8.3 ACD Backsplash

The capability of the LAT to measure photon energies up to 300 GeV with good energy resolution requires the presence of a heavy calorimeter to absorb enough of the electromagnetic cascade produced by the incident γ-ray. Most of the charged particles and photons in the electromagnetic shower travel along the direction of the incident photon, but a small fraction of them travel backwards. This radiation consist mostly of 100-1000 keV photons and is known as *backsplash.* When backsplash photons cross the ACD, they can interact via Compton scattering thereby producing ACD signals. If any of the backsplash signals is over veto threshold, the event would be interpreted as background and thus rejected. The LAT was designed to avoid this problem by using a *segmented* ACD [1]. When a particle is incident on the instrument, only the ACD segment intersected by the backwards projected path of the particle is used to veto the event. Therefore, the ACD area that can contribute to backsplash is relatively small.

The ACD hit probability per unit area as a function of energy and distance backwards from the shower has been studied with past beam tests for different calorimeter materials [2]. Beam test studies in the past were used to set the level of segmentation in the ACD design and to validate the design choices. Our goals for this beam test regarding backsplash are: i) to determine the backsplash probability with *as-built* detectors and readout electronics, and ii) to verify the capabilities of the LAT Monte Carlo simulations to reproduce backsplash effect.

Our Monte Carlo simulation of the backsplash effect considers the energy loss by backsplash radiation in the ACD tile, Poisson fluctuations in the number of photoelectrons created in the PMT, and corrections due to the non-uniform light collection at the edge of each tile. The amount by which the light collection decreases near the edge is different tile to tile, but in general, it is known from the LAT that the light collection is as low as ~70% of nominal value at the tile edge, and recovers back to 100% when measured ~3 cm away from the edge [1]. *This currently represents the largest source of uncertainty in our simulation.* The expected backsplash distribution is therefore bracketed in this analysis by two extreme scenarios:

- In the *maximum light leakage* scenario, edge corrections are applied within 3 cm of the tile edge. The light collection efficiency is assumed to decrease linearly from 100% (away from the edge) to 70% at the edge.
- In the *minimum light leakage* scenario, edge corrections are applied within 1 cm of the tile edge. The light collection efficiency is assumed to decrease linearly from 100% (away from the edge) to 90% at the edge.

Backsplash is calculated as the fraction of events for which the signal in an ACD tile was above a given threshold in units of mips (1 mip is equal to the energy lost by a Minimum-ionizing particle (MIP) crossing the tile at normal incidence). Figure 1 shows the obtained backsplash distributions with statistical errors (1σ) for one of the tiles as obtained from the beam test data (black points) for a 200 GeV electron beam. As can be seen from the figure, the Monte Carlo simulation is able to reproduce very well the backsplash distribution.

The measured backsplash energy dependence observed in one of the tiles is shown in fig. 2. As expected, the backsplash probability correlates with the beam energy. Furthermore, it can be seen that backsplash does not increase dramatically at the highest energies. This is due to the fact that the electromagnetic shower cannot be fully contained in the calorimeter at very high energies[1].

An empirical formula was found in the beam test of the ACD design choices in 2002 to describe the backsplash probability [2]. The energy dependence of such formula is given by,

$$P_{backsplash} \propto \sqrt{E} \tag{1}$$

and as can be seen in fig. 2, it fits well the data and thus corroborates the results obtained in that beam test.

References

[1] Moiseev, A., et al. 2007, *The Anti-Coincidence Detector for the GLAST Large Area Telescope*, in preparation

[2] Moiseev, A. A., et al. 2004, Astroparticle Physics, 22, 275

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[1] Nevertheless, the segmented calorimeter provides a clear image of the shower profile, which is used to calculate the actual energy of the event.

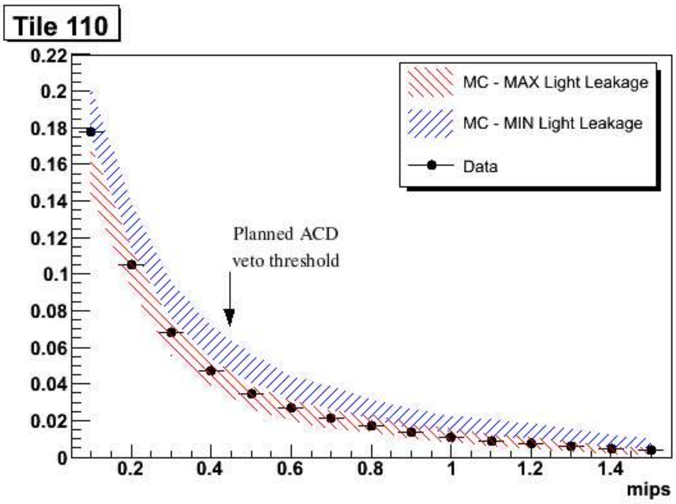

Figure 1: Backsplash distribution for an ACD tile as obtained from beam test data (black points) and Monte Carlo expectations. In every case, backsplash is expressed as the fraction of events for which the signal in the tile is above a given threshold. The error bars in the data are statistical (1σ). Monte Carlo simulations consider two extreme scenarios of light leakage through the tile edge. In the MAX light leakage scenario, the light collection efficiency decreases linearly from 100% (3 cm away from the edge) to 70% at the tile edge. In the MIN case, the light collection decreases linearly from 100% (1 cm away from the edge) to 90% at the tile edge. Both scenarios are shown in the backsplash distribution as “bands” that bracket the expected backsplash distribution. The width of each band is given by twice the statistical error (2σ) obtained from the simulation.

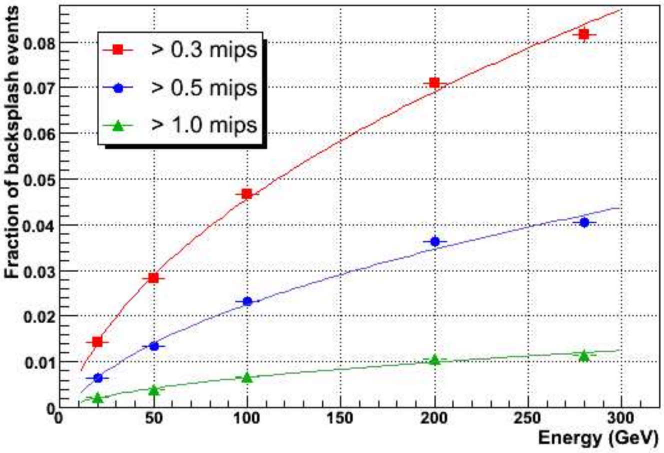

Figure 2: Energy dependence of backsplash in tile 110 for different thresholds. The data is well fitted by a function of the form $\sqrt{E}$.