IL NUOVO CIMENTO Vol. 36 C, N. 1 Gennaio-Febbraio 2013
DOI 10.1393/ncc/i2013-11419-4

Colloquia: IFAE 2012

The AMS-02 experiment on International Space Station

G. Gallucci
Università di Pisa and INFN, Sezione di Pisa - Pisa, Italy

ricevuto il 31 Agosto 2012

Summary. — AMS-02 (Alpha Magnetic Spectrometer) is a particle detector designed to operate in space, on the International Space Station (ISS). The launch and subsequent installation on the ISS took place successfully May 16, 2011 with the mission STS-134, second last shuttle mission. The apparatus is fully operational by May 19 2011 and has collected over 13 billions of events in nine months. AMS-02 will collect about 150–320 bilions of events in 10–20 years of operation allowing to achieve an unprecedented sensitivity in the search for new physics in the space.

PACS 07.87+v – Spaceborne and space research instruments, apparatus, and components (satellites, space vehicles, etc.).

1. – Introduction

AMS is an international collaboration that includes more than 60 institutes from 16 different countries for a total of more than 500 physicists. The launch and subsequent installation on the ISS took place successfully May 16, 2011 with the mission STS-134. All detectors were perfectly running 3 days after the launch. The Payload Operations Control Center (POCC) is located at CERN from June 19th and takes care of monitoring proper functioning and termic status of the apparatus, and flux of data from the ISS to the Earth. AMS will be operational until the end of the ISS life currently estimated for not earlier than 2020 and, most likely, around 2028. AMS can provide important contributions to the cosmic ray spectroscopy (protons, electrons, ions, exotic matter, etc.), to the search for anti matter and dark matter, to measure the spectrum of the diffuse gamma radiation.

2. – Apparatus

The AMS-02 detector is quite unusual for a space-borne detector: it has a volume of $12\,\mathrm{m}^3$ for 7 tons of weight, 20000 electronics channels for a total power consumption of 2 kW. Its structure is similar to the apparatus of the experiments at large accelerators. Figure 1 shows a scheme of AMS apparatus.

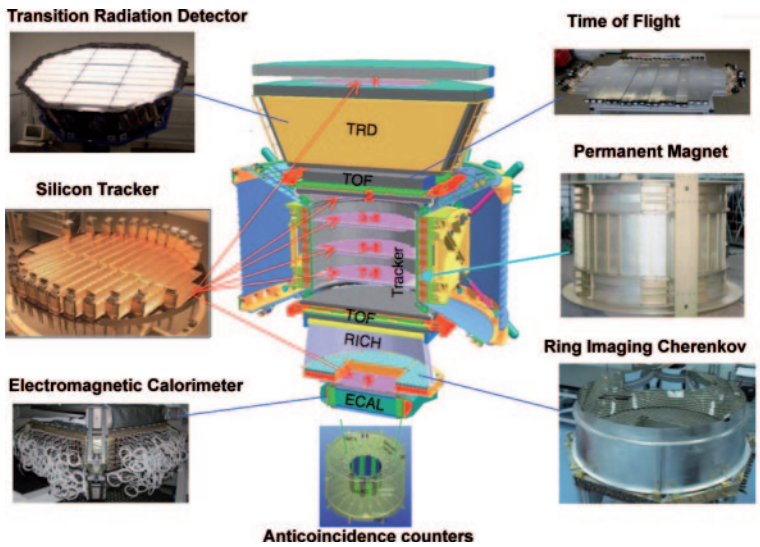

Fig. 1. – Scheme of the AMS apparatus.

2˙1. *The Transition Radiation Detector (TRD).* – The TRD is useful to distinguish heavy particles from light ones. It is made of 20 layers of foam and straw tubes oriented to allow a 3D tracking. The tubes are filled with a mixture of Xenon and CO_2 and the leakage is low ensuring a good efficiency for about 20 years [1]. Figure 2 shows a preliminary proton rejection as a function of electron efficiency for flight data.

