MISHA STOLPOVSKIY, 9 JULY 2022, ICHEP, BOLOGNA

LATEST RESULTS FROM DAMPE

DAMPE MISSION

DArk Matter Particle Explorer (DAMPE)

- Payload: 1300 kg
- Altitude: 500 km
- Orbit:

  95 minutes

  97° inclination Sun-synchronous

Launched in Dec 2015

DAMPE COLLABORATION

China

- Purple Mountain Observatory, CAS, Nanjing
- University of Science and Technology of China, Hefei
- Institute of High Energy Physics, CAS, Beijing
- Institute of Modern Physics, CAS, Lanzhou
- National Space Science Center, CAS, Beijing

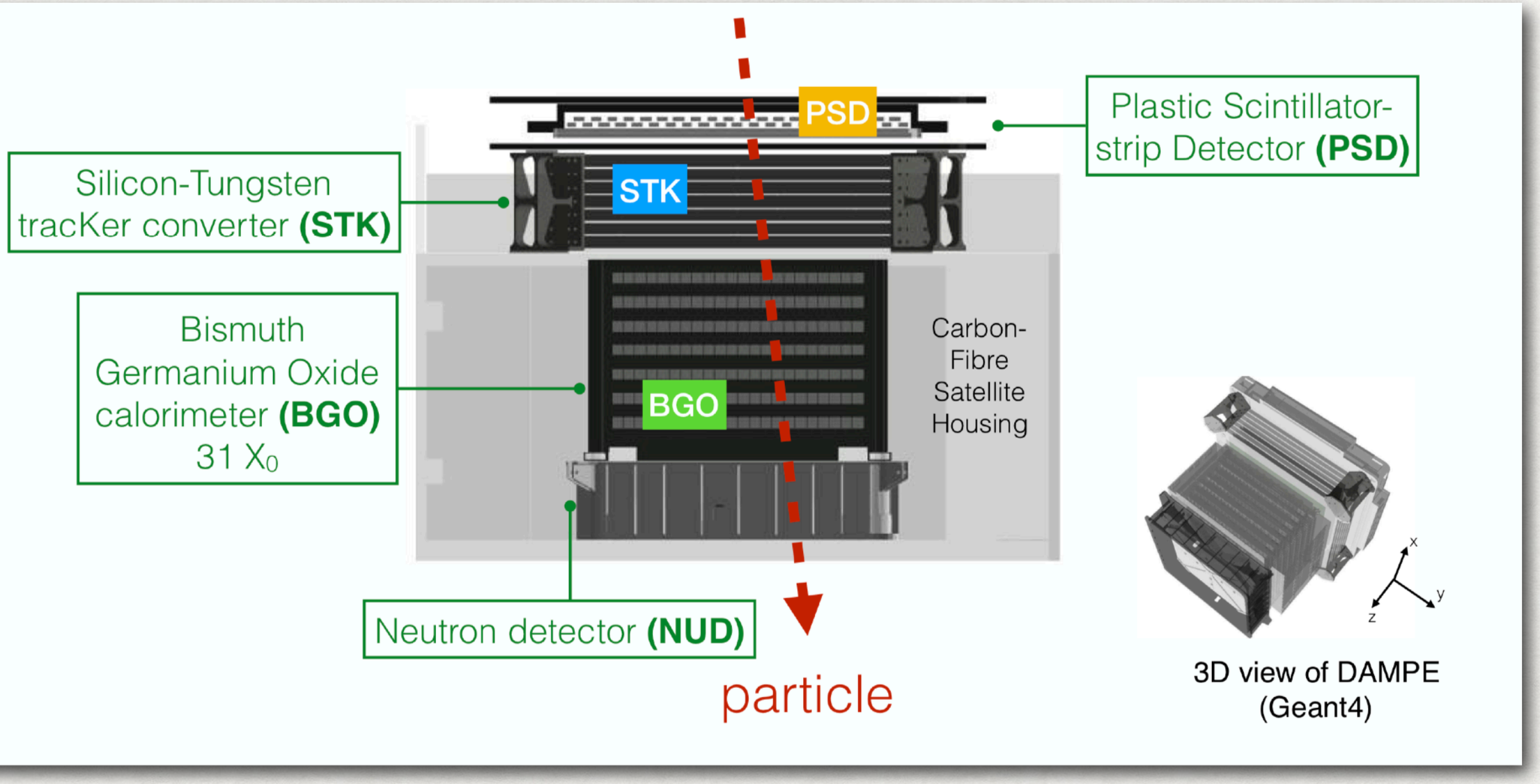
Switzerland

- University of Geneva
- EPFL Lausanne

Italy

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

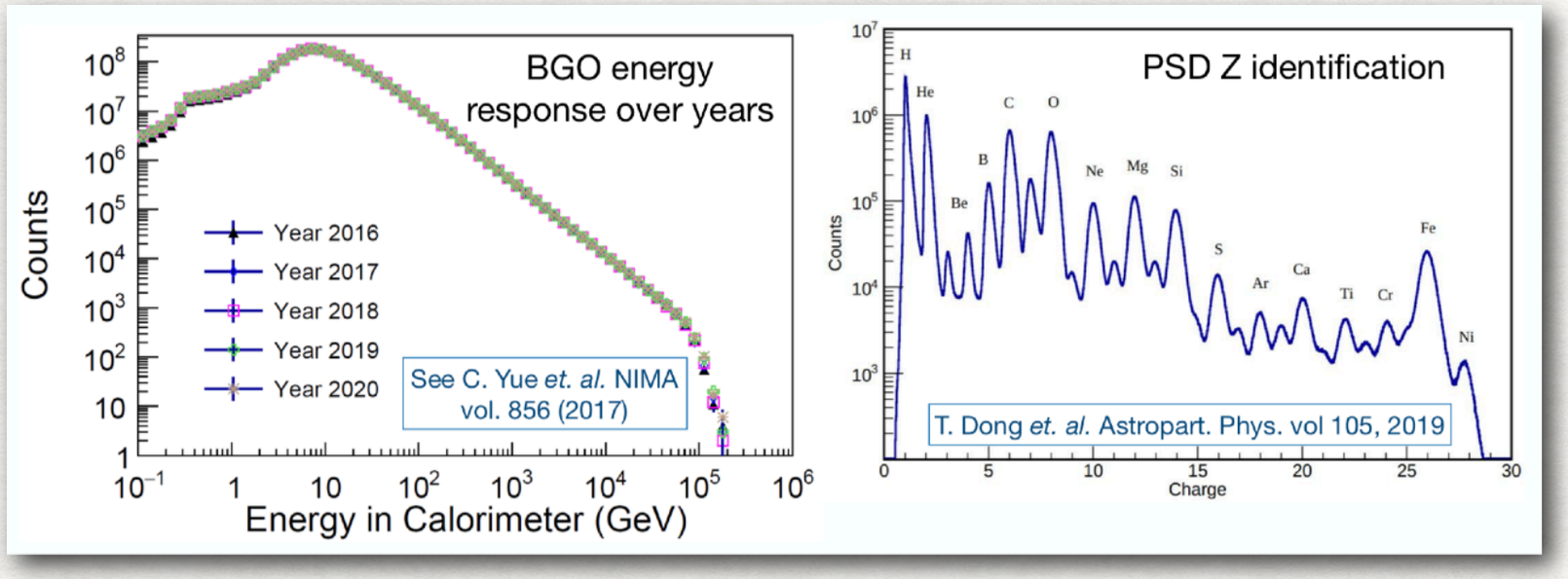
DAMPE DETECTOR

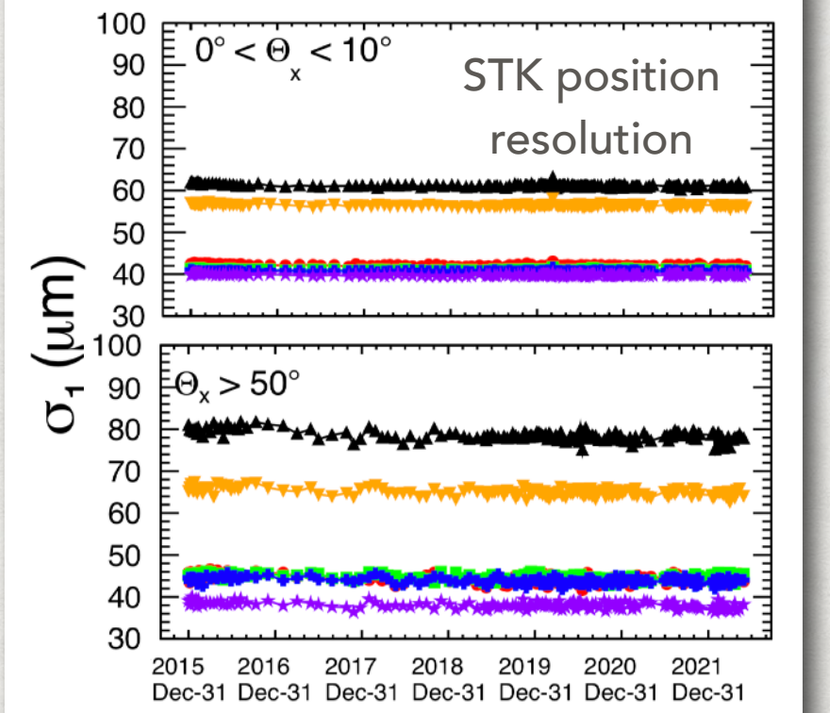


3D view of DAMPE (Geant4)

ON-ORBIT DETECTOR STATUS

- Stable BGO energy response throughout more than 6 years
- Excellent PSD Z resolution
- Excellent STK noise stability and position resolution (alignment every 2 weeks)





[A. Tykhonov *et. al.* NIMA vol. 893 (2018), vol. 924 (2019)]

Stable data taking since December 2015!
Over 11 billion events for analysis,
>250 million events above 20GeV deposit energy
Almost a million events above 1TeV deposit energy

$e^{\pm}$ FLUX WITH DAMPE

Relatively big geometric acceptance ~0.35 m^2 sr

Deep hodoscopic calorimeter:

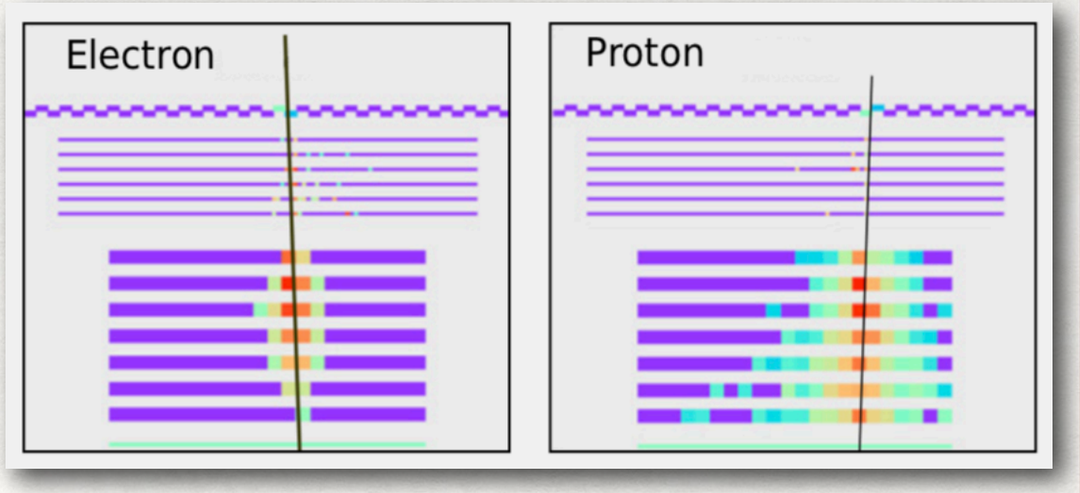
- ~31X_0, 14 layers, 22 bars in each
- Energy resolution ~1% at >100GeV

