The half life of ^{34}Ar

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Currently, precise *ft*-values measured for superallowed $0^+ \rightarrow 0^+$ β transitions provide the most accurate value for V_{ud}, the up-down quark mixing element of the Cabibbo-Kobayashi-Maskawa (CKM) matrix [1]. This enables the most demanding test of CKM unitarity, a basic tenet of the Standard Model. Recently it has been shown [2] that further improvements in precision are possible if the *ft* values for pairs of mirror $0^+ \rightarrow 0^+$ transitions can be measured with 0.1% precision or better. The decays of ^{34}Ar and ^{34}Cl are members of such a mirror pair, but so far the former has not been known with sufficient precision. In the 10 years since the publication of our result for the half-life of ^{34}Ar [3], we have improved significantly our acquisition set-up and our analysis techniques: We have added features [4] and refinements that allow a better control of the acquired data and thus lead to increased accuracy and precision in the final result.

We report here an experiment aiming to improve the half-life of ^{34}Ar. The experiment detected positrons as in Ref. [3] but with improved controls. The total decay spectrum is presented in Fig. 1; it contains more than $3{\times}10^8$ combined ^{34}Ar and ^{34}Cl decays. The main difficulty in this type of measurement is caused by the decaying daughter nucleus, in this case ^{34}Cl, whose half-life is about twice that of ^{34}Ar.

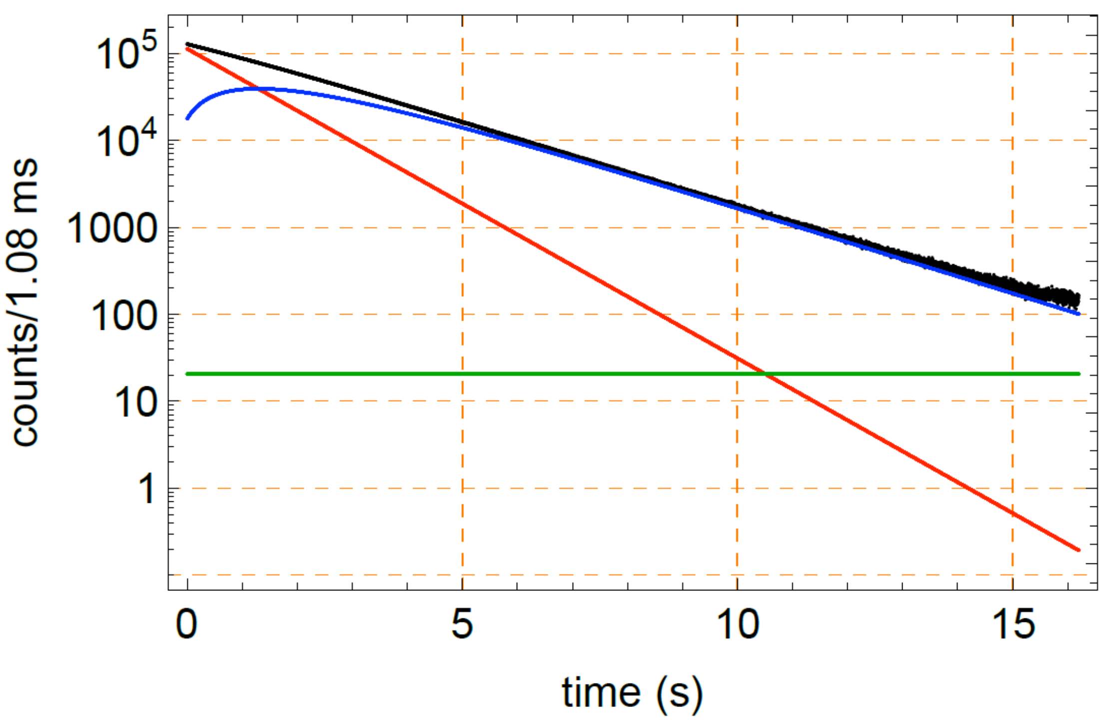

FIG. 1. Total decay spectrum observed in the decay of ^{34}Ar. There is a total of more than $3{\times}10^8$ events in the spectrum distributed over 15,000 time channels, each 1.08 ms wide. The total spectrum (black) is decomposed into its contributors: ^{34}Ar (red), ^{34}Cl (blue) and background (green).

