Testbeam Performance of the T2K ND280 Downstream ECal

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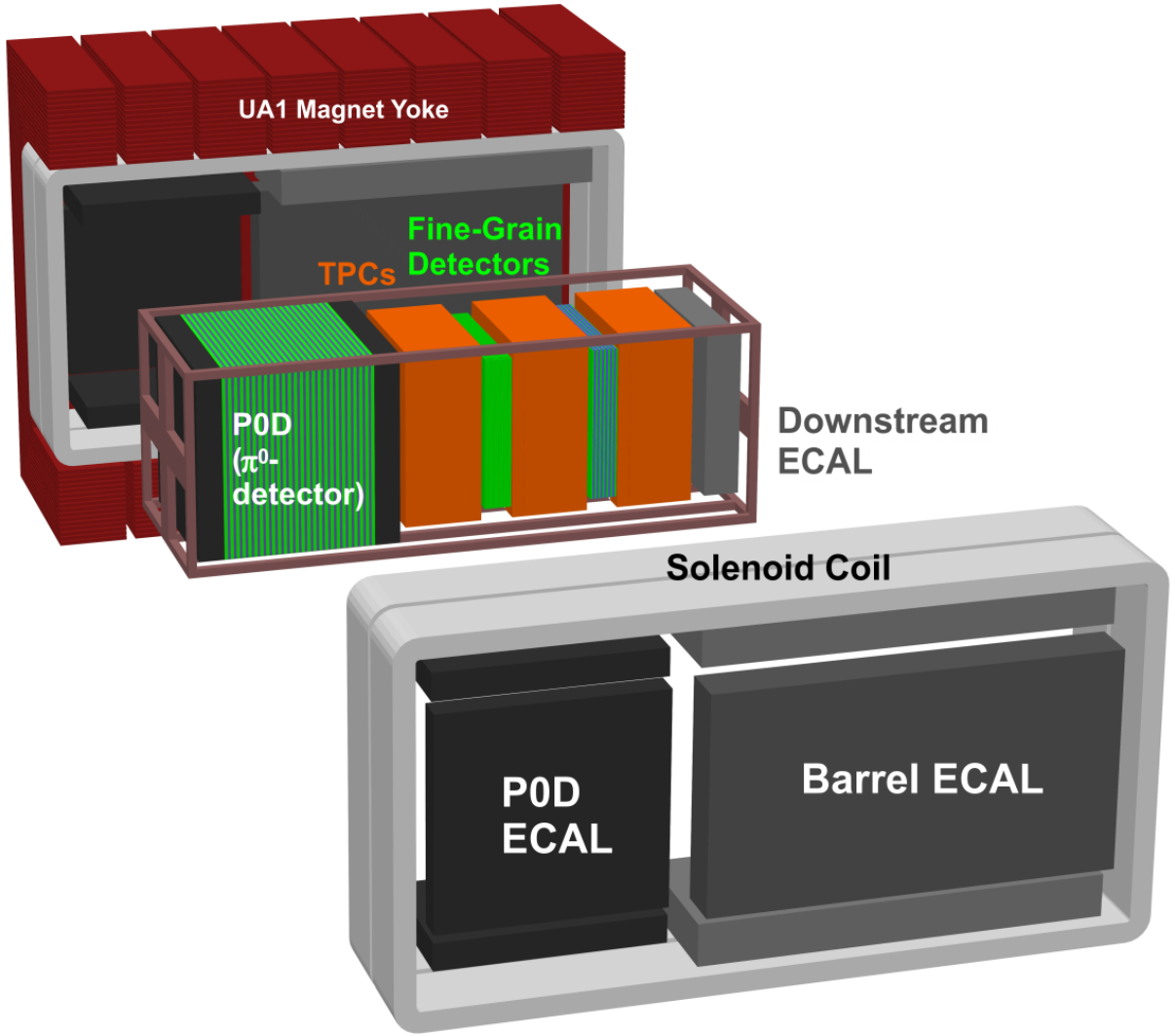
ND280 and the ECals



The ECals were all built in the UK.

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Why do we need ECals?

Electromagnetic calorimeters measure energy.

Why do we need an energy measurement from the ECals?

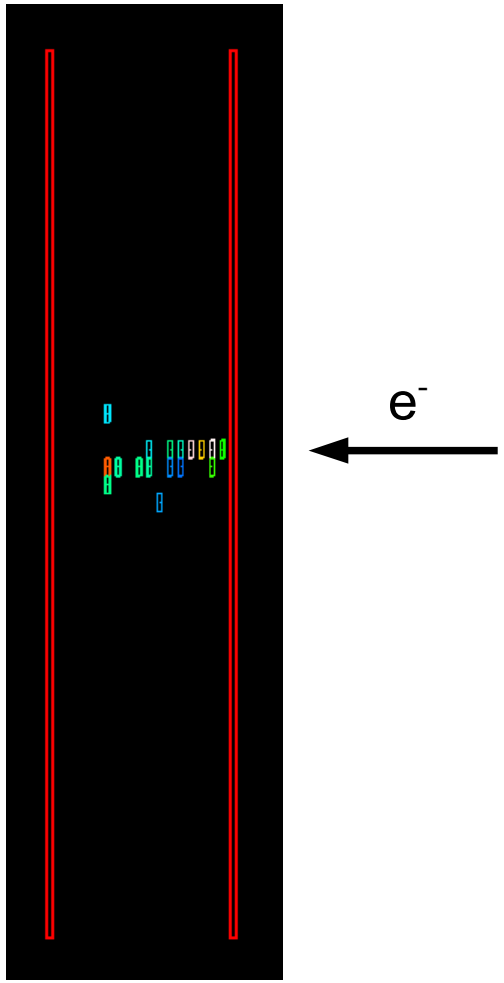
- Charged particles:
  - Provides a complimentary measurement to the TPC momentum.
  - E / p can also be used as a PID tool.
- Photons:
  - The only energy measurement available.

In addition:

- Track vs Shower PID.
- Tag or stop incoming external particles.

The Downstream ECal (DsECal)

- The most downstream detector in ND280.
- 34 layers of plastic scintillator bars.
  - 50 bars per layer.
  - 17 layers with bars along Y.
  - 17 layers with bars along X.
  - Separated by lead sheets.
- Bars threaded with wavelength shifting optical fibres.
- Read out at both end with silicon photodiodes called MPPCs.
- Placed in the CERN T9 Beamline during May and June 2009.