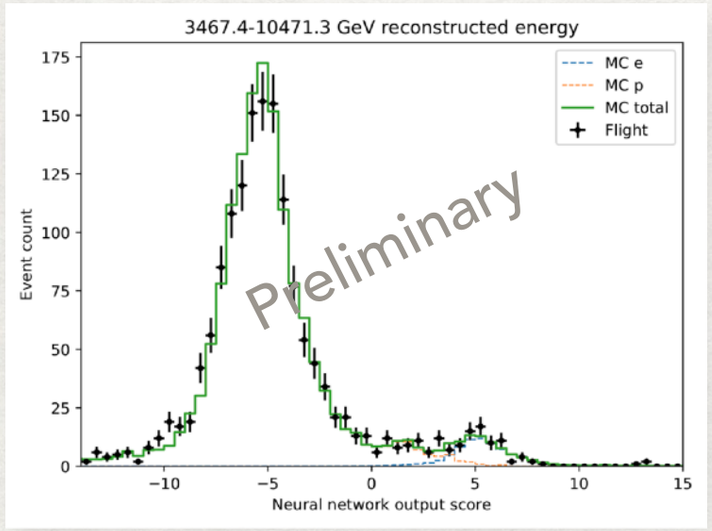
CRE loose energy due synchrotron radiation :

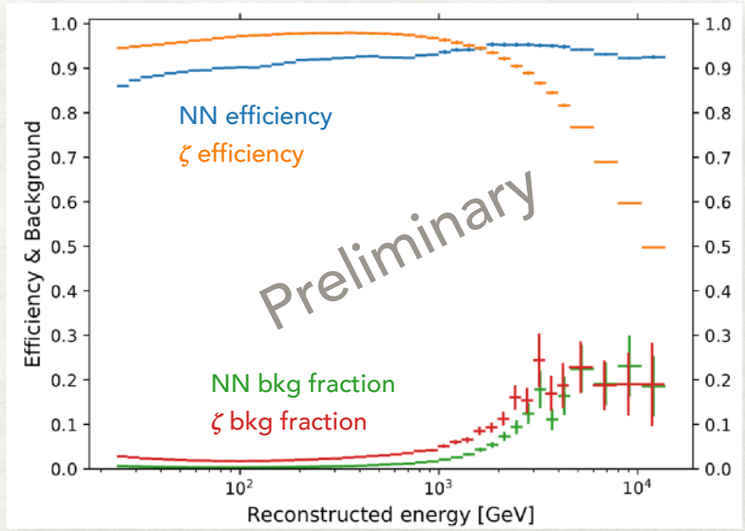
sources <1kpc at >~TeV

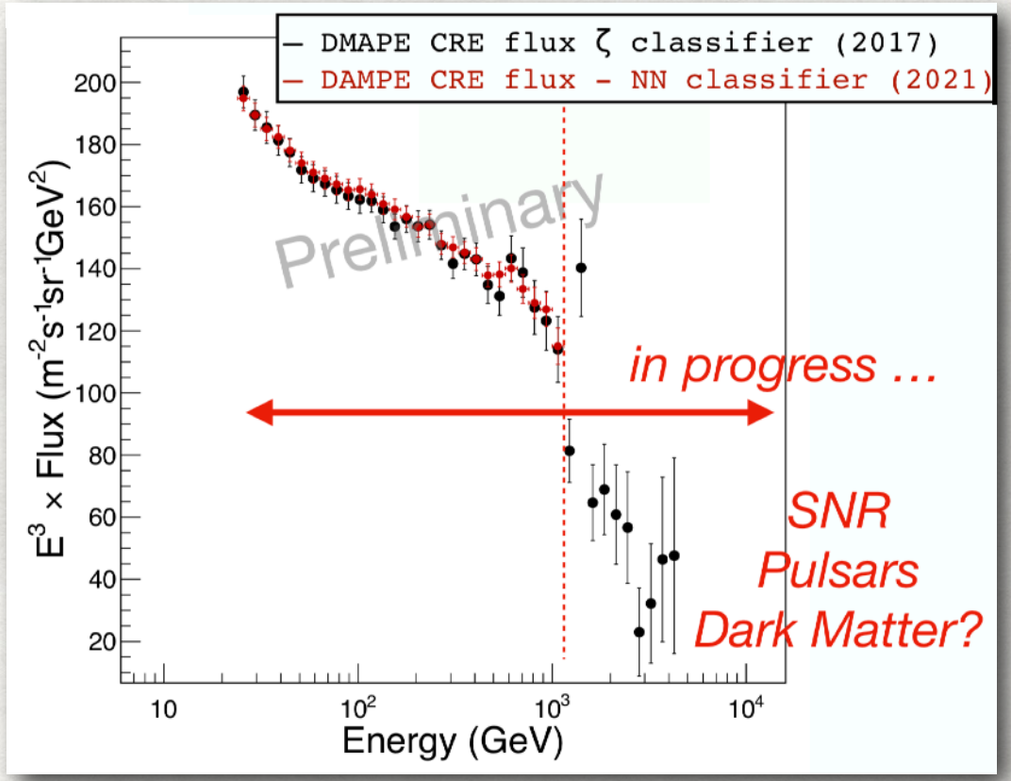
p background critical at ~10TeV —>

NN classifier is of great help









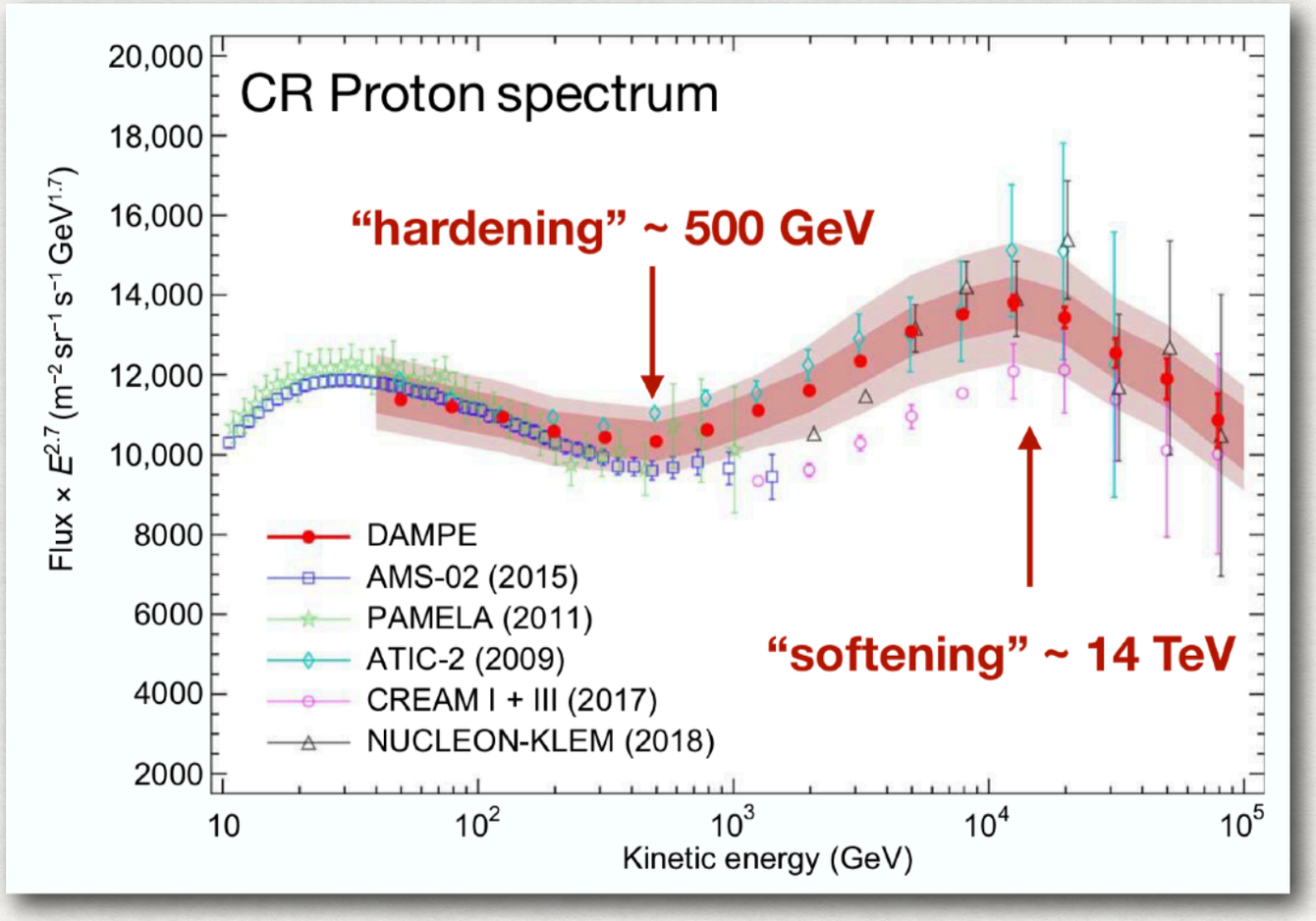
ζ-flux : [Ambrosi *et al* Nature vol 552, (2017)]

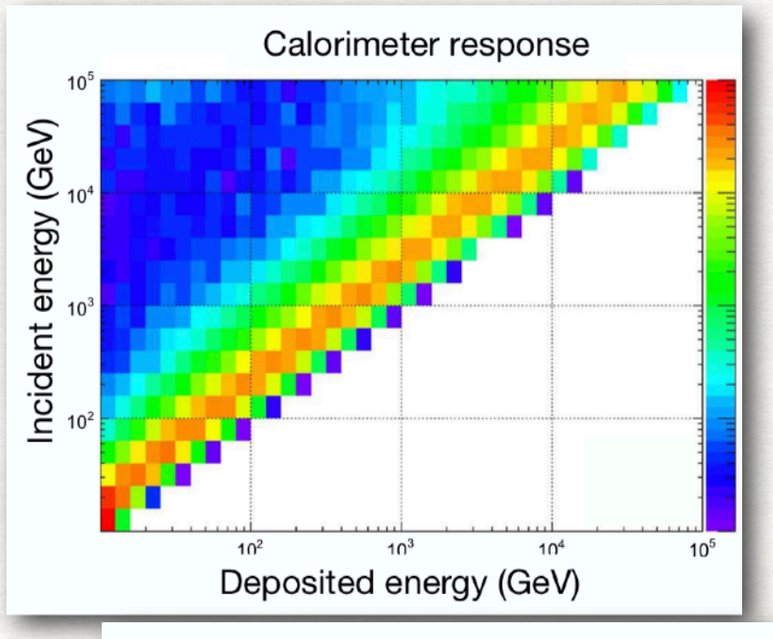
NN-classification : [EPS-HEP2021 n. 47 (D. Droz)]

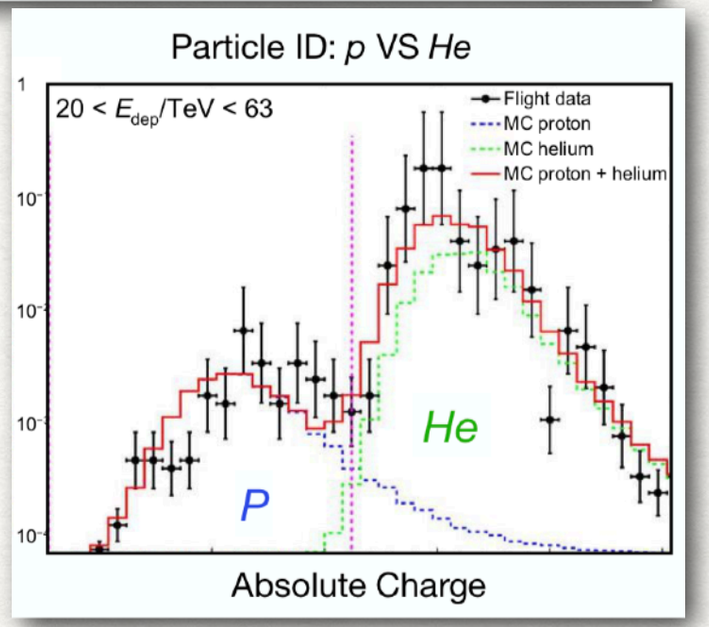
[D. Droz et al 2021 JINST 16 P07036]

PROTON FLUX WITH DAMPE

[DAMPE collaboration, *Science advances* 5.9 (2019): eaax3793.]





