^{148}Sm(^{20}Ne,4nγ) 1987Bl06

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen[#]	NDS 147, 1 (2018)	30-Nov-2017

Includes ^{128}Te(^{40}Ca,4nγ) from 1998We02.

1987Bl06 (also 1989Mu13): E=106-117 MeV, measured Eγ, Iγ, γγ-coin, γγ(θ)(DCO) for 30° and 90° geometry. 1989Mu13 report lifetimes by Doppler-shift attenuation method.

1998We02: ^{128}Te(^{40}Ca,4nγ) E=175 MeV. Measured g factor of the first 2$^+$ state, and average g factor of yrast states by transient-field technique.

1981Ri08: E=114 MeV. Measured γγ coin. Ground-state band reported up to 26$^+$ with a cascade of 12 transitions.

^{164}Hf Levels

Quasiparticle labels for neutrons:
A: (π=+,α=+1/2); $i_{13/2}$ orbital, ν5/2[642].
B: (π=+,α=−1/2); $i_{13/2}$ orbital, ν5/2[642].
C: (π=+,α=+1/2)$_2$; $i_{13/2}$ orbital, ν3/2[651].
E: (π=−,α=+1/2); $h_{9/2}$ orbital, ν3/2[521].
F: (π=−,α=−1/2); $h_{9/2}$ orbital, ν3/2[521].
Average g factor (for yrast states)=0.23 2 (1998We02).

E(level)[†]	Jπ[#]	$T_{1/2}$[‡]	Comments
0.0[@]	0+		
210.8[@] *3*	2+	301 ps *44*	g=0.33 *6* (1998We02) $T_{1/2}$: unweighted average of 344 ps *20* (1998We02) and 256 ps *21* (1989Mu13), both from RDDS method. g: from transient-field technique (1998We02). The quoted value is based on $T_{1/2}$=349 ps *20*. Additional information 1.
587.2[@] *5*	4+	13.0 ps *+26−22*	
1072.9 *9*	(3−)		
1085.4[@] *5*	6+	2.0 ps *+26−4*	
1521.0[a] *6*	5−		
1614.4 *7*	(4−,5−)		
1668.9[@] *6*	8+	<1.4 ps	
1836.4[a] *6*	7−		
1946.9[b] *6*	6−		
2245.2[a] *6*	9−		
2302.0[b] *6*	8−		
2304.5[@] *6*	10+		
2576.1[b] *6*	10−		
2698.8[a] *6*	11−	3.0 ps *+16−10*	
2871.4[&] *7*	12+	5.2 ps *+15−12*	
2961.8[b] *6*	12−		
2995.1[@] *8*	(12+)		
3156.1[a] *7*	13−	4.1 ps *+12−10*	
3210.4[&] *7*	14+	14.8 ps *+10−12*	
3494.0[b] *7*	14−		
3618.4 *8*	(14+)		
3679.8[&] *8*	16+	2.9 ps *+10−7*	

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^{148}Sm(^{20}Ne,4nγ) 1987Bl06 (continued)

^{164}Hf Levels (continued)

E(level)[†]	Jπ[#]	$T_{1/2}$[‡]	E(level)[†]	Jπ[#]
3701.1[a] *8*	15⁻		7062.6[a] *14*	25⁻
4130.7[b] *8*	16⁻		7443.2[b] *14*	26⁻
4263.0[&] *9*	18⁺	2.1 ps +*12*−*10*	7458.8[&] *11*	26⁺
4335.9[a] *8*	17⁻		7873.3[a] *17*	27⁻
4766.2[b] *8*	18⁻		8291.7[b] *11*	28⁻
4939.7[&] *9*	20⁺		8436.2[&] *15*	28⁺
5009.9[a] *9*	19⁻		8764.2[a] *20*	29⁻
5359.1[b] *9*	20⁻		9214.7[b] *20*	(30⁻)
5669.7[a] *9*	21⁻		9323.2?[&] *18*	(30⁺)
5699.8[&] *10*	22⁺		9726.3[a] *22*	(31⁻)
5981.9[b] *9*	22⁻		10178.8?[&] *21*	(32⁺)
6335.7[a] *10*	23⁻		10187.3?[b] *23*	(32⁻)
6545.2[&] *10*	24⁺		11161.4?[&] *23*	(34⁺)
6673.0[b] *10*	24⁻		11216.6?[b] *25*	(34⁻)

