



On-orbit Performance of the DAMPE BGO Calorimeter

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(On behalf of the DAMPE Collaboration)

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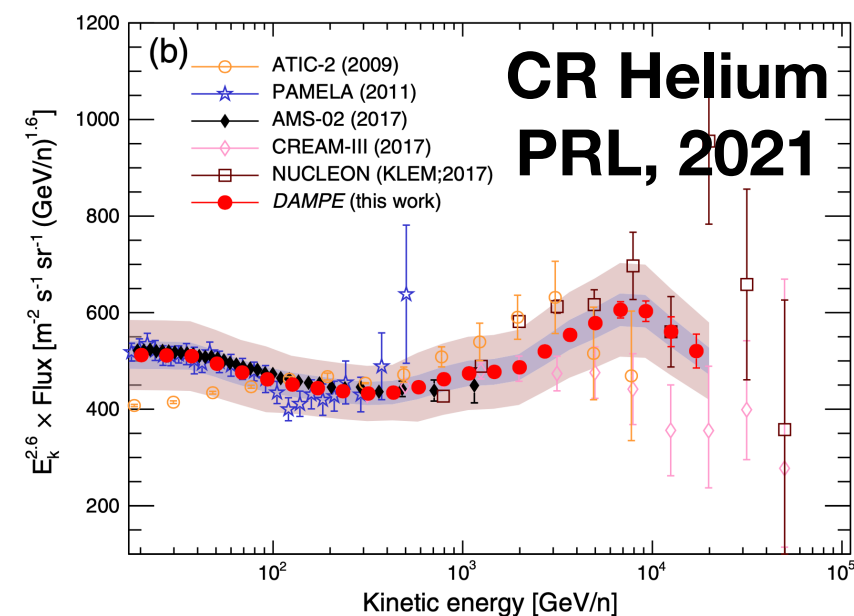
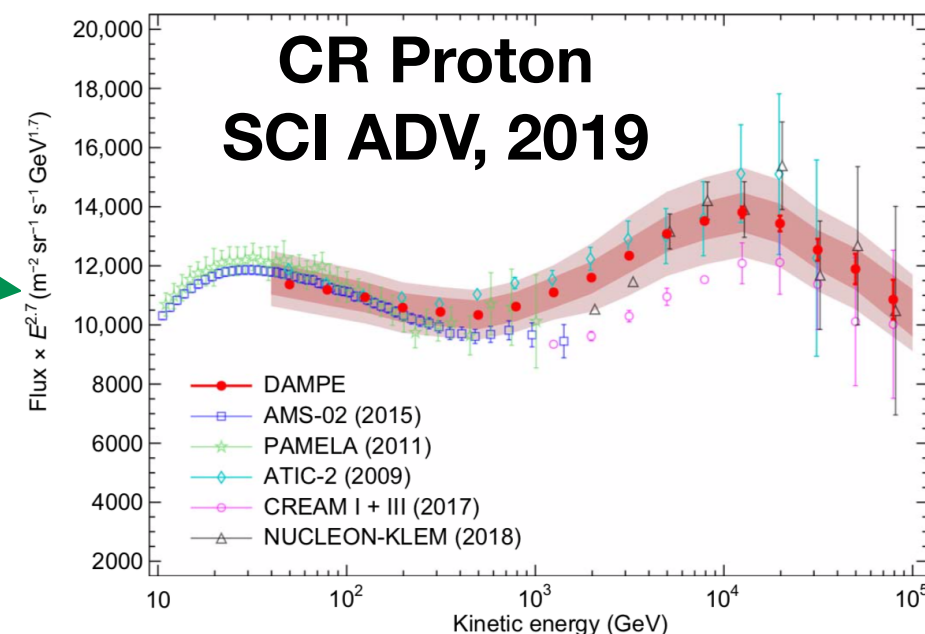
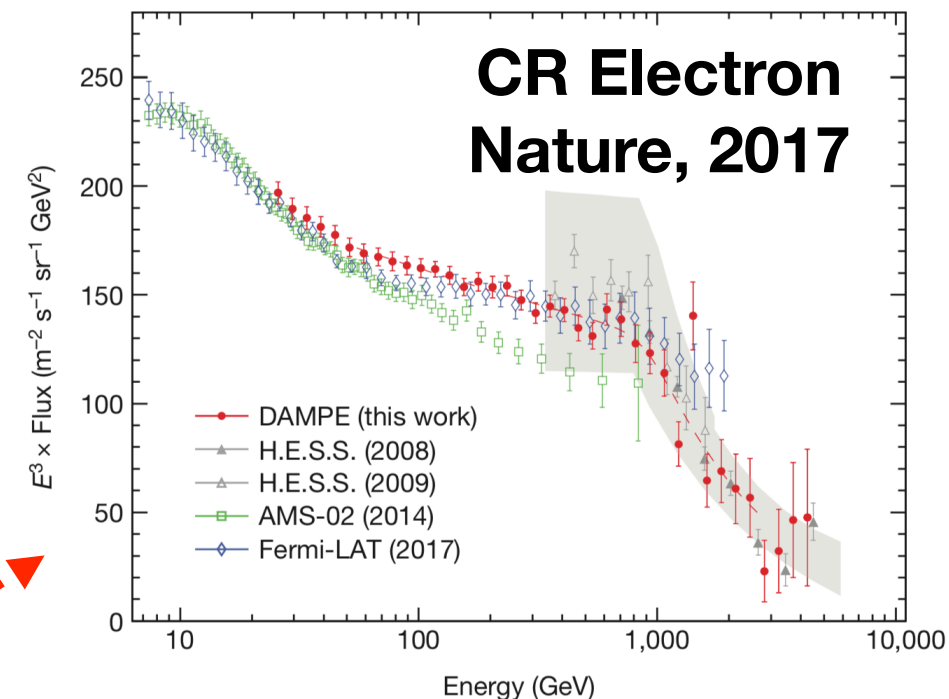
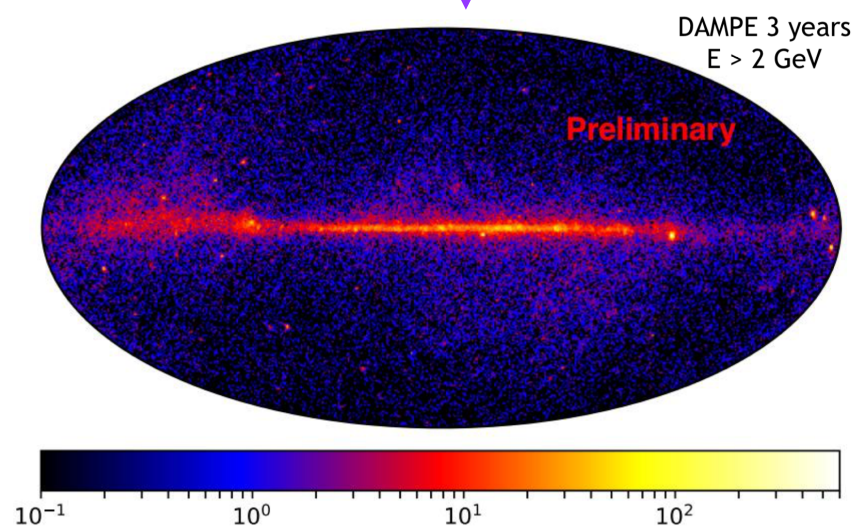
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Outline

