Development of an ion beam Buncher for SCRIT experiment

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We have developed low-energy ion-beam buncher named FRAC (Fringing-RF-Field-Activated Ion-Beam Compressor)[1)] for the SCRIT (Self-Confining Radioactive isotope Ion Target)[2)]. FRAC is based on a linear RFQ ion trap widely used in the world[3)], but is a new-type buncher without using buffer gas and making active use of fringing fields of RFQ.

Figure 1 schematically shows the experimental setup together with the longitudinal electrostatic potential diagrams. It consists of the ERIS (Electron-beam-driven RI separator for SCRIT)[4)] ion source with a grid pulser, RFQ with endcap electrodes as its both edges, and two Faraday cups for measuring total charge. The ion source provides $^{132}Xe^{+}$ beams with accelerating energy of 6.0 keV. In this time, ERIS provided not only continuous beams but also pulsed beams with pulse width of 220 μs by switching grid pulser voltage $V_{\rm grid}$ with repetition frequency of 500 Hz. Averaged ion-beam current is identical in both cases. The voltages $V_{\rm barr1}$ and $V_{\rm barr2}$ are slightly lower than $V_{\rm acc}$ by a few volts, and higher than the $V_{\rm DC}$ applied to RFQ by about 15 V. The switching action of $V_{\rm barr1}$ is synchronized with arrival of each pulsed beam. At this situation, some parts of injected ions are longitudinally decelerated by fringing RF field and stacked in FRAC. For the extraction of the stacked ions from FRAC, the voltage of barrier 2 is switched to $V_{\rm acc} - 150$ V with appropriate frequency (1～50 Hz) depending on favorable stacking time. The conversion efficiency ε is defined as $\varepsilon = N_{\rm ext}/N_{\rm inj}$, where $N_{\rm inj}$ and $N_{\rm ext}$ are the number of ions injected into and extracted from FRAC, respectively. Figure 2 shows typical waveforms obtained at FC 1 and 2. Typical value of the efficiency ε at extraction frequency of 10 Hz is 5.7 % in case of continuous beam injection.

We aimed to improve the efficiency, and we tried to use synchronized pulsed beam injection. The efficiency ε was improved by a factor of 2.7 compared with continuous beam injection, and it is typically 15.3 % at extraction frequency of 10 Hz. The efficiency enhancement factor is nearly identical at any extraction frequency as shown in Figure 3.

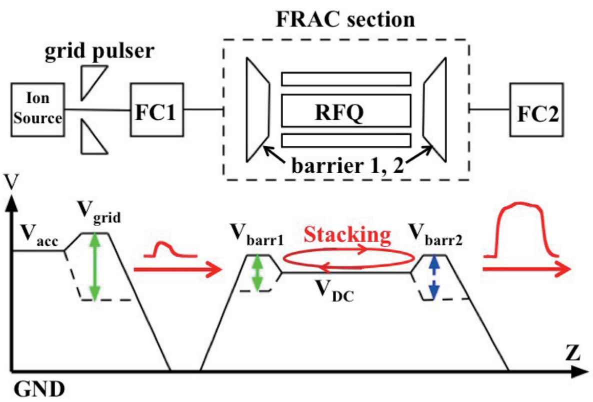

Fig. 1. Experimental setup of FRAC together with longitudinal electrostatic potential diagram for pulsed beam injection.

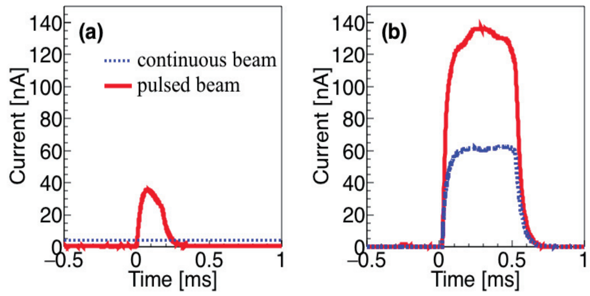

Fig. 2. Typical waveforms of injected continuous and pulsed ion beams measured at FC 1 (a), and extracted beams measured at FC 2 in case of extraction frequency of 10 Hz (b).

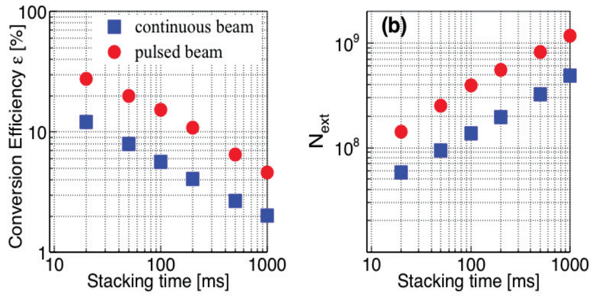

Fig. 3. Dependence on the extraction frequency of the conversion efficiency ε (a), and the number of ions extracted from FRAC $N_{\rm ext}$ (b) for both injection methods.

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