^{40}Ca(α,γ) E=res 1977Di07,1971Si13

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen and Balraj Singh	NDS 190,1 (2023)	20-Jun-2023

Also includes resonances based on γ-ray data in 1977Di07 and 1974Pe13.

1977Di07, 1971Si13 (also 1969Si14, 1972Si34, 1973Di04, 1973Si28, 1976Di06, 1978Di11, 1980Di14, 1981Di09, 1982Di05): E=3.8-6.0 MeV α beam produced at the 4-MV Van de Graaff generator of NRC, Ottawa. A $^{40}CaCO_3$ isotopically enriched target prepared by evaporation on a gold backing. NaI(Tl) and Ge(Li) detectors. Measured Eγ, Iγ, $\gamma(\theta)$, $\gamma\gamma$-coin. Deduced levels, J^π, branching ratios, mixing ratios, resonance strengths, half-lives using Doppler Shift Attenuation Method (DSAM). 1977Di07 also report resonances up to E(level)=10520 based on γ-ray data.

2013Sc16 (also 2014Sc05): E=4.5 MeV alpha beam was produced from the 3-MV Tandetron at Helmholtz-Zentrum, Dresden-Rossendorf bombarded a 36 μg/cm^2 $Ca(OH)_2$ target that was deposited on 0.22 mm Ta backing. Prompt gamma rays were detected by two HPGe detectors and the escape suppression was done with a BGO detector. The γ rays from the activated target were detected with a p-type HPGe detector in the Felsenkeller underground facility. Effective stopping power and target properties were determined by elastic recoil detection analysis and nuclear reactions. Measured Eγ, Iγ, yields, branching ratios. Deduced resonance energies, resonance strengths and reaction rates.

Others:

2007Vo06 (also 2007Vo03 and 2008Vo01): ^{4}He(^{40}Ca,γ), E=0.60-1.15 MeV/nucleon ^{40}Ca beam, covering the energy range of astrophysics interest, produced from the off-line ion source of the ISAC facility at TRIUMF and separated in the recoil mass spectrometer DRAGON. High efficiency BGO detectors. Measured γ-ray yields. Deduced resonance strengths for known resonances.

1977Co12: E=2.75-4.0 MeV alpha beam produced from the CSULA 4-MV Van de Graaff accelerator. A target of natural calcium metal evaporated on tantalum backings. A 10% efficient coaxial Ge(Li) counter for detecting γ-rays. Measured Eγ, Iγ, $\gamma(\theta)$. Deduced levels, J^π, branching ratios, resonance strengths.

1974Pe13: E=6.5-17.5 MeV alpha beam produced from the MP tandem accelerator of the Wright Nuclear Structure Laboratory (WNSL) at Yale University. 0.75-1.5 mg/cm^2 ^{40}Ca targets prepared by evaporation of natural calcium onto gold foils. A 29.2 cm by 30.5 cm NaI(Tl) crystal for detecting γ-rays. Measured Eγ, Iγ, $\gamma(\theta)$. Deduced levels, J^π.

1967Ve07, 1968Ve10: first experimental study of excited states in ^{44}Ti.

Yield measurements, and ^{44}Ti atom counting, including counting activity from supernova, and astrophysical reaction rates: 2000Hu16, 2003Pa34, 2005Na30, 2006Na02.

^{44}Ti Levels

E(α)(lab) under comments are from 1977Di07, unless otherwise noted.

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$[&]	Comments
0.0[h]	0$^+$		
1082.9[h] *1*	2$^+$	3.1 ps *8*	
1904.3[i] *3*	0$^+$	>0.5 ps	
2454.1[h] *3*	4$^+$	0.42 ps *7*	J$^\pi$: while spin=4 is favored, spin=3 is not completely ruled out by $\gamma(\theta)$ (1971Si13).
2530.6[i] *2*	2$^+$	0.97 ps *14*	
2886.6[j] *4*	2$^+$	0.35 ps *7*	
3175.7[k] *4*	3$^{(-)}$	>2 ps	J$^\pi$: spin from $\gamma(\theta)$ data (1981Di09); parity is required to be the same as that for 3646 level (1981Di09) and the long lifetime favors negative parity over positive parity (1977Di07).
3364[i] *1*	(4$^+$)	0.36 ps *7*	J$^\pi$: 1977Di07 suggested a band structure for 1904, 2531 and 3364 levels and assigned 4$^+$ to this level; parentheses added by the evaluators. T$_{1/2}$: weighted average of 0.42 ps *14* from DSAM and 0.35 ps *7* from line shape (1977Di07).
3415.3[j] *3*	(3$^+$)	0.49 ps *7*	J$^\pi$: (2,3) from $\gamma(\theta)$ in 1971Si13 and 1977Di07; J^π=3$^+$ is proposed in 1977Di07 assuming this level has unnatural parity due to non-observation in particle transfer reaction.
3645.8[k] *4*	4$^{(-)}$		J$^\pi$: spin from $\gamma(\theta)$ in 1981Di09; parity is required to be the same as that for 3176 level (1981Di09).

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^{40}Ca(α,γ) E=res 1977Di07,1971Si13 (continued)

^{44}Ti Levels (continued)

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$[&]	$\omega\gamma$ (eV)[a]	Comments
3755.9 *4*	2$^+$	0.17 ps *4*		E(level): from 1977Di07 and 1978Di11. J$^\pi$: spin from $\gamma(\theta)$ in 1977Di07.
3942.7 *3*	3$^-$[#]	0.8 ps *2*		
3980[j] *1*	4$^+$[#]	0.35 ps *14*		
4015.2[h] *4*	6$^+$	0.39 ps *6*		J$^\pi$: spin=6 not 5 is supported by $\gamma(\theta)$ in 1977Di07.
4060.5[k] *4*	(5$^-$)	1.5 ps *+13−5*		J$^\pi$: (3$^-$,5$^-$) from $\gamma(\theta)$ of 1606γ and primary transitions from (α,γ) resonance at 9908; 5$^-$ is favored by 1977Di07. See also J$^\pi$ comments for the 9908 level.
4116.5 *10*	2$^+$	111 fs *49*		J$^\pi$: spin from primary 5582$\gamma(\theta)$ from 9698 resonance level in 1977Di07.
4227 *1*	(2$^-$,3$^-$)			J$^\pi$: suggested in 1977Di07 from γ decays to 3176 and 3646 levels.
4792.2 *5*		0.35 ps *14*		
5305 *2*		0.35 ps *14*		
5423 *5*				
6600 *10*				T=(1) E(level): from 1972Si34. T: from 1972Si34.
7216[c] *2*	1$^+$			T=1 E(level): from 1972Si34. J$^\pi$: possible analog of (1$^+$;T=1) state at 669 keV in ^{44}Sc (1972Si34). $\gamma(\theta)$ of 7216γ to 0$^+$ is isotropic; primary γ from 0$^+$ resonances at 9298 and 9338. T: from 1972Si34.
7634[b] *20*			0.013 *3*	J$^\pi$: π=natural for (α,γ) resonance (1977Co12).
8067[b] *20*			0.022 *4*	J$^\pi$: π=natural for (α,γ) resonance (1977Co12).
8318[b] *5*			0.12 *2*	J$^\pi$: π=natural for (α,γ) resonance (1977Co12).
8385[b] *5*	2$^+$[@]		0.52 *10*	
8416[b] *5*	(0$^+$,1$^-$)[@]		0.33 *7*	
8449[b] *5*	2$^+$[@]		0.28 *6*	
8511[b] *5*	2$^+$[@]		0.22 *4*	
8534[b] *5*	(2$^+$,3$^-$)[@]		0.33 *7*	
8565 *5*	2$^+$[@]		0.11 *2*	E(α)(lab)=3790. E(level): from 1977Di07 and 1977Co12.
8627 *6*	2$^+$[@]		0.08 *2*	E(α)(lab)=3860. E(level): from 1977Di07 and 1977Co12.
8639[b] *6*	2$^+$[@]		0.23 *5*	
8754 *3*	2$^+$[@]		0.33 *7*	E(α)(lab)=4000. E(level): from 1977Di07 and 1977Co12. J$^\pi$: other: (1,2) from 1977Di07.
8946 *3*			0.11 *2*	E(α)(lab)=4210.
8954 *3*	1$^-$		0.22 *4*	E(α)(lab)=4220. $\omega\gamma$ (eV): from 1981Di09, 0.6 eV *1* from 1977Di07.
8960[e] *3*	(3$^-$,4$^+$)		0.40 *8*	E(α)(lab)=4220. J$^\pi$: spin from $\gamma(\theta)$ in 1981Di09; parity=natural for (α,γ) resonance, with 2$^+$ rejected. $\omega\gamma$ (eV): from 1981Di09.
8987 *2*	2$^+$		0.30 *6*	E(α)(lab)=4257.
8992 *2*	4$^+$		0.6 *1*	E(α)(lab)=4263.
9073[g] *5*				E(α)(lab)=4350.
9100[g] *5*				E(α)(lab)=4380.
9120[g] *5*				E(α)(lab)=4400.

