# Analysis of Individual p and He Cosmic-Ray Fluxes towards PeV energies with DAMPE

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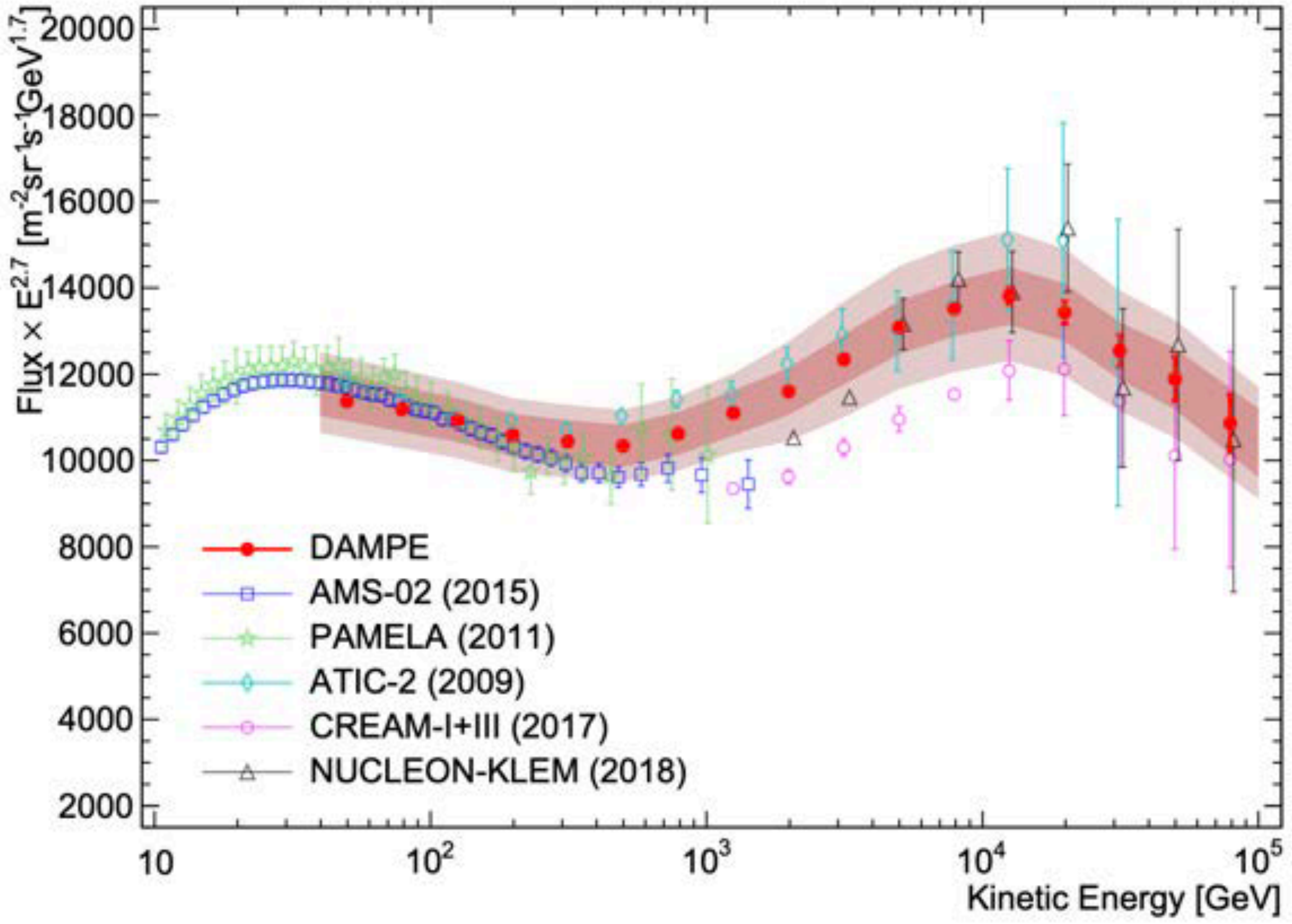
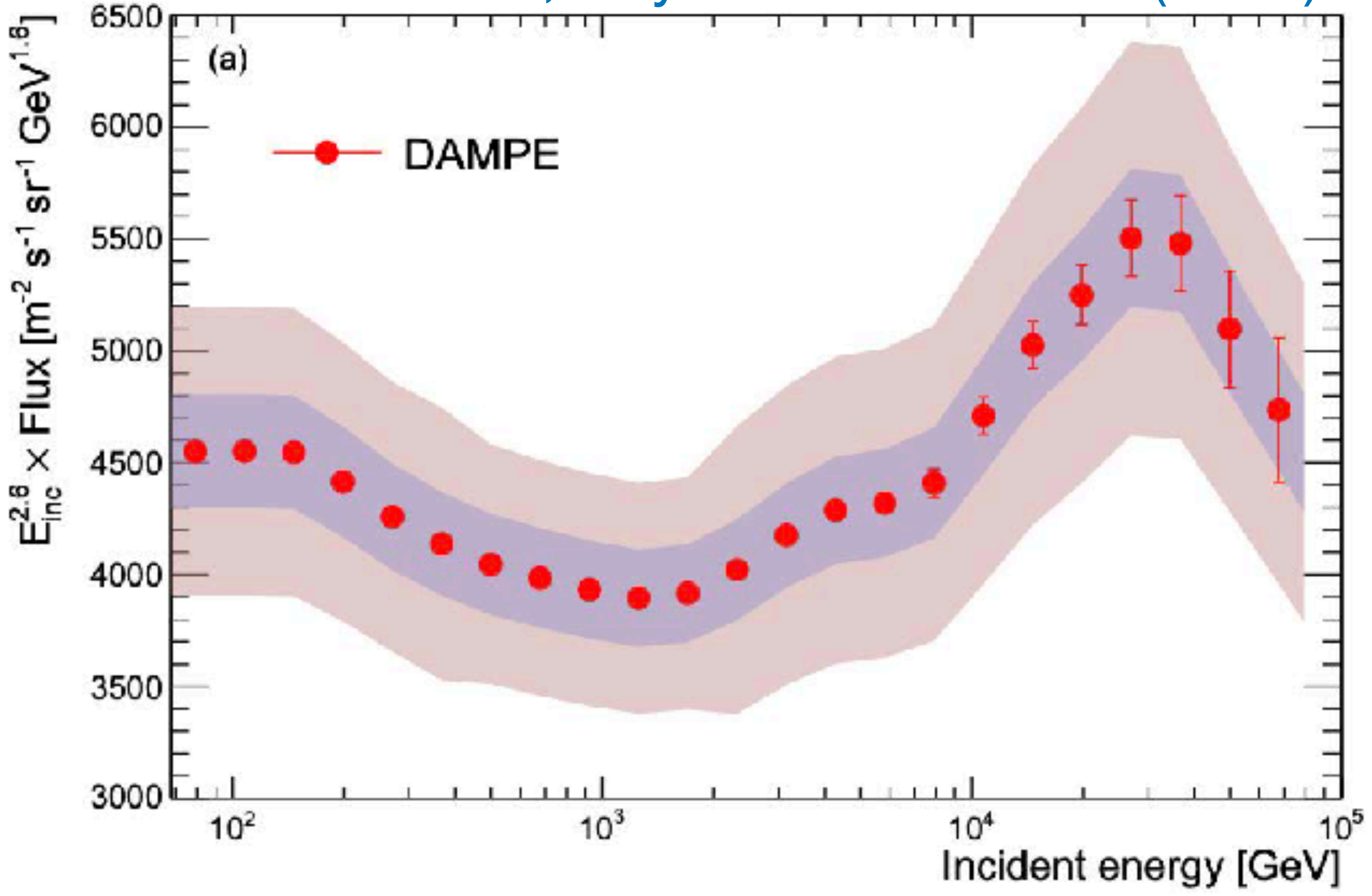
# Motivation

- Two lightest and the most abundant elements in CRs
- Previous direct measurements up to several TeV - spectral features observed, large uncertainties
- Particle ID challenging above ~100 TeV, explore new methods incl. machine learning (ML)

DAMPE proton flux: Q. An et al., Sc. Adv. 5 (2019)

