Adopted Levels, Gammas

History

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

Q(β^-)=−4517 *4*; S(n)=10357.0 *19*; S(p)=3908.4 *21*; Q(α)=−2912.5 *21* 2021Wa16
Q(ε)=7171.2 *15*, S(2n)=22988.4 *15*, S(2p)=10623.2 *15* (2021Wa16).
Mass measurements: 2008Go23, 2007Cl01, 2007Gu09, 2007Sc24, 2005Ch60, 2005Gu36.
Theoretical calculations: consult the NSR database at www.nndc.bnl.gov/nsr/ for 20 primary references dealing with nuclear structure and radioactive decay of ^{64}Ga,
Additional information 1.
2012Pr11: measured isotope shifts and rms charge radii by collinear laser spectroscopy using COLLAPS setup at ISOLDE-CERN.

^{64}Ga Levels

Cross Reference (XREF) Flags

A	^{64}Ge ε decay (63.7 s)	D	^{64}Zn(p,nγ)
B	^{54}Fe(^{12}C,pnγ)	E	^{64}Zn(^{3}He,t)
C	^{64}Zn(p,n)		

E(level)†	J$^\pi$	T$_{1/2}$	XREF	Comments
0.0	0$^+$	2.627 min *12*	ABCDE	%ε+%β^+=100 %ε=98, %β^+=2. δ<r^2>(^{71}Ga,^{64}Ga)=−0.579 fm^2 *18*(stat) *119*(syst) (2012Pr11). Isotope shift $\delta\nu$(^{71}Ga,^{64}Ga)=+94 MHz *7*(stat) *15*(syst) (2012Pr11). Measured matter r.m.s. radius=3.75 fm *10* (2004Li29, from Si(^{64}Ga,X),E=56.8 MeV/nucleon at GANIL, Glauber analysis); reduced strong absorption r$_0$=1.017 fm *12*, with measured σ=2.51 b *6*. J$^\pi$: $\beta^+\gamma$ circular polarization (1966De10,1967Ma04); L(^{3}He,t)=0 from 0$^+$ target. T$_{1/2}$: 157.6 s *7* from weighted average of 157.6 s *7* (1990SuZR, probably from γ decay); 157.4 s *7* (1973Da01, 992γ decay); 159 s *2* (1972Mo08, 992γ decay); 2.7 min *1* (1967Ko02, γ decay); 2.6 min *1* (1953Cr15, γ-decay). Others: 2.6 min (1980Na15,1980NaZS, γ decay); 2.5 min (1953Co14).
42.86 *8*	(2$^+$)	21.9 μs *7*	ABCDE	J$^\pi$: (E2) γ to 0$^+$. T$_{1/2}$: from pulsed-beam method in ^{63}Cu(^{3}He,2n) (1999Ta29). Other: >1 μs (γ(t) in (p,nγ), 1974Ha42).
128.02 *11*	1$^+$@	6.9 ns *7*	A CDE	T$_{1/2}$: γ(t) in (p,nγ) (1974Ha42).
170.99 *10*	(3$^+$)‡	≈3 ns	BCDE	E(level): may be weakly populated in ^{64}Ge ε decay. T$_{1/2}$: from two-component analysis of 128γ(t) curve in (p,nγ) (1974Ha42), T$_{1/2}$≈3 ns or less.
322.98 *8*	(2$^+$)		BCDE	J$^\pi$: (2$^+$,1$^+$) from measured and calculated (Hauser-Feshbach) $\sigma(\theta)$ and σ(integral) in (p,nγ); γ from (4$^+$).
427.03 *6*	1$^+$@		A CDE	
534.55 *11*	(3$^+$)‡		BcD	XREF: c(535). E(level): level in (p,n) probably corresponds to 534+538.
538.03 *11*	(4$^+$)‡		BcD	XREF: c(535).
550.28 *11*	(1,2$^+$)		CDE	XREF: E(545.2). J$^\pi$: γ to 0$^+$ (g.s.).
605.24 *23*	(2$^+$,3$^-$)#		BCDE	XREF: E(598.6).
666.94 *16*	1$^+$@		A CDE	
707.51 *10*	(4$^+$)‡		BCDe	XREF: C(709)e(710). E(level): the 710 group in (^{3}He,t) corresponds to 707 and/or 712 levels.
712.16 *15*			CDe	XREF: C(719)e(710).

