

Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	M. J. Martin	NDS 108,1583 (2007)	1-Jun-2007

$Q(\beta^-) = -2814$ 15; $S(n) = 7314$ 16; $S(p) = 2613$ 12; $Q(\alpha) = 5751.0$ 22 [2012Wa38](#)

Note: Current evaluation has used the following Q record -2843 28 7320 34 2634 27 5751.0 22 [2003Au03](#).

 ^{208}At LevelsCross Reference (XREF) Flags

- A ^{212}Fr α decay
 B ^{208}Rn ε decay
 C $^{209}\text{Bi}(\alpha, 5n\gamma)$

E(level) [†]	J ^π	T _{1/2}	XREF	Comments
0.0	6 ⁺	1.63 h 3	ABC	$\% \alpha = 0.55$ 6; $\% \varepsilon + \% \beta^+ = 99.45$ 6 $\% \alpha$: from $I(^{208}\text{At a})/I(^{208}\text{Po a})$ (1950Hy27). J^π : HF=2.5 for α decay to the 6 ⁺ ^{204}Bi ground state. $T_{1/2}$: from 1964Th07 . Others: 1950Hy27 (1.7 h), 1963Uh01 (1.6 h), 1969BaZM (1.58 h 9, preliminary value). configuration= $\pi 1h_{9/2} \nu 2f_{5/2}^{-1}$ is suggested by 1981Va29 .
23.527 20	(5) ⁺ $\ddagger$		AB	configuration= $\pi 1h_{9/2} \nu 2f_{5/2}^{-1}$ is suggested by 1981Va29 .
63.695 22	(4) ⁺ $\ddagger$		AB	configuration= $\pi 1h_{9/2} \nu 2f_{5/2}^{-1}$ is suggested by 1981Va29 .
71.83 16	7 ⁺		A C	J^π : M1 γ to 6 ⁺ , M1 γ from 8 ⁺ . configuration= $\pi 1h_{9/2} \nu 2f_{5/2}^{-1}$ is suggested by 1981Va29 .
113.784 24	(3) ⁺ $\ddagger$		AB	J^π : M1(+E2) γ to (4) ⁺ . Analogy with ^{210}At α decay where the α branch to the 3 ⁺ member of the multiplet with probable configuration= $\pi 1h_{9/2} \nu 2f_{5/2}^{-1}$ has a large hindrance factor. HF/HF(branch to 5 ⁺ member)=204. Here, the ratio is ≥ 9 .
147.95 7	5 ⁺		A	J^π : HF=2.6 for α branch from $J=5^+$ ^{212}Fr . Probable configuration= $\pi 1h_{9/2} \nu 3p_{1/2}^{-1}$.
173.75 3	(2) ⁺ $\ddagger$		B	J^π : not seen in ^{212}Fr α decay. Analogy with $^{210}\text{At}(\alpha$ decay) where the possible 2 ⁺ member of the $\pi 1h_{9/2} \nu 2f_{5/2}^{-1}$ multiplet is apparently not fed.
208.12 4	(4,5) ⁺		AB	J^π : M1(+E2) γ 's to (4) ⁺ and (5) ⁺ .
227.16 7	(4 ⁺ , 5, 6 ⁺)		A	J^π : γ 's to (4) ⁺ and 6 ⁺ .
237.22 4	(4) ⁺		AB	J^π : M1+E2 γ 's to (3) ⁺ and (5) ⁺ .
283.62 7	(4 ⁺ , 5 ⁺)		A	J^π : γ 's to (3) ⁺ and 6 ⁺ .
334.71 7	(4 ⁺ , 5, 6 ⁺)		A	J^π : γ 's to (4) ⁺ and 6 ⁺ .
424.83 4	(3) ⁺		B	J^π : M1(+E2) γ 's to (4) ⁺ and (2) ⁺ .
429.47 13			A	
588.36 10	(4 ⁺ , 5, 6 ⁺)		A	J^π : γ 's to (4) ⁺ and 6 ⁺ .
600.53 3	(2, 3) ⁺		B	J^π : M1(+E2) γ 's to (2) ⁺ , (3) ⁺ .
681.7 5			A	
734.20 3	(2, 3) ⁺		B	J^π : M1(+E2) γ 's to (2) ⁺ , (3) ⁺ .
788.4	8 ⁺		C	J^π : stretched E2 γ to 6 ⁺ . No γ 's to levels with $J < 6$.
853.41? 5	(2, 3, 4) ⁺		B	J^π : M1(+E2) γ to (3) ⁺ .
904.0	9 ⁺		C	J^π : stretched E2 γ to 7 ⁺ . No γ 's to levels with $J < 7$.
904.47 5			B	
1090.5	10 ⁻	47.8 ns 10	C	$\mu = +2.69$ 3 (1985No09 , 2005St24) J^π : μ . Analogy with 10 ⁻ levels in ^{204}Bi and ^{208}Bi . $T_{1/2}$: from 1985No09 in ($\alpha, 5n\gamma$). Other: 45 ns 2 (1984Fa10). μ : from g-factor in ($\alpha, 5n\gamma$) using the time-dependent perturbed angular correlation method. configuration= $\pi 1h_{9/2} \nu 1i_{13/2}^{-1}$ (1985No09 , 1984Fa10).

