Endcap Hadronic Testbeam Data Analysis

Preliminary Electron and Pion Results from April 1998

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May 7, 1998

Outline

- Electron Analysis
  - the data
  - clustering, energy reconstruction
  - response
  - energy resolution
- Pion Analysis
  - the data
  - clustering, energy reconstruction
  - calculating the hadronic scale
  - energy resolution

The Data

- Electron data were analysed at 4 different impact points:
  - Point D: $x = -100$ mm $y = +83$ mm
  - Point E: $x = +100$ mm $y = +83$ mm
  - Point H: $x = -100$ mm $y = -67$ mm
  - Point I: $x = +100$ mm $y = -67$ mm

Energy (GeV)	point D Run #	point E Run #	point H Run #	point I Run #
20	7353	7350	7352	7351
40	7298	7291	7295	7294
60	7255	7259	7253	7260
80	7299	7311	7303	7309
100	7334	7341	7330	7342
120	7065	7088	7071	7079

- Results presented here are only from point H, but results from all impact points are consistent.

Electron Analysis

Clustering, Energy Reconstruction

- A three cell cluster was chosen to reconstruct the energy of the electrons; the hit cell in the first depth and two cells in the second depth are shown in the cell map in Figure 1.
- Using this cluster, the energy was reconstructed and fit in a $\pm 3\sigma$ range for each run, as shown in Figure 2.
- Determination of the global electromagnetic scale (α_{em}) was done by minimizing the following χ^2

$$\chi^2 = \sum_{\mathrm{runs}} \frac{\left(\alpha_{\mathrm{em}} \langle E_{\mathrm{cl}}(\mathrm{adc}) \rangle - E_{\circ}\right)^2}{\sigma^2}$$

where $\langle E_{\mathrm{cl}}(\mathrm{adc}) \rangle$ is the average from the fits shown in Figure 2.

This results in a value of $\alpha_{\mathrm{em}} = 0.108$ GeV/adc.

Electron Analysis

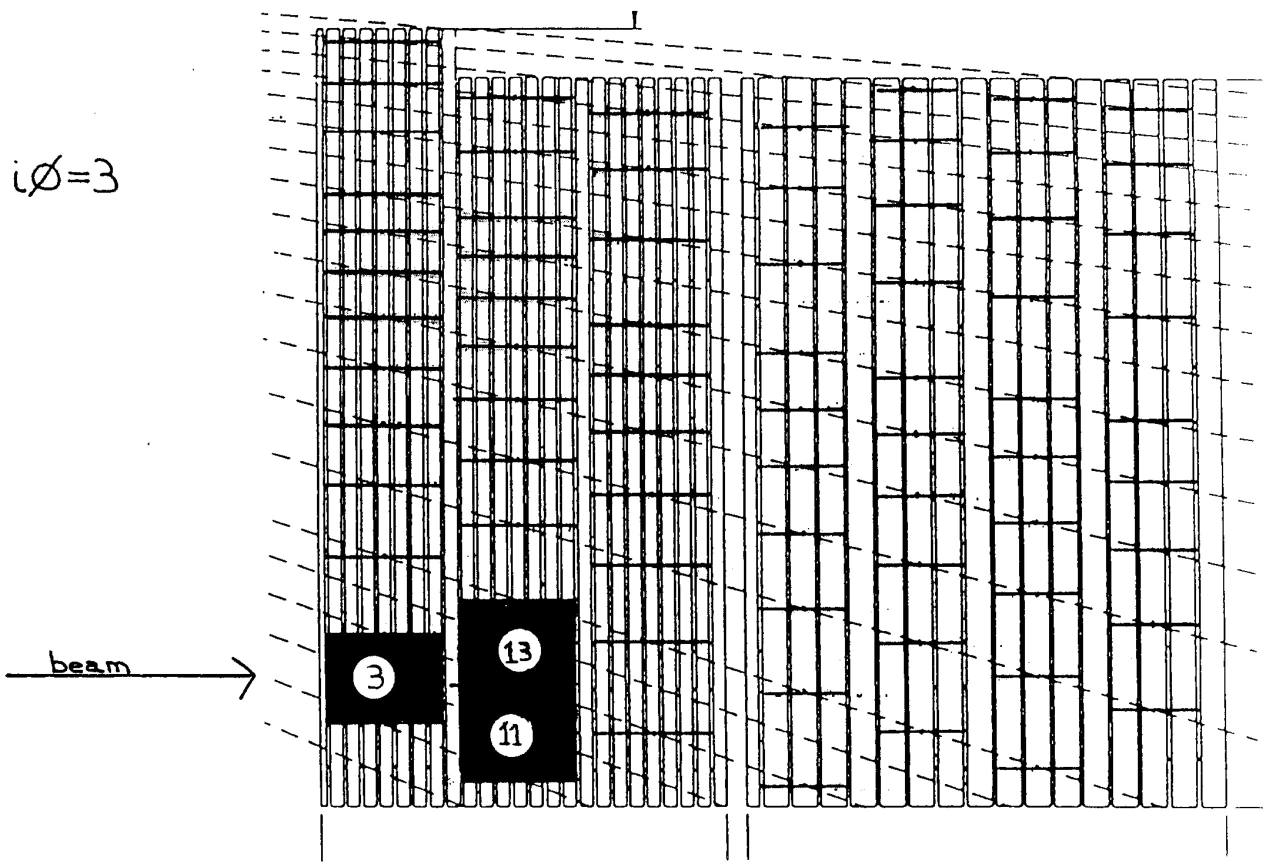

Figure 1: Map of cells used in electron clusters.

