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Performance of the AMS02 TRD prototype

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ABSTRACT

AMS02 is a spectrometer for the International Space Station ISS. Particle identification will be a key issue for dark-matter and SUSY searches relying on positron spectroscopy up to 300 GeV. This requires a proton background reduction to 10^{-2} from the Transition Radiation Detector (TRD). The design for safe and reliable operation over three years in space consists of 20 layers of 20 mm fleece material equipped with modules made from 16 6mm straw tubes filled with a Xe/CO2 gas mixture and operated in proportional mode at a gas-gain of 3000. A prototype with 20 layers was built in Aachen for beamtests at CERN. Its performance was tested with electrons, myons and pions up to beam energies of 100 GeV and with protons up to 250 GeV. For these energies proton rejections below 10^{-2} are observed. The beamtest results in comparison with simulation studies will be presented.
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1 Introduction

The AMS-collaboration demonstrated with the succesful 10 days precursor flight (STS91) of AMS-01 that it is possible to operate a modern particle physics detector in space [1]. The AMS-02 detector is a high energy physics experiment for the International Space Station ISS. During a period of three years the experiment will measure the cosmic ray particle spectra and will search for antimatter and dark matter. The scientific reach of AMS-02 extendes AMS-01 by several orders of magnitude. Specially for dark matter and SUSY searches relying on positron spectroscopy lepton identification up to 300 GeV energy is required. Therefore AMS-02 will be equipped with a transition radiation detector (TRD) on top and an electromagnetic calorimeter below the silicon tracker. The combination of both devices is designed to reject protons at the 10^6 level, allowing high precision positron spectroscopy. The design and construction of the TRD is described in [1].

2 The AMS-02 TRD Prototype

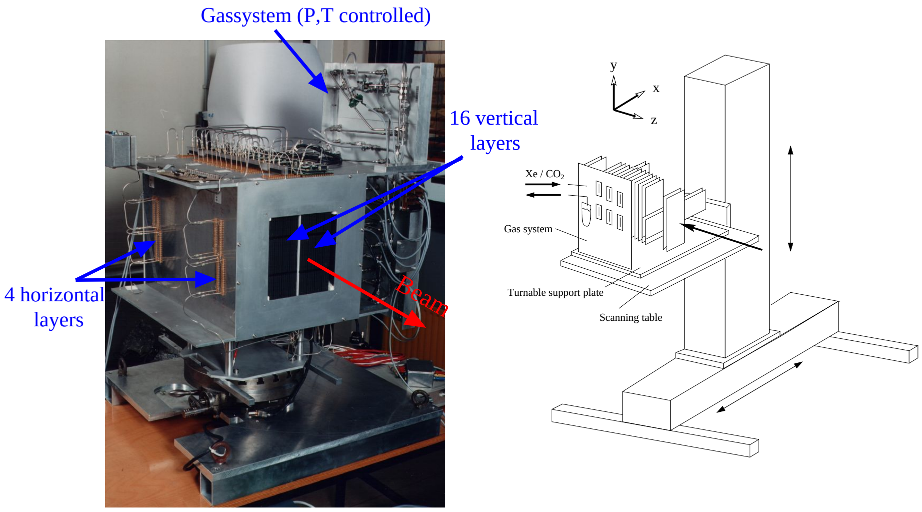

Figure 1: *AMS-02 TRD 20 layer prototype for CERN beamtest. Schematic view of beamtest setup showing only the left tower with 16 of 32 vertical modules and the lower tower with 4 of 8 horizontal modules. The right vertical and upper horizontal towers are shifted by half a layer in beam direction.*

To verify the performance of the proposed TRD design a 20 layer prototype detector was built from 2 times 20 modules, each 400 mm in length and covered with 20 mm of fleece radiator in front. The Xe/CO_2 (80%/20%) mixture was flushed through the straw modules at 0.3 l/h in six open-ended gas-circuits each connecting 6 or 8 modules in series.

3 Beamtest results

During three beamtest periods in summer 2000 at CERN 3 million events were recorded at the T9, X7 and H6 beam lines providing signal responses for protons, electrons, muons, and pions at energies between 5 and 250 GeV.
Muon events are used to intercalibrate the individual tubes to a relative accuracy below 2%.
For the absolute energy calibration an Fe^{55} source emitting 5.9 keV photons was used.
To account for environmental influences on the gasgain, temperature and pressure were monitored continuously. A 1% gas-density variation (3 K) leads to 5.4% gasgain variation.
To determine the electron-efficiency and proton-rejection a sample of clean single track events is preselected. For those events Figure 2 shows the energy deposition in each straw tube for 20 GeV protons and electrons in . The detection of TR photons is clearly visible in the electron-spectrum at energies above 5 keV. The cut-off at 30 keV is due to the limited dynamic range of the VA-readout.
Particles are then identified based on a maximum likelihood method. This algorithm selects electrons with 90% efficiency and rejects protons as shown in Fig. 2 well below 1% up to 250 GeV particle energy. Over the full energy range the required proton rejection of better than 10^2 is more than fulfilled. The obtained proton rejection is an upper limit since expected corrections due to beam impurities and readout-effects, which are still under investigation, can only improve the result.
The Monte-Carlo simulation shown in Fig. 2 is based on a modified GEANT version to account for transition radiation photon production in fleece radiators [2)] and absorption in thin gas layers [3)]. For primary particles up to 160 GeV a fair agreement with the beamtest data is reached. The MC-tuning is in progress.

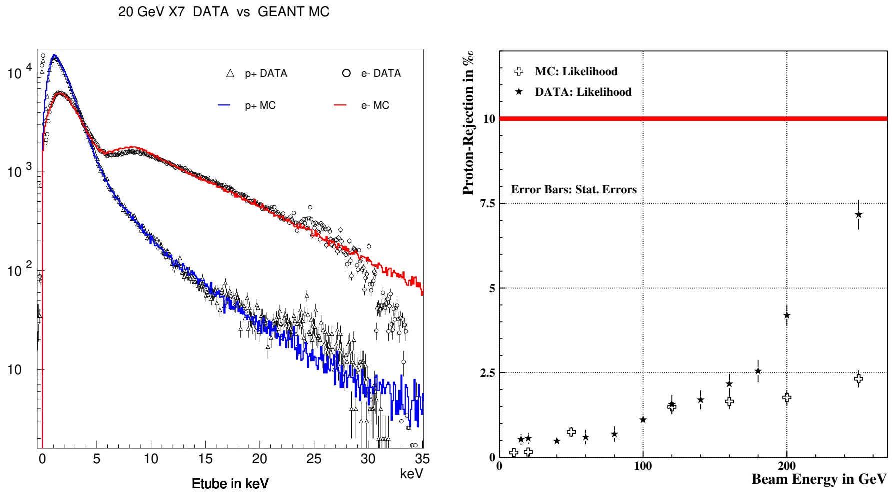

Figure 2: *Single straw tube energy deposition spectra for 20 GeV protons and electrons, normalized to the same number of entries. Preliminary proton rejections for* 90% *electron efficiency for particle energies between 15 and 250 GeV determined from clean single track beamtest events with a maximum likelihood algorithm. These numbers are upper limits.*

4 Acknowledgements

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