ISCRA 2019

PAMELA a Payload for Antimatter Matter Exploration and Light–nuclei Astrophysics

TeVs electrons and positrons measured by PAMELA spectrometer

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For PAMELA collaboration

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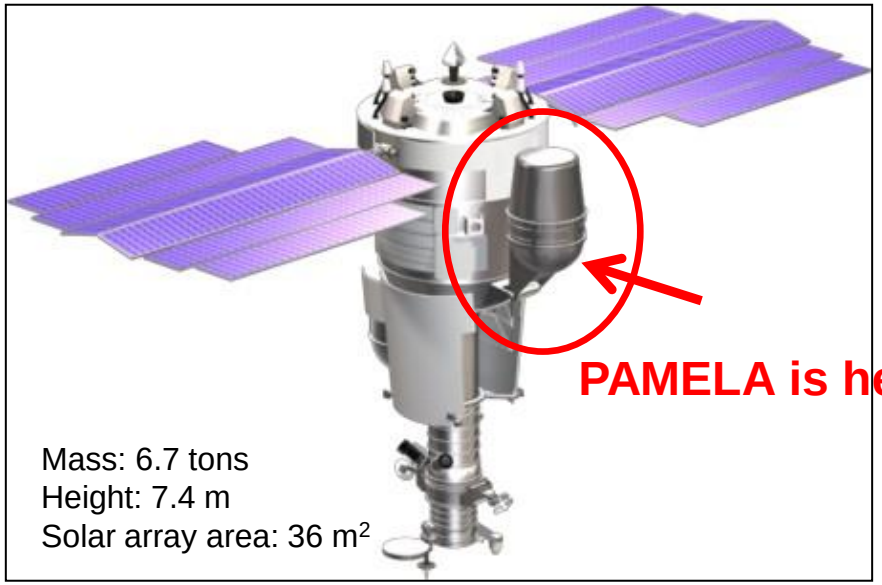
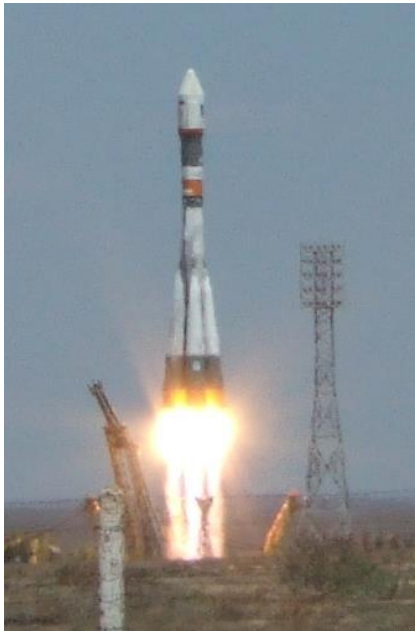
The PAMELA Experiment

Resurs DK satellite





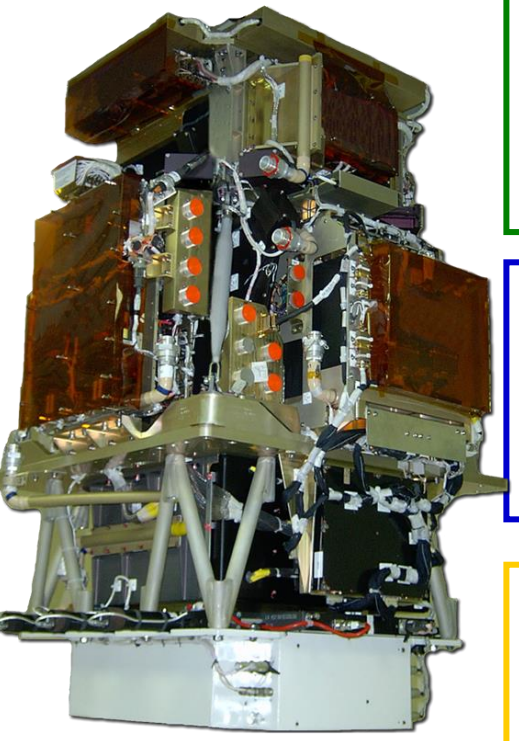
Satellite was launched 15.06.2006 on elliptical polar orbit with inclination 70^0, altitude 350-610km. Circular orbit with altitude ~570km from September 2010

Since July 2006 till January 2016:
~3700 days of data taking (~80%)
~55 TByte of raw data downlinked
~$9 \cdot 10^9$ triggers recorded and analyzed

Trigger rate **~25Hz** (outside radiation belts)
Event size (compressed mode) ~ **5kB**
25 Hz x 5 kB/ev → **~ 10 GB/day**

PAMELA instrument

Main requirements → high-sensitivity antiparticle identification and precise momentum measure

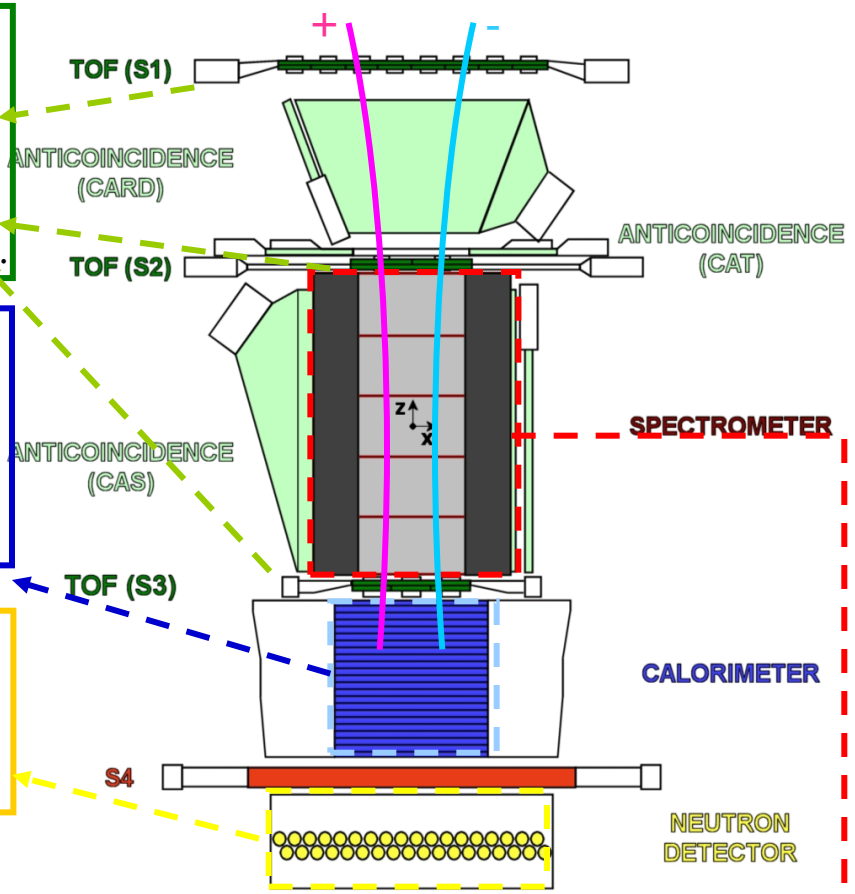


GF: 21.5 cm^2 sr
Mass: 470 kg
Size: 130x70x70 cm^3
Power Budget: 360W

Time-Of-Flight
plastic scintillators + PMT:
- Trigger
- Albedo rejection;
- Mass identification up to 1 GeV;
- Charge identification from dE/dX.