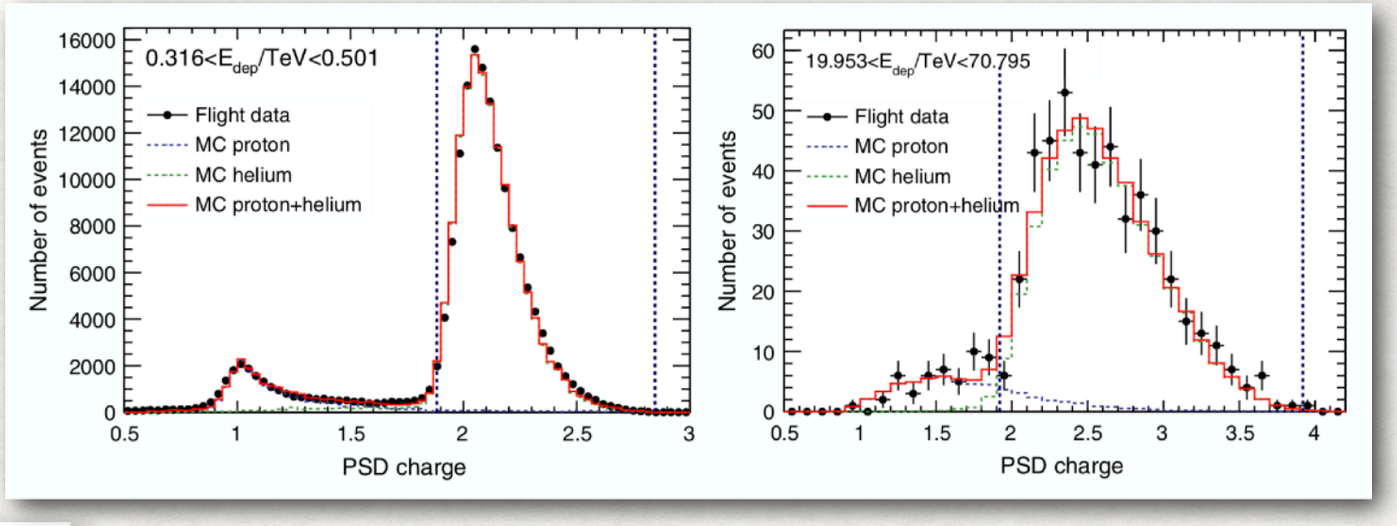


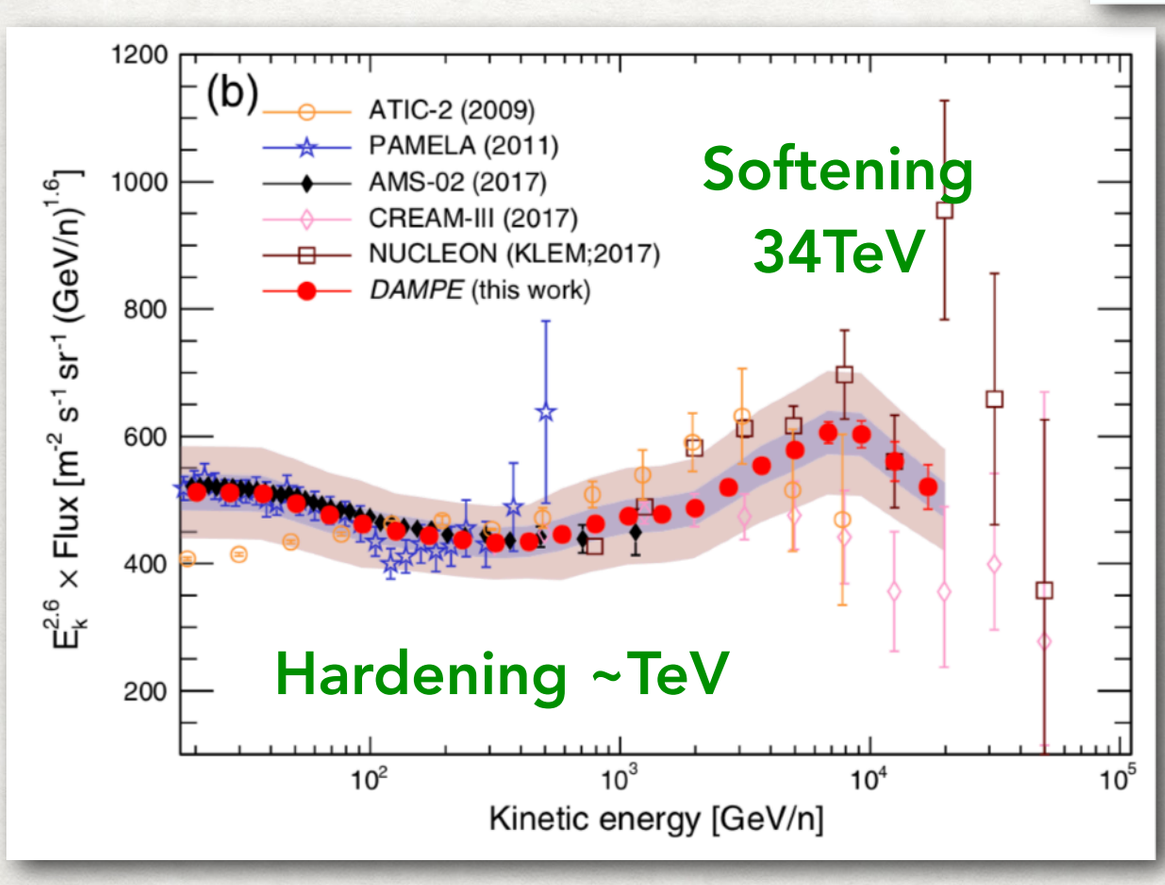
Dampe measurement : no single PL up to the knee (~4PeV)
=> new production/propagation mechanism? Nearby sources?

Systematics:
Hadronic models,
p-He separation

He FLUX WITH DAMPE

[Alemanno, F., et al., *Physical Review Letters* 126.20 (2021): 201102.]





- Tracker helps provides additional charge measurement
- Dominant systematics : hadronic model

Together with proton results:

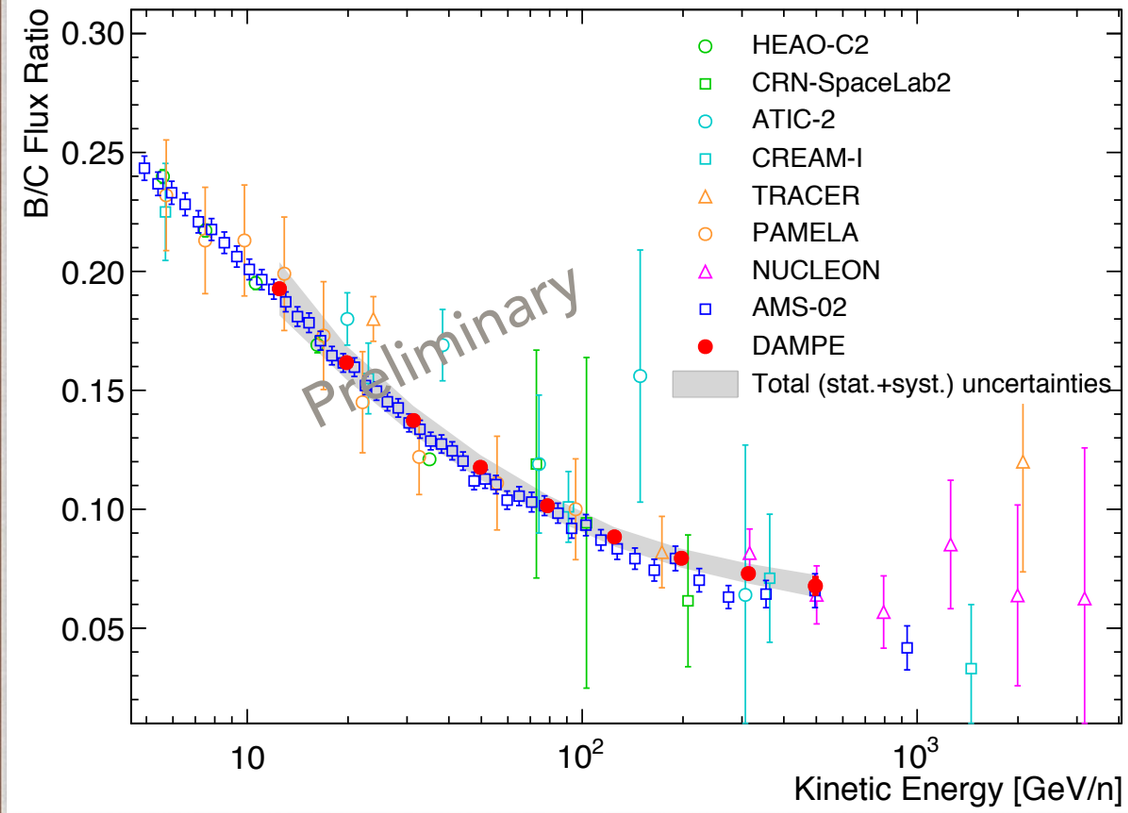
- indication for a Z-dependent source
- (A-dependent is not excluded)