Electron Analysis

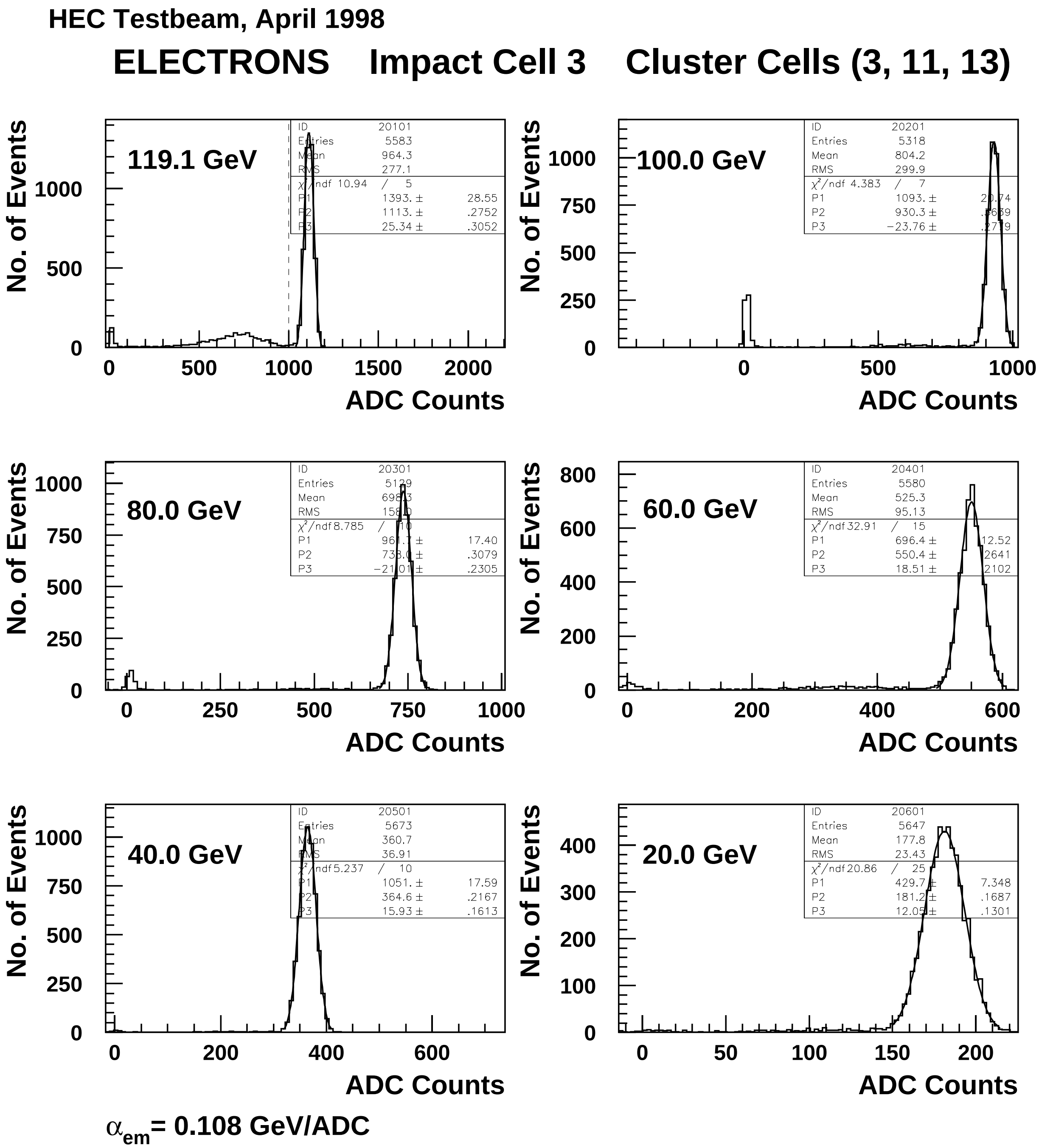

Figure 2: Electron cluster energy (uncalibrated data).

Response

- Using $\alpha_{\rm em} = 0.108$ GeV/adc, we obtain the response plot shown in Figure 3. The response uniformity is improved by the calibration.

