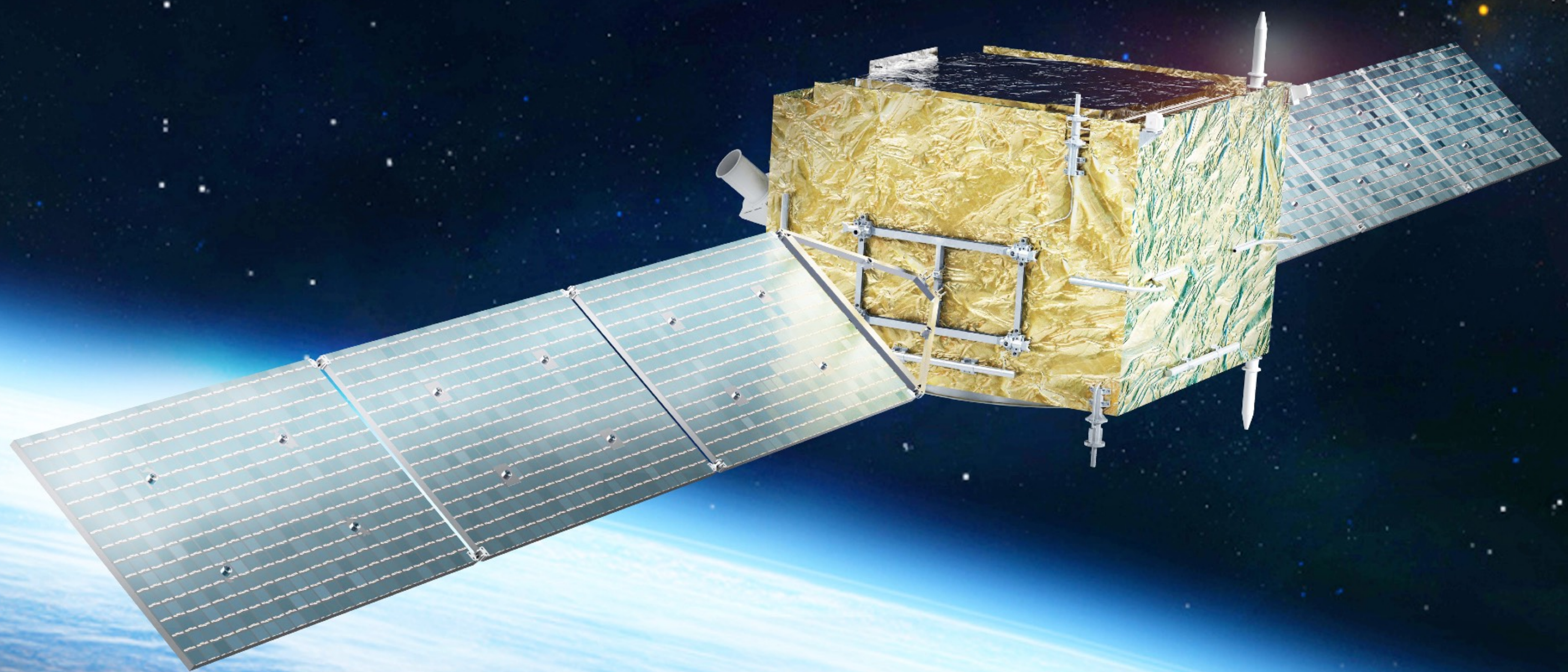
Combined analysis of CNO group with DAMPE



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On bebalf of the DAMPE Collaboration.

COSPAR 2024
45th Scientific Assembly
July 13-21, 2024
BEXCO, Busan, Korea

DAMPE collaboration

- China

  1. **Purple mountain observatory, CAS, Nanjing.**
  2. University of Science and Technology of China, Hefei.
  3. Institute of Modern Physics, CAS, Lanzhou.
  4. Insitute of High Energy Physics, CAS, Beijing.
  5. National Space Science Center, CAS, Beijing.
- Italy

