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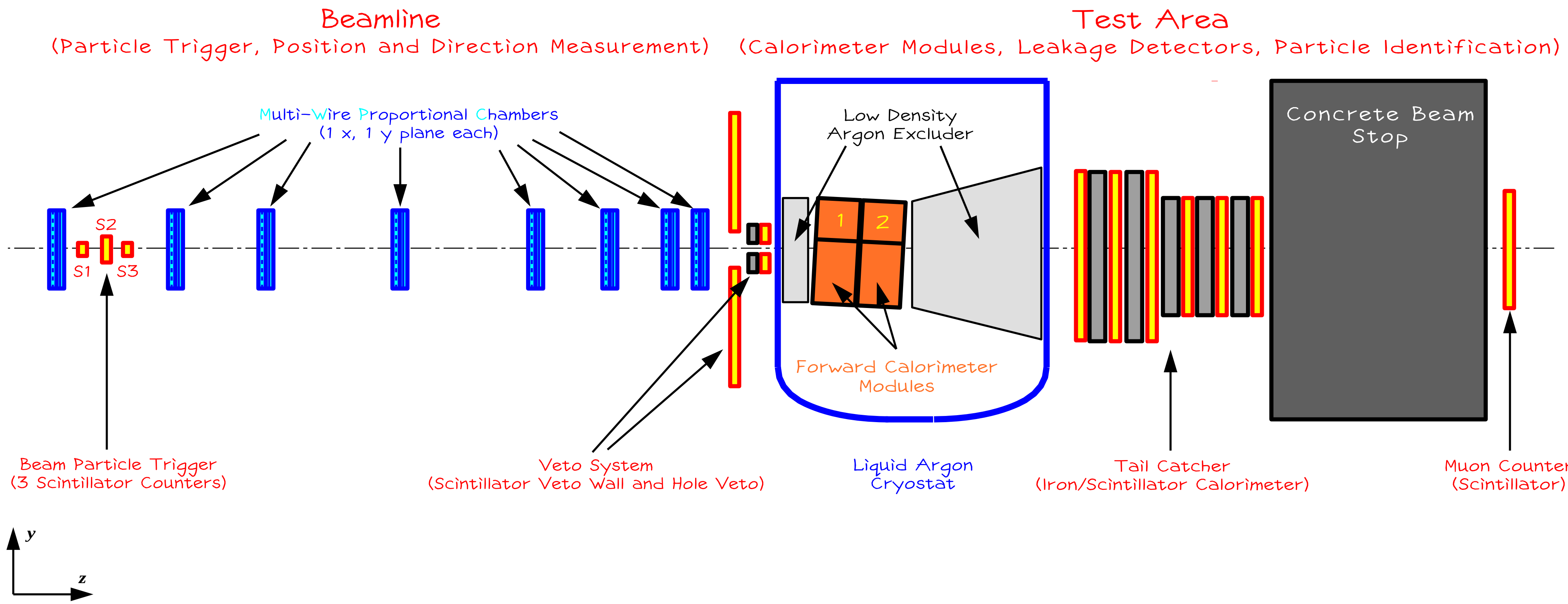
# Recent Results for Electrons in FCal1 from the Combined FCal Module 0 Testbeam 1998

(Teresa Embry & Peter Loch, U of Arizona)

- ∴ Setup
- ∴ Event Selection
- ∴ Impact Point Determination
- ∴ Signal Treatment and Clustering
- ∴ Signal Linearity and Energy Resolution
- ∴ Conclusions

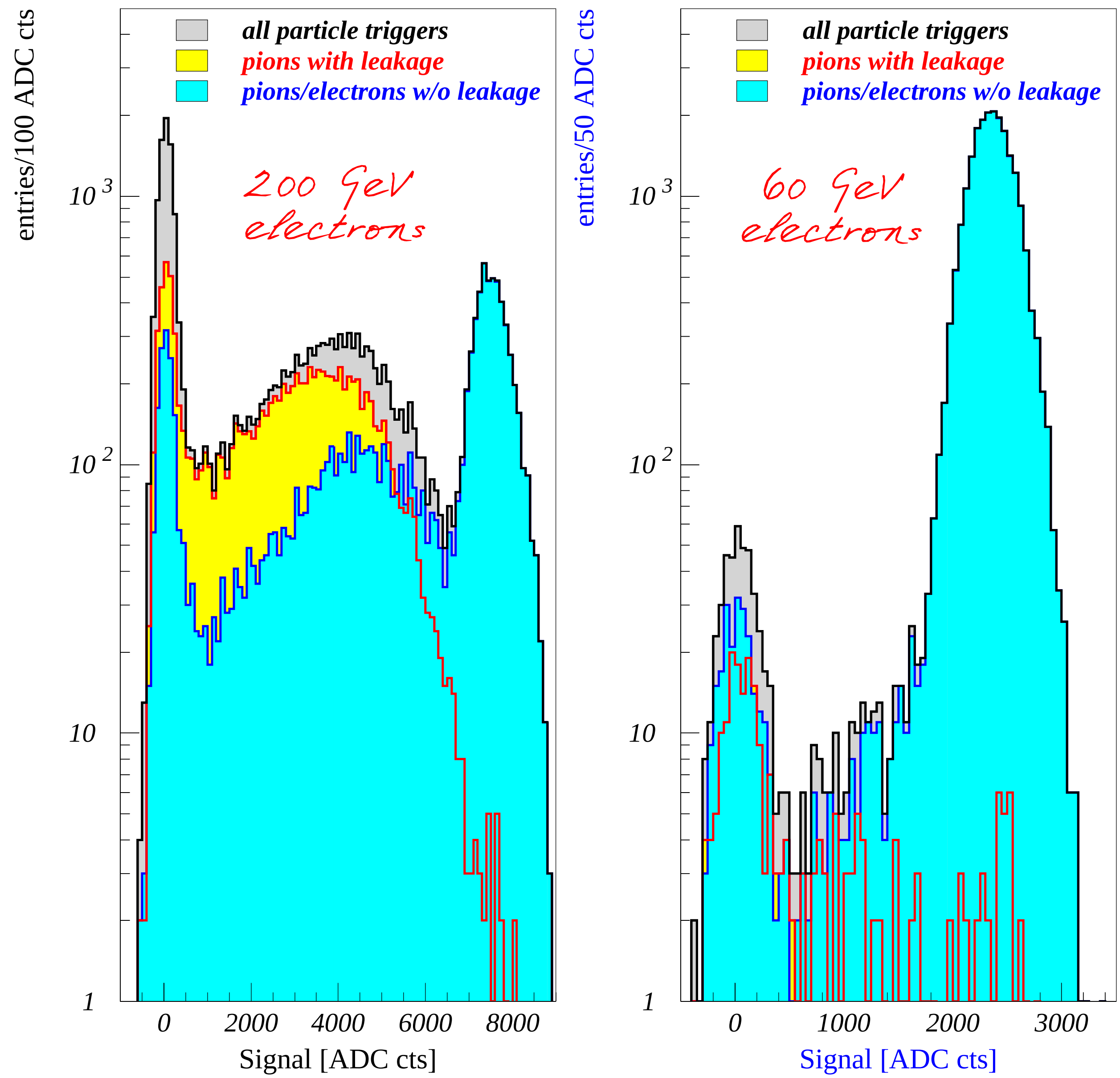


Beamline
(Particle Trigger, Position and Direction Measurement)
Test Area
(Calorimeter Modules, Leakage Detectors, Particle Identification)
Multi-Wire Proportional Chambers
(1 x, 1 y plane each)
S1
S2
S3
Low Density
Argon Excluder
1
2
Forward Calorimeter
Modules
Concrete Beam
Stop
Beam Particle Trigger
(3 Scintillator Counters)
Veto System
(Scintillator Veto Wall and Hole Veto)
Liquid Argon
Cryostat
Tail Catcher
(Iron/Scintillator Calorimeter)
Muon Counter
(Scintillator)
y
z

# Electron Event Selection (1)

* hardware trigger:

