Observation of time evolution of cosmic ray electron and positron flux with the Dark Matter Particle Explorer

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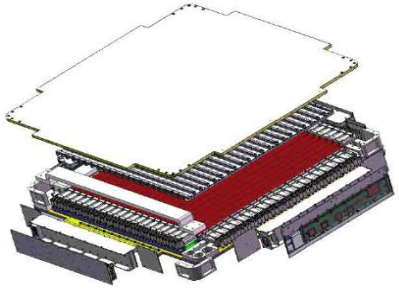
Introduction

Current status of measurements of the time evolution of GCRs

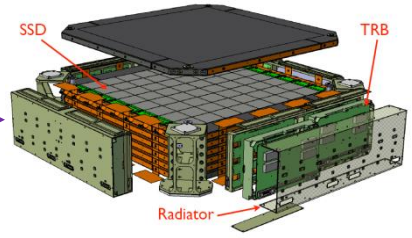
- **Cosmic ray electron and positron (CRE) flux is modulated by the solar cycle, precise measurement of time evolution of CRE helps to understand the particle transport and interaction in the heliosphere.**
- **Indirect monitor: ground-based neutron monitors* and muon telescopes** *: http://cosmicrays.oulu.fi/
  - **Advantages: high time resolution (hour level)**
  - **Disadvantages: low energy resolution, no particle species**
- **Direct measurement: PAMELA(arXiv:1801.07112), AMS02(PRL 121 (2018) 051101, PRL 121(2018) 051102)**
  - **Advantages: high energy resolution, H-He-e species**
  - **Disadvantages: low time resolution (days level)**

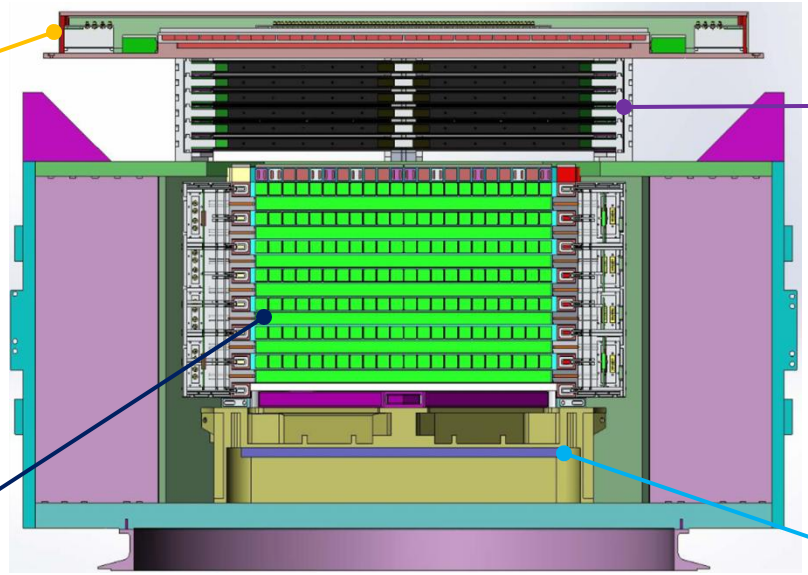
DAMPE Detectors

Plastic Scintillator Detector(PSD)
- γ anticoincidence
- Z-measurement

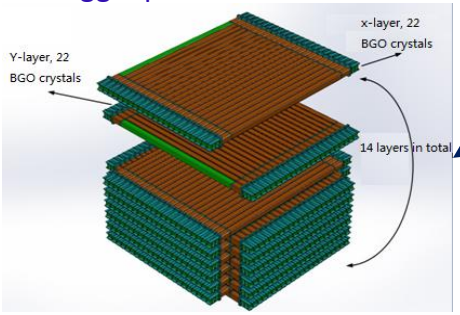


Silicon Tungsten Tracker(STK)
- γ convertor, particle track
- Z-measurement

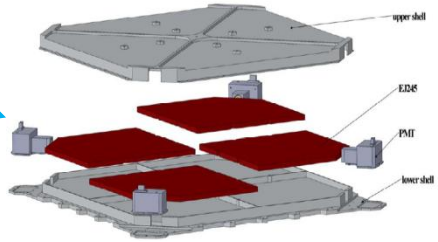




BGO Calorimeter(BGO)
- Calorimeter ($32X_0$&$1.6\lambda_I$)
- e/p separation
- Trigger primitives

