

Adopted Levels, Gammas

Type	Author	History	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen, Balraj Singh		NDS 164, 1 (2020)	15-Feb-2020

$Q(\beta^-)=2238$ 10; $S(n)=6415$ 8; $S(p)=12454$ 11; $Q(\alpha)=-4866$ 9 [2017Wa10](#)

$S(2n)=11990$ 8, $S(2p)=22940$ 12 ([2017Wa10](#)).

Mass measurements: [2006Ha03](#) (also [2006Jo14](#)), [2004Ri12](#) (also [2005Jo22,2004Jo18](#)).

[Additional information 1](#).

Theory references: consult the NSR database (www.nndc.bnl.gov/nsr/) for 79 primary references, 75 dealing with nuclear structure calculations and 4 with decay modes and half-lives.

 ^{98}Zr LevelsCross Reference (XREF) Flags

A	^{98}Y β^- decay (0.548 s)	E	^{248}Cm SF decay	I	$^{100}\text{Mo}(^{14}\text{C}, ^{16}\text{O}), (^6\text{Li}, ^8\text{B})$
B	^{98}Y β^- decay (2.32 s)	F	^{252}Cf SF decay	J	$^{235}\text{U}(n, \text{F}\gamma), ^{241}\text{Pu}(n, \text{F}\gamma)$
C	^{98}Zr IT decay (1.9 μs)	G	$^9\text{Be}(^{238}\text{U}, \text{F}\gamma)$	K	$^{238}\text{U}(\alpha, \text{F}\gamma)$
D	^{99}Y β^-n decay (1.478 s)	H	$^{96}\text{Zr}(t, p), (t, p\gamma)$	L	Coulomb excitation

E(level) [†]	J ^π [‡]	T _{1/2}	XREF	Comments
0.0 [#]	0 ⁺	30.7 s 4	A B C D E F G H I J K L	$\% \beta^- = 100$ Evaluated rms charge radius=4.401 fm 16 (2013An02). Evaluated $\delta \langle r^2 \rangle (^{90}\text{Zr}, ^{98}\text{Zr}) = +1.002$ fm ² 5 (2013An02). T _{1/2} : from 1976He10 . Others: 1968DeZZ , 1967Hu08 , 1960Or02 . $\langle r^2 \rangle^{1/2} (^{90}\text{Zr}, ^{98}\text{Zr}) = +0.981$ fm ² 5 (2003Th03, 2002Ca37); systematic uncertainty=0.043 fm ² . Also 2005Bi25 from the same group.
854.06 [@] 6	0 ⁺	64 ns 7	A B C D E F G H I J K L	J ^π : E0 transition to 0 ⁺ . T _{1/2} : weighted average of 64 ns 7 from ^{98}Y β^- decay (0.548 s) and 65 ns 10 from (n, Fγ).
1222.91 [#] 5	2 ⁺	2.63 ps 55	A B C D E F G H I J K L	J ^π : E2 368.8γ to 0 ⁺ . T _{1/2} : from RDDS in $^9\text{Be}(^{238}\text{U}, \text{F}\gamma)$ (2018Si26). Others: ≥0.68 ps from B(E2)(W.u.)=8.9 20 or <11 (2018Wi09) deduced from γ-ray yields in Coulomb excitation; <4 ps from fast-timing γγ-coin in $^{235}\text{U}(n, \text{F}\gamma)$, $^{241}\text{Pu}(n, \text{F}\gamma)$, and analysis by generalized centroid difference method (2017An15); <11 ps (2010Be30), <21 ps (1989Ma38), <0.2 ns (1982Ka03), all from βγ(t) in ^{98}Y decay (0.548 s); <0.20 ns (2001AhZY , γγ(t) in ^{252}Cf SF decay).
1436.17 ^{&} 7	0 ⁺	0.72 ns 8	A E F G H J	μ: >+0.38 17 (integral PAC method, preliminary result from 2001AhZY). J ^π : E0 to 0 ⁺ . T _{1/2} : from βγγ(t) or βγ(t) in ^{98}Y β^- decay (0.548 s). Unweighted average of 0.611 ns 33 (2010Be30), 0.865 ns 42 (1989Ma38), 0.69 ns 10 (1982Ka03). Weighted average is 0.71 ns 9, but reduced $\chi^2=11$ is too high.
1590.78 [@] 6	2 ⁺		A B E F G H J K	J ^π : L(t,p)=2.
1744.61 ^{&} 6	2 ⁺		A E F H J	J ^π : L(t,p)=2.
1806.18 ^a 6	3 ⁻		A B C E F G H J K	J ^π : L(t,p)=3.
1843.41 [@] 6	4 ⁺	5.2 ps 10	B C E F G H J K	J ^π : 620.5γ E2 to 2 ⁺ ; 204.3γ from 4 ⁺ ; probable band assignment (1995HaZT). However, γγ(θ) in ^{98}Y β^- decay (2.32 s) suggests J=3. T _{1/2} : from RDDS in $^9\text{Be}(^{238}\text{U}, \text{F}\gamma)$ (2018Si26). Others: 20 ps 6 from βγ(t) in ^{98}Y β^- decay (2.32 s) (2010Be30); ≤10 ps (2017An15 , γγ(t) fast-timing technique, ≤14 ps in $^{241}\text{Pu}(n, \text{F}\gamma)$, and ≤10 ps in $^{235}\text{U}(n, \text{F}\gamma)$); 28 ps 12 (from ^{98}Y decay (2.32 s), quoted by 1994St31 from thesis by M.

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Adopted Levels, Gammas (continued) ^{98}Zr Levels (continued)

