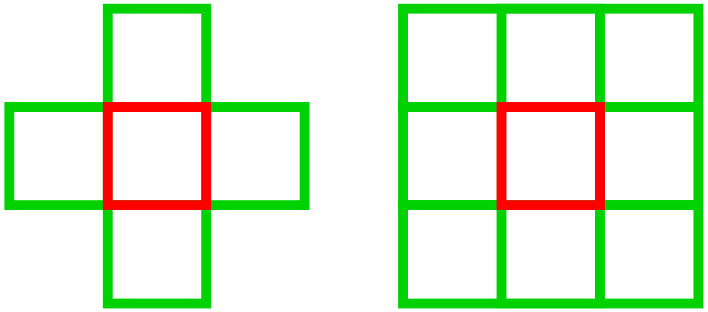
# CellNN Status:
# Energy Correction
# Outlines

- Short Overview of the Algorithm: calorimeter clustering cell by cell.
- Little Changes.
- Energy Correction Method:
  - $e^-$ in cracks
  - $e^-$ (not in cracks)
  - $\pi^\pm$
- First Results.
- Conclusion.

# CLUSTERISATION IN A FLOOR

all floors ~~ICD~~ ~~MG~~ ~~CH2-3~~

EM HAD



neighbours

loop over cells

local E maximun → F-Cluster

1 cell $\in$ 1 F-Cluster

↓

share E of cells

from overlapping F-Cluster

↓

merge fake F-Clusters

from shower fluctuation

- transverse shower shape parametrisation
- F-Cluster center from weighted mean (Dokee)

# GLOBAL CLUSTERISATION

each F-Cluster of EM3 ✳
initiates a G-Cluster

↓

step by step
angular matching
→ G-Cluster

↓

add cells from ICD, MG, CH2-3

↓

search for longitudinal minimum
in E distribution
→ split G-Clusters

✳ if no F-Cluster
then start from
EM4 ( FH1 .... , EM2, EM1 )

- $\geqslant$ 1 match :
  E sharing of F-Clusters
- allow for empty floors in HAD

# Few Changes (1)

- Longitudinal Matching :
  - before $\Longrightarrow$ cone (square section) in $\eta \times \phi$ from the primary vertex.
  - now $\Longrightarrow$ real cone from the primary vertex. Its section is defined in cm to have the same cone for the whole calorimeter even if the real cell size gets smaller with $\eta$ in the end calorimeters.

# Few Changes (2)

- In hadronic floors, most of problems came from shower fluctuations producing satellite clusters.
  - A first try has been to recover the energy of clusters below threshold (adding it to the nearest accepted Global Cluster at the end of the algorithm) $\Rightarrow$ doesn't help a lot.
  - Now, at the level of floor clustering, when 2 F-Clusters have at least one common cell $\Longrightarrow$ 2 criteria to decide if they are 2 genuine F-Clusters or if one is a fluctuation from the other. In case of fluctuation the 2 F-Clusters are merged :

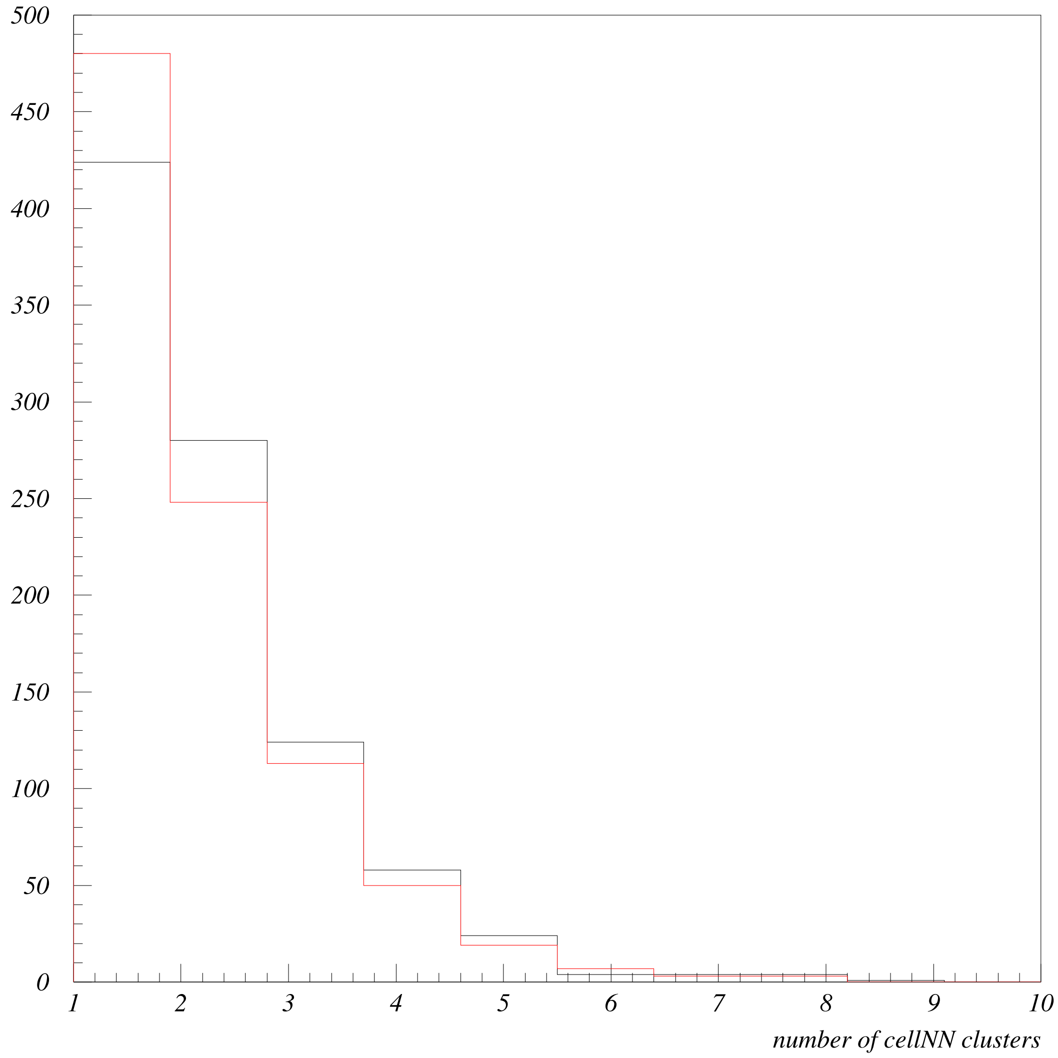
$$\frac{E(smallest\ F{-}Cluster)}{E(biggest\ F{-}Cluster)} < 80\%$$