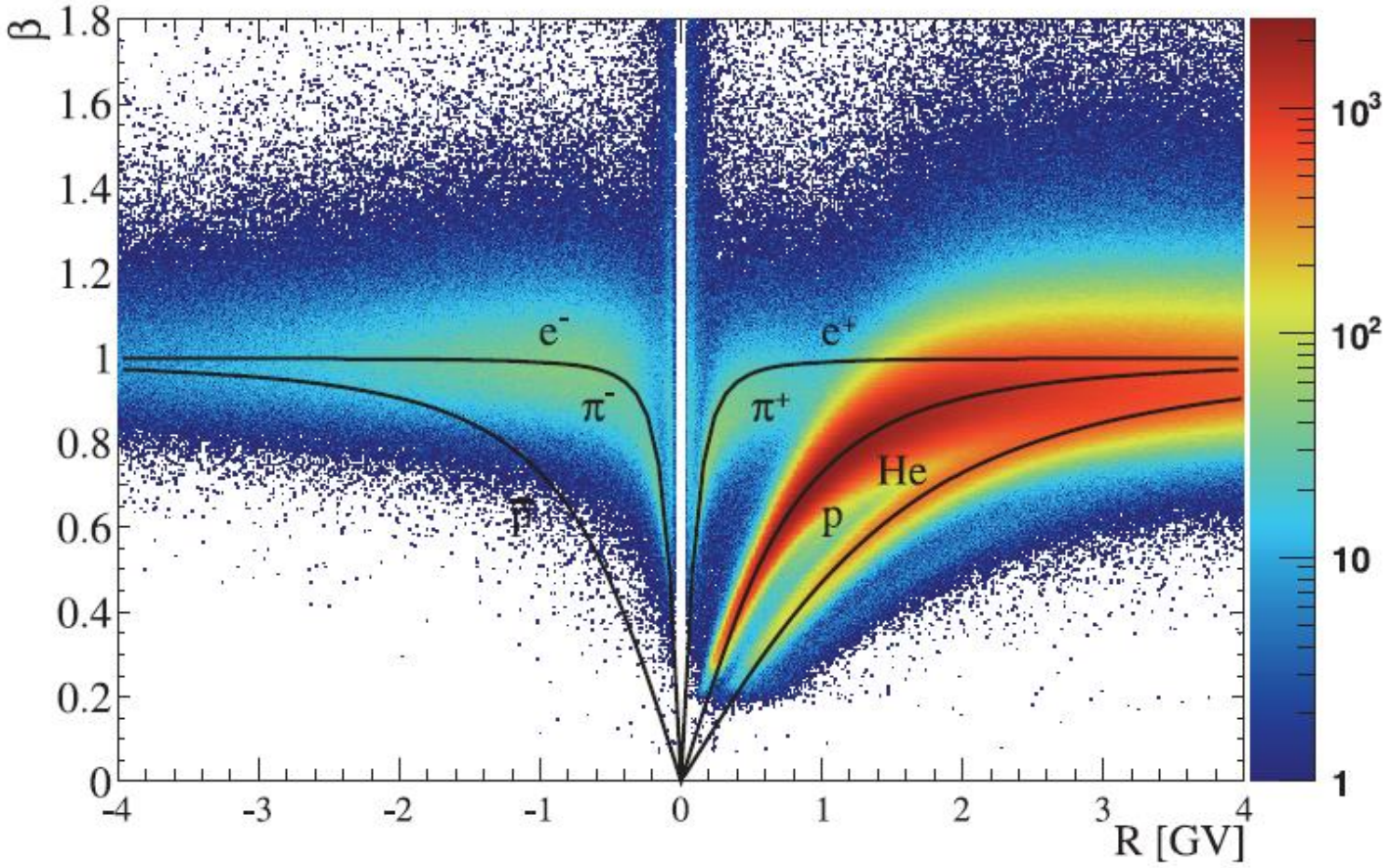
Electromagnetic calorimeter
W/Si sampling (16.3 X_0, 0.6 λI)
- Discrimination e+ / p, anti-p / e$^-$ (shower topology)
- Direct E measurement for e$^-$

Neutron detector
^{3}He tubes + polyethylene moderator:
- High-energy e/h discrimination



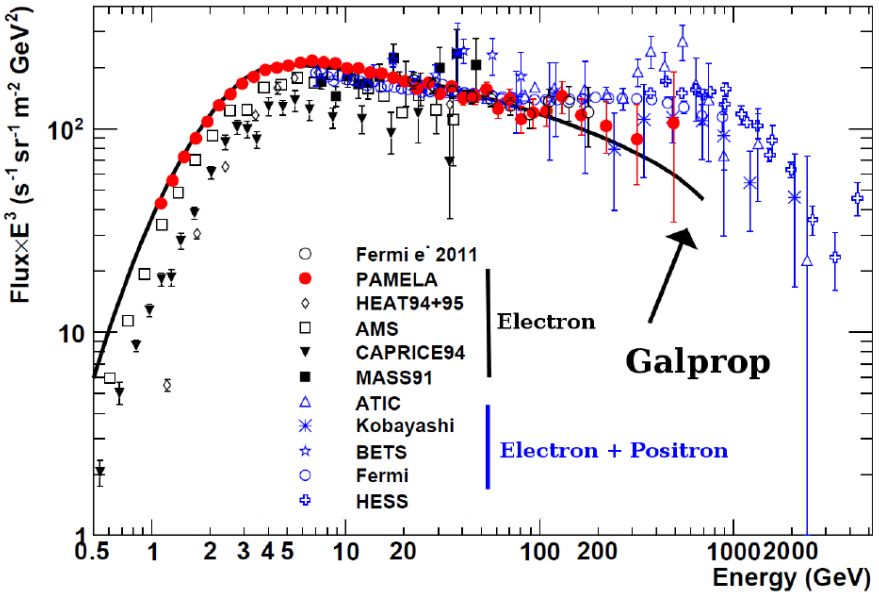
Spectrometer
microstrip silicon tracking system + permanent magnet
It provides:
- *Magnetic rigidity* → R = pc/Ze
- *Charge sign*
- *Charge value from dE/dx*

Particle identification at low energies



Beta vs rigidity plot : experimental data

Electron spectrum



Phys.Rev.Lett. 2011 (e-)

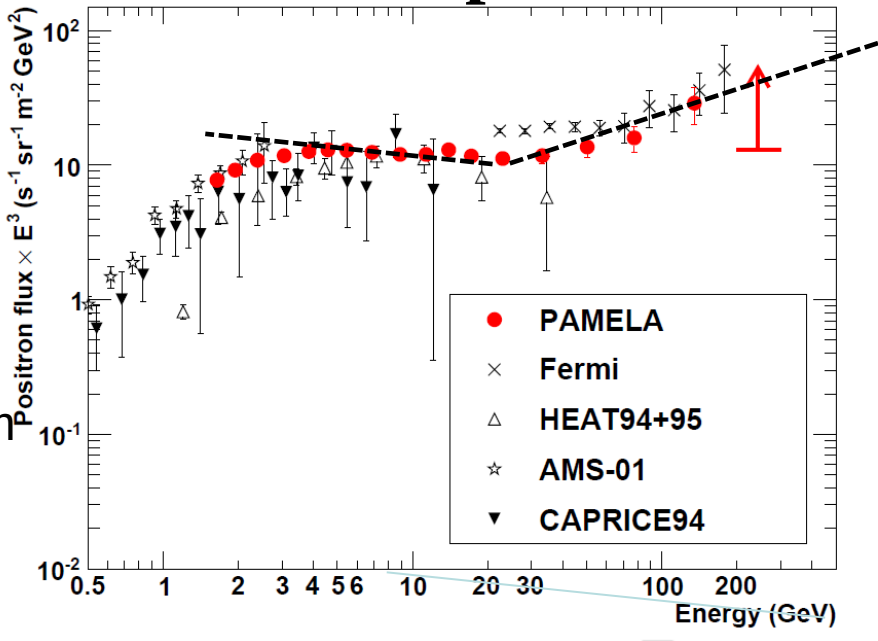
- First electron measurement above 50 GeV;
- Both (e-) (e+) spectra show some structure (breaks and bumps)
- Above ~10 GeV flatter than extrapolated from low energies.
- Concave shape in both e+&e- cases is clear indication of an additional component above ~10 GeV

- Cannot be reproduced with a single power-law injection spectrum
- Origin :

✓ Local astrophysical sources (pulsars)?

