EMC FastSim update

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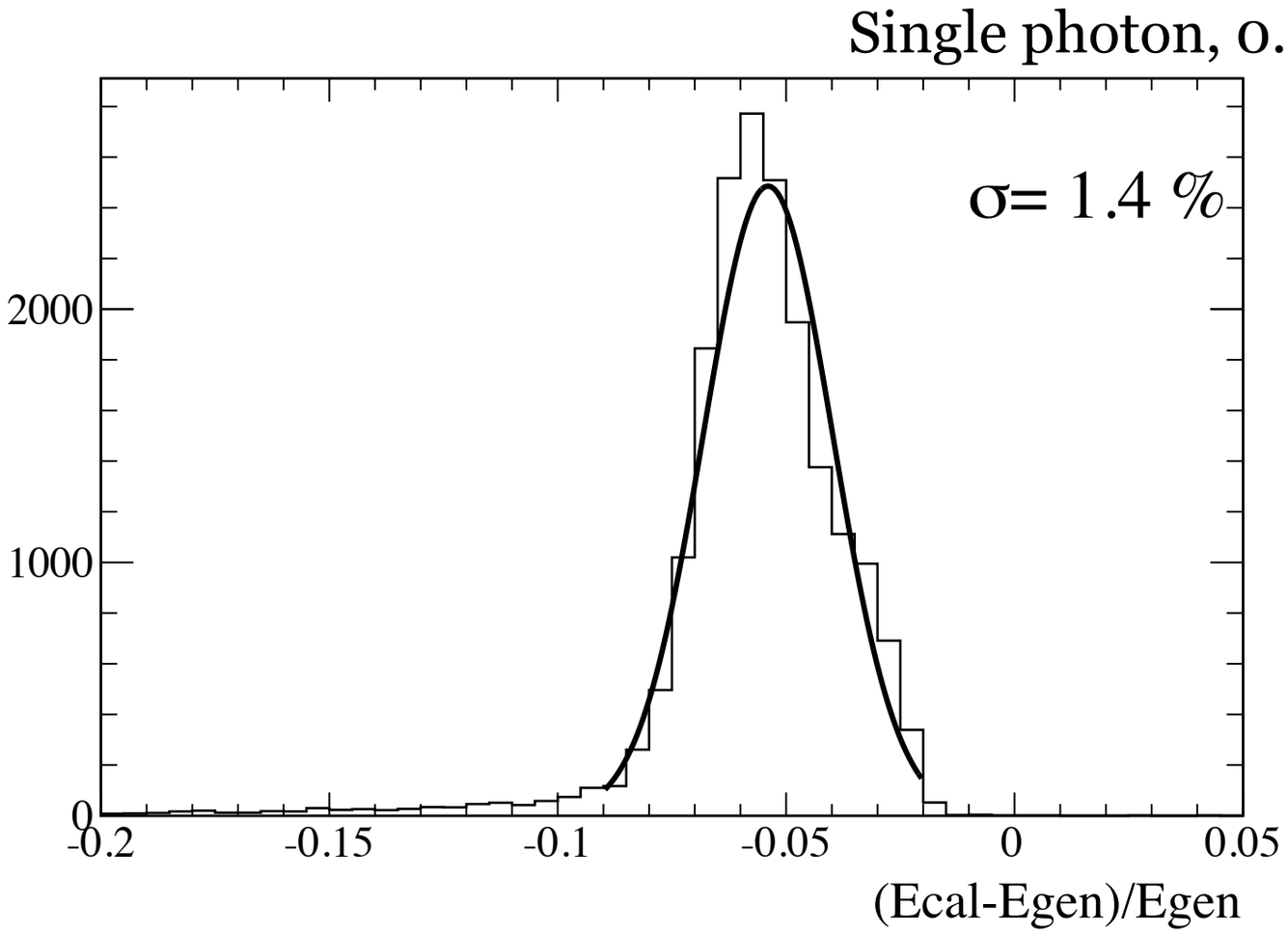
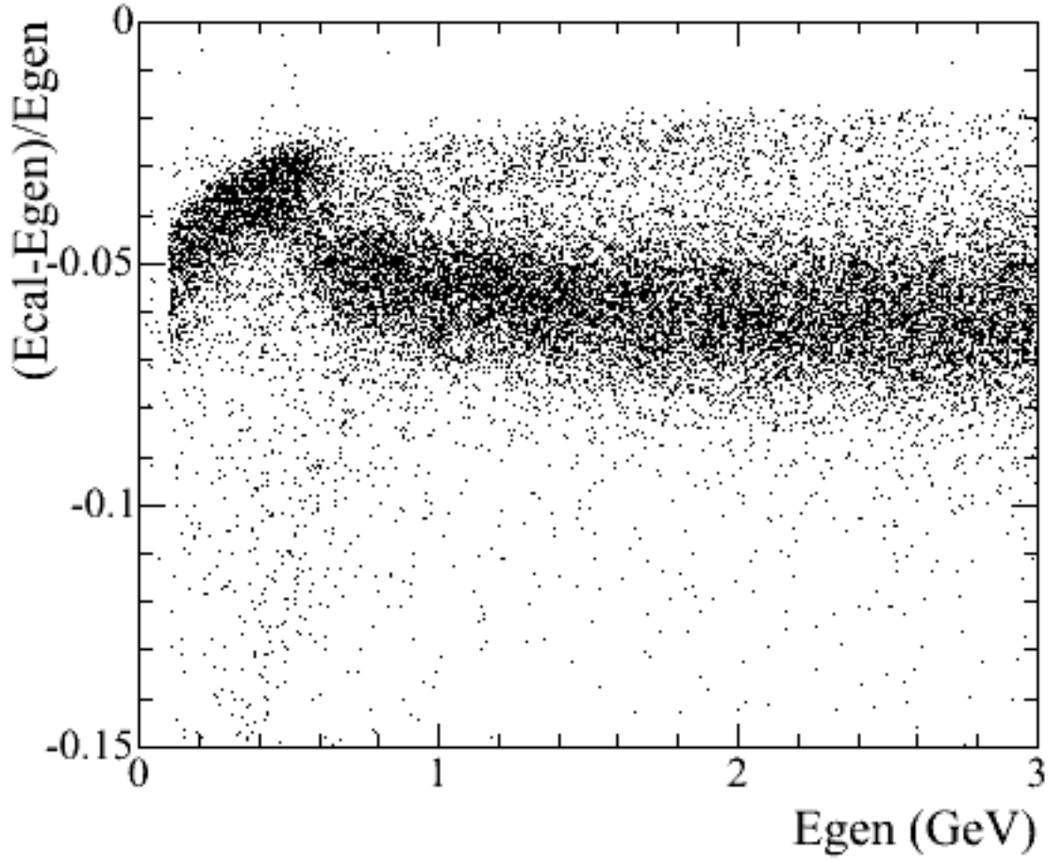
“Intrinsic” energy resolution

- Before we apply energy smearing with a resolution function, there are already fluctuations in shower energy deposition.
  - ✦ Shower leaks at the back
  - ✦ Randomized shower starting point
  - ✦ Polar angle dependence in EMC radiation lengths
  - ✦ Gaps between crystals
  - ✦ Approximation in projecting crystal front surface geometry to a grid when calculating energy fraction in each one.
  - ✦ etc.
- This makes modeling resolution function more difficult. Smearing function is not the same as measured resolution.

