^{48}Ti(n,n′γ) 1993Ko57,1974Di08

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 179, 1 (2022)	30-Nov-2021

1993Ko57: E=1 to 7 MeV fast neutrons were produced from the reactor VVR-K. Target was 20 g metallic Ti. γ rays were detected with a Ge(Li) detector. Measured Eγ, Iγ, γ(θ) (θ=90°,110°,124°,135°, 140°),Doppler-shift attenuation. Deduced levels, $T_{1/2}$, J, π, level populations, γ-ray multipolarities, mixing ratios. Note that lifetimes reported in 2011Ad14 are taken from 1993Ko57.

1974Di08: E=4.9, 5.4 and 5.9 MeV neutrons were produced via D(d,n) with deuterons from the ORNL 5-MV Van de Graaff accelerator. Targets were 21.49 g metallic ^{48}Ti (73.94% enriched) or Ti oxide (99.3% enriched). γ rays were detected with a Ge(Li) detector. Measured Eγ, Iγ, σ(Eγ), at 55° and 125°. Deduced levels.

1989Ge05,1989Ge09,1988Ge06: fast reactor neutrons. Measured $T_{1/2}$ using DSAM.

1993BeZL: no experimental details. DSAM. Compared DSAM lifetime results from inelastic neutron scattering to lifetimes obtained from nuclear resonance fluorescence.

Others: 1996Be51.

^{48}Ti Levels

E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	Comments
0.0	0^+		
983.6 *6*	2^+		
2295.9 *8*	4^+	1.5 ps *8*	$T_{1/2}$: from DSAM in 1993BeZL.
2421.3 *7*	2^+	25 fs *6*	$T_{1/2}$: unweighted average of 28 fs *12* (1989Ge05), 13.9 fs *28* (1993Ko57) and 31.9 fs *21* (1993BeZL).
2998.1 *12*	0^+	64 fs *11*	$T_{1/2}$: from DSAM in 1989Ge05. Other: 208 fs *35* (1993Ko57) is discrepant.
3224.2 *8*	3^+	29 fs *18*	
3240.0 *13*	4^+	50 fs *11*	
3333.4 *12*	6^+	>7 ps	
3359.1 *8*	3^-	180 fs *56*	
3370.9 *12*	2^+	11 fs *2*	$T_{1/2}$: unweighted average of 13.2 fs *14* (1993BeZL) and 9.0 fs *14* (1989Ge05). Other: 29.1 fs *56* (1993Ko57) is discrepant.
3508.8 *12*	6^+		
3618.1 *8*	2^+	8.3 fs *28*	$T_{1/2}$: from DSAM 1989Ge05; discrepant with adopted value of 42 fs *11*.
3699.4 *8*	$1^{(-)}$	11.3 fs *21*	$T_{1/2}$: weighted average of 9.0 fs *21* (1993BeZL), 13.9 fs *28* (1993Ko57), and 14.6 fs *42* (1989Ge05).
3739.4 *8*	1^+	3.1 fs *18*	$T_{1/2}$: from DSAM (1993BeZL). Other: 18 fs *7* (1989Ge05) is discrepant with adopted values.
3782.7 *9*	$3^-,4^-$		
3852.9 *8*	3^-	97 fs *66*	$T_{1/2}$: from DSAM in 1989Ge05.
4035? *10*	2^+		
4045? *10*			
4071? *10*	2^+		
4210 *8*	2^-		
4314? *10*	1^+		
4355 *9*	(2^+)		
4382.4 *17*	$(3,4,5^-)$	28 fs *14*	
4389.0 *13*	4^+	55 fs *+49−28*	
4579.9 *13*	3^-	62 fs *21*	
4717.9 *17*	4^+	66 fs *18*	
4946?	$(2,3,4)^+$		
5149?	4^+		
5314? *10*	2^+		
5508?			
6178?	$(2^+,3,4,5^-)$		

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^{48}Ti(n,n′γ) 1993Ko57,1974Di08 (continued)

^{48}Ti Levels (continued)

† From a least-squares fit to γ-ray energies, assuming ΔEγ=1 keV where not given.
‡ From Adopted Levels.
# From DSAM in 1993Ko57, except as noted.

