Construction of the gas cell and isotope separation system with resonant laser ionization for astatine-211 production

T. Sonoda,[*1] H. Haba,[*1] Y. Shigekawa,[*1] Y. Kanayama,[*1] A. Nambu,[*1] H. Shimizu,[*1] T. Nakashita,[*1,*2] T. Mochizuki,[*3] D. Ishikura,[*3] H. Tomita,[*3] and N. Sato[*1]

The gas cell and isotope separation system for the feasibility study of the medical radioisotope production of astatine-211 was constructed in 2024. This system consists of a gas cell, sextupole rf-ion beam guide (SPIG) with differential pumping and a quadrupole mass separator (QMS). The transversal length for the entire system is about 1 m. Owing to its compact structure, the entire system can be installed inside the standard draft chamber. Figure 1 shows a side view of the entire system.

The developing new collection method for ^{211}At is not applying a chemical separation. One feature of this method is that the isotope separation is feasible. The extraction and collection process for ^{211}At takes the following steps. ^{211}At is produced by the ^{209}Bi$(\alpha, 2n)^{211}$At nuclear reaction. The target is created by vapor-depositing Bi on an aluminium foil.[1] The irradiated target is put into the alumina crucible placed inside the gas cell. The alumina crucible is spiraled by a tungsten filament. A carefully adjusted current is applied to the filament to extract ^{211}At from the target. The evaporated ^{211}At atoms flow together with the highly purified argon gas in a laminar flow and arrive at the gas cell exit. The laser beam irradiates ^{211}At atoms during the transport of gas cell exit hole, where resonant photoionization occurs. The photo-ionized ^{211}At ions are sent to the QMS via SPIG and are finally detected by an ion counter/silicon detector. In this way, the element and mass selections are dedicated for ^{211}At.

The system performance was examined by using a stable isotope of ^{209}Bi. The bismuth atoms were produced by evaporation in the gas cell. Figures 2 and 3 show the scan results for the laser wavelength and masses of ^{209}Bi, respectively. The element and mass selections were confirmed for ^{209}Bi.

The gas cell and isotope separation system was successfully constructed. Currently, we are applying ^{211}At for the collection test.

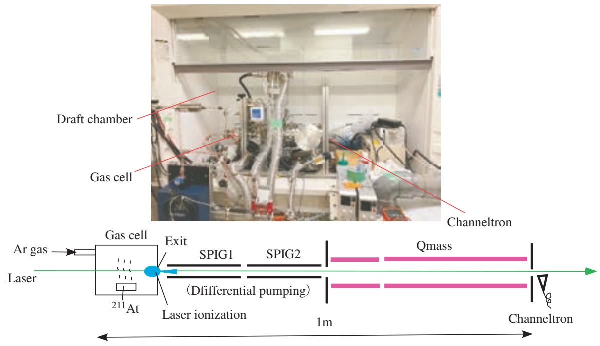

Fig. 1. Side view and layout of the gas cell and isotope separation system for the production of astatine-211.

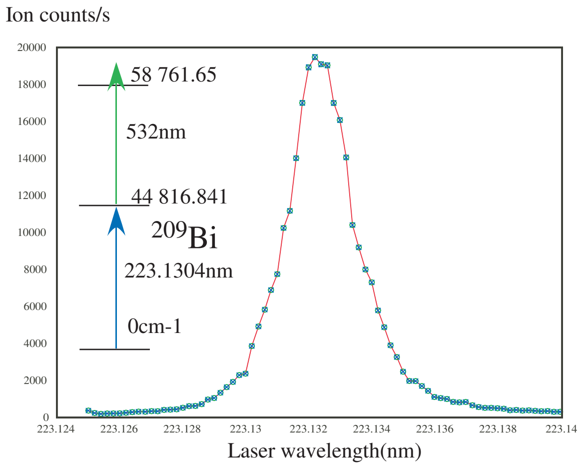

Fig. 2. Examination result of the system performance using a stable Bi isotope (^{209}Bi): ion counts versus the wavelength scan of the first step for resonant laser ionization in the gas cell.

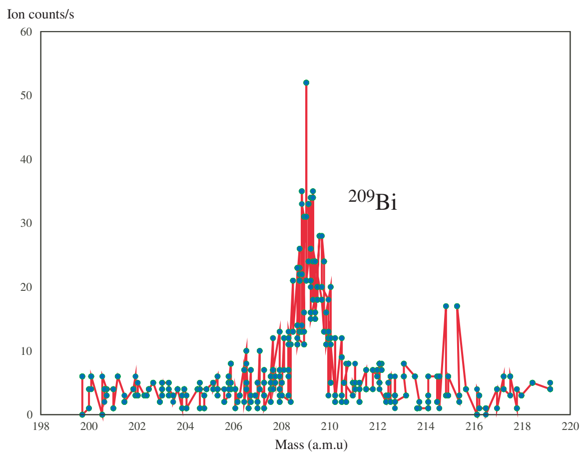

Fig. 3. Result of mass scan for ^{209}Bi by QMS when the laser wavelength was fixed on resonance for the ionization.

Reference
1) N. Sato *et al.*, RIKEN Accel. Prog. Rep. **50**, 262 (2017).

*1 RIKEN Nishina Center
*2 Graduate School of Arts and Sciences, University of Tokyo
*3 Faculty of Engineering, Nagoya University

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