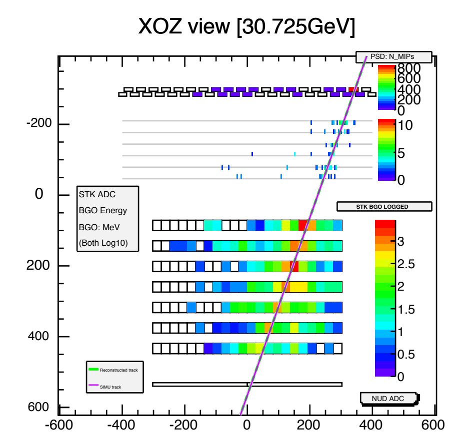
FTFP
Quenching

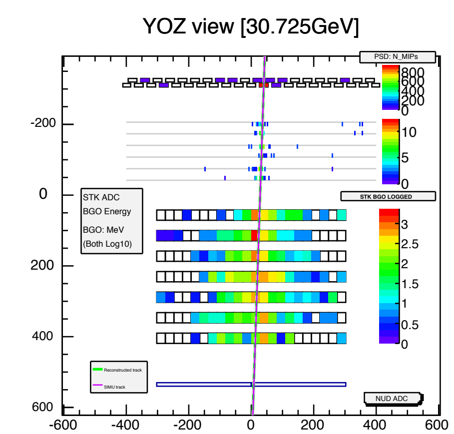
Energy deposition ratio of irons with energy from 80 to 160 GeV.





