^{89}Y(α,2nγ), ^{93}Nb(α,α'2nγ) 1979Fi06,1975Sc30,1974Be36

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 114, 1293 (2013)	1-Sep-2013

Additional information 1.
Others: 1979Pl05, 1977Ba34, 1976Ba50, 1976Ba02, 1973BeYD.
1979Fi06: (α,2nγ); E=24.0 MeV, 35.7 MeV; measured Eγ, Iγ, $\gamma(\theta)$, γ(t).
1976Ba50: (α,2nγ); E=24.6 to 27.8 MeV; coaxial and planar Ge(Li), scin detectors; measured Eγ, Iγ, $\gamma(\theta)$ at seven angles for Eα=24.7 MeV, γ(t), $\gamma\gamma$ coin at Eα=26 MeV, particle-γ coin, γ excit; shell-model level-energy calculations.
1976Ba02: (α,2nγ); E=21 MeV; NaI(Tl),Ge(Li) detectors. Measured α-$\gamma(\theta$,H,t); deduced $T_{1/2}$, g-factor for 13/2$^-$ 1984 level.
1975Sc30: (α,α'2nγ); E=48 MeV, pulsed beam; measured α-Ce(t).
1974Be36: (α,2nγ); E=17 MeV to 25 MeV, pulsed beam; measured Eγ, Iγ, I(x), $\gamma(\theta)$, γ(t), γ excit.
1973BeYD: (α,2nγ); E=17.3 MeV to 19.8 MeV. The energies chosen were just above the threshold for each level. Ge(Li). Measured Eγ and DSA.

^{91}Nb Levels

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$[#]	Comments
0	9/2$^+$		J$^\pi$: from Adopted Levels.
102.0 *7*	1/2$^-$		J$^\pi$: from Adopted Levels.
1184.4 *7*	5/2$^-$	2.6[@] ps *+15−7*	
1310.1 *8*	3/2$^-$	0.166[@] ps *17*	
1580.61 *10*	7/2$^+$	0.33[@] ps *3*	
1609.6 *8*	3/2$^-$	0.054[@] ps *12*	J$^\pi$: from Adopted Levels.
1636.72 *10*	9/2$^+$	1.8[@] ps *+11−4*	
1790.44 *18*	9/2$^-$	>1.6[@] ps	
1963.0 *4*	(5/2$^+$)	0.17[@] ps *4*	J$^\pi$: from Adopted Levels.
1983.95 *17*	13/2$^-$	10.0 ns *4*	g=+1.26 *4* g: From time-differential perturbed angular distribution (1976Ba02). $T_{1/2}$: from α-γ(t) (1976Ba02). Other: 8 ns *2* (1976Ba50).
2034.2 *4*	17/2$^-$	3.8 μs *2*	g=+1.272 *18* $T_{1/2}$: from α-γ(t) (1974Be36). g: From time-differential perturbed angular distribution (1979Pl05; diamagnetic correction applied, Knight shift of 0.6% 3 assumed). Consistent with expected value for configuration=((π $g_{9/2}$)^2 (π $p_{1/2}$)) (1979Pl05).
2119.0	7/2$^-$		
2170	(11/2)		
2290.85 *20*	13/2$^+$	0.250[@] ps *21*	
2324.1 *11*	(5/2$^-$)	0.111[@] ps *14*	J$^\pi$: from Adopted Levels.
2329.6 *5*	(11/2$^+$)		
2413.8 *5*	11/2$^-$	0.65[@] ps *25*	
2531.2? *7*	(11/2$^-$)		J$^\pi$: from Adopted Levels.
2578.0? *11*	(5/2$^+$)		J$^\pi$: from Adopted Levels.
2660.0 *4*	15/2$^-$		
3110.3 *3*	17/2$^+$		
3466.9 *3*	21/2$^+$	0.92 ns *10*	g=+1.18 *18* (1977Ba34) $T_{1/2}$: from α-Ce(t) (1975Sc30).
4097.1 *4*	19/2		
4351.4 *4*	21/2$^{(+)}$		note that adopted π=(−).
4772.5[&] *4*	(23/2$^+$)		
4852.7 *4*	(21/2)		
5270.4[&] *4*	(23/2$^+$)		
5349.7 *11*	(23/2)		

Continued on next page (footnotes at end of table)

^{89}Y(α,2nγ), ^{93}Nb(α,α'2nγ) 1979Fi06,1975Sc30,1974Be36 (continued)

^{91}Nb Levels (continued)

E(level)[†]	Jπ[‡]
5455.4 *7*	(25/2$^+$)
5792.3 *15*	
6009.5 *15*	

† From least-squares fit to Eγ, assigning ΔE_γ=1 keV whenever no γ deexciting a given level has been assigned an uncertainty by the authors.

