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Overview of ISOL facilities and production techniques

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Isotope Separator On-Line (ISOL) facilities are central to the production of high-purity radioactive ion beams (RIBs) for a variety of research applications. Emerging facilities are increasingly focused on high-power operation, where radioisotope yields are expected to scale directly with the primary beam power. However, significant engineering challenges must be addressed to ensure that high-power Target and Ion Source Systems (TISS) are as efficient as those operating in the low-power regime. Moreover, RIB yields at ISOL facilities typically degrade over time due to extreme operating conditions—such as targets and ion sources functioning at temperatures exceeding 2000 ℃—a problem expected to intensify in high-power TISS scenarios.

TISS development typically aims to maximize the efficiency of isotope extraction and ionization, enabling access to shorter-lived isotopes and even new elements. In parallel, the growing interest in using the ISOL technique to produce research-scale quantities of novel medical isotopes introduces new challenges. For example, high-throughput ion sources with high ionization efficiencies are increasingly in demand. High-power targets, in particular, face issues such as cold spots that can trap isotopes of interest, or high mechanical stresses in target disks caused by localized beam power deposition. Offline extraction, from previously irradiated targets or even external sources of radioisotopes has also become of interest, introducing new challenges into the ISOL systems. Other TISS related components such as converter targets (e.g. proton to neutron, electron to gamma), in-situ purifying transfer lines or reactive gas leaks or dispenser ovens for molecular beam formation can also be part of the TISS, opening up new beams for the applications mentioned, but making them even more complicated which can affect the TISS reliability.

Research on targets and ion sources systems is often conducted as small, isolated projects driven by the scientific interests of the user community. These technological advancements can lead to significant increases in RIB yields and enable access to new isotopes and elements at the extremes of the nuclear chart. This lecture aims to provide a comprehensive overview of the present and future ISOL facilities and their status, with a focused discussion on their recent technological developments in target and ion source systems (TISS).

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