The Alpha Magnetic Spectrometer AMS-02: soon in Space

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Abstract

AMS-02 is a magnetic spectrometer designed to perform accurate and long duration measurements of cosmic radiation on the International Space Station. With its large acceptance (0.45 m^2sr), the long duration (3 years) and the state of the art of the particle identification techniques, AMS will accurately measure charged cosmic rays spectra and high energy photons in the hundreds MeV to few TeV energy range. It will provide the most sensitive search for the existence of primordial anti matter and multi-channel indirect search for dark matter. AMS-02 integration has been started at CERN in September 2007 and after a final space qualification test at ESTEC (ESA) and a beam test (CERN) the whole apparatus will be moved to KSC (NASA) in December 2009.

1. The Alpha Magnetic Spectrometer

The Alpha Magnetic Spectrometer (AMS) is an extremely high profile space-based particle physics experiment that is led by Nobel laureate Samuel Ting of the Massachusetts Institute of Technology (MIT). The AMS experiment is a high energy particle detector aimed at making a high precision measurement of Cosmic Ray (CR) and gamma fluxes at low Earth orbit from few hundred MeV/n up to few TeV/n.

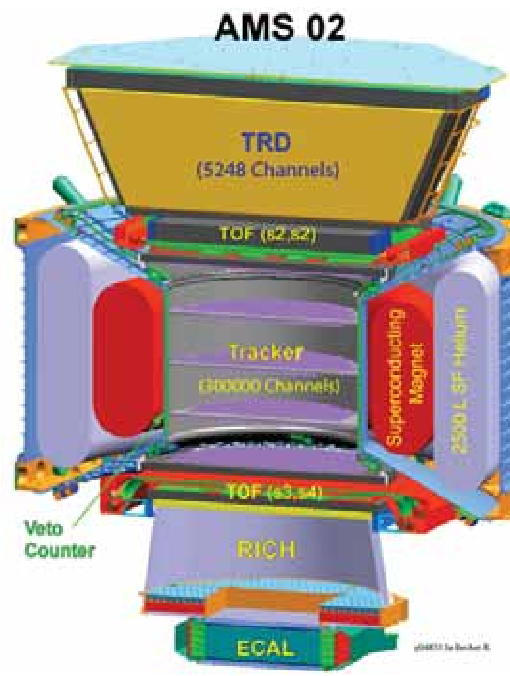

Figure 1: The AMS-02 Spectrometer. The detector components are: Transition Radiation Detector (TRD), Time Of Flight detector (TOF), silicont Tracker (Tracker), Ring Imaging CHerenkov detector (RICH), Electromagnetic CALorimeter (ECAL), AntiCoincidence Counters (ACC) and finally the magnet.

AMS-02 (see figure 1), 7 tons, 3 kwatt consumption and 3x3x3 m shuttle payload, is currently scheduled to fly on the International Space Station (ISS) in 2010, where it will operate for at least three years.

The experiment utilizes a large, cryogenic superfluid helium (1.8 K) superconducting magnet to produce a strong, uniform magnetic field (0.8 Tesla) over a large acceptance of 0.5 m^2 sr. The magnetic field is used to bend the path of charged cosmic particles as they pass through five different types of detectors [1].

The Transition Radiation Detector (TRD) is designed to separate e^+/e from p^+/p^- up to 300 GeV. TRD consists of 20 layers of straw tubes, filled with a mixture of Xe/CO_2 , alternating with fleece radiators [2].

The Ring Imaging CHerenkov detector (RICH) provides Z measurement up to iron and a precision velocity measurement with $\Delta\beta/\beta \approx 0.1/Z\%$ allowing for isotope separation in the kinetic energy range from 0.5 GeV/n to 10 GeV/n for $A = 10$.

The Time of Flight detector (ToF) consists of four planes of plastic scintillators placed at both ends of the superconducting magnet. It provides a fast trigger to the experiment, velocity with a $\Delta\beta/\beta \approx 3\%$ for protons and a charge identification up to $Z = 20$ [3].

The AMS-02 Tracker consists of eight layers of double side silicon microstrip detectors mounted on 5 carbon fiber planes for a total active area of about 6.4 m^2. In each layer, simultaneous measurements of position and energy loss in silicon are performed along the particle trajectory. With its high spatial resolution, 10 μm for singly charged particles ($\approx$ 6μm for Z> 1), the silicon tracker allows the determination of the rigidity (R) and the charge sign of particles up to several TVs, with a resolution $\sigma R/R \approx 2.5\%$ up to $O(100)$ GV. The low noise and wide dynamic range of the silicon readout electronics allow to exploit the energy loss measurements to determine the particle absolute charge for nuclei up to Fe [4].

The Electromagnetic CALorimeter detector (ECAL) consists of 9 superlayers of lead foils with glued scintillating fibers resulting into a total radiation depth of 16 X_0 for shower development. ECAL is designed to assure precise e^-, e^+ and γ spectra from 1 GeV to 1 TeV with $dE/E < 5\%$ and good e^+/p discrimination (below 500 GeV). For gamma ray studies, ECAL acts as an independent photon detector with an angular resolution of approximately 1°.

The Anti Coincidence Counter (ACC) ensures that only particles passing the magnet aperture and not being scattered in the tracker are accepted. The ACC system is composed by 16 plastic scintillator paddles, displaced in order to form a cylinder of an inner diameter of 109.1 cm.

The AMS-02 has interesting and ambitious targets during the three years of mission [1]. The most importants are briefly summarized below:

- AMS-02 improve the actual knowledge of the cosmic ray spectra up to TeV region energy range. It can perform high statistics secondary-to-primary ratios measurements, all useful quantities to distinguish between different cosmic ray propagation and confinement models.
- AMS-02 will improve by three orders of magnitude the actual knowledge of primordial anti-matter by direct detection of anti-nuclei.
- Finally AMS-02 will explore the indirect detection of dark matter combining searches in several different channels.

2. Conclusions

The AMS-02 detector integration has started in September 2007 in a dedicated clean assembly area at CERN (see figure 2). After the end of the flight integration in November 2009, a beam test is foreseen at CERN, in order to verify the performance of the apparatus and to calibrate the spectrometer. At the beginning of 2010 the whole apparatus will undergo ElectroMagnetic Interference (EMI) compatibility test and thermal test in vacuum chamber at the ESA facility. The delivery of the AMS-02 at the NASA KSC is scheduled on May 2010, for the preparation of space shuttle lunch forseen on September 2010.

Figure 2: The Alpha Magnetic Spectrometer shuttle payload during the integration phase inside the clean room at CERN.

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