E(level) [†]	J ^π [‡]	T _{1/2}	XREF	Comments
1859.37 7	0 ⁺	0.290 ns 13	A H J	Liang, University of Koln (1992)). Note that in 2017An15 , lifetime of this state could not be determined precisely due to imprecise lifetime of the first 2 ⁺ state. J ^π : 636.5γ E2 to 2 ⁺ ; E0 to 0 ⁺ . T _{1/2} : from βγ(t) in ^{98}Y β ⁻ decay (0.548 s). Weighted average of 0.318 ns 27 (2010Be30), 0.283 ns 15 (1989Ma38), and 0.24 ns 10 (1982Ka03).
2047.71 [#] 8 2104 1	4 ⁺		BC EFGH JK H	J ^π : L(t,p)=4. J ^π : 1986Me11 quote 2 ⁺ from decay characteristics; however, no details of γ rays from this level are available.
2225.15 8	(2 ⁺)		A	J ^π : 2225.2γ and 789.0γ to 0 ⁺ ; no β feeding from 0 ⁻ parent.
2276.93 ^{&} 8	(4 ⁺)		B EFG JK	J ^π : γγ(θ) in $^{235}\text{U}(\text{n},\text{F}\gamma)$ (2017Ur03); 686.2γ and 1053.9γ to 2 ⁺ ; possible band member.
2487 1			H	J ^π : 1986Me11 quote 3 ⁺ from decay characteristics; however, no details of γ transitions from this level are available.
2490.98 [@] 6	6 ⁺	1.80 ps 62	BC EFGH JK	J ^π : 647.6γ ΔJ=2, E2 to 4 ⁺ ; band member. T _{1/2} : from RDDS in $^9\text{Be}(^{238}\text{U},\text{F}\gamma)$ (2018Si26). Other: <10 ps from βγ(t) in ^{98}Y β ⁻ decay (2.32 s) (2010Be30).
2568 1			H	J ^π : 1986Me11 quote 4 ⁺ from decay characteristics; however, no details of γ transitions from this level are available.
2613 1			H	J ^π : 1986Me11 quote 2 ⁺ from decay characteristics; however, no details of γ transitions from this level are available.
2778.71 7	(2 ⁺)		A	J ^π : 2779γ to 0 ⁺ , 972.2γ to 3 ⁻ , no β feeding from 0 ⁻ parent.
2800.22 ^a 9	5 ⁻		BC EF H K	J ^π : L(t,p)=5.
3035 8			H	
3064.37 ^b 13	5 ⁽⁻⁾		BC EFGH J	J ^π : ΔJ=2, Q 1258.2γ to 3 ⁻ , 1221.0γ and 1016.7γ to 4 ⁺ .
3065.61 15	(1)		A h	J ^π : 3065.5γ to 0 ⁺ ; possible β feeding from 0 ⁻ parent.
3117.10 ^{&} 11	(6 ⁺)		B EFG K	J ^π : 1273.7γ ΔJ=2, Q to 4 ⁺ ; member of a sequence.
3160 8			H	
3216.35 [@] 12	8 ⁺	1.95 ps 47	BC EFGH JK	XREF: H(3205). J ^π : 725.4γ ΔJ=2, E2 to 6 ⁺ ; spin=8 from γγ(θ) in ^{252}Cf SF decay; band member. T _{1/2} : from DSAM in ^{248}Cm SF decay (2012Sm02).
3249.02 22	(5,6,7 ⁻)		B E	J ^π : 448.8γ to 5 ⁻ ; possible β feeding from (7 ⁺ ,6 ⁺) parent.
3271 8	4 ⁺		H	J ^π : L(t,p)=4.
3336.4 5			EF	
3354 8	5 ⁻		H	J ^π : L(t,p)=5.
3435 8	2 ⁺		H	J ^π : L(t,p)=2.
3506 8			H	
3539 8			H	
3576.26 ^b 12	(7 ⁻)		C EF	J ^π : 776γ to 5 ⁽⁻⁾ ; member of a sequence built on 5 ⁽⁻⁾ .
3592.2 ^a 5	(7 ⁻)		EF	J ^π : 792γ to 5 ⁻ ; member of a sequence.
3739 8			H	
3763 8			H	
3812.1 ^{&} 4	(8 ⁺)		EFG K	J ^π : 1321.6γ to 6 ⁺ ; member of a sequence.
3825 8			H	
3855 8			H	
3894.1 4	(7 ⁻)		EFGH K	XREF: H(3886). J ^π : L(t,p)=(7).
3984.73 [@] 14	(10 ⁺)	1.42 ps 34	C EFG JK	J ^π : 768.4γ to 8 ⁺ ; possible band member. T _{1/2} : from DSAM in ^{248}Cm SF decay (2012Sm02).
4005 8	(5 ⁻ ,6 ⁺)		H	J ^π : L(t,p)=(5,6).
4061 8	(6 ⁺)		H	J ^π : L(t,p)=(6).

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Adopted Levels, Gammas (continued)

^{98}Zr Levels (continued)					
E(level) [†]	J ^π [‡]	T _{1/2}	XREF	Comments	
4097 8	(5 ⁻ ,6 ⁺)		H	J ^π : L(t,p)=(5,6).	
4108.67 13	(1)		A	J ^π : 2672.7γ, 3254.4γ and 4108.5γ to 0 ⁺ ; possible β feeding from 0 ⁻ parent.	
4165.18 6	1 ⁻		A F J	J ^π : log ft=4.3 (allowed transition) from 0 ⁻ ; 2728.9γ to 0 ⁺ ; spin=1 from γγ(θ) in ^{252}Cf SF decay.	
4198.88 ^b 14	(9 ⁻)		C EF	J ^π : 622.6γ to (7 ⁻); member of a sequence built on 5 ⁽⁻⁾ .	
4225 8	6 ⁺		H	J ^π : L(t,p)=6.	
4271.11 6	1 ⁻		A J	J ^π : log ft=5.2 (allowed transition) from 0 ⁻ ; 2411.9γ to 0 ⁺ ; also supported by γγ(θ) in (n,Fγ).	
4278.79 12			B	J ^π : (5,6,7,8 ⁺) from 1787.8γ to 6 ⁺ ; log ft=6.0 from (7 ⁺ ,6 ⁺).	
4292.41 10	6 ⁺		B EF J	J ^π : log ft=4.9 from (7 ⁺ ,6 ⁺); spin=6 from γγ(θ) in (n,Fγ) and ^{98}Y β ⁻ decay (2.32 s).	
4365 8			H		
4387 8			H		
4399.07 12	1 ⁻		A	J ^π : log ft=5.3 (allowed transition) from 0 ⁻ ; 2174.4γ to 0 ⁺ .	
4450 8	(7 ⁻)		H	J ^π : L(t,p)=(7).	
4452.59 9	1 ⁻		A J	J ^π : log ft=4.5 from 0 ⁻ ; 2593γ to 0 ⁺ ; spin=1 from γγ(θ) in (n,Fγ).	
4492.35 15	1 ⁻		A	J ^π : log ft=5.3 from 0 ⁻ ; 4492γ, 3638.6γ to 0 ⁺ .	
4545.81 14	(7 ⁺)		B EF	J ^π : 253.4γ to 6 ⁺ ; possible (weak) β feeding (log ft=6.3) from (7 ⁺ ,6 ⁺) parent.	
4608 8			H		
4754.71 [@] 16	(12 ⁺)		C EF K	J ^π : 770γ to (10 ⁺); band member.	
4916.61 ^b 16	(11 ⁻)		C F	J ^π : 717.7γ to (9 ⁻), member of a sequence.	
5589.29 [@] 17	(14 ⁺)		C F K	J ^π : 834.6γ to (12 ⁺); band member.	
5720.94 ^b 17	(13 ⁻)		C F	J ^π : 804.3γ to (11 ⁻); member of a sequence.	
6538.9 [@] 11	(16 ⁺)		K	E(level): see comment for 6541 level for the two levels being separate. J ^π : γ to (14 ⁺), band member.	
6541.37 ^b 17	(15 ⁻)		C F	E(level): 2006Si36 suggest that 6541 level is most likely different from a (16 ⁺) level at 6539 decaying by a 949.6γ proposed by 2004Wu08 , as no 820γ was reported in 2004Wu08 .	
6601.9 11	(17 ⁻)	1.9 μs 2	C	J ^π : γs to (14 ⁺) and (13 ⁻); member of a sequence. %IT=100	
				J ^π : proposed configuration= $\pi g_{9/2}^2 \otimes \nu(g_{7/2} h_{11/2})$.	
				T _{1/2} : from sum of time spectra gated on 952γ+835γ+820γ+804γ+770γ+768γ+725γ+718γ (2006Si36). Other: 1.4 μs 5 (2013RuZX , from 1223γ(t)).	
7595.9 [@] 15	(18 ⁺)		K	J ^π : 1057γ to (16 ⁺); band member.	
8725.4 [@] 18	(20 ⁺)		K	J ^π : 1229.5γ to (18 ⁺); band member.	

