Superallowed β-decay branching ratio measurement of ^{26}Si

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We have measured the branching ratios for the superallowed $0^+ \rightarrow 0^+$ β^+ emitter ^{26}Si (Fig. 1). Since the Q_{EC} [1] value and half-life [2] have already been measured, the branching ratio for the superallowed transition allows us to determine the *ft* value. This completes the second pair of mirror superallowed transitions between T=1 states: ^{26}Si → ^{26m}Al and ^{26m}Al → ^{26}Mg. Previous measurements of the *A*=38 mirror transitions, ^{38}Ca → ^{38m}K and ^{38m}K → ^{38}Ar, showed that the ratio of mirror *ft* values is very sensitive to the model used to calculate the small isospin-symmetry-breaking corrections required to extract V_{ud}. In calculating this correction both Woods-Saxon (WS) and Hartree-Fock (HF) radial wave functions have been used, with the experimental results from the first pair favoring the Woods-Saxon option [3]. In an effort to determine if this conclusion is generally applicable we undertook the measurement of ^{26}Si decay.

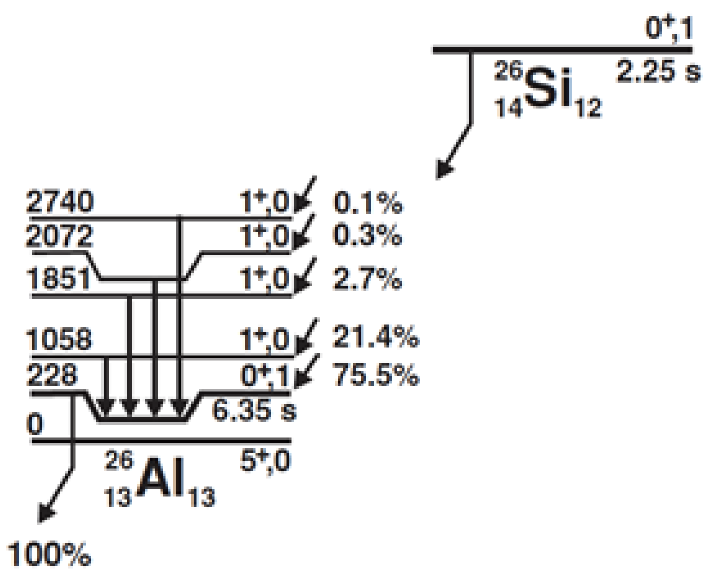

FIG. 1. Decay scheme of ^{26}Si showing only those features of relevance to the superallowed β decay. All energies in keV. Data taken from Ref. [4].

In our last report, we focused on explaining some of the largest corrections that need to be taken into account in our analysis in order to obtain a branching ratio. We explained in some detail the corrections for random coincidences, parent-daughter fraction, coincidence summing and impurities. Other smaller corrections, such as dead time, bremsstrahlung, and preemption of real coincidences were only mentioned. We have now determined these smaller corrections and obtained branching ratios for the 1^+ states populated by Gamow-Teller β decay, and from that we have determined the superallowed branching ratio to the 0^+ state by subtraction. Here we present the results for the corrections not previously reported:

Dead time - This refers to the time during which the electronics are busy processing a signal from the detector. The dead time for β detection is small, ~450 ns. The γ detection on the other hand is much slower and the dead time depends on the rate of coincident and singles γ rays. The rate of coincident γ rays averaged 116 counts/s and the γ singles averaged 457 counts/s. The correction factor was determined to be 1.0235.

Preemption of real coincidences - There is a small probability that coincidences are lost due to random coincidences preempting a real one. This occurs when the master trigger for our system is activated by a real β-γ coincidence opening a coincidence window, but a random β event closes it before the real one does. The correction factor was determined to be 1.0038.