- beam counter S1&S2&S3 coincidence
- no longitudinal energy leakage (no hit in TailCatcher)
- no hit in VetoWall or HoleVeto

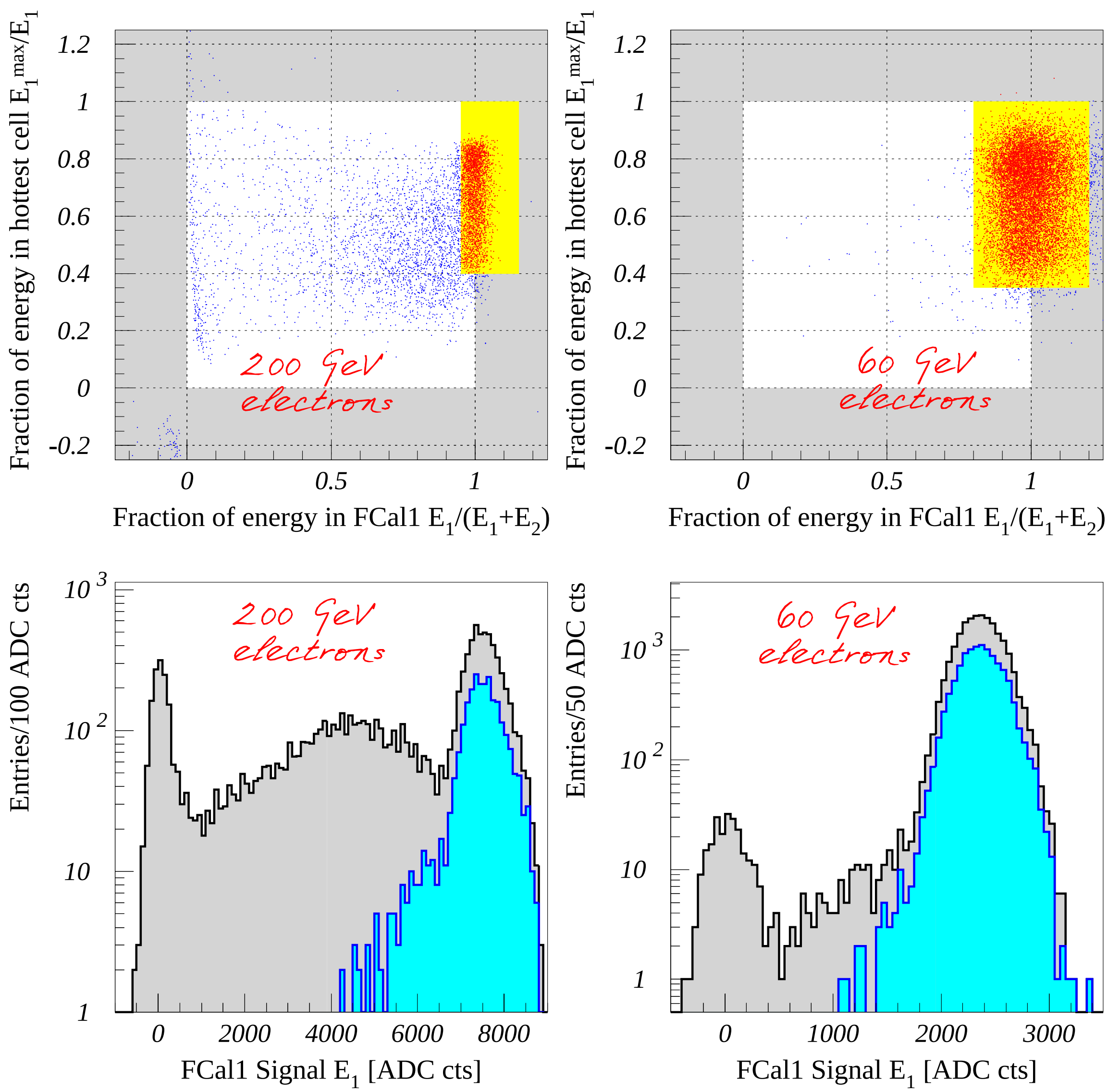



Signal in FCal1 [ADC cts]

# Electron Event Selection (2)

* additional selection

  - single hit cluster in (x,y) planes in MWPC closest to cryostat (MWPC #4)
  - particles in region of flat response (versus impact)
  - large fraction of energy in FCal1 (> 95% for $E_{beam}$ > 80 GeV)
  - significant fraction of energy in one cell in FCal1 (typically >40%)



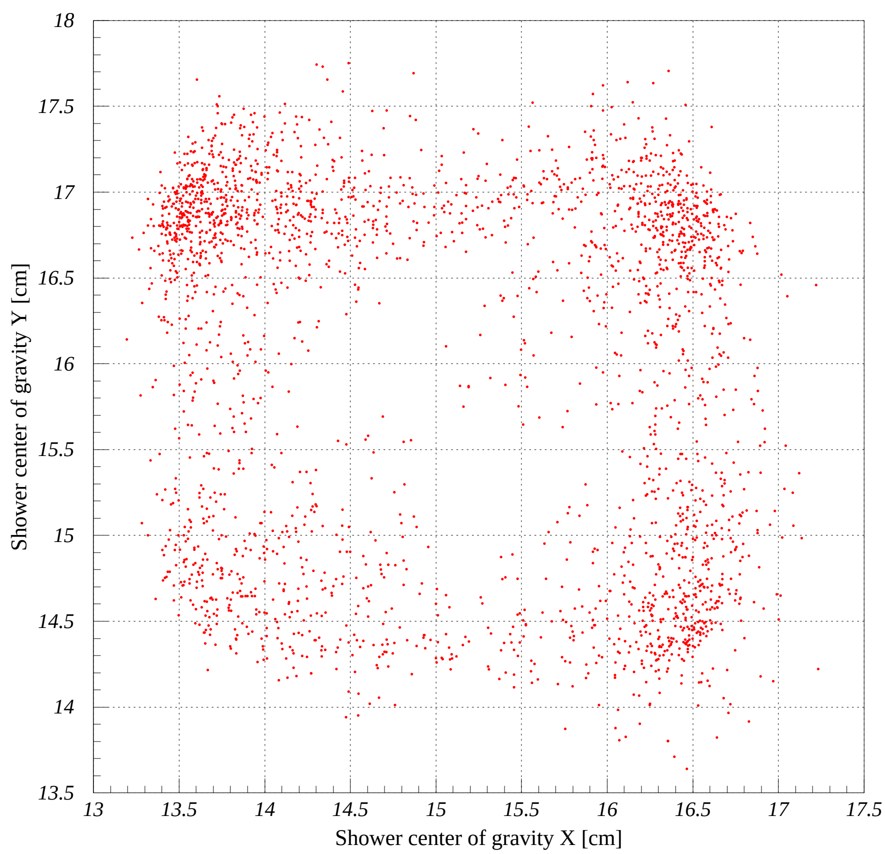

cuts on energy fractions

all cuts applied here!

# Impact Point Determination (1)

* from shower center of gravity in FCal1

- naive approach does not allow precise impact point determination due to small lateral size of electromagnetic showers compared to FCal1 cell sizes -> CoG pulled towards tile center by the large fraction of the total signal in the (one!) corresponding cell:



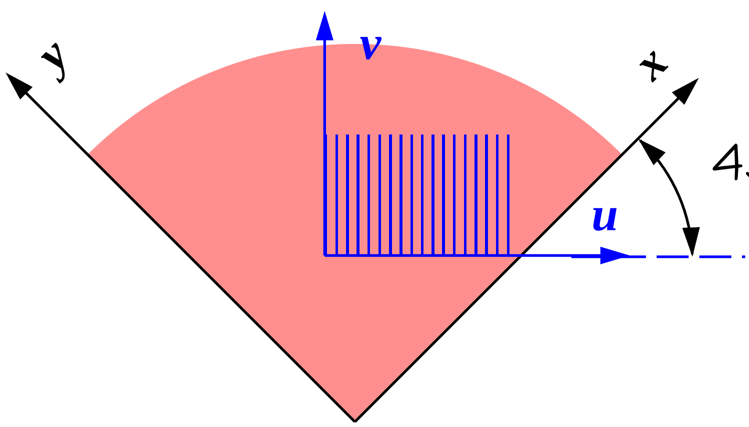

Center of gravity (X,Y) in FCal1 for 200 GeV electrons

- more sophisticated approach using electromagnetic shower shapes has been developed by A. Savine for the 1995 testbeam data (finer granularity!), but not yet studied for the module 0 data.

