Dark Matter Introduction
Our current model of the universe does not account for the scale of the phenomenon of gravity. The missing mass not yet directly observed has been dubbed “dark matter.”
- Dark matter is thought to make up around 85% of all gravitationally observable matter in the universe.
- This matter is difficult to observe because it does not interact with electromagnetic or strong nuclear forces.
- One school of thought is that dark matter is a new kind of unknown elementary particle, known as a Weakly-Interacting Massive Particle (WIMP).
- Many projects are currently attempting to determine the existence of WIMPs, using techniques such as cryogenic crystals, noble gas and crystal scintillators, and bubble chambers.

Project Overview
The PICO dark matter project seeks to observe interactions between WIMPs and a superheated liquid by examining bubbles formed as a result of those interactions.
- Interactions with other types of known particles (alphas, gammas, neutrons) can also generate bubbles in the chamber.
  ○ Shielding in the form of earth and water is used to minimize these interactions.
  ○ Bubbles caused by known interactions also have certain characteristics (volume, size, multiplicity, etc.) that can be used to classify detections.
- The group working on the PICO project at Pacific Northwest National Lab (PNNL) has built a prototype bubble chamber (top center) on the same principles as the main PICO detector underground at SNOLAB.
  ○ The goal of this prototype detector is to test possible improvements to both the current PICO detector and future models.
  ■ These improvements are elements such as new target liquids and efficient placement of the acoustic sensors.

Simulation of Test Detector
A simulation in Geant4 of the test chamber at PNNL (bottom) is used to calibrate the chamber for the sample sources being used.
- The primary goal of the simulation is to determine the optimal placement of the test sources.
  ○ A Monte Carlo simulation using multiple runs of millions of particles is taken to obtain data for various locations around the detector.
  ○ The simulation produces events which are then sorted using ROOT and organized into graphs (right) in Excel.

Results and Conclusion
The data obtained can be used to efficiently place the Cf-252 detector to achieve the desired number of seconds between events. Currently, the ideal location looks to be either far to the right of the detector or near to the front-left corner. Future work will involve determining how to incorporate the distance related to gamma events into the data obtained. When an accurate estimate is reached, the model will be used to decide which gamma source should be used and where it should best be placed.

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