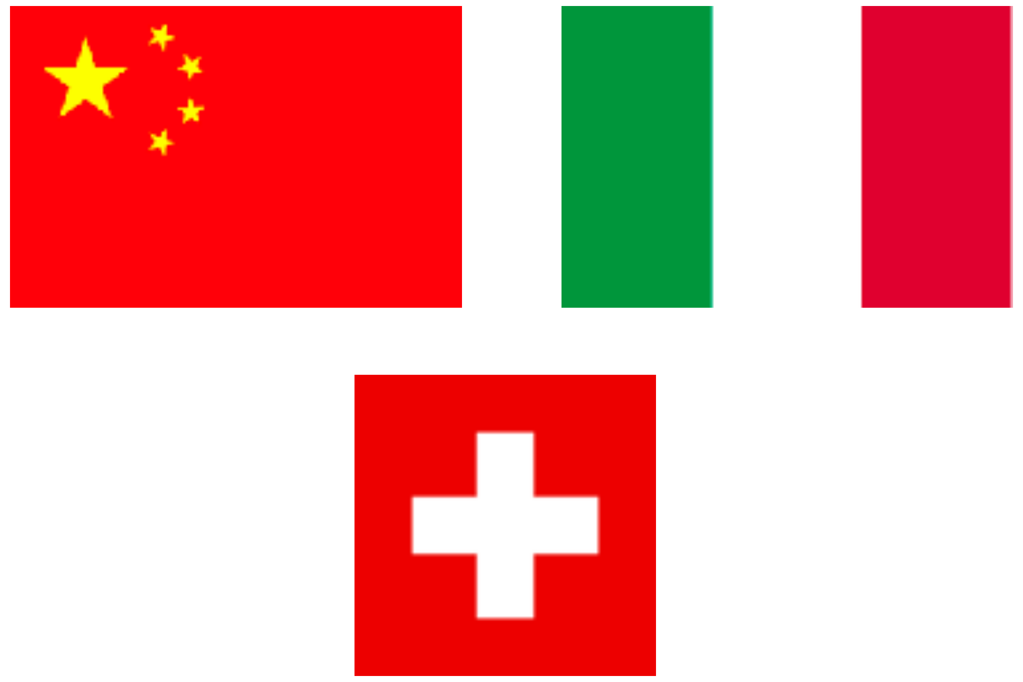


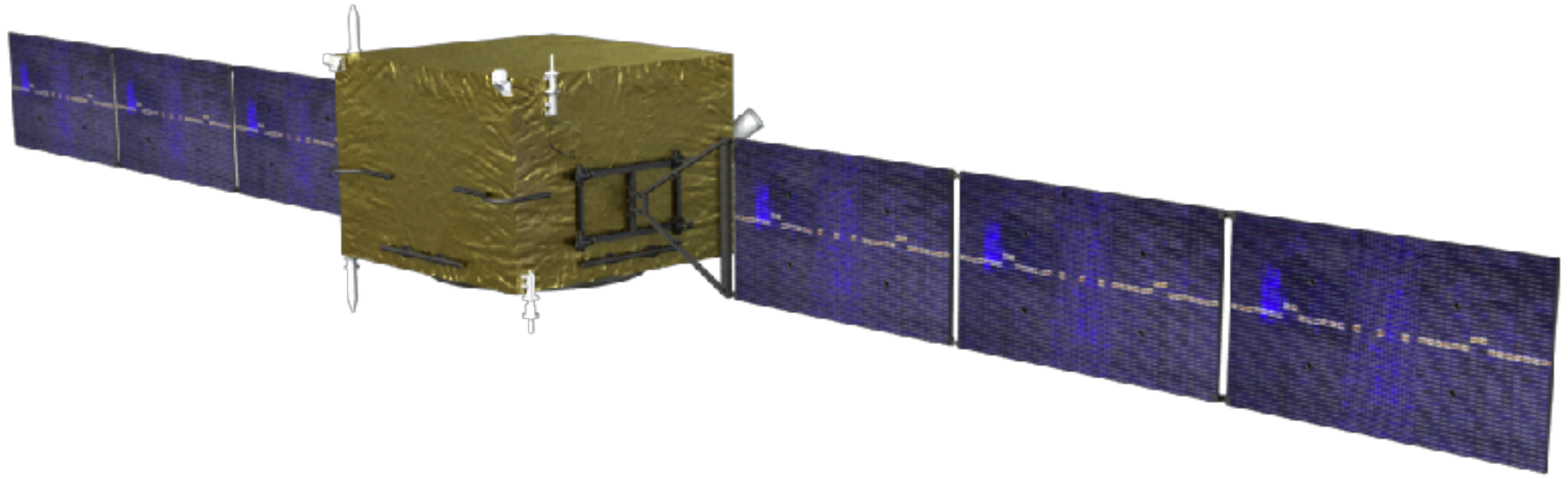

DAMPE He flux:
F. Alemanno et al., Phys. Rev. Lett. 126 (2021)



# DArk Matter Particle Explorer (DAMPE)

- International collaboration between institutes in China, Italy and Switzerland
- Launched in December, 2015 from the Jiuquan Satellite Launch Center in China
- Main scientific goals:
  - Measurements of high energy spectra of electrons and gamma rays
  - Studying cosmic ray composition and spectrum
  - Indirect dark matter probing
- Orbit:
  - sun-synchronous
  - altitude: 500km
  - period: 95 min
  - inclination: 97.4°





# Detector system

**Plastic Scintillator Detector (PSD):**

- 82 plastic scintillator bars arranged in 2 double-layer planes

**Silicon-Tungsten Tracker (STK):**

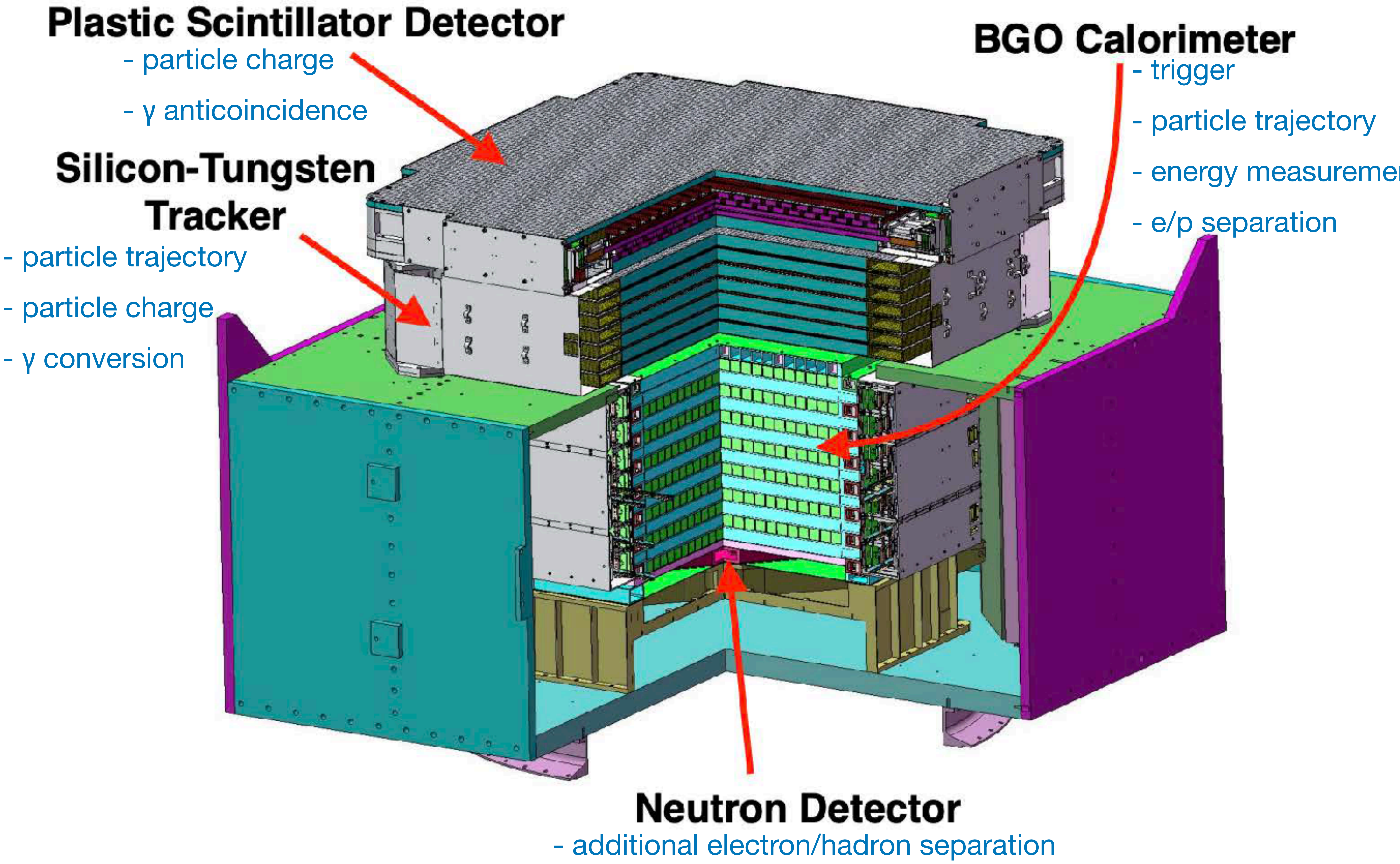
- 6 double-layers with <80 μm resolution
- 3 tungsten conversion plates

