Abstract 3

This week, my new work largely focused on a different way of evaluating the performance of a scintillator and its implications. This new way involves conducting measurements on the transmittance (and consequently the absorbance) of the samples using a spectrophotometer. The transmittance of a material is defined as the ratio of the transmitted intensity of light through a sample to the incident intensity of that light. It naturally denotes the impedance, if you will, of a material and naturally defines how well a sample allows light to pass through it. For example, a completely opaque source (let’s say for the visible light spectrum) would have a transmittance of 0%, for those corresponding wavelengths, while a completely transparent source would have a transmittance of 100% for the visible light spectrum. In the case of scintillating material, knowing the transmittance offers an understanding of how much practical light output one may receive from the scintillation process, as inevitably some of the light that is emitted will be absorbed. Additionally, there are many key factors that impact the transmittance response, for example, as you can see via this graph, transmittance strongly depends on the incident frequency of light. The lead tungstate crystal completely attenuates light with a frequency of less than 340 nm, while the glass shows appreciable transmittance (~1.4%) all the way into the 200 nm range. Some other factors, as I will discuss promptly with the graph, that impact transmittance include crystal purity, physical/superficial defects, and the thickness and overall shape of the crystal. Another independent variable that I implemented to test was wrapping the samples as we traditionally do, in Teflon and electrical tape, to see how that affects the transmittance. The lead tungstate displayed little variation in transmittance upon wrapping while the glass displayed a peak variation of a little over 1%. With regard to orientation, the glass displayed impressive uniformity, demonstrating little to no variation regardless of its orientation along the longitudinal axis. For my next point, it is important to note there were no appreciable superficial defects on the glass. The lead tungstate, however, had several chips on its square faces. I noticed when orienting the chip on one face where the chip was in the bottom left with respect to the perspective of the integrating sphere, there was up to a 5% higher transmittance than with the chip in the top left, indicating that manufacturing/shipping defects and the orientation of the crystal with respect to a PMT or other device can impact how much light yield it may demonstrate.

Furthermore, I ran several light-yield experiments this week with different crystals. Continuing from last week, I wanted to determine the effect of temperature on the light yield of reference crystal J24. I ran a light yield on J24 last week after letting it cool down for about 1.5 hours. This week I tried letting it cool for only 30 minutes and got a result of 9.07 pe/MeV, which was already quite low, as based on experimental data, the temperature dependence on light yield is about 2.4%/\*C. Nonetheless, I ran the experiment again, letting it cool overnight, and unfortunately got a light yield of less, 6.06 pe/MeV. This means that there are other factors to be considered. I have discussed with Dr. Horn that this could be due to radiation damage affecting the scintillation process. Experimental data has shown promising results of blue-light curing, that is the recovery of the crystal properties by shining blue light onto it in a controlled environment. I look to see if I can use this to recover the initial 12.5 pe/MeV yield or greater. As another comparison, I ran a light yield on reference crystal J39 giving a yield of 10.36 pe/MeV after letting it cool overnight, which is still somewhat low and may be affected by radiation damage.

Lastly, I’ve optimized my electron-proton scattering code using Rosenbluth formalism which is the most experimentally up-to-date and agreed-upon metric for analyzing this process. It is formalized via relativistic quantum mechanics; therefore, it takes into account the finite size of the proton and its magnetic moment via form factors. These form factors are essentially empirical functions of the momentum transfer that have to be determined experimentally by measuring many differential cross-sections of many momentum transfers. In the mid-20th century, experimental physicists developed the dipole model, an approximate representation of the form factors using a fitting model based on data, which is accurate to about 10 (GeV/c)^2 momentum transfer. Therefore, in my comparisons, I’ve chosen to neglect these transfers.