
# GLAST Large Area Telescope:

## Calorimeter Simulation and Reconstruction Overview

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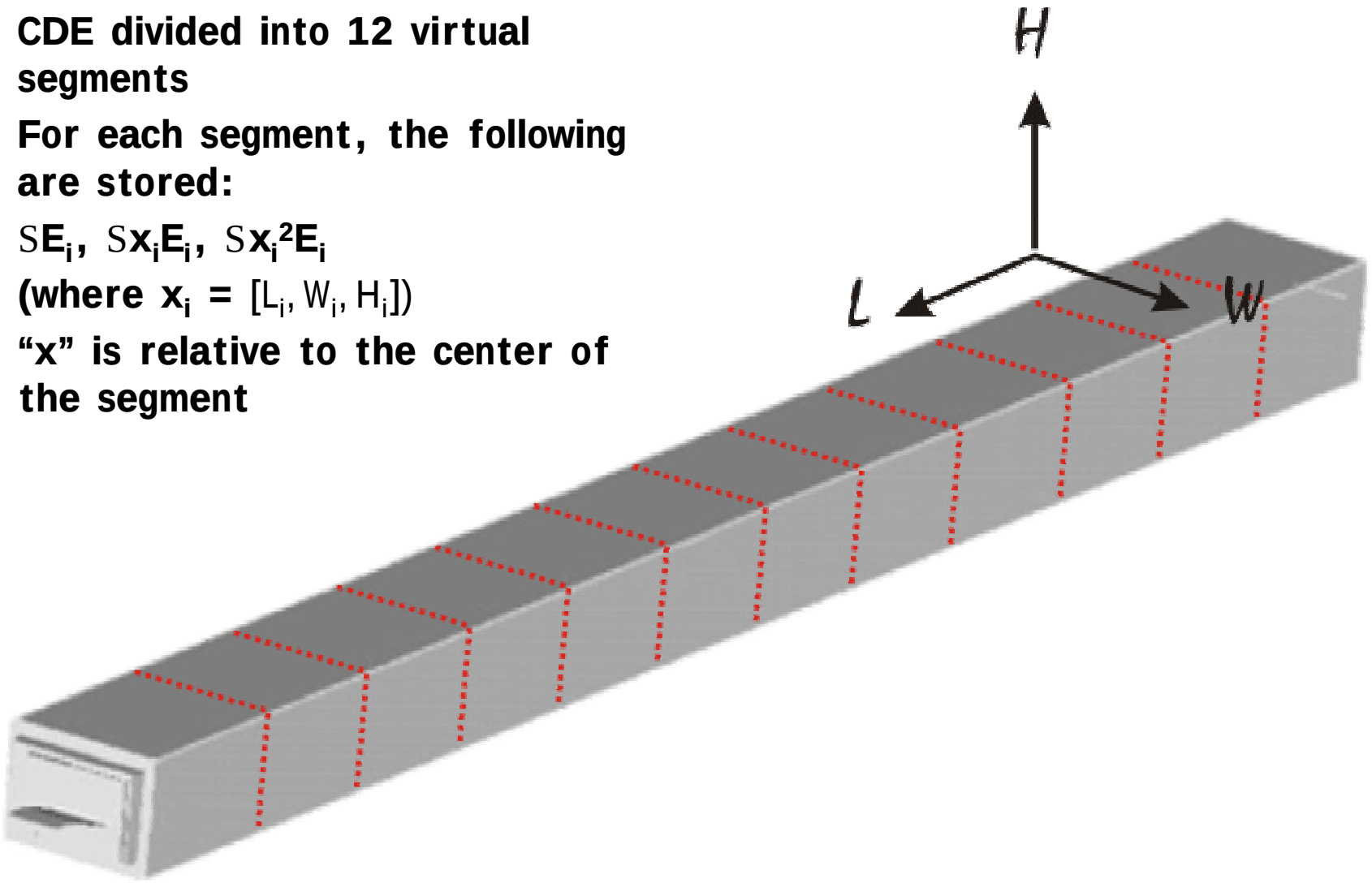
# CAL Sim and Recon

