^{63}Ni(n,γ) E=th 1992Ha21,2020Ma37

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen	NDS 178,41 (2021).	12-Nov-2021

J^π(^{63}Ni g.s.)=1/2$^-$.

1992Ha21: double neutron capture in enriched (97.5%) ^{62}Ni with thermal neutrons from the ILL high-flux reactor. γ rays measured with pair and Compton suppressed Ge detectors. Measured Eγ, Iγ. Deduced levels.

2020Ma37: E=thermal at ILL, Grenoble. Measured primary and secondary γ rays in singles and coincidence, γγ(θ), using 2GBq ^{63}Ni radioactive target from CERN n_TOF using FIPPS array of 16 clover HPGe detectors. Detailed results of this experiment are to be published elsewhere.

1975Wi06: thermal neutrons from the Oak Ridge high-flux isotope reactor (HFIR) on a ^{63}Ni target. γ rays were detected with a pair spectrometer. Two primary γ rays, 9655.9 *4* (Iγ=2.51 *5*) and 8311.7 *5* (Iγ=0.37 *9*), feeding g.s. and 1344 level, respectively, were reported.

Other: 1972Mo46.

Additional information 1.

Thermal capture σ=20 b *+5−2* (1992Ha21).

^{64}Ni Levels

S(n)=9657.46 *20* (2021Wa16).

E(level)†	J^π#	Comments
0.0	0$^+$	
1345.775 *22*	2$^+$	
2276.58 *3*	2$^+$	
2867.35 *6*	0$^+$	
2972.11 *5*	(1,2$^+$)	J^π: 2$^+$ proposed in 2020Ma37 but no arguments given.
3025.85 *4*	0$^+$	J^π: spin=0 from 1680γ-1346γ(θ) in (n,γ) E=th (2020Ma37); 1680γ E2, ΔJ=2 to 2$^+$.
3153.73 *4*	2$^+$	J^π: 1$^+$ reported by 2020Ma37, but no arguments given.
3275.99 *5*	2$^+$	
3463.63 *4*	0$^+$@	J^π: spin=0 from 2117γ-1346γ(θ) in (n,γ) E=th (2020Ma37); primary γ from 1$^-$ expected to be E1; 310γ, 492γ and 1187γ to 2$^+$.
3578.61?‡ *5*	(1$^+$)	
3647.98 *6*	2$^+$	J^π: spin=2 from 2302γ-1346γ in (n,γ) E=th (2020Ma37).
3749.01 *5*	2$^+$	J^π: spin=2 from 2403γ-1346γ in (n,γ) E=th (2020Ma37).
3798.7	2$^+$	E(level),J^π: from 2020Ma37. The authors state that J^π=2$^+$ is firmly established in their (n,γ) E=th experiment, but no further details are given. This level is not seen in other studies.
3856.1 *7*	0$^+$	J^π: 2020Ma37 note that 0$^+$ is established based on a 702γ-3154γ correlation cascade from a (n,γ) E=th experiment at ILL, which has not been published.
4268.26 *5*	0$^+$@	
4573.15 *5*	2$^+$	
4615.60 *6*	(1,2)	
4640.68 *5*	2$^+$	
4704.09 *5*	0$^+$@	
4868.53 *5*	(1,2)	
5155.52 *6*	(0$^+$,1,2,3$^-$)	
5418.22 *6*	(1)$^-$	
5768.67 *6*	0$^+$@	
(9657.66 *3*)	1$^-$	E(level): S(n)=9657.46 *20* (2021Wa16). J^π: s-wave capture in 1/2$^-$ (^{63}Ni g.s.), strong γ transition to 0$^+$. The 0$^-$ component in the capture state is expected to be negligible.

† From a least-squares fit to γ-ray energies.

Continued on next page (footnotes at end of table)

^{63}Ni(n,γ) E=th 1992Ha21,2020Ma37 (continued)

^{64}Ni Levels (continued)

‡ Proposed by the evaluators from the placements of unplaced transitions in 1992Ha21 based on the decay scheme in ^{64}Co β^- decay (2012Pa39).

From Adopted Levels, unless otherwise noted. Supporting arguments from this dataset are given in footnotes or comments where available.

@ From 2020Ma37. The authors state that the decay pattern is only consistent with 0^+ based on an unpublished (n,γ) E=th experiment at ILL and that $\gamma\gamma(\theta)$ of a cascade toward 1346 level also yields firm 0^+ assignment.

