A Parametric Energy Recon for GLAST

A 3rd attempt at Energy Reconstruction

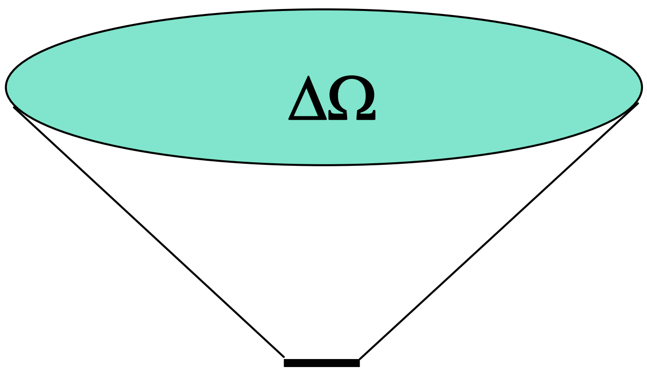
Keep in mind:

1) The large phase-space of GLAST –
20 MeV – 300 GeV, FoV ~ 2.5 str, etc.

2) The multiple detector features
- Tracker Thin & Thick layers
- Large gaps between Cal Modules
- Lack of depth (8.5 r.l. Cal at normal inc.)

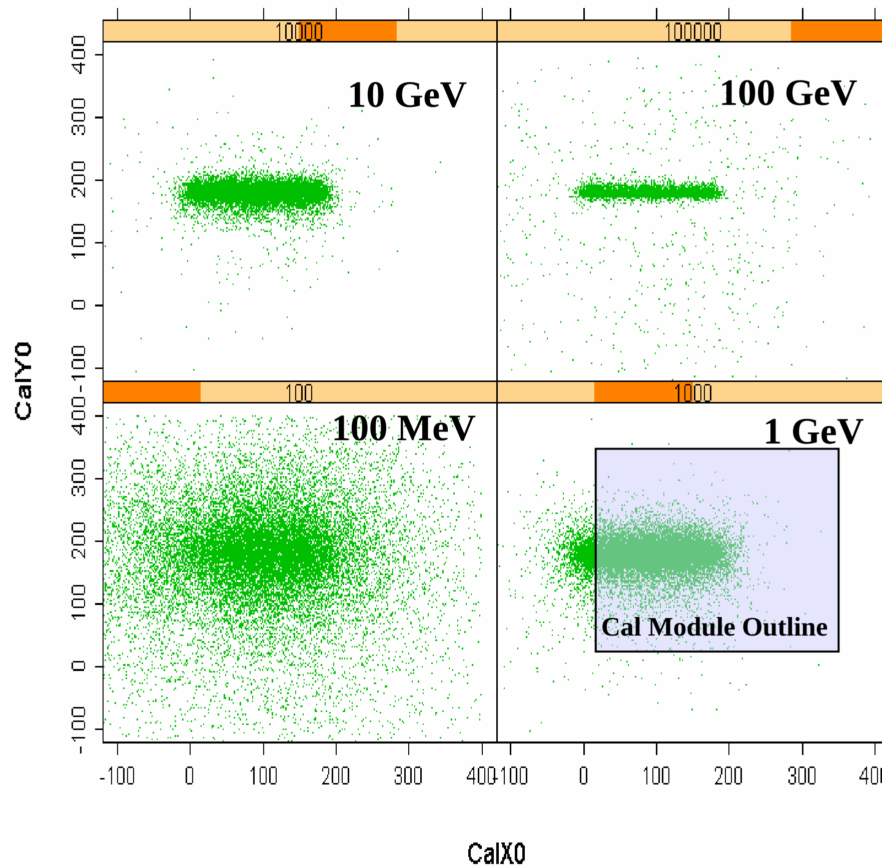
MC Sources

To help separate out various effects and run MC efficiently a new type of source was made: All trajectories pass through a designated piece of the detector.



Line Patch
Top of Cal

$\Delta\Omega$: $\cos(\theta) < -.2$



(CalX0,CalY0) is the reconstructed entry point on the top Cal Face

Shower Model

Wallet Card: $$\frac{dE}{dt} = E_0 b \frac{(bt)^{a-1} e^{-bt}}{\Gamma(a)}$$ where t is the depth in rad. lens.

***a* and *b* are parameters:**

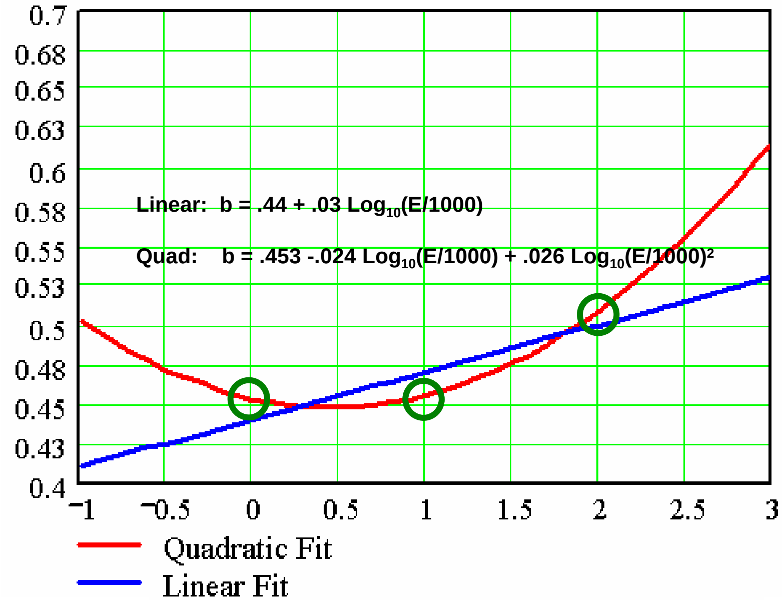
b scales the radiation length

a set the location of the energy centroid: $$\langle t \rangle = \frac{a}{b}$$

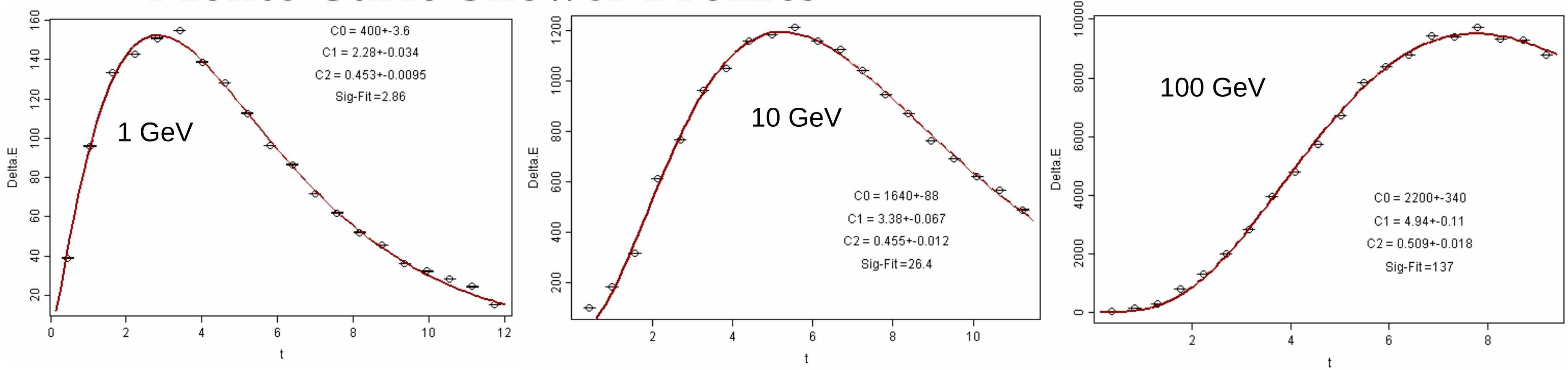
Data: Verticle at the (CalX0, CalY0) = (180, 180)

Variation in depth due to Track conversion point adding .1 ➡ 1.5 rad. lens.

