# Tuning response of the central calorimeter to hadrons

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- To be tuned:
  - **Calorimeter scale:** response (E/P) for hadronic showers
  - **Resolution**
  - **Lateral profile**
  - **Longitudinal profile**
  - Response in the cracks
- CEM and CHA are different
- In general no simple parameters (compare to resolution in COT), have to vary functions of energy and other parameters
- GFLASH has many parameters varying which leads to correlated effects
- For this study: see what can be achieved by rescaling of certain parameters: shower width, resolution, response

# Introduction (contd)

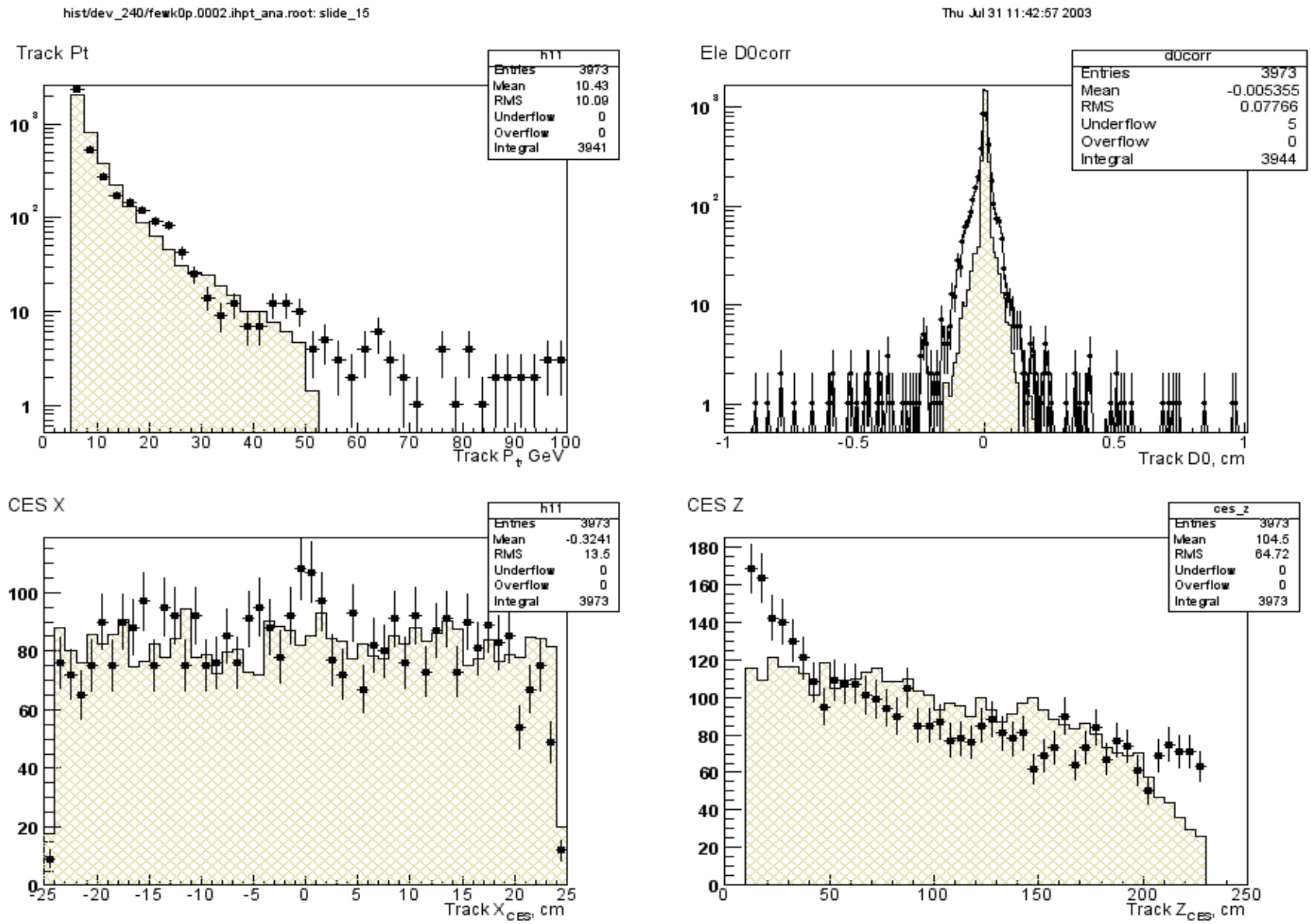
- History of CDF calorimeter simulation tuning starts from cdf-1066 by Marjorie, Steve Behrends and E. Pare
- Run II studies:
  - Sarah Demers
  - Mel Shochet, Matt Baumgart
- CDF-5886 Soon, Charles et al: tuning of GFLASH – 1997 test beam , lateral profiles using minbias (1 GeV)
  - Lateral profiles were tuned by looking at the energy sharing in eta
- Tau ID:
  - Hadronic tau's : isolated jets
  - Tau clustering thresholds: lateral leakages increase energy in the isolation cone
- For tau embedding to work need reliable simulation of the lateral shapes of hadronic showers
- Technique:
  - Use isolated tracks and compare shower shapes in the data to MC (single pions)
- Most difficult part of the work is to create a sample of isolated tracks and verify that comparison of the data to MC makes sense
  - Low-pt sample: minbias (gmbs08 stntupled)
  - **High-Pt: stripped from gjet08/09**

# High-Pt isolated track sample (strip)

- Stripping requirements:
  - Pt > 5 GeV, |eta| < 1.2
  - N(axial seg) >= 3, N(stereo seg) >= 3 (segment: “ >=6 hits” )
  - |D0| < 2 cm
  - In 2D sector of 0.4 there is no other track with Pt > 0.5
  - No other track with Pt > 0.5 extrapolates into the same wedge
- 25,649 events

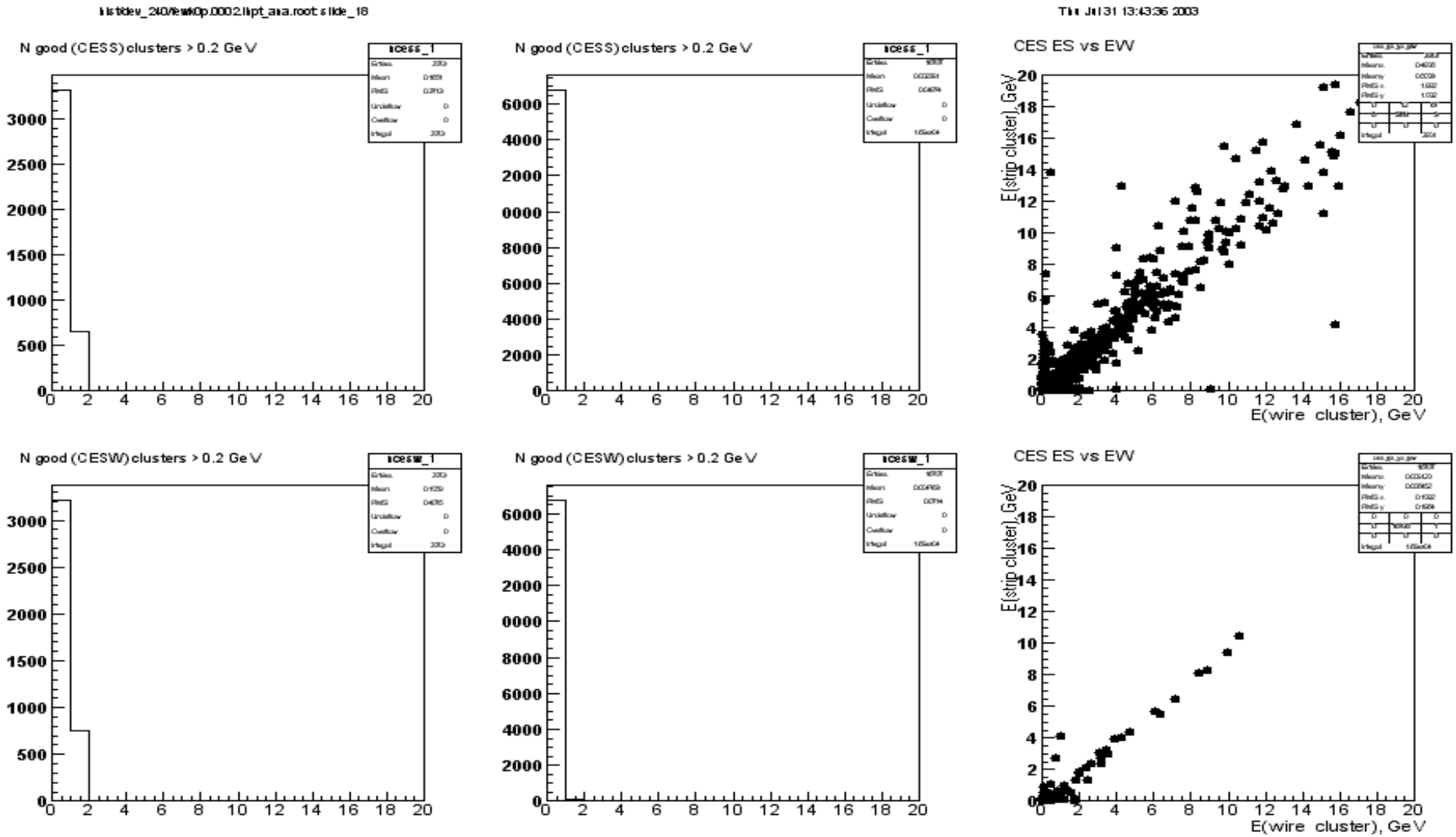
- Analysis:
  - No other track with Pt > 0.4 in 2D sector of 0.5
  - no other track with Pt > 0.4 points to the same or neighbouring wedges (on the same side )
  - 9 cm < CES Z <230 cm
  - |CES X| < 25 cm
  - CES isolation:
    - no CES clusters with E>0.2 in the neighboring wedges on the same side
    - Only 1 strip / 1 wire CES cluster in the hit chamber with E > 0.2, should be within 5 cm from the track
- 3,973 events