“Intrinsic” energy resolution

- V0.3.2 out-of-the-box

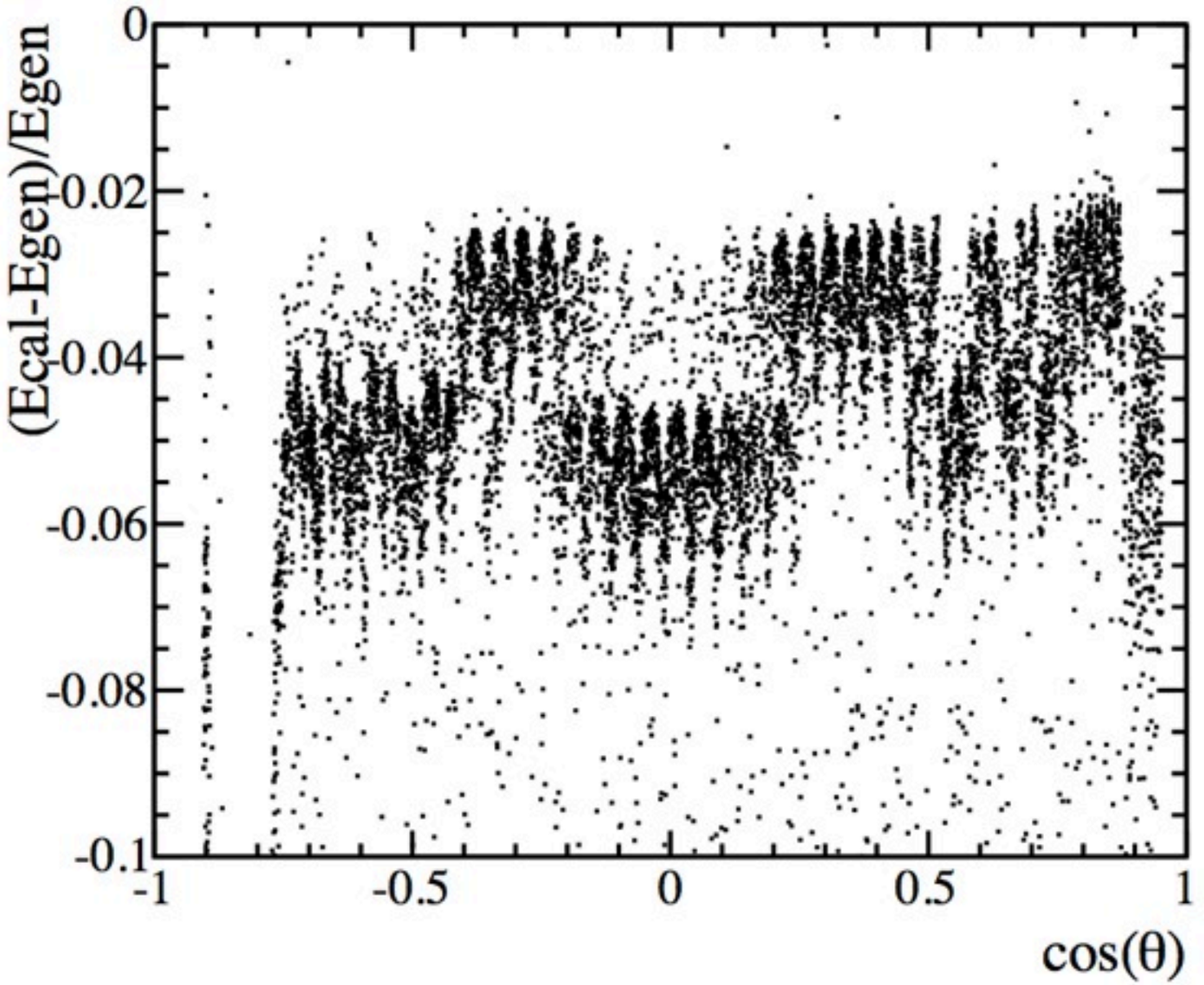


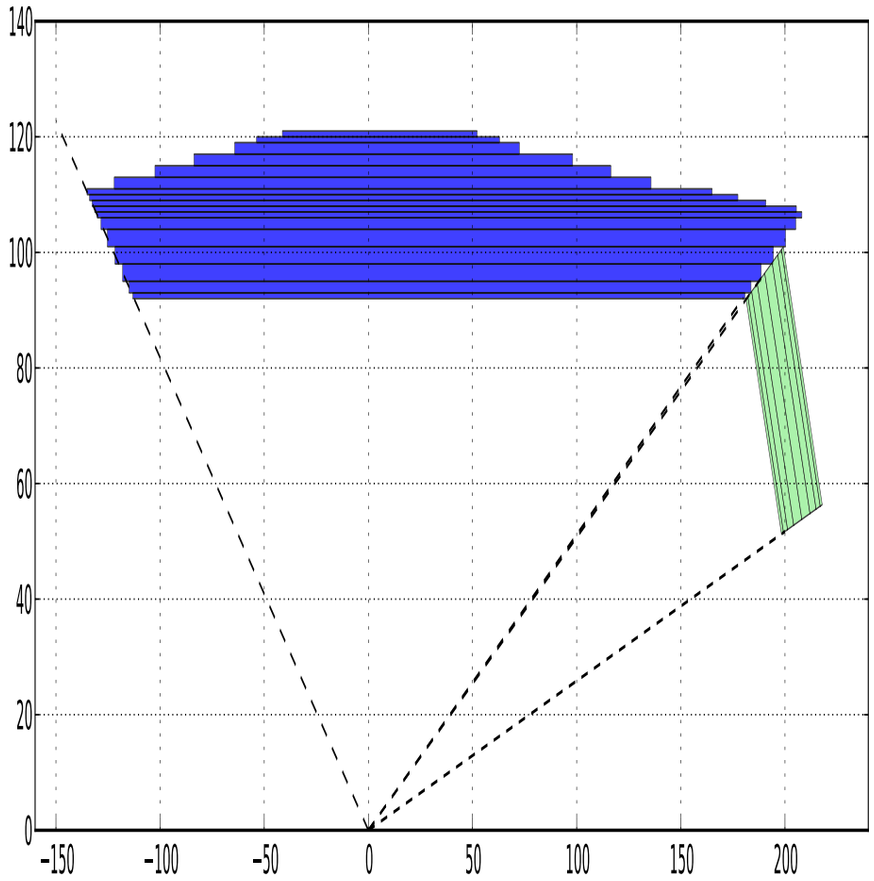


- Significant fraction of real energy resolution.
- Strange transition of mean values around 600 MeV.
  - ✦ also makes energy calibration difficult.

