Update on EMC FastSim and Backward EMC in FullSim

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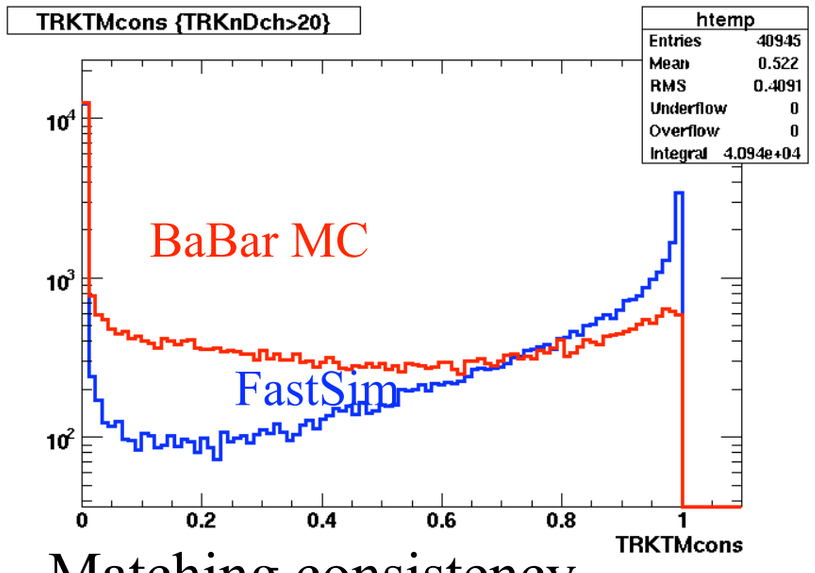
2009/12/01−04
SuperB General Meeting, Frascati

Status at last meeting (Oct. 09)

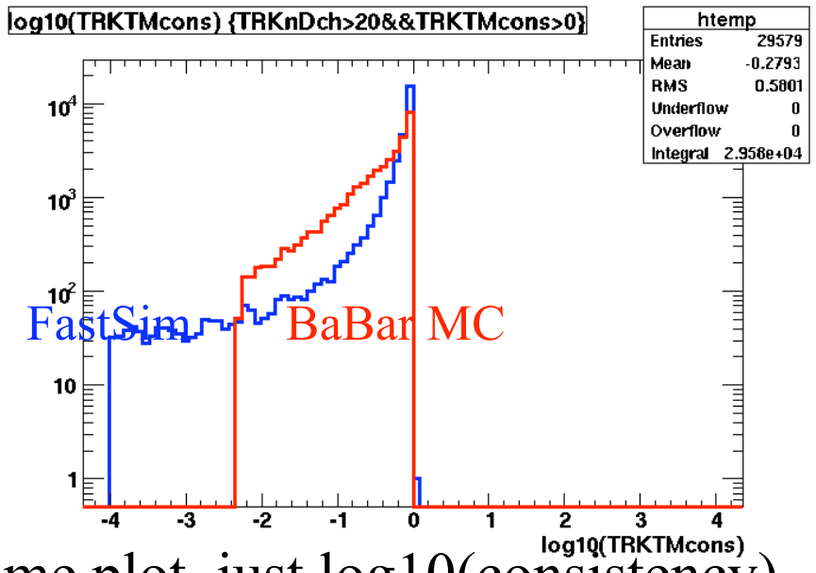
- Model energy resolution using Gauss⊗Exp function
  - $f(x;m,\sigma,\tau) = \frac{1}{2\tau}\exp\left(\frac{\sigma^2}{2\tau^2}+\frac{x-m}{\tau}\right)\mathrm{erfc}(\frac{\sigma}{\sqrt{2}\tau}+\frac{\mathrm{x-m}}{\sqrt{2}\sigma})$
  - fit to BaBar full sim energy resolution, only accurate for CsI.
- Ad hoc function to calibrate energy.
- Extra energy added to crystals surrounding clusters to simulate noise.
- Slightly reduce the active region to simulate gaps between crystals
- $\pi^0 \rightarrow \gamma\gamma$ resolution looks fine, but too much background (unknown extra neutrals).
- Track-cluster matching problem?

Track-cluster matching

- Matching is done by finding a cluster that has the most consistent point of closest approach to a trajectory.
- A χ^2 is calculated using ($\Delta\theta$,$\Delta\varphi$,ΔR) between cluster centroid and POCA, and ($\sigma\theta$,$\sigma\varphi$,σR)
  - $\sigma\theta$ and $\sigma\varphi$ are the RMS of the crystal distribution in a cluster
  - σR is a fixed number (configuration parameter)
- We had too few clusters associated with tracks despite generous cut and degrees of freedom (3).



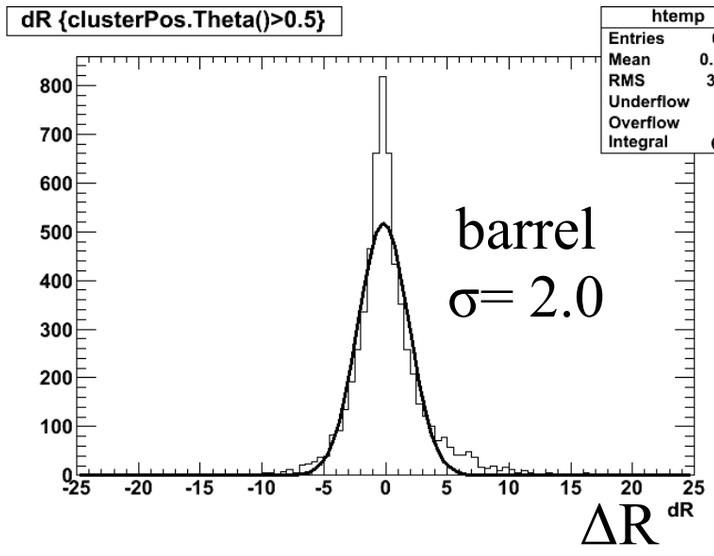
Matching consistency

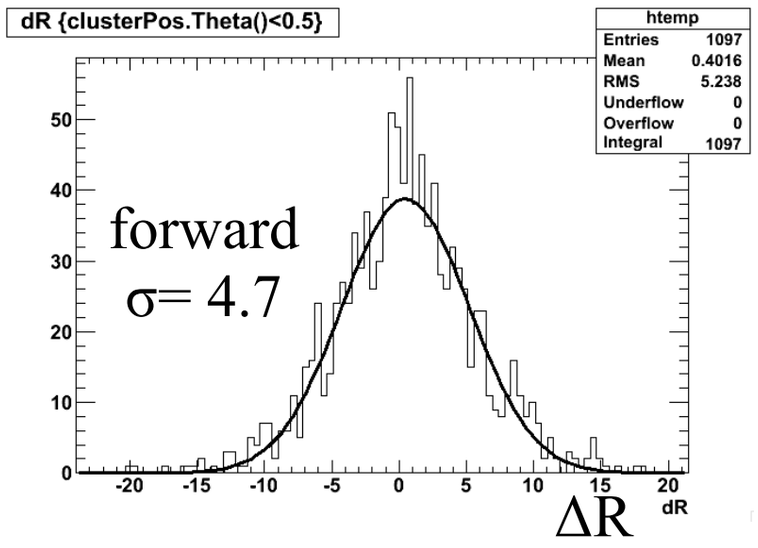


same plot, just log10(consistency)

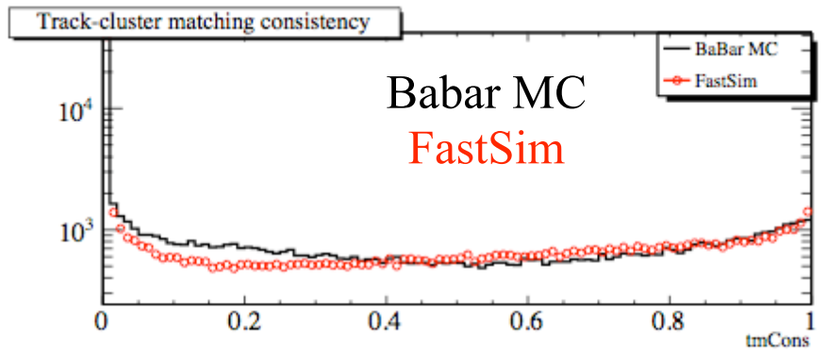
Fix track-cluster matching bug

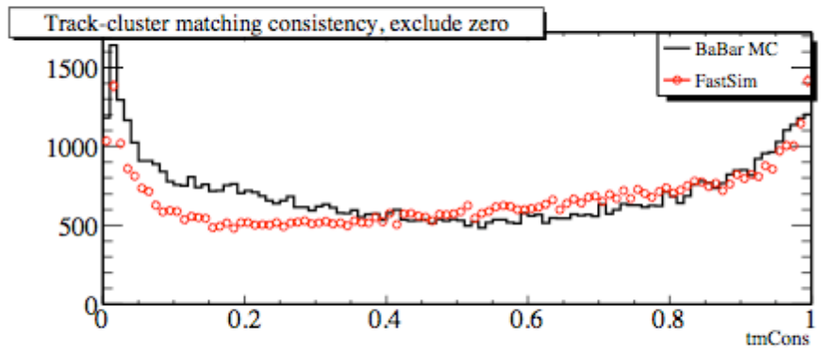
- First of all, the source of low matched clusters has nothing to do with the matching. It was because some minimum ionizing tracks did not create a cluster at all due to a bug.
- Modify nDof to 2 and study the radial resolution
  - set σR to 2 and 4 for barrel and forward.

