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Millikelvin Atomic Tritium for Project 8

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The most powerful technique for directly studying the absolute neutrino mass is spectroscopy of beta-decay electrons at the endpoint of the spectrum. Project 8 has pioneered a new frequency-based method, cyclotron radiation emission spectroscopy (CRES), and intends to reach a sensitivity of 40 meV/c^2.

Replacing the traditional molecular T_2 with atomic T is key to this sensitivity; free from rovibrational energy broadening, atomic T boosts sensitivity 10-30x over a similar molecular experiment. Since tritium atoms recombine into molecules on contact with (most) surfaces, magnetic confinement is key to cooling, slowing, and storing the atoms.

Project 8's atomic system begins with production of a high flux ($> 10^{19}$ s^{-1}) of hot atoms in a 2500 K tungsten capillary. Initial cooling to $\sim$ 30 K follows, using surface collisions. Atoms are then captured in a magnetic evaporative cooling beamline (MECB), which will evaporate away internal energy in the beam while simultaneously converting the forward beam momentum into internal energy for removal by evaporation. This section may be augmented by a cold buffer gas or rotating magnetic elements. Finally, the cold and slow beam of atoms will be guided through a small opening into a > 10 m^3 magneto-gravitaitonal atom trap. Sensitivity calculations show we need a density of $10^{17} - 10^{18}$ m^{-3}, and the trap height sets a maximum temperature of $\sim$ 1 mK. A high-order multipole magnet (100-1000 poles) will confine the atoms radially and at the bottom, leaving the top of the trap open so that excess electrons escape. Compatibility with CRES imposes several coupled requirements on the magnetic design, so joint CRES-atomic design is a major focus of the collaboration.

This contribution will highlight the present status of Project 8's calculation, simulation, and prototyping work on the atomic system and show how these efforts support our design sensitivity to the absolute neutrino mass.

Poster prize

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Project 8 Collaboration

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