Beta decay of $N = 82$ nuclei, and the astrophysical conditions of the $r$-process


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The shell structure at $N = 82$ plays a crucial role for the rapid neutron capture ($r$-) process. For example, it determines the shape of the large $A \sim 130$ peak in the solar system abundance pattern, and effects the timescale of the $r$-process as well as the amount of neutrons later available for fission. However, below $Z = 50$, as the proton orbit $g_{9/2}$ is progressively emptied, all proton-neutron interactions become important and could modify the ordering of neutron orbits. As a consequence, the evolution of the $N = 82$ gap is still unknown, and the predictions of neutron separation energies, half-lives, and neutron capture cross sections are unreliable making the location and duration of the $r$-process uncertain. Clearly, more experimental data are needed to constrain the $N = 82$ shell structure and provide $r$-process calculations with experimental input.

To address these open questions we have performed a decay-spectroscopy experiment at the Radioactive Ion Beam Factory (RIBF, RIKEN) in the neutron rich region below $^{132}$Sn. The recent beam development of RIBF, along with the installation of the EUROBALL $\gamma$-ray detector have made this region accessible to decay-spectroscopy experiments. The experiment was part of the EURICA uranium beam campaign in 2012.

In our experiment, the nuclei of interest were produced by fission of a 345 MeV/A $^{238}$U primary beam colliding with a $^9$Be target. Beam purification was provided by the BigRIPS fragment Separator. The fragments of interest were unambiguously identified, and their following beta decays were recorded by the WASABi silicon stopper in conjunction with the EUROBALL germanium array. Implantations were correlated with their subsequent decays on an event-by-event basis, allowing for the direct measurement of half-lives, $\beta$-delayed $\gamma$ rays, and $\gamma$ rays from implanted microsecond isomers.

With our experiment we have studied two new $r$-process waiting points: $^{128}$Pd and $^{127}$Rh. The $^{129}$Ag waiting point was studied with high statistics. The decay properties of these nuclei provide direct input for $r$-process calculations, new insights in the nuclear structure in this region, and specially on the dynamical conditions of the $r$-process (temperature, neutron density and duration of the process).

In this contribution we will present the experiment, the status and preliminary result of the data analysis.