Search for antihelium in cosmic rays with «PAMELA» experiment

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on behalf of "PAMELA" collaboration

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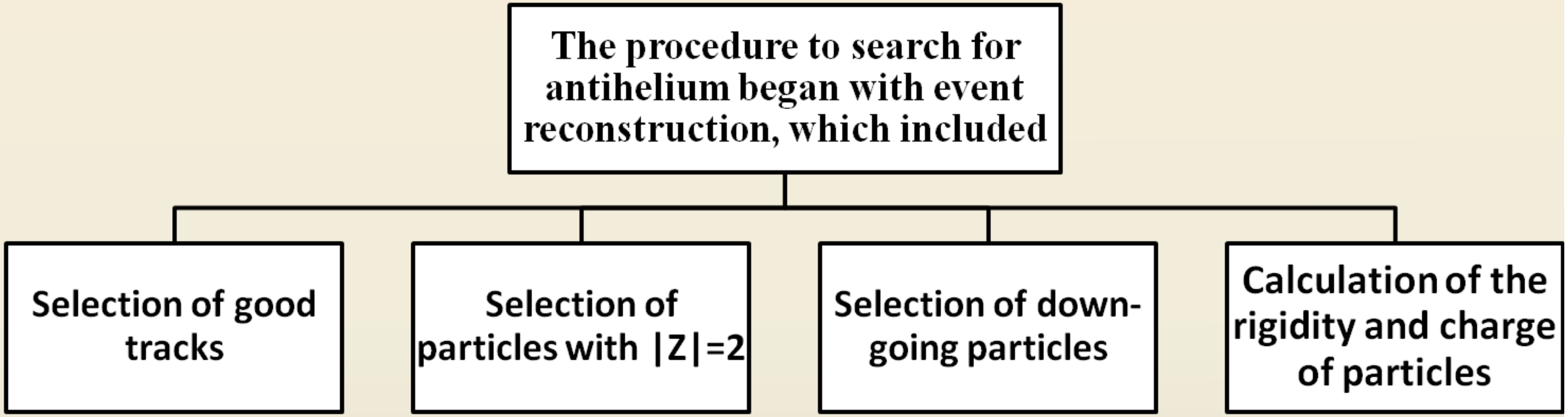
Introduction

One of the most important questions of cosmology is the explanation of the observed baryon asymmetry. The real value of this asymmetry can be established by direct measurements of antinuclei in the cosmic rays. Therefore, among the objectives of the experiment "PAMELA" [1] is a search of antihelium nuclei.



For analysis was taken data collected from 06.2006 up to 12.2009, data collected while passing through the South Atlantic Anomaly was excluded.

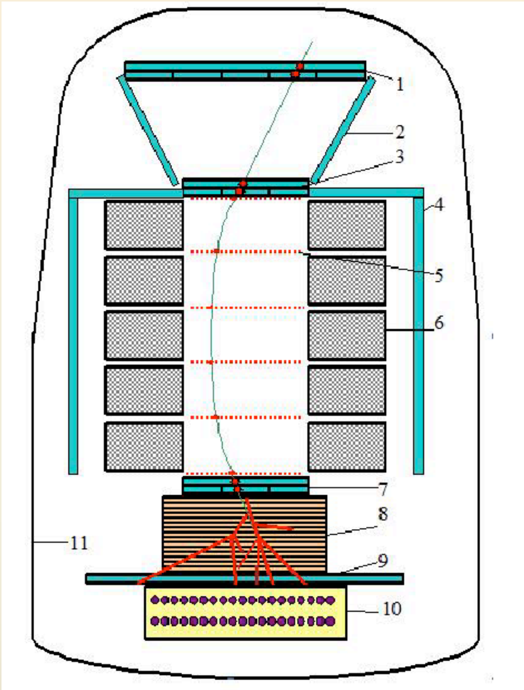
[1] Picozza P., Galper A.M. et al. // Astropart. Phys. 2007. V. 27. P. 296-315.