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{208}At Levels (continued)

E(level) [†]	J ^π	T _{1/2}	XREF	Comments
1255.7	10 ⁺		C	J ^π : stretched E2 to 8 ⁺ . No γ's to levels with J<8.
1299.9	11 ⁺		C	J ^π : stretched E2 γ to 9 ⁺ . No γ's to levels with J<9.
1376.1	12 ⁺ #		C	
1525.5	(13) ⁺ #		C	
1539.83 5			B	
1544.7	11 ⁻		C	J ^π : stretched M1 γ to the 1090, 10 ⁻ level.
1648.7	12 ⁻		C	J ^π : stretched E2 to 10 ⁻ . No γ's to levels with J<10.
1804.2	13 ⁺		C	J ^π : E3 γ from 16 ⁻ . M1 γ to 13 ⁺ .
1826.61 5			B	
1979.48? 6			B	
2194.2	@		C	
2226.7	@		C	
2268.8	13 ⁻		C	J ^π : stretched M1 γ to 12 ⁻ 1649 level.
2270.15 5			B	
2276.4	16 ⁻ #	1.5 μs 2	C	Q=1.7 3 (1991Sc15,2005St24) Q,T _{1/2} : from (α,5nγ). configuration=π1h9/2 ⁺ 2π1i13/2ν3p _{1/2} ⁻² ν2f _{5/2} ⁻¹ is suggested by 1991Sc15 based on a comparison of a calculated Q with the measured value.
2371.8	@		C	
2480.4	@		C	
2576.7? 2			B	E(level): the two deexciting transitions do not give consistent E(level) values. The 306γ gives E(level)=2576.92 4 and the 2152 level gives E(level)=2576.48 9. The evaluator adopts 2576.7 2.
2717.1	@		C	
2745.4	17 ⁻		C	J ^π : stretched M1 γ to 16 ⁻ .
2768.7	@		C	
2771.4	14 ⁻		C	J ^π : stretched M1 γ to 13 ⁻ 2269 level.
2801.7	(15,16)		C	
2829.6?	17 ⁻		C	J ^π : stretched M1 γ to 16 ⁻ .
2935.9			C	
3123.1	@		C	
3269.0	@		C	
3283.6	@		C	
3307.7			C	
3315.9	@		C	
3333.2	@		C	
3460.3			C	
3479.3			C	
3547.0?			C	
3867.0	@		C	
4366.9			C	

[†] E(level) data with ΔE<0.5 keV are from ^{208}Rn ε decay. Others are from ^{212}Fr α decay. Values without uncertainties are from $^{209}\text{Bi}(\alpha,5n\gamma)$.

[‡] The M1 character of the 23.5, 40.2, 50.1 and 60.0 γ's, the strong feeding of this cascade of transitions in ^{208}Rn ε decay (J=0⁺), and the absence of crossover transitions from the 63.7, 113.8 and 173.8 levels suggest that these levels form a monotonically decreasing ΔJ=1, π=+ spin sequence built on the J=6⁺ ground state.