[†] From least-squares fit to E_γ data, assuming 0.5 keV uncertainty when not stated.

[‡] Ascending spins are assumed for levels populated in SF decays due to yrast pattern of excitation of levels in such studies.

Seq.(B): γ cascade based on g.s.

@ Band(A): Band based on 854, 0⁺. The 2⁺ member of this band is either at 1590.8 keV as in [2001Ur01](#) or at 1222.9 keV as in [2006Si36](#). Q(intrinsic)=2.00 10 ([2001Ur01](#)) from lifetime data for 12⁺, 10⁺ and 8⁺ states.

& Seq.(C): γ cascade based on 1436, 0⁺.

^a Seq.(D): γ cascade based on 3⁻. Possible octupole structure.

^b Seq.(E): γ cascade based on (5⁻), 3064.

Adopted Levels, Gammas (continued)

$\gamma(^{98}\text{Zr})$										Comments
$E_i(\text{level})$	J_i^π	$E_\gamma^\dagger$	$I_\gamma^\dagger$	E_f	J_f^π	Mult.	δ	$\alpha^\#$	$I_{(\gamma+ce)}$	
854.06	0 ⁺	854.06 6		0.0	0 ⁺	E0			100	Monopole strength $\rho^2(E0)=0.0112$ 12 (2005Ki02 evaluation), based on data in 1994Lh01. Energy of E0 transition from level energy difference.
1222.91	2 ⁺	368.8 1	2.5 2	854.06	0 ⁺	[E2]		0.0109		Mult.: from ce data in (t,p γ) and ^{98}Y β^- decay (0.548 s). B(E2)(W.u.)=29 +8-6 E γ : other: 370.0 10 in (α ,F γ). I γ : from ^{98}Y β^- decay (0.548 s). Others: 2.1 2 in (α ,F γ), 0.9 3 in ^{248}Cm SF decay.
		1222.9 1	100.0 2	0.0	0 ⁺	E2		0.00044		B(E2)(W.u.)=2.9 +8-5 E γ : others: 1222.7 2 in ^{98}Zr IT decay, 1222.7 10 in (α ,F γ). I γ : deduced from ^{98}Y β^- decay (0.548 s). Uncertainty of 0.2 is from deduced absolute γ -branching ratios to the 854 level and the ground state.
1436.17	0 ⁺	213.2 1	100 4	1222.91	2 ⁺	E2		0.0716		Mult.: $\gamma\gamma(\theta)$ in β^- decay (0.548 s) and ^{235}U (n,F γ), and RUL. B(E2)(W.u.)=58 8 Mult.: $\gamma\gamma(\theta)$ in β^- decay (0.548 s) and ^{235}U (n,F γ), and RUL.
		582.0 $\ddagger$ 2		854.06	0 ⁺	E0 $\ddagger$			6.6 6	Mult.: ce data in (t,p γ) and ^{98}Y β^- decay (0.548 s). Evaluated $q_K^2(E0/E2)=1.05$ 7, X(E0/E2)=0.054 3, $\rho^2=0.076$ 6 (2005Ki02), based on data in 1994Lh01 and 1982Ka03. Monopole strength $\rho=0.274$ 15 (1994Lh01), 0.29 8 (1982Ka03). I(E0)/I(E2)=0.065 4 (1994Lh01).
1590.78	2 ⁺	154.5 367.8 1 736.8 1 1590.9 1	1.9 11.7 8 14.6 8 100 3	1436.17 1222.91 854.06 0.0	0 ⁺ 2 ⁺ 0 ⁺ 0 ⁺	[E2] [M1+E2] [E2] E2		0.228 0.0088 22		Mult.: from $\gamma\gamma(\theta)$ in ^{98}Zr β^- decay (0.548 s), and (n,F γ), and ΔJ^π , where J^π of each level is known independently.
1744.61	2 ⁺	152.7@ 521.6 1	3 79 3	1590.78 1222.91	2 ⁺ 2 ⁺	[M1+E2] M1+E2	+0.44 4	0.15 9 0.00302		Mult., δ : $\gamma\gamma(\theta)$ in ^{235}U (n,F γ), D+Q from $\gamma\gamma(\theta)$, M1+E2 from ΔJ^π , where each J^π is determined uniquely in different experiments. Other δ : +0.2 1 from $\gamma\gamma(\theta)$ in ^{98}Y β^- decay (0.548 s).
1806.18	3 ⁻	890.6 1 1744.5 1 215.5 2	43 3 100 4 6.7 17	854.06 0.0	0 ⁺ 0 ⁺					
1843.41	4 ⁺	583.258 30 252.7 2	100 3 1.7 4	1222.91 1590.78	2 ⁺ 2 ⁺	E1 [E2]		0.0122 0.0392		Mult.: $\gamma(\theta)$ and $\gamma(\text{pol})$ in ^{248}Cm SF decay. B(E2)(W.u.)=54 +18-16

Adopted Levels, Gammas (continued)

$\gamma(^{98}\text{Zr})$ (continued)

