Coulomb excitation 1991Wu05,1989Ku04

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 111,275 (2010)	1-Oct-2009

Others: 1961Ha21, 1961Mc01, 1962Bi05, 1962Go17, 1963Gr04, 1964Al25, 1965Eb03, 1965Sc05, 1967As03, 1967Gi03, 1968St13, 1971KaYW, 1971Mi08, 1972Ca12, 1974Ba81, 1974Ga20, 1974Ro30, 1975Le22, 1975Ro24, 1977Mc11, 1977Ob01, 1977Ob02, 1977Ro02, 1977Bo02, 1979KoZF, 1979Hu01, 1985St18, 1986Ba19, 1987St14, 1988St09 (transient field for W In Fe), 1989Wu04.

1961Ha21: p,d, E=?.

1961Mc01: p, E=5.000, 5.028 MeV.

1962Bi05: α, E=3 MeV: α,γ(t).

1962Go17: p, E=1.4,2.0 MeV: p,$\gamma(\theta$,H) H=20.3 *2* kG.

1963Gr04: ^{16}O, E=14-50 MeV: ce(L).

1964Al25: ^{14}N, E=37 MeV.

1965Eb03: p, E=2.1 MeV: p,$\gamma(\theta$,H) H=41.6 kG.

1965Sc05: p, E=2.04 MeV: p,$\gamma(\theta$,H) H=?.

1967As03: ^{16}O, E$\approx$35 MeV: recoil distance.

1967Gi03: ^{16}O, E=35,41 MeV: IMPAC in Ni,CO,Fe.

1968St13: α, E=8.0 MeV.

1971KaYW: ^{16}O, E=42 MeV: IMPAC in Gd.

1971Mi08: p, E=5.0 MeV; α, E=14 and 15 MeV; ^{16}O, E=45.5 MeV.

1972Ca12: p, E=2.5 MeV: p,$\gamma(\theta$,H) in 5% W-95% Fe alloy.

1974Ba81: α, E=13.25-13.50 MeV.

1974Ga20: ^{16}O, E=36 MeV: IMPAC in Ni,CO.

1975Le22: α, E=12.5-19 MeV.

1975Ro24: ^{16}O, E=40 MeV: IMPAC in Te,Zn,Cd,Gd. see also 1974Ro30.

1977Mc11: α, E=15 MeV; ^{16}O, E=42 MeV.

1977Ob01, 1977Ob02: ^{16}O, E=54 MeV; Q.

1977Bo02: α, E=13.5 MeV; ^{16}O, E=54 MeV.

1979KoZF: ^{86}Kr, E=340 MeV.

1979Hu01: ^{84}Kr, E=340 MeV.

1985St18: ^{58}Ni and ^{63}Cu, E=220 MeV.

1989Ku04: ^{208}Pb, E=4.9 MeV/U.

1989Wu04, 1991Wu05: ^{58}Ni, E=235 MeV, ^{136}Xe E=561 MeV; measured Eγ, Iγ, $\gamma(\theta)$, $T_{1/2}$ from recoil distance; deduced static and transition matrix elements using GOSIA code.

^{184}W Levels

1975Le22 deduce and compare deformation parameters, β_2 and β_4, from data in sub-Coulomb and nuclear-Coulomb interference energy regions for 111 and 364 levels.

E(level)[†]	J^π[‡]	$T_{1/2}$[#]	Comments
0.0[&]	0+		
111.13[&d] *6*	2+	1.23 ns *4*	B(E2)↑=3.78 *6* B(E2)↑: Weighted average of 3.84 *7* (1968St13), 3.76 *8* from <0+ M(E2) 2+> =1.94 *2* (1975Le22), 3.57 *15* from <0+ M(E2) 2+> =+1.89 *4* (1991Wu05). Others: 1956Hu49, 1958Mc02 (4.4 *4*), 1961Ha21 (3.62 *20*), 1961Mc01 (4.5 *5*), 1963Gr04 (4.2 *3*), 1989Ku04 (4.5 *5* from <0+ M(E2) 2+> =+2.12 *11*). <$2+_g$ M(E2) $2+_g$> =−2.16 *22* (1977RuZV), −2.29 *+23−75* (1989Ku04), −1.97 *+6−4* (1991Wu05; presumed to supersede 1.98 *+6−4* In 1989Wu04). β_2(COULOMB)=+0.262 *13* (1975Le22). $T_{1/2}$: other values: 1.24 ns *3* (1962Bi05), 1.282 ns *21* (1965Sc05) pulsed beam; 1.22 ns *9* (1967As03) recoil distance.

