Decay spectroscopy in exotic neutron-rich nuclei near the $N = 50$ shell closure

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β-decay and β-delayed neutron emission play key roles in determining the final elemental abundances of the rapid neutron-capture (r-) process. Current r-process models rely heavily on theoretical data but, with new generations of radioactive ion beam facilities coming online, swaths of neutron-rich nuclei will become available for experimental study. Delayed neutron emission is expected to be the dominant decay mode for these newly-accessible nuclei and has been shown to be crucial in determining r-process abundances.[1)]

In 2016, the BRIKEN collaboration constructed and commissioned the world's most efficient β-delayed neutron detector[2,3)] at RIBF to conduct a wide-ranging and systematic study into the decay properties of hundreds of the most exotic neutron-rich nuclei currently available. The BRIKEN detector consists of 140 ^{3}He tubes within a HDPE moderator surrounding the highly-segmented active stopper AIDA[4)] and two HPGe clover detectors in close geometry.

The NP1412-RIBF127R1 experiment implemented the BRIKEN detector to measure β-delayed neutron emission probabilities and half-lives, as well as conduct decay spectroscopy studies, around the $N = 50$ shell closure near the doubly-magic ^{78}Ni. This region has been highlighted as sensitive to β-decay properties,[5)] however, little to no spectroscopy data exist in this region.

The TRIUMF-based analysis focuses on γ-ray decay spectroscopy of $^{85-90}$Ge, $^{88-92}$As, $^{91-95}$Se and $^{94-97}$Br isotopes, with some high-statistics known cases at lighter masses studied for calibration. During the experiment, approximately $7.5 \cdot 10^{4}$ ^{85}Ge nuclei and $5.75 \cdot 10^{6}$ ^{86}Ge nuclei were implanted into AIDA. Figures 1 and 2 show preliminary decay spectra for the de-excitation of states within ^{85}As and ^{86}As, chosen as two of the few isotopes in this region with any previous spectroscopic data and also relatively high statistics.

With approximately two orders of magnitude fewer ^{85}Ge implants compared to ^{86}Ge, a significant fraction of the decays to ^{85}As are expected to come from the βn decay of ^{86}Ge, with its P_{1n} value of 45%.[6)]

Many of the peaks identified in ^{85,86}As by Mazzocchi *et al.*[7)] are labelled in the spectra, as well as peaks identified from decays into the daughter nuclei ^{85,86}Se.[8,9)]

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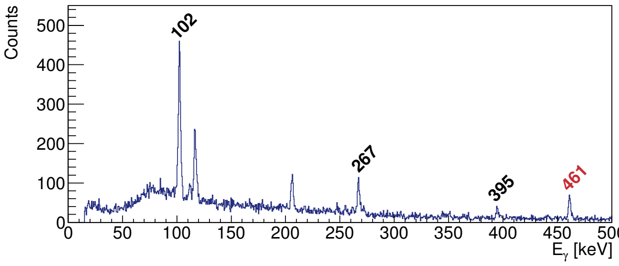

Fig. 1. Preliminary γ-spectrum for decays into ^{85}As, considering both β- and βxn-decay modes from parent nuclei. Known peaks in ^{85}As are labelled in black and peaks identified from the decay of ^{85}As into ^{85}Se are in red.

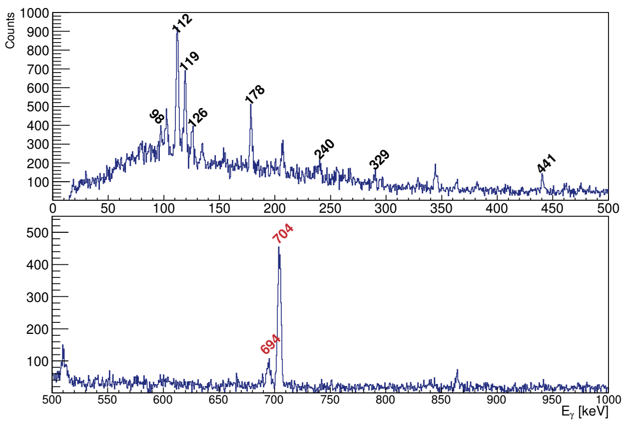

Fig. 2. Preliminary γ-spectrum for decays into ^{86}As, considering both β- and βxn-decay modes from parent nuclei. Known peaks in ^{86}As are labelled in black and peaks identified from the decay of ^{86}As into ^{86}Se are in red.

Analysis of the Ge, As, Se and Br isotopes of interest is on-going and we expect to obtain the first spectroscopic data for some of these isotopes.

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