Simulation and Design of the next phase of Project 8, a Direct Neutrino Mass Measurement Experiment

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January 4, 2018

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Abstract

The Project 8 experiment seeks to determine the absolute neutrino mass scale via the precise measurement of the electron energy in beta decays. We have developed a novel technique called Cyclotron Radiation Emission Spectroscopy (CRES), which allows single electron detection and characterization through the measurement of cyclotron radiation emitted by magnetically-trapped electrons produced by a gaseous radioactive source. The advantages of this technique include excellent energy resolution and low backgrounds. We present an overview of the Project 8 experimental program, and highlight recent advances in the development of the next phase of Project 8, a "Large Volume Demonstrator" that will be used to validate the technique's scalability. The demonstrator consists of a tritium-filled 200 cm^3 volume, surrounded by magnetic trap coils and antenna arrays, all within an MRI magnet. Experimental parameters like uniform detector coverage and the reduction of Doppler effects are obtained via simulations using High Performance Computing methods. We discuss geometric constraints and design optimizations to maximize SNR at the tritium endpoint energy range. This material is based upon work supported by the U.S. Department of Energy Office of Science, Office of Nuclear Physics under various awards.