Superallowed beta branching-ratio measurement of ^{10}C

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Superallowed beta decays yield the most precise value for V_{ud}, the top-left matrix element of the Cabibbo-Kobayashi-Maskawa (CKM) quark-mixing matrix [1,2]. The ^{10}C superallowed β-decay is one of the 14 transitions that are included in the determination. In addition to contributing to the CKM matrix, ^{10}C decay is also sensitive to the possible existence of a scalar current, the existence of which would signal the presence of new physics beyond the Standard Model. A scaler current would manifest itself by causing the comparative half-life, or $\mathcal{F}t$ value, for the ^{10}C superallowed transition to deviate from the world-average value established from the average of the other 13 transitions. Currently, the ^{10}C $\mathcal{F}t$ value is slightly above the average.

The beta decay of ^{10}C is rather simple, as shown in Figure 1. It populates either the 0^+ state at

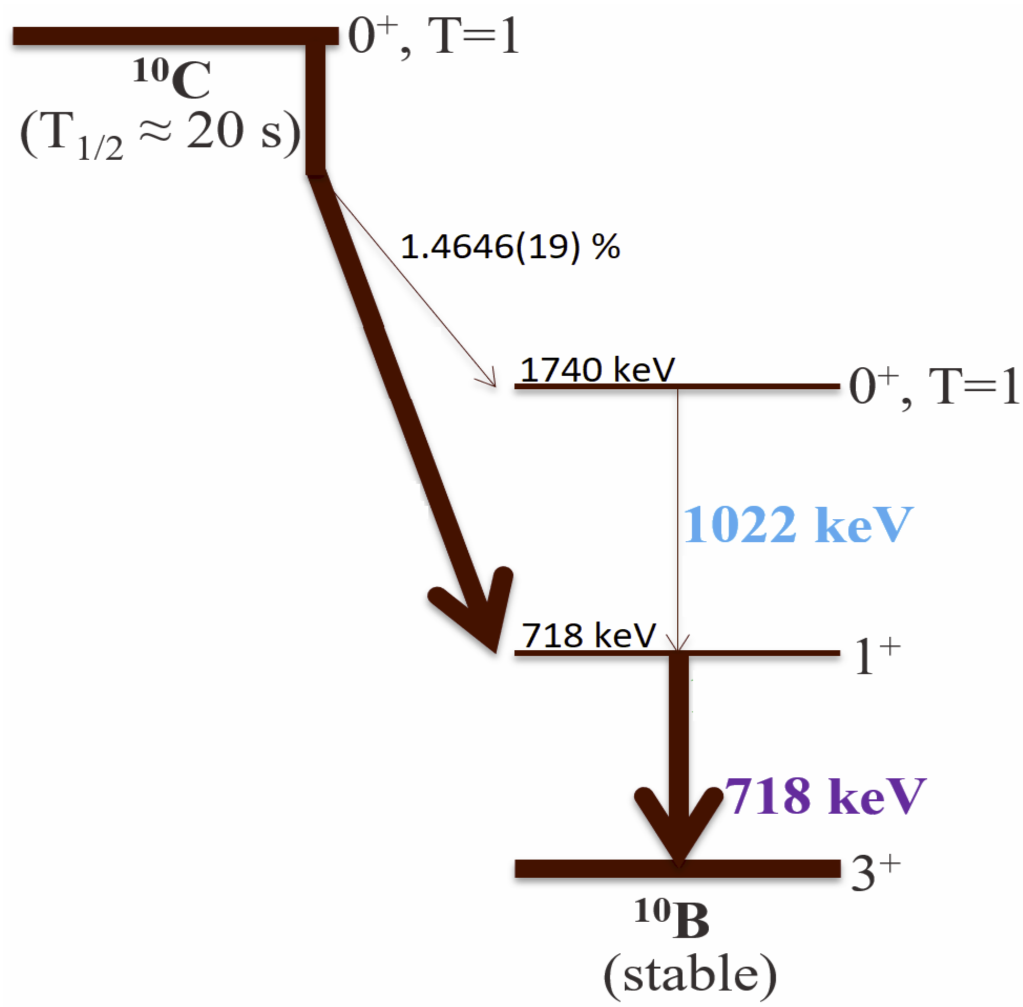

FIG. 1. Beta decay of ^{10}C to states in ^{10}B. The superallowed $0^+ \rightarrow 0^+$ transition is between the ground state of ^{10}C and the state at 1740 keV in ^{10}B.

1740 keV (by the superallowed branch) or the 1^+ state at 718 keV in ^{10}B. Feeding to the 0^+ state is rather weak – the currently adopted value is 1.4646(19)% [2] – rendering the high precision branching ratio determination experimentally challenging. Another difficulty is that the superallowed 0^+ state depopulates by the emission of a 1022 keV gamma-ray, which is exactly twice the energy of annihilation radiation. Since ^{10}C is a positron emitter, there is no lack of annihilation radiation present and, at the high event rate needed to attain sufficient statistics for the branching-ratio measurement, the pile-up of two 511 keV gamma rays must be carefully accounted for.

In September 2017, we had our third run in pursuit of a new measurement of the ^{10}C branching ratio. The earlier two runs took place in 2015 and 2016 [3]. The 2015 experiment utilized a plastic scintillator and the 2016 one, a gas counter for beta detection. The gas counter was chosen in order to get a factor-of-two boost to the beta-detection efficiency but, unfortunately, it also substantially increased the 511+511 keV pile-up as well as Compton scattering. Also, our well-calibrated germanium detector suffered a vacuum failure during the run, though a replacement detector allowed us to continue the run after some delay. In the end, no reliable branching ratio could be obtained from this measurement.

Since the statistics collected during the first experiment in 2015 were rather low, it was decided to run one more time with that configuration (*i.e.* with the plastic scintillator as beta detector). The decay rate of ^{10}C in the September-2017 run was kept just at the maximum tolerable level, which insured that pile-up would not be a limiting effect. Adding the data from both the 2015 and 2017 runs roughly triples our statistics. Analysis is in progress.

[1] J.C. Hardy *et al., Progress in Research,* Cyclotron Institute, Texas A&M University (2017-2018), p. I-11.

[2] J.C. Hardy and I.S. Towner, Phys. Rev. C **91**, 025501 (2015).

[3] T. Eronen *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2016-2017), p. I-15.