Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 196,17 (2024)	30-Sep-2023

Q(β^-)=3661 *19*; S(n)=8498 *26*; S(p)=10262 *19*; Q(α)=−8751 *19* 2021Wa16
S(2n)=15096 *19*, S(2p)=24687 *19* (2021Wa16).
Additional information 1.

^{63}Co Levels

Cross Reference (XREF) Flags

A	^{63}Fe β^- decay (6.1 s)	E	^{64}Ni(t,α)
B	^{18}O(^{48}Ca,p2nγ)	F	^{64}Ni(^{238}U,Xγ)
C	^{64}Ni(d,^{3}Heγ)	G	^{238}U(^{64}Ni,Xγ)
D	^{64}Ni(pol d,^{3}He),(d,^{3}He)	H	^{238}U(^{70}Zn,Xγ)

E(level)[†]	J^π	$T_{1/2}$[‡]	XREF	Comments
0.0[&]	7/2⁻	27.4 s *4*	ABCDEFGH	%β^-=100 J^π: L(pol d,^{3}He)=L(t,α)=3 from 0⁺; L+1/2 transfer from analyzing powers. $T_{1/2}$: weighted average of 26 s *1* (1969Wa15), 27.5 s *3* (1972Jo08), 27.4 s *5* (1995ItZY). Other: 52 s *5* from 1960Mo01 is discrepant.
995.05 *13*	3/2⁻	10.7 ps *12*	ABCDEF	J^π: L(pol d,^{3}He)=L(t,α)=1 from 0⁺; L+1/2 transfer from analyzing powers. $T_{1/2}$: from RDDS in (^{238}U,Xγ). Other: >10 ps from (d,^{3}Heγ).
1383.54[&] *12*	(9/2⁻)	0.62 ps *28*	BCDEF H	XREF: E(1373). J^π: 1382.8γ (D), ΔJ=(1) to 7/2⁻; 290.3γ (D), ΔJ=(1) from 11/2⁻; also band assignment. But L(d,^{3}He)=(3) from 0⁺ gives (5/2⁻,7/2⁻). $T_{1/2}$: from RDDS in (^{238}U,Xγ).
1427.16 *15*	(5/2⁻)		A CDE	J^π: L(d,^{3}He)=(3) from 0⁺; 460.7γ from 1/2⁻.
1494.80 *11*	(3/2⁻)		A CDE	J^π: L(t,α)=(1) from 0⁺; 1495γ to 7/2⁻. Other: L(d,^{3}He)=(3) from 0⁺ is inconsistent; see comments in (d,^{3}He) dataset.
1577.0 *3*	(3/2,5/2,7/2⁻)		A	J^π: 582γ to 3/2⁻; possible β^- feeding from 5/2⁻ parent.
1673.6 *4*	11/2⁻	0.48 ps *15*	BCDEFGH	J^π: 1673.5γ E2, ΔJ=2 to 7/2⁻ gives 3/2⁻ or 11/2⁻; although L(d,^{3}He)=(5) favoring 11/2⁻ is tentative, but L=1 favoring 3/2⁻ is ruled out from analysis of measured $\sigma(\theta)$ in 1991Se09 and 1979Ha03. $T_{1/2}$: weighted average of 0.38 ps *13* from (^{238}U,Xγ) and 0.7 ps *2* from (^{64}Ni,Xγ), both using RDDS.
1888.47 *24*	1/2⁻	>244 fs	A CDE	J^π: L(pol d,^{3}He)=1 from 0⁺ and L-1/2 transfer from analyzing powers.
2077.81 *21*	(5/2⁻,7/2⁻)		CD	J^π: L(d,^{3}He)=(3) from 0⁺.
2128.63 *15*	7/2⁻	155 fs +*46*−*41*	CDE	J^π: L(pol d,^{3}He)=L(t,α)=3 from 0⁺; L+1/2 transfer from analyzing powers.
2191.42 *20*	1/2⁺	47 fs +*46*−*23*	CDE	J^π: L(pol d,^{3}He)=L(t,α)=0 from 0⁺.
2330.20 *9*	7/2⁻	143 fs +*36*−*33*	CDE	J^π: L(pol d,^{3}He)=L(t,α)=3 from 0⁺; L+1/2 transfer from analyzing powers.
2374.8 *12*		0.14 ps +*11*−*5*	CD	J^π: 2374.8γ to 7/2⁻ gives (3/2⁻,5/2,7/2,9/2,11/2⁻).
2473 *5*	(5/2⁻,7/2⁻)		D	J^π: L(d,^{3}He)=(3) from 0⁺.
2539.5[&] *6*	(11/2⁻)		B H	J^π: 1155.7γ D, ΔJ=1 to (9/2⁻); band assignment.
2689.43 *20*	3/2⁺	238 fs +*72*−*63*	CDE	J^π: L(pol d,^{3}He)=L(t,α)=2 from 0⁺; 497.8γ to to 1/2⁺ cannot

