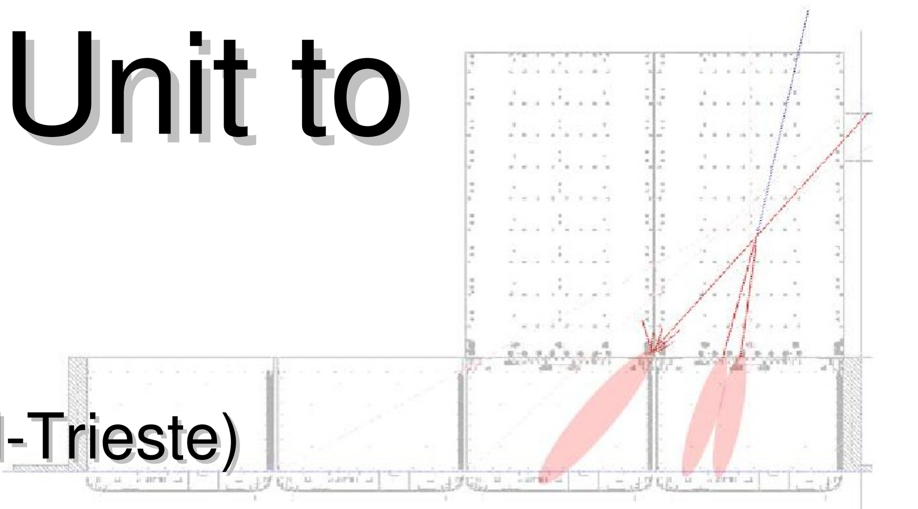
Response of the GLAST-LAT Calibration Unit to Sources of Background



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for the GLAST Beam Test Team

Abstract

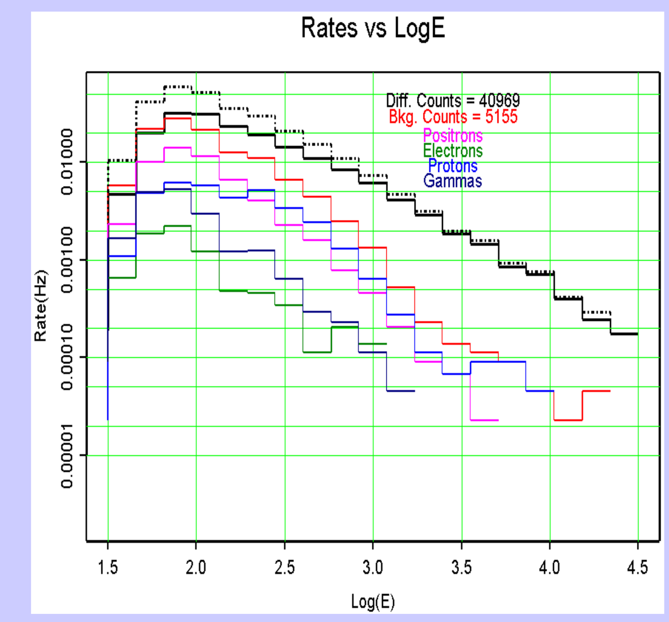
The main sources of background for the operation of the GLAST-Large Area Telescope are primary protons, albedo gammas from the earth and photons coming from interaction of positron and protons in the micro-meteoroid-shield (MMS) surrounding the LAT, which creates photon pairs through annihilation and π^0 decay. An extensive beam test campaign was performed in summer 2006 on the LAT Calibration Unit (CU), a detector built with flight spare parts of the LAT; the goal of the program was to support the LAT Instrument Calibration by providing direct measurements of the physical processes taking place in the CU detector when exposed to different beams, by comparing the obtained measurements with Monte Carlo predictions and by eventually validating the full LAT MC code used to provide instrument calibrations and background rejection strategies. The study of the signal produced in the CU by sources of the LAT background was performed with photon beams shot from the side of the CU, proton beams and positrons beams reaching the CU after crossing an MMS target. Results from analysis of these data are presented in this poster.

Introduction to LAT Background fluxes

- Photons represent a very small fraction of the particles that will go through the LAT on orbit.
  - At 10 GeV, the science requirements dictate a **rejection of 10^6 to 1**.
- The LAT segmented ACD will allow the identification of most charged particles, but the biggest part of the remaining background is still due to protons and positrons.
  - **Reducible background** needs to be clearly identify and removed.
  - **Irreducible background**, when photons are produced within the LAT Field of View, need to be well modeled in order to be statistically subtracted to measured fluxes.

The full GLAST simulation in association with the beam test data is our best tool to achieve these two goals and meet the science requirements.