for the smaller F-Cluster,

$$\frac{E(seed\ cell) - E(common\ cell)}{E(seed\ cell) + E(common\ cell)} < 50\%$$

# Few Changes (2): illustration

Effect of the satellite cluster correction: number of reconstructed clusters for a sample of 1000 evts of $50GeV$ pions.



# Energy Correction Method

$\Longrightarrow$ Assumption: an energy correction derived on single particles (electrons for the EM calorimeter and pions for the HAD calorimeter) is enough for energy reconstruction on more complex events. This assumption should be verified at the end.

Samples :

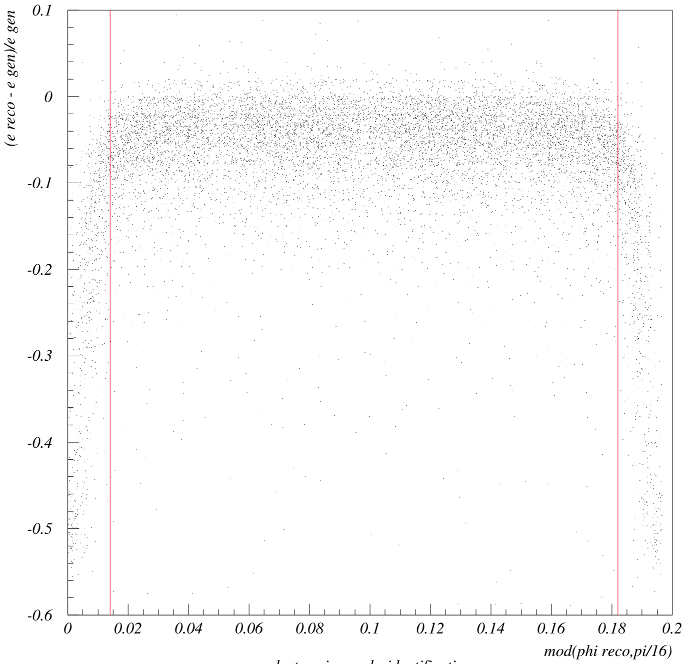
- $e^-$
  - 20000 evts, $15GeV <$ E $< 150GeV$, $0. < \eta < 1.$
  - 30000 evts, $15GeV <$ E $< 200GeV$, $1. < \eta < 3.2$
  - 50000 evts, $5GeV <$ E $< 25GeV$, $0. < \eta < 3.2$
- $\pi^\pm$
  - 100000 evts, $2GeV <$ E $< 50GeV$, $0. < \eta < 3.2$

Choose events with 1 reconstruted cluster for calibration.

# $e^-$ in $\phi$ cracks
# in the central calorimeter

- $e^-$:
  $mod(\phi_{reco}, \frac{\pi}{16}) < 0.014$
  or
  $mod(\phi_{reco}, \frac{\pi}{16}) > 0.182$

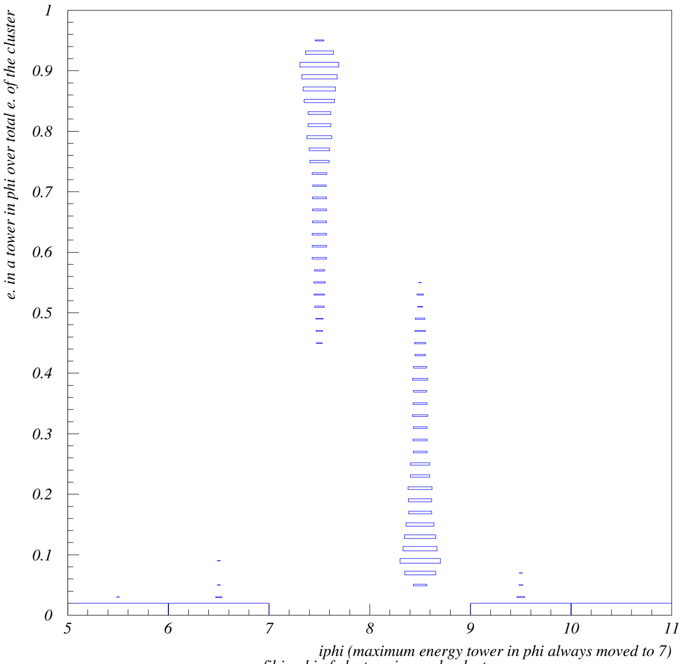
  $\Longrightarrow$ in a crack!



electron in cracks identification

Then, construction of "towers in $\phi$" for a cluster:
◇ energies of cells with the same iphi are summed,
◇ energy in each tower in $\phi$ is divided by the cluster energy
$\Longrightarrow$ fraction of the cluster energy by tower in $\phi$

- $\phi$ towers: energy fraction (highest energy tower rotated to $iphi = 7$, crack between $iphi = 7$ and $iphi = 8$.)