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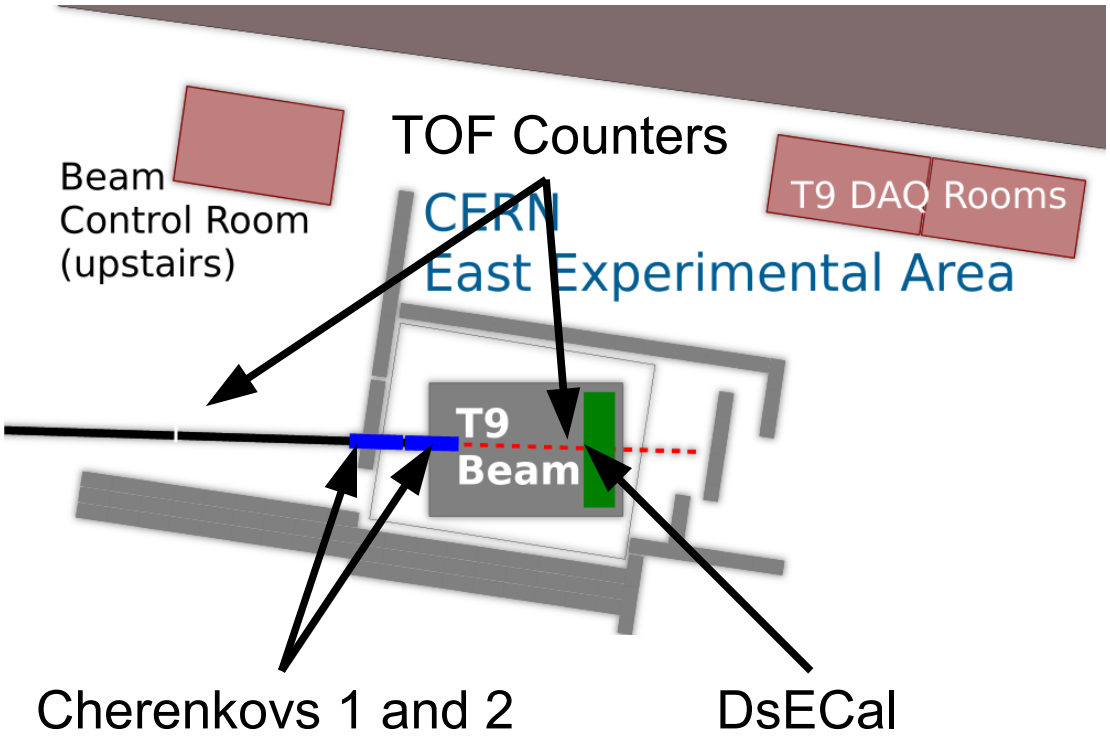
The T9 Beamline

Right: Photo of the DsECal.

Below: Schematic diagram of the beamline.



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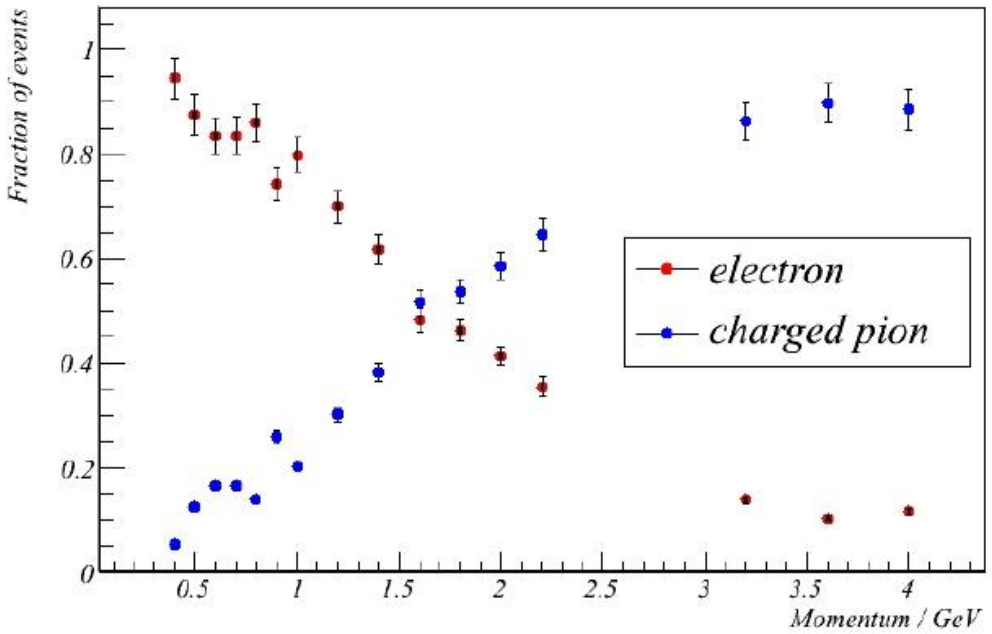
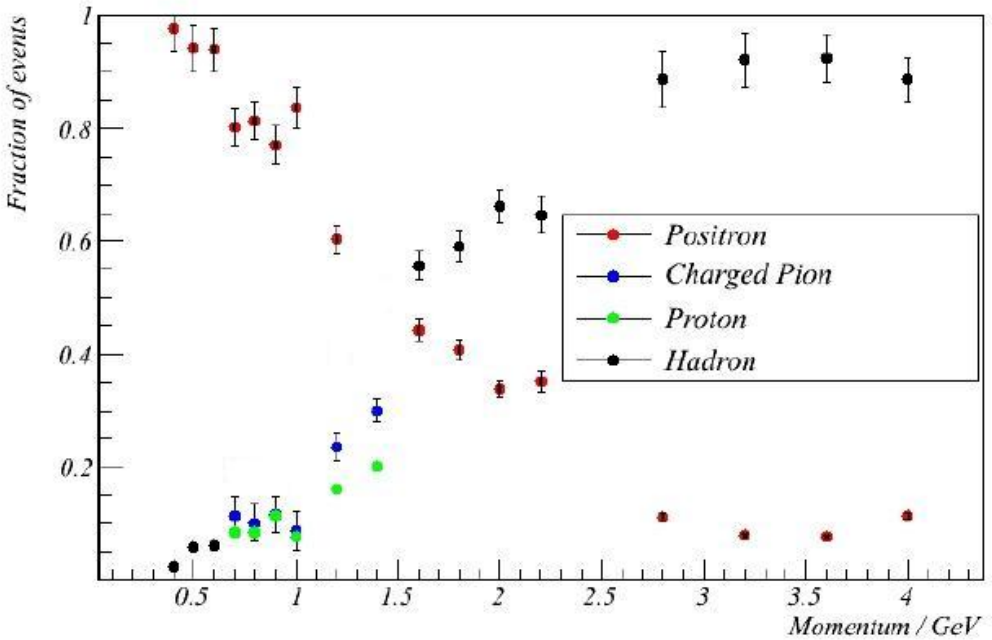
T2K

