Elemental analysis of Cosmic-Ray Flux with DAMPE

Ya-Peng Zhang[1,2], Ming-Yang Cui[3], Tie-Kuang Dong[3], Antonio Surdo[4,5], Li-Bo Wu[6], Yong-Jie Zhang[1] and Cheng-Ming Liu[6]

(On behalf of DAMPE collaboration)

1. Institute of Modern Physics, Chinese Academy of Sciences (CAS)
2. University of Chinese Academy of Sciences
3. Purple Mountain Observatory, CAS
4. Istituto Nazionale di Fisica Nucleare (INFN) - Sezione di Lecce
5. Dipartimento di Matematica e Fisica E. De Giorgi, Università del Salento
6. University of Science and Technology of China

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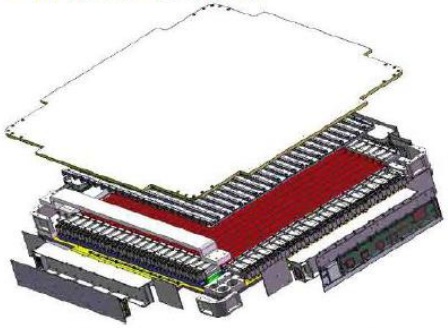
Outline

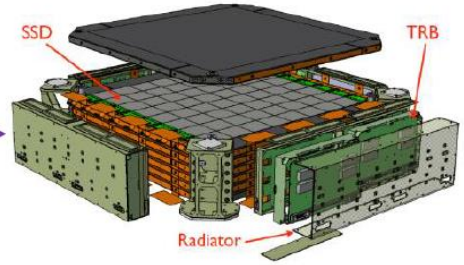
- **DAMPE introduction**
- **Charge reconstruction method**
- **Cosmic-ray nuclei analysis**
  - ✓ Preliminary proton and helium fluxes
  - ✓ Carbon nuclei analysis status
  - ✓ Ultra-heavy nuclei reconstruction
  - ✓ Fractional charge particle searching method
- **Summary**

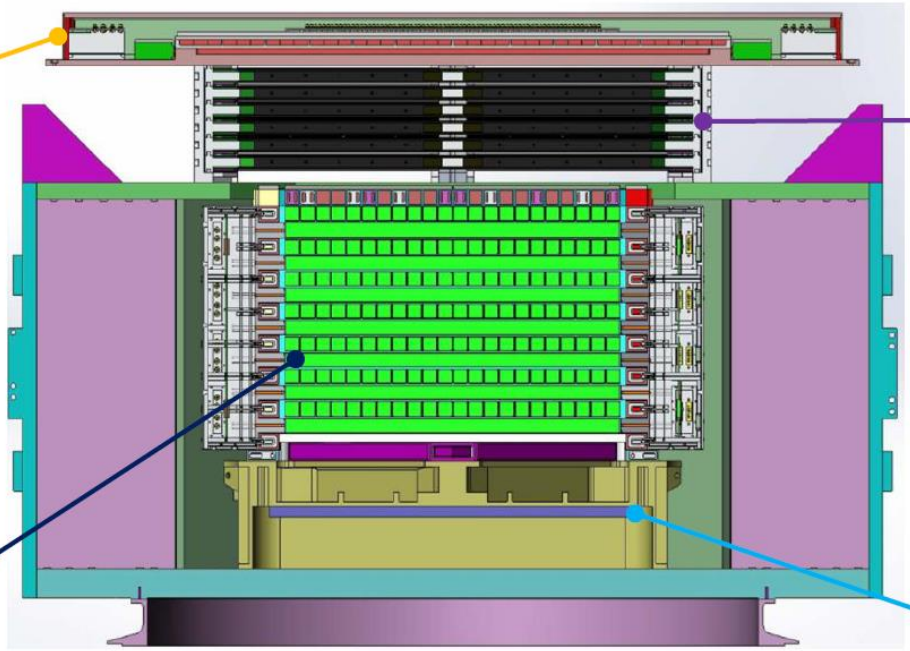
1. Dark Matter Particle Explorer （DAMPE）

Plastic Scintillator Detector(PSD)
- γ anticoincidence
- Z-measurement

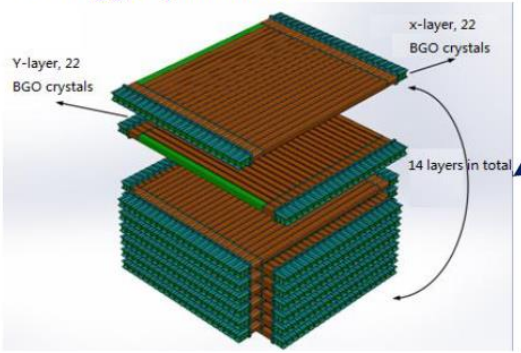


Silicon Tungsten Tracker(STK)
- γ convertor, particle track
- Z-measurement

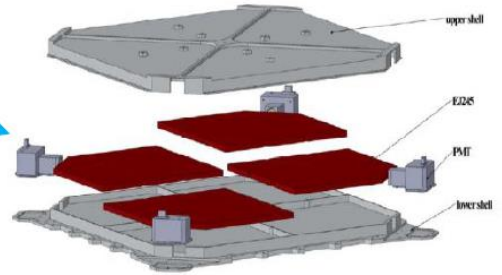




BGO Calorimeter(BGO)
- Calorimeter ($32X_0$&$1.6\lambda_I$)
- e/p separation
- Trigger primitives