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Adopted Levels, Gammas (continued)

^{63}Co Levels (continued)

E(level)†	J$^\pi$	T$_{1/2}$‡	XREF	Comments
				be E2 (ruled out by RUL).
2793.96 *21*	(5/2$^-$,7/2$^-$)		A D	J$^\pi$: L(d,^{3}He)=(3) from 0$^+$; supported by possible β^- feeding from 5/2$^-$ parent.
2882 *5*	(1/2$^-$,3/2$^-$)		D	J$^\pi$: L(d,^{3}He)=(1) from 0$^+$.
2929 *5*	7/2$^-$,5/2$^-$		DE	E(level): from (pol d,^{3}He). Other: 2932 *25* from (t,α). J$^\pi$: L(t,α)=3 from 0$^+$.
3007.3 *7*	(13/2$^-$)		B	J$^\pi$: 1333.5γ to to 11/2$^-$; 1623.9γ to (9/2$^-$); (13/2$^-$) proposed in (^{48}Ca,p2nγ), assuming J increases as excitation energy increases.
3034.4& *8*	(13/2$^-$)		B H	J$^\pi$: 495.1γ D, ΔJ=1 to (11/2$^-$); band assignment.
3037.0 *10*	5/2$^-$,7/2$^-$		CDE	J$^\pi$: L(t,α)=3 from 0$^+$; also L(d,^{3}He)=(3) from 0$^+$.
3133.4 *9*	(5/2$^-$,7/2$^-$)	0.15 ps *+11−6*	CDE	J$^\pi$: L(d,^{3}He)=(3) from 0$^+$.
3179.9 *8*	5/2$^-$,7/2$^-$	56 fs *+17−15*	CDE	J$^\pi$: L(t,α)=3 from 0$^+$; also L(d,^{3}He)=(3) from 0$^+$.
3204.1 *7*	(15/2$^-$)		B H	J$^\pi$: 1530.4γ (Q), ΔJ=(2) to 11/2$^-$; 196.8γ (D), ΔJ=(1) to (13/2$^-$).
3225.7& *8*	(15/2$^-$)		B H	J$^\pi$: 191.2γ (D), ΔJ=(1) to (13/2$^-$); band assignment.
3412.6 *6*	5/2$^-$,7/2$^-$	41 fs *+42−22*	CDe	XREF: e(3421). J$^\pi$: L(d,^{3}He)=3 from 0$^+$.
3422.1 *10*	(3/2,5/2,7/2$^-$)		A e	XREF: e(3421). J$^\pi$: possible β^- feeding from 5/2$^-$ parent; 2427γ to 3/2$^-$.
3581.4& *9*	(17/2$^-$)	1.2@ ps *+6−4*	B H	J$^\pi$: 356.0γ D, ΔJ=1 to (15/2$^-$); band assignment.
3602 *6*	(5/2$^-$,7/2$^-$)		CD	J$^\pi$: L(d,^{3}He)=(3) from 0$^+$.
3611.1 *8*	(17/2$^-$)	0.69@ ps *+21−14*	B H	J$^\pi$: 407.1γ (D), ΔJ=(1) to (15/2$^-$); (17/2$^-$) proposed in (^{48}Ca,p2nγ) assuming J increases in excitation energy increases.
3676 *5*	(5/2$^-$,7/2$^-$)		D	J$^\pi$: L(d,^{3}He)=(3).
3766 *5*	(5/2$^-$,7/2$^-$)		D	J$^\pi$: L(d,^{3}He)=(3).
3893 *5*	(7/2$^-$)		D	J$^\pi$: L(pol d,^{3}He)=(3); 7/2$^-$ favored by analyzing powers.
3985 *5*	(5/2$^+$)#		D	J$^\pi$: L(pol d,^{3}He)=(2); 5/2$^+$ favored by analyzing powers.
4039 *5*	3/2$^+$,5/2$^+$		D	J$^\pi$: L(d,^{3}He)=2.
4094 *5*	(3/2$^+$,5/2$^+$)#		D	
4127 *5*	(3/2$^+$,5/2$^+$)#		D	
4167.1& *9*	(19/2$^-$)	0.21@ ps *7*	B H	J$^\pi$: 587γ (D), ΔJ=(1) to (17/2$^-$); band assignment.
4234 *5*	(3/2$^+$,5/2$^+$)#		D	
4376 *5*	(3/2$^+$,5/2$^+$)#		D	
4453 *5*	(3/2$^+$,5/2$^+$)#		D	
4524 *5*	(3/2$^+$,5/2$^+$)#		D	
4538 *5*	(3/2$^+$,5/2$^+$)#		D	
4588 *5*	(3/2$^+$,5/2$^+$)#		D	
4700 *5*	(3/2$^+$,5/2$^+$)#		D	
4722 *5*	(3/2$^+$,5/2$^+$)#		D	
4820 *5*	(3/2$^+$,5/2$^+$)#		D	
4886 *5*	(3/2$^+$,5/2$^+$)#		D	
4968 *5*	(3/2$^+$,5/2$^+$)#		D	
5010 *5*	(3/2$^+$,5/2$^+$)#		D	
5080 *5*	(3/2$^+$,5/2$^+$)#		D	
5132 *5*	(3/2$^+$,5/2$^+$)#		D	
5215 *5*	(3/2$^+$,5/2$^+$)#		D	

