^{92}Zr(p,nγ), Y(α,xnγ) 1977Da01,1975Ke12,1974Ku01

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 113, 2187 (2012)	15-Sep-2012

Other measurements: 1988BeYU, 1979Ba54, 1979Mi08, 1975Le05, 1974BrXM, 1972Ku03, 1971Co06.
1971Co06: E(p)=6.3 MeV. Eγ, n-γ(t), γγ(t).
1972Ku03: E(p) not given. 90γ(t).
1974BrXM: Eα=14 MeV. $T_{1/2}$ from DSA.
1974Ku01: E(p)=3.0-4.8 MeV. Eγ (±0.2 keV), Iγ, σ(E).
1974Le05: E(p)=5.5 MeV. g-factor from p-γ(θ,H,t).
1975Ke12: E(p)=3.4-5.1 MeV. Eγ (±1 keV), γγ coin, σ(E) across IAR.
1977Da01: E(p)=3.0-5.0 MeV, E(α)=7.0-12.5 MeV. Eγ (±0.5 keV), Iγ, γγ coin, γ(θ), γγ(θ), σ(E); statistical compound nuclear model analysis of γ(θ), γγ(θ).
1979Ba54: E(p) not given. Iγ(+θ)-Iγ(-θ) for 749γ.
1979Mi08: E(p)=5.055, 5.270 MeV. Eγ (ΔE=0.2-0.4 keV), I(γ,ce), γ yield on and off IAR.
1988BeYU: Eα=28-32 MeV. Pulsed beam-γ(t).

^{92}Nb Levels

The adopted level scheme is based on information from γ excitation functions (1977Da01,1974Ku01,1975Ke12), Hauser-Feshbach analysis of σ(E) (1974Ku01), γ(θ) and γγ(θ) data (1977Da01), conversion electron coefficients (1979Mi08) and γγ-coin information (1977Da01,1975Ke12). It is a combination of schemes from 1977Da01, 1975Ke12, 1979Mi08 and 1974Ku01, which are mutually consistent, except for the 1974Ku01 placement of 1129γ, 1132γ (placed without the benefit of γγ coin data and subsequently rejected by the evaluator).

E(level)[†]	Jπ[@]	$T_{1/2}$[‡]	Comments
0.0	(7)+[&]		
135.5 3			
225.9 3	2−[&g]	4.4[#] μs 5	J=2,4 from γ(θ).
285.8 3	3+	1.1 ns +6−3	J=3 from γ(θ). $T_{1/2}$: after correction for cascade feeding (1974BrXM).
357.44 17	5+	1.91[e] ns 4	J=3,5 from γ(θ). J=3 rejected because it would imply J(g.s.)≤5 (unlikely, given $T_{1/2}$ and decay mode of g.s. and 136 (2)+ level).
389.8 3	3−[g]	≤10 ns	J=3 from γ(θ).
480.51 24	4+	0.62 ns 10	J=4 from γ(θ).
501.40 20	(6)+[&]	0.35 ns 5	J=6,8 from γ(θ) if J(g.s.)=7.
975.1 4	(1+,2−)[f]	≤10 ns	
1089.5 3	1	≤10 ns	J=1 from γ(θ) (1977Da01).
1150.1 4	1−		
1310.8[d] 6		≤10 ns	J=1,2,3 from γ(θ).
1324.0 4	(1,2,3)−[a]		J=1,2,3 from γ(θ).
1345.7 4	(2+)[a]	≤10 ns	J=2 from γ(θ) in (p,nγ); no consistent solution from (α,2nγ).
1406.3[c] 4	5		
1410.4[d] 6	5+[&]		γ(θ) allows J=5, but not J=4.
1415.3 4	4+[a]	≤10 ns	J=3,4 from γ(θ).
1422.8 4	4−[a]	≤10 ns	J=4 from γ(θ).
1468.0[c] 4	4+,5+		
1472.8 6			
1481.5 4	1+		
1554.0 4	(2,3)−[a]	≤10 ns	J=2,3 from γ(θ).
1565.8[b] 11			
1632.8[b] 11			

Continued on next page (footnotes at end of table)

^{92}Zr(p,nγ), Y(α,xnγ) 1977Da01,1975Ke12,1974Ku01 (continued)

^{92}Nb Levels (continued)