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Coulomb excitation 1991Wu05,1989Ku04 (continued)

^{184}W Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	$T_{1/2}$[#]	Comments
			g-factor: 0.207 *16* (1962Go17), 0.282 *18* (1965Eb03), 0.275 *25* (1965Sc05),
363.9[&] *6*	4$^+$	46.3 ps *+25−13*	B(E2)↑=1.86 *+5−10* B(E2)↑: Weighted average of 1.85 *13* (1971Mi08), 1.53 *+15−39* (1989Ku04; from <2+$_g$ M(E2) 4+$_g$> =+2.77 *+14−35*), 1.91 *+7−12* from <2+$_g$ M(E2) 4+$_g$> =+3.09 *+6−10* (1991Wu05). <4+$_g$ M(E2) 4+$_g$> =−3.1 *+3−4* (1989Ku04), −2.28 *11* (1991Wu05). <0+$_g$ M(E4) 4+$_g$> =−0.68 *25*; β_4(COULOMB)=−0.19 *6* (1975Le22). other $T_{1/2}$: 40 ps *5* from recoil distance (1991Wu05). g-factor: 0.30 *9* (1967Gi03).
748.1[&] *9*	6$^+$	5.75 ps *18*	B(E2)↑=1.63 *5* B(E2)↑: Weighted average of 1.68 *17* (1971Mi08), 1.70 *12* (1979Hu01), 1.74 *18* from <4+$_g$ M(E2) 6+$_g$> =+3.96 *+20−21* (1989Ku04), 1.61 *5* from <4+$_g$ M(E2) 6+$_g$> =+3.81 *6* (1991Wu05). <6+$_g$ M(E2) 6+$_g$> =−3.5 *+7−4* (1989Ku04), −2.45 *+22−9* (1991Wu05). other $T_{1/2}$: 5.2 ps *6* from recoil distance (1991Wu05). g/g(364 level)=1.05 *8* (1985St18).
903.4[ad] *6*	2$^+$	1.80 ps *4*	B(E2)↑=0.130 *3* B(E2)↑: Weighted average of 0.126 *6* (1971Mi08), 0.138 *6* (1974Ba81), 0.128 *5* (1991Wu05, from <0+$_g$ M(E2) 2+$_\gamma$> =+0.358 *7*). Other: 1961Mc01. <2+$_g$ M(E2) 2+$_\gamma$> =+0.494 *+10−18* (1991Wu05), so B(E2)=0.049 *3* for 792γ. other B(E2): 0.045 *3* (1971Mi08). <4+$_g$ M(E2) 2+$_\gamma$> =+0.127 *+5−6* (1991Wu05), so B(E2)↑=0.00179 *+14−17* for 540γ. <2+$_\gamma$ M(E2) 2+$_\gamma$> =+2.36 *+11−5* (1991Wu05, 1989Wu04). Other Q: +0.1 *4* (1977Ob02,1977Ob01), reason for discrepancy not known. $T_{1/2}$: from B(E2)(903γ) and adopted transition properties. Other $T_{1/2}$: 1.89 ps *12* from B(E2)(792γ), 1.59 ps *+16−13* from B(E2)(539γ) and adopted transition properties; 2.3 ps *3* from recoil distance (1991Wu05). <2+$_g$ M(M1) 2+$_\gamma$> =−0.0182 *+14−38* (1991Wu05). g/g(364 level)=0.42 *14* (1985St18).
1006.4[a] *8*	3$^+$		
1121.0[@d] *6*	2$^+$		Additional information 1. B(E2)↑,$T_{1/2}$: 1971Mi08 deduce B(E2)(g.s. to 1121 level)=0.00052 *6* assuming a 22% branch for the 1121γ (adopted % branching is 18.3 *10*); they also note that B(E2)(W.u.)≈0.17, but this implies B(E2)↑≈0.00106. $T_{1/2}$=56 ps *7* from adopted transition properties if B(E2)↑(1121γ)=0.00052 *6*. band assignment proposed by 1977Mc11.
1130.4[b] *12*	2$^-$		
1133.0[a] *7*	4$^+$	2.30 ps *17*	B(E2)↑=1.10 *+17−5* (1991Wu05) B(E2)↑: from <2+$_\gamma$ M(E2) 4+$_\gamma$> =+2.35 *+18−5* (1991Wu05, 231γ). <2+$_g$ M(E2) 4+$_\gamma$> =+0.282 *6* (1991Wu05), so B(E2)↑=0.0159 *7* for 1023γ. <4+$_g$ M(E2) 4+$_\gamma$> =+0.682 *+14−51* (1991Wu05), so B(E2)↑=0.0517 *+21−77* for 770γ. <6+$_g$ M(E2) 4+$_\gamma$> =+0.25 *+5−4* (1991Wu05), so B(E2)↑=0.0048 *+19−15* for 385γ. <4+$_\gamma$ M(E2) 4+$_\gamma$> =−1.45 *+6−17* (1991Wu05). <4+$_g$ M(M1) 4+$_\gamma$> =−0.037 *+23−18* (1991Wu05). $T_{1/2}$: from authors′ analysis of their B(E2) data (1991Wu05). the evaluator obtains 2.37 ps *15*, 2.21 ps *+34−11*, 1.75 ps *+14−30*, respectively, from B(E2) for 1022γ, 770γ and 230γ and adopted transition properties. other $T_{1/2}$: 2.6 ps *3* from recoil distance (1991Wu05).
1221.9[bd] *7*	3$^-$	45 ps *5*	B(E3)↑=0.082 *6* (1977Mc11)
1251.8[&] *14*	8$^+$	1.49 ps *3*	B(E2)↑=1.50 *3* (1991Wu05) B(E2)↑: from <6+$_g$ M(E2) 8+$_g$> =+4.42 *5* (1991Wu05). Other B(E2)↑: 1.97 *17* (1979Hu01), 2.34 *+23−37* (1989Ku04; from <6+$_g$ M(E2) 8+$_g$> =+5.5 *+3−4*). <8+$_g$ M(E2) 8+$_g$> =−4.5 *+4−5* (1989Ku04), −3.38 *+9−42* (1991Wu05). other $T_{1/2}$: 1.37 ps *17* from recoil distance (1991Wu05). g/g(364 level)=1.22 *24* (1985St18).