[†] From least-squares fit to Eγ data.
[‡] From recoil-distance Doppler-shift (RDDS) method (1989Mu13), unless otherwise stated.
[#] From 1987Bl06, based on γ(θ), γγ(θ) and γ(lin pol). See also Adopted Levels.
[@] Band(A): (π=+,α=0) g.s. band.
[&] Band(a): (π=+,α=0) AB band. This band is continuation of g.s. band, with a possible band crossing at 10⁺.
[a] Band(B): (π=−,α=1) AE band. Possible band crossing at 19⁻, changing to ABCE.
[b] Band(b): (π=−,α=0) AF band. The two negative-parity bands are signature partners. Possible band crossing at 16⁻, changing to ABCF.

γ(^{164}Hf)

With gates on ΔJ=2, quadrupole transitions, expected values of DCO values are ≈1 for ΔJ=2, quadrupoles, ≈0.5 for ΔJ=1, dipole, and ≈1.1 for ΔJ=0 or 1, unstretched dipoles.

Eγ[†]	Iγ[‡]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	Comments
210.8 *3*	70.4	210.8	2⁺	0.0	0⁺	E2[@]		DCO=0.76 *2* Additional information 2.
215.2 *3*	0.6	3210.4	14⁺	2995.1	(12⁺)			
263.0 *3*	1.0	2961.8	12⁻	2698.8	11⁻	(M1+E2)[a]	+0.30 *19*	DCO=0.88 *18* δ: from γγ(θ). δ=4.5 +∞−*14* is also allowed by γγ(θ) but less likely from δ=0.37 *2* calculated from branching ratio.
274.1 *3*	6.7	2576.1	10⁻	2302.0	8⁻	Q[@]		DCO=0.83 *7* Additional information 4.
315.4 *3*	1.8	1836.4	7⁻	1521.0	5⁻			DCO=0.73 *32*
331.0 *3*	7.4	2576.1	10⁻	2245.2	9⁻	(M1+E2)	+0.33 *8*	DCO=0.91 *10* δ: from γγ(θ). δ=4.2 +*22*−*12* is also allowed by γγ(θ) but less likely from δ=0.34 *3* calculated from branching ratio.
332.5 *3*	2.1	1946.9	6⁻	1614.4	(4⁻,5⁻)			DCO=0.8 *4*
339.0 *3*	38.9	3210.4	14⁺	2871.4	12⁺	E2[@]		DCO=1.02 *3*

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^{148}Sm(^{20}Ne,4nγ) 1987Bl06 (continued)

