EMC response in FastSim

Elisa Manoni - INFN PG

IV SuperB Collaboration meeting - Pisa

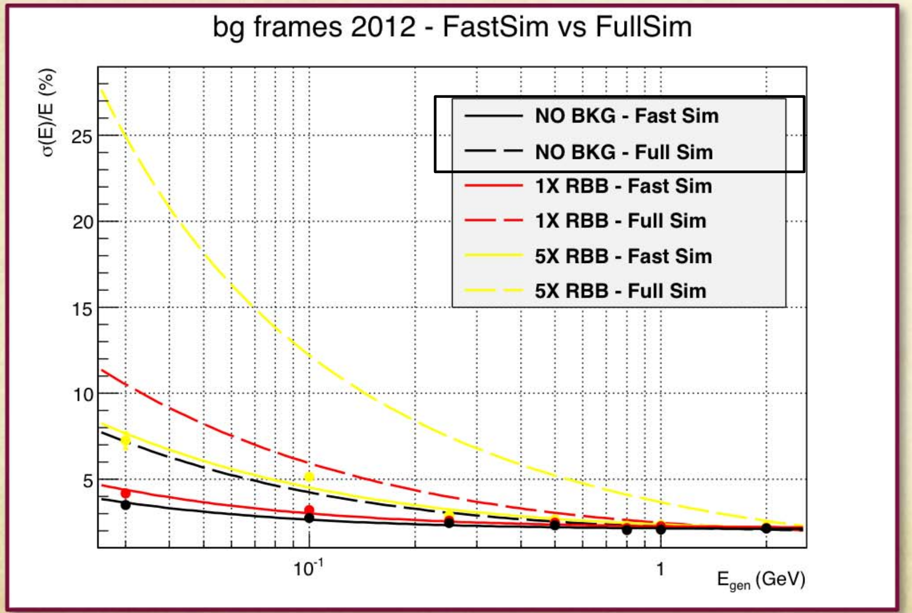
EMC II session – September 20th 2012

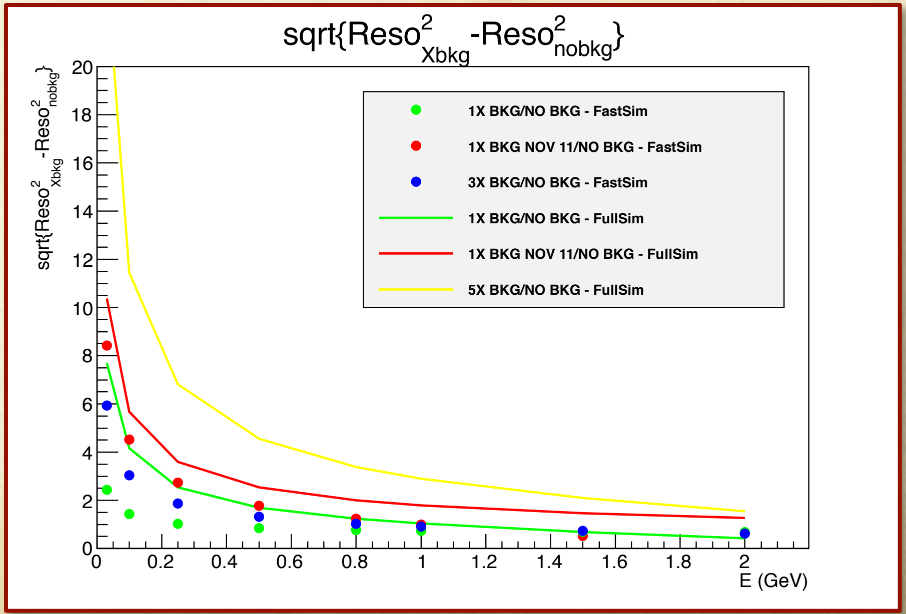
Outline

- FastSim vs FullSim @ Elba12
- Old smearing algorithm overview
- New smearing algorithm steps
- Validation without machine background

FastSim vs FullSim @ Elba2012

- EMC resolution in different machine bkg conditions, radiative bhabha only
- Big discrepancy between Fast and Full performances
  - also considering, bkg contribution only





Smearing in FastSim up to now

- Resolution parameterization: gaussian component + exponential tail

$$\text{gfluct} = \sqrt{\left(\frac{f_a}{E^{ep}}\right)^2 + f_b^2}$$

$$\text{efluct} = \sqrt{\left(\frac{c_{exp}}{E^{p_{exp}}}\right)^2 + d_{exp}^2}$$

par	fwd	brr	bwd
f_a	0.0102	0.0102	0.14
f_b	0.0	0.0	0.03
ep	0.264	0.264	0.5
c_{exp}	0.0165	0.0165	0.0
d_{exp}	0.0284	0.0284	0.0
p_{exp}	0.50	0.50	0.0

