# $^{34}$Ar half-life

V.E. Iacob, J.C. Hardy, M. Bencomo, L. Chen, V. Horvat, N. Nica, H.I Park,
B.T. Roeder, and A. Saastamoinen

We report here a fine-tuned fit of the half-life of $^{34}$Ar, based on significant improvements in both data acquisition and fit method since our first measurement of this half-life in 2004 [1]. The experiment itself is described in [2].

The data were acquired in cycles: We turned the beam on, and for 0.7 s implanted $^{34}$Ar nuclei in the 76.2 μm-thick mylar tape of our fast tape transport system; then the beam was turned off, and the collected activity was moved rapidly into the center of a 4π proportional counter, which then recorded the emitted positrons for 16.2 s. Cycles were repeated until the desired statistics had been accumulated. The detected events triggered a discriminator, whose signals were passed to two gate generators, which each introduced a different dominant non-updating dead time. The signals from these two gate generators were then passed to two multi-scalers. To allow us to test for the presence of undesired biases in our results, the experiment was subdivided into individual runs, each with a different set of three critical detection parameters: detector bias, discrimination threshold, and dominant dead times.

Each cycle was separately analyzed and accepted only if:

(1) the implantation beam provided more than 5000 $^{34}$Ar nuclei;

(2) the ratio of detected positrons to implanted nuclei was at least 95% of the maximum (expected) value; and

(3) a preliminary fit to the decay for that cycle yielded a $\chi^2$ that was below the value corresponding to a probability of less than $10^{-4}$ for the occurrence of higher values.

The first condition eliminates cycles with anomalously low beam current; the second condition

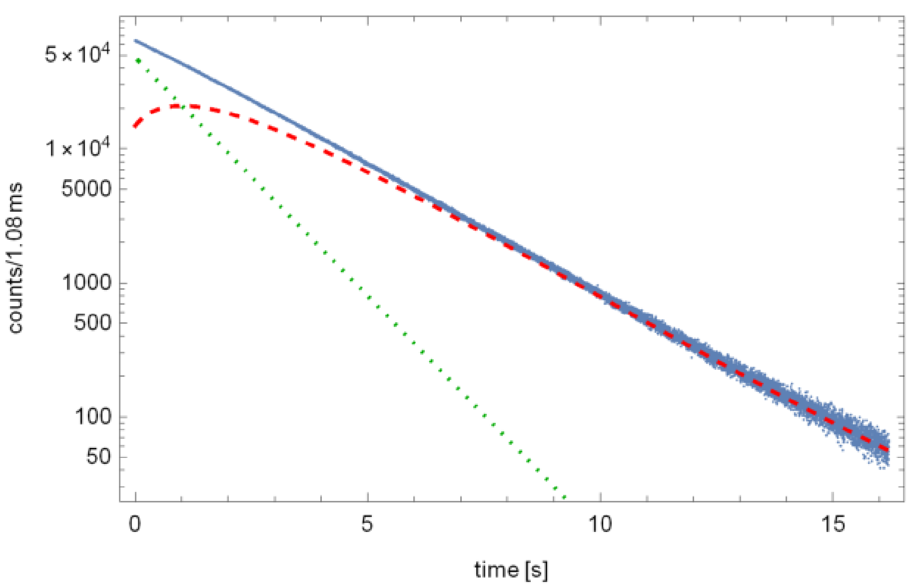


**FIG. 1**. Total decay spectrum recorded in our measurement. The combined $^{34}$Ar and $^{34}$Cl decays were recorded in 15,000 channels, each 1.08 ms wide. The total measured spectrum (blue) is shown, along with dotted lines giving the separate contributions calculated for the parent $^{34}$Ar (green) and daughter $^{34}$Cl (red).

eliminates those with poor positioning of the activity inside the detector; and the third removes any cycles that experienced electrical interference in the detector. The total decay spectrum derived from the cycles that passed these criteria is presented in Fig. 1.

As observed in Fig. 1, the decay of $^{34}$Ar is obscured by the decay of its daughter. As the proportional counter cannot disentangle $^{34}$Ar decays from $^{34}$Cl decays, we use the parent-daughter link dictated by the decay to overcome this difficulty. This is possible because we implant no $^{34}$Cl in the collected samples.

