^{204}Pb(n,n′γ) 1988Ha16,1989DeZT,1977SmZV

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	C. J. Chiara and F. G. Kondev	NDS 111,141 (2010)	1-Oct-2009

1988Ha16: 93-g Pb target enriched to 71.4% ^{204}Pb; E(n)=1.4-3.0 MeV, 6-ns pulsed beam; HPGe detector, efficiency 20% and FWHM=1.9 keV at 1332 keV; measured Eγ, Iγ, γ excitation functions, γ(θ) at E(n)=2 and 3 MeV.
1989DeZT: measured Eγ, γ(θ), γ polarization.
1977SmZV: 9.569-g Pb target enriched to 99.73% ^{204}Pb; irradiation with up to 10-MeV n′s to activate isomer for $T_{1/2}$ measurements, E(n)<3 MeV for prompt γ study; twoGe(Li)′s for measuring Eγ, γγ-coin, γ(θ), γ(t), γ excitation functions.
Others: 1980Da10, 1973De11.
Additional information 1.

^{204}Pb Levels

Additional information 2.

E(level)†	Jπ‡	$T_{1/2}$	Comments
0	0^+		
899.21 *4*	2^+		
1274.29 *6*	4^+		
1351.21 *5*	2^+		
1563.60 *8*	4^+		
1582.82 *6*	2^+		
1604.90 *9*	3^+		
1665.30 *7*	2^+		
1681.21 *8*	$1^{(+)}$#		
1712.30 *7*	$2^{(+)},3^{(+)}$		Jπ: J=2,3 established by 361.1- and 813.1-keV D′s to 2^+ levels; 604.0-keV (M1+E2) from 2316.3-keV, 2^+ level fixes π=(+).
1730.01 *12*	0^+		
1761.11 *7*	2^+		
1817.41 *10*	4^+		
1872.11 *10*	$1^{(+)}$#		
1933.31 *8*	$1^{(+)}$#		
1948.38 *7*	3^+		Jπ: From γ(θ) and/or polarization measurements in 1989DeZT.
1960.41 *7*	2^+		Jπ: γ(θ) in 1988Ha16 indicate $J^\pi=2^+,3^+$, but the authors conclude it must be 2^+ based on L=2 in (p,t) studies.
2065.00 *10*	5^+		
2105.51 *7*	2^+		
2158.10 *9*	$3^+,4^+$		
2185.3 *10*	9^-	67.2 min *9*	Jπ: From Adopted Levels. $T_{1/2}$: From study of delayed γ′s from activated isomer in 1977SmZV.
2201.91 *11*	2,3,4		
2257.80 *10*	5^-		
2269.01 *10*	(1,2)		Jπ: Not explicitly given by 1988Ha16, but observed 2269.0γ to g.s. implies this assignment.
2304.01 *8*	3^+		
2316.31 *6*	2^+		
2338.10 *12*	4^-		Jπ: J=4,5 from 1988Ha16. If J=5 then δ(1063.8γ)=0.3, which is excluded by α(K)exp in ^{204}Bi ε decay.
2386.50 *13*	5^+		
2400.38 *7*	1,2,3		
2409.01 *11*	3		
2433.01 *13*	0^+		1988Ha16 argue that this level does not involve intruder orbitals but can be described within the valence shell-model space, contrary to the conclusions of 1986Ka07 in (p,2nγ).
2475.41 *11*			

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^{204}Pb(n,n′γ) 1988Ha16,1989DeZT,1977SmZV (continued)

^{204}Pb Levels (continued)

E(level)†	Jπ‡	Comments
2491.71 *8*	3^+	
2524.91 *8*		
2547.02 *11*	2,3,4	
2549.86 *9*	2^+,3	Jπ: 1988Ha16 assigned Jπ=2,3,4; evaluator further constrains Jπ based on 1650.6-keV D(+Q) to 2^+ and 1275.6γ to 4^+.
2591.51 *8*	1,2,3	
2620.71 *9*	3^-	Jπ: 1721γ(θ) implies J=3; large n inelastic scattering cross section indicates strong collective nature of 3^- level.
2627.60 *12*	3,4,5	
2654.72 *11*	1,2,3	
2666.22 *8*	2^+	
2719.50 *10*	4,5	
2732.01 *11*	1,2,3	
2767.10 *12*	(4,5)	
2887.22 *11*	2,3	

† From a least-squares fit to Eγ.
‡ From 1988Ha16 based on Iγ(θ), unless otherwise noted.
# Parity assigned by 1988Ha16 based on shell-model systematics.