- determine parameters from BaBar data, corresponding to BaBar resolution:

$$\frac{\sigma(\mathrm{E})}{\mathrm{E}} = \frac{2.35\%}{\sqrt[4]{\mathrm{E}}} \oplus 1.35\%$$

- Not trivial to find a set of (6) parameters corresponding to a given resolution without data

Cluster reconstruction in FastSim

- 3 experimental effects incorporated:
  1. energy smearing due to finite energy resolution
  2. electric noise, i.e. randomly switch on crystals around the reconstructed cluster
  3. global calibration

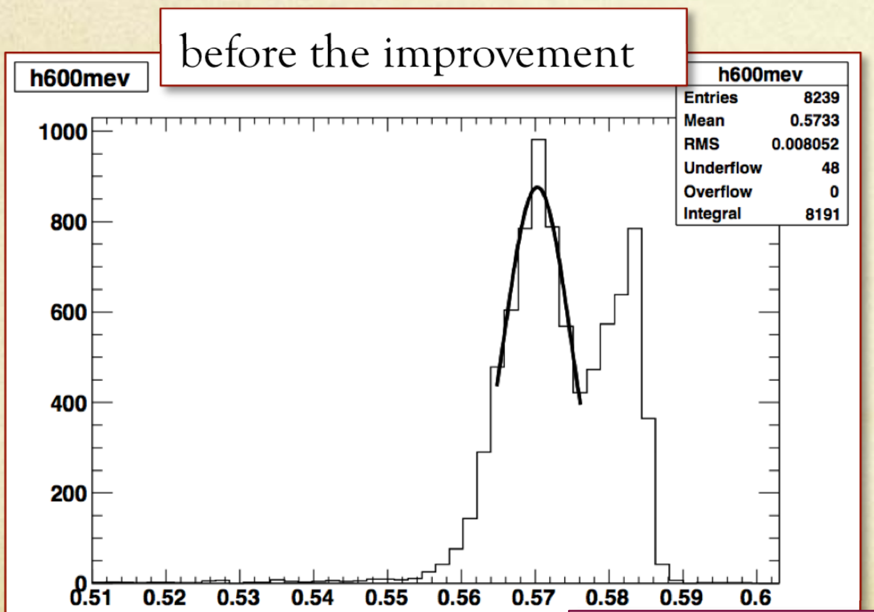
- modifying smearing parameters allows to change emc resolution

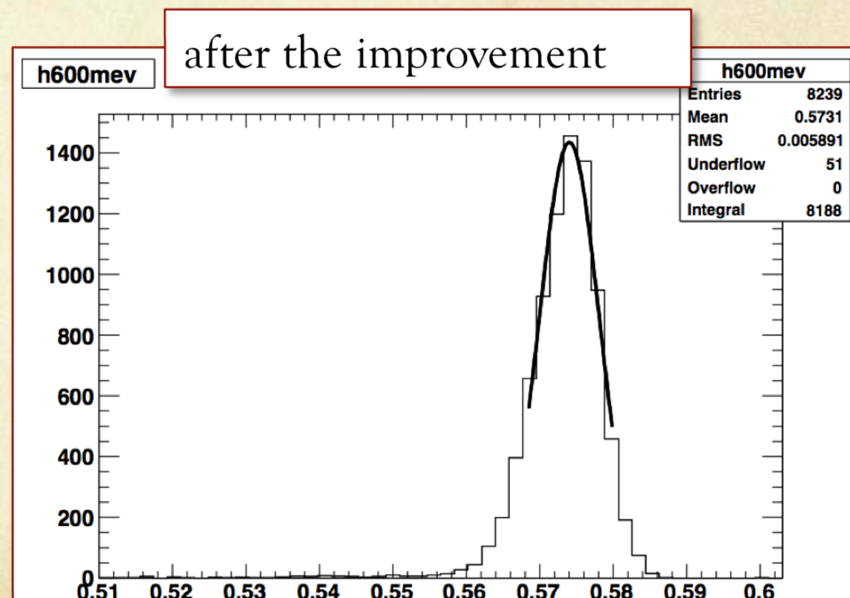
- official FastSim smearing alghoritm: calibration compensate smearing effects
  → different resolutions need different calibration constants
  → try to implement simplified smearing algorithm with calibration independent from resolution

FastSim improvements on EMC simu. wrt Elba 12
(relevant for this study)

- See Chih-hsiang’s talk for all the details
- Improvement in the modeling of EM shower