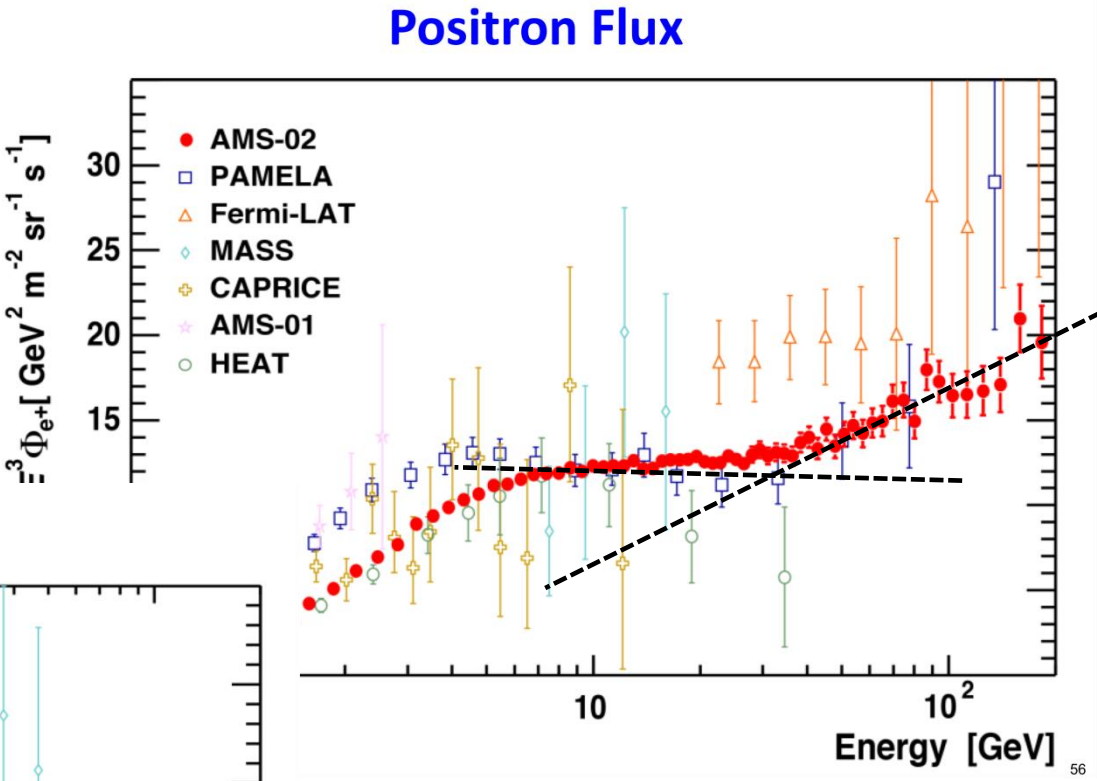
✓ Hard component?

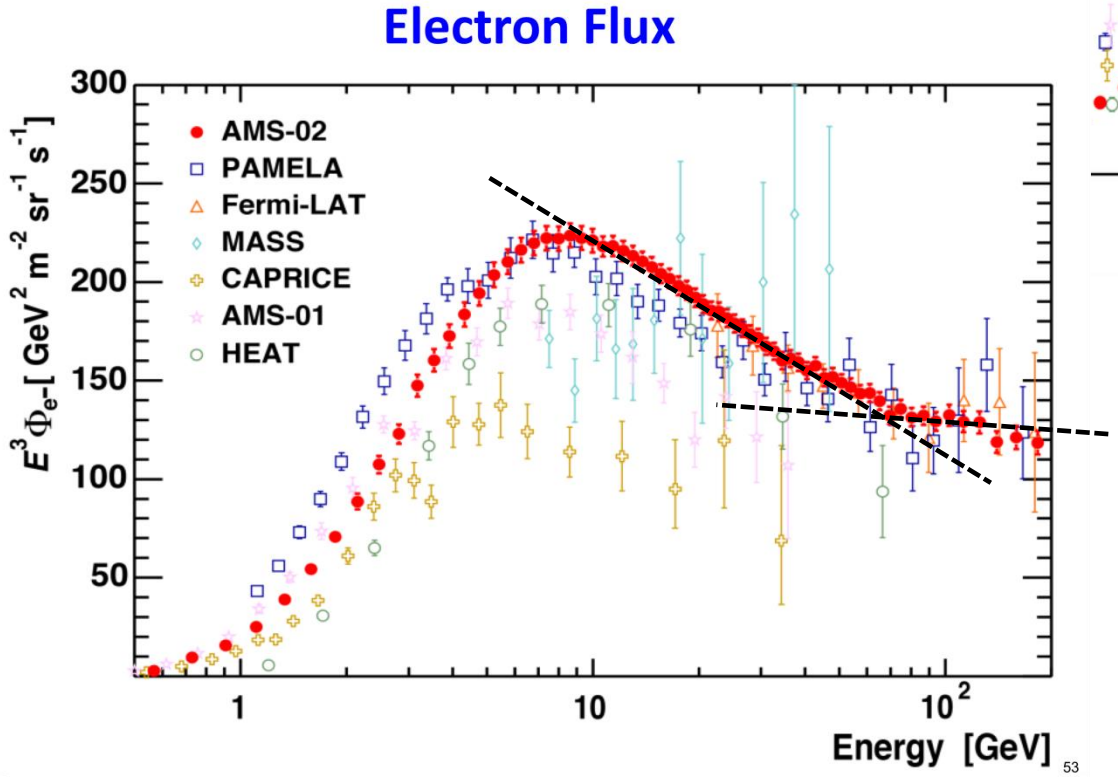
Positron spectrum



Phys Rev.Lett. 2013 (e+)

- AMS02 extended measurements to ~1000 GeV for e+ for very high statistic accuracy

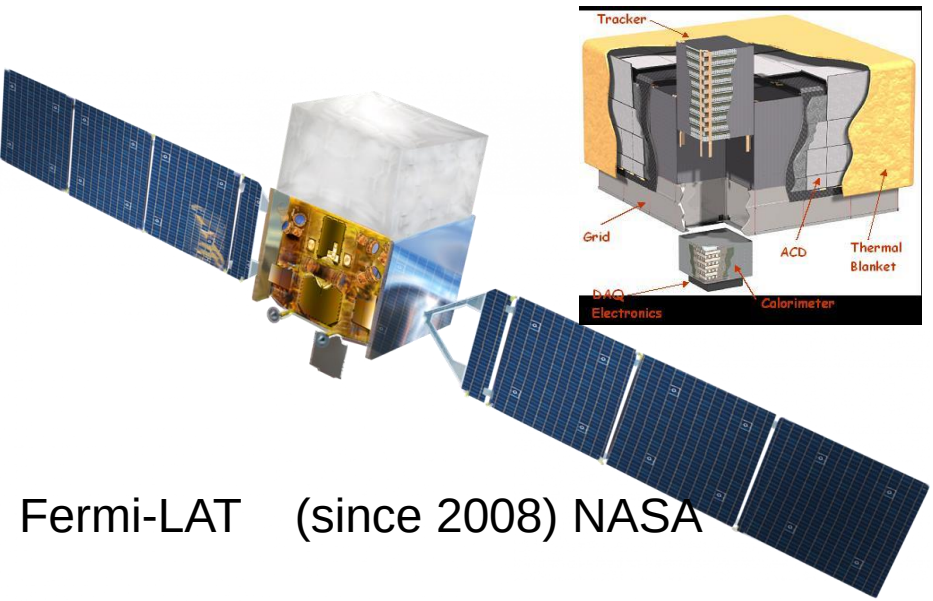




e+
AMS-02 collaboration
Phys. Rev. Lett. 113 (2014)
Phys. Rev. Lett. 122 (2019)