^{63}Ni(n,γ) E=th 1992Ha21,2020Ma37 (continued)

γ(^{64}Ni)

E_γ[†]	I_γ[†d]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[b]	δ	Comments
310[@]	0.11	3463.63	0$^+$	3153.73	2$^+$			I_γ: from I(310γ)/I(1187γ)=4.6/100 (2020Ma37) and I(1187γ).
492[@]	0.025	3463.63	0$^+$	2972.11	(1,2$^+$)			I_γ: from I(492γ)/I(1187γ)=1.0/100 (2020Ma37) and I(1187γ).
^{x}658.14 *5*	0.51 *10*							
702[e]		3856.1	0$^+$	3153.73	2$^+$			E_γ: 2020Ma37 mention a 702γ-3154γ correlation cascade from a (n,γ) E=th experiment at ILL, which has not been published.
749.23 *4*	1.12 *22*	3025.85	0$^+$	2276.58	2$^+$			I_γ: other: I(749γ)/I(1680γ)=3.6 *2*/100 (2020Ma37).
877.15[&e] *5*	0.80 *16*	3153.73	2$^+$	2276.58	2$^+$			
930.81 *3*	10.9 *22*	2276.58	2$^+$	1345.775	2$^+$			
1114.58[&e] *4*	1.08 *22*	4268.26	0$^+$	3153.73	2$^+$			
1187.02 *3*	2.5 *5*	3463.63	0$^+$	2276.58	2$^+$			
1345.84 *3*	57.0 *11*	1345.775	2$^+$	0.0	0$^+$			
1521.56[&e] *5*	0.42 *8*	2867.35	0$^+$	1345.775	2$^+$			
1626.30[e] *7*	0.40 *8*	2972.11	(1,2$^+$)	1345.775	2$^+$			
^{x}1637.03[‡] *13*	0.30 *6*							
1680.07 *4*	24 *5*	3025.85	0$^+$	1345.775	2$^+$	Q		
1807.97[&e] *5*	0.83 *17*	3153.73	2$^+$	1345.775	2$^+$			
1930.19 *10*	0.21 *4*	3275.99	2$^+$	1345.775	2$^+$	(M1+E2)		
^{x}2059.51 *13*	0.201 *20*							
2117.86 *7*	0.49 *5*	3463.63	0$^+$	1345.775	2$^+$	Q		I_γ: other: I(2117γ)/I(1187γ)=23/100 (2020Ma37).
^{x}2190.01 *22*	0.29 *3*							
^{x}2197.30 *20*	0.218 *22*							
^{x}2214.47[#] *9*	0.27 *3*					[c]		
2232.89[&e] *6*	1.04 *10*	3578.61?	(1$^+$)	1345.775	2$^+$			
2302.30 *17*	0.58 *6*	3647.98	2$^+$	1345.775	2$^+$	(M1+E2)		
2339.17 *12*	0.34 *4*	4615.60	(1,2)	2276.58	2$^+$			
2403.25 *7*	0.54 *5*	3749.01	2$^+$	1345.775	2$^+$	E2+M1	+1.23 *10*	Mult.,δ: D+Q and δ from $\gamma\gamma(\theta)$ in ^{63}Ni(n,γ) E=th; E1+M2 disfavored by the large δ and RUL.
2427.50 *9*	0.37 *4*	4704.09	0$^+$	2276.58	2$^+$			
2453[e]		3798.7	2$^+$	1345.775	2$^+$	(M1+E2)		E_γ: from level-energy difference. A transition to 1346 level is mentioned but its energy is not given by 2020Ma37.
^{x}2500.56 *15*	0.129 *13*							
^{x}2502.38 *20*	0.098 *10*							
^{x}2571.44 *8*	0.124 *12*							
^{x}2686.85 *6*	0.237 *24*							
^{x}2747.63 *8*	0.124 *12*							
^{x}2765.76 *9*	0.100 *10*							
^{x}2837.29 *11*	0.110 *11*							
2878.94 *8*	0.146 *15*	5155.52	(0$^+$,1,2,3$^-$)	2276.58	2$^+$			
^{x}2888.24 *8*	0.116 *12*							

$^{64}_{28}$Ni$_{36}$-3

γ(^{64}Ni) (continued)

