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

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We have acquired data, which we are currently analyzing, on the branching ratio 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 will allow us to determine the *ft* value. This would be the second pair of mirror superallowed transitions from a T_Z = -1 parent, ^{26}Si → ^{26m}Al and ^{26m}Al → ^{26}Mg. Our previous measurement of the 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 correction required to extract V_{ud}. In calculating this correction, two alternative models were used, one based on Woods-Saxon (WS) radial wave functions and the other on Hartree-Fock (HF), with the experimental results from the first pair favoring Woods-Saxon [3]. In an effort to determine if this conclusion is supported more generally, we continue this type of work with ^{26}Si.

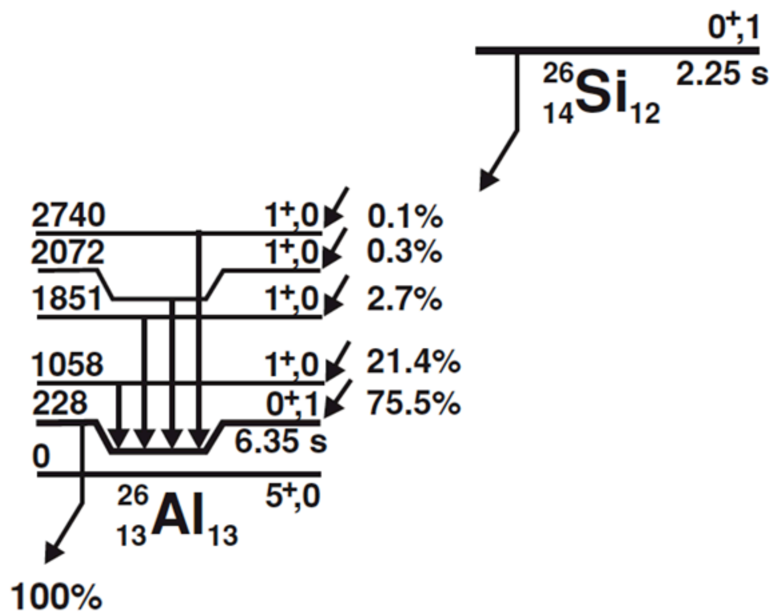

FIG. 1. Decay scheme of ^{26}Si showing only those features of relevance to the superallowed β decay. All energies in keV. Data taken from Ref. [4].

Last year, we reported [5] the experimental procedure followed in the measurement, which used the Momentum Achromat Recoil Separator (MARS) along with the fast tape transport system. It was also reported, how the analysis for this particular isotope was to be carried out, with the branching ratios to the 1^+ states in ^{26m}Al being determined and then subtracted from 100% to yield the superallowed branching ratio. Corrections to the branching ratio were mentioned but none had been done at the time. These small corrections need to be made in order to determine the branching ratio precisely. Most of the corrections have now been made:

Random coincidences - We need to make sure that every β-γ coincidence involves a γ-ray and β particle from the same decay event. Because of the way data are collected and stored event-by-event we are able to remove random coincidences by gating on the prompt peak in the β-γ time-difference spectrum. The result is a β-coincident γ-ray spectrum only including events that correspond to the decay of ^{26}Si.

Parent fraction - As data are being collected ^{26}Si is decaying into ^{26m}Al, which itself decays into ^{26}Mg. This means that the number of β-singles we detect during the counting period includes both the decay of the parent nucleus and a fraction of the decay of the daughter. This is important since we need to determine the total number of β-singles that correspond to ^{26}Si. As a necessary control, we record the number of ^{26}Si ions deposited in the tape as a function of time during each cycle. Knowing this, along with the half-life of both ^{26}Si and its daughter ^{26m}Al, we can determine the activities of both and obtain a ratio. It was determined that 57.13% of the β-singles recorded were produced by the decay of ^{26}Si.

Real Coincidence summing - With β^+ decay we have annihilation radiation being recorded by the HPGe detector in addition to the β-delayed γ rays. One of the 511 keV gammas from annihilation and an 829-

