The Time Of Flight detector of the AMS-02 experimenton the International Space Station

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Abstract

The Alpha Magnetic Spectrometer AMS-02 has been installed in May 19th 2011 on the International Space Station, where it will detect cosmic rays for the next decades. AMS-02 with its accurate measurements up to the TeV scale will contribute to our knowledge of the Universe providing the most sensitive search for the existence of primordial anti matter and indirect search for dark matter. The Time Of Flight (TOF) detector of the AMS-02 experiment provides the trigger to the AMS detector, the time of flight and the absolute charge measurements. The flight operations and the performances of the TOF in Space will be presented.

1. Introduction

The Alpha Magnetic Spectrometer AMS-02 has been installed in May 19th 2011 on the International Space Station where it will perform accurate measurements of the cosmic rays up to the TeV scale, providing the most sensitive search for the existence of primordial anti matter and indirect search for dark matter [1]. The Time Of Flight (TOF) [2] is composed by four planes of respectively 8,8 10 and 8 plastic scintillators, two planes are located above the magnet and two planes below. The TOF detector main objectives are to provide: the trigger to AMS-02 and the measurement of the velocity and of the charge of the crossing particles.

2. TOF operations in Space

During this first year of operation in Space, 15 billions physical events were acquired thank to the trigger given by the TOF. TOF kept during all this year the nominal settings in terms of high voltages and thresholds. All TOF channels are working as expected.

In the figure 1 the track hit point on the TOF planes are shown. The distributions agree with AMS acceptance. AMS-02 operates at trigger rates up to 2 kHz with an average event size of about 2 KBytes. The absolute rate of one counter in the first plane in different geographical location along the orbit of the ISS is shown of figure 2. Higher rates correspond to regions with lower values of the geomagnetic cutoff as in the polar regions as shown in figure 2, and in the South Atlantic Anomaly as shown in figure 3.

3. The beta measurement

The cosmic rays velocity (Beta) is measured by TOF using the particle flight time between the upper and lower planes and

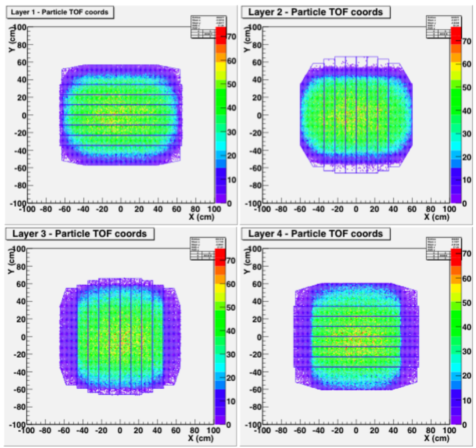

Figure 1: The track hit points in X and Y coordinates on TOF layer one (top left corner), layer two (top right corner), layer three (bottom left corner) and layer four (bottom right corner) are shown. The distributions agree with the AMS-02 acceptance.

the trajectory length. The resolution in velocity measurement is about 4% for protons and decrease for high Z nuclei. Measuring simultaneously the particle momentum and its velocity, from the relation:

$$p/c = m\beta\gamma$$

it is possible to identify the mass of the particle. The TOF detector can distinguish electron from protons in the momentum range p=(0.5-1.5) Gev/ c.

4. The charge measurement

The ionization released in the TOF counters by He and higher Z cosmic nuclei grows with Z^2 up to about C, N nuclei and then

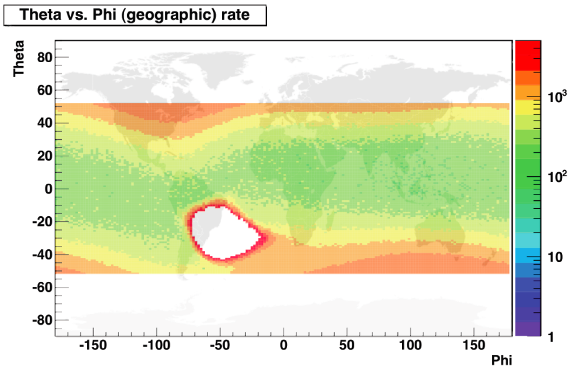

Figure 2: The absolute rate of one counter in the first plane in different geographical location (Theta, Phi) along the orbit of the ISS is shown. High rates correspond to regions with lower values of the geomagnetic cutoff as the polar regions.

