π^0 reconstruction within the full simulation framework

Ph.Gris
LPC Clermont-Ferrand
IN2P3-CNRS

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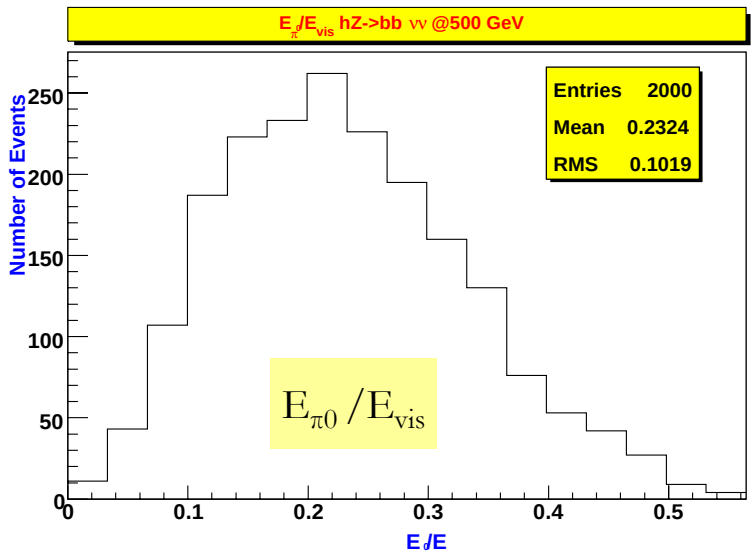
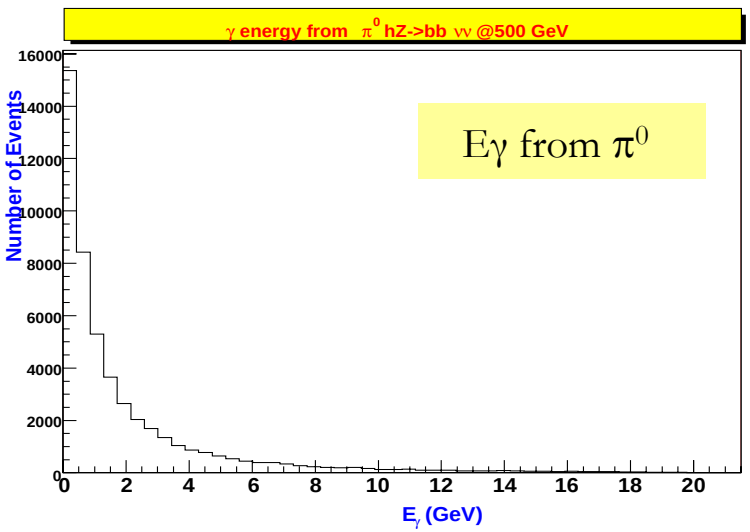
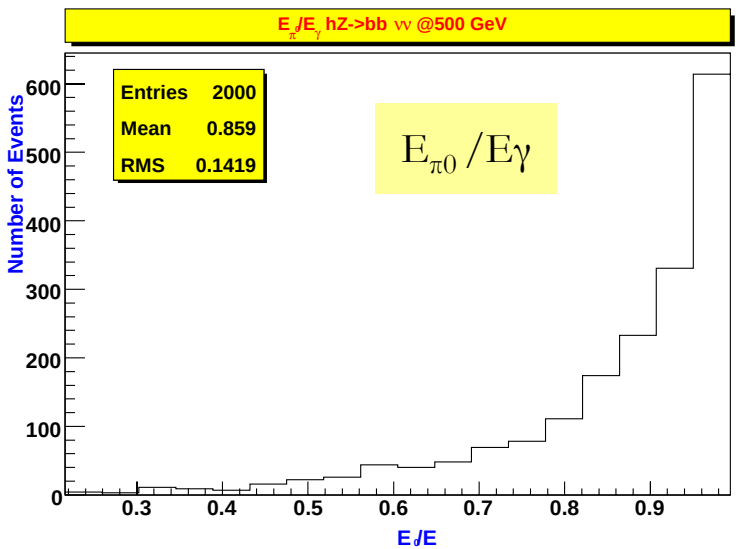
Importance of π^0

- π^0 are an important part of the particle content in hadronic events
  - ~ 20% of the visible energy in tt or hZ events (@500 GeV)
  - most of the photon in an event come from π^0 decays
  - Energy spectrum: rather soft photons (55% of the photons with E<1 GeV)
  - τ ID