Analysis of experimental data

Particles passing through the aperture of apparatus with measurements of velocity and rigidity must satisfy next criteria:

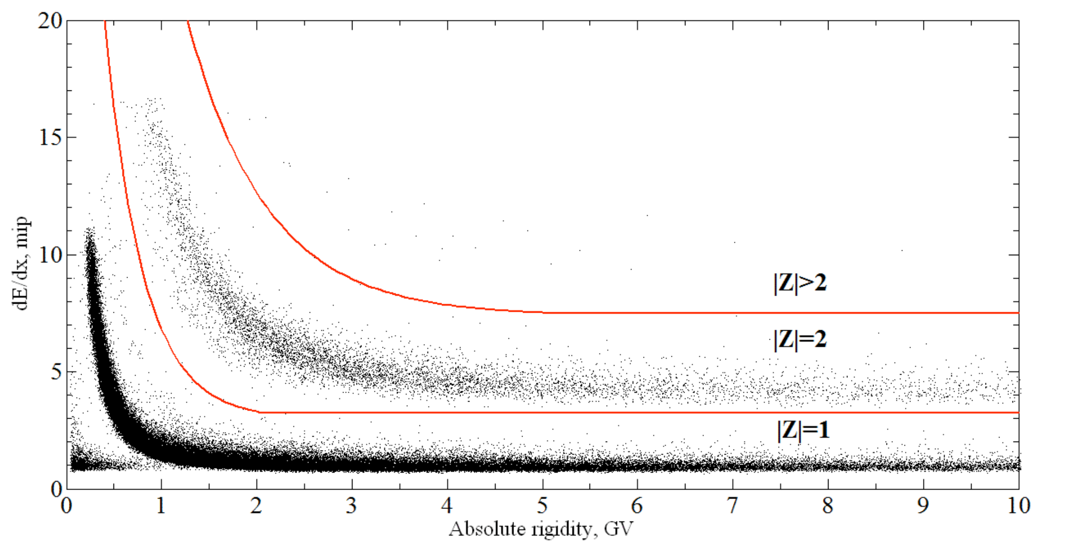
- single track without interactions in tracker;
- quality selection of fitting of the track, characterized by χ^2;
- fitted track does not touch the walls of magnet;
- number of points in tracker, using for fit the track is ≥ 4 in banding (X) direction, in Y direction ≥ 3;
- selection by hits in ToF: at least one hit in the top (1) counters, 1 hit in each middle (3) counters, not more than 2 hits in last (7) counters;
- no signal from anticoincidence system.

This criteria are not depends from sign of charge of particles.



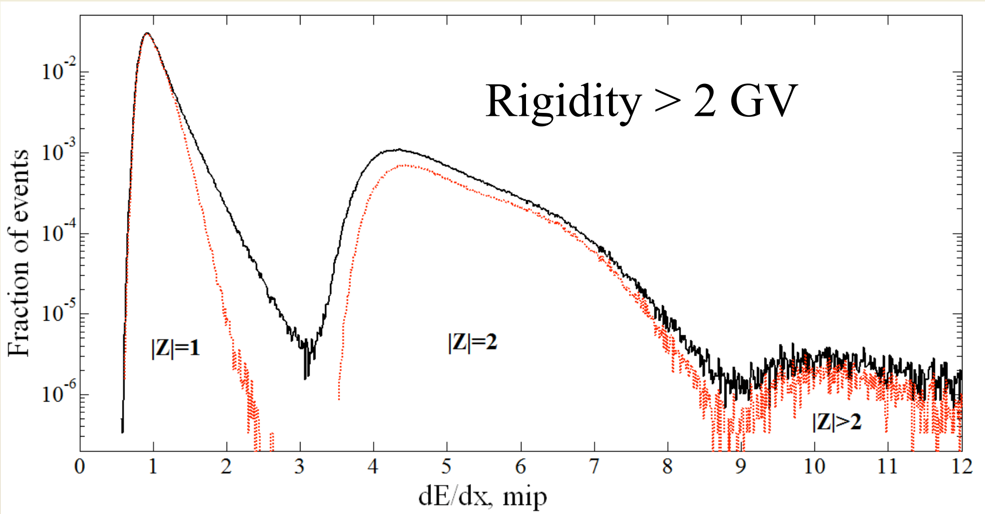
1, 3, 7- Time-of-flight system (ToF); 2, 4 –anticoincidence system;
5 – coordinate tracking system (six double layers) or tracker;
6 – magnet (five sections); 8 - an electromagnetic calorimeter;
9 - a shower tail catcher scintillator; 10 - a neutron detector;
11 – a pressurized container.