γ(^{48}Ti)

dσ/dΩ given under comments are from 1974Di08, in units of mb/sr.

E_i(level)	J_i^π	E_γ†	I_γ‡	E_f	J_f^π	Mult.&	δ&	Comments
983.6	2^+	983.5	100	0.0	0^+			Iγ(rel)=100 *6* (1993Ko57). dσ/dΩ=70 *7* (E=4.9 MeV, θ=125°). dσ/dΩ=75 *7* (E=5.9 MeV, θ=55°). dσ/dΩ=72 *7* (E=5.4 MeV, θ=55°).
2295.9	4^+	1312.1	100	983.6	2^+	[E2]		A_2=+0.32 *4*, A_2=−0.06 *7* (1993Ko57). Iγ(rel)=8.7 *5* (1993Ko57). dσ/dΩ=15.6 *23* (E=4.9 MeV, θ=125°). dσ/dΩ=22 *4* (E=5.9 MeV, θ=55°). dσ/dΩ=18 *3* (E=5.4 MeV, θ=55°).
2421.3	2^+	1437.7	100 *5*	983.6	2^+	M1+E2	+0.18 *3*	Iγ(rel)=8.1 *4* (1993Ko57). dσ/dΩ=10.0 *15* (E=4.9 MeV, θ=125°). dσ/dΩ=10.9 *16* (E=5.9 MeV, θ=55°). dσ/dΩ=10.0 *15* (E=5.4 MeV, θ=55°). A_2=+0.25 *4*, A_2=−0.03 *5* (1993Ko57).
		2420.9	5.0 *12*	0.0	0^+			Iγ(rel)=0.4 *1* (1993Ko57). dσ/dΩ=0.41 *16* (E=4.9 MeV, θ=125°). dσ/dΩ=0.7 *2* (E=5.9 MeV, θ=55°). dσ/dΩ=0.5 *2* (E=5.4 MeV, θ=55°).
2998.1	0^+	2014.4	100	983.6	2^+			Iγ(rel)=0.9 *2* (1993Ko57). dσ/dΩ=2.8 *4* (E=4.9 MeV, θ=125°). dσ/dΩ=1.45 *25* (E=5.9 MeV, θ=55°). dσ/dΩ=2.3 *4* (E=5.4 MeV, θ=55°).
3224.2	3^+	802.9	9 *5*	2421.3	2^+			Iγ(rel)=0.10 *5* (1993Ko57).
		928.3	35 *6*	2295.9	4^+			Iγ(rel)=0.4 *1* (1993Ko57). dσ/dΩ=1.43 *25* (E=4.9 MeV, θ=125°). dσ/dΩ=1.8 *3* (E=5.9 MeV, θ=55°). dσ/dΩ=1.6 *3* (E=5.4 MeV, θ=55°).
		2240.4	100 *15*	983.6	2^+	M1+E2	+0.26 *3*	Iγ(rel)=1.1 *3* (1993Ko57). dσ/dΩ=4.2 *7* (E=4.9 MeV, θ=125°). dσ/dΩ=5.2 *8* (E=5.9 MeV, θ=55°). dσ/dΩ=4.6 *7* (E=5.4 MeV, θ=55°). A_2=+0.08 *5*, A_2=−0.013 *50* (1993Ko57).
3240.0	4^+	944.1	100	2295.9	4^+	M1+E2	−0.30 *5*	Iγ(rel)=2.3 *1* (1993Ko57). dσ/dΩ=3.7 *6* (E=4.9 MeV, θ=125°). dσ/dΩ=5.9 *9* (E=5.9 MeV, θ=55°). dσ/dΩ=5.4 *8* (E=5.4 MeV, θ=55°). A_2=+0.18 *4*, A_2=+0.02 *5* (1993Ko57).
3333.4	6^+	1037.5	100	2295.9	4^+			Iγ(rel) 0.4 (1993Ko57). dσ/dΩ=0.74 *17* (E=4.9 MeV, θ=125°). dσ/dΩ=1.8 *3* (E=5.9 MeV, θ=55°). dσ/dΩ=1.4 *4* (E=5.4 MeV, θ=55°).
3359.1	3^-	938.0	8 *3*	2421.3	2^+			Iγ(rel)=0.10 *4* (1993Ko57).
		1063.2	23 *8*	2295.9	4^+			Iγ(rel)=0.3 *1* (1993Ko57).
		2375.2	100 *23*	983.6	2^+	D+Q	0.00 *3*	Iγ(rel)=1.3 *3* (1993Ko57). dσ/dΩ=5.7 *9* (E=4.9 MeV, θ=125°).

