Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Caroline D. Nesaraja, Scott D. Geraedts and Balraj Singh	NDS 111, 897 (2010)	12-Jan-2010

Q(β^-)=−9.37×10^3 *5*; S(n)=12430.2 *7*; S(p)=2872.9 *7*; Q(α)=−6082.7 *6* 2012Wa38
Note: Current evaluation has used the following Q record.
Q(εp)=393.2 *15* (2009AuZZ,2003Au03).
S(2n)=29200 *140* (2009AuZZ,syst); S(2p)=10200.5 *25* (2009AuZZ).
Q(β^-)=−9364 *50*; S(n)=12423 *16*; S(p)=2869.0 *23*; Q(α)=−6077.6 *16* 2009AuZZ,2003Au03
Additional information 1.
Structure calculations (levels, transition probabilities, etc.): 2008Na24, 2007BeZX (Gamow-Teller transitions) 2006Va21, 2004Ho08, 2004Va38, 1977Ko02, 1975Wa29, 1971Ru09.

^{58}Cu Levels

Isotopic spins T are from (p,nγ) and (^{3}He,t).

Cross Reference (XREF) Flags

A	^{58}Zn ε decay (86 ms)	D	^{58}Ni(p,nγ)
B	^{28}Si(^{36}Ar,αpnγ)	E	^{58}Ni(^{3}He,t),(^{3}He,tγ)
C	^{58}Ni(p,n)	F	^{58}Ni(^{6}Li,^{6}He)

E(level)†	J$^\pi$	T$_{1/2}$‡	XREF	Comments
0.0	1$^+$	3.204 s *7*	ABCDEF	%ε+%β^+=100 μ=+0.479 *13* (2010Co01); μ=+0.52 *8* (2008St12) T=0 Isotope shift(^{58}Cu,^{63}Cu)=3.14 GHz *18* (2010Co01). Isotope shift(^{58}Cu,^{65}Cu)=1.99 GHz *30* (2008St12). 2010Co01: Cocolios et al, Phys Rev C (accepted Jan 11, 2010; pre-publication copy received from the authors Jan 12, 2010). μ: 2010Co01: from in-gas-cell laser hyperfine spectroscopy at LISOL facility, where radioactive source was produced in (p,n) reaction on ^{58}Ni target at CRC in Louvain-La-Neuve. The measurements were made with reference to magnetic moment of ^{63}Cu. The authors also measured isotope shifts. 2008St12: from in-source laser spectroscopy at ISOLDE, CERN using Zr(p,X) reaction at 1.4 GeV. The isotope shift relative to ^{65}Cu was also measured. J$^\pi$: log *ft*=4.9 to 0$^+$; L(^{3}He,t)=0+2. Hyperfine structure measurements of 2010Co01 rule out 0$^+$, and are consistent with 1$^+$. From comparison of measured magnetic-dipole moment with calculated values from shell-model using GXPF1 interaction, proposed dominant configuration=$\pi p_{3/2}\otimes\nu p_{3/2}$ (2010Co01). T$_{1/2}$: from 1965Fr06 (also 1965Fr03). Others: 3.0 s *7* (1973Di17), 3.2 s *2* (1969Jo24), 3.21 s *2* (1962Mi13), 3.30 s *10* (1958Ge33), 3 s (1954Ty33), 3.04 s (1952Ma55).
202.99 *24*	0$^+$		A CDE	T=1 J$^\pi$: IAS of ^{58}Ni ground state as indicated by strong β feeding from ^{58}Zn g.s.; L(^{3}He,t)=0.
443.64 *18*	3$^+$	0.32 ns *6*	BCDEF	T=0 T$_{1/2}$: From γ(t)-radio frequency method in (p,nγ). J$^\pi$: ΔJ=2, E2 γ to 1$^+$; also L(^{6}Li,^{6}He)=2 and L(^{3}He,t)=(2+4).
1051.5 *3*	1$^+$	78 fs *+19−13*	A CDEF	T=0 J$^\pi$: L(^{3}He,t)=0; L(^{6}Li,^{6}He)=0+2; γ to 0$^+$; Gamow-Teller transition.
1427.85 *25*	2$^+$	>0.66 ps	CDEF	T=0