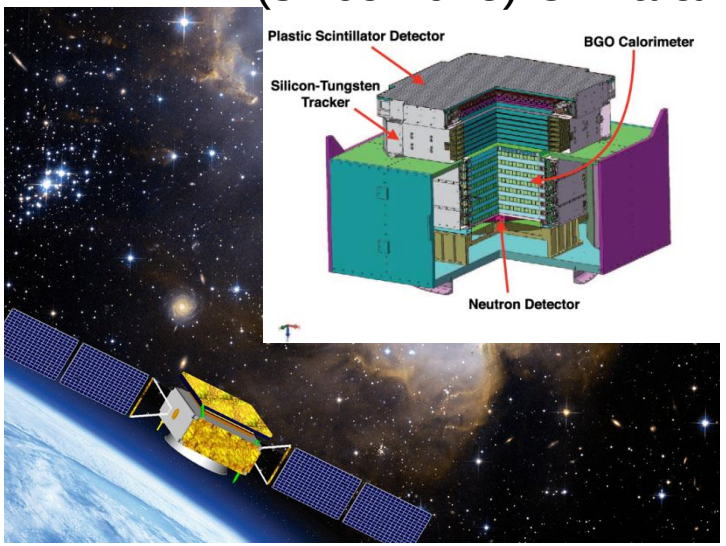
Fermi-LAT collaboration
Phys. Rev. Lett. 108 (2012)