Data Taken

The beam particle content:

- Negative:
  - Electrons
  - Pions
- Positive:
  - Positrons
  - Pions
  - Protons





Data taken at a variety of settings:

- 400 MeV to 4 GeV
- 0, 15, 30, 60 and 75°

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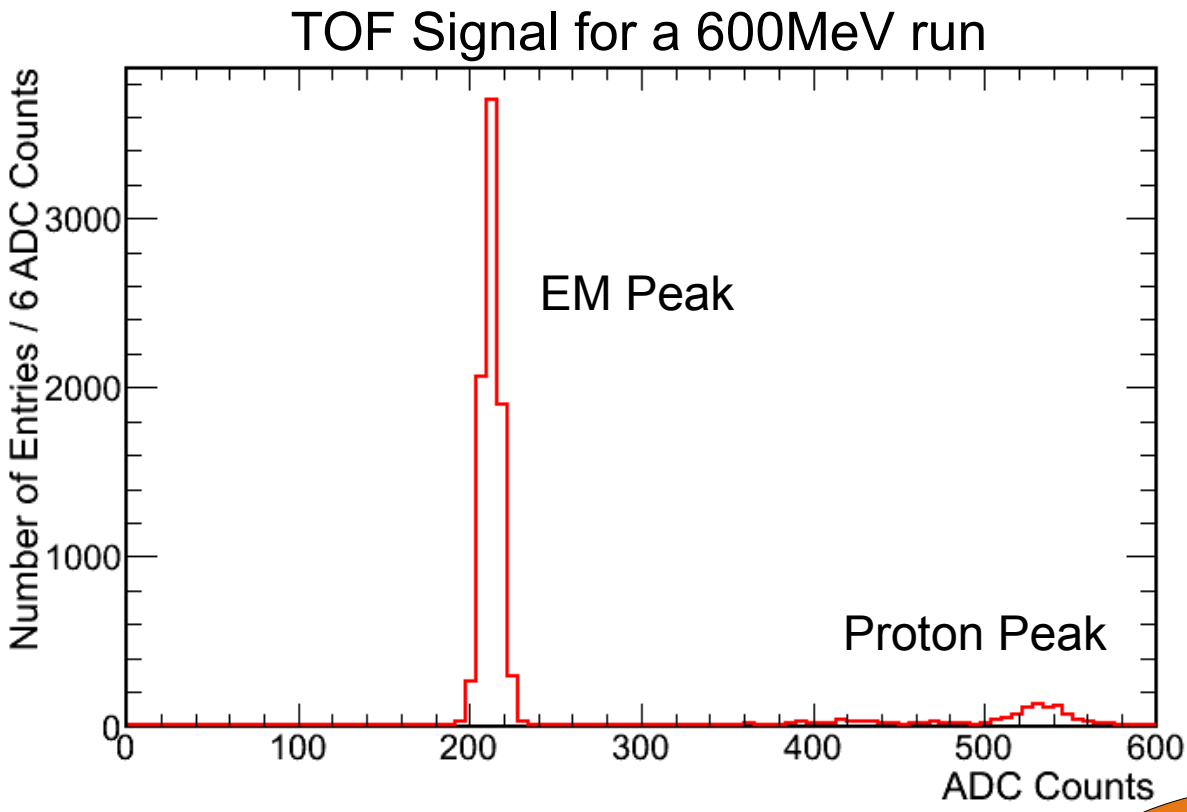
Selecting Electrons

The Cherenkovs and TOF were used to select a sample of electrons. The Cherenkovs were set to trigger only on electrons.

Require:

- Signal in Cherenkov 1.
- Signal in Cherenkov 2.
- TOF signal within EM peak.



Also require:

- Single reconstructed object.
- Object arrives at the expected time.

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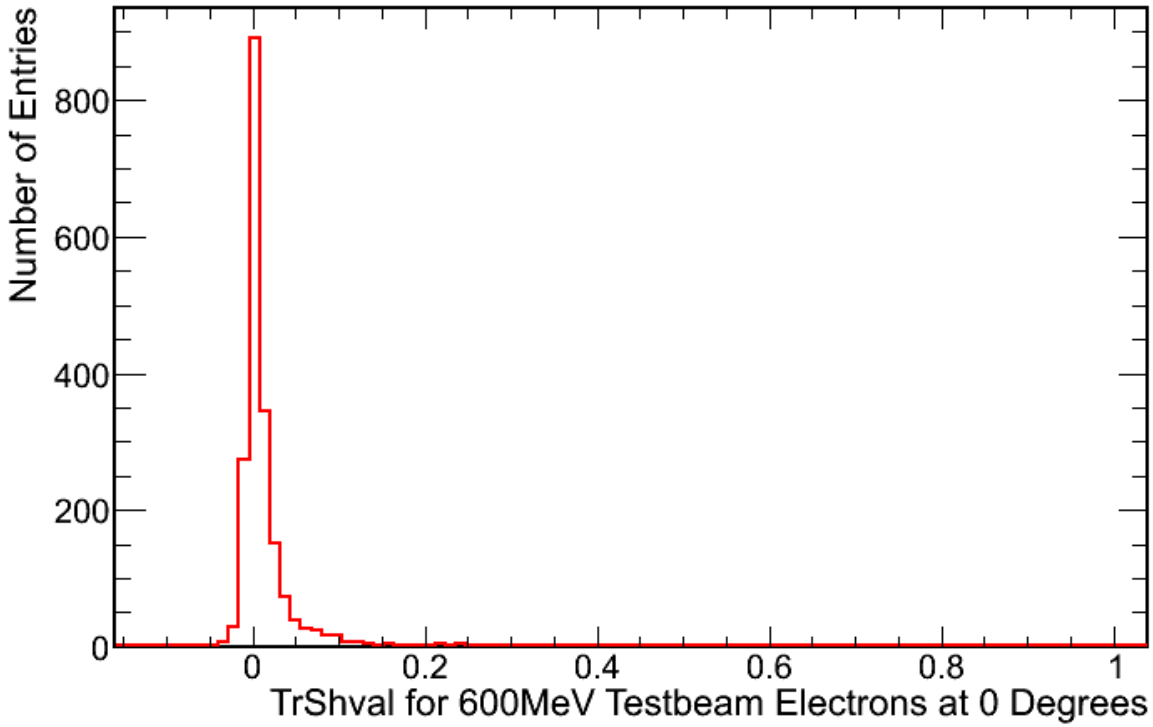
Electron Sample

Use the ECal PID to be sure that electron sample is pure.