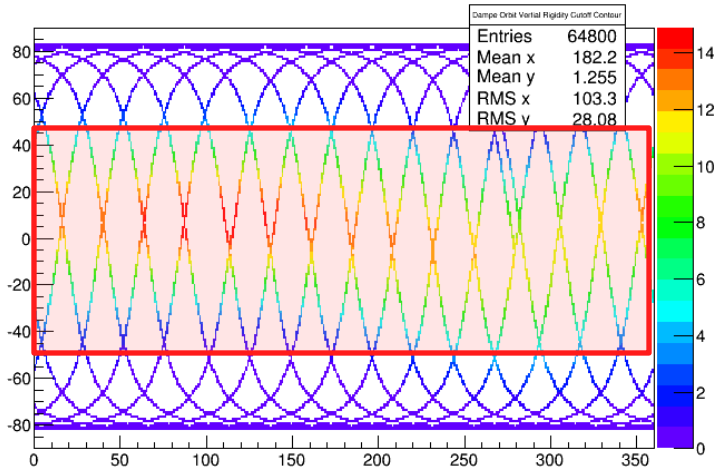


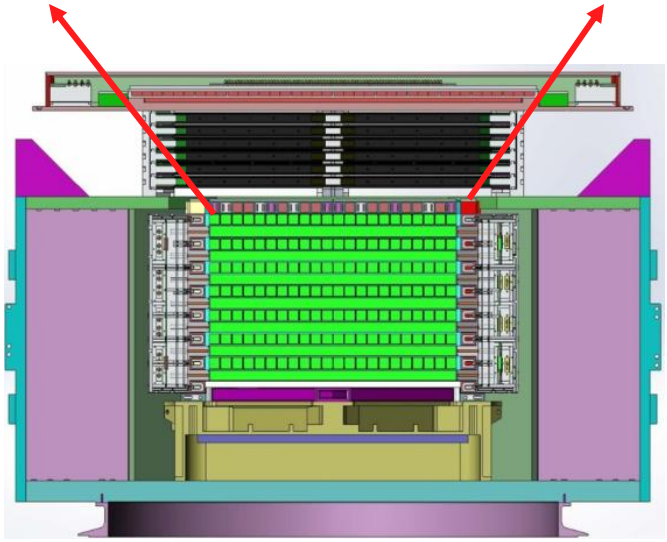
Neutron Detector(NUD)
- e/p separation



More details can be found at arXiv:1706.08453

Two advantages of DAMPE on measurement of variation of CRE





Orbit inclination 97°

reach polar region, limit affect from geomagnetic rigidity cutoff.

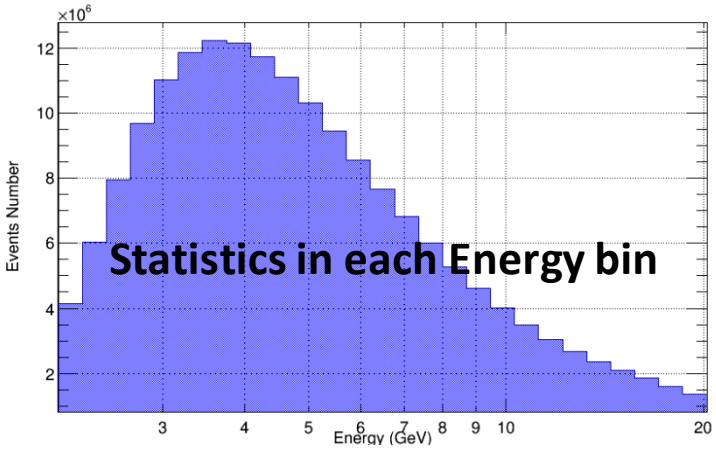
Large acceptance (~0.35 m^2sr for CRE)

Collect sufficient statistic within several hours.

