Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 176, 1 (2021)	1-May-2021

Q(β^-)=−4330 *60*; S(n)=8630 *70*; S(p)=1730 *60*; Q(α)=4140 *60* 2021Wa16
S(2n)=19200 *60*, S(2p)=6140 *60*, Q(εp)=3010 *60* (2021Wa16).

In addition to the well-established 36-s activity in ^{160}Lu, 1984Au13 report the existence of an activity with $T_{1/2}$=40 s *1*. The relative position in ^{160}Lu of the two levels corresponding to these activities has not yet been determined. It is assumed here that the 36-s activity is the ground state. From the observation that some gammas from low-spin states in the ^{160}Yb daughter decay with shorter half-lives than some from higher-spin states, 1984Au13 infer that the spin of the 36-s activity is lower than that of the 40-s activity.

All the data on the levels for which no $T_{1/2}$ values are given are from the ^{144}Sm(^{19}F,3nγ).

1995Hi12 report two γ rays, having Eγ=185.2 and Eγ=193.6, in ^{160}Lu that are associated with the $\varepsilon+\beta^+$ decay of ^{160}Hf. Their placement in the ^{160}Lu level scheme is not known at this time and essentially nothing else is known about the decay scheme of ^{160}Hf to ^{160}Lu. Consequently, no further mention of $\varepsilon+\beta^+$ decay of ^{160}Hf is made here.

For a discussion of the systematic features of signature inversion in (π $h_{11/2}$)(ν $i_{13/2}$) bands in nuclides in this mass region, see 1995Li40, 2001Ri19, 2003Ya19.

^{160}Lu Levels

Cross Reference (XREF) Flags

- A ^{160}Hf ε decay
- B ^{164}Ta α decay:not observed
- C ^{144}Sm(^{19}F,3nγ)

E(level)†	J$^\pi$‡	$T_{1/2}$	XREF	Comments
≥0.0#		36.1 s *3*		%ε+%β^+=100; %$\alpha\le 1\times10^{-4}$ $T_{1/2}$: weighted average of 36.2 s *3* (1984Au13), 36 s *1* (1981RaZH,1983Ge08) and 34.5 s *15* (1979Al16). %α: from 1981Ga36.
0.0+x#		40 s *1*		%ε+%$\beta^+\le$100; %α=? E(level): the position of this level relative to the ^{160}Lu g.s. has not yet been established. $T_{1/2}$: from 1984Au13.
0.0+y[e]	(6$^+$)		C	Additional information 1.
161.3+y[d] *10*	(7$^+$)		C	
323.4+y[e] *5*	(8$^+$)		C	
463.0+y[d] *8*	(9$^+$)		C	
558.5+y[@] *14*	(9$^-$)		C	
625.0+y[c] *10*	(8$^+$)		C	
669.5+y *14*	(10$^+$)		C	Possible isomeric state based on $\pi h_{11/2}\otimes\nu h_{9/2}$ configuration (2012Wa17).
705.7+y[e] *7*	(10$^+$)		C	
734.1+y[&] *14*	(10$^-$)		C	
810.6+y[@] *13*	(11$^-$)		C	
857.8+y[d] *8*	(11$^+$)		C	
933.2+y[c] *9*	(10$^+$)		C	
1058.6+y[&] *13*	(12$^-$)		C	
1160.6+y[e] *8*	(12$^+$)		C	
1217.8+y[@] *13*	(13$^-$)		C	
1264.3+y? *10*	(13$^+$)		C	

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Adopted Levels, Gammas (continued)

^{160}Lu Levels (continued)

