Reduction in contaminants originating from primary beam by using beam stoppers in GARIS-II

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An apparatus consisting of a multireflection time-of-flight mass spectrograph (MRTOF-MS) and a gas-filled recoil ion separator GARIS-II[1] has been developed to measure the masses of superheavy elements[2]. The MRTOF-MS is connected to GARIS-II via a gas cell and an ion transport system. It is known that the ion extraction efficiency of the gas cell decreases as the incoming rate increases[3]. If some charge states of the primary beam have $B\rho$-values that are close to the target nuclide's values, the gas cell efficiency could be drastically reduced by the huge contaminants and space charge. In addition, the intense contaminant beam could lead to breakage of the thin Mylar window foils located at both the exit of GARIS-II and the gas cell entrance.

To avoid this situation, two water-cooled primary beam stoppers, Stopper1 and Stopper2, were installed in the first dipole (D1) of GARIS-II as shown in Fig. 1. Stopper1 installed at the entrance of the D1 chamber consisted of a copper plate of 80 mm width and 30 mm height and could vary its effective area to the beam by rotating. Stopper2, located near the D1 chamber exit, was made of a 400 mm wide and 60 mm high copper board mounted on a linear manipulator to change its position, and had tantalum fins on its surface to prevent scattering of the colliding particles.

The performance of the both stoppers was evaluated by using the ^{208}Pb(^{18}O, 3n) ^{223}Th reaction. In this reaction, the 4+ state of the ^{18}O beam after the targets has a $B\rho$-value that is close to the optimum one for ^{223}Th. A silicon detector array was employed to count both the incoming ^{223}Th and the contaminants at the GARIS-II focal plane. The primary beam was chopped to measure the α-decay from ^{223}Th in low background conditions. The evaluation results are shown in Fig. 2. An intensity ratio of contaminants to ^{223}Th of $\sim$20 was reached without both stoppers. As the Stopper1 effective area began to increase, the intensity of the contaminants rapidly decreased, in contrast with the ^{223}Th counting rate, which varied gradually (Fig. 2 (top)). As a result, we could suppress $\sim$95% of the contaminants from reaching the focal plane by using Stopper1, while $\sim$80% of ^{223}Th was still transported. The same measurements were conducted by changing the Stopper2 position as shown in Fig. 2 (bottom). When measuring the Stopper2 performance, the Stopper1 effective area was set to the maximum value: 2400 mm^2. The Stopper2 measurement shows results similar to those obtained with Stopper1. Thus, we can improve the signal noise ratio up to $\sim$250 times higher than before by using both stoppers.

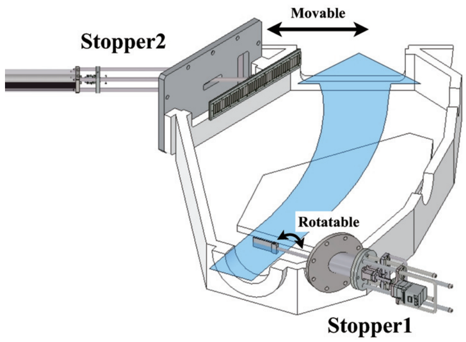

Fig. 1. Schematic view of the primary beam stoppers. The D1 chamber is shown as a cross-sectional view. The blue arrow indicates the beam direction.

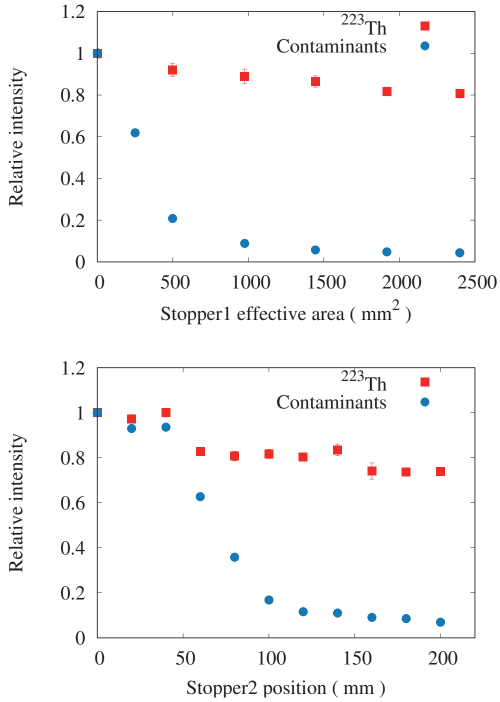

Fig. 2. Results of both stoppers' performance evaluations. The figures indicate the dependencies of the counting rates on the Stopper1 effective area (top) and on the Stopper2 position (bottom).

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