1 Introduction

AMS is a multi-purpose experiment intended to perform measurements of charged cosmic rays in space (at about 450 km height) during a 3 year mission. AMS will search for primary antimatter and dark matter contents of the Universe with a sensitivity never reached before. In addition, the high statistics study of the cosmic ray elements and isotopes and their energy flux in a wide energy range will result in a greatly improved understanding of the cosmic ray propagation in our Galaxy.

2 AMS detector

AMS is a magnetic spectrometer equipped with several subdetectors devoted to the identification of the particle and the measurement of its energy (see Fig. 1). The detector strategy is based on redundant measurements which ensure a proper background rejection for rare signal searches. In addition, the design has to meet the specific constraints imposed by the launch and the operational environment conditions.
The main components of the detector are:

- A cryogenic superconducting magnet that consists of an arrangement of 2 main dipole coils and 12 racetrack coils designed to give the maximum field in the perpendicular direction, while minimising the stray field outside the magnet. The magnetic flux density at the geometric centre of the system is 0.86 T.

- A silicon tracker detector (STD) made of 8 double-sided silicon sensor layers, 6 of them contained inside the magnet, will measure the charged particle bending.

- A time of flight system (ToF) consisting of 2 double planes of scintillator counters which is able to reach a precision in the time of around 120 ps

- A transition radiation detector (TRD) which detects the transition radiation light produced by ultra-relativistic particles in a set of polypropylene fiber radiators by means of 5248 straw tubes operated at high voltage with a mixture of Xe and CO₂.

- A ring imaging Čerenkov counter (RICH) will measure the velocity of relativistic particles from its Čerenkov cone opening angle. The Čerenkov radiator consists of a set of aerogel and NaF tiles, while the detection plane is instrumented with 680 R7600-M16 multianode Hamamatsu photo-multipliers.

- An electromagnetic calorimeter (ECAL) that consists of layers of lead foils with glued scintillating fibers resulting into a total radiation depth of 17 X₀ for shower development.

The STD measures the particle rigidity (p/Z) in the range from 0.5 GV to 2 TV with a resolution of 1.5% at 10 GV. The ECAL takes charge of the electromagnetic particle identification, determining the electron energy with a resolution of 3% at 100 GeV.

The particle identification is done through its electric charge and its mass. The charge is determined by a combined measurement of the deposited energy in the ToF and STD planes and by the Čerenkov light detected in the RICH from Z=1 to Z≤ 26 with very small charge confusion. The RICH will also provide a very precise velocity measurement, σ ≈ 0.1% for protons with β > 0.95, which allows a resolution in the mass determination of 2%. Below the RICH threshold the velocity is measured by the ToF with a resolution of 3.5%.

In addition, the different response of hadronic and electromagnetic particles in the interaction with the TRD and ECAL provides a hadron-electron separation: The TRD differentiates protons
from electrons with a rejection factor of $10^2 - 10^3$ in the range from 1.5 to 300 GeV while the ECAL provides a rejection factor of $10^4$ for electrons with energy smaller than 1 TeV.

3 Galactic Cosmic Rays

The high energy cosmic ray nuclei are accelerated particles that travel through the interstellar medium (ISM), where they are scattered, reaccelerated and lose energy before reaching the Earth. They can also produce secondary nuclei by fragmentation of heavier ones (spallation), decay and even escape from the Galaxy. The propagation models must provide a reliable description of the CR propagation through the ISM taking into account all these phenomena and reproduce the observed CR fluxes in the heliosphere. A very precise knowledge of the elemental and isotopic spectra of CR in a wide energy range is essential to understand their origin, the matter content and the magneto-hydrodynamical properties of our Galaxy.

AMS will be able to cover a set of critical measurements with very high precision, extending significantly their energy range.

3.1 H and He spectrum

Hydrogen and helium constitute about 99% of the hadronic CR, their energy spectrum provides information about the primary acceleration mechanism. Differences in the origin and acceleration among species could be obtained by comparing both high statistics spectra. Precise measurements of H and He fluxes are used to determine the expected fluxes of antiprotons and positrons, to compute the diffuse gamma-ray background spectrum and to define the expected fluxes of atmospheric neutrinos. The most precise measurements come from magnetic spectrometres with uncertainties of about 5-10% up to rigidities of 100-200 GV$^1$. AMS should be included in this set of experiments but improving the resolution and increasing the dynamic range up to 2-3 TV (see Fig. 2). Other experiments, as calorimeters and nuclear emulsions$^2$, have measured the H spectrum up to $10^{15}$eV/n but with poor accuracy, i.e., 25-50%.

3.2 Secondary CR spectrum

AMS will measure the energy spectrum of primary CR up to Fe, but it will keep a larger sensitivity for C, N and O, the most abundant elements after H and He. A very interesting measurement is the ratio of secondary particles produced by spallation to the corresponding primary one, like for example B/C. It gives information about the amount of matter traversed by the CR and, therefore, about the confinement volume. Boron to carbon ratio has been obtained by several experiments in different energy ranges from $10^{-1}$ to $10^2$ GeV/n$^3$$^4$$^5$. Until now the smallest uncertainties in the ratio come from HEAO-3 experiment, $\sim 5\%$ for $0.6 < E < 35$ GeV/n. AMS will measure the B/C ratio from 0.2 to 1000 GeV/n with a resolution better than 5% in the whole range.

3.3 Unstable Isotopes

Some of the species created by spallation are radioactive. $^{10}$Be is particularly interesting because its half time is of the same order than the confinement time of the CR in the Galaxy. The relative abundances of the isotopes of Be can tell us whether or not all the $^{10}$Be have decayed, and consequently provide an estimate of the mean age of the CR observed at the Earth. Present measurements of the ratio $^{10}$Be/$^9$Be have been performed using space-borne spectrometers for energies $\leq$ 100 MeV/n and ISOMAX balloon-borne magnetic spectrometer$^6$ for energies in the range 0.26–2 GeV/n, as it is shown in Fig. 2. AMS will be able to separate $^{10}$Be from $^9$Be for $0.15$ GeV/n $< E < 10$ GeV/n, the sensitivity after 1 year of data taking is shown in Fig. 2.
3.4 Antiparticles

Antiparticles, like antiprotons and positrons, are secondary CR created by interaction of primary CR with the ISM. They constitute the best signature for new physics because of the low background. Distortions in the antiparticle spectrum, related to its secondary origin, could arise from primary source contributions such as neutralino annihilation in the galactic halo, hence a very good understanding of the expected fluxes becomes necessary. The detection of antiparticles is reserved to magnetic spectrometers that have the capabilities for charge sign identification. The current measurements of the antiproton spectrum are dominated by the balloon-borne spectrometer BESS. These measurements together with the ones obtained by AMS-01 and CAPRICE agree with the theoretical predictions for a pure secondary origin. For positrons, the experimental results are not conclusive. In spite of the most recent measurements, generally compatible with a secondary origin, there is some indication of a structure around 7 GeV in the energy dependence of the positron fraction as measured by HEAT. Only new measurements over a larger energy range and more statistics will be able to better constrain propagation models and give a clear signal physics. After 3 years AMS will collect around $10^6$ antiprotons and will identify and measure positrons up to 400 GeV. This flux will provide sensitivity to new physics in several scenarios.

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