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The γ-rays sky with the AMS-02 electromagnetic calorimeter

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Summary. — The Alpha Magnetic Spectrometer (AMS-02) is a multipurpose astroparticle physics detector installed since May 2011 as an external module on the International Space Station (ISS). AMS-02 orbits at an altitude of about 430 km for measuring with an unprecedented accuracy the flux and composition of primary cosmic rays in the GeV-TeV energy range, searching for primordial Anti-Matter and probing the nature of Dark Matter. Despite the fact that AMS-02 is designed primarily as a charged-particle detector, it is also an instrument able to perform precision observations of γ-rays. The key sub-detector in the photon identification and reconstruction is the e.m. calorimeter that, besides having an excellent energy resolution, can also provide the direction of the incoming particle. In this paper the AMS-02 γ-rays sky obtained with the first 22 months of data is presented.

PACS `29.40.Vj` – Calorimeters.
PACS `95.85.Pw` – γ-ray.
PACS `98.70.Sa` – Cosmic rays (including sources, origin, acceleration, and interactions).

1. – Introduction

AMS-02 is composed by several subdetectors, extensively described in [1]: a Silicon Tracker (TRK) inside a permanent magnet, a Time-of-Flight (ToF) system, a Transition Radiation Detector (TRD), a Ring Imaging Čerenkov counter (RICH) and an Electromagnetic Calorimeter (ECAL).

2. – The shower axis reconstruction in the ECAL

The ECAL, described in details in [2], is a fine grained lead-scintillating fibers sampling calorimeter (~2% energy resolution) that can provide a precise 3D imaging of the shower with a granularity of $9 \times 9\,\text{mm}^2$. This not only guarantees a $\sim 10^{-5}$ stand-alone hadron rejection but also allows the reconstruction of the incoming particle direction. For each event the shower axis direction is determined separately in the (x, z) and (y, z)

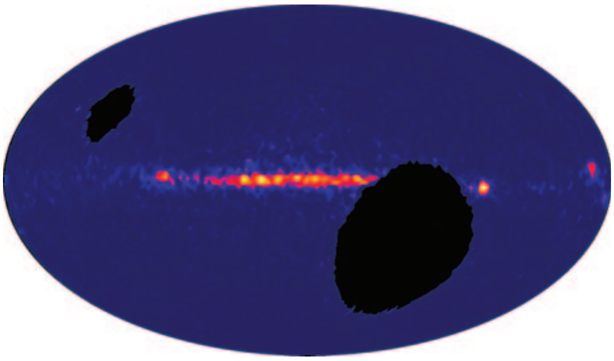

Fig. 1. – The γ-rays flux above 2 GeV observed by ECAL in 22 months.

view by fitting the reconstructed axis position in each layer. Three different methods for the reconstruction have been developed and tested directly on flight data using a *golden* electron selection. Best results have been obtained with the *lateral fit* method. Using this method a detailed GEANT-4 based simulation of the shower development is performed to parametrize, layer by layer, the lateral shower shape as a function of deposited energy. A comparison of data with the parametrized shape is performed and the shower axis position in each layer is obtained minimizing a χ^2 function. In this way, the angular resolution above 50 GeV is less then 0.5 degrees.

3. – Charged background rejection

In order to maximize the separation between charged particles and photons a classifier based on the Boosted Decision Tree (BDT) technique has been developed. The BDT algorithm uses a large set of experimental variables (like the longitudinal and lateral development of the shower in ECAL, the matching of the axis shower with the hits in the other sub-detectors and timing information) taking into account their correlations. By means of a cut on the BDT output value, preserving 90% of efficiency for photons, a 10^6 proton and 10^4 electrons rejection factor can be obtained up to the TeV scale.

4. – Conclusions

The sky map (fig. 1) obtained with photon candidates confirms the expected low residual background level and the good angular resolution: the events in the map are concentrated around the galactic plane and the brightest spots reveal the emissions from Vela, Geminga, Crab and Cygnus. More results are forecasted as soon as more statistics will be available, concerning in particular the investigation of structures in the γ-rays spectrum.

REFERENCES

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