Polar angle dependence

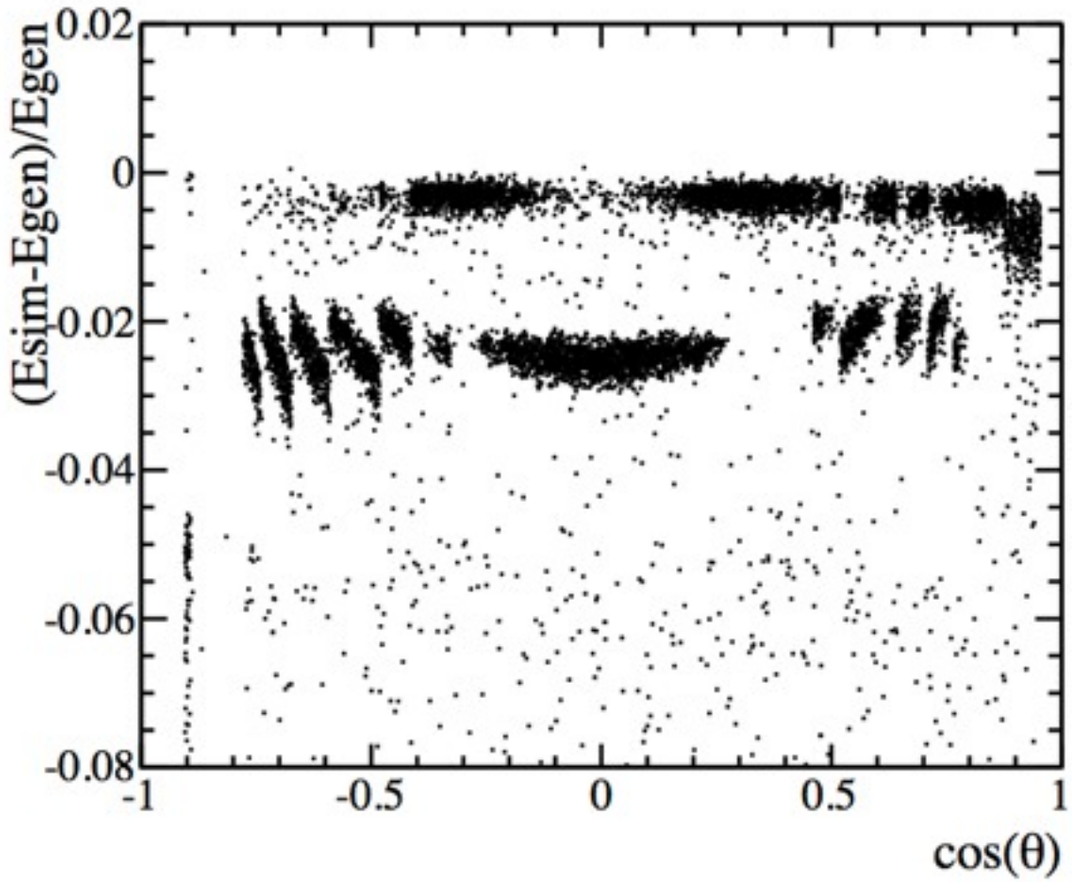
- In the transition region, the resolution shows double peaks, very sensitive to total radiation length.

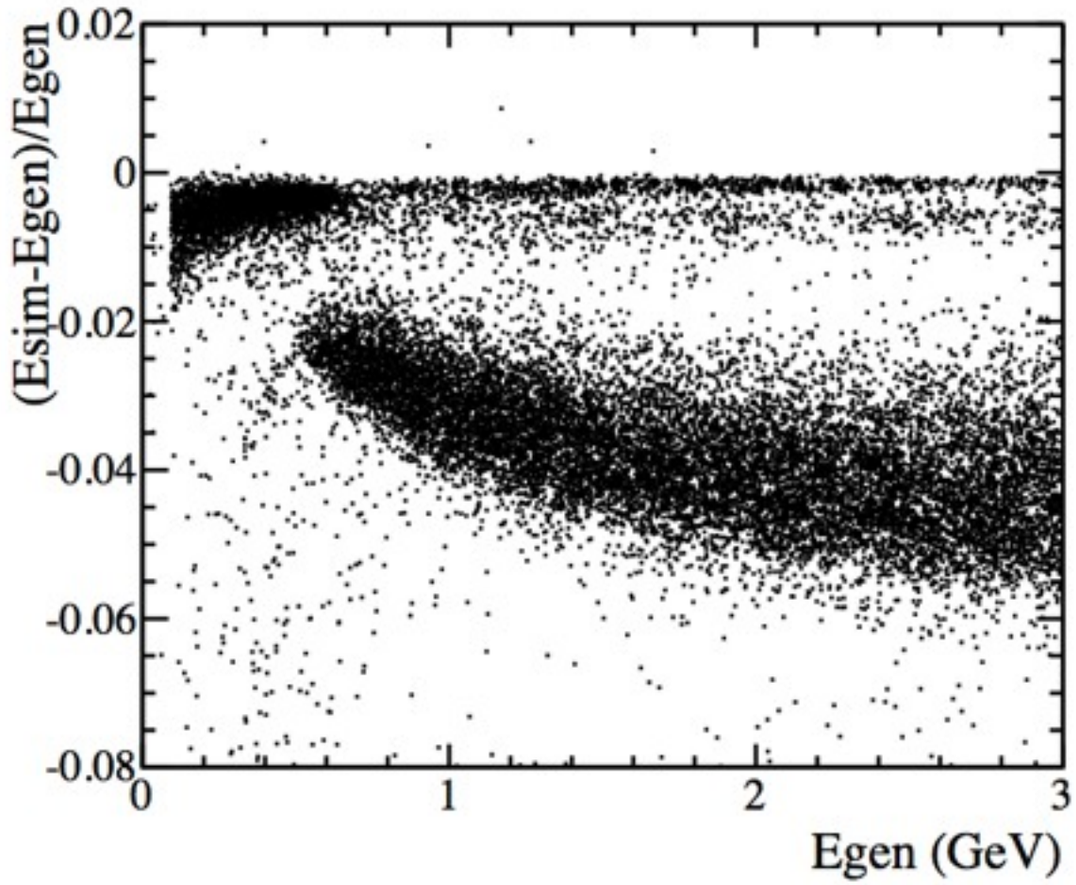




Remove reconstruction effects

- (most of them anyway)
- Collect all energy deposition by SimTrack for a given cluster.