<u>E_i(level)</u>	<u>J_i^{π}</u>	<u>E_{γ}^{$\dagger$}</u>	<u>I_{γ}^{$\dagger$}</u>	<u>E_f</u>	<u>J_f^{π}</u>	<u>Mult.</u>	<u>$\alpha^{\#}$</u>	<u>I_($\gamma+ce$)</u>	<u>Comments</u>
1843.41	4 ⁺	620.505 19	100 3	1222.91	2 ⁺	E2	0.00225		I _{γ} : others: 1.4 2 in (α ,F γ), 5.2 17 in ²⁴⁸ Cm SF decay, 4.8 in ²⁵² Cf SF decay. Values in SF decay seem too high by a factor of ≈ 3 . B(E2)(W.u.)=42 +10-7
1859.37	0 ⁺	268.7 1	100 3	1590.78	2 ⁺	E2	0.0316		I _{γ} : other: 100 in (α ,F γ), 100 5 in ²⁴⁸ Cm SF decay. Mult.: $\gamma(\theta)$ and $\gamma(\text{pol})$ in ²⁴⁸ Cm SF decay. B(E2)(W.u.)=42 3
		423.0 $\ddagger$ 2		1436.17	0 ⁺	E0 $\ddagger$		1.5 2	Mult.: $\gamma\gamma(\theta)$ and RUL. Mult.: ce data in (t,p γ) and ⁹⁸ Y β^- decay (0.548 s). Evaluated q _K ² (E0/E2)=5.4 14, X(E0/E2)=26 7, $\rho^2=0.061$ 8 (2005Ki02), based on data in 1994Lh01 and 1982Ka03.
		636.5 1	18.1 9	1222.91	2 ⁺	E2	0.00209		Monopole strength $\rho=0.237$ 25 (1994Lh01), 0.29 15 (1982Ka03). I(E0)/I(E2(269 γ))=0.0130 16 (1994Lh01). B(E2)(W.u.)=0.103 8
2047.71	4 ⁺	204.3 1	14 3	1843.41	4 ⁺	[M1+E2]	0.06 3		Mult.: Q from $\gamma\gamma(\theta)$ in ⁹⁸ Y β^- decay (0.548 s); M2 ruled out by RUL.
		241.5 1	100 8	1806.18	3 ⁻	[E1]	0.00885		I _{γ} : other: 21 7 in ²⁴⁸ Cm SF decay. I γ =67 in ²⁵² Cf SF decay is discrepant.
		456.8 2	11 3	1590.78	2 ⁺	[E2]			E _{γ} : other: 240.1 1 from ⁹⁸ Zr IT decay.
		824.8 2	28 3	1222.91	2 ⁺	E2			I _{γ} : others: 100 14 in ²⁴⁸ Cm SF decay, 100 in ²⁵² Cf SF decay. I _{γ} : other: 21 7 in ²⁴⁸ Cm SF decay. I γ =67 in ²⁵² Cf SF decay is discrepant.
2225.15	(2 ⁺)	789.0 2	45 9	1436.17	0 ⁺				I _{γ} : other: 36 7 in ²⁴⁸ Cm SF decay. I γ =133 in ²⁵² Cf SF decay is discrepant.
		1002.3 1	100 18	1222.91	2 ⁺				Mult.: $\gamma(\theta)$ in ²⁴⁸ Cm SF decay, and ΔJ^{π} .
		2225.2 2	45 18	0.0	0 ⁺				
2276.93	(4 ⁺)	433.5 1	36 7	1843.41	4 ⁺				I _{γ} : from ⁹⁸ Y β^- decay (2.32 s).
		686.2 1	100 7	1590.78	2 ⁺				I _{γ} : 24 in ²⁵² Cf SF decay is discrepant.
2490.98	6 ⁺	1053.9 1	100 7	1222.91	2 ⁺				I _{γ} : from ⁹⁸ Y β^- decay (2.32 s), 414 from ²⁵² Cf SF decay.
		647.580 30	100	1843.41	4 ⁺	E2	0.0020		B(E2)(W.u.)=106 +56-27
									Mult.: $\gamma(\theta)$ and $\gamma(\text{pol})$ in ²⁴⁸ Cm SF decay, also supported by $\gamma\gamma(\theta)$ in ⁹⁸ Y β^- decay (2.32 s).
2778.71	(2 ⁺)	972.2 2	25 4	1806.18	3 ⁻				
		1033.9 3	18 4	1744.61	2 ⁺				
		1187.8 2	14 4	1590.78	2 ⁺				
		1555.7 1	100 11	1222.91	2 ⁺				
		2779.0 2	14 4	0.0	0 ⁺				
2800.22	5 ⁻	752.5 1	100 8	2047.71	4 ⁺				I _{γ} : others: 100 19 in ⁹⁸ Zr IT decay, 100 17 in ²⁴⁸ Cm SF decay, 100 in ²⁵² Cf SF decay.
		956.6 2	13 4	1843.41	4 ⁺				I _{γ} : others: 50 17 in ²⁴⁸ Cm SF decay, 12.5 in ²⁵² Cf SF decay.
		994.0 1	38 8	1806.18	3 ⁻				I _{γ} : others: 50 19 in ⁹⁸ Zr IT decay, 50 17 in ²⁴⁸ Cm SF decay, 63 in ²⁵² Cf SF decay.

Adopted Levels, Gammas (continued)

$\gamma(^{98}\text{Zr})$ (continued)

$E_i(\text{level})$	J_i^π	$E_\gamma^\dagger$	$I_\gamma^\dagger$	E_f	J_f^π	Mult.	$\alpha^\#$	Comments
3064.37	5 ⁽⁻⁾	1016.7 1221.0 5 1258.6 4	50 25 75 25 100 25	2047.71 1843.41 1806.18	4 ⁺ 4 ⁺ 3 ⁻	Q		E_γ, I_γ : from ²⁴⁸ Cm SF. E_γ from IT decay. I_γ from ²⁴⁸ Cm SF. E_γ : unweighted average of 1258.9 1 from ⁹⁸ Y β^- decay (2.32 s) and 1258.2 2 from ⁹⁸ Zr IT decay (1.9 μ s). I_γ : from ²⁴⁸ Cm SF. Mult.: $\gamma\gamma(\theta)$ in IT decay.
3065.61	(1)	3065.5 2	100	0.0	0 ⁺			
3117.10	(6 ⁺)	840.1 1 1273.7 2	100 11 28 11	2276.93 1843.41	(4 ⁺) 4 ⁺	Q		Mult.: $\gamma(\text{DCO})$ in ²⁴⁸ Cm SF decay.
3216.35	8 ⁺	725.4 1	100	2490.98	6 ⁺	E2	0.00148	B(E2)(W.u.)=54 13 E_γ : from IT decay. Other: 725.3 2 in ⁹⁸ Y β^- decay (2.32 s). Mult.: $\gamma\gamma(\theta)$ and $\gamma(\text{pol})$ in ²⁴⁸ Cm SF decay ,also supported by $\gamma\gamma(\theta)$ in ²⁵² Cf SF decay and RUL.
3249.02	(5,6,7 ⁻)	448.8 2	100	2800.22	5 ⁻			
3336.4		846 @ 1493.0	20×10 ¹ 10 100 50	2490.98 1843.41	6 ⁺ 4 ⁺			E_γ, I_γ : from ²⁴⁸ Cm SF. E_γ, I_γ : from ²⁴⁸ Cm SF.
3576.26	(7 ⁻)	511.9 1	70 25	3064.37	5 ⁽⁻⁾			E_γ : from IT decay. I_γ : unweighted average of 111 25 in IT decay, 50 25 in ²⁴⁸ Cm SF decay and 47 in ²⁵² Cf SF decay.
3592.2	(7 ⁻)	776.0 1 792.0	100 21 100	2800.22 2800.22	5 ⁻ 5 ⁻			E_γ, I_γ : from IT decay. Others: I_γ =100 50 in ²⁴⁸ Cm SF and 100 in ²⁵² Cf SF.
3812.1	(8 ⁺)	694.6 10	25	3117.10	(6 ⁺)			E_γ : from ($\alpha, F\gamma$). Others: 694.3 from ²⁴⁸ Cm SF, 694.8 from ²⁵² Cf SF. I_γ : from ²⁵² Cf SF.
3894.1	(7 ⁻)	1321.6 677.7 3	100 100	2490.98 3216.35	6 ⁺ 8 ⁺			E_γ : average of 1321.0 from ²⁴⁸ Cm SF and 1322.2 from ²⁵² Cf SF.
3984.73	(10 ⁺)	768.4 1	100	3216.35	8 ⁺	[E2]	0.00127	B(E2)(W.u.)=55 14 E_γ : from IT decay. Other: 770.0 10 from ($\alpha, F\gamma$).
4108.67	(1)	2672.7 2 3254.4 2 4108.5 2	60 10 100 20 40 10	1436.17 854.06 0.0	0 ⁺ 0 ⁺ 0 ⁺			
4165.18	1 ⁻	1099.5 2 1386.3 1 2305.9 1 2420.6 1 2574.4 1 2728.9 1 2942.3 1 3311.1 1 4164.9 2	2.8 4 11.1 7 16.7 7 26.4 7 22.9 7 7.6 4 100 3 52.4 17 3.8 4	3065.61 (1) 2778.71 (2 ⁺) 1859.37 0 ⁺ 1744.61 2 ⁺ 1590.78 2 ⁺ 1436.17 0 ⁺ 1222.91 2 ⁺ 854.06 0 ⁺ 0.0 0 ⁺	(1) (2 ⁺) 0 ⁺ 2 ⁺ 2 ⁺ 0 ⁺ 2 ⁺ 0 ⁺ 0 ⁺	(E1) (E1)		Mult.: $\gamma\gamma(\theta)$ in ²³⁵ U(n,F γ). Mult.: $\gamma\gamma(\theta)$ in ⁹⁸ Y β^- (0.548 s), ²⁵² Cf SF, and ²³⁵ U(n,F γ).
4198.88	(9 ⁻)	622.6 1	100	3576.26	(7 ⁻)			E_γ : from IT decay.
4271.11	1 ⁻	1492.4 1 2045.9 2	94 6 19 6	2778.71 2225.15	(2 ⁺) (2 ⁺)			

