Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 112,1163 (2011)	15-Dec-2010

Q(β^-)=90.3 *16*; S(n)=6734.4 *5*; S(p)=9595 *10*; Q(α)=−3338.9 *21* 2012Wa38

Note: Current evaluation has used the following Q record 90.8 16 *6734.4 5* 9594 9 −3337.0 *22* 2003Au03,2009AuZZ.

Q(β^-), S(n), S(p), Q(α): from 2009AuZZ (cf. 91.2 *16*, 6734.5 *4*, 9593 *9*, −3332.8 *25*, respectively, from 2003Au03).

Other Reactions:

^{93}Zr(μ^-,nγ) (1971Ba10): observed 267 level to g.s. transition (Eγ=265.7 *6*).

^{93}Zr Levels

See ^{92}Zr(n,γ) E=res dataset for neutron resonance energies and widths.

Cross Reference (XREF) Flags

A	^{92}Zr(α,^{3}He)	E	^{93}Y β^- decay	I	^{162}Dy(^{36}S,Fγ)
B	^{92}Zr(d,p)	F	^{94}Zr(d,t)	J	^{173}Yb(^{24}Mg,Fγ)
C	^{92}Zr(n,γ) E=thermal	G	^{94}Zr(p,d), (pol p,d)	K	^{176}Yb(^{28}Si,Xγ), ^{176}Yb(^{31}P,Xγ)
D	^{92}Zr(n,γ) E=2, 24 keV	H	^{94}Zr(^{3}He,α)	L	^{92}Zr(n,γ) E=res

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$	XREF	Comments
0.0[#]	5/2$^+$	1.61×10^6 y *5*	ABCDEFGHIJK	%β^-=100 J$^\pi$: ΔJ=2, yes shape for β spectrum in ^{93}Y β^- decay to ^{93}Zr (1959Kn38); L(d,p)=2. J$^\pi$(^{93}Y)=1/2$^-$,3/2$^-$ from L(d,^{3}He)=1. Hence, J$^\pi$(^{93}Y)=1/2$^-$, J$^\pi$(^{93}Zr)=5/2$^+$. T$_{1/2}$: weighted average of 1.53×10^6 y 10 (1972FlZM) and 1.64×10^6 y 6 (2010Ca01). Others: 1.13×10^6 y 11 (2010Ya01; reason for discrepancy not known); 1950St90 (1.5-8.5 ×10^6 y).
266.82 *5*	3/2$^+$	1.45 ns *5*	BCDE	XREF: B(272). J$^\pi$: L=2 in (d,p); J=5/2 excluded by 679γ-267γ(θ) in ^{93}Y β^- decay. configuration: ν(3s$_{1/2}$)⊗92ZR(0$^+$) (2005Pa48). T$_{1/2}$: $\beta\gamma$ and $\gamma\gamma$ delayed coin (1968Pr11).
947.09 *8*	1/2$^+$		BCDEF	XREF: B(942). J$^\pi$: L=0 in (d,p).
949.8[#] *6*	(9/2$^+$)		IJK	J$^\pi$: parentheses added by evaluator to J$^\pi$ suggested from (^{28}Si,Xγ), (^{31}P,Xγ). configuration: ν(2d$_{5/2}$)⊗ ^{92}Zr(2$^+$) (2005Pa48).
1018?[&]	1/2$^+$		B	J$^\pi$: L(d,p)=0.
1168.62? *20*	1/2$^+$		B E	J$^\pi$: L(d,p)=0.
1222?[&]	1/2$^+$		B	J$^\pi$: L(d,p)=0.
1425.27 *14*	3/2$^+$,5/2$^+$		ABCDE	XREF: B(1419). J$^\pi$: L(d,p)=2.
1450.42 *8*	(1/2$^+$,3/2,5/2$^+$)		DEf h	J$^\pi$: γ to 5/2$^+$; log *ft*=8.9 from 1/2$^-$; the probable isobaric analog of this state (in ^{93}Nb) has J$^\pi$=3/2$^+$.
1463 *5*	7/2$^+$,9/2$^+$		AB f	J$^\pi$: L=4 in (d,p) and (α,^{3}He).
1470.11 *7*	(1/2$^+$,3/2,5/2$^+$)		DEf h	J$^\pi$: γ to 5/2$^+$; log *ft*=9.3 from 1/2$^-$.
1598 *5*	7/2$^+$,9/2$^+$		AB	J$^\pi$: L=4 in (d,p) and (α,^{3}He).
1642	3/2$^+$,5/2$^+$		B D F	J$^\pi$: L(d,p)=2.
1735?[&]			B	