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Adopted Levels, Gammas (continued)

^{64}Ga Levels (continued)

E(level)[†]	Jπ	XREF	Comments
765.26 *15*	(3,2$^+$)[#]	CDE	
817.4 *3*	(1$^+$)[@]	A CDE	XREF: C(818)E(818.1). E(level): population uncertain in ^{64}Ge ε decay and in (p,nγ). The level suggested by the evaluator on the basis of 774.5γ seen in both these studies (but not placed) and a corresponding level at 818 reported in (p,n) and (^{3}He,t).
828.95 *15*		BCD	
852 *3*	(2$^+$,1$^+$)[#]	C E	XREF: C(855)E(851).
937 *2*	1$^+$[@]	C E	XREF: C(943)E(936.0).
1020.82 *11*	(5$^+$)[‡]	BC E	XREF: C(1023)E(1016.9).
1032 *5*		C E	
1054 *4*		C E	XREF: C(1063)E(1053).
1065 *5*	(1$^+$)[@]	E	
1136 *5*		C E	XREF: C(1140)E(1134).
1233 *4*		C E	XREF: C(1250)E(1232.0).
1279.82 *15*	(4$^+$)[‡]	BC E	XREF: C(1290)E(1273.5).
1357.13 *17*	(5$^+$)[‡]	B E	XREF: E(1359.5).
1421 *3*		E	
1460 *3*		E	
1478.74 *17*		B	
1552 *5*		E	
1578 *6*		E	
1685.12 *16*	(5$^+$)[‡]	B E	XREF: E(1682.7).
1759 *5*		E	
1785 *4*		E	
1798.53 *11*	(6$^+$)[‡]	B	
1803 *5*	1$^+$[@]	E	
1818 *4*		E	
1842.82 *12*	(5$^-$)[‡]	B	
1859.4 *17*		E	
1923 *5*	0$^+$[@]	C E	XREF: C(1950). Jπ: σ(θ) and IAS of ^{64}Zn g.s.; L(^{3}He,t)=0 from 0$^+$.
1949.54 *18*	(6$^+$)[‡]	B	
1991 *5*		E	
2033.23 *12*	(7$^-$)[‡]	B	
2052.93 *15*	(6$^+$)[‡]	B E	XREF: E(2056). E(level): may be a separate level in (^{3}He,t).
2104.3 *4*		B	
2189 *5*		E	
2223 *5*		E	
2313 *5*		E	
2336.7 *18*		E	
2353.6 *4*		B E	XREF: E(2356).
2384 *4*		E	
2396.3 *3*	(7$^-$)[‡]	B	
2415 *3*		E	
2448 *5*		E	
2547.6 *17*		E	
2585 *5*	1$^+$[@]	E	
2645 *5*	1$^+$[@]	E	
2730 *5*		E	
2874 *5*		E	

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Adopted Levels, Gammas (continued)

^{64}Ga Levels (continued)