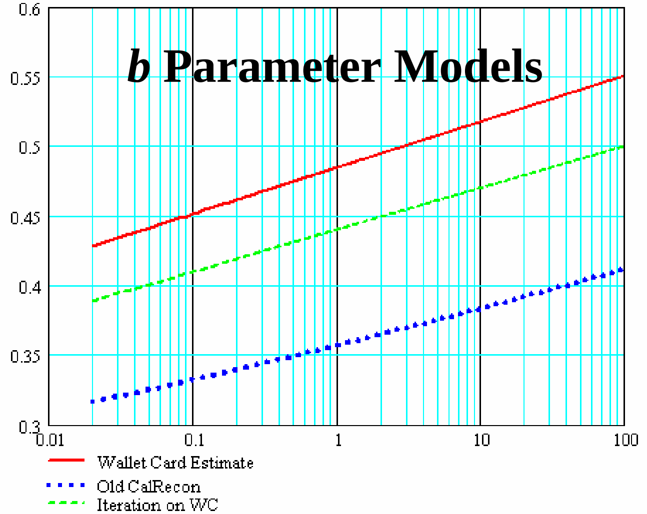
b Parameter Fits



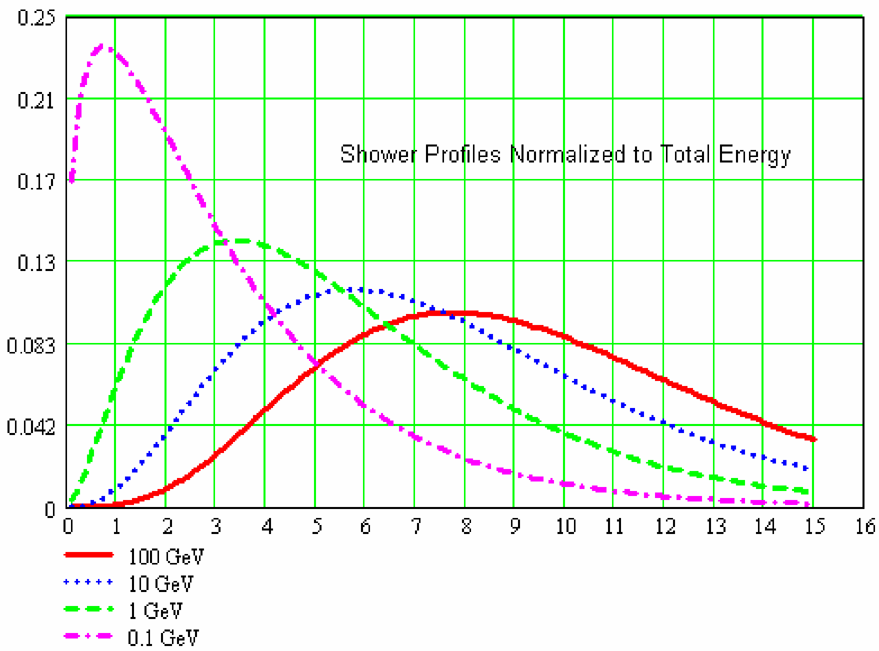
Monte Carlo Shower Profiles



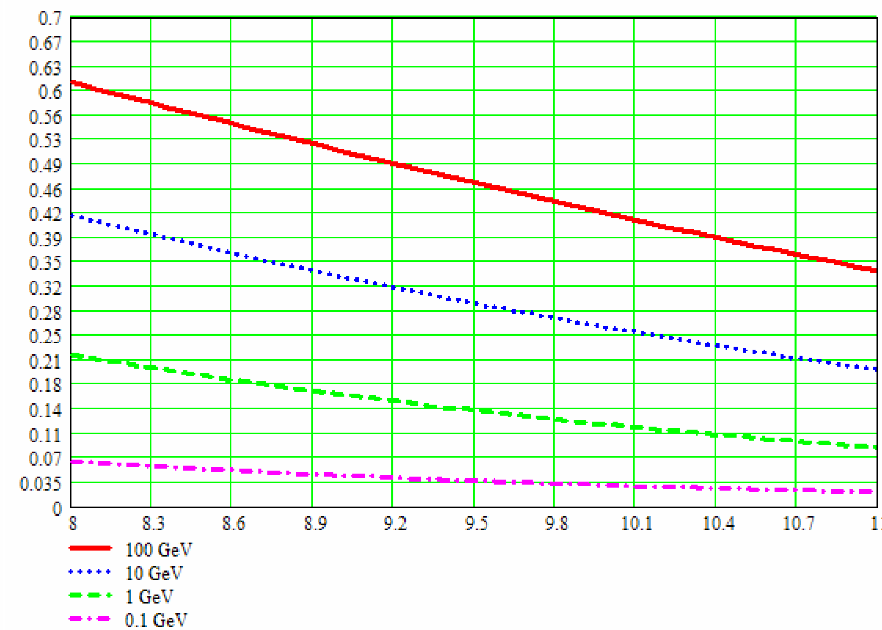
Shower Model



The Shower Profile from 100 MeV -> 100 GeV



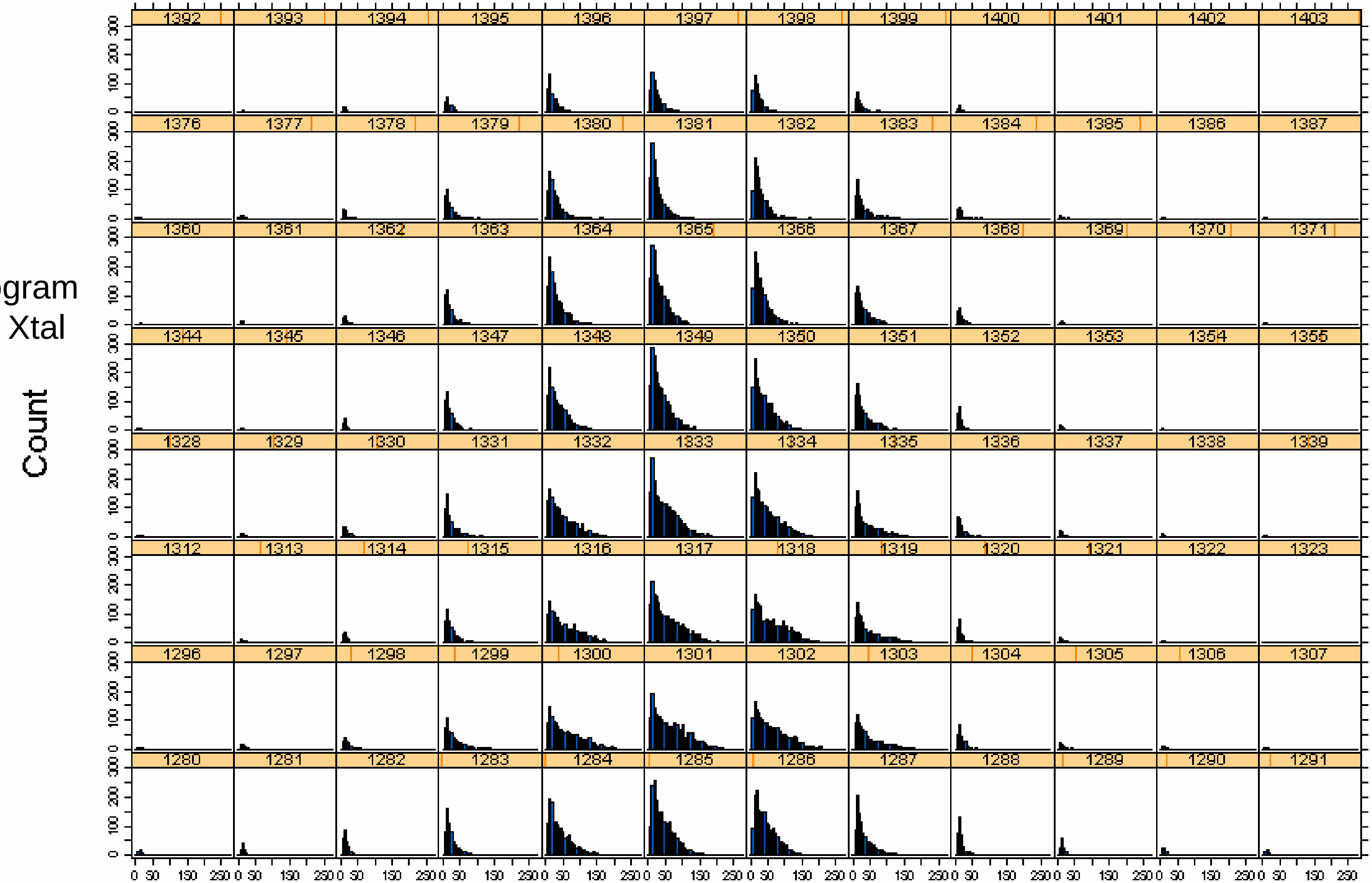
The Leakage Fraction



Xtal Shower Profiles – Conversion in Thin Tracker

A Full CAL Module - 1 GeV Verticle Gammas in the center of the CAL

