Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 154, 1 (2018)	20-Nov-2018

Q(β^-)=−429 *7*; S(n)=7941 *10*; S(p)=5029 *9*; Q(α)=−1080 *50* 2017Wa10

2006Ut01, 2006Ut02: measured σ=97 mb *8* for ^{141}Pr(γ,n)^{140}Pr.

2001Sa27, 1997KaZT: measured σ for ^{141}Pr(n,2n)^{140}Pr E=13.4-14.9 MeV.

2008Br05, 2000Jo17, 1998JoZW, 1998Or04, 1997TeZZ, 1985Ni06, 1982Or08, 1980ZoZY, 1976Fo08, 1975Sc17, 1974Hu03, 1973GuZC, 1973GuZD, 1972GuZL, 1967Fu01: measured or analyzed data for IA $\Delta J^\pi=0^+$ (Fermi ^{140}Ce(p,n)^{140}Pr (n spectra, p spectra, γ, $\gamma\gamma$, differential σ type) transitions, Γ_{IAS}, $T_{1/2}$.

1999Ab40, 1999Ab39: measured (γ,n) differential and integral effective σ and yields with γ source from 20 MeV electron bremsstrahlung; 2000Le02: same reaction with electron bremsstrahlung with electrons from pulsed laser.

^{140}Pr Levels

Cross Reference (XREF) Flags

A	^{140}Pr IT decay (3.05 μs)	E	^{140}Ce(p,nγ)	I	^{142}Nd(d,α)
B	^{140}Nd ε decay	F	^{141}Pr(p,d) E=30 MeV	J	^{143}Nd(pol p,α) E=23.5 MeV
C	^{130}Te(^{14}N,4nγ)	G	^{141}Pr(d,t) E=16 MeV		
D	^{140}Ce(p,n)	H	^{142}Nd(p,^{3}He) E=40 MeV		

E(level)†	Jπ‡	$T_{1/2}$	XREF	Comments
0.0	1$^+$	3.39 min *1*	AB EFGHIJ	%ε+%β^+=100 Jπ: atomic beam (1972Ek04), log *ft*=4.4 to 0$^+$. $T_{1/2}$: weighted average of 3.39 min *1* (1965Eb01), 3.40 min *2* (1968Bo25), 3.36 min *5* (1977Ca12), 3.28 min *10* (2010NiZR), 3.5 min *3* (2000Le02).
27.23 *3*	2$^+$#		A EFGHI	
29.51 *18*	3$^+$#		A C E HIJ	
127.8 *3*	5$^+$	0.35 μs *2*	A C E GHIJ	%IT=100 %IT: no other decay modes reported. $T_{1/2}$: from IT decay (1975Sc17). Others; 0.54 μs *2* (1964Kr02) (IT decay), 0.5 μs (1973GuZD) (p,nγ). Jπ: 5$^+$,6$^+$,7$^+$ from L(p,^{3}He)=6; D,E2 γ to 3$^+$.
191.76 *17*	3$^+$#		EFGHIJ	
271.25 *17*	2$^+$		E GH J	Jπ: γ to 2$^+$ is ΔJ=0, D+Q; L(n)=2.
287.08 *16*	3$^+$		EFGHIJ	Jπ: γ to 29.5, 3$^+$ is ΔJ=0, D+Q; L(n)=0.
330.9 *3*	(4,5)$^+$		EFGHIJ	Jπ: L=4 in (p,^{3}He), γ to 191.8, 3$^+$, no γ to 2$^+$, 1$^+$.
390.9 *3*	(4,5)$^+$		E GHIJ	Jπ: L=4 in (p,^{3}He), no γ to 2$^+$, 1$^+$.
419.91 *17*	2$^+$,3$^+$		EFGHIJ	Jπ: L(n)=0 in (d,t).
576.7 *4*	(4,5)$^+$		E GHIJ	Jπ: L=4 in (p,^{3}He), no γ to 2$^+$, 1$^+$.
604.3 *3*	(3)$^+$		E G I	Jπ: L(n)=0 in (d,t), γ to 390.9, (4,5)$^+$, no γ to 2$^+$, 1$^+$.
630 *2*	1$^+$,2$^+$,3$^+$		GH	Jπ: L=2 in (p,^{3}He).
642 *2*			G IJ	
670.2 *5*			E	
763.7 *5*	(7)$^-$@	3.05 μs *20*	A C FGH	%IT=100 %IT: no other decay modes reported. Jπ: L=(7) in (p,^{3}He), L=5 in (p,d) and (d,t), shell model. $T_{1/2}$: from 1964Kr02. Others: 3.0 μs *6* (1969Iv02,1973GuZD), 2.5 μs *4* (1975Sc17).
784.5 *9*	(8)$^-$@		C G IJ	Jπ: L=5 in (d,t), shell model.
862.0 *4*	(4)$^-$		E GHIJ	Jπ: L=5 in (d,t), L=(5) in (p,^{3}He), γ to 3$^+$. E(level),Jπ: large S=3.2 in (d,t) may suggest a doublet structure for the level with components J=4$^-$ and J=6$^-$.