Electron Analysis

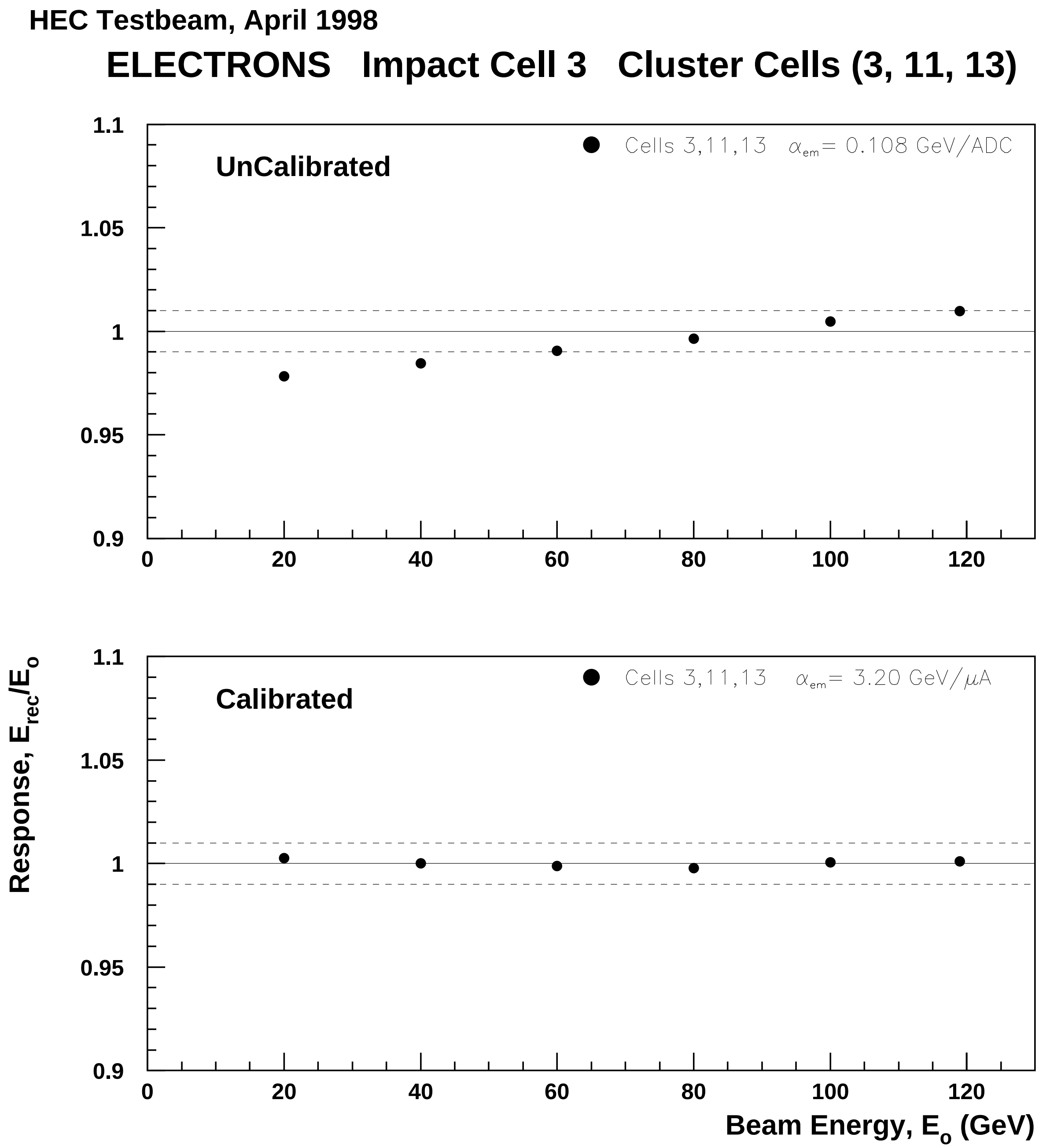

Figure 3: Electron response of calorimeter vs. energy.

Energy Resolution

- Fit energy resolution to usual parametrisation:

$$\frac{\sigma}{E} = \frac{\alpha}{\sqrt{E_\circ}} \oplus \beta \oplus \frac{\gamma}{E_\circ}$$

- Fit this function with either two or three parameters free. To fix the third parameter, the cell noise was assumed to be uncorrelated and was added in quadrature within the chosen cluster. This does not exactly reflect the noise induced in the electron cluster by the cubic fit, but is a good approximation.

- Results of these fits are shown in Figures 4 and 5. For the 2 parameter fit we obtain (calibrated case):

$$\frac{24\%}{\sqrt{E_\circ}} \oplus 0.0\% \oplus \frac{0.77 \text{ GeV}}{E_\circ}$$

For the three parameter fit:

$$\frac{24\%}{\sqrt{E_\circ}} \oplus 0.0\% \oplus \frac{0.79 \text{ GeV}}{E_\circ}$$

- Within errors, the energy resolution obtained is the same for calibrated and uncalibrated data.

