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CAPRICE98: A Balloon Borne Magnetic Spectrometer To Study Cosmic Ray At Different Atmospheric Depths

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Abstract

CAPRICE98 is a superconducting magnetic spectrometer built by the WiZard collaboration. It was launched from Ft. Sumner (USA) on the 28th of May 1998. For the first time a gas rich imaging Cherenkov (RICH) detector flew together with a silicon electromagnetic calorimeter. The detector configuration was completed by a time of flight for particle identification, and a set of three drift chambers for rigidity measurement. The scientific objectives are the study of antimatter in cosmic rays and the cosmic rays composition in the atmosphere with special focus on muons. The performance of the detector during the flight will be presented.

1 Introduction

CAPRICE98 (Cosmic AntiParticle Ring Imaging Cherenkov Experiment, 1998) is the latest balloon borne detector built and flown by the WiZard collaboration. Its primary scientific objective is the study of antimatter in cosmic rays and the investigation of cosmic rays spectra and composition at different atmospheric depths.

CAPRICE98 is the evolution of the CAPRICE94 detector (Barbiellini et al. 1996a, Barbiellini et al. 1996b, Bocciolini et al. 1996). The solid radiator RICH (Carlson et al. 1994) used in the 1994 flight was replaced by a gas radiator one. Besides the multiwire proportional chambers used in the tracking system (Lacy and Lindsey 1974) were replaced by a new drift chamber.

The CAPRICE98 gas RICH was the first one, able to identify charge one particles, ever flown. Besides, in this flight, for the first time a gas RICH was used in combination with a silicon-tungsten calorimeter.

In this configuration, the CAPRICE98 detector, has the capability to identify mass resolved antiprotons with energy greater than 17 GeV. Its primary scientific goals were to measure the absolute spectra of positrons and antiprotons up to 50 GeV along with muon spectra in the atmosphere.

2 The CAPRICE98 Apparatus

The CAPRICE98 apparatus is shown in fig.1. Inside a cylindrical aluminum vessel four detectors and a superconducting magnet were stacked, from the top to the bottom: the gas radiator RICH detector, a time of flight (ToF) system, a tracking system, a silicon-tungsten imaging calorimeter.

Detailed description of the RICH is presented elsewhere (Bergström, et al. 1999).

The ToF consisted of two planes of scintillators placed just above and below the tracking system. Each plane was made of two scintillator paddles viewed at each end by Hamamatsu R5924 phototubes.

The ToF informations were used to form the trigger and to identify albedo particles. At low energy, it provided particle identification and it may be used to select homogeneous sets of particles in order to study the other detector efficiencies.

Because CAPRICE98 primary scientific objective is the study of antiparticle in the energy range greater than $\approx$ 4.5 GeV, special attention was placed in upgrading the spectrometer to obtain a higher maximum detectable rigidity (MDR) with respect to the past flights. The tracking system consisted of 3 sets of drift chambers (Hof et al. 1994) and a superconducting magnet. Each drift chamber set, which was flushed with CO_2, contained 10 layers made of hexagonal cells providing 6 position measurements along the bending direction, x axis, and 4 along the non bending one, y axis, as shown in fig.2.

The magnet consisted of a 61 cm diameter coil made out of 11161 turns of a copper-clad Nb-Ti wire. It was housed in a 80 l liquid Helium dewar in thermal contact with a Nitrogen dewar. Both dewars were contained in a vacuum jacket packed with superinsulating material foils. It produces an inhomogeneous field of about 4 T in the coil center when operated at 120A.

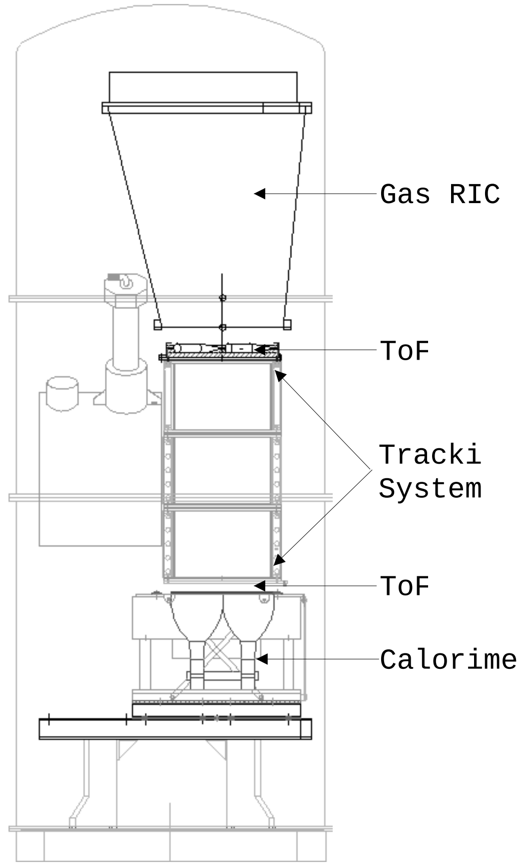


Figure 1: The CAPRICE98 apparatus.

