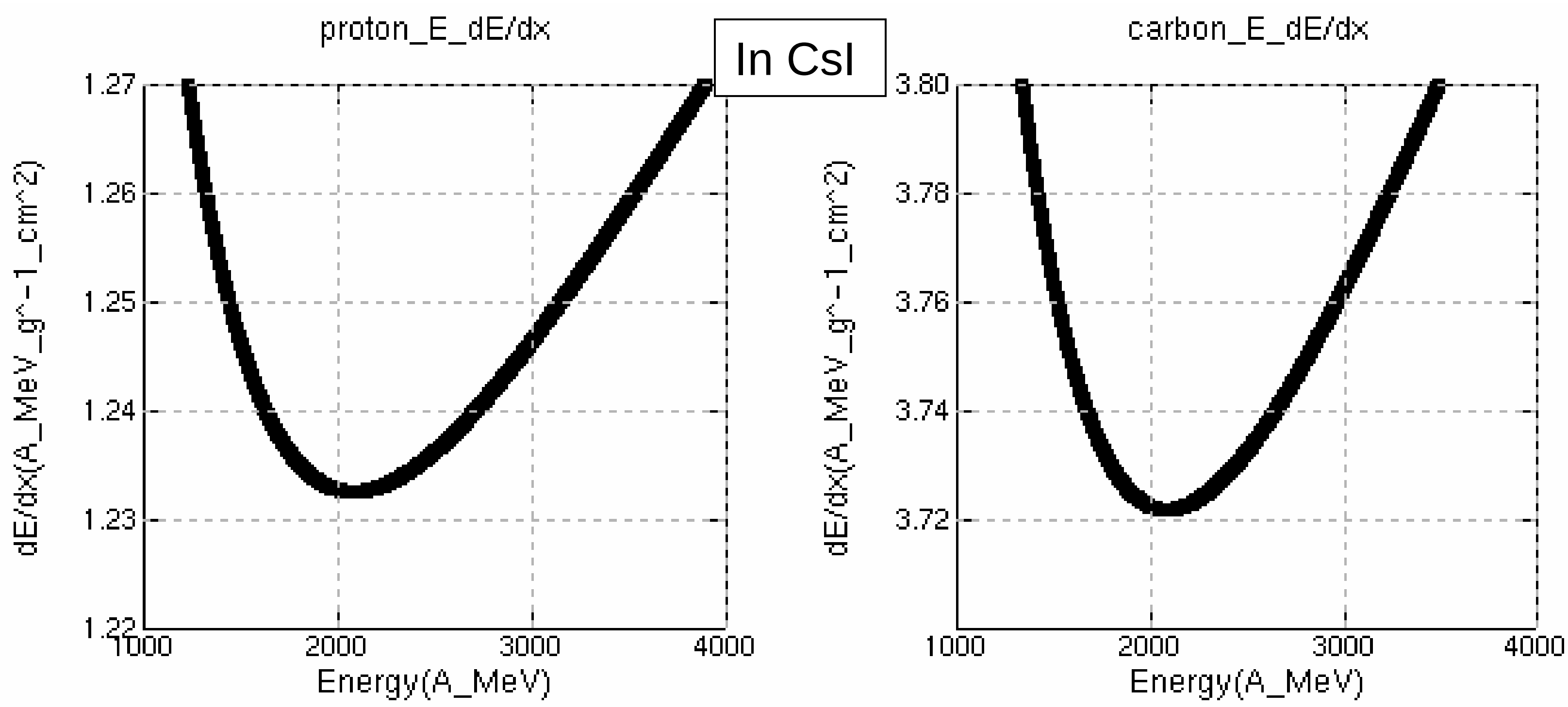
CAL variables and “antiquenching” effect - GSI carbon data

Ping Wang

06/11/07

Dedx code

- Weaver & Westphal, Nucl. Instrum. Methods Phys. Res. B 187, 285-301 (2002)
- Code is available at http://snfactory.lbl.gov/~weaver/dedx/