80GeV





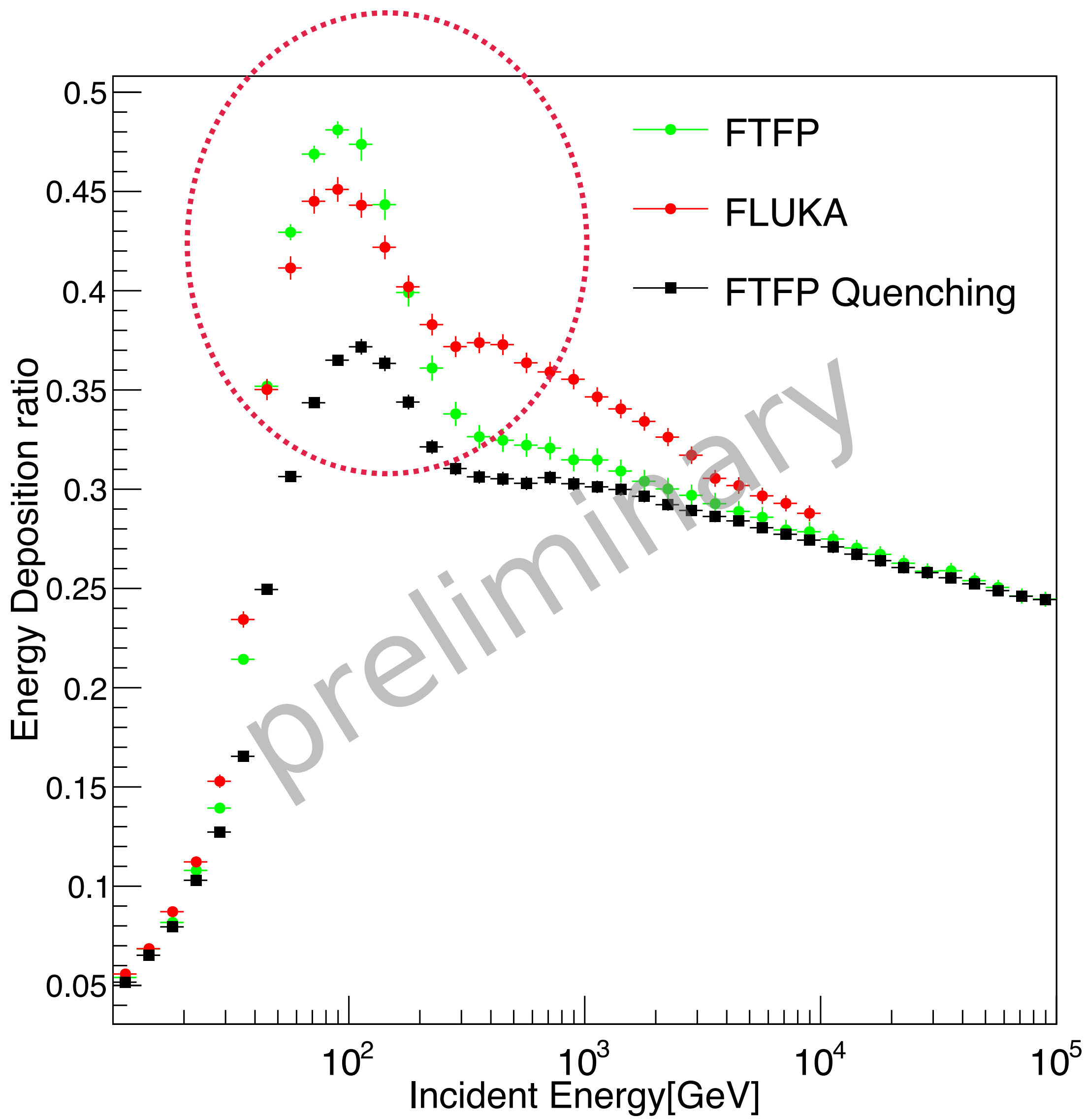
48GeV

31GeV

Iron fragment in BGO detector.
Hight energy deposition ratio in BGO detector.

Irons fragment in STK detector,
It is difficult to select track.and deposit much energy in PSD and STK detector