E_γ †	I_γ †d	E_i(level)	J^π_i	E_f	J^π_f	Comments
2922.07[&e] 9	0.117 12	4268.26	0^+	1345.775	2^+	
[x]2925.55 9	0.167 17					
[x]2956.61 9	0.123 12					
2972.04[e] 6	0.28 3	2972.11	$(1,2^+)$	0.0	0^+	
[x]3029.90 8	0.186 9					
3153.68[&e] 7	1.10 5	3153.73	2^+	0.0	0^+	
3227.31 6	0.61 3	4573.15	2^+	1345.775	2^+	
3275.90 6	0.65 3	3275.99	2^+	0.0	0^+	
3294.90 7	0.429 21	4640.68	2^+	1345.775	2^+	
3358.24 6	0.59 3	4704.09	0^+	1345.775	2^+	
3492.33 11	0.220 11	5768.67	0^+	2276.58	2^+	
3522.66 6	4.35 22	4868.53	(1,2)	1345.775	2^+	
3578.32[&e] 8	0.317 16	3578.61?	(1^+)	0.0	0^+	
3647.86 7	0.312 16	3647.98	2^+	0.0	0^+	
[x]3696.28 8	0.234 12					
3748.77 8	0.160 8	3749.01	2^+	0.0	0^+	I_γ: other: I(3748γ)/I(2403γ)=31/100 (2020Ma37).
[x]3768.51 9	0.130 7					
[x]3798.74 7	0.52 3					
3809.64 9	0.176 9	5155.52	$(0^+,1,2,3^-)$	1345.775	2^+	
[x]3836.89 10	0.156 8					
[x]3867.93 8	0.262 13					
3888.97 8	0.90 5	(9657.66)	1^-	5768.67	0^+	
[x]3961.01 10	0.112 6					
[x]4011.56 18	0.152 8					
[x]4017.40 8	0.360 18					
[x]4047.49 10	0.185 9					
4072.32 9	0.149 7	5418.22	$(1)^-$	1345.775	2^+	
[x]4169.09 8	0.62 3					
[x]4180.07 8	0.402 20					
4239.29 8	0.351 18	(9657.66)	1^-	5418.22	$(1)^-$	
[x]4264.23 8	0.303 15					
[x]4299.87 11	0.215 11					
[x]4351.23 12	0.080 4					
4422.60 10	0.269 13	5768.67	0^+	1345.775	2^+	
[x]4443.61 10	0.198 10					
4502.08 9	0.380 19	(9657.66)	1^-	5155.52	$(0^+,1,2,3^-)$	
[x]4512.86 9	0.206 10					
[x]4543.02 13	0.118 6					
4572.94 9	0.304 15	4573.15	2^+	0.0	0^+	
4615.27 9	0.456 23	4615.60	(1,2)	0.0	0^+	
4640.34 8	0.62 3	4640.68	2^+	0.0	0^+	

γ(^{64}Ni) (continued)

