Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen	NDS 191,1 (2023)	22-Aug-2023

Q(β^-)=−8340 *syst*; S(n)=11070 *syst*; S(p)=240 *syst*; Q(α)=5276 *syst* 2021Wa16
ΔQ(β^-)=90, ΔS(n)=100, ΔS(p)=40, ΔQ(α)=13 (syst,2021Wa16).
S(2n)=20320 *50*, S(2p)=3560 *40*, Q(εp)=3980 *50*, Q(ε)=7260 *40* (syst,2021Wa16).
Q(α)=5409 *3* from Eα=5279 *3* (1982De11) if g.s. to g.s. α transition in the decay of ^{167}Re to ^{163}Ta.
1984Sc06: identification in excitation functions for ^{144}Sm(^{27}Al,xn) reactions (x=3 to x=5), Eα(Re) systematics, and theoretical half-life predictions (1973Ta30). 1984Sc06 reassign to ^{166}Re the Eα=5330 *10*, 2.0 s *3*, %$\alpha\approx$100 (1978Sc26) and the Eα=5440 *3* (1982De11) activity previously attributed to ^{167}Re, and, to ^{167}Re, the Eα=5140 *10*, 2.9 s *3* (1978Sc26) activity previously attributed to ^{168}Re along with their own observation of 5136 *9*, 6.1 s 2 α's. 1992Me10, however, reject 1984Sc06's assignments to ^{167}Re and reassign to ^{167}Re the 5250 *10*, 6.6 s *15* activity (attributed in 1984Sc06 to isomeric ^{168}Re), presumably along with the 5279 *3* (1982De11) and 5260 *10*, $T_{1/2}$=5.5 s *5* (1978Ca11) activities.
Additional information 1.
Theory for nuclear structure: 1992St01, 1984Al36.

^{167}Re Levels

Quasiparticle Labels:
A=$\nu i_{13/2}$1/2[660]; α=+1/2.
B=$\nu i_{13/2}$1/2[660]; α=−1/2.
E=$\nu h_{9/2}$5/2[523]; α=+1/2.
B_p=$\pi h_{11/2}$9/2[514]; α=+1/2.
A_p=$\pi h_{11/2}$9/2[514]; α=−1/2.

Cross Reference (XREF) Flags

A	^{167}Os ε decay (839 ms)
B	^{171}Ir α decay (3.2 s)
C	^{171}Ir α decay (1.27 s)
D	^{112}Sn(^{58}Ni,3pγ)

E(level)†	J$^\pi$‡	$T_{1/2}$	XREF	Comments
0.0#	(1/2$^+$)#	3.4 s *4*	B	%$\alpha\approx$100 %α: α decay observed, but no gammas associated with ε+β^+ decay could be identified (1992Me10). J$^\pi$: tentative configuration=π1/2[411], analogous to ^{161},^{163},^{165}Re. $T_{1/2}$: from 5015α decay curve (1992Me10).
0.0+x#@	(9/2$^-$)#	5.9 s *5*	CD	%ε+%$\beta^+\approx$99; %$\alpha\approx$1 %α: from 1992Me10, assuming the 137γ and 221γ observed following ε decay of this level represent total ε decay intensity. Supported by $T_{1/2}$=5.7 s *14* (1992Me10) from γ(^{167}W)(t), which suggests that ^{167}Re ε decay occurs predominantly from the 5.9-s activity. E(level),J$^\pi$: from systematics, and possible configuration=π9/2[514], analogous to g.s. of ^{169}Re. $T_{1/2}$: weighted average of 6.2 s *5* (from 5263α(t), 1992Me10), 6.6 s *15* (1984Sc06, originally assigned to isomeric ^{168}Re) and 5.5 s *5* (1978Ca11, originally assigned to ^{168}Re). Others: 5.6 s *19* from 137γ(t) and 5.8 s *22* following ε decay of ^{167}Re (1992Me10).
91.6+x& *1*	(11/2$^-$)		CD	J$^\pi$: tentative configuration=π11/2[505], analogous to ^{169}Re (1992Sc16). Unhindered α decay from (11/2$^-$) ^{171}Ir.