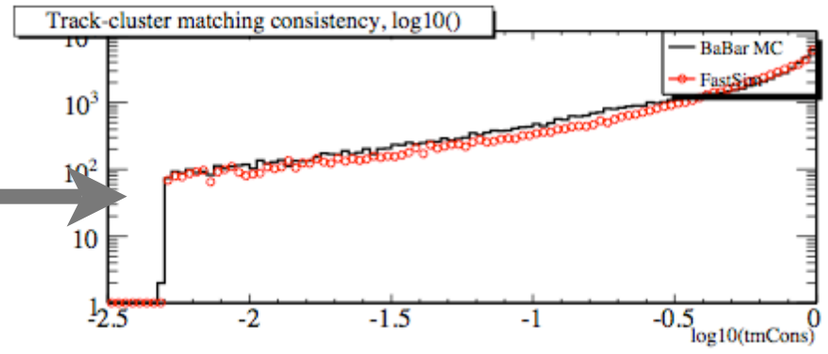




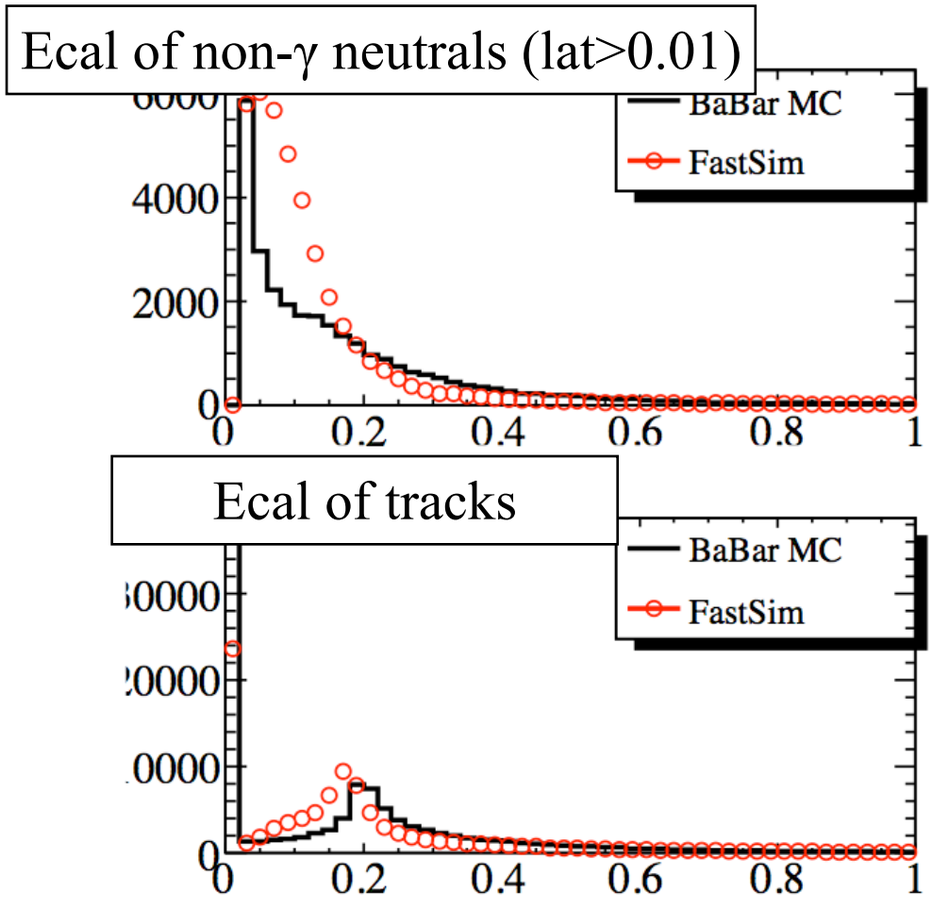
Much better!



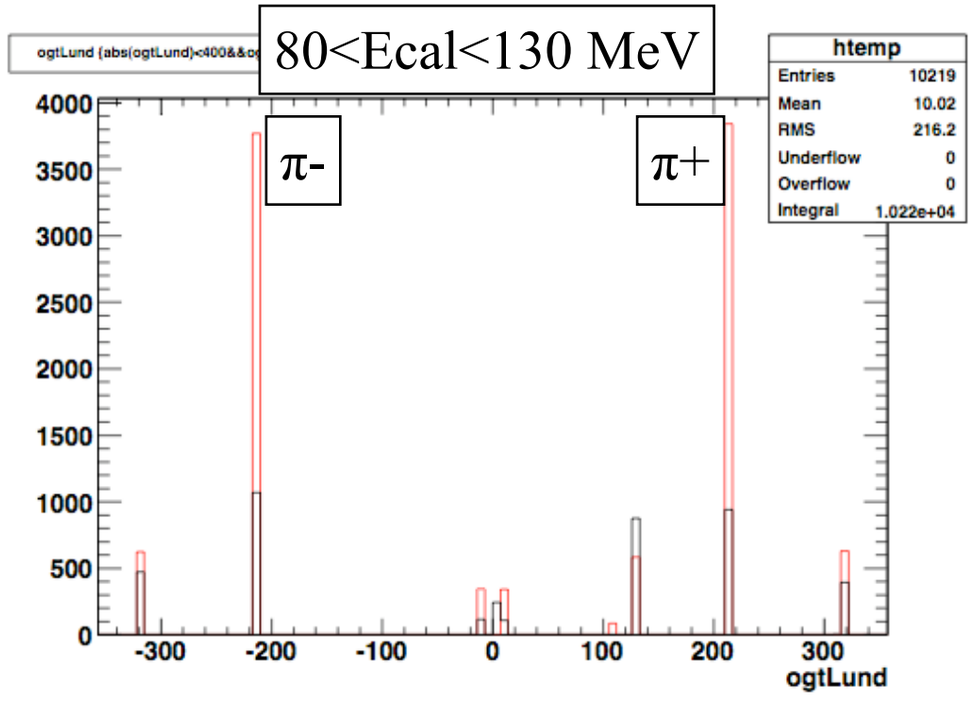


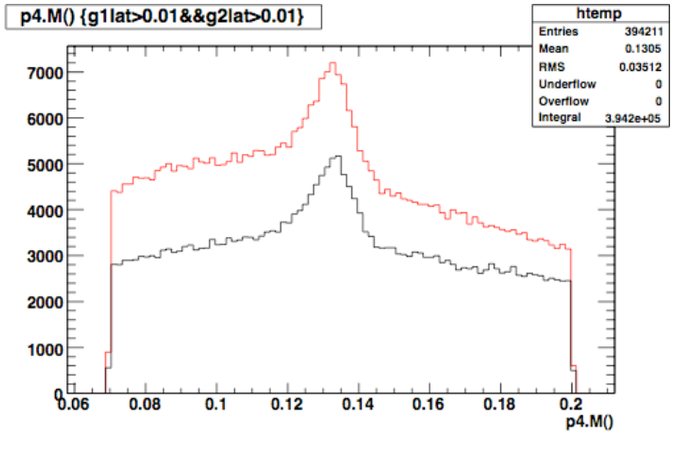


Problem with extra neutrals

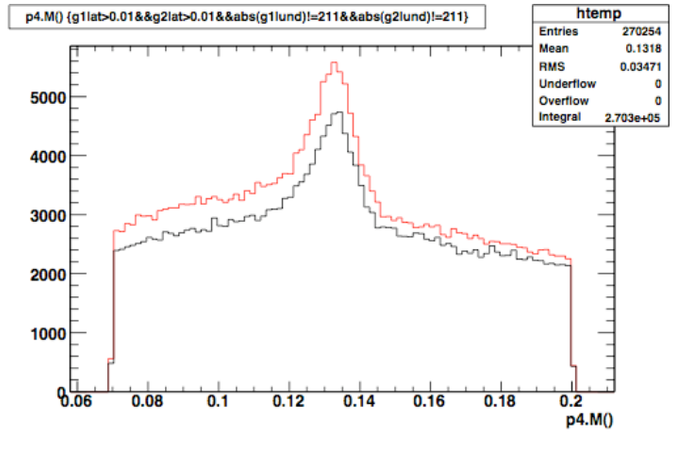


- Most extra neutrals come from pion.



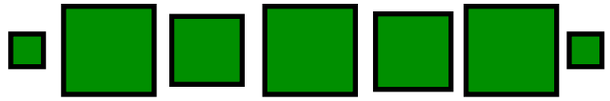


Remove neutrals from pions



Too many split-offs...

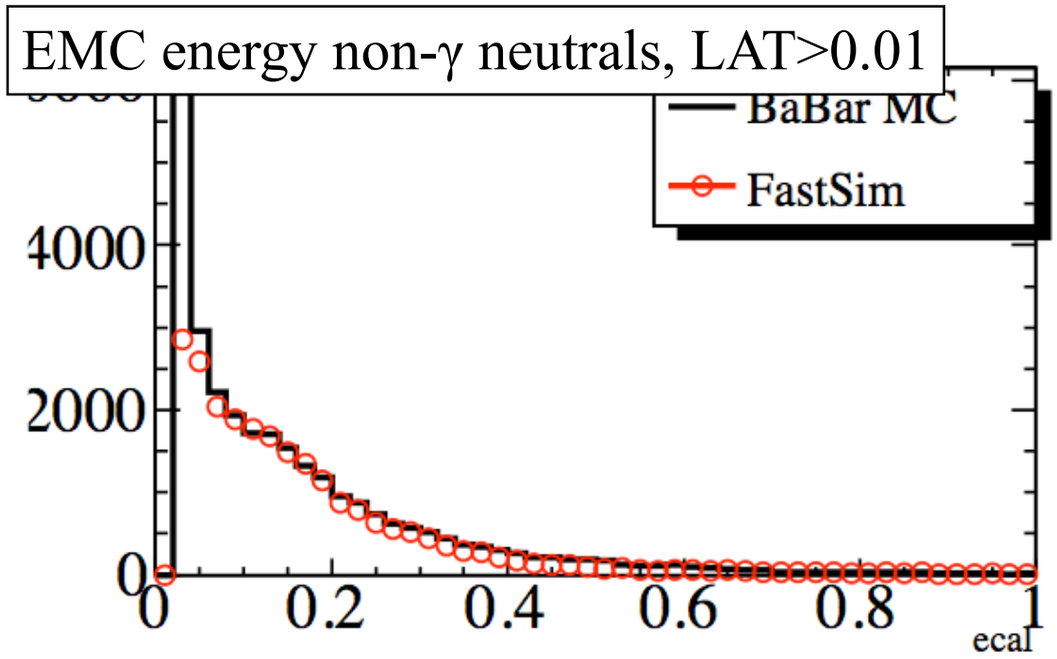
- Clusters with N local maxima are splitted into N clusters.
- Can get too many for low energy MIP clusters: A track travels through several crystal; each receives similar energy. Because of fluctuation, it can be splitted into many clusters.

