Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen and Balraj Singh	NDS 157, 1 (2019)	15-Apr-2019

Q(β^-)=−8151 *8*; S(n)=13078.3 *22*; S(p)=4583.5 *22*; Q(α)=−7977.2 *5* 2017Wa10
Q(β^-): other: −8150 *6* from 2017Zh12 based on their measured mass excess=−34477 *6*.
S(2n)=29474 *7*, S(2p)=12727.8 *11* (2017Wa10).
Theory references: consult the NSR database (www.nndc.bnl.gov/nsr/) for 79 primary references dealing with various aspects of nuclear structure.
Additional information 1.

^{50}Mn Levels

T(Isotopic spin): from ^{40}Ca(^{12}C,pnγ), except as noted.

Cross Reference (XREF) Flags

A	^{50}Fe ε decay (152.0 ms)	E	^{50}Cr(p,n)
B	^{24}Mg(^{32}S,αpnγ)	F	^{50}Cr(p,nγ)
C	^{28}Si(^{28}Si,αpnγ)	G	^{50}Cr(^{3}He,t)
D	^{40}Ca(^{12}C,pnγ)		

E(level)[†]	J$^\pi$	T$_{1/2}$[‡]	XREF	Comments
0.0[&]	0$^+$	283.19 ms *10*	ABCDEFG	%ε+%β^+=100 T=1 J$^\pi$: spin from hyperfine structure using laser-spectroscopy (2010Ch15 and e-mail replies from F. Charlwood on June 18 and June 30, 2010); super-allowed β^+ decay to 0$^+$. T$_{1/2}$: from timing of positron spectra. The adopted value is the weighted average of 283.10 *14* (2006Ba33), 283.29 *8* (1997Ko65; their earlier value was 284.0 *4* (1974Ha59)), 282.72 *26* (1976Wi08; their earlier value was 285.1 *9* (1973Al02)) and 282.8 *3* (1975Fr02; their earlier value was 285.7 *6* (1965Fr08)). Others: 288 *7* (2013Su07, decay-time spectra fitted with exponential curves), 304 *5* (1962Su10), 295 *1* (1958Mi84), 270 (1954Ty33), 280 *20* (1952Ma55). All values are quoted in ms. T: IAS(^{50}Cr g.s.). δ<r^2>(^{55}Mn,^{50}Mn)=+0.168 fm^2 *4*(stat) *53*(syst) (2016He14, hyperfine spectra using collinear laser spectroscopy on ionic transitions). δ<r^2>(^{55}Mn,^{50}Mn)=+0.046 fm^2 *3*(stat) (2010Ch15, laser spectroscopy at Jyvaskyla accelerator laboratory). The systematic uncertainty is ≈15%. Isotope shift measurement: $\delta\nu$(^{55}Mn,^{50}Mn)=−1573 Hz *2* (2010Ch15, laser spectroscopy).
225.28[a] *9*	5$^+$	1.75 min *3*	BCDEFG	%ε+%β^+=100 μ=+2.76 *1* (2010Ch15); Q=+0.80 *12* (2010Ch15) Additional information 2. E(level): from Penning-trap mass measurement (2008Er04). 2017Au03 (NUBASE) give 225.31 keV *7* from mass difference. J$^\pi$: spin from hyperfine structure using laser-spectroscopy (2010Ch15 and e-mail replies from F. Charlwood on June 18 and June 30, 2010); log *ft*=5.0 *1* to 4$^+$ and 6.0 *2* to 6$^+$. T$_{1/2}$: weighted average of 1.74 min *10* (2013Su07, decay curve for γ-spectrum gated by β rays and ΔE-TOF); 1.76 min *3* (1972Ra14, decay curves for 783γ and 1098γ, 1 h counting period); 1.72 min *4* (1962Su10, β^+ decay curve). μ,Q: hyperfine structure using laser-spectroscopy (2010Ch15). See also 2014StZZ

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Adopted Levels, Gammas (continued)

^{50}Mn Levels (continued)

