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Innovation in EBIS/T Charge State Breeders for Stable and Radioactive Elements

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The most attractive features of EBIS/T based charge breeders are short breeding times, narrow charge distributions, low background, high efficiency and the flexible time structure of the ejected low-emittance ion pulses. Notably driven by the need for high-performance charge breeders at radioactive ion beam (RIB) facilities, significant progress has been made to further improve these characteristics: Increasing the electron-beam current density to reduce charge breeding times is conceptually simple, but has turned out rather difficult in reality. Several groups have made progress in moving away from immersed-cathode electron-gun designs with current densities of hundreds of A/cm² towards 10³ to 10⁴ A/cm². These current densities will become necessary to deliver high charge states of heavy nuclei in a short time and/or provide sufficient space-charge capacity to handle high-current ion beams in next-generation RIB facilities. As an alternative to pulsed injection, efficient capture of DC beams has become possible with the development of high-density electron beams of >1A.

Requests for the time structure of the charge bred ion pulse range from ultra-short pulses, e.g. for injection into isolated RF ‘buckets’ in accelerators, to quasi-continuous beams. Progress is being made on both ends of this spectrum, by either dividing the extracted charge in many time-focused pulse-lets, adjusting the extraction potential for a near-uniform long pulse (>ms) or adding dedicated devices to spread the ion bunches delivered from the EBIS/T in time.

Recent advances in EBIS/T charge state breeding will be presented, along with progress in simulations and device models that have been vital to pushing performance limits.