CALOR–2000

Hadronic Energy Resolution Improvement

in calorimeters with fine transversal segmentation

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Problems of Hadronic Calorimetry

- e/π response ratio (compensation)
- Proportionality of response
- Signal/Noise ratio
  - Stochastic noise $\rightarrow$ R
  - Correlated noise $\rightarrow$ R^2
- Energy resolution

Means to improve Hadronic Measurements

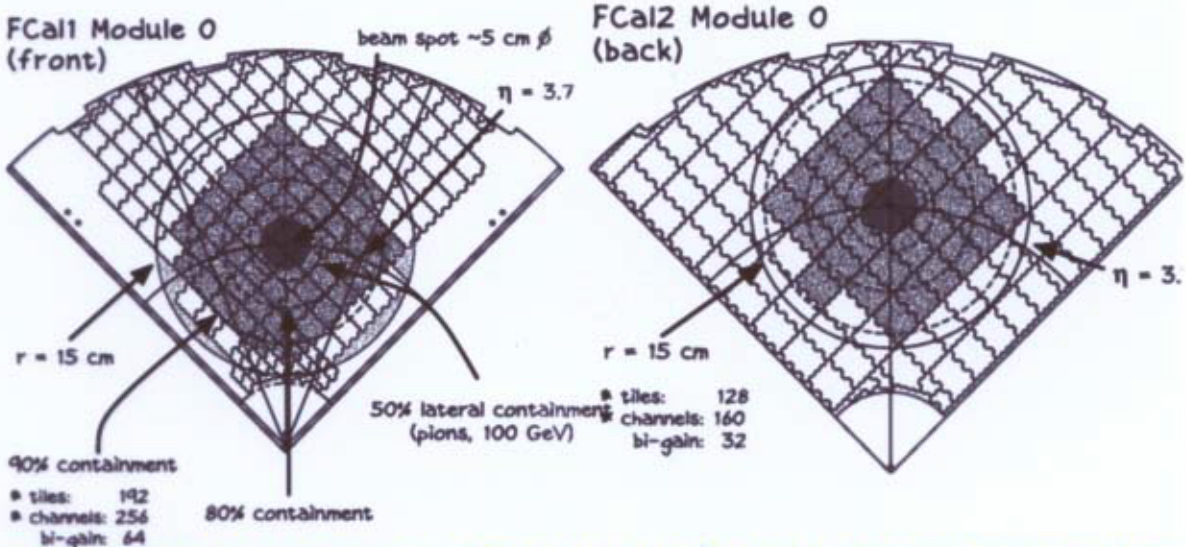
- Technology choice
- Cluster size optimization
- Weighting Schemes :
  - Longitudinal segments
  - ★ Transverse segments ?

Radial Weighting Technique

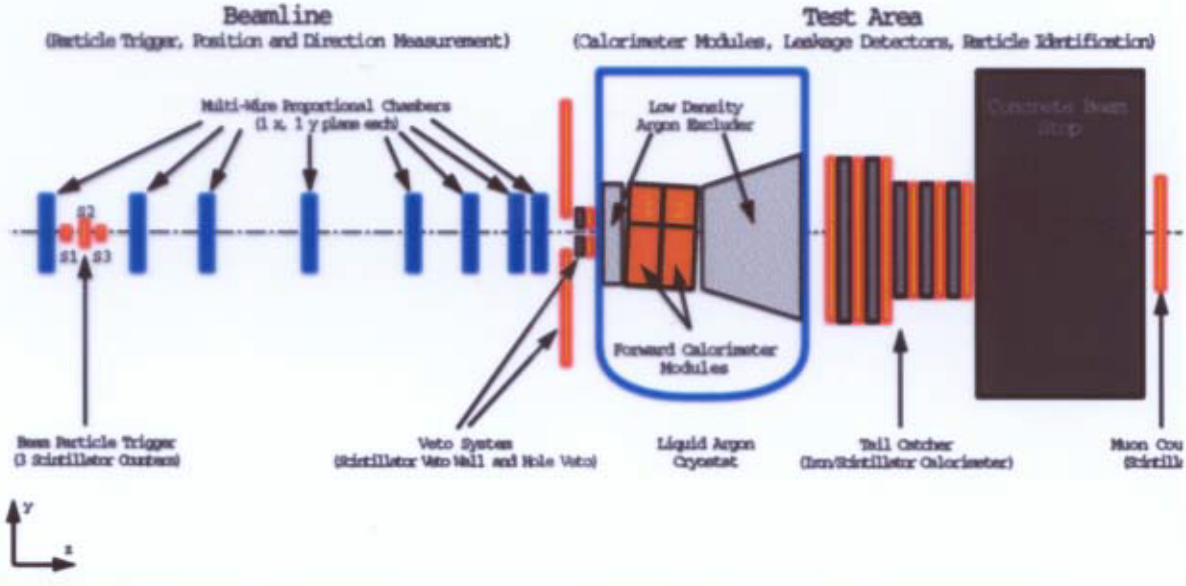
1. Cluster position is determined
2. Each channel receives its Weight depending on distance to the cluster center
3. Weight as a function of distance is optimised to provide the best possible performance of the calorimetric system