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Adopted Levels, Gammas (continued)

^{58}Cu Levels (continued)

E(level)†	J^π	$T_{1/2}$‡	XREF	Comments
				J^π: L(^{3}He,t)=2; ΔJ=1, (M1+E2) γ to 3$^+$; γ to 0$^+$.
1549.5 *3*	(4$^+$)	>0.34 ps	BCDEF	T=0 J^π: ΔJ=1, (M1+E2) γ to 3$^+$; L(^{3}He,t)=(4).
1647.41 *18*	(3$^+$)	>0.90 ps	B D f	J^π: ΔJ=(2) γ to 1$^+$.
1652.5 *5*	2$^+$	35 fs *7*	CDEf	XREF: C(1638). J^π: L(^{3}He,t)=2; ΔJ=1 γ's to (1)$^+$ and 3$^+$; IAS of first excited 2$^+$ state in ^{58}Ni.
2065.0 *3*	(5$^+$)		B D	J^π: ΔJ=2 γ to 3$^+$; ΔJ=1 γ to (4$^+$).
2070 *20*			E	
2170 *20*			E	
2249.2 *8*			D	
2270 *20*			E	
2690 *20*	4$^+$		EF	J^π: L(^{3}He,t)=4; IAS of ^{58}Ni 4$^+$ state (possible).
2750.2 *6*	(4$^+$)		D	T=1 J^π: ΔJ=1 γ to (3$^+$).
2780 *20*			E	
2815.2 *6*			D	
2840 *20*			E	
2920.6 *5*	(5$^+$)		B D f	J^π: ΔJ=2 γ to 3$^{(+)}$.
2930.9 *8*	(0$^+$ to 4$^+$)		D f	J^π: γ to 2$^+$.
2949 *10*	(1)$^+$#		E	
3230 *20*			E	
3280.2 *8*	(0$^+$ to 4$^+$)		D	J^π: γ to 2$^+$.
3310 *20*			E	
3421.0 *5*	(7$^+$)@		B D	
3460.1 *11*	(1)$^+$#		EF	
3512.6 *7*			B D	
3570 *20*			E	E(level): multiplet.
3677.9 *8*	(1)$^+$#		Ef	
3717 *10*	(1)$^+$#		C Ef	
3820 *20*			E	
3890 *20*			E	
4010			F	
4065.6 *6*	(7$^+$)@		B	
4210 *20*			E	
4441.4 *6*	(8$^+$)@		B	
4720 *10*	(1)$^+$#		EF	T=0
5065 *20*	(1)$^+$#		E	T=0
5160 *20*	(1)$^+$#		C EF	T=0
5190.6 *23*	(7$^+$)		B	
5348.0 *8*	(9$^+$)@		B	
5451 *20*	(1)$^+$#		EF	T=0
5574.9 *8*	(9$^+$)@		B	
5645 *20*	(1)$^+$#		EF	T=0
6038 *20*	(1)$^+$#		E	T=0
6086 *20*	(1)$^+$#		E	T=0
6387.2 *10*	(10$^+$)@		B	
6497 *20*	(1)$^+$#		C E	T=0
6794.1 *12*	(9)		B	
6844 *20*	(1)$^+$#		E	T=0
7105 *20*	(1)$^+$#		E	T=0
7143 *20*	(1)$^+$#		E	T=0

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Adopted Levels, Gammas (continued)

^{58}Cu Levels (continued)