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^{40}Ca(α,γ) E=res 1977Di07,1971Si13 (continued)

^{44}Ti Levels (continued)

E(level)[†]	J$^\pi$[‡]	$\omega\gamma$ (eV)[a]	Comments
9140 *5*			E(α)(lab)=4420.
9180 *5*			E(α)(lab)=4470.
9215[d] *2*	2$^+$	0.71 *21*	T=0 E(α)(lab)=4510. J$^\pi$: spin from $\gamma(\theta)$ in 1980Di14. T: from 1980Di14. $\omega\gamma$ (eV): weighted average of 0.5 *1* (1980Di14) and 0.92 *20* (2013Sc16).
9227 *2*	2$^+$	6.2 *5*	T=1 E(α)(lab)=4520. E(level): from 1977Di07 and 1980Di14. T: from 1980Di14. $\omega\gamma$ (eV): weighted average of 6 *1* (1977Di07) and 6.2 *5* (2013Sc16).
9239[d] *2*	2$^+$	1.5 *3*	T=0 J$^\pi$: from $\gamma(\theta)$ in 1980Di14. T: from 1980Di14. $\omega\gamma$ (eV): weighted average of 2.0 *4* (1980Di14) and 1.32 *24* (2013Sc16).
9290[g] *5*			E(α)(lab)=4590.
9294[c] *2*			E(level): possible doublet with 9298 keV level (1978Di11).
9298[c] *2*	0$^+$[#]	0.112 *25*	T=2 $\omega\gamma$ (eV): from 1978Di11. T: from 1978Di11. Isospin-mixed doublet with the 9338 keV level. Possible isospin mixture of T=0 and 1. %α=87 *20*, %p<6 (1978Fr10). See 1978Fr10 (also 1976Fr01 and 1979Fr04) for measurement of α/γ decay branching ratio in (p,t).
9338 *2*	0$^+$[#]	0.24 *5*	T=2 E(α)(lab)=4640. E(level): from 1972Si34, 1977Di07 and 1978Di11. See 1978Fr10 (also 1976Fr01 and 1979Fr04) for measurement of α/γ decay branching ratio in (p,t). $\omega\gamma$ (eV): from 1978Di11. T: from 1972Si34. Possible isospin mixture of T=0 and 1. Γ_α=0.36 eV *8* and Γ_γ=0.77 eV *20* (1978Di11) from measured $\omega\gamma$ in 1978Di11 and Γ_α/Γ=0.32 *5* (1978Fr10).
9361 *3*	(2$^+$,3$^-$)	1.2 *3*	E(α)(lab)=4670.
9388[g] *5*			E(α)(lab)=4700.
9427[g] *5*	(4$^+$)	0.9 *3*	E(α)(lab)=4740. J$^\pi$: proposed in 1977Di07.
9478[g] *5*			
9500[g] *10*			E(α)(lab)=4820.
9542[g] *5*			E(α)(lab)=4870.
9589[g] *5*			E(α)(lab)=4920.
9632[g] *10*			E(α)(lab)=4970.
9668[g] *10*			E(α)(lab)=5000.
9698 *5*	2$^+$		E(α)(lab)=5040.
9713 *3*	4$^+$	2.5 *5*	E(α)(lab)=5060.
9737[g] *5*			E(α)(lab)=5080.
9873[g] *10*			E(α)(lab)=5230.
9895[g] *5*			E(α)(lab)=5260.
9908 *3*	(3$^-$,5$^-$)	1.9 *4*	J$^\pi$: $\gamma(\theta)$ of transitions to 3176, 3646 and 4061 levels is consistent with J(9908)=(3,5), J(4061)=3 or 5, J(3646)=4 and J(3176)=3; and with J(9908)=(2,4), J(4061)=4, J(3646)=3, and J(3176)=2 (1977Di07). E(α)(lab)=5270.
10014[g] *10*			E(α)(lab)=5380.
10046[g] *10*			E(α)(lab)=5420.

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^{40}Ca(α,γ) E=res 1977Di07,1971Si13 (continued)

^{44}Ti Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	$\omega\gamma$ (eV)[a]	Comments
10129[g] *10*	(1$^-$,2$^+$)		E(α)(lab)=5510.
10166[g] *10*			E(α)(lab)=5550.
10209[g] *5*	(0$^+$,1$^-$,2$^+$)		E(α)(lab)=5600.
10258[g] *10*			E(α)(lab)=5650.
10303[g] *5*			E(α)(lab)=5700.
10327[g] *5*			E(α)(lab)=5730.
10386 *6*	(2$^+$,3$^-$)	5 *1*	E(α)(lab)=5800.
10461[g] *10*			E(α)(lab)=5880.
10520[g] *10*			E(α)(lab)=5940.
12.20×10^3[f] *20*			J$^{\pi}$: 1974Pe13 propose (1$^-$).
13.00×10^3[f] *19*			J$^{\pi}$: 1974Pe13 propose (1$^-$).
14.10×10^3[f] *18*			J$^{\pi}$: 1974Pe13 propose (3$^-$).
14.55×10^3[f] *17*			J$^{\pi}$: 1974Pe13 propose (1$^-$).
15.45×10^3[f] *16*			
15.95×10^3[f] *16*			J$^{\pi}$: 1974Pe13 propose (3$^-$).

[†] From 1977Di07 based on Eγ data, unless otherwise noted. For resonances, energies can be also obtained from E(α)(c.m.)+S(α) with S(α)=5127.1 *7* (2021Wa16). Levels up to 5423 correspond to bound states.

[‡] Spin from $\gamma(\theta)$ in 1971Si13 up to 9227 level and from 1977Di07 above this level, unless otherwise noted; parity deduced from experimental γ transition strengths compared with RUL, natural parity for (α,γ) resonances or systematics where applicable.

[#] From the Adopted Levels.

[@] Spin from $\gamma(\theta)$ in 1977Co12 and parity=natural for (α,γ) resonance.

[&] From 1977Di07 using DSAM, unless otherwise noted.

[a] Resonance strength $\omega\gamma=(2J+1)(\Gamma_\alpha\Gamma_\gamma/\Gamma)$, from 1977Co12 for resonances below 8756 and from 1977Di07 for resonances above this energy, unless otherwise noted.

[b] For E(α)=2.75-4.0 MeV (1977Co12).

[c] For E(α)=4.0-10.5 MeV (1978Di11).

[d] For E(α)=4.0-10.5 MeV (1980Di14).

[e] For E(α)=4.0-10.5 MeV (1981Di09).

[f] For E(α)=8.2-11.5 MeV (1974Pe13).

[g] Decay γ not reported.

[h] Band(A): Ground-state band. Assignment from 1973Si28.

[i] Band(B): Band based on excited 0$^+$. Assignment from 1973Si28.

[j] Seq.(C): γ cascade based on 2886.6, 2$^+$. Assignment from 1973Si28.

[k] Seq.(D): γ cascade based on 3175.7, 3$^{(-)}$. Assignment from 1973Si28.