‡ Authors′ values, based primarily on $\gamma(\theta)$; from 1976Ba50 for E(level)<3500, and from 1979Fi06 for higher energy levels, except as noted.

For values from Doppler-shift attenuation, experimental uncertainties only are quoted; an additional uncertainty of 20% should be added to account for the error in the slowing-down theory (1973BeYD). Additionally, $T_{1/2}$<4 ns for all levels above 3500 keV (1979Fi06).

@ From Doppler-shift attenuation (1973BeYD).

& E differs In Adopted Levels because adopted order differs for 185γ, 497γ and 422γ cascade; the adopted order defines levels At 4848 and 5034 instead of 4773 and 5270 shown here.

^{89}Y(α,2nγ), ^{93}Nb(α,α'2nγ) 1979Fi06,1975Sc30,1974Be36 (continued)

$\gamma(^{91}Nb)$

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	α[d]	Comments
51.7[&] *20*		2034.2	17/2$^-$	1983.95	13/2$^-$	(E2)		12.4 *19*	α(K)exp=6.3 *20*; α(exp)=8.7 *20* α(K)exp: From measured I(K x ray) and Iγ (1974Be36). α(exp): From intensity balance of the delayed components (1974Be36). Eγ: given as 50.1 in fig. 3 of 1979Fi06; it is unclear whether this is a measured value. Eγ=50 (uncertainty unstated) in 1976Ba50. Mult.: from α(K)exp and α(exp).
(102.0 *7*)		102.0	1/2$^-$	0	9/2$^+$				Eγ: γ not observed in this experiment. E from level energy difference.
[x]122[b]									Placed by 1976Ba50 from a tentative 2439 level for which no other evidence exists.
[x]148[b]									Placed by 1976Ba50 from a tentative 2439 level for which no other evidence exists.
185.0[c] *5*	15.9 *6*	5455.4	(25/2$^+$)	5270.4	(23/2$^+$)	D(+Q)	−0.05 *5*		A_2=−0.34 *4*, A_4=−0.01 *1* (1979Fi06).
193.5 *1*	26.7 *7*	1983.95	13/2$^-$	1790.44	9/2$^-$	(E2)		0.1062	A_2=+0.19 *2*, A_4=0.00 *1* (1979Fi06). Other: 1976Ba50. Mult.: (Q) from $\gamma(\theta)$, not M2 from RUL.
254.3 *1*	18.7 *9*	4351.4	21/2$^{(+)}$	4097.1	19/2	D(+Q)	−0.07 *5*		A_2=−0.35 *4*, A_4=+0.01 *2* (1979Fi06). Others: 1974Be36, 1976Ba50. Iγ: I(254γ):I(885γ)=7.0 *7*:7.0 *7* in 1974Be36, 15:10 in 1976Ba50.
328.6	1	2119.0	7/2$^-$	1790.44	9/2$^-$				
356.6 *1*	89.8 *9*	3466.9	21/2$^+$	3110.3	17/2$^+$	E2		0.01287	A_2=+0.32 *3*, A_4=−0.08 *1* (1979Fi06). Others: 1974Be36, 1976Ba50. Mult.: Q from $\gamma(\theta)$, not M2 from RUL.
421.1 *1*	15.7 *6*	4772.5	(23/2$^+$)	4351.4	21/2$^{(+)}$	D(+Q)	−0.04 *4*		A_2=−0.33 *5*, A_4=+0.02 *4* (1979Fi06).
429.3[&] *7*	5	2413.8	11/2$^-$	1983.95	13/2$^-$	M1+E2[@]	−0.49[@] *+5−6*		A_2=+0.42 *7*, A_4=+0.08 *6* (1974Be36); A_2=+0.34 *3*, A_4=+0.01 *3* (1976Ba50). Mult.: D+Q from $\gamma(\theta)$, not E1+M2 from RUL.
442.6	3	5792.3		5349.7	(23/2)				
450.0[&] *7*	16	3110.3	17/2$^+$	2660.0	15/2$^-$	D			A_2=−0.34 *8*, A_4=+0.07 *8* (1976Ba50). Iγ: I(450γ):I(819γ)=6.0 *6*:61 *6* in 1974Be36, 7:77.2 in 1976Ba50.
497[e]	8[e]	5270.4	(23/2$^+$)	4772.5	(23/2$^+$)	(D)			Iγ=21.0 *10*, A_2=−0.45 *5*, A_4=−0.02 *2* for doublet (1979Fi06); inconsistent with mult=stretched Q for either component. Eγ: for doublet; Eγ=497.9 in fig. 3 of 1979Fi06.
497[e]	13[e]	5349.7	(23/2)	4852.7	(21/2)				Iγ=21.0 *10*, A_2=−0.45 *5*, A_4=−0.02 *2* for doublet (1979Fi06). Inconsistent with mult=stretched Q for either component. Eγ: for doublet; Eγ=497.2 in fig. 3 of 1979Fi06.
603.8	2	1790.44	9/2$^-$	1184.4	5/2$^-$				
625.8 *1*	19.1 *9*	2660.0	15/2$^-$	2034.2	17/2$^-$	(D+Q)	−0.04 *5*		δ: −0.09<δ<0 from 1979Fi06. δ=+0.12 *+4−3* from 1974Be36