Selection of particles with charge |Z|=2



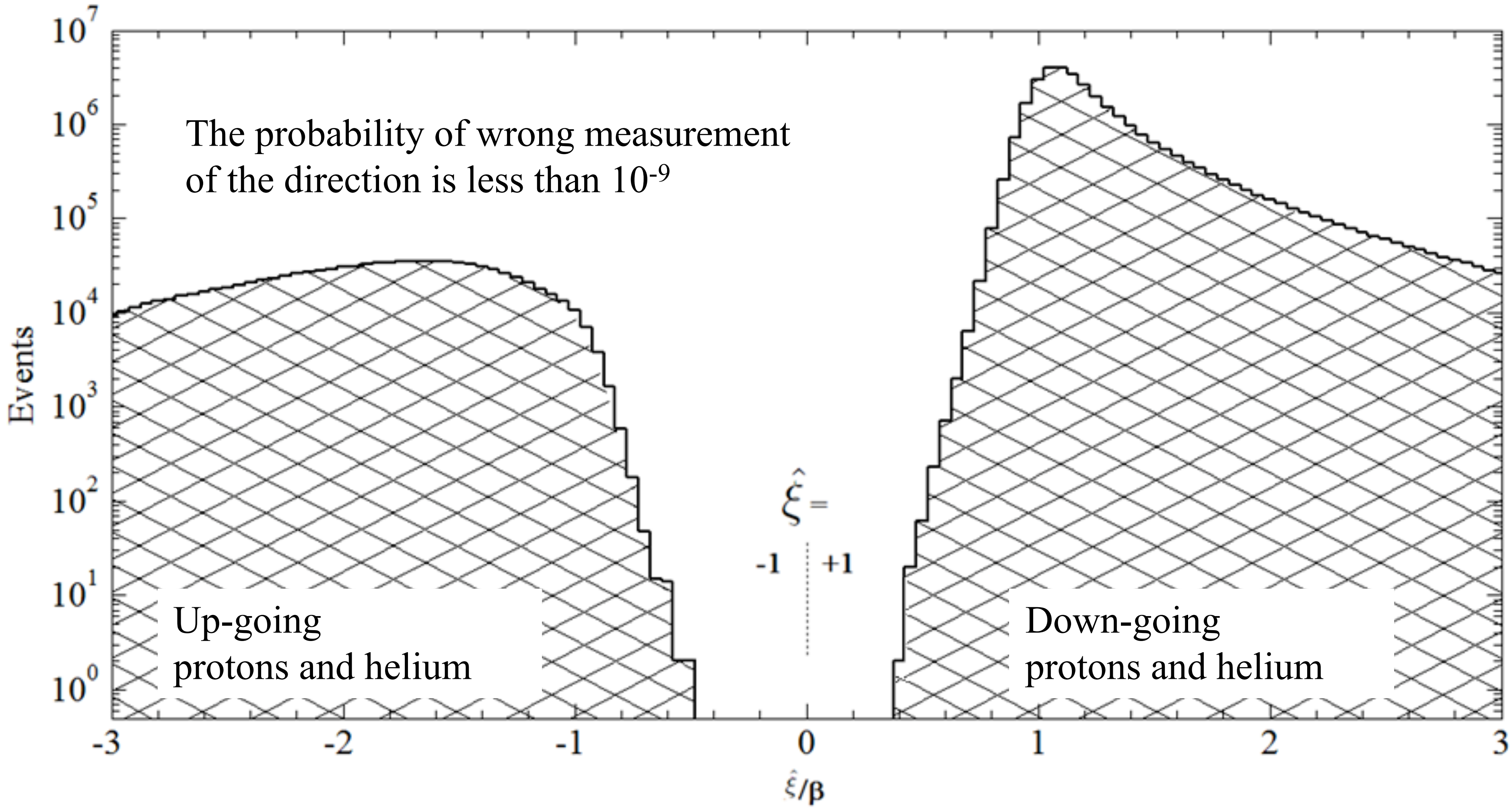
Selection of particles with |Z|=2 was done by using dependence of mean ionization losses in tracker versus rigidity.

An additional condition that all measurements of charge in planes of tracker give the same value. Probability of imitation of particles with |Z|=2 by particles with charge |Z|=1 is less than 10^{-9}.