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Adopted Levels, Gammas (continued)

^{93}Zr Levels (continued)

E(level)†	Jπ‡	XREF	Comments
1909.51 *11*	1/2+	BC EF	XREF: B(1896). Jπ: L(d,p)=0.
1917.9 *6*	(1/2,3/2,5/2+)	CDE	Jπ: γ to 1/2+.
2025 *10*	9/2−,11/2−	AB F	XREF: F(2000). Jπ: L(d,p)=5.
2040 *8*	7/2+,9/2+	H	Jπ: L(^{3}He,α)=4.
2047		D	Fed by primary γ in (n,γ) E=22, 24 keV.
2075		D	Probably differs from the 2078 level because fed by primary γ in (n,γ) E=2 keV.
2078 *6*	7/2+,9/2+	AB F H	Jπ: L=4 in (d,p) and (^{3}He,α).
2094.64 *21*	1/2+	BCDE	Jπ: L(d,p)=0.
2184.58 *7*	(1/2+,3/2)	BC EF	Jπ: log $f^{1u}t$<8.5 from 1/2−; γ to 5/2+.
2276?&		B	
2284.3# *8*	(13/2+)	IJK	XREF: J(1655). E(level): in ^{173}Yb(^{24}Mg,Fγ), 2002Fo03 reported a 1655 *13*/2+ level based on the reverse order of the 705γ-1334γ cascade. In ^{176}Yb(^{28}Si,Xγ), the 1335γ is clearly stronger than the 705γ, so the evaluator adopts the placement that positions the 1335γ below the 705γ. Jπ: (13/2+) and (11/2−) proposed in (^{24}Mg,Fγ) and (^{28}Si,Xγ), respectively; the evaluator favors the former since it avoids the implication of M2 multipolarity for the 706γ from (15/2+,17/2+) 2990 level that would result from the level scheme in (^{28}Si,Xγ).
2302 *10*		B f	XREF: f(2330). Jπ: γ to 3/2+.
2363& *10*	9/2−,11/2−	B f	XREF: f(2330). Jπ: L(d,p)=5. Possibly the same level as that adopted at E=2375 keV.
2374.6@ *8*	(11/2−)	IJK	Jπ,$T_{1/2}$: 1425γ to (9/2+) 950. *Jπ*=(13/2−) suggested in (^{28}Si,Xγ) but *Jπ*=(11/2−) in (^{24}Mg,Fγ). The former implies M2 multipolarity for the 1425γ and, if correct, the 2375 level should consequently exhibit $T_{1/2}$≥0.25 ns based on RUL; the evaluator considers (11/2−) to Be the more likely value. This may Be the 9/2−,11/2− 2363 level seen in (d,p); if so, *Jπ*=(11/2)−.
2391?&	1/2+	B	Jπ: L(d,p)=0.
2457.50 *18*	(1/2+,3/2)	bC E	XREF: b(2464). Jπ: log $f^{1u}t$<8.5 from 1/2−; γ to 5/2+. L(d,p)=2 for 2458 and/or 2474 level(s).
2473.84 *20*		abC EF	XREF: a(2490)b(2464). Jπ: γ to 5/2+. L(d,p)=2 for 2458 and/or 2474 level(s).
2485.7@ *9*	(15/2−)	IJK	
2531.4 *5*	3/2+,5/2+	aBC H	XREF: a(2490)H(2490). Jπ: L(d,p)=2.
2548	3/2+,5/2+	B D	XREF: B(2555). Jπ: L(d,p)=2. E(level): from (n,γ) E=2 keV.
2600.8 *11*		IJK	Jπ: 115γ to (15/2−) 2486.
2638 *10*	7/2+,9/2+	AB	Jπ: L(d,p)=4.
2662 *10*	9/2−,11/2−	aB	XREF: a(2690). Jπ: L(d,p)=5.
2716 *10*	9/2−,11/2−	aB	XREF: a(2690). Jπ: L(d,p)=5.
2770 *10*	(3/2)+	AB	Jπ: L(d,p)=2; possible analog of this state in ^{93}Nb has *Jπ*=3/2+.
2774.3 *8*	(13/2+)	JK	Jπ: value suggested in (^{24}Mg,Fγ); 1824γ to (9/2+) 950.
2873 *10*	9/2−,11/2−	AB	Jπ: L(d,p)=5.
2919& *10*	(3/2+,5/2+)	B	Jπ: L(d,p)=(2).
2989.6# *8*	(15/2+,17/2+)	IJK	Jπ: (15/2+) is proposed in (^{28}Si,Xγ) but (17/2+) in (^{24}Mg,Fγ); see also the comment on the 706γ. 504γ to (15/2−) 2486, 706γ to 2284.