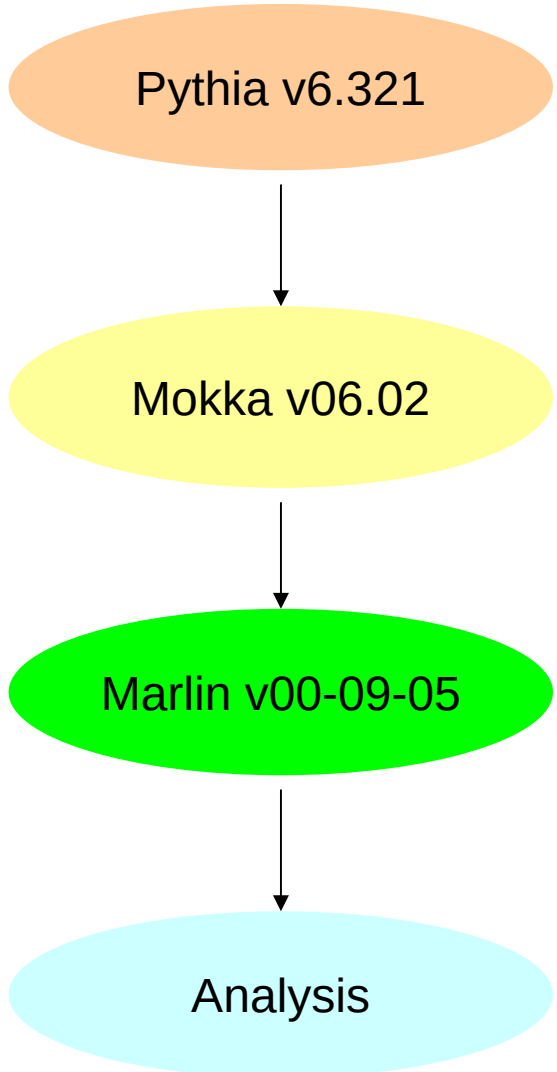






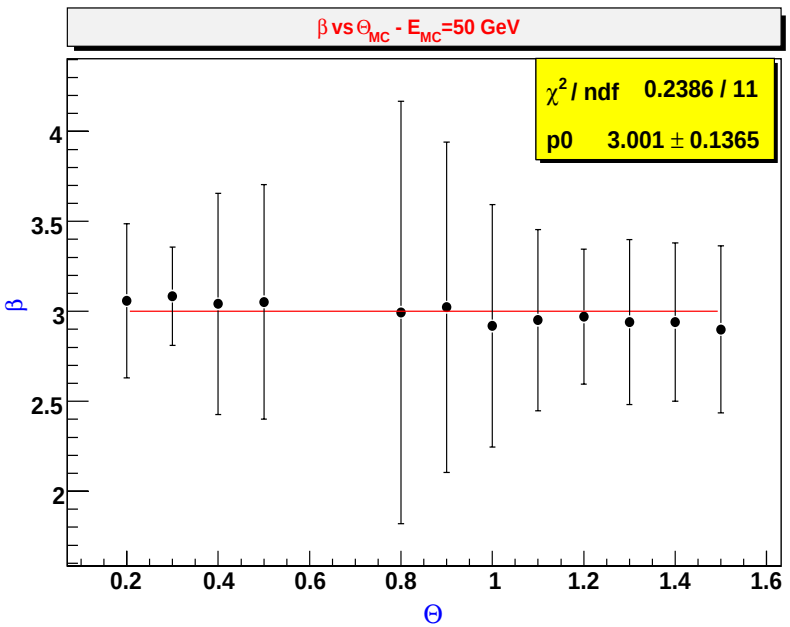
Framework of the study

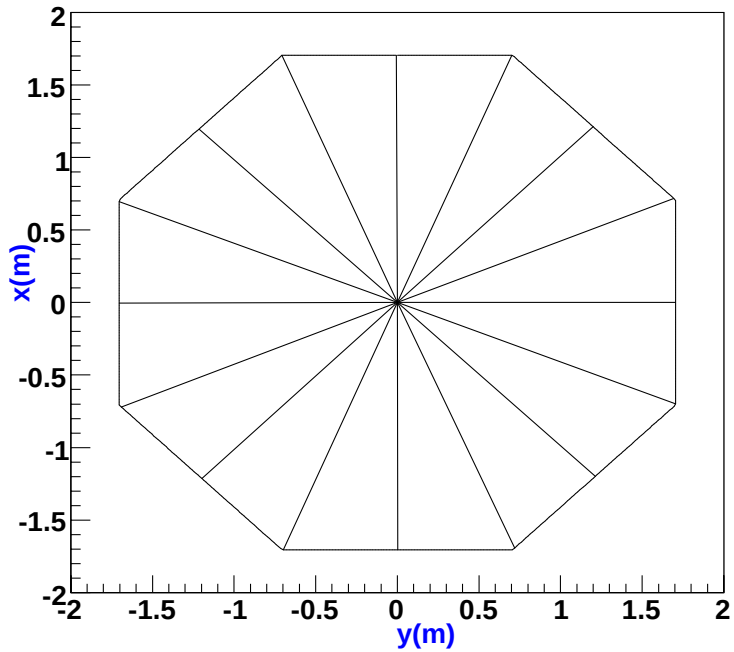
- Detector: LDC00
- Events: single γ, single π^0, hZ->bb$\nu\nu$ @500 GeV
- Events were processed through the full simulation chain
- Clustering: TrackWiseClustering