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Adopted Levels, Gammas (continued)

^{140}Pr Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	XREF	Comments
885.2		I	
888.0 *4*		E G J	
889 *2*	(5)$^{-}$	GH	J$^{\pi}$: L=(5) in (p,^{3}He), L=5 in (d,t), large S=1.6 in (d,t).
904.3 *3*	(2^{-})	E G I	J$^{\pi}$: L=(5) in (d,t), γ to 1^{+}.
913.4 *5*		E	
967.0 *5*		E G	
983.2 *6*		E	
1018 *2*	3^{+},4^{+},5^{+}	GH	J$^{\pi}$: L=4 in (p,^{3}He).
1024.5		I	
1034.3 *6*	2^{-},3^{-}	E G IJ	J$^{\pi}$: L=5 in (d,t), γ to 2^{+}.
1036.2 *9*	(8)[&]	C j	XREF: j(1045).
1053.7 *4*	(1^{+},2,3^{+})	E G j	XREF: j(1045). J$^{\pi}$: γ's to 1^{+} and (3)$^{+}$.
1061.5 *8*		E G J	
1079		IJ	
1133.2		HI	
1147.4 *4*	(2)$^{-}$	E G	J$^{\pi}$: L=3 in (p,^{3}He), γ to 1^{+}.
1183.2 *4*	(1,2,3)$^{+}$	E GH	J$^{\pi}$: L=2 in (d,t), L=(2) in (p,^{3}He).
1204 *2*	(5^{+})	GH J	XREF: J(1208). J$^{\pi}$: L=4+6 in (p,^{3}He), L=2 in (d,t) (if levels 1204 *2* in (d,t) and 1220 *20* in (p,^{3}He) are identical).
1214.5 *11*	(9)[&]	C IJ	XREF: J(1217).
1230 *2*	5^{+}	G IJ	J$^{\pi}$: L=2 in (d,t), see comment to 1204 level.
1293 *2*	1^{+},2^{+},3^{+}	GH	J$^{\pi}$: L=2 in (d,t), L=2 in (p,^{3}He).
1320	(5^{+},6^{+},7^{+})	H	J$^{\pi}$: L=(6) in (p,^{3}He).
1327.6		IJ	
1335		J	
1341.9		I	
1370	4^{-}	H	J$^{\pi}$: L=3+5 in (p,^{3}He).
1378		J	
1385		J	
1405		J	
1430	(1^{+},2^{+},3^{+})	H	J$^{\pi}$: L=(2) in (p,^{3}He).
1487.6 *15*		C J	XREF: J(1484).
1502		J	
1525		J	
1565		J	
1586		J	
1652		J	
1672		J	
1684		J	
1718		J	
1751		J	
1761.7 *12*	(9^{+})[&]	C	
1768		J	
1815.7 *14*	(10^{+})[&]	C	
1825		J	
1860	1^{+},2^{+},3^{+}	H	J$^{\pi}$: L=2 in (p,^{3}He).
1939		J	
1960	4^{-},5^{-},6^{-}	H	J$^{\pi}$: L=5 in (p,^{3}He).
1973		J	
1984		J	
2020		J	
2117		J	
2196.9 *14*	(11^{+})[&]	C	

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Adopted Levels, Gammas (continued)

^{140}Pr Levels (continued)