γ(^{164}Hf) (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ	Comments
355.1 *3*	5.2	2302.0	8⁻	1946.9	6⁻	Q[@]		DCO=1.00 *11*
376.4 *3*	100.0	587.2	4⁺	210.8	2⁺	E2[@]		DCO=0.84 *3* Additional information 3.
385.7 *3*	13.5	2961.8	12⁻	2576.1	10⁻	Q[@]		DCO=1.08 *9*
394.4 *3*	2.8	2698.8	11⁻	2304.5	10⁺	D[&]		DCO=0.60 *14*
408.8 *3*	14.5	2245.2	9⁻	1836.4	7⁻	Q[@]		DCO=0.91 *6*
425.8 *3*	2.9	1946.9	6⁻	1521.0	5⁻	(M1+E2)[a]	+0.41 *+19−14*	DCO=1.00 *15* δ: from $\gamma\gamma(\theta)$. δ=3.5 *+33−43* is also allowed by $\gamma\gamma(\theta)$.
453.6 *3*	19.1	2698.8	11⁻	2245.2	9⁻	E2[@]		DCO=0.87 *6* Additional information 5.
457.3 *3*	17.4	3156.1	13⁻	2698.8	11⁻	E2[@]		DCO=0.95 *4*
465.6 *3*	6.0	2302.0	8⁻	1836.4	7⁻	(M1+E2)[a]	+0.6 *+5−2*	DCO=1.26 *10* δ: from $\gamma\gamma(\theta)$. δ=1.0 *9* is also allowed.
468.4 *3*	33.8	3679.8	16⁺	3210.4	14⁺	E2[@]		DCO=1.00 *4*
498.2 *3*	90.4	1085.4	6⁺	587.2	4⁺	E2[@]		DCO=1.04 *4*
532.2 *3*	12.2	3494.0	14⁻	2961.8	12⁻	Q[@]		DCO=1.16 *8*
541.4 *10*	1.7	1614.4	(4⁻,5⁻)	1072.9	(3⁻)			DCO=0.93 *39*
545.0 *3*	19.0	3701.1	15⁻	3156.1	13⁻	Q[@]		DCO=0.97 *7*
566.9 *3*	49.2	2871.4	12⁺	2304.5	10⁺	E2[@]		DCO=0.97 *3*
[x]569.0 *3*	7.0							DCO=1.03 *8*
576.2 *3*	16.3	2245.2	9⁻	1668.9	8⁺	D[&]		DCO=0.43 *4*
583.7 *3*	<104.7	1668.9	8⁺	1085.4	6⁺	E2[@]		DCO=1.05 *3* I_γ: 104.7 for 583.7γ+584.2γ. DCO for doublet.
584.2 *3*	<104.7	4263.0	18⁺	3679.8	16⁺	E2		
592.9 *3*	13.6	5359.1	20⁻	4766.2	18⁻	Q[@]		DCO=1.21 *15*
[x]602 *1*	4.8							DCO=1.10 *20*
[x]607.3 *3*	10.2							DCO=1.32 *19*
622.8 *3*	<7.4	5981.9	22⁻	5359.1	20⁻	Q[@]		DCO=0.88 *9*
623.3 *3*	<7.4	3618.4	(14⁺)	2995.1	(12⁺)			DCO=1.24 *13* I_γ: 7.4 for 622.8γ+623.3γ.
[x]630.7 *10*	4.8							DCO=1.0 *3*
633.2 *3*	8.5	2302.0	8⁻	1668.9	8⁺	D		DCO=0.62 *24* Mult.: ΔJ=0, dipole from DCO.
634.8 *3*	<95.4	4335.9	17⁻	3701.1	15⁻	Q[@]		DCO=0.89 *5*
635.5 *3*	<95.4	4766.2	18⁻	4130.7	16⁻	Q[@]		DCO=1.03 *5*
635.6 *3*	<95.4	2304.5	10⁺	1668.9	8⁺	Q[@]		DCO=1.07 *4* I_γ: 95.4 for 634.8γ+635.5γ+635.6γ+636.7γ unresolved multiplet.
636.7 *3*	<95.4	4130.7	16⁻	3494.0	14⁻	Q[@]		DCO=1.05 *5*
659.8 *3*	9.4	5669.7	21⁻	5009.9	19⁻	(Q)[b]		DCO=0.78 *9* Additional information 6.
666.0 *3*	6.7	6335.7	23⁻	5669.7	21⁻	Q[@]		DCO=1.02 *8*
674.0 *3*	14.2	5009.9	19⁻	4335.9	17⁻	Q[@]		DCO=0.93 *5*
676.7 *3*	18.7	4939.7	20⁺	4263.0	18⁺	Q[@]		DCO=1.07 *3*

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^{148}Sm(^{20}Ne,4nγ) 1987Bl06 (continued)

γ(^{164}Hf) (continued)

