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

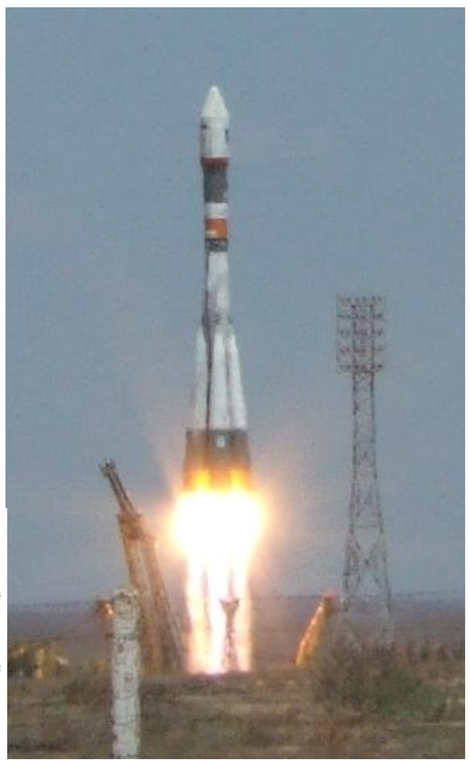
Observations of high energy trapped electrons and positrons in the inner radiation belt by the PAMELA experiment.

Vladimir Mikhailov (NRNU MEPHI) for PAMELA collaboration

vvmikhajlov@mephi.ru

- Geomagnetically trapped electrons and positrons with energy above 50 MeV were observed in PAMELA experiment on board Resurs DK satellite. The instrument consists of magnetic spectrometer, imaging electromagnetic calorimeter, time of flight system, anticoincidence and neutron detectors that provide unique particle identification and background rejection. PAMELA was collecting data since June 2006 till January 2016. The satellite orbit with initial altitude 350-600km and inclination 70 degrees crosses the inner radiation belt in South Atlantic Anomaly at L-shell ~1.2. The trapped electrons and positrons were selected on the basis of a trajectory simulation in the Earth magnetic field. Features of energy spectra of electrons and positrons at low energies are analyzed.

Multi-purpose cosmic ray experiment:
- Origin, propagation, composition;
- Antimatter component;
- Indirect dark matter detection;
- Solar physics and solar modulation;
- Trapped radiation



Orbit

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

Magnetic spectrometer PAMELA

Geometric factor ~21.6 cm^2sr

Electron/positron energy range 50 MeV - 1 TeV

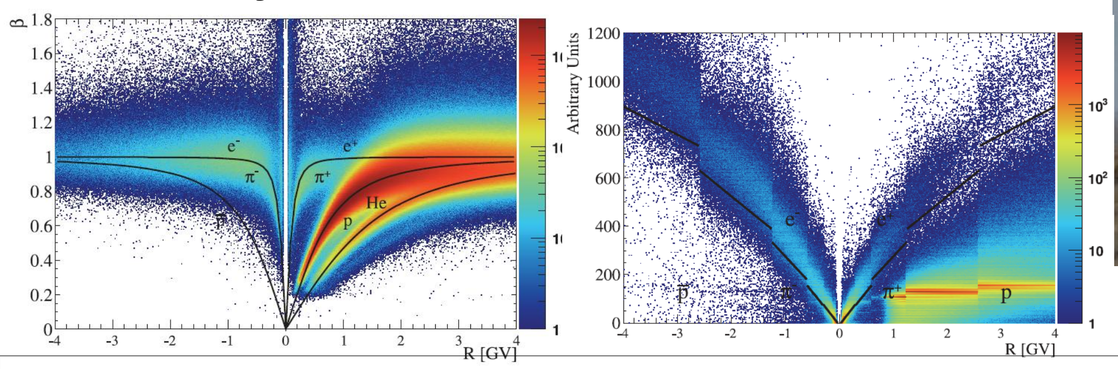
Energy resolution ~10%

Angular resolution ~2 degrees

Results : since July 2006 till January 2016:

~3200 days of data taking, ~50 TByte of data downlinked , ~$9 \cdot 10^9$ triggers recorded