E(level)†	Jπ‡	XREF	E(level)†	Jπ‡	XREF	E(level)†	Jπ‡	XREF
2221		J	2748		J	3630.9 *16*		C
2277		J	2822		J	3734.4 *16*		C
2281.6 *12*		C	2859		J	3788.2 *16*		C
2333		J	2869.7 *16*		C	3865.5 *18*		C
2349		J	2877.9 *16*	(13)&	C	3912.2 *19*		C
2416		J	2895		J	4030.8 *17*		C
2446		J	2929		J	4035.0 *19*		C
2466		J	2953		J	4078.6 *19*	(17)&	C
2476.6 *14*	(12)&	C	2990		J	4396.7 *20*		C
2491		J	3005		J	4549.7 *21*		C
2542		J	3018.7 *15*	(14)&	C	4718.0 *22*		C
2570		J	3117.9 *16*	(15)&	C	6500		D
2602		J	3246.8 *16*		C	11037		D
2632		J	3587.9 *15*		C	12100		D
2655		J	3627.2 *18*		C			

† From least-squares fit of γ's to levels (GTOL).

‡ From L and (2J+1) rule for σ's ((p,d), (d,t), (p,^{3}He)), except where noted otherwise.

L(p,^{3}He)=2 for 27.2 level and D γ to 1^+, along with L(d,t)=0+2 for 191.8 level and ΔJ=1 for the γ to 27.2 level and ΔJ=0 for γ to 29.5 level, uniquely establish $J^\pi=2^+$, 3^+, and 3^+ for the 27.2, 29.5, and 191.8 levels, respectively.

@ Assignment of (7^-) and (8^-) for 764.0 keV and 784.7 keV levels from (^{14}N,4nγ) (2005Yu06), based on deduced (fast) 20.7γ (M1) in between these levels, and non-observed (slow) 656.9γ (E3) from 784.7 keV level to 127.8 keV level; inverted as compared to ^{141}Pr(d,t) (1974Hu03), which considered these assignments very likely based on DWBA analysis, but finally preferred the inverted assignment based on 2J+1 rule.

& From experimental asymmetries in (^{14}N,4nγ) (2005Yu05).

γ(^{140}Pr)

E_i(level)	J_i^π	E_γ†	I_γ†	E_f	J_f^π	Mult.‡	α&	Comments
27.23	2^+	27.23 *3*	100	0.0	1^+	(M1)	8.71	α(L)=6.88 *10*; α(M)=1.450 *21* α(N)=0.324 *5*; α(O)=0.0520 *8*; α(P)=0.00378 *6* Mult.: observation of 27γ (not completely converted) (1976Fo08) suggest E1 or M1, shell model favor similar parity for the lowest levels of ^{140}Pr.
127.8	5^+	98.5 *3*	100	29.51	3^+	E2	2.24	B(E2)(W.u.)=1.25 *8* α(K)=1.266 *21*; α(L)=0.758 *15*; α(M)=0.171 *4* α(N)=0.0369 *8*; α(O)=0.00515 *10*; α(P)=6.59×10^{-5} *11* Mult.: D,E2 from comparison with RUL; E2 or E2(+M1) from I(K x ray)/Iγ in IT decay.
191.76	3^+	162.2 *3*		29.51	3^+	D+Q@		
		164.4 *3*		27.23	2^+	D		Mult.: ΔJ=1 ((p,nγ), 1974Hu03).
271.25	2^+	241.6 *3*		29.51	3^+			
		243.8 *3*		27.23	2^+	D+Q@		
		271.8 *3*		0.0	1^+			
287.08	3^+	95.3 *3*		191.76	3^+			
		257.6 *3*		29.51	3^+	D+Q@		
		259.8 *3*		27.23	2^+			
		287.1 *3*		0.0	1^+			
330.9	$(4,5)^+$	139.2 *3*		191.76	3^+			

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Adopted Levels, Gammas (continued)

