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High Purity Radioactive Ion Beam (RIB) Production at ISOLDE by the Laser Ion Source and Trap (LIST)

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ISOLDE, the radioactive ion beam (RIB) facility at CERN, takes a top position among the world´s leading isotope production plants, allowing for all kinds of investigations on exotic nuclides far off the valley of β-stability. Most of these experiments require highest ion beam purity in respect to isobaric beam contaminations as well as contributions from neighboring isotopes. On the other hand a high production yield as well as ionization probability for the isotope of choice is crucial, even when dealing with isotopes of shortest half-life. Both conditions are most perfectly met by using the selective ionization method of the well-established resonant ionization laser ion source (RILIS) which ensures considerable ionization efficiency for the element of interest and, in theory, only for that. In addition to existentially supporting user experiments the ISOLDE RILIS meanwhile has become an independent research unit for laser spectroscopic studies and isomer selection. However, under real working conditions, also the RILIS technology does not eliminate all disturbing contaminants in the RIB, stemming from surface or thermal plasma processes within the hot ion source cavity. Hence, one specific upgrade of the ISOLDE RILIS concerned the introduction of the laser ion source and trap (LIST). It ensures unrivaled suppression of isobaric contaminations already within the ionization process by decoupling the atomization process on the hot ion source surfaces from the laser ionization region, which takes place inside a radiofrequency ion guide structure.
As has been demonstrated under realistic on-line conditions, the LIST suppresses isobaric contaminations by more than a factor of 1000 in respect to the conventional RILIS. However, the gain in ion beam purity is obtained at the expense of a reduced ionization efficiency, typically by about a factor of 20 to 50. Nevertheless, by running the LIST in one of the two possible modes of operation, i.e. the high purity LIST-mode or the high efficiency ion guide-mode without suppression, respectively, the best of both worlds can be chosen in accordance with the needs and a broad variety of investigations becomes feasible.
The principle of the LIST, the technical premises for the on-line operation at ISOLDE, which had to be met, and the necessary adaptations will be presented. These were based on methodic developments and investigations, as carried out off-line at the Mainz University RISIKO mass separator, as well as on the results from the on-line LIST runs 2011 and 2012. Rather similar activities are also under way at ISAC, TRIUMF, confirming the usefulness of the LIST ion source unit.

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