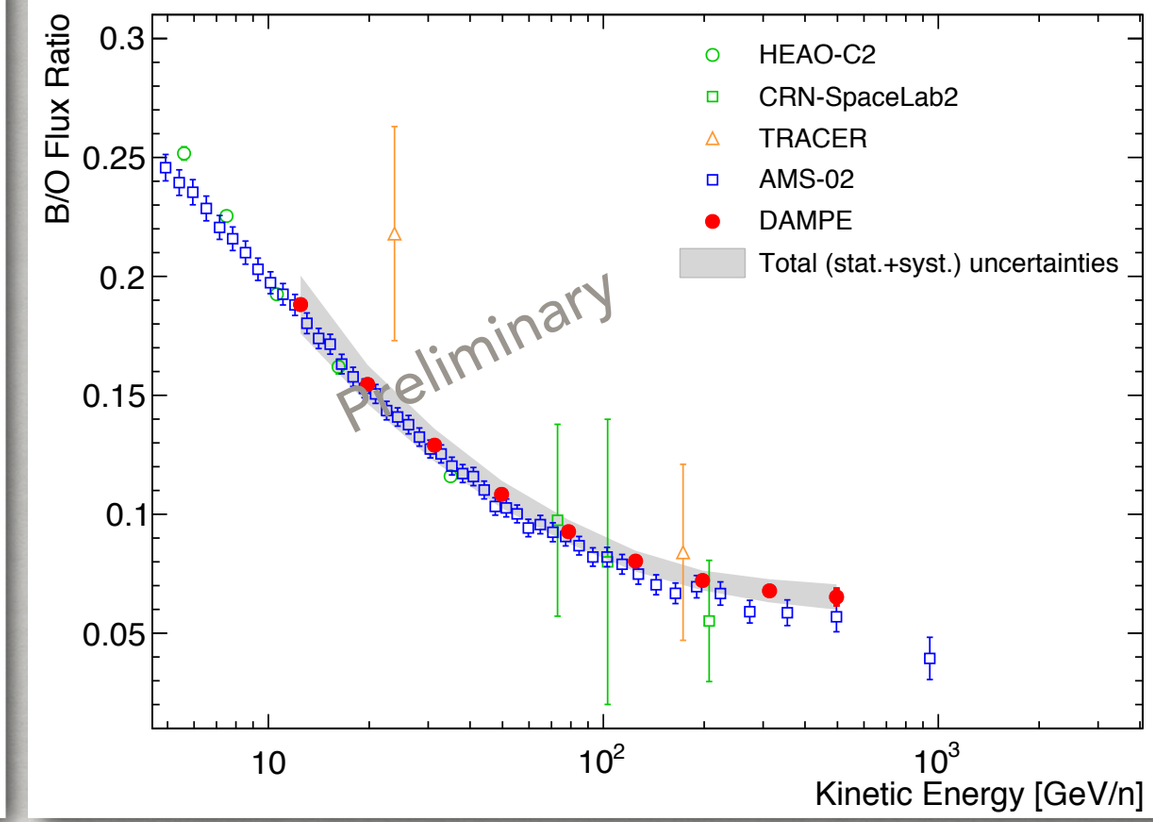
More results are coming:

- More statistics,
- Improved analysis (see later)

B/C, B/O FLUX RATIOS

- B is secondary, C&O are primary : ideal for CR propagation study
- Most of systematics cancel out

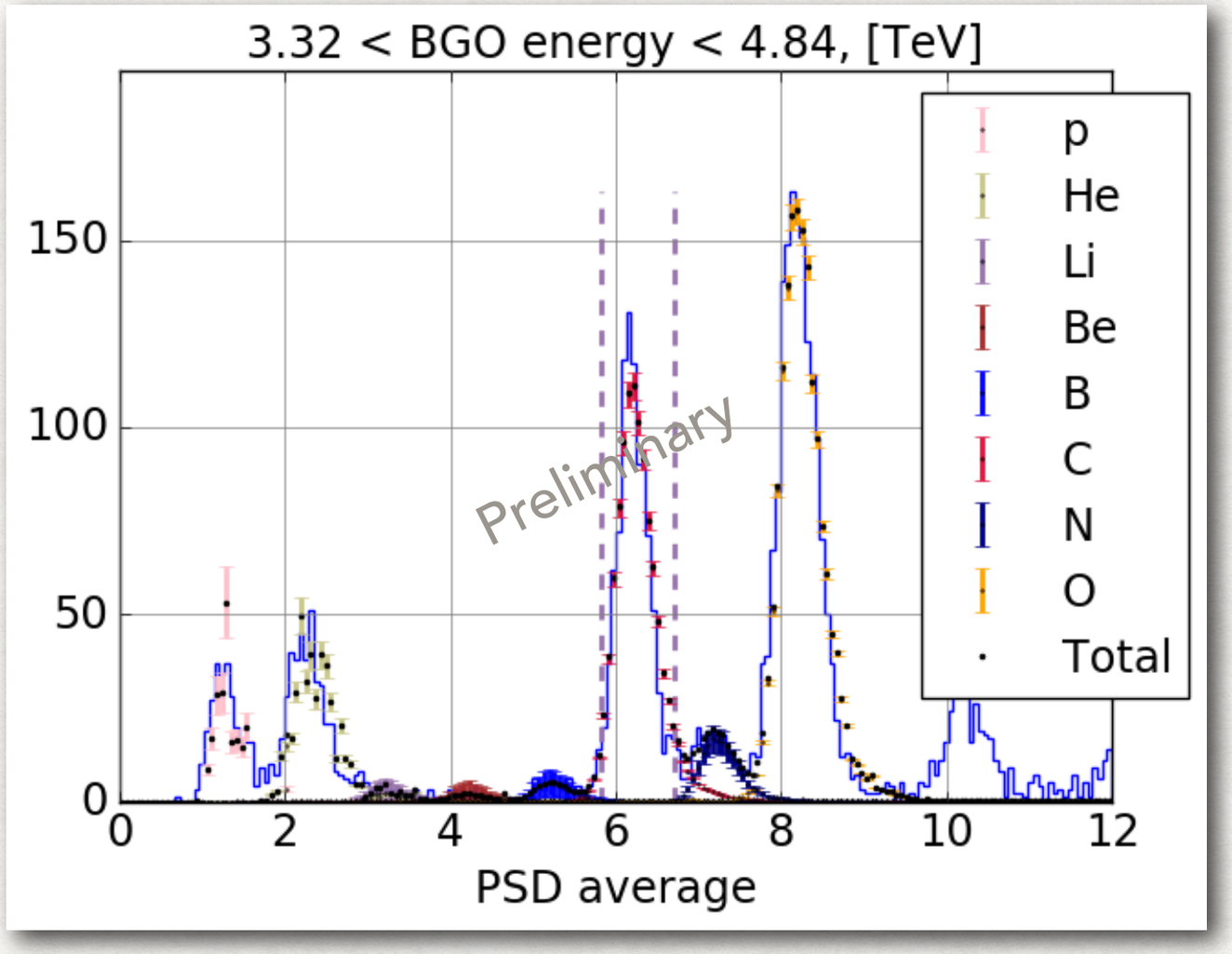


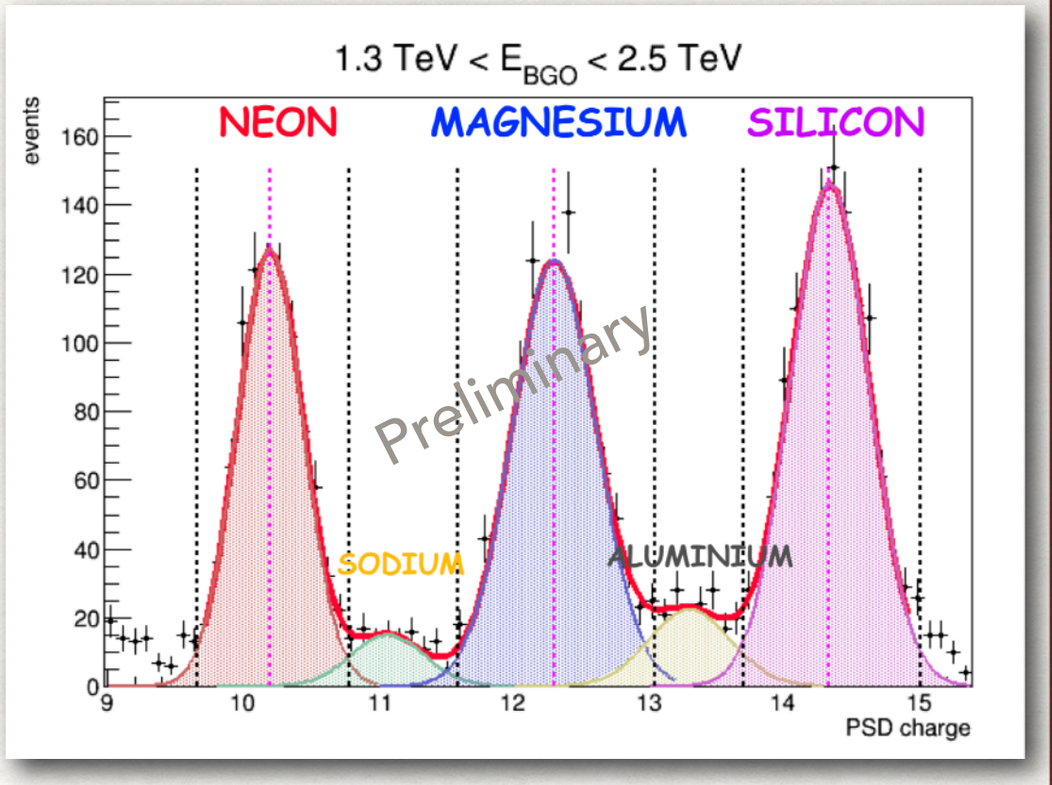


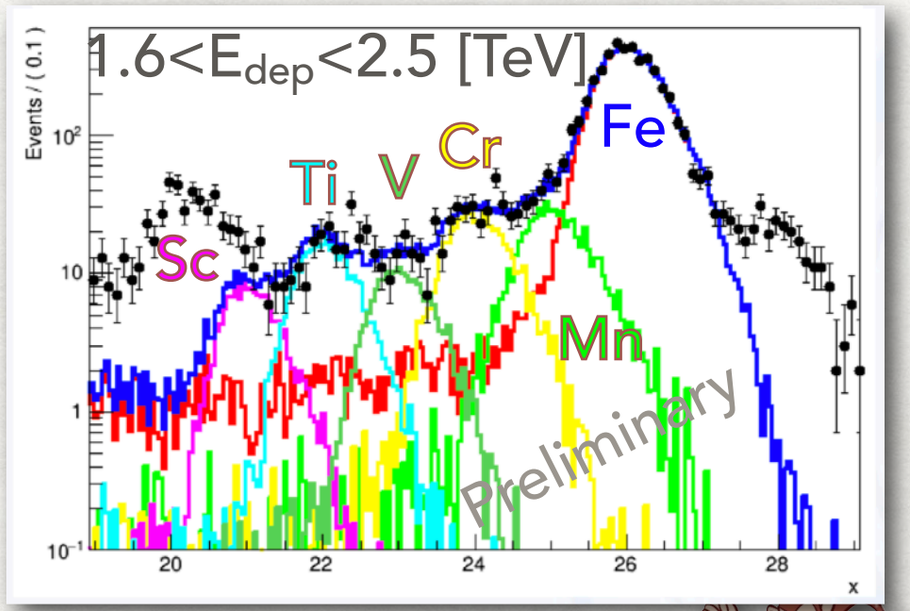
A hint for the hardening at about 100 GeV/n :
- Break in diffusion coefficient? - B production at source? - Re-acceleration?..