E(level)[†]	J^π	$T_{1/2}$[‡]	XREF	Comments
7392.6 *11*	(11^+)[@]		B	
7586 *20*	$(1)^+$[#]		E	T=1
7700 *20*	$(1)^+$[#]		E	T=0
7752 *20*	$(1)^+$[#]		E	T=0
7907 *20*	$(1)^+$[#]		E	T=1
7993 *20*	$(1)^+$[#]		E	T=0
8063 *20*	$(1)^+$[#]		E	T=(1).
8127.3 *13*	(11)[@]		B	
8159 *20*	$(1)^+$[#]		E	T=0
8199 *20*	$(1)^+$[#]		E	T=0
8228.2? *13*	(9^+)[@]		B	
8282 *20*	$(1)^+$[#]		E	T=0
8370 *10*	$(1)^+$[#]		E	T=1 E(level): analog of 8203 level in ^{58}Ni.
8421 *10*	$(1)^+$[#]		E	T=1 E(level): analog of 8274 level in ^{58}Ni.
8487.3 *16*	(12^+)[@]		B	
8520 *10*	$(1)^+$[#]		E	T=1 E(level): analog of 8372 level in ^{58}Ni.
8566 *10*	$(1)^+$[#]		E	T=1 E(level): analog of 8419 level in ^{58}Ni.
8614 *10*	$(1)^+$[#]		E	T=1 E(level): analog of 8461 level in ^{58}Ni.
8725 *10*	$(1)^+$[#]		E	T=1 E(level): analog of 8602 level in ^{58}Ni.
8837 *10*	$(1)^+$[#]		E	T=1 E(level): analog of 8677 level in ^{58}Ni.
8881.6 *13*			B	
8900		2.8 MeV	F	E(level): Gamow Teller (L=0) resonance.
8916.9[&] *11*	(9^+)[@]	0.22 ps *18*	B	%p=96 *4* %p: from author's estimation of $\%\gamma<3$ in 1998Ru01 and conservative lower limit of 93% in 2002Ru09. %p: Main decay is through prompt proton transition of angular momentum 3 to 5 and E(p)(c.m. system)= 2290 *20* (2002Ru09) to 3701, $9/2^+$ level in ^{57}Ni. Weak proton transition to 3864, $11/2^-$ level in ^{57}Ni is not confirmed by 2002Ru09. A 2330γ from this level proposed earlier is not confirmed by 2002Ru09. Proton decay is identified from the observation of following γ transitions in ^{57}Ni in coincidence experiments: 769 (from 769 level), 2577 (from 2577 level), 1124 and 2932 (from 3701 level).
8959 *10*	$(1)^+$[#]		E	T=0
9000 *10*	$(1)^+$[#]		E	T=1 E(level): analog of 8856 level in ^{58}Ni.
9129 *20*	$(1)^+$[#]		E	T=1 E(level): analog of 8959 level in ^{58}Ni.
9172 *10*	$(1)^+$[#]		E	T=0
9209 *10*	$(1)^+$[#]		C E	T=1 XREF: C(9200). E(level): analog of 9071 level in ^{58}Ni. Wide structure at 9200 *400* in (p,n) with

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Adopted Levels, Gammas (continued)

^{58}Cu Levels (continued)

E(level)[†]	J^π	$T_{1/2}$[‡]	XREF	Comments
				Γ≈1.3 MeV. Other levels may be involved in this peak.
9307 *10*	$(1)^{+}$[#]		E	T=1 E(level): analog of 9156 level in ^{58}Ni.
9371 *10*	$(1)^{+}$[#]		E	T=1 E(level): analog of 9242 level in ^{58}Ni.
9444 *20*	$(1)^{+}$[#]		E	T=1 E(level): analog of 9326 level in ^{58}Ni.
9567 *10*	$(1)^{+}$[#]		E	T=0
9645 *10*	$(1)^{+}$[#]		E	T=1 E(level): analog of 9526 level in ^{58}Ni; also assigned as an E1 transition (2000Ba63).
9680.7 *23*			B	
9747.2[&] *11*	(11^{+})[@]	0.38 ps *4*	B	$T_{1/2}$: from DSAM (2001Ru02). Q(transition)=2.75 *+27−24* (2001Ru02).
9783 *10*	$(1)^{+}$[#]		E	T=0
9804.3 *15*	(12)[@]		B	
9861 *10*	$(1)^{+}$[#]		E	T=2 E(level): analog of 9739 level in ^{58}Ni.
9989 *10*	$(1)^{+}$[#]		E	T=1 E(level): analog of 9835 level in ^{58}Ni.
10291 *10*	$(1)^{+}$[#]		E	T=1 E(level): analog of 10115 level in ^{58}Ni.
10329 *10*	$(1)^{+}$[#]		E	T=1 E(level): analog of 10156 level in ^{58}Ni.
10388 *10*	$(1)^{+}$[#]		E	T=2 E(level): analog of 10211 level in ^{58}Ni.
10554 *10*	$(1)^{+}$[#]		E	T=0
10597 *10*	$(1)^{+}$[#]		E	T=2 E(level): analog of 10492 level in ^{58}Ni.
10776.6 *17*			B	
10825 *10*	$(1)^{+}$[#]		E	T=2 E(level): analog of 10664 level in ^{58}Ni.
10944.5[&] *12*	(13^{+})[@]	0.104 ps *14*	B	$T_{1/2}$: from DSAM (2001Ru02). Q(transition)=2.55 *+19−15* (2001Ru02).
11137 *10*	$(1)^{+}$[#]		C E	T=2 XREF: C(11200). E(level): analog of 11003 level in ^{58}Ni. Wide structure at 11200 *400* in (p,n) with Γ≈0.7 MeV. Other levels may be involved in this peak.
11358 *10*	$(1)^{+}$[#]		E	T=2 E(level): analog of 11165 level in ^{58}Ni.
11553 *4*			B	
11562 *20*	$(1)^{+}$[#]		E	T=(2) E(level): analog of 11423 level in ^{58}Ni.
11815 *20*	$(1)^{+}$[#]		E	T=2 E(level): analog of 11672 level in ^{58}Ni.
11842 *3*			B	
11903 *20*	$(1)^{+}$[#]		E	T=0
12034 *20*	$(1)^{+}$[#]		E	T=2 E(level): analog of 11883 level in ^{58}Ni.

