PERFORMANCE THE GLAST-LAT: BEAM TEST RESULTS

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Between July and November 2006, the LAT Collaboration has performed a massive campaign of particle beam test on a Calibration Unit (CU), in order to study the performance of the LAT and validate the LAT Geant4 based simulation. We have tested the LAT Calibration Unit at CERN, both at PS and SPS accelerators, and at GSI. The Calibration Unit is a detector built with two complete flight spare modules, a third spare calorimeter module, five antocoincidence tiles located around the telescope and flight-like readout electronics. The LAT response to minimum ionizing particles, high energy electrons, gamma ray and ions (C,Xe) in a wide energy range, has been studied. This large amount of data allowed to determine the LAT performance, such as the capability to reconstruct the direction of the incident gamma-rays.

1. Introduction

The Gamma-ray Large Area Telescope (GLAST) is a satellite-borne observatory to study the high-energy gamma-ray sky. The Large Area Telescope (LAT) is the main instrument on board GLAST. It is a pair-conversion telescope which will survey the sky in the energy range from 20 MeV up to 300 GeV. The LAT has a modular structure , consisting of a 4x4 array of identical towers, supported by a low-mass grid. Each tower is composed by a silicon strip detector (SSD) tracker (TKR), a CsI calorimeter (CAL) and data acquisition module (DAQ). A plastic segmented scintillator anticoincidence (ACD) system covers all the towers and provides most of the rejection of the charged particle backgrounds.
A second instrument, the GLAST Burst Monitor (GBM) will provide spectra and timing in the energy range from 8 keV to 30 MeV for Gamma-Ray Bursts (GRB) [1,2].

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2. The GLAST LAT Beam test

As a part of the LAT calibration strategy, a beam test campaign was performed between July and November 2006 on a reduced scale LAT prototype (Calibration Unit, CU). The CU is a detector consisting of two complete flight towers, a third calorimeter module and five anticoincidence tiles. The CU was exposed at the CERN (PS and SPS) and GSI accelerator facilities, to beams of photons, electrons, hadrons (pions and protons) and ions (C, Xe) with different momenta (see Table 1) and incoming direction, representing the whole spectrum of the signal that will be detected by the LAT [3].

Particle	***PS***	***SPS***	***GSI***
γ	0.5,1,1.5,2.5 GeV/c (electron beam)		
e^-	0.5,1,1.5,2.5,5 GeV/c	10,20, 50, 100, 200, 280 GeV/c	
e^+	0.5,1 GeV/c		
π-	5 GeV/c	20 GeV/c	
p	6,10 GeV/c	20,100,150 GeV/c	
^{12}C			1.5 GeV/n
^{131}Xe			1.5 GeV/n

Table 1. Features of the beams at CERN-PS and SPS and at GSI facilities.

3. Beam test data analysis

3.1. Photon Angular Dispersion

For angular dispersion studies, photon data from runs in both tagged and non-tagged mode have been used [4]. The runs in non-tagged mode were taken with a 2.5 GeV/c electron beam; the runs in tagged mode were taken with electron momenta ranging from 0.5 to 2.5 GeV/c. The gamma direction for non-tagged mode runs was assumed to be coincident with the nominal electron beam direction. The systematic errors in the evaluation of the angular dispersion in non-tagged mode runs are due to the electron incoming beam divergence (4 mrad at 2.5 GeV/c), to the uncertainty of the CU position with respect to the beam (0.1 degrees), and to the photon production angle by bremsstrahlung with respect to the electron (0.1 degrees).

We have classified all acceptable events into three classes, using the output of the tracking and vertexing algorithms: events with a single vertex, events with two vertices, and events with more than two vertices. In addition, since one or two tracks can be associated to a vertex, it is possible to introduce sub-classes in each of these classes. For our analysis we selected events with a single vertex and two associated tracks. Figure 1 shows a comparison between data and Monte Carlo simulation for the angle dispersion at 68% containment value for events at normal incidence.

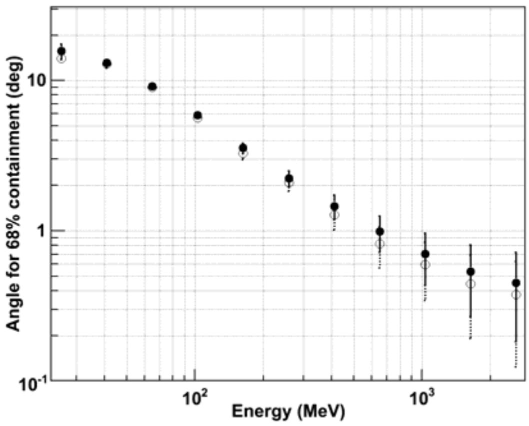

Figure 1: Angular dispersion at 68% containment. Full circles: real data; open circles: simulation predictions.