ECal uses a neural network based on five parameters to separate tracks and showers.

TrShval is the output variable from the ECal PID:

- 0 = shower-like
- 1 = track-like



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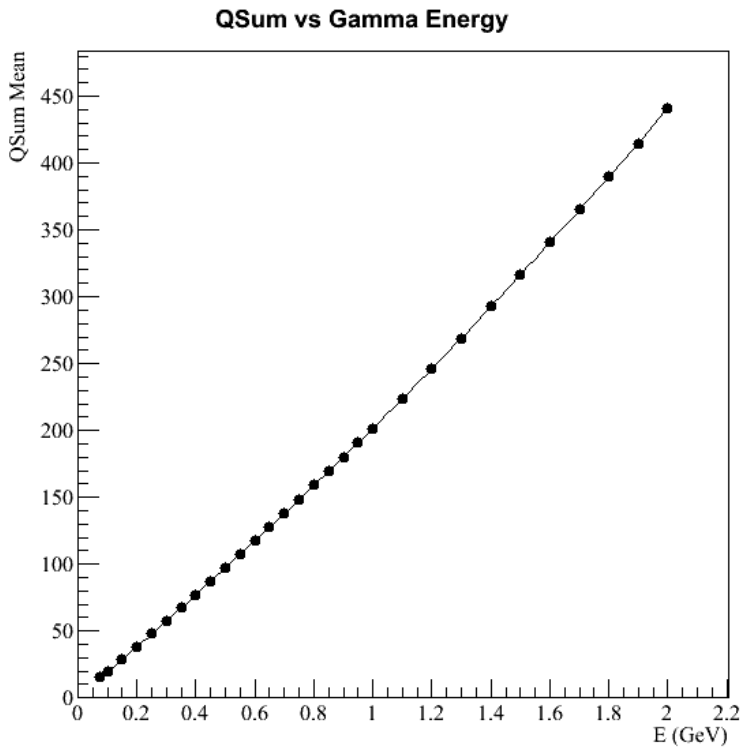
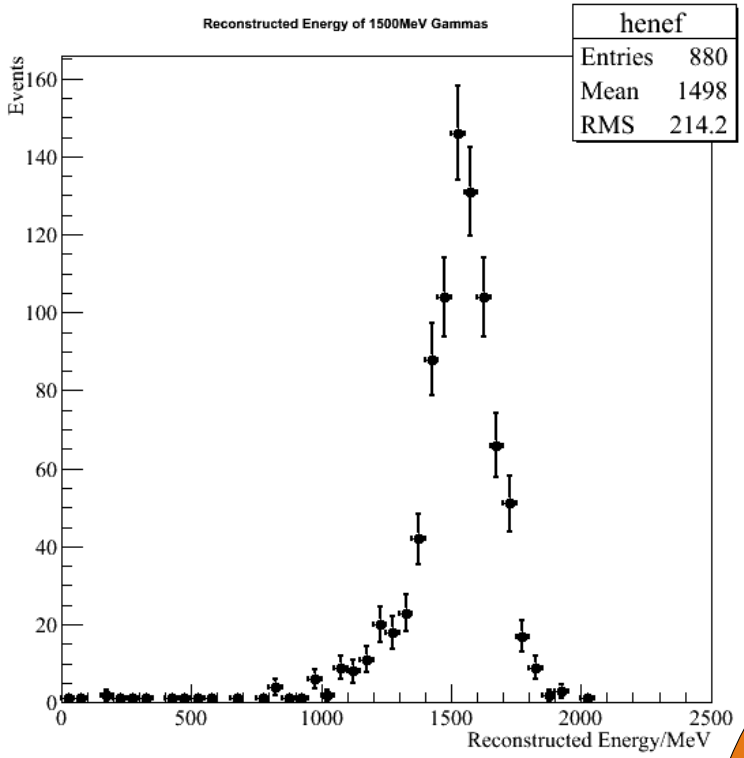
Energy Reconstruction

Likelihood fit based on three parameters.

- Total charge in the cluster.
- RMS of the charge distribution.
- Skew of the charge distribution.

Tuned with photon MC from 75MeV – 25GeV.





