JYFLTRAP : Q_{EC}-values of the superallowed decays of ^{10}C, ^{34}Ar, ^{38}Ca and ^{46}V

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This We have now completed and published four successful measurements of the Q_{EC} values for superallowed $0^+ \rightarrow 0^+$ transitions from $T_z = 0$ and $T_z = -1$ nuclei using the JYFLTRAP Penning-trap mass spectrometer at the University of Jyvaskyla cyclotron facility in Finland. The first contained the results for $^{26}Al^m$, ^{42}Sc and ^{46}V [1]; the second, ^{50}Mn and ^{54}Co [2] and the third, ^{34}Cl and $^{38}K^m$ [3]. In the most recent [4], our collaboration determined the Q_{EC} values for the superallowed decays of ^{10}C, ^{34}Ar, ^{38}Ca and ^{46}V. Our original intention was to measure the Q_{EC} values for ^{10}C and ^{14}O but the latter proved to be impossible because of the presence of relatively high levels of residual ^{14}N in the system. We decided to defer the ^{14}O measurement and measure three other superallowed Q_{EC} values instead. All three had been measured previously with a Penning trap, but with JYFLTRAP we could reduce the experimental uncertainties by a substantial amount.

As we did in our previous experiments, we produced ^{10}C and ^{46}V via (*p*,*n*) reactions. A powerful advantage of this approach is that, not only were the superallowed emitters of interest produced in the primary reactions but ions from the target material itself – the beta-decay daughters of these emitters – were also released by elastic scattering of the cyclotron beam. To produce ^{34}Ar and ^{38}Ca we used (*p*,2*n*) reactions, with their daughters and granddaughters produced by (*p*,*pn*) and (*p*,2*p*) reactions As explained in Ref. [1], with the JYFLTRAP system we can isolate a specific nuclide from the reaction products and measure the cyclotron frequency of its ions in the Penning trap. For each determination of a Q_{EC} value, the cyclotron frequency measurements were interleaved: first we recorded a frequency scan for the daughter, then for the mother, then for the daughter and so on. This way, most potential systematic effects could be reduced to a minimum or eliminated. For each measurement, data were collected in several sets, each comprising ~10 pairs of parent-daughter frequency scans taken under the same conditions.

Our four new Q_{EC}-value results for superallowed transitions are shown in Figure 1, where they are compared with previous measurements of the same quantities. The agreement is generally good although our uncertainties are much small than the others. Only for ^{34}Ar is there a significant disagreement with an earlier measurement. In this case, that earlier measurement also used a Penning trap – ISOLTRAP [6] – but, while our measurement obtained the ^{34}Ar Q_{EC} value directly by a measurement of the frequency ratio of the daughter to parent ions, theirs used ^{39}K as a reference ion. Thus, to get the ^{34}Ar Q_{EC} value, the mass of the daughter ^{34}Cl also had to be linked to ^{39}K. This link via ^{39}K – 5 mass units away – may well have been the source of their error.

Our results also appear in Table I, where they are compared with the equivalent values that appeared in the most recent survey of superallowed $0^+ \rightarrow 0^+$ nuclear β decay [5]. In all cases, our new results have reduced the uncertainties considerably, although for ^{34}Ar the reduction is constrained by the inconsistency already noted between our result and one of the previous measurements [6]. That inconsistency leads to a normalized χ^2 of 7 for the average and, following the procedures used in [5], we increase the uncertainty on the average by a scale factor equal to the square root of the normalized χ^2.