**BGO calorimeter:**

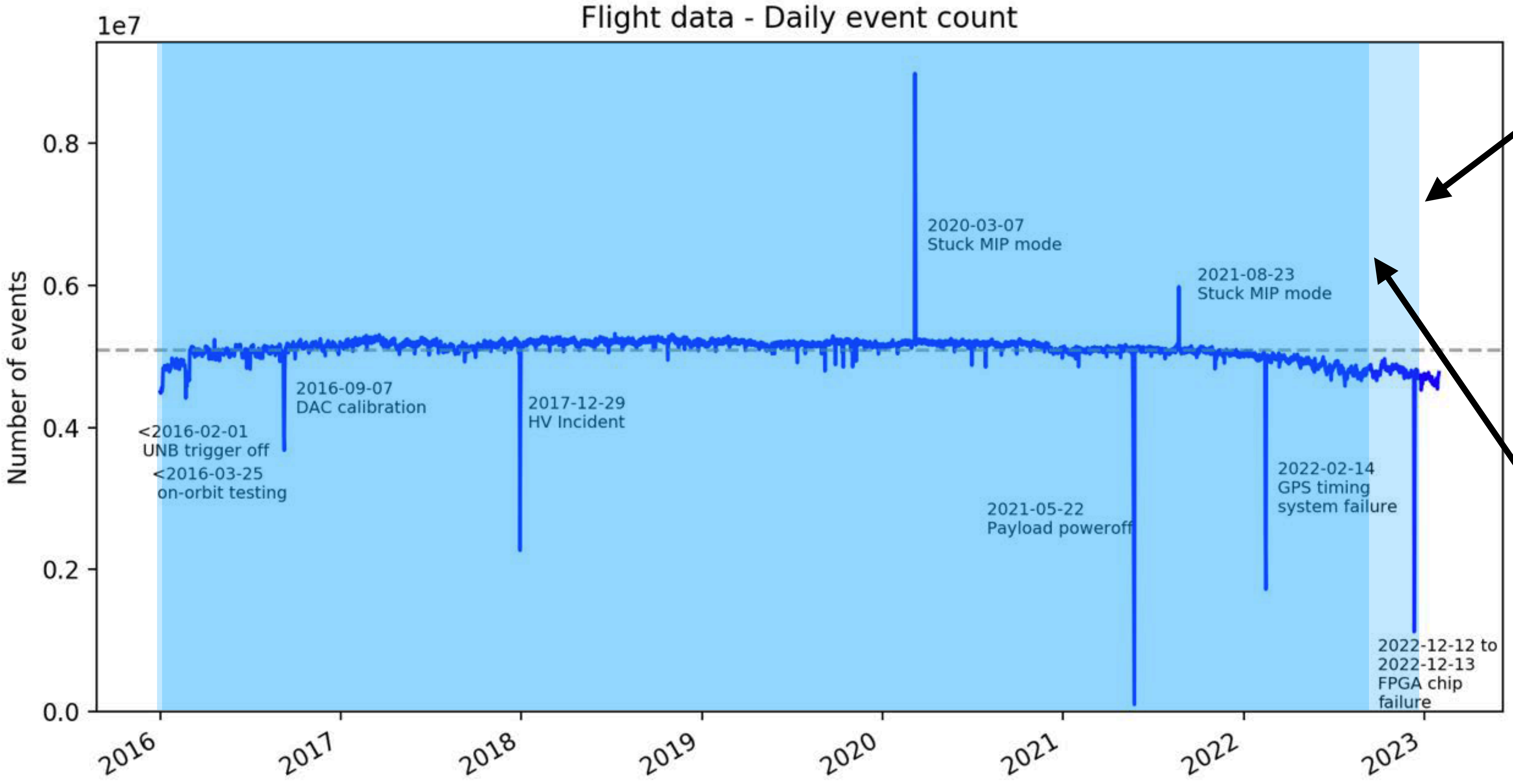
- 14 layers 22 bars each arranged hodoscopically
- 32 radiation lengths, 1.7 interaction lengths

**Neutron Detector (NUD):**

- 16 1 cm-thick boron-doped plastic scintillator plates



# Flight Data and Livetime




p analysis:

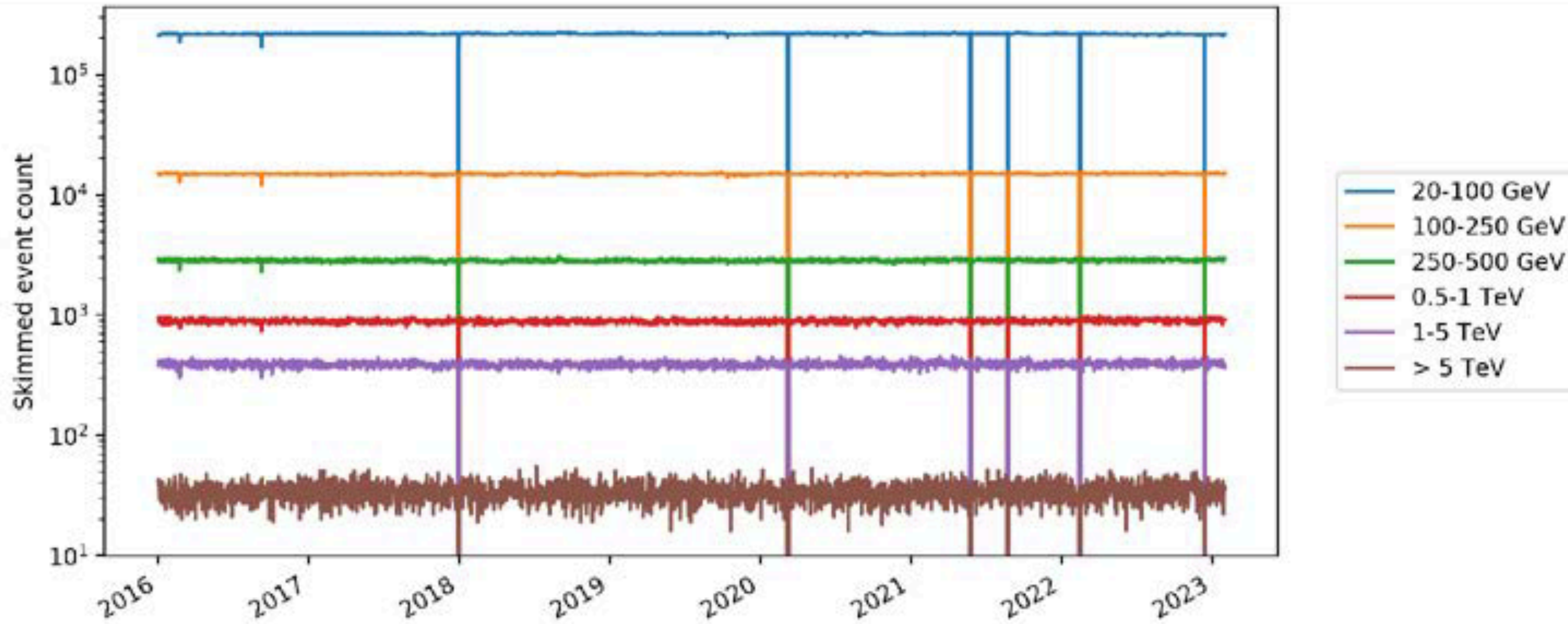
- 84 months of data
- ~13 billion events
- livetime ~ 1.63 x $10^8$ s