E(level)[†]	J$^{\pi}$	XREF	Comments
2913 *5*	1^{+}[@]	E	
2940	(2^{+})	C	E(level): value may be high, since the 1905 (from (^{3}He,t)) state was reported at 1950 in (p,n). J$^{\pi}$: $\sigma(\theta)$ and IAS of first 2^{+} state of ^{64}Zn.
2994 *5*		E	
3084 *5*	1^{+}[@]	E	
3089.54 *15*	(8^{-})[‡]	B	
3102.74 *15*	(9^{-})[‡]	B	
3163.9 *3*		B E	XREF: E(3168).
3222 *5*	1^{+}[@]	E	
3289 *5*	1^{+}[@]	E	
3332 *5*	1^{+}[@]	E	
3430 *5*		E	
3527 *5*	1^{+}[@]	E	
3573.9 *2*	(9^{+})[‡]	B	
3586 *5*		E	
3690 *5*		E	
3764 *5*		E	
3829 *5*	1^{+}[@]	E	
3911 *5*	1^{+}[@]	E	
3954 *5*		E	
4033 *5*	(1^{+})[@]	E	
4086 *5*	1^{+}[@]	E	
4121 *5*	1^{+}[@]	E	
4197 *5*		E	
4323 *5*		E	
4437 *5*		E	
4473.0 *3*	(11^{+})[‡]	B	
4679 *5*	1^{+}[@]	E	
4721 *5*	1^{+}[@]	E	
4937 *5*	(1^{+})[@]	E	
5004 *5*	1^{+}[@]	E	
5134 *5*	1^{+}[@]	E	
5272 *5*	1^{+}[@]	E	
5322 *5*	1^{+}[@]	E	
5349 *5*		E	
5505 *5*		E	
5578 *5*	1^{+}[@]	E	
5629.2 *4*	(12)[‡]	B	
5643 *5*		E	
5746 *5*		E	
5853 *5*	(1^{+})[@]	E	
6131 *5*		E	
6171 *5*		E	
6247 *5*	1^{+}[@]	E	
6285 *5*	1^{+}[@]	E	
6359 *5*	1^{+}[@]	E	
6412 *5*	1^{+}[@]	E	
6562 *5*	1^{+}[@]	E	

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Adopted Levels, Gammas (continued)

^{64}Ga Levels (continued)

E(level)[†]	J^{π}	XREF
6608 *5*	1^+[@]	E
6682 *5*	1^+[@]	E
6733 *5*	1^+[@]	E
6774 *5*	1^+[@]	E
6850 *5*	1^+[@]	E
6884 *5*	1^+[@]	E
6971 *5*	1^+[@]	E
7065 *5*	1^+[@]	E
7173 *5*	1^+[@]	E
7301 *5*	1^+[@]	E
7335 *5*		E
7389 *5*	1^+[@]	E
7416 *5*	1^+[@]	E
7450 *5*	1^+[@]	E
7511 *5*	1^+[@]	E
7578 *5*		E
7619 *5*	1^+[@]	E
7679 *5*	1^+[@]	E
7713 *5*		E
7740 *5*		E
7760 *5*		E
7787 *5*		E
7841 *5*	(1^+)[@]	E
7888 *5*		E
7942 *5*	1^+[@]	E
7996 *5*		E
8037 *5*	(1^+)[@]	E
8070 *5*	1^+[@]	E
8151 *5*	1^+[@]	E
8300 *5*		E
8496 *5*	(1^+)[@]	E
8577 *5*	1^+[@]	E
8665 *5*		E
8838 *5*	1^+[@]	E
8902 *5*	1^+[@]	E
9010 *5*	(1^+)[@]	E
9058 *5*		E
9112 *5*	1^+[@]	E
9146 *5*		E
9207 *5*		E
9254 *5*		E
9376 *5*		E
9437 *5*		E
9471 *5*		E
9586 *5*	(1^+)[@]	E
9641 *5*	(1^+)[@]	E
9695 *5*	1^+[@]	E
9851 *5*	1^+[@]	E

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Adopted Levels, Gammas (continued)

^{64}Ga Levels (continued)

E(level)[†]	J$^\pi$	XREF	Comments
9973 *5*	(1$^+$)[@]	E	
10055 *5*		E	
10095 *5*	1$^+$[@]	E	
10163 *5*		E	
10442 *10*	(1$^+$)[@]	E	
10544 *10*	(1$^+$)[@]	E	
10639 *10*	(1$^+$)[@]	E	
13990	(1$^+$)	E	E(level),J$^\pi$: interpreted by 2019Di08 as isospin T=3 analog state of 2660, 1$^+$ level in ^{64}Cu.
14080		E	
14510	(1$^+$)	E	E(level),J$^\pi$: interpreted by 2019Di08 as isospin T=3 analog state of 3190, 1$^+$ level in ^{64}Cu.