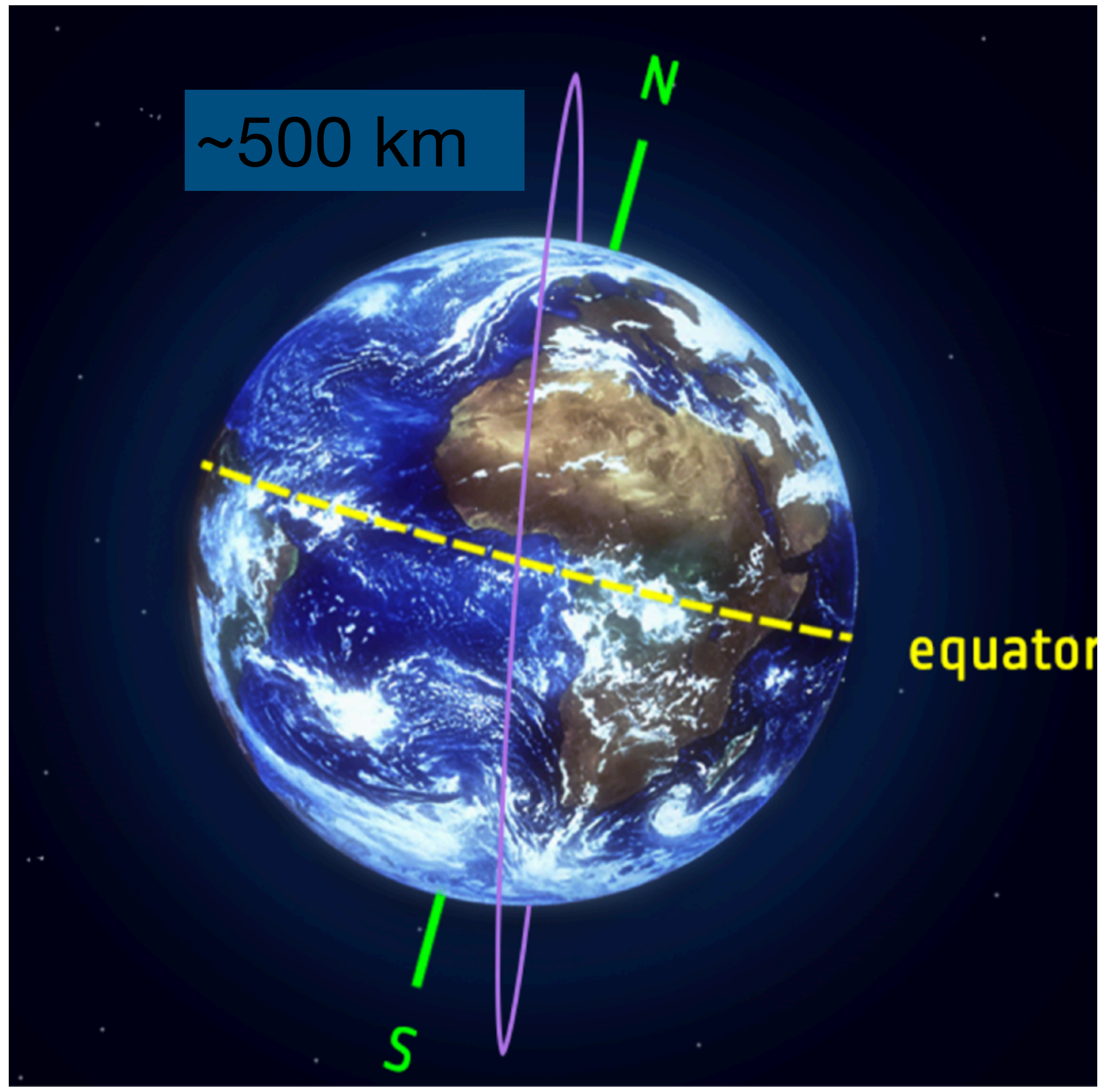
  

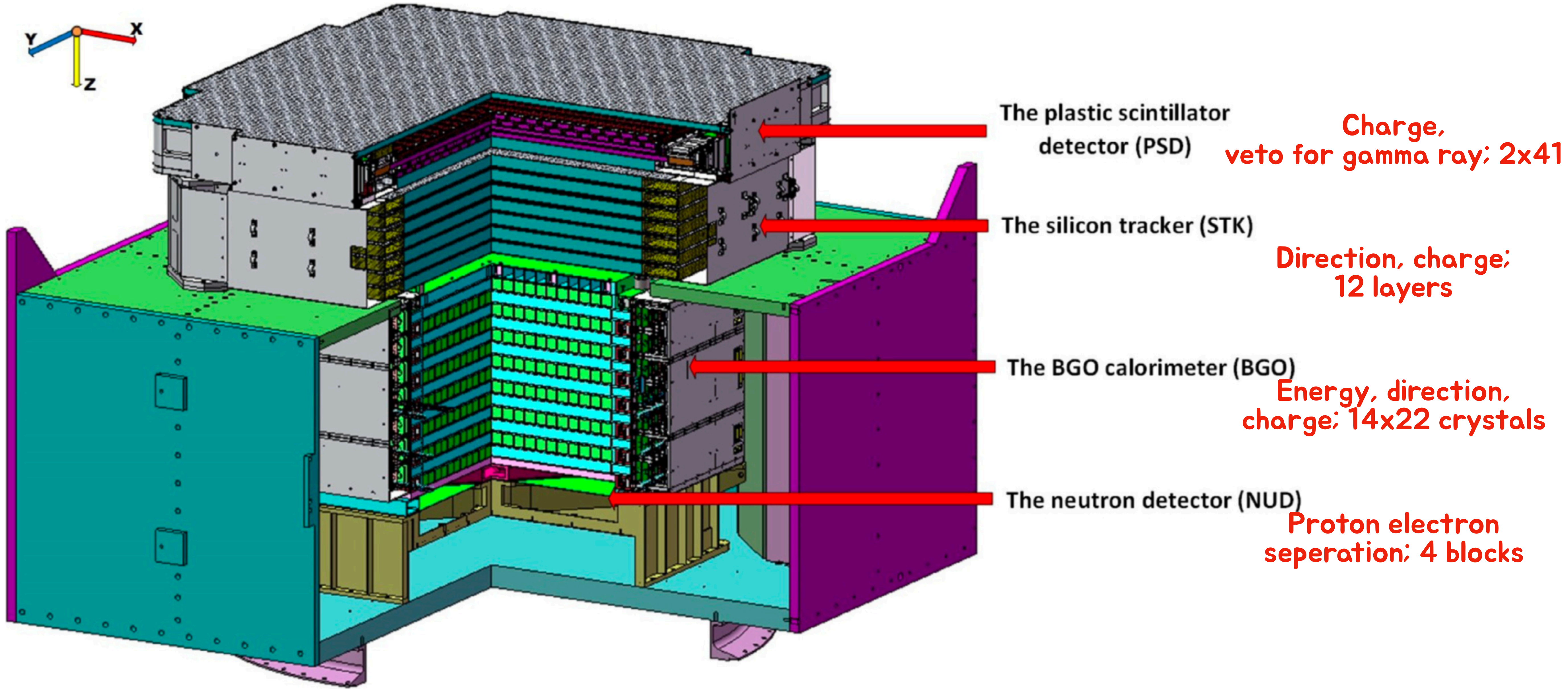
  1. INFN Perugia and University of Perugia.
  2. INFN Bari and University of Bari.
  3. INFN-LNGS and Gran Sasso Science Institute.
  4. LNFN Lecce and University of Salento.
- Switzerland