γ(^{204}Pb)

A_2,A_4 coefficients determined by 1988Ha16 at E(n)=2 MeV for initial levels below 1900 keV and at E(n)=3 MeV for above 1900 keV.
In the delayed spectra of 1977SmZV, counted for over ten half-lives of the 67.2-min isomer, only 375γ, 899γ, and 911γ were observed.

E_i(level)	J_i^π	E_γ†	I_γ‡	E_f	J_f^π	Mult.#	δ@	Comments
899.21	2^+	899.2 *1*	100	0	0^+	E2		Mult.: A_2=0.14 *1*, A_4=−0.04 *1*.
1274.29	4^+	375.1 *1*	100	899.21	2^+	E2		E_γ: 374.76 *7* in ^{204}Bi ε decay. Mult.: A_2=0.29 *7*, A_4=−0.14 *10*.
1351.21	2^+	452.0 *1*	22	899.21	2^+	M1+E2	+0.80 *12*	δ: From 1989DeZT. δ=+0.8 or +3.4 in 1988Ha16, no uncertainties given. Mult.: A_2=−0.17 *2*.
		1351.2 *1*	78	0	0^+	E2		Mult.: A_2=0.23 *1*, A_4=−0.09 *2*.
1563.60	4^+	289.3 *1*	100	1274.29	4^+	M1+E2	+0.09 *2*	δ: 1989DeZT report δ=+0.16 *4*. Mult.: A_2=0.31 *2*.
1582.82	2^+	683.6 *1*	97	899.21	2^+	M1+E2	−0.18 *2*	E_γ: Possibly a doublet from 1582.4, 0^+ state (see 1989Tr14). δ: from 1989DeZT. δ=−1.7 or −0.2 in 1988Ha16, no uncertainties given. Mult.: A_2=0.31 *1*.
		1582.8 *1*	3	0	0^+	E2		Mult.: A_2=0.37 *7*.
1604.90	3^+	330.6 *1*	59	1274.29	4^+	M1+E2	≈+0.1	δ: The second solution of δ=+23 of 1988Ha16 is excluded by α(K)exp in ^{204}Bi ε decay. Mult.: A_2=−0.12 *2*, A_4=−0.04 *3*.
		705.7 *1*	41	899.21	2^+	M1+E2	+0.30 *4*	δ: Weighted average of +0.2 *1* (1988Ha16) and +0.32 *4* (1989DeZT). Mult.: A_2=−0.45 *3*.
1665.30	2^+	766.1 *1*	51	899.21	2^+	M1(+E2)	+0.11 *4*	δ: From 1989DeZT. δ=+0.1 or +3.0 in 1988Ha16, no

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^{204}Pb(n,n′γ) 1988Ha16,1989DeZT,1977SmZV (continued)