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Coulomb excitation 1991Wu05,1989Ku04 (continued)

^{184}W Levels (continued)

E(level)[†]	J^π[‡]	$T_{1/2}$[#]	Comments
1296.2[a] *12*	5$^+$		
1386.1[cd] *6*	2$^+$	1.08 ps *10*	B(E2)↑=0.021 *2* (1971Mi08) B(E2)↑: for g.s. to 1386 excitation. B(E2)(2+$_g$ to 1386 level)=0.0074 *15* (1971Mi08). see comment on 1023γ from 1133 level.
1431.0? *10*	2$^+$	>5 ps	B(E2)↑<0.005 (1977Mc11) level not observed by 1977Mc11, but authors could place an upper limit on B(E2)(g.s. to 1431 level).
1476.5[a] *8*	6$^+$	1.82 ps *9*	B(E2)↑=1.60 *+7−9* (1991Wu05) B(E2)↑: from <4+$_\gamma$ M(E2) 6+$_\gamma$> =+3.80 *+8−11* (1991Wu05, 343γ). <4+$_g$ M(E2) 6+$_\gamma$> =+0.302 *+7−9* (1991Wu05), so B(E2)↑=0.0101 *+5−6* for 1113γ. <6+$_g$ M(E2) 6+$_\gamma$> =+0.920 *22* (1991Wu05), so B(E2)↑=0.065 *3* for 728γ. <8+$_g$ M(E2) 6+$_\gamma$> =+0.45 *+16−4* (1991Wu05), so B(E2)↑=0.0119 *+85−21* for 225γ. <6+$_\gamma$ M(E2) 6+$_\gamma$> =−3.66 *+8−37* (1991Wu05). <6+$_g$ M(M1) 6+$_\gamma$> =−0.13 *+10−5* (1991Wu05). $T_{1/2}$: authors′ value deduced from their measured B(E2) data (1991Wu05). other $T_{1/2}$: 2.0 ps *3* from recoil distance (1991Wu05).
1860.4[&] *17*	10$^+$	0.570 ps *+24−31*	B(E2)↑=1.45 *+8−6* (1991Wu05) B(E2)↑: from <8+$_g$ M(E2) 10+$_g$> =+4.97 *+13−10* (1991Wu05). Other B(E2)↑: 1.43 *15* (1989Ku04; from <8+$_g$ M(E2) 10+$_g$> =+4.93 *23*), 2.25 *2* (1979Hu01). <10+$_g$ M(E2) 10+$_g$> =−4.4 *+4−9* (1989Ku04), −4.16 *+43−13* (1991Wu05). other $T_{1/2}$: 0.66 ps *9* from DSA (1991Wu05).
1925.3[a] *11*	8$^+$		B(E2)↑=1.79 *+11−8* (1991Wu05) B(E2)↑: from <6+$_\gamma$ M(E2) 8+$_\gamma$> =+4.83 *+15−10* (1991Wu05, 449γ). <6+$_g$ M(E2) 8+$_\gamma$> =+0.258 *+11−23* (1991Wu05), so B(E2)↑=0.0052 *+5−9* for 1177γ. <8+$_g$ M(E2) 8+$_\gamma$> =+1.08 *+4−13* (1991Wu05), so B(E2)↑=0.069 *+5−16* for 674γ. <10+$_g$ M(E2) 8+$_\gamma$> =+0.49 *+24−14* (1991Wu05), so B(E2)↑=0.114 *+11−7* for 65γ. <8+$_\gamma$ M(E2) 8+$_\gamma$> =−4.41 *+11−55* (1991Wu05). <8+$_g$ M(M1) 8+$_\gamma$> =−0.27 *+55−6* (1991Wu05).
