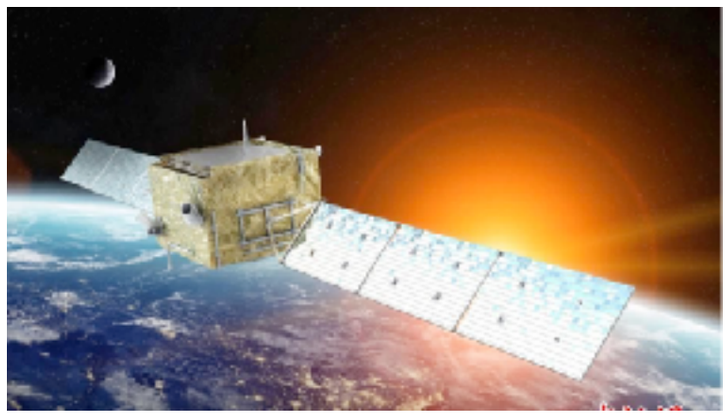
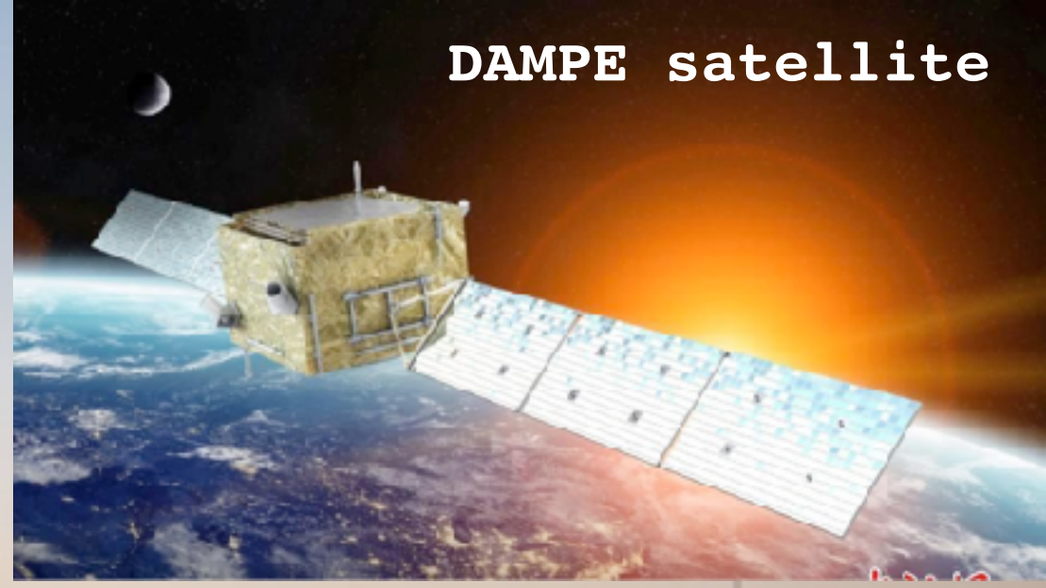
# First results from the DAMPE mission

Andrii Tykhonov *(for the DAMPE collaboration)*

UNIVERSITÉ DE GENÈVE



**ICHEP 2018, Seoul, Korea, July 7, 2018**




**DArk Matter Particle Explorer (DAMPE)**

Launched on Dec 17, 2015,
from the Jiuquan Satellite Launch Center,
Gobi desert, China.

Operates on a sun-synchronous
Sky-survey mode, permanently oriented to zenith

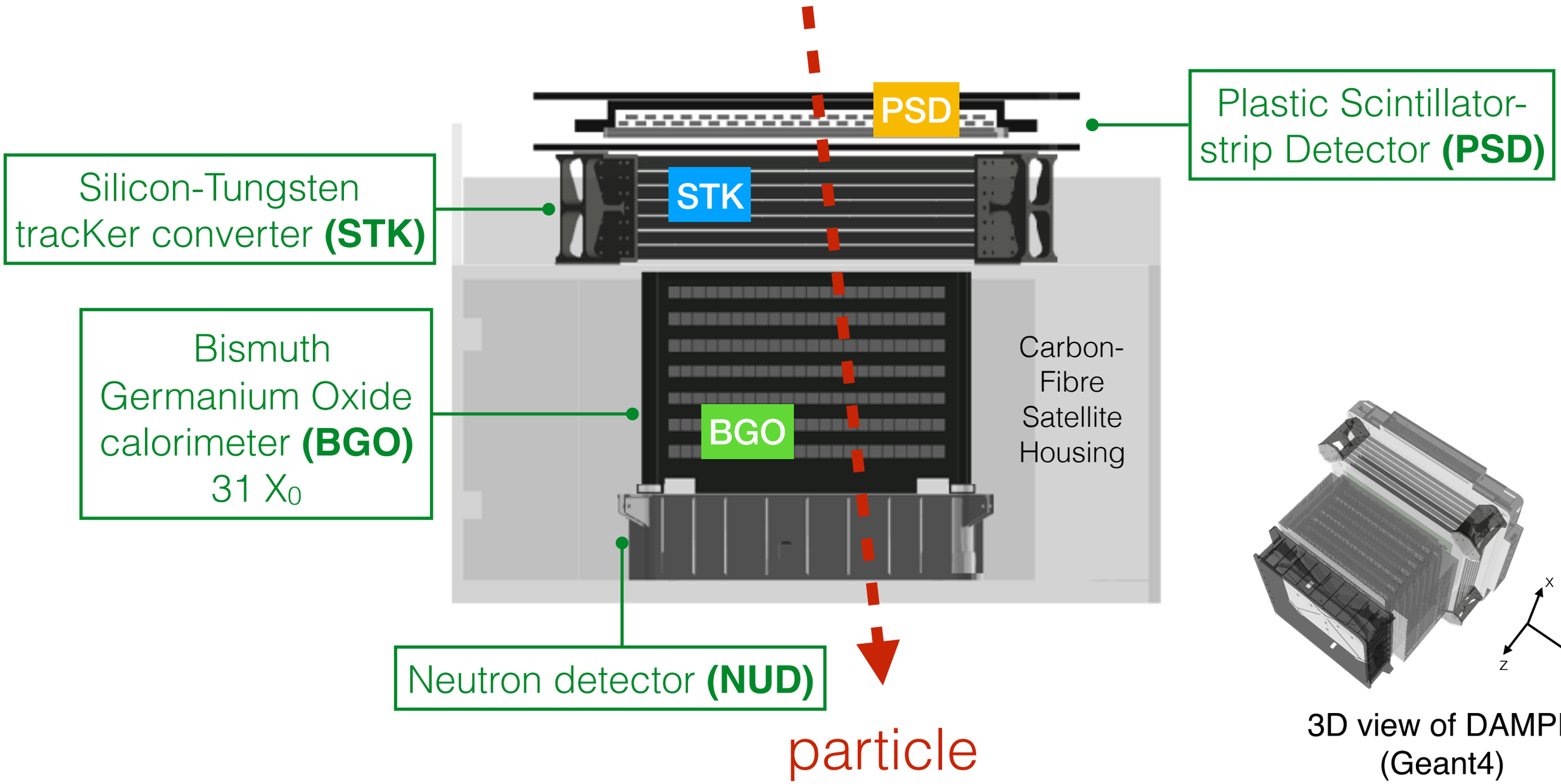
# DAMPE collaboration

- **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

- **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

# The detector







3D view of DAMPE (Geant4)

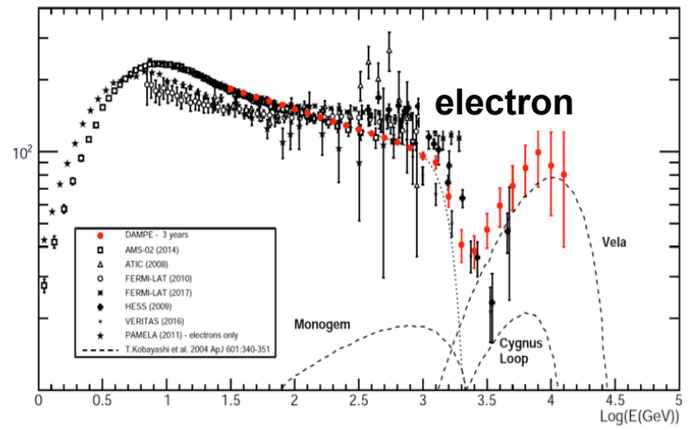
# Scientific Goals

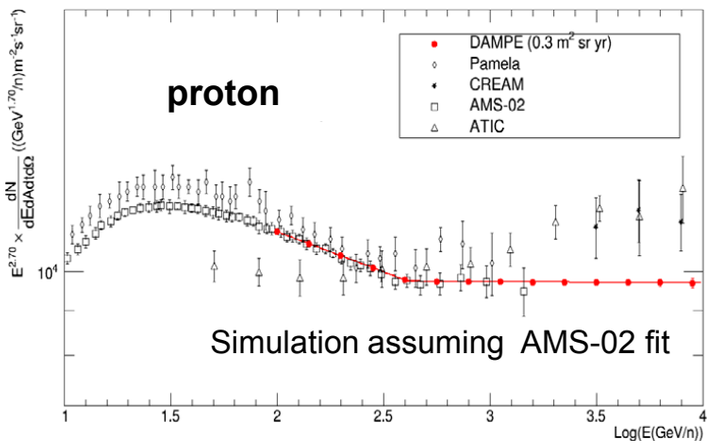
Detection of:

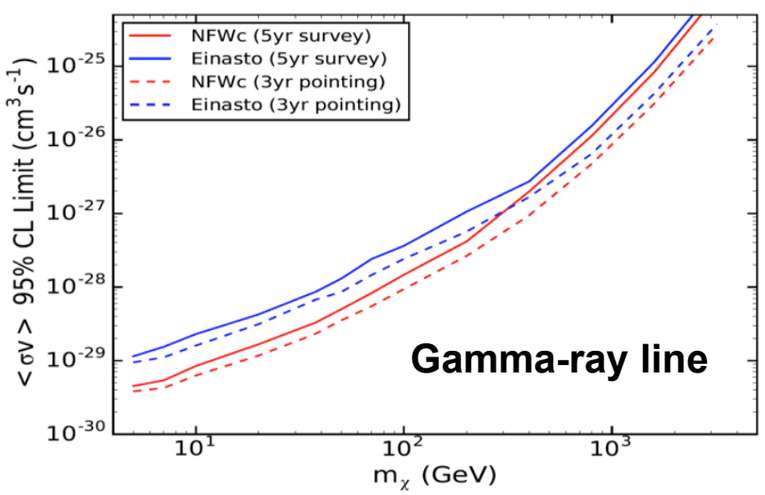
- e/γ @ 1GeV — 10 TeV
  (1% energy resolution)
- p/nuclei @ 50GeV — 500 TeV
- γ-rays

**Excellent energy resolution (1% for 100 GeV electrons), direction and particle identification capabilities.**

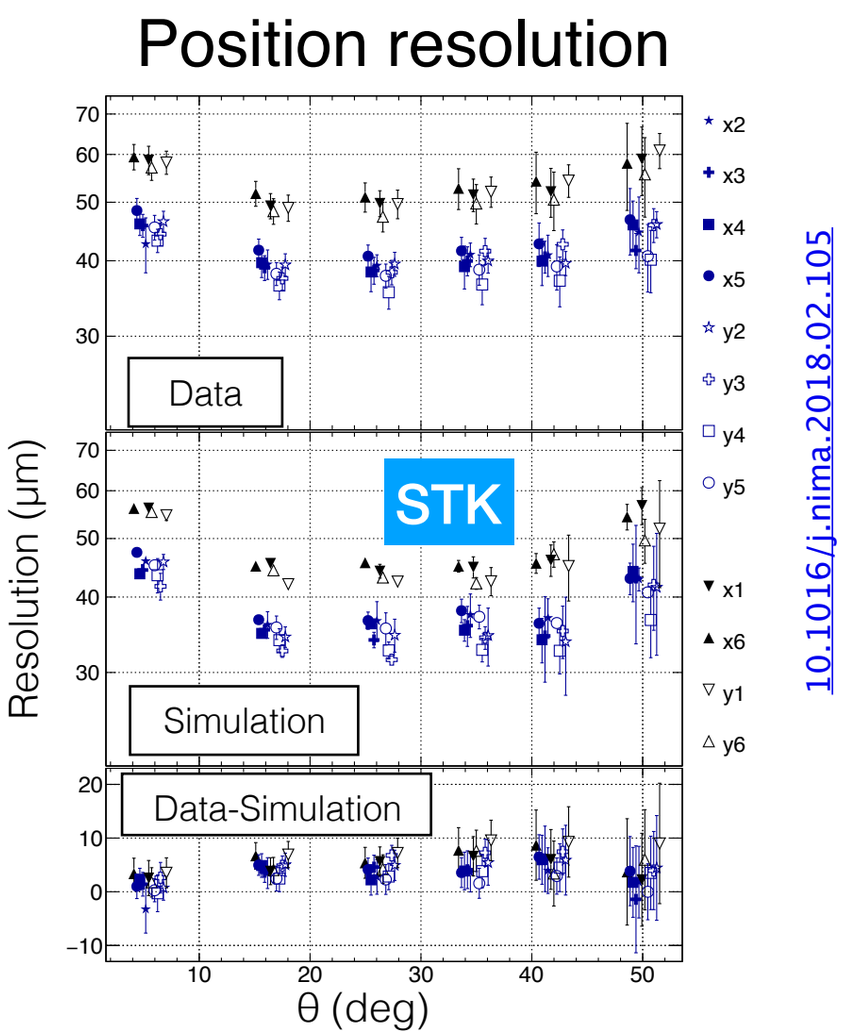
Search for Dark Matter annihilation/decay signatures.