This almost completely obscures the ^{34}Ar contribution to the total spectrum since we detect positrons and are thus unable to differentiate between parent and daughter decays. The case is illustrated in Fig. 1 which contains, along with the total decay spectrum, the individual contributions of the two nuclear decays.

We solved this problem [3] by using a restricted fit that makes use of the parent-daughter link involved in the decay. However, at the time of our previous measurement [3] we did not recognize the importance of the small difference in detection efficiency between the two decays, which have slightly different end-point energies. This is because the low-energy cut-off has a smaller effect on decay spectra with higher end-point energies than it does on lower energy decays. The result in our case is a slightly higher detection efficiency for the ^{34}Ar decay. Fig. 2 illustrates this point by presenting the energy distribution of the positrons emitted by the two nuclei along with the detection efficiency curve. The inset zooms in on the low energy region relevant for the cut-off effect. For the particulars of our detector, this amounts to $\varepsilon_{Cl}/\varepsilon_{Ar} = 0.9996$.

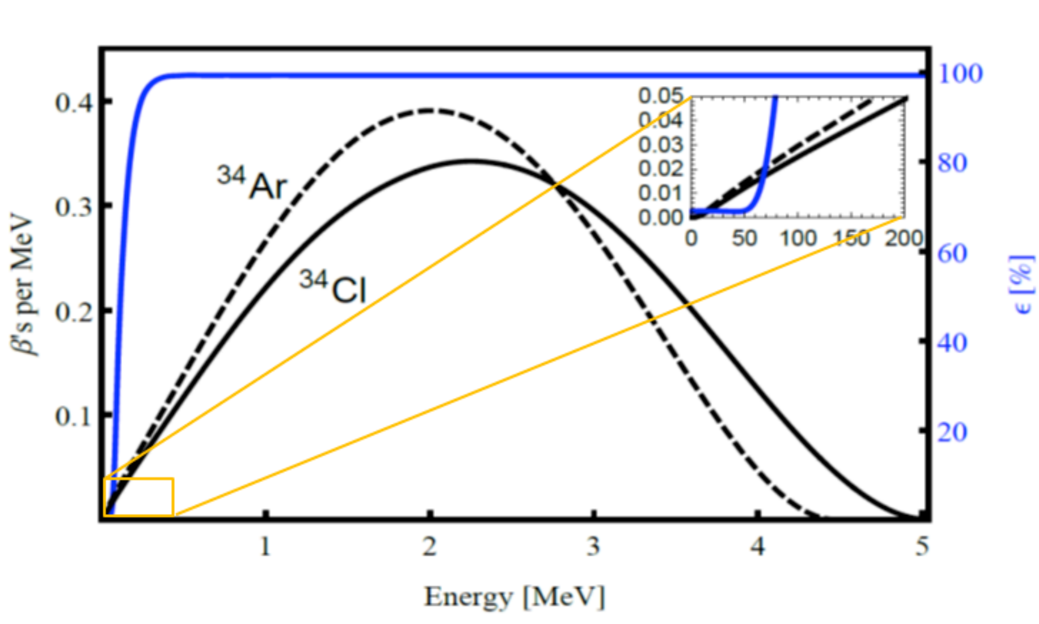

FIG. 2. Energy distribution of the positrons emitted in the decay of ^{34}Ar (solid line, black) and ^{34}Cl (dashed line, black). The detection efficiency (solid line, blue) is superimposed to illustrate the cut-off effect; the efficiency units are given in the right vertical axis. The inset zooms in the energy region relevant to the cut-off; the energy axis in the inset is given in keV's.

When included in the fit, this difference in detection efficiencies increases the half-life of ^{34}Ar. The preliminary result obtained from the thorough analysis of about one third of the total statistics gives for this increase a value of 1.5 σ relative to the result in Ref. [3].

[1] J.C. Hardy and I.S. Towner, Phys. Rev. C **91**, 025501 (2015).

[2] H.I. Park, J.C. Hardy, V.E. Iacob, M. Bencomo, L. Chan, V. Horvat, N. Nica, B.T. Roeder, E. Simmons, R.E. Tribble, and I.S. Towner, Phys. Rev. Lett. **112**, 102502 (2014).

[3] V. Iacob *et al.*, Phys. Rev. C **74**, 055502 (2006).

[4] V.E. Iacob, *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2008-2009), p. V-43.