^{87}Rb(α,2nγ) 1992Fu04,1988Ba32

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

1992Fu04: E=27 MeV. Measured Eγ, Iγ, $\gamma\gamma$, $\gamma(\theta)$, γ(lin pol), γ(t), excitation functions (Eα=16-27 MeV), DSA. Comparisons with shell-model calculations.

1988Ba32: E=28 MeV. Measured Eγ, Iγ, $\gamma\gamma$, $\gamma\gamma$(t), $\gamma(\theta)$, excitation function (Eα=24-34 MeV). Comparisons with semi-empirical shell-model and particle-core weak coupling description.

1979Fi05: E=35.9 MeV. Measured γ, $\gamma\gamma$, $\gamma(\theta)$. Singles γ data at Eα=24.3 MeV also.

1978Da13: E=35 MeV. Measured Eγ, Iγ, $\gamma\gamma$, $\gamma(\theta)$, excitation functions (30-55 MeV).

^{89}Y Levels

A level at 4404 (1978Da13) with proposed deexciting 1061.5 and 1509.6 gammas has been omitted here due to lack of confirmation of any of these γ rays in other studies.

Other discarded levels are: 4793, 4889, 5581, 6051 and 6516 (from 1978Da13); 5156, 6497, 6596 (also from 1988Ba32), 6602 and 7032 (from 1979Fi05). Transitions connected with these levels have been reassigned (1988Ba32,1992Fu04) from other levels.

See also 1988Ba32 for alternative shell-model configurations, based on proton excitations only, for some of the levels.

E(level)	J^{π} †	$T_{1/2}$ ‡	Comments
0.0	$1/2^-$		Configuration=$\pi p_{1/2}$ (90%) (1992Fu04).
909.1 *1*	$9/2^+$	15.663 s *5*	$T_{1/2}$: from Adopted Levels. Configuration=$\pi g_{9/2}$ (92%) (1992Fu04).
1507.2 *2*	$3/2^-$		Configuration=$\pi p_{3/2}^{-1}$ (90%) (1992Fu04).
1744.9 *3*	$5/2^-$	0.62 ps *14*	Configuration=$\pi f_{5/2}^{-1}$ (80%) (1992Fu04).
2222.4# *3*	$5/2^+$	0.97 ps *28*	
2529.9# *4*	$7/2^+$		
2566.7# *2*	$11/2^+$	0.35 ps *7*	
2622.2# *4*	$9/2^+$	0.21 ps *10*	
2893.3# *2*	$13/2^+$	0.18 ps *3*	
3107.1? *3*	$(5/2)^-$		From 1978Da13 only. Population of this level in (α,2nγ) is considered (evaluator) uncertain since 3107γ with Iγ=25 (1978Da13) should have been detected in other studies, either as a double escape or as a full energy peak.
3343.8@ *2*	$13/2^-$	0.42 ps *14*	
4132.4@ *2*	$15/2^-$	1.59 ps *28*	
4254.6 *3*	$(15/2^+)$	1.4 ps *7*	Configuration=$\pi(f_{5/2}^{-1},g_{9/2},p_{1/2})$ (75%) (1992Fu04).
4450.0& *2*	$17/2^-$	4.5 ps *10*	
4825.5 *2*	$17/2^+$	≥3.5 ps	Complex configuration including $\pi(g_{9/2})\otimes\nu(g_{9/2}^{-1},d_{5/2})$ (1992Fu04).
4838.8& *2*	$19/2^-$	21 ps *8*	
4920.6a *2*	$(19/2^+)$	0.55 ns *28*	$T_{1/2}$: γ(t) (1992Fu04).
5264.2a *2*	$(21/2^+)$	1.46 ps *28*	Additional information 1.
5310.1& *2*	$(21/2^-)$	4.5 ps *9*	Additional information 2.
5412.3 *4*	$(19/2^-)$	1.25 ps *28*	
5879.5a *3*	$(19/2^+)$	0.14 ps *10*	
6159.2? *4*			
6199.3a *3*	$(23/2^+)$	0.19 ps *4*	
6674.8 *3*	$(23/2^+)$	≤0.7 ps	
7184.1 *3*	$(25/2^+)$	0.21 ps *7*	Configuration=$\pi(f_{5/2}^{-2},g_{9/2}^{3})$ (65%) (1992Fu04).
7194.3 *4*	$(23/2^+)$	0.35 ps *14*	
7259.9b *3*	$(23/2^+)$		
7432.0b *3*	$(25/2^+)$	0.49 ps *14*	
7590.3 *4*	$(25/2^+)$	0.35 ps *14*	