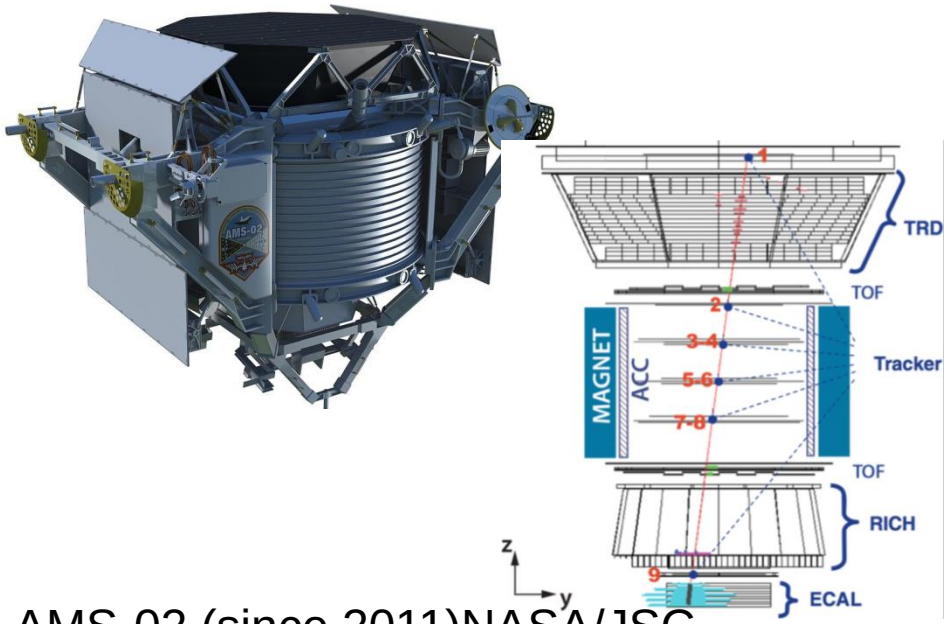
New generation space instruments



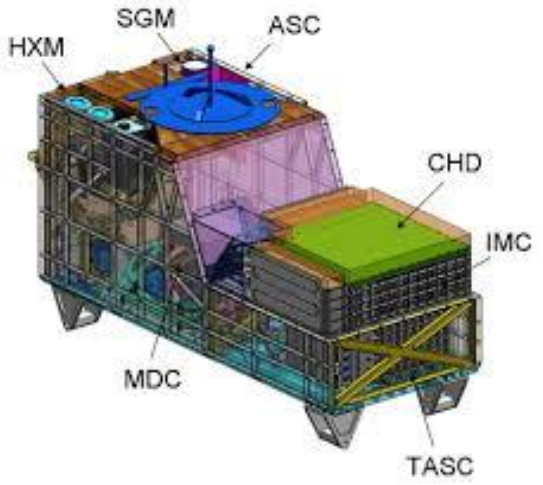
Fermi-LAT (since 2008) NASA

DAMPE (since 2015) China & ASI



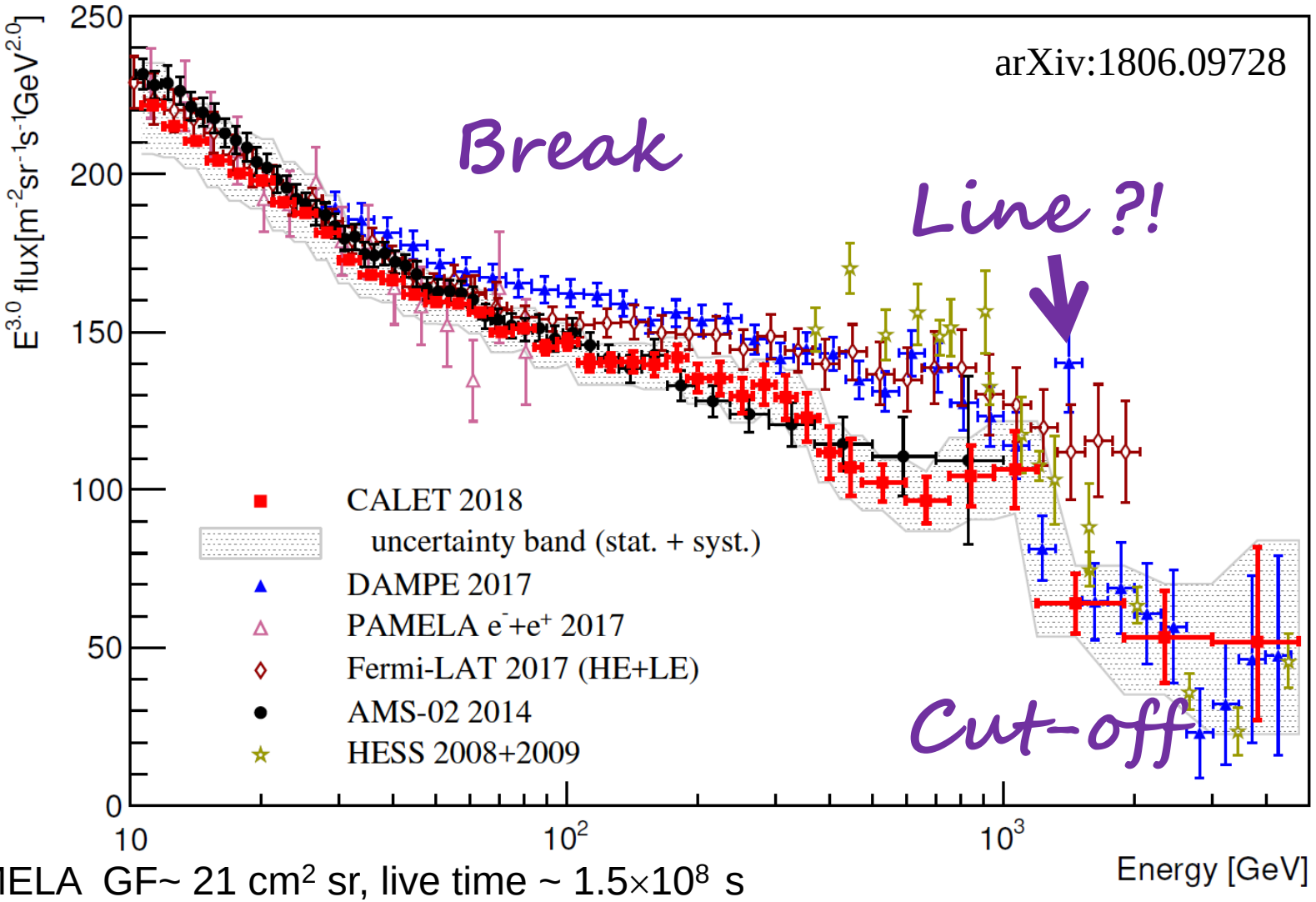


AMS-02 (since 2011)NASA/JSC



CALET (since 2015) ASI & NASA

Total electron + positron spectrum

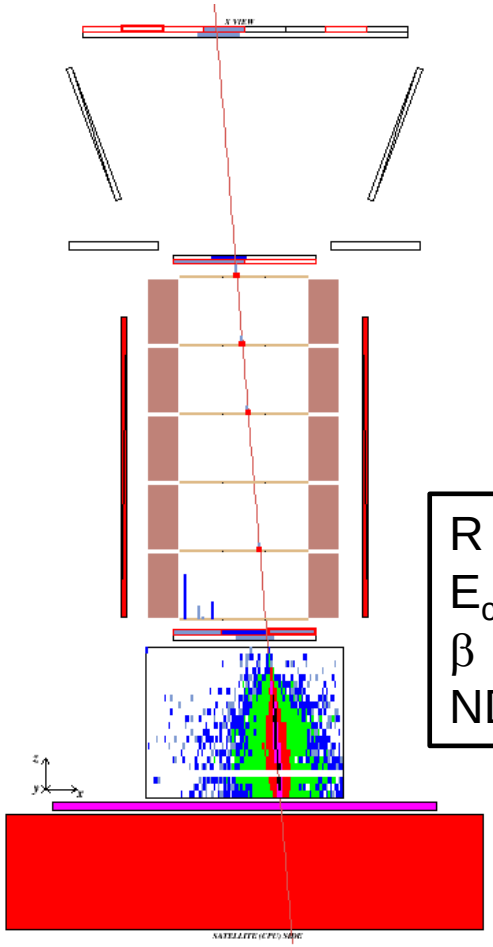


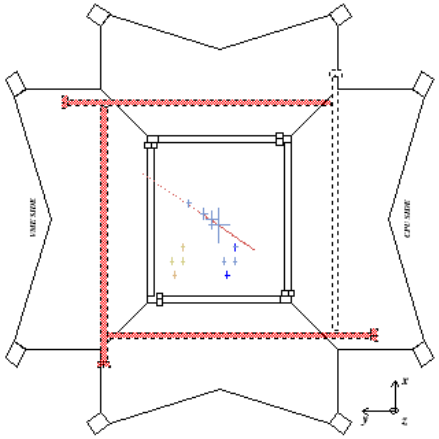
PAMELA GF~ 21 cm^2 sr, live time ~ 1.5×10^8 s

Expected number of detected events ~5000 with E>100GeV (DAMPE-Fermi-LAT flux)

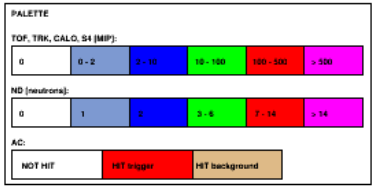
Expected number of selected events up to 2000

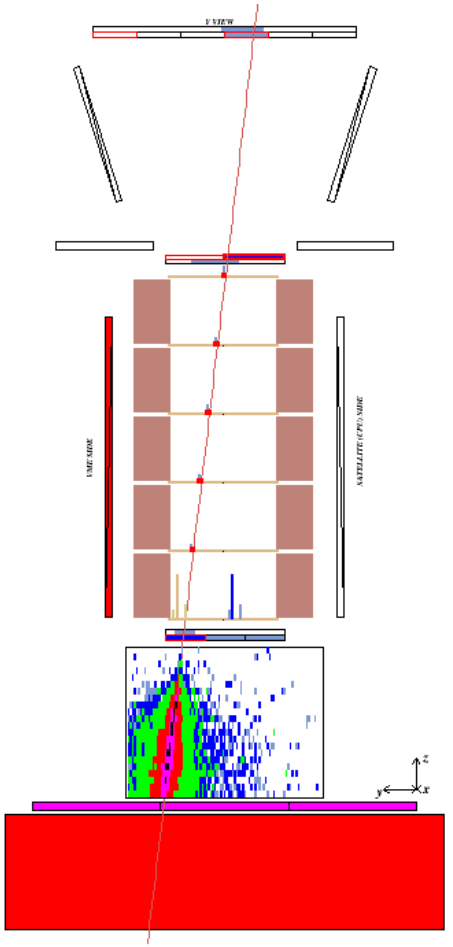
MC simulation for e- with E=1000 GeV





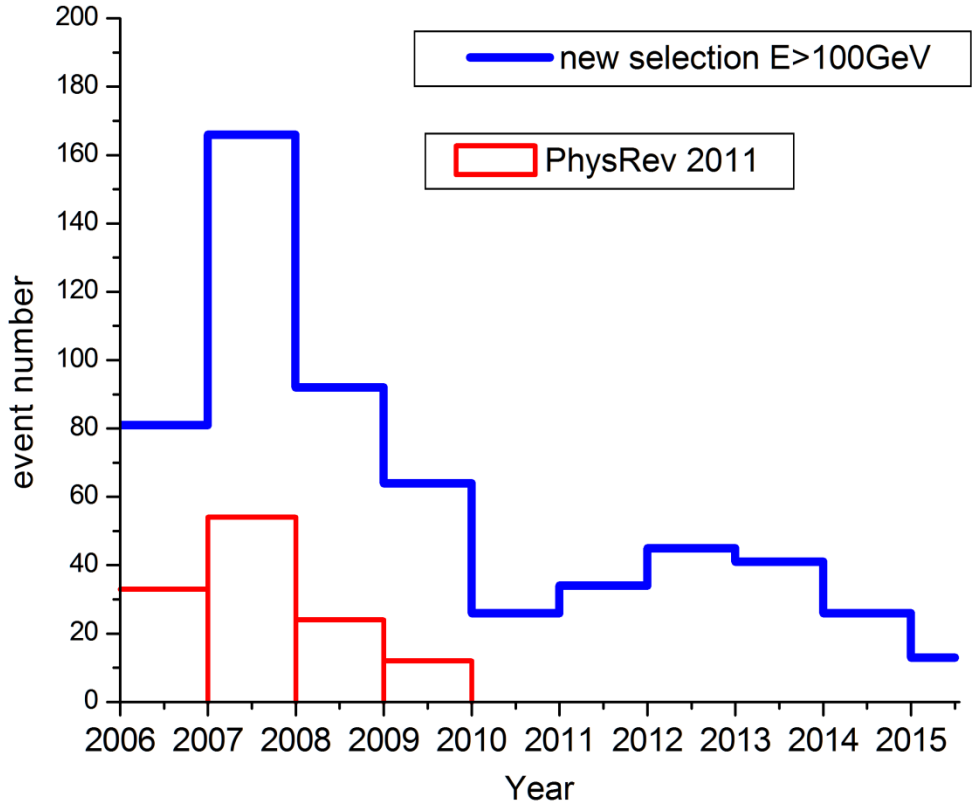
R = - 641 GV
E_{calo} = 673 GeV
β = 1.18
ND = 13





