Precise Half-Life Measurement of ^{62}Ga

V. E. Iacob, J. C. Hardy, C. A. Gagliardi, M. Sanchez-Vega, A. Azhari, E. V. Mayes,
R. G. Neilson, L. Trache, and R. E. Tribble

In last year's Progress Report we reported on measurements of the β-decay of ^{62}Ga, including a preliminary value for its half-life [1]. We report here on an additional measurement of the half-life focused on exposing systematic effects that could affect the result. We obtained ^{62}Ga from the MARS recoil spectrometer by bombarding a cooled hydrogen gas target with ^{64}Zn at 42A MeV. Special care was taken for the optimization of the ^{62}Ga beam from MARS in order to minimize the impurities. At the exit of MARS, the beam was degraded and then implanted in the aluminized mylar tape of our fast tape-transport system. The short half-life of ^{62}Ga ($t_{1/2}$ = 116 ms) made it impractical to use our normal reel-to-reel tape system; instead, we employed a closed single-loop path design, similar to that described in [1], which removed the need for frequent tape rewinds.

The ^{62}Ga was collected on tape for 0.25 s; then the beam was turned off and the collected activity was moved within 135 ms in the center of a 4π proportional gas counter placed in a low background region. The counter signals were then multiscaled for 3.00 s and a decay spectrum consisting of 250 channels was recorded. About 10^5 separate decay spectra, one from each collect/move/detect cycle, were recorded. To allow for tests of possible systematic errors, the data were split into separate runs typically of over a thousand cycles each. The detector bias, discriminator threshold, time interval per channel and the setting for the dominant dead-time were changed sequentially from run to run.

In analysis, each run underwent a pre-sorting procedure that removed the cycles in which less than 25 decay events were recorded in the 4π detector, and the cycles for which the ratio of the recorded β-decays versus the number of deposited nuclei was anomalous, indicating either high noise (too many events) or bad tape positioning (too few events). Runs passing the pre-sort procedure with less than 50 valid cycles were nevertheless removed entirely as not having statistical significance. About 3 million events, in total, survived this procedure. The spectrum for the data subset with a timing of 12 ms per channel is presented in Fig. 1.

To achieve a high-precision half-life measurement we require a very good knowledge of the beam composition. As ^{62}Ga is an N=Z nucleus, the radioactive beam provided by MARS inherently includes other N=Z nuclei produced by the beam. The main contaminant was ^{58}Cu – an abundant presence among the ^{64}Zn+p reaction products. To evaluate the level to which the tape-collected activity was

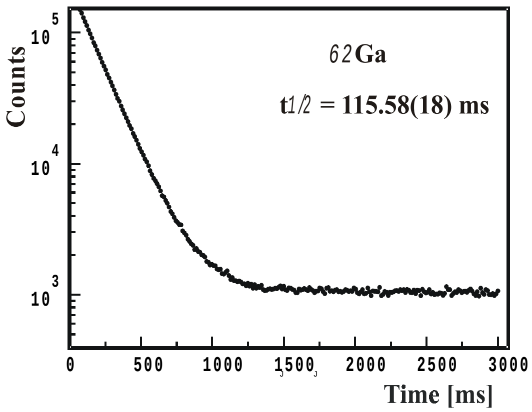

Figure 1: Total time spectrum of the β^+ decay of ^{62}Ga corresponding to the data subset recorded with 12 ms/channel.

contaminated with ^{58}Cu ($t_{1/2}$ = 3.2 s), a separate experiment was performed with collect/detect times of 2s/23s: the analysis of these data gave a contribution of 1.1(1)% ^{58}Cu in the deposited activity. This value is consistent with the result obtained during set-up of the MARS spectrometer, when particle-identification spectra were acquired with a particle detector in the MARS focal plane. Another N=Z impurity present in our samples is ^{54}Co. As the $J^{\pi} = 0^{+}$ ($t_{1/2}$ = 193.2 ms) ground state has a half-life close to that of ^{62}Ga, this impurity could affect our final result. Fortunately, the total ^{54}Co contribution is below 0.5% in the particle identification spectra, which do not separate the ground state from the 1.5-min. isomer. Furthermore, because of the difference in the stopping powers between ^{54}Co and ^{62}Ga, less than 0.1% of the ^{54}Co is implanted in the mylar tape, and only part of that is the troublesome 0^{+} ground state. Computer fits of all decay spectra were then performed with two (^{62}Ga and ^{54}Co) and three (^{62}Ga, ^{58}Cu and ^{54}Co) decaying components plus background. These allowed us to establish a maximum residual ^{54}Co contribution of ~0.05% and to determine that the maximum effect this could have on the ^{62}Ga half-life is 0.04%, a factor of four below our statistical uncertainty.