  1. University of Geneva.

DAMPE

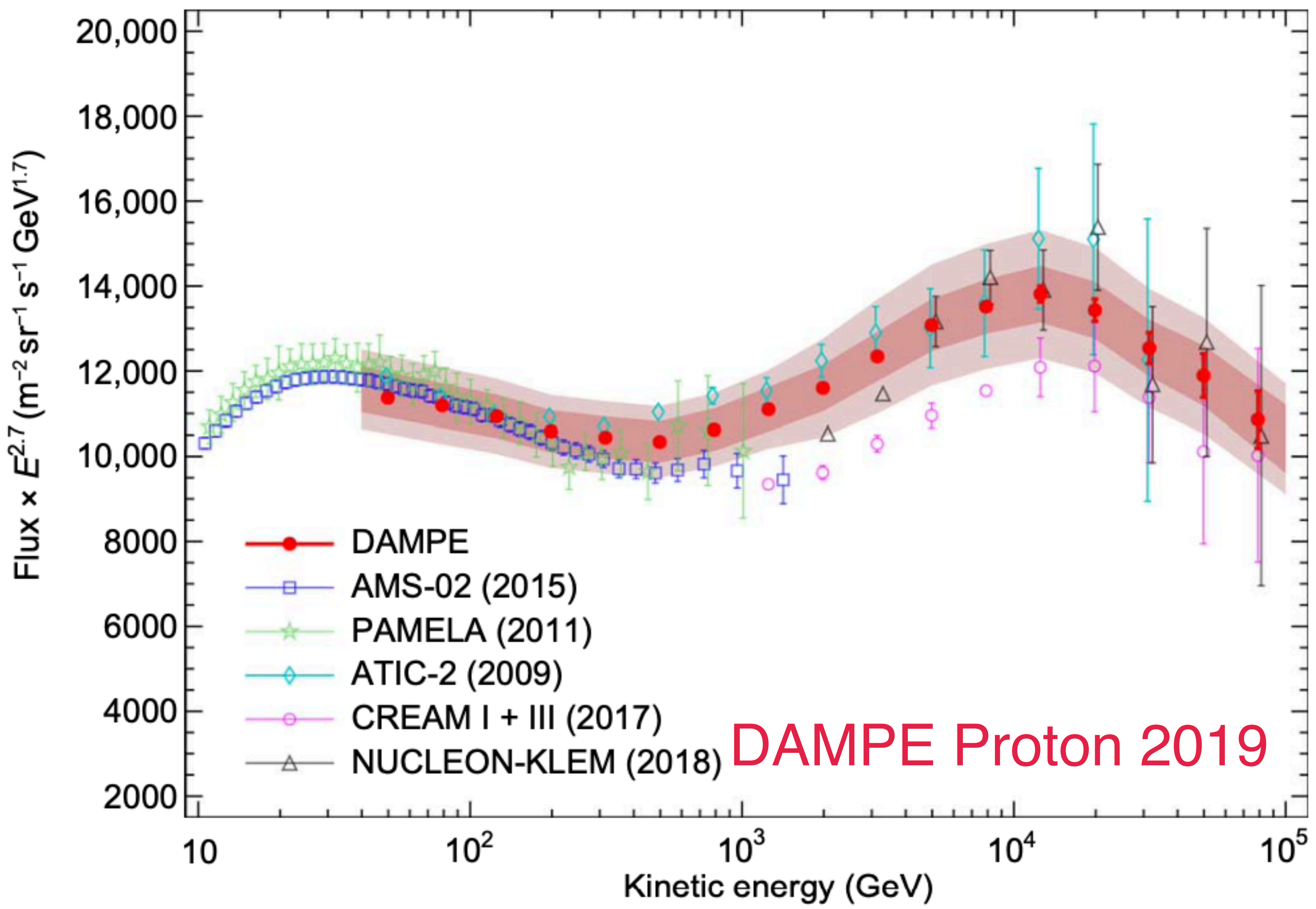


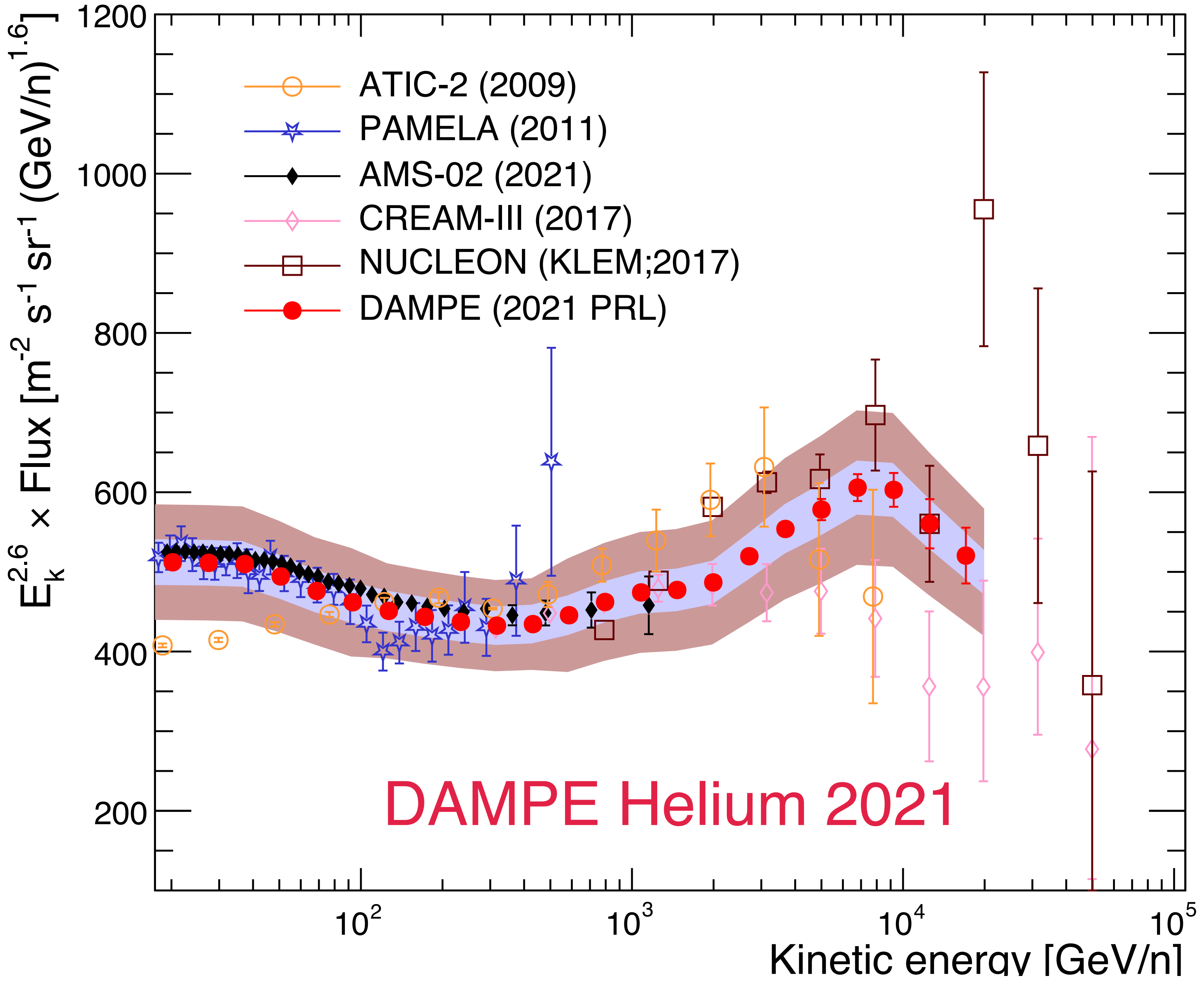


- Expected lifetime: 3 years
- Raw data: 16GB per day.
- Orbit: sun-sync. ~500km, ~95minutes
- Smoothly operated since launch for more than 8 years.

√ Four sub-detectors, 1.4 tons in total. 32 radiation length & 1.6 nuclear interaction length

What can we know more with DAMPE.

