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Tue-Af-Po2.23-09 [96]: A 10+ m^3 Ioffe Trap for Project 8

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This work was performed as part of the international Project 8 collaboration. The goal of the Project 8 experiment is to measure the absolute neutrino mass using tritium beta decays, which involves precisely measuring the energies of the beta-decay electrons in the high-energy tail of the spectrum.

To achieve its design sensitivity of $m_\beta \sim 40$ meV, Project 8 has chosen an *atomic* tritium source to eliminate the energy smearing inherent to past and current molecular tritium experiments. The design sensitivity assumes a fiducial population of at least 10^{18} tritium atoms. The second key element which enables this sensitivity is a frequency-based energy measurement invented by Project 8 called Cyclotron Radiation Emission Spectroscopy. The CRES technique, however, has optimal sensitivity at an atom density of 10^{12} cm^{-3}. At this density, 10^{18} atoms occupy 10 m^3.

To prevent recombination of the tritium atoms on the container walls, it is necessary to trap them in a magnetic minimum. The baseline trap depth is $\Delta B = 2$ T, but even this substantial depth can only trap a population of atoms below ~ 30 mK. The atom trapping field minimum simultaneously traps the beta decay electrons. I will discuss a candidate magnetic velocity and state selector to supply a sufficient trappable flux of atoms.

CRES further relies on a highly uniform magnetic field and precise knowledge of that field to convert the measured frequency into the electron energy. Our baseline is a background solenoid field of 1 T and a field uniformity in the fiducial volume of well below 10^{-5}. With a fiducial volume fraction of perhaps 50%, the magnet itself takes on quite sizable proportions. I will discuss a preliminary design for a NbTi superconducting multipole (Ioffe-Pritchard) trap in the context of this large scale as required for a next-generation neutrino mass measurement.

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