EM calorimeter calibration: the method

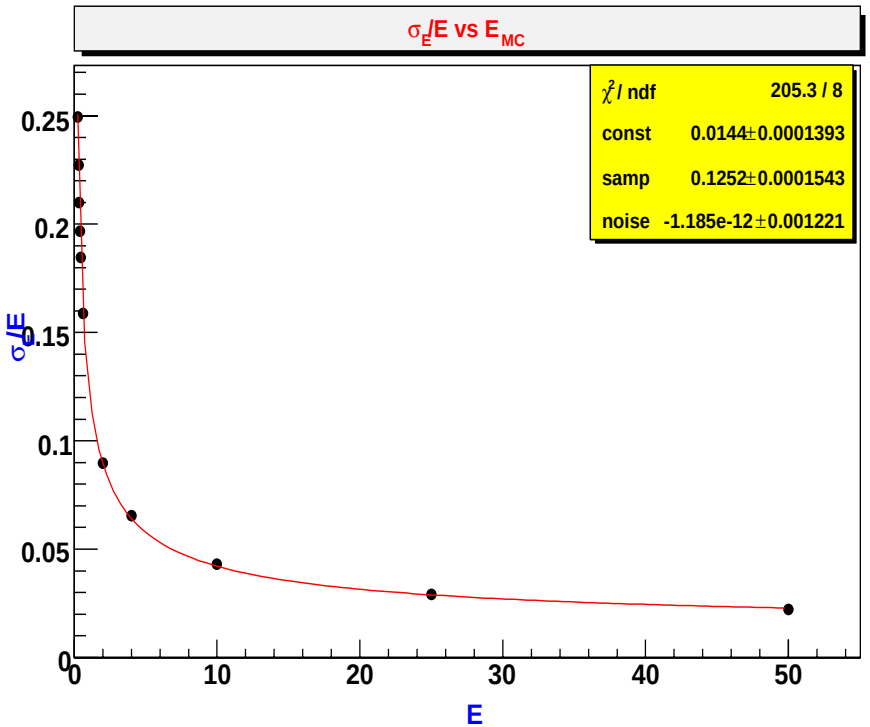
- Sets of single photon generated in Mokka
- E=0.25, 0.30, 0.35, 0.40, 0.50, 1, 2, 4, 10, 25, 50 GeV
- $0 \leq \theta \leq \pi/2$: step 0.1
- $0 \leq \Phi \leq 2\pi$: step $2\pi/16$
- Calibration: $E_{clus}=\alpha\ (E^{30}+\beta\ E^{40})$
- β gives the smallest $\sigma(E^{30}+\beta\ E^{40})$
- α is adjusted after β