E(level)[†]	J$^{\pi}$[@]
1642.1 *3*	1
1650.4[c] *3*	5,6
1666.7 *4*	1
1678.2 *4*	1
1738.3 *4*	0,3
1768.2[c] *3*	4

[†] From least-squares fit to Eγ.
[‡] Upper limits are from 1977Da01, based on observation of level in γγ coin; other values are from DSAM (1974BrXM), except as noted.
[#] Weighted average of 4.3 μs *5* (1971Co06), 5.0 μs *10* (1972Ku03).
[@] From 1974Ku01, based on Hauser-Feshbach analysis of σ(E), unless indicated otherwise. Values from 1977Da01, which are based on γ(θ), are given in comments.
[&] From 1977Da01, based on γ(θ), γγ(θ) from their work combined with L values from others′ transfer reaction data, and assuming J$^{\pi}$(136 level)=2^{+}.
[a] From 1977Da01. 1974Ku01 obtain J$^{\pi}$ assignments for 1324,1346,1423,1554 levels (4^{-}, (3^{-},4^{-}), (4^{+},5^{+}), (1), respectively) which differ from those of 1977Da01. 1974Ku01 did not include the weak 934γ deexciting the 1324-level or the strong 1210γ deexciting the 1346 level in their analysis, thereby underestimating the total yield of each state and probably overestimating J; also, they associated γ rays deexciting the 1415 and 1423 levels with higher energy states, so deduced J$^{\pi}$ values for these levels are unreliable.
[b] Reported by 1975Ke12 only.
[c] Reported by 1974Ku01 only.
[d] Reported by 1977Da01 only.
[e] Weighted average of 1.89 ns *6* (1971Co06), 1.92 ns *5* (1988BeYU).
[f] J≠0 because 749γ is polarized (1979Ba54).
[g] π=− from IAR enhancement (1979Mi08).

γ(^{92}Nb)

See 1977Da01 for additional δ values deduced for other J(level) values consistent with authors′ A_2 and A_4 data from γ(θ) and/or γγ(θ).

E$_i$(level)	J$^{\pi}_i$	E$_{\gamma}$[‡]	E$_f$	J$^{\pi}_f$	Mult.[#]	δ[@]	α[†]	Comments
225.9	2^{-}	90.50 *14*	135.5		E1		0.1602	α(K)=0.1408 *21*; α(L)=0.01618 *24*; α(M)=0.00283 *5*; α(N+..)=0.000425 *7* α(N)=0.000405 *6*; α(O)=2.07×10^{-5} *3* α(K)exp=0.142 *10* and 0.145 *13*, α(L+...)exp=0.0198 *18* and 0.0180 *16* give δ≈0.
285.8	3^{+}	150.25 *14*	135.5		M1(+E2)	+0.070 *14*	0.0749 *12*	α(K)=0.0657 *10*; α(L)=0.00768 *13*; α(M)=0.001357 *22*; α(N+..)=0.000209 *4* α(N)=0.000198 *4*; α(O)=1.121×10^{-5} *17* α(K)exp=0.064 *6* (implying δ≤0.16). A_2=−0.33 *2*, A_4=+0.01 *2* (E(p)=3340); A_2=−0.25 *1*, A_4=+0.02 *2* (E(p)=4000); A_2=−0.16 *1*, A_4=+0.02 *1* (α,xnγ).
357.44	5^{+}	357.44 *17*	0.0	(7)$^{+}$	E2		0.01277	α(K)=0.01112 *16*; α(L)=0.001368 *20*;

Continued on next page (footnotes at end of table)

^{92}Zr(p,nγ), Y(α,xnγ) 1977Da01,1975Ke12,1974Ku01 (continued)

γ(^{92}Nb) (continued)

