^{64}Zn(p,γ),(p,p$'\gamma$) E=res 1975We24,1979Ra12,1982Ra11

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 202,59 (2025)	25-Feb-2025

1975We24: (p,γ) E(p)=1.0-2.2 MeV from the van de Graaff of the University of Helsinki. γ rays were detected with a Ge(Li) detector. Measured Eγ, Iγ and γ excitation functions. Deduced levels.

1979Ra12: (p,γ) E(p)≈2.82-3.03 MeV from 7 MV CN Van de Graaff at Laval University. γ rays were detected with a Ge(Li) detector. Measured Eγ, Iγ, $\gamma(\theta)$, excitation functions.

1982Ra11: (p,γ),(p,p$'\gamma$) E(p)=3.17-3.27 MeV from 7 MV CN Van de Graaff at Laval University. Measured Eγ, Iγ, $\gamma(\theta)$, $\gamma\gamma(\theta)$, excitation functions.

1987Ni14,1987Vi01 (p,γ) E(p)=1.1-4.3 MeV from the 3 MV Pelletron Tandem at University of Lund. γ rays were detected with a pair spectrometer of Ge(Li) and NaI(Tl) detectors. Measured Eγ, Iγ, γ yields. Deduced strength functions for primary E1 transitions.

1972Sz01: (p,γ) E(p)=2.84-3.02 MeV from the 4 MV Van de Graaff of the Central Research Institute for Physics, Budapest. γ rays were detected with a NaI(Tl) detector and a Ge(Li) detector. Measured γ excitation functions. Deduced widths.

1971Ne06: (p,γ) E(p)=2 MeV from FTI AN UkrSSR electrostatic accelerator. γ rays were detected with Ge(Li) and NaI(Tl) detectors. Measured Eγ and Iγ. Deduced levels, Note that a band of levels reported at ≈5390 (1971Ne06) is probably due to a misprint and should read 5930. Transitions from these states are reported to populate levels at 0, 62, 191, 650, 815, and 1076 (1971Ne06).

1973Ne07: (p,γ) E(p)=2 MeV from the electrostatic accelerator of Ukrainian Academy of Sciences. Measured triple $\gamma\gamma(\theta)$. Deduced level spins, γ-ray mixing ratios.

2002Fe14: E≈1.7-5 MeV. Measured Eγ, σ. Deduced electric dipole radiative strength.

Data are mostly from ^{64}Zn(p,γ) reported in 1975We24, 1979Ra12 and 1982Ra11. See also 1983PaZP.

Others: 1971KeZY (no copy), 1973BuYY (has copy).

^{65}Ga Levels

E(level)[†]	J$^\pi$[‡]	Comments
0	3/2$^-$	
62.0 *2*	(1/2)$^-$	
190.8 *2*	5/2$^-$	J$^\pi$: spin=5/2 from triple $\gamma\gamma(\theta)$ (1973Ne07).
649.7 *1*	1/2$^-$,3/2$^-$	
809.2 *1*	1/2$^-$,3/2$^-$	
814.9 *2*	3/2$^-$	J$^\pi$: spin=3/2 from triple $\gamma\gamma(\theta)$ for a level at 821 (1973Ne07).
1075.9 *2*	7/2$^{(-)}$	
1135?[a] *7*		
1286[a] *7*	9/2$^-$	J$^\pi$: spin=9/2 from $\gamma\gamma(\theta)$ (1979Ra12).
1298.6 *3*	(1/2$^-$,3/2,5/2$^-$)	
1352.9 *5*		
1377.4 *3*		
1469		
1662.0 *2*	1/2$^-$,3/2$^-$	
1807		
1856	1/2$^-$,3/2$^-$	
1880 *2*	(1/2,3/2,5/2)$^-$	
1966.7 *3*		
1983.1 *5*	(1/2$^-$,3/2,5/2$^-$)	
2037[a] *7*	9/2$^+$	E(level): anti-analog state of 1066 level in ^{65}Zn (1979Ra12).
2163 *2*	(1/2$^-$,3/2$^-$,5/2$^-$)	E(level): also seen by 1987Ni14.
2206.5 *5*	5/2$^-$	E(level): also seen by 1987Ni14 at 2208. J$^\pi$: spin=5/2 consistent with $\gamma\gamma(\theta)$ data for a level at 2210 (1982Ra11).
2280		
2323.8 *5*		
2357		
2388		