- ✔ Protons: Interaction in the protective blanket that surrounds the LAT (MMS) produces π^0 that decays in two photons within the LAT field of view, contributing to the irreducible background flux.
- ✔ Positrons: Annihilation in the MMS produces photons that can't be individually distinguished from celestial photons.
- ✔ Albedo Gamma-rays: Usually back-entering photons and thus with a different topology than usual events.



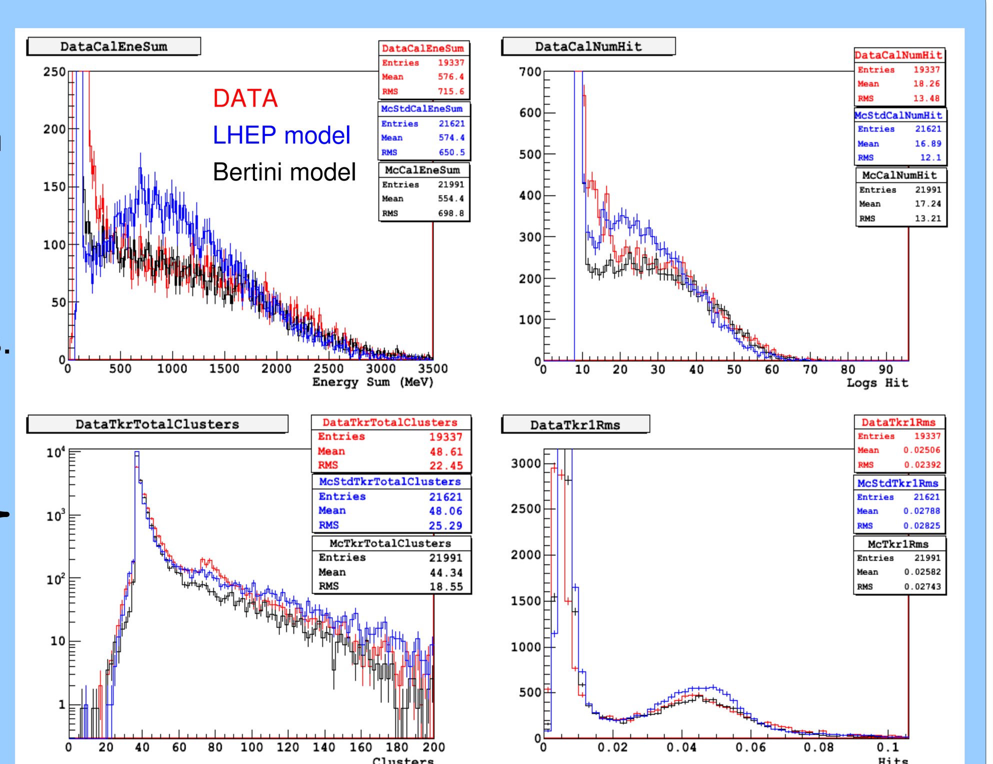
Simulation of hadronic processes

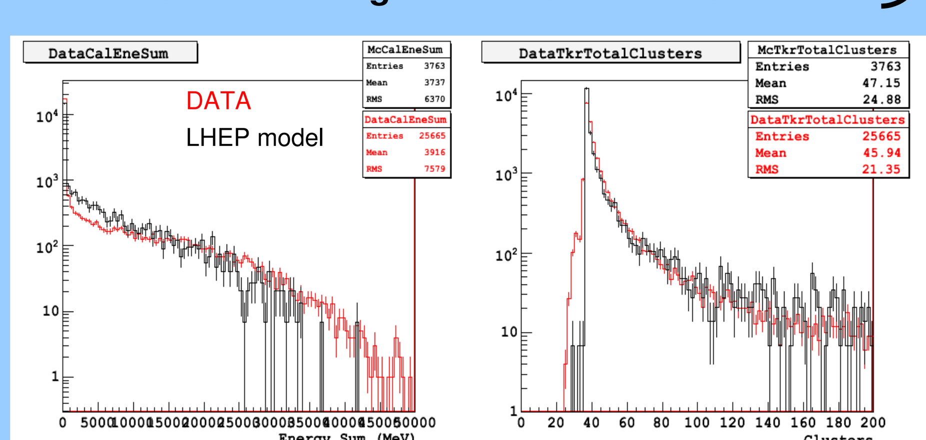
Hadronic processes induced by protons are responsible for a part of the reducible background. For instance, protons can interact in the spacecraft and generate a hadronic cascade in the calorimeter.

The beam test data help us to verify how well the simulation can reproduce all kind of hadronic processes for energies ranging from 1GeV up to 200 GeV, for our standard variables.

