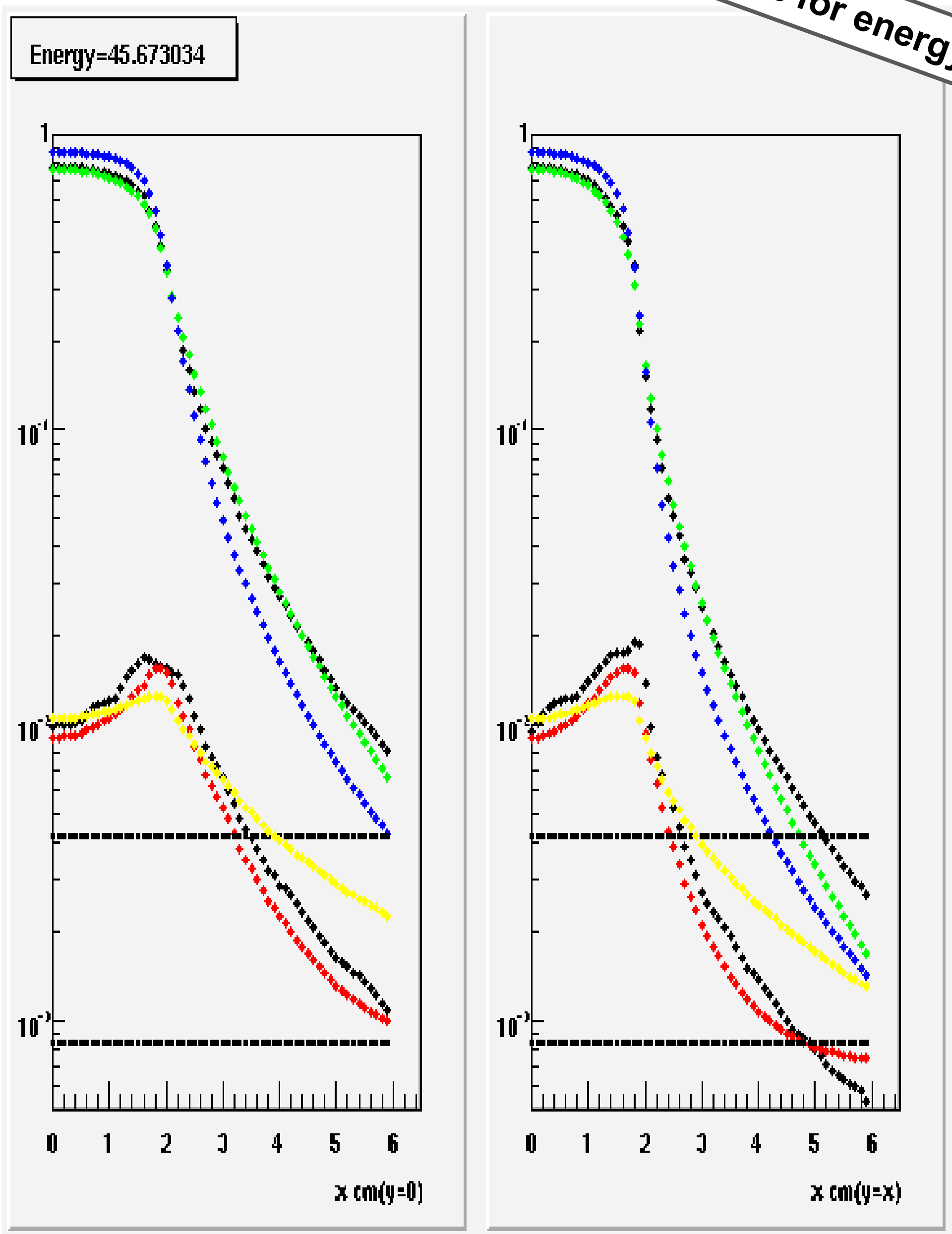
<u>Optical Photons in Geant 4</u>

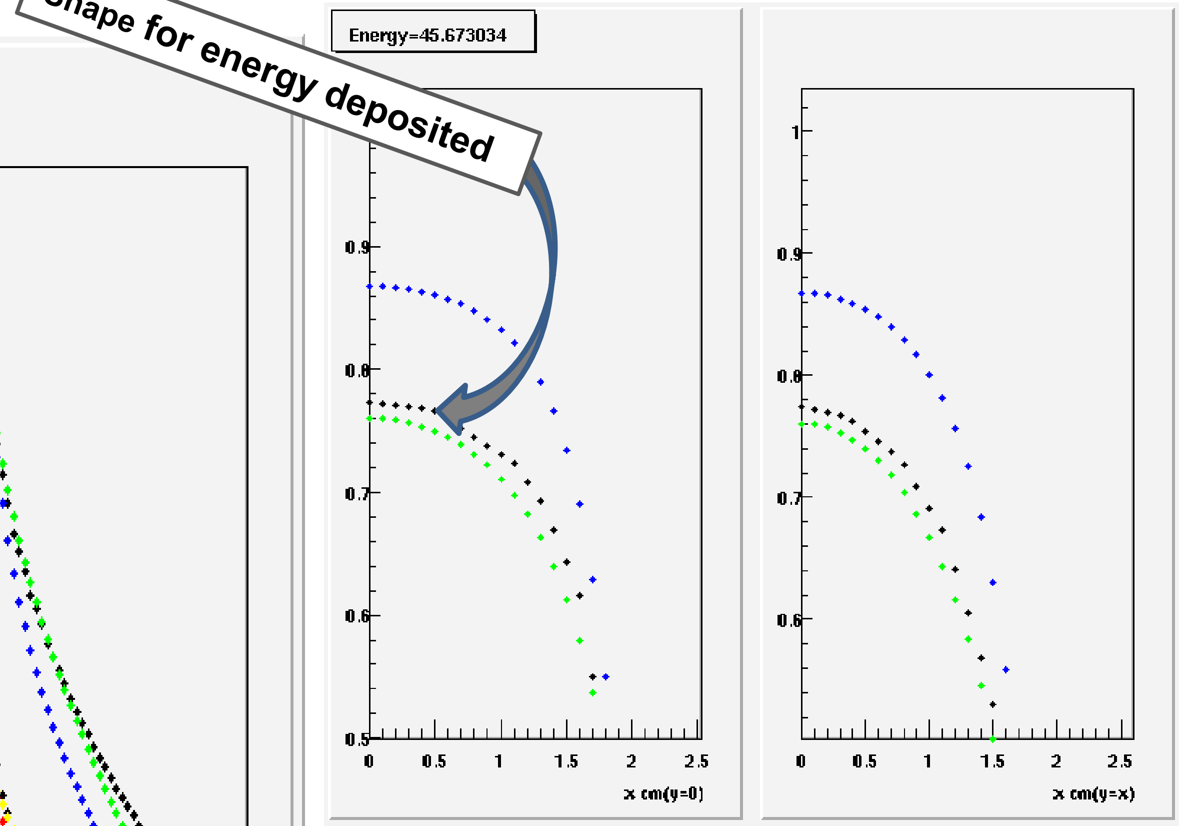
It is possible to turn on production of Cerenkov optical photons and track them.

1. In Geant 4, tracking has an implicit low energy cutoff that is input not as an **energy cutoff** but as **a maximum step size**. The idea is that soft processes are included as “deposited energy” when the produced tracks would not be expected to survive a certain distance. **We are currently running with the cutoff set at 1cm.**
2. Under these conditions, **(cutoff set at 1cm.),** a 50 GeV photon directed toward the center of a cell produces about 57,000 trajectories (e+, e-, gamma) in the detector array. Although there is no explicit energy cutoff, in practice this implies that these tracks have kinetic energies above about 100 KeV. For comparison, if the cutoff is set at 1 mm., the number of trajectories will increase by about 15%.

3. Turning on Cerenkov photon production , for a 50 GeV photon, produces over 3,000,000 optical photons. Geant4 can track these photons with reflection, refraction and absorption through the system but the time and memory required is too great. For this analysis, the optical photons are created but not tracked through the system. This increases the computation time only by a modest factor.

