Electron and Pion Data Analysis

August 1999 Beam Test

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Abstract

Outline

- Analysis Procedure
- Electronic Noise Studies
  - Electronic noise in cells
  - Electronic noise in clusters
  - Asymmetry of distribution
  - Investigations and hypothesis
  - Correction and effect on response
- Electron Beams Results
  - Resolution
  - Comparison with Monte Carlo
  - Effect of tie-rod observed via Y-scan
  - Calibration problems observed via X-scan
- Pion Beams Results
  - Resolution
  - Comparison with Monte Carlo
- Conclusions

Analysis Procedure

Procedure used for this Analysis

- Pedestals computed on the 1st time sample over all physics events
- Digital Filtering used (over first 5 time samples for electronic noise analysis)
- Analysis was done in nA
- 12/10/99 Calibration files
- HV correction factors to account for dead subgaps :
  - 4.0/3.0 for module 1, layer 2
  - 4.0/3.0 for module 2, layer 4
  - 4.0/2.0 for module 3, layer 2
  - 4.0/3.0 for module 3, layer 4
- Correction factor of 2.0 applied to cell #61
  (This applies only for run number greater than 8605)
- Dead cell #91 was not used

Analysis Procedure

Monte Carlo Samples:

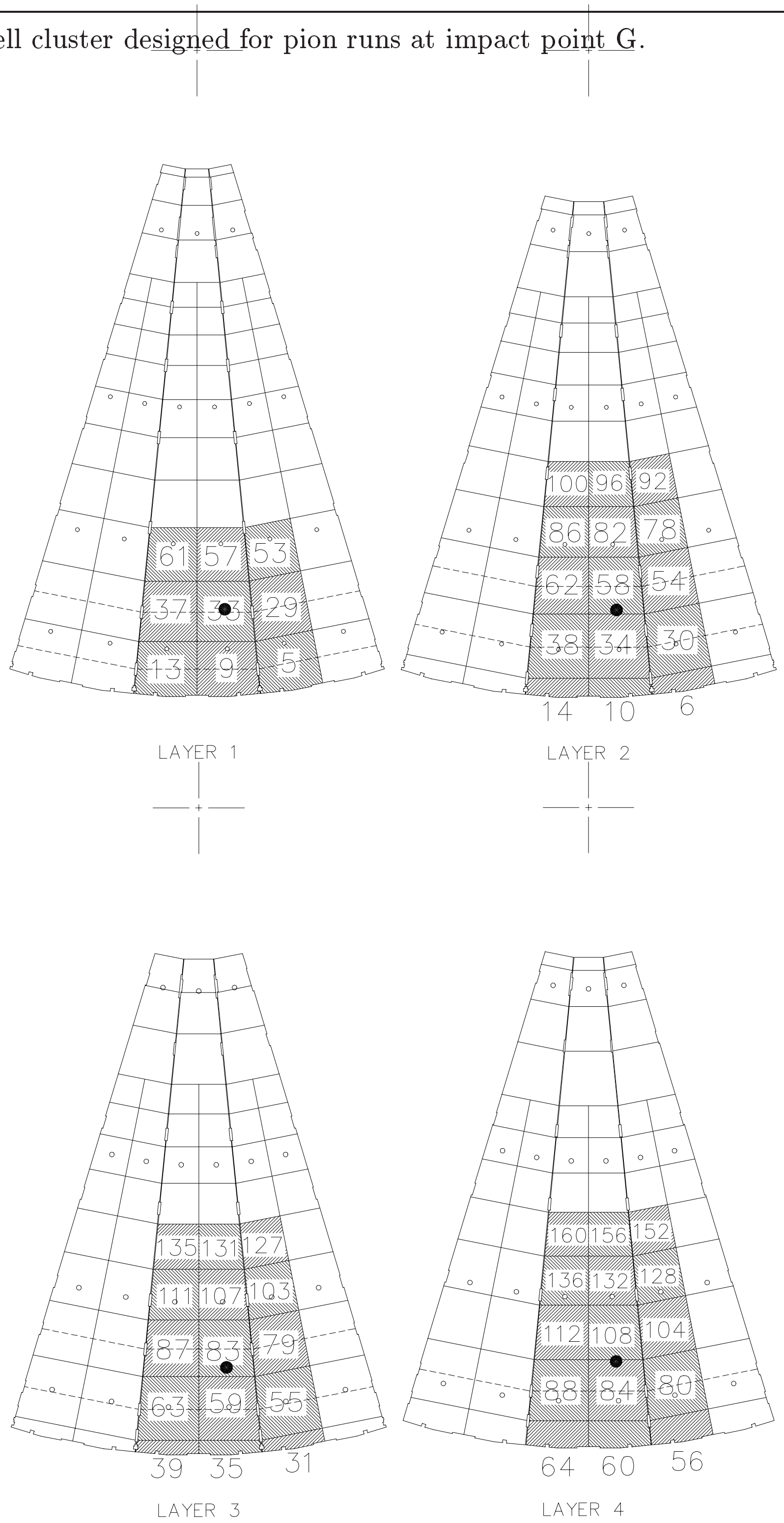
- HEC-BEAM 3.1 simulated events for August 1999 beam test was used (Thanks to A. Kiryunin)
- 2000 events for each Monte Carlo electron run
- 4000 events for each Monte Carlo (G-CALOR) pion run
- ZEBRA Monte Carlo files translated to HBOOK format with a structure identical to the output of HEC ADC

Beam Test and Monte Carlo Analysis:

- Same software used for beam test and Monte Carlo
- 9 cell clusters were used for the analysis of beam test and Monte Carlo electrons (12 at impact C)
- 53-54 cell clusters were used for the analysis of beam test and Monte Carlo pions

