Detecting β-delayed neutron emission using Recoil-ion spectroscopy

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In nuclear β decay, β-delayed neutron (βn) emission is a viable process if the Q_β value of the parent (*precursor*) nucleus is greater than the neutron separation energy S_n in the daughter (*emitter*) nucleus, making it a common decay mode in neutron-rich nuclei. The lack of experimental βn data is being addressed with experimental efforts at radioactive ion facilities worldwide, including recoil-ion time-of-flight spectroscopy.

The use of trapped ions for βn spectroscopy is a relatively new and powerful technique. By design this technique avoids any difficulties inherent in neutron detection, but instead infers all neutron information from a distinct signature of the recoiling emitter nucleus. The Beta-decay Paul Trap (BPT) at Argonne National Laboratory (ANL) is used to confine ions to a small volume (~1 mm^3) and decay products are detected by a simple detector system. From the detection of the β, the recoiling nucleus and any γ rays, β decay can be distinguished from βn decay, and a neutron energy spectrum can be inferred. The measurements are relatively low in background and can potentially be made with beam intensities as low as ~0.1 ions/s, which opens up a wide range of exotic nuclei for study.

Following the success of this technique with the BPT, the next generation of trap and detector array for recoil-ion time-of-flight spectroscopy has been designed for use with beams from the CAlifornium Rare Isotope Breeder Upgrade (CARIBU) at ANL, and has been fully funded by the US DOE Office of Nuclear Physics. The BEtA-Recoil ion trap, or BEARtrap, is a dedicated setup, which incorporates improvements on the BPT that have been investigated using simulations with GEANT4 and SimIon.

This talk will discuss details of this technique and present the various physical phenomena that influence the reconstruction of the βn energy inferred from the trapped ion technique. The finalized design of BEARtrap will be presented, including results from simulations, and details of approved upcoming experiments and future prospects.