$^{91}_{41}Nb_{50}$-3

^{89}Y(α,2nγ), ^{93}Nb(α,α'2nγ) 1979Fi06,1975Sc30,1974Be36 (continued)

$\gamma(^{91}Nb)$ (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	Comments
								is inconsistent with datum from 1979Fi06 and with result from (^{6}Li,3nγ).
								A_2=−0.22 *4*, A_4=+0.06 *4* (1979Fi06); A_2=−0.01 *7*, A_4=+0.12 *7* (1974Be36); A_2=−0.06 *3*, A_4=−0.02 *3* (1976Ba50).
659.8	9	6009.5		5349.7	(23/2)			
755.6 *1*	25.8 *6*	4852.7	(21/2)	4097.1	19/2	D+Q	+1.1 *2*	A_2=+0.74 *7*, A_4=+0.19 *3* (1979Fi06).
819.4 *2*	99.9 *9*	3110.3	17/2$^+$	2290.85	13/2$^+$	(Q)		A_2=+0.34 *3*, A_4=+0.13 *3* (1979Fi06); A_2=+0.47 *8*, A_4=−0.05 *6* (1974Be36); A_2=+0.30 *3*, A_4=−0.06 *4* (1976Ba50).
[x]858.8[b]						D		A_2=−0.6 *3*, A_4=+0.3 *5* (1976Ba50). Mult.: from $\gamma(\theta)$ in 1976Ba50. Placed by 1976Ba50 from a tentative 5209 level for which no other evidence exists.
884.5 *2*	20.3 *1*	4351.4	21/2$^{(+)}$	3466.9	21/2$^+$	(D+Q)	−0.22 *18*	A_2=+0.29 *7*, A_4=−0.03 *5* (1979Fi06). Other: 1976Ba50. I_γ: uncertainty much lower than that for strongest lines; evaluator suspects that it May be an order of magnitude too low.
919.0 *2*	20.4 *1*	5270.4	(23/2$^+$)	4351.4	21/2$^{(+)}$	D+Q	−0.22 *8*	A_2=−0.56 *9*, A_4=+0.17 *7* (1979Fi06). Other: 1976Ba50. I_γ: uncertainty much lower than that for strongest lines; evaluator suspects that it May be an order of magnitude too low.
[x]935.4[&] *7*								I_γ: placed by 1974Be36 from 2119 level, but γ absent in 1976Ba50 and 1979Fi06; also, Iγ(935):Iγ(2118)=19.0 *19*:17.0 *17* (1974Be36) is inconsistent with adopted branching from that level.
1014.0[&] *7*		2324.1	(5/2$^-$)	1310.1	3/2$^-$			
1082.4[a] *2*	3	1184.4	5/2$^-$	102.0	1/2$^-$	E2[@]	[@]	A_2=+0.23 *3*, A_4=−0.03 *3* (1976Ba50). Other: 1974Be36. Mult.: Q from $\gamma(\theta)$, not M2 from RUL.
1208.1[a] *3*		1310.1	3/2$^-$	102.0	1/2$^-$			
1267.9[&f] *7*		2578.0?	(5/2$^+$)	1310.1	3/2$^-$			
1507.6[a] *2*		1609.6	3/2$^-$	102.0	1/2$^-$			
1580.6[a] *1*		1580.61	7/2$^+$	0	9/2$^+$	M1+E2	+0.24 *+10−9*	A_2=−0.38 *6*, A_4=+0.03 *5* (1976Ba50). Other: 1974Be36. Mult.: D+Q from $\gamma(\theta)$, not E1+M2 from RUL.
1636.7[a] *1*		1636.72	9/2$^+$	0	9/2$^+$	(M1+E2)[@]	−0.53[@] *+12−16*	A_2=−0.10 *6*, A_4=−0.06 *6* (1976Ba50). Other: 1974Be36. Mult.: (D+Q) from $\gamma(\theta)$, not E1+M2 from RUL.
1790.4 *3*	42.0 *2*	1790.44	9/2$^-$	0	9/2$^+$	(D+Q)	<0.25	Other Eγ: 1790.3 *1* (1973BeYD). A_2=+0.28 *2*, A_4=+0.02 *3* (1976Ba50). Others: 1974Be36, 1979Fi06.
1963.0[a] *4*		1963.0	(5/2$^+$)	0	9/2$^+$			
1983.9 *2*	78.8 *9*	1983.95	13/2$^-$	0	9/2$^+$	(M2)		A_2=+0.15 *4*, A_4=−0.03 *3* (1979Fi06). Others: 1974Be36, 1976Ba50. Mult.: Q from $\gamma(\theta)$, $\Delta\pi$=yes from level scheme.
2063.0 *2*	46.9 *7*	4097.1	19/2	2034.2	17/2$^-$	D(+Q)	<0.9	A_2=−0.18 *4*, A_4=0.00 *3* (1979Fi06). Other: 1974Be36.
[x]2117.5[&] *7*								Placed by 1974Be36 from 2119 level, but Eγ inconsistent with adopted value; also, Iγ(328):Iγ(2120)=3:10 (1976Ba50) is inconsistent with adopted branching from that level.
2170[b]		2170	(11/2)	0	9/2$^+$	D		A_2=+0.23 *4*, A_4=+0.10 *5* (1976Ba50). Mult.: from $\gamma(\theta)$ in 1976Ba50.