E_γ†	$I_\gamma$$^{\dagger d}$	E_i(level)	J^π_i	E_f	J^π_f
^{x}4765.17 9	0.373 19				
4788.96 8	4.61 23	(9657.66)	1$^-$	4868.53	(1,2)
4868.34 11	0.149 7	4868.53	(1,2)	0.0	0$^+$
^{x}4892.07 9	0.378 19				
4953.45 9	1.19 6	(9657.66)	1$^-$	4704.09	0$^+$
5016.70 9	1.13 6	(9657.66)	1$^-$	4640.68	2$^+$
5041.80 9	0.74 4	(9657.66)	1$^-$	4615.60	(1,2)
5084.30 9	1.02 5	(9657.66)	1$^-$	4573.15	2$^+$
^{x}5130.09 13	0.122 6				
^{x}5158.77 12	0.126 6				
5389.13^{ae} 10	1.31 7	(9657.66)	1$^-$	4268.26	0$^+$
5417.92 12	0.143 7	5418.22	(1)$^-$	0.0	0$^+$
^{x}5477.11 12	0.173 9				
^{x}5639.79 13	0.160 8				
5801$^{@}$		(9657.66)	1$^-$	3856.1	0$^+$
5908.30 12	0.402 20	(9657.66)	1$^-$	3749.01	2$^+$
^{x}5960.85 15	0.141 7				
6009.42 11	0.60 3	(9657.66)	1$^-$	3647.98	2$^+$
6193.58 11	2.55 13	(9657.66)	1$^-$	3463.63	0$^+$
6381.37 13	0.378 19	(9657.66)	1$^-$	3275.99	2$^+$
6503.26^{ae} 16	0.204 10	(9657.66)	1$^-$	3153.73	2$^+$
6631.34 12	21.6 11	(9657.66)	1$^-$	3025.85	0$^+$
6791$^{@}$		(9657.66)	1$^-$	2867.35	0$^+$
^{x}7015.6 4	0.023 1				
^{x}7057.8 5	0.018 1				
^{x}7075.5 4	0.019 1				
^{x}7086.23 18	0.066 3				
^{x}7157.8 7	0.014 1				
^{x}7177.8 4	0.024 1				
^{x}7189.4 6	0.013 1				
^{x}7233.3 6	0.013 1				
^{x}7250.3 9	0.010 1				
^{x}7256.8 10	0.009 1				
^{x}7273.65 23	0.045 2				
^{x}7295.8 10	0.008 1				
^{x}7305.1 8	0.009 1				
^{x}7325.6 4	0.022 1				
^{x}7339.0 7	0.011 1				
^{x}7348.2 6	0.018 1				
7380.62 13	2.45 12	(9657.66)	1$^-$	2276.58	2$^+$
^{x}7393.0 4	0.027 1				
^{x}7427.6 7	0.012 1				
^{x}7437.6 8	0.010 1				
^{x}7465.8 4	0.020 1				
^{x}7553.2 8	0.010 1				
^{x}7589.2 4	0.022 1				
^{x}7598.17 16	0.114 6				
^{x}7649.91 21	0.083 4				
^{x}7680.7 7	0.013 1				
^{x}7800.1 8	0.011 1				
^{x}7840.6 5	0.023 1				
^{x}7860.7 6	0.015 1				
^{x}7876.9 9	0.010 1				
^{x}7886.8 6	0.016 1				
^{x}7915.3 4	0.031 2				
^{x}7921.4 4	0.030 1				
^{x}8203.2 7	0.016 1				
8311.45 16	5.6 3	(9657.66)	1$^-$	1345.775	2$^+$
9656.89 15	46 7	(9657.66)	1$^-$	0.0	0$^+$

