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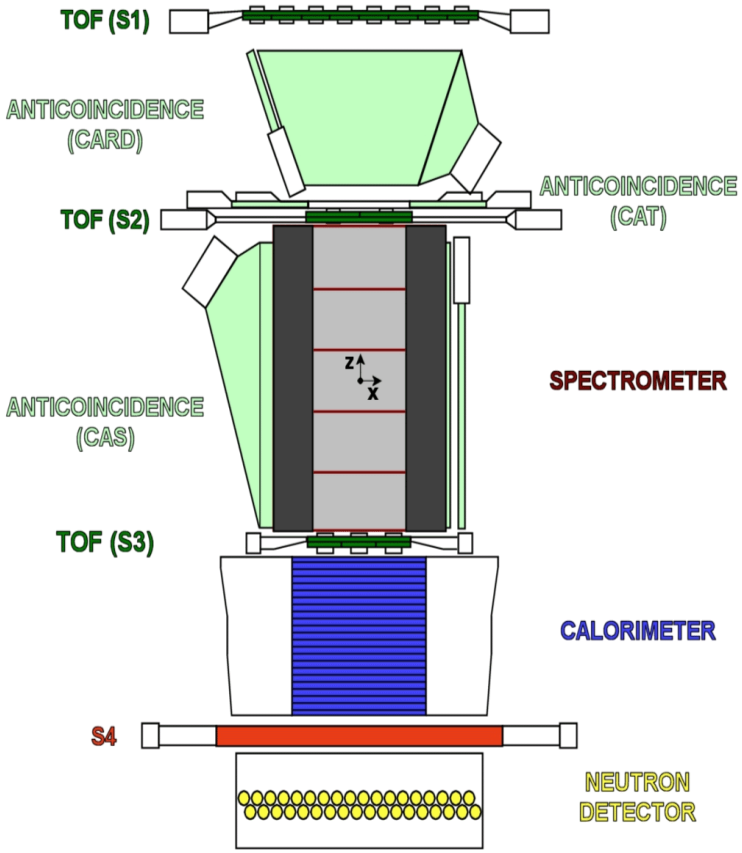
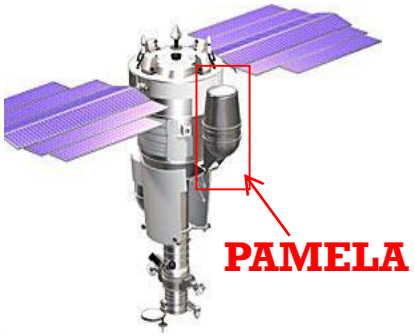
on behalf of PAMELA collaboration

Study on CRE arrival distributions with PAMELA experiment

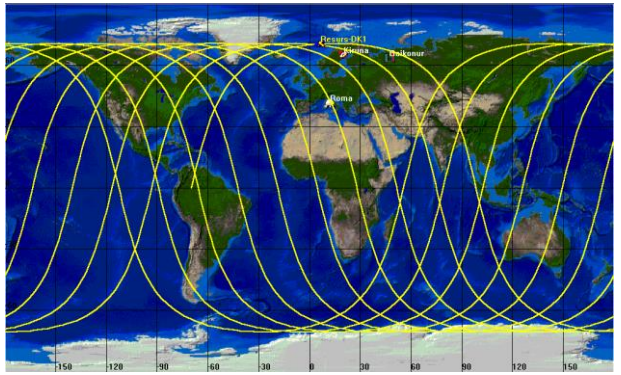
The PAMELA experiment

Payload for Antimatter/Matter Exploration and Light-nuclei Astrophysics





- ✓Search for antimatter
- ✓Search for dark matter
- ✓Study of cosmic-ray propagation
- ✓Study solar physics and solar modulation
- ✓Study of electron spectrum
- ✓Study terrestrial magnetosphere