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^{87}Rb(α,2nγ) 1992Fu04,1988Ba32 (continued)

^{89}Y Levels (continued)

E(level)	J$^{\pi}$[†]	T$_{1/2}$[‡]
7835.0[b] *3*	(27/2$^+$)	1.25 ps *28*
8264.6[b] *4*	(29/2$^+$)	0.97 ps *21*
8720.8[b] *4*	(31/2$^+$)	0.48 ps *14*

† From Adopted Levels.

‡ From DSA (1992Fu04), unless otherwise stated. 1988Ba32 quote T$_{1/2}$<2 ns for all observed states. A long-lived isomer with T$_{1/2}$>100 ns is suggested by 1988Ba32 on the basis of γ(t) data but no such isomer was confirmed in γ(t) (r.f.) work of 1992Fu04.

Member of $\pi g_{9/2}\otimes(^{88}Sr,2^+)$ configuration. Dominant configuration=$\pi p_{3/2}^{-1}\otimes\pi p_{1/2}\otimes\pi g_{9/2}$ (1992Fu04).

@ Member of $\pi g_{9/2}\otimes(^{88}Sr,3^-)$ configuration (1992Fu04).

& Member of a complex including configuration= $\pi f_{5/2}^{-1}\otimes\nu(g_{9/2}^{-1},d_{5/2})$ (1992Fu04).

a Member of $\pi g_{9/2}\otimes\nu(g_{9/2}^{-1},d_{5/2})$ configuration (1992Fu04).

b Member of $\pi(g_{9/2},f_{5/2}^{-2})\otimes\nu(g_{9/2}^{-1},d_{5/2})$ configuration (1992Fu04).

$\gamma(^{89}Y)$

A$_2$, A$_4$ and POL are from 1992Fu04, unless otherwise indicated.

γ-ray intensities at other energies			
Eγ ±0.3 (1988Ba32)	Iγ E=28 MeV (1988Ba32)	Iγ E=35.9 MeV (1979Fi05)	Iγ E=35 MeV (1978Da13)
95.0	4.8 10	5.8 2	4.0 6
317.6	9.5 6	10.4 1	7.8 8
343.6	17.6	18.5 1	14.2 14
388.9	7.6 6	9.5 1	3.5 7
396.3	3.1 6	4.0 5	
402.8	2.9 5	7.2 4	
429.5	1.3 5	2.0 5	
450.2	1.1 4		
456.0	1.0 5		
470.5	a		
		24.9 1 b	16.0 16 b
470.8 c	a		
570.4	1.8 6		
616.0	1.4 6		
693.1	10.5	10.3 10	5.0 7
706.5	5.1	5.1 10	
715.0	<0.5		
757.2	1.3 4		
776.8	33.5 1	35.9 1	31.2 30
788.5	11.3 6	14.2 10	10.0 15
859.7	1.8 5		
895.0	1.2 4		
909.2	100.0	100.0	100 5
935.1	7.2 7	11.5 10	10 2
1061.5 d			<2
1106.1	14.5 7	20.8 2	16.3 16
1232.6	3.3 20	3.8 5	
1238.7	22.7 9	24.0 2	
1313.0	0.9 5		
1360.3	3.0 4		