FCal Module 0

- prototypes for the electromagnetic (Fcal1) and one hadronic module (Fcal2);
- 1/4 ring modules at full depth sufficient for latera electromagnetic and hadronic shower containment 6.4 λ total hadronic depth $\longrightarrow$ longitudinal accep- tance limitations at higher energies;



- Testbeam setup at CERN: H6(North area beam line 10-200 GeV/c pions, electrons and muons:)

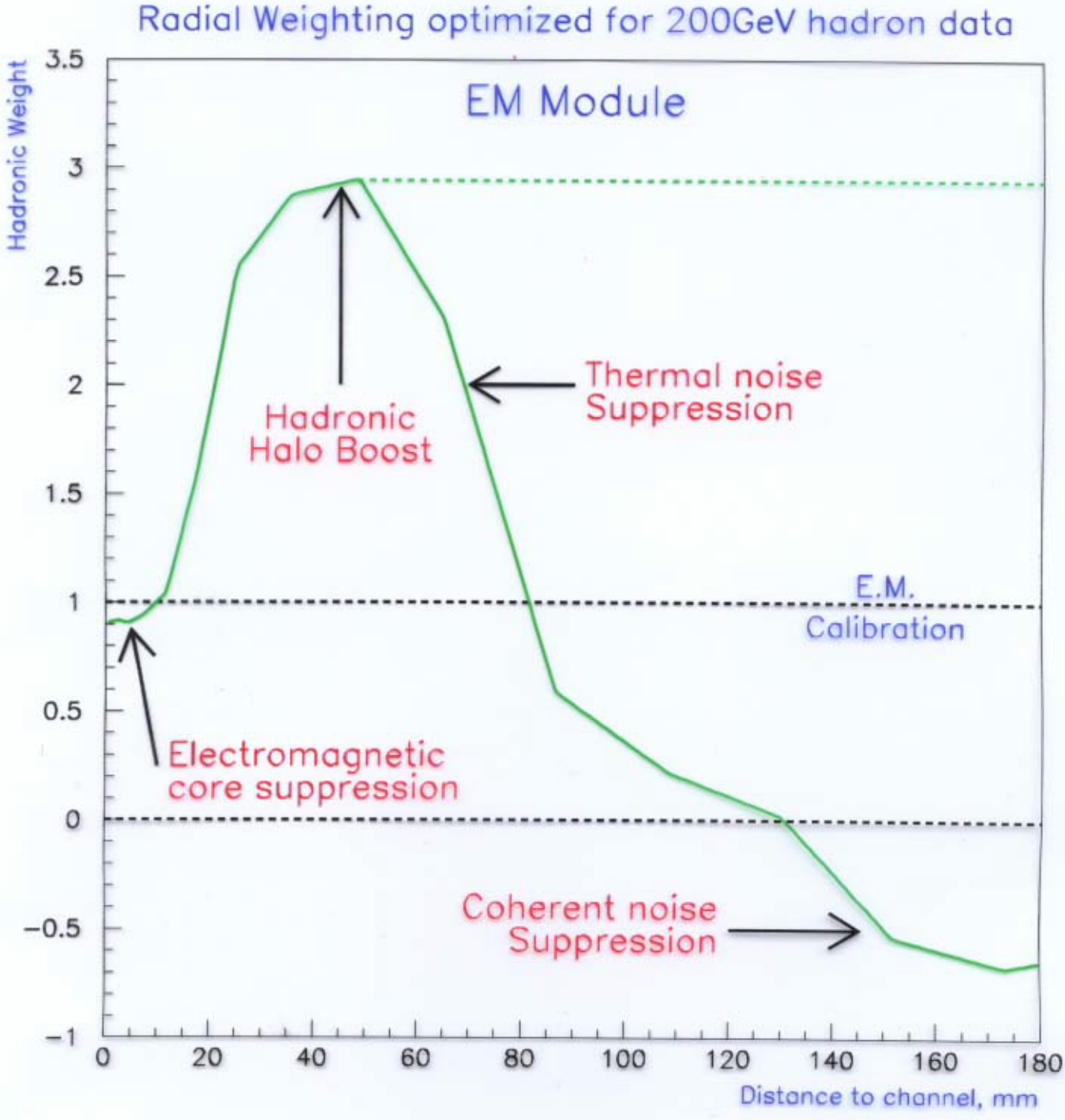


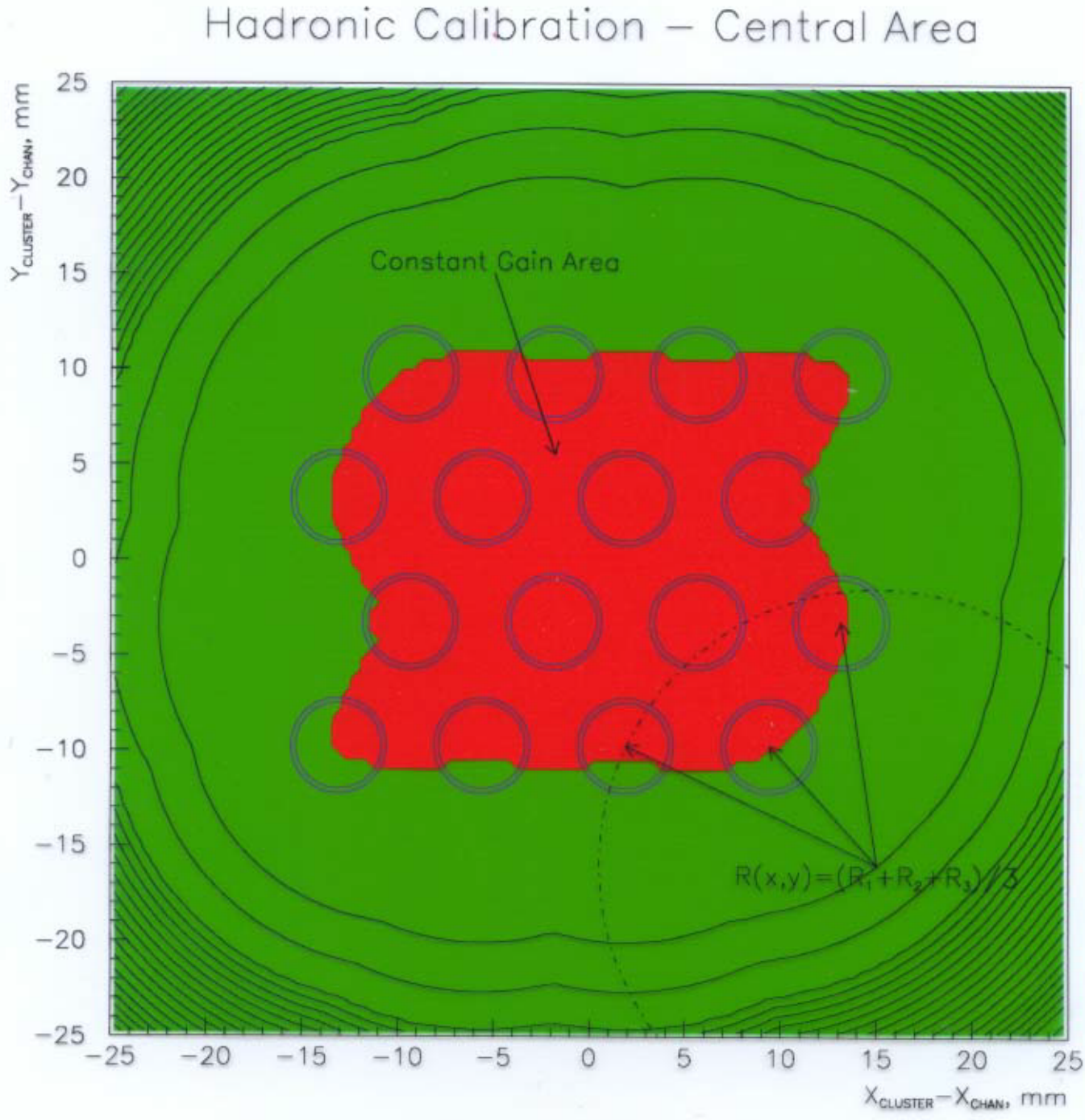