Single 600 MeV γ reconstructed energy





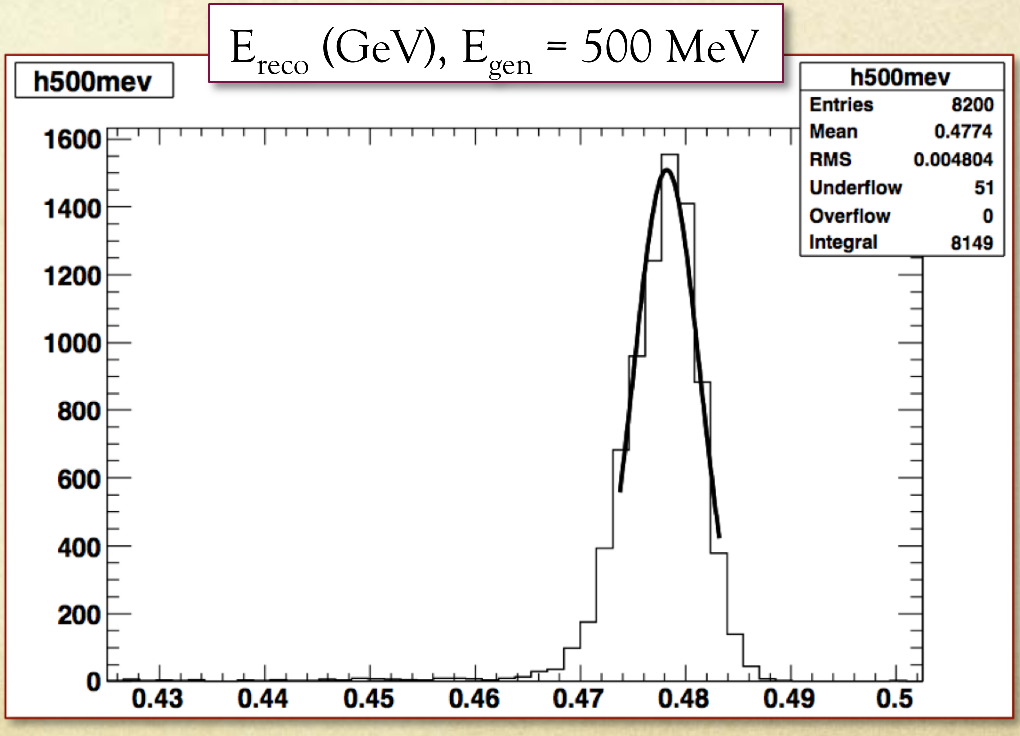
E_{reco} (GeV), E_{gen} = 600 MeV

New smearing strategy

- The usual resolution function: $$\frac{\sigma(E)}{E} = \frac{a}{\sqrt{E}} \oplus \frac{b}{E} \oplus c$$
- From FullSim, extract *a*, *b*, and *c* + params for Crystal-Ball describing reconstructed energy
- Start from monochromatic single γ beams (without simulating any experimental effect) and evaluate
  - calibration coefficients
  - “intrinsic width”
- smear calibrated energy accounting for “intrinsic width” and expected shape of reconstructed energy (Crystal Ball function) from FullSim
- Validate on single-γ samples

Simplified smearing algorithm: starting point

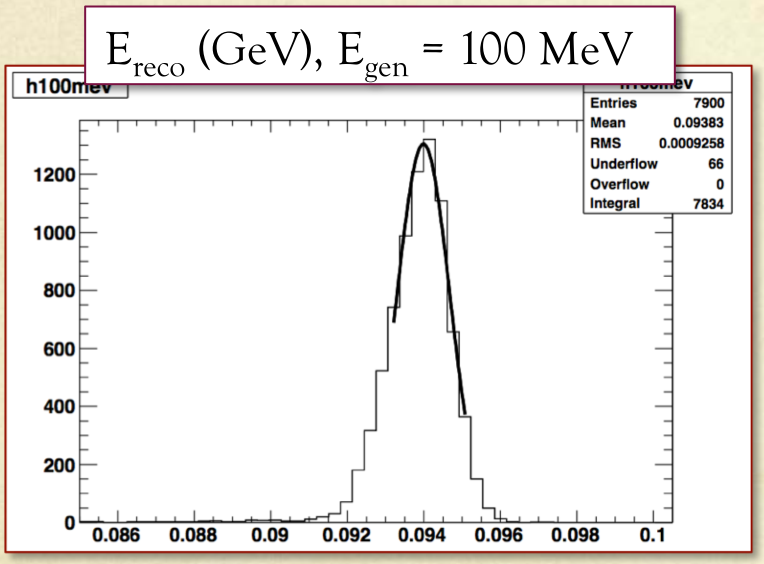
- Energy distribution after clustering: no smearing, electronic noise nor calibration included
- Distribution asymmetric and peak shifted wrt generated value due to reconstruction effects
- Need calibration factor to shift the peak to the right position
- Smearing algorithm should also take "intrinsic" width distribution into account

