High precision half-life measurement of ^{38}Ca

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The measured *ft* values for superallowed $0^+ \rightarrow 0^+$ nuclear β decay, can be used to test the unitarity of the Cabibbo-Kobayashi-Maskawa (CKM) matrix. One of the essential elements of this test is accurate calculations of radiative and isospin-symmetry-breaking corrections that must be applied to the experimental data [1]. Some of these corrections depend on nuclear structure and have relatively large uncertainties as a result. However, these uncertainties can, in principle, be reduced by experiment. The efficacy of the nuclear-structure-dependent corrections can be examined, based on how well they convert the scatter in the uncorrected *ft* values for many transitions into a consistent set of corrected $\mathscr{F}t$ values for all transitions, as required by the Conserved Vector Current (CVC) hypothesis. The decay of ^{38}Ca is a good candidate to investigate for this purpose since the calculated nuclear-structure-dependent correction for the superallowed transition is larger than that of any of the nine well-known nuclei ^{10}C, ^{14}O, ^{26m}Al, ^{34}Cl, ^{38m}K, ^{42}Sc, ^{46}V, ^{50}Mn, and ^{54}Co [1]. If the measured and corrected $\mathscr{F}t$ values for ^{38}Ca with its large calculated nuclear-structure-dependent correction is consistent with the average $\mathscr{F}t$ value established from the well-known cases, then it validates the calculation's reliability for the smaller corrections. To extract a meaningful *ft* value from the experimental data, it is necessary to measure the half-life with a high precision of 0.1%.

We produced ^{38}Ca via the ^{1}H(^{39}K, 2*n*) reaction at a primary beam energy of 30*A* MeV. A 99%-pure ^{38}Ca beam was obtained at the focal plane of the MARS spectrometer, from which it exited the vacuum system through a 50-μm thick Kapton window, passed through a 0.3-mm thick BC404 scintillator and a stack of aluminum degraders, and finally stopped in the 76-μm thick aluminized Mylar tape of a fast tape-transport system. After ^{38}Ca was collected on the tape for 0.5 s, the cyclotron beam was interrupted and the collected sample was moved in 196 ms to the center of a 4π proportional gas counter. Multiscaled signals from the counter were recorded for 15 s into two separate decay spectra, each corresponding to a different pre-set dominant dead-time. This "collect-move-count" cycle was repeated until high statistics were obtained. In this preliminary test run, over 18 million β events were recorded under various detecting conditions, with different settings for dominant dead time, bias voltage of the detector, and threshold of the discriminator.

The development of a new data analysis package is in progress. At the current stage, the new analysis package has been successfully tested with simulated data, mimicking the real data obtained from an experiment. By our applying this new analysis package to the real data, the half-life of ^{38}Ca from this preliminary test run will be extracted soon.

[1] I. S. Towner and J. C. Hardy, Phys. Rev. C **77**, 025501 (2008).