E(level)[†]	Jπ	$T_{1/2}$[‡]	XREF	Comments
				and 2016St14 compilations. %ε+%β+,%IT: %IT<7.4 from Iγ(IT)/Iγ(783γ)<0.02 (1972Ra14), assuming Eγ(IT)≤229, and α(229γ; M5 theory (1976Ba63))≈3. δ<r²>(^{55}Mn,^{50m}Mn)=+0.051 fm² *16*(stat) *53*(syst) (2016He14, hyperfine spectra using collinear laser spectroscopy on ionic transitions). δ<r²>(^{55}Mn,^{55m}Mn)=−0.057 fm² *13*(stat) (2010Ch15, laser spectroscopy at Jyvaskyla accelerator laboratory). The systematic uncertainty is ≈15%. Isotope shift measurement: δν(^{55}Mn,^{50}Mn)=−1514 Hz *8* (2010Ch15, laser spectroscopy).
651.06[b] *7*	1+		ABCDEFG	Jπ: M1 650.9γ to 0+; L(^{3}He,t)=0 from 0+.
659.17[c] *12*	(6+)		BCD	Jπ: 434.0γ to 5+; possible bandhead from model predictions.
800.20[&] *7*	2+	4.44 ps *14*	ABCDEFG	T=1 Jπ: E2 799.9γ to 0+. $T_{1/2}$: from RDDS in ^{40}Ca(^{12}C,pnγ) (M.M. Giles et al., Phys. Rev. C, accepted April 9, 2019). Other: >0.7 ps (2002Pi04, DSAM in (^{12}C,pnγ)).
1030.55[a] *12*	(7+)		BCDEFG	T=0 Jπ: ΔJ=(2) 805.4γ to 5+; band member.
1143.28[b] *8*	3+	0.33 ps *+11−8*	BCDEFG	T=0 XREF: G(1147). Jπ: ΔJ=1, M1(+E2) 343.0γ to 2+; L(^{3}He,t)≥1; band member.
1727.36 *10*	1−		DEF	Jπ: E1 1727.4γ to 0+.
1765.4 *5*	(3+ to 7+)		EF	XREF: E(+1770). Jπ: 1540.1γ to 5+.
1797.91 *12*	(3+)		eFG	XREF: e(1770)G(1805). Jπ: ΔJ=1, D(+Q) 997.7γ to 2+; possible 1572.9γ to 5+; L(^{3}He,t)≥1.
1874.60 *8*	2(+)		B DEFG	XREF: G(1860). Jπ: 1874.4γ to 0+; ΔJ=1, D 731.2γ 3+; 1223.6γ D(+Q) to 1+.
1917.11[b] *12*	5+	>0.7 ps	BCDeFg	T=0 XREF: e(1940)g(1920). Jπ: ΔJ=2, E2 γ to 3+; γ rays to (6+) and (7+).
1931.53[&] *10*	4+	<0.090 ps	B DeFg	T=1 XREF: e(1940)g(1920). Jπ: spin from γγ(θ) in ^{50}Cr(p,nγ); ΔJ=2, E2 1131.2γ to 2+.
2119.81[c] *18*	(8+)	<0.73 ps	BCD	T=0 ΔJ=(2) 1460.6γ to (6+); 1089.3γ to (7+); band member.
2157.59 *13*	(1+ to 5+)		F	Jπ: 1014.3γ to 3+.
2300.72 *12*	(0+ to 4+)		FG	XREF: G(2290). Jπ: 1500.5γ to 2+.
2340.11[d] *16*	(3−)		B D FG	XREF: G(?). Jπ: 3− proposed in ^{50}Cr(p,nγ) from ΔJ=1, D+Q γ to 2+ and γ to 1−. 4+ proposed in (^{32}S,αpnγ) based on cascade of ΔJ=2 quadrupole transitions feeding this level. 612.5γ to 1− favors 3−.
2403.87 *9*	1+		A G	XREF: G(2411). Jπ: log *ft*=4.4 from 0+ parent; also L(^{3}He,t)=0 from 0+ target.
2477.93 *12*	(3)		FG	XREF: G(2455). Jπ: ΔJ=1, D(+Q) 1677.1γ to 2+.
2534.26[a] *23*	(9+)	0.52 ps *8*	BCD	T=0 Jπ: ΔJ=2, (E2) 1503.7γ to (7+); band member. $T_{1/2}$: from DSAM (1999Br40) in (^{28}Si,αpnγ). Other: <0.77 ps in (^{12}C,pnγ) (2002Pi04).
2556.98 *14*	(5+)		B D FG	Jπ: ΔJ=1, D 625.2γ to 4+; 1413.0γ to 3+ and 1897.9γ to (6+).

