

Observations of Rare Events with DAMPE

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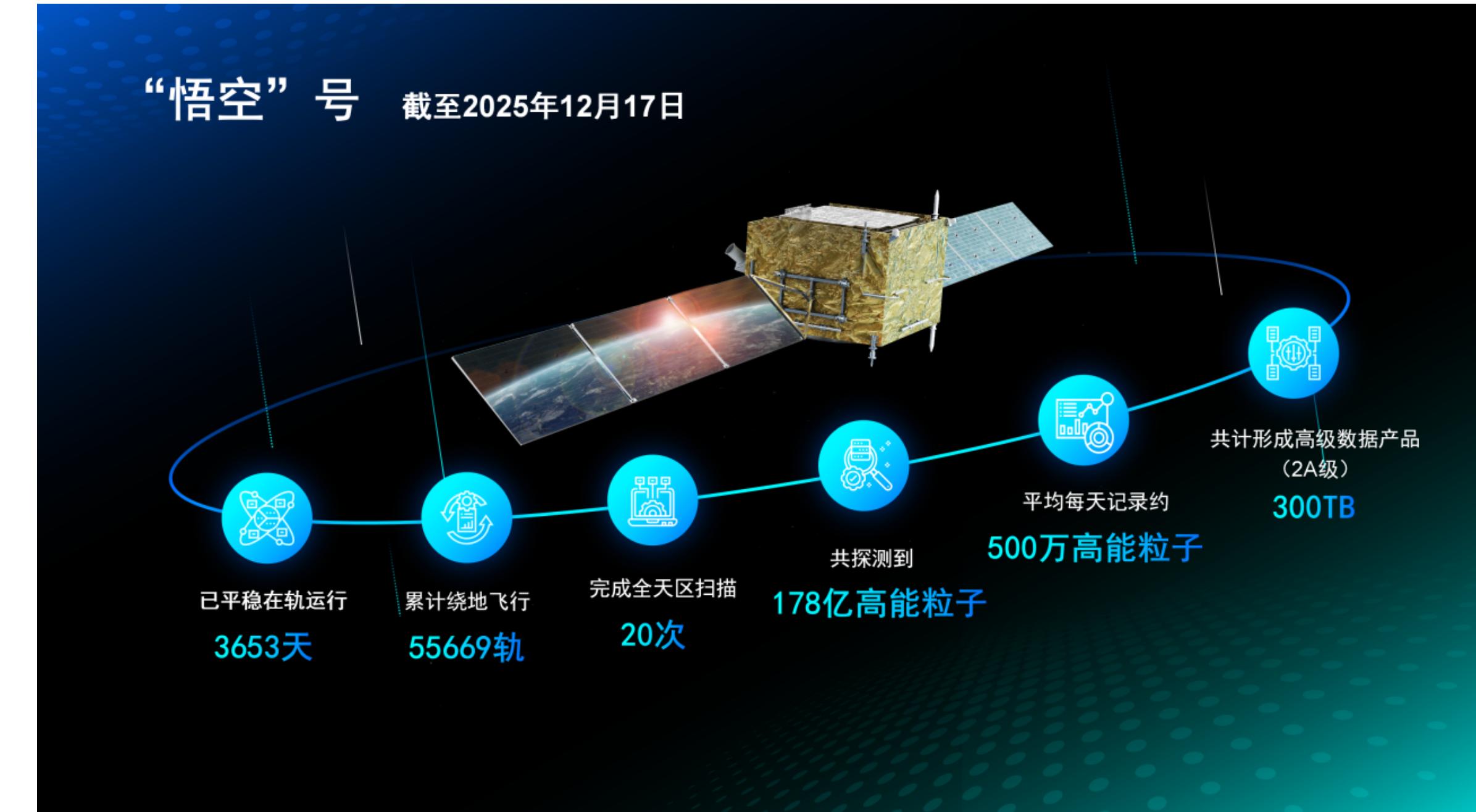
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DArk Matter Particle Explorer (DAMPE)

- **DAMPE (悟空)** : a space-based particle detector operating successfully **for 10 years**.

- 3,653 days
- 55,669 orbits
- 20 all-sky surveys
- **17.8 billion** events
- 5 million events/day
- 300 TB high-level data

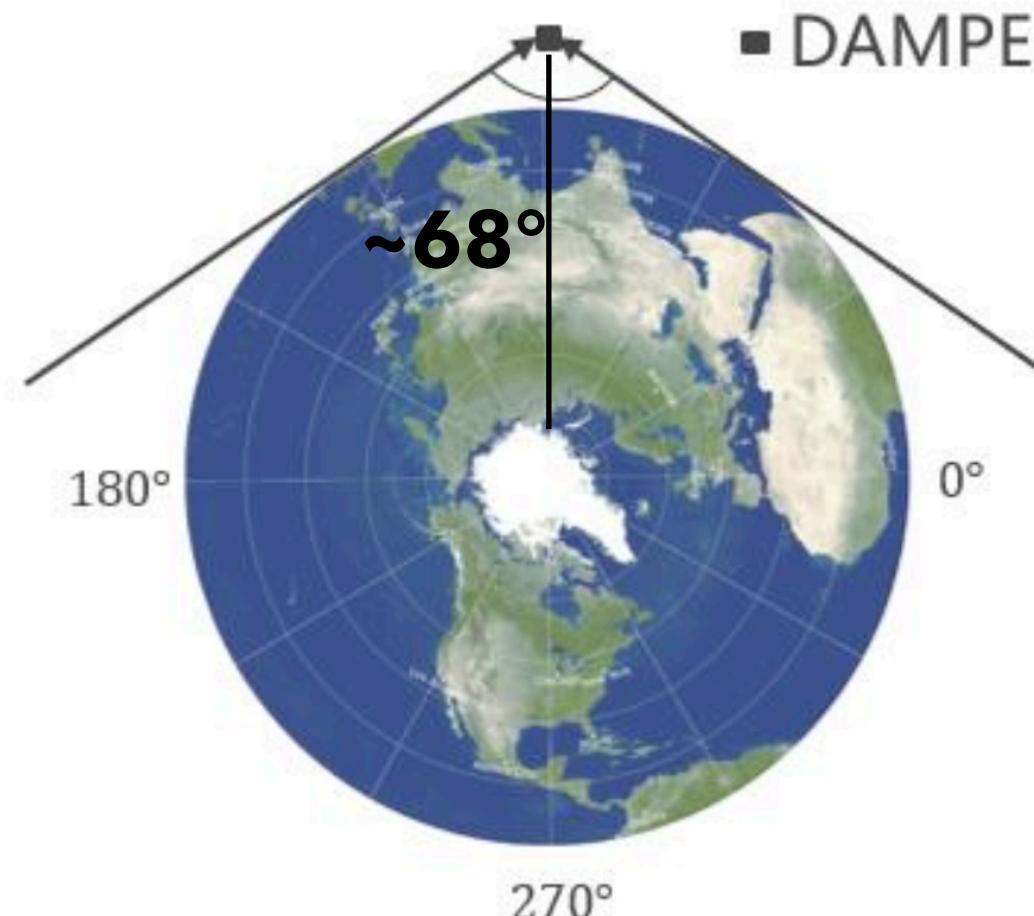
- Enables the search for **rare events** in cosmic rays



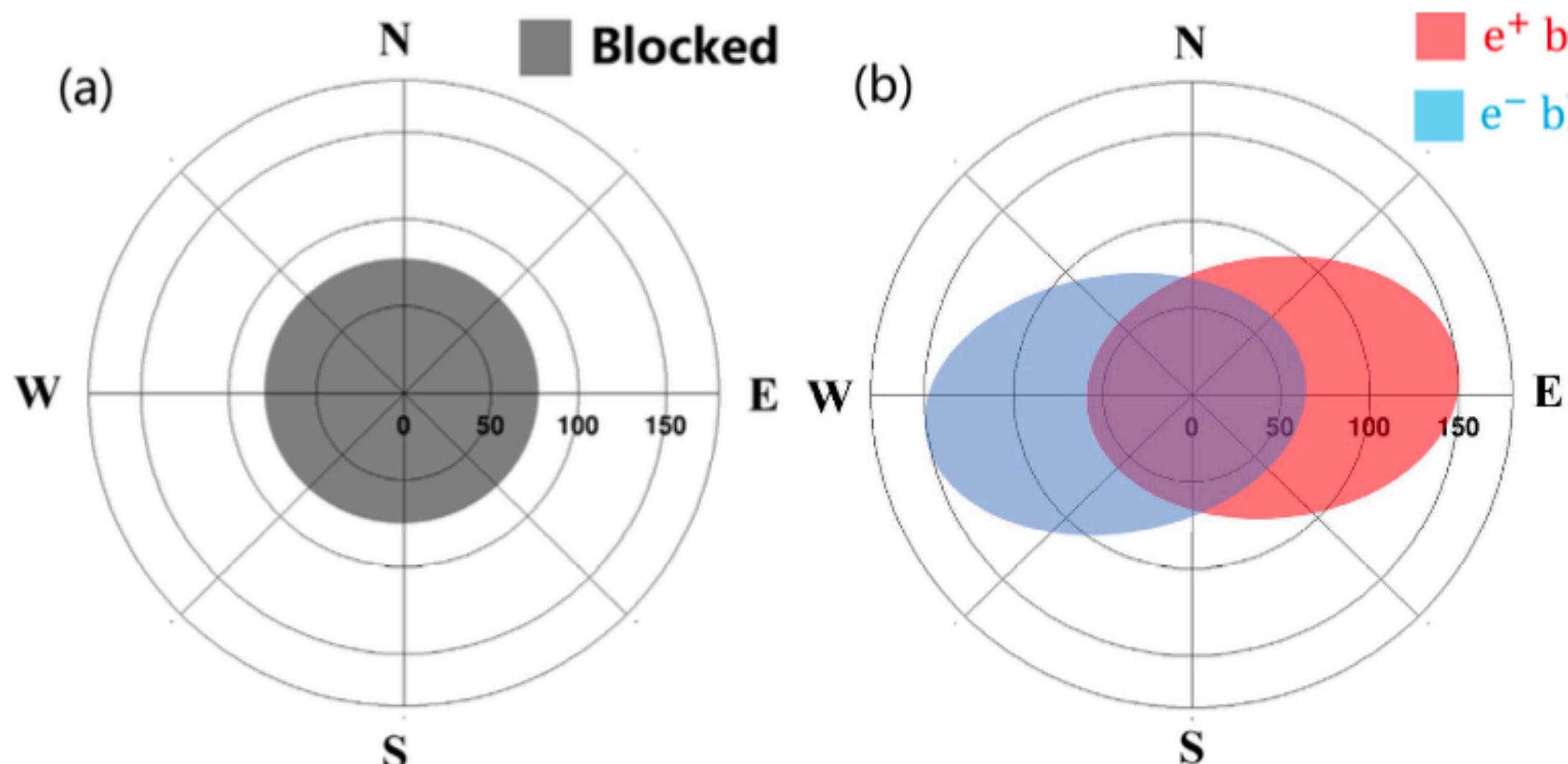
Outline

- DAMPE experiment
- Results of Measurement and Search for Rare Events
 - Separate **e⁺** and e⁻ measurement
 - Measurements of **nuclei beyond iron**
 - Search for **fractional charged particle**
 - Search for **anti-matter**
- Summary

Separate e^+ and e^- Measurement



- **Motivation:** cosmic-ray **positrons** and electrons are crucial probes of high-energy processes and dark matter indirect search
- DAMPE has no onboard magnet; we exploit **Earth's geomagnetic field** as a natural spectrometer