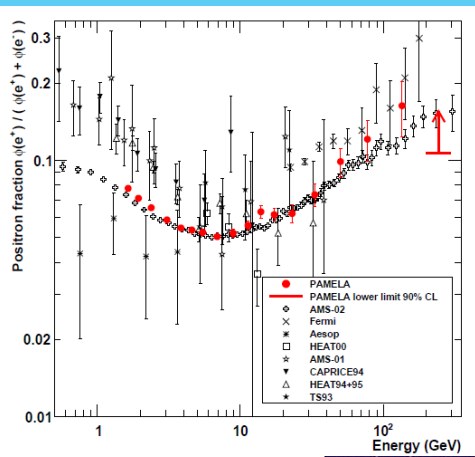
- ❑ Quasi polar and elliptical orbit
- ❑ Inclination ~ 70°
- ❑ Altitude ~ 300 - 600 km
- ❑ From 2010 circular orbit

- Launched on 15th June 2006

- Continuous operation mode

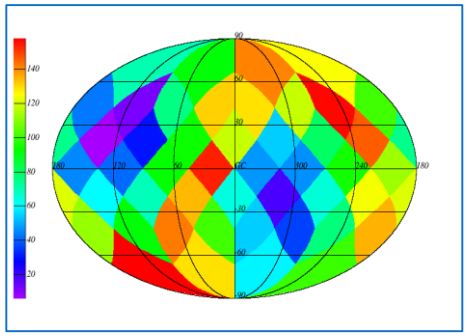
Searching for anisotropies

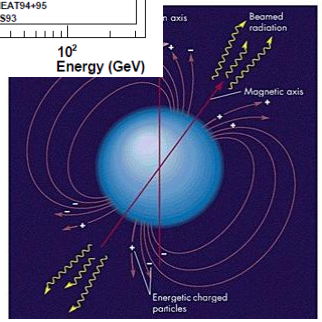
Adriani et al. **Nature** 2009



Study of e^++e^- (CREs) arrival directions could help to understand the nature of the positron excess revealed by PAMELA

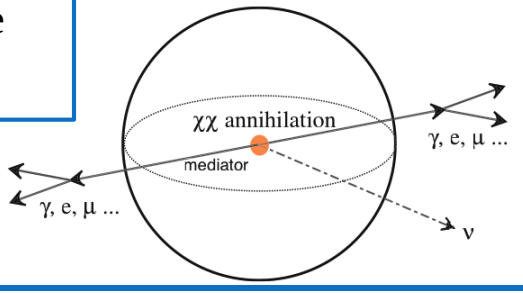
- *The entire sky can be explored by PAMELA*
- *Separation of electrons and positrons*





Local nearby sources: anisotropy in the angular e^+e^- distribution

Dark Matter: the electron/positron pair emission would be strongly correlated with the center of the DM clump and would produce visible effect in anisotropy study.



Blind search for anisotropy

Reference map :
Arrival directions of particles with an isotropic flux

Event map :
Experimental arrival directions

The comparison between signal and background to highlight deviations from isotropy is made with different approaches:

Li & Ma Statistical significance test

Excess in Sun direction?

Power Spectrum Analysis

Data sets

Data period : 2006 - 2010

~ 1.5 · 10^3 positrons with energy E > 10 GeV

~ 1.9 · 10^4 electrons with energy E > 10 GeV

~ 4.1 · 10^5 protons with energy E > 10 GeV

MC simulation

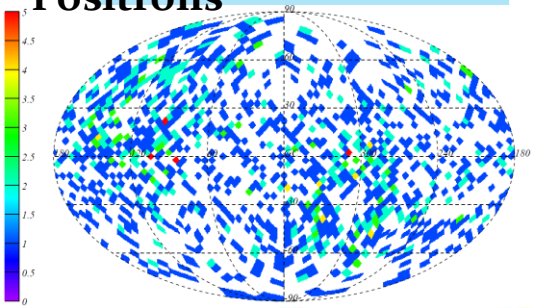
~ 10^6 electrons with energy E > 10 GeV

- ✓ **Same period**
- ✓ **Selection criteria with same efficiency**
- ✓ **Same exposure**

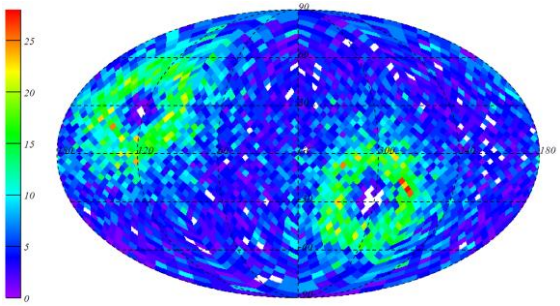
Reference frame - Galactic coordinate system
The equatorial plane is the projection of the plane of our Galaxy onto the celestial sphere