$^{91}_{41}Nb_{50}$-4

^{89}Y(α,2nγ), ^{93}Nb(α,α'2nγ) 1979Fi06,1975Sc30,1974Be36 (continued)

γ(^{91}Nb) (continued)

E_γ [†]	I_γ [‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	Comments
2290.8 *2*	100	2290.85	$13/2^+$	0	$9/2^+$	E2	A_2=+0.29 *4*, A_4=−0.03 *2* (1979Fi06). Others: 1974Be36, 1976Ba50. Mult.: Q from $\gamma(\theta)$, not M2 from RUL.
2316 [b]	6.3	4351.4	$21/2^{(+)}$	2034.2	$17/2^-$		Iγ from I(2316γ):(I(885γ)+I(254γ))=4:25 in 1976Ba50. Placement from 1976Ba50.
2329.6 [a] *5*		2329.6	$(11/2^+)$	0	$9/2^+$	Q(+D)	A_2=−0.09 *3*, A_4=+0.23 *5* (1976Ba50). Mult.: from 1976Ba50.
2414.4 [&] *7*	8.7	2413.8	$11/2^-$	0	$9/2^+$	D	I_γ: calculated from I(429γ):I(2414γ)=15.0 *15*:26.0 *26* (1974Be36) and I(429γ). Other I(429γ):I(2414γ)=11:15 (1976Ba50). Mult.: from $\gamma(\theta)$ in 1976Ba50. A_2=−0.18 *5*, A_4=−0.04 *6* (1976Ba50). Other: 1974Be36.
2531.2 [&] [f] *7*		2531.2?	$(11/2^-)$	0	$9/2^+$		