# High-Pt isolated track sample, contd



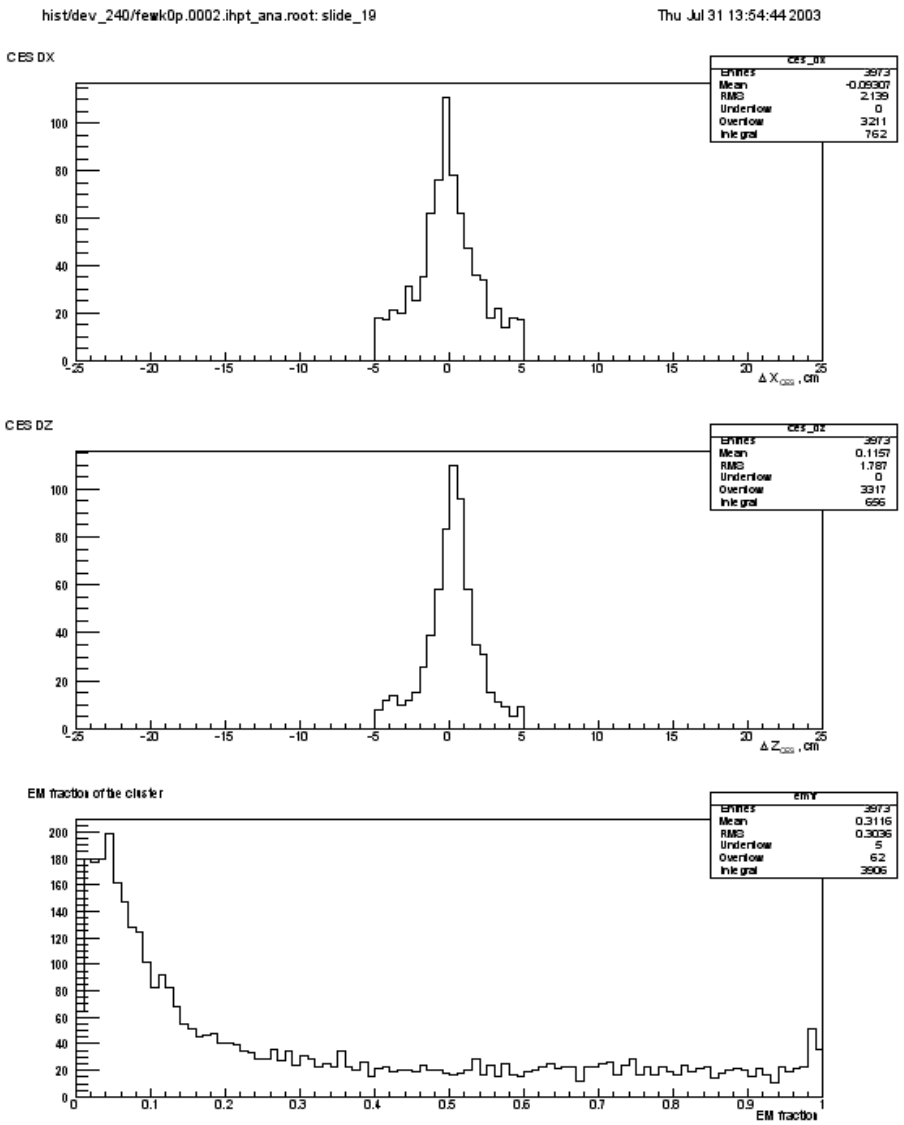
# CES clusters, produced by the hadrons

- Significantly more (x10-20) CES clusters in the data, than in the MC
- Contribution from electrons? conversions?



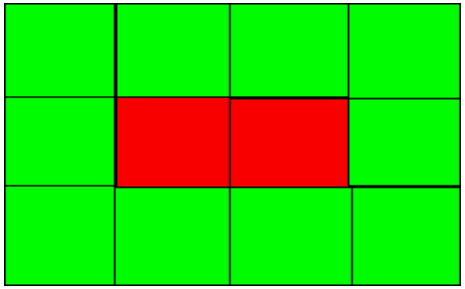
# CES clusters, contd

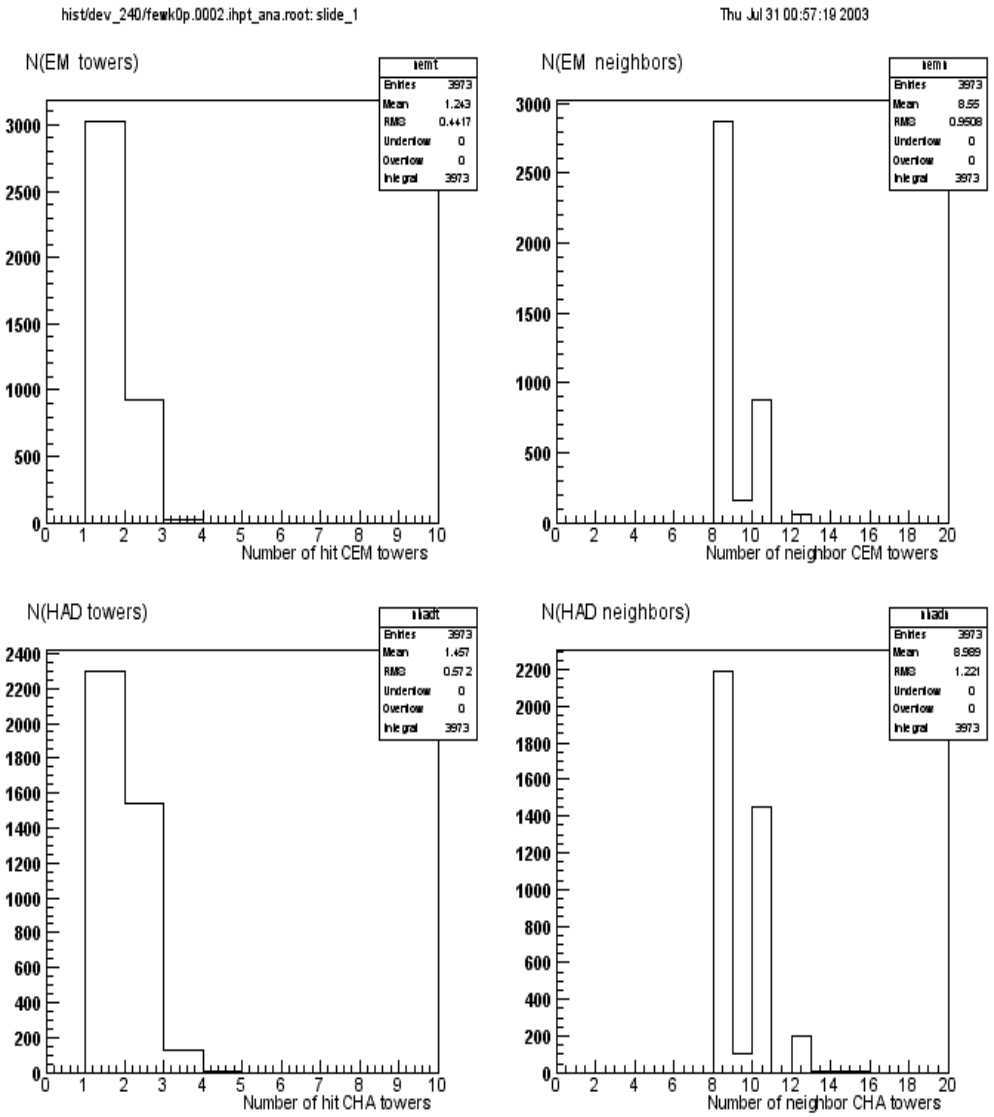
- Delta X/Z distributions show that the clusters are definitely associated with the track
- Distributions for EM fraction of deposited energy shows that fraction of electrons is small



