The Silicon Tracker of AMS02

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Abstract

AMS02 is a general purpose spectrometer to measure cosmic rays and search for antimatter in near Earth orbit and is scheduled to be installed on the International Space Station in 2007. The Silicon Tracker is a key component of the AMS02 experiment. It's production status and performance are presented in this note together with a brief overview of the AMS02 experiment.

Key words: AMS, AMS-02, Silicon Tracker
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1 Introduction

The Alpha Magnetic Spectrometer (AMS) will analyze cosmic radiation of galactic and extragalactic origin at an altitude of about 400 km above Earth on the International Space Station (ISS). A precursor flight on NASA Space shuttle mission STS-91 in June 1998 has been performed with a prototype detector. The results from this mission can be found in [1]. Based on experience from this first mission a more ambitious detector, AMS-02 is being built. It is foreseen to be installed on the ISS in mid-2007.

The new detector will extend the energy range of the spectrometer into the TeV region and improve its particle identification capabilities. Its main physics goals are the study of: Dark Matter, to look for particles like the neutralino $\tilde{\chi}^0$ via processes like $\tilde{\chi}^0\tilde{\chi}^0 \to \bar{\mathrm{p}} + \cdots, \to \mathrm{e}^+ + \cdots, \to \gamma + \cdots$; Antimatter, to resolve the puzzle of non-observation of antimatter in our current universe; Cosmic rays (D, He, Li, Be, B and C) to determine accurately the isotope abundances over a wide range of energies and High Energy Photons to study and identify galactic and extra-galactic sources like pulsars and active galactic nuclei.

2 The AMS-02 Detector

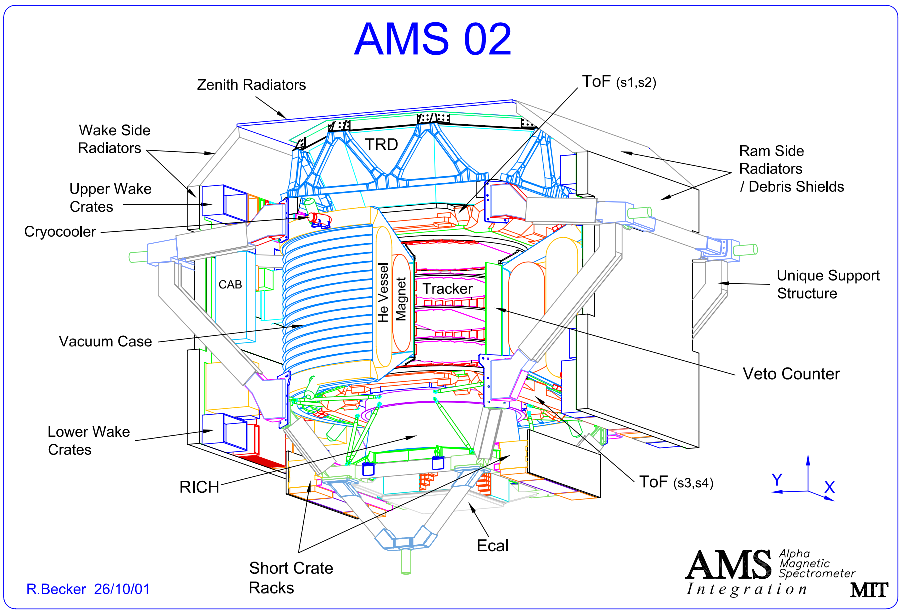

Fig. 1. The AMS-02 Detector

The layout of the AMS-02 detector [3] is shown in Fig. 1. The detector is built around a central spectrometer which consists of a silicon tracker inside a superconducting magnet, supplemented with particle identification devices like a time-of-flight system, a transition radiation detector, a ring imaging Cerenkov detector and an electromagnetic calorimeter. The full detector has an accpetance of about 0.1 m^2sr (the tracker alone has an acceptance of 0.45 m^2sr) and weighs a little more than 6 tons. The whole power consumption of the detector has to remain below 2 kW.

3 The Silicon Tracker of AMS-02

The Silicon Tracker of AMS-02 is built out of 2264 double-sided silicon sensors with a total surface of about 6.4 m^2. The sensors are combined into ladders of 7-15 sensors each as shown in Fig. 2. Each ladder provides 1024 readout channels, 640 for the Sensor-side (S) and 384 for the Kapton-side (K). The readout is performed through AC-coupling via a 64 channel PreAmp/shaper with capacitors and a multiplexed analog readout by custom-made frontend-electronics from IDEAS (Norway) [2].

