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Optimizing Lanthanide Accelerator Mass Spectrometry for its use in Nuclear Data Production

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Accelerator Mass Spectrometry (AMS) is traditionally applied to radiocarbon dating, and cosmogenic nuclides but has the capability of analyzing lanthanides [1], [2]. Lanthanides prove difficult to measure via AMS due to their inherent contamination with each other and the isobar suppression limits of the system. This study aims to develop a sensitive technique for measuring lanthanides via Accelerator Mass Spectrometry at the SUERC AMS Laboratory. AMS measurements of lanthanide reaction products from neutron and charge particle reactions will provide nuclear data that is of interest to the nuclear data community, that is currently unmeasurable by standard decay spectroscopy [3]. The method development includes ion source characterisation, radiochemistry, accelerator optimization and detector development for the rare earth elements (REE).

The initial exploration determined baseline low energy mass scans for all REE in oxide form. The optimal starting material was determined by collecting mass scans of varying REE starting samples. The counterions (oxide, fluoride), mixtures of calcium fluoride, metal binders (niobium, silver) and cathode material (aluminum and copper) were altered to determine the effect on the current output. The general trend showed that samples performed better when in an oxide:niobium, 1:2 ratio in an aluminum cathode. All data is applied to a machine learning algorithm that predicts ion current, starting sample and ranks feature importance for the model.

The 5 MV tandem accelerator was used to explore high energy mass scans of the top five performing REE from the low energy system. This provided insight on the length of irradiation needed, ion efficiency, and the purity required to get a well resolved ratio of reaction products and therefore relative cross section measurement at the final detector. High energy data will be used alongside gas stopping simulations to determine the expected energy deposits in the final detector along with any changes that need to be made to the detector.

[1] L. K. Fifield, "Accelerator mass spectrometry and its applications,"Reports on Progress in Physics, vol. 62, p. 1223, Aug 1999.
[2] R. Middleton, A Negative-Ion Cookbook. Department of Physics, University of Pennsylvania, 1989.
[3] T. Wright, S. Bennett, S. Heinitz, U. Koester, R. Mills, T. Soldner, P. Steier, A. Wallner, and T. Wieninger, "Measurement of the 13c(n,γ) thermal cross section via neutron irradiation and AMS,"The European Physical Journal A, vol. 55, 11 2019

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