γ(^{204}Pb) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.[#]	δ[@]	Comments
								uncertainties given. Mult.: A_2=0.17 *3*.
1665.30	2$^+$	1665.3 *1*	49	0	0$^+$	E2		Mult.: A_2=0.36 *3*, A_4=−0.12 *4*.
1681.21	1$^{(+)}$	782.0 *1*	48	899.21	2$^+$	D+Q		δ: +0.1 or +3.7 in 1988Ha16. Mult.: A_2=0.0.
		1681.2 *1*	52	0	0$^+$	D		Mult.: A_2=−0.18 *2*, A_4=−0.04 *4*. Additional information 3.
1712.30	2$^{(+)}$,3$^{(+)}$	361.1 *1*	72	1351.21	2$^+$	D(+Q)[&]		Mult.: A_2=−0.28 *10*.
		438.0 *1*	15	1274.29	4$^+$			Mult.: A_2=0.0.
		813.1 *1*	12	899.21	2$^+$	D(+Q)[&]		Mult.: A_2=−0.46 *17*.
1761.11	2$^+$	409.9 *1*	7	1351.21	2$^+$			
		861.9 *1*	52	899.21	2$^+$	M1+E2	+1.4 *4*	δ: 1989DeZT report δ=+4.5 *5*. Mult.: A_2=−0.30 *3*.
		1761.1 *1*	41	0	0$^+$	E2		Mult.: A_2=0.33 *4*, A_4=−0.14 *6*.
1817.41	4$^+$	918.2 *1*	100	899.21	2$^+$	E2		Mult.: A_2=0.39 *4*, A_4=−0.16 *5*.
1872.11	1$^{(+)}$	1872.1 *1*	100	0	0$^+$	D		Mult.: A_2=−0.09 *2*, −0.04 *3*.
1933.31	1$^{(+)}$	1034.1 *1*	11	899.21	2$^+$			Mult.: A_2=−0.26 *10*, A_4=−0.29 *17*.
		1933.3 *1*	89	0	0$^+$	D		Mult.: A_2=−0.09 *3*.
1948.38	3$^+$	365.5 *1*	22	1582.82	2$^+$	(M1+E2)		Mult.: A_2=−0.34 *8*.
		597.2 *1*	31	1351.21	2$^+$	(M1+E2)		Mult.: A_2=0.39 *12*.
		674.1 *1*	18	1274.29	4$^+$	(M1+E2)		Mult.: A_2=0.17 *6*.
		1049.2 *1*	29	899.21	2$^+$	M1+E2	−2.4 *2*	δ: From 1989DeZT. Mult.: A_2=0.30 *6*, A_4=0.12 *8*.
1960.41	2$^+$	377.6 *1*	23	1582.82	2$^+$	D+Q		δ: −0.1 or −1.8 in 1988Ha16. Mult.: A_2=0.18 *8*.
		609.2 *1*	21	1351.21	2$^+$			Mult.: A_2=0.74 *40*.
		1061.2 *1*	56	899.21	2$^+$	D+Q		δ: −0.2 or +1.6 in 1988Ha16. Mult.: A_2=0.27 *3*.
2065.00	5$^+$	501.4 *1*	25	1563.60	4$^+$	M1(+E2)	+0.1 *1*	Mult.: A_2=−0.41 *11*.
		790.7 *1*	75	1274.29	4$^+$	M1+E2	−1.2 *2*	E_γ: 791.20 *9* in ^{204}Bi ε decay. δ: Weighted average of −0.9 *5* (1988Ha16) and −1.25 *25* (1989DeZT). Contrary to the statement of 1988Ha16, there is no disagreement about the sign of δ(791γ); the α data in ^{204}Bi decay do not determine the sign of δ. Mult.: A_2=0.65 *7*, A_4=0.18 *10*.
2105.51	2$^+$	754.3 *1*	31	1351.21	2$^+$			Mult.: A_2=0.10 *7*, A_4=−0.14 *1*.
		1206.3 *1*	24	899.21	2$^+$			
		2105.5 *1*	45	0	0$^+$	E2		Mult.: A_2=0.28 *5*.
2158.10	3$^+$,4$^+$	883.8 *1*	25	1274.29	4$^+$			Mult.: A_2=0.38 *14*, A_4=−0.35 *19*.
		1258.9 *1*	75	899.21	2$^+$			Mult.: A_2=0.27 *8*, A_4=−0.13 *10*.
2185.3	9$^-$	911		1274.29	4$^+$	[E5]		E_γ: From 1973De11, no uncertainty given.
2201.91	2,3,4	850.7 *1*	100	1351.21	2$^+$			Mult.: A_2=0.28 *8*, A_4=−0.18 *11*.
2257.80	5$^-$	440.4 *1*	7	1817.41	4$^+$			
		592.5[a] *1*	3	1665.30	2$^+$			I_γ: Not observed in ^{204}Bi ε decay. Based on γ spectrum of 1970CrZY, evaluator estimates that Iγ(592.5)<0.5% rather than the 3% reported by 1988Ha16. Note that J^π assignments would imply mult E3.
		983.5 *1*	90	1274.29	4$^+$	D(+Q)	−0.05 *9*	Mult.: Consistent with pure D; 1988Ha16 assign E1, but γ(θ) does not rule out M1. δ: From 1980Da10. δ=0.0 in 1988Ha16, no uncertainty given. A_2=−0.22 *1*.