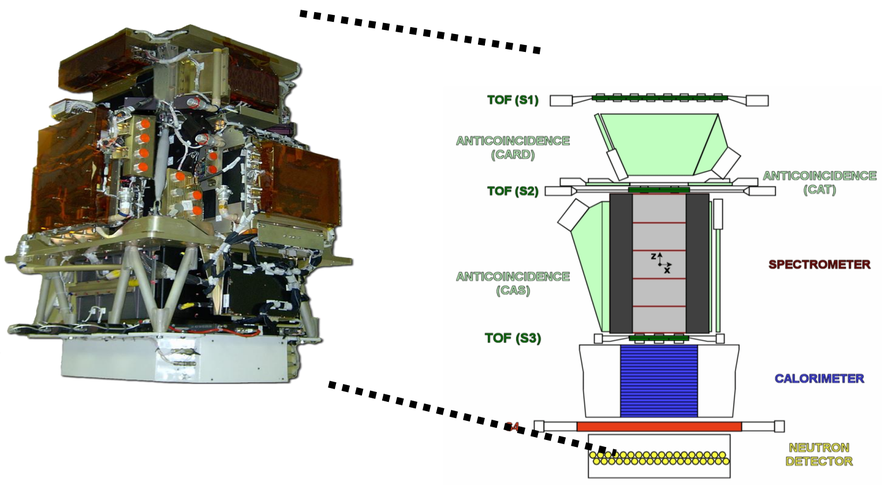
Data analysis

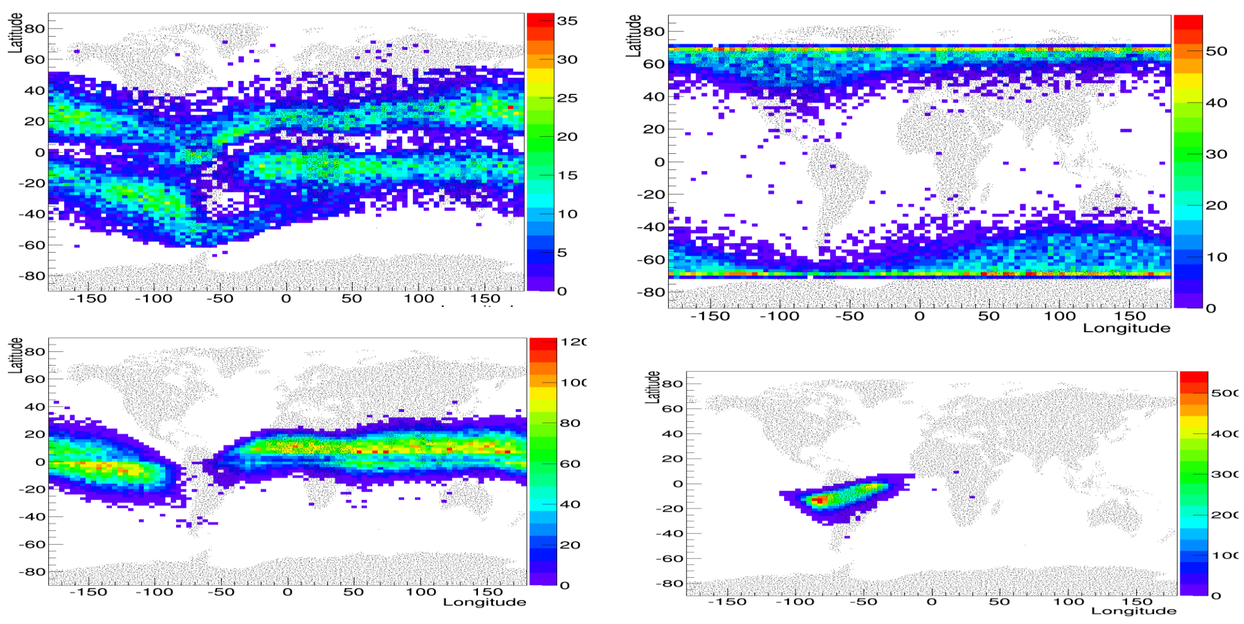


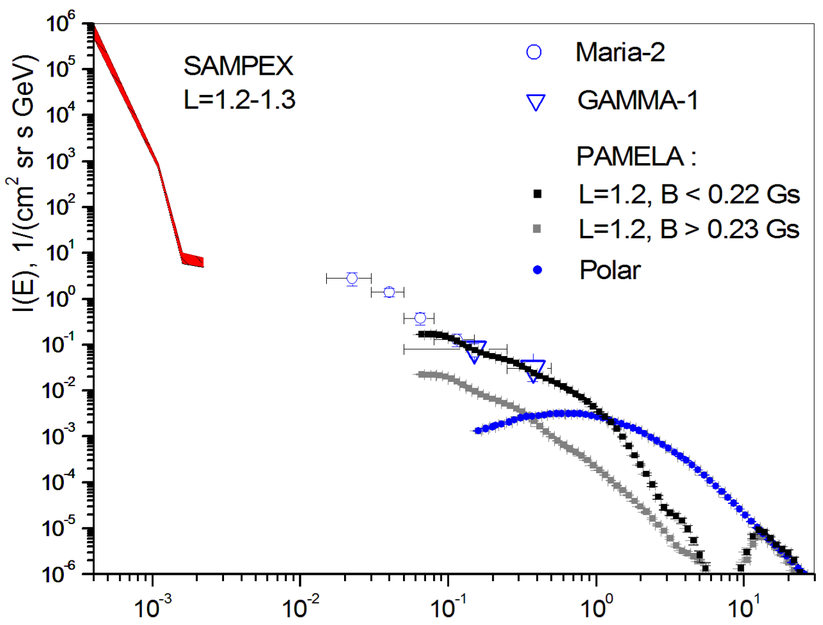
ToF velocity β (left) and topological variable (rigth) as a function of the rigidity. PAMELA magnetic spectrometer and imaging calorimeter , ToF , AC, provides clean electron identification.

All trajectories of positrons and electrons were tracing back in the Earth's magnetic field with IGRF field model : altitude Hmin=30 km, Hmax=20000 km,

Time of tracing Tmax=50 s. MSIS-90 model for atmospheric density was used for solar quiet condition.

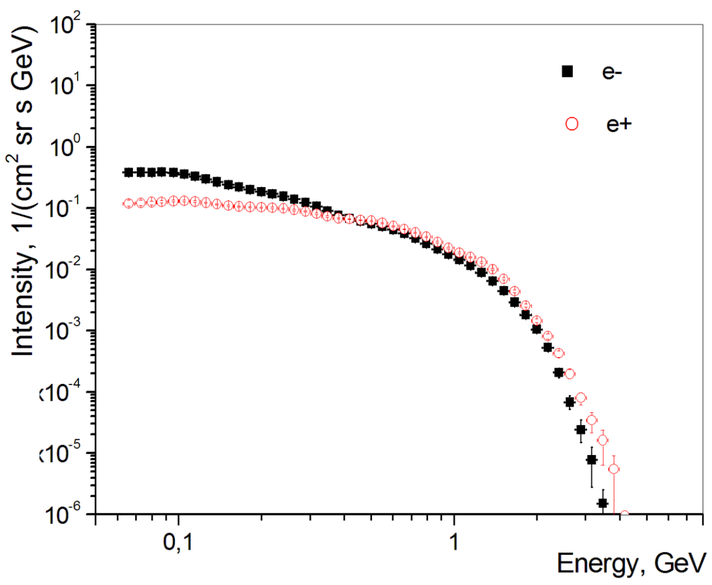




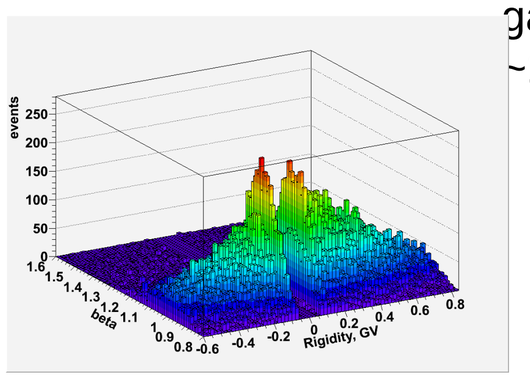


Detection coordinates of positrons: Albedo,Quasitrapped (left: top, bottom) , Galactic and Trapped (right:top, bottom)

Differential energy spectrum of electrons ($e^+ + e^-$) for Lshell ~1.2 B<0.22 (black points)) with other measurements and with galactic (Lshell >6, blue) and albedo spectra (B >0.23 , Lshell ~1.2 , gray points)



Trapped positron and electron energy spectra at Lshell ~1.2, There is cut-off at about 2 GeV



Beta vs rigidity distribution for trapped particles. Electron excess is visible at low energies

Conclusion

New particle selection was applied to PAMELA data to obtain clean sample of electrons and positrons from 50 MeV. Energy spectra of the trapped electrons and positrons have similar slope with cut-off at ~2 GeV. Below 300 MeV excess of electrons over positrons which can not be explained by conventional cosmic ray production mechanism. Possible explanation takes into account e-e scattering mechanism (Phys. Atomic Nuclei v.81.N4 , p.520 2018)