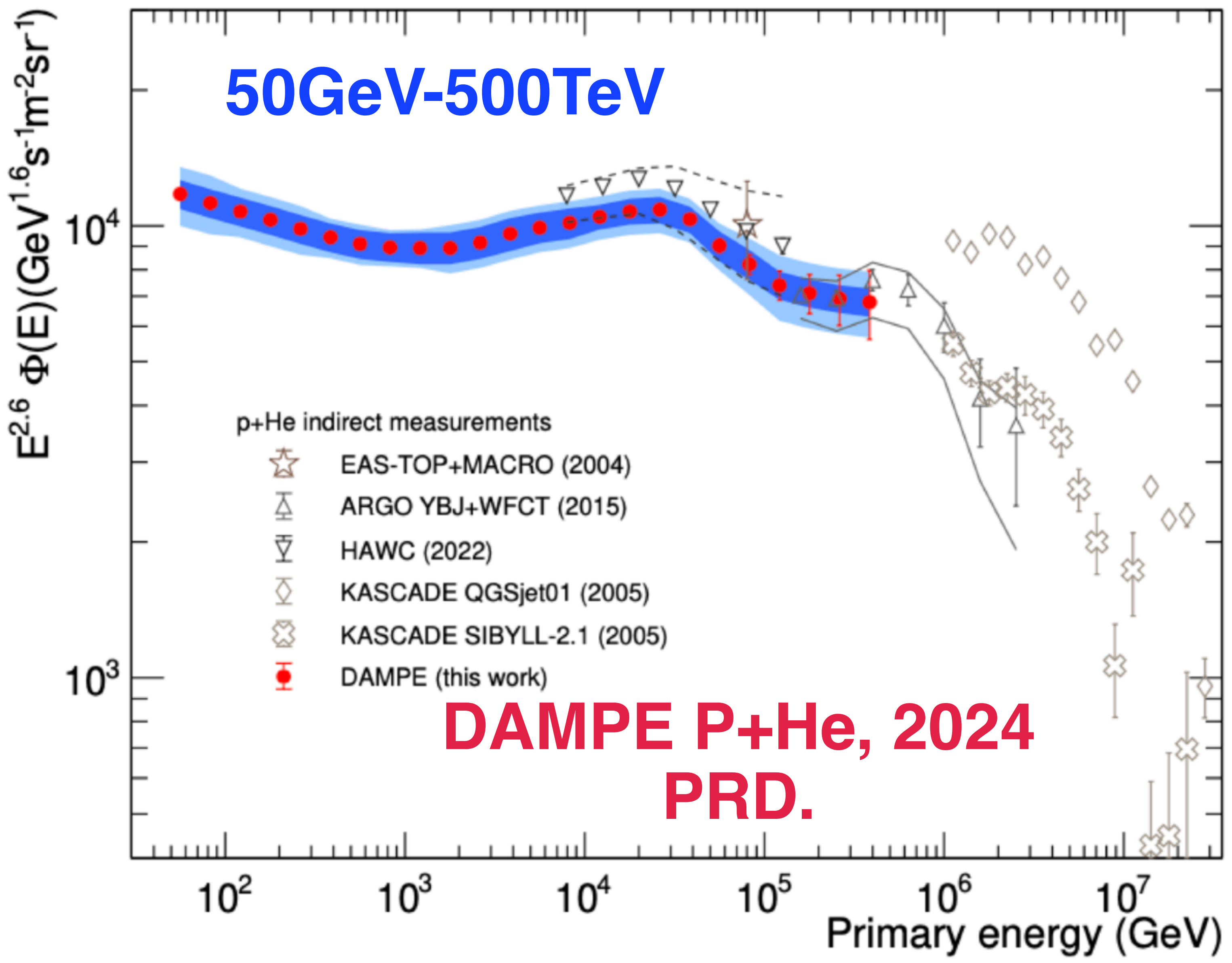




1. **There is a clear softening for proton (~14TeV) & helium (~34TeV) with DAMPE, which is also approved by latest measurement from CALET, ~~NUCLEON?~~.**

2. **How about for other species?**

3. **Could space-based experiment reach the PeV region?**



https://link.aps.org/doi/10.1103/PhysRevD.109.L121101

Data selection

Cut 1: BgoE > 100GeV in the first 13layers or all 14layers and HET

Cut 2: Rule out the event taking across South Atlantic Anomaly

Cut 3: Nhits>=3 and Chi2Ndof < 5 && Maximum total ADC of track

Cut 4: Selected STK track pass through whole detector [First 13layers and second PSD plane]

Cut 4: $\Delta_{diff} < 200mm$ between BGO and STK track on the PSD

Cut 6: Downward going event E0+E1 < E2+E3

The case of standard track

Cut 7: Maximum Eratio in one layer less than 35% of whole energy deposit

(1)Maximum BGO crystal is not at the edge of each layer for all first 10 BGO layers.

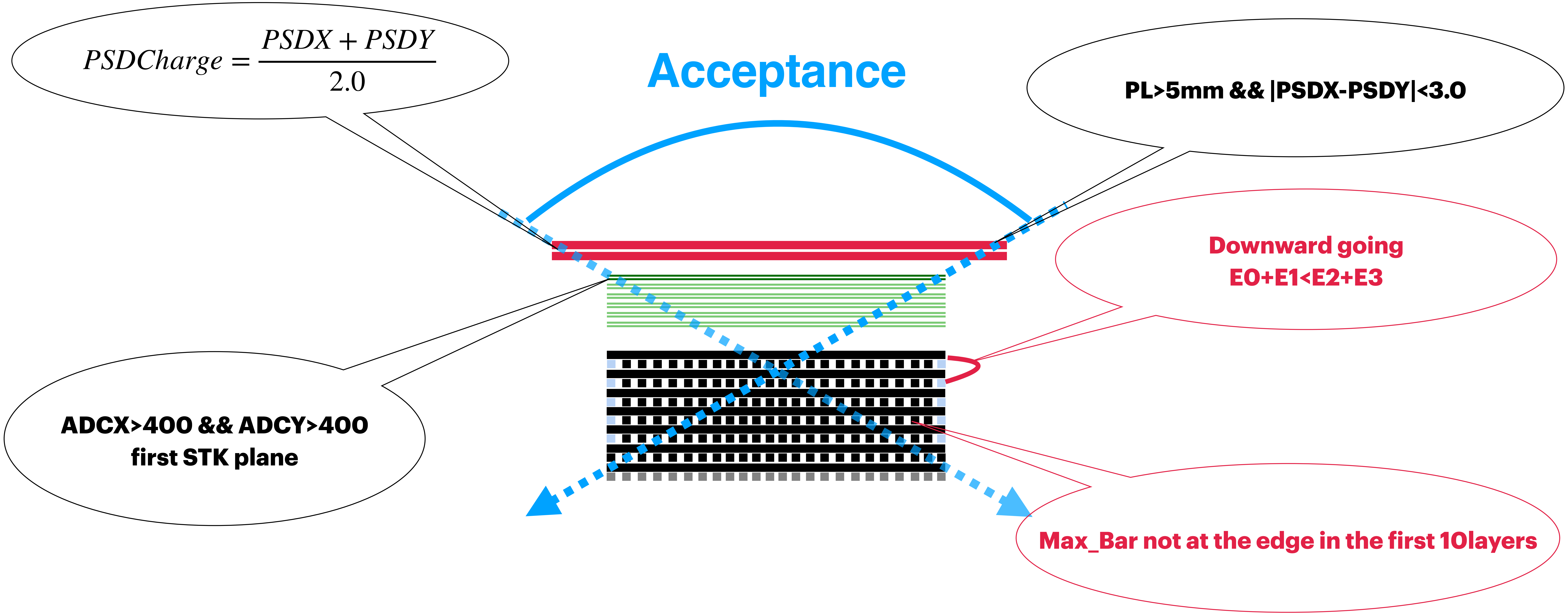
(2) Path-length should be larger than 5mm within the passed PSD

(3) Difference between charge-x and charge-y should be less than 3.