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^{204}Pb(n,n′γ) 1988Ha16,1989DeZT,1977SmZV (continued)

γ(^{204}Pb) (continued)

E_i(level)	J_i^π	E_γ [†]	I_γ [‡]	E_f	J_f^π	Mult.[#]	δ[@]	Comments
2269.01	(1,2)	2269.0 *1*	100	0	0^+			
2304.01	3^+	721.2 *1*	41	1582.82	2^+	M1+E2		Mult.: A_2=−0.11 *8*.
		740.4 *1*	41	1563.60	4^+	(M1+E2)		δ: −0.3 or −15 in 1988Ha16. Large δ favors M1+E2 over E1+M2. Mult.: A_2=−0.34 *8*.
		1404.8 *1*	18	899.21	2^+			Mult.: A_2=0.32 *16*, A_4=0.23 *20*.
2316.31	2^+	586.3 *1*	25	1730.01	0^+	E2		Mult.: A_2=0.21 *14*, A_4=−0.28 *22*.
		604.0 *1*	32	1712.30	$2^{(+)},3^{(+)}$	(M1+E2)		δ: −0.3 or −7 in 1988Ha16. Large δ favors M1+E2 over E1+M2. Mult.: A_2=−0.15 *6*, A_4=0.23 *9*.
		965.1 *1*	18	1351.21	2^+	(M1+E2)		δ: +1.0 or +2.5 in 1988Ha16. Mult.: A_2=−0.22 *8*.
		1417.1 *1*	18	899.21	2^+			
		2316.3 *1*	10	0	0^+	E2		Mult.: A_2=0.33 *15*.
2338.10	4^-	1063.8 *1*	100	1274.29	4^+	E1+M2	≈+0.2	E_γ: In ^{204}Bi ε decay, Eγ=1064.32 *4*. The (n,n′γ) experiments were not sensitive to the low-energy (80.15-keV) transition deexciting the 2338.30-keV level in ^{204}Bi ε decay. Mult.: A_2=0.21 *4*.
2386.50	5^+	822.9 *1*	100	1563.60	4^+	M1+E2	+1.5 *5*	δ: Average of +2.0 (1988Ha16, no uncertainty given) and +0.9 *3* (1989DeZT). Mult.: A_2=−0.80 *6*, A_4=0.24 *9*.
2400.38	1,2,3	735.1 *1*	12	1665.30	2^+			Mult.: A_2=0.19 *15*.
		817.6 *1*	9	1582.82	2^+			
		1501.1 *1*	79	899.21	2^+	M1+E2[&]		Mult.: γ(θ) in 1988Ha16 rules out stretched E2 and pure D. A_2=−0.09 *4*, A_4=−0.12 *5*.
