^{89}Nb ε decay (2.03 h) 1974Vo08,1969HaZP

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	NDS 114, 1 (2013)	20-Oct-2012

Parent: ^{89}Nb: E=0.0; J^π=(9/2$^+$); $T_{1/2}$=2.03 h *7*; Q(ε)=4226 *27*; %ε+%$β^+$ decay=100.0

^{89}Nb-Q(ε): From 2011AuZZ. Other: 4218 *27* (2003Au03).

1974Vo08 (also 1971Ar16, one author common in two papers): measured Eγ, Iγ, γγ.

1969HaZP (also 1970HaZH): measured Eγ, Iγ, $T_{1/2}$, E(endpoint), I($γ^±$). A total of 46 γ rays and a detailed level scheme reported.

1997Hi06: measured μ by NMR on oriented nuclei and γ(θ,H,t) of 920γ, 1259γ, 1627γ, 1833γ, 2960γ and 3093γ.

Others: 1984HaZC (K-, L- conversion lines for 1448, 1465, 1511, 1581, 1627 γ rays), 1966Ha45, 1966Hy02, 1964Bu11, 1955Ma13, 1954Di16.

Energy balance: total decay energy of 4220 keV *379* deduced (using RADLIST code) from proposed decay scheme is in agreement with the expected value of 4226 keV *27*, indicating that the decay scheme is complete.

^{89}Zr Levels

The level scheme is from 1974Vo08 and 1969HaZP.

E(level)†	J^π‡	$T_{1/2}$‡	E(level)†	J^π‡
0.0	9/2$^+$	78.41 h *12*	2925.9 *6*	7/2$^+$,9/2$^+$
588.0 *2*	1/2$^-$	4.161 min *10*	2959.8 *2*	(7/2$^+$,9/2$^+$)
1095.2 *3*	3/2$^-$		2981.1 *8*	(7/2,9/2,11/2)
1451.0 *3*	5/2$^-$		3016.2 *4*	7/2$^-$
1511.6 *2*	(9/2)$^+$		3092.6 *2*	(7/2$^+$)
1627.4 *2*	5/2$^+$		3141.3 *9*	9/2$^+$
1833.5 *2*	5/2$^+$		3281.0 *7*	7/2$^+$,9/2$^+$
2101.1 *3*	(7/2)$^+$		3467.0 *6*	(7/2,9/2,11/2)
2128.5 *4*	(7/2$^+$)		3512.6 *7*	(7/2,9/2,11/2)
2132.0 *15*	(7/2$^+$,9/2$^+$)		3531.1 *15*	(7/2,9/2,11/2)
2221.9 *11*	(9/2$^-$)		3534.1 *15*	(7/2,9/2,11/2)
2297.1 *7*	(7/2)$^+$		3557.3 *7*	(7/2,9/2,11/2)
2388.6 *10*	(5/2)$^+$		3575.8 *5*	(5/2)$^-$
2572.2 *3*	7/2$^+$,9/2$^+$		3837.1 *9*	7/2$^+$,9/2$^+$
2612.1 *5*	9/2$^+$		3907.1 *15*	(7/2$^-$,9/2$^-$)
2730.5 *5*	(7/2,9/2)$^-$		3931.1 *15*	(7/2,9/2,11/2)
2753.9 *3*	(7/2$^+$)		3948.1 *15*	(7/2,9/2,11/2)
2889.5 *6*	(7/2,9/2,11/2)		3965.6 *12*	(7/2$^-$)

† From least-squares fit to Eγ data.

‡ From Adopted Levels.