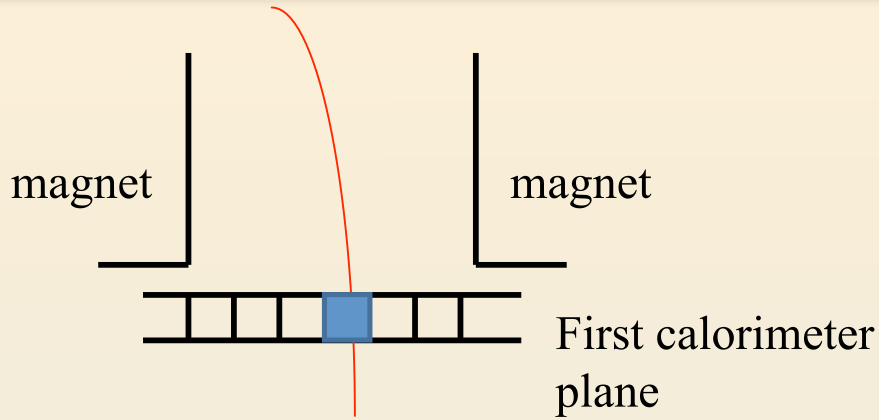
Sign of charge for particles with |Z|=2: β - measurements

$\hat{\xi}$ - is a particles direction



Sign of charge for particles with |Z|=2: scattering

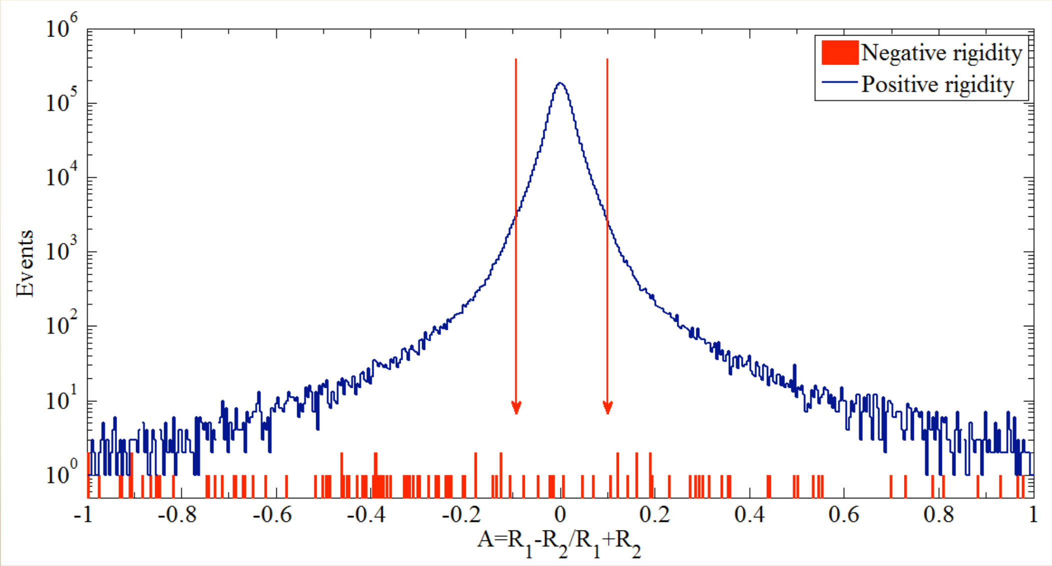
To identify the scattering of particles leading to incorrect determination of the rigidity and charge:



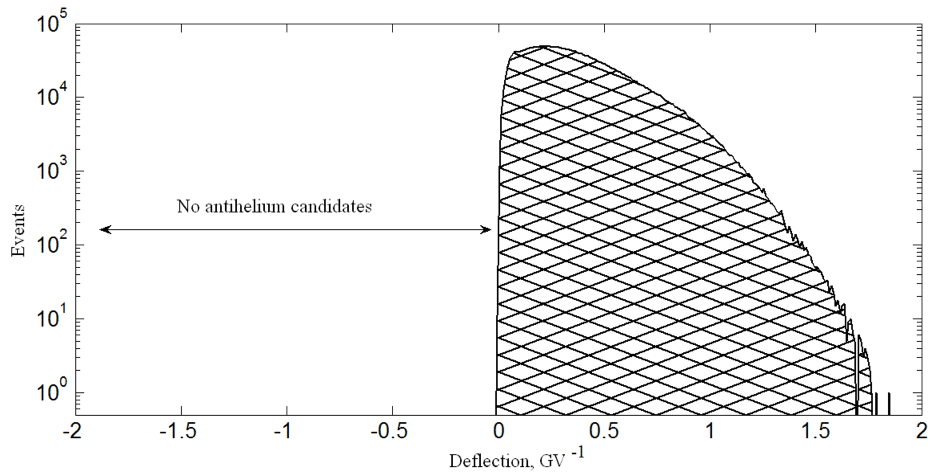
- Fitted tracker trajectory should pass through the strip in the first calorimeter plane with energy release more than 3.5 mip.