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^{48}Ti(n,n′γ) 1993Ko57,1974Di08 (continued)

γ(^{48}Ti) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Comments
						dσ/dΩ=7.2 *11* (E=5.9 MeV, θ=55°).
						dσ/dΩ=6.8 *10* (E=5.4 MeV, θ=55°).
						A_2=−0.18 *6*, A_2=+0.001 *30* (1993Ko57).
3370.9	2^+	2387.2	100 *15*	983.6	2^+	Iγ(rel)=1.2 *2* (1993Ko57).
						dσ/dΩ=4.0 *6* (E=4.9 MeV, θ=125°).
						dσ/dΩ=3.5 *6* (E=5.9 MeV, θ=55°).
						dσ/dΩ=4.2 *7* (E=5.4 MeV, θ=55°).
		3371[ab]	20[a] *5*	0.0	0^+	dσ/dΩ=0.95 *18* (E=4.9 MeV, θ=125°).
						dσ/dΩ=0.5 *3* (E=5.9 MeV, θ=55°).
						dσ/dΩ=0.76 *25* (E=5.4 MeV, θ=55°).
3508.8	6^+	175.4	≈100	3333.4	6^+	Iγ(rel)≈0.2 (1993Ko57).
		1212.9	≈50	2295.9	4^+	Iγ(rel)≈0.1 (1993Ko57).
3618.1	2^+	1195.8		2421.3	2^+	E_γ,I_γ: transition not reported in 1974Di08.
						Iγ(rel)=0.10 *3* (1993Ko57).
		2633[b]		983.6	2^+	I_γ: intensity not reported in 1993Ko57.
						dσ/dΩ=3.3 *5* (E=4.9 MeV, θ=125°).
						dσ/dΩ=3.4 *5* (E=5.9 MeV, θ=55°).
						dσ/dΩ=3.5 *5* (E=5.4 MeV, θ=55°).
		3619		0.0	0^+	
3699.4	$1^{(-)}$	2716[#]	100 *15*	983.6	2^+	Iγ(rel)=0.8 *2* (1993Ko57).
						dσ/dΩ=2.4 *10* (E=4.9 MeV, θ=125°).
						dσ/dΩ=2.6 *4* (E=5.9 MeV, θ=55°).
						dσ/dΩ=2.3 *5* (E=5.4 MeV, θ=55°).
		3699	54 *8*	0.0	0^+	Iγ(rel)≈0.1 (1993Ko57).
						dσ/dΩ=1.3 *2* (E=4.9 MeV, θ=125°).
						dσ/dΩ=1.6 *4* (E=5.9 MeV, θ=55°).
						dσ/dΩ=1.15 *25* (E=5.4 MeV, θ=55°).
3739.4	1^+	2756	42 *10*	983.6	2^+	Iγ(rel)≈0.5 (1993Ko57).
						dσ/dΩ=0.94 *18* (E=4.9 MeV, θ=125°).
						dσ/dΩ=0.6 *2* (E=5.9 MeV, θ=55°).
						dσ/dΩ=0.77 *17* (E=5.4 MeV, θ=55°).
		3739	100 *16*	0.0	0^+	Iγ(rel)≈0.3 (1993Ko57).
						dσ/dΩ=1.9 *3* (E=4.9 MeV, θ=125°).
						dσ/dΩ=2.0 *4* (E=5.9 MeV, θ=55°).
						dσ/dΩ=1.6 *4* (E=5.4 MeV, θ=55°).
3782.7	3^-,4^-	423.6	≈50	3359.1	3^-	I_γ: from Iγ(rel)≈0.1 (1993Ko57). Note that 1974Di08 report this transition as the strongest one from 3783 level.
						dσ/dΩ=1.5 *5* (E=4.9 MeV, θ=125°).
						dσ/dΩ=1.00 *25* (E=5.9 MeV, θ=55°).
		558.6	50 *15*	3224.2	3^+	I_γ: from Iγ(rel)=0.10 *3* (1993Ko57).
						dσ/dΩ=0.33 *13* (E=4.9 MeV, θ=125°).
						dσ/dΩ=0.5 *2* (E=5.9 MeV, θ=55°).
		1486.8	100 *25*	2295.9	4^+	E_γ: unplaced by 1974Di08.
						I_γ: from Iγ(rel)=0.20 *5* (1993Ko57).
						dσ/dΩ=0.8 *3* (E=5.9 MeV, θ=55°).
3852.9	3^-	1432	≈2.50	2421.3	2^+	Iγ(rel)≈0.01 (1993Ko57).
		1556.6	≈50	2295.9	4^+	Iγ(rel)≈0.2 (1993Ko57).
		2869	≈100	983.6	2^+	Iγ(rel)≈0.4 (1993Ko57).
						dσ/dΩ=1.8 *5* (E=4.9 MeV, θ=125°).
						dσ/dΩ=2.8 *5* (E=5.9 MeV, θ=55°).
						dσ/dΩ=2.0 *4* (E=5.4 MeV, θ=55°).
4035?	2^+	811[b] *3*	41 *9*	3224.2	3^+	E_γ: unplaced in 1974Di08; placement suggested by evaluator based on energy and branching ratio agreement with (n,γ).
						dσ/dΩ=0.7 *3* (E=4.9 MeV, θ=125°).
						dσ/dΩ=0.72 *17* (E=5.9 MeV, θ=55°).
						dσ/dΩ=1.0 *3* (E=5.4 MeV, θ=55°).