Data Analysis

Flight Data pre-selections

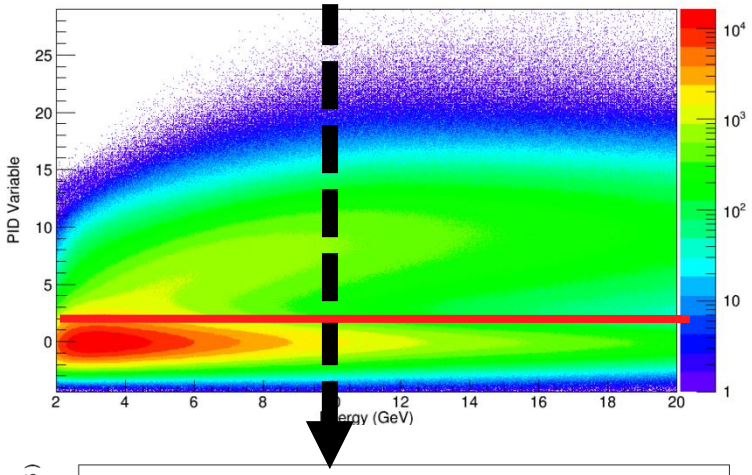
- 2016/04/01 to 2019/06/30 (**1185**days, **6.5B** events in total)
- Pre-selections:
  1. Exclude SAA events
  2. High Energy Trigger or LET Energy Trigger
  3. Charge Selection to reject heavy nuclei and photons
  4. Good containment of shower development in BGO
  5. Interested energy [2, 20] GeV
  6. Low edge of energy bin > 1.2*Vertical rigidity cutoff



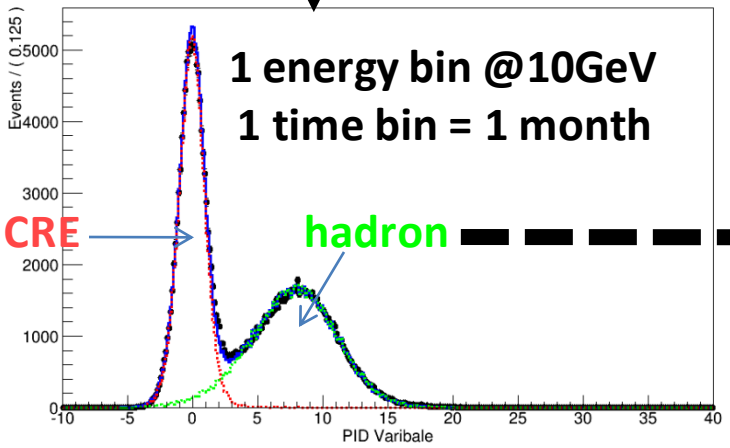
Efficiency of pre-selection is determined by MC and validated with flight data.