He analysis:

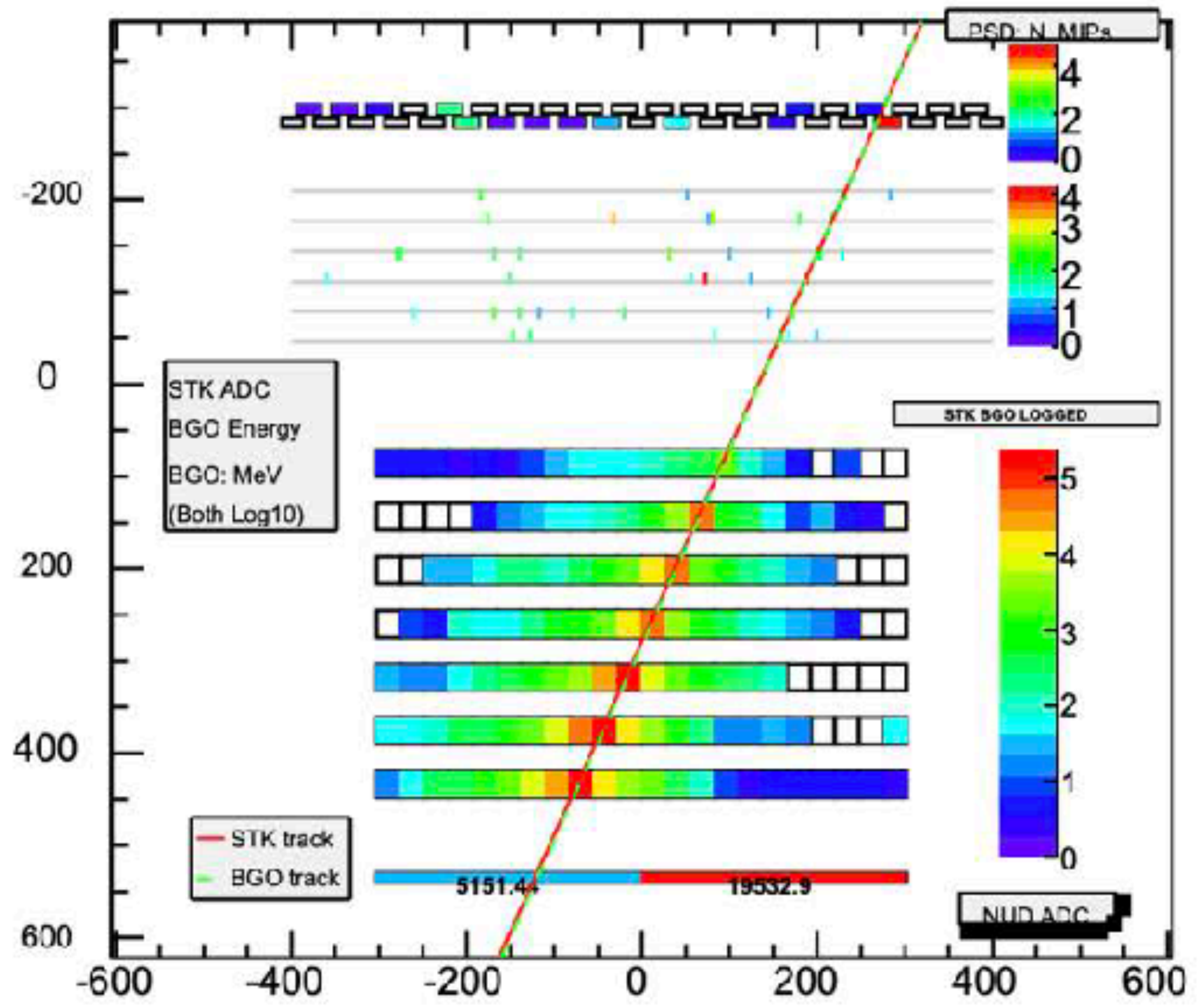
- 81 months of data
- ~12.6 billion events
- livetime ~ 1.58 x $10^8$ s

# Event selection

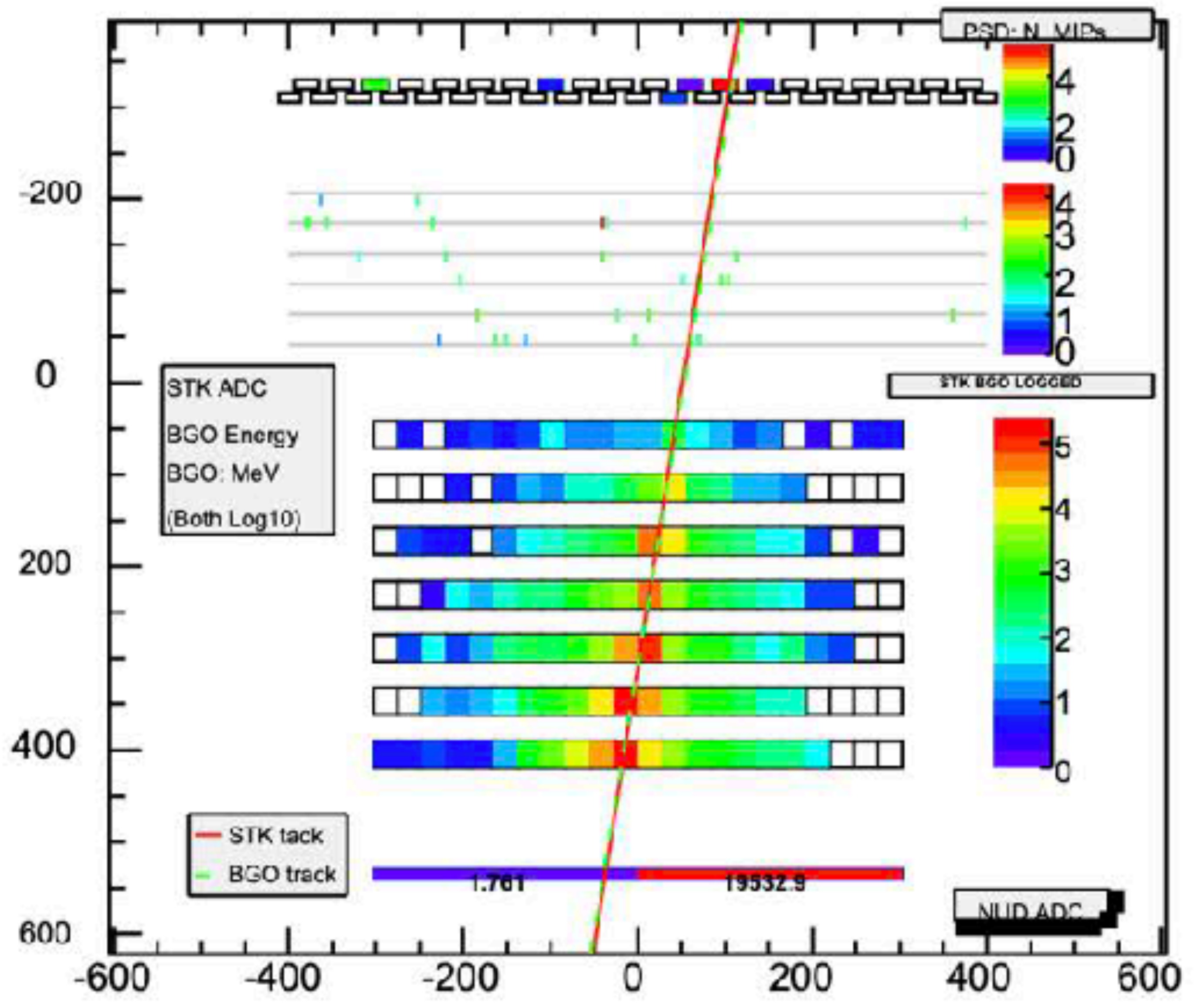
- Skim: ensuring well-reconstructed and fully-contained events
- Electron removal
- BGO fiducial containment of a track reconstructed using ML techniques*
- Ensuring PSD charge measurement
- Reconstructed charge selection




