Improved decay data for the long-lived fission product ^{111}Ag

V.E. Iacob,[1] J.C. Hardy,[1] D. Melconian,[1] K. Kolos,[2] D.E.M. Hoff,[2] N.D. Scielzo,[2] M. Brodeur,[4] N. Callahan,[3] J.A. Clark,[3] M. Gott,[3] B. Liu,[3,4] W-J. Ong,[2] R. Orford,[4] D. Ray,[3,5] A. Richard,[2] D. Santiago-Gonzalez,[3] G. Savard,[3,7] K.S. Sharma,[5] M.A. Stoyer,[2] A.A. Valverde,[3,6] and L. Varriano[7]

[1]*Cyclotron Institute, Texas A&M University, College Station, Texas, 77843*

[2]*Lawrence Livermore National Laboratory,*

[3]*Argonne National Laboratory,*

[4]*University of Notre Dame,*

[5]*Lawrence Berkeley National Laboratory,*

[6]*University of Manitoba,*

[7]*University of Chicago*

Continuing our collaborative effort TAMU-LLNL-ANL [1,2,3] to improve the experimental data for long lived fission products, we performed a branching ratio measurement on ^{111}Ag ($t_{1/2}$ = 7.5d). We combined measurements of g singles, b-g coincidences, and scaled b singles in a manner similar to the one described in Ref. [1].

Two high purity ^{111}Ag sources implanted in a thin (40 μg/cm^2) carbon foil were collected at the CARIBU facility at ANL. Immediately after harvesting, each source was shipped to the Cyclotron Institute (CI) at TAMU. The source activities at the time of their arrival at the CI were 1140 Bq and 1830 Bq.

The experimental setup involved a 4π proportional counter with continuous methane flow, our high-precision absolute efficiency calibrated HPGe detector [4,5] and the acquisitions system described in Refs. [1,6].

We inserted the first source in the gas counter and carefully adjusted the source to HPGe distance to 151 mm, the distance used in the absolute efficiency calibration. We could then start a g-singles measurement. The start of the b-g coincidences had to be postponed for ~6 hr, time needed to flush the gas counter after the source insertion. We stopped the measurements of the first source at the arrival of the second, more intense one.

Repeating the steps followed for the previous source, we measured g singles, b-g coincidences and scaled b singles for the canonical distance source to HPGe cap of 151 mm. The top panel in Fig. 1 presents the g ray spectrum observed in prompt coincidence with b$^-$ particles. The main peak at 342 keV (a 6.7% intense transition) contains ~2.2×10^5 events, enough to guarantee the aimed branching ratio accuracy of 0.5%. Along with g peaks from the ^{111}Ag decay, we identified peaks from ^{95}Zr ($t_{1/2}$=64d) and its daughter ^{95}Nb ($t_{1/2}$=35d). These radioactive impurities originate in oxides of ^{95}Zr and ^{95}Nb or their A=95 precursors in the b decay chain ($t_{1/2}$<11min): These oxides have the mass needed to pass the isobar separator at ANL that was set for A=111 nuclei. Notice the high background for the energy region above the dominant peak at 342 keV. This significantly increases the uncertainty in the areas of peaks in this region, up to the point of making some of them undetectable.