Neutron Detector(NUD)
- e/p separation

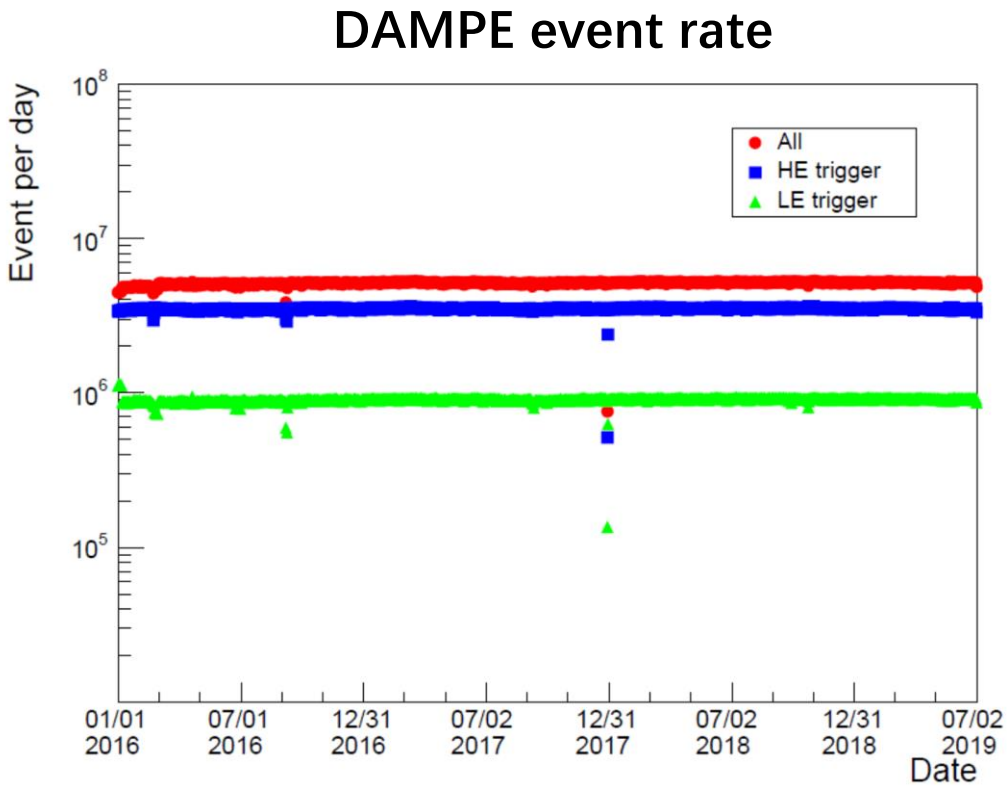


Chang et al. Astropart.Phys. 95 (2017) 6

DAMPE event rate

Trigger mode:

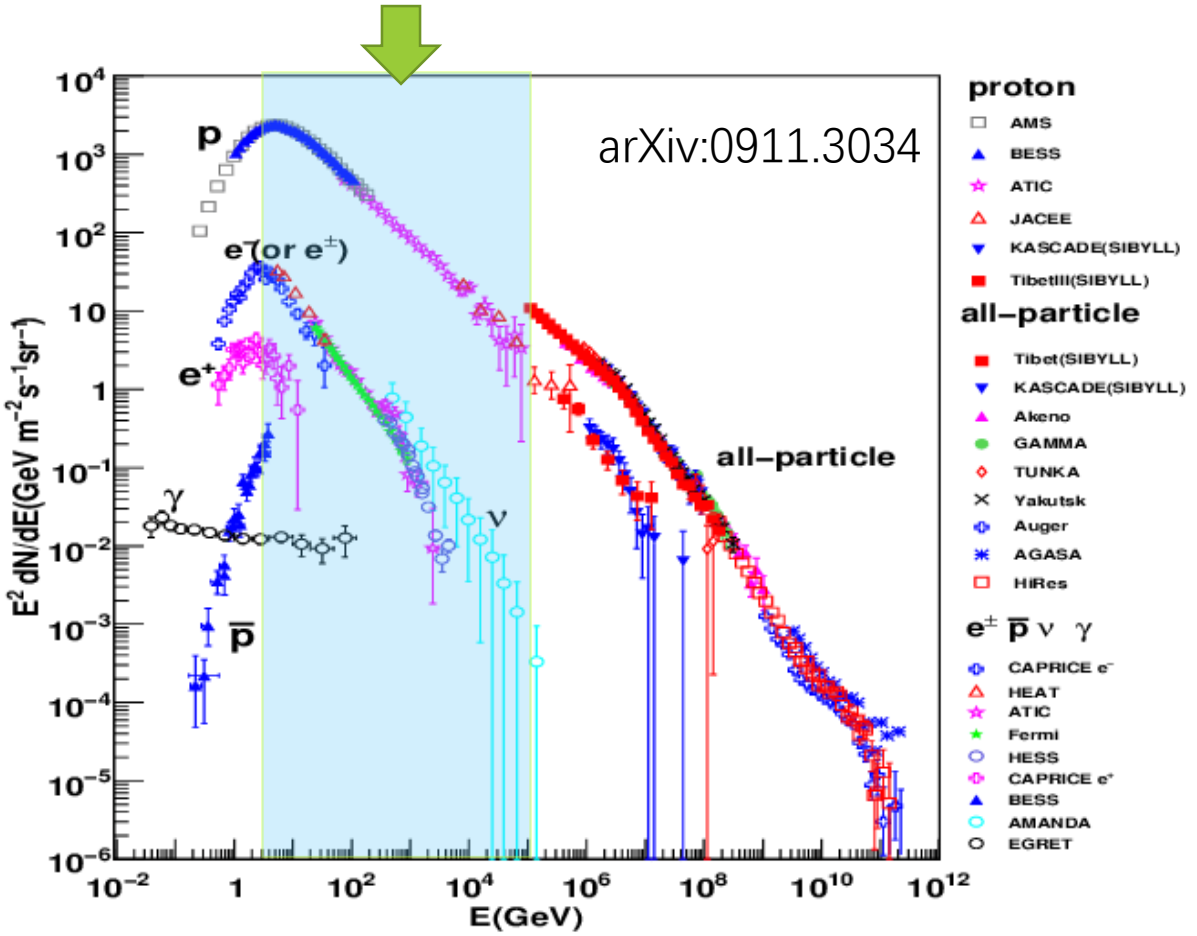
- High energy trigger (HE)
- Low energy trigger (LE)
- MIPs trigger
- Unbiased trigger



