Detector Simulation with WCSim (3)
(coding Cherenkov angle/isotropy test)

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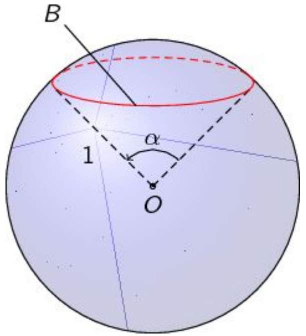
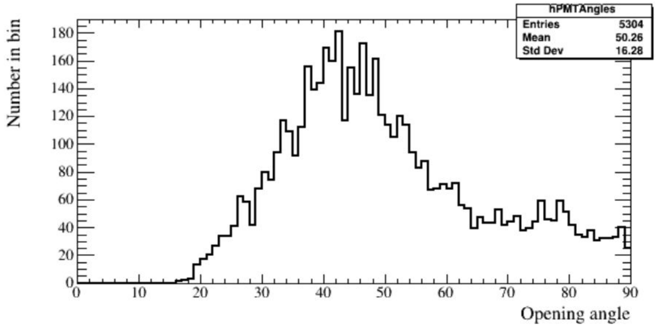
Method for Determining Opening Angle

1. From a generated particle event, read all PMT hits and get respective (x,y,z) positions of PMTs
2. Get initial particle vertex (via true position or Bonsai) and then the unit vectors from the vertex to the PMT hit positions.
3. Of all possible 3 PMT hit combinations, the triplet should create a circle cross section defined by a cone with the vertex at the cone apex.
4. Calculate the radius of this circle using the Law of Sines.
5. With the radius of the circle and the fact that the cone slanted heights/sides are unit length, can get the opening angle with arcsin.
6. (If the triangle area is too small, < 0.1, then the calculated angle is not put into the triplet angle histogram)
7. The most frequent angle in the histogram is finally taken as the Cherenkov angle





Example of all triplet angles for a 4 MeV electron using the true vertex from detector center, 30% pc.

General Information

Neutron discrimination would hopefully be similar to multiple gamma Cherenkov angle cut of muon capture of oxygen-16 in Super-K (which releases higher total energy though). Besides trying to calculate the Cherenkov angle, it also work as a basic test of anisotropy/isotropy

The electrons generated are quite low energy so they may not exactly produce angles of ~42 degrees (they will likely be more isotropic). The gamma would produce an even lower energy electron after a Compton scattering event. Plan to try to code MSG to hopefully distinguish the two.

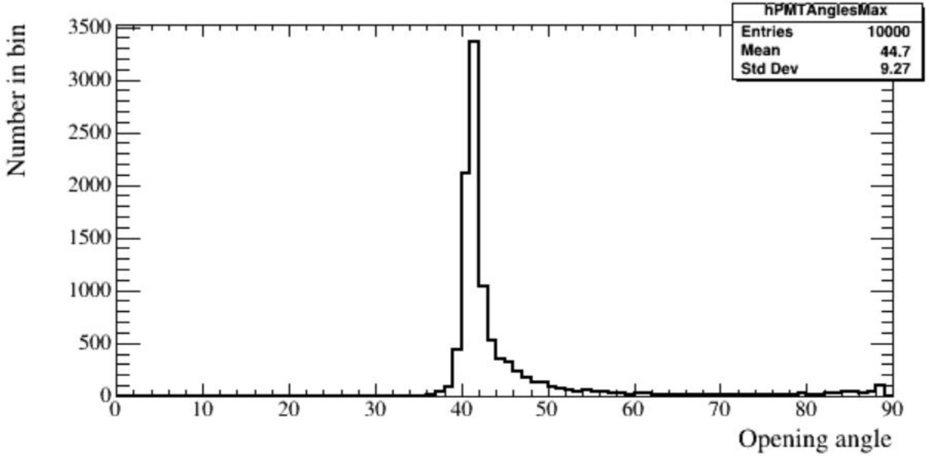
Possible Limiting factors (energy and detector size). Super-K uses a cut of the reconstructed vertex being 2 m from the detector wall.