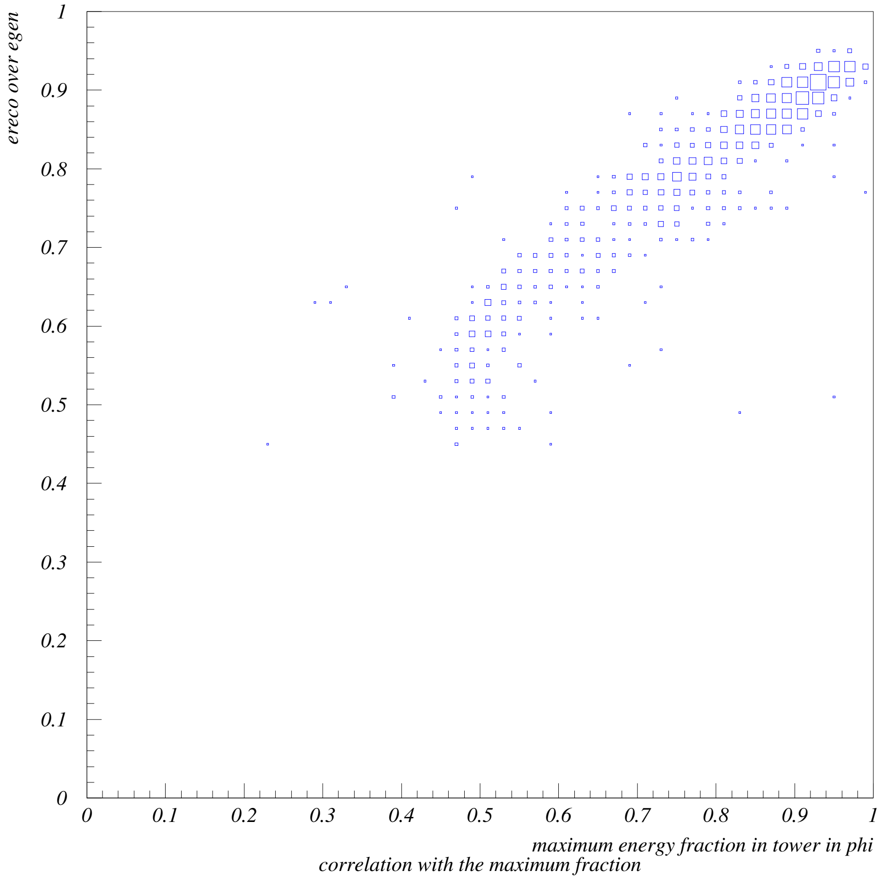


profil in phi of electron in cracks cluster

# $e^-$ in $\phi$ cracks in the central calorimeter

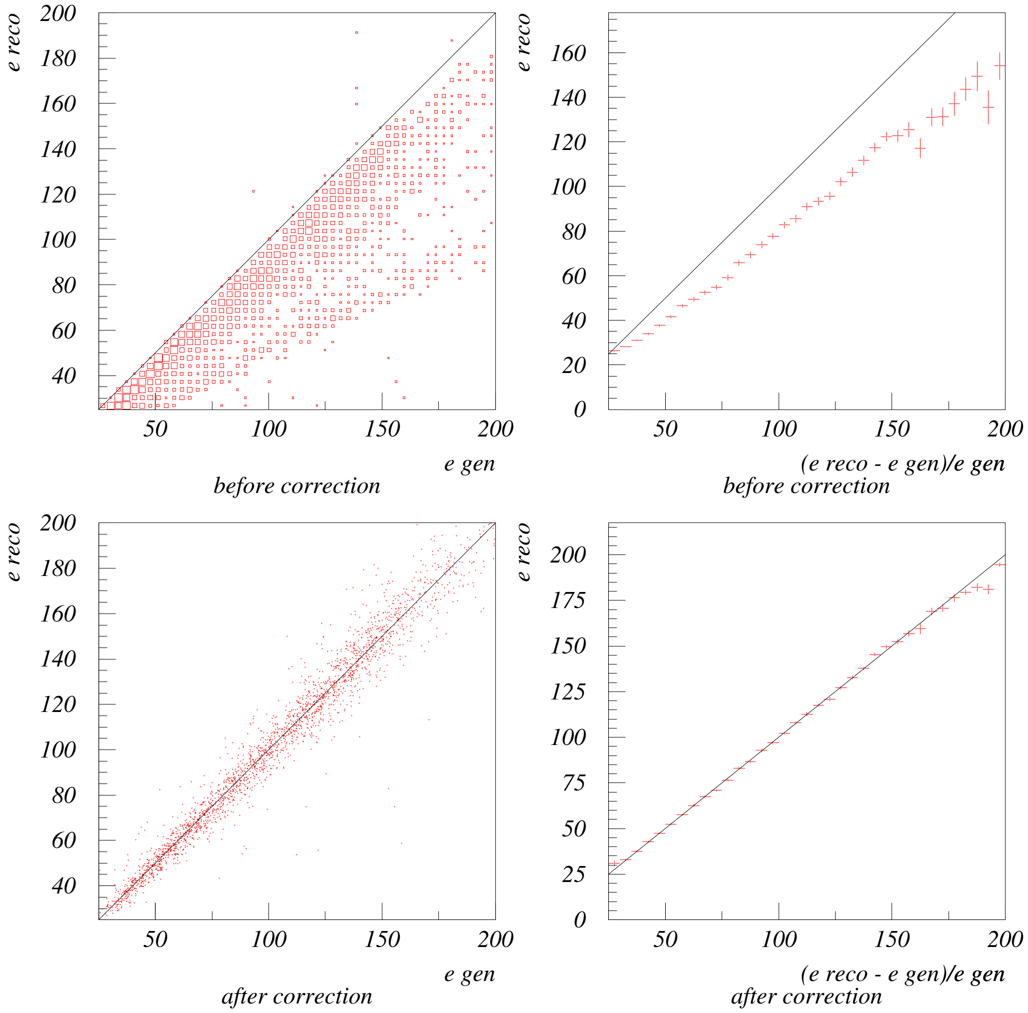
Lost energy is correlated to the maximum energy fraction and to the next to maximum energy fraction in $\phi$ tower because the crack is between those 2 $\phi$ towers.