The cascade from the 2276 level to the 1300 level via the 750.9 E3 γ, 149.4 M1, ΔJ=1 γ, and the 76.2 M1 γ, given J^π=11⁺ for the 1300 level, and the absence of any crossover transitions from these levels to levels with J<11, establishes J^π=16⁻, 13⁺,

Adopted Levels, Gammas (continued)

 ^{208}At Levels (continued)

and 12^+ for the 2276, 1526, and 1376 levels, respectively.

@ [1984Fa10](#), in $^{209}\text{Bi}(\alpha, 5n\gamma)$, have proposed J^π assignments for several cascades feeding into the 2226 level. The arguments are complex and two of the arguments, in particular, do not seem to be justified by the data. The authors assign mult=M1 for the 42γ from the 2269 level, based on the non-measurable half-life (<1 ns). $B(E2)(W.u.) > 120$ rules out mult=E2; however, while $B(M1)(W.u.) > 0.01$ is consistent with mult=M1, $B(E1)(W.u.) > 0.001$ does not rule out mult=E1. Second, the authors assign the 545.6γ feeding the 12^- 1649 level as being a stretched dipole; however, in their table 1, the 545.6γ is not resolved from the 544.5γ , and no angular distribution or conversion data are given. The authors may have additional data not mentioned in the paper. Please see the authors' paper for detailed J^π arguments for the indicated levels. The authors give a thorough discussion on the probable configurations of many of the ^{208}At levels.

Adopted Levels, Gammas (continued)

$\gamma(^{208}\text{At})$

γ data with uncertainties are from ²⁰⁸Rn ε decay, except where from ²¹²Fr α decay as noted. E γ and I γ data without uncertainties are from ²⁰⁹Bi(α ,5n γ) as are the multipolarity data for these transitions.

E _i (level)	J ^{π} _i	E γ	I γ	E _f	J ^{π} _f	Mult.	δ	$\alpha^{\ddagger}$	Comments
23.527	(5) ⁺	23.53 2		0.0	6 ⁺	M1(+E2)	≤0.028	166 3	
63.695	(4) ⁺	40.17 1		23.527	(5) ⁺	M1(+E2)	≤0.026	33.8 2	
71.83	7 ⁺	71.9 [†] 2	[†]	0.0	6 ⁺	M1		6.065	
113.784	(3) ⁺	50.09 1		63.695	(4) ⁺	M1(+E2)	≤0.046	18.6 2	
147.95	5 ⁺	84.1 [†] 5	76 [†] 24	63.695	(4) ⁺	[M1]		3.84	
		124.5 [†] 1	100 [†] 10	23.527	(5) ⁺	M1		6.48	
		147.9 [†] 1	5 [†] 1	0.0	6 ⁺	(M1+E2)	≈2.3	≈2.0	
173.75	(2) ⁺	59.96 1		113.784	(3) ⁺	M1(+E2)	≤0.070	11.0 2	
208.12	(4,5) ⁺	144.44 [†] 3	100 [†]	63.695	(4) ⁺	M1(+E2)	≤0.92	3.7 6	
		184.56 [†] 5	75 [†] 11	23.527	(5) ⁺	M1(+E2)	≤0.89	1.8 4	
227.16	(4 ⁺ ,5,6 ⁺)	163.5 [†] 2	6 [†] 2	63.695	(4) ⁺				
		203.7 [†] 1	51 [†] 4	23.527	(5) ⁺				
		227.2 [†] 1	100 [†] 3	0.0	6 ⁺				
237.22	(4) ⁺	123.42 3	49 7	113.784	(3) ⁺	M1+E2	0.7 3	5.7 8	
		173.50 6	100 10	63.695	(4) ⁺	M1(+E2)	≤0.6	2.5 4	
		213.61 10	53 6	23.527	(5) ⁺	M1+E2	3.3 +17-8	0.49 6	I γ : I γ :I γ (173 γ)=84 10:100 9 in ²¹² Fr α decay.
283.62	(4 ⁺ ,5 ⁺)	169.9 [†] 2	99 [†] 9	113.784	(3) ⁺				
		219.9 [†] 1	53 [†] 6	63.695	(4) ⁺				
		260.1 [†] 1	100 [†] 5	23.527	(5) ⁺				
		283.2 5	2 1	0.0	6 ⁺				
334.71	(4 ⁺ ,5,6 ⁺)	271.0 [†] 2	35 [†] 4	63.695	(4) ⁺				
		311.2 [†] 1	31 [†] 3	23.527	(5) ⁺				
		334.7 [†] 1	100 [†] 6	0.0	6 ⁺				
424.83	(3) ⁺	187.52 5	5.1 8	237.22	(4) ⁺	M1(+E2)	≤0.54	2.03 24	
		251.05 4	100.0 24	173.75	(2) ⁺	M1(+E2)	≤0.44	0.91 9	
429.47		202.3 [†] 8	28 [†] 20	227.16	(4 ⁺ ,5,6 ⁺)				
		281.6 [†] 2	100 [†] 13	147.95	5 ⁺				
		357.7 [†] 2	65 [†] 14	71.83	7 ⁺				
		405.8 [†] 2	77 [†] 14	23.527	(5) ⁺				
588.36	(4 ⁺ ,5,6 ⁺)	304.7 [†] 2	40 [†] 18	283.62	(4 ⁺ ,5 ⁺)				
		361.30 10	100 14	227.16	(4 ⁺ ,5,6 ⁺)	M1(+E2)	≤0.46	0.309 23	E γ ,Mult.: from ε decay.