First will show plots with optimistic, ideal conditions then work towards more realistic conditions:

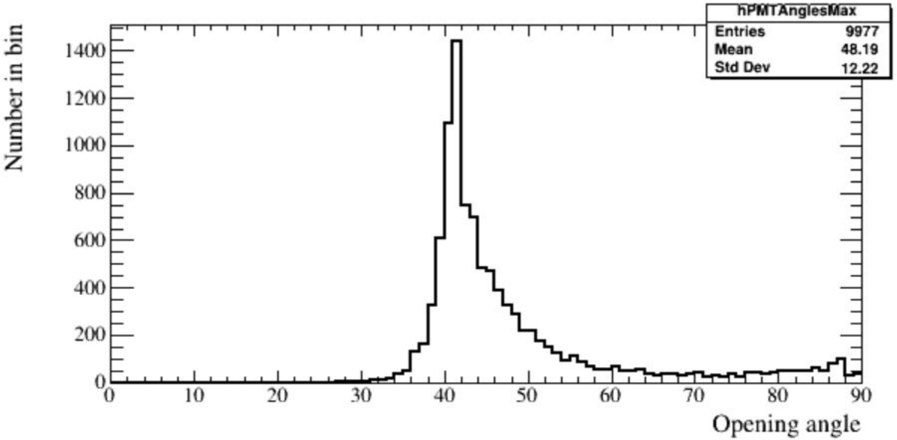
1. Particles generated from detector center, using the true vertex
2. Particles generated uniformly in the detector, using the true vertex
3. Particle generated from detector center, using the bonsai reconstructed vertex
4. Particles generated uniformly in the detector, using the bonsai reconstructed vertex

4 MeV Electron, generated from detector center and using true vertex, 10,000 events, no dark noise

78% pc



30% pc

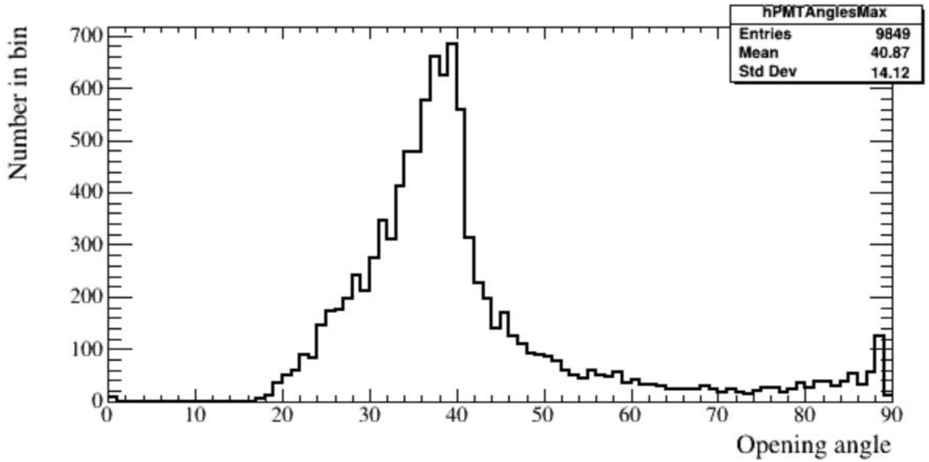


(Histograms of final Cherenkov angle that was the most frequent opening angle of all triplet PMT hits)

Notes: Both pc pick up nearly all events. 30% pc has worse resolution though

4 MeV Gamma

78% pc



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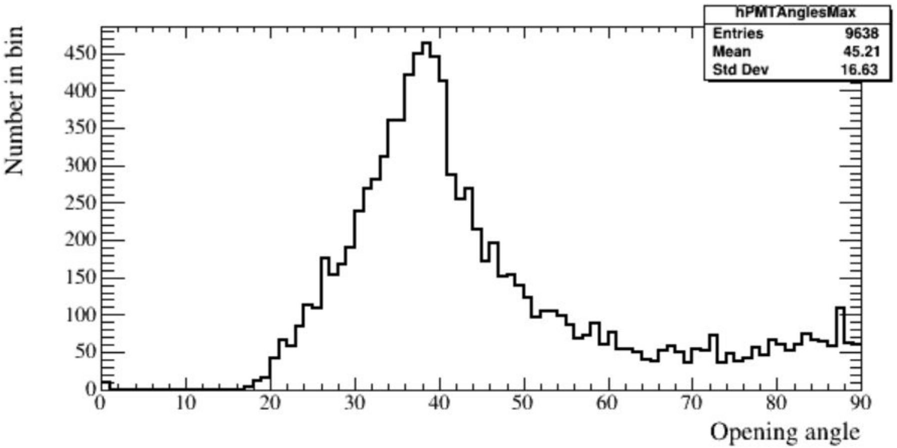
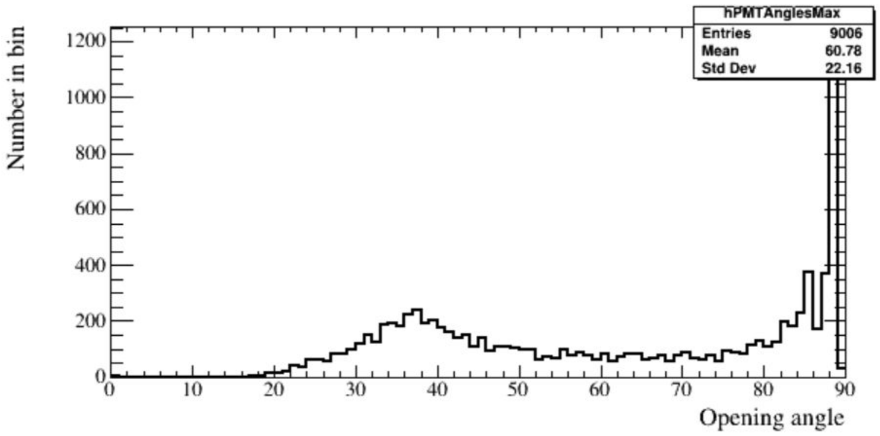


