β and β-n decay of $^{131-135}$In

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The shell-model is often central to our understanding of basic nuclear structure and allows many properties of nuclei in the vicinity of closed shells to be reliably described. Two ingredients are necessary for shell-model calculations; two-body matrix elements, describing the interactions between nucleons in the chosen valence space, and single-particle energies. While the former are often derived via a range of sophisticated methods the latter are taken from experimental data on single valence nucleon nuclei, if possible.

Studies of the nuclei near ^{132}Sn offer a rare opportunity to test the effective interactions used in shell-model calculations in a heavy, neutron-rich region. Nearly all single-particle energies are accurately known here, with the exception of the $\nu i_{13/2}$ and $\pi s_{1/2}$ states in ^{133}Sn and ^{133}Sb respectively. We have studied the β and β-n decays of ^{133,134}In to search for the former level in ^{133}Sn and more generally to study excited states in the semi-magic Sn nuclei. Such studies often allow the neutron-neutron part of the effective interaction to be examined, as performed recently for ^{134,136,138}Sn, using μs isomer-decay data from the present experiment[1)]. New information on the β-decaying states of the parent indium nuclei has also been obtained in the present work.

The experiment was performed at the F11 focal plane of the BigRIPS spectrometer of RIBF. The in-flight fission of a 345-MeV/nucleon ^{238}U beam was used to produce $^{131-135}$In ions, along with others, with sufficient intensity for ion–$\beta-\gamma$ spectroscopy studies. The detectors of the BigRIPS spectrometer allowed these ions to be identified according to their Z and mass-to-ionic-charge ratios before they were implanted in the WAS3ABi stopper, which was situated at the F11 focal plane. The high segmentation of the WAS3ABi stopper allowed detected β decays to be correlated with identified and implanted ions. The EURICA Ge array was used to detect any γ rays emitted following the β decay of identified $^{131-135}$In ions. Use of ion–$\beta-\gamma$ and occasionally ion–$\beta-\gamma-\gamma$ coincidences allowed decay schemes, half-lives and β-delayed neutron values (P_n) to be obtained. More details on the experimental setup can be found in Ref.[2)].

Excited states in the one-valence-neutron nucleus ^{133}Sn have been populated via the β and β-n decay of ^{133,134}In, respectively. This has allowed a search for the decay of the $13/2^+$ state in ^{133}Sn and for the energies of some previously reported states to be confirmed.

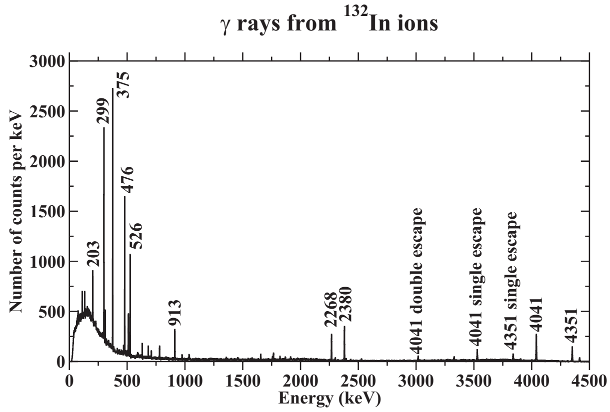

Fig. 1. Spectrum of γ rays obtained from the β decay of ^{132}In. Strong previously reported decays are present[4)].

A first γ ray has been tentatively assigned to ^{135}Sn and a level scheme of ^{134}Sn has been obtained from the β decay of ^{134}In for the first time. This has allowed the limits of the ground-state spin of latter nucleus to reduced. Inconsistencies have also been found between the level schemes of two neutron-rich Sn isotopes obtained in the present work and those previously reported, raising questions about several spin/parity assignments.

The ground-state half-lives of $^{131-135}$In have been measured, along with those of any β-decaying isomers, via ion–$\beta-\gamma$ coincidences. There are some discrepancies between the half-lives measured using this technique and those obtained from only ion–β correlations [3)] and values found elsewhere in the literature[4)].

An examination of the γ-ray intensities in the daughter Sn and grand-daughter Sb nuclei, populated via β decay, has allowed preliminary P_n values for the indium parent and grandparent nuclei to be obtained. This includes the first P_n measurement for ^{135}In. These preliminary values still require corrections to account for reactions occurring between the last particle detector in BigRIPS and the ions being stopped in WAS3ABi.

References
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