The progress of on-line commissioning study on parasitic production of low-energy RI-beam system (PALIS) at BigRIPS

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The progress of the on-line commissioning study on parasitic production of low-energy RI-beam system (PALIS)[1] is reported. The beam time was dedicated for 24 hours in FY2017. Although PALIS can operate in a parasitic manner during the BigRIPS main experiment, the present commissioning study was used a main beam. The main aim of this experiment, which is the confirmation of photo-ionized RI-ions after thermalization in the gas cell, was not achieved in this limited experimental period. However, the ion extraction behaviors in terms of the degrader thickness and laser wavelength were investigated during RI-beam implantation to the gas cell.

The main beam was chosen from Cu isotopes such as ^{66}Cu (5×10^4 pps/pnA primary beam) and ^{68}Cu (2×10^4 pps/pnA primary beam), other isotope beams such as ^{67}Ni (5×10^2 pps/pnA primary beam) were also included. We adjusted the primary beam intensity from 0.01 pnA to 10 pnA. The RI-beams were first decelerated by a copper degrader, where the energy was reduced from around 280 to 10 MeV/nucleon, and then thermalized in the gas cell. A part of the RI-beams are stopped within the finite gas cell. In the case of ^{68}Cu, we estimated a stopping efficiency of about 10% by LISE calculation, when the gas cell pressure is set at one atmosphere of argon gas. When the high energy RI-beams enter the gas cell, gas ionization occurs by the beam itself. These ions comprise of mainly argon ions, and impurity ions included in the gas. We detected these ions in the high-vacuum region, after the ions were extracted from the gas cell and transported to the ion detector via SPIG and QMS in the differential pumping region. Figure 1 shows the ion intensity around mass 68 (a.m.u) when the degrader thickness was varied (circle points scaled by the left vertical axis). We remark that the behavior of this ion signal is consistent with the calculated estimation from the stopping efficiency (square points scaled by the right vertical axis). We confirmed that the number of ions produced by RI-beams is maximum, when the stopping efficiency is maximum.

As we could not find the photo-ionized radioactive Cu ion signal, we confirmed the performance of the laser ionization, extraction and ion transportation by using stable copper atoms that were evaporated from a filament. As shown in Fig. 2, photo-ionized $^{63-65}$Cu ions were observed even when RI-beams were implanted into the gas cell. In the next beam time, we will further investigate the stopping efficiency, optimum size of the gas cell and space charge effect.

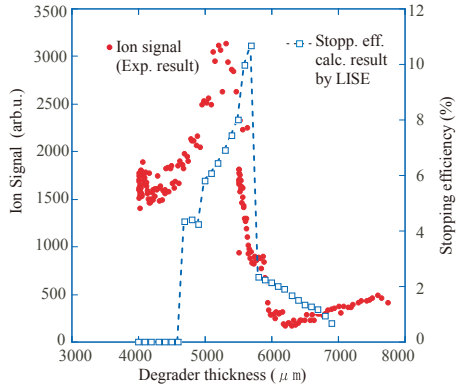

Fig. 1. The extracted ion signal (circle points scaled by the left vertical axis) and the calculated stopping efficiency (square points scaled by the right vertical axis) versus the degrader thickness.

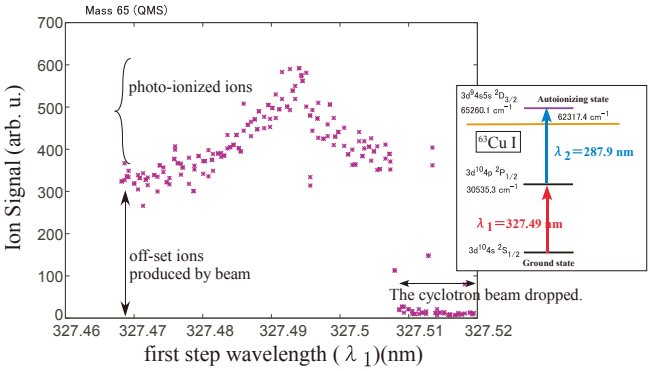

Fig. 2. The wavelength scan for the first-step laser versus the photo-ionized Cu ions, when the RI-beams enter the gas cell and Cu atoms are evaporated by a filament.

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Reference

1) T. Sonoda *et al.*, AIP Conf. Proc. **1104**, 132 (2009).