E_i(level)	J_i^π	E_γ[‡]	I_γ[&]	E_f	J_f^π	Mult.[#]	δ[@]	α[†]	Comments
									α(M)=0.000241 *4*; α(N+..)=3.64×10^{-5} *6* α(N)=3.46×10^{-5} *5*; α(O)=1.771×10^{-6} *25* A_2=+0.15 *5*, A_4=−0.07 *6* (E(p)=3340); A_2=+0.17 *1*, A_4=−0.04 *2* (E(p)=4000); A_2=+0.13 *1*, A_4=0.00 *1* (α,xnγ). Mult.,δ: α(K)exp=0.0119 *11*, α(L+...)exp=0.0013 *2* (implying $\delta\approx0$); δ(Q,O)=−0.012 *21* from $\gamma(\theta)$; <0.0003 from RUL.
389.8	3⁻	104.3 *4*	<1	285.8	3⁺				E_γ: from 1979Mi08.
		164.10 *14*	97 *1*	225.9	2⁻	M1+E2	+0.135 *23*	0.0608 *13*	α(K)=0.0533 *11*; α(L)=0.00627 *15*; α(M)=0.00111 *3*; α(N+..)=0.000170 *4* α(N)=0.000161 *4*; α(O)=9.04×10^{-6} *17* α(K)exp=0.053 *5*, α(L+...)exp=0.0070 *6* require δ=0.11 *+13−11* and$\leq$0.11, respectively. A_2=−0.38 *2*, A_4=+0.03 *2* (E(p)=3340); A_2=−0.28 *1*, A_4=−0.02 *1* (E(p)=4000); A_2=−0.19 *1*, A_4=0.00 *1* (α,xnγ).
		254.09 *17*	3 *1*	135.5		E1+M2	+0.20 *7*	0.0114 *25*	α(K)=0.0100 *22*; α(L)=0.0012 *3*; α(M)=0.00021 *5*; α(N+..)=3.2×10^{-5} *8* α(N)=3.0×10^{-5} *8*; α(O)=1.7×10^{-6} *4* α(K)exp=0.0116 *16*, α(L+...)exp=0.0023 *8*. A_2=−0.16 *27* A_4=+0.05 *8* (E(p)=4000); A_2=−0.17 *2*, A_4=0.00 *2* (α,xnγ). δ: unweighted average of +0.06 *9*, 0.25 *5* and 0.30 *+17−9* from $\gamma(\theta)$, α(K)exp, α(L+...)exp, respectively.
480.51	4⁺	123.07 *17*	24 *4*	357.44	5⁺	M1(+E2)	−0.044 *25*	0.1281 *22*	α(K)=0.1122 *19*; α(L)=0.0132 *3*; α(M)=0.00233 *5*; α(N+..)=0.000359 *7* α(N)=0.000339 *7*; α(O)=1.92×10^{-5} *3* α(K)exp=0.109 *11*, α(L+...)exp=0.016 *5* require $\delta\leq$0.15. A_2=−0.11 *5*, A_4=+0.06 *6* (E(p)=4000); A_2=−0.14 *2*, A_4=−0.02 *3* (E(p)=4500); A_2=−0.12 *1*, A_4=+0.03 *1* (α,xnγ). 123γ-358$\gamma(\theta)$: A_2=+0.02 *3*, A_4=+0.04 *3* and A_2=+0.17 *4*, A_4=+0.07 *4* (α,xnγ).
		194.60 *14*	76 *4*	285.8	3⁺	M1		0.0372	α(K)=0.0326 *5*; α(L)=0.00377 *6*; α(M)=0.000665 *10*; α(N+..)=0.0001028 *15* α(N)=9.73×10^{-5} *14*; α(O)=5.57×10^{-6} *8* α(K)exp=0.0344 *30*, α(L+...)exp=0.0039 *4* [giving δ=0.2 *+1−2*, cf. δ=+0.009 *+17−18* from $\gamma\gamma(\theta)$, $\gamma(\theta)$]. A_2=−0.26 *2*, A_4=+0.01 *2* (E(p)=4000); A_2=−0.22 *1*, A_4=0.00 *2* (E(p)=4500); A_2=−0.14 *2*, A_4=+0.02 *2* (α,xnγ).

Continued on next page (footnotes at end of table)

^{92}Zr(p,nγ), Y(α,xnγ) 1977Da01,1975Ke12,1974Ku01 (continued)

γ(^{92}Nb) (continued)