# Calorimeter response

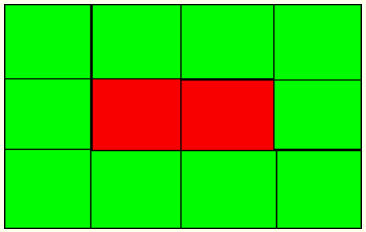
- track energy deposition in the calorimeter:
  - Find hit towers (1,2,3..- red) - in red
  - Determine ring of the neighboring towers - green(8,10,..)
  - Sum energies in the hit and neighboring towers separately
  - sum energy depositions in the central and neighboring wedges (3 of them)
- more sofisticated procedure allows to keep the statistiscs



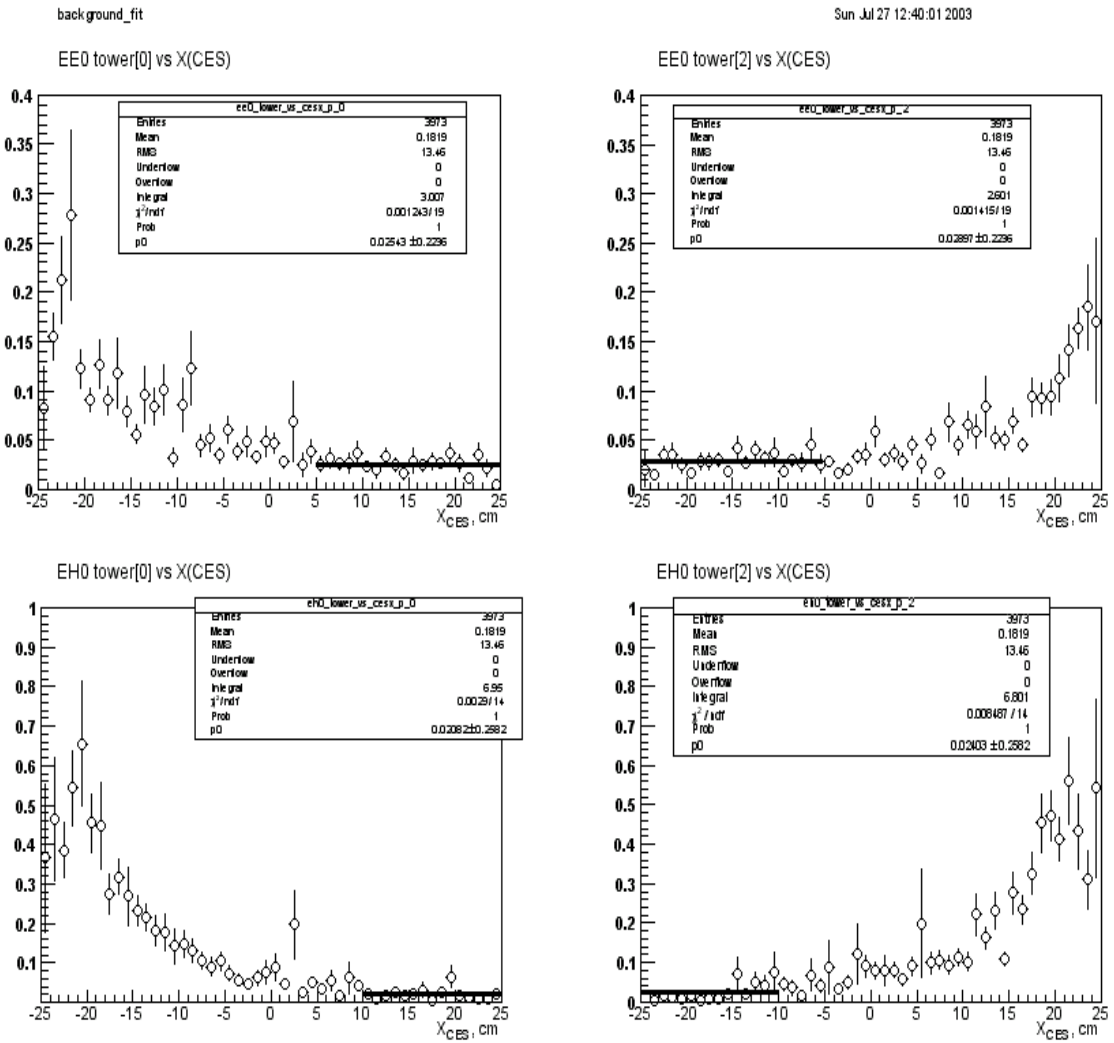


# Background

- Study energy deposition in the neighboring wedges as a function of X(CES), assume leakage into the next-to-closest ring of towers to be small