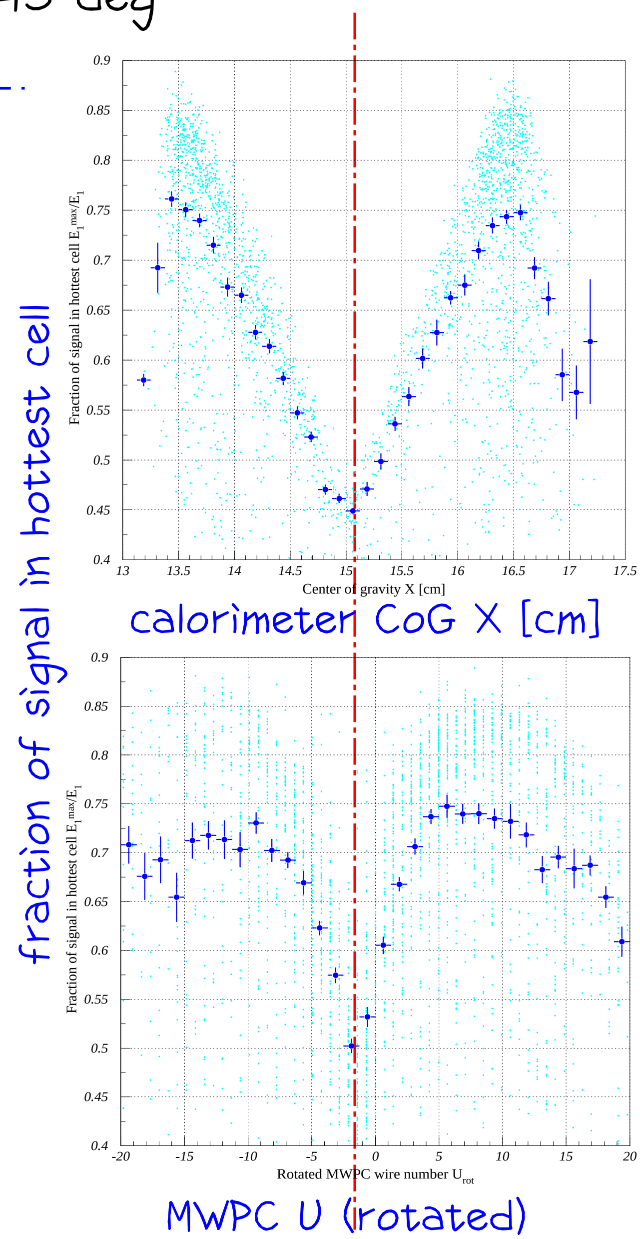
# Impact Point Determination (2)

* for this study use MWPC to find impact point

  - needs relative alignment of calorimeter and MWPC:




  - use energy sharing for electrons between tiles to relate FCal coordinate (x,y) to MWPC #4 (u,v)



# Signal Treatment & Clustering

## * signal corrections

- medium gain cell signal are "boosted" to the high gain signal scale by factors $g_i$, determined channel-by-channel from sufficiently large particle signals (> $5\sigma_{noise}$ in both gains):

$$E_{med} = \sum g_i \, E_{medium,i} \qquad \text{(medium gain response)}$$

$$E_{mix} = \sum_{\substack{\text{non-overflow} \\ \text{channels}}} E_{high,i} + \sum_{\substack{\text{overflow} \\ \text{channels}}} g_j \, E_{medium,j} \qquad \text{(mixed gain response)}$$

- channels with very low (< 5[0.5] ADC cts) or very high (> 25[5] ADC cts) in high [medium] gain are excluded from signal sums

- signals in channels with HV problems (1 electrode shorted) are corrected by a factor of 4/3 (FCal2 only)

## * collecting signals in cylinders of various radii

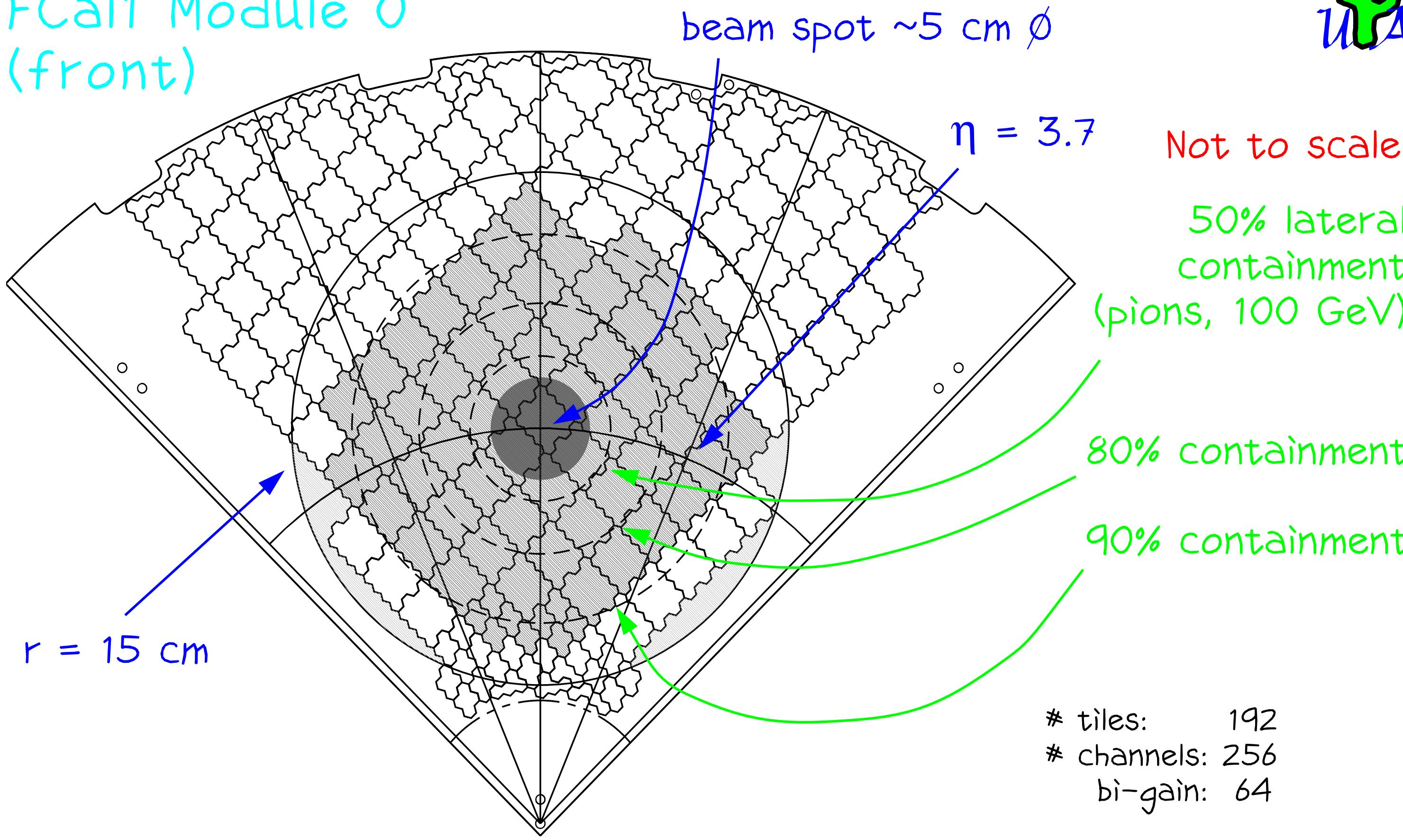
- impact point from MWPC #4 is used as reference
- signals from tiles partly covered by the cylinder are weighted by: (M. Shupe/Dzero clustering):

$$E(r) = \sum w_i \, E_i \text{ with } w_i = (\, A_{shared,i} \, / \, A_i \,)^{1/2}$$

$$\text{and } w_i = \begin{cases} 0 & \text{for tiles outside cylinder} \\ 1 & \text{for tiles completely inside cyl.} \\ >0 \ldots <1 & \text{for partly covered tiles} \end{cases}$$