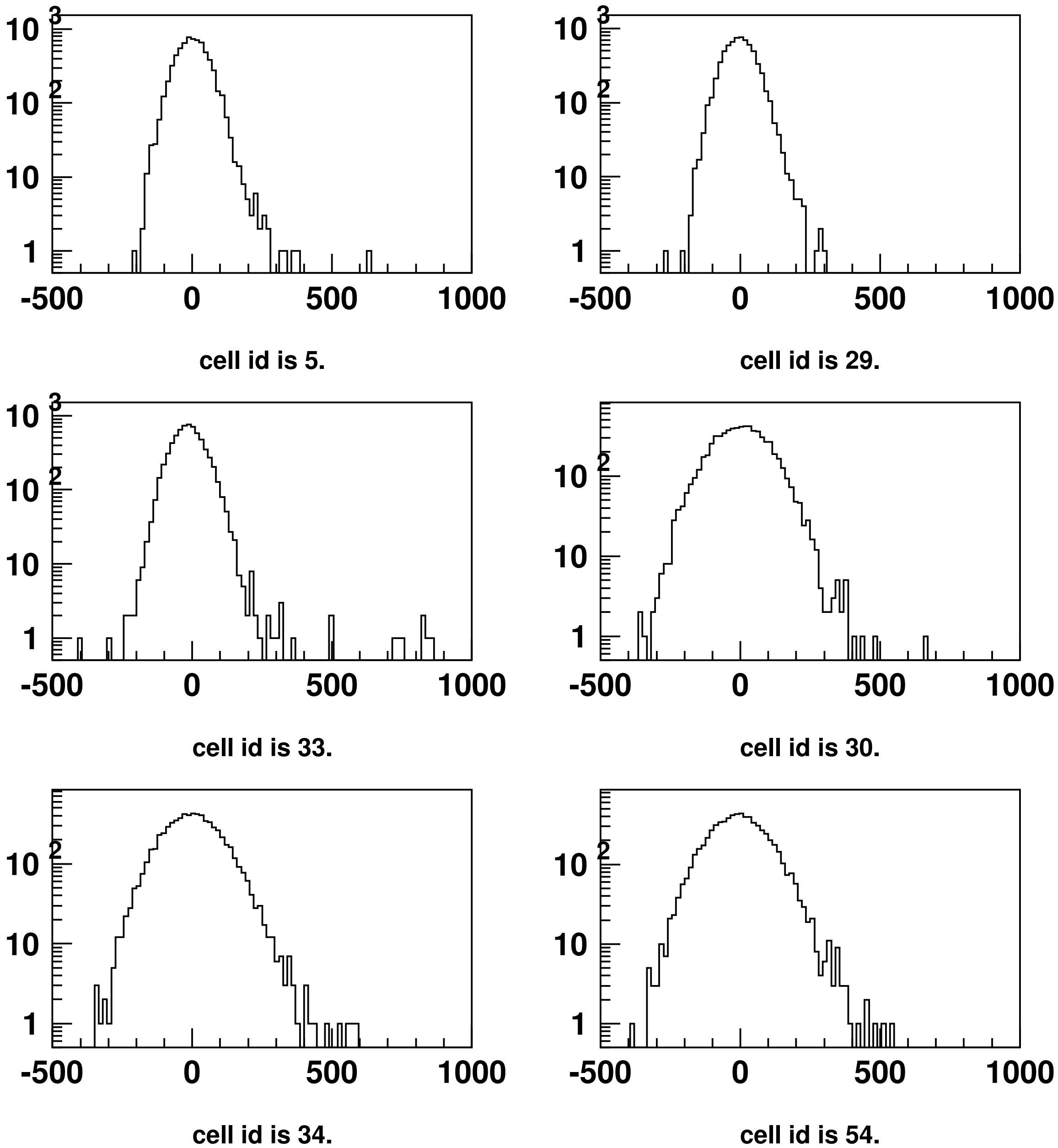
Analysis Procedure

Distribution of a 54 cell cluster designed for pion runs at impact point G.



Electronic Noise Studies

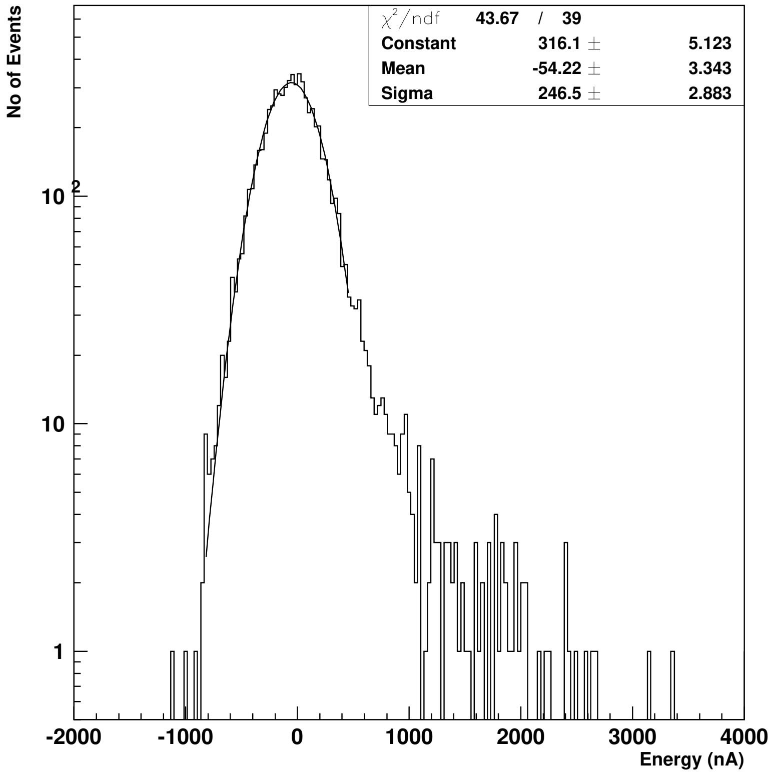
Cell electronic noise for run 9011 (10 GeV electrons):



- Non-gaussian positive tails observed.
- Most probable value non-zero.

Electronic Noise Studies

Cluster electronic noise for run 9011 (10 GeV electrons):

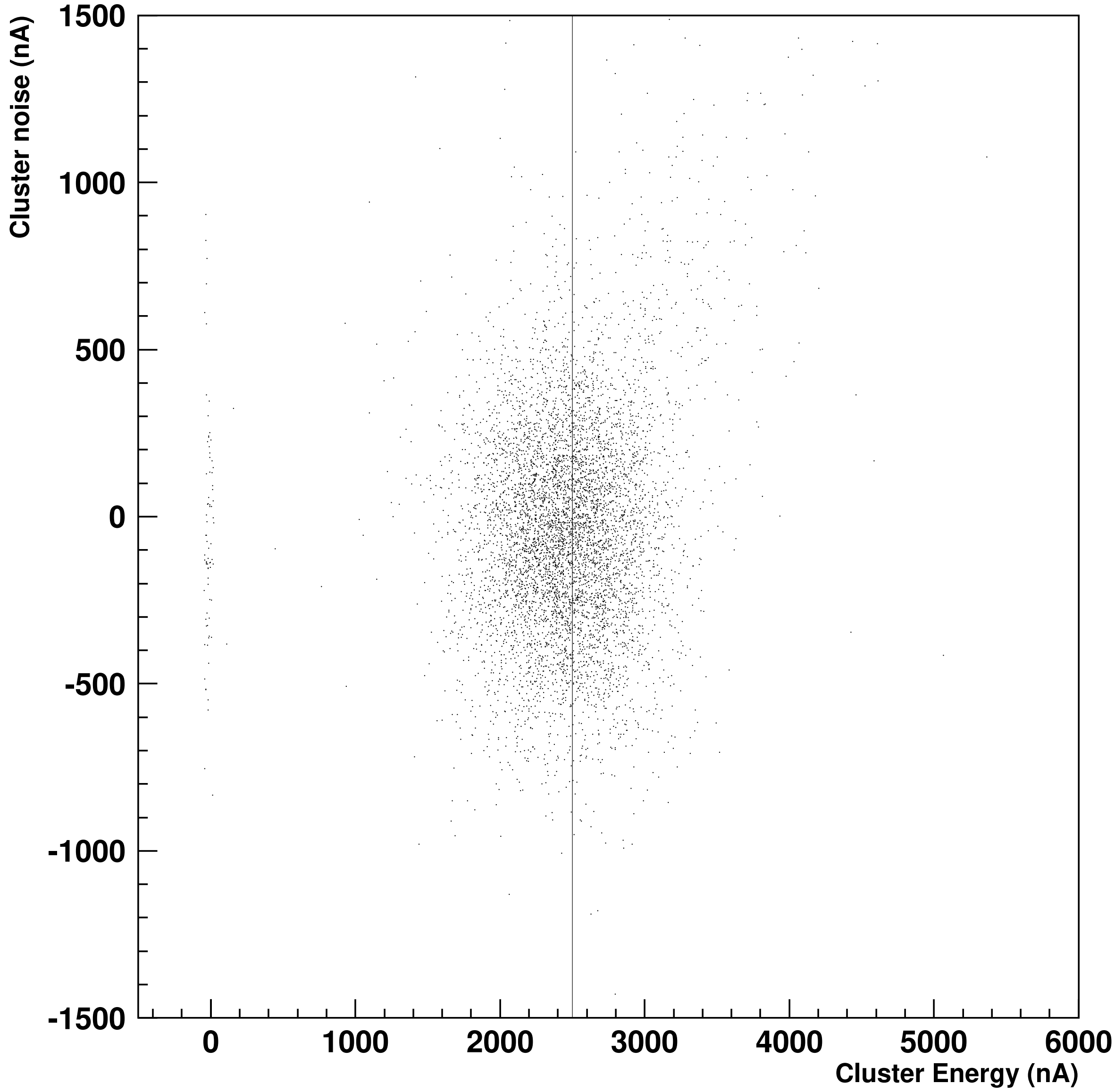


Fit performed on interval -3σ to +2σ

- Non-gaussian positive tails observed
- Most probable value non-zero
- Cluster noise and cell noise distribution are found to be truly gaussian on the negative side

Electronic Noise Studies

Electronic noise vs energy for cluster, run 9011 (10 GeV e^-):



Vertical line denotes average electron signal

- Correlation between high electronic noise and high signal (energy) in the cluster

Electronic Noise Studies

Summary of the observations:

- Non-gaussian positive tails for the electronic noise distribution for most cells

- Most probable current for individual cells is found to be between -20 and 0 nA (within errors)

- The non-gaussian positive right tails of cells noise are found to be correlated and result in a non-gaussian positive tail in the cluster noise

- Most probable current for 9 cell (electron) clusters is found to be between -300 and 0 nA (within errors) [1]

- Most probable current for 54 cell (pion) clusters is found to be between -2400 and 200 nA [2]

- Correlations between high electronic noise and high signal (energy) in the cluster

[1] Problem for run 8679 (119 GeV at C)
[2] Problem for 120 GeV runs

Electronic Noise Studies

Investigations of possible causes of positive tails:

- Digital filtering not working properly?
  Same distribution observed when average signal over first 5 times samples is used to calculate the noise.