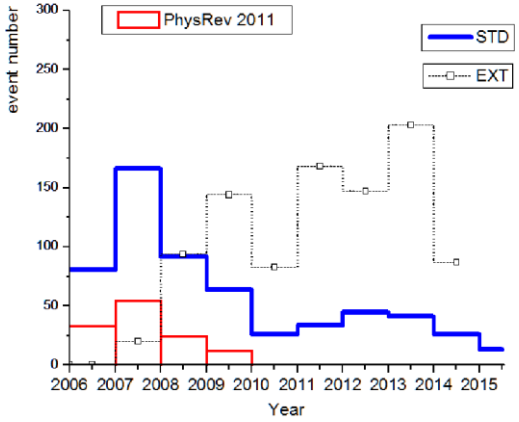
New electron analysis

Event number with E>100 GeV per Year



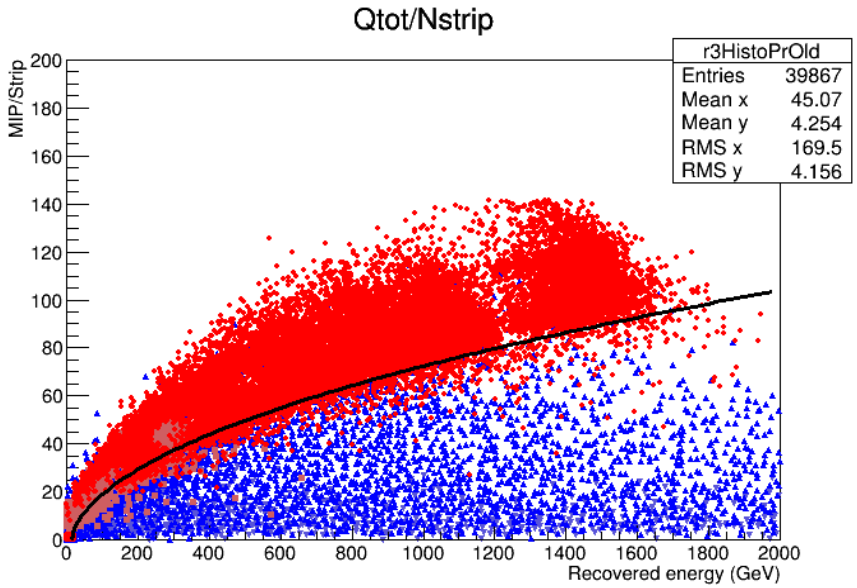
-New 10th data reduction
-Only “standard” track finding algorithm of previous 9th reduction was used
-Soft tracker condition :
Only |Z| discrimination, not R
-Allow multiple hits in TOF S1-S3
-No AC selection
- Proton rejection with CALO
-Energy reconstruction with CALO
- Corrections for energy leakage

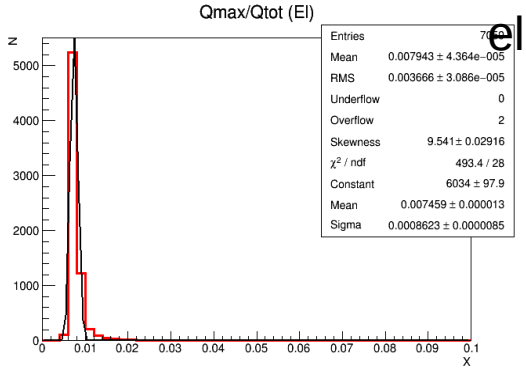
Next step with EXTended tracks



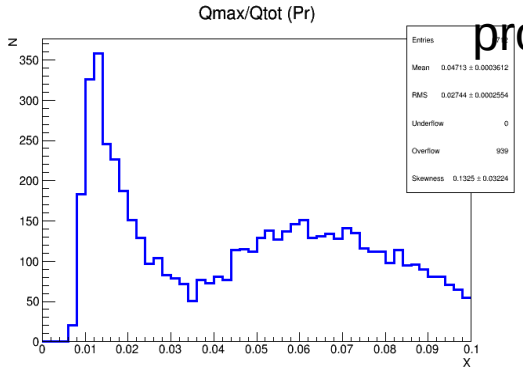
Above 100 GeV : ~160 events in (PhRev 2011), new selection ~1000 events

Examples of calorimeter selection : Monte Carlo simulations

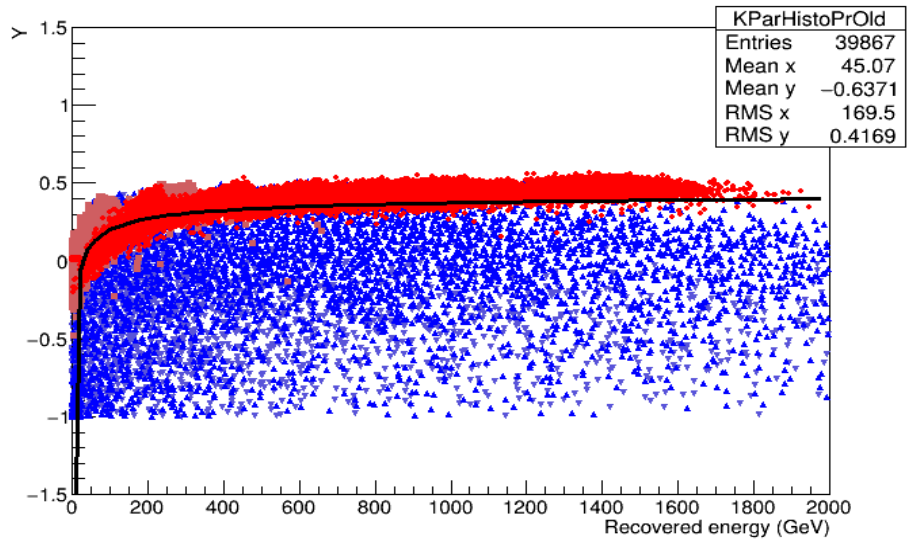




electrons



protons



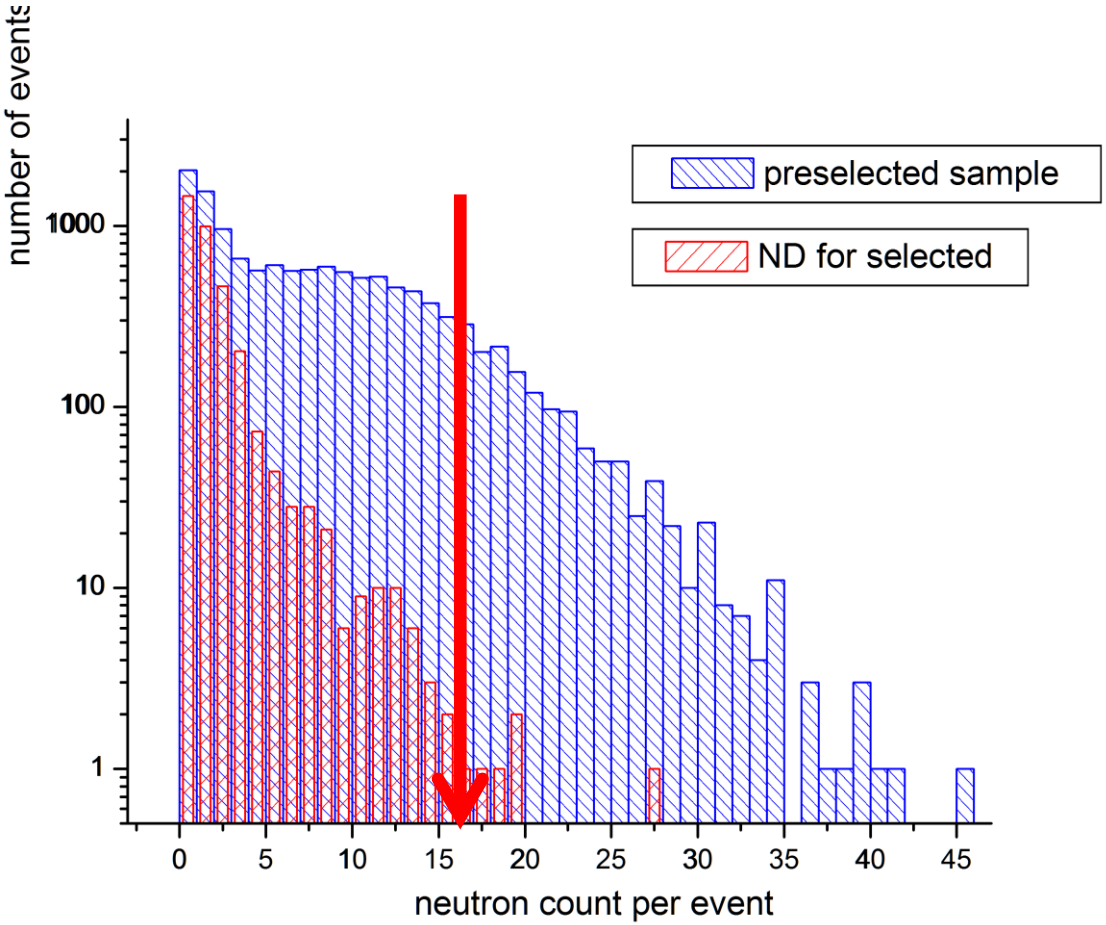
Kparameter = (n−s)/(n+s),where ***n*** is number of clusters, ***S*** is number of single strips;

Qtot is total energy release;

Nstrip is total number od hit strips;