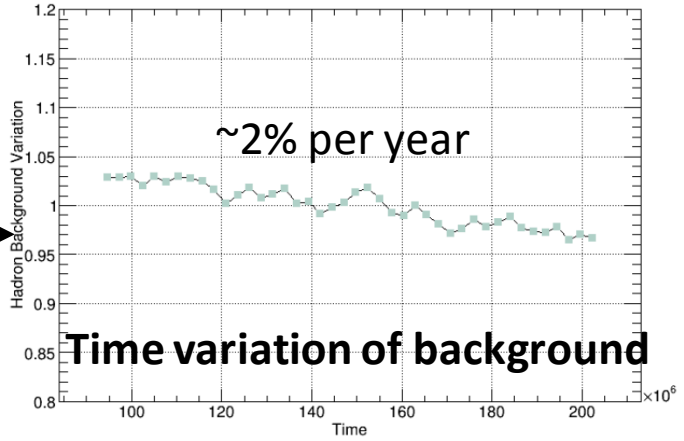
Particle Identification

$$PID = F(E)\left[\log(rmsr)\sin(\theta) + \log(rmsl)\cos(\theta)\right]$$



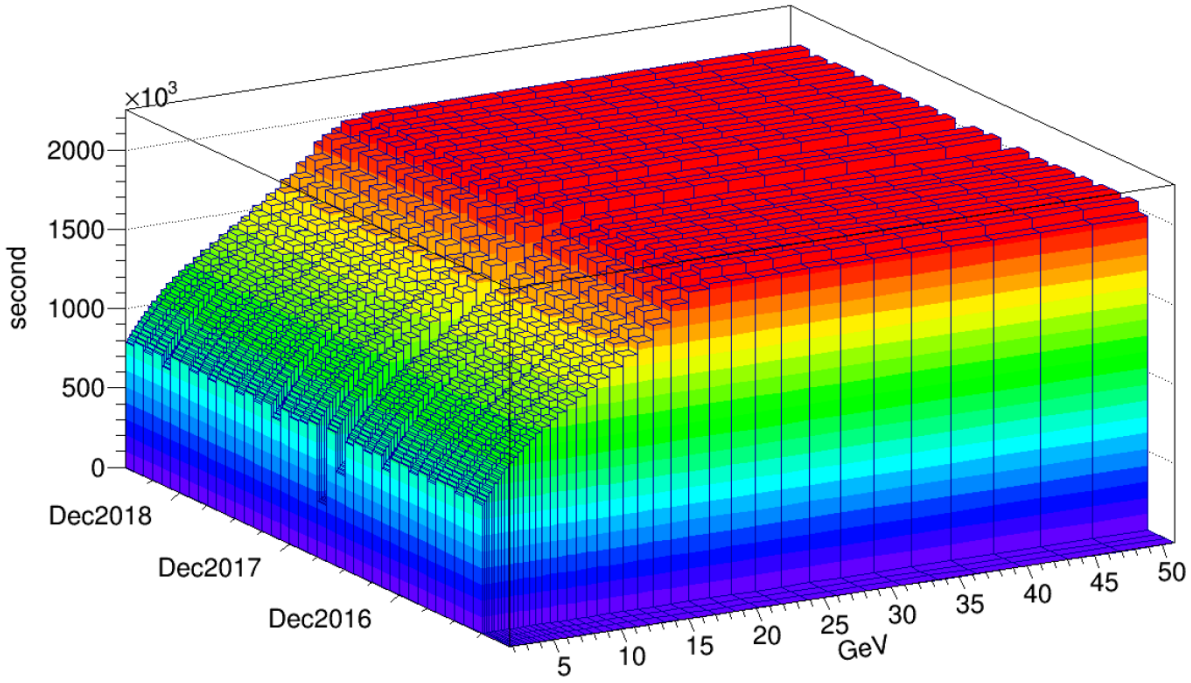
Hadron background is estimated based on the shower development in each energy bin and each time bin





Exposure Time

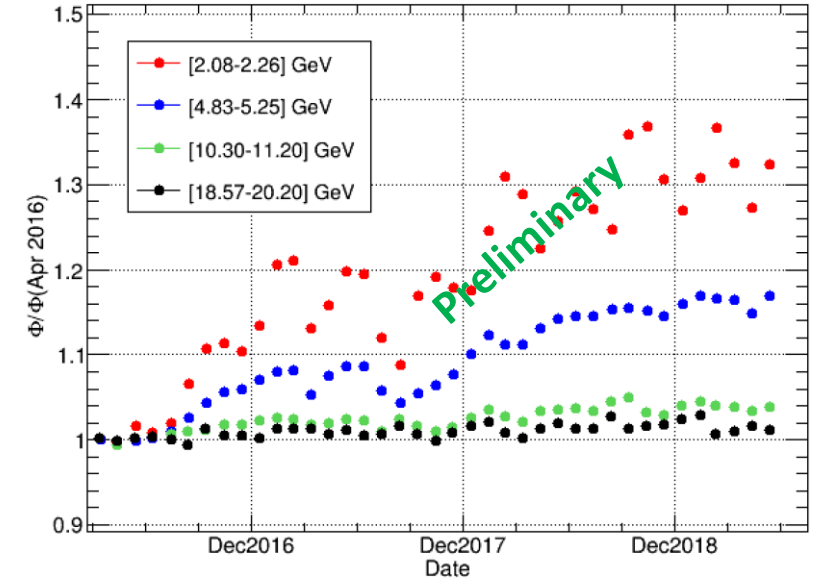
- Exposure time is calculated by adding DAMPE operation time in the regions with VRC < 1/1.2 * low edge of the energy bin,
- Subtract time in SAA, dead time of DAQ and calibration time

