EMC response in FastSim: Updates for TDR

Elisa Manoni - INFN PG

6th SuperB Collaboration Meeting

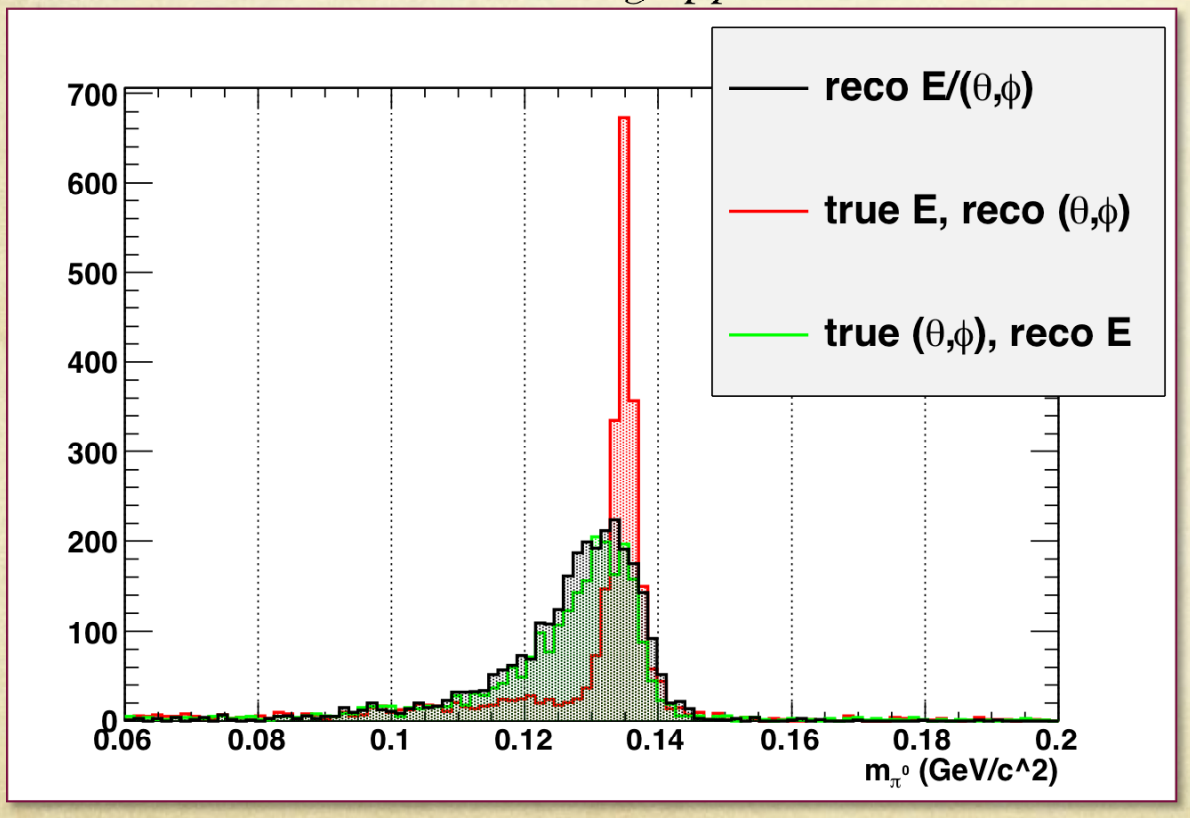
December 12th 2012, LNF

State-of-the-art before this study

- New smearing algorithm steps (as @ Pisa):
  1. calibrate raw gamma energy
  2. evaluate intrinsic width
  3. apply smearing with CB function centered at zero (shouldn't affect the calibration) and tail shape taken from FullSim
- Result: the photon energy is well calibrated and the agreement between FastSim and FullSim resolution (without machine background) is satisfactory
  - ...but the π^0 mass distribution peaks at lower values

π^0 mass: starting point

- π^0 beams, $p_{\pi 0} \in [0.1,3]$ GeV, $E_{\gamma 1,\gamma 2} > 30$ MeV, γ_1 and γ_2 reconstructed in the barrel
- calibration and smearing applied



- compute π^0 mass using
  - reconstructed γ energies and angles
  - MC true γ energies and reco γ angles
  - MC true γ angles and reco γ energies