Technical Implementation

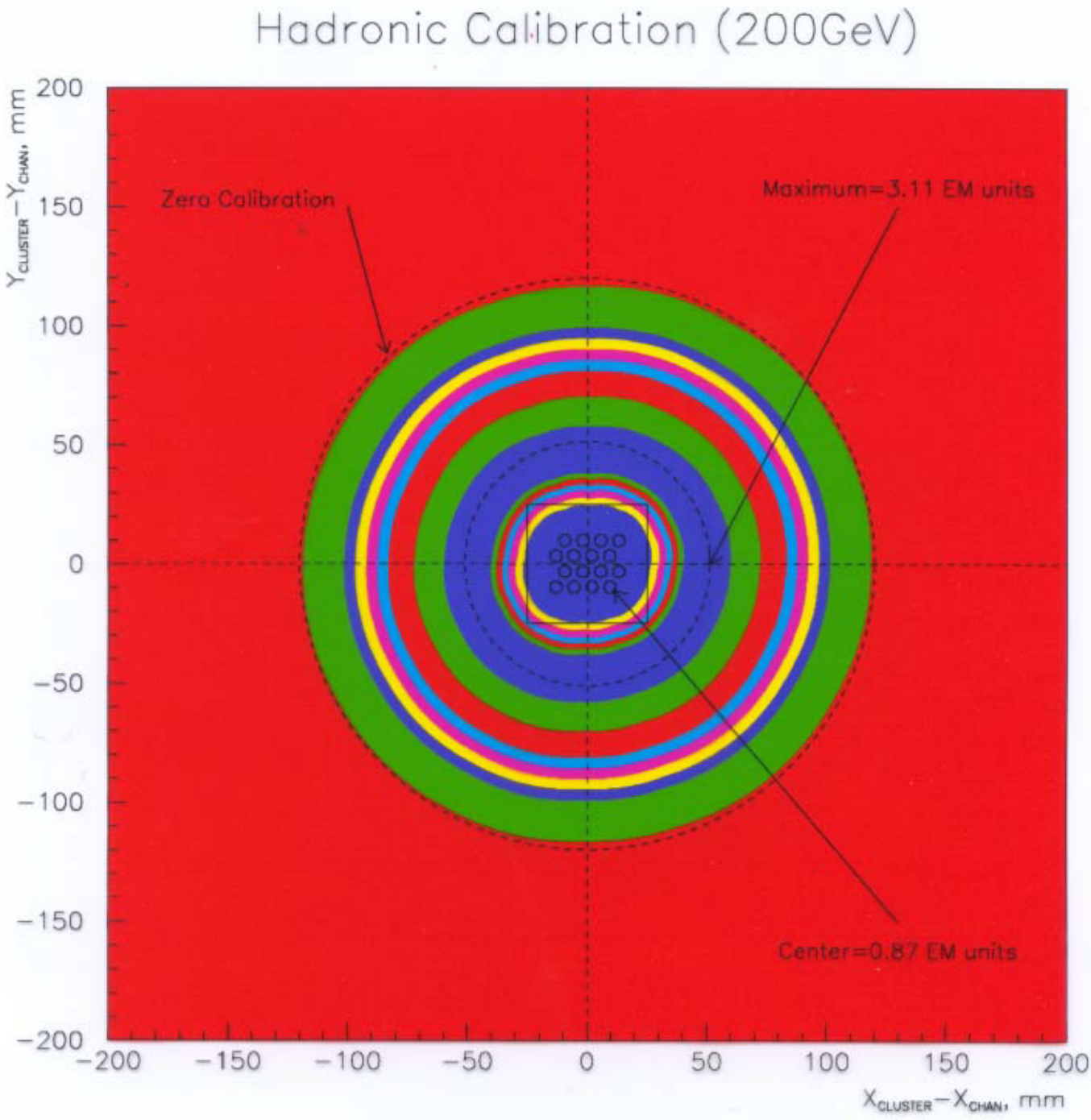
1. Radial Weight Function is presented as
   $W(r)=W(R_i)x(R_{i+1}-r)/\Delta R+W(R_{i+1})x(r-R_i)/\Delta R$
   where discrete $W(R_i)$ $(i=1...N)$ are
   used as free optimization parameters