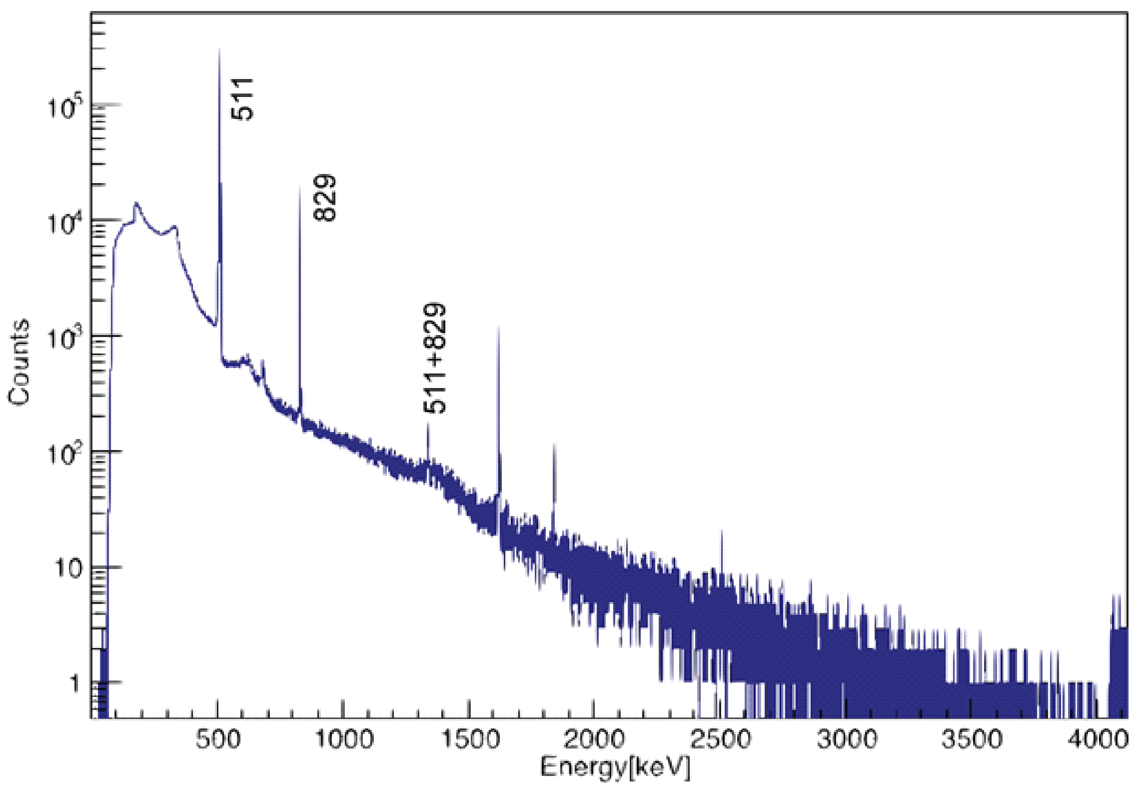

FIG. 2. Spectrum of β-delayed γ rays coincident with beta particles from the decay of ^{26}Si. Peaks are labeled according to their energy in keV. The '511+829' peak is a result of coincidence summing between a 511-keV γ ray from annihilation and an 829-keV γ ray**.**

keV gamma from the 1058 keV state, for example, can reach the detector simultaneously, creating a 1340-keV peak in our spectrum (see Fig. 2). This sum peak steals counts from the peak of interest; therefore a correction (~2.6%) has to be applied to the 829-keV peak to correct for this loss.

Impurities - Just as the decay from the daughter contributes to the beta singles rate, so impurities can also contribute, albeit at a much smaller scale. First, we need to determine which of the impurities that we observe at the focal plane of MARS actually get implanted in the tape by running calculations that use SRIM software. With this result, we can use the known half-lives of the contaminants to determine their contributions, usually a small fraction of a percent. In this measurement, the two contaminants that could potentially be implanted in the tape are ^{23}Mg and ^{24}Al. However, with the thickness of the Al degraders used during the experiment (146.05 μm), we determine that no impurities were implanted during the experiment (see Fig. 3).

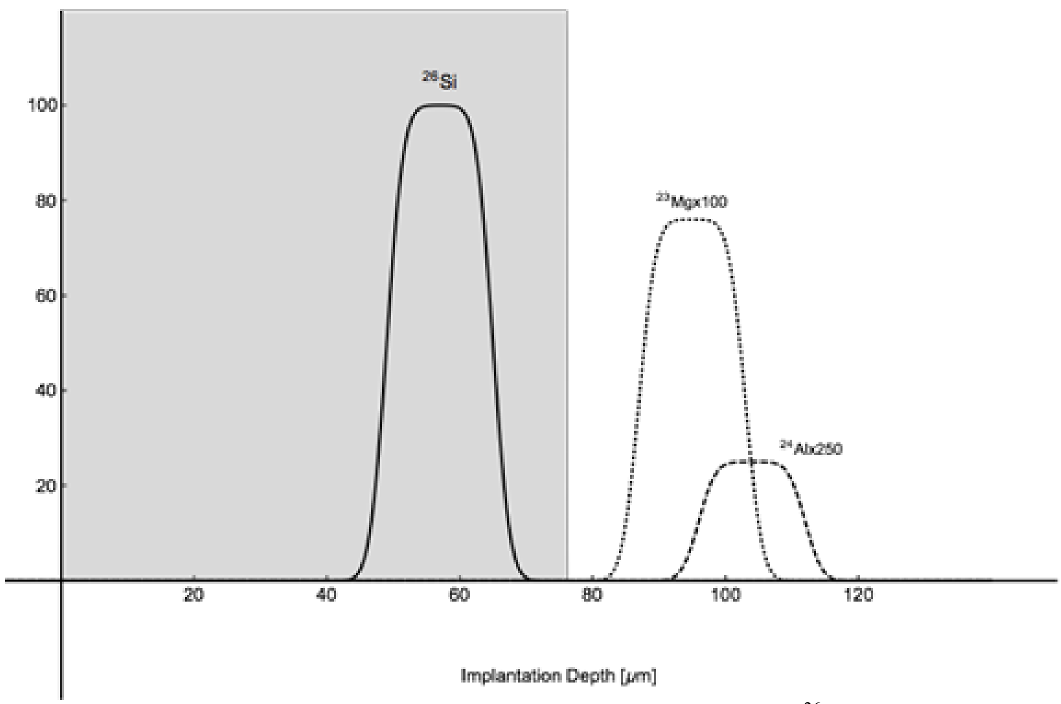

FIG. 3. Illustration of calculated implantation profiles in Mylar for the ^{26}Si beam and those impurities with similar ranges. All beams enter from the left. The shaded region corresponds to the actual thickness of our collection tape. Those ions within the shaded region are collected in our sample, all others are not.

Dead time - This refers to the time during which the electronics are busy processing a signal from the detector. The dead time for β processing is small, ~450 ns. The γ–ray detection on the other hand is much slower and the dead time depends on the rate of coincident and singles γ rays. This correction is still in progress.

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