The peak displacement is related to the usage of smeared energy

Fixing recipe # 1

Strategy

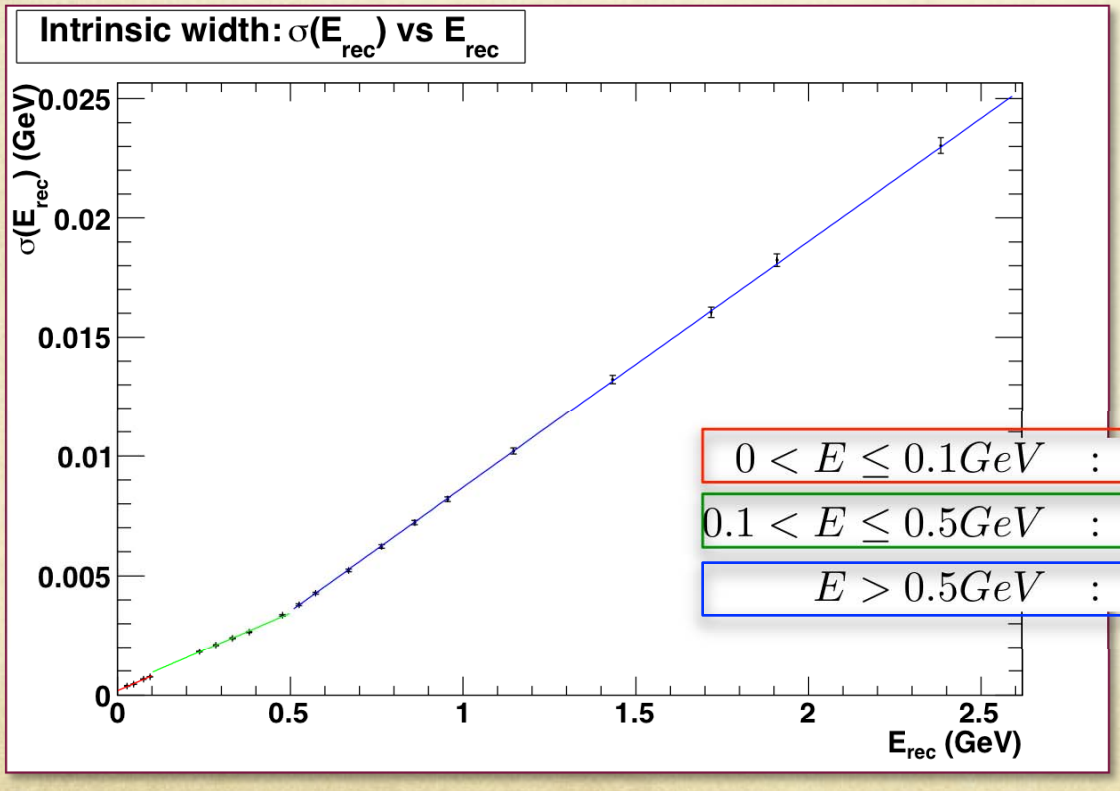
- Change smearing/calibration order*:
  1. evaluate intrinsic width
  2. apply smearing with CB function centered at zero and tail shape taken from FullSim
  3. calibrate smeared gamma energy

- [Result: the photon energies are well calibrated and the agreement between FastSim and FullSim resolution (without machine background) is satisfactory
  - ...but the π^0 mass distribution still peaks at lower values]

* the assumption, made at page 2, that the smearing doesn't affect the calibration is true if the raw energy distribution are symmetric and this is not the case

Intrinsic width

- New width parameterization, 3 energy regions (which should correspond to different approximations in the energy deposit in EMC in FastSim)