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^{48}Ti(n,n′γ) 1993Ko57,1974Di08 (continued)

γ(^{48}Ti) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Comments
4035?	2^+	1614#b *4*	100 *15*	2421.3	2^+	dσ/dΩ=1.8 *3* (E=4.9 MeV, θ=125°). dσ/dΩ=1.9 *3* (E=5.9 MeV, θ=55°). dσ/dΩ=2.0 *3* (E=5.4 MeV, θ=55°).
4045?		1624b *4*	100	2421.3	2^+	dσ/dΩ=1.36 *25* (E=4.9 MeV, θ=125°). dσ/dΩ=1.8 *4* (E=5.9 MeV, θ=55°). dσ/dΩ=2.0 *4* (E=5.4 MeV, θ=55°).
4071?	2^+	3088b *7*	100	983.6	2^+	dσ/dΩ=0.68 *22* (E=4.9 MeV, θ=125°). dσ/dΩ=1.23 *23* (E=5.9 MeV, θ=55°). dσ/dΩ=0.75 *15* (E=5.4 MeV, θ=55°).
4210	2^-	3226 *8*	100	983.6	2^+	dσ/dΩ=0.5 *2* (E=4.9 MeV, θ=125°). dσ/dΩ<0.5 (E=5.9 MeV, θ=55°). dσ/dΩ=0.7 *3* (E=5.4 MeV, θ=55°).
4314?	1^+	3332b *8*	45 *22*	983.6	2^+	dσ/dΩ=0.30 *15* (E=4.9 MeV, θ=125°). dσ/dΩ<0.5 (E=5.9 MeV, θ=55°). dσ/dΩ=0.4 *2* (E=5.4 MeV, θ=55°).
		4314b *9*	100 *22*	0.0	0^+	dσ/dΩ=0.67 *15* (E=4.9 MeV, θ=125°). dσ/dΩ=0.60 *22* (E=5.9 MeV, θ=55°). dσ/dΩ=0.8 *3* (E=5.4 MeV, θ=55°).
4355	(2^+)	3372ab *8*	*a*	983.6	2^+	Iγ: see dσ/dΩ values for 3371γ from 3371 level.
4382.4	$(3,4,5^-)$	1142.3		3240.0	4^+	
4389.0	4^+	1164.9		3224.2	3^+	
		3401 *8*		983.6	2^+	dσ/dΩ=0.4 *2* (E=4.9 MeV, θ=125°). dσ/dΩ=0.8 *3* (E=5.9 MeV, θ=55°). dσ/dΩ=0.5 *2* (E=5.4 MeV, θ=55°).
4579.9	3^-	1220.8		3359.1	3^-	
		2162b *5*		2421.3	2^+	Iγ: I(2162γ)/I(3600γ) from E(beam)=5.9 and 5.4 Mev in 1974Di08 don′t agree. dσ/dΩ=1.20 *25* (E=5.9 MeV, θ=55°). dσ/dΩ=0.55 *11* (E=5.4 MeV, θ=55°).
		3600b *8*		983.6	2^+	dσ/dΩ=0.25 *11* (E=4.9 MeV, θ=125°). dσ/dΩ=0.8 *3* (E=5.9 MeV, θ=55°). dσ/dΩ=0.95 *22* (E=5.4 MeV, θ=55°).
4717.9	4^+	1477.8		3240.0	4^+	
4946?	$(2,3,4)^+$	2650@b		2295.9	4^+	Iγ(rel)≈0.05 (1993Ko57).
		3963b *9*		983.6	2^+	dσ/dΩ=0.6 *2* (E=5.9 MeV, θ=55°). dσ/dΩ=0.3 *2* (E=5.4 MeV, θ=55°).