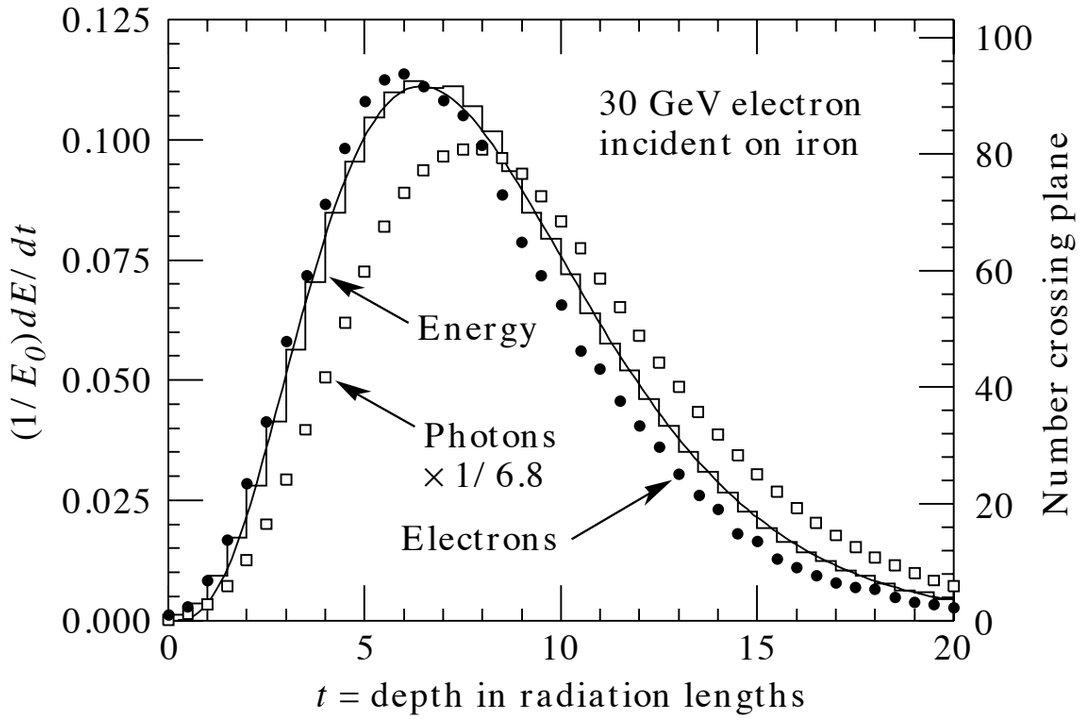




Explanation

- We use a gamma distribution to model shower. Energy in a layer is a slice of the integral.
- When remaining energy falls below a critical energy E_c, all remaining energy is deposited.
- For a low energy photon, when it reaches the last layer, the remaining energy is small (< E_c) so ~100% energy is deposited.
- For a high energy photon, at the last layer, the energy is still high, so only a slice of the tail is deposited; a few % loss.
- In between energy (~600 MeV), both happen, sensitive to radiation length.

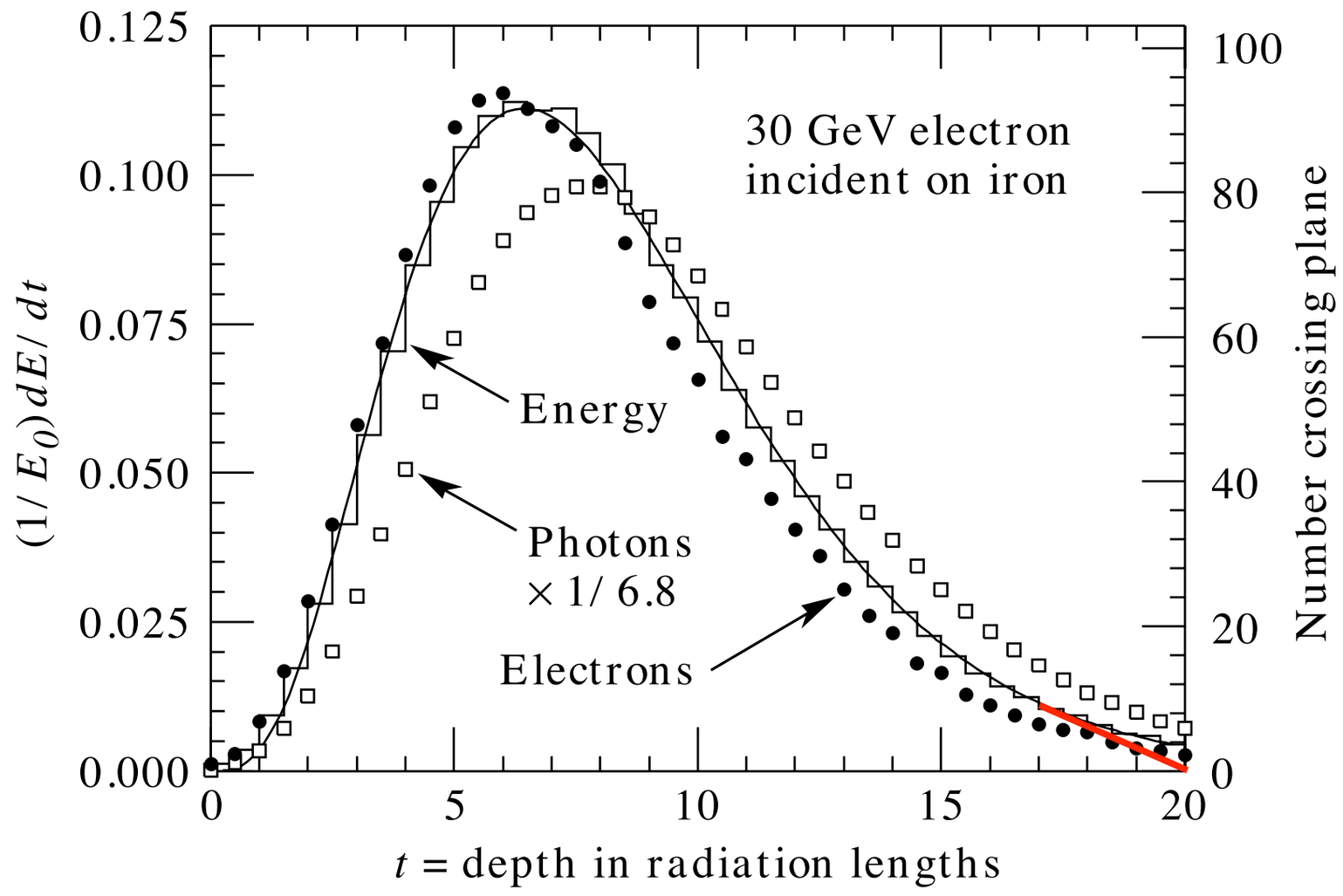
$$\frac{dE}{dt} = E_0\, b\, \frac{(bt)^{a-1} e^{-bt}}{\Gamma(a)}$$



Ec = 0.8/(1.2+mat->zeff())

