Properties of ion trapping measured by the SCRIT LMon

A. Enokizono,[*1,*2] T. Fujita,[*1] K. Adachi,[*1] M. Hori,[*1] K. Kasama,[*3] K. Kurita,[*1] K. Namba,[*3] T. Ohnishi,[*2] S. Sasamura,[*1] T. Suda,[*2,*3] T. Tamae,[*3] N. Uchida,[*1] K. Tsukada,[*2,*3] M. Togasaki,[*1,*2] M. Wakasugi,[*2] M. Watanabe,[*2] and K. Yamada[*1]

The SCRIT detector is composed of a Window-frame Spectrometer for Electron Scattering (WiSES) to measure the angular distribution of scattered electrons[1)] and a Luminosity Monitor (LMon) to measure the absolute luminosity of electron-RI scatterings.[2)] LMon is measuring the bremsstrahlung photons and determine the luminosity as $L = N_{br}/t\sigma_{br}\epsilon$ ($\mathrm{cm}^{-2}\mathrm{s}^{-1}$), where N_{br}/t is the number of bremsstrahlung photons per second, σ_{br} is the bremsstrahlung cross-section, and ϵ is the detector acceptance. σ_{br} can be calculated using a theoretical model[3)], and LMon consists of two main components to measure the remaining factors: a CsI calorimeter to measure N_{br}/t and a two-dimensional fiber scintillator detector to measure the spatial distribution of bremsstrahlung photons which have to be compared with GEANT4 to determine ϵ. The first physics experiment using ^{132}Xe and ^{208}Pb targets was performed in 2015-2016. Results of the experiment using WiSES are reported elsewhere,[4)] and progress on LMon with respect to the determination of ϵ and its uncertainty is described in a separate report.[5)] In this article, detailed measurements of ion trapping by LMon using ^{132}Xe data are reported.

With a recent upgrade of LMon, it has acquired the ability to measure N_{br} as a function of trapping-time, which revealed detailed properties of the ion trapping. Figure 1 shows N_{br} as a function of the trapping-time measured at an electron beam energy ($\mathrm{E_e}$) of 150 MeV for different beam currents. Here Ion IN and Ion OUT denote measurements with and without trapped ^{132}Xe ions, respectively. That is, Ion OUT is the background contribution from residual gases (e.g $\mathrm{H_2}$, $\mathrm{O_2}$), and the net amount of N_{br} from ^{132}Xe ions is estimated as Ion IN-OUT. The Ion IN-OUT decreases as a function of the trapping-time, implying that trapped target ^{132}Xe ions are depleted with time. On the other hand, the number of trapped residual gas ions, which is shown by Ion OUT, can be increased as a function of the trapping-time since there are virtually infinite neutral residual gas atoms inside the chamber, which are continuously ionized by the electron beam and trapped by the SCRIT device. Figure 2 shows the N_{br}/t of Ion IN-OUT as a function of the trapping-time for several currents and beam energies. N_{br}/t increases as the electron beam current/energy increases, which can be naturally explained by the fact that the beam density increases with increasing beam current/energy. It is interesting to note that there are fast and slow components in the trapping-time dependence, and the slow component becomes prominent as the beam energy and/or current increases. A feasible explanation is that the slow component originates from high-charged-state nuclei, which increase at time scales on the order of hundreds of milliseconds.

In summary, the properties of ion trapping at the SCRIT experiment have been measured by LMon. This information is useful for tuning the electron beam and SCRIT device parameters to optimize the ion trapping and maximize the luminosity, even though more detailed studies using simulations and calculations are required to reproduce the observation.

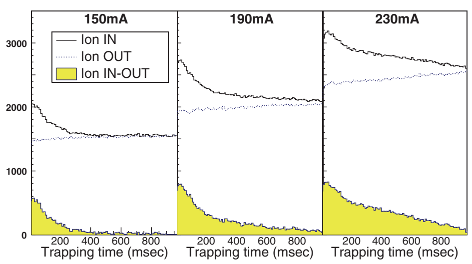

Fig. 1. Trapping-time dependence of N_{br} measured for different beam currents for ^{132}Xe at $\mathrm{E_e} = 150$ MeV.

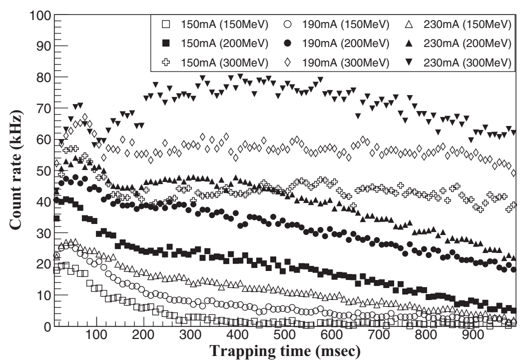

Fig. 2. Trapping-time dependence of N_{br}/t measured for different beam currents and energy regions.

[*1] Department of Physics, Rikkyo University
[*2] RIKEN Nishina Center
[*3] Research Center for Electron-Photon Science, Tohoku University

References
1) T. Suda et al., Accel. Prog. Rep. **47**, 195 (2014).
2) S. Yoneyama et al., Accel. Prog. Rep. **48**, 227 (2015).
3) Y. S. Tsai, Rev. Mod. Phys. **46**, 815 (1974).
4) K. Tsukada et al., in this report.
5) T. Fujita et al., in this report.