Adopting the beam composition just obtained, we extracted a ^{62}Ga half-life from each run, using a maximum-likelihood fit to a spectrum obtained by summing the dead-time-corrected spectra from all accepted cycles. To increase the reliability of the extracted half-lives, a parallel fit was also performed on Monte-Carlo-generated spectra with the same statistics and composition (^{62}Ga, impurities and background) as the experimental data set. The retrieval of the parameters used in the generation of this artificial data set confirmed the validity of the fitting procedure. Averaging over all the runs, we obtain a value for the ^{62}Ga half-life of $t_{1/2}$ = 115.58(18) ms.

To rule out the presence of possible systematic errors, the half-lives extracted from the runs performed under different experimental conditions (detector bias, discrimination threshold, time interval per channel or dominant dead-time) were inter-compared. Fig. 2 presents the extracted half-lives for the different runs performed with various values of the detector bias and/or discrimination threshold. No evidence of systematic bias could be found. To further test for the presence of short-lived impurities other than ^{54}Co, we performed four more fits to the data, each obtained by the removal of successively more channels from the beginning of the decay cycle. As seen in Fig. 3, the extracted half-life is stable as channels are removed.

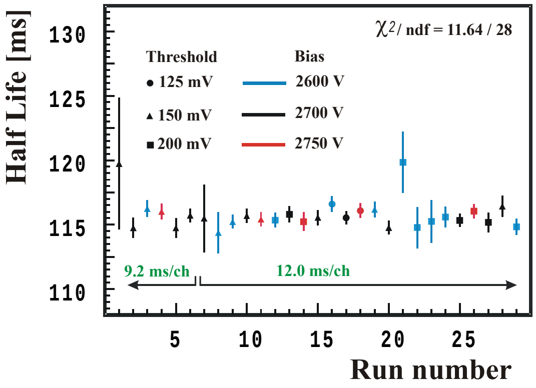

Figure 2: Search for possible systematic bias due to the acquisition set-up: discriminator threshold, detector bias, and time per channel. The first six runs were performed with 9.2 ms/channel; the rest were performed with 12 ms/channel.

Finally, we have re-examined the data acquired in the 2000 test run [1], this time including the effects of a ^{58}Cu impurity. The revised result for the ^{62}Ga half-life becomes $t_{1/2}$ = 115.58(69) ms, fortuitously the same value as we obtained from the 2001 run, but with a larger

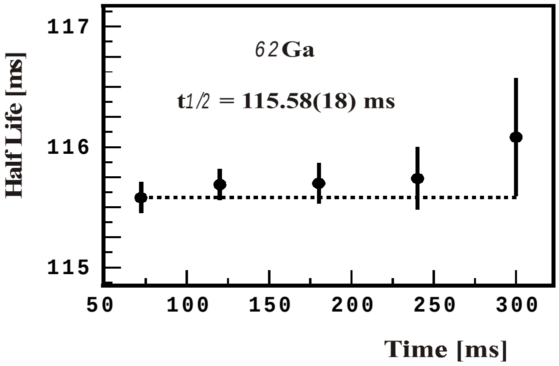

Figure 3: Test for systematic errors possibly caused by undetected short-lived impurities or by rate-dependent counting losses. The abscissa represents the time period at the beginning of the counting cycle for which the data is omitted from the fit.

uncertainty that reflects the much lower statistics of the earlier run. Thus, the value obtained from the most recent experiment stands as our final result for the ^{62}Ga half-life: *viz.* $t_{1/2}$ = 115.58(18) ms. This value agrees with one previously published value, $t_{1/2}$ = 115.95(30) ms [2], but is slightly smaller than the other [3], which is $t_{1/2}$ = 116.34(35) ms.

References

[1] C. A. Gagliardi *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2000-2001), p. I-36.
[2] D. E. Alburger, Phys. Rev. C **18**, 1875 (1978).
[3] C. N. Davids *et al.*, Phys. Rev. C **19**, 1463 (1979).