^{40}Ca(α,γ) E=res 1977Di07,1971Si13 (continued)

$\gamma(^{44}Ti)$

E_i(level)	J_i^π	E_γ[†]	I_γ[#]	E_f	J_f^π	Mult.[‡]	δ[‡]	Comments
1082.9	2^+	1082.9 *1*	100	0.0	0^+	E2		A_2=+0.018; A_4=+0.289 (1971Si13) Mult.: ΔJ=2 from $\gamma(\theta)$ in 1971Si13; M2 ruled out by RUL. B(E2)(W.u.)=13 *4* (1973Di04).
1904.3	0^+	821.3 *8*	100	1082.9	2^+			$\gamma(\theta)$ consistent with J(1904)=0 (1971Si13).
2454.1	4^+	1371	100	1082.9	2^+	E2(+M3)	+0.07 *+20−12*	Mult.,δ: δ(O/Q) from $\gamma(\theta)$ for J(2454)=4 (1971Si13); M2(+E3) ruled out by RUL. Other: δ(Q/D)=+0.42 *+12−9* for J(2454)=3. B(E2)(W.u.)=30 *6* for pure E2 (1973Di04).
2530.6	2^+	626	5 *1*	1904.3	0^+	E2		Mult.: ΔJ=2 from $\gamma(\theta)$ in 1971Si13; M2 ruled out by RUL. B(E2)(W.u.)=23 (1971Si13), 24 *6* (1973Di04).
		1447.68 *12*	100	1082.9	2^+	E2+M1	−7.5 *+25−80*	Mult.,δ: δ(D+Q) with ΔJ=0 from $\gamma(\theta)$ in 1971Si13; E1+M2 ruled out by RUL. B(E2)(W.u.)=6.5 (1971Si13), 7.0 *13* (1973Di04).
		2531	35 *7*	0.0	0^+	E2		Mult.: ΔJ=2 from $\gamma(\theta)$ in 1971Si13; M2 ruled out by RUL. B(E2)(W.u.)=0.14 (1971Si13), 0.15 *+50−20* (1973Di04).
2886.6	2^+	982	5 *3*	1904.3	0^+	[E2]		B(E2)(W.u.)<28 (1973Di04).
		1803	43 *14*	1082.9	2^+			B(E2)(W.u.)≤3.4 *+20−14* (1973Di04).
		2886.1 *6*	100 *14*	0.0	0^+	E2		Mult.: ΔJ=2 from $\gamma(\theta)$ in 1971Si13; M2 ruled out by RUL. B(E2)(W.u.)=0.75 *+40−20* (1973Di04).
3175.7	$3^{(-)}$	645	<1	2530.6	2^+			
		721	2 *1*	2454.1	4^+			
		2092.9 *8*	100 *2*	1082.9	2^+	(E1(+M2))	+0.01 *4*	Mult.,δ: D(+Q) from $\gamma(\theta)$ in 1981Di09; δ=+0.15 *10* in authors′ previous 1977Di07 work. Δπ=(yes) from level scheme. Other δ=−4.3 *7* or −3.6 *10* (1981Di09) implying large M2 admixtures are unlikely from RUL. 1981Di09 give δ values of −1.3 and −1.0 for other spin sequences which have been rejected.
		3175	1.0 *5*	0.0	0^+	[E3]		B(E3)(W.u.)<15 (1977Di07).
3364	(4^+)	833	5 *2*	2530.6	2^+			
		2281	100 *2*	1082.9	2^+			
3415.3	(3^+)	529	2.2 *5*	2886.6	2^+			
		885	<1.5	2530.6	2^+			
		2332	100.0 *5*	1082.9	2^+	D+Q		δ: δ=+2.3 *+40−12* for J(3415)=2 and $\|\delta\|$>11 for J(3415)=3 (1977Di07); revised values of their previous results in 1971Si13, with δ=+1.6 *+12−6* for J(3415)=2, and >+6 or +0.4 *+10−9* for J(3415)=3; second result for J=3 ruled out in 1977Di07. $\gamma(\theta)$ consistent with J(3415)=2 or 3 (1971Si13,1977Di07).
3645.8	$4^{(-)}$	470	100	3175.7	$3^{(-)}$	(E2+M1)		Mult.,δ: D+Q from $\gamma(\theta)$ in 1981Di09; δ=−4.2 *8* for J(8960)=3; −5.7 *14* for J(8960)=4. Other: −4.4 for J(3646)=4, −3.8 for J(3646)=3 in earlier 1977Di07 paper. Δπ=(no) from level scheme. 1981Di09 give δ values of −3.1 *20*, −3.8 *4*, and −4.6 *10* for other spin sequences which have been rejected.
		1191	4.2 *21*	2454.1	4^+			
		2563	<1	1082.9	2^+			

$^{44}_{22}Ti_{22}$-5

^{40}Ca(α,γ) E=res 1977Di07,1971Si13 (continued)

$\gamma(^{44}Ti)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[#]	E_f	J_f^π	Mult.[‡]	Comments
3755.9	2^+	1852	<6	1904.3	0^+		
		2673	39 *7*	1082.9	2^+		
		3756	100 *7*	0.0	0^+	E2	$\gamma(\theta)$ in 1977Di07 consistent with J(3756)=2; M2 ruled out by RUL.
3942.7	3^-	767	<2	3175.7	$3^{(-)}$		
		1412	<2.1	2530.6	2^+		
		1489	5 *2*	2454.1	4^+	[E1]	δ(Q/D)≈0 (1977Di07). B(E1)(W.u.)<1×10^{-5} (1977Di07).
		2859	100 *3*	1082.9	2^+	[E1]	δ(Q/D)≈0 (1977Di07). B(E1)(W.u.)<2.6×10^{-5} (1977Di07).
3980	4^+	565	8 *4*	3415.3	(3^+)		
		804	8 *6*	3175.7	$3^{(-)}$		
		1094	48 *10*	2886.6	2^+		
		1526	29 *10*	2454.1	4^+		
		2897	100 *15*	1082.9	2^+		
4015.2	6^+	1561	100	2454.1	4^+		ratio of intensities at 0° to 90° consistent with J(4015)=6 but not J=5 (1977Di07).
4060.5	(5^-)	885	100 *10*	3175.7	$3^{(-)}$		δ: |δ|<2.0 for J(4061)=3; 0 for J(4061)=5 or 4 (1977Di07). B(E2)(W.u.)<40 for J^π=3$^-$ or 5$^-$ (1977Di07).
		1606	100 *10*	2454.1	4^+	[E1]	$\gamma(\theta)$ from 1977Di07 is consistent with J(4061)=3,4,5. δ: +0.15 *10* for J(4061)=3, |δ|>0.5 for J(4061)=4, |δ|<0.1 for J(4061)=5 (1977Di07). B(E1)(W.u.)<5×10^{-5}, B(M2)(W.u.)<5 for J^π=3$^-$ or B(M2)(W.u.)<1 for J^π=5$^-$ (1977Di07).
		2978[c]	<4	1082.9	2^+		
4116.5	2^+	1230	11 *11*	2886.6	2^+		
		1585	47 *11*	2530.6	2^+		
		2212	<11	1904.3	0^+		
		3033	100 *16*	1082.9	2^+		
		4117	64 *11*	0.0	0^+		
4227	$(2^-,3^-)$	581	26 *12*	3645.8	$4^{(-)}$		
		812	15 *9*	3415.3	(3^+)		
		1051	100 *12*	3175.7	$3^{(-)}$		
		1341	85 *12*	2886.6	2^+		
		1696	50 *12*	2530.6	2^+		
		3144	18 *9*	1082.9	2^+		
4792.2		1036	4 *2*	3755.9	2^+		
		1617	6 *2*	3175.7	$3^{(-)}$		
		1906	3 *2*	2886.6	2^+		
		3709	100 *3*	1082.9	2^+		
5305		4222	100	1082.9	2^+		
5423		4340	100	1082.9	2^+		
7216	1^+	5312	3[a] *1*	1904.3	0^+		
		6133	1.0[a] *5*	1082.9	2^+		

$^{44}_{22}Ti_{22}$-6

^{40}Ca(α,γ) E=res 1977Di07,1971Si13 (continued)