At PS: 6 GeV/c protons at 0°:

- **the Energy distribution produced by LHEP model does not match well the one observed in the data.**
- **the Bertini model proposes quite a good agreement for most low and high level distributions.**





At SPS: 100 GeV/c protons at 0°:

- **the default LHEP model seems to simulate well low level variables, such as the calorimeter energy or the number of cluster in the tracker.**
- **other models available in GEANT4 still needs to be evaluated.**

Albedo Gamma rays

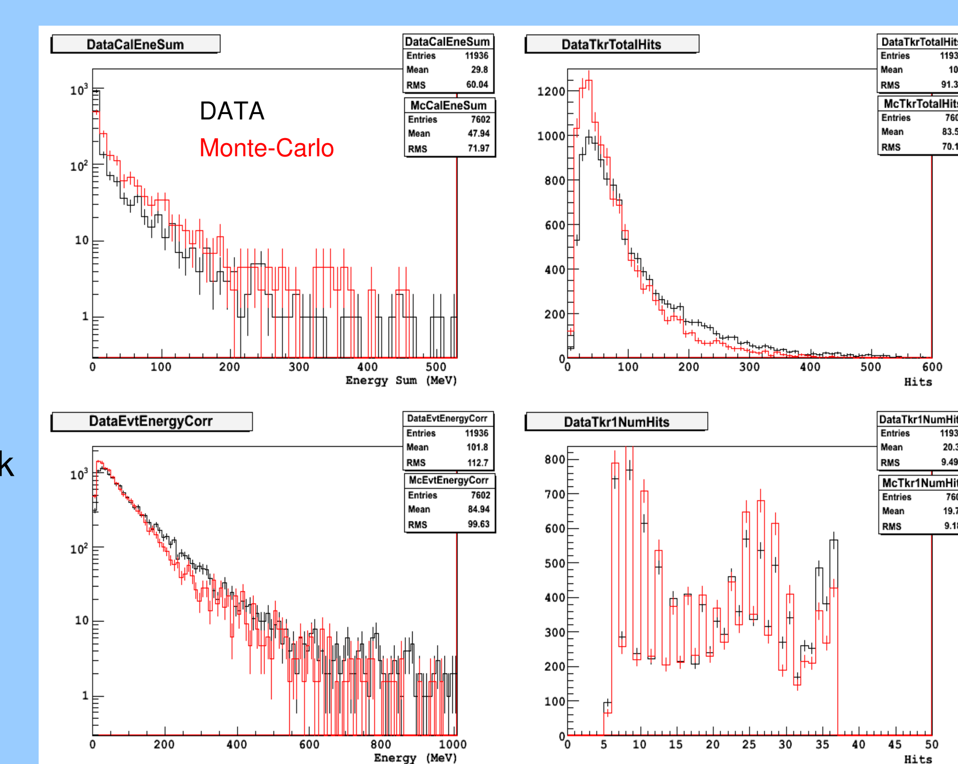
Beam Test Data vs. Monte-Carlo Simulation

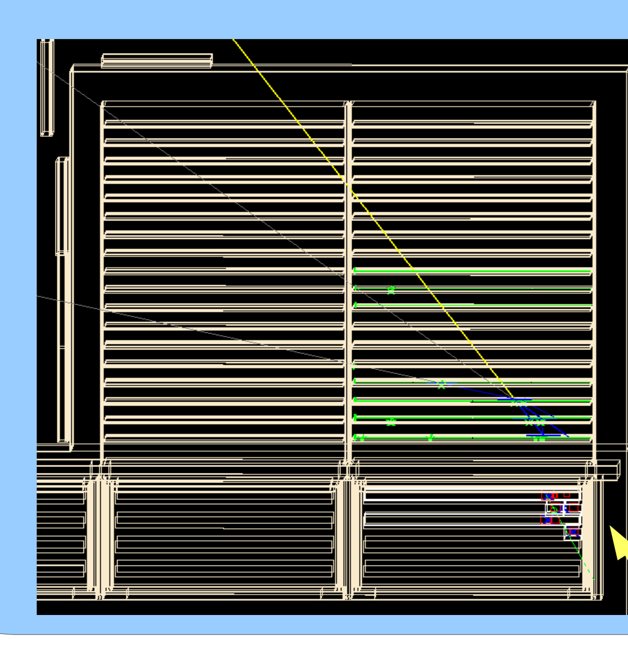
Beam Test Data:

- Gamma-rays from a 2.5 GeV/c electron beam
  - In the back of the Calibration Unit
  - At mid-distance between the Tracker and the Calorimeter

