The CLAS forward electromagnetic calorimeter : NIM A 460, 239 (2001)

Main functions

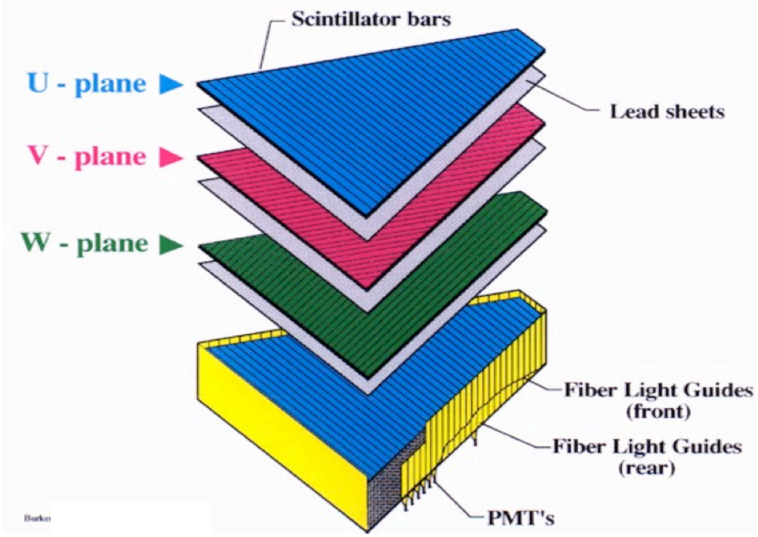
- Identification of pions and electrons

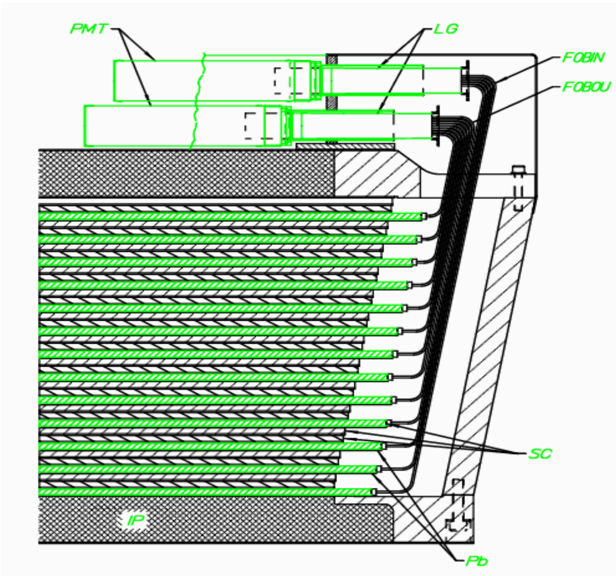
  Using momentum, energy deposition in EC & its pattern

- Fast analog sum of the energy

  When Q^2 and W are needed at trigger level

- Reconstruction of π^0 and η decays
- Neutron detection





Design

- $8^0 - 45^0$ forward angle coverage
- 10 mm scintillator + 2.2 mm lead = 1 layer (*39 = 16 RL)
- 3 orientations of scintillator layers (U, V, W)
- 13 sub modules (5 inner + 8 outer)
- Each scintillator layer consists 36 strips
- $36 \times 3 \times 2 = 216$ PMTs in each EC sector module
- Scintillator light is transmitted to PMTs by optical fibers.

Scintillator (Bicron BC412)

- 10 mm thick, 100 mm wide, 0.15-4.2 mm length
- Light transmission
- Absolute light yield
  - fraction of the scintillation light reaching a PMT
  - determined number of photoelectrons (n_{pe})
  - with direct readout n_{pe} ~ 200/MeV
- Time response
  - decay time (τ) ~ 3.6 ns
- Radiation dose
  - 10 yr operation of CLAS ~ 100 Gy
  - no significant effect on scintillators
- Thermal expansion
  - observed 60% smaller thermal expansion than expected.
- Total internal reflection
  - maintained by opaque wrapping between lead and scintillator

Light collection system

- Consider wavelength shifter (WLS) and fiber optics (FO).
- Light transmission
  - show no significant difference between WLS and fiber optics
- Time characteristics
  - fiber optics readout was clearly superior.
- Light attenuation
  - fiber optics showed less attenuation.
- Chose fiber optics (total efficiency ~ 80%)

Simulation and event reconstruction

- GEANT simulations of EC summarized followings:

  - ~95% of the shower is concentrated on a 4cm transverse diameter

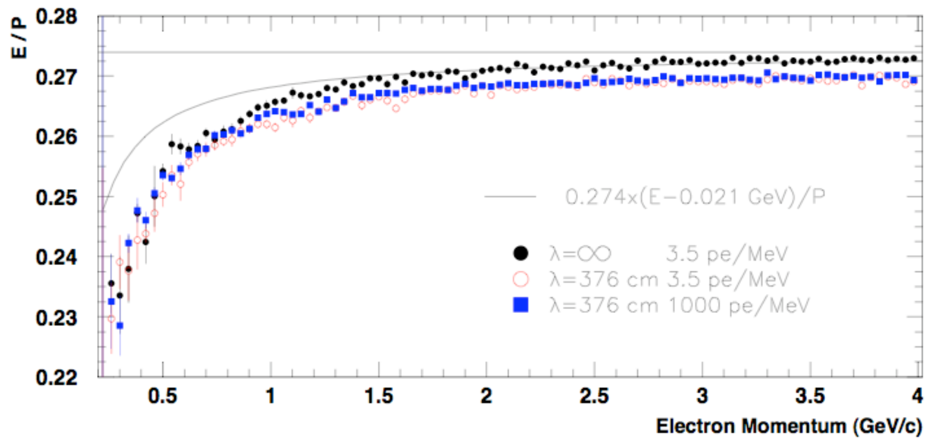
  - for electrons (0.5-4.5GeV), the longitudinal shower peaks between layer 6 and 12

  - for same energy range, shower leakage from the rear amounts to 0.8-2.2% of total shower.

- GEANT also implemented to categorized the readouts MIP tracks and EM showers.
- Three types of particle interactions
  - Minimum ionizing
  - Electromagnetic shower
  - Hadronic interactions
- Identify the group of stripes which involved in each view.
- Re-sort by energies and calculated the centroid and RMS.
- Match these peaks into hits using triangle sum rule.
- Correct for the light attenuation.
- Recalculate centroid, RMS and momentums.

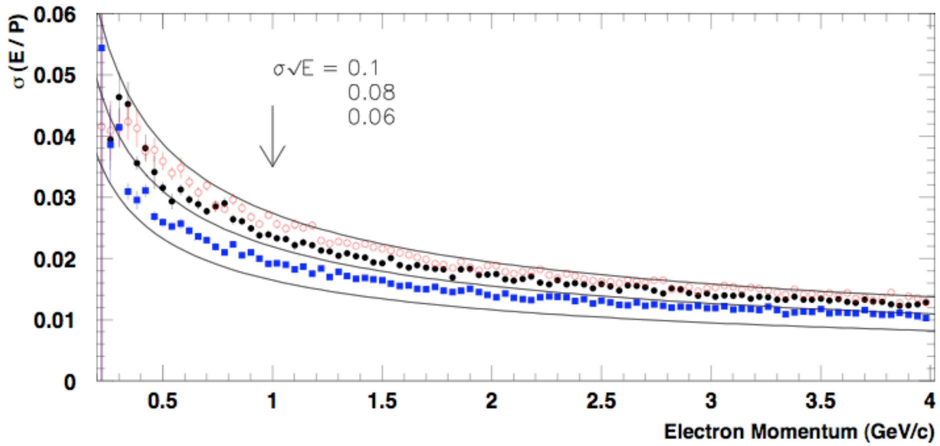
Sampling fraction

f_s = total energy deposited incident energy



Resolution

$\sigma/E \propto \sqrt{(t_s/f_s)}$ where t_s is the sampling thickness



Preliminary performance

- Strong correlation between measured EC energy and DC momentum for electrons.
- Longitudinal sampling of deposited energy is well demonstrated using separate inner and outer readouts.
- Both sampling fraction and resolution are slightly higher than GEANT predictions.
- EC-DC track matching residuals (Fig.16) show some systematic shift in x residuals and need to consider in reconstruction.
- Above 1.6 GeV/c, the neutron detection efficiency is ~60%.

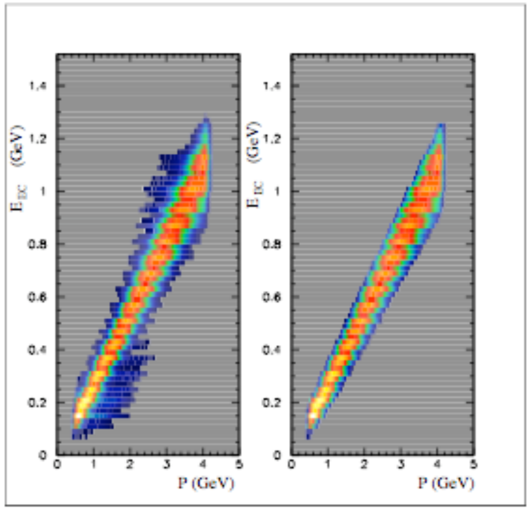


Figure 4.8: The above plots of the total energy deposited in the calorimeter versus the momentum of the particles show the distribution before and after the three sigma cut for the 4 GeV beam setting.

EC energy calibration

- Adjusting the individual PMT gains until the reconstructed energy matched the incident energy.

EC timing calibration

- Discriminate neutrons and photons
- Calculate neutron kinetic energy
- When SC counters are in-operative EC timing is sufficient to identify the initial RF pulse of the event.
- Procedure

- Use single charged tracks (electron and charged pions) passed through EC & SC.
- Five-parameter model for EC time
- Use chi-squared minimization of (SC time - EC time)

- Timing accuracy

- 200ps for electrons with few GeV
- 500-600ps neutrons and photons

- Ein > 5 MeV and Eout > 5 MeV to avoid background neutrons