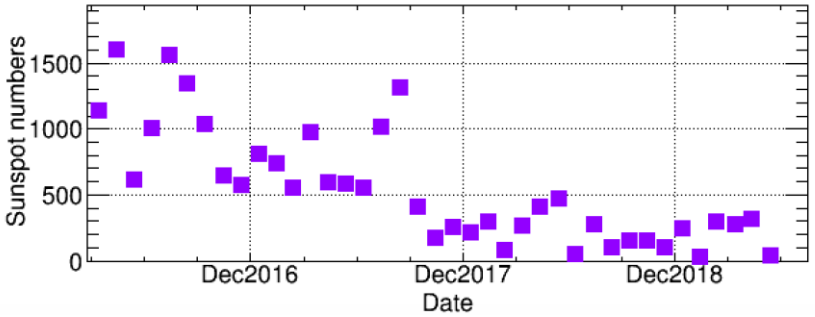


Results

Time variation of CRE fluxes

$$\Phi_{j,i} = \frac{N_{j,i}(1-\sigma_{j,i})}{A\eta_{j,i}\Delta T_j \Delta E_i},$$





Sunspot numbers

Monthly variation of CRE fluxes in four typical energy bins. Error bars (too small to be visible) are statistical errors only.

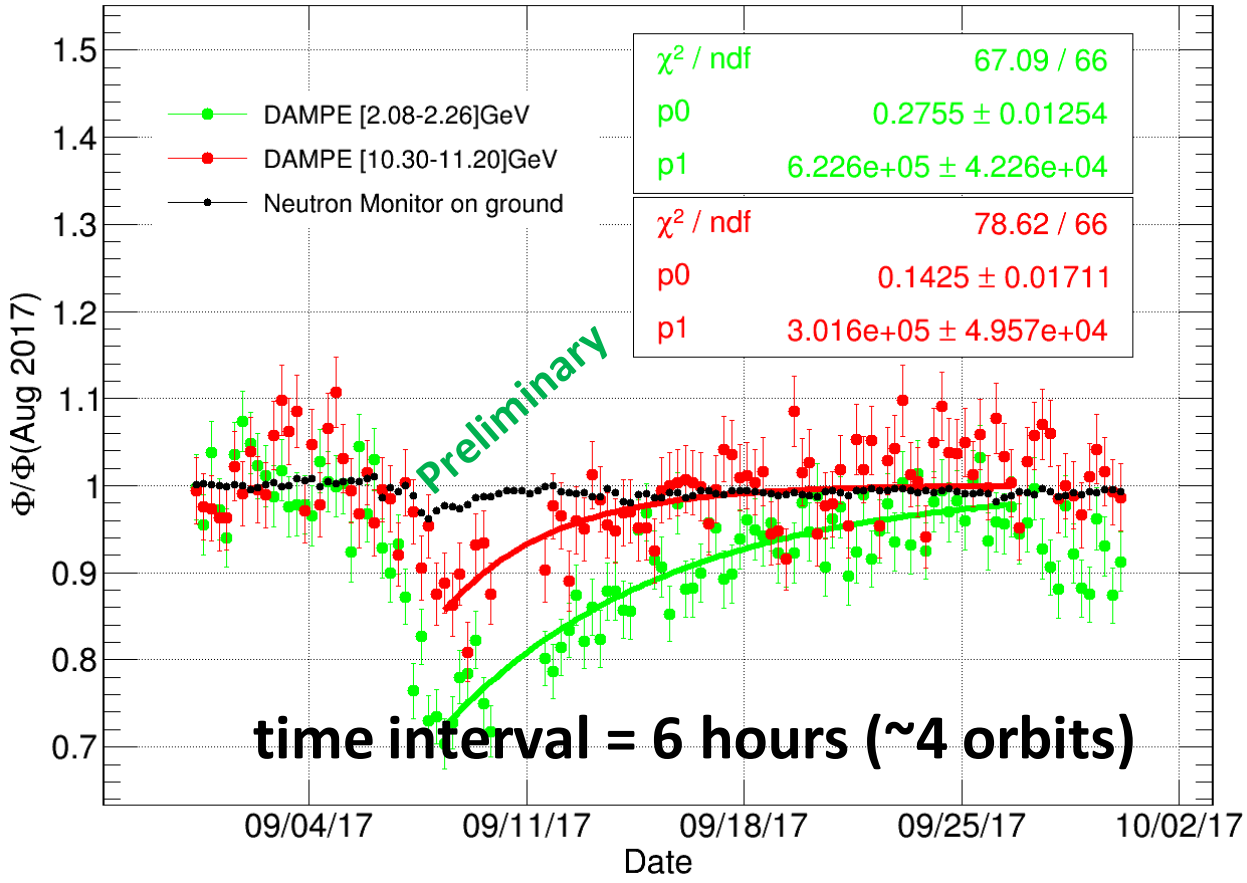
An overall trend that the CRE fluxes increase with time is clearly seen below 10 GeV.