Adopted Levels, Gammas (continued)

$\gamma(^{98}\text{Zr})$ (continued)

$E_i(\text{level})$	J_i^π	$E_\gamma^\dagger$	$I_\gamma^\dagger$	E_f	J_f^π	Mult.	δ	$\alpha^\#$	Comments
4271.11	1 ⁻	2411.9 2	25 6	1859.37	0 ⁺				
		2526.3 1	69 6	1744.61	2 ⁺				
		2680.3 1	100 6	1590.78	2 ⁺	(E1)			Mult.: $\gamma\gamma(\theta)$ in ²³⁵ U(n,F γ).
		2834.4 3	25 6	1436.17	0 ⁺				
		3048.3 1	56 6	1222.91	2 ⁺				
		3416.9 1	63 6	854.06	0 ⁺				
		4271.3 2	31 6	0.0	0 ⁺				
4278.79		1787.8 1	100	2490.98	6 ⁺				
4292.41	6 ⁺	698.6 @	4.4	3592.2	(7 ⁻)				E_γ : from ²⁵² Cf SF decay only.
		1174.9 3	9.2 15	3117.10	(6 ⁺)				
		1492.0 2	11.5 15	2800.22	5 ⁻				
		1801.6 1	100 3	2490.98	6 ⁺	M1+E2	+0.17 8		Mult.: $\gamma\gamma(\theta)$ in ⁹⁸ Y β^- (2.32 s), ²⁵² Cf SF, and ²³⁵ U(n,F γ). δ : from $\gamma\gamma(\theta)$ in ⁹⁸ Y β^- (2.32 s). Other: -0.77 12 from $\gamma\gamma(\theta)$ in (n,F γ).
		2015.4 2	5.4 8	2276.93	(4 ⁺)				
		2244.0 4	1.5 8	2047.71	4 ⁺				
		2448.8 2	3.1 8	1843.41	4 ⁺				
4399.07	1 ⁻	2174.4 2	54 18	2225.15	(2 ⁺)				
		2539.5 2	25 4	1859.37	0 ⁺				
		2962.1 5	7 4	1436.17	0 ⁺				
		3176.0 3	11 4	1222.91	2 ⁺				
		4398.8 2	100 4	0.0	0 ⁺				
4452.59	1 ⁻	2227.3 2	5.9 12	2225.15	(2 ⁺)				
		2593.0 3	2.9 6	1859.37	0 ⁺				
		2707.8 3	3.5 12	1744.61	2 ⁺				
		2861.7 3	2.9 6	1590.78	2 ⁺				
		3016.6 2	4.7 6	1436.17	0 ⁺				
		3229.8 2	35.9 12	1222.91	2 ⁺	E1			Mult.: $\gamma\gamma(\theta)$ in ²³⁵ U(n,F γ).
		3598.4 2	4.7 6	854.06	0 ⁺				
		4452.4 2	100 4	0.0	0 ⁺				
4492.35	1 ⁻	3056.3 3	11 3	1436.17	0 ⁺				
		3638.6 3	11 2	854.06	0 ⁺				
		4492.0 2	100 3	0.0	0 ⁺				
4545.81	(7 ⁺)	253.4 1	100	4292.41	6 ⁺	[M1+E2]		0.028 11	
4754.71	(12 ⁺)	770.0 1	100	3984.73	(10 ⁺)				E_γ : from IT decay.
4916.61	(11 ⁻)	717.7 1	100	4198.88	(9 ⁻)				E_γ : from IT decay.
5589.29	(14 ⁺)	834.6 1	100	4754.71	(12 ⁺)				E_γ : from IT decay.
5720.94	(13 ⁻)	804.3 1	100	4916.61	(11 ⁻)				E_γ : from IT decay.
6538.9	(16 ⁺)	949.6 10		5589.29	(14 ⁺)				E_γ : from (α ,F γ).
6541.37	(15 ⁻)	820.4 1	100 19	5720.94	(13 ⁻)				E_γ, I_γ : from IT decay.
		952.1 1	59 12	5589.29	(14 ⁺)				E_γ, I_γ : from IT decay.
6601.9	(17 ⁻)	63.0 1	100	6541.37	(15 ⁻)	(E2)		5.91 9	$\alpha(K)=4.52$ 7; $\alpha(L)=1.157$ 19; $\alpha(M)=0.204$ 4; $\alpha(N)=0.0260$ 4; $\alpha(O)=0.000682$ 11

Adopted Levels, Gammas (continued)