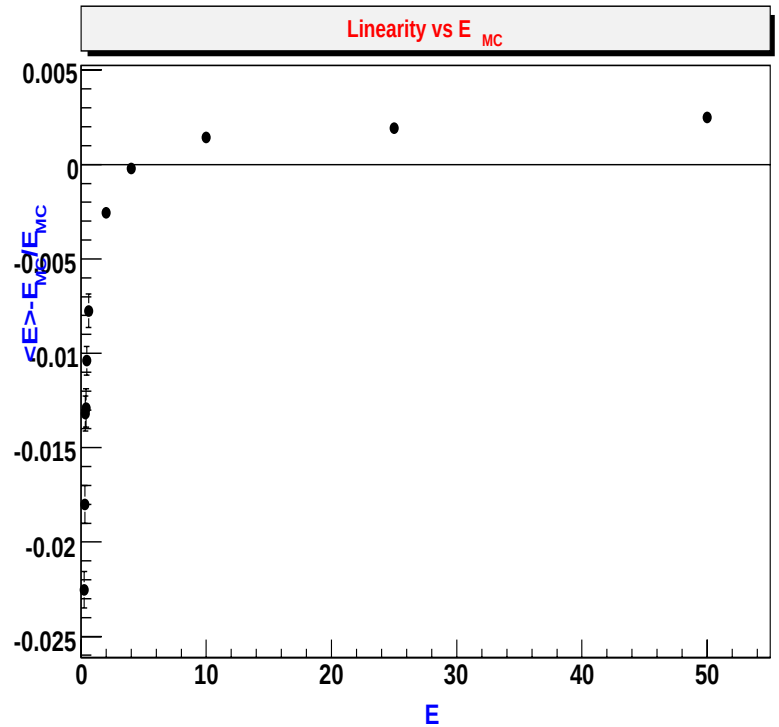




$\beta = 3.0 \pm 0.1$
$\alpha = 27.6 \pm 0.5$ (central)
$\alpha = 28.8 \pm 0.5$ (endcap)

