The PAMELA experiment, scheduled to be launched in 2003, will provide a better understanding of the antimatter component of the cosmic radiation. The PAMELA experiment (Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics) will lift off aboard a Soyuz TM2 rocket in 2003, hitching a ride on the Russian Resurs-DK1 earth-observation satellite. While one end of the satellite will look down towards the earth, PAMELA will enjoy a clear view into space from the other. Data taking is expected to last for three years, and will result in better understanding of the antimatter component of the cosmic radiation.

The primary objective of PAMELA is to measure the energy spectrum of antiprotons and positrons in the cosmic radiation. At least $10^5$ positrons and $10^4$ antiprotons are expected per year. All existing antiproton measurements originate from balloon-borne experiments operating at altitudes around 40 km for approximately 24 h (figure 1; this also shows the situation for positrons). There is still a residual amount of the earth’s atmosphere above the detecting apparatus at this altitude, with which cosmic rays can interact. A satellite-borne experiment benefits from a lack of atmospheric interactions and a much longer data-taking time. In figure 1, the PAMELA expectation after three years of data taking is shown. These data sets exceed what is available today by several orders of magnitude, and will allow significant comparisons between competing models of antimatter production in our galaxy. Distortions to the energy spectra could originate from exotic sources, such as the annihilation of supersymmetric neutralino particles – candidates for the dark matter in the universe. Sensitivity to the low-energy part of the spectrum is a unique capability of PAMELA, and arises because the semi-polar Resurs-DK1 orbit overcomes the earth’s geomagnetic cut-off. Another PAMELA goal is to measure the antihelium to helium ratio with a sensitivity of the order of $10^{-8}$ – a 50-fold improvement on the current limits. An observation of antihelium would be a significant discovery, as it would be the first sign of primordial antimatter left over from the Big Bang.

WiZard collaboration
PAMELA is being constructed by the WiZard collaboration, which was originally formed around Robert Golden, who first observed antiprotons in space. There are now 14 institutions involved. Italian INFN groups in Bari, Florence, Frascati, Naples, Rome and Trieste, and groups from CNR, Florence and the Moscow Engineering and Physics Institute form the core. They are joined by groups from The Royal Institute of Technology (KTH) in Sweden, Siegen University in Germany, Russian groups from the Lebedev Institute, Moscow, and the Ioffe Institute, St Petersburg, and American groups from New Mexico State University and NASA’s Goddard Spaceflight Centre. The WiZard collaboration has a long history of performing cosmic-ray experiments. It ran six balloon flights between 1989 and 1998 using instrumentation novel for space, such as multisense drift cham-

Fig. 1. The current status of measurements of the antiproton (top) and positron (bottom) energy spectra. The solid lines indicate the expected spectra from different models of secondary production. The dotted lines indicate the distortion to the spectrum expected from “exotic” sources, in this case the annihilation of supersymmetric neutralinos. Current data can be explained only using secondary production models. The red squares indicate the quality of data expected from PAMELA after three years of data taking.
Particle physics into orbit

AUniversity of California, Berkeley and Lawrence Berkeley National Laboratory

The first flight of the PAMELA mission, from the Baikonur cosmodrome next year, is set to

ber in the strong magnetic field of a superconducting magnet; imaging streamer tubes and silicon–tungsten calorimeters; a transition radiation detector (TRD); and solid and gas ring-imaging Cerenkov detectors. Many important results were obtained during studies of antiprotons, positrons and light nuclei. In particular, the last balloon flight experiment of the WIZard collaboration, CAPRICE98, was the first to mass-resolve high-energy (above 20 GeV) antiprotons in cosmic rays. A subset of the collaboration has also built several small space experiments: the NINA-1 and NINA-2 satellite experiments (silicon detector systems used to investigate cosmic-ray nuclei); and SILEYE-1, -2 and -3 (silicon sensor telescopes used to study the radiation environment inside the MIR and the ISS space stations). These experiments were also used to study the nature of particles producing the light flashes seen by astronauts.

PAMELA is built around a 0.48 T permanent magnet spectrometer tracker equipped with double-sided silicon detectors, which will be used to measure the sign, absolute value of charge and momentum of particles. The tracker is surrounded by a scintillator veto shield (anti-counters) that will reject particles that do not pass cleanly through the acceptance of the tracker. Above the tracker is a TRD based around proportional straw tubes and carbon fibre radiators. This will allow electron–hadron separation through threshold velocity measurements. Mounted below the tracker is a very compact and deep silicon–tungsten calorimeter, to measure the energies of incident electrons and allow topological discrimination between electromagnetic and hadronic showers (or non-interacting particles). A scintillator telescope system will provide the primary experimental trigger and time-of-flight particle identification. A scintillator mounted beneath the calorimeter will provide an additional trigger for high-energy electrons. This is followed by a neutron detection system (3He-filled tubes within a polyethylene moderator) for the selection of very high-energy electrons and positrons (up to 3 TeV), which will shower in the calorimeter but will not necessarily pass through the spectrometer.

Final versions of the anticounters, calorimeter and tracker and a final prototype of the TRD were successfully tested with proton and electron beams at CERN in June. Integration and final tests of the other subdetectors continue in Rome and will be completed by the end of the year. PAMELA will then be shipped to Samara in Russia for integration with the Resurs-DK1 satellite. After this, the satellite will move to the Baikonur cosmodrome in Kazakhstan for launch preparations.

Further reading
http://wizard.roma2.infn.it/pamela.

Mark Pearce, KTH Stockholm (for the PAMELA collaboration).

PAMELA’s flight model tracker (upper) and calorimeter (lower) mounted together in preparation for beam tests at CERN. Four of the five magnet segments are visible, along with the tracker’s front-end electronics. The silicon–tungsten layered structure of the calorimeter can also be seen.
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