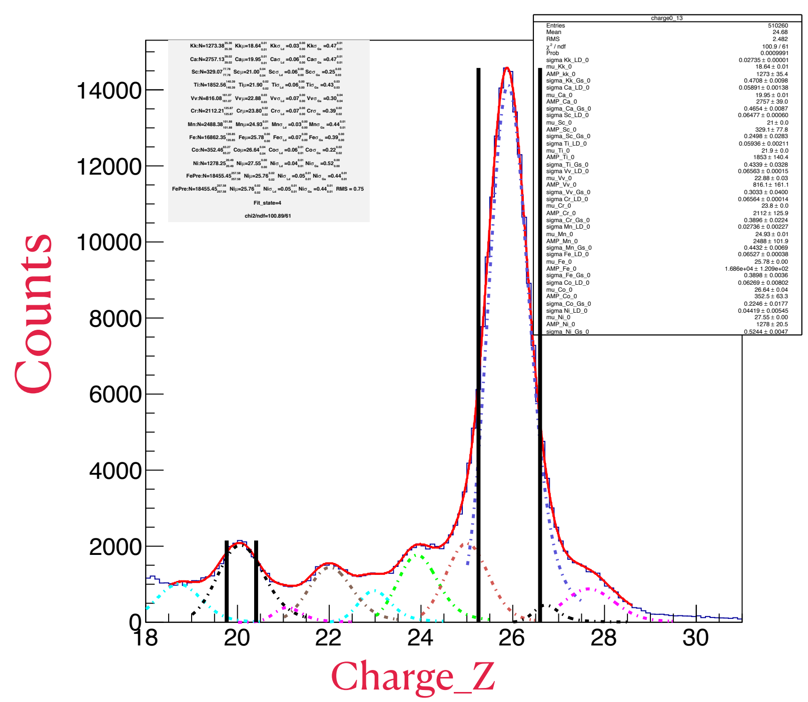
Energy deposition

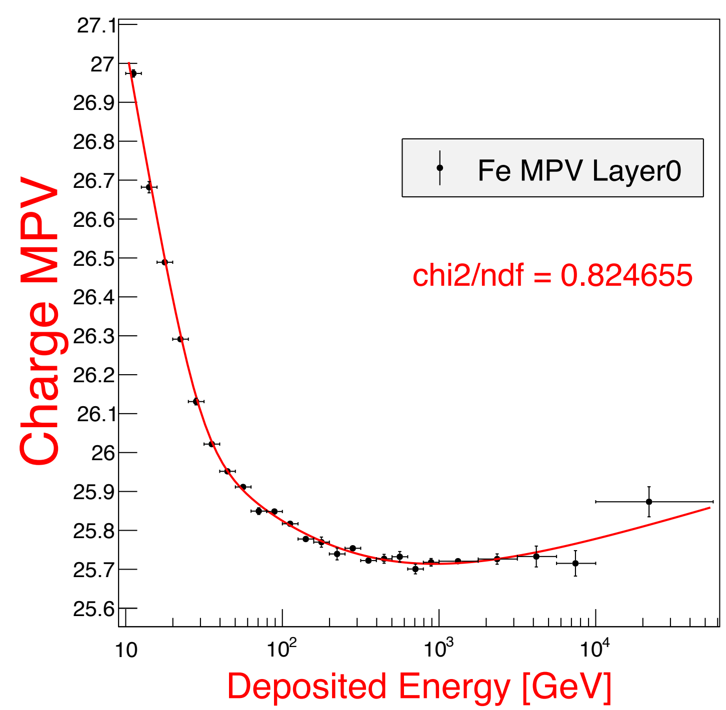


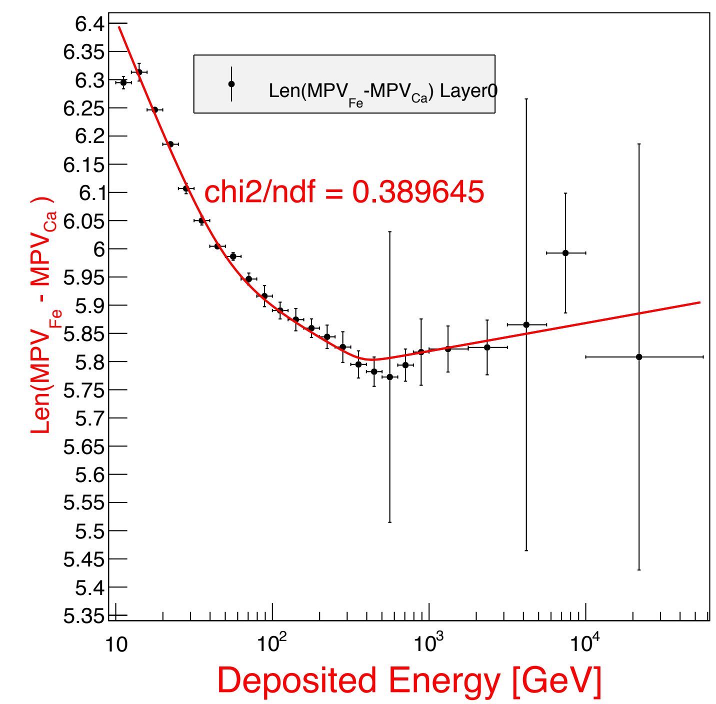
- Fragmentation affect the energy deposition and quenching effect. (sub-iron carry more energy to BGO)
- Low energy range (<80GeV): iron loss too much energy in PSD and STK