2˙2. *The Time of Flight (TOF).* – TOF is made by 2 pairs of scintillators located above and below the Silicon Tracker. Each scintillation paddle is read by two or three pthotomultipliers allowing to reach a time resolution of 160 ps which corresponds to a resolution on speed of $\frac{\Delta\beta}{\beta} \approx 4\%$ [2]. TOF is the primary element of charged trigger, it is used to measure the charge of lighest nuclei ($\frac{\mathrm{d}E}{\mathrm{d}x}$) and also to measure the charged particle direction (upgoing and downgoing).

2˙3. *The Silicon Tracker (ST) and the Permanent Magnet (PM).* – ST is made of 192 ladders cointainig 100 μm pitch silicon strips with a total active area of 6.45 m^2. ST is disposed on 3 double-side planes located in the center of the detector (inner tracker)

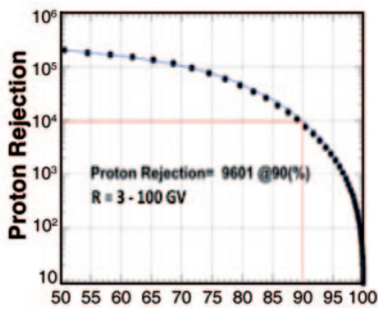

Fig. 2. – Preliminary TRD proton rejection as a function of electron efficiency for flight data.

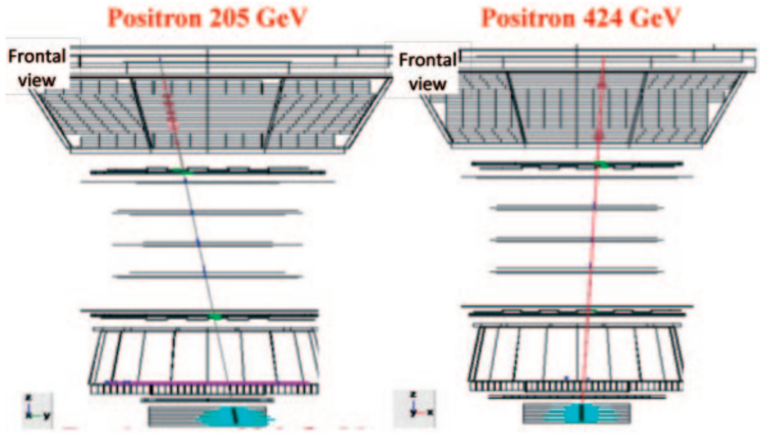

Fig. 3. – Two collected positron events.

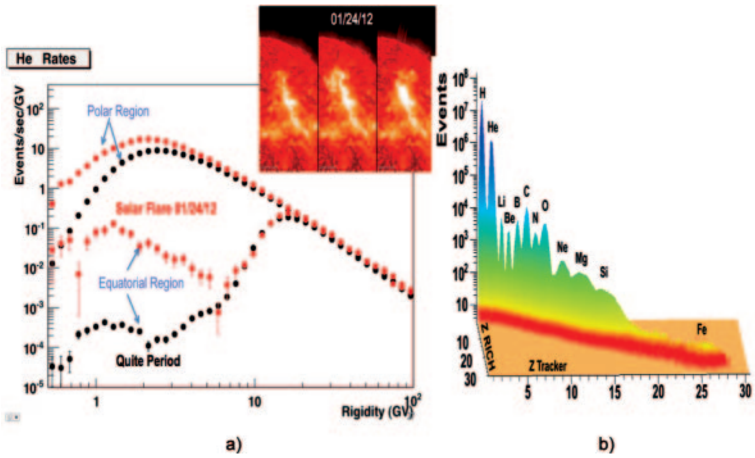

Fig. 4. – a) Helium rate: normal (black) and during the 24 January Solar flare (red). b) Ion spectrum up to the iron measured using 70 days data.

and 3 single-paddle planes located on top of TRD, after the first TOF planes and on top of electromagnetic calorimeter. Only the inner tracker is immersed in a dipolar magnetic field of 1.5 kG created by a set of permanent dipoles. Due to the long period of taking data, a permanent magnet was preffered to a more powerful but less durable superconducting one. The intenisty of magnetic field has been measured stable within 1% after 12 years. The system ST+PM measures the coordinates of tracks with a resolution of 10 μm allowing a maximum detectable rigidity of 2 TeV for protons and 3.7 TeV for helium nuclei. ST is used to measure the charge of particles up to iron ($\frac{\mathrm{d}E}{\mathrm{d}x}$) too [3].