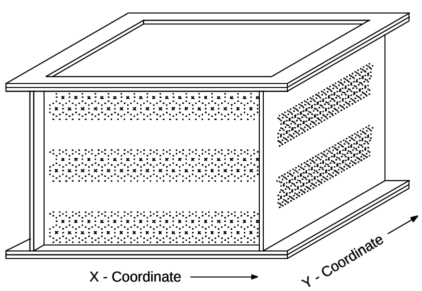


Figure 2: A drift chamber set.

The lowest detector is a silicon-tungsten calorimeter; performances and detailed description are presented elsewhere (Ricci et al., 1999).

On-board data acquisition was supervised by two CPUs. One, a VME based, was dedicated to the RICH read-out, while the other was in charge for the read-out of all the other detectors, house-keeping monitor, event building, data storage, and ground communications. Detector calibrations and slow controls along with several payload operations, like valve handling, disks management and on-board data storage, were remote controlled from ground stations by means of telecommands. Data were also transmitted, through an interface between the telemetry system and a local computer cluster, to the ground where detector performances were continuously monitored. In this way real-time monitoring was possible also by collaborators at their home institutions.

3 The Flight

CAPRICE98 was successfully launched on the 28th of May 1998 from Ft. Sumner, NM, USA (34.30°N 104.13°W), by the NASA National Science Balloon Facility (NSBF). The effective geomagnetic vertical cut-off is ≈4 GV for this site.

The payload flew for ≈20h at a float altitude of ≈5.5 g/cm^2. Slightly more than 5 million triggers were collected during the flight and all detectors performed normally.

At the moment of writing all the detectors have been calibrated and several preliminary results will be presented at this conference (Boezio et al. 1999, Circella et al. 1999, Carlson 1999). Both the calorimeter and the RICH showed a proton rejection factor greater than 10^6 up to 18GeV in selecting positrons.

In fig.3 the uncertainty in the deflection determination is reported as calculated on a reduced data set. This quantity is calculated in the fitting procedure that calculates the rigidity, on event by event basis. The MDR can be determined from this distribution as the reciprocal of the peak value of this distribution (Golden et al. 1991, Hof et al. 1994). From the flight data the drift chambers spatial resolution was found to be better than 100 μm allowing a MDR greater than 300 GV.