EM calorimeter calibration: energy resolution



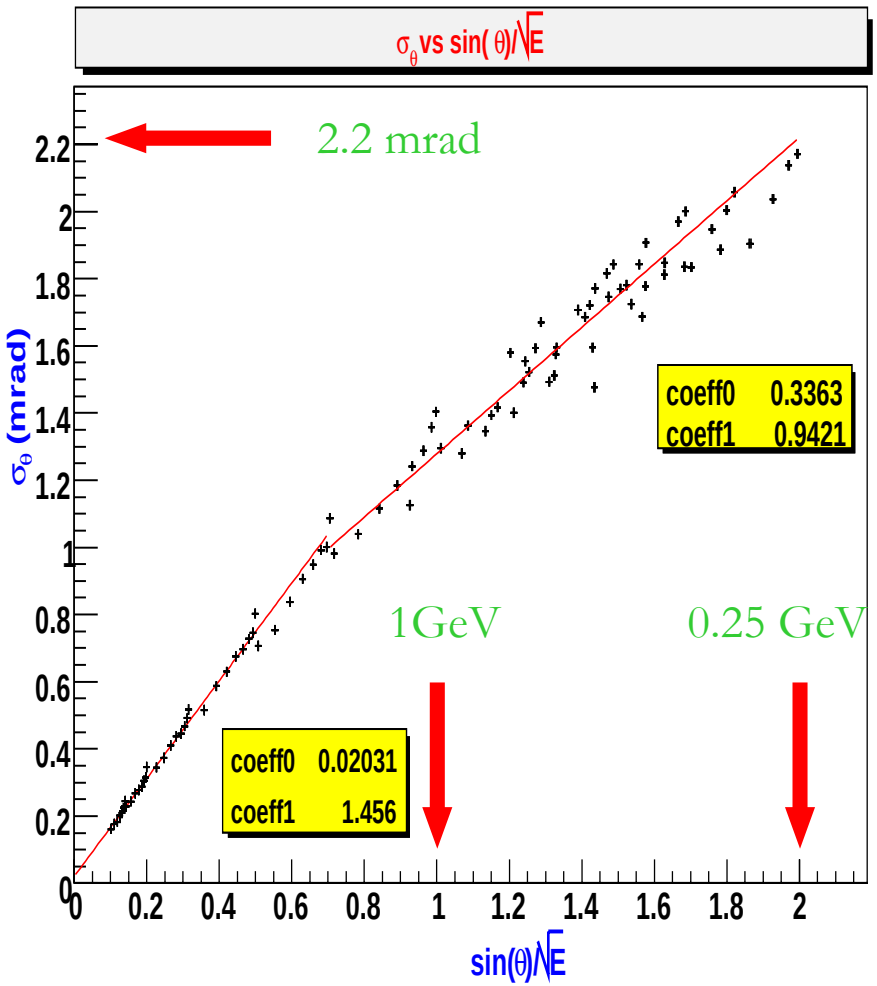


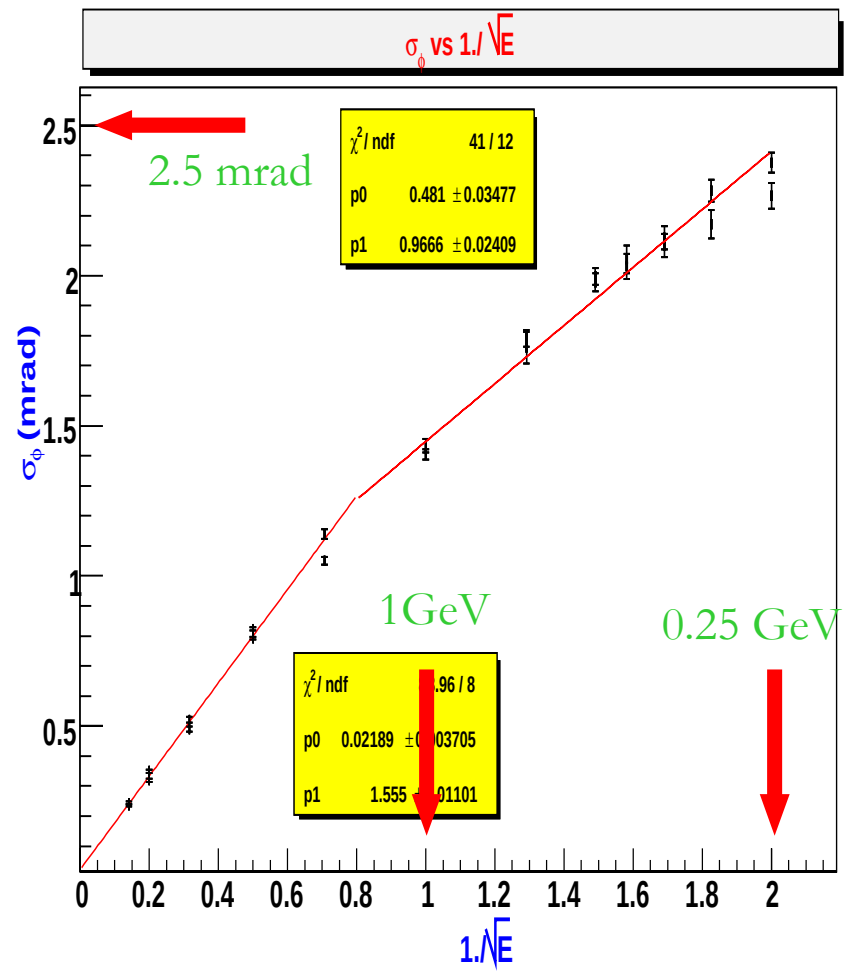
$$\frac{\sigma(E)}{E} = 1.4\% \oplus \frac{12.5\%}{\sqrt{E}} \text{ (central)}$$

$$\frac{\sigma(E)}{E} = 1.2\% \oplus \frac{12.3\%}{\sqrt{E}} \text{ (endcap)}$$

Non linearity:
< 2.5% (central)
< 5% (endcap)

EM calorimeter calibration: angular resolution





σ_θ depends on θ and on E

σ_Φ depends only on E

Single π^0 fits

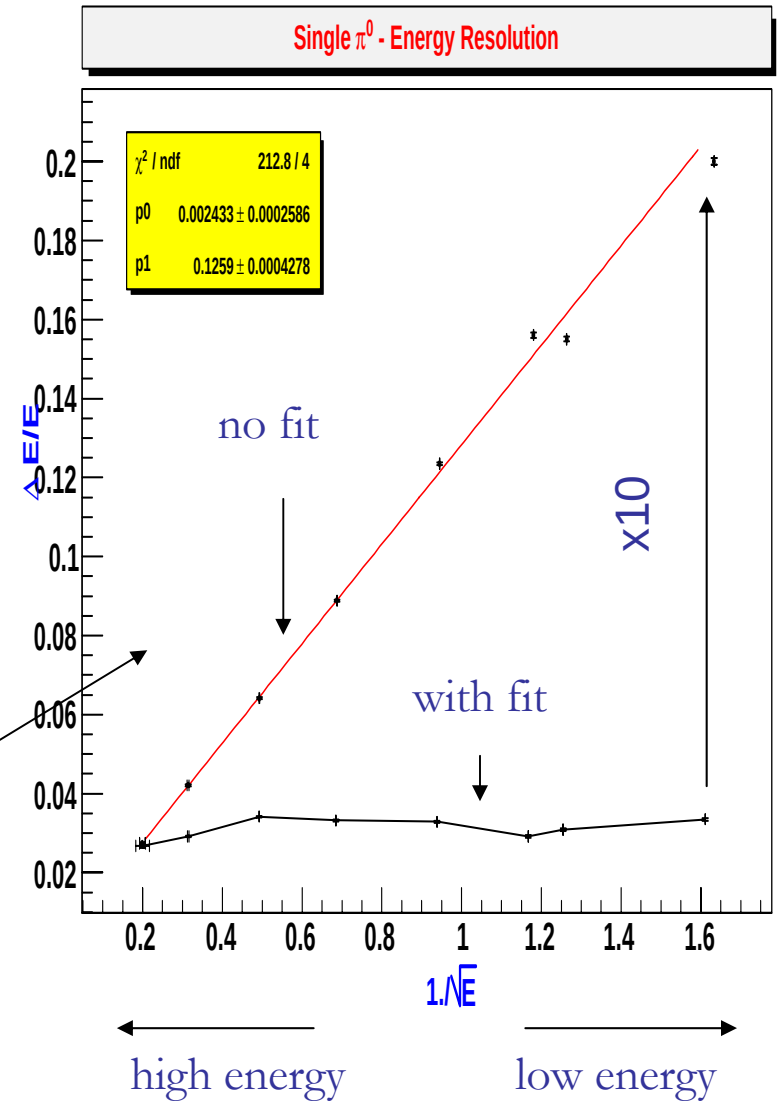
- To correct for mismeasurements and fluctuations, a constrained fit is applied to cluster pairs (single π^0 generated in Mokka):