$\gamma(^{44}Ti)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[#]	E_f	J_f^π	Comments
7216	1^+	7216	100[a] *1*	0.0	0^+	$\gamma(\theta)$ is isotropic (1978Di11).
7634		5730	61[&] *32*	1904.3	0^+	
		7634	100[&] *32*	0.0	0^+	
8067		8067	100	0.0	0^+	
8318		5432	85[&] *19*	2886.6	2^+	
		7235	100[&] *19*	1082.9	2^+	
8385	2^+	5499	100[&] *20*	2886.6	2^+	
		7302	40[&] *20*	1082.9	2^+	
		8385	60[&] *20*	0.0	0^+	
8416	$(0^+,1^-)$	7333	100	1082.9	2^+	
8449	2^+	5995	27[&] *13*	2454.1	4^+	
		7366	100[&] *13*	1082.9	2^+	
8511	2^+	7428	100	1082.9	2^+	
8534	$(2^+,3^-)$	7451	100	1082.9	2^+	
8565	2^+	5200	32[&] *16*	3364	(4^+)	
		6034	29[&] *16*	2530.6	2^+	
		7482	100[&] *16*	1082.9	2^+	
8627	2^+	7544	100	1082.9	2^+	
8639	2^+	7556	100[&] *13*	1082.9	2^+	
		8639	33[&] *13*	0.0	0^+	
8754	2^+	6223	18[@]	2530.6	2^+	
		7671	64[@]	1082.9	2^+	
		8754	100[@]	0.0	0^+	
8946		6415	82[@] *13*	2530.6	2^+	I_γ: 92 *14* from 1981Di09.
		7863	100[@] *13*	1082.9	2^+	I_γ: 100 *14* from 1981Di09. $\gamma(\theta)$ consistent with J(8954)=0 or 3 and J(1083)=2 (1971Si13).
8954	1^-	4727	20[b] *5*	4227	$(2^-,3^-)$	
		6068	24[b] *3*	2886.6	2^+	
		7049	100[b] *5*	1904.3	0^+	$\gamma(\theta)$ consistent with J(8954)=1 and J(1905)=2 or 0 (1971Si13). δ(Q/D)=+0.5 to +4.5 (1971Si13) for J(1905)=2.
		8954	8[b] *2*	0.0	0^+	$\gamma(\theta)$ consistent with J(8954)=1 (1971Si13).
8960	$(3^-,4^+)$	4899	9[b] *4*	4060.5	(5^-)	
		5017	19[b] *4*	3942.7	3^-	
		5204	7[b] *4*	3755.9	2^+	

$^{44}_{22}Ti_{22}$-7

^{40}Ca(α,γ) E=res 1977Di07,1971Si13 (continued)

$\gamma(^{44}Ti)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[#]	E_f	J_f^π	Mult.[‡]	δ[‡]	Comments
8960	(3$^-$,4$^+$)	5314	100[b] *4*	3645.8	4$^{(-)}$	D+Q		δ: −0.475 *52* or −0.091 *23* (1981Di09). δ: 1981Di09 give −0.091 *22* for J(8960)=2 and J(3646)=4; +0.169 *16* (not isoscalar M2/E1) for J(8960)=3 and J(3646)=2; +0.153 *16* (not isoscalar M2/E1) for J(8960)=4 and J(3646)=3; +0.200 *15* (not isoscalar M2/E1) for J(8960)=2 and J(3646)=1; −0.324 *23* (marginal M2/E1) for J(8960)=2 and J(3646)=2; −0.416 *35* (marginal M2/E1) for J(8960)=2 and J(3646)=2; −0.475 *54* (marginal M2/E1) for J(8960)=4 and J(3646)=4; −0.084 *24* for J(8960)=2 and J(3646)=3; −0.091 *22* for J(8960)=3 and J(3646)=4; −0.095 *22* for J(8960)=4 and J(3646)=5. Other: δ(Q/O)=+0.153 *25* for J(8960)=2 and J(3646)=4 (1981Di09) is inconsistent with M2 and M3 strengths deduced by authors which disfavors J=2 for 8960 level, thus rejected by 1981Di09. For recommended J^π=(3$^-$,4$^+$) for 8960 level and 4$^{(-)}$ for the 3646 level, two values of δ(Q/D) are: −0.475 *52* and −0.091 *23*.
		5596	12[b] *2*	3364	(4$^+$)			
		5784	58[b] *4*	3175.7	3$^{(-)}$	D+Q		δ: 1981Di09 give δ=−0.76 *40* (not isoscalar M2/E1) for J(8960)=2 and J(3176)=3; +0.041 *57* for J(8960)=3 and J(3176)=3; +0.44 *5* (not isoscalar M2/E1) for J(8960)=4 and J(3176)=3; +0.027 *37* for J(8960)=2 and J(3176)=2; +0.43 *5* (not isoscalar M2/E1) for J(8960)=3 and J(3176)=2; d=−0.61 *11* (not isoscalar M2/E1) for J(8960)=3 and J(3176)=4; +0.056 *80* for J(8960)=4 and J(3176)=4; δ=+0.44 *6* (not isoscalar M2/E1) for J(8960)=2 and J(3176)=1. For recommended J^π=(3$^-$,4$^+$) for 8960 level and 3$^{(-)}$ for the 3176 level, values of δ(Q/D) are: +0.041 *57* and +0.44 *5*.
		6506	22[b] *2*	2454.1	4$^+$			
8987	2$^+$	6456	60[@] *3*	2530.6	2$^+$	D+Q		δ: −0.29 *11* or +4.0 *+30−4* (1971Si13). $\gamma(\theta)$ consistent with J(8987)=2 and J(2531)=2 (1971Si13).
		6533	<16[@]	2454.1	4$^+$			
		7904	<16[@]	1082.9	2$^+$			
		8987	100[@] *3*	0.0	0$^+$			$\gamma(\theta)$ consistent with J(8987)=2 (1971Si13).
8992	4$^+$	6461	<9[@]	2530.6	2$^+$			
		6538	100[@] *6*	2454.1	4$^+$	D+Q	−0.64 *11*	Mult.,δ: from $\gamma(\theta)$ in 1971Si13 for J(2454)=4; δ=+0.09 *5* for J(2454)=3. Others: δ(O/Q)=+0.20 *7* for J(8992)=2 and J(2454)=4, −0.06 *6* for J(8992)=2 and J(2454)=3. $\gamma(\theta)$ consistent with J(8992)=4 and J(2454)=4 or 3 (1971Si13).
		7909	90[@] *6*	1082.9	2$^+$	Q(+O)	+0.02 *3*	δ: from $\gamma(\theta)$ in 1971Si13. Other: δ(Q/D)=+1.9 *+4−3* if J(8992)=2. $\gamma(\theta)$ consistent with J(8992)=2 or 4 and J(1083)=2 (1971Si13).
		8992[c]	<9[@]	0.0	0$^+$			
9140		6609		2530.6	2$^+$			
		9140		0.0	0$^+$			
9180		5238		3942.7	3$^-$			
		5535		3645.8	4$^{(-)}$			
		6005		3175.7	3$^{(-)}$			

$^{44}_{22}Ti_{22}$-8

^{40}Ca(α,γ) E=res 1977Di07,1971Si13 (continued)