•Asymmetry selection
If R_1 – rigidity measured without first hit along the track and R_2 – rigidity measured without last hit along the track than asymmetry

$$A = \frac{R_1 - R_2}{R_1 + R_2}$$



Results



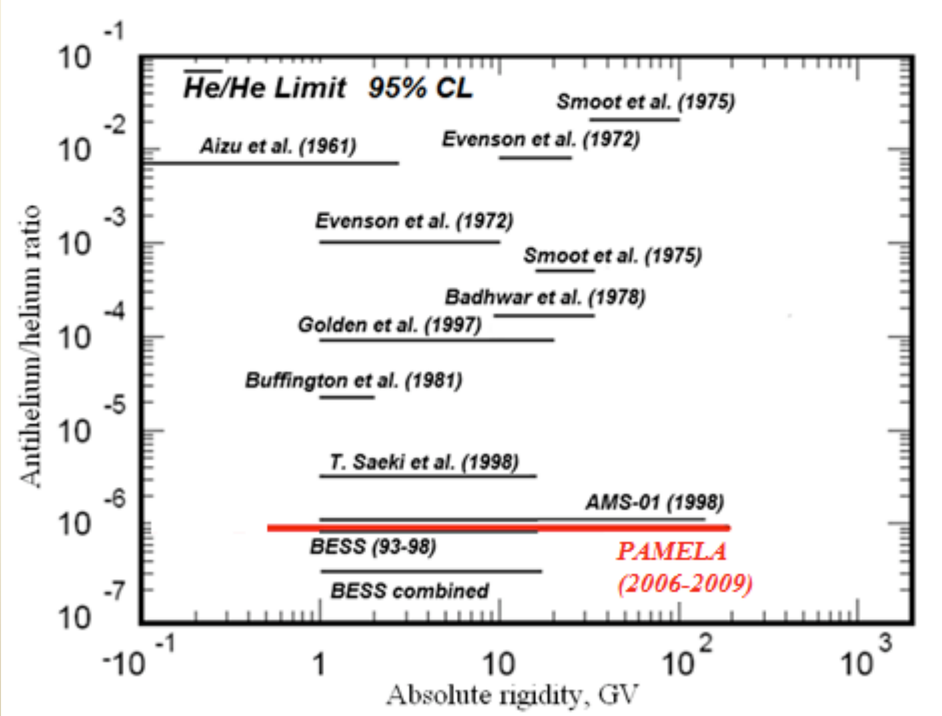
There are no antihelium candidates (events with negative rigidity) in energy range 0.5-180 GeV on about 3.200.000 helium events.

At the 95% confidence level number of antihelium is taken to be less than 3 and the differential upper limit for the flux ratio is given by:

$$\frac{N_{\overline{He}}}{N_{He}} = \frac{\sum N_{\overline{He}}(R_i)}{\sum N_{He}(R_i)} < \frac{3 < 1/\varepsilon_{\overline{He}} >}{\sum N_{He}'(R_i)/\varepsilon_{He}(R_i)}$$

In assumption that helium and antihelium has the same shapes

$$\overline{He}/He < 9.7 \cdot 10^{-7}$$



Conclusion

1. The ratio of antihelium/helium fluxes was measured with magnetic spectrometer “PAMELA” in primary cosmic rays

$$\overline{He} / He < 9.7 \cdot 10^{-7}$$

2. It is important an upper limit at high energies (R > 10-15 GV) because with decreasing energy significantly increases the cross section of annihilation, which complicates their passage through the interstellar medium and through the Solar system. Measured ratio can lead to restrictions on the existing theoretical models of production and propagation of antimatter in the Galaxy

3. Experiment continues …