The ladders are then combined into planes as shown in Fig. 3. The complete spectrometers consists of 3 double-sided inner planes and 2 single-sided outer planes. The Silicon Tracker of AMS-02 has to track charged particles and mea-

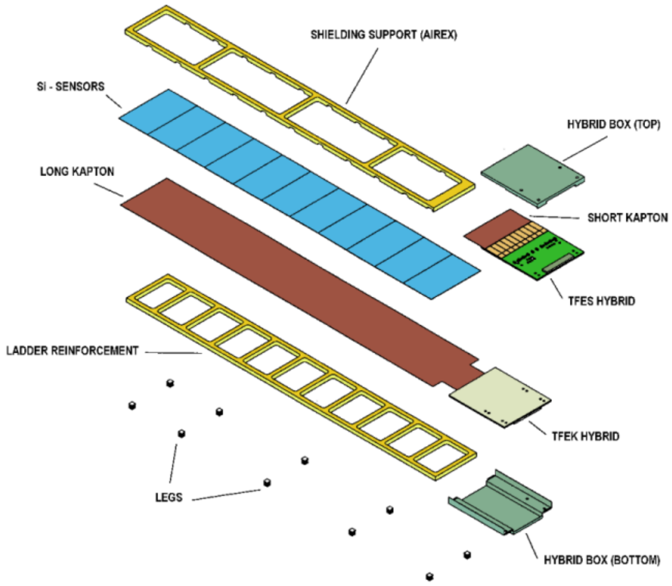

Fig. 2. Schematic View of a Ladder for the AMS-02 Silicon Tracker

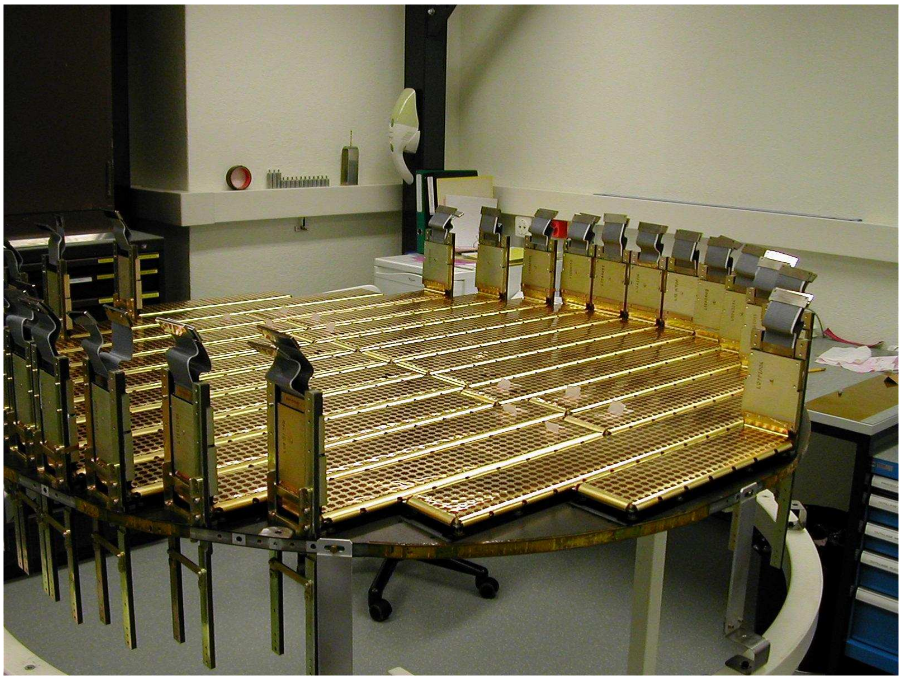

Fig. 3. A silicon tracker inner plane fully equipped with shielded ladders

sure their rigidities $R = p/Z$ up to around 2.5 TeV with a relative resolution of $\Delta R/R \approx 1.5\%$ in the range up to 100 GeV. In addition it can be used to identify elements via dE/dx.

4 The Tracker Readout Electronics

In total, about 200k channels have to be read out from the Silicon tracker at an estimated rate of about 2 kHz. The data needs to be compressed on-the-fly for the event building by about a factor 200. The Tracker Readout Electronics has been designed by University of Geneva and INFN Perugia.

It consists of the following parts: A Tracker Power Distribution Crate (TPD) converts the 28 V DC from the ISS into the needed voltages for the tracker electronics and filters it. The Tracker Readout-Crate contains modules to provide the needed bias voltage to the silicon ladders (TBS) and to supply the power for the frontend hybrids (TPSFE). In addition it contains Tracker Data Reduction boards (TDR2). These boards collect the analog data and digitize it. Afterwards the digital part compresses the data. It consists of a DSP, a Gate-Array, some buffer memory and a flash memory to store the executable code and detector specific variables. The event compression is done by removing pedestals and common noise before performing a cluster search on the remaining data. The compressed data is then collected on each readout crate by an interface module to the main data acquisition and transferred to the next higher level of event-building.