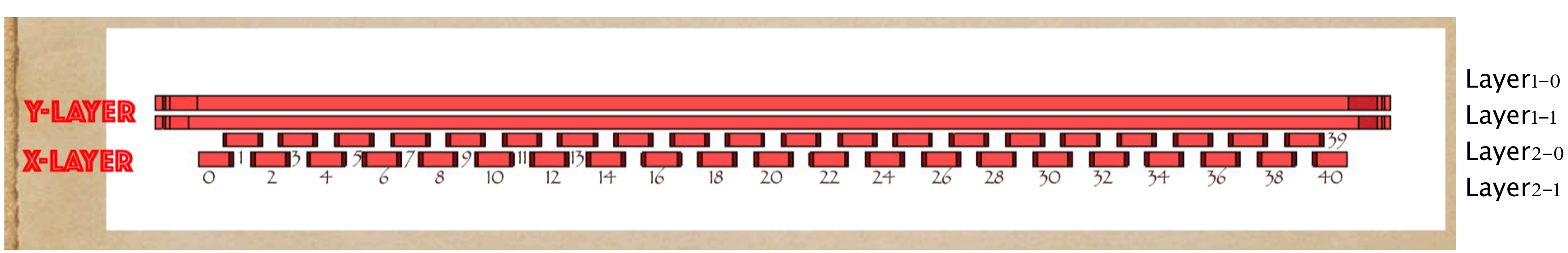
Reconstruct PSD charge Bin by Bin

$$C = (c - MPV_{Fe}) \cdot 6/len_{FeCa} + 26 \qquad Len(Fe - Ca)! = 6$$



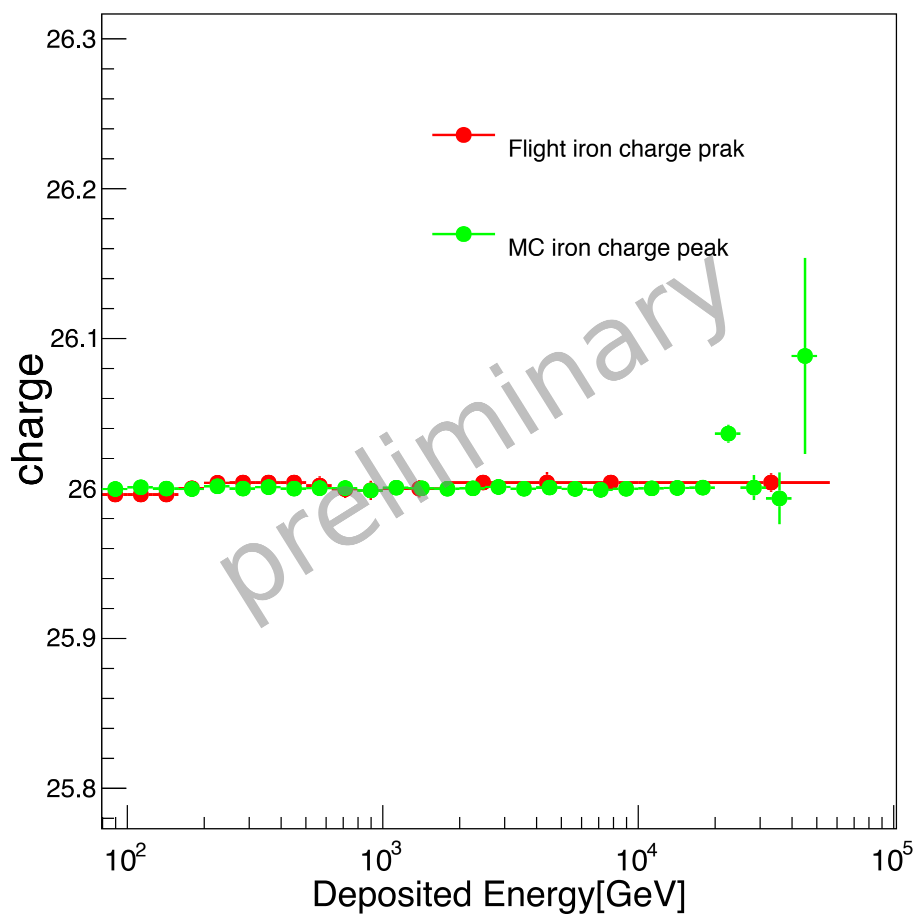


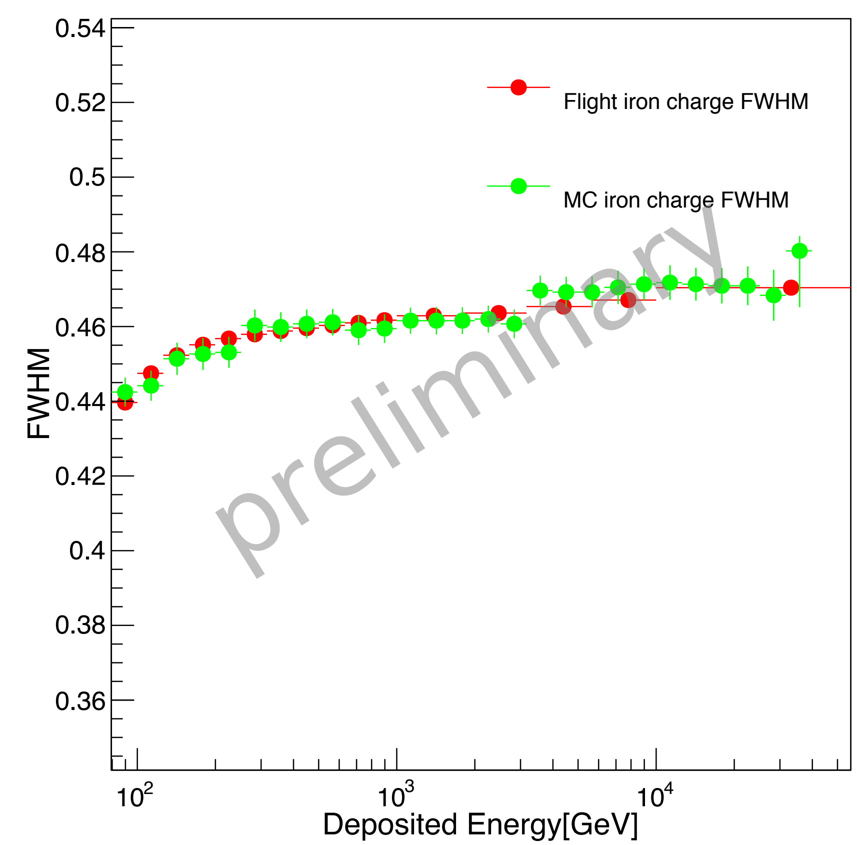




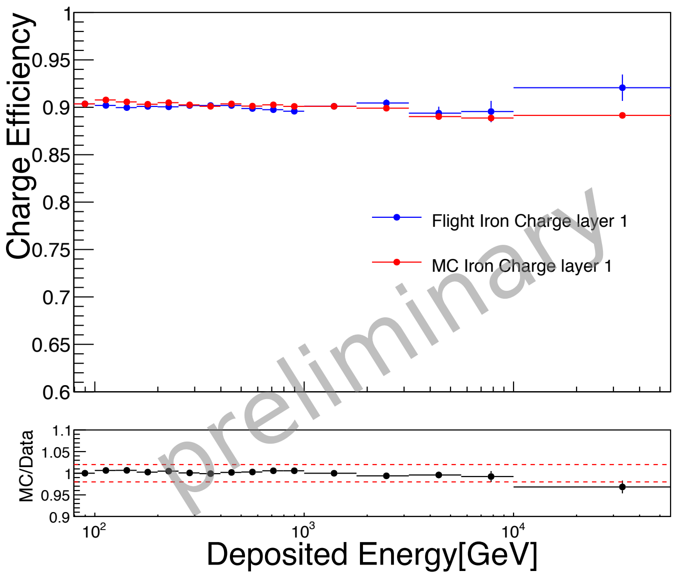
Charge of flight data and MC data