# FCal Module 0 ReadOut

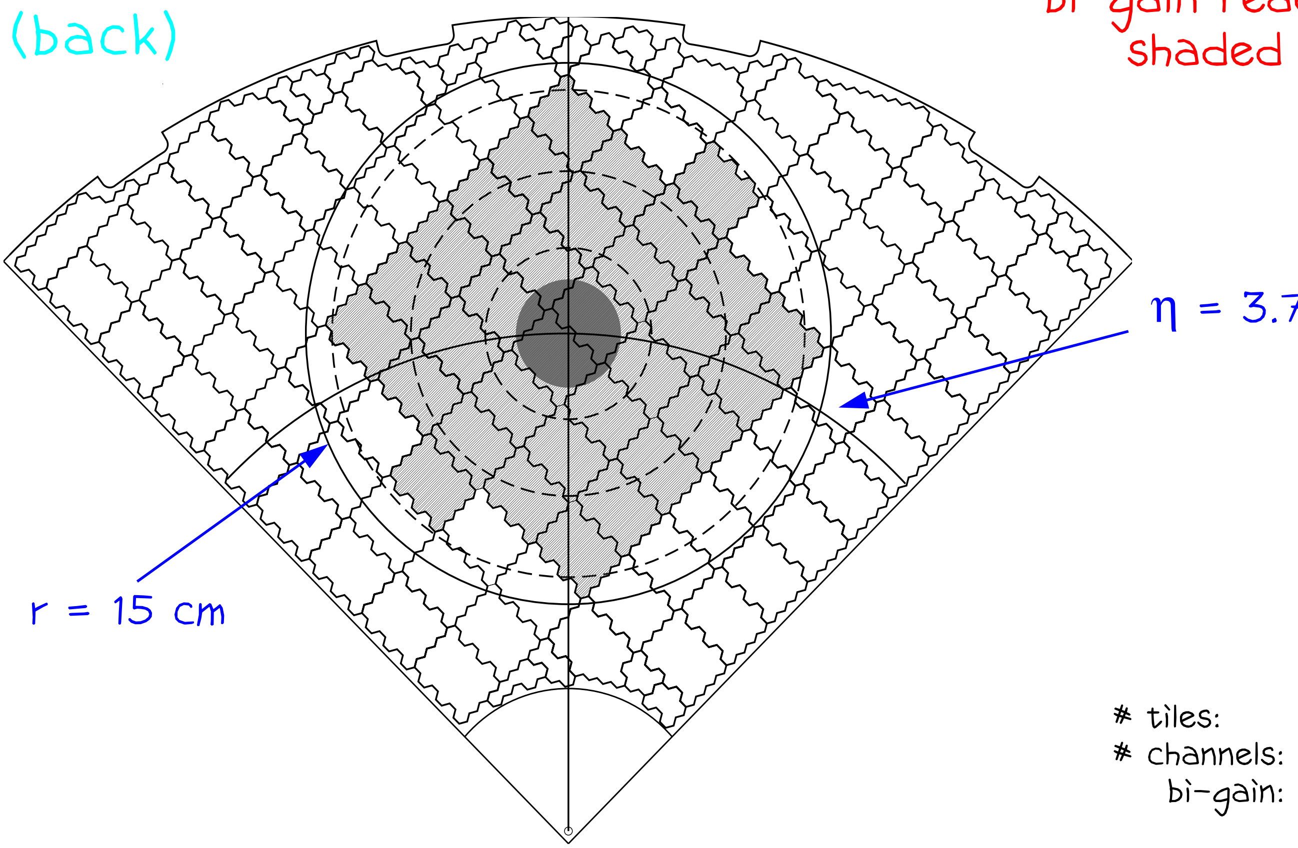
## FCal1 Module 0 (front)




\# tiles: 192
\# channels: 256
bi-gain: 64

## FCal2 Module 0 (back)

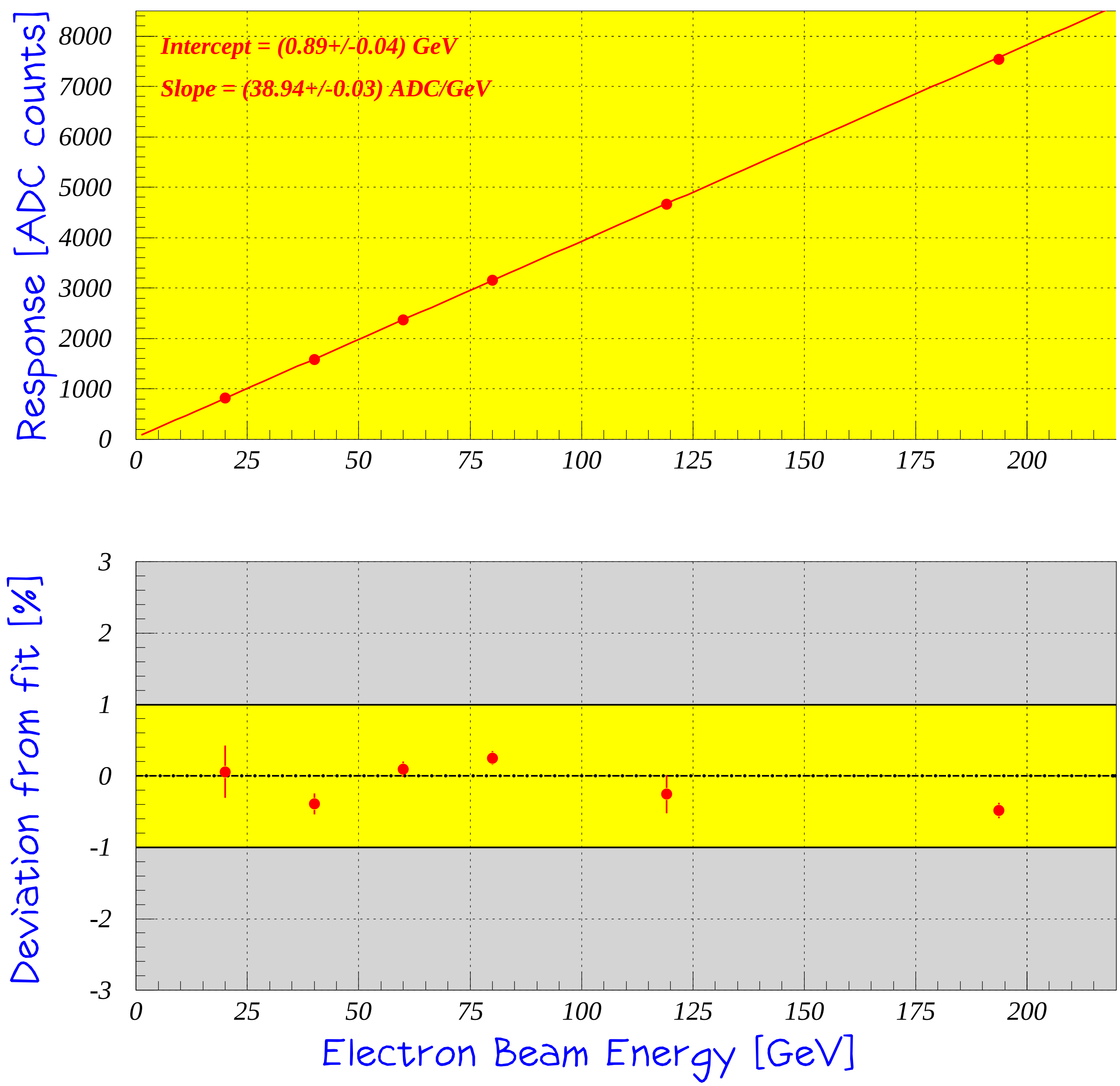
bi-gain readout for shaded tiles!