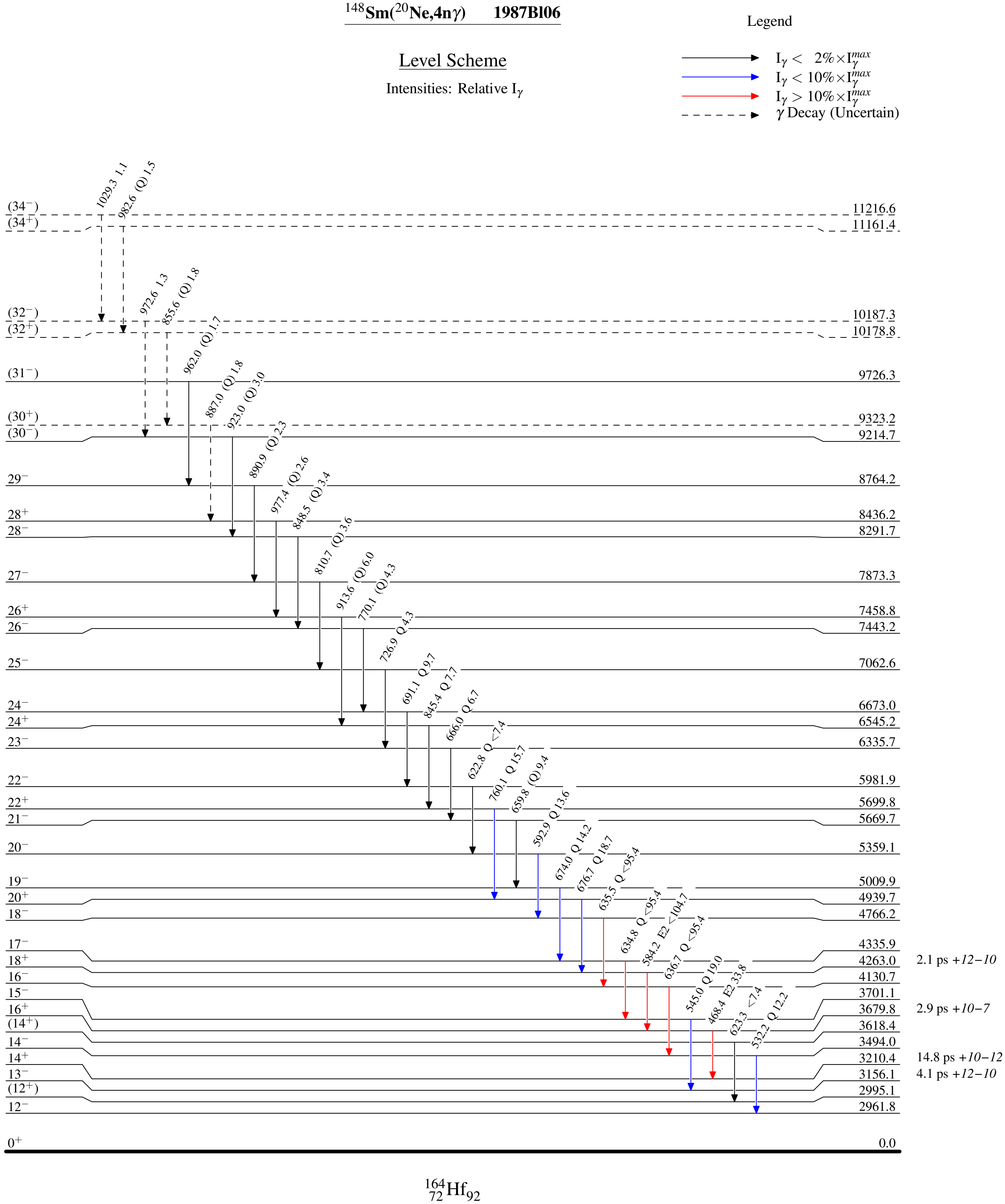
E$_\gamma$[†]	I$_\gamma$[‡]	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Mult.[#]	Comments
[x]682.7 *3*	6.2						DCO=1.06 *9*
690.5 *10*	3.7	2995.1	(12$^+$)	2304.5	10$^+$	(Q)[b]	DCO=1.23 *21*
691.1 *3*	9.7	6673.0	24$^-$	5981.9	22$^-$	Q[@]	DCO=0.96 *13*
[x]693.7 *3*	6.1						DCO=0.82 *22*
726.9 *10*	4.3	7062.6	25$^-$	6335.7	23$^-$	Q[@]	DCO=1.06 *16*
[x]742.1 *3*	5.0						DCO=0.96 *22*
750.9 *3*	18.9	1836.4	7$^-$	1085.4	6$^+$	D[&]	DCO=0.48 *7*
[x]756.8 *3*	5.7						DCO=1.16 *20*
760.1 *3*	15.7	5699.8	22$^+$	4939.7	20$^+$	Q[@]	DCO=1.04 *6*
770.1 *10*	4.3	7443.2	26$^-$	6673.0	24$^-$	(Q)[b]	DCO=0.77 *17* Additional information 7.
[x]780 *1*	3.2						
[x]784 *1*	4.8						
810.7 *10*	3.6	7873.3	27$^-$	7062.6	25$^-$	(Q)[b]	DCO=1.27 *28*
845.4 *3*	7.7	6545.2	24$^+$	5699.8	22$^+$	Q[@]	DCO=0.91 *6*
848.5 *10*	3.4	8291.7	28$^-$	7443.2	26$^-$	(Q)[b]	DCO=0.84 *23*