# Simulation

- CDE divided into 12 virtual segments
- For each segment, the following are stored:

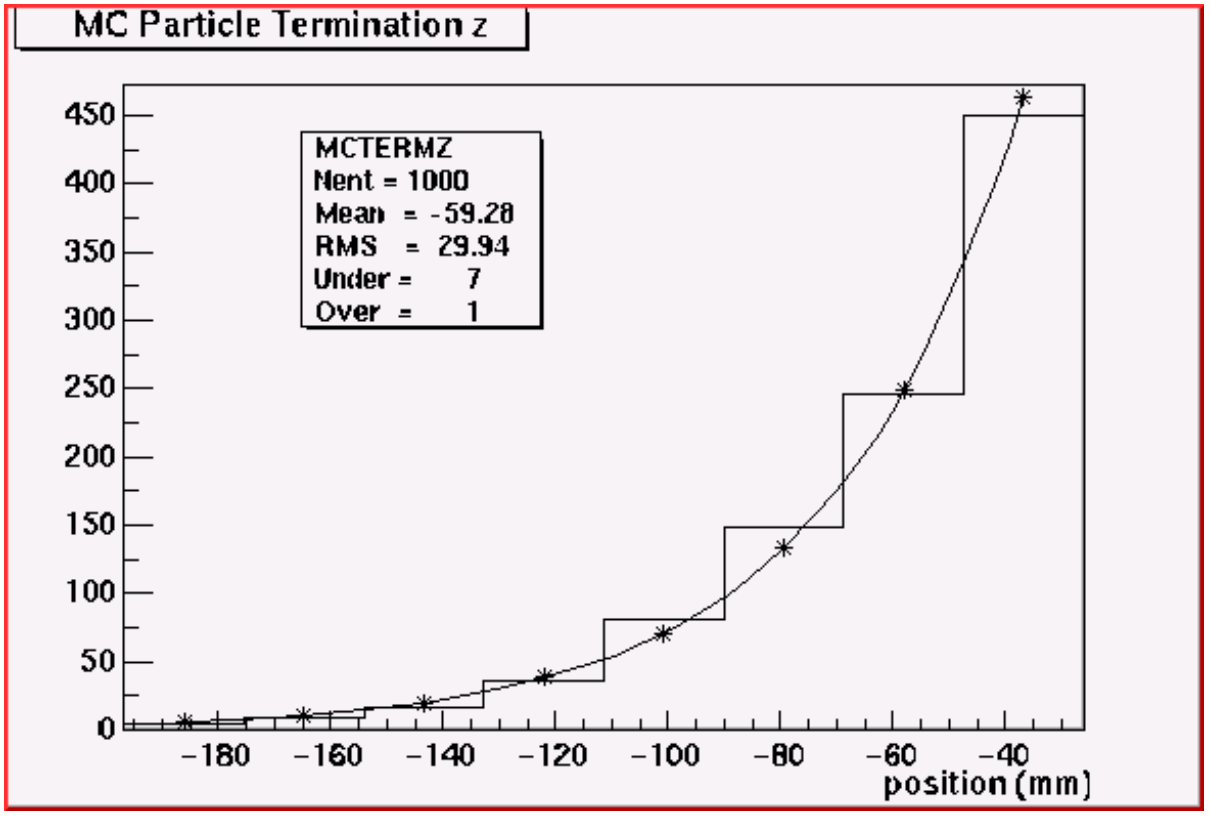
  $SE_i$, $Sx_iE_i$, $Sx_i^2E_i$

  (where $x_i = [L_i, W_i, H_i]$)
- "x" is relative to the center of the segment



# Simulation

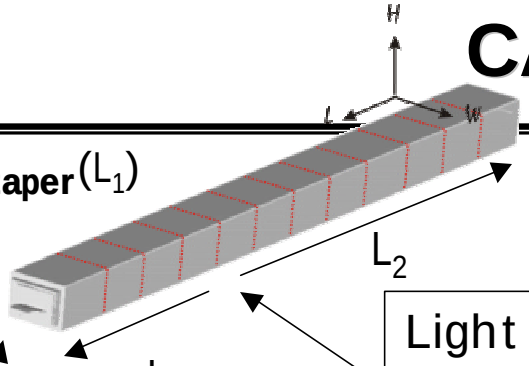
- **Verification of pair conversion rate vs. depth in CAL**
  - **100 MeV vertical gammas**
  - **Gammas start after TKR**
  - **Data and predictions integrated over each layer**