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^{64}Zn(p,γ),(p,p′γ) E=res 1975We24,1979Ra12,1982Ra11 (continued)

^{65}Ga Levels (continued)

E(level)[†]	Jπ[‡]	Comments
2426.6 *10*	(1/2,3/2,5/2⁻)	
2447.0 *5*		
2470		
2502.9 *5*		
2548		
2575		
2647		
2669		
2704.0 *15*		It is estimated (1975We24) that 40% *10* of the decay of this level is not observed.
2716		
2754		
2811.0 *15*	(3/2,5/2)	E(level): anti-analog state of the 1370 level in ^{65}Zn (1982Ra11). Jπ: spin=3/2, 5/2 consistent with γγ(θ) data for a level at 2820 (1982Ra11).
2819	3/2⁺,5/2⁺	
2906		
2960		
3036		
3143		
3173		
3229		
3250		
3310		
3415		
3488		
5116 *1*		
5240 *1*		
5298 *1*		
5339 *1*		
5352 *1*	(1/2⁺)	E(level): corresponds to E(lab)=1431 keV. Jπ: most likely from isotropic γ(θ) (1987Vi01).
5384 *1*		
5393 *1*		
5438 *1*		
5467 *1*		
5481 *1*		
5507 *1*		
5759.2[#] *9*		E(p)=1845.5 *7* (1975We24).
5819.7[#] *9*		E(p)=1906.9 *6* (1975We24).
5852.8[#] *9*		E(p)=1940.5 *6* (1975We24).
5934.9[#] *9*		E(p)=2023.9 *7* (1975We24).
6815[@] *5*		E(p)=2917 *5* (1979Ra12).
6823[@] *5*	(9/2)	E(p)=2926 *5* (1979Ra12), E(p)=2926 *4* (1972Sz01). Jπ: γγ(θ) data in ^{64}Zn(p,γ) are consistent with J=9/2, γ(θ) data in ^{64}Zn(p,p′γ) are reported to rule out all other J possibilities (1979Ra12).
6834[@] *5*		E(p)=2937 *5* (1979Ra12), E(p)=2937 *4* (1972Sz01).
6839[@] *5*		E(p)(lab)=2942 *5* (1982Ra11).
7137[&] *5*	(3/2)	Jπ: from γ(θ) (1982Ra11). E(p)(lab)=3245 *5* (1982Ra11). Resonance only observed in ^{64}Zn(p,p′γ) channel (1982Ra11).
7141[&] *5*	(5/2)	Jπ: from γ(θ) in ^{64}Zn(p,p′γ) (1982Ra11). E(p)(lab)=3249 *5* (1982Ra11).
7145[&] *5*	(5/2)	Jπ: from γ(θ) in ^{64}Zn(p,p′γ) (1982Ra11). E(p)(lab)=3253 *5* (1982Ra11).

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^{64}Zn(p,γ),(p,p′γ) E=res 1975We24,1979Ra12,1982Ra11 (continued)

^{65}Ga Levels (continued)

E(level)[†]	Comments
7151[&] *5*	E(p)(lab)=3259 *5* (1982Ra11). Resonance only observed in ^{64}Zn(p,p′γ) channel (1982Ra11). J^π: J≥3/2 from γ(θ) (1982Ra11).