- DAMPE experiment
- BGO calorimeter
- Calorimeter units status
- Performance of energy measurement
- summary

DAMPE Physics Goals

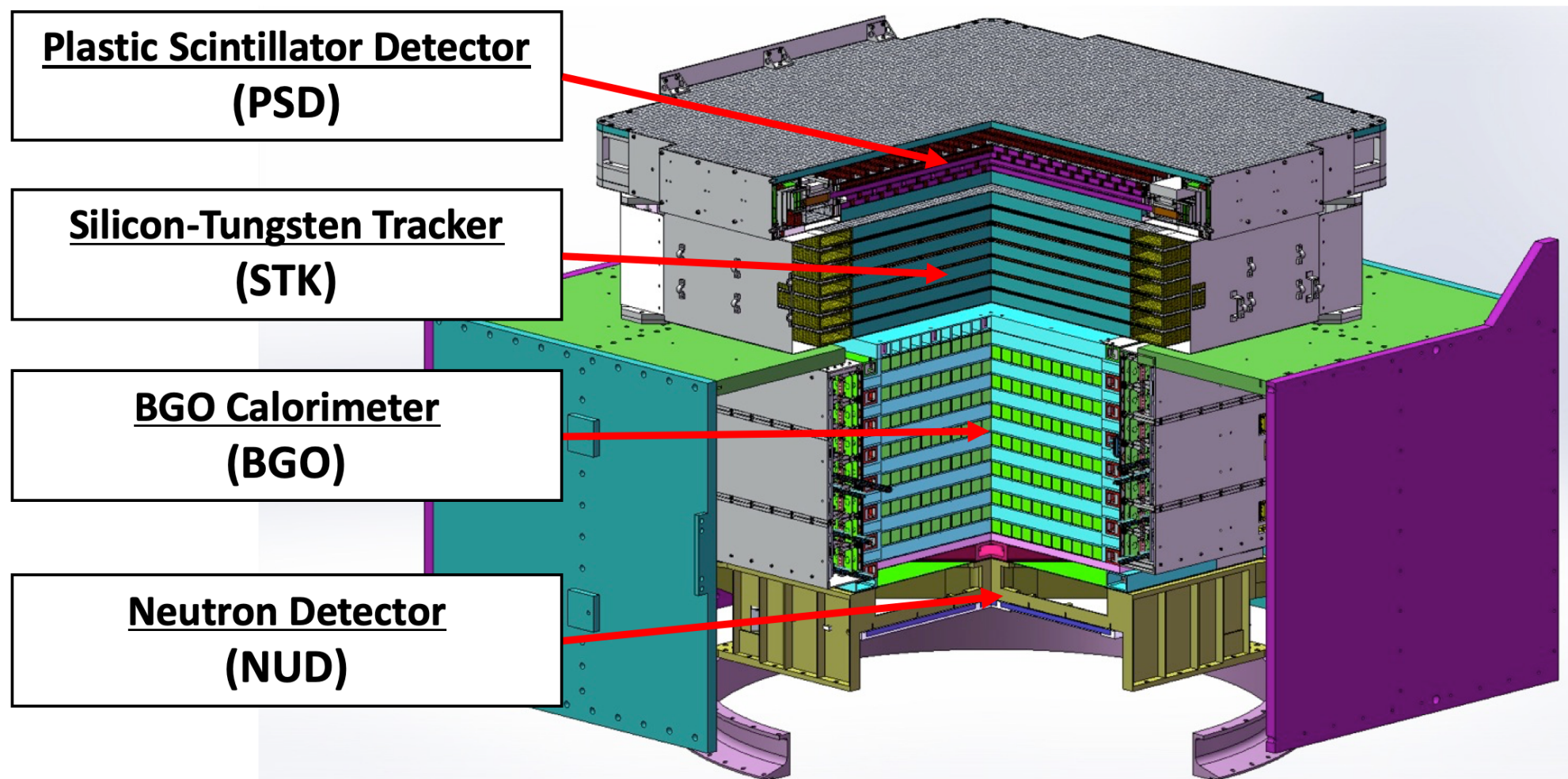
- **D**Ark **M**atter **P**article **E**xplorer (**DAMPE**) is a space experiment for detecting high energy cosmic rays (CR)
 - Measurement of cosmic ray $e^+ + e^-$ spectra $\rightarrow$ DM search
 - Study of cosmic ray nuclei spectrum and composition
 - High energy gamma ray astronomy



