Single particle & Jet energy resolution in a homogeneous detector

A.Para & N. Saoulidou, Fermilab

09-20-06

Outline

- MC Files Used for :
  - Single Particles
  - Jets
- Basic Idea of the Analysis:
  - Calibration using electrons
  - Calibration using pions
- Results (Energy Resolution) :
  - Single Pions
  - Jets
- Conclusions/Ongoing Work

MC Files Used

- The MC files used are the ones the Eiko has produced so far for :
  - – Large Homogenous detector and for
  - – Single pions of energies 0.1-0.5-1- 5-10 & 20 GeV
  - – Single electrons of energies 0.1-0.5 -1-5 -10&20 GeV
- These single files are used in order to “calibrate” the detector.

MC Files Used cont'd

- The Jet MC files are produced from merging the single ones in several different ways in order to obtain:
  - Jets composed of only 20 GeV pions ("High" case)
  - Jets composed of ("Basic" case)
    - 52% of 1 GeV pions,
    - 21% of 5 GeV pions,
    - 17% of 10 GeV pions and
    - 10% of 20 GeV pions
  - Jets composed of only 5 GeV pions ("Low" case)
  - Jets composed of only 100 GeV pions ("Extra low" case)
  - All of the above assuming an electromagnetic fraction of 0 and also of 0.2 (20%)
- The Jet MC Files are used to obtain the energy resolution of the "detector" when the calibration done using single particles is applied.

Basic Idea of the Analysis

- Calibration using electrons :
  - Using the response of this homogenous detector to electrons we calculate the ratio of the total deposited energy due to scintillation E_{sc} to the total deposited energy due to Cherenkov radiation E_{ce}:

$$Cal_e = E_{sc}/E_{ce} \qquad (1)$$

  - Then, using the response of this homogenous detector to pions we calculate the function "f" such that:

$$E_{sc}/E_p = f(1-E_{ce} \times Cal_e/E_{sc}) \qquad (2)$$

where E_p is the incident energy of the pion.