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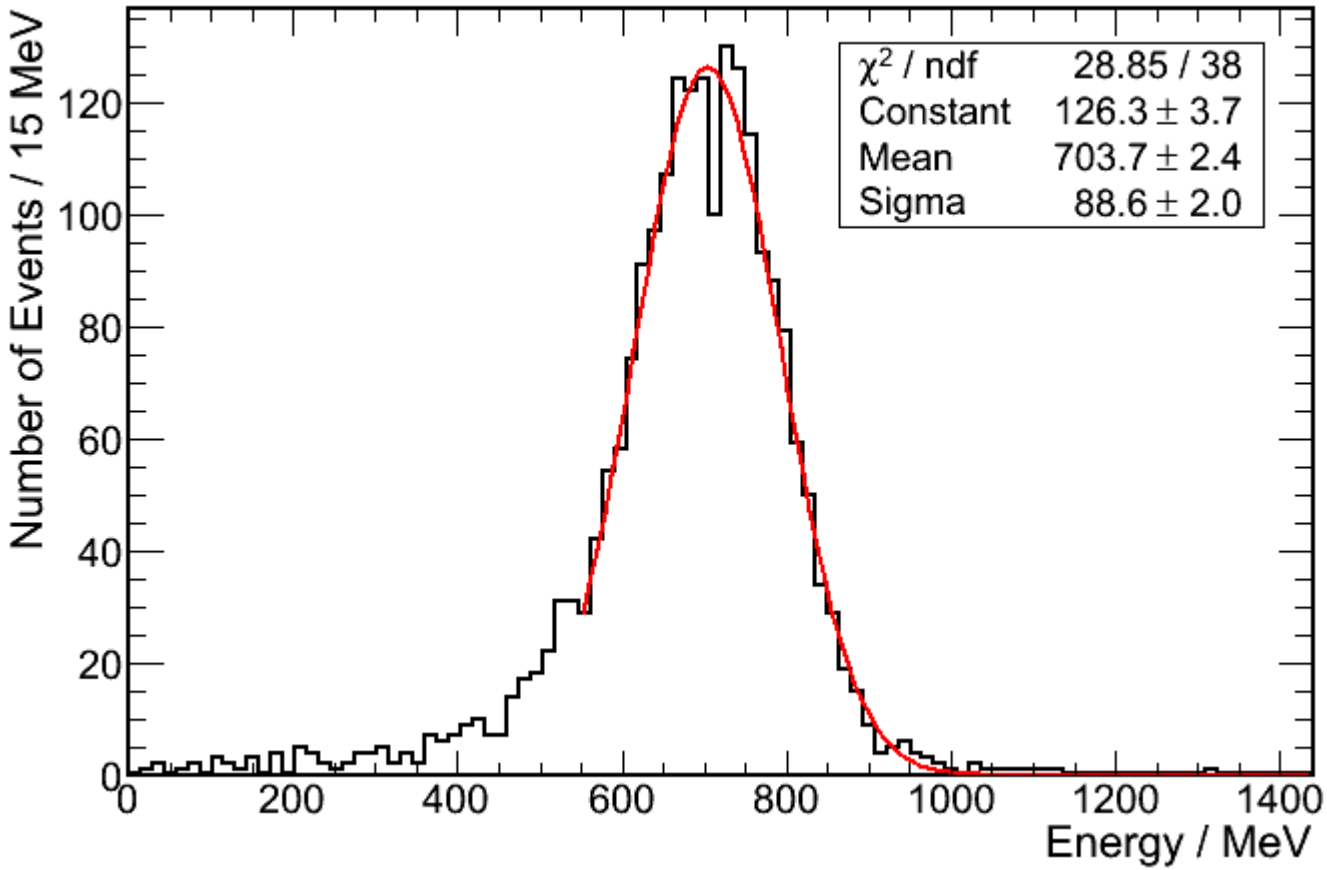
Energy Reconstruction

600 MeV Electron Sample at 30° angle of incidence.



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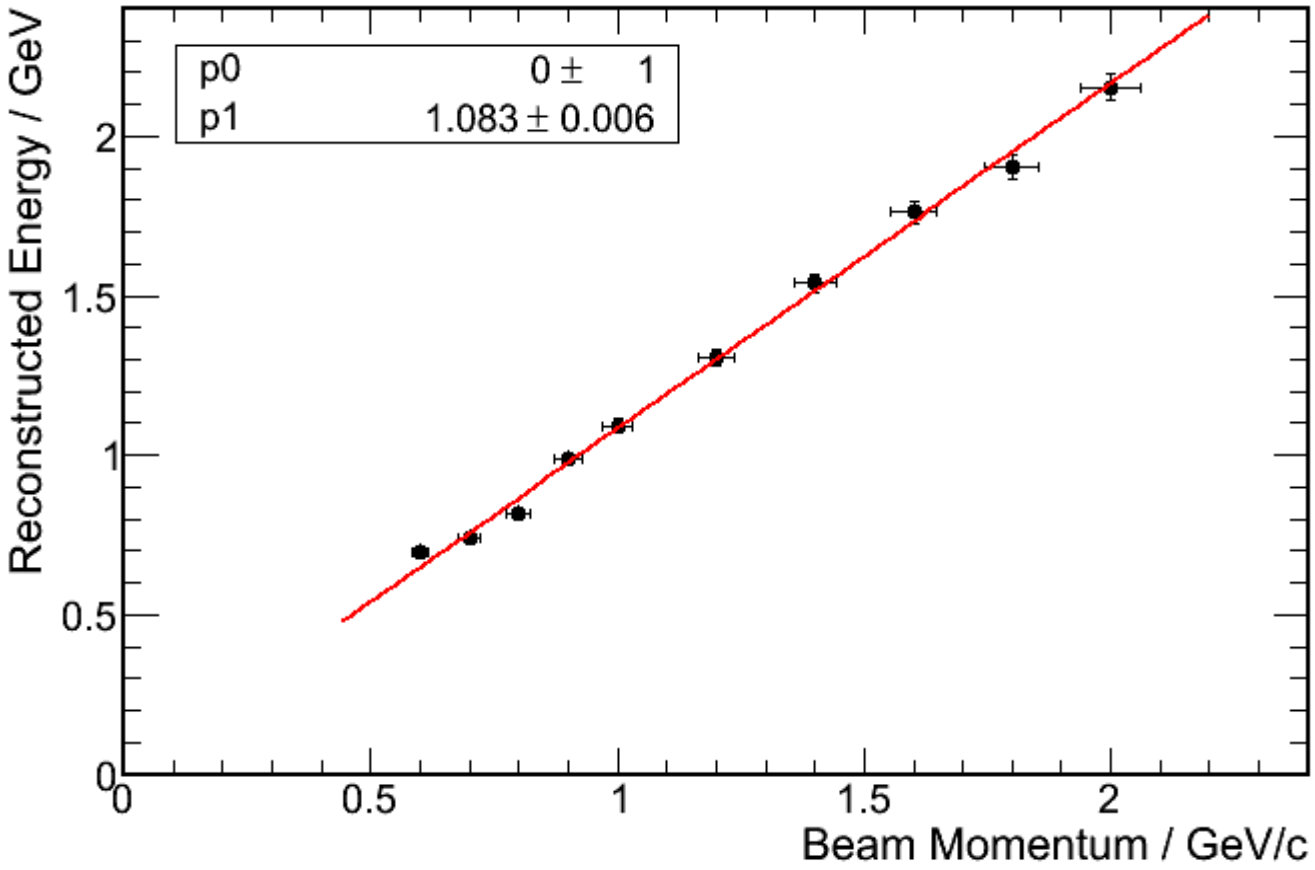
Energy vs Momentum

- Fit the energy spectrum for 10 runs at different beam momenta.
- Plot the mean of the Gaussian fit against momentum.