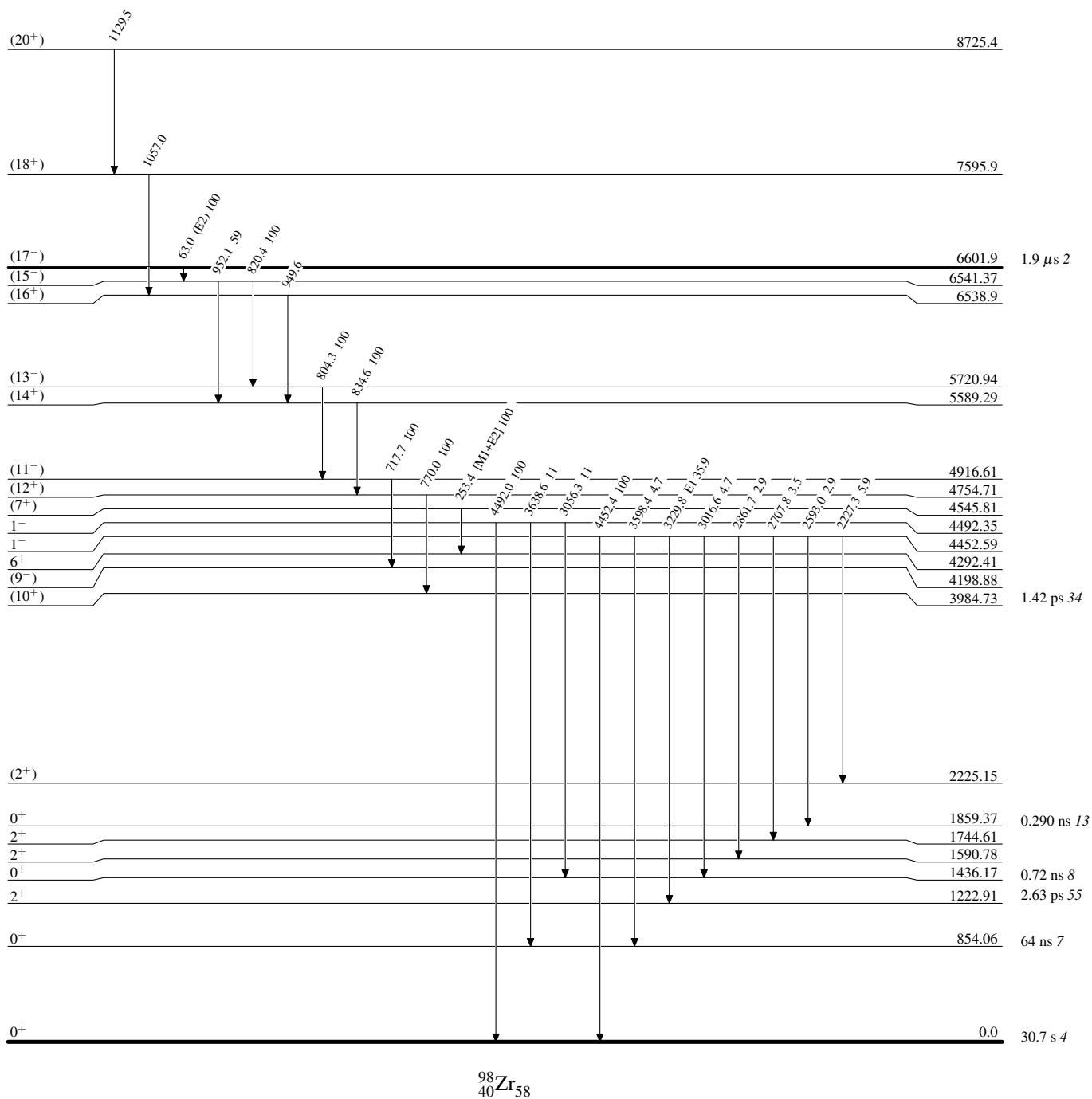
$\gamma(^{98}\text{Zr})$ (continued)

<u>E_i(level)</u>	<u>J^{π}_i</u>	<u>E_{γ}[†]</u>	<u>E_f</u>	<u>J^{π}_f</u>	<u>Comments</u>
					$\alpha(\text{exp})=5.5\ 16$ (2006Si36) B(E2)(W.u.)=1.62 18 E _{γ} : from IT decay. Mult.: from $\alpha(\text{expt})=5.5\ 16$ (2006Si36), deduced from intensity balance. Value is consistent with E2(+M1), $\delta>1.25$ or E2(+M3), $\delta<0.09$. E _{γ} : 2006Si36 discussed another scenario for the placement of 63.0 γ : two closely-spaced 63.0-keV gamma rays, an E1 to 6540, (16 ⁺) level (from 2004Wu08) and E2 to 6541, (15 ⁻) level, however, based on intensity-balance arguments, this scenario was considered unlikely.
7595.9	(18 ⁺)	1057.0 10	6538.9	(16 ⁺)	E _{γ} : from (α ,F γ).
8725.4	(20 ⁺)	1129.5 10	7595.9	(18 ⁺)	E _{γ} : from (α ,F γ).

[†] Most γ -ray data for low-spin ($J\leq 2$) levels are from $^{98}\text{Y}\ \beta^-$ decay (0.548 s), and for high-spin ($J>2$) are from $^{98}\text{Y}\ \beta^-$ decay (2.32 s), based on detailed studies by 2017Ur03, when a level is populated in these decays. Exceptions are noted.
[‡] E0 transitions are from ce data in (t, γ) (1986Me11) and from $^{98}\text{Y}\ \beta^-$ decay (0.548 s) (1994Lh01,1982Ka03).
[#] 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.
[@] Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas**Level Scheme**