- Calibration related problems?
  Same distribution observed in ADC with or without digital filtering.

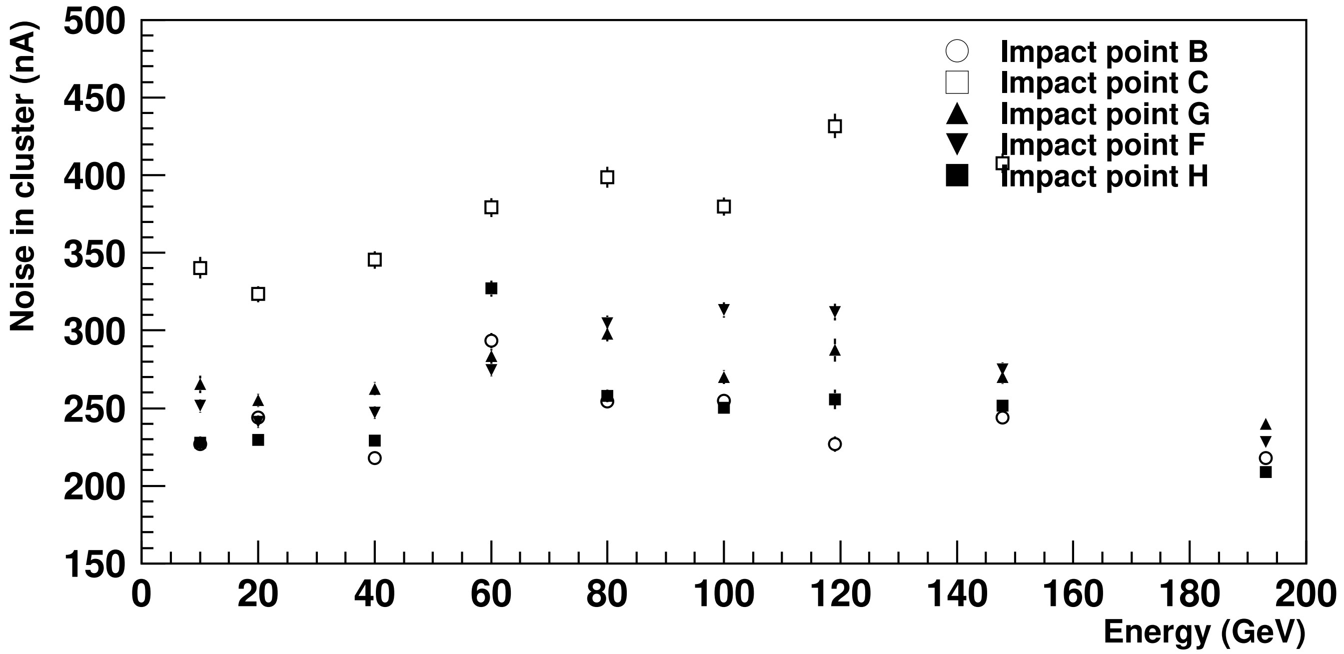
- Signal leakage in the 5th time sample?
  Removed events for which the signal in the 5th time sample was the greatest of the 5. Still same distribution observed.

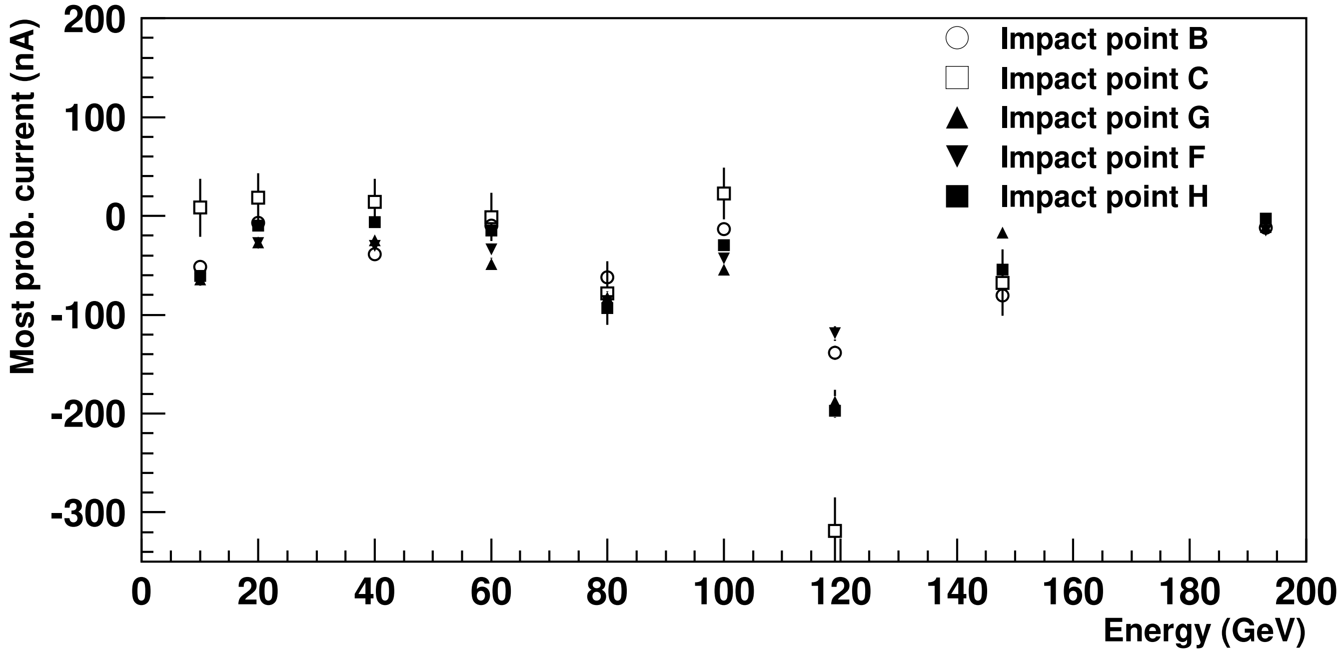
Our working hypothesis:
The positive non-gaussian tails in the distributions are caused by some positive signal picked-up by all time samples for many events.

To go around this problem in assessing the HEC intrinsic performance:
Use asymmetric gaussian fits to estimate most probable and σ of true distribution.