DAMPE Detector

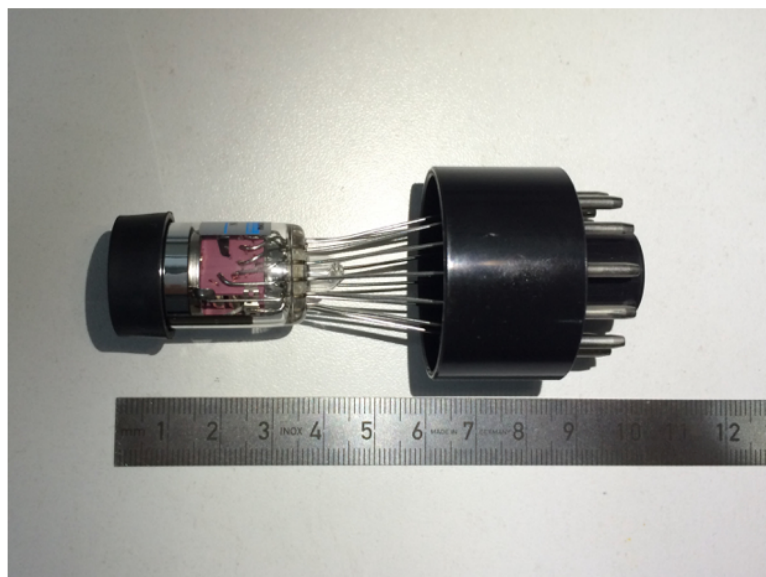
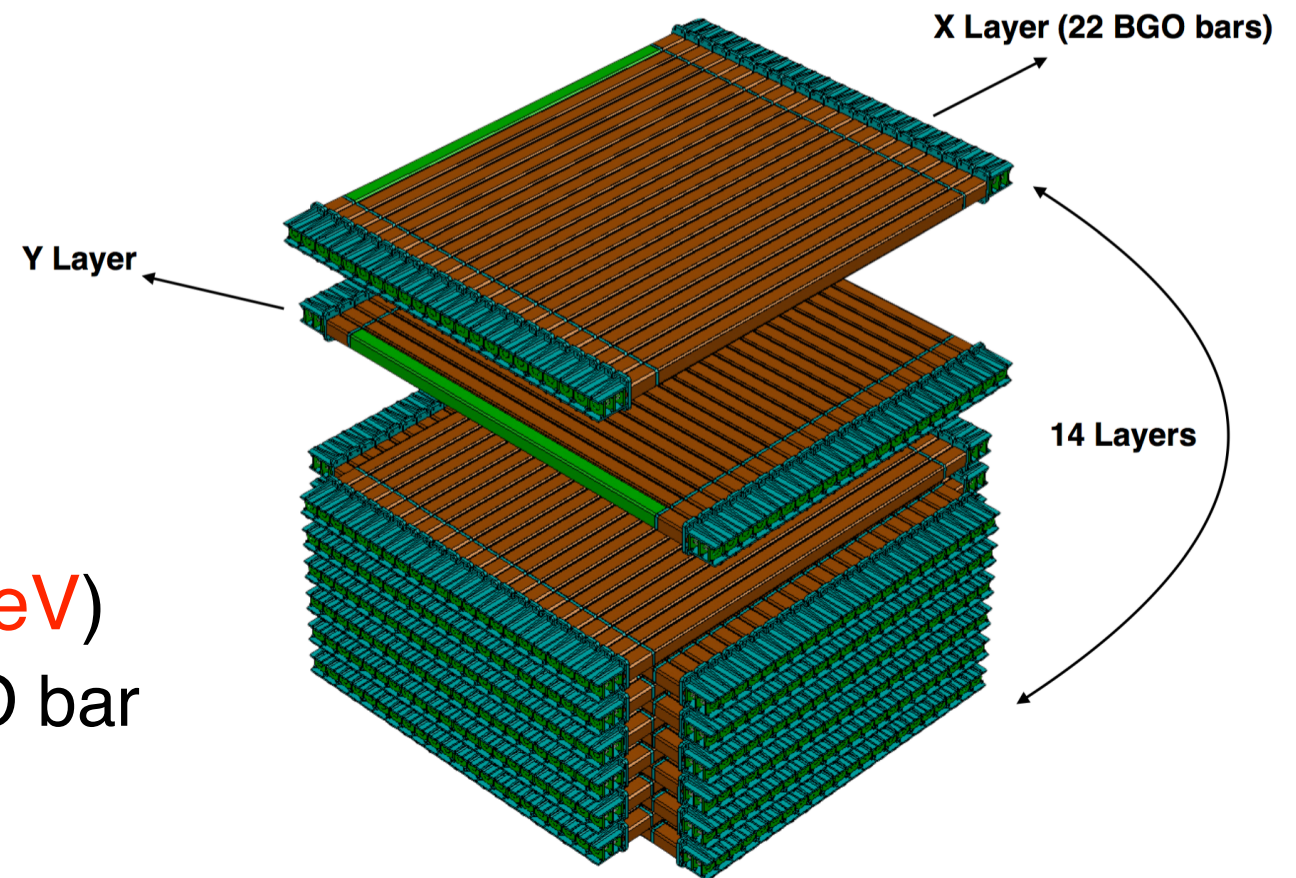
- Charge measurement (dE/dx in PSD, STK)
- Gamma-ray converting and tracking (STK + BGO)
- Precise energy measurement (BGO)
- Hadron rejection (BGO + NUD)

(Chang et al. Astropart.Phys. 95 (2017) 6–24)