# CAL Digi

$\text{Signal}_1 = F_{taper}(L_1)$

$\text{Signal}_2 = F_{taper}(L_2)$




Light taper applied from each segment to each crystal end

Result is signal at each end.

One signal is generated:

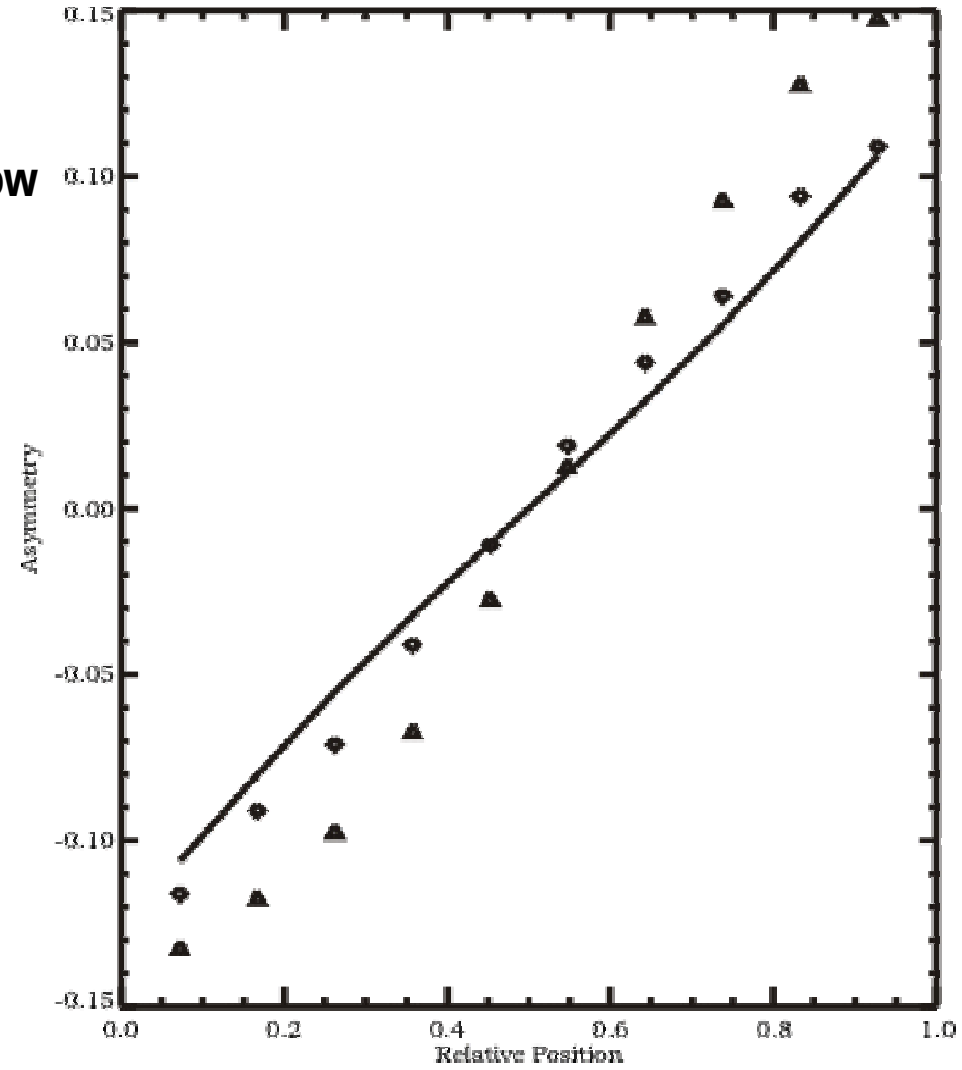
- Direct diode deposit added
- Poisson fluctuations in photoelectrons added
- Gaussian electronic noise added
- 2 MeV threshold applied
- Conversion to ADC units (2 ranges for each of 4 diodes