$\gamma(^{44}Ti)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[#]	E_f	J_f^π	Mult.[‡]	δ[‡]	Comments
9180		6726		2454.1	4^+			
9215	2^+	5800	54 *7*	3415.3	(3^+)	D+Q		δ: −0.09 *17* for J(3415)=3 (1980Di14). I_γ: weighted average of 49 *5* (1980Di14) and 62 *6* (2013Sc16).
		6329	28 *5*	2886.6	2^+	D+Q		δ: −0.3 *2* or +3.7 *13* (1980Di14). I_γ: weighted average of 27 *5* (1980Di14) and 28 *5* (2013Sc16).
		6684	100 *5*	2530.6	2^+	D+Q	−0.07 *8*	δ: from 1980Di14. I_γ: other: 100 *12* (2013Sc16).
		7311	2.4 *12*	1904.3	0^+			
		8132	49 *10*	1082.9	2^+	D+Q		δ: −0.84 *25* or −11 *7* (1980Di14). I_γ: unweighted average of 39 *5* (1980Di14) and 59 *7* (2013Sc16).
		9215	31 *7*	0.0	0^+			I_γ: unweighted average of 24.0 *20* (1980Di14) and 38 *4* (2013Sc16).
9227	2^+	5812	51.1 *13*	3415.3	(3^+)	D+Q	−0.32 *+5−10*	δ: +0.01 *4* for J(3415)=3 (1980Di14); previous results in 1971Si13: −0.32 *+5−10* for J(3415)=2, −0.09 *7* for J(3415)=3. I_γ: weighted average of 51 *5* (1980Di14) and 51.1 *13* (2013Sc16).
		6341	16.8 *7*	2886.6	2^+	D+Q	+1 *+0−1*	I_γ: weighted average of 18 *5* (1980Di14) and 16.8 *7* (2013Sc16). δ: 0<δ<+1 (1980Di14). $\gamma(\theta)$ consistent with J(9227)=2 and J(2886)=2 (1971Si13).
		6696	100.0 *15*	2530.6	2^+	D+Q	+0.03 *4*	δ: from 1980Di14. Other: +0.02 *4* (1971Si13). $\gamma(\theta)$ consistent with J(9227)=2 and J(2531)=2 or 3 (1971Si13). I_γ: from 2013Sc16. Other: 100 *5* (1980Di14).
		7323	<2	1904.3	0^+			I_γ: from 1980Di14.
		8144	46.9 *11*	1082.9	2^+	D+Q	−0.08 *5*	I_γ: weighted average of 51 *5* (1980Di14) and 46.7 *11* (2013Sc16). δ: from 1980Di14 for J(9227)=2. Other: +0.02 *7* (1971Si13). $\gamma(\theta)$ consistent with J(9227)=2 or 3 (1971Si13).
		9227	1.50 *18*	0.0	0^+			I_γ: weighted average of 1.3 *5* (1980Di14) and 1.53 *18* (2013Sc16). $\gamma(\theta)$ consistent with J(9227)=2 or 3 (1971Si13).
9239	2^+	5824	84 *4*	3415.3	(3^+)	D+Q		I_γ: weighted average of 89 *7* (1980Di14) and 82 *4* (2013Sc16). Mult.,δ: −0.11 *7* from $\gamma(\theta)$ for J(3415)=3 (1980Di14).
		6353	39 *3*	2886.6	2^+	D+Q	+0.06 *12*	I_γ: weighted average of 39 *7* (1980Di14) and 39 *3* (2013Sc16). Mult.,δ: from $\gamma(\theta)$ in 1980Di14.
		6708	100 *6*	2530.6	2^+	D+Q	+0.14 *8*	I_γ: from 2013Sc16. Other: 100 *7* (1980Di14). δ: from $\gamma(\theta)$ in 1980Di14.
		7335	23 *5*	1904.3	0^+			I_γ: weighted average of 18 *4* (1980Di14) and 27 *4* (2013Sc16).
		8156	90 *7*	1082.9	2^+	D+Q	−0.45 *6*	I_γ: unweighted average of 96 *4* (1980Di14) and 83 *5* (2013Sc16). δ: from $\gamma(\theta)$ in 1980Di14.
		9239	18 *4*	0.0	0^+			I_γ: unweighted average of 14.0 *20* (1980Di14) and 21.6 *18* (2013Sc16).
9298	0^+	2082	69[a] *14*	7216	1^+	[M1]		B(M1)(W.u.)=0.27 *7* from Γ_γ=0.051 eV *12* (1978Di11). Measured $\omega_\gamma=\Gamma_\alpha\Gamma_\gamma/\Gamma$=0.046 eV *11* (1978Di11).
		5542	100[a] *14*	3755.9	2^+	[E2]		B(E2)(W.u.)=1.9 *7* from Γ_γ=0.073 eV *25*(1978Di11). Additional information 1. Measured $\omega_\gamma=\Gamma_\alpha\Gamma_\gamma/\Gamma$=0.066 eV *22* (1978Di11).

$^{44}_{22}Ti_{22}$-9

^{40}Ca(α,γ) E=res 1977Di07,1971Si13 (continued)

$\gamma(^{44}Ti)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[#]	E_f	J_f^π	Mult.[‡]	Comments
9338	0^+	2122	100[a] *6*	7216	1^+	[M1]	B(M1)(W.u.)=3.8 *10* from Γ_γ=0.75 eV *20* (1978Di11). Measured $\omega_\gamma=\Gamma_\alpha\Gamma_\gamma/\Gamma$=0.24 eV *5* (1978Di11).
		5582	2.5[a] *6*	3755.9	2^+	[E2]	B(E2)(W.u.)=0.5 *2* from Γ_γ=0.019 eV *7* (1978Di11). Additional information 2. Measured $\omega_\gamma=\Gamma_\alpha\Gamma_\gamma/\Gamma$=0.006 eV *2* (1978Di11).
		6452	<0.5[a]	2886.6	2^+	[E2]	B(E2)(W.u.)<0.046 from $\Gamma_\gamma<3.8\times10^{-3}$ eV (1978Di11).
		6807	<0.5[a]	2530.6	2^+	[E2]	B(E2)(W.u.)<0.035 from $\Gamma_\gamma<3.8\times10^{-3}$ eV (1978Di11).
		8255	<0.2[a]	1082.9	2^+	[E2]	B(E2)(W.u.)<0.0042 from $\Gamma_\gamma<1.2\times10^{-3}$ eV (1978Di11).
9361	$(2^+,3^-)$	3938	16 *5*	5423			
		4056	32 *11*	5305			
		4569	63 *11*	4792.2			
		5134	21 *5*	4227	$(2^-,3^-)$		
		5245	21 *5*	4116.5	2^+		
		5381	32 *5*	3980	4^+		
		5418	26 *5*	3942.7	3^-		
		5715	21 *5*	3645.8	$4^{(-)}$		
		5946	11 *5*	3415.3	(3^+)		
		6185	100 *11*	3175.7	$3^{(-)}$		
		6475	21 *5*	2886.6	2^+		
		6830	21 *5*	2530.6	2^+		
		6907	16 *5*	2454.1	4^+		
		8278	95 *11*	1082.9	2^+		
		9361	32 *11*	0.0	0^+		
9698	2^+	5582	18 *4*	4116.5	2^+		$\gamma(\theta)$ consistent with J(9698)=2 and J(4116)=2 (1977Di07).
		6283	100 *4*	3415.3	(3^+)		$\gamma(\theta)$ consistent with J(9698)=2 and J(3415)=3 (1977Di07).
		6522	6 *2*	3175.7	$3^{(-)}$		
		6812	57 *4*	2886.6	2^+		
		7167	12 *4*	2530.6	2^+		
		7244	6 *2*	2454.1	4^+		
		8615	2.7 *6*	1082.9	2^+		
		9698	2.7 *6*	0.0	0^+		
9713	4^+	4921	26 *7*	4792.2			
		5486	7 *2*	4227	$(2^-,3^-)$		
		5957	100 *7*	3755.9	2^+		$\gamma(\theta)$ consistent with J(9173)=4 and J(3756)=2 (1977Di07).
		6298	41 *7*	3415.3	(3^+)		
		6827	26 *7*	2886.6	2^+		
		8630	17 *4*	1082.9	2^+		
9908	$(3^-,5^-)$	5847	100 *9*	4060.5	(5^-)		
		6152	23 *6*	3755.9	2^+		
		6262	66 *6*	3645.8	$4^{(-)}$		
		6732	17 *6*	3175.7	$3^{(-)}$		

$^{44}_{22}Ti_{22}$-10

^{40}Ca(α,γ) E=res 1977Di07,1971Si13 (continued)

$\gamma(^{44}Ti)$ (continued)

E_i(level)	J_i^π	E_γ †	I_γ #	E_f	J_f^π	Comments
9908	$(3^-,5^-)$	8825	6 *3*	1082.9	2^+	
10386	$(2^+,3^-)$	6159	17 *9*	4227	$(2^-,3^-)$	
		6443	87 *13*	3942.7	3^-	
		6740	57 *9*	3645.8	$4^{(-)}$	
		7210	100 *13*	3175.7	$3^{(-)}$	
		7500	70 *9*	2886.6	2^+	
		9303	91 *9*	1082.9	2^+	
		10386	9 *4*	0.0	0^+	
12.20×10^3		11120		1082.9	2^+	
		12200		0.0	0^+	
13.00×10^3		11900		1082.9	2^+	
		13000		0.0	0^+	
14.10×10^3		13020		1082.9	2^+	
14.55×10^3		13470		1082.9	2^+	
		14550		0.0	0^+	
15.45×10^3		12960		2454.1	4^+	Final states: 2454+2531.
15.95×10^3		13460		2454.1	4^+	Final states: 2454+2531.
		14870		1082.9	2^+	

† Values with ΔE from 1973Di04 and others from level-energy differences, rounded off to nearest keV. Note that 1977Di07 report level energies based on their measured Eγ data, which however are not listed in 1977Di07.