XOZ view [1848.225 GeV]




YOZ view [1848.225 GeV]




*: A. Tykhonov et al., Astropart. Phys. 146 (2023) 102795)

# Charge separation

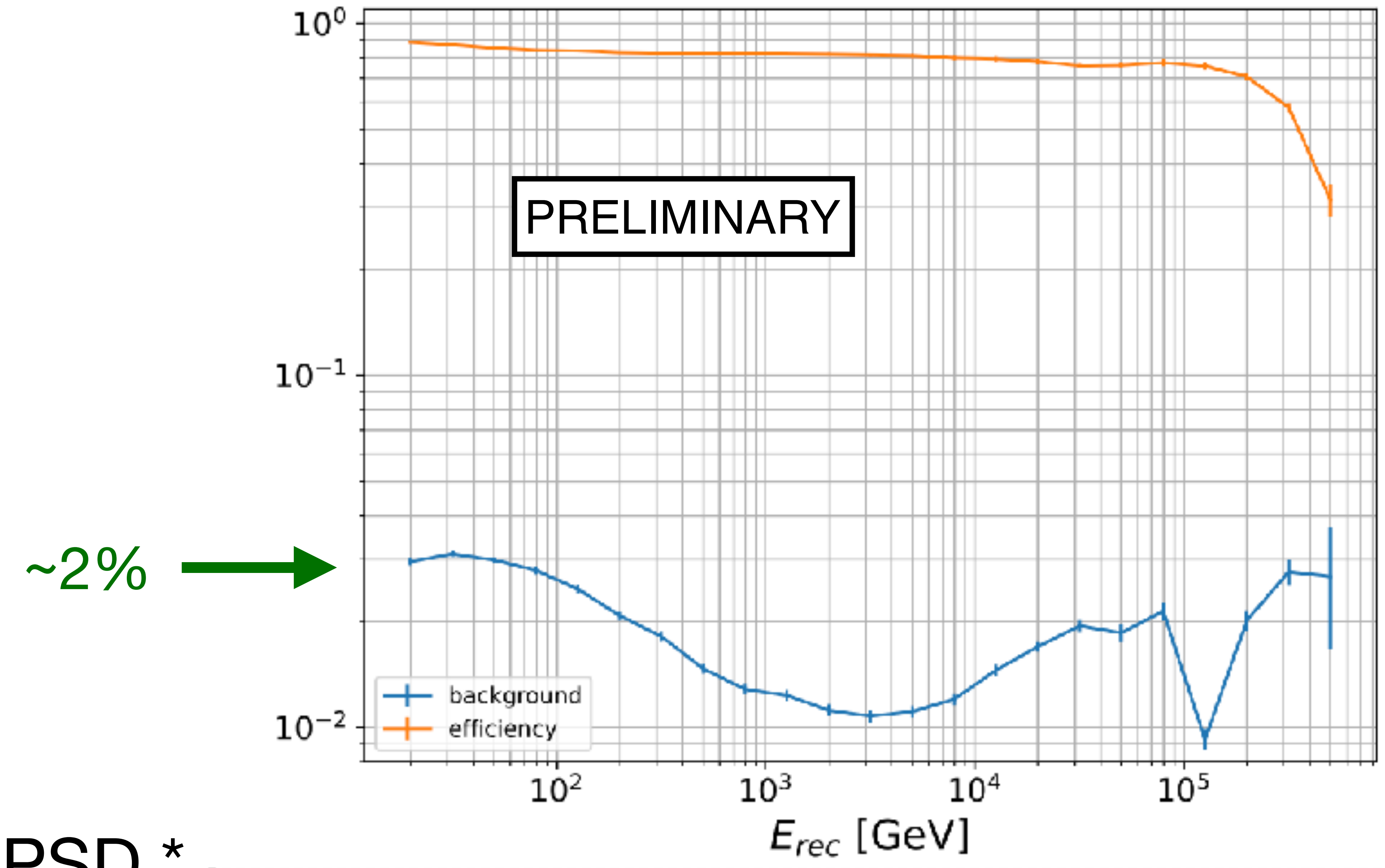
## Proton analysis

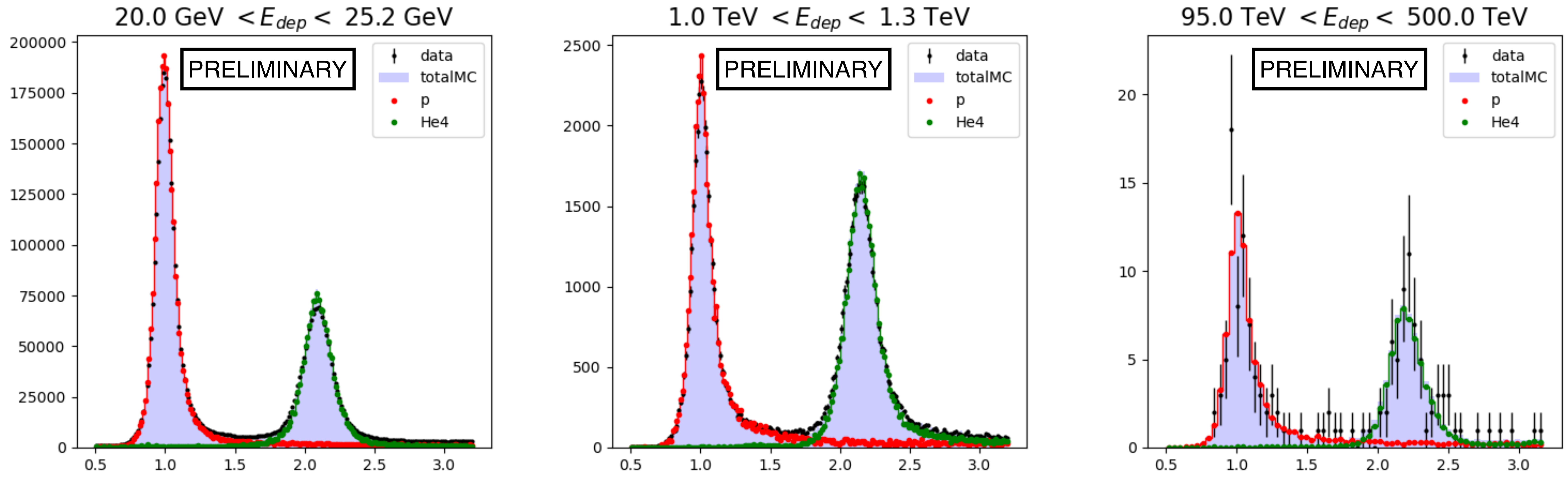
Charge value is defined using:

- STK for “good” vertex events
- PSD for “bad” vertex events

where vertex is a probability that inelastic interaction after PSD *

*: A. Tykhonov et al., Astropart. Phys. 146 (2023) 102795)