4 MeV Neutron with 0.1% Gd

78% pc



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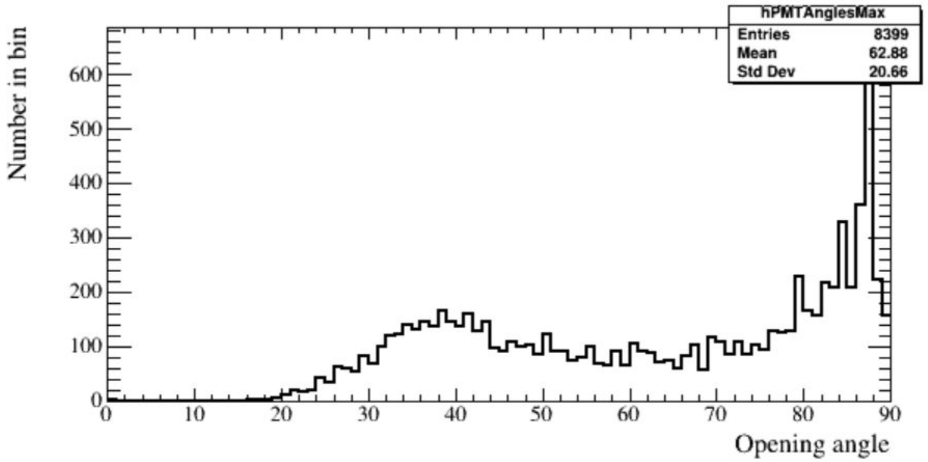
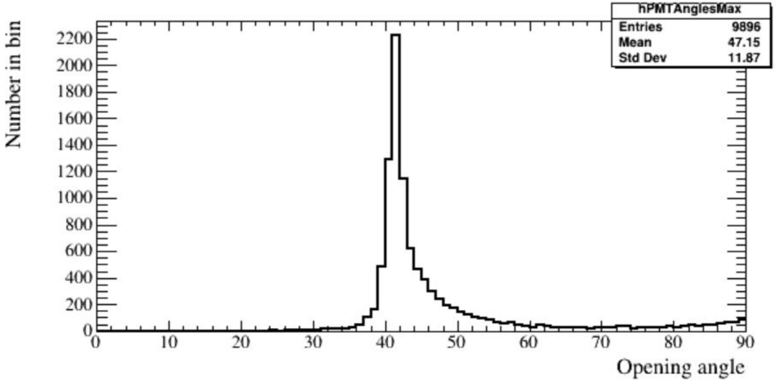


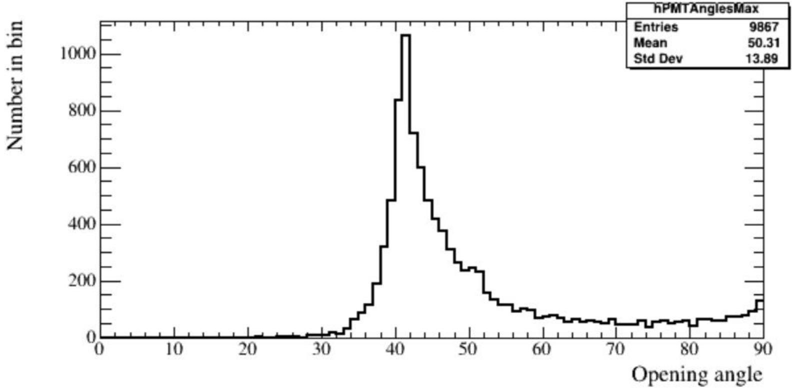
Still a wide peak around ~38. Could be due to escaping gamma…

