The Alpha Magnetic Spectrometer on the International Space Station

Simonetta Gentile
on behalf of the AMS-02 Collaboration
Università di Roma "La Sapienza", I.N.F.N Sez. Roma1, Roma, Italy

Abstract

The *Alpha Magnetic Spectrometer (AMS)* is a particle physics experiment scheduled to be installed on the International Space Station (ISS). The purpose of this experiment is to provide a high statistics measurement of charged particles and nuclei in rigidity range 0.5GV to few TV, and to provide a sensitive search for cosmic antimatter (antihelium) and dark matter, and to study the properties of cosmic rays. The construction of the final detector will be completed by 2004. We describe the detector and the working principles.

1. Introduction

AMS is a large acceptance, superconducting magnetic spectrometer which will measure, on board of ISS Fig. 1., charged cosmic rays spectra of individual elements below Z$\sim$ 25 and up to TeV region[7], high energy γ rays up to few hundreds GeV with good point-source localization. It will provide the most sensitive search in cosmic rays for the existence of antimatter nuclei and for the indirect studies of the origin of dark matter[9].

2. AMS-02 detector

A preliminary version of the detector (AMS-01) operated successfully during a 10-day NASA Shuttle flight in June 1998[1]. The AMS02 detector construction is due to be completed by 2004 and installed in ISS in 2005.

Remote Payload Operations Command Centers (POCC) on the ground segment will allow to monitor and control the experiment. Data will be continuously transmitted at same rate which it is acquired by AMS (2 Mbit/s). The data will also be collected in crew quarters of ISS by a dedicated computer, AMS Crew Operation Post (ACOP). The electronics for the readout of subdetectors is being build based on a total of 650 microprocessors (2-to-4 fold redundant)[5].

Fig. 2. shows the AMS-02 detector. It contains the following main components:

- A 20 layer Transition Radiation Detector (TRD) to distinguish $p/\bar{p}$ from

pp. 2145–2148

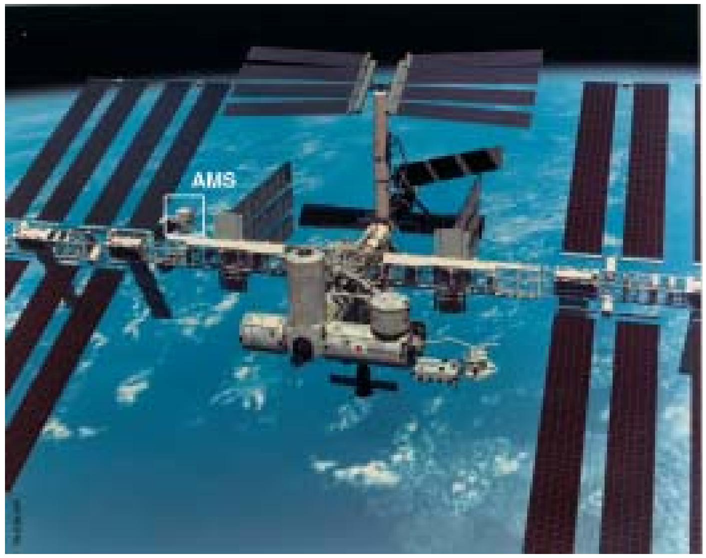

Fig. 1. The Alpha Magnetic Spectrometer on the International Space Station.

e^+/e^- with a rejection factor of $10^2 - 10^3$ in a range from 1.5 to 300 GeV[4]. This will be used in conjunction with an electromagnetic calorimeter to provide overall e^+/p rejection $< 10^{-6}$. Four layers of Time of Flight (TOF) hodoscopes provide precision time of flight measurements (~ 120 ps), dE/dx measurements and the primary trigger[6].