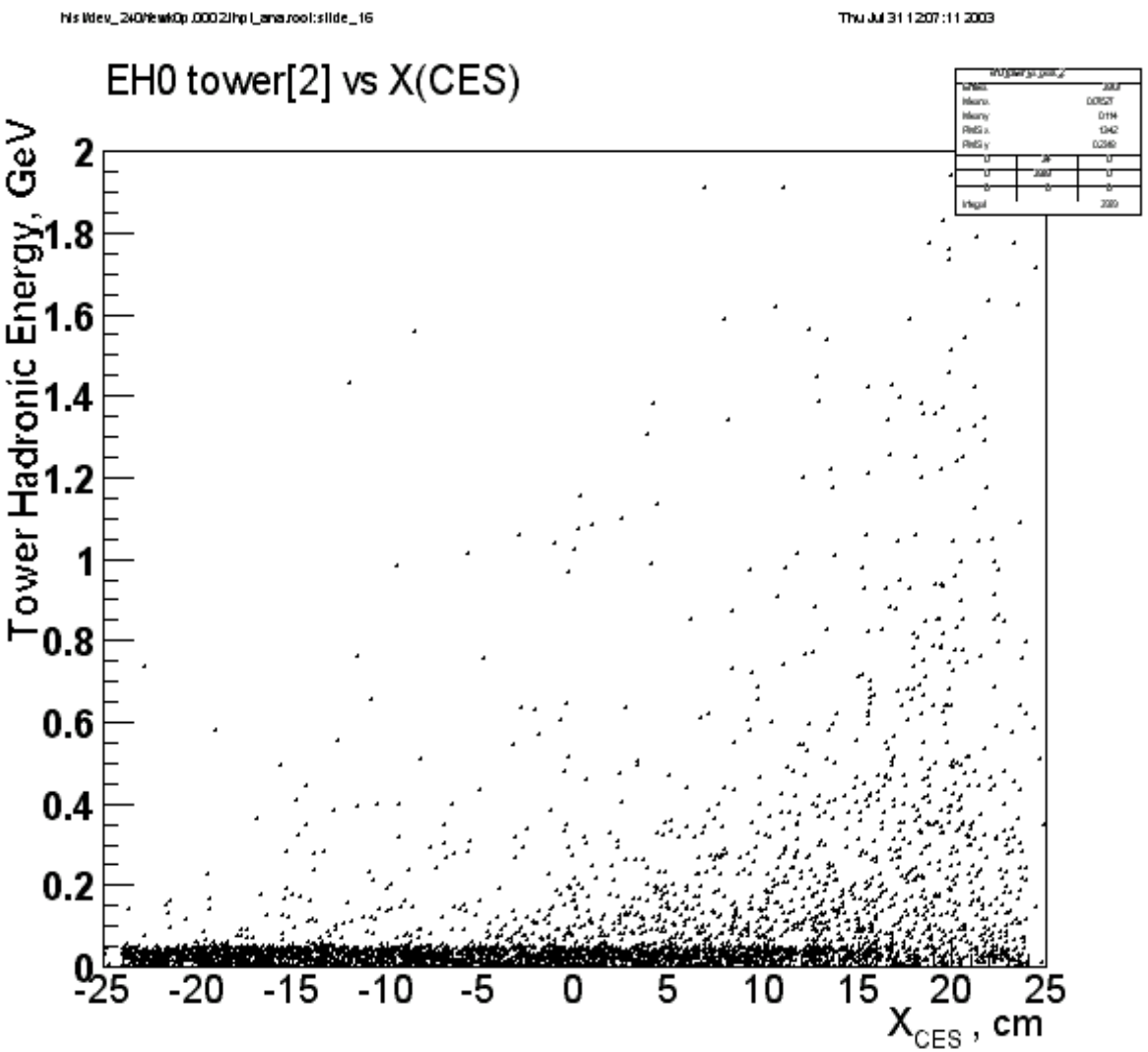


- Determine mean background separately for HAD and EM compartents
  - <E(EM)> = (27 +/- 2) MeV,
  - <E(HAD)> = (22 +/-2) MeV



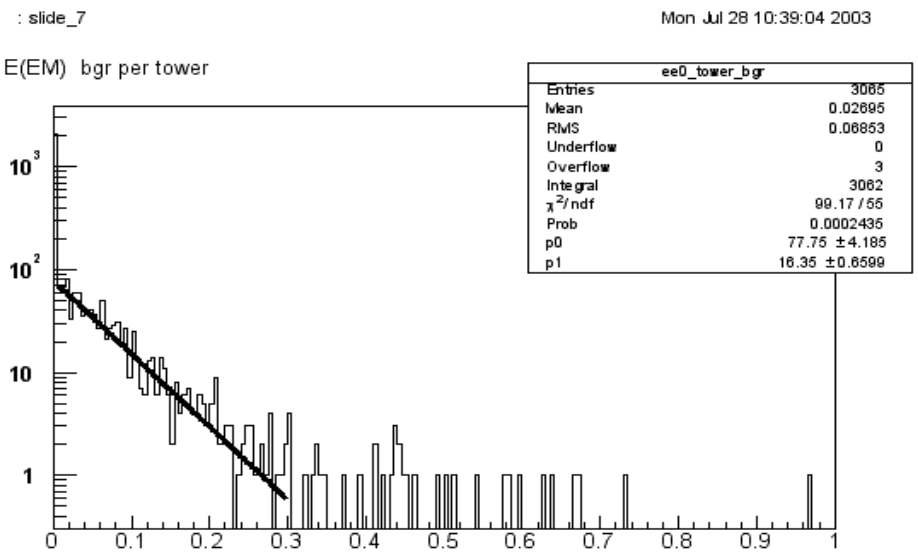
# Mean value of the background?

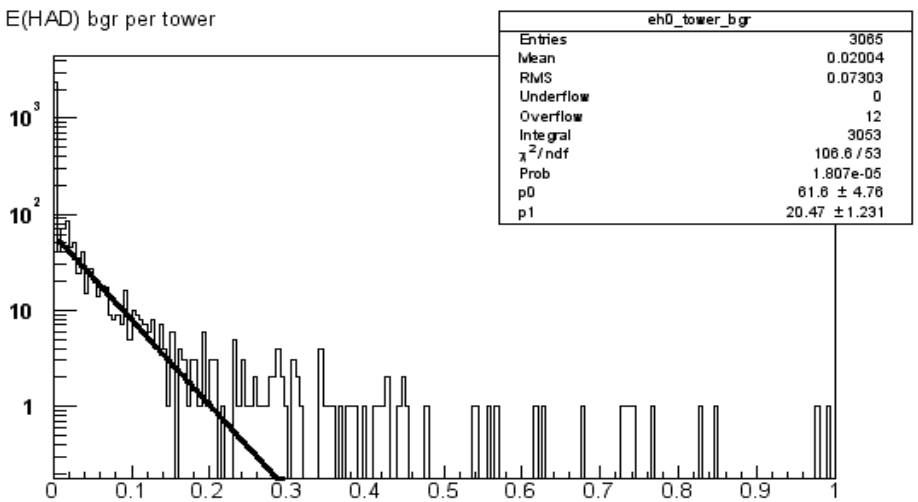
- <Mean value of the background> is a given by a combination of 2 components
  - Towers with zero energy
  - Non-zero tail
- subtracting <mean background> leads to negative energies
- Energy depositions in the shoulder towers are small, subtracting the mean is always wrong



# Background Parametrization

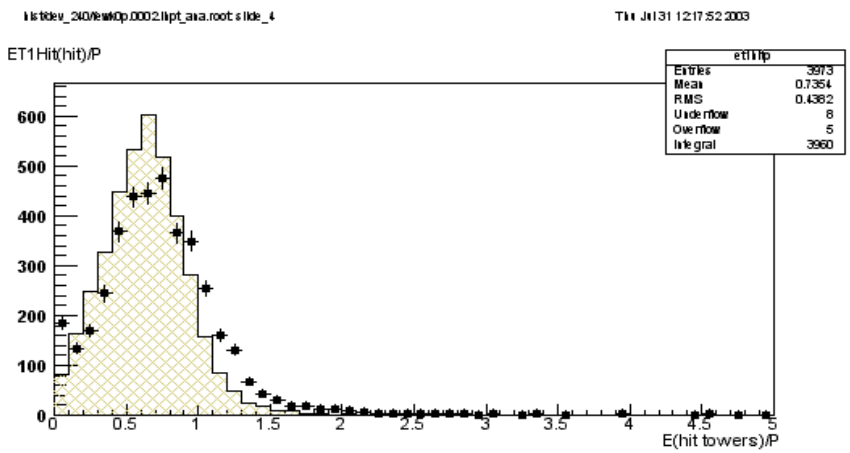
- Determine distribution for the background
  - X(CES) > 5 cm or X(CES) < -5 cm
  - EM and had separately
- 2 inputs :
  - Probability for a tower to have non-zero energy
  - Energy distribution in "non-zero" case
- Fit region 50-300 MeV with the exponential
- EM: 0.65 + 0.35*exp(-16.4*E)
- HAD: 0.76+0.24*exp(-20.5*E)
- Simulate "background" in CEM (CHA) and add it to the MC distributions