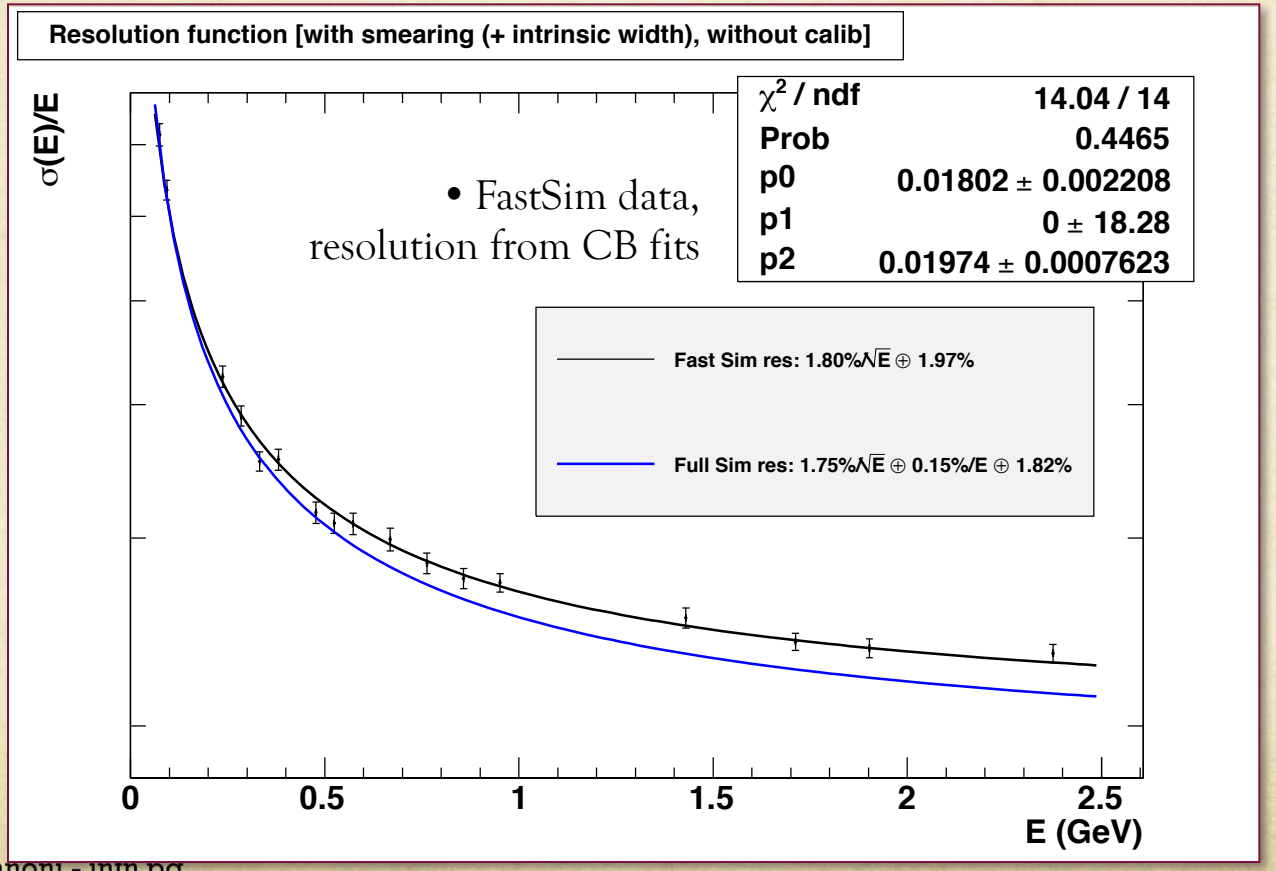
$$0 < E \leq 0.1GeV \quad : \quad f(E) = 0.00018 + 0.00626 \cdot E$$