$$\chi^2 = \sum_{i=1}^{2} \frac{(E_i^{cl} - E_i)^2}{\sigma_{E_i}^2} + \sum_{i=1}^{2} \frac{(\theta_i^{cl} - \theta_i)^2}{\sigma_{\theta_i}^2} + \sum_{i=1}^{2} \frac{(\Phi_i^{cl} - \Phi_i)^2}{\sigma_{\Phi_i}^2}$$

Fit request: niter≤4, χ^2 <3.9

Variances from resolution study (slides 5&6)

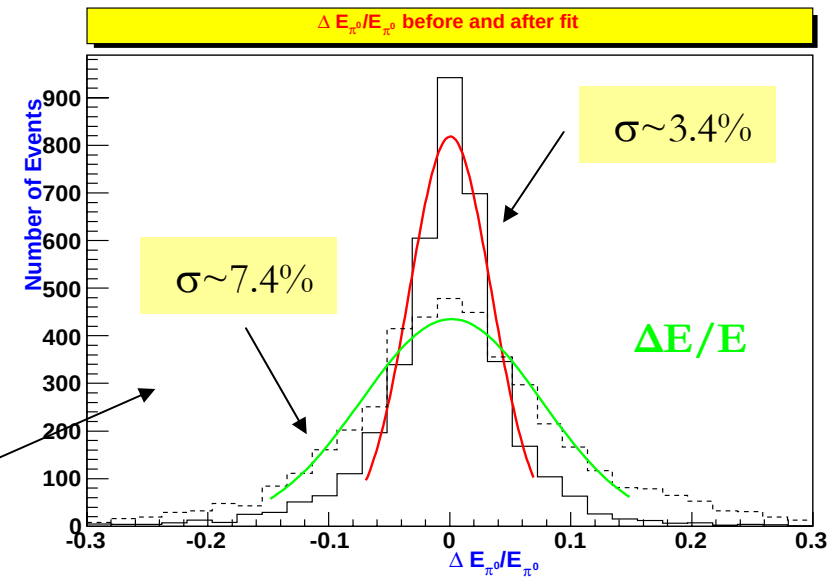
Single π^0 – full reconstruction



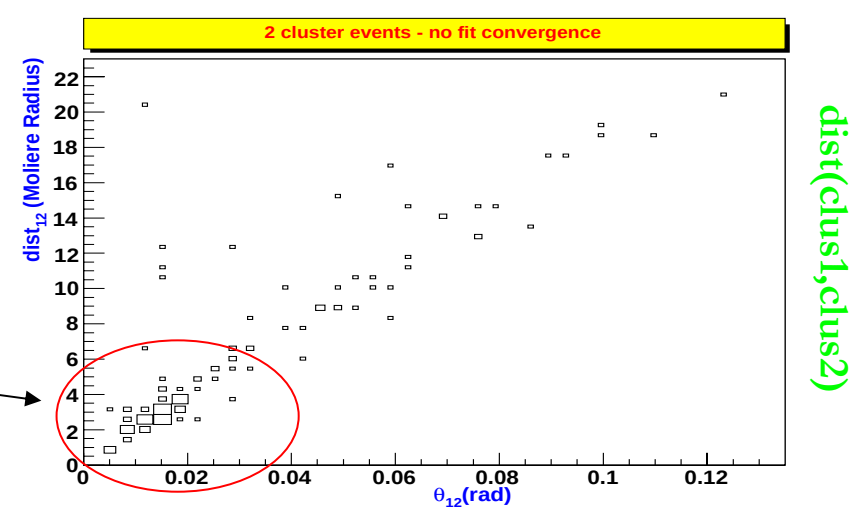
Single π^0 fits

- A more realistic case: take single π^0 from hZ events @500 GeV

nclus	0	1	2	≥3
fraction of events	0.3%	14.3%	73.2%	12.2%



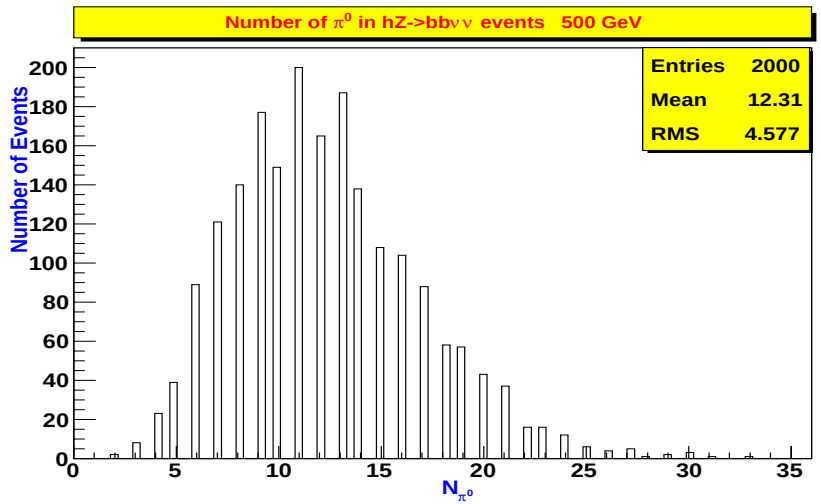
87.4% of the 2-cluster events successfully fitted

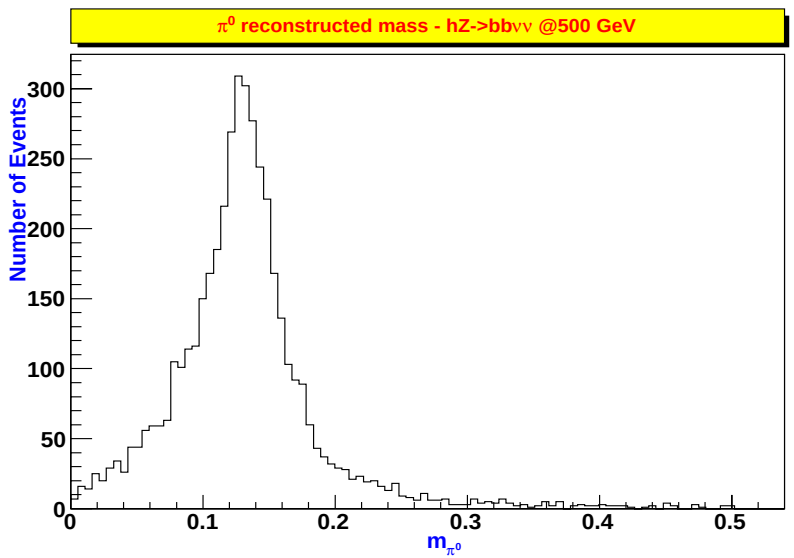


most (40%) of the 2-cluster events that did not fit are very close at the calorimeter entrance