Visualization of the sky map in a 2D-sphere:
Healpix package
Each pixel covers the same surface area as every other pixels and is regularly distributed on lines of constant latitudes

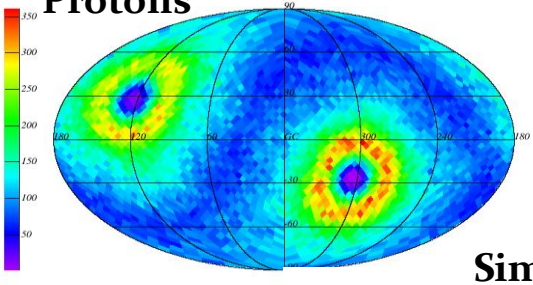
Positrons



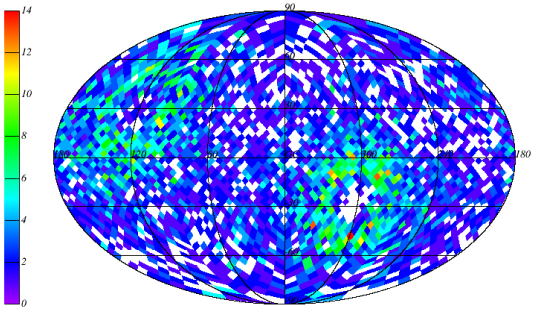
Electrons



Protons



Simulated Electrons

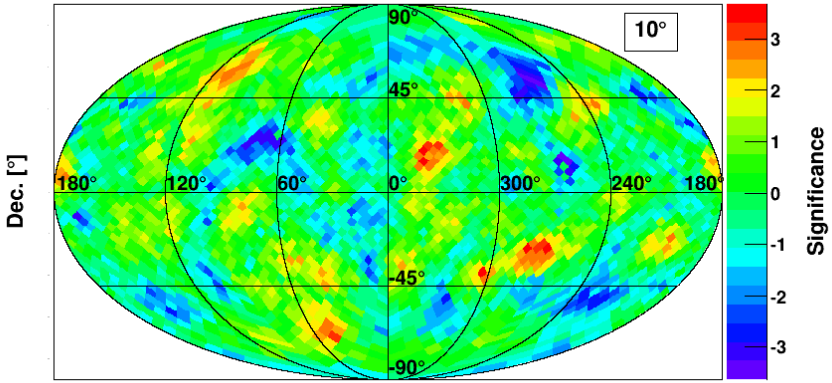


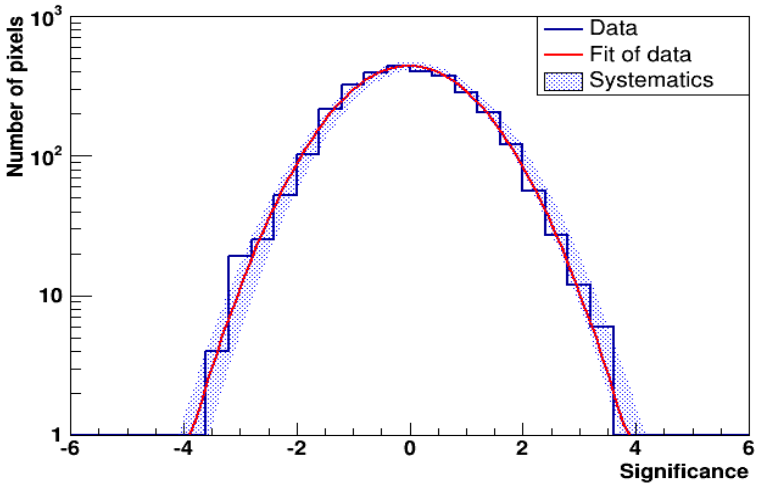
Results

Significance sky maps as a function of the integration radius

Statistical significance test using Li & Ma method

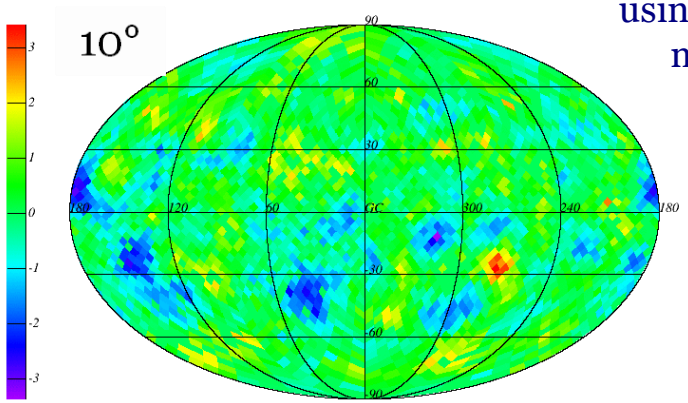
Positrons

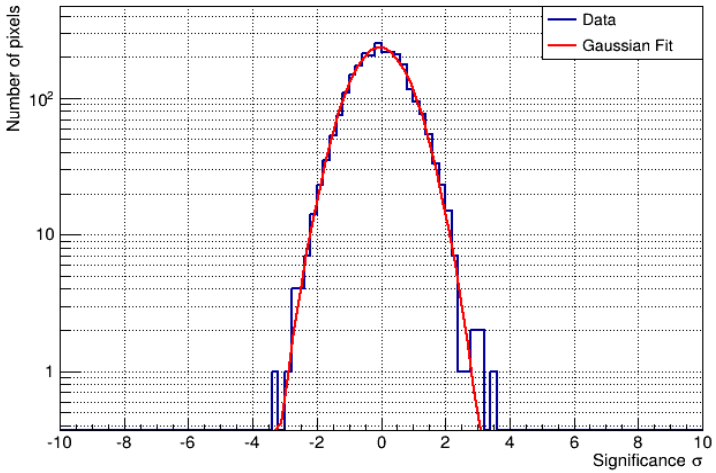




Cleaner sample of cosmic rays produced by possible sources respect to electrons

Electrons





- No evidence of excess
