Effects of electron beam conditions on the SCRIT ion-trapping properties

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The self-confining RI ion target (SCRIT) technique forms an ion target in an electron storage ring for electron-RI scattering experiments. The target ions are trapped transversely by periodic focusing forces of electron beam bunches and longitudinally by an electrostatic well potential. The target density of the trapped ions is an important parameter for evaluating the SCRIT performance and is strongly affected by the conditions of the electron beam (*i.e.*, current, size, and stability).[1] In this work, we evaluated the time evolutions of target densities and the charge state distributions of trapped ions under two different conditions of electron beams.

The energy of the electron beams in the SCRIT facility can be controlled from 150–700 MeV. The electron beam conditions vary significantly with changes in the electron beam energy. In this study, the electron beam energies were 150 and 500 MeV, with an electron beam current ranging from 180–250 mA. The lifetime of the electron beam was used as a parameter to indicate electron beam stability and was obtained from the slope of the decrease in the electron beam current.

The time evolution of the target density during ion trapping in the SCRIT was evaluated from the luminosity measured with the luminosity monitor.[2] After ion trapping in SCRIT, the trapped ions were extracted from SCRIT and transported to the ion analyzer for measuring their charge-state distributions.[3] We evaluated the charge-state distribution of the trapped ions for trapping times of 50–900 ms using both electron beam energies. The target ion beam injected into the SCRIT was $^{132}Xe^{+}$ (∼6 keV, 1×10^8 ions/pulse) produced by electron-beam-driven RI separator for SCRIT (ERIS).[2]

The lifetimes of the electron beams at 150 MeV and 500 MeV were 40 minutes and 340 minutes, respectively. These results indicates that the electron beam stability at 500 MeV was higher than that at 150 MeV. Figure 1 shows the time evolutions of the SCRIT target density at both electron beam energies. At the electron beam energy of 150 MeV, the target density decreased to one-tenth in ∼450 ms. In contrast, the target density remained approximately constant for ∼1 s with the 500 MeV electron beam. The escape rate of the trapped ions from the SCRIT increased with a decrease in the electron beam stability. Figure 2 shows the time evolutions of charge-state distributions of the trapped ^{132}Xe ions using both electron beam energies. The event rates for each charge state were normalized by dividing them by the total event rate. Trapped ions with charge states above 10+ were observed at the electron beam energy of 500 MeV, but not at 150 MeV. This implies that highly charged ions are difficult to trap for long periods in SCRIT when using electron beams with reduced stability. These results are in agreement with the previous simulation study.[1]

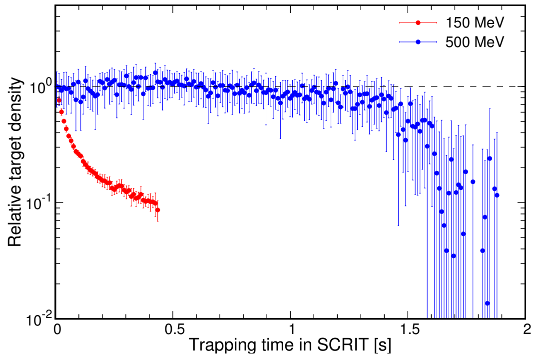

Fig. 1. Time evolutions of relative target densities during ion trapping in the SCRIT using electron beam energies of 150 and 500 MeV.

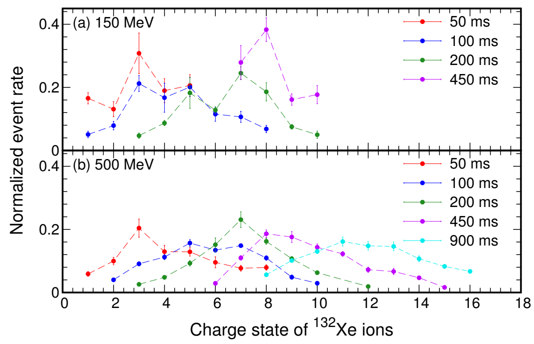

Fig. 2. Charge state distributions of trapped ^{132}Xe ions for trapping times of 50–900 ms using electron beam energies of (a) 150 and (b) 500 MeV.

We demonstrated the importance of electron beam conditions on SCRIT ion-trapping properties. Upgrades to the SCRIT electron scattering facility are underway to improve the stability of the electron beam.

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