Brief Overview on CAL Calibration work at KIPAC-SLAC

E. Bloom, Y. Edmonds, D. Paneque, P. Wang

GLAST LAT Collaboration Meeting

Beam Test WG FtoF

November 13, 2007

Overview

- On orbit environment.
- B. Lott, et al GSI beam test result.
- Compare dE/dx mean energy loss from GLEAM simulation of muons and protons with the calculation using the dE/dx code
- Compare proton beam test data to GLEAM MC
- Compare C beam data to GLEAM MC
- Review conclusions of these preliminary studies with B. Lott, et al NIM paper.

On Orbit Expectation from CREME

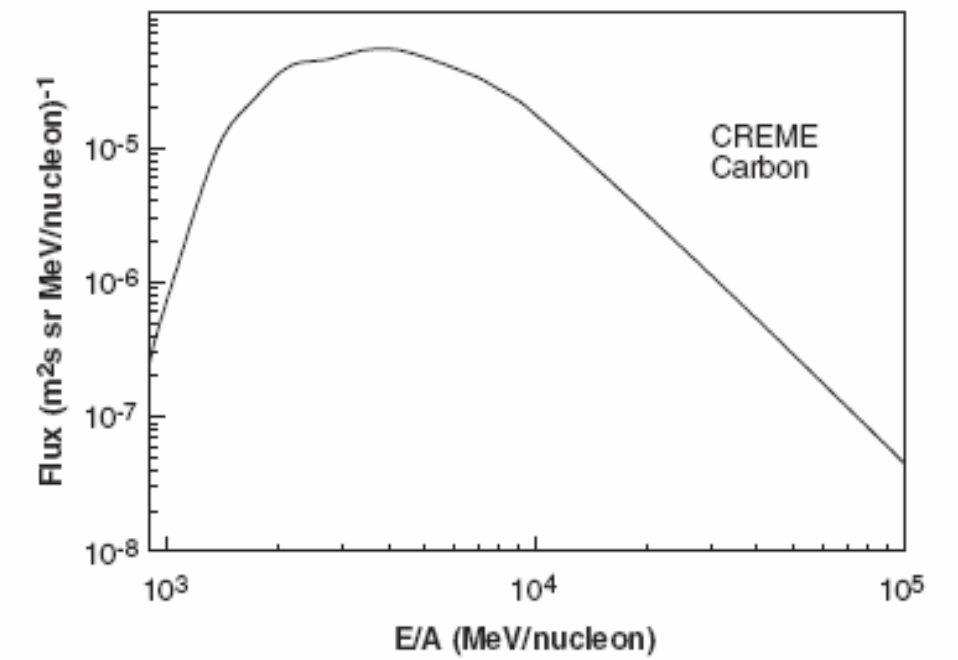


Fig. 1. Kinetic-energy distribution of cosmic-ray carbon ions at GLAST flight altitude as calculated with CREME.

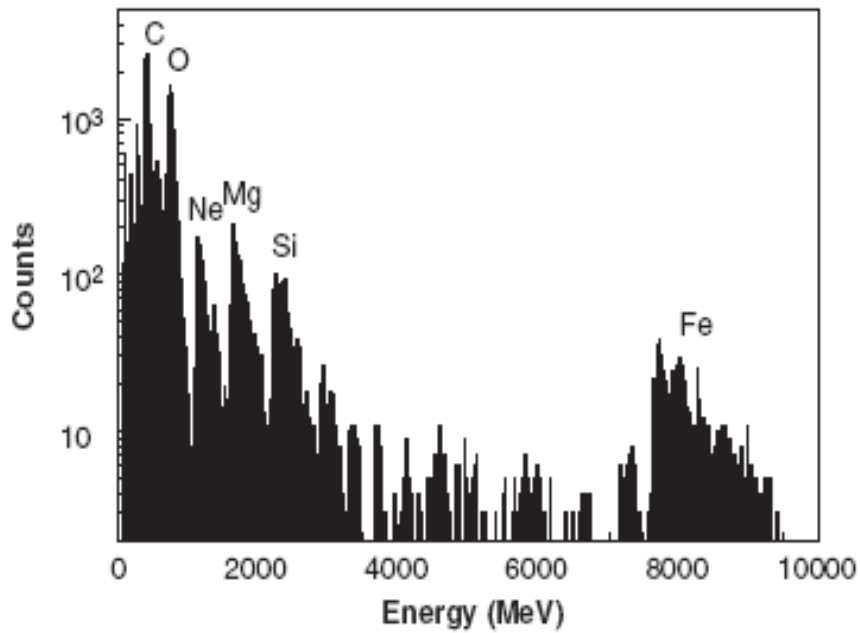


Fig. 2. Expected distribution of ionization energy deposited by the cosmic-ray ions in one CsI crystal, corrected for geometrical effects due to slanted trajectories. The main peaks are labeled according to the elements they correspond to.

GSI Beam Test Result

B. Lott, et al., Nuclear Instruments and Methods in Physics Research A 560 (2006) 395–404

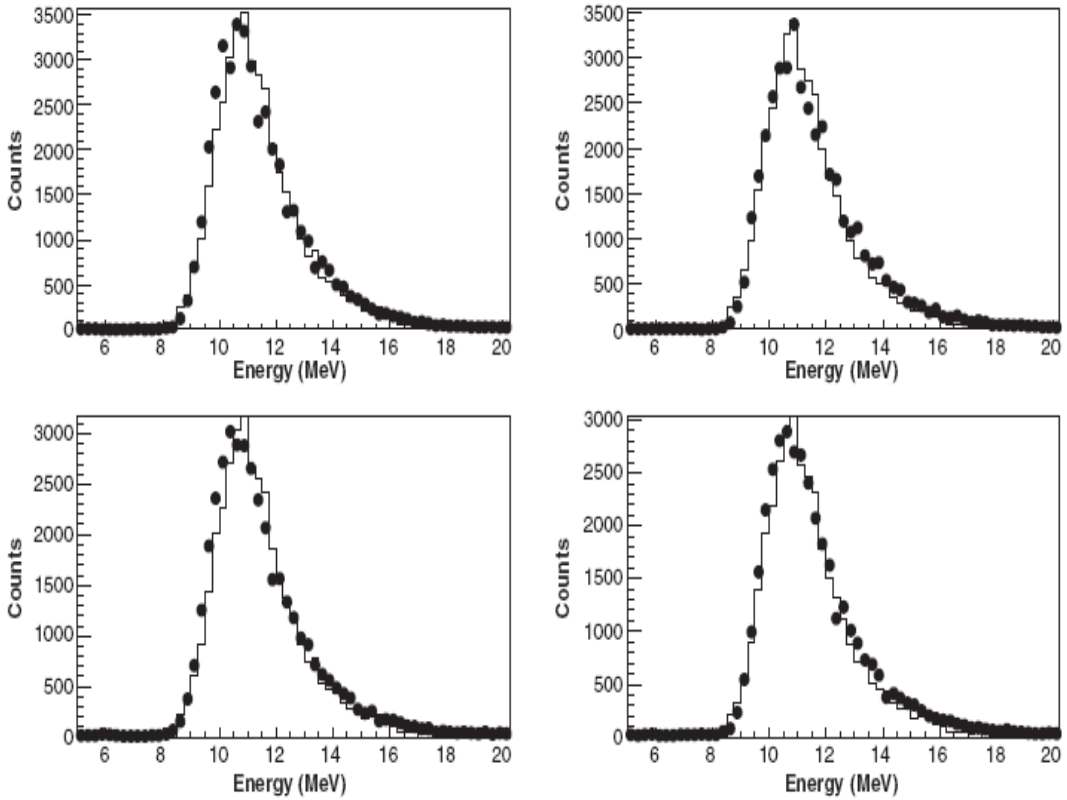


Fig. 4. Calibrated deposited-energy distributions for 1.7 GeV protons (symbols) compared to the corresponding GEANT4 predictions smeared 0.6 MeV (histograms), for the first four EM layers.

What cuts were used?