γ(^{140}Pr) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	α[&]	Comments
330.9	(4,5)$^+$	301.4 *5*		29.51	3$^+$			
390.9	(4,5)$^+$	198.9 *4*		191.76	3$^+$			
		263.2 *3*		127.8	5$^+$			
419.91	2$^+$,3$^+$	132.8 *4*		287.08	3$^+$			
		228.1 *3*		191.76	3$^+$			
		390.5 *4*		29.51	3$^+$			
		392.7 *3*		27.23	2$^+$			
		419.9 *3*		0.0	1$^+$			
576.7	(4,5)$^+$	384.9 *4*		191.76	3$^+$			
		547.2 *4*		29.51	3$^+$			
604.3	(3)$^+$	213.5 *5*		390.9	(4,5)$^+$			
		412.6 *4*		191.76	3$^+$			
		574.7 *4*		29.51	3$^+$			
670.2		640.7 *6*		29.51	3$^+$			
763.7	(7)$^-$	635.9 *3*	100	127.8	5$^+$	(M2,E3)	0.0211 *60*	α(K)=0.0175 *54*; α(L)=0.0028 *5*; α(M)=0.00061 *10* α(N)=0.000136 *22*; α(O)=2.1×10^{-5} *4*; α(P)=1.37×10^{-6} *48* Mult.: D,Q,E3 from comparison with RUL; E1,M2,E3 from different π′s for parent (764) and daughter (128) levels, from reaction L values and shell model; M2,E3 from independent parent-daughter J′s (ΔJ=2).
784.5	(8)$^-$	(20.7[#])		763.7	(7)$^-$	(M1)	19.7	α(L)=15.53 *22*; α(M)=3.27 *5* α(N)=0.731 *11*; α(O)=0.1173 *17*; α(P)=0.00853 *12* Mult.: deduced in (^{14}N,4nγ) (2005Yu05) based on (unobserved) transition in between (8$^-$) and (7$^-$) levels.
862.0	(4)$^-$	471.2 *4*		390.9	(4,5)$^+$			
		670.2 *5*		191.76	3$^+$			
888.0		888.0 *4*		0.0	1$^+$			
904.3	(2$^-$)	633.3 *4*		271.25	2$^+$			
		904.1 *4*		0.0	1$^+$			
913.4		243.2 *5*		670.2				
967.0		939.7 *6*		27.23	2$^+$			
		967.0 *6*		0.0	1$^+$			
983.2		652.4 *8*		330.9	(4,5)$^+$			
		955.8 *7*		27.23	2$^+$			
1034.3	2$^-$,3$^-$	763.1 *5*		271.25	2$^+$			
1036.2	(8)	251.8		784.5	(8)$^-$			
		272.5		763.7	(7)$^-$			
1053.7	(1$^+$,2,3$^+$)	140.3 *4*		913.4				
		449.2 *5*		604.3	(3)$^+$			
		1053.8 *6*		0.0	1$^+$			
1061.5		730.6 *7*		330.9	(4,5)$^+$			
1147.4	(2)$^-$	876.4 *5*		271.25	2$^+$			
		1147.1 *6*		0.0	1$^+$			
1183.2	(1,2,3)$^+$	896.1 *6*		287.08	3$^+$			
		1155.9 *7*		27.23	2$^+$			
		1183.2 *7*		0.0	1$^+$			
1214.5	(9)	178.3		1036.2	(8)			
		430.3		784.5	(8)$^-$			
1487.6		273.1		1214.5	(9)			

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Adopted Levels, Gammas (continued)

$\gamma(^{140}Pr)$ (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
1761.7	(9^+)	547.4	1214.5	(9)	3587.9		1390.8	2196.9	(11^+)
		977.0	784.5	$(8)^-$	3627.2		1430.3	2196.9	(11^+)
1815.7	(10^+)	(53.9#)	1761.7	(9^+)	3630.9		1154.1	2476.6	(12)
2196.9	(11^+)	381.1	1815.7	(10^+)	3734.4		103.2	3630.9	
2281.6		1067.4	1214.5	(9)			616.8	3117.9	(15)
		1497.0	784.5	$(8)^-$			715.7	3018.7	(14)
2476.6	(12)	195.1	2281.6		3788.2		157.4	3630.9	
		280.0	2196.9	(11^+)			200.1	3587.9	
2869.7		393.2	2476.6	(12)	3865.5		846.8	3018.7	(14)
2877.9	(13)	401.5	2476.6	(12)	3912.2		177.8	3734.4	
3018.7	(14)	140.8	2877.9	(13)	4030.8		242.5	3788.2	
		149.1	2869.7				296.5	3734.4	
		542.0	2476.6	(12)	4035.0		917.1	3117.9	(15)
3117.9	(15)	99.5	3018.7	(14)	4078.6	(17)	960.7	3117.9	(15)
		240.1	2877.9	(13)	4396.7		365.9	4030.8	
3246.8		1049.8	2196.9	(11^+)	4549.7		471.1	4078.6	(17)
3587.9		341.0	3246.8		4718.0		321.3	4396.7	
		1111.4	2476.6	(12)					

† γ's with uncertainties ($\Delta E\gamma$) from ^{140}Ce(p,nγ), except for 98.5γ and 635.9γ from ^{140}Pr IT; γ's with no uncertainties from ^{130}Te(^{14}N,4nγ).