# Charge separation

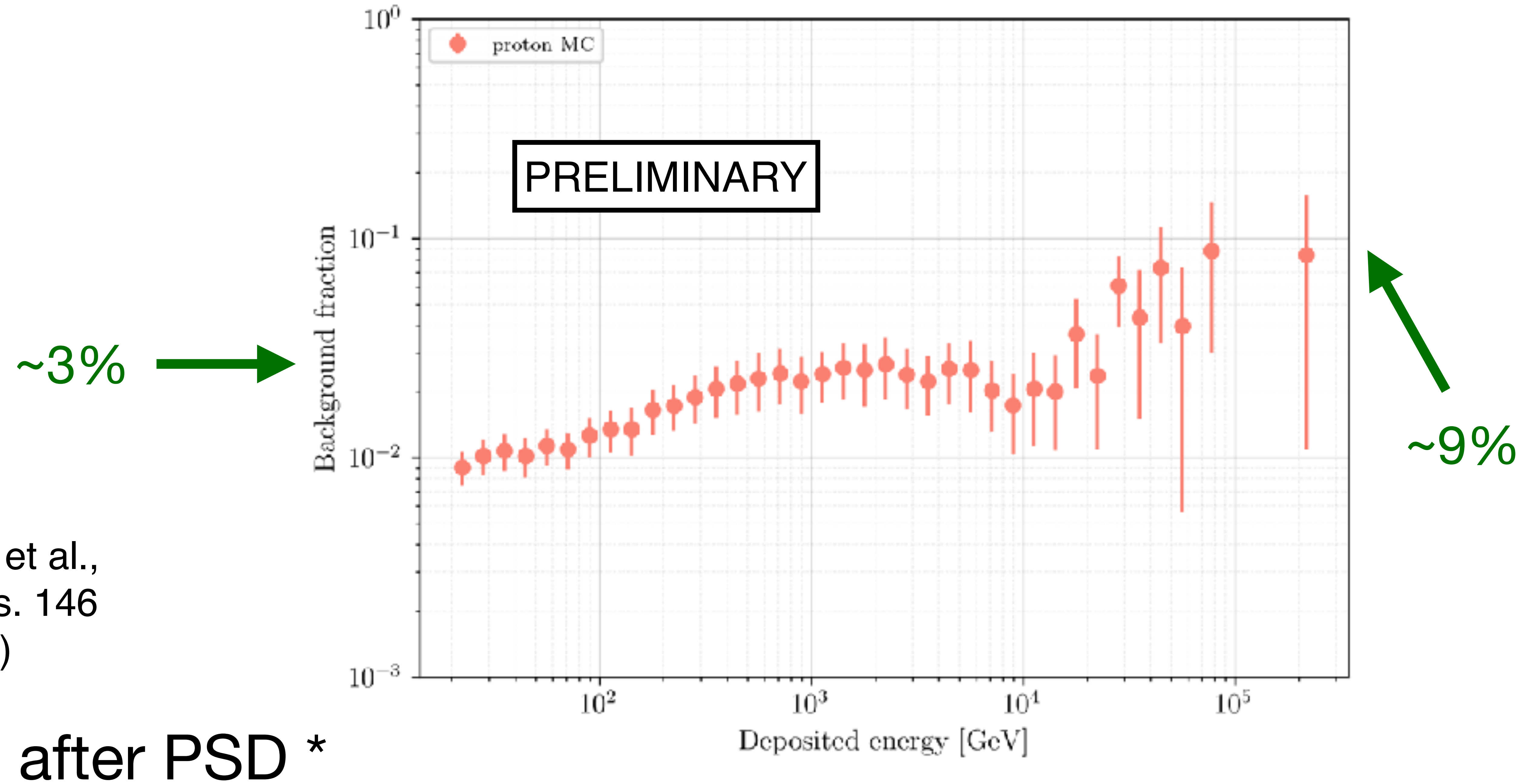
## He analysis

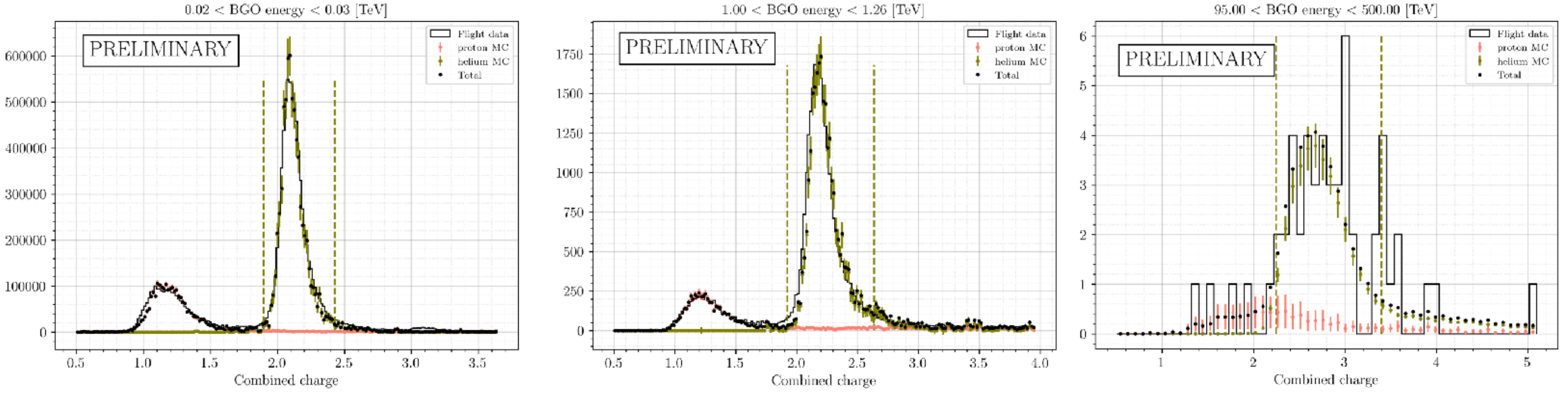
Charge value is defined using:

- STK and PSD for "good" vertex events
- PSD for "bad" vertex events

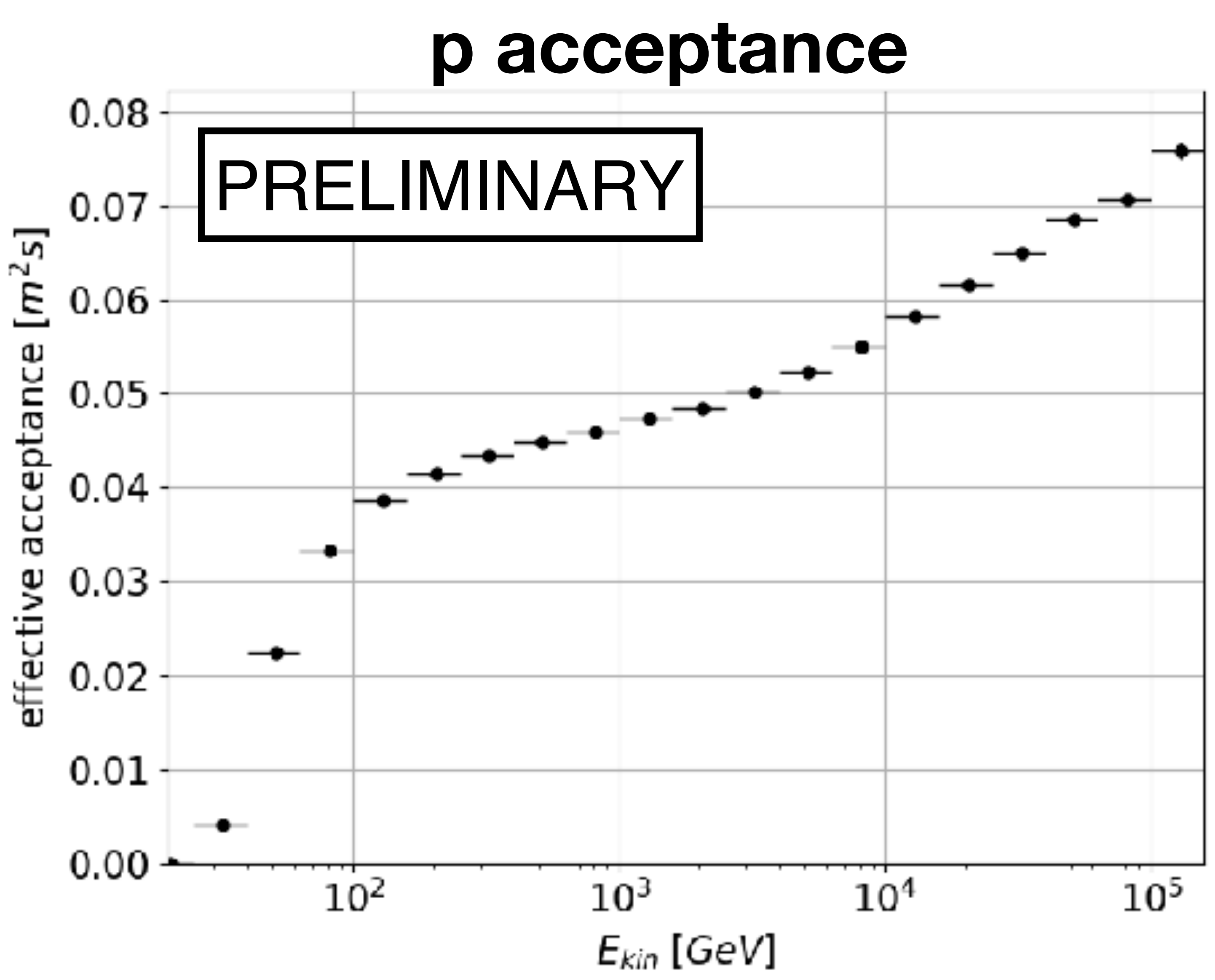
where vertex is a probability that inelastic interaction after PSD *