DAMPE running status: Talk by Zhang Y.L., ICRC2019;
DAMPE calibration: G. Ambrosi, et al., Astroparticle Physics 106 (2019) 18.

DAMPE energy coverage for CR-proton and nuclei

DAMPE energy coverage



Charge reconstruction method

According to Bethe-Bloch equation， the energy loss of high-energy charged particle in the matter:

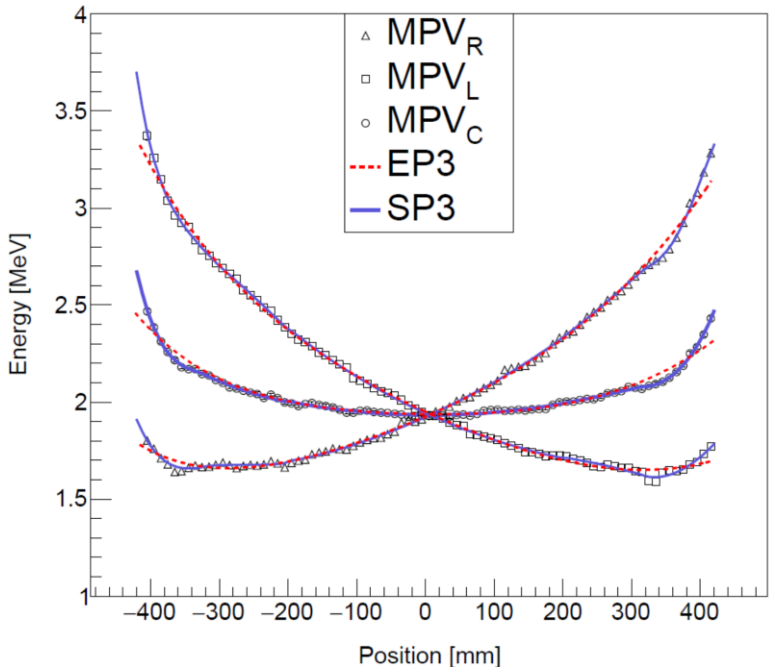
$$\left\langle \frac{dE}{dx} \right\rangle \propto Z^2$$

Charge reconstruction by PSD:

$$Q_{rec}^{L,R,C} = \sqrt{\frac{\mathrm{E}^{L,R,C}}{A^{L,R,C}(x)} \times \frac{S}{L}}$$

Quenching effect correction:

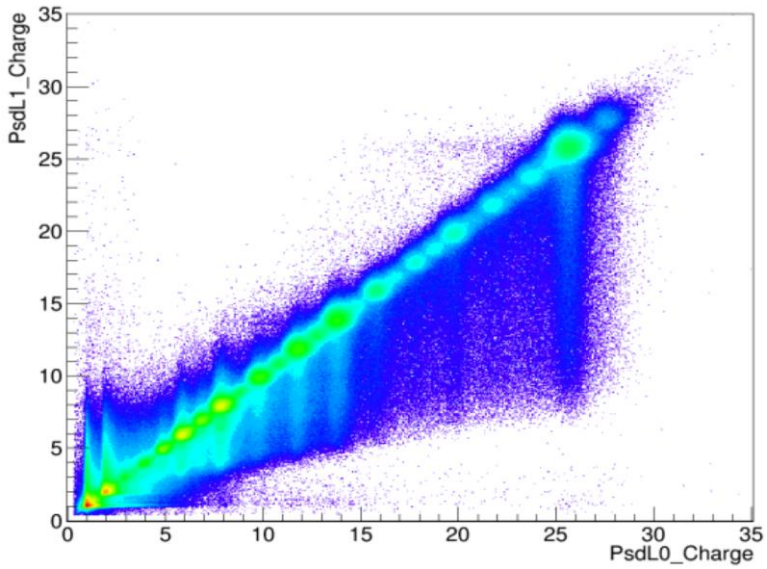
$$Q^{L,R,C} = f(Q_{rec}^{L,R,C})$$

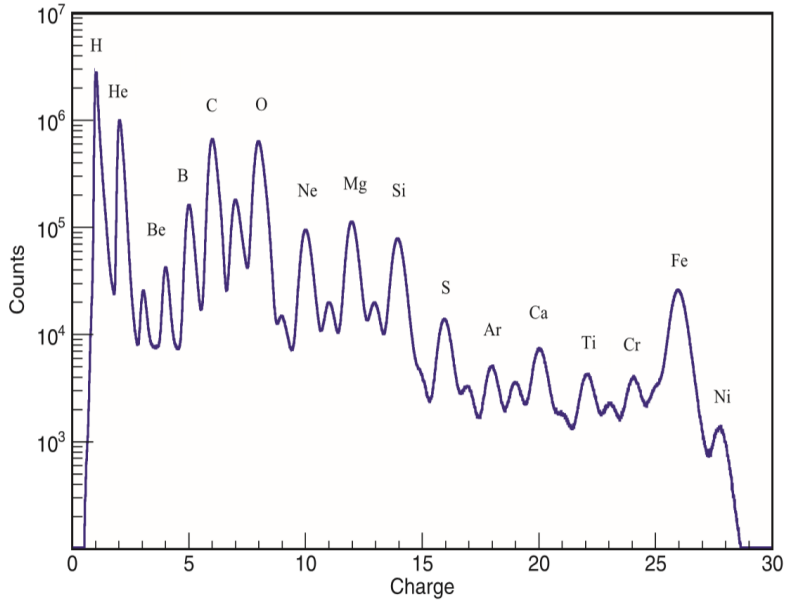


PSD alignment: Poster: Ma. P.X., ICRC2019 (100)
Charge reconstruction: Poster: Dong. T.K., ICRC2019 (063)

PSD Charge Spectrum

Poster： Dong T.K., ICRC 2019 (063).
Dong T.K. et al. Astroparticle Physics 105 (2019), 31-36;

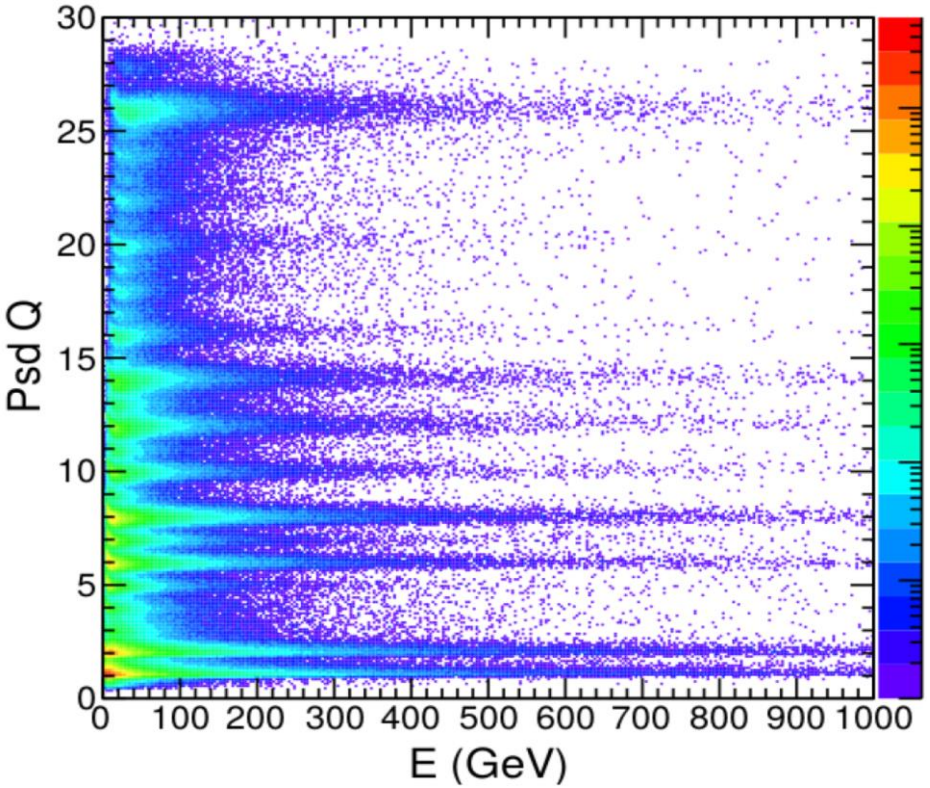




Element	σ_Z	Element	σ_Z	Element	σ_Z	Element	σ_Z
Li	0.14	C	0.18	Ne	0.21	S	0.25
Be	0.21	N	0.21	Mg	0.22	Ca	0.29
B	0.17	O	0.20	Si	0.25	Fe	0.30