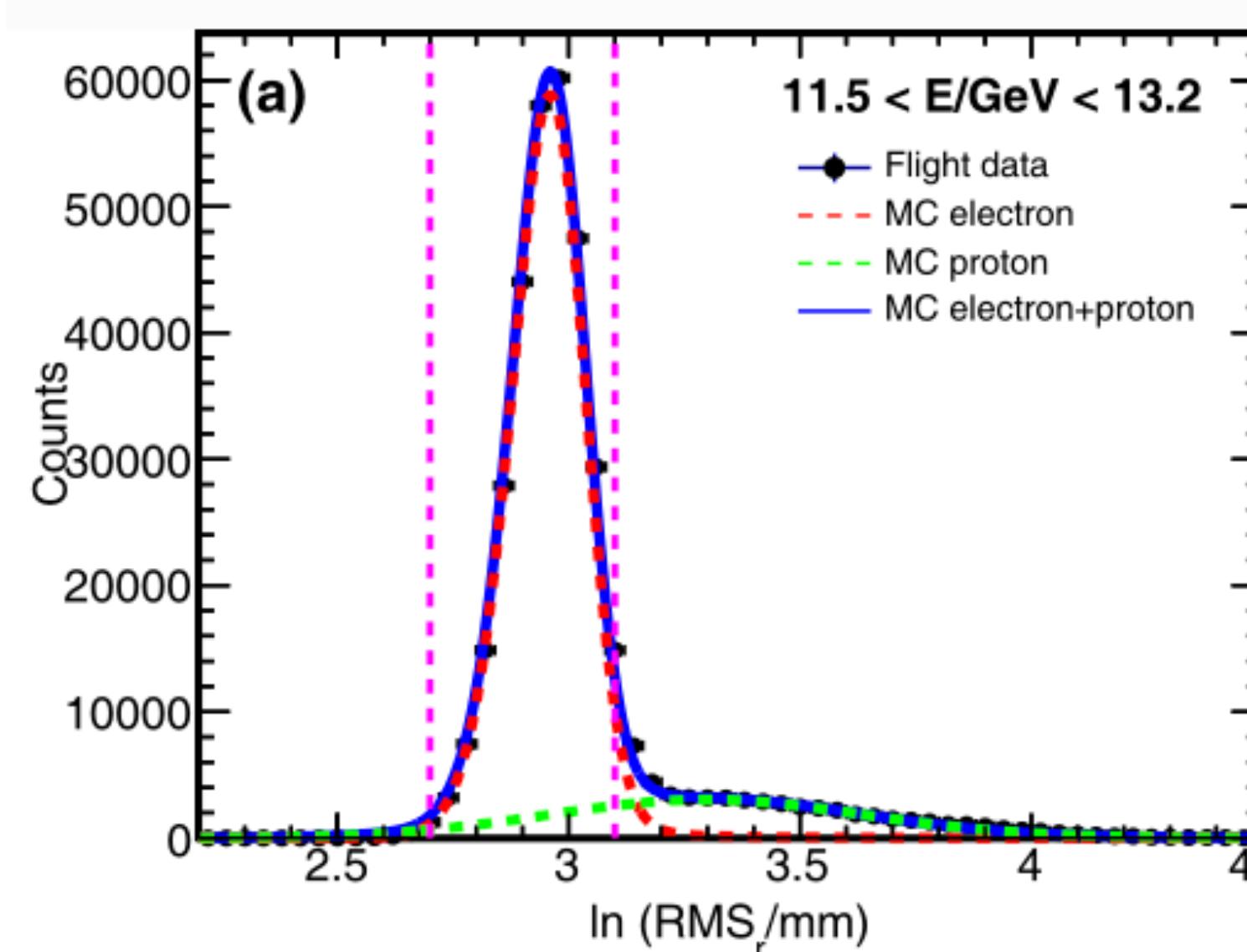
Polar axis: nadir angle (0° = particle direction from Earth's center to satellite)

- Method: **search for positrons (electrons) in the electron-(positron-) blocked region.**
- e^+/e^- blocked regions are decided with back-tracing technique

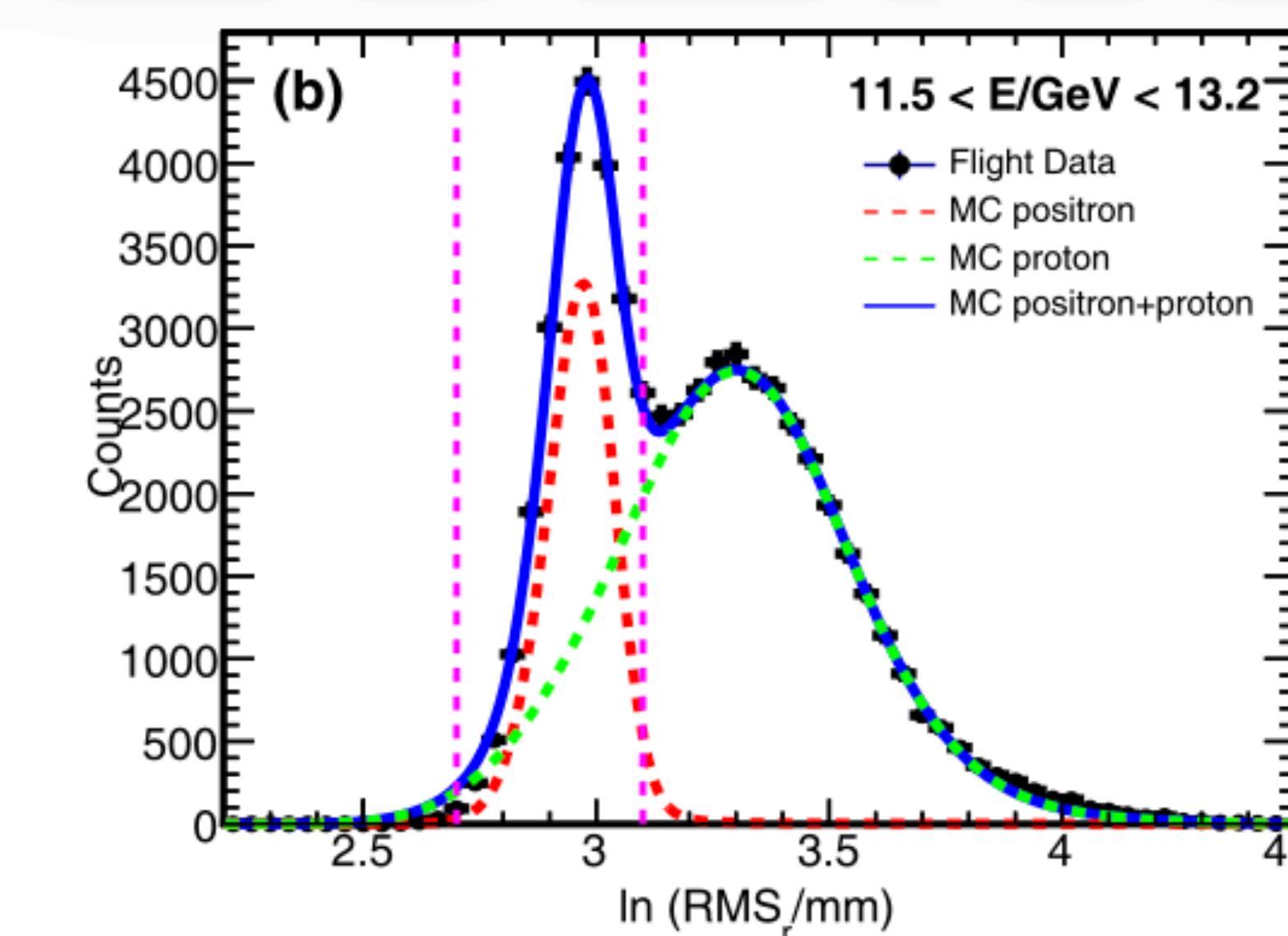
Separate e^+ and e^- Measurement

- Use shower development info to reject proton background.
- Contamination level:
 - $\sim 5\%$ @ 12 GeV to $\sim 16\%$ @ 19 GeV for electron;
 - $\sim 39\%$ @ 12 GeV to $\sim 65\%$ @ 19 GeV for position.

