Precise measurement of branching ratios in the β decay of ^{38}Ca

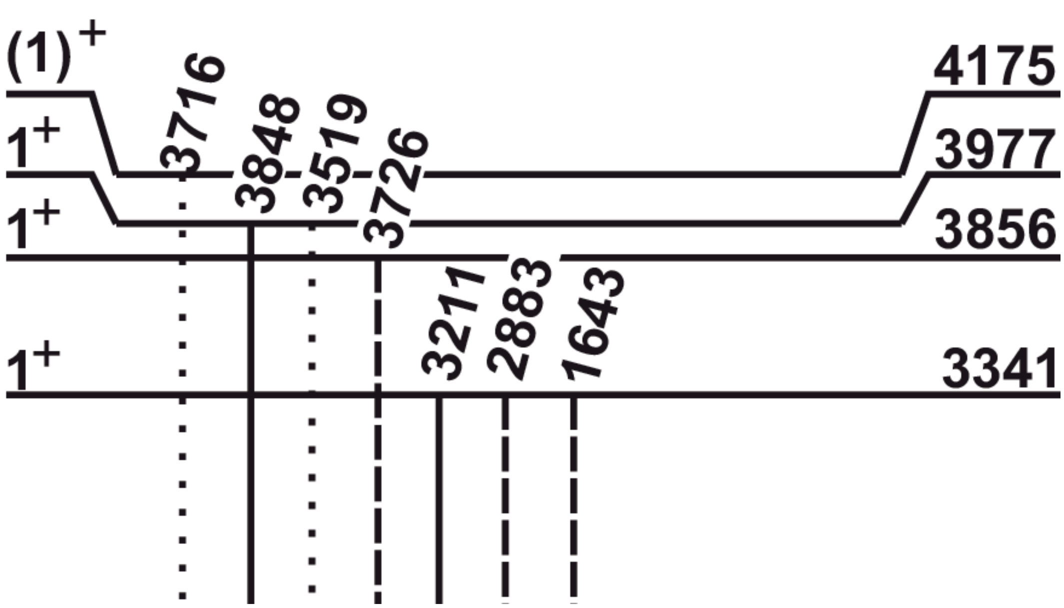
H.I. Park, J.C. Hardy, V.E. Iacob, M. Bencomo, L. Chen, V. Horvat, N. Nica, B.T. Roeder, E. McCleskey, R.E. Tribble, and I.S. Towner

Last year we published a letter [1] briefly describing our measurement of the branching ratio for the superallowed β-transition from ^{38}Ca and applying the result to a sensitive test of isospin-symmetry-breaking corrections from the mirror superallowed $0^+ \rightarrow 0^+$ decays, ^{38}Ca → ^{38m}K, and ^{38m}K → ^{38}Ar. This year we have written a detailed description of the measurement including results for the branching ratios of all the β-decay transitions from ^{38}Ca. This manuscript has been accepted for publication [2].

Our experimental method is to produce pure samples of ^{38}Ca using the K500 cyclotron and the MARS spectrometer; and then record decay γ rays in coincidence with β's. Fuller explanations appear in Refs. [1,2]. The coincident γ-ray spectrum has been examined meticulously to determine, or set limits on, the relative intensities of all γ rays that follow the decay of ^{38}Ca; our search was guided by the results of previous studies [3,4]. Our results appear in Table I and Fig. 1. Also given in Table I are the results from those previous studies [3,4]. Our sensitivity is similar to the most recent previous measurement, by Anderson *et al.* [4], but our results show some significant discrepancies with theirs. The most egregious is for the intensity of the 2883-keV γ transition, which we determine to be an order of magnitude less than their result. It seems very likely that the value quoted by Anderson *et al.* is simply a misprint since it does not seem to be supported by their own γ-ray spectrum (see Fig. 5 in Ref. [4]), in which the 2883-keV peak is clearly not one-half the intensity of the nearby peak at 3211 keV as their tabulated intensity would lead one to believe. There are two other smaller, but still significant, discrepancies between our results and those of Anderson *et al.* for the peaks at 1643 and 3726 keV. These discrepancies give us good reason to use our results exclusively in all subsequent determinations of the Gamow-Teller β-branching ratios from ^{38}Ca.