[†] From a least-squares fit to Eγ data for levels populated in γ-ray studies. Other level energies are mainly from (^{3}He,t) and some from (p,n), with weighted averages taken when a level is populated in both the reactions. The levels populated only in ^{54}Fe(^{12}C,pnγ) should be considered as tentative since the details of this study are not available. In addition, γ-ray energy uncertainties in (^{12}C,pnγ) are not given. For fitting purpose, evaluators have assumed 0.1 keV uncertainty for strong γ rays, 0.2 keV for medium intensity and 0.3 keV for weak γ rays.

[‡] Taken from ^{54}Fe(^{12}C,pnγ) (1984ScZO), presumably based on $\gamma(\theta)$ and ce data. Since details of this study are not available, the assignments should be considered tentative.

[#] From measured and calculated (Hauser-Feshbach) $\sigma(\theta)$ and σ(integral) in (p,nγ).

[@] L(^{3}He,t)=0 or (0) in some cases from 0$^+$ target, and probable Gamow-Teller excitation, with isospin T=1, as interpreted by 2019Di08.

γ(^{64}Ga)

E$_i$(level)	J$_i^\pi$	E$_\gamma$[†]	I$_\gamma$[‡]	E$_f$	J$_f^\pi$	Mult.	α[a]	Comments
42.86	(2$^+$)	42.89 *10*	100	0.0	0$^+$	(E2)	16.23 *27*	B(E2)(W.u.)=0.67 *3* α(K)=13.28 *22*; α(L)=2.57 *4*; α(M)=0.367 *6* α(N)=0.01072 *18* Mult.: from (p,nγ).
128.02	1$^+$	85.29 *14*	≈36	42.86	(2$^+$)	[M1+E2]	0.7 *6*	α(K)=0.6 *5*; α(L)=0.08 *7*; α(M)=0.011 *10* α(N)=5.E−4 *4* If E2, B(E2)(W.u.)≈230. If M1, B(M1)(W.u.)≈0.0013.
		128.2 *2*	100 *7*	0.0	0$^+$	[M1]	0.0359 *5*	B(M1)(W.u.)=0.00092 *21* α(K)=0.0320 *5*; α(L)=0.00337 *5*; α(M)=0.000493 *7* α(N)=2.62×10^{-5} *4* 128γ is a close doublet (<1 keV apart) in (p,nγ) deexciting 128 and 171 levels. It is most likely a single line in ^{64}Ge ε decay (deexciting only the 128 level) and in ^{54}Fe(^{12}C,pnγ) (deexciting only the 171 level).
170.99	(3$^+$)	128.2 *2*	100	42.86	(2$^+$)	[M1+E2]	0.16 *12*	α(K)=0.14 *10*; α(L)=0.016 *13*; α(M)=0.0023 *18* α(N)=1.1×10^{-4} *8* E$_\gamma$: from (p,nγ), where it is a doublet, the other placement from 128 level. Other: 128.1 in (^{12}C,pnγ). If E2, B(E2)(W.u.)≈280. If M1, B(M1)(W.u.)≈0.0034.

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Adopted Levels, Gammas (continued)