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1410.5      4.5 9      1.4 10
1507.0      4.1 5                 8 2
1509.6 d                          3 1
1620.8      1.4 3                 1.6 6
1657.7     36.2 16    36.0 10    37 4
1713.0      0.8 4
1745.0      2.0 4
1931.8      1.1 4
1984.3     23.0 13    34.8 3     29.7 30
3107.0 d                          25 4

a: Iγ not given by 1988Ba32
b: for 470.5+470.8
c: 471.8 in table I (1988Ba32) seems a misprint
d: from 1978Da13 only
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E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	α[c]	Comments
95.1 *1*	5.0 *2*	4920.6	(19/2$^+$)	4825.5	17/2$^+$	(M1+E2)[a]	−0.05 *3*		δ: from 1988Ba32. δ=−0.07 *2* (1979Fi05). A_2=−0.25 *3*, A_4=+0.05 *5*. Additional information 14.
172.1[&] *1*	0.41 *5*	7432.0	(25/2$^+$)	7259.9	(23/2$^+$)	(M1)[a]		0.0417	α(K)=0.0367 *6*; α(L)=0.00417 *6*; α(M)=0.000714 *10*; α(N+..)=0.0001023 *15* α(N)=9.58×10^{-5} *14*; α(O)=6.58×10^{-6} *10* A_2=−0.29 *6*, A_4=+0.19 *10*.
244.6[&] *1*	0.31 *4*	7835.0	(27/2$^+$)	7590.3	(25/2$^+$)	(M1)[a]		0.0167	α(K)=0.01473 *21*; α(L)=0.001657 *24*; α(M)=0.000283 *4*; α(N+..)=4.07×10^{-5} *6* α(N)=3.81×10^{-5} *6*; α(O)=2.63×10^{-6} *4* A_2=−0.28 *18*, A_4=−0.06 *26*.
317.6 *1*	10.3 *3*	4450.0	17/2$^-$	4132.4	15/2$^-$	M1(+E2)	−0.05 *8*		δ: from 1988Ba32. δ=−0.09 *3* (1979Fi05). A_2=−0.27 *3*, A_4=+0.07 *6*, POL=−0.18 *5*. Additional information 9.
326.5[&] *5*	≈0.5	2893.3	13/2$^+$	2566.7	11/2$^+$				
343.6 *1*	16.8 *3*	5264.2	(21/2$^+$)	4920.6	(19/2$^+$)	M1(+E2)	−0.05 *5*		δ: −0.05 *11* (1988Ba32), −0.18 *6* (1979Fi05). A_2=−0.35 *3*, A_4=0.00 *5*, POL=−0.23 *5*. Additional information 16.
388.9 *1*	8.5 *2*	4838.8	19/2$^-$	4450.0	17/2$^-$	M1+E2	+0.20 *5*		δ: +0.23 *9* (1988Ba32). A_2=+0.04 *2*, A_4=−0.02 *3*, POL=−0.47 *7*. Additional information 12.
396.0 *2*	0.48 *3*	7590.3	(25/2$^+$)	7194.3	(23/2$^+$)	(M1)[a]			δ(Q/D)=−0.17 *7* (1979Fi05). A_2=−0.35 *6*. Additional information 21.
402.9 *2*	≈1.2	7835.0	(27/2$^+$)	7432.0	(25/2$^+$)	M1			I_γ: contaminated by 402.7γ

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^{87}Rb(α,2nγ) 1992Fu04,1988Ba32 (continued)