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Adopted Levels, Gammas (continued)

^{167}Re Levels (continued)

E(level)[†]	J^{π}[‡]	XREF
364.2+x[@] 6	(13/2⁻)	D
600.9+x[&] 7	(15/2⁻)	D
958.2+x[@] 8	(17/2⁻)	D
1240.4+x[&] 9	(19/2⁻)	D
1304.0+x[e] 9	(19/2⁻)	D
1364.6+x[d] 9	(15/2⁻)	D
1452.8+x[c] 8	(17/2⁻)	D
1576.0+x[d] 9	(19/2⁻)	D
1662.8+x[@] 10	(21/2⁻)	D
1695.0+x[e] 10	(21/2⁻)	D
1758.0+x[c] 10	(21/2⁻)	D
1959.0+x[d] 11	(23/2⁻)	D
1971.2+x[&] 11	(23/2⁻)	D
2008.0+x[e] 11	(23/2⁻)	D
2166.0+x[c] 12	(25/2⁻)	D
2325.0+x[b] 16	(27/2⁺)	D
2390.0+x?[d] 16	(27/2⁻)	D
2431.3+x[@] 11	(25/2⁻)	D
2478.8+x[a] 18	(29/2⁺)	D
2660.1+x[b] 18	(31/2⁺)	D
2742.2+x[&] 12	(27/2⁻)	D
2861.2+x 13	(27/2⁻)	D
2882.4+x[a] 18	(33/2⁺)	D
2947.3+x[@] 12	(29/2⁻)	D
3082.3+x[&] 14	(31/2⁻)	D
3146.3+x[b] 19	(35/2⁺)	D
3267.3+x[@] 16	(33/2⁻)	D
3436.3+x[a] 19	(37/2⁺)	D
3487.3+x[&] 16	(35/2⁻)	D
3744.3+x[@] 17	(37/2⁻)	D
3777.3+x[b] 20	(39/2⁺)	D
4035.3+x[&] 17	(39/2⁻)	D
4120.3+x[a] 21	(41/2⁺)	D
4366.3+x[@] 20	(41/2⁻)	D

† From a least-squares fit to γ-ray energies.

‡ As assigned by 2003Jo06 in ^{112}Sn(^{58}Ni,3pγ) for levels above 92 keV, based on band associations, decay modes, and multipolarity assignments for selected transitions.

\# The 3.4-s activity in ^{167}Re is assigned as the ground state with J^{π}=(1/2$^+$), and the 5.9-s activity with J^{π}=(9/2$^-$); the J^{π} assignment based on systematics: 1/2$^+$ g.s. and 11/2$^-$ isomer in ^{161},^{163},^{165}Re. The energy ordering of the two activities is guided by Eα=5015 keV *12* from the decay of the 3.4-s activity and Eα=5263 keV *12* from the 5.9-s activity. Note that 1992Me10 and 1992Sc16 assigned the 5.9-s activity as the g.s., considering this analogous to ^{169}Re g.s. However, 1992Me10 point out that for small deformations, the 75th proton is expected to occupy the π9/2[514] orbital but, with increasing deformation, the π1/2[411] and then the π5/2[402] orbital crosses the 9/2[514] orbital. Note that the decays of the two activities of ^{167}Re by α decay to ^{163}Ta in the ENSDF database (April 2010 update) are assigned as follows: 3.4 s *4* activity to (9/2$^-$)

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Adopted Levels, Gammas (continued)

^{167}Re Levels (continued)

ground state, and 5.9 s *3* activity to ($1/2^+$) isomer at ≈130 keV, with energy of the isomer taken from systematic trend. The same ordering and arrangement is given in 2021Ko07.

@ Band(A): $A_p \rightarrow A_pAB$. A_p at low spins; A_pAB at high spins.

& Band(a): $B_p \rightarrow B_pAB$. B_p at low spins; B_pAB at high spins.

[a] Band(B): A_pAE.

[b] Band(b): B_pAE.

[c] Band(C): Band based on ($17/2^-$). $\pi9/2[514]\otimes\gamma$−vibration or $\pi5/2[402]$ coupled to 2-quasineutron configuration of negative parity; α=+1/2.

[d] Band(c): Band based on ($15/2^-$). $\pi9/2[514]\otimes\gamma$−vibration or $\pi5/2[402]$ coupled to 2-quasineutron configuration of negative parity; α=−1/2.

[e] Seq.(D): γ cascade based on ($19/2^-$).

$\gamma(^{167}Re)$

E_i(level)	J^π_i	E_γ[†]	I_γ	E_f	J^π_f	Mult.[‡]	δ	α[#]	Comments
91.6+x	($11/2^-$)	91.6 *1*	100	0.0+x	($9/2^-$)	M1+E2	0.28 *15*	6.60 *12*	E_γ: other: 92.1 *2* in ^{171}Ir α decay (1.27 s). Mult.: ΔJ=1, dipole from (^{58}Ni,3pγ), M1+E2, δ=0.28 *15* from α(K)exp in ^{171}Ir α decay (1.27 s).
364.2+x	($13/2^-$)	272 *1*		91.6+x	($11/2^-$)	D			
		365 *1*		0.0	($1/2^+$)				
600.9+x	($15/2^-$)	237 *1*		364.2+x	($13/2^-$)				
		509 *1*		91.6+x	($11/2^-$)				
958.2+x	($17/2^-$)	357 *1*		600.9+x	($15/2^-$)				
		594 *1*		364.2+x	($13/2^-$)	Q			
1240.4+x	($19/2^-$)	282 *1*		958.2+x	($17/2^-$)				
		640 *1*		600.9+x	($15/2^-$)				
1304.0+x	($19/2^-$)	346@ *1*		958.2+x	($17/2^-$)				
		703 *1*		600.9+x	($15/2^-$)	Q			
1364.6+x	($15/2^-$)	764 *1*		600.9+x	($15/2^-$)				
		1000 *1*		364.2+x	($13/2^-$)				
1452.8+x	($17/2^-$)	88 *1*		1364.6+x	($15/2^-$)				
		494 *1*		958.2+x	($17/2^-$)				
		852 *1*		600.9+x	($15/2^-$)				
		1089 *1*		364.2+x	($13/2^-$)				
1576.0+x	($19/2^-$)	123 *1*		1452.8+x	($17/2^-$)				
		272 *1*		1304.0+x	($19/2^-$)				
		336 *1*		1240.4+x	($19/2^-$)				
		618 *1*		958.2+x	($17/2^-$)				
		975 *1*		600.9+x	($15/2^-$)				
1662.8+x	($21/2^-$)	422 *1*		1240.4+x	($19/2^-$)				
		705 *1*		958.2+x	($17/2^-$)				
1695.0+x	($21/2^-$)	242 *1*		1452.8+x	($17/2^-$)				
		391 *1*		1304.0+x	($19/2^-$)				
1758.0+x	($21/2^-$)	182 *1*		1576.0+x	($19/2^-$)	D			
		305 *1*		1452.8+x	($17/2^-$)				
		454 *1*		1304.0+x	($19/2^-$)				
1959.0+x	($23/2^-$)	201 *1*		1758.0+x	($21/2^-$)	D			
		383 *1*		1576.0+x	($19/2^-$)				
1971.2+x	($23/2^-$)	308 *1*		1662.8+x	($21/2^-$)				
		731 *1*		1240.4+x	($19/2^-$)	Q			
2008.0+x	($23/2^-$)	313 *1*		1695.0+x	($21/2^-$)				

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Adopted Levels, Gammas (continued)

$\gamma(^{167}Re)$ (continued)

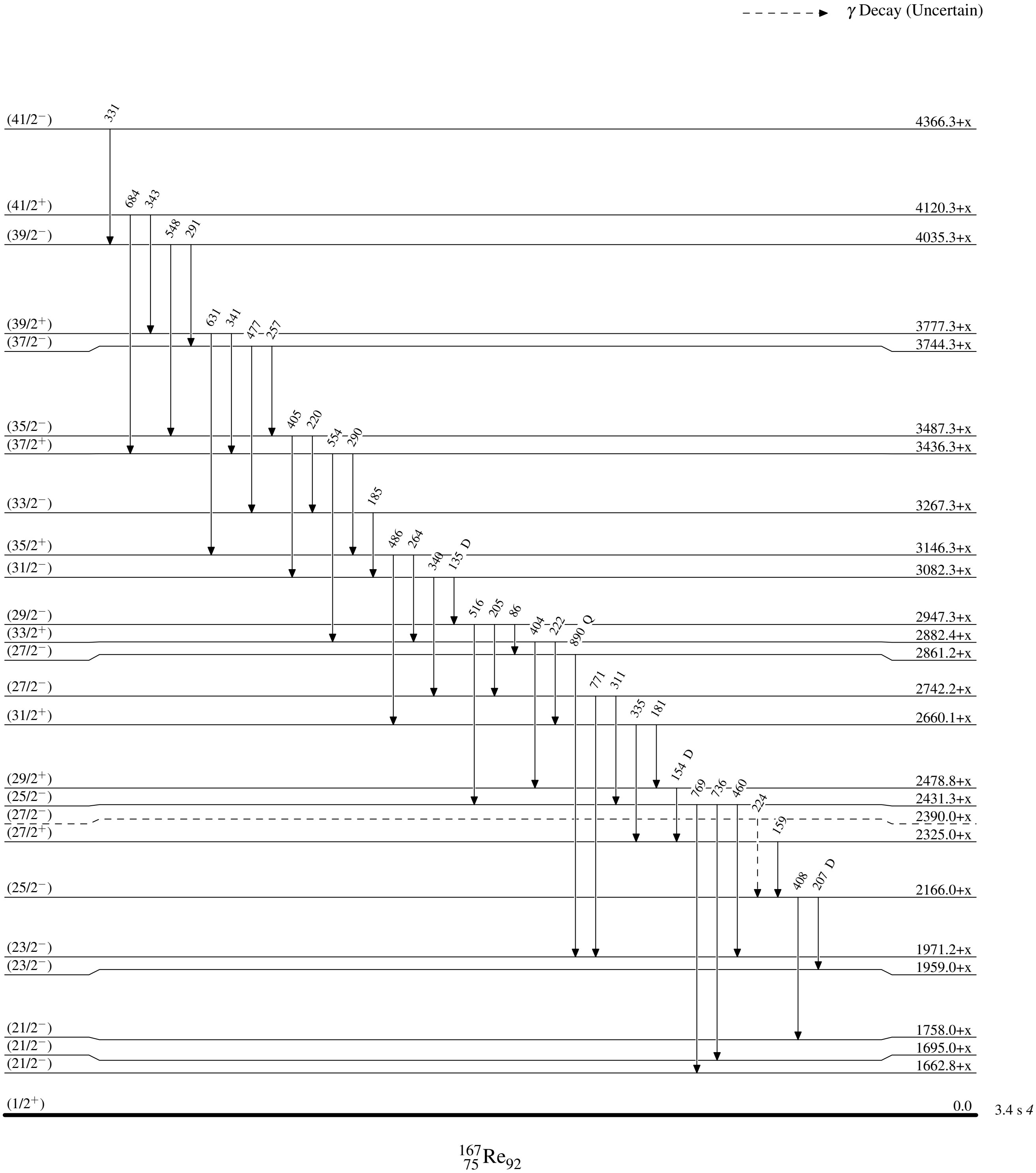
E_i(level)	J_i^π	E_γ †	E_f	J_f^π	Mult. ‡
2008.0+x	(23/2⁻)	704 *1*	1304.0+x	(19/2⁻)	
		768@ *1*	1240.4+x	(19/2⁻)	
2166.0+x	(25/2⁻)	207 *1*	1959.0+x	(23/2⁻)	D
		408 *1*	1758.0+x	(21/2⁻)	
2325.0+x	(27/2⁺)	159 *1*	2166.0+x	(25/2⁻)	
2390.0+x?	(27/2⁻)	224@ *1*	2166.0+x	(25/2⁻)	
2431.3+x	(25/2⁻)	460 *1*	1971.2+x	(23/2⁻)	
		736 *1*	1695.0+x	(21/2⁻)	
		769 *1*	1662.8+x	(21/2⁻)	
2478.8+x	(29/2⁺)	154 *1*	2325.0+x	(27/2⁺)	D
2660.1+x	(31/2⁺)	181 *1*	2478.8+x	(29/2⁺)	
		335 *1*	2325.0+x	(27/2⁺)	
2742.2+x	(27/2⁻)	311 *1*	2431.3+x	(25/2⁻)	
		771 *1*	1971.2+x	(23/2⁻)	
2861.2+x	(27/2⁻)	890 *1*	1971.2+x	(23/2⁻)	Q
2882.4+x	(33/2⁺)	222 *1*	2660.1+x	(31/2⁺)	
		404 *1*	2478.8+x	(29/2⁺)	
2947.3+x	(29/2⁻)	86 *1*	2861.2+x	(27/2⁻)	
		205 *1*	2742.2+x	(27/2⁻)	
		516 *1*	2431.3+x	(25/2⁻)	
3082.3+x	(31/2⁻)	135 *1*	2947.3+x	(29/2⁻)	D
		340 *1*	2742.2+x	(27/2⁻)	
3146.3+x	(35/2⁺)	264 *1*	2882.4+x	(33/2⁺)	
		486 *1*	2660.1+x	(31/2⁺)	
3267.3+x	(33/2⁻)	185 *1*	3082.3+x	(31/2⁻)	
3436.3+x	(37/2⁺)	290 *1*	3146.3+x	(35/2⁺)	
		554 *1*	2882.4+x	(33/2⁺)	
3487.3+x	(35/2⁻)	220 *1*	3267.3+x	(33/2⁻)	
		405 *1*	3082.3+x	(31/2⁻)	
3744.3+x	(37/2⁻)	257 *1*	3487.3+x	(35/2⁻)	
		477 *1*	3267.3+x	(33/2⁻)	
3777.3+x	(39/2⁺)	341 *1*	3436.3+x	(37/2⁺)	
		631 *1*	3146.3+x	(35/2⁺)	
4035.3+x	(39/2⁻)	291 *1*	3744.3+x	(37/2⁻)	
		548 *1*	3487.3+x	(35/2⁻)	
4120.3+x	(41/2⁺)	343 *1*	3777.3+x	(39/2⁺)	
		684 *1*	3436.3+x	(37/2⁺)	
4366.3+x	(41/2⁻)	331 *1*	4035.3+x	(39/2⁻)	

† From $^{112}Sn(^{58}Ni,3p\gamma)$.
‡ From angular asymmetry ratios in $^{112}Sn(^{58}Ni,3p\gamma)$.
# 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

Level Scheme

Intensities: Relative photon branching from each level



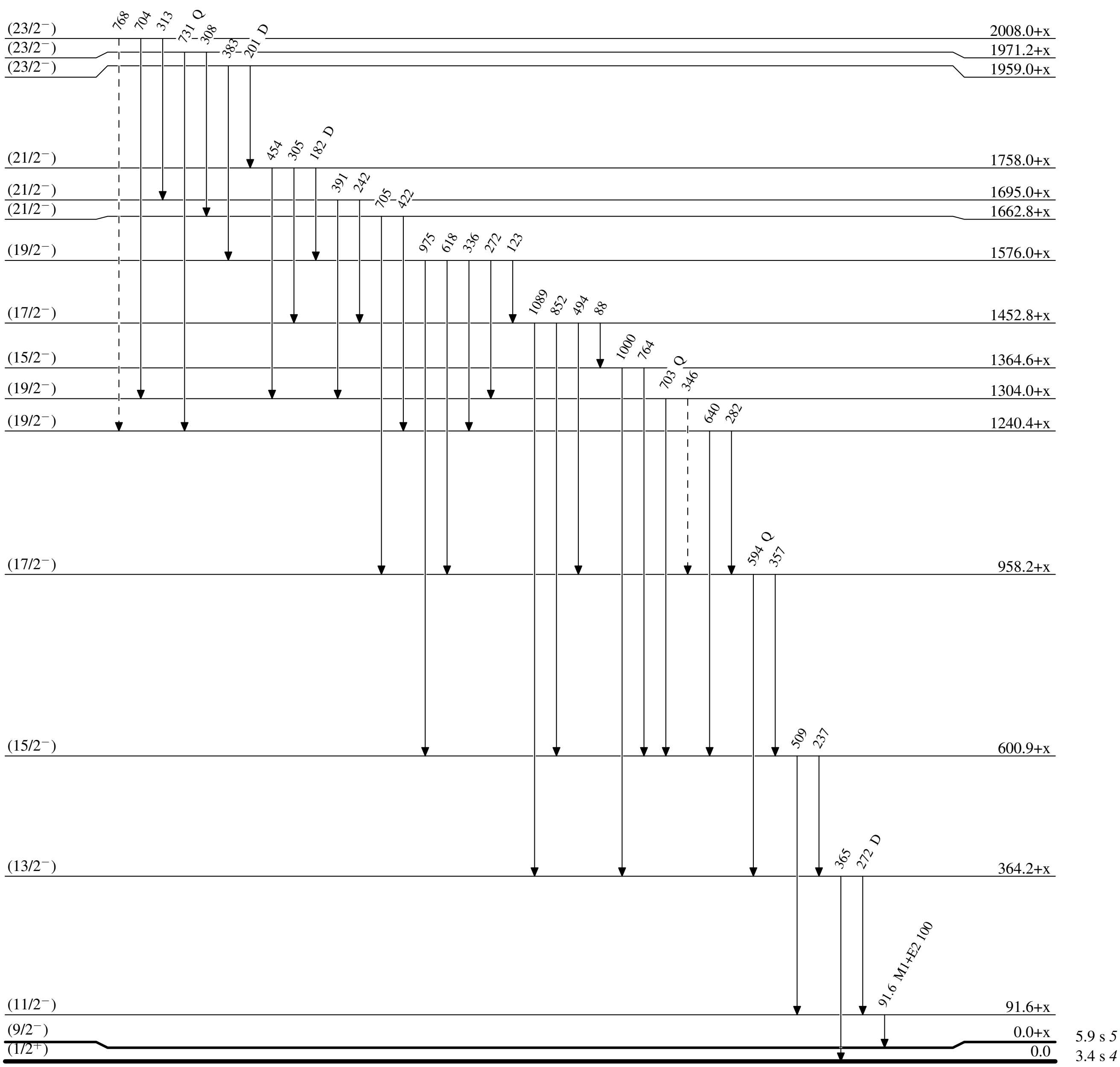
Adopted Levels, Gammas

Legend

Level Scheme (continued)

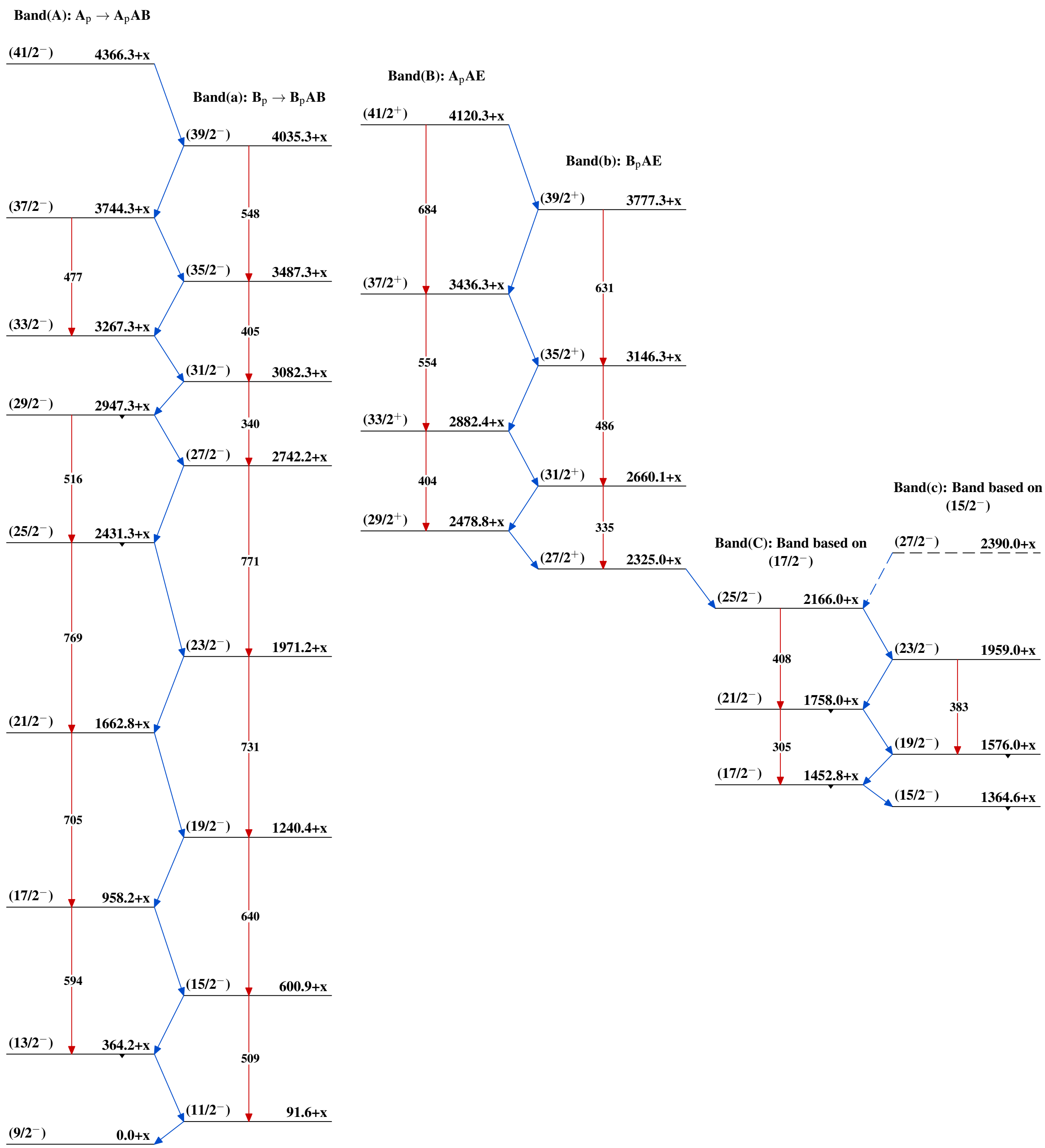
Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{167}_{75}Re_{92}$

Adopted Levels, Gammas



$^{167}_{75}Re_{92}$

Adopted Levels, Gammas (continued)