Charge selection： Mean value of two planes: $5.5 + 0.002 \times \left(lg\frac{E_{GeV}}{10}\right)^{3.5}$,$8.9 + 0.01 \times \left(lg\frac{E_{GeV}}{10}\right)^{3.5}$

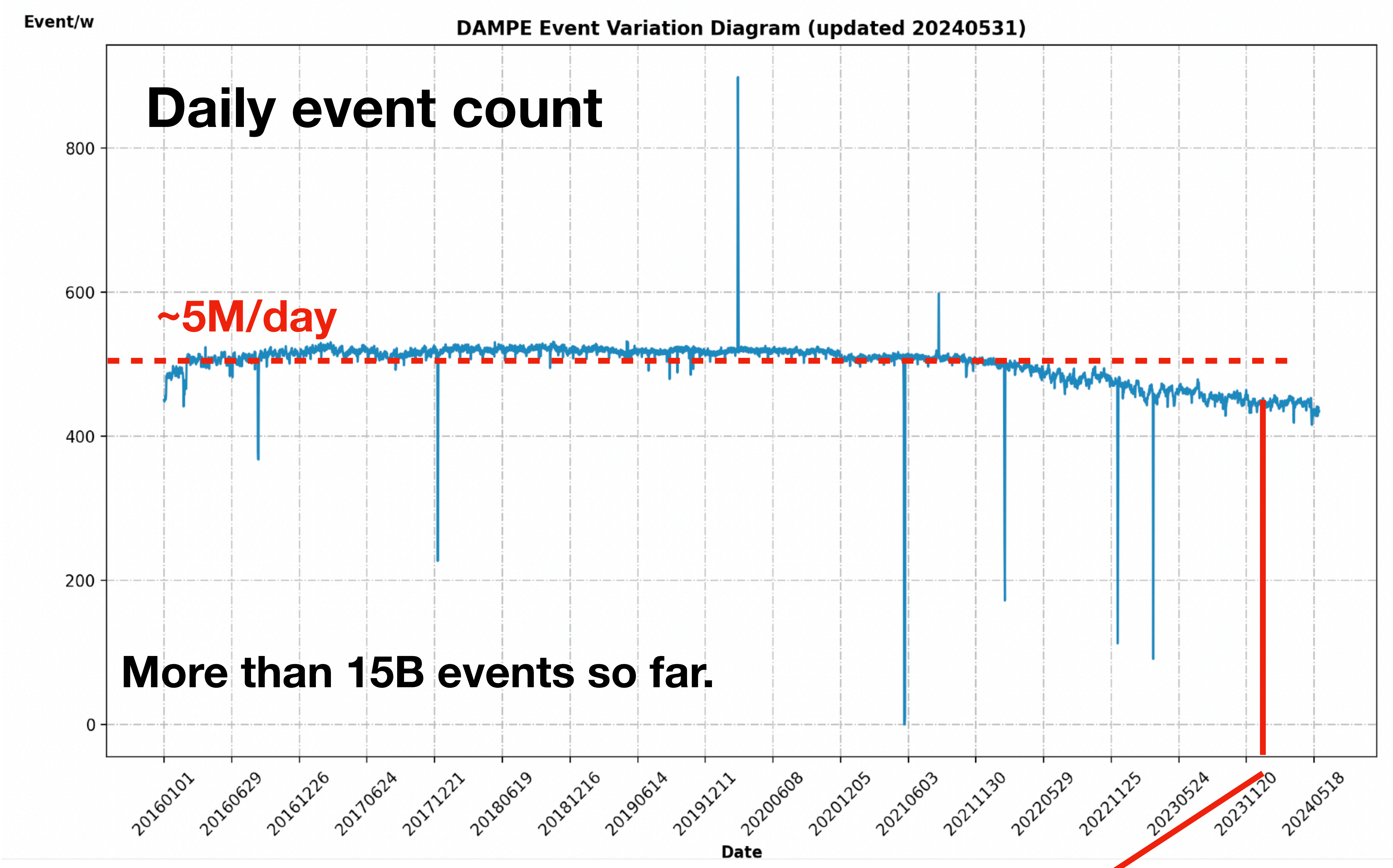
&& Both two clusters in the first STK plane have ADC larger than 400.

Sketch of an event selection



- **Geometry: second PSD plane && first 13 BGO layers.**
- **Areas of PSD and BGO are 408.5mm*408.5mm and 280mm*280mm, respectively.**

