Performance Studies of the Anticounter System of the PAMELA Space Experiment

J. Lund[1], M. Boezio[2], P. Carlson[1], J. Lundquist[1], S. Orsi[1] and M. Pearce[1]
(1) Dept. of Physics, The Royal Institute of Technology, Stockholm, Sweden.
(2) INFN Trieste, Via A. Valerio 2, 34127 Trieste, Italy.

Abstract

The PAMELA space experiment is equipped with a permanent magnet spectrometer surrounded by an anticounter veto shield which aids in the rejection of particles which do not pass cleanly through the spectrometer's acceptance. The construction of the anticounter flight model is now complete and its perfomance has been studied. Cosmic ray muons have been used to determine the MIP detection efficiency and the anticounters have also been studied with particle beams at CERN. A focus of the test beam studies has been the backscattering of particles from the calorimeter mounted close to the anticounters.

1. Introduction

The PAMELA space experiment [2] is built around a tracking system placed within the bore of a permanent magnet. This paper concerns the anticoincidence (AC) system [3], consisting of 5 plastic scintillators with photomultiplier read-out, 4 of which completely covers the lateral sides of the tracker (CAS) and one which defines the acceptance at the tracker's entrance (CAT). The purpose of the AC system is to provide information that will enable the rejection of triggers not caused by particles cleanly entering and traversing the acceptance of the tracker (e.g. in a second level trigger [1]). This paper presents two aspects of tests performed on the AC system: performance studies using cosmic ray muons and comparisons between test beam data and simulations.

2. Performance Studies Using Cosmic Ray Muons

To evaluate the performance of the AC detectors, a test utilizing cosmic ray muons was performed. The aim of the test was to measure the efficiency of the large CAS anticounters (excluding electronics) and to study possible attenuation effects. The test set-up consisted of a drift chamber sandwiched between two trigger scintillators on top of which the CAS anticounters were stacked. This allowed the selection of single charged tracks from the multiparticle events produced by interacting particles. Furthermore, in the efficiency analysis the tracks

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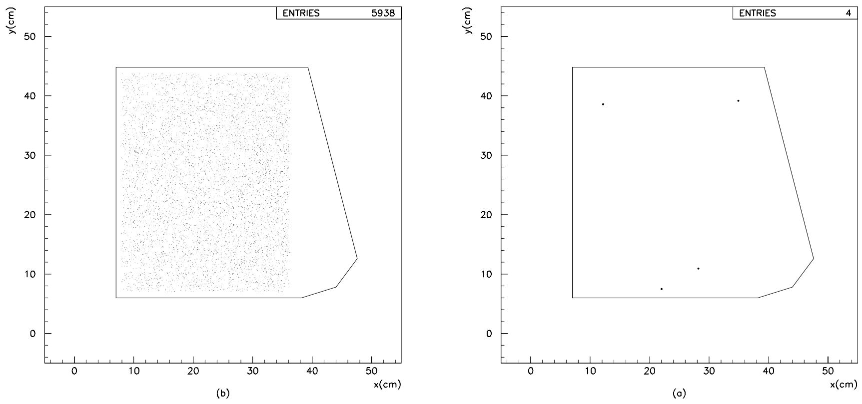

Fig. 1. Left: The hit distribution in a CAS anticounter reconstructed by the drift chamber. Right: The distribution of hits for events which were not tagged as hits by the AC detector, i.e. inefficiencies.

reconstructed in the drift chamber were required to point into the anticounters' volume. Figure 1 (left) shows the hit distribution in one of the AC scintillators as reconstructed by the drift chamber. The 'raw' PMT outputs were fed into charge sensitive ADCs. If a signal exceeding half of the energy deposited by a minimum ionizing particle (MIP) was registered in *both* PMTs of a detector simultaneously the event was tagged as a hit. Figure 1 (right) show the hit distribution for events which were not tagged as hits by AC and are therefore classified as inefficiencies. The efficiency averaged over all detectors was found to be (99.94±0.03)%. In the attenuation study the track reconstruction capabilities of the drift chamber were used to group particles traversing the anticounters depending on the distance between their impact position and the photomultiplier. To ensure sufficient statistics for each group the width of the different regions were set to 10 cm as can be seen in the left part of figure 2. The results of these measurements can be viewed in the right part of figure 2 where the output is expressed in MIP (the value of one MIP is calculated as an average over the whole detector area) and show that the attenuation does not present a problem, since the threshold will be set at 0.5 MIP.

3. Test Beam Validation of 'Self-veto' Simulations

A second level trigger for the PAMELA experiment has been designed based on the AC information [1]. A fundamental issue for the second level trigger is the impact of 'self-veto' (i.e. when backscattered particles from the calorimeter produce a signal in the AC system) and this was studied using simulations. In order to validate this study the anticounters and the calorimeter were placed in a test beam facility at the CERN SPS in a 'flight-like' configuration, i.e. with

