Measurement of the Half-Life of ^{22}Mg

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

As part of our program [1] to test CKM unitarity via superallowed ∃-decays, we have measured the half-life of ^{22}Mg with a precision close to $\pm$0.05%. We performed the measurement at the end of the MARS recoil spectrometer, using our fast tape-transport system [2]. A high purity radioactive beam (containing more than 99.6% ^{22}Mg) was produced via the MARS spectrometer with the ^{1}H(^{23}Na,2n)^{22}Mg reaction at 28A MeV. The 23A MeV ^{22}Mg ions exited the beam-line through a 50-:m-thick Kapton window, passed through a 0.3-mm-thick BC-404 scintillator and a stack of aluminum degraders, and eventually implanted in a 76-:m-thick aluminized mylar tape. Since the few remaining impurities in the beam had different ranges from ^{22}Mg, they were not collected on the tape: the purity of the collected sample was thus >99.9% [3].

In our experiment, the ^{22}Mg activity was collected for 8 s, about two half-lives; then the beam was turned off and the sample moved within 180 ms to the center of a 4B proportional gas counter [4], located in a low background region. The detected counter signals were then multiscaled for a period of 80 s and an 8000-channel decay spectrum was recorded. This collect/move/detect cycle was clock-controlled and was repeated continuously. Within the counting period a pulse synthesizer accurate to 5 ppm provided the time-stamp. Special care was taken to avoid any systematic errors that could be generated by the acquisition system. The counter signals were amplified and sent to a fast discriminator, whose signals then went to a gate

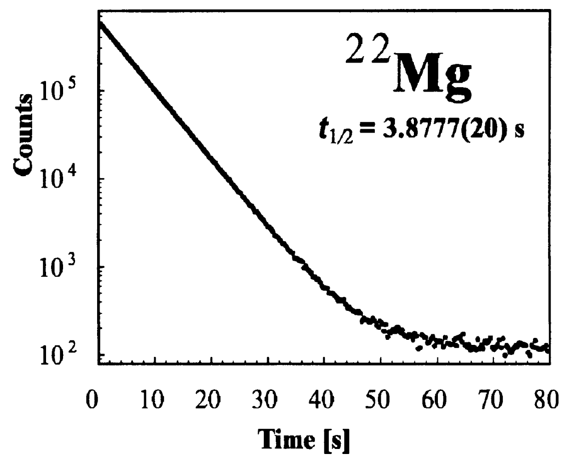

Figure 1: Total decay spectrum of ^{22}Mg ∃ particles

generator. The time duration of the gate signal was chosen to be much longer than any dead time introduced by the up-stream modules. This produced a well-defined non-extendable dead-time.

A total of about 10 million ^{22}Mg decays were recorded in 14 separate runs (see Fig. 1).We pre-sorted the data by testing each cycle for the ratio of ∃-particles recorded in the proportional counter versus the number of ^{22}Mg nuclei deposited on the tape (as determined by the scintillator at the exit of MARS); thus, we discarded any anomalous cycles with low counts or high noise. Then we analyzed the results with two different fitting procedures to extract the half-life: (i) a maximum-likelihood fit to the sum of all dead-time corrected decay spectra; and (ii) a global fit of individual cycle spectra, with common half-life but with amplitudes and dead-times correctly matched to each cycle. The second procedure gives the best precision, as it contains no approximation. To further

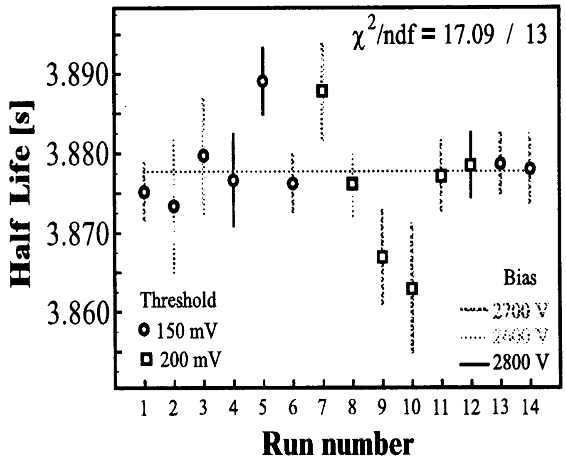

Figure 2: Test for possible systematic errors due to the acquisition chain (discriminator threshold and detector bias)

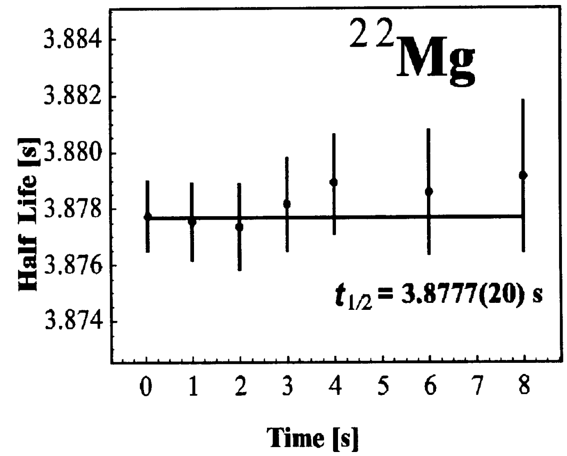

Figure 3: Test for possible systematic errors due to the presence of short lived isomers or count-rate dependence. The abscissa is the time omitted from the fitting procedure at the start of the counting period.

consolidate the results, both fitting procedures and all tests were repeated on a parallel set of Monte-Carlo generated spectra, mimicking the trend of the real data, but with a known half-life and background. The accurate retrieval of the decay parameters used in the generation of the artificial data validated the fitting procedures and the final half-life result.

To test for possible systematic errors introduced by the electronics, we made measurements at various different settings of the discriminator threshold and the detector bias. No evidence of a systematic bias was found when these measurements were compared (see Fig. 2). We also tested for the possible presence of some short-lived impurities and/or counting-rate dependence. To do so, we removed the contribution of data from the first second of the counting period and repeated the fit; we then repeated the procedure removing the first two seconds, three seconds and so on. As seen in Fig. 3, the half-life is very stable against these changes. There is no evidence for either short lived contaminants or count-rate dependencies.

We still have not checked the stability of the result as a function of the value set for the dominant dead time. This test will be performed in late May. Since this check is not completed, our result is still preliminary: $t_{1/2}$ = 3.8777(20)s.

References

[1] J. C. Hardy *et al., Progress in Research*, Cyclotron Institute, Texas A&M University (2000-2001) p. I-24.

[2] J. C. Hardy, F. Abegglen, G. Derrig, R. Haisler, H. Peeler, M. Potter and W. Zajicek, *Progress in Research,* Cyclotron Institute, Texas A&M Universtiy (1998-1999), p. V-20.

[3] M. Sanchez-Vega *et al.*, *., Progress in Research*, Cyclotron Institute, Texas A&M University (2000-2001) p. I-27.

[4] V. E. lacob and J. C. Hardy, *Progress in Research,* Cyclotron Institute, Texas A&M Universtiy (1998-1999), p. V-22.