E(level)†	Jπ‡	XREF	E(level)†	Jπ‡	XREF	E(level)†	Jπ‡	XREF
1337.8+y[d] *9*	(13$^+$)	C	2727.5+y[&] *12*	(18$^-$)	C	4175.5+y[&] *13*	(22$^-$)	C
1360.7+y[c] *8*	(12$^+$)	C	2957.0+y[a] *12*	(17$^+$)	C	4287.9+y[b] *12*	(22$^+$)	C
1522.4+y[&] *13*	(14$^-$)	C	3024.2+y[c] *11*	(18$^+$)	C	4392.0+y[c] *13*	(22$^+$)	C
1661.1+y[e] *9*	(14$^+$)	C	3040.8+y[@] *13*	(19$^-$)	C	4520.1+y[@] *13*	(23$^-$)	C
1730.8+y? *11*	(15$^+$)	C	3276.0+y[b] *12*	(18$^+$)	C	4608.8+y[a] *12*	(23$^+$)	C
1754.8+y[@] *13*	(15$^-$)	C	3416.6+y[a] *12*	(19$^+$)	C	4961.4+y[b] *13*	(24$^+$)	C
1854.4+y[c] *9*	(14$^+$)	C	3426.7+y[&] *13*	(20$^-$)	C	5001.8+y[&] *14*	(24$^-$)	C
1898.3+y[d] *9*	(15$^+$)	C	3657.0+y[c] *12*	(20$^+$)	C	5311.7+y[a] *13*	(25$^+$)	C
2085.4+y[&] *12*	(16$^-$)	C	3682.9+y[b] *12*	(20$^+$)	C	5379.8+y[@] *14*	(25$^-$)	C
2371.7+y[@] *12*	(17$^-$)	C	3752.2+y[@] *13*	(21$^-$)	C	5695.0+y[b] *13*	(26$^+$)	C
2422.4+y[c] *10*	(16$^+$)	C	3975.0+y[a] *12*	(21$^+$)	C			

† From least-squares fit to Eγ′s assuming 0.5 keV uncertainty for all Eγ′s.

‡ Where given, the J^π values are those suggested by 2012Wa17 also previously suggested in part by 2001Yi03 and 1995Su11 from ^{144}Sm(^{19}F,3nγ). See the comments there.

1984Au13 report two activities in ^{160}Lu, with half-lives of 36.2 s *3* and 40 s *1*.

@ Band(a): $\pi h_{11/2}\otimes\nu i_{13/2}$,α=1 Yrast band. From systematics in the neighboring isotopes and odd-odd nuclides, 1995Su11 propose K=5 for this band (at least for the lower-spin members) and suggest (π 9/2[514] + ν 1/2[660]) as a possible configuration.

& Band(A): $\pi h_{11/2}\otimes\nu i_{13/2}$,α=0. Yrast band − see the comment for the signature=1 branch.

[a] Band(b): π7/2[523]⊗ν(3/2[521]⊗$ni^2_{13/2}$),α=1. 7/2[523] from $h_{11/2}$ and 3/2[521] from $h_{9/2}$ orbitals.

[b] Band(B): π7/2[523]⊗ν(3/2[521]⊗$ni^2_{13/2}$),α=0. 7/2[523] from $h_{11/2}$ and 3/2[521] from $h_{9/2}$ orbitals.

[c] Band(C): π1/2[411]⊗ν1/2[660],α=0. 1/2[411] from $d_{3/2}$ and 1/2[660] from $i_{13/2}$ orbitals.

[d] Band(d): π5/2[402]⊗ν1/2[660],α=1. 5/2[402] from $d_{5/2}$ and 1/2[660] from $i_{13/2}$ orbitals.

[e] Band(D): π5/2[402]⊗ν1/2[660],α=0. 5/2[402] from $d_{5/2}$ and 1/2[660] from $i_{13/2}$ orbitals.

γ(^{160}Lu)

E_i(level)	J^π_i	E_γ†	I_γ‡	E_f	J^π_f	Mult.#
323.4+y	(8$^+$)	323.4	100	0.0+y	(6$^+$)	
463.0+y	(9$^+$)	301.7	100	161.3+y	(7$^+$)	
705.7+y	(10$^+$)	243.1		463.0+y	(9$^+$)	
		382.3		323.4+y	(8$^+$)	
734.1+y	(10$^-$)	175.7	100	558.5+y	(9$^-$)	
810.6+y	(11$^-$)	75.7		734.1+y	(10$^-$)	
		141.1		669.5+y	(10$^+$)	D[@]
		252.0	100	558.5+y	(9$^-$)	E2
857.8+y	(11$^+$)	152.5		705.7+y	(10$^+$)	
		394.3		463.0+y	(9$^+$)	
933.2+y	(10$^+$)	227.5		705.7+y	(10$^+$)	
		308.2		625.0+y	(8$^+$)	
1058.6+y	(12$^-$)	247.2	100	810.6+y	(11$^-$)	D
		325.4	8.2 *10*	734.1+y	(10$^-$)	E2
1160.6+y	(12$^+$)	302.3		857.8+y	(11$^+$)	
		454.9		705.7+y	(10$^+$)	
1217.8+y	(13$^-$)	159.1	100	1058.6+y	(12$^-$)	D
		407.0	91 *9*	810.6+y	(11$^-$)	E2
1337.8+y	(13$^+$)	177.5		1160.6+y	(12$^+$)	
		480.3		857.8+y	(11$^+$)	

