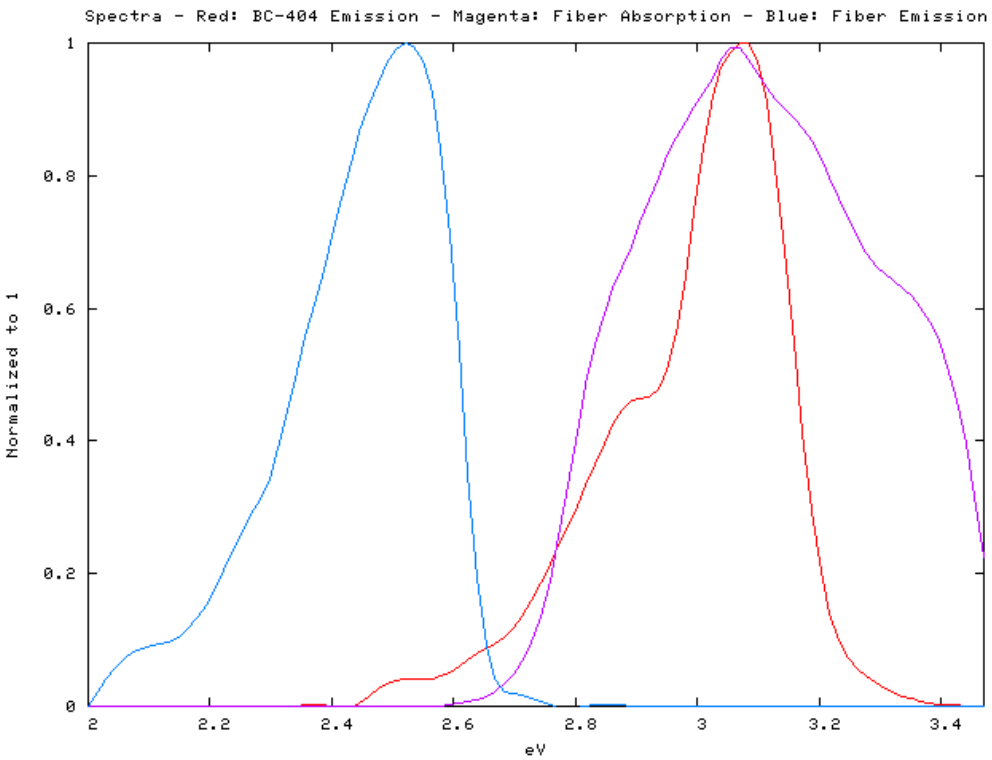
Addendum to the October 18th Report

Parameters

Material	Index of Refraction
Air	1.00
BC-404	1.58
Fiber	1.60
Inner Cladding	1.49
Outer Cladding	1.42
TiO Coating	1.94

Parameter	Value
BC-404 Photon Absorption Length	1.6m
BC-404 Emission Time	1.8ns
Fiber Emission Time Constant	2.7ns
Scintillation Yield	1 photon / 100eV

Energy	BC-404 Emission	Fiber Absorption Length	Fiber Emission
2.00eV	0	300cm	0
2.07eV	0	300cm	0.08
2.14eV	0	300cm	0.1
2.22eV	0	300cm	0.2
2.26eV	0	300cm	0.28
2.30eV	0	300cm	0.35
2.34eV	0	300cm	0.5
2.39eV	0	300cm	0.67
2.44eV	0	300cm	0.85
2.48eV	0.03	200cm	0.95
2.54eV	0.04	100cm	1
2.59eV	0.05	23cm	0.75
2.64eV	0.08	4cm	0.08
2.70eV	0.12	.9cm	0
2.76eV	0.22	.225cm	0
2.82eV	0.34	.09cm	0
2.89eV	0.46	.065cm	0
2.96eV	0.54	.053cm	0
3.03eV	0.94	.047cm	0
3.05eV	1	.045cm	0
3.11eV	0.93	.048cm	0
3.19eV	0.28	.053cm	0
3.27eV	0.05	.065cm	0
3.45eV	0	.13cm	0
3.47eV	0	.2cm	0



Glue

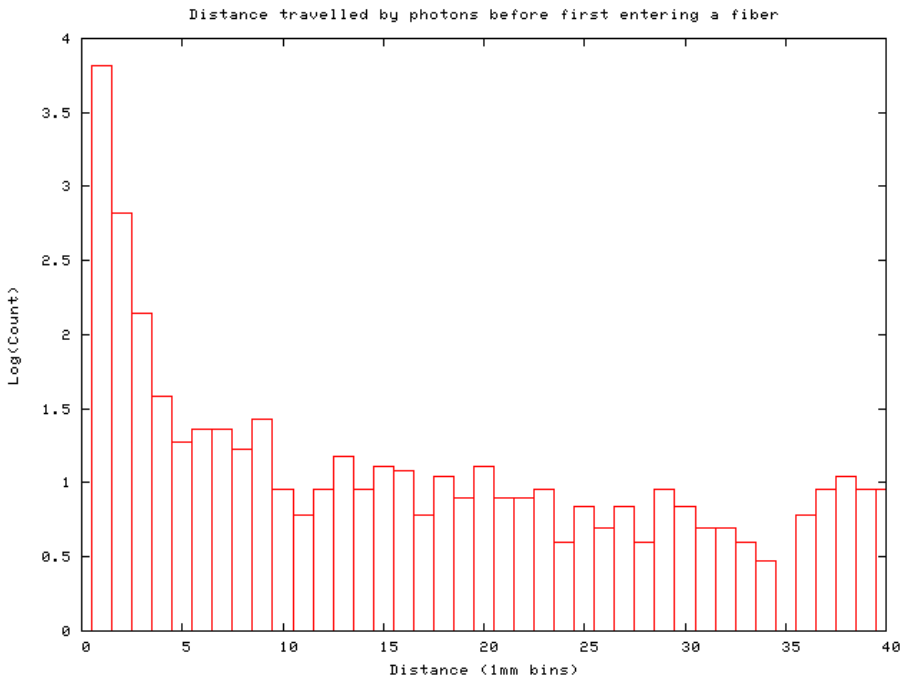
- Two 200cm x 10cm panels glued together were compared against one 200cm x 20cm panel.
- Glue thicknesses of 2μm, 5μm, 10μm, and 100μm were examined.
- No change outside of statistical variation was observed.
- Glue was simulated using parameters from a cyanoacrylate-like product. This product, designed for gluing scintillator sheets together, is optically transparent and has a very similar index of refraction to that of the scintillator (1.585 versus 1.58). Consequently, it is not surprising that no change in the simulation was observed.
- For these glue parameters, simulating the scintillator as a 200cm x 200cm slab is appropriate.

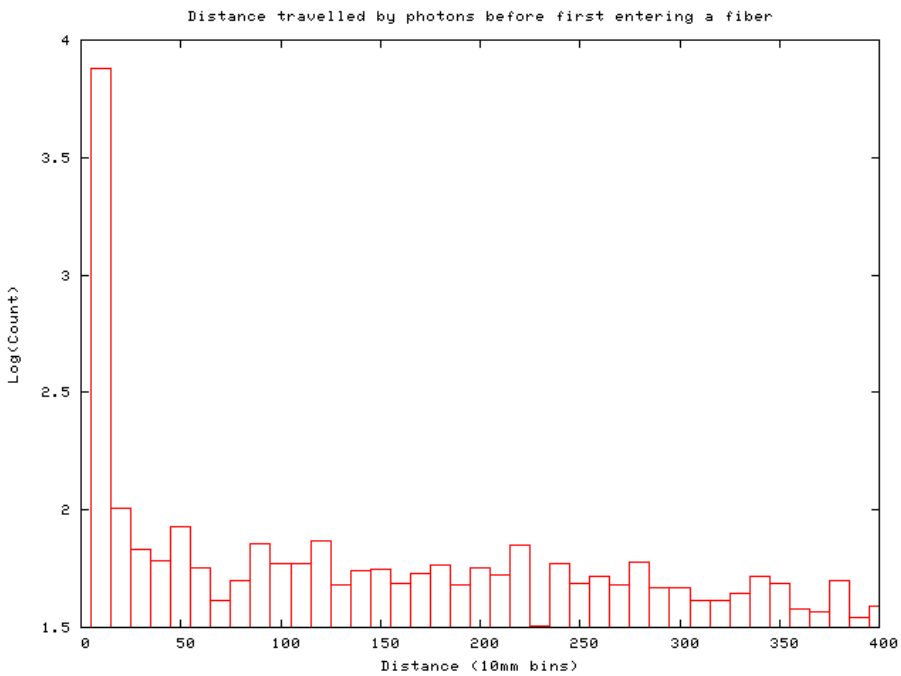
Path Lengths and Photon Counts

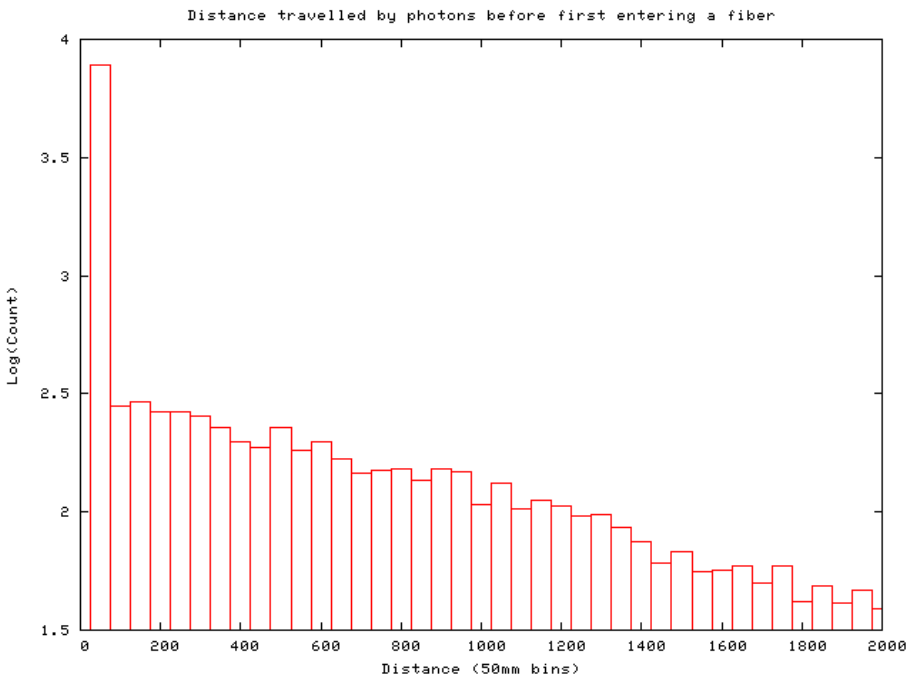
- The average path length of a photon before entering a fiber is 33.4cm.
- The average path length of a photon before entering the fiber in which its child photon is detected is 46.2cm.
- The average y-distance from an e^- energy deposit to the fiber in which a child photon of that energy deposit is detected is 27.3cm.
- For a single event, the number of photons arriving at all of the PMTs is 380, leaving 57 (15%) after quantum efficiency.

Path length before first entering a fiber

- Average Path Length: 33.4cm
- Total Count: 13716
- Graphs are semilog
- Graphs are binned from [0:40mm], [0:400mm], and [0:2000mm]

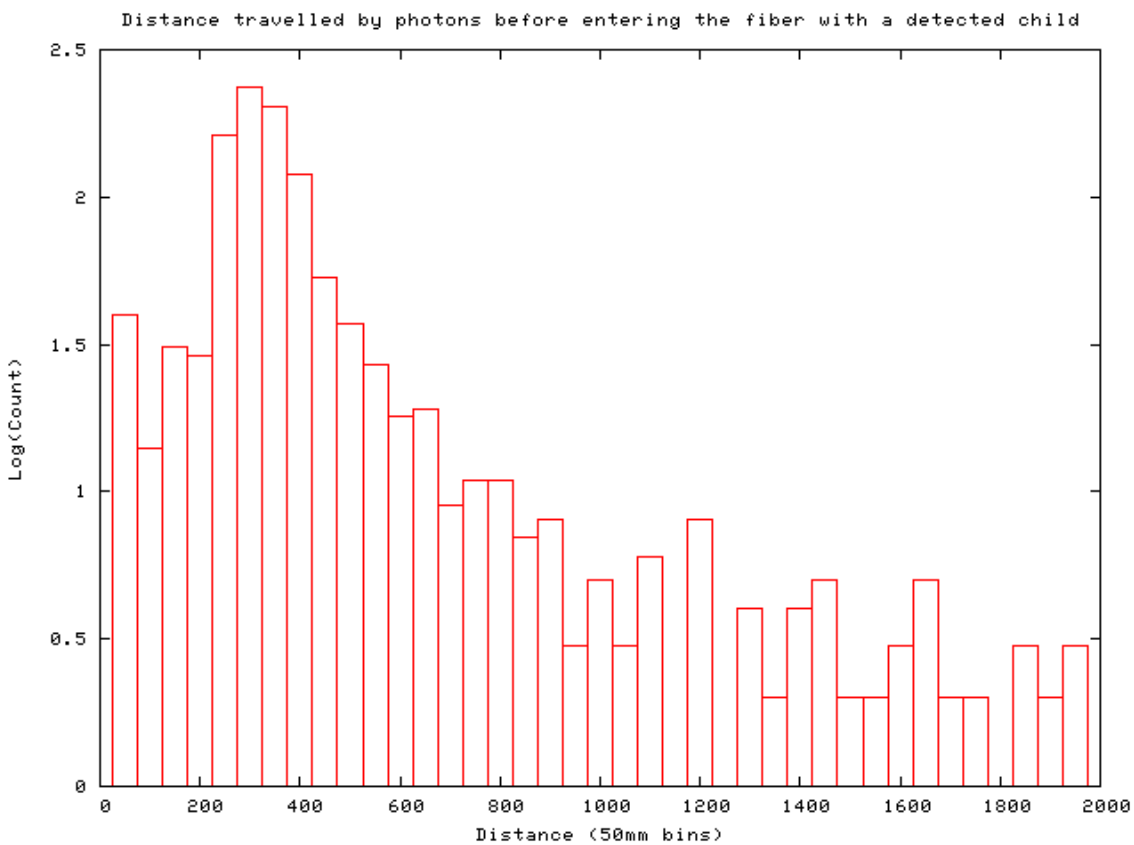






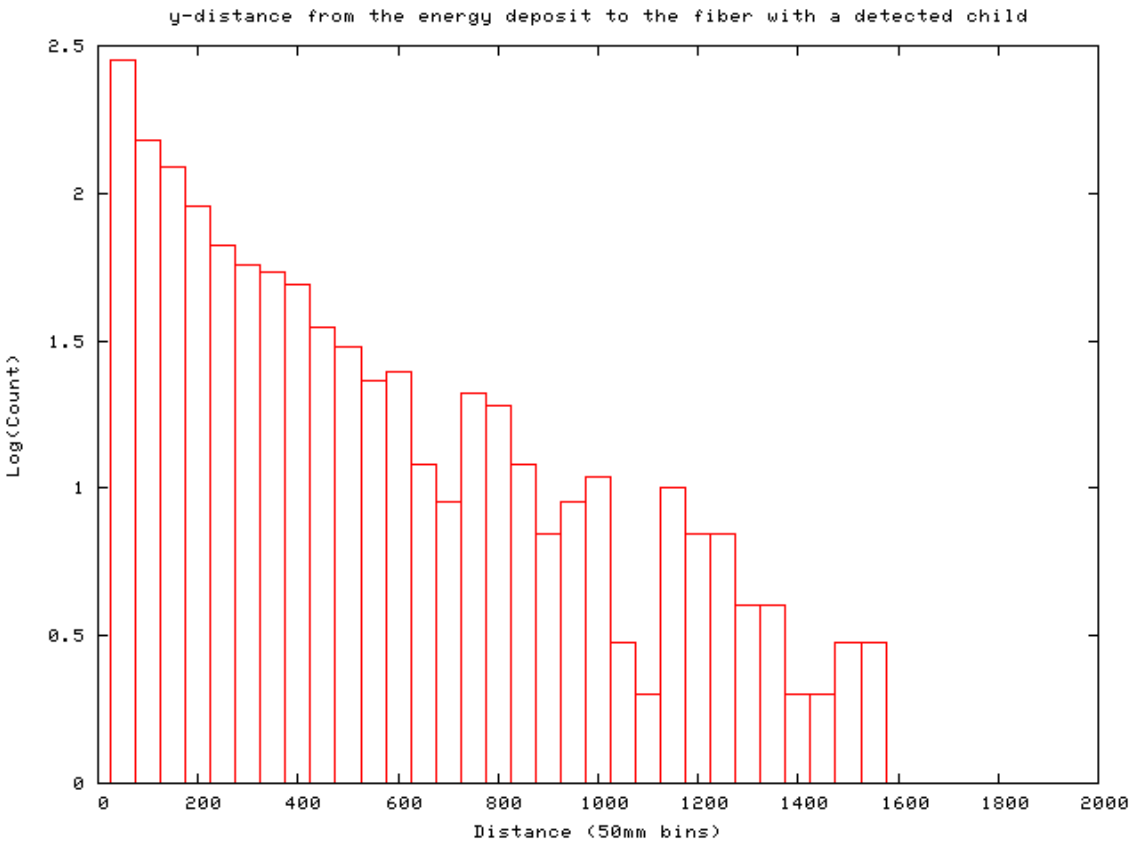
Path length before entering the fiber with a detected child photon

- Average Path Length: 46.2cm
- Total Count: 1133
- Graphs are semilog
- Graphs is binned from [0:2000mm]



y-distance (perpendicular to fibers) from energy deposit to the fiber with a detected child photon

- Average Path Length: 27.3cm
- Total Count: 1133
- Graphs are semilog
- Graphs is binned from [0:2000mm]



Late Arrivals

- The simulation parameters have been adjusted with respect to the difference between how Geant4 generates photons with respect to time and how the actual scintillator material does.
- A consequence of these adjustments is that the likelihood of the very late arriving photons is reduced, although it still remains a possibility as outlined below.

- Consider a photon from an energy deposit near x=95.0cm, the "front" of the scintillator.
- From the previous report, the minimum time for a photon to reach a PMT (for an energy deposit near x=95.0cm) is about 3.5ns.
- Geant4 generates photons from the energy deposit according to TimeConstant * -ln(UniformRandom()). With a time constant of 1.8ns, one would expect that for one out a thousand events (UniformRandom()=0.001) that the photon would be generated at time = 1.8 * -ln(0.001) = 12.4ns.
- Considering an average path length of 20cm until the photon enters a fiber adds an additional 1.0ns.
- If the photon then travels "backwards" down the fiber, towards the PMTs at the opposite end, it has a distance of approximately 220cm to cover. Assuming it is bouncing at an angle of 45º to the perpendicular, then the path length is more like 220cm * $\sqrt{2}$ = 310cm which will take approximately 46.5ns to traverse.
- The total time from energy deposit to arrival the PMT window for this photon would then be 12.4ns + 1.0ns + 46.5ns = 59.9ns.