4. In the following analysis, the photon energy deposited in the 49 cell FPD is redistributed over the surrounding 7x7 array of cells in proportion to the number of optical photons with Cos(theta)>0. (~2,500,000 photons) that are produced in each cell.





Black upper: Shower shape from Geant4 analysis. FPD cells filled with **energy deposited** by stopping tracks.

Green: default Shower Shape from reconstruction

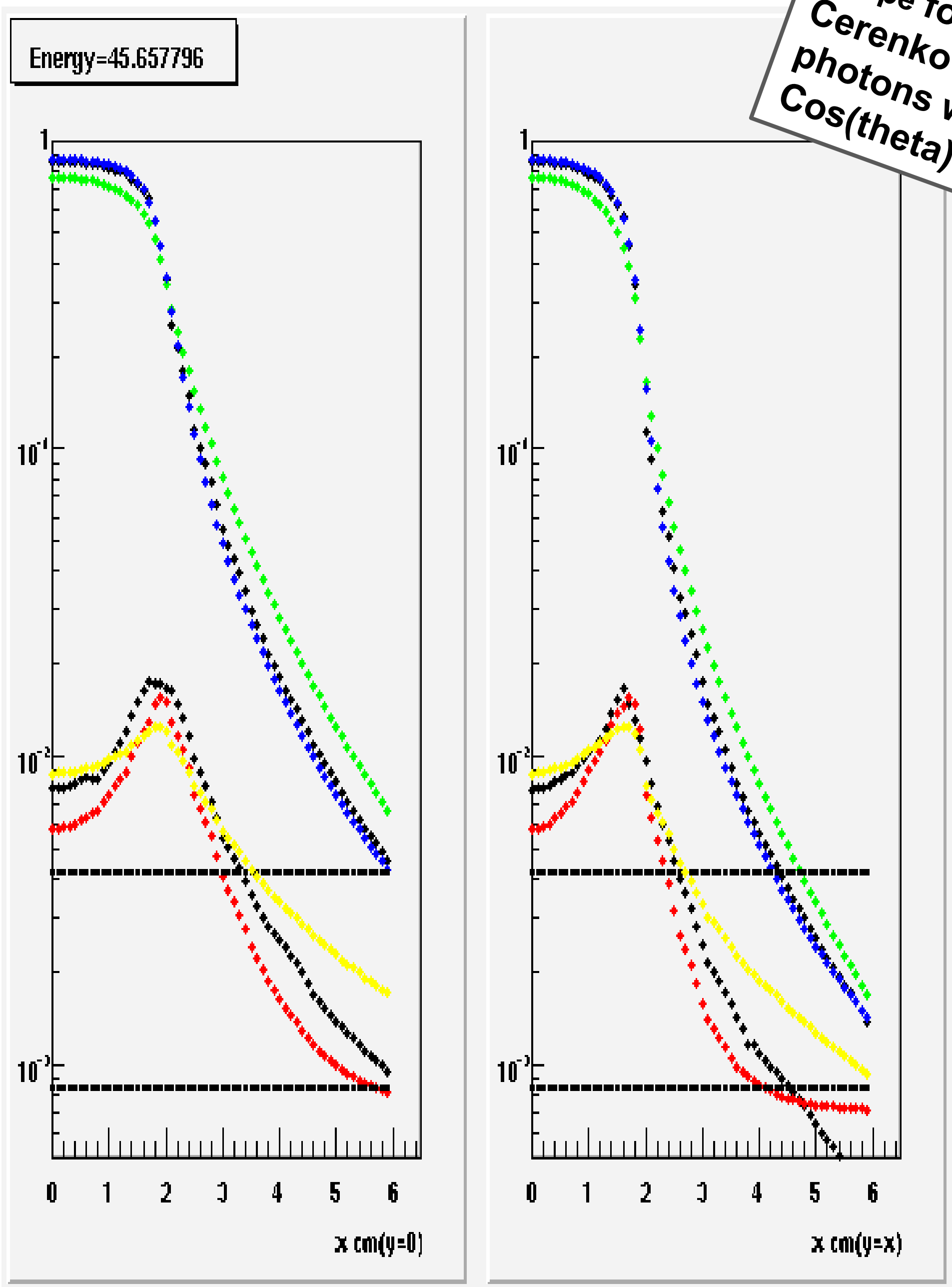
a0[3]={.8,.3,-.1};