C, O, Fe AND MORE

in progress





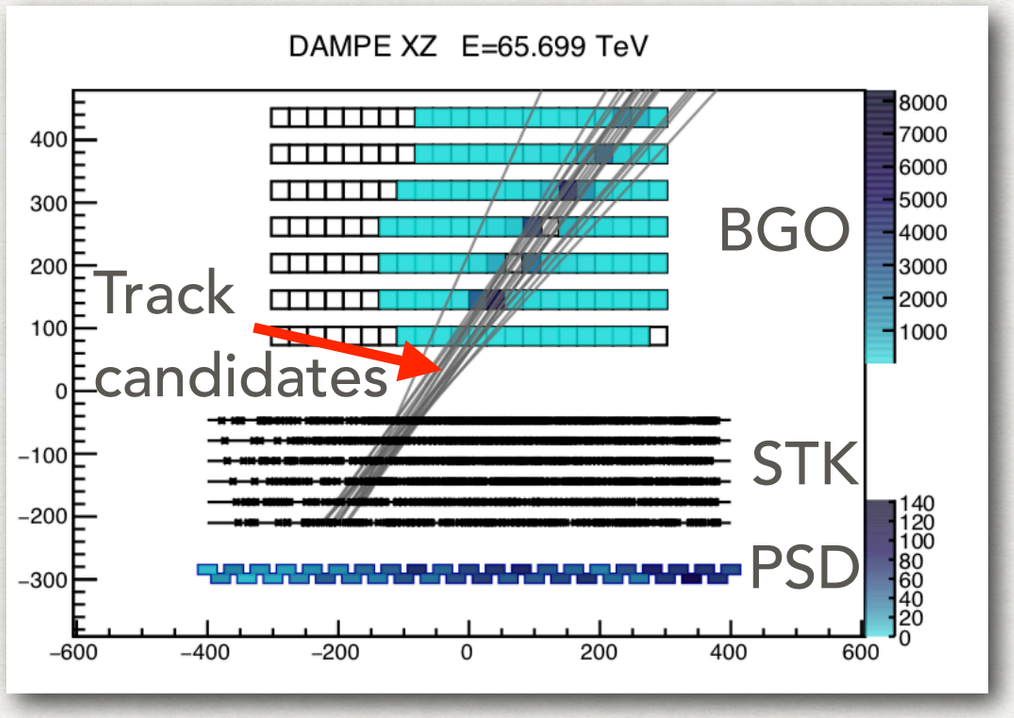


At highest energies the accurate track reconstruction is crucial for the charge measurement : see next slides

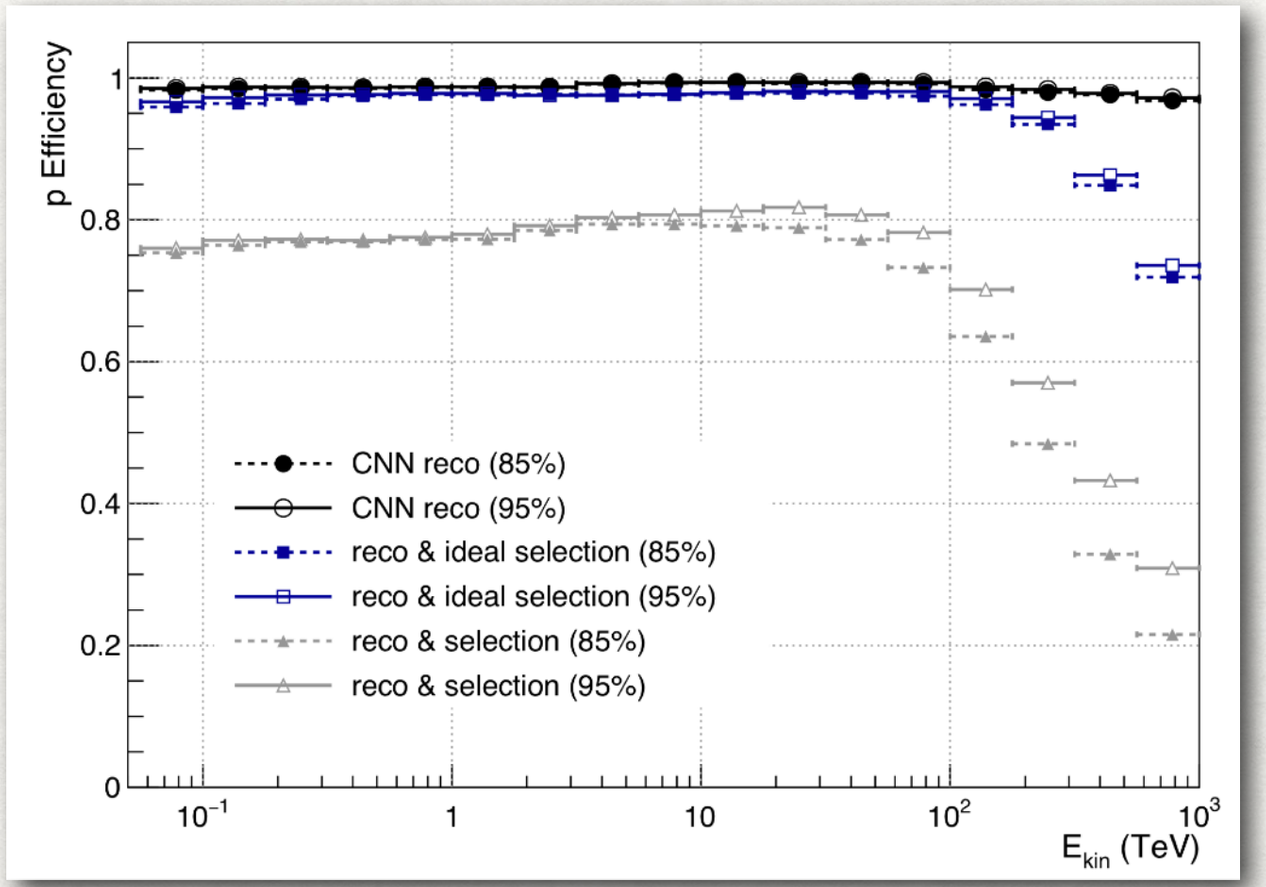
TOWARDS PeV FLUXES

MACHINE LEARNING TRACKING

Machine learning track identification: advantageous over classical approach at multi-TeV

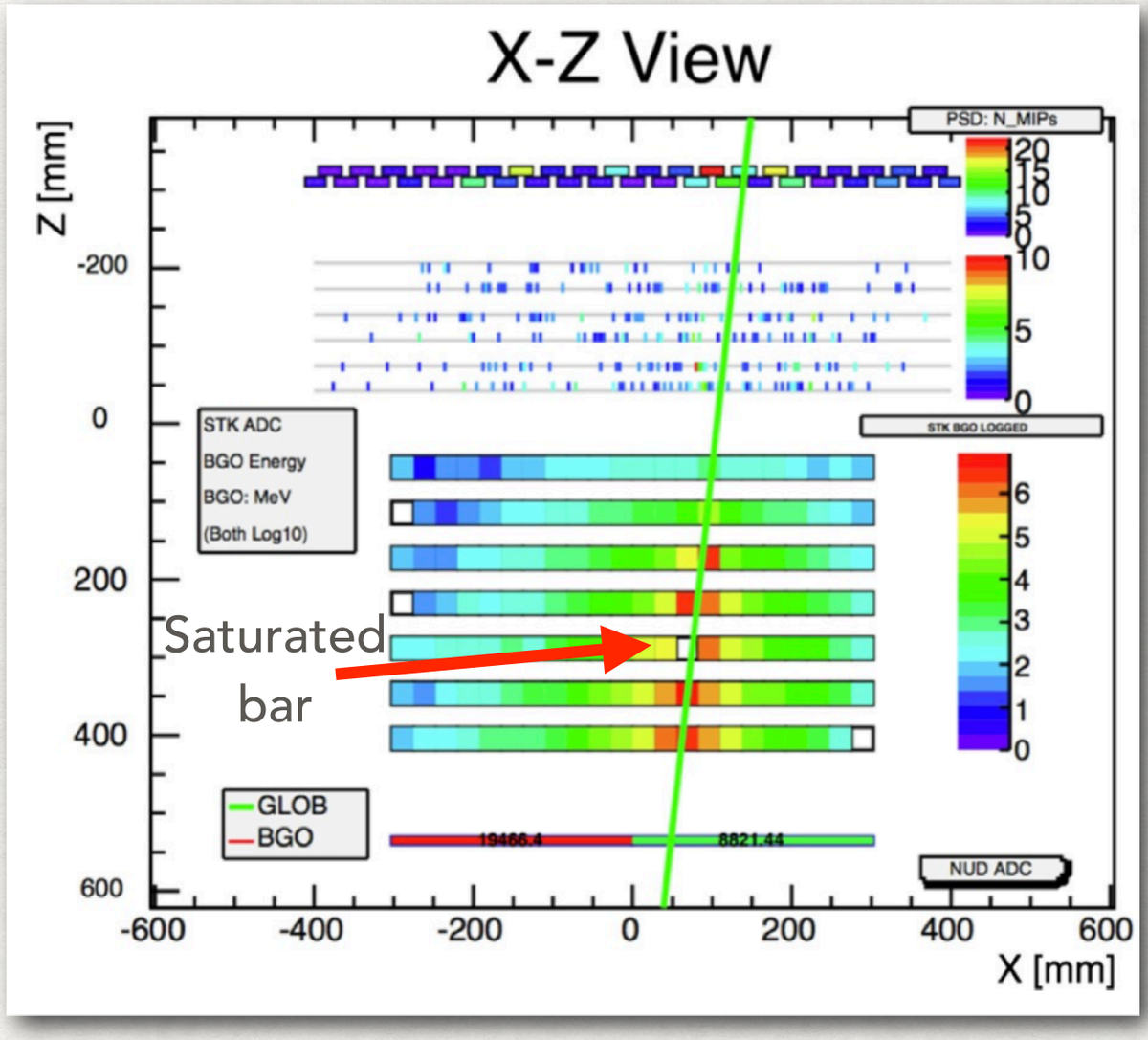


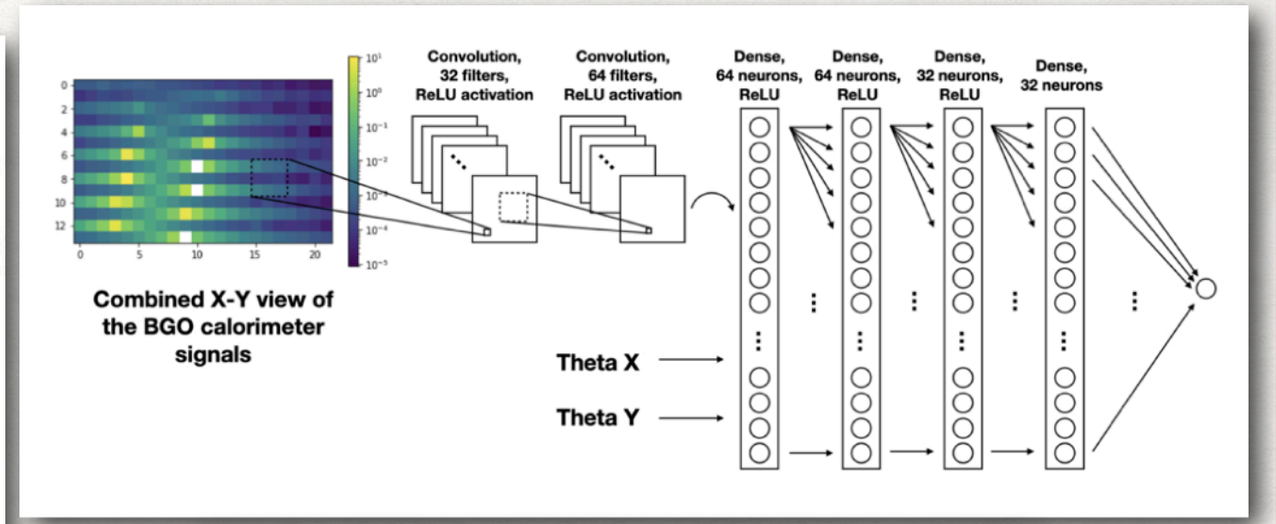
[Tykhonov, Andrii, et al., *arXiv:2206.04532* (2022).]