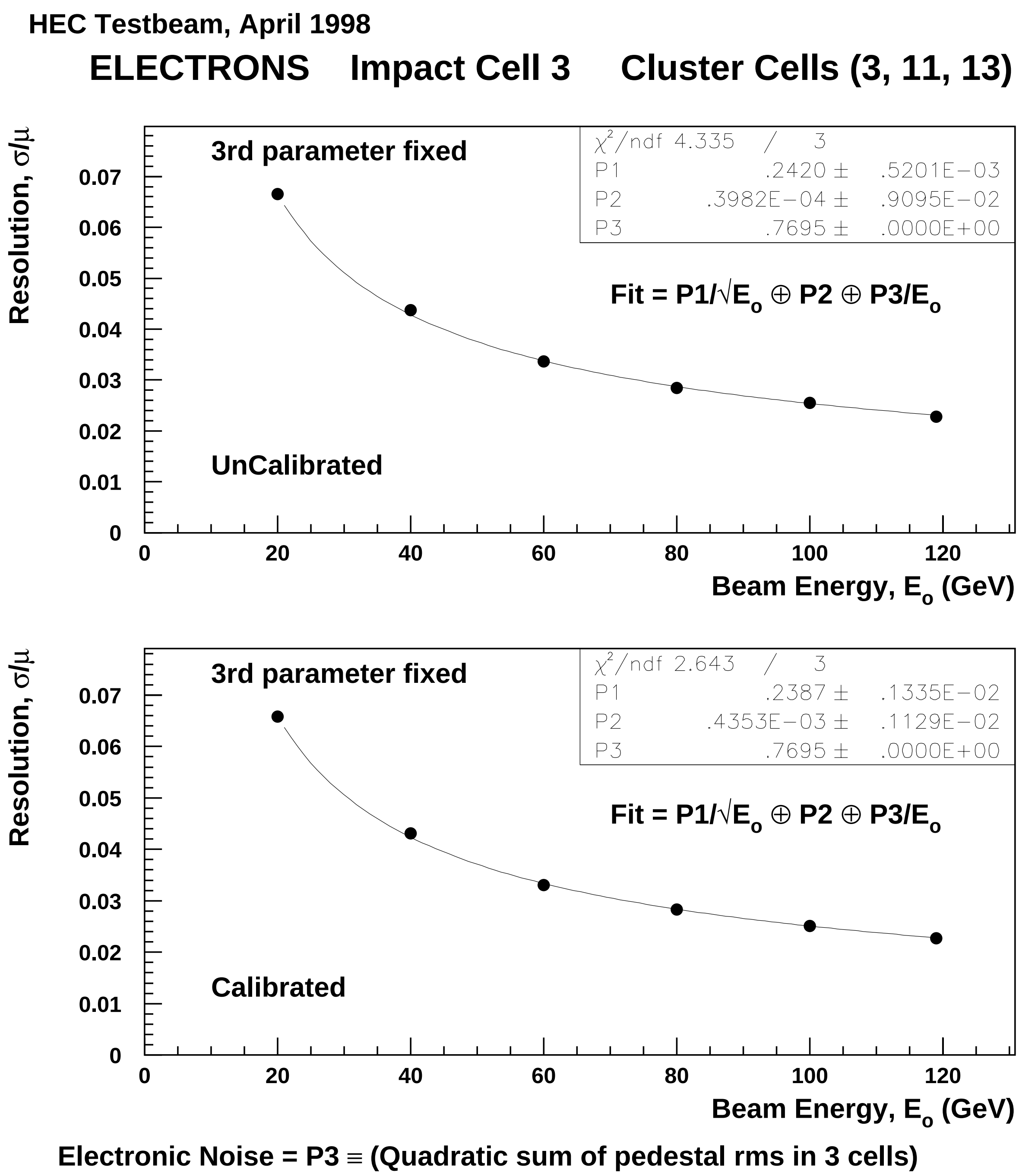

Figure 4: Electron energy resolution with one parameter fixed.