ε,$β^+$ radiations

E(decay)	E(level)	Iε†	Log *ft*	I(ε+$β^+$)†	Comments
(2.6×10^2 *3*)	3965.6	0.010 *4*	6.70 *21*	0.010 *4*	εK=0.8593 *19*; εL=0.1146 *15*; εM+=0.0261 *4*
(2.8×10^2 *3*)	3948.1	0.005 *2*	7.07 *20*	0.005 *2*	εK=0.8603 *16*; εL=0.1138 *13*; εM+=0.0259 *4*
(2.9×10^2 *3*)	3931.1	0.0034 *21*	7.3 *3*	0.0034 *21*	εK=0.8611 *14*; εL=0.1132 *12*; εM+=0.0257 *3*
(3.2×10^2 *3*)	3907.1	0.009 *4*	6.94 *21*	0.009 *4*	εK=0.8621 *12*; εL=0.1124 *10*; εM+=0.02550 *25*
(3.9×10^2 *3*)	3837.1	0.061 *15*	6.29 *13*	0.061 *15*	εK=0.8644 *8*; εL=0.1106 *6*; εM+=0.02504 *16*
(6.5×10^2 *3*)	3575.8	0.26 *4*	6.12 *8*	0.26 *4*	εK=0.8683 *3*; εL=0.10744 *20*; εM+=0.02422 *6*
(6.7×10^2 *3*)	3557.3	0.05 *1*	6.86 *10*	0.05 *1*	εK=0.8685 *3*; εL=0.10731 *19*; εM+=0.02419 *5*

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^{89}Nb ε decay (2.03 h) 1974Vo08,1969HaZP (continued)

ε,β+ radiations (continued)