Event selection:

- Cuts on MIPs contamination
- Good gamma candidates: at least 1 reconstructed track
- No big EM shower: no signal in ACD



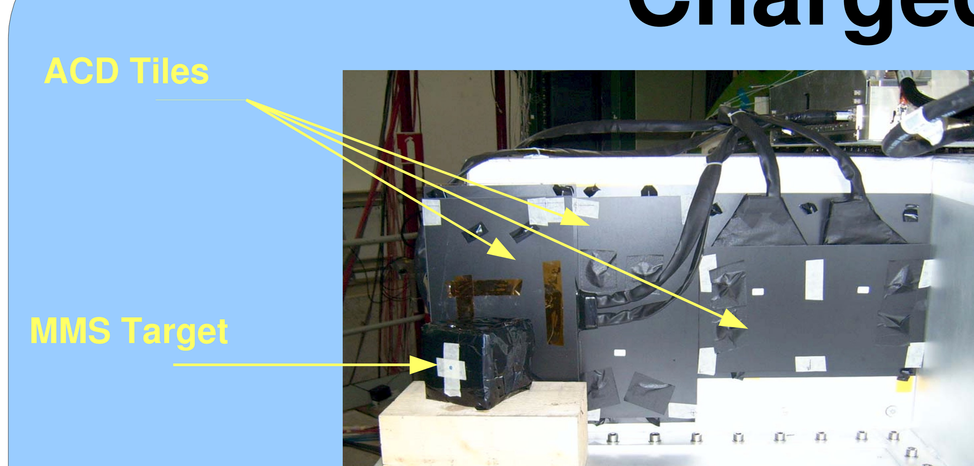


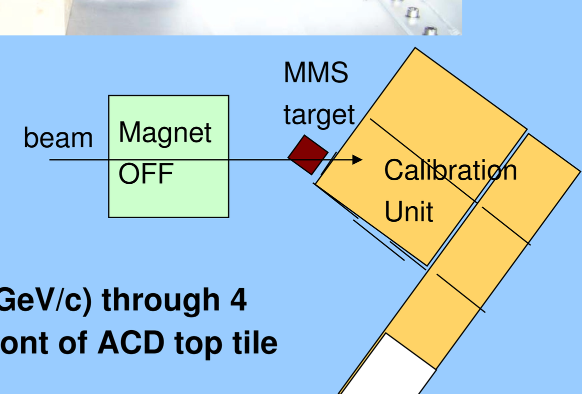
γ-rays Beam Direction

The preliminary analysis shows that these special events seems to be well reproduced by the GLAST simulation both for:

- **low level variables (integrated tracker hits...)**
- **high level reconstructed parameters (event energy...)**

Charged particle interactions in the Micro-Meteoroid Shield



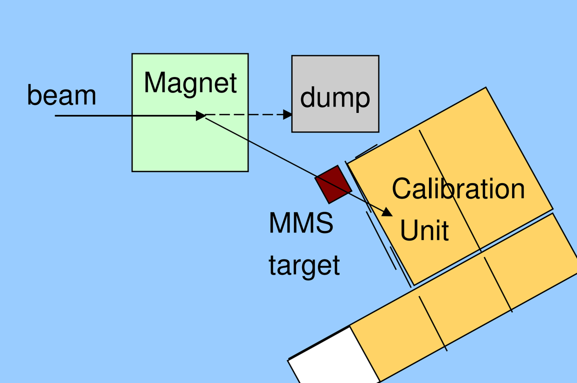


Proton setup:

- **Magnet OFF**
- **Shoot ~2M p (6 and 10 GeV/c) through 4 layers MMS placed in front of ACD top tile**

Positrons setup:

- **Magnet ON and extended dump to stop bremsstrahlung γ from e+**
- **Shoot 1M e^+ (1 GeV/c) through 4 layers MMS placed in front of ACD side top tile**
- **Also shoot 1M e^- for comparison and background subtraction**