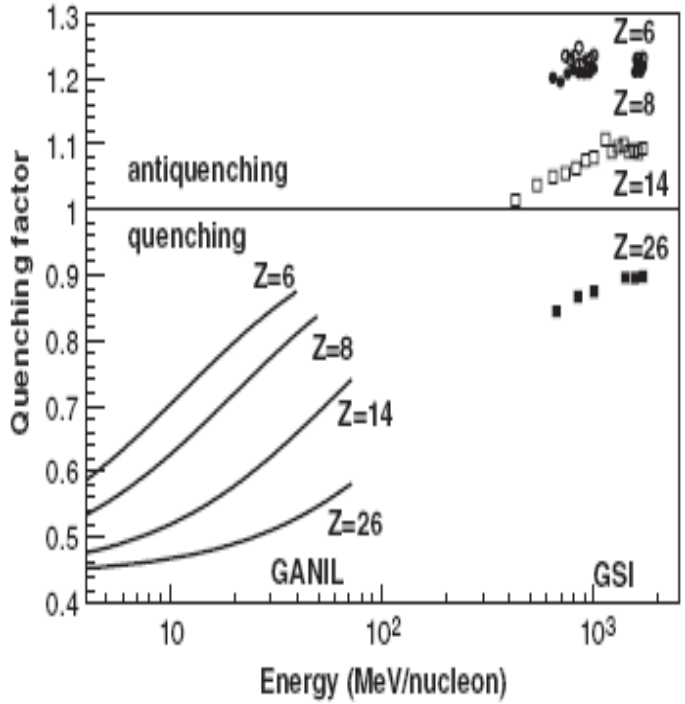
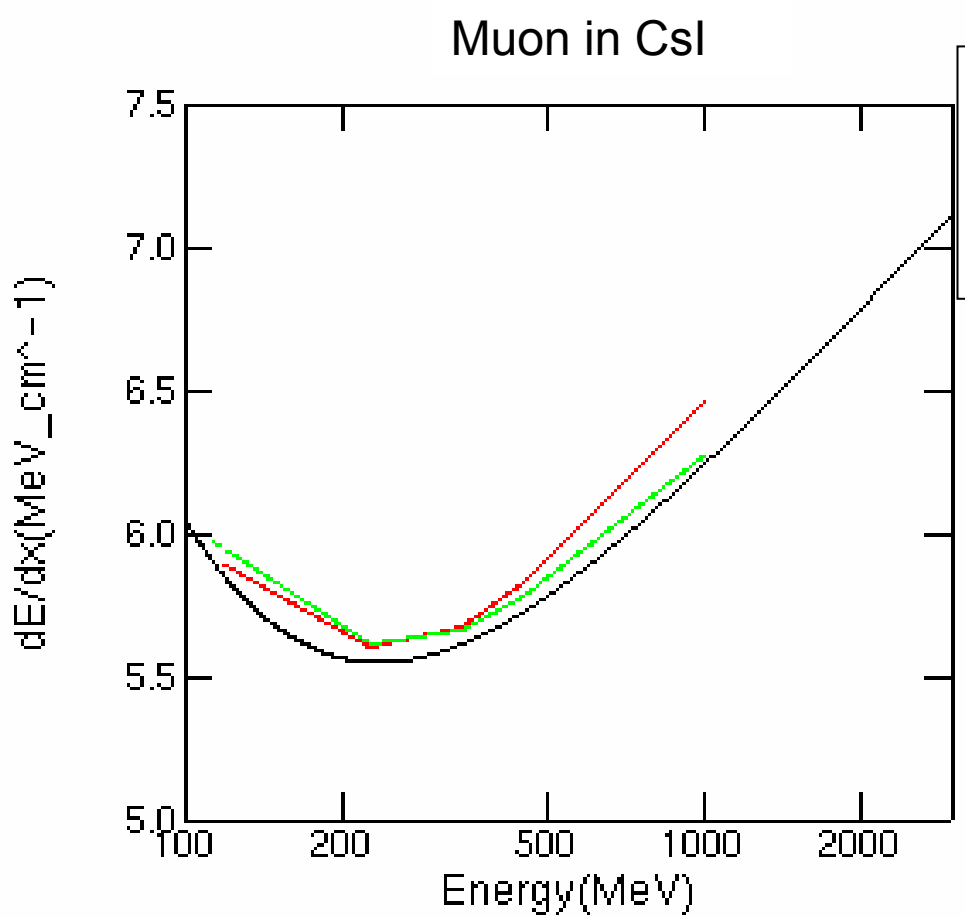


Fig. 11. Compilation of the quenching factors measured at GANIL and GSI as a function of the ion's energy per nucleon, for the different ions relevant to the on-orbit calibration of GLAST's calorimeter.

The mean rate of energy loss of muons in CsI



At E_kin = 1.021 GeV, dE/dx code gives *6.255* MeV/cm

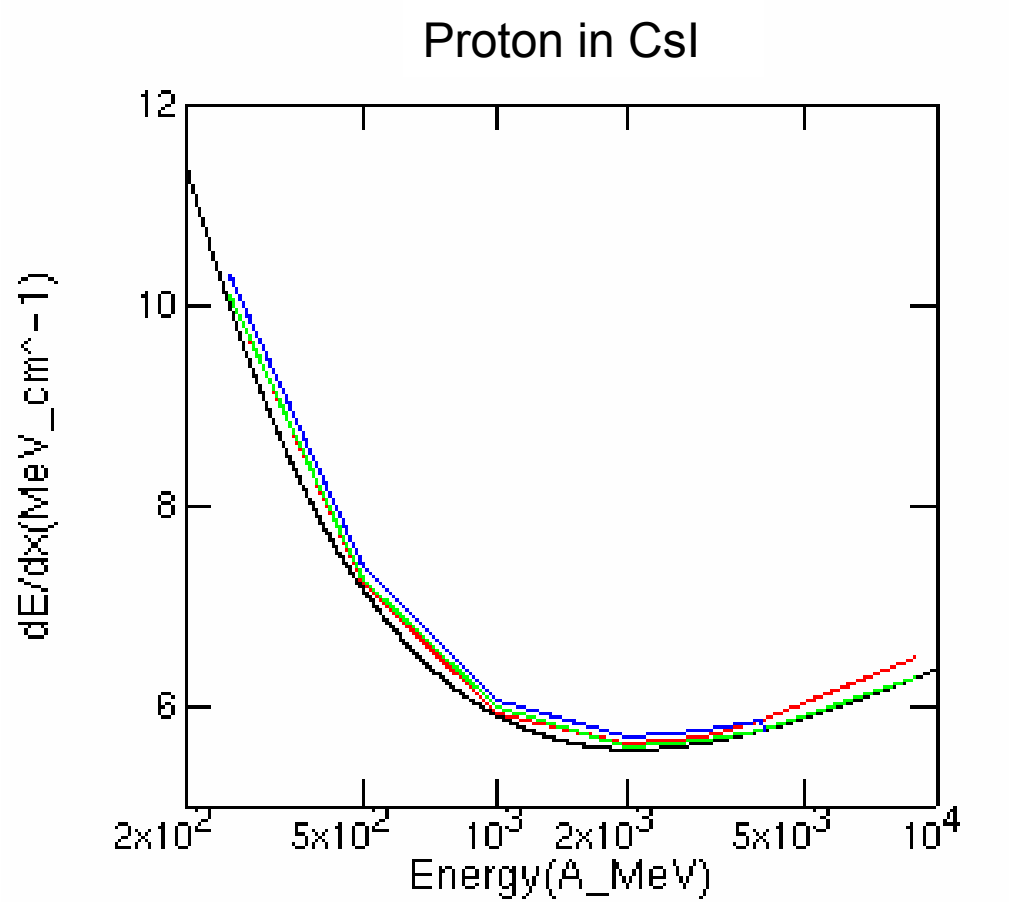
Muon Mean Energy Loss in CsI

- dE/dx code – predicts the mean energy loss.
  - <dE/dx> = ***6.255*** MeV/cm for 1.021 GeV muons.
- GEANT4 8.0.p01 (simple geometry)
  - <dE/dx_FC> = ***6.349*** MeV/cm with no cuts on muons.
- GLEAM
  - GlastRelease-v11r17
  - Muons – launch in center and just at top of 1st crystal.
    - Launch point x = y = 201.17 mm, z = -48.12 mm (the top crystal)
    - Vertical incidence
    - Energy = 1.021 GeV
  - <dE/dx_FC> = ***6.373*** MeV/cm with no cuts on muons.
  - <dE/dx_FC> = ***6.542*** MeV/cm with cut on CalZDir>0.98

Comparison Summary for Muon Energy Loss (MC truth)

E_{muon} (GeV)	dE/dx Theory	dE/dx GEANT	dE/dx GLEAM	dE/dx GLEAM, cut on CalZDir >0.98	dE/dx GLEAM from Johan Bregeon
1.021	6.255 MeV/cm	6.349 MeV/cm	*6.373* MeV/cm	*6.542* MeV/cm	6.206 MeV/cm
Ratio of MC to Theory	1.0	1.015	1.019	1.046	0.992