E(decay)	E(level)	Iβ+ †	Iε†	Log *ft*	I(ε+β+)†	Comments
(6.9×10²‡ *3*)	3534.1		≈0.02	≈7.3	≈0.02	εK=0.8687 *3*; εL=0.10716 *18*; εM+=0.02415 *5*
(6.9×10²‡ *3*)	3531.1		≈0.03	≈7.1	≈0.03	εK=0.8687 *3*; εL=0.10714 *18*; εM+=0.02415 *5*
(7.1×10² *3*)	3512.6		0.11 *6*	6.57 *24*	0.11 *6*	εK=0.8688 *2*; εL=0.10703 *17*; εM+=0.02412 *5*
(7.6×10² *3*)	3467.0		0.041 *8*	7.06 *10*	0.041 *8*	εK=0.8692 *2*; εL=0.10679 *15*; εM+=0.02406 *4*
(9.5×10² *3*)	3281.0		0.034 *8*	7.33 *11*	0.034 *8*	εK=0.8701 *2*; εL=0.10603 *9*; εM+=0.02386 *3*
(1.08×10³ *3*)	3141.3		0.020 *7*	7.68 *16*	0.020 *7*	εK=0.8706; εL=0.10563 *7*; εM+=0.02376 *2*
(1.13×10³ *3*)	3092.6		6.1 *7*	5.24 *6*	6.1 *7*	εK=0.8707; εL=0.10551 *7*; εM+=0.02372 *2*
(1.21×10³ *3*)	3016.2		0.24 *4*	6.70 *8*	0.24 *4*	εK=0.8704 *4*; εL=0.1053 *1*; εM+=0.02367 *3*
(1.24×10³‡ *3*)	2981.1	5.×10⁻⁵ *4*	0.04 *2*	7.51 *22*	0.04 *2*	av Eβ=104 *12*; εK=0.8699 *7*; εL=0.10515 *14*; εM+=0.02364 *4*
(1.27×10³ *3*)	2959.8	0.007 *4*	3.4 *4*	5.59 *6*	3.4 *4*	av Eβ=113 *12*; εK=0.8694 *9*; εL=0.10505 *16*; εM+=0.02361 *4*
(1.30×10³ *3*)	2925.9	0.0007 *4*	0.22 *6*	6.80 *12*	0.22 *6*	av Eβ=128 *12*; εK=0.8683 *13*; εL=0.10484 *21*; εM+=0.02356 *5*
(1.34×10³ *3*)	2889.5	0.0014 *6*	0.26 *5*	6.76 *9*	0.26 *5*	av Eβ=143 *12*; εK=0.8665 *18*; εL=0.1046 *3*; εM+=0.02350 *6*
(1.47×10³ *3*)	2753.9	0.10 *3*	4.3 *6*	5.62 *7*	4.4 *6*	av Eβ=201 *12*; εK=0.853 *5*; εL=0.1027 *6*; εM+=0.02306 *13*
(1.61×10³ *3*)	2612.1	0.006 *3*	0.10 *5*	7.32 *20*	0.11 *5*	av Eβ=262 *12*; εK=0.822 *9*; εL=0.0988 *10*; εM+=0.02218 *23*
(1.65×10³ *3*)	2572.2	0.21 *4*	2.8 *4*	5.91 *7*	3.0 *4*	av Eβ=279 *12*; εK=0.809 *10*; εL=0.0972 *12*; εM+=0.0218 *3*
(1.84×10³‡ *3*)	2388.6	0.008 *3*	0.04 *2*	7.83 *18*	0.05 *2*	av Eβ=359 *12*; εK=0.733 *14*; εL=0.0879 *17*; εM+=0.0197 *4*