- For example, correlation with the max energy fraction in $\phi$ tower:

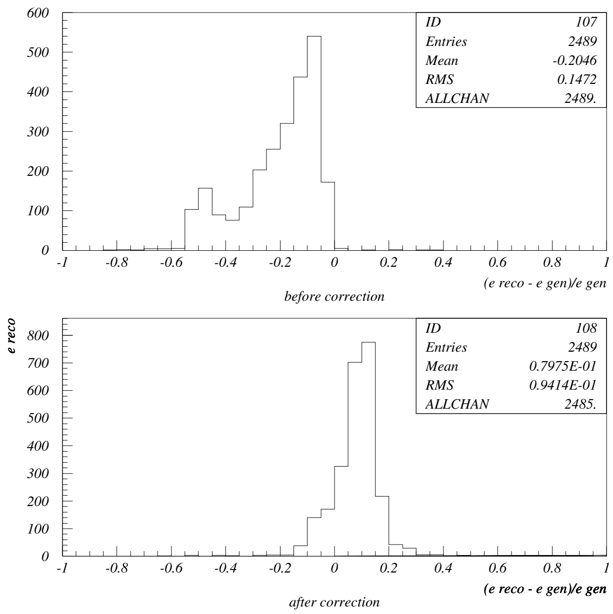



$\Longrightarrow$ a fit for low and high energies:

$$e_{gen} = (\alpha \times \ energy\ fraction\ in\ \phi^{max}_{tower} + \beta \times energy\ fraction\ in\ \phi^{next\ to\ maximum}_{tower} + \gamma) \times e_{reco}$$



e reco
e gen
before correction
e reco
(e reco - e gen)/e gen
before correction
e reco
e gen
after correction
e reco
(e reco - e gen)/e gen
after correction

ID 107
Entries 2489
Mean -0.2046
RMS 0.1472
ALLCHAN 2489.
(e reco - e gen)/e gen
before correction
e reco
ID 108
Entries 2489
Mean 0.7975E-01
RMS 0.9414E-01
ALLCHAN 2485.
(e reco - e gen)/e gen
after correction

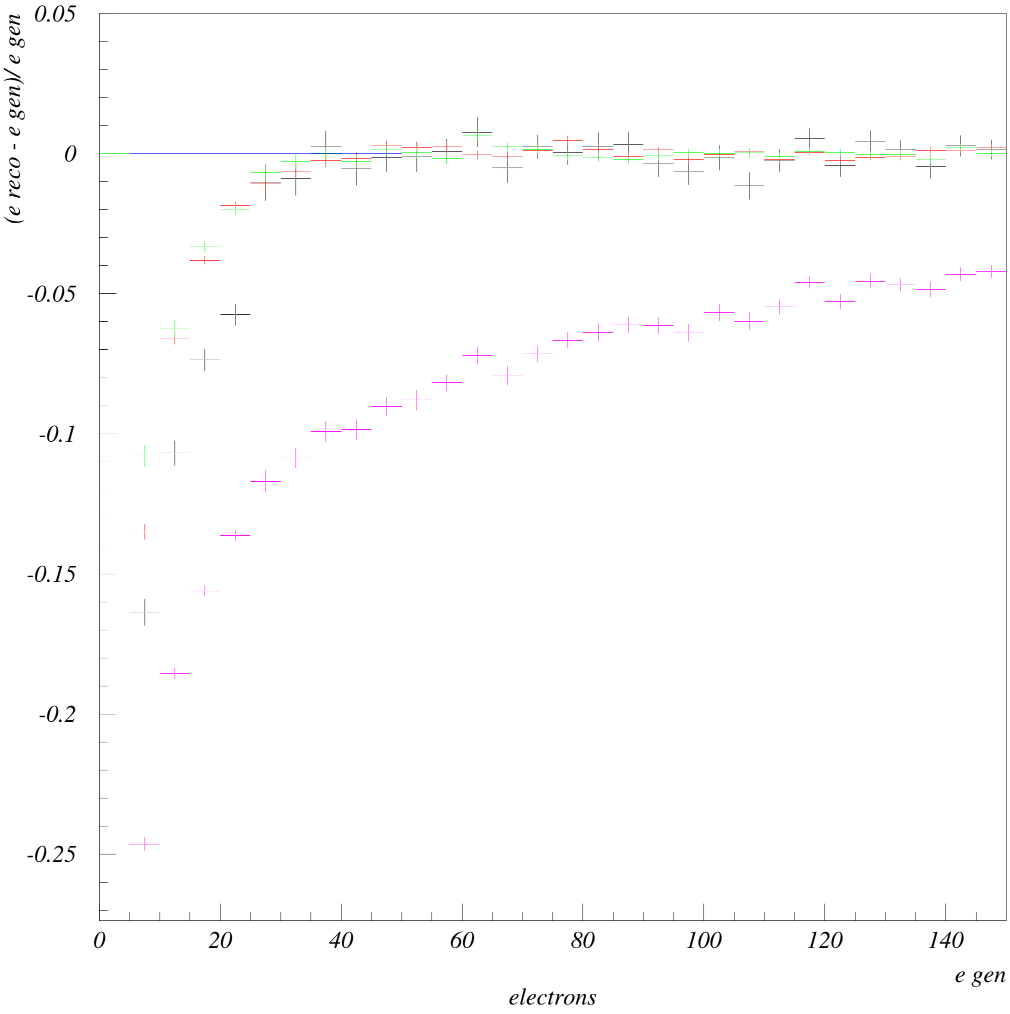
## $e^-$ (not in cracks)

Same method for 3 parts: central, ICR, end calorimeters.