- The superconducting magnet which provides a bending power of $BL^2 \sim 0.8 Tm^2$[2].
- Eight layers (6.45 m^2) of double-sided silicon tracker which provide a coordinate resolution of 10μ in the bending plane and 30 μ in the non-bending plane[8].
- Veto counters to ensure that only particles passing the magnet aperture will be accepted.
- A Ring Imaging Cerenkov Counter (RICH) which measures the velocity (to 0.1 % accuracy) of particles or nuclei and their charge. This information, together with the momentum measurement in the magnet, will enable AMS to directly measure the mass of particles and nuclei[3].
- A 3-D sampling calorimeter (ECAL) made out of $15X_0$ of lead and plastic fibers to measure the energy of electrons, positrons and gamma rays and to distinguish electrons and positrons from hadrons with a rejection of 10^4 in the range 1.5 GeV-1 TeV[10].

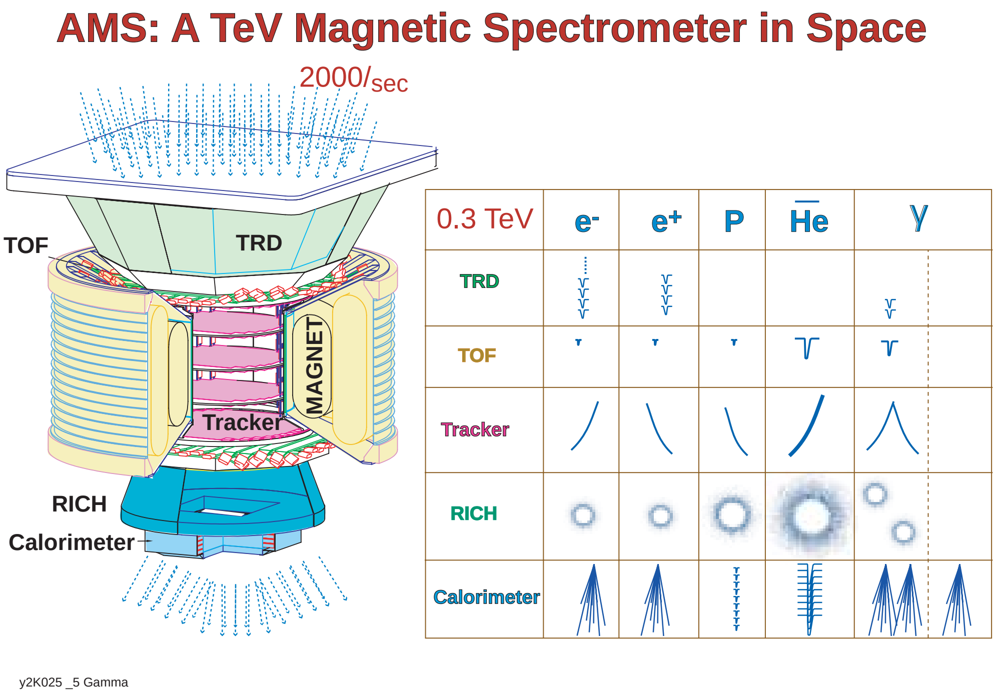

Fig. 2. The Alpha Magnetic Spectrometer. The detector components are: Transition Radiation Detector(TRD), Time-of-flight Scintillators(TOF), Silicon Tracker (Tracker), Ring Imaging Cerenkov detector(RICH), lead/plastic fiber calorimeter(ECAL), the anticoincidence counters are located in inner side in the magnet.The blue arrows represent the acceptance of the tracker.

Thus the value of the particle charge $|Q|$ is measured independently in the Tracker, RICH and TOF. The signed charge ($\pm Q$) and the momentum of the particle are measured by the 8 layers of double-sided silicon tracker in the magnet. The velocity, β, is measured by the TOF, TRD and RICH. Hadron rejection is provided by TRD and ECAL. The detector is designed with the following properties:

- Minimal material in the particle trajectory so that the material itself is not a source of background nor a source of large angle nuclear scattering.
- Many repeated measurements of velocity and rigidity over the particle trajectory so as to ensure that particles which experience large angle nuclear scattering within the detector be swept away by the spectrometer and not confused with the signal.
- A solid angle of 0.5 m^2 sr for the $\overline{\mathrm{He}}$ search.
- Hadron/positron rejection of $> 10^6$. $\Delta\beta/\beta$ =0.1% to distinguish ^{9}Be, ^{10}Be, and ^{3}He, ^{4}He isotopes.