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Adopted Levels, Gammas (continued)

^{50}Mn Levels (continued)

E(level)[†]	Jπ	$T_{1/2}$[‡]	XREF	Comments
2614.6 *5*	(0 to 3$^-$)		D F	Jπ: 887.2γ to 1$^-$.
2684.23 *9*	1$^+$		A G	XREF: G(2694). Jπ: log *ft*=4.6 from 0$^+$ parent; also L(^{3}He,t)=0 from 0$^+$ target.
2716.16 *10*	(4$^+$)		B FG	Jπ: ΔJ=2, Q 841.6γ to 2$^{(+)}$; 1572.8γ to 3$^+$.
2790[@] *20*	(1)$^+$[#]		G	
2980.12 *21*	(0 to 3$^+$)		FG	Jπ: 2329.0γ to 1$^+$.
3177[@] *20*			G	Not a GT transition from L(^{3}He,t)≥1.
3256.1[&] *10*	(6$^+$)	<0.07 ps	B D G	T=(1) XREF: G(3240). Jπ: ΔJ=1, D 1339.0γ to 5$^+$; band member.
3370.11[d] *19*	(5$^-$)		B D F	Jπ: ΔJ=2, Q 1030.0γ to (3$^-$); band member.
3380.12 *10*	1$^+$		A G	XREF: G(3392). Jπ: log *ft*=4.1 from 0$^+$ parent; also L(^{3}He,t)=0 from 0$^+$ target.
3438.76 *14*	(2$^+$ to 6$^+$)		D FG	Jπ: 1507.2γ to 4$^+$.
3477.66 *10*	(0$^+$ to 3$^-$)		F	Jπ: 1603.0γ to 2$^{(+)}$ and 1750.3γ to 1$^-$.
3520 *20*			G	
3561.94 *24*			F	
3638.12 *19*	(2$^+$ to 5$^+$)		F	Jπ: 2494.9γ to 3$^+$ and 1706.5γ to 4$^+$.
3643.5 *3*	1$^+$		A G	XREF: G(3654). Jπ: log *ft*=4.8 from 0$^+$ parent; also L(^{3}He,t)=0 from 0$^+$ target.
3723.1 *11*	(3,4,5$^-$)		B	Jπ: 1383γ to (3$^-$); lower spins less likely in heavy-ion reactions.
3850			G	
4012.9 *12*	1$^+$		A G	XREF: G(4028). Jπ: log *ft*=5.1 from 0$^+$ parent; also L(^{3}He,t)=0 from 0$^+$ target.
4253.9[e] *5*	(8$^-$)		BC	Jπ: 1720γ to (9$^+$) and 3223γ to (7$^+$); band member.
4315.9 *14*	1$^+$		A G	XREF: G(4333). Jπ: log *ft*=4.6 from 0$^+$ parent; also L(^{3}He,t)=0 from 0$^+$ target.
4584[@] *20*	(1)$^+$[#]		G	
4585.3[a] *11*	(11$^+$)		BC	Jπ: 2051γ to (9$^+$); band member.
4837.9[e] *11*	(10$^-$)		BC	Jπ: 584γ to (8$^-$); band member.
4875.1[d] *11*	(7$^-$)		B	Jπ: ΔJ=2, Q 1505γ to (5$^-$); band member.
5728 *4*			G	
6147.9[e] *15*	(12$^-$)		BC	Jπ: 1310γ to (10$^-$); band member.
6461.2[d] *15*	(9$^-$)		B	Jπ: ΔJ=2, Q 1586γ to (7$^-$), band member.
6937.4[a] *15*	(13$^+$)		BC	Jπ: 2352γ to (11$^+$); band member.
8277.4[a] *18*	(15$^+$)	>2 ps	BC	Jπ: 1340 γ to (13$^+$), band member. $T_{1/2}$: fully stopped peak shape in (^{28}Si,αpnγ) for 1340γ implies that lifetime is longer than the recoil-stopping time of ≈2 ps.

[†] From least-squares fit to Eγ values for levels populated in γ-ray studies. Reduced χ^2=2.0 is somewhat higher than the critical χ^2=1.8. Other levels are from (^{3}He,t). Comparison of level energies in ε decay and corresponding energies in (^{3}He,t) from 2005Fu16 shows that level energies in the latter are systematically higher, differing by as much as 17 keV at 4.3 MeV. Evaluators have increased the uncertainty to 20 keV, from the original uncertainty of 4 keV in 2005Fu16, when the level energy is taken from this work.

[‡] From DSAM in ^{40}Ca(^{12}C,pnγ) (2002Pi04), except as noted.

[#] L(^{3}He,t)=0 from 0$^+$ target, interpreted as Gamow-Teller transition (2005Fu16).

[@] Energy uncertainty increased to 20 keV from 4 keV listed by 2005Fu16. See general comment for level energies.

[&] Band(A): Band based on g.s.,T=1.

[a] Band(B): Band based on 5$^+$,T=0.