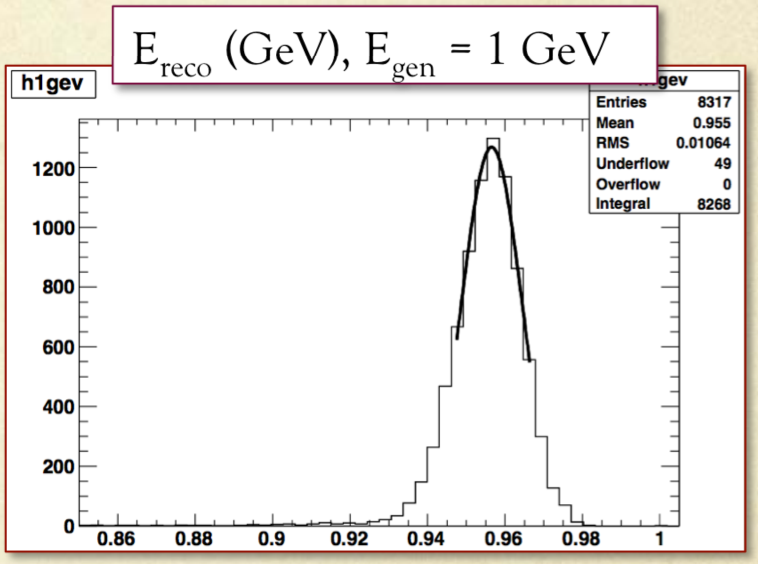


Calibration (I)

- mono-energetic single γ beams in barrel, reconstructed without exp. effects (just clustering)

- Reco energy distributions:

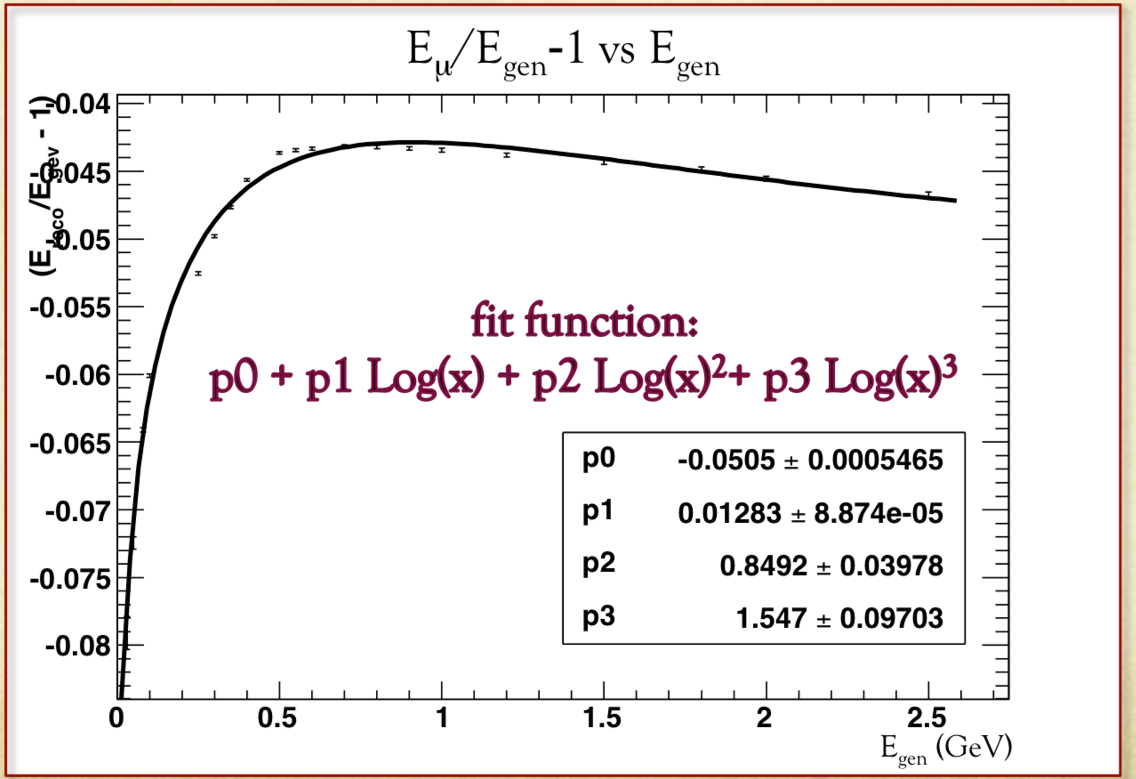




- Peak position = mean determined by gaussian fits in the peak region

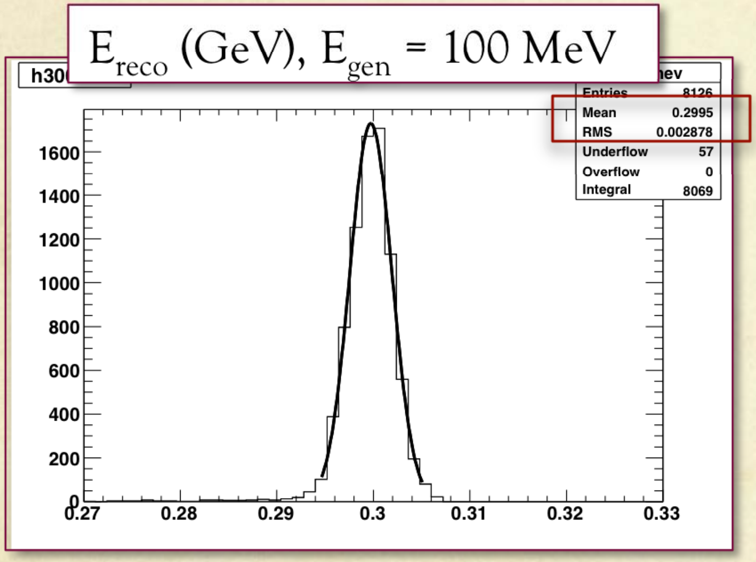
Calibration (II)

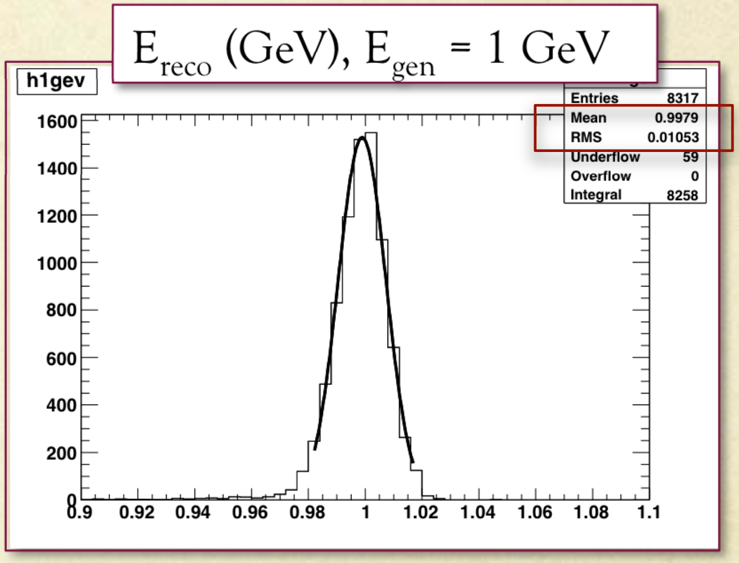
- In this plot, E_{μ} = mean from gaussian fits
- Calibration factor = $E_{\mu}/E_{gen}-1$ [$\rightarrow E_{reco,\ calib} = E_{reco}/(1+\text{calib factor})$]



Intrinsic Width (I)

- mono-energetic single γ beams in barrel, clustering + calibration
- Reco energy distributions:





- Intrinsic width = RMS determined by gaussian fits

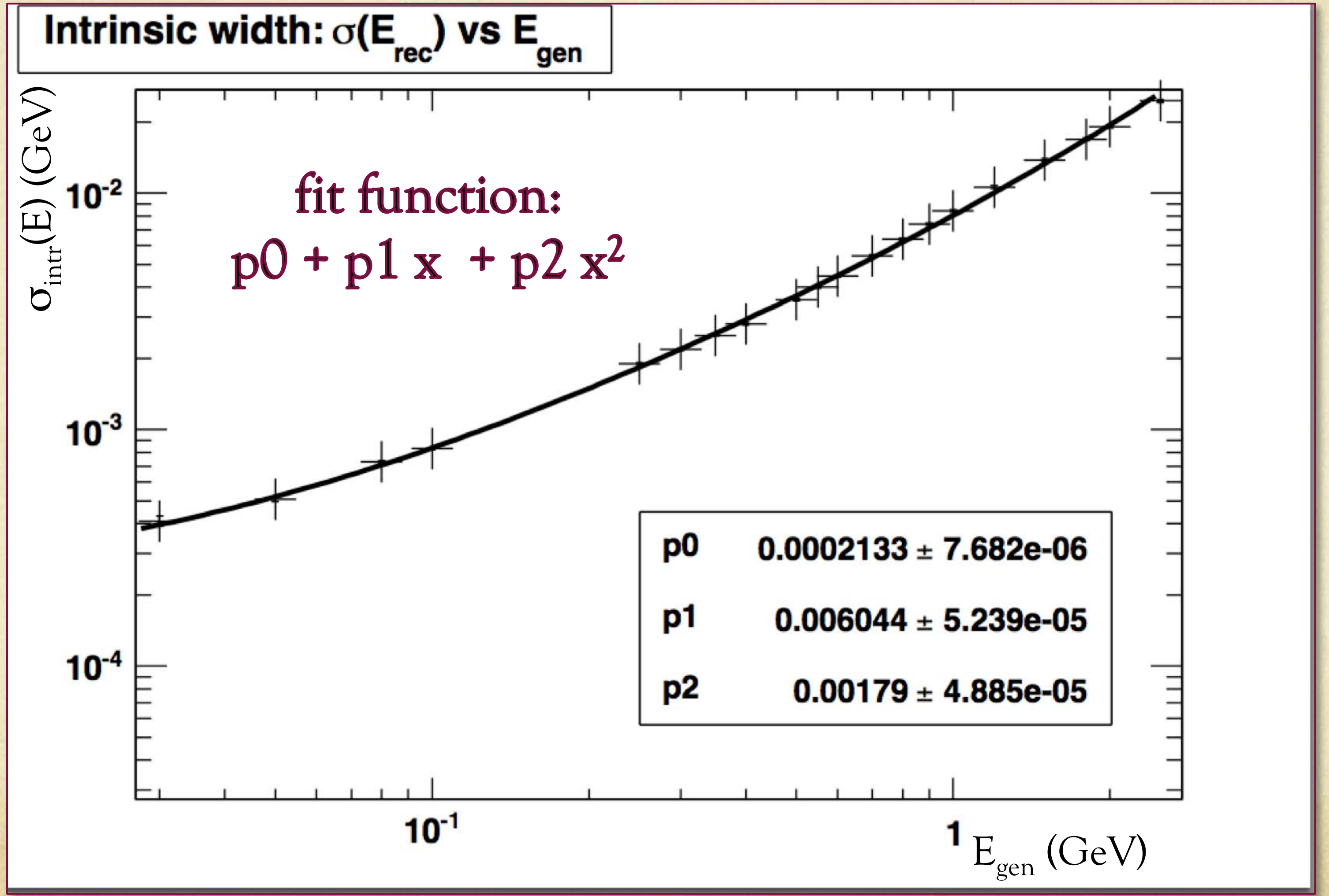
Intrinsic Width (II)

- Intrinsic width due to modeling of EMC geometry, cannot be eliminated
- Always smaller than expected experimental width (from FullSim resolution)

E_{gen} (MeV)	σ(E)/E - INTR	σ(E)/E - TOT
30	1.32%	8.29%
50	1.04%	6.59%
80	0.88%	5.39%
100	0.83%	4.93%
250	0.73%	3.59%
300	0.73%	3.41%
350	0.73%	3.28%
400	0.73%	3.17%
500	0.74%	3.02%
550	0.74%	2.96%

E_{gen} (MeV)	σ(E)/E - INTR	σ(E)/E - TOT
600	0.75%	2.91%
700	0.76%	2.83%
800	0.77%	2.77%
900	0.79%	2.72%
1000	0.80%	2.68%
1200	0.84%	2.62%
1500	0.89%	2.56%
1800	0.94%	2.52%
2000	0.97%	2.50%
2500	1.06%	2.46%

Intrinsic Width (III)



Smearing Algorithm (I)

- compute expected resolution $\frac{\sigma(E)}{E} = \frac{a}{\sqrt{E}} \oplus \frac{b}{E} \oplus c$
- compare expected resolution with intrinsic width (σ_{intr}) and compute smearing coefficient
  - if ($\sigma_{exp} > \sigma_{intr}$) {
    σ=sqrt(σ_{exp}^2-σ_{intr}^2);
    generate a random number (δE) with CB distribution
    CB parameters: m=0; σ_{CB}=f(σ, α, n); α, n= from CB shape of simulations
    }
    else: do not apply smearing
- scale energy: $E_{reco} = E \bullet (1+\delta E)$

Smearing Algorithm (II)

- mono-energetic single γ beams in barrel, no electronic noise [*]
- Nominal resolution (from FullSim):

$$\frac{\sigma(E)}{E} = \frac{1.38\%}{\sqrt{E}} \oplus 2.3\%$$

- CB parameters used in the smearing (from FullSim):
  - a = 0.4 : almost constant in FullSim, for all energies
  - n = 10 : in FullSim, increase with energy in the range [2,100]

[*] bug in the code related to electronic noise addition, now fixed. The noise effect was very small and with the new smearing may not be needed, this will be checked in the next weeks

Validation

- Compare FullSim and FastSim resolution functions
  - FastSim resolution from CB fits to reconstructed energy for different monochromatic γ samples

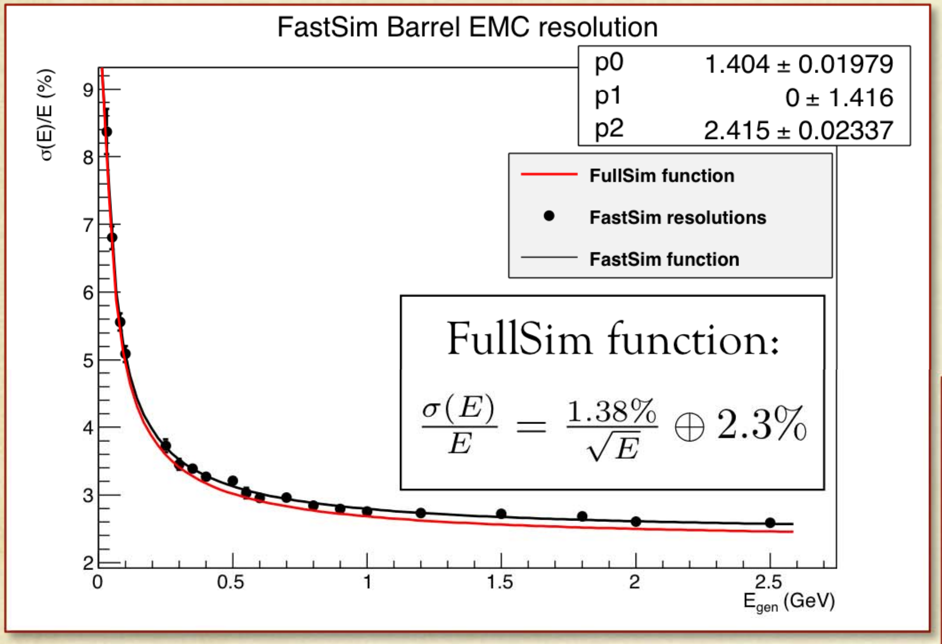
- Two set of tests
  1. nominal set of resolution parameters and other resolution functions used as FastSim inputs
  2. different values of α and n

- Test 1. gives satisfactory results for all the resolution functions considered

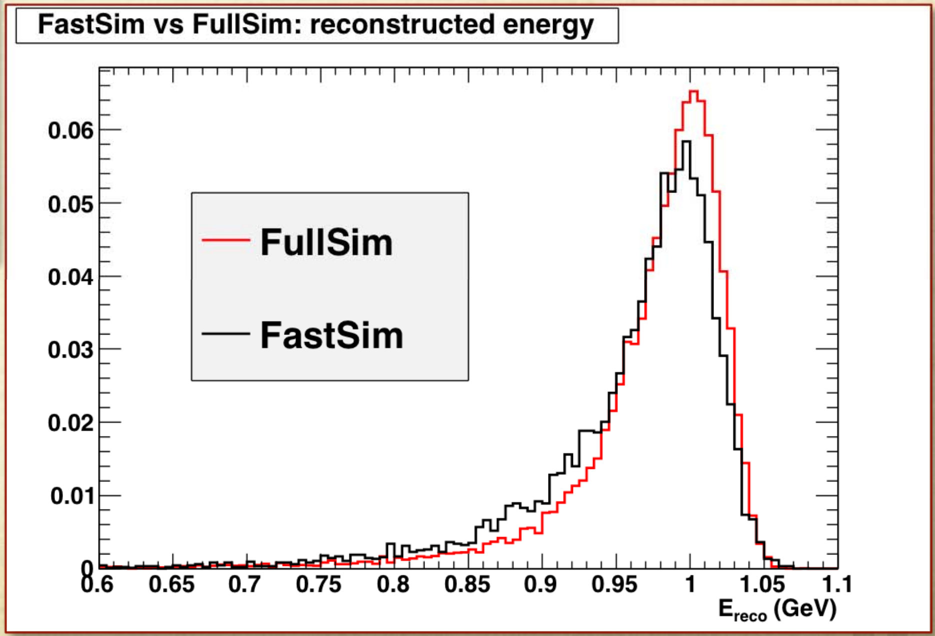
- From test 2. : the goodness of the agreement depends on the choice of α and n (define the non-gaussian component of CB distribution) $\rightarrow$ values chosen according to FullSim

Results (I)

NO MACHINE BKG

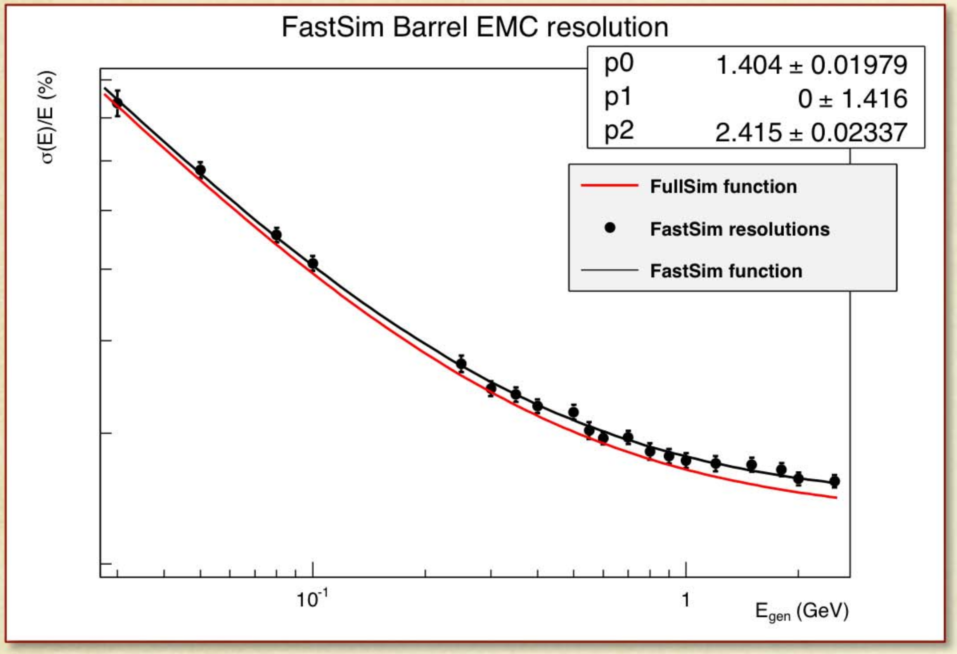


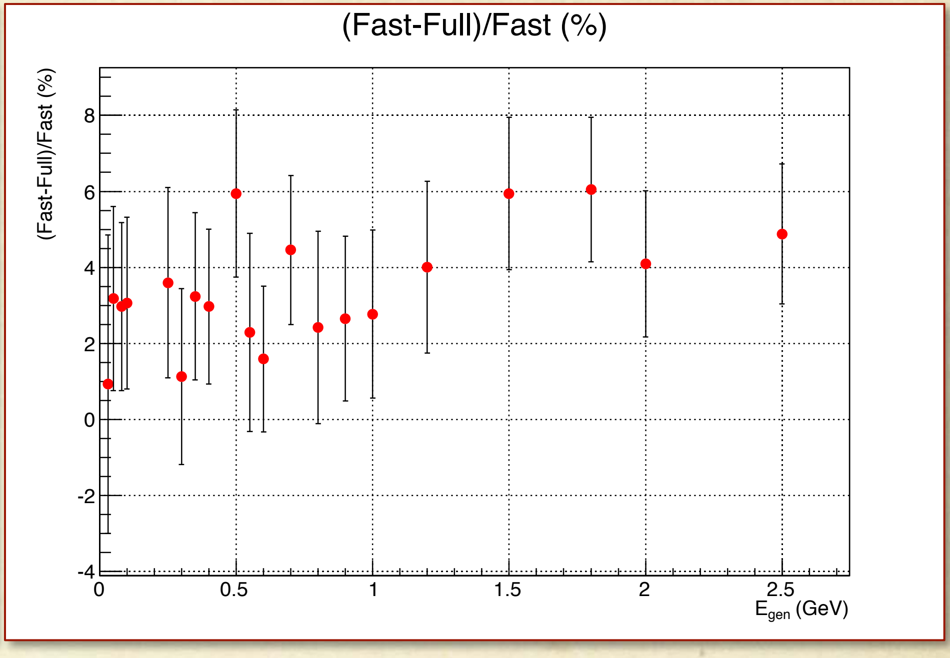
- Reconstructed energy distribution @ E_{gen} = 1 GeV
- higher FastSim tails ⟵⟶ higher FastSim resolution



Results (II)

NO MACHINE BKG





- Better agreement in the low energy region ((Fast-Full)/Full ~3% level)
- Disagreement in the high energy region (3-5% level)

Conclusions

- Implemented new smearing algorithm in FastSim
  - suitable to perform studies with different EMC resolutions
- Tested and optimize on Barrel only
  - need to perform the same studies for FWD region
- FullSim/FastSim resolution agreement at % level
- Other pending issues
  - study resolution scaling with machine background: resolution function, reconstructed energy distribution
  - compare impact of machine bkg using old and new smearing method
  - commit the code

Extra - Slides

Resolutions (I)

E_{gen} (MeV)	σ(E)/E – INTR (%)	σ(E)/E – Full (%)		σ(E)/E – Fast (%)
30	1.32	8.29		8.4± 0.3
50	1.04	6.59		6.80 ± 0.17
80	0.88	5.39		5.56 ± 0.13
100	0.83	4.93		5.09 ± 0.12
250	0.73	3.59		3.73 ± 0.10
300	0.73	3.41		3.45 ± 0.08
350	0.73	3.28		3.39 ± 0.08
400	0.73	3.17		3.27 ± 0.07
500	0.74	3.02		3.21 ± 0.07
550	0.74	2.96		3.03 ± 0.08

Resolutions (II)

E_{gen} (MeV)	σ(E)/E – INTR (%)	σ(E)/E – Full (%)		σ(E)/E – Fast (%)
600	0.75	2.91		2.96 ± 0.06
700	0.76	2.83		2.96 ± 0.06
800	0.77	2.77		2.84 ± 0.07
900	0.79	2.72		2.80 ± 0.06
1000	0.80	2.68		2.76 ± 0.06
1200	0.84	2.62		2.73 ± 0.06
1500	0.89	2.56		2.72 ± 0.06
1800	0.94	2.52		2.68 ± 0.05
2000	0.97	2.50		2.60 ± 0.05
2500	1.06	2.46		2.59 ± 0.05