e^-/p separation

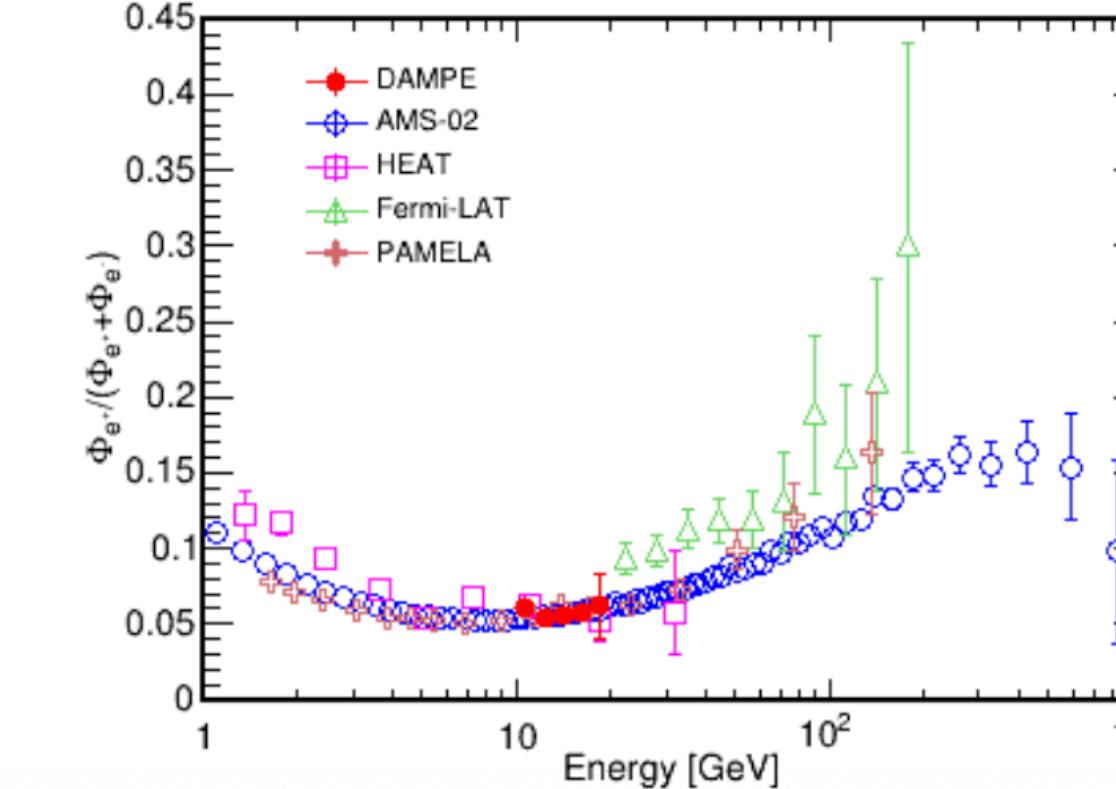
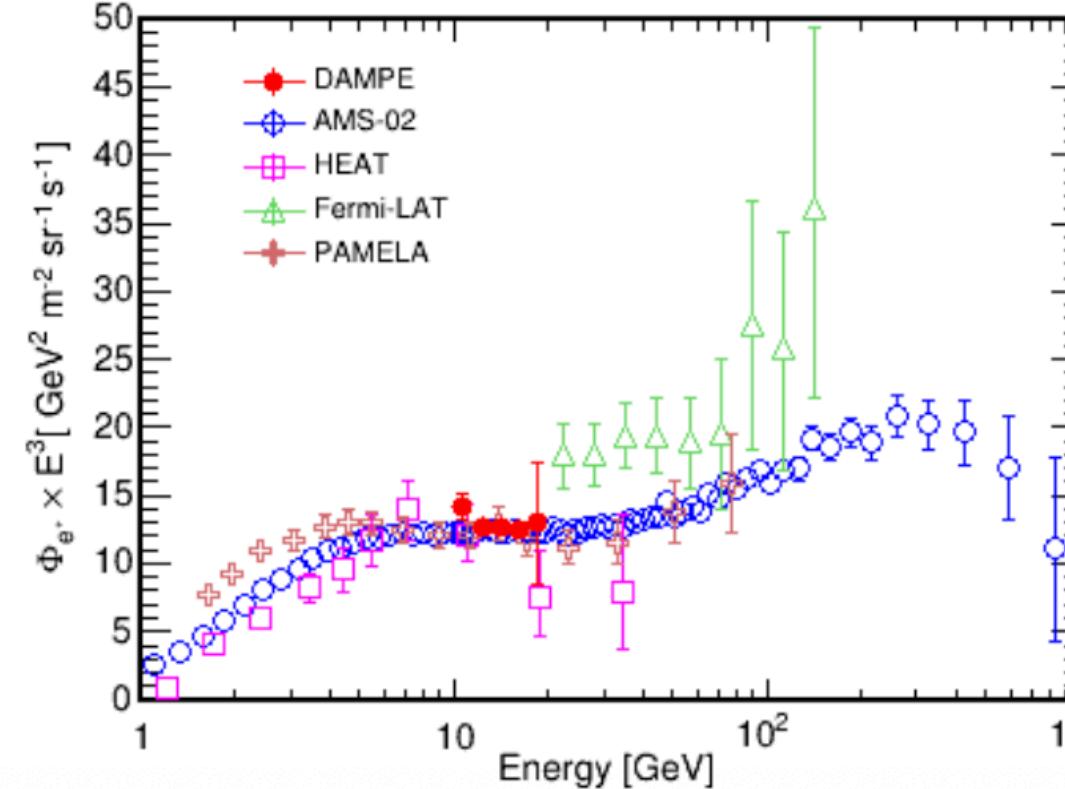
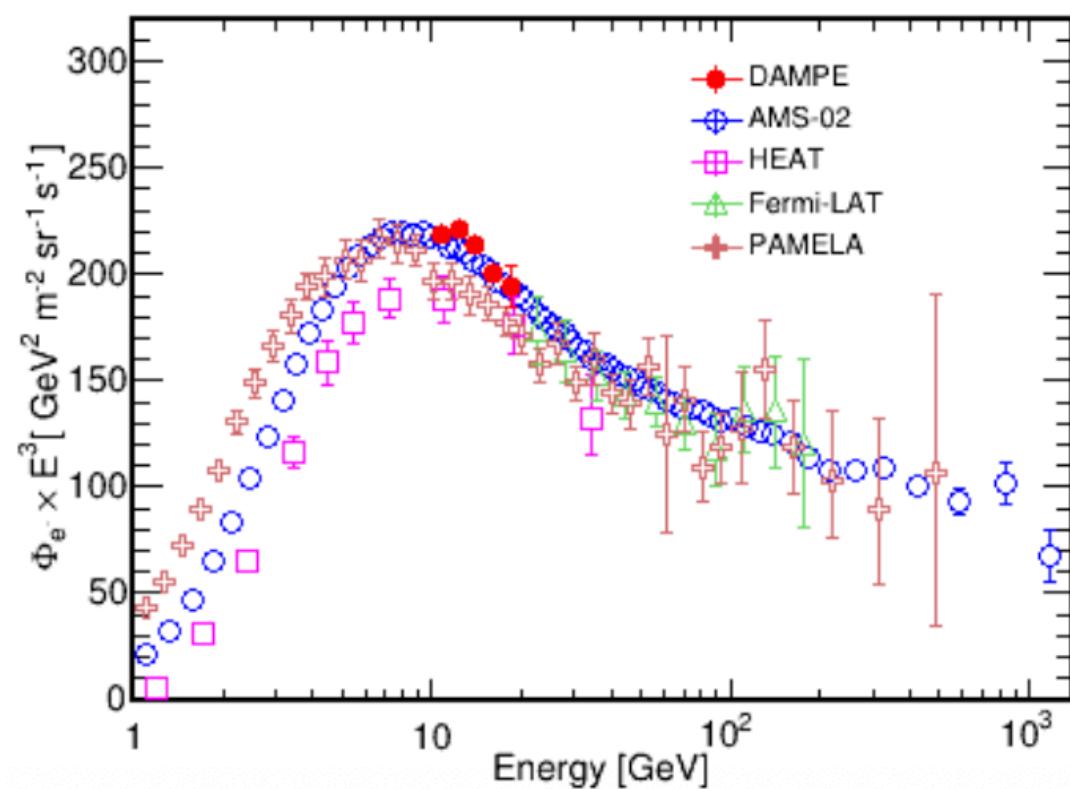
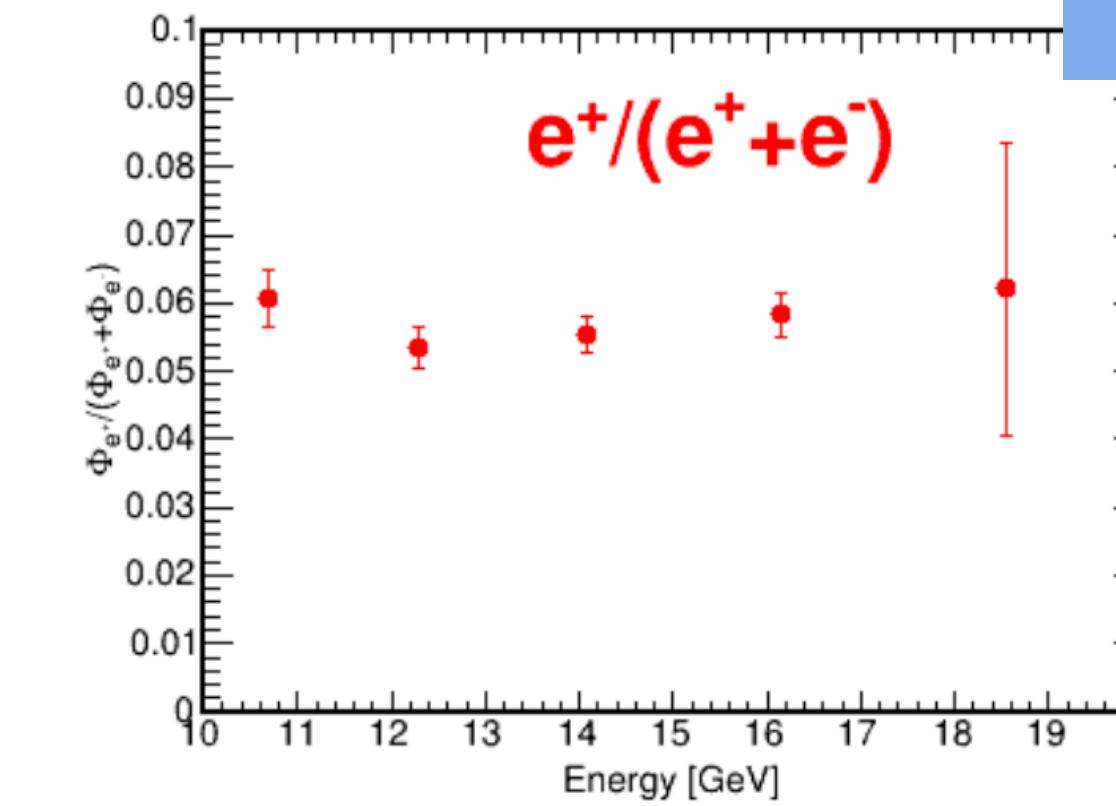
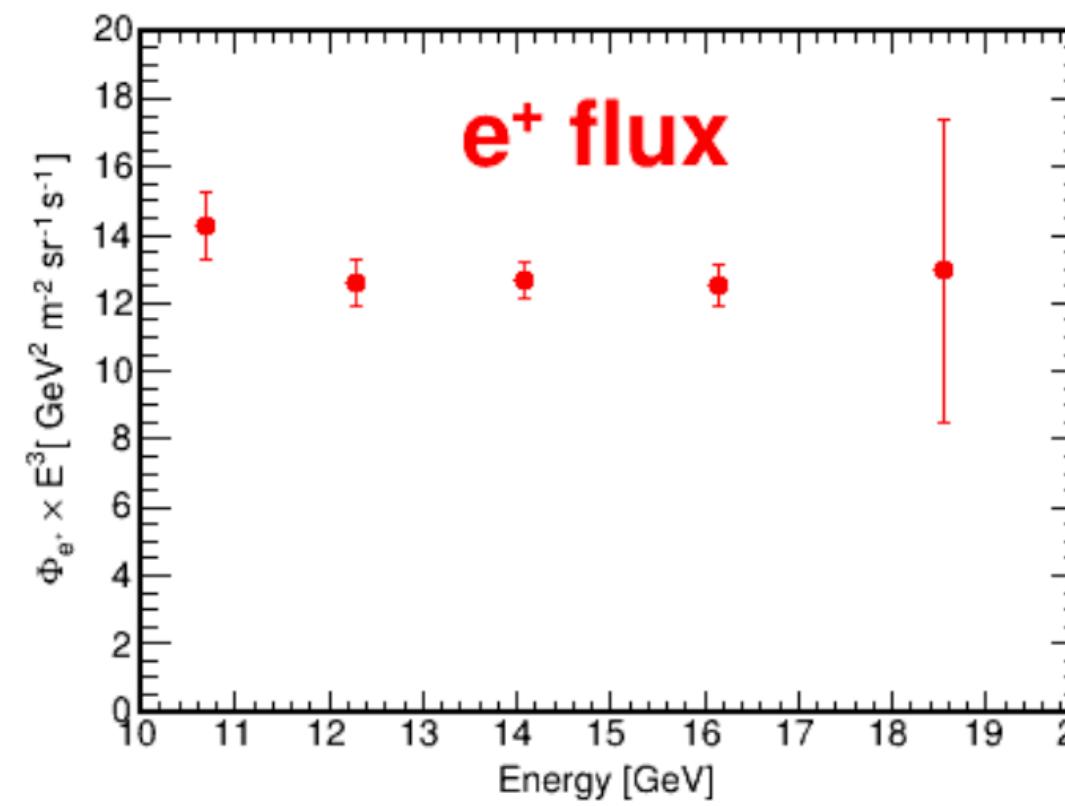
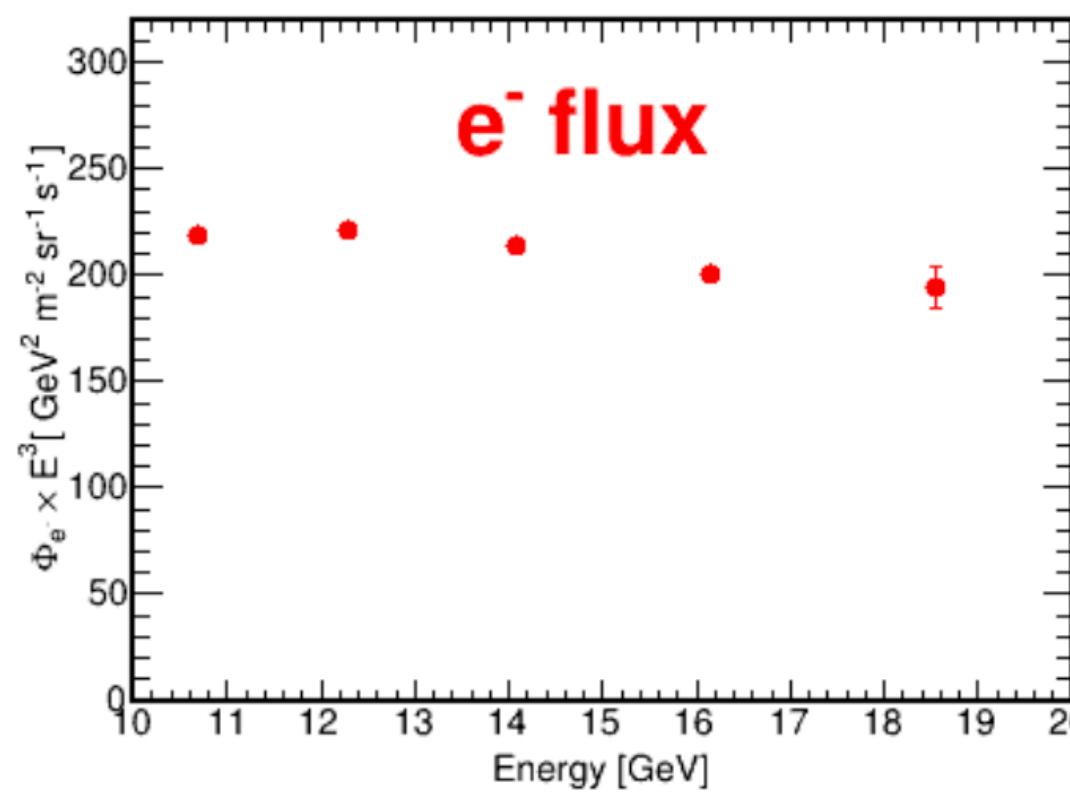


e^+/p separation

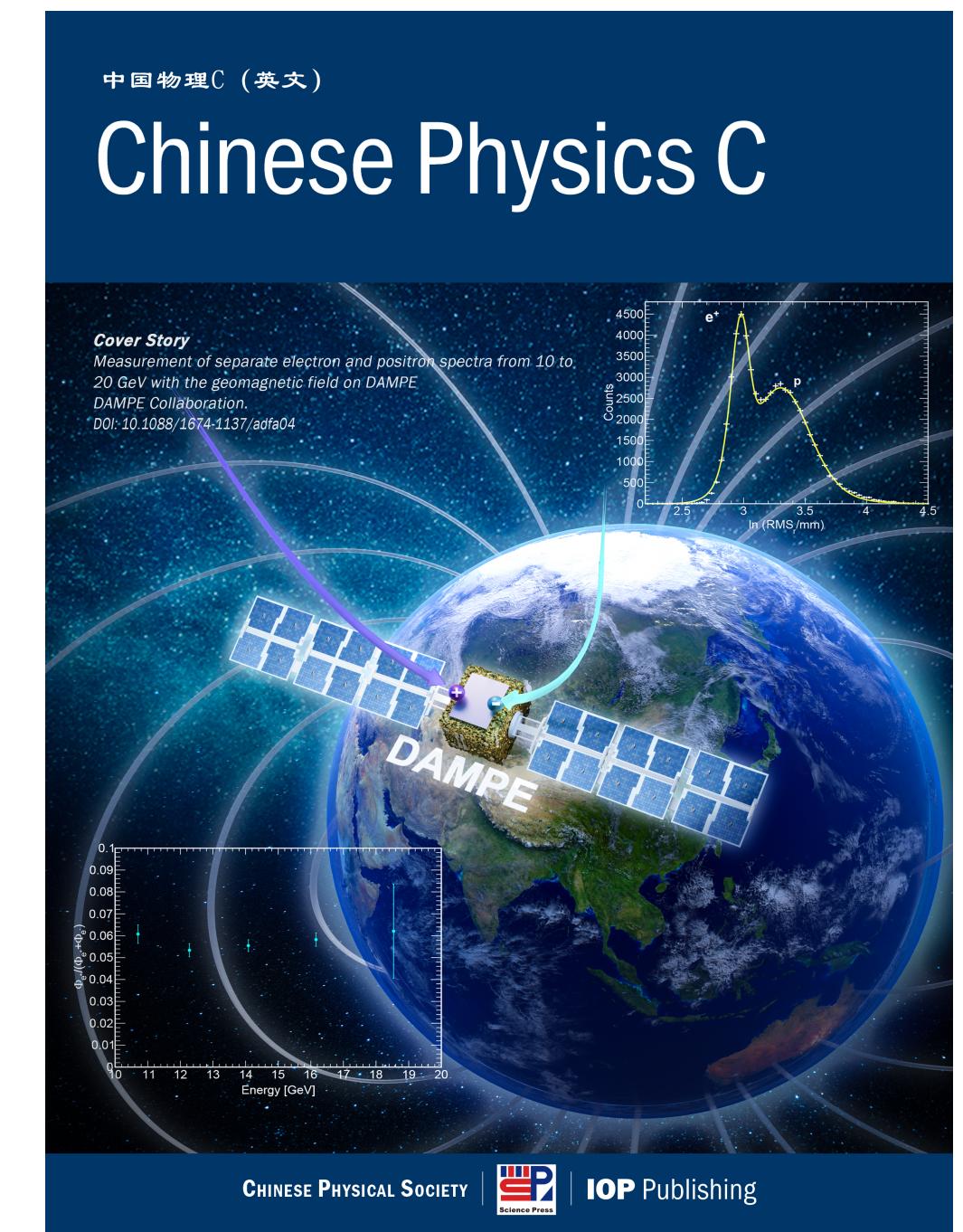


Results of Separate e^+ and e^- Measurement

- Separate e^+ and e^- measurements from 10 to 20 GeV are consistent with the previous results of AMS-02 and PAMELA.