$\gamma(^{89}Y)$ (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	Comments
								(mult=M1) from ^{87}Rb. Total Iγ=3.2 *3*. δ(Q/D)=+0.09 *20* (1988Ba32), <+0.08 (1979Fi05). For composite line: A_2=−0.19 *2*, A_4=+0.02 *4*, POL=−0.24 *12*. Additional information 22.
425.6[&] *3*	0.26 *4*	5264.2	(21/2$^+$)	4838.8	19/2$^-$	[a]		A_2=−0.35 *17*.
429.6 *1*	1.0 *1*	8264.6	(29/2$^+$)	7835.0	(27/2$^+$)	M1+E2	−0.07 *4*	δ: +0.10 *20* (1988Ba32), −0.35 *10* (1979Fi05). A_2=−0.42 *6*, A_4=+0.14 *10*, POL=−0.25 *25*. Additional information 23.
450.5 *1*	2.0 *2*	3343.8	13/2$^-$	2893.3	13/2$^+$	E1		Iγ: Iγ(450.5)/Iγ(777.0)=0.062 *6* (1992Fu04), 0.033 *12* (1988Ba32). δ(Q/D)=−0.15 *10* (1988Ba32). A_2=+0.30 *7*, A_4=−0.08 *9*, POL=−0.44 *17*. Additional information 5.
456.2 *2*	0.44 *7*	8720.8	(31/2$^+$)	8264.6	(29/2$^+$)	(M1)[a]		A_2=−0.44 *10*, A_4=+0.24 *15*.
470.5 *2*	12.6 *10*	4920.6	(19/2$^+$)	4450.0	17/2$^-$	(E1)		A_2=−0.26 *5*, A_4=0.00 *8*, POL=+0.21 *4*. Additional information 15.
471.1 *2*	9.0 *9*	5310.1	(21/2$^-$)	4838.8	19/2$^-$	(M1)[a]		A_2=−0.33 *5*, A_4=+0.18 *10*. Additional information 17.
[x]486.8[&] *3*	≈1.0							A_2=−0.07 *12*. Coin with 317γ, 343γ, 388γ, 471γ, 777γ, 1239γ, 1657γ and 1984γ suggest its placement from a certain level above 5264 (1992Fu04).
[x]499.2[&] *3*	0.64 *5*							A_2=−0.29 *16*. Coin with 343γ, 396γ, 471γ, 777γ, 1657γ and 1984γ suggest its placement from a certain level above 5264 (1992Fu04).
570.6 *3*	≈0.3	4825.5	17/2$^+$	4254.6	(15/2$^+$)			Placement from 1992Fu04. 1988Ba32 suggested it from 5880 level which does not agree with energy difference. Appearance of a 570γ in γγ with gate at 95γ (figure 3 in 1988Ba32) supports placement from 4825 level, not 5880.
615.3 *2*	1.0 *2*	5879.5	(19/2$^+$)	5264.2	(21/2$^+$)	(M1)[a]		A_2=−0.27 *11*, A_4=−0.07 *20*.
650.9[&] *1*	0.53 *7*	7835.0	(27/2$^+$)	7184.1	(25/2$^+$)	D[a]		A_2=−0.43 *14*, A_4=+0.17 *22*.
693.3 *2*	6.8 *5*	4825.5	17/2$^+$	4132.4	15/2$^-$	E1		δ(Q/D)=+0.03 *13* (1988Ba32). A_2=−0.34 *6*, A_4=−0.11 *10*, POL=+0.37 *8*. Additional information 11.
706.3 *1*	3.9 *8*	4838.8	19/2$^-$	4132.4	15/2$^-$	E2		A_2=+0.44 *6*, A_4=−0.02 *9*, POL=+0.51 *22*. Additional information 13.
715.5 *5*	0.31 *6*	2222.4	5/2$^+$	1507.2	3/2$^-$	[a]		A_2=−0.42 *15*, A_4=+0.14 *23*.
757.1 *2*	≈0.5	7432.0	(25/2$^+$)	6674.8	(23/2$^+$)	(D)		Iγ: contaminated by an unidentified isotope. Total Iγ=1.5 *2*. δ(Q/D)=+0.14 *13* (1988Ba32). For composite line A_2=−0.41 *5*, A_4=+0.15 *8*. Additional information 19.
777.0 *1*	32.5 *9*	3343.8	13/2$^-$	2566.7	11/2$^+$	E1		δ(Q/D)=−0.03 *8* (1988Ba32), <+0.05 (1979Fi05). A_2=−0.23 *3*, A_4=+0.05 *5*, POL=+0.35 *4*. Additional information 6.
788.6 *1*	10.0 *3*	4132.4	15/2$^-$	3343.8	13/2$^-$	M1+E2	+0.08 *4*	δ: +0.07 *10* (1988Ba32). A_2=−0.12 *1*, A_4=+0.07 *2*, POL=−0.31 *10*. Additional information 7.