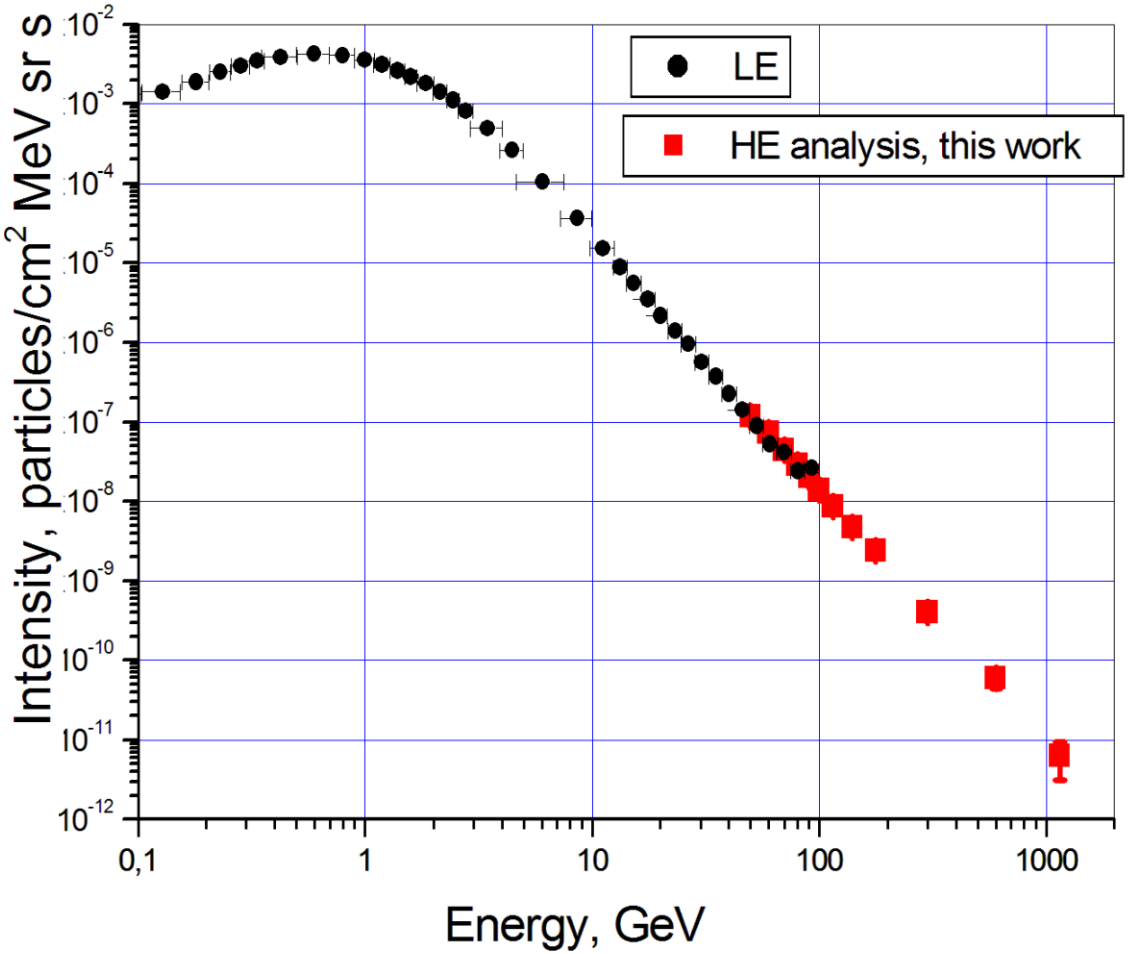
Qmax is maximum strip energy

Test of selection with neutron detector



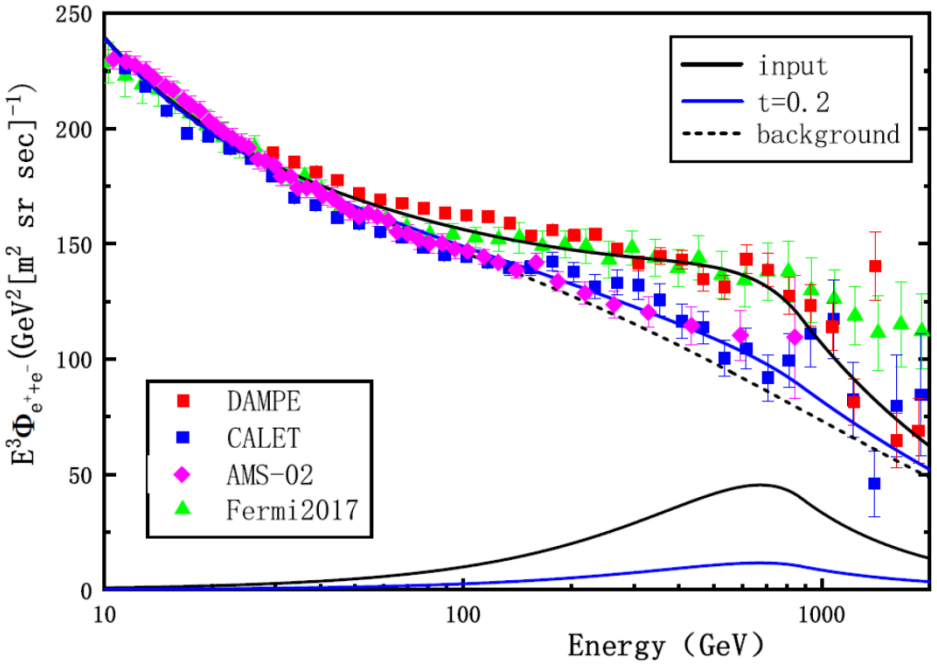
High energy protons produce more neutrons them electrons