- Variance decreases with larger integration angles

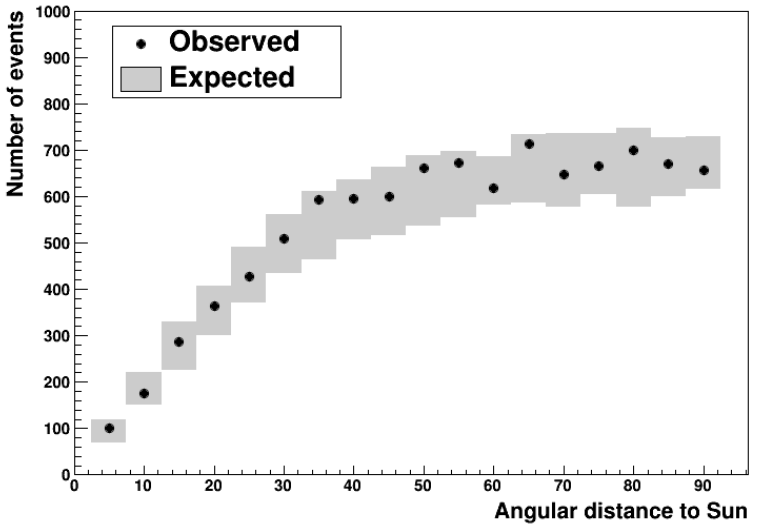
Results

Search in the Sun direction

Some models predict a significant flux of e^+ and e^- around the Sun direction due to DM particles

Method:

- Calculate the events direction in the solar frame
- Calculate the number of events at a given angular distance from the Sun
- Compare the observed events with the expected number of events from an isotropic flux



Angular power spectrum

- **Relative map in the basis of spherical harmonics**

$$I(l,b) = \sum_{l=1}^{\infty} \sum_{m=-l}^{m=l} a_{lm} Y_{lm}$$

- **Angular power spectrum obtained**

$$C(l) = \frac{1}{2l+1} \sum_{m=-l}^{m=l} a_{lm}^2$$

- **Dipole upper limit δ = 0.166 at 95% C.L.**