Data samples in this work

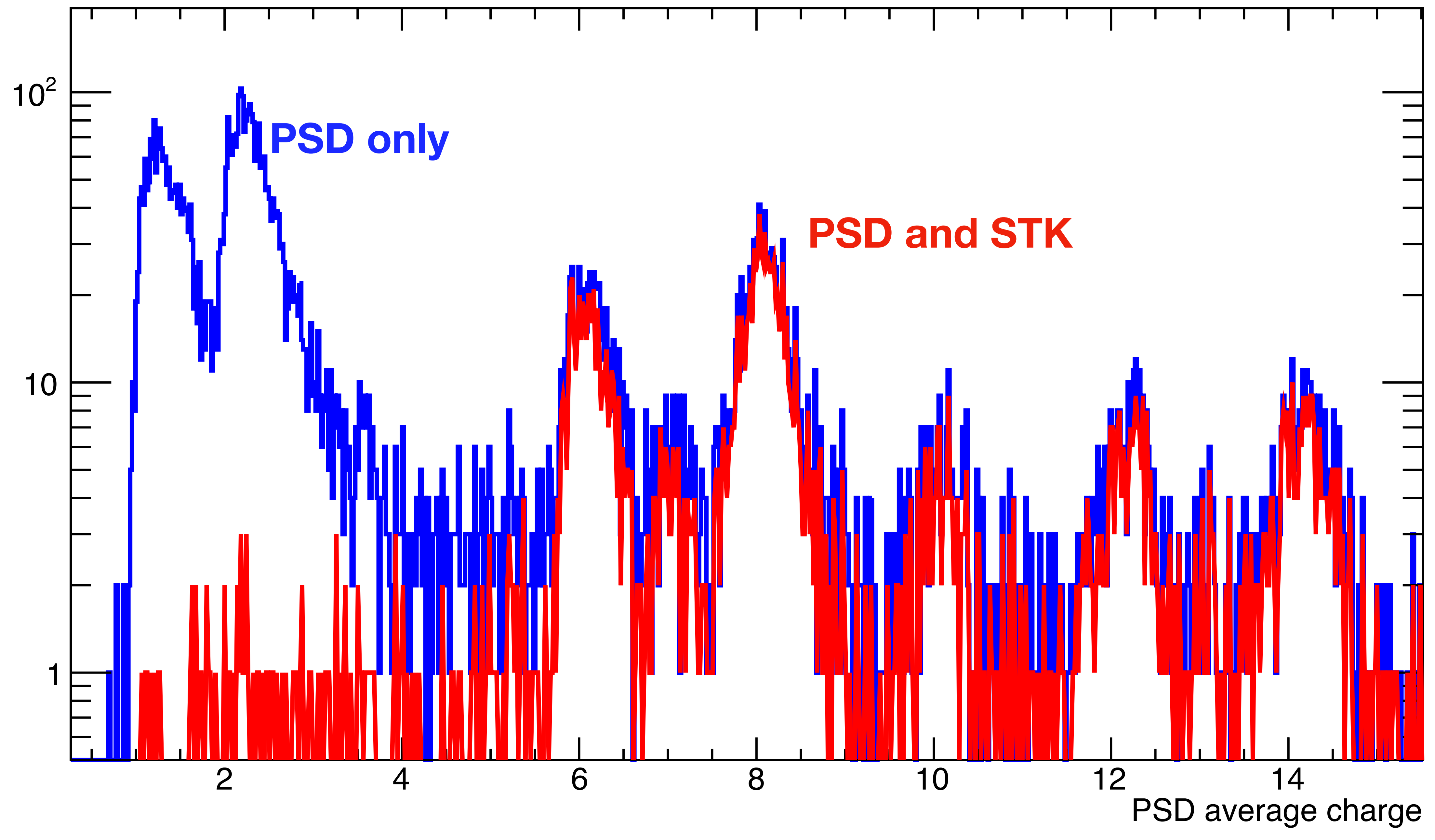


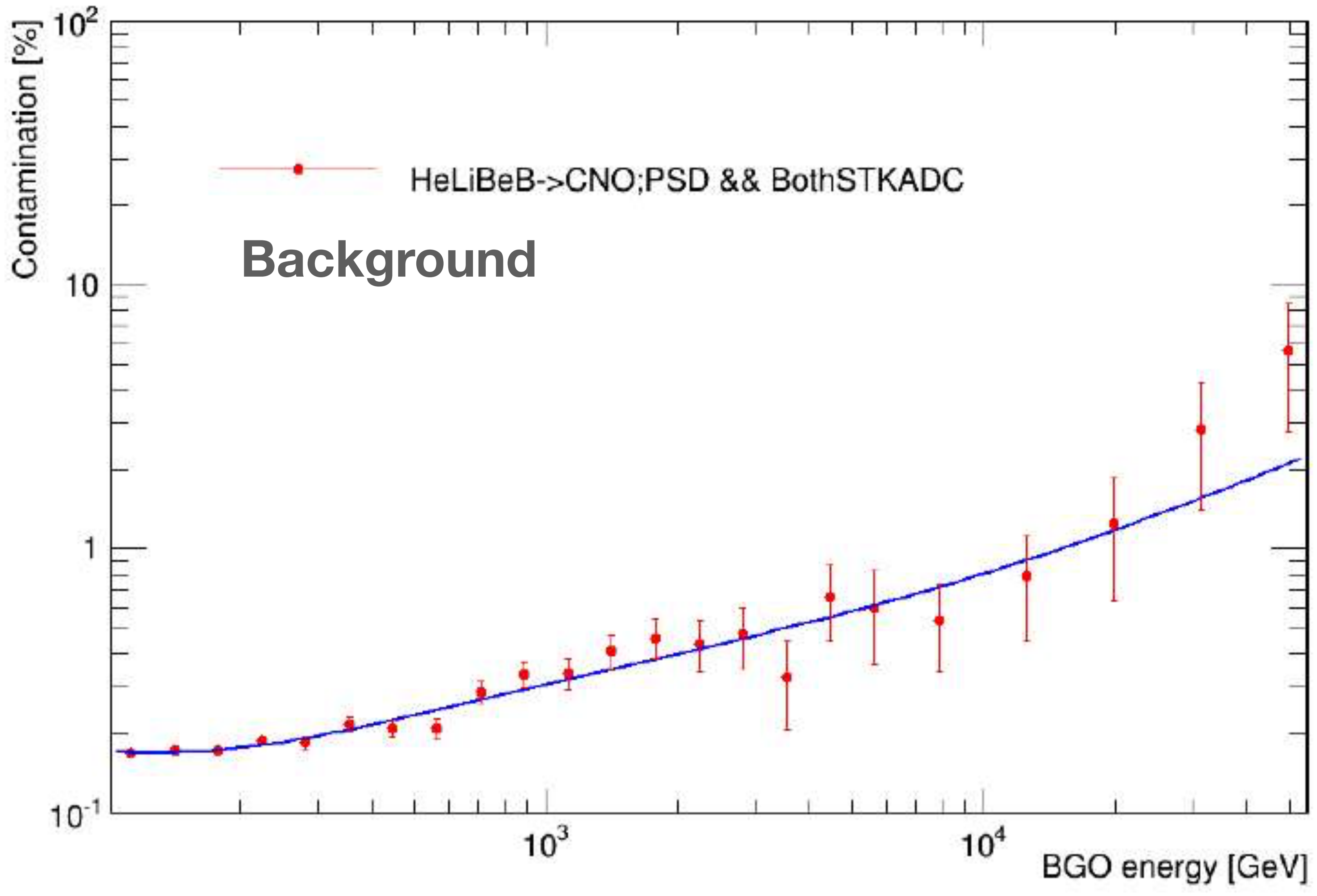
We have used the flight data from Jan.1 2016 to Dec. 31 20223.

1. MC data sets include C12, N14, N15 and O16, maximum energy can be as high as 3PeV.
2. There are also Li, Be and B MC samples available for background estimation.
3. All MC data sets are available for both Geant4 and Fluka-based geometry, hadronic models used include FTFP_BERT, EPOS_LHC in case of Geant4, DPMJET is used in the latter case.
4. We also have beam test data from CERN taken before launch.

