Abstract

Thus far in our program, I have been introduced to my research topic through a decomposition of its constituent parts in order to synthesize them with a better understanding of the functionality of each part and how it contributes to the research overall. My research topic is regarding the application of scintillating crystals for electromagnetic calorimetry (EMCal). With the help of my graduate student advisors, Avnish, Rasmita, and my supervisor, Dr. Horn, we’ve decomposed this topic into three components: theory (which consists of familiarizing myself with the fundamental terminologies and scientific background of the topic through reading research papers), computation, and experiment. From my theoretical research, I’ve learned what scintillating crystals are, what EMCal is, and what their relevance is for nuclear physics. To summarize, crystal scintillators are materials that experience an electronic excitation when bombarded with gamma radiation or energetic particles and a subsequent electronic deexcitation, resulting in the emission of light. Conventional particle calorimeters are devices that measure the energy of a particle through the heat generated upon the total absorption of said particle in a block of matter. EMCal utilizes the properties of scintillation and the photoelectric effect to generate a measurable current from the light emissions of the crystal. Thus, this process alludes to a radiation detector. EMCal using crystal scintillators allows for accurate measurements of the resultant energy from particle collisions, consequently facilitating the identification of new particles generated from the collision. Furthermore, my immediate project aims to examine the performance of a popular crystal scintillator, lead tungstate. Rasmita and I walked through a light yield simulation which I aim to perform independently next week. Light yield is an important characteristic regarding the proficiency of a material as a scintillator. It measures the amount of light generated per unit of radiation energy deposited (units of photoelectrons/eV). The lead tungstate crystals were among other scintillators (glass) and they are superficially very similar; thus, I had to devise a mini-experiment to ensure my chosen crystal for next week is lead tungstate. Knowing the index of refraction for lead tungstate (~2.18), I used a laser to find the critical angle of the crystal (see picture). I found this to be about 27.5 degrees. Using Snell’s Law, I found the refractive index to be 2.166, thus verifying the lead tungstate. Lastly, I’ve been working on a Python program to describe non-relativistic electron-proton elastic scattering. There are several ways to describe scattering, but I’ve chosen to describe it using the differential cross-section, essentially, a measurement of the probability of the impinging particle being scattered at a certain angle. The program uses the Rutherford Scattering formula which is non-relativistic, it does not consider the recoil of the proton, and it only considers the Coulomb interaction of the two particles. Thus, it is ultimately an approximation. However, for experiments run with these assumptions, it proves to be accurate. Looking forward, I look to improve this code by allowing for relativistic energies, considering the recoil energy of the proton, and including quantum mechanical effects like the magnetic field interaction of the particles due to their magnetic moment.