855.6[c] *10*	1.8	10178.8?	(32$^+$)	9323.2?	(30$^+$)	(Q)[b]	DCO=1.42 *35*
861.4[c] *10*	<2.8	1946.9	6$^-$	1085.4	6$^+$		I$_\gamma$: 2.8 for 861.4γ+862.1γ.
862.1 *10*	<2.8	1072.9	(3$^-$)	210.8	2$^+$		DCO=0.7 *3* I$_\gamma$: 2.8 for 861.4γ+862.1γ. DCO for doublet.
887.0[c] *10*	1.8	9323.2?	(30$^+$)	8436.2	28$^+$	(Q)[b]	DCO=1.18 *26*
890.9 *10*	2.3	8764.2	29$^-$	7873.3	27$^-$	(Q)[b]	DCO=1.02 *40*
913.6 *3*	6.0	7458.8	26$^+$	6545.2	24$^+$	(Q)[b]	DCO=0.82 *18*
923.0 *10*	3.0	9214.7	(30$^-$)	8291.7	28$^-$	(Q)[b]	DCO=0.66 *30*
933.5 *10*	4.0	1521.0	5$^-$	587.2	4$^+$	D[&]	DCO=0.69 *27*
962.0 *10*	1.7	9726.3	(31$^-$)	8764.2	29$^-$	(Q)[b]	DCO=1.32 *75*
972.6[c] *10*	1.3	10187.3?	(32$^-$)	9214.7	(30$^-$)		
977.4 *10*	2.6	8436.2	28$^+$	7458.8	26$^+$	(Q)[b]	DCO=1.31 *40*
982.6[c] *10*	1.5	11161.4?	(34$^+$)	10178.8?	(32$^+$)	(Q)[b]	DCO=1.39 *38*
1029.3[c] *10*	1.1	11216.6?	(34$^-$)	10187.3?	(32$^-$)		