[†] From 1979Fi06, except as noted. Values taken from fig. 3 of 1979Fi06 are of unknown precision.
[‡] Relative intensity at 35.7 MeV (1979Fi06), except as noted. Data given without uncertainty are from fig. 3 of 1979Fi06.
[#] From $\gamma(\theta)$ (1979Fi06), if not indicated otherwise.
[@] Based on $\gamma(\theta)$ from 1974Be36.
[&] From 1974Be36.
[a] From 1973BeYD.
[b] Observed only by 1976Ba50.
[c] 180.0 *5* in table 1 of 1979Fi06, but 185.0 in figs. 1 and 3; the latter value is in accord with datum from (^{6}Li,3nγ).
[d] 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.
[e] Multiply placed with intensity suitably divided.
[f] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

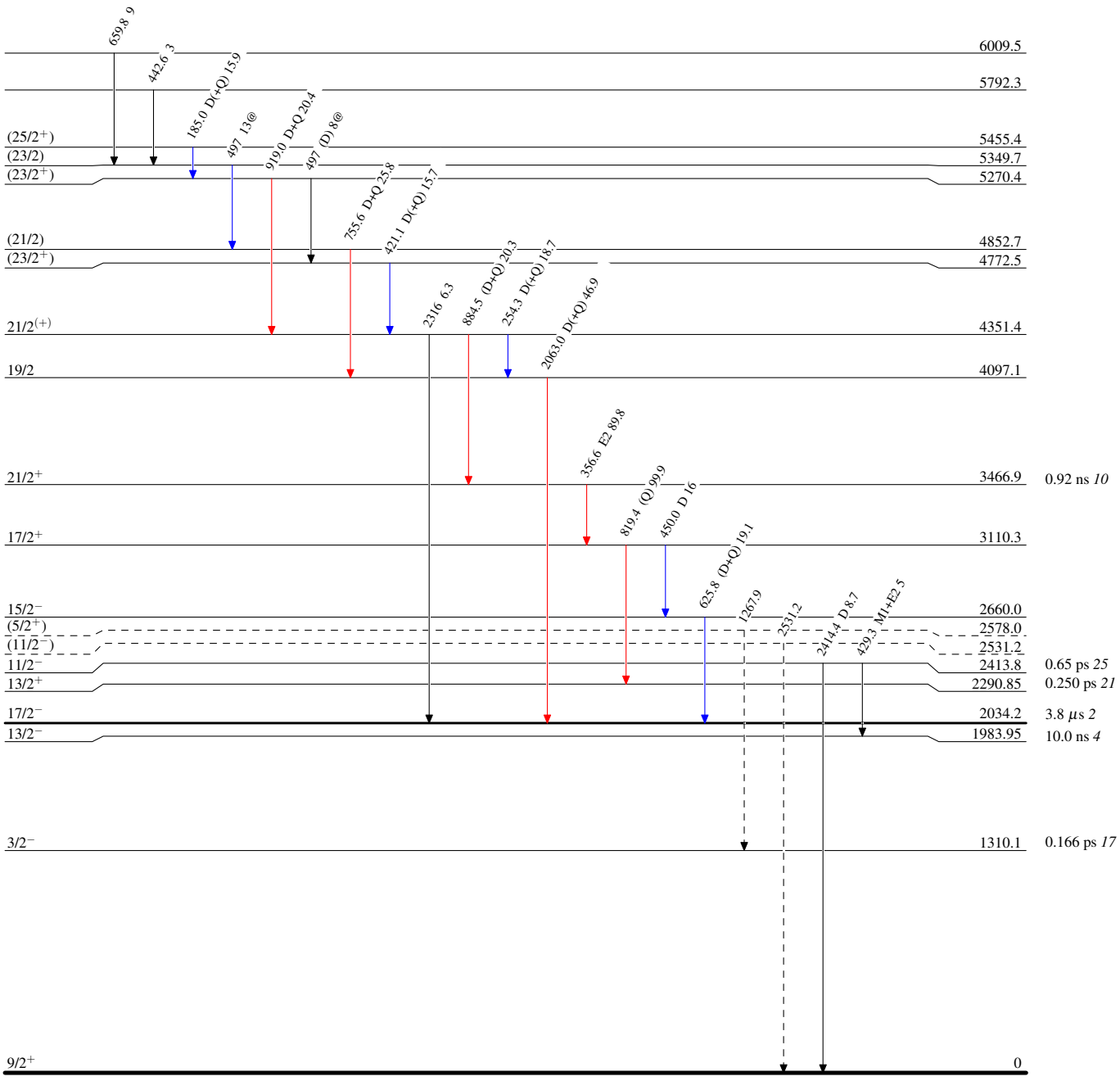
$^{91}_{41}Nb_{50}$-5

^{89}Y(α,2nγ), ^{93}Nb(α,α'2nγ) 1979Fi06,1975Sc30,1974Be36

Level Scheme

Intensities: Relative Iγ from (α,2nγ) At 35.7 MeV
@ Multiply placed: intensity suitably divided