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Adopted Levels, Gammas (continued)

^{93}Zr Levels (continued)

E(level)†	Jπ‡	XREF	Comments
2991 *10*	7/2+,9/2+	AB	Jπ: L(d,p)=4.
3044& *10*	7/2+,9/2+	B	Jπ: L(d,p)=4.
3077?&	1/2+	B	Jπ: L(d,p)=0.
3184& *10*	3/2+,5/2+	B	Jπ: L(d,p)=2.
3215& *10*	1/2−,3/2−	B	Jπ: L(d,p)=1.
3230 *12*	7/2+,9/2+	H	Jπ: L(^{3}He,α)=4.
3264.8 *10*	(17/2+,21/2+)	IJK	275γ to (15/2+,17/2+) 2990. Jπ=(17/2+) proposed in (^{28}Si,Xγ) but (21/2+) in (^{24}Mg.(fragment)γ). If J=21/2, J(2990)=(17/2) is favored.
3274.5 *6*	3/2+,5/2+	BC	Jπ: L(d,p)=2.
3322 *10*	7/2+,9/2+	AB	Jπ: L(d,p)=4.
3330.5 *11*	(19/2+)	IJK	
3363?&	1/2−,3/2−	B	Jπ: L(d,p)=1.
3391& *10*	3/2+,5/2+	B	Jπ: L(d,p)=2.
3421?&	5/2−,7/2−	B	Jπ: L(d,p)=3.
3486?&	1/2−,3/2−	B	Jπ: L(d,p)=1.
3576?&	5/2−,7/2−	B	Jπ: L(d,p)=3.
3604.6 *12*		K	
3649?&	1/2−,3/2−	B	Jπ: L(d,p)=1.
3656.6# *11*	(21/2+)	IJK	
3697& *10*	3/2+,5/2+	B	Jπ: L(d,p)=2.
3791& *10*	(3/2+,5/2+)	B	Jπ: L(d,p)=(2).
3830 *40*	7/2+,9/2+	H	Jπ: L(^{3}He,α)=4.
3870 *10*	9/2−,11/2−	AB	Jπ: L(d,p)=5.
3910& *10*	(3/2+,5/2+)	B	Jπ: L(d,p)=(2).
3966?&	5/2−,7/2−	B	Jπ: L(d,p)=3.
3989& *10*	(3/2+,5/2+)	B	Jπ: L(d,p)=(2).
4035 *10*	7/2+,9/2+	AB	Jπ: L(d,p)=4.
4061?&	5/2−,7/2−	B	Jπ: L(d,p)=3.
4118 *10*	9/2−,11/2−	AB	Jπ: L(d,p)=5.
4141?&	5/2−,7/2−	B	Jπ: L(d,p)=3.
4218?&		B	
4282?&	5/2−,7/2−	B	Jπ: L(d,p)=3.
4419& *10*	5/2−,7/2−	B	Jπ: L(d,p)=3.
4486.4 *13*	(23/2+)	K	
4618?&		B	
4691& *10*	5/2−,7/2−	B	Jπ: L(d,p)=3.
4716.3 *13*	(25/2+)	I K	
4785&	1/2−,3/2−	B	Jπ: L(d,p)=1.
4840?&	5/2−,7/2−	B	Jπ: L(d,p)=3.
4932& *10*		B	
5478.8 *14*		I K	
5487.9 *14*		K	
6646.6 *16*		I K	
7294.1 *17*		JK	XREF: J(4302).

† From least-squares fit to adopted Eγ, except as noted. The evaluator has assumed an uncertainty of 0.6 keV in Eγ data for which the authors did not state an uncertainty; this represents the largest difference between the data from the three different sources for

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Adopted Levels, Gammas (continued)

^{93}Zr Levels (continued)

which specific uncertainties are not known.