Comparison with low energy analysis

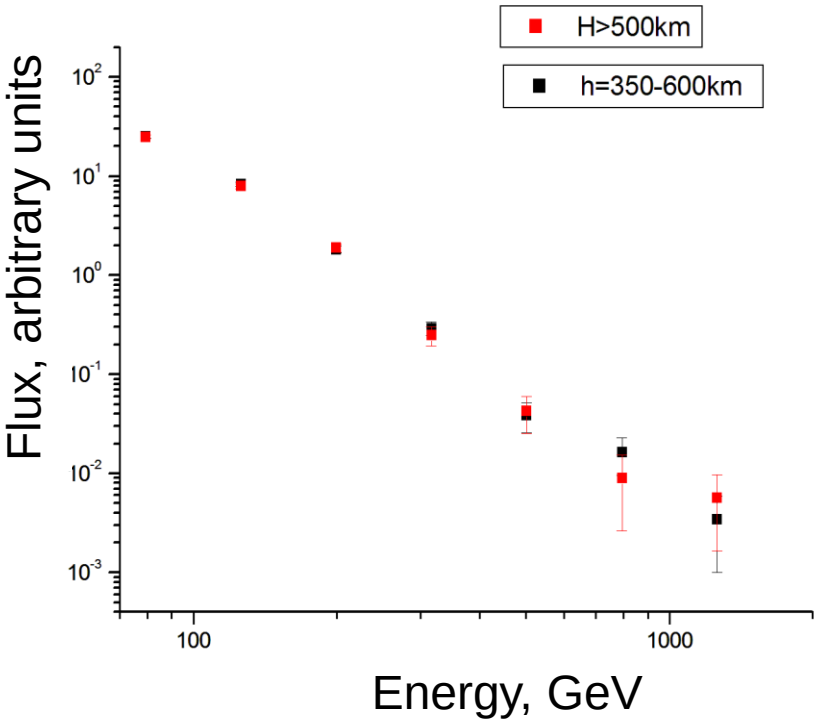


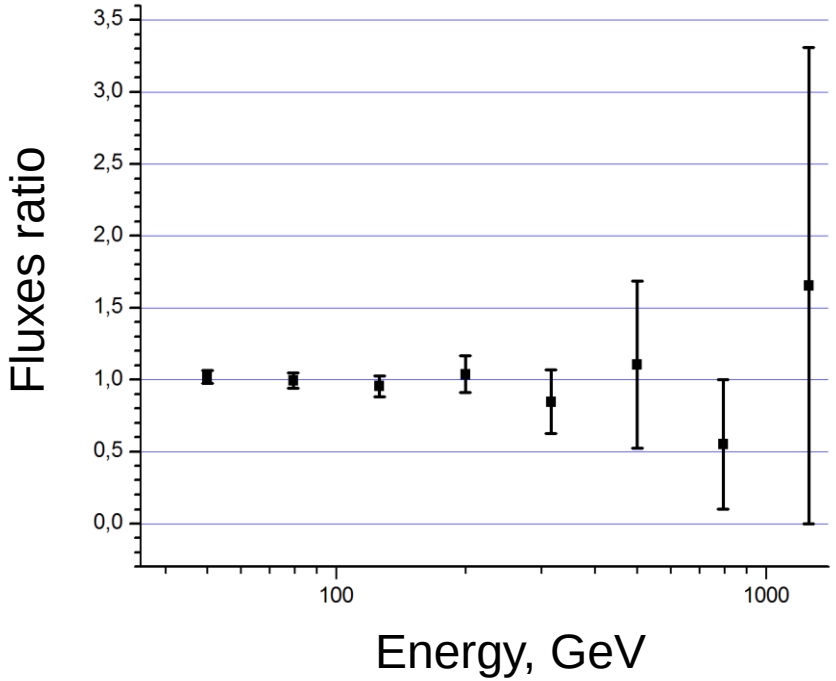
A Speculation About a Puzzled Result in Energy Spectrum of Cosmic-Ray Electrons Around TeV Energies

- 1811.09335v2
- Nuclear Coulomb potential at completely ionized and extremely thin atmosphere can leaks to a macroscopic spatial scale. This effect is used to explain the difference between the energy spectra of cosmic-ray electrons around 1 *TeV* measured by different experimental groups. The energy spectrum of cosmic-ray electrons, which are measured by Fermi-LAT and DAMPE at a higher altitude is more closer to a true signature



Measurements at different altitudes





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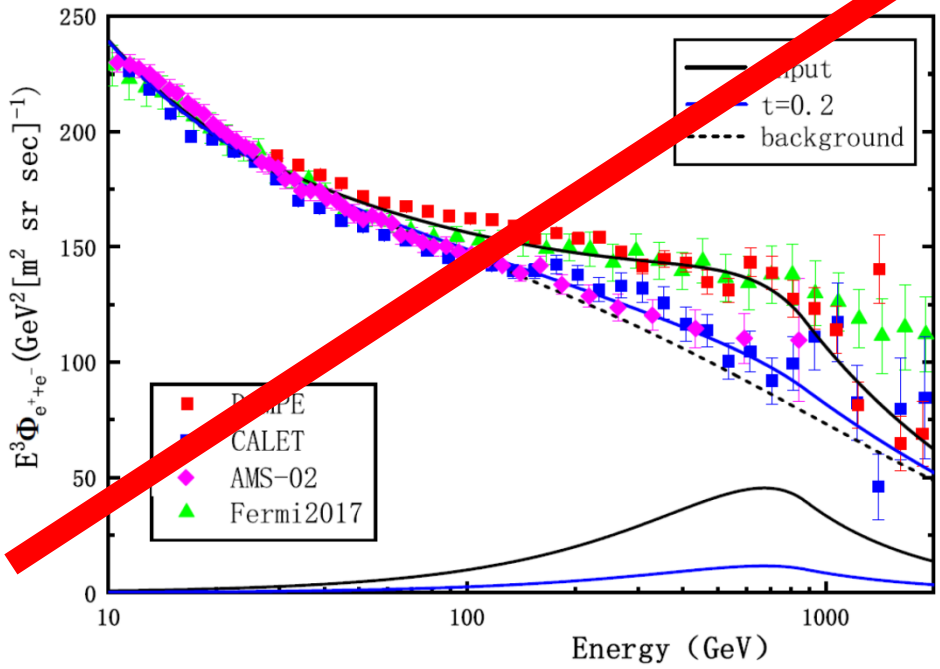
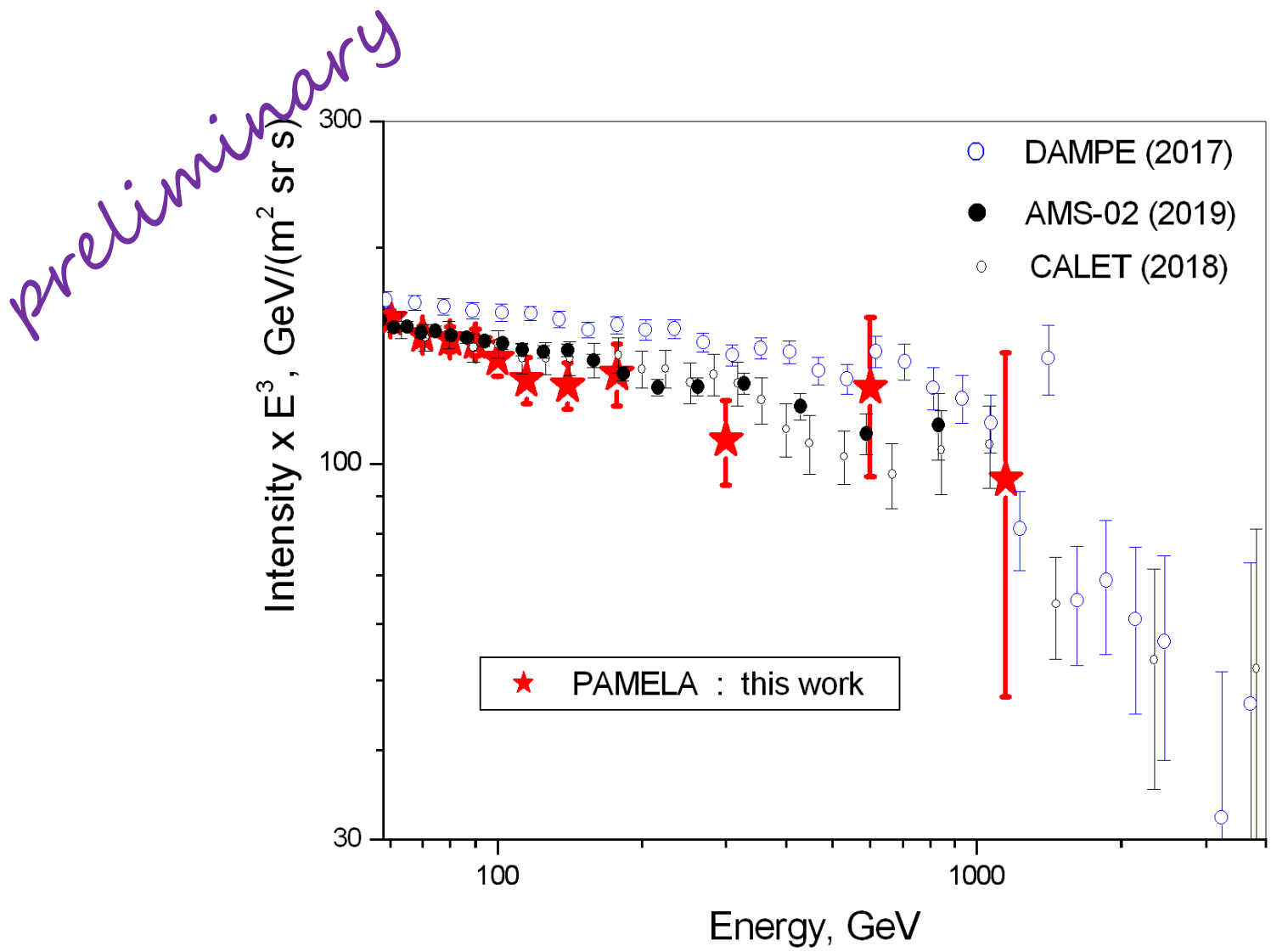


PAMELA all electron spectrum



THANK YOU