† Values with uncertainties up to 2811 level are from 1975We24, values without uncertainties up to 3488 level are from average resonance γ spectra in 1987Ni14 and values from 5116 to 5507 are from average resonance γ spectra in 1987Vi01, unless otherwise noted. Values for resonance levels are from E(level)=E(p)(c.m.)+S(p)(^{65}Cu), where S(p)=3942.4 *6* (2021Wa16) and E(p)(c.m.)=E(p)(lab)×m(^{64}Zn)/[m(p)+m(^{64}Zn)].

‡ From Adopted Levels. Supporting arguments from this dataset are indicated in comments where available.

Reported in 1975We24, possibly IAS fragments of the 54 keV level in ^{65}Zn.

@ Fragments corresponding to the IAS of the 1066 level in ^{65}Zn (1979Ra12). Data for the 6823 *5* level and transitions depopulating it are reported to be typical for all fragments (1979Ra12).

& Fragments corresponding to the IAS of the 1370 level in ^{65}Zn (1982Ra11). Absolute uncertainty estimated by evaluators as 5, consistent with uncertainties on E(p) reported by same author in 1979Ra12.

a From 1979Ra12.

γ(^{65}Ga)

Relative intensity I_{rel} under comments is from 1971Ne06.

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.	δ[#]	Comments
62.0	$(1/2)^-$	62.0 *2*	100	0	$3/2^-$			
190.8	$5/2^-$	190.8 *2*	100	0	$3/2^-$	D+Q		E_γ: other: 192 *1* (1971Ne06). I_{rel}=28 *3* (1971Ne06). Mult.: from triple γγ(θ) (1973Ne07). δ: −0.04 *2* or +3.6 *4* (phase convention undefined), from triple γγ(θ) (1973Ne07).
649.7	$1/2^-$,$3/2^-$	459.0 *2*	6 *3*	190.8	$5/2^-$			
		587.7 *2*	8 *3*	62.0	$(1/2)^-$			
		649.7 *2*	86 *3*	0	$3/2^-$			E_γ: other: 655 *3* (1971Ne06). I_{rel}=15.0 *14* (1971Ne06).
809.2	$1/2^-$,$3/2^-$	618.2 *2*	5 *3*	190.8	$5/2^-$			
		747.4 *2*	5 *3*	62.0	$(1/2)^-$			
		809.2 *2*	90 *3*	0	$3/2^-$			
814.9	$3/2^-$	166[@] *1*		649.7	$1/2^-$,$3/2^-$			E_γ: from 1971Ne06, not observed by 1975We24. I_{rel}=7 *2* (1971Ne06).
		752 *2*	70 *20*	62.0	$(1/2)^-$			
		814.9 *2*	30 *20*	0	$3/2^-$	D+Q		Branching: uncertainty given as 5 in 1975We24. I_γ: 16.0 *15*, for Eγ=820 *3* (1971Ne06). Mult.: from triple γγ(θ) (1973Ne07). δ: +0.12 *6* or −12 *+3−5* (phase convention undefined), for a level at 821 with $J^\pi=3/2^-$, from triple γγ(θ) (1973Ne07).
1075.9	$7/2^{(-)}$	884.9 *3*	45 *5*	190.8	$5/2^-$			
		1075.9 *2*	55 *5*	0	$3/2^-$			I_{rel}=7.0 *16* for Eγ=1079 *3* (1971Ne06).
1286	$9/2^-$	1095		190.8	$5/2^-$	Q+O	−0.07 *7*	E_γ: from level energy difference. Mult.,δ: from γγ(θ) (1979Ra12).

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^{64}Zn(p,γ),(p,p′γ) E=res 1975We24,1979Ra12,1982Ra11 (continued)

γ(^{65}Ga) (continued)