- Fit with a $2^{nd}$ order polynomial of $\frac{e_{reco}-e_{gen}}{e_{gen}}$ as a function of $e_{gen}$ in the "good" linear part ($e_{gen} > 30GeV$).
- As a result, formula of $e_{reco}$ function of $e_{gen}$.
- Inversion of the formula, now $e_{gen}$ function of $e_{reco}$.
- Apply the formula to all energies.

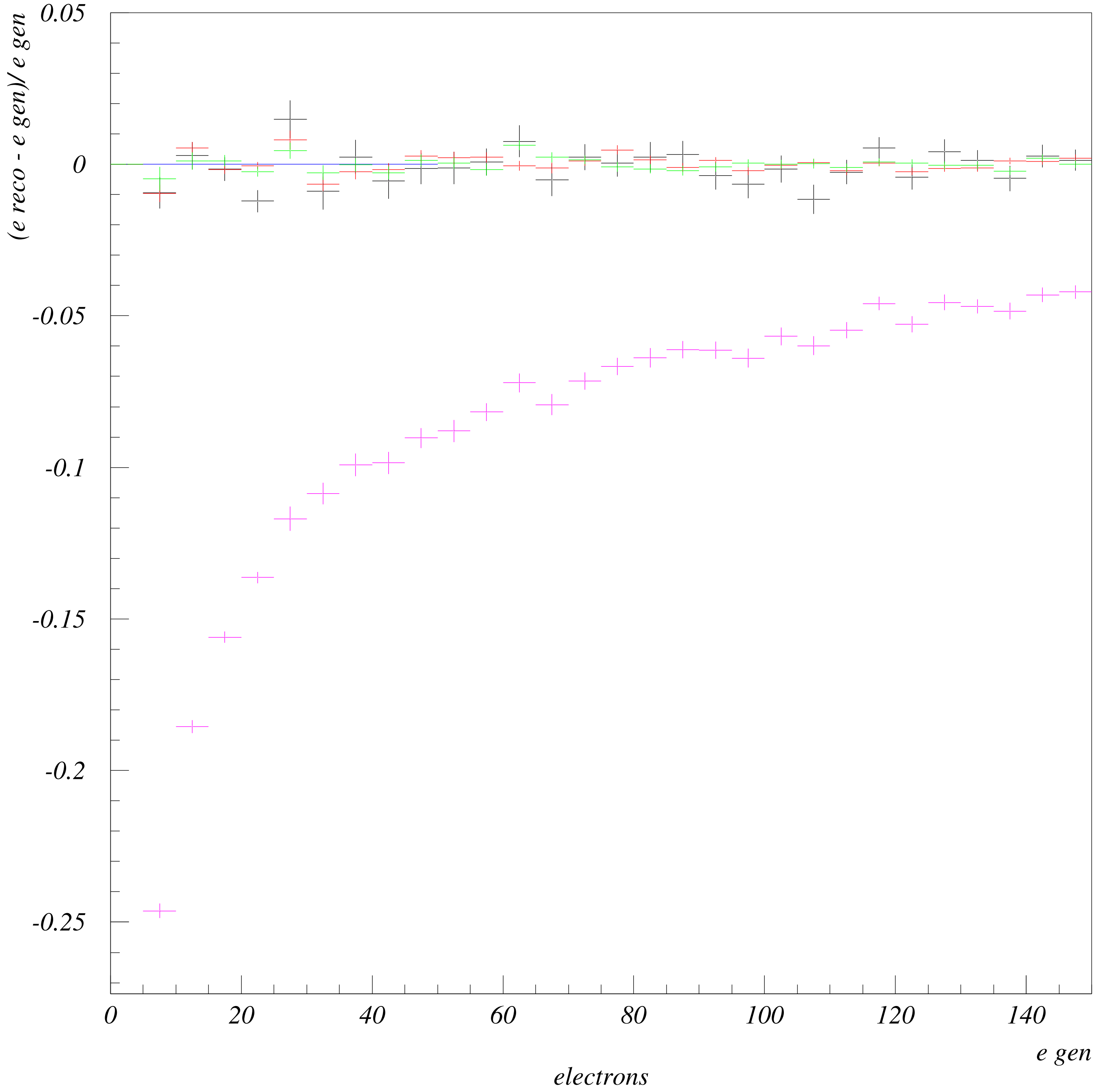
Color code is the following:

- pink = before correction
- green = after correction (CC)
- black = after correction (ICR)
- red = after correction (EC)




Then exactly the same procedure applies for $e_{gen} < 30GeV$ because now this "low" energy part can be fit by a polynomial. The polynomial correction is used for clusters with $e_{reco} < 150GeV$. Above $150GeV$ , a fit by a line is used because the polynomial parametrisation is restricted to the energy range for which the fit has been performed.