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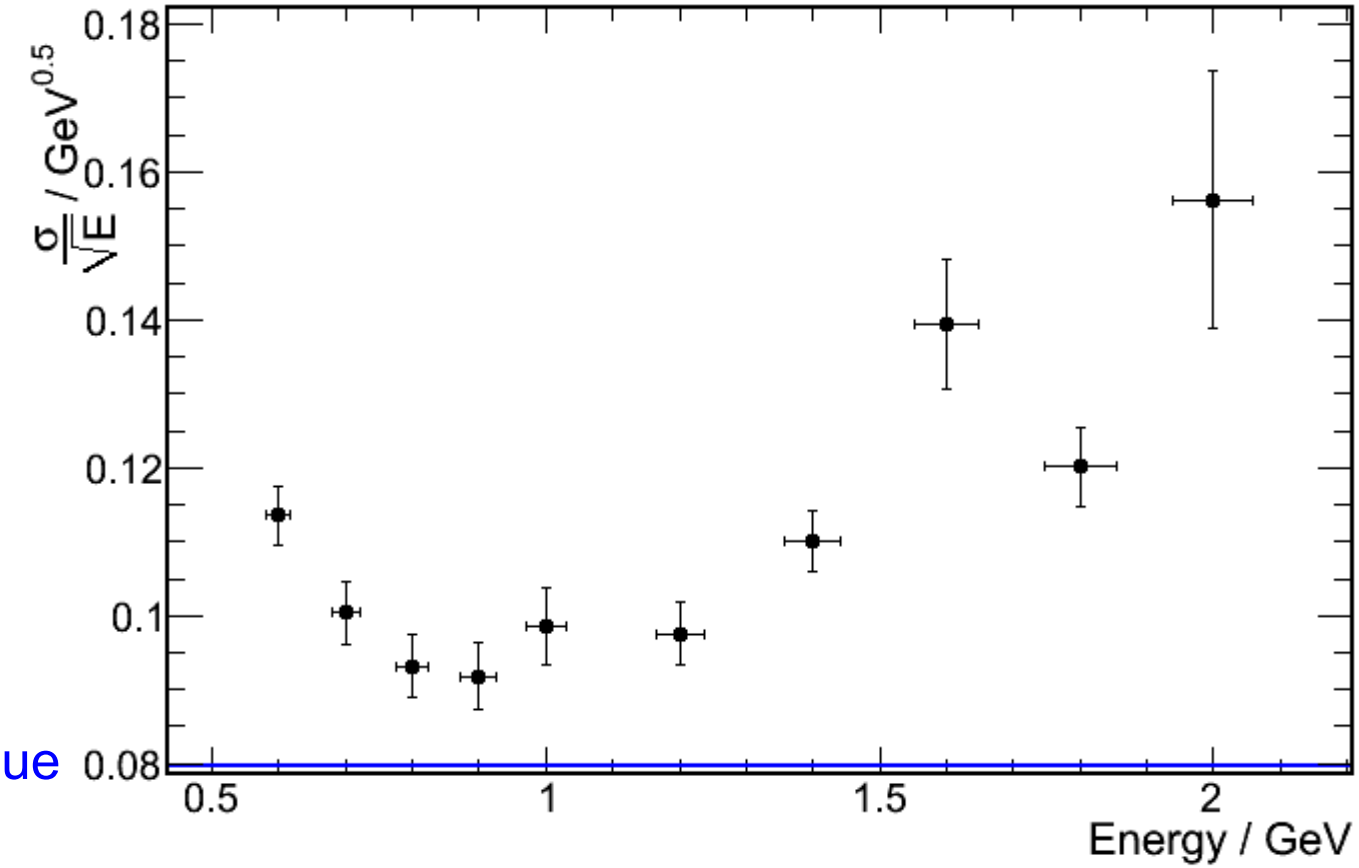
Energy Resolution vs Energy