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Adopted Levels, Gammas (continued)

^{50}Mn Levels (continued)

[b] Band(C): Band based on 1^+.
[c] Band(D): Band based on (6^+).
[d] Band(E): Band based on (3^-). Conflicting J^π assignments are proposed for the bandhead at 2340 keV in the two reactions: 4^+ in (^{32}S,αpnγ) and $3^{(-)}$ in (p,nγ). Further work is needed to resolve the discrepancy.
[e] Band(F): Band based on (8^-).

$\gamma(^{50}Mn)$

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[a]	δ[a]	Comments
651.06	1^+	650.94 *8*	100	0.0	0^+	M1		E_γ: weighted average of 650.99 *6* from ^{50}Fe ε decay (152.0 ms) and 650.8 *1* from (p,nγ).
659.17	(6^+)	434.0[@] *1*	100	225.28	5^+			
800.20	2^+	149.1 *1*	100 *9*	651.06	1^+	(M1)		E_γ: weighted average of 149.0 *1* from ^{50}Fe ε decay (152.0 ms), 149.2 *1* from (^{12}C,pnγ), and 149.2 *1* from (p,nγ). Mult.: ΔJ=1, dipole from DCO in (^{32}S,αpnγ); ΔJ^π requires M1. δ(Q/D)=+0.02 *3* from $\gamma\gamma(\theta)$ in (p,nγ). I_γ: from ^{50}Fe ε decay. Others: 100 *30* from (^{28}Si,αpnγ), 100 *2* from 2000Sc35 and 100 from (1971Ki17) in (p,nγ).
		799.9 *2*	64 *8*	0.0	0^+	E2		B(E2)(W.u.)=13.9 *+24−22* E_γ: weighted average of 799.6 *2* from ^{50}Fe ε decay (152.0 ms) and 800.0 *1* from (p,nγ). I_γ: from ^{50}Fe ε decay. Others: 60 *30* from (^{28}Si,αpnγ), 56 *2* from 1971Ki17 in (p,nγ), but 156 *3* from 2000Sc35 in (p,nγ) is in disagreement.
1030.55	(7^+)	371.4[@] *1*	15 *3*	659.17	(6^+)			I_γ: weighted average of 17.6 *24* from (^{28}Si,αpnγ) and 12 *3* from (^{12}C,pnγ).
		805.4 *1*	100 *2*	225.28	5^+	(Q)[b]		E_γ: weighted average of 805.4 *1* from (^{12}C,pnγ) and 805.1 *5* from (p,nγ). I_γ: from (^{12}C,pnγ). Other: 100.0 *24* from (^{28}Si,αpnγ).
1143.28	3^+	343.0 *1*	100 *2*	800.20	2^+	M1(+E2)	+0.01 *2*	B(M1)(W.u.)=1.7 *5* Mult.: also ΔJ=1,D from DCO in (^{32}S,αpnγ).
		492.0 *1*	1.2 *1*	651.06	1^+	[E2]		B(E2)(W.u.)=64 *+30−21*
1727.36	1^-	927.1 *1*	49.5 *12*	800.20	2^+	D(+Q)	+0.05 *10*	
		1727.4 *2*	100.0 *23*	0.0	0^+	E1		
1765.4	$(3^+$ to $7^+)$	1540.1 *5*	100	225.28	5^+			
1797.91	(3^+)	997.7 *1*	100	800.20	2^+	D(+Q)	−0.12 *10*	
		1572.9[d] *5*		225.28	5^+			
1874.60	$2^{(+)}$	731.2 *2*	34.4 *10*	1143.28	3^+	D[c]		
		1074.4 *1*	31 *1*	800.20	2^+	(M1+E2)	−3.7 *+4−5*	Mult.: D+Q from $\gamma\gamma(\theta)$ in (p,nγ); polarity from level scheme.
		1223.6 *1*	100.0 *24*	651.06	1^+	D(+Q)	−0.01 *2*	

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Adopted Levels, Gammas (continued)