Proton in CsI: Compare with MC



: dE/dx code

: Bethe-Bloch formula

: NIST

: SRIM

At 6 GeV, dE/dx code gives *5.979* MeV/cm

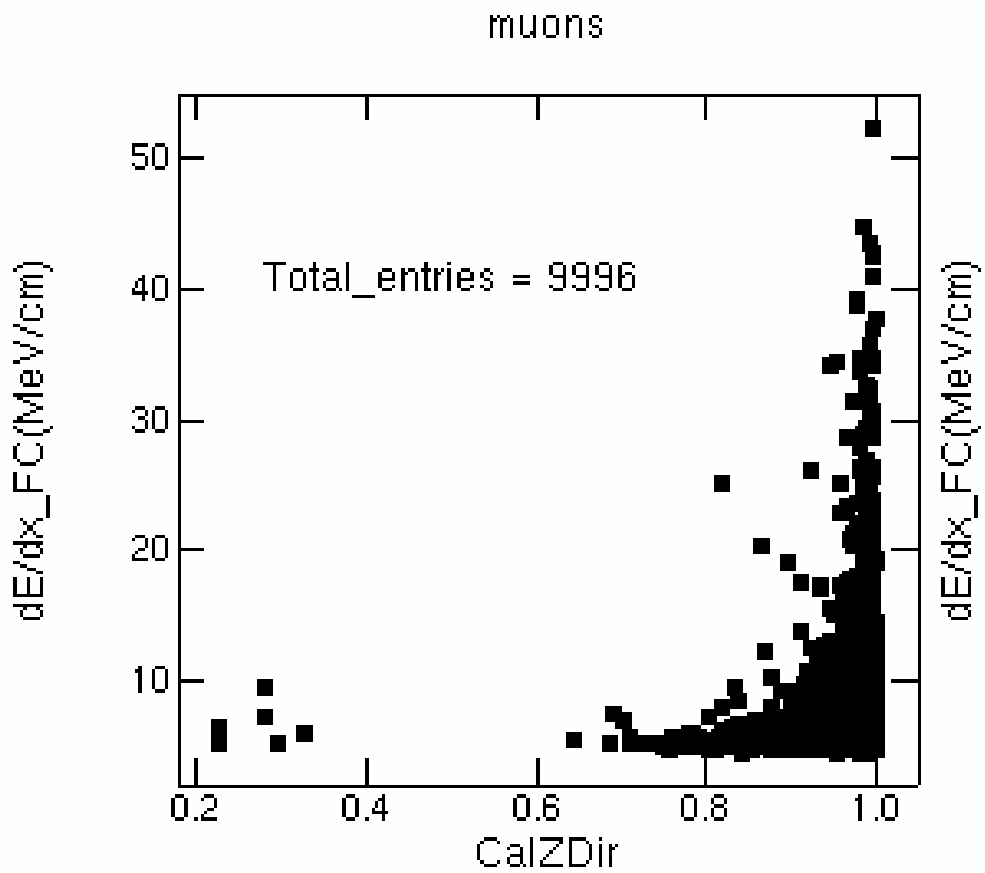
Protons

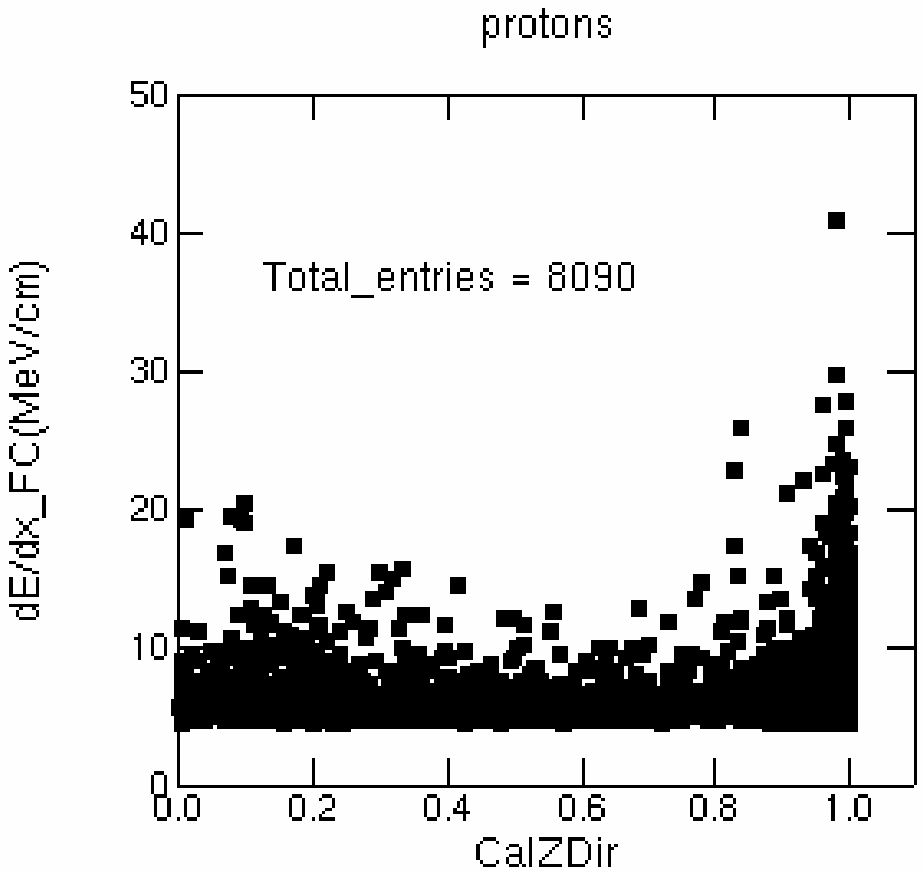
- dE/dx code
  - <dE/dx> = ***5.979*** MeV/cm for 6 GeV protons
- GLEAM
  - GlastRelease-v11r17
  - Protons
    - Launch point x = y = 201.17 mm, z = -48.12 mm (the top crystal)
    - Vertical incidence
    - Energy = 6 GeV
  - <dE/dx_FC> = ***6.102*** MeV/cm with no cuts on protons.
  - <dE/dx_FC> = ***6.242*** MeV/cm with cut on CalZDir>0.98

Comparison Summary for Proton Energy Loss (MC truth)

E_{proton} (GeV)	dE/dx Theory	dE/dx GLEAM	dE/dx GLEAM, cut on CalZDir >0.98
6.0	5.979 MeV/cm	*6.102* MeV/cm	*6.242* MeV/cm
Ratio of MC to Theory	1.0	1.021	1.044

Correlation between dE/dx and CalZDir for muon and proton (MCs)



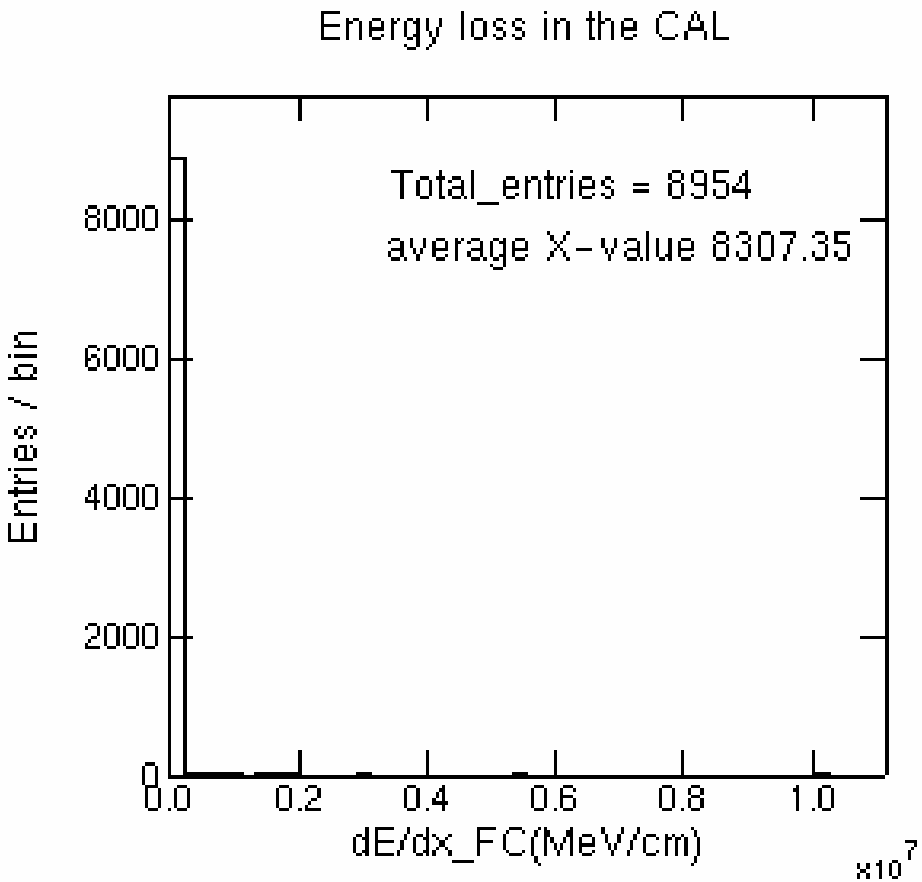


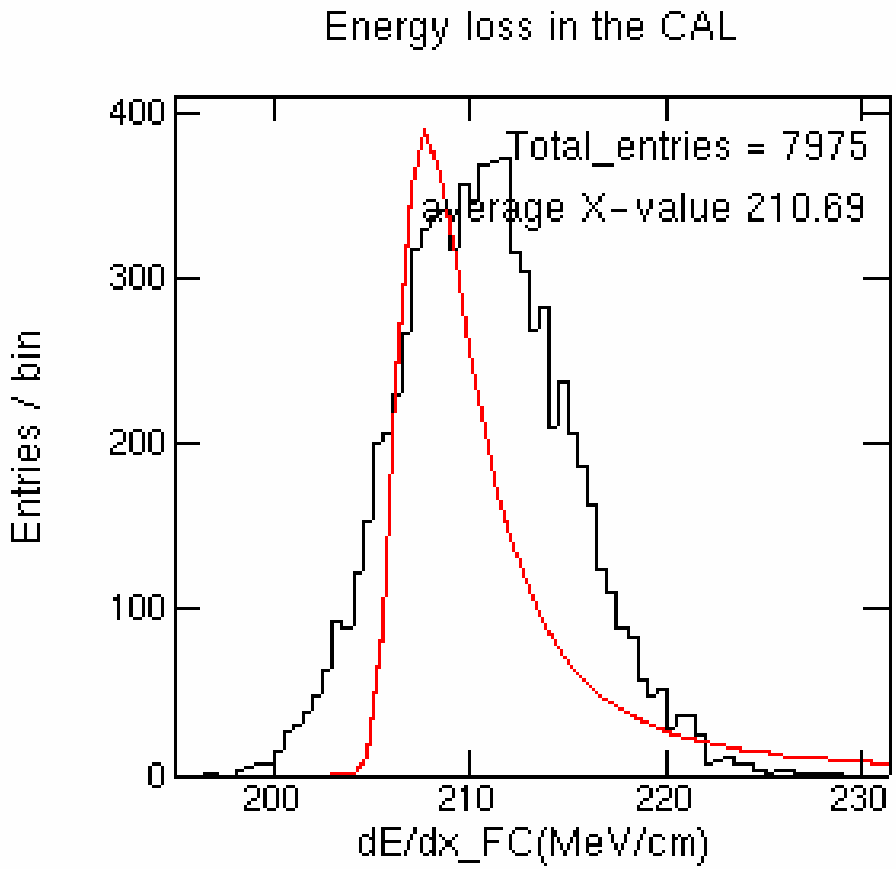
Carbon

- dE/dx code
  - <dE/dx> = ***203.64*** MeV/cm for 1.5 GeV/A carbon
- GLEAM
  - GlastRelease-v11r17
  - Carbons
    - Launch point x = y = 201.17 mm, z = -48.12 mm (the top crystal)
    - Vertical incidence
    - Energy = 18 GeV
  - <dE/dx_FC> = ***210.69*** MeV/cm with no cuts on carbon.
  - <dE/dx_FC> = ***210.7*** MeV/cm with cut on CalZDir > 0.98
  - For carbon, CalZDir Cut doesn't matter to dE/dx