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Adopted Levels, Gammas (continued)

^{63}Co Levels (continued)

E(level)†	J$^{\pi}$	XREF
5294 *5*	(3/2$^+$,5/2$^+$)#	D
5342 *5*	(3/2$^+$,5/2$^+$)#	D
5457 *5*	(3/2$^+$,5/2$^+$)#	D
5659 *5*	(3/2$^+$,5/2$^+$)#	D

† From a least-squares fit to γ-ray energies with uncertainties for level connected with those γ transitions, and from transfer reactions for other levels, unless otherwise noted.
‡ From DSAM in (d,^{3}Heγ), unless otherwise noted.
# From L(d,^{3}He)=(2).
@ From DSAM in (^{48}Ca,p2nγ).
& Band(A): K=7/2$^-$ g.s. band.

γ(^{63}Co)

Additional information 2.

E$_i$(level)	J$^{\pi}_i$	E$_{\gamma}$†	I$_{\gamma}$†	E$_f$	J$^{\pi}_f$	Mult.‡	Comments
995.05	3/2$^-$	994.6 *1*	100	0.0	7/2$^-$	[E2]	B(E2)(W.u.)=3.65 *+47−36* E$_{\gamma}$: weighted average of 994.8 *2* from ^{63}Fe β$^-$ decay, 995.0 *5* from (^{48}Ca,p2nγ), and 994.5 *1* from (d,^{3}Heγ).
1383.54	(9/2$^-$)	1382.8 *4*	100	0.0	7/2$^-$	(D)	E$_{\gamma}$: weighted average of 1382.6 *10* from (^{48}Ca,p2nγ), 1381.9 *8* from (d,^{3}Heγ), and 1383.0 *4* from (^{70}Zn,Xγ).
1427.16	(5/2$^-$)	432.1@ *2*	13.3@ *6*	995.05	3/2$^-$		
		1426.6 *7*	100@ *9*	0.0	7/2$^-$		E$_{\gamma}$: unweighted average of 1427.2 *2* from ^{63}Fe β$^-$ decay and 1425.9 *6* from (d,^{3}Heγ).
1494.80	(3/2$^-$)	499.5 *2*	17.5@ *25*	995.05	3/2$^-$		E$_{\gamma}$: weighted average of 499.6 *3* from ^{63}Fe β$^-$ decay and 499.4 *2* from (d,^{3}Heγ). I$_{\gamma}$: other: 45 *5* from (d,^{3}Heγ) is discrepant.
		1495.0 *3*	100@ *6*	0.0	7/2$^-$		E$_{\gamma}$: weighted average of 1494.6 *3* from ^{63}Fe β$^-$ decay and 1495.2 *2* from (d,^{3}Heγ). I$_{\gamma}$: other: 100 *5* from (d,^{3}Heγ).
1577.0	(3/2,5/2,7/2$^-$)	149.7@ *4*	14.7@ *33*	1427.16	(5/2$^-$)		
		582.0@ *3*	100@ *13*	995.05	3/2$^-$		
1673.6	11/2$^-$	290.3 *4*	9.6 *20*	1383.54	(9/2$^-$)	(M1)	B(M1)(W.u.)=0.164 *+85−49* E$_{\gamma}$: from (^{48}Ca,p2nγ). Other: 290.3 *5* from (^{70}Zn,Xγ). I$_{\gamma}$: weighted average of 15 *6* from (^{48}Ca,p2nγ) and 9.0 *20* from (^{70}Zn,Xγ). Mult.: (D), ΔJ=(1) from γ(θ) in (^{48}Ca,p2nγ); Δπ=no from level scheme.
		1673.5 *6*	100 *8*	0.0	7/2$^-$	E2	B(E2)(W.u.)=5.5 *+25−13* E$_{\gamma}$: weighted average of 1673.2 *10* from (^{48}Ca,p2nγ), 1671.5 *10* from (d,^{3}Heγ), and 1673.9 *4* from (^{70}Zn,Xγ). I$_{\gamma}$: from (^{70}Zn,Xγ). Other: 100 *12* from

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Adopted Levels, Gammas (continued)

$\gamma(^{63}Co)$ (continued)