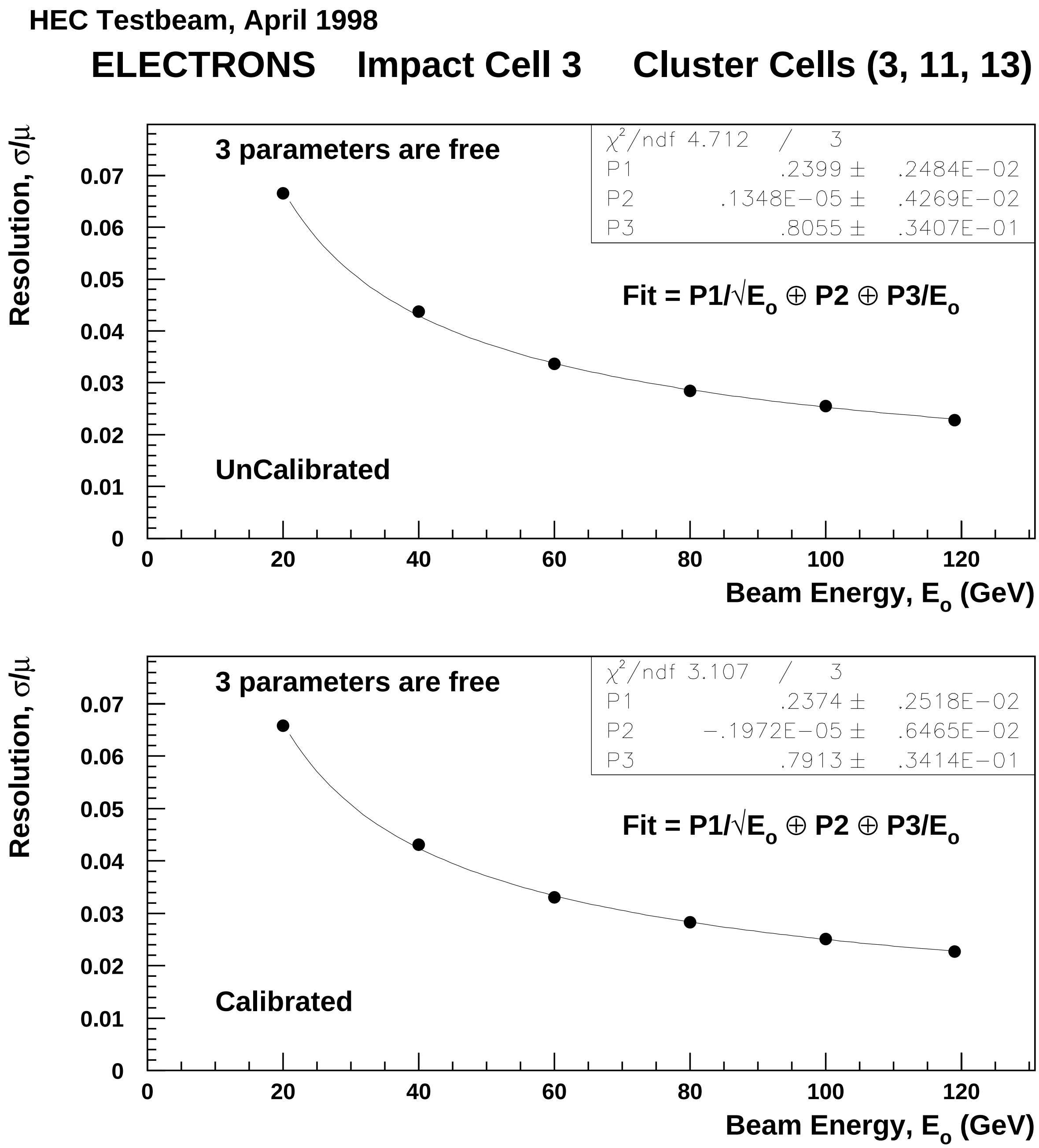

Figure 5: Electron energy resolution with 3 free parameters

The Data

- Pion data at impact point H was analysed:
  - Point H: $x = -100$ mm $\qquad y = -67$ mm

Energy (GeV)	point H Run #
20	7369
40	7296
60	7280
80	7304
100	7331
120	7182
180	7356

- The 20 GeV run (7369) is not included in any of the results presented here. This energy point requires more study and work is ongoing.

Clustering and Energy Reconstruction

- A 19 cell cluster was used. The map of the chosen cells is shown in Figure 6.
- The signal peak was found using a the hec_adc cubic fit package with corrections to more properely treat low energy cells. The maximum time slice is constrained to be between the 7th and 9th and if the signal in a cell is below a given threshold, the value of the height of the 8th time slice is used instead of the cubic fit result. This is an attempt to remove biases injected by the peak-finding method (always giving positive signals for cells with zero energy).
  We are looking forward to a digital filtering signal reconstruction!
- Only events that were physics triggers, not muons triggers and not random triggers were included in the energy reconstruction shown in Figure 7.