\# tiles: 128
\# channels: 160
bi-gain: 32

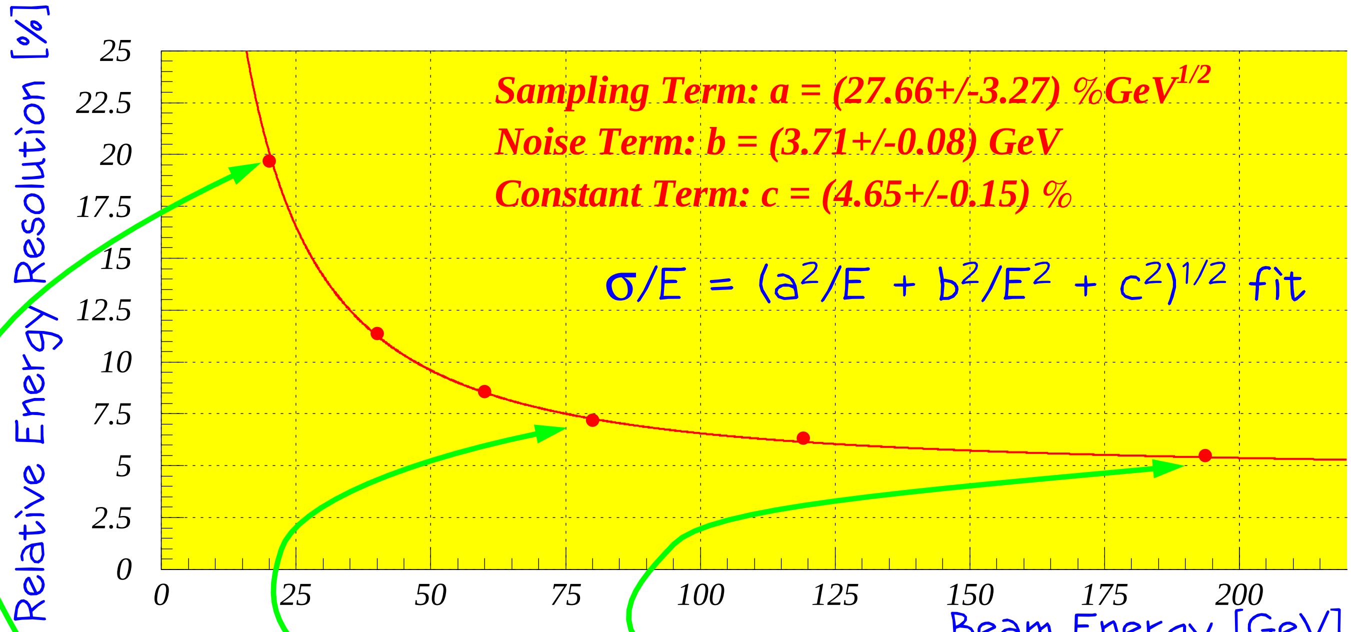
# Medium Gain Signal Linearity for Electrons

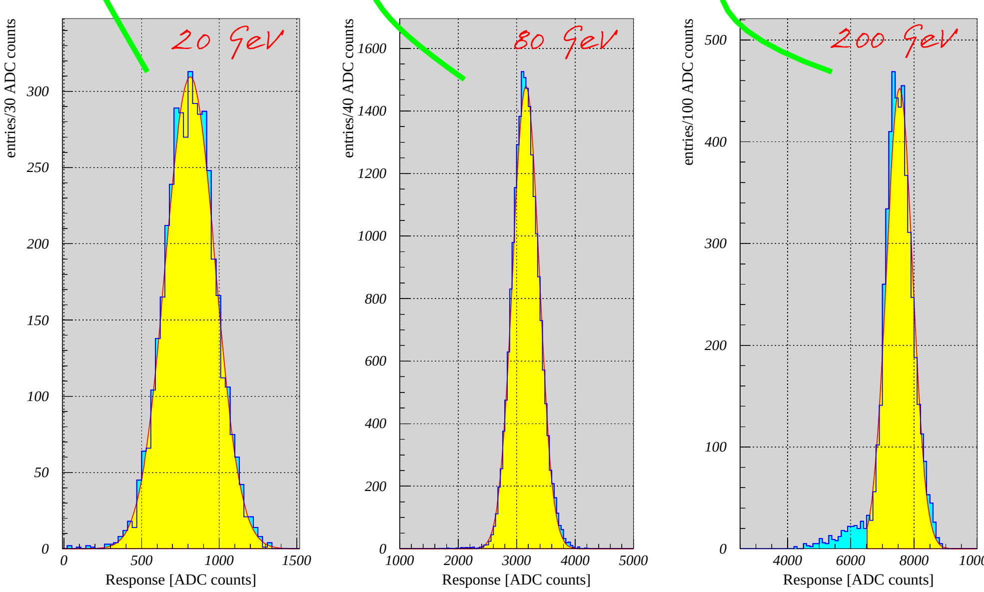
## Signal summed over whole bi-gain area!



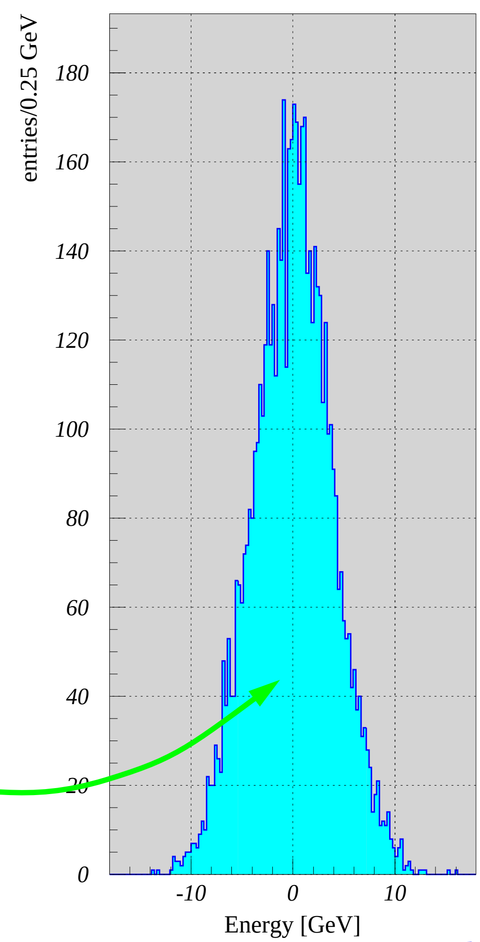
# Medium Gain
# Energy Resolution for Electrons

## Signal summed over whole bi-gain area!




Beam Energy [GeV]