Bremsstrahlung - Bremsstrahlung radiation is emitted when positrons from ^{26}Si stop in or near the β detector. This is another source of coincident summing. Bremsstrahlung produces a continuous energy spectrum instead of a clear peak in the γ-ray spectrum. To determine this contribution we need the areas of all γ-ray peaks multiplied by their total-to-peak ratio we then sum the results and subtract from the total spectrum area. The difference is then the contribution from bremsstrahlung. The contribution was determined to be 162 counts.

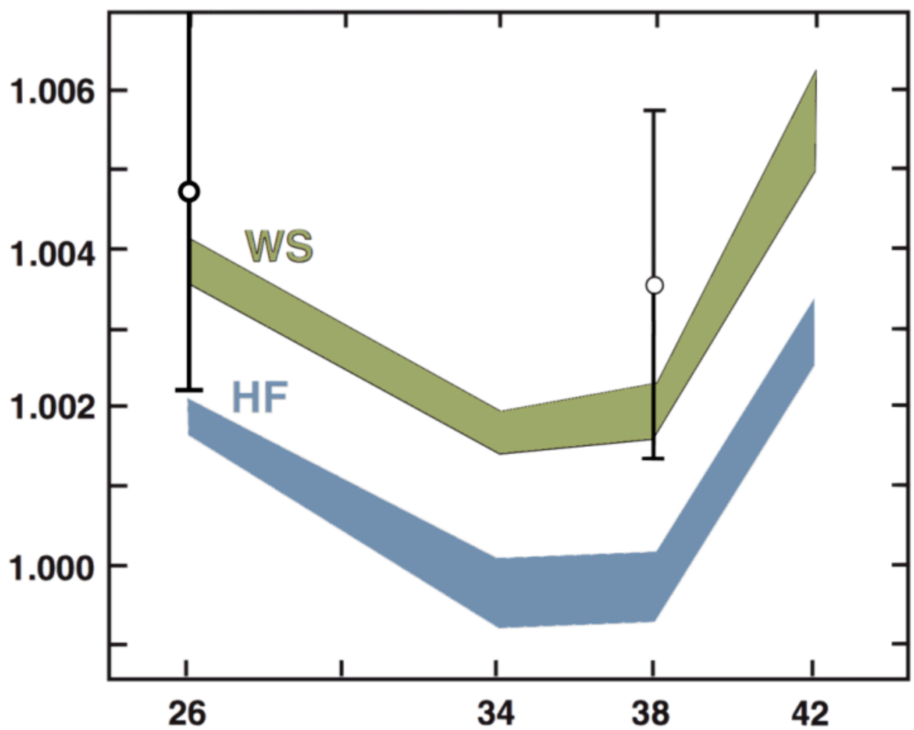

FIG. 2. Preliminary result for the ratio of *ft* values of the *A* = 26 pair as well as the previous result for *A* = 38.

With all these corrections completed, we can determine the branching ratio to the 1^+ state in ^{26}Si at 1058 keV, the most intense branch. Obtaining the relative intensities of the other γ-ray peaks with respect to the 829-keV peak, we determine the total of the Gamow-Teller branches to be 24.31%. If we then subtract from 100% we obtain the superallowed branching ratio to be 75.69%. (The final uncertainty is yet to be determined.) These numbers should be considered preliminary since one more correction – to account for the small probability that γ rays are recorded by the β detector – still needs to be done. However if this preliminary number is combined with the known half-life and Q_{EC} value for ^{26}Si decay, the ratio of *ft* values for the mirror *A*=26 pair supports the A=38 result (see Fig. 2) in favoring the calculation with Woods-Saxon radial wavefunctions.

[1] T. Eronen *et al.*, Phys. Rev. C **79**, 032802(R) (2009).
[2] V.E. Iacob, J.C. Hardy, A. Banu, L. Chen, V.V. Golovko, J. Goodwin, V. Horvat, N. Nica, H.I. Park, L. Trache, and R.E. Tribble. Phys. Rev. C **82**, 035502 (2010).
[3] H.I. Park *et al.*, Phys. Rev. Lett. **112**, 102502 (2014).
[4] J.C. Hardy and I.S. Towner, Phys. Rev. C **79**. 055502 (2009).