E_i(level)	J_i^π	E_γ †	I_γ ‡	E_f	J_f^π	Mult.	δ #	Comments
1298.6	(1/2$^-$,3/2,5/2$^-$)	1107.8 *3*	25 *5*	190.8	5/2$^-$			
		1236.6 *3*	70 *5*	62.0	(1/2)$^-$			
		1299 *3*	5 *3*	0	3/2$^-$			
1352.9		1352.9 *5*	100	0	3/2$^-$			
1377.4		1315.3 *5*	30 *5*	62.0	(1/2)$^-$			
		1377.4 *3*	70 *5*	0	3/2$^-$			
1662.0	1/2$^-$,3/2$^-$	852.7 *3*	37 *2*	809.2	1/2$^-$,3/2$^-$			
		1471.1 *3*	14 *2*	190.8	5/2$^-$			
		1600.0 *3*	43 *2*	62.0	(1/2)$^-$			
		1662.0 *3*	6 *2*	0	3/2$^-$			
1880	(1/2,3/2,5/2)$^-$	1689 *2*	100	190.8	5/2$^-$			
1966.7		1966.7 *3*	100	0	3/2$^-$			
1983.1	(1/2$^-$,3/2,5/2$^-$)	1174.0 *8*	15 *5*	809.2	1/2$^-$,3/2$^-$			
		1792.3 *8*	70 *5*	190.8	5/2$^-$			
		1921.0 *8*	15 *5*	62.0	(1/2)$^-$			
2037	9/2$^+$	751 *10*		1286	9/2$^-$	D+Q	−0.18 *9*	E_γ: from level energy difference. Mult.,δ: from γγ(θ) (1979Ra12).
2163	(1/2$^-$,3/2$^-$,5/2$^-$)	1511 *3*	20 *20*	649.7	1/2$^-$,3/2$^-$			
		2101 *3*	65 *10*	62.0	(1/2)$^-$			
		2165 *3*	15 *10*	0	3/2$^-$			
2206.5	5/2$^-$	2015.8 *10*	30 *10*	190.8	5/2$^-$			
		2206.5 *5*	70 *10*	0	3/2$^-$			Mult.,δ: δ(E2/M1)≈+0.3 for J(2207)=5/2 and δ(E2+M3)>−3 for J(2207)=7/2, from γγ(θ) of 5/2(4934γ)J(2207γ)3/2$^-$ cascade in 1982Ra11.
2323.8		2323.8 *5*	100	0	3/2$^-$			
2426.6	(1/2,3/2,5/2$^-$)	1617.8 *15*	40 *5*	809.2	1/2$^-$,3/2$^-$			
		1777.0 *20*	14 *5*	649.7	1/2$^-$,3/2$^-$			
		2364.0 *20*	30 *5*	62.0	(1/2)$^-$			
		2426.1 *20*	16 *5*	0	3/2$^-$			
2447.0		2447.0 *5*	100	0	3/2$^-$			
2502.9		1688.2 *10*	10 *10*	814.9	3/2$^-$			
		1693.0 *10*	10 *10*	809.2	1/2$^-$,3/2$^-$			
		1853.5 *10*	10 *10*	649.7	1/2$^-$,3/2$^-$			
		2440.9 *10*	70 *10*	62.0	(1/2)$^-$			
2704.0		2704.0 *15*		0	3/2$^-$			%branching=60 *10*. It is estimated that 40% *10* of the decay of the 2704 level is not observed.
2811.0	(3/2,5/2)	2620.2 *15*	80 *10*	190.8	5/2$^-$	D+Q		Mult.: from γγ(θ) (1982Ra11). δ: ≈−1 for J(2811)=3/2 and <+2 for J(2811)=5/2, from γγ(θ) of 5/2(4330γ)J(2620γ)5/2$^-$ cascade in 1982Ra11.
		2810.7 *25*	20 *10*	0	3/2$^-$			
5852.8		4190.3 *12*		1662.0	1/2$^-$,3/2$^-$			
5934.9		3230.5 *20*		2704.0				
6815		4777		2037	9/2$^+$			Γ(p)Γ(γ)/Γ=0.031 eV *10* (1979Ra12).
6823	(9/2)	4786	93 *6*	2037	9/2$^+$	D+Q	−0.14 *+18−9*	Γ(p)Γ(γ)/Γ=0.077 eV *20* (1979Ra12). Γ(p)Γ(γ)/Γ=0.29 eV *5* (1972Sz01). Mult.: from γγ(θ) (1979Ra12). δ: from γγ(θ) of