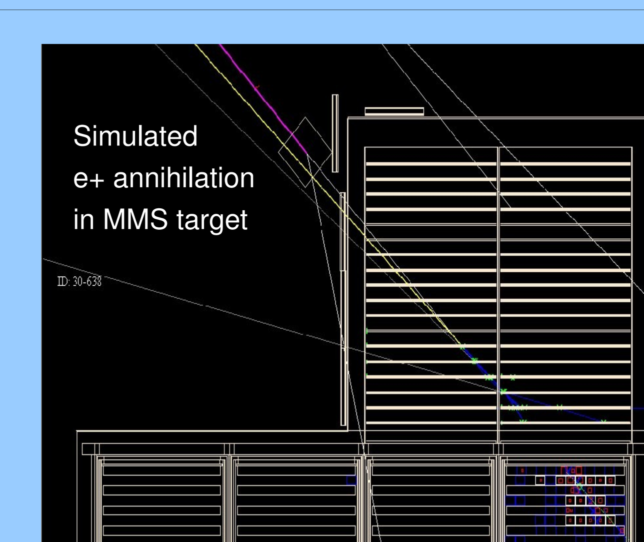


Positron Annihilation

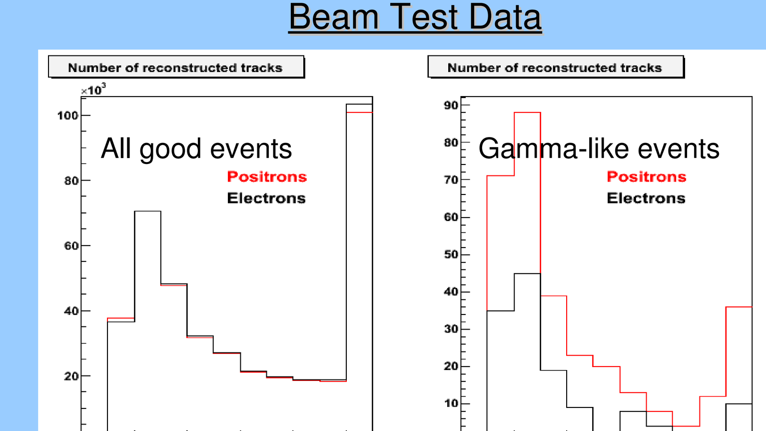
Analysis based on:

- Tracker + Calorimeter ("good" events):
  - Identify particles crossing the MMS
  - Select well reconstructed events
- Tracker + ACD ("gamma-like" events) :
  - Veto incoming charged particles and identify photons
- Electron data:
  - Study residual background
- Monte Carlo comparison:
  - Validate the detector description and the Geant4 physics description

A preliminary analysis showed a clear excess in the e^+ data in agreement with the expected ~10^{-4} annihilation probability.



Beam Test Data

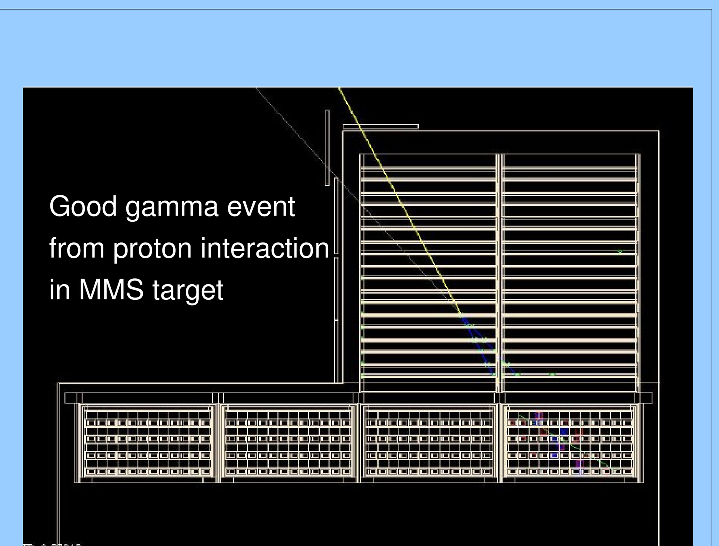


Proton Induced Background

Goal : Measure the probability for incident proton to create gamma (>30-50 MeV) in MMS without a signal in ACD, to be compared with the results of simulations.

Selection:

- Use Tracker and Calorimeter to select good events
- No Signal in ACD and Tracker first layers
- Manual removal of obviously bad events (double particle, charged particle tracks)



A preliminary evaluation of the photon production probability is in reasonable agreement with a Geant-3.21 simple model simulation

	Total number of events	Number of events passed "auto" cuts	Number of events passed "visual" cuts	"Irreducible" background
6 GeV Protons, MMS	2.24×10^6	452	318	1.4×10^{-4}
10 GeV protons, MMS	2.6×10^6	567	414	1.6×10^{-4}

Conclusion

Understanding the irreducible gamma-ray background is a key point for the success of the GLAST mission. The preliminary analysis of the GLAST beam test data allowed us to check qualitatively that our simulation is able to reproduce reasonably well the main quantities measured by the LAT.

The analysis of beam test data is still on-going in order to work out all the details of the different processes linked to the gamma-ray background.

Acknowledgment : Thanks to W. Atwood for his comments and suggestions.