Universality of the Supernova r-Process and Radioactive Nuclei [1]

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The discovery of how chemical elements are made in stars is one of the humanity's greatest achievement but several important questions are still unanswered. One of them surely concerns the rapid neutron capture (*r*) process, a key to the creation of the elements from Iron to Uranium (Z=26–92). The astrophysical site and exact mechanism of the *r* process have not yet been identified with certainty, a problem requiring astrophysics, astronomy, particle and nuclear physics to work together.

We have produced and studied exotic nuclei with neutron number $N \approx 82$ that have filled or nearly filled neutron shells configuration. These nuclei lie in the pathway of *r* process nucleosynthesis predicted for some of the most promising *r* process sites such as neutrino-driven wind in core-collapse supernovae. The enhanced stability of these nuclei is reflected in the large abundance of Xe and Te in the solar system. The experiment aimed at half-life measurements, was carried out at the Radioactive Ion Beam Factory (RIBF, RIKEN) where exotic nuclei were produced by fission of a Uranium beam induced by collision with a Be target. Fission fragments were unambiguously identified (see Fig. 1) and their following decay studied with the WAS3ABi silicon stopper and the EURICA germanium array.

The study evidences the persistence of shell structure and robust half-life systematics that underpin our current understanding of exotic neutron-rich nuclei. The new measurements also have a direct impact in *r* process models that achieve \emph{hot} conditions, i.e., strong $(n, \gamma) \Leftrightarrow (\gamma, n)$ equilibrium (see Fig. 2). In this case we find that the new data alleviate the long standing model underproduction of isotopes just below and above the mass $A \approx 130$ peak, and greatly improve the description of rare-earth elements. The latter is a prerequisite for understanding why the abundance of such elements matches coherently solar system and metal-poor stars (*r* process universality), and what is the full elemental range of such universal feature.

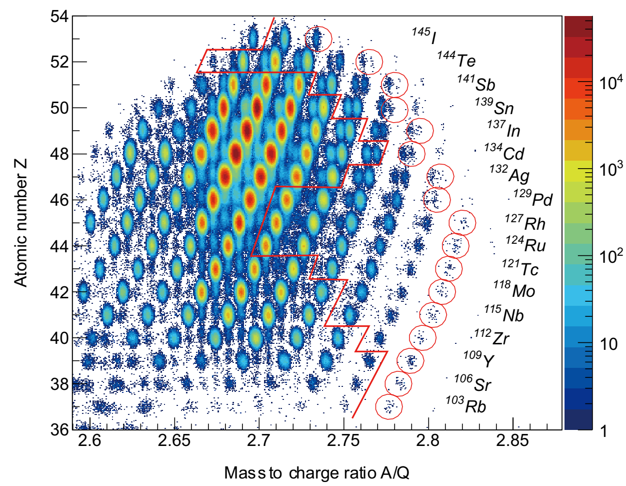

Figure 1: Particle Identification Plot. Nuclei on the right side of the red line were studied for the first time [1].

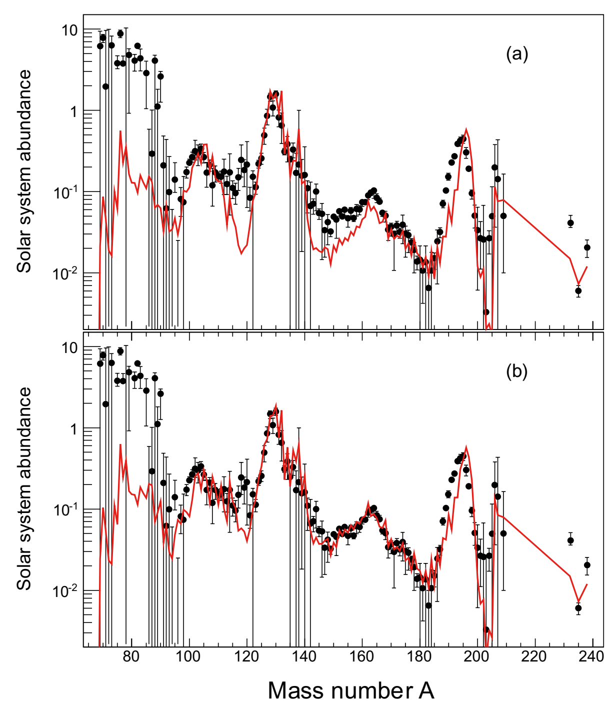

Figure 2: Comparison between the *r* process solar system abundance pattern and the abundances calculated (a) without and (b) with our new half-lives [1].

Reference

[1] Lorusso, G., et al.: 2015, *Phys. Rev. Lett.*, **114**, 192501.