# CAL Digi

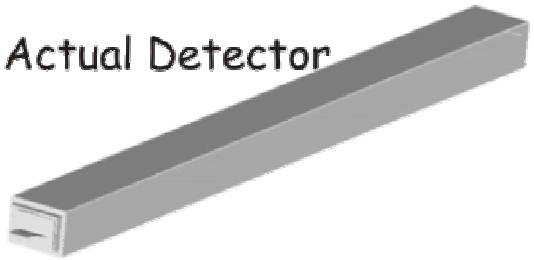
- **Current Limitations**
  - "Calibrations" do not reflect real instrument
    - Linear taper function
    - $e^-$/MeV must be modified
    - 1 pedestal and gain applied for all crystals
    - Integral nonlinearity function (i.e. shape of gain curve) from balloon flight detector
    - No mechanism in place for storing calibration constants
- **Plans to Address Limitations**
  - More realistic exponential taper function implement for digi, but not yet in recon
  - Exponential taper function needs tweaking to reflect EM crystal measurements
  - Calibration classes in design process
    - Will hold all calibration quantities for all crystals
    - For use by digi and recon
  - EM calibrations will supply better parameters

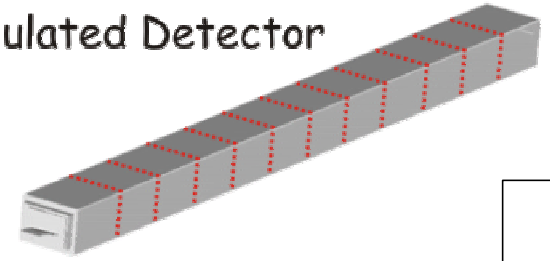
# Light Taper Function

- Sample exponential taper function
- Purposely exaggerated to show shape
- Data from two EM crystals show similar but not identical shape



# CAL Recon




CALRecon

- **Reconstructed incident energy**
- **Reconstructed gamma direction**
- **Reconstructed position**

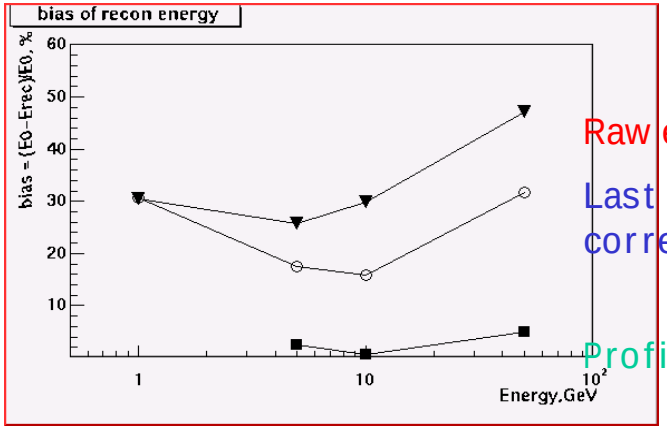
# CAL Recon

- **For Each Crystal**
  - **ADC Scale to Energy measured at each crystal end**
    - **Gain and pedestal defined from muon (ground) and cosmic ray (flight) calibrations**
    - **Integral nonlinearity defined from charge injection calibration**
  - **Centroid Position**
    - **Use position vs signal asymmetry**
    - **Asymmetry defined as $(s_2 - s_1)/(s_2 + s_1)$ for linear taper**
    - **Asymmetry defined as log(s2/s1) for exponential taper**