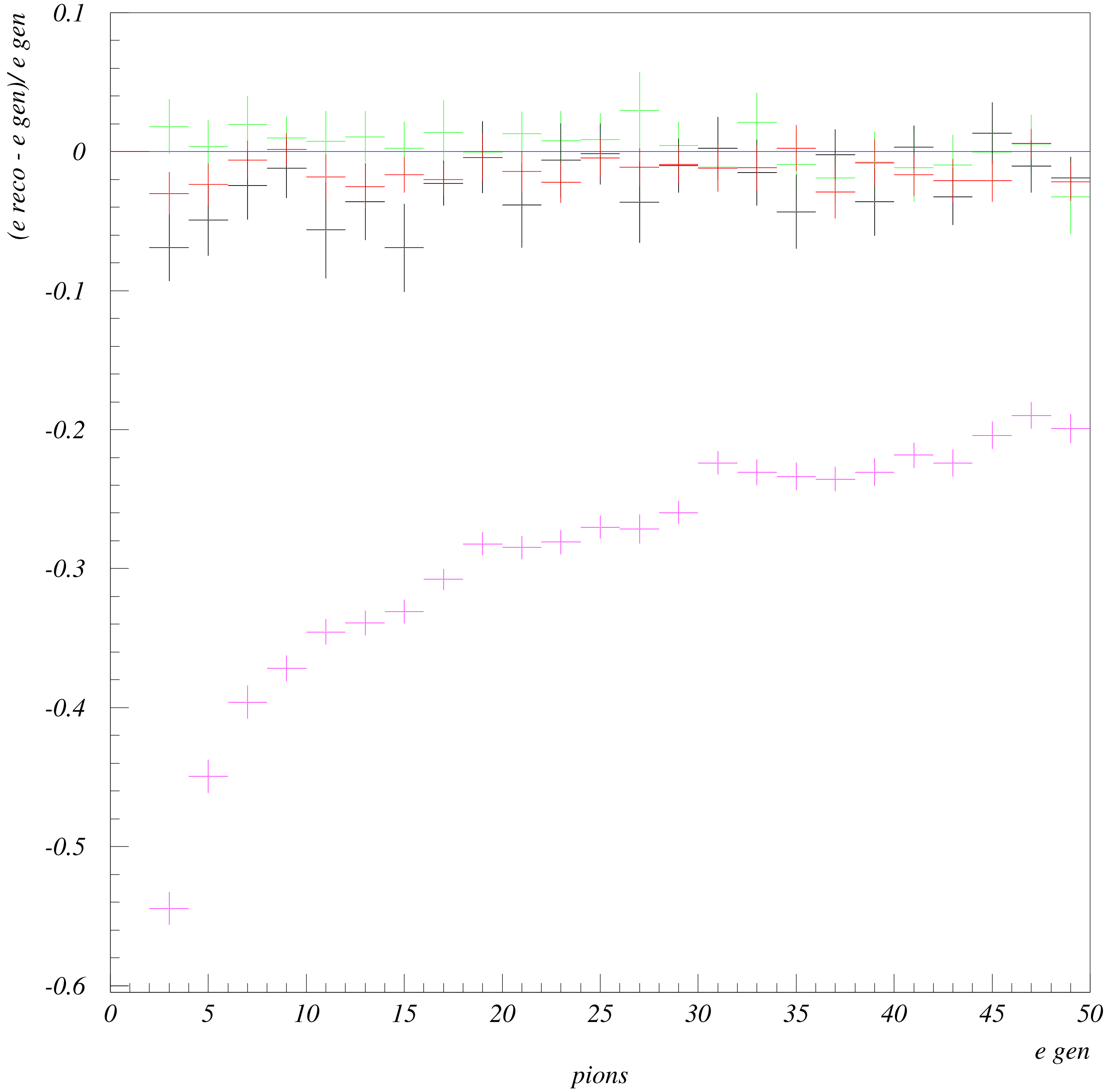
# $e^-$ (not in cracks)



# $\pi^{\pm}$

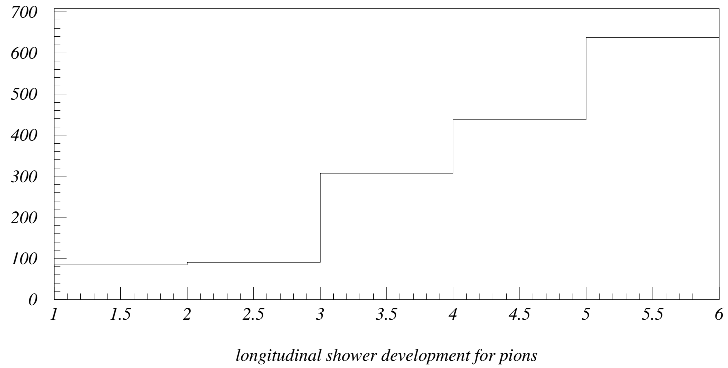
- no crack effect seen
- exactly the same procedure as for $e^{-}$ not in cracks
  - first fit for $e_{gen} > 30GeV$
  - correction applied to all the energies
  - fit again for $18 < e_{gen} < 30GeV$
  - correction applied to energies $< 30GeV$
  - fit again for $10 < e_{gen} < 18GeV$
  - correction applied to energies $< 18GeV$
  - fit again for $e_{gen} < 10GeV$
  - correction applied to energies $< 10GeV$
  - fit again for $e_{gen} < 10GeV$
  - correction applied to energies $< 10GeV$
- Because of large non linearities, 2 fit iterations are performed for pions with energies $< 10GeV$.
- Again for pions with $e_{reco} > 50GeV$ a fit by a line is used instead of a $2^{nd}$ order polynomial.

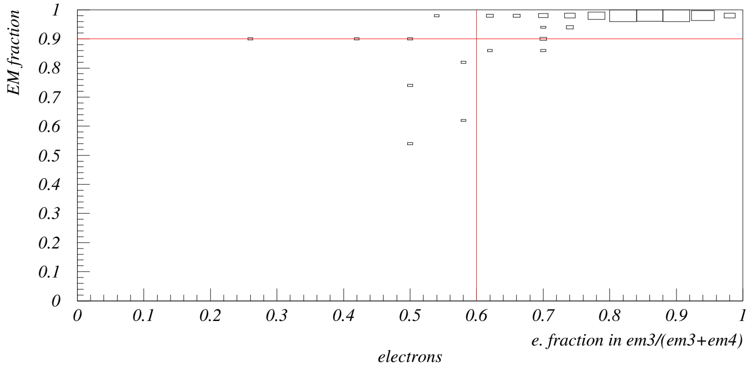
$\pi^{\pm}$

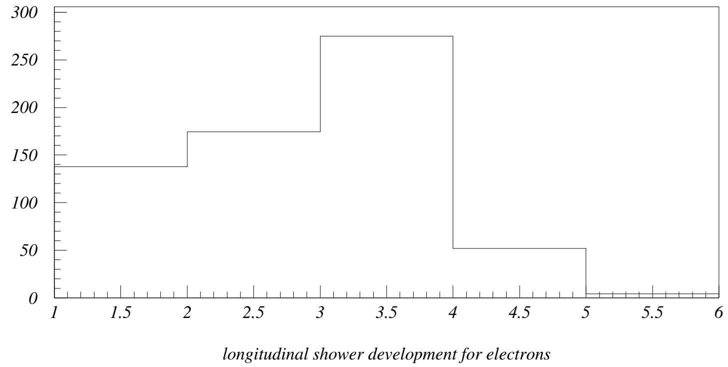

(e reco - e gen)/ e gen
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0
5
10
15
20
25
30
35
40
45
50
e gen
pions