$$0.1 < E \leq 0.5GeV \quad : \quad f(E) = 0.00033 + 0.00622 \cdot E$$

$$E > 0.5GeV \quad : \quad f(E) = -0.00165 + 0.01033 \cdot E$$

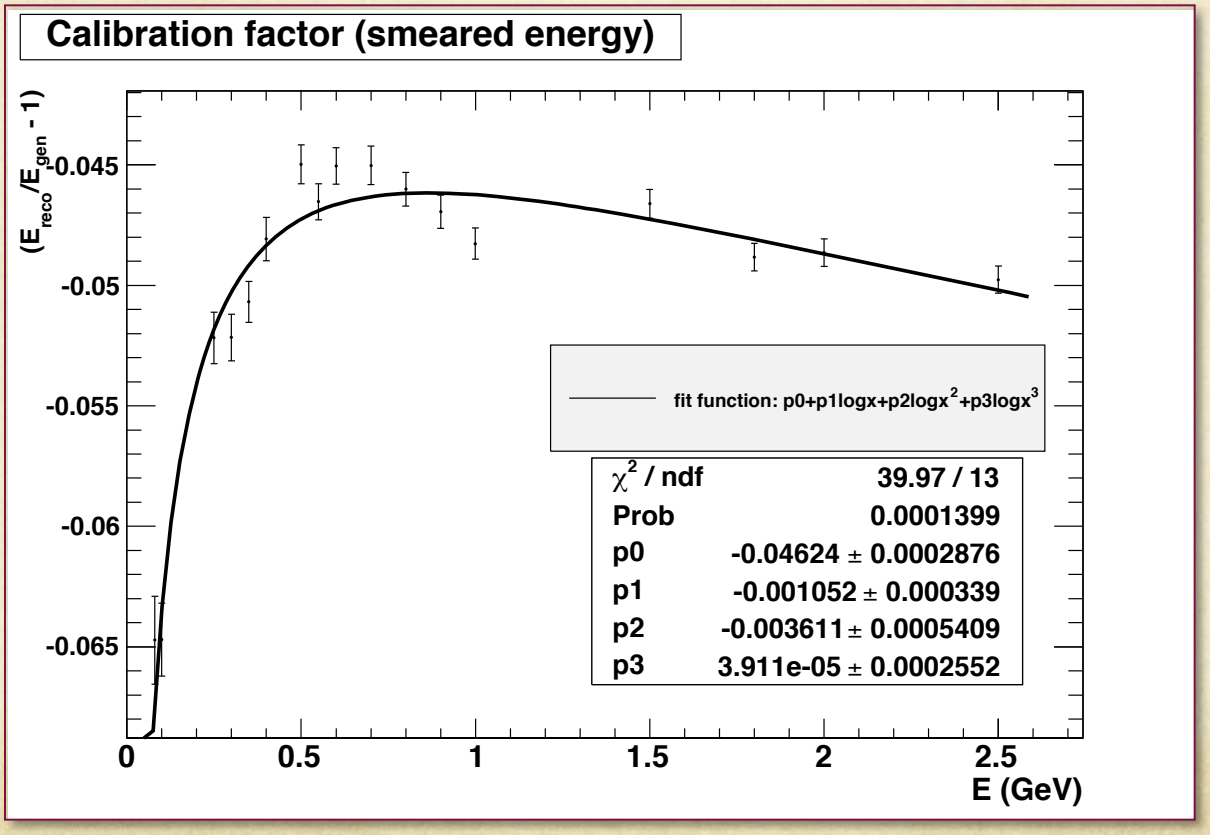
Smearing

- Resolution after smearing
  - similar level of agreement wrt Pisa results