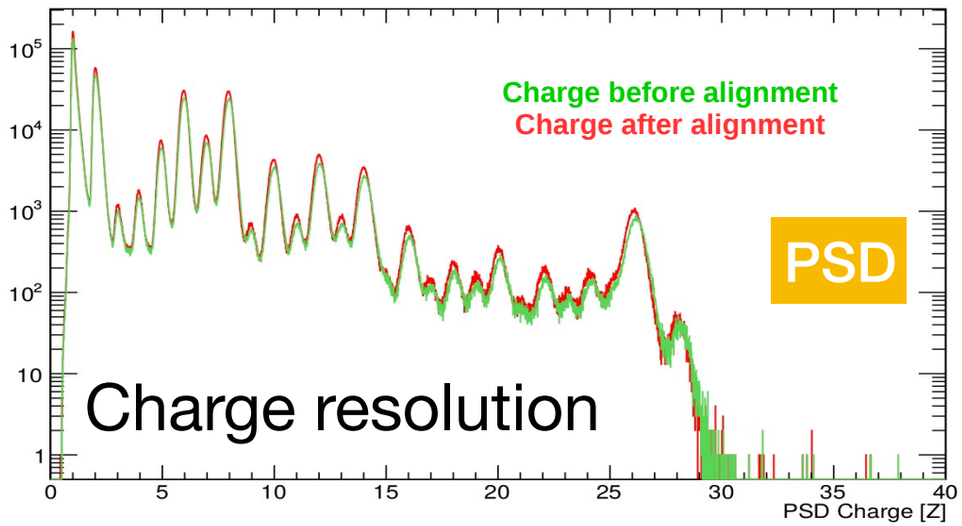


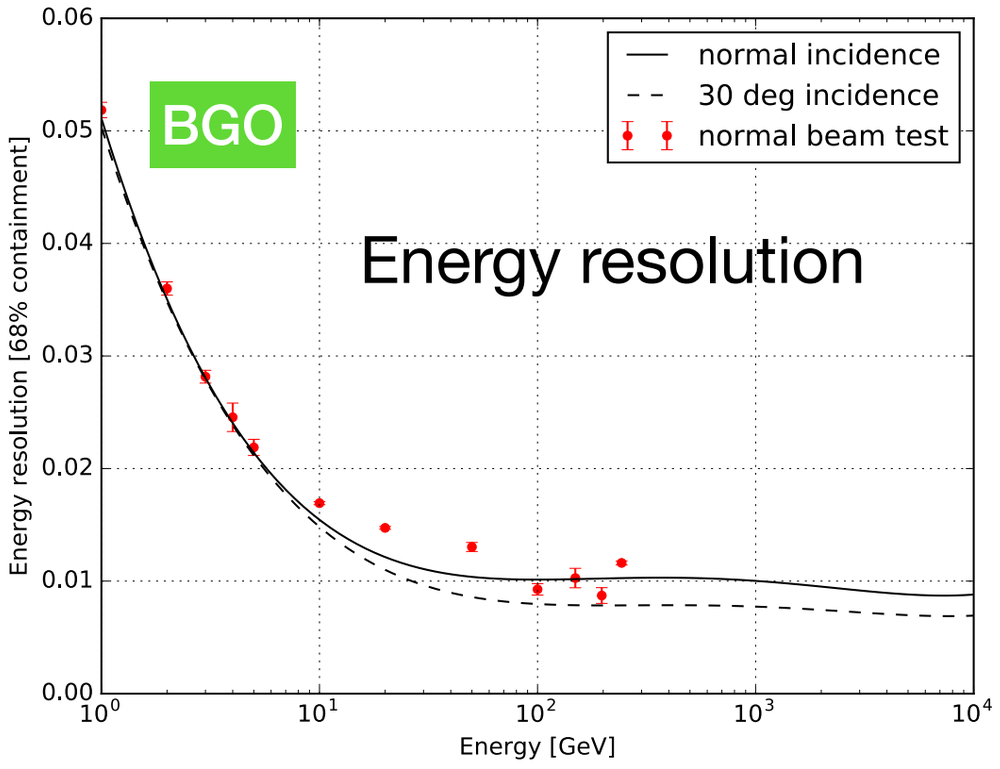



# Detector performance



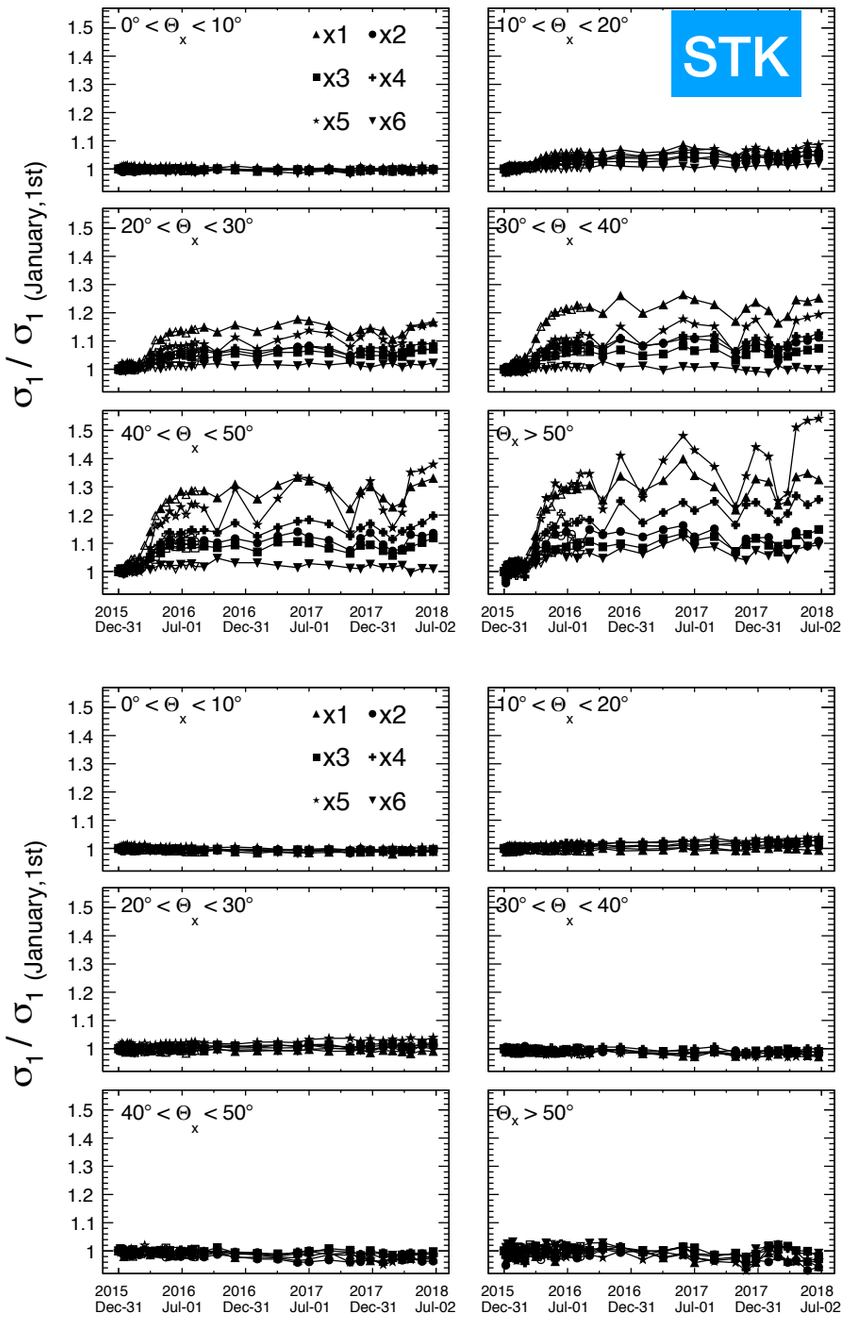




- **Energy resolution: 1% at > 100 GeV**
- **Position resolution: < 70 μm**
- **Charge resolution: 3.5% (p) and 5.1% (He)**

# In-flight stability

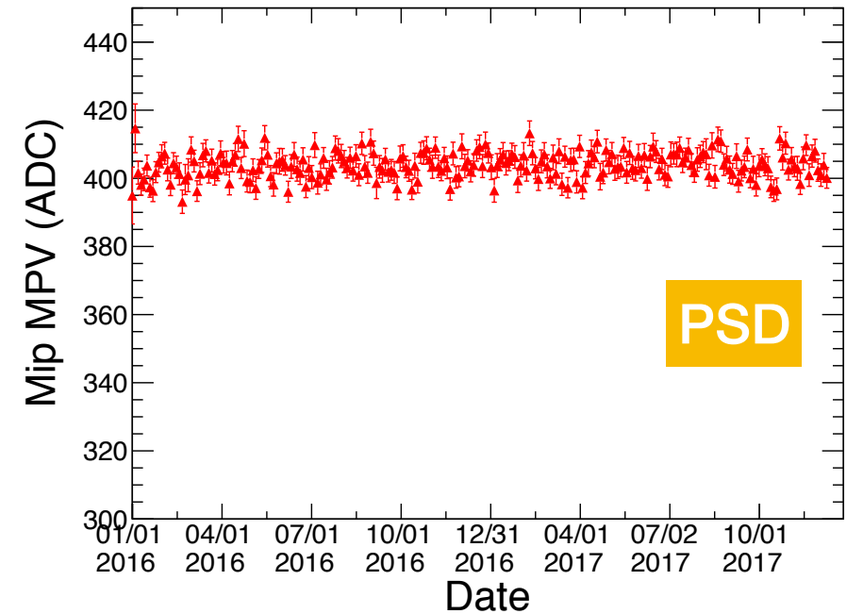
Variation of position resolution with time

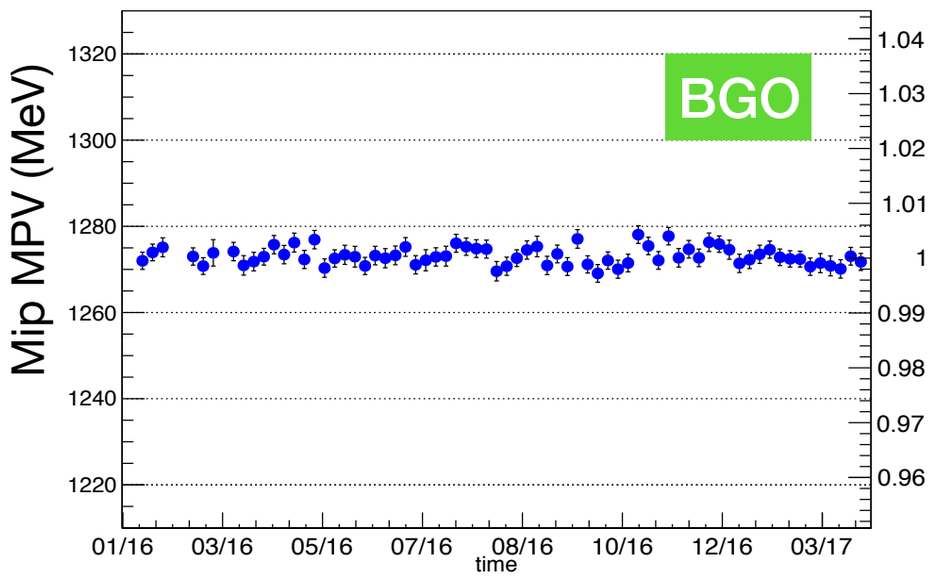



**Fixed alignment**

**Time-dependent alignment**

Energy and charge reconstruction are extremely stable with time! (variations < 1%)