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Adopted Levels, Gammas (continued)

^{58}Cu Levels (continued)

E(level)†	J^{π}	$T_{1/2}$‡	XREF	Comments
12.45×10^{3} *15*			E	E(level): wide structure in the energy range of 12.3-12.6 MeV.
12520.9& *13*	(15^{+})@	0.035 ps *7*	B	$T_{1/2}$: from DSAM (2001Ru02). Q(transition)=2.21 *+26−19* (2001Ru02).
12880 *20*	(1)$^{+}$#		C E	T=2 XREF: C(13000). E(level): analog of 12738 level in ^{58}Ni. Wide structure at 13000 *400* in (p,n) with Γ≈0.5 MeV. Other levels may be involved in this peak.
13130 *3*			B	
14475.9& *16*	(17^{+})@		B	
14881 *4*			B	
16000		14 MeV	F	E(level): spin dipole resonance (L=1).
16818& *3*	(19^{+})@		B	
19566& *4*	(21^{+})@		B	
22747& *5*	(23^{+})@		B	
24000		25 MeV	F	E(level): spin quadrupole (L=2) and spin isovector (L=0) resonance.

† From least-squares fit to Eγ′s for levels populated in γ-ray studies. Other values are mostly from (^{3}He,t).
‡ From DSAM in (p,nγ), except where noted otherwise.
# From L(^{3}He,t)=0, interpreted as Gamow-Teller transition.
@ As proposed by 1998Ru01 and 2001Ru02, based on γγ(θ)(DCO) data in ^{28}Si(^{36}Ar,αpnγ); ascending spins assumed with increasing excitation energy. Parentheses in some cases have been added by the evaluators.
& Band(A): $\nu 4^{1}\pi 4^{1}$ intruder (SD) band. Band assignment from 1998Ru01 and 2001Ru02. Average Q(transition)= 2.0 *2* (1998Ru01), β_2=0.37. Interpreted as a well-deformed rotational band in the second minimum.

γ(^{58}Cu)