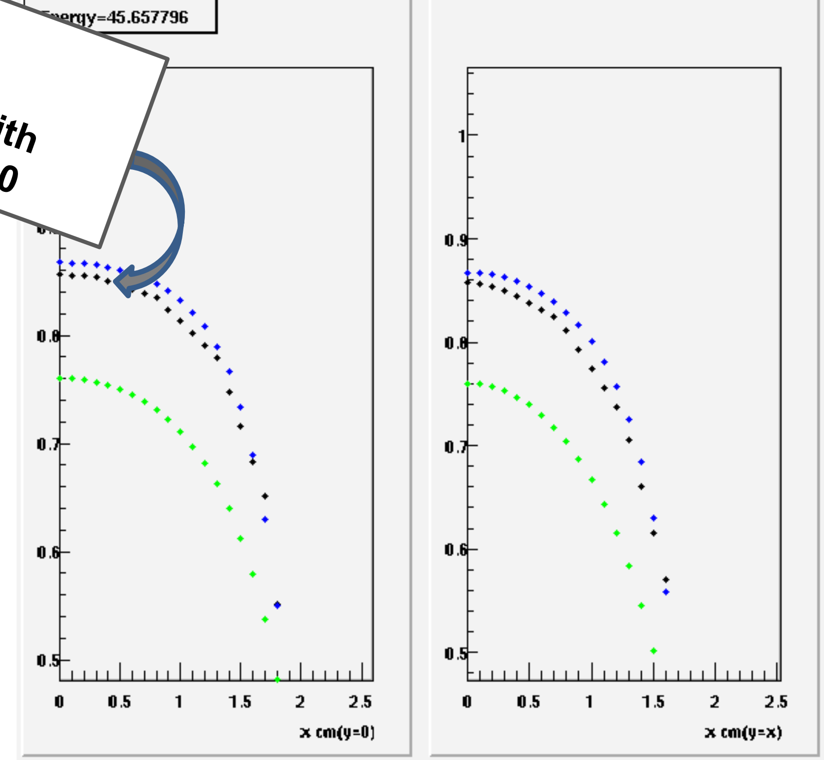
b0[3]={.8,.2,7.6};

Blue Fit to FMS data (Eta photon)

a1[3]={0.814, 0.882, -0.64};

b1[3]={0.33 , 0.318, 0.32};





<u>Black upper</u>: Shower shape from Geant4 analysis. FPD cells filled with **energy fraction defined by number of Cerenkov photons (Cos(theta)>0).**

Green: default Shower Shape from reconstruction

a0[3]={.8,.3,-.1};
b0[3]={.8,.2,7.6};