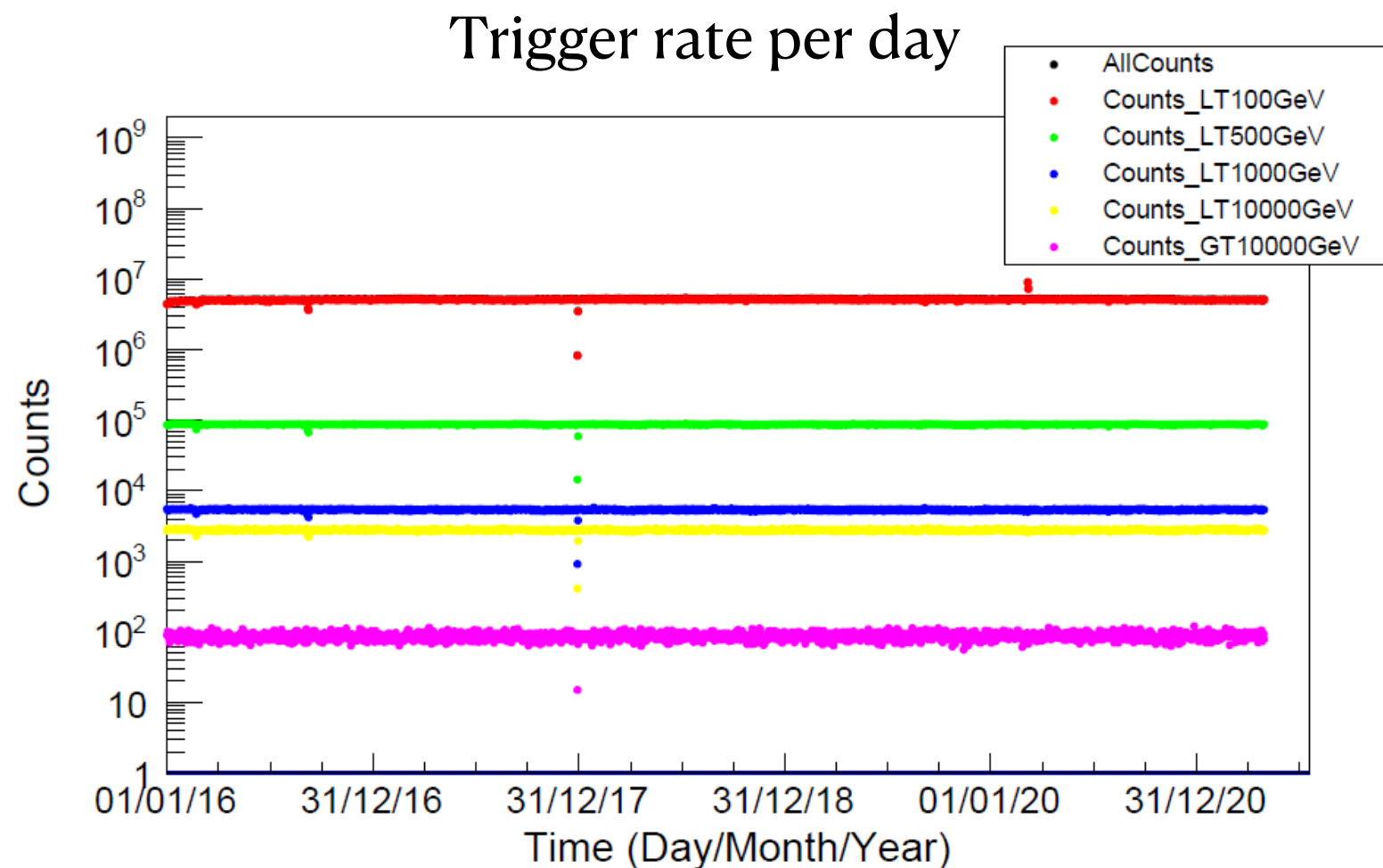
BGO Calorimeter

- 308 BGO bars ($25 \times 25 \times 600 \text{ mm}^3$)
- 14 layers, 22 bars per layer
- Depth: $32 X_0$, $1.6 \lambda_I$
- Energy resolution:
 - 1.5% @ 800 GeV for e/ γ
 - $\sim 30\%$ for hadron
- Large dynamic range ($5 \text{ GeV} - 10 \text{ TeV}$)
 - Two-end measurement of one BGO bar
 - Multi-dynode readout of one PMT
- Providing trigger



Overview Performance

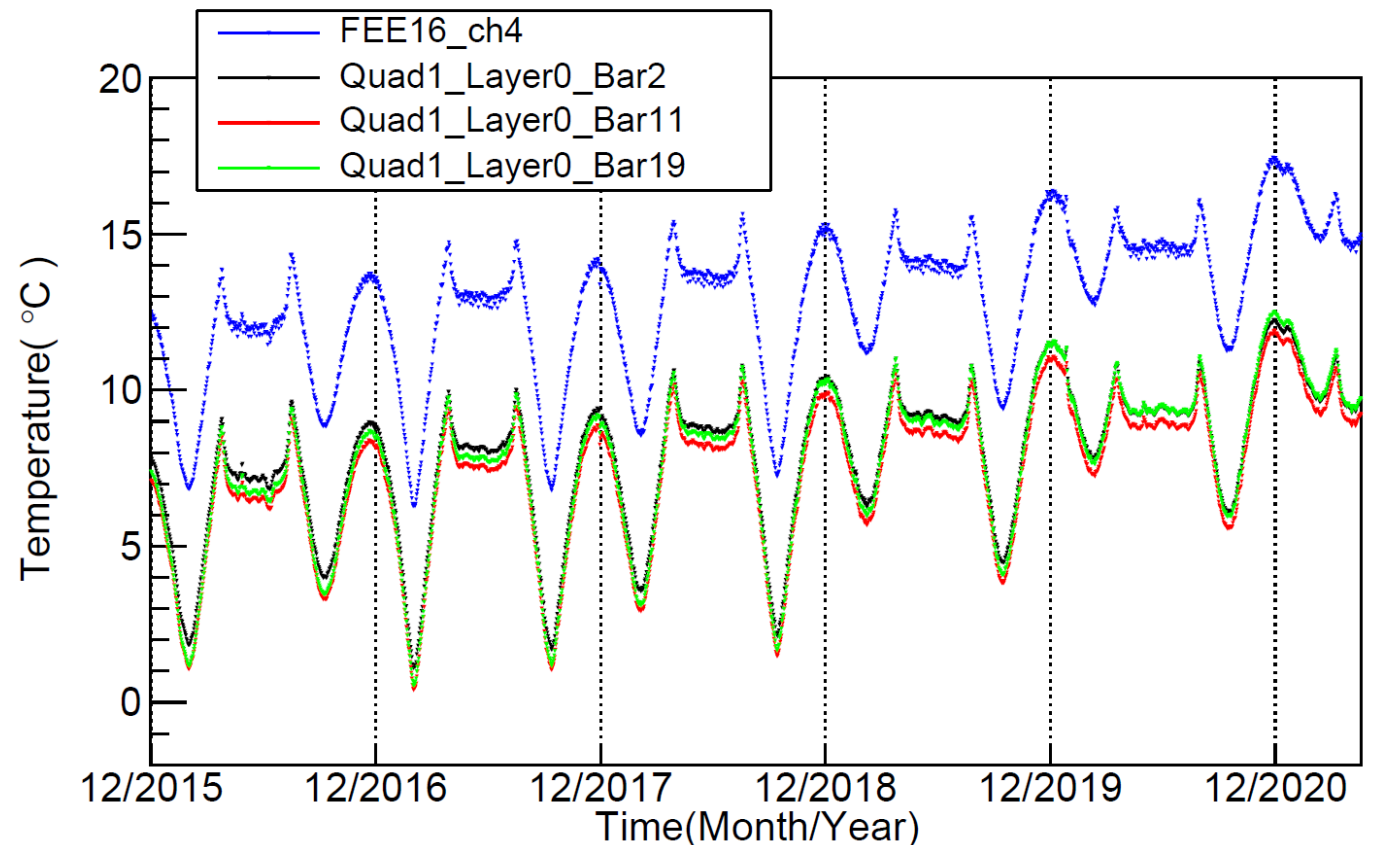
- The BGO calorimeter has been operating on-orbit for 5.5 years
- Time interval: 2016/01/01 - 2021/06/01
- **5 million** events are acquired every data, in which averagely **90 events** are **beyond 10 TeV**