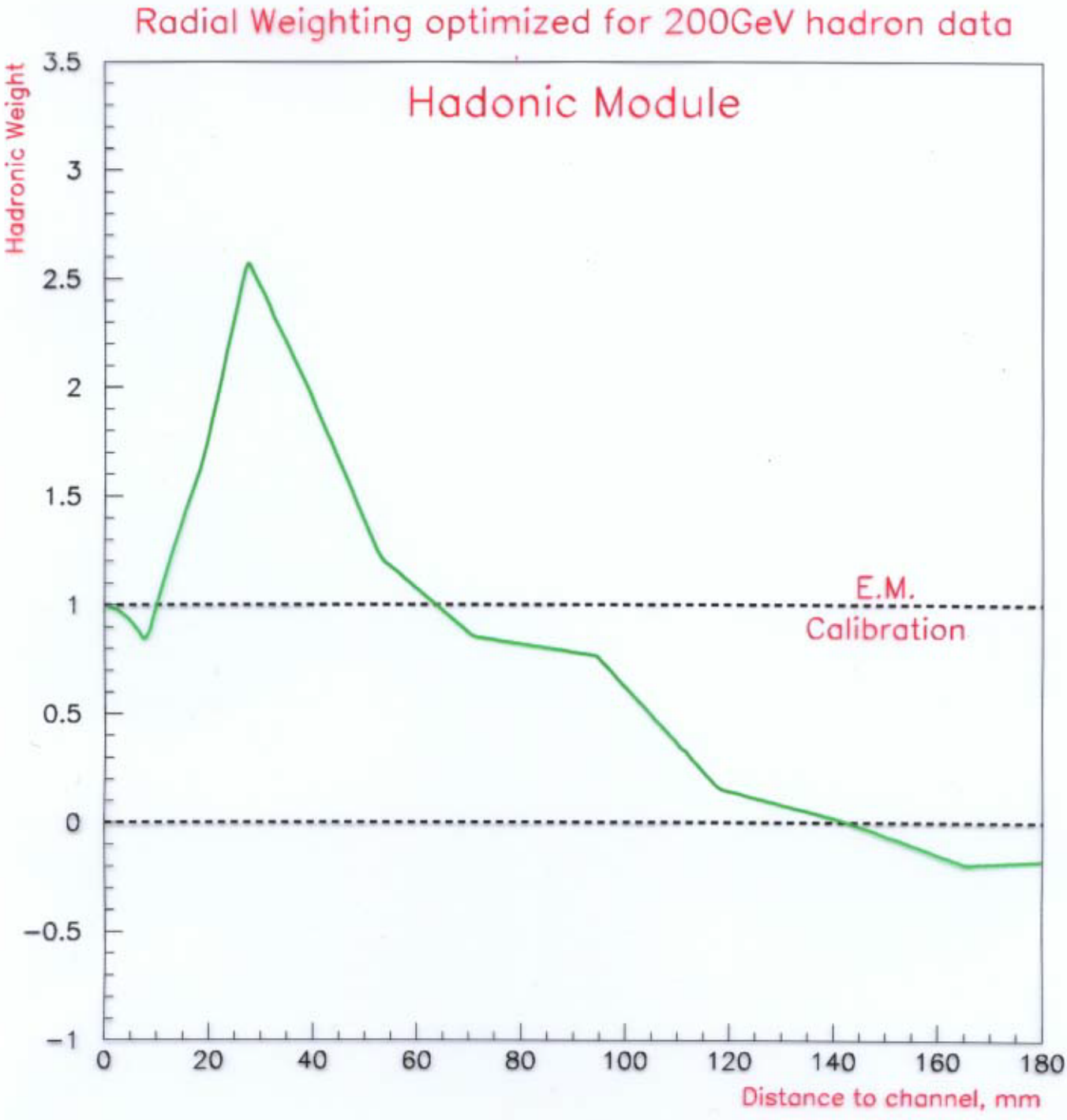
2. Minimum of the energy resolution at
   highest available beam energy RMS(E_{REC})