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^{64}Zn(p,γ),(p,p$'\gamma$) E=res 1975We24,1979Ra12,1982Ra11 (continued)

$\gamma(^{65}Ga)$ (continued)

E_i(level)	J_i^π	E_γ †	I_γ ‡	E_f	J_f^π	Mult.	Comments
							9/2(4786γ)9/2+(751γ)9/2(1095γ)5/2$^-$ cascade in 1979Ra12.
6823	(9/2)	5688@	<4	1135?			
		5739@ *5*	<4	1075.9	7/2$^{(-)}$		
		6173@ *5*		649.7	1/2$^-$,3/2$^-$		E_γ: reported in 1971KeZY.
		6632@ *5*	<2	190.8	5/2$^-$		
6834		4797		2037	9/2$^+$		$\Gamma(p)\Gamma(\gamma)/\Gamma$=0.040 eV *10* (1979Ra12). $\Gamma(p)\Gamma(\gamma)/\Gamma$=0.20 eV *5* (1972Sz01).
6839		4801		2037	9/2$^+$		$\Gamma(p)\Gamma(\gamma)/\Gamma$=0.035 eV *10* (1979Ra12).
7141	(5/2)	4330 *6*	24 *2*	2811.0	(3/2,5/2)	D+Q	$\Gamma(p)\Gamma(\gamma)/\Gamma$=0.014 eV *4* (1982Ra11). Mult.: from $\gamma\gamma(\theta)$ (1982Ra11). δ: ≈+1 for J(2811)=3/2 and ≈0 for J(2811)=5/2 from $\gamma\gamma(\theta)$ of 5/2(4330γ)J(2620γ)5/2$^-$ cascade in 1982Ra11.
		4934 *5*	55 *4*	2206.5	5/2$^-$	D+Q	$\Gamma(p)\Gamma(\gamma)/\Gamma$=0.031 eV *5* (1982Ra11). Mult.: from $\gamma\gamma(\theta)$ (1982Ra11). δ: ≈−0.2 for J(2207)=5/2 and ≈−2 for J(2207)=7/2 from $\gamma\gamma(\theta)$ of 5/2(4934γ)J(2207γ)3/2$^-$ cascade in 1982Ra11.
		6491 *5*	21 *2*	649.7	1/2$^-$,3/2$^-$		$\Gamma(p)\Gamma(\gamma)/\Gamma$=0.012 eV *3* (1982Ra11).
7145	(5/2)	4938 *5*		2206.5	5/2$^-$		$\Gamma(p)\Gamma(\gamma)/\Gamma$=0.044 eV *8* (1982Ra11). Branching: >80 for this transition. For upper limit on branchings of unobserved transitions see 1982Ra11.

† From 1975We24 up to 2811 level with uncertainty estimated by the evaluator from energy uncertainties of connected levels, and values for primary γ rays are from level-energy differences, unless otherwise noted.

‡ Percent photon branching from each level. Quoted values are from 1975We24 up to 2811 level and values for primary γ transitions are from 1979Ra12 and 1982Ra11 as indicated in comments, unless otherwise noted.

Values quoted in comments from $\gamma\gamma(\theta)$ in 1982Ra11 are estimated by the evaluator from plots of arctan(δ(1)) against arctan(δ(2)) and are only approximate.