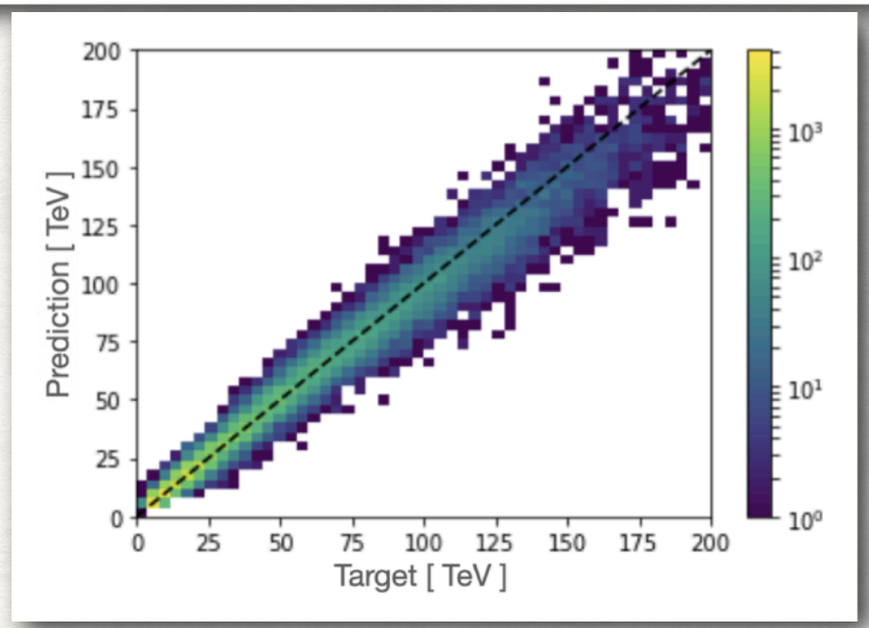


TOWARDS PeV FLUXES

BGO SATURATION CORRECTION







[M. Stolpovskiy et al., 2022 *JINST* **17** P06031]

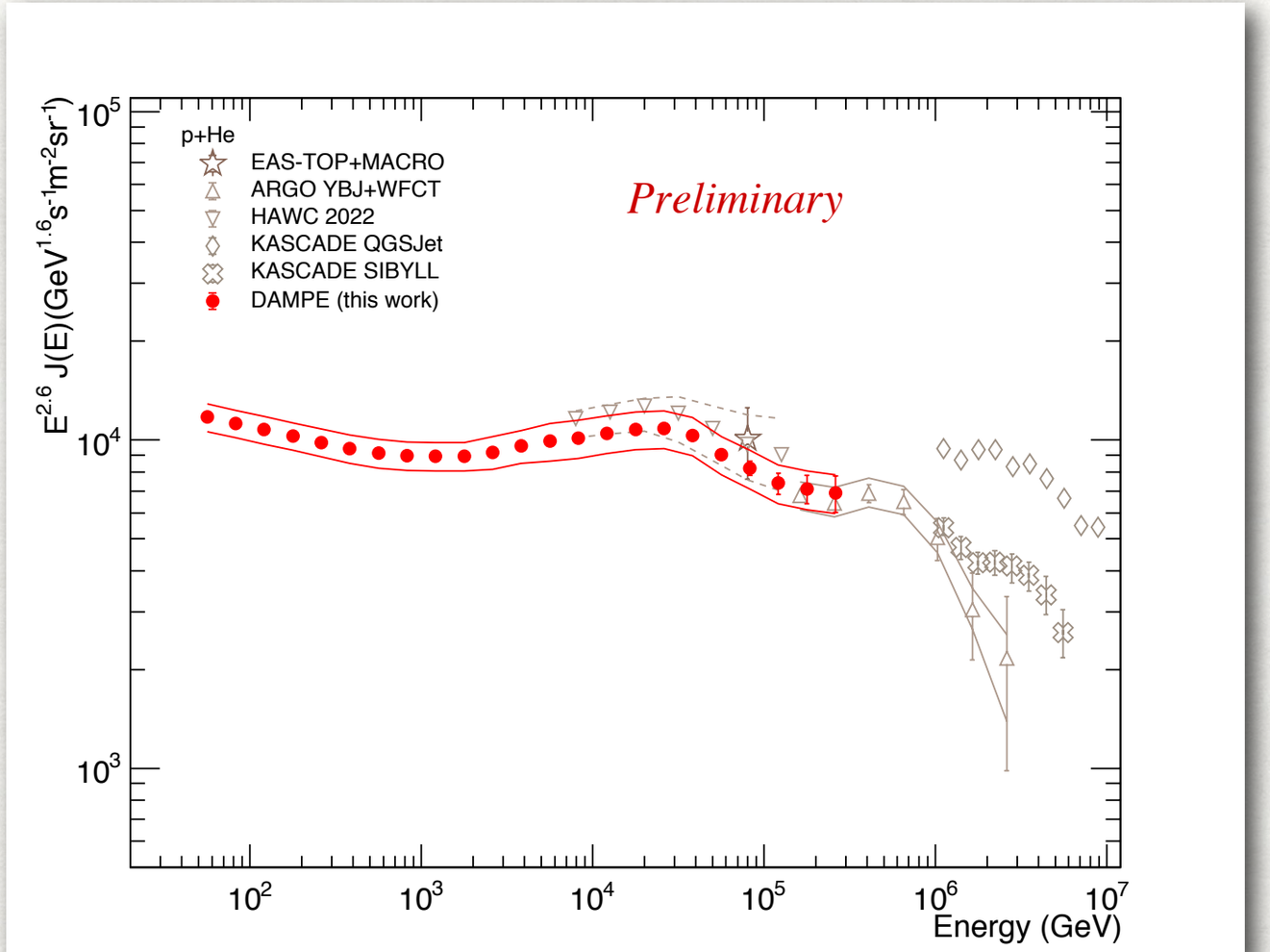
In some events: saturation => lost >~10TeV
We are able to recover this lost energy
Better deposit-kinetic E correspondence

NEWEST STUDIES, TOWARDS PeV

p+He

Combined analysis of p+He:

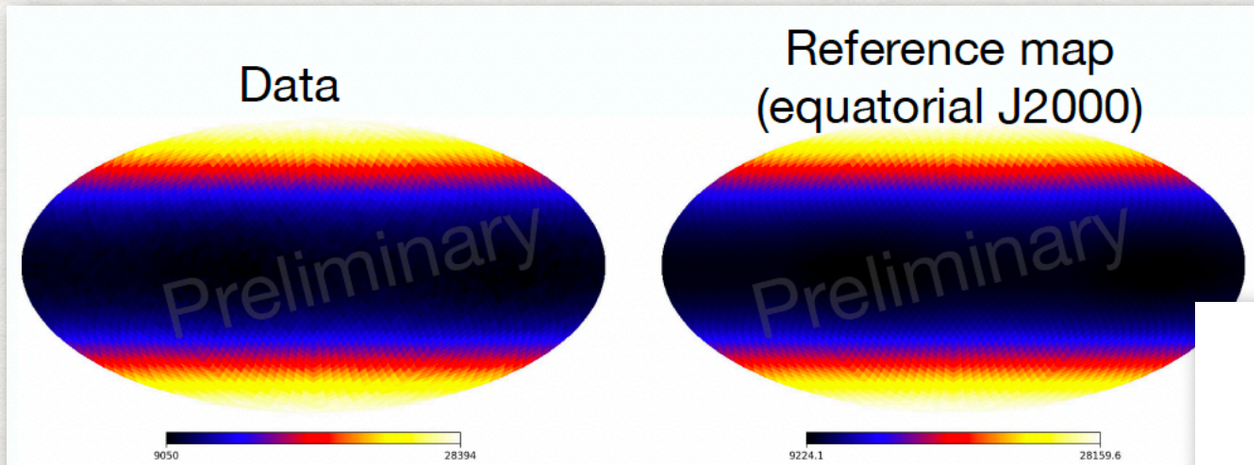
- Direct comparison with ground-based experiments,
- Larger acceptance => can measure at larger energies



Another break is suggested by ground based experiments at ~0.5PeV. Will we see it with DAMPE?..

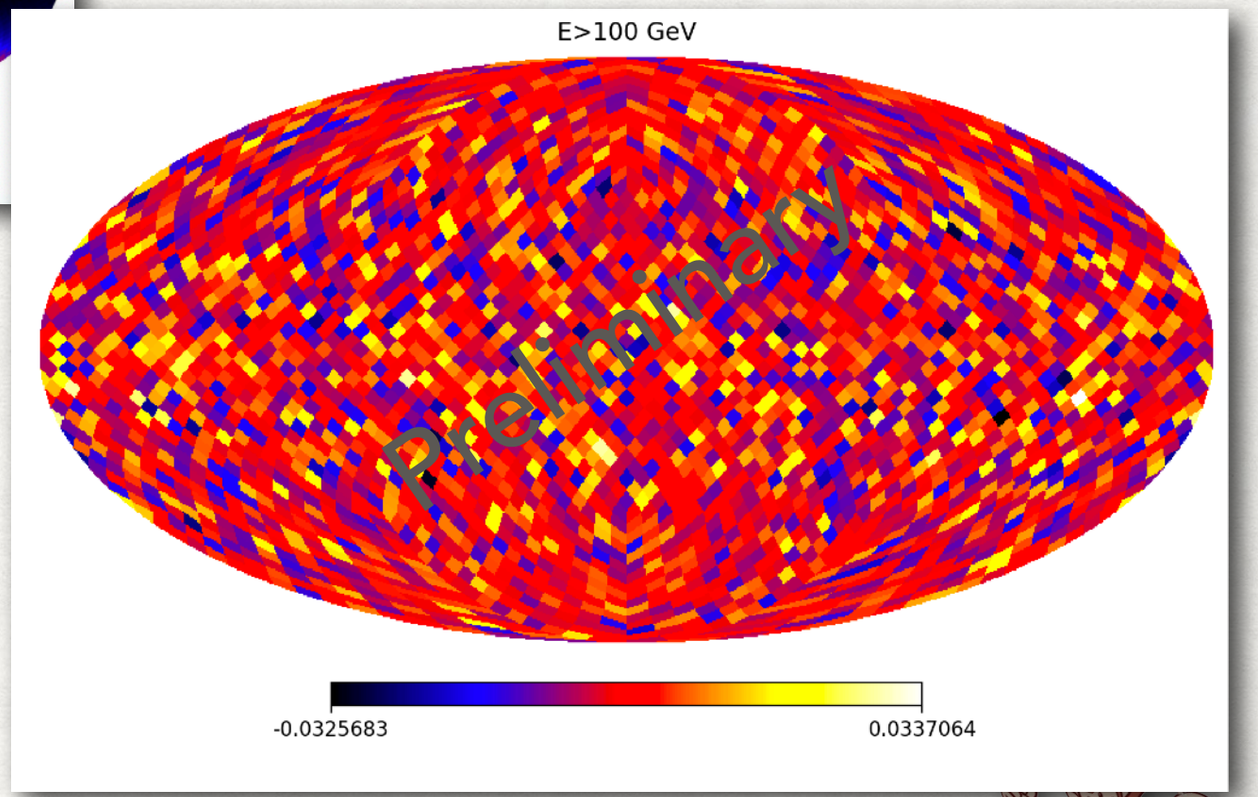
CR ANISOTROPY

- CR are highly isotropic. Small anisotropies are seen with ground-based experiments
- No anisotropy so far with any cosmic experiment, but worth trying:
  - Full sky coverage
  - Particle identification capability