(1.93×10³ *3*)	2297.1	0.047 *9*	0.17 *3*	7.25 *9*	0.22 *4*	av Eβ=399 *12*; εK=0.686 *15*; εL=0.0821 *19*; εM+=0.0184 *4*
(2.00×10³‡ *3*)	2221.9	0.02 *1*	0.06 *1*	7.75 *12*	0.08 *2*	av Eβ=432 *12*; εK=0.643 *16*; εL=0.0770 *19*; εM+=0.0173 *5*
(2.09×10³ *3*)	2132.0	0.042 *20*	0.09 *4*	7.62 *21*	0.13 *6*	av Eβ=471 *12*; εK=0.590 *16*; εL=0.0706 *20*; εM+=0.0159 *5*
(2.10×10³ *3*)	2128.5	0.10 *5*	0.3 *1*	7.13 *12*	0.4 *1*	av Eβ=473 *12*; εK=0.588 *16*; εL=0.0704 *20*; εM+=0.0158 *5*
(2.12×10³ *3*)	2101.1	0.20 *5*	0.3 *1*	7.06 *10*	0.5 *1*	av Eβ=485 *12*; εK=0.572 *16*; εL=0.0684 *20*; εM+=0.0154 *5*
(2.71×10³ *3*)	1511.6	0.3 *1*	0.1 *1*	7.68 *22*	0.4 *2*	av Eβ=750 *13*; εK=0.282 *10*; εL=0.0337 *12*; εM+=0.0076 *3*
(2.78×10³‡ *3*)	1451.0	0.04 *4*	0.06 *6*	9.5[1u] *5*	0.10 *10*	av Eβ=801 *13*; εK=0.497 *12*; εL=0.0601 *15*; εM+=0.0135 *4*
4362 *10*	0.0	74 *15*	5.0 *10*	6.48 *9*	79 *16*	av Eβ=1453 *13*; εK=0.0552 *14*; εL=0.00656 *16*; εM+=0.00147 *4* E(decay): from E(endpoint)=3340 *10* (1970HaZH). Others: 3320 *50* (1974Vo08), 3100 (1964Bu11). Iβ+: from 1969HaZP, uncertainty of 20% assigned by evaluator.

† Absolute intensity per 100 decays.
‡ Existence of this branch is questionable.

^{89}Nb ε decay (2.03 h) 1974Vo08,1969HaZP (continued)

γ(^{89}Zr)

Iγ normalization: from Iβ$^+$(g.s.)=74 (1969HaZP) with 20% uncertainty assigned by the evaluator and ε/β$^+$(g.s.)=0.0635.
The following γ rays of Eγ(Iγ) reported by 1971Ar16 only have been omitted since these are not confirmed by 1974Vo08: 1520 (1.1), 1540 (1), 1744 (4.3), 1866.5 (10), 1884.3 (19), 2111 (5), 2417 (4), 2429 (2), 2444 (4.5), 2465 (3.8), 2481 (3.2), 2510 (4.6), 2518 (2.0), 2624 (4.2), 2656 (4.6), 2675 (3), 2802 (5), 2816 (6), 3058 (3), 3911 (8), 3917 (5).