‡ Values given without comment are from ^{176}Yb(^{28}Si,Xγ), ^{176}Yb(^{31}P,Xγ); they are tentative values from 2005Pa48 based on previously-known J^{π} for some low-spin states, comparison with theoretical calculations and the assumption that yrast J values increase with excitation energy. Assignments are supported by comparison of corresponding states in neighboring Zr isotopes using a weak-coupling scheme.

Band(A): π=+ ν $2d_{5/2}\otimes$(^{92}Zr or ^{94}Zr). Possible π=+ states resulting from weak coupling of $d_{5/2}$ valence neutron to π=+ states in ^{92}Zr or ^{94}Zr core (2002Fo03).

@ Band(B): π=− ν $2d_{5/2}\otimes$(^{92}Zr or ^{94}Zr). Possible π=− states resulting from weak coupling of $d_{5/2}$ valence neutron to π=− states in ^{92}Zr or ^{94}Zr core (2002Fo03).

& From (d,p).

Adopted Levels, Gammas (continued)

$\gamma(^{93}Zr)$

E_i(level)	J^{π}_i	E_{γ}†	I_{γ}†	E_f	J^{π}_f	Mult.	δ	α@	Comments
266.82	$3/2^+$	266.78 *7*	100	0.0	$5/2^+$	M1+E2	1.2 *+12−5*	0.025 *5*	B(M1)(W.u.)=0.0003 *+4−3*; B(E2)(W.u.)=7 *6* B(M1)(W.u.)=0.00032 *16*; B(E2)(W.u.)=6.6 *23* E_{γ}: from (n,γ) E=thermal. Mult.,δ: from α(K)exp in ^{93}Y β^- decay.
947.09	$1/2^+$	680.2 *1*	31.4 *6*	266.82	$3/2^+$	(M1+E2)		0.00166 *10*	Mult.: D+Q from β^- decay; adopted $\Delta\pi$=no. δ: −3.2 to −4.0 or +0.23 to +0.29 if abs[δ(267γ)]=1.2 (from $\gamma\gamma(\theta)$ in ^{93}Y β^- decay).
		946.86 *24*	100 *5*	0.0	$5/2^+$				E_{γ}: unweighted average of 946.62 *20* from (n,γ) E=thermal and 947.1 *1* from β^- decay.
949.8	$(9/2^+)$	949.8	100	0.0	$5/2^+$				E_{γ}: from $^{173}Yb(^{24}Mg,F\gamma)$.
1168.62?	$1/2^+$	1168.61& *20*	100	0.0	$5/2^+$				
1425.27	$3/2^+,5/2^+$	1158.50 *20*	12.3 *12*	266.82	$3/2^+$				
		1425.21 *19*	100 *3*	0.0	$5/2^+$				E_{γ}: unweighted average of 1425.02 *18* from (n,γ) E=thermal and 1425.4 *1* from β^- decay.
1450.42	$(1/2^+,3/2,5/2^+)$	1183.5 *1*	14.7 *16*	266.82	$3/2^+$				
		1450.5 *1*	100 *4*	0.0	$5/2^+$				
1470.11	$(1/2^+,3/2,5/2^+)$	1203.3 *1*	100 *5*	266.82	$3/2^+$				
		1470.1 *1*	61 *12*	0.0	$5/2^+$				
1909.51	$1/2^+$	962.3 *2*	23 *3*	947.09	$1/2^+$				
		1642.7 *1*	100 *6*	266.82	$3/2^+$				
1917.9	$(1/2,3/2,5/2^+)$	971.0 *8*	29 *10*	947.09	$1/2^+$				
		1650.9 *8*	100 *13*	266.82	$3/2^+$				E_{γ}: unweighted average of 1650.09 *20* from (n,γ) E=thermal and 1651.7 *2* from β^- decay.
2094.64	$1/2^+$	1827.8 *2*	100	266.82	$3/2^+$				
2184.58	$(1/2^+,3/2)$	714.4 *2*	1.12 *15*	1470.11	$(1/2^+,3/2,5/2^+)$				
		1237.4 *1*	1.9 *4*	947.09	$1/2^+$				
		1917.78 *10*	100.0 *19*	266.82	$3/2^+$				E_{γ}: weighted average of 1917.4 *4* from (n,γ) E=thermal and 1917.8 *1* from β^- decay.
		2184.6 *1*	10.1 *4*	0.0	$5/2^+$				
2284.3	$(13/2^+)$	1334.6#	100	949.8	$(9/2^+)$				
2374.6	$(11/2^-)$	1424.7#	100	949.8	$(9/2^+)$				
2457.50	$(1/2^+,3/2)$	273.0 *10*	42 *9*	2184.58	$(1/2^+,3/2)$				

