Present status of ERIS at the SCRIT electron scattering facility

T. Ohnishi,[*1] S. Ichikawa,[*1] A. Enokizono,[*1] K. Kurita,[*2] S. Sato,[*1,*2] M. Watanabe,[*1] and M. Wakasugi[*1,*3]

The electron-beam-driven RI separator for SCRIT (ERIS)[1)] at the SCRIT electron scattering facility[2)] is an online isotope separator system used to produce low-energy RI beams using the photofission of uranium. Recently, we developed ion-stacking and pulse-extraction systems to improve the DC-to-pulse conversion efficiency using an RFQ cooler buncher named the fringing-RF-field activated DC-to-pulse converter (FRAC).[3)] With a surface-ionization ion source, a high conversion efficiency was obtained.[4)] In the present year, we produced RI beams using the surface-ionization ion source and applied the ion-stacking and pulse-extraction systems to RI beams. In this paper, we report the results.

Details of the RI production method and the surface-ionization ion source of ERIS are reported in Refs. 4–5). In this measurement, 43 uranium-carbide disks, with a thickness of 0.8 mm and a diameter of 18 mm, were used as production targets. The total amount of uranium was about 30 g. The uranium-carbide disks were irradiated with an electron beam accelerated to 150 MeV. The electron beam power was adjusted to approximately 0.25–1 W to reduce background events. The target and ionization chamber were heated to 1500–2000°C by using registive heating. The electric currents applied to the ionization chamber and target heater were 120 A and 900 A, respectively. Ionized RIs were extracted by the exit grid of the ionization chamber, accelerated to 10 keV, and transported to the PID system[1)] located at the exit of FRAC. Particle identification was performed by measuring specific γ rays corresponding to the decay of the RIs by using a Ge detector.

Each measurement was performed as follows. First, we irradiated production targets for 4 min to achieve the equilibrium state of the RI production. Next, RI beams were injected to the PID system for 1 min while continuing the target irradiation. Finally, the target irradiation was stopped, and γ rays were measured for 1 min. The rate of RI production is estimated from the observed γ-ray yield using the efficiency of the Ge detector and the half-life of the RI. For example, the rate of ^{140}Cs production is estimated as 4×10^5 atoms/s with an electron beam power of 1 W. The transmission efficiency from the ion source to the PID system was measured as 23% using a stable Cs ion beam. This low efficiency was due to the insufficient adjustment of the ion-beam optics for the injection to FRAC.

The ion stacking and pulse extraction were examined using the ^{140}Cs beam. The stacking and extraction voltages of the exit grid were 100 and -200 V, respectively. The pulse shape of the pulsed RI beam was measured with a fixed time window, 10 μs, by changing the time interval between the extraction from ERIS and the injection to FRAC. Fig.ure 1(a) shows the time-interval dependence of the measured yield of ^{140}Cs with a 100-ms stacking time and 1-W electron beam power. RI beams were extracted within 20 μs, which helps realize zero escape of stacked ions from FRAC during the injection. The stacking-time dependence of the stacking ratio is shown in Fig. 2(b). Here, the stacking ratio is the ratio of the total number of RIs measured with stacking inside the ion source to that measured without stacking. A stacking ratio of almost 0.9 was obtained at a stacking time of 100 ms, which corresponds to the cooling time inside FRAC with a relatively small amount of buffer gas ($\sim 10^{-3}$ Pa).

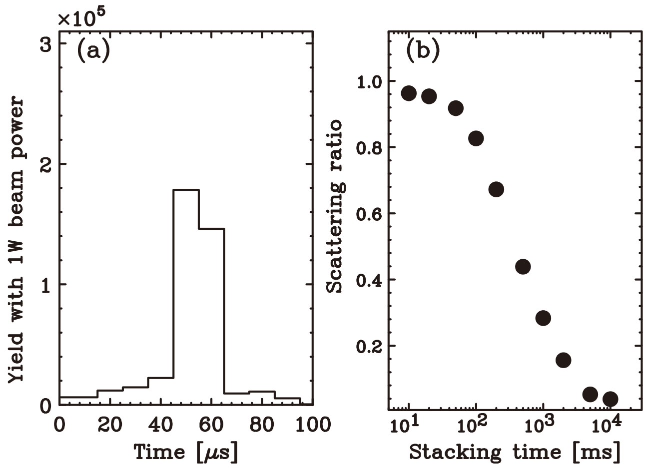

Fig. 1. (a) Pulse shape of the ^{140}Cs beam with a 100-ms stacking time and 1-W electron beam power. (b) Stacking-time dependence of the stacking ratio.

Considering these results, ERIS is almost ready for the first electron scattering experiment with unstable nuclei. We consider ^{137}Cs as a candidate isotope due to its high production rate. Under the condition of 100% transmission efficiency and a 10-W electron beam power, which is the present maximum beam power, the rate of ^{137}Cs is expected to be 4×10^7 atoms/s, which is sufficient for the experiment.

References

1) T. Ohnishi *et al.*, Nucl. Instrum. Methods Phys. Res. B **317**, 357 (2013).
2) M. Wakasugi *et al.*, Nucl. Instrum. Methods Phys. Res. B **317**, 668 (2013).
3) M. Wakasugi *et al.*, Rev. Sci. Instrum. **89**, 095107 (2018).
4) T. Ohnishi *et al.*, RIKEN Accel. Prog. Rep. **52**, 142 (2019).
5) T. Ohnishi *et al.*, RIKEN Accel. Prog. Rep. **48**, 229 (2015).

*1 RIKEN Nishina Center
*2 Department of Physics, Rikkyo University
*3 ICR, Kyoto University