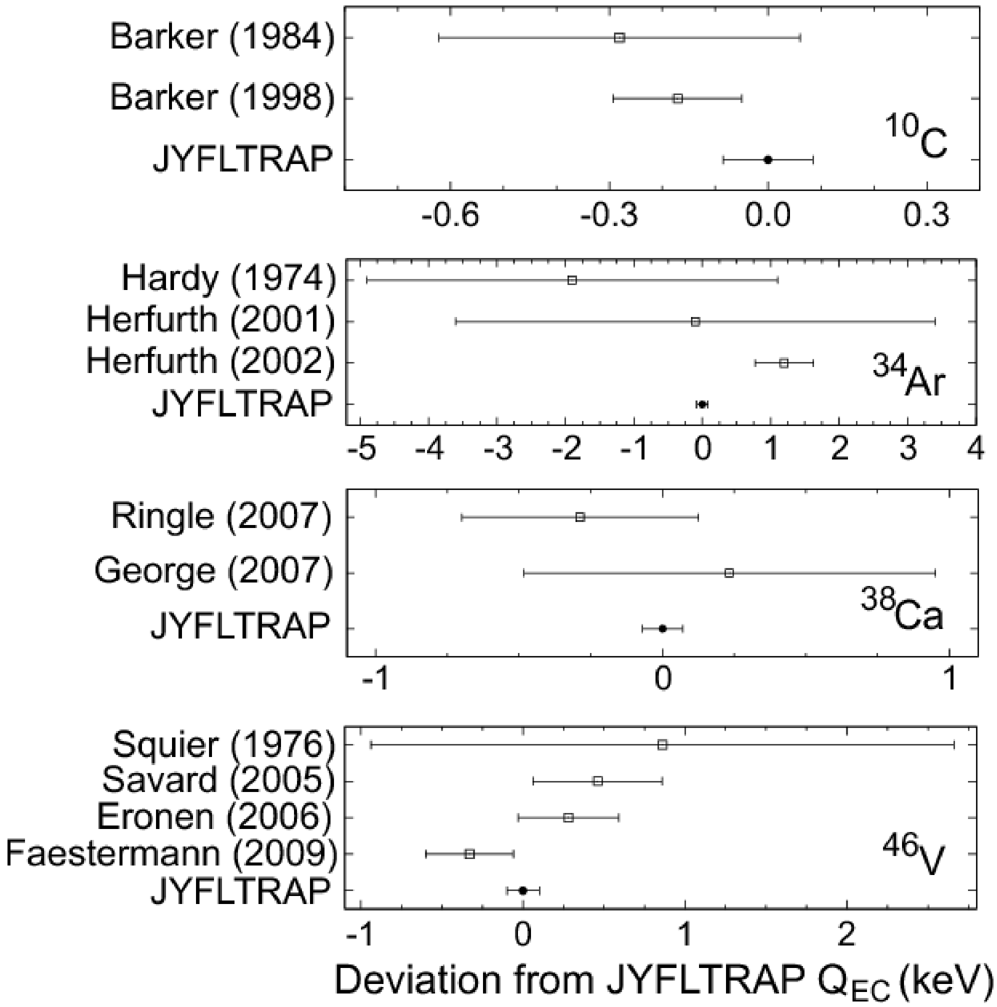

FIG. 1. Comparison of our Q_{EC}-value measurements, labeled JYFLTRAP, with previous measurements. For each transition, our result is plotted at 0 on the abscissa, and the other results are plotted as differences (Q_{EC}^{LIT} - $Q_{EC}^{JYFLTRAP}$) . The details of the previous references are given in our published paper [4].

Table I. The four Q_{EC} values for superallowed transitions that were obtained in this work. Also shown are the equivalent values quoted in the most recent survey of data [5] and the new weighted averages including our measurements.

		Q_{EC} values (keV)		
Parent	Daughter	This work	Survey [5]	Average
^{10}C	^{10}B	1908.05(8)	1907.87(11)	1907.99(7)
^{34}Ar	^{34}Cl	6061.83(8)	6062.98(48)	6061.86(21)
^{38}Ca	^{38}K^{m}	6612.12(7)	6611.75(41)	6612.11(7)
^{46}V	^{46}Ti	7052.44(10)	7052.40(16)	7052.45(9)

We plan to complete our measurements on the “traditional nine” superallowed transitions by measuring the Q_{EC} value for ^{14}O in an improved experimental set-up in the future.

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