DAMPE Collab., *Chinese Phys. C*
109 (2025), Editor's Suggestion



Nuclei beyond Iron

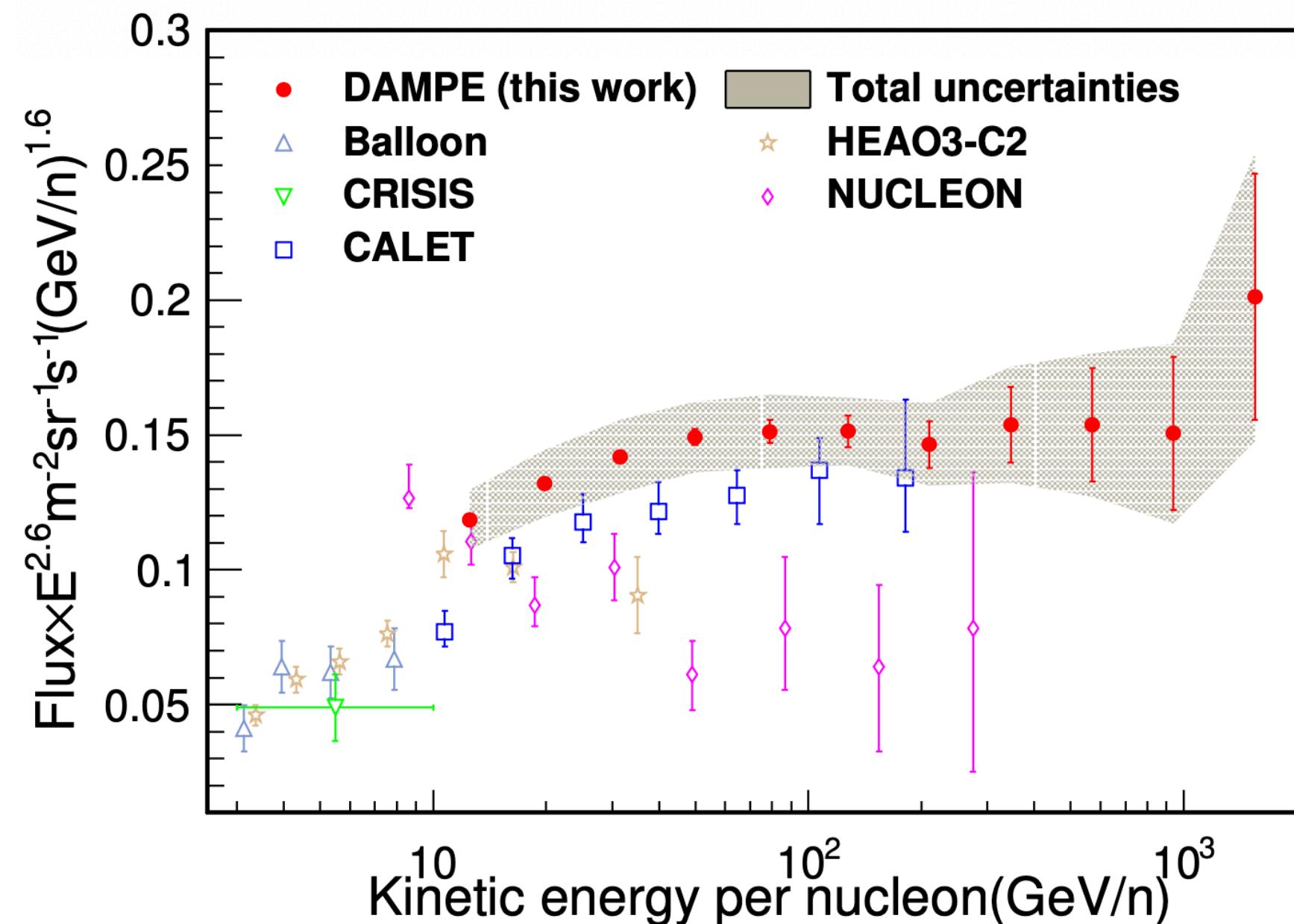
- **Motivation:** Elements below and beyond iron may originate from different astrophysical processes. Their spectra probe cosmic-ray sources and acceleration mechanisms.
- Detailed studies in the DAMPE experiment (see Zihui Xu's talk for more information):
 - Differential flux of nickel
 - Relative abundances of elements of nuclei beyond iron
 - ...

Results of Nuclei beyond Iron

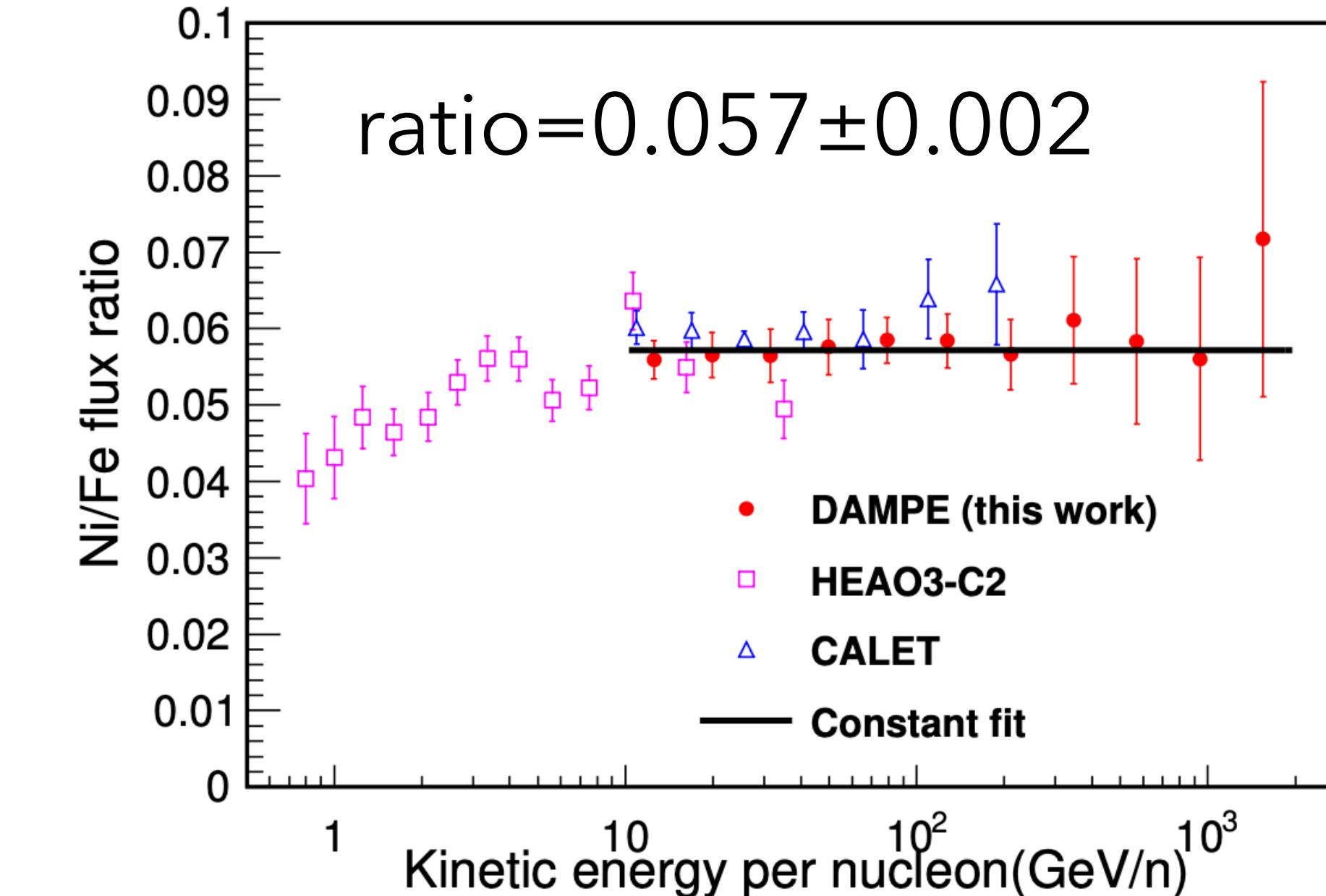
arXiv:2512.11425

- First measurement of nickel flux **up to 2 TeV/n**
- Spectral index = -2.60 ± 0.03 in $40 \text{ GeV/n} - 1 \text{ TeV/n}$, consistent with a single power law