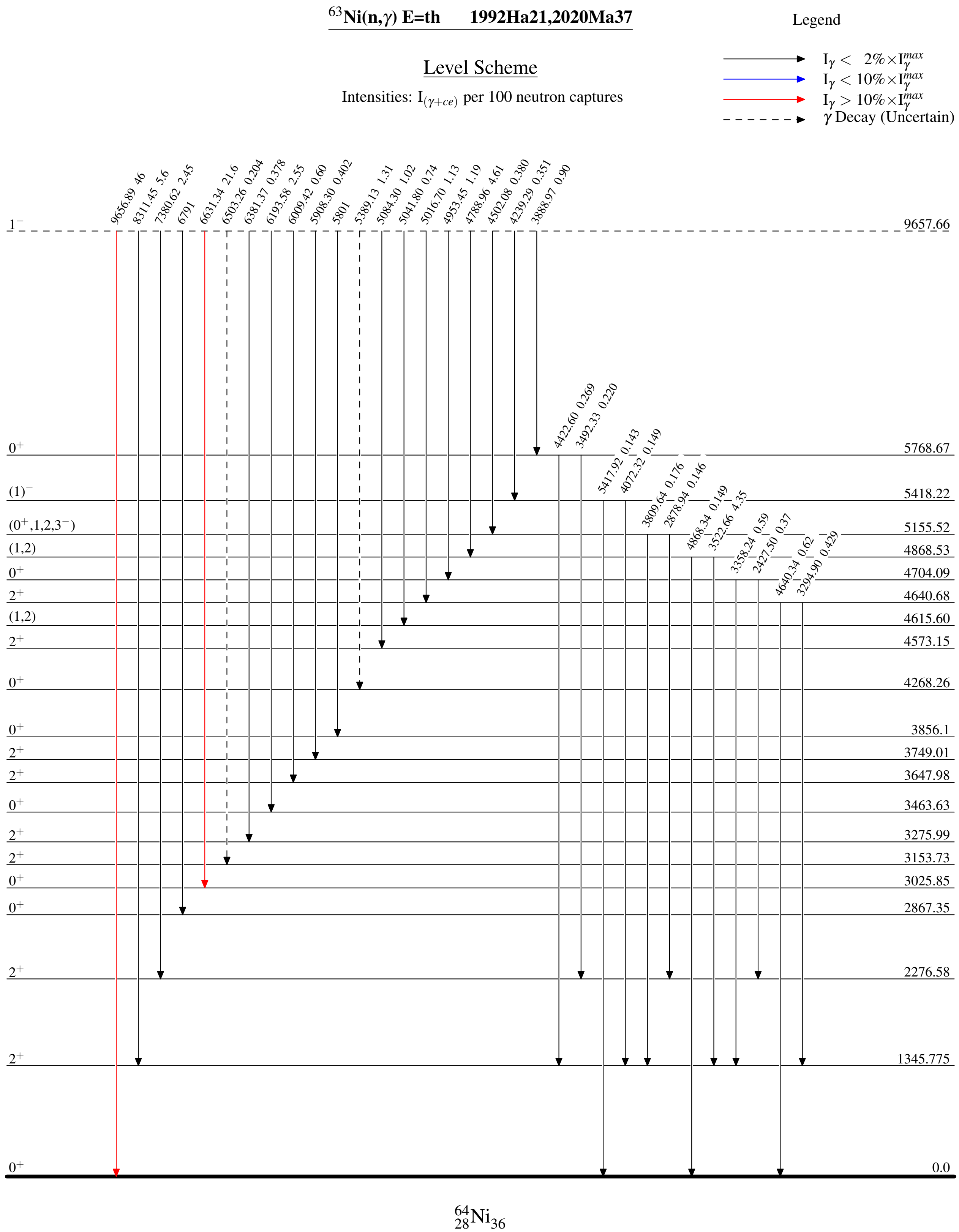
† From 1992Ha21, unless otherwise noted.
‡ Possibly 2983-1346 transition (see Adopted Gammas).
$^{\#}$ Possibly 3560-1346 transition (see Adopted Gammas).
$^{@}$ From 2020Ma37.
$^{\&}$ Placed by the evaluators based on the decay scheme in ^{64}Co β^- decay (2012Pa39); unplaced by 1992Ha21.
^{a} Placed from the capture state by the evaluators; unplaced by 1992Ha21.
^{b} From $\gamma\gamma(\theta)$ in 2020Ma37.

^{63}Ni(n,γ) E=th 1992Ha21,2020Ma37 (continued)

γ(^{64}Ni) (continued)

[c] 2020Ma37 states that $\gamma\gamma(\theta)$ of the cascade toward 1346 level indicates a dominant M1 character, with only a small E2 admixture.
[d] For intensity per 100 neutron captures, multiply by 1.0.
[e] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

$^{64}_{28}Ni_{36}$-6


^{63}Ni(n,γ) E=th 1992Ha21,2020Ma37
Level Scheme
Intensities: $I_{(\gamma+ce)}$ per 100 neutron captures
Legend
$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$
γ Decay (Uncertain)
9656.89 46
8311.45 5.6
7380.62 2.45
6791
6631.34 21.6
6503.26 0.204
6381.37 0.378
6193.58 2.55
6009.42 0.60
5908.30 0.402
5801
5389.13 1.31
5084.30 1.02
5041.80 0.74
5016.70 1.13
4953.45 1.19
4788.96 4.61
4502.08 0.380
4239.29 0.351
3888.97 0.90
4422.60 0.269
3492.33 0.220
5417.92 0.143
4072.32 0.149
3809.64 0.176
2878.94 0.146
4868.34 0.149
3522.66 4.35
3358.24 0.59
2427.50 0.37
4640.34 0.62
3294.90 0.429
1⁻ 9657.66
0⁺ 5768.67
(1)⁻ 5418.22
(0⁺,1,2,3⁻) 5155.52
(1,2) 4868.53
0⁺ 4704.09
2⁺ 4640.68
(1,2) 4615.60
2⁺ 4573.15
0⁺ 4268.26
0⁺ 3856.1
2⁺ 3749.01
2⁺ 3647.98
0⁺ 3463.63
2⁺ 3275.99
2⁺ 3153.73
0⁺ 3025.85
0⁺ 2867.35
2⁺ 2276.58
2⁺ 1345.775
0⁺ 0.0
$^{64}_{28}Ni_{36}$