The subdivision of the experiment into runs with different experimental parameters, allowed us to test the data for the presence of possible systematic effects from those parameters. Fig. 2 presents the distribution of the fit results as obtained in one of the multichannel scalers (MCS-A): all points represent fit results in a Poisson maximum-likelihood procedure, using the parent-daughter link in the decay.

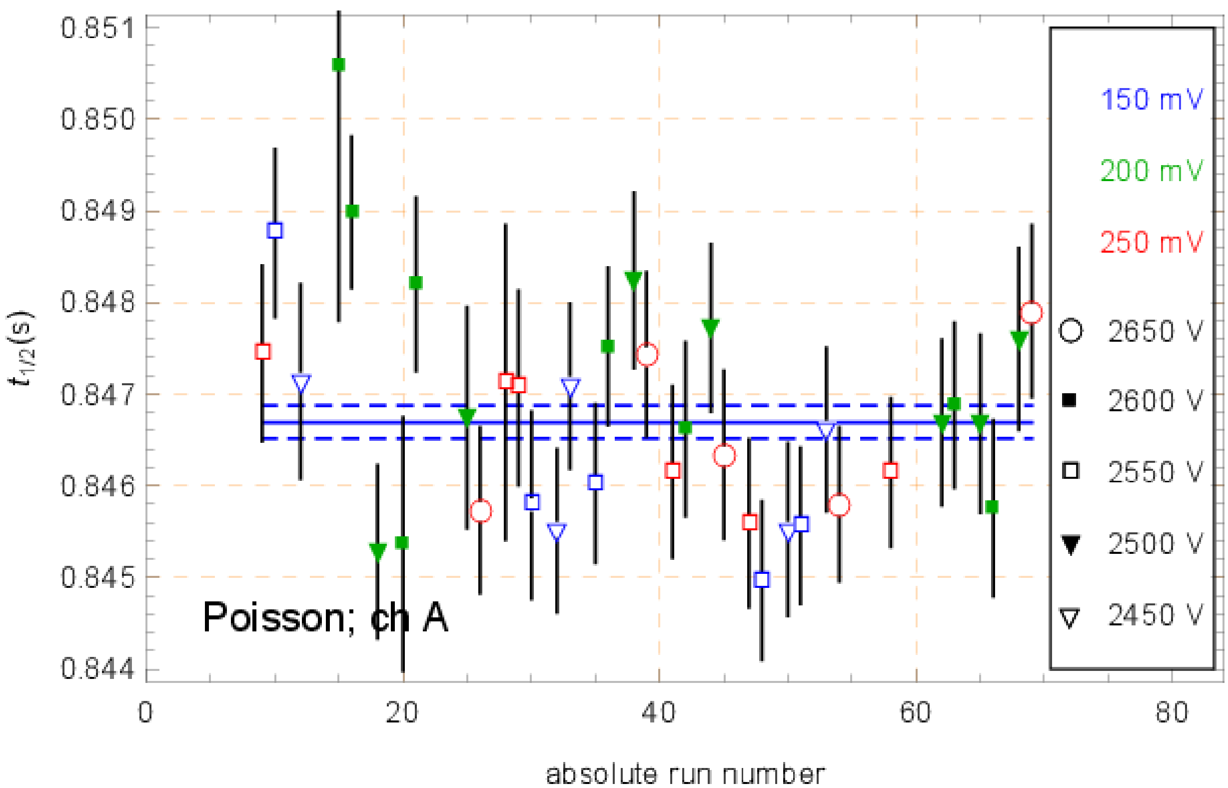


**FIG. 2**. Distribution of the fit result for the half-life of $^{34}$Ar: detector biases are marker coded, while discrimination thresholds are color coded.

The two multichannel scalers collected data from the same detected events but processed them with different imposed dominant dead-times. Thus, a parallel fit of the runs that used different multi-scalar channels offered another check for the consistency of the results and, in particular, the efficacy of our dead-time corrections. No difference between the results associated with different dead-times was observed.

