IL NUOVO CIMENTO **41 C** (2018) 57
DOI 10.1393/ncc/i2018-18057-0

Colloquia: IFAE 2017

The flight calibration of the ECAL of AMS-02 on ISS

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received 21 April 2018

Summary. — The Alpha Magnetic Spectrometer (AMS-02) is a Cosmic Ray (CR) detector installed on the International space Station (ISS) on May 19th, 2011. The large statistics of events collected and the high resolution of the detector allow a precision measurement of rare component of CR, like e^- and e^+, essential for the indirect search of Dark Matter. The key detector in such measurement is the Electromagnetic CALorimeter (ECAL), both for its discrimination capabilities and, more important, to accurately measure the particle energy. In this contribution the flight calibration of the energy scale will be reviewed.

1. – The Electromagnetic CALorimeter (ECAL) and its fligh calibration

The AMS-02 Electromagnetic CALorimeter (ECAL) is a fine grained lead-scintillating fibers sampling calorimeter ($64.8 \times 64.8 \times 16.2\,\text{cm}^3$) that allows for a precise 3D imaging of the longitudinal and lateral shower development [1]. The shape of the shower identifies the particle kind (electromagnetic of hadronic). Beside the particle discrimination, the main purpose of the ECAL is the energy measurement. The detector consists of a lead/scintillating fiber sandwich composed of 9 *super layers* (SL), each 18.5 mm thick and made of thin lead foils (11 mm in total) interleaved with layers of scintillating fibers (1 mm diameter) glued to the foils by means of optical epoxy. In each super layer, the fibers run in one direction only. The detector imaging capability is obtained by stacking super layers with fibers alternatively parallel to x-axis (5 superlayers) and y-axis (4 superlayers). Each SL is read out on one end by 36 photomultipliers (PMTs), alternatively arranged on the two opposite sides to avoid mechanical interference. Each PMT has 9 channels: the photocathode is pixelated in 4, each corresponding to one anode, with High and Low gain used for energy measurements, and 1 global dynode used for the trigger signal. The pixel size is $8.9 \times 8.9\,\text{mm}^2$ and corresponds to 35 fibers: this is often indicated as *cell*. The sandwich structure provides an high ($>10^4$) electron/hadron discrimination and good energy resolution ($<2\%$ @ 100 GeV).

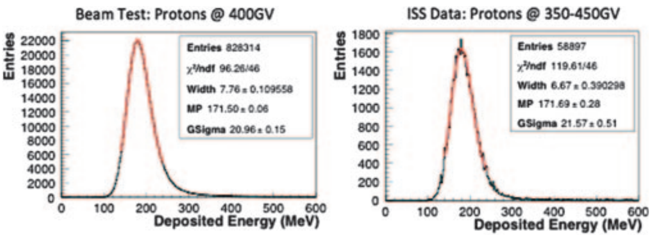

Fig. 1. – Deposited energy for BT protons at 400 GV (left) and for ISS protons in the (350–450) GV rigidity interval. A Landau-Gaussian fit is performed (superimposed in red) to extract the Most Probable (MP) value. The agreement is at the ‰ level, well within the errors.

1˙1. *The flight calibration.* – To ensure the design energy resolution it is necessary to correct for dependences of the collected signal on impact position and electronics response of each cell. The ECAL Calibration procedure has been developed and checked at Beam Test (BT) with particles at different energies: e^- at 100, 120, 180, 290 GeV, e^+ at 10, 20, 80, 120, 180 GeV and p at 400 GeV.

The temperature changes in orbit, however, involve a variation of the response of each cell, so an additional calibration procedure is needed to equalize the response over the detector and to calibrate the absolute energy scale. This is done studying the response of the different cells to Minimum Ionizing Particles (MIP) protons. The calibration is performed equalizing the MIP deposited energy Most Probable (MP) value, for each cell, to the same value, with a procedure based on 1 day of low energy (>5 GeV) data. An *a posteriori* check of the calibration results is done comparing the energy deposited in the whole ECAL by MIP protons at BT and on ISS: the check must be done at the same energy since the deposited energy is rigidity-dependent, following a Bethe-Bloch. The deposited energy distribution for MIP protons at BT and on ISS is shown in fig. 1. The ECAL absolute energy scale is then checked using the comparison with the independent momentum (P) measurement from the tracker. The flight E/P ratio is checked against the BT one, as shown in fig. 2 (left). In addition the energy scale stability has been also checked splitting the ISS data into 2 days subsamples, as shown in fig. 2 (right).

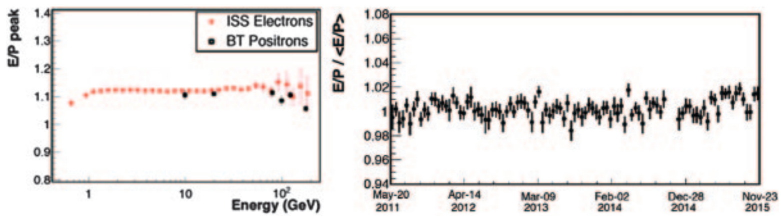

Fig. 2. – Left: comparison between the E/P ratio on ISS electrons (red) and BT positrons (black). Right: distribution of the E/P as a function of time.

2. – Conclusion

The ECAL calibration procedure has been cross-checked verifying the goodness of the procedure. The absolute scale has been verified by means of the comparison between the E/p ratio observed in orbit and the BT one, confirming a 2% uncertainty in the BT region (cfr. [2-4]). Its stability has been evaluated to be better than 0.5%.

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