TRIUMF E-823 – Beta Decay Measurements in ^{74}Rb

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The primary goal of the E-823 experimental program is to measure precise half-lives and branching ratios for superallowed $0^+ \rightarrow 0^+$ beta transitions in medium-mass (A > 60) nuclei produced by the new ISAC1 radioactive-beam facility at TRIUMF. These data, together with accurate experimental Q-values anticipated from the Canadian Penning Trap (CPT) Mass Spectrometer at the ATLAS facility [1], will be used to extract precise *ft*-values for the superallowed transitions. The *ft*-values will add to the body of data now accumulating for nuclei with $A \leq 54$, improving our knowledge of isospin symmetry-breaking effects in nuclei and possibly improving the precision with which these data can test CVC and the unitarity of the Cabibbo-Kobayaski-Maskawa (CKM) matrix. The experiment at TRIUMF is undertaken as a collaboration among scientists from TRIUMF, Lawrence Berkeley National Laboratory, Simon Fraser University, Argonne National Laboratory, Queen's University and Texas A&M.

During the past year, test half-life measurements first described in the last Annual Report [2] were completed on the potassium isotopes ^{36,37,38m}K. Although half-life measurements are rather simple in principle, the precision (< ±0.05%) that we require is very demanding. Our results proved to be internally consistent and agreed with the previously known half-lives, thus demonstrating the reliability of our methods and equipment. We then proceeded to measure the half-life of ^{74}Rb.

The experimental set-up comprises a 4π proportional counter similar to that described in ref. [3], a fast tape transport system and two HPGe detectors. Since the energy of a radioactive beam delivered by ISAC1 is 60 keV, the ions must be implanted in vacuum into the aluminized-mylar tape of the tape-transport. The tape passes into and out of the vacuum system via two stages of differential pumping. For the ^{74}Rb experiment, each measurement cycle began with an implantation period of 2-3 half-lives; after that, the beam was interrupted and the radioactive sample moved into the center of the 4π proportional counter. Then the proportional-counter signals were multiscaled for 20 to 25 half-lives, and a 250-channel decay spectrum recorded for that sample. The cycle was then repeated, with a separate decay spectrum stored for each cycle. The HPGe detectors also monitored γ-rays emitted by each sample.

Special care was taken to eliminate, so far as possible, any systematic effects that could bias the data. The proportional-counter signal was sent directly to a fast discriminator whose output passed to an instantly re-triggerable gate generator with a well-defined and non-extendable dead time. This dead time was chosen to be, by far, the dominant dead time in the system so that its value alone could be used in the data analysis. As a consistency check, during the measurement we actually processed each detector signal in two independent, parallel blocks of electronics, one set with a 3-μs dominant dead time and the other with 4-:s value. Two independent analyses, one for each dead time, were carried out for all measurements. Dead-time corrected results for the two analyses were generally in excellent agreement. Further tests for systematic errors were incorporated by our changing the acquisition conditions (counting rate, discriminator threshold, detector bias and dwell time, *i.e.* the time-spectrum channel width) from one run to another.

A total of about 1.3×10^7 events were collected in the ^{74}Rb measurements over many runs, each accumulating 2000 to 4000 cycles of data with between 20 and 100 decay events per cycle. The collected data were analyzed after being pre-selected on a sample-by-sample basis, to reject cycles with evident electronic noise. The beam-purity check, performed with the HPGe detectors, showed the presence only of small quantities of ^{74}Ga ($t_{1/2}$ = 8.12 min), whose half-life is sufficiently long that, in the analysis, it could be treated together with other contributions to a small constant background. We performed a careful computer fit to the data using maximum-likelihood procedures. As the average cycle contained only about 80 counts, we analyzed each run by summing together the dead-time-corrected spectra from all accepted cycles in that run. We then compared the results from each run, many of them taken under different conditions. In every case, our results were found to be stable versus (reasonable) changes in detector bias and discriminator threshold, as well as different dead times and counting rates. Our preliminary result for the half-life of ^{74}Rb is $t_{1/2} = 64.761 \pm 0.027$ ms.

Branching-ratio measurements in the $-decay of ^{74}Rb are currently in progress. These measurements are also challenging, not only because ^{74}Rb has a short half-life but because the Q-value is large and its decay is likely dispersed over several branches.

References

[1] J.C. Hardy, *Progress in Research 1998-1999*, Cyclotron Institute, TAMU, pg. V-20.

[2] J.C Hardy and V.E. Iacob, *Progress in Research 1998-1999*, Cyclotron Institute, TAMU, pg. I-30.

[3] V.E. Iacob and J.C Hardy, Progress in Research 1998-1999, Cyclotron Institute, TAMU, pg. V.-22.