- A proton rigidity, $R = pc/|Z|e$ (GV), resolution of 20% at 0.5 TV and a helium resolution of 20% at 1 TV.

The Alpha Magnetic Spectrometer (AMS) is the first large acceptance magnetic spectrometer to perform a high statistics study of cosmic particles in the background free environment of the International Space Station and will start to collect data at the end of 2005.*

3. References

1. M. Aguilar et al. 2002, Phys. Rep. 366, 331
2. B. Blau, "The Superconducting Magnet System of AMS-02.", these proc.
3. M. Buenerd, "AMS RICH Detector", these proceedings.
4. J. Burger, "AMS-02 TRD "," Performance of the AMS-02 TRD" these proc.
5. M. Capell, "AMS-02 Electronics", these proceedings.
6. D. Casadei, "The AMS-02 Time of flight sistem:final Design" these proc.
7. J. Casaus, "Cosmic-Ray Astrophysics with AMS-02", these proceedings.
8. E. Cortina, "AMS-02 Tracker"," AMS-02 Tracker Performance" these proc.
9. G. Lamanna, "Astroparticle Physics with AMS-02", these proceedings.
10. J.P. Vialle, "A 3D Imaging calorimeter for the AMS-02."," Performance of 3D Imaging electromagnetic Calorimeter" these proc.

* **Acknowledgments**. The construction of AMS-02 is an undertaking of many individuals and organizations. The support of NASA and the U.S. Dept. of Energy has been vital in the inception, development and fabrication of the experiment. The interest and support of Mr. Daniel S. Goldin, former NASA Administrator, is gratefully acknowledged. The dedication of Dr. John O'Fallon, Dr. Peter Rosen and Dr. P.K. Williams of U.S. DOE, our Mission Management team, Dr. Douglas P. Blanchard, Mr. Mark J. Sistilli and Mr. James R. Bates, NASA, Dr. Susan Breon, GSFC-NASA, Mr. Kenneth Bollweg and Mr. T. Martin, Lockheed-Martin, the support of the space agencies from Germany (DLR), Italy (ASI), France (CNES), Spain (CDTI) and China (CALT) and the support of CSIST, Taiwan, have made the construction possible.

The support of GSI–Darmstadt, particularly of Dr. Reinhard Simon made it possible for us to test electronics components for radiation effects.

The support of INFN, Italy, IN2P3, Region Rhône-Alpes and Haute Savoie, France, CIEMAT and CICYT, Spain, LIP, Portugal, CHEP, Korea, the Chinese Academy of Sciences, the National Natural Science Foundation and the Ministry of Science and Technology of China, Academia Sinica, Taiwan, the U.S. NSF, M.I.T., ETH-Zrich, the University of Geneva, National Central University and National Cheng Kung University, Taiwan, Moscow State University, SEU, Nanjing, Shanghai Jiao Tong University, RWTH-Aachen, the University of Turku and the University of Technology of Helsinki, is gratefully acknowledged.

We are also grateful for the strong support and interest shown from the private sector, including Dr. E. Ettlinger, Linde, Dr. R. Herzog, ILK, Dresden, Mr. J. Ross, Mr. S. Milward and Mr. S. Harrision of SCL, Culham, UK, Mr. M. Molina, CGS, Milan, Mr. F. Petroni, CAEN, Viareggio, Mr. A. Poseda, CRISA (Astrium), Madrid, Ing. A. Pontetti, G&A Engineering, Italy, Dr. E.A. Werner and Dr. J. Krieger, ISATEC, Aachen, and Dr. H. Bieri, Bieri Engineeering, Switzerland. We thank Professors A. De Rujula, J. Ellis, A. Guth, L. Maiani, for many interesting discussions and support.