E_i(level)	J^π_i	E_γ†	I_γ†	E_f	J^π_f	Mult.‡	Comments
							(^{48}Ca,p2nγ). Mult.: Q, ΔJ=2 from $\gamma(\theta)$ in (^{48}Ca,p2nγ) and (^{70}Zn,Xγ); M2 ruled by RUL.
1888.47	1/2$^-$	460.7 *5*	54@ *16*	1427.16	(5/2$^-$)	[E2]	E_γ: weighted average of 461.3 *5* from ^{63}Fe β^- decay and 460.3 *4* from (d,^{3}Heγ). I_γ: other: 118 *13* from (d,^{3}Heγ) is discrepant. B(E2)(W.u.)<3593 upper limit exceeds RUL=300.
		893.2 *4*	100@ *23*	995.05	3/2$^-$	[M1,E2]	E_γ: weighted average of 893.8 *5* from ^{63}Fe β^- decay and 893.0 *3* from (d,^{3}Heγ). I_γ: other: 100 *13* from (d,^{3}Heγ). B(M1)(W.u.)<0.097 if M1, B(E2)(W.u.)<210 if E2.
2077.81	(5/2$^-$,7/2$^-$)	582.9 *2*	100 *12*	1494.80	(3/2$^-$)		
		2078.7 *6*	92 *12*	0.0	7/2$^-$		
2128.63	7/2$^-$	745.1 *1*	89 *4*	1383.54	(9/2$^-$)	[M1,E2]	B(M1)(W.u.)=0.162 *+61−38* if M1. B(E2)(W.u.)=5.0×10^2 *+19−12* exceeds RUL=300 if E2.
		2128.5 *3*	100 *4*	0.0	7/2$^-$	[M1,E2]	B(M1)(W.u.)=0.0078 *+29−18* if M1, B(E2)(W.u.)=3.0 *+11−7* if E2.
2191.42	1/2$^+$	302.8 *2*	4.2 *11*	1888.47	1/2$^-$	[E1]	B(E1)(W.u.)=0.013 *+13−7* exceeds RUL=0.01.
		1196.3 *2*	100.0 *11*	995.05	3/2$^-$	[E1]	B(E1)(W.u.)=0.0051 *+47−25*
2330.20	7/2$^-$	835.5 *1*	71.1 *26*	1494.80	(3/2$^-$)	[E2]	B(E2)(W.u.)=176 *+53−37*
		946.6 *1*	100 *8*	1383.54	(9/2$^-$)	[M1,E2]	B(M1)(W.u.)=0.069 *+21−15* if M1, B(E2)(W.u.)=133 *+41−29* if E2.
		2330.1 *1*	92 *8*	0.0	7/2$^-$	[M1,E2]	B(M1)(W.u.)=0.0043 *+13−9* if M1, B(E2)(W.u.)=1.35 *+41−29* if E2.
