

A BATCH-MODE NEGATIVE ION SOURCE FOR RIB GENERATION

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Negative radioactive-ion beams of isotopes with lifetimes in excess of a few hours and electron affinities in excess of ~ 1 eV can be efficiently generated by use of the Cs-sputter technique. In this scenario, the species of interest are sequentially produced by irradiating target materials with 10-40 MeV, light-ion beams for a time sufficiently long for secular equilibrium to transpire (a few half-lives), followed by transfer of the target to a Cs-sputter or plasma-sputter negative-ion source where the irradiated volume is sputtered away by the action of a 1-5 keV Cs⁺ beam. The Cs⁺ beam not only serves to eject particles from the surface but also lowers the work function of the surface, thereby greatly enhancing the probability for negative-ion formation since the probability of negative-ion formation depends exponentially on the difference between the electron affinity of the atom and the work function of the surface. RIBs formed by this technique avoid the high target temperatures required for fast diffusion and fast effusive-flow to the ion source. Direct negative-ion formation also avoids losses related to the charge-exchange process required to convert initially positive ion beams to negative polarity as required for post acceleration with the 25-MV tandem accelerator. During this reporting period, we have designed and fabricated a Cs-sputter negative-ion source for the batch-mode generation of RIBs of long-lived species for HRIBF research programs. Although it was conceived specifically for the generation of ⁵⁶Ni, it can be employed for the generation of several other long-lived species such as ⁷Be and ¹⁸F. The source is mounted in a vacuum envelope specifically designed for remote installation/removal with the robot controlled radiation handling system used for installing/removing conventional modular sources routinely used for RIB generation at the HRIBF. Source operation adheres to ALARA (as low as reasonably achievable) safety principles for personnel exposure to radioactive work tasks. The source features an eight-position, water-cooled target wheel that can be remotely indexed from the ORIC production position into the Cs-sputter position. The target wheel can be loaded with eight separate targets, thus, providing target variety and the ability to irradiate a second target with beams from ORIC while generating negative-ion beams from an initial target. Beams of Cs⁺ are generated by surface ionization of Cs vapor as it comes in contact with a conical geometry W-surface ionizer. The ionizer/target-electrode system for accelerating Cs⁺ was specifically designed to achieve a large ($\phi \sim 7$ mm),

uniform irradiation pattern with good overlap with the ORIC production beam ($\phi \sim 6-8$ mm at impact with the target surface) while efficiently extracting negative-ion beams generated in the sputter process. The efficiency for generating $^{56}\text{Ni}^-$ is expected to range between 2% and 5%.

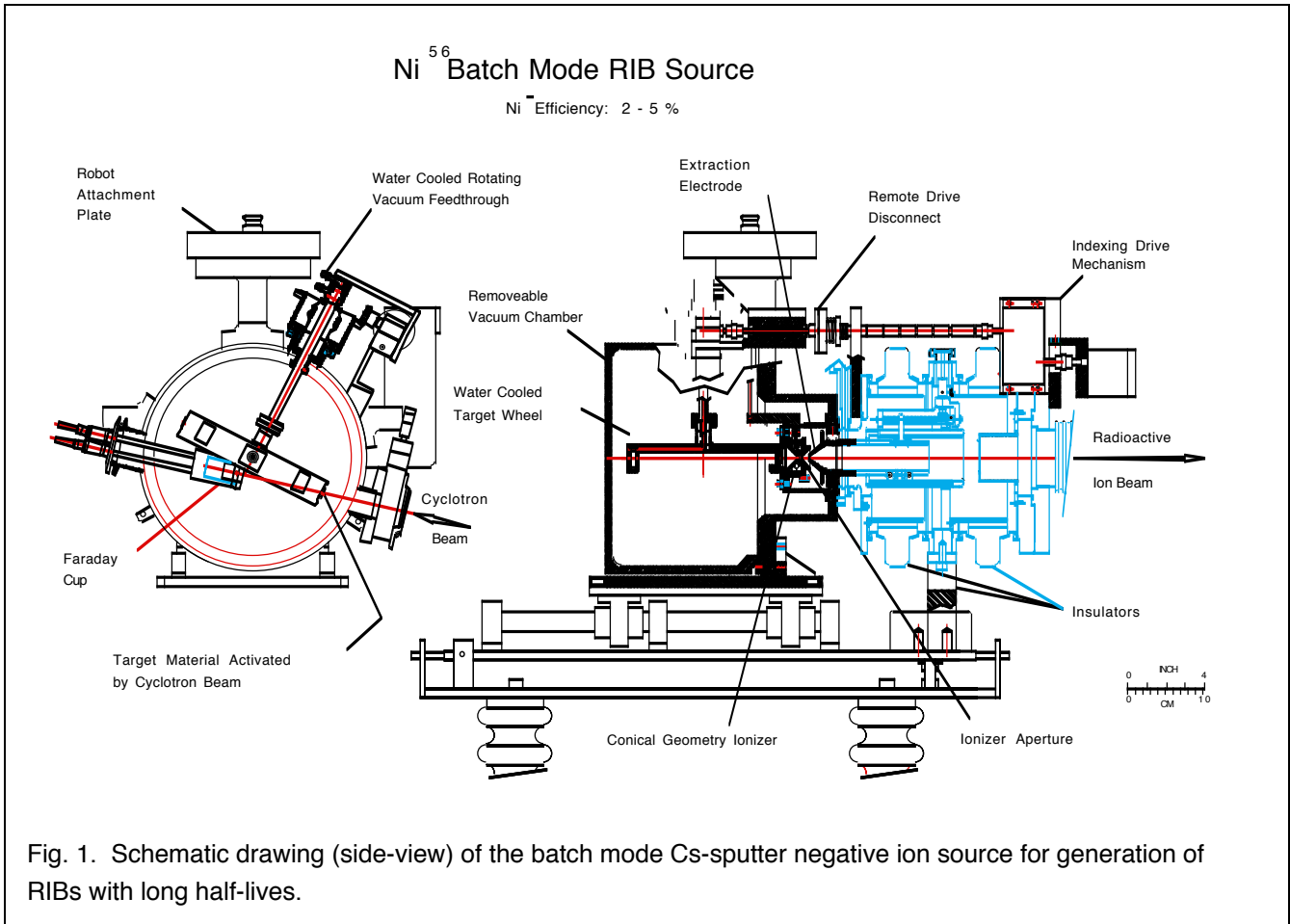


Fig. 1. Schematic drawing (side-view) of the batch mode Cs-sputter negative ion source for generation of RIBs with long half-lives.