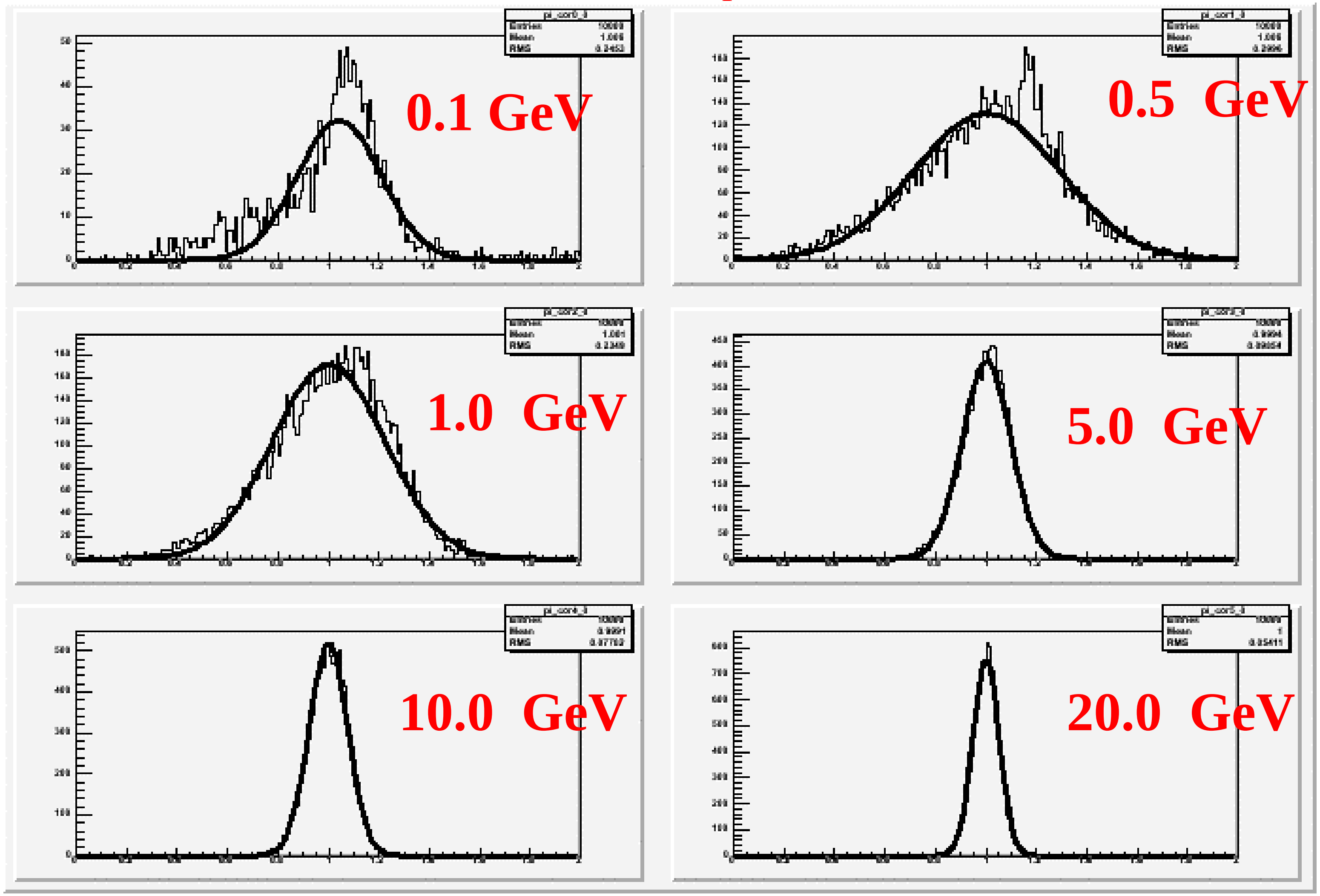
Basic Idea of the Analysis cont'd

- After obtaining from the previous step:
  - $Cal_e = E_{sc}/E_{ce}$ (1) AND
  - $E_{sc}/E_p = f(1 - E_{ce} \times Cal_e/E_{sc})$ (2)
- We calculate the Jet energy E_{out} :

$$E_{out} = E_{sc}/f(1 - E_{ce} \times Cal_e/E_{sc}) \quad (3)$$

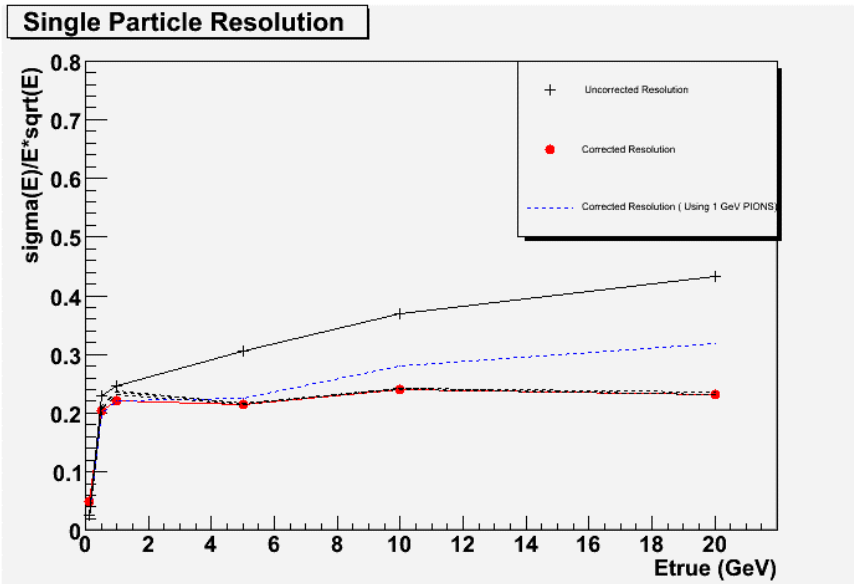
Results : Energy Resolution of Single Pions