γ(^{50}Mn) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[a]	δ[a]	Comments
1874.60	2(+)	1874.4 *2*	50.0 *15*	0.0	0+			
1917.11	5+	773.6 *1*	100 *5*	1143.28	3+	E2		Mult.: ΔJ=2, Q from DCO in (^{32}S,αpnγ); RUL.
		886.7[@] *1*	35[@] *5*	1030.55	(7+)			
		1258.0[@] *1*	22[@] *5*	659.17	(6+)			
1931.53	4+	788.0 *1*	100 *3*	1143.28	3+	(M1(+E2))	−0.01 *2*	Mult.: D from DCO in (^{32}S,αpnγ), M1(+E2) from ΔJ^π.
		1131.2 *2*	5.9 *8*	800.20	2+	E2		B(E2)(W.u.)>15 Mult.: Q from γγ(θ) in (p,nγ); M2 ruled out by RUL.
2119.81	(8+)	1089.3[@] *2*	100[@] *12*	1030.55	(7+)			
		1460.6[@] *2*	90[@] *20*	659.17	(6+)	(Q)[b]		
2157.59	(1+ to 5+)	1014.3 *1*	100	1143.28	3+			
2300.72	(0+ to 4+)	1500.5 *1*	100	800.20	2+			
2340.11	(3−)	612.5 *2*	13.1 *14*	1727.36	1−			
		1540.2 *2*	100 *3*	800.20	2+	D+Q	−0.13 *4*	
2403.87	1+	1603.7[&] *2*	16.1[&] *20*	800.20	2+			
		2403.8[&] *1*	100[&] *5*	0.0	0+			
2477.93	(3)	1677.7 *1*	100	800.20	2+	D(+Q)	+0.01 *6*	
2534.26	(9+)	1503.7[@] *2*	100	1030.55	(7+)	(E2)		B(E2)(W.u.)=12.9 *+24−17* Mult.: (Q) from DCO ratio and γ(θ) in ^{28}Si(^{28}Si,αpnγ); M2 ruled out by RUL.
2556.98	(5+)	625.2 *1*	100 *3*	1931.53	4+	D[c]		
		1413.9 *1*	52 *2*	1143.28	3+			
		1897.9[@] *3*	81[@] *3*	659.17	(6+)			
2614.6	(0 to 3−)	887.2 *4*	100	1727.36	1−			
2684.23	1+	1883.8[&] *2*	10[&] *3*	800.20	2+			
		2684.2[&] *1*	100[&] *7*	0.0	0+			
2716.16	(4+)	841.6 *1*	100 *4*	1874.60	2(+)	Q[c]		
		1572.8 *1*	7.6 *4*	1143.28	3+			
2980.12	(0 to 3+)	2329.0 *2*	100	651.06	1+			
3256.1	(6+)	1339.0[@] *10*	100[@]	1917.11	5+	D[c]		
3370.11	(5−)	1030.0 *1*		2340.11	(3−)	Q[c]		
		1437[‡]		1931.53	4+			Mult.: ΔJ=2, Q from DCO in (^{32}S,αpnγ). Conflicting assignment if J^π(3370 level)=5−.
3380.12	1+	3380.0[&] *1*	100	0.0	0+			
3438.76	(2+ to 6+)	1507.2 *1*	100	1931.53	4+			
3477.66	(0+ to 3−)	1603.0 *1*	100 *6*	1874.60	2(+)			
		1750.3 *1*	99 *6*	1727.36	1−			
3561.94		1261.2 *2*	100	2300.72	(0+ to 4+)			
3638.12	(2+ to 5+)	1706.5 *2*	29 *2*	1931.53	4+			
		2494.9 *3*	100 *6*	1143.28	3+			
3643.5	1+	3643.4[&] *3*	100	0.0	0+			
3723.1	(3,4,5−)	1383		2340.11	(3−)			
4012.9	1+	4012.7[&] *12*	100	0.0	0+			

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Adopted Levels, Gammas (continued)

γ(^{50}Mn) (continued)