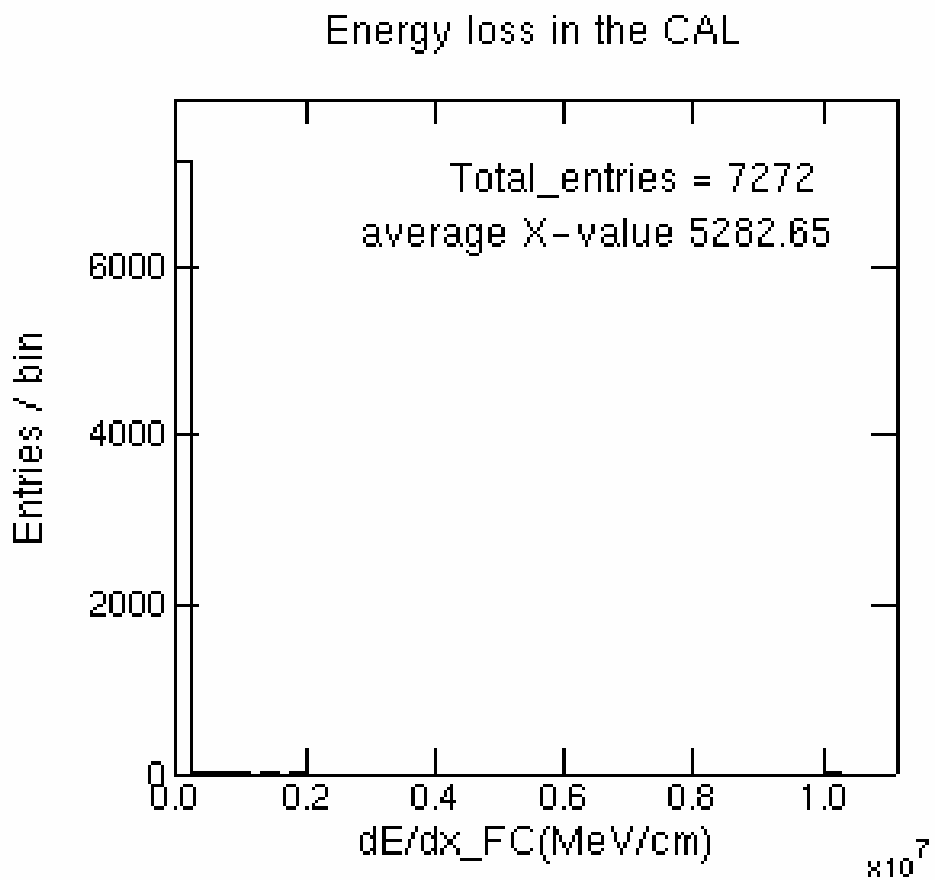
Carbon

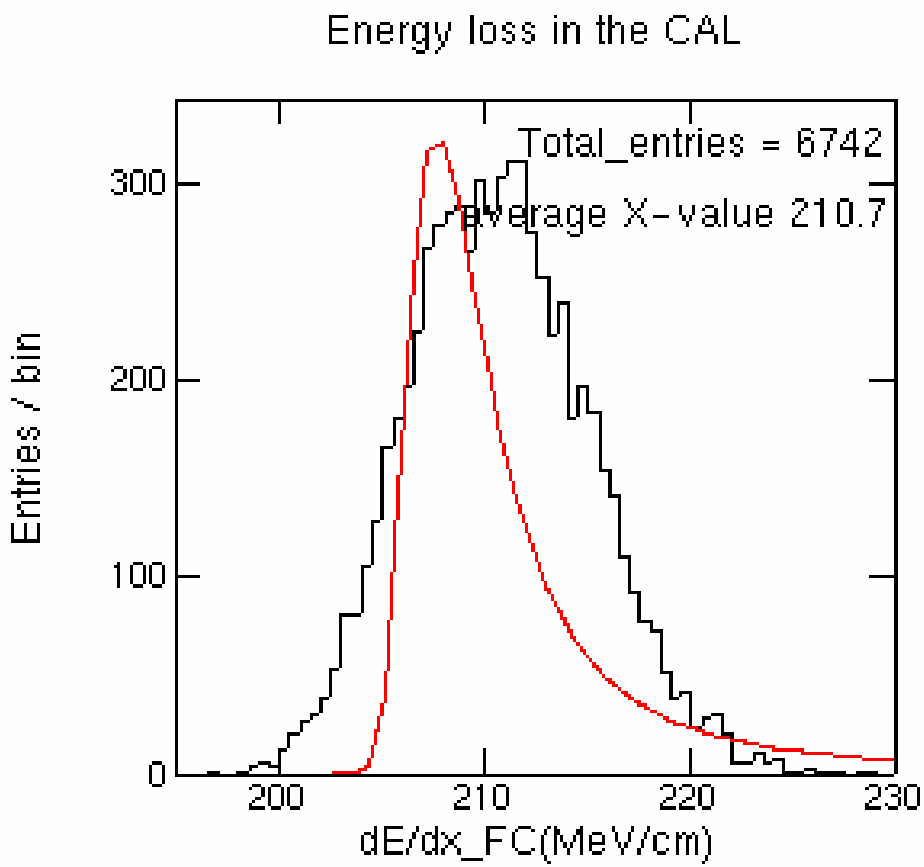
- No cuts
  - Not a Landau distribution





- Cut on CalZDir > 0.98
  - Not a Landau distribution

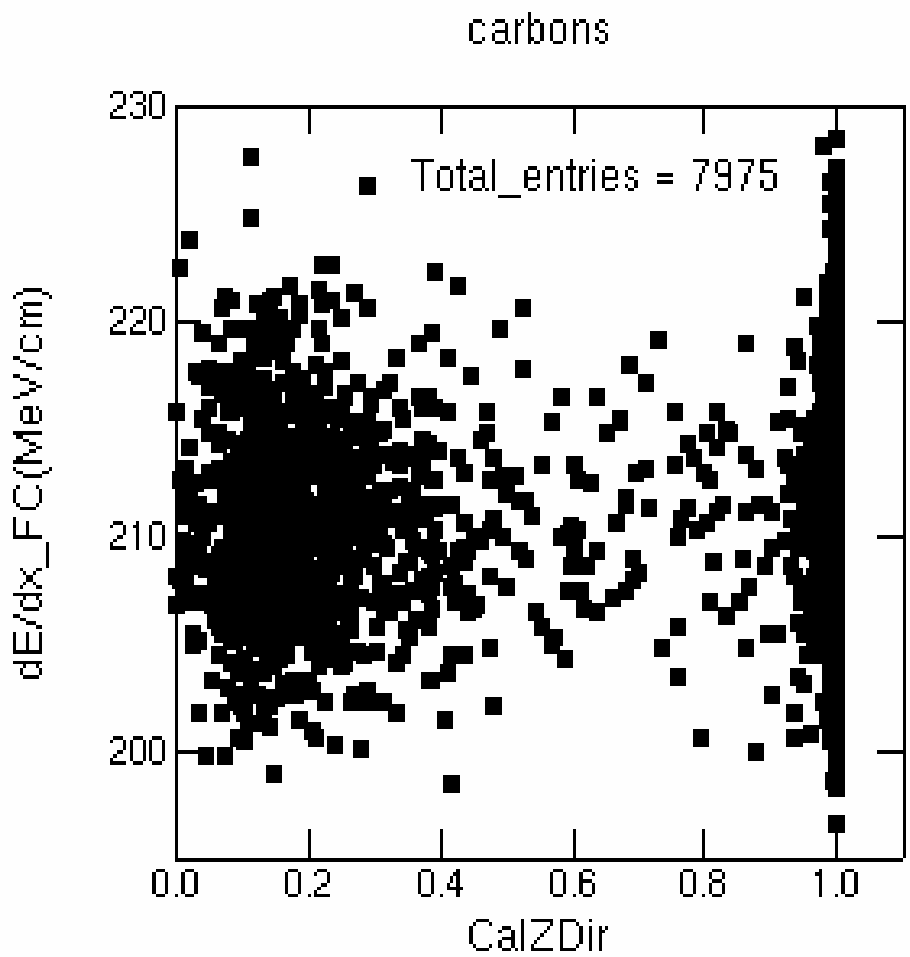


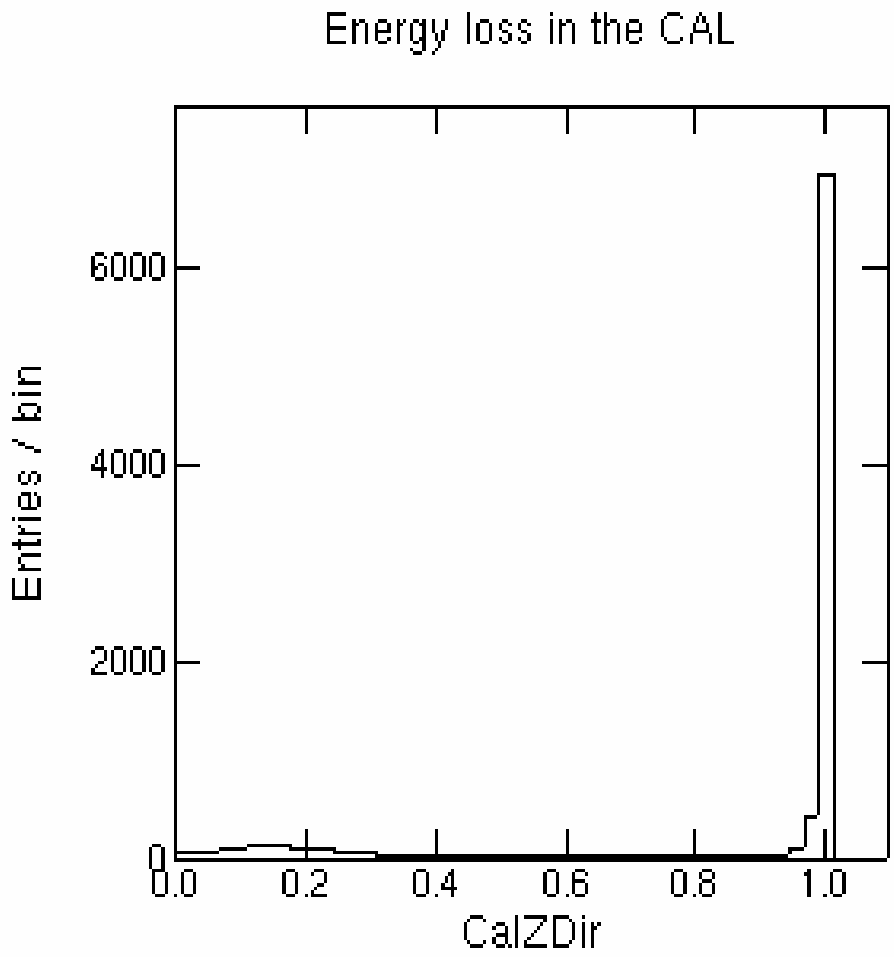


Comparison Summary for Carbon Energy Loss (MC truth)