‡ From $\gamma(\theta)$ in 1971Si13, 1977Di07, 1980Di14 and 1981Di09 (all references from the same group) with magnetic or electric nature determined based on RUL where measured $T_{1/2}$ is available. Note that sign convention for mixing ratio δ in 1971Si13, 1977Di07, 1980Di14 and 1981Di09 is that of Rose and Brink. According to Krane-steffen convention in ENSDF, all the signs of δ values have been reversed here from those in above references.

From 1977Di07, unless otherwise noted.

@ From 1971Si13.

& From 1977Co12.

a From 1978Di11.

b From 1981Di09.

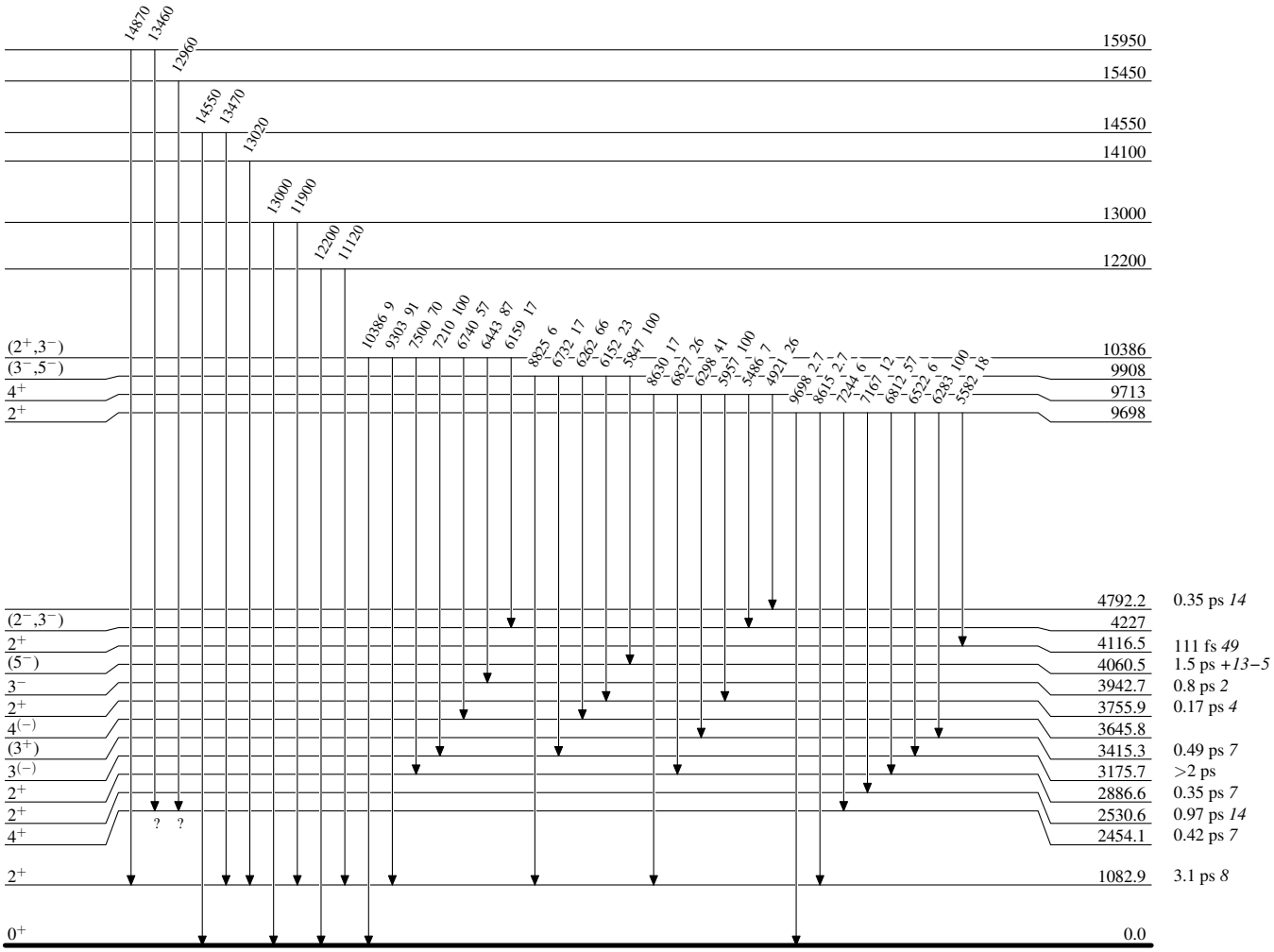
c Placement of transition in the level scheme is uncertain.

