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# EBIS charge breeder producing highly charged ions for RAON facility

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The Rare Isotope Accelerator complex for ON-line experiments (RAON), a Korean heavy-ion accelerator, is under development at the Institute for Basic Science and is currently in the commissioning phase.[1,2] Within the RAON facility, diverse rare isotope (RI) ions are generated through the Isotope Separation On-Line (ISOL) system and subsequently transported to the post-accelerator. The ISOL system is composed of several components, including the Cyclotron, the Target Ion Source (TIS) module, the pre-mass separator, and the beam transport and manipulation line.[3] In the TIS module, a 70 MeV proton beam collides with the target, resulting in the creation of RI elements, which are subsequently ionized and extracted. These various RI ions are then separated based on their mass using the dipole magnet in the pre-mass separator, enabling the selection of specific elements. The RI ions with the desired mass are required to undergo manipulation before being utilized in the post-accelerator. This manipulation is necessary because the post-accelerator has specific criteria, namely a mass-to-charge (A/q) ratio of less than 6 and an energy per nucleon matched to 10 keV/u.

The Electron Beam Ion Source (EBIS) is utilized to meet these criteria by generating ions with a high charge state. The design and installation of the EBIS charge breeder are focused on harnessing an electron beam with a maximum intensity of 2 A, operating within a 6 T superconducting magnet, as illustrated in Figure 1.[4,5]

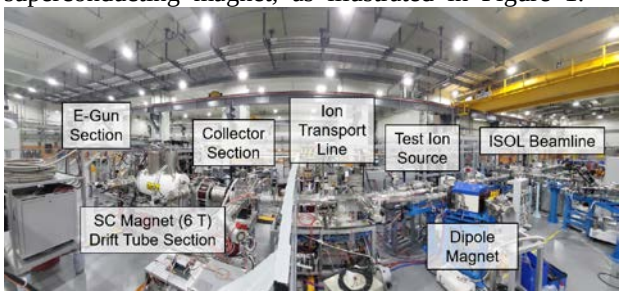


**Figure 1.** Installation of the RAON EBIS charge breeder.[5]

The electron beam originates from the E-Gun section and is directed toward the Collector section. Here, it undergoes radial compression through a powerful magnetic field. Interaction takes place between the electron beam and a singly charged RI ion beam that is introduced and subsequently trapped within the EBIS. This interaction leads to the removal of electrons from the ion beam. Through the EBIS process, highly charged ions are generated, thereby fulfilling the prerequisites necessary for achieving the desired A/q value. These highly charged ions are then extracted from the EBIS, with adjustments made to the high voltage (HV) platform to ensure their energy reaches 10 keV/u.

As part of the commissioning process for the ISOL system, the EBIS charge breeding experiment incorporates the utilization of several stable ions, specifically Cs, Sn, and Na. These ions are sourced from either the test ion source or the ISOL beamline.[4,5] By applying an electron beam current of 1 A, ions such as $^{133}Cs^{27+}$, $120Sn^{24+}$, and $^{23}Na^{7+}$ have been effectively generated and categorized. The outcomes of the A/q distribution of charge-bred Sn ions are presented in Figure 2. Following this, the A/q separator is employed to classify these ions based on their A/q ratio. Those ions that fulfill the predefined selection criteria are subsequently transported to the post-accelerator, satisfying the distinct prerequisites of that stage. The performance of the EBIS has been verified through the outcomes of the commissioning process. Furthermore, ongoing tests of the RAON EBIS are being conducted using RI ions.

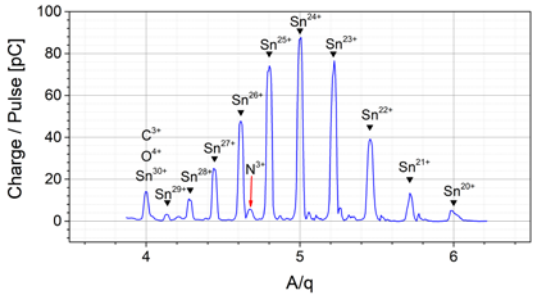


**Figure 2.** A/q (mass-to-charge ratio) distribution of charge-bred Sn ions with residual gases.[3]

References
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