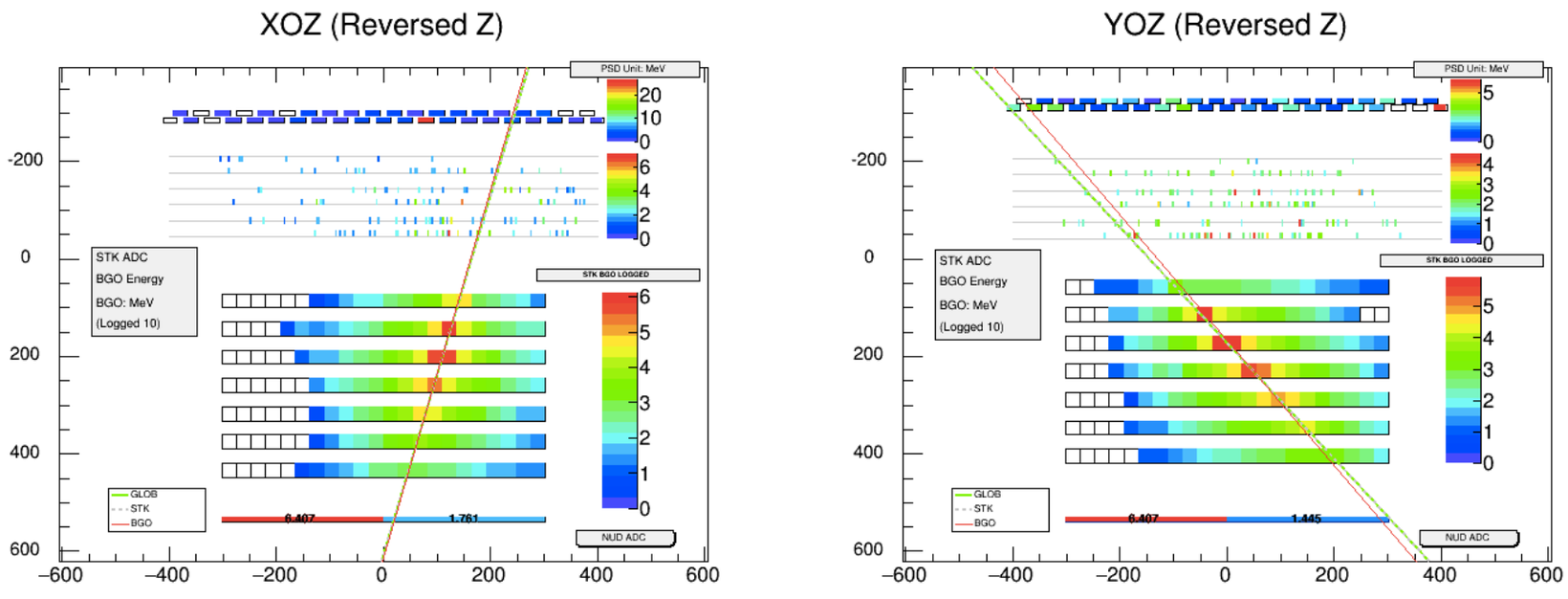



# Analysis

## Electrons: e/p discrimination

- Electron showers are narrow and short
  - **Longitudinal shower shape**
    SumRMS - sum of shower RMS in 14 layers of BGO
  - **Lateral shower shape**

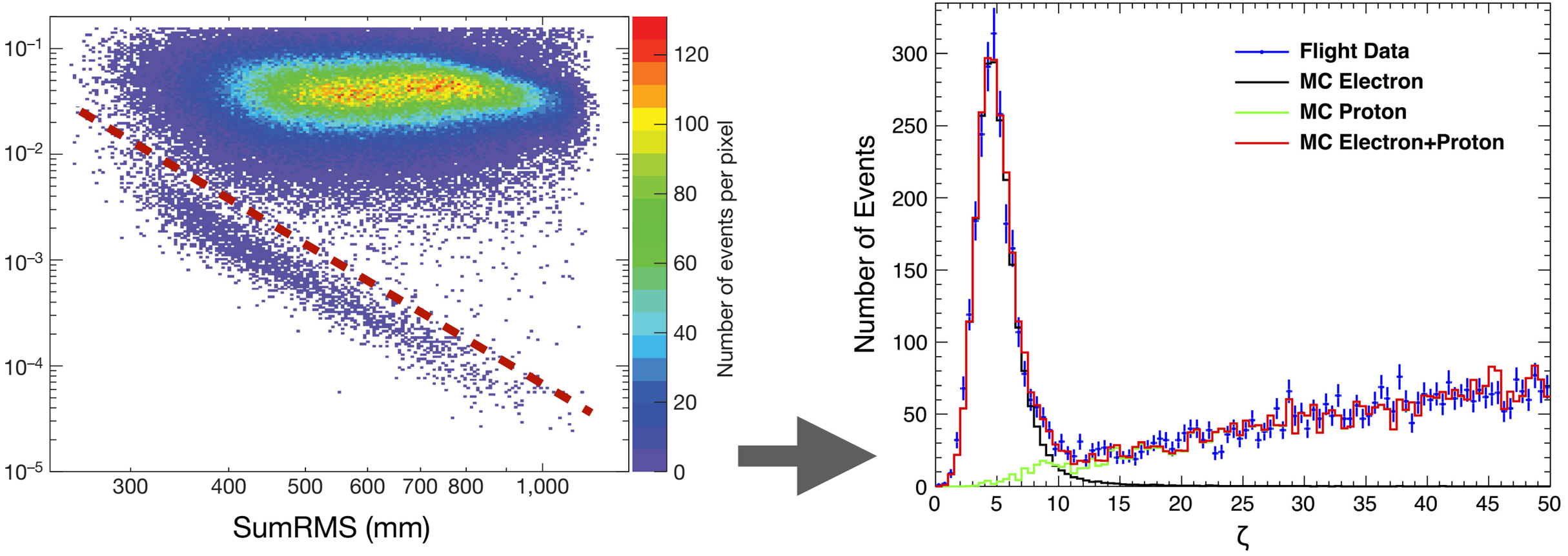
$\mathcal{F}_{last}$ —fraction of total shower energy in the last shower layer.




**5.6 TeV electron candidate**

# Analysis

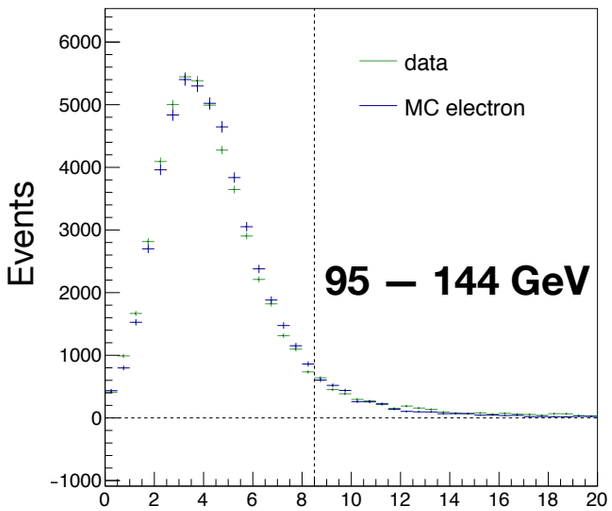
## Electrons: e/p discrimination

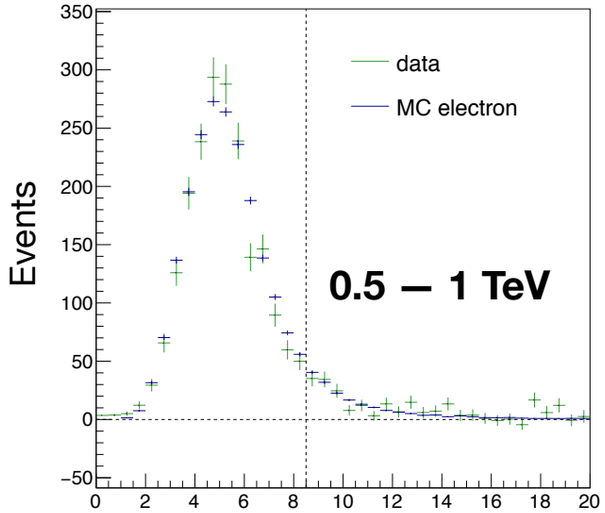


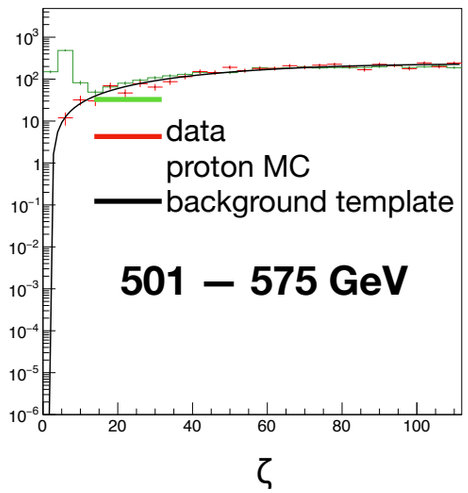

$$\zeta = \mathcal{F}_{last} \times [\text{SumRMS} / \text{mm}]^4 / (8 \times 10^6)$$