2471.6[a] *15*	10$^+$	0.82 ps *+15−4*	B(E2)↑=1.73 *+8−31* (1991Wu05) B(E2)↑: from <8+$_\gamma$ M(E2) 10+$_\gamma$> =+5.42 *+13−49* (1991Wu05). <8+$_g$ M(E2) 8+$_\gamma$> =+1.08 *+4−13* (1991Wu05). <10+$_\gamma$ M(E2) 10+$_\gamma$> =−3.7 *+3−10* (1991Wu05).
2556.6[&] *20*	12$^+$	0.265 ps *+21−24*	B(E2)↑=1.54 *+14−12* (1991Wu05) B(E2)↑: from <10+$_g$ M(E2) 12+$_g$> =+5.69 *+26−22* (1991Wu05). Other B(E2)↑: 1.42 *+16−14* (1989Ku04; from <10+$_g$ M(E2) 12+$_g$> =+5.47 *+31−27*). <12+$_g$ M(E2) 12+$_g$> =−4.9 *+5−10* (1989Ku04), −5.9 *+8−5* (1991Wu05).
3108.7?[a] *18*	(12$^+$)	0.35 ps *+14−3*	B(E2)↑=1.79 *+15−71* (1991Wu05) B(E2)↑: from <10+$_\gamma$ M(E2) 12+$_\gamma$> =+6.13 *+26−122* (1991Wu05).
3319.5[&] *22*	14$^+$	0.140 ps *+25−10*	B(E2)↑=1.80 *+13−32* (1991Wu05) B(E2)↑: from <12+$_g$ M(E2) 14+$_g$> =+6.71 *+25−60* (1991Wu05). Other: 1.70 *+17−43* (1989Ku04; from <12+$_g$ M(E2) 14+$_g$> =+6.5 *+3−8*). <14+$_g$ M(E2) 14+$_g$> =−5.2 *+6−10* (1989Ku04).
4116.5[&] *24*	16$^+$	0.125 ps *+32−13*	B(E2)↑=1.59 *+16−41* (1989Ku04) B(E2)↑: from <14+$_g$ M(E2) 16+$_g$> =+6.8 *+3−9* (1989Ku04). <16+$_g$ M(E2) 16+$_g$> =−5.6 *+7−14* (1989Ku04). Reported by 1989Ku04 only.

† From least-squares fit to Eγ, assigning 1 keV uncertainty to Eγ data for which the authors did not assign an uncertainty.
‡ From band assignments.
\# Calculated from B(E2) values and adopted transition properties, except as noted.
@ Band(A): $K^\pi=0^+$ β band.

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Coulomb excitation 1991Wu05,1989Ku04 (continued)

^{184}W Levels (continued)

& Band(B): $K^{\pi}=0^{+}$ g.s. band.
[a] Band(C): $K^{\pi}=2^{+}$ γ band.
[b] Band(D): $K^{\pi}=2^{-}$ octupole band.
[c] Band(E): $K^{\pi}=2^{+}$ band.
[d] Level directly populated In Coulomb excitation (1977Mc11).