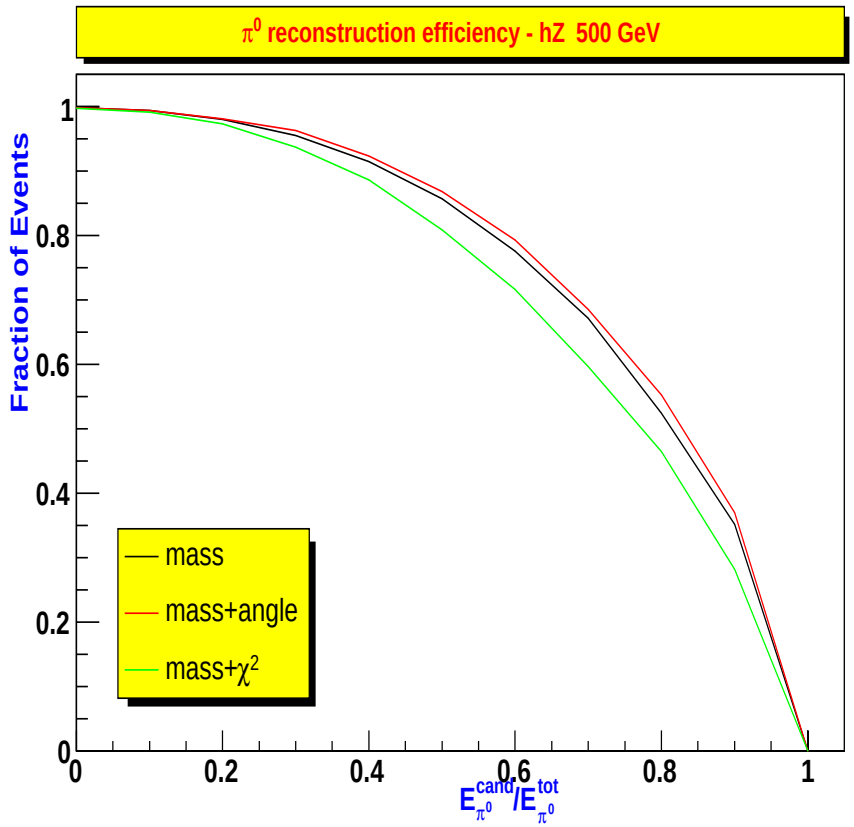
π^0 reconstruction in hZ events@500 GeV

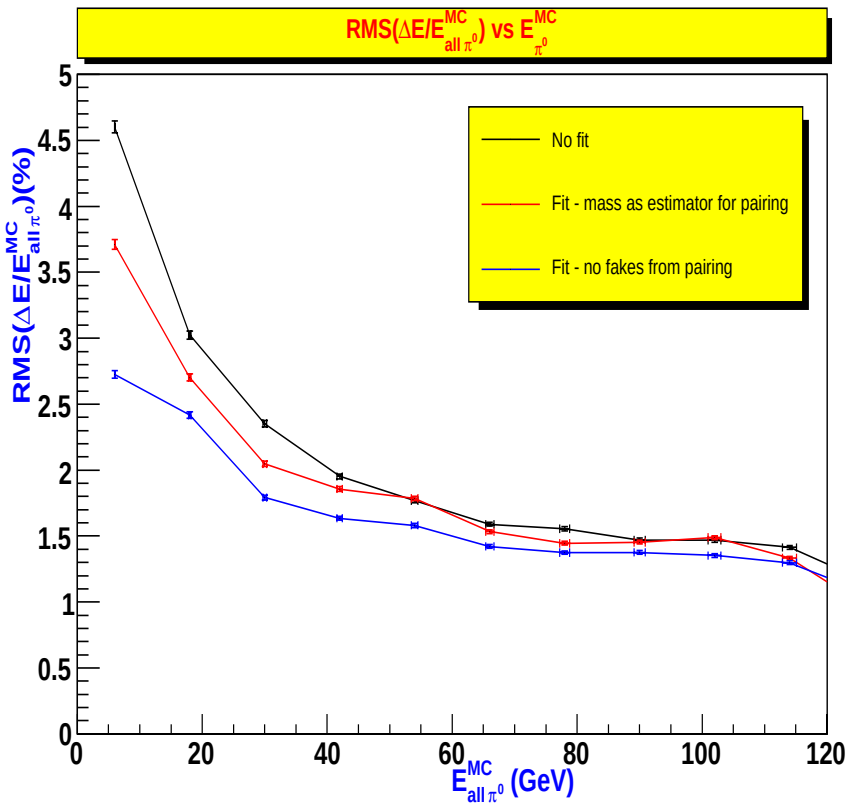
- Many π^0 may be produced in physics events
- A strategy is needed to perform correct cluster pairings.
- A study has been performed in the following conditions:
  - take hZ->bbνν events @500 GeV
  - For each event: retain only π^0
  - Smear energy and angles of the photons coming from the π^0 decays according to slides 5&6
  - Build an estimator using various information (mass, angle between the two photons, results from a pair fit,…) to make cluster pairs.
  - Estimate our efficiencies and fakes in term of the total π^0 energy of the event





π^0 reconstruction in hZ events@500 GeV





With this estimators:

- in 80% of our events, we reconstruct at least 60% of the total energy coming from π^0
- in 50% of our events, we reconstruct at least 80% of the total energy coming from π^0

The gain due to the fit is visible at low energy

Conclusions and prospects

- π^0s are an important part of the particle content in hadronic events (20 to 25% of the visible energy in tt or hZ events@500 GeV)
- π^0 energy resolution is highly improved using a constrained fit (from 7.4% to 3.4% overall) in particular at low energies.
- The challenge is now to reconstruct properly π^0s in hadronic events:
  - multiplicity (24 em clusters from π^0s on average for hZ->bbνν events@500 GeV) -> need to have the good pairing to avoid fakes
  - clustering: needs to be accurate
- A study was performed on hZ events @ 500 GeV (MC smearing): in 60% of the events, at least 80% of the π^0 energy was properly reconstructed.
- We believe that these results can be improved with refined pairing estimators.
- The next step is to use PFA and PhotID algorithms to perform π^0 reconstruction in the most realistic conditions.