2409.01	3	1509.8 *1*	100	899.21	2^+	D+Q	≈+0.07	Mult.: A_2=−0.36 *6*.
2433.01	0^+	751.8 *1*	100	1681.21	$1^{(+)}$			
2475.41		1576.2 *1*	100	899.21	2^+			
2491.71	3^+	1140.5 *1*	65	1351.21	2^+	M1+E2	≈−0.5	Mult.: A_2=0.35 *6*.
		1592.5 *1*	35	899.21	2^+	M1+E2	≈−1.0	Mult.: A_2=0.66 *12*.
2524.91		1173.7 *1*	37	1351.21	2^+			
		1625.7 *1*	63	899.21	2^+			Mult.: A_2=0.20 *7*.
2547.02	2,3,4	1647.8 *1*	100	899.21	2^+			Mult.: A_2=0.22 *10*.
2549.86	2^+,3	1275.6 *1*	83	1274.29	4^+			Mult.: A_2=−0.07 *5*.
		1650.6 *1*	17	899.21	2^+	D(+Q)[&]		Mult.: A_2=−0.16 *5*, A_4=−0.17 *7*.
2591.51	1,2,3	1240.3 *1*	21	1351.21	2^+			
		1692.3 *1*	79	899.21	2^+	D(+Q)[&]		Mult.: A_2=−0.15 *9*.
2620.71	3^-	1057.1 *1*	9	1563.60	4^+	D(+Q)[&]		Mult.: A_2=−0.13 *11*.
		1721.5 *1*	91	899.21	2^+	D+Q	≈+0.04	Mult.: A_2=−0.33 *2*.
2627.60	3,4,5	1353.3 *1*	100	1274.29	4^+	D(+Q)[&]		Mult.: A_2=−0.35 *14*.
2654.72	1,2,3	1755.5 *1*	100	899.21	2^+	D(+Q)[&]		Mult.: A_2=−0.23 *16*.
2666.22	2^+	1767.0 *1*	23	899.21	2^+			
		2666.2 *1*	77	0	0^+	E2		Mult.: A_2=0.48 *9*.
2719.50	4,5	1155.9 *1*	30	1563.60	4^+	M1+E2[&]		Mult.: γ(θ) in 1988Ha16 rules out stretched E2 and pure D. A_2=0.00 *5*.
		1445.2 *1*	70	1274.29	4^+			Mult.: A_2=0.35 *11*.
2732.01	1,2,3	1380.8 *1*	100	1351.21	2^+	D(+Q)[&]		Mult.: A_2=−0.12 *7*.
2767.10	(4,5)	1492.8 *1*	100	1274.29	4^+			Mult.: A_2=0.55 *10*.
2887.22	2,3	1988.0 *1*	100	899.21	2^+	D(+Q)[&]		Mult.: A_2=−0.31 *7*.