E_{out}/E_p

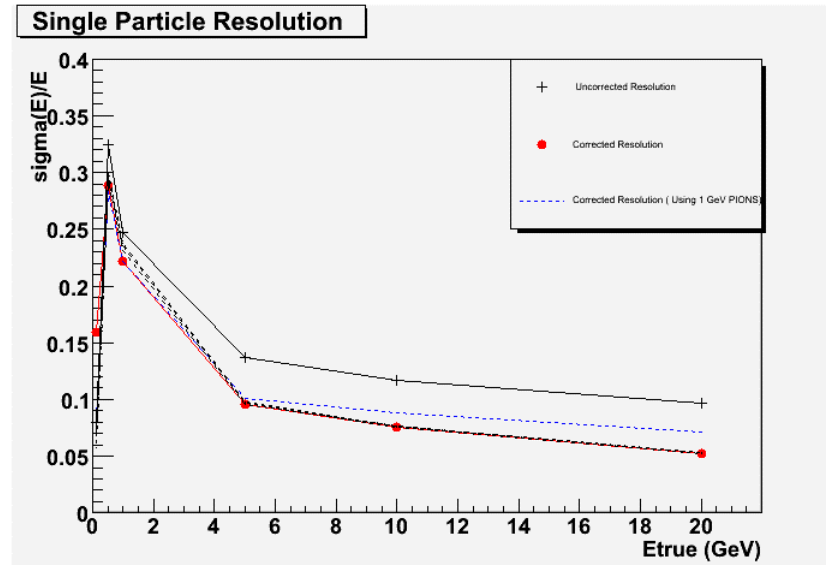


Results : Energy Resolution of Single Pions

$\sigma(E)/E \bullet \sqrt{E}$ vs E



$\sigma(E)/E$ vs E



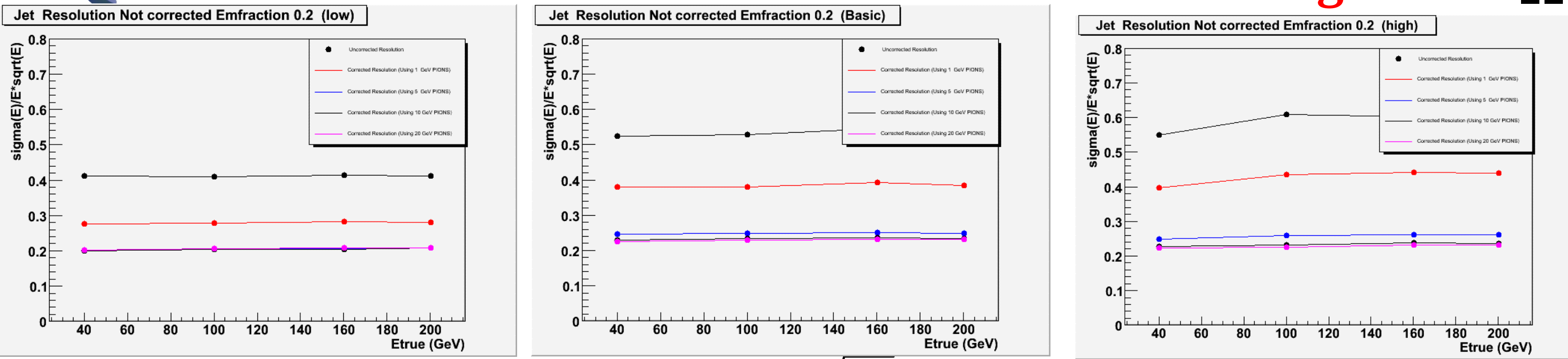
- Black is uncalibrated response , Red is calibrated (corrected) response following the steps of the calibration chain described previously, and dashed black is the corrected response when all possible combinations of calibrations produced from the single particles are used
- The calibration procedure improves the energy resolution significantly
- The 1GeV pion calibration is not as good as the rest

