



紫金山暗物质研讨会



The status and latest progresses of the DARK Matter Particle Explorer (DAMPE) space mission

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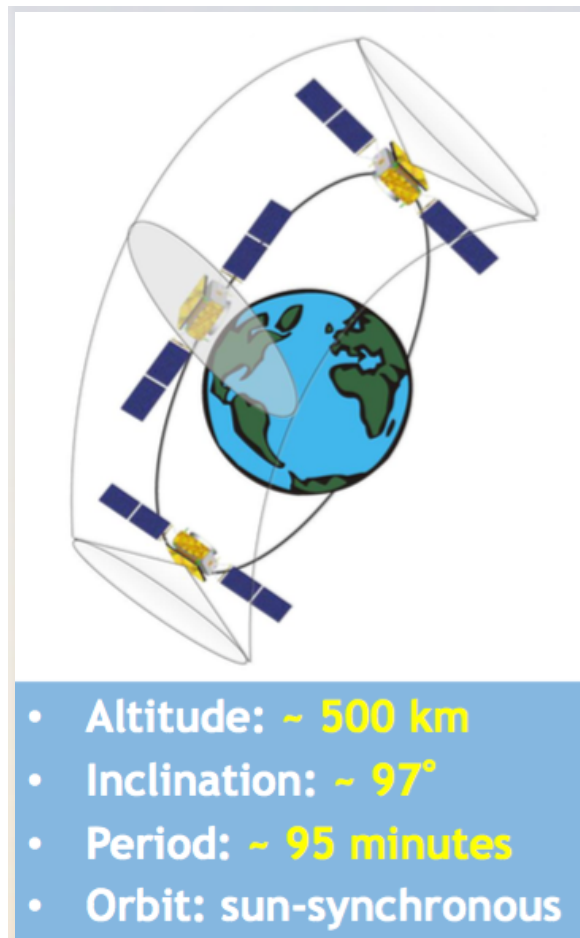
Purple Mountain Observatory, CAS
on behalf of the DAMPE Collaboration



2026/07/21, 新疆·乌鲁木齐

DAMPE collaboration

DAMPE (“Wukong” 悟空) is a satellite-borne particle detector proposed in the framework of the Strategic Pioneer Program on Space Science, promoted by the **Chinese Academy of Sciences (CAS)**



17th Dec. 2015
@Jiuquan



150+
members

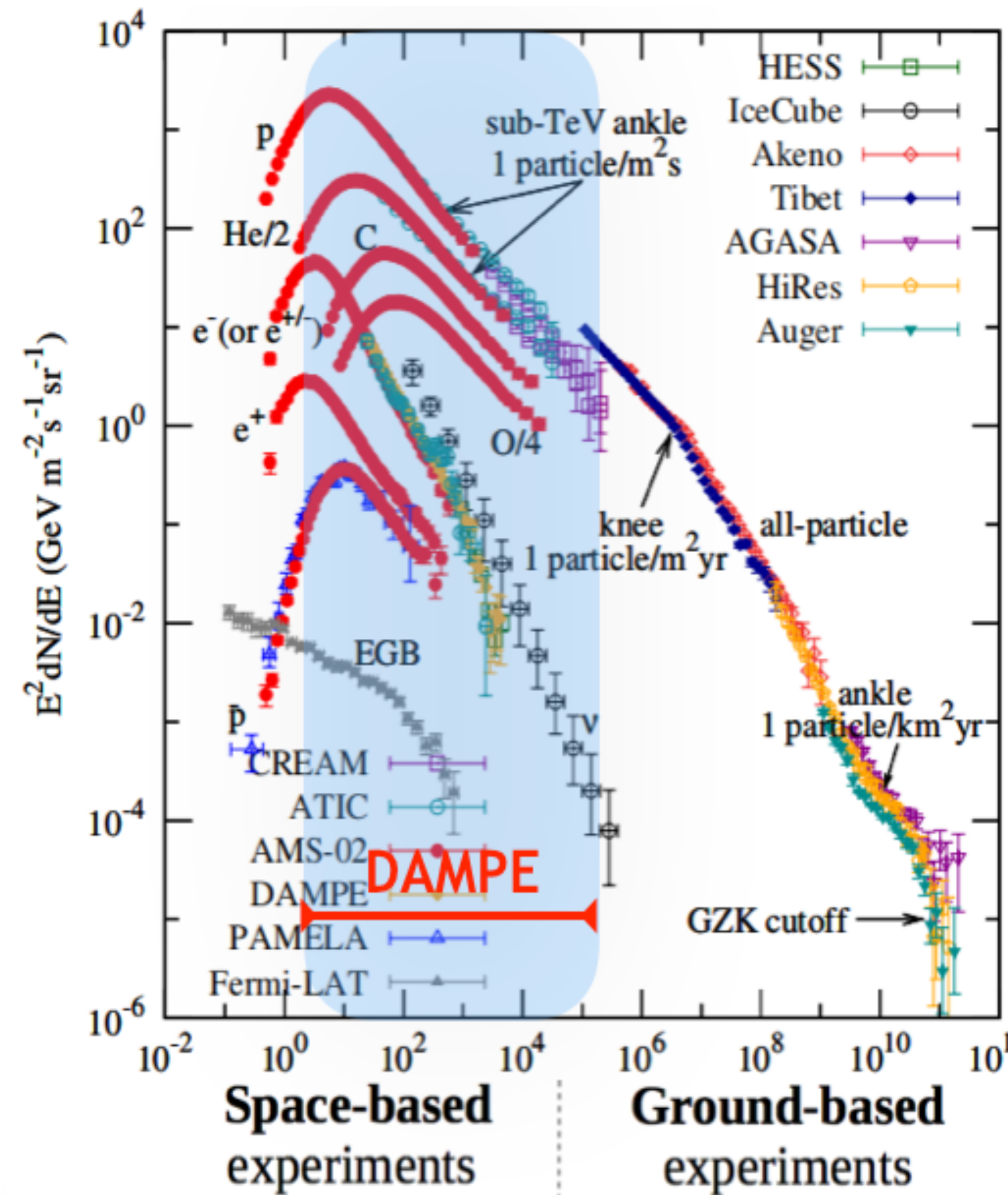
- CHINA
 - Purple Mountain Observatory, CAS, Nanjing
 - Institute of High Energy Physics, CAS, Beijing
 - National Space Science Center, CAS, Beijing
 - University of Science and Technology of China, Hefei
 - Institute of Modern Physics, CAS, Lanzhou
- ITALY
 - INFN Perugia and University of Perugia
 - INFN Bari and University of Bari
 - INFN Lecce and University of Salento
 - INFN LNGS and Gran Sasso Science Institute
- SWITZERLAND
 - University of Geneva

Outline

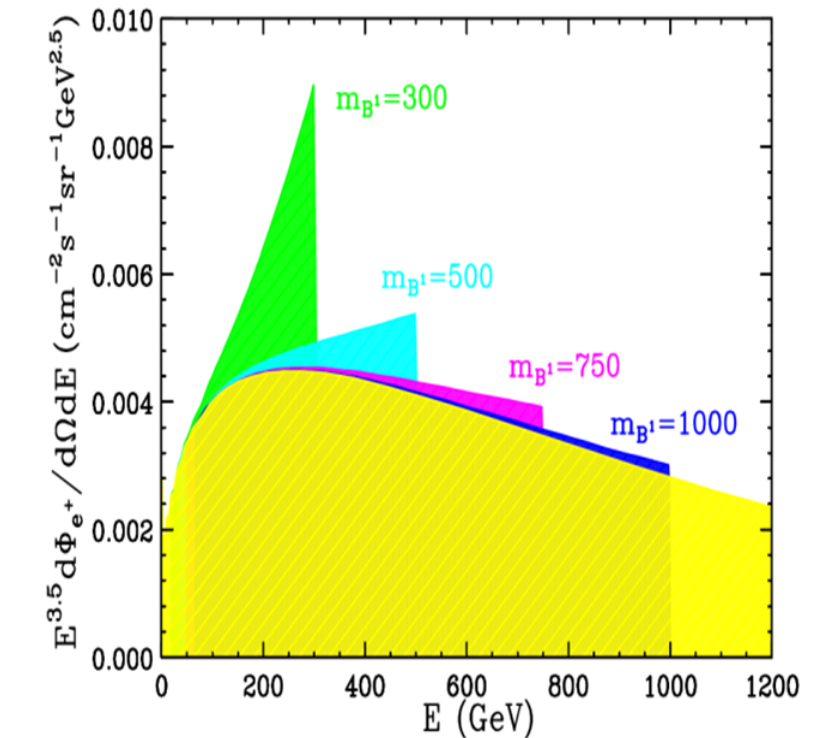
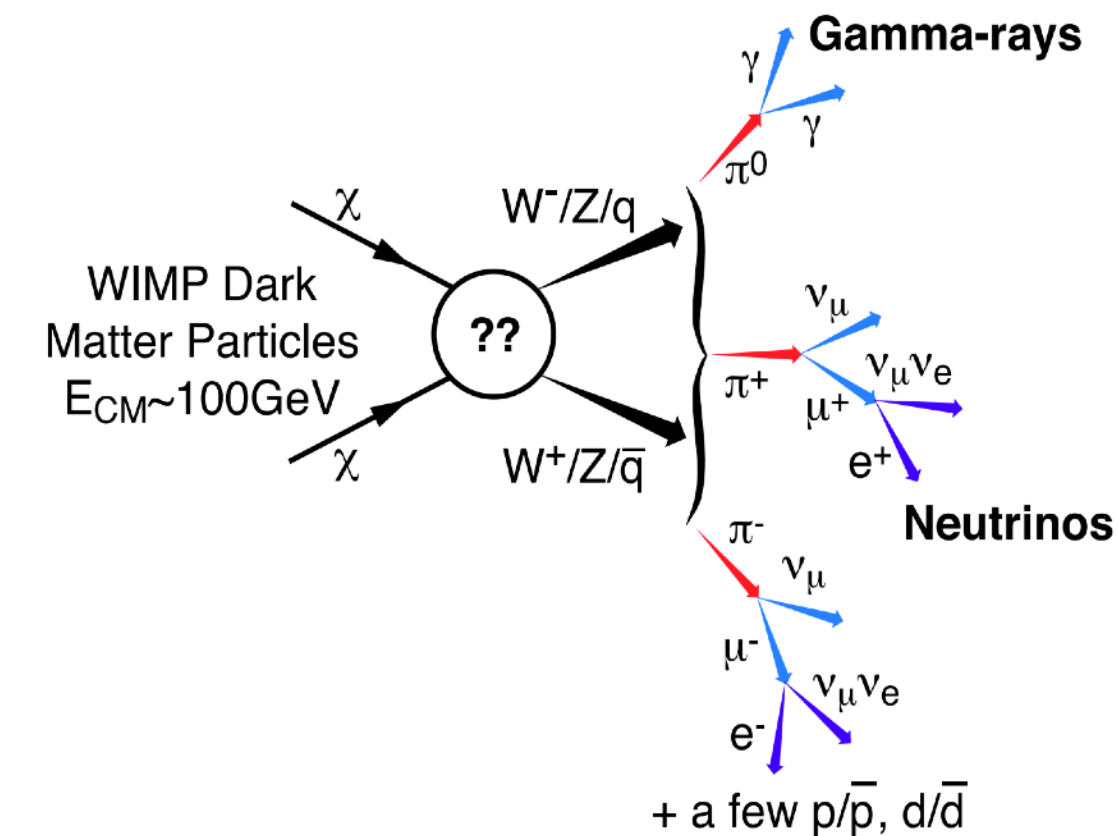
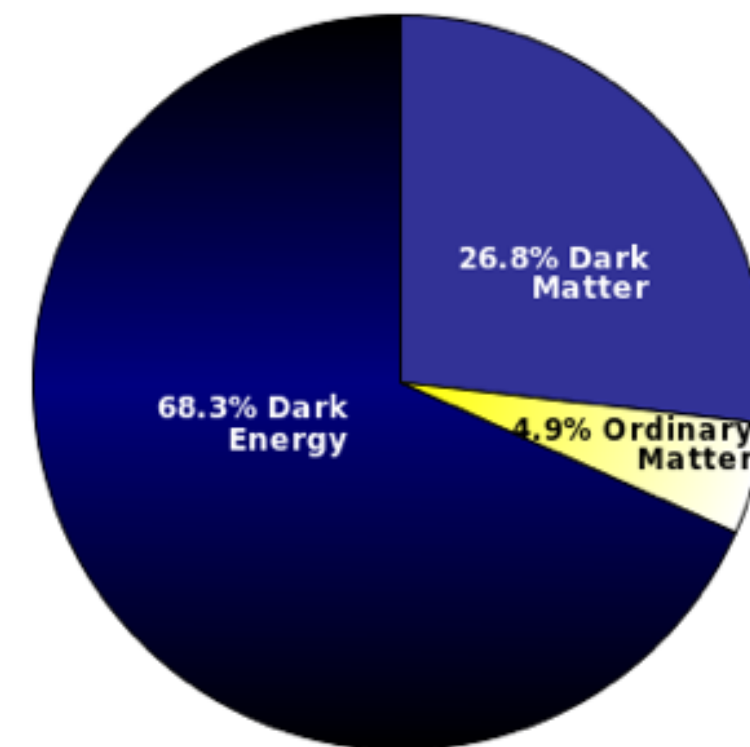
- **DAMPE mission**
- **On-orbit operation with DAMPE**
- **Scientific progresses of DAMPE**
- **Summary**



Cosmic-ray physics

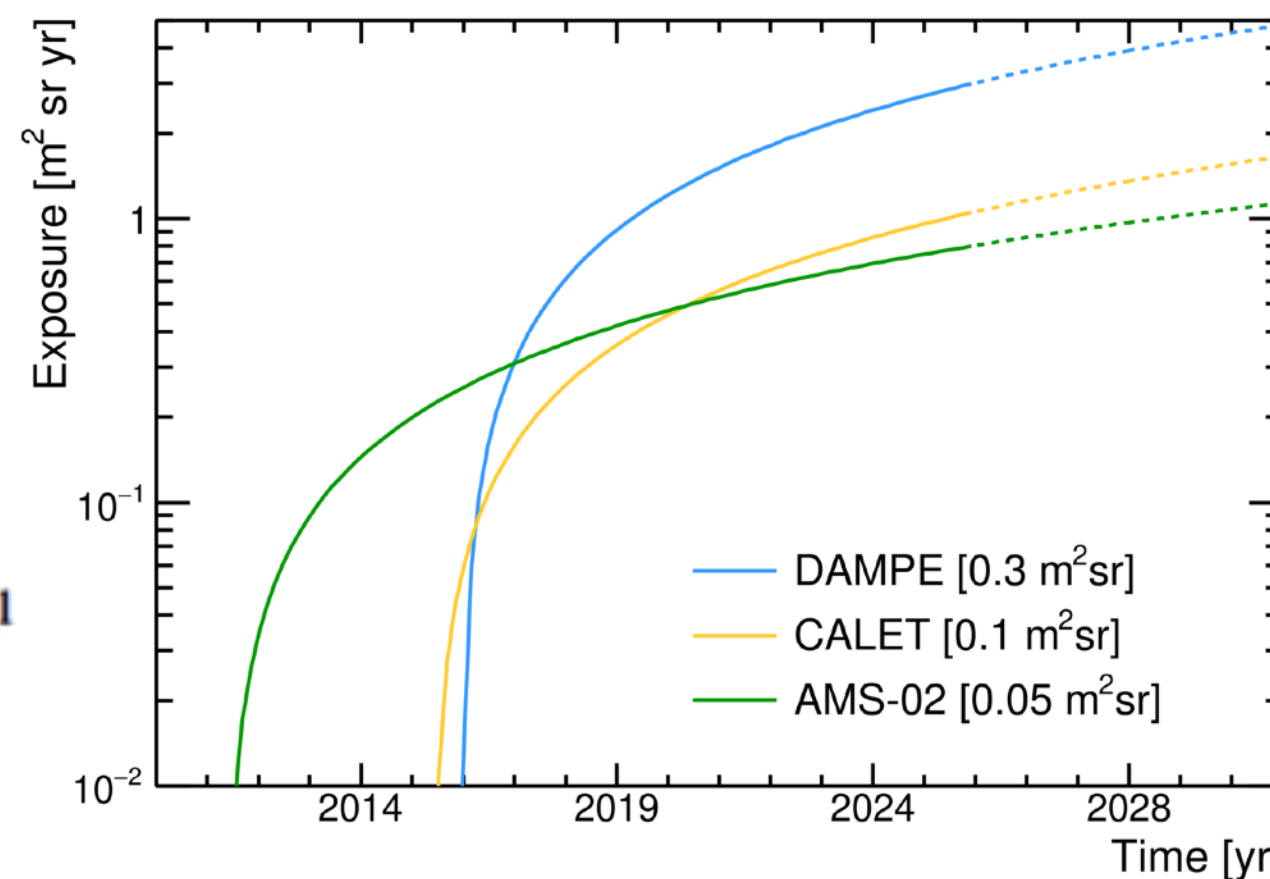
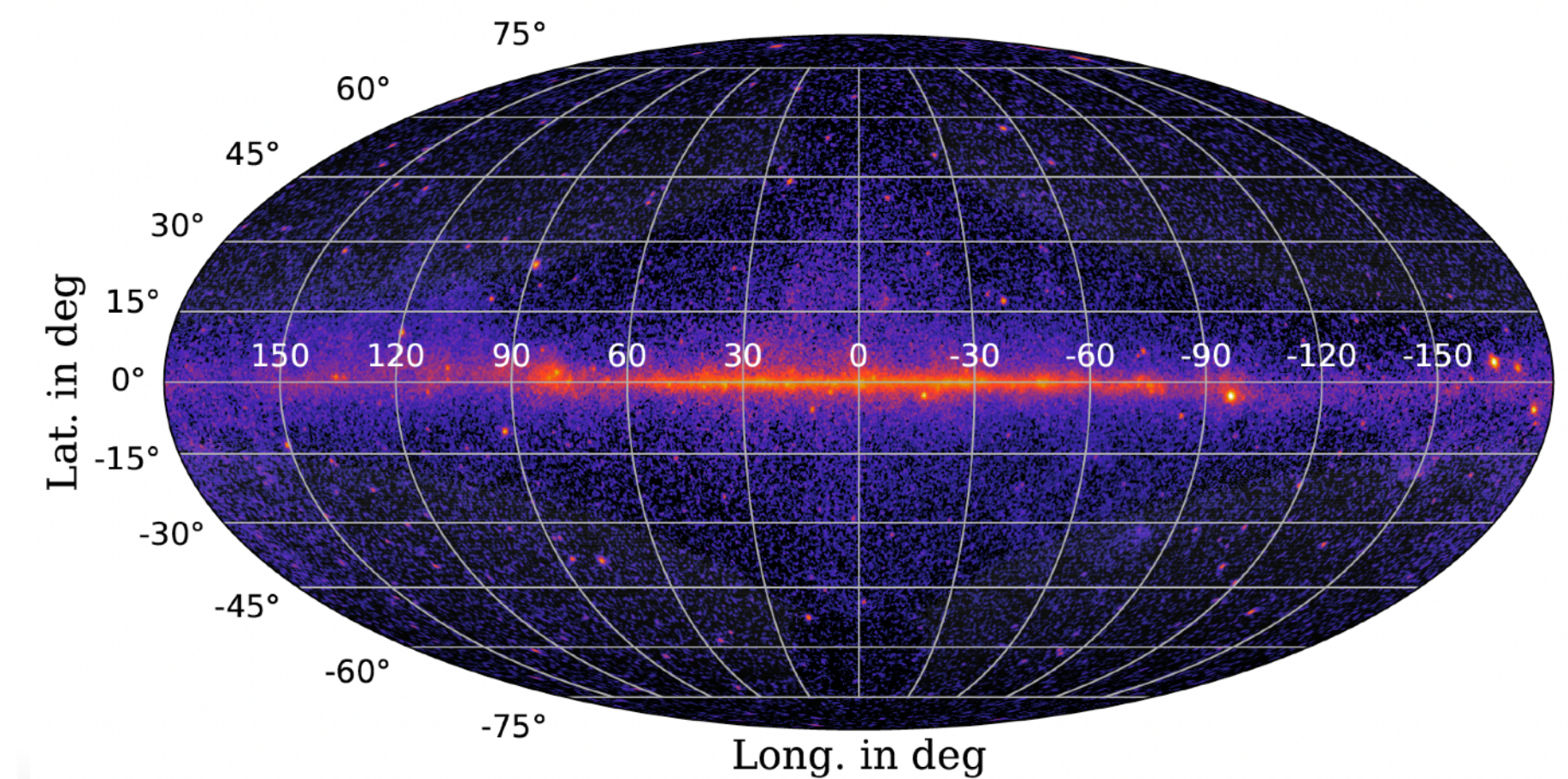


Indirect DM detection



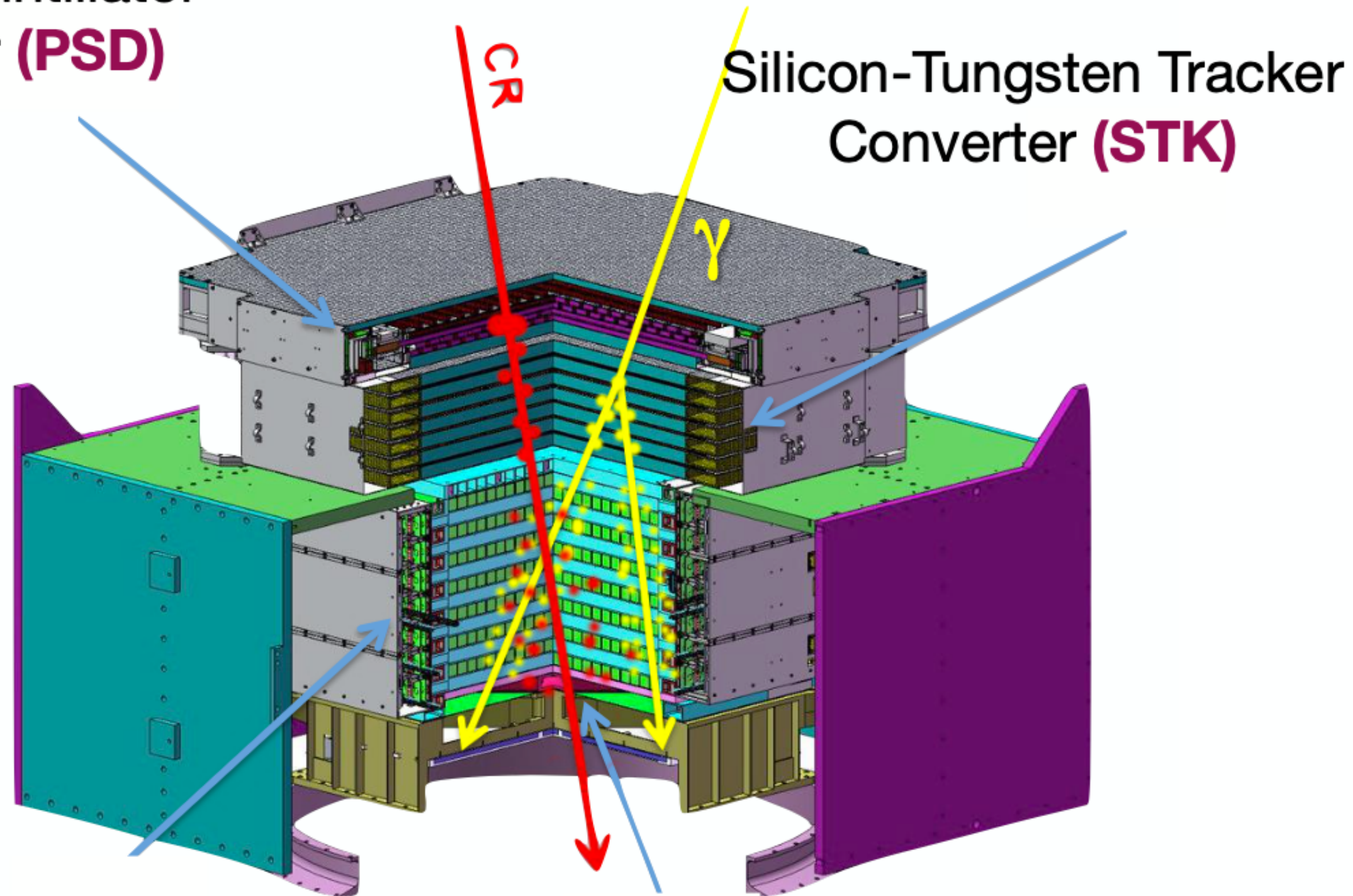
Gamma-ray astronomy

Flux map with 9 years of DAMPE flight data



DAMPE detector

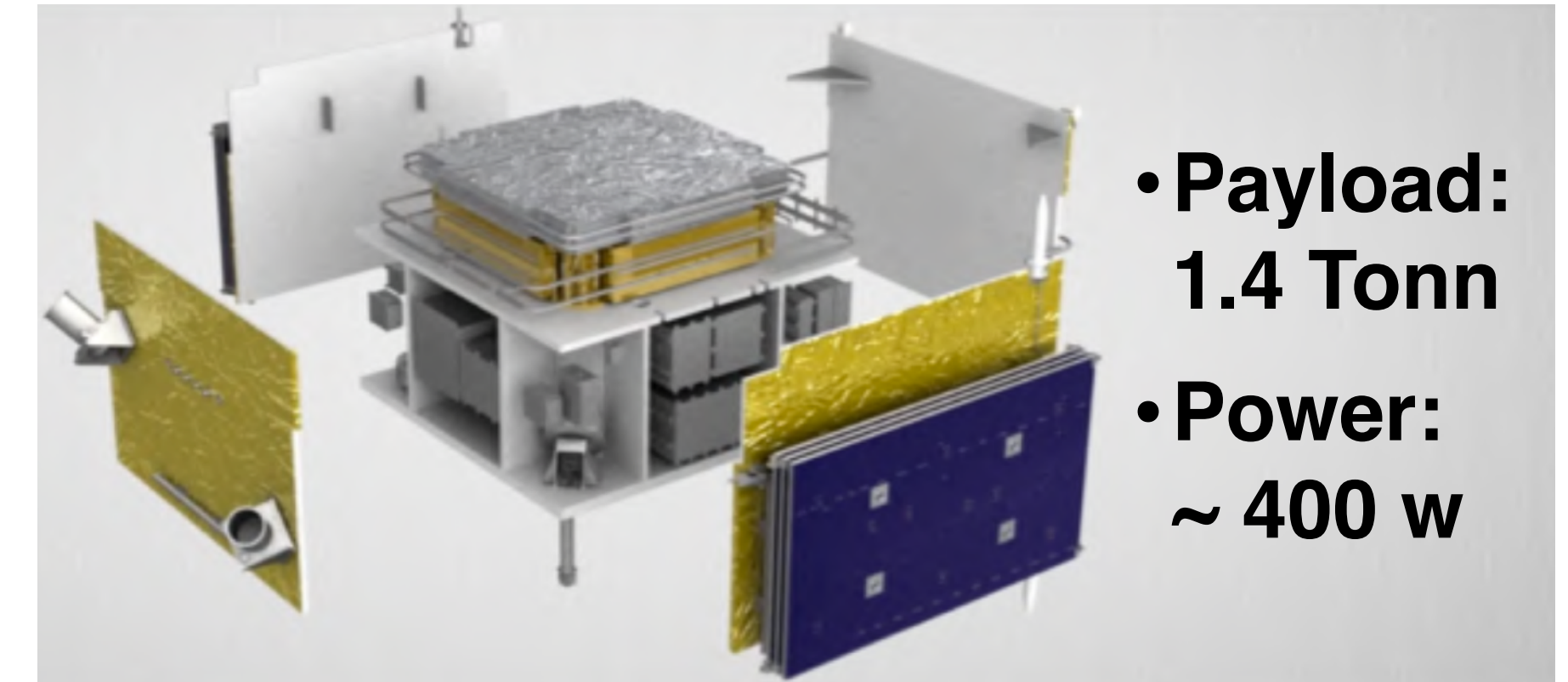
Plastic Scintillator
Detector (**PSD**)



Calorimeter (**BGO**)

Neutron Detector (**NUD**)

- PSD: Charge measurement via dE/dx , ACD for photons
- STK: Track, charge, and photon converter
- BGO: Energy measurement, particle (e/p) identification
- NUD: Additional e/p identification in high energy range



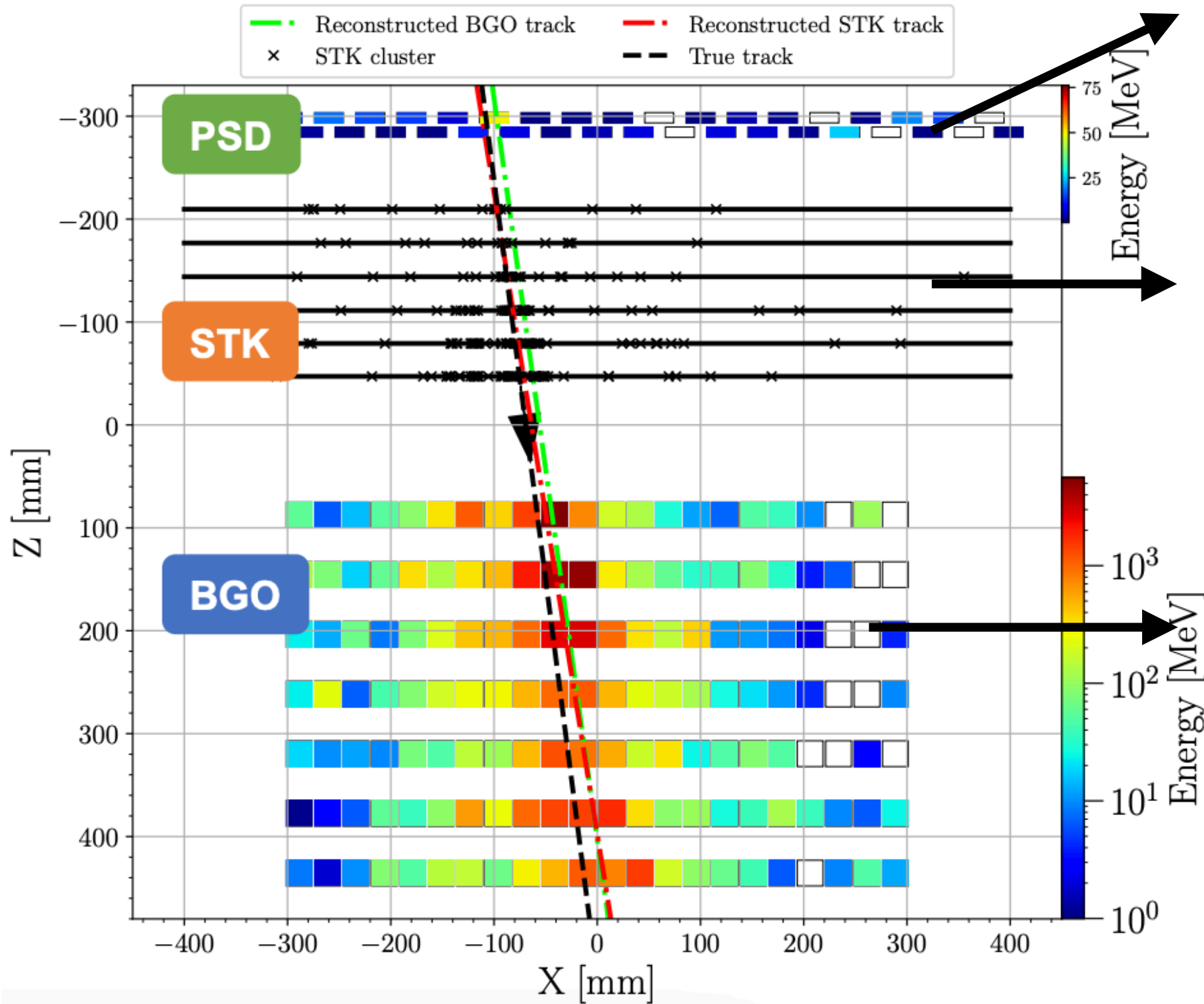
• Payload:
1.4 Tonn

• Power:
~ 400 w

Parameter	Value
Energy range (e/ γ)	5 GeV to 10 TeV
Energy resolution (e/ γ)	1.5% at 800 GeV
Energy range (p/ion)	50 GeV to 500 TeV
Energy resolution (p)	40% at 800 GeV
Geometric factor (e)	0.3 m ² sr above 30 GeV
Angular resolution (γ)	0.1 degree at 100 GeV
Field of view	1.0 sr

Particle detection of DAMPE

A shower event

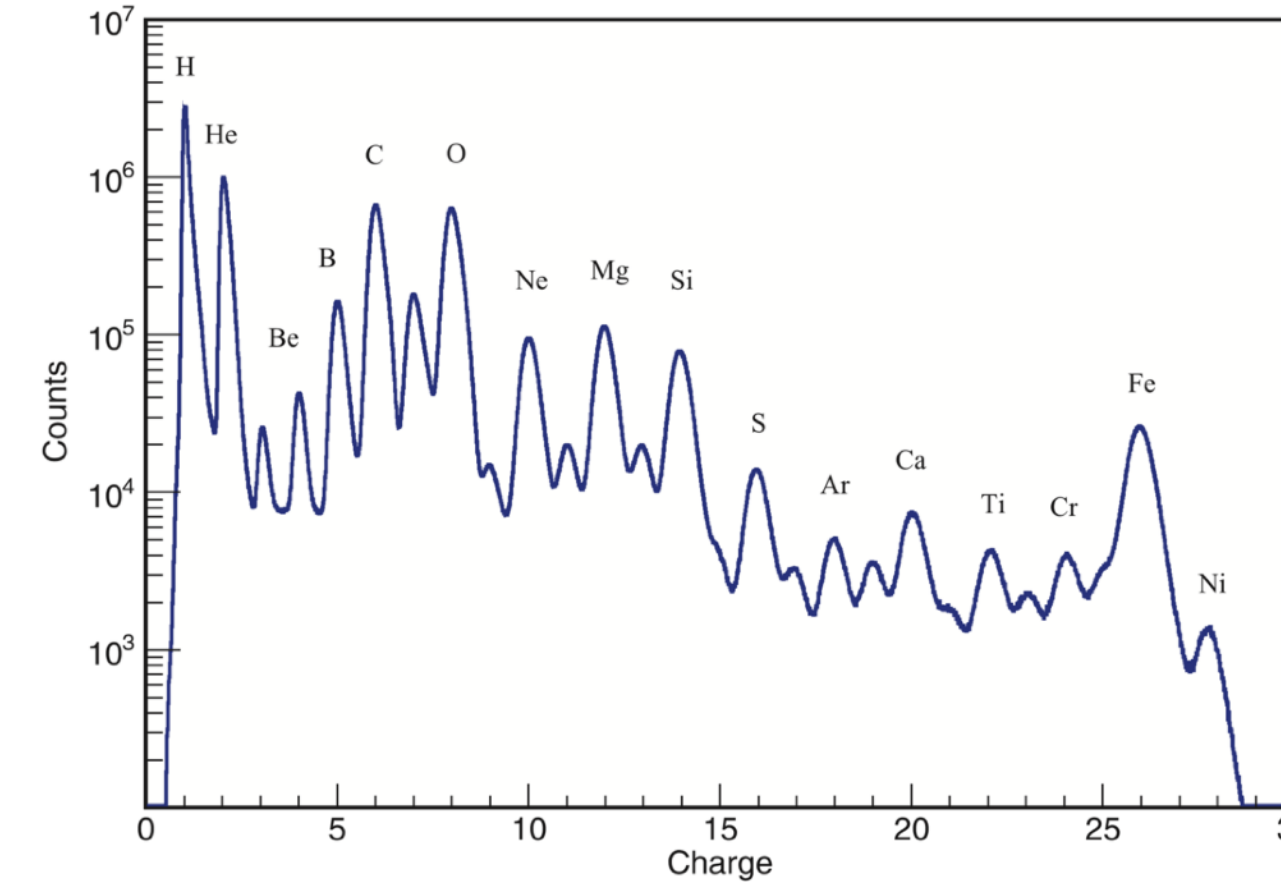


Charge
Measurement

Track
Measurement

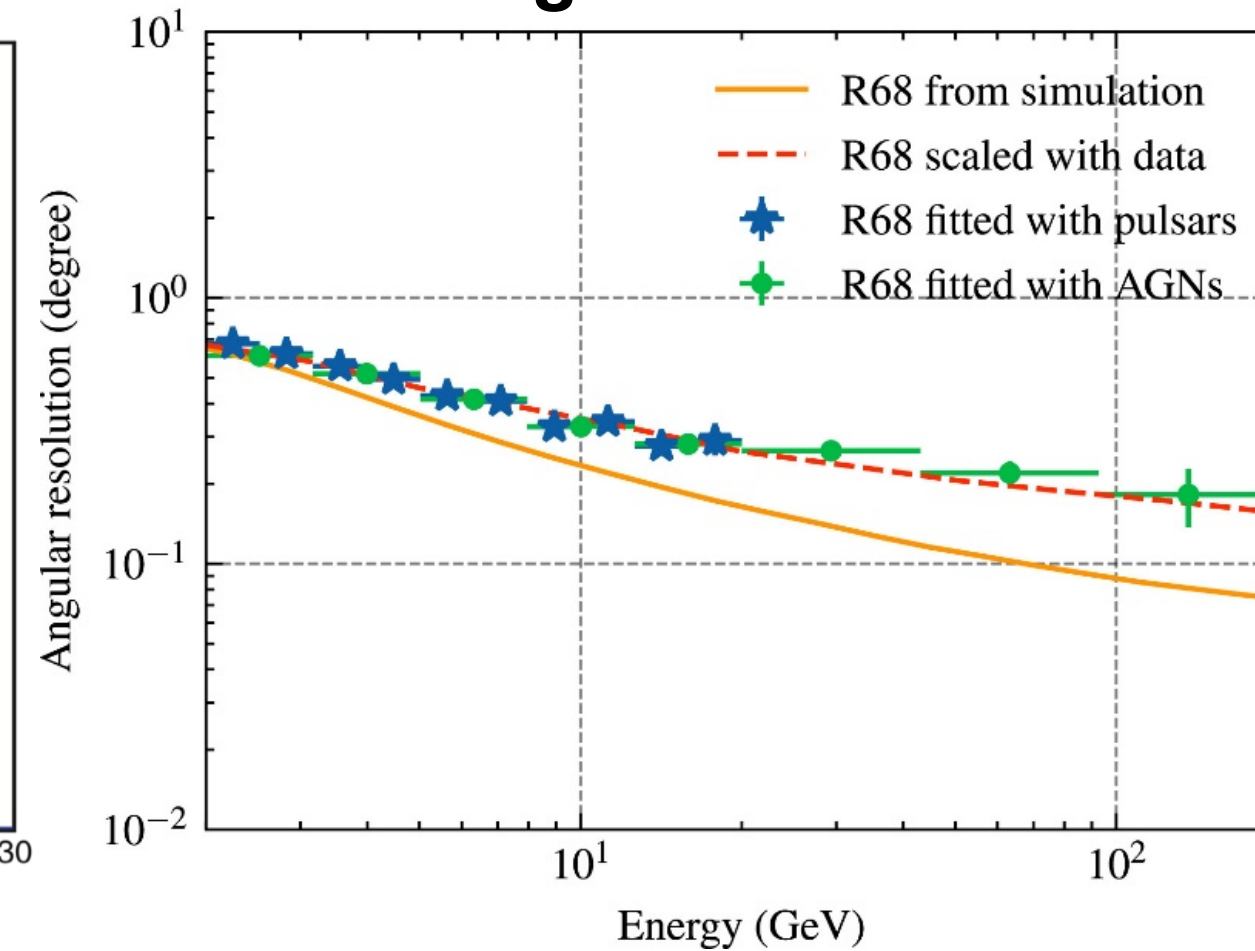
Energy
Measurement

Charge distribution



T. Dong et al., Astropart. Phys. 105 (2019)

Angular resolution

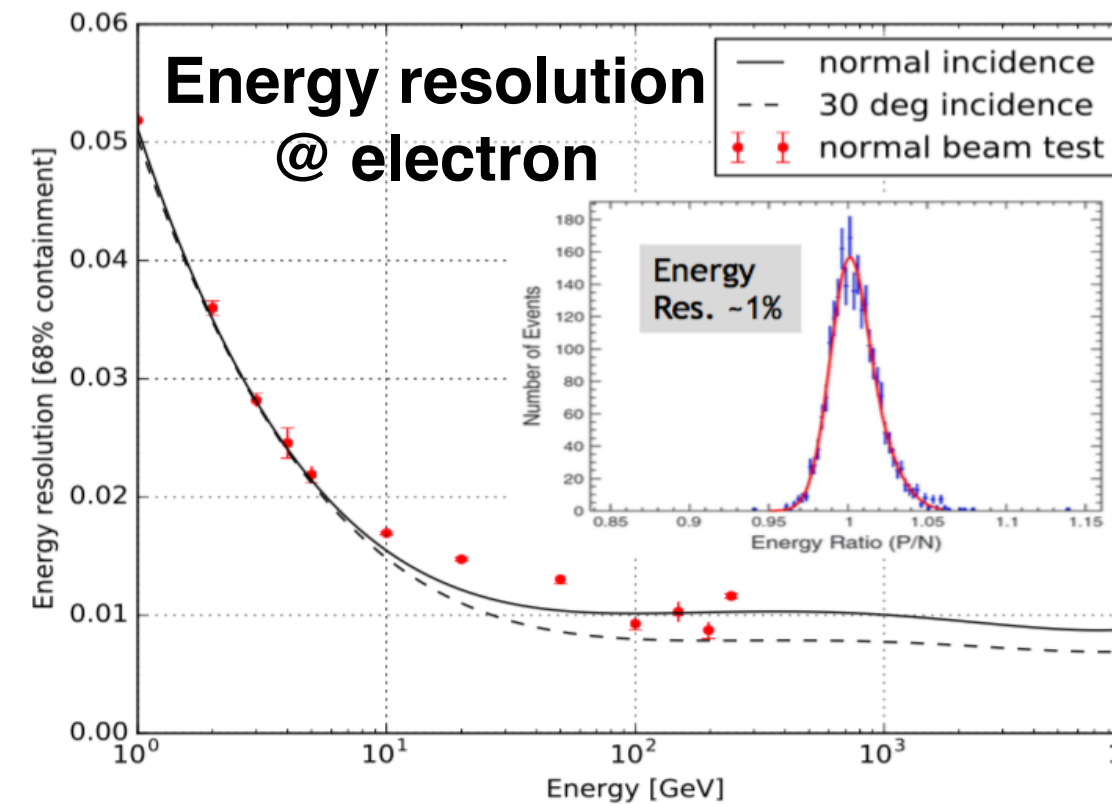


K. Duan et al., Astropart. Phys. 165 (2025)

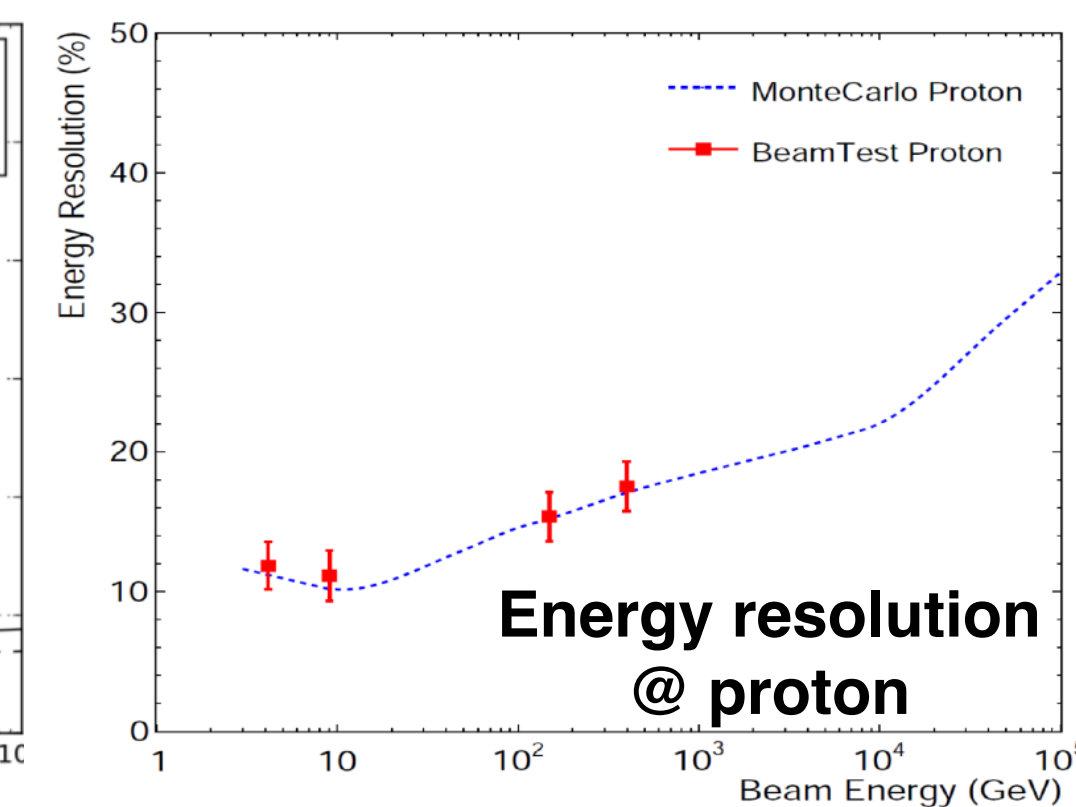
BGO Cal. depth:

~ 32 X_0 (radiation length)

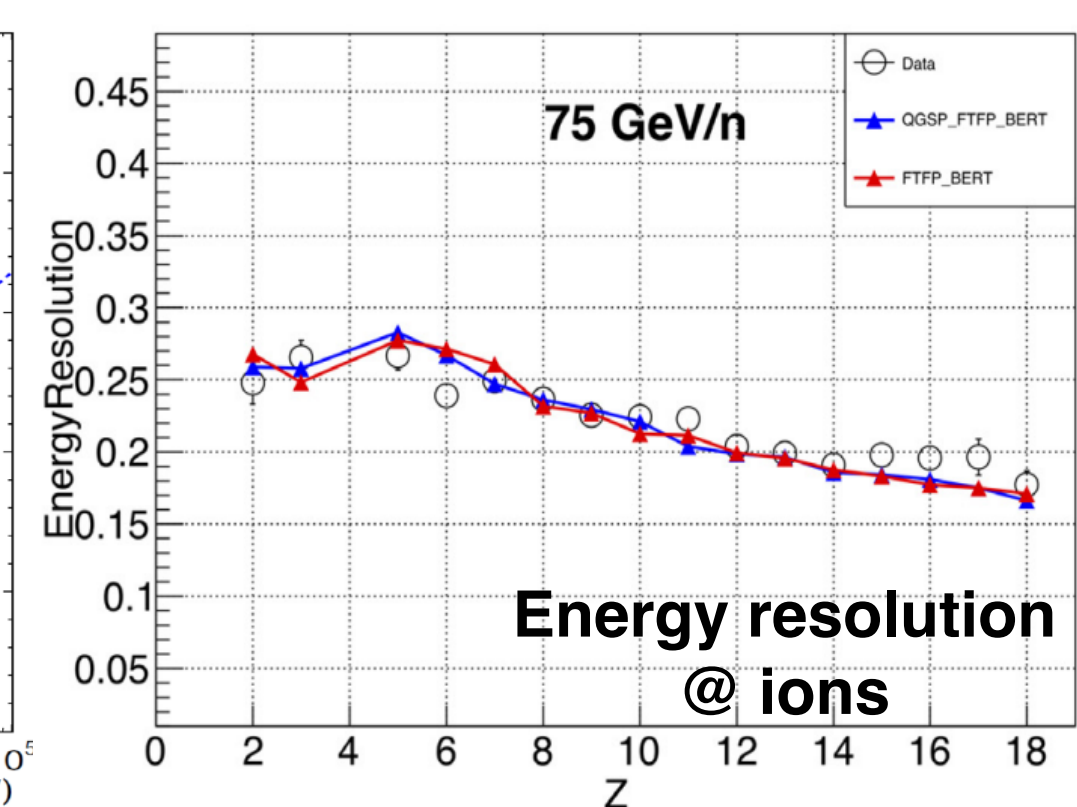
~ 1.6 λ (nuclear integration length)



J. Chang et al., Astropart. Phys. 95 (2017)

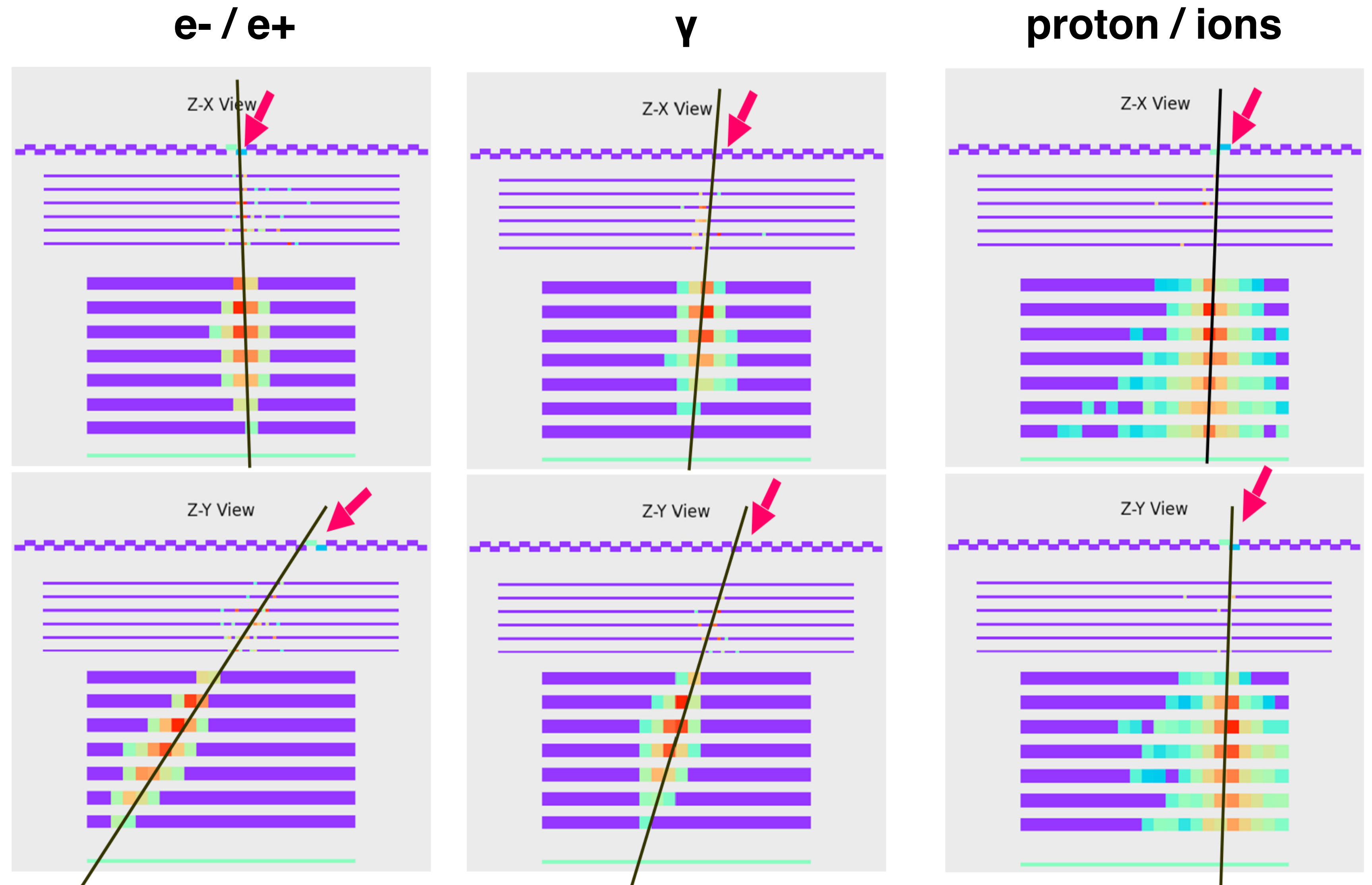
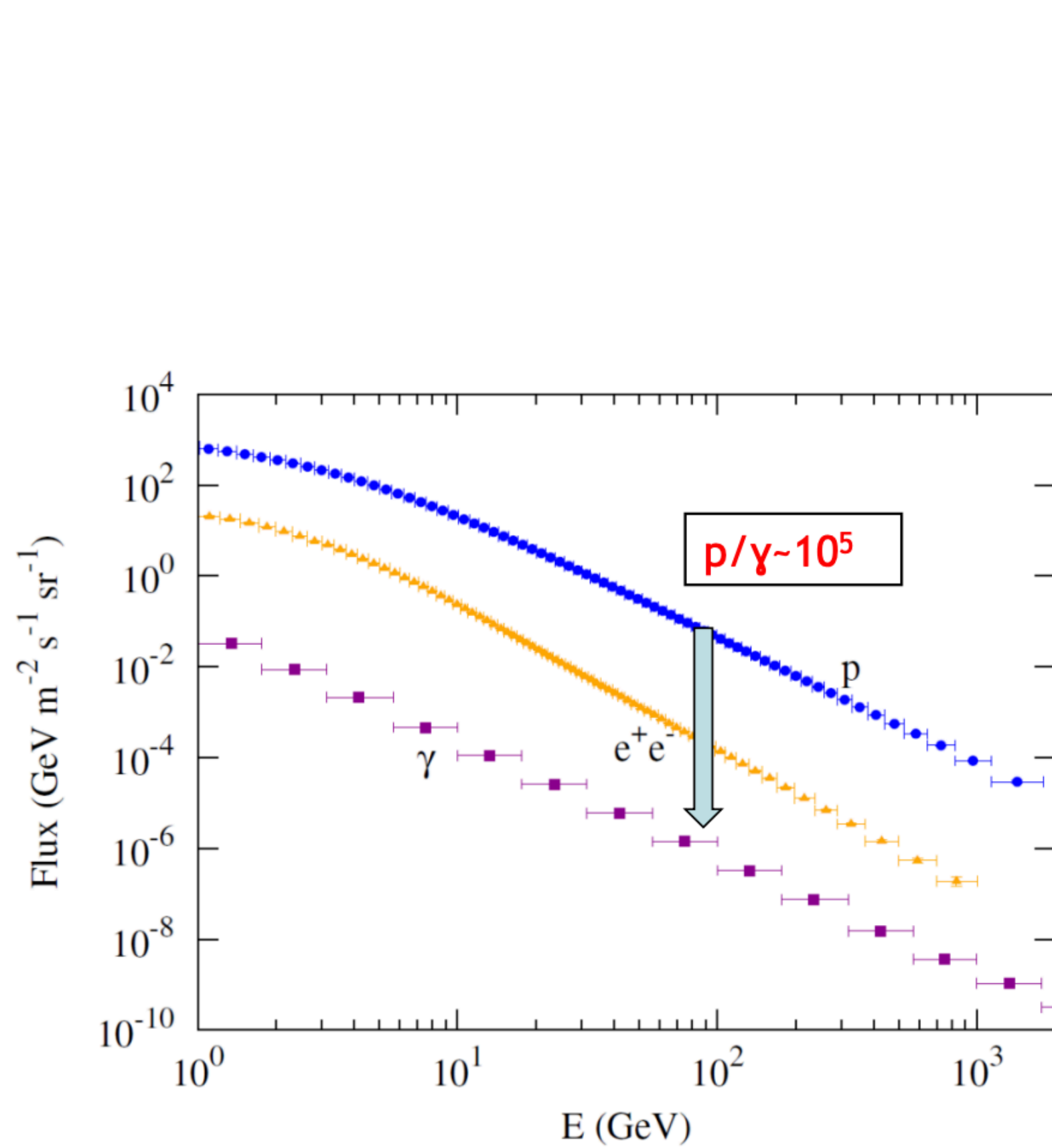


Energy resolution
@ proton



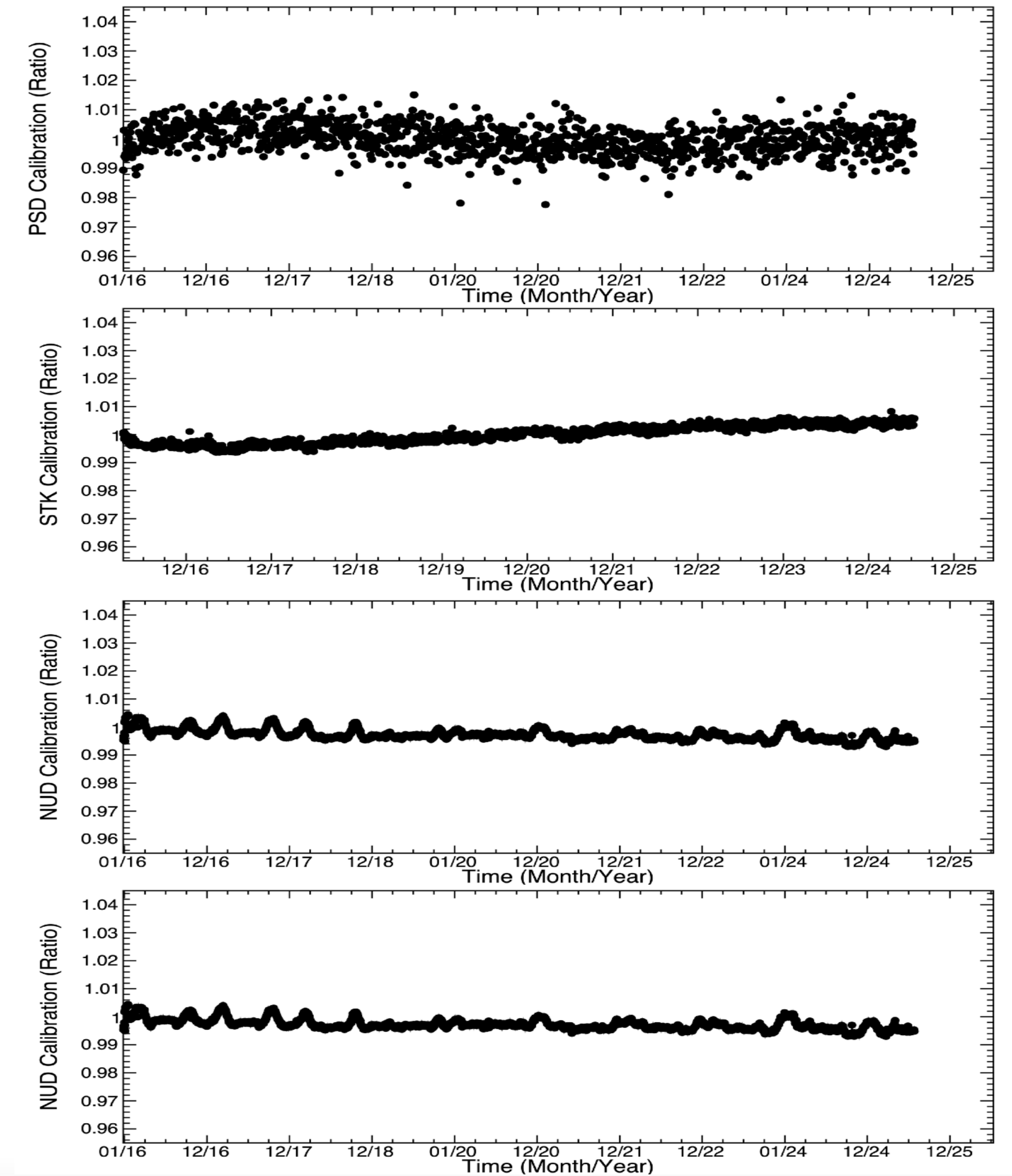
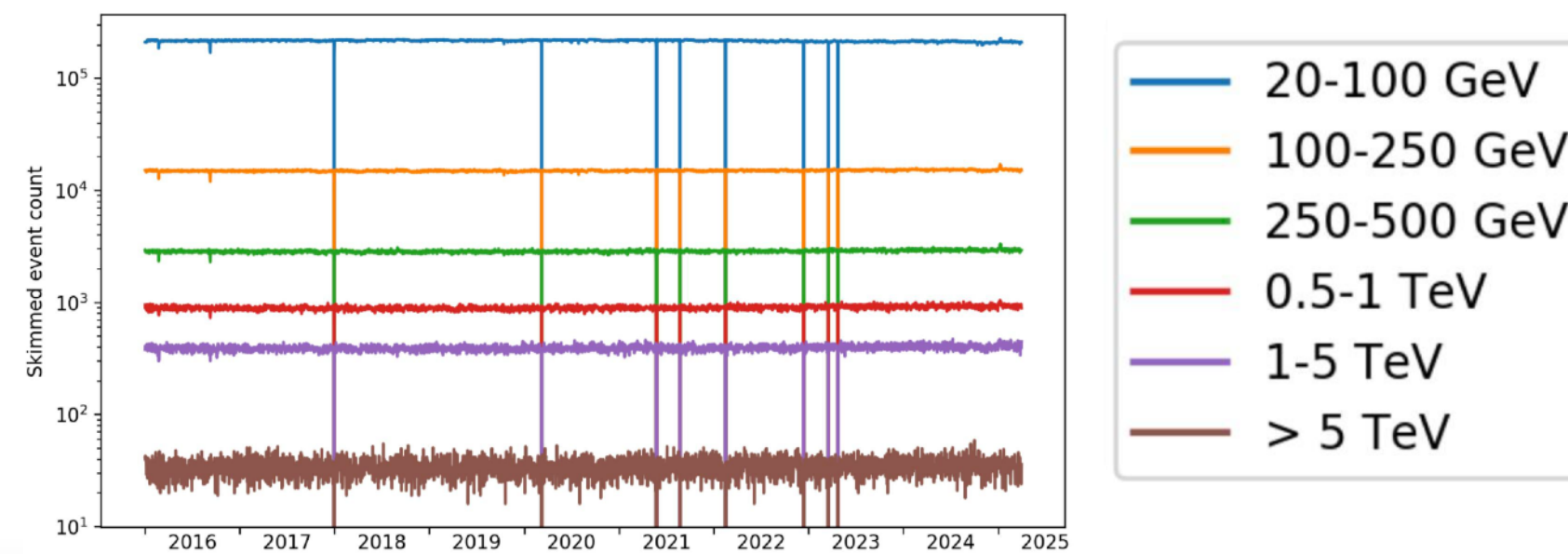
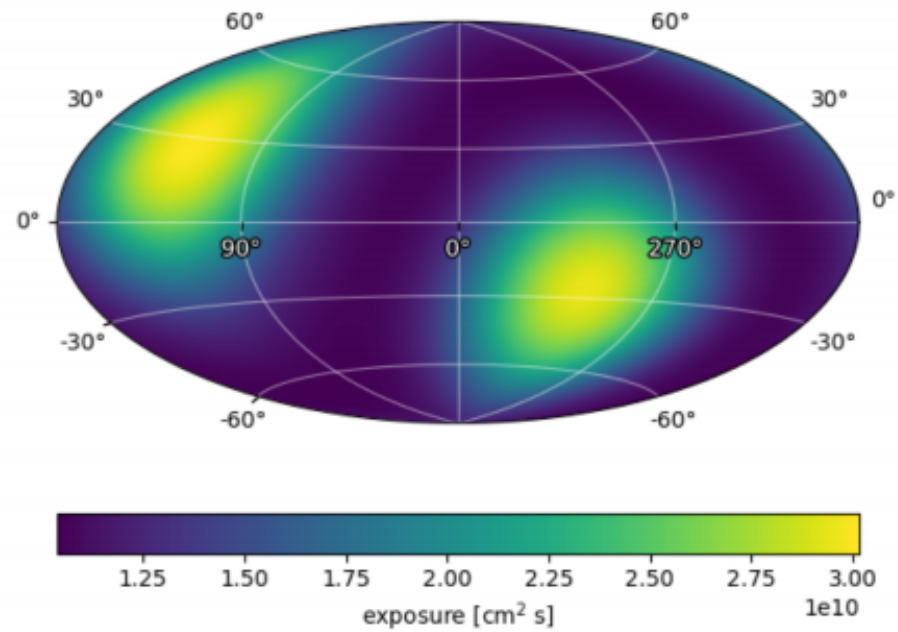
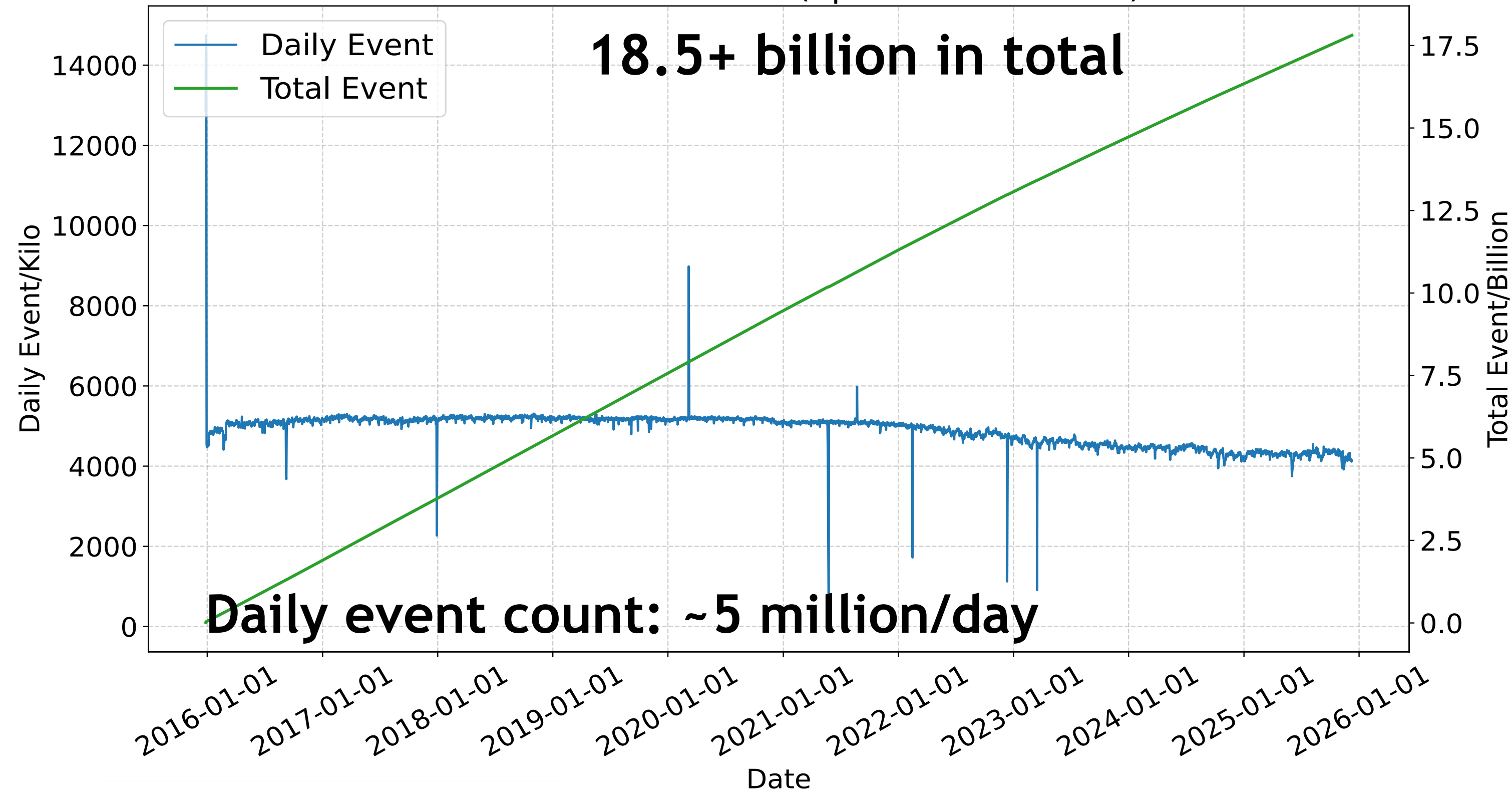
Energy resolution
@ ions

Y. Wei et al. NIMA 922 (2019)



On-orbit operation of DAMPE

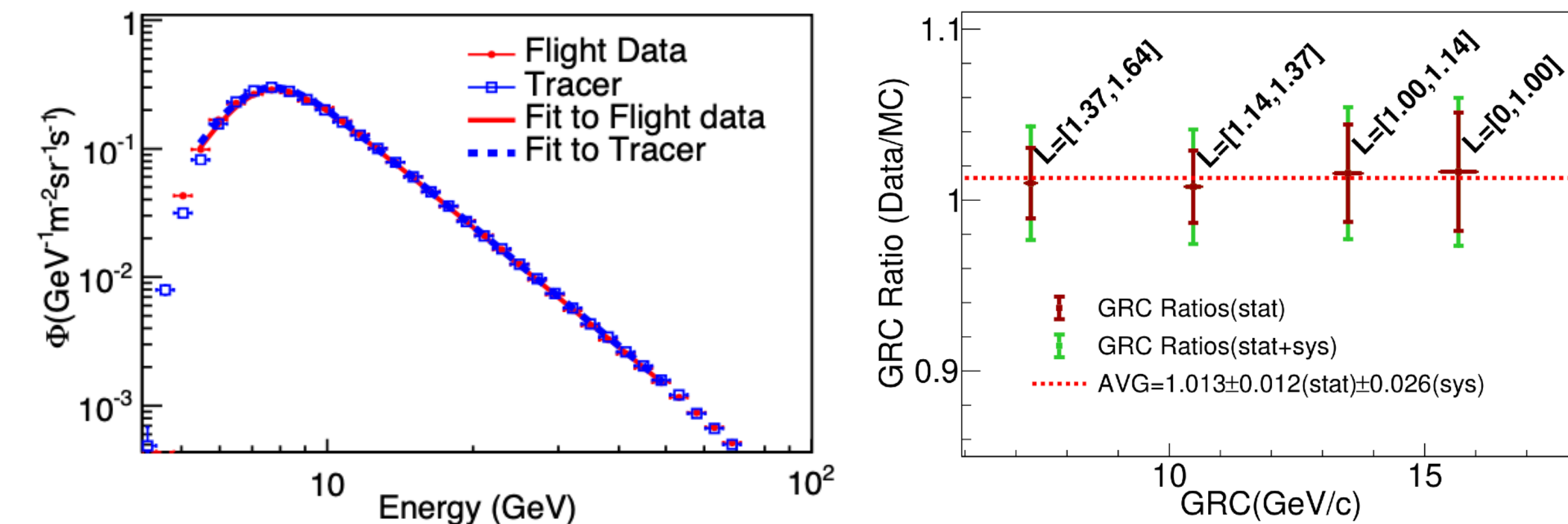
DAMPE Data Statistics (updated 20251209)



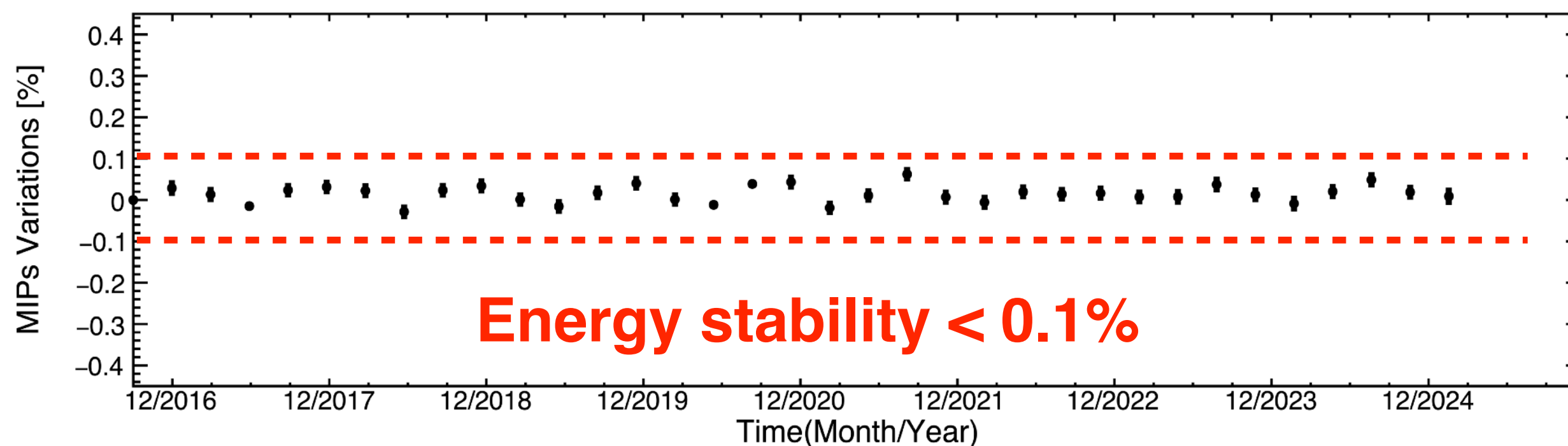
Energy scale and linearity

- On-orbit energy scale verified with geomagnetic cut-off of all electron spectrum
- Good linearity up to ~2.5 (100) TeV with electron (nuclei) events

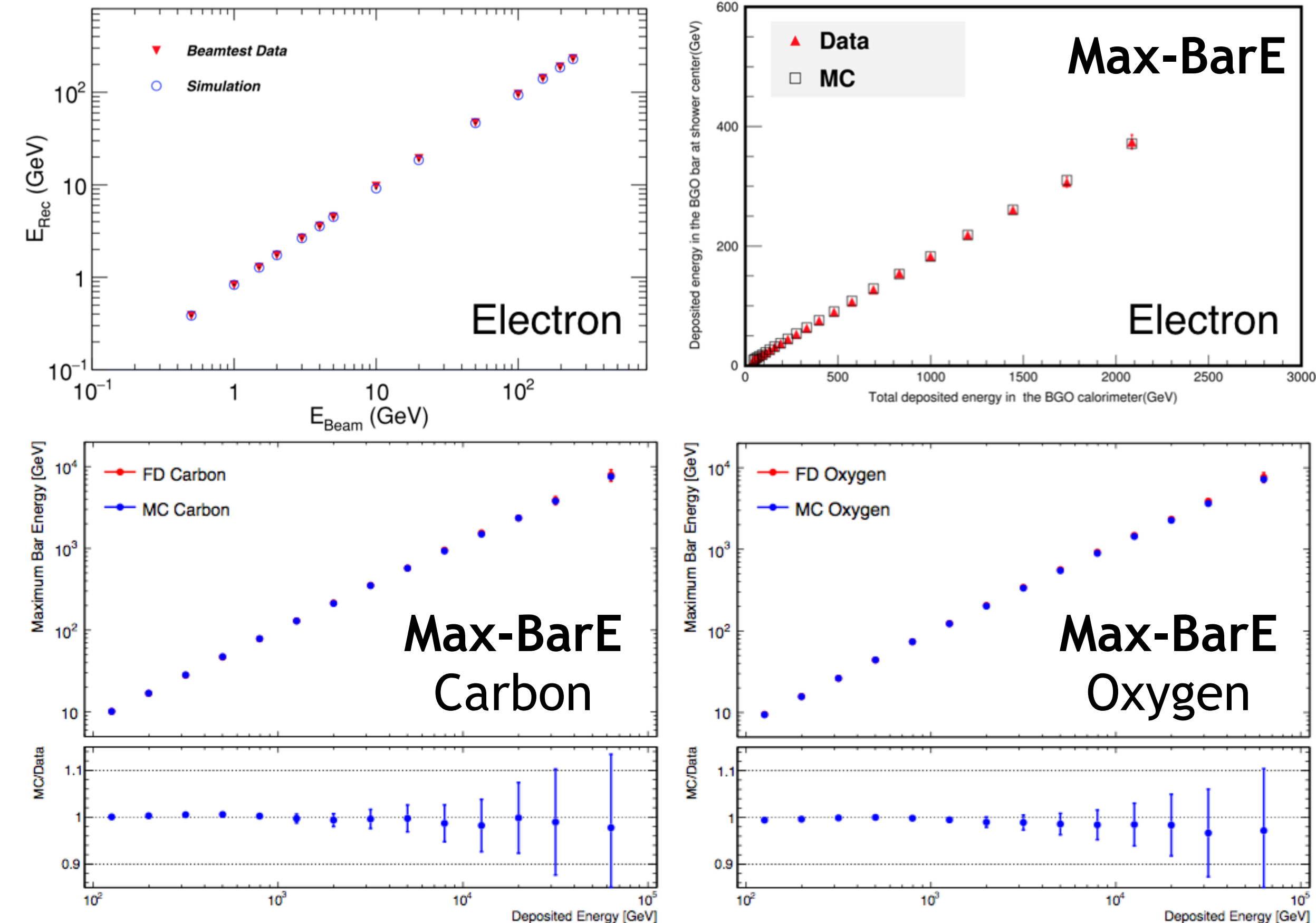
J. Zang et al. *Astropart. Phys.* 173 (2025)



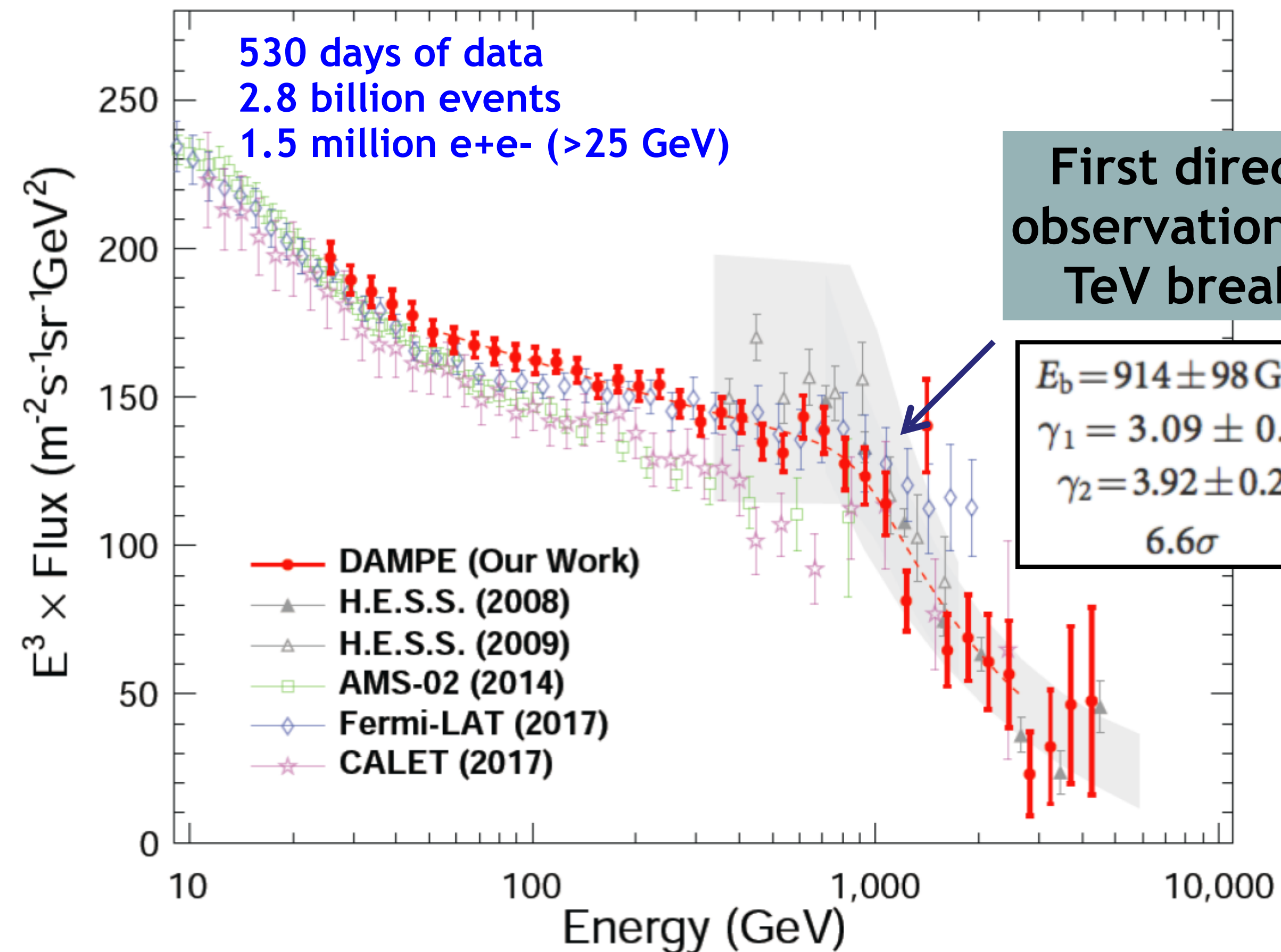
Absolute energy scale: $1.3\% \pm 1.2\%(\text{stat.}) \pm 2.6\%(\text{sys.})$



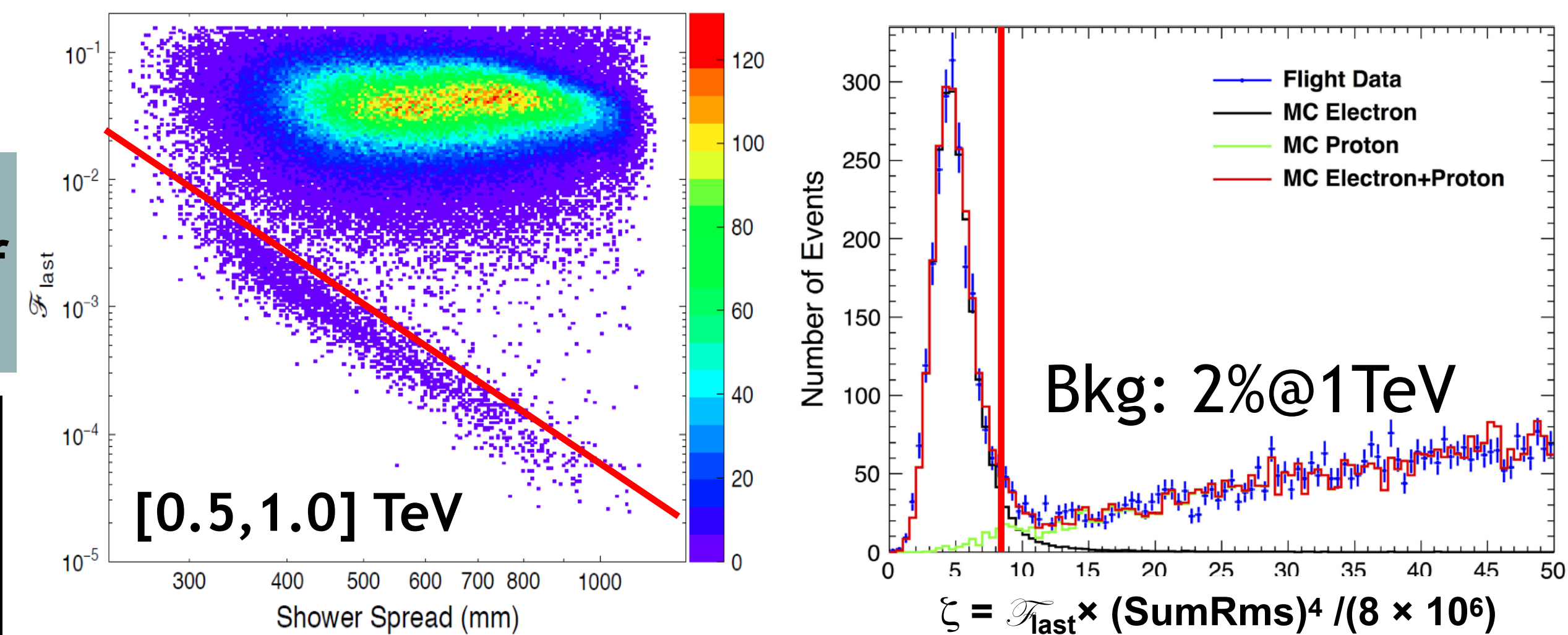
C. Zhao et al. *NIMA* 1092 (2022)



CR e^+e^- spectrum



DAMPE collaboration, Nature 552, 63-66 (2017)



Work in process:

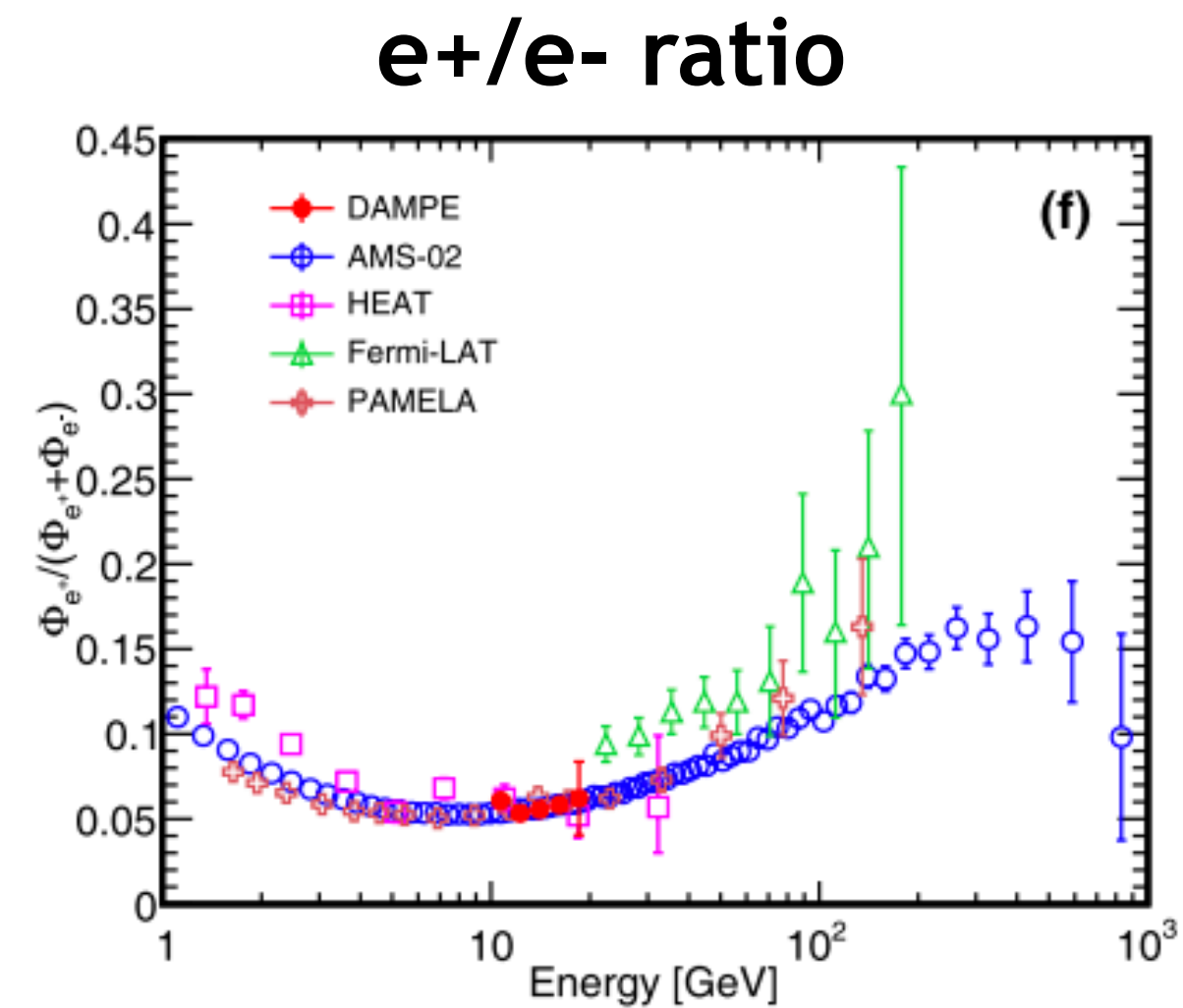
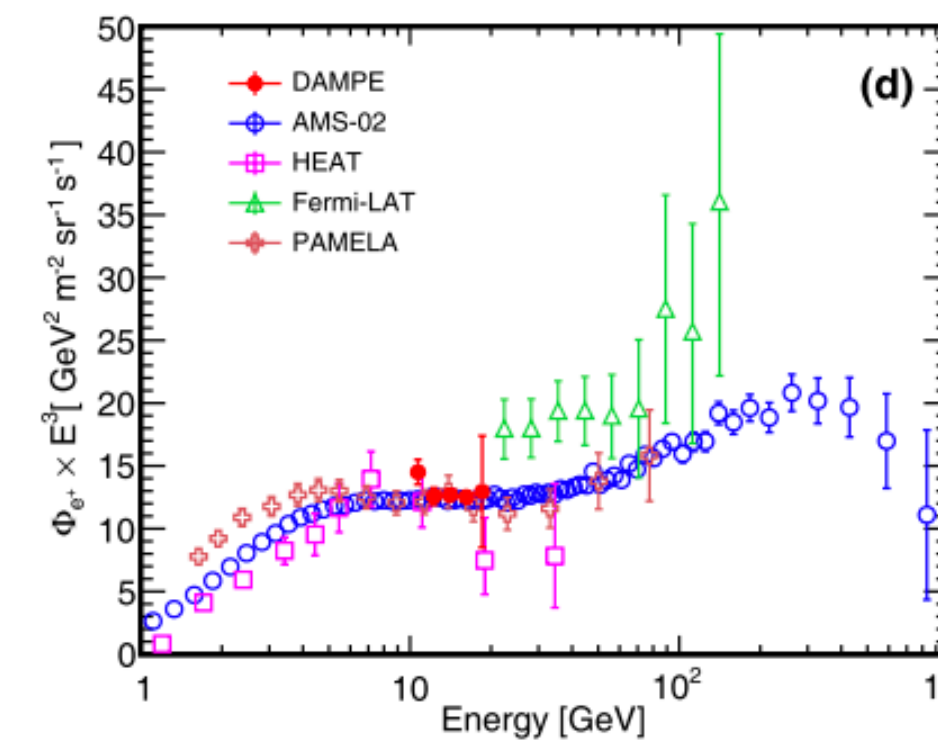
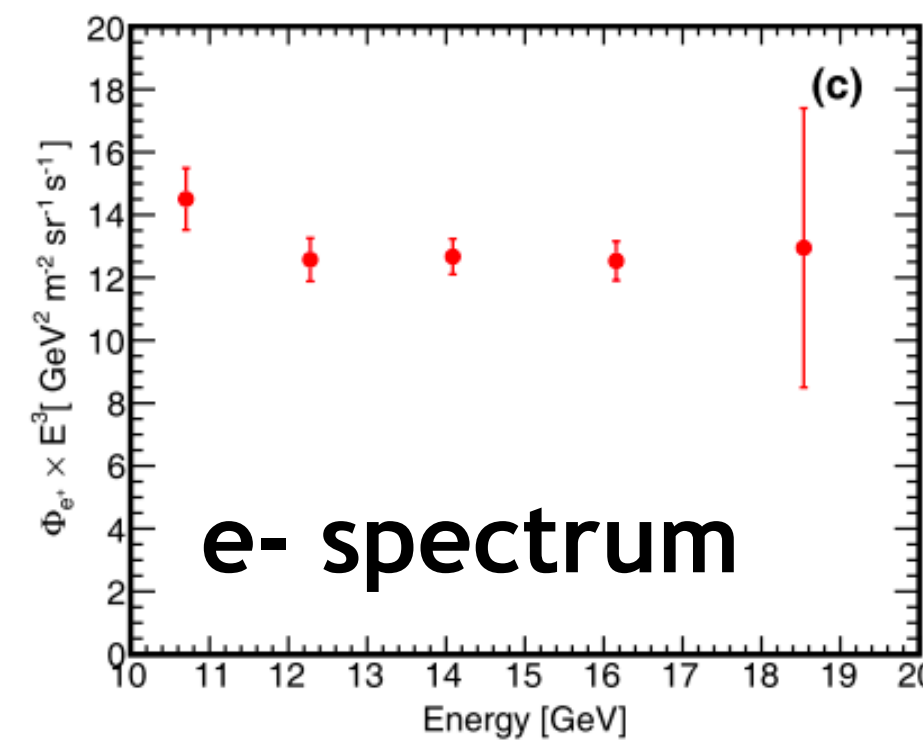
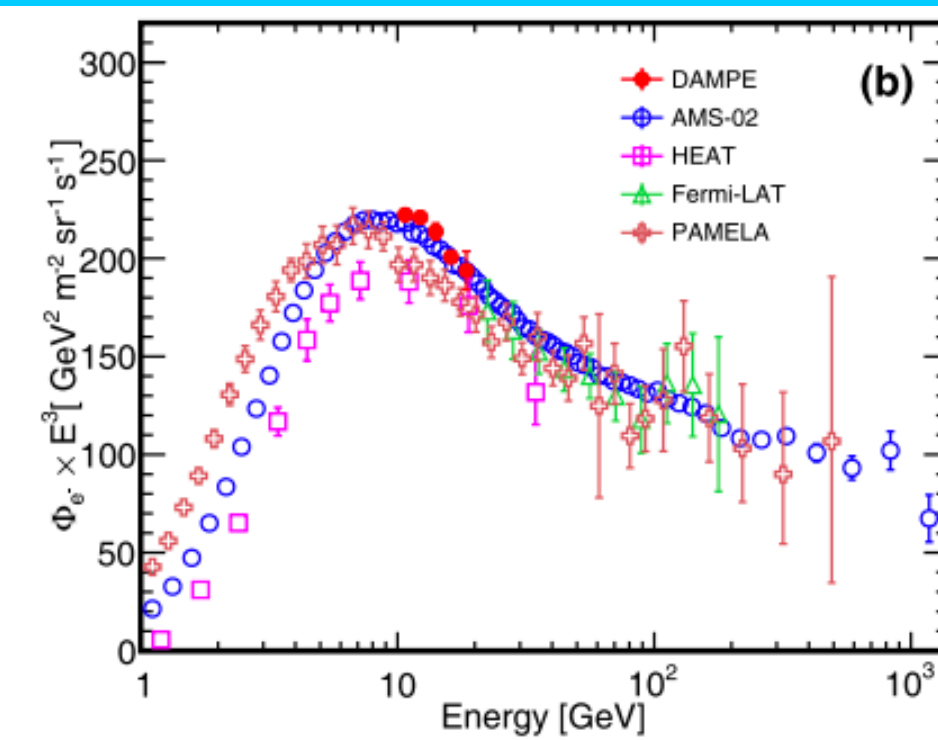
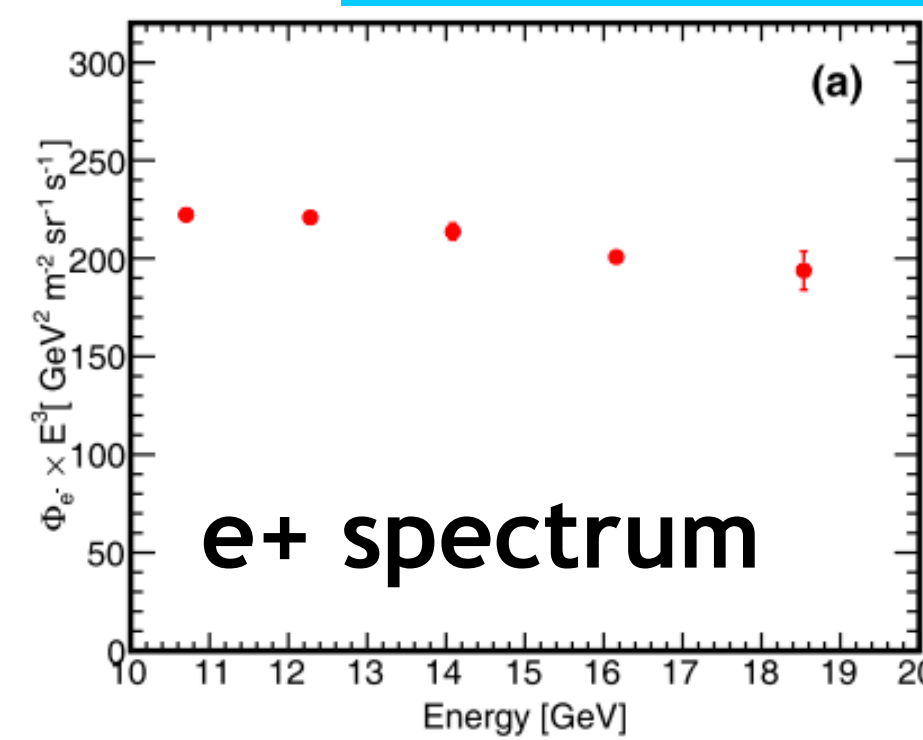
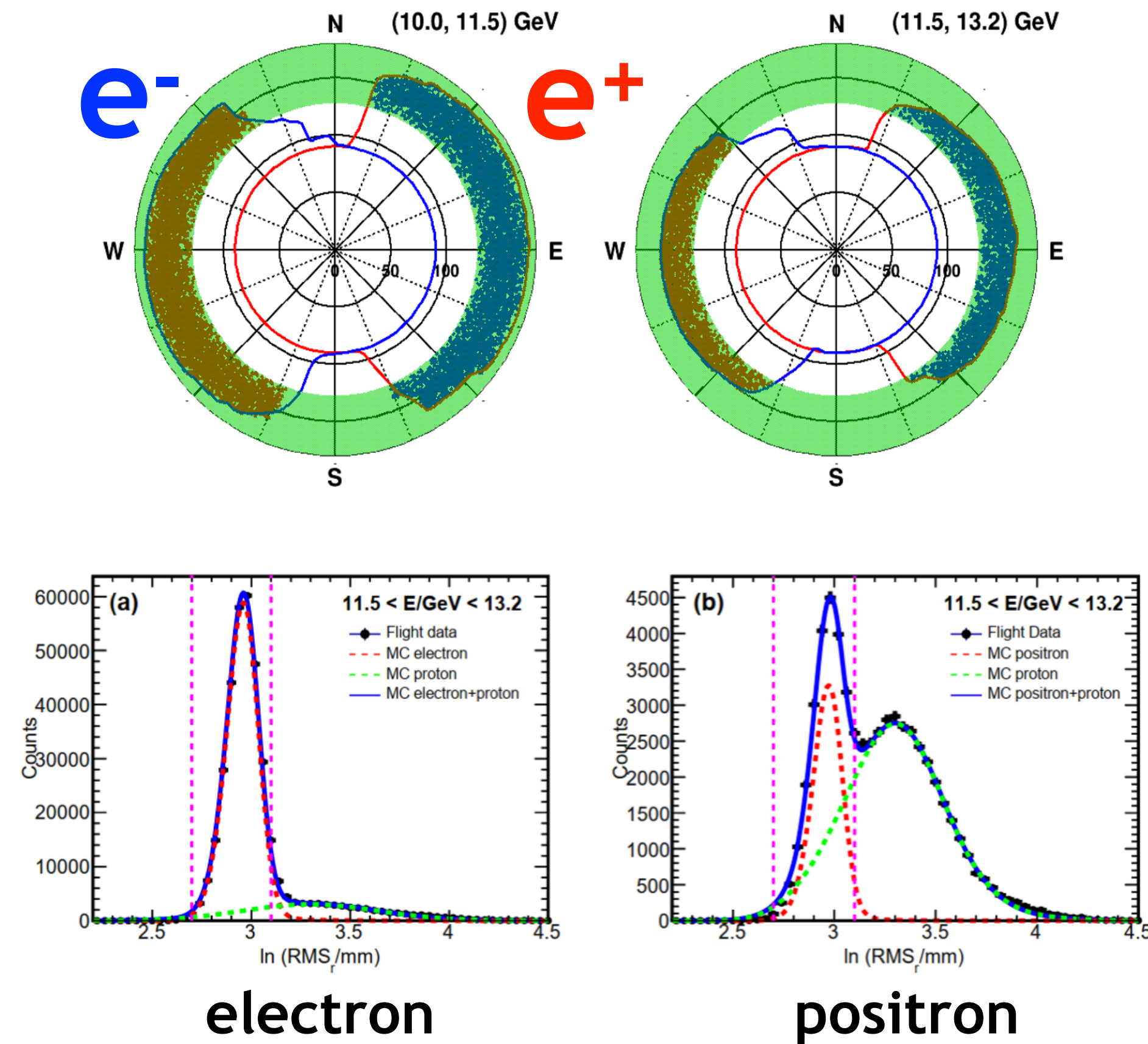
1. Deep and long-term detector calibration.
2. New particle ID for high energies:
Neural Networks (NN), Principal Component Analysis (PCA),
Application of Neutron Detector (NUD)
3. Non-fiducial event selection and reconstruction

◎ Excellent energy resolution and powerful e/p identification, analysis up to ~15 TeV is in progress

e^+/e^- spectrum

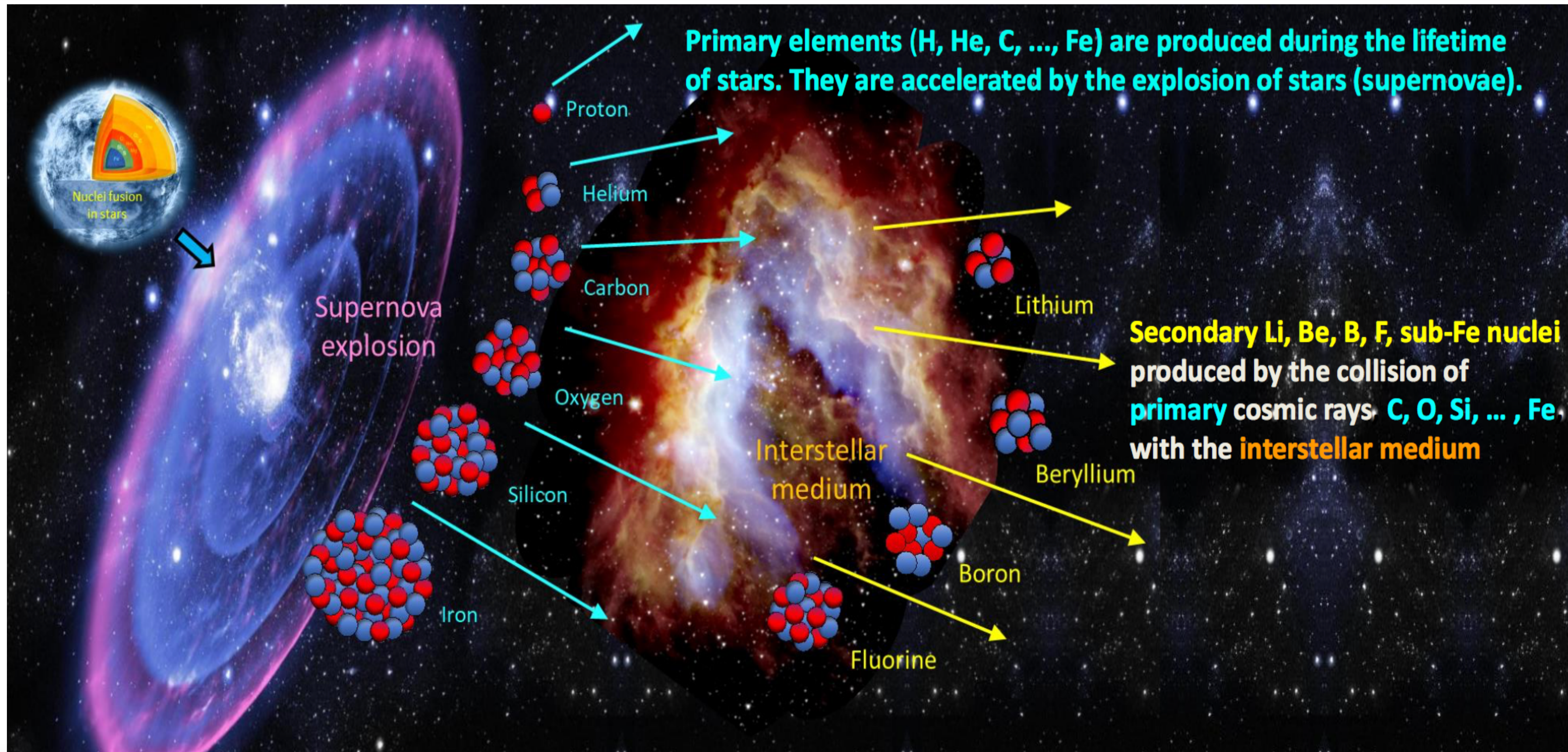
◎ CR e^+/e^- discrimination based on the East-West effect in the Geomagnetic field

DAMPE collab., Chin. Phys. C 49, 115001 (2025)



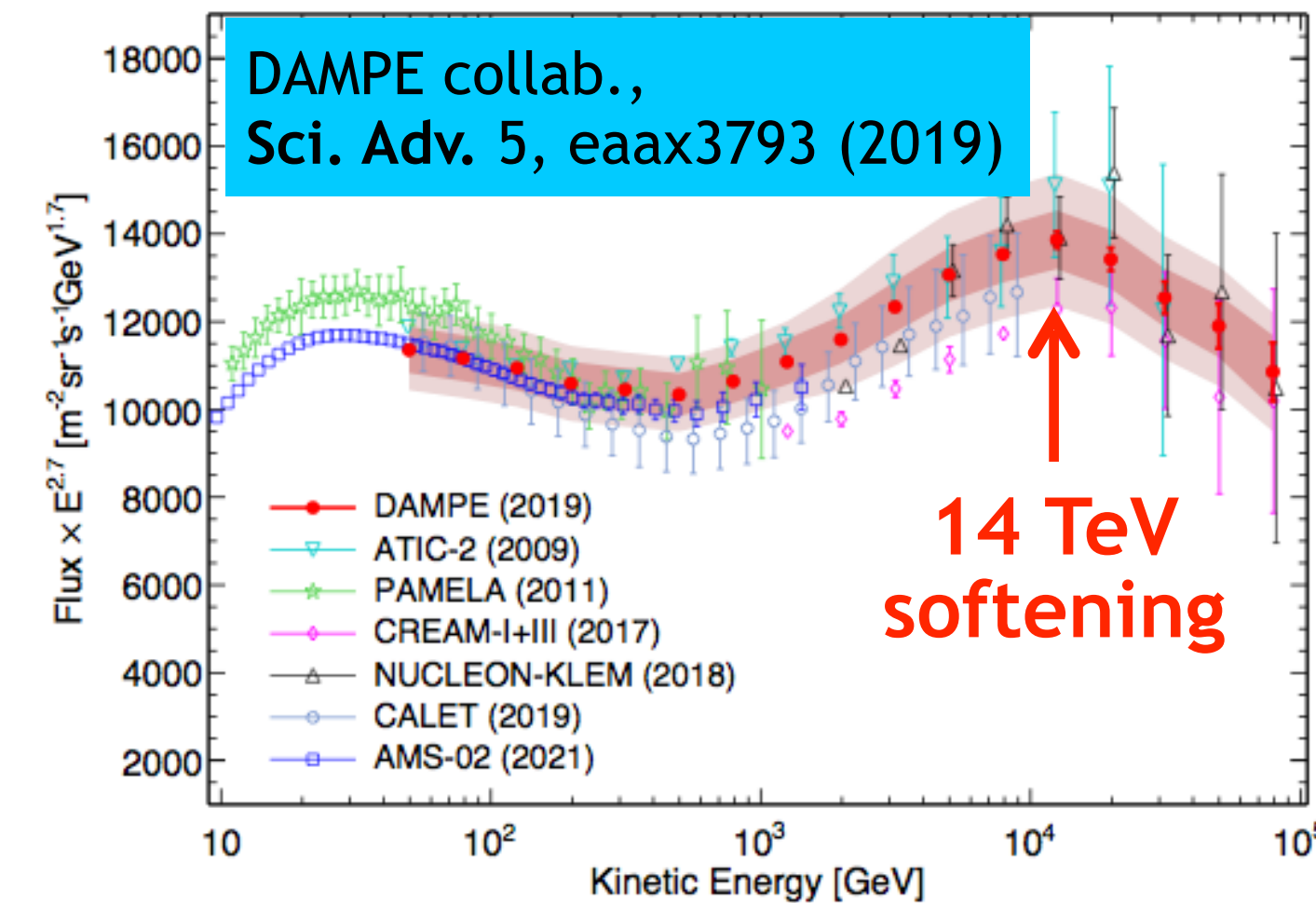
◎ DAMPE measurements from 10 to 20 GeV are consistent with the previous results of AMS-02 and PAMELA

CR nuclei

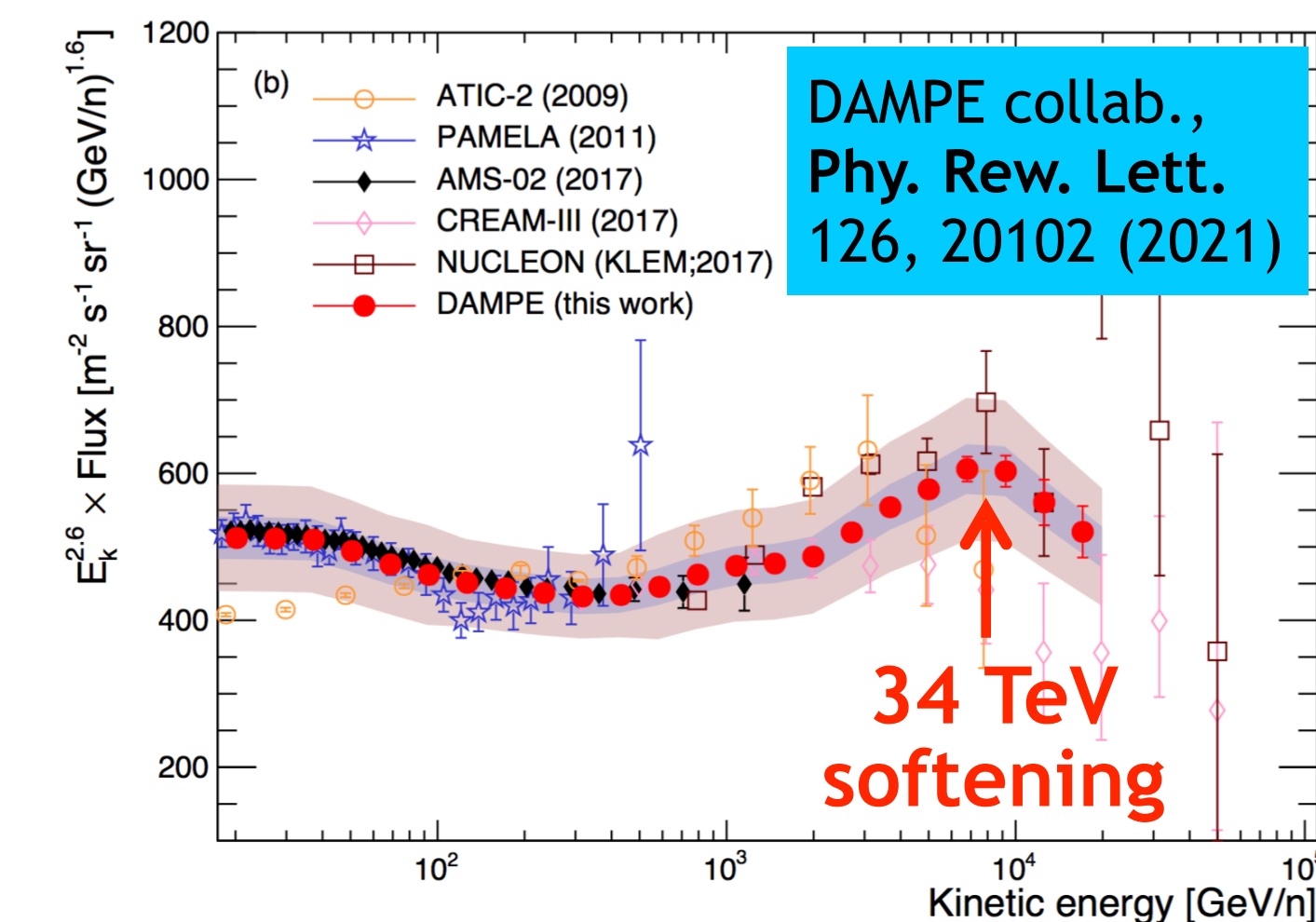


Primary cosmic-ray: p, He

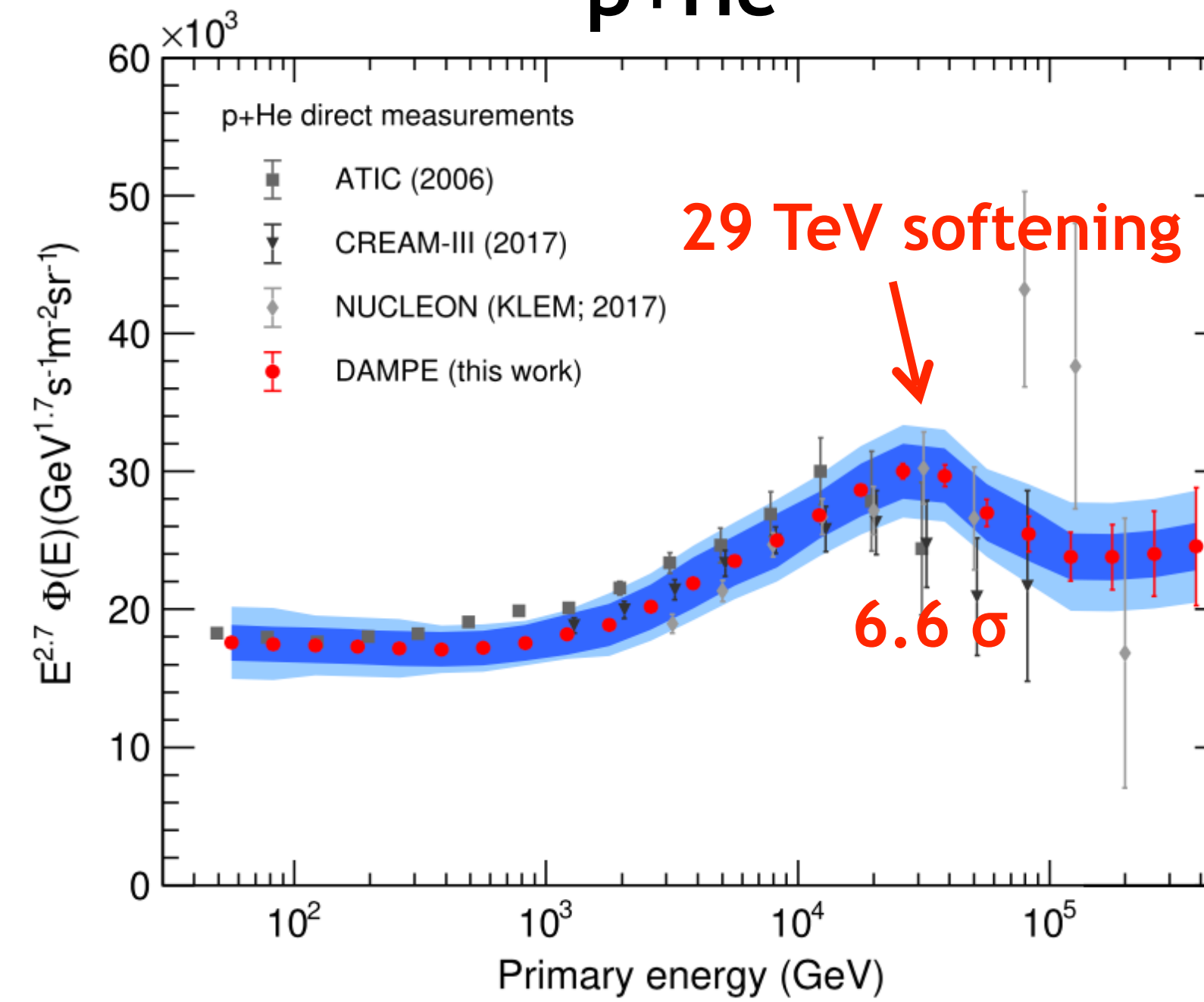
Proton



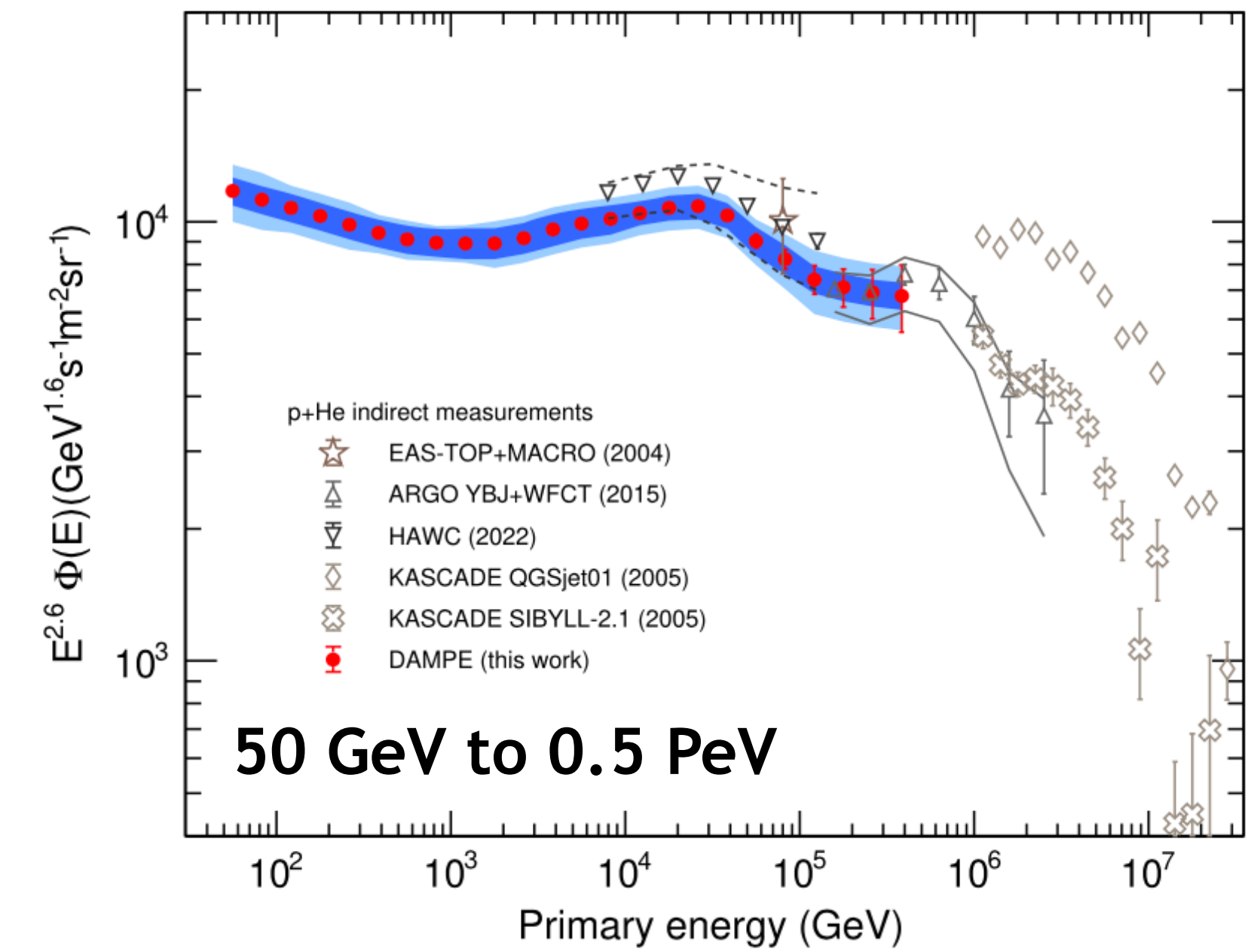
Helium



p+He



DAMPE collab., Phy. Rev.D 109, L121101 (2024)

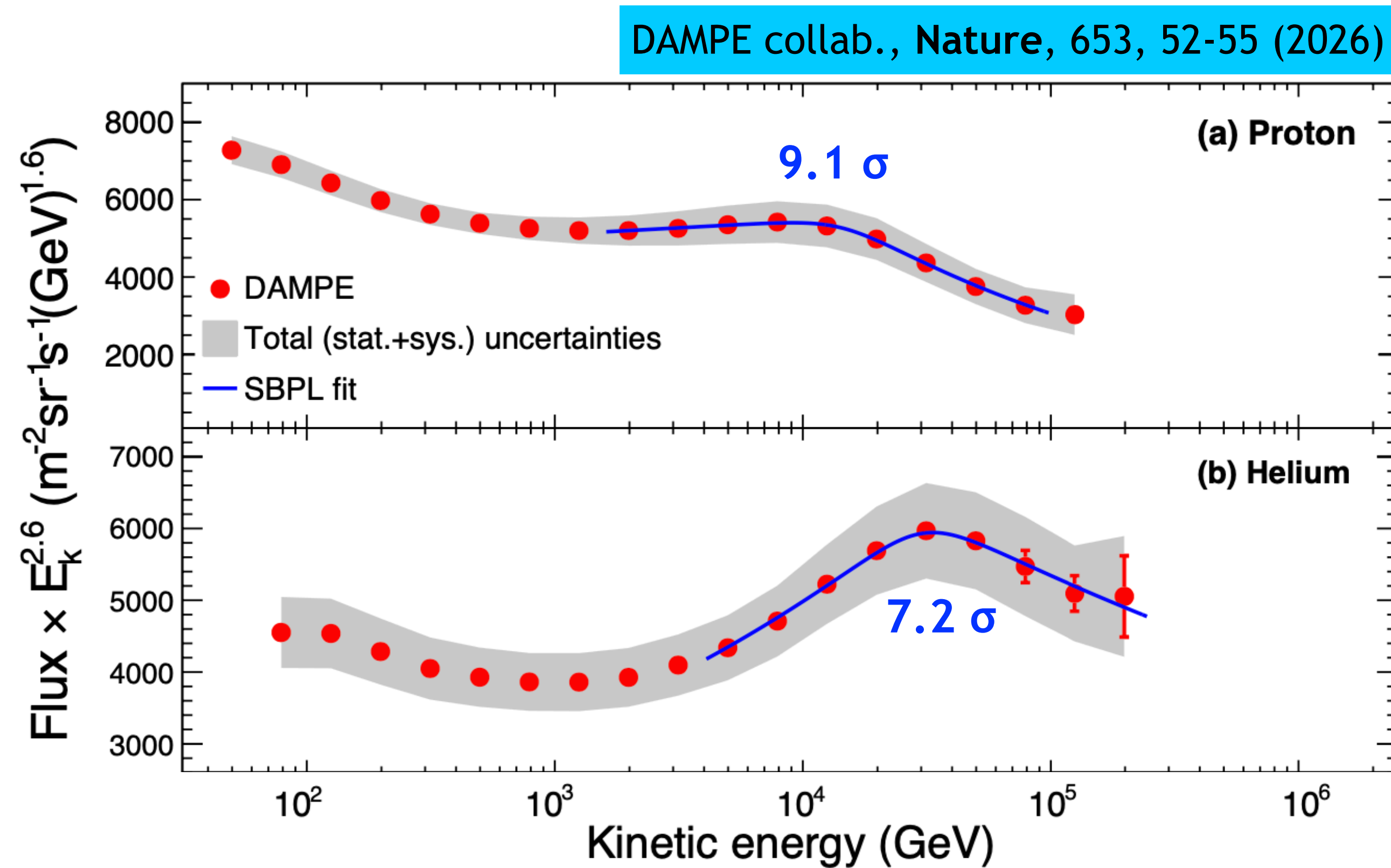
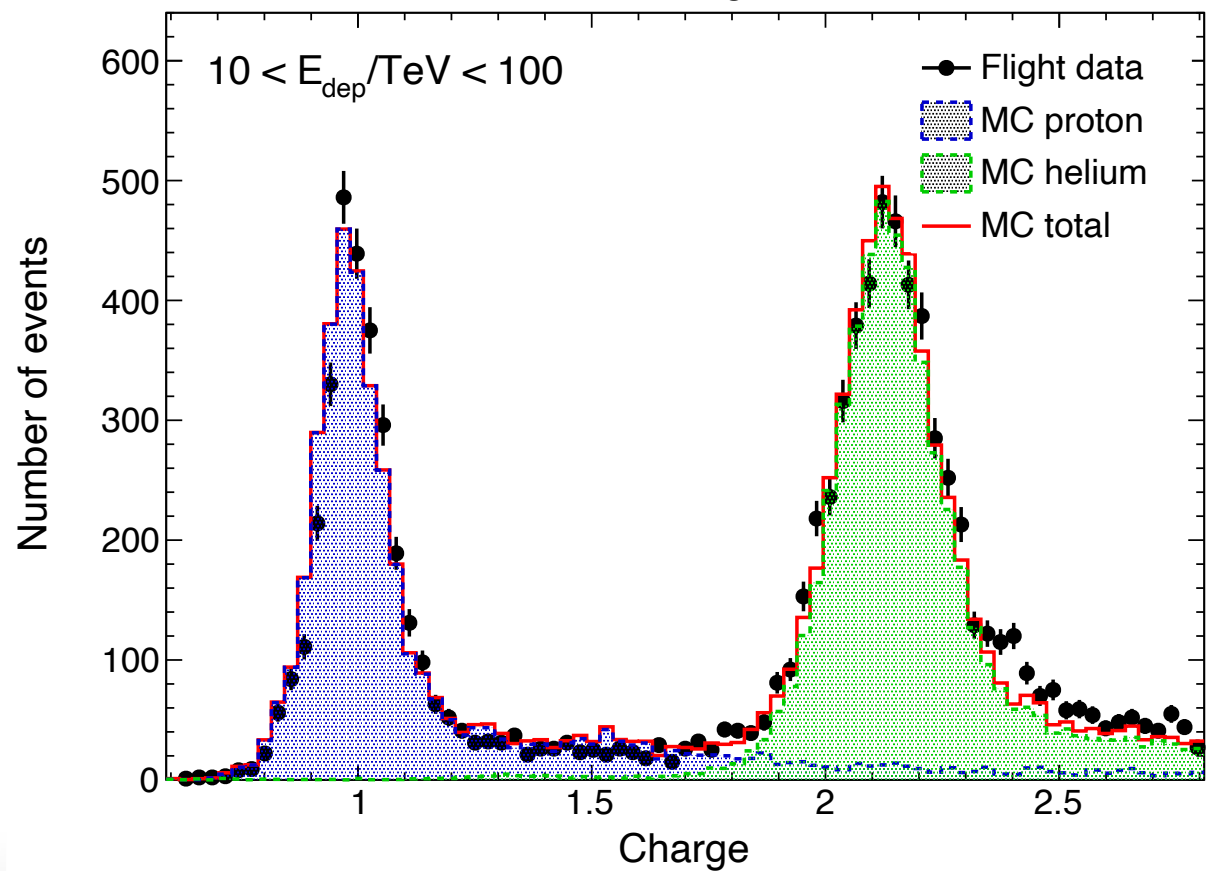
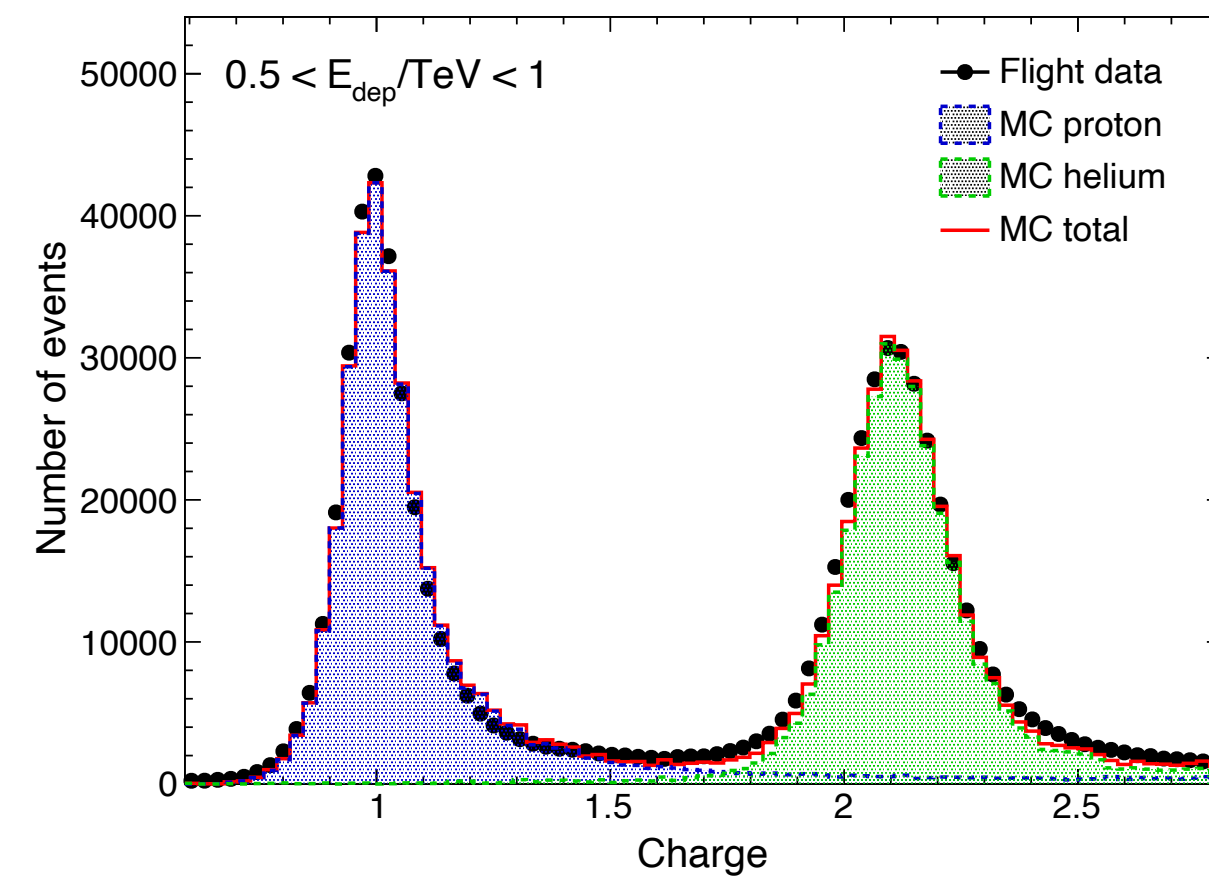