5 Performance of the Silicon Tracker

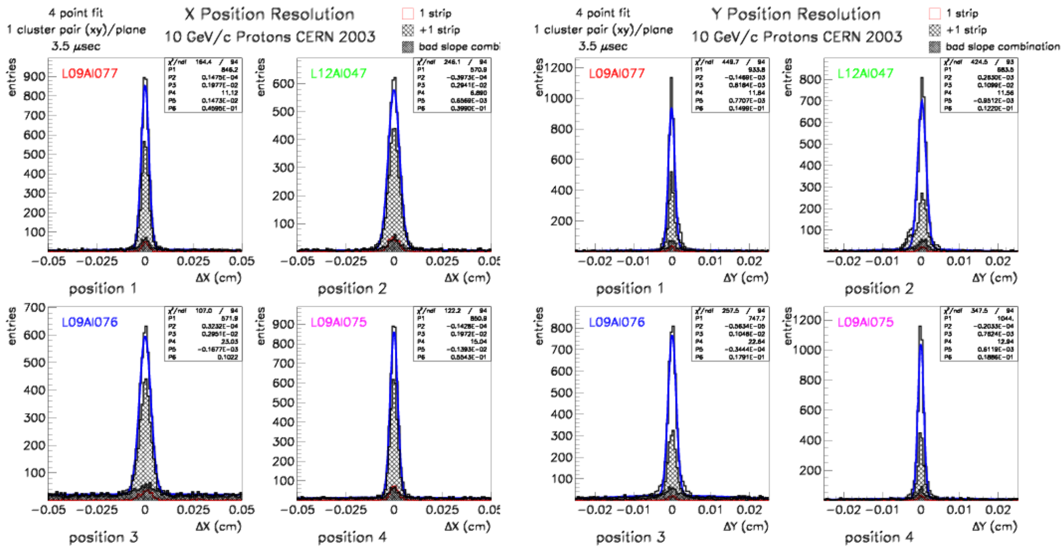

Fig. 4. The resolution of the AMS-02 silicon detector

The performance of the silicon tracker has been evaluated lately in 2 testbeams performed at CERN PS (using protons) and SPS (using heavy ions) with a spectrometer of 6 silicon ladders and engineering models of the tracker electronics. One of the parameters that needed to be defined is the best shaping time for the signals. It has been found to be 4-5 μs for the kapton-side and 2.5-3.5 μs for the sensor-side.

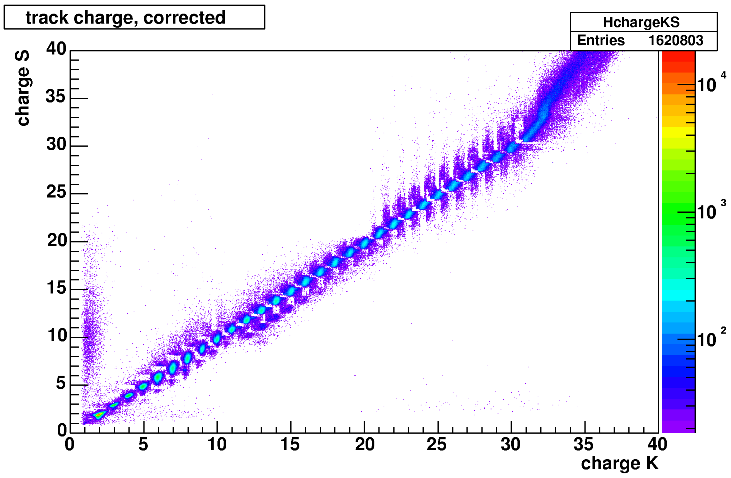

Fig. 5. The dE/dx-performance of the AMS-02 silicon detector

In additon the resolution and the dE/dx performance have been evaluated. Fig. 4 shows the performance for S(y)- and K(x)-side of the detector. The S-side has a resolution of 8-10 μm and the K-side has about 25 μm. This confirms the expected resolution of the readout pitch of 110 $\mu m/\sqrt{12}$ for the S-side and 210 $\mu m/\sqrt{12}$ for the K-side. For the particle identification via dE/dx the raw ADC-values have been corrected for effects from center-of-gravity, for charge-dependence and for effects coming from different gains of the readout electronics. After that a truncated charge has been calculated for sensor- and kapton-side. The dE/dx performance is shown in Fig. 5. Elements up to zinc(Z=30) can be identified, exceeding the design goal of identifcation capabilities up to oxygen (Z=8).

6 Conclusions

The construction of the Silicon Tracker of AMS-02 is on schedule and expected to be finished end of 2004. The silicon sensors fulfill or exceed the design goals in terms of resolution and dE/dx particle identification. The development of the readout eletronics has finished and the modules have been thoroughly tested. Production of the readout electronics will start end of 2003. The tracker will be ready in time for the integration into the full AMS-02 detector.

References

[1] M. Aguilar-Benitez *et al.*, Phys. Rep. **366** (2002) 331.

[2] http://www.ideas.no.

[3] M. Pohl, Nucl. Phys. B (Proc. Suppl.) **122** (2003) 151.