Ni flux

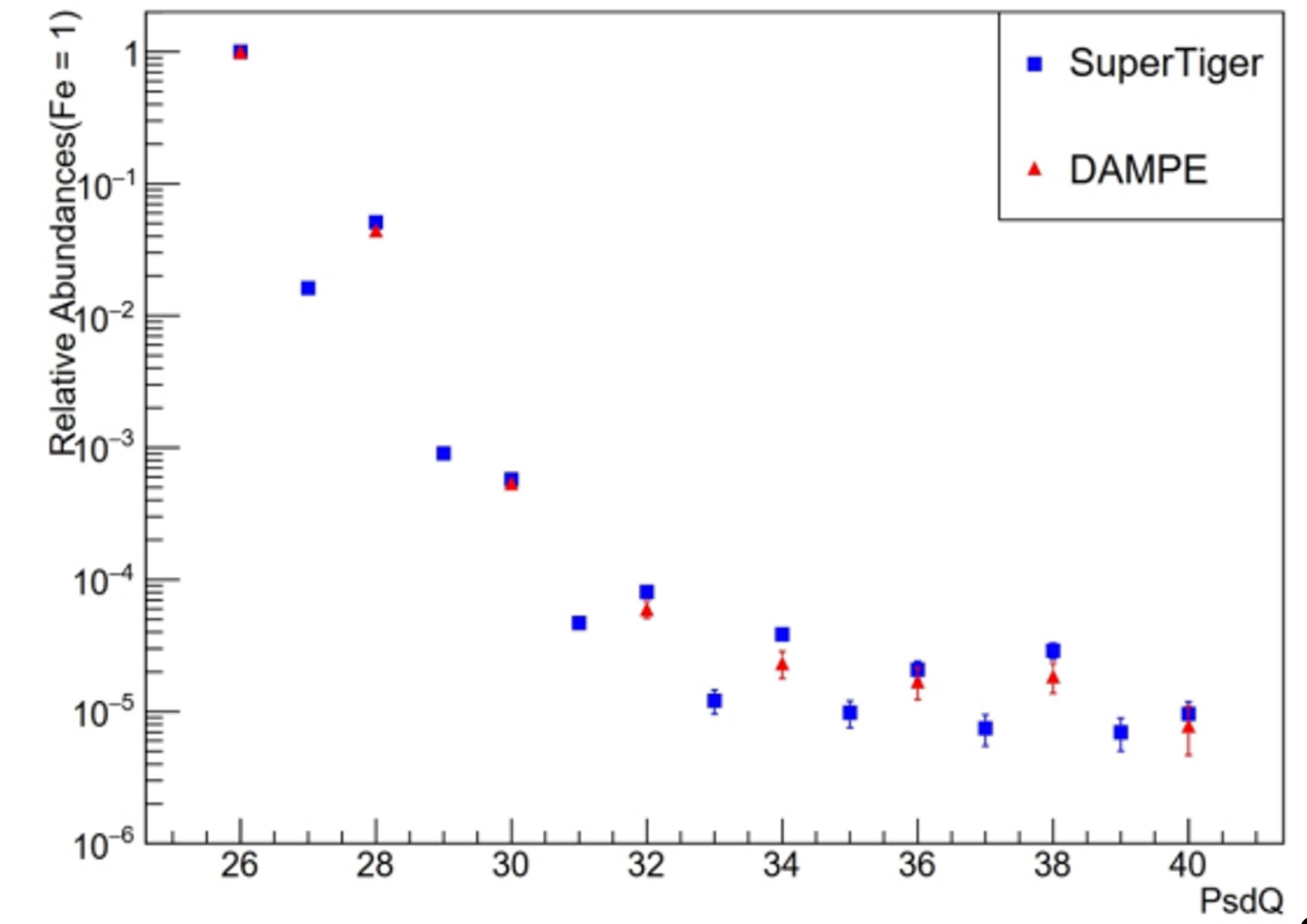
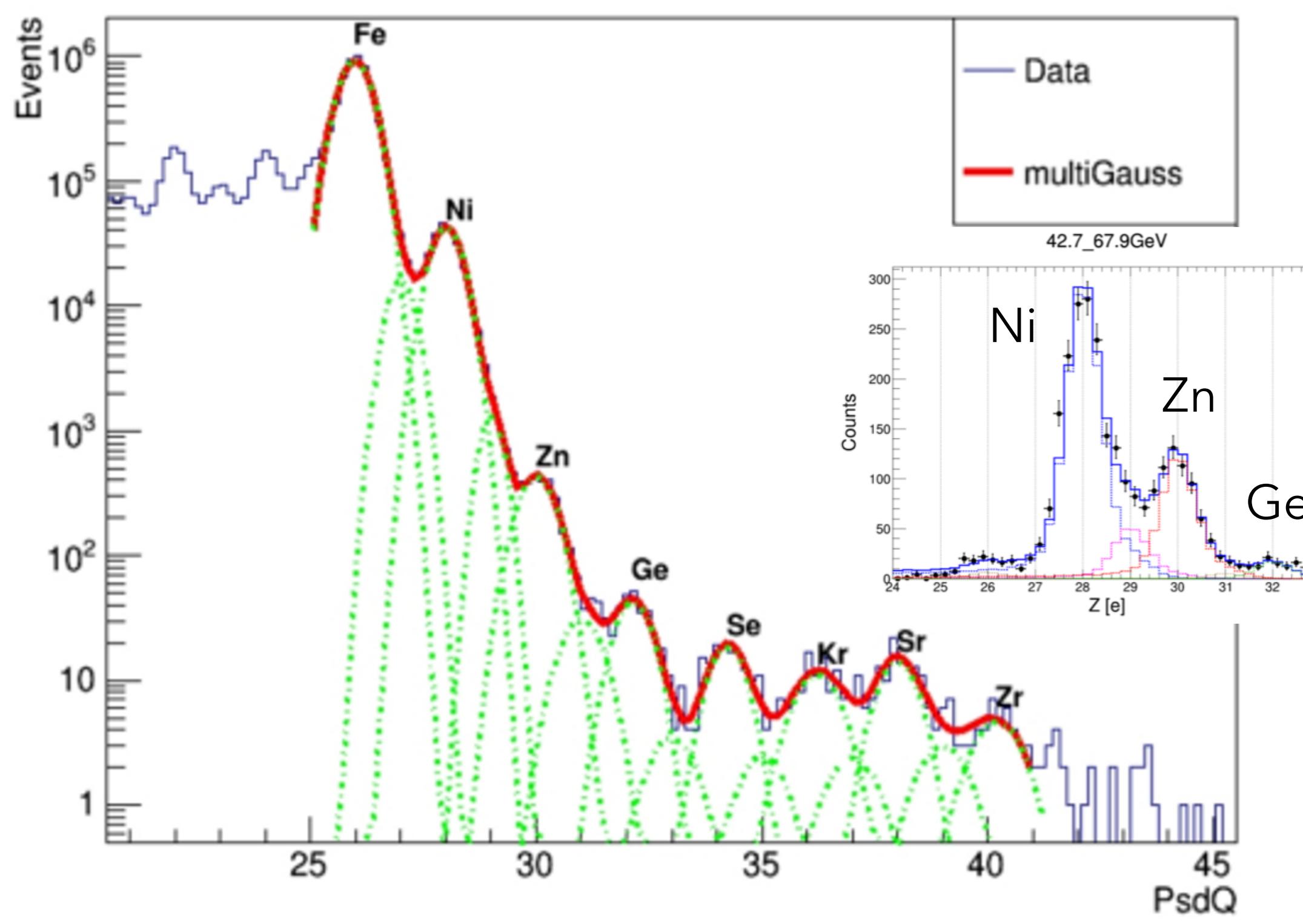


Ni/Fe ratio



Results of Nuclei beyond Iron

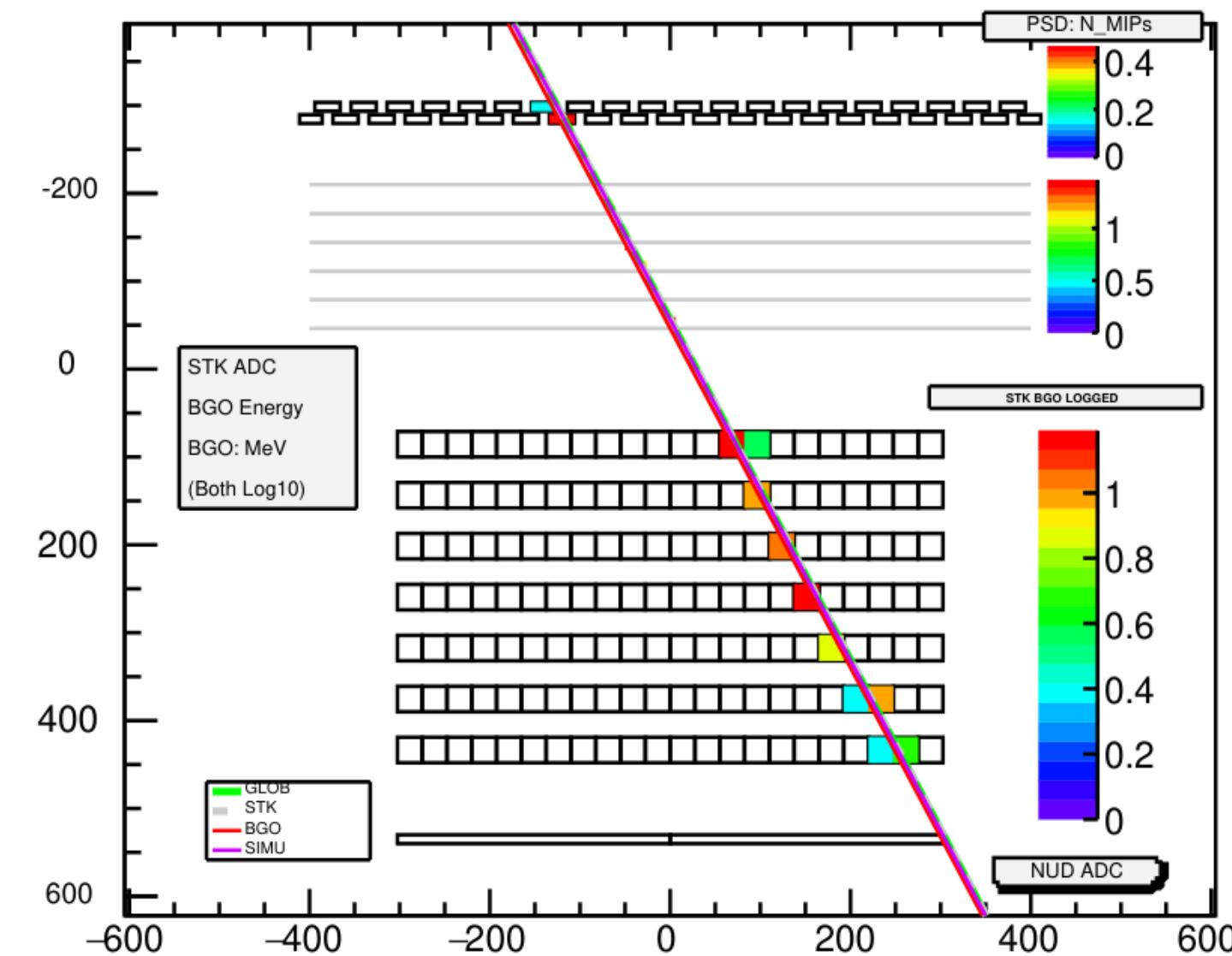
- Relative abundance of nuclei beyond iron (norm. to iron)
- Enhanced visibility of heavy nuclei peaks by suppressing iron and nickel



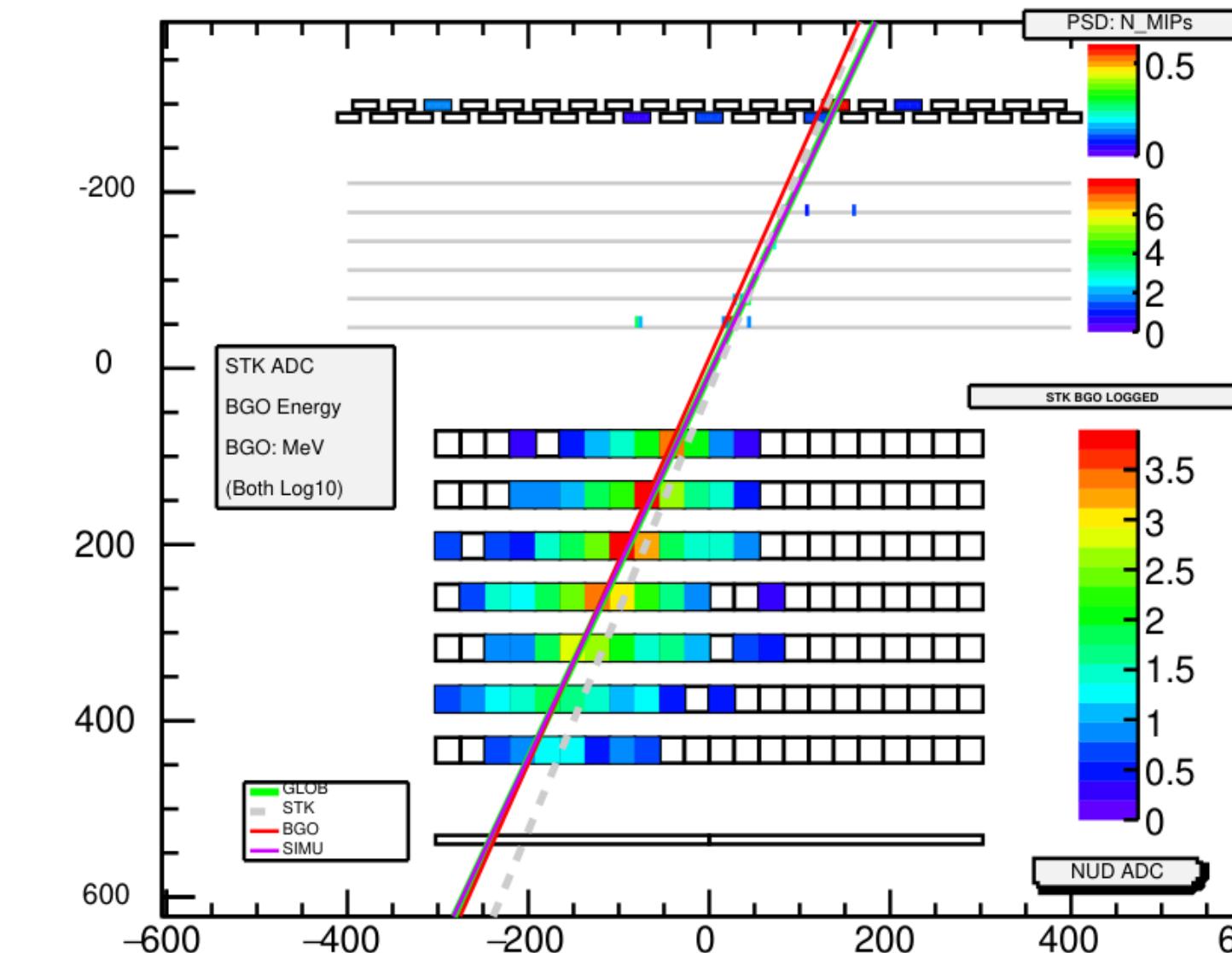
Search for Fractional Charged Particle

- **Motivation:** Do fractionally charged particles exist beyond the Standard Model? Could FCPs exist in cosmic rays?
- Low-energy cosmic-ray FCPs: absorbed in atmosphere/rock, detectable only in space.
- Search for FCPs under two mass hypotheses: light and heavy

