Evaluation of average kinetic energy of ^{132}Xe ions trapped in SCRIT

Y. Kikuchi,[*1] R. Ogawara,[*2] K. Kurita,[*3] T. Ohnishi,[*2] M. Wakasugi,[*4] and T. Yamaguchi[*1]

The SCRIT method is a technique for forming an ion target for electron-RI scattering. Target ions injected into SCRIT device are trapped as an ion cloud with low energies by the well-shaped electrostatic potential and the electron beam potential.[1] To improve the target density, it is crucial to understand the dynamics of SCRIT target formation. A previous study suggested that the target density is affected by the energies of the trapped ions.[2] In this study, we aim to evaluate the energy distributions of the trapped ions in SCRIT.

After ion-trapping in SCRIT device, the trapped ions are transported to the ion analyzer through the spherical surface (SS) deflector (electrode gap of 15 mm, curvature radius of 150 mm), as shown in Fig. 1. The ion analyzer consists of a slit, an E × B velocity filter, and a 43-channeltron array for measuring the charge state distributions of the trapped ions.[3] At the slit position, ions transported from SCRIT device are spatially spread and only a small fraction passes through the slit aperture (1 mm × 1 mm), depending on the applied voltage of the SS deflector (V_{SS}). A previous study evaluated the ion spatial distribution at this position by varying V_{SS}, and suggested that it is influenced by the energy distribution and emittance of the trapped ions.[2] This indicates that the energy distribution of the trapped ions can be inferred from their spatial distributions using ion transport simulations of the SS deflector. In this study, to evaluate the energy distributions, we measured the spatial distributions of ^{132}Xe ions and ^{12}C residual gas ions.

The injected target ions were $^{132}Xe^{+}$ ions (10^8 ions/pulse) with an energy of approximately 6 keV. The electron beam energy and current were 500 MeV and 190–220 mA, respectively. V_{SS} was varied from 1127 V to 1137 V with a trapping time of 200 ms in SCRIT.

Figure 2 shows the event rates of the target $^{132}Xe^{4+,6+}$ and the $^{12}C^{2+}$ residual gas ions varied with V_{SS}. The target ions peaked at V_{SS} of 1131 V and were distributed with a FWHM of 6 V, while the residual gas ions peaked at 1129 V with a FWHM of 7 V. The V_{SS} for the peak event rate of ^{132}Xe ions was 2 V greater than the ^{12}C ions. The FWHMs are considered to be influenced by the energy distribution and emittance of the trapped ions, while the V_{SS} at which event rate peaks indicates the average energy of the trapped ions. This suggests that the ^{12}C ions from residual gas have lower average energy than the target ions. To evaluate the average energy, we calculated the relationship between ion energy and V_{SS} using the ion transport

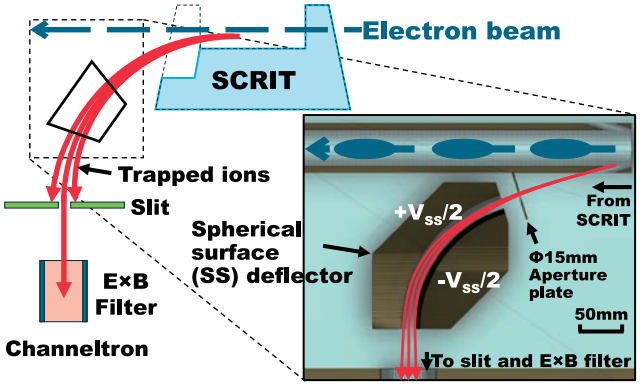

Fig. 1. Schematic diagram of transport line for the trapped ions from SCRIT device.

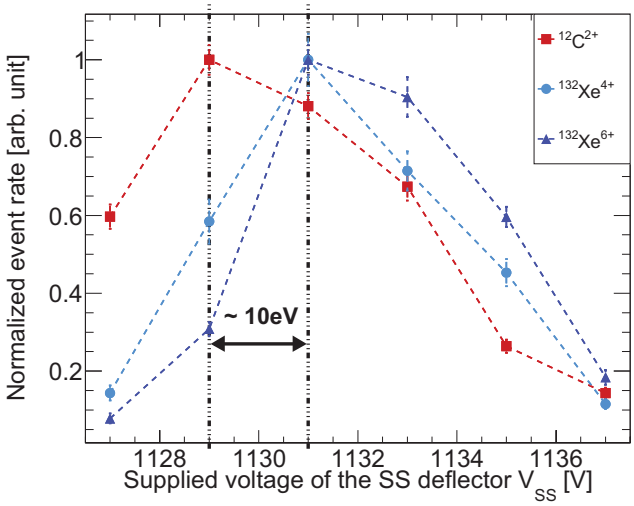

Fig. 2. Event rate dependence on the applied voltage of the SS deflector(V_{SS}) for $^{132}Xe^{4+,6+}$ and $^{12}C^{2+}$ ions.

simulations performed with SIMION. From the simulations, we evaluated the energy difference ∼10 eV corresponding to the 2 V peak position difference between $^{132}Xe^{4+,6+}$ ions and the $^{12}C^{2+}$ ions in Fig. 2. Assuming that the energy of the residual gas ions is approximately the same as the thermal energy, the average energy of target ions in SCRIT is expected to be around 10 eV.

In summary, we evaluated the average energy of ions trapped in SCRIT device. In future work, we will evaluate the energy distributions of the trapped ions through more detailed simulations.

References

1) M. Wakasugi *et al.*, Nucl. Instrum. Methods Phys. Res. B **317**, 668 (2013).
2) R. Ogawara *et al.*, RIKEN Accel. Prog. Rep. **57**, 153 (2024).
3) R. Ogawara *et al.*, Nucl. Instrum. Methods Phys. Res. B **541**, 90 (2023).

*1 Department of Physics, Saitama University
*2 RIKEN Nishina Center
*3 Department of Physics, Rikkyo University
*4 Institute for Chemical Research, Kyoto University

DOI:10.34448/RIKEN.APR.58-203