Performance of the GLAST-LAT: beam test results

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The GLAST Large Area Telescope (LAT)

The Gamma-ray Large Area Telescope (GLAST) is a satellite-based 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 (Fig. 1), 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 a data acquisition module (DAQ). A plastic segmented scintillator anticoincidence system (ACD) 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).

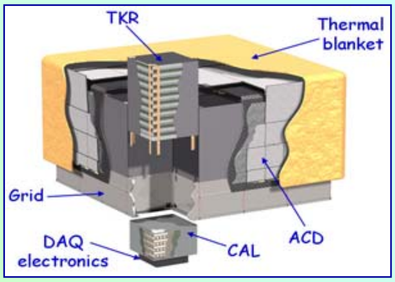

Fig. 1: GLAST LAT modular structure

Fig. 2: LAT Calibration Unit

The GLAST LAT beam test

To validate the LAT simulation, a massive campaign of particle beam tests was performed between July and November 2006 on the LAT Calibration Unit (CU). As shown in Fig. 2, the CU is a detector built with two complete flight towers, a third calorimeter module and five anticoincidence tiles. The CU was exposed to a large variety of beams, representing the whole spectrum of the signal that will be detected by the LAT, using the CERN (PS and SPS) and GSI accelerator facilities. Beams of photons, electrons, hadrons (pions and protons) and ions (C, Xe) with different momenta and direction were shot through the CU.

Photon configuration set-up

The gamma ray beam at the CERN PS T9 line was produced by bremsstrahlung between electrons and the upstream materials. A magnet has been used to separate electrons from photons. Deflected electrons are absorbed by the beam dump (see Fig. 3). In the "tagged mode" runs, an external tracker (4 x-y view SSDs) was used to track electrons upstream and downstream the magnet, while in "not tagged mode" runs, the tracker was not used and full bremsstrahlung spectrum from 2.5 GeV/c electron beam was produced.

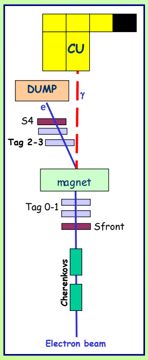

Fig. 3: Photons set-up

Detector response to electrons

The experimental set-up is the same shown in Fig. 3 with the magnet off.

We selected electron events requiring at least one reconstructed track in the TKR and an energy deposition in the CAL greater than 300 MeV (to reject hadrons).

Fig. 5 shows the average number of hit strips in the TKR planes for electrons at different momenta and for 6 GeV/c protons. The electron hit strip profiles are consistent with the development of the electromagnetic showers. For increasing beam energies, the number of hit strips also increases. In the case of protons, the hit strip profile is flat since the interaction length in the TKR is negligible. Fig. 6 shows the average energy deposition in CAL layers for different electron energies. For increasing electron energies, the electromagnetic showers develop deeper inside the CAL. Moreover, at high energies the showers are not fully contained.

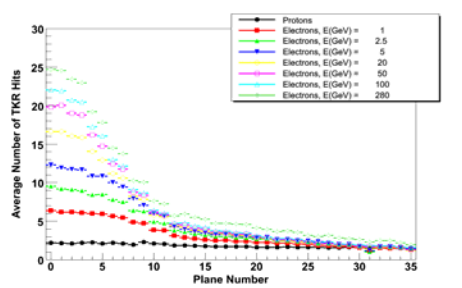

Fig. 5: Average number of hit strips Vs plane

Angular dispersion evaluation

We selected photon events with a single reconstructed vertex and two tracks in the TKR.

For the evaluation of the angular dispersion we calculated the angle between the reconstructed photon direction and the nominal beam direction. Fig. 4 shows the 68% containment angle obtained as a function of the photons energy. The associated errors have been evaluated taking into account that the measured beam divergence is 4 mrad for 2.5 GeV/c momentum.

The predictions from a MC simulation are also shown in the plot. Experimental data are well reproduced by the MC simulation.

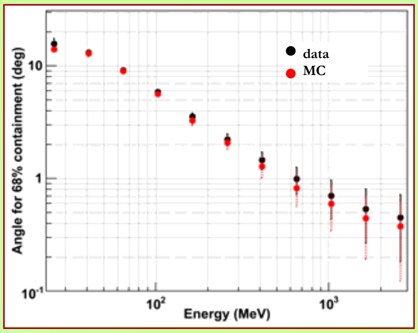

Fig. 4: Angular resolution at 68%

Energy Calibration

We analyzed a huge sample of electron data, with different momenta and different incoming direction with respect to the CU.

Fig.7 shows the average energy reconstructed by the CU at different nominal beam energies in the case of vertical incidence: the CU reconstructs correctly the energies of incoming electrons.

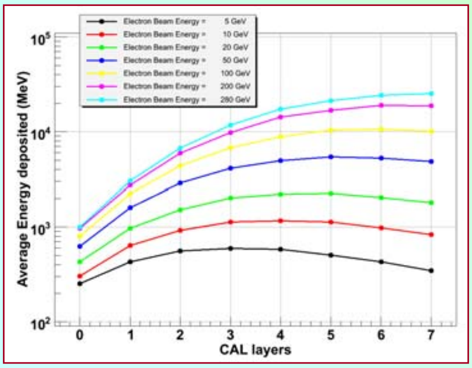

Fig. 6: Average energy deposition in CAL layers

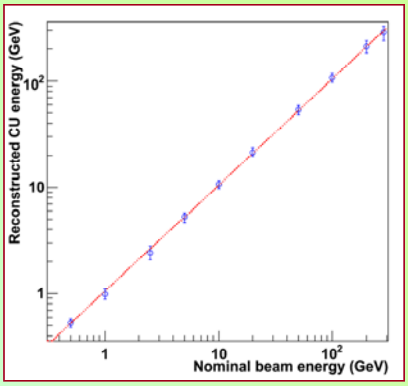

Fig. 7: Average CU energy Vs Nominal beam energy

Conclusions

During the beam test campaign, a large set of configurations (particles, energies and angles) have been explored. Preliminary results confirm that:

- the apparatus correctly reconstructs the energy of incoming particles;
- the measured photon angular resolution is well reproduced by Monte Carlo simulation.