Results : Energy Resolution of Jets

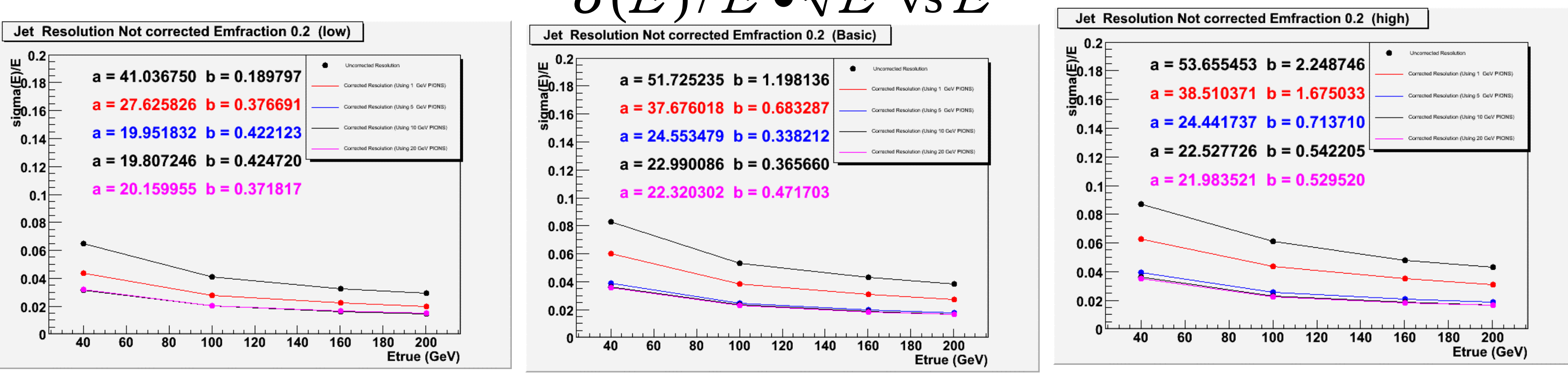
- What we studied:
  - 1) Energy resolution of each Jet configuration (“High, “Basic”, “Low”) as a function of the calibration factors obtained from single particles
  - 2) The above for EM fraction of Zero and EM fraction of 20%

Results : Energy Resolution of Jets 1

"Low" "Basic" "High"



$$\sigma(E)/E \bullet \sqrt{E} \text{ vs } E$$



$$\sigma(E)/E \text{ vs } E$$

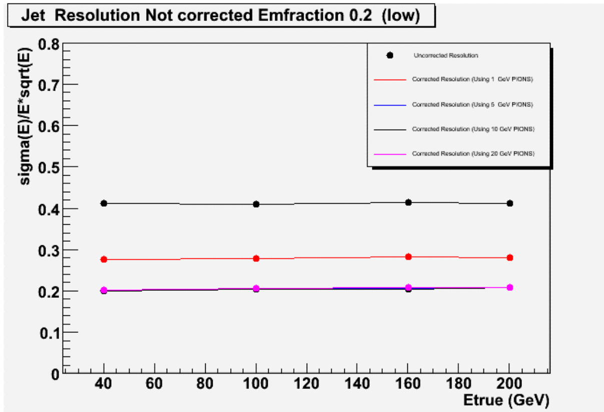
– Black is uncalibrated response , Red is calibrated (corrected) response using 1 GeV pions, the remaining colors are for the calibrated (corrected) response when using 5-10 and 20 GeV pions. (EM Fraction 20%)

