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# Direct measurement of neutron capture on radioactive isotopes at CERN n_TOF

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Neutron-capture reactions drive the formation of elements heavier than iron, occurring through both the slow (s-) process in low-mass AGB and massive stars, and the rapid (r-) process in explosive stellar environments. In the s-process mechanism, unstable branching isotopes serve as unique tracers, offering crucial insights into the physical conditions and intricate details of stellar nucleosynthesis. Neutron-capture measurements on radioactive isotopes, in combination with stellar spectroscopy and isotopic analyses of primitive meteorites, can help to better understand the role of stellar mass, rotation or metallicity and to refine further our understanding of galactic chemical evolution. However, from an experimental standpoint, determining neutron-capture cross-sections of radioactive isotopes remains a challenge. The primary obstacles include the production of high-quality radioactive samples and the need for highly sensitive and selective detection techniques to isolate the reaction channel of interest.

This contribution presents a comprehensive overview of the key s-process branching isotopes measured at the CERN neutron Time-of-Flight (n_TOF) facility over the past two decades. The astrophysical significance of these studies will be highlighted and it will be shown how upgrades in the neutron-beam facility and state-of-the-art detector developments have led to a stunning progress on the measurement of such radioactive nuclides. Despite these breakthroughs, significant limitations still persist, particularly concerning isotopes with short half-lives (smaller than a few years), restricted neutron energy ranges (beyond a few keV), and statistical uncertainties exceeding 10%. In this respect, CERN n_TOF has ambitious plans to push the boundaries of neutron-capture measurements, along with innovative approaches to overcoming current limitations in sample production and isotopic half-life constraints. These advancements hold the potential to unlock new frontiers in our understanding of stellar nucleosynthesis and may enable access to direct measurements of neutron-capture cross sections on other nucleosynthesis mechanisms, such as the intermediate (i-) process and the r-process.

**Author:** DOMINGO PARDO, Cesar (IFIC (CSIC-UV))

**Presenter:** DOMINGO PARDO, Cesar (IFIC (CSIC-UV))

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