‡ From $\gamma(\theta)$ in (p,nγ), except where noted.

γ below detection limit deduced from level scheme in ^{130}Te(^{14}N,4nγ) (2005Yu05).

@ $\Delta J=0$ ((p,nγ), 1974Hu03).

& Additional information 1.

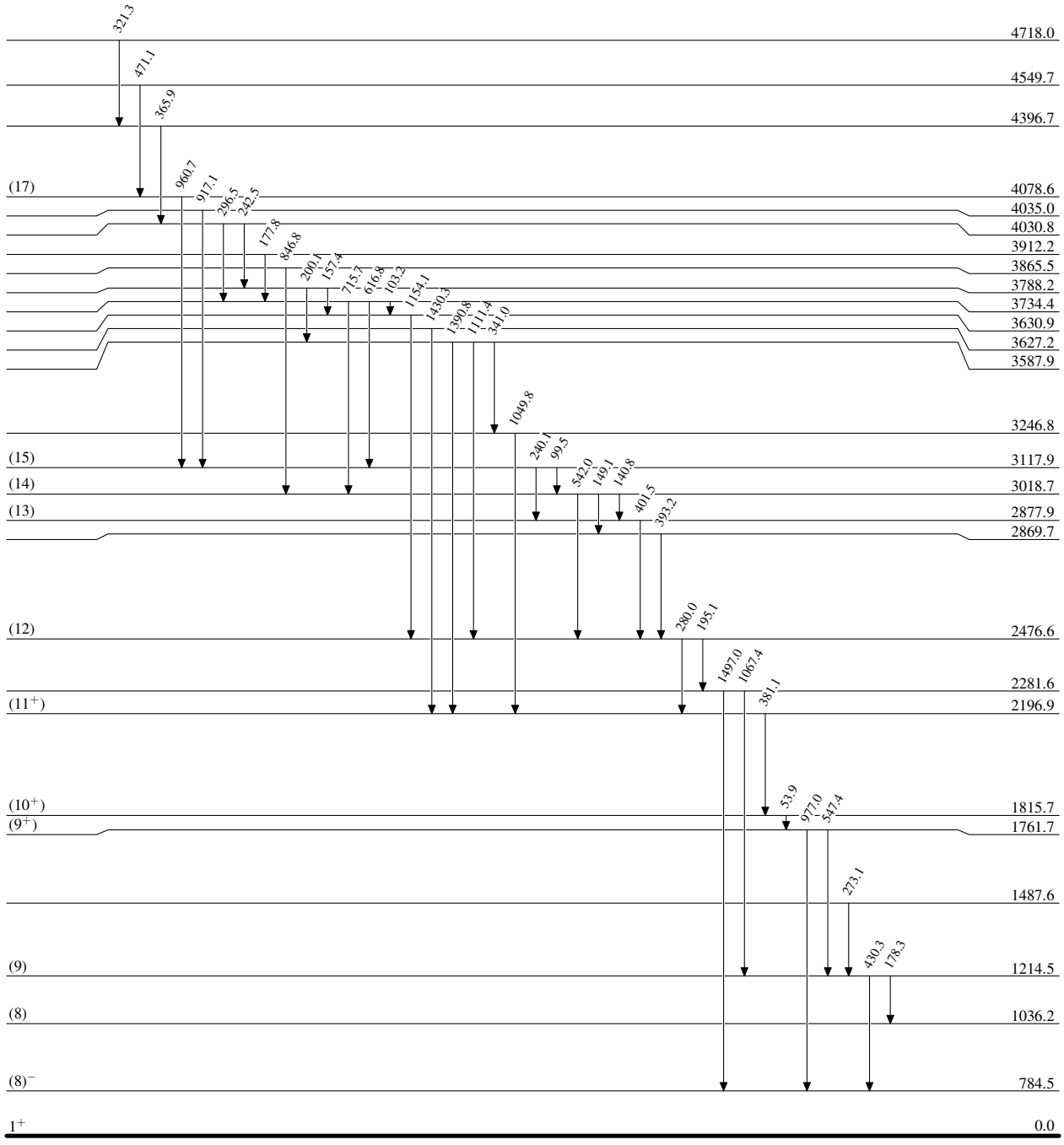
Adopted Levels, Gammas

Legend

Level Scheme

Intensities: Relative photon branching from each level

- - - - - - ► γ Decay (Uncertain)