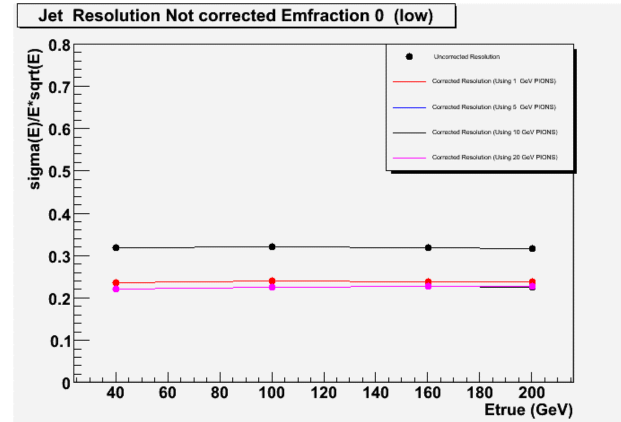
Results : Energy Resolution of Jets 1

- Except for the 1 GeV "calibration" all the rest (5-10 & 20 GeV) give very similar results
- The results of the calibration are significantly improved with respect to the uncalibrated case.
- As we increase the energy of the pions composing the Jets the energy resolution becomes worse.
- Next we compare the energy resolution in the case of zero and 20% EM fraction for each jet configuration.

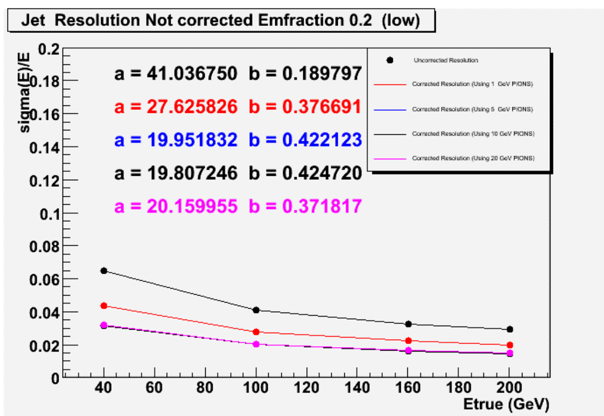
Results : Energy Resolution of Jets 2

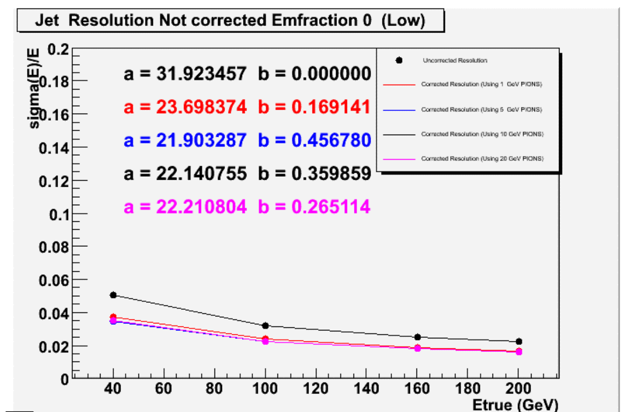
"Low" EM fraction 20% — "Low" EM fraction 0