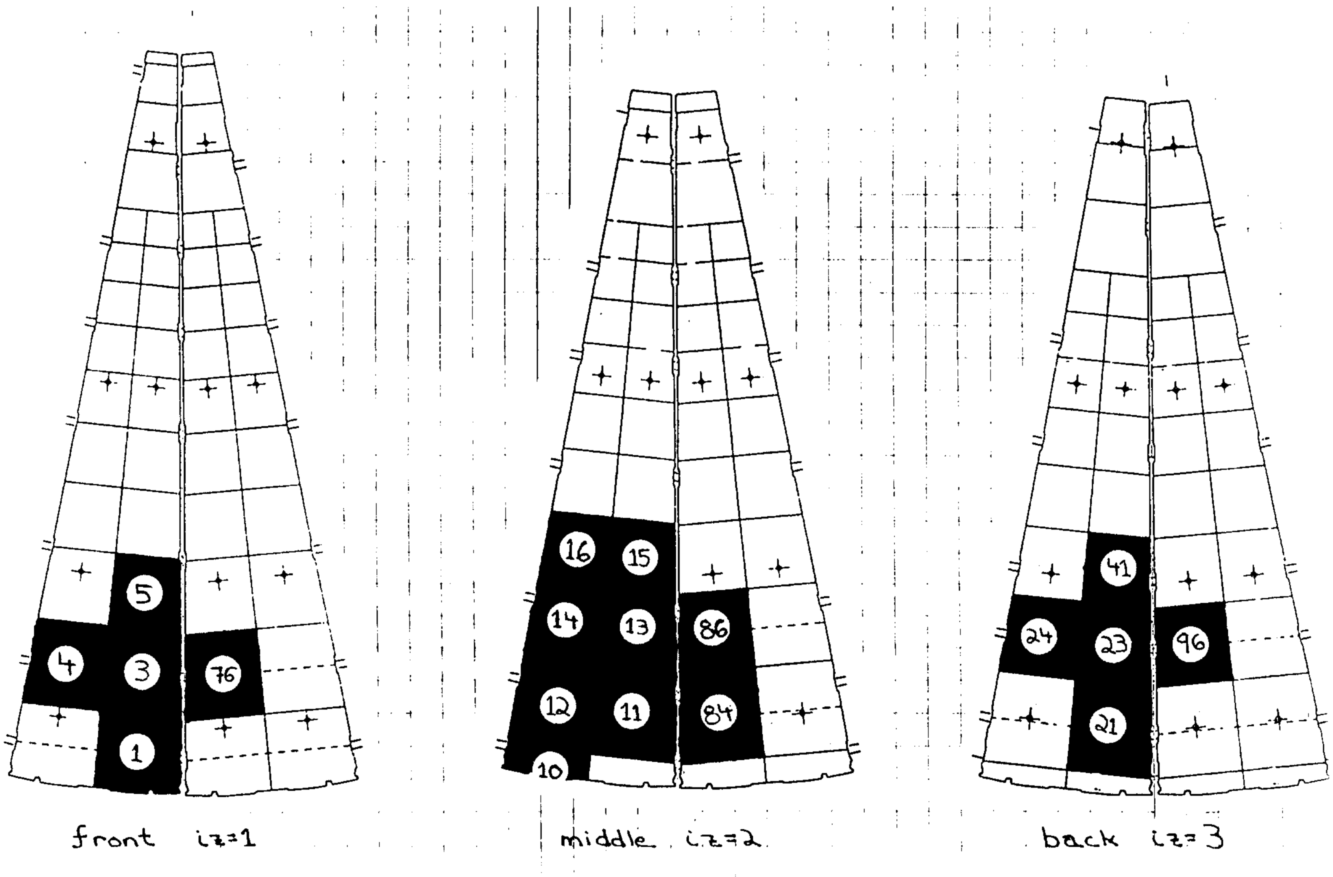

Figure 6: Map of chosen pion cells for point H.

Pion Analysis

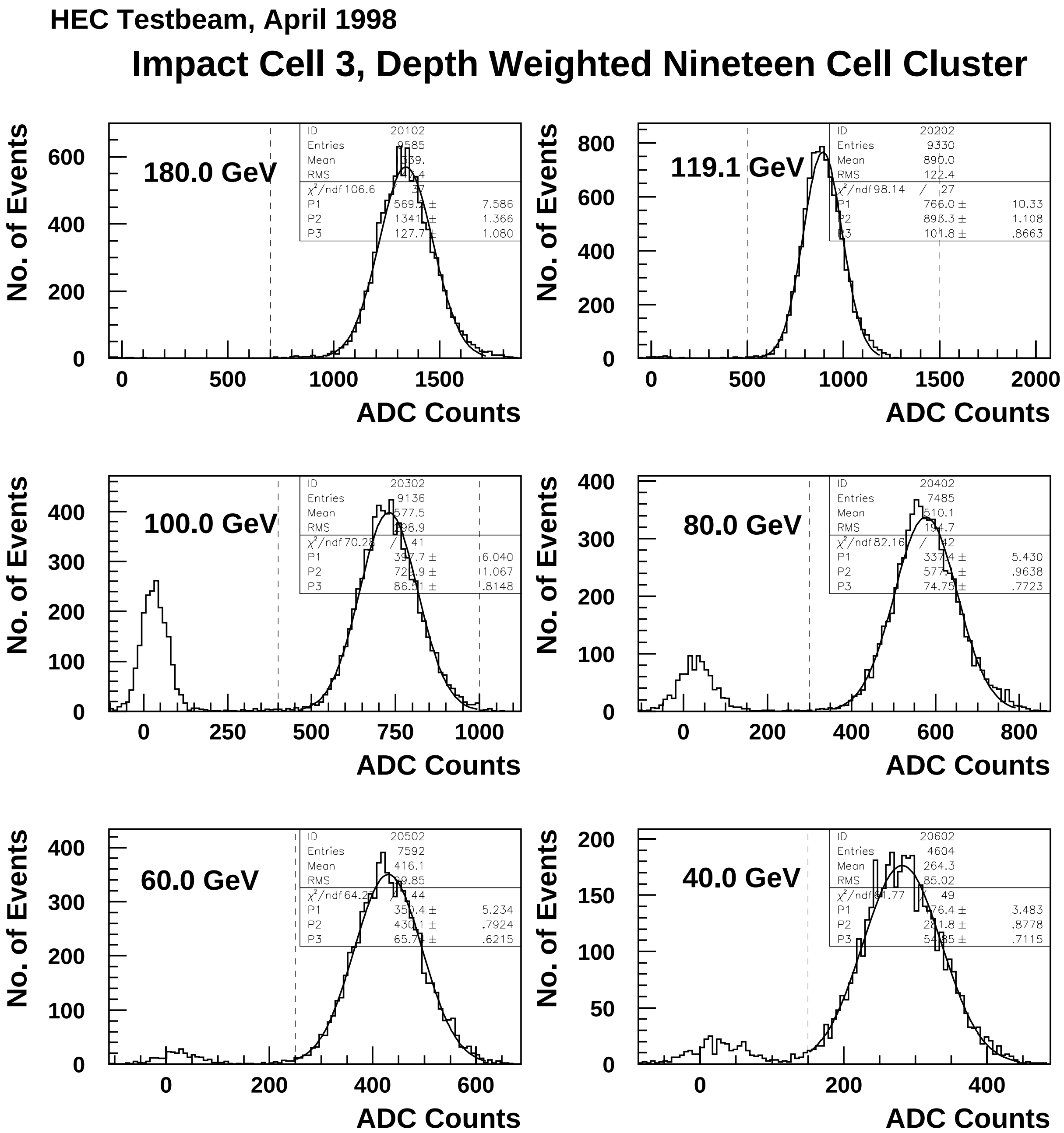

Figure 7: Pion cluster energy (uncalibrated data).