To further check for possibly inconsistent dead-time corrections or for the presence of an unexpected short-lived impurity, we successively removed channels starting from time-zero and repeated the fit. Fig. 3 presents the fit-stability against front-channel chopping, covering a time interval of three half-lives. No hint of any inconsistency can be identified.

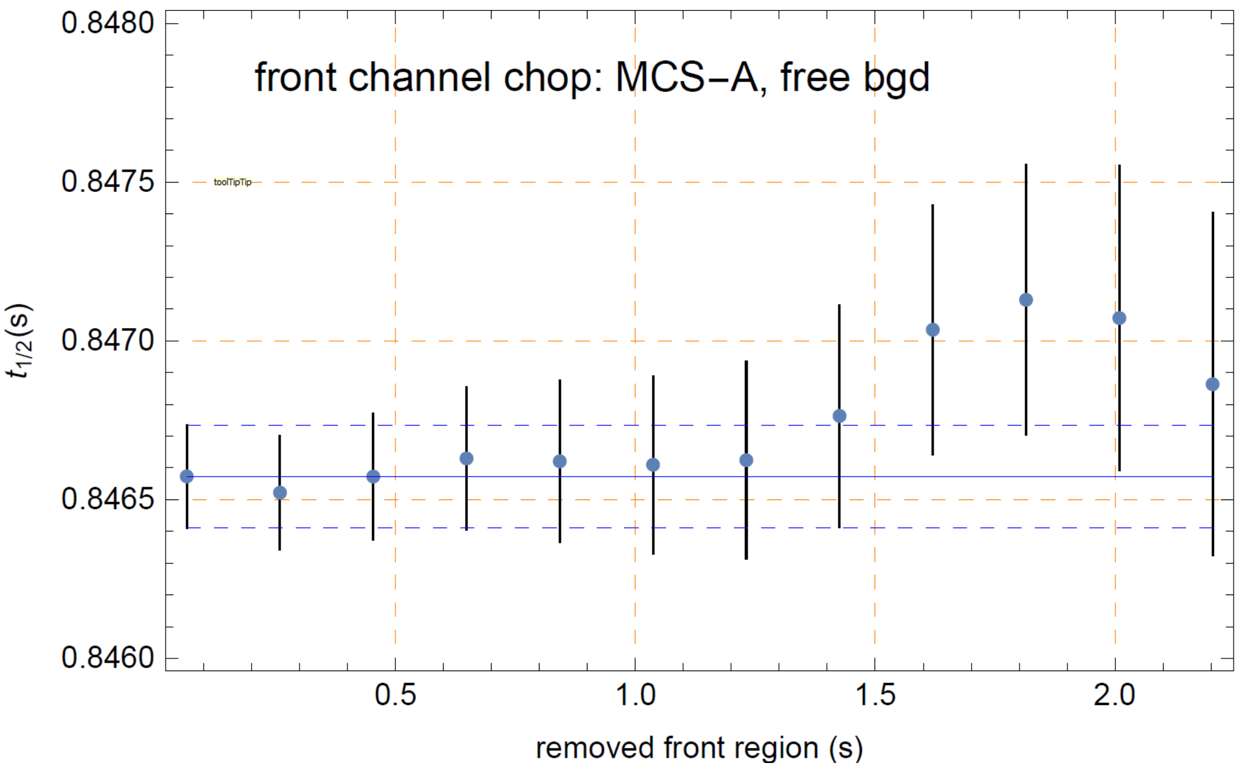


**FIG. 3**. Fit stability against removal of channels from the front part of the spectrum. This clearly demonstrates the absence of any short-lived contaminants or inconsistent dead-time corrections.

Finally, as mentioned in [2] and [3], the decay of $^{34}$Ar is now known to very weakly populate the 32-min isomeric level in $^{34}$Cl. This reduces the number of expected daughter decays that are observed during the 16.2 s detect-time, thus modifying the parent-daughter link. A measurement to determine the strength of this "leak" from the parent-daughter link is currently being analyzed [3]. Once this last ingredient is in place, we will complete the full analysis of $^{34}$Ar decay.


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

[2] V.E. Iacob, *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2015-2016), p. I-14.

[3] H.I. *Park et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2018-2019), p. I-8.