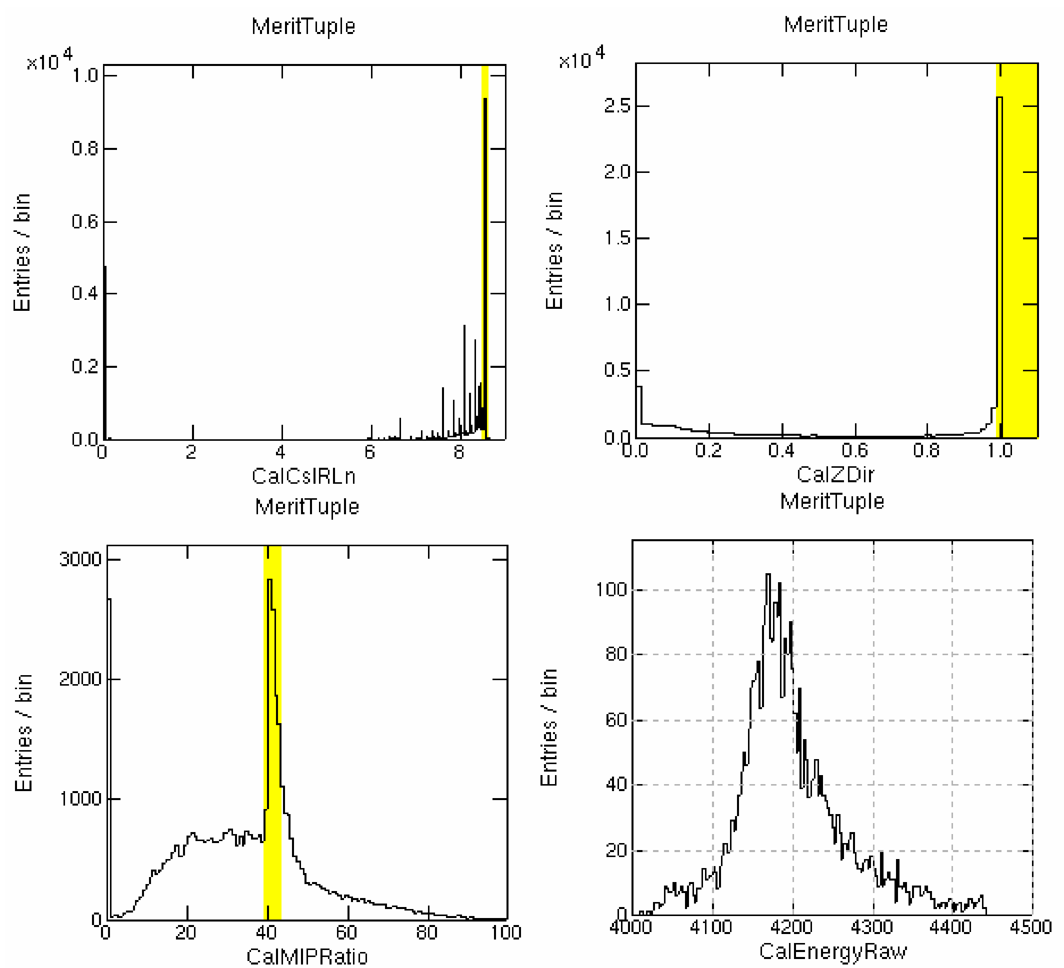


Minimum ionizing energy: E_proton = 1.232 MeV cm^2 /g, E_carbon = 3.722 MeV cm^2 /g/A