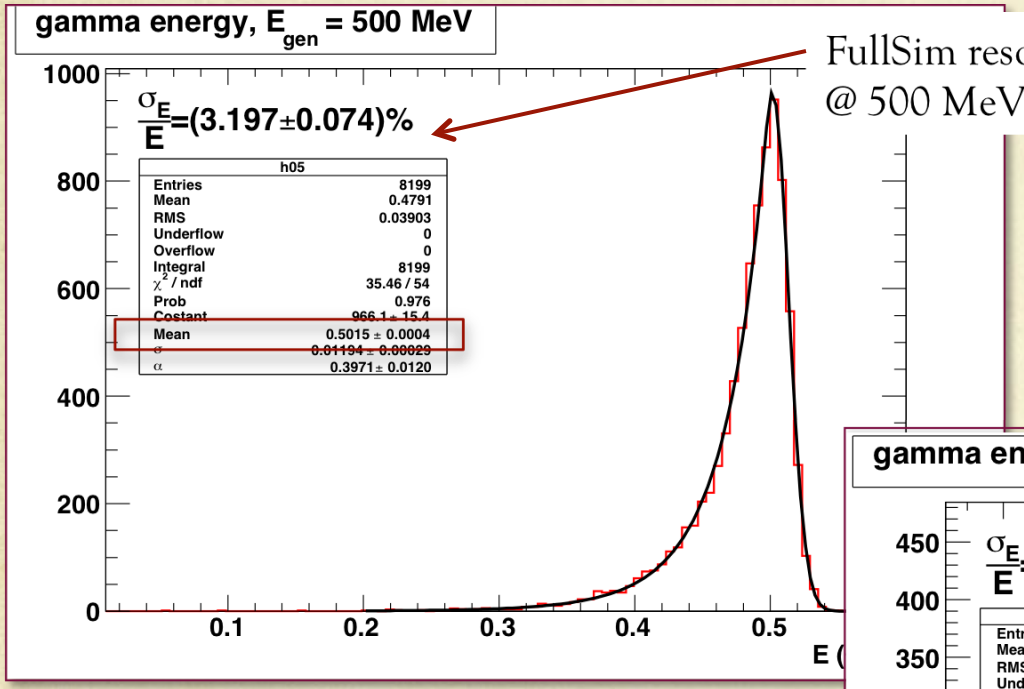


Calibration

- New calibration parameterization



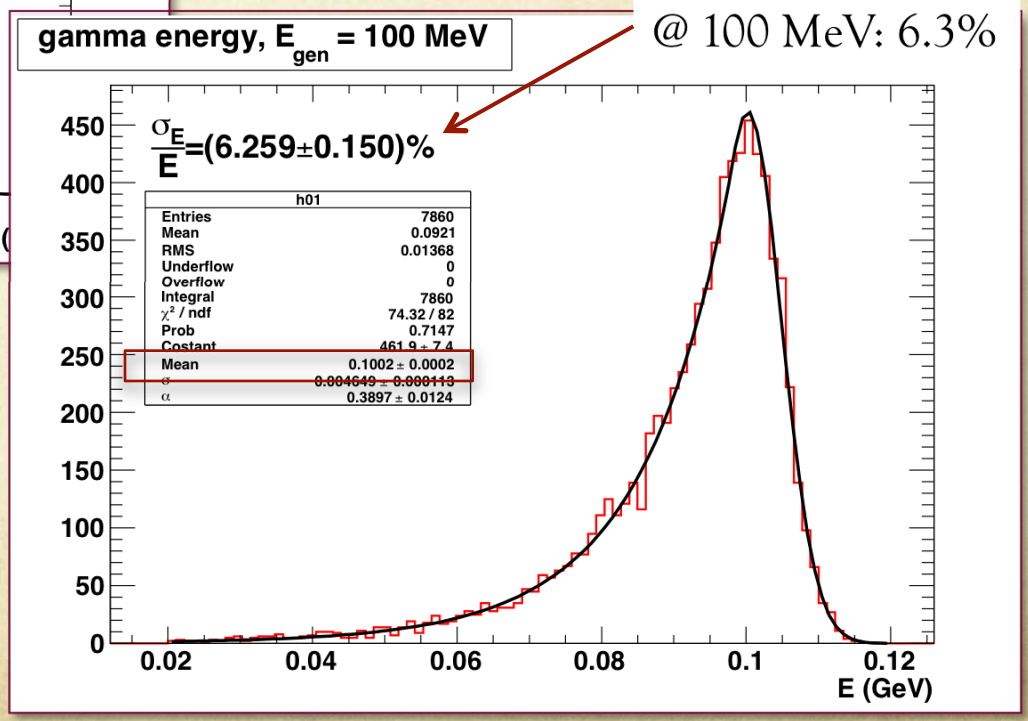
Results: gamma energy



FullSim reso
@ 500 MeV: 3.0%

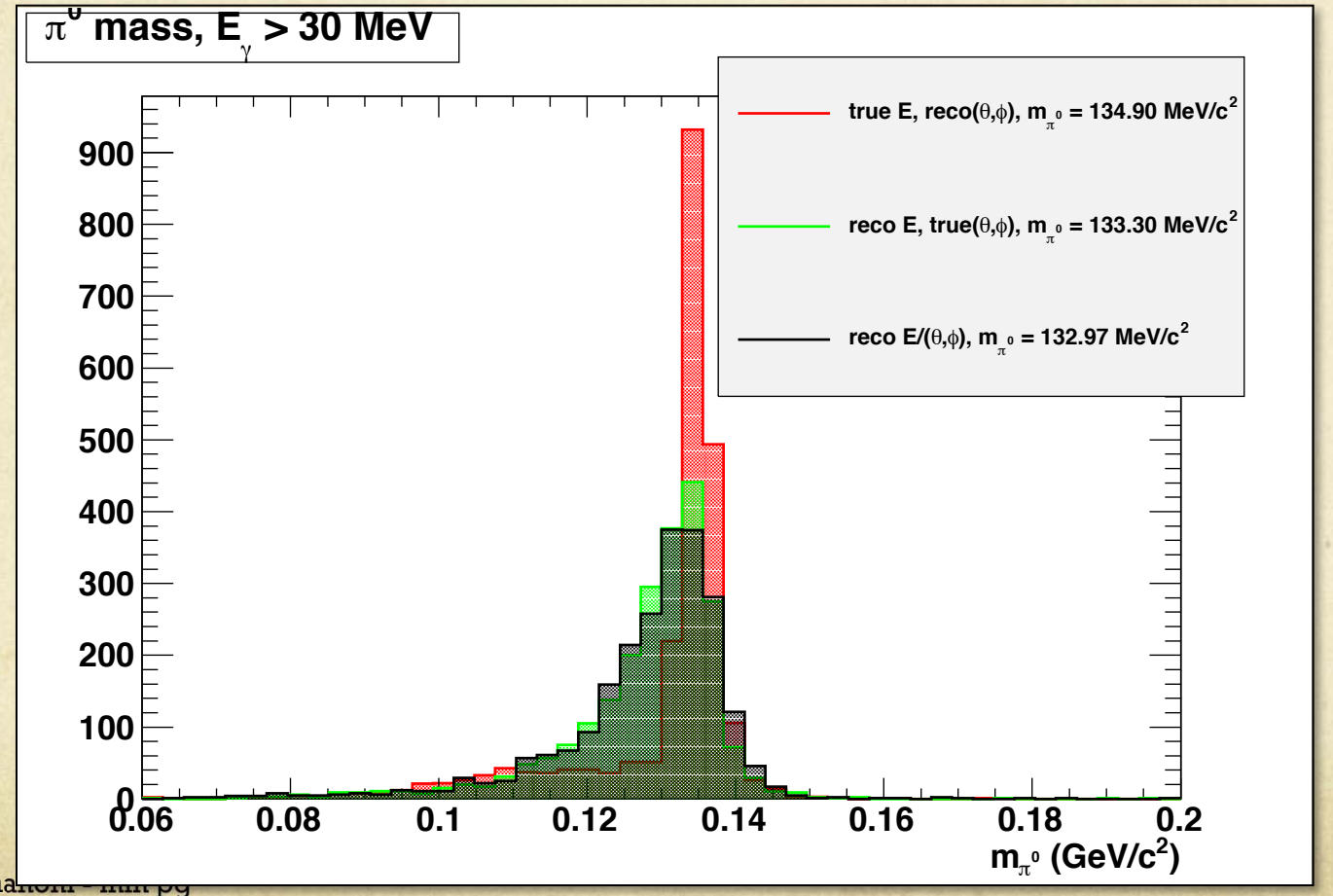
peak positions and width
almost where expected