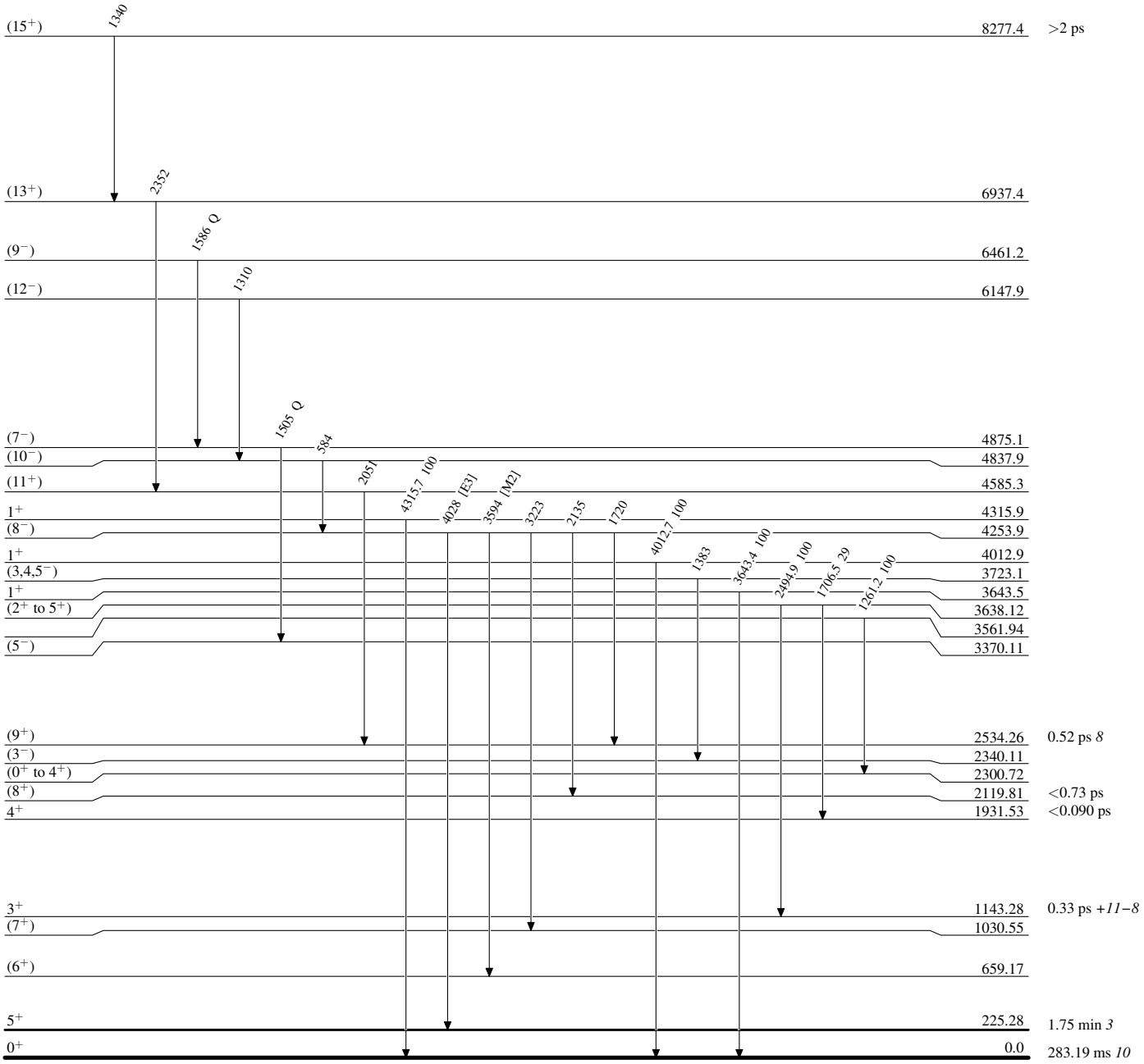
E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[a]
4253.9	(8$^-$)	1720[‡]		2534.26	(9$^+$)	
		2135[‡]		2119.81	(8$^+$)	
		3223[‡]		1030.55	(7$^+$)	
		3594[#]		659.17	(6$^+$)	[M2]
		4028[#]		225.28	5$^+$	[E3]
4315.9	1$^+$	4315.7[&] *14*	100	0.0	0$^+$	
4585.3	(11$^+$)	2051[‡]		2534.26	(9$^+$)	
4837.9	(10$^-$)	584[‡]		4253.9	(8$^-$)	
4875.1	(7$^-$)	1505[‡]		3370.11	(5$^-$)	Q[c]
6147.9	(12$^-$)	1310[‡]		4837.9	(10$^-$)	
6461.2	(9$^-$)	1586[‡]		4875.1	(7$^-$)	Q[c]
6937.4	(13$^+$)	2352		4585.3	(11$^+$)	
8277.4	(15$^+$)	1340		6937.4	(13$^+$)	

† From ^{50}Cr(p,nγ), except as noted.
‡ From ^{24}Mg(^{32}S,αpnγ).
# From ^{28}Si(^{28}Si,αpnγ) only.
@ From ^{40}Ca(^{12}C,pnγ).
& From ^{50}Fe ε decay.
[a] From γγ(lin pol) and γγ(θ) data in ^{50}Cr(p,nγ), unless stated otherwise.
[b] From DCO ratio and γ(θ) in ^{28}Si(^{28}Si,αpnγ).
[c] From DCO ratio in ^{24}Mg(^{32}S,αpnγ).
[d] Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level