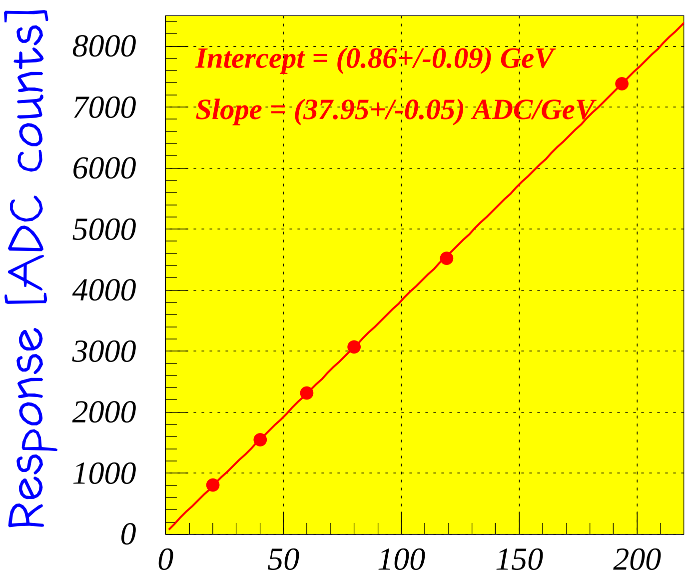


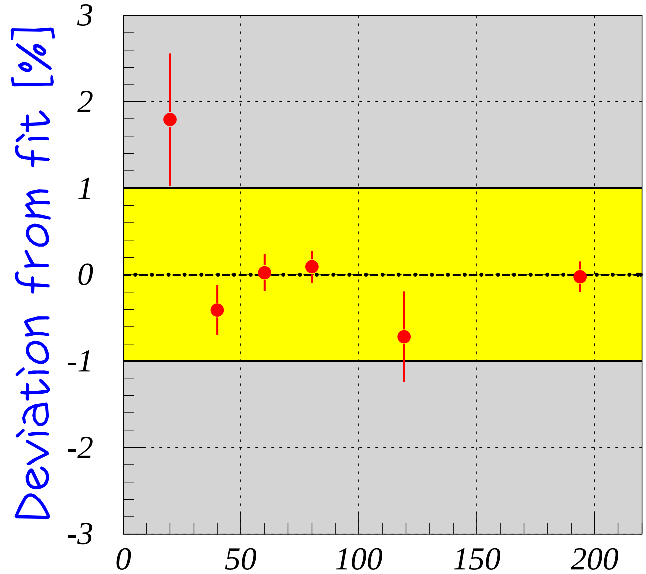

Contribution from noise determined from randomly triggered "empty" events in FCal1 is about 3.89 GeV RMS summed over the area with bi-gain readout (64 channels in FCal1, with one excluded because of noise problems)

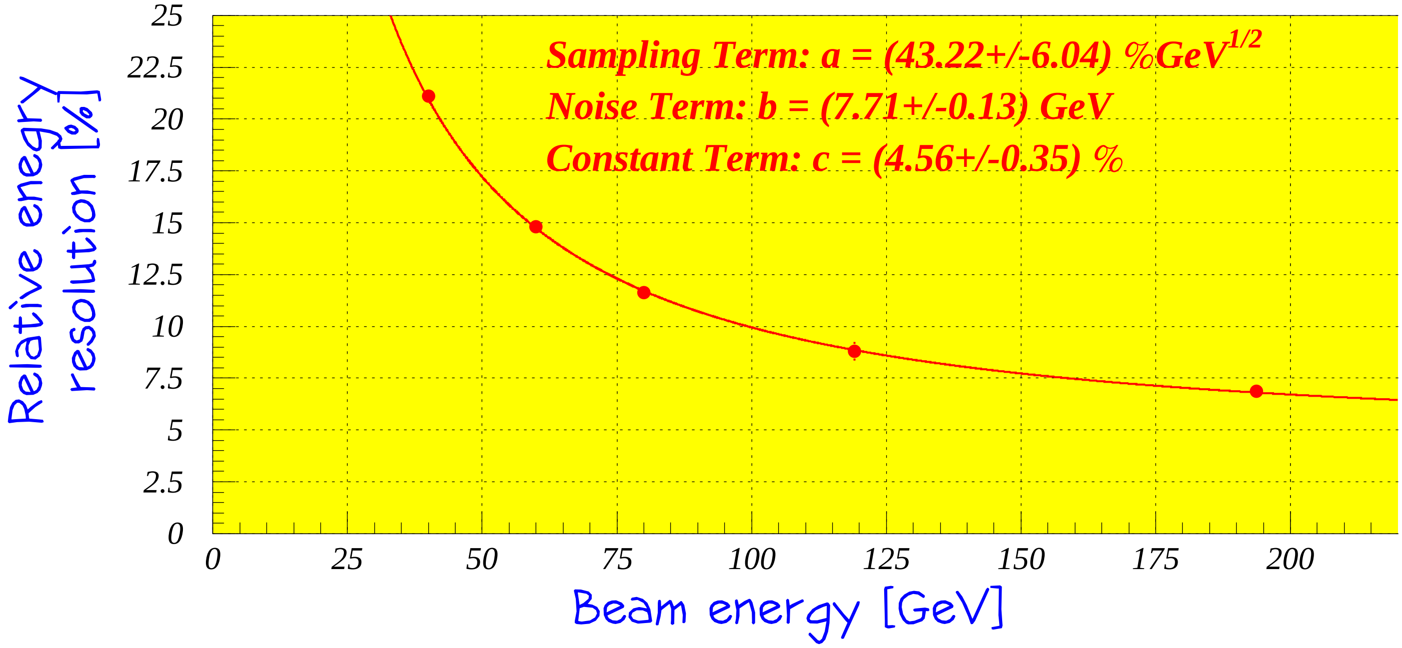
Noise Energy [GeV]

# Mixed Gain Electron Response

## Signal summed over full FCal1 acceptance!




* summing signal over full FCal1 introduces significant noise:
  - expected about $(192/64)^{1/2}$ * 3.9 GeV = 6.8 GeV
  - from fit about 7.7 GeV
  - from random events 8.2 GeV
  - -> some indication of coherent noise ??
* constant term for mixed gain/medium gain identical -> no severe intercalibration/gain ratio problem.

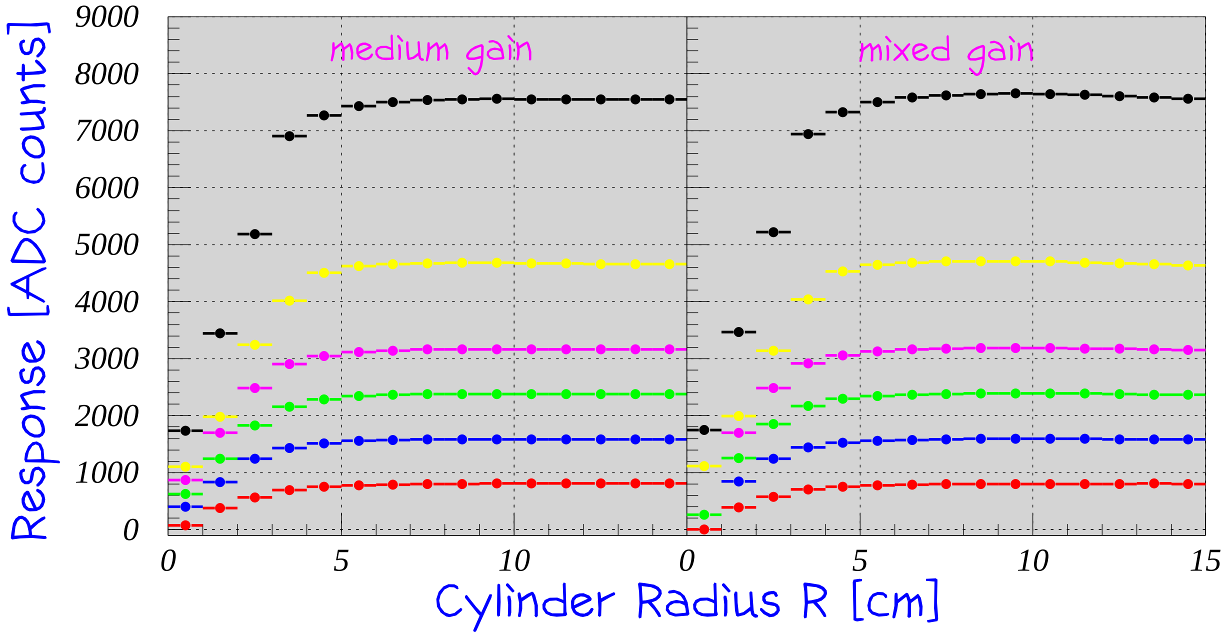
-> study signal in smaller volumes (cylinders)