Pion Analysis

Calculation of the Hadronic Scale ($\alpha_{\mathbf{had}}$)

- First a global α_{had} was calculated using the same minimization procedure as for electrons (described previously). This gives a global constant of: $\alpha_{\text{had}} = 0.137$ GeV/adc.
- To compensate for the fluctuations of hadronic showers with depth, one weight for each depth (c_z) was calculated by minimising the following equation for each energy:

$$\sum_{\text{runs}} \frac{\left(\alpha_{\text{had}} \left\langle \Sigma_z \, c_z E_{\text{cl}}^z(\text{adc}) \right\rangle - E_\circ)\right)^2}{\sigma^2}$$

  Typical depth weights were 0.9, 0.95, 2.2

- Using the global α_{had} to set the scale, the calorimeter's response to pions is shown in Figure 8.

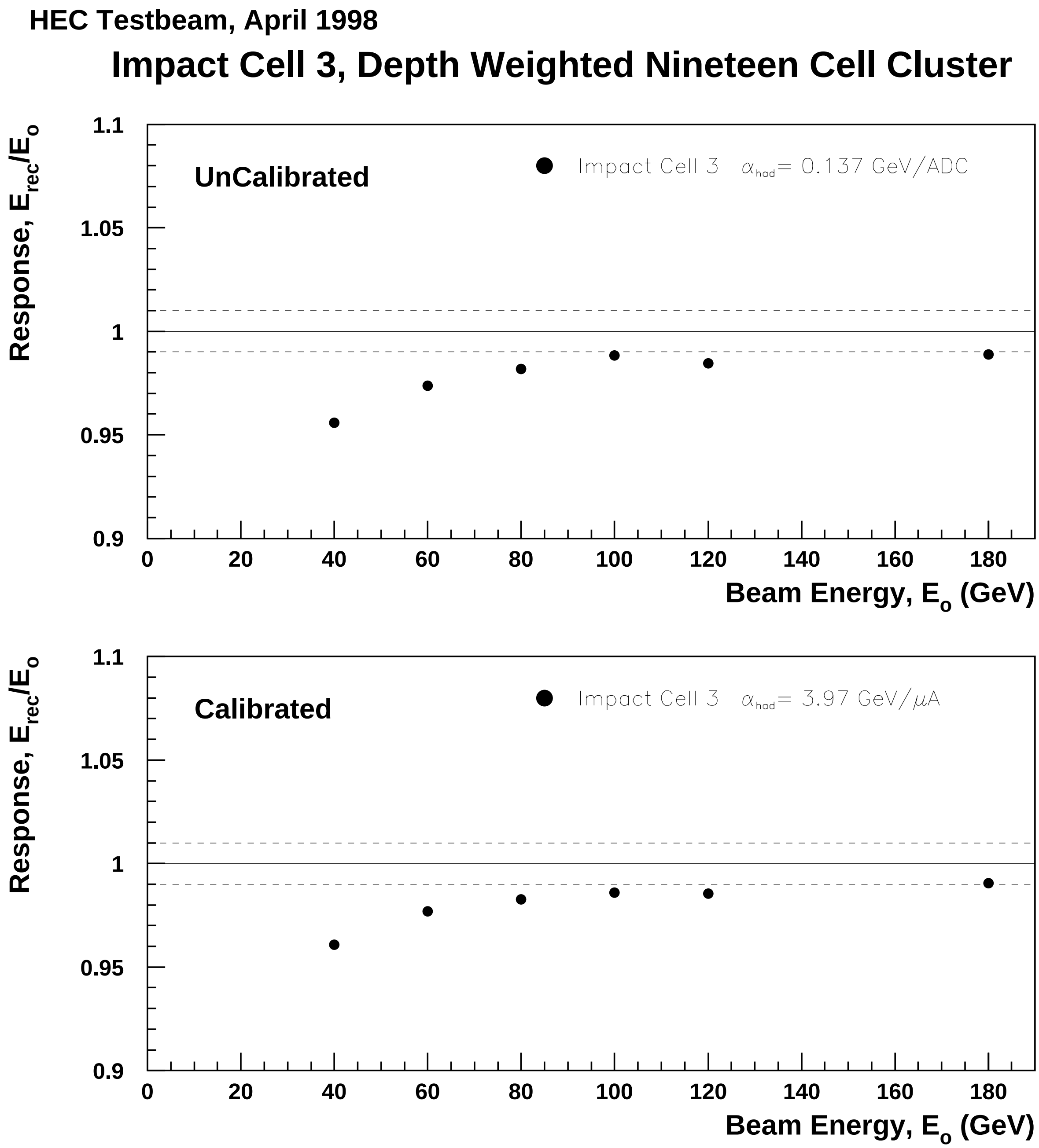
HEC Testbeam, April 1998
Impact Cell 3, Depth Weighted Nineteen Cell Cluster
UnCalibrated
Impact Cell 3 α_{had}= 0.137 GeV/ADC
Response, E_{rec}/E_o
Beam Energy, E_o (GeV)
Calibrated
Impact Cell 3 α_{had}= 3.97 GeV/μA
Response, E_{rec}/E_o
Beam Energy, E_o (GeV)