4 MeV Electron Uniformly, True Vertex

78% pc

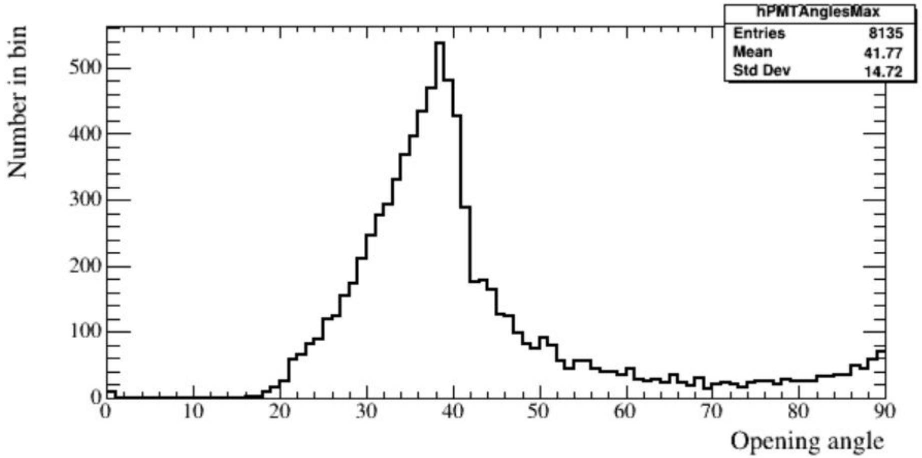


30% pc



4 MeV gamma uniformly, true vertex

78% pc



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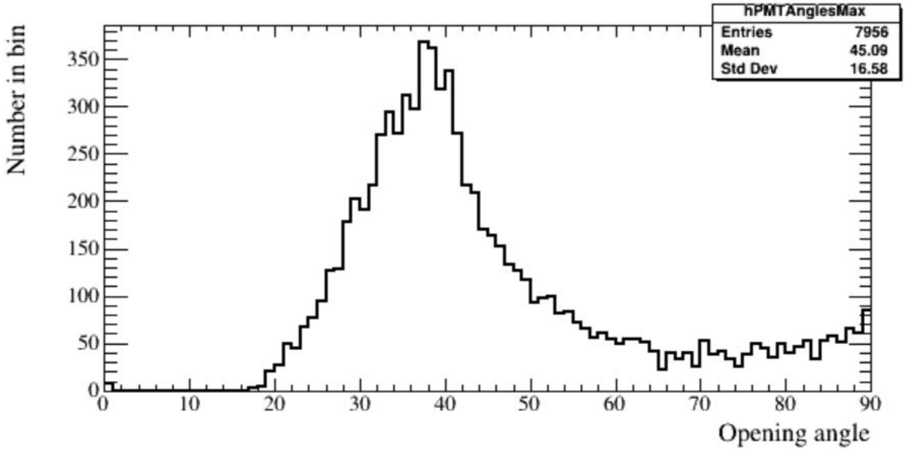
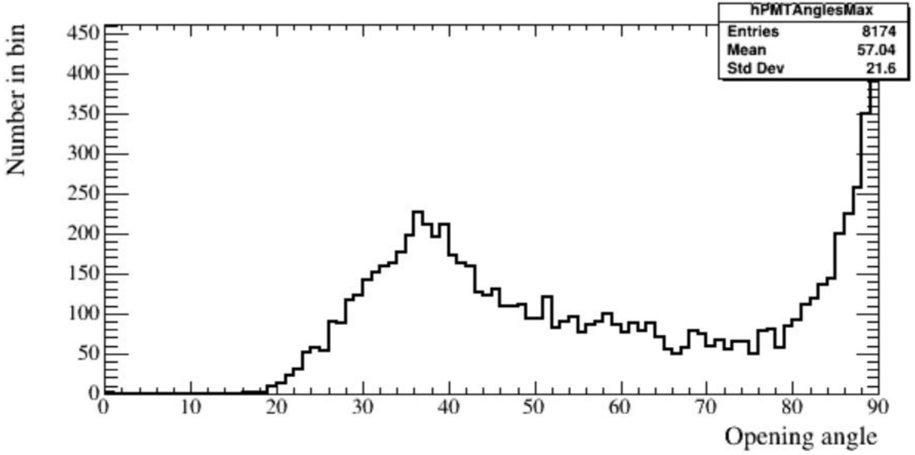