5149?	4^+	2728@b	100	2421.3	2^+	Iγ(rel)<0.1 (1993Ko57).
5314?	2^+	2890#b *5*	100 *28*	2421.3	2^+	dσ/dΩ=2.5 *7* (E=5.9 MeV, θ=55°). dσ/dΩ=0.7 *3* (E=5.4 MeV, θ=55°).
		4332b *9*	12 *6*	983.6	2^+	dσ/dΩ=0.30 *15* (E=5.9 MeV, θ=55°).
5508?		2284b *6*	100	3224.2	3^+	Eγ: it is probably the same transition as 2285γ from 4581 level in (n,γ) E=thermal. dσ/dΩ=0.3 *1* (E=5.9 MeV, θ=55°). dσ/dΩ<0.2 (E=5.4 MeV, θ=55°).
6178?	$(2^+,3,4,5^-)$	2819b	100	3359.1	3^-	Eγ: placement by 1993Ko57 based on agreement with (α,pγ) data of 1979Gl07 and small Iγ. Iγ(rel)≈0.1 (1993Ko57).

[†] Values without uncertainties are from 1993Ko57 (up to 4719 level) and values with uncertainties are from 1974Di08, unless otherwise noted. Unplaced transitions are from 1974Di08.

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^{48}Ti(n,n′γ) 1993Ko57,1974Di08 (continued)

γ(^{48}Ti) (continued)

‡ Quoted intensities are relative branchings from each level, deduced by the evaluator by normalizing relative intensities from 1993Ko57 (at 124°) and γ yields at different beam energies and angles from 1974Di08 to Iγ=100 for the strongest transition of each level. Weighted averages are taken where available. Original intensities and yields are given under comments.

Peak at this energy is likely due to more than one γ (1974Di08).

@ 2644γ placed as deexciting a 3634 state by 1969Mo09 in (p,p′γ) and 2728γ placed as deexciting 3713 state by 1979Gl07 in (α,pγ). Alternate placements suggested by 1993Ko57 based on small Iγ.

& D+Q from γ(θ) in 1993Ko57 and electric or magnetic nature from comparisons of transition strengths to RUL where measured $T_{1/2}$ is available. γ(θ) in 1993Ko57 is normalized to 1312γ(θ).

a Multiply placed with intensity suitably divided.

b Placement of transition in the level scheme is uncertain.

x γ ray not placed in level scheme.