$\gamma(^{184}W)$

E_i(level)	J^π_i	E_γ[†]	I_γ[‡]	E_f	J^π_f	Mult.[#]	δ[#]	α[b]	Comments
111.13	2^+	111.13 *6*	100	0.0	0^+	E2		2.58	E_γ: from 1957Ch39.
363.9	4^+	252.8	100	111.13	2^+	E2		0.1438	other $E\gamma$: 252.3 (1963Gr04).
748.1	6^+	384.3	100	363.9	4^+	E2[a]		0.0418	
903.4	2^+	540[&c]	2.2 *2*	363.9	4^+	E2		0.01738	I_γ: I(540γ)/I(903γ)=0.022 *2* (1971Mi08). Authors state peak is weak in spectrum and could be contaminated; the adopted ratio is 0.0083 *3*.
		792.1	93 *3*	111.13	2^+	M1+E2	−16.8 *5*	0.00733	I_γ: I(792γ)/I(903γ)=0.934 *30* (1971Mi08). other δ:−19 *+6−21* from A_2(792γ)=−0.114 *14* (1971Mi08); −18 *+4−2* from <M(E2)>/<M(M1)> (1991Wu05).
		903.3	100	0.0	0^+	E2		0.00554 *8*	
1006.4	3^+	894.8	100	111.13	2^+	M1+E2	−13.2 *9*	0.00569 *8*	Mult.: W(0°)/W(90°)=0.99 *13* (1977Mc11).
1121.0	2^+	757[&]	100	363.9	4^+	E2		0.00803	
		1010[&]	≈180	111.13	2^+	M1+E2+E0			I_γ: I(1010γ)/I(757γ)≈1.8 (1971Mi08).
		1121[&]		0.0	0^+	E2		0.00359	I_γ: 79 if 22% branch, As assumed from literature by 1971Mi08.
1130.4	2^-	227[@]	100	903.4	2^+	E1+M2+E3		0.059 *5*	
1133.0	4^+	231		903.4	2^+	E2		0.193	
		(385)		748.1	6^+	[E2]		0.0414	
		769.8		363.9	4^+	M1+E2	−12 *+5−20*	0.0080 *4*	δ: from <M(E2)>/<M(M1)> (1991Wu05).
		1022.6		111.13	2^+	E2		0.00431 *6*	1977Mc11 observe a 1022γ but place it, instead, from the 1386 level, inconsistent with Adopted Levels, Gammas; they do not report the 1133 level.
1221.9	3^-	91[@]		1130.4	2^-	M1+E2	0.62 *4*	6.03	
		215[@]	100	1006.4	3^+	E1		0.0521	Mult.: W(0°)/W(90°)=1.25 *6* (1977Mc11).
		318[@]	206	903.4	2^+	E1+M2	−0.020 *10*	0.0202 *5*	I_γ: from Ti(318γ)/Ti(215γ)=2.0 (1977Mc11). Mult.: W(0°)/W(90°)=0.742 *25* (1977Mc11).
		857		363.9	4^+	E1		0.00238 *4*	E_γ: rounded value from Adopted Gammas.
		(1222)		0.0	0^+	(E3)		0.00639 *9*	E_γ: unobserved, but must Be present because level is Coulomb excited directly. Eγ from level energy difference.
1251.8	8^+	503.7	100	748.1	6^+	E2[a]		0.0206	Mult.: Coulomb excited with B(E2) consistent with a lower yrast transition.
1296.2	5^+	932.2	100	363.9	4^+				
1386.1	2^+	483[&]	14 *3*	903.4	2^+	M1+E2		0.15 *10*	I_γ: from Ti(483γ)/Ti(1386γ)=0.14 *3* (1971Mi08, calculated from Iγ assuming α(483γ)=0.023 and α(1386γ)=0). δ(M1,E2)≤10 (1971Mi08).
		1275[&]	119 *9*	111.13	2^+	M1+E2	≥+3		I_γ: I(1275γ)/I(1386γ)=1.19 *9* (1971Mi08). δ(M1,E2)=+6 *+6−3* (1971Mi08) from A_2(1275γ)=+0.05 *6*; authors favor this solution over the smaller one.
		1386[&]	100	0.0	0^+	E2		0.00242 *4*	Mult.: anisotropy consistent with J=2 to 0 transition (1971Mi08).
1431.0?	2^+	1431[@c]	100	0.0	0^+	E2		0.00230 *4*	
1476.5	6^+	(225)		1251.8	8^+	E2		0.210	