Above 10 GeV, the CRE fluxes is less affected by the solar activities

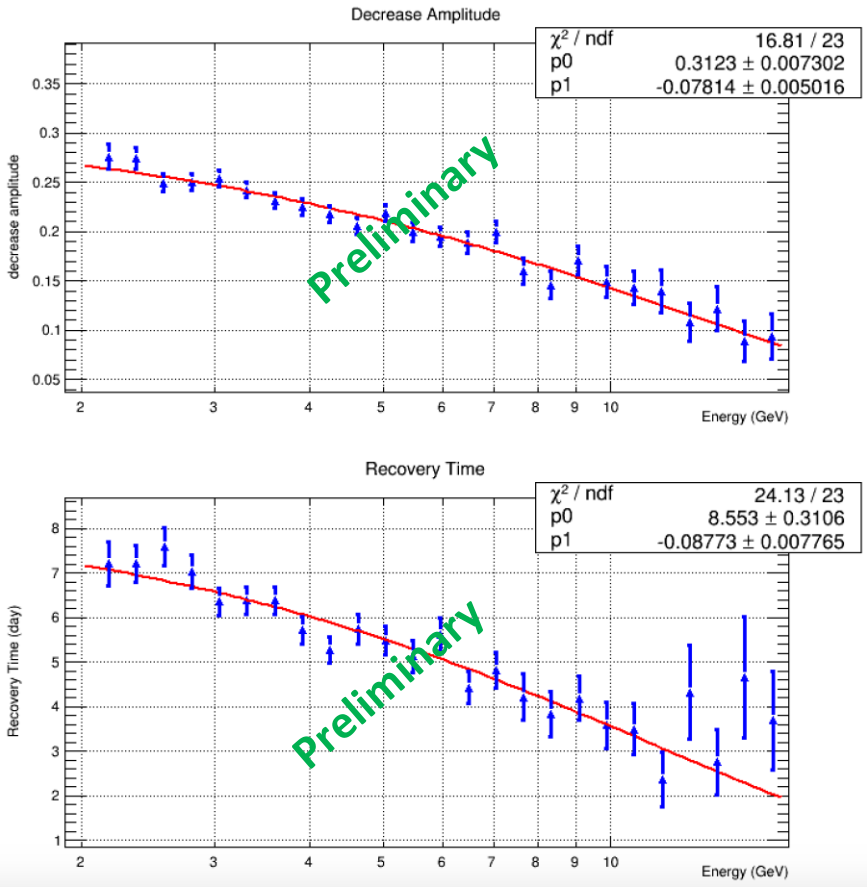
Forbush Decrease of CRE fluxes

$$R_\Phi = 1 - p_0 \exp[(t - t_0)/p_1]$$

p_0 is decease amplitude , p_1 is recovery time



Decrease Amplitude & Recovery Time



Both decrease amplitude and recovery time are well fitted by an exponential function $y = p_0 exp(p_1 x)$