E_i(level)	J^{π}_i	E_{γ}†	I_{γ}†	E_f	J^{π}_f	Mult.‡	δ#	α@	Comments
202.99	0^{+}	203.2 *3*	100	0.0	1^{+}	[M1]		0.00846	
443.64	3^{+}	443.5 *2*	100	0.0	1^{+}	E2(+M3)	−0.02 *4*		B(E2)(W.u.)=7.7 *15*
1051.5	1^{+}	607	<5	443.64	3^{+}				
		848.6 *2*	100	202.99	0^{+}	[M1]			B(M1)(W.u.)=0.43 *+8−11*
		1052	<9	0.0	1^{+}				
1427.85	2^{+}	376.6	3.4 *19*	1051.5	1^{+}				
		984.2	8.5 *41*	443.64	3^{+}	(M1+E2)	−0.8 *+2−15*		B(M1)(W.u.)<0.0019?; B(E2)(W.u.)<2.7
		1225.1	1.7 *5*	202.99	0^{+}	[E2]			B(E2)(W.u.)<0.35
		1427.8 *3*	100	0.0	1^{+}	[M1+E2]			B(M1)(W.u.)<0.010; B(E2)(W.u.)<10
1549.5	(4^{+})	1105.8 *3*	100	443.64	3^{+}	(M1+E2)	−0.77 *5*		B(M1)(W.u.)<0.032; B(E2)(W.u.)<30
1647.41	(3^{+})	220	<4.3	1427.85	2^{+}				
		596	<5	1051.5	1^{+}				
		1203.5	27 *8*	443.64	3^{+}	(M1+E2)	+0.53 *13*		B(M1)(W.u.)<0.0023; B(E2)(W.u.)<1.1
		1445	<19	202.99	0^{+}				
		1647.4 *2*	100 *8*	0.0	1^{+}	(E2(+M3))	−0.06 *+16−27*		B(E2)(W.u.)<2.8
1652.5	2^{+}	601.4	5.9 *2*	1051.5	1^{+}	(M1(+E2))	+0.02 *5*		B(M1)(W.u.)=0.15 *4*
		1208.2	100 *3*	443.64	3^{+}	(M1(+E2))	−0.02 *2*		B(M1)(W.u.)=0.31 *7*
		1449.5	5.3 *18*	202.99	0^{+}	[E2]			B(E2)(W.u.)=9 *4*

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Adopted Levels, Gammas (continued)

$\gamma(^{58}Cu)$ (continued)