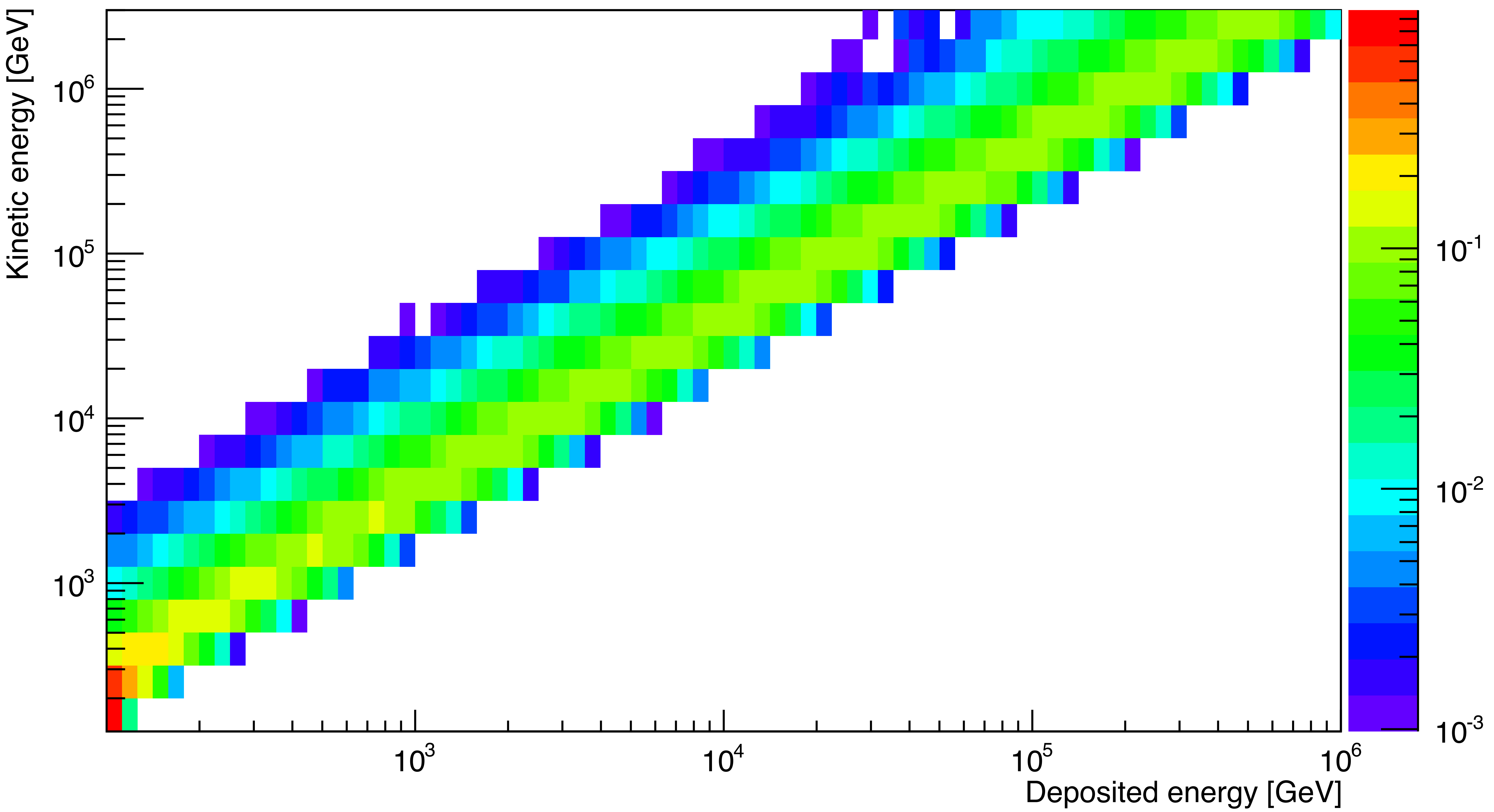
Relative abundance after pre-selection

PSD Charge distribution at 3TeV inside of BGO





How we obtain the flux as function of kinetic energy?



- Bayesian unfolding is applied to obtain the primary flux (G. D'Agostini et al. 1995; arXiv:1105.1160)
- Smoothing is applied during iteration to control the statistical fluctuations.
- 1000 times Possion sampling are used to figure out the uncertainty from unfolding process.

Uncertainties during data processing

✓Track

$$Eff_{STK\ track} = \frac{N_{STK\ track\ \&\&\ BGO\ track}}{N_{BGO\ track}}$$

✓Trigger (HET)

$$Eff_{HET} = \frac{N_{HET\ \&\&\ LET}}{N_{LET}}$$

✓Charge efficiency

$$Eff_{STKY} = \frac{N_{PSD\ \&\&\ STKX\ \&\&\ STKY}}{N_{PSD\ \&\&\ STKX}}$$

$$Eff_{STKX} = \frac{N_{PSD\ \&\&\ STKY\ \&\&\ STKX}}{N_{PSD\ \&\&\ STKY}}$$

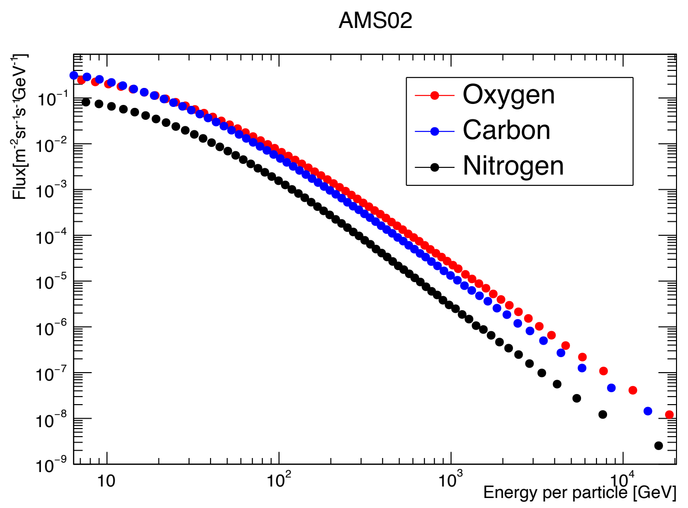
$$Eff_{PSDX} = \frac{N_{PSDX\ \&\&\ PSDY\ \&\&\ STK}}{N_{PSDY\ \&\&\ STK}}$$

$$Eff_{PSDY} = \frac{N_{PSDY\ \&\&\ PSDX\ \&\&\ STK}}{N_{PSDX\ \&\&\ STK}}$$

✓Mixture ratio C:N:O

A. Template from AMS-02 measurements

B. 1:1:1



✓Weighting factor[-3.0, -2.3]

Our MC data is generated with a power law index at -1.

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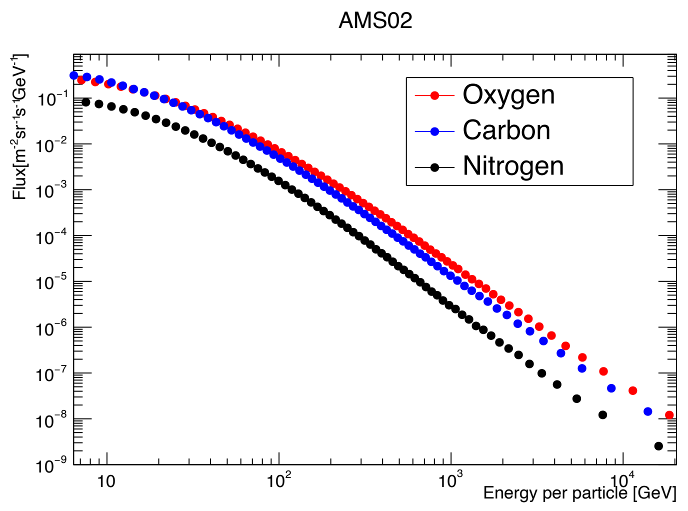
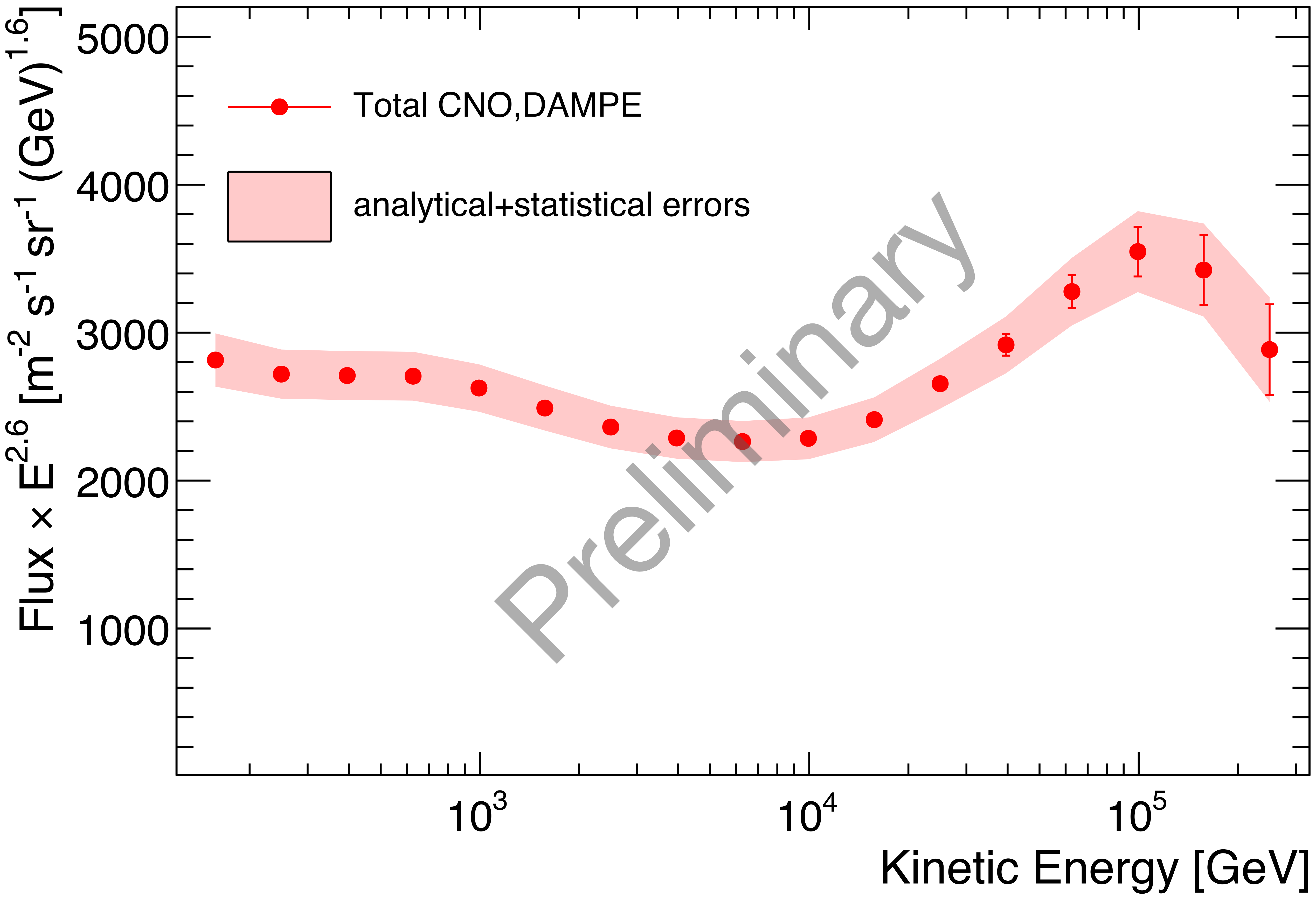