γ(^{64}Ga) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Comments
322.98	(2$^+$)	152.06 *17*	15 *3*	170.99	(3$^+$)	
		280.10 *14*	100 *20*	42.86	(2$^+$)	
		322.91 *10*	31 *6*	0.0	0$^+$	
427.03	1$^+$	384.1[&] *3*	12.6[&] *13*	42.86	(2$^+$)	
		427.03 *6*	100 *3*	0.0	0$^+$	
534.55	(3$^+$)	363.61 *14*	70 *15*	170.99	(3$^+$)	
		491.69 *12*	100 *20*	42.86	(2$^+$)	
538.03	(4$^+$)	367.12 *15*	62 *14*	170.99	(3$^+$)	
		495.18 *13*	100 *20*	42.86	(2$^+$)	
550.28	(1,2$^+$)	227.23[b] *10*	<18[b]	322.98	(2$^+$)	
		422.56 *20*	100 *20*	128.02	1$^+$	
		550.2 *3*	27 *5*	0.0	0$^+$	
605.24	(2$^+$,3$^-$)	282.1[@]		322.98	(2$^+$)	
		434.4 *3*	100 *20*	170.99	(3$^+$)	
666.94	1$^+$	666.94 *16*	100	0.0	0$^+$	
707.51	(4$^+$)	173.0[@]		534.55	(3$^+$)	
		384.59 *16*	34 *12*	322.98	(2$^+$)	E_γ: from (p,nγ). Other: 384.5 in (^{12}C,pnγ).
		536.5[@]		170.99	(3$^+$)	
		664.6[#]	100 *20*	42.86	(2$^+$)	E_γ: from (^{12}C,pnγ). Other: 663.89 *16* in (p,nγ) is poorly fitted.
712.16		541.10 *15*	100 *20*	170.99	(3$^+$)	
		584.25 *19*	55 *11*	128.02	1$^+$	
765.26	(3,2$^+$)	227.23[b] *10*	100[b]	538.03	(4$^+$)	
817.4	(1$^+$)	774.5[c] *3*		42.86	(2$^+$)	
828.95		290.93 *12*	100	538.03	(4$^+$)	E_γ: from (p,nγ). Other: 290.9 in (^{12}C,pnγ).
1020.82	(5$^+$)	313.3		707.51	(4$^+$)	
		482.8		538.03	(4$^+$)	
		486.3		534.55	(3$^+$)	
		849.8		170.99	(3$^+$)	
1279.82	(4$^+$)	572.3		707.51	(4$^+$)	
		741.8		538.03	(4$^+$)	
		745.3		534.55	(3$^+$)	
		1108.8		170.99	(3$^+$)	
1357.13	(5$^+$)	819.1		538.03	(4$^+$)	
		1186.1		170.99	(3$^+$)	
1478.74		771.2		707.51	(4$^+$)	
		940.7		538.03	(4$^+$)	
		944.2		534.55	(3$^+$)	
1685.12	(5$^+$)	664.3		1020.82	(5$^+$)	
		856.2		828.95		
		1514.1		170.99	(3$^+$)	
1798.53	(6$^+$)	777.7		1020.82	(5$^+$)	
		969.6		828.95		
		1091.0		707.51	(4$^+$)	
		1260.5		538.03	(4$^+$)	
1842.82	(5$^-$)	563.0		1279.82	(4$^+$)	
		822.0		1020.82	(5$^+$)	
		1135.3		707.51	(4$^+$)	
1949.54	(6$^+$)	592.4		1357.13	(5$^+$)	
		928.7		1020.82	(5$^+$)	
		1411.5		538.03	(4$^+$)	
2033.23	(7$^-$)	190.4		1842.82	(5$^-$)	
		234.7		1798.53	(6$^+$)	
		1012.4		1020.82	(5$^+$)	

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Adopted Levels, Gammas (continued)

$\gamma(^{64}Ga)$ (continued)

E_i(level)	J_i^π	E_γ †	E_f	J_f^π	E_i(level)	J_i^π	E_γ †	E_f	J_f^π
2052.93	(6^+)	210.1	1842.82	(5^-)	3089.54	(8^-)	1056.3	2033.23	(7^-)
		367.8	1685.12	(5^+)	3102.74	(9^-)	1069.5	2033.23	(7^-)
		695.8	1357.13	(5^+)	3163.9		1111.0	2052.93	(6^+)
		1032.1	1020.82	(5^+)	3573.9	(9^+)	471.2	3102.74	(9^-)
2104.3		419.2	1685.12	(5^+)			484.4	3089.54	(8^-)
2353.6		1332.8	1020.82	(5^+)	4473.0	(11^+)	899.1	3573.9	(9^+)
2396.3	(7^-)	553.5	1842.82	(5^-)	5629.2	(12)	1156.1	4473.0	(11^+)
3089.54	(8^-)	693.2	2396.3	(7^-)					

† Values represent averages when corresponding data are available in more than one of the three γ-ray datasets. Above 830-keV level energy, gamma-ray data are available from $^{54}Fe(^{12}C,pn\gamma)$ only.

‡ Relative photon branching ratios are mainly from (p,nγ). Averages taken for γ rays from 128 and 427 level, where data are available from (p,nγ) and ^{64}Ge ε decay.

From $^{54}Fe(^{12}C,pn\gamma)$.

