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Production, purification, and analysis of a Ho-163 sample for the neutrino mass determination

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The ECHO collaboration investigates the electron capture decay (EC) of Ho-163 for determining the mass of the electron neutrino. The spectrum of the EC is recorded by metallic magnetic calorimeters (MMC) and the neutrino mass is deduced from the analysis of the endpoint region of the spectrum. The required Ho-163 samples are produced by reactor activation of enriched Er-162. By ion exchange chromatography a pure Ho fraction can be obtained, leaving Ho-166m as the only remaining long-lived contamination. Resonance ionization at the RISIKO mass separator offers a suitable method to further purify the sample and to implant Ho-163 into the calorimeters in a single step. This method results in no radioactive co-implants beyond a fraction of 1 ppb with respect to Ho-163. In addition to the calorimetric spectrum, an independent measurement of the EC Q-value by high-precision Penning-trap mass spectrometry is necessary to quantify systematics such as solid state effects. Ion production from samples with only 10^{16} atoms was studied at TRIGA TRAP using an improved laser ablation ion source. Determination of the Q-value was demonstrated and the uncertainty of the atomic masses of Ho-163 and Dy-163 improved by a factor of two compared to literature. This know-how can now be used at SHIPTRAP to perform the measurements on a 50 eV uncertainty level, thus providing the very important input for the ECHO project.

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