4 MeV neutron with 0.1 Gd uniformly, true vertex

78% pc



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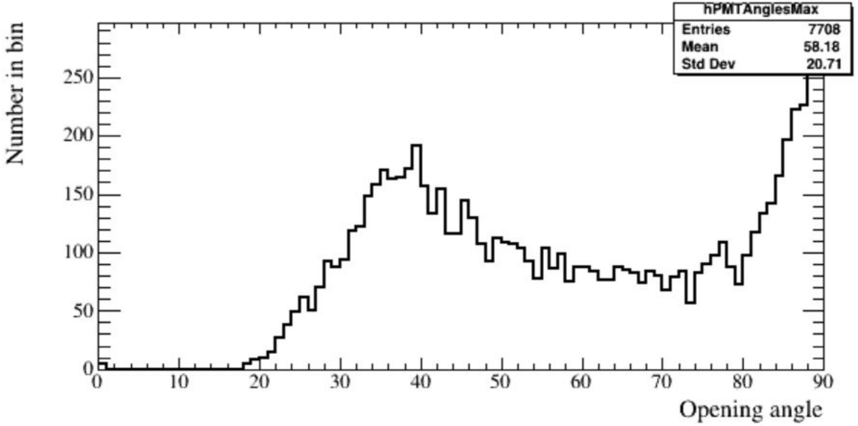
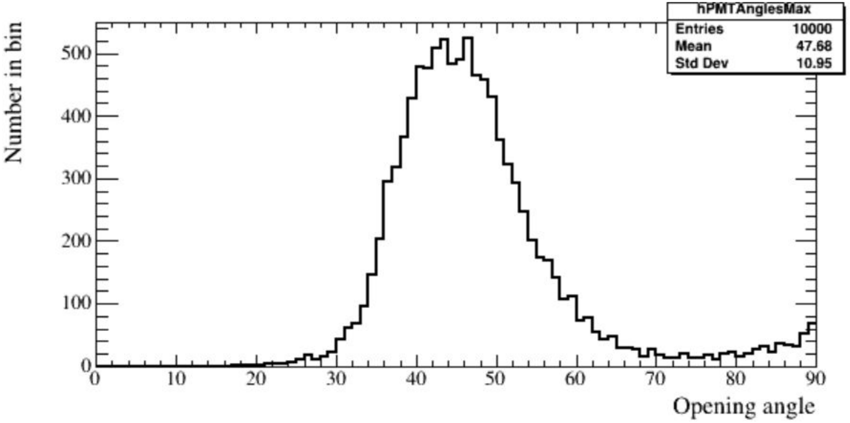
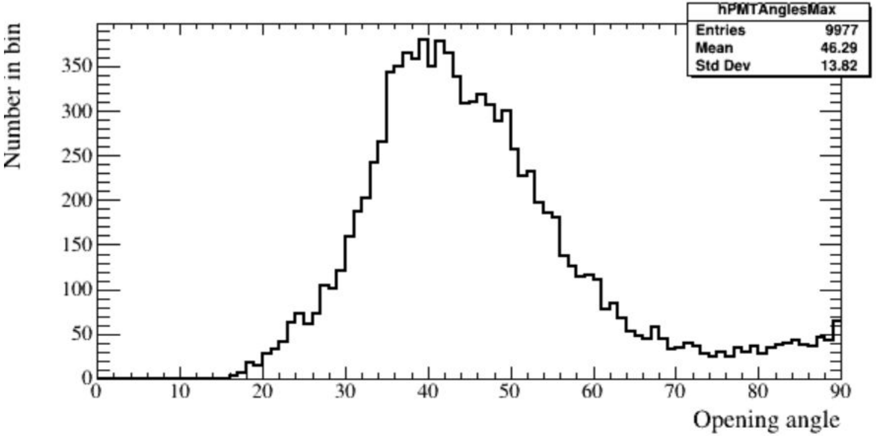


