HIGH-PRECISION HALF-LIFE MEASUREMENTS FOR SUPERALLOWED FERMI β DECAYS*

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On behalf of the 8π and GPS collaborations

High-precision measurements of the ft values for superallowed Fermi β decays between 0^+ isobaric analogue states have, for decades, provided demanding tests of the Standard Model description of electroweak interactions. In order to significantly contribute to these tests experimentally, β decay half-lives and branching ratios must be determined to overall precisions of $\pm$ 0.05% or better, and β decay Q values must be deduced to at least $\pm$ 0.01%. For β decay half-lives in particular, this demanding requirement is generally accomplished using direct β counting techniques. This method was employed as part of this work in order to deduce the half-life of the superallowed β^+ emitter ^{62}Ga using mass-separated radioactive ion beams provided by the Isotope Seperator and Accelerator (ISAC) facility at TRIUMF. The result of this analysis, $T_{1/2}(^{62}\text{Ga})_\beta$ = 116.100 $\pm$ 0.025 ms, is now the single most precise superallowed half-life measurement reported to date.

In cases where there are significant contaminant or daughter activities, one must instead rely on a measurement of the half-life using the γ-ray activity. Half-life measurements using the technique of γ-ray photopeak counting have, however, been previously limited by a systematic bias associated with detector pulse pile-up effects. While detector pulse pile-up has been qualitatively understood for decades, there has not been a quantitative description of its effects on half-life measurements to the level of precision required ($\pm$ 0.05%) for superallowed Fermi β decay studies. Using the 8π γ-ray spectrometer, a spherical array of 20 HPGe detectors at ISAC, a new method was developed that, for the first time, provides the necessary quantitative description of detector pulse pile-up to the required level of precision. This novel technique has been verified through both a detailed Monte-Carlo simulation and experimentally using radioactive beams of ^{26}Na. Following a correction of nearly 30 statistical standard deviations for pulse pile-up, the half-life of ^{26}Na deduced in this work, $T_{1/2}(^{26}\text{Na})_\gamma$ = 1.07167 $\pm$ 0.00055 s, is precise to the level of 0.05% and is in excellent agreement with the corresponding value, $T_{1/2}(^{26}\text{Na})_\beta$ = 1.07128 $\pm$ 0.00025 s, deduced from direct β counting. This study has demonstrated that high-precision β decay half-life measurements via γ-ray photopeak counting are feasible at the $\pm$ 0.05% level. As an extension to this work, the half-life of the superallowed β^+ emitter ^{18}Ne was determined to be, $T_{1/2}(^{18}\text{Ne})_\gamma$ = 1.6656 $\pm$ 0.0019 s, a result that is a factor of four times more precise than the previous world average.

*This work was partially supported by the Natural Sciences and Engineering Research Council of Canada. TRIUMF recieves federal funding via a contribution agreement through the National Research Council of Canada.

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