Half-life of the superallowed beta emitter, ^{30}S

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The superallowed $0^+ \rightarrow 0^+$ β-decay branch from ^{30}S is not one of the fourteen $0^+ \rightarrow 0^+$ transitions that have been measured to ±0.1% precision or better. The most recent survey of world data [1] gives *ft* = 3005(41) s and $\mathcal{F}t$ = 3016(41) s for the ^{30}S transition, a precision of ±1.35%, which is more than a factor of 10 too large for it to contribute to fundamental tests of the weak interaction or of isospin symmetry breaking [2]. The predominant contribution (±1.34%) to the large uncertainty is from the branching ratio, which is based on a single 1963 measurement. Though the half-life is known much more precisely, it is still not adequate since its world-average value [1] is quoted to ±0.14% and that is based on two measurements, only one of which has 0.14% precision. Alone among the three required experimental quantities, the Q_{EC} value can be considered to be measured with sufficient precision: Its contribution to the *ft*-value uncertainty is merely ±0.03%.

The ^{30}S case is an interesting one because its calculated nuclear-structure-dependent correction term is unusually large: *viz.* $\delta_C - \delta_{NS}$ = 1.040(32)%. We argue that such a case offers a good test of the correction terms themselves: If the measured *ft* value for such a transition yields a corrected $\mathcal{F}t$ value that is consistent with the other well-known cases, then this serves to verify the calculations' reliability for the existing cases, which have smaller corrections [2].

We have chosen to begin with a measurement of the half-life of ^{30}S. Quite apart from its ultimate benefit in contributing to a usefully precise *ft* value, the measurement also offers an excellent opportunity to verify one of the techniques we have used in previous half-life measurements. Unlike most T_Z = -1 superallowed β emitters, ^{30}S does not feed a second $0^+ \rightarrow 0^+$ β transition from its daughter. The 0^+, T=1 state populated in ^{30}P decays electromagnetically to the ground state, which proceeds by ordinary allowed β decay to ^{30}Si with a half-life of 2.498(4) min. Thus there is a very clean separation between the ^{30}S half-life of 1.18 s and that of its daughter, which is more than a factor of 100 longer. In the T_Z = -1 cases we have measured before, the parent and daughter half-lives differ by only a factor of ~2, and because we detect the positrons from both decays together in the same detector, we must use the parent-daughter linkage as input to the fit in order to extract the parent half-life with any precision. This requires us to know the time-dependence of the source deposit rate and also to incorporate the subtle difference between the parent and daughter detection efficiencies for positrons; together, these effects can introduce systematic uncertainties. In the case of ^{30}S, the large difference between parent and daughter half-lives makes it possible to extract a result by treating the two decays as independent components and to compare that half-life result to the one obtained when the linkage between parent and daughter is enforced. This is our first opportunity to make such a comparison.

The experimental details of our measurement were presented in last year's Annual Report [3]. The analysis of the results is now complete and a paper describing them has been published [4]. Our final result for the ^{30}S half-life, obtained with the parent and daughter decays unlinked in the fit, was 1.17992(34) s, a result with ±0.029% precision, which is a factor of 5 better than the most precise previous measurement. If the two decays were treated as being linked, our result became 1.17986(34), in complete agreement. This convincingly validates the method we have used in the past to determine precise half-lives for $T_Z = -1$ superallowed emitters.

As a byproduct of this measurement, we determined the half-life of the daughter, ^{30}P, to be 2.501(2) min. This agrees with, but is a factor of 2 more precise than, the literature value.

[1] J.C. Hardy and I.S. Towner, Phys. Rev. C **91**, 025501 (2015).
[2] J.C. Hardy *et al.*, *Progress in Research,* Cyclotron Institute, Texas A&M University (2017-2018), p. I-11.
[3] J.C. Hardy *et al.*, *Progress in Research,* Cyclotron Institute, Texas A&M University (2016-2017), p. I-10.
[4] V.E. Iacob *et al.*, Phys. Rev. C **97**, 035501 (2018).