$^{44}_{22}Ti_{22}$-11

^{40}Ca(α,γ) E=res 1977Di07,1971Si13

Level Scheme

Intensities: Relative photon branching from each level

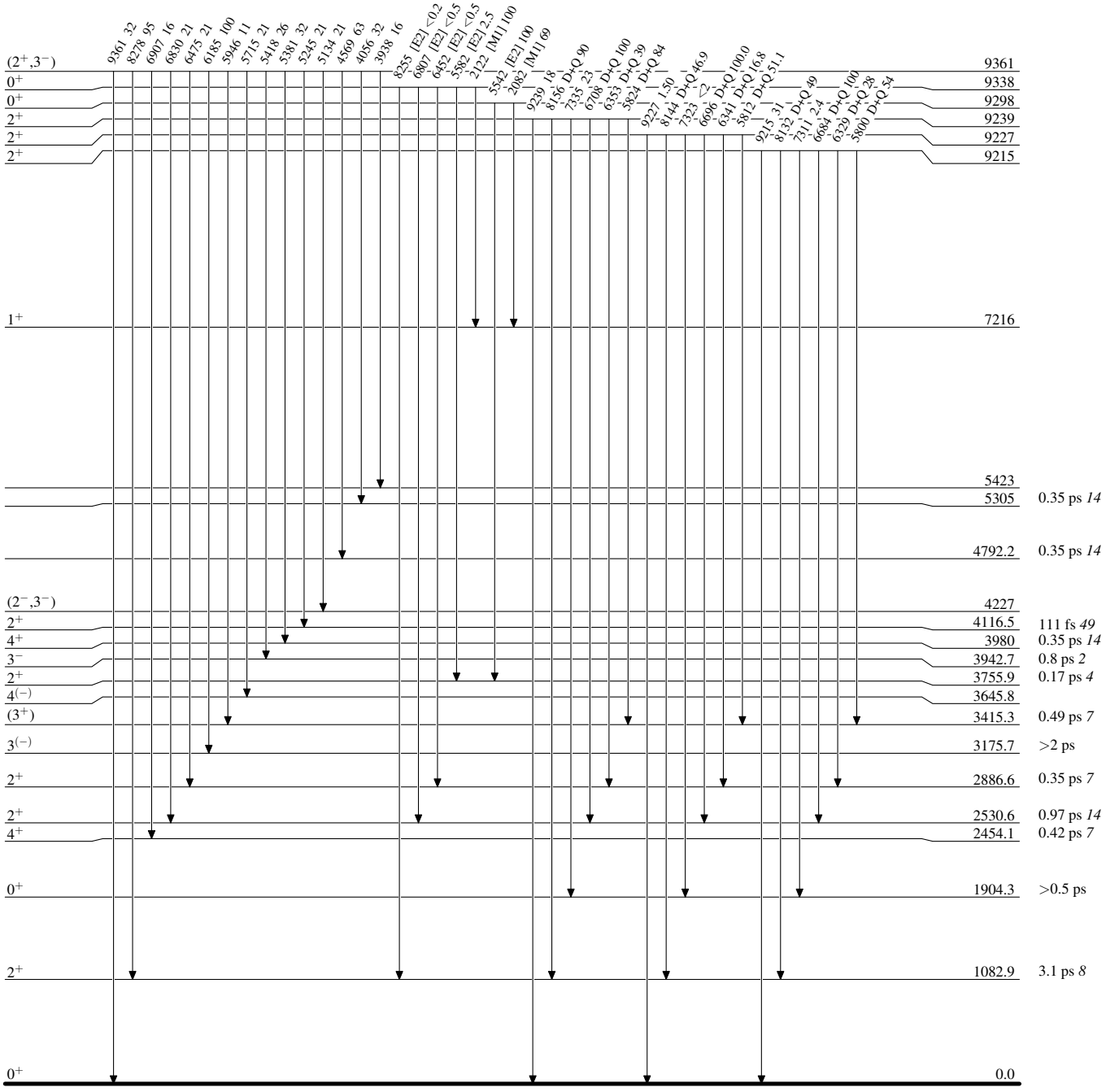


$^{44}_{22}Ti_{22}$

^{40}Ca(α,γ) E=res 1977Di07,1971Si13

Level Scheme (continued)