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^{87}Rb(α,2nγ) 1992Fu04,1988Ba32 (continued)

$\gamma(^{89}Y)$ (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	Comments
832.9[&d]	<0.15	8264.6	(29/2$^+$)	7432.0	(25/2$^+$)			
860.1 *1*	0.48 *5*	5310.1	(21/2$^-$)	4450.0	17/2$^-$	(E2)[b]		A_2=+0.24 *16*, A_4=−0.3 *2*.
885.9[&d]	<0.1	8720.8	(31/2$^+$)	7835.0	(27/2$^+$)			
895.0[d] *3*		6159.2?		5264.2	(21/2$^+$)			E_γ,I_γ: γ reported by 1988Ba32 only with Iγ=1.2 *4*.
909.1 *1*	100.0	909.1	9/2$^+$	0.0	1/2$^-$	M4+E5		Mult.: from Adopted Gammas. A_2=A_4=POL=0 (normalized value). $\gamma(\theta)$ data for other transitions normalized to 909γ.
935.1 *1*	5.8 *7*	6199.3	(23/2$^+$)	5264.2	(21/2$^+$)	M1+E2	−0.12 *4*	δ: −0.6 *2* (1979Fi05). A_2=−0.52 *6*, POL=−0.20 *17*. Additional information 18.
962.3[&] *3*	≈1.5	5412.3	(19/2$^-$)	4450.0	17/2$^-$			I_γ: contaminated by 1984γ double escape peak. Total Iγ=3.0 *5*. For composite line A_2=+0.09 *11*.
985[&d] *1*	≈0.5	7184.1	(25/2$^+$)	6199.3	(23/2$^+$)			
994.5[&] *5*	0.9 *2*	7194.3	(23/2$^+$)	6199.3	(23/2$^+$)			A_2=+0.25 *9*.
[x]1061.5[@] *3*								Composite peak, Iγ<2. Tentative placement from a 4404 level (1978Da13).
1106.3 *1*	20.0 *6*	4450.0	17/2$^-$	3343.8	13/2$^-$	E2		A_2=+0.32 *4*, A_4=−0.13 *6*, POL=+0.40 *9*. Additional information 10.
1232.6 *2*	1.2 *1*	7432.0	(25/2$^+$)	6199.3	(23/2$^+$)	(D)		δ(Q/D)=+4.0 *3* (1988Ba32). A_2=−0.32 *6*, A_4=+0.09 *9* (1992Fu04). A_2=+0.36 *20*, A_4=0.0 (1988Ba32). Note disagreement of sign of A_2. Additional information 20.
1239.2 *1*	21.8 *7*	4132.4	15/2$^-$	2893.3	13/2$^+$	E1		δ(Q/D)=−0.10 *16* (1988Ba32), −0.06 *3* (1979Fi05). A_2=−0.27 *3*, A_4=+0.03 *4*, POL=+0.36 *9*. Additional information 8.
1313.2 *3*	1.4 *2*	2222.4	5/2$^+$	909.1	9/2$^+$			A_2=+0.4 *2*.
1360.3[d] *3*		6199.3	(23/2$^+$)	4838.8	19/2$^-$			Eγ and placement from 1988Ba32. See comment on 1361.2γ.
1361.2 *2*	2.3 *2*	4254.6	(15/2$^+$)	2893.3	13/2$^+$			E_γ: from 1992Fu04. Eγ=1360.3 *3* (1988Ba32). A_2=−0.21 *7*, A_4=−0.01 *11* (1992Fu04). A_2=+0.41 *15*, A_4=+0.10 *10* (1988Ba32). Note disagreement of sign of A_2. Placement from 1992Fu04 on the basis of 1361-1984 $\gamma\gamma$, thus suggesting incorrect placement from 6199 level by 1988Ba32. Poor energy agreement and different sign of A_2 in 1988Ba32 may suggest that there are two different γ rays near this energy.
1410.5 *2*	≈2.0	6674.8	(23/2$^+$)	5264.2	(21/2$^+$)			I_γ: contaminated by a line from ^{37}Ar. Total Iγ=3.0 *2*. For composite line A_2=−0.02 *6*, A_4=−0.06 *10*.
1507.2 *2*	≈2.0	1507.2	3/2$^-$	0.0	1/2$^-$			I_γ: contaminated by a line from ^{37}Ar.