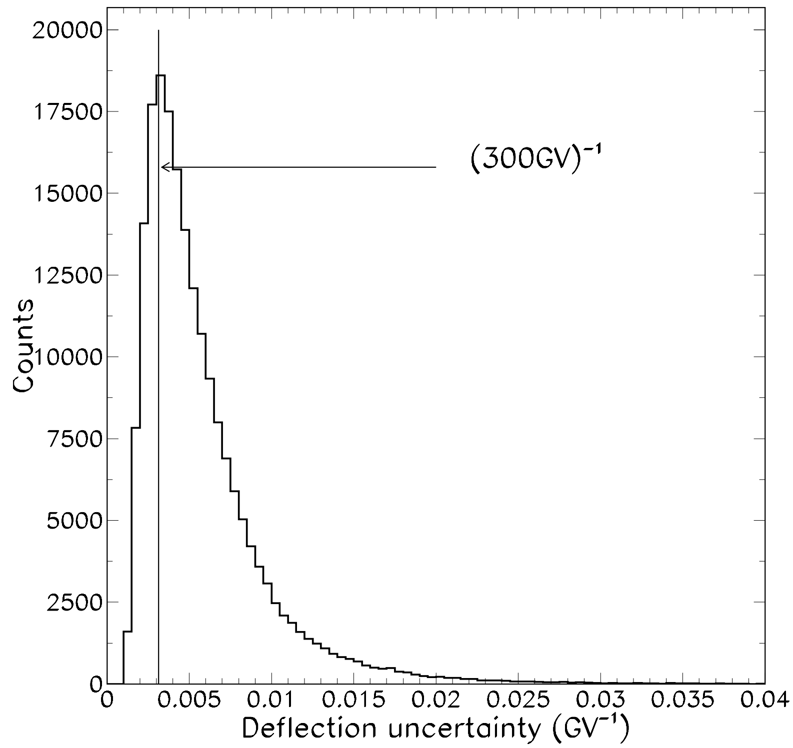


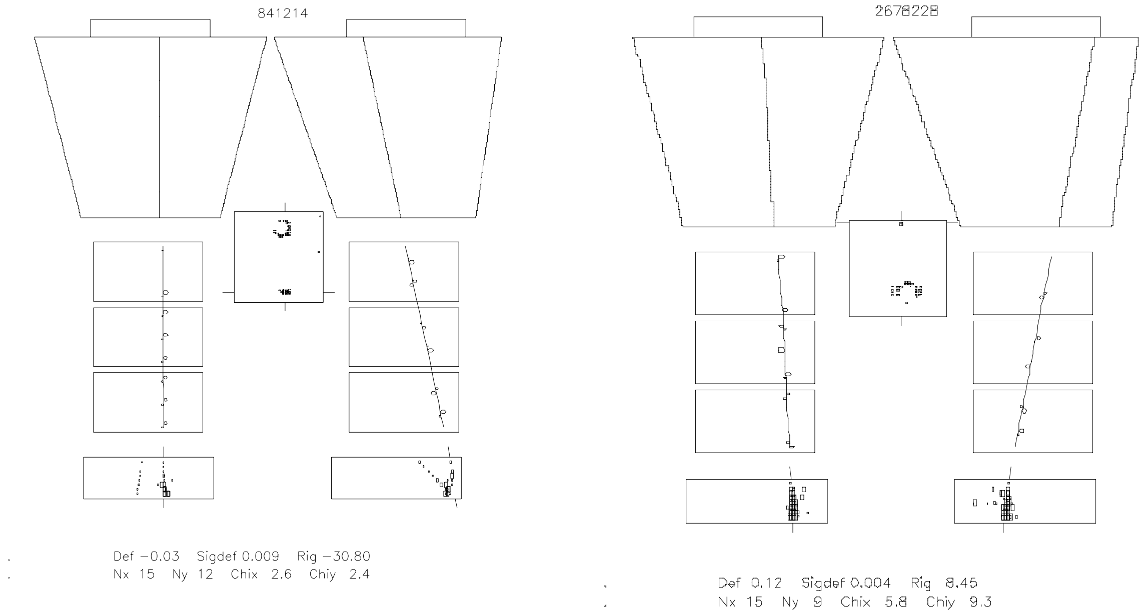
Figure 3: The deflection uncertainty. The value corresponding to a MDR of 300 GV is marked

Redundancy offered the possibility of detector cross calibrations. Using both the tracker and the calorimeter information, ToF pulse heights and time measurements were calibrated showing a time resolution of ≈230 ps.

The unique capability of particle identification by means of different techniques is shown in fig.4 where an antiproton candidate with an energy greater than 17 GeV is shown along with a positron candidate. The RICH top-view, in the middle of each picture, shows a clear ring along with the ionization where the particle crossed the chamber. In addition a hadronic interaction is present in the calorimeter, drawn at the bottom.

4 Conclusions

The WiZard collaboration launched for the first time a gas RICH detector and a silicon calorimeter together in a balloon borne instrument: CAPRICE98. This detector is able to produce the first mass resolved measurements of $\bar{p}$ above 17 GeV. Besides detector redundancy will provide excellent cross calibration capability, for a precise determination of efficiencies and systematic errors, making possible an excellent determination of cosmic rays spectra. This payload was launched successfully on the 28th of May 1998 and remained at float for more than 20 hours. Detector performances were nominal during the flight.



(a) (b)

Figure 4: (a) An antiproton candidate with energy greater than 17 GeV. (b) A positron candidate

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This work is dedicated to the memory of Dr. Robert L. Golden.

References

Barbiellini, G. et al. 1996a, Nucl. Instr. Meth. A 371, 169
Barbiellini, G. et al. 1996b, A&A, 309, L15
Barbiellini, G. et al., Proc. 25th ICRC (Durban, 1997) 5, 1
Bergström, D. et al., Proc. 26th ICRC (Salt Lake City, 1999), OG 4.1.21
Bocciolini, M. et al. 1996, Nucl. Instr. Meth. A 370, 403
Boezio, M. et al., Proc. 26th ICRC (Salt Lake City, 1999), OG 1.1.16
Carlson, P. et al. 1994, Nucl. Instr. Meth. A 349, 577
Carlson, P. et al., Proc. 26th ICRC (Salt Lake City, 1999), HE 3.2.05
Circella, M. et al., Proc. 26th ICRC (Salt Lake City, 1999), HE 3.2.02
Lacy, J.L. and Lindsey,R.S. 1974, Nucl. Instr. Meth. 119, 483
Golden, R.L. et al. 1991, Nucl. Instr. Meth. A306, 366
Hof, M. et al. 1994, Nucl. Instr. Meth. A 345, 561
Ricci, M. et al., Proc. 26th ICRC (Salt Lake City, 1999), OG 4.1.13