E_i(level)	J^π_i	E_γ[‡]	I_γ[&]	E_f	J^π_f	Mult.[#]	δ[@]	Comments
								195γ-150γ(θ): A_2=−0.23 *2*, A_4=+0.06 *2* and A_2=−0.23 *2*, A_4=0.00 *2* (α,xnγ).
501.40	(6)$^+$	501.4 *2*		0.0	(7)$^+$	D(+Q)	−0.02 *+4−3*	A_2=−0.09 *7*, A_4=−0.11 *8* (E(p)=4500); A_2=−0.18 *1*, A_4=+0.03 *2* (α,xnγ).
975.1	(1$^+$,2$^-$)	749.3[a] *2*		225.9	2$^-$			A_2=−0.03 *2*, A_4=0.00 *2* (E(p)=4000); A_2=−0.01 *1*, A_4=−0.01 *1* (α,xnγ).
1089.5	1	803.8 *2*	20 *2*	285.8	3$^+$	(Q)		A_2=−0.01 *2*, A_4=+0.01 *2* (E(p)=4000); A_2=−0.02 *1*, A_4=0.00 *2* (E(p)=4500); A_2=+0.05 *3*, A_4=−0.02 *4* (α,xnγ). 804γ-150γ(θ): A_2=+0.34 *5*, A_4=−0.08 *6* and A_2=+0.15 *6*, A_4=+0.02 *7* (E(p)=4500). incorrectly identified As 954γ-150γ(θ) In table II of 1977Da01. Mult.: assumed to be pure Q.
		863.5 *2*	54 *2*	225.9	2$^-$	D(+Q)	−0.3 *3*	A_2=−0.04 *1*, A_4=0.00 *1* (E(p)=4000); A_2=−0.03 *1*, A_4=0.00 *1* (E(p)=4500); A_2=−0.04 *1*, A_4=+0.01 *1* (α,xnγ). δ: ≤−3 or −0.34 *+27−33*. Since adopted Δπ=yes, the first solution is unlikely.
		953.8 *2*	26 *2*	135.5		D+Q		A_2=−0.05 *3*, A_4=−0.01 *3* (E(p)=4000); A_2=−0.09 *1*, A_4=0.00 *2* (E(p)=4500); A_2=−0.12 *2*, A_4=+0.02 *2* (α,xnγ). δ: ≤−0.8 or −0.7 *+6−16*.
1150.1	1$^-$	175.2 *2*	2 *1*	975.1	(1$^+$,2$^-$)	D+Q		E_γ: from 1974Ku01. A_2=−0.14 *3*, A_4=−0.05 *3* (E(p)=4500).
		760.2 *2*	5 *1*	389.8	3$^-$			A_2=+0.01 *3*, A_4=+0.01 *4* (E(p)=4500); A_2=+0.16 *13*, A_4=+0.07 *14* (α,xnγ).
		924.08 *18*	93 *2*	225.9	2$^-$			A_2=−0.01 *1*, A_4=−0.01 *1* (E(p)=4500); A_2=+0.01 *1*, A_4=0.00 *1* (α,xnγ).
1310.8		921.0 *5*	65 *2*	389.8	3$^-$			E_γ: from 1977Da01; not reported by other authors. A_2=+0.06 *6*, A_4=−0.06 *6* (E(p)=4500); A_2=+0.01 *1*, A_4=−0.02 *1* (α,xnγ). 921γ-164γ(θ): A_2=+0.20 *11*, A_4=+0.12 *13* (E(p)=4500); A_2=+0.14 *11*, A_4=+0.11 *12* (α,xnγ).
1324.0	(1,2,3)$^-$	934.0 *5*	5 *3*	389.8	3$^-$			E_γ: from 1977Da01.
		1098.1 *2*	95 *3*	225.9	2$^-$			A_2=−0.02 *2*, A_4=0.00 *2* (E(p)=4500); A_2=+0.03 *1*, A_4=+0.01 *1* (α,xnγ).
1345.7	(2$^+$)	1059.9 *2*	29 *2*	285.8	3$^+$	D		A_2=−0.21 *2*, A_4=+0.01 *2* (E(p)=4500); A_2=−0.30 *3*, A_4=+0.02 *4* (α,xnγ). 1060γ-150γ(θ): A_2=−0.13 *6*, A_4=−0.09 *7* and A_2=−0.33 *6*, A_4=+0.09 *6* (E(p)=4500).
		1210.0 *5*	71 *2*	135.5		(D)		E_γ: from 1977Da01; not reported by other authors. A_2=−0.04 *1*, A_4=−0.01 *1* (E(p)=4500); A_2=−0.04 *1*, A_4=+0.01 *2* (α,xnγ).
1406.3	5	1120.5 *2*		285.8	3$^+$			
1410.4	5$^+$	909.0 *5*		501.40	(6)$^+$	D		E_γ: from 1977Da01; not reported by other authors. A_2=−0.22 *6*, A_4=−0.08 *7* (E(p)=4500).
1415.3	4$^+$	933.8 *5*	50 *10*	480.51	4$^+$			934γ-195γ(θ): A_2=+0.02 *9*, A_4=−0.20 *12* or A_2=−0.07 *12*, A_4=−0.17 *14* (E(p)=4500); A_2=−0.01 *11*, A_4=+0.12 *11* (α,xnγ).
		1129.7 *2*	50 *10*	285.8	3$^+$			A_2=+0.12 *3*, A_4=−0.01 *4* (E(p)=4500).