FullSim reso
@ 100 MeV: 6.3%



Results: pion mass

- single π^0 beams, π^0 mass peak still lower than expected

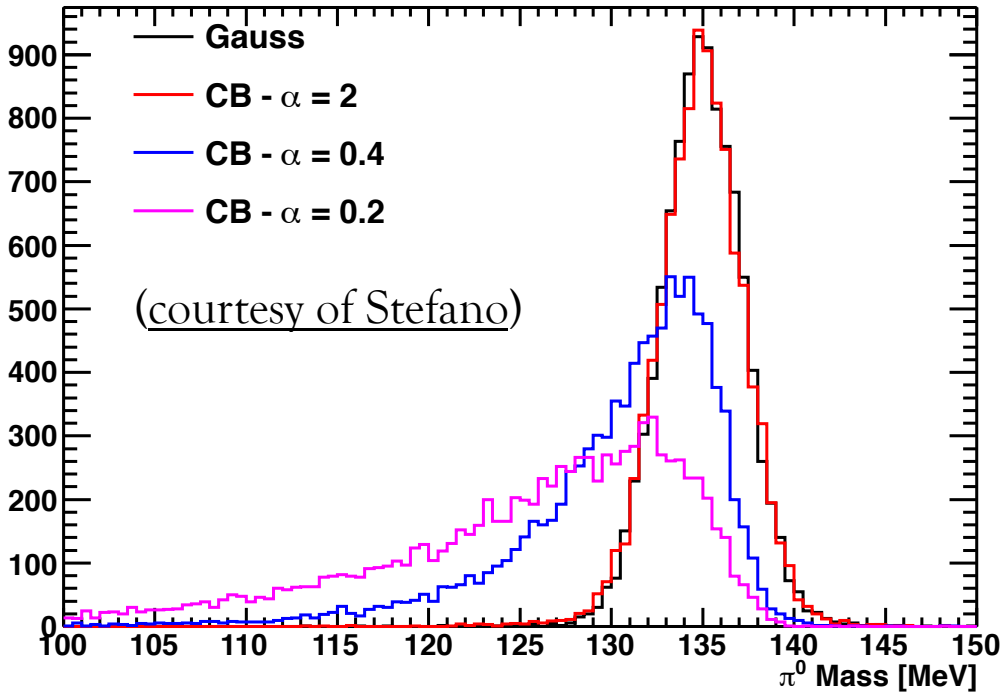


Further investigation

Effect of the tails (I)

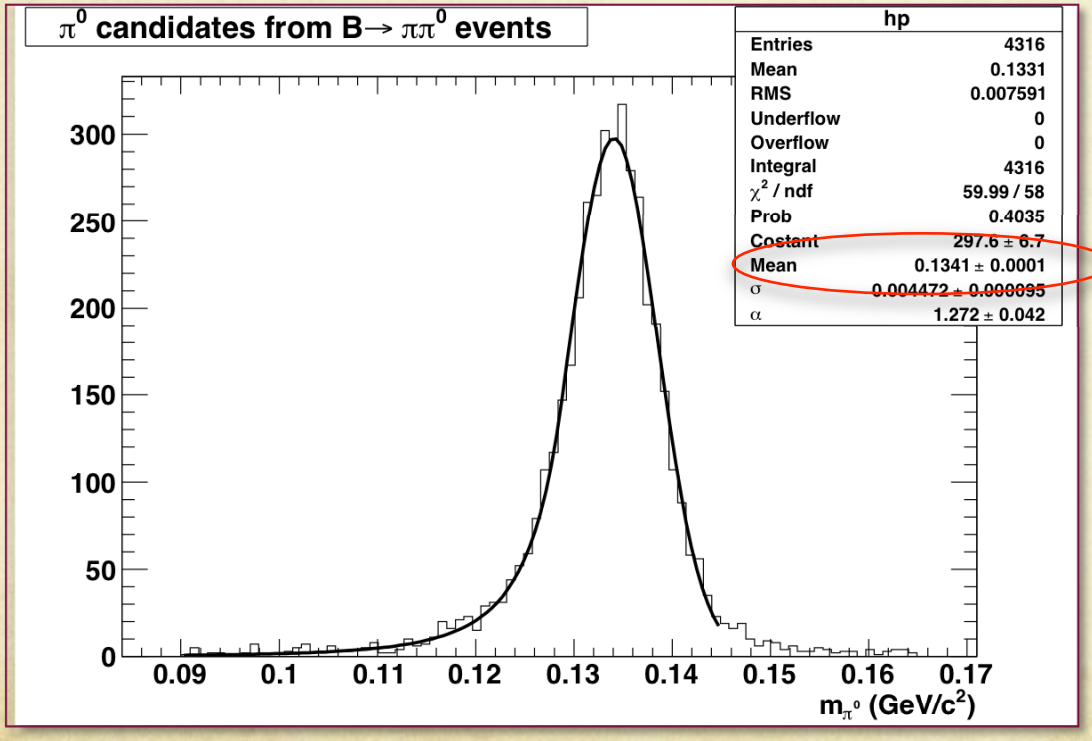
- Smearing assume CB shape for reconstructed energy distribution
- the larger the tails, the bigger the shift in the π^0 mass
- α = #σ at which the tail starts
- In FastSim α = 0.4 (from FullSim)