E_γ [†]	I_γ [†#]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [‡]	α [@]	Comments
173.1[a] *4*	2.1 *5*	2925.9	7/2$^+$,9/2$^+$	2753.9	(7/2$^+$)			E_γ,I_γ: from 1975Ko21, who probably adopted from 1975HaYQ. Eγ=172 *2*, Iγ≈2 (1969HaZP). γ not reported by 1974Vo08.
206 *1*	1.9 *9*	1833.5	5/2$^+$	1627.4	5/2$^+$			
229.2[a] *5*	4.0 *15*	2959.8	(7/2$^+$,9/2$^+$)	2730.5	(7/2,9/2)$^-$			
347.5 *10*	1.3 *7*	2959.8	(7/2$^+$,9/2$^+$)	2612.1	9/2$^+$			
355.7 *4*	6.8 *7*	1451.0	5/2$^-$	1095.2	3/2$^-$			
[x]361 *1*	2.5 *5*							
480.8 *7*	4 *1*	3092.6	(7/2$^+$)	2612.1	9/2$^+$	(E2)		
507.4 *7*	22 *3*	1095.2	3/2$^-$	588.0	1/2$^-$	(M1)		I_γ: from intensity balance at 1095 level.
520 *1*	2.4 *12*	3092.6	(7/2$^+$)	2572.2	7/2$^+$,9/2$^+$			
532.4 *4*	15 *2*	1627.4	5/2$^+$	1095.2	3/2$^-$			
588.0 *2*	32 *4*	588.0	1/2$^-$	0.0	9/2$^+$	(M4)	0.0466	α(K)=0.0401 *6*; α(L)=0.00544 *8*; α(M)=0.000960 *14*; α(N+..)=0.0001429 *21* α(N)=0.0001343 *19*; α(O)=8.60×10^{-6} *13* I_γ: from intensity balance at 588 level.
617 *1*	1.2 *5*	2128.5	(7/2$^+$)	1511.6	(9/2)$^+$			
624.2[a] *9*	2.6 *5*	2753.9	(7/2$^+$)	2128.5	(7/2$^+$)			
[x]657.8 *10*	≈2							
738.6[&] *4*	6.3[&] *6*	1833.5	5/2$^+$	1095.2	3/2$^-$			
738.6[&] *4*	6.3[&] *6*	2572.2	7/2$^+$,9/2$^+$	1833.5	5/2$^+$			
757[a] *1*	2.5 *4*	3512.6	(7/2,9/2,11/2)	2753.9	(7/2$^+$)			Placement from 1969HaZP.
787.0 *15*	1.0 *4*	2297.1	(7/2)$^+$	1511.6	(9/2)$^+$			
794.0 *15*	1.2 *4*	3016.2	7/2$^-$	2221.9	(9/2$^-$)			
845.5 *10*	2.2 *6*	2297.1	(7/2)$^+$	1451.0	5/2$^-$			
863.1 *4*	13 *2*	1451.0	5/2$^-$	588.0	1/2$^-$			
920.5 *3*	41 *4*	2753.9	(7/2$^+$)	1833.5	5/2$^+$			
964 *1*	3 *1*	3092.6	(7/2$^+$)	2128.5	(7/2$^+$)			
992 *1*	2.6 *5*	3092.6	(7/2$^+$)	2101.1	(7/2)$^+$			
[x]1004.5 *10*	2.7 *5*							
1060.5 *8*	7.5 *10*	2572.2	7/2$^+$,9/2$^+$	1511.6	(9/2)$^+$			
1127 *2*	60 *9*	2753.9	(7/2$^+$)	1627.4	5/2$^+$			E_γ,I_γ: from γγ.
1242.5 *8*	6.8 *9*	2753.9	(7/2$^+$)	1511.6	(9/2)$^+$			
1259.0 *3*	35 *3*	3092.6	(7/2$^+$)	1833.5	5/2$^+$	(M1,E2)		
1303.0 *7*	9 *1*	2753.9	(7/2$^+$)	1451.0	5/2$^-$			
1332.3 *3*	35 *3*	2959.8	(7/2$^+$,9/2$^+$)	1627.4	5/2$^+$			
1377.5 *10*	2.0 *8*	2889.5	(7/2,9/2,11/2)	1511.6	(9/2)$^+$			
[x]1412 *2*	≈0.5							
1447.7 *7*	11 *1*	2959.8	(7/2$^+$,9/2$^+$)	1511.6	(9/2)$^+$			
1464.8 *5*	25 *2*	3092.6	(7/2$^+$)	1627.4	5/2$^+$			
1511.4 *3*	55 *4*	1511.6	(9/2)$^+$	0.0	9/2$^+$	(M1+E2)		Mult.: from 1984HaZC. Other: E1