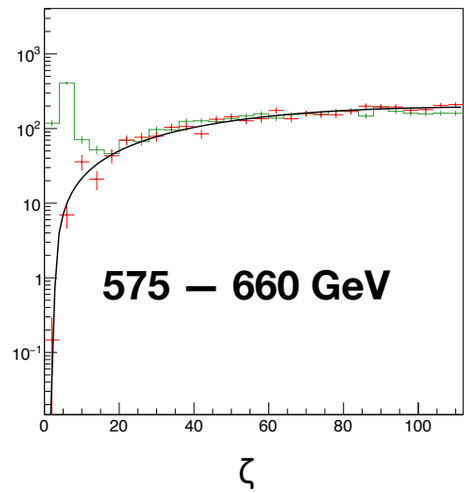
# Analysis

## Electrons: background estimation and signal efficiency

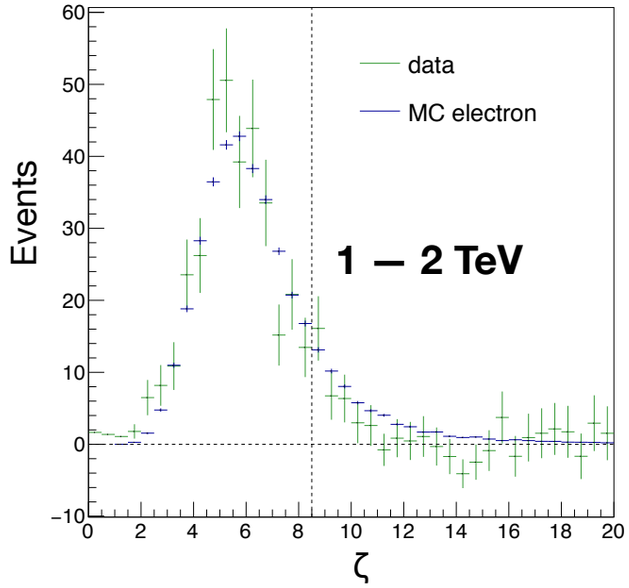


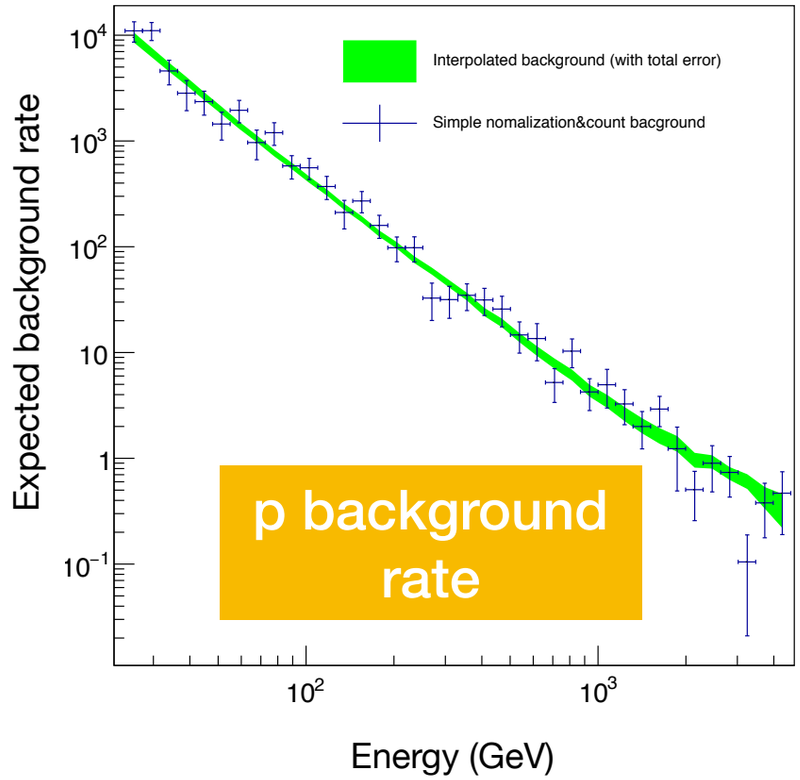




electrons



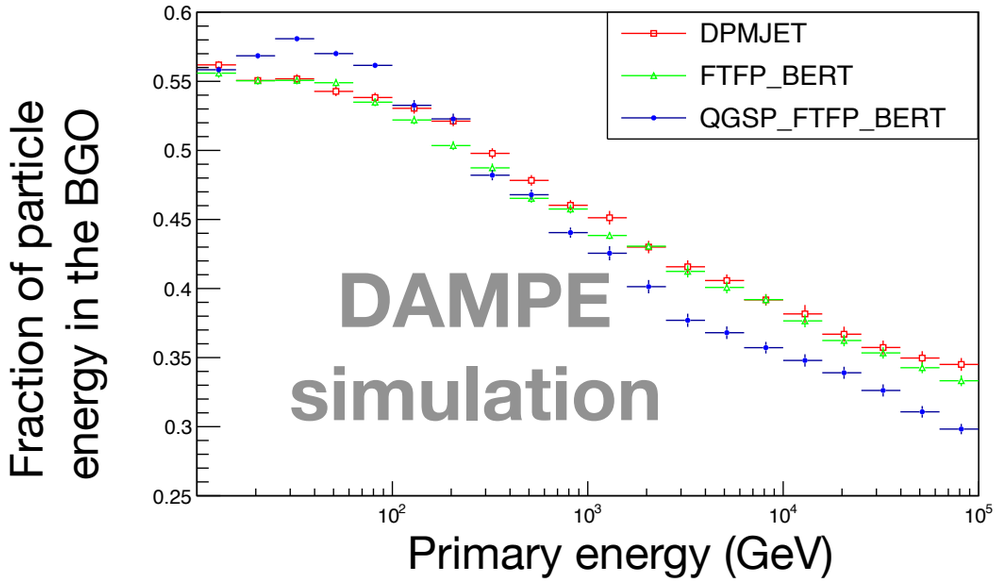




**Semi-analytic background templates obtained from the Simulation. Good data-MC agreement of ζ both for electrons and protons.**

# Analysis

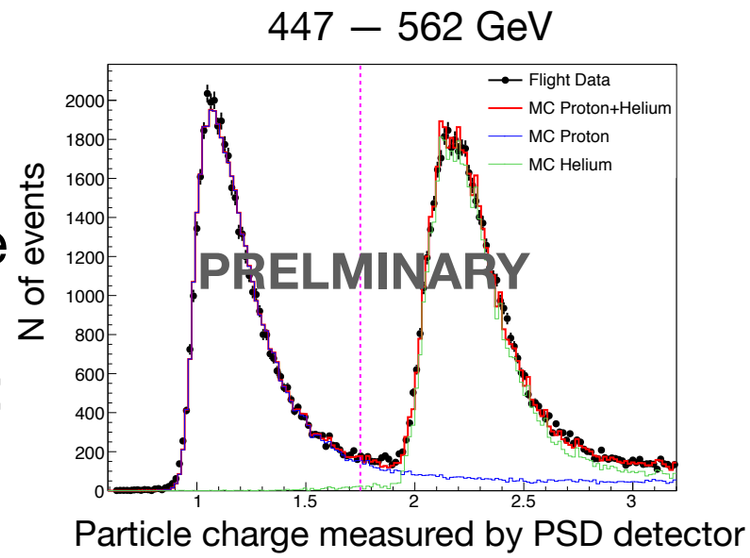
## Protons, Helium

Different hadronic models are checked in the Simulation:

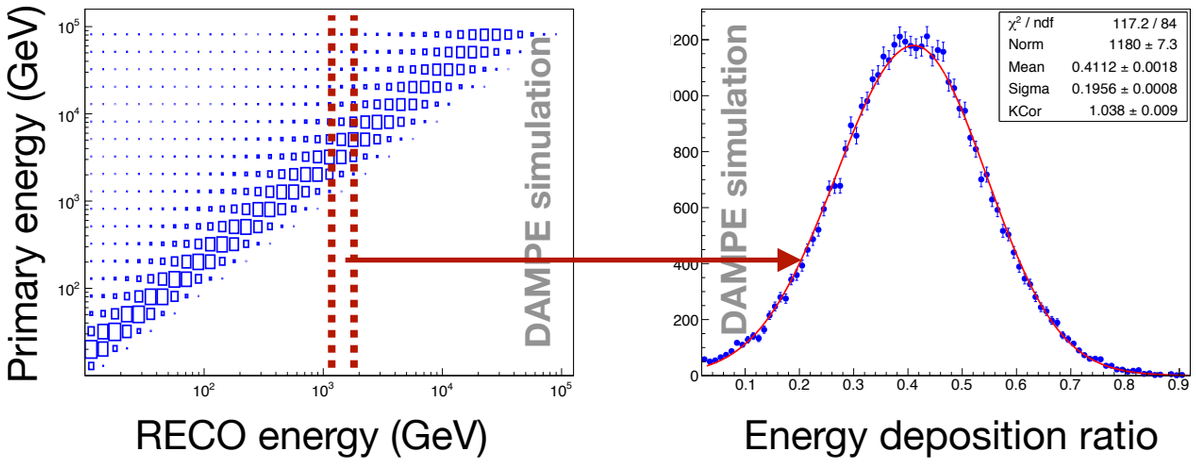



DPMJET (Fluka) and FTF (Geant4) models are consistent between each other

Proton / Helium discrimination is done using the particle track and PSD signal:

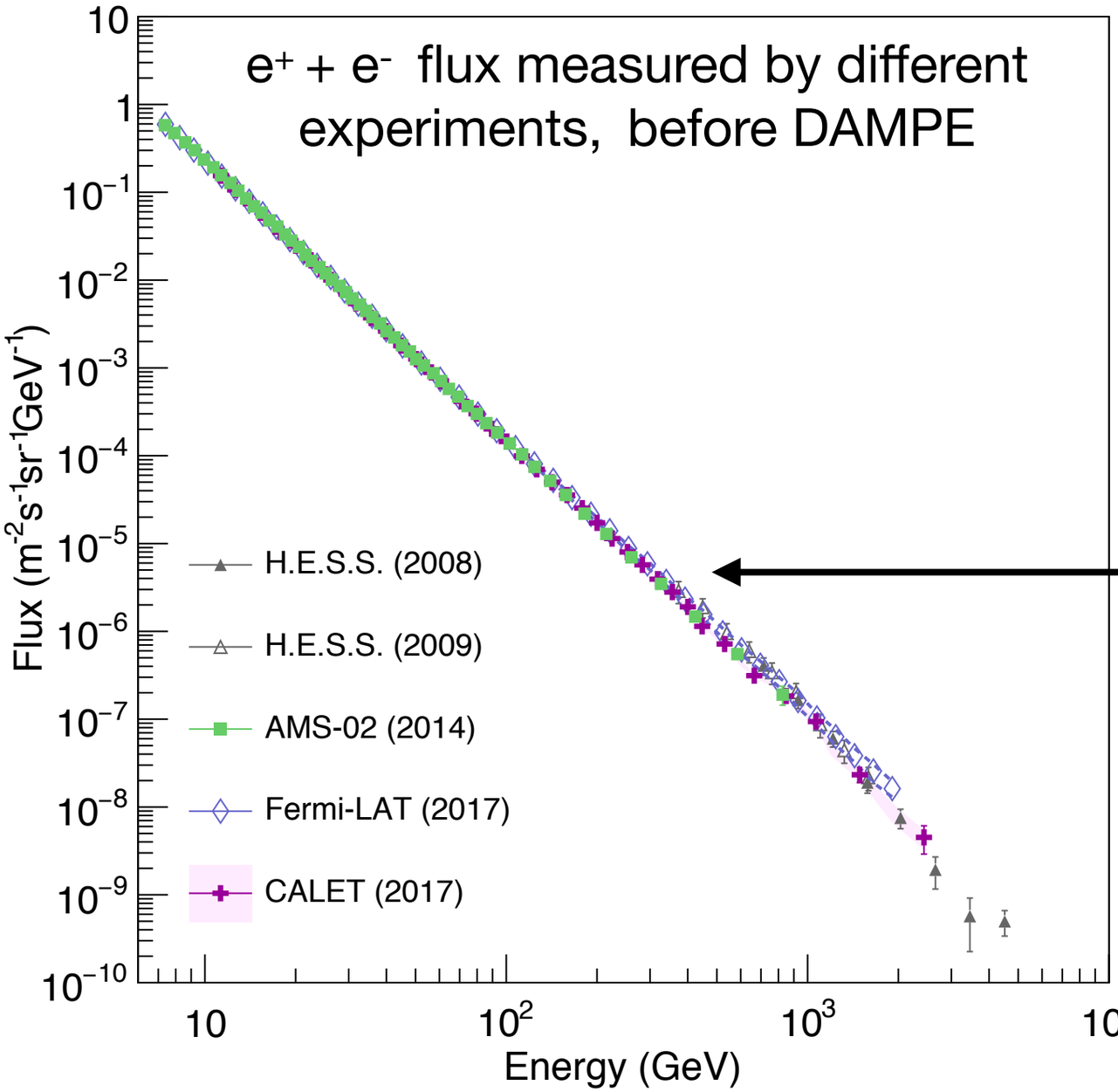



About 1.6 nuclear length in the calorimeter → a deconvolution of measured energy into primary is applied



# First results

## $e^+ + e^-$ flux measurement




$$\left(\frac{N}{N_0}\right) = \left(\frac{E}{E_0}\right)^{\frac{\ln P}{\ln \beta}}$$

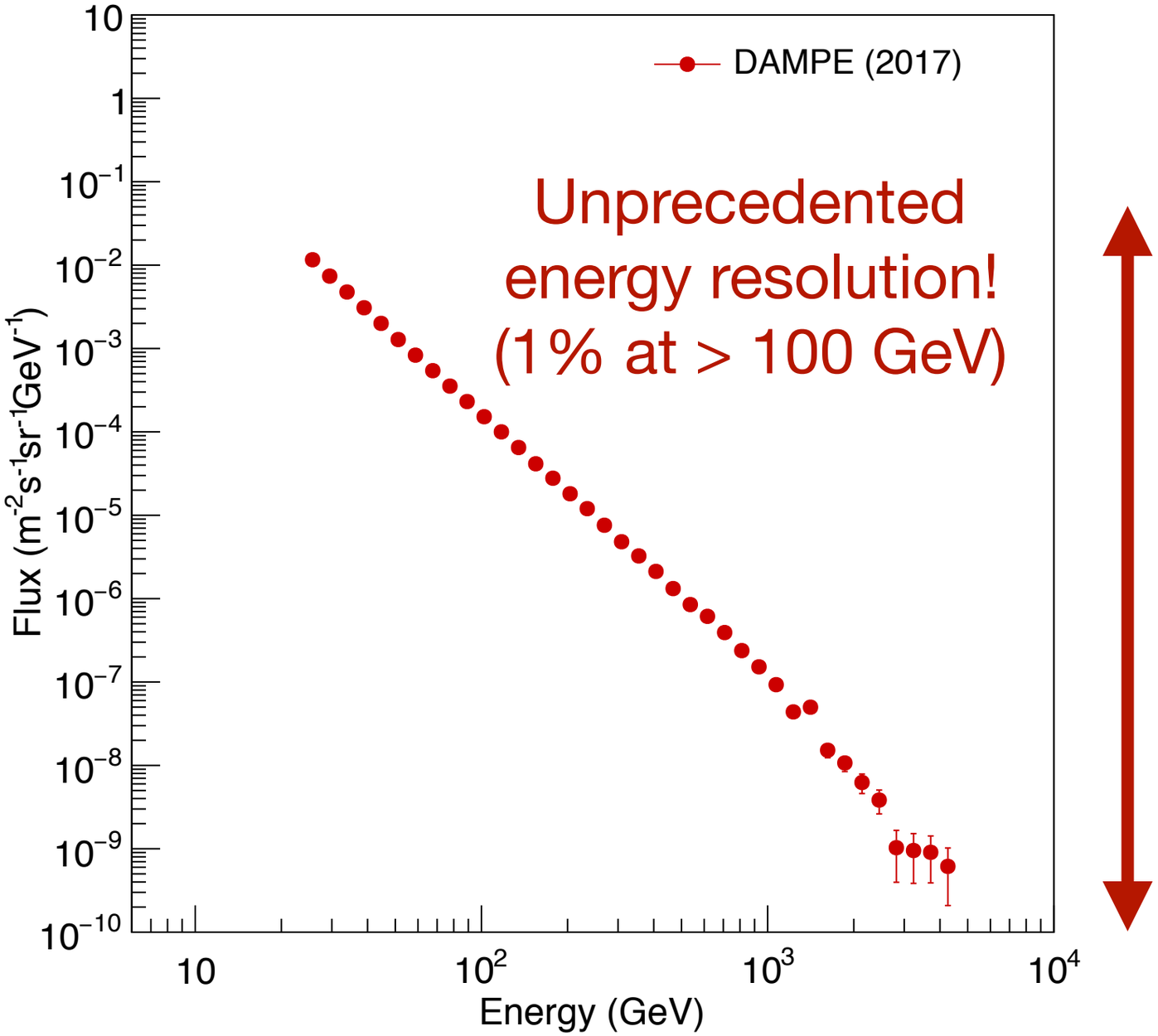
Particle diffusion in the accelerating medium results in the power-law spectrum