=> MIP ratio = 3.722 * 12 / 1.232 = 36.25

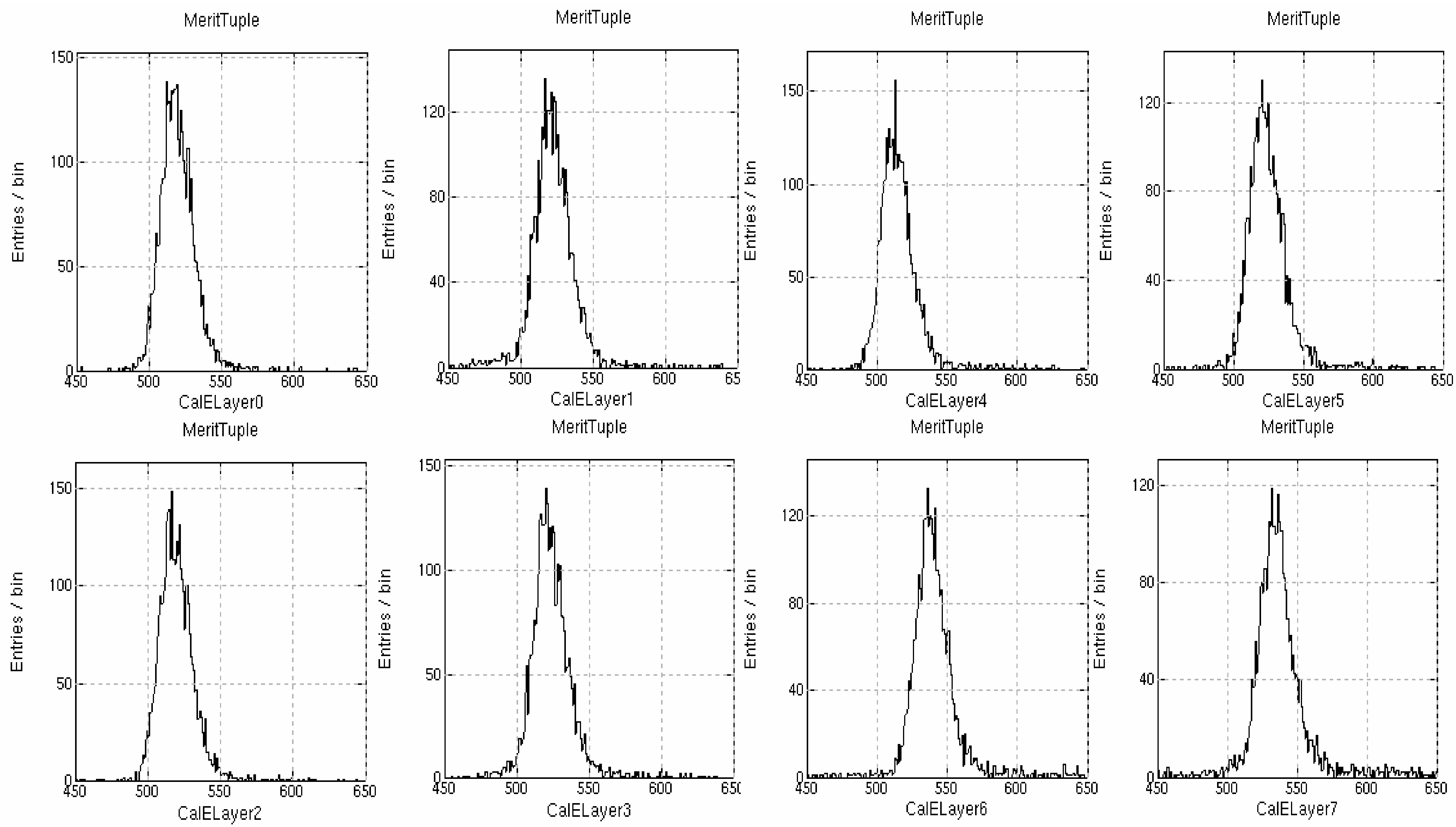
GSI Carbon run 700002528

- Total events: 50781
- Cuts: (3525 events after cuts)
  - CalCsIRLn >= 8.5
  - CalZDir >= 0.99
    - Radiation length of CsI is 1.86 cm (PDG).
    - These two cuts select carbons with normal direction and going through the whole CAL
  - 39 <= CalMIPRatio <=43
    - This cut selects carbons which are perfect minimum ionizing particles



Why dose CalMIPRatio peak at ~40?

Cal energy in every layer (after cuts)



How to get the peak of MIP ratio at ~40

- The peak energy deposit in every layer is almost the same (~520 MeV), although has a little shift.
- CalMIPRatio is calculated in AnalysisNtuple, in the file CalValsTool.cxx.
  - CAL_MIP_Ratio = CAL_EnergyRaw/(12.07*std::max(CAL_CsI_RLn*1., minRadLen));
  - We think 12.07 is the expected mean value of the energy deposit per radiation length (1.86 cm) of a MIP
- The peak of CalEnergyRaw is ~520 * 8 = 4160 MeV, using CalCsIRLn = 8.5, then CalMIPRatio = 40.5

Why is 12.07 MeV per radiation length of a MIP?

Energy deposit of a MIP

- PDG data
  - Energy loss of a MIP = 1.243 MeV cm^2 / g
    - Energy loss per radiation length = 1.243 MeV cm^2 / g * 4.51 g / cm^3 * 1.86 cm = 10.43 MeV
- Weaver's dedx code
  - Energy loss of a MIP = 1.232 MeV cm^2 / g
    - Energy loss per radiation length = 10.33 MeV
- The above two are comparable, but much less than 12.07 MeV.