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^{87}Rb(α,2nγ) 1992Fu04,1988Ba32 (continued)

$\gamma(^{89}Y)$ (continued)

E_γ [†]	I_γ [‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	δ [#]	Comments
								Total Iγ=4.5 *4*. For doublet: A_2=+0.04 *8*, A_4=−0.15 *22*.
[x] 1509.6 [@] *3*								Composite peak, Iγ=3 *1*. Placement from a 4404 level (1978Da13).
1620.8 *3*	2.1 *5*	2529.9	7/2$^+$	909.1	9/2$^+$	*a*		A_2=−0.12 *15*.
1657.6 *2*	40.0 *12*	2566.7	11/2$^+$	909.1	9/2$^+$	M1+E2	−15 *8*	δ: −14.3 (1988Ba32), −0.08 *3* (1979Fi05). A_2=−0.13 *3*, A_4=+0.10 *5*, POL=+0.25 *10*. Additional information 3.
1713.1 *3*	2.3 *5*	2622.2	9/2$^+$	909.1	9/2$^+$			A_2=+0.14 *19*.
1744.9 *3*	2.2 *5*	1744.9	5/2$^-$	0.0	1/2$^-$	*b*		A_2=+0.38 *16*, A_4=−0.37 *25*.
1920.2 [&] *3*	1.4 *3*	7184.1	(25/2$^+$)	5264.2	(21/2$^+$)			A_2=+0.6 *4*.
1930 [&] *1*	≈0.8	7194.3	(23/2$^+$)	5264.2	(21/2$^+$)			
1931.9 *3*	1.2 *3*	4825.5	17/2$^+$	2893.3	13/2$^+$			A_2=+0.29 *13* A_4=−0.05 *19*.
1984.1 *2*	37.0 *12*	2893.3	13/2$^+$	909.1	9/2$^+$	E2		A_2=+0.29 *3*, A_4=−0.10 *6*, POL=+0.83 *24*. Additional information 4.
1995.6 [&] *4*	0.8 *2*	7259.9	(23/2$^+$)	5264.2	(21/2$^+$)			
3107.0 [@] *3*		3107.1?	(5/2)$^-$	0.0	1/2$^-$			I_γ: 25 *4* (1978Da13).

[†] Weighted averages from 1992Fu04, 1988Ba32 and 1979Fi05. Energies quoted by 1978Da13 are not in good agreement with the other studies.

[‡] From 1992Fu04, corresponding to A0 term in $\gamma(\theta)$ at E(α)=27 MeV. Iγ data at other Eα are available from 1988Ba32 (E=28 MeV), 1979Fi05 (E=35.9, 24.3 MeV), 1978Da13 (E=35 MeV).

[#] From $\gamma(\theta)$ and γ(lin pol) data (1992Fu04).

[@] From 1978Da13 only. It is considered as uncertain (evaluator) since it is not confirmed in any other (α,2nγ) study.

[&] γ reported by 1992Fu04 only.

[a] $\gamma(\theta)$ indicates ΔJ=1, dipole or D+Q. From RUL, D+Q is most likely M1+E2. For low energy transitions (Eγ<500) 1992Fu04 exclude E1 on the basis that implied B(E1)(W.u.) is too large.

[b] $\gamma(\theta)$ indicates ΔJ=2, Q (E2 from RUL).

[c] 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.

[d] Placement of transition in the level scheme is uncertain.

[x] γ ray not placed in level scheme.