Overview Performance

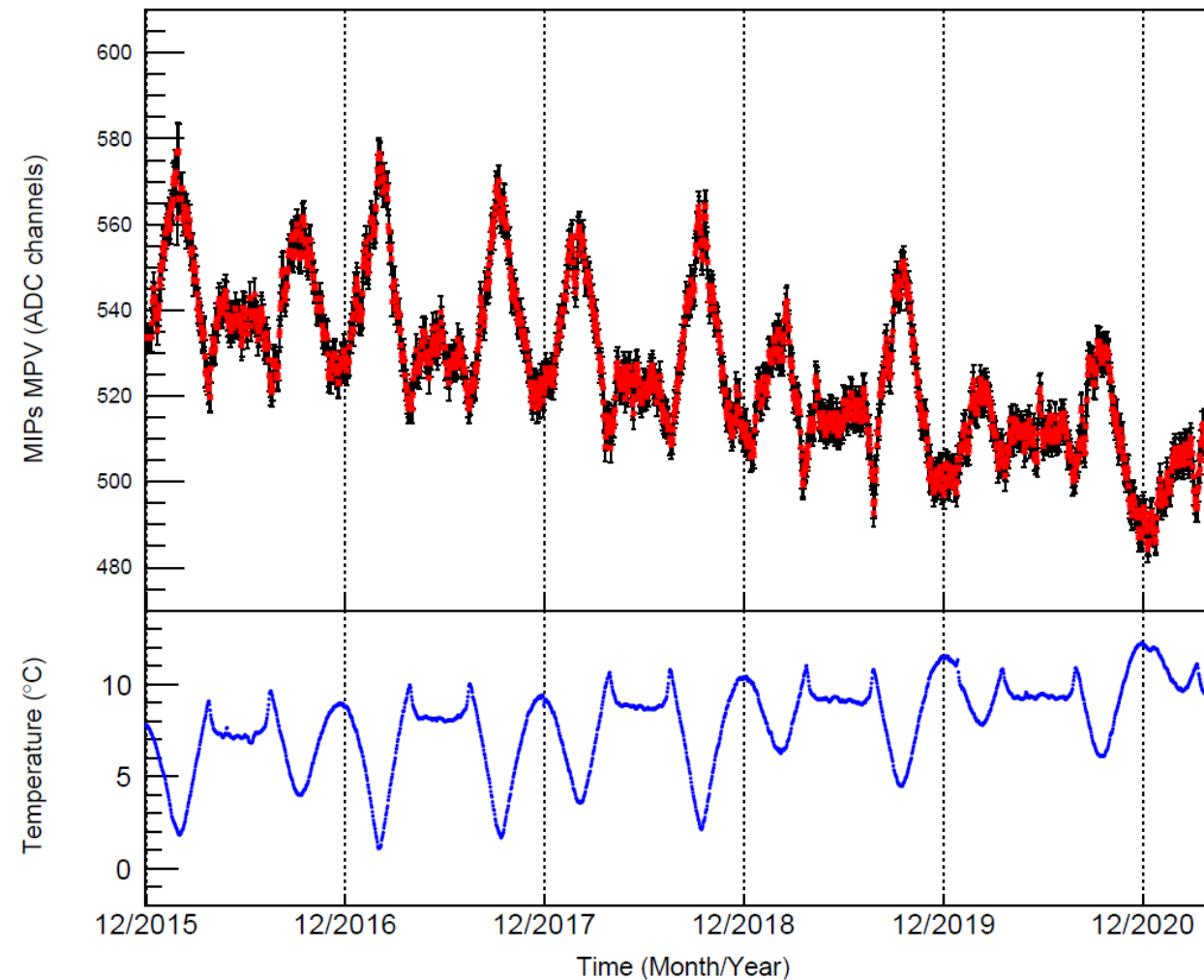
- Temperature is **one of the most important factors** which affects the detector performances on-orbit
 - Daily temperature variation is **$\sim 0.1^{\circ}\text{C}$**
 - Temperature **varies periodically** with the change of the solar illumination angle
 - Temperature showed an upward trend because of the **aging of satellite thermal insulation materials**