Quenching factor for GSI data

- Benoit’s presentation – a comparison between data and G4 MC
  https://confluence.slac.stanford.edu/download/attachments/13893/BeamTest_22_11_06.pdf?version=1
  - Compare the energy deposit layer by layer and get the quenching factor ~ 1.22
  - Apply this factor, MIP ratio ~ 520 MeV / 1.22 / (1.232 * 4.51 * 1.99) = 38.55
- Estimate quenching factor using dedx code
  - Kinetic energy of carbon = 1.5 GeV / A
  - From dedx code, the energy loss dE/dx = 203.64 MeV / cm
  - Energy loss per layer = 203.64 MeV / cm* 1.99 cm = 405.24 MeV
  - Quenching factor ~ 520 MeV / 405.24 MeV = 1.28
  - Apply this factor, MIP ratio ~ 405.24 / (1.232 * 4.51 * 1.99) = 36.65
  - This estimation doesn’t take into account the energy loss in the traker

Compare with the previous result

- B. Lott, et al, Response of the GLAST LAT calorimeter to relativistic heavy ions
  http://adsabs.harvard.edu/abs/2006NIMPA.560..395F

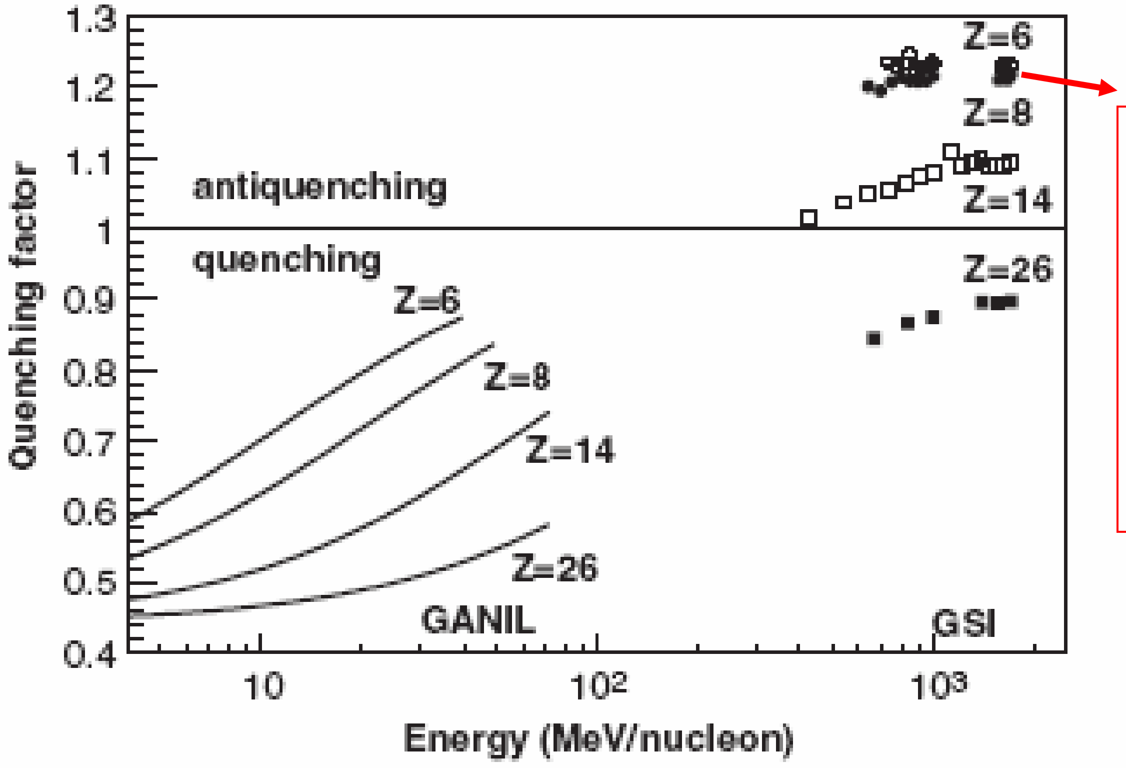


Fig. 11. Compilation of the quenching factors measured at GANIL and GSI as a function of the ion's energy per nucleon, for the different ions relevant to the on-orbit calibration of GLAST's calorimeter.

For 1.5 GeV / A carbon, quenching factor ~ 1.22 is the same with Benoit's presentation (both using G4 MC, maybe different versions)

Summary and plan

- “Antiquenching” effect affects the measurements in CAL, eg. CalMIPRatio, Cal energy
- Need more investigation
  - Compare with the latest/appropriate G4
  - Compare with other MCs