Cosmic-ray flux reconstruction

Charge Vs. BGO energy



Flux reconstruction

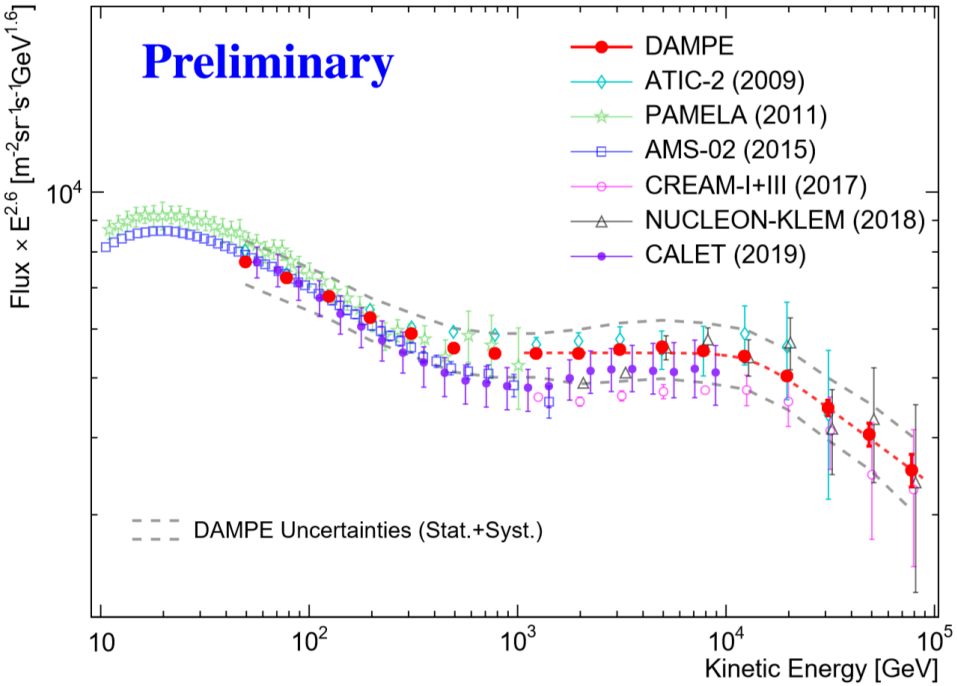
$$\Phi(E_i + \Delta E_i) = \frac{N_i}{\Delta E_i A_{Eff,i} T_{exp}}$$

N_i : The number of object nuclei in $[E_i+\Delta E_i]$
ΔE_i : The width of i-th energy bin
$A_{Eff,i}$: The effective acceptance
T_{exp} : The exposure time

Preliminary Proton and Helium fluxes

Proton flux

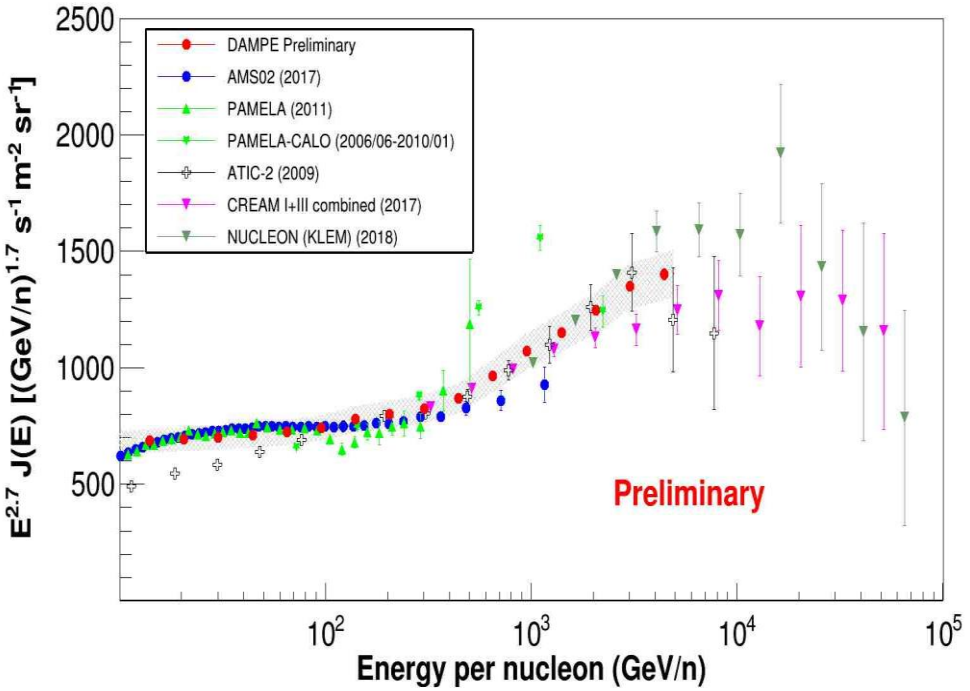
Data: 2016/01/01-2018/07/30



Talk: Yue C. et al., ICRC2019(163)