Adopted Levels, Gammas (continued)

$\gamma(^{93}Zr)$ (continued)

E_i(level)	J^{π}_i	E_{γ}†	I_{γ}†	E_f	J^{π}_f	Mult.	Comments
2457.50	(1/2+,3/2)	987.7 3	6.2 13	1470.11	(1/2+,3/2,5/2+)		
		2190.5 3	100 6	266.82	3/2+		E_{γ}: unweighted average of 2190.15 22 from (n,γ) E=thermal and 2190.8 2 from β^- decay.
		2457.3 3	4.0 9	0.0	5/2+		
2473.84		2473.8 2	100	0.0	5/2+		
2485.7	(15/2−)	111.1#	100	2374.6	(11/2−)		
2531.4	3/2+,5/2+	2531.4 5	100	0.0	5/2+		E_{γ}: from (n,γ) E=thermal.
2600.8		115.1#	100	2485.7	(15/2−)		
2774.3	(13/2+)	1824.4#	100	949.8	(9/2+)		
2989.6	(15/2+,17/2+)	215.2#	18.8# 20	2774.3	(13/2+)		Other I(215γ):I(504γ)=20.5 25:100 20 in ^{173}Yb(^{24}Mg,Fγ).
		503.8#	100# 8	2485.7	(15/2−)		
		705.5#	65# 6	2284.3	(13/2+)		M2 multipolarity is implied by a (15/2+) to (11/2−) placement proposed in (^{28}Si,Xγ); if correct, RUL would then imply $T_{1/2}$(2990 level)>3.0 ns. The proposed (17/2+) to (13/2+) placement from (^{24}Mg,Fγ) seems more plausible for this strong branch. Other Iγ: 94 25 from ^{173}Yb(^{24}Mg,Fγ), 75 from ^{162}Dy(^{36}S,Fγ). Note that adopted order of 705γ and 1334γ is the reverse of that proposed in (^{24}Mg,Fγ).
3264.8	(17/2+,21/2+)	275.2#	100	2989.6	(15/2+,17/2+)		
3274.5	3/2+,5/2+	3274.4 6	100	0.0	5/2+		E_{γ}: from (n,γ) E=thermal.
3330.5	(19/2+)	65.6‡	100‡	3264.8	(17/2+,21/2+)	D	Mult.: from intensity balance at 3265 level in ^{173}Yb(^{24}Mg,Fγ).
3604.6		1003.8#	100	2600.8			
3656.6	(21/2+)	326.0#	100# 7	3330.5	(19/2+)		
		391.9#	31.5# 13	3264.8	(17/2+,21/2+)		
4486.4	(23/2+)	829.8#	100	3656.6	(21/2+)		
4716.3	(25/2+)	1059.7#	100	3656.6	(21/2+)		
5478.8		762.5#	100	4716.3	(25/2+)		
5487.9		771.6#	100	4716.3	(25/2+)		
6646.6		1167.8#	100	5478.8			
7294.1		647.5#	100	6646.6			

† From β^- decay, except as noted.
‡ From ^{173}Yb(^{24}Mg,Fγ).
# From ^{176}Yb(^{28}Si,Xγ), ^{176}Yb(^{31}P,Xγ).
@ Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned

$^{93}_{40}Zr_{53}$-6

$\gamma(^{93}Zr)$ (continued)

multipolarities, and mixing ratios, unless otherwise specified.