Adopted Levels, Gammas (continued)									
$\gamma(^{208}\text{At})$ (continued)									
$E_i(\text{level})$	J_i^π	E_γ	I_γ	E_f	J_f^π	Mult.	δ	$\alpha^\ddagger$	Comments
588.36	(4 ⁺ ,5,6 ⁺)	440.6 [†] 7	24 [†] 8	147.95	5 ⁺				
		524.2 [†] 3	75 [†] 17	63.695	(4) ⁺				
		587.9 [†] 3	53 [†] 13	0.0	6 ⁺				
600.53	(2,3) ⁺	426.78 2	100 3	173.75	(2) ⁺	M1(+E2)	≤0.28	0.22 1	
		486.79 3	22.1 10	113.784	(3) ⁺	M1+E2	1.0 5	0.10 3	
681.7		681.7 [†] 5	[†]	0.0	6 ⁺				
734.20	(2,3) ⁺	560.42 2	100 4	173.75	(2) ⁺	(M1+E2)		0.07 4	
		620.47 3	99 6	113.784	(3) ⁺	M1+E2	1.1 5	0.05 2	
788.4	8 ⁺	716.7	19	71.83	7 ⁺	M1		0.057	
		788.2	100	0.0	6 ⁺	E2		0.013	
853.41?	(2,3,4) ⁺	739.62 4	100	113.784	(3) ⁺	M1(+E2)	≤1.3	0.040 12	
904.0	9 ⁺	115.7	0.9	788.4	8 ⁺	[M1]		8.4	
		832.2	100	71.83	7 ⁺	E2		0.011	
904.47		169.7 5	5.8 15	734.20	(2,3) ⁺	[M1]		2.81	
		479.65 2	100 3	424.83	(3) ⁺	M1+E2	0.66 24	0.125 20	
		731.7 10	7.1 13	173.75	(2) ⁺				
1090.5	10 ⁻	186.5	100	904.0	9 ⁺	E1		0.100	B(E1)(W.u.)=5.9×10 ⁻⁷
		1018.5	≈0.7	71.83	7 ⁺				
1255.7	10 ⁺	351.9	9.9	904.0	9 ⁺	(M1)			
		467.1	100	788.4	8 ⁺	E2		0.040	
1299.9	11 ⁺	44.5	3.6	1255.7	10 ⁺	M1(+E2)		26.0	
		396.0	100	904.0	9 ⁺	E2		0.061	
1376.1	12 ⁺	76.2		1299.9	11 ⁺	M1		5.39	
1525.5	(13) ⁺	149.4	100	1376.1	12 ⁺	M1		4.05	
		226.0	≤28	1299.9	11 ⁺	(E2)			
1539.83		805.24 [#] 3	94 4	734.20	(2,3) ⁺	(E2)		0.012	
		939.30 3	100 3	600.53	(2,3) ⁺	M1+E2	1.7 5	0.014 3	
1544.7	11 ⁻	454.2		1090.5	10 ⁻	M1			
1648.7	12 ⁻	104.2	≤1.4	1544.7	11 ⁻	(M1)			
		558.2	≈100	1090.5	10 ⁻	E2		0.026	
1804.2	13 ⁺	278.7		1525.5	(13) ⁺	M1		0.708	
1826.61		1226.08 4	100	600.53	(2,3) ⁺	E1(+M2)	≤0.22		
1979.48?		1125.1 20	7.5 14	853.41?	(2,3,4) ⁺				
		1378.95 5	100 5	600.53	(2,3) ⁺	E1(+M2)	≤0.28		
2194.2		545.6		1648.7	12 ⁻				
2226.7		577.8	≤100	1648.7	12 ⁻				
		701.3	20	1525.5	(13) ⁺				
2268.8	13 ⁻	42.1		2226.7		D			
		620.1		1648.7	12 ⁻	M1+E2			
2270.15		1365.69 7	79 3	904.47		E2(+M1)	≥2.2		