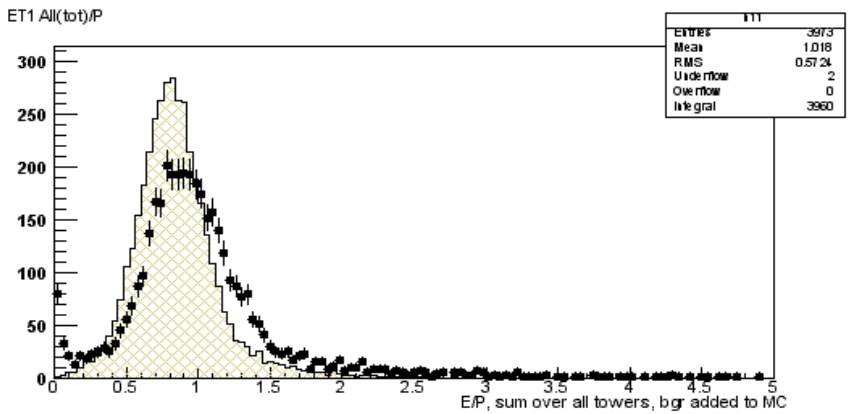


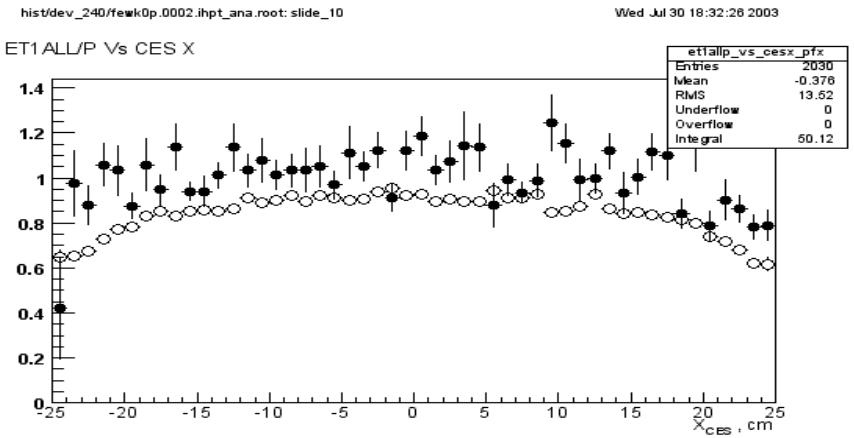



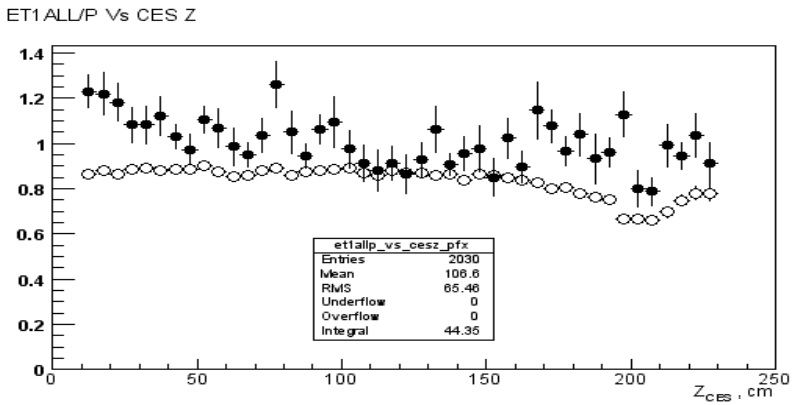
# Overall response

- E/P distributions for 2 different ways of summing the E
  - Sum E over the hit towers
  - Sum E over the hit and neigbor towers
- Differences between the data and MC are also seen in the profile dist vs X/Z(CES)



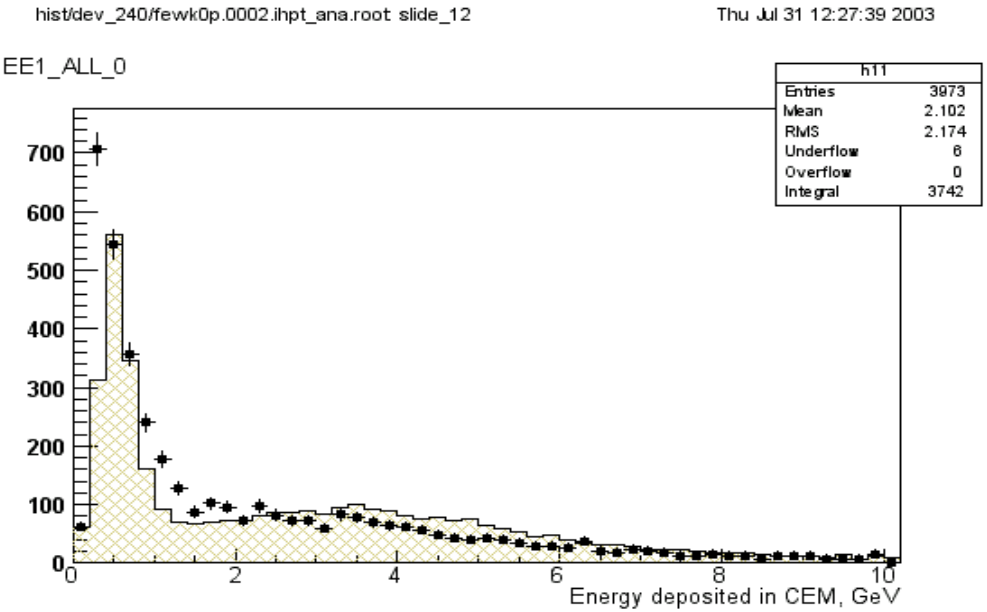



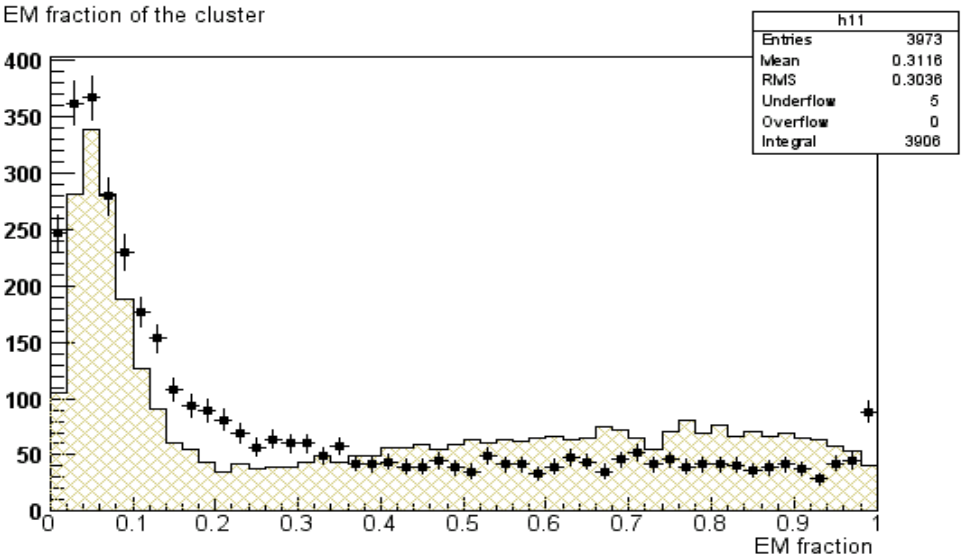



# Electromagnetic fraction

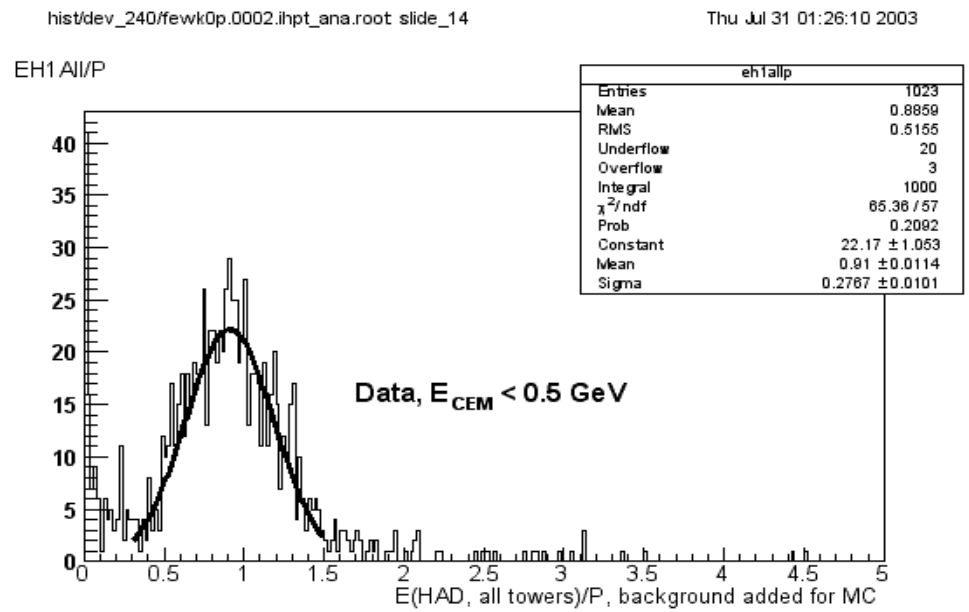
- MC distributions have “random noise” added
- Data distribution for EM energy deposition has a tail compared to MC
- Same tail is reflected in the distribution for the EM fraction of the cluster, corresponding the the isolated track
- Use “MIP-like” particles E(EM) < 0.5 GeV to study CHA response
- Track Pt is above 5 GeV, subtracting 0.5 GeV is less than 10% effect