E_{carbon} (GeV/A))	dE/dx Theory	dE/dx GLEAM	dE/dx GLEAM, cut on CalZDir >0.98
1.5	203.64 MeV/cm	*210.69* MeV/cm	*210.70* MeV/cm
Ratio of MC to Theory	1.0	1.035	1.035

- Relation between dE/dx and CalZDir for Carbon (MC)

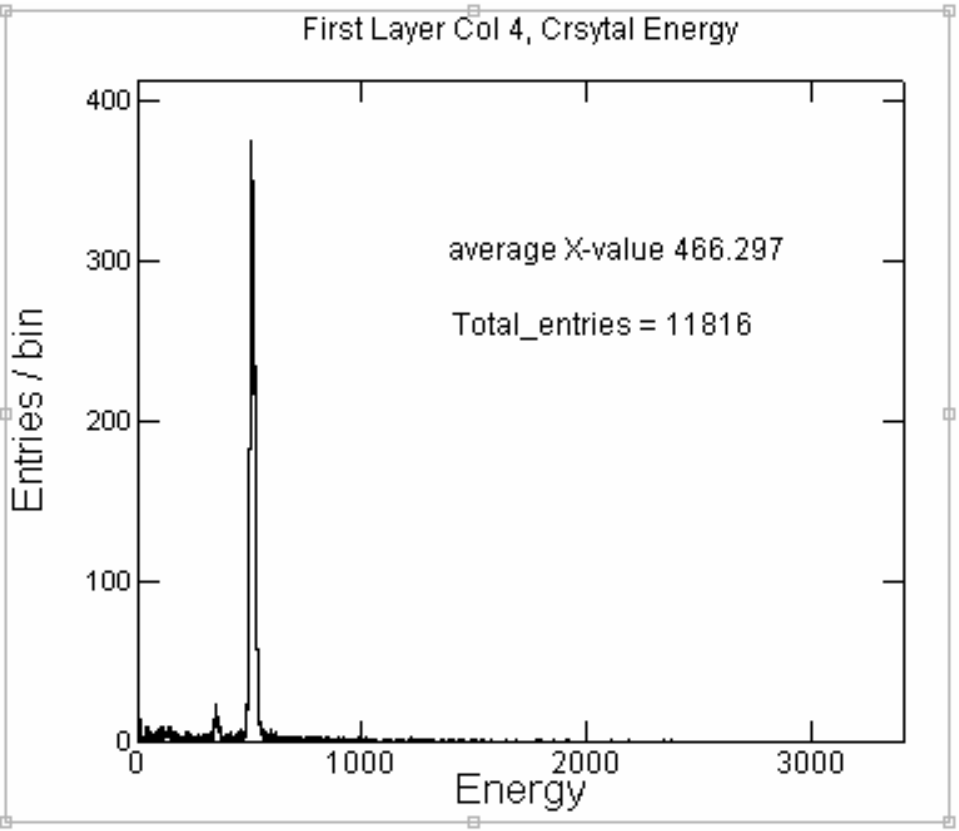




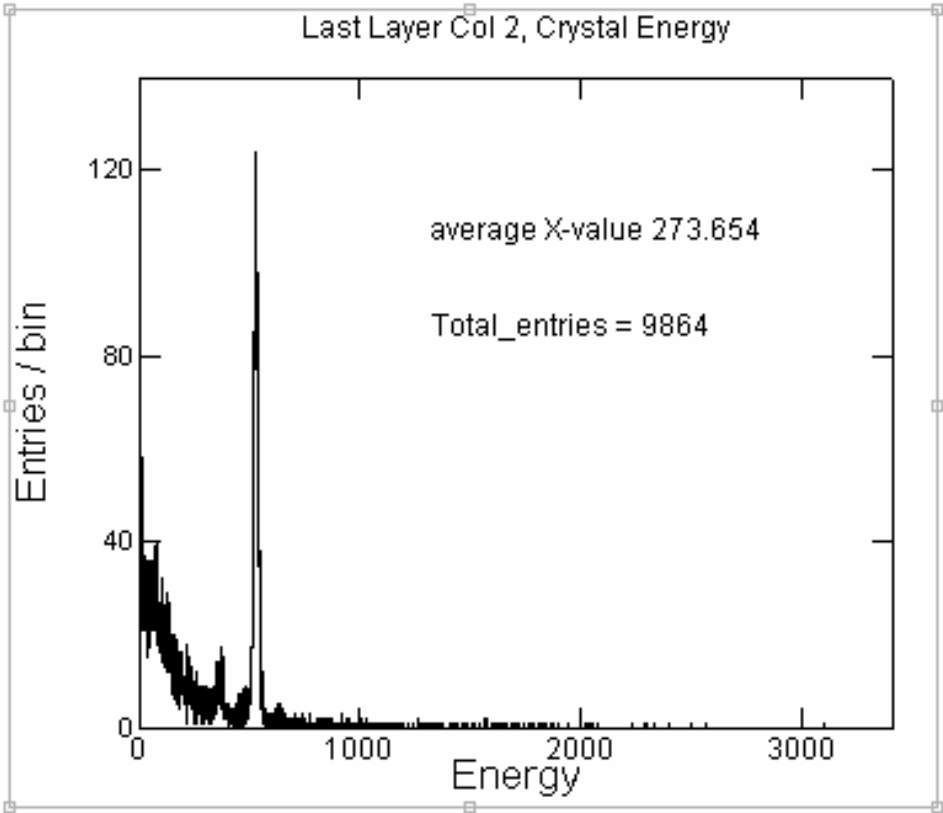
Compare C BT data and MC

- Beam angle = 0 deg
- Goal: determine energy deposited in 1st CsI crystal for carbon at normal incidence w/o nuclear interactions
- Require CalZDir>0.98 for Carbon
  - sizable Boron peak
- Require Cal energy for the event is deposited:
  - in a single tower
  - in each layer of that tower
  - in a single crystal in each layer

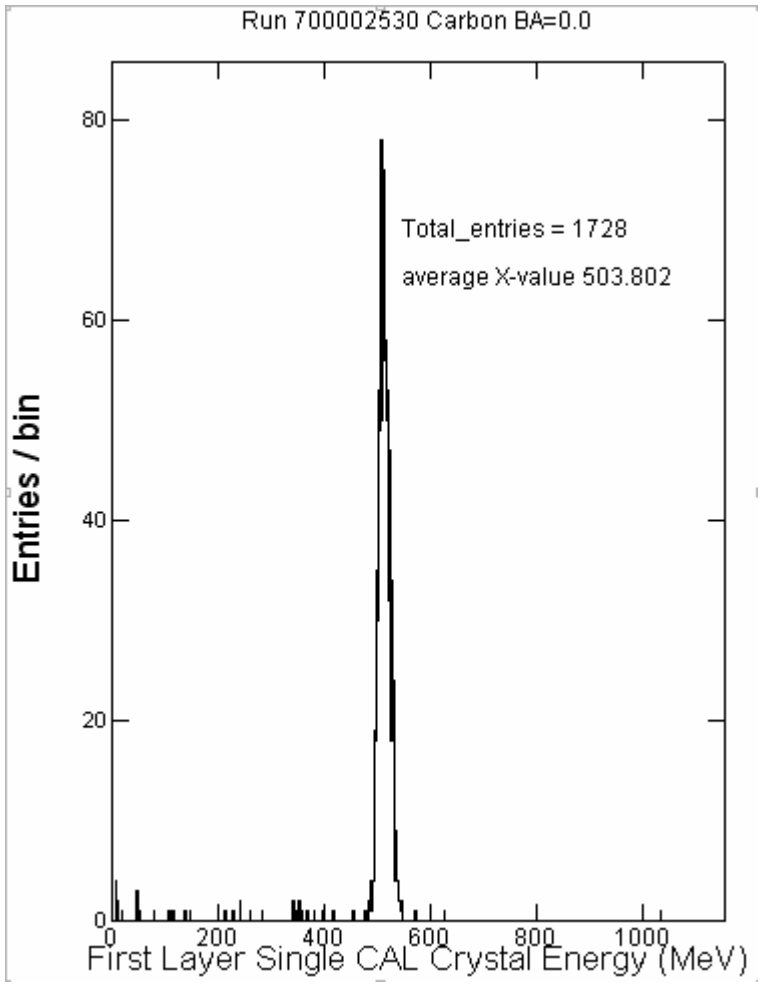
Run 700002530 Carbon Beam Angle =0.0 w/ CalZDir>0.98 Cut