$\gamma(^{184}W)$ (continued)

E_i(level)	J^π_i	E_γ[†]	I_γ[‡]	E_f	J^π_f	Mult.[#]	δ[#]	α[b]	Comments
1476.5	6^+	343.1		1133.0	4^+	E2		0.0574	
		728.6		748.1	6^+	M1+E2	−4 *+1−15*	0.0095 *8*	δ: −4.4 *+13−149* from <M(E2)>/<M(M1)> (1991Wu05).
		1112.9		363.9	4^+	E2		0.00364 *6*	
1860.4	10^+	608.6	100	1251.8	8^+	E2		0.01309	
1925.3	8^+	64.9		1860.4	10^+	E2		24.0	E_γ: from level energy difference.
		448.7		1476.5	6^+	E2		0.0276	
		674		1251.8	8^+	M1+E2	−2.3 *+42−4*	0.0129 *10*	δ: from <M(E2)>/<M(M1)> (1991Wu05).
		1177.3		748.1	6^+	E2		0.00327 *5*	
2471.6	10^+	546.3	100	1925.3	8^+	[E2]		0.0169	
2556.6	12^+	696.2	100	1860.4	10^+	E2[a]		0.00965 *14*	
3108.7?	(12^+)	637.1[c]	100	2471.6	10^+	[E2]		0.01178	
3319.5	14^+	762.9	100	2556.6	12^+	[E2]		0.0079	
4116.5	16^+	797.0	100	3319.5	14^+	[E2]		0.00720 *10*	E_γ: from 1989Ku04.

[†] From 1991Wu05, except as noted; uncertainty unstated by authors. values for transitions within the g.s. band are taken from table 6 of 1991Wu05; others are based on the level energies shown In fig. 5.

[‡] Relative photon branching.

[#] From Adopted Gammas, except As noted.

[@] From 1977Mc11; uncertainty unstated by authors.

[&] From 1971Mi08; uncertainty unstated by authors.

[a] From comparison of experimental yields At several angles with Coulomb excitation predictions using deduced matrix elements (1991Wu05).

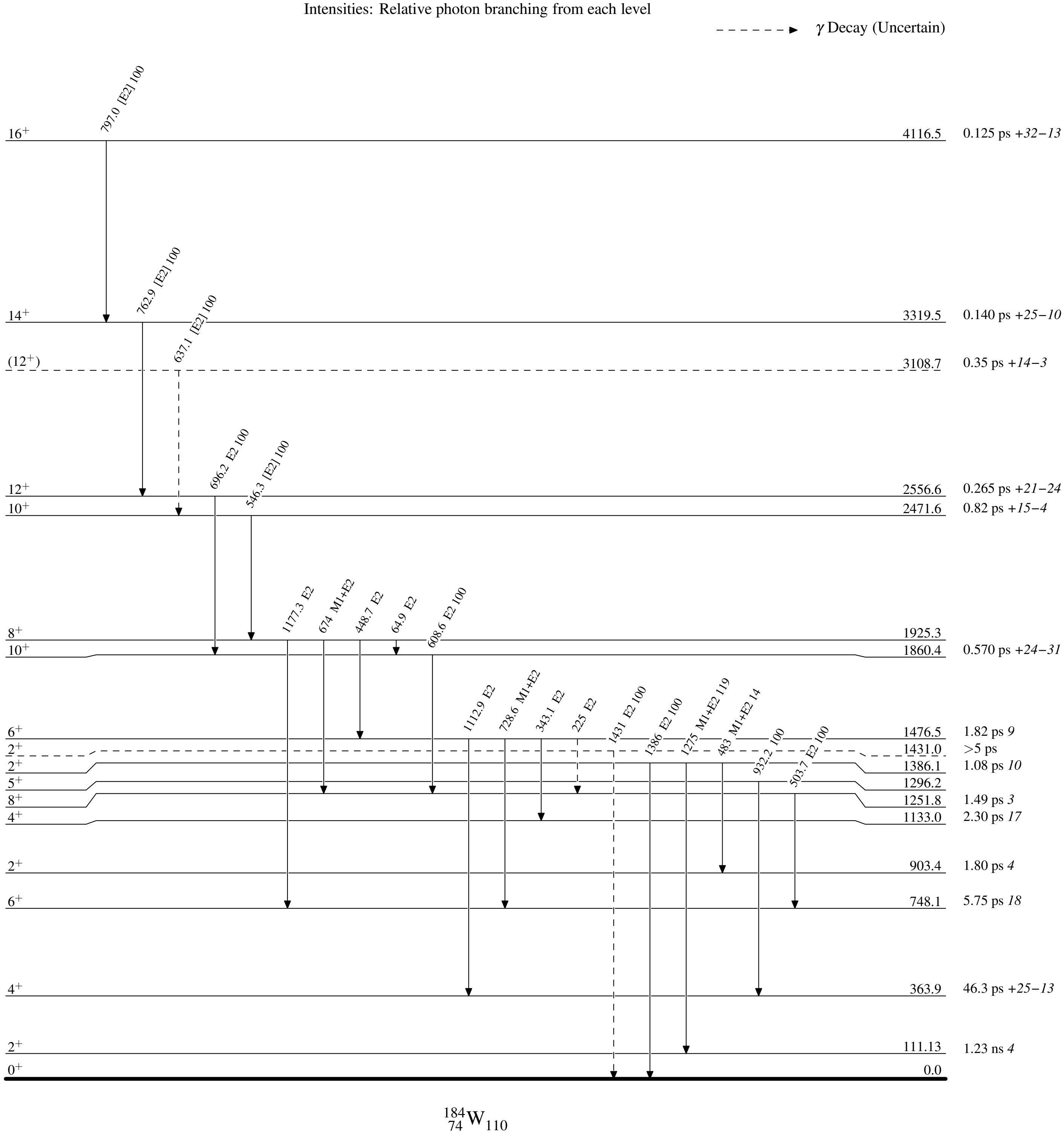
[b] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