$$\sigma(E)/E \bullet \sqrt{E} \text{ vs } E$$



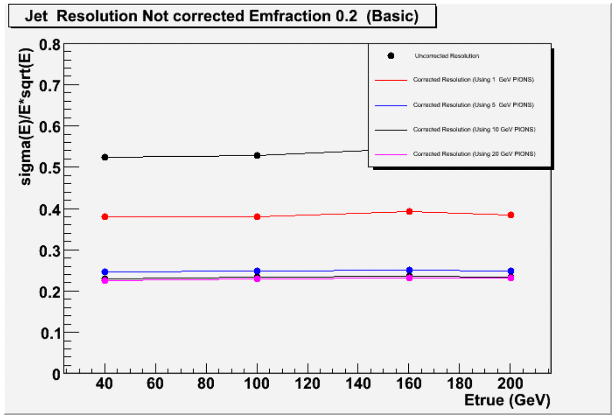


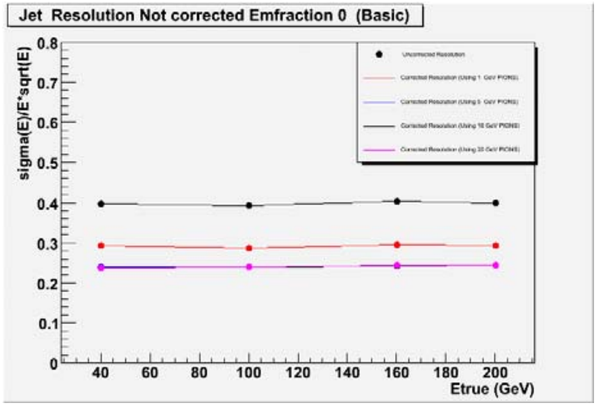
$$\sigma(E)/E \text{ vs } E$$

– Black is uncalibrated response , Red is calibrated (corrected) response using 1 GeV pions, the remaining colors are for the calibrated (corrected) response when using 5-10 and 20 GeV pions.

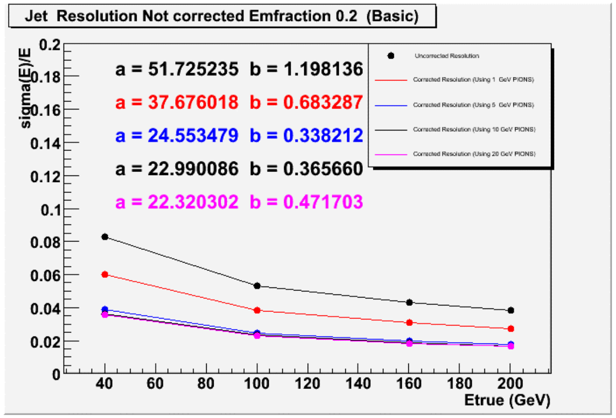
Results : Energy Resolution of Jets 2 cont'd

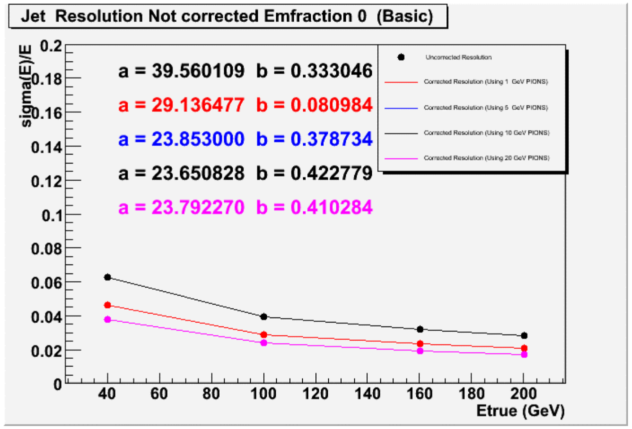
"Basic" EM fraction 20% — "Basic" EM fraction 0