Daily temperature variation



Status of Detector Units

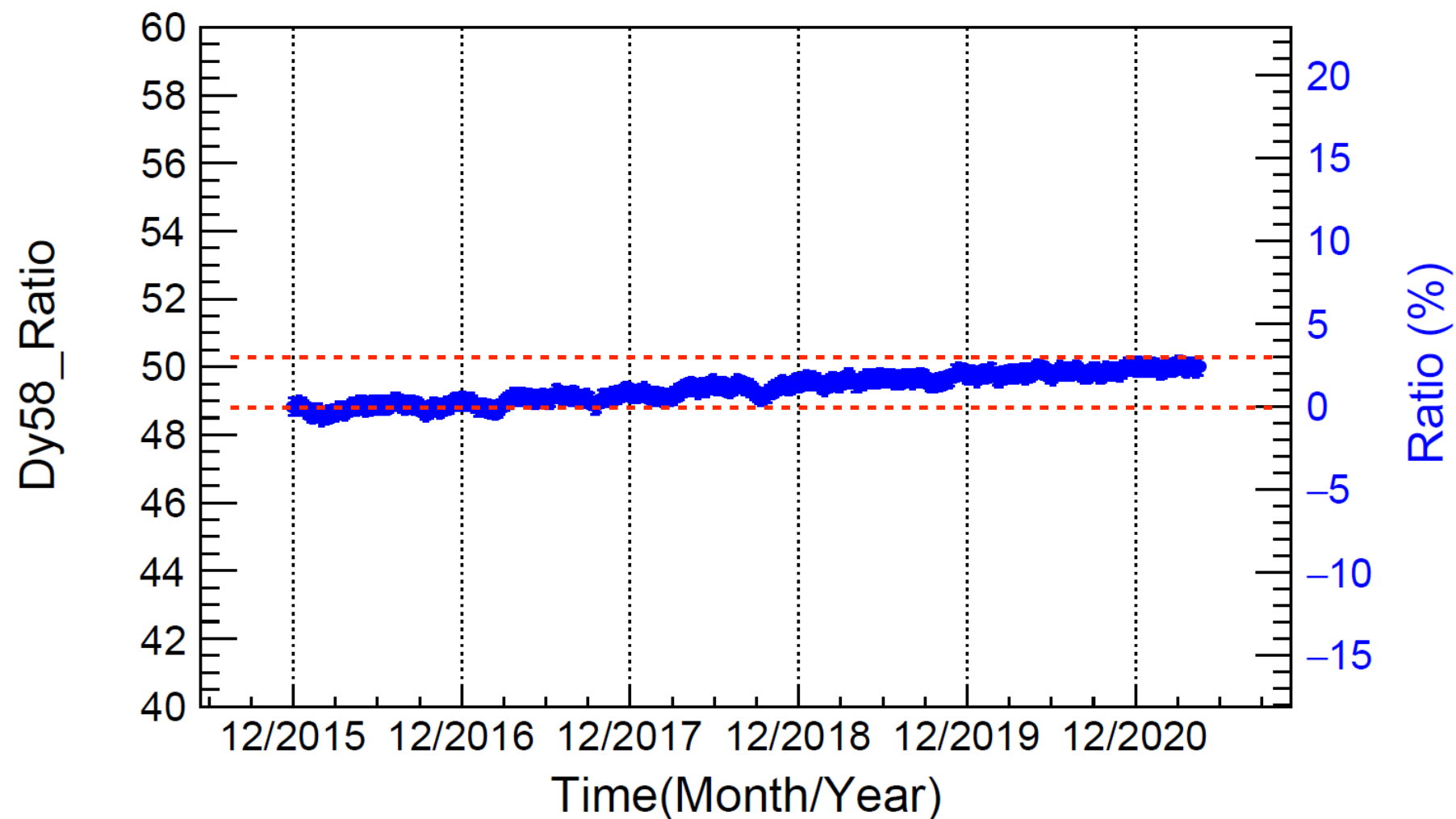
Energy scale calibration with CR proton MIPs



- The MIPs MPV value and the temperature are roughly **anti-correlated** due to the temperature effect on the **light yield of BGO crystals**
- The MIPs calibration is performed very frequently to correct the temperature effect

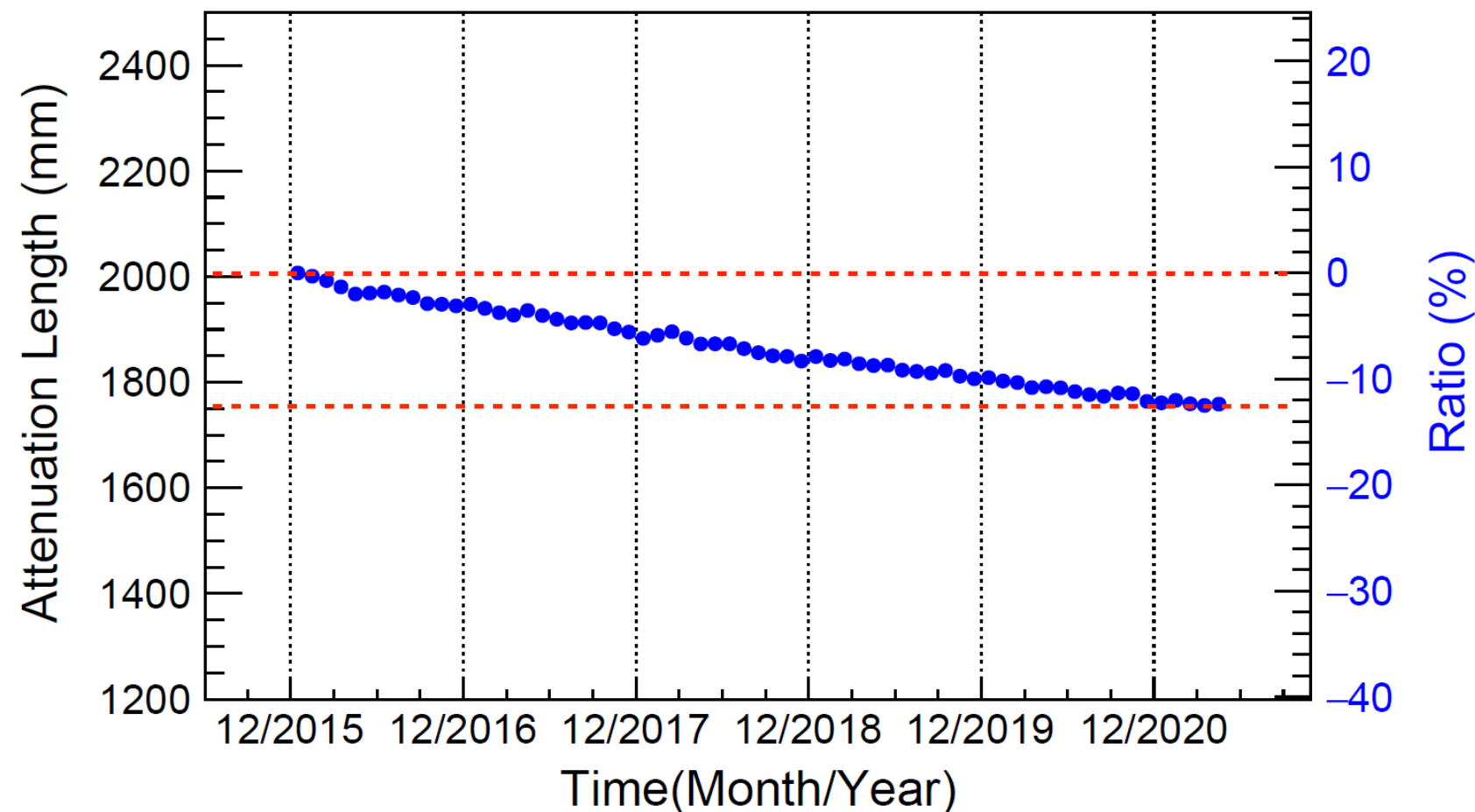
Status of Detector Units

- Most channels of PMT gains have slightly increased/decreased for several percent in whole operation time