	Proton	Helium	Proton+Helium
E_b (TeV)	$13.6^{+4.1}_{-4.8}$	$34.4^{+6.7+11.6}_{-9.8-0.0}$	$28.8^{+6.2+2.9}_{-4.4-0.0}$
γ	2.60 ± 0.01	$2.41^{+0.02+0.02}_{-0.02-0.00}$	$2.51^{+0.021+0.01}_{-0.024-0.00}$
$\Delta\gamma$	-0.25 ± 0.07	$-0.51^{+0.18+0.01}_{-0.20-0.00}$	$0.43^{+0.066+0.066}_{-0.057-0.00}$

- ◎ Link between space- and ground- based CR measurements
- ◎ Observation of the softening at 29 TeV and a hardening hit at ~150 TeV

Advanced analysis in high energies:

1. New ML track reconstruction & New charge identification : STK + PSD
2. Quenching correction, cross-section correction and new saturation correction up to PeV



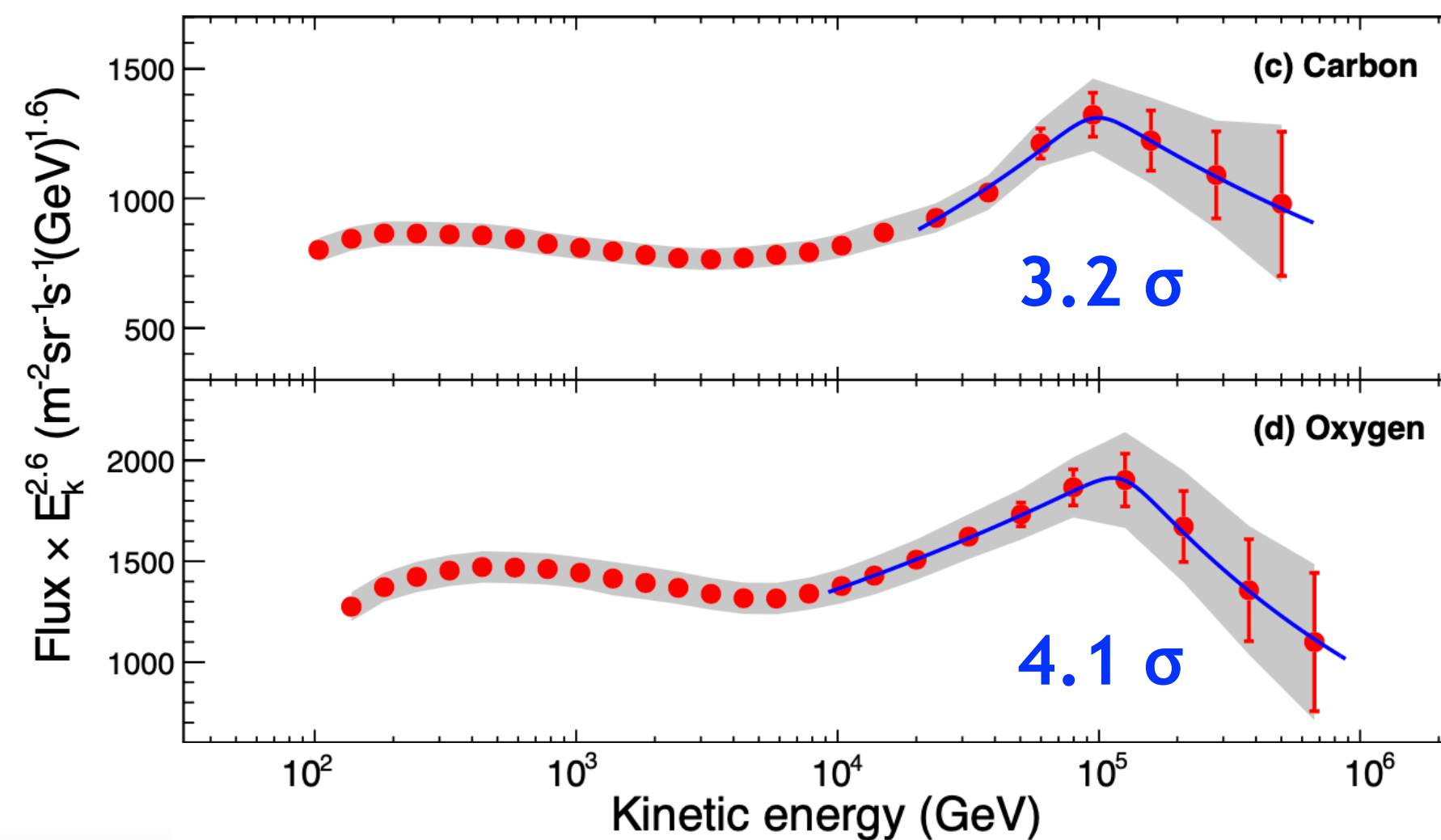
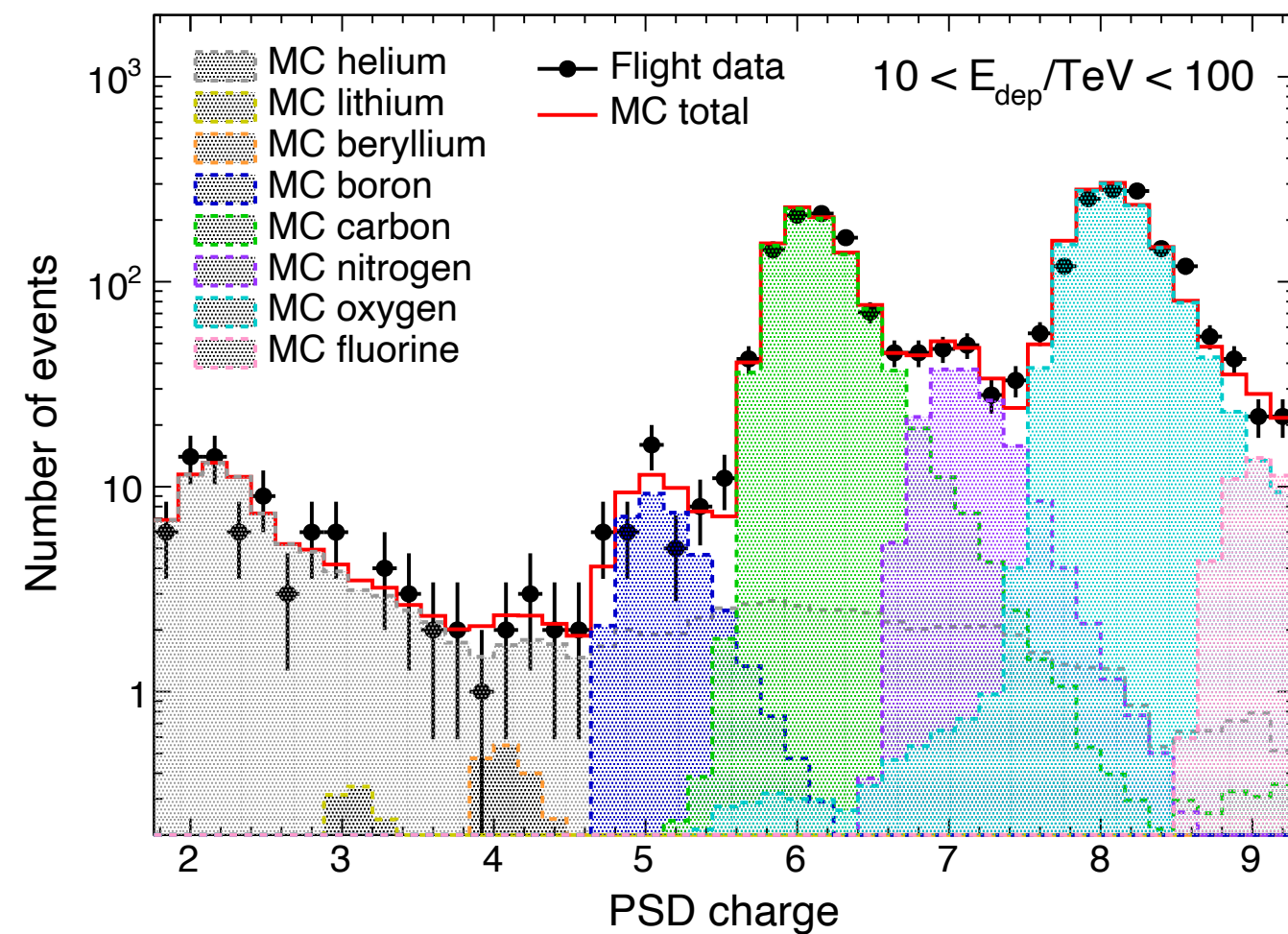
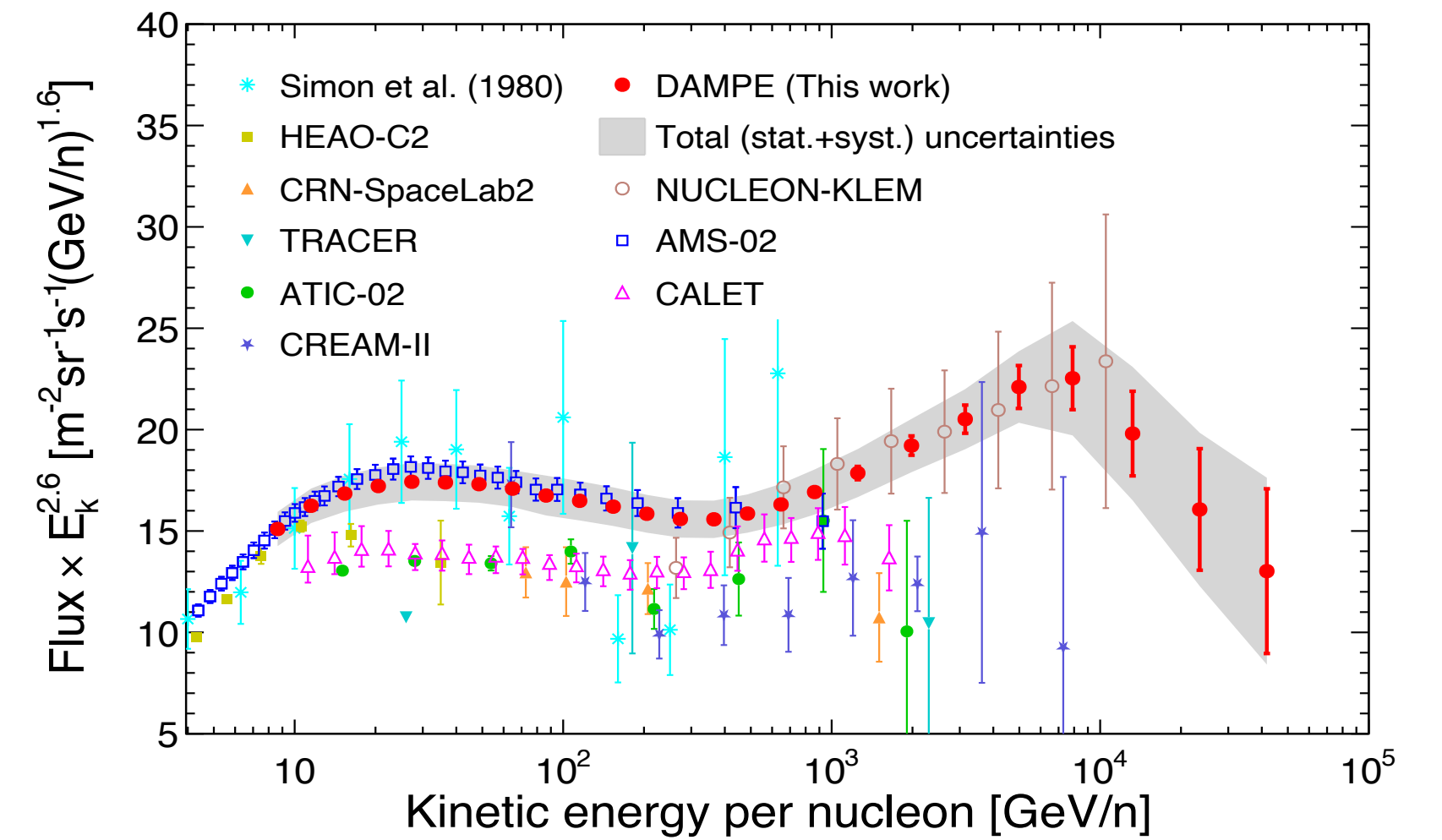
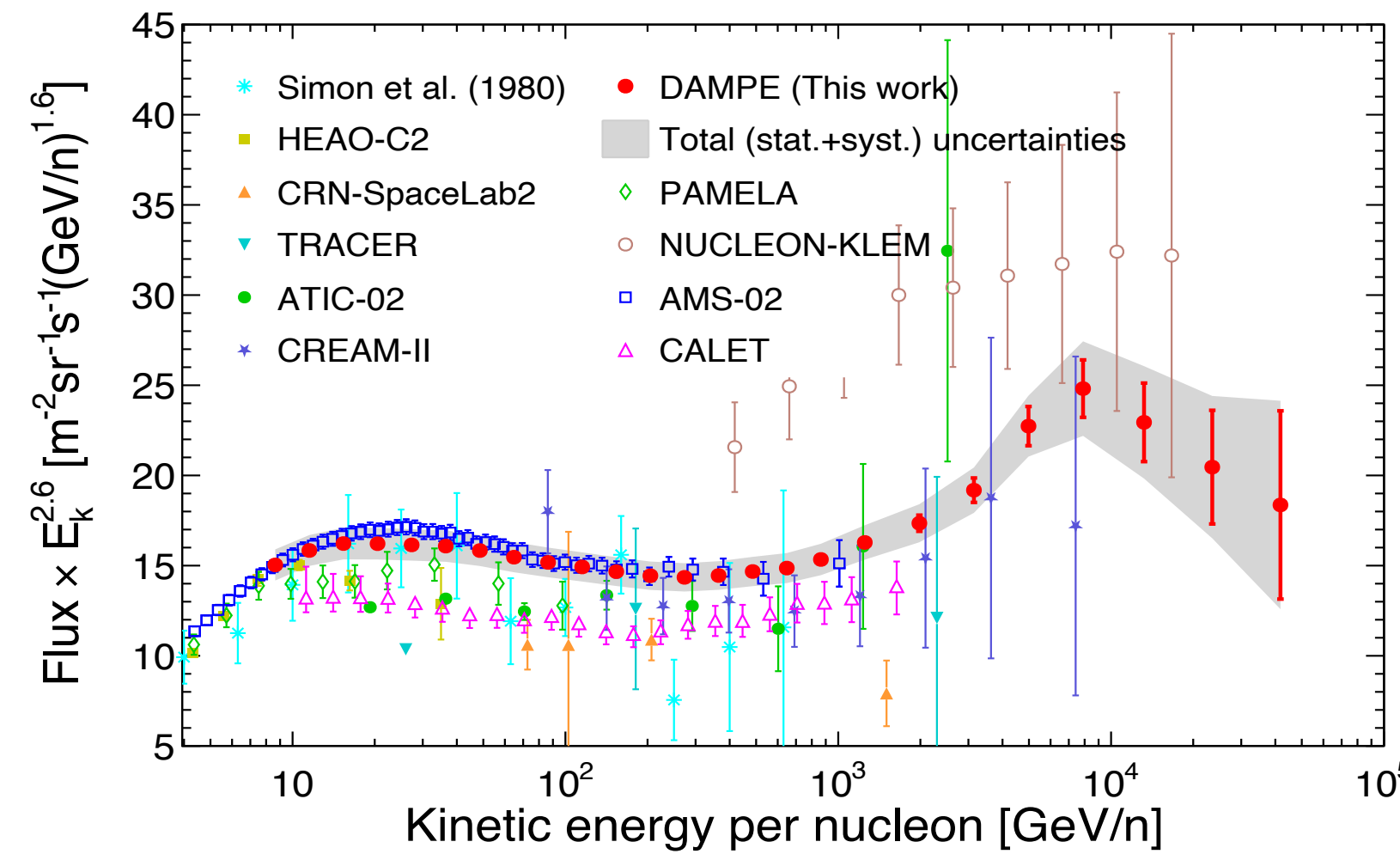
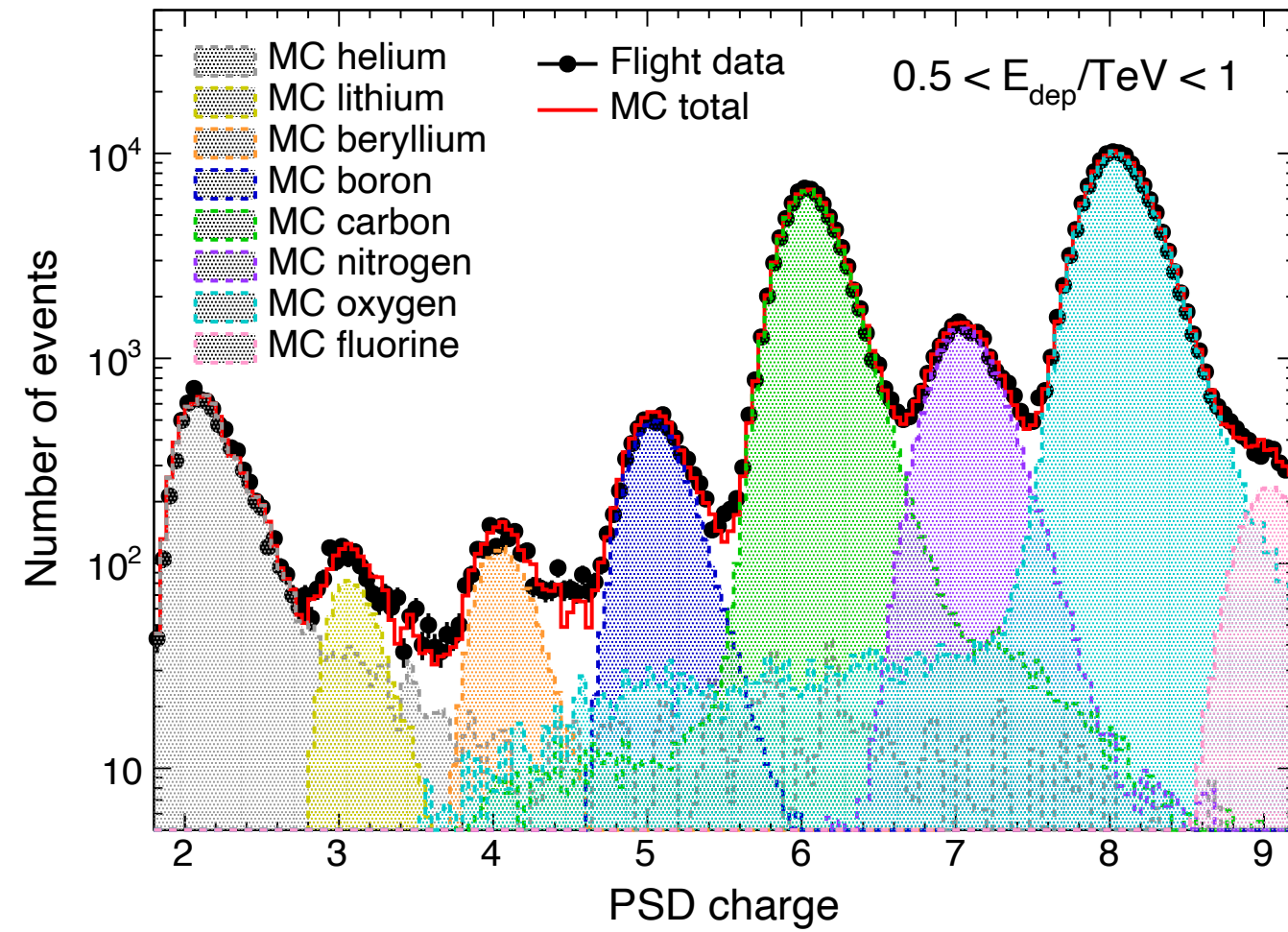
$$\Phi_{\text{SBPL}}(E) = \Phi_0 \cdot \left(\frac{E}{10^3 \text{ GeV}} \right)^{-\gamma} \left[1 + \left(\frac{E}{E_{\text{br}}} \right)^s \right]^{\frac{\Delta\gamma}{s}}$$

Particle	Proton	Helium
Fit energy range	1.58 - 100 TeV	3.98 - 250 TeV
Nuisance parameters	3	3
Φ_0 ($10^{-5} \text{ GeV}^{-1} \text{ m}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$)	8.08 ± 0.48	5.03 ± 0.35
E_{br} (TeV)	14.6 ± 1.3	30.6 ± 4.4
γ	2.57 ± 0.01	2.40 ± 0.01
$\Delta\gamma$	-0.34 ± 0.05	-0.32 ± 0.07
s	5 (fixed)	5 (fixed)

© Latest results based on 9 years' DAMPE data

◎ Latest results based on 9 years' DAMPE data

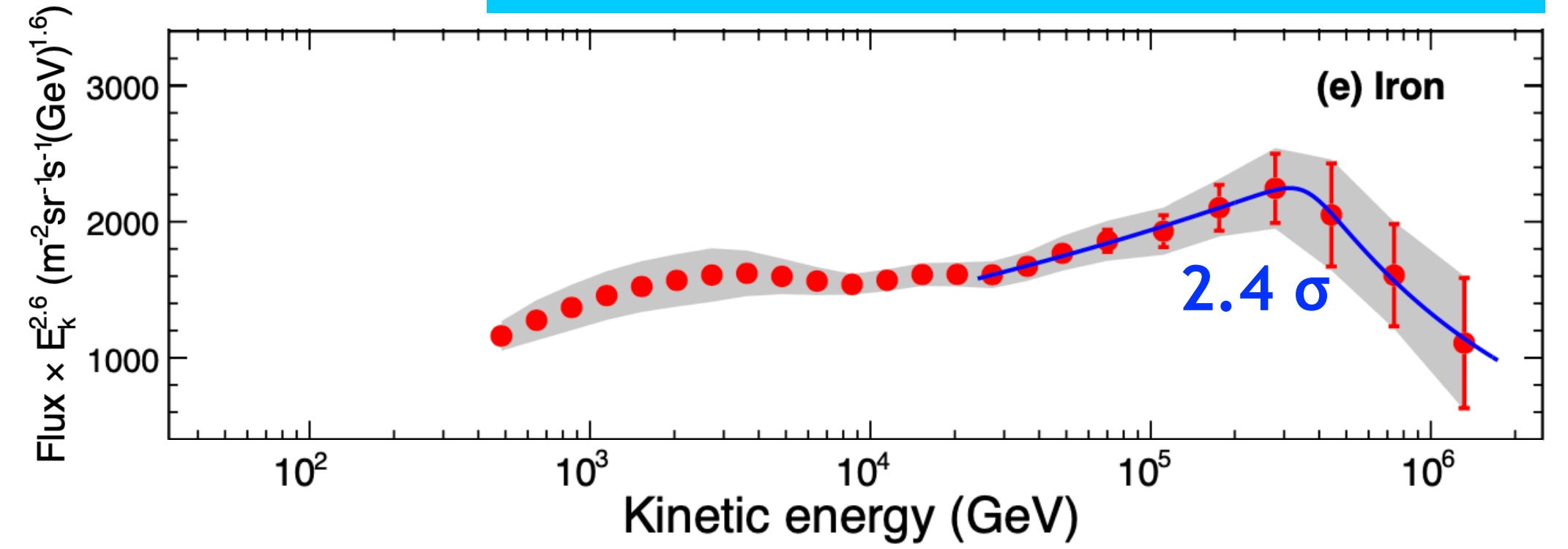
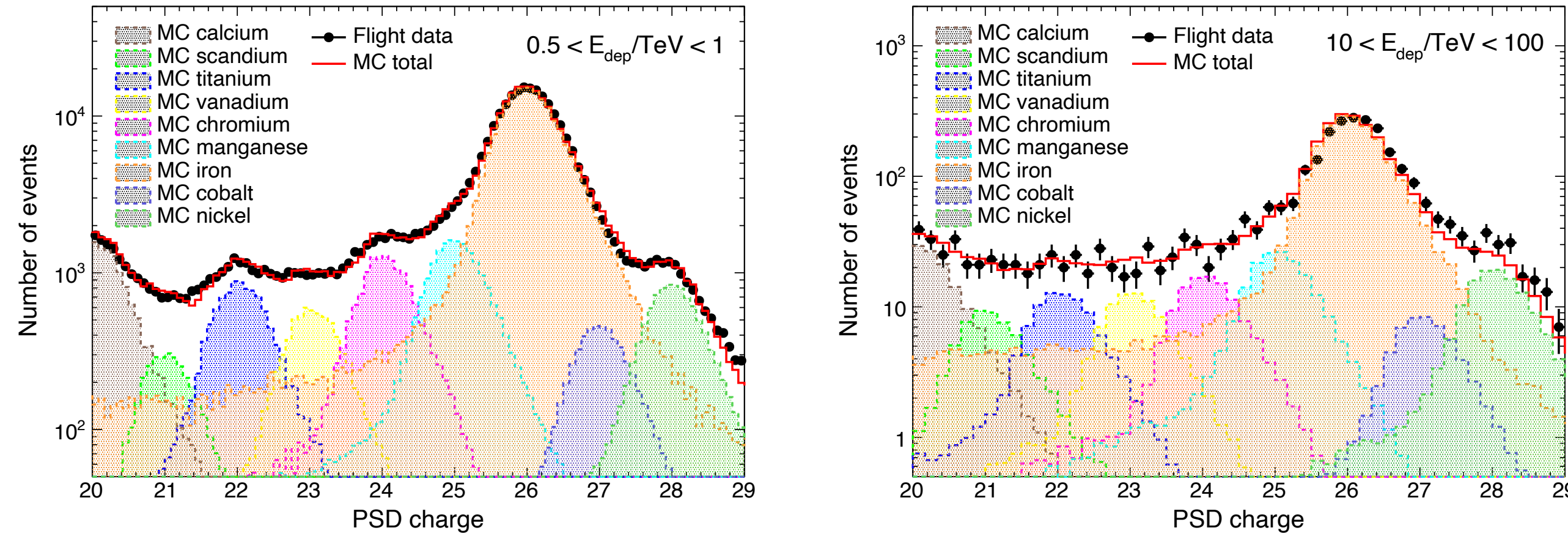
DAMPE collab., Nature, 653, 52-55 (2026)



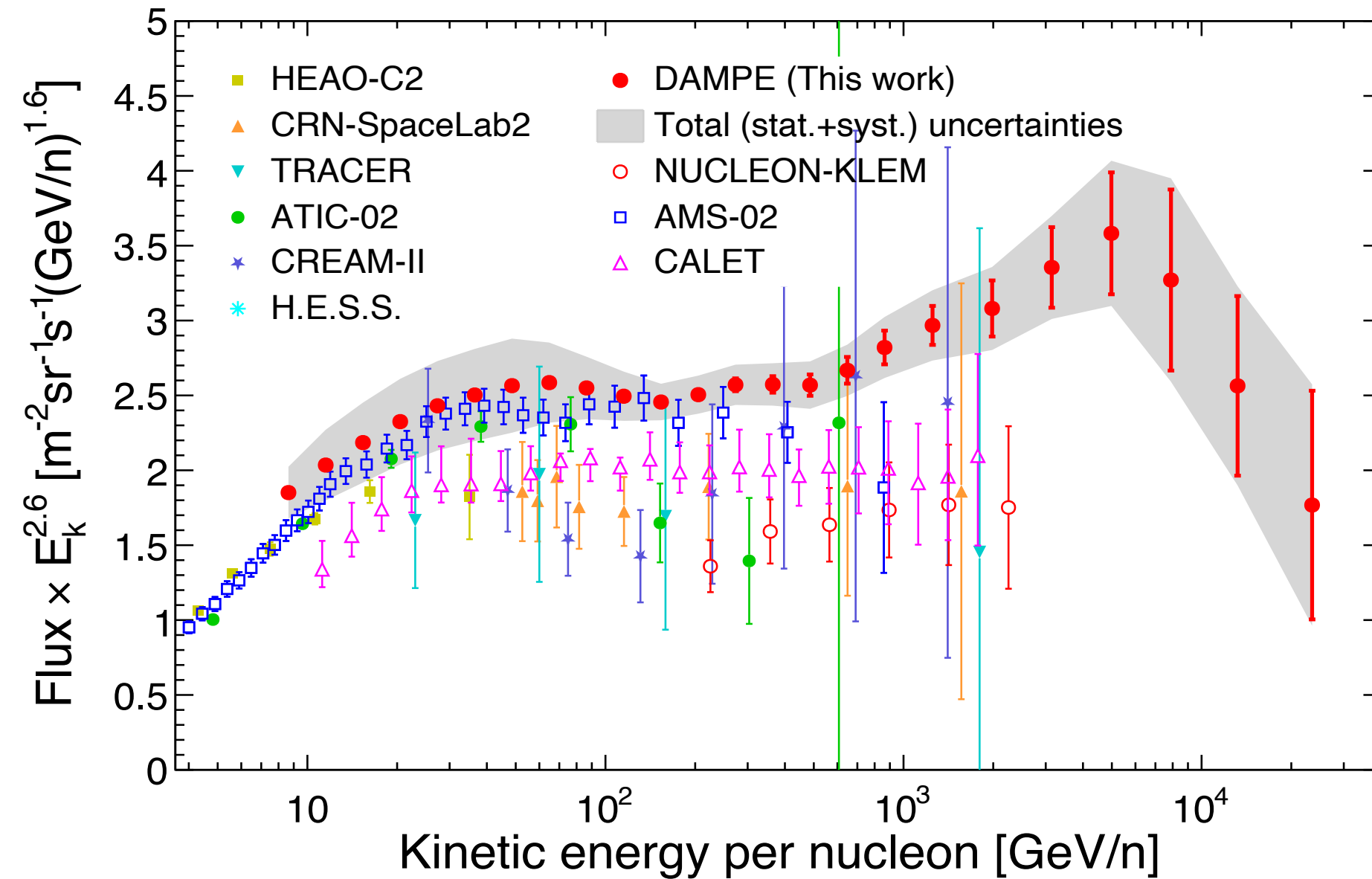
$$\Phi_{\text{SBPL}}(E) = \Phi_0 \cdot \left(\frac{E}{10^3 \text{ GeV}} \right)^{-\gamma} \left[1 + \left(\frac{E}{E_{\text{br}}} \right)^s \right]^{\frac{\Delta\gamma}{s}}$$

Particle	Carbon	Oxygen
Fit energy range	19.0 - 675 TeV	9.0 - 900 TeV
Nuisance parameters	2	3
Φ_0 ($10^{-5} \text{ GeV}^{-1} \text{ m}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$)	0.60 ± 0.12	1.54 ± 0.16
E_{br} (TeV)	96.5 ± 33.5	123 ± 38
γ	2.32 ± 0.06	2.45 ± 0.03
$\Delta\gamma$	-0.49 ± 0.17	-0.48 ± 0.18
s	10 (fixed)	10 (fixed)

◎ Latest results based on 9 years' DAMPE data



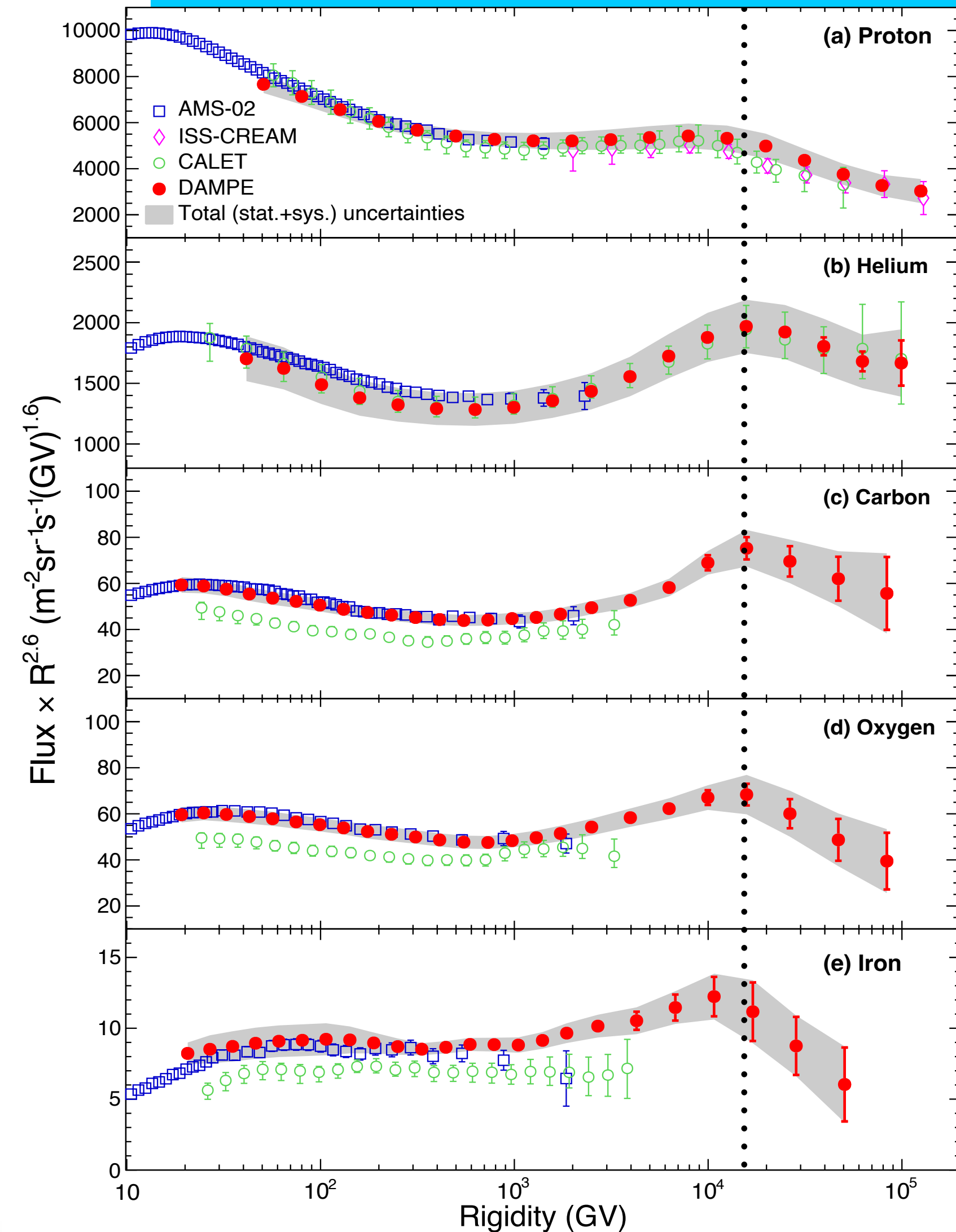
$$\Phi_{\text{SBPL}}(E) = \Phi_0 \cdot \left(\frac{E}{10^3 \text{ GeV}} \right)^{-\gamma} \left[1 + \left(\frac{E}{E_{\text{br}}} \right)^s \right]^{\frac{\Delta\gamma}{s}}$$



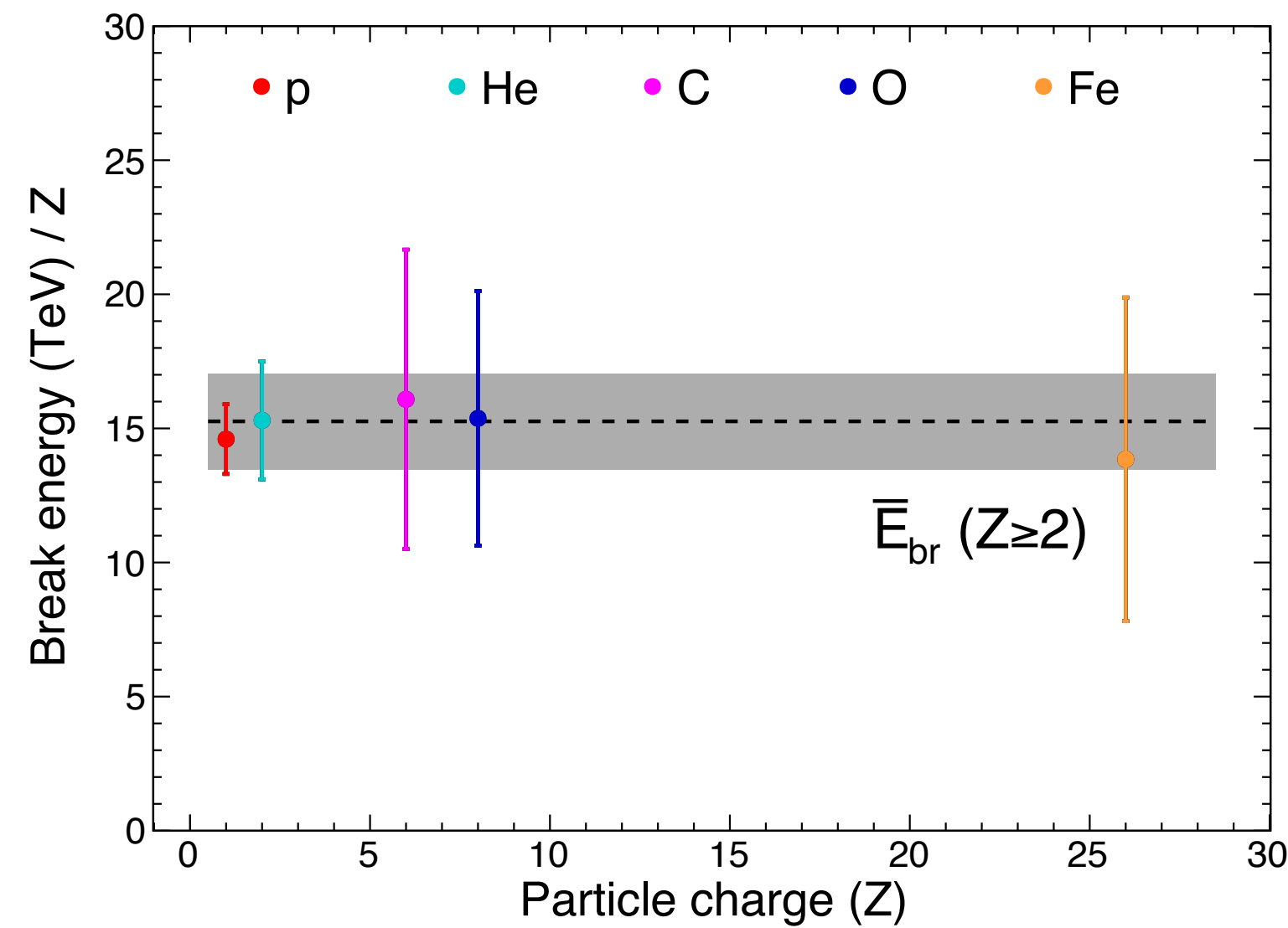
Particle	Carbon	Oxygen	Iron
Fit energy range	19.0 - 675 TeV	9.0 - 900 TeV	236 - 1771 TeV
Nuisance parameters	2	3	3
Φ_0 ($10^{-5} \text{ GeV}^{-1} \text{ m}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$)	0.60 ± 0.12	1.54 ± 0.16	1.50 ± 0.47
E_{br} (TeV)	96.5 ± 33.5	123 ± 38	360 ± 157
γ	2.32 ± 0.06	2.45 ± 0.03	2.46 ± 0.05
$\Delta\gamma$	-0.49 ± 0.17	-0.48 ± 0.18	-0.69 ± 0.41
s	10 (fixed)	10 (fixed)	10 (fixed)

