Precise Branching Ratio Measurement of the Superallowed Beta Decay of ^{22}Mg

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This year, we completed the data-taking phase of our high-precision measurement of the branching ratio for the superallowed β-decay of ^{22}Mg. This work is part of our experimental program (see [1]) to measure the *ft*-values for superallowed $0^+ \rightarrow 0^+$ decays of nuclei with $22 \leq A \leq 34$ to a precision approaching ±0.1%. We have begun with ^{22}Mg because the calculated charge correction, δ_C, for the superallowed transition in ^{22}Mg is very low, 0.26%, and because the transition to the ^{22}Na ground state, being second-forbidden unique, is suppressed by ten orders of magnitude and can be neglected (see Fig. 1). Thus, since all significant β branches are followed by γ-rays, we need only measure the relative intensities of these γ-rays to obtain the β-branching ratios.

The experimental input to any *ft*-value comprises the branching ratio and decay energy of the particular transition, together with the half-life of the parent nucleus. We report here on the status of our measurement of the branching ratios for β-transitions from ^{22}Mg. The following report [2] describes our completed half-life measurement, and another [3] outlines progress on a measurement of the mass of ^{22}Mg, from which the decay energy can be obtained.

A general description of the branching-ratio experiment was presented in last year's Progress Report [4]. Some significant improvements in the electronics have been implemented since that time but the general experimental arrangement remains the same. This year, we had two scheduled data-taking periods, totaling 15 days of cyclotron beam time. Pure

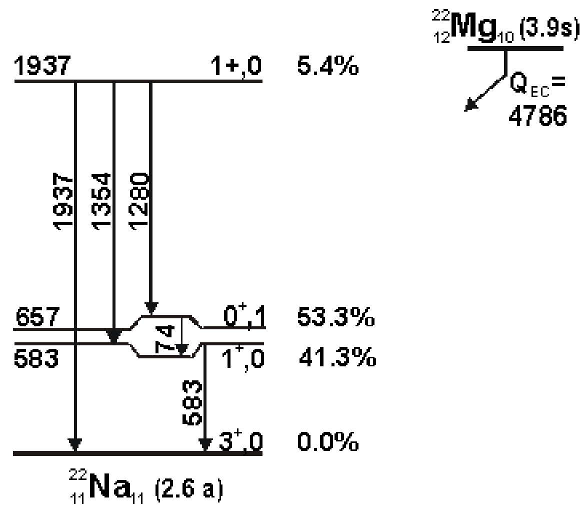

Figure 1. Decay scheme for the β-decay of ^{22}Mg.

^{22}Mg activity was collected and then counted in a repetitive cycle: it began with a 5-s implantation in aluminized-mylar tape, after which the beam was interrupted and the tape moved, placing the sample in a shielded counting location 90 cm away in 180 ms; there data were recorded for a further 5 s while the beam remained off. This cycle was clock-controlled and was repeated continuously. We recorded β-γ coincidence data with our well-calibrated HPGe γ-ray detector [5] placed at 15 cm from the sample. Data were recorded for a wide range of different counting rates, thus providing us with a means to test for any count-rate effects in our results. We also recorded singles γ-ray spectra with two different data-acquisition systems: the first was the same as the one we used for acquiring coincidence data; the second was an Ortec TRUMP™-8k/2k analog-to-digital converter card controlled by the MAESTRO™ software, the same system we had used previously for off-line calibration measurements [5]. Background spectra were recorded in both coincidence and singles mode under various conditions.

Analysis of the data is progressing well but is not yet complete. Our goal is to achieve unprecedented precision on the superallowed branching ratio and, as a result, we require a level of consistency in all aspects of the analysis that exceeds normal expectations in nuclear physics. We have already achieved a detector efficiency calibration that contributes no more than 0.15% to the uncertainty in the measured branching ratio. Now we are seeking to reduce the uncertainties from small experimental effects to even lower levels. Corrections due to the following factors are currently being examined: (a) background subtraction, (b) peak analysis under conditions that differ slightly from those pertaining to the calibration spectra, (c) the 245-ns half life of the 583-keV state in ^{22}Na, (d) coincidence γ-ray summing including angular correlations and energy-dependent total-to-peak ratios in the HPGe detector, and (e) rate dependence in random γ-ray summing. We expect this analysis to lead to a branching-ratio result with 0.2% precision.

A byproduct of our recent measurements will impact on future experiments. Because every ^{22}Mg decay channel includes at least one γ-ray, the γ-ray data on ^{22}Mg determine our system's overall counting efficiency relative to the number of ^{22}Mg ions detected at the exit of MARS. Since we record these ions as a function of time during the collection period, we know precisely the number of ^{22}Mg nuclei present in each collected sample at the beginning of the counting period. This provides an *in situ* calibration of our absolute γ-ray detection efficiency cycle by cycle. In the measurements reported here, we were able to observe this ratio over many cycles. In future measurements of other superallowed decays in which there is direct ground-state β feeding, we must rely on this ratio to extract branching ratio results at all. We found this ratio to be unstable at the 1% level owing to small variations (± 3 mm) in the position of the sample from cycle to cycle. We are modifying our system to record the β-singles count-rate for each cycle as an independent measure of the sample position. The efficacy of this procedure will be tested in the near future.

References

[1] J. C. Hardy *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2000-2001), p. I-21.

[2] V. E. Iacob *et al., Progress in Research*, Cyclotron Institute, Texas A&M University (2001-2002), p. I-26.

[3] J. C. Hardy *et al., Progress in Research*, Cyclotron Institute, Texas A&M University (2001-2002), p. I-36.

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

[5] J. C. Hardy *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2001-2002), p. V-14.