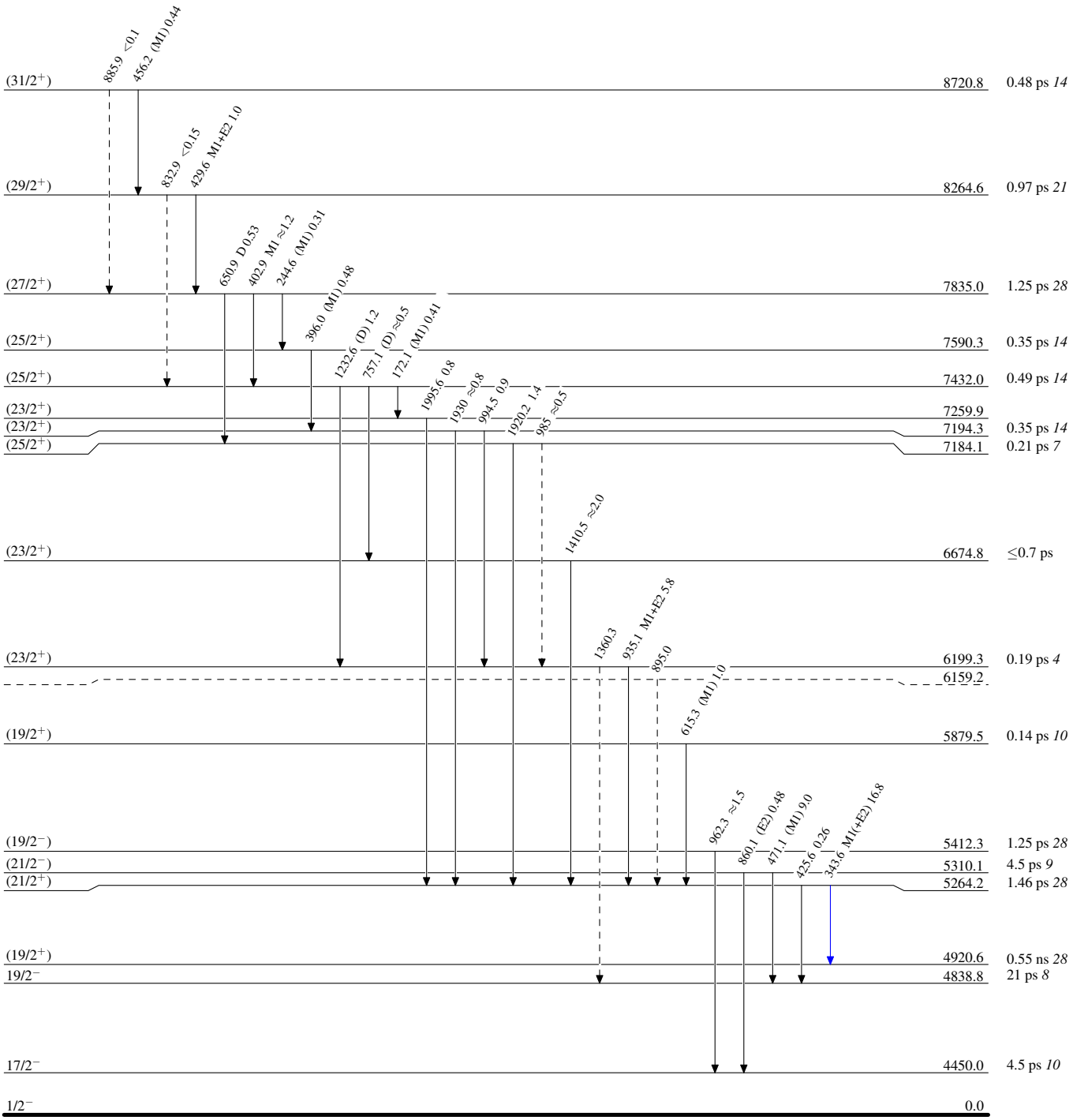
^{87}Rb(α,2nγ) 1992Fu04,1988Ba32

Level Scheme

Intensities: Relative I_γ

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)