East-West, Compton-Getting effects are taken into account

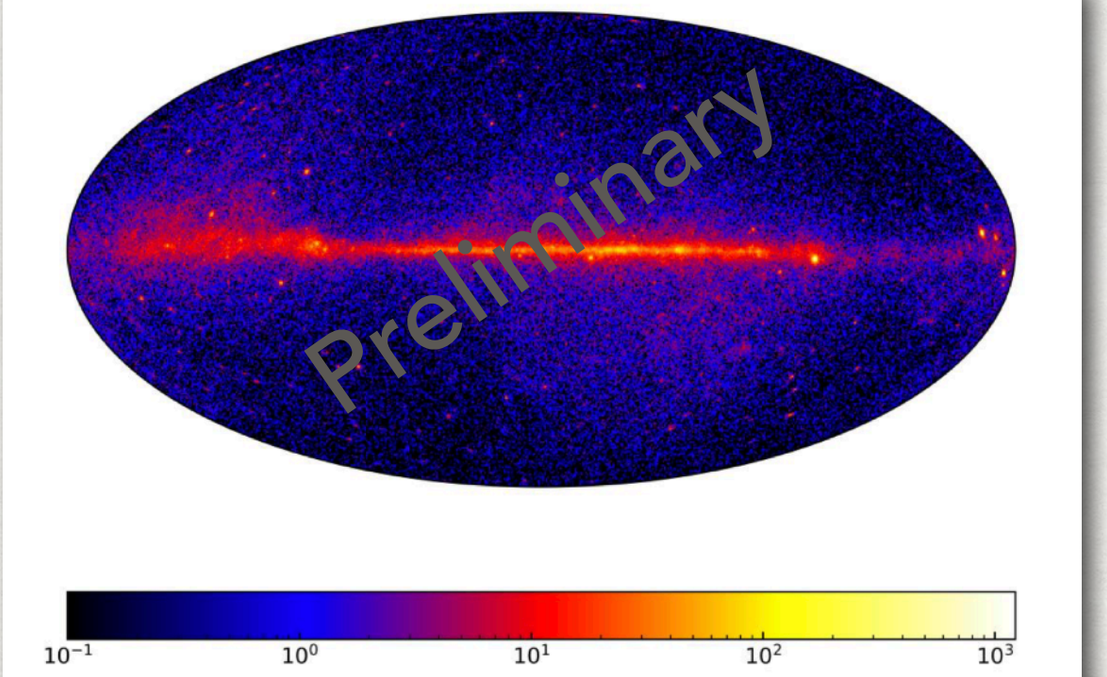
Consistent with no anisotropy



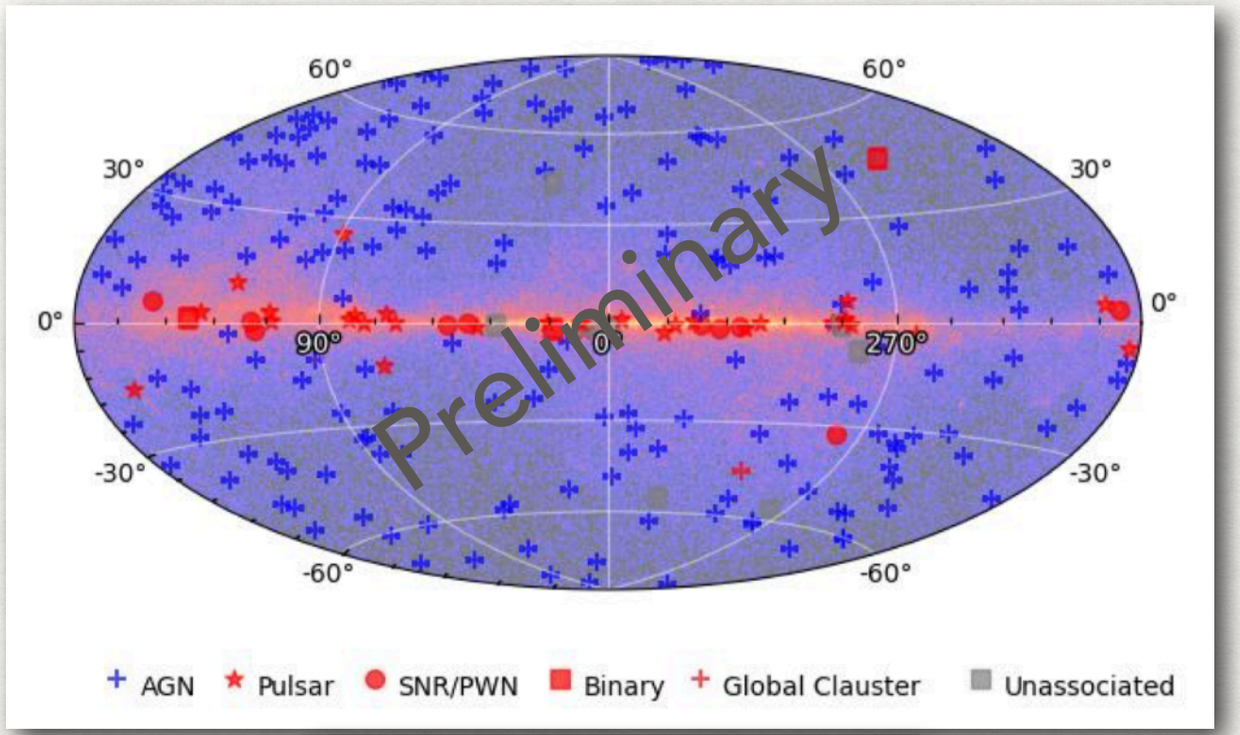
GAMMA-RAYS

SKY MAP AND SOURCES

6-years count map



Sources

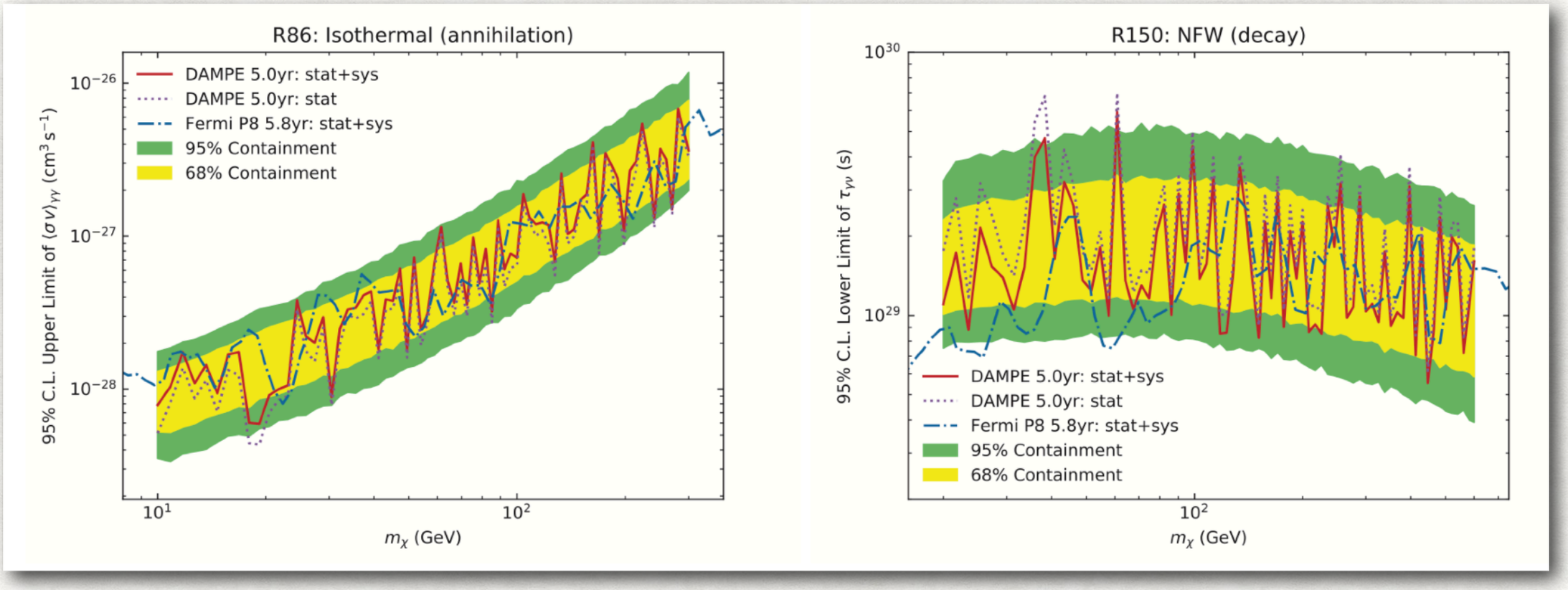


Source Type	Number
AGN	188
Pulsar	30
SNR/PWN	10
Binary	3
Globular cluster	1
Unassociated	9
Total	260

GAMMA-RAYS

LINE SEARCH

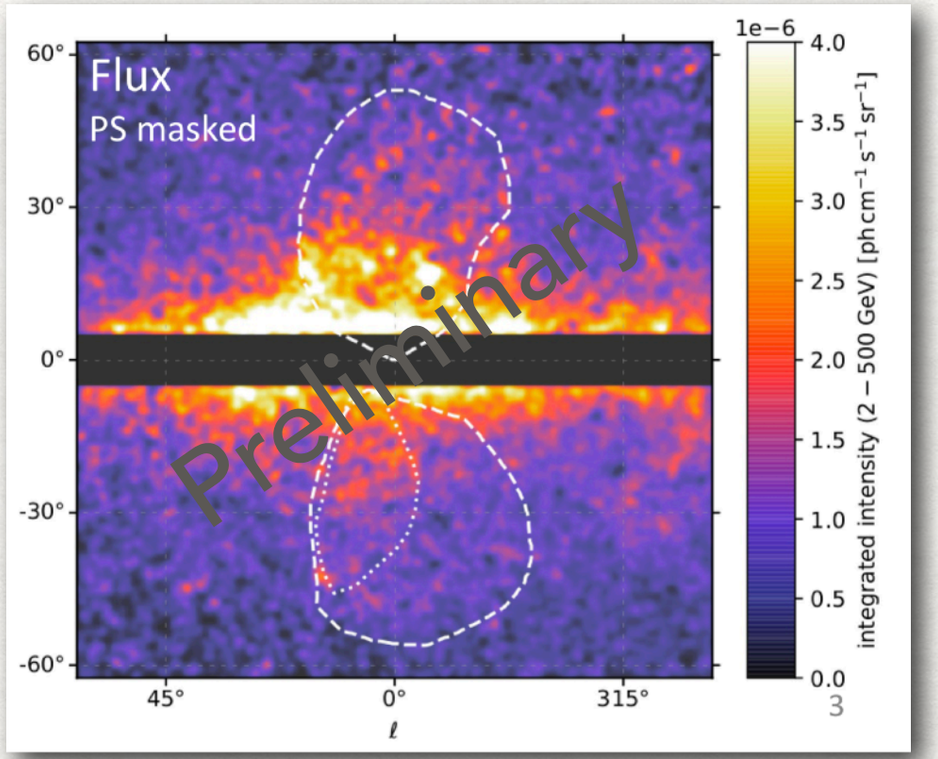
- Excellent energy resolution
  - Sensitivity comparable with FermiLAT (in spite of lower acceptance)
- Decaying DM: most stringent limit on decay lifetime for DM mass < 100 GeV

