

¹⁹⁸Pt(¹⁹F,5n γ), ²⁰⁵Tl(¹²C,5n γ) 1986By01,1990By02

Type	Author	History	Citation	Literature Cutoff Date
Full Evaluation	K. Auranen and E. A. McCutchan		NDS 168, 117 (2020)	1-Aug-2020

1986By01: E(¹⁹F)=95-110 MeV, E(¹²C)=77-96 MeV. Measured E γ , I γ , excitation function, $\gamma\gamma$, n- γ , $\gamma(\theta)$, $\gamma(t)$ using two Compton-suppressed spectrometers, a Ge detector, LEPS detector, and Ge(Li) detector. Measured E_{ce}, I_{ce} using cooled Si(Li) detector with “mini-orange filter”. Measured g-factor using TDPAD technique.

1990By02: E(¹²C)=90 MeV. Measured E γ , I γ , $\gamma\gamma$, $\gamma(t)$ using CAESAR array consisting of 6 Compton-suppressed HPGe detectors and one LEPS. Observed decay of isomeric 8.53 MeV state.

Other: **1977Be56:** ²⁰⁶Pb(¹²C,4n γ) E=87 MeV; measured: $\gamma\gamma$, $\gamma(\theta, H, t)$.

For additional configuration assignments and discussions, see **1990By02**.

All data are from **1986By01**, unless otherwise indicated.

²¹²Fr Levels

E(level) [†]	J π [‡]	T _{1/2} [@]	Comments
0.0	5 ⁺		Configuration=($\pi h_{9/2}^{+5}(\nu p_{1/2}^{-1})$)
542.20 10	7 ⁺	<0.4 ns	Configuration=($\pi h_{9/2}^{+5}(\nu f_{5/2}^{-1})$)
1389.40 22	9 ⁺	<2 ns	Configuration=($\pi h_{9/2}^{+5}(\nu p_{1/2}^{-1})$)
1551.40 24	11 ⁺	31.9 μ s 7	Configuration=($\pi h_{9/2}^{+5}(\nu p_{1/2}^{-1})$); g=0.899 4 (1977Be56) T _{1/2} : from 1990By02 ; other: 27 μ s (1977Be56).
1879.8 3	12 ⁺	<2 ns	Configuration=($\pi(h_{9/2}^{+4}(\pi f_{7/2}^1)(\nu p_{1/2}^{-1})$)
2337.7 4	(13 ⁺)	<2 ns	
2492.2 3	15 ⁻	603 ns 28	Configuration=($\pi h_{9/2}^{+4}(\pi i_{13/2}^1)(\nu p_{1/2}^{-1})$) T _{1/2} : other: 560 ns (1977Be56). Knight shift measured: Fr in Cs (1987Ha27), Fr in Tl (1977Be56).
2495.8 4	(14 ⁻)	<2 ns	
2612.5 4	(14 ⁺)	<1.4 ns	Configuration=($\pi h_{9/2}^{+4}(\pi f_{7/2}^1)(\nu f_{5/2}^{-1})$)
2951.7 4	(16 ⁺)	<2 ns	Configuration=($\pi h_{9/2}^{+4}(\pi f_{7/2}^1)(\nu p_{1/2}^{-1})$)
2964.1 3	16 ⁻	<1.4 ns	Configuration=($\pi h_{9/2}^{+4}(\pi i_{13/2}^1)(\nu f_{5/2}^{-1})$)
3241.0 3	17 ⁻	<1.4 ns	Configuration=($\pi(h_{9/2}^{+4})(\pi i_{13/2}^1)(\nu f_{5/2}^{-1}) + (\pi(h_{9/2}^{+4})(\pi i_{13/2}^1)(\nu p_{1/2}^{-1})$).
3256.3? 5		<1.4 ns	E(level): ordering of the 495 γ -304 γ cascade is not certain.
3583.6 4	19 ⁻	<1.4 ns	Configuration=($\pi h_{9/2}^{+4}(\pi i_{13/2}^1)(\nu p_{1/2}^{-1})$)
3750.9 5		<1.4 ns	
4025.6 4	20 ⁻	<2 ns	Configuration=($\pi h_{9/2}^{+4}(\pi i_{13/2}^1)(\nu f_{5/2}^{-1})$)
4081.9? 6		<1.4 ns	E(level): ordering of the 331 γ -365 γ cascade is not certain.
4137.3 4	20 ⁻	<2 ns	Configuration=($\pi h_{9/2}^{+3}(\pi i_{13/2}^1)(\pi f_{7/2}^1)(\nu p_{1/2}^{-1})$)
4447.2 6		<1.4 ns	
4499.2 5		<2 ns	
4547.0 4	21 ⁻	<2 ns	configuration=($\pi h_{9/2}^{+4}(\pi i_{13/2}^1)(\nu f_{5/2}^{-1}) + (\pi h_{9/2}^{+3})(\pi i_{13/2}^1)(\pi f_{7/2}^1)(\nu p_{1/2}^{-1})$).
4632.2 6			
4634.2 6			
4765.1? 5			
4834.3 4	22 ⁺	4.23 ns 35	Configuration=($\pi h_{9/2}^{+3}(\pi i_{13/2}^2)(\nu p_{1/2}^{-1})$) g=1.0 2 (1986By01) g: from TDPAD technique (1986By01).
4907.8 6			
5056.1 5	(23 ⁺)	<2.4 ns	
5161.2? 6			
5266.3 5	(24 ⁺)	<2 ns	
5803.2 6	(25 ⁺)	<2 ns	
5854.6 6	(27 ⁻)	312 ns 21	Configuration=($\pi h_{9/2}^{+3}(\pi i_{13/2}^2)(\nu p_{1/2}^{-1})(\nu g_{9/2}^1)$) g=0.81 1 (1986By01) g: from TDPAD technique (1986By01).
6055.6 [#] 6	(28 ⁺)		
6344.8 6	(28 ⁻)	<1.4 ns	