*P*: probability to escape the acceleration region after the collision

*β*: relative increase of particle energy after the collision

# First results

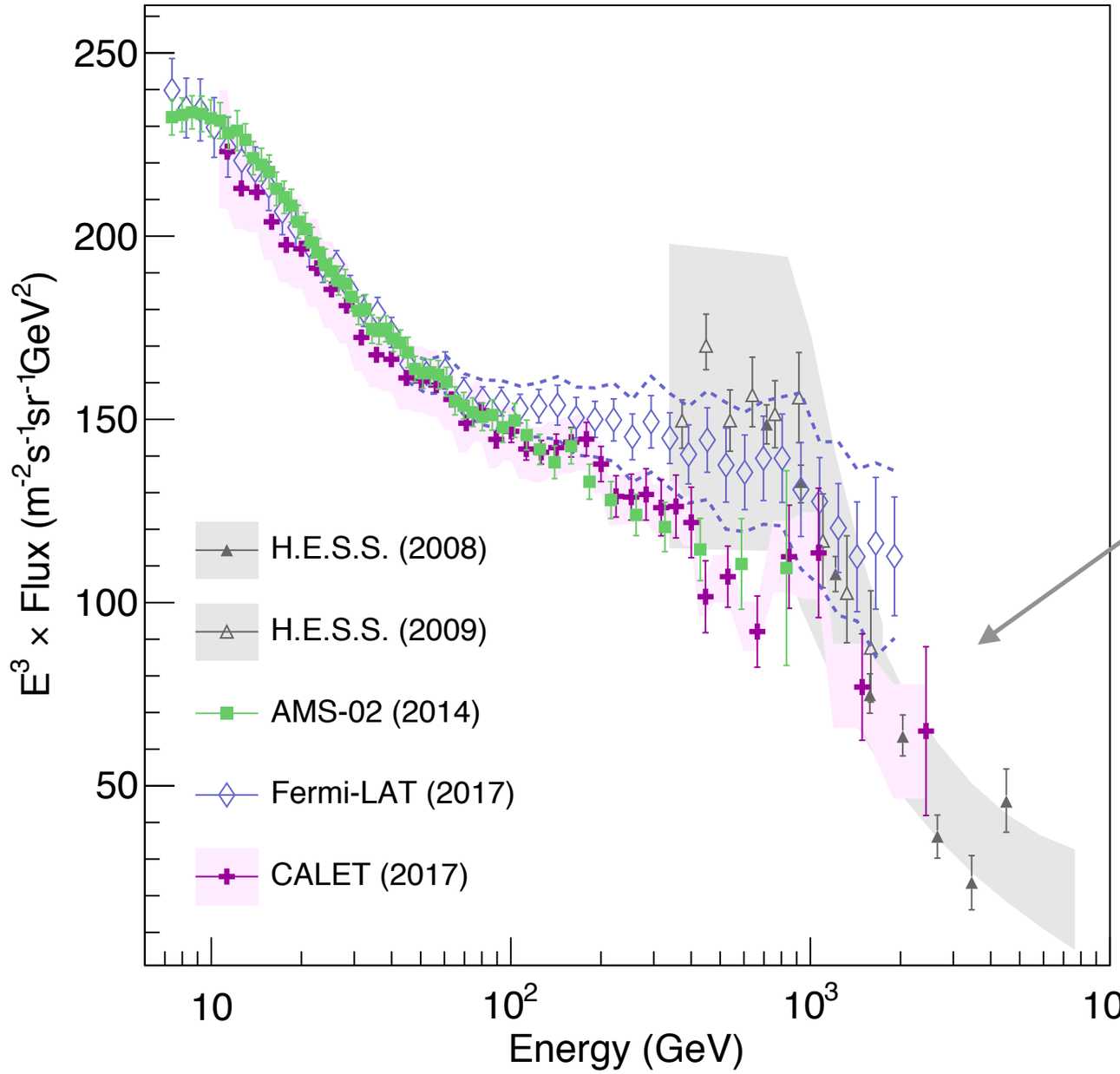
**$e^+ + e^-$ flux measurement**



# First results

**$e^+ + e^-$ flux measurement**

Flux is usually scaled by $E^3$ to see the features in the spectrum




**Hints of spectral break by H.E.S.S.**

# First results

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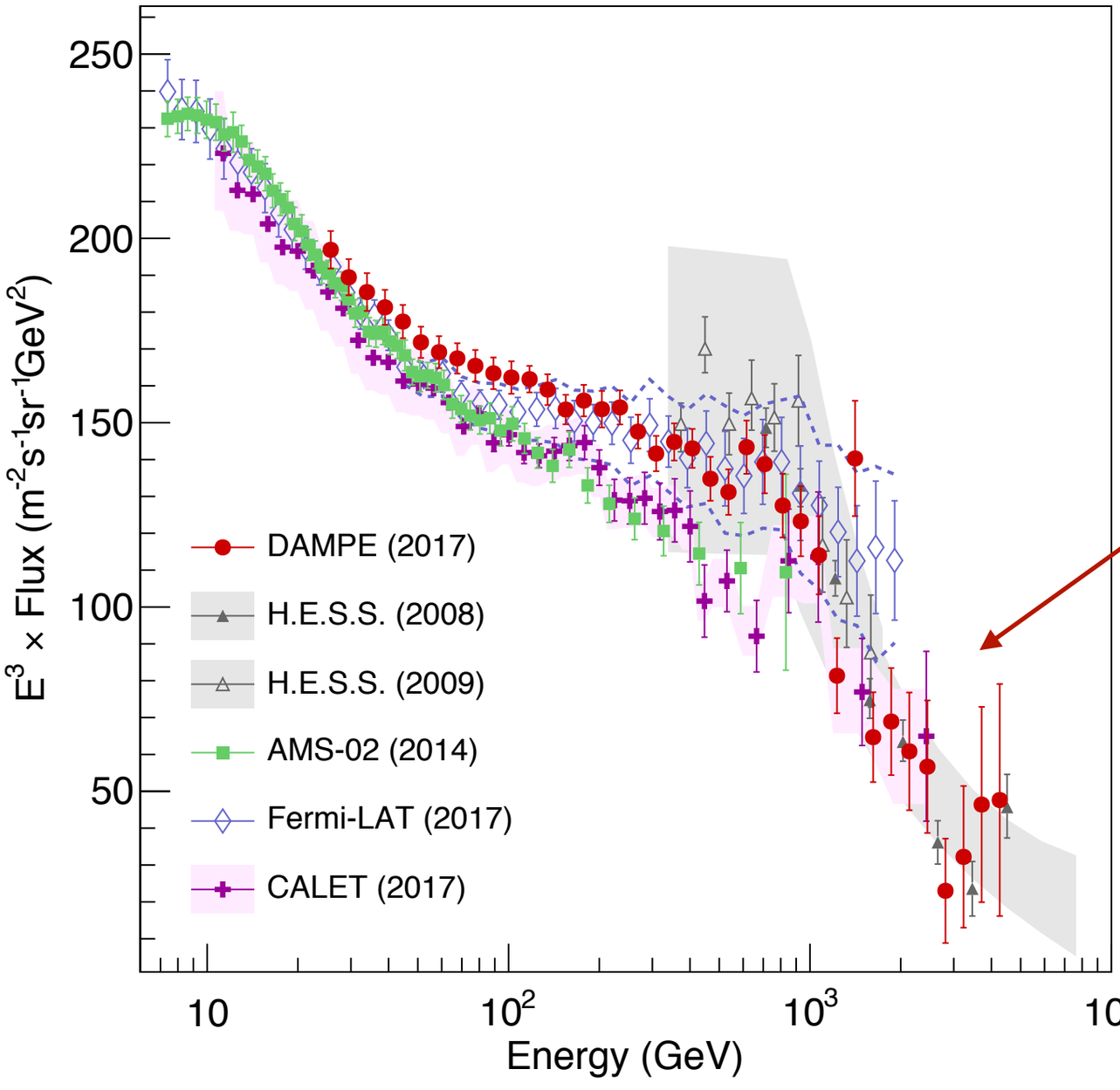


**DAMPE is the first to directly observe the spectral break**

https://www.nature.com/articles/nature24475

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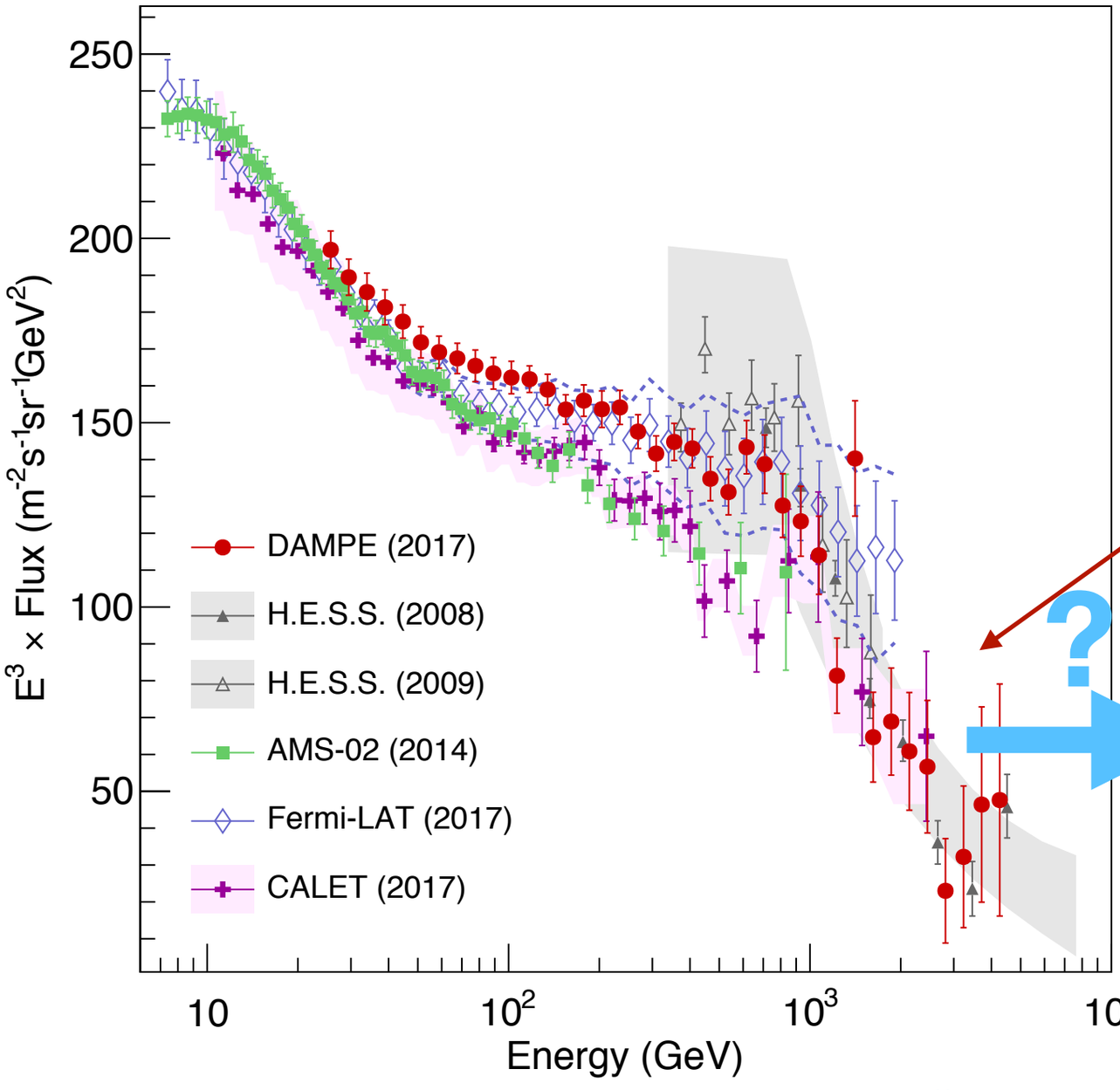
Flux is usually scaled by $E^3$ to see the features in the spectrum