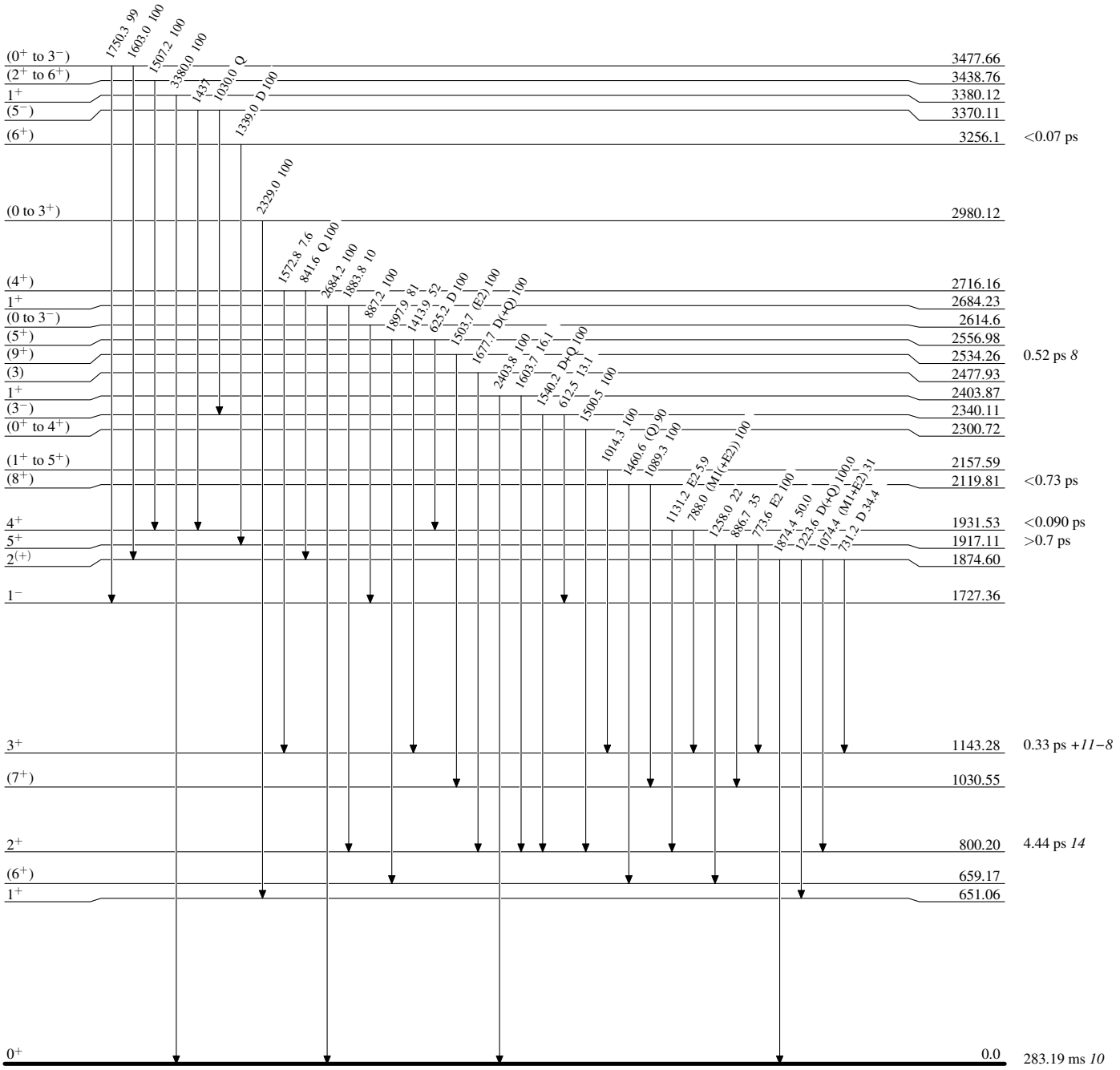


$^{50}_{25}Mn_{25}$

Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level



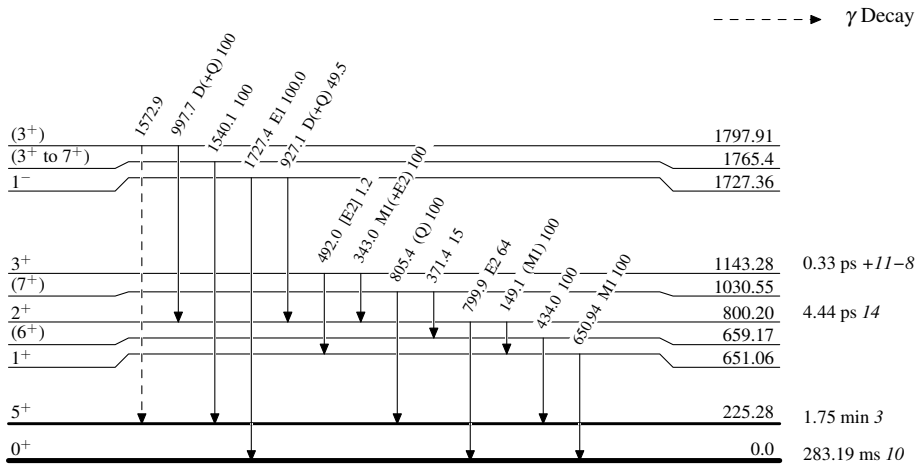
$^{50}_{25}Mn_{25}$

Adopted Levels, Gammas

