Excited states of $^{136-138}$Sb from β decay

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The properties of nuclei close to the doubly magic ^{132}Sn, with $N \geq 82$, have some of the highest impact on the final r-process abundances[1,2]. Studies of the nuclear structure of the nuclei $^{135-139}$Sb can therefore provide important input into r-process calculations, especially as the exact site of this astrophysical reaction is presently unclear. The nucleus ^{135}Sb is the most neutron-rich one currently whose excited states have been studied via β decay[3].

The Sb nuclei have one valence proton with respect to the $Z = 50$ shell closure hence their nuclear structure can provide a sensitive test of the neutron-proton part of the effective interactions used in shell-model calculations. The predicted structure of these nuclei can vary considerably, depending on the effective interaction used. Recently it has been shown that weaker neutron pairing may be necessary to reproduce the features of the Sn nuclei beyond $N = 82$[4]. An interesting consequence of weak pairing is the appearance of low-lying seniority-4 neutron states in ^{137}Sb which has been predicted to cause a rapid compression and considerable mixing, of the low-lying excited states in this nucleus[5]. A consequence of this is that levels with $\pi s_{1/2}$ and $\pi d_{3/2}$ components predicted at energies above 2 MeV in ^{135}Sb may be found at energies below 500 keV in ^{137}Sb.

In order to investigate the structure of the nuclei $^{136-138}$Sb in-flight fission of a 345-MeV/nucleon ^{238}U beam was performed at RIBF. Ions including $^{135-139}$Sn were selected using the BigRIPS spectrometer and implanted in the WAS3ABI stopper, situated at the F11 focal plane. The high segmentation of the WAS3ABI stopper allows 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 $^{135-139}$Sn ions. Use of ion–$\beta-\gamma$ and ion–$\beta-\gamma-\gamma$ coincidences has allowed new level schemes to be established for the nuclei $^{136-138}$Sb.

When adding neutrons beyond the $N = 82$ shell closure the probability for $\beta-n$ emission increases rapidly to values of > 50 %. Therefore performing only an ion–$\beta-\gamma$ coincidences is not sufficient to assign a detected γ ray to a particular nucleus. Common transitions emitted from parent isotopes with masses A and $A+1$ can be assigned to a daugher nucleus with mass A. Gates set on strongly produced transitions along with observed γ decays in grand-daugher nuclei in the same event allow masses to be assigned too. This is thanks to the high granularity and efficiency of the WAS3ABI and EURICA arrays.

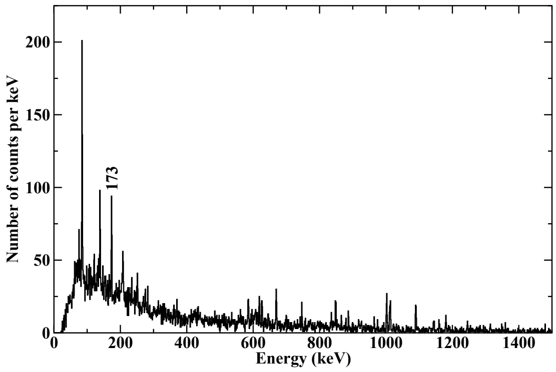

Fig. 1. Spectrum of γ rays obtained from the β and $\beta - n$ decay of ^{137}Sn.

An example of such analysis is shown in Fig. 1, which shows a portion of the γ-rays detected following the β and $\beta - n$ decay of ^{137}Sn. The 173-keV transition has previously been assigned to ^{136}Sb via isomer spectroscopy[6].

Analysis of the decays of the nuclei $^{136-138}$Sn and hence first level schemes for the isotopes $^{136-138}$Sb is nearing completion. Comparisons with the predictions of shell-model calculations will also aid in assigning spins.

References
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