TOY MC



Effect of the tails (II)

- The effect of the tail on the π^0 mass, depends on the photon spectrum
- Generate BBbar events with $B \rightarrow \pi\pi^0$

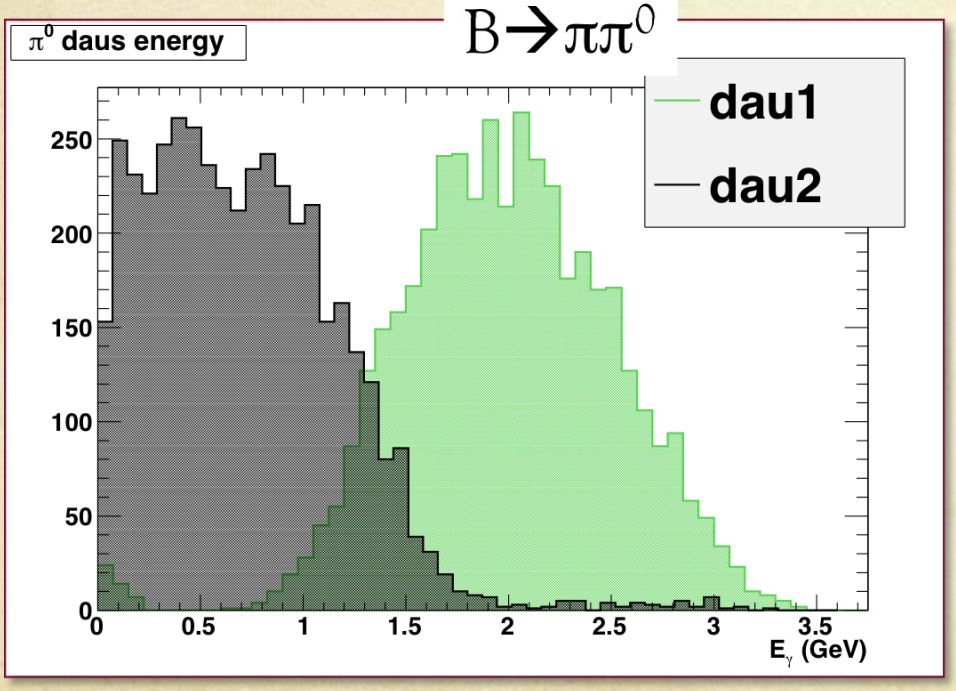


was 0.1330 GeV in single π^0 beam sample

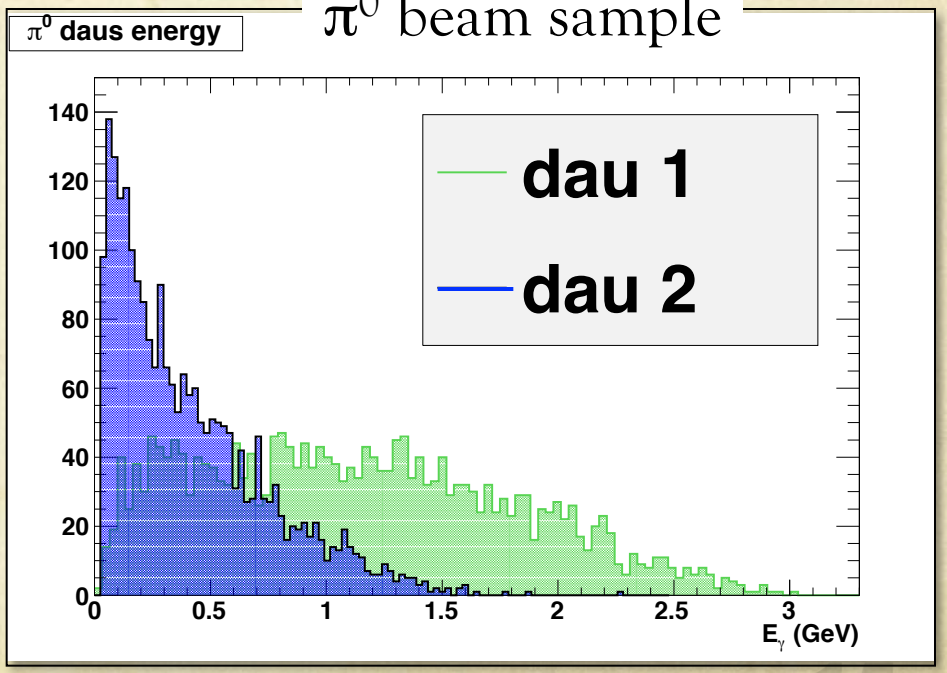
Effect of the tails (III)

- Photon spectrum: the harder the photons, the higher the mother mass

$B \rightarrow \pi\pi^0$



single π^0 beam sample



BaBar calibration

- Marks @ Calor 2008, "**Calibration of the *BABAR* CsI (Tl) calorimeter**", opscience.iop.org/1742-6596/160/1/012005

- "The asymmetric line shape of the photon response causes the invariant mass $m_{\gamma\gamma}$ of the π^0 candidates to be shifted by $\Delta m = m(\pi^0) - m_{\gamma\gamma}$, even if the photon response is perfectly calibrated. Δm is a function of the photon energy resolution, the tail of the photon response function and the position resolution of the photons"