Design Value

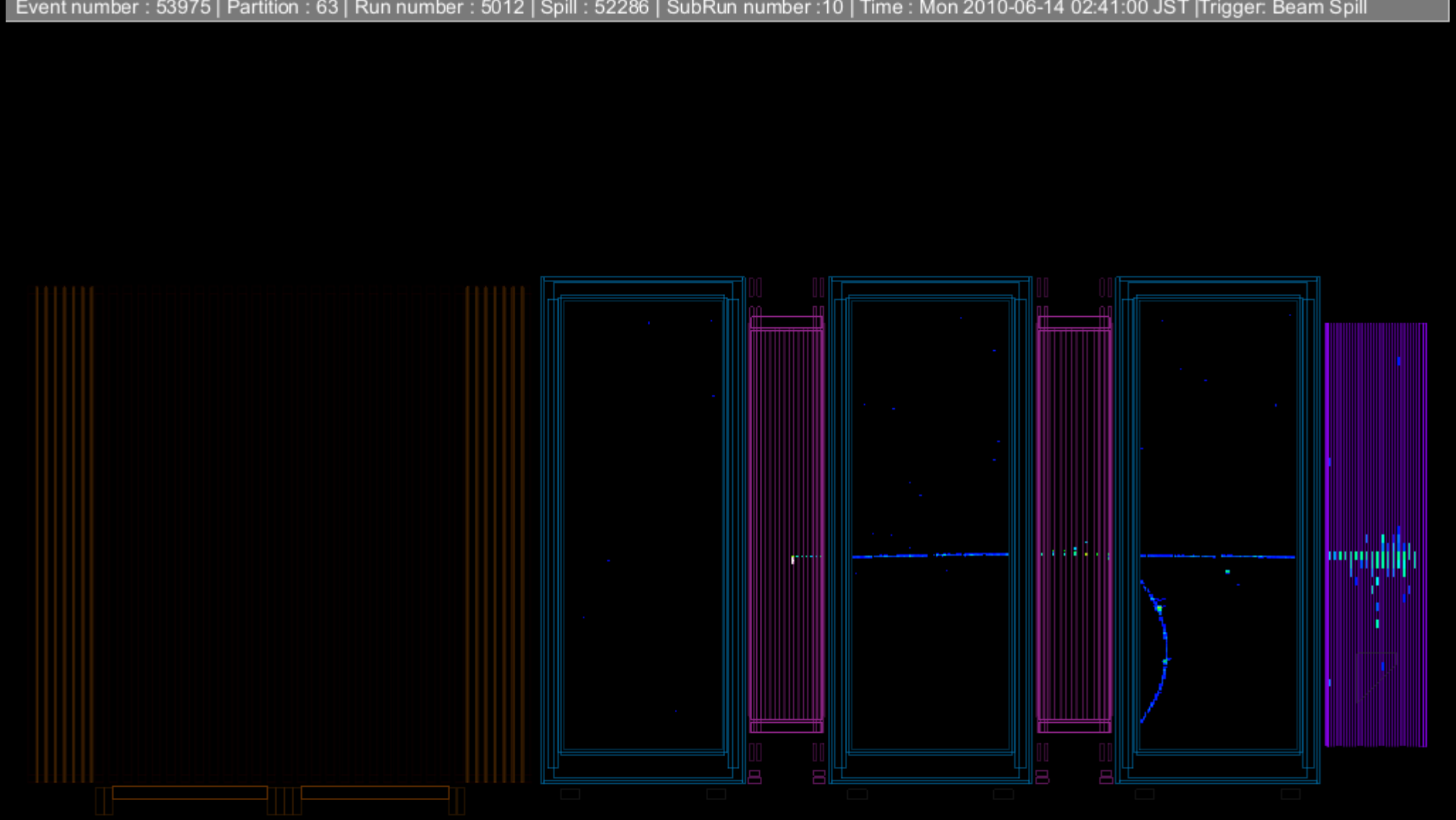
Summary

- Data was successfully taken over a wide range of energies.

- The EM Energy response was found scale linearly with the particle energy, as expected.
  - Work ongoing to understand the difference in gradient.

- The resolution of the ECal was found to be around 10% in the main region of interest.

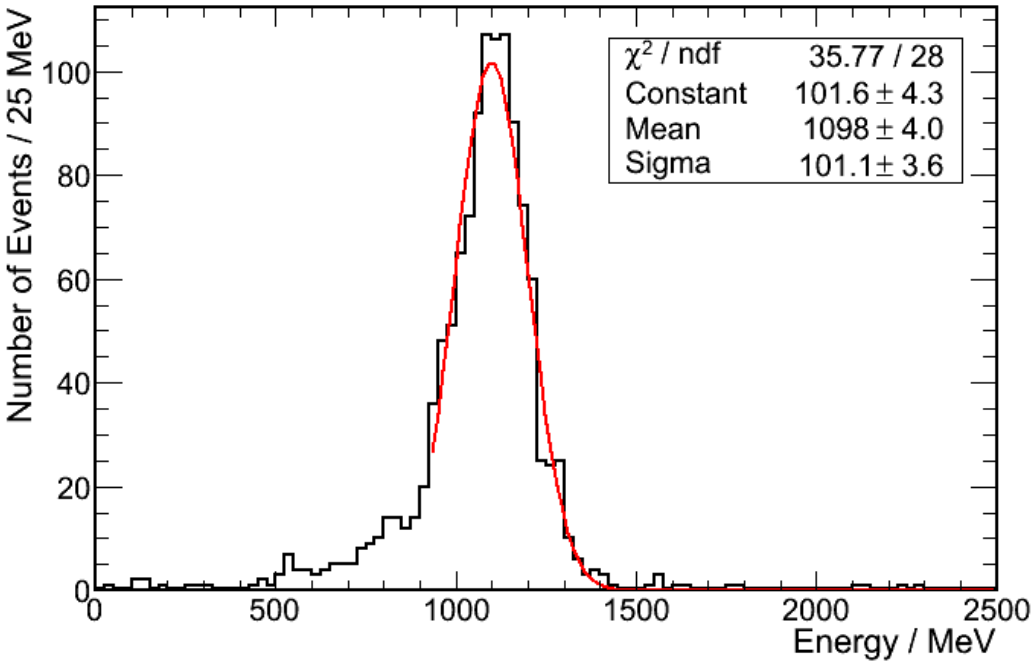
- Data will be re-processed shortly with improved software which will hopefully show improvements.
  - Improvements to both calibration and reconstruction.


Event number : 53975 | Partition : 63 | Run number : 5012 | Spill : 52286 | SubRun number :10 | Time : Mon 2010-06-14 02:41:00 JST |Trigger: Beam Spill