Adopted Levels, Gammas (continued)

$\gamma(^{208}\text{At})$ (continued)

$E_i(\text{level})$	J_i^π	E_γ	I_γ	E_f	J_f^π	Mult.	δ	$\alpha^\ddagger$	Comments
2270.15		1669.86 7	21 3	600.53	(2,3) ⁺				
		1845.30 6	100 4	424.83	(3) ⁺				
2276.4	16 ⁻	472.2	81	1804.2	13 ⁺	E3		0.143	B(E3)(W.u.)=25
		750.9	100	1525.5	(13) ⁺	E3		0.037	B(E3)(W.u.)=1.2
2371.8		567.5		1804.2	13 ⁺				
2480.4		253.6	43	2226.7		(M1)			
		286.3	100	2194.2		(M1)			
2576.7?		306.77 [#] 4	100 10	2270.15		M1(+E2)	≤0.8	0.49 11	
		2151.65 [#] 8	22 3	424.83	(3) ⁺				
2717.1		345.2	87	2371.8		M1			
		490.5	100	2226.7		M1			
2745.4	17 ⁻	469.1		2276.4	16 ⁻	M1			
2768.7		288.2	64	2480.4		(M1)			
		542.1	≤100	2226.7		M1			
2771.4	14 ⁻	54.3		2717.1		D			
		502.6		2268.8	13 ⁻	M1			
2801.7	(15,16)	575.0		2226.7					
2829.6?	17 ⁻	553.1 [#]		2276.4	16 ⁻	M1		0.112	
2935.9		106.1		2829.6?	17 ⁻				
		190.6		2745.4	17 ⁻				
3123.1		354.4		2768.7					
3269.0		145.9		3123.1					
3283.6		481.9		2801.7	(15,16)				
3307.7		184.1		3123.1					
3315.9		544.5		2771.4	14 ⁻				
3333.2		64.2		3269.0		D			
3460.3		630.7		2829.6?	17 ⁻				
3479.3		733.9		2745.4	17 ⁻				
3547.0?		611.1 [#]		2935.9					
3867.0		533.8		3333.2		(M1)			
4366.9		499.9		3867.0					

[†] From ²¹²Fr α decay.

[‡] 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.

