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The Resonance Ionization Laser Ion Source for Radioactive Ion Beams at CERN-ISOLDE: Expanding Limits of Selectivity, Intensity, and Nuclear Structure Laser Spectroscopy

The Resonance Ionization Laser Ion Source RILIS, employing laser radiation in a hot cavity ion source diretly coupled to an isotope production target, has become a principal method for provision of radioactive ion beams at facilities world-wide, such as at CERN-ISOLDE or -MEDICIS. Stepwise resonant excitation and subsequent detachment of an electron via element-unique atomic shell transitions allows for highly efficient and chemically selective provision of the desired nuclide in the mass-separated ion beam.

Alongside a summary of its use in standard operation, we report on developments regarding key aspects for specific applications:
The specialized high selectivity RILIS variant LIST, employing spatial separation of the hot cavity from a dedicated laser ionization volume in a directly adjacent RF quadrupole unit, has been augmented with perpendicular laser beam access. It allows for reduction of the effective Doppler broadening in interaction with the hot atom vapor, thus enhancing spectral resolution from linedwidths in the GHz regime down to a few 100 MHz. This novel unit was employed to perform nuclear structure investigations on neutron-rich actinium isotopes. The results outline its potential for further high-resolution applications, and greatly enhanced capabilities for isomer-selective ionization of nuclides for experiments demanding highest ion beam purity.
On a parallel development route, various facilities undertake joint efforts to maintain the high efficiency of RILIS sources also under exceptionally high ion load circumstances. These occur, e.g., during the time-critical extraction of radioisotopes from pre-irradiated targets in off-line operation mode, as part of the European medical radionuclide provision program PRISMAP. Systematic investigations of the required plasma ion confinement are carried out by combination of simulation models and dedicated analysis experiments on different laser ion source models employed by the network participants.

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