✓Weighting factor[-3.0, -2.3]

Our MC data is generated with a power law index at -1.

- Total analytical uncertainty is 6.1% over energies by adding all above items together quadratically.

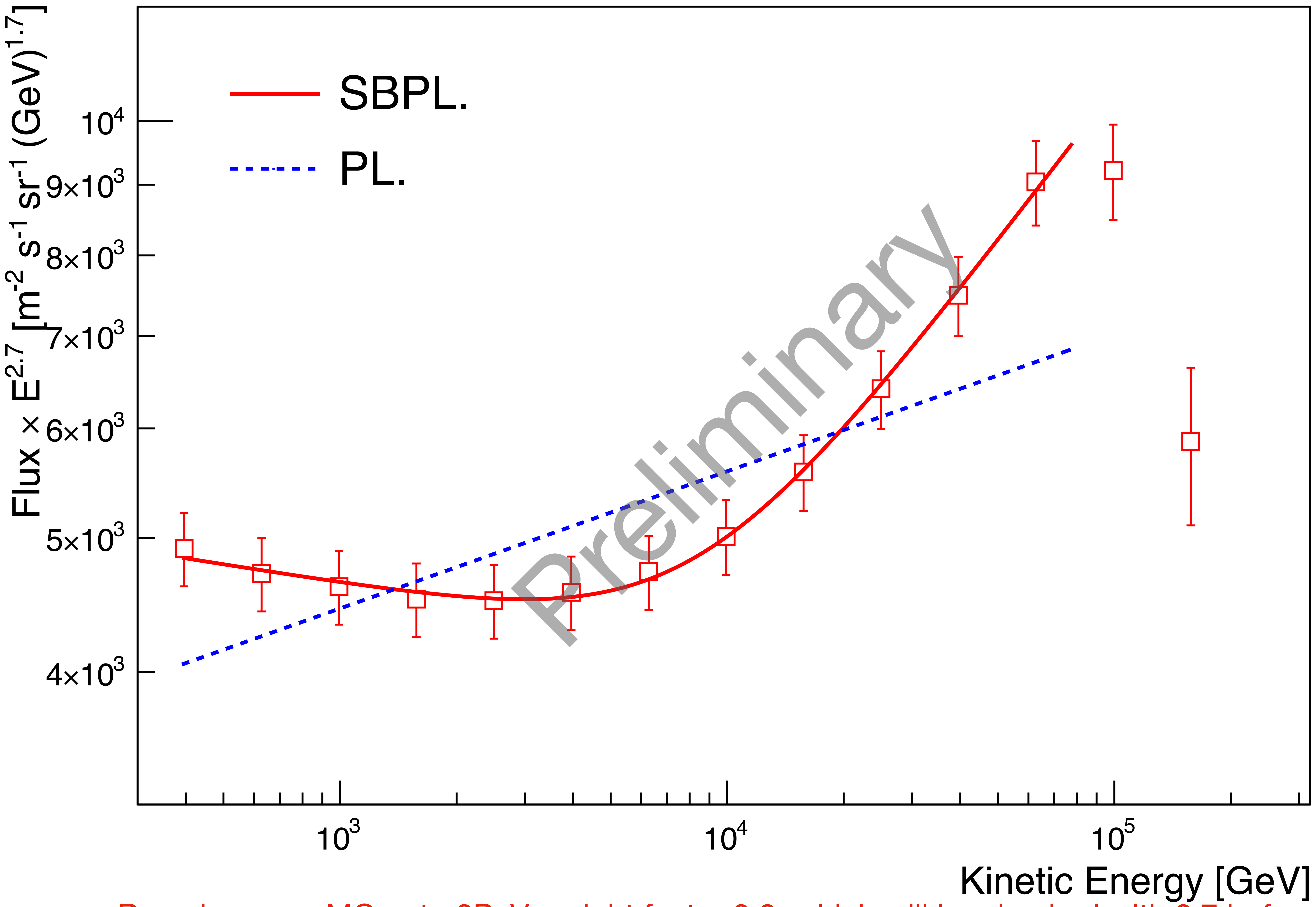
CNO spectrum from 0.1TeV to 316 TeV



Based on new MC upto 3PeV, weight factor 3.0, which will be checked with 2.7 before the Cospar meeting

- We also conducted other data processing for this measurement, all results show great consistence within this shaded band here.

Hardening @ ~8TeV



Based on new MC upto 3PeV, weight factor 3.0, which will be checked with 2.7 before the Cospar meeting

Summary

- Thanks to the large acceptance and long-term smooth operation of DAMPE, we can measure the CNO combined spectrum more than 100TeV.
- Hardening at 8TeV is observed in this group, which confirms again the hardening break reported by previous measurements.
- Our data shows the softening hint around 100TeV, which could be studied forwardly.