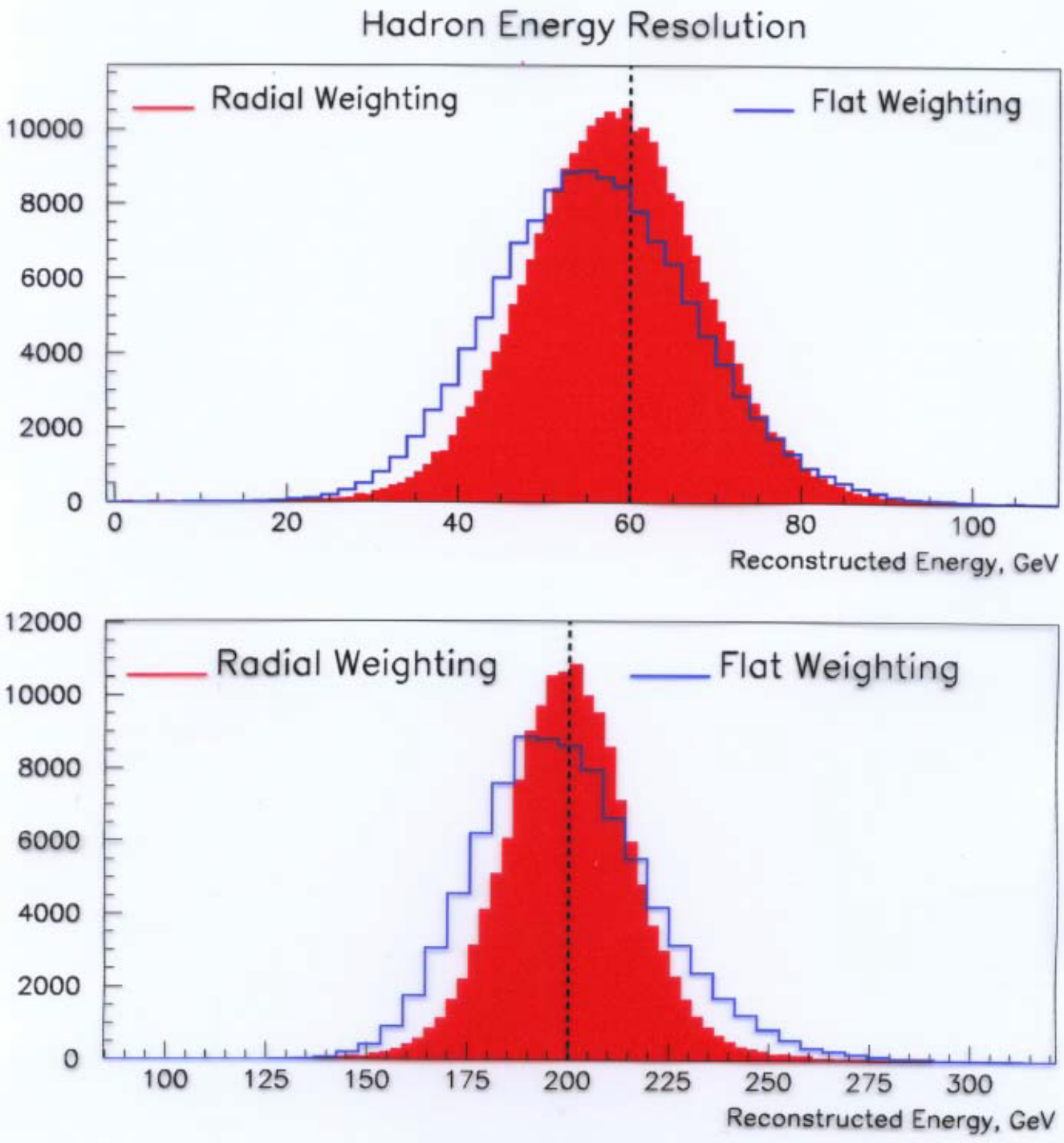
3. Subsidiary constrains may be applied
   to achieve better proportionality $E_{REC}/E_{BEAM}=1$
   and/or compensation $e/\pi=1$