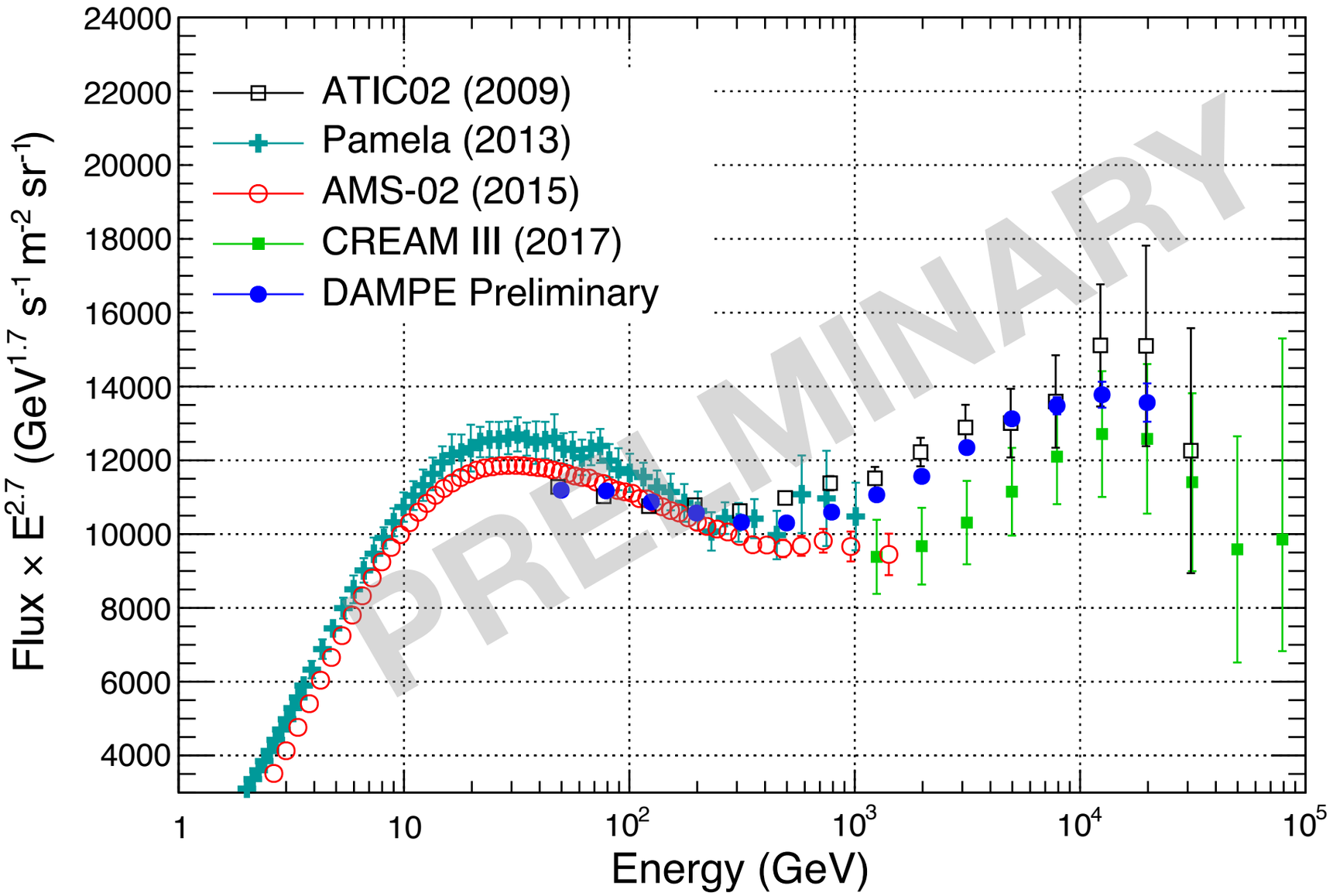

**DAMPE is the first to directly observe the spectral break**

**Features at > 10 TeV?**

https://www.nature.com/articles/nature24475

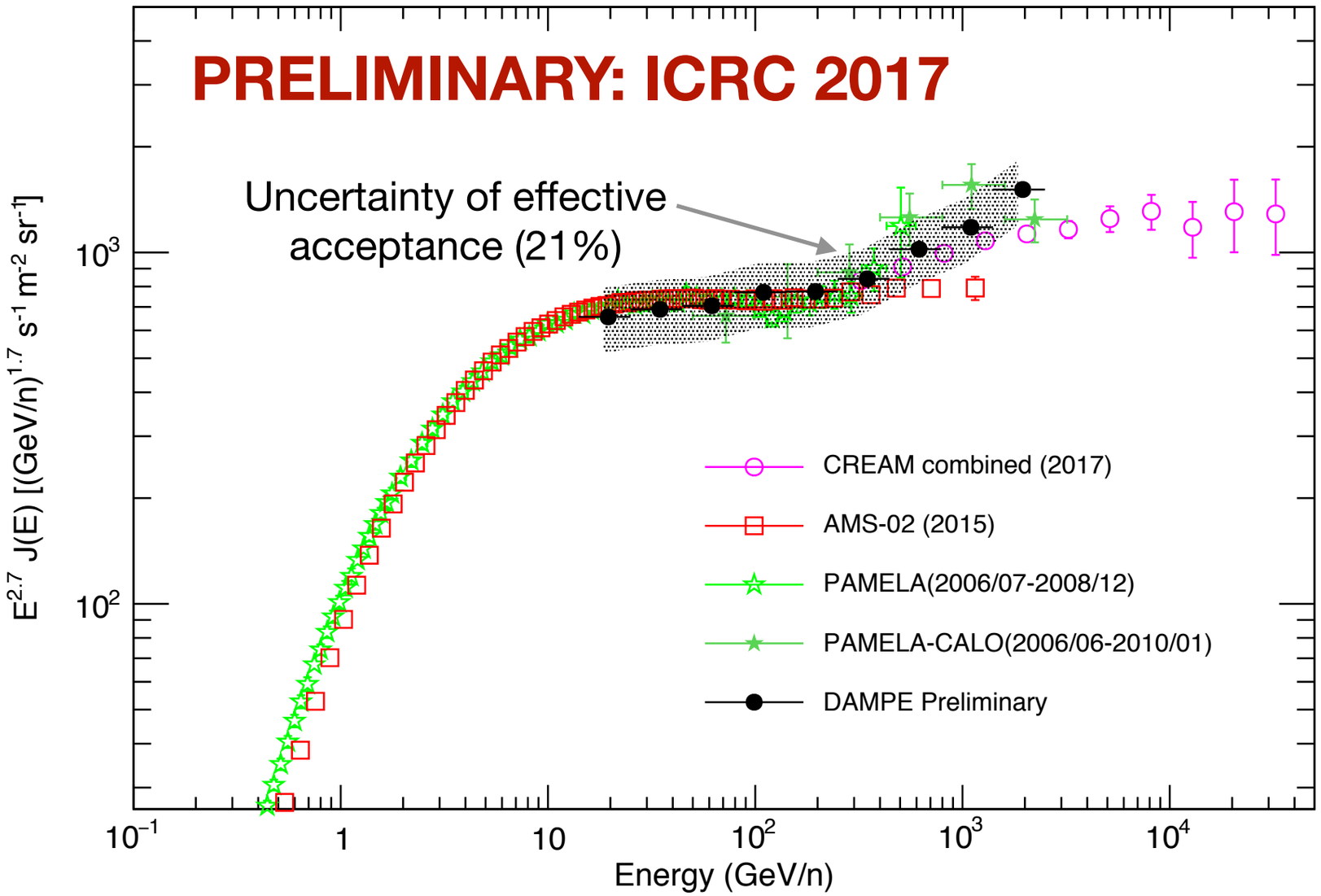
# First results

## $p^+ + p^-$ flux measurement



# First results

## Helium flux measurement

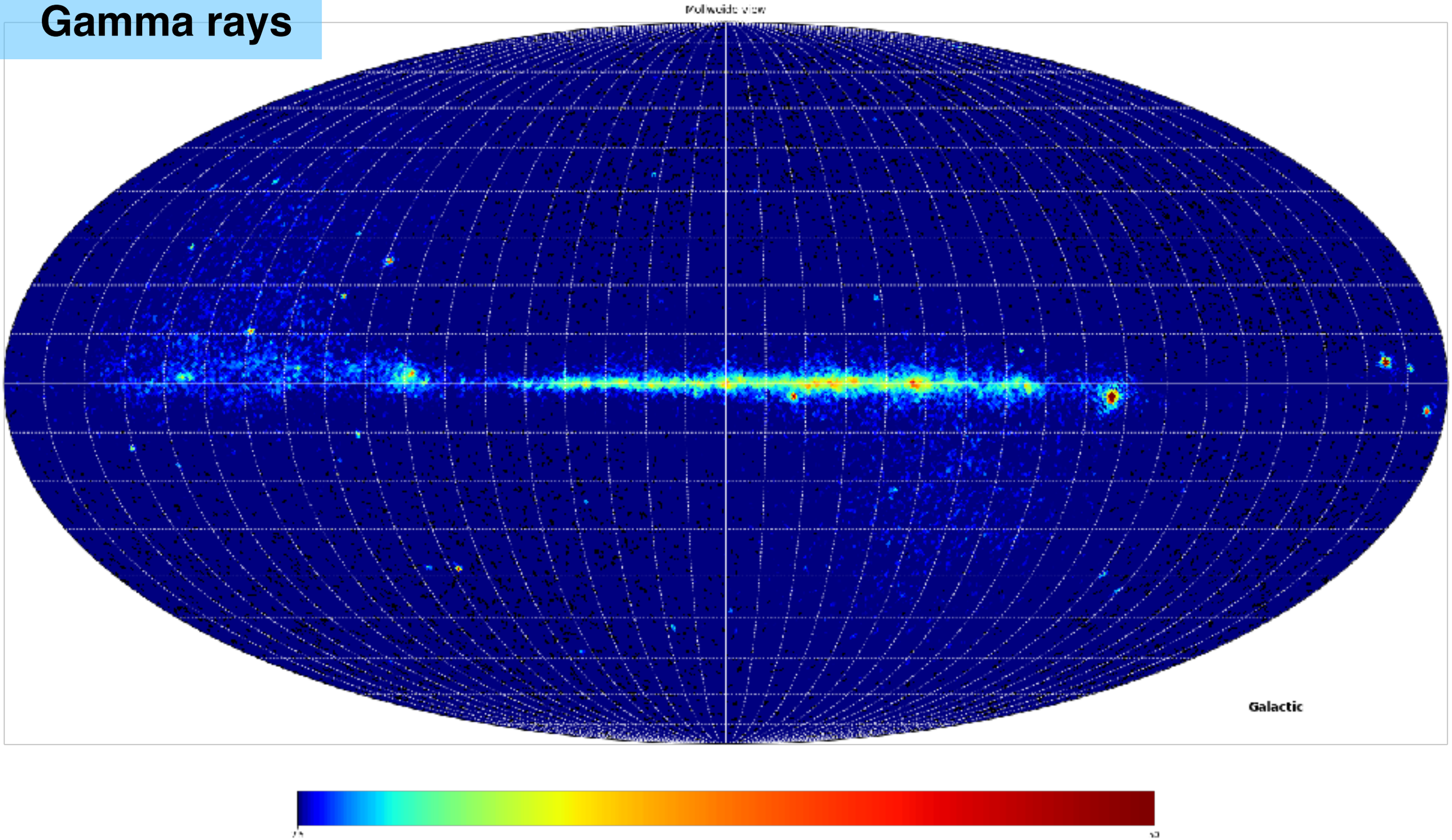



https://pos.sissa.it/301/169/pdf

Uncertainty on the unfolding method is not taken into account as well as the energy resolution for Helium.