E_i(level)	J^{π}_i	E_γ†	I_γ†	E_f	J^{π}_f	Mult.‡	δ#	Comments
1652.5	2^+	1653	<4.1	0.0	1^+			
2065.0	(5^+)	418 *1*	13 *2*	1647.41	(3^+)			
		515.4 *3*	43 *2*	1549.5	(4^+)	D		
		1621.2 *4*	100 *3*	443.64	3^+	(E2+M3)	−0.12 *4*	
2249.2		596.7	100 *6*	1652.5	2^+			
		821.3	12 *6*	1427.85	2^+			
2750.2	(4^+)	1103.1	73 *15*	1647.41	(3^+)	(M1(+E2))	−0.07 *+5−12*	
		1200.6	100 *15*	1549.5	(4^+)	(M1(+E2))	0.00 *5*	
		2306.4	8.9 *33*	443.64	3^+			
2815.2		1162.7	100 *19*	1652.5	2^+			
		1387.2	57 *14*	1427.85	2^+			
		2371.5	81 *19*	443.64	3^+			
2920.6	(5^+)	856	<2.8	2065.0	(5^+)			
		1274	<2.8	1647.41	(3^+)			
		1372	<2.8	1549.5	(4^+)			
		2477.5	100 *4*	443.64	3^+	Q		
2930.9	$(0^+$ to $4^+)$	1278.3	100 *8*	1652.5	2^+			
		1503.0	30 *8*	1427.85	2^+			
3280.2	$(0^+$ to $4^+)$	1627.7	100 *6*	1652.5	2^+			
		1852.2	19 *6*	1427.85	2^+			
3421.0	(7^+)	500.5 *3*	8 *1*	2920.6	(5^+)	Q		
		1355.6 *4*	100 *3*	2065.0	(5^+)	Q		
3460.1	$(1)^+$	3257	100	202.99	0^+			
3512.6		592.0 *5*	100	2920.6	(5^+)			
3677.9	$(1)^+$	3234		443.64	3^+			
		3475		202.99	0^+			
4065.6	(7^+)	1145.2 *5*	60 *7*	2920.6	(5^+)			
		2000 *1*	100 *7*	2065.0	(5^+)	Q		
4441.4	(8^+)	1020.4 *4*	100	3421.0	(7^+)	D		
5190.6	(7^+)	3125 *3*	100	2065.0	(5^+)			
5348.0	(9^+)	906 *1*	24 *3*	4441.4	(8^+)	D		
		1927 *1*	100 *6*	3421.0	(7^+)	Q		
5574.9	(9^+)	1509.3 *5*	100	4065.6	(7^+)	Q		
6387.2	(10^+)	1039 *1*	21 *4*	5348.0	(9^+)	D		
		1946 *1*	100 *8*	4441.4	(8^+)	Q		
6794.1	(9)	1446 *1*	100	5348.0	(9^+)			
7392.6	(11^+)	1818	16 *5*	5574.9	(9^+)			
		2044 *2*	100	5348.0	(9^+)	Q		
8127.3	(11)	1740 *1*	100	6387.2	(10^+)	(D)		
8228.2?	(9^+)	2654 *2*	100 *25*	5574.9	(9^+)			
		3037 *3*	50 *25*	5190.6	(7^+)			
8487.3	(12^+)	2100 *2*	100	6387.2	(10^+)	(Q)		
8881.6		1489 *1*	100 *20*	7392.6	(11^+)			
		2087 *2*	80 *20*	6794.1	(9)			
9680.7		2288 *2*	100	7392.6	(11^+)			
9747.2	(11^+)	830.2 *3*	100 *5*	8916.9	(9^+)	E2		B(E2)(W.u.)=183 *25*
		1519 *1*	23 *5*	8228.2?	(9^+)	E2		B(E2)(W.u.)=2.0 *6*
		4171 *3*	27 *5*	5574.9	(9^+)	E2		B(E2)(W.u.)=0.015 *4*
		4399	5 *5*	5348.0	(9^+)			
9804.3	(12)	1317 *1*	50 *12*	8487.3	(12^+)			
		1677 *1*	100 *12*	8127.3	(11)			
10776.6		1895 *1*	100	8881.6				
10944.5	(13^+)	1197.3 *5*	100	9747.2	(11^+)	E2		B(E2)(W.u.)=166 *23*
11553		3066 *3*	100	8487.3	(12^+)			
11842		2038 *2*	100	9804.3	(12)			
12520.9	(15^+)	1576.4 *4*	100	10944.5	(13^+)	E2		B(E2)(W.u.)=125 *25*

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Adopted Levels, Gammas (continued)

$\gamma(^{58}Cu)$ (continued)

E_i(level)	J^π_i	E_γ †	I_γ †	E_f	J^π_f	Mult. ‡
13130		2353 *2*	100	10776.6		
14475.9	(17^+)	1955 *1*	100	12520.9	(15^+)	Q
14881		3039 *3*	100	11842		
16818	(19^+)	2342 *2*	100	14475.9	(17^+)	Q
19566	(21^+)	2748 *2*	100	16818	(19^+)	Q
22747	(23^+)	3181 *3*	100	19566	(21^+)	

† Mainly from ^{28}Si(^{36}Ar,αpnγ) and (p,nγ).

‡ From $\gamma\gamma(\theta)$ and γ(lin pol) In (p,nγ) and $\gamma\gamma(\theta)$(DCO) In (^{36}Ar,αpnγ) and RUL (for E2 and M2 transitions).