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^{89}Nb ε decay (2.03 h) 1974Vo08,1969HaZP (continued)

γ(^{89}Zr) (continued)

E_γ [†]	I_γ [†#]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	Comments
							from 1972PhZS is in disagreement.
1580.8 *4*	15.0 *15*	3092.6	(7/2$^+$)	1511.6	(9/2)$^+$		
1627.2 *2*	100	1627.4	5/2$^+$	0.0	9/2$^+$		
1641.2 *9*	5.6 *5*	3092.6	(7/2$^+$)	1451.0	5/2$^-$		
1833.4 *2*	93 *7*	1833.5	5/2$^+$	0.0	9/2$^+$	(E2)	
1948.0 *15*	1.9 *8*	3575.8	(5/2)$^-$	1627.4	5/2$^+$		
2101.1 *3*	17 *2*	2101.1	(7/2)$^+$	0.0	9/2$^+$		
2128.2 *4*	16 *2*	2128.5	(7/2$^+$)	0.0	9/2$^+$		
2132.0 *15*	3.7 *15*	2132.0	(7/2$^+$,9/2$^+$)	0.0	9/2$^+$		
2221.5 *15*	≈3.5	2221.9	(9/2$^-$)	0.0	9/2$^+$		
[x]2279.0 *15*	≈1						
2297 *1*	3.2 *5*	2297.1	(7/2)$^+$	0.0	9/2$^+$		
2388.6 *10*	1.5 *4*	2388.6	(5/2)$^+$	0.0	9/2$^+$		
2572.3 *4*	76 *6*	2572.2	7/2$^+$,9/2$^+$	0.0	9/2$^+$		
2612.1 *6*	8.5 *8*	2612.1	9/2$^+$	0.0	9/2$^+$		
[x]2714 *2*	≈1						
2730 *1*	1.9 *8*	2730.5	(7/2,9/2)$^-$	0.0	9/2$^+$		
[x]2740.0 *15*	≈0.8						
2753.5 *10*	13 *2*	2753.9	(7/2$^+$)	0.0	9/2$^+$		
2889.6 *6*	5.7 *7*	2889.5	(7/2,9/2,11/2)	0.0	9/2$^+$		
2925.8 *6*	5.2 *6*	2925.9	7/2$^+$,9/2$^+$	0.0	9/2$^+$		
2960.1 *3*	50 *5*	2959.8	(7/2$^+$,9/2$^+$)	0.0	9/2$^+$		
2981.0 *8*	1.3 *4*	2981.1	(7/2,9/2,11/2)	0.0	9/2$^+$		
3016.2 *4*	6.0 *6*	3016.2	7/2$^-$	0.0	9/2$^+$		
3092.7 *2*	87 *8*	3092.6	(7/2$^+$)	0.0	9/2$^+$		
3141.2 *9*	0.6 *2*	3141.3	9/2$^+$	0.0	9/2$^+$		
3280.9 *7*	1.0 *2*	3281.0	7/2$^+$,9/2$^+$	0.0	9/2$^+$		
3466.9 *6*	1.2 *2*	3467.0	(7/2,9/2,11/2)	0.0	9/2$^+$		
3512.7 *7*	1.8 *3*	3512.6	(7/2,9/2,11/2)	0.0	9/2$^+$		
3531.0 *15*	≈0.9	3531.1	(7/2,9/2,11/2)	0.0	9/2$^+$		
3534.0 *15*	≈0.5	3534.1	(7/2,9/2,11/2)	0.0	9/2$^+$		
3557.2 *7*	1.5 *3*	3557.3	(7/2,9/2,11/2)	0.0	9/2$^+$		
3575.8 *5*	5.6 *6*	3575.8	(5/2)$^-$	0.0	9/2$^+$		
3837.0 *9*	1.8 *4*	3837.1	7/2$^+$,9/2$^+$	0.0	9/2$^+$		
3907.0 *15*	0.25 *10*	3907.1	(7/2$^-$,9/2$^-$)	0.0	9/2$^+$		
3931.0 *15*	1.0 *6*	3931.1	(7/2,9/2,11/2)	0.0	9/2$^+$		
3948.0 *15*	0.15 *6*	3948.1	(7/2,9/2,11/2)	0.0	9/2$^+$		
3965.5 *12*	0.3 *1*	3965.6	(7/2$^-$)	0.0	9/2$^+$		

