Holmium Electron Capture Spectroscopy with Transition Edge Sensors

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Holmium-163 has become the center of attention for the determination of the kinematic mass of the electron neutrino using microcalorimeters. Holmium-163 is a rare, unusual, synthetic isotope that decays purely by electron capture. The very low total nuclear decay energy (QEC<3 keV) and reasonable half life (4570 years) 163Ho, make it attractive for high precision electron-capture spectroscopy (ECS) near the kinematic endpoint (where the neutrino momentum goes to zero). In the ECS approach, an electron-capture-decaying isotope is embedded directly and completely inside a microcalorimeter designed to capture and measure the energy of all the decay radiation except that of the escaping neutrino. Future studies of the ECS endpoint region with large sensor arrays are planned to measure or put limits on the neutrino kinematic mass. The central challenges for this approach are: isotope production and purification;

incorporation of 163Ho into sensors; high resolution spectroscopy of electron capture decays; independent measurement of QEC; and a complete understanding of the nuclear and atomic physics to determine the neutrino kinematic mass. We have developed the production of 163Ho using proton irradiation of isotopically natural dysprosium targets with both a low-beam-current cyclotron (University of Wisconsin, Madison) and a much higher current proton accelerator (Los Alamos National Laboratory Isotope Production Facility). We performed 163Ho purification with high performance liquid chromatography, producing nanogram scale isotope samples. Over the last two years we have successfully demonstrated the incorporation the 163Ho in absorbers attached to transition-edge-sensor microcalorimeters, and we have measured 163Ho spectra of the M and N line pairs. We will present a detailed discussion of the spectral resolution, line separation and counting statistics depending on the initial target material, purification methods and incorporation techniques.

References:
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