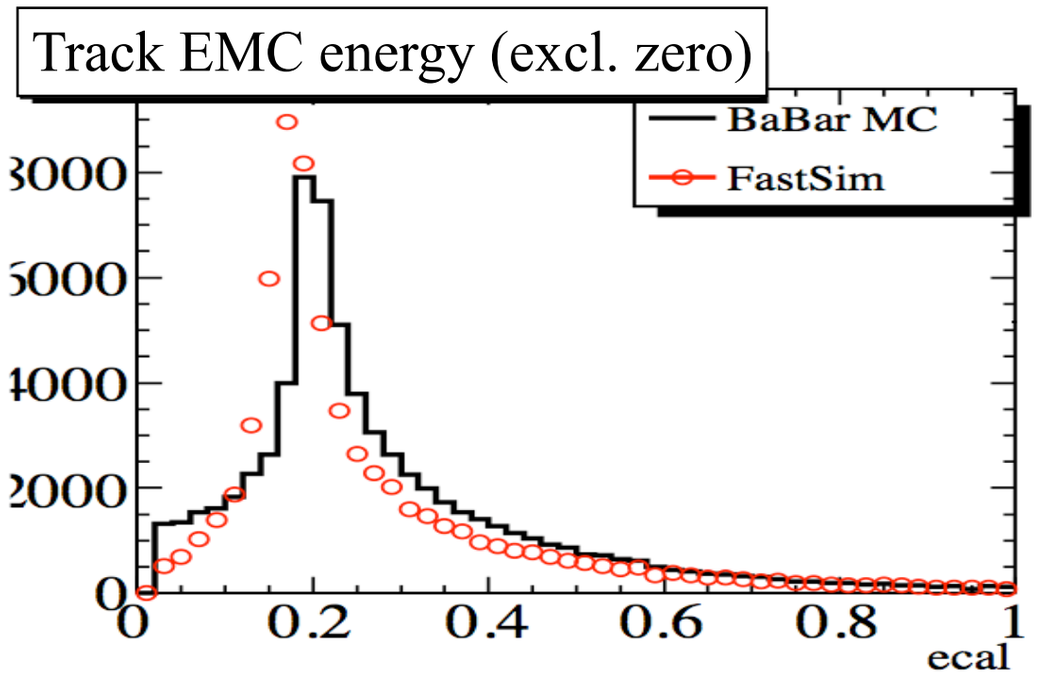


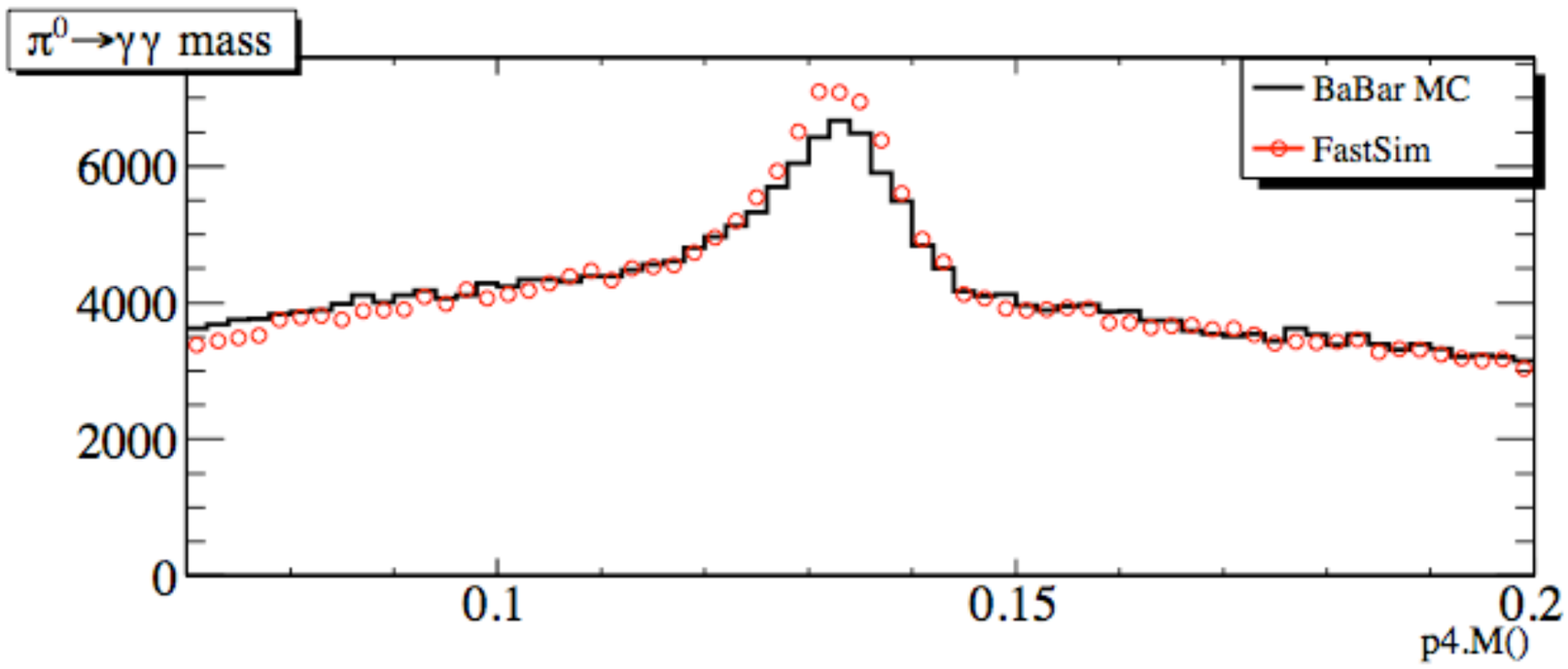
will become 3 clusters

- So, apply a condition to restrict the qualification of local maxima:
  - $0.5*(N_{neighbor}-2.5) > E_{max\_neighbor} / E_{localmax}$ [Babar NIM]
  - or only one or no neighbor.