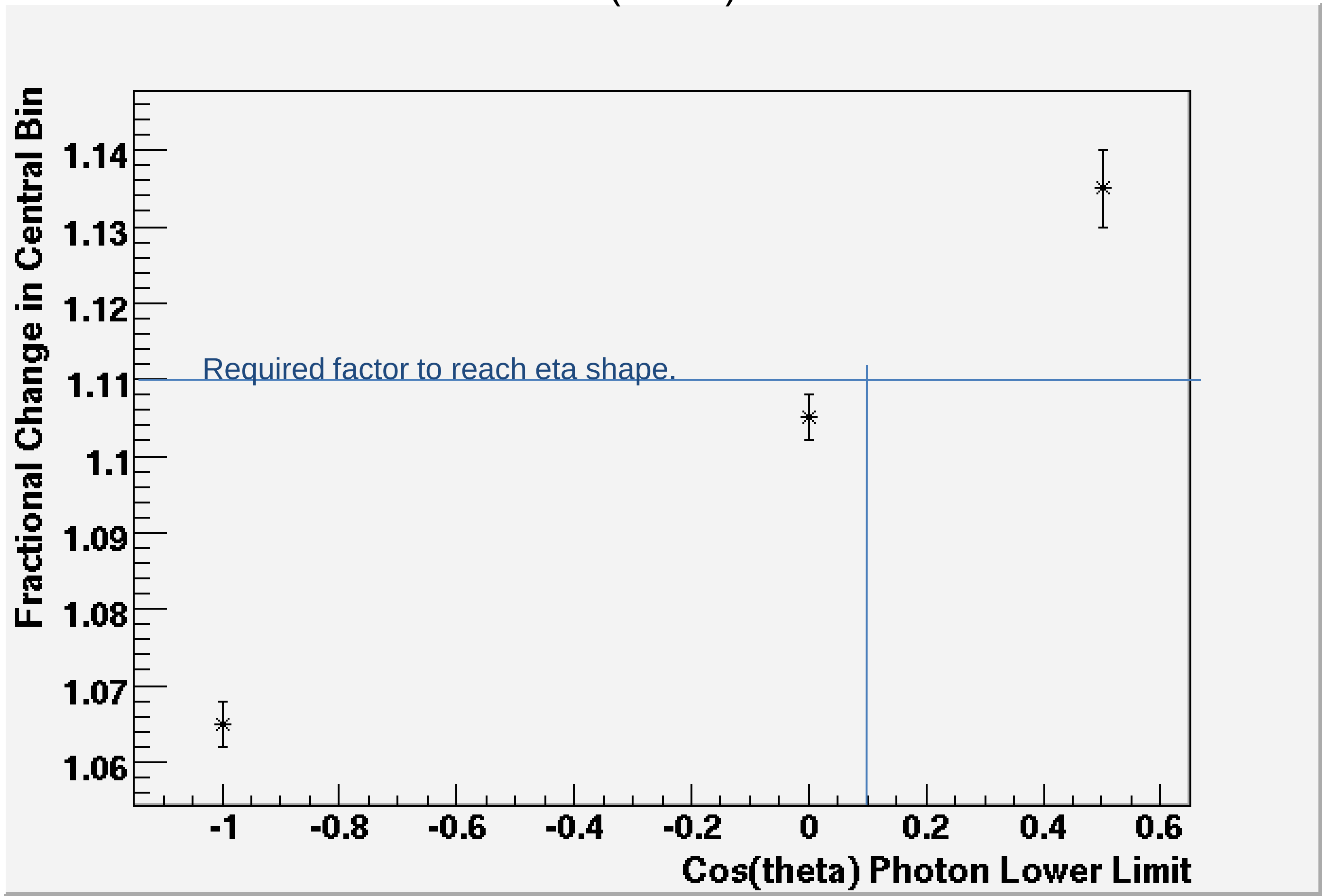
Blue Fit to FMS data (Eta photon)

a1[3]={0.814, 0.882, -0.64};
b1[3]={0.33 , 0.318, 0.32};

The Cerenkov photons are produced mostly in the forward direction and this leads to enhancement of the high tower cell for photons that strike the center of the high tower cell.
The factional change is larger for more forward photons.

For simulation to agree with eta shape we will need the cos(theta) limit:

"Cos(theta)>.1"