Helium flux

Data: 2016/01/01-2019/03/31

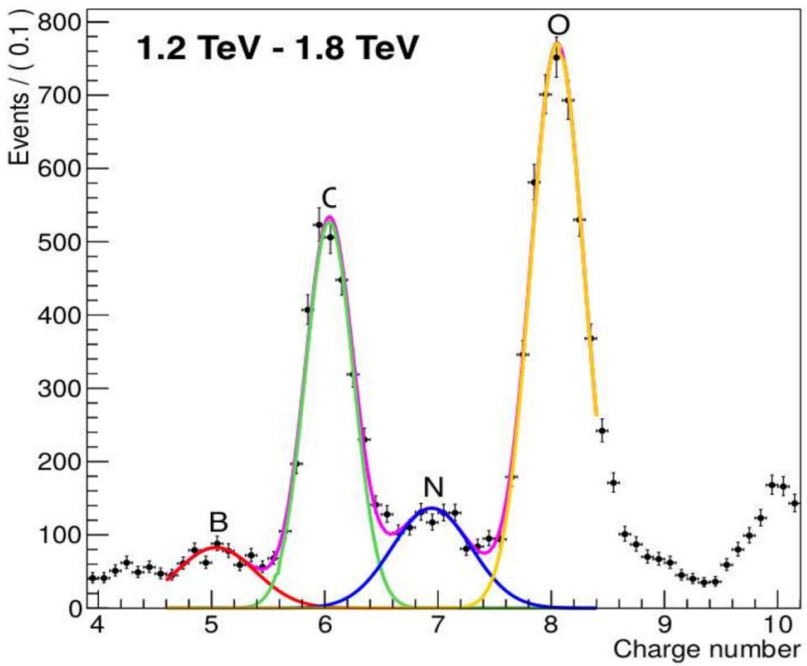


Talk: Di Santo M. et al., ICRC2019 (058)

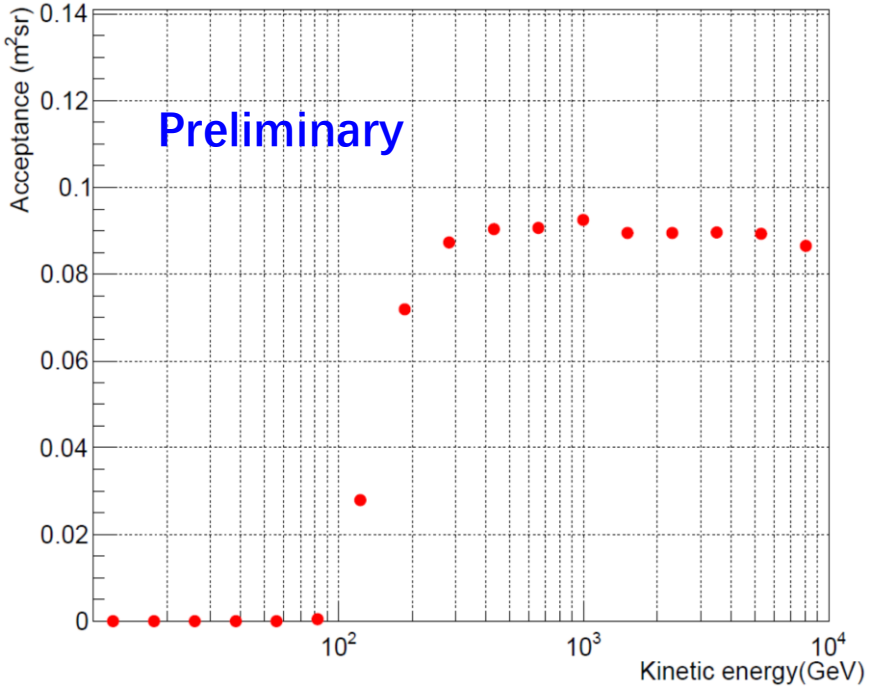
Poster: “Proton+helium flux” Wang Z.M. et al., ICRC2019

Carbon nuclei analysis status

Charge spectrum for carbon event selection



Carbon Effective Acceptance

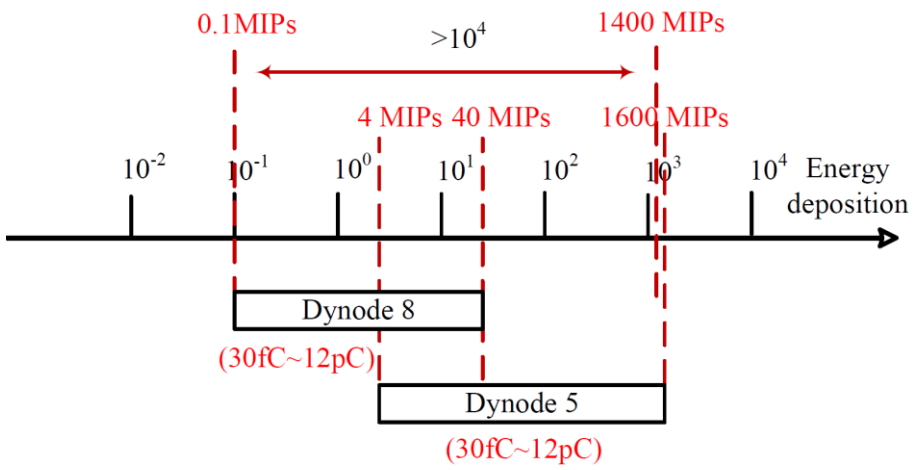


MC validation, flux calculation and error evaluation are on going.

