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Identification of γ-rays sources with the AMS-02 electromagnetic calorimeter

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Summary. — The Alpha Magnetic Spectrometer AMS-02 is a particle physics experiment designed to operate for a long time in space. It was installed on the International Space Station ISS in May 2011 and its purpose is to obtain accurate and high-statistics measurements of cosmic rays spectra and composition up to TeV energies, searching for primordial Anti-Matter and probing the nature of Dark Matter. AMS-02 is mainly conceived as a charged-particle detector, but the unique features of its electromagnetic calorimeter also allow the identification of γ-rays. ECAL has an excellent energy resolution and a high granularity that makes possible the reconstruction of the direction of the incoming particle with an unprecedent angular resolution for a calorimeter. In this paper the AMS-02 gamma sky obtained with the first 3 years of data and the highest energy detected photon are presented.

1. – Introduction

The experiment AMS-02 measures particle mass, momentum and energy of the cosmic particles combining the information coming from different subdetectors [1]: a *Transition Radiation Detector* (TRD) for electron/proton discrimination; a *Silicon Tracker* (TRK) and a *permanent magnet* tracking charged particles in a magnetic field and measuring their momentum, charge sign and Z; a *Time of Flight System* (TOF) providing particle timing information, velocity and Z; a *Ring Imaging Cherenkov Detector* (RICH) measuring particle velocity and Z; an *Electromagnetic Calorimeter* (ECAL), triggering, identifying and measuring the energy of the electromagnetic particles.

2. – The shower axis reconstruction in ECAL

ECAL is a fine-grained lead-scintillating fibers sampling calorimeter [2], with 2% energy resolution up to the TeV scale and a total thickness corresponding to $\sim 17X_0$ for perpendicular incidence particles. Thanks to its high granularity ($9 \times 9\,\text{mm}^2$), ECAL has an excellent 3D imaging capability: it guarantees an efficient leptonic/hadronic shower

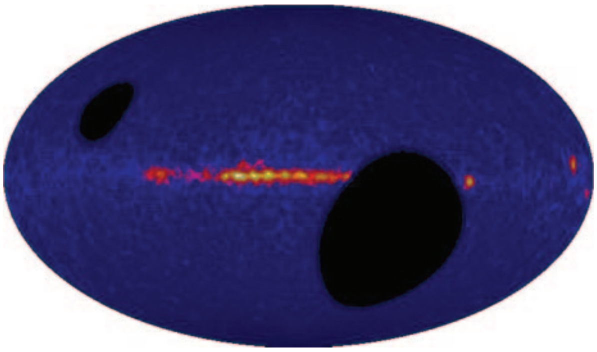

Fig. 1. – The AMS-02 γ-sky map obtained with 3 years of data taking.

discrimination and the reconstruction of the incoming particle direction with an excellent angular resolution. For each event the shower direction is obtained by fitting the axis position in each layer. The fit is perfomed separately in the (x, z) and (y, z) view. Three methods have been developed and tested using a golden electron sample of flight data. Best results have been obtained with the *Lateral Fit Method*, where the shower axis position is obtained by fitting the lateral energy distribution in each layer with the Monte Carlo templates depending on shower depth and energy. With all the methods the ECAL angular resolution results to be better than 0.5° above 50 GeV.

3. – Charged background rejection

The signal to noise ratio for photons is very unfavorable: $\sim 10^{-5}$ with respect to protons and $\sim 10^{-3}$ with respect to electrons. A BDT (Boosted Decision Tree) classifier has been built using the longitudinal and lateral development of the ECAL shower, the matching of the axis shower with hits in other sub-detectors and timing informations. Its photon selection efficiency is $\sim 90\%$ while the photon purity is 90% at 2 GeV and improves with energy.

4. – Conclusions

The excellent purity of the photon sample and the good angular resolution on the photon direction allow to build the γ-sky map from AMS-02 376 fligh data (fig. 1). Photon emission is concentrated in the galactic plane and the brightest spots correspond to the most powerful γ sources: Vela, Geminga, Crab and Cygnus. The highest energy photon detected with ECAL has an energy of 1.7 TeV and a reconstructed direction within 0.1° from the known TeV source (2006) HESS J1640465. This is the highest energy photon ever detected by a space-based experiment!

REFERENCES

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