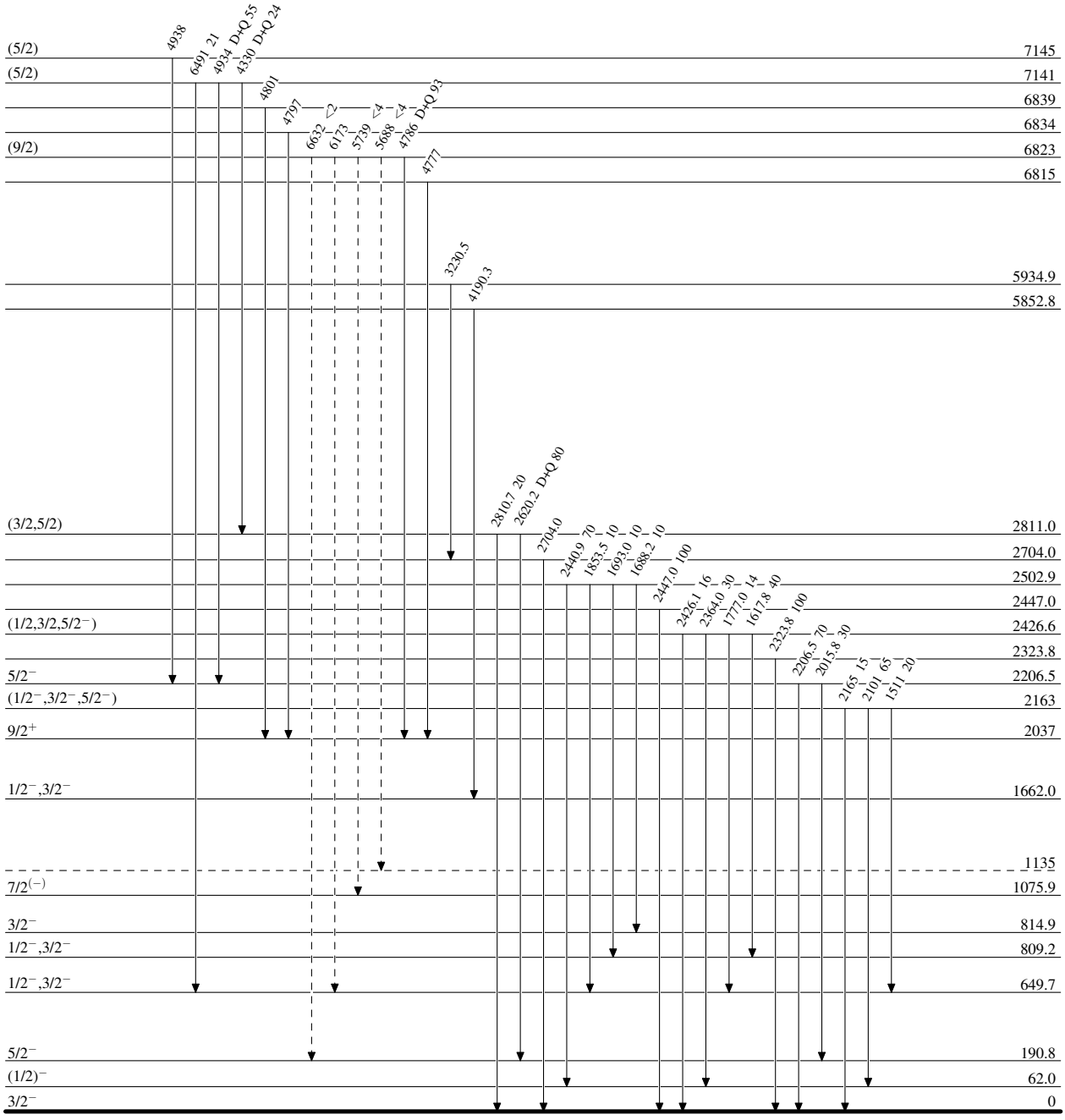
@ Placement of transition in the level scheme is uncertain.