After fixing local maxima

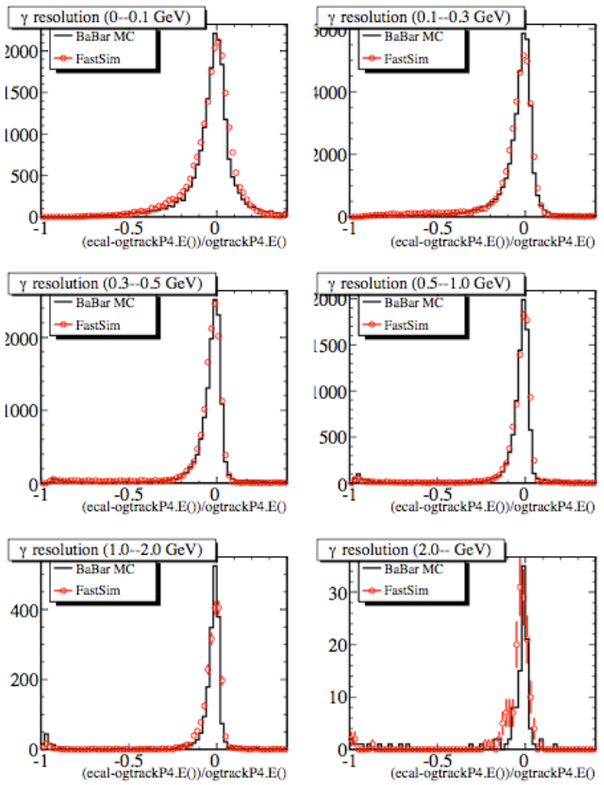


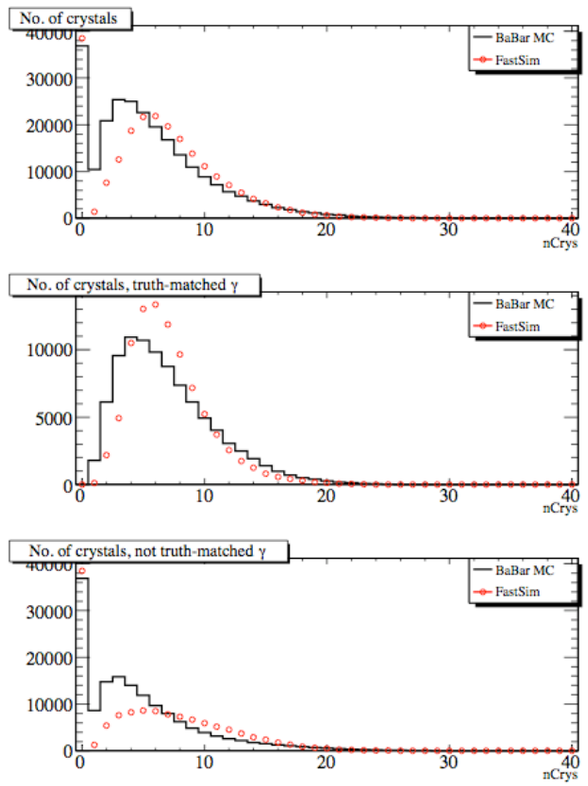


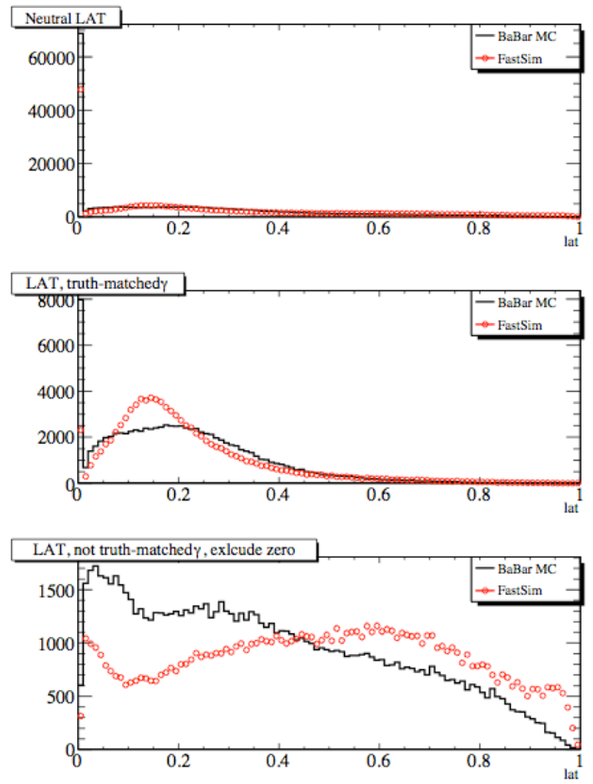


B0B0bar events

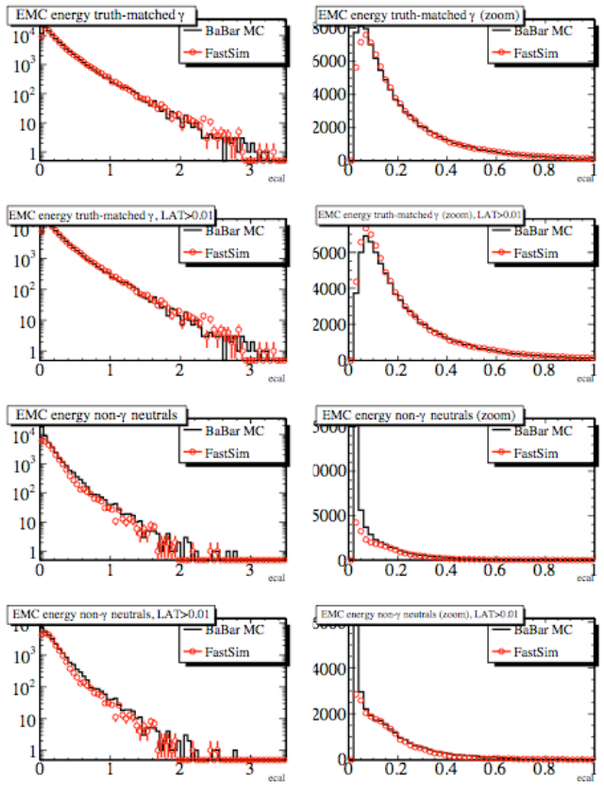
EMC QA plots

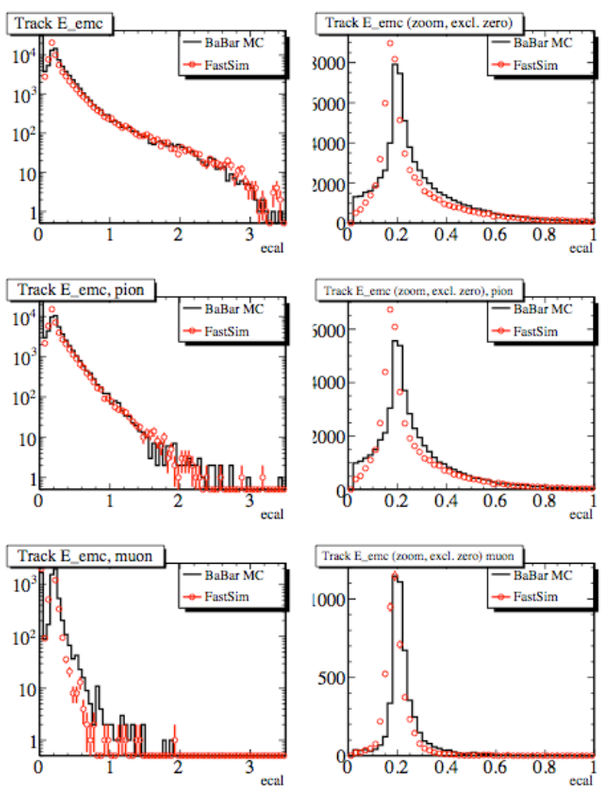


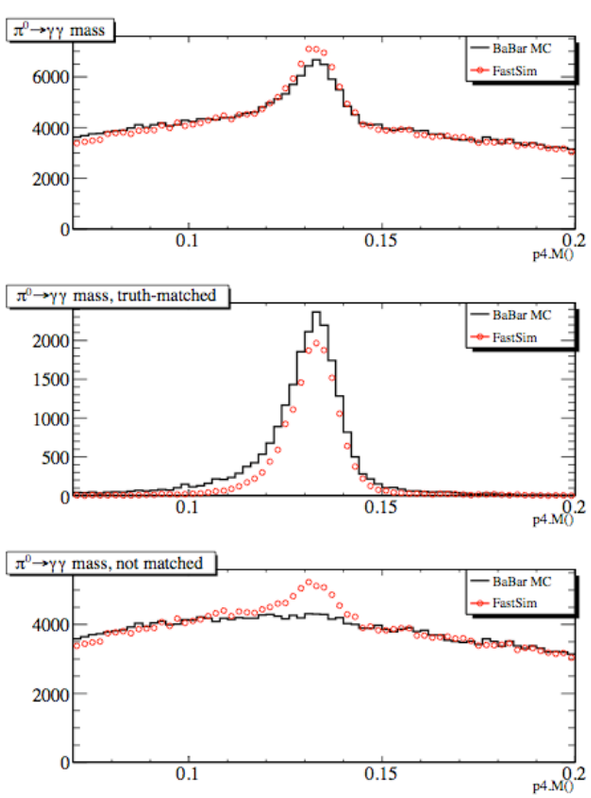




comparing fastsim in Babar configuration and Babar full MC

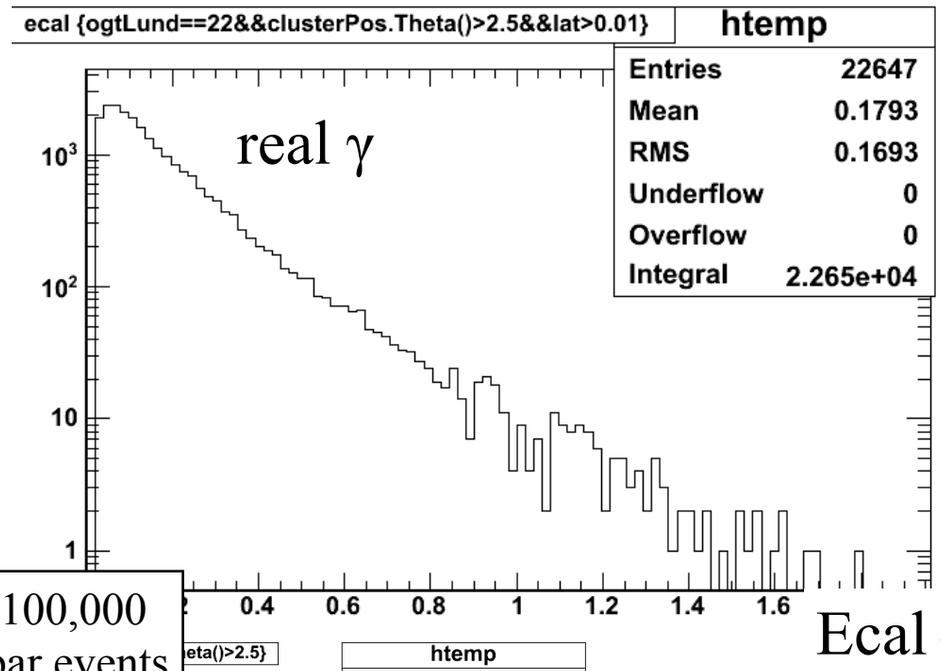






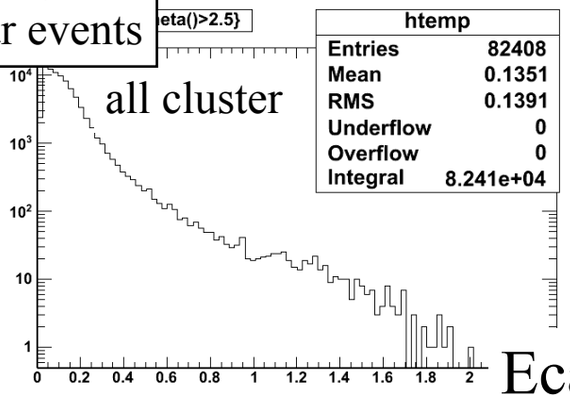
Backward EMC resolution

- Geometry: 8 rings of 48 “crystals”. Not the realistic model, but simple, to avoid new reconstruction algorithm. (was 60 “crystals”).
- Model the resolution using $\frac{\sigma_E}{E} = \frac{14\%}{\sqrt{E(\mathrm{GeV})}} \oplus 1\%$
  - was 3% constant term.

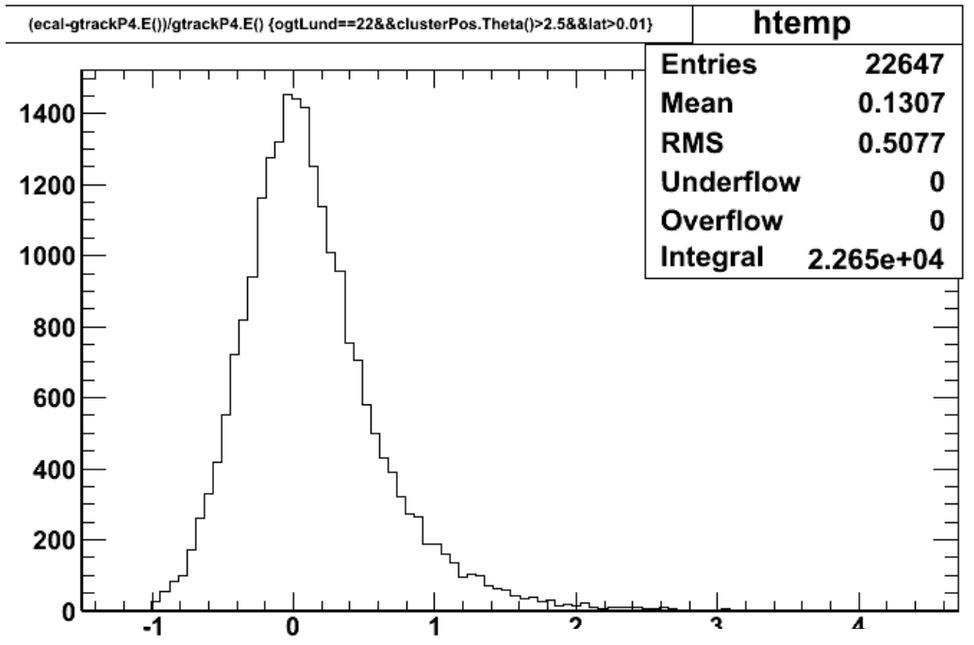


Ecal

from 100,000 B0B0bar events



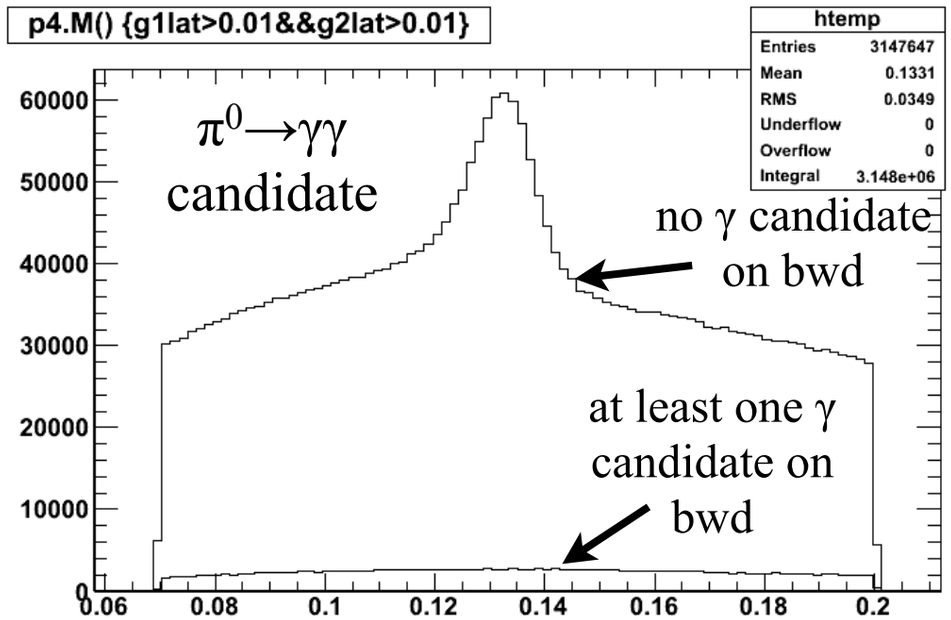
Ecal

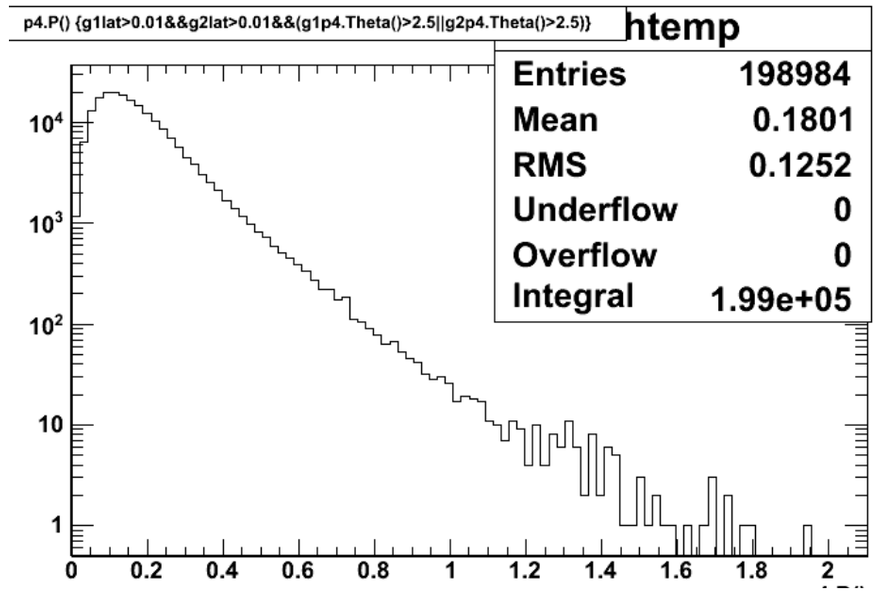


(Ecal-Etrue)/Etrue

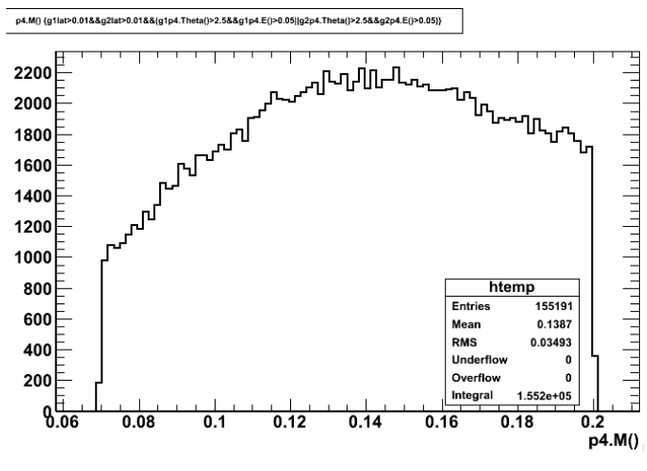
Spectrum is quite soft on the back.
Resolution is a lot worse then barrel/forward.

$\pi^0 \rightarrow \gamma\gamma$ resolution

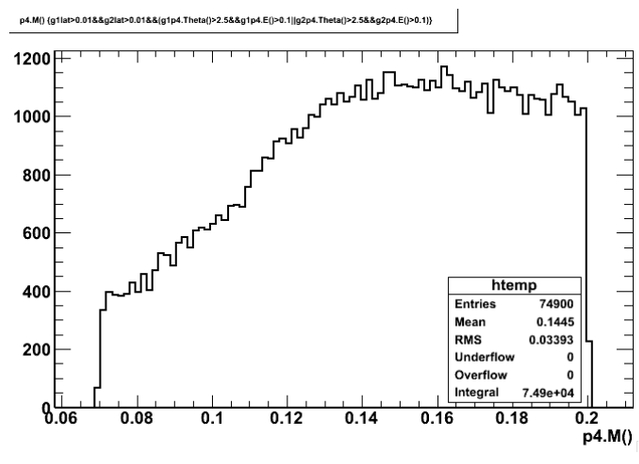




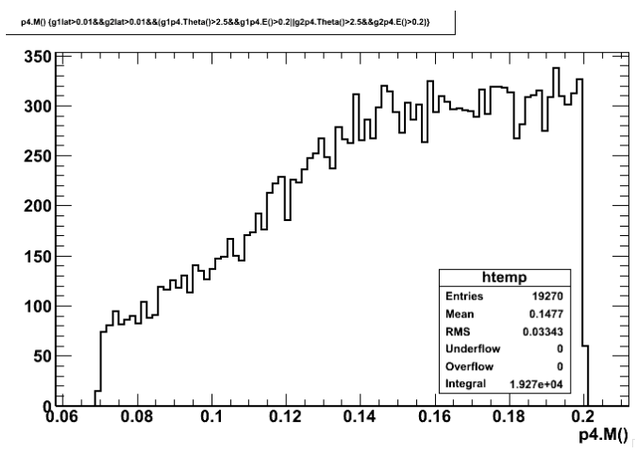
$\pi^0 \rightarrow \gamma\gamma$ candidate momentum with at least one γ candidate on bwd.



bwd Eγ > 50MeV



bwd Eγ > 100MeV



bwd Eγ > 200MeV

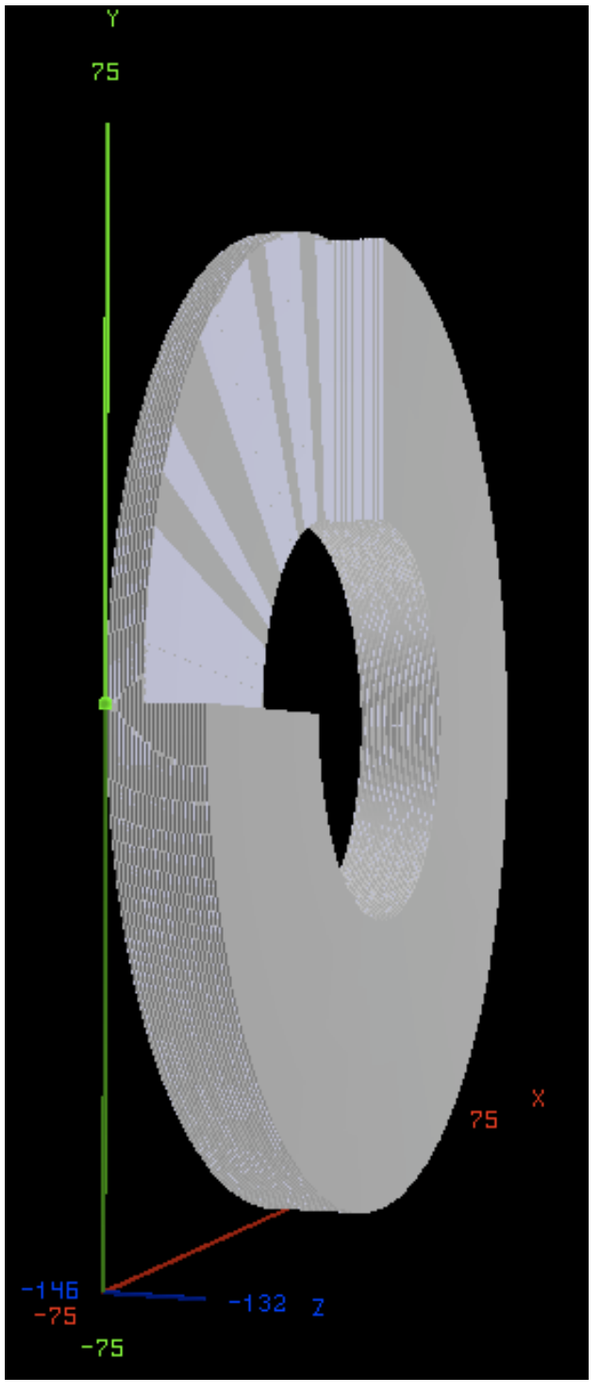
Quite difficult to reconstruct $\pi^0 \rightarrow \gamma\gamma$

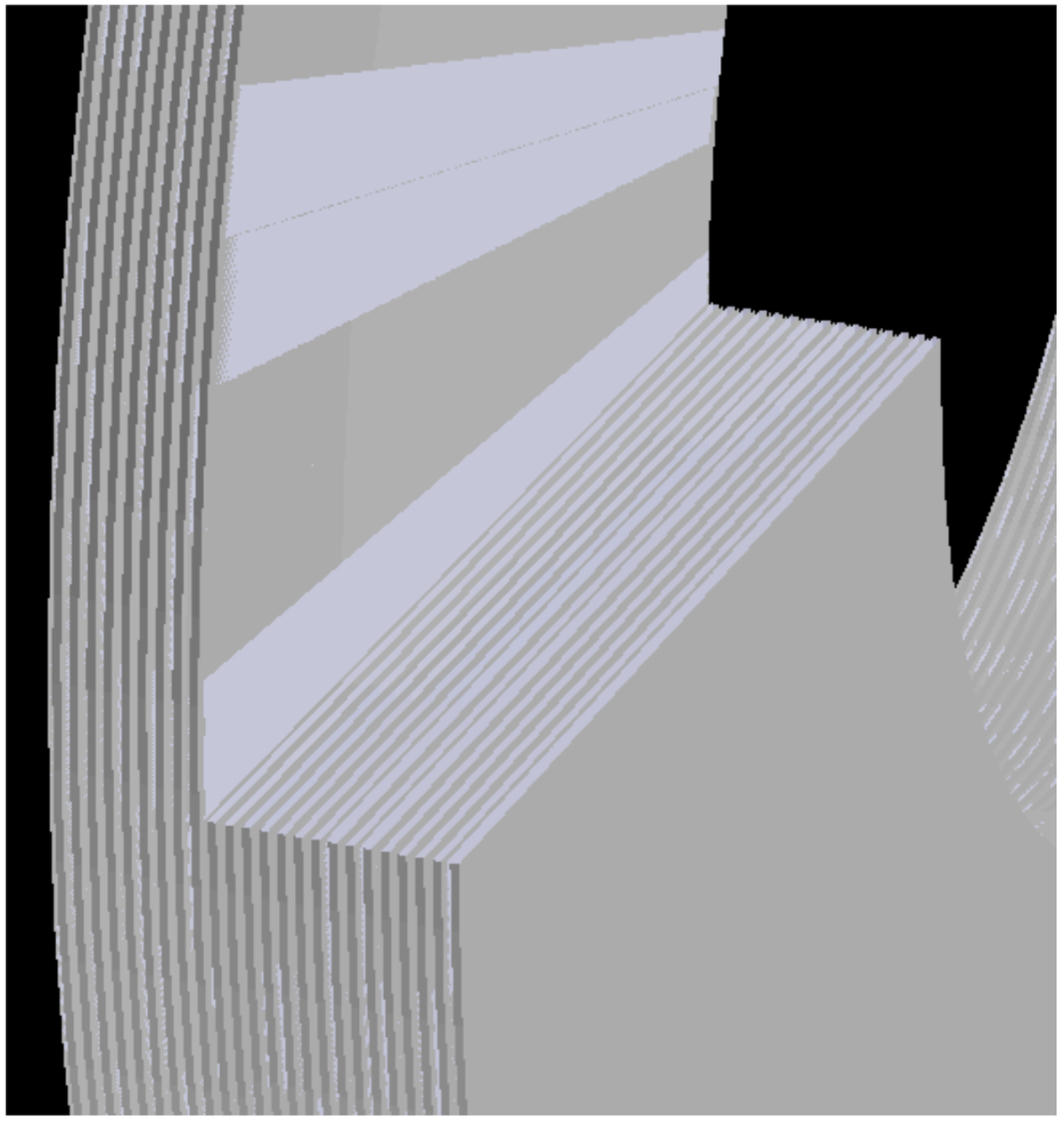
Backward EMC in Full Sim

Geometry

- Twenty-four layers of Pb and plastic scintillator.
- Inner/outer radii: 310 mm / 750 mm
- Center z-coordinator: -1390 mm
- Thickness: Pb: 2.8 mm, Scintillator: 3.0 mm
- Scintillator material: [~polystyrene] d= 1.06 g/cm^3, C:H = 1:1.
- Pb side faces the IP. [probably will change to scintillator, and add one more scintillator layer at the outer most layer]
- No supporting structure.
- No segmentation in individual layer geometry description.
- GDML file: `EMC_backward_PbScint.gdml`, committed to `Bruno`. [Oct. 16]

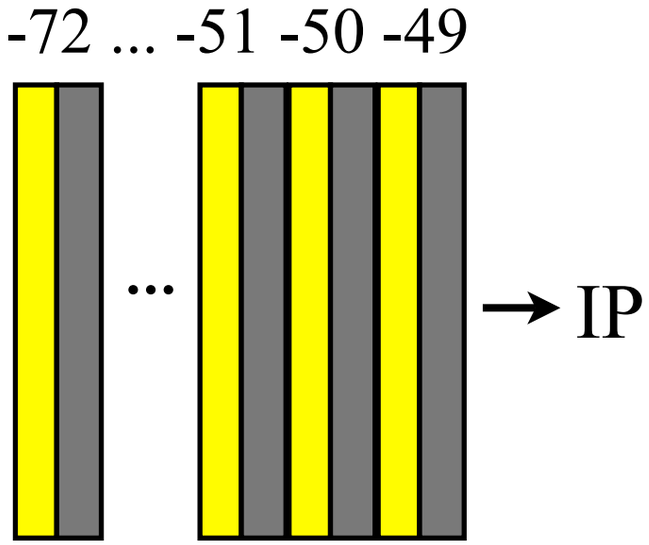
Visualization





Segmentation

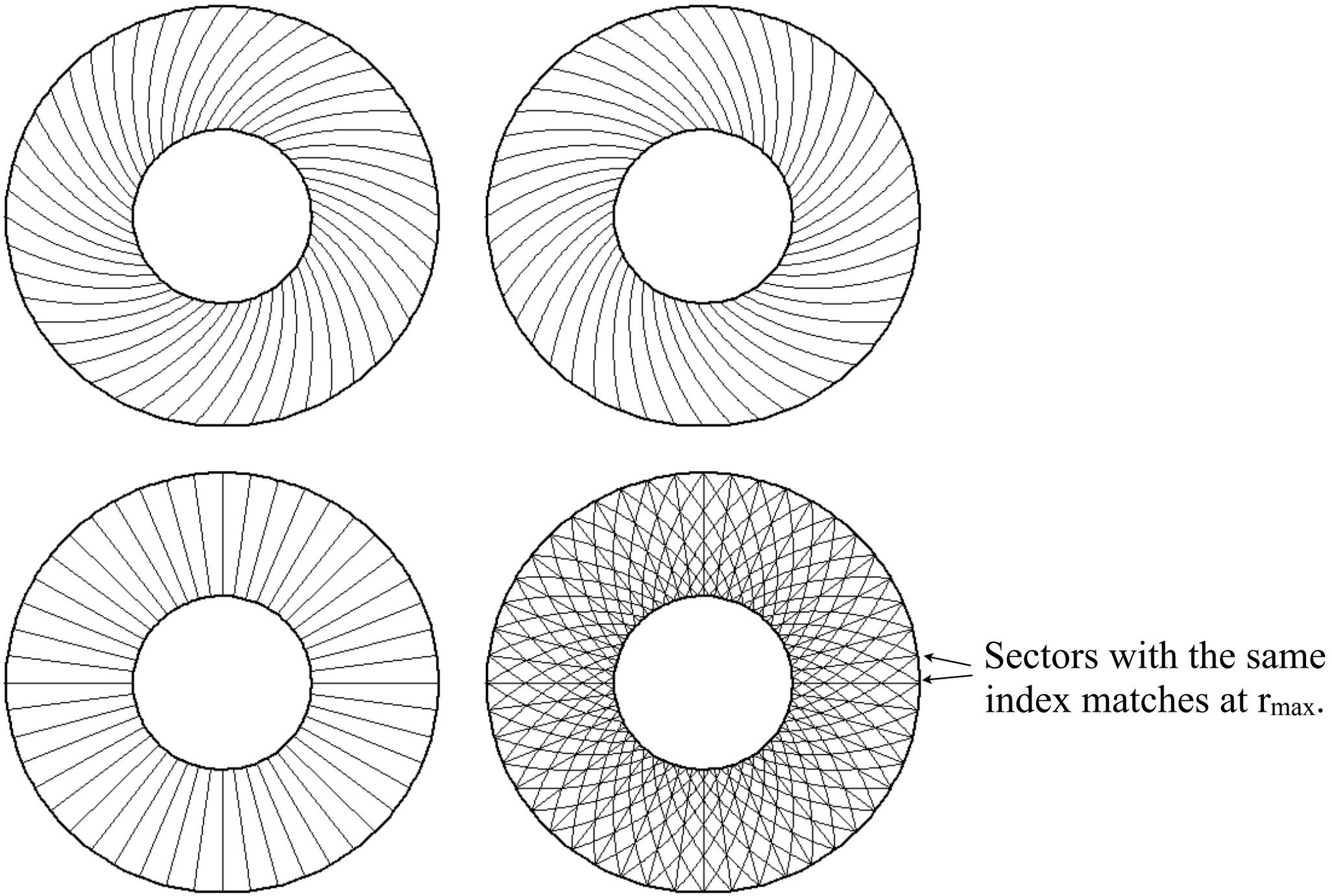
- There is not segmentation in θ. We use θ index (used in barrel and forward endcap to index rings) to index layers, continuing the index for barrel (which ends at -48).
- φ segmentation is done logically. Each layer has 48 sectors. There are three types of segmentation:
  - left-handed spiral (3n+1)
  - right-handed spiral (3n+2)
  - straight sectors (3n+3)



Lower bound of φ for sector j at r.

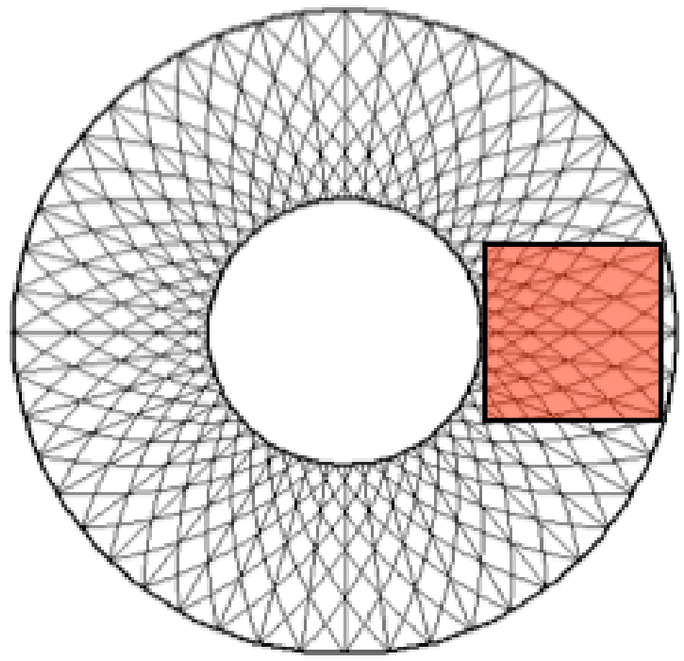
$$\phi_{\text{left}} = -A \cdot \log(r/r_{\max}) + (j-1)\Delta\phi$$
$$\phi_{\text{right}} = +A \cdot \log(r/r_{\max}) + (j-1)\Delta\phi$$
$$\phi_{\text{straight}} = (j-1)\Delta\phi$$

$$\Delta\phi = 2\pi/48 \quad r_{\max} = 750\text{mm}$$
$$A = 34\Delta\phi/\log(r_{\max})$$

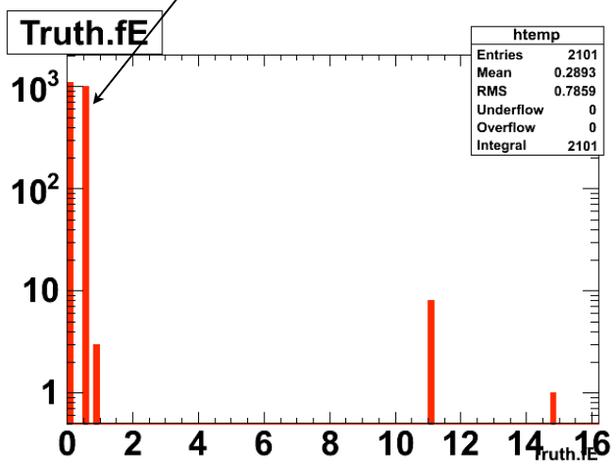

Sectors with the same
index matches at r_{max}.

Test with single gammas

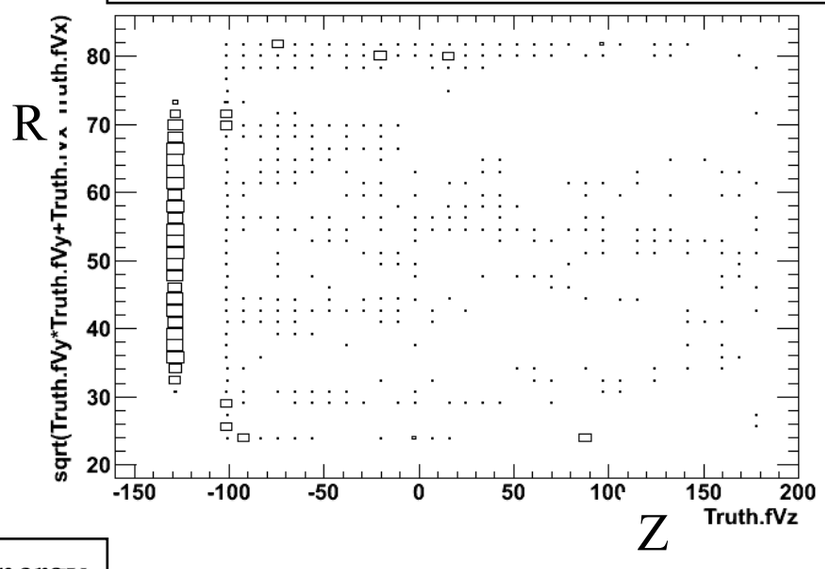
- Shoot single gammas toward the backward EMC along the z-axis. Starting position is right in front of the EMC (z=-132cm), and random in x-y plane within a square [31 < x < 71; -22 < y < 22]. (no material interaction before EMC but the entire SuperB detector is present)

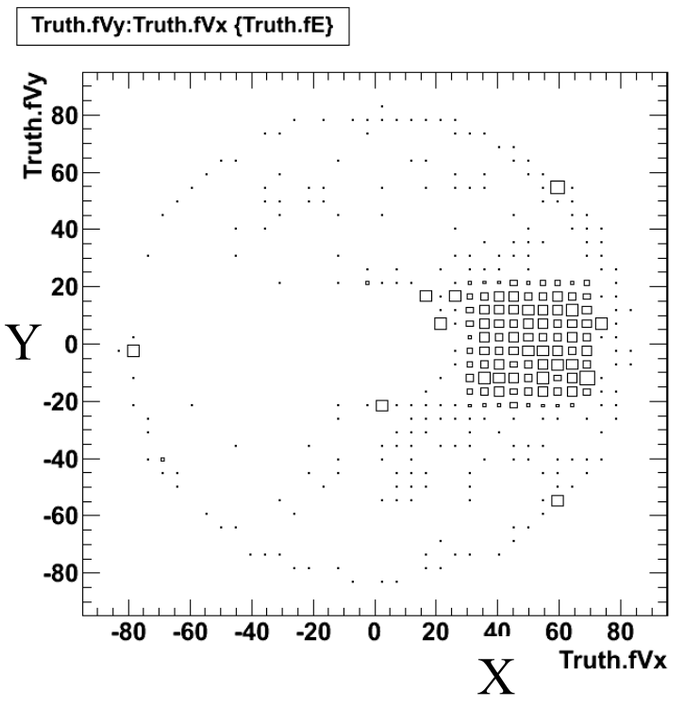


Example: 500 MeV generated



Truth particle position distribution weighted by energy

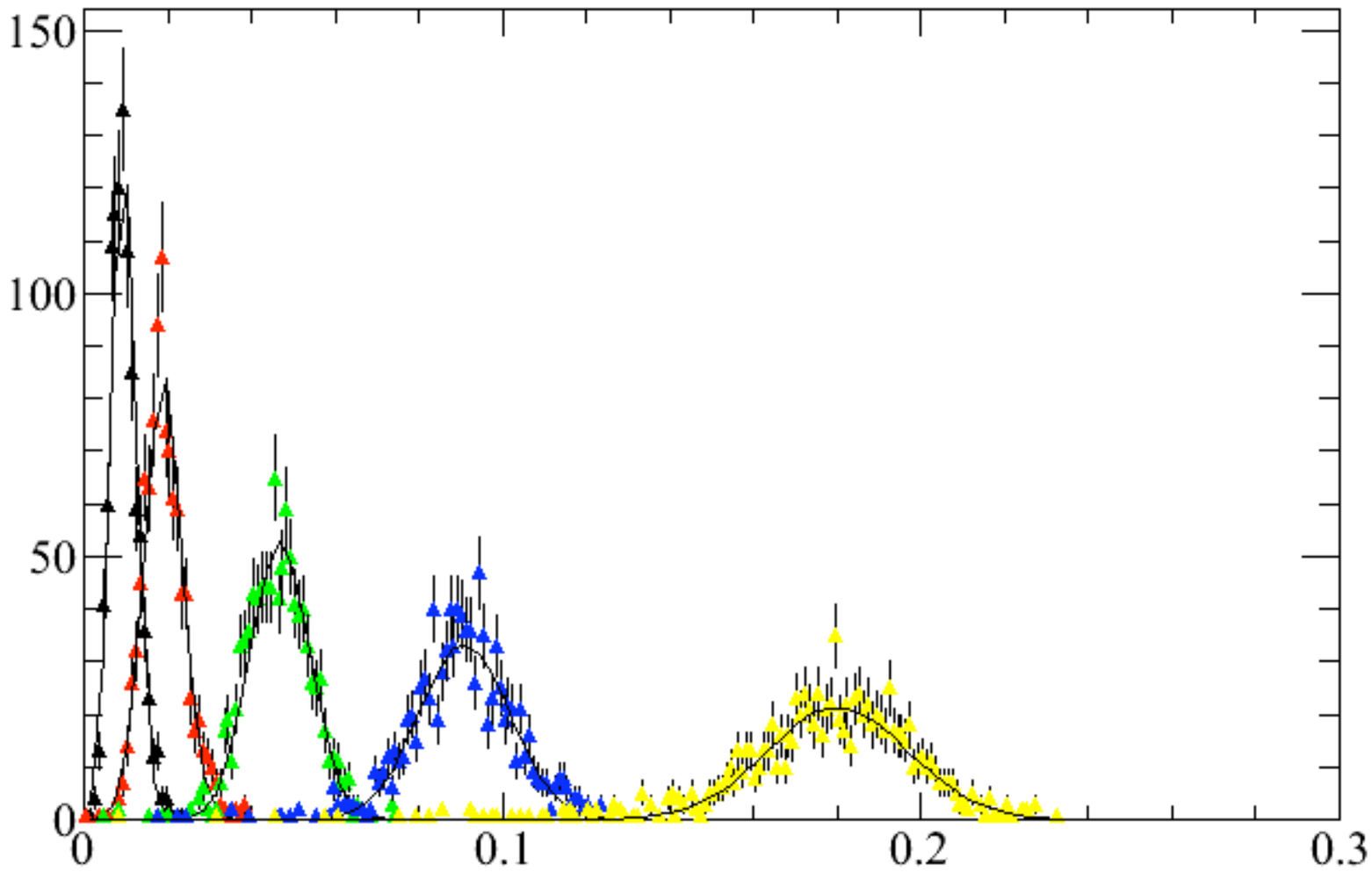




There are some very high energy secondaries, why?

