The AMS-02 Tracker Performance

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Abstract

The silicon tracker is the central detector of the AMS-02 magnetic spectrometer. Eight planes of double sided microstrip detectors embedded in a magnetic field of ∼0.8 T allow for an accurate 3D reconstruction of particle trajectories and a rigidity measurement up to several TVs. Charge separation of ions up to Oxygen is achieved through multiple measurements of the energy loss in silicon. Beam test results will be presented as well as the figures of merit for the tracking in AMS-02.

1. Introduction

AMS is a large area, high resolution spectrometer that is going to be installed on the International Space Station (ISS) in 2005 and exposed to cosmic rays for a period of three years. After a successful test flight in 1998 with a reduced version of the final setup, the detector has been redesigned using the experience gained both in the operation and in the physics analysis. A description of the AMS-02 detector can be found in [1].

The central part of AMS is a spectrometer composed by a superconducting magnet (0.87 T) and a tracking device (tracker), composed of 8 layers arranged in 5 planes of about 1 m^2, built with close to 2500 double sided silicon sensors achieving a spatial resolution of $\sim 10\mu m$ in the bending direction and $\sim 30\mu m$ orthogonal to it. The measurement of energy deposition in silicon will allow also to identify nuclei up to $Z \sim 13$. A description of the AMS-02 tracker and its

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construction can be found in reference[2].

In order to test the performance of the detector two beam tests have been carried out at the CERN SPS:

- In September 2000, with 400 GeV muons. Spatial resolution for MIP particles was studied and the new silicon sensor design was tested.

- In October 2002, with Pb at 20 GeV/A impinging on a Be target. This produces fragmentation ions (all ions from Z=1 to Z=92), that were selected through their Z/A ratio and their momentum with dipole magnets between the target and the detector. With this rich particle environment, identification capabilities of the tracker as well as spatial resolution for heavy ions were studied. The results presented in this paper from this beam test are preliminary.

2. Experimental Setup

For the 2000 beam test a simple setup was used composed by one AMS-02 prototype ladder, a standard beam telescope to predict the particle position and scintillators for trigger purposes. The readout electronics was still the one used in AMS-01. About 400.000 events were recorded.

In 2002, the test was performed together with RICH and TOF of AMS-02. At this time six ladders were used and a common event number distributed to correlate the three detectors. Prototypes of the final electronic boards, both for power supply and readout were used together for the first time giving no problem during the 5 days data taking. The acquisition system was also a reduced version of the flight one, experiencing also no problems. More than 10 million events were recorded.

3. Spatial Resolution

Spatial resolutions were studied in both tests, for MIP particles in the 2000 test and for protons and helium for the 2002 test. In both cases an alignment of the system was performed. This means to find out the relative position and angles between all measurement planes with respect to a reference one.

Special effort has been made to reduce and control the noise in the whole system. This has provided a most probable value of the signal-to-noise ratio for MIP particles of 12.0 on the p-side and 9.0 on the n-side, measured in the 2000 test. Compatible results have been founded in the 2002 test.

The spatial resolutions achieved are summarized in Table 1. Preliminary results for the spatial resolution of heavier ions up to Z=6 have also been obtained, comparable to the He ones.

Table 1. Spatial resolution summary table

Particle	p-side	n-side
μ 400 GeV	$8.5\mu m$	$29.5\mu m$
p 20 GeV	$11.6\mu m$	$29.2\mu m$
He 20 GeV/A	$7.1\mu m$	$22.1\mu m$