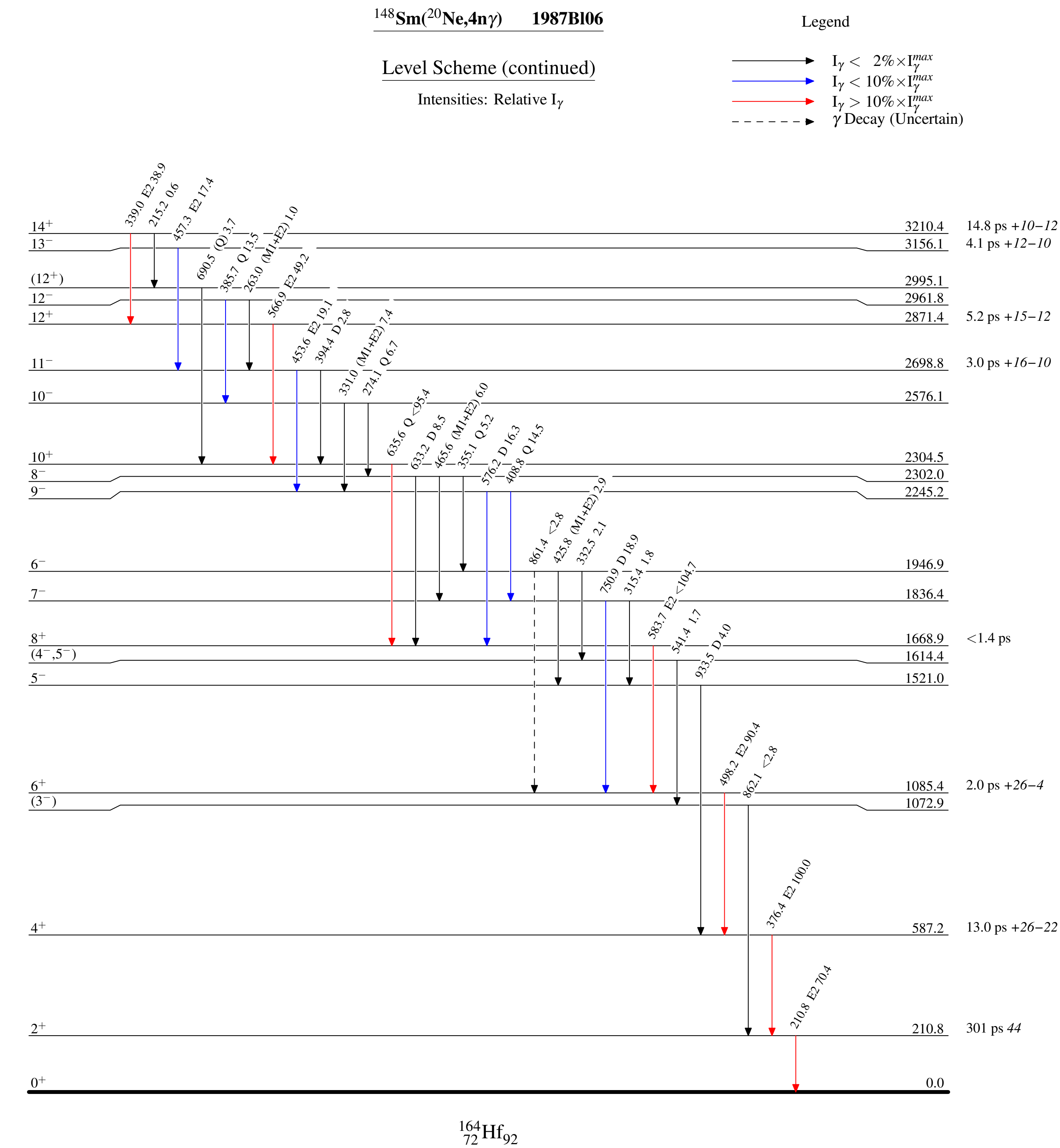
[†] Uncertainties are based on a general comment by 1987Bl06 that Δ(Eγ)=0.3 keV for most transitions, 1 keV for weak and high-energy transitions.
[‡] From spectra coincident with 211γ or 376γ. Uncertainties are <20% for Iγ<5, <10% for Iγ=5-20 and <5% for Iγ>20.
[#] Explicit assignments made by evaluators based on conclusions in 1987Bl06 for J^π assignments based on their DCO data.
[@] ΔJ=2, quadrupole (probable E2) from DCO. For levels of known half-lives, RUL used to assign E2.
[&] ΔJ=1, dipole (assigned E1 by 1987Bl06) transition from DCO.
[a] ΔJ=1, dipole+quadrupole from DCO, assigned as (M1+E2), as (E1+M2) admixture is less likely for in-band transitions.
[b] Possible ΔJ=2, quadrupole (likely to be E2) from DCO, however, large uncertainty for DCO allows ΔJ=1, D+Q or ΔJ=0 assignments.
[c] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