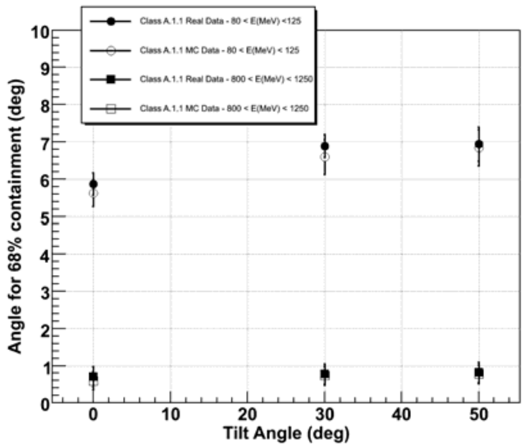

Figure 2: Angular dispersion at 68% containment at different photon incidence angles. Full symbols: real data; open symbols: simulation predictions. Circles: energy in the range 80-125 MeV; squares: energy in the range 800-1250 MeV.

Figure 2 shows the dependence of the 68% containment angle on the tilt angle of the CU with respect to the normal direction at different photon energies. Experimental data are well reproduced by the Monte Carlo simulation.

3.2. *Detector response to electrons*

Using the electron set-up [4], we collected a large set of electron runs with different configurations (different momenta and incoming directions with respect to the CU). We selected electron events with at least one vertex and one track reconstructed in the TKR and an energy deposition in the CAL greater than 300 MeV (to reject hadrons).
Figure 3 shows the average energy deposited in CAL layers by electrons of different energies entering the CU with normal incidence. For increasing electron energies, the electromagnetic showers tend to develop deeper inside the CAL and at high energies the showers are not fully contained.
The electron energy is reconstructed taking into account the information from both the TKR and the CAL. For each configuration (incident electron energy and direction) we have compared the CU reconstructed energy to the nominal beam energy. Figure 4 shows this comparison in the case of vertical electrons: the CU reconstructs correctly the energies of incoming electrons.

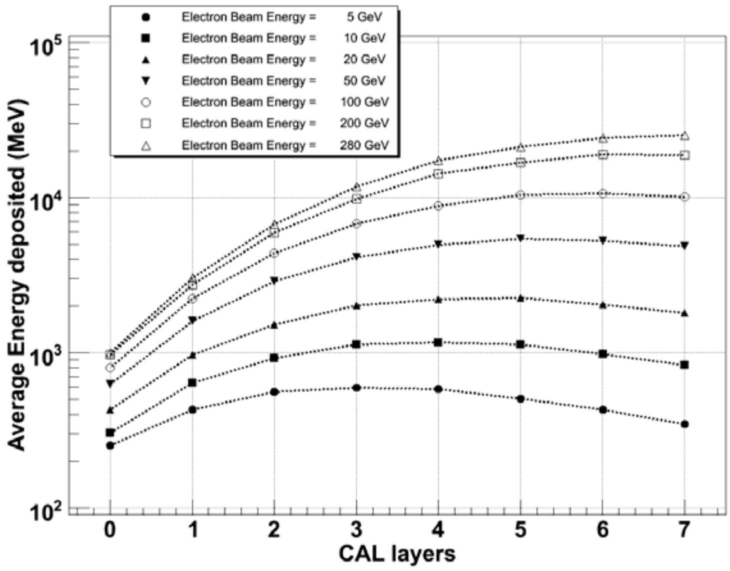

Figure 3: Average energy deposited in the CAL layers by electrons of different energies with normal incidence.

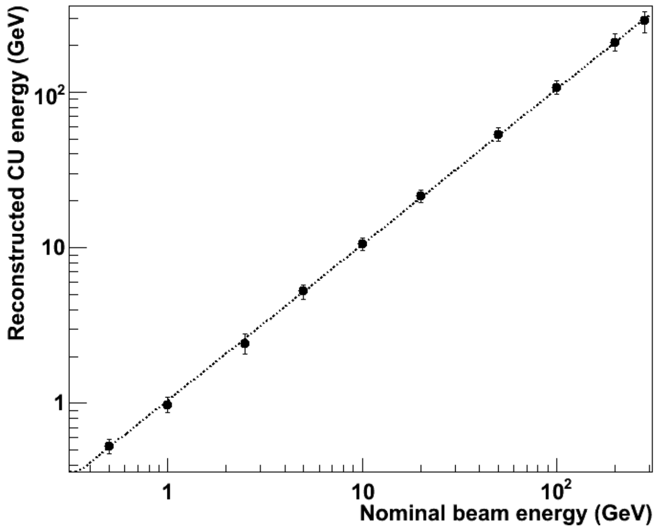

Figure 4: Reconstructed CU energy Vs Nominal beam energy for vertical electrons. The dotted line is drawn as a guide for the eye.

4. Conclusions

A beam test campaign on a GLAST-LAT Calibration Unit was performed in 2006. During the test, a large set of configurations (particles, energies and angles) have been explored.
The measured photon angular resolution is well reproduced by the Monte Carlo simulation. Preliminary results also confirm that the apparatus correctly reconstructs the energy of incoming particles.

References

1. http://glast.gsfc.nasa.gov/
2. “GLAST-LAT – Scientific and Technical Plan”, AO 99-OSS-03 (2000)
3. L. Baldini et al. – “Preliminary results of the LAT Calibration Unit beam tests”, proceedings of the first GLASST symposium, AIP Conference Proceedings Vol. 921 (2007) 190-204
4. M. Brigida et al. – ”Particle beam tests for the GLAST-LAT calibration”, these proceedings