Table I. Relative intensities of β-delayed γ rays from the β^+ decay of ^{38}Ca.

E_γ (keV)	I_γ		
	Ref. [3]	**Ref. [4]**	**This work**
328	0.126(16)	0.159(10)	0.1489(26)
1240	<0.010	0.0024(5)	0.0036(13)
1567	1	1	1
1643	<0.010	0.0040(5)	0.0010(7)
1698	<0.0082	0.0008(4)	<0.0008
2883	<0.0033	0.007(2)	0.0006(4)
3211	0.0139(15)	0.0138(10)	0.0150(9)
3519	<0.0042	0.0004(3)	<0.0003
3716	<0.0045	0.0002(1)	<0.0005
3726	<0.0036	0.0019(2)	0.0007(3)
3848	<0.0081	0.0056(5)	0.0051(7)



By comparing the intensity of the β-coincident 1567-keV γ ray with the singles β intensity – and correcting for dead-time losses, real-coincidence summing and a variety of other smaller effects – we determined the branching ratio for the (β^+ + ec) transition to the 1628-keV state to be 0.1948(13) [2]. Combining this value with the relative γ-ray intensities in Table I, we obtain the final branching ratios and log *ft* values listed in Table II. The branching ratio for the superallowed branch was derived by subtracting the total of all the Gamow-Teller branches from 1. The uncertainty budget for this important result is given in Table III.

Table II. Measured β-branching ratios to all the states in ^{38}K populated by the β decay of ^{38}Ca

E_x (keV)	E_{bmax} (keV)	Branching ratio	log *ft*	Superallowed $\mathcal{F}t$ (s)
130.4	5590.1	0.7728(16)	3.4860(10)	3076.4(72)
458.5	5262.0	0.0281(6)	4.804(1)	
1697.8	4022.7	0.1948(13)	3.426(3)	
3341.2	2379.3	0.0032(3)	4.19(4)	
3856.0	1864.5	0.00014(6)	5.09(19)	
3977.3	1743.2	0.0010(2)	4.11(9)	

Table III. Uncertainty budget for ^{38}Ca branching ratios.

	Uncertainty (%)	
Source	∑GT branches	$0^+ \rightarrow 0^+$ branch
Counting statistics, γ_{1567} & β singles	0.49	0.14
Contaminant contribution to β singles	0.30	0.09
$\sum \gamma / \gamma_{1567}$	0.25	0.08
Coincidence summing with 5110keV γ's	0.21	0.06
HPGe detector efficiency	0.20	0.06
Dead time	0.07	0.021
Bremsstrahlung coincidence summing	0.05	0.015
^{38}Ca component of β singles	0.06	0.017
Random preemption of real coincidences	0.04	0.012
Total uncertainty	0.70	0.21

[1] H.I. Park, J.C. Hardy, V.E. Iacob, M. Bencomo, L. Chan, V. Horvat, N. Nica, B.T. Roeder, E. Simmons, R.E. Tribble, and I.S. Towner, Phys. Rev. Lett. **112**, 102502 (2014).

[2] H.I. Park, J.C. Hardy, V.E. Iacob, M. Bencomo, L. Chen, V. Horvat, N. Nica, B.T. Roeder, E. McCleskey, R.E. Tribble, and I.S. Towner, Phys. Rev. C (to be published).

[3] H.S. Wilson, R.W. Kavanagh, and F.M. Mann, Phys. Rev. C **22**, 1696 (1980).

[4] B.D. Anderson, A.R. Baldwin, P. Baumann, B.A. Brown, F. Didierjean, C.C. Foster, L.A.C. Garcia, A. Huck, A. Knipper, R. Madey, D.M. Manley, G. Marguier, M. Ramdhane, H. Ravn, C. Richard-Serre, G. Walter, and J.W. Watson, Phys. Rev. C **54**, 602 (1996).