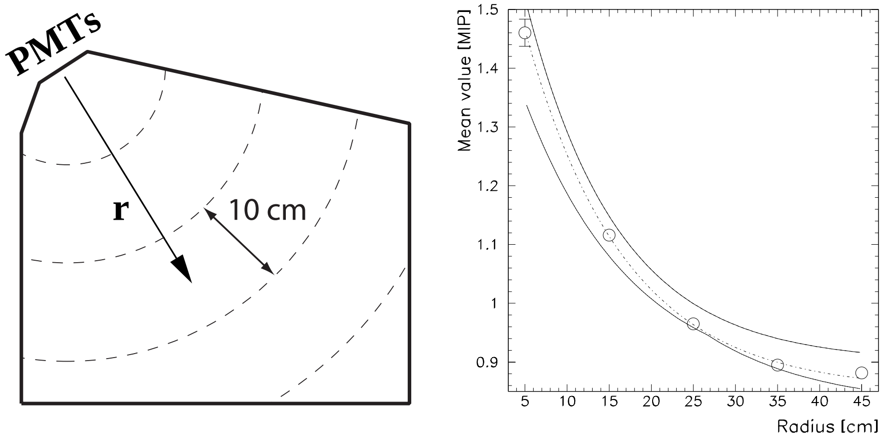

Fig. 2. Left: the spatial divisions used for grouping the events. Right: the attenuation as function of distance to the photomultiplier tube in units of MIP. The solid curves display the extremes seen for different detectors. The dashed line is an exponential function fitted to the data points from a representative detector.

the calorimeter in the beam and the CAS detector to the side (out of the beam). Electrons and pions were selected in the test beam data using the calorimeter to avoid the muon contamination which increases with energy. This configuration was simulated and the results compared with experimental measurements. The comparisons were performed at varying beam momenta (figure 3) and as can be seen the agreement is better for electrons than pions. A study using electrons with varying amounts of material between the calorimeter and the anticounter was also performed. Good agreement between data and simulations was observed, as shown in figure 4.

4. Conclusions

The performance test results show that the design efficiency is met and that attenuation does not present a problem. The measured efficiency is (99.94±0.03)%. The comparison between test beam data and simulations show good agreement for electrons and reasonable agreement for pure pions, thus giving confidence in the second level trigger study [1].

5. References

1. Lundquist J. et al., 2003, these proceedings.
2. Pearce M., 2002, Nucl. Phys. B 113, 314
3. Pearce M. et al., 2003, these proceedings.

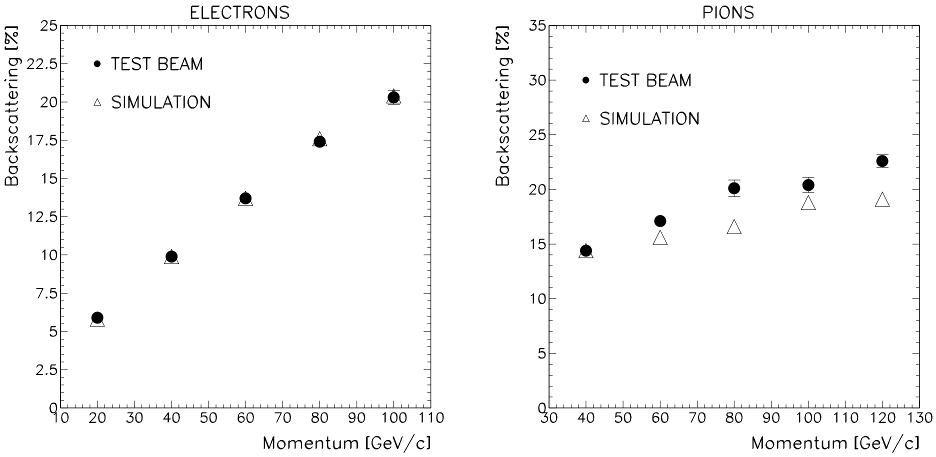

Fig. 3. The ratio of events where activity was recorded in the CAS counter (backscattering ratio) as function of electron (left) and pion (right) momentum. The discrepancies seen for pions is mostly due to the simulation program's inability to accurately treat hadronic interactions.

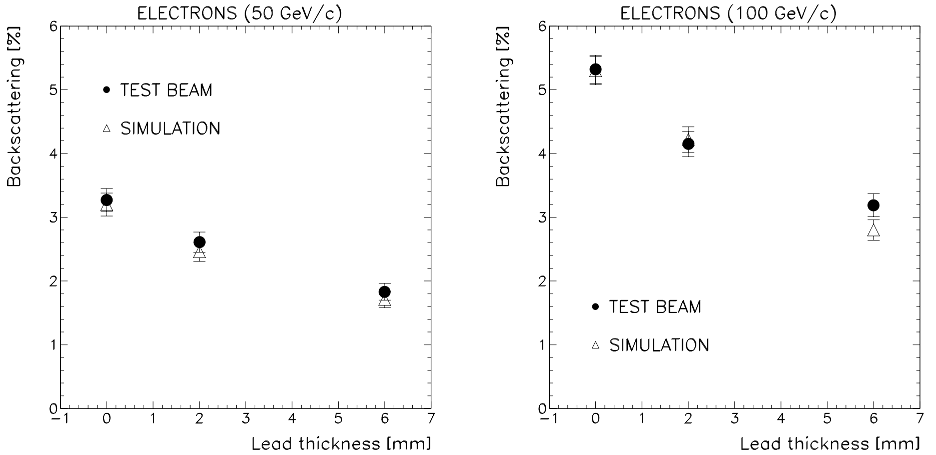

Fig. 4. Backscattering ratio (in %) by 50 GeV/c (left) and 100 GeV/c (right) electrons as function of lead thickness between calorimeter and anticounter.