Universal softening at 15 GV

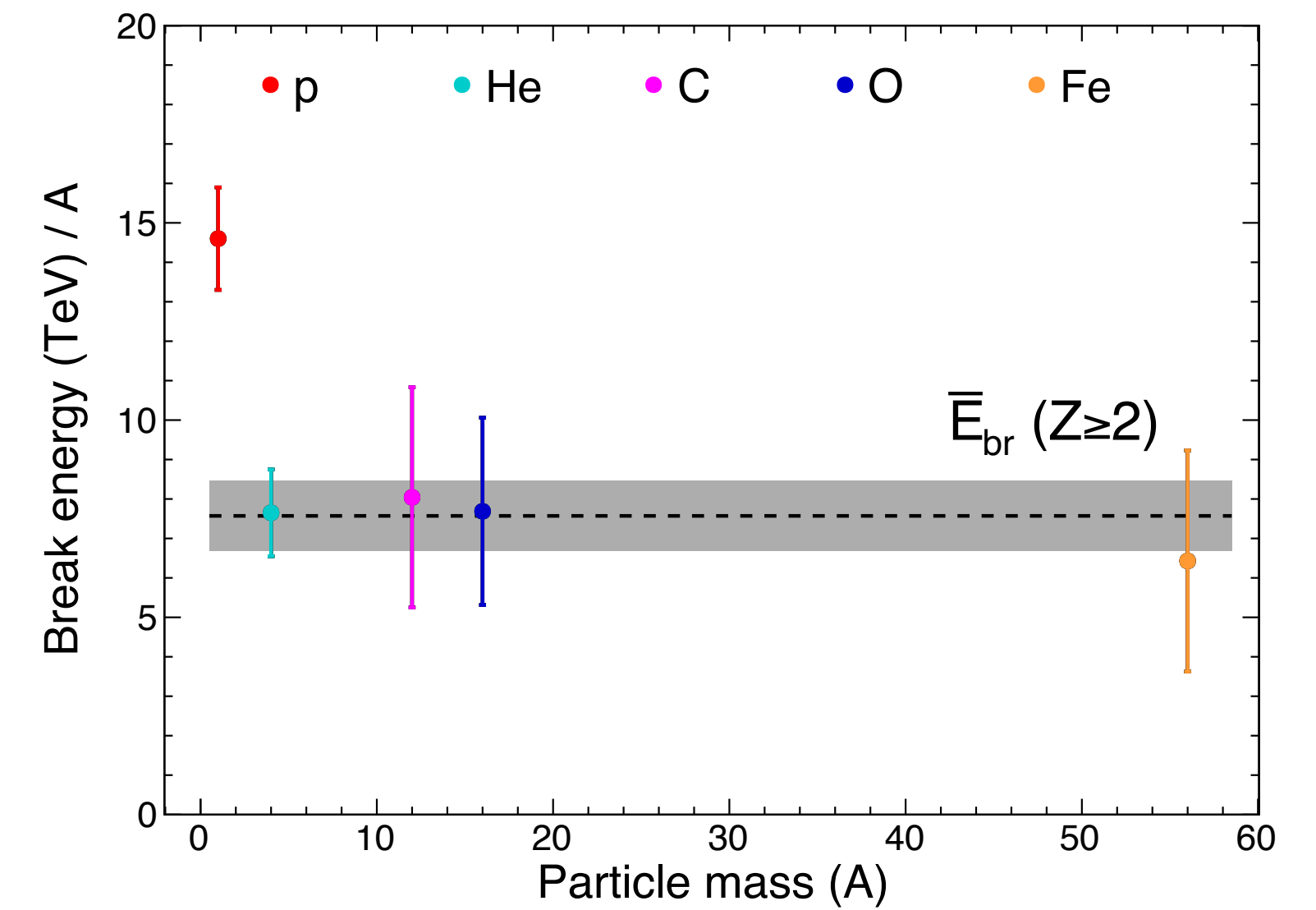
DAMPE collab., Nature, 653, 52-55 (2026)



E_{br} v.s. Z



E_{br} v.s. A

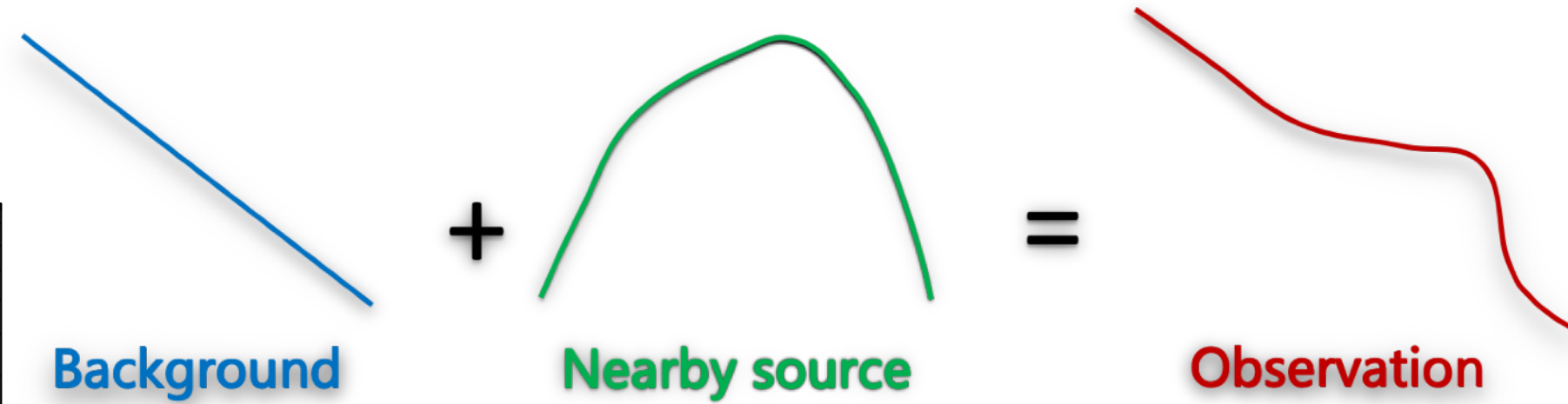
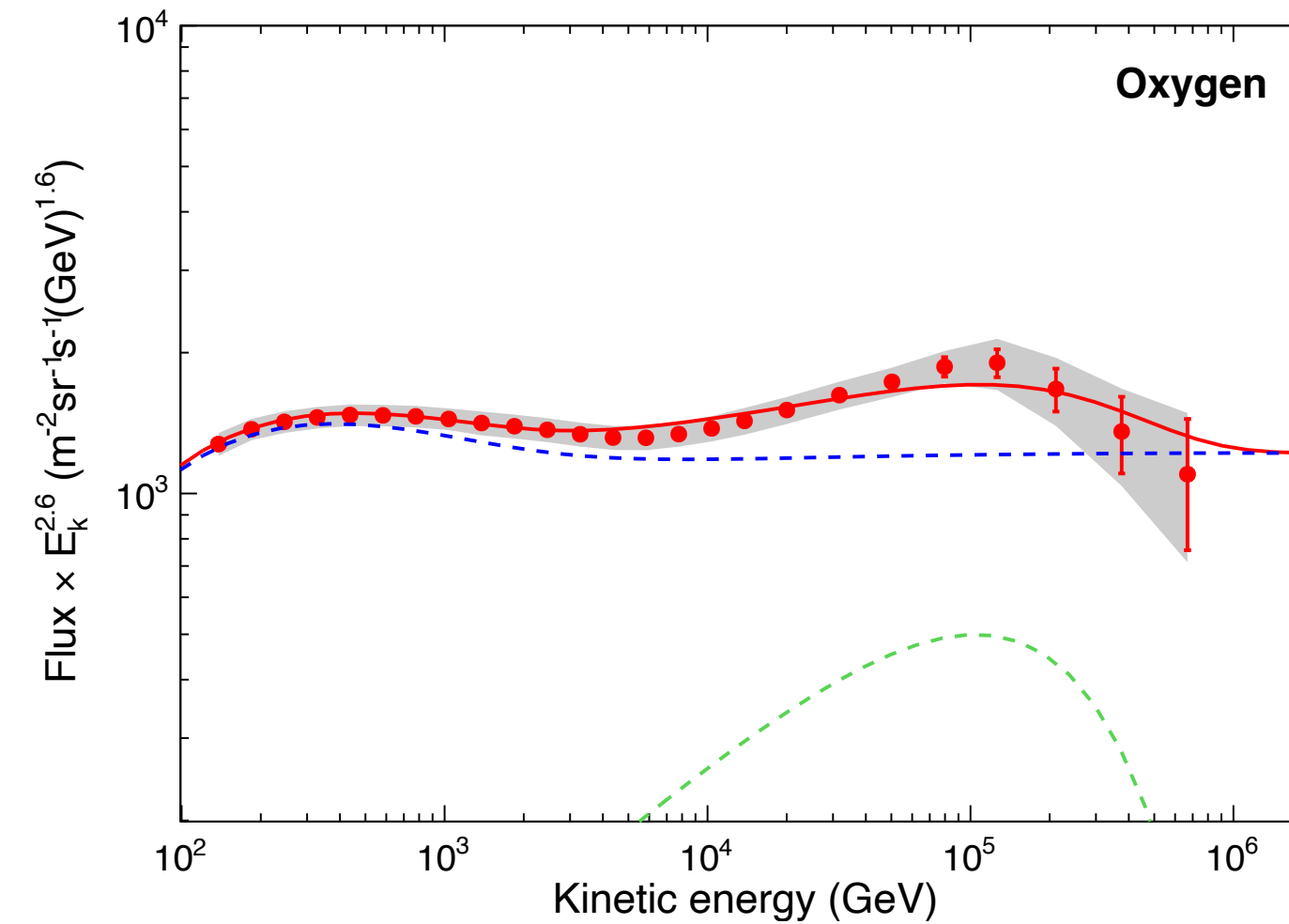
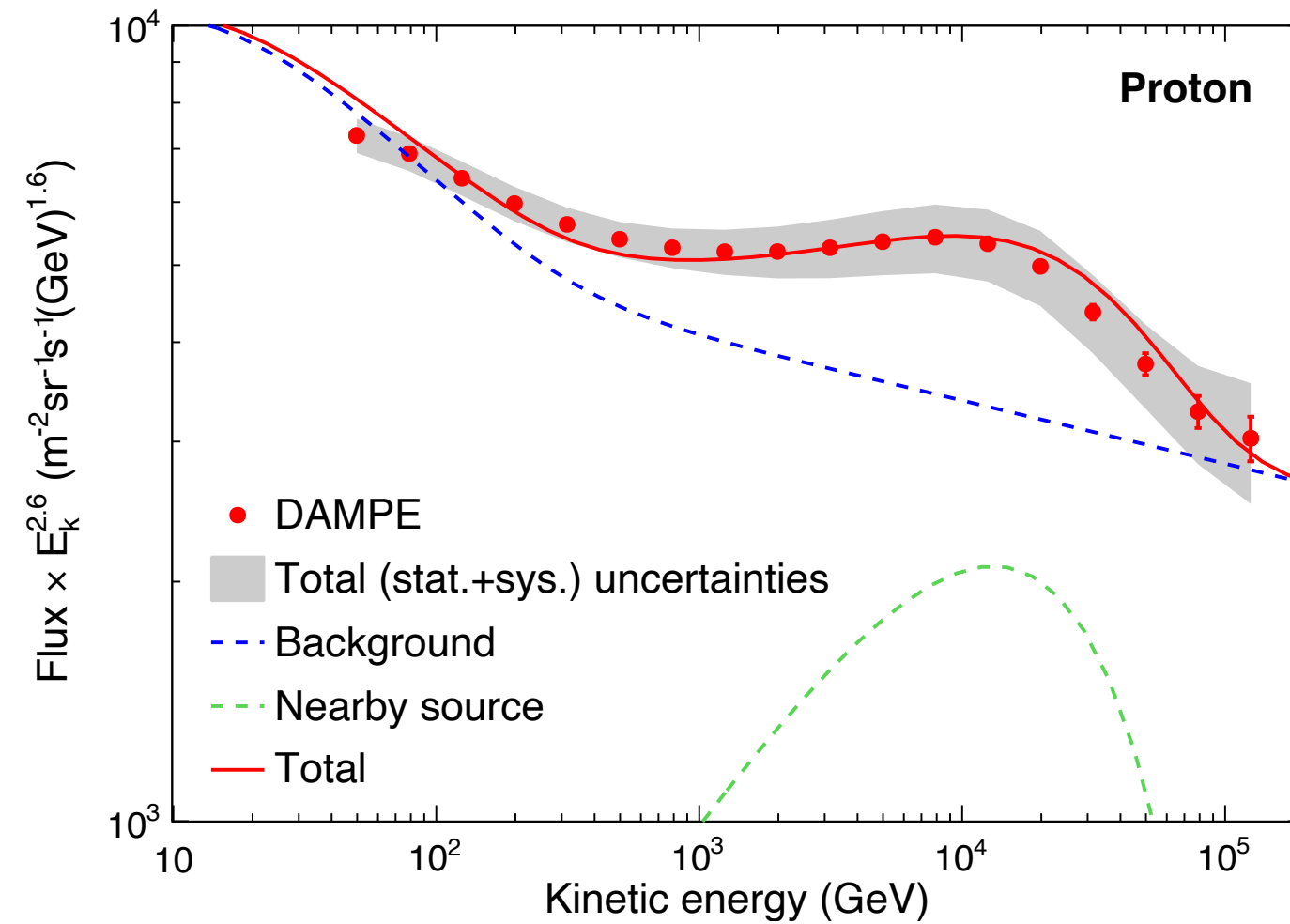


- **A universal softening feature in five primary CR spectra at a unified rigidity ($E_{\text{br}} \sim 15$ GV) is observed for the first time, providing observational verification of the charge-dependent energy limit of cosmic ray acceleration**
- The mass(A) dependence of the softening energies can be excluded at a confidence level of **$> 99.999\%$ (4.4σ)**

Nearby source model

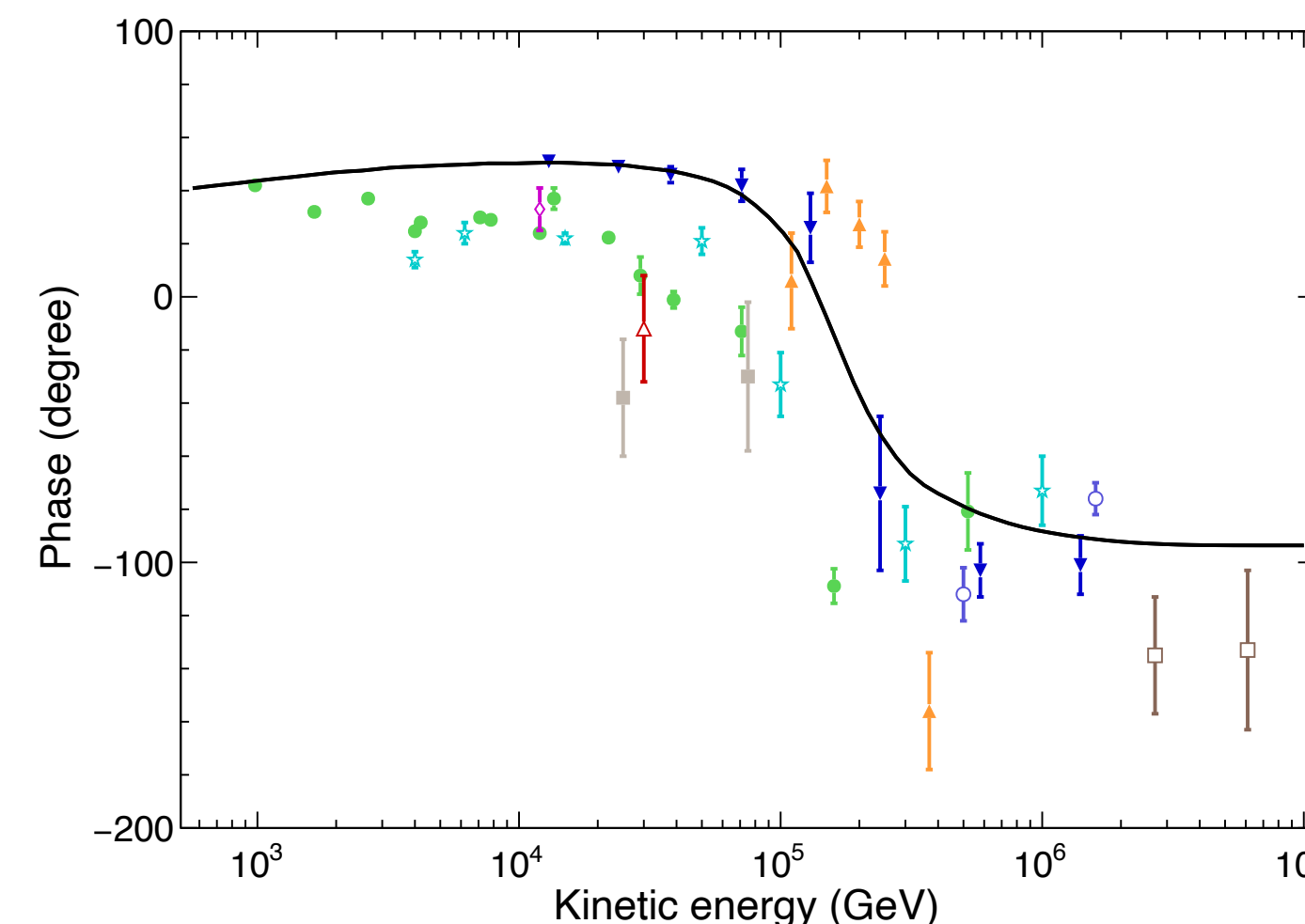
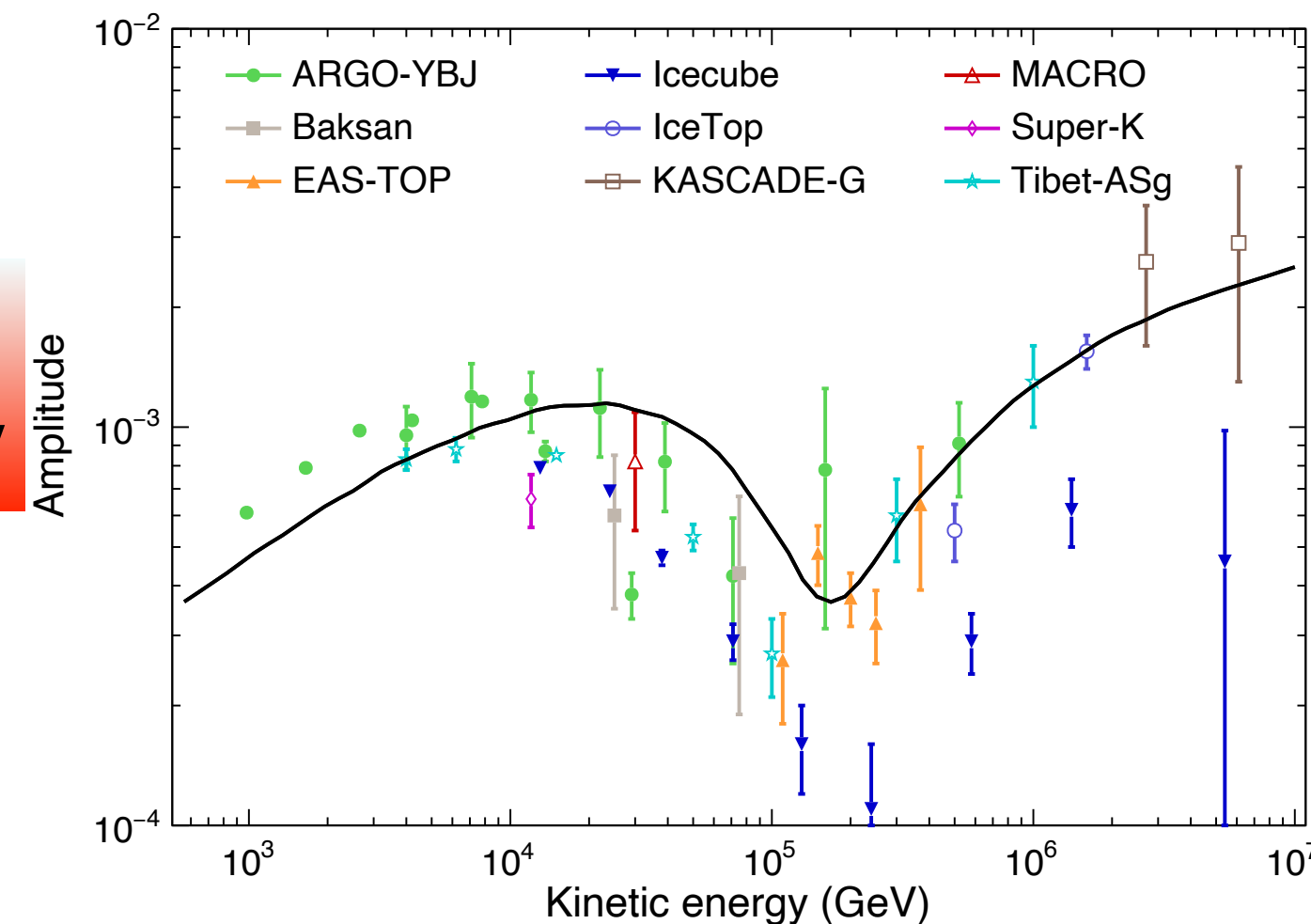
Physical interpretation: Background + Nearby source

CR
Spectra



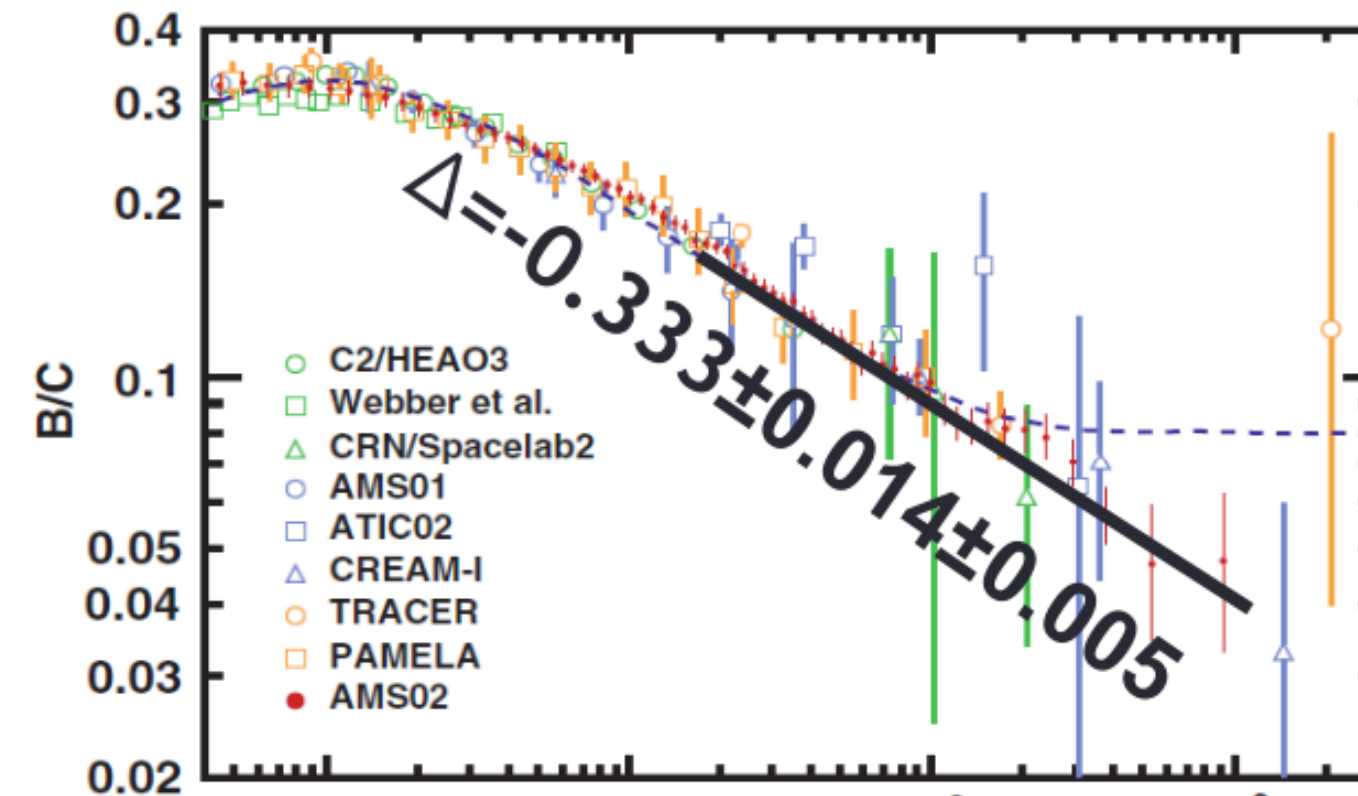
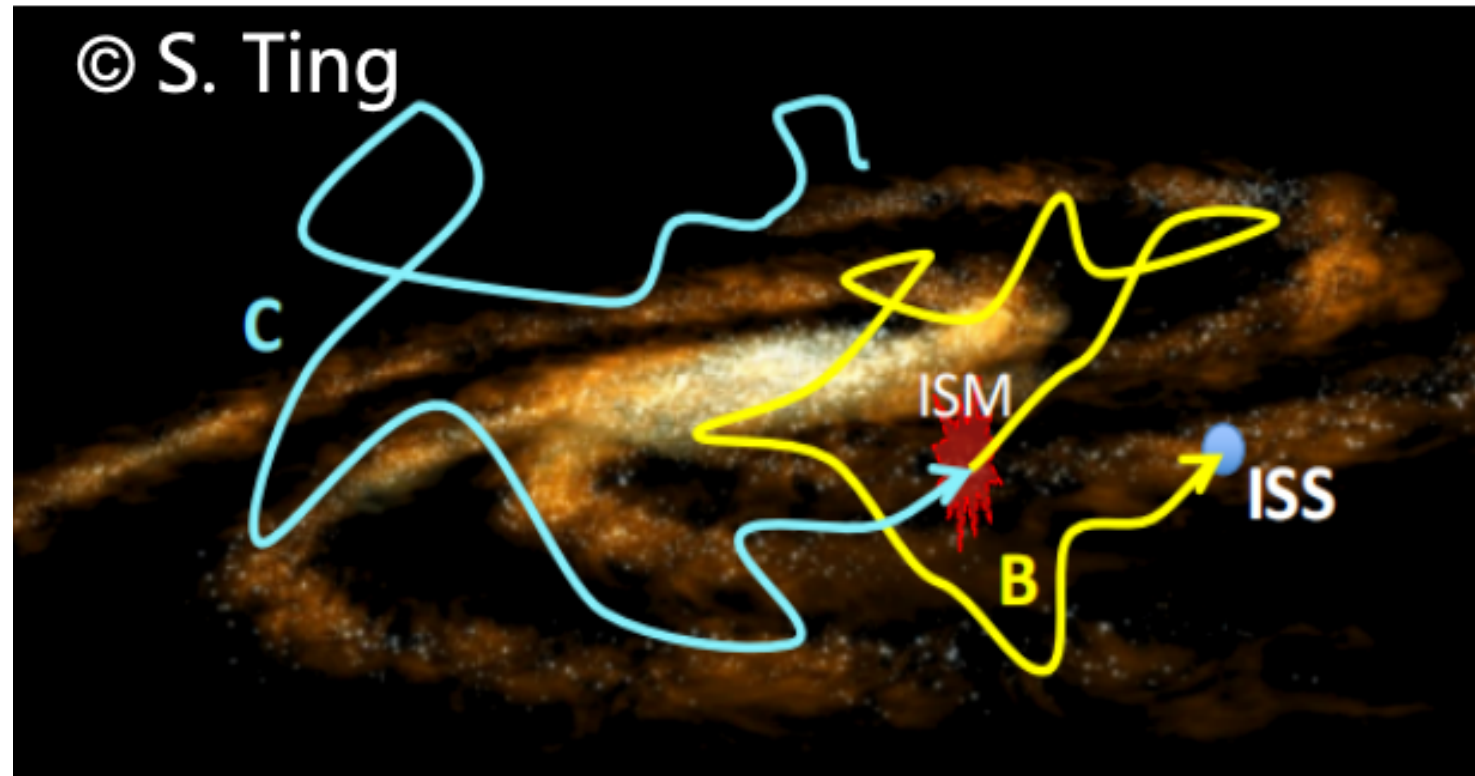
Nearby source:
Geminga-like
250 pc, 3.4×10^5 yr
 $q_{\text{src}} \propto (R/\text{GV})^{-\beta} \exp(-R/R_c)$

CR
Anisotropy

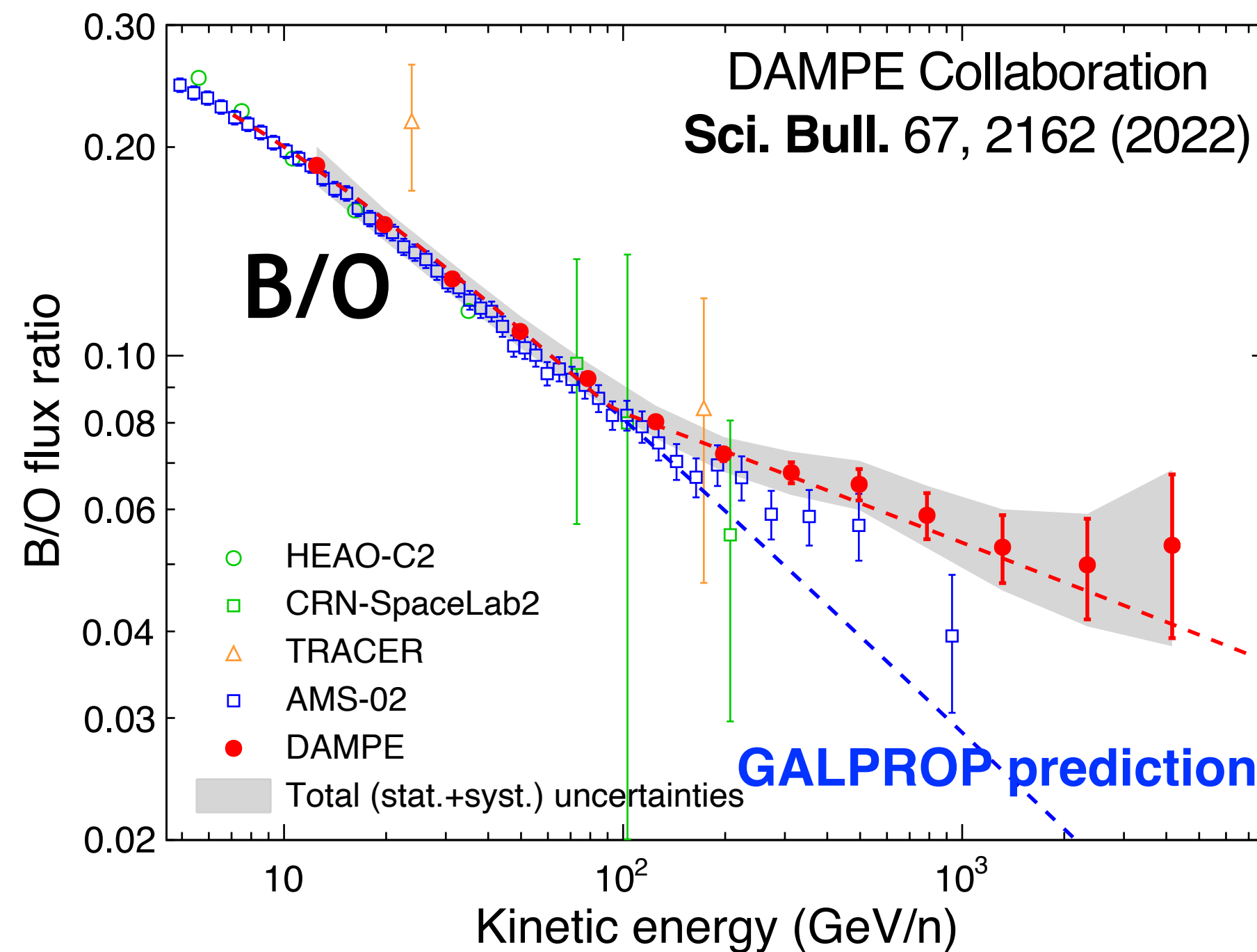
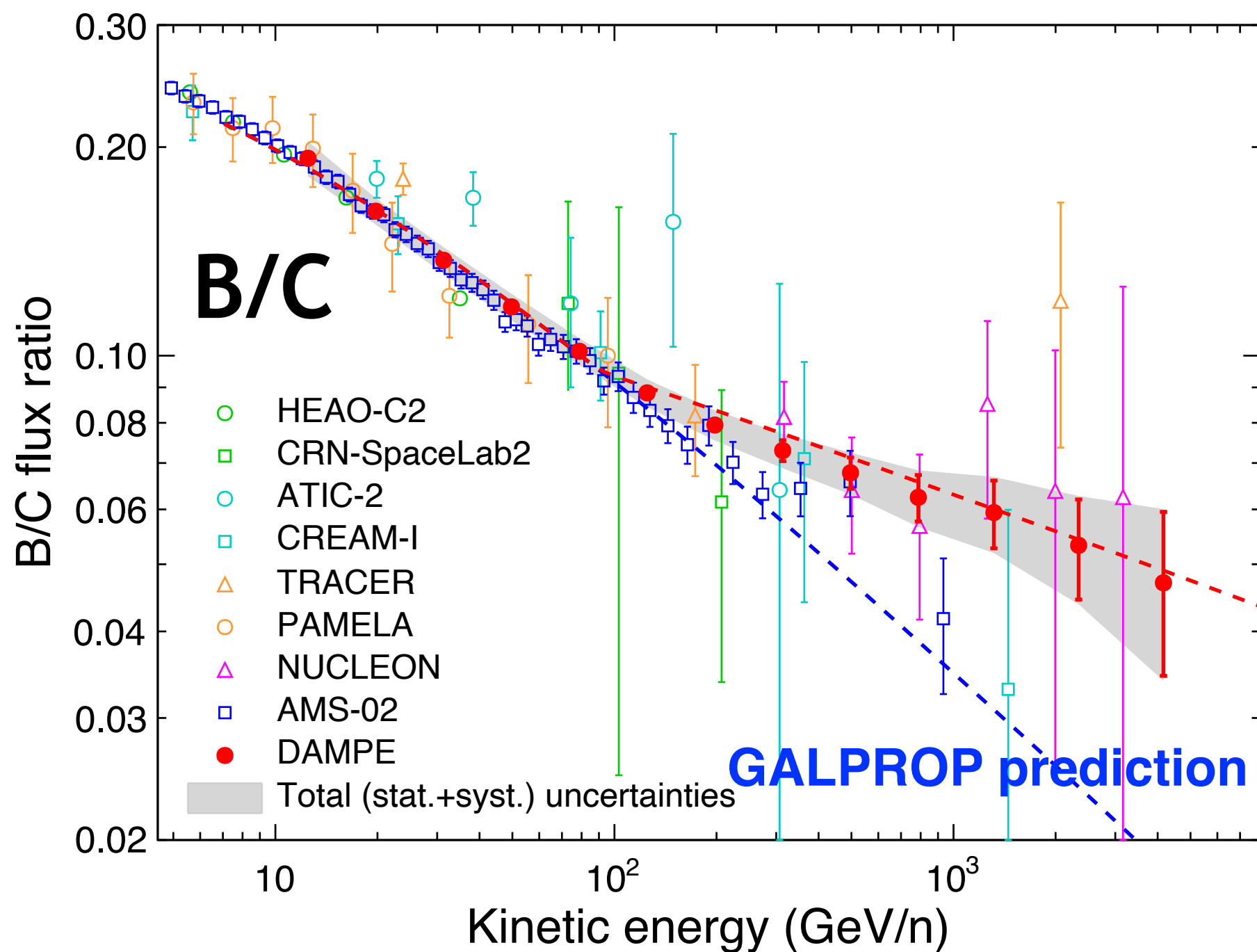


Simultaneously explain observations of the CR spectral bumps and the large-scale CR anisotropies

Secondary cosmic-ray: B/C, B/O



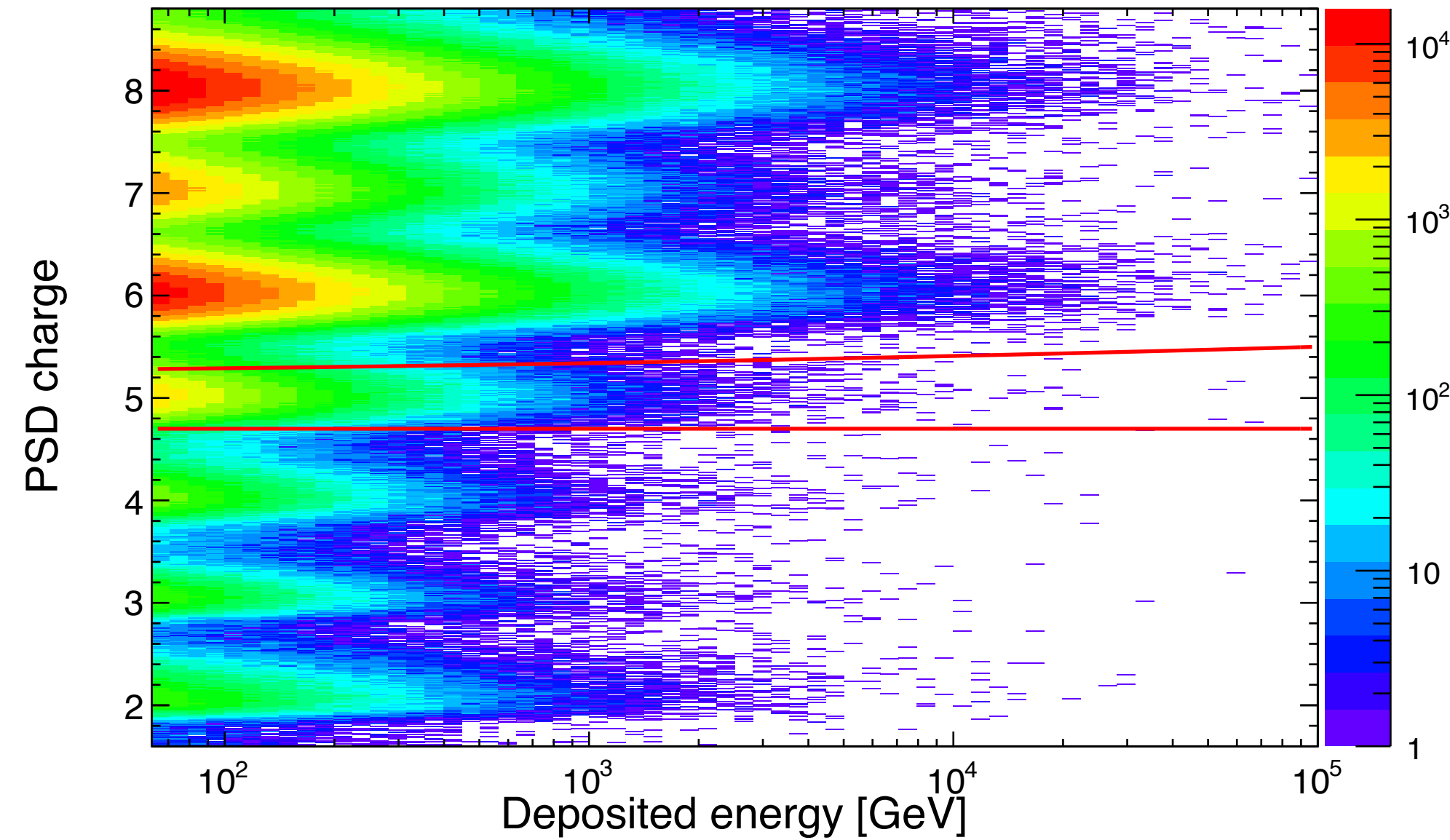
- B/C is an essential variable to characterize the CR diffusion/propagation
- AMS measurement showed a good power-law behavior with $\Delta = -1/3$, consistent with the Kolmogorov's turbulence theory



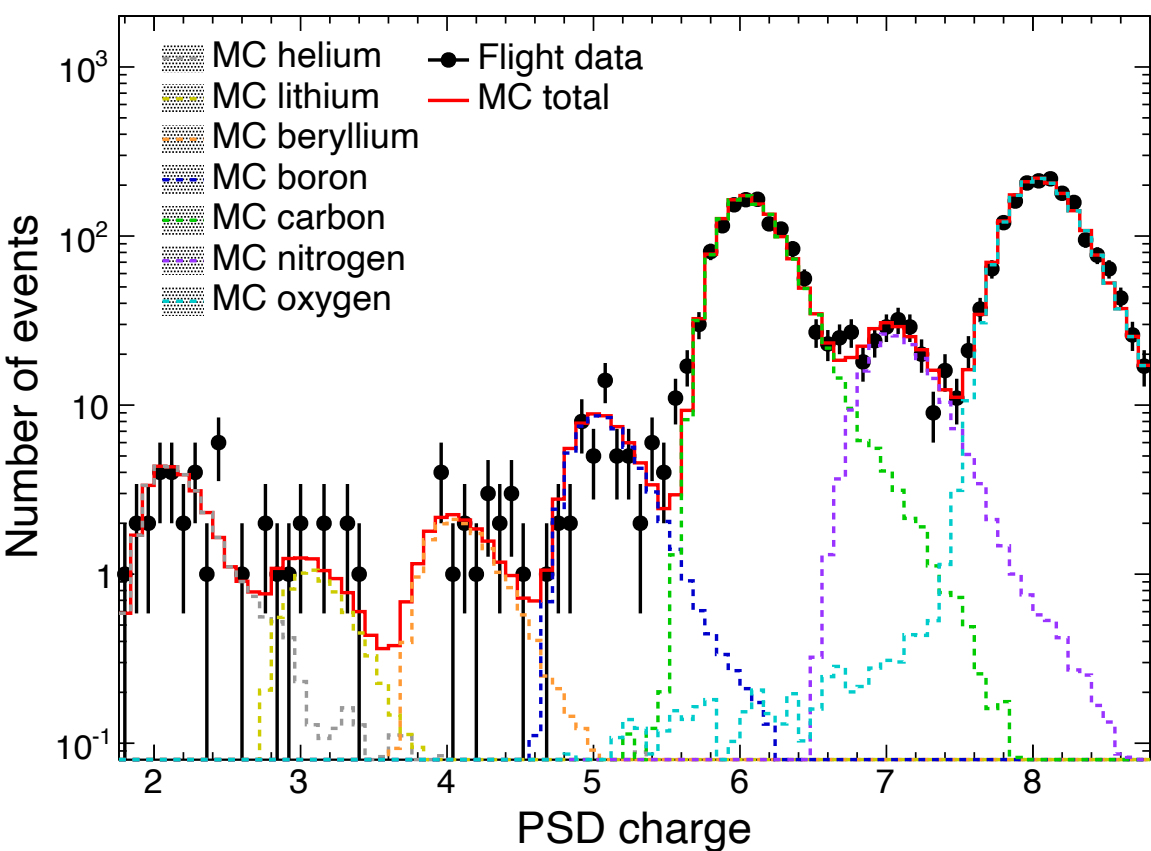
DAMPE measurements:
Common spectral hardening feature above 100 GeV/n is observed for both of B/C and B/O, deviating from the traditional model prediction