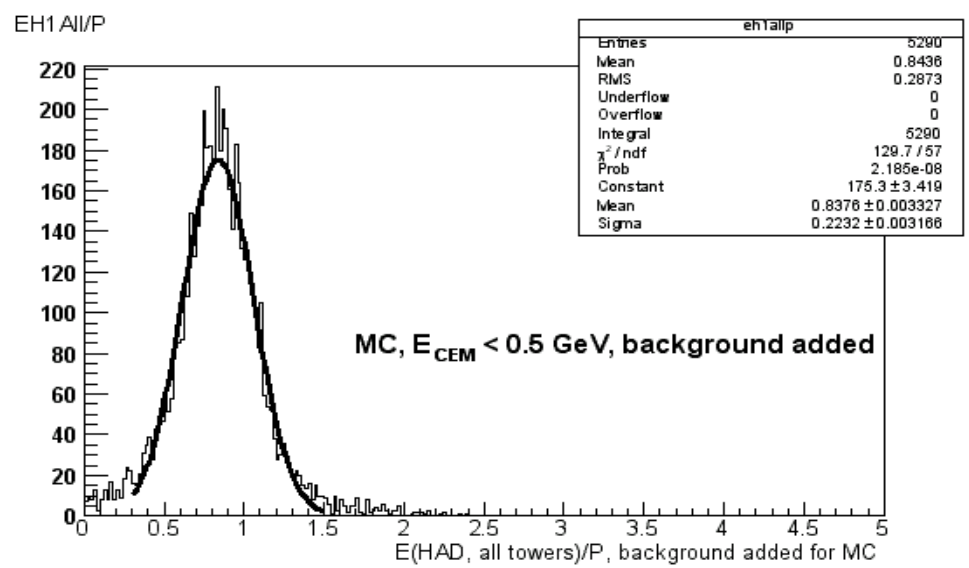


# Overall response, contd

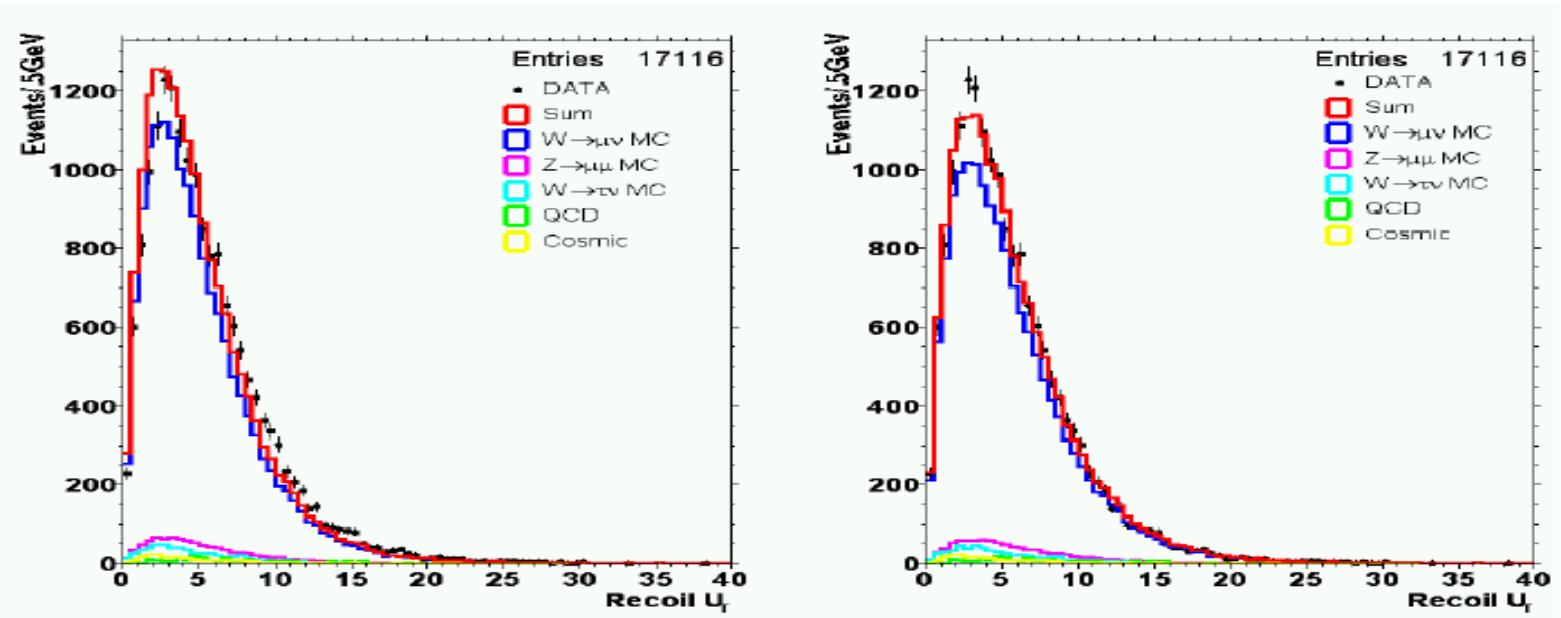
- Follow Run I strategy – use CEM MIP particles to analyse differences between the data and MC
- Data:
  - <E/P> = 0.91 +/- 0.01 (fit)
  - Sigma = 0.28 +/- 0.01 (fit)
- MC:
  - <E/P> = 0.84 +/- 0.003 (fit)
  - Sigma = 0.22 +/- 0.003 (fit)
- CHA scale factors:
  - Scale: Data/MC = 1.11 +/- 0.01 (fit)
  - Resolution: 1.24 +/- 0.04 (fit) +/- 0.1(syst)
- Estimate of the systematic uncertainty comes from the variation of the fit conditions



# Overall response, III

- Work on understanding of the recoil energy by the W/Z cross-section group
  - Compare energy deposition by the particles recoiling against the W in the data to the simulated one
- Studies done by Jian Kang et al: best agreement when **MC response is scaled up by about 5-10%** (latest numbers closer to 5%)
- For <EM fraction> of 0.5 scaling total energy by 5% = scaling hadronic response by 10%