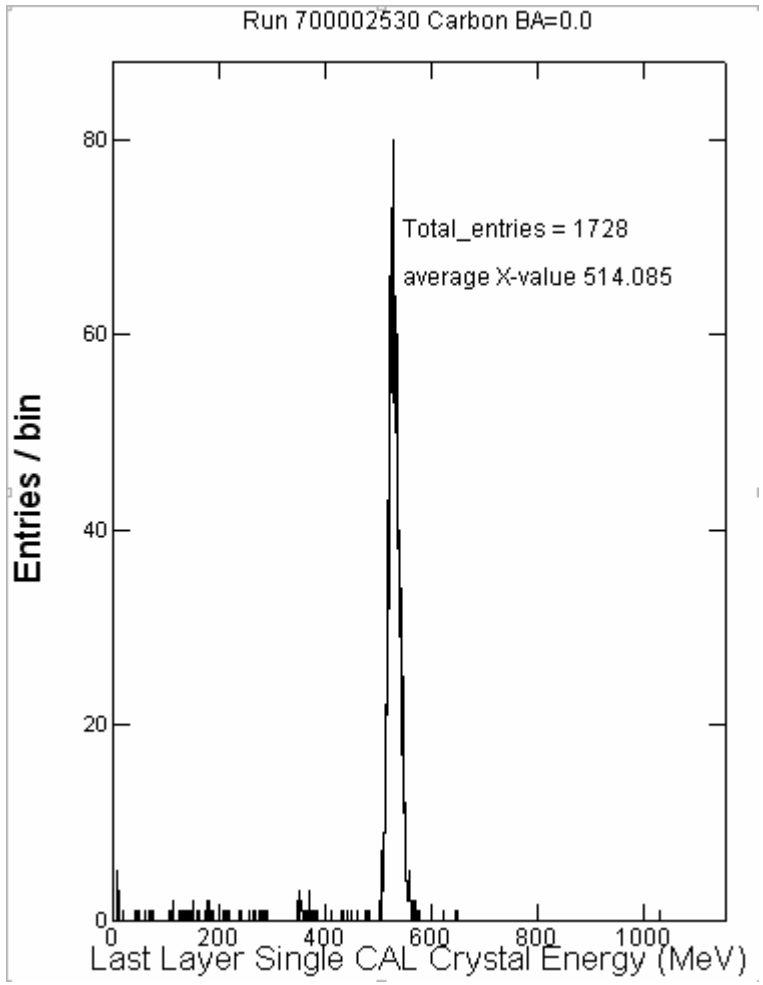


Theory <dE/dx >
energy loss in xtal= 405.2 MeV

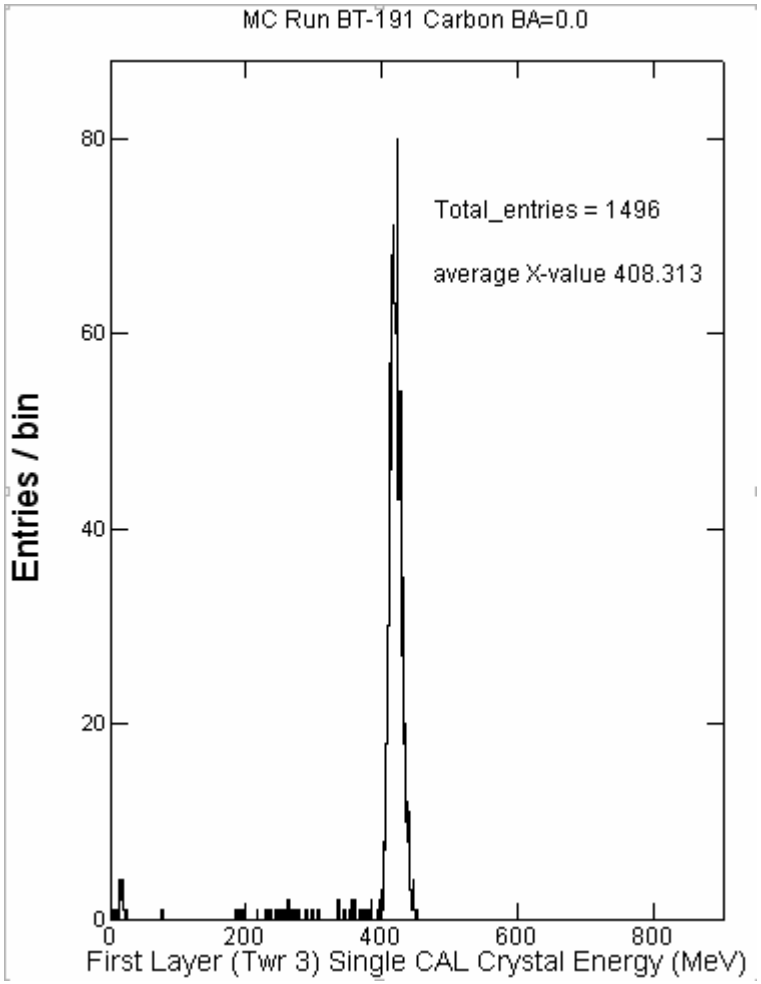


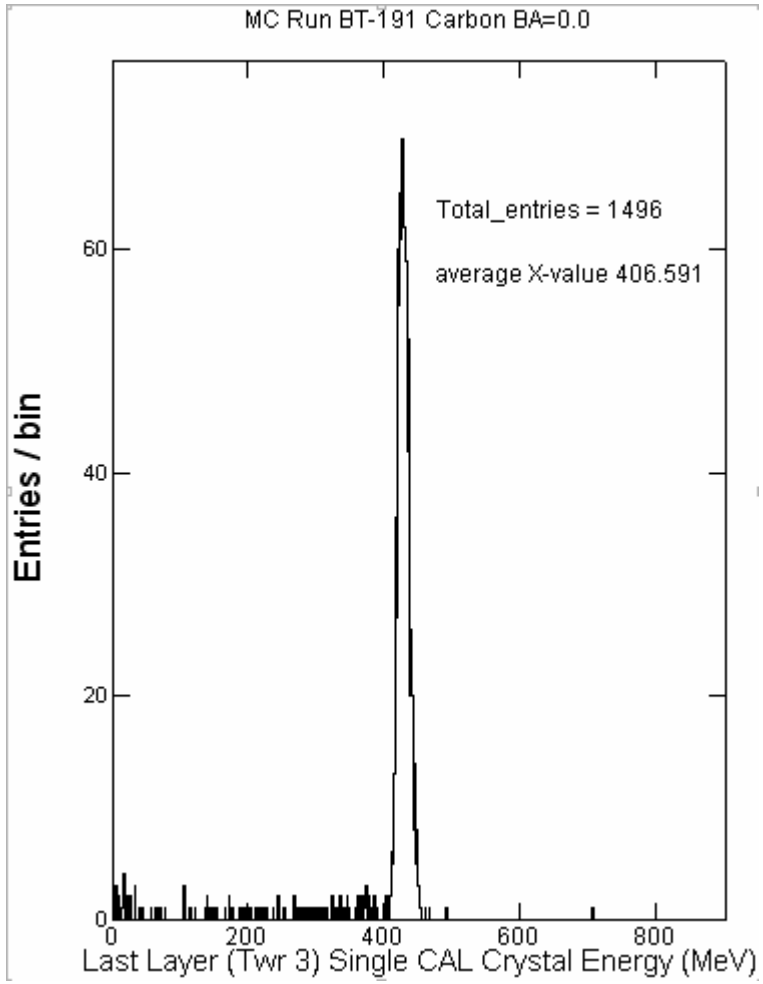
Carbon Real Run 700002530 18 GeV





Carbon MC Run BT-191 18 GeV





- dE/dx(Westphal-Weaver) for 1.5 GeV/n Carbon in CSI = 203.6 MeVcm^{-1}
- $\Delta E_{deposited}/\Delta x$ for MC = 408.3MeV/1.99cm = 205 MeVcm^{-1}

Summary

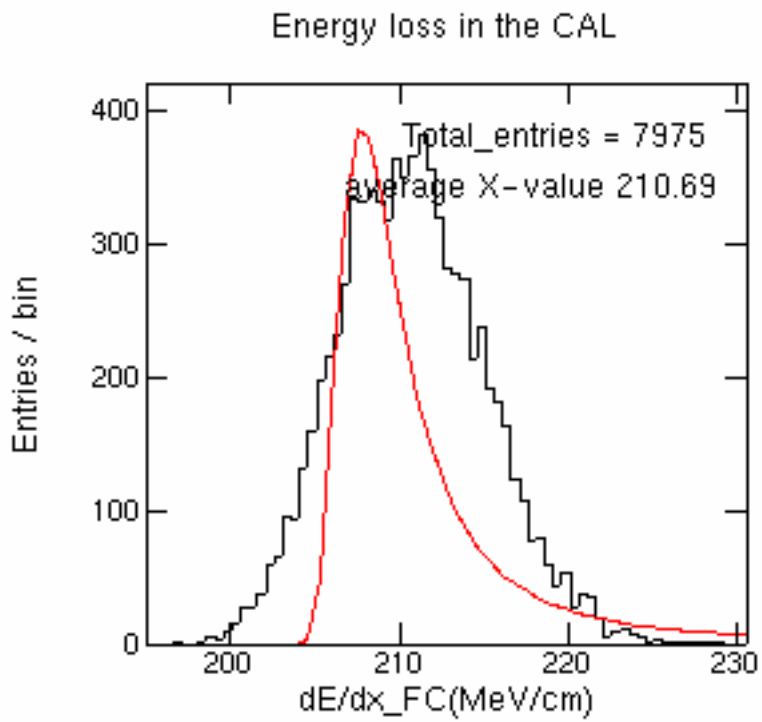
- The GLEAM simulation of muons and protons energy loss using MC truth is consistent with the dE/dx code calculation for no cuts.
- The energy mean energy loss (<dE/dx>) changes with CalZDir cut.
- Carbon data and MC don’t agree at all.
- What cuts were used in B. Lott, et al. analysis?

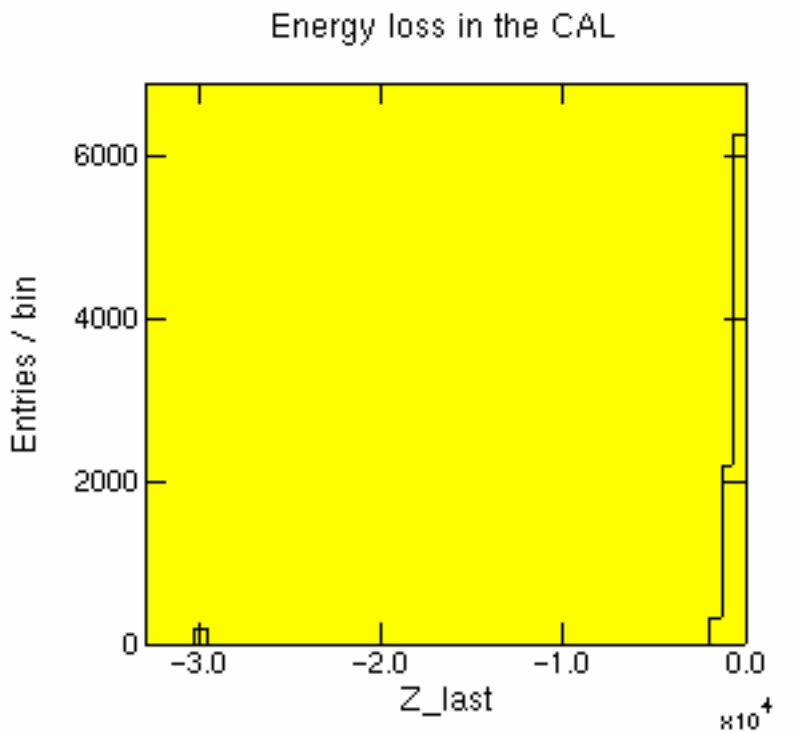
EXTRA SLIDES

Johan Bregeon's Results for Muons

	G4:1mm	G4: 10mu	Gleam
<Esum(MeV)>	98.99	99.09	99.37
<dEsum(MeV/cm)>	6.218	6.224	6.241
%Diff<dEsum>	-0.5%	-0.5%	-0.2%
<EL0(MeV)>	12.29	12.36	12.35
<dEL0(MeV/cm)>	6.176	6.211	6.206
%Diff<dEL0>	-1.3%	-0.7%	-0.8%

