High precision half-life measurement in $^{38}$Ca

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It has been recently argued that the nuclear-structure-dependent corrections can be tested against experiment in the context of the unitarity test of the Cabibbo-Kobayashi-Maskawa (CKM) matrix [1]. The test is based on how well the calculated corrections convert the scatter in the uncorrected $\cal T$ values for many transitions into a consistent set of corrected $\cal T$ values for all transitions, as required by CVC. The decay of $^{38}$Ca is a good case to investigate for this purpose since, for the superallowed transitions, the calculated nuclear-structure-dependent correction is larger than that of any of the nine well-known nuclei ($^{10}$C, $^{14}$O, $^{26}$Al, $^{34}$Cl, $^{38m}$K, $^{42}$Sc, $^{46}$V, $^{50}$Mn, $^{54}$Co) [2]. If the measured $\cal T$ value with large calculated nuclear-structure-dependent corrections converts into the average $\cal T$ value established from these well-known cases, then it further demonstrates the calculation’s reliability for the smaller corrections. For the $\cal T$ value to be useful for this purpose, it is necessary to measure the half-life with a high precision of 0.1%.

The half-life of $^{38}$Ca was measured via the $^1$H ($^{39}$K, 2$n$) reaction at a primary beam energy of 30.4 MeV. The MARS spectrometer provided a pure $^{38}$Ca beam from the fully stripped reaction products at the extraction slits in the focal plane. This beam exited the vacuum system through a 50$\mu$m-thick Kapton window, passed through a 0.3-mm-thick BC-404 scintillator and a stack of aluminum degraders, and finally stopped in the 76$\mu$m-thick aluminized Mylar tape of a fast tape-transport system. We collected the activity of $^{38}$Ca on the tape for 0.5 s. At the end of the collection time, the beam was interrupted and the collected sample was moved in 196 ms to the center of a 4$\pi$ proportional gas counter. Signals from the counter were multiscaled for 15 s, and separate decay spectra were recorded. For the measurement of a highly precise half-life, this “collect-move-count” cycle must be repeated until high statistics are obtained. In a preliminary test run, over 18 million $\beta$ 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 data analysis is currently underway.