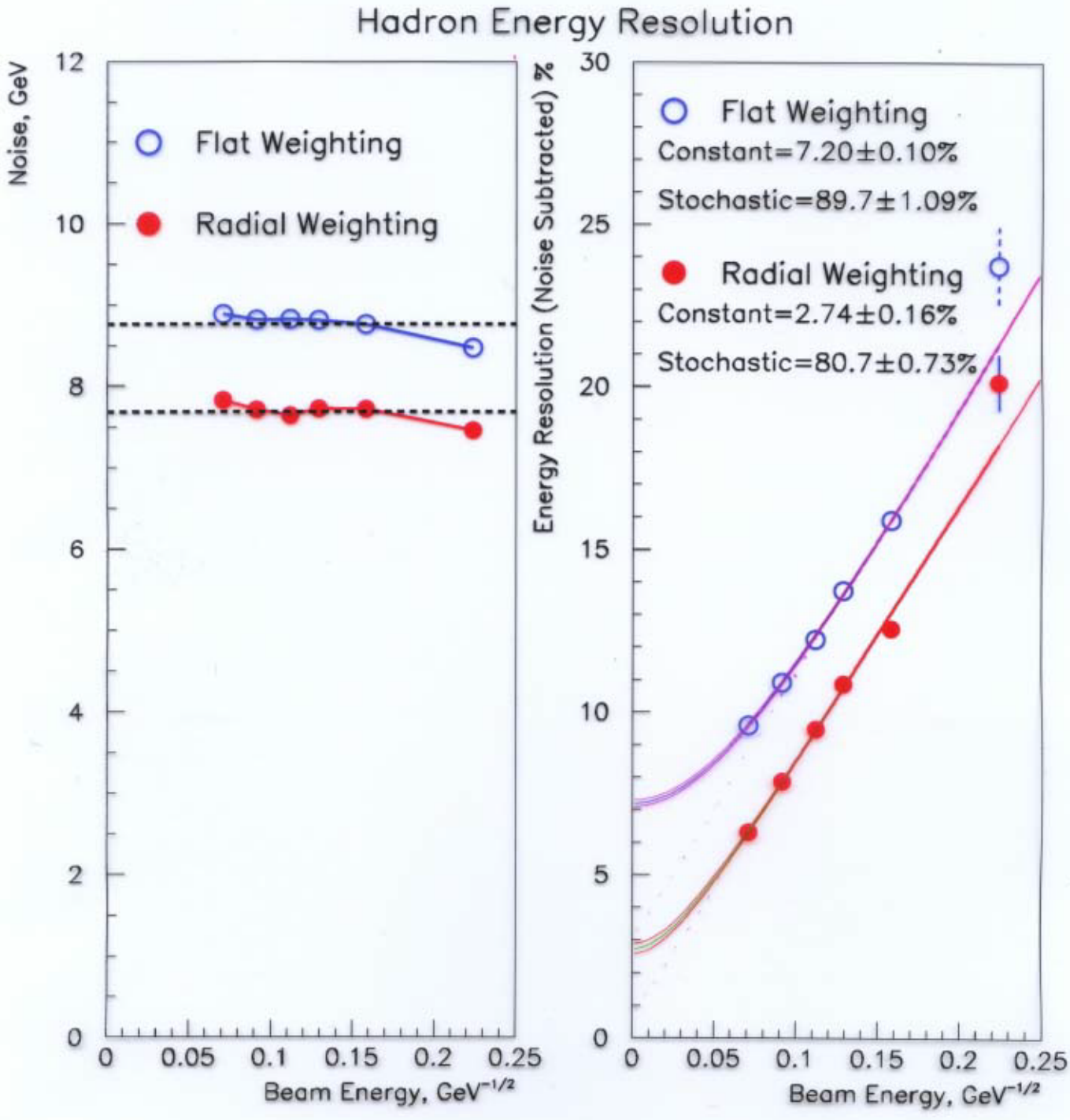

Radial Weighting optimized for 200GeV hadron data
EM Module
Hadronic Weight
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
−1
0
20
40
60
80
100
120
140
160
180
Distance to channel, mm
Hadronic
Halo Boost
Thermal noise
Suppression
E.M.
Calibration
Electromagnetic
core suppression
Coherent noise
Suppression

