Improving the *ft* value of ^{37}K via a precision measurement of the branching ratios

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As part of the TRIUMF Neutral Atom Trap (TRINAT) collaboration, our goal is to search for physics beyond the standard model via precision measurements of the polarized angular correlations of the isobaric analogue β^+ decay of ^{37}K. A recent measurement of the β asymmetry parameter, A_β, has reached 0.3% precision [1] which, when combined with the comparative half-life or *ft* value, was used to improve the value of V_{ud} for this decay as well as to search for right-handed currents. Plans are underway to improve the A_β measurement, at which point uncertainties in the ft value will no longer be negligible. Presently, the uncertainty in the ft value is dominated by the 97.99(14)% branch to the ground state following an improved half-life measurement performed at the Cyclotron Institute [2]. The 1997 measurement which dominates the present value of the branching ratio [3] was limited by the absolute efficiency of the HPGe detector. Using the fast-tape-transport system at the Cyclotron Institute and the world's most precisely calibrated HPGe, we measured the decay of ^{37}K to significantly improve the branching ratio and hence the ft value.

We have filtered the data to obtain a clean data set (e.g. vetoing bad cycles where the tape does not stop between the HPGe γ detector and the plastic scintillator β detector) and minimized accidental coincidences via the E_γ vs β-γ timing 2D spectrum. In order to optimize the reduction of backgrounds and random coincidences, we iteratively optimized our cuts in both the γ energy and β-γ timing.

Branches were acquired from fits to the areas of the γ photopeaks that account for the random coincidences and background, and include small effects such as incomplete charge collection. These branches were corrected for dead-time, pile-up, pre-emption, β-singles losses, annihilation and bremsstrahlung summing.

Systematic uncertainties that were quantitatively known (the first block of Table I) was propagated as usual. For the remaining, quantitative values were obtained via a rigorous process of isolating systematics from every relevant steps of the analysis to account for any possible bias introduced (second block in Table I). This process involved making objective variations in a given systematic procedure and analyzing the response in the final result. The final result for the branching ratio is

$$\mathrm{BR} = 97.81(2)\%.$$

We improved the uncertainty in the branching ratio by a factor of 5. This has doubled the precision of the *ft* value which is being used to test the standard model. With our contribution (Fig. 1), uncertainties in the *ft* value will not impact the precision of V_{ud} from ^{37}K even after precision of ρ, the Gamow-Teller to Fermi mixing ratio, is measured to < 0.1%.

Table I. Systematic and statistical uncertainties in the branching ratios for the transitions observed. Blank entries indicate an uncertainty below 0.001% and are therefore negligible.

Source	Uncertainty, σ_{BR} [%]			
	$E_\gamma = 1184$ keV	1611 keV	2796 keV	3601 keV
γ efficiencies	–	–	0.011	–
Internal conversion	–	–	–	–
Peak-to-total	–	–	–	–
$t_\beta - t_\gamma$ cuts	0.001	0.001	0.006	0.001
Pre-emption correction	–	–	0.005	–
β/HI cuts	0.001	–	0.004	–
Fitting range	–	–	–	–
Total systematics	0.001	0.001	0.015	0.001
Statistical	0.003	0.003	0.017	0.002
Total uncertainty	0.004	0.003	0.022	0.003

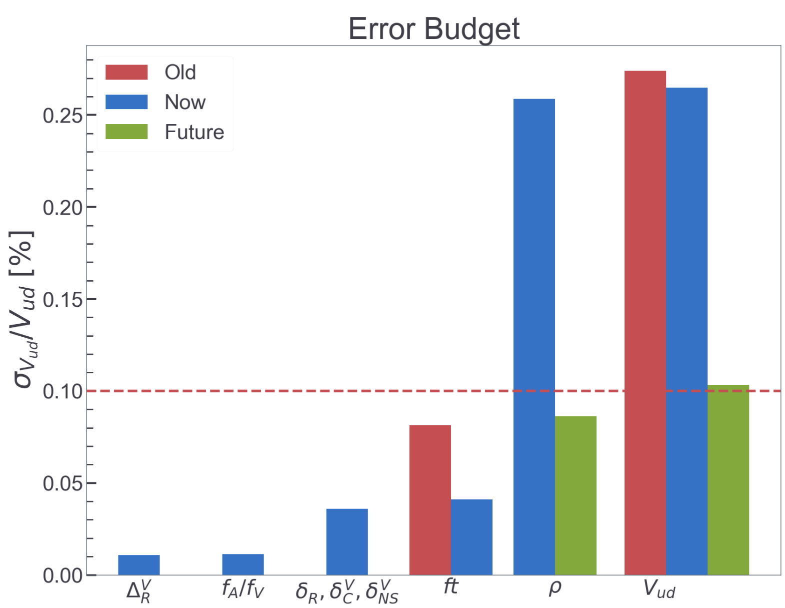

Fig. 1. Final error budget showing the previous, current (our contribution) and expected future uncertainty contributions to V_{ud} in ^{37}K.

[1] B. Fenker *et al.*, Phys. Rev. Lett. **120**, 062502 (2018).

[2] P.D. Shidling *et al.*, Phys. Rev. C **90**, 032501(R) (2014).

[3] E. Hagberg *et al.*, Phys. Rev. C **56**, 135 (1997).