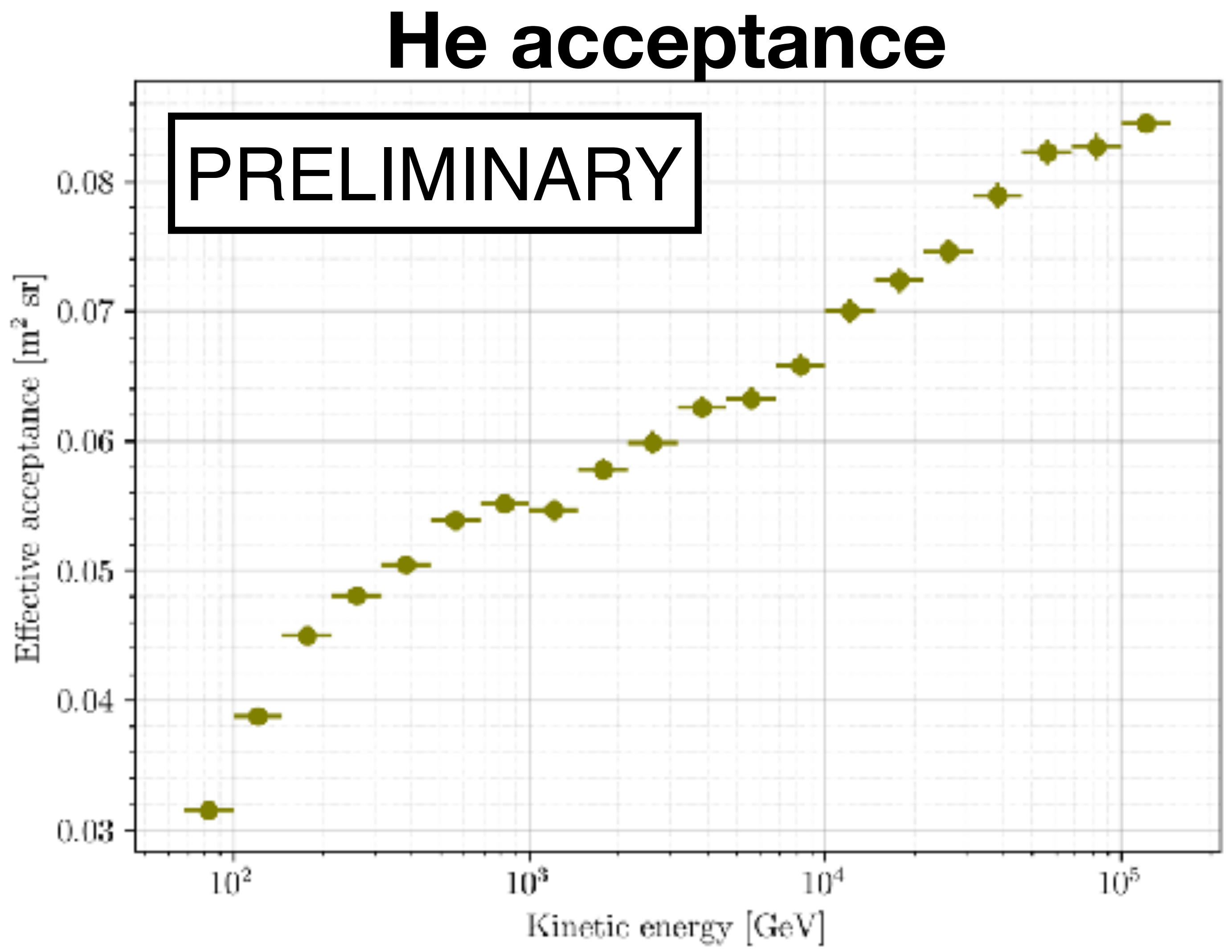
*: A. Tykhonov et al., Astropart. Phys. 146 (2023) 102795)