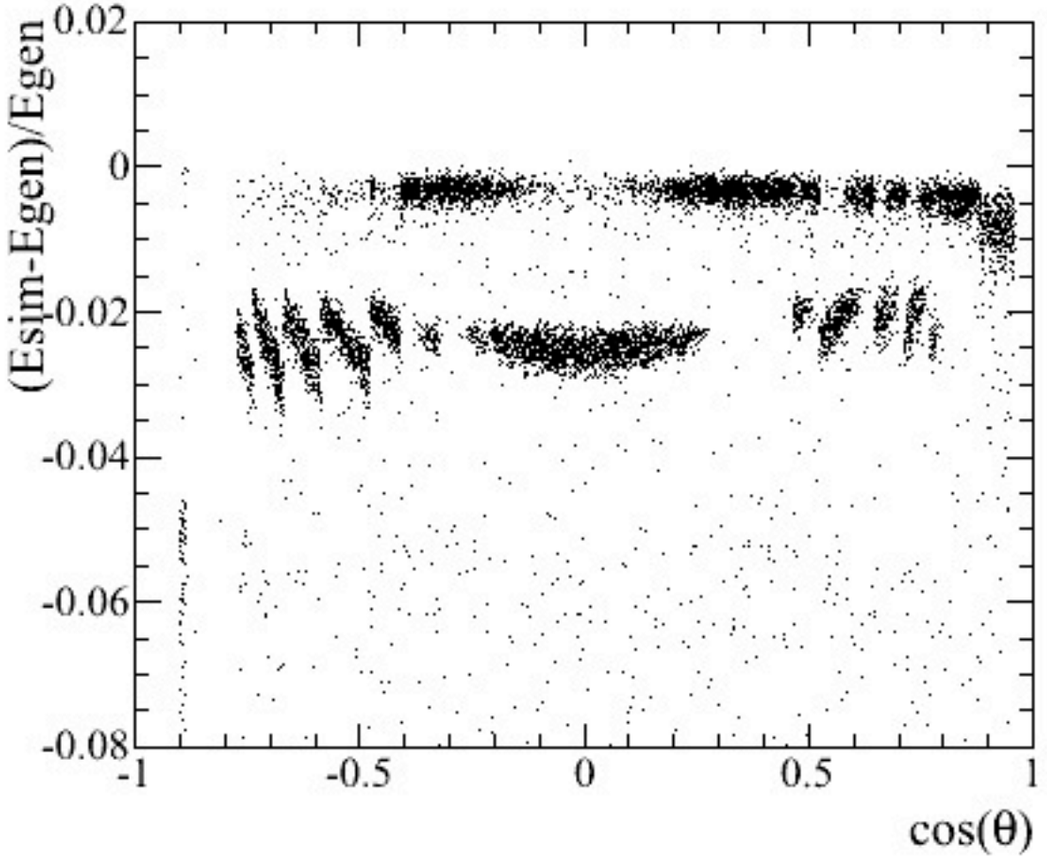
Fix

- Modify the function after 17 X_0, so that it linearly goes to zero at 20 X_0. Don't dump the remaining energy if it is less than E_c.

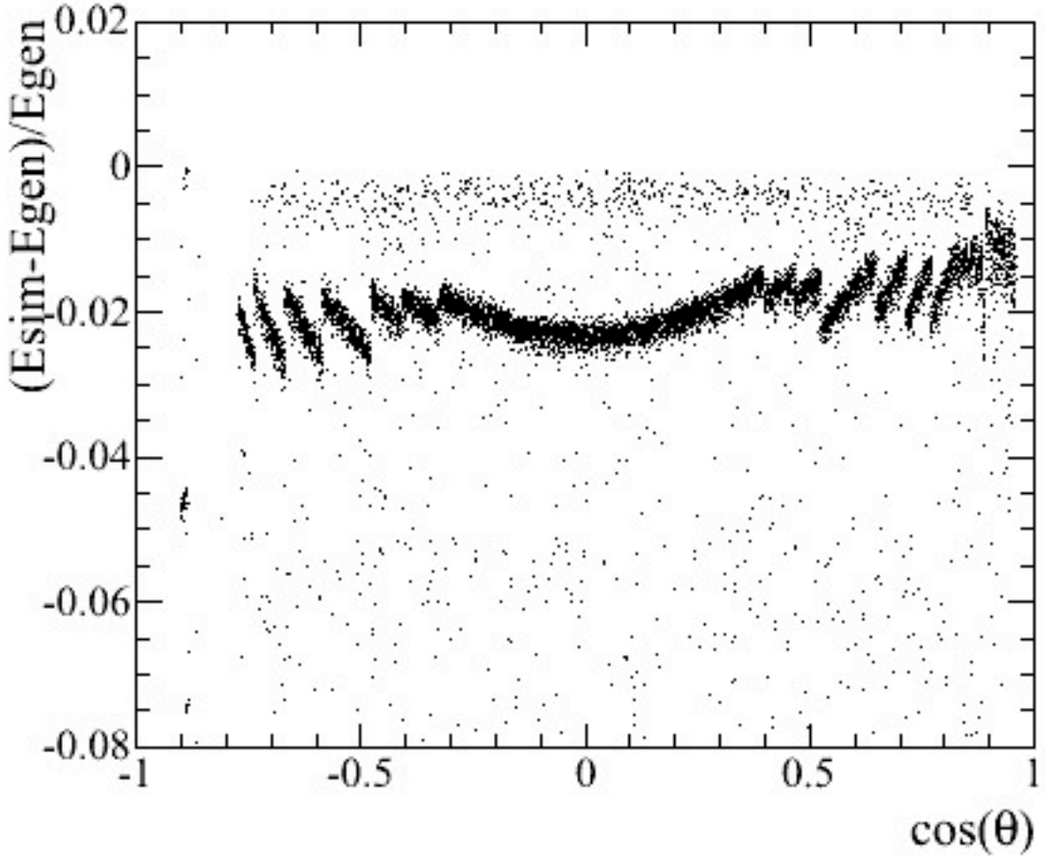


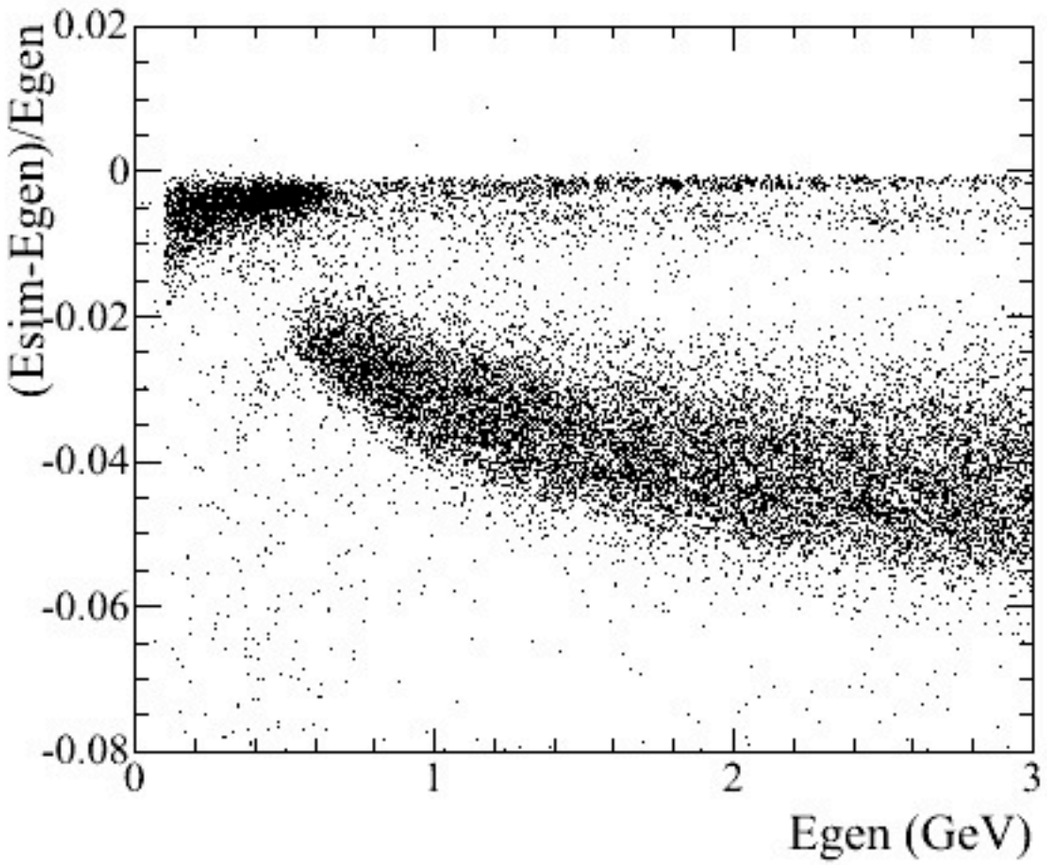
Sim energy, absence of most reconstruction effects