Massive FCP

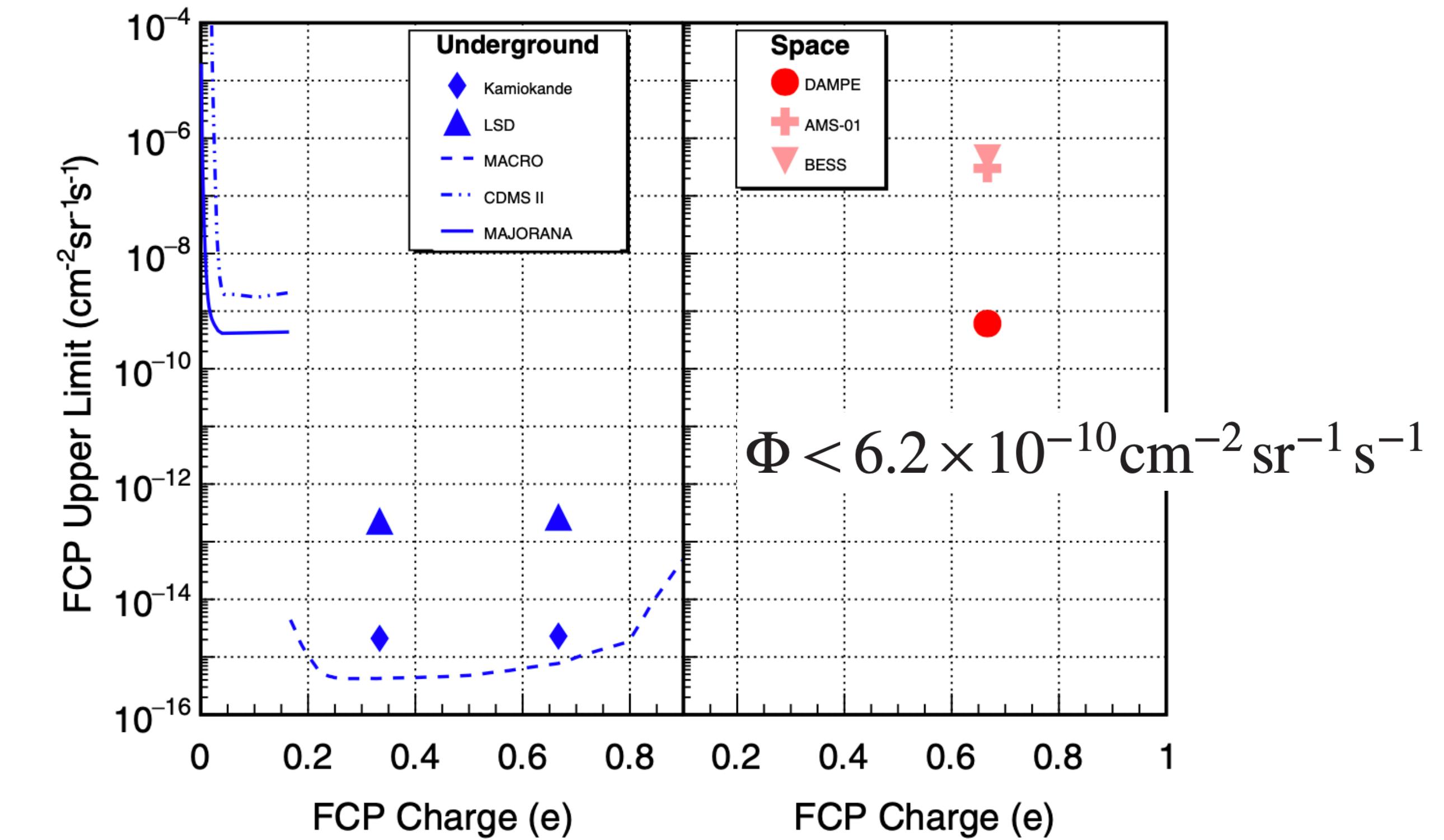
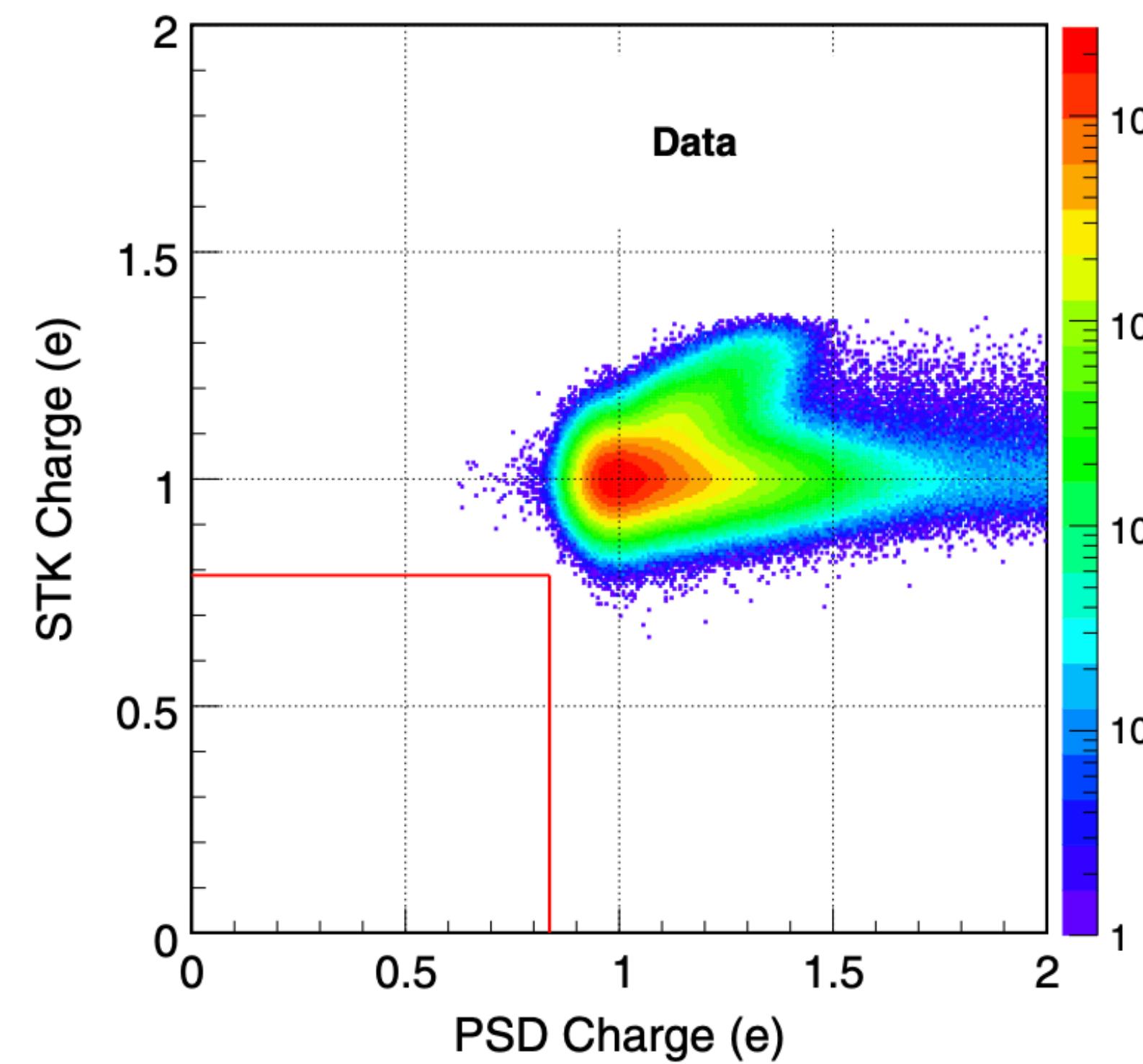


Light-mass FCP



Search for Fractional Charged Particle

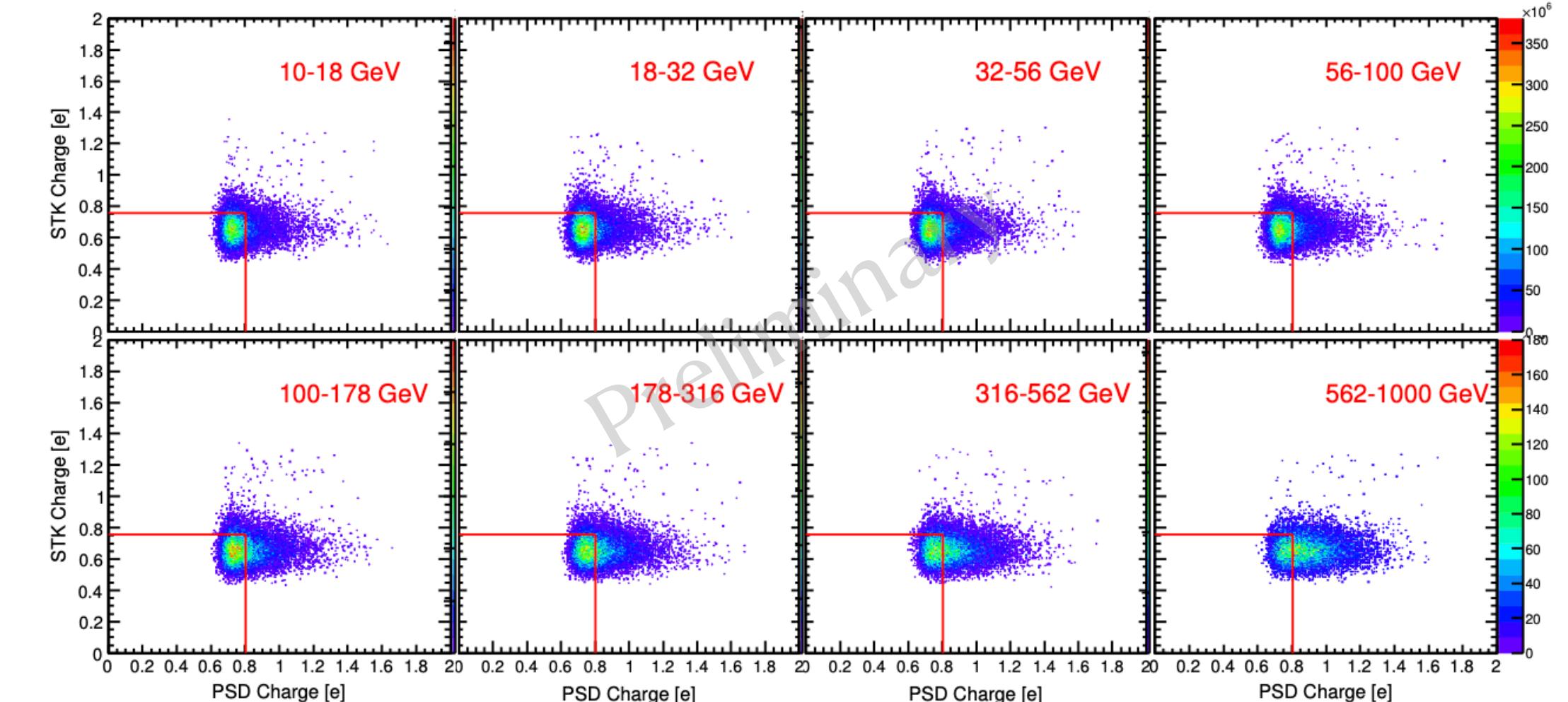
- With the massive FCP hypothesis, DAMPE achieves the **most stringent FCP flux constraint** in space