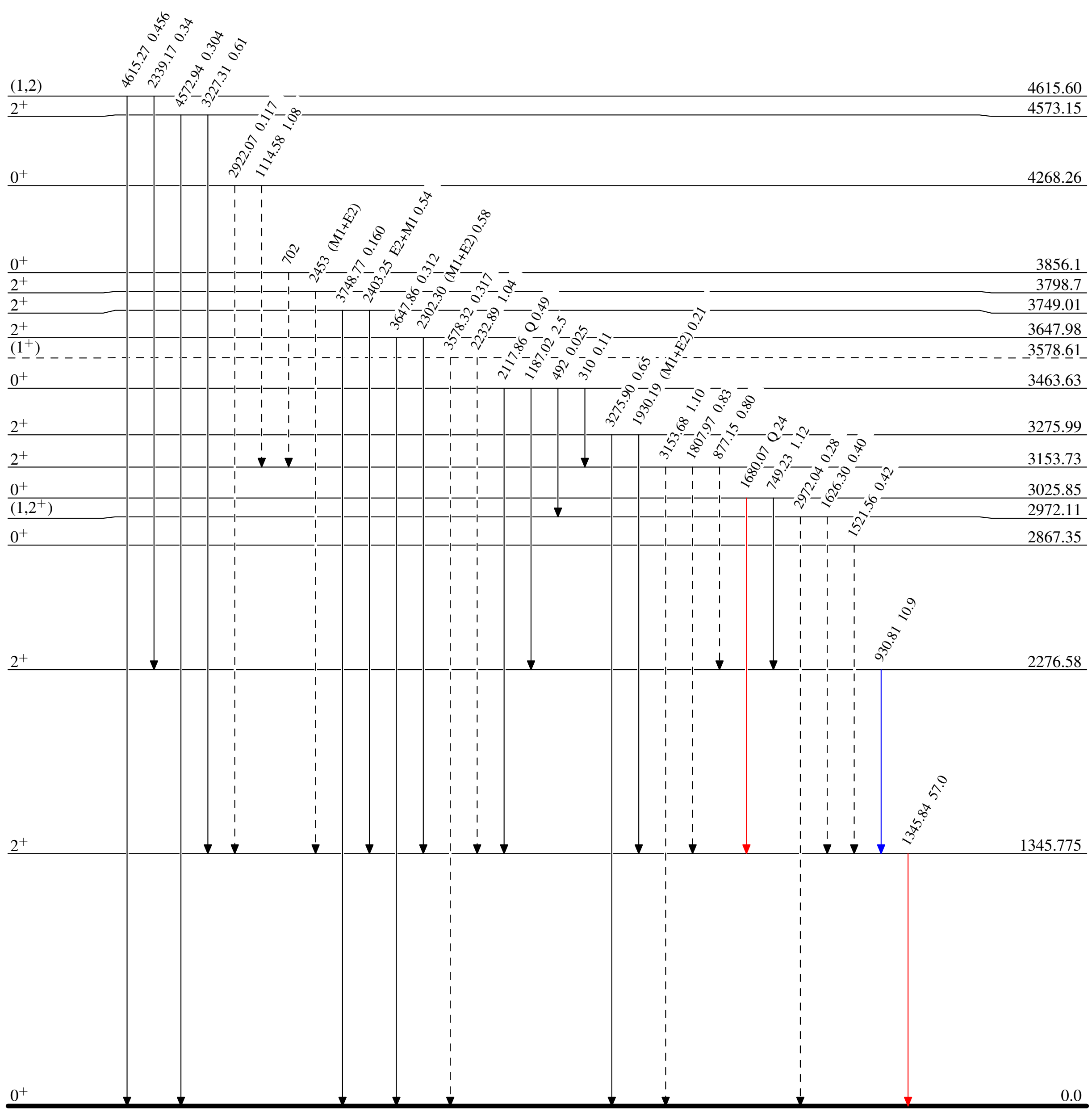
^{63}Ni(n,γ) E=th 1992Ha21,2020Ma37

Level Scheme (continued)

Intensities: $I_{(\gamma+ce)}$ per 100 neutron captures

Legend

- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- γ Decay (Uncertain)



$^{64}_{28}Ni_{36}$