Study of ^{130}Sn(d,p) reaction in inverse kinematics for r-process nucleosynthesis

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The r-process nucleosynthesis is a major origin of heavy elements beyond iron. Because of rich neutrons in explosive astrophysical conditions, neutron-rich radioactive isotopes (RIs) are involved in the r-process. Though the scenario of the r-process was proposed more than fifty years ago, the astrophysical sites of the r-process are still one of the biggest problems in physics. Nucleosynthesis simulations require precise nuclear-physics inputs such as β decay rates, masses of the nuclei, and neutron capture rates, which can constrain the astrophysical conditions. However, as the neutron targets are not available yet, it is impossible to measure the capture cross sections and related rates directly. In the case of the compound neutron-capture rates, since there are significant uncertainties in the level density of the unbound state and the γ emission probability from the highly excited state, the cross sections differ by more than one order of the magnitude even in the statistical model calculations.

We have evaluated the neutron capture reaction rate on ^{79}Se with the surrogate reaction of ^{79}Se(d,p) in inverse kinematics, where the γ emission probabilities in the unbound states of ^{80}Se have been determined by measuring the residual nuclei without detecting the γ rays.[1)] The present study aims to determine the neutron capture rate on ^{130}Sn via (d,p) reaction with a ^{130}Sn beam. In addition, to evaluate the systematic error of the method, (d,p) reactions on ^{130}Te and ^{124}Sn were also measured.

The experiment was conducted at the OEDO beamline at RIBF. The cocktail beam including ^{130}Sn was produced by the in-flight fission of ^{238}U at 345 MeV/nucleon. The energy of the beam from F3 to FE9 was chosen to be around 170 MeV/nucleon. RI beams were identified by the $B\rho$-TOF method. Figure 1 shows the particle identification (PID) map of the secondary beam, demonstrating that ^{130}Sn beam is well separated from the other isotopes. Thanks to the new optics developed in the MS22-1 and described elsewhere in this volume, the transmission between F3 and FE9 was improved to be 85% for the beam with the F1 momentum slit of $\pm 0.5\%$. The energy of the cocktail beam was further degraded to 20 MeV/nucleon by a combination of the angle-tunable degrader and a flat degrader.

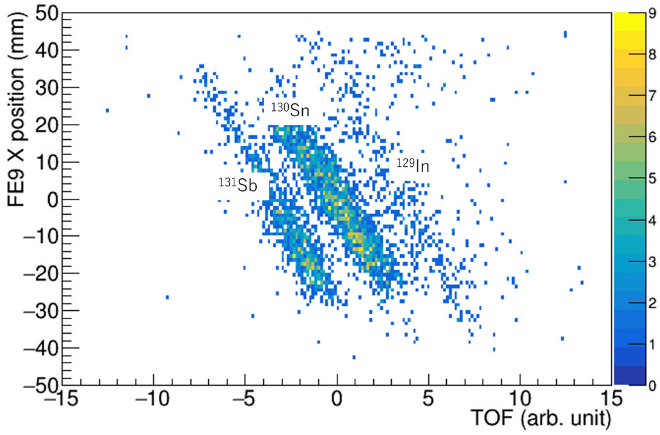

Fig. 1. PID map of the secondary beams at FE9. See the text for details.

The ^{130}Sn beam of around 150 kcps was focused on the secondary target of 287 μg/cm^2-thick deuterated polyethylene. The recoil protons were detected by the TiNA2 array which was composed of four TTT double-sided square-shape Si detectors, six YY1 single-sided sector-shape Si detectors, and sixteen CsI(Tl) detectors. The four CsI(Tl) were placed behind each TTT to measure the ΔE-E correlation of the charged particles. The outgoing residual nuclei were momentum-analyzed by the D1 magnet of the SHARAQ spectrometer. Two SR-PPACs and an ionization chamber were installed at the final focal plane to identify the residual nuclei. Analysis of the data is on going.

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Reference

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