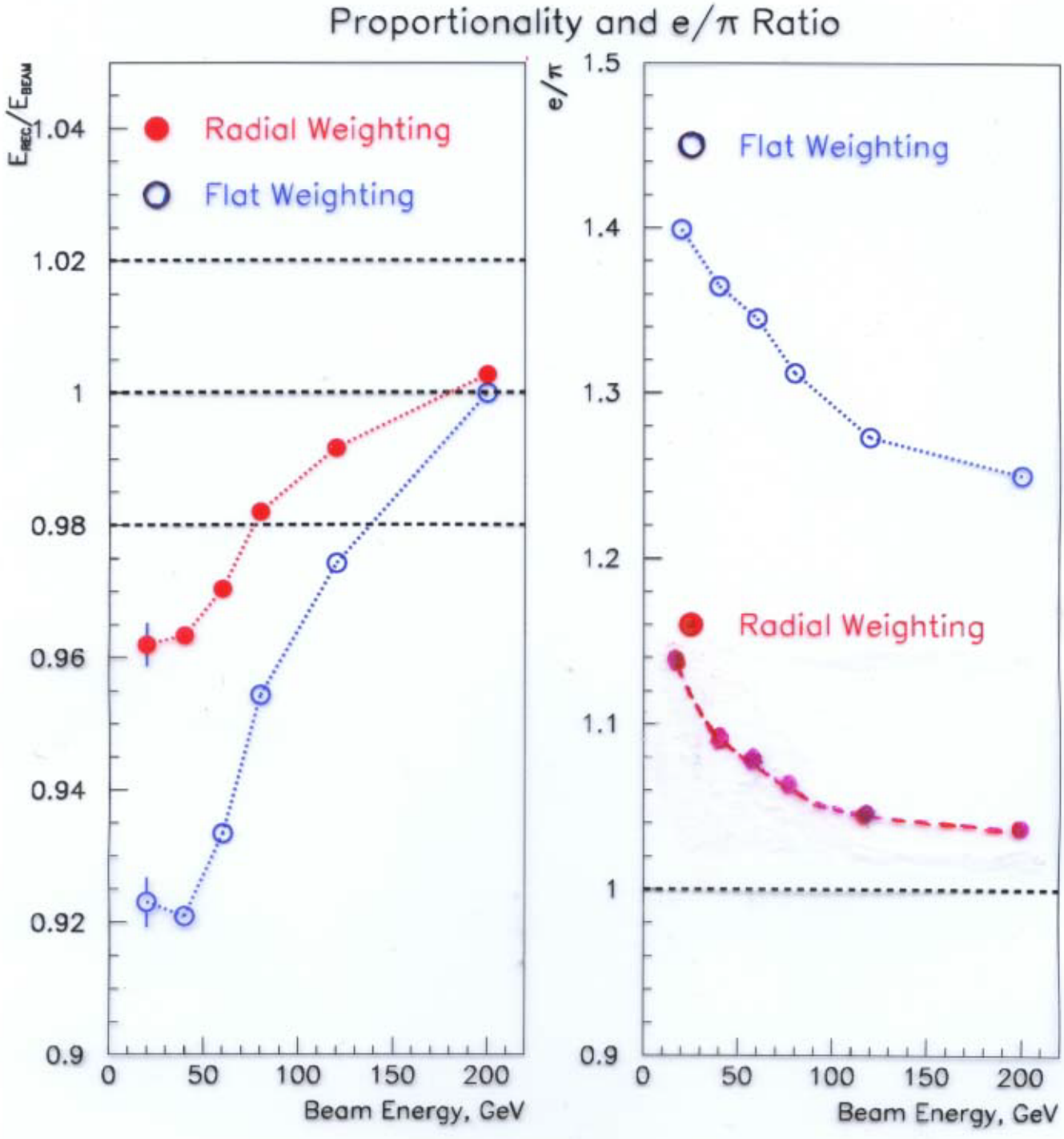

Hadronic Calibration – Central Area
Constant Gain Area
R(x,y)=(R1+R2+R3)/3
YCLUSTER−YCHAN, mm
XCLUSTER−XCHAN, mm
25
20
15
10
5
0
−5
−10
−15
−20
−25


Hadronic Calibration (200GeV)
Zero Calibration
Maximum=3.11 EM units
Center=0.87 EM units
$Y_{CLUSTER} - Y_{CHAN}$, mm
$X_{CLUSTER} - X_{CHAN}$, mm
200
150
100
50
0
−50
−100
−150
−200
−200
−150
−100
−50
0
50
100
150
200


Radial Weighting optimized for 200GeV hadron data
Hadonic Module
Hadronic Weight
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
−1
E.M.
Calibration
0
20
40
60
80
100
120
140
160
180
Distance to channel, mm


Hadron Energy Resolution
Radial Weighting
Flat Weighting
10000
8000
6000
4000
2000
0
0
20
40
60
80
100
Reconstructed Energy, GeV
Radial Weighting
Flat Weighting
12000
10000
8000
6000
4000
2000
0
100
125
150
175
200
225
250
275
300
Reconstructed Energy, GeV


Hadron Energy Resolution
Noise, GeV
Flat Weighting
Radial Weighting
Beam Energy, GeV$^{-1/2}$
Energy Resolution (Noise Subtracted) %
Flat Weighting
Constant=7.20±0.10%
Stochastic=89.7±1.09%
Radial Weighting
Constant=2.74±0.16%
Stochastic=80.7±0.73%
Beam Energy, GeV$^{-1/2}$


Proportionality and e/π Ratio
E_{REC}/E_{BEAM}
Radial Weighting
Flat Weighting
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
0
50
100
150
200
Beam Energy, GeV
e/π
1.5
1.4
1.3
1.2
1.1
1
0.9
Flat Weighting
Radial Weighting
0
50
100
150
200
Beam Energy, GeV

Conclusions

Radial Weighting :

1. Provides very intuitive solution for Hadronic Calorimeter Performance improvement, compared with Flat weighting
2. Deviation of Hadronic responce from proportionality is reduced by half
3. Non−compensation reduced 4 to **6** times
4. Energy Resolution improved :
   - Constant Term from 7.20% to 2.74%
   - Stochastic Term from 89.7% to 80.7%
   - Noise from 8.8GeV to 7.7GeV
5. Perspective Studies :
   - Application to Jets (MCarlo+Data)
   - Coherent Noise Suppression (MCarlo+Data)
   - Subsidiary Constrains for further performance optimization (MCarlo, Data)