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The CERN n_TOF neutron-time-of-flight facility: present and future

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The neutron time-of-flight facility, n_TOF at CERN, will approach the 25th year of operation in 2026. Its long successful history can be ascribed to the unique features of the neutron beams available, that combine a wide energy range, excellent neutron energy resolution and high instantaneous flux. Neutron-induced reaction experiments can be performed at n_TOF, providing new fundamental data of significance for nuclear astrophysics, advanced nuclear technologies and basic nuclear science. Currently, three distinct experimental areas are operational: two dedicated to time-of-flight measurements placed at 186 and 20 meters (EAR1, EAR2), and one for neutron irradiations and activation studies located at 5 meters (NEAR) from the target assembly. This variety of working areas effectively meets the demands for energy resolution and neutron beam intensity, required in in a wide assortment of neutron-induced nuclear reaction experiments.
n_TOF research activities on neutron-induced reactions provide key insights for astrophysics in understanding the origin of the chemical elements in the universe, notably for the slow neutron capture nucleosynthesis (s-process). Nuclear data with unprecedented accuracy, in broad energy domains, are routinely produced at n_TOF, instrumental for innovation of advanced nuclear technologies, in several areas of nuclear sciences. Upcoming upgrades will enhance the capabilities of the facility, enabling new research areas such as space technology and fusion science. These improvements include a new transmission station, a moderator for the NEAR station, high-pressure gas cells for gaseous targets, and advanced detectors to widen the range of nuclear reaction channels that can be exploited.
The n_TOF Collaboration is investigating the opportunities provided by the incoming CERN SPS Beam Dump Facility (BDF), to expand its capabilities for activation measurements, thus enhancing the core activities of neutron induced reactions. The recently endorsed facility will produce ultra-high neutron fluxes over a wide energy range. The neutron beam, opportunely filtered and complemented by the installation of a pneumatic rabbit system, can be used for measurements of neutron induced activation cross sections on radioactive nuclear species with short half-lives. This represents a particularly interesting development, for its potential synergy with the radioactive ion beam facility ISOLDE, aiming at the study of nuclear structure properties and neutron interaction with unstable nuclei.
A community grown to include over 150 scientists has formed around the n_TOF facility at CERN. The n_TOF Collaboration is a well-established and thriving research community, deeply integrated within the nuclear physics landscape, both in Europe and worldwide.

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