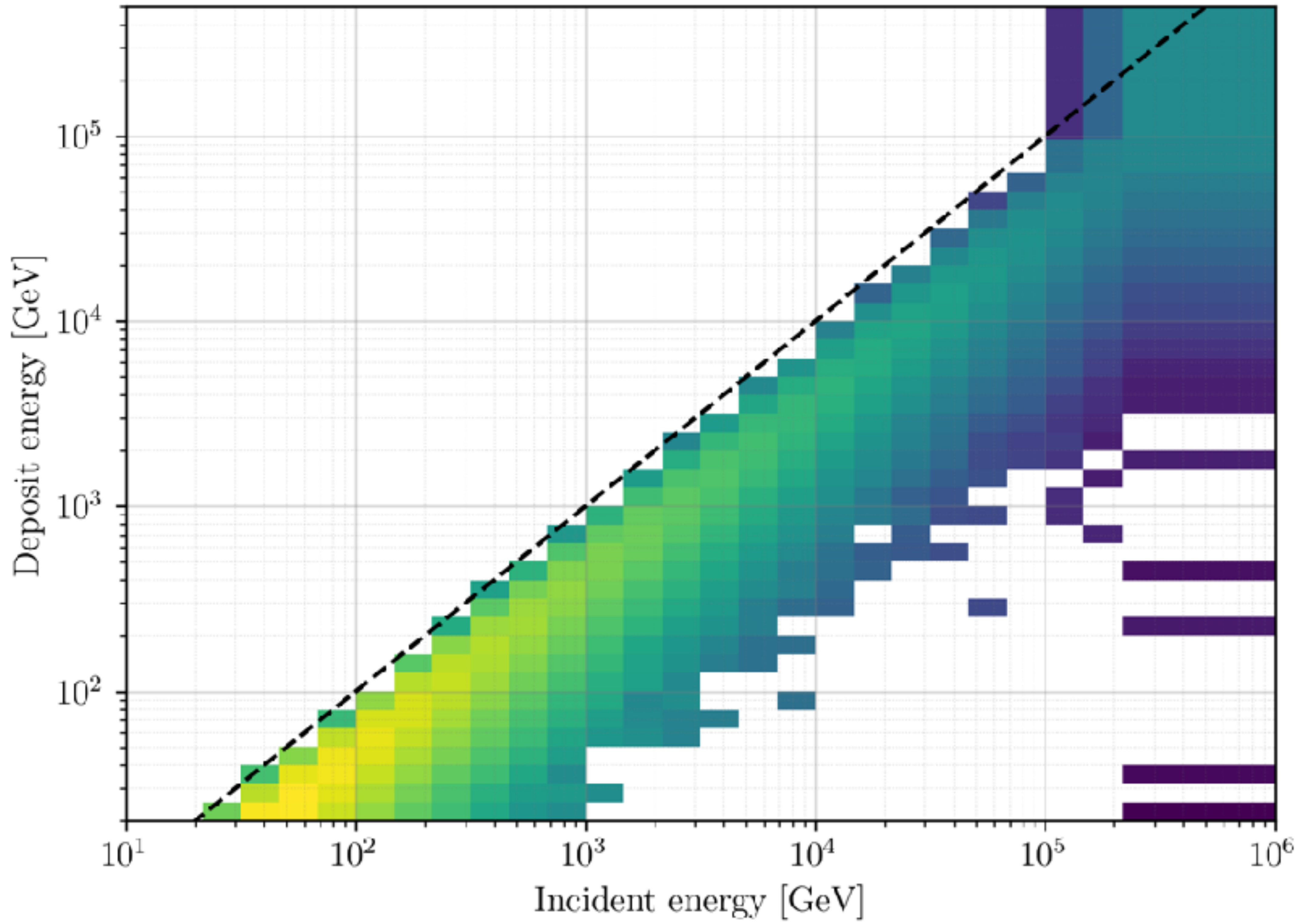


# Acceptances and unfolding



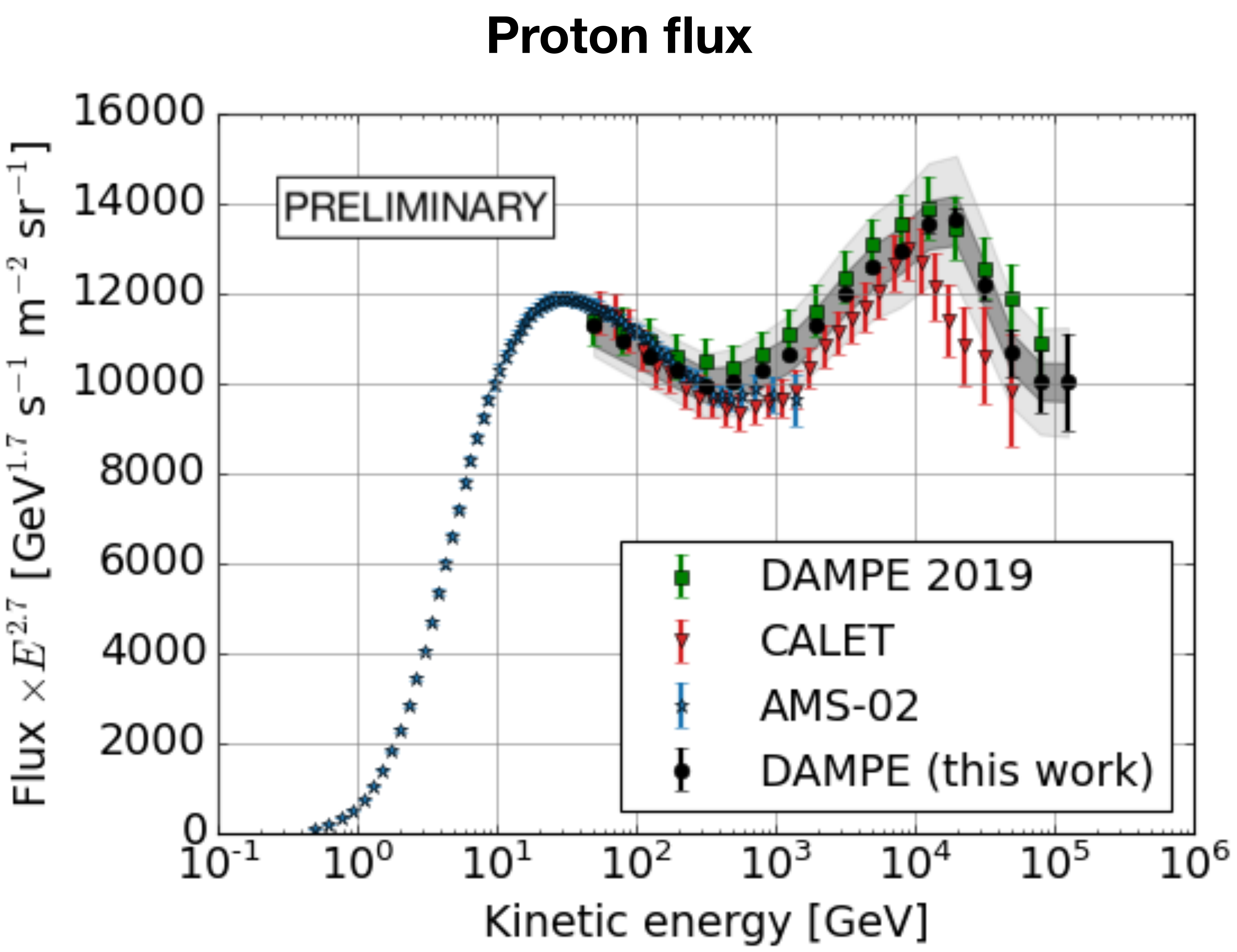



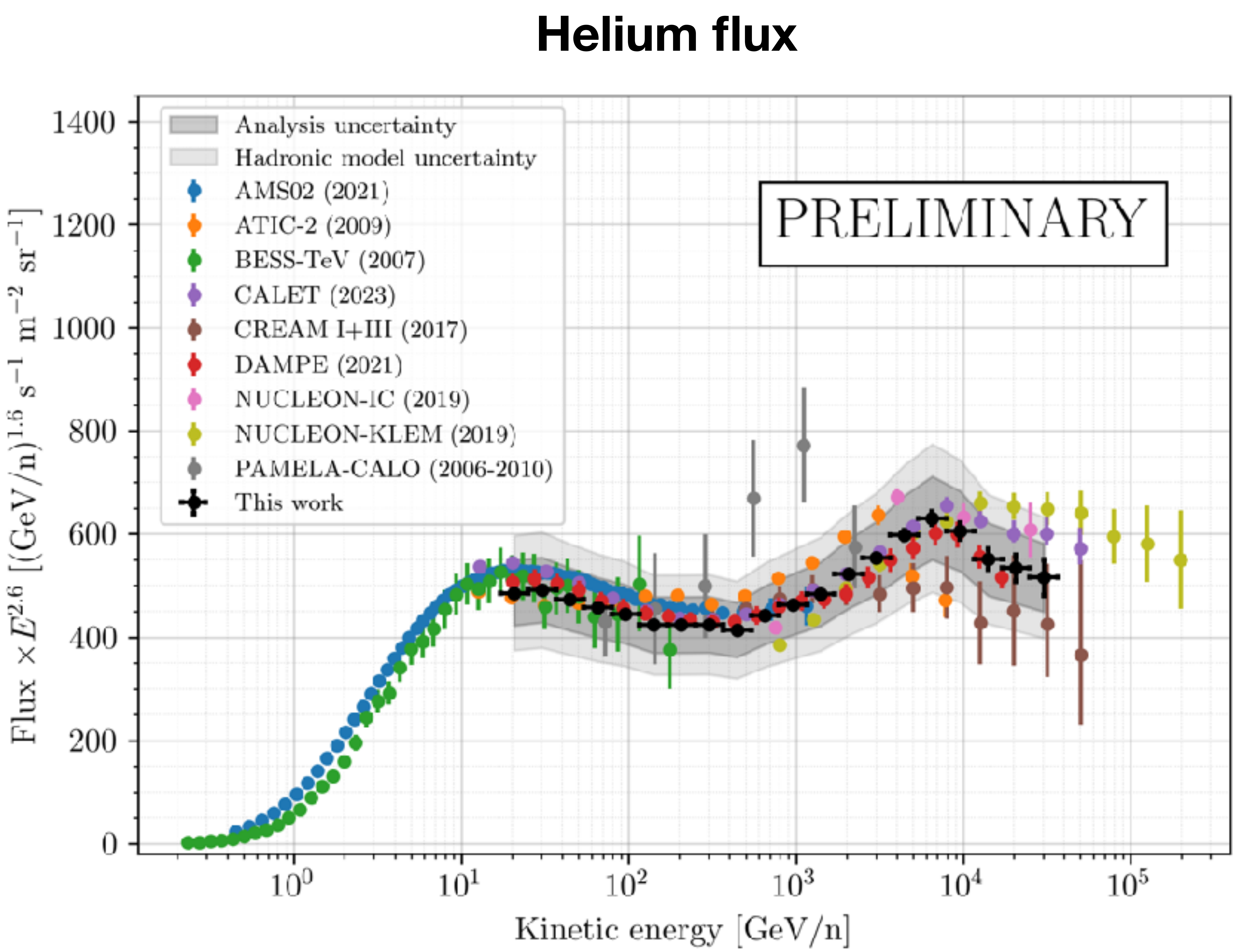




Statistical unfolding based on Bayes formula:

$$P(E_{\mathrm{true},j}|E_{\mathrm{meas},i}) = \frac{P(E_{\mathrm{meas},i}|E_{\mathrm{true},j})\,P(E_{\mathrm{true},j})}{\sum_k P(E_{\mathrm{meas},i}|E_{\mathrm{true},k})\,P(E_{\mathrm{true},k})}$$

# Preliminary results




- Good agreement with previous DAMPE results
- Statistical uncertainties change from ~0.05% at 100GeV to ~7% at 100TeV
- Systematic uncertainties without hadronic systematics are below 10%

# Summary

- Preliminary update of proton and helium fluxes
- ML-based method for particle track reconstruction developed and applied in the analysis
- Good agreement with previous DAMPE results based on classical methods
- Work in progress:
  - systematics uncertainties
  - reducing the effect of uncertainties from the simulations of hadronic interaction
  - extension of flux measurements to higher energies
  - Statistical analysis of the flux features