@ γ seen in $^{54}Fe(^{12}C,pn\gamma)$ only.

& From ^{64}Ge ε decay.

[a] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

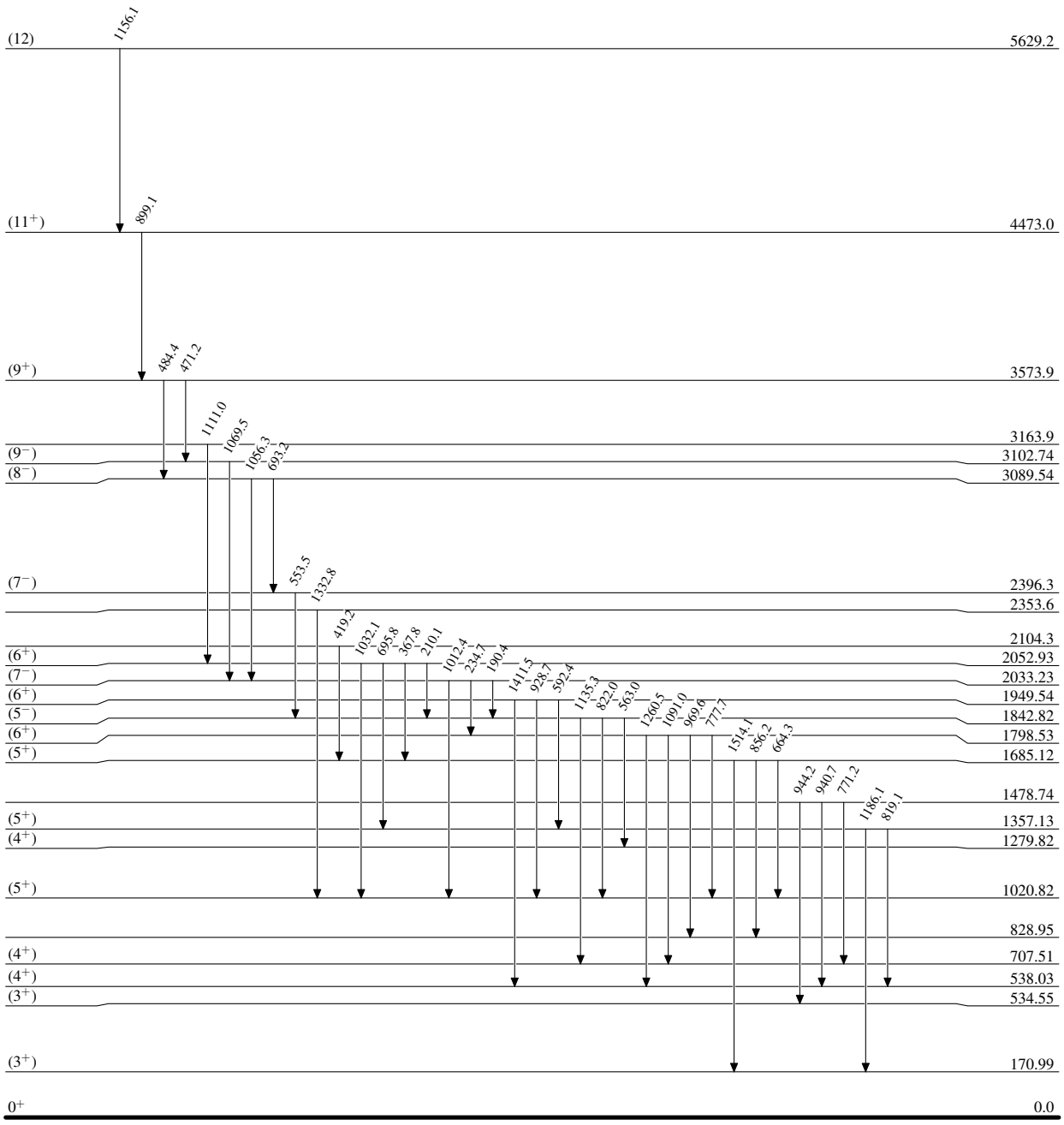
[b] Multiply placed with undivided intensity.

