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The Pamela experiment ready for flight

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Abstract

The Pamela apparatus will allow precise measurements of cosmic rays in Low Earth Orbit, mainly focusing on the antiparticles component. The apparatus is now ready for flight, and the launch is foreseen during June 2006. The paper briefly reports the status of the experiment, and the performances of the various components as measured before the launch.

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1. The Pamela experiment

The Pamela experiment (Fig. 1) is a powerful detector designed to do a wide range analysis of cosmic rays around the earth in the 100 MeV/few hundred GeV energy range [1]. The detector is installed inside a pressurized container on board of the Russian Resurs-DK1 satellite, that will be put in a low earth orbit (350–600 km height, 70° inclination, semi-polar) through a Soyuz TM2 rocket. The launch is foreseen in the time window between 14 and 16 June, 2006. The main Pamela's scientific objective is a precise and statistical significant study of antiparticles in cosmic rays (mainly $\bar{p}$ and e^+). This paper will report on the performances of the various Pamela's subdetectors, as obtained from the ground data, and on the status of the integration of the apparatus inside the satellite during the pre-launch phases.

1.1. Magnetic spectrometer

The magnetic spectrometer [2] is the core of the Pamela apparatus, used to precisely measure the rigidity of the cosmic rays entering in the geometrical acceptance of the experiment ($\simeq 21.5\,cm^2sr$). It is composed by a permanent magnet, providing an almost uniform magnetic field (0.48 T in the center of the magnet). The magnet is divided in five identical canisters, allowing the insertion in between them of six detection planes, realized by means of six double-sided silicon microstrips detectors. The fine pitch of the silicon strips, matched with a low noise readout electronics, allow to reconstruct the impact point of the charged particles on the silicon planes with a spatial resolution better that 3 μm in the bending view. The full spectrometer has been repeatedly tested during many beam tests at CERN SPS accelerator; its global performances are summarized in Fig. 2, showing the measured rigidity resolution for the flight model configuration. The Maximum Detectable Rigidity (MDR) is greater than 1 TV,

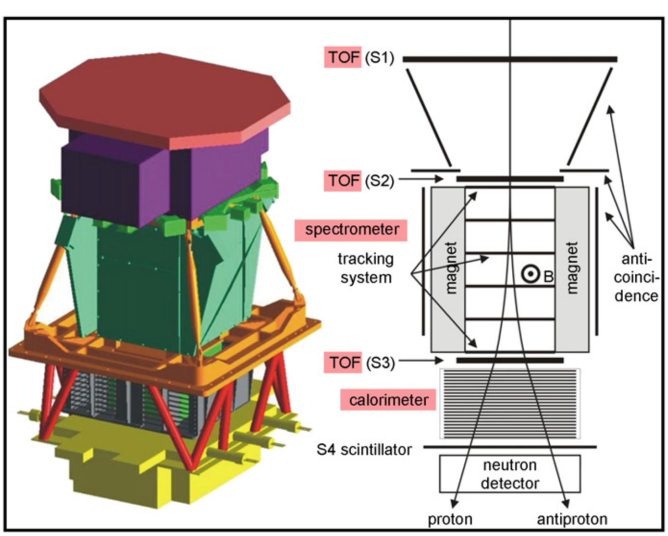

Fig. 1. Schematic view of the Pamela apparatus.

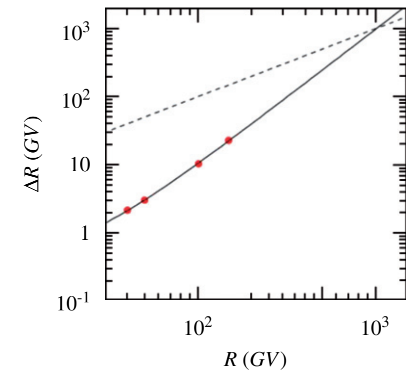

Fig. 2. The measured rigidity resolution for the magnetic spectrometer. The obtained MDR is greater than 1 TV.

clearly demonstrating the effectiveness of this detector in cosmic rays measurements in the energy region relevant to fulfill the Pamela's scientific objectives.

1.2. Calorimeter

The sampling electromagnetic calorimeter [3] is composed by 22 layers of tungsten absorbers, interleaved with 44 layers of single-sided silicon sensors planes. The total thickness of the calorimeter amounts to 16.3 X_0 (0.6λ). Each sensitive plane is composed by a 3×3 matrix of sensors, with 2.4 mm strip pitch. The excellent longitudinal and transverse granularity of this detector allows a very precise image reconstruction of the showers, hence providing a powerful tool to discriminate between electromagnetic and hadronic particles.