Secondary cosmic-ray: B

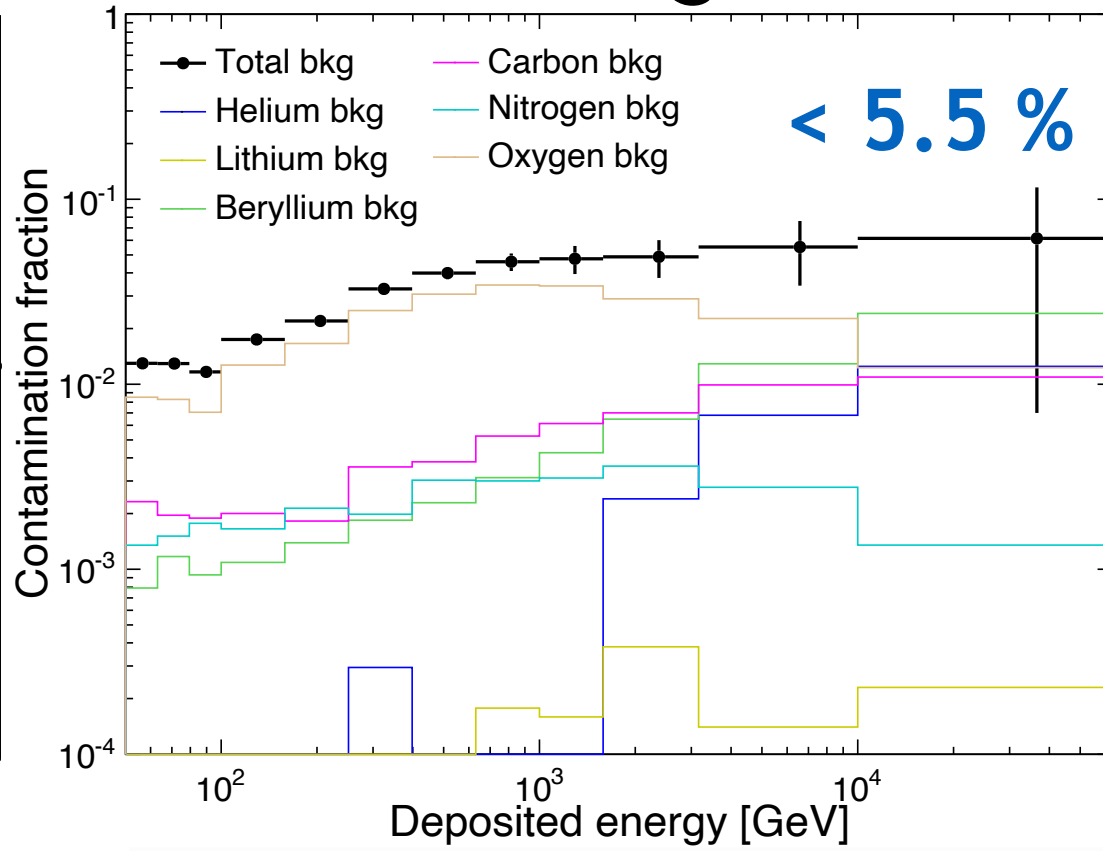
PsdQ vs. BgoE



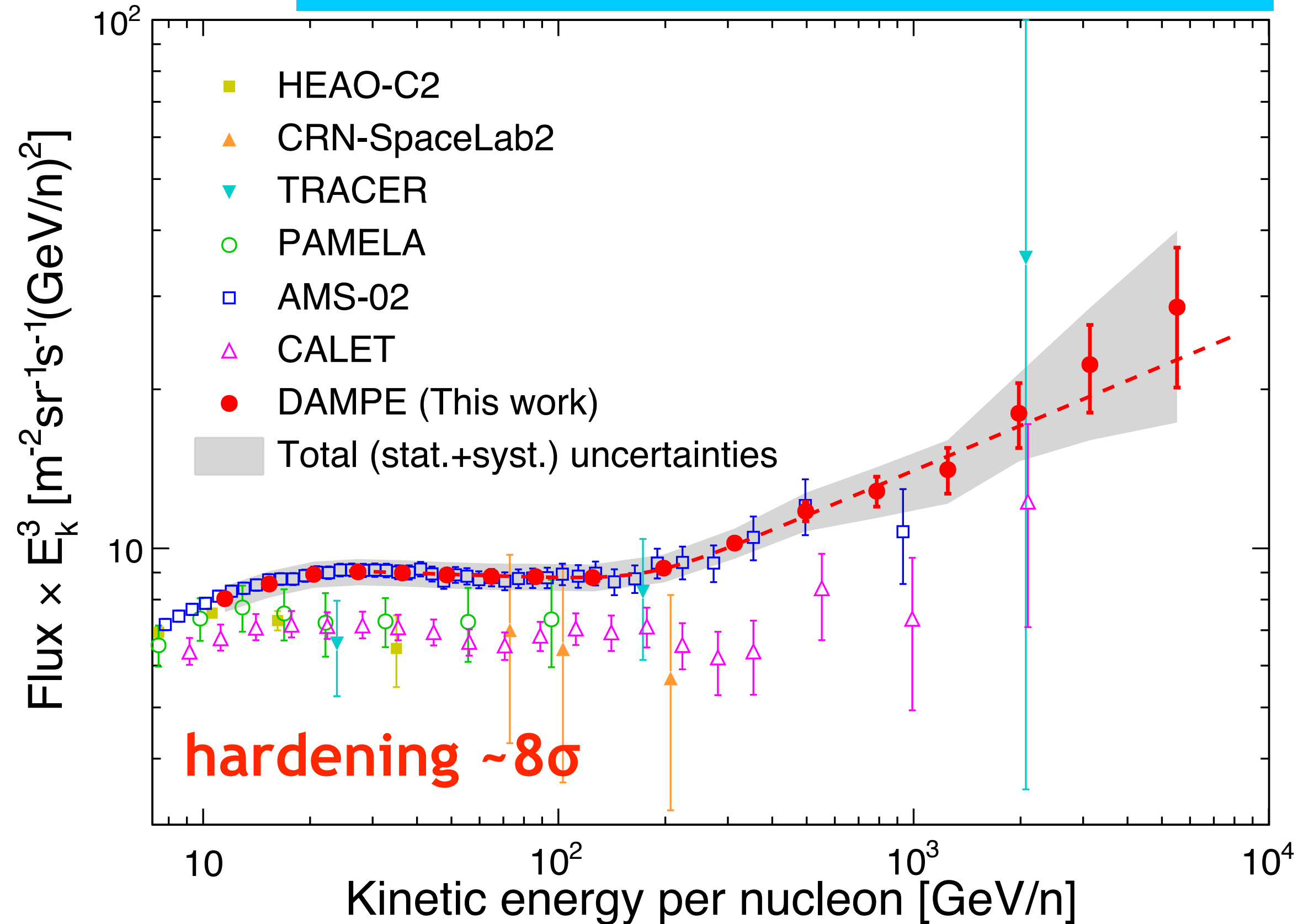
BgoE: [6.3, 20] TeV



Boron background

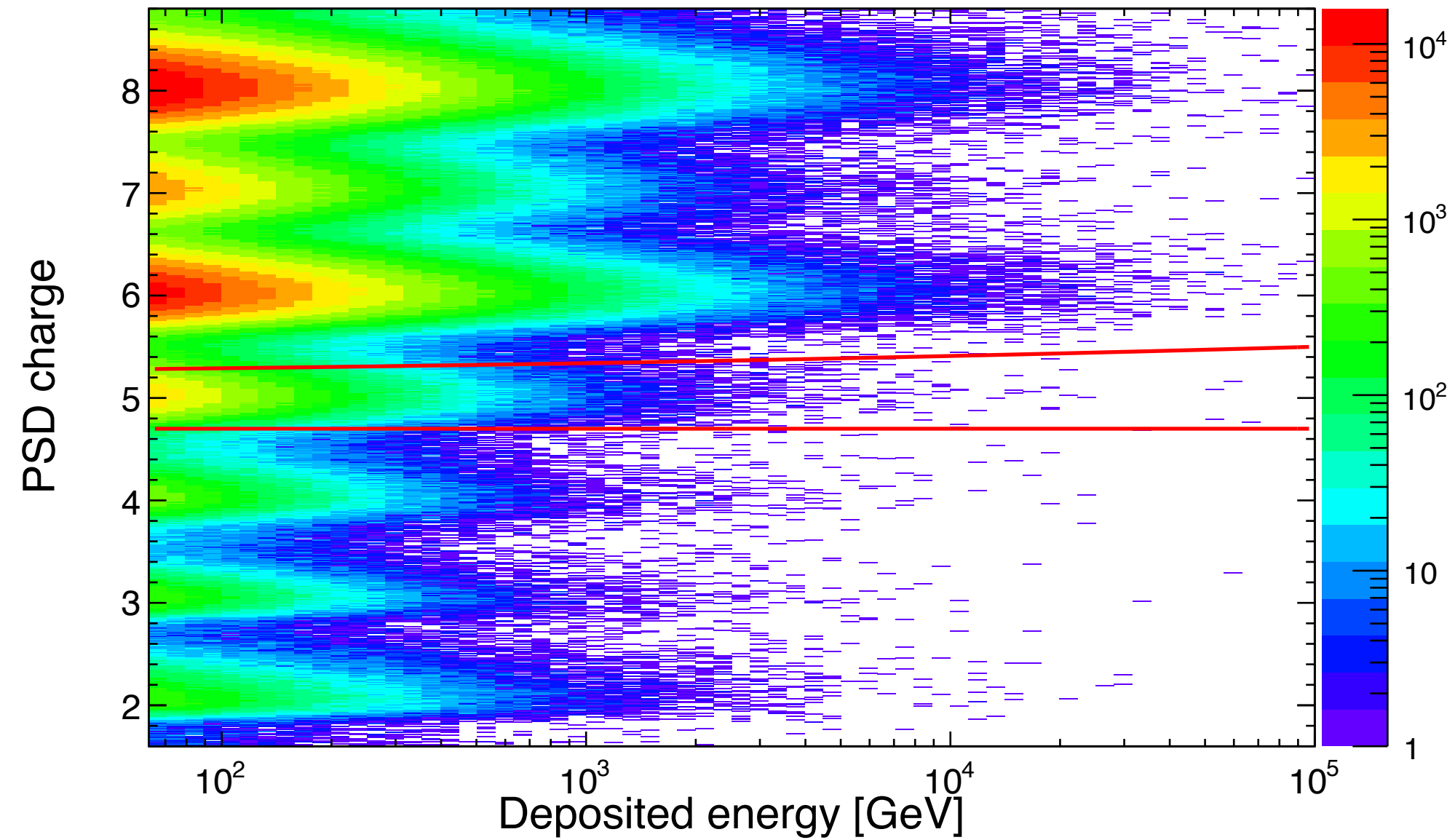


DAMPE collab., Phy. Rev. Lett. 134, 191001 (2025)

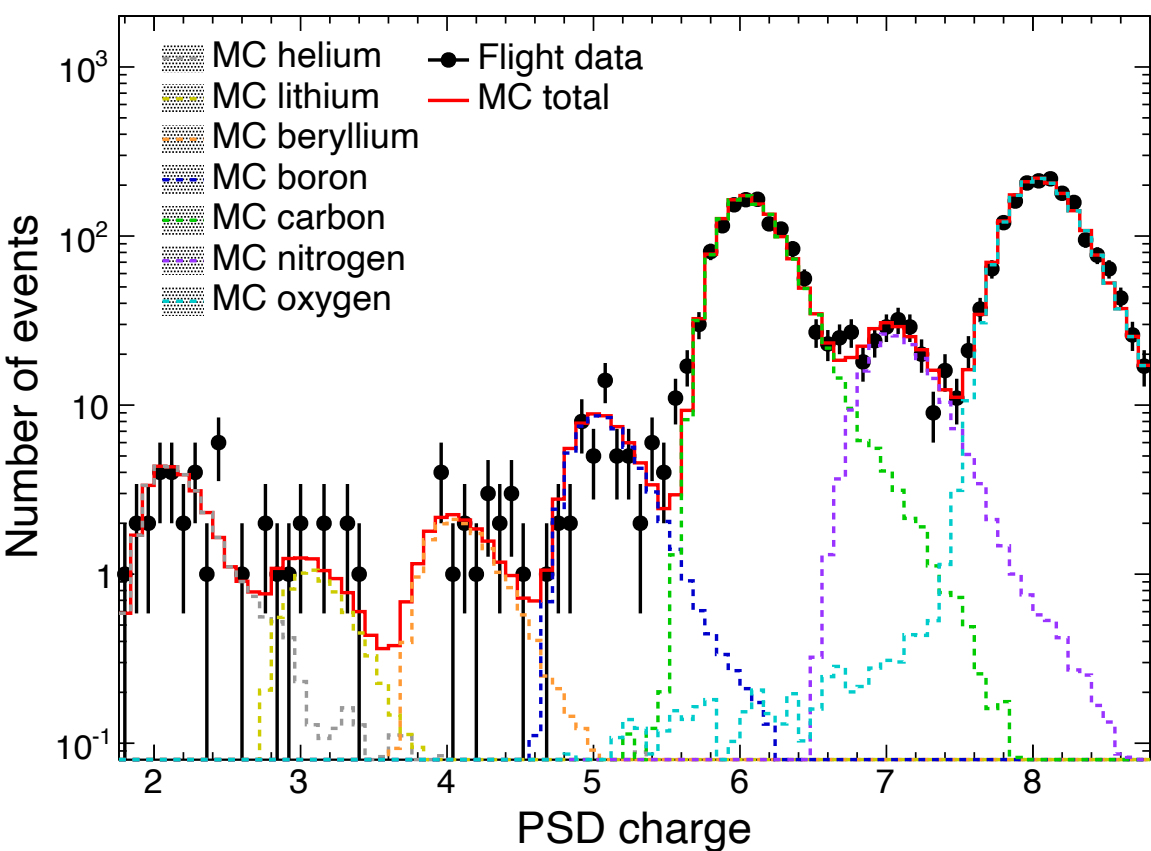


◎ A spectral hardening at ~ 200 GeV/n with 8 sigma of CL. is observed

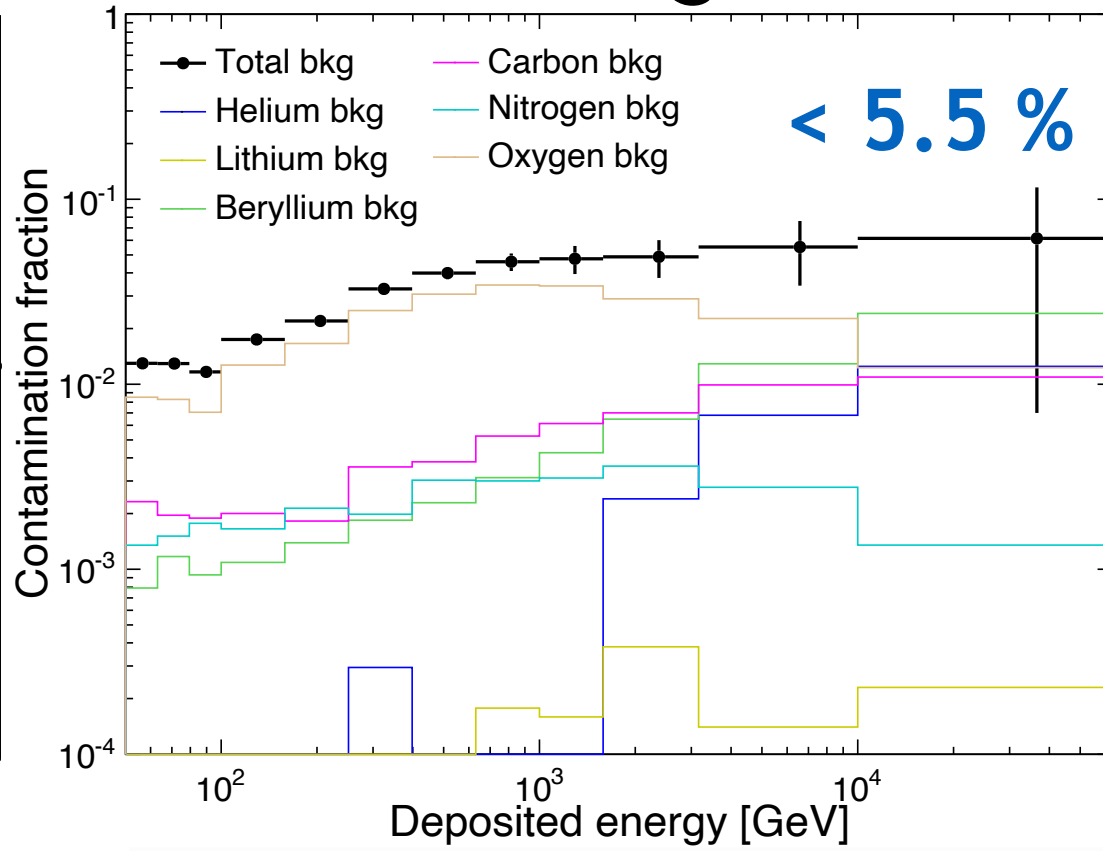
PsdQ vs. BgoE



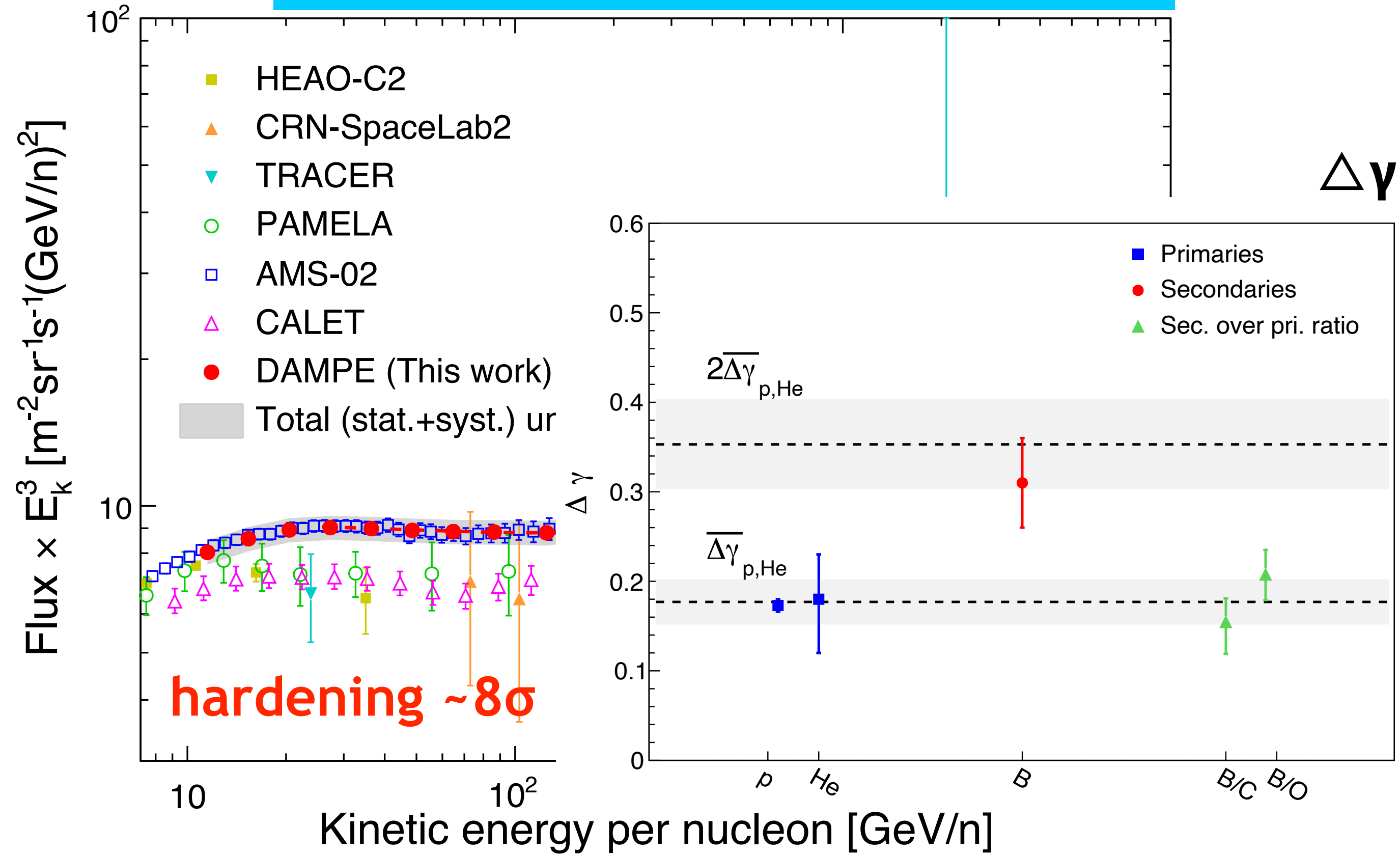
BgoE: [6.3, 20] TeV



Boron background



DAMPE collab., Phy. Rev. Lett. 134, 191001 (2025)



◎ A spectral hardening at ~ 200 GeV/n with 8 sigma of CL. is observed

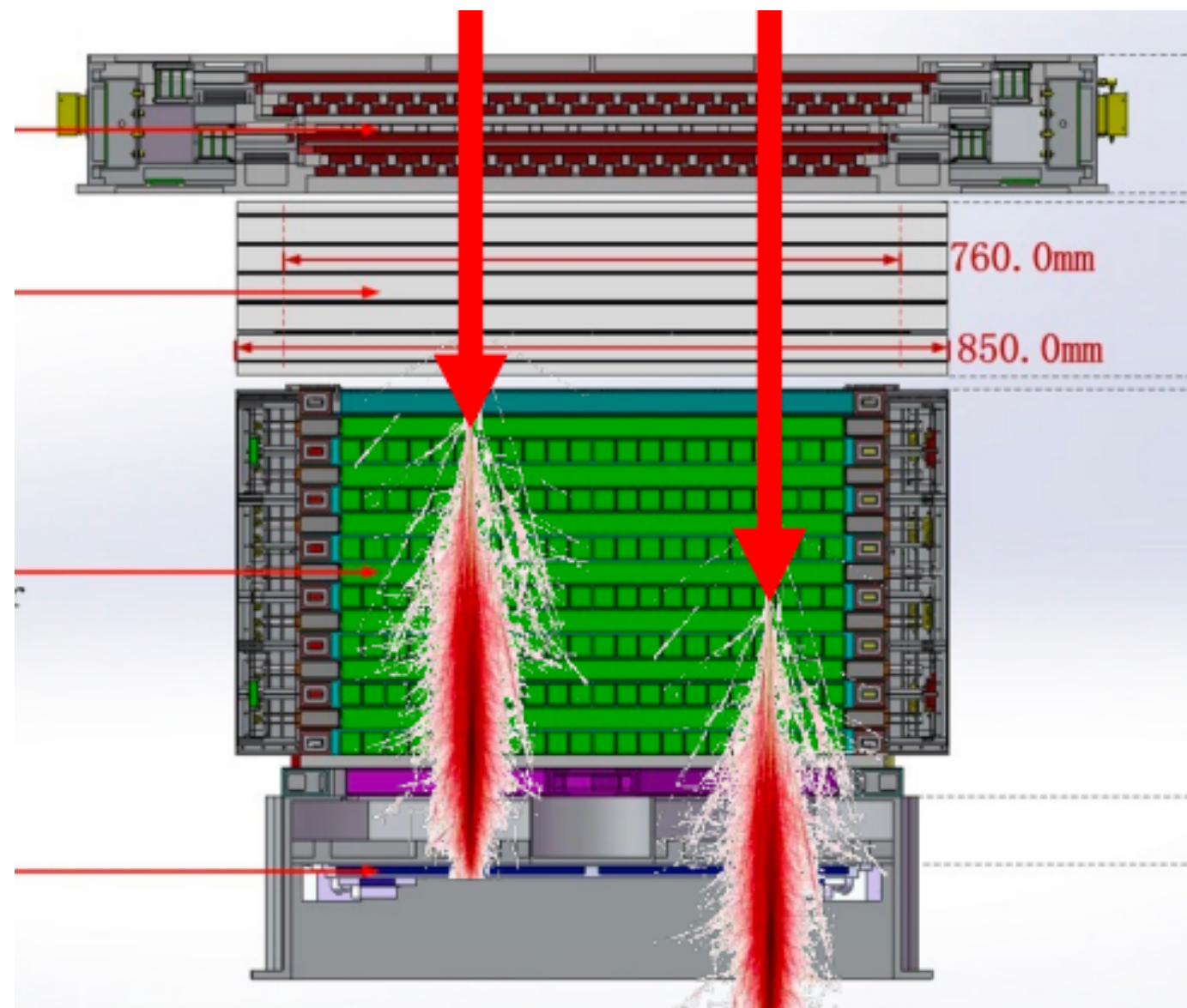
◎ $\Delta\gamma$ of hardening is about twice vs. p & He

Cross-section: p,He vs. BGO

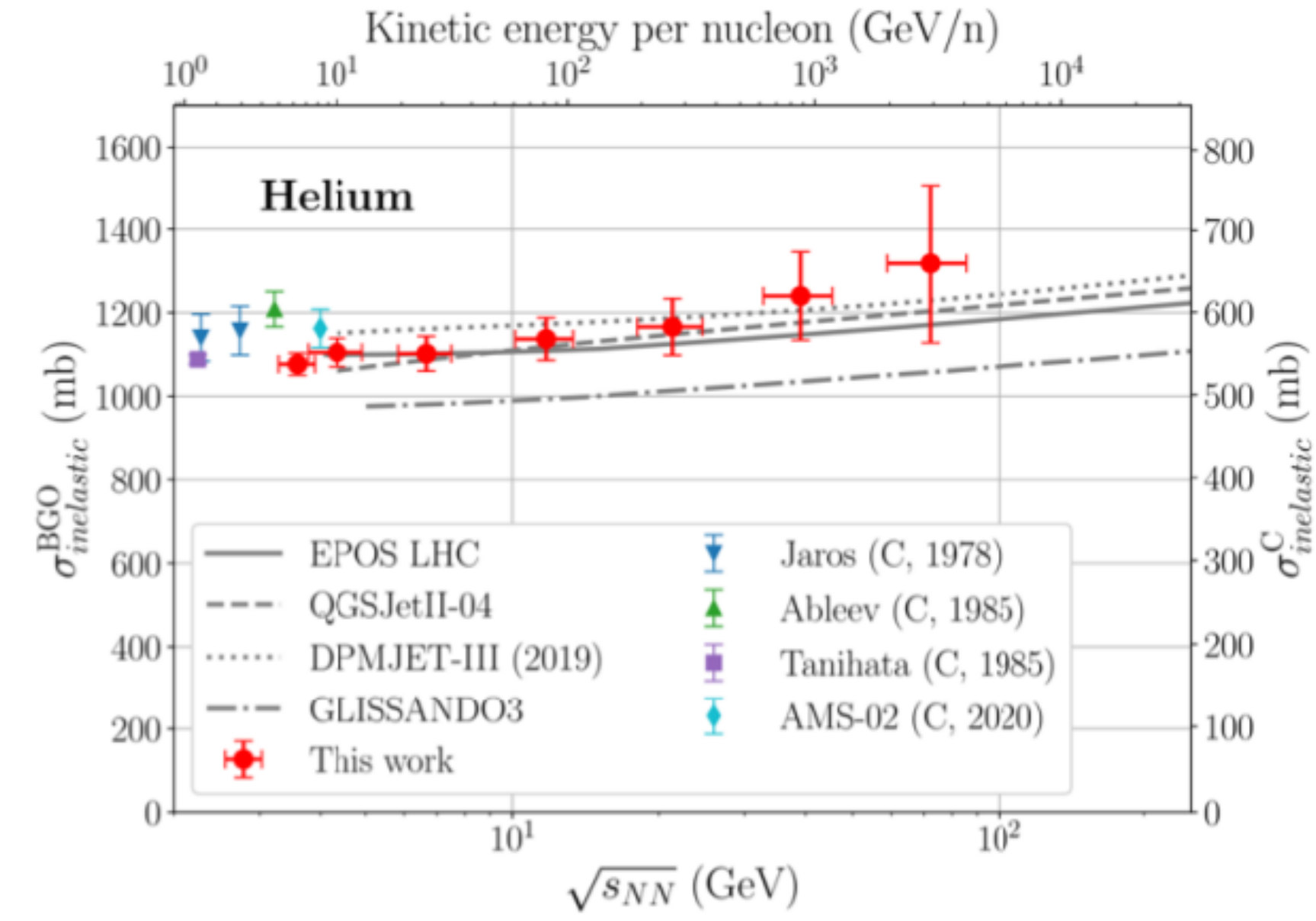
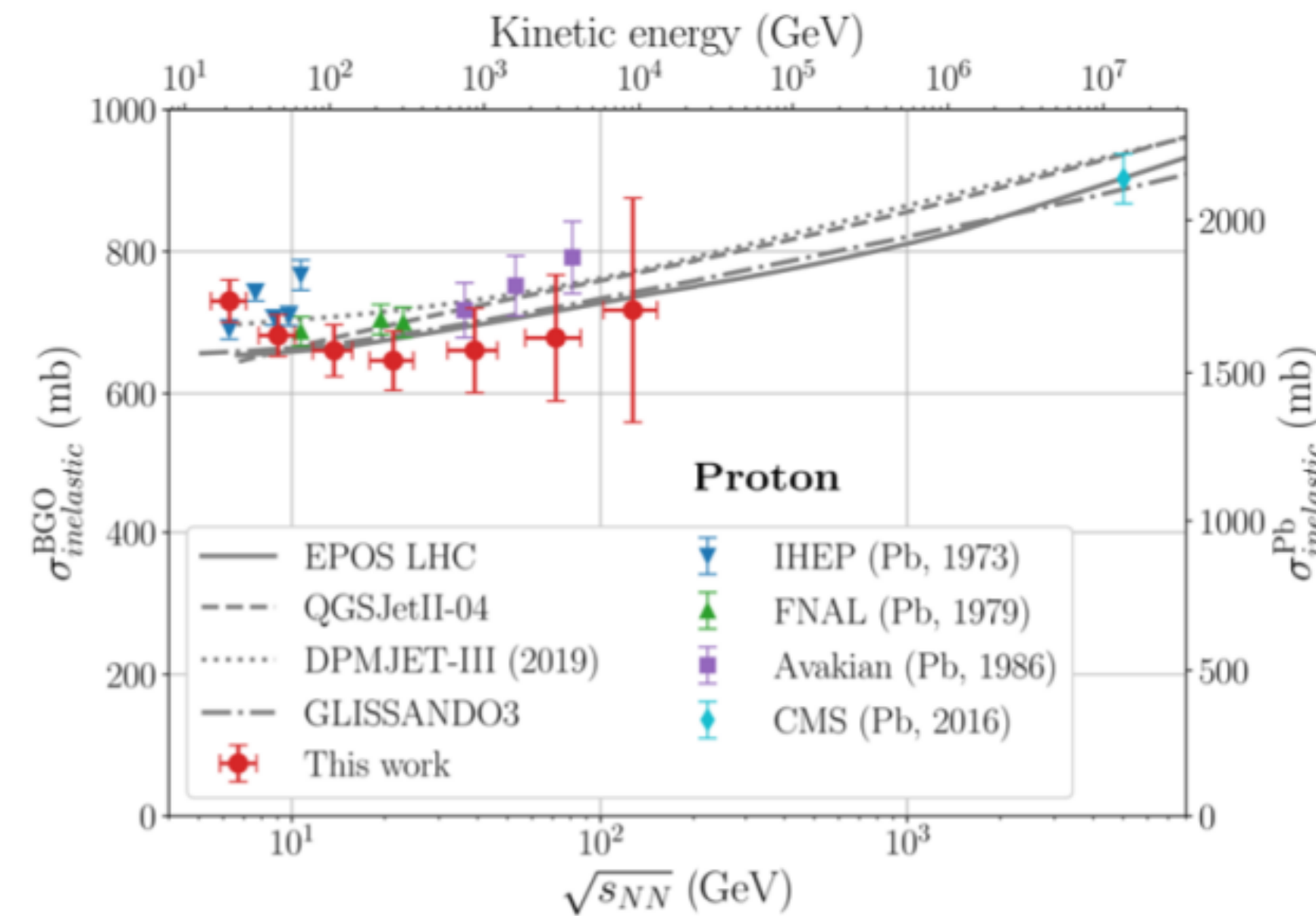
A beam-target experiment

Beam: CR particles

Target: BGO (Bi₄Ge₄O₁₂)



DAMPE collab., *Phy. Rev. D* 111, 012002 (2025)



Survive possibility $\longrightarrow$ Hadronic cross-section

$$\alpha_i = \frac{N_i}{\sum_{j=2}^{10} N_j}$$

$$\sigma_{true}(E) = (1 + \kappa) \cdot \sigma_{MC}(E)$$

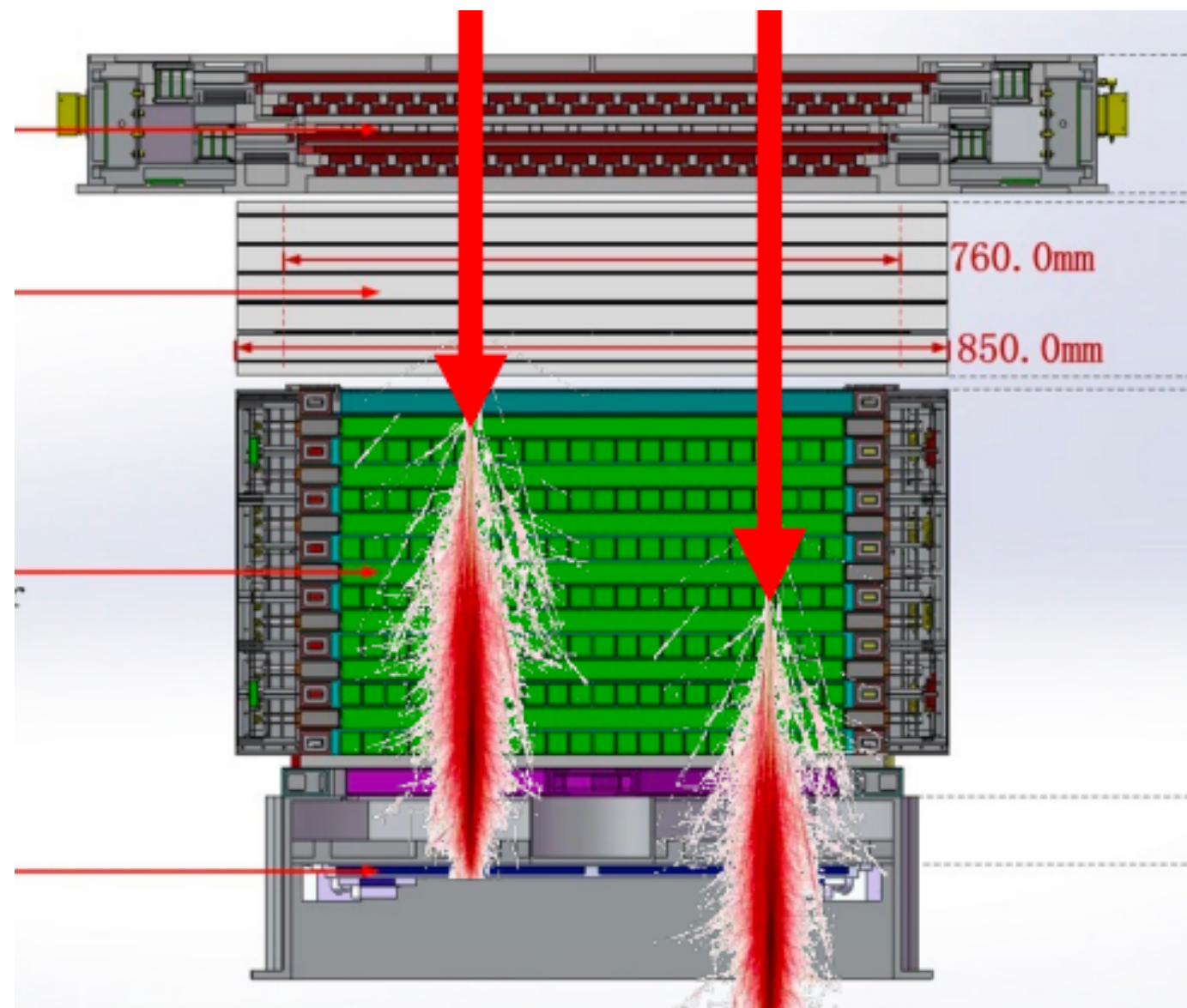
- ◎ Inelastic cross-section of p/He vs. BGO up to 10 TeV
- ◎ Effective validation for the hadronic models above TeV

Cross-section: C,O vs. BGO

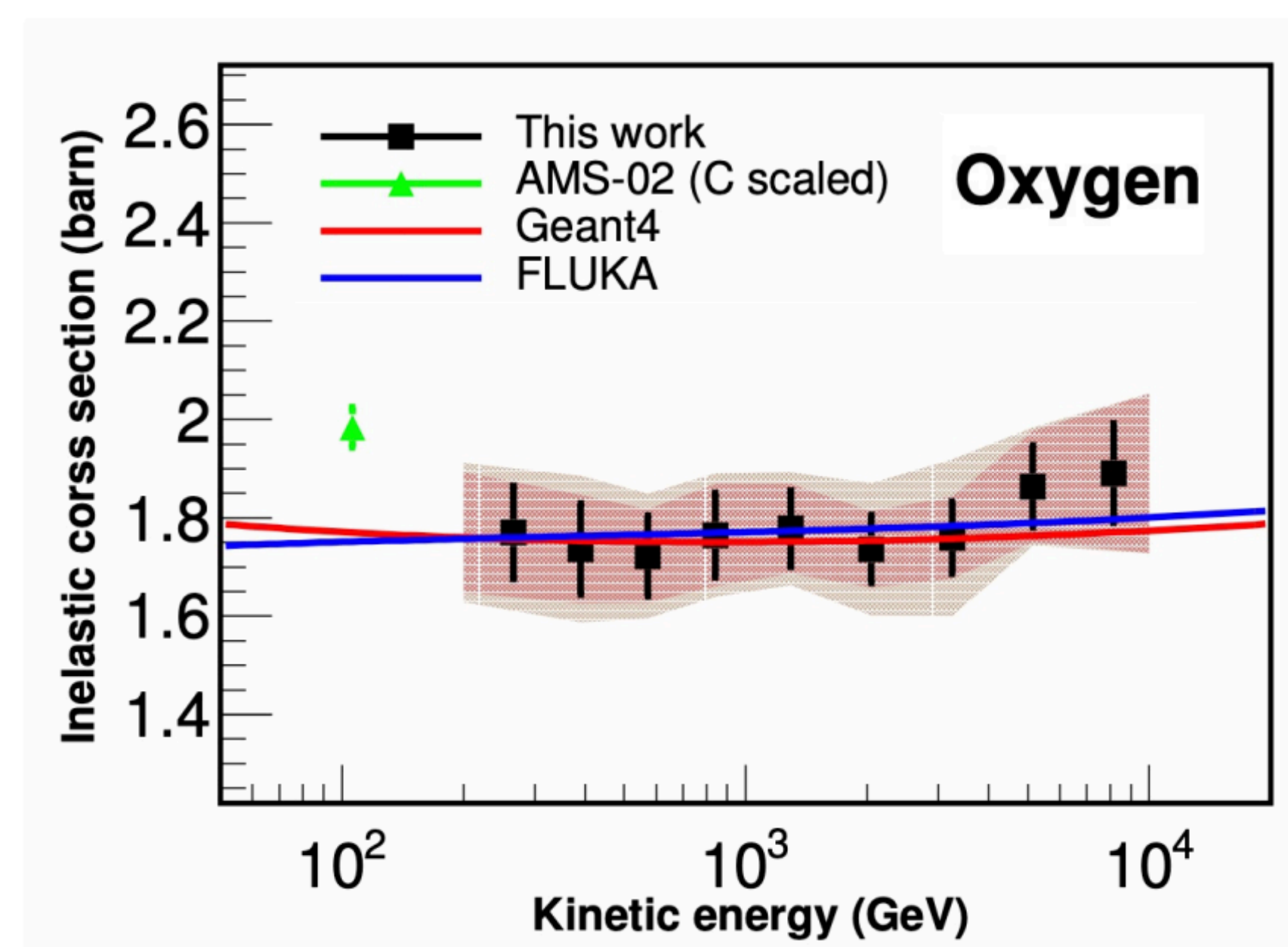
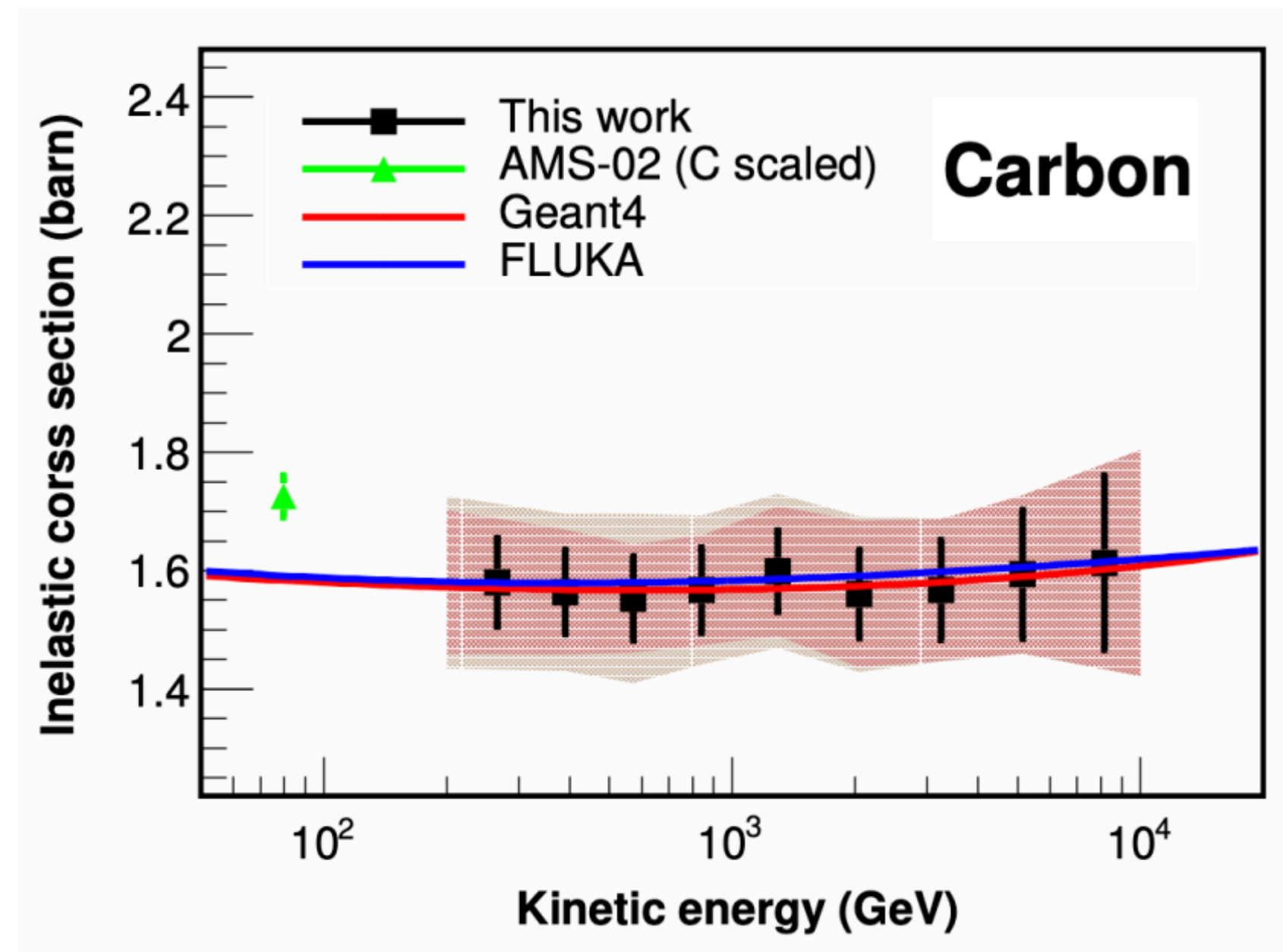
A beam-target experiment