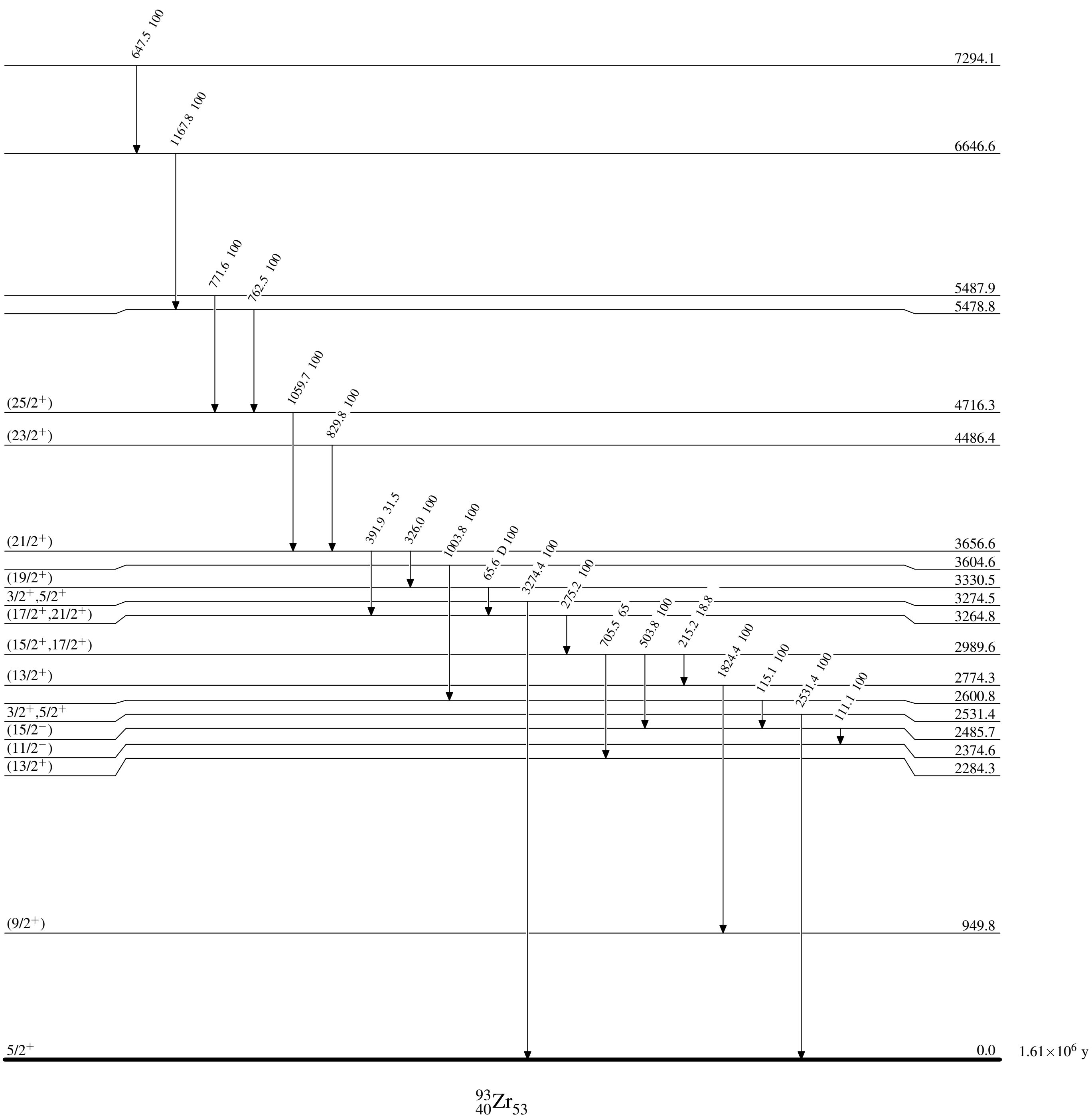
& Placement of transition in the level scheme is uncertain.