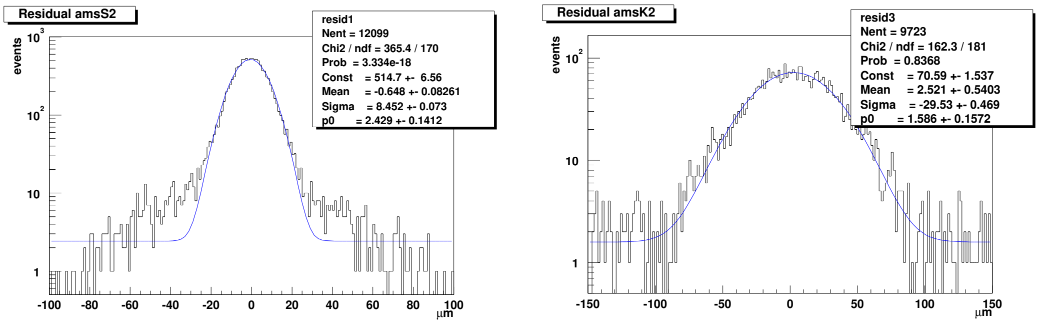

Figure 1. Residua distribution of hits obtained on the prototype ladder in the 2000 test with respect to the position estimated by the beam telescope. Left plot corresponds to p-side and right plot to n-side.

In Figure 1. the residuals obtained by comparing the predicted and measured positions for 400 GeV muons for p-side and n-side are shown.

In the final spatial resolution of the whole detector, a good knowledge of the relative position of the silicon sensors will play an important role. As it is shown in reference [2] the relative position is known to better than $4\mu m$.

4. Identification capabilities

In the 2002 test beam, all ions from p to Pb were produced at the fragmentation target. In order to identify different ions the fact that energy loss in silicon is proportional to the incident particle charge ($dE/dx \propto Z^2$) is used. This energy loss follows a Landau distribution, so with a single measurement large spreads are expected. The situation is clearly improved if multiple measurements of the energy loss are performed.

In AMS-02 there will be up to eight such measurements for any track detected. In the 2002 test six measurements were used. As charge can be measured on both silicon sides, two independent measurements of the same energy depositions can also be correlated.

In Figure 2. the combination of the six measurements collected on one side of the detector up to Z=10 can be distinguished with no problem. Combining the information of p and n sides this identification range can be enlarged up to Z=13.

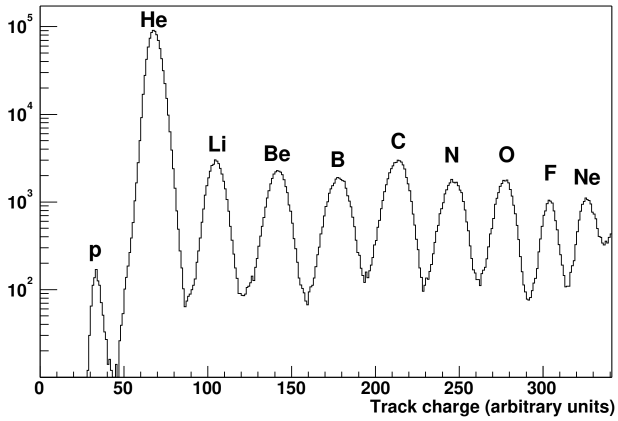

Figure 2. n-side distribution of $\sqrt{dE/dx} \sim Z$ in arbitrary units for a run in the 2002 test. Besides the He peak, up to Z=10 smaller peaks can be easily recognized. Please note the logarithmic scale on the y-axis.

Preliminary studies show encouraging results, but still a lot of work in order to understand the non linear behaviour of the front-end electronics for high energy depositions should be done.

5. Conclusions

Performance of the silicon tracker detector has been studied in two beam test performed at the CERN SPS with a large variety of ions, obtaining spatial resolutions for MIP particles of $8.5\mu m$ on p-side and $30\mu m$ on n-side. Preliminary results show that the spatial resolution is not degraded for higher Z.

Identification capabilities through the specific energy loss in silicon have also been studied, allowing to identify up to Z=10 using information on only one side and up to Z=13 using both sides.

Still a lot of studies have to be done, like the response of different ions as a function of configuration parameters (i.e. preamplifier shaping time). This is why new beam tests have been foreseen at the CERN SPS (Switzerland) and GSI (Germany) during 2003 and 2004.

We want to thank the many organizations and individuals, listed in the acknowledgments of reference [1]

References

[1] Gentile S., these proceedings

[2] Cecchi C., these proceedings