Each Histogram is a single Xtal

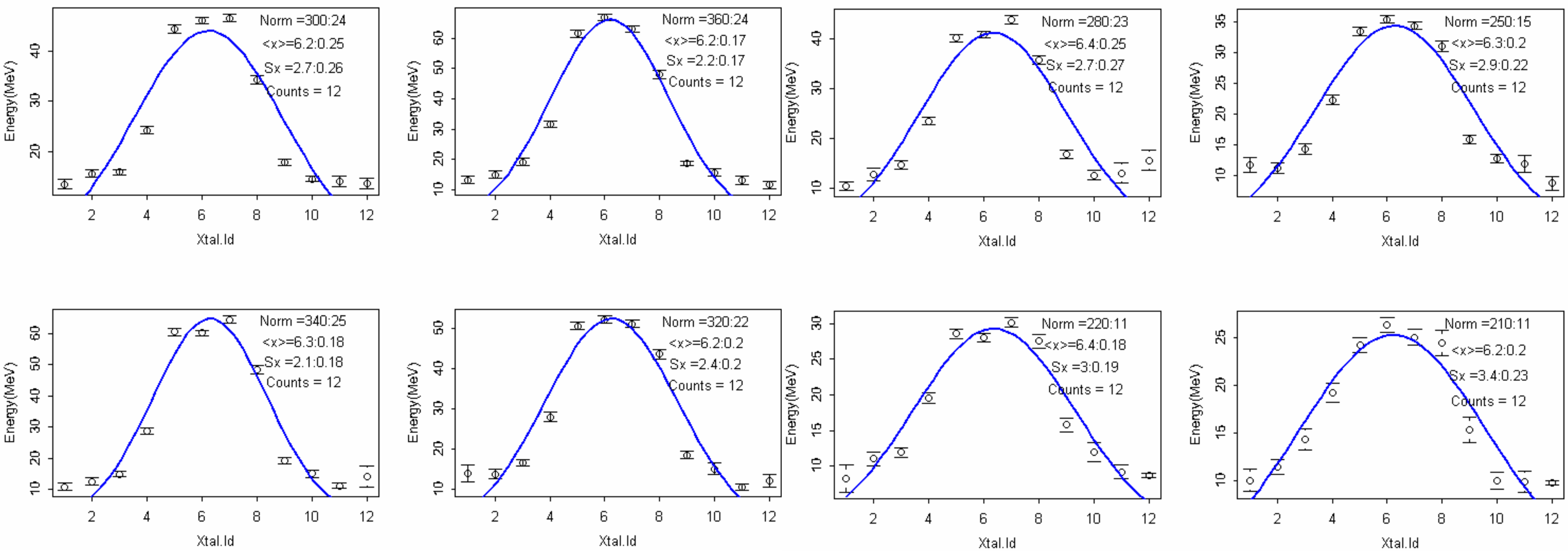


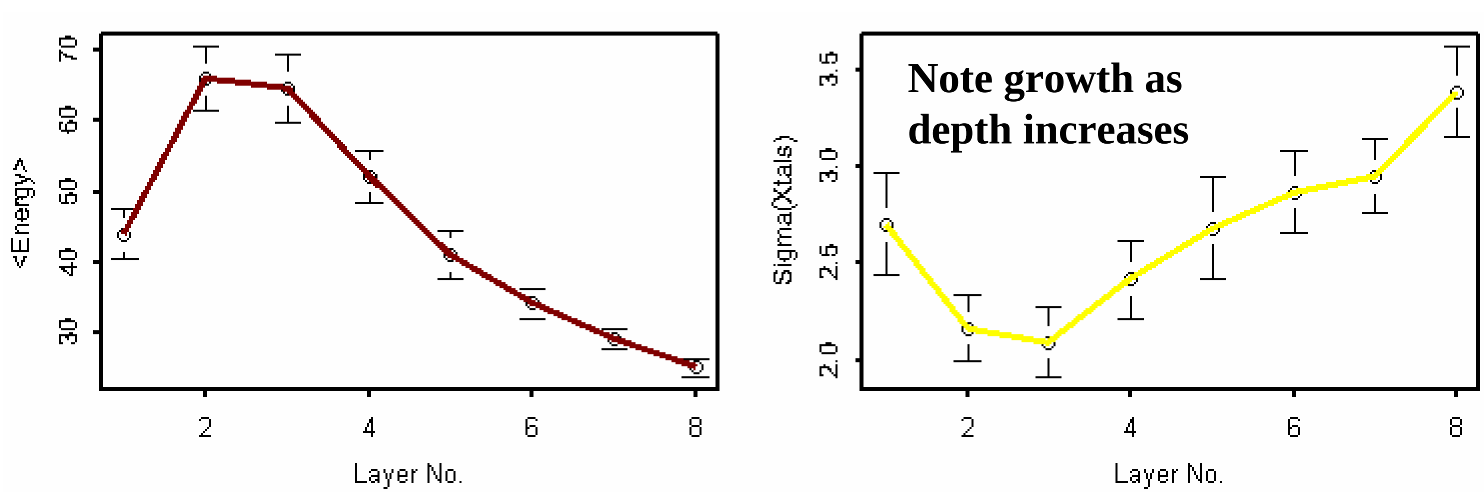
Top Face of the CAL

This side

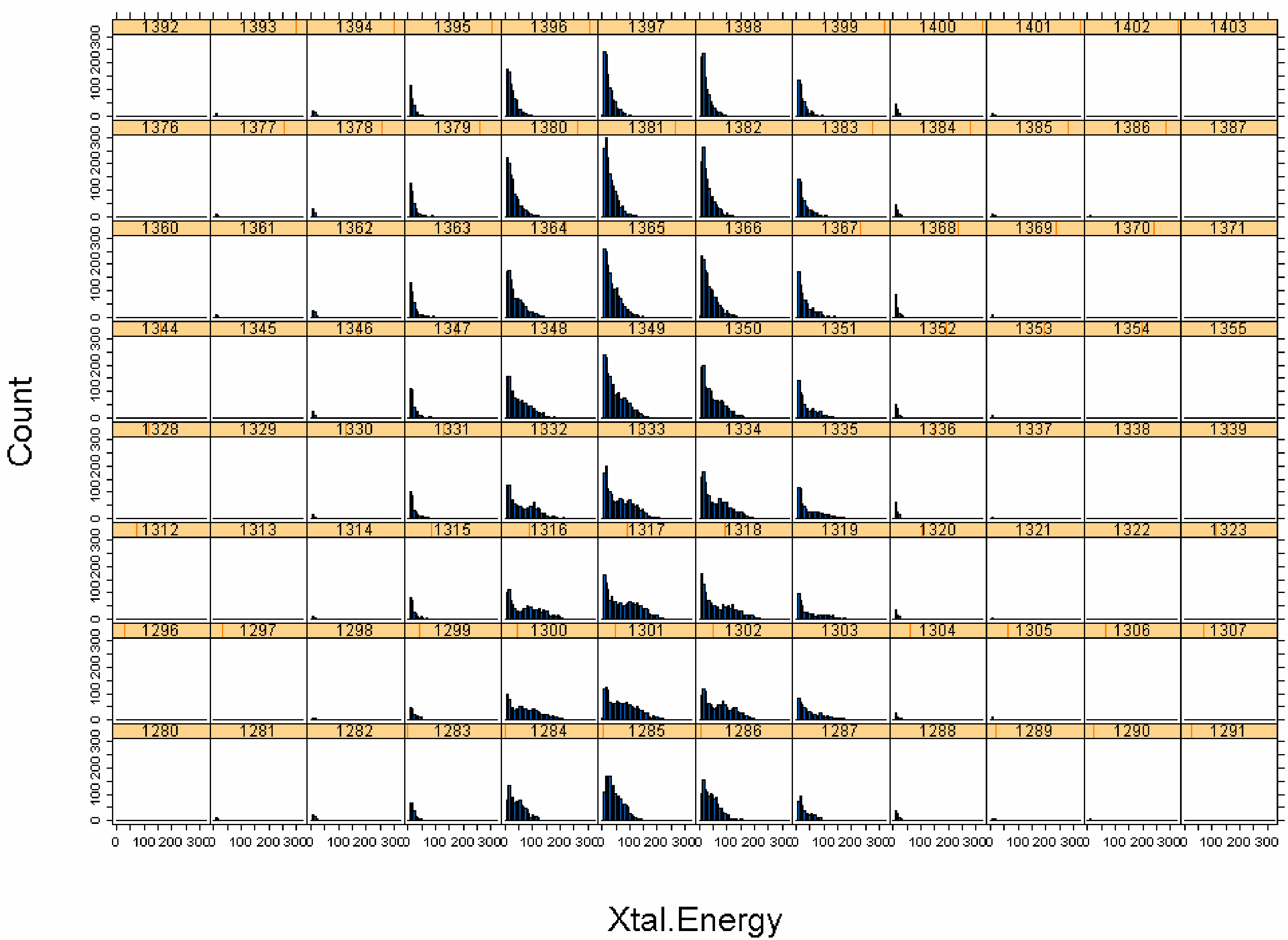
Xtal.Energy

Fits to Transverse Profiles – Thin Conversions

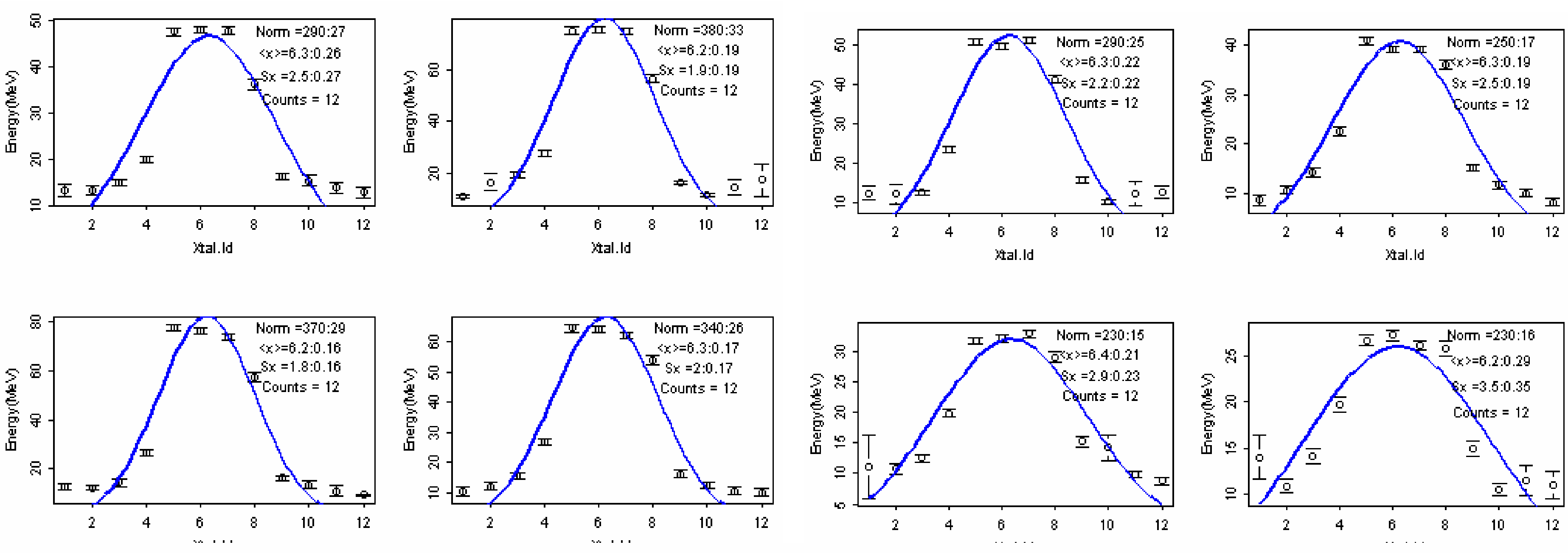


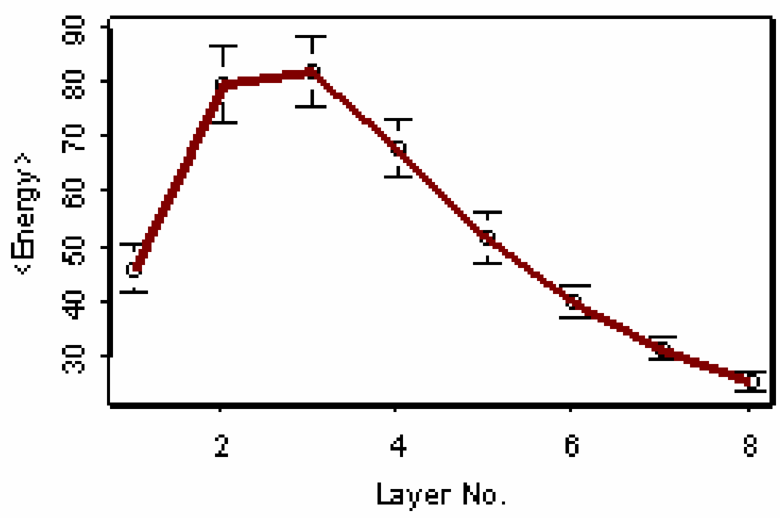


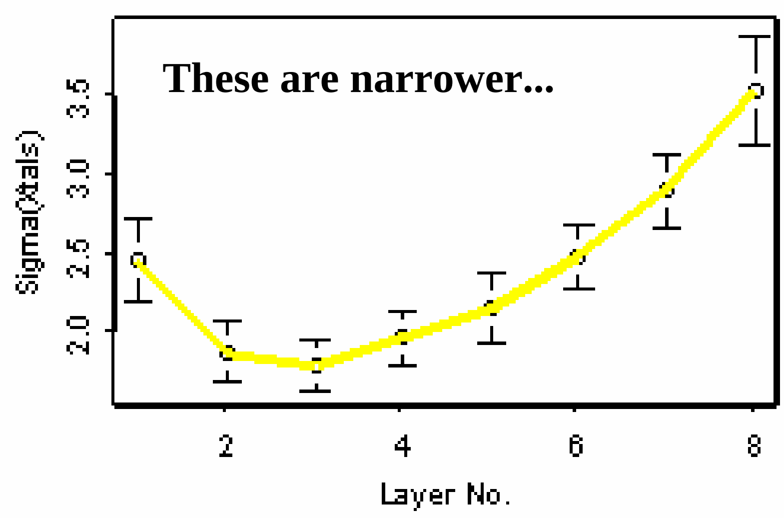
Xtal Shower Profiles – Conversion in Thick Tracker