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

Coulomb excitation 1991Wu05,1989Ku04

Level Scheme

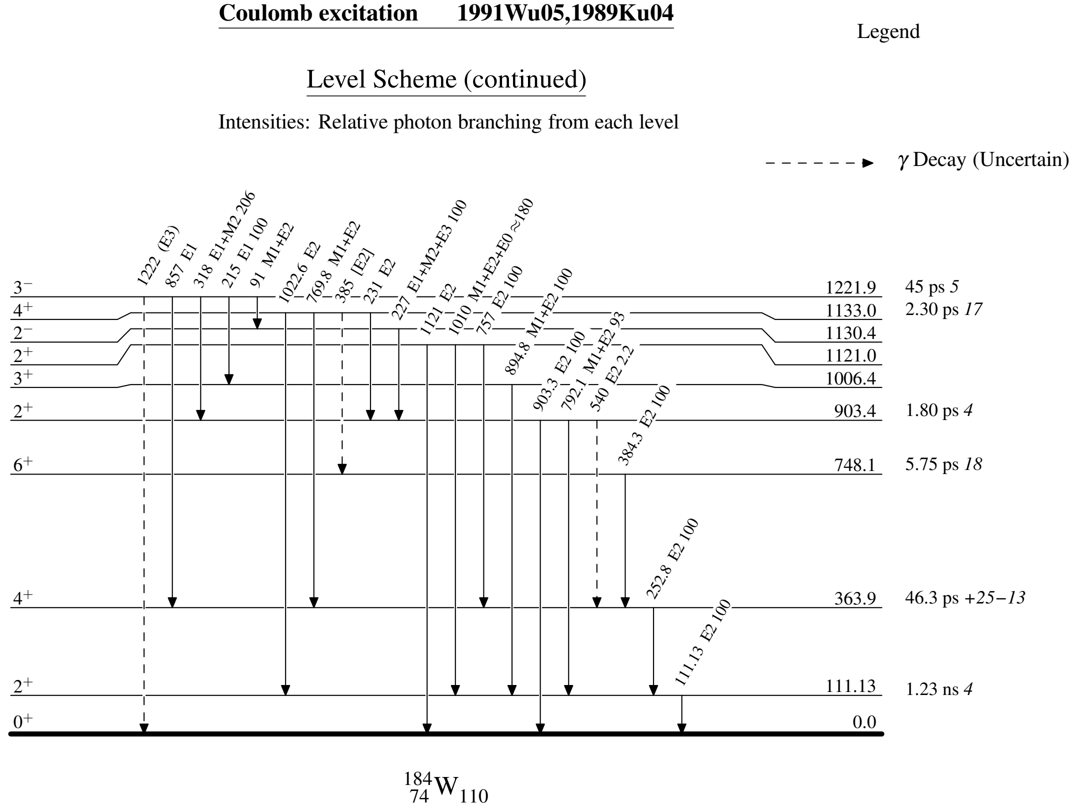
Intensities: Relative photon branching from each level