Intensities: Relative photon branching from each level



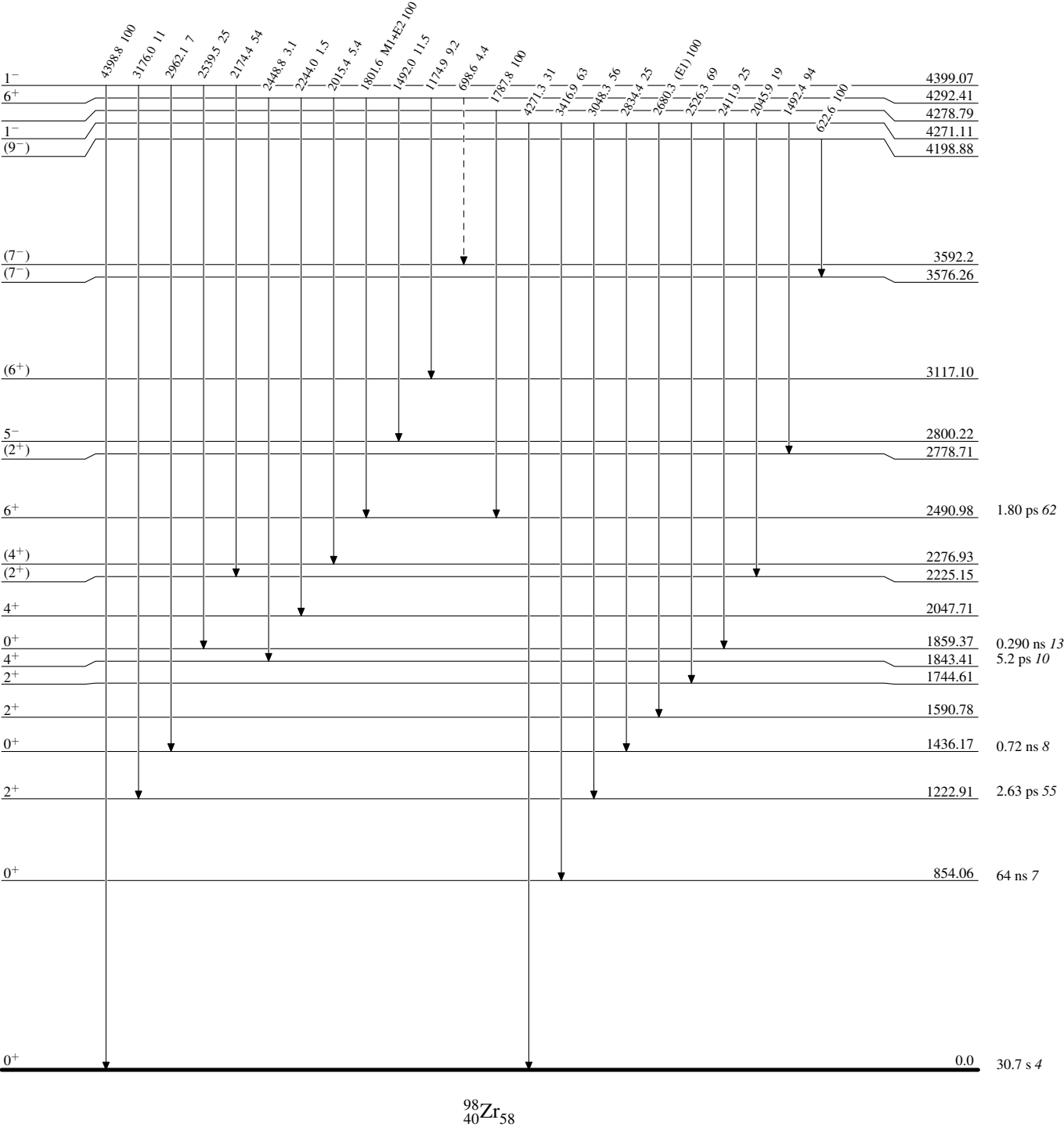
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

-----► γ Decay (Uncertain)