Fits to Transverse Profiles – Thick Conversions





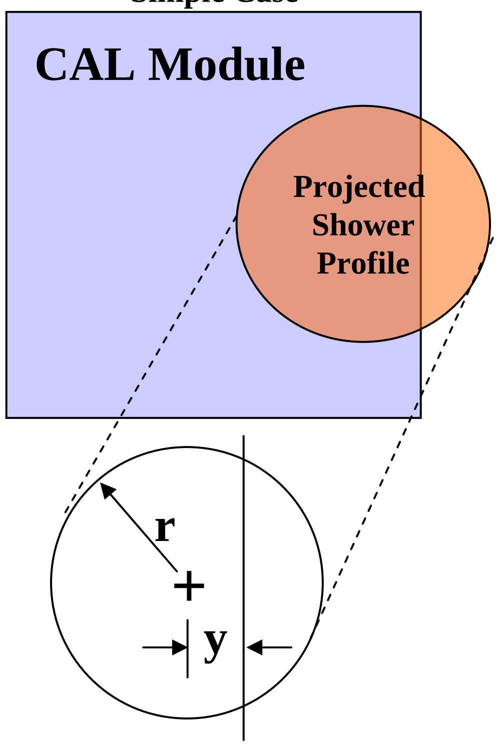


Correction Algorithms

Losses due to Gaps and Transverse Shower Spread

Estimate the fraction of the shower in a Gap at each layer

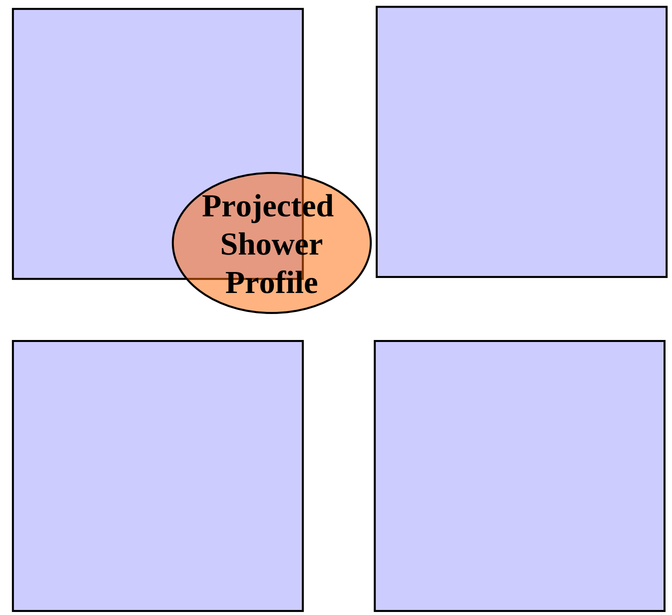
Simple Case



The fraction outside is

$$f(outside) = \frac{1}{2} - \frac{y}{r}\sqrt{1 - \left(\frac{y}{r}\right)^2} - \sin^{-1}\left(\frac{y}{r}\right)$$