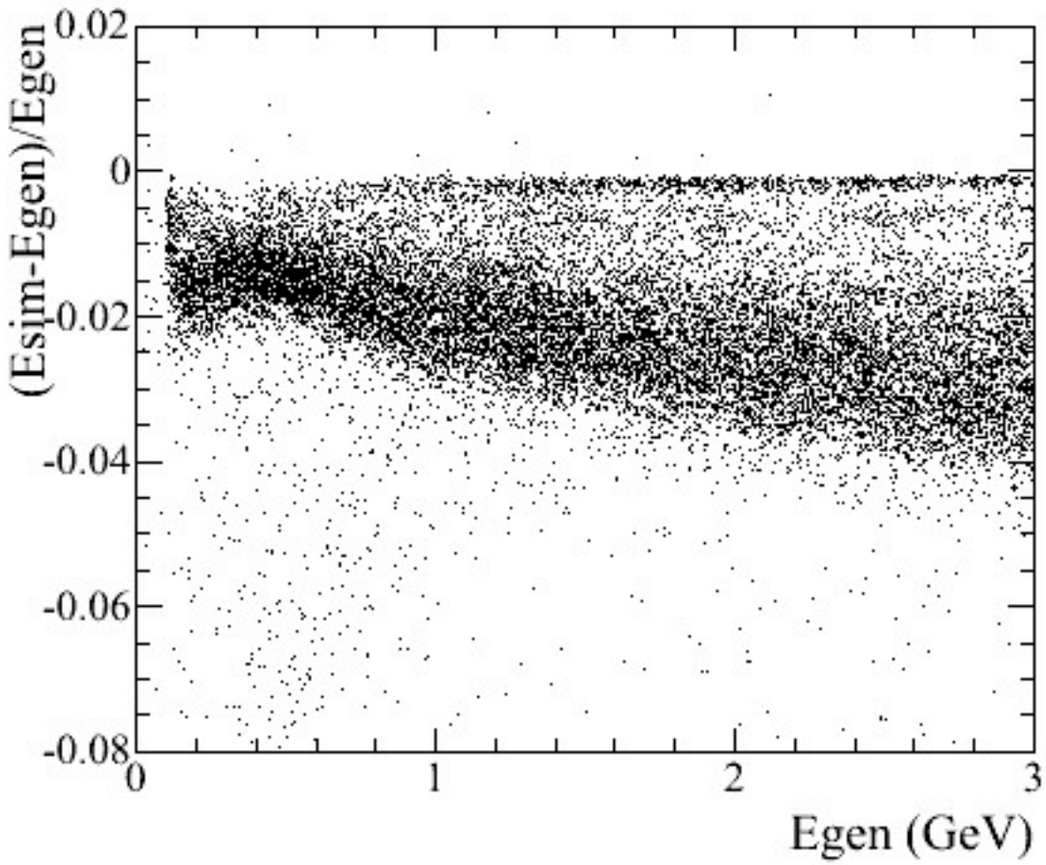
Before



After

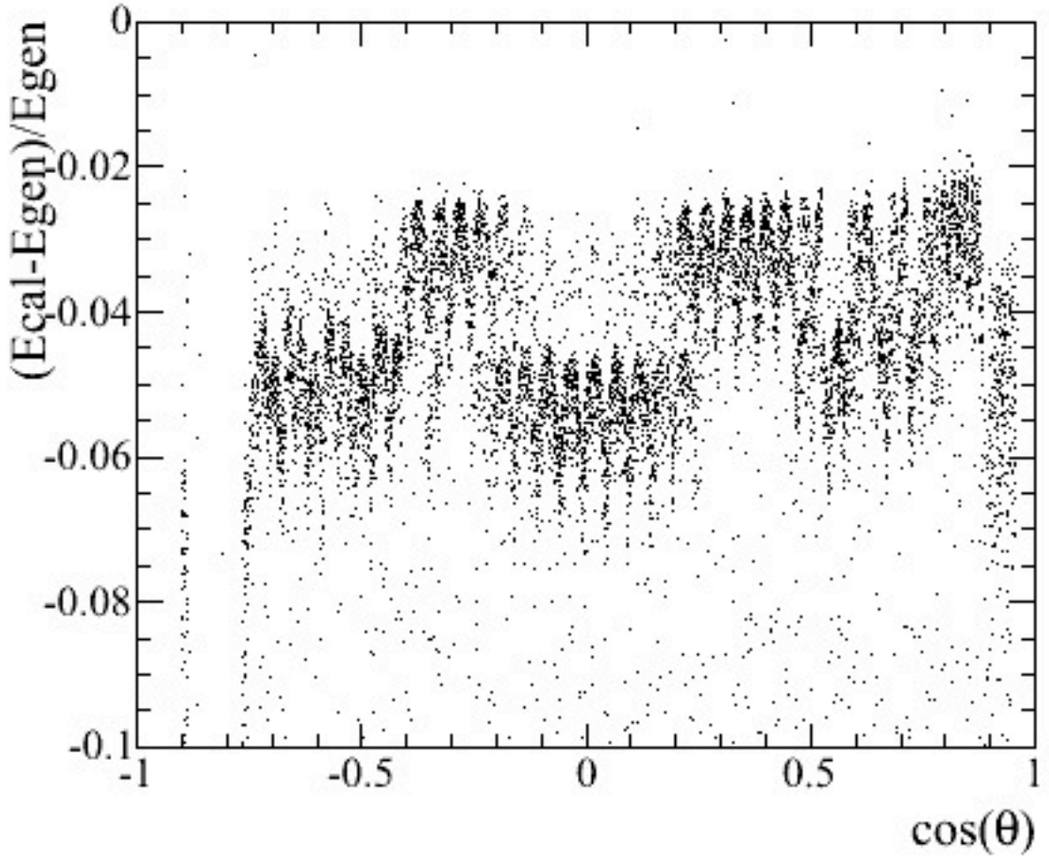