Electronic Noise Studies

Results from asymmetric gaussian fits for electron runs:

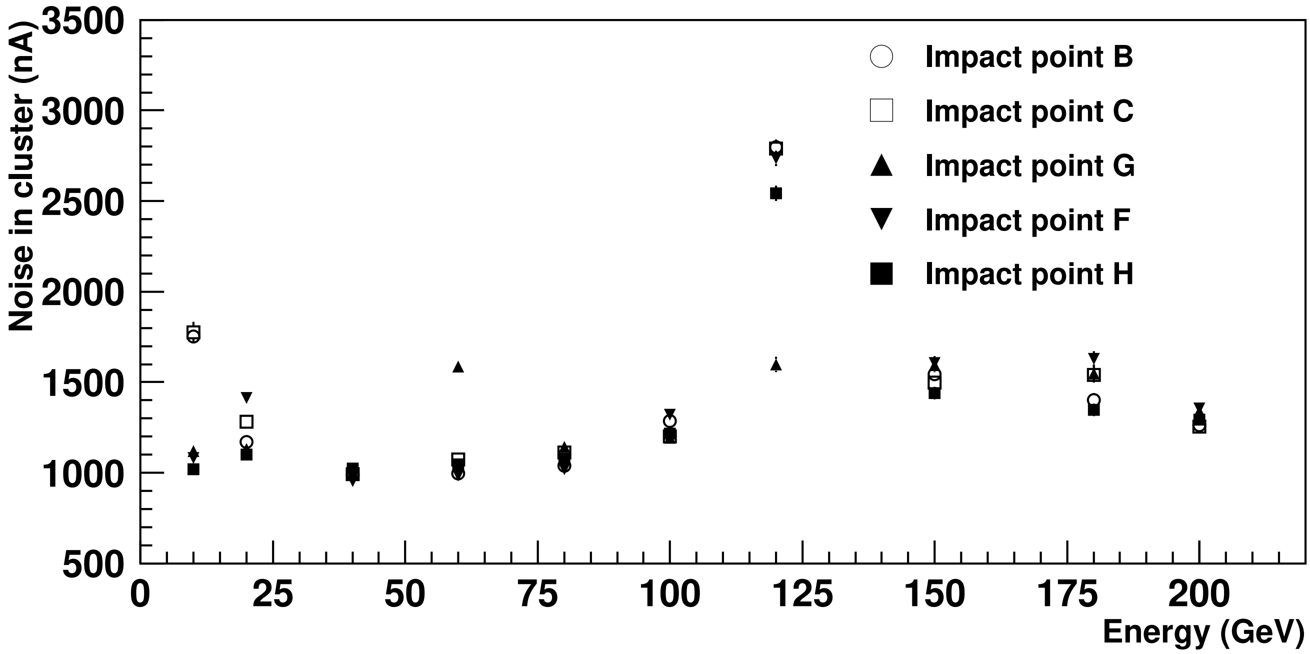


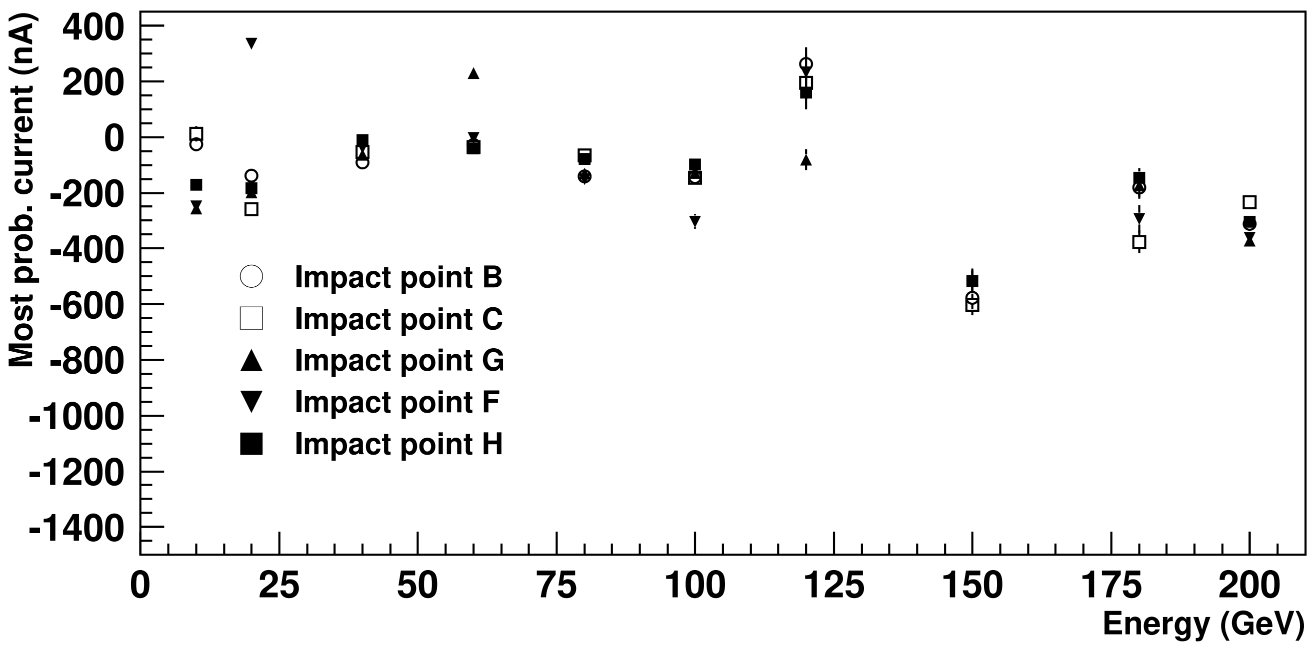


Electronic noise is time dependent

Electronic Noise Studies

Results from asymmetric gaussian fits for pion runs:





Electronic noise is time dependent

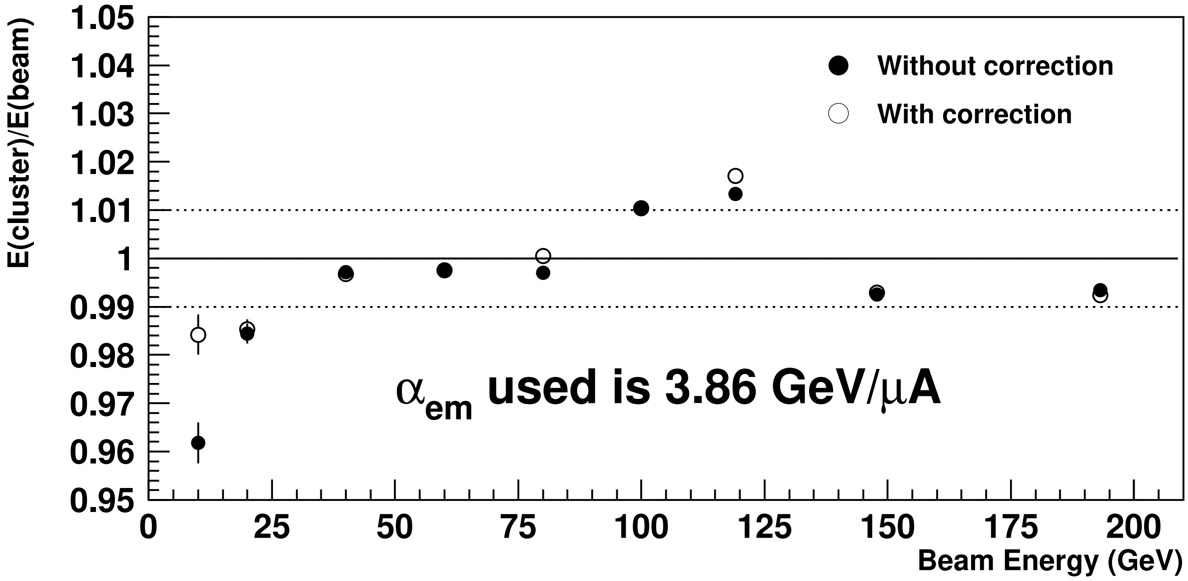
Electronic Noise Studies

Correction of the response from electronic noise observation:

- Most probable value for pedestal region signal is often negative because pedestals were overestimated due to the positive tails
- Ideally, the pedestals should be obtained from most probable pedestal region signal
- A very good approximation is done here: we correct the response using the cluster most probable current
- Expect effects only at low energy, or for run with severe asymmetric noise distribution
- Results are preliminary