[†] From 1974Vo08, unless otherwise stated.
[‡] From 1972PhZS, unless otherwise stated.
[#] For absolute intensity per 100 decays, multiply by 0.035 *7*.
[@] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.
[&] Multiply placed with undivided intensity.
[a] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

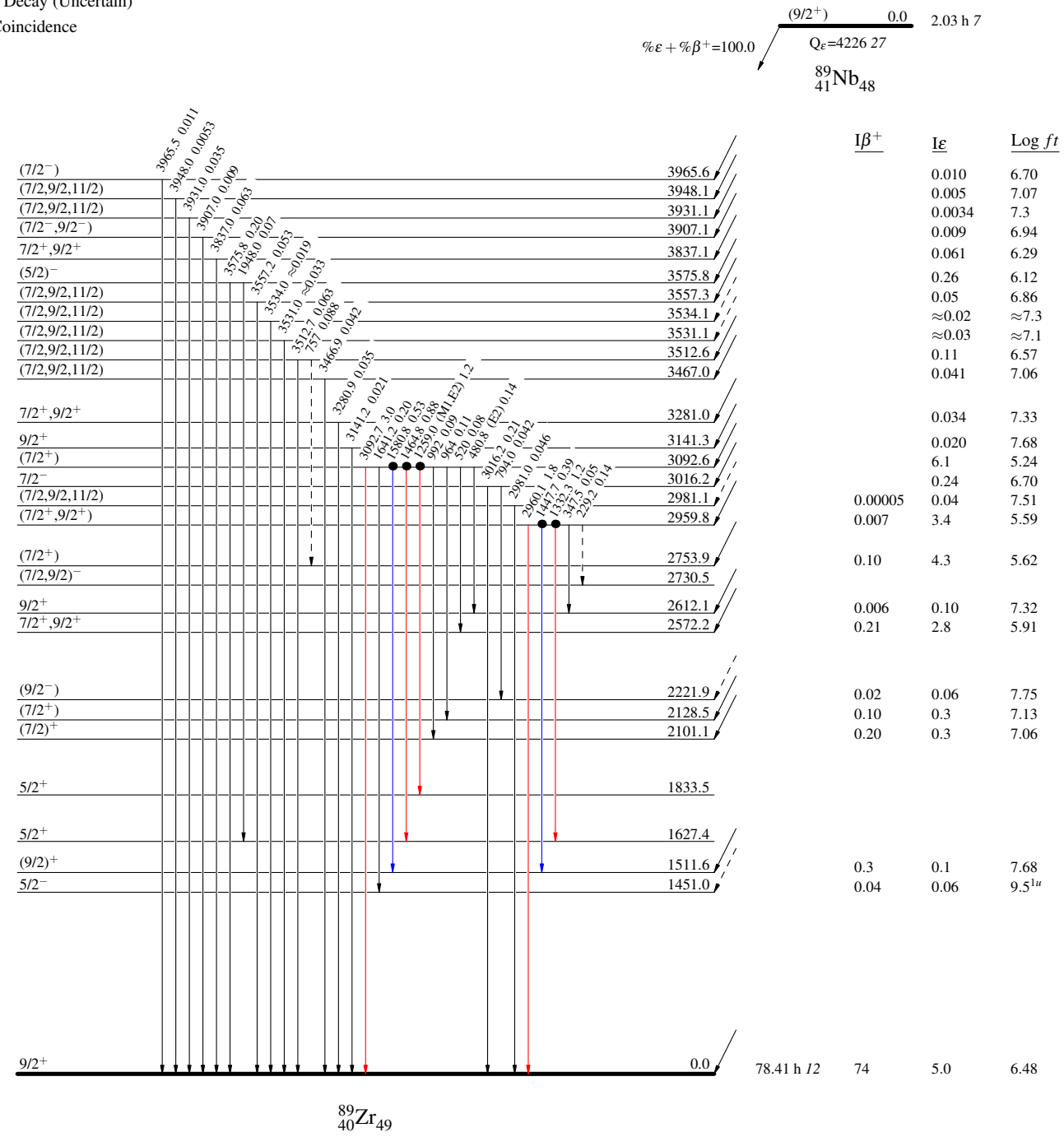
^{89}Nb ε decay (2.03 h) 1974Vo08,1969HaZP