Continued on next page (footnotes at end of table)

^{92}Zr(p,nγ), Y(α,xnγ) 1977Da01,1975Ke12,1974Ku01 (continued)

γ(^{92}Nb) (continued)

E_i(level)	J_i^π	E_γ[‡]	I_γ[&]	E_f	J_f^π	Mult.[#]	δ[@]	Comments
								1129γ-150γ(θ): A_2=+0.13 *12*, A_4=−0.03 *15* (E(p)=4500).
1422.8	4^-	1033.0 *2*		389.8	3^-	D+Q	+0.9 *+3−2*	A_2=−1.00 *6*, A_4=+0.19 *6* (E(p)=4500). 1033γ-164γ(θ): A_2=−1.2 *3*, A_4=+0.2 *3* (E(p)=4500).
1468.0	4^+,5^+	1332.4 *2*		135.5				
1472.8		1083.0[b] *5*	[b]	389.8	3^-			E_γ: from 1977Da01; not reported by other authors. A_2=+0.04 *6*, A_4=−0.14 *7* (E(p)=4500).
1481.5	1^+	1255.6 *2*	17	225.9	2^-			
		1345.9 *2*	83	135.5				A_2=0.00 *1*, A_4=−0.01 *1* (E(p)=4500).
1554.0	$(2,3)^-$	1164.2 *2*	62 *2*	389.8	3^-			A_2=−0.08 *2*, A_4=+0.02 *2* (E(p)=4500); A_2=+0.06 *2*, A_4=−0.07 *3* (α,xnγ). 1164γ-164γ(θ): A_2=+0.33 *21* A_4=−0.30 *27* (E(p)=4500); A_2=−0.02 *14*, A_4=−0.02 *14* (α,xnγ).
		1328.1 *2*	38 *2*	225.9	2^-			A_2=−0.08 *2*, A_4=+0.02 *3* (E(p)=4500).
1565.8		1280 *1*		285.8	3^+			E_γ: from 1975Ke12; not reported by other authors.
1632.8		1347 *1*		285.8	3^+			E_γ: from 1975Ke12; not reported by other authors.
1642.1	1	552.6 *2*	25	1089.5	1			
		1252.5 *2*	14	389.8	3^-			
		1356.1 *2*	38	285.8	3^+			
		1416.2 *2*	23	225.9	2^-			
1650.4	5,6	1149.0 *2*		501.40	$(6)^+$			
1666.7	1	1276.6 *2*	68	389.8	3^-			
		1441.0 *2*	32	225.9	2^-			
1678.2	1	702.9 *2*	8	975.1	$(1^+,2^-)$			
		1452.5 *2*	92	225.9	2^-			
1738.3	0,3	1512.4 *2*		225.9	2^-			
1768.2	4	1287.6 *2*	65	480.51	4^+			
		1482.5 *2*	35	285.8	3^+			

[†] Additional information 1.

[‡] Weighted average of data from 1979Mi08 and 1974Ku01 for Eγ<400; from 1974Ku01 for Eγ≥400. Exceptions are noted.

[#] From conversion electron data of 1979Mi08 and/or γ(θ), γγ(θ) data of 1977Da01.

[@] From γ(θ) and/or γγ(θ) data of 1977Da01.

[&] Intensity branchings with uncertainties are from 1977Da01; others are intensity ratios at 90° from 1974Ku01, presumably uncorrected for angular distribution effects. Note that 1974Ku01 obtain different ratios for I(123γ):I(195γ) (viz., 7:93) and I(1164γ):I(1328γ) (viz., 53:47).