$^{140}_{59}Pr_{81}$

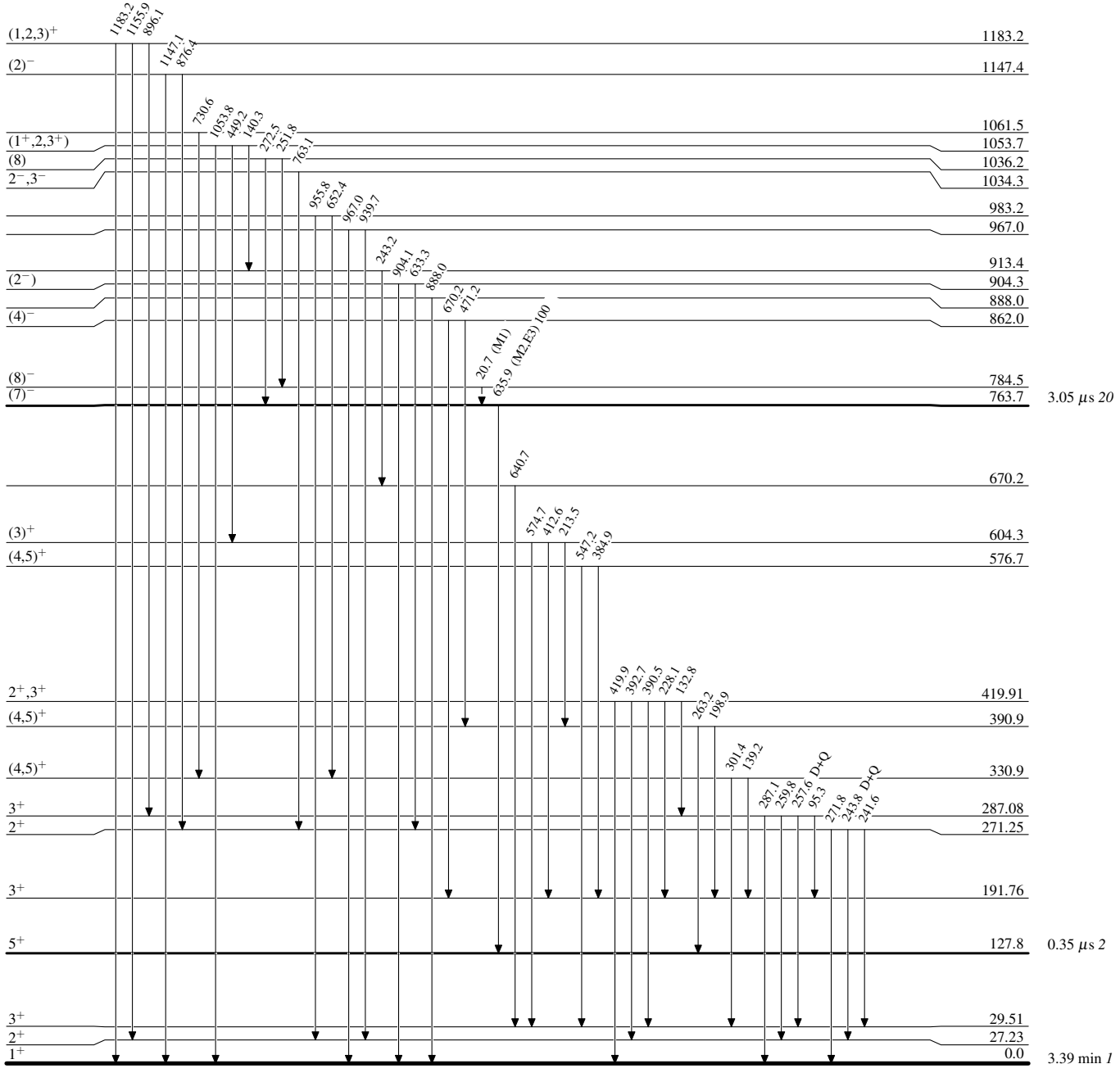
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)

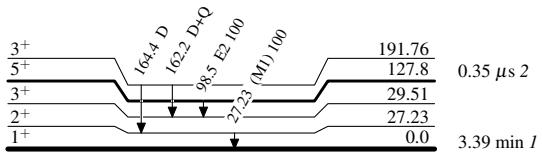


$^{140}_{59}Pr_{81}$

Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level



$^{140}_{59}Pr_{81}$