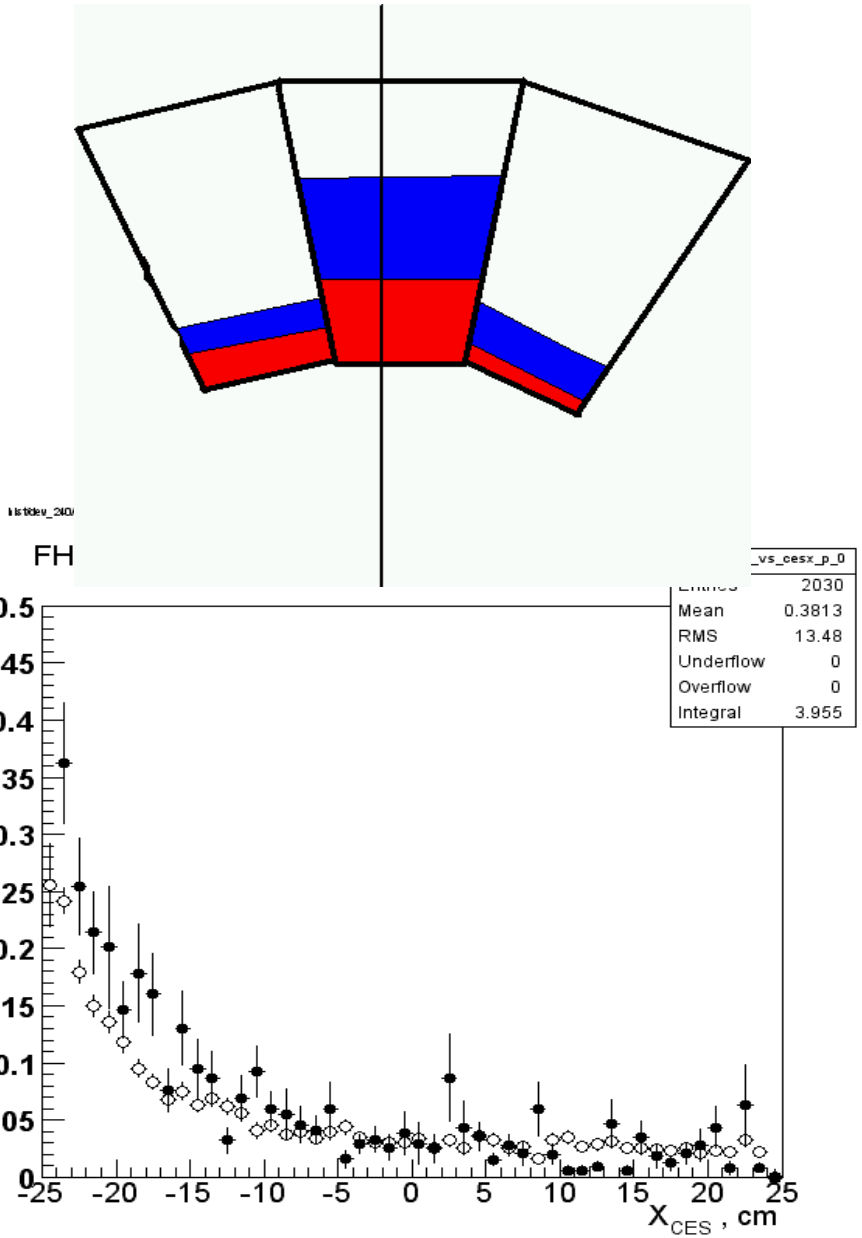
# Lateral profiles: distributions to study

- Study energy distributions for the central and shoulder wedges as a function of track position in the central wedge (X(CES)
- Effects
  - Leakage into the neighboring wedge
  - Response in the crack region
  - Energy dependence of above
- To reduce energy dependence use distributions for the fraction of energy deposited in the wedge:

$$F_{EM}(\text{wedge}) = E_{EM}(\text{wedge})/E_{EM}(\text{total})$$

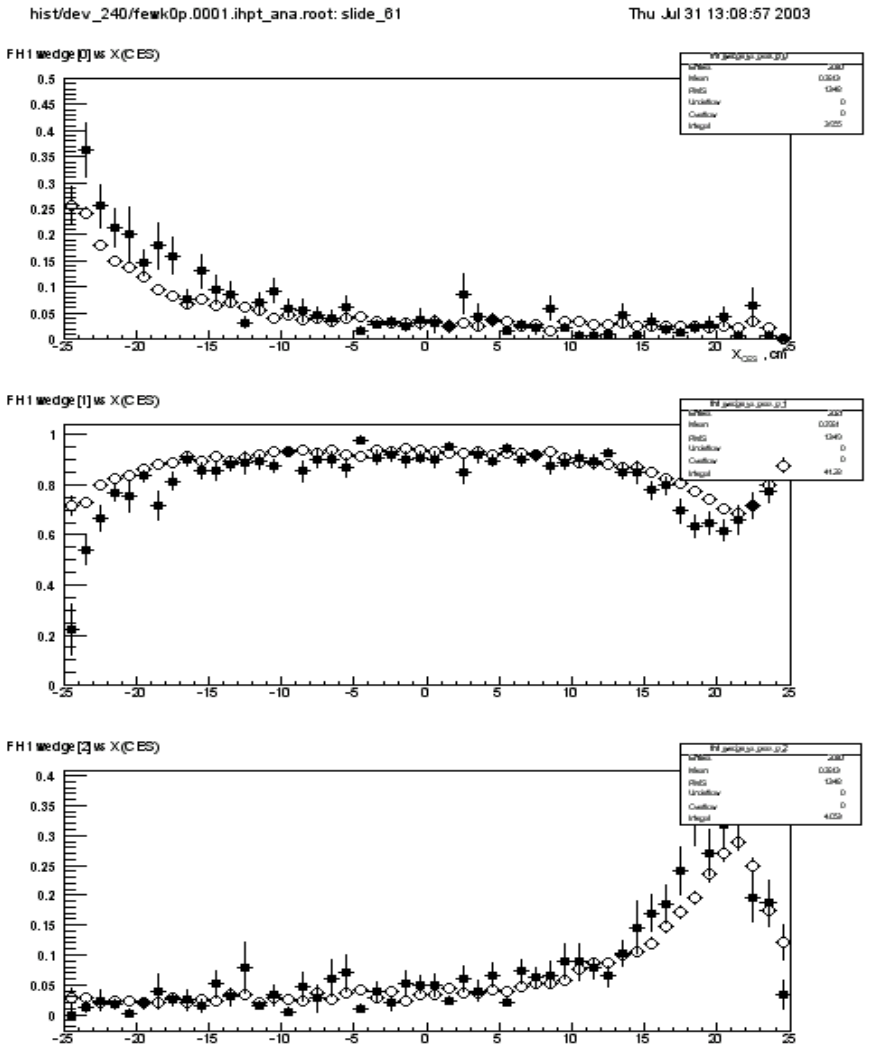
where total is sum over 3 wedges

- Use only positive tracks (for technical reasons)