Real Case



Ellipse: Simpson Integration of Simple Case

X-Y Edges: Treat separately – Subtract overlap

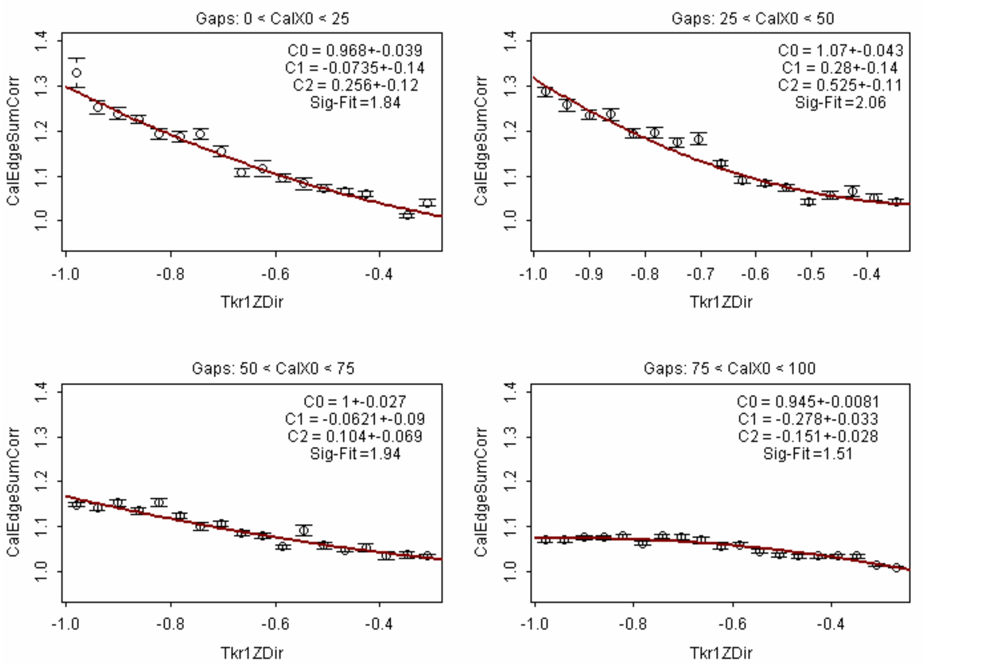
Energy dependence on Radius: Below 1 GeV – broaden by ~ 2 by 100 MeV

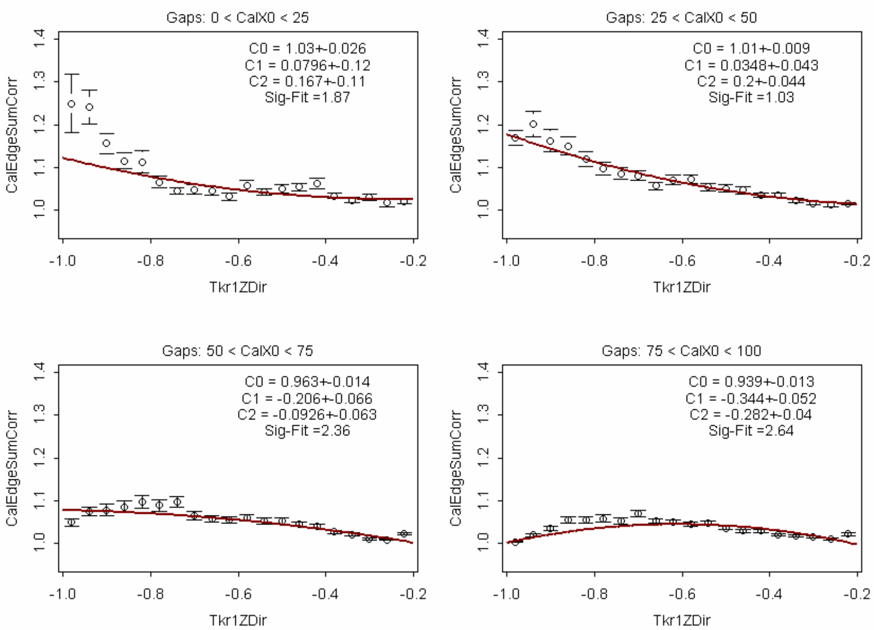
Transverse Energy Density: 2 samples – .8*R_m and 1.8*R_m
(R_m is the Moliere Radius ~ 50 mm)

Dip Angle Dependence: Close-up gaps as cos(θ)

Correction Algorithms

Edge Loss Correction at 100 MeV





Edge Loss Correction at 10 GeV

Becomes more abrupt

Correction Algorithms

Losses due to Shower Leakage

The set of E_{obs} (observed energy), <*t*> (Cal energy centriod in rad. len.), and t_{TOTAL} (Cal + Tracker rad. len.) form a consistent set to predict E_0 (the incoming energy) using the Gamma Function Shower Model:

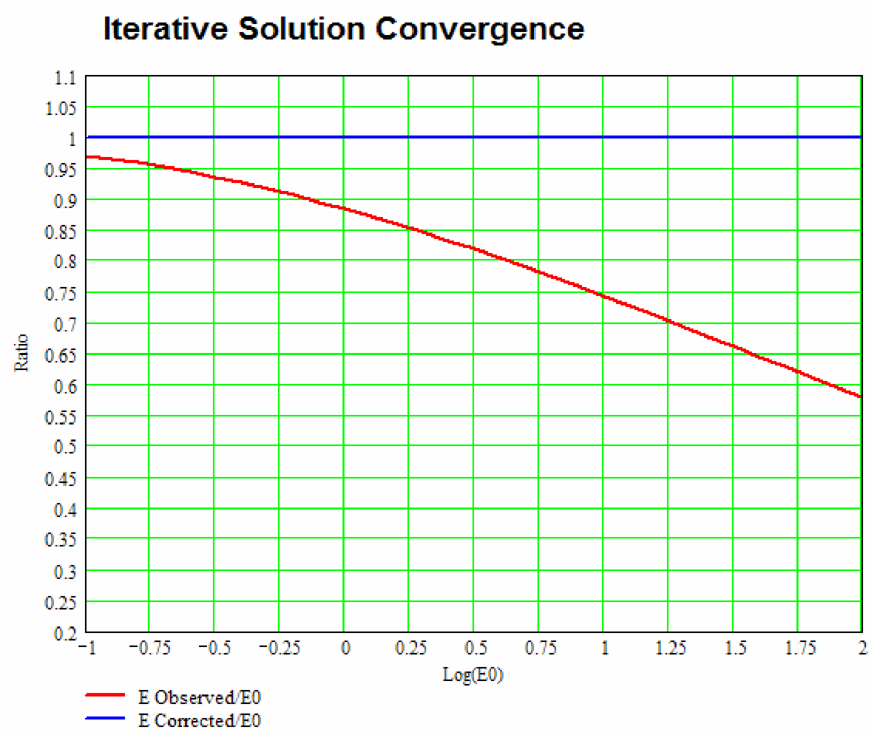
$$E_{Obs} = \int_0^{t_{TOTAL}} E_0 b(bt)^{a-1} e^{bt} dt \quad \text{and} \quad a = b\langle t \rangle$$

This can be inverted via iterating:

$$E_0 = E_{obs}$$

$$a = b(E_0)\cdot\langle t \rangle$$

$$E_0 = E_{obs} \frac{1}{\int_0^{t_{TOTAL}} b(bt)^{a-1} e^{-bt} dt}$$

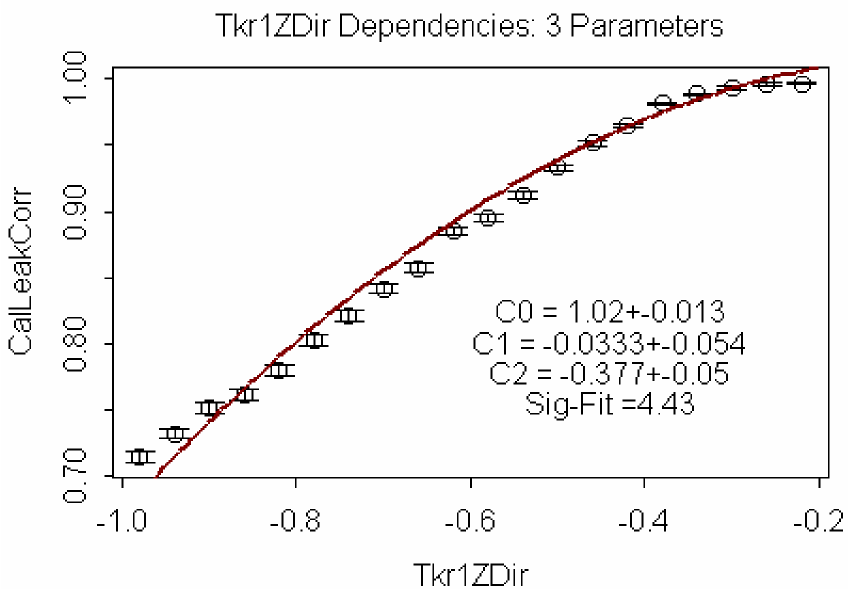


For convergence to < 1% requires a few iterations at 1 GeV and ~ 10 iterations at 100 GeV

