The β^+ Decay of ^{34}Ar

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We chose ^{22}Mg as the first new superallowed β emitter to study because its calculated charge correction, δ_C, has the very low value 0.26%, and because ^{22}Mg has no β-decay branch feeding its daughter's ground-state; thus, its β-decay branching ratios can be determined entirely from the relative intensities of its β-delayed γ-rays. We have now chosen ^{34}Ar ($t_{1/2}$ = 0.84 s) as the second case to study for two reasons: 1) Its calculated charge correction is 0.68%, higher than any other known case, and consequently it offers an important test [1] of the δ_C calculations; and 2) it is the case next most tractable to experimental precision after ^{22}Mg. The superallowed β-decay branch from ^{34}Ar, which directly populates the ^{34}Cl ground state, accounts for 94% of its total decay strength. This means that, unlike ^{22}Mg, the branching ratios in the decay of ^{34}Ar require a measurement of the *absolute* intensities of the β-delayed γ-rays from the non-superallowed transitions – a normally challenging requirement. However, because these transitions comprise less than 6% of the total decay strength from ^{34}Ar, they need only be determined to a precision of 2% in order to yield 0.1% precision on the superallowed branch.

We plan to measure both the branching ratio and half-life of ^{34}Ar at the cyclotron. A test run with MARS in March yielded a beam of ^{34}Ar with ~95% purity. We produced this beam using the reaction p(^{35}Cl, 2n)^{34}Ar, with a 30*A* MeV beam from the cyclotron bombarding a LN_2-cooled hydrogen gas target. After MARS had been optimized, we observed ~5000 ^{34}Ar ions per second at its focal plane. This beam was extracted from MARS through a Kapton window, then passed though a thin scintillator and a stack of aluminum degraders, and finally was implanted in the aluminized Mylar tape of the fast tape-transport system. (For a more complete description of the experimental arrangement, see [2].) Each collected sample was conveyed to a shielded counting station, where it was positioned between a thin plastic scintillator and a 70% HPGe detector. There, we recorded β-γ coincidences event-by-event. A counting cycle consisted of a 2-s collection period, a 180-ms transfer time and a 2-s counting period. The accelerator beam was off during the transfer and counting periods.

This cycle was clock-controlled and was repeated continuously. The coincident γ-ray spectrum obtained in this way is shown in Figure 1. Although the counting statistics are

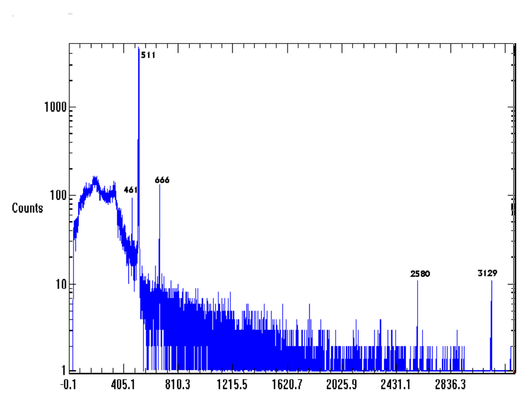

Figure 1: Coincidence (-ray spectrum at 15 cm from March run.

very low, there is no evidence of any radioactivity other than ^{34}Ar.

The energy-level diagram for the decay of ^{34}Ar is shown in Figure 2, and the current values for the known γ-ray intensities and β branching ratios are shown in the table. It is evident from the spectrum that we observe all of the γ-rays known to be emitted in the decay of ^{34}Ar. Furthermore, the spectrum is substantially cleaner than the best spectrum obtained previously [3]. A preliminary analysis of the γ-ray intensities in this spectrum gives a result for the intensity of the 461 keV γ-ray relative to the one with 666 keV of 0.35±0.04, in good agreement with the prior results[3].

In order to determine intensities for all of the γ-rays, it will be necessary to extend our current efficiency curve for the HPGe detector from 1800 keV to 3200 keV. This will be accomplished using a ^{56}Co source. In addition, Monte Carlo simulations are currently being performed in order to determine the limits of our precision in measuring the half-life of ^{34}Ar with the 4π β-detector [4]. Measurements of this half-life are complicated by the fact that the daughter of ^{34}Ar is ^{34}Cl, which has a similar short half-life ($t_{1/2}$ = 1.53 s). Any measurement of β-particles alone will include the growth and decay of ^{34}Cl along with the decay of ^{34}Ar. If we cannot obtain sufficient precision with the 4π detector, it will then be necessary to consider another method for measuring the half-life, such as the *β-γ* coincidence method, in order to differentiate between the decay of ^{34}Ar from that of ^{34}Cl.

Table 1: Branching ratios and relative γ-ray intensities for ^{34}Ar

Excitation Energy (keV)	Relative intensity of γ-rays (%)	Branching ratios (%)
0	0.00	94.4 ± 0.25
461	36.5 ± 3.6	0.91 ± 0.10
666	100	2.49 ± 0.12
2580	34.5 ± 1.0	0.86 ± 0.12
3129	52.1 ±1.2	1.30 ± 0.10

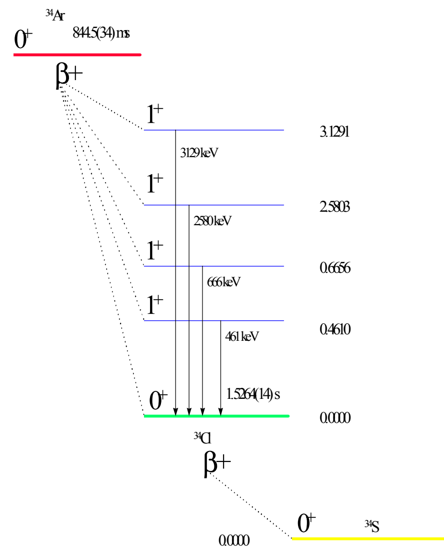

Figure 2: Energy level diagram for the decay of ^{34}Ar

References

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