The half life of ^{10}C

V. E. Iacob, J. C. Hardy, V. Golovko, J. Goodwin, N. Nica, H. I. Park,
L. Trache and R. E. Tribble

Although the uncertainty in the $\mathcal{F}t$ value for the $0^+ \rightarrow 0^+$ superallowed transition from ^{10}C is dominated by the uncertainty in its branching ratio, the half-life uncertainty actually does contribute significantly and has, in fact, a larger percent uncertainty than the half-life of any other "well-known" superallowed emitter [1]. The two previous measurements [2,3] are consistent with one another and average to 19.290(12) s, a precision that, with our current techniques, we should be able to improve by at least a factor of two.

In our first attempt to improve the half-life of ^{10}C [4], we reported a value that was only marginally more precise than the accepted value. At that time, the precision of our result was limited to only ~0.1% by a relatively high background/noise rate in our proportional gas counter and insufficient control over impurities in the collected sample. These problems prompted us to make a second measurement, in which we focused on three main objectives: (i) increasing the statistics, (ii) improving our control over the impurities and (iii) lowering the background/noise rate.

Our experimental setup was similar to the one used in Ref. [4]: the 18.5*A* MeV radioactive beam was produced in a ^{1}H(^{11}B,2n)^{10}C reaction, then separated by our spectrograph MARS and ultimately extracted in air and implanted into a 76-μm-thick aluminized mylar tape. The ^{10}C nuclei were collected in the tape for 10 s, then the beam was turned off and the activity was moved rapidly to the center of a 4π proportional gas counter. The gas counter was shielded against neutrons and gammas to reduce the background rate to a minimum. Once the activity arrived at the center of the gas counter, the emitted

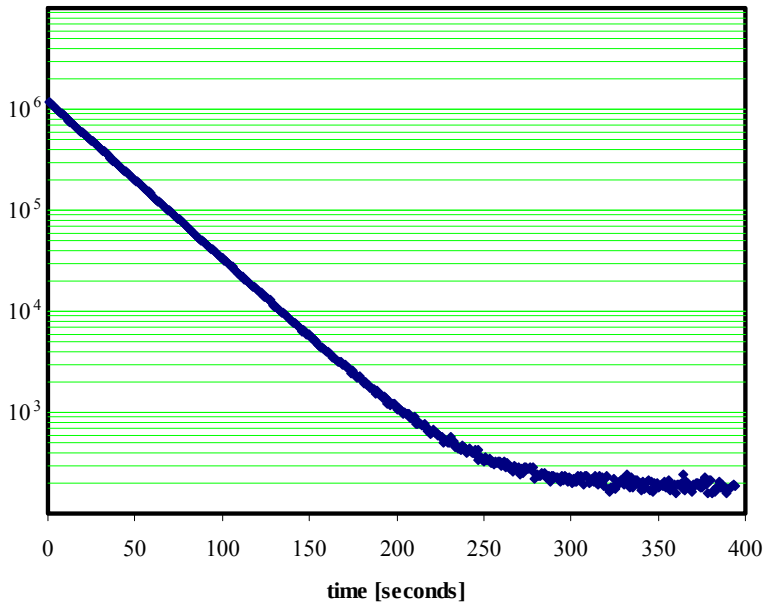

Figure 1. Total decay spectrum of ^{10}C

positrons were detected with >95% efficiency and their signals multiscaled for 400 s. Such collect-move-detect cycles were repeated until the desired statistics were achieved (8.5×10^7 decays). The total decay spectrum obtained in this experiment is presented in Fig. 1.

As with our previous experiment, we divided the total measurement into a number of separate runs, each with different critical settings in the acquisition chain: discriminator threshold, dead-time and detector bias. No evidence of a systematic bias was observed in the analysis of these runs, as evidenced by Fig. 2.