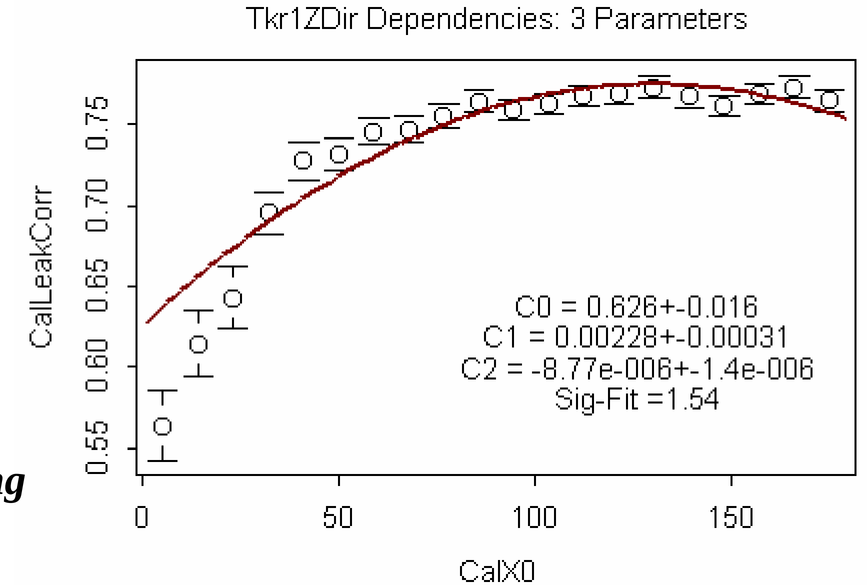
Correction Algorithms

Examples of Contained Fractions at 10 GeV

As θ increases so does t_{TOTAL} and leakage goes down (contained fraction increases)



For tracks near verticle (cos(θ) < -.9) as track gets near the gap, t_{TOTAL} goes down and the leakage goes up (contained fraction decreases)



Critical to have good a good estimate of t_{TOTAL} and <t>

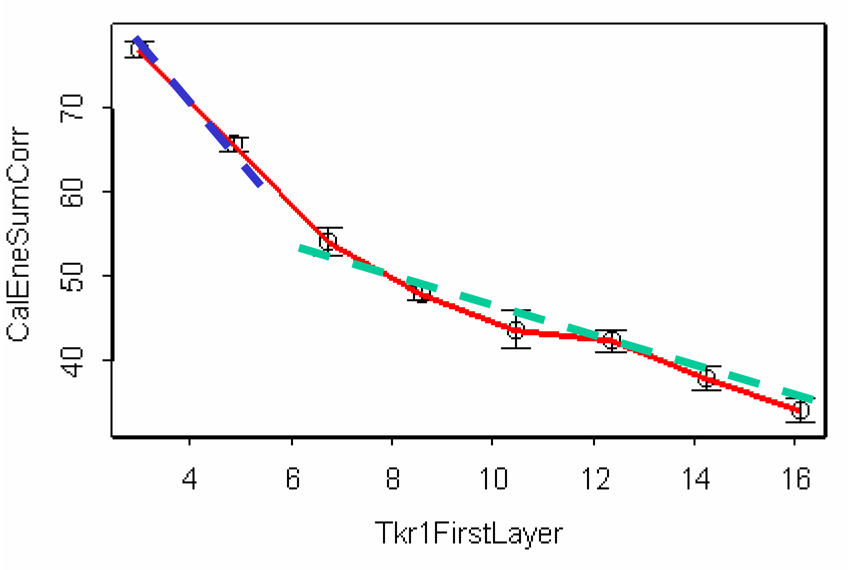
Achieved by Simpson Integration/Sampling of Calorimeter

Tracker Energy

Tracker treated as a Sampling Calorimeter:
every $\Delta\chi$ count the number of tracks

Complications:
1) Large gaps between samples
This leads to large losses "out the sides"
2) Super Layers are ~ 4.3 time thicker in rad. lens.
This leads to balancing the two sections

Process: Estimate energy in Tracker from that observed in Cal.



Ratio of slopes is consistance ~ 4.3

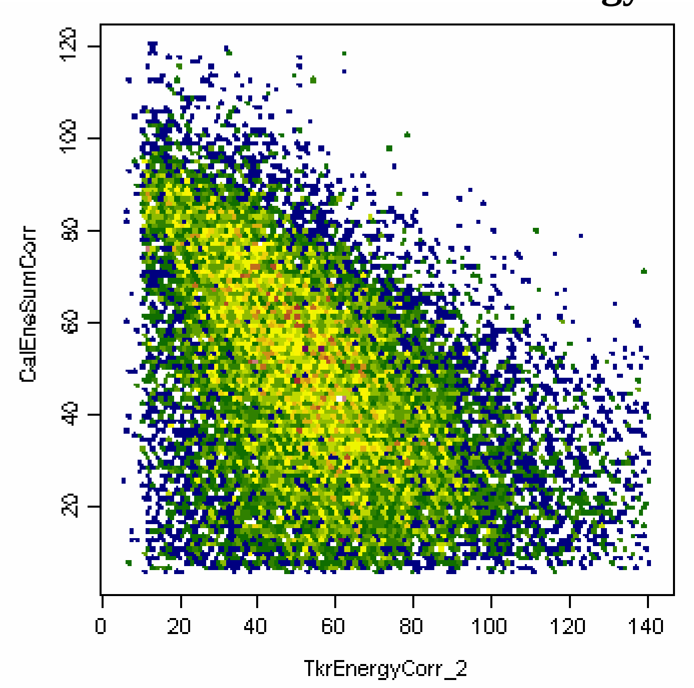
Fix the ratio:
Thick/Thin = 4.3

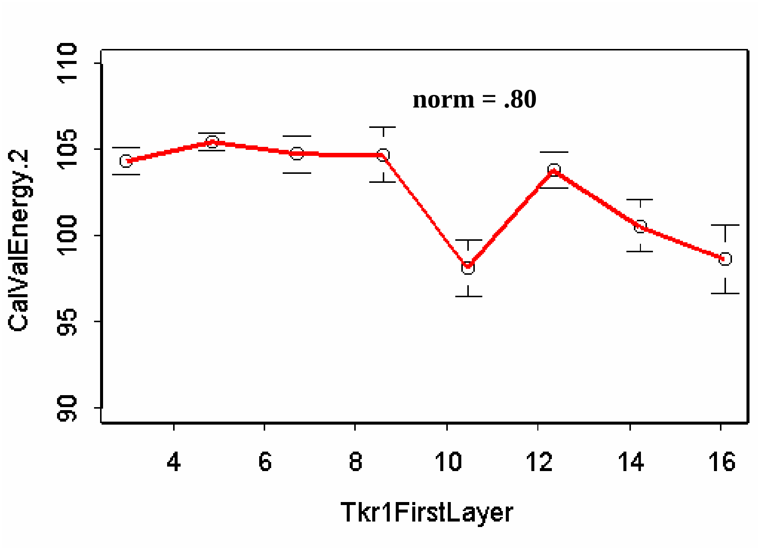
Tracker Energy

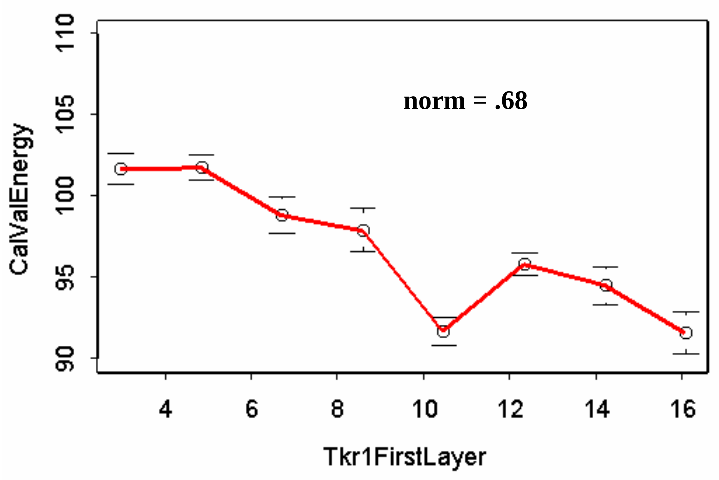
Next – set overall size to flatten energy vs layer number:

Problem: Increasing Tracker contribution flattens response, BUT it creates a "pedistal" of ~ 4-5%