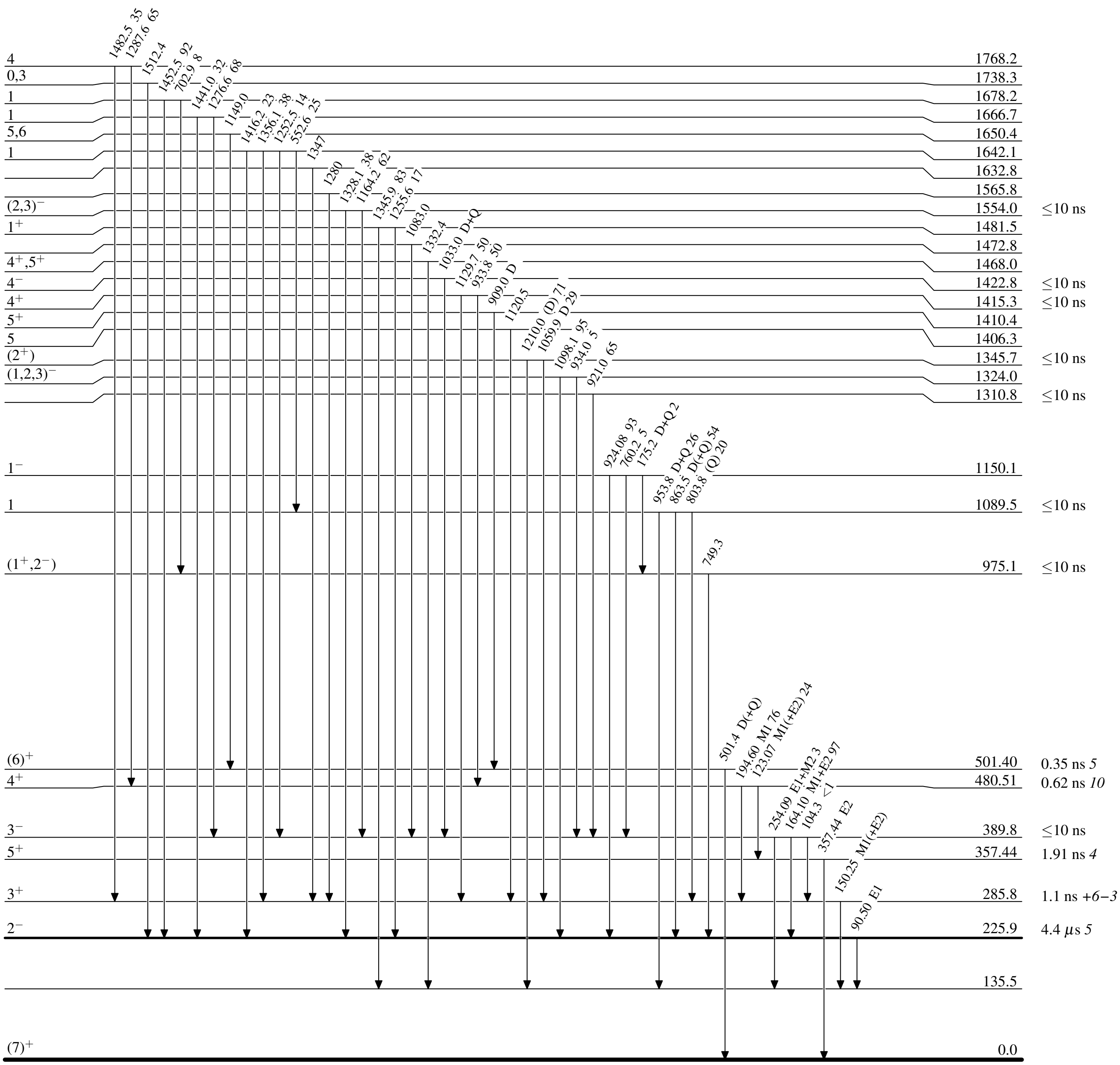
[a] 749γ is polarized (1979Ba54); this rules out J(975 level)=0.

[b] 1977Da01 placed 1083γ between 1310- and 226-keV levels, without the benefit of coin information, and energy fit is not good. Evaluator has relocated this γ ray between a 1473 level (not previously reported in (p,nγ) or (α,xnγ)) and the 390 level, in accord with 1083γ placement in (^{3}He,p2nγ) and with ≈1082γ−163γ coin reported in (^{7}Li,3nγ). 1977Da01 report I(921γ):I(1083γ)=65 *2*:35 *2*.

$^{92}Zr(p,n\gamma)$, $Y(\alpha,xn\gamma)$ 1977Da01,1975Ke12,1974Ku01

Level Scheme

Intensities: % photon branching from each level



$^{92}_{41}Nb_{51}$