Intensities: Relative photon branching from each level



$^{44}_{22}Ti_{22}$

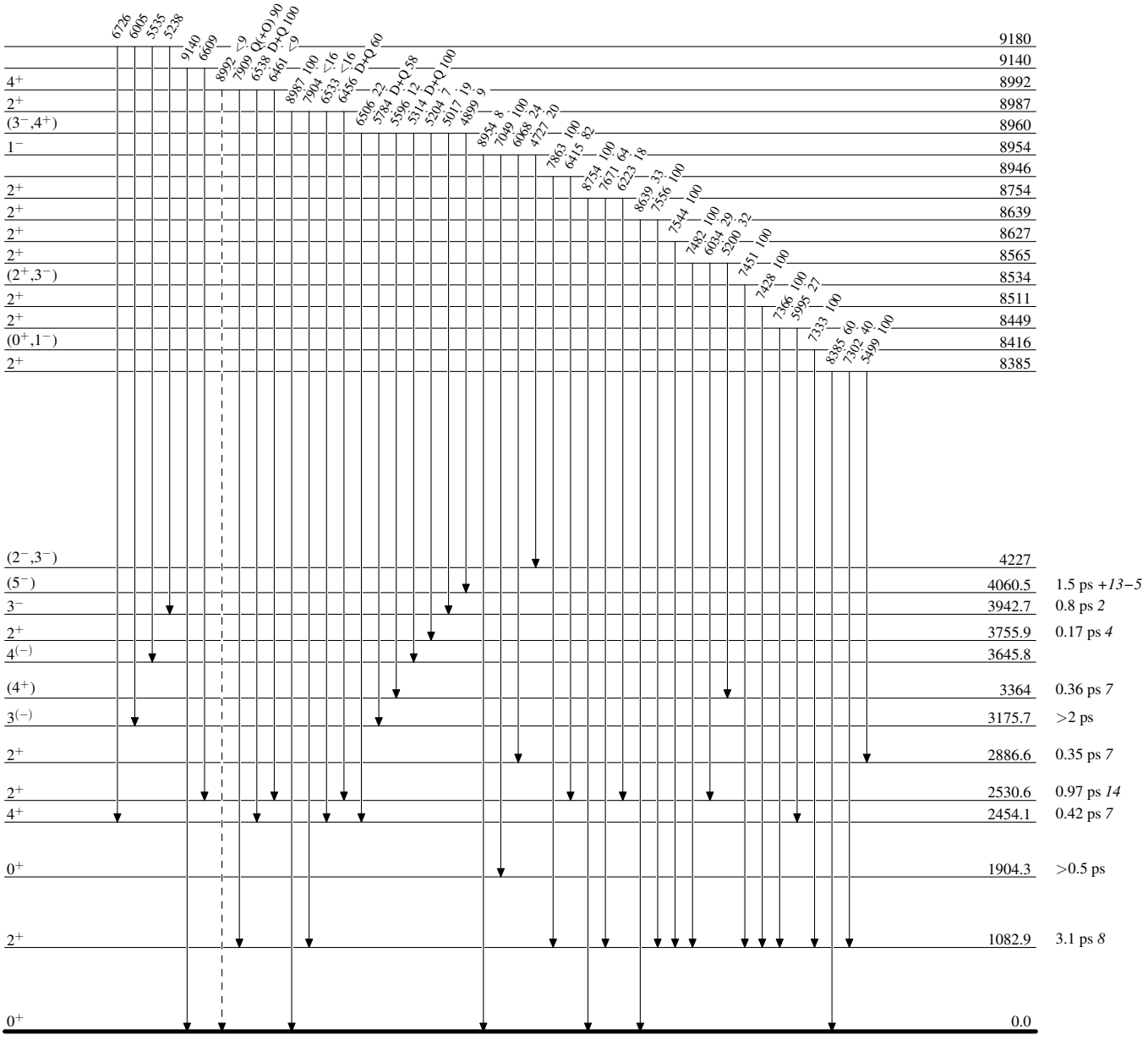
^{40}Ca(α,γ) E=res 1977Di07,1971Si13

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{44}_{22}Ti_{22}$

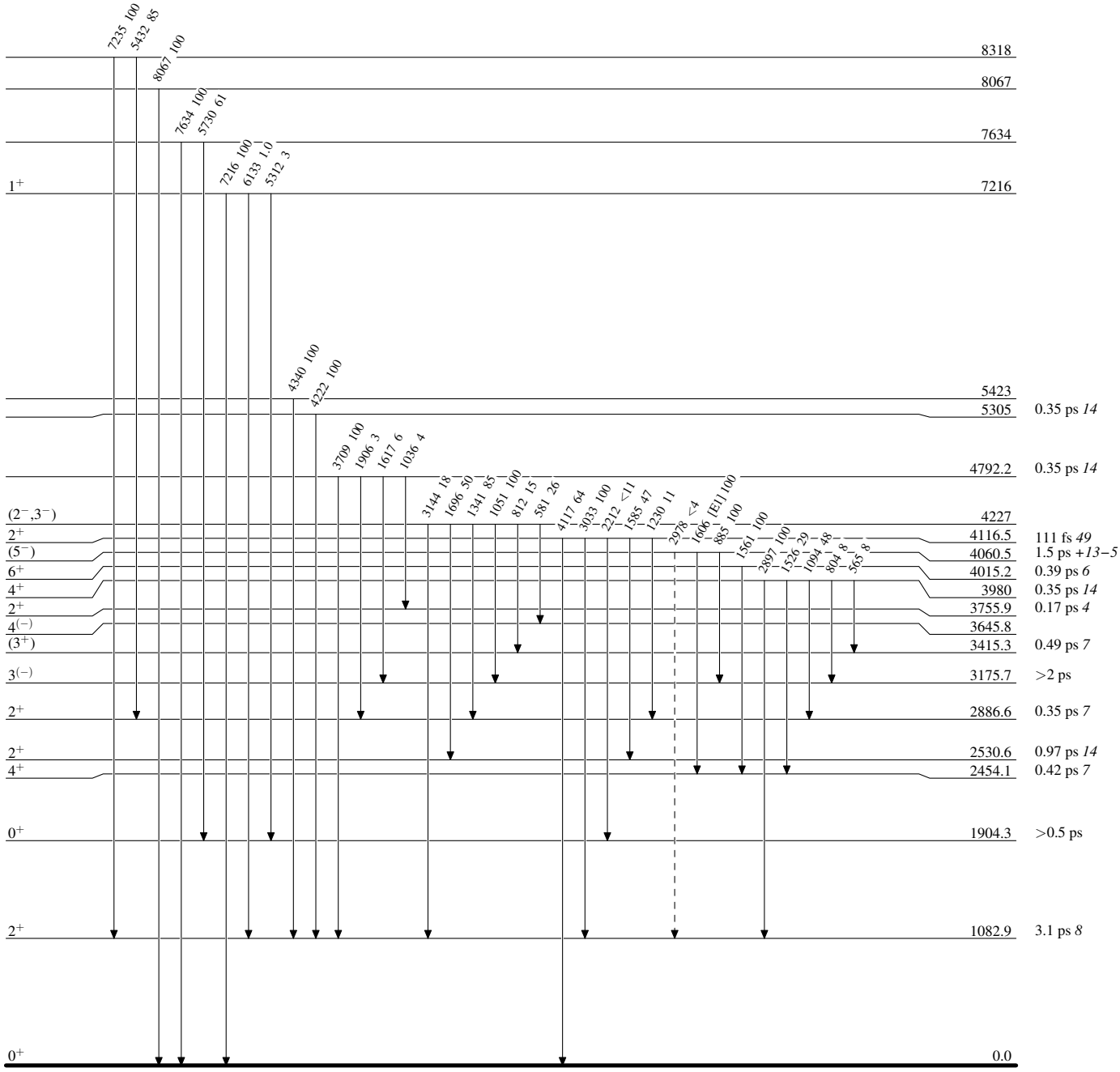
^{40}Ca(α,γ) E=res 1977Di07,1971Si13

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)

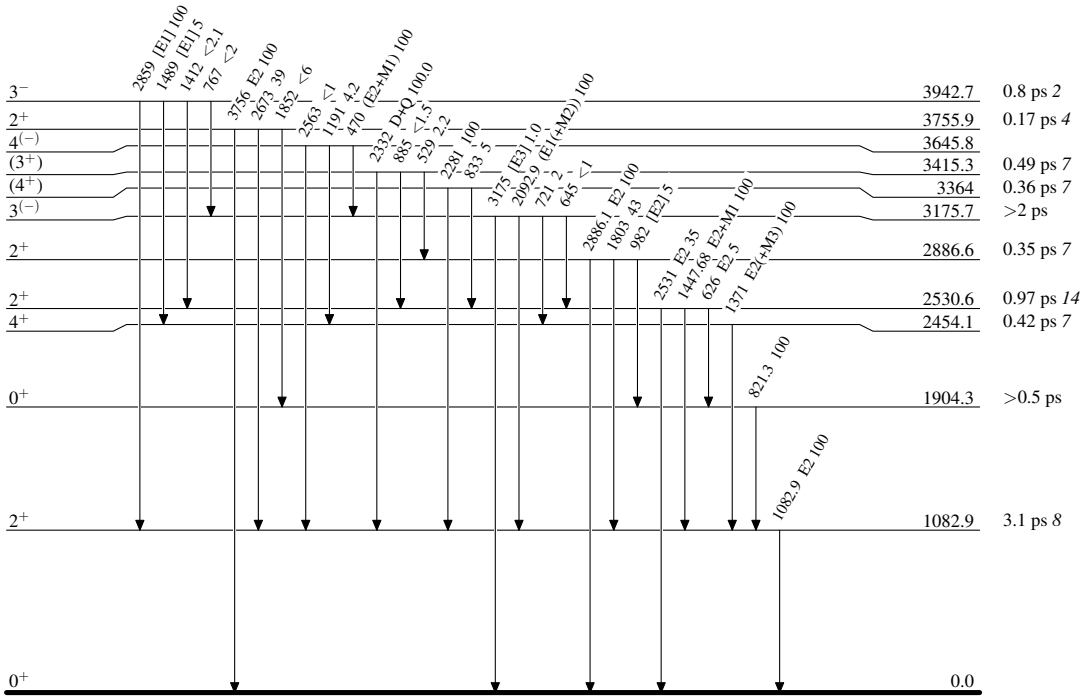


$^{44}_{22}Ti_{22}$

^{40}Ca(α,γ) E=res 1977Di07,1971Si13

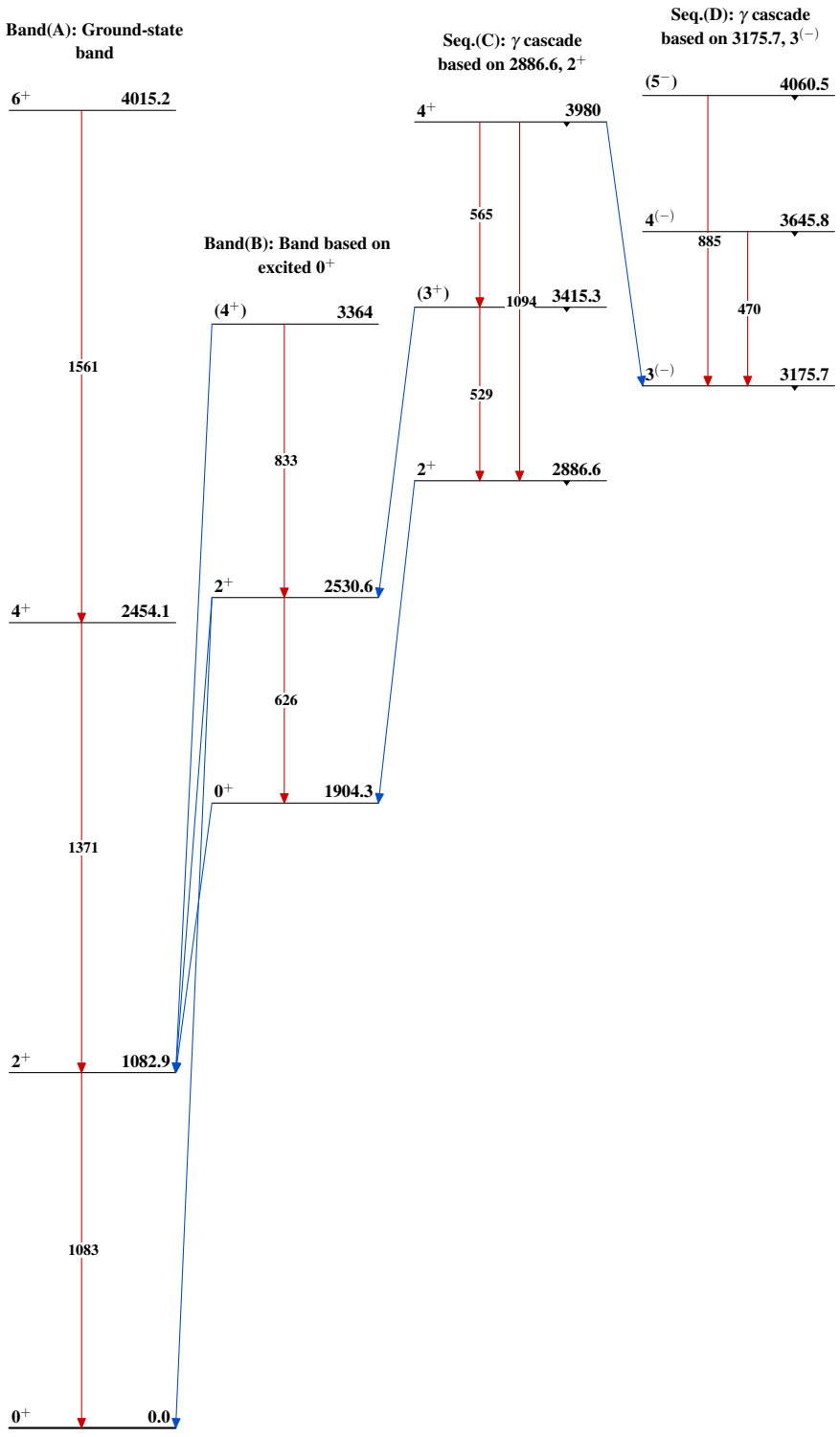
Level Scheme (continued)

Intensities: Relative photon branching from each level



$^{44}_{22}Ti_{22}$

^{40}Ca(α,γ) E=res 1977Di07,1971Si13



$^{44}_{22}Ti_{22}$