Legend

- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- γ Decay (Uncertain)
- Coincidence

Decay Scheme

Intensities: I_γ per 100 parent decays



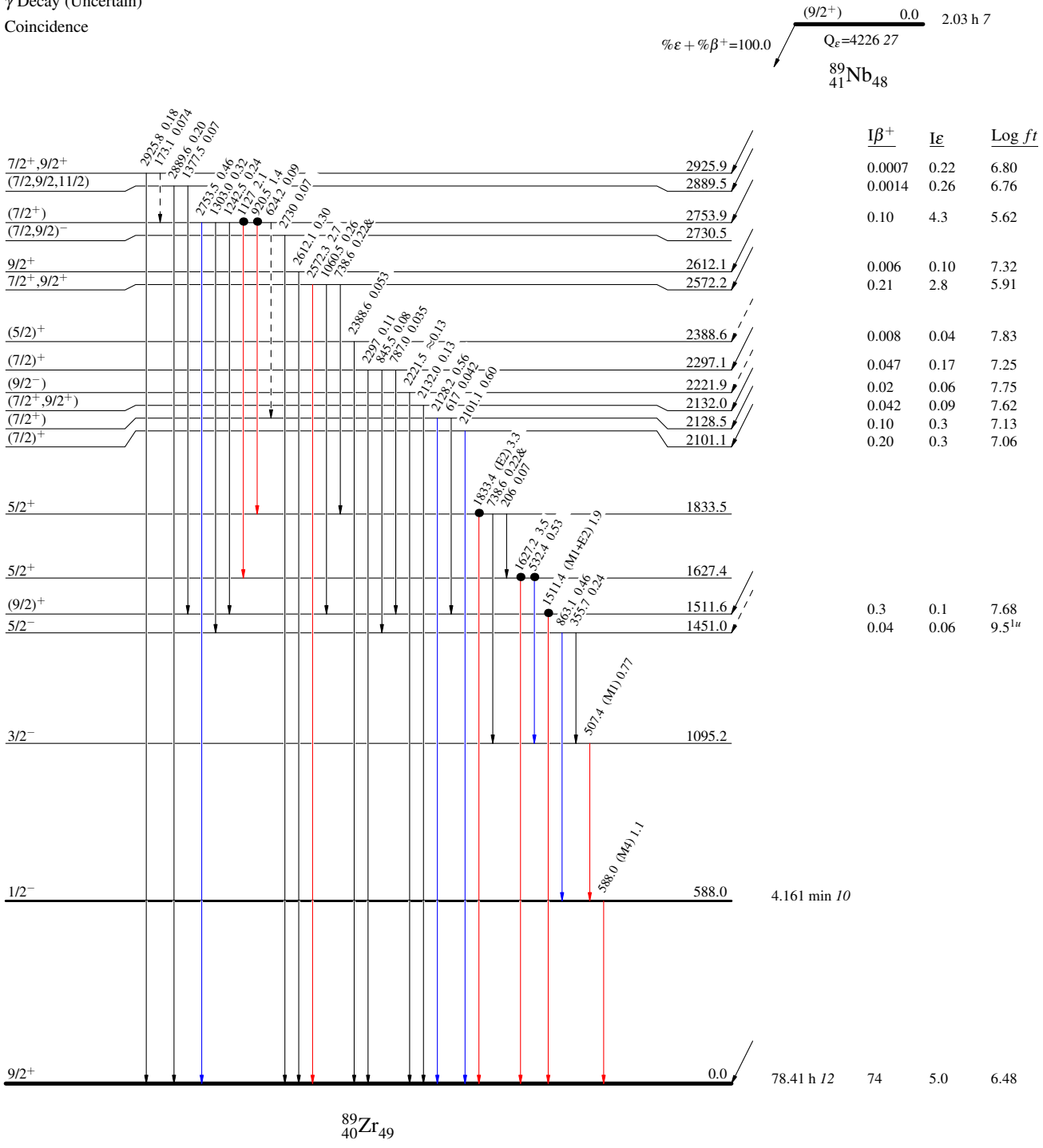
	Iβ+	Iε	Log *ft*
3965.6		0.010	6.70
3948.1		0.005	7.07
3931.1		0.0034	7.3
3907.1		0.009	6.94
3837.1		0.061	6.29
3575.8		0.26	6.12
3557.3		0.05	6.86
3534.1		≈0.02	≈7.3
3531.1		≈0.03	≈7.1
3512.6		0.11	6.57
3467.0		0.041	7.06
3281.0		0.034	7.33
3141.3		0.020	7.68
3092.6		6.1	5.24
3016.2		0.24	6.70
2981.1	0.00005	0.04	7.51
2959.8	0.007	3.4	5.59
2753.9	0.10	4.3	5.62
2730.5			
2612.1	0.006	0.10	7.32
2572.2	0.21	2.8	5.91
2221.9	0.02	0.06	7.75
2128.5	0.10	0.3	7.13
2101.1	0.20	0.3	7.06
1833.5			
1627.4			
1511.6	0.3	0.1	7.68
1451.0	0.04	0.06	9.5[1u]
0.0	78.41 h *12*	74	5.0	6.48

^{89}Nb ε decay (2.03 h) 1974Vo08,1969HaZP

Decay Scheme (continued)

Intensities: I_γ per 100 parent decays
& Multiply placed: undivided intensity given

Legend
- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- γ Decay (Uncertain)
- Coincidence



	Iβ+	Iε	Log *ft*
2925.9	0.0007	0.22	6.80
2889.5	0.0014	0.26	6.76
2753.9	0.10	4.3	5.62
2612.1	0.006	0.10	7.32
2572.2	0.21	2.8	5.91
2388.6	0.008	0.04	7.83
2297.1	0.047	0.17	7.25
2221.9	0.02	0.06	7.75
2132.0	0.042	0.09	7.62
2128.5	0.10	0.3	7.13
2101.1	0.20	0.3	7.06
1511.6	0.3	0.1	7.68
1451.0	0.04	0.06	9.5[1u]
0.0	74	5.0	6.48