$^{148}Sm(^{20}Ne,4n\gamma)$ 1987Bl06

Level Scheme

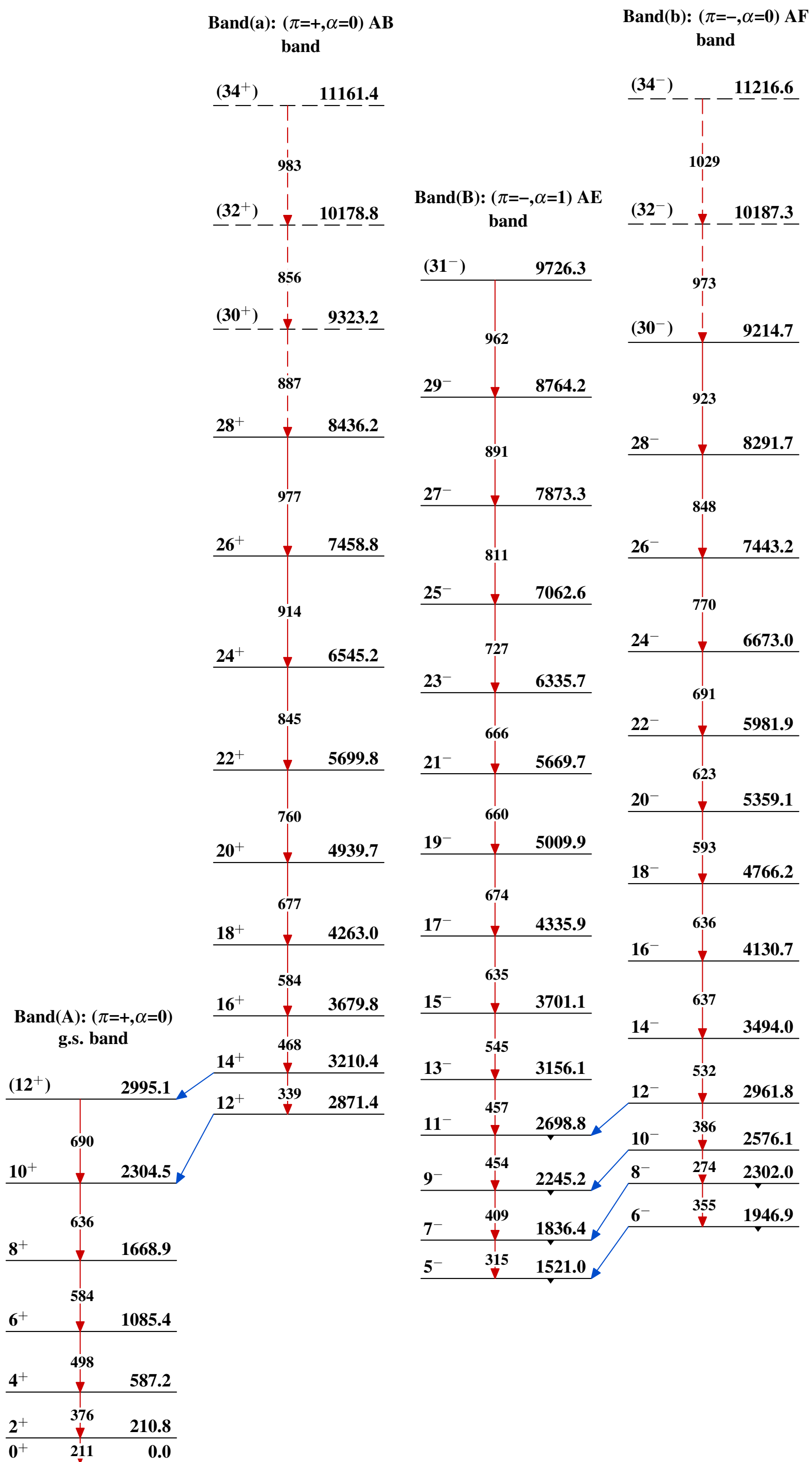
Intensities: Relative I_γ





148Sm(20Ne,4nγ) 1987Bl06
Level Scheme (continued)
Intensities: Relative Iγ
Legend
Iγ < 2%×Iγmax
Iγ < 10%×Iγmax
Iγ > 10%×Iγmax
γ Decay (Uncertain)
14+ 3210.4 14.8 ps +10−12
13− 3156.1 4.1 ps +12−10
(12+) 2995.1
12− 2961.8
12+ 2871.4 5.2 ps +15−12
11− 2698.8 3.0 ps +16−10
10− 2576.1
10+ 2304.5
8− 2302.0
9− 2245.2
6− 1946.9
7− 1836.4
8+ 1668.9 <1.4 ps
(4−,5−) 1614.4
5− 1521.0
6+ 1085.4 2.0 ps +26−4
(3−) 1072.9
4+ 587.2 13.0 ps +26−22
2+ 210.8 301 ps 44
0+ 0.0
339.0 E2 38.9
215.2 0.6
457.3 E2 17.4
690.5 (Q) 3.7
385.7 Q 13.5
263.0 (M1+E2) 1.0
566.9 E2 49.2
453.6 E2 19.1
394.4 D 2.8
331.0 (M1+E2) 7.4
274.1 Q 6.7
635.6 Q <95.4
633.2 D 8.5
465.6 (M1+E2) 6.0
355.1 Q 5.2
576.2 D 16.3
408.8 Q 14.5
861.4 <2.8
425.8 (M1+E2) 2.9
332.5 2.1
750.9 D 18.9
315.4 1.8
583.7 E2 <104.7
541.4 1.7
933.5 D 4.0
498.2 E2 90.4
862.1 <2.8
376.4 E2 100.0
210.8 E2 70.4
164 72 Hf 92

$^{148}Sm(^{20}Ne,4n\gamma)$ 1987Bl06



$^{164}_{72}Hf_{92}$