Role of ^{66}Se in the *rp*-process nucleosynthesis in type I X-ray bursts

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The important role of ^{66}Se in the dynamics of the *rp*-process occuring in type I X-ray bursts was pointed out by several theoretical studies.[1,2] The resonant proton capture reaction ^{65}As$(p,\gamma)^{66}$Se can provide a potential breakout path from the waiting-point nucleus ^{64}Ge. Theoretical variations of the rate of this reaction predict a dramatic effect on the resulting chemical abundances and light curves of the X-ray bursts, while the experimental constrains have not yet been well established.

The experiment NP1406-SAMURAI24 was conducted in March 2019 to measure the time-reversal process, namely one- and two-proton emission from the unbound states of ^{66}Se populated by neutron removal from a ^{67}Se projectile at 250 MeV/nucleon in a carbon target. A secondary beam of ^{67}Se was obtained by the fragmentation of the primary ^{78}Kr beam at 345 MeV/nucleon from SRC in a 2 mm Be target. The secondary ^{67}Se beam intensity at the end of BigRIPS was on the order of 10^3 pps with a purity of approximately 10%.

A schematic of the experimental setup at SAMURAI is shown in Fig. 1. Two carbon targets with thicknesses of 0.425 mm and 2 mm were used inside the CATANA gamma detector[3)] followed by an array of GLAST-type[4)] silicons-strip detectors (SSDs) for coincident measurements of the forward-focused protons and heavy fragments. The SSDs are equipped with dedicated dual-gain ASIC preamplifiers.[5,6)] In addition, two drift chambers (FDC0 and FDC1) are placed behind the SSDs for tracking the fragments. The SAMURAI spectrometer is used to separate the reaction products and direct them into corresponding tracking systems. Protons are measured by two drift chambers (PDCs) and a hodoscope (HODP), and heavy fragments are measured by two other drift chambers (FDC2k and FDC3k) and a hodoscope (HODS).

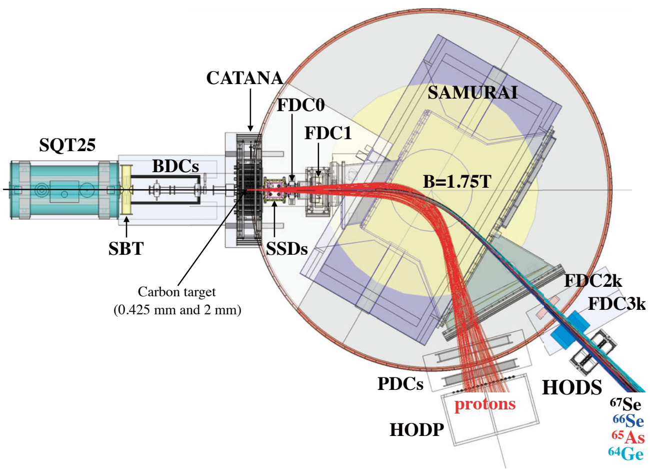

Fig. 1. The experimental setup in NP1406-SAMURAI24.

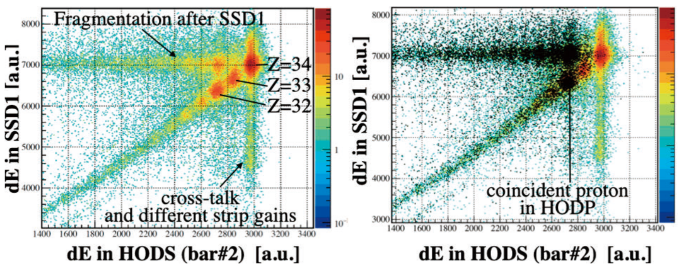

Fig. 2. Charge identification of outgoing fragments in the first SSD and in HODS.

Figure 2 shows an example of coincident charge identification of the heavy fragments in the first SSD behind the target and in one scintillating bar of HODS with a cut on the ^{67}Se projectile. Secondary fragmentation occurring in the beamline materials downstream of the target can be clearly identified. The events on the diagonal line indicate the reactions that occur in the target. The right panel of Fig. 2 shows the overlap of the same correlation plot with an additional condition on the coincident proton signal in HODP (black dots). Further analysis of the experimental data is ongoing.

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