Two-Proton Radioactivity of ^{67}Kr†

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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_{2p} 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 ^{48}Ni [4] and ^{54}Zn [5] 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 DSSSDs 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. Figure 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 ℓ^2 configurations.

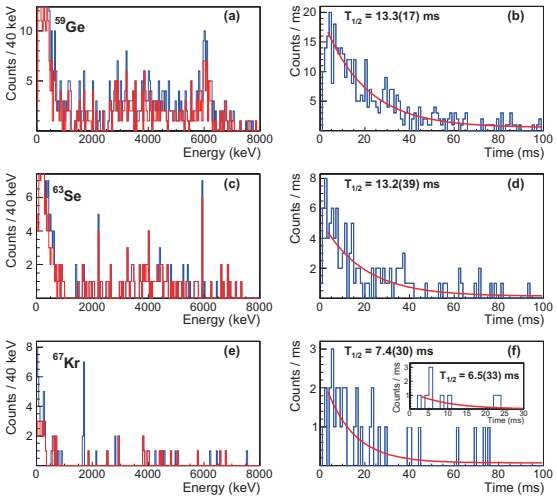

Fig. 1. Charged-particle energy spectra (left) and decay-time distributions (right) for events above 1 MeV to reject β decays without protons, for ^{59}Ge, ^{63}Se and ^{67}Kr. For the charged-particle spectra: in blue all decay events correlated within a 100 ms time window, and in red in coincidence with β particles detected in neighbouring detectors. The inset in (f) is obtained from the 1690-keV peak events of spectrum (e).[7]

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