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$^{198}\text{Pt}(^{19}\text{F},5\text{n}\gamma), ^{205}\text{Tl}(^{12}\text{C},5\text{n}\gamma)$ **1986By01,1990By02 (continued)**
 ^{212}Fr Levels (continued)

E(level) [†]	J ^π [‡]	T _{1/2} [@]	Comments
6671.1 [#] 8			
6976.9 6	(29 ⁺)	<1.4 ns	
7054.0 [#] 8			
7253.8 [#] 9			
7660.7 7	(29 ⁺)	<2 ns	
8255.7 [#] 7			
8407.0 [#] 11			
8533.3 [#] 11		23.6 μs 21	T _{1/2} : from 1990By02.

- [†] From a least-squares fit to E_γ data. For γ rays given without uncertainty, 1 keV uncertainty has been assumed for the calculation.
[‡] Spin and parity assignments are based on multipolarities determined by angular distribution, conversion coefficient, transition strength and excitation function measurements in 1986By01.
[#] Reported only in 1990By02.
[@] From 1986By01, except where noted.

 $\gamma(^{212}\text{Fr})$

γ(θ) and ce measurements given in comments are from 1986By01, except where noted.

E _γ [†]	I _γ [‡]	E _i (level)	J _i ^π	E _f	J _f ^π	Mult.	δ ^d	Comments
77 [#]		7054.0		6976.9	(29 ⁺)			
111 ^e		4137.3	20 ⁻	4025.6	20 ⁻			
126 [#]		8533.3		8407.0				
^x 129 1								
^x 130.0 3	8 1							
(148 [@])		5056.1	(23 ⁺)	4907.8				
151 [#]		8407.0		8255.7				
158.0 3	39 ^c 2	2495.8	(14 ⁻)	2337.7	(13 ⁺)	D		A ₂ =-0.13 11.
162.0 1	440 2	1551.40	11 ⁺	1389.40	9 ⁺	E2		A ₂ =0.02 1, A ₄ =0.019 15. α(exp)=1.23 13 (determined from delayed intensities). Mult.: from α(exp) and γ(θ).
^x 178								
201.2 ^a 3	31 ^c 1	6055.6	(28 ⁺)	5854.6	(27 ⁻)	D		A ₂ =-0.77 6, A ₄ =0.22 10. Mult.: from γ(θ).
210.2 1	106 4	5266.3	(24 ⁺)	5056.1	(23 ⁺)	M1+E2	1.3 +6-4	A ₂ =-0.22 6, A ₄ =-0.02 6. α(exp)=0.92 20 (determined from delayed intensities), α(L)exp=0.30 5. Mult.: from α(exp) and α(L)exp; γ(θ) indicates D.
217.8 ^e 5		4765.1?		4547.0	21 ⁻			
221.9 3	92 5	5056.1	(23 ⁺)	4834.3	22 ⁺	(M1)		A ₂ =0.29 11, A ₄ =-0.02 165. α(exp)=1.5 3 (obtained from delayed intensities after subtraction of ²¹³ Fr component); α(K)exp=2.5 9 (contaminated peak). Mult.: from α(exp) and α(K)exp; γ(θ) indicates considerable E2 admixture, or a J-to-J transition.

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$^{198}\text{Pt}(^{19}\text{F},5\text{n}\gamma), ^{205}\text{Tl}(^{12}\text{C},5\text{n}\gamma)$ **1986By01,1990By02 (continued)** $\gamma(^{212}\text{Fr})$ (continued)

E_γ [†]	I_γ [‡]	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult.	Comments
$^{253.5}$ 3	30 1						
273.6 ^e 3	25 ^c 1	4907.8		4634.2			$A_2=-0.21$ 9, $A_4=0.10$ 14.
275.0 3	45 ^c 1	2612.5	(14 ⁺)	2337.7	(13 ⁺)	D	$A_2=-0.13$ 5, $A_4=0.009$ 76.
277.0 1	125 2	3241.0	17 ⁻	2964.1	16 ⁻	M1	$A_2=-0.28$ 2, $A_4=0.06$ 2. $\alpha(\text{exp})=0.86$ 6 (assuming the same delayed total intensity as the 471.9 transition), $\alpha(\text{K})\text{exp}=0.5$ 3, $\alpha(\text{L})\text{exp}=0.16$ 4. Mult.: from $\alpha(\text{exp})$, $\alpha(\text{K})\text{exp}$, and $\alpha(\text{L})\text{exp}$; $\gamma(\theta)$ suggests D.
278 [#]		8533.3		8255.7		(E3)	$\alpha(\text{exp})=1.05$ 45. Mult.: 1990By02 suggest E3 based on $\alpha(\text{exp})$ deduced from delayed intensity balance. In this calculation the competing 151 γ was assumed to be M1.
287.3 1	255 4	4834.3	22 ⁺	4547.0	21 ⁻	E1	$A_2=-0.18$ 3, $A_4=0.07$ 4. $\alpha(\text{K})\text{exp}<0.14$, $\alpha(\text{L})\text{exp}=0.010$ 5. Mult.: from $\alpha(\text{K})\text{exp}$ and $\alpha(\text{L})\text{exp}$; $\gamma(\theta)$ suggests D.
289.3 2	26 ^c 1	3241.0	17 ⁻	2951.7	(16 ⁺)	D	$A_2=-0.10$ 7, $A_4=-0.03$ 9. Mult.: from $\gamma(\theta)$.
304 [#]		6976.9	(29 ⁺)	6671.1			
304.5 3	64 ^c 1	3256.3?		2951.7	(16 ⁺)		$A_2=0.10$ 3, $A_4=0.03$ 3. $\alpha(\text{K})\text{exp}=0.74$ 36, $\alpha(\text{L})\text{exp}=0.096$ 30. Mult.: $\alpha(\text{K})\text{exp}$ and $\alpha(\text{L})\text{exp}$ indicate M1, however, $\gamma(\theta)$ suggests stretched E2 character.
326 [#]		6671.1		6344.8	(28 ⁻)		
328.4 2	535 3	1879.8	12 ⁺	1551.40	11 ⁺	M1	$A_2=-0.179$ 8, $A_4=0.03$ 1. $\alpha(\text{exp})=0.50$ 6, $\alpha(\text{K})\text{exp}=0.42$ 11. Mult.: from $\alpha(\text{exp})$, $\alpha(\text{K})\text{exp}$, and $\gamma(\theta)$.
331.0 3	44 ^c 2	4081.9?		3750.9			$A_2=-0.08$ 7, $A_4=0.03$ 10.
339.3 3	88 ^c 1	2951.7	(16 ⁺)	2612.5	(14 ⁺)		$A_2=-0.031$ 28, $A_4=0.013$ 39.
342.6 2	421 13	3583.6	19 ⁻	3241.0	17 ⁻	E2	$A_2=0.21$ 1, $A_4=-0.04$ 2. $\alpha(\text{K})\text{exp}=0.042$ 15. Mult.: from $\alpha(\text{K})\text{exp}$; $\gamma(\theta)$ suggests Q.
361.9 3	8 ^c 1	4499.2		4137.3	20 ⁻		$A_2=-0.14$ 26.
365.3 2	33 ^c 1	4447.2		4081.9?			$A_2=0.33$ 5, $A_4=0.22$ 9.
407 [#]		7660.7	(29 ⁺)	7253.8			
409.6 1	81 1	4547.0	21 ⁻	4137.3	20 ⁻	M1	$A_2=-0.32$ 3, $A_4=0.02$ 5. $\alpha(\text{K})\text{exp}=0.35$ 19. Mult.: from $\alpha(\text{K})\text{exp}$; $\gamma(\theta)$ indicates D.
442.0 2	209 2	4025.6	20 ⁻	3583.6	19 ⁻	M1	$A_2=-0.39$ 1, $A_4=0.014$ 19. $\alpha(\text{K})\text{exp}=0.24$ 6, $\alpha(\text{L})\text{exp}=0.04$ 1. Mult.: from $\alpha(\text{K})\text{exp}$ and $\alpha(\text{L})\text{exp}$; $\gamma(\theta)$ indicates D.
457.9 2	76 ^c 1	2337.7	(13 ⁺)	1879.8	12 ⁺	(M1+E2)&	Mult.: from $\gamma(\theta)$ and $\alpha(\text{K})\text{exp}$. $A_2=-0.51$ 2, $A_4=0.04$ 4.
459.5 2	64 ^c 1	2951.7	(16 ⁺)	2492.2	15 ⁻	(E1)&	Mult.: from $\gamma(\theta)$ and $\alpha(\text{K})\text{exp}$. $A_2=-0.16$ 3, $A_4=0.02$ 4.
468.0 ^e 5	15 ^c 1	2964.1	16 ⁻	2495.8	(14 ⁻)		$A_2=0.09$ 17.
471.9 1	219 2	2964.1	16 ⁻	2492.2	15 ⁻	M1	$A_2=-0.66$ 1, $A_4=0.07$ 2. $\alpha(\text{K})\text{exp}=0.15$ 4. Mult.: from $\alpha(\text{K})\text{exp}$ and $\gamma(\theta)$.
490.1 2	59 2	6344.8	(28 ⁻)	5854.6	(27 ⁻)	M1	$A_2=-0.50$ 4, $A_4=0.06$ 6. $\alpha(\text{K})\text{exp}=0.37$ 10. Mult.: $\alpha(\text{K})\text{exp}$ suggests M2 or possibly M1, $\gamma(\theta)$ rule out M2.

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¹⁹⁸Pt(¹⁹F,5n γ), ²⁰⁵Tl(¹²C,5n γ) **1986By01,1990By02 (continued)**

γ (²¹²Fr) (continued)

E_γ [†]	I_γ [‡]	E_i (level)	J_i^π	E_f	J_f^π	Mult.	δ^d	Comments
494.6 2	56 2	3750.9		3256.3?		M1+E2	0.7 5	$A_2=-0.67$ 4, $A_4=0.04$ 7. $\alpha(K)\text{exp}=0.10$ 3. Mult.: from $\alpha(K)\text{exp}$; $\gamma(\theta)$ indicates D.
521.4 2	107 2	4547.0	21 ⁻	4025.6	20 ⁻	M1		$A_2=-0.29$ 3, $A_4=-0.01$ 5. $\alpha(K)\text{exp}=0.21$ 5. Mult.: from $\alpha(K)\text{exp}$; $\gamma(\theta)$ suggests D.
529.0 ^e 3	92 ^c 2	5161.2?		4632.2				$A_2=0.08$ 4.
536.9 2	62 ^c 3	5803.2	(25 ⁺)	5266.3	(24 ⁺)	M1+E2	1.1 +19-6	$A_2=-0.20$ 7, $A_4=0.01$ 10. $\alpha(K)\text{exp}=0.06$ 3.
542.2 1	1000 4	542.20	7 ⁺	0.0	5 ⁺	E2		Mult.: from $\alpha(K)\text{exp}$; $\gamma(\theta)$ suggests D. $A_2=0.017$ 8, $A_4=-0.002$ 12 (1977Be56). $\alpha(K)\text{exp}=0.023$ 5, $\alpha(L)\text{exp}=0.007$ 2.
553.7 2	151 2	4137.3	20 ⁻	3583.6	19 ⁻	M1		Mult.: from $\alpha(K)\text{exp}$, $\alpha(L)\text{exp}$, and $\gamma(\theta)$. $A_2=-0.39$ 3, $A_4=0.04$ 3. $\alpha(K)\text{exp}=0.112$ 19, $\alpha(L)\text{exp}=0.020$ 5.
^x 569.8 3								Mult.: from $\alpha(K)\text{exp}$ and $\alpha(L)\text{exp}$; $\gamma(\theta)$ suggests D.
^x 583								
588.3 2	180 10	5854.6	(27 ⁻)	5266.3	(24 ⁺)	E3		I_γ : corrected for contamination from ²¹³ Fr. $A_2=0.18$ 3, $A_4=-0.05$ 4. $\alpha(K)\text{exp}=0.044$ 8, $\alpha(L)\text{exp}=0.027$ 6. Mult.: from $\alpha(K)\text{exp}$, $\alpha(L)\text{exp}$.
595.0 ^a 3	22 ^c 2	8255.7		7660.7	(29 ⁺)			$A_2=0.22$ 13.
607 [#]		7660.7	(29 ⁺)	7054.0				
612.4 1	592 3	2492.2	15 ⁻	1879.8	12 ⁺	E3		$A_2=0.11$ 1, $A_4=0.01$ 1. $\alpha(K)\text{exp}=0.043$ 6, $\alpha(L)\text{exp}=0.025$ 4, $\alpha(M)\text{exp}=0.008$ 1. Mult.: from $\alpha(K)\text{exp}$, $\alpha(L)\text{exp}$, $\alpha(M)\text{exp}$.
^x 619.4 3	33 ^c 2							
632.1 3	27 ^c 2	6976.9	(29 ⁺)	6344.8	(28 ⁻)			$A_2=-0.19$ 8.
684 [#]		7660.7	(29 ⁺)	6976.9	(29 ⁺)			
732.6 3	44 2	2612.5	(14 ⁺)	1879.8	12 ⁺	(Q)		$A_2=0.17$ 7. Mult.: $\gamma(\theta)$ suggests Q.
739.6 ^e 3	16 1	4765.1?		4025.6	20 ⁻			$A_2=-0.63$ 12.
748.8 1	236 4	3241.0	17 ⁻	2492.2	15 ⁻	E2		$A_2=0.24$ 2, $A_4=-0.047$ 27. $\alpha(K)\text{exp}=0.010$ 1, $\alpha(L)\text{exp}=0.002$ 1. Mult.: from $\alpha(K)\text{exp}$, $\alpha(L)\text{exp}$ and $\gamma(\theta)$.
^x 808.1 3	40 ^c 1							
847.2 2	1070 10	1389.40	9 ⁺	542.20	7 ⁺	E2		I_γ : contaminated by Fe(n,n') line. Intensity from delayed spectrum. $A_2=-0.005$ 14. $\alpha(K)\text{exp}=0.0087$ 10, $\alpha(L)\text{exp}=0.0020$ 2. Mult.: from $\alpha(K)\text{exp}$ and $\alpha(L)\text{exp}$. $\gamma(\theta)$ is not in agreement with pure Q transition.
881.3 ^e 3	53 ^c 2	4632.2		3750.9				$A_2=-0.10$ 5.
883.3 ^e 3	42 ^c 2	4634.2		3750.9				$A_2=0.01$ 7.
909 [#]		7253.8		6344.8	(28 ⁻)			
921.5 ^a 3	38 2	6976.9	(29 ⁺)	6055.6	(28 ⁺)	(M1+E2)	0.6 6	$A_2=0.47$ 6. $\alpha(K)\text{exp}=0.022$ 6. Mult.: from $\alpha(K)\text{exp}$, $\gamma(\theta)$ suggests a J to J transition or considerable E2 admixture.
^x 987.8 4	75 ^c 2							
990.0 ^a 5	48 ^c 2	7660.7	(29 ⁺)	6671.1				$A_2=0.14$ 6.

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$^{198}\text{Pt}(^{19}\text{F},5\text{n}\gamma), ^{205}\text{Tl}(^{12}\text{C},5\text{n}\gamma)$ **1986By01,1990By02** (continued) $\gamma(^{212}\text{Fr})$ (continued)

E_γ [†]	I_γ [‡]	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult.	Comments
1199 ^{#b}		7054.0		5854.6	(27 ⁻)		
1201 ^{#b}		8255.7		7054.0			
1315.6 5	98 ^c 2	7660.7	(29 ⁺)	6344.8	(28 ⁻)	E1	$\alpha(\text{K})\text{exp}\leq 0.0015$. $A_2=-0.58$ 17. Mult.: from $\alpha(\text{K})\text{exp}$; $\gamma(\theta)$ indicates D.

[†] From 1986By01, except where noted.

[‡] Relative intensity from $\gamma(\theta)$ experiment using HPGe detector (1986By01). See 1986By01 for intensities measured with planar Ge detector and for delayed transition intensities.

[#] From 1990By02.

@ Transition not observed, its existence was deduced from coincidence and delayed intensity data.

& $\alpha(\text{K})\text{exp}=0.069$ 18 for 457.9+459.5 gammas.

^a γ placement in level scheme from 1990By02.

^b $E_\gamma=1200$ I seen by 1986By01.

^c Areas extracted by fits to the data where neighboring peaks in the fitting region form a significant contribution to total area.

^d Extracted from the measured internal conversion coefficients with the BrIccMixing software by the evaluator.

^e Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

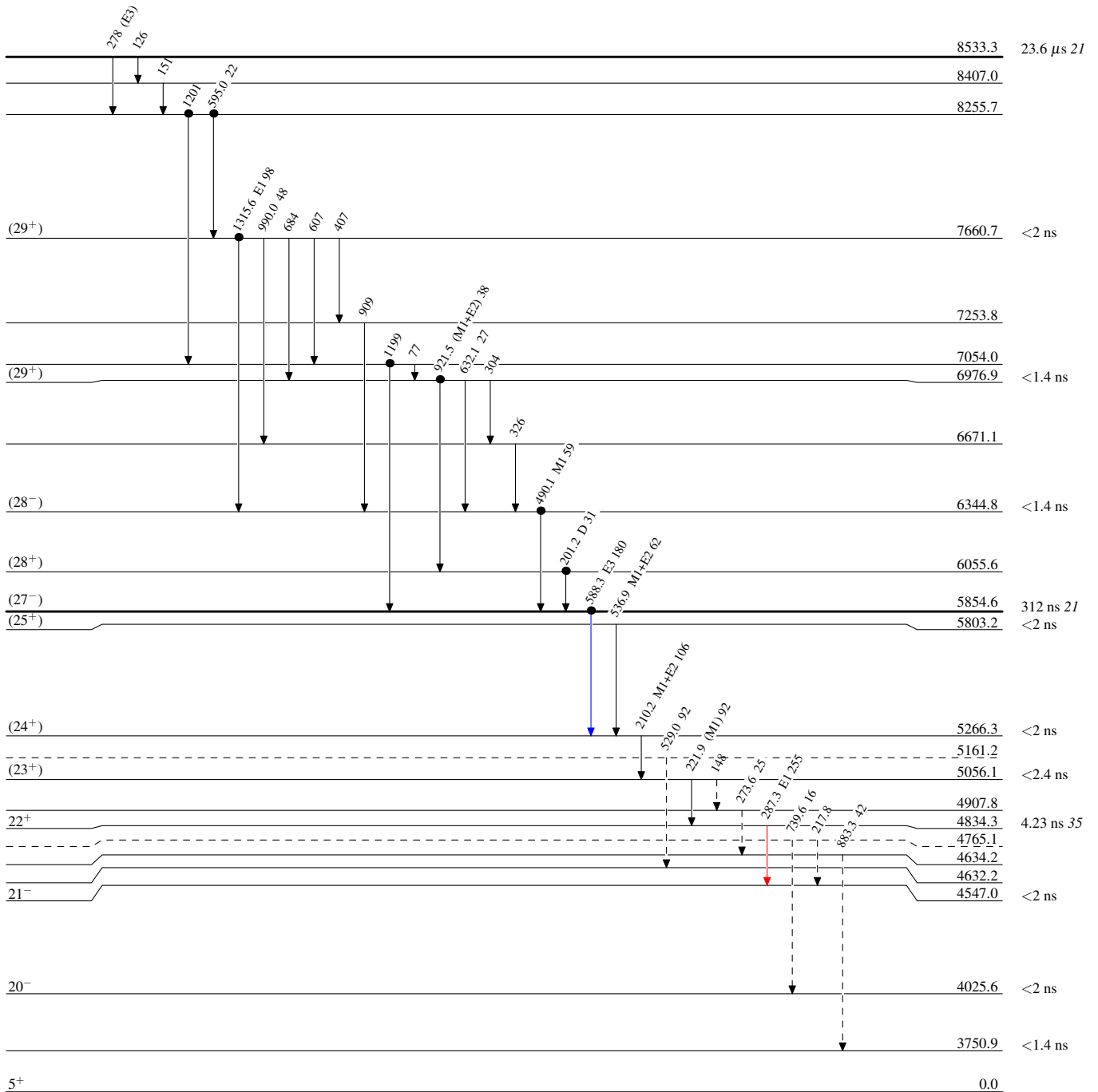
$^{198}\text{Pt}(^{19}\text{F},5\text{n}\gamma), ^{205}\text{Tl}(^{12}\text{C},5\text{n}\gamma)$ 1986By01,1990By02

Level Scheme

Intensities: Relative I_γ

Legend

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

 $^{212}_{87}\text{Fr}_{125}$

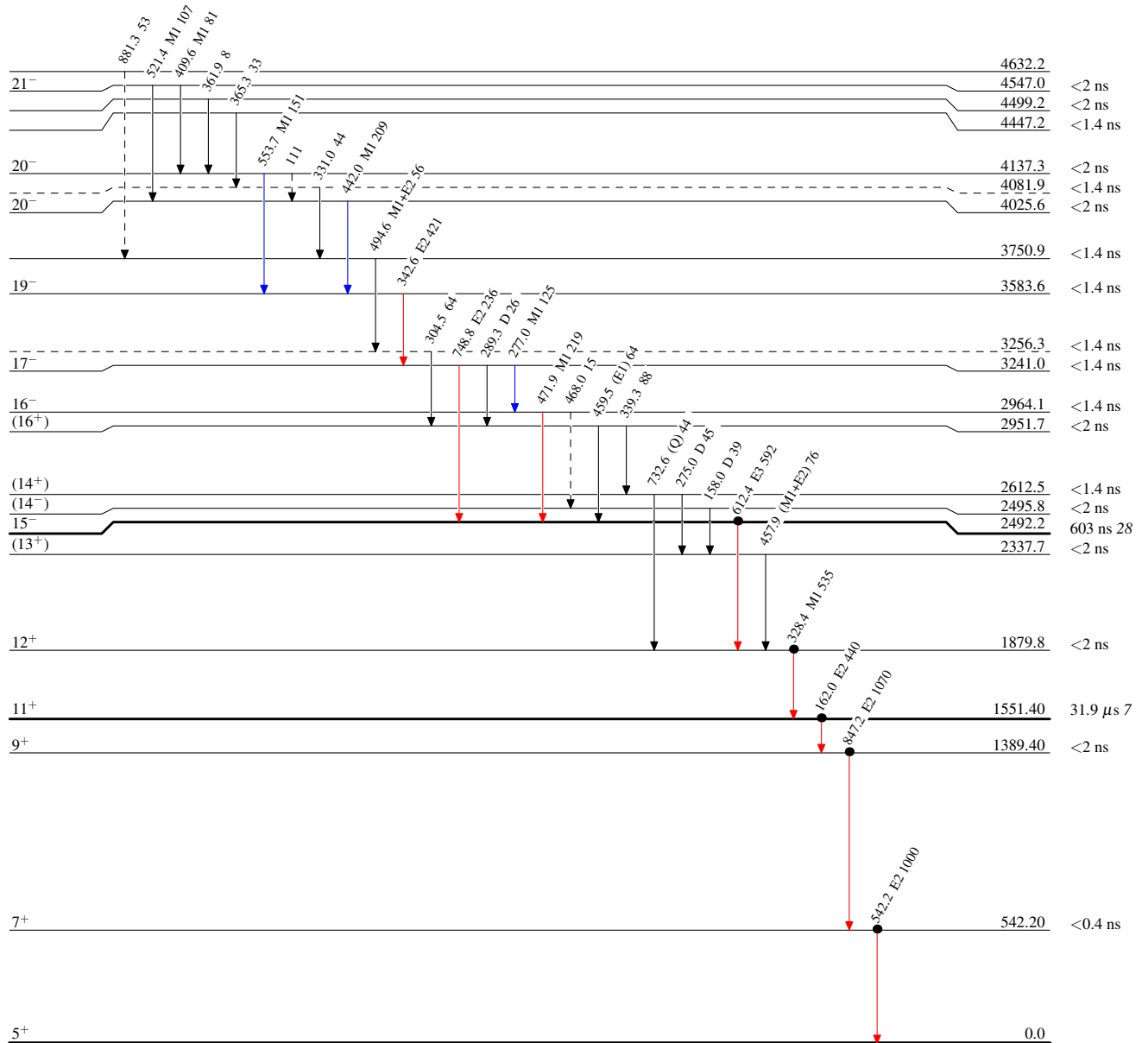
$^{198}\text{Pt}(^{19}\text{F},5n\gamma)$, $^{205}\text{Tl}(^{12}\text{C},5n\gamma)$ 1986By01,1990By02

Level Scheme (continued)

Intensities: Relative I_γ

Legend

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

 $^{212}\text{Fr}_{125}$