Beam: CR particles

Target: BGO (Bi₄Ge₄O₁₂)



DAMPE collab., *Phy. Rev. D* 112, 022004 (2025)



Survive possibility $\longrightarrow$ Hadronic cross-section

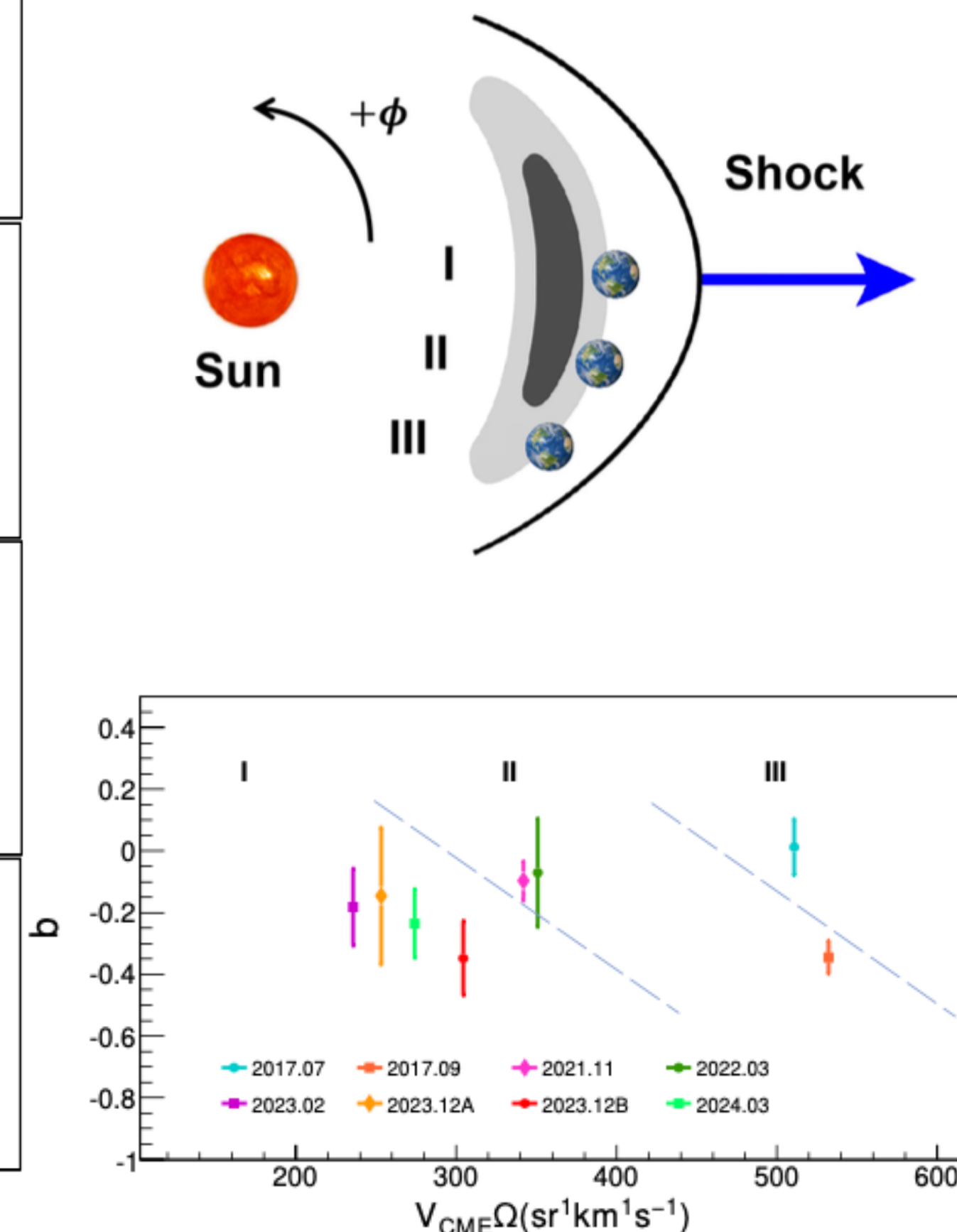
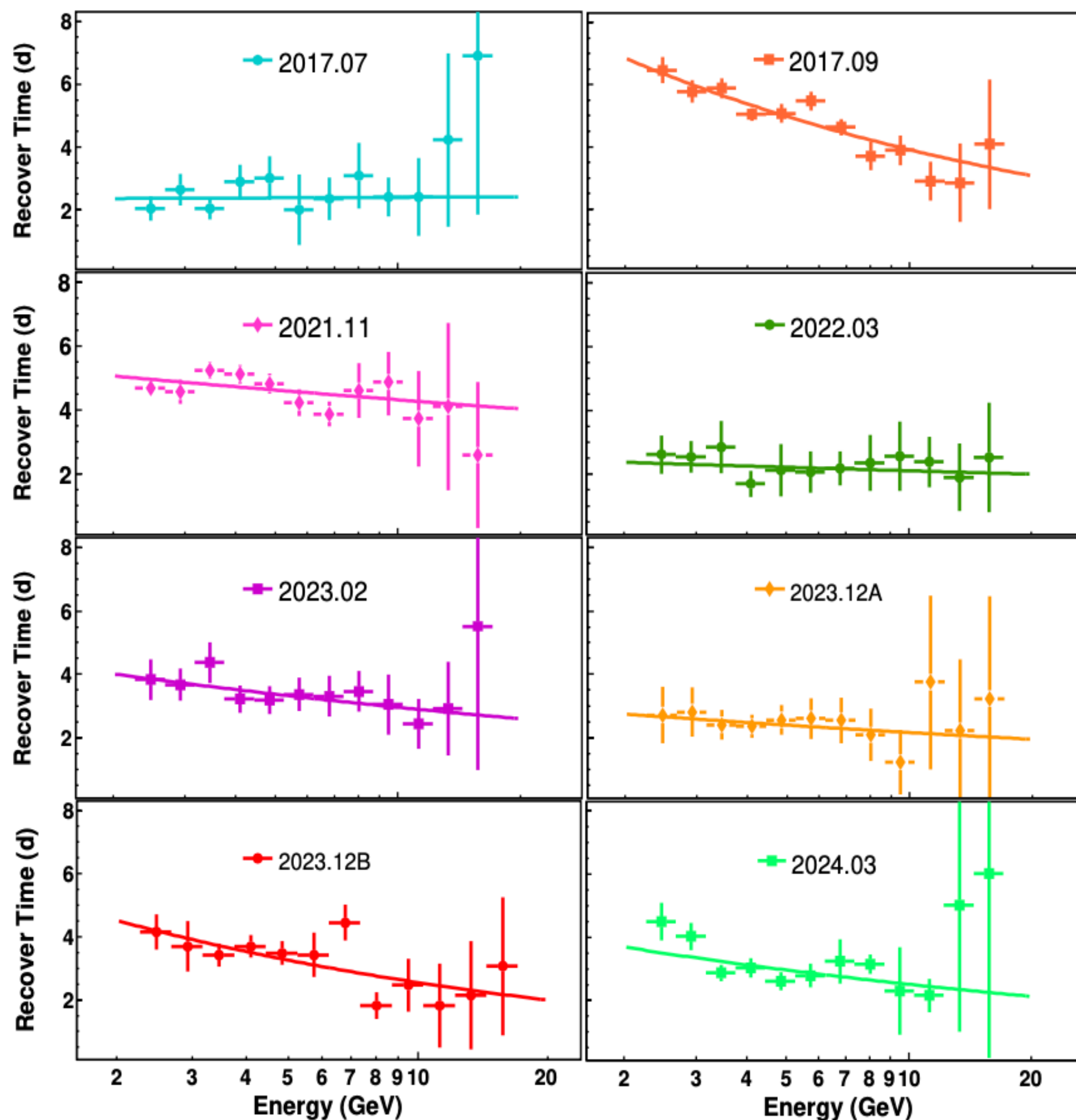
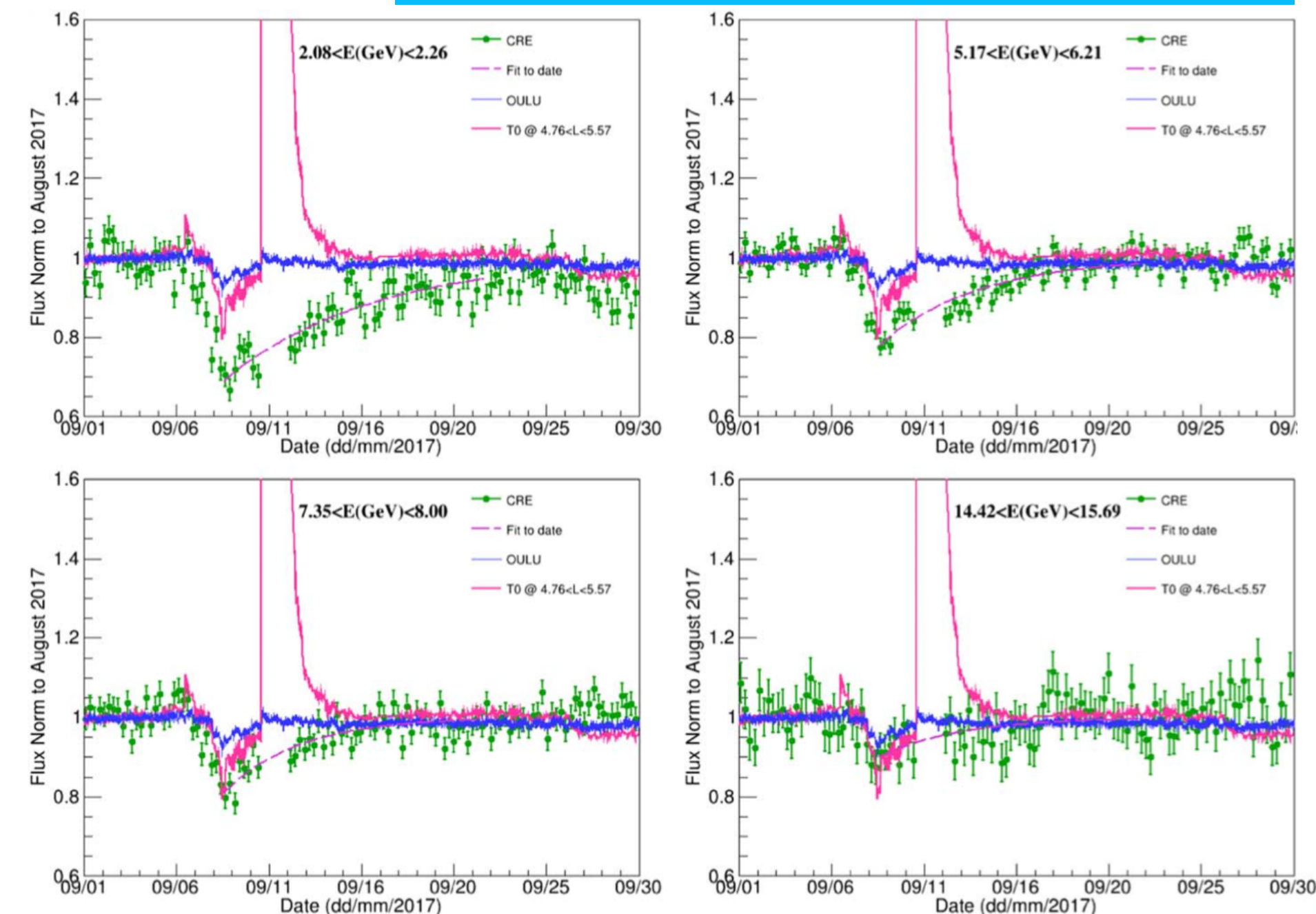
$$\alpha_i = \frac{N_i}{\sum_{j=2}^{10} N_j}$$

$$\sigma_{true}(E) = (1 + \kappa) \cdot \sigma_{MC}(E)$$

- ◎ Inelastic cross-section of C/O vs. BGO up to 10 TeV
- ◎ Effective validation for the hadronic models above TeV

- ◎ **Forbush Decrease (FD)** — CR follow-up of explosive solar activity, e.g. CME
- ◎ **Large acceptance and polar orbit of DAMPE**— allows precise FD measurement

DAMPE collab., *ApJL* 920, L43 (2021)

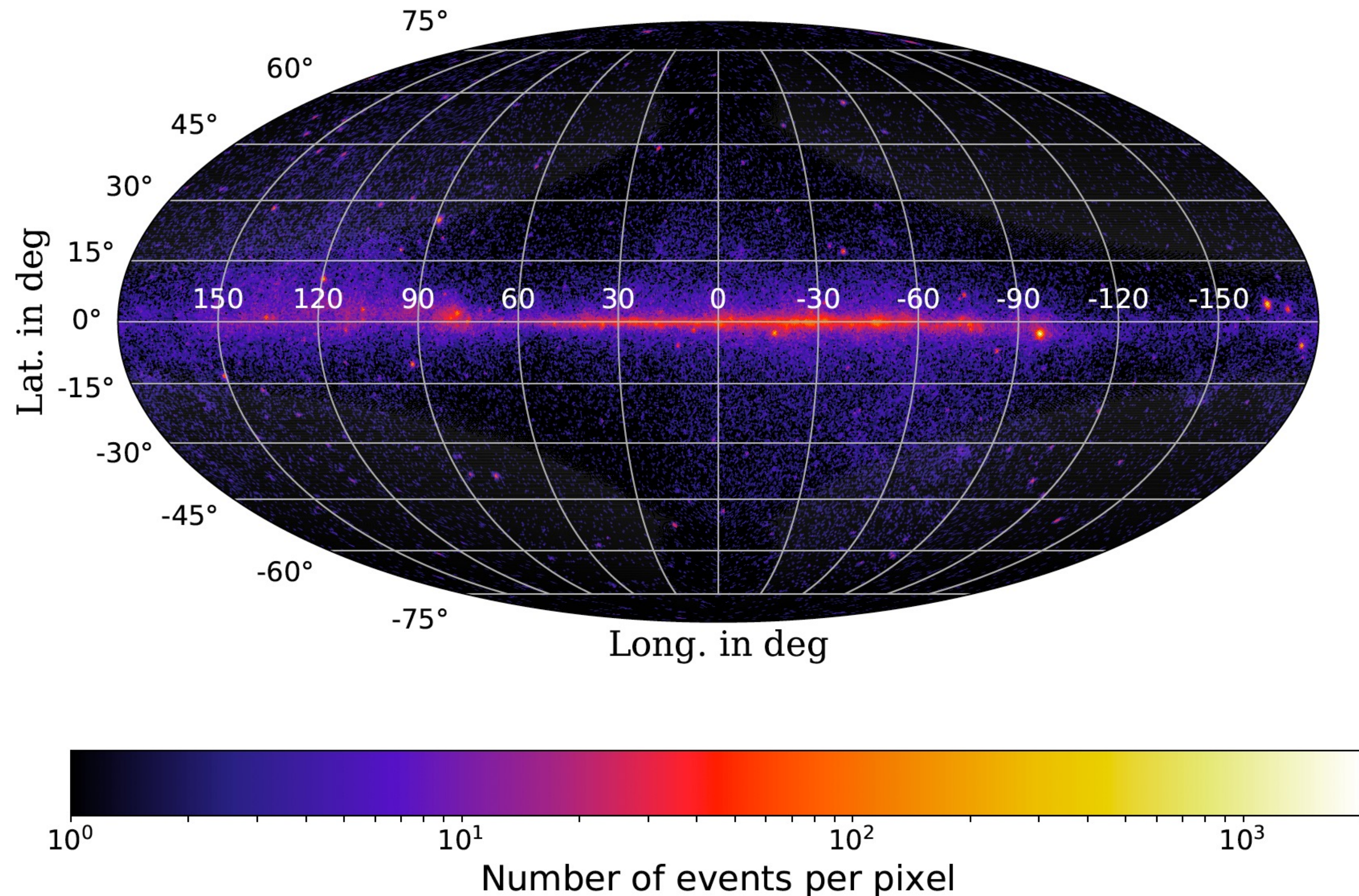


DAMPE collab., *Phy. Rev. Lett.* 136, 101004 (2026)

New FD features for the relation: recovery time vs. decrease amplitude → diverse properties of FDs

Gamma-ray observations of DAMPE

About 450k photons ($> 2\text{GeV}$) collected by December 2025



DAMPE Photon and Spacecraft Data Query

Coordinate system:
'J2000' for equatorial coordinates, 'Galactic' for Galactic coordinates

Coordinates(degree):
(RA, DEC) in J2000 or (L, B) in Galactic coordinate pair for a target, for example '128.84, -45.1' in J2000 or '263.55, -2.79' in Galactic for Vela pulsar, the range of RA or L is from 0 to 360, the range of DEC or B is from -90 to 90.

Search radius (degree):
search radius around the target, for example '7', the range of search radius is from 0 to 180.

Time system:
'UTC' for Coordinated Universal Time or 'MET' for Mission Elapsed Time

Observation starts:
for example '2016-01-01 00:00:00' or '2016-01-01' in UTC or '94608000' in MET

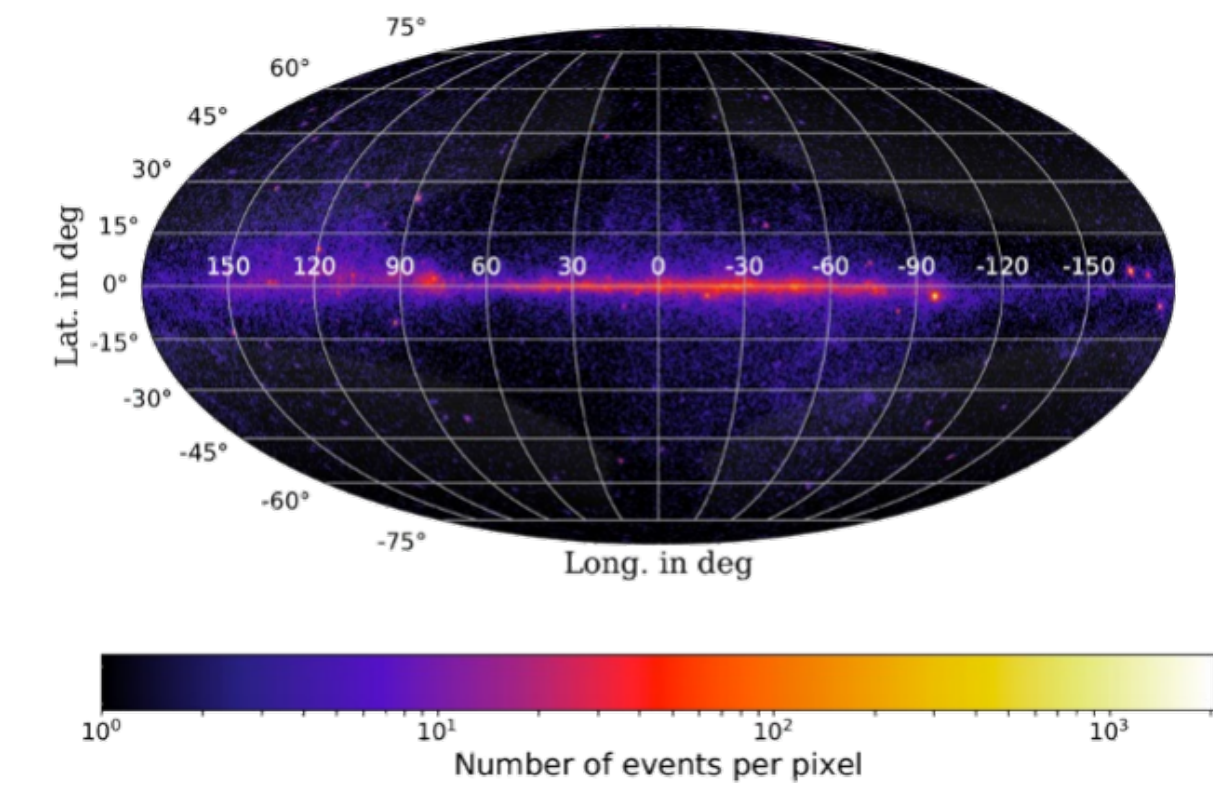
Observation ends:
for example '2016-02-01 00:00:00' or '2016-02-01' in UTC or '97286400' in MET

Energy range (GeV):
the minimum and maximum event energies, for example '3, 300', the ranges of minimum and maximum energy are from 3 to 1000.

Spacecraft data: ☐
use this option to download spacecraft data for the requested time range

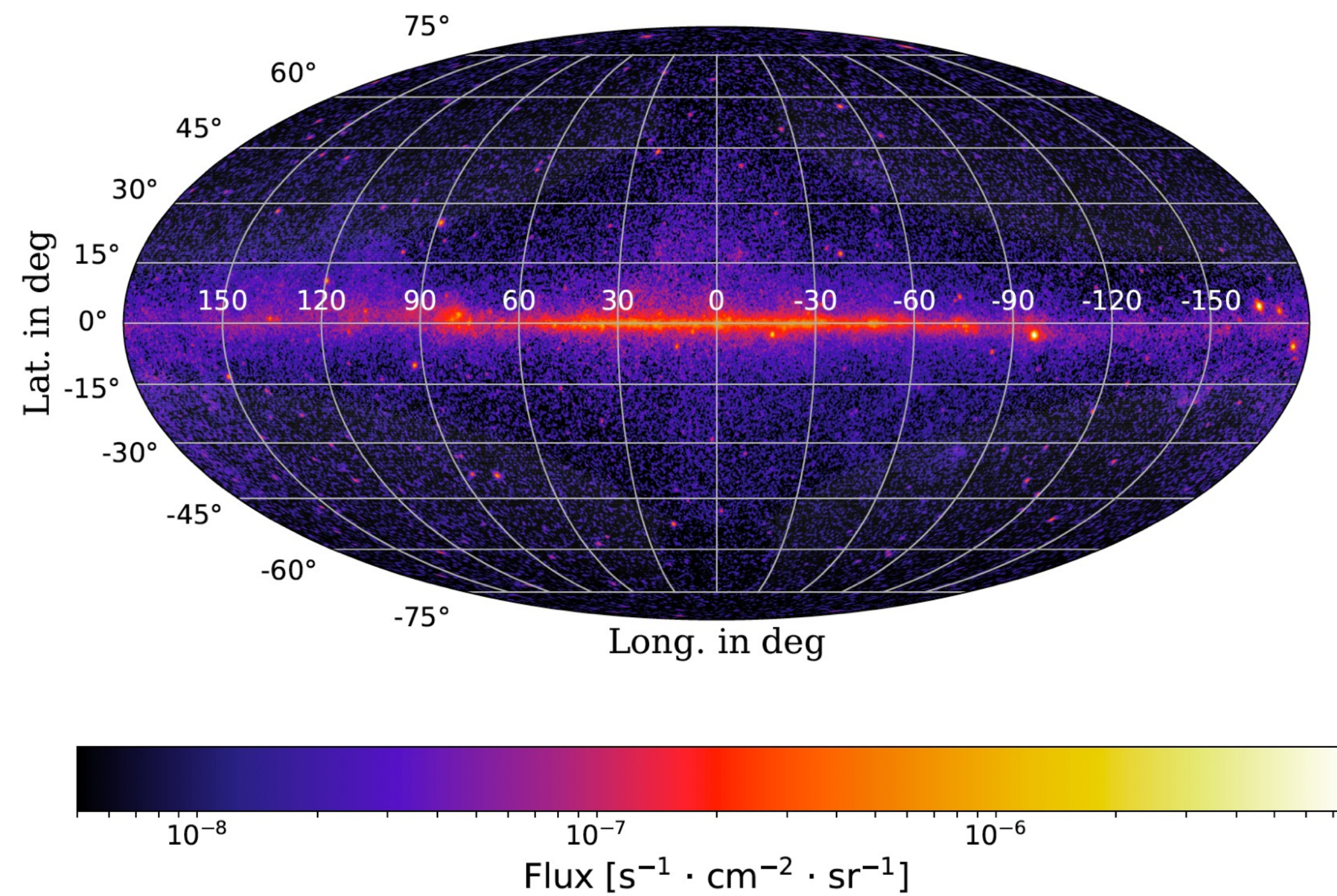
<https://dampe.nssdc.ac.cn/dampe/dataquerysc.php>
<http://dgdb.pmo.ac.cn/dampe/>

Counts

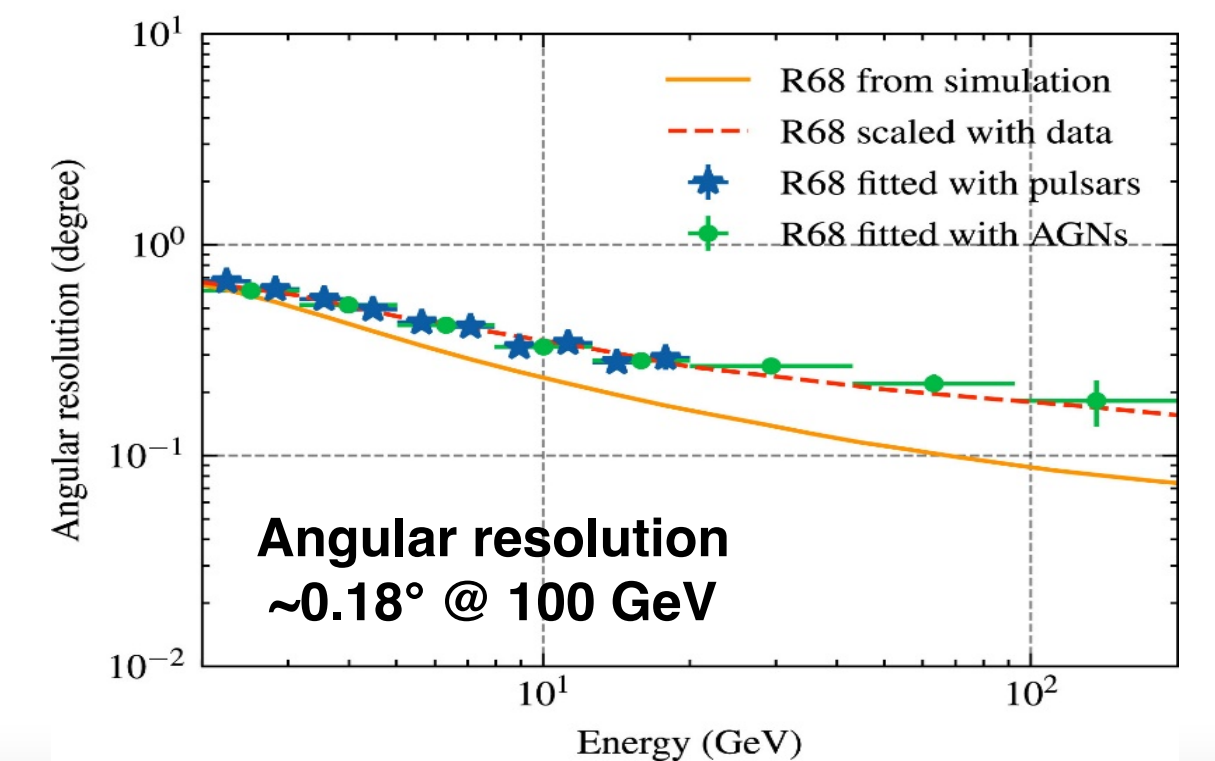
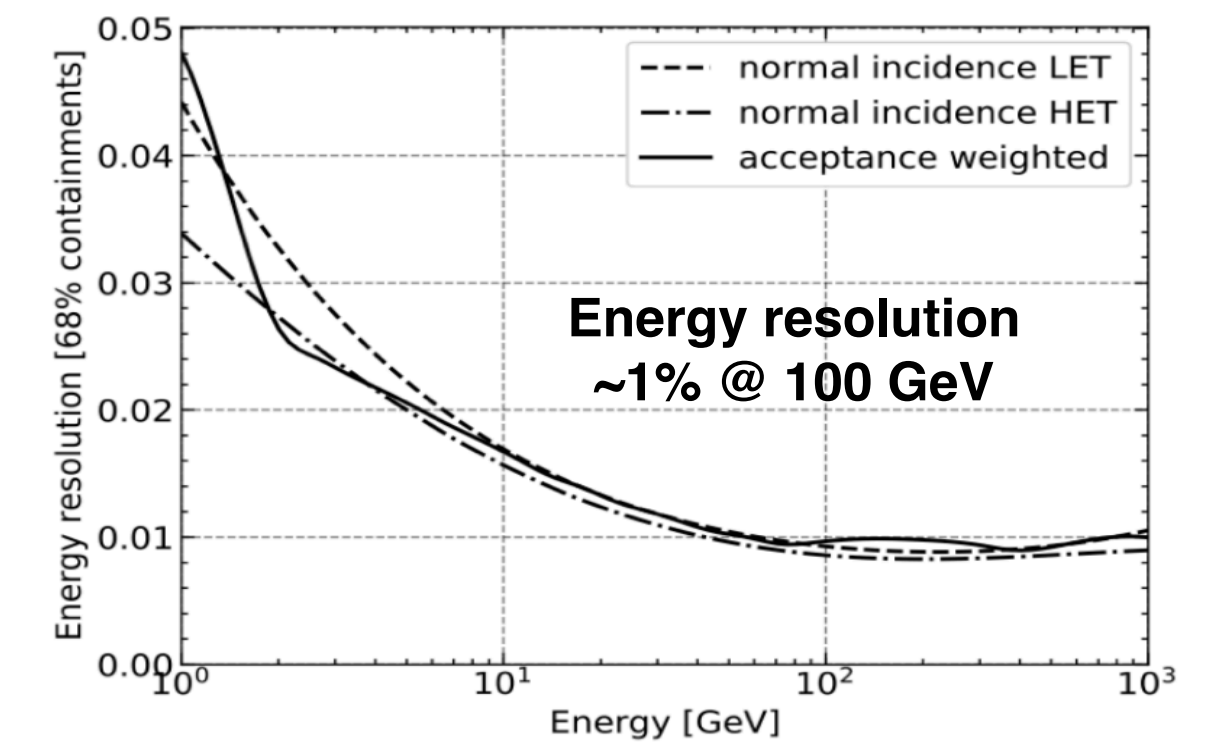
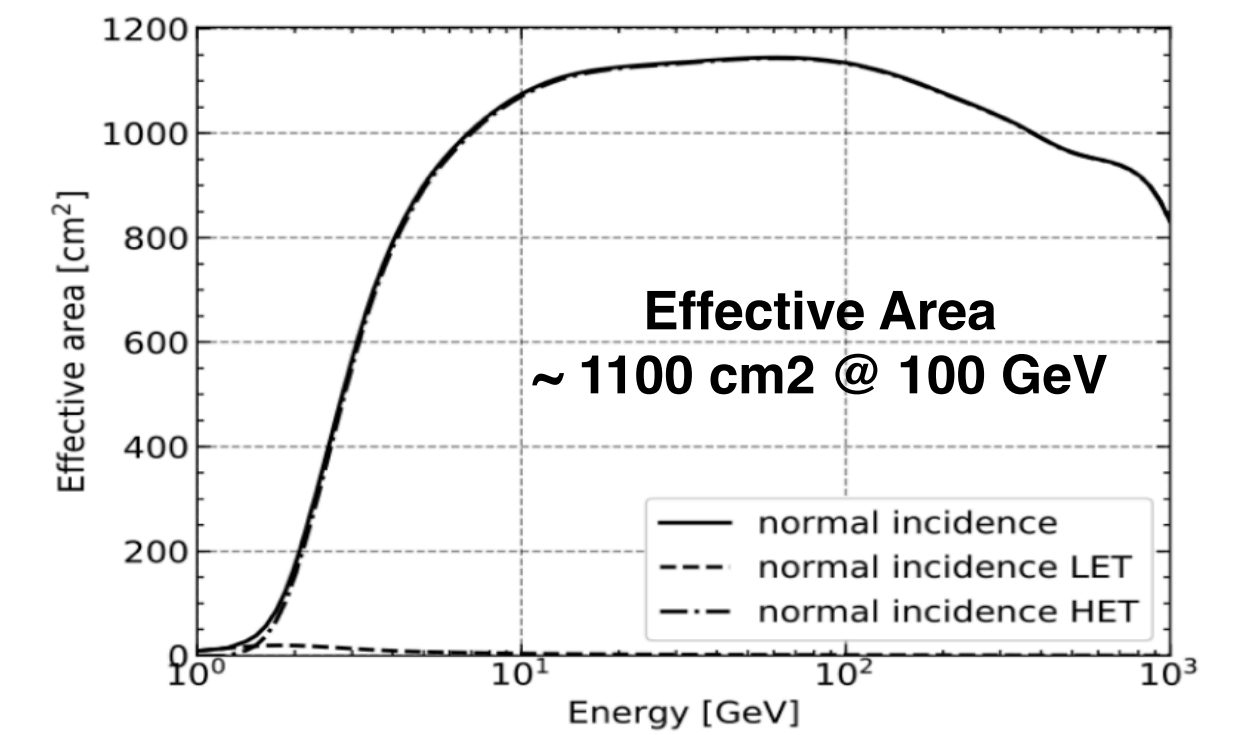
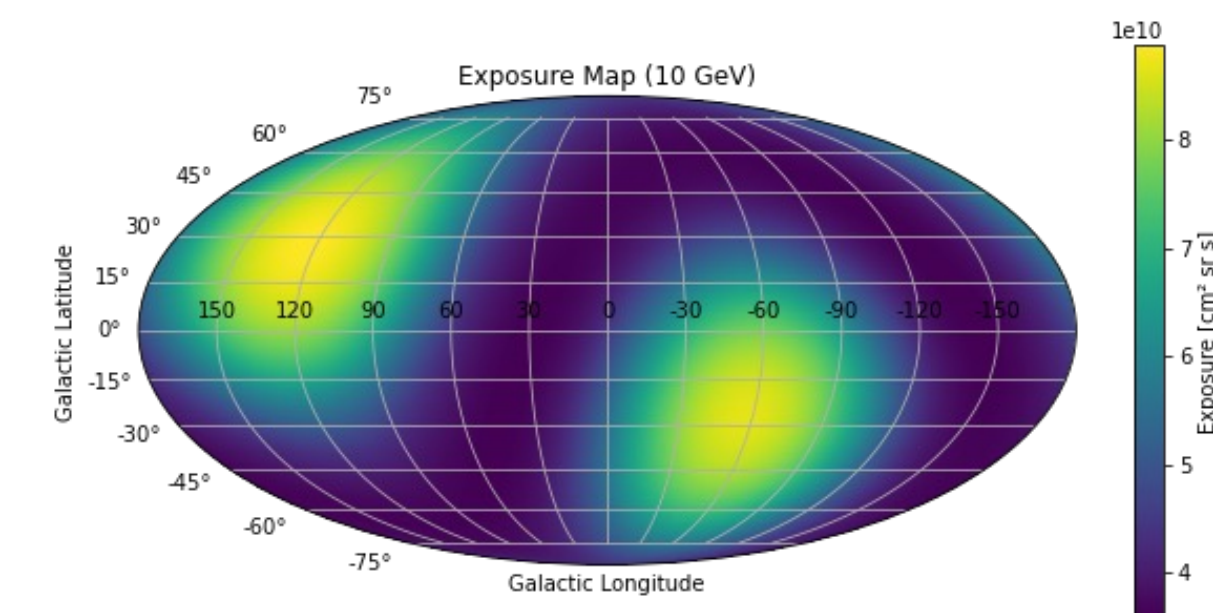