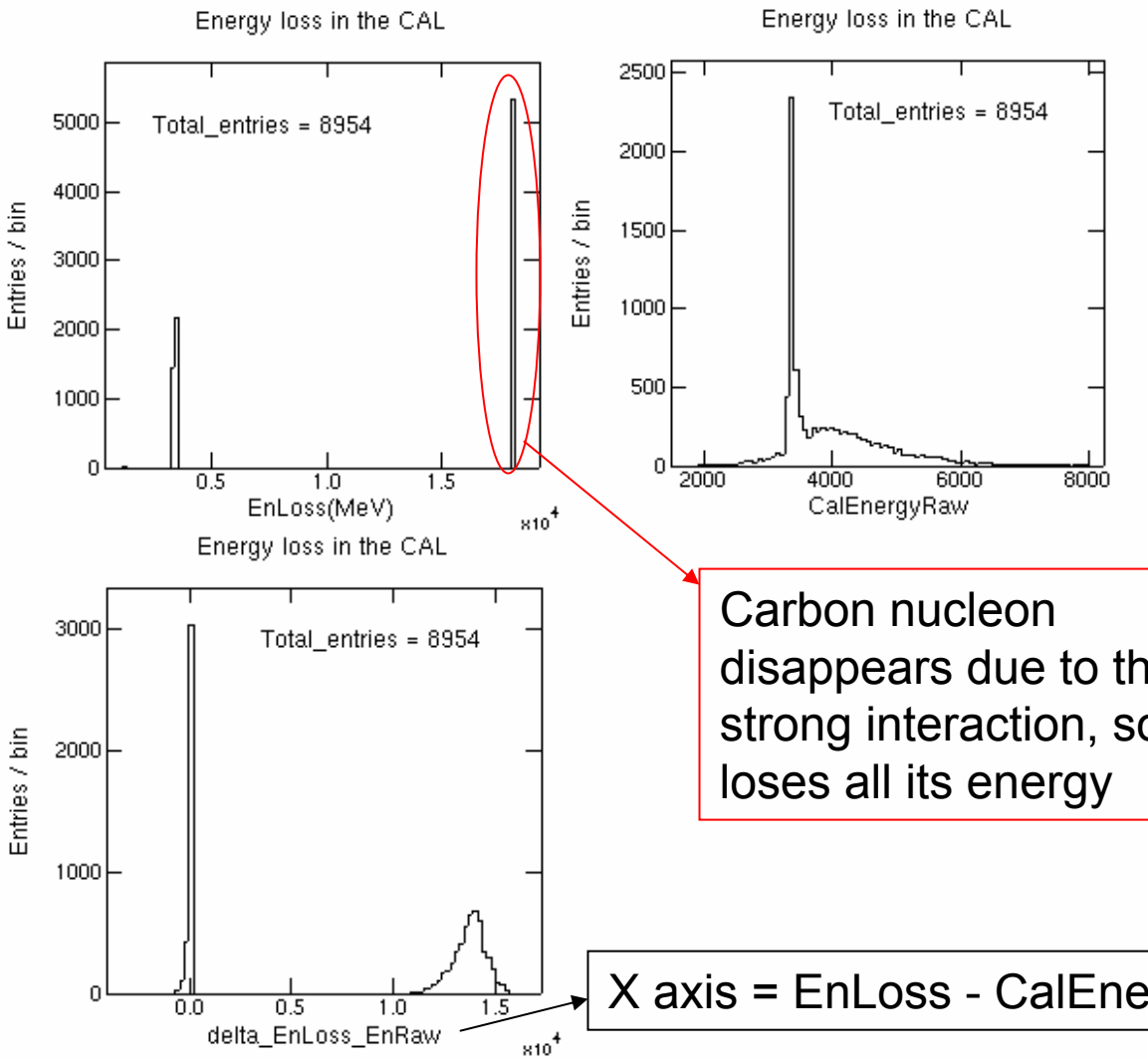
- If cut on the z coordinate of the last step of C to make sure C goes out of the first crystal, the long tail in dE/dx is removed. But it's still not a Landau distribution.





Energy loss in the CAL VS. CalEnergyRaw (no cuts)

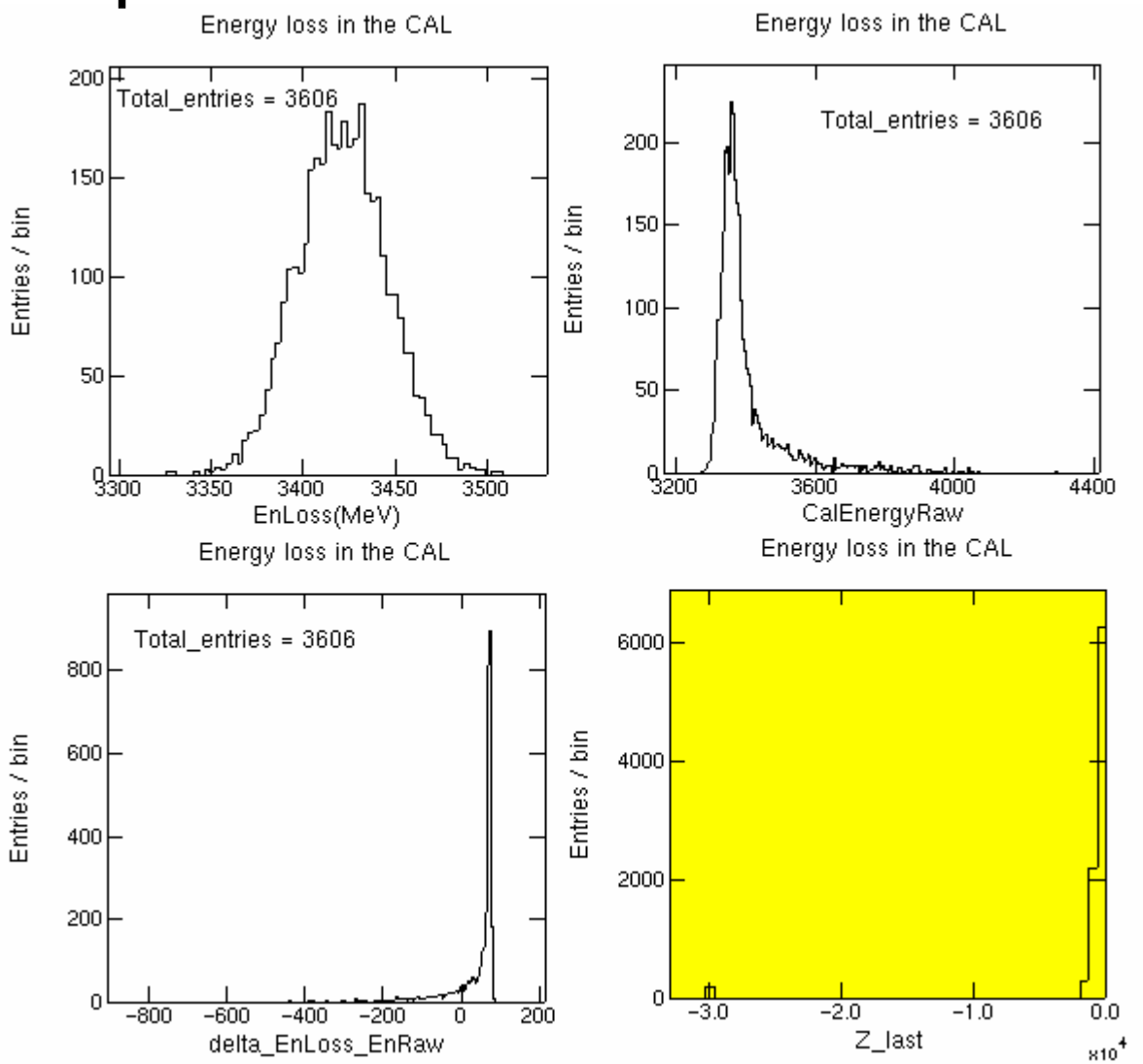
- Carbons 18GeV



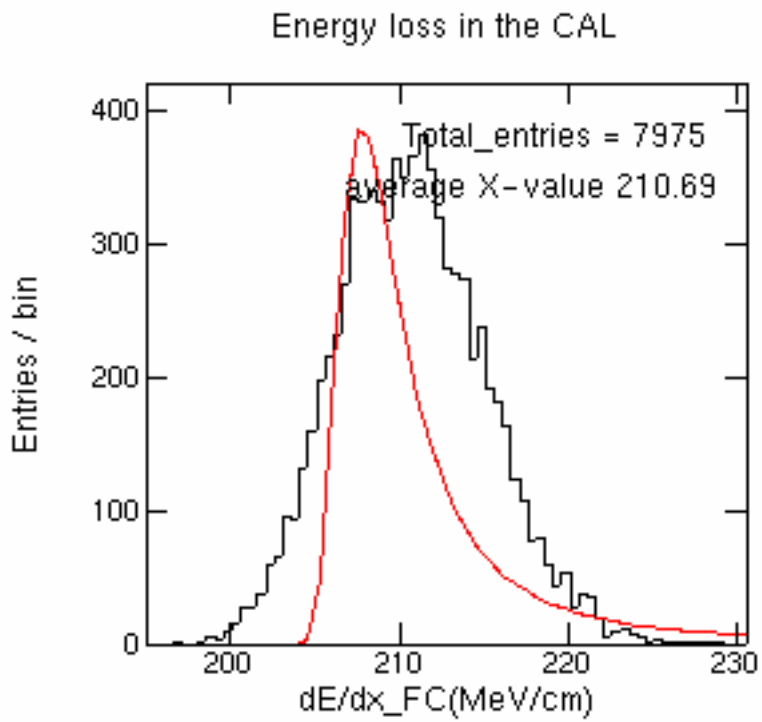
Carbon nucleon disappears due to the strong interaction, so it loses all its energy