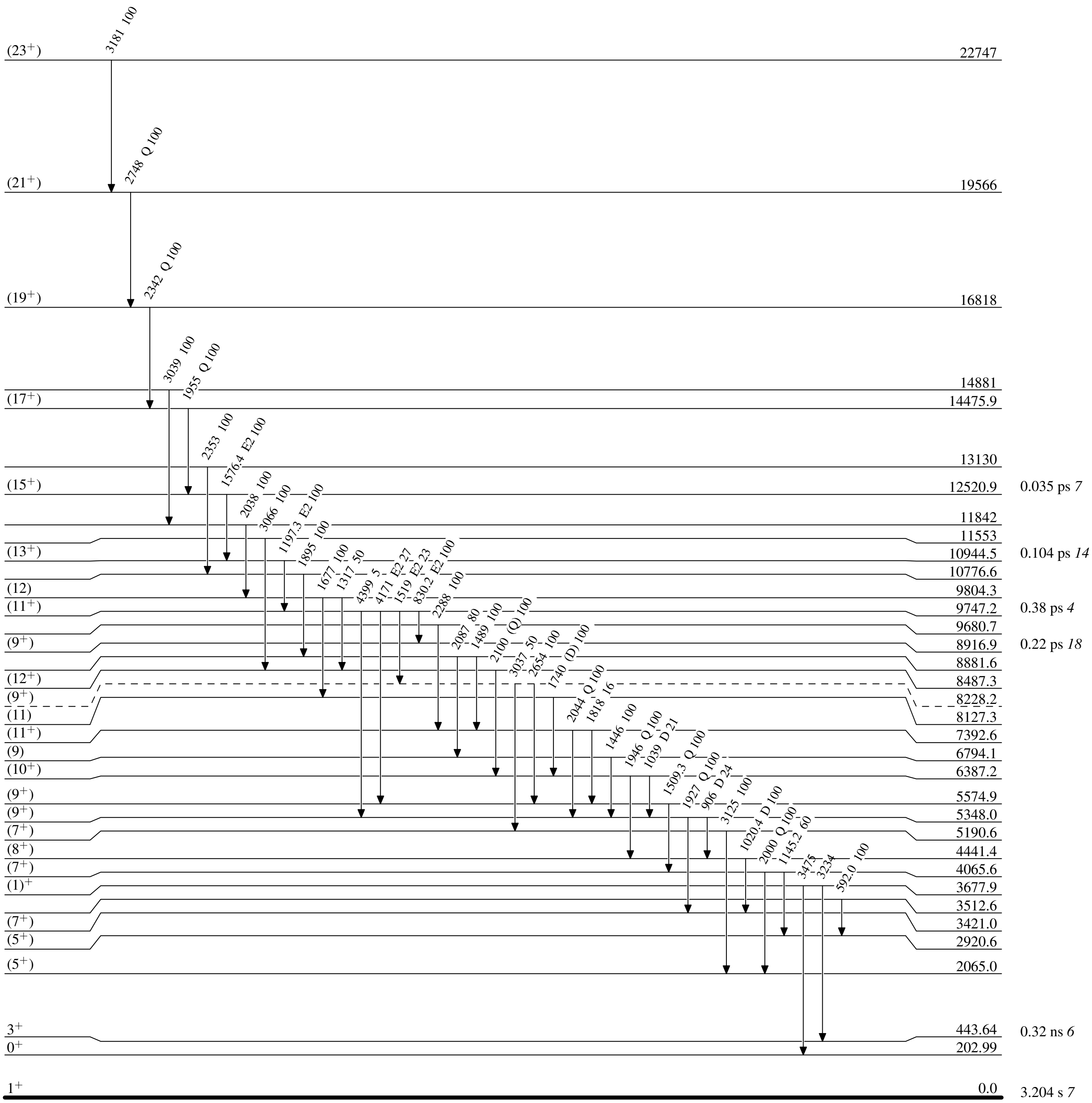
From $\gamma\gamma(\theta)$ In (p,nγ).

@ 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.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level