=

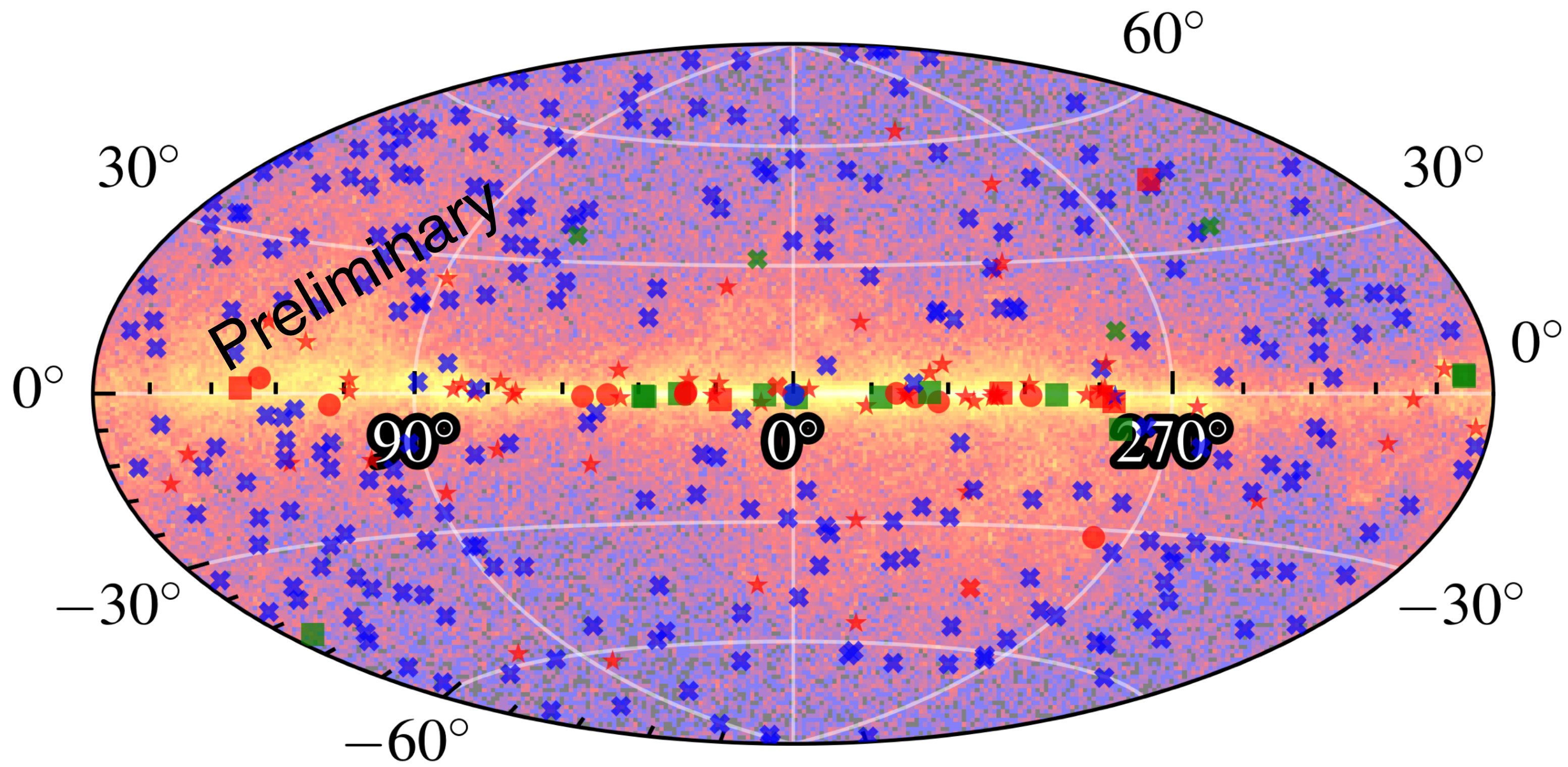
Flux map



Exposure



Gamma-rays: Point-like sources



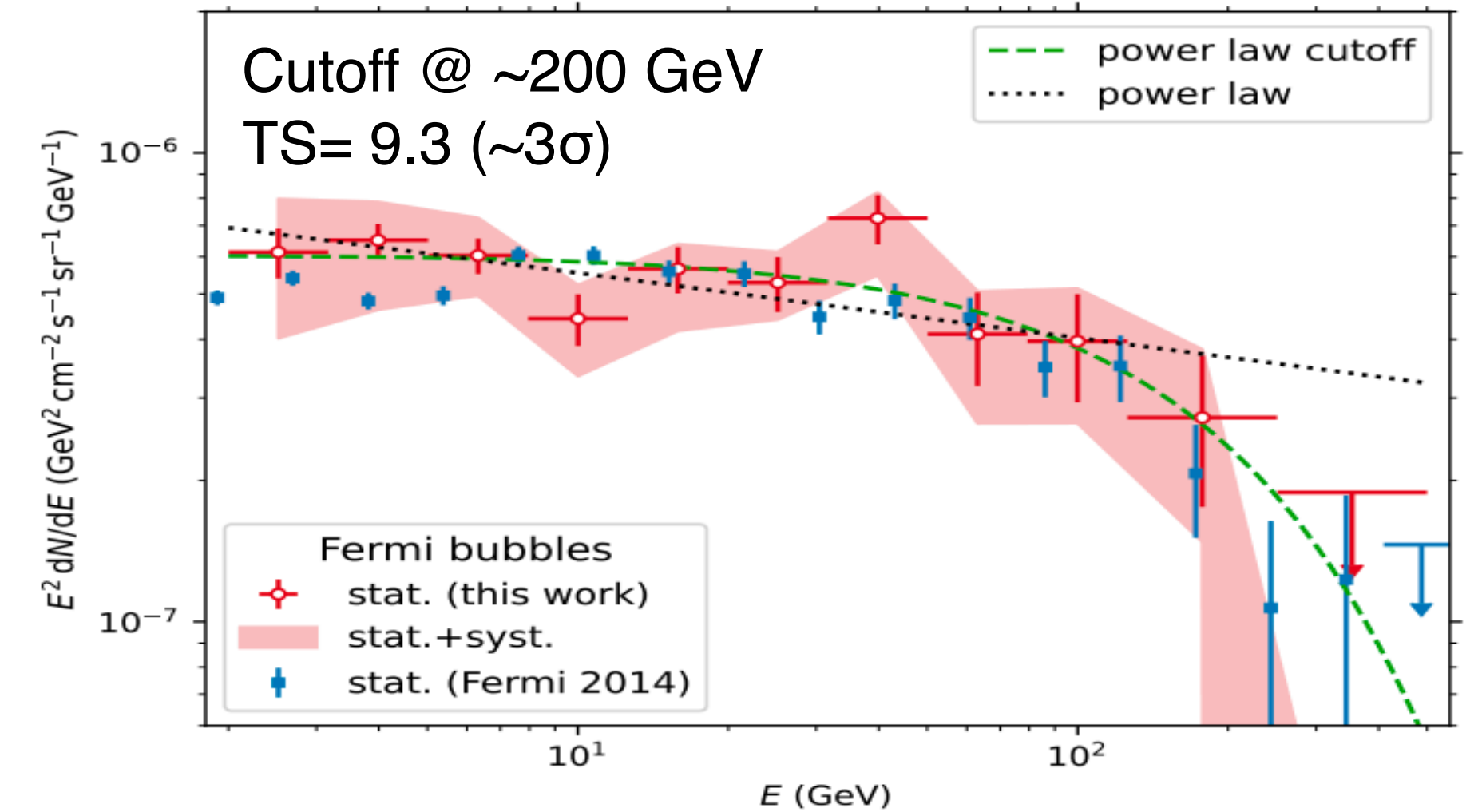
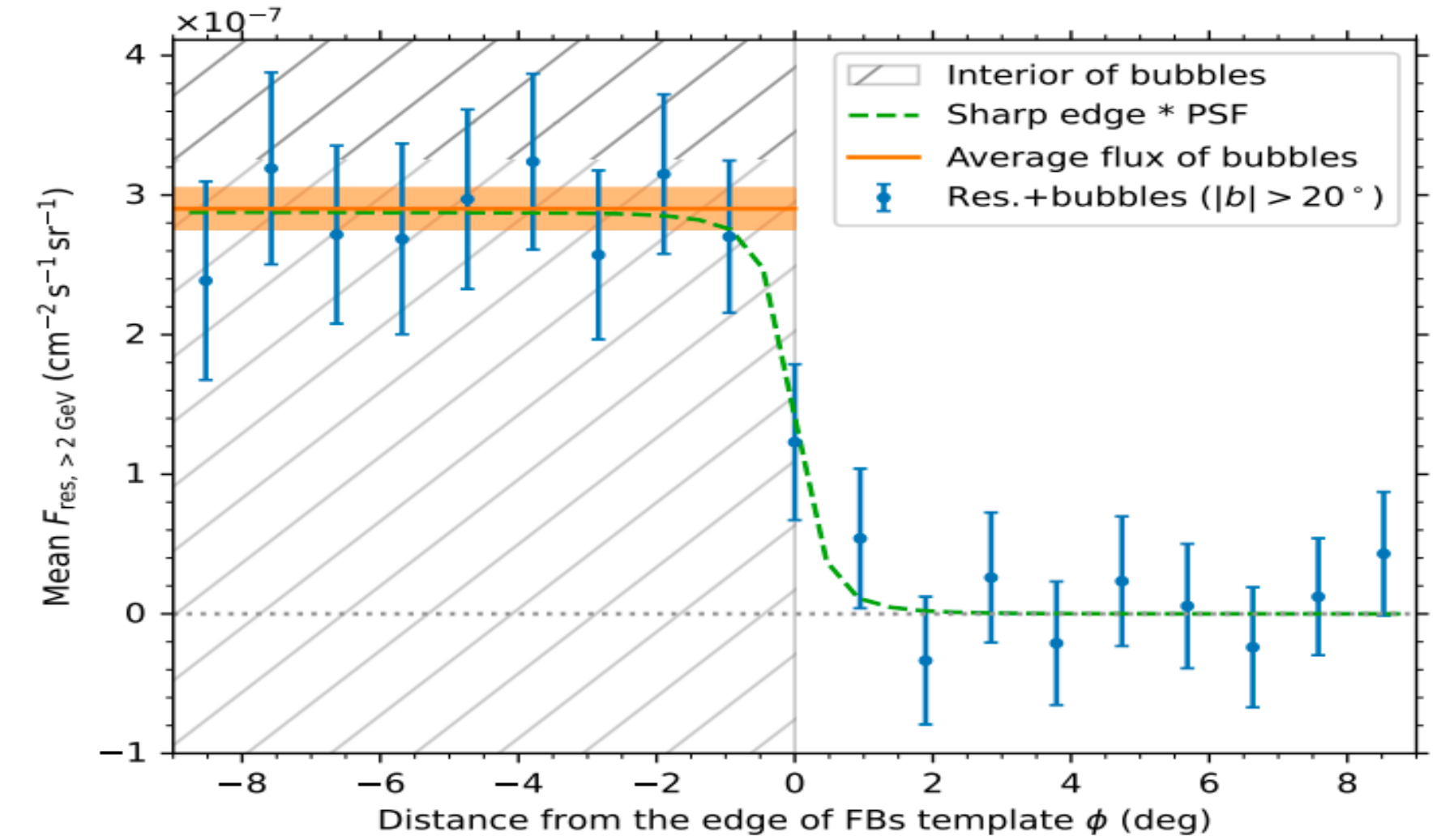
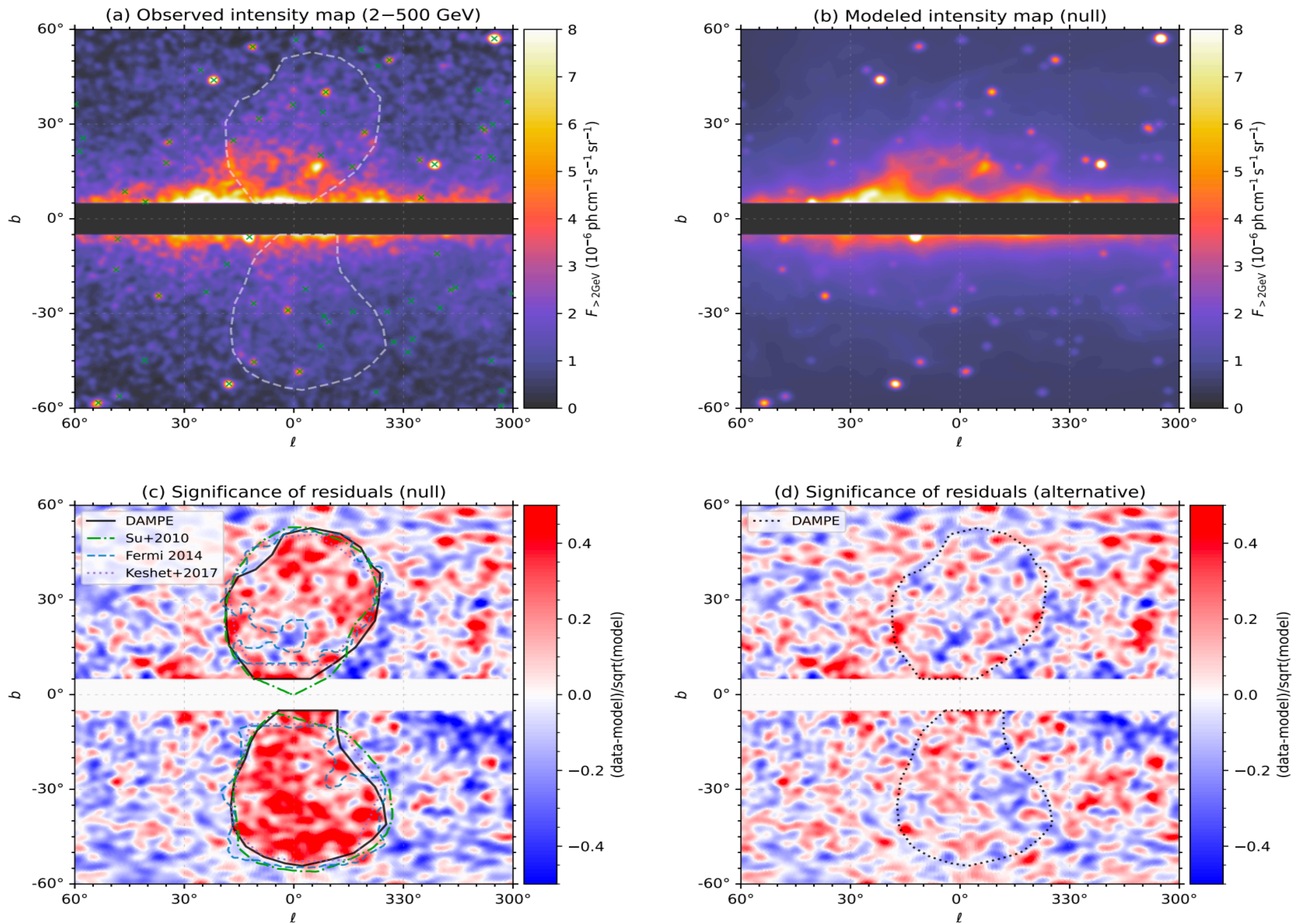
- ✕ AGN
- ✕ Pulsar
- ✕ Globular Cluster
- Fermi Unassociated
- SNR/PWN
- ✕ Unassociated
- Galactic Center
- Binary
- ★ Star Forming Region

Point-like catalog

Source type	Number
AGN	261
Pulsar	61
SNR/PWN	11
Binary system	6
Globular Cluster	2
Star Forming Region	1
Galactic Center	1
Fermi Unassociated	12
Unassociated	4
Total	359

359 point sources detected
73% are AGNs

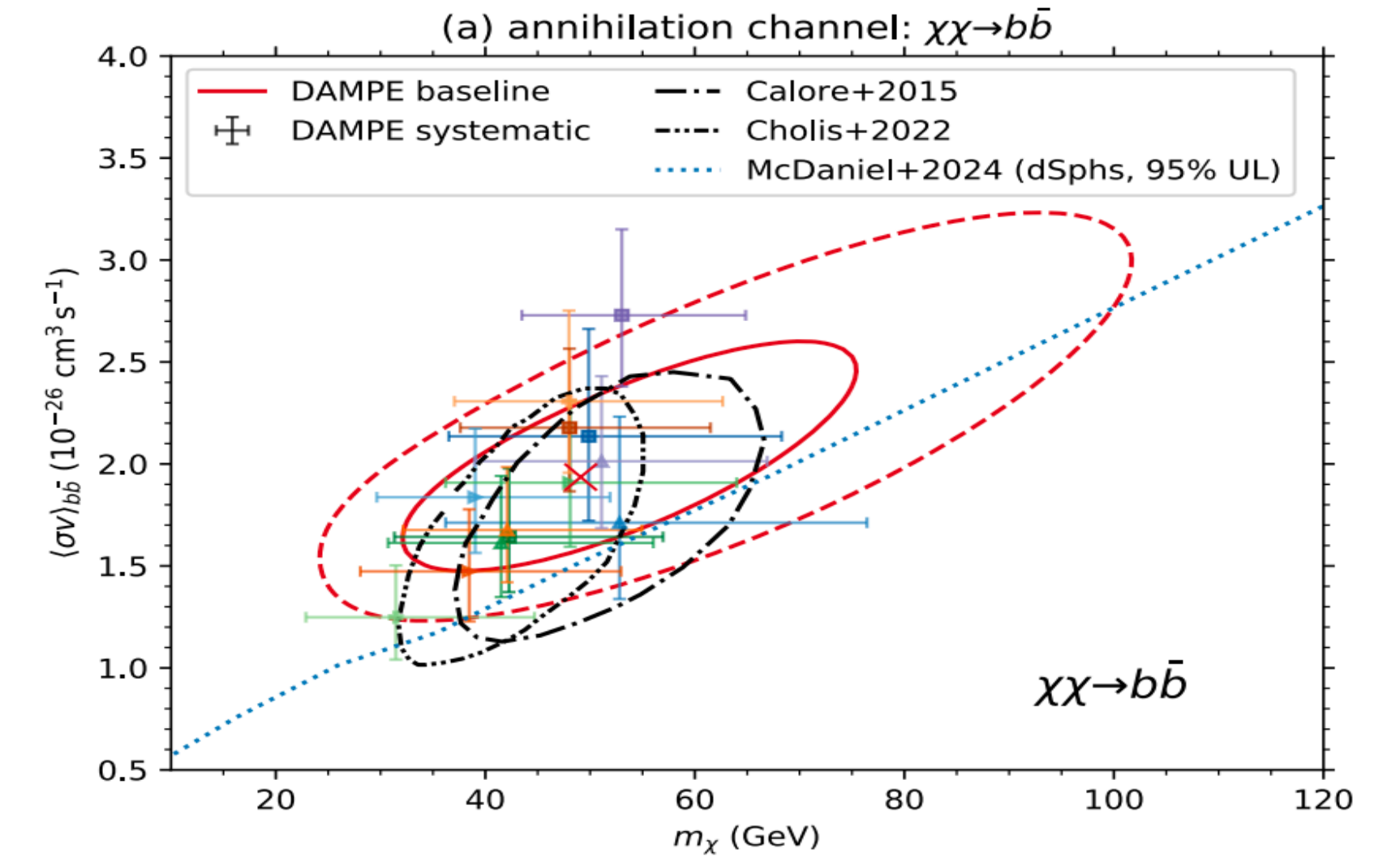
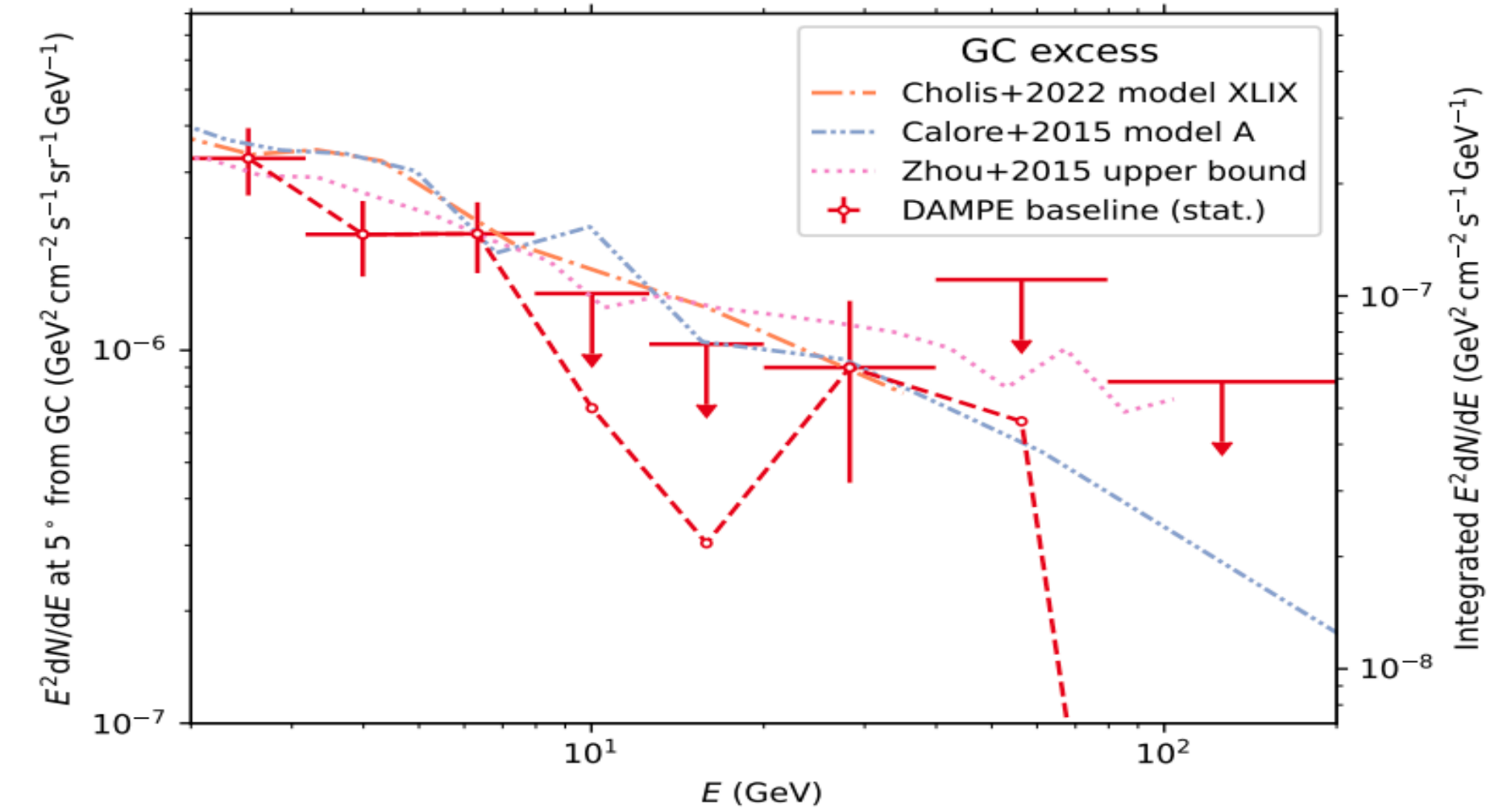
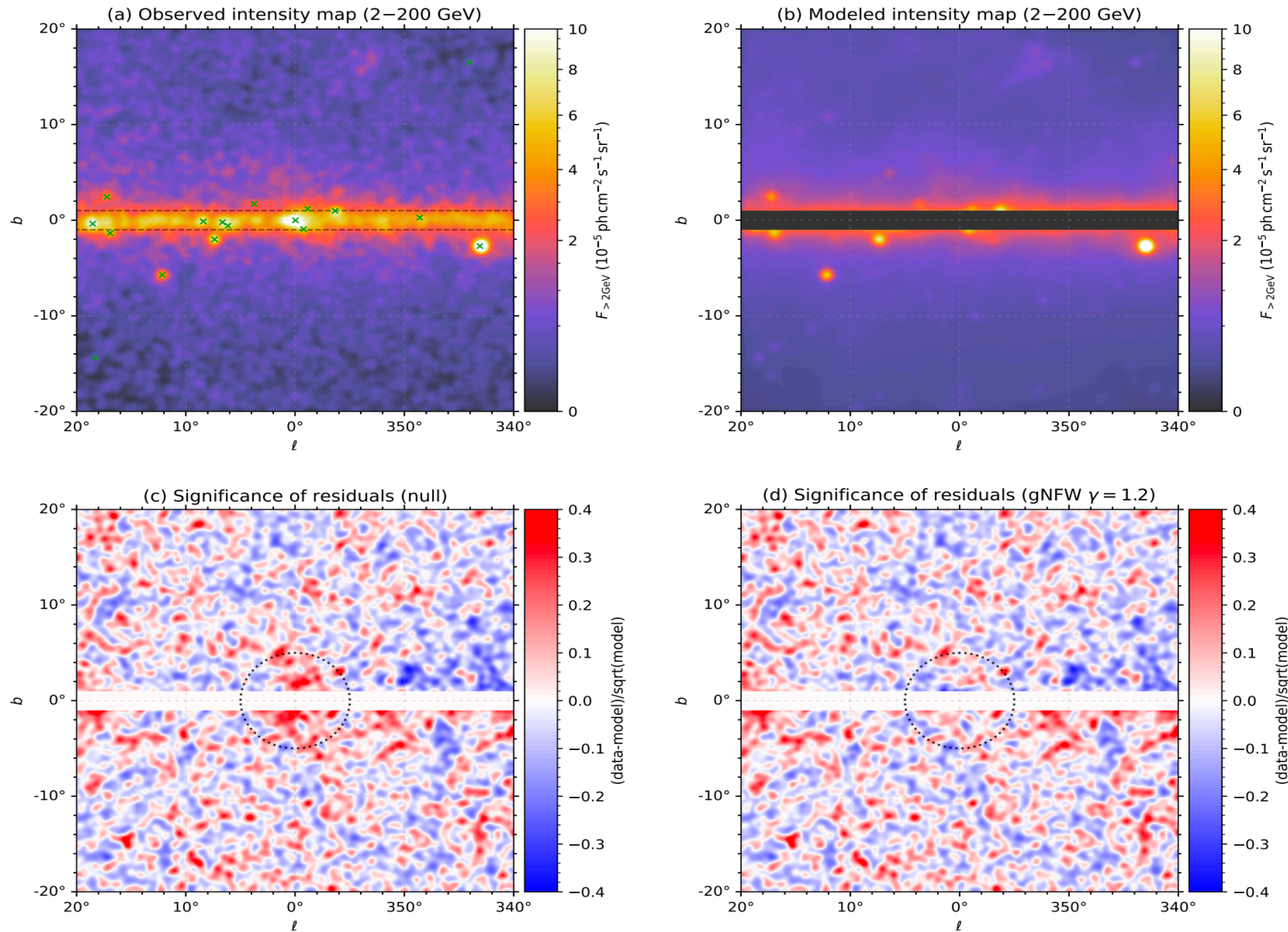
Gamma-rays: Fermi-Bubbles



© 9 years data, **FB detected with TS=757 (26.5 σ for 11 dof)**

DAMPE collab., *Astrophys. J. Suppl. S.* 284, 22 (2026)

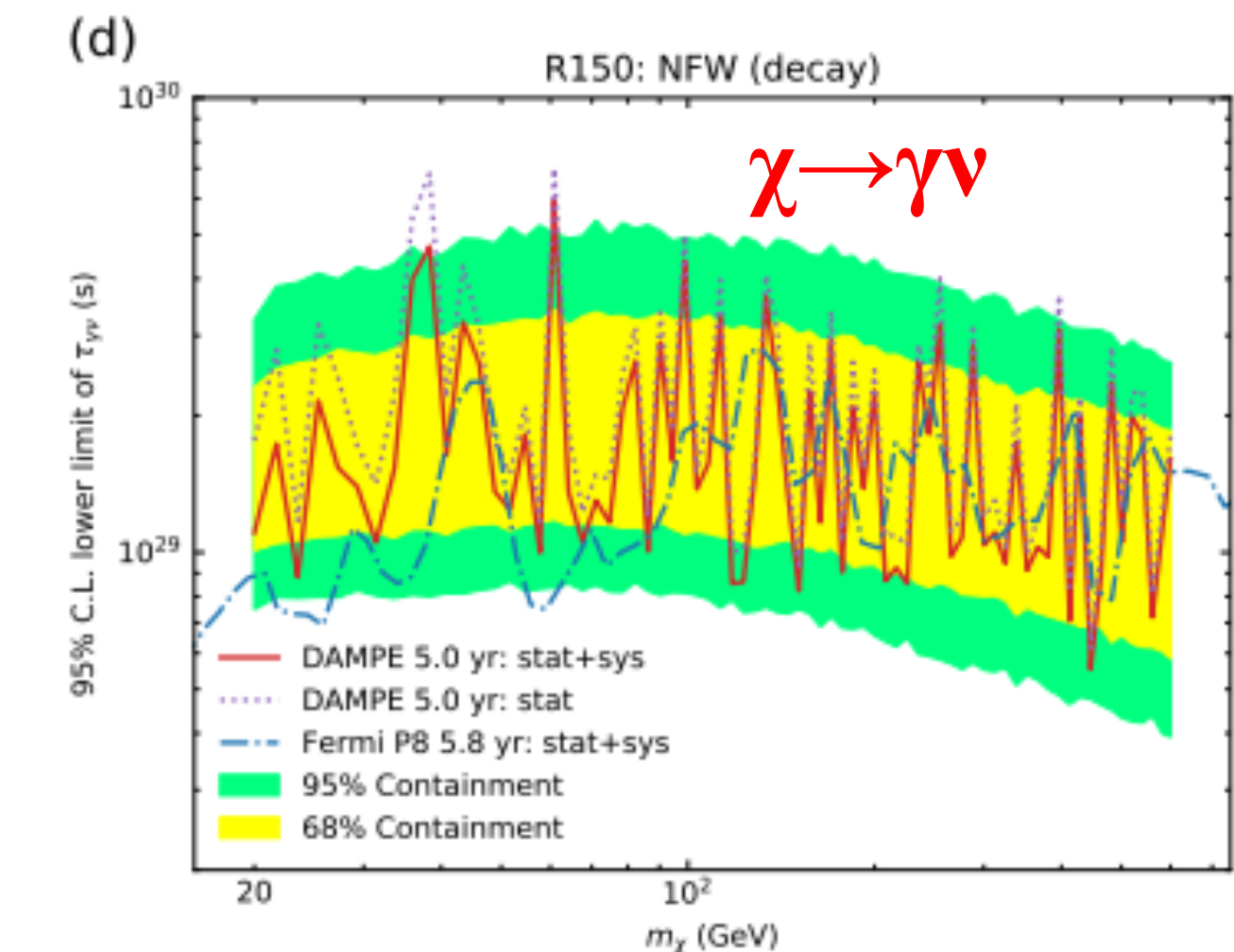
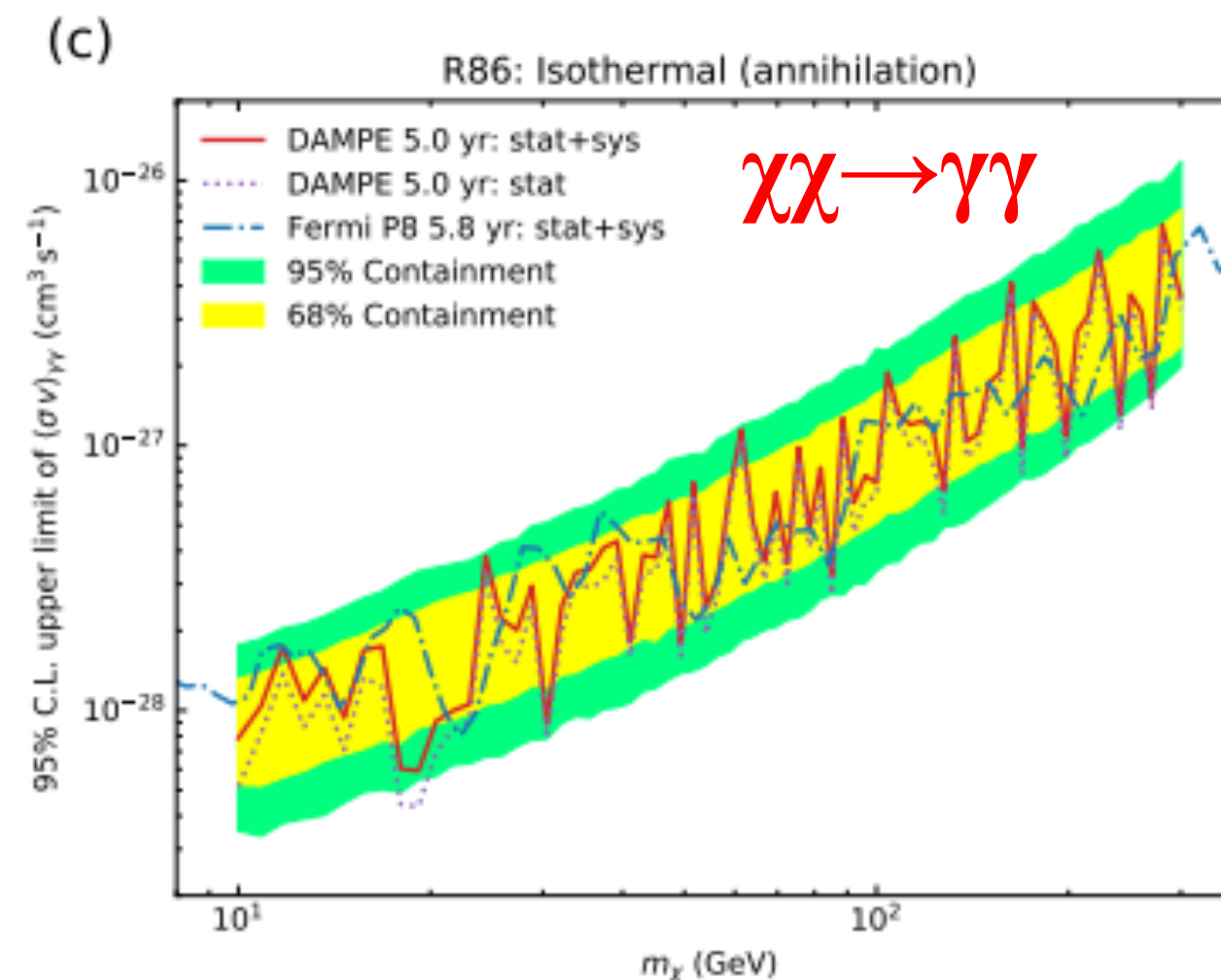
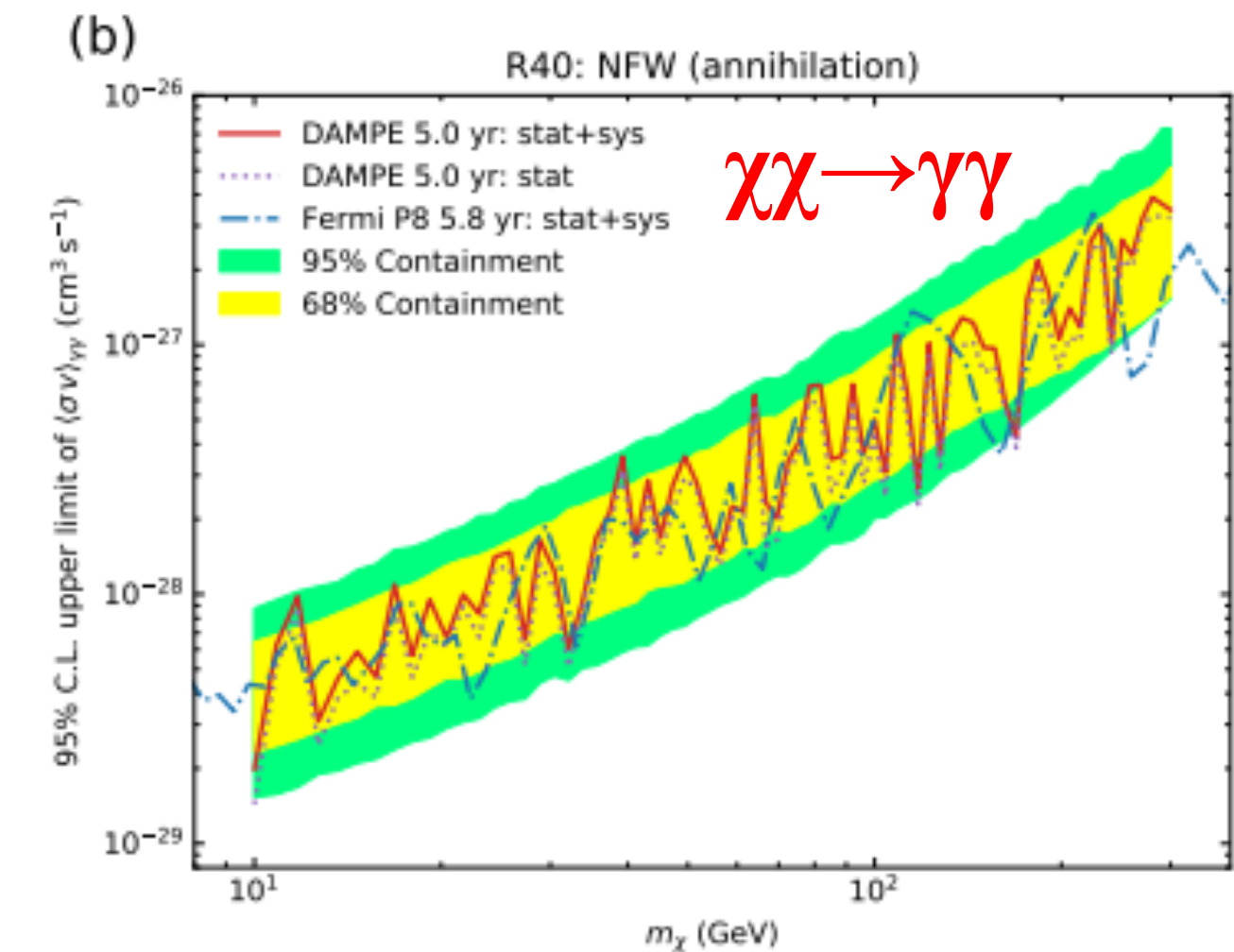
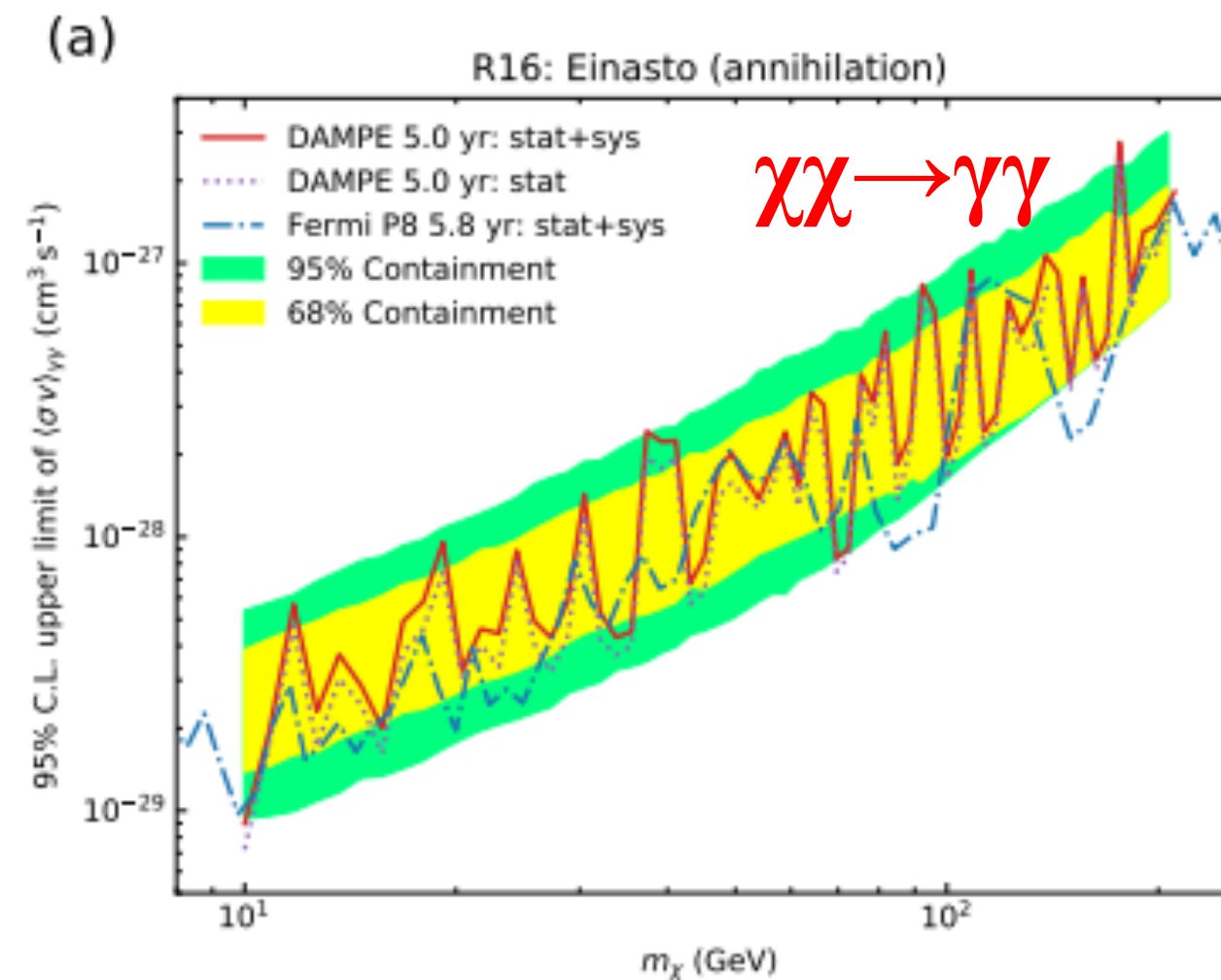
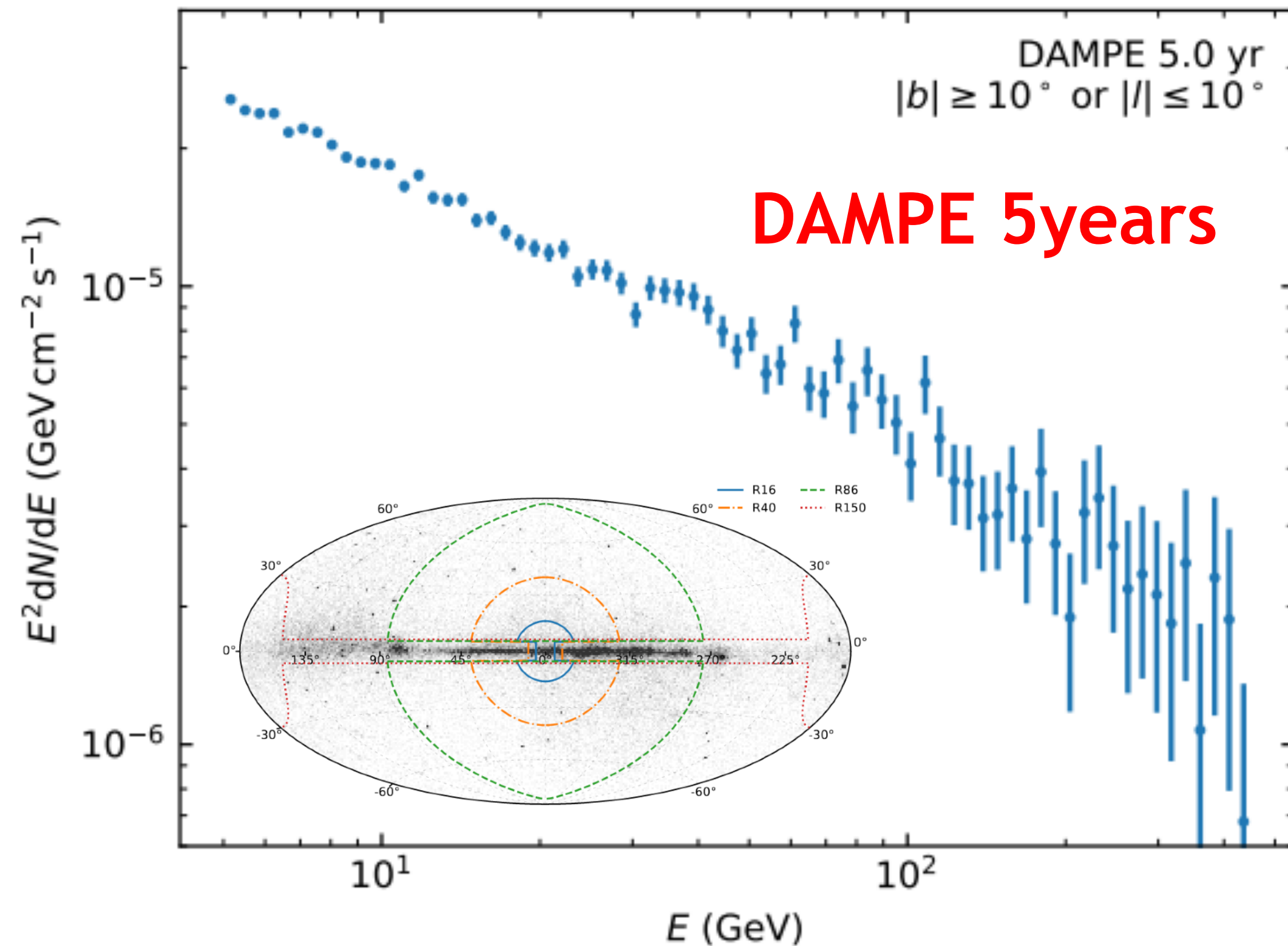
Gamma-rays: Galactic Center Excess



© 9 years data, **GCE detected with TS=72.8 (26.5 σ for 6dof)**

DAMPE collab., *Astrophys. J. Suppl. S.* 284, 22 (2026)

- γ line: “smoking gun” DM signal
- DAMPE: Excellent energy resolution

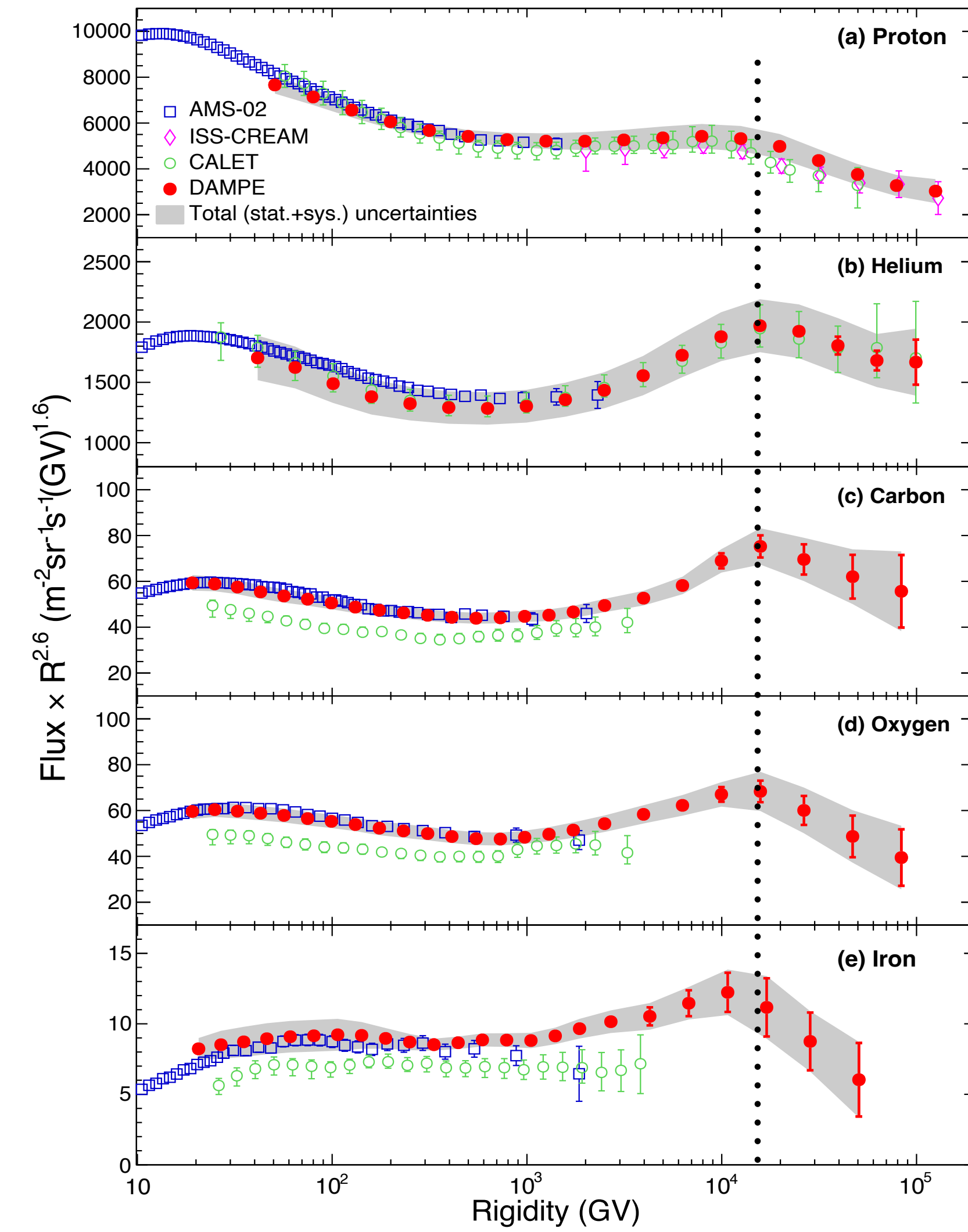


DAMPE collab., **Science Bulletin** 67, 679 (2022)

Summary

- ◉ DAMPE has operated smoothly or-orbit for 10 years, all the four sub-detectors keep in good status.
- ◉ A universal softening feature in five primary CR spectra (p, He, C, O, Fe) at a unified rigidity ($E_{br} \sim 15$ GV) is detected for the first time, providing observational verification of the charge-dependent energy limit of cosmic ray acceleration.
- ◉ For gamma ray observation, about 450k photons (>2 GeV) are collected by DAMPE in 10 years.
- ✦ 359 point-like sources with $TS > 25$ are identified
- ✦ The Galaxy center excess and the Fermi bubbles are significantly detected
- ✦ Strong constraints on dark matter annihilation into γ -ray lines are established

Thanks for your attention!



DAMPE collab., Nature, 653, 52-55 (2026)