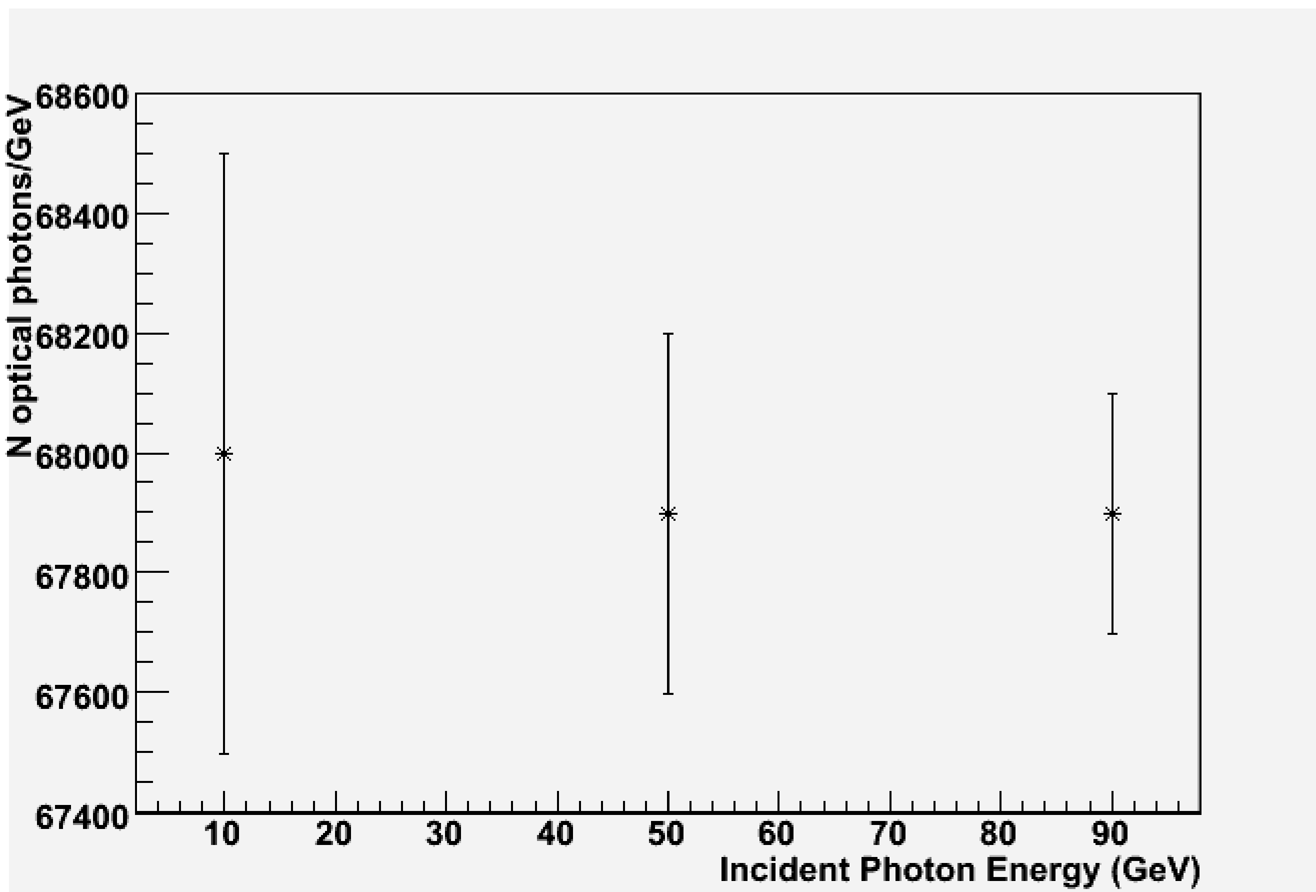
Cerenkov optical photons / (deposited E)=?
~ 68 Photons/ MeV (Geant for FPD Pb Glass)

Scintillation photons/(deposited E) ~<10 Photons/MeV
(open to discussion)

•Scintillation photons are produced in good proportion to energy deposition.

•Cerenkov photons are (75% in forward hemisphere)
- produced more in the core of the shower(
- more peaked shower shape for forward angles.

•The Forward Cerenkov photons show the most peaking, (up to 15% enhancement of FPD central bin over deposited energy for photons with Cos(theta)>0.5).


N optical photons/GeV
68600
68400
68200
68000
67800
67600
67400
10
20
30
40
50
60
70
80
90
Incident Photon Energy (GeV)

Extra Time to Track single photon (90 GeV incident) with/without optical phot

Without Cerenkov photons:
For geant4 without optical photons, on Dell PC at psu, about ~1 sec/event.
(X4 for quad processor).

With Cerenkov photons:
1 meter absorption length : cpu factor = x40;   memory~1.6 Gbytes
10 meter absorption length: cpu factor = x80; memory~2.0 Gbytes