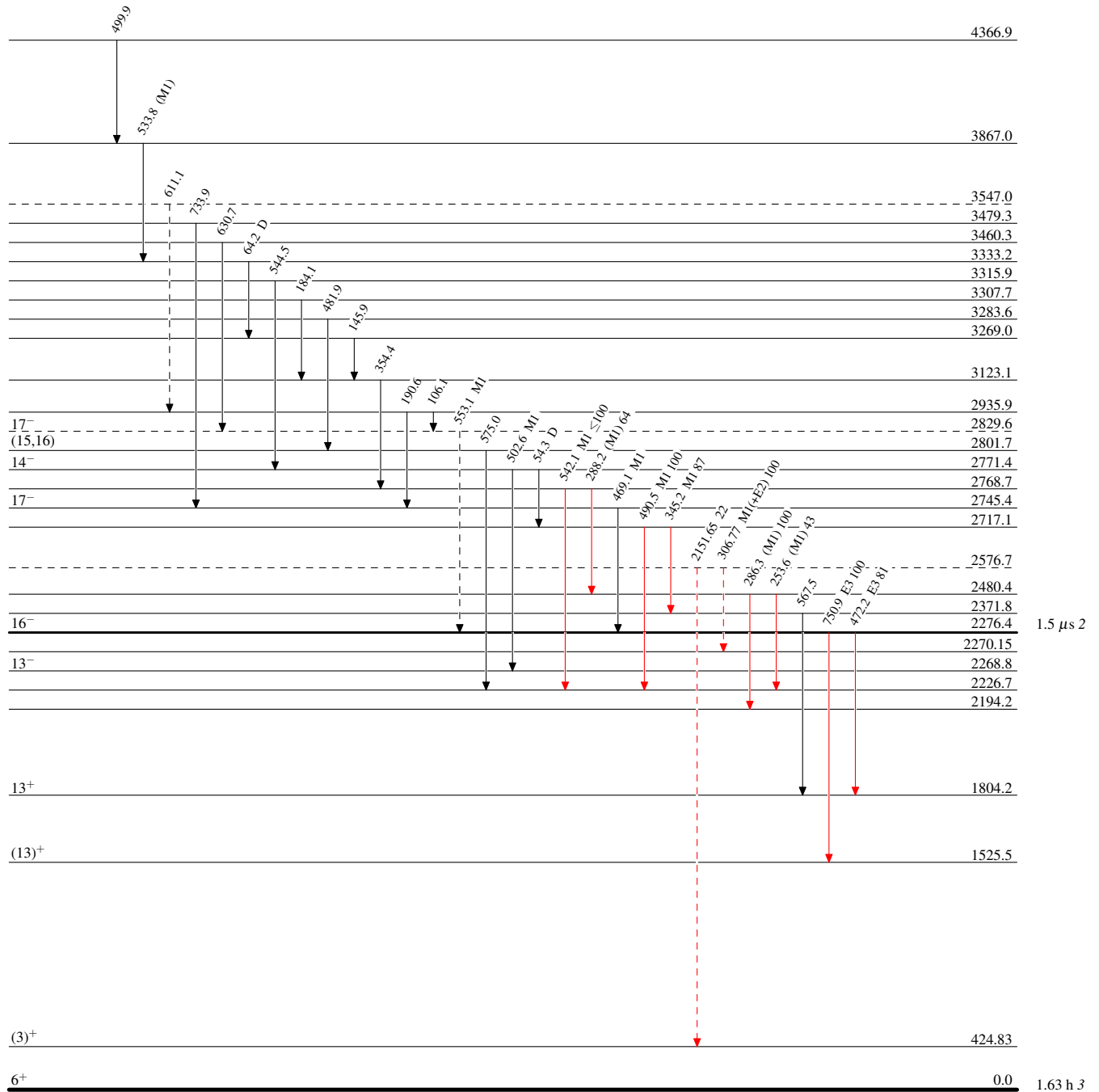
[#] Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas

Legend

Level Scheme
Intensities: Type not specified

- $I_\gamma < 2\% \times I_\gamma^{\max}$
- $I_\gamma < 10\% \times I_\gamma^{\max}$
- $I_\gamma > 10\% \times I_\gamma^{\max}$
- γ Decay (Uncertain)

