The extraction test aiming for the laser spectroscopy of actinoid elements by PALIS

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The laser spectroscopy of actinide RIs offers an opportunity to study atomic/nuclear structure in terms of relativistic effects, nuclear shell effects, deformations *etc*. The BigRIPS provides a wide variety of actinide RI-beams by using in-flight projectile fragmentation of uranium. In this year, we were granted 24 hours beam time for the extraction test of actinide isotopes and simultaneously performing a commissioning test for the low-energy RI-beam production system by laser ionization(PALIS),[1] in a director's beam times.

During the beam time, the BigRIPS optics were taken over from the previous beam user's setup. The main beam optics was ^{225}Ac ($T_{1/2}$ = 10 d), which was expedient for the extraction test of actinides. However as the half-life of ^{225}Ac was too long to measure for our experimental setup, we fully opened the F1 slits at BigRIPS to obtain more yield of the relatively short-lived ^{223}Ac ($T_{1/2}$ = 2.1 min). Figure 1 shows the expected RI-beams and its intensity which were implanted to the PALIS gas cell, simulated by LISE.

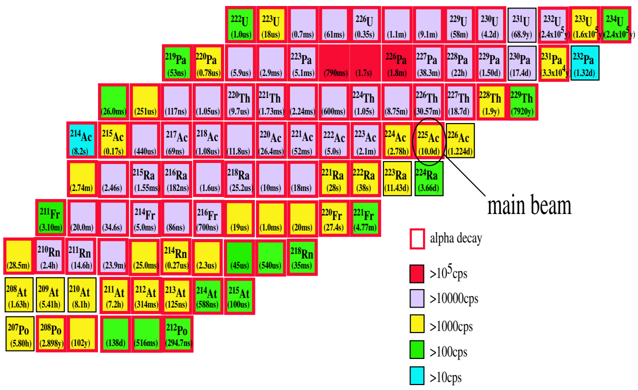

Fig. 1. Expected RI-beams and its beam intensity (primary beam 1 particle nA, fully opened F1 slits) by LISE.

To confirm the low-energy RI-beam extraction, the α-rays produced via α decays were detected at the silicon detector, which was placed in the differential pumping area at the PALIS, as shown in Fig. 2. The stopped and extracted RIs from the gas cell were transported through the sextupole and quadrupole ion beam guides, respectively, and then deposited to the surface of the silicon detector. To reduce the background, the beam was stopped during α-ray measurement.

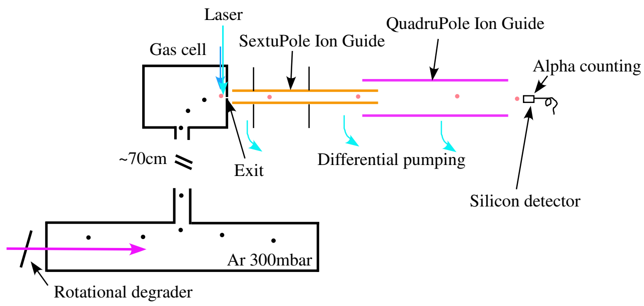

Fig. 2. PALIS experimental setup.

Figure 3 shows the energy spectra of detected alpha particles, taken with a primary beam intensity of 10 particle nA and implantation/measurement period of 300 s each. The rate enhancement of the alpha counting by laser effect was not clearly confirmed, implying that the extracted alpha emitters were ions that survived against neutralization inside the gas cell. The insensitivity of the laser effect is attributed to the impossibility of identifying only ^{223}Ac from the superimposed α-ray's spectra by many types of α emitters, which hindered the optimization of the proper degrader thickness for ^{223}Ac. In addition, the evaluation of laser effect was distorted by other alpha-rays. Next we will utilize a precise mass identification device for extracted RIs.

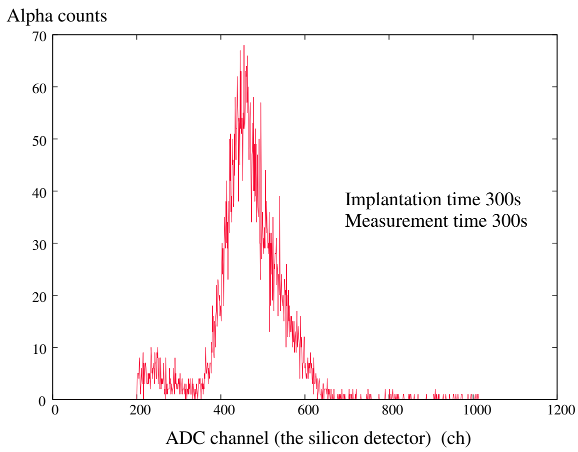

Fig. 3. Observed alpha spectra at silicon detector.

We successfully observed the extracted RIs as a low-energy RI-beam. The efficiency improvement and the installation of the mass identification are in progress.

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Reference
1) T. Sonoda *et al.*, Prog. Theor. Exp. Phys. **113**, D02 (2019).