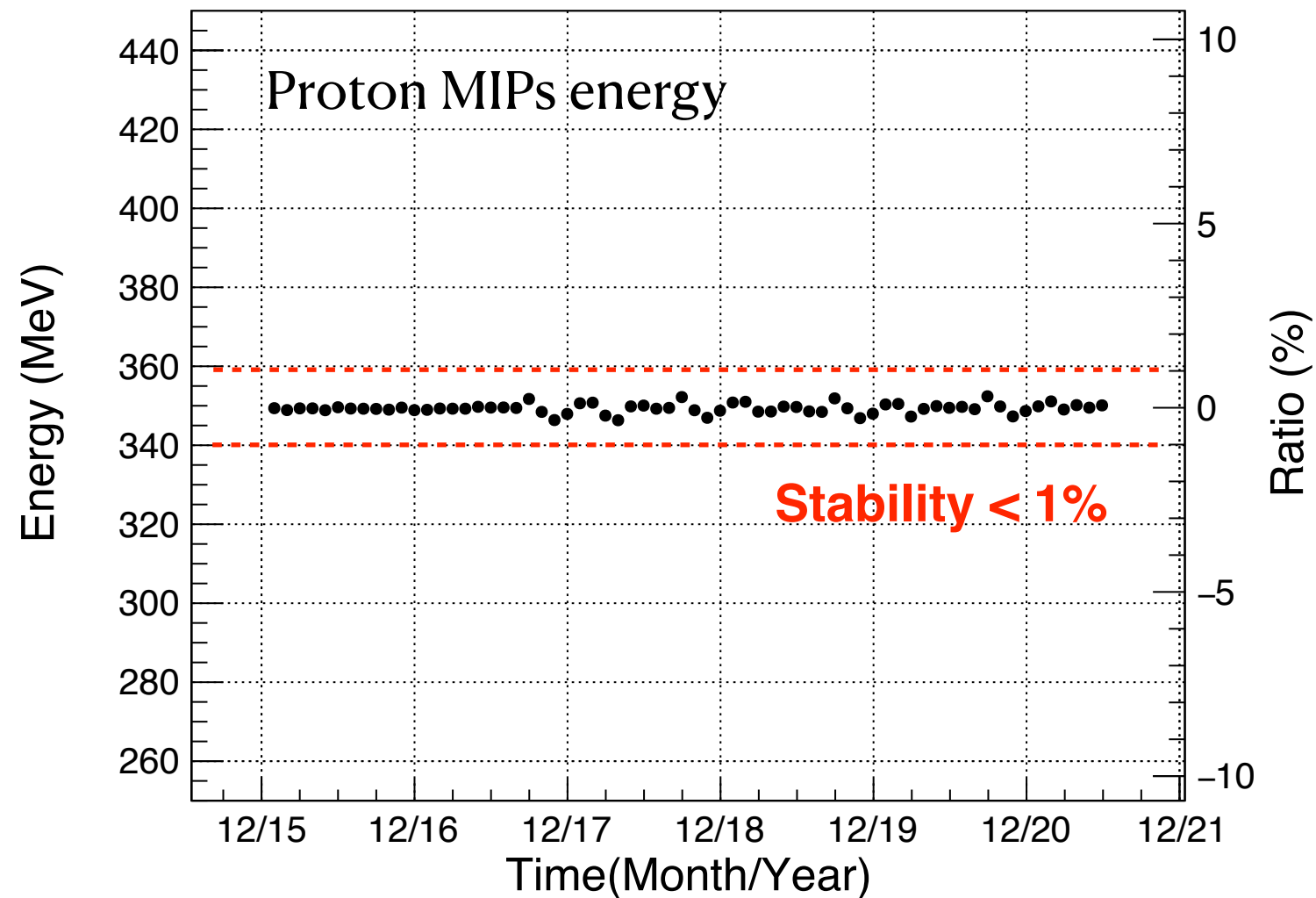


Status of Detector Units

- Radiation dose expectation: 20k rad for 3 years
- The attenuation lengths of the long BGO bars reduce for **over 10 %** due to the crystal **aging in the radiation environment**
- Scintillation Light attenuates **5%** more than before when it pass through a 60 cm BGO crystal bar

