First attempt at in-beam γ-ray spectroscopy of ^{100}Sn

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The study of the heaviest self-conjugate exotic doubly magic nucleus ^{100}Sn and the single-particle nature of its neighboring nuclei are of great importance to the fundamental understanding of nuclear structure and the astrophysical *rp*-process path. Owing to the low production rate, no spectroscopic information, except β-decay, has been measured for ^{100}Sn so far. As one of the first observables for nuclear structure, we aim at the measurement of the first 2^+ state of ^{100}Sn, which indicates the strength of the $N = Z = 50$ shell closures. A proposal was made to populate the excited states from neutron-removal reations of heavier Sn isotopes to perform an in-beam γ-ray spectroscopy measurement.[1)] In order to properly estimate the beam time required, the production cross sections for ^{100}Sn through secondary fragmentation reactions need to be known. We performed an experiment with a beam time of 4 days to measure the production cross sections of ^{100}Sn produced in neutron-removal reations from ^{101,102}Sn.

A ^{124}Xe primary beam at 345 MeV/nucleon was provided by SRC with an average intensity of ∼140 pnA. The beam impinged on a 5-mm-thick ^{9}Be target to produce radioactive beams containing neutron-deficient Sn isotopes with the BigRIPS separator. It was tuned to center on ^{101}Sn nuclei while accepting ^{102}Sn simultaneously. Average beam intensities in front of the secondary targets were 2 pps and 27.5 pps for ^{101,102}Sn. A 5-mm-thick CH_2 target and a 3-mm-thick C target were used to induce the $1n$- and $2n$-removal reactions of ^{101,102}Sn on C and H. The beam particles and reaction products were identified with the BigRIPS and ZeroDegree spectrometers, respectively, via the measurements of $B\rho$, ΔE, and ToF on an event-by-event basis. The beam energies were measured to be ∼173 MeV/nucleon in BigRIPS and only ∼98 MeV/nucleon in ZeroDegree. The DALI2$^+$ high-efficiency γ-detection array[2)] was employed to detect the γ rays emitted in flight from reaction products in the vicinity of ^{100}Sn.

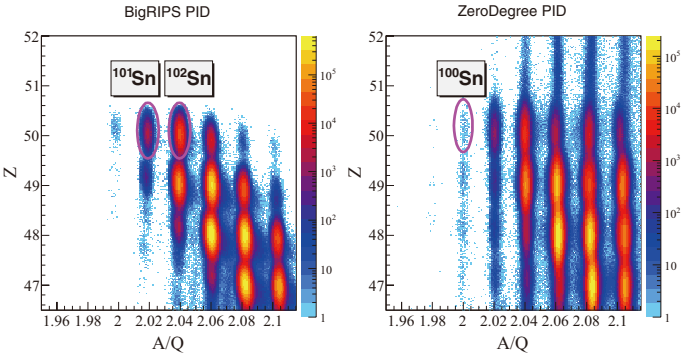

Fig. 1. BigRIPS particle identification (left) and ZeroDegree particle identification (right). The isotopes ^{101,102}Sn are selected in BigRIPS, while ^{100}Sn is selected in ZeroDegree.

Table 1. Number of identified events and rates.

	5 mm CH_2	3 mm C
$-1n$: ^{101}Sn→ ^{100}Sn^{50+}	53 (1.3/h)	40 (1.0/h)
$-2n$: ^{102}Sn→ ^{100}Sn^{50+}	42 (1.0/h)	30 (0.8/h)

The particle identification plots of BigRIPS and ZeroDegree are shown in Fig. 1. Data were accumulated for 41 h on a CH_2 target and 38 h on a C target. The total numbers and counting rates of fully stripped ^{100}Sn produced by $1n$- and $2n$-removal reactions are summarized in Table 1.

The cross sections on the C target were determined from the number of incident projectiles, the number of reaction products identified in ZeroDegree, the atom number in the target, as well as the ZeroDegree transmission and acceptance measured in the same setting. The cross sections on H were determined using the data with the CH_2 target, subtracting the contribution measured on the C target, after normalization. To maximize the statistics, hydrogen-like charge states of ^{100}Sn in the ZeroDegree were considered to be used in $1n$-removal reactions. Preliminary values for cross sections have been obtained. Several new γ transitions were also observed in this region. Detailed analyses for cross sections and γ spectroscopy are ongoing.

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