

$^{208}\text{Pb}(^{14}\text{C},3n\gamma) E=65 \text{ MeV}$ 1992Wi02

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh et al. ,	NDS 175, 1 (2021)	19-May-2021

1992Wi02: E(^{14}C)=65 MeV. Target was >99% enriched ^{208}Pb , with thickness of 5 mg/cm². Measured E γ , I γ , $\gamma\gamma$ -coin, $\gamma\gamma(\theta)$ (DCO) using an array of 12 Compton-suppressed Ge detectors and the multidetector array 'Chateau de Crystal' of 26 BaF² detectors, as a sum energy and multiplicity filter. Experiment was performed at the MP tandem accelerator facility in Strasbourg. Deduced reflection asymmetric structures, and B(E1)/B(E2) ratios.

2001Sh14 (also 1993Sh43): analyzed spectroscopic data from in-beam γ -ray and α -decay experiments. Discussed configurations.

 ^{219}Ra Levels

E(level) [†]	J π^{\ddagger}	T _{1/2}	Comments
0.0	7/2 ⁺		
16.7 [#] 3	11/2 ⁺	10 ms 3	% α ≈100 (2018Sa45); %IT=? T _{1/2} : isomer half-life from 2018Sa45.
113.8 ^{&} 2	9/2 ⁺		
251.2 [#] 3	15/2 ⁺		
475.3 ^{&} 3	13/2 ⁺		
512.5 [@] 3	17/2 ⁻		
546.2 [#] 3	19/2 ⁺		
556.0 ^b 4	13/2 ⁺		
604.3 ^a 3	15/2 ⁻		
751.5 [@] 4	21/2 ⁻		
779.8 ^c 4	15/2 ⁻		
853.6 ^{&} 4	17/2 ⁺		
876.5 ^b 4	17/2 ⁺		
893.4 [#] 4	23/2 ⁺		
937.9 ^a 3	19/2 ⁻		
1053.6 [@] 4	25/2 ⁻		
1131.3 ^c 4	19/2 ⁻		
1245.9 ^{&} 4	21/2 ⁺		
1257.3 ^b 4	21/2 ⁺		
1288.6 [#] 4	27/2 ⁺		
1325.2 ^a 4	23/2 ⁻		
1411.7 [@] 4	29/2 ⁻		
1426.5? 11			Level in 1992Wi02 only, treated as uncertain by evaluators.
1504.5 ^c 5	23/2 ⁻		
1638.5 ^{&} 4	25/2 ⁺		
1671.7 ^b 5	25/2 ⁺		
1701.9 [#] 4	31/2 ⁺		
1738.5 ^a 4	27/2 ⁻		
1833.5 [@] 4	33/2 ⁻		
2039.1 ^{&} 4	29/2 ⁺		
2130.4 [#] 4	35/2 ⁺		
2153.3 ^a 4	31/2 ⁻		
2289.8 [@] 4	37/2 ⁻		
2460.5 ^{&} 5	33/2 ⁺		
2568.4 ^a 4	35/2 ⁻		
2580.6 [#] 5	39/2 ⁺		

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$^{208}\text{Pb}(^{14}\text{C},3n\gamma) E=65 \text{ MeV}$ **1992Wi02 (continued)** ^{219}Ra Levels (continued)

E(level) [†]	J^π [‡]
2767.8 [@] 5	41/2 ⁻
3003.9 ^a 5	39/2 ⁻
3045.4 [#] 5	43/2 ⁺

[†] Deduced from least-squares fit to γ -ray energies. The levels are based on 7/2⁺ g.s. and 16.7, 11/2⁺ first excited state as proposed in 2000Ri12 and 2017He15, thus the level energies listed in 1992Wi02 have been adjusted upwards by 16.6 keV.

[‡] As given in 1992Wi02, based on band structures, γ -ray multiplicities from DCO ratios, except that all the J^π assignments in 1992Wi02 are adjusted upwards by two units due to the revision of level based on the first excited state at 16.8 keV, $J^\pi=11/2^+$.

[#] Band(A): Band based on 11/2⁺. Reflection asymmetric structure, average B(E1)/B(E2)=1.7 \times 10₆ fm⁻² (1992Wi02).

[@] Band(a): Band based on 17/2⁻. Alternating-parity band. Average B(E1)/B(E2)=1.7 \times 10₆ fm⁻² (1992Wi02).

[&] Band(B): Band based on 9/2⁺. Alternating-parity band. Average B(E1)/B(E2)=1.1 \times 10₆ fm⁻² (1992Wi02).

^a Band(b): Band based on 15/2⁻. Alternating-parity band. Average B(E1)/B(E2)=1.1 \times 10₆ fm⁻² (1992Wi02).

^b Band(C): Band based on 13/2⁺. Alternating-parity band. Average B(E1)/B(E2)=2.7 \times 10₆ fm⁻² (1992Wi02).

^c Band(c): Band based on 15/2⁻. Alternating-parity band. Average B(E1)/B(E2)=2.7 \times 10₆ fm⁻² (1992Wi02).

 $\gamma(^{219}\text{Ra})$

DCO ratios from 1992Wi02 are for 30°, 90° and 150° geometry with gates on $\Delta J=2$ quadrupole or $\Delta J=1$, dipole transitions, and for $(\sigma/J)<0.15$. Expected DCO ratios are 1.0 when multiplicities are the same for the two gamma transitions, 0.51 for $\Delta J=1$, dipole when gated on a $\Delta J=2$, quadrupole, and 1.98 for $\Delta J=2$, quadrupole when gated on a $\Delta J=1$, dipole transition. DCO(Q) is for gate on $\Delta J=2$, quadrupole, and DCO(D) for $\Delta J=1$, dipole.

E_γ [†]	I_γ [†]	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. [‡]	α [#]	Comments
(48.3)		604.3	15/2 ⁻	556.0	13/2 ⁺			
(61.4)		937.9	19/2 ⁻	876.5	17/2 ⁺			
79.3 3	0.6 2	1325.2	23/2 ⁻	1245.9	21/2 ⁺			
84.3 3	2.6 7	937.9	19/2 ⁻	853.6	17/2 ⁺	D		DCO(D)=0.81 15
96.7 3	1.5 1	876.5	17/2 ⁺	779.8	15/2 ⁻			
97.1 3	>0.5	113.8	9/2 ⁺	16.7	11/2 ⁺			γ placed tentatively from a 97.1 level in 1992Wi02.
100.1 5		1738.5	27/2 ⁻	1638.5	25/2 ⁺			
108.1 3	0.2 1	2568.4	35/2 ⁻	2460.5	33/2 ⁺			
113.8 2		113.8	9/2 ⁺	0.0	7/2 ⁺			E_γ : from 2000Ri12, uncertainty assigned by evaluators. This γ is not given in 1992Wi02 Such a level was known from the α decay of ^{223}Th (1992Li09).
114.0 3	1.3 5	2153.3	31/2 ⁻	2039.1	29/2 ⁺			
123.1 2	19.3 9	1411.7	29/2 ⁻	1288.6	27/2 ⁺	D		DCO(Q)=0.48 8
125.9 3	1.7 2	1257.3	21/2 ⁺	1131.3	19/2 ⁻			
129.0 2	9.4 7	604.3	15/2 ⁻	475.3	13/2 ⁺	[E1]	0.260	
131.7 2	7.6 3	1833.5	33/2 ⁻	1701.9	31/2 ⁺	D		DCO(Q)=0.43 5
141.9 2	38.3 19	893.4	23/2 ⁺	751.5	21/2 ⁻	(E1)	0.207	DCO(Q)=0.51 8
159.4 3	2.7 5	2289.8	37/2 ⁻	2130.4	35/2 ⁺			
160.1 2	47.2 67	1053.6	25/2 ⁻	893.4	23/2 ⁺	(E1)	0.1545	DCO(Q)=0.42 4
167.3 3	0.4 1	1671.7	25/2 ⁺	1504.5	23/2 ⁻	D		DCO(Q)=0.58 20
187.2 3	1.4 2	2767.8	41/2 ⁻	2580.6	39/2 ⁺	D		DCO(Q)=0.67 11
205.3 2	67.0 33	751.5	21/2 ⁻	546.2	19/2 ⁺	(E1)	0.0849	DCO(Q)=0.52 7
223.8 3	1.3 2	779.8	15/2 ⁻	556.0	13/2 ⁺			
234.5 1	112 8	251.2	15/2 ⁺	16.7	11/2 ⁺	[E2]	0.336	

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$^{208}\text{Pb}(^{14}\text{C},3n\gamma) E=65 \text{ MeV}$ **1992Wi02 (continued)** $\gamma(^{219}\text{Ra})$ (continued)

E_γ †	I_γ †	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. ‡	$\alpha^\#$	Comments
235.0 2	32.0 41	1288.6	27/2 ⁺	1053.6	25/2 ⁻			
238.9 3	2.6 1	751.5	21/2 ⁻	512.5	17/2 ⁻	(E2)	0.316	
247.2 3	0.4 1	1504.5	23/2 ⁻	1257.3	21/2 ⁺			
249.4 3	3.9 2	853.6	17/2 ⁺	604.3	15/2 ⁻	D		DCO(D)=1.08 18
254.9 3	1.3 1	1131.3	19/2 ⁻	876.5	17/2 ⁺	D		DCO(Q)=0.73 15
261.3 1	22.5 12	512.5	17/2 ⁻	251.2	15/2 ⁺			
277.7 5		3045.4	43/2 ⁺	2767.8	41/2 ⁻			
290.2 2	20.2 42	1701.9	31/2 ⁺	1411.7	29/2 ⁻			
290.8 3	4.4 7	2580.6	39/2 ⁺	2289.8	37/2 ⁻			
295.0 1	100.0 51	546.2	19/2 ⁺	251.2	15/2 ⁺	[E2]	0.1602	
295.2 @ 10		1426.5?		1131.3	19/2 ⁻			This γ is not reported by 2017He15.
296.9 2	9.8 8	2130.4	35/2 ⁺	1833.5	33/2 ⁻	D		DCO(Q)=0.42 9
300.4 3	2.5 1	2039.1	29/2 ⁺	1738.5	27/2 ⁻			
302.0 2	12.3 6	1053.6	25/2 ⁻	751.5	21/2 ⁻	(E2)	0.1492	DCO(Q)=1.06 14
307.4 3	0.9 3	2460.5	33/2 ⁺	2153.3	31/2 ⁻			
308.1 3	2.9 3	1245.9	21/2 ⁺	937.9	19/2 ⁻			
313.3 3	2.7 7	1638.5	25/2 ⁺	1325.2	23/2 ⁻			
320.4 3	2.3 11	876.5	17/2 ⁺	556.0	13/2 ⁺	(E2)	0.125	DCO(D)=2.13 68
333.6 2	8.9 4	937.9	19/2 ⁻	604.3	15/2 ⁻	(E2)	0.111	DCO(D)=2.17 43
347.2 2	31.9 20	893.4	23/2 ⁺	546.2	19/2 ⁺	(E2)	0.0991	DCO(Q)=0.98 11
351.2 5		1131.3	19/2 ⁻	779.8	15/2 ⁻			DCO(Q)=0.79 32
353.0 3	1.0 2	604.3	15/2 ⁻	251.2	15/2 ⁺			
358.1 1	27.3 13	1411.7	29/2 ⁻	1053.6	25/2 ⁻	(E2)	0.0911	DCO(Q)=0.92 11
361.5 2	8.1 4	475.3	13/2 ⁺	113.8	9/2 ⁺	(E2)	0.0887	DCO(D)=1.64 27
373.3 @ 5		1504.5	23/2 ⁻	1131.3	19/2 ⁻			γ shown only in level-scheme Fig. 2 of 1992Wi02.
378.3 3	1.4 3	853.6	17/2 ⁺	475.3	13/2 ⁺			
381.0 3	1.5 3	1257.3	21/2 ⁺	876.5	17/2 ⁺			DCO(Q)=0.45 15 DCO gives $\Delta J=1$, dipole, but $\Delta J=2$ is implied from level scheme.
387.4 2	8.5 4	1325.2	23/2 ⁻	937.9	19/2 ⁻	Q		DCO(D)=2.13 32
391.9 5		937.9	19/2 ⁻	546.2	19/2 ⁺			γ from 1992Wi02 only, with no I_γ value.
392.3 @ 5		1245.9	21/2 ⁺	853.6	17/2 ⁺			γ shown only in level-scheme Fig. 2 of 1992Wi02.
392.6 @ 5		1638.5	25/2 ⁺	1245.9	21/2 ⁺			γ shown only in level-scheme Fig. 2 of 1992Wi02.
395.1 2	11.5 5	1288.6	27/2 ⁺	893.4	23/2 ⁺	Q		DCO(Q)=0.88 18
400.6 3	0.8 2	2039.1	29/2 ⁺	1638.5	25/2 ⁺			
413.3 3	4.8 7	1701.9	31/2 ⁺	1288.6	27/2 ⁺			
413.4 2	5.6 12	1738.5	27/2 ⁻	1325.2	23/2 ⁻	Q		DCO(D)=1.64 26
414.1 5		1671.7	25/2 ⁺	1257.3	21/2 ⁺			
415.0 2	5.8 15	2153.3	31/2 ⁻	1738.5	27/2 ⁻	Q		DCO(D)=2.33 46
415.1 3	1.1 5	2568.4	35/2 ⁻	2153.3	31/2 ⁻			
421.5 @ 5		2460.5	33/2 ⁺	2039.1	29/2 ⁺			γ shown only in level-scheme Fig. 2 of 1992Wi02.
421.8 1	20.9 10	1833.5	33/2 ⁻	1411.7	29/2 ⁻	Q		DCO(Q)=0.89 8
425.4 3	1.1 2	937.9	19/2 ⁻	512.5	17/2 ⁻			
428.5 2	2.5 1	2130.4	35/2 ⁺	1701.9	31/2 ⁺	Q		DCO(Q)=0.98 15
435.5 3	1.7 1	3003.9	39/2 ⁻	2568.4	35/2 ⁻			
450.2 3	1.3 1	2580.6	39/2 ⁺	2130.4	35/2 ⁺	Q		DCO(Q)=0.93 9
456.3 2	8.0 4	2289.8	37/2 ⁻	1833.5	33/2 ⁻	Q		DCO(Q)=0.93 13
458.6 2	5.1 5	475.3	13/2 ⁺	16.7	11/2 ⁺	(M1)	0.224	DCO(D)=0.81 16
464.8 2	1.4 1	3045.4	43/2 ⁺	2580.6	39/2 ⁺			
478.0 3	3.3 1	2767.8	41/2 ⁻	2289.8	37/2 ⁻			
539.2 2	5.1 2	556.0	13/2 ⁺	16.7	11/2 ⁺	D		DCO(Q)=0.50 14

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$^{208}\text{Pb}(^{14}\text{C},3n\gamma) E=65 \text{ MeV}$ **1992Wi02 (continued)** $\gamma(^{219}\text{Ra})$ (continued)

E_γ [†]	I_γ [†]	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. [‡]	Comments
573.6 3	1.4 2	1325.2	23/2 ⁻	751.5	21/2 ⁻		
619 [@] 1	1.3 2	1131.3	19/2 ⁻	512.5	17/2 ⁻		E_γ : γ in 1992Wi02 only. With the intensity reported in 1992Wi02 , this γ should have been detected by 2017He15 . Evaluators treat this γ as uncertain.
625.4 3	2.7 3	876.5	17/2 ⁺	251.2	15/2 ⁺	D	DCO(Q)=0.42 13
685.1 3	1.6 2	1738.5	27/2 ⁻	1053.6	25/2 ⁻		
711.1 3	1.0 1	1257.3	21/2 ⁺	546.2	19/2 ⁺		
734.6 3	1.3 2	2568.4	35/2 ⁻	1833.5	33/2 ⁻		
741.6 3	1.5 2	2153.3	31/2 ⁻	1411.7	29/2 ⁻		
753 [@] 1	1.7 3	1504.5	23/2 ⁻	751.5	21/2 ⁻		E_γ : γ from 1992Wi02 only. With the intensity reported in 1992Wi02 , this γ should have been detected by 2017He15 . Evaluators treat this γ as uncertain.

[†] From **1992Wi02**. Uncertainties for E_γ values are given as 0.1-0.3 by **1992Wi02**. For observed γ rays, evaluators assign 0.1 keV for strong γ rays ($I_\gamma \geq 20$), 0.2 keV for medium intensity ($I_\gamma = 5-19$), 0.3 keV for weak γ rays ($I_\gamma < 5$), 0.5 keV when I_γ not stated, and 1 keV when E_γ stated to nearest keV.

[‡] From DCO ratios (**1992Wi02**). Evaluators assign mult=D for $\Delta J=1$, dipole, and mult=Q for $\Delta J=2$, quadrupole, the latter are expected to be E2, based on band assignments, and from RUL for E2 and M2, assuming all the excited states have half-lives no longer than 10 ns or so.

[#] 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.

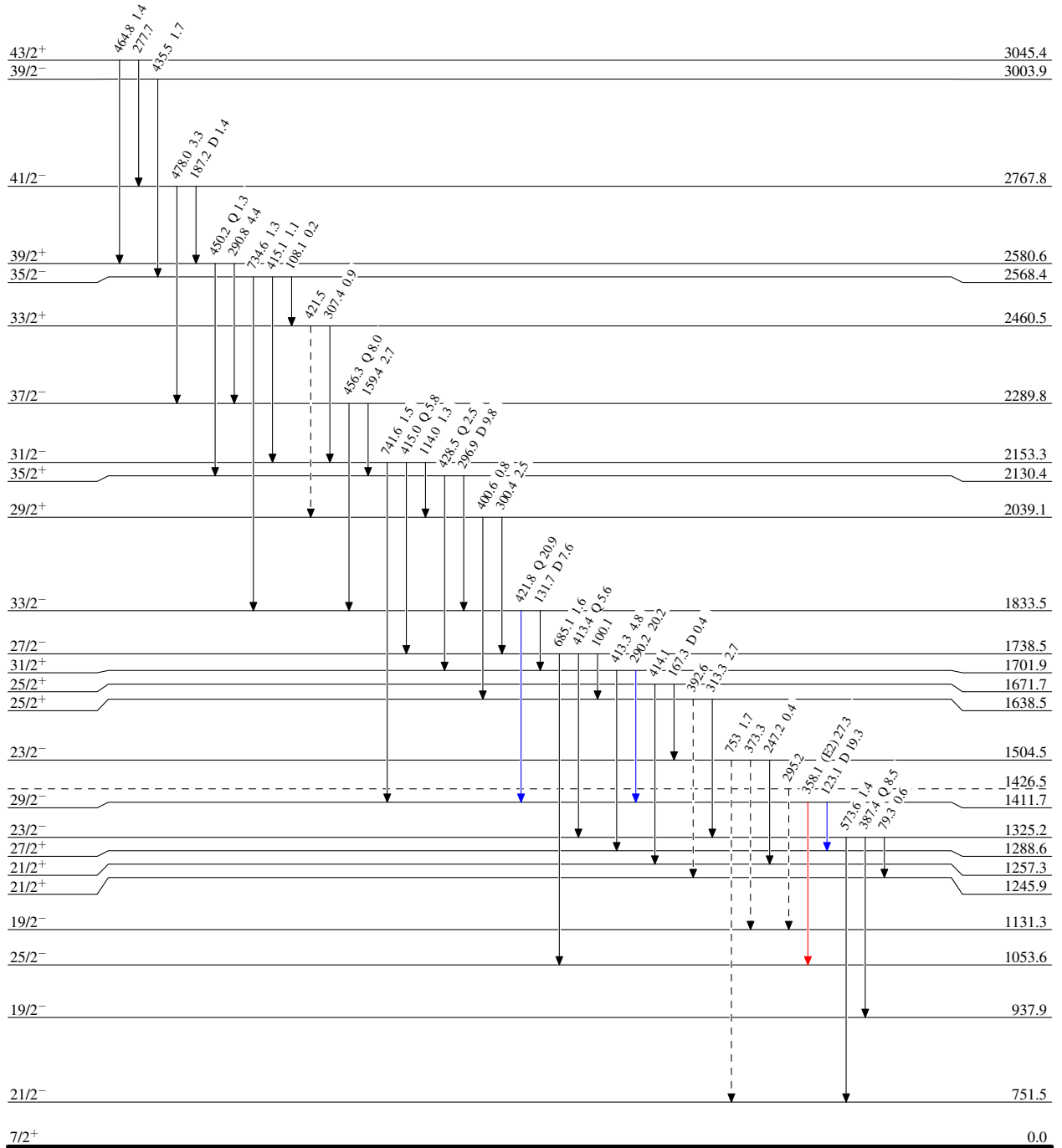
[@] Placement of transition in the level scheme is uncertain.

²⁰⁸Pb(¹⁴C,³ⁿγ) E=65 MeV 1992Wi02

Legend

Level Scheme
Intensities: Relative I_γ

- I_γ < 2% × I_γ^{max}
- I_γ < 10% × I_γ^{max}
- I_γ > 10% × I_γ^{max}
- - - - - γ Decay (Uncertain)



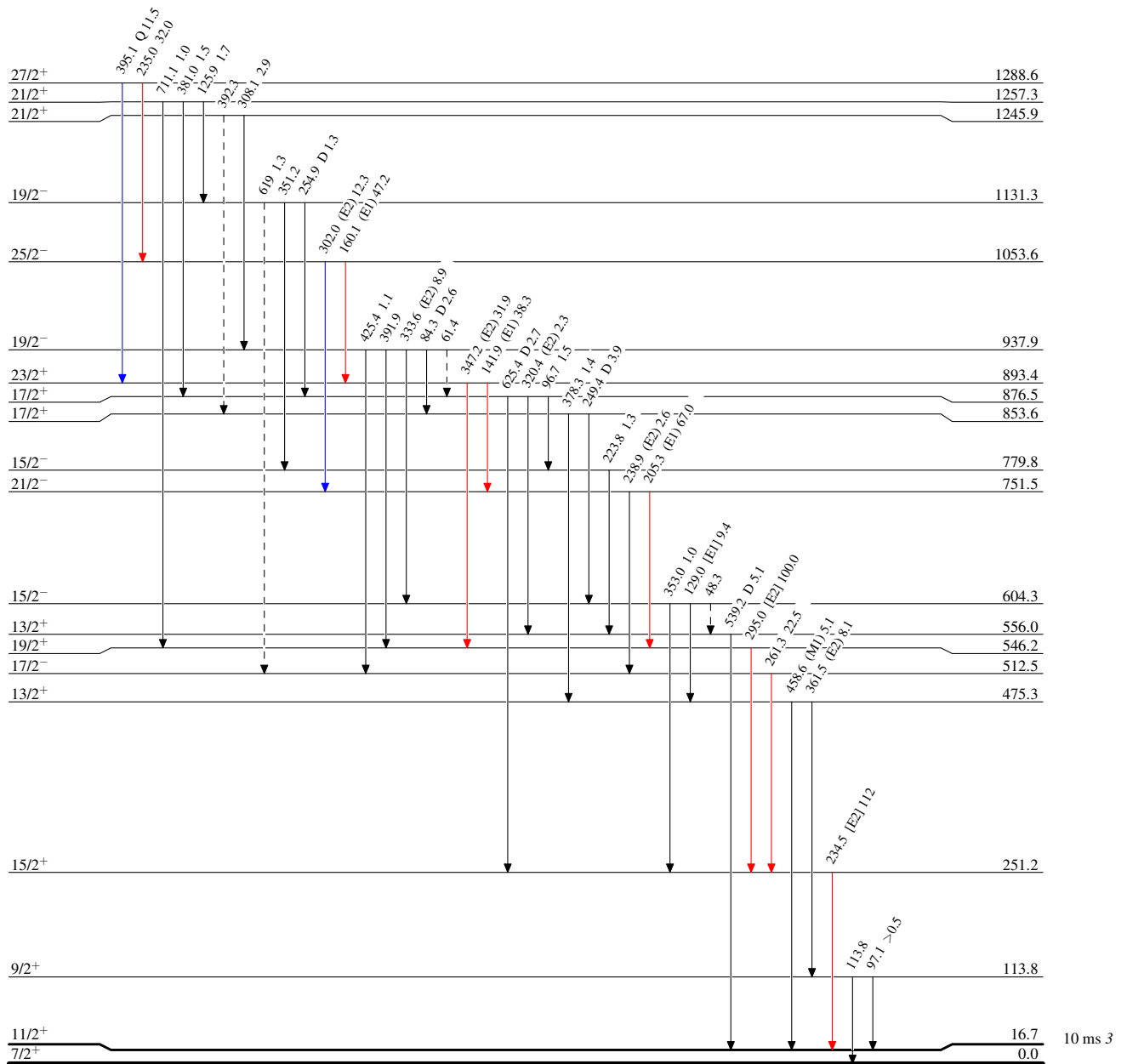
$^{208}\text{Pb}(^{14}\text{C},3n\gamma) E=65 \text{ MeV}$ 1992Wi02

Legend

Level Scheme (continued)

Intensities: Relative I_γ

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



$^{219}_{88}\text{Ra}_{131}$

10 ms 3

$^{208}\text{Pb}(^{14}\text{C},3n\gamma) E=65 \text{ MeV}$ 1992Wi02