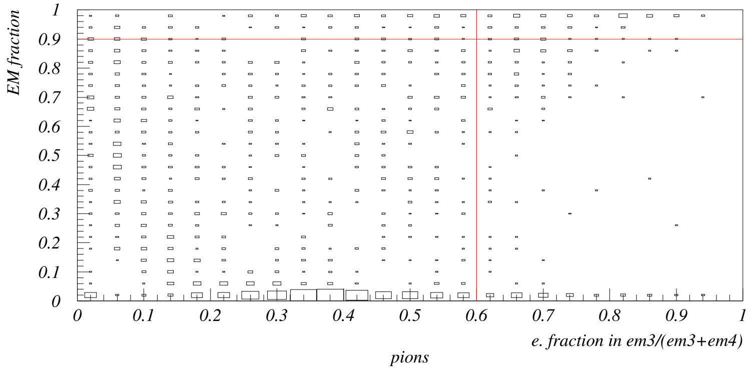
# Applying corrections in the algorithm: identification

- All the corrected energies shown before were applied to single particles samples $\Longrightarrow$ it was known if they were $\pi^{\pm}$ or $e^{-}$.
- In the algorithm, EM objects should be identified. For now, use:
  - EM fraction $> 90\%$
  - $\frac{E(EM3)}{E(EM3)+E(EM4)} > 60\%$