Total energy deposition

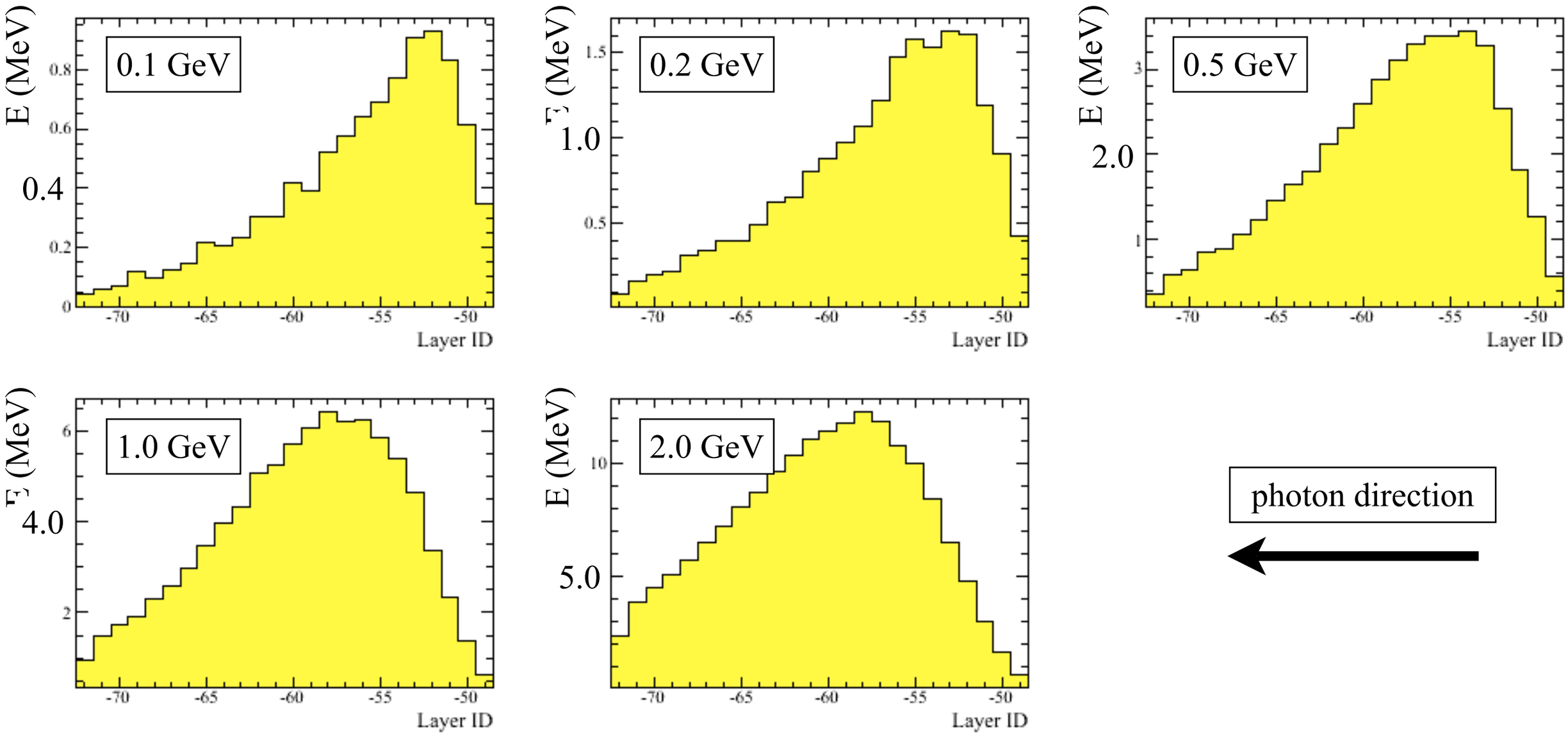
- Generate 0.1, 0.2, 0.5, 1.0, 2.0 GeV photons, 1000 photons in each job. Record all energy deposited in the scintillator.



Gaussian fits seem adequate

Energy by layer

- Average energy deposition in each layer per event.

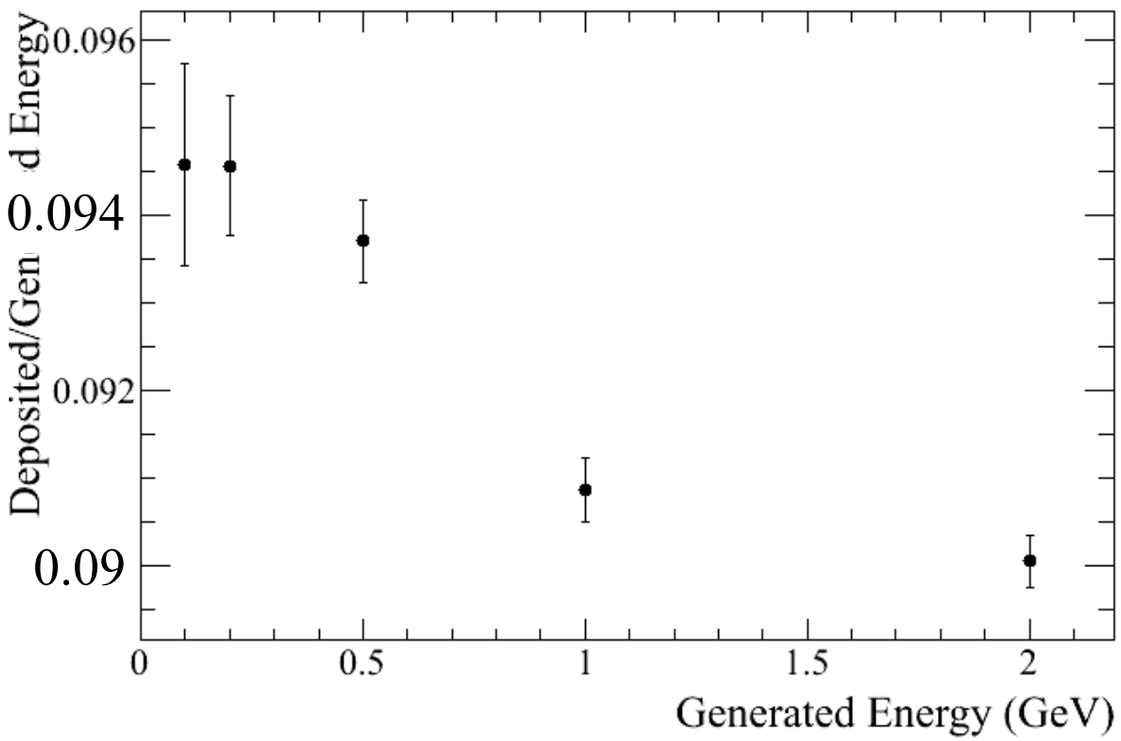


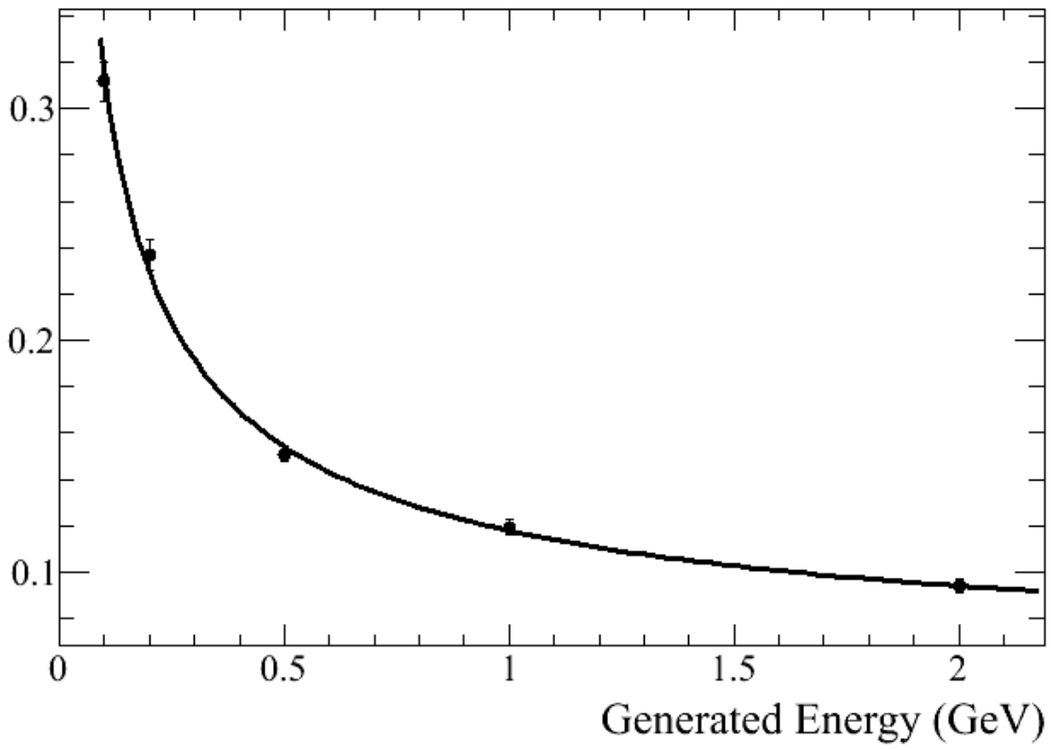
Energy resolution

Gaussian fit width

$$\frac{\sigma_E}{E} = \frac{10\%}{E(\mathrm{GeV})^{0.485}} \oplus 6\%$$

Energy deposition / Generated energy





Compare with what we put in the fast sim: $\frac{\sigma_E}{E} = \frac{14\%}{\sqrt{E(\mathrm{GeV})}} \oplus 1\%$

Summary

- A couple of bug fixes in fastsim.
- Improve neutrals modeling. Extra neutral problem fixed.
- Poor backward EMC energy resolution and soft photon spectrum make it difficult to reconstruct π^0 using the backward EMC.
- Backward EMC G4 model implemented in Bruno.
- First look at Backward EMC full sim result. It look reasonable.
- Have not considered clustering effect yet.