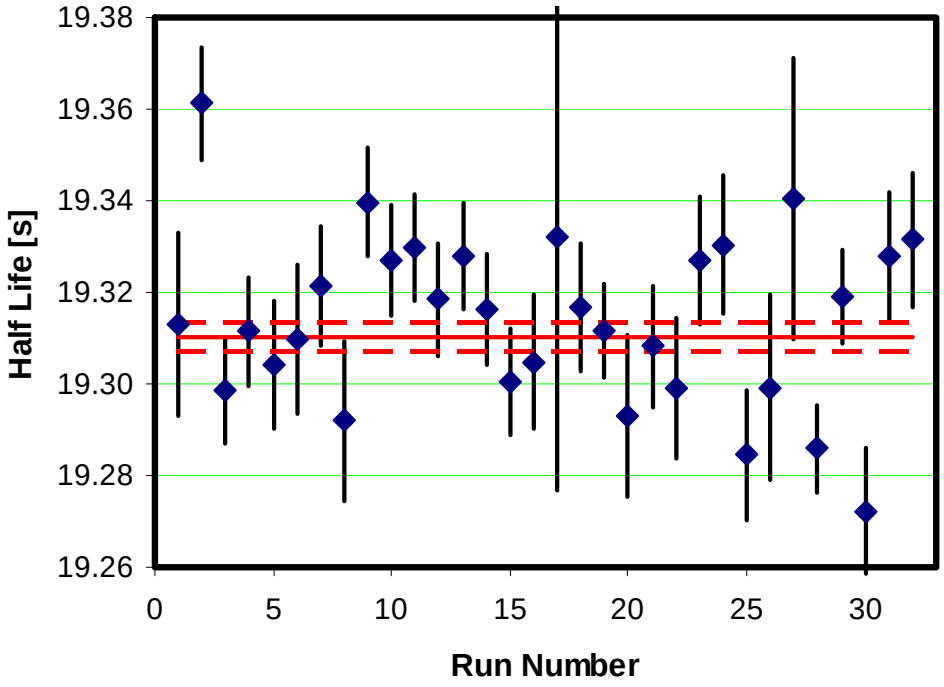

Figure 2. Scatter of the ^{10}C half-life as extracted in the different runs, each having different detection settings: discriminator threshold, detector bias and major dead-time.

In order to gain more complete control over the long-lived impurities, we added to the "normal" runs, which had collect-move-detect intervals of 10s-0.180s-400s, two additional runs with collect-move-detect settings of 20s-0.180s-900s and 120s-0.180s-900s. Analyzing these latter runs we found that the main "impurity" was actually the result of neutron activation of the detector's copper housing during the beam-on intervals. Only the ^{65}Cu(n,γ)^{66}Cu component, with a half-life of $t_{1/2} = 5.10$ min, had to be considered in the analysis since the ^{63}Cu(n,γ)^{64}Cu activation leads to an activity with a half-life of 12.7 hours and thus serves only to increase slightly the constant background. We determined that the activity of ^{66}Cu produced by activation was 0.078% of the activity of ^{10}C implanted in the tape.

With provisions incorporated for the copper contaminant, we determined the half-life of ^{10}C to be 19.312(4) s with a fit quality of χ^2/ndf=44.9/31. When redoing the fit of our 2005 data [4], now including the same amount of ^{66}Cu as observed in this experiment, we obtained a half-life of 19.313(7) s, in complete agreement with the more recent measurement. However, because there was additional noise

present in the earlier experiment, we have not averaged the two results; instead we keep only the result from the clean data obtained in the new experiment.

To make the result more definitive, we also tested the data for the possible presence of unidentified short-lived impurities and/or inconsistent dead-time corrections. We did this by applying the standard technique of successively removing early-time channels, where both effects would have the most significant contribution, and obtaining the fitted half-life with larger and larger numbers of early channels removed from the fit. The results are presented in Fig. 3, where it can be seen that the half life is statistically independent of the number of channels removed. There is no indication of any inconsistencies.

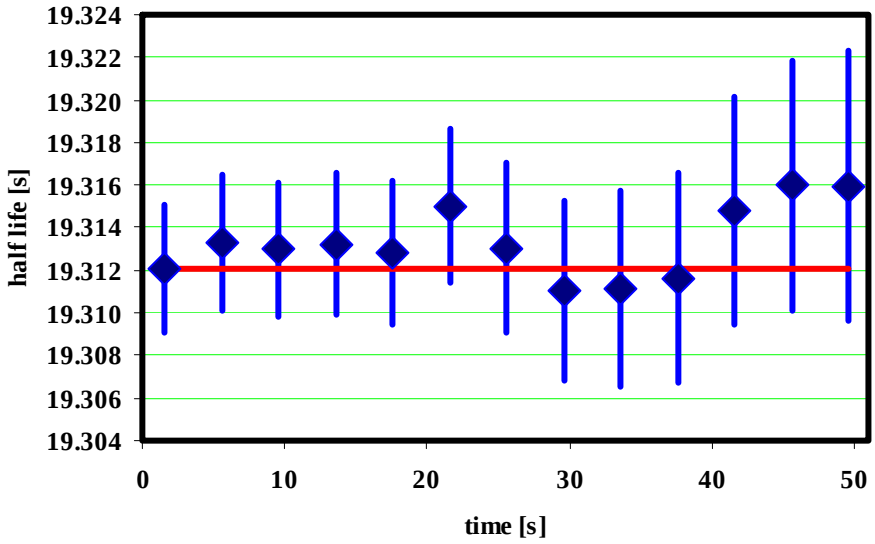

Figure 3. Scatter of the ^{10}C half-life as extracted from subsets defined by gradually removing the early part of the decay spectrum. The abscissa represents the length of time for which data was removed from the first part of the decay spectrum

Our new half-life result, $t_{1/2}(^{10}C) = 19.312(4)$ s, is nearly two standard deviations higher than the previously accepted average of 19.290(12) s [1] but it is a factor of three more precise. It should be noted, though, that, of the two previous measurements, the most recent [3], 19.295(15) s, does agree with our result and it is only the earliest one [2], 19.280(20) s, that disagrees significantly. That value was measured more than 30 years ago.

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[2] G. Azuelos, J. E. Crawford and J. E. Kitching, Phys. Rev. C **9**, 1213 (1974).

[3] P. H. Barker and G. D. Leonard, Phys. Rev. C **41**, 246 (1990).

[4] V. E. Iacob *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2005-2006), p. I-28.