^{64}Zn(p,γ),(p,p′γ) E=res 1975We24,1979Ra12,1982Ra11 Legend

Level Scheme

Intensities: % photon branching from each level

γ Decay (Uncertain)



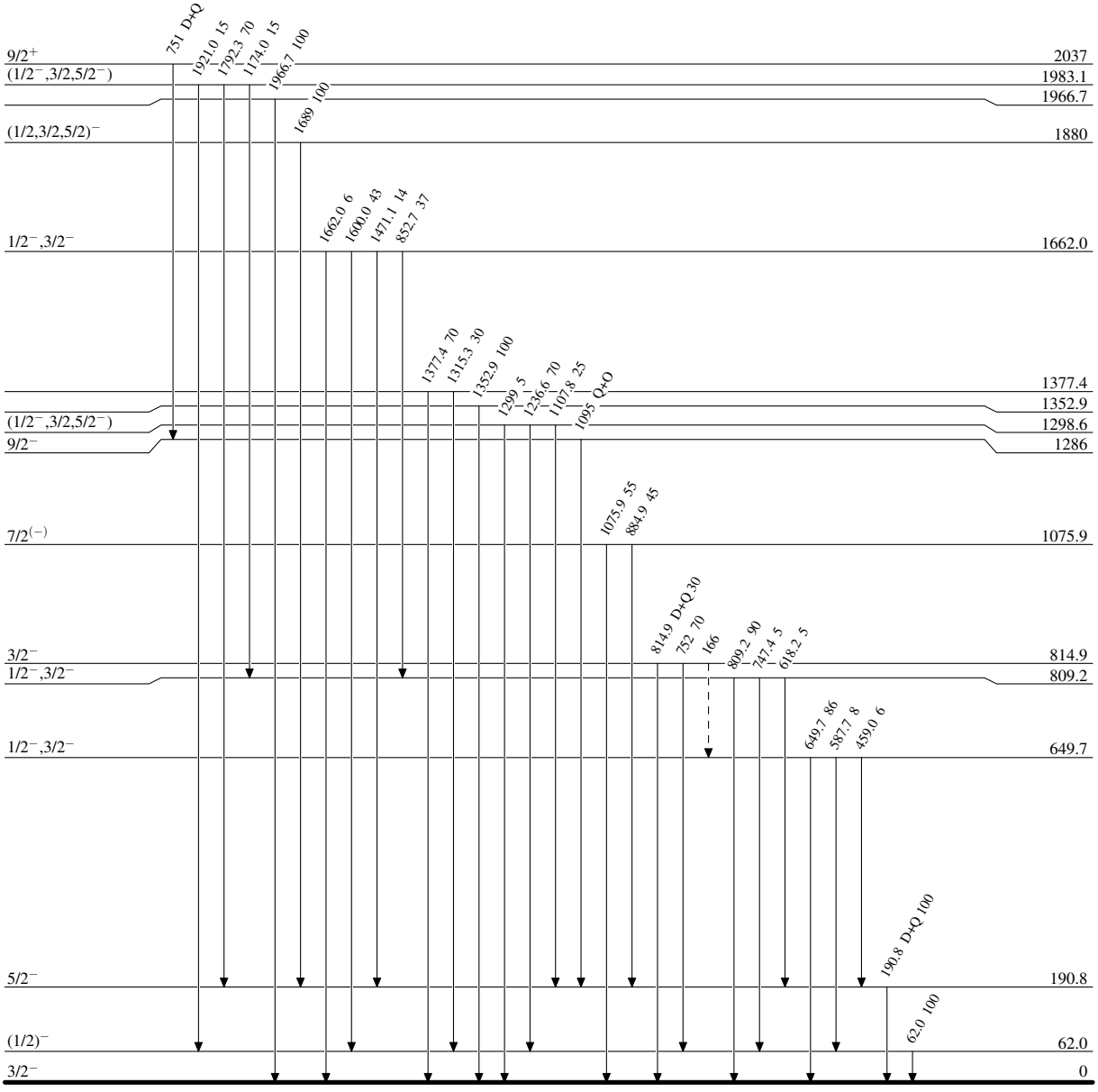
$^{65}_{31}Ga_{34}$

^{64}Zn(p,γ),(p,p′γ) E=res 1975We24,1979Ra12,1982Ra11 Legend

Level Scheme (continued)

Intensities: % photon branching from each level

- - - - - - ► γ Decay (Uncertain)



$^{65}_{31}Ga_{34}$