Legend

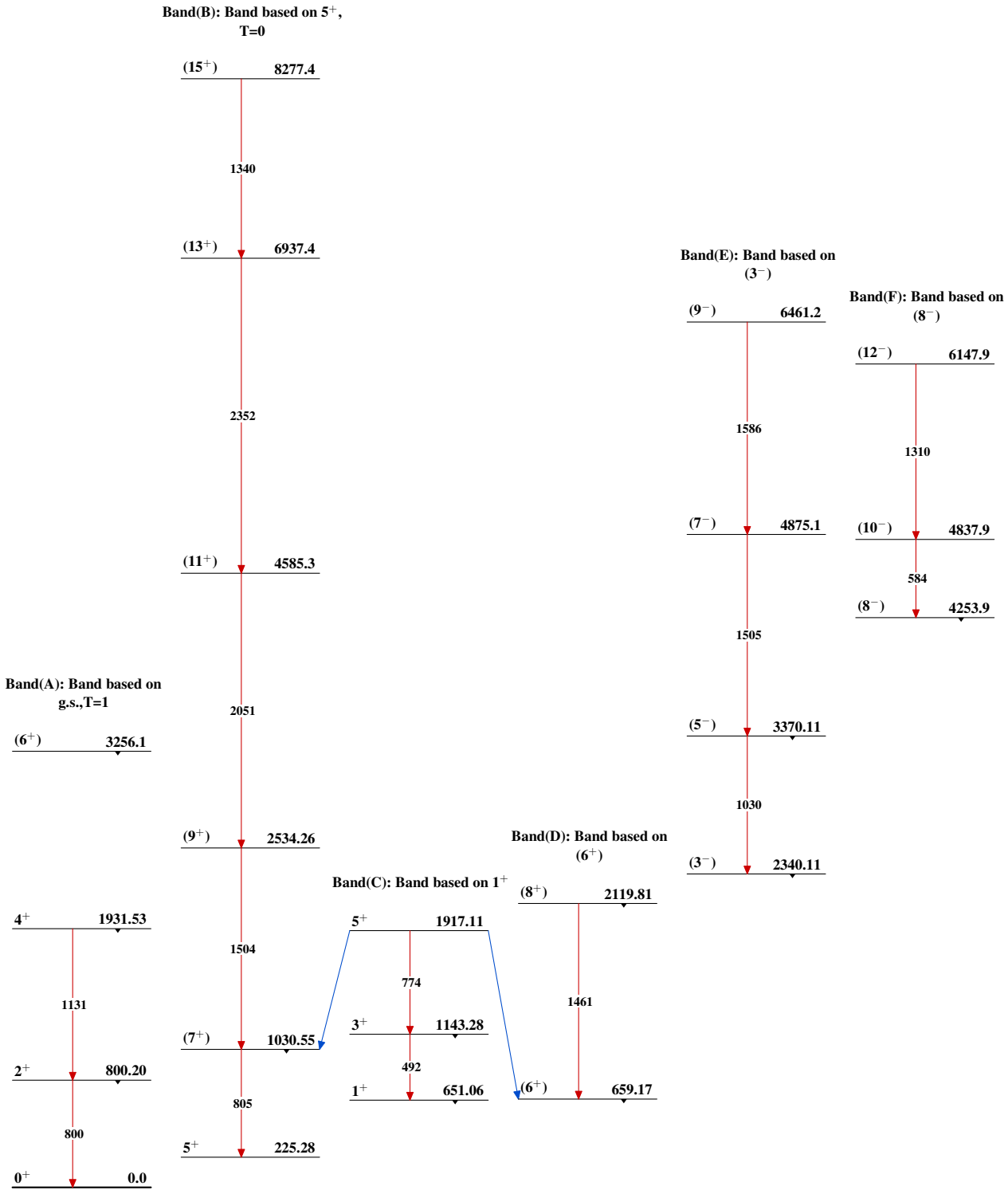
Level Scheme (continued)

Intensities: Relative photon branching from each level



$^{50}_{25}Mn_{25}$

Adopted Levels, Gammas



$^{50}_{25}Mn_{25}$