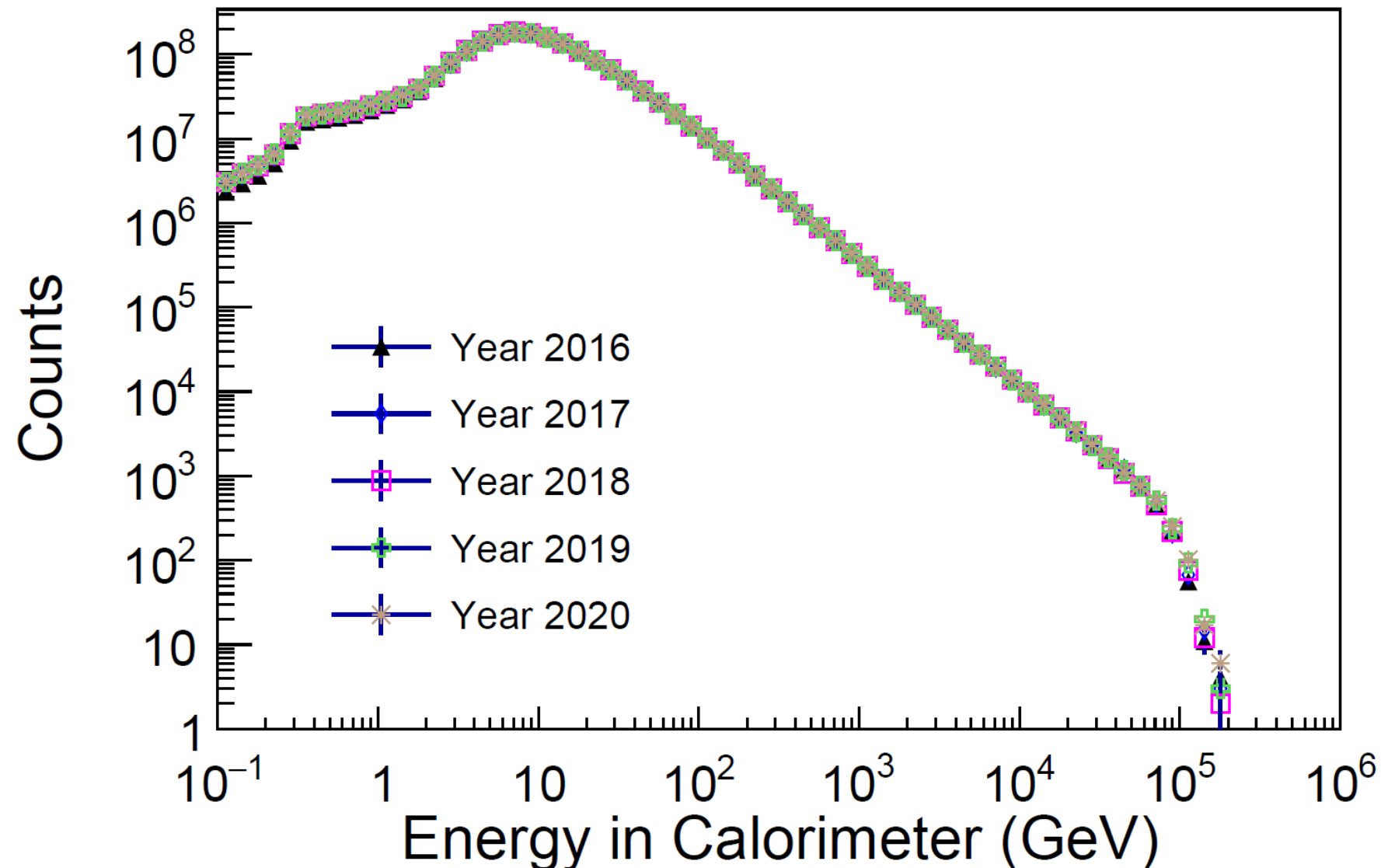


Energy Reconstruction



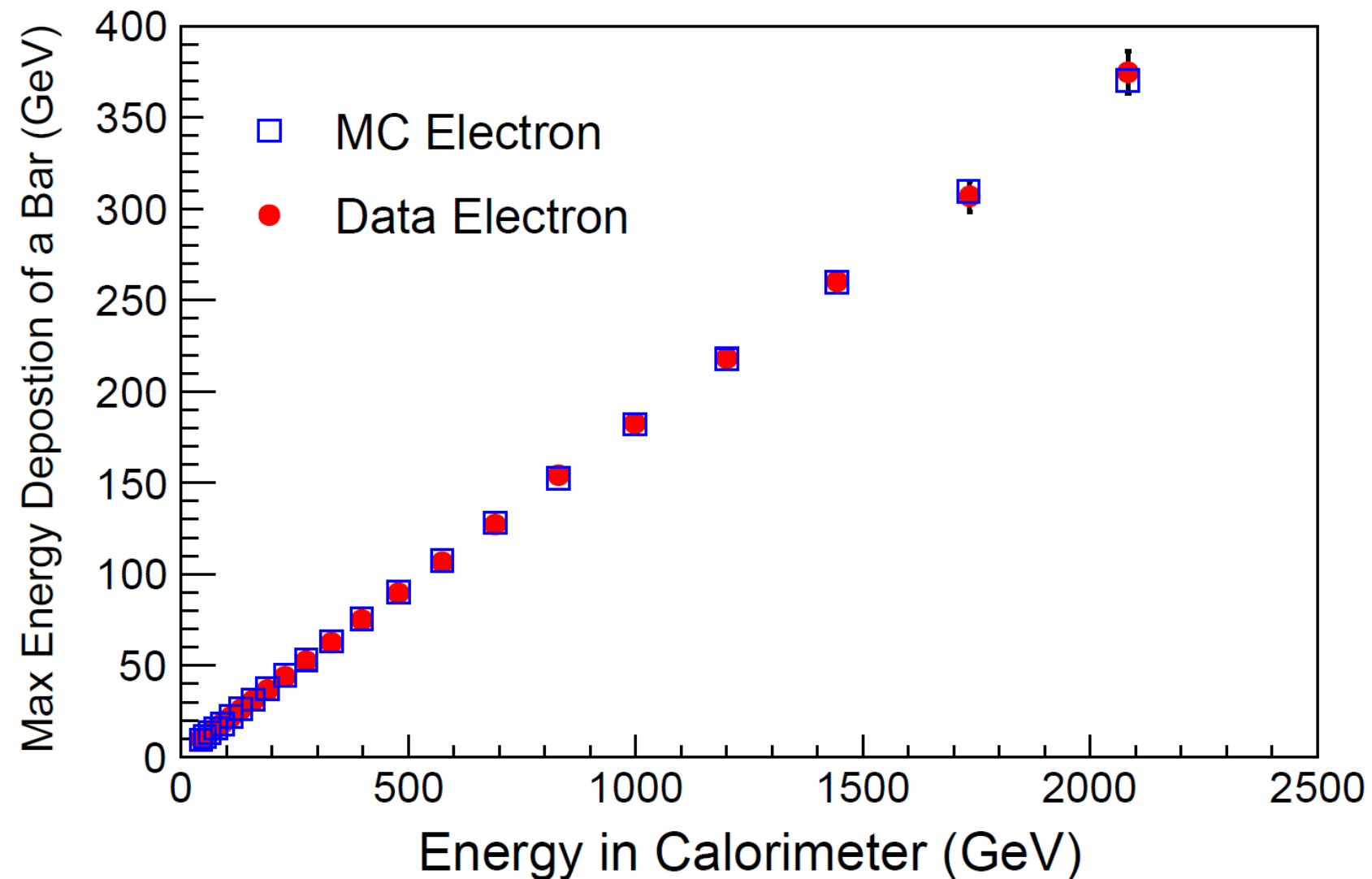
- After temperature correction, Proton MIPs energy reconstruction stability is **better than 1%**

Energy Reconstruction



- The raw energy spectrum reconstructed with different years' data show a **good consistency**
- Calibration procedure **works well for correcting aging and environmental effects**

Energy Reconstruction



- The energy deposition in electromagnetic shower center is investigated with MC simulation
- Fluorescence saturation of BGO is not observed up to 2.5 TeV

Summary

- DAMPE calorimeter has been working on orbit for 5.5 years
- Detector units are in good working order
- Calibration and energy reconstruction procedures work well for producing high-quality scientific data

Thank you !