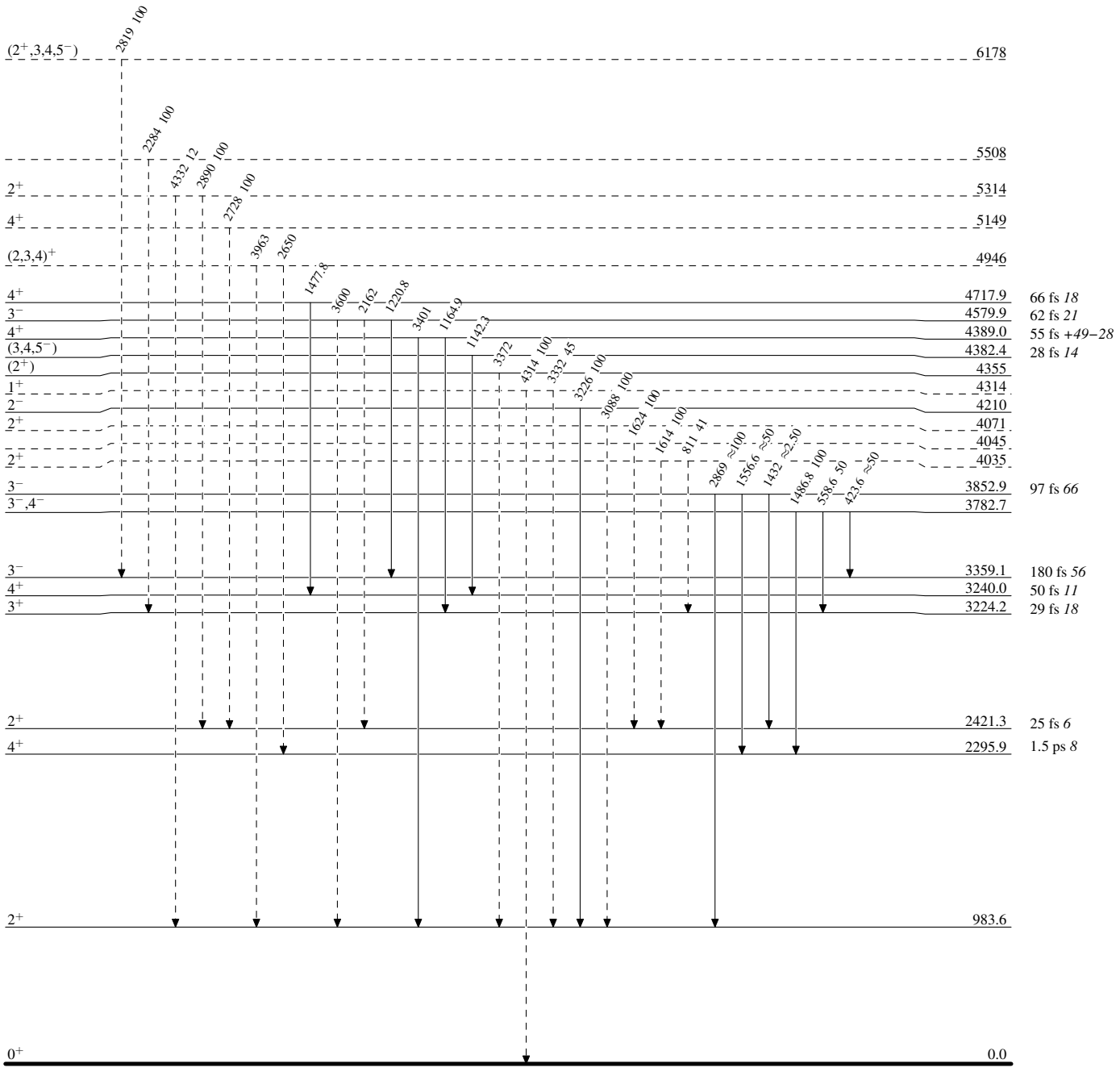
^{48}Ti(n,n′γ) 1993Ko57,1974Di08

Legend

Level Scheme

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{48}_{22}Ti_{26}$

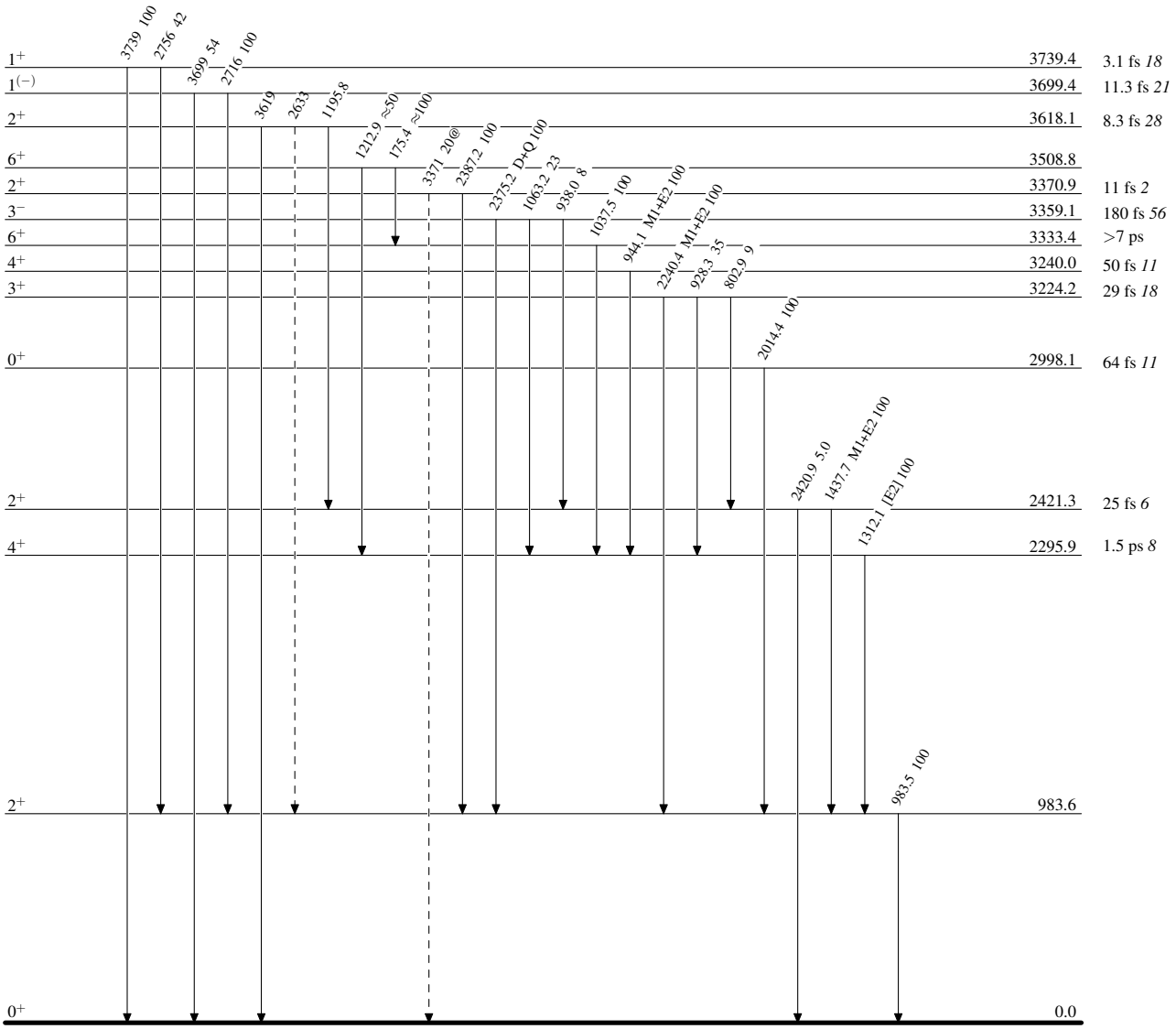
^{48}Ti(n,n′γ) 1993Ko57,1974Di08

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level
@ Multiply placed: intensity suitably divided

- - - - - - ► γ Decay (Uncertain)



$^{48}_{22}Ti_{26}$