4 MeV electron, Bonsai reconstructed vertex, generated from center

78% pc

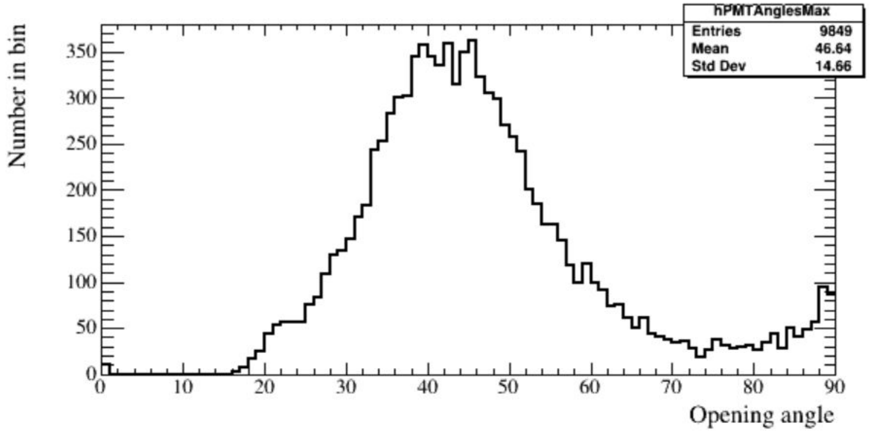


30% pc

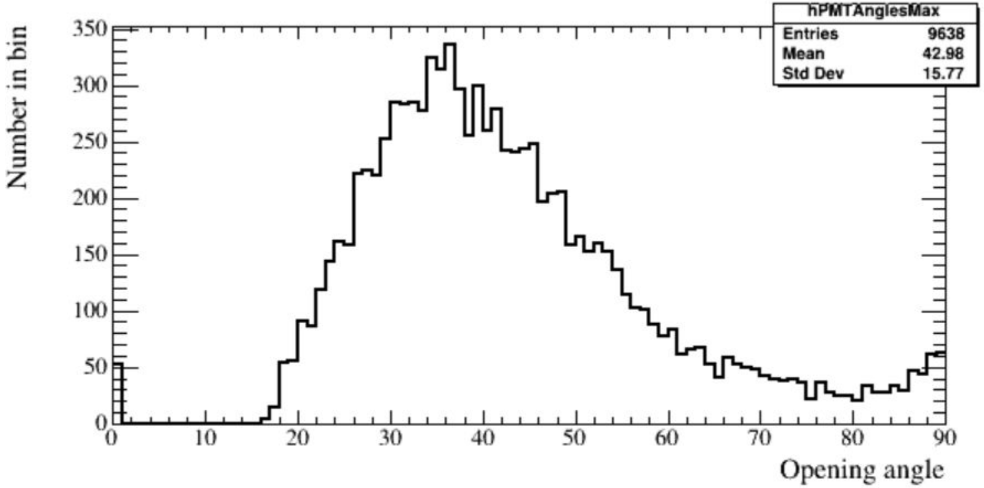


4 MeV gamma, Bonsai reconstructed vertex, generated from center

78% pc

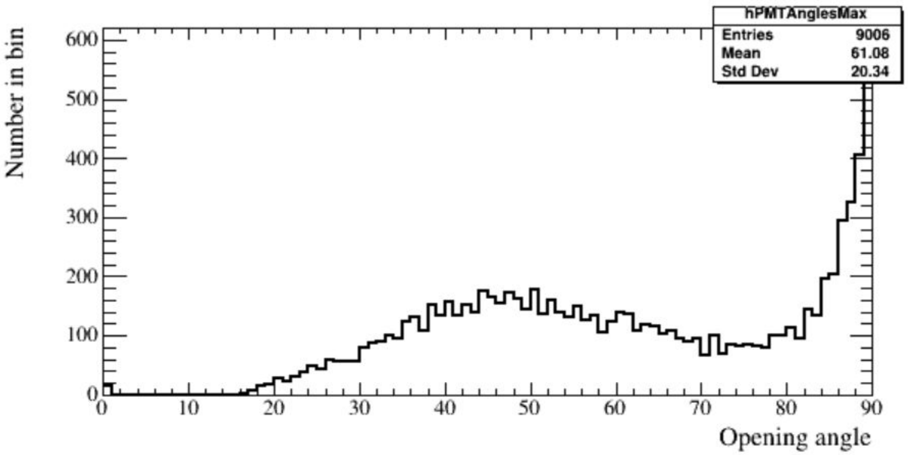


30% pc

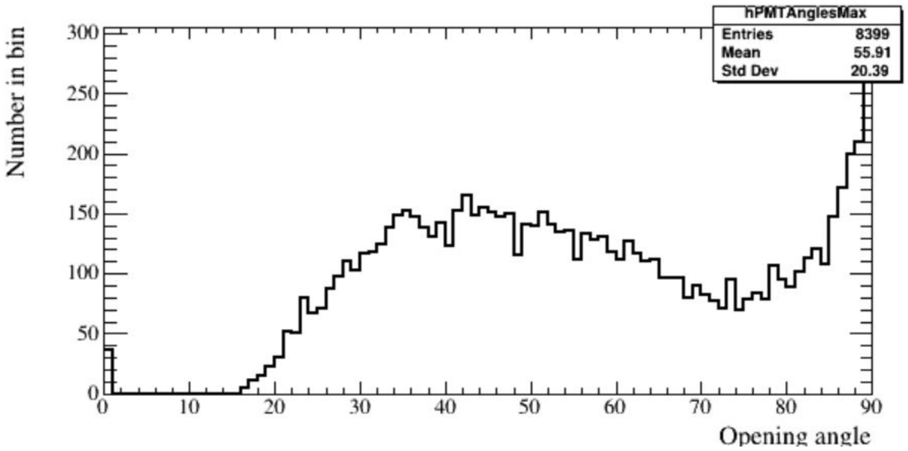


4 MeV neutron with 0.1 Gd, Bonsai reconstructed vertex, generated from center