2374.8		2374.8 *12*	100	0.0	7/2$^-$	[D,E2]	B(E2)(W.u.)=3.6 *+21−15* if E2.
2539.5	(11/2$^-$)	1155.7 *4*	100# *9*	1383.54	(9/2$^-$)	D	E_γ: weighted average of 1156.1 *7* from (^{48}Ca,p2nγ) and 1155.5 *4* from (^{70}Zn,Xγ).
		2538.7# *15*	9# *4*	0.0	7/2$^-$		
2689.43	3/2$^+$	497.8 *2*	16.7 *13*	2191.42	1/2$^+$	[M1]	B(M1)(W.u.)=0.098 *+35−24*
		1263.3 *5*	11.5 *13*	1427.16	(5/2$^-$)	[E1]	B(E1)(W.u.)=8.0×10^{-5} *+29−21*
		1694.4 *2*	100.0 *13*	995.05	3/2$^-$	[E1]	B(E1)(W.u.)=2.9×10^{-4} *+10−7*
2793.96	(5/2$^-$,7/2$^-$)	1299.0@ *2*	100@ *7*	1494.80	(3/2$^-$)		
		1799.3@ *5*	28@ *5*	995.05	3/2$^-$		
		2796@ *1*	9.1@ *34*	0.0	7/2$^-$		
3007.3	(13/2$^-$)	1333.5# *10*	100# *37*	1673.6	11/2$^-$		
		1623.9# *10*	82# *37*	1383.54	(9/2$^-$)		
3034.4	(13/2$^-$)	495.1 *4*	100	2539.5	(11/2$^-$)	D	E_γ,I_γ: from (^{70}Zn,Xγ). Other: 495.0 *5* from (^{48}Ca,p2nγ).
3037.0	5/2$^-$,7/2$^-$	3036.9 *10*	100	0.0	7/2$^-$		
3133.4	(5/2$^-$,7/2$^-$)	3133.3 *9*	100	0.0	7/2$^-$	[M1,E2]	B(M1)(W.u.)=0.0048 *+32−20* if M1, B(E2)(W.u.)=0.84 *+57−35* if E2.
3179.9	5/2$^-$,7/2$^-$	3179.8 *8*	100	0.0	7/2$^-$	[M1,E2]	B(M1)(W.u.)=0.0122 *+45−28* if M1, B(E2)(W.u.)=2.09 *+77−48* if E2.
3204.1	(15/2$^-$)	196.8# *4*	100# *33*	3007.3	(13/2$^-$)	(D)	
		1530.4# *10*	80# *27*	1673.6	11/2$^-$	(Q)	
3225.7	(15/2$^-$)	191.2 *2*	100	3034.4	(13/2$^-$)	(D)	E_γ,I_γ: from (^{70}Zn,Xγ). Other: 191.3 *4* from (^{48}Ca,p2nγ).
3412.6	5/2$^-$,7/2$^-$	2028.8 *7*	37 *4*	1383.54	(9/2$^-$)	[M1,E2]	B(M1)(W.u.)=0.017 *+20−9* if M1, B(E2)(W.u.)=7.3 *+83−37* if E2.