# Electron Response in Cylindrical Clusters (1)

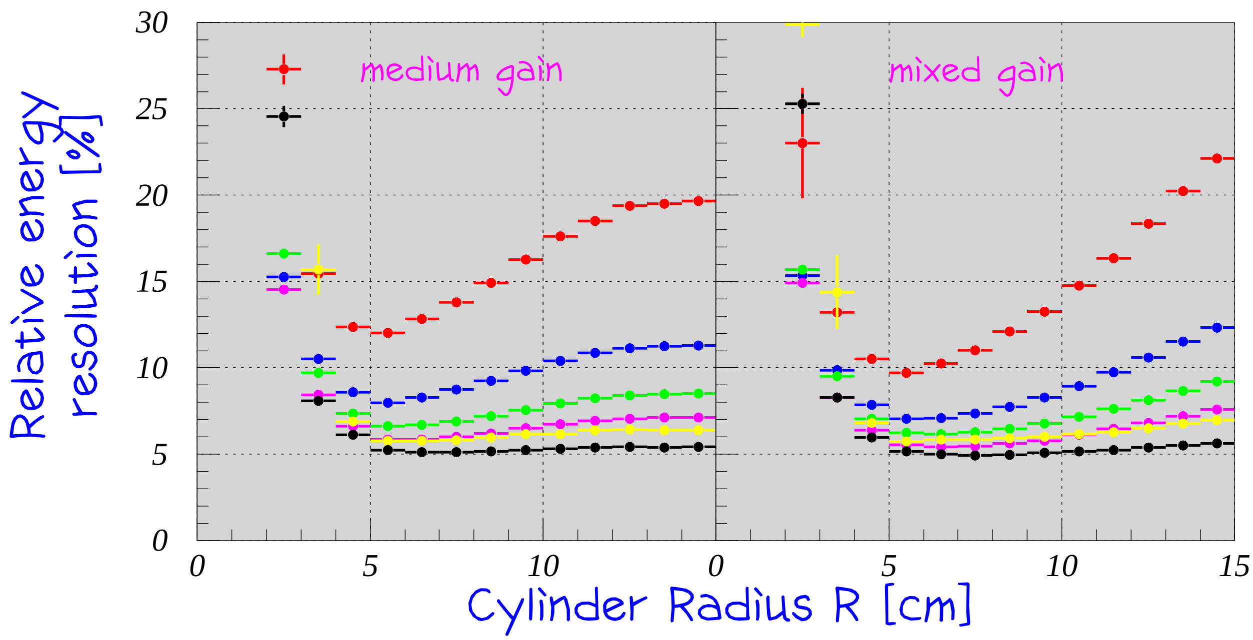
● $E_{beam}$ = 20 GeV ● $E_{beam}$ = 40 GeV ● $E_{beam}$ = 60 GeV