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)

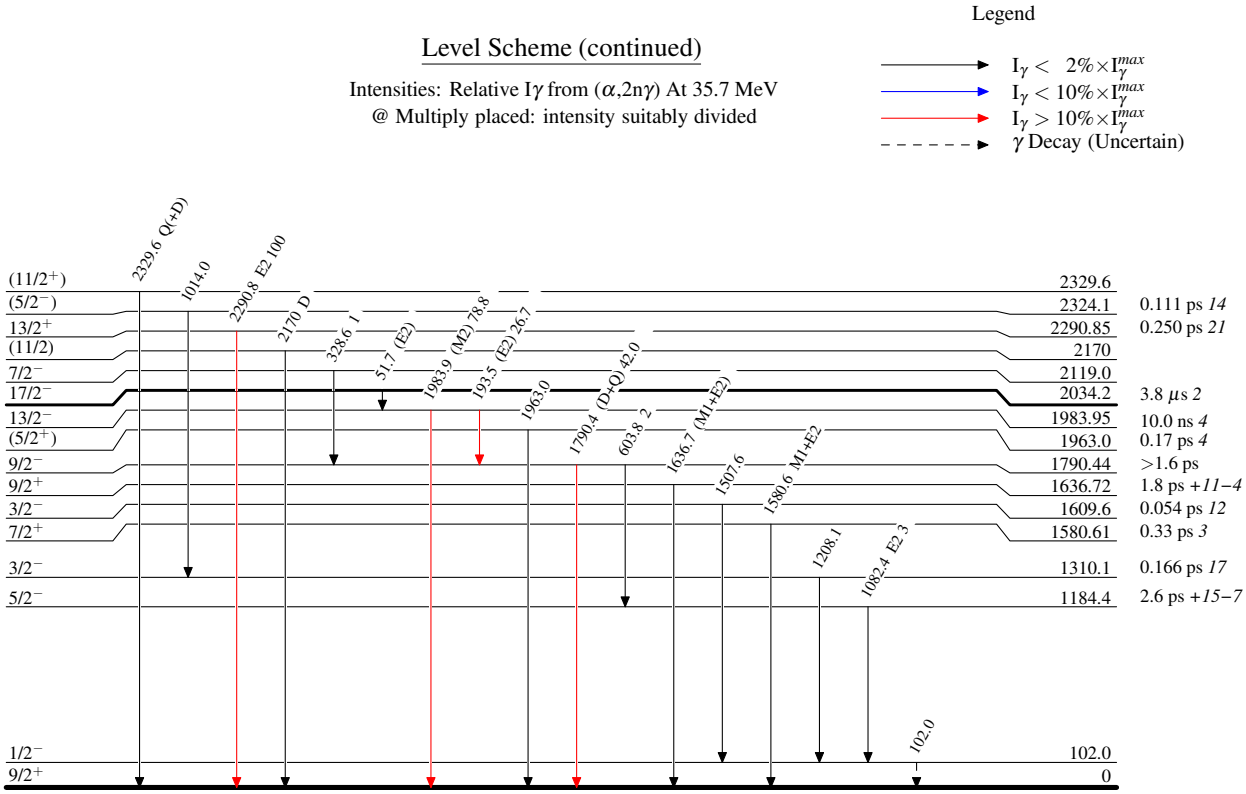


$^{91}_{41}Nb_{50}$

^{89}Y(α,2nγ), ^{93}Nb(α,α'2nγ) 1979Fi06,1975Sc30,1974Be36

Level Scheme (continued)

Intensities: Relative Iγ from (α,2nγ) At 35.7 MeV
@ Multiply placed: intensity suitably divided



$^{91}_{41}Nb_{50}$