Extraction test of stopped Bi isotopes in PALIS gas cell

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We are developing a scheme of parasitic low-energy RI-beam production (PALIS)[1)] in the second focal chamber (F2) of BigRIPS to effectively use rare isotopes and to perform comprehensive measurements of the physical properties of exotic nuclei.

In our previous experiment,[2)] we confirmed the feasibility of a new gas-cell geometry that separates high- and low-radiation areas with a long gas tube. The current setup for the PALIS on-line examination evaluates RI extraction by detecting alpha rays via alpha-emitter decay, which results in enhanced sensitivity because of the extremely low background environment. While the alpha-emitter element should be available on resonant laser ionization in an off-line or on-line experiment. Therefore, we chose a bismuth (^{191}Bi) beam that can be produced by projectile fragmentation via a uranium beam and beryllium target. In a 12 hours online PALIS experiment, we focused on two objectives: 1) identify the stopped Bi isotope and 2) extract the stopped Bi isotope from the gas cell.

To achieve the first objective, we observed alpha rays created via decays from the alpha emitters that were stopped in the ΔE solid-state detector (SSD) placed in front of the gas cell by adjusting the energy degrader, as shown in Fig. 1. As the energy resolution was considerably low because of the high electrical background at F2, isotope identification by alpha energy (E_α) was impossible from this energy spectrum. However, we obtained other information from the timing chart by using a pulsed BigRIPS beam. The half-lives extrapolated by decay fitting to individual timing charts for specific energy ranges were 42.12 ± 4.66 s (5.4–6.1 MeV), 11.87 ± 0.73 s (6.1–6.6 MeV) and 7.7 ± 0.3 s (6.6–7.5 MeV). The tentative isotope candidates for these half-lives are ^{192}Bi ($T_{1/2} = 39.6$ s, $E_\alpha = 6060$ keV), ^{191}Bi ($T_{1/2} = 12.4$ s, $E_\alpha = 6309$ keV), and ^{190}Bi ($T_{1/2} = 6.4$ s, $E_\alpha = 6456$ keV).

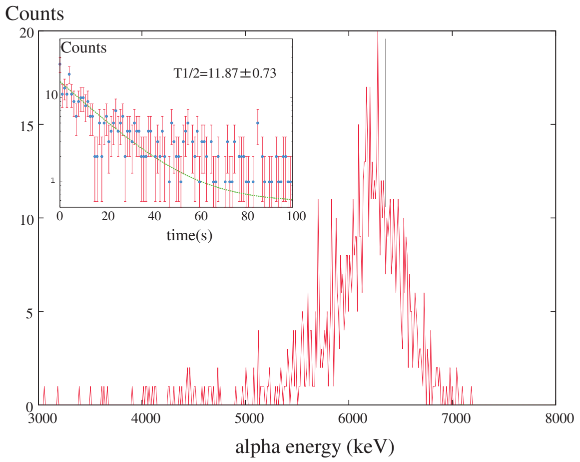

Fig. 1. Alpha spectrum observed using a ΔE Solid-state detector (SSD) placed in front of the gas cell. The inset shows the alpha counts versus time in the beam-off period in the energy range of 6.1–6.6 MeV in the alpha spectrum.

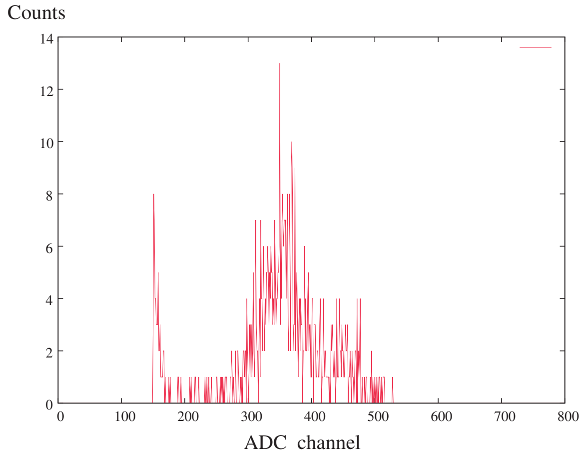

Fig. 2. Alpha spectrum observed using a silicon PIN diode placed after the gas-cell exit.

To achieve the second objective, we performed an extraction test of RIs that were stopped in argon gas (50 kPa) and transported to the gas-cell exit via a long gas tube by simple gas flow to finally impinge on a silicon PIN diode detector located after the gas-cell exit hole. We confirmed the extracted RIs from alpha spectra observed using the silicon PIN diode, as shown in Fig. 2. These extracted RIs included species of all charge states such as neutral and positive/negative ions. By comparison with the total number of alpha counts detected at the ΔE SSD, normalizing primary beam intensity, and considering the solid angle of the detector, we preliminarily evaluated the extraction efficiency as approximately 1%.

The extraction of stopped RIs out of the gas cell was confirmed. In the next beam time, we will apply laser ionization for producing low-energy RI beam.

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References

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