● $E_{beam}$ = 80 GeV ● $E_{beam}$ = 120 GeV ● $E_{beam}$ = 200 GeV

* response versus cylinder radius



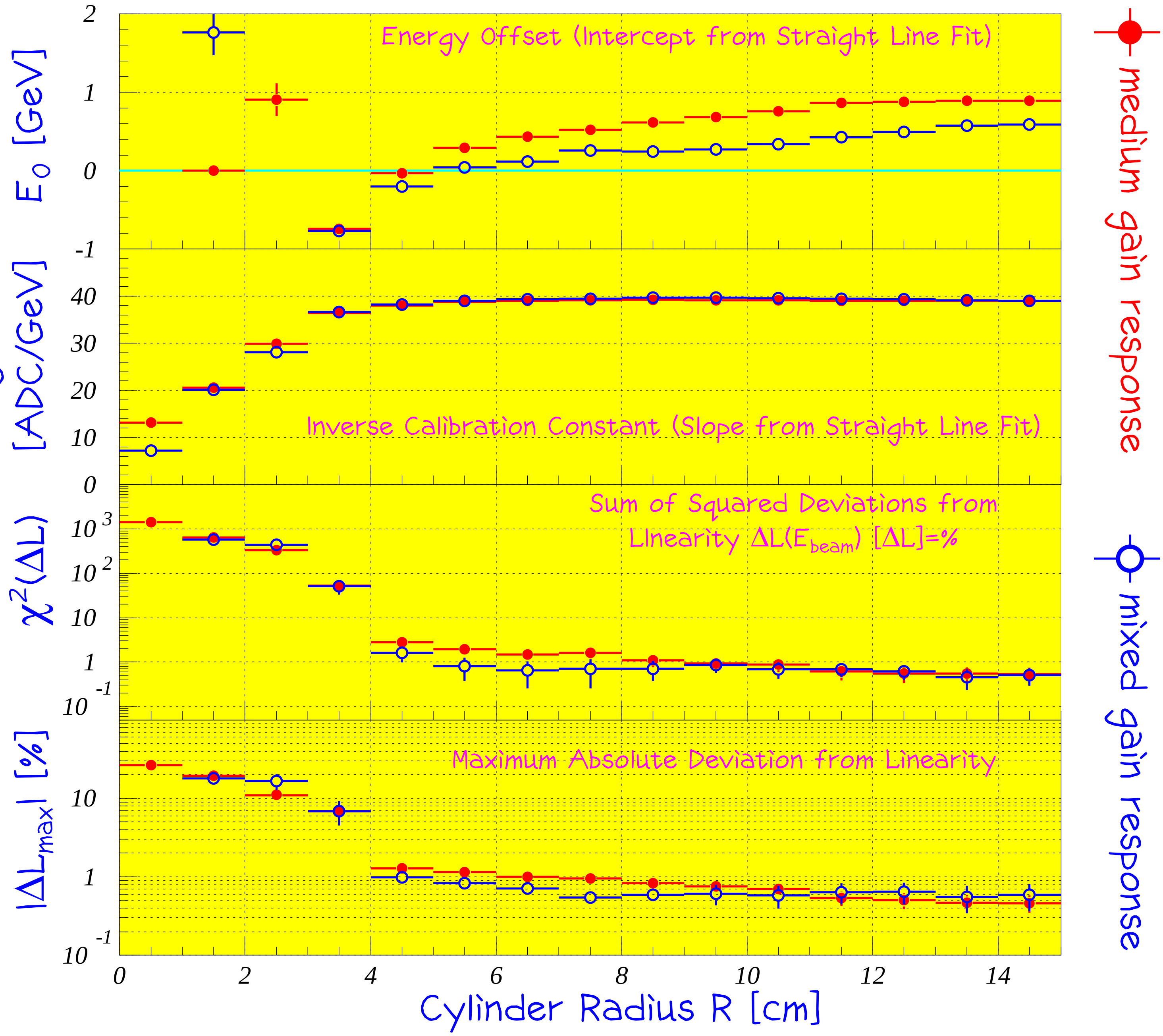

* energy resolution versus cylinder radius



# Electron Response in Cylindrical Clusters (2)

* parameters from linearity fits

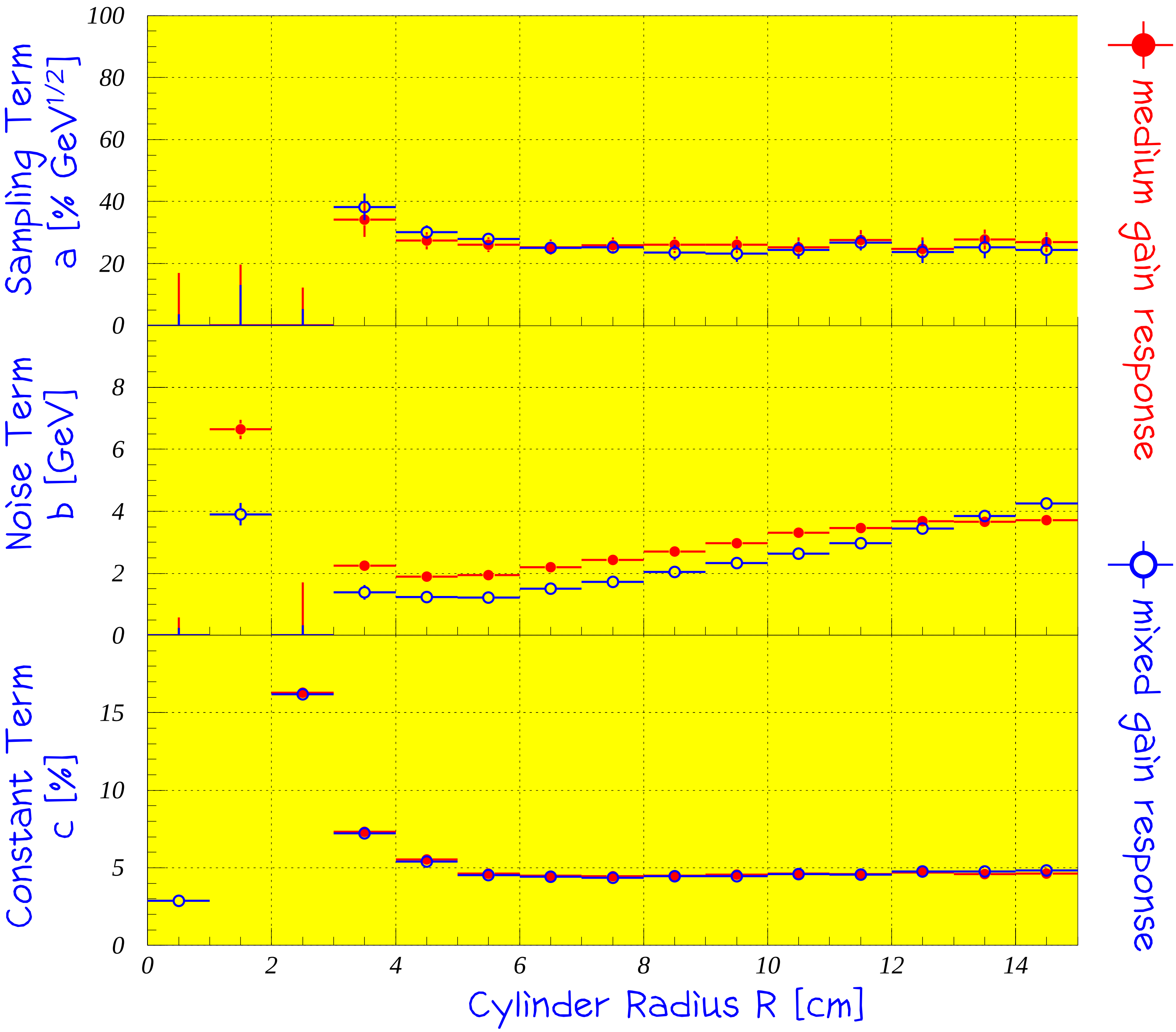
$E_{rec}(r) = C\ A(r) + E_0 \overset{!}{=} E_{beam}$, (A(r) is the response in ADC cts)



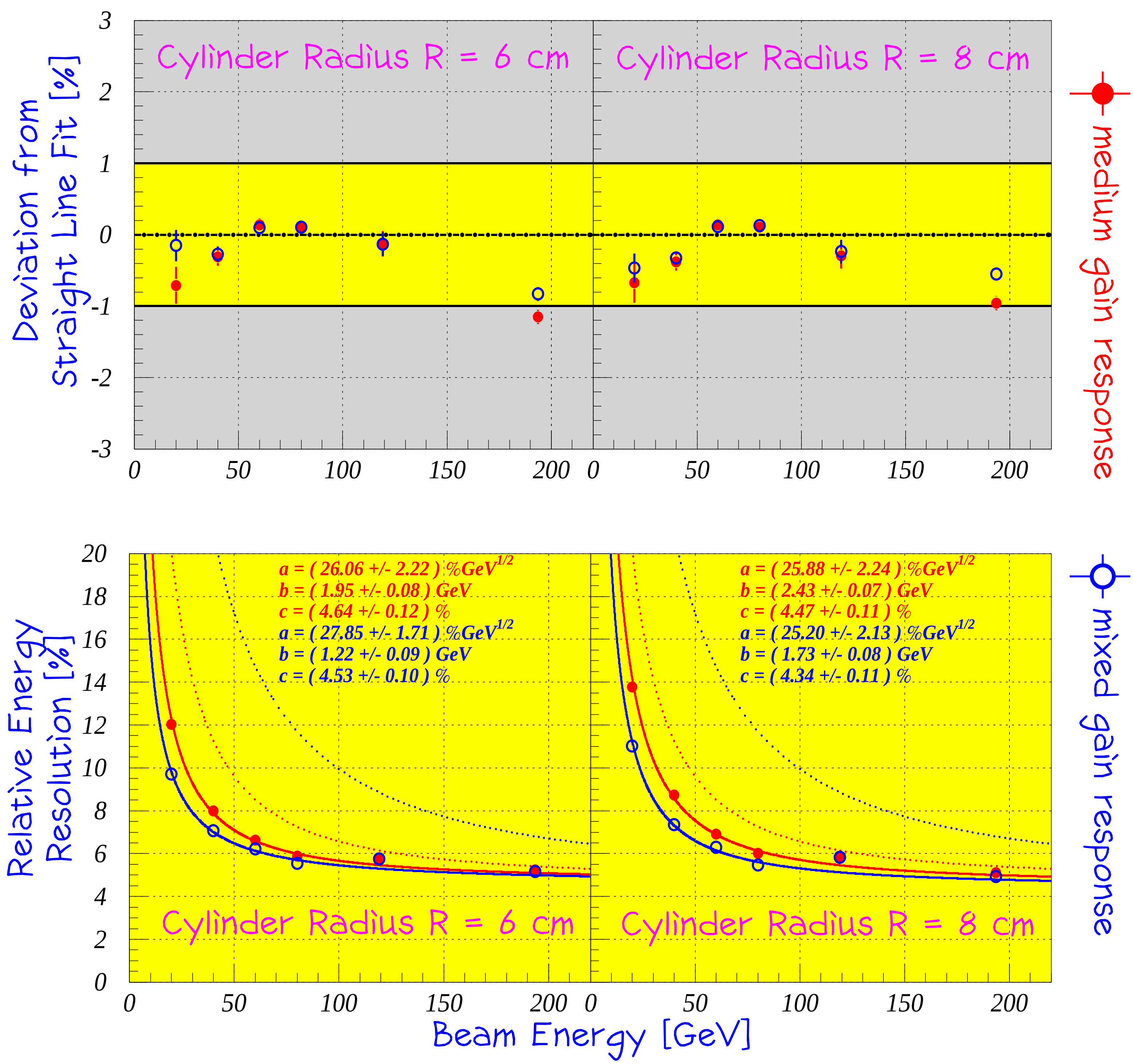
# Electron Response in Cylindrical Clusters (3)

* parameters from resolution fits

$\sigma(r)/E(r) = (a^2/E(r) + b^2/E^2(r) + c^2)^{1/2}$ fits



# Optimized Electron Response



# Conclusions & Outlook

* a first more in-depth look at the electron signal in the FCal1 module 0 shows very good performance with deviations from linearity of significantly less than 1%, a small sampling term in the energy resolution (< 30%), an acceptable constant term of about 4.5% and noise within the theoretical expectations.

* one of the influences on the constant term of the energy resolution comes from low signal tails in the resolution functions for 120 and 200 GeV electrons. This tail indicates pion background and/or radiative events. Explicit use of the MWPCs allows to suppress the later by severe cuts on particle directions (presently under study by A. Savine). Further improvement of particle identification using the calorimeter (isolation cylinder criteria) are also under investigation

* the presently reconstructed signals have no electronic calibration applied. Understanding of channel-to-channel gain variations, cross-talk and the observed relatively large fluctuation in the high and medium gain signal ratio (determined with particle signals) require careful studies of the electronics and the electronic calibration system. Corresponding test stands will be set up at Arizona early next year.

* in addition to electrons we also study the signals from pions and muons. For pions we are presently investigating particle identification using the FCal signals, CEDARs, TailCatcher etc. (J. Seely). First calibration fits show promising signal linearity (also shown by A. Artamonov) but still non-satisfactory fluctuations. Simulations may be necessary to understand the effect of the shorts in FCal2 on the pion resolution. The same is true for muon signals (studied by C. Goldman). The understanding of the absolute signal magnitude may also require detailed simulations (evidence for a significant signal can be shown already). The setup of the testbeam experiment in GEANT3.21 has started at Arizona. First simulations are expected to be available early next year.