The PAMELA space mission

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The PAMELA (a Payload for Antimatter-Matter Exploration and Light-nuclei Astrophysics) space mission has been launched on-board the Resurs-DK1 satellite on June 15\textsuperscript{th} 2006 from the Baikonur cosmodrome, in Kazakhstan. PAMELA is a particle spectrometer designed to study charged particles in the cosmic radiation with special focus on the investigation of the nature of dark matter, by mean of the measure of the cosmic-ray antiproton and positron spectra over the largest energy range ever achieved.

1. Introduction

PAMELA is a particle spectrometer housed inside a pressurized container attached to the Russian satellite Resurs–DK1. It was launched into space on the 15\textsuperscript{th} June 2006, by a Soyuz-U rocket, from the Baikonur cosmodrome in Kazakhstan, and deployed in a semi-polar (70\degree) elliptical orbit at altitude in the range 350–600 km. PAMELA was switched on for the first time on 21\textsuperscript{st} June 2006 and has been in a nearly continuous data collection mode since then. The mission is still running and will end on 2011.
takingsince 11thJuly 2006.

PAMELA has been designedtomasure in detail the spectra of primary and secondary components of the cosmic radiation. Its major scientific goal is the indirect detection of dark matter by means of the precise measurement of antiprotons and positrons spectra in cosmic rays, over the largest energy range ever achieved. The long term period of data taking provides unprecedented statistics with no atmospheric overburden reducing the systematic uncertainties of previous measurements obtained by balloon-borne experiments.

2. PAMELA apparatus

The PAMELA apparatus is composed of the following sub-detectors stacked, as in Fig. 1, from top to bottom: a time of flight system (ToF) (S1,S2,S3), a magnetic spectrometer, an anticoincidence system (CARD, CAT, CAS), an electromagnetic imaging calorimeter, a shower tail catcher scintillator (S4), and a neutron detector [1].

The ToF is made out of 3 double–layer plastic scintillator paddles. It provides the first–level trigger and helps in particle identification, for rigidity (R) <1GV, and in rejecting albedo particles by measuring particle β and dE/dx.

Particle rigidity and charge sign are determined by the spectrometer. Six layer of double–side silicon sensors are stacked in between five permanent magnet modules. Thanks to spatial resolution of 3±4 μm and 8÷13 μm, in bending and not bending view respectively, it is possible to reach a maximum detectable rigidity (MDR) of ≈1 TeV/c.

A plastic scintillator anticoincidence system shields the spectrometer, covering the magnet top (CAT), lateral sides (CAS), and the upper part of the detector(CARD).

The electromagnetic imaging calorimeter comprises 44 single–sided silicon sensor planes, orthogonally arranged, interleaved with 22 plates of tungsten absorber. With a total depth of 16.3 X0 and 0.6 nuclear interaction lengths, combines the topological information of the two views with the dE/dx, achieving proton rejection factor of at least 105 above 10 GeV while maintaining an electron selection efficiency of ~90%.

The neutron detector consists of 36 3He counters, inserted into a polyethylene moderator. It helps in hadrons and leptons discrimination in the high energy events along with the shower tail catcher scintillator, that is attached at the calorimeter bottom above the neutron detector.

PAMELA overall size is about 130×70×70 cm3, corresponding to a geometric factor of 21.5 cm2sr (for R>1GV), for a total mass of ~470 kg, and a maximum power consumption of 360 W.

3. Data analysis and results

Since the first days of operation, PAMELA, is transmitting to ground about 16 GB of data every day. After a quick look, to check the status of the detector, data are reduced and calibrated.

Using the ToF and AC, only down-going particles, cleanly entering the PAMELA acceptance, are selected. Then the charge sign is identified and the rigidity determined, using the spectrom-
Figure 2. Antiproton to proton ratio between 1 and 100 GeV (left)[3]. Positron to electron ration between 1.5 and 100 GeV (right)[4]. Both ratios are compared to recent measurements, see [3,4] for references.

The final identification is provided by the calorimeter, combining $dE/dx$ with the topological information, the $\beta$ measurements from the ToF and ionization losses in the tracker system at low momenta.

A full detector simulation has been used to estimate or cross validate selection efficiencies and detector acceptance as well as possible backgrounds from secondary particles produced in the material surrounding the detectors.

The fluxes of proton and antiproton, electron and positron have been calculated and charge ratio estimated. Results are showed in Fig. 2 where the antiproton to proton ratio is showed along with the one of the positron to electron. For the first time these charge ratios have been investigated at energy larger than 50 GeV. Antiproton result are compatible with earlier data and do not show any clear deviation from a secondary production.

Positrons, instead, clearly show an excess at high energy; this can be due to dark matter particle annihilation in the galactic halo or to nearby sources, such as pulsar [4].

4. Conclusions

PAMELA is smoothly collecting data recording the largest antiparticle statistic in the energy range up to 100 GeV. So far ~8×10^9 triggers have been registered allowing for precise measurement of cosmic-ray spectra over a wide energy range, candidating PAMELA to be a permanent cosmic ray laboratory in space.

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