$^{93}_{40}Zr_{53}$-7

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



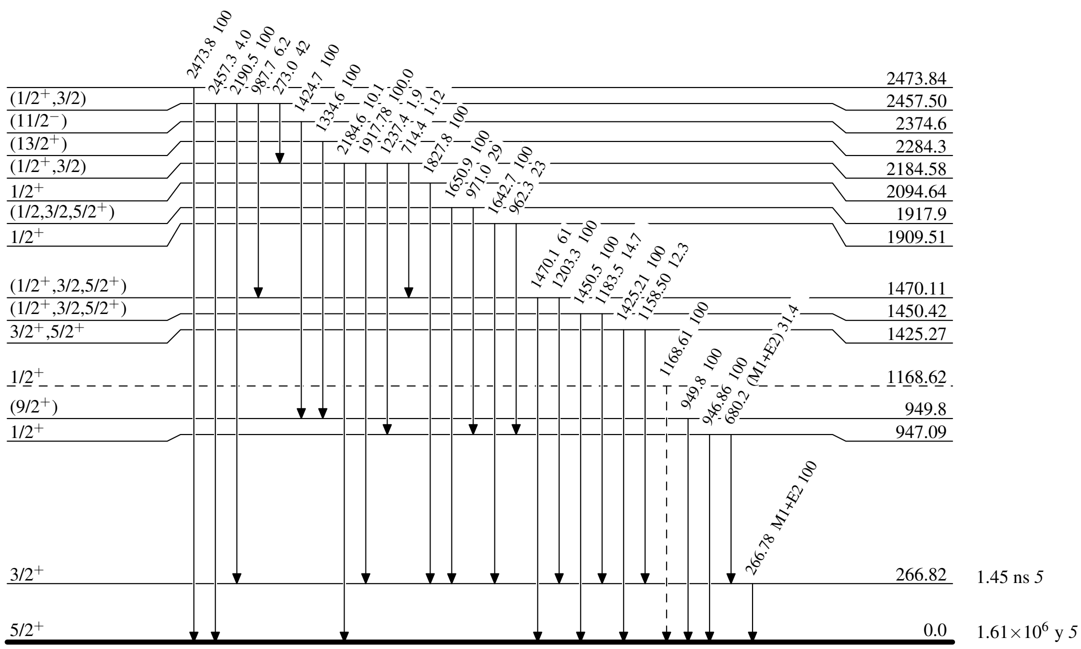
Adopted Levels, Gammas

Legend

Level Scheme (continued)

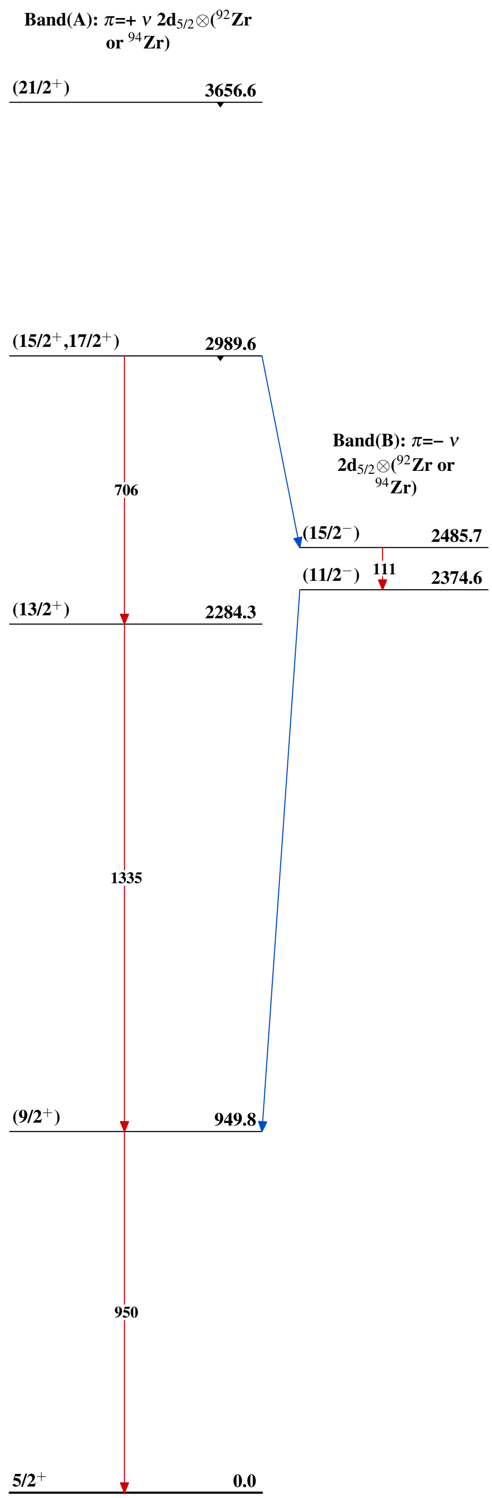
Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{93}_{40}Zr_{53}$

Adopted Levels, Gammas



$^{93}_{40}Zr_{53}$