Measurement of β-delayed neutron emission probabilities for progenitors of the $A = 130$ r-process abundance peak

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The first observation of a merger of two neutron stars,[1)] with both gravitational and electromagnetic wave signals, offers tantalizing opportunities to finally identify the astrophysical site of the r-process. The new observations will increase the demand for precise nuclear data necessary to reach a detailed understanding of the r-process mechanism. The r-process abundance peak around $A = 130$ is of particular interest because its shape and position is very sensitive to the the neutron-richness of the astrophysical environment, as its formation reflects the break-out of the reaction flow from the $N = 82$ classical waiting point isotopes. However, the effect on the final r-process abundance is obscured by a numbers of β-delayed neutron emitters along the decay path back to stability. In fact, the β-delayed neutron emission probabilities (P_n values) in the region south-east of ^{132}Sn have a most pronounced effect on the final r-process abundance, according to the recent sensitivity study in Ref. 2).

In June 2017, we have performed an experiment to study the decay properties of the β-delayed neutron emitters in the mass region $A = 130$ near the doubly magic nucleus ^{132}Sn. These neutron-rich isotopes were produced by the projectile fragmentation of a 345 MeV/nucleon ^{238}U beam on a Be target, before being purified and identified by the BigRIPS spectrometer. They were then transported through the Zero-degree spectrometer to reach the decay station located at the F11 focal plane. In the decay station, the active stopper array AIDA[3)] was placed at a central position for the implantation of nuclei of interested, and it detected their subsequent β decay. The AIDA detector is a stack of six 8×8 cm^2 DSSDs with 128×128 pixels each. Neutrons emitted from the β decay of ions implanted in AIDA were detected by the BRIKEN neutron detector array[4)] consisting of 140 gas-filled ^{3}He counters, which were inside a large moderation block made of high-density polyethylene. In addition, two clover-type high-purity Germanium detectors were employed to measure β-delayed and isomeric γ rays.

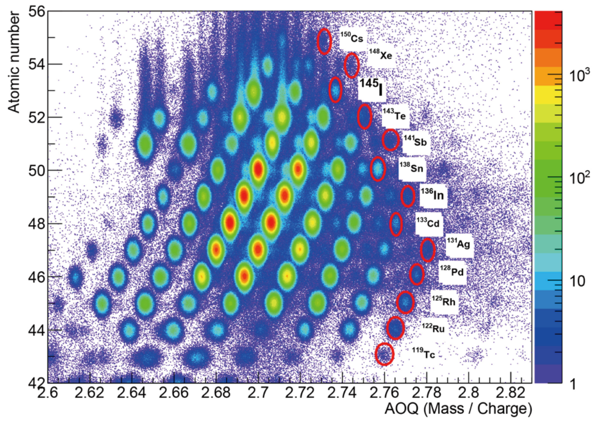

Fig. 1. Particle identification plot for isotopes transported to the decay station at F11, indicating the most neutron-rich isotopes for each element.

The particle identification plot combining data of the two settings of the experiment, centered at ^{130}Ag and ^{140}Xe, is shown in Fig. 1. The data analysis is ongoing. Preliminary results indicate that new or improved measurements of P_n values will be obtained for over 40 isotopes, and for 11 isotopes in the case of half-lives. These new measurements would make a significant contribution to the available experimental data for r-process models.

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