7 - 23 A New Ion Beam Stacking Method Using Pulsed Electron Beam Cooling*

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Barrier bucket scheme associated with beam cooling is an effective method for longitudinal beam stacking in synchrotrons. Generally, the barrier bucket method is based on longitudinal voltage pulses that synchronized with the ion beam. The barrier voltage is usually created by a broad-band RF system consisting of ferromagnetic loaded cavities, and the bandwidth is in the range of tens of kHz to hundreds of MHz. Since 2019, a series of pulsed electron beam cooling experiments were carried out at HIRFL-CSR in collaboration between IMP and Jlab[1]. For the first time, longitudinal bunching of the coasting ion beam was observed in the experiment, which is caused by the barrier voltage that created by the space charge field at the electron beam edges. Accordingly, it gives us the idea of accumulating the ion beam using only pulsed electron beam cooling in synchrotrons.

Assuming a pulsed electron beam with rectangular distribution in the longitudinal direction, and the beam current varies linearly at the edges. Due to the space charge effect, a longitudinal electric field is generated at the rising and falling edges of the pulsed electron beam, resulting in the barrier voltage. Due to the synchrotron motion, all particles will encounter the electron beam and can be cooled to a small momentum spread. Because the stable area coincides with the cooling region, the ion beam will be finally bunched into the stable area under the effects of the barrier voltage and electron cooling. Thereafter, the unstable area is vacated for new beam injection.

Based on the design report of HIAF project, the beam cooling and stacking processes in SRing using pulsed electron beam are simulated, in which we use the fully stripped stable $^{238}U^{92+}$ beam at the energy of 800 MeV/u that is corresponds to the maximum magnetic rigidity of SRing. The electron beam current is 2.0 A with the rising/falling time of 10 ns. Considering a uniform distribution of electron beam and linearly increased line density, a rectangular barrier voltage of 240.5 V is obtained. The beam distribution in longitudinal phase space for a single turn and the beam stacking process with different e-beam settings are shown in Fig. 1. It demonstrates that this method works for the ion beam stacking. In HIAF, the primary goal of SRing is to accumulate secondary or stripped ion beams for various experiments, usually with medium energy ions. Based on the electron cooler design of SRing and the simulation, we conclude that the beam stacking method using pulsed electron beam could be a candidate for the beam stacking device.

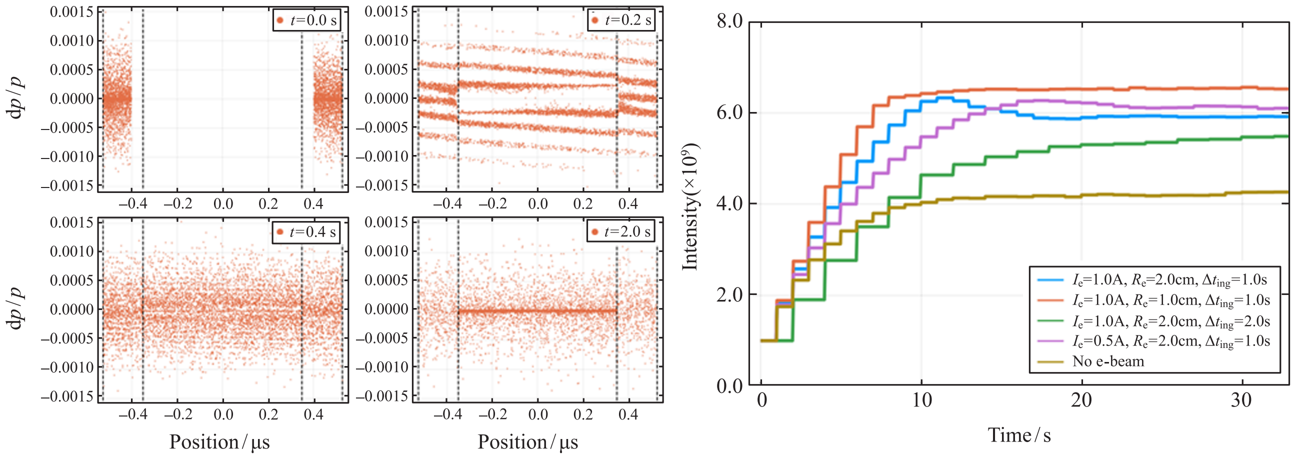

Fig. 1 (color online) Simulation results of the beam distribution in longitudinal phase space during one injection and the stacking process with different e-beam settings. The boundaries of the ring and the pulsed electron beam are marked with dashed line.

Reference

[1] M. W. Bruker, Phys. Rev. Accel. Beams, 24(2021)012801.

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