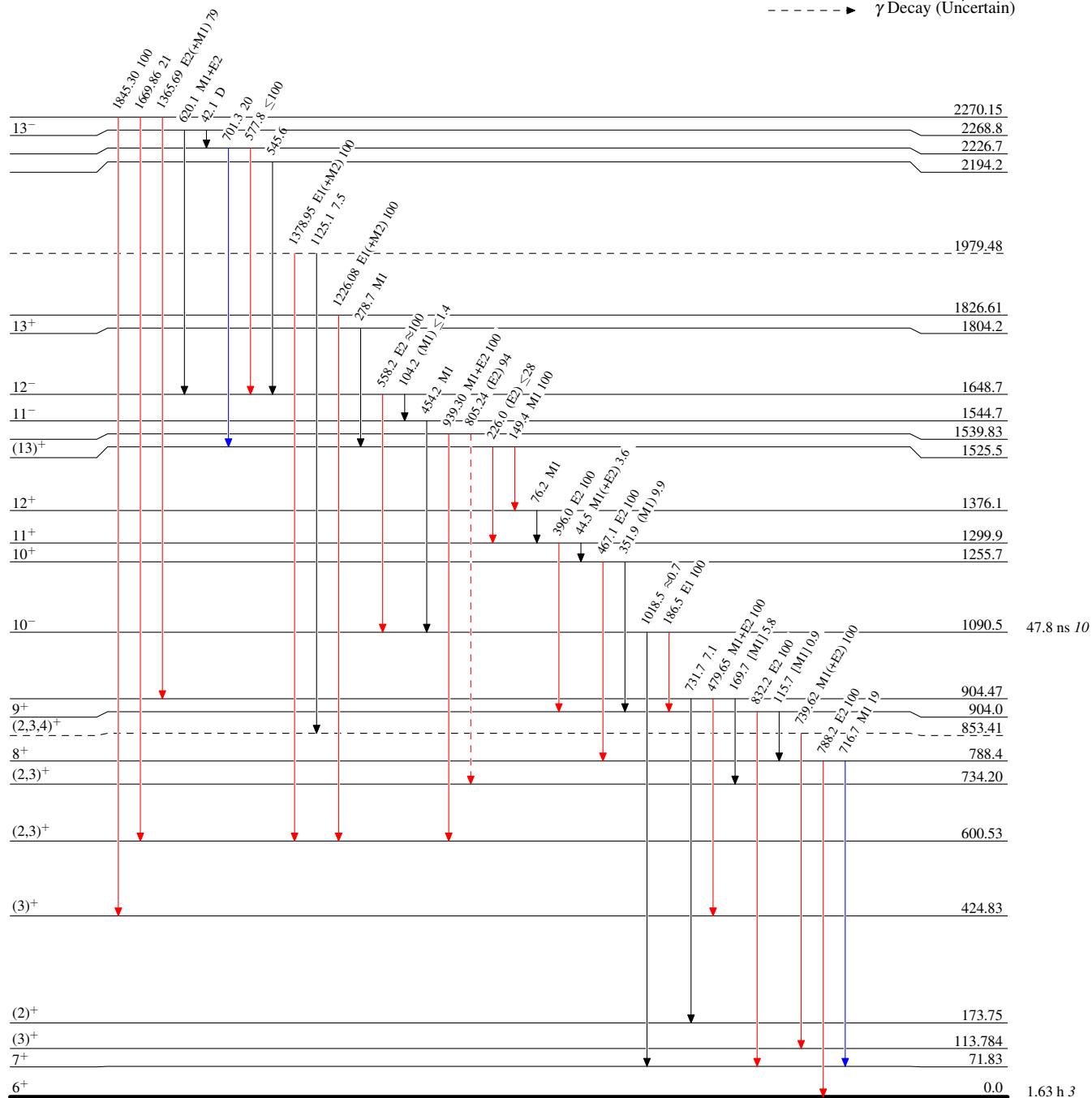


Adopted Levels, Gammas**Level Scheme (continued)**

Intensities: Type not specified

Legend

- $\longrightarrow$ $I_\gamma < 2\% \times I_\gamma^{\max}$
 $\longrightarrow$ $I_\gamma < 10\% \times I_\gamma^{\max}$
 $\longrightarrow$ $I_\gamma > 10\% \times I_\gamma^{\max}$
 $\longrightarrow$ γ Decay (Uncertain)