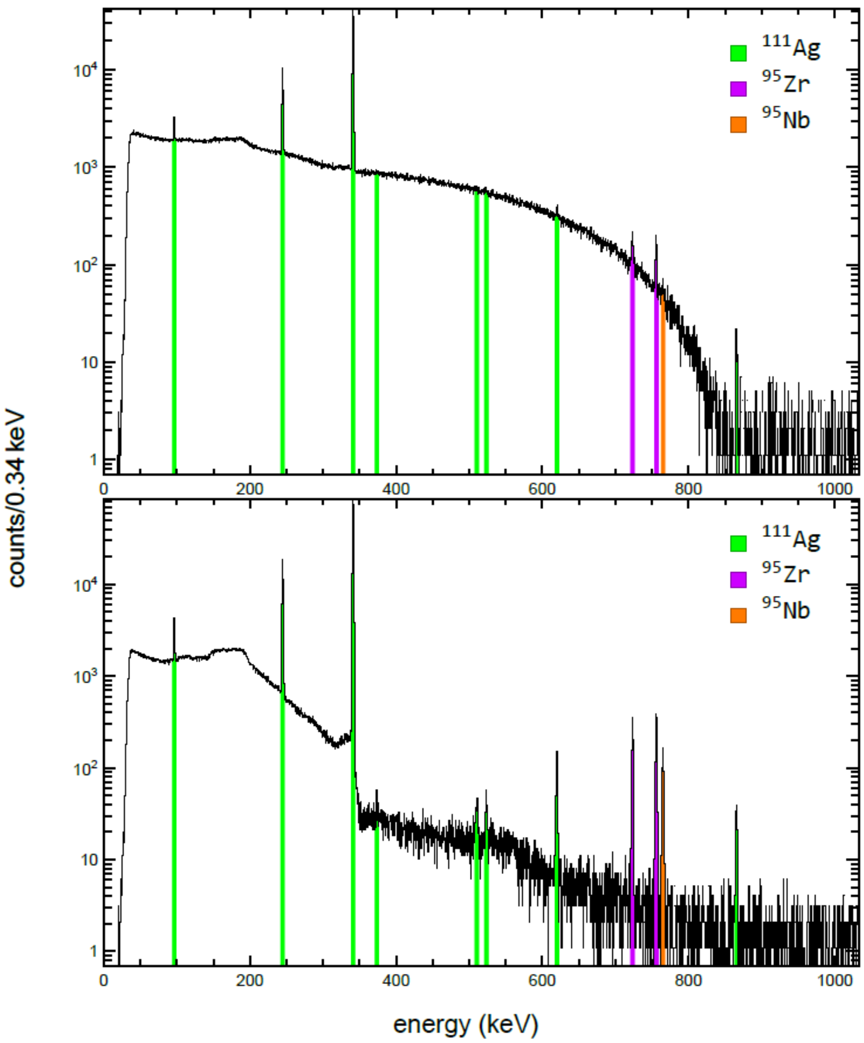

Fig. 1. γ ray spectra observed in prompt coincidence with electrons from the decay of the second ^{111}Ag source. The spectrum in the upper panel was measured with the source at the canonical distance of 151 mm to the HPGe detector cap. The spectrum in the lower panel was measured with the source at 51 mm to the HPGe cap, and a 4.7 mm thick Plexiglass plate in-between serving as a β^- screen.

A second measurement of this source began a week after its arrival at the CI. We made two important changes: (i) to compensate for the activity drop, we positioned the source at 51 mm to the HPGe cap, and (ii) to reduce the above-mentioned background, we introduced between the source and HPGe a 4.7 mm thick Plexiglass plate acting as a β^- screen. The observed γ ray spectrum coincident with β^- particles is presented in the bottom panel of Fig. 1. Notice the significant improvement in the data quality for the weak g rays. Data extracted from this measurement require however absolute efficiencies for the close geometry (with the Plexiglass screen); these can be obtained from pairs of source measurements in close canonical geometries.

Data analysis is in progress.

[1] K. Kolos *et al*, Nucl. Instrum. Methods Phys. Res. **A1000**, 165240 (2021).
[2] K. Kolos *et al*., *Progress in Research*, Cyclotron Institute, Texas A&M University (2018-2019), p. I-37.
[3] M. Bencomo *et al*., *Progress in Research*, Cyclotron Institute, Texas A&M University (2020-2021), p. I-21.
[4] R.G. Helmer *et al.*, Nucl. Instrum. Methods Phys. Res. **A511**, 360 (2003).
[5] R.G. Helmer *et al.*, Appl. Radiat. Isot. **60**, 173 (2004).
[6] V.E. Iacob *et al.*, Phys. Rev. C **101**, 045501 (2020).