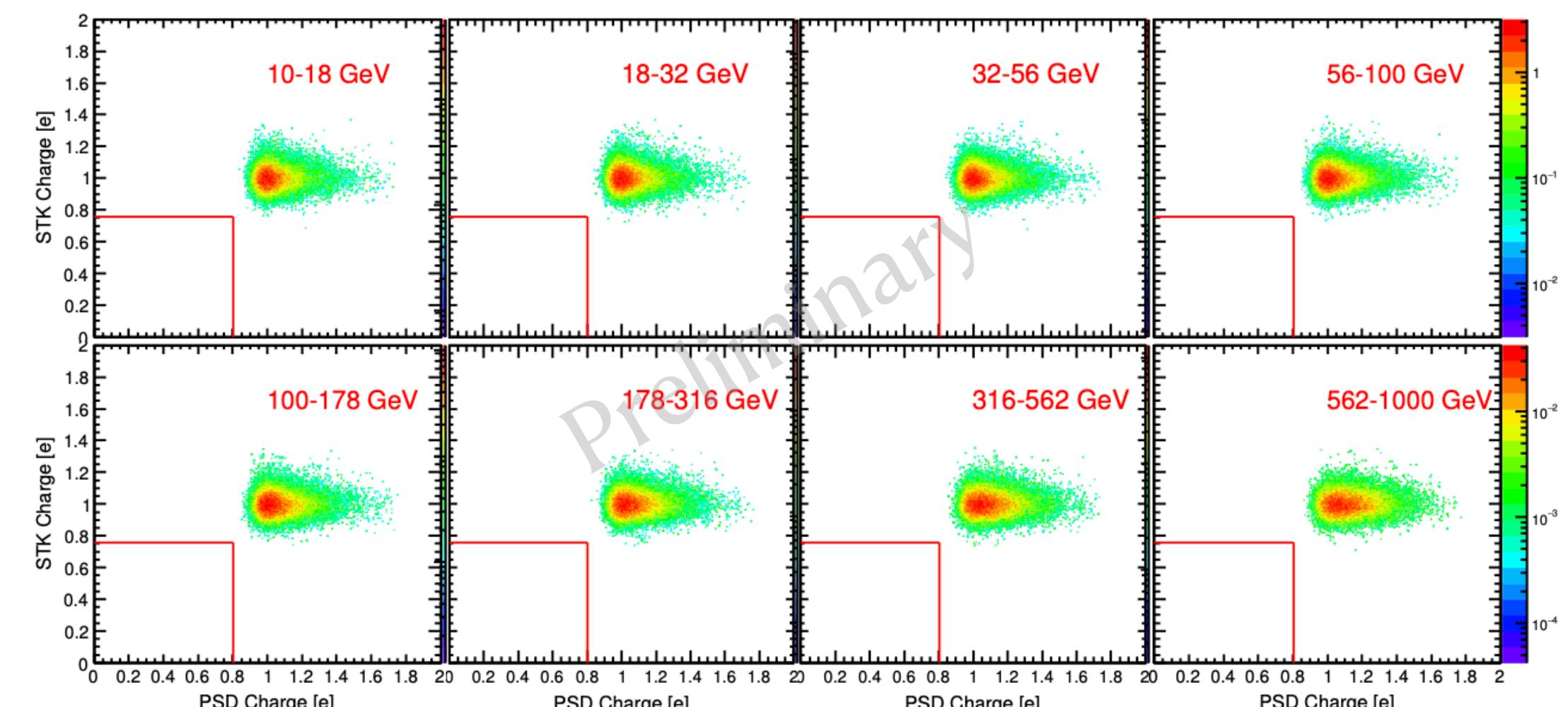
Search for Fractional Charged Particle

- With the light-mass FCP hypothesis, DAMPE can measure both charge and energy
- Mass assumption strongly influences results
- Analysis in progress ...

LFCP signal (MC)

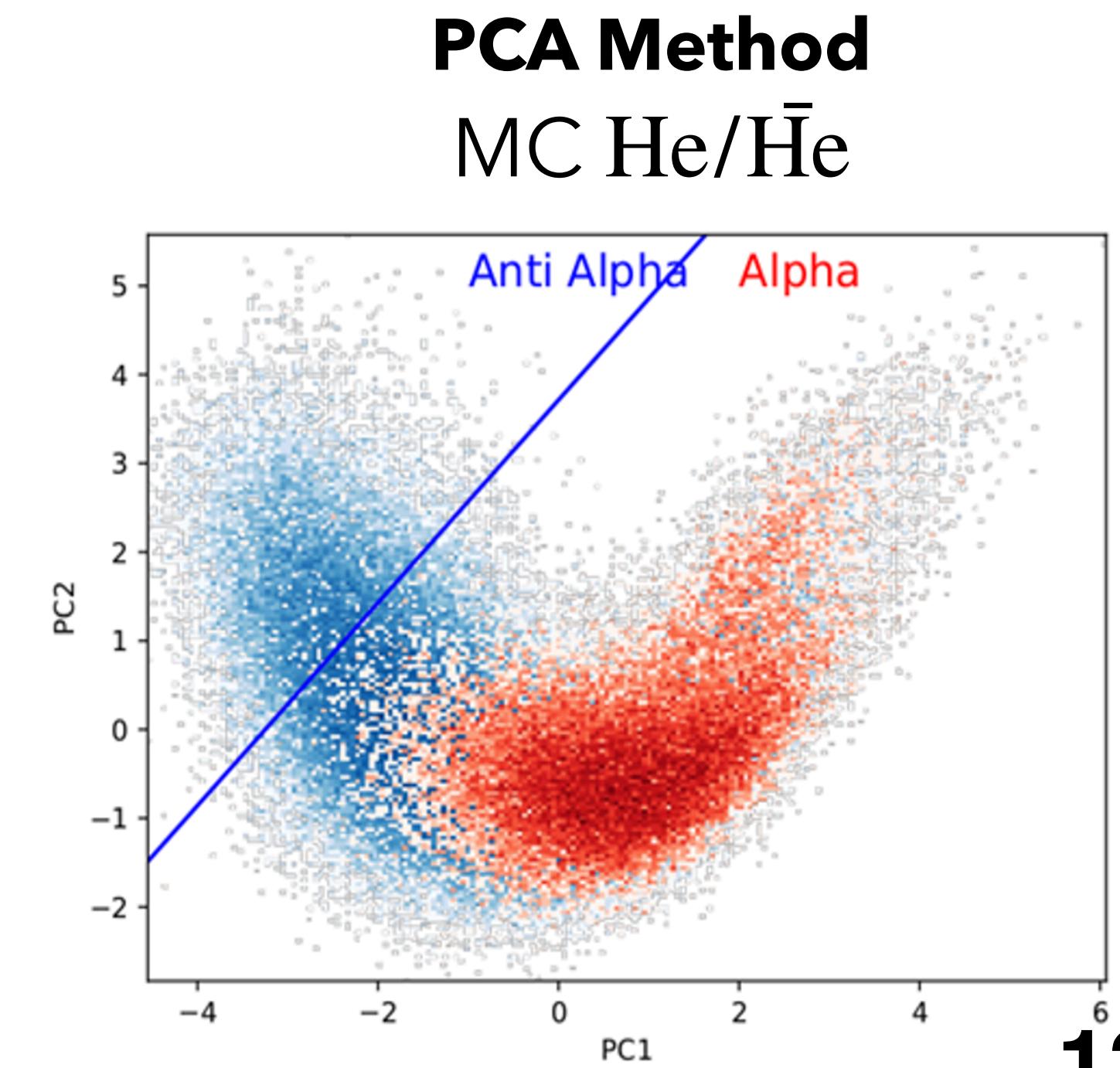
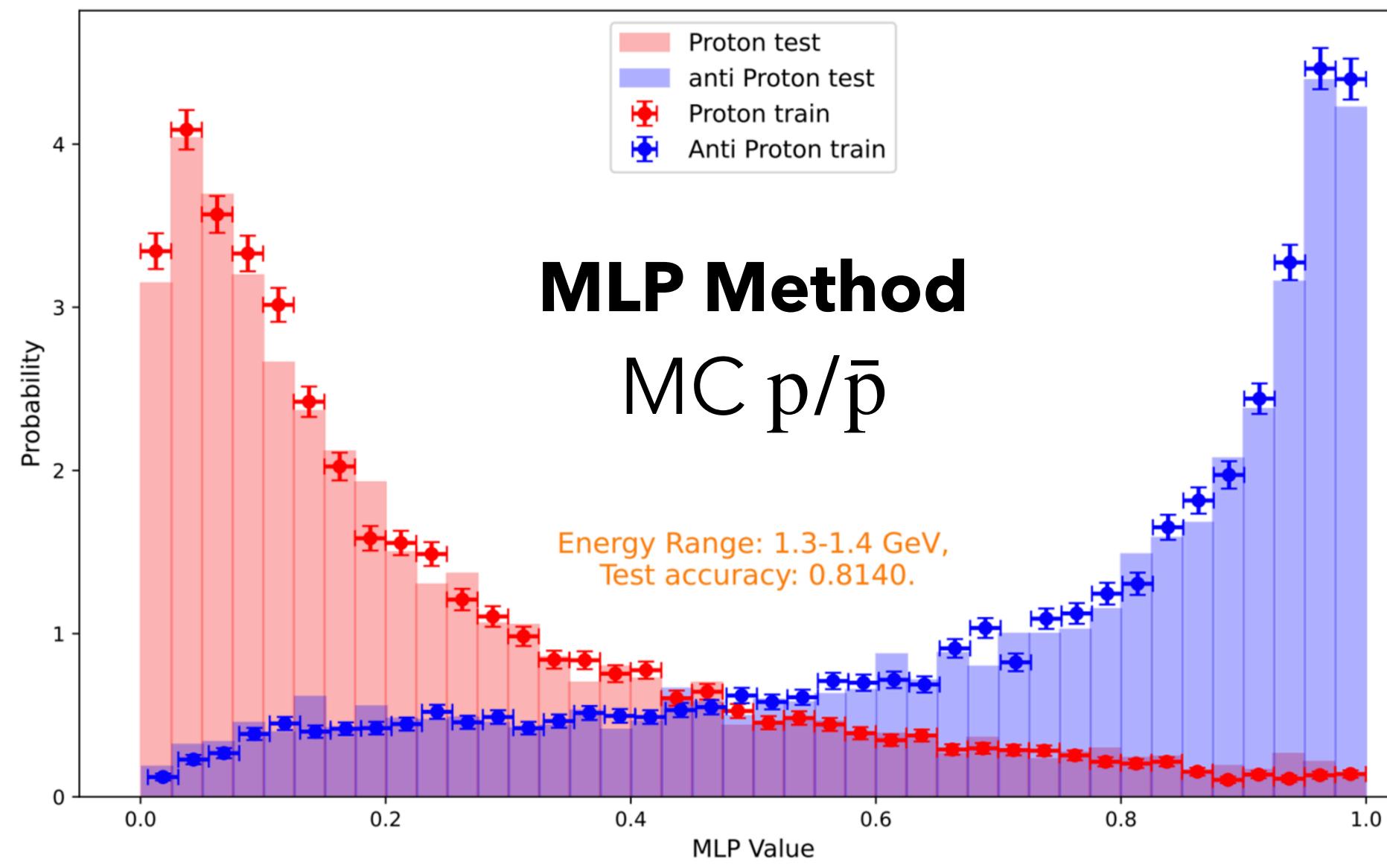
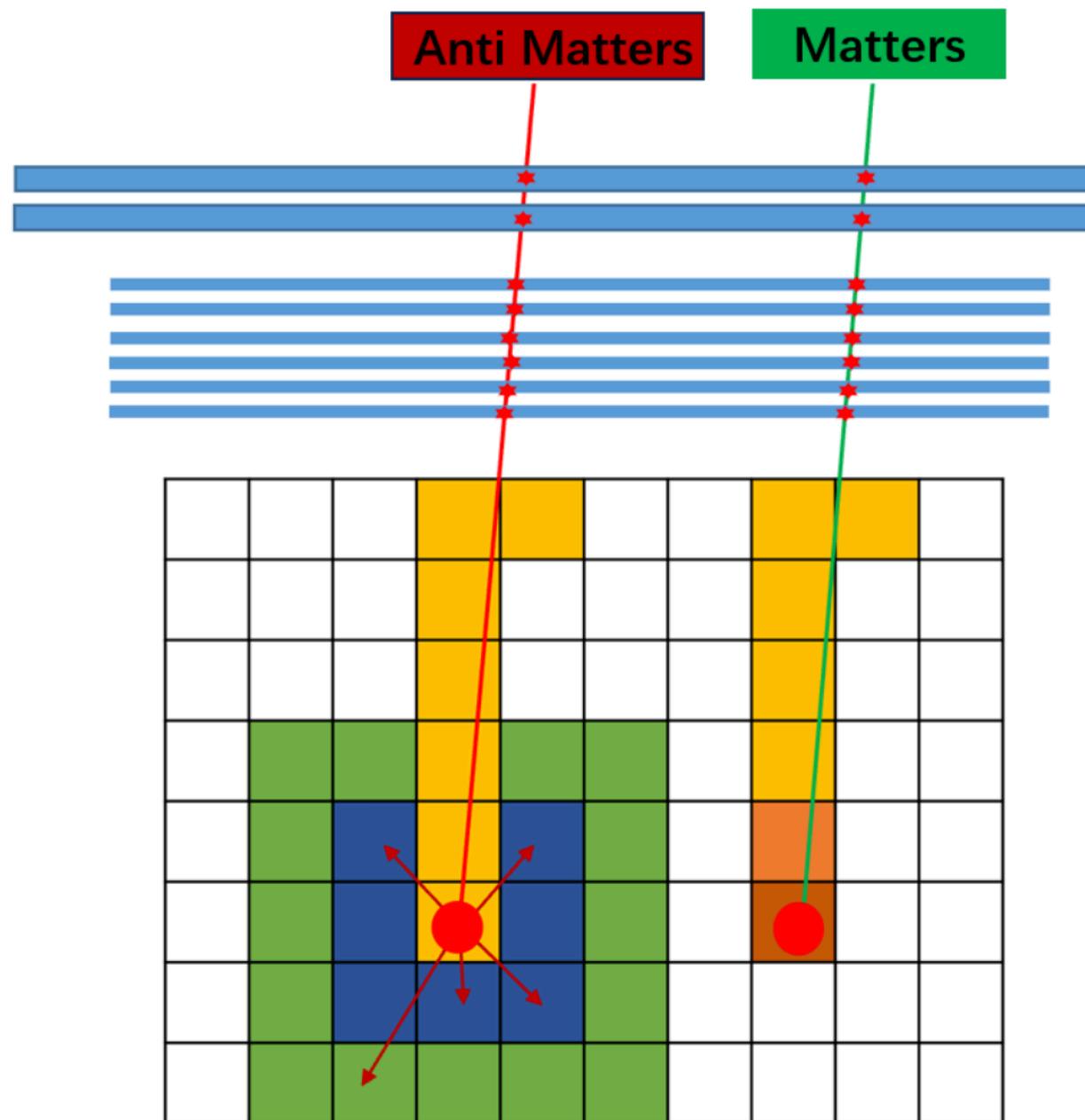