78% pc

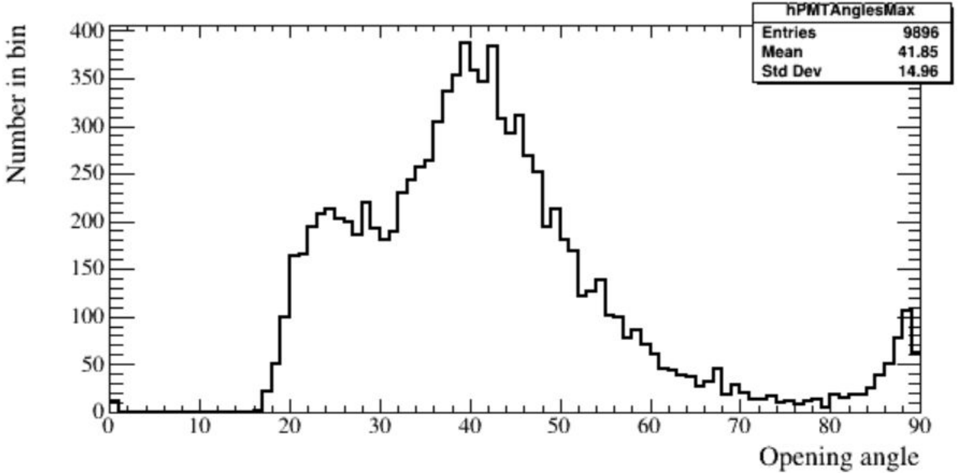


30% pc

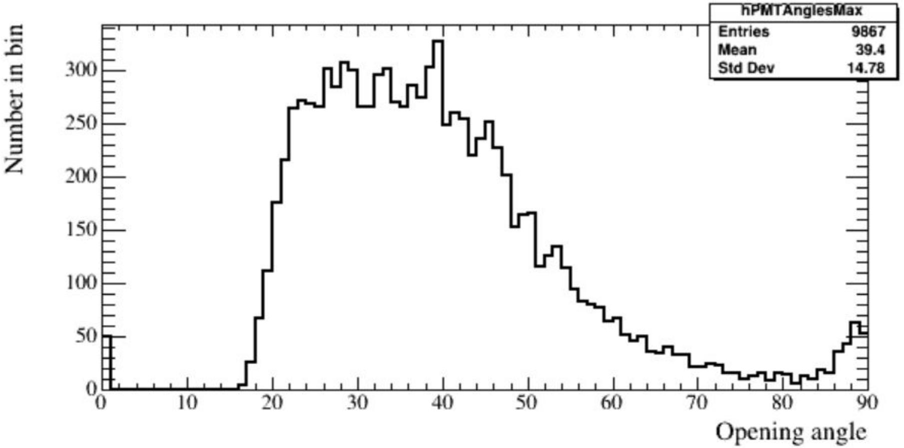


4 MeV electron, Bonsai reconstructed vertex, generated uniformly

78% pc

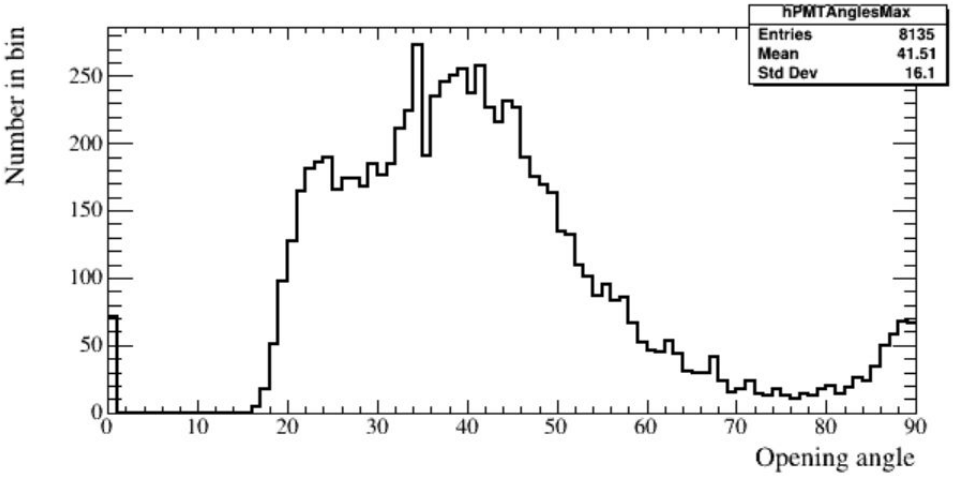


30% pc



4 MeV gamma, Bonsai reconstructed vertex, generated uniformly

78% pc



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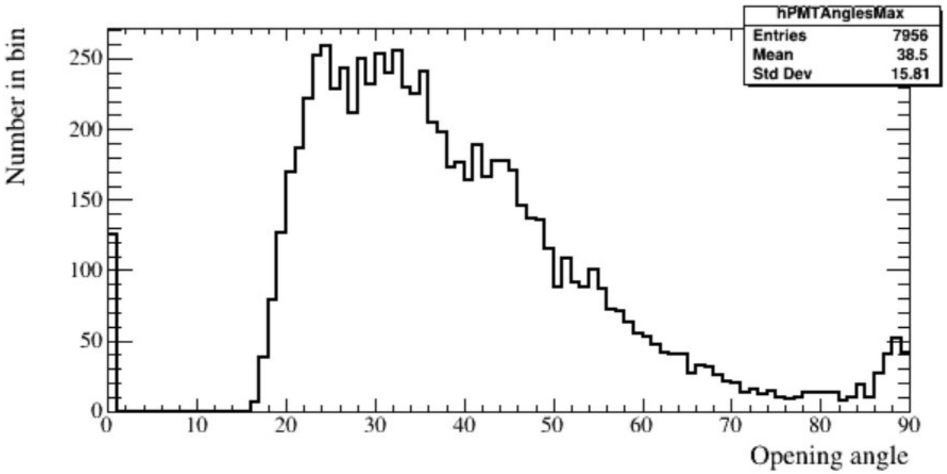
