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Particle Discrimination Using Machine Learning Techniques

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The PICO experiment utilizes a bubble chamber to search for weakly interacting massive particles (WIMPs). Events in the detector generate acoustic signals due to bubble creation caused by energetic incident particles, e.g., alpha particles, neutrons, gammas, or WIMPs. A use of these acoustic signals is to distinguish among the different events triggered by different types of incident particles, more specifically between alphas and neutrons.

One tool being used to make this discrimination is the acoustic parameter (AP). This tool is highly effective and has an accuracy rate of up to 99%, but we do not fully understand how the AP emerges in the signal. Our goal is to use machine learning techniques to better understand how discrimination among signals from different types of incident particles can be modelled, and furthermore learn more about how the bubble grows.

To do this we are designing a gradient boosted decision tree that will distinguish between different types of trigger particles based on specific sets of features found in the signals. The signals used in this analysis will come from both the PICO experiment as well as earlier experiments (specifically PICASSO) which had the same goals but used a superheated droplet technique instead of a bubble chamber. Our work involves finding a group of specific variables that the classification tree can use to obtain accuracy results comparable to a neural network being designed concomitantly by Kyle Yeates (also presenting a talk at CASST 2021), and through those variables be able to explain the physical properties of the signal that can be used to distinguish between different types of particles.

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