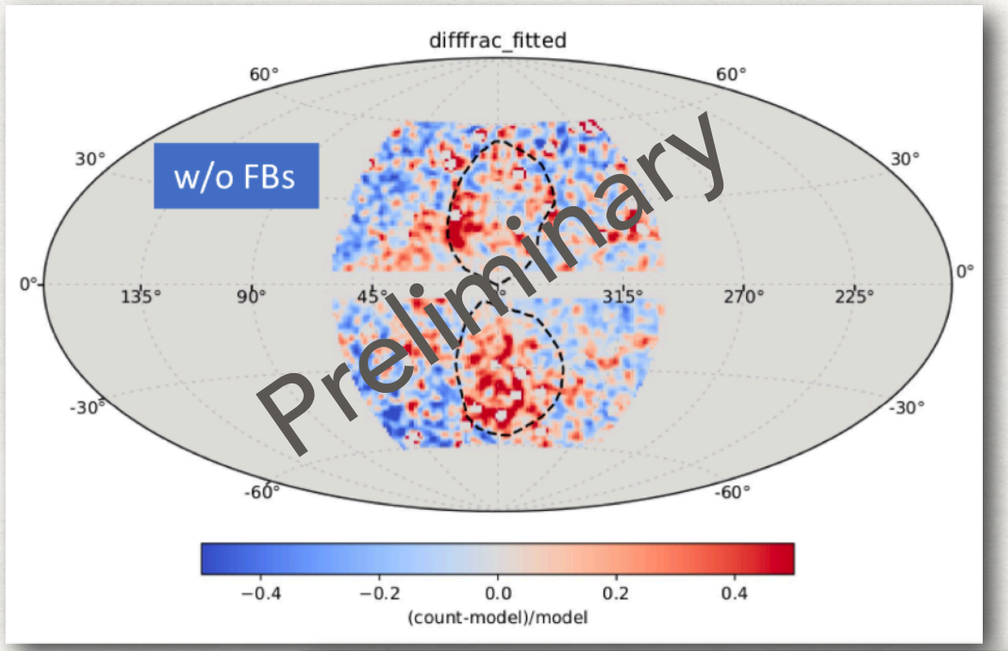


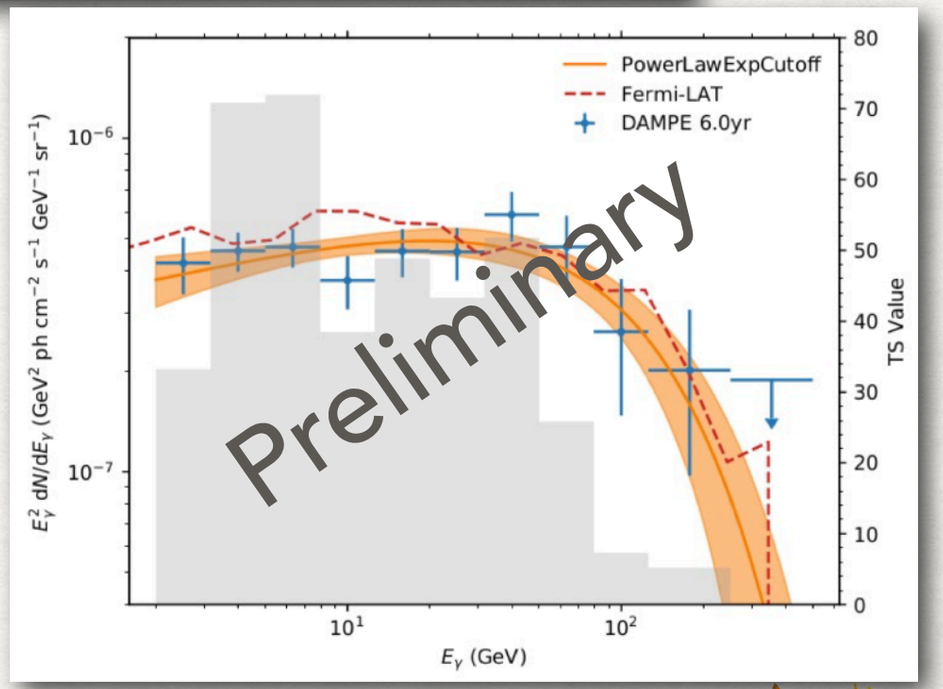
[F. Alemanno et al. Search for gamma-ray lines in the Galaxy with DAMPE, December 2021]

GAMMA-RAYS

FERMI BUBBLES

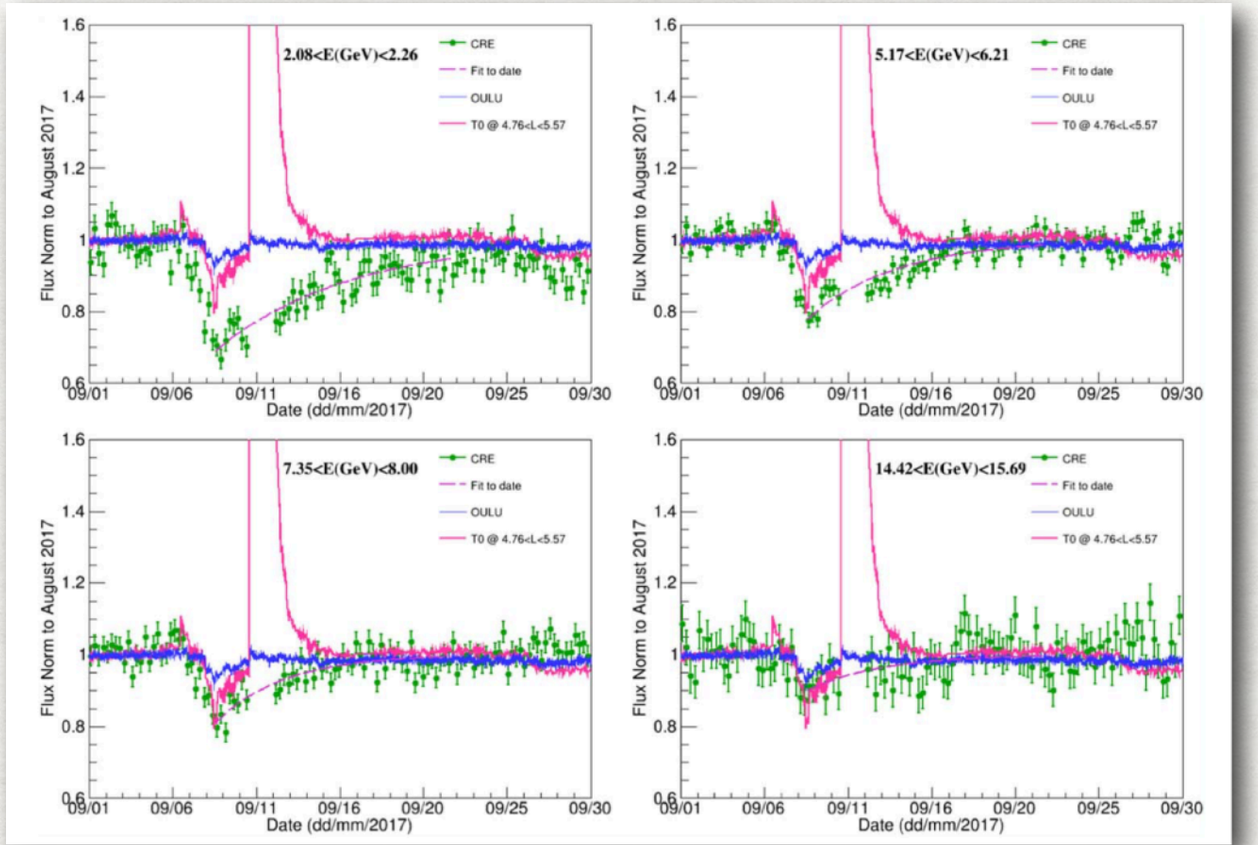






- Fermi Bubbles : diffuse structures discovered by Fermi LAT, associated with Galactic Centre
- Spectrum consistent with Fermi LAT
- Features: spectrum curvature (>3σ), excess in cocoon (>3σ), more to come…

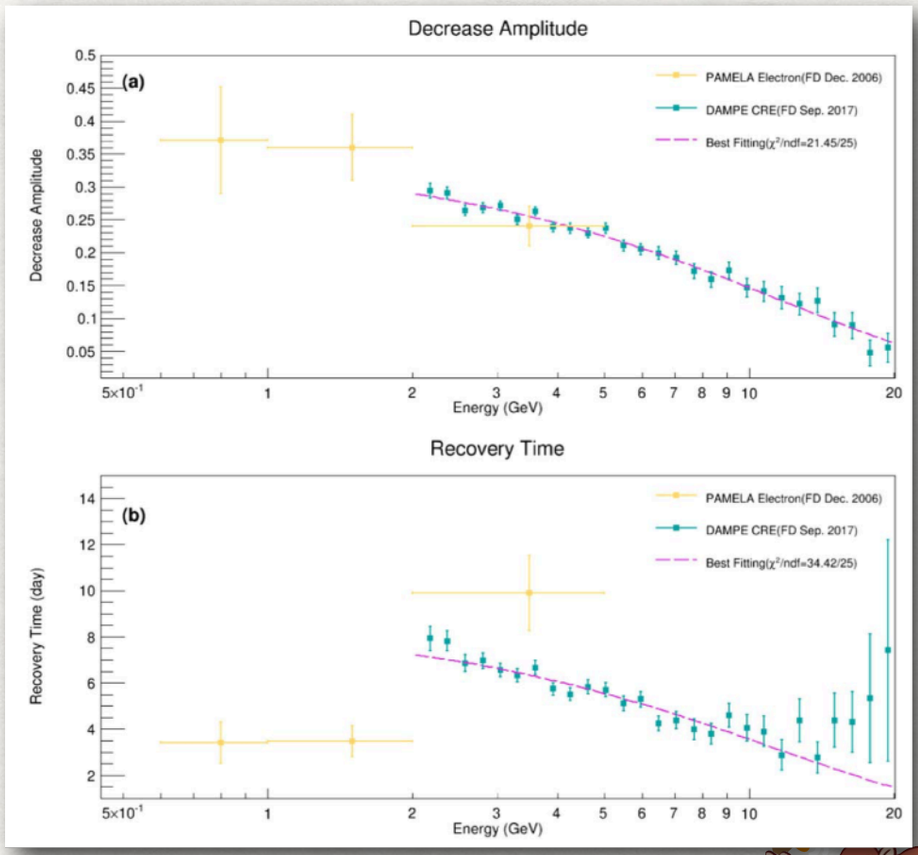
HELIOPHYSICS



[Alemanno, F., et al., *The Astrophysical Journal Letters* 920.2 (2021): L43.]

Forbush Decrease (FD) — CR follow-up of energetic solar flares

- Orbit reaching polar regions (reduced geomagnetic cutoff)
- 0.35 m2 sr acceptance => high-precision measurement of FD



CONCLUSIONS

- DArk Matter Particle Explorer (DAMPE)
  - In-flight operation 2015 — now
  - Excellent performance & stability
  - Unique for multi-TeV Cosmic Rays (CR)
- Rich Physics Program:
  - CR e± — direct observation of TeV-break, more is coming…
  - CR p & He — enter TeV-PeV frontier, more is coming…
  - CR B, C, O, Fe and + — in progress… Interesting results on B/C and B/O are coming soon.
  - γ-ray sky, Fermi Bubbles, DM search
  - Heliophysics
- ML for 100TeV-PeV energies