$$\sigma(E)/E \bullet \sqrt{E} \text{ vs } E$$



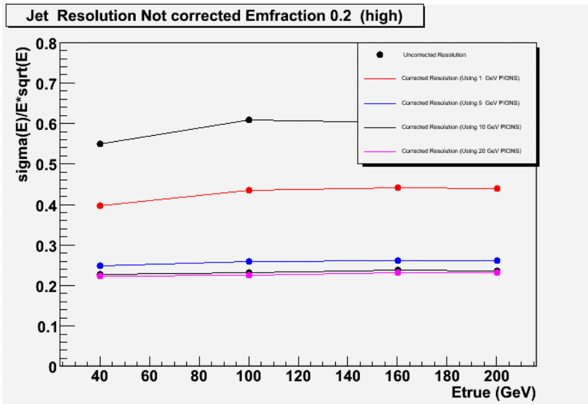


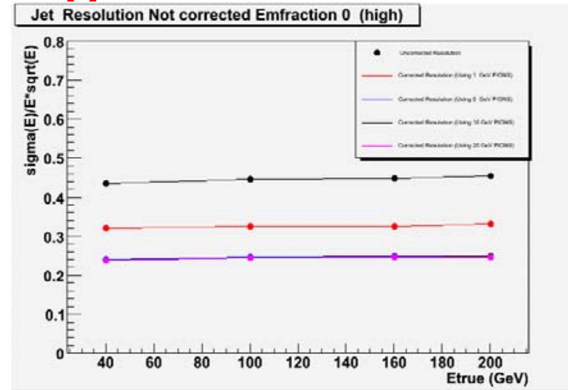
$$\sigma(E)/E \text{ vs } E$$

– Black is uncalibrated response , Red is calibrated (corrected) response using 1 GeV pions, the remaining colors are for the calibrated (corrected) response when using 5-10 and 20 GeV pions.

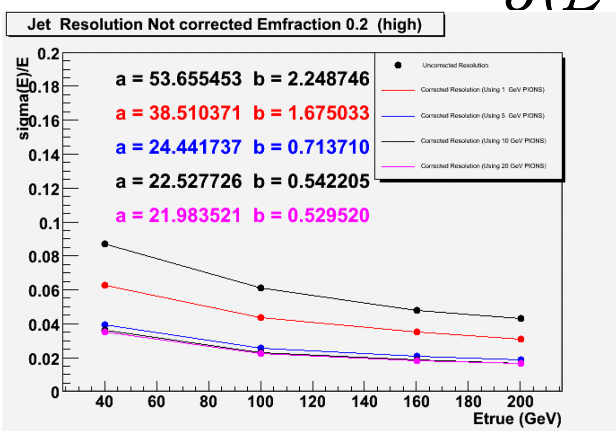
Results : Energy Resolution of Jets 2 cont'd

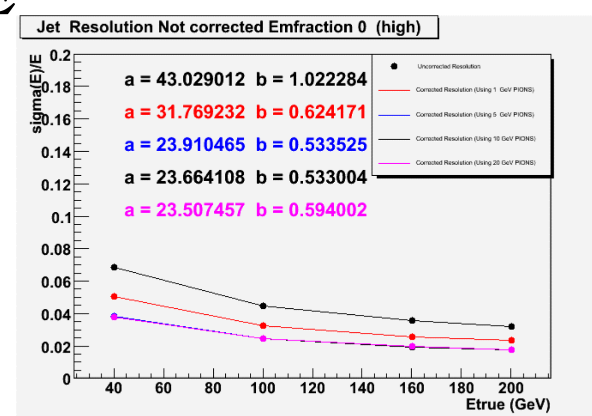
"High" EM fraction 20%   "High" EM fraction 0





$$\sigma(E)/E \bullet \sqrt{E} \text{ vs } E$$





$$\sigma(E)/E \text{ vs } E$$

- Black is uncalibrated response , Red is calibrated (corrected) response using 1 GeV pions, the remaining colors are for the calibrated (corrected) response when using 5-10 and 20 GeV pions.

Results : Energy Resolution of Jets 2

- The energy resolution of the corrected case is slightly better for the Jets with 20% EM fraction with respect to the Jets with 0% EM fraction

- This energy resolution can perhaps be further improved if we make the assumption the EM fraction will be "measured" in the actual detectors

Summary & Conclusions

- **We described the "calibration/correction" procedure for a large homogenous detector where both scintillation and Cherenkov light are measured.**
- **The energy resolution of Jets, in the ideal case of a large homogenous detector, is improved by a factor of 1.5-2 when we perform this "calibration/correction" procedure.**
- **This improvement is largely independent of the :**
  - **Energy of the single pions used for calibration (for pion energies above 5 GeV)**
  - **Jet composition (low or high energy pions)**
  - **Jet Electromagnetic Fraction**
- **We would like to further develop and study the same analysis for a realistic jet simulation and various realistic detector simulations (instead of the ideal large homogenous ones)**