# Improvement of evacuation time of RI from argon gas cell

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An argon gas cell coupled to a resonant laser ionization is a powerful tool for the production of high-purity low-energy RI-beam. This method utilizes neutral RI transportation using simply a gas flow, until it reaches the location for laser ionization which is typically close to the exit of the gas cell. A feasible RI is restricted by its half-life, which should be longer than the evacuation time of the gas cell. The evacuation time can be determined from the conductance of a small exit aperture and gas cell volume. Under adiabatic expansion, the conductance depends only on the diameter of the exit aperture[1] as follows:

$$C = 0.14 \times \phi^2. \tag{1}$$

where the units are L/s for $C$ and mm for $\phi$. The gas is argon. The evacuation time of a gas cell of volume $V$ can be written as:

$$t = \frac{V}{C}. \tag{2}$$

For example, when the gas cell volume is 100 cm$^3$ and the exit diameter is 1 mm, the evacuation time is 714 ms. This value makes it difficult to aim for very rare RI regions, where the half-lives are typically less than 100 ms.

In order to address a fast evacuation, two solutions can be considered: (1) using a small volume for the gas cell and (2) using a large exit aperture. However, these improvements are limited by the stopping efficiency for high-energy RIs, which require a large volume acceptance. They are also limited by the capability of differential pumping. Here we propose installation of an rf-carpet with a very small exit aperture in the initial differential pumping room while using a large aperture for the gas cell exit. Figure 1 shows a schematic layout. The rf-carpet is placed after the gas cell exit. The pressure in this room can be increased up to 1 kPa at which the ion extraction by the rf-carpet is still practical without a discharge problem. The ions move with a gas jet toward the rf-carpet after exiting the gas cell; subsequently they are guided by the rf- and dc-electric fields to the exit of the rf-carpet. Owing to the small exit aperture of the rf-carpet, the loads from the following differential pumping are suppressed. When the exit aperture of the gas cell is large, the total gas throughput becomes very high, leading to an extremely high gas consumption cost. However, by using a gas circulation system,[2] the gas consumption rate can be drastically saved.

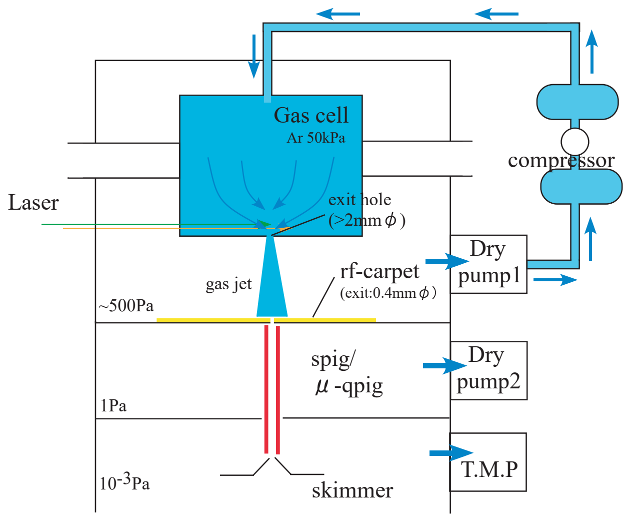


Fig. 1. Proposed gas cell and differential pumping layout in combination with rf-carpet.

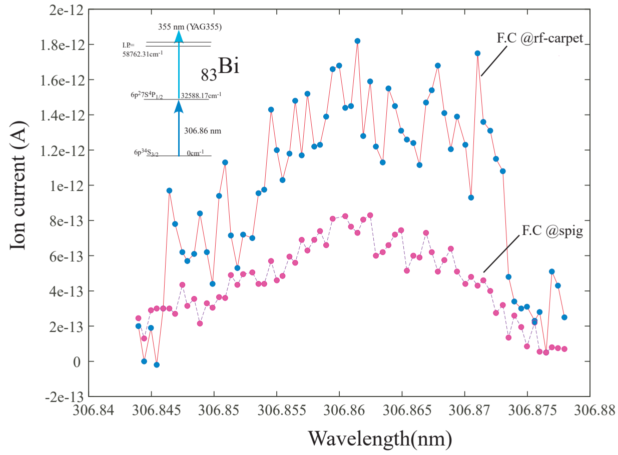


Fig. 2. Ionization spectrum by scanning first step excitation when rf-carpet/spig is used as Faraday cup.

A preliminary off-line experiment was conducted with a 0.4 mm rf-carpet aperture for photo-ionized Bi ions. The pressure at the rf-carpet was approximately 500 Pa. Bi atoms were produced inside the gas cell, and subsequently they were ionized by the laser and extracted from the gas cell exit (2 mm$\phi$). Figure 2 shows the result of the comparison when the ions are collected on the rf-carpet and on the spig rods placed next to the rf-carpet. We confirmed a reasonable extraction efficiency for the rf-carpet. The feasibility study is in progress.

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