$$note; MPV_{Fly} = 26$$



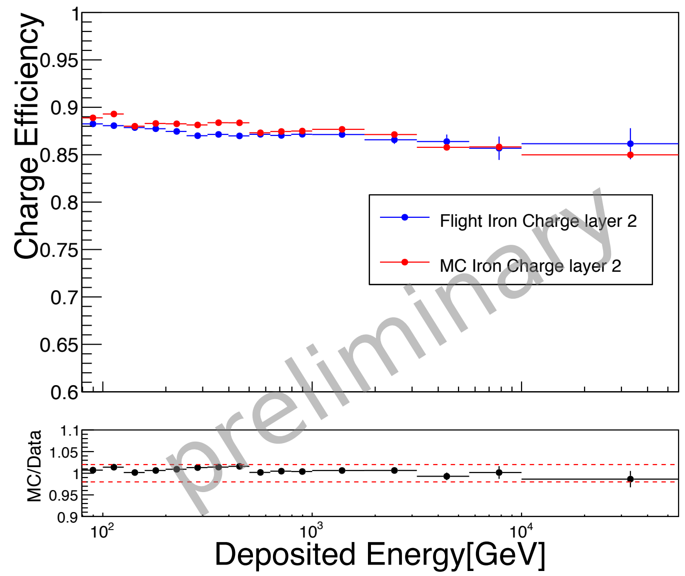


Charge and HET efficiency



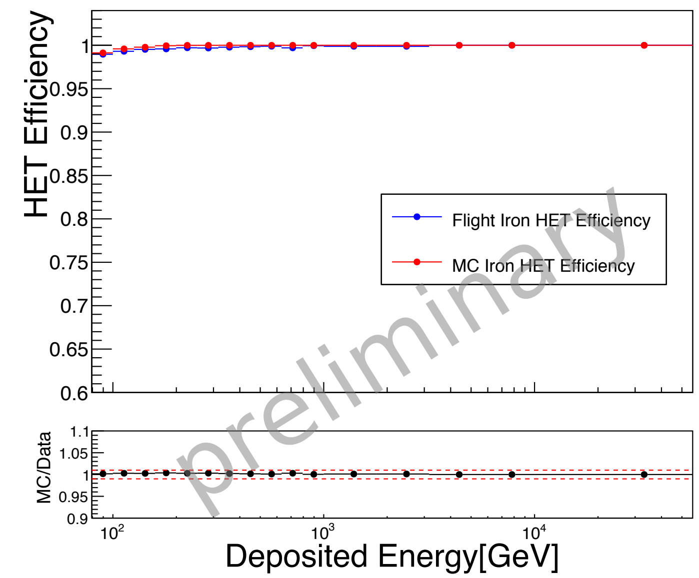
Layer 1

$$\varepsilon_{PSD1} = \frac{N_{PSD1|PSD2}}{N_{PSD2}}$$



Layer 2

$$\varepsilon_{PSD2} = \frac{N_{PSD2|PSD1}}{N_{PSD1}}$$



HET

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