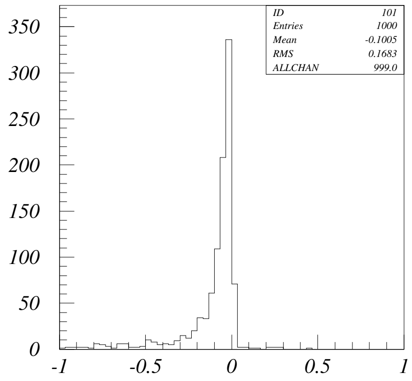


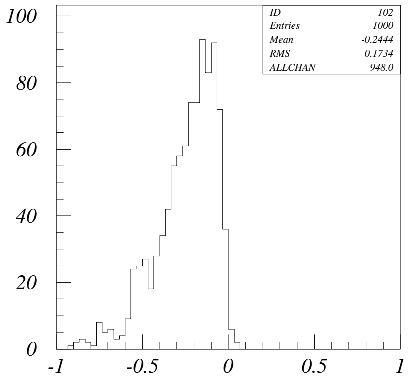



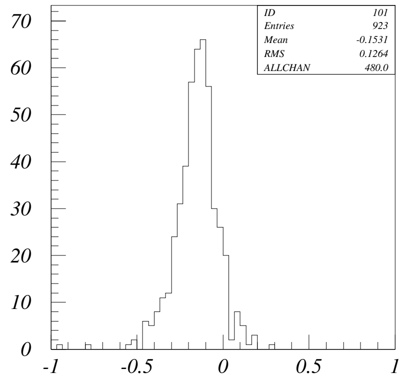
# Identification Examples



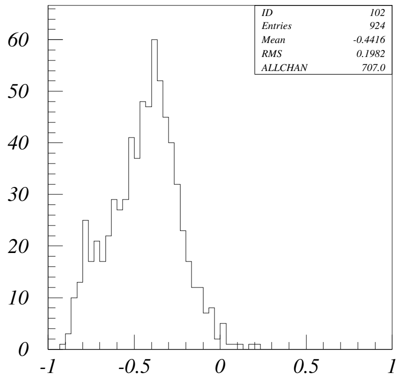

*high energy, single electrons, before corrections*



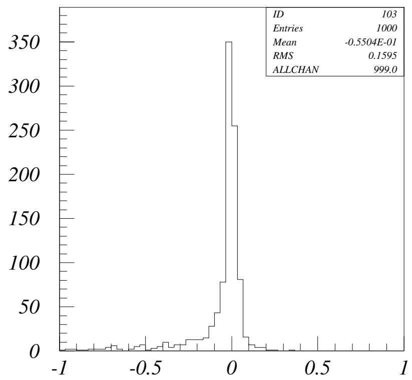

*low energy, single electrons, before corrections*



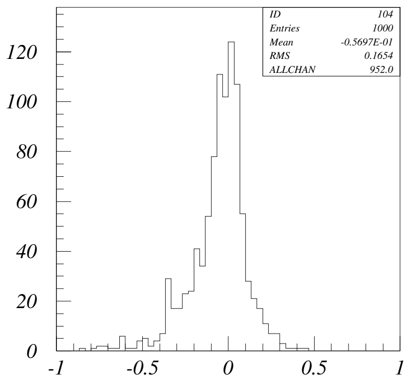

*high energy, single pions, before corrections*



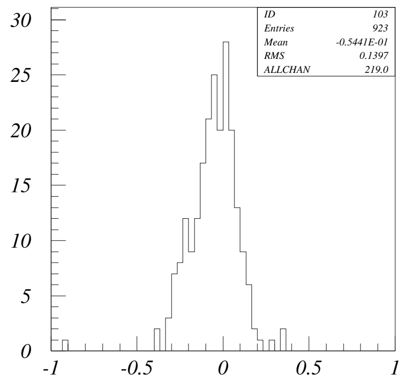

*low energy, single pions, before corrections*



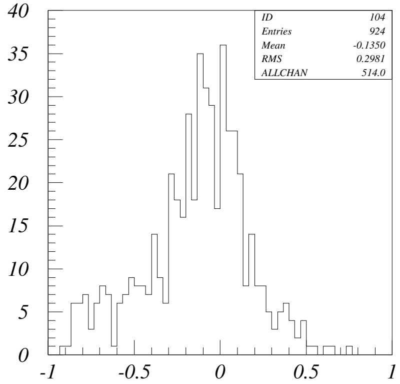

*high energy, single electrons, after corrections*




*low energy, single electrons, after corrections*




*high energy, single pions, after corrections*

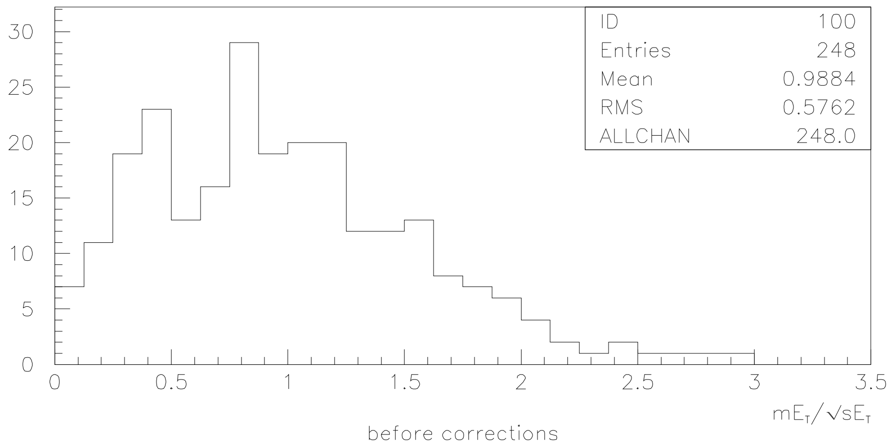


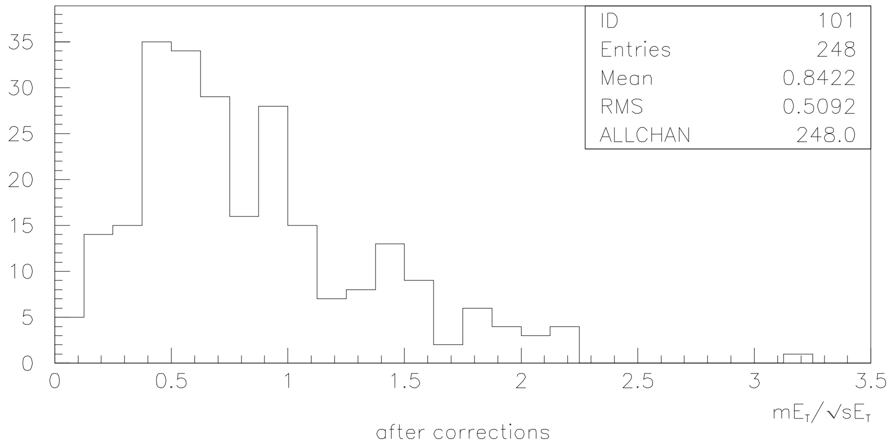

*low energy, single pions, after corrections*

# Assumption Verification

Results of all those corrections on more complex events?

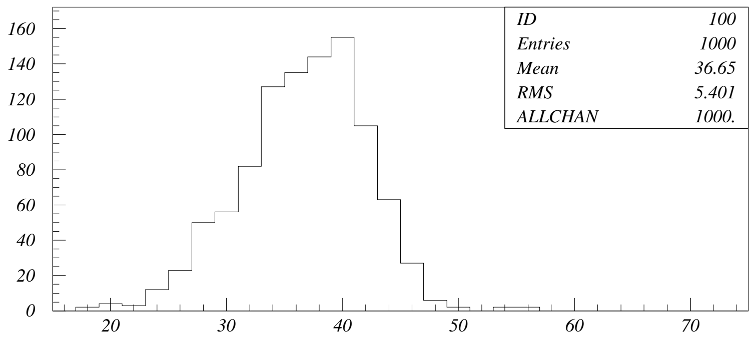
- Example with a QCD sample, $p_T > 20GeV$,
- If previous corrections work, the corrected distribution should have less $\not{E}_T$, because QCD events are balanced.

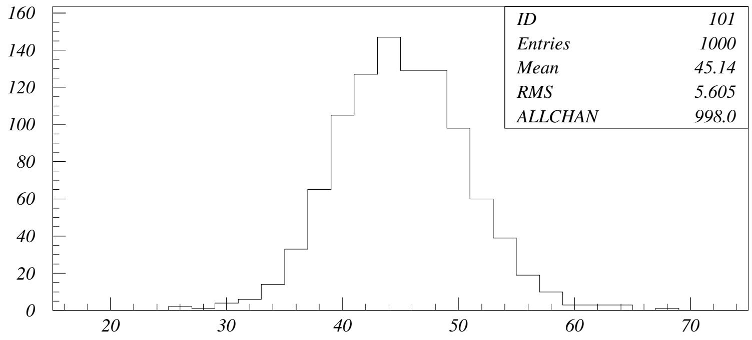


# Assumption Verification

- Example for a sample a 1000 single jets of $p_T = 48.5 GeV$ (kinematic),
- If previous corrections work, the corrected distribution should peak at $45.5 GeV = p_T$ from the calorimeter ....




The resolution goes from $\frac{89\%}{\sqrt{E}}$ to $\frac{83\%}{\sqrt{E}}$ after corrections ( $\frac{78\%}{\sqrt{E}}$ in the central region ).

## Conclusion

- Preliminary Results
- Need more tests
- Promising Correction Method
- For the future, it could be possible to improve those results with an optimisation of the weights floor by floor depending if the cluster was indentified as an hadronic or an electromagnetic particle.