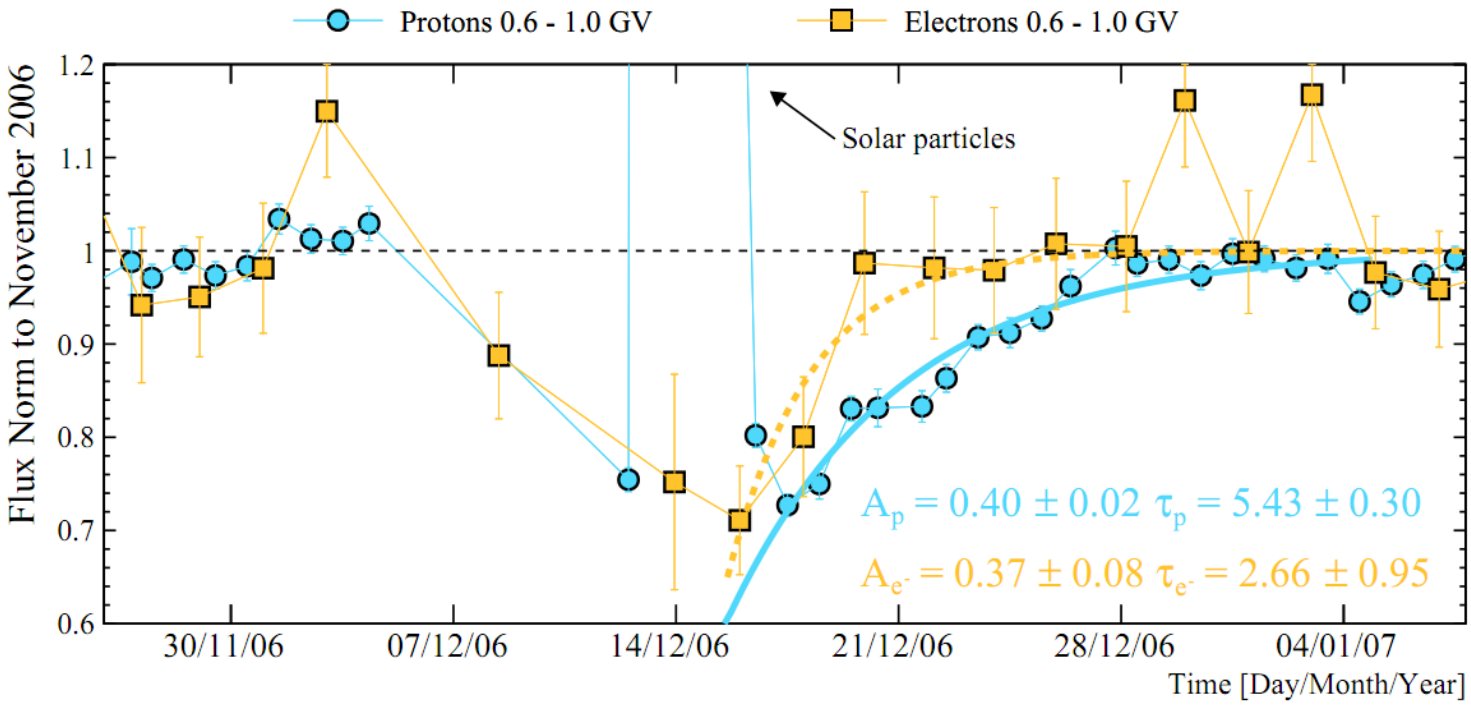
Summary

- Monthly evolution of CRE fluxes is studied with more than three years of DAMPE data.
- An overall anti-correlation between the CRE fluxes and the solar activities is observed.
- With a time resolution of 6 hours, time profiles of CRE fluxes of a FD event on September 7, 2017 are obtained, recovery time and decrease amplitude decrease with energy.
- This analysis illustrates that the DAMPE is well suitable to study the time variation of CRE fluxes with high energy resolution and time resolution.

Thanks

Backup slides

Forbush Decrease of CRE fluxes with PAMELA



PAMELA 2006 48h for each point

arXiv: 1801.07112