Poster: WU L.B. et al., ICRC2019 (156)

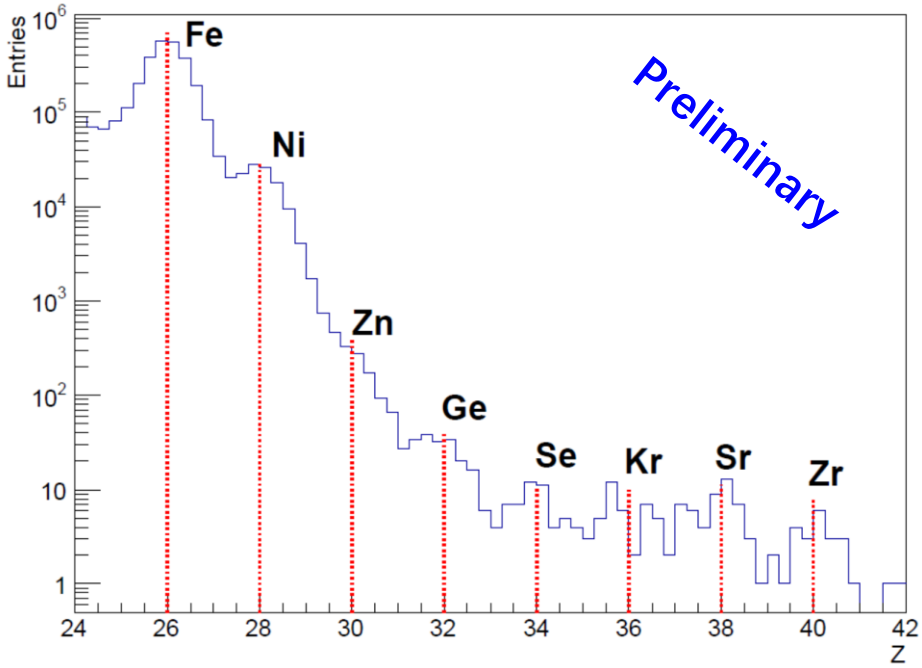
Ultra-heavy CR-nuclei reconstruction

Dynamic range of PSD



Poster: Zhang Y.J. et al., ICRC2019

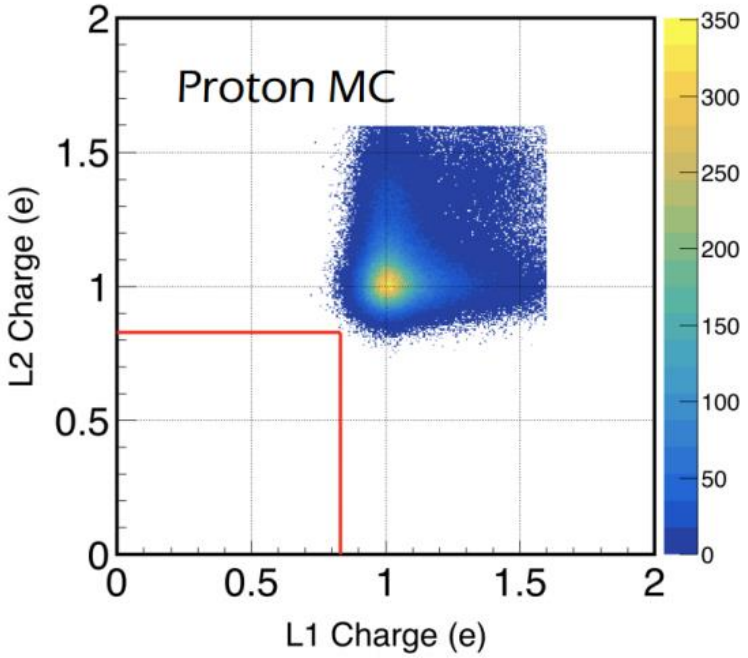
Data: 2016/01/01—2018/12/31

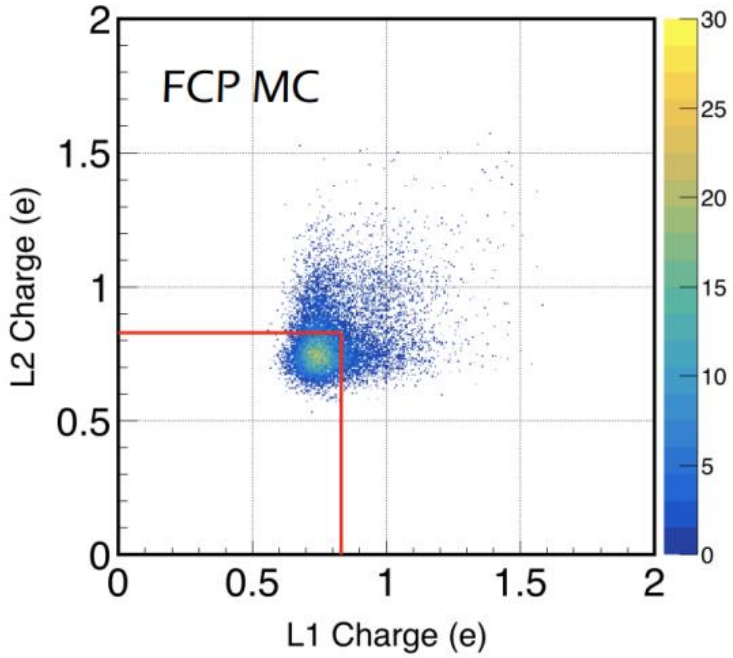


Efficiency optimization, charge reconstruction, abundance analysis are on going.

Fractional charge particle (FCP) searching

Why FCP? Any observation of CR-FCP would mean new physics beyond standard model





Liu C.M. et al., ICRC2019 (poster)

Summary

- DAMPE is capable to measure fluxes of H to Ni nuclei from tens GeV up to 100 TeV
- Preliminary results of proton and helium are obtained
- Carbon flux analysis status is presented
- DAMPE is capable to measure the charge of nuclei up to Zr (Z=40)
- Fractional charge particle searching method is presented

Thanks for your attention!