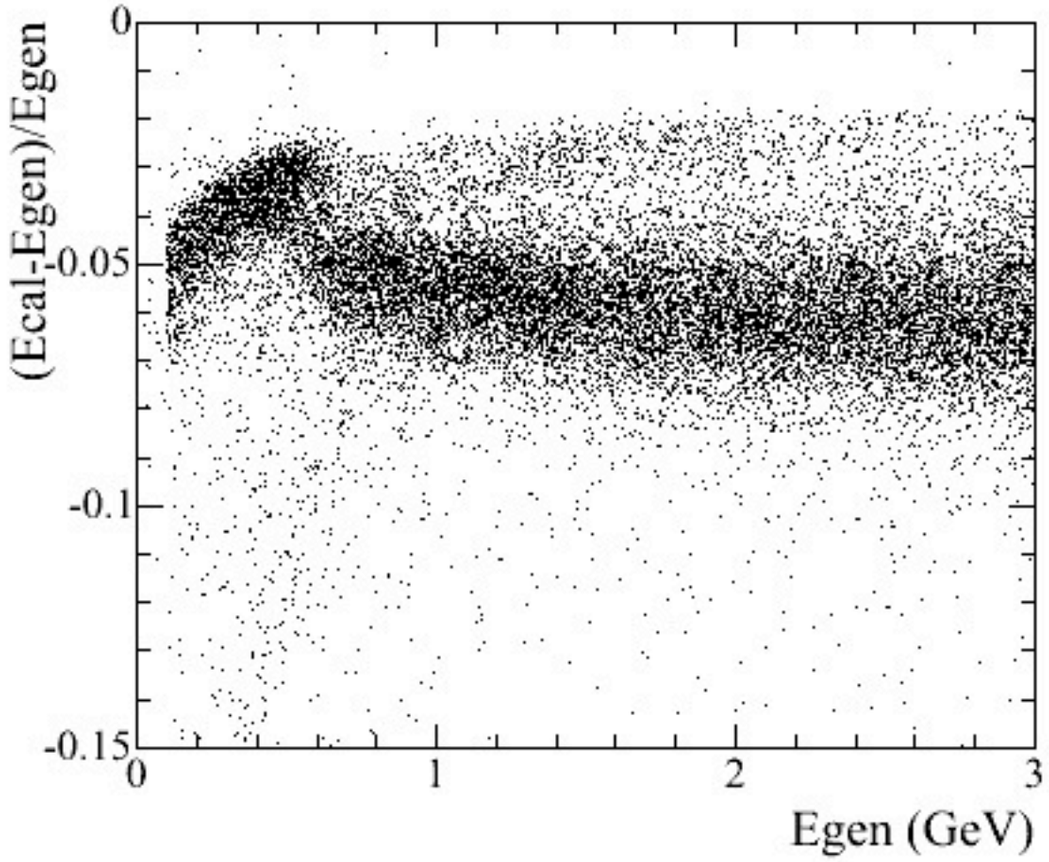




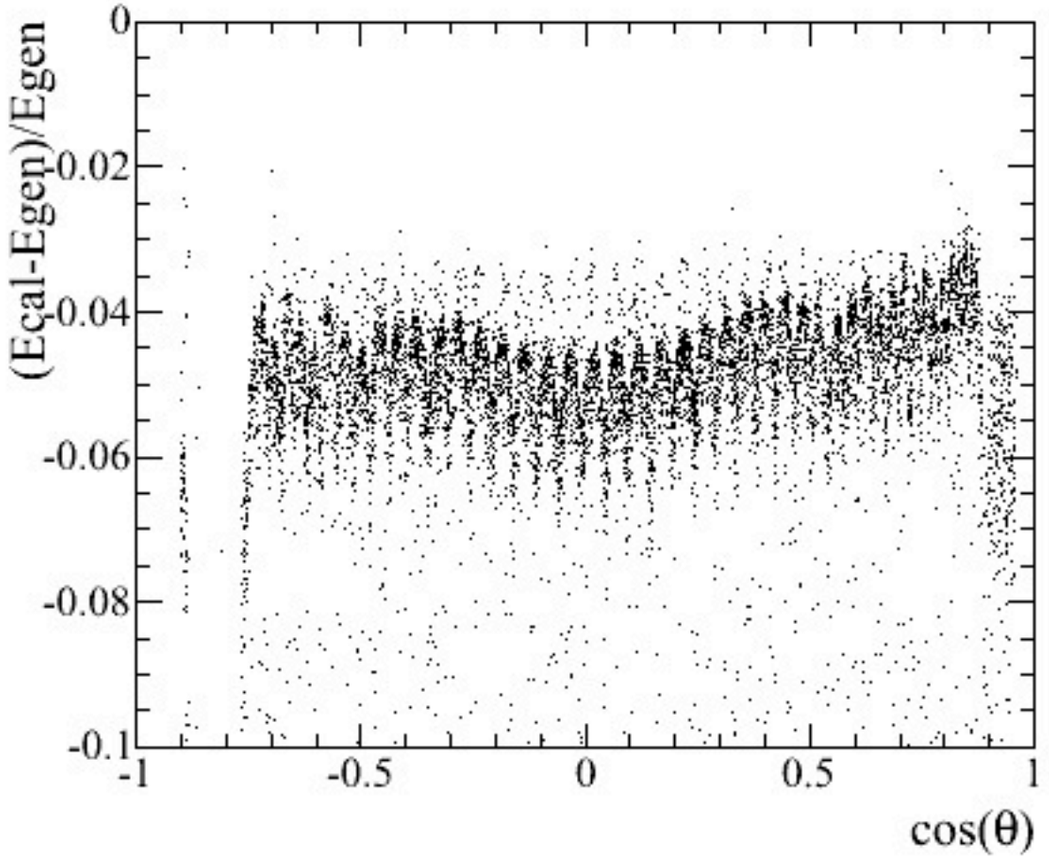
Reconstructed energy but without smearing