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^{204}Pb(n,n′γ) 1988Ha16,1989DeZT,1977SmZV (continued)

γ(^{204}Pb) (continued)

† From 1988Ha16, except as noted. Others: 1977SmZV, 1980Da10. 1988Ha16 estimate Eγ uncertainty of 0.1 keV for all γ′s; however, comparison with ^{204}Bi ε decay shows discrepancies of up to 0.5 keV in a number of cases.
‡ % photon branching from each level (1988Ha16). No uncertainties were given.
# From γ(θ) of 1988Ha16. For δ>0.3, 1988Ha16 assume M1+E2 rather than E1+M2.
@ From γ(θ) of 1988Ha16, except as noted;≈sign indicates uncertainties were not given by 1988Ha16. Those δ′s from 1989DeZT are from γ(θ) and γ polarization; the sign convention of 1989DeZT is opposite the Nuclear Data Sheets convention and has been changed accordingly here. The ce data from ^{204}Bi ε decay eliminated some of the ambiguity in the γ(θ) results from (n,n′γ).
& Mult assigned by evaluators, γ(θ) in 1988Ha16 rules out stretched E2.
a Placement of transition in the level scheme is uncertain.

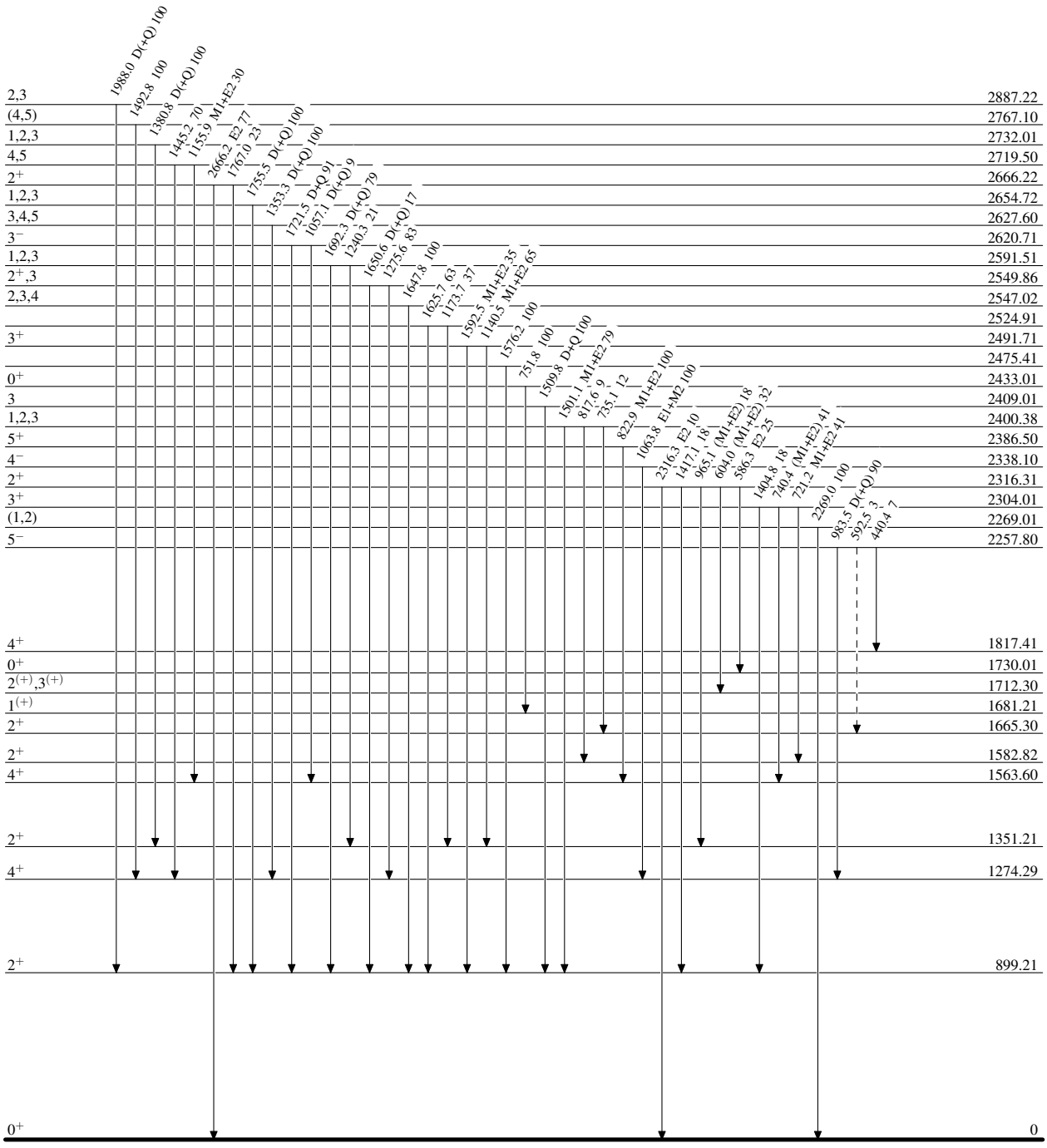
^{204}Pb(n,n′γ) 1988Ha16,1989DeZT,1977SmZV

Legend

Level Scheme

Intensities: % photon branching from each level

γ Decay (Uncertain)

