Extraction test of photo ionized Bi in PALIS gas cell

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We are developing a scheme for parasitic low-energy radioactive isotope(RI) beam production (PALIS)[1] in the second focal chamber (F2) of the BigRIPS.

Our previous experiment,[2] confirmed the extraction of Bi isotopes after exiting the PALIS gas cell. As the next stage, we are aiming for laser photo ionization of Bi, which results in highly pure RI beam production. Figure 1 shows the present PALIS experimental setup. Bi atoms are irradiated by two colors of laser beam for multi-step resonance ionization. Photo ionized Bi species are emitted as a gas jet into differential pumping area, where the ions are confined by rf electric fields and move along an axial direction to the rf-carpet. The rf-carpet makes superimposed electric fields: one is dc-guidance sloping to the small exit hole whereas, the other is rf-barrier that prevents the ions from hitting the rf-carpet. For the fast evacuation, we utilized a large exit aperture for the gas cell (3.0 mm) compared to that for a conventional gas cell. Owing to the small exit aperture of the rf-carpet (0.4 mm), efficient differential pumping can be realized, even though several small vacuum dry pumps are arranged in the differential pumping area.

The extracted ions from the rf-carpet are detected by an ion counter in off-line experiments. In on-line beam experiment, the ion counter is replaced by a silicon detector to observe the alpha rays created by the decay of alpha-emitting Bi isotopes.

First, we examined the system performance by off-line experiments. Stable Bi atoms were produced in the gas cell via evaporation. The applied laser ionization scheme of Bi is shown in Fig. 2(1). For identification of Bi ionization, the first-step laser wavelength was scanned as a function of the ion intensity shown in Fig. 2(2). We also confirmed reasonable performance of the rf-carpet by scanning its rf-voltage, and the plot is shown in Fig. 2(3).

In November 2021, a 12-h on-line beam experiment was conducted for the extraction test of ^{191}Bi. The setting $B\rho$ at the BigRIPS provided the specific isotope region including ^{191}Bi in the order of 10^5 cps. We monitored the alpha rays after implantation of a catcher plate in front of the silicon detector, during the beam was stopped for avoiding background noise. Figure 3 shows the accumulated signals at the silicon detector. We considered that a few signals caused by alpha rays were observed in the expected area, >180 (MCA-ch) area. As the extraction efficiency was not achieved for expected value, some improvements are in progress.

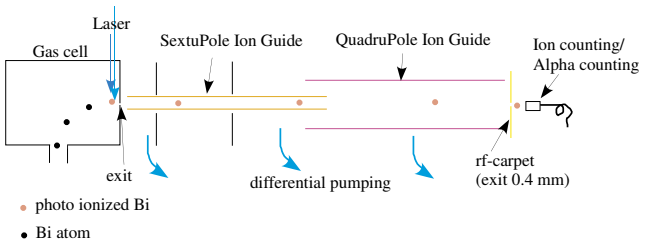

Fig. 1. Present experimental setup.

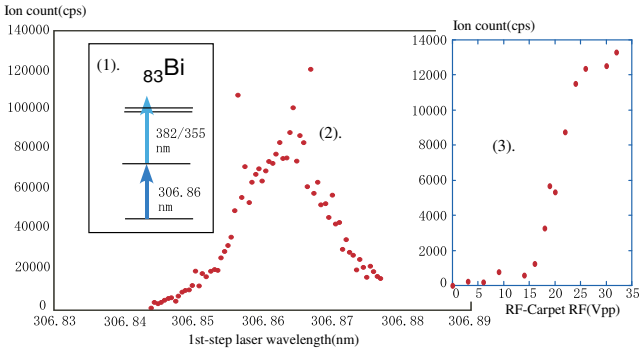

Fig. 2. (1): Bi-ionization scheme and number of ions per second versus (2): first-step wavelength, (3): rf voltage at the rf-carpet measured in off-line experiment.

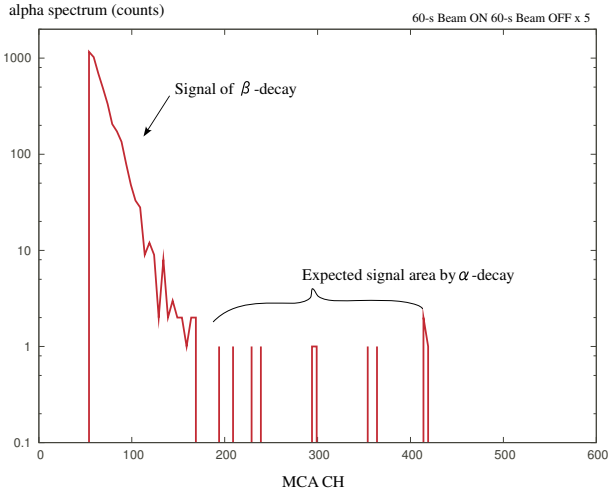

Fig. 3. Observed signals at silicon detector in online experiment.

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References
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2) T. Sonoda *et al.*, RIKEN Accel. Prog. Rep. **54**, 91 (2020).