Fig. 3 shows the performances of the Pamela calorimeter (in particular the electron identification efficiency and the proton contamination) as obtained from the PS and SPS beam tests, compared to the simulated ones. At high energies ($E\geqslant 100$ GeV) an electron identification efficiency of the order of 90% can be achieved by keeping the hadron contamination well below 10^{-5}. This performance will allow to identify the rare antiprotons and positron components in cosmic rays with a background at the percent level, hence fulfilling the main Pamela physics goals.

1.3. Time Of Flight and trigger

A set of 24 plastic scintillator paddles (readout by means of 48 PMTs) is used to realize three detection planes, placed as shown in Fig. 1. These planes are used to generate the trigger for the experiment and to measure the Time Of Flight of the cosmic rays crossing the apparatus, increasing the discrimination capabilities in the low energy region. Moreover, this system is also used to precisely measure the charge of the incident particles by analyzing the energy released in the various planes. The performances in the nuclei measurements were determined in a 2006 beam tests at GSI, showing (for ^{12}C nuclei) a time

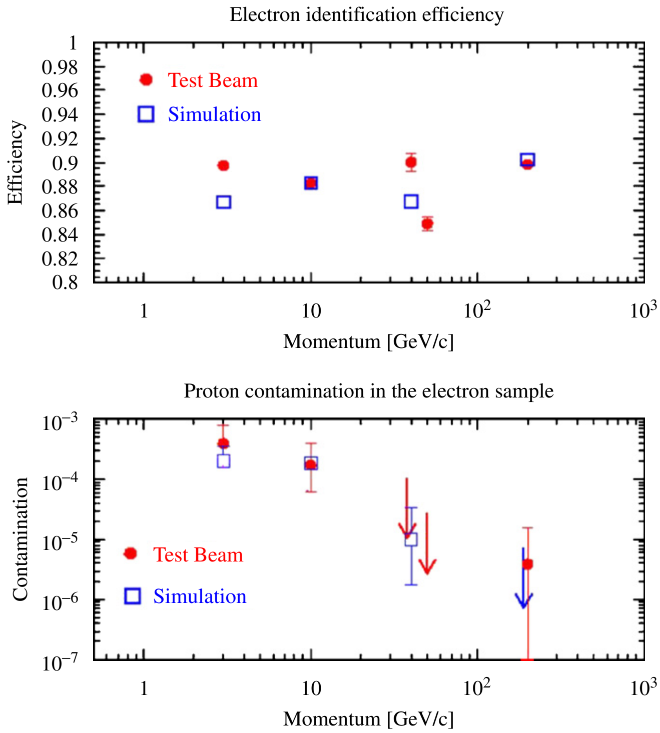

Fig. 3. The electron identification efficiency and the proton contamination as function of the momentum.

resolution of the order of 70 ps and a charge resolution of the order of 0.26.

1.4. Auxiliary detectors

The Pamela apparatus is complemented by three auxiliary detectors, to increase its overall performances:

- an anticoincidence system, realized with a set of nine plastic scintillators. This subdetector is used to identify the background particles that are not passing through the magnetic cavity. The system shows a very good efficiency ($\geqslant 99\%$), and can eventually be used in a second level trigger to reduce the DAQ rate;
- a neutron detector, realized by means of ^{3}He filled tubes and polyethylene moderator, useful to increase the hadron/electromagnetic rejection by measuring the neutrons created in the hadronic showers and escaping from the calorimeter;
- a tails catcher scintillator, used to measure the leaking particles from the calorimeter and to provide an additional stand-alone trigger for high energy electrons.

2. Status of Pamela

- All the various parts of Pamela were separately tested on particles beams before the final assembly of the apparatus that has been done between 2003 and 2005 in the Roma2 INFN clean rooms.
- The assembled flight model successfully passed the vibration and shocks tests that have been done in IABG (Munich, Germany) to qualify the apparatus for the launch.
- The flight model was delivered in March 2005 to the TSSKB factory in Russia, responsible for the production of the Resurs-DK1 satellite.
- All the integration tests with the satellite were successfully passed between March 2005 and March 2006.
- Pamela was transported to the launch base in Bajkonour (Kazakhstan) on March 28, 2006.
- The final tests with the satellite were done between April and May 2006, and Pamela is now 'ready for flight'; the launch is foreseen between June 14, 2006 and June 16, 2006.

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