Electronic Noise Studies

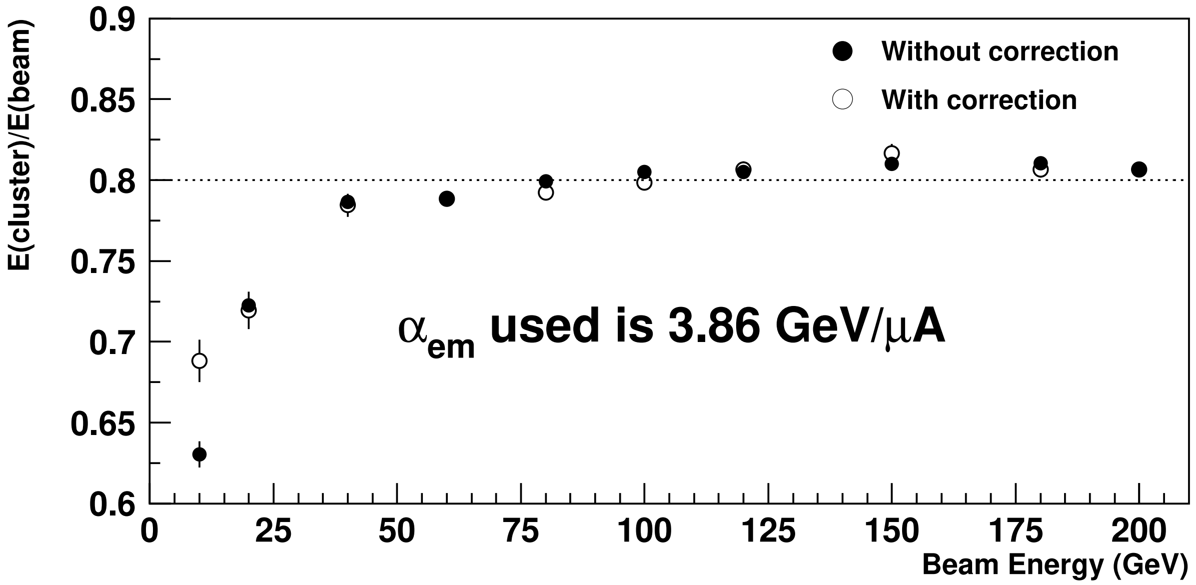
Results of correction on electron response:



- Increase response and improve linearity at low E
- Offset on the response is found to be smaller than previously:
  (30 ± 16) MeV vs (150 ± 15) MeV at H
- α_{em} does not change

Electronic Noise Studies

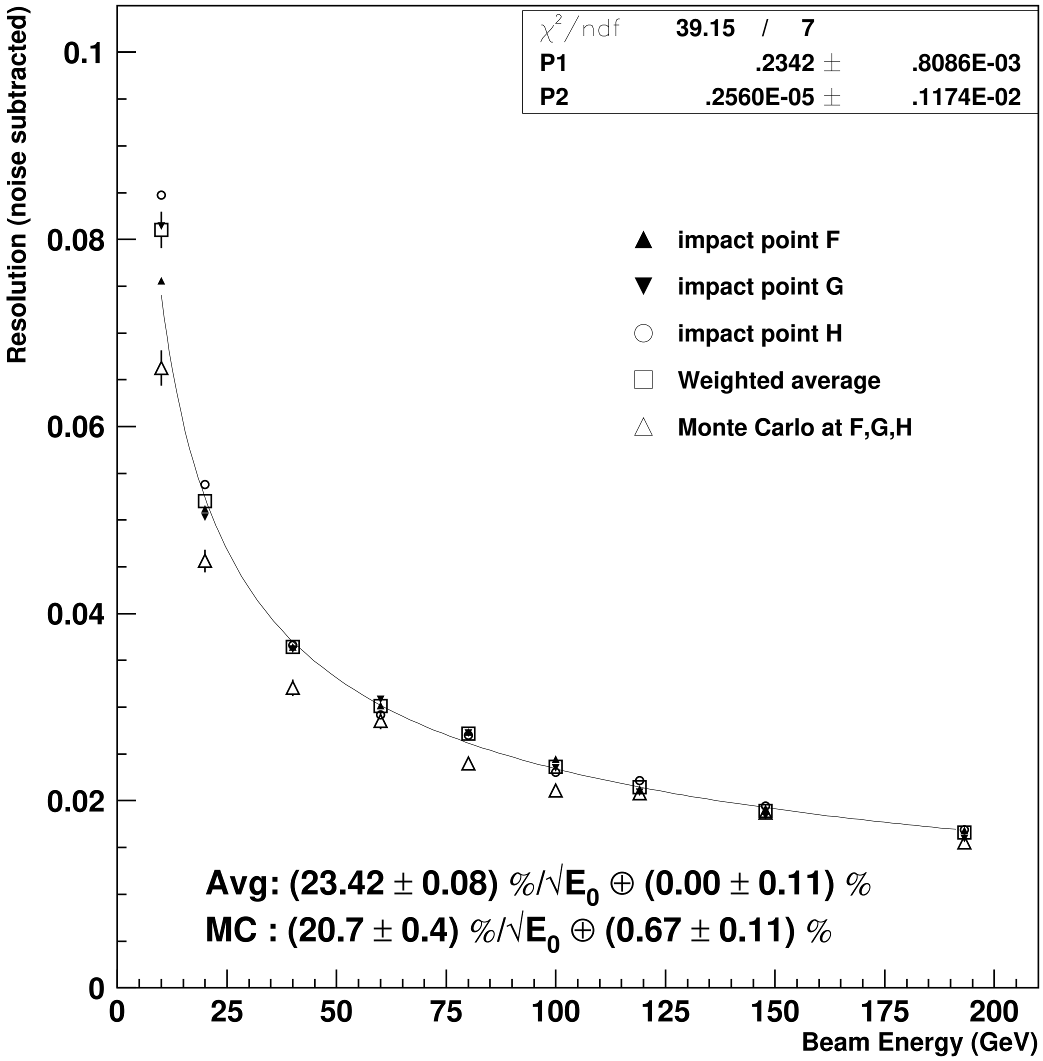
Results of correction on pion response:



- Increase response at low Energy

Electron Beams Results

Combined resolution for impacts F, G, and H :



Combined energy resolution (noise subtracted) vs. beam energy for electrons at impact F, G, and H. Error bars are calculated from the RMS deviation of the combined resolution at the impact positions.

Monte Carlo is found to give too good a resolution
Or perhaps quadrature subtraction of noise is not valid ?

Electron Beams Results

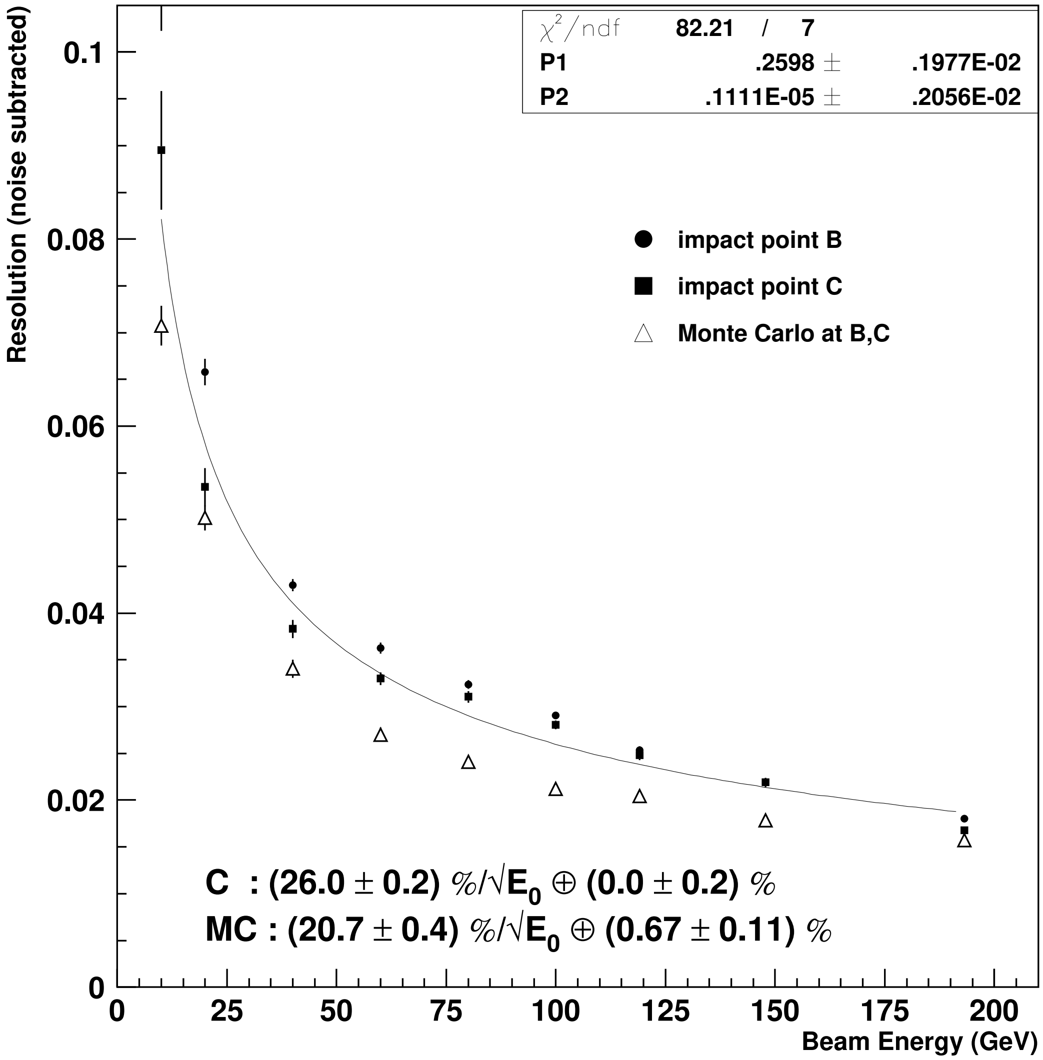
Resolution parameters for studied impacts:

Impact point	Sampling term (A) ($\%\sqrt{\text{GeV}}$)	Constant term (B) (%)	χ^2/ndf
B	27.5 0.2	0.00 0.2	58.7/7
C	26.0 0.2	0.0 0.2	82.21/7
F	23.54 0.17	0.0 0.6	16.31/7
G	23.10 0.14	0.0 0.13	33.56/7
H	23.59 0.15	0.0 0.4	25.37/7
Combined Avg at F, G and H	23.42 0.08	0.00 0.12	39.15/7
Monte Carlo at F, G and H	20.7 0.4	0.67 0.11	11.02/7
Monte Carlo at B and C	21.8 0.2	0.0 0.7	6.11/7

- Noise calculated from signal on the first 5 times slices (using digital filtering)
- Noise (σ) subtracted in quadrature
- Monte Carlo gives too good a resolution for all impact locations
- Resolution worse at B and C because of contiguity with tie-rods

Electron Beams Results

Resolution for impacts B and C:

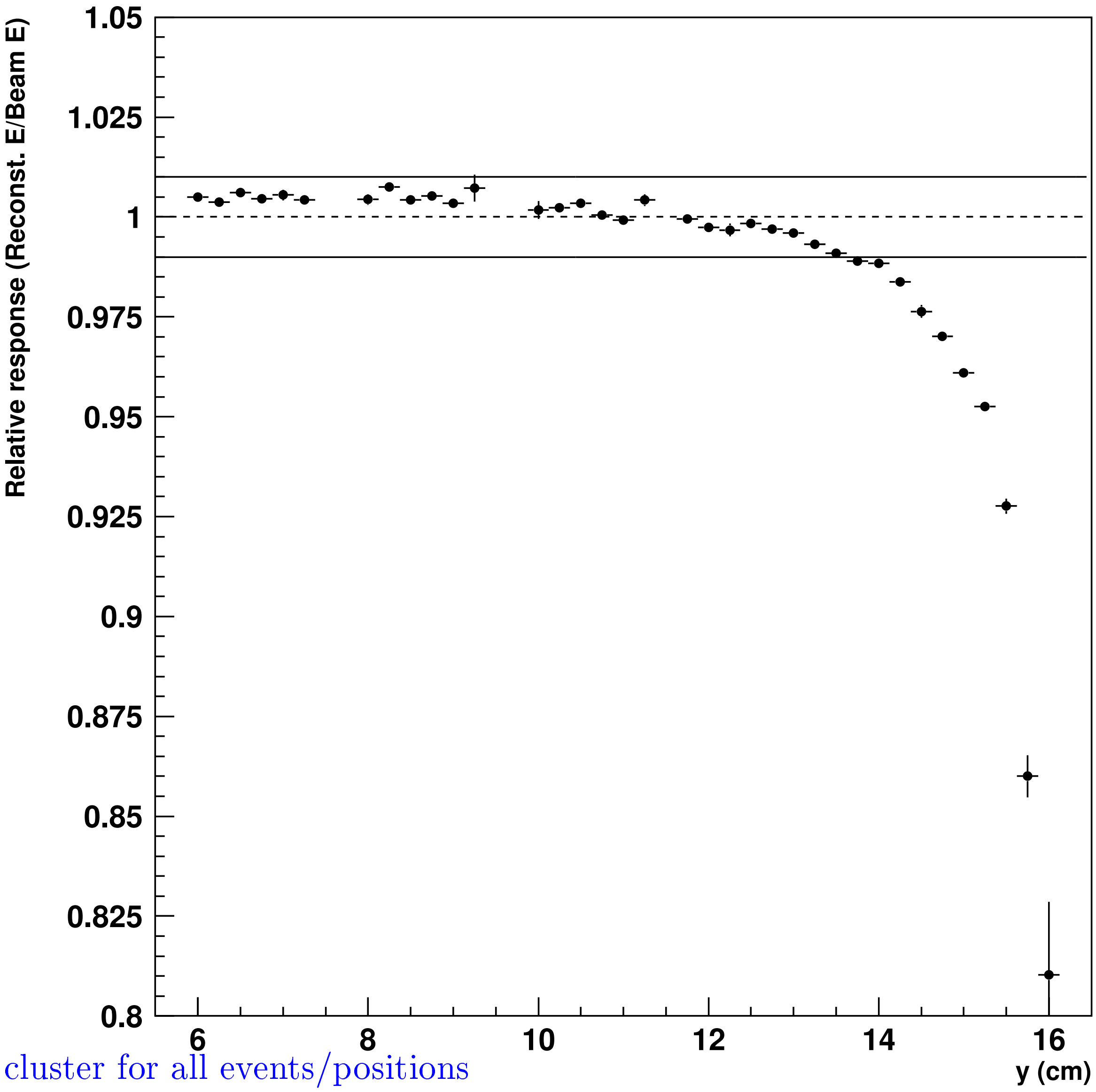


Energy resolution (noise subtracted) vs. beam energy for electrons. Fit performed for resolution at impact C only. Error bars are purely statistical. The resolution from Monte Carlo simulations is also displayed. Resolution for 10 GeV at B is 0.105

Resolution strongly disagree with Monte Carlo's due to contiguity of impacts B and C with tie-rods.

Electron Beams Results

Visible effect of tie-rod in the response using Y-Scan:



Same cluster for all events/positions

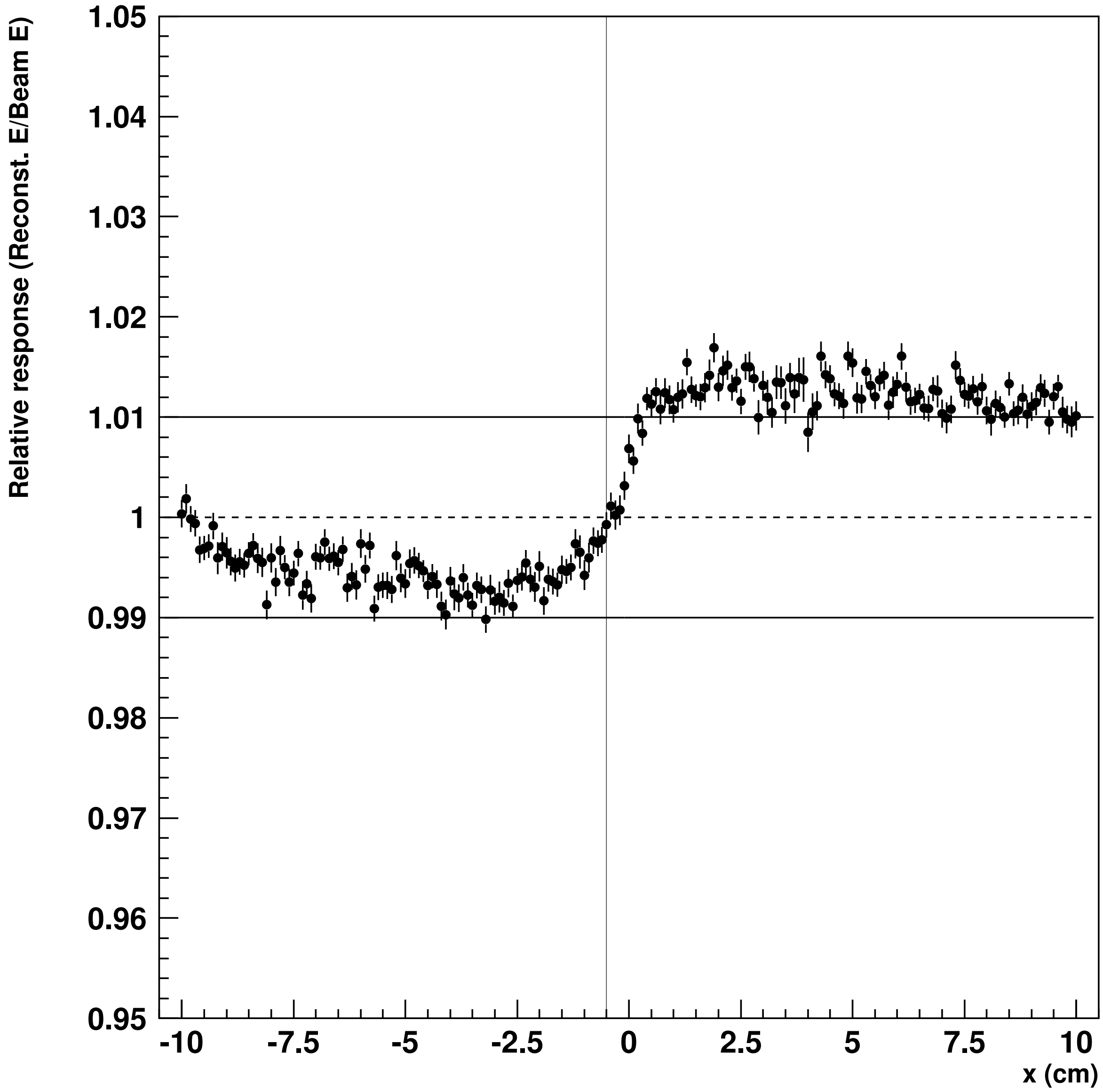
Error bars shown are purely statistical

X = 80 mm

Response drops with electrons closer to tie-rod (Y = 16.0 cm)
Explains poorer response/resolution for impacts B and C

Electron Beams Results

Proof of calibration problems through X-Scans:

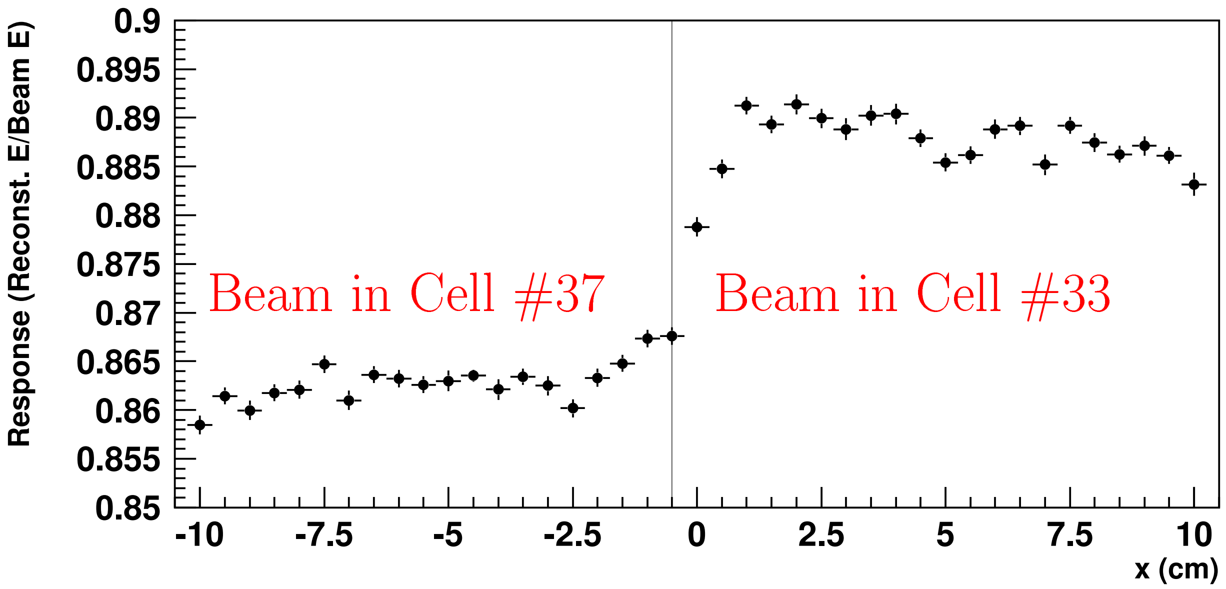


Relative response of the calorimeter vs. beam location for 147.8 GeV electrons. A response of 1 means that the energy calculated in the cluster is the same as the beam energy. The cluster selected for reconstruction was the same for all events/positions. The error bars shown are purely statistical. Y = -39 mm.

Vertical line shows the boundary between cells #33 and #37

Electron Beams Results

Relative response for cells 33 and 37 only:

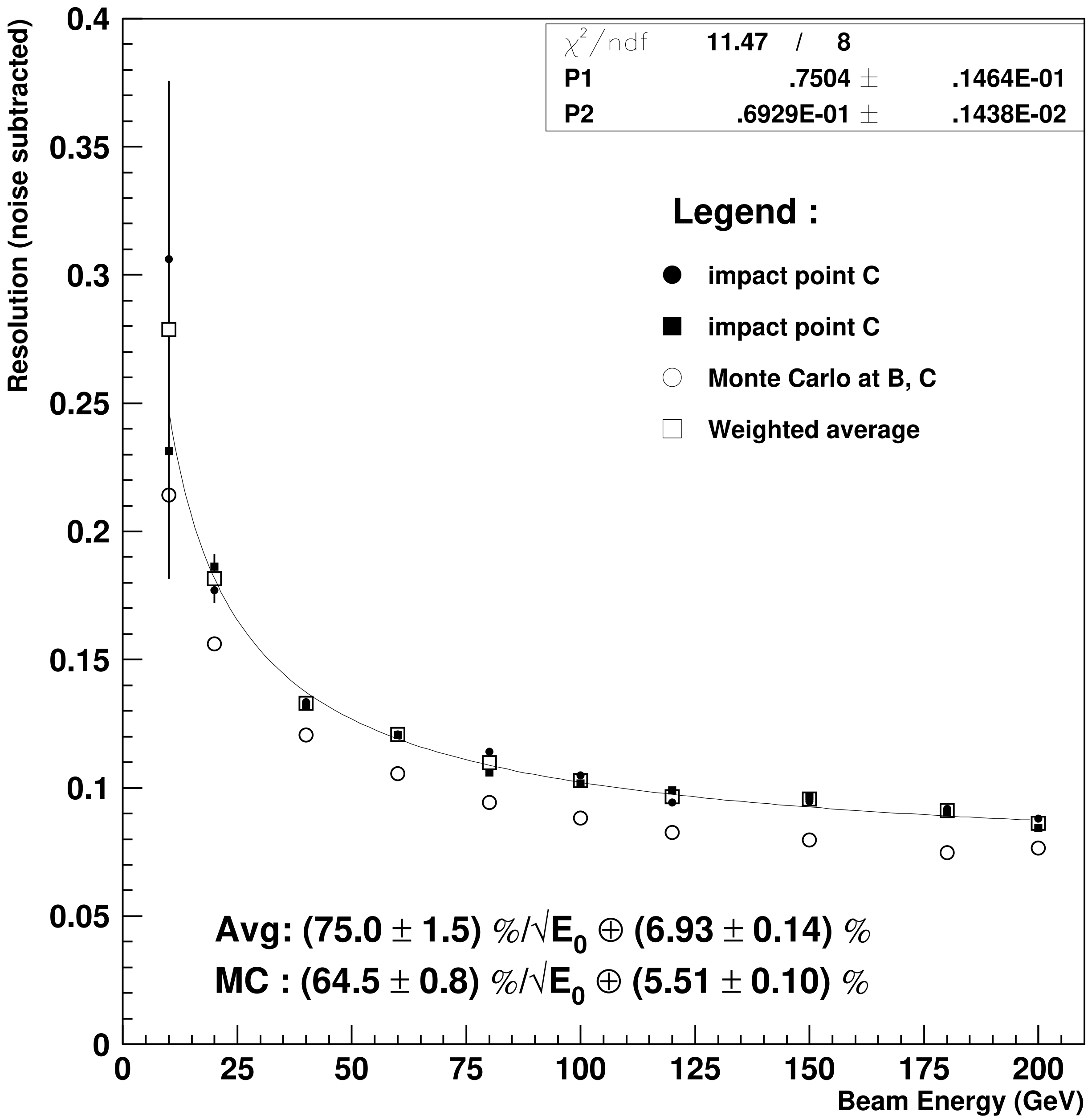


The response is the sum of the signal from cells 33 and 37 only. The difference between the signal across the symmetry axis (X = -5.1 mm) is about 2.5 %. The error bars shown are purely statistical.

Response 2.5 % higher in cell #33 than in cell #37:
Bad calibration

Pion Beams Results

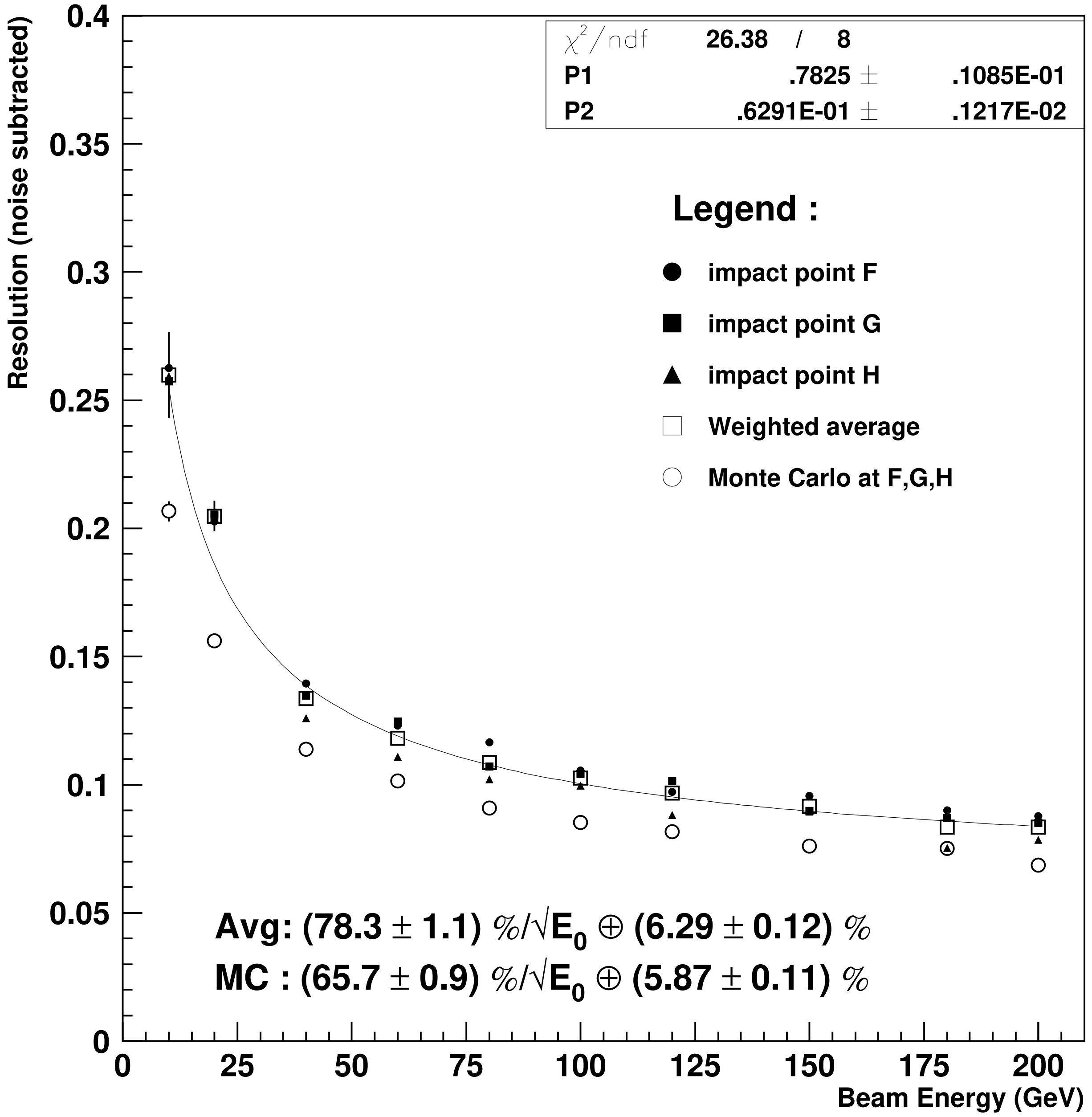
Combined resolution to pions at impact B and C:



Monte Carlo is found to give too good a resolution

Pion Beams Results

Combined resolution to pions at impact F, G, H:



Monte Carlo is found to give too good a resolution

Pion Beams Results

Resolution parameters for studied impacts:

Impact point	Sampling term (A) ($\%\sqrt{\text{GeV}}$)	Constant term (B) (%)	χ^2/ndf
B	75 2	7.1 0.2	8.172/8
C	75 2	6.8 0.2	10.75/8
F	80 2	6.8 0.2	7.651/8
G	78.8 2.0	6.5 0.2	13.34 /8
H	75.7 1.8	5.8 0.2	27.54/8
Combined Avg at B and C	75.0 1.5	6.93 0.14	11.47/8
Combined Avg at F, G and H	78.3 1.1	6.29 0.12	26.38/8
Monte Carlo for B, C	65.7 0.9	5.87 0.11	9.03/8
Monte Carlo for F,G and H	64.5 0.8	5.51 0.10	17.1/8

- Preliminary results
- Results are compatible with figures obtained by Andrei Mineanko

Conclusions

- Study conducted over 5 impact points : B, C, F, G and H.
- Non-gaussian positive tails observed in electronic noise distribution caused by picked-up signal in all time samples.
- Used asymmetric gaussian fit to estimate the most probable and σ from the cluster electronic noise distribution.
- Cluster response was corrected by adding the most probable current which resulted in an increased response at low energy for electron and pion runs.
- Electron energy resolution :

$$\frac{\sigma'}{E'} = \frac{(23.42 \pm 0.08)\%}{\sqrt{E_0(\mathrm{GeV})}} \oplus (0.00 \pm 0.12)\%, \qquad \frac{\chi^2}{ndf} = \frac{39.15}{7}$$

- Resolution worse at B and C due to contiguity with tie-rods in cells #57 and # 61.

Conclusions

- The response of the HEC to electrons was shown to drop by 20% near the tie-rods.

- Calibration problems appeared in the study of electrons X-scans.

- Pion energy resolution :

$$\frac{\sigma'}{E'} = \frac{(77.1 \pm 0.9)\%}{\sqrt{E_0(\mathrm{GeV})}} \oplus (6.54 \pm 0.09)\%, \qquad \frac{\chi^2}{ndf} = \frac{28.85}{8}$$

- Most results consistant with those from A. Minaenko.

- Monte Carlo gives too good a resolution for both electrons and pions.