Electron background (MC)



Search for Anti-Matter

- **Motivation:** probing dark matter; testing matter-antimatter symmetry; studying cosmic ray propagation;...
- Method: Additional energy release due to matter-antimatter annihilation
- Target energy range: ~ 1 GeV



Summary

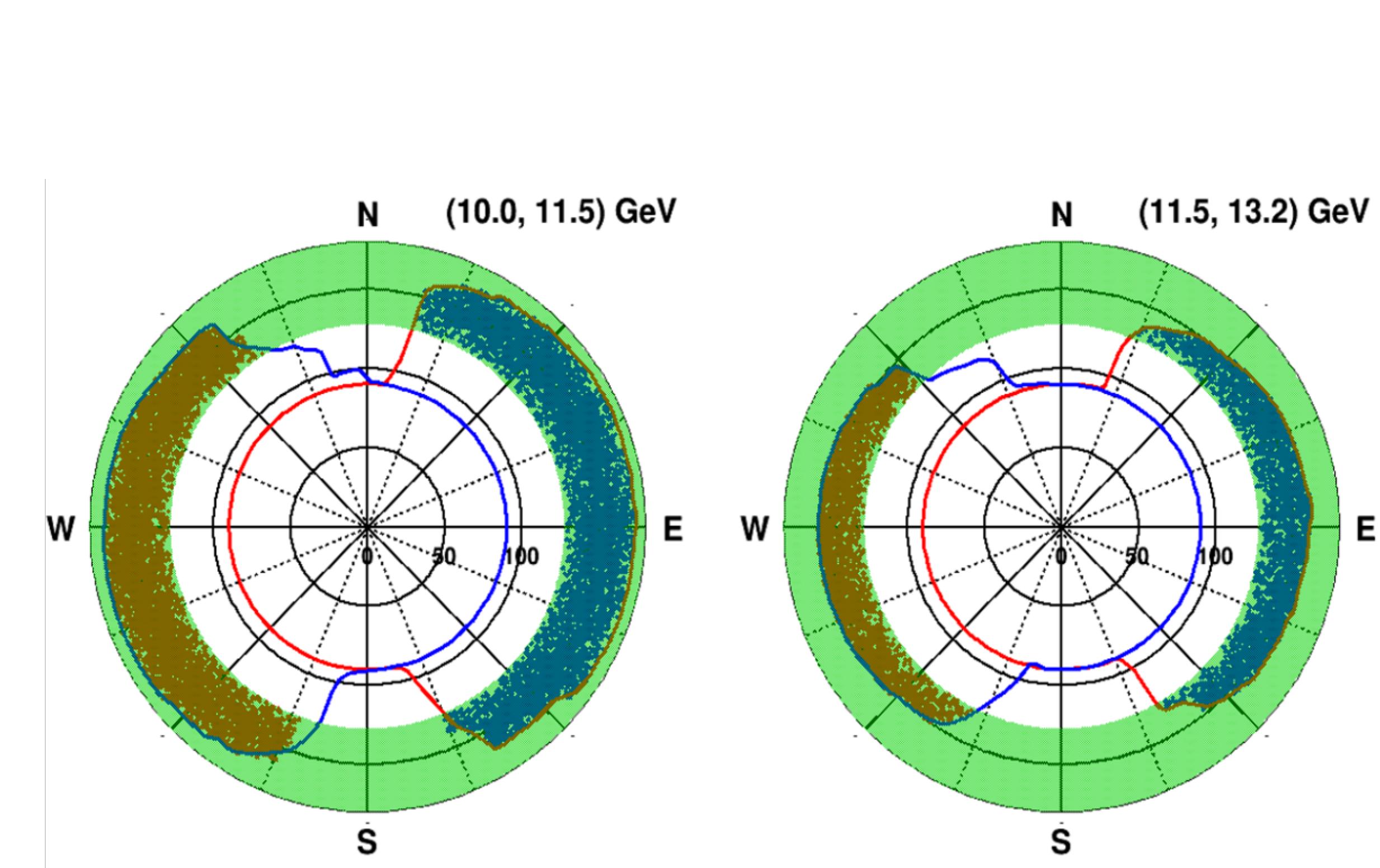
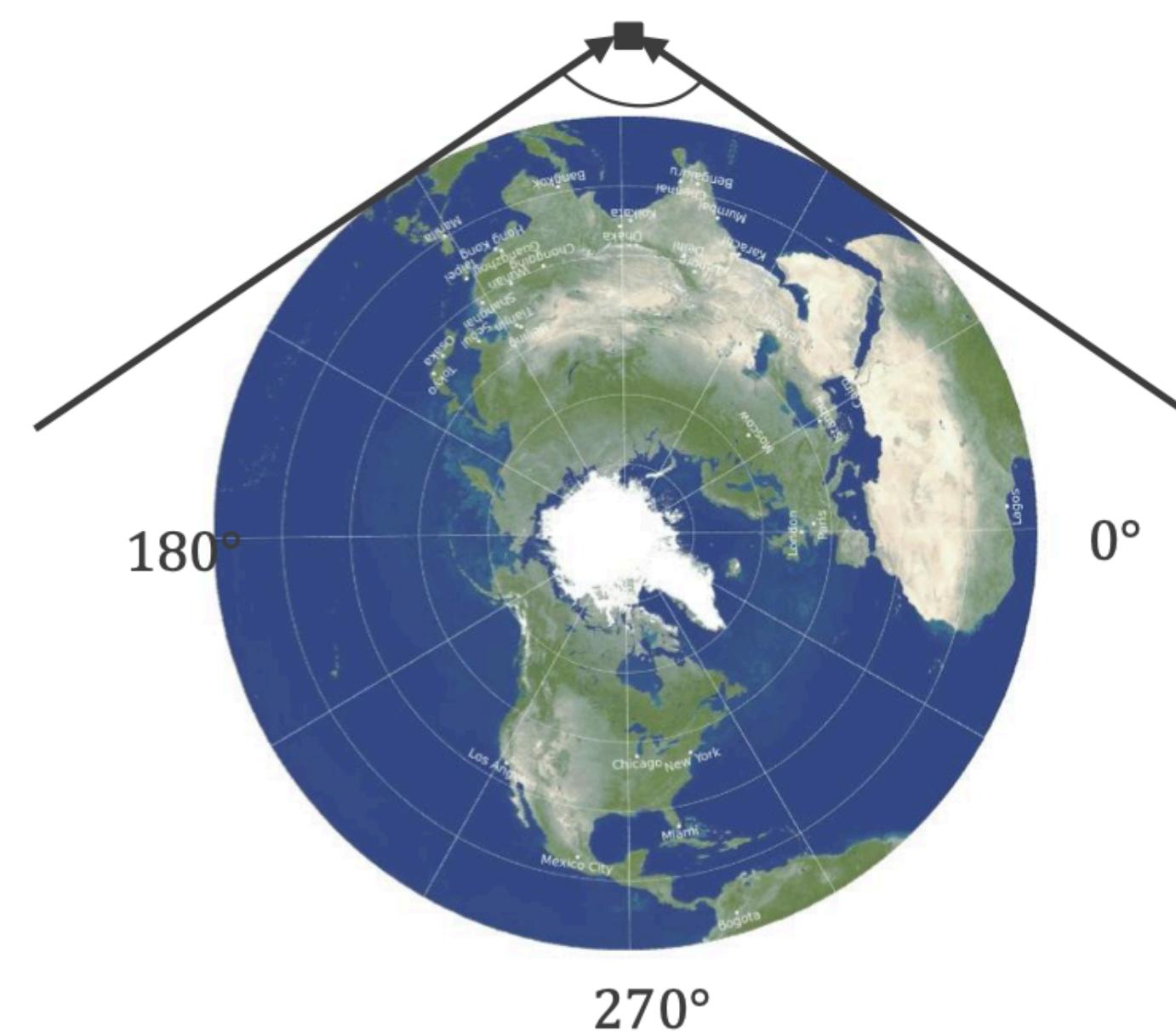
- DAMPE's ten years of operation have provided opportunities for detecting rare events and exotic particles
- Published results:
 - ✓ Separate e^+ and e^- fluxes
 - ✓ Upper limits on massive FCPs
- Submitted for publication:
 - Nickel flux measurement
- Ongoing studies:
 - Elements beyond nickel
 - LFCPs and other exotic particles
 - Anti-matter searches

Thank you !

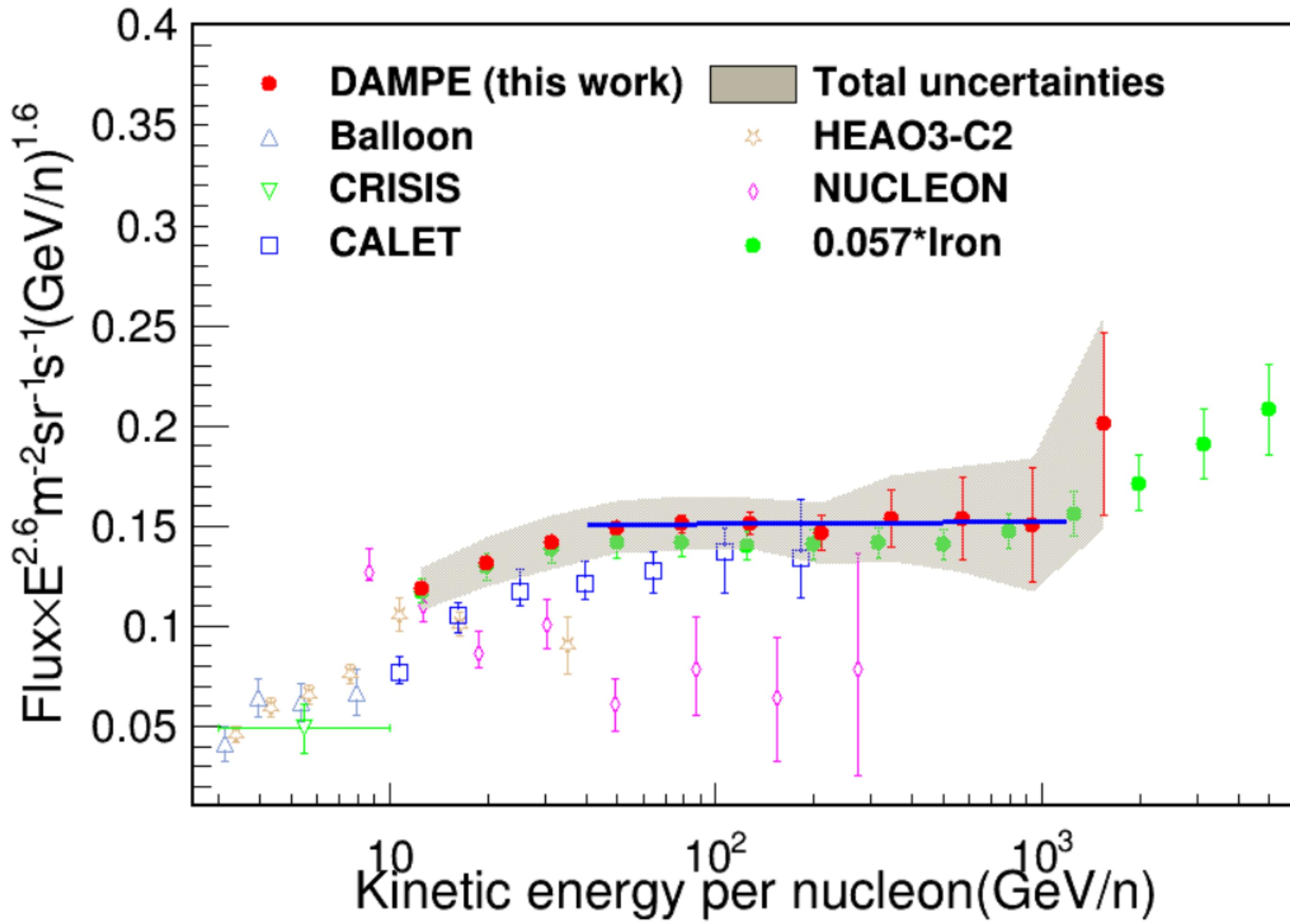
Backup

e⁺ / e⁻ Spectrum

- CR e⁺/e⁻ **discrimination** based on the **East-West effect** in the Geomagnetic field



Results of Nuclei beyond Iron



Search for Fractional Charged Particle