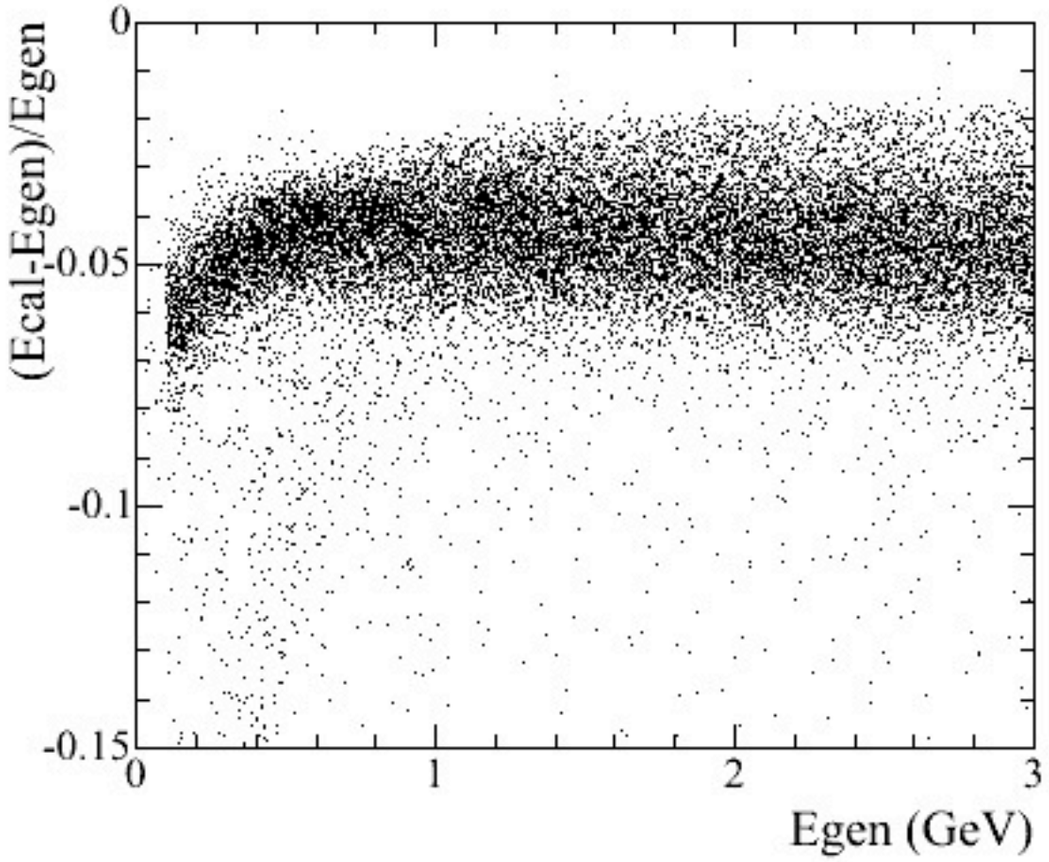
Before



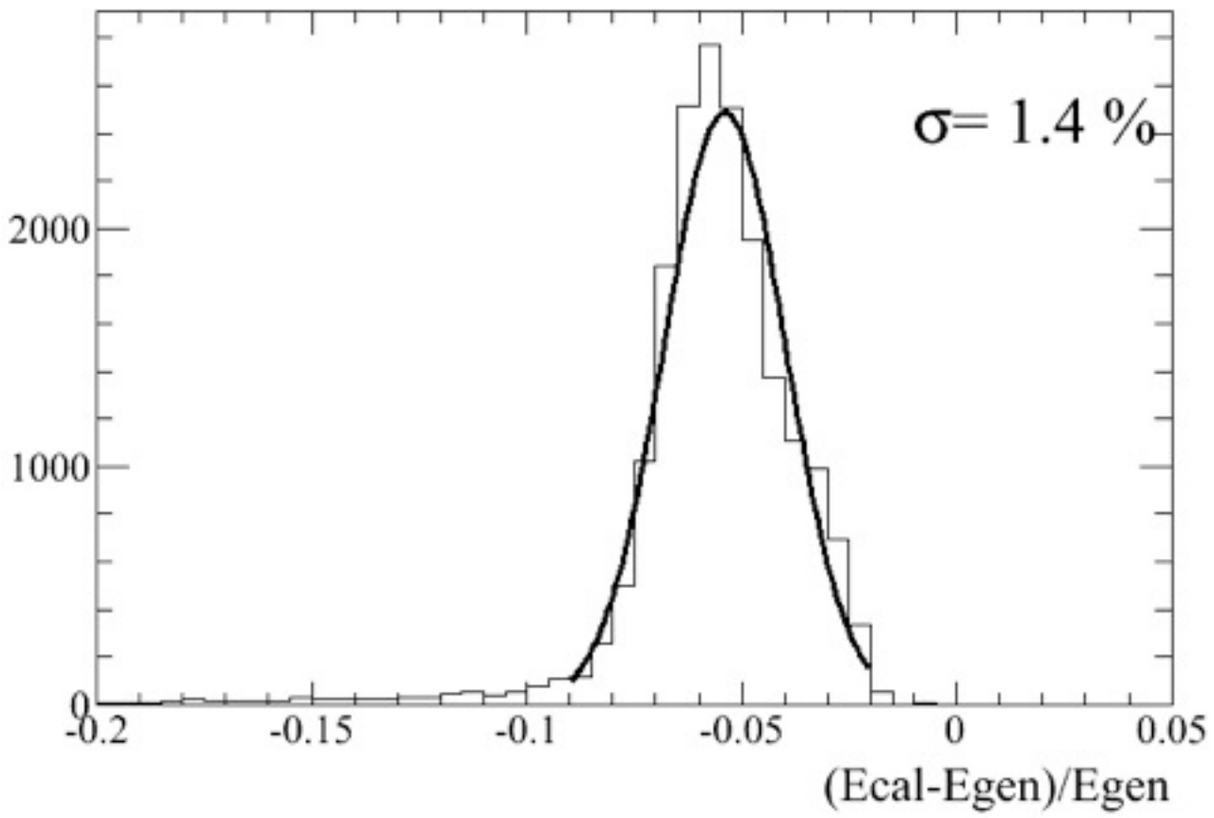


After

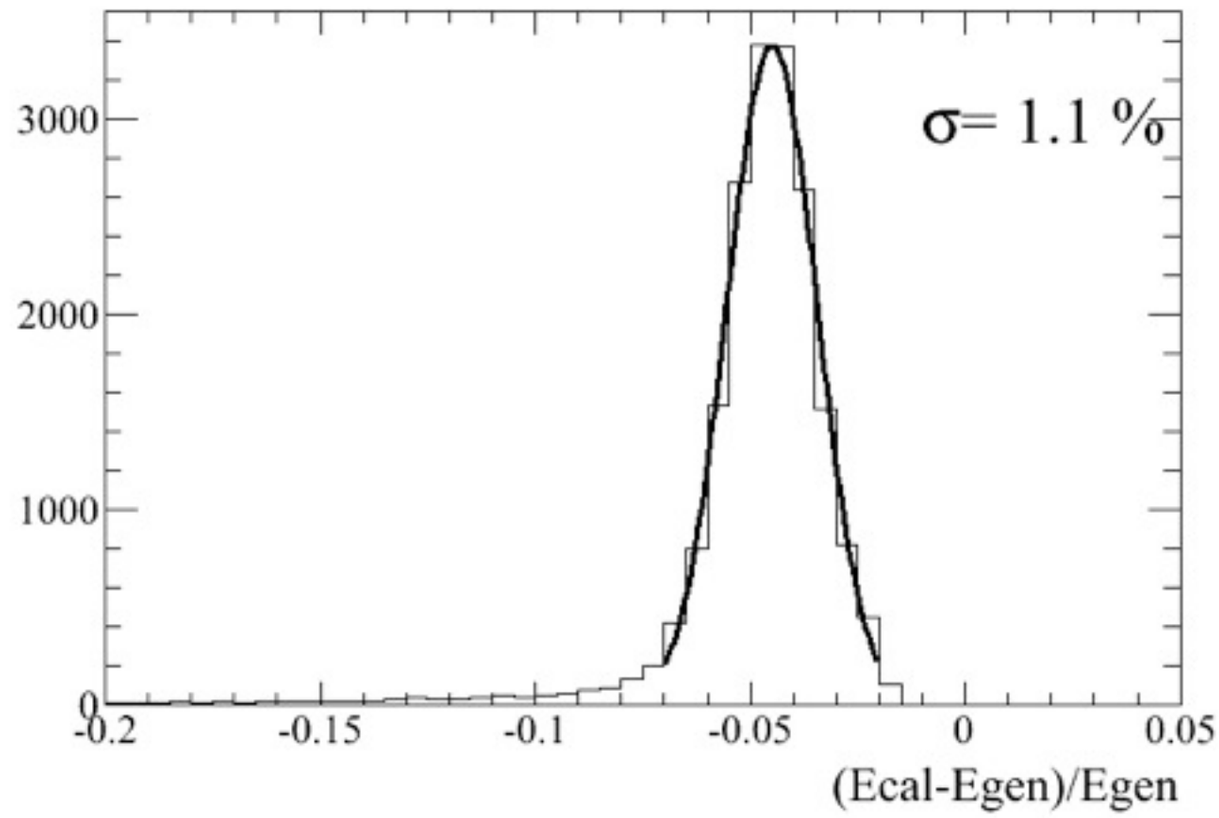




Before



After



Single photon, 0.1–3.0 GeV

Summary

- Fixed an ugly feature in EM shower longitudinal profile.
- The “intrinsic” energy resolution is improved.
  - ✦ cannot be completely eliminated due to the complex nature of FastSim.
- ~1% is still significant especially for high energy photons, but it should be easier to model or correct the resolution if we want to better reproduce the resolution function we put in.