Conceptual design of a heavy ion storage ring RUNBA

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We plan to construct a heavy ion storage ring, RUNBA (Recycled-Unstable-Nuclear Beam Accumulator) adjacent to the SCRIT facility in the E21 experimental room. RUNBA will be a research and development machine for developing and establishing a beam recycling technique in a storage ring for application to nuclear reaction studies for rare RI beam. This project is ongoing under the joint research program between ICR Kyoto University and RIKEN Nishina Center (RNC). In the last year, we transfered the storage ring (sLSR),[1] which was avandoned for more than ten years, from ICR to RNC. RUNBA is a rebuilt machine of sLSR and we are designing the lattice structure and machine layout in E21. Figure 1 shows a current floor plan of the RUNBA facility. RUNBA will be connected to ERIS, which is an ISOL system for SCRIT experiments.

Continuous singly-charged ion beams from ERIS are converted into a pulsed ion beam by FRAC and a highly-charged ion beam by RECB (Resonant Extraction Charge Breeder),[2] which is under development at ICR. A fully-stripped pulsed ion beam with 10 keV/nucleon is injected into RUNBA with a multi-turn injection method. Consequently, it can be accelerated up to 10 MeV/nucleon by repeating five times the acceleration process in which the ion velocity doubled by sweeping an RF frequency at the non-resonant ferrite cavity and synchronously ramping up the magnetic field.

The concept of beam recycling is that the energy loss, energy straggling, and transverse angular straggling produced when the beam passes through the internal target are corrected turn by turn and particle by particle, and beam circulation is stably maintained until nuclear reaction occurs at the target. Therefore, devices required to be equipped in RUNBA in addition to the fundamental optical elements include an internal target system, acceleration cavity, energy-dispersion corrector, and transverse emittance corrector. The fundamental properties in the current design of RUNBA are summarized in Table 1. The beta and dispersion functions over the whole ring are shown in Fig. 2. RUNBA optics is formed with 6 bending magnets, 3-family 12 quadrupole magnets, 2-family 4 sextupole magnets, and a triple-bend achromatic arc structure that is adopted to provide achromatic focus points for internal target insertion in the straight section. In another straight section, an energy-dispersion corrector will be installed and emittance correctors in the horizontal and vertical directions are placed at positions where the betatron phase advances are 0.75 from the target. The diffusion of energy spread would be suppressed by giving appropriate positive or negative energy gain determined from the difference in flight time from the target to energy-dispersion corrector. The emittance correctors transversely kick ions according to the transverse position measured at the target. These new feedback systems are now being developed at ICR.

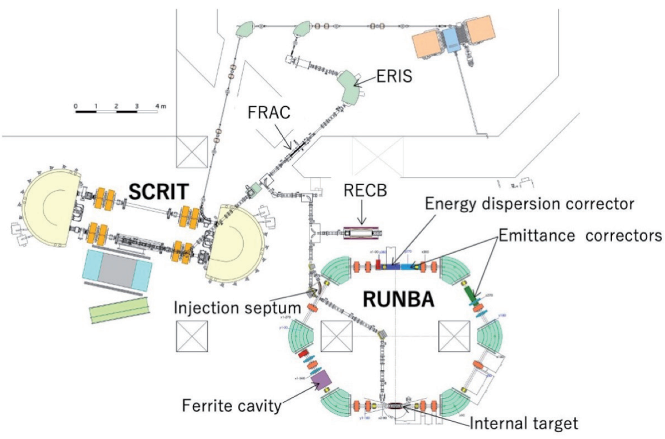

Fig. 1. A plane view of RUNBA facility.

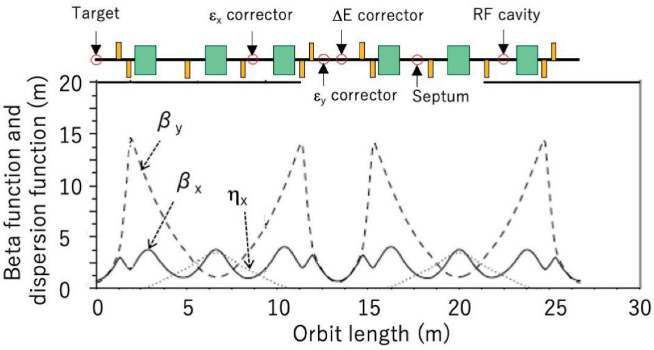

Fig. 2. Beta and dispersion functions of RUNBA.

Table 1. Lattice structure and properties of RUNBA.

Circumference (m)	26.557
Maximum Bρ (Tm)	1.05
Transition γ	1.855
Harmonics (10 keV/nucleon, 10 MeV/nucleon)	(32, 1)
RF frequency (MHz)	1.674–3.348
Tunes (ν_x, ν_y)	(2.368, 1.695)
Max. dispersion functions (η_x, η_y) (m) at focal point	(3.497, 0.0)
Beta functions (β_x, β_y) (m)	(0.697, 0.527)
Dispersion functions (η_x, η_y) (m)	(0.0, 0.0)

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References
1) A. Noda *et al.*, Proc. EPAC2006, 237 (2006).
2) R. Ogawara *et al.*, in this report.