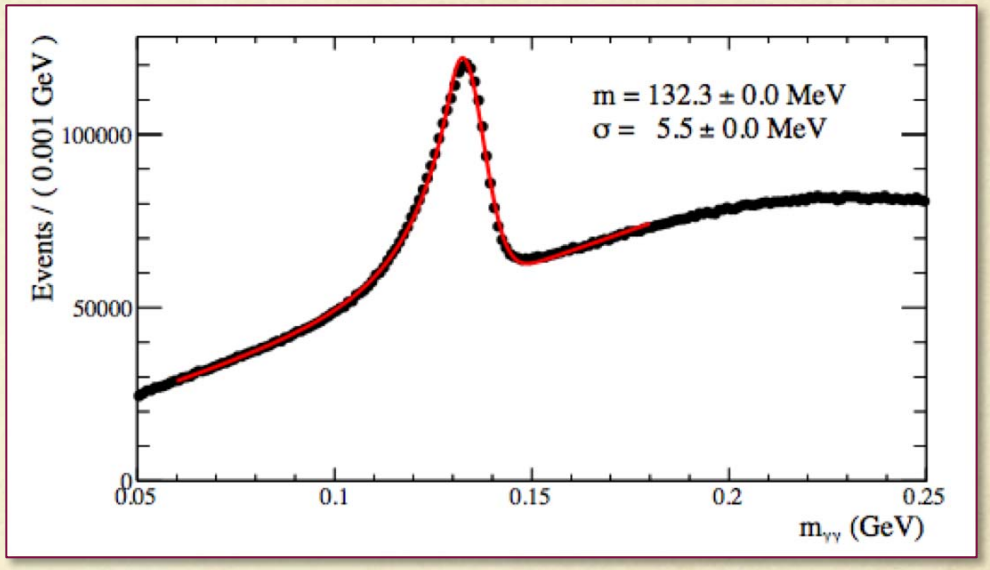
- Calibration function is angle and energy dependent and is extracted from 2 samples:

- Symmetric π^0's ($\pi^0 \to \gamma\gamma$) from $e^+e^- \to hadrons$ $\quad 70\,MeV < E_\gamma < 2\,GeV$
- γ's from $e^+e^- \to \mu^+\mu^-\gamma$ $\quad 400\,MeV < E_\gamma < 6\,GeV$

Conclusions

- Improved smearing algorithm used by Chih-hsiang to produce TDR plots

"There is a slight shift in the mass from the expected peak positions; the Fastsim absolute calibration is undergoing further tuning.
The $\gamma\gamma$ mass resolution in the MC could be somewhat underestimated, partly due to inac-curate modeling of the angular resolution compared with data, which slightly affects the $\gamma\gamma$ mass resolution here. "



- Parameters optimized for the barrel only
  - efficiency loss in FWD and BWD with the committed set of parameters