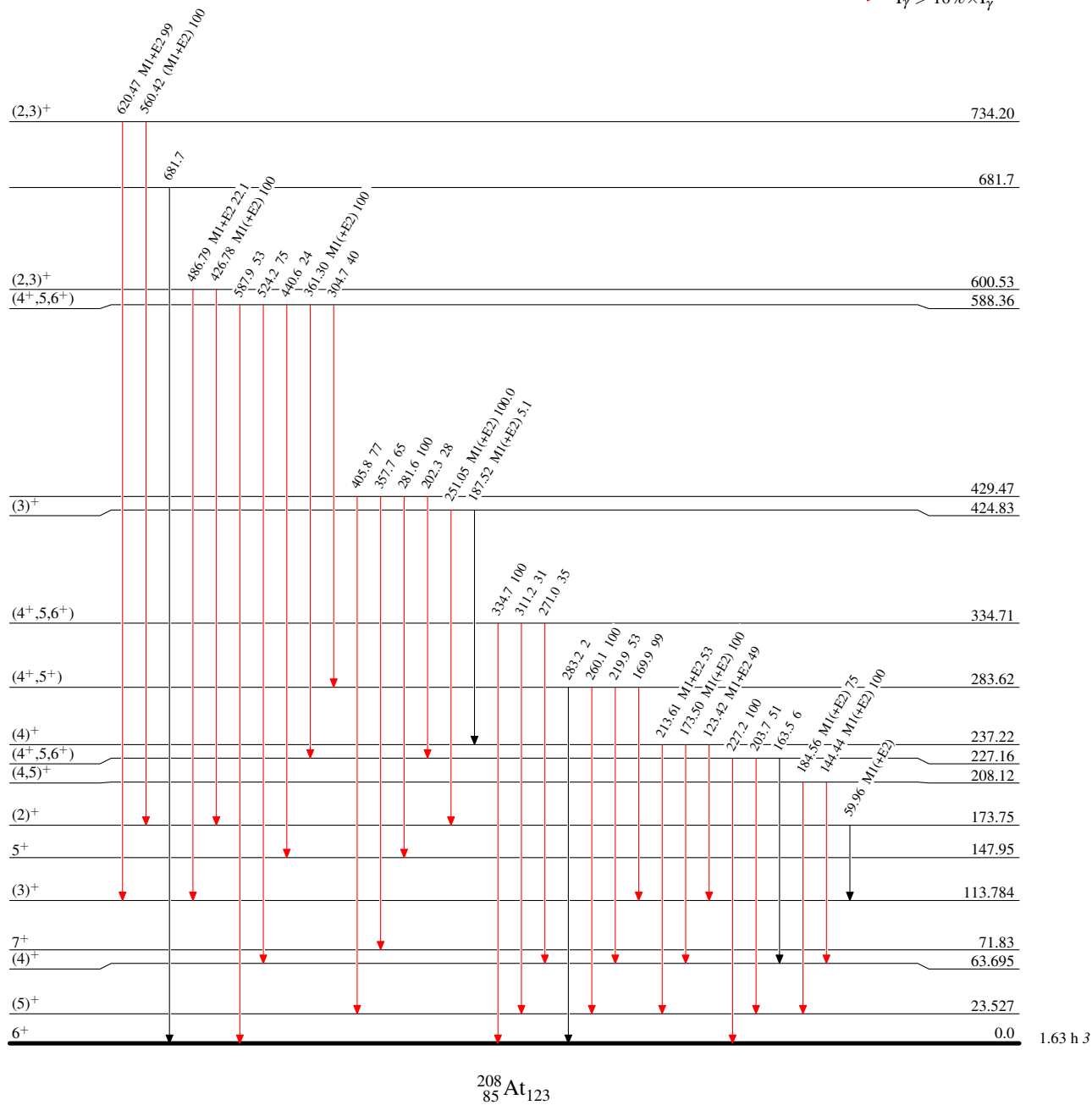


Adopted Levels, Gammas**Level Scheme (continued)**

Intensities: Type not specified

Legend

-  $I_\gamma < 2\% \times I_\gamma^{\max}$
 $I_\gamma < 10\% \times I_\gamma^{\max}$
 $I_\gamma > 10\% \times I_\gamma^{\max}$

 $^{208}_{85}\text{At}_{123}$

1.63 h 3

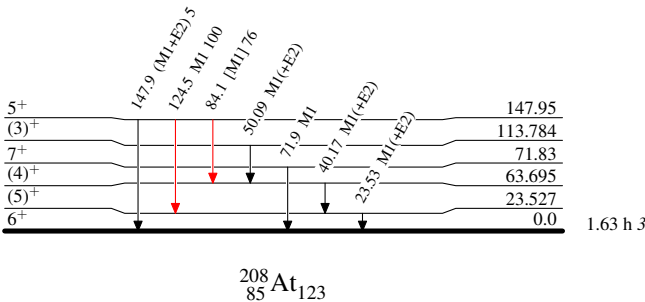
Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Type not specified

Legend

- $\longrightarrow$ $I_\gamma < 2\% \times I_\gamma^{max}$
- $\longrightarrow$ $I_\gamma < 10\% \times I_\gamma^{max}$
- $\longrightarrow$ $I_\gamma > 10\% \times I_\gamma^{max}$



$^{208}_{85}\text{At}_{123}$