$$MC/Data < 2\,\%\,(Energy < 10TeV)$$

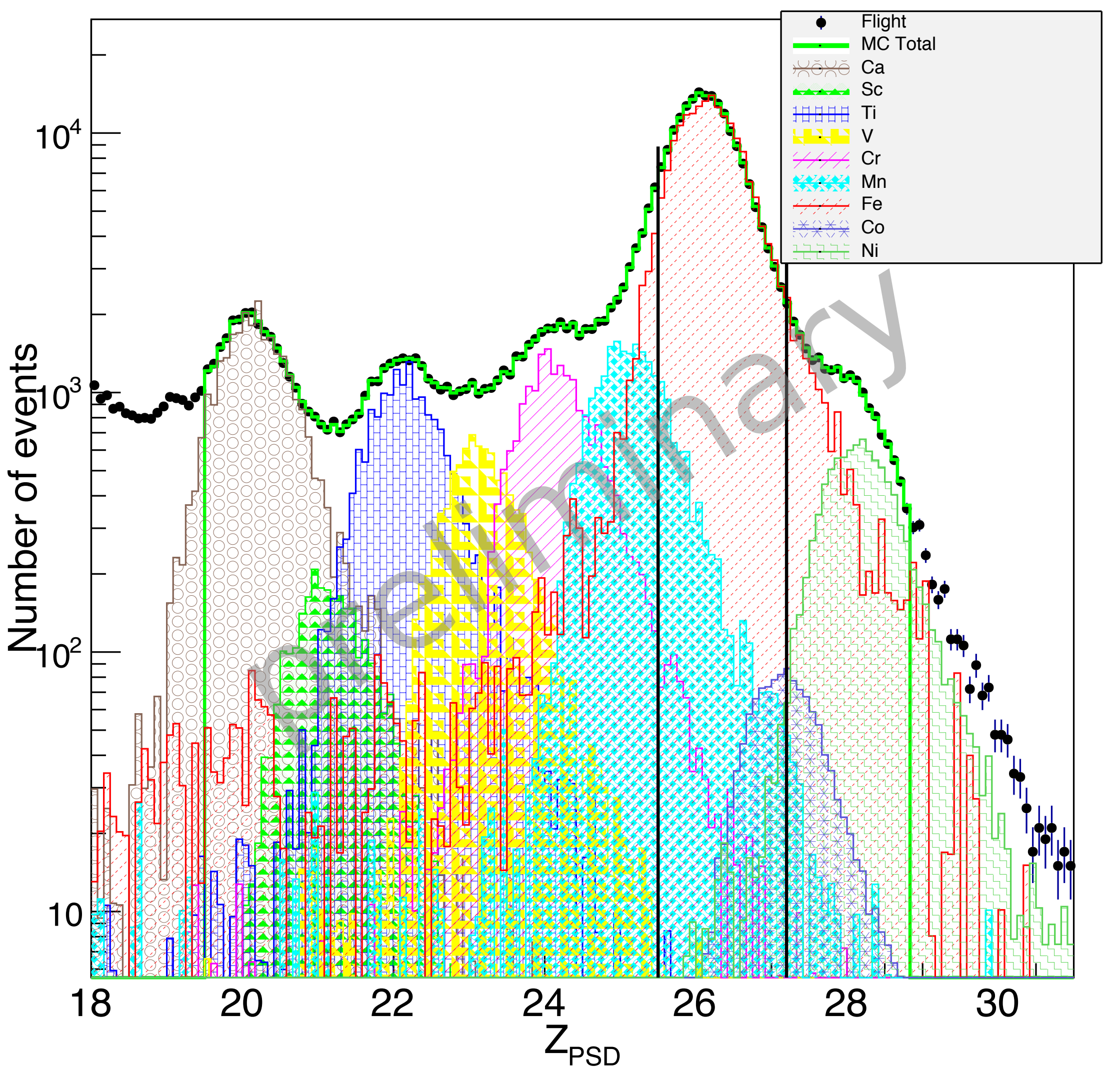
$$MC/Data < 0.3\,\%$$

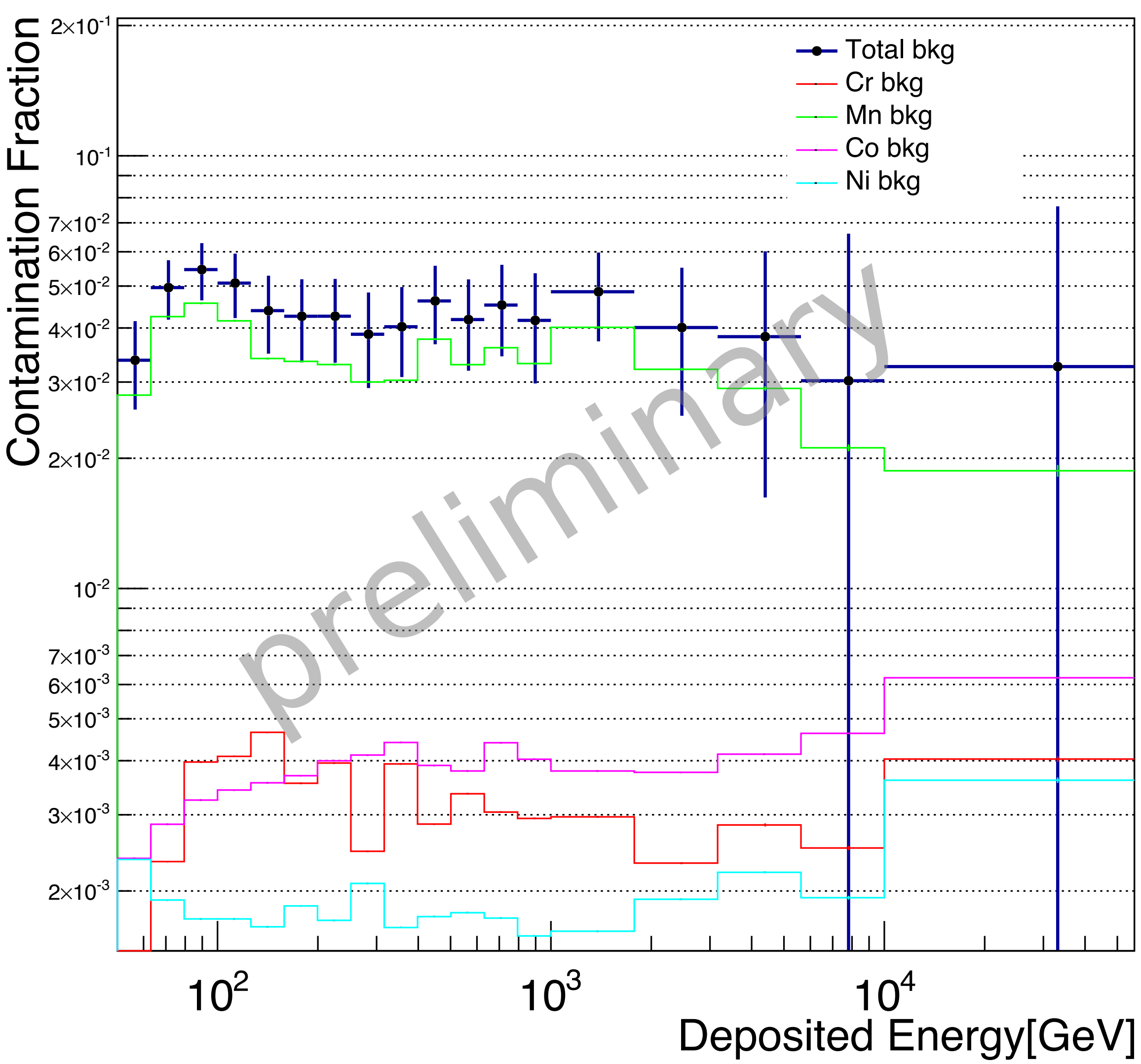
Template Fit

$$25.5 < Z_{PSD} < 27.2$$

$$158 < E_{dep}/GeV < 200$$

Contamination < 5%





Summary

- Iron fragmentation channel affect the track reconstruction and energy deposition ratio(model dependent).
- DAMPE has accurate particle identification capability for Fe
- There are still a lot of detailed work to be done. In the future, we will give an iron spectrum up to few TeV/n and improve the precision at higher energies.

Thanks for your attention