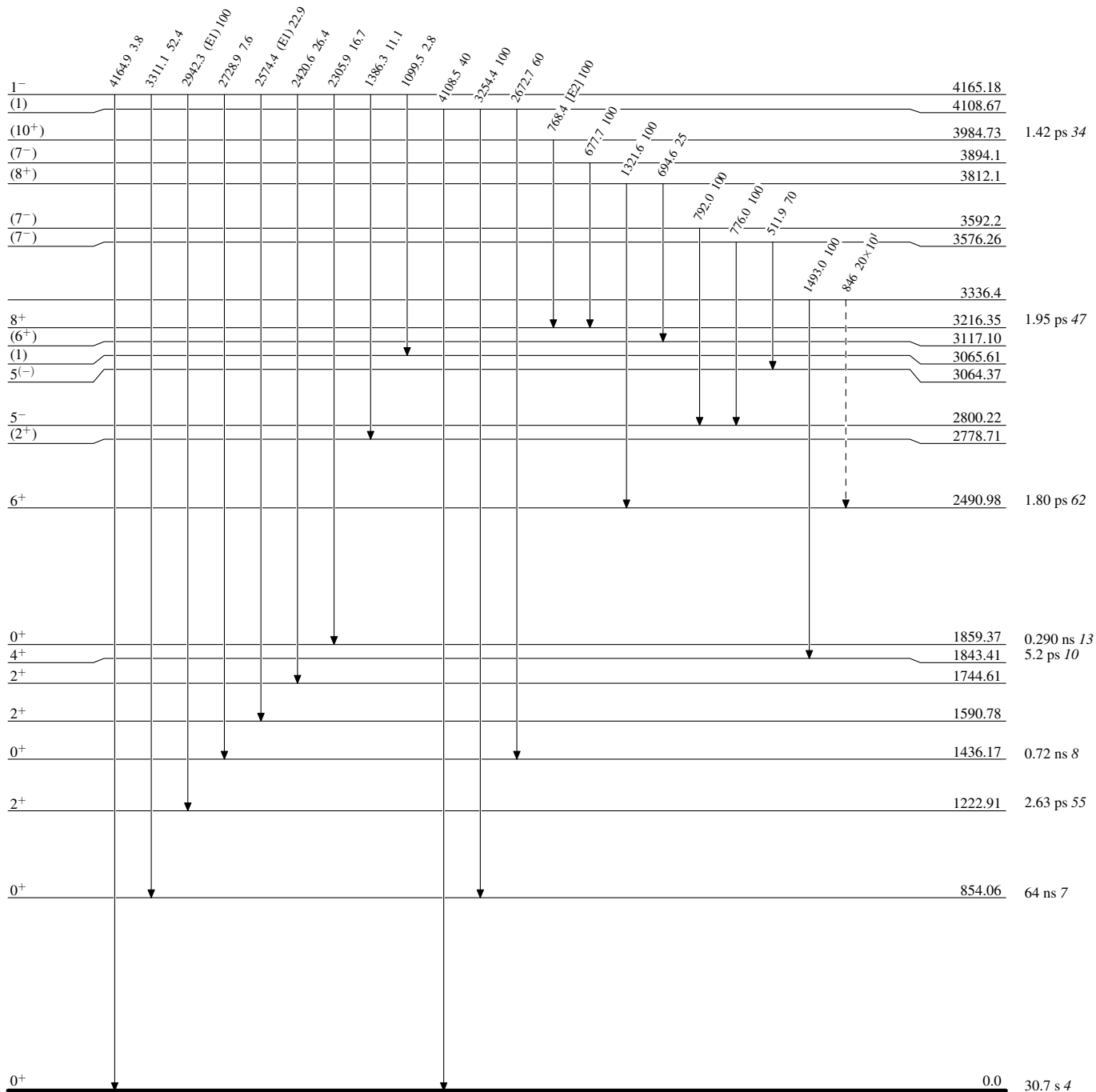


Adopted Levels, Gammas

Legend

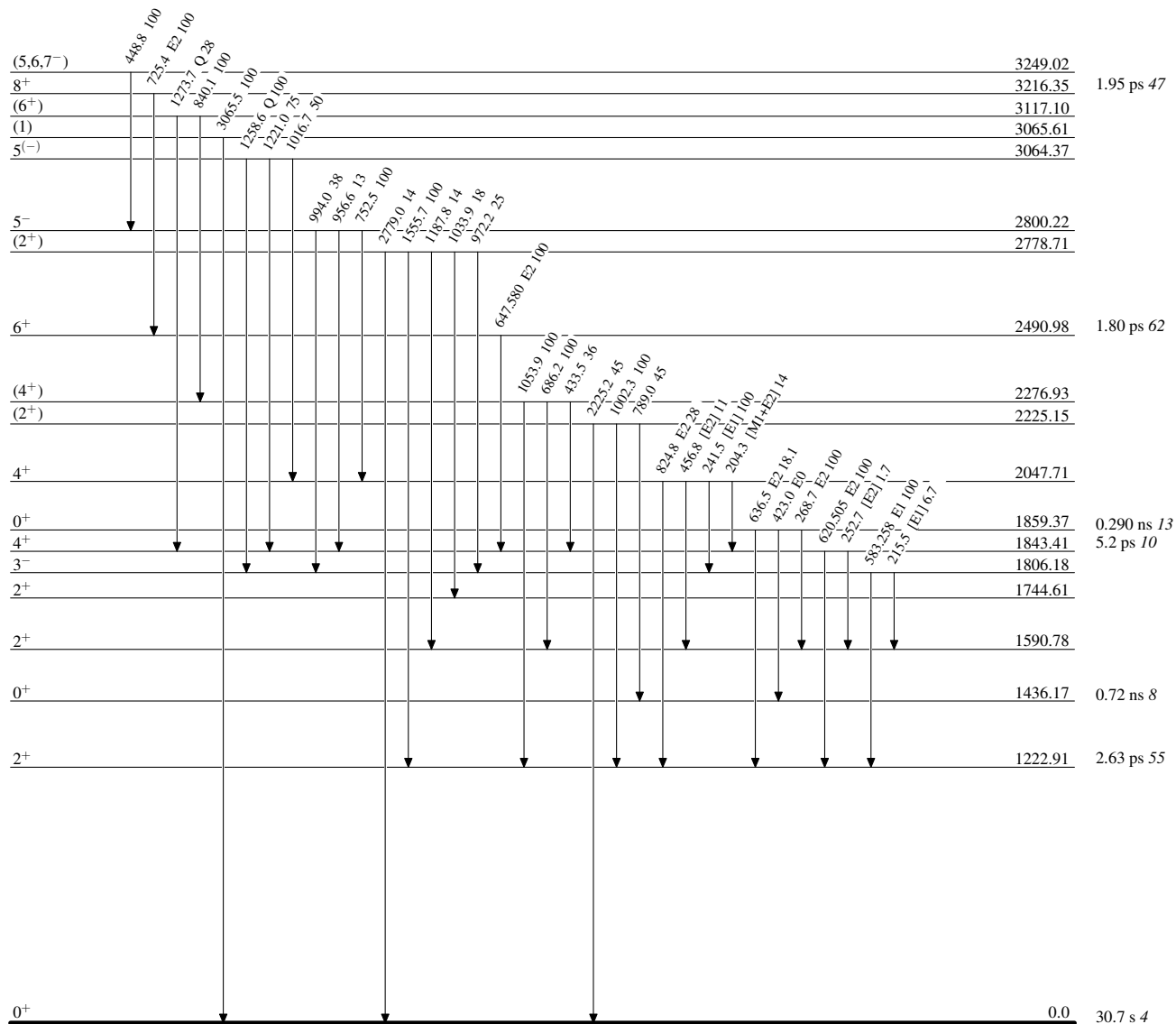
Level Scheme (continued)

Intensities: Relative photon branching from each level

-----► γ Decay (Uncertain)

Adopted Levels, Gammas**Level Scheme (continued)**

Intensities: Relative photon branching from each level

 $^{98}_{40}\text{Zr}_{58}$

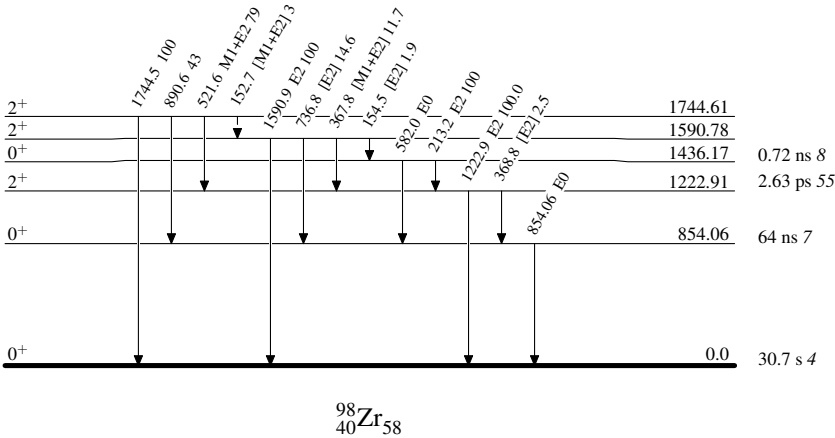
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

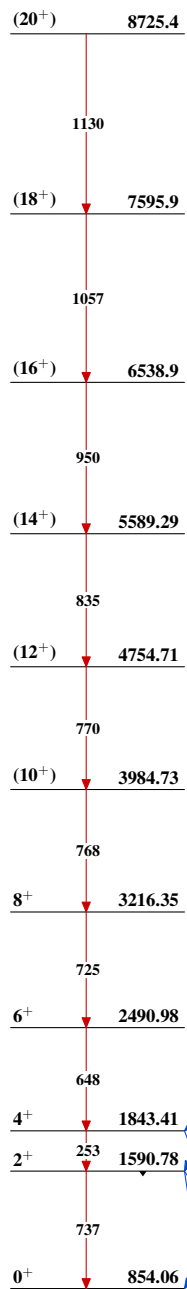
-----► γ Decay (Uncertain)



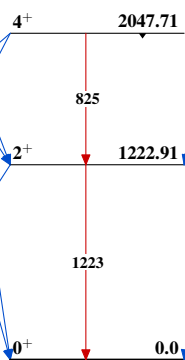
⁹⁸Zr₅₈

Adopted Levels, Gammas

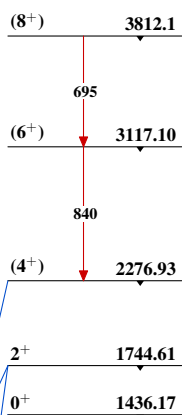
Band(A): Band based on
854, 0^+



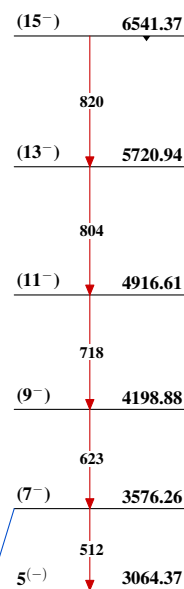
Seq.(B): γ cascade
based on g.s



Seq.(C): γ cascade
based on 1436, 0^+



Seq.(E): γ cascade
based on (5^-) , 3064



Seq.(D): γ cascade
based on 3^-