CalEneSumCorr vs TkrEnergyCorr



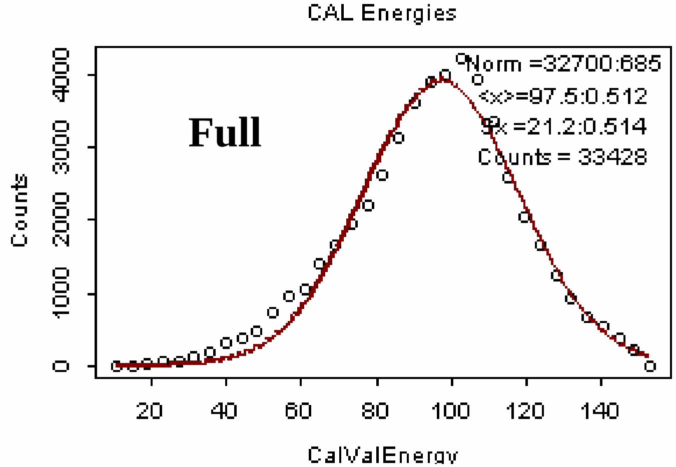


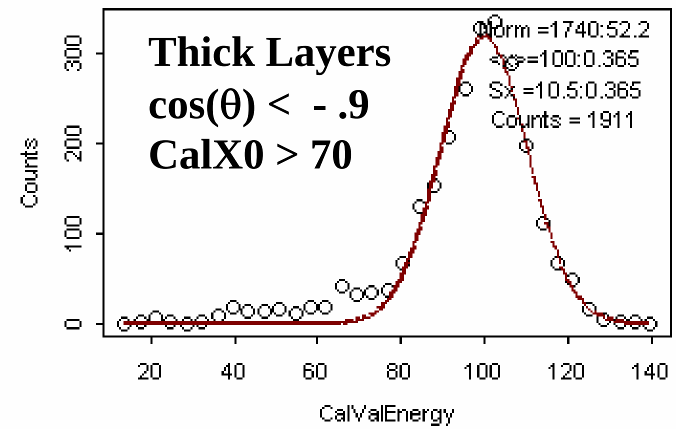


Glast Energy

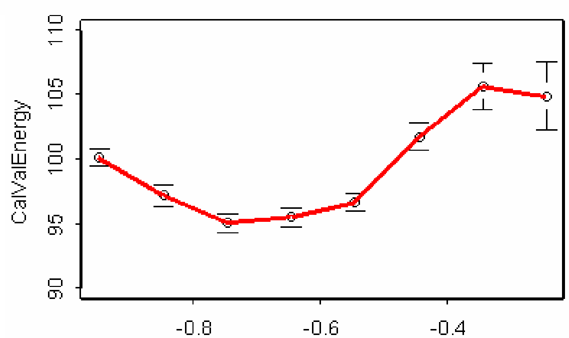
Survey of Correction from 100 MeV ⇨ 100 GeV

