Stopping examination for high-energy RI beams in the parasitic gas cell†

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We are developing a scheme of parasitic low-energy RI-beam production (PALIS)[1)] to establish the effective utilization of rare isotopes and to perform comprehensive measurements of physical properties of exotic nuclei. So far, we spent totally about two days of on-line commissioning beam time from 2015,[2,3)] thanks to the RIBF MT committee. However, as the beam time is insufficient to optimize the new device, we requested the PAC committee for authentic beam time in 2017, and 3 days of beam time was approved. Our plan in this formally provided beam time consists of 3 stages: 1) stopping examination for high-energy RI beams in the parasitic gas cell, 2) an extraction test for stopped RIs and efficiency evaluation, and 3) the demonstration of physical spectroscopy using a low-energy RI beam. Here we report the results of the 12 h of on-line experiment in the first stage.

A schematic of the experimental setup is shown in Fig. 1.

Two silicon surface barrier Detectors (SSDs) were installed inside the BigRIPS F2-chamber and used for examining the ΔE-E relation. The first detector (ΔE-SSD) was mounted immediately after the (glass) energy degrader, and the second (E-SSD) was mounted inside the gas cell. A radioactive ^{67}Se beam was introduced to this setup as the main secondary beam, which was produced by projectile fragmentation via ^{78}Kr (340 MeV/nucleon) and a beryllium target. We confirmed that each isotone beam with the same neutron number (N) = 31, 32, and 33 was well separated energetically after the energy degrader. Here, the N = 33 isotone-beam, consisting of ^{67}Se, ^{66}As, ^{65}Ge, and ^{64}Ga, was adjusted to maximize

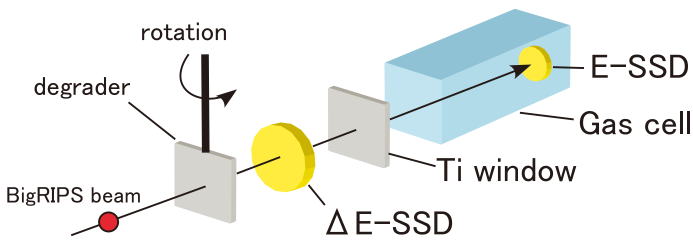

Fig. 1. Experimental setup.

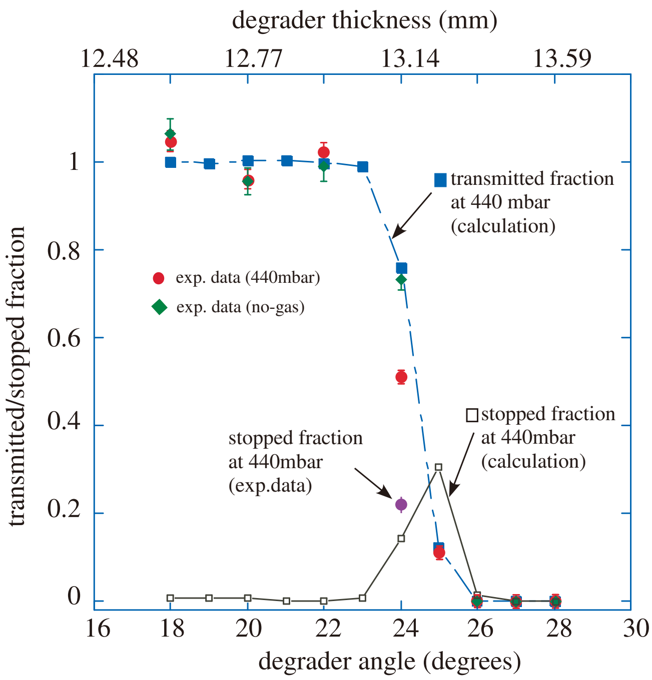

Fig. 2. Normalized transmitted and estimated stopped fractions as functions of the degrader angle.

the stopping efficiency in the gas. The effective thickness of the energy degrader was varied by adjusting its rotation using a stepping motor. Energy-loss spectra were obtained with ΔE-SSD and E-SSD as the angle of the glass degrader was varied from 18 to 28 degrees.

The normalized transmitted fraction at E-SSD and expected stopped fractions in the gas cell are plotted in Fig. 2 as functions of the degrader angle for the cases of no-gas (green rhombuses) and 440 mbar argon (red circles) in the gas cell. The experimental data at 440 mbar were well reproduced by LISE^{++} calculations. In addition, the expected stopped fraction in the gas was estimated by comparing the transmitted fractions with and without gas. In this experiment, we confirmed that approximately 30% of the ensemble of N = 33 isotone beams were stopped in 440 mbar argon at the optimum degrader angle.

As a next step, we will establish the extraction technique of stopped RIs for low-energy RI-beams.

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