Figure 8:

Energy Resolution for Pions

- Still some bias in response shape. More investigation required
- Signal finding method used not adequate for low signals. This causes the large peak for the empty events that somehow survive the trigger cuts
- The 20 GeV data suffers heavily from these effects, all this requires more study.
- Results of the resolution fits with 3 free parameters are shown in Figure 9. For the calibrated data case, we obtain

$$\frac{94\%}{\sqrt{E_\circ}} \oplus 4.5\% \oplus \frac{4.6\ \mathrm{GeV}}{E_\circ}$$

Pion Analysis

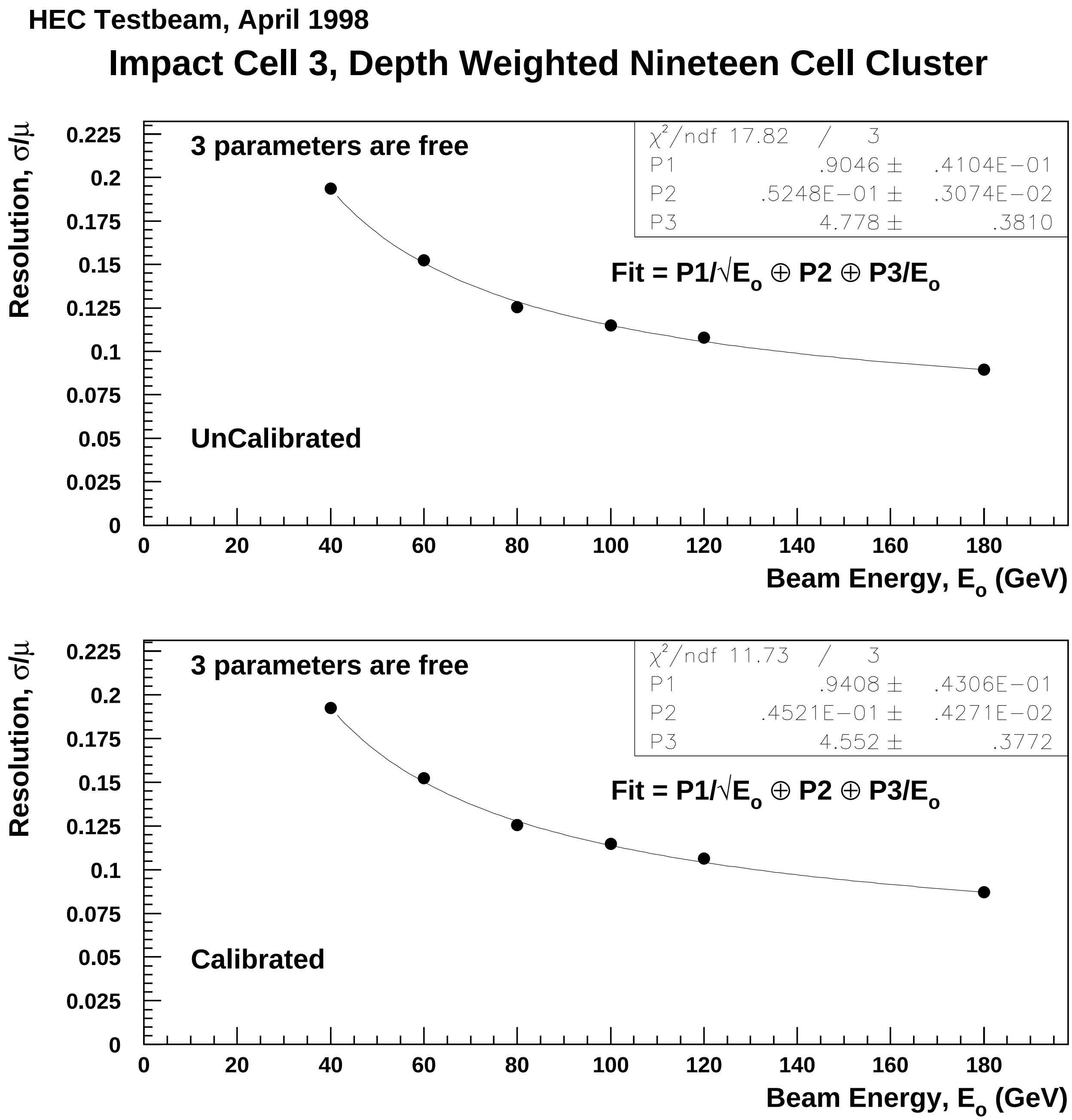

Figure 9: