Two-Proton Radioactivity of $^{67}$Kr†


β decay is the predominant decay mode in proton-rich nuclei close to stability, but further away from stability valley the binding energy of excess protons decreases and β-delayed proton emission becomes more likely. When the one or two-proton separation energies $S_p$ and $S_{p^2}$ become negative, the dripline is reached and one- or two-proton emission from the ground state for odd- and even-Z elements, respectively, competes with β decay.

Two-proton (2p) radioactivity is a unique tool to study nuclear structure beyond the proton dripline. Predicted in 1960, 1) this direct emission of two protons was discovered in 2002 in the decay of $^{45}$Fe. 2,3) The other known medium-mass cases $^{58}$Ni4) and $^{54}$Zn5) were discovered in the same decade.

According to mass predictions, the heavier nuclei $^{59}$Ge, $^{63}$Se and $^{67}$Kr are candidates for 2p emission. They were successfully produced and identified during the $^{78}$Kr beam campaign in 2015 6) at RIBF. $^{63}$Se and $^{67}$Kr were observed for the first time and $^{59}$Ge for the second.

The nuclei of interest 7) were implanted in WAS3ABi, a set of three DSSDs to measure the energy of β particles and protons. The vertical and horizontal strips allowed ion-decay position correlations, greatly reducing the background in the energy spectra. WAS3ABi was surrounded by the EURICA γ-ray array. 8)

No 2p evidence was found for $^{59}$Ge and $^{63}$Se. Fig. 1(a) and (c) do not show any peak without coincident β detection. However, the $^{67}$Kr spectrum (e) shows a clear peak at 1690(17) keV originating from 2p radioactivity without any coincident β particle or 511-keV γ ray. A 2p branching ratio of 37(14)% and a half-life of 7.4(30) ms were found, leading to a 2p partial half-life of 20(11) ms, in strong disagreement with the three-body half-lives 9) for different ℓ̂ configurations.

References