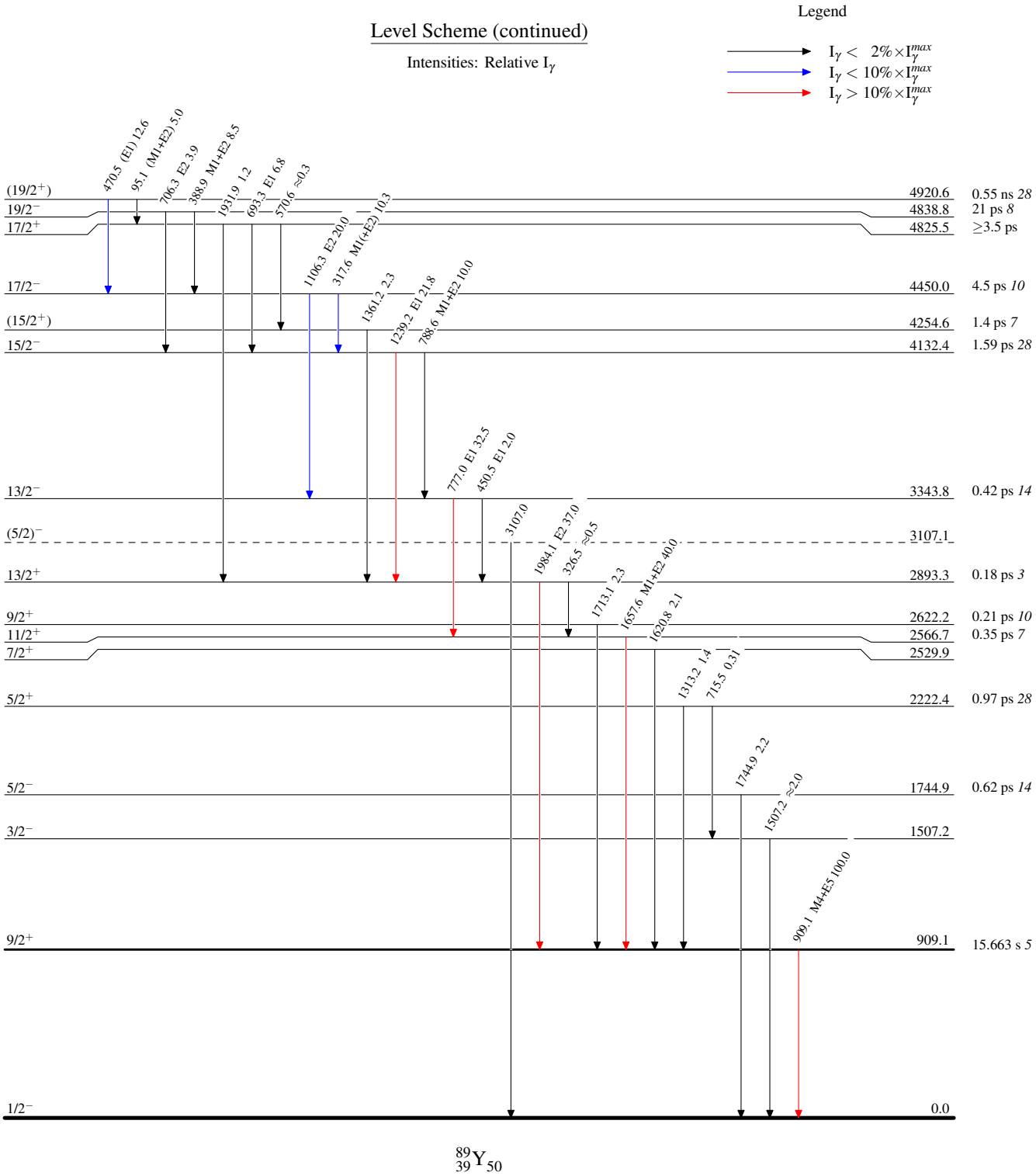


$^{89}_{39}Y_{50}$

^{87}Rb(α,2nγ) 1992Fu04,1988Ba32

Level Scheme (continued)

Intensities: Relative I_γ



$^{89}_{39}Y_{50}$