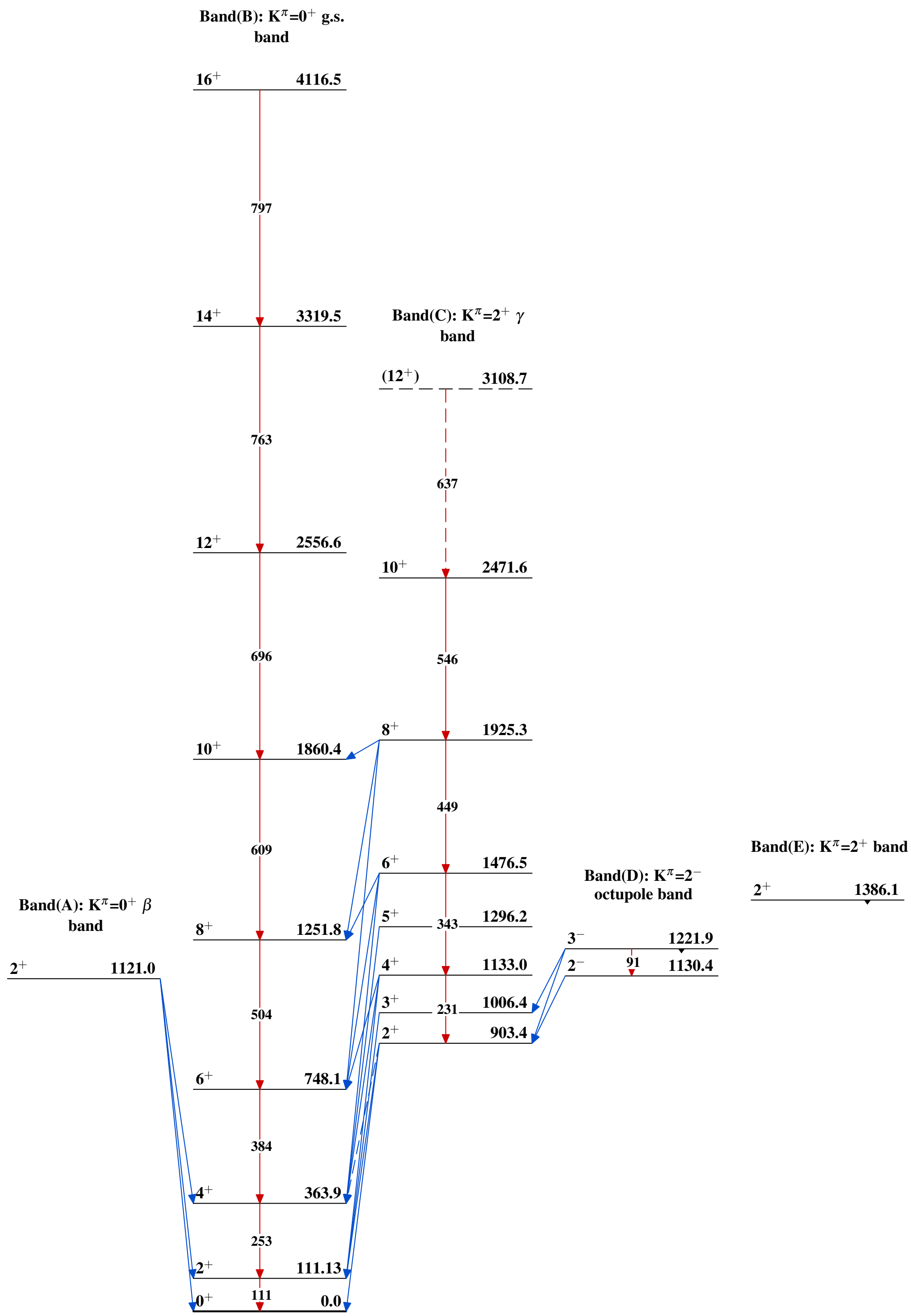
Coulomb excitation 1991Wu05,1989Ku04

Level Scheme (continued)

Intensities: Relative photon branching from each level



Coulomb excitation 1991Wu05,1989Ku04



$^{184}_{74}W_{110}$