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Numerical ionization model for the TRIUMF FEBIAD and the experimental comparison of ion beam properties

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TRIUMF currently uses a FEBIAD ion source to generate 1+ radioactive ion beams of noble gases, halogens, or molecules. Typically, the offline ionization efficiency obtained for a TRIUMF FEBIAD source tends to be < 1 % for 40Ar+, however, other ISOL facilities report values ranging from 10-25%. To understand the limitation and optimize performance for both ISAC and the upcoming ARIEL facility, a numerical and experimental campaign has been performed. The numerical model predicts a spatial distribution of ions, and their simulated extraction can explain observables such as emittance and energy spread. Using numerically optimized operation parameters yields immediately in 10-fold improvements of the experimental 40Ar+ ionization efficiency. However, when operating the source at more extreme parameters, the measured ionization efficiency even ranges from 15% to 30% before the source fails. To mitigate these particular failures modes, the numerical model has further been used to perform optimization for reliability and better efficiencies. With the proposed geometrical optimization, it is expected to provide a reliable operation and therefore maintain high experimental efficiencies.

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