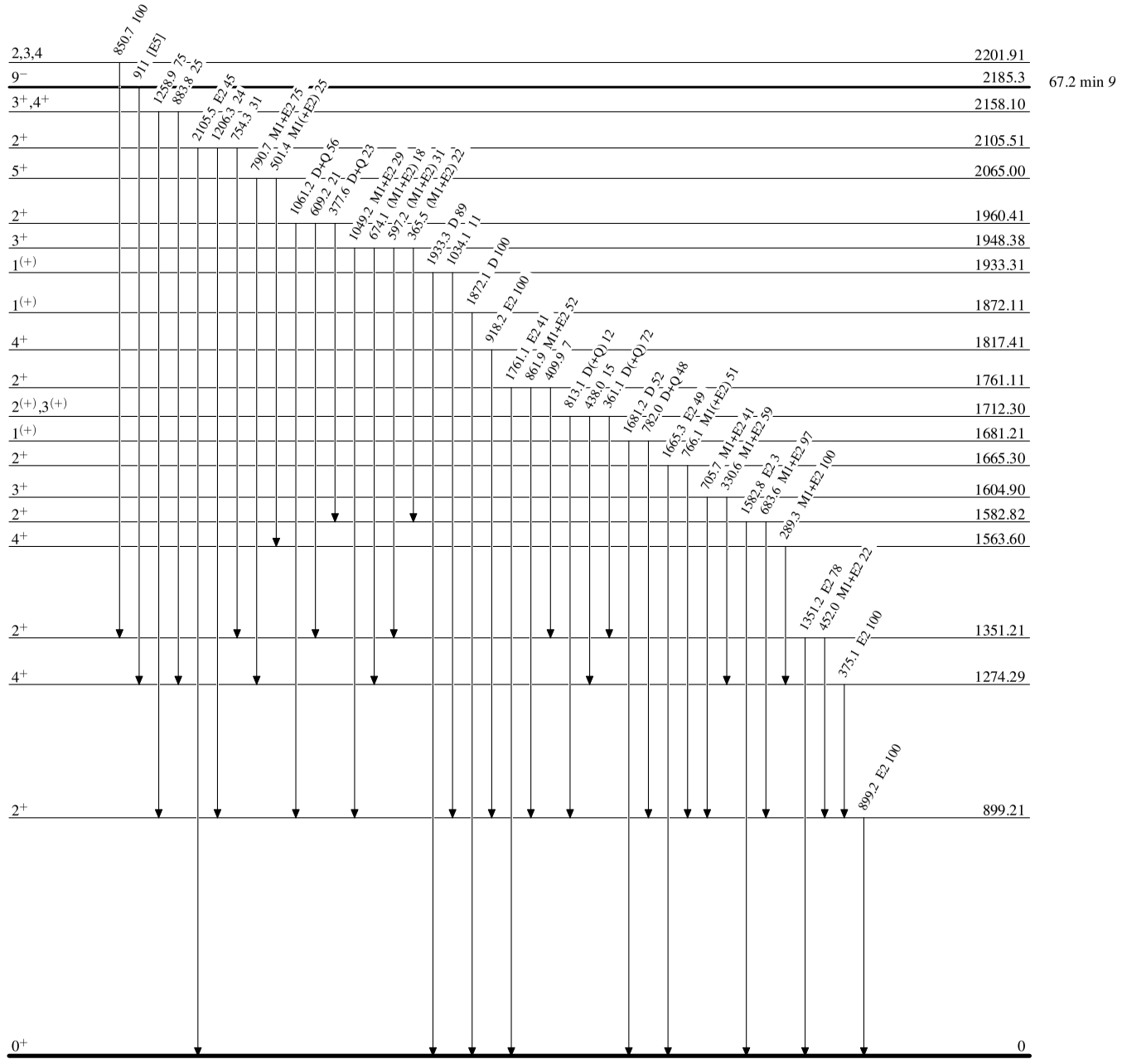


$^{204}_{82}Pb_{122}$

^{204}Pb(n,n′γ) 1988Ha16,1989DeZT,1977SmZV

Level Scheme (continued)

Intensities: % photon branching from each level



$^{204}_{82}Pb_{122}$