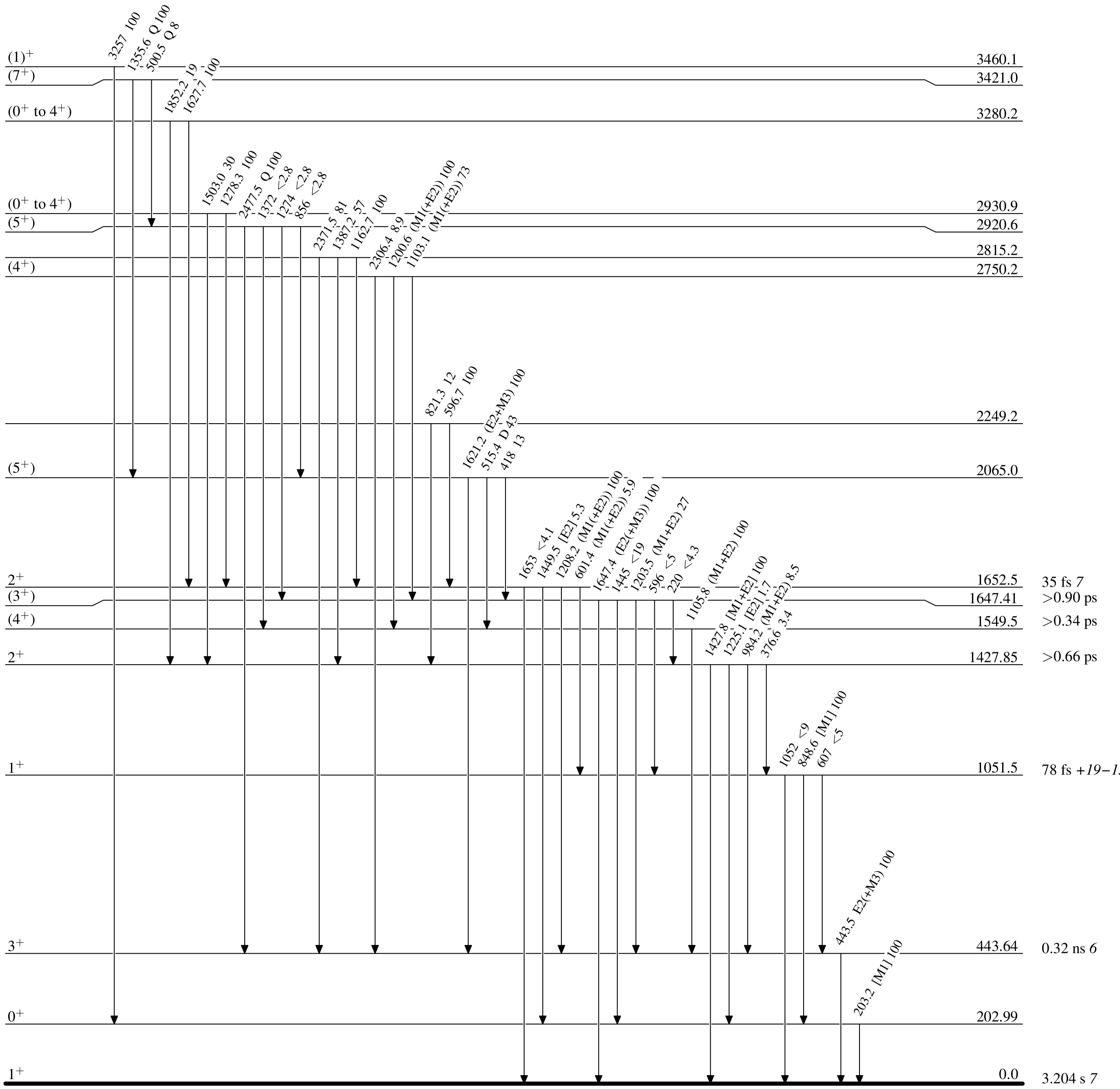


$^{58}_{29}$Cu$_{29}$

Adopted Levels, Gammas

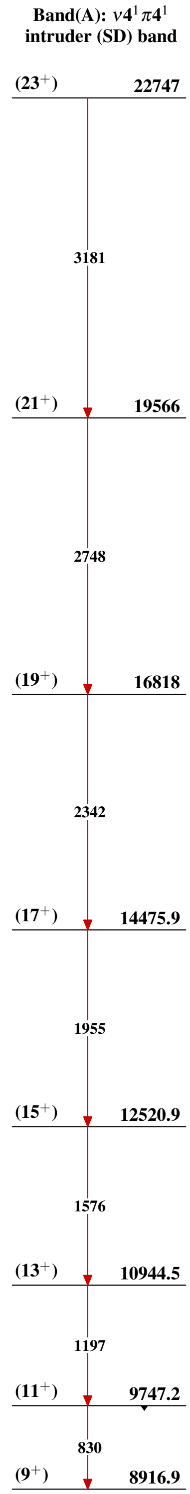
Level Scheme (continued)

Intensities: Relative photon branching from each level



$^{58}_{29}Cu_{29}$

Adopted Levels, Gammas



$^{58}_{29}Cu_{29}$