# CAL Recon

- **Add crystal energies for Energy per Layer**
- **Energy Reconstruction**
  - **Sum all layers**
    - **Simple**
    - **Wrong answer**
  - **Shower profile fitting**
    - **Works well at all energies**
    - **Not dependent on CAL geometry details**
    - **Needs to be modified to work at all incident angles**
    - **Approximate due to ignoring correlations between layers**
  - **Use correlation between leakage and energy deposited in last layer**
    - **Generally produces better resolution than profile fitting**
    - **Works well when shower maximum is contained in CAL (<50 GeV)**
    - **Works poorly at higher energies**
    - **Parameters are dependent on CAL geometry**
    - **Needs to be retuned for current geometry**

# CAL Recon

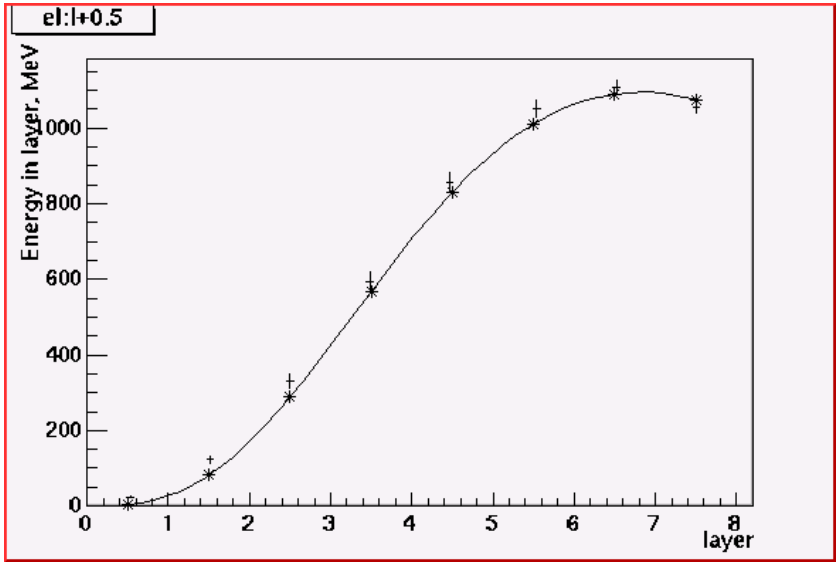



Fractional Bias of Reconstructed Energy vs. Incident Energy (on axis) for current model

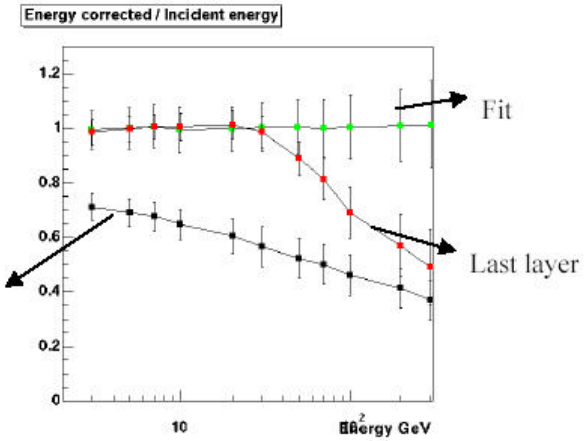
10 GeV Shower Profile:

+ : GLEAM simulation

* : Prediction from PDG

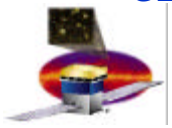



As above but old geometry with better last layer tuning



# CAL Recon

- **Direction Reconstruction**
  - Construct centroid position for each layer
  - Fit line to centroid positions
  - Tricky part is weighting of layers since uncertainties differ between longitudinal and transverse direction
- **Position Reconstruction**
  - Centroid of all layers
  - Weighting still tricky
  - Used for comparison to TKR trajectory



# Summary


- CAL sim and recon status
  - "Schematically complete"
  - Lots of details need to be filled in
  - Examples:
    - Realistic calibrations
    - Retuned energy recon
    - Better uncertainty estimation
    - Investigation of the possibilities of clustering
    - Investigation of effects of dead areas
- "Ensemble" energy reconstruction rather than photon by photon?