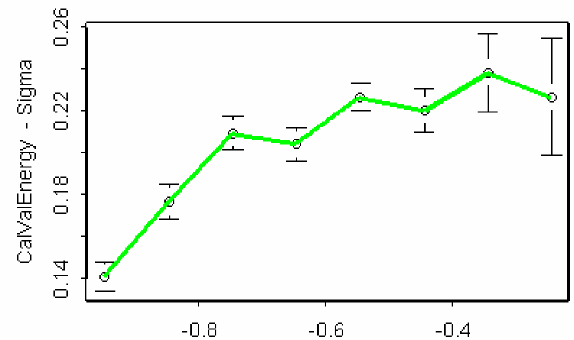
100 MeV



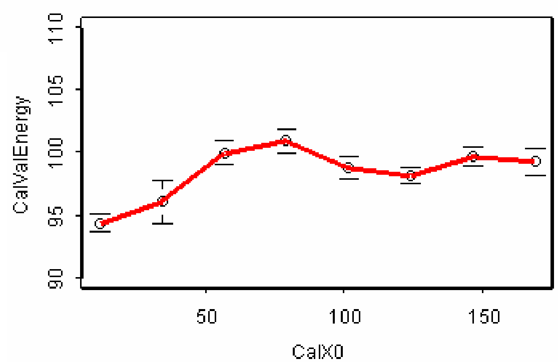


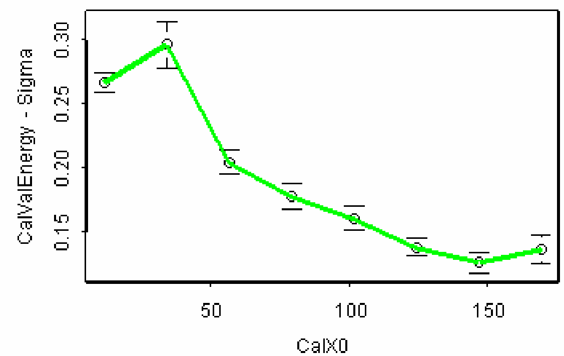
cos(θ) Dependence
CalX0 > 50





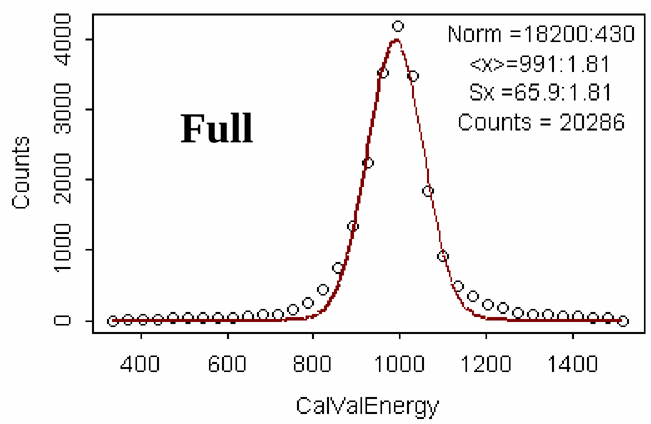
CalX0 Dependence
cos(θ) < -.80

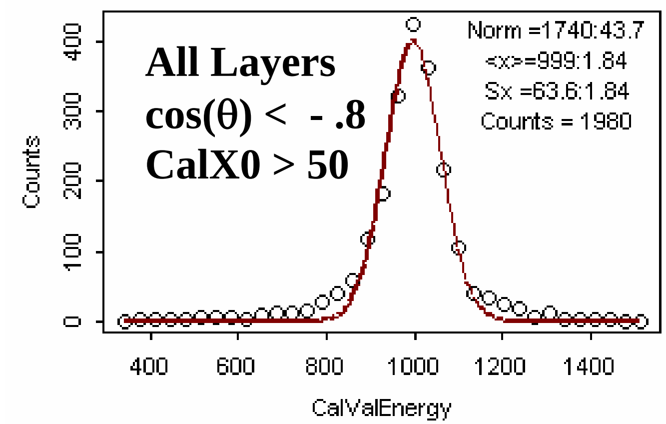




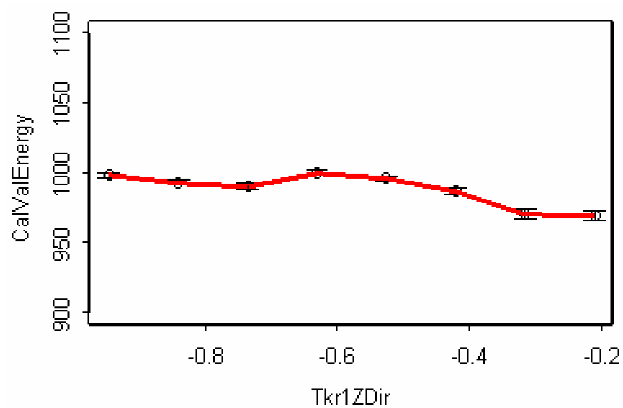
Glast Energy

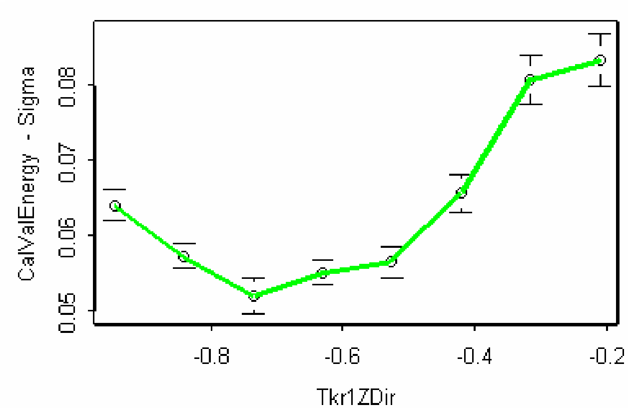
1 GeV



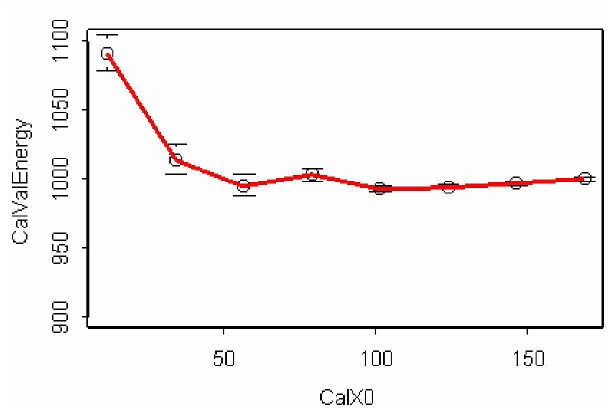


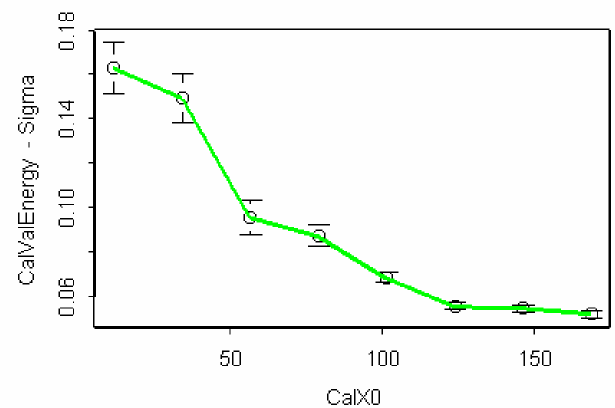
cos(θ) Dependence
CalX0 > 50





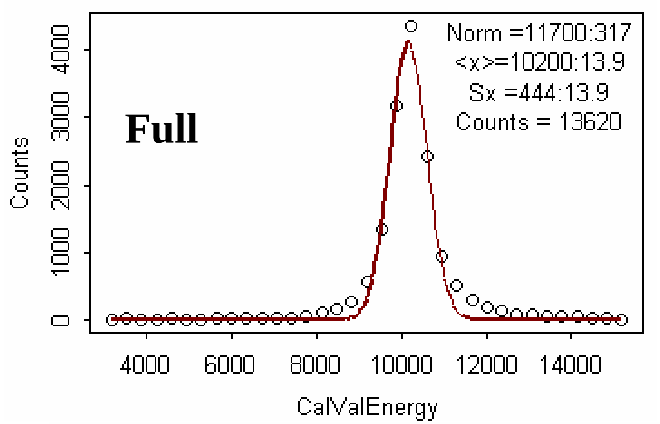
CalX0 Dependence
cos(q) < -.80

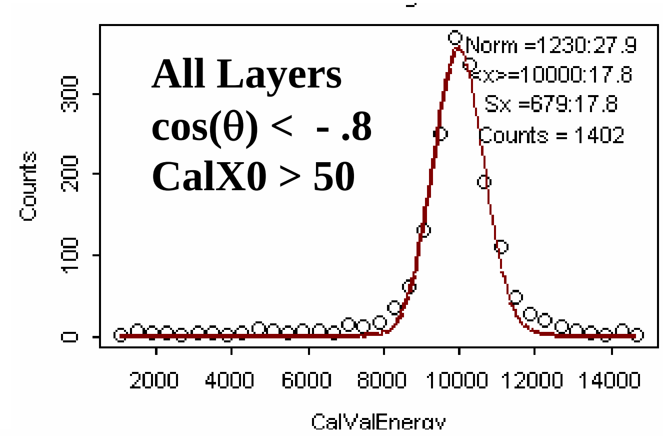




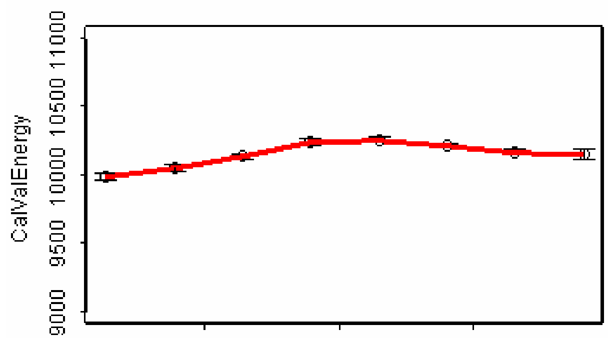
Glast Energy

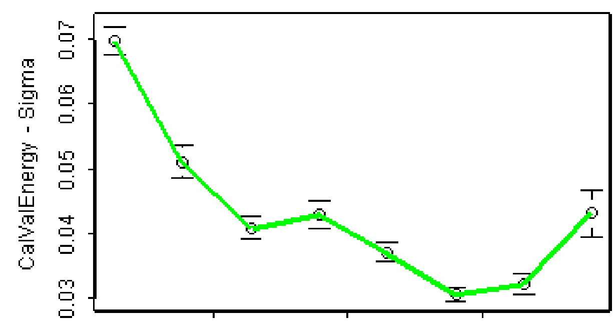
10 GeV



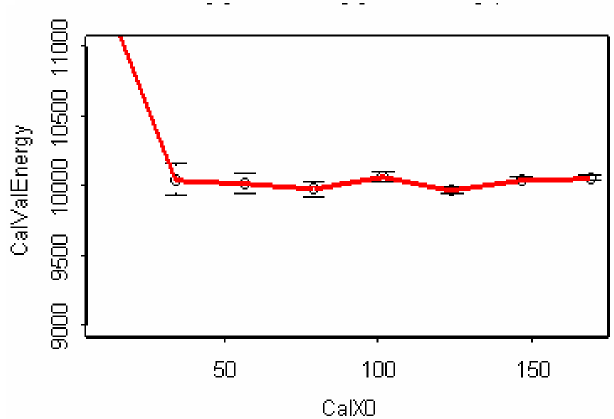


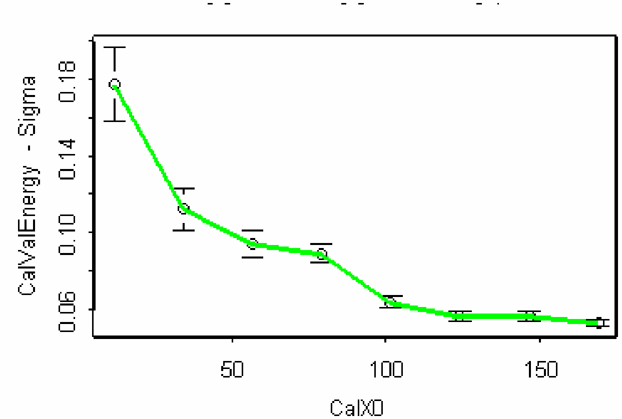
cos(θ) Dependence
CalX0 > 50





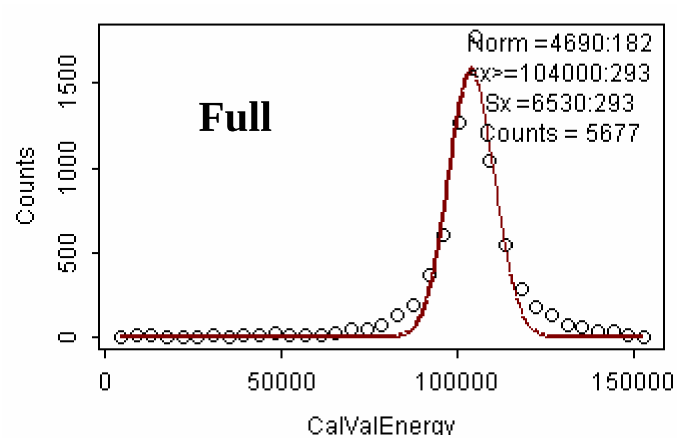
CalX0 Dependence
cos(q) < -.80

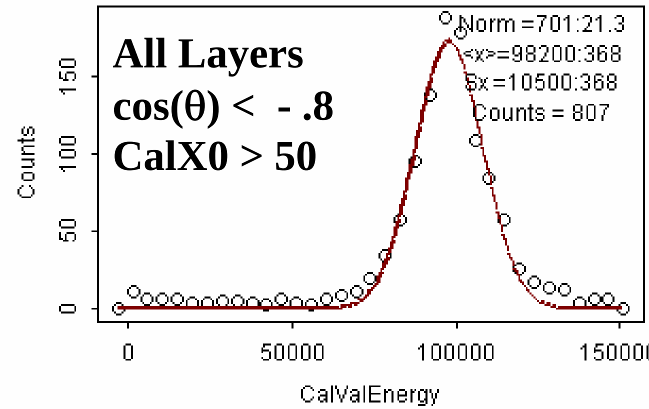




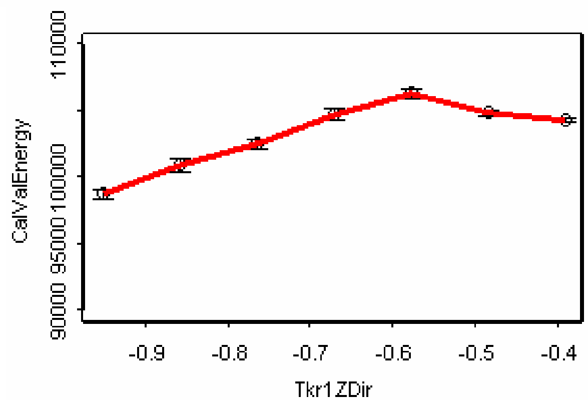
Glast Energy

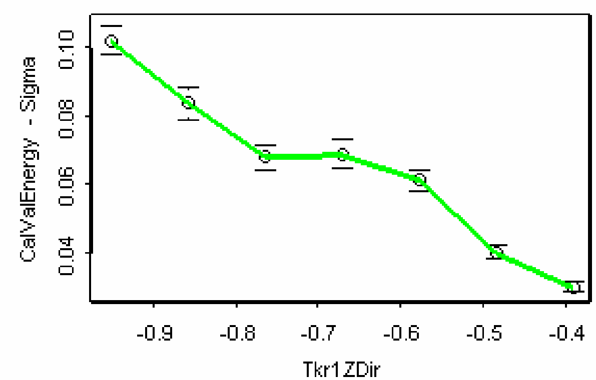
100 GeV





cos(θ) Dependence
CalX0 > 50





CalX0 Dependence
cos(q) < -.80