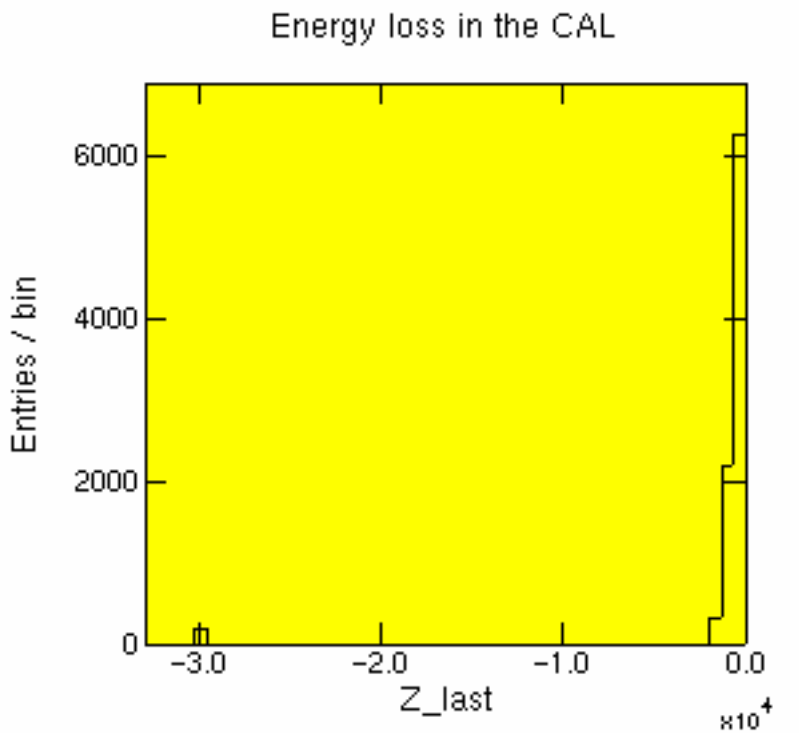
X axis = EnLoss - CalEnergyRaw

- If cut on the z coordinate of the last step of C to make sure C goes out of the CAL, the second peak is removed

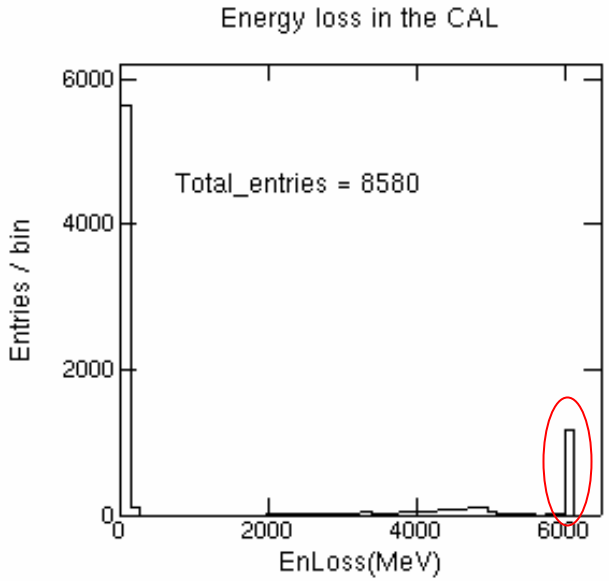


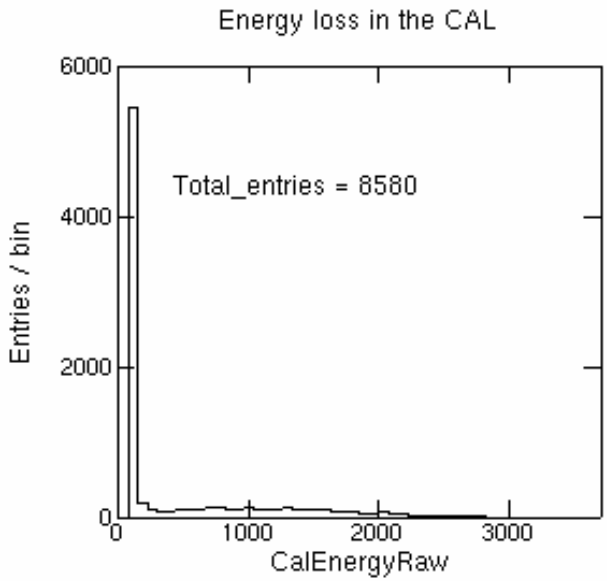
- If cut on the z coordinate of the last step of C to make sure C goes out of the first crystal, the long tail in dE/dx is removed. But it's still not Landau distribution.

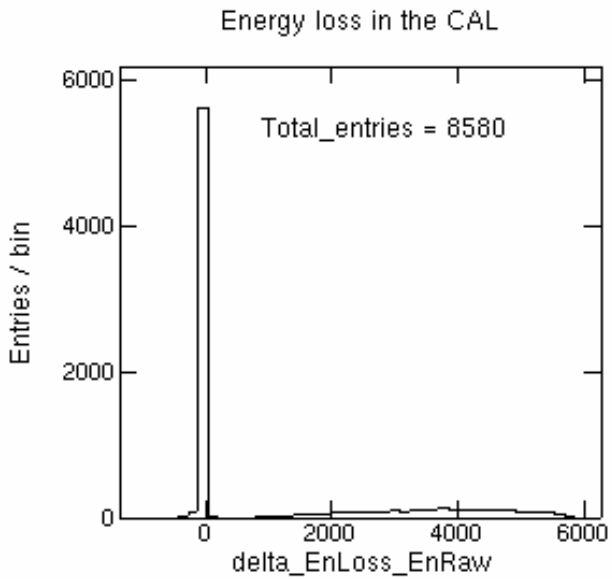




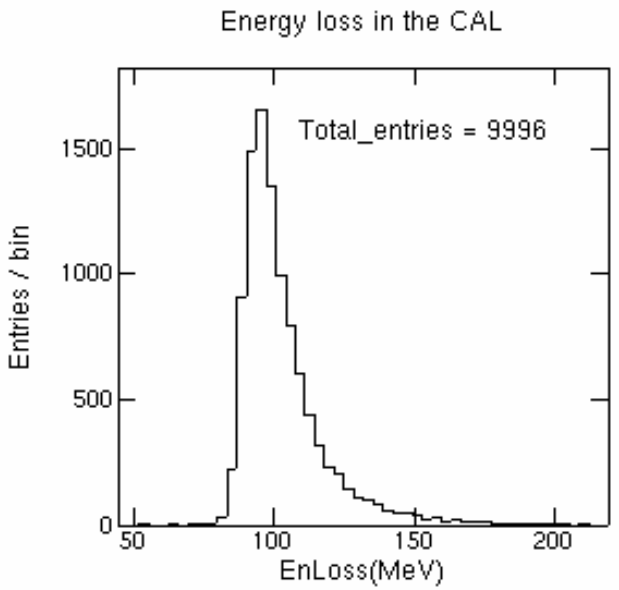
- Protons 6GeV

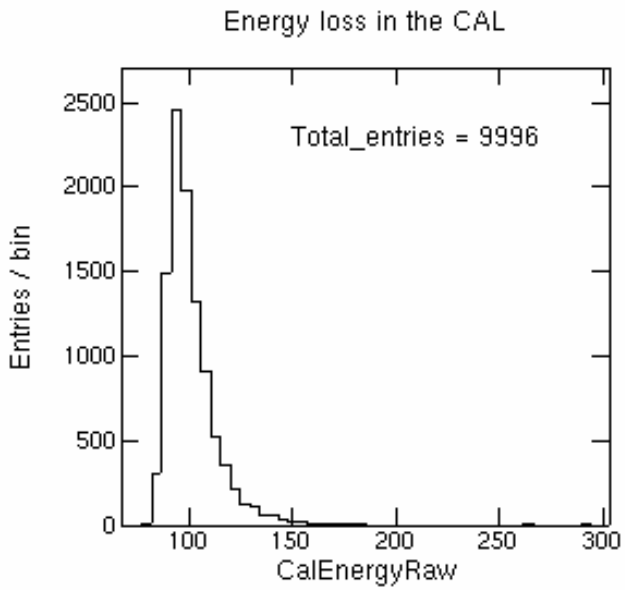


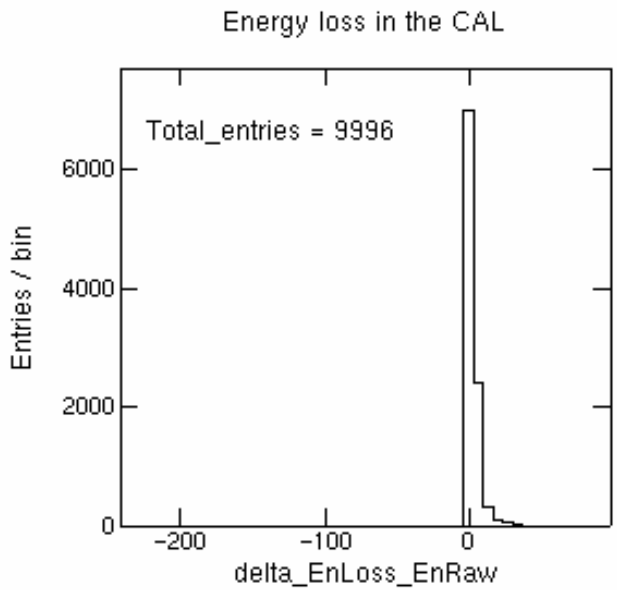




- Muons 1.021GeV







Run 700002539 Carbon BA=-30.0 w/ cut energy deposited in 1 crystal per layer