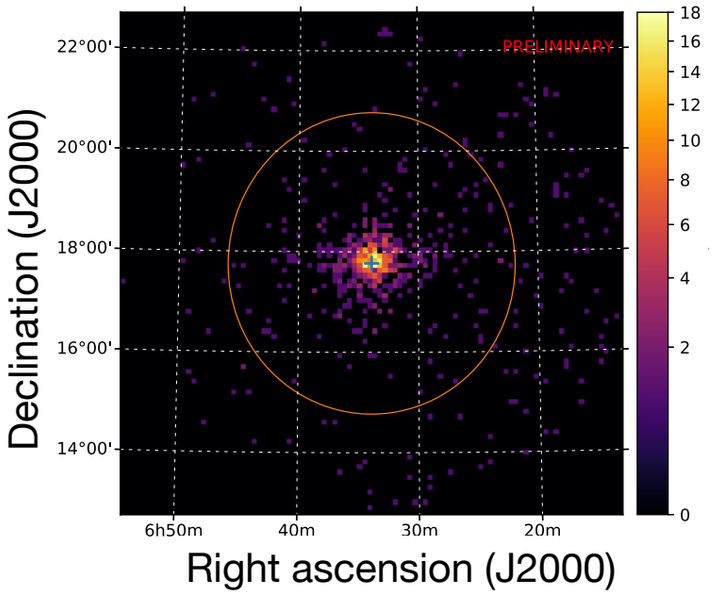
# First results

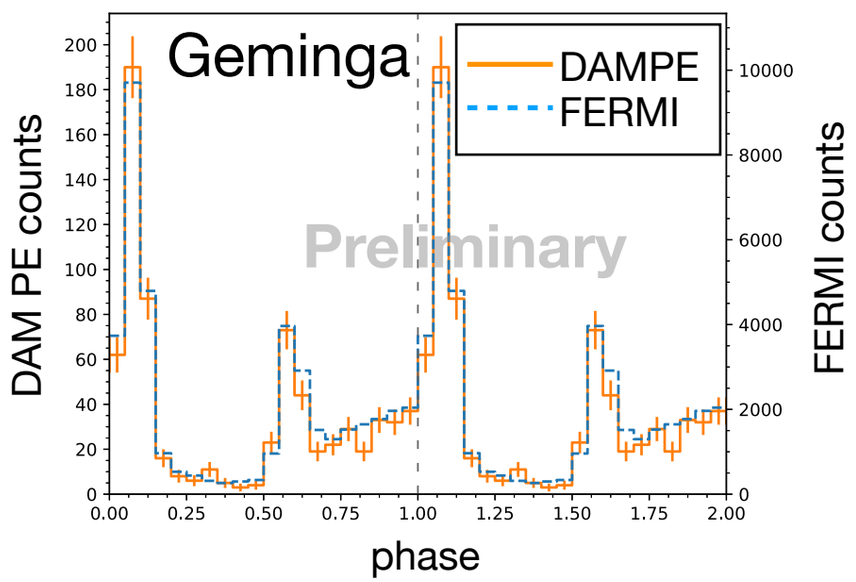
**Gamma rays**

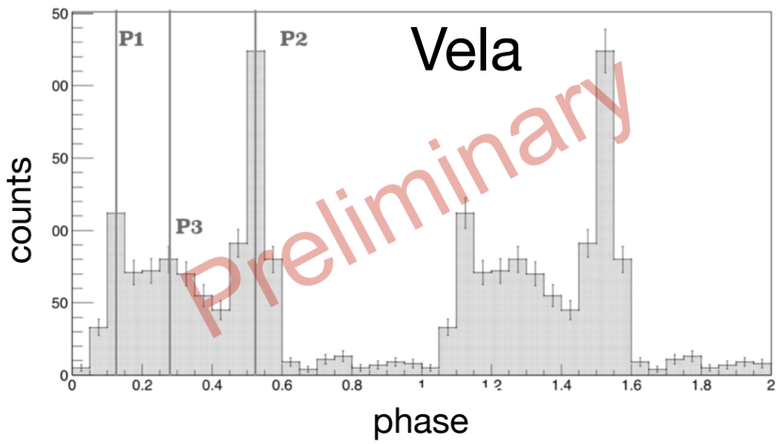


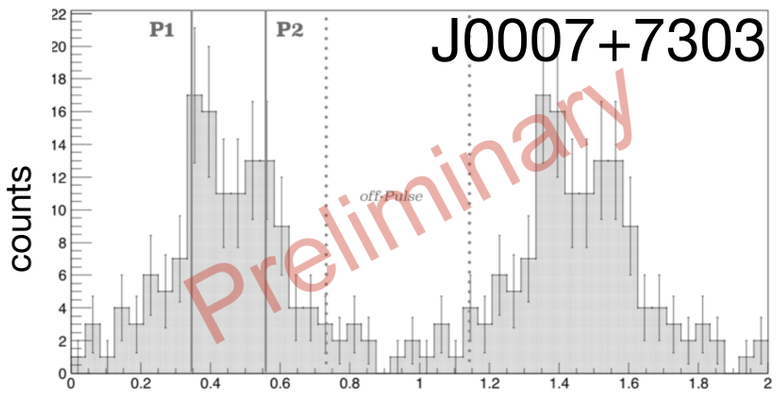
# First results

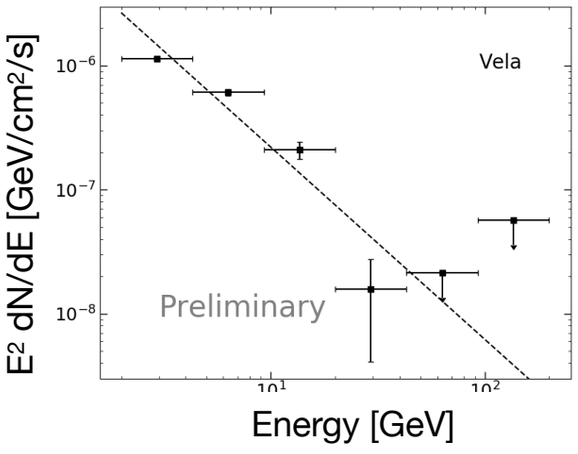
## Gamma rays: pulsars

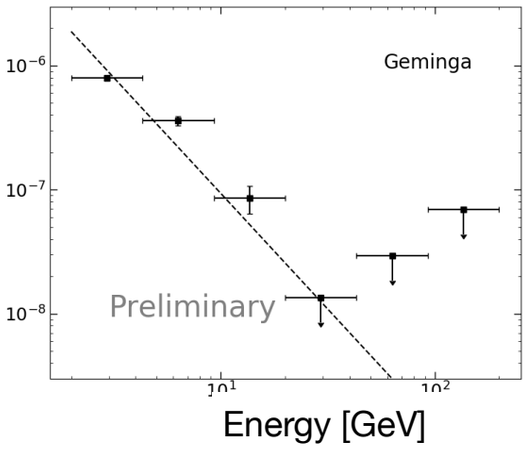


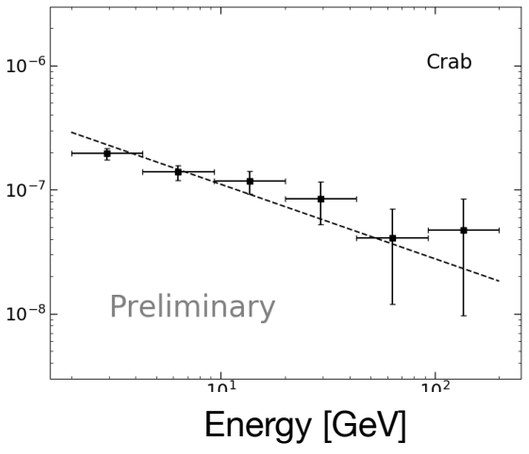



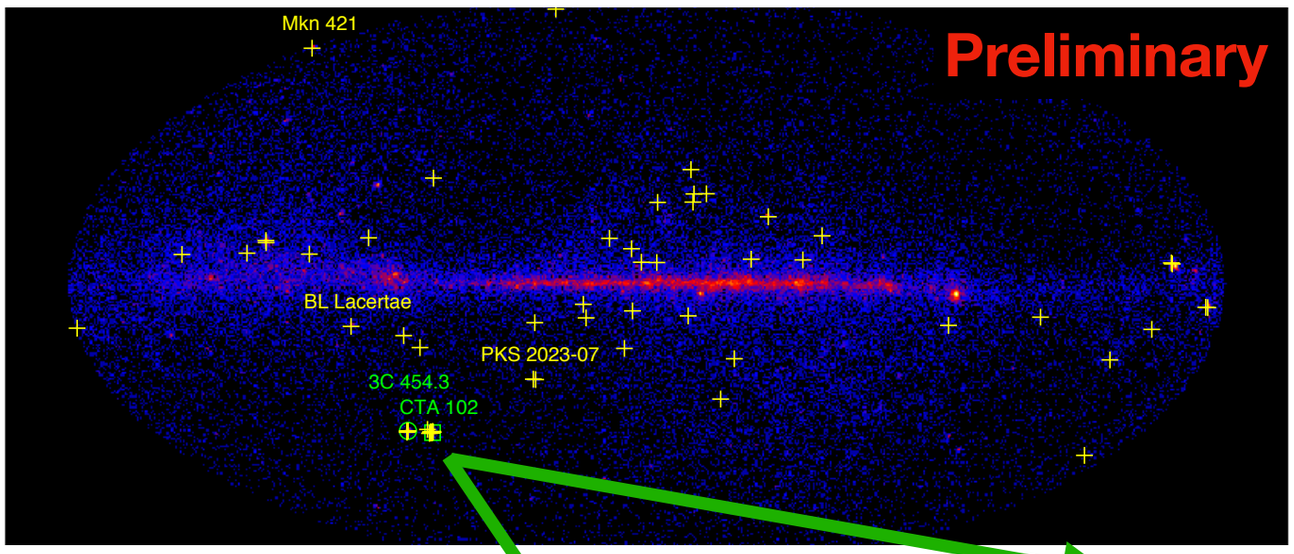




https://pos.sissa.it/301/709/pdf
https://pos.sissa.it/301/616/pdf

**An excellent instrument for the identification and analysis of pulsars in an energy 1-100 GeV!**

# First results

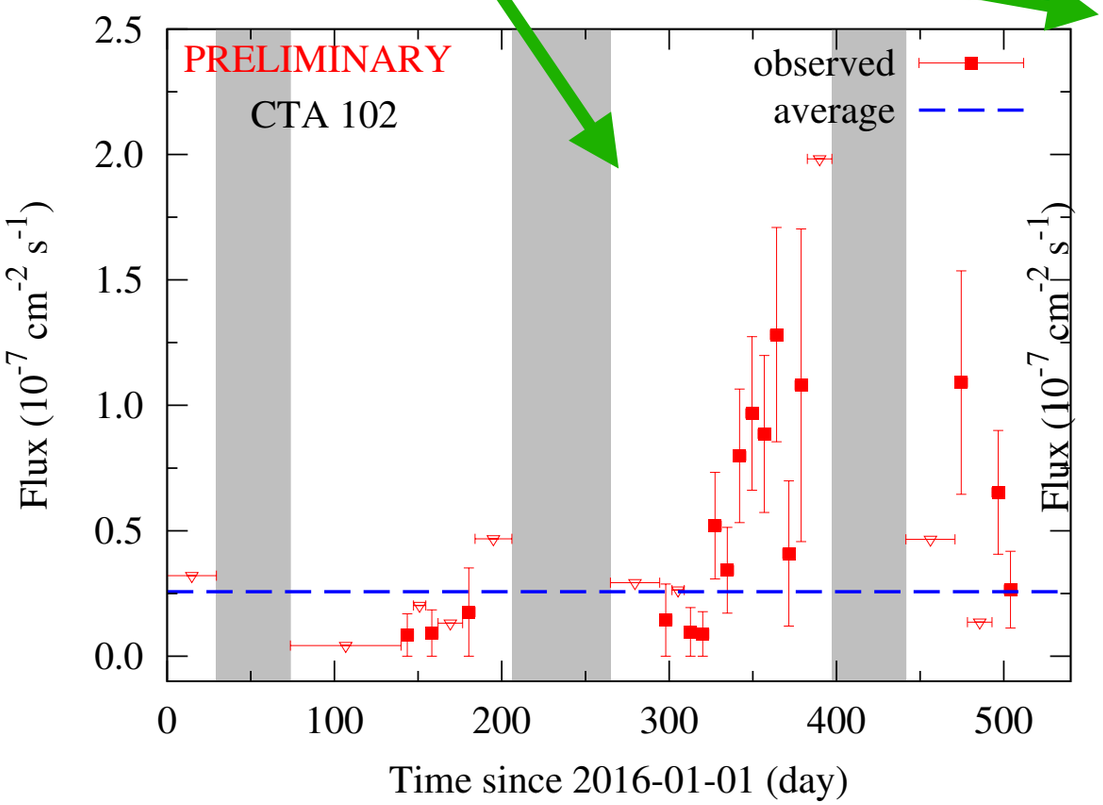
## Gamma rays: variable sources

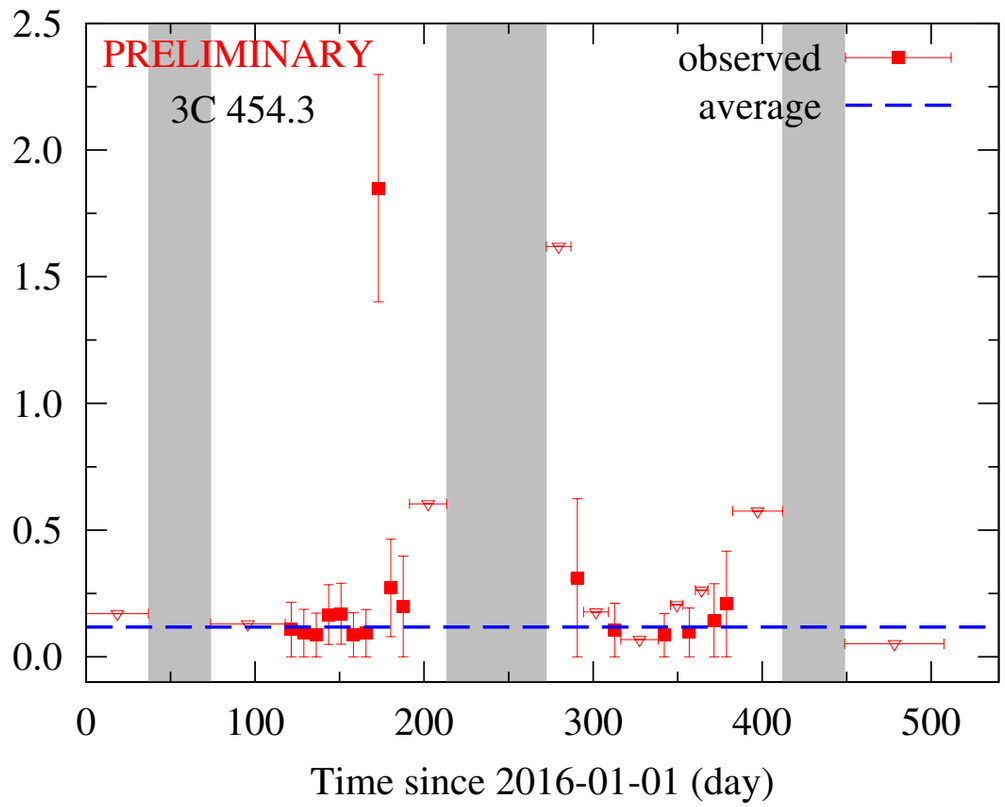



Two AGNs, CTA 102 and 3C 454.3 are found to be significantly variable at time scales longer than one week.

Photon clusterings: 63 photon pairs, one photon triple, and one quadruple ($\Delta T < 1500$s and $\Delta\Theta < 1°$)

Astronomy telegram: astronomerstelegram.org/?read=9901
For details: pos.sissa.it/301/617/pdf, pos.sissa.it/301/616/pdf



# Conclusions

- DAMPE detector works extremely well since launch in December 2015.
- Electron + positron flux measured with very high precision:
    - A clear spectral break directly observed at ~ 1 TeV.
- Cosmic-ray nuclei measurements (proton and helium) coming soon.
- Photon detection capabilities demonstrated.
    - More statistics needed to profit from the excellent energy resolution.

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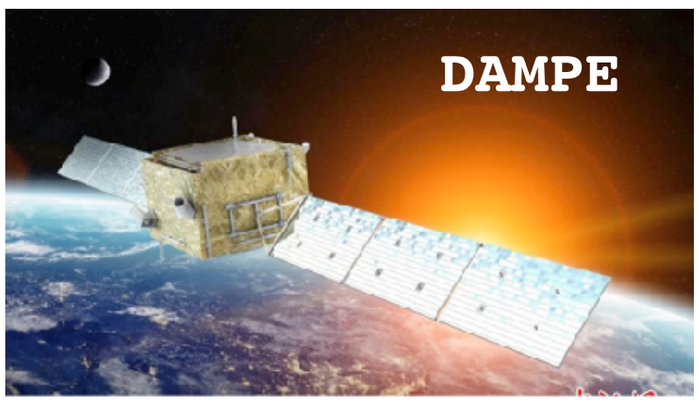
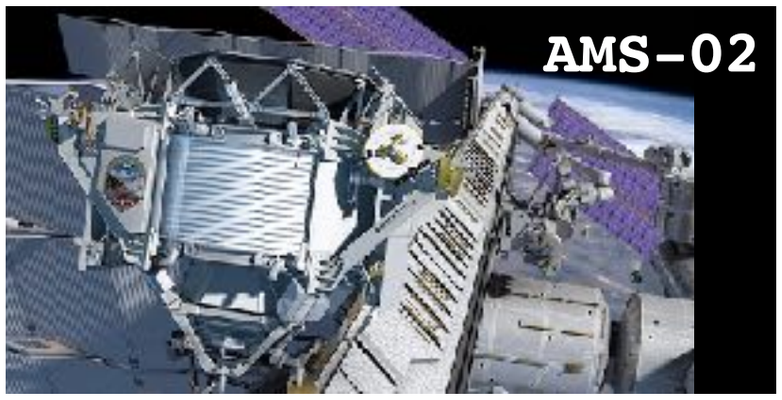
**Thank You!**

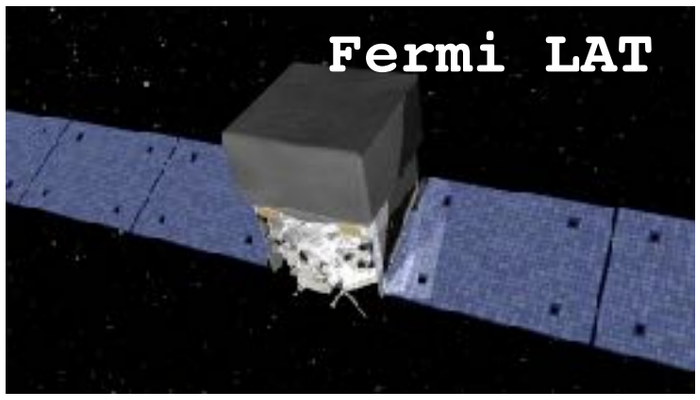
# Something more

# Comparison with AMS-02 and FERMI

| | DAMPE | AMS-02 | Fermi LAT |
|---|---|---|---|
| e/γ Energy res.@100 GeV (%) | **1.5** | 3 | 10 |
| e/γ Angular res.@100 GeV (°) | 0.1 | 0.3 | 0.1 |
| e/p discrimination | $10^5$ | $10^5$ - $10^6$ | $10^3$ |
| Calorimeter thickness ($X_0$) | **32** | 17 | 8.6 |
| Geometrical accep. ($m^2sr$) | **0.29** | 0.09 | 1 |



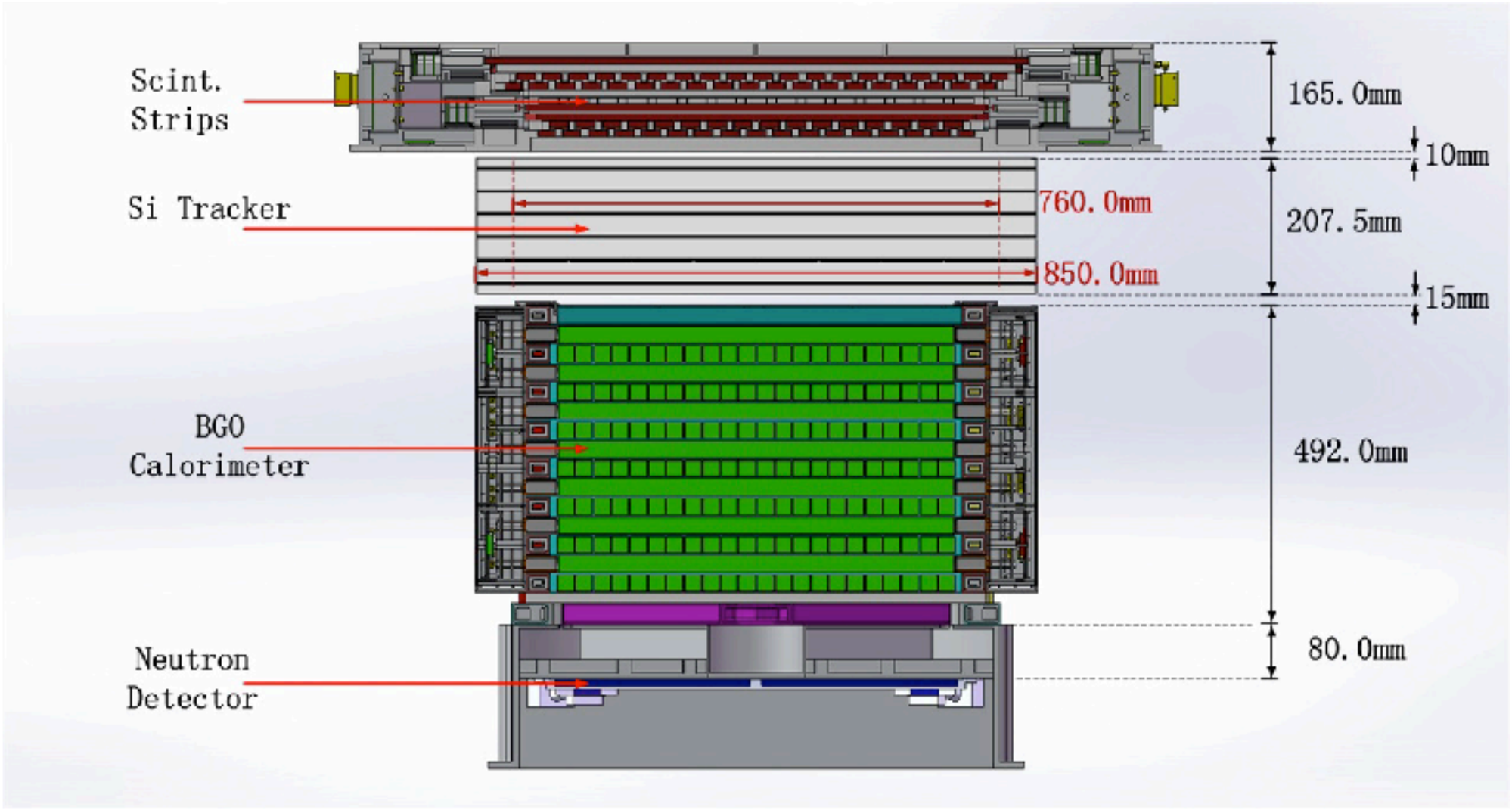



# Boresight alignment

| Source Name | Photon Number | $\theta_X$ (degree) | $\theta_Y$ (degree) | $\theta_Z(degree)$ |
|---|---|---|---|---|
| Vela | 1438 | 0.13±0.01 | 0.02±0.01 | -0.14±0.02 |
| Geminga | 446 | 0.13±0.02 | -0.02±0.02 | -0.14±0.02 |
| Crab | 265 | 0.11±0.02 | -0.03±0.03 | -0.15±0.03 |

# The DAMPE detector




**Mass: 1400 Kg**
**Power: 400 W**
**Data: 13 GB/day**
**Lifetime: 5 years**