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Adopted Levels, Gammas (continued)

$\gamma(^{63}Co)$ (continued)

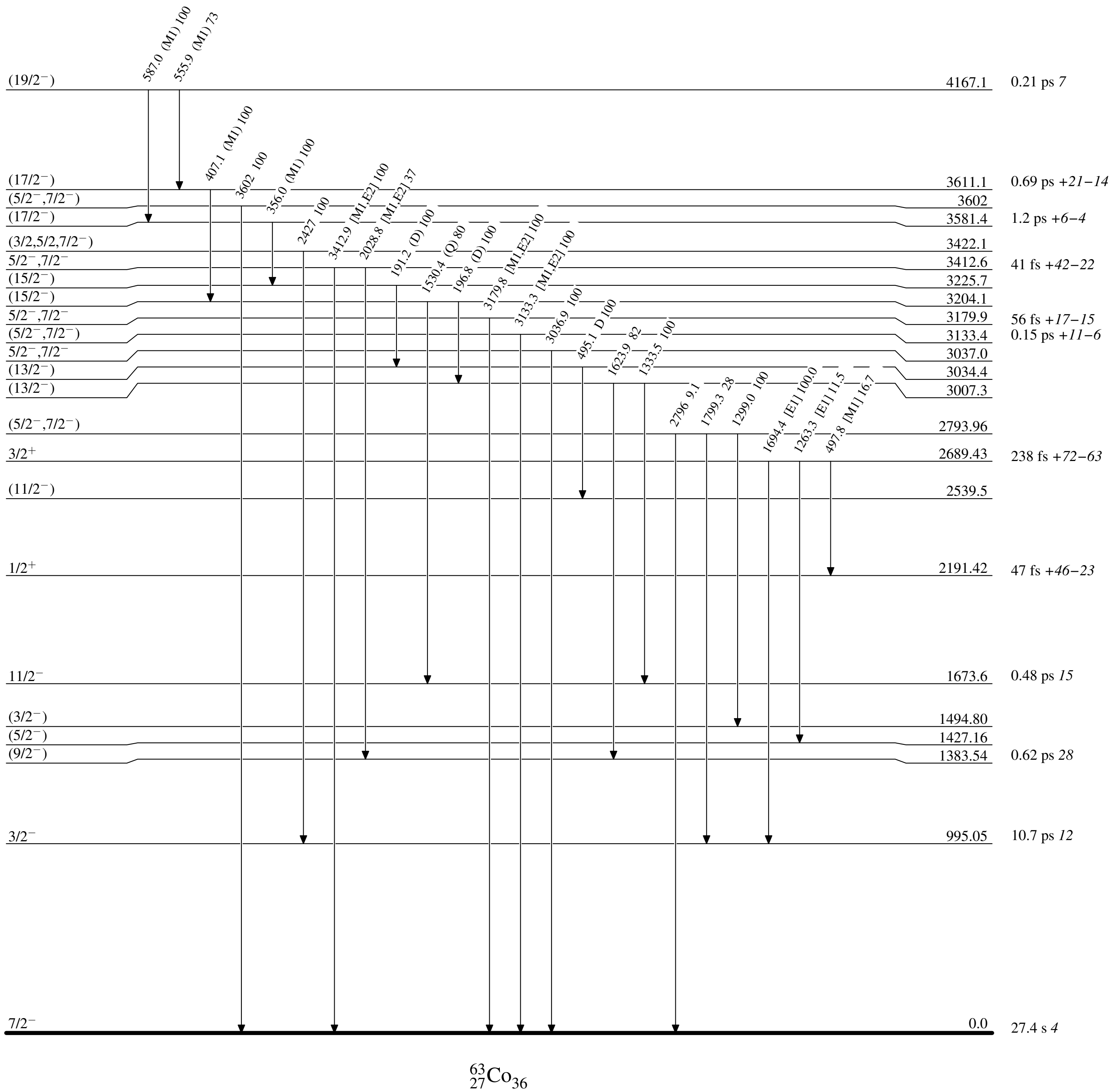
E_i(level)	J^π_i	E_γ†	I_γ†	E_f	J^π_f	Mult.‡	Comments
3412.6	$5/2^-,7/2^-$	3412.9 *11*	100 *4*	0.0	$7/2^-$	[M1,E2]	B(M1)(W.u.)=0.010 +*12*−*5* if M1, B(E2)(W.u.)=1.5 +*17*−*7* if E2.
3422.1	$(3/2,5/2,7/2^-)$	2427@ *1*	100	995.05	$3/2^-$		
3581.4	$(17/2^-)$	356.0 *3*	100	3225.7	$(15/2^-)$	(M1)	B(M1)(W.u.)=0.41 +*21*−*13* E_γ: weighted average of 355.7 *4* from (^{48}Ca,p2nγ) and 356.2 *3* from (^{70}Zn,Xγ). Mult.: D, ΔJ=1 from $\gamma(\theta)$ in (^{48}Ca,p2nγ); $\Delta\pi$=(no) from level scheme in band assignment.
3602	$(5/2^-,7/2^-)$	3602 *6*	100	0.0	$7/2^-$		
3611.1	$(17/2^-)$	407.1 *3*	100	3204.1	$(15/2^-)$	(M1)	B(M1)(W.u.)=0.47 +*12*−*11* E_γ: from (^{70}Zn,Xγ). Other: 407.0 *5* from (^{48}Ca,p2nγ). Mult.: (D) from $\gamma(\theta)$ in (^{48}Ca,p2nγ); $\Delta\pi$=(no) from level scheme.
4167.1	$(19/2^-)$	555.9# *8*	73# *23*	3611.1	$(17/2^-)$	(M1)	B(M1)(W.u.)=0.26 +*14*−*9* Mult.: (D), ΔJ=1 from $\gamma(\theta)$ in (^{48}Ca,p2nγ); $\Delta\pi$=(no) from level scheme based on band assignment.
		587.0 *5*	100# *13*	3581.4	$(17/2^-)$	(M1)	B(M1)(W.u.)=0.30 +*17*−*8* E_γ: weighted average of 585.8 *10* from (^{48}Ca,p2nγ) and 587.2 *4* from (^{70}Zn,Xγ). Mult.: (D), ΔJ=1 from $\gamma(\theta)$ in (^{70}Zn,Xγ); $\Delta\pi$=(no) from level scheme based on band assignment.