[c] Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



$^{64}_{31}Ga_{33}$

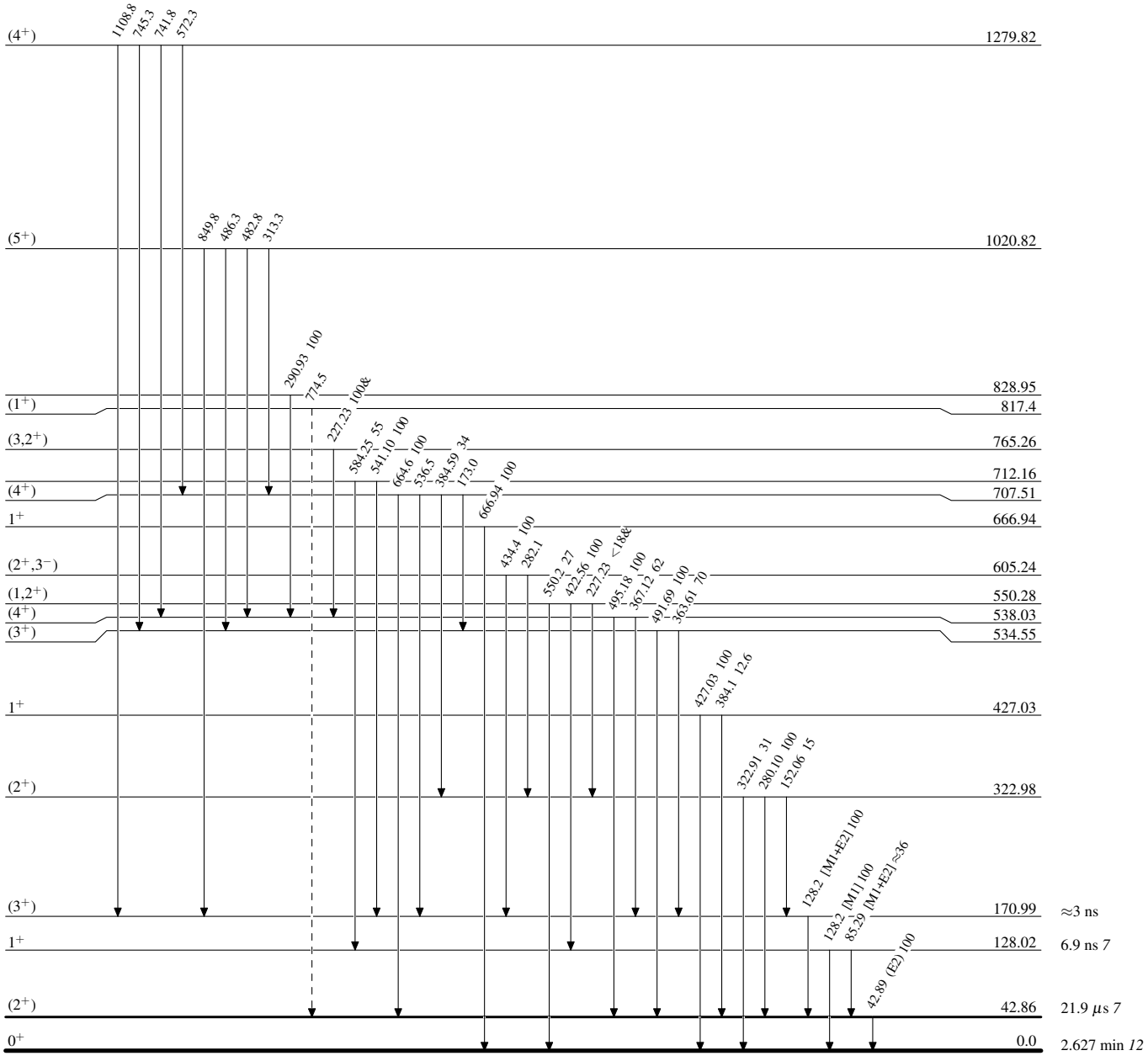
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given

– – – – – – ► γ Decay (Uncertain)



$^{64}_{31}Ga_{33}$