n_TOF: accurate measurements of neutron induced cross sections at the CERN neutron time-of-flight facility

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The production of the chemical elements in the Universe has always been an intriguing topic, as it bears fundamental information on the origin of matter, as well as on the history and evolution of the Universe. All elements heavier than lithium are synthesized in stars and several processes contribute to the so-called "stellar nucleosyntesis". Elements up to iron are mostly produced by fusion and reaction involving light charged particles (mainly protons), while elements heavier than iron are the result of neutron capture processes and β-decay. Nuclear reaction data are then a fundamental ingredient for a comprehensive understanding of element production in the Universe. In several decades of intense experimental and theoretical activity in the field of nuclear astrophysics, a good understanding of the structure and composition of a large variety of cosmic objects has been achieved. In particular, advances in the understanding of stellar nucleosynthesis of heavy elements have been obtained thanks to studies, of neutron-induced reaction cross-sections, carried out over a period of several decades at neutron facilities around the world. While the major characteristics of the process have now been well understood, some open questions still remain to be addressed. In this view improved and accurate nuclear data are needed to solve the remaining problems and refine the knowledge of primordial and stellar nucleosynthesis. In particular, new frontier measurements of neutron-induced reaction cross sections are needed in order to address specific problems in (i) Big Bang Nucleosynthesis (BBN) and (ii) stellar nucleosynthesis beyond iron.

Another important aspect of neutron-induced reactions is related to nuclear technology. The strategy foreseen for future employment and development of nuclear power generation underline the use of nuclear energy systems in which the nuclear fuel contains consistent amounts of the minor actinides (MA). These minor actinides, particularly neptunium and americium, are produced as normal by-products of the operation of thermal power reactors. Because of the existence of long-lived isotopes of these elements, they constitute the major sources of the residual radiation in spent fuel and in wastes resulting from reprocessing. Therefore, it is mandatory to gain availability of reliable and accurate neutron-induced reaction cross section data for the important isotopes of the MAs. Relatively low uncertainties in these data are required for core design studies, as well as for high burn-up strategies.

Another aspect of the importance of nuclear data for advanced nuclear technologies that has been addressed has been that of the Th/U nuclear fuel cycle. The use of thorium in the nuclear fuel cycle for either critical or subcritical systems is now a topic of great interest. An interesting advantage in using this fuel cycle, as compared to the conventional uranium/plutonium cycle currently used in all operating power plants, is related to its low production of high-mass actinides, including plutonium, making it appealing for the reduced proliferation capabilities.

The challenging nature of the measurements resides in the fact that they involve short-lived radioactive isotopes, or isotopes available in very small amount, or isotopes with small cross-sections. These characteristics have prevented so far an accurate measurement of key cross sections at existing neutron facilities around the world.

The use of unprecedented characteristics of the CERN n_TOF facility, i.e. the extremely high neutron flux, the wide energy range, matching exactly the region of interest for nuclear astrophysics, and a good energy resolution, in combination with innovative detectors will offer the unique opportunity to perform measurements not feasible up to now.