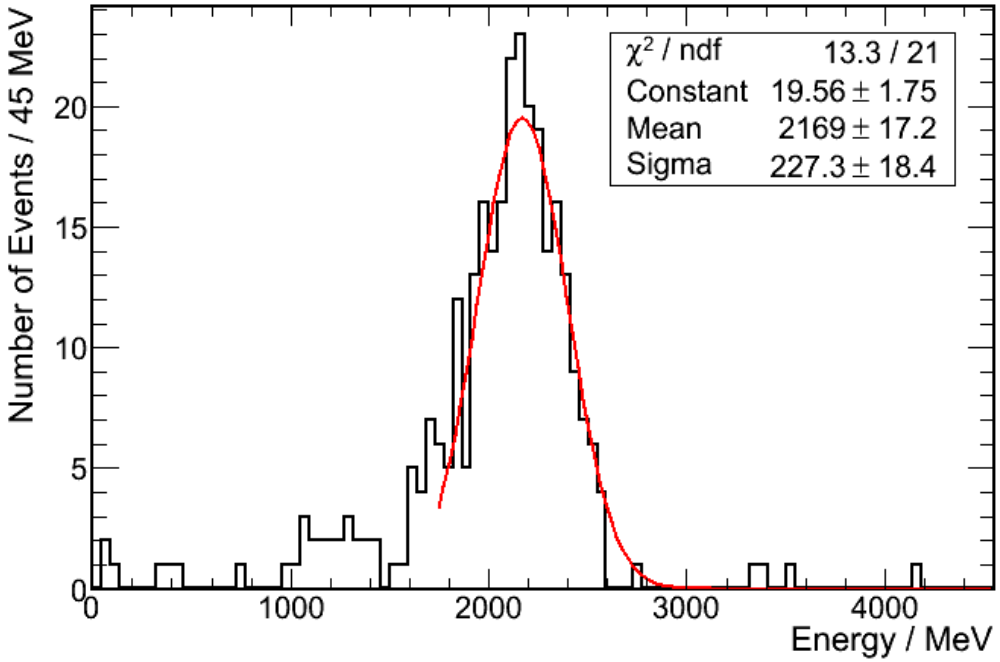
Backup Slides

Energy Reconstruction

1 GeV Electrons at 30 degrees.



2 GeV Electrons at 30 degrees.



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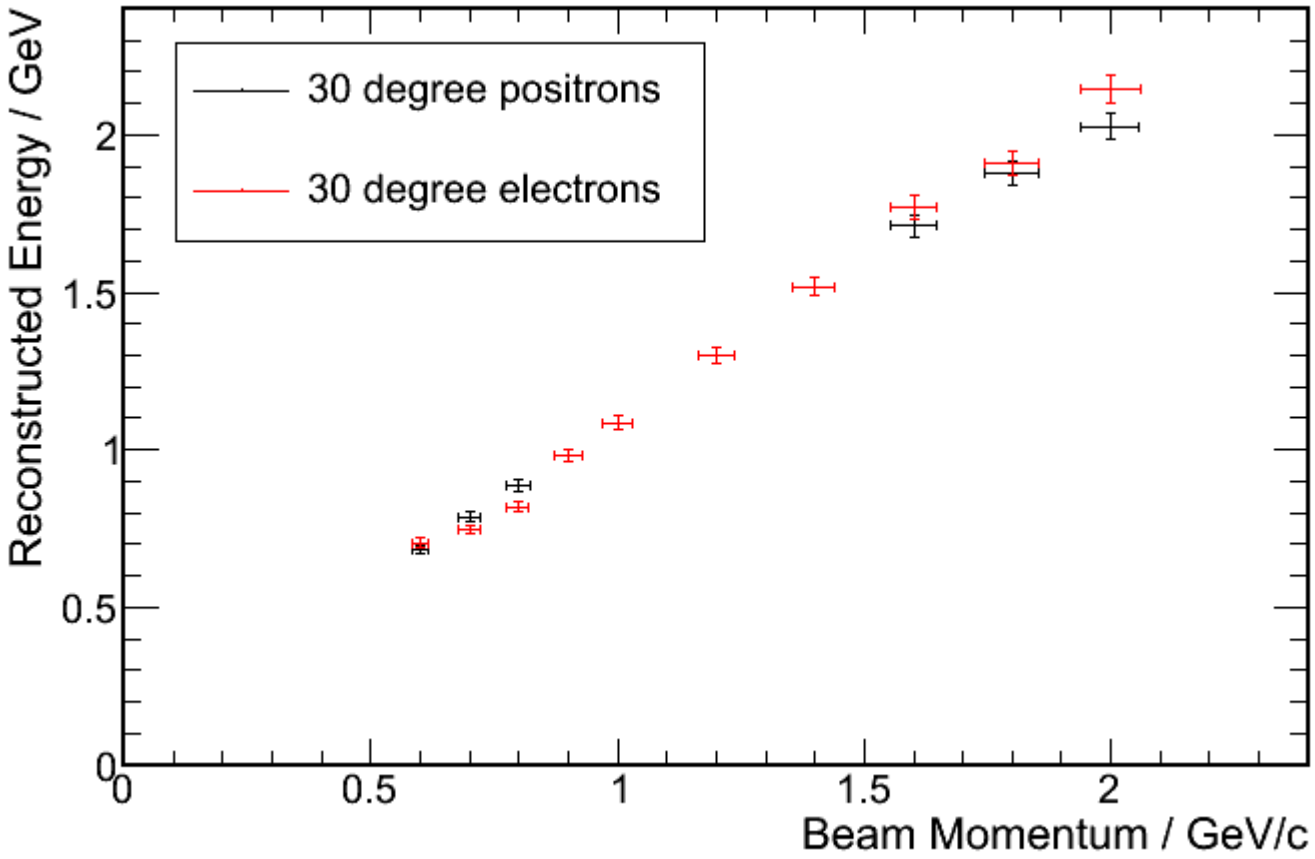
Electrons and Positrons

Electrons and positrons at a 30° angle of incidence.



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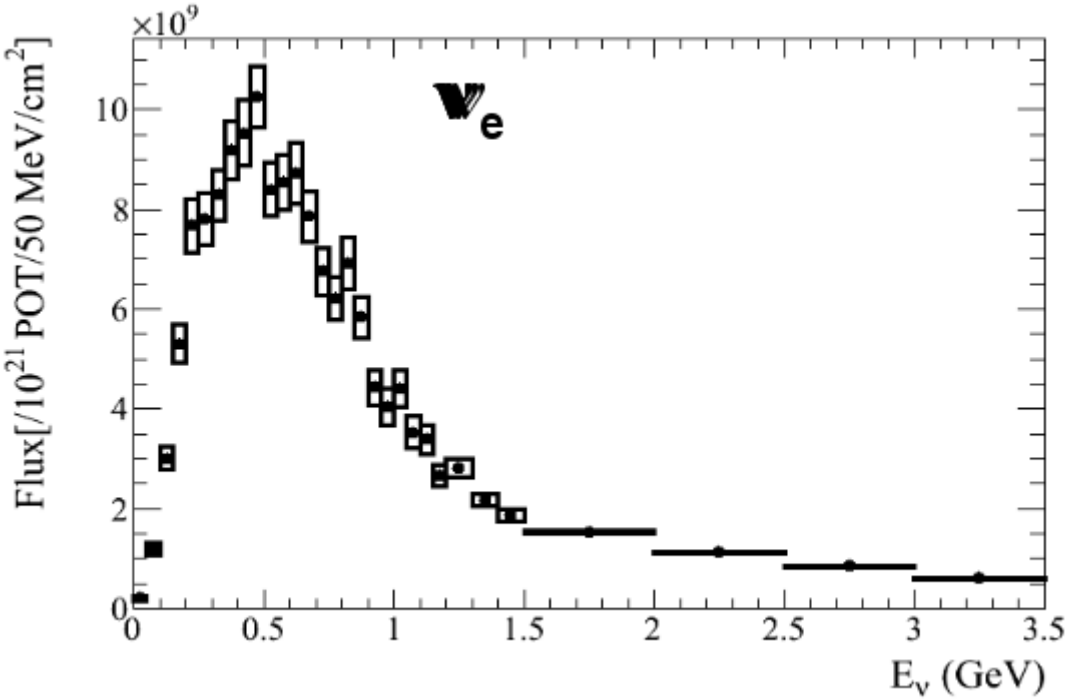
ND280 ν_e Spectrum

• Spectrum of the electron neutrino component of the beam at the near detector.



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ECal PID

- Tuned the PID using the development release v9r1.
  - DsECal and Barrel ECals.
  - Electrons, Photons, Muons and Pions.
  - 0, 20, 40, 60 and 80 degrees
- Five variables go into making the Track-Shower output:
  - AMR – Ratio of major to minor axes from PCA Analysis
  - Max Ratio – Ratio of highest to lowest layer charge.
  - EM Likelihood – Likelihood from the energy fitter
  - ShowerAngle – Opening angle of the shower
  - ShowerWidth – Maximum width of the shower