2˙4. *The Ring Imaging Cherenkov (RICH) and the Anticoincidence counters (ACC).* – ACC are 16 curved scintillators surronding the ST and useful to reject charged particles entering from lateral sides of the detector [4]. RICH is made by two different types of radiator (a silica aerogel at the center and sodium fluoride on the sides), a reflecting mirror and 10880 photomultiplier anodes. It is able to measure the particle speed with resolution of $\frac{\Delta\beta}{\beta} \approx 0.1\%$ and the particle charge up to the nickel [5].

2˙5. *The Electromagnetic Calorimeter (ECAL).* – ECAL is a fine grained lead- scintillating fiber sampling calorimeter consists of an active volume (pancake) composed by 9 Superlayers for a total active area of $685 \times 685\,\mathrm{mm}^2$ and a thickness of 167 mm. The detector imaging capability is obtained by stacking Superlayers with fibers alternatively parallel to the X-axis (5 layers) and Y-axis (4 layers). The pancake has an average density of $6.8\,\frac{\mathrm{g}}{\mathrm{cm}^3}$, for a total weight of 487 kg. Each super-layer is read out by 36 PMTs arranged alternately on the two opposite ends. Fibers are read out, on one end only, by four anodes Hamamatsu PMTs; each anode covers an active area of $9 \times 9\,\mathrm{mm}^2$, corresponding to 35 fibers, defined as a cell (the minimum detection unit). In total the ECAL is subdivided into 1296 cells (324 PMTs) and this allows for an accurate 3D imaging-sampling of the longitudinal shower profile. The ECAL thickness corresponds to about 17 radiation lengths, including almost all the electromagnetic shower generated by incident electrons or photons. The calorimeter also provides a stand-alone photon trigger capability to AMS-02. The trigger efficiency is 90% at 2 GeV and more than 99% for energies greater than 10 GeV. The energy linearity has been measured to be better than 1% up to 250 GeV while the angular resolution is better than 1 degree above 50 GeV [6]. ECAL allows to measure the energy of electromagnetic particles with a resolution of $\frac{\sigma_E}{E} = \frac{9.9\%}{\sqrt{E(\mathrm{GeV})}} \oplus 1.5\%$. Due to the excellent 3D imaging of electromagnetic shower development, AMS is able to reach together with TRD identification and energy/momentum macthing, an electron/hadron rejection factor $> 10^6$.

3. – A short look at the first data

In the first nine months of operations AMS collected about 13 bilions of events. Figures 3 and 4a show some collected event and helium rate, respectively. In particular in fig. 4a it is possible to note the effect of solar flare of 24 January 2012. Figure 4b shows ion spectrum up to the iron measured using the first 70 days data.

4. – Conclusions

AMS-02 is fully operational on ISS by May 19, 2011 and is taking data performing well in agrement with previous results. It will collect about 150–320 bilions of events in 10–20 years of operation allowing to achieve an unprecedented sensitivity in the search for new physics in the space.

REFERENCES

[1] Hauler F. *et al.*, *IEEE Trans. Nucl. Sci.*, **51** (2004) 1365.
[2] Amati L. *et al.*, *IEEE Trans. Nucl. Sci. Symp. Conf. Rec.*, **1** (2004) 366.
[3] Haino S. *et al.*, *Nucl. Instrum. Methods Phys. Res. A*, **630** (2011) 78.
[4] Bruch T. and Wallraff W., *Nucl. Instrum. Methods A*, **572** (2007) 505.
[5] Arruda L. *et al.*, *Nucl. Phys. Proc. Suppl.*, **172** (2007) 32.
[6] Difalco S., *Adv. Space Res.*, **45** (2010) 112.