† From (d,^{3}Heγ), unless otherwise noted. Where intensities are also available from ^{63}Fe β^- decay but discrepant with values from (d,^{3}Heγ), the evaluator has adopted values from ^{63}Fe β^- decay because of better statistics as seen in the γ spectra.
‡ From (^{48}Ca,p2nγ) deduced based on measured $\gamma(\theta)$, unless otherwise noted.
# From (^{48}Ca,p2nγ).
@ From ^{63}Fe β^- decay.

Adopted Levels, Gammas

Level Scheme

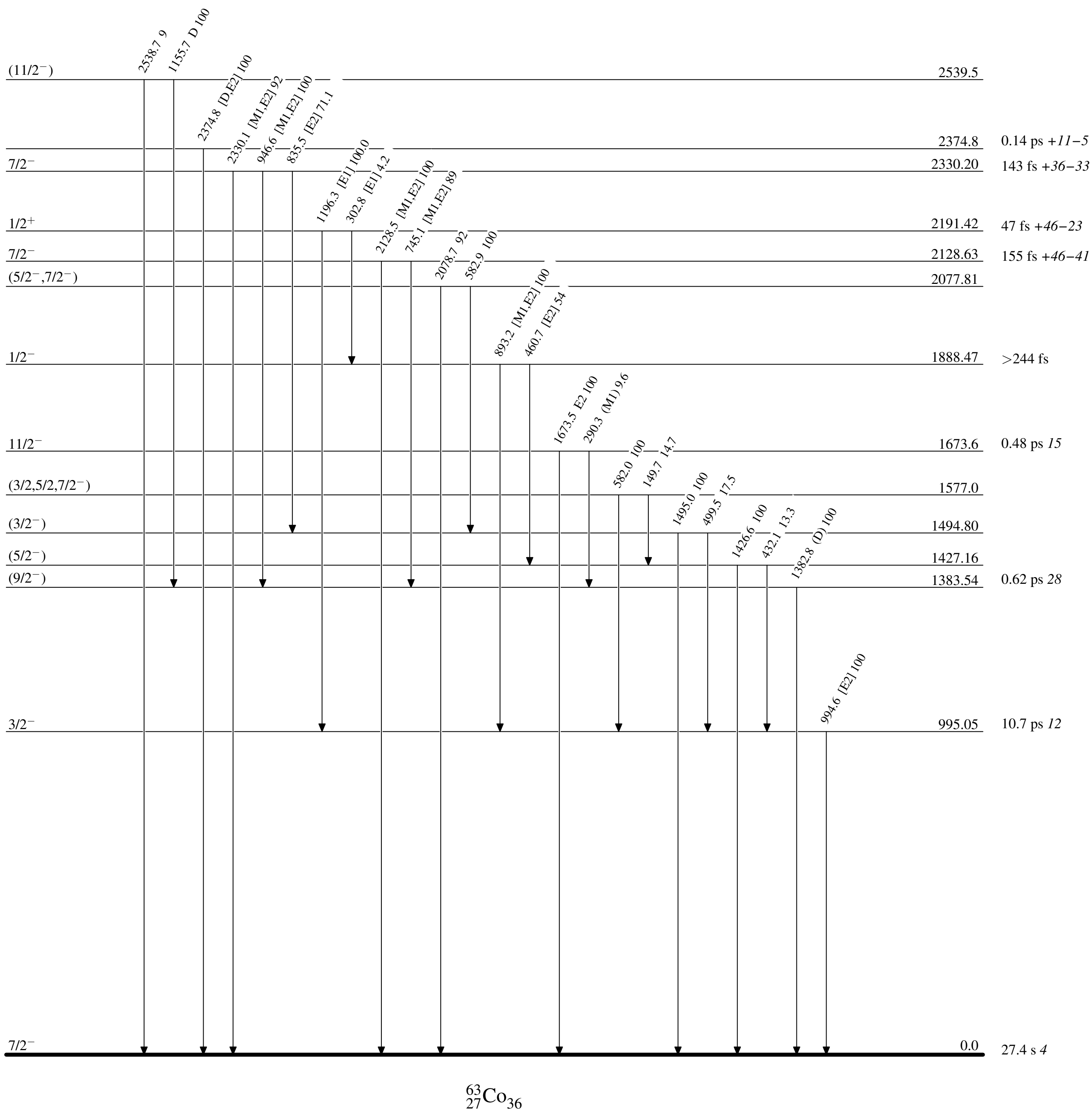
Intensities: Relative photon branching from each level



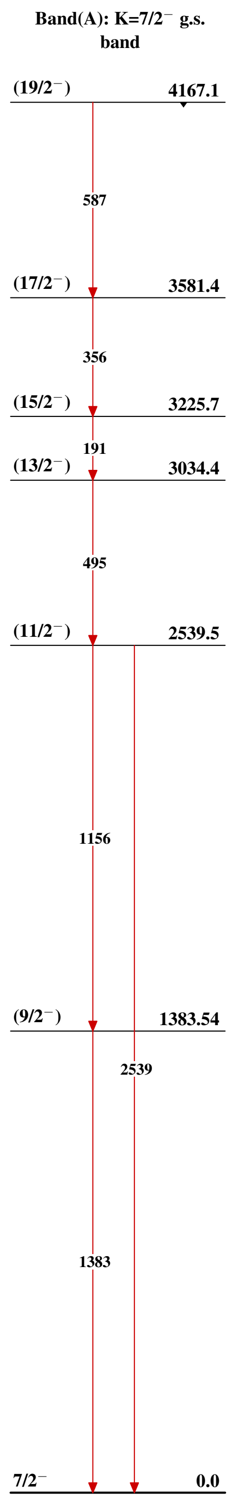
Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level



Adopted Levels, Gammas



$^{63}_{27}Co_{36}$