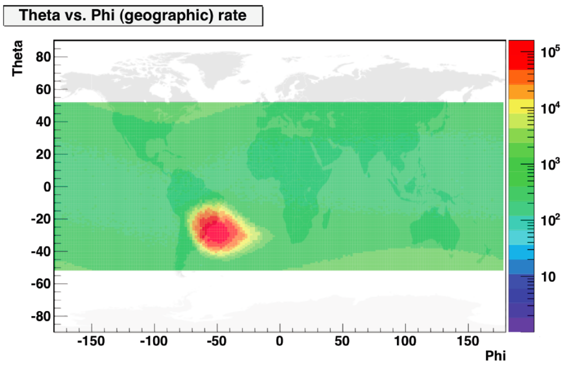

Figure 3: The absolute rate of one counter in the first plane in different geographical location (Theta, Phi) along the orbit of the ISS is shown. High rates correspond to the South Atlantic Anomaly region.

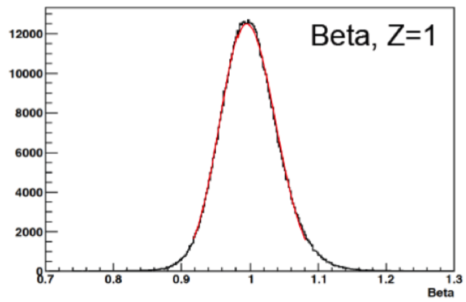

Figure 4: The value of the velocity beta measured for protons is equal to 1 with a resolution in velocity measurement of about 4%.

the scintillator light output slowly saturates for specific ionizations larger than 100 MeV/ g cm^2 where the Z dependence becomes almost linear as described by the Brirk's law [2]. The sum of the anode signal from each counter side and the last third dynode from each TOF photomultiplier are acquired. To distinguish different nuclei in a wide dynamic range both anode and dynode signal are used in the measurement of the charge. In figure 5 the anode charge resolution and the dynode charge resolution with respect to the charge of the crossing particle are shown. The anode signals distinguish the charged particles with charge below $Z = 4$, when anode signal starts to saturate, the dynode signals are used to enlarge the dynamical range for particle with higher Z.

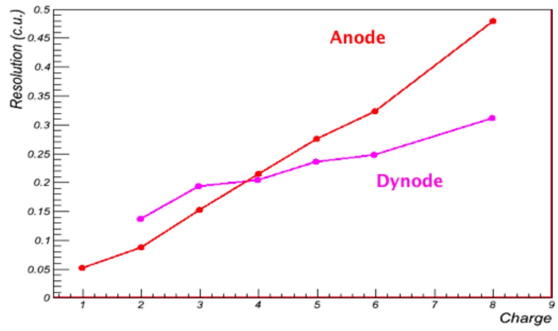

Figure 5: The anode and dynode resolution with respect to the particle charge.

Using the combination of the anode and dynode signals, it is possible to measure the charge released by the particle in the scintillator up to at least charge $Z = 14$ distinguishing among the different species of cosmic rays as shown in figure 6.

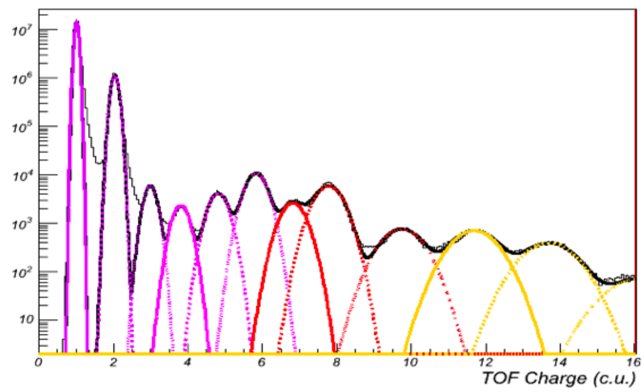

Figure 6: The peaks of charge measured by the TOF for the different species of cosmic rays. It's possible to distinguish up to at least charge Z=14.

Acknowledgements

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[1] AMS-02 web site: http://www.ams02.org

[2] "The scintillator detector for the fast trigger and time-of-flight (TOF) measurement of the space experiment AMS-02", Bindi et al., Nuclear Instruments and Methods in Physics Research Section A, vol. 623, 3, 968 - 981, 2010, doi: 10.1016/j.nima.2010.08.019.