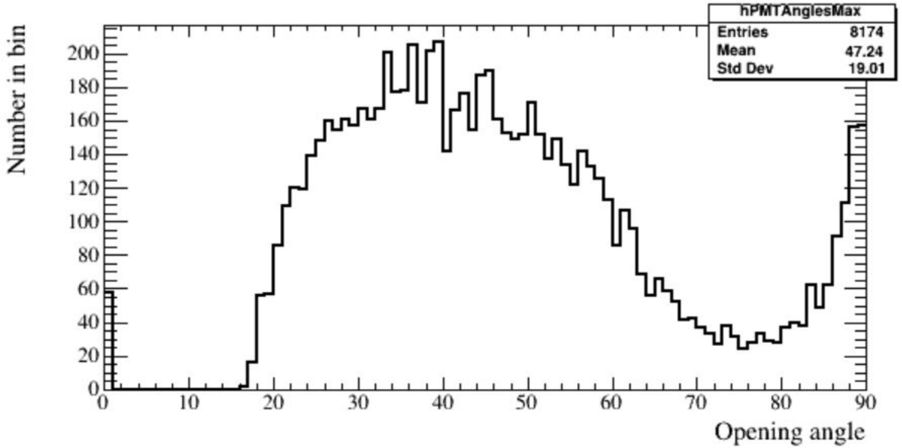


4 MeV Neutron with 0.1% Gd, Bonsai reconstructed vertex, generated uniformly

78% pc



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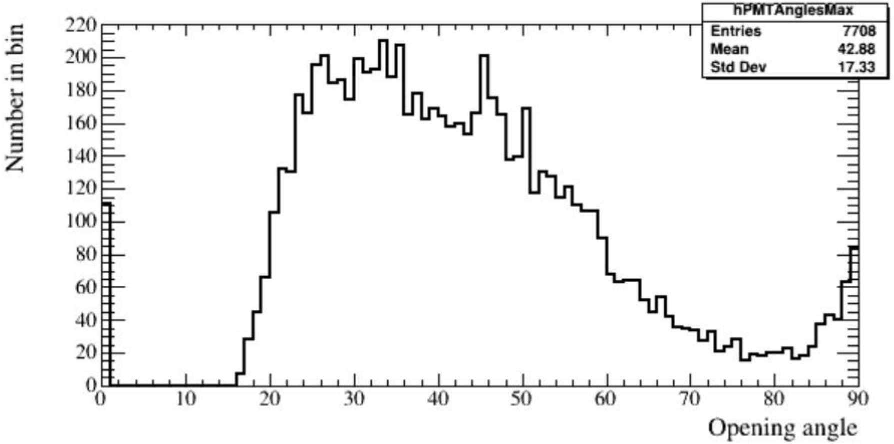

Suggests maybe defining a reconstructed vertex cut to keep events more towards center of detector.

Reminder that usual geometry is 3 m diameter, 2 meter height