TRIUMF Advanced Rare Isotope Laboratory (ARIEL)

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The neighborhood of ^{78}Ni: Probing the N = 50 Shell Closure with ARIEL Photofission

The neutron-rich region surrounding ^{78}Ni provides a stringent test of nuclear structure far from stability and plays a central role in the astrophysical r-process responsible for the A≈80 abundance peak. As a doubly-magic nucleus, ^{78}Ni offers a key benchmark for investigating the persistence of the N = 50 shell closure in extremely neutron-rich nuclei. However, direct mass measurements have reached only as far as ^{75}Ni (N=47). Extrapolated mass models beyond this diverge from each other as the shell closure is approached. In particular, sensitivity studies identify ^{76}Ni as a critical r-process waiting-point nucleus whose mass strongly impacts predicted abundance patterns. Achieving these measurements at TRIUMF requires both improved beam development and reduced contamination, capabilities that will be enabled by the ARIEL facility, which will deliver cleaner radioactive ion beams to the existing TITAN mass spectrometers.

At TRIUMF's Ion Trap for Atomic and Nuclear science (TITAN), the Multiple-Reflection Time-of-Flight Mass Spectrometer (MR-TOF-MS) can reach mass resolving powers exceeding 400,000, with measurement times on the order of milliseconds, making it ideal for measuring these short-lived, neutron-rich nuclei. Its mass-selective re-trapping feature further suppresses background contaminants in the delivered beam by factors of 10^4–10^8. This enables both yield characterization and high-precision mass measurements, even for low-intensity beams during the early ARIEL ramp-up phase, as part of the ongoing collaboration between the Target and Ion Source Department and TITAN. This symbiosis will be critical to extending mass measurements toward ^{78}Ni. Thus, TITAN will constrain two-neutron separation energies across the N = 50 shell closure and provide critical nuclear inputs for r-process nucleosynthesis models in the A ≈ 80 region.

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