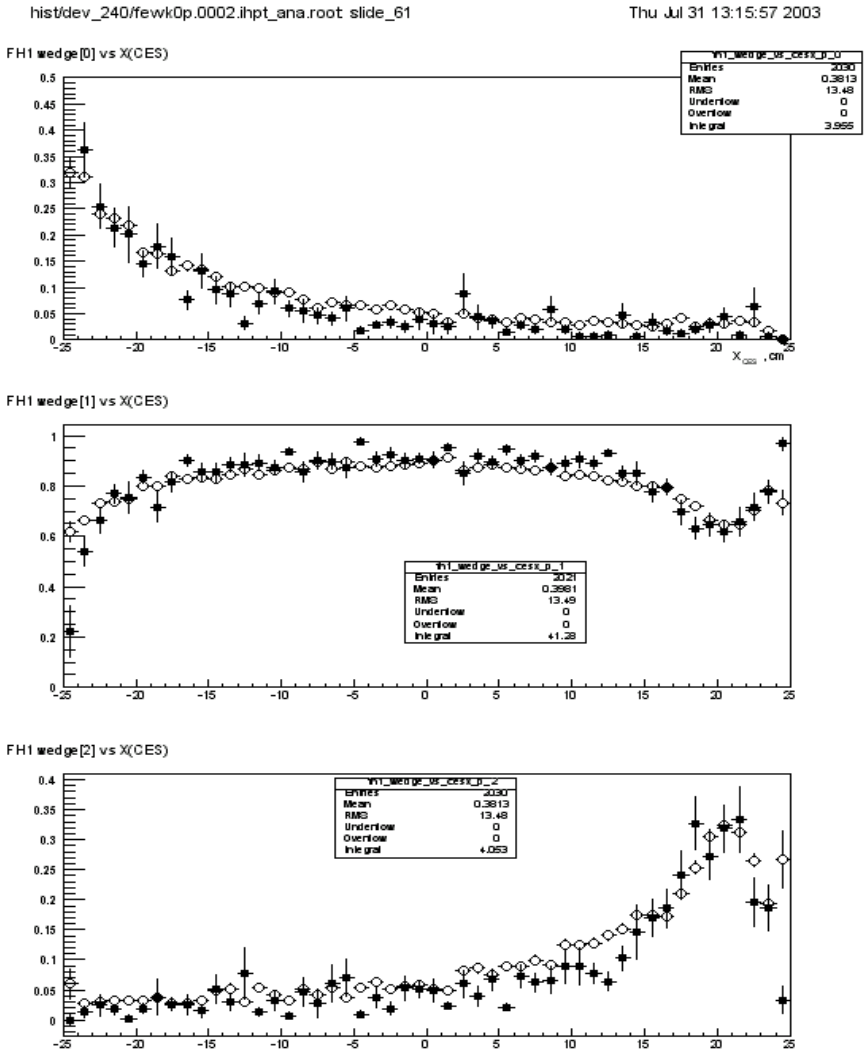
# Input for the fit

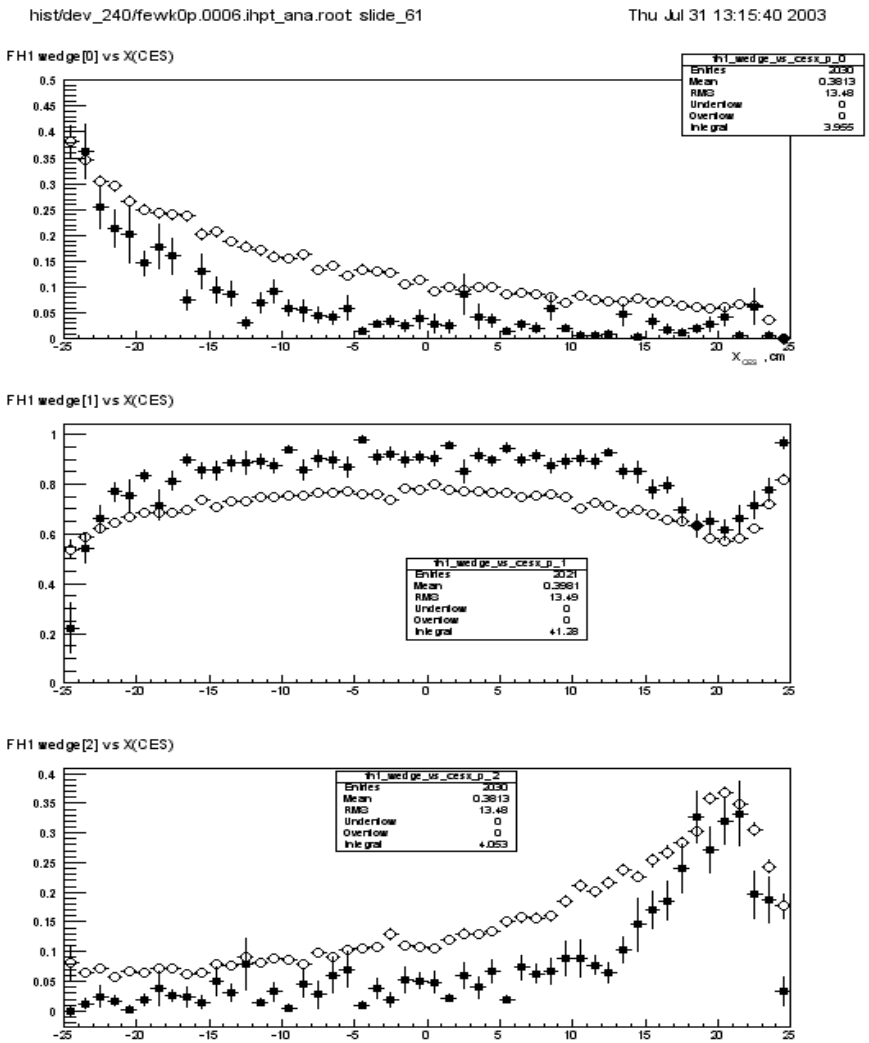
- Use 6 histograms: (CEM+CHA)x3 wedges for the fractions of deposited energy
- Overlay data and MC histogramss, calculate chi2 between them
- Generate MC samples for 6 different scale factors applied to the GFLASH parameter, defining "radius" of the hadronic shower :
  - 1, 1.5, 2, 3, 4, 5



# The best and the worst points

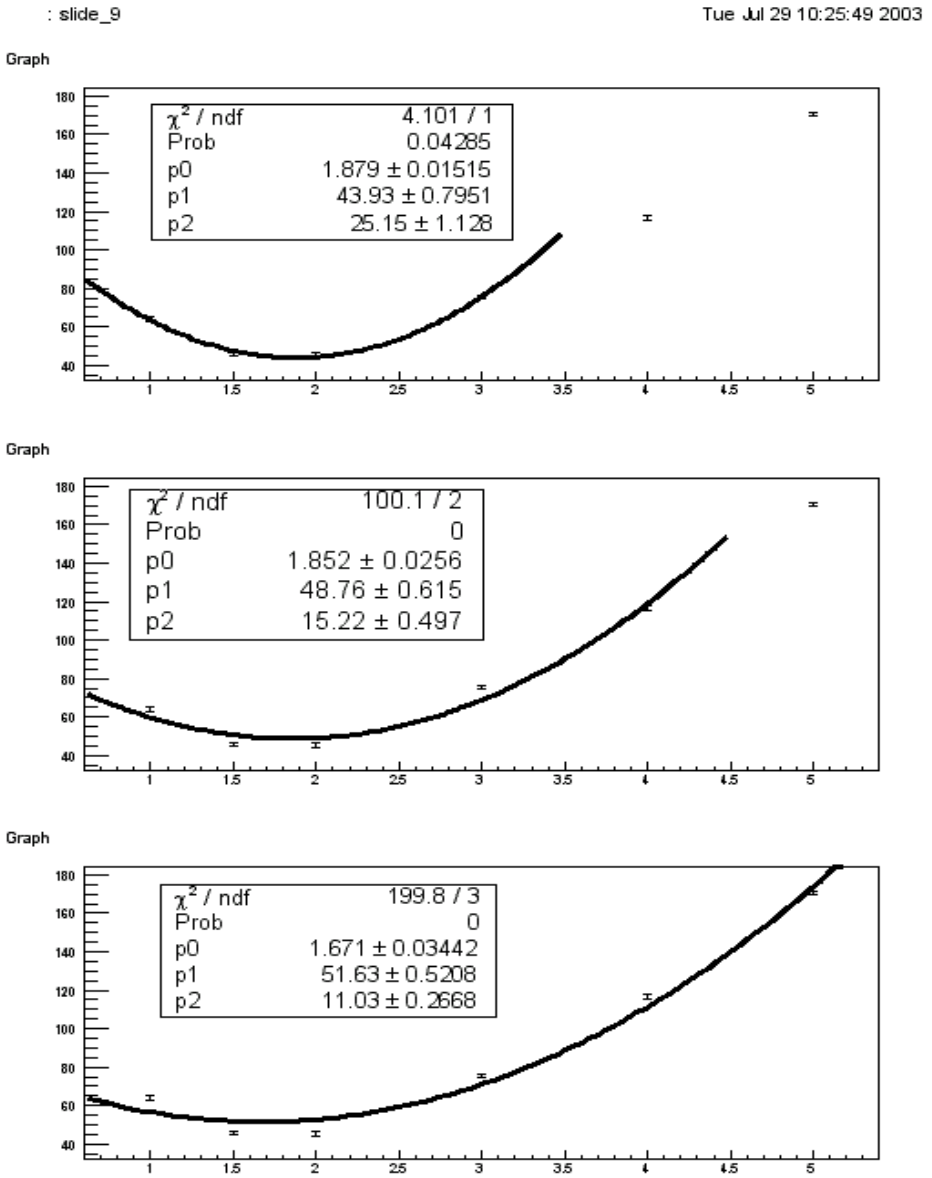
- The best generated point: scale factor of x2 (left), the worst one: x5 (right)



# Tuning : first step

- 
- 6 histograms per data point: 3 wedges x (EM and HAD)
- Fit chi2 dependence on the scale factor with the 2nd order polynomial, rescale chi2 of the fit
- Results (correlated)
  - N=4 : 1.88 +/- 0.03
  - N=5 : 1.85 +/- 0.18
  - N=6 : 1.67 +/- 0.28
- **Scale = 1.75 +/- 0.3**



# Summary

- CHA response to hadrons in MC needs to be scaled up by ~10% , this result agrees with the recoil energy studies done by W/Z cross section group
- No experimental proof that CEM response needs to be changed
- May want to scale resolution up by 20-30%, no independent proof however
- Lateral shower profile: the data described best if parameter, responsible for the lateral shower width is scaled up in both CEM and CHA
  - Scale factor : 1.75 +/- 0.3
- Discrepancy between the number of CES clusters in the data and MC (soft electron tagging, pi^0 reconstruction studies)
- Next steps:
  - Include negative tracks
  - Look at the energy sharing in eta
  - Cross check with minimum bias sample
- **Hope that this will be a conclusion**