Backup

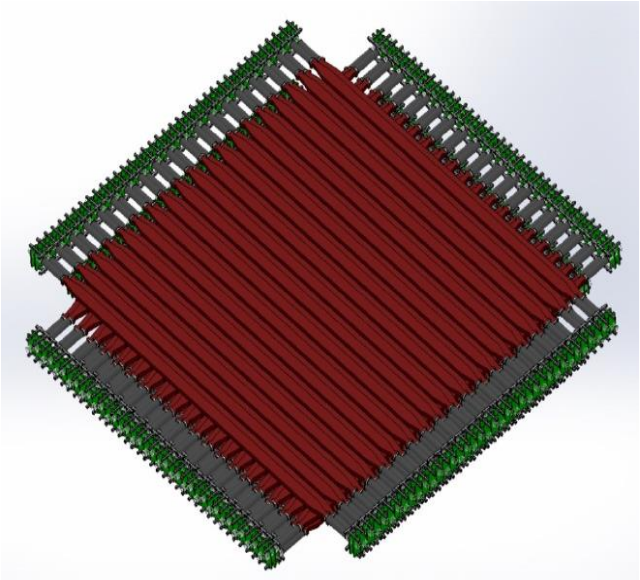
DAMPE trigger modes:

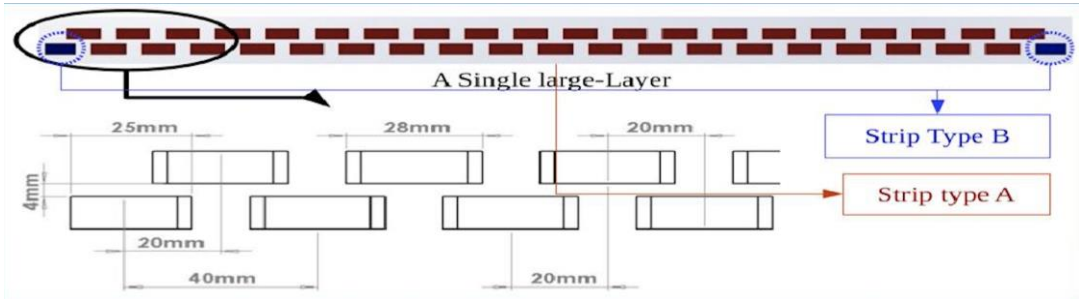
Trigger Type	Logic	Energy Threshold	Pre-scale factor
HE	L1_P_dy5	~10 MIPs	1
	& L2_P_dy5	~10 MIPs	
	& L3_P_dy5	~10 MIPs	
	& L4_N_dy8	~2 MIPs	
MIPs (Type I)	L3_P_dy8	~0.4 MIPs	4 (low latitude(±20°))
	& L11_P_dy8	~0.4 MIPs	
	& L13_P_dy8	~0.4 MIPs	Turn Off (other region)
MIPs (Type II)	L4_P_dy8	~0.4 MIPs	4 (low latitude(±20°))
	& L12_P_dy8	~0.4 MIPs	
	& L14_P_dy8	~0.4 MIPs	Turn Off (other region)
LE	L1_N_dy8	~0.4 MIPs	
	& L2_N_dy8	~0.4 MIPs	8 (low latitude(±20°))
	& L3_N_dy8	~2 MIPs	
	& L4_N_dy8	~2 MIPs	64 (other region)
Unbiased	(L1_P_dy8 & L1_N_dy8)	~0.4 MIPs ~0.4 MIPs	512 (low latitude(±20°))
	| (L2_P_dy8 & L2_N_dy8)	~0.4 MIPs ~0.4 MIPs	2048 (other region)

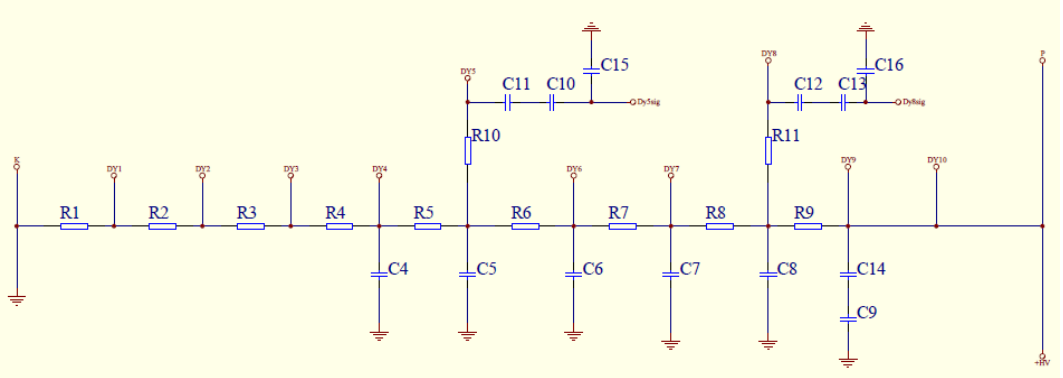
Table 1: The sub-trigger settings of DAMPE

Backup

PSD detector







Backup

Quenching correction: