GlueX Document
Updated: November 15, 2007

Estimating BCAL Photoelectron Statistics

Alex R. Dzierba

The Regina group estimates[1] that for the BCAL prototype module, the number of photoelectrons per cell is about 25. R. Jones questions[2] the methodology used to arrive at this number. G. Lolos pointed out[3] that this yield is a factor of four lower than expected. This note summarizes an estimation of the expected photoelectron yield using information from fiber spec sheets.

Using data from the Kuraray[4] and Bicron[5] spec sheets, I generated the plot of Figure 1. The emission curves are shown for scintillating fibers along with the quantum efficiency of the XP2020. The dashed emission curve is based on the emission spectrum for BC-F12 shown in reference 5. I digitized the graph and fitted the result to a polynomial. The other four emission curves are based on digitizing and subsequent fitting using the four curves on page 7 of reference 4 for SCSF-78. These curves are based on using a UV source to excite the fiber and measuring the spectrum at 10, 30, 100 and 300 cm from the source. These four spectra are presumably properly normalized with respect to each other. I normalized the BCF-12 spectrum to agree at the high wavelength end. By integrating these curves one can estimate that if 8000 photons are produced at the source in the middle of the 4 m fiber, the yield at one end will be 2900 photons times the capture fraction. The capture fraction is the solid angle subtended by a cone of half-angle θ divided by 4π which is $(1-\cos\theta)/2$. For the double-clad fiber $\theta = 26.7°$ (see page 4 of reference 4). The capture fraction is 0.053. The average quantum efficiency over the range of relevant wavelengths is about 0.15.

So a 1 MeV of energy deposition in the center of 4 m fiber should result in $2900 \cdot 0.053 \cdot 0.15 = 23$ photoelectrons at one end. For the BCAL test module, the cell size was 3.8×3.8 cm^2. The mean deposited energy for a minimum ionizing particle should be about 3.8 MeV per cell based on 2 MeV/cm for scintillator and assuming that, on average, that 50% of the matrix by volume is scintillator. So one should expect about 90 photoelectrons per cell.

So I get about the same number as G. Lolos. He uses an average quantum efficiency of 0.1 instead of my 0.15 and his capture fraction is 0.093. I claim that this should be divided by 2 in order to estimate the yield at one end. He also uses uses an overall attenuation length of 280 cm whereas I used the integrals of the emission spectra. So there is a factor of four discrepancy.

In Figure 1 I also show the estimates of attenuation length for wavelengths of 420, 430, 440, 450 and 460 nm.

[1] A. Semenov and Z. Papendreou, GlueX-doc-845-v3.
[2] R. Jones, GlueX-doc-847-v4.
[3] G. Lolos, GlueX-doc-886-v1.
[4] GlueX-doc-916.
[5] GlueX-doc-917.

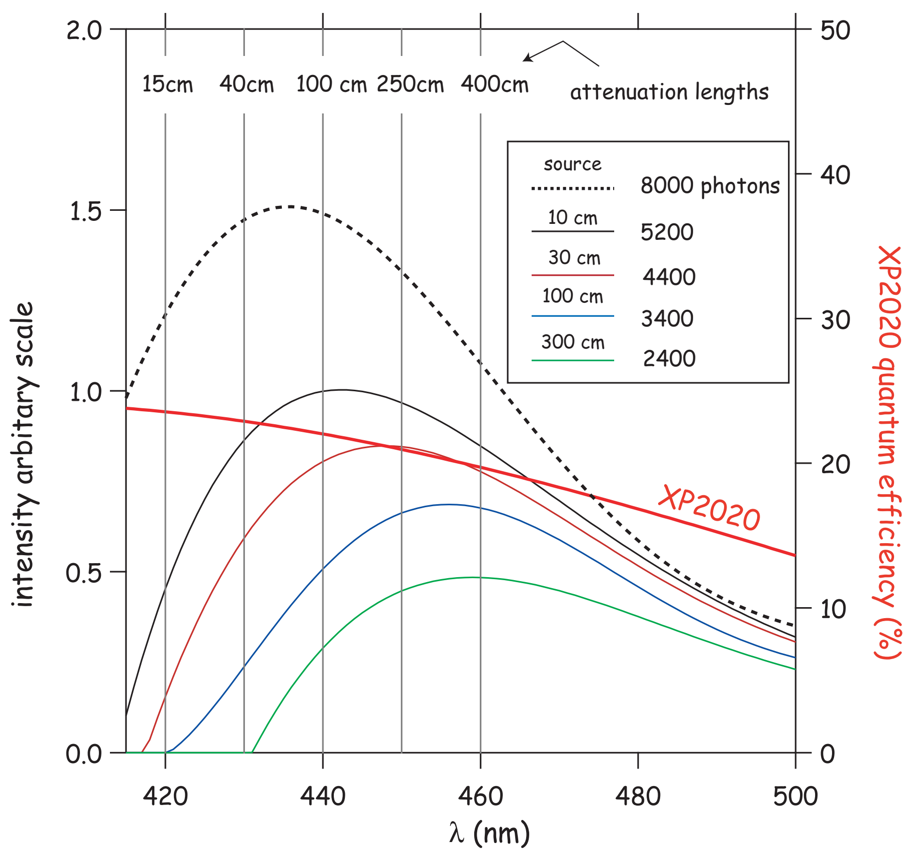

Figure 1: See text for details.