PAMELA mission: constraints to cosmic rays propagation from nuclei

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Abstract. The PAMELA (Payload for Antimatter Matter Exploration and Light nuclei Astrophysics) experiment is a satellite-borne apparatus that performs measurements of the cosmic radiation with a particular focus on antiparticles and light nuclei. Accurate measurements of the elemental composition of cosmic rays are required in order to understand the origin, propagation and lifetime of the cosmic radiation. In particular PAMELA measures the light nuclear component of cosmic rays from Hydrogen up to Oxygen in the interval 200 MeV/n-200 GeV/n. Object of this paper is the presentation of light-charge identification capabilities of PAMELA instrument as evaluated during the first three years of flight.

1. Introduction
The relative abundances of the constituents of galactic cosmic rays (GCRs) provide information about cosmic ray transport within the Galaxy. In particular, cosmic rays of primary origin such as Carbon and Oxygen may interact with the interstellar medium to produce secondary fragments such as Lithium, Beryllium and Boron. The measured ratio of secondary to primary cosmic rays can be used to compute the mean amount of interstellar matter that cosmic rays have encountered before reaching the Earth. One of the most sensitive quantity is the Boron to Carbon ratio (B/C), as B is purely secondary and its main progenitors C and O are primaries. Measuring the energy dependence of the B/C ratio we can infer the diffusion coefficient [1]. Moreover, B/C ratio is the quantity measured with the best accuracy, so that it is ideal to test models.

A better determination of the cosmic ray propagation is fundamental for the search of exotic matter, like dark matter candidates or antimatter produced in exotic processes, since the signature of such processes can be recognized only by knowing with great precision the fluxes due to the conventional production, acceleration and transport models [1, 2, 3].

2. The PAMELA mission
The PAMELA mission is focused on the investigation of antimatter and dark matter, cosmic ray propagation in our Galaxy and Solar System, solar modulation and interaction of cosmic rays with the Earth’s magnetosphere.

The PAMELA apparatus comprises a magnetic spectrometer, a Time of Flight system, a silicon-tungsten electromagnetic calorimeter, an anticoincidence system, a shower tail catcher scintillator and a neutron detector. The combination of these devices allows antiparticles to be reliably identified from a large background of other charged particles. For more details see [4].
3. Charge Identification and Intrinsic Detectors Resolution

PAMELA is able to discriminate nuclei events, from Boron up to Oxygen, in the energy range from 200 MeV/n up to 200 GeV/n. In this section the intrinsic detector resolutions in Z reconstruction for nuclei from Z = 3 up to Z = 6 will be presented.

In figure 1, two nuclear events (Boron and Carbon respectively) detected by PAMELA instrument are shown. The hadronic interactions inside the Calorimeter are clearly visible, as well as the activity recorded by the Neutron Detector.

![Figure 1](image)

Figure 1. Boron (left) and Carbon (right) as detected by the PAMELA instrument. For each figure, on the left(right) the x, bending view (y, non-bending view) of PAMELA are indicated. A plan view of PAMELA is shown in the centre.

PAMELA can determine the particle charge in a redundant way, by means of the ToF scintillating paddles, the silicon microstrips of the Tracking system and the ministrips of the imaging Calorimeter.

The particle charge can be measured in the Calorimeter by considering the energy released in one, or more than one, plane of the detector. The gaussian fit of the peaks of the charge histogram gives the following peak/sigma: 3.01/0.20; 4.01/0.23; 5.00/0.26; 6.01/0.29.

The ToF system provides the charge of the incident particles by the energy deposit measurements in the scintillators. The six scintillator layers enable six independent charge determinations, thus significantly improving the charge resolution of the whole ToF system. Combining by a weighed average the charges reconstructed with this method it is possible to obtain the following resolution: 3.00/0.11; 4.00/0.14; 4.99/0.18; 5.99/0.21.

Moreover also the Tracking system can be used to determine the absolute value of the charge by multiple measurements of the mean rate of energy loss in the silicon sensors with the following resolution: 2.99/0.16; 4.00/0.23; 4.98/0.28; 6.01/0.34.

4. Conclusions

Preliminary results on PAMELA charge identification capabilities and the consequent charge resolution has been presented in this paper. The ToF system seems to be the most powerful detector. This is only a first analysis of the nuclear components of cosmic rays detected by the PAMELA instruments. This work is in progress. However, PAMELA confirms the possibility to improve our knowledge in the mechanisms involved in the generation, acceleration and propagation of cosmic rays.

References

[1] Castellina A and Donato F 2005 *Astropart. Phys.* 24 146
[2] Maurin D et al 2002 Galactic Cosmic Ray Nuclei as a tool for Astroparticle Physics *Preprint astro-ph/0212111*
[3] Bottino A, Donato F, Fornengo N and Scopel S 2004 *Phys. Rev.* D 70 015005
[4] Picozza P et al 2007 *Astropart. Phys.* 27 296