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Adopted Levels, Gammas (continued)

γ(^{160}Lu) (continued)

E_i(level)	J_i^π	E_γ [†]	I_γ [‡]	E_f	J_f^π	Mult. [#]	Comments
1360.7+y	(12$^+$)	200.0		1160.6+y	(12$^+$)		
		427.5		933.2+y	(10$^+$)		
		503.2		857.8+y	(11$^+$)		
1522.4+y	(14$^-$)	304.5	100	1217.8+y	(13$^-$)	D	
		463.9	27 *3*	1058.6+y	(12$^-$)	E2	
1661.1+y	(14$^+$)	499.8	100	1160.6+y	(12$^+$)		
1754.8+y	(15$^-$)	232.3	83 *14*	1522.4+y	(14$^-$)	D	
		537.1	100	1217.8+y	(13$^-$)	E2	
1854.4+y	(14$^+$)	192.7		1661.1+y	(14$^+$)		
		493.9		1360.7+y	(12$^+$)		
		516.6		1337.8+y	(13$^+$)		E_γ: 524.6 given by 2012Wa17 is incorrect (see (^{144}Sm(^{19}F,3nγ) dataset).
		590.1		1264.3+y?	(13$^+$)		
1898.3+y	(15$^+$)	561.0	100	1337.8+y	(13$^+$)		
2085.4+y	(16$^-$)	330.1	100	1754.8+y	(15$^-$)	D	
		563.1	48 *6*	1522.4+y	(14$^-$)	E2	
2371.7+y	(17$^-$)	286.0	87 *14*	2085.4+y	(16$^-$)	D	
		617.1	100	1754.8+y	(15$^-$)	E2	
2422.4+y	(16$^+$)	524.6		1898.3+y	(15$^+$)		
		567.5		1854.4+y	(14$^+$)		
		691.6		1730.8+y?	(15$^+$)		
2727.5+y	(18$^-$)	355.5	100	2371.7+y	(17$^-$)	D	
		642.3	91 *9*	2085.4+y	(16$^-$)	E2	
2957.0+y	(17$^+$)	871.6	100	2085.4+y	(16$^-$)		
3024.2+y	(18$^+$)	601.8	100	2422.4+y	(16$^+$)		
3040.8+y	(19$^-$)	313.1	64 *8*	2727.5+y	(18$^-$)	D	
		669.2	100	2371.7+y	(17$^-$)	E2	
3276.0+y	(18$^+$)	904.6	100	2371.7+y	(17$^-$)	D	The DCO ratio indicates a dipole transition. From its high energy compared with the in-band M1 and E2 transitions, 2001Yi03 assume that this is rather E1 and, thus, that the two bands involved have opposite parity.
3416.6+y	(19$^+$)	140.7		3276.0+y	(18$^+$)		
		392.4		3024.2+y	(18$^+$)		
		459.5		2957.0+y	(17$^+$)		
		688.9	100	2727.5+y	(18$^-$)	D	The DCO ratio indicates a dipole transition. From its high energy compared with the in-band M1 and E2 transitions, 2001Yi03 assume that this is rather E1 and, thus, that the two bands involved have opposite parity.
3426.7+y	(20$^-$)	385.5	100	3040.8+y	(19$^-$)	D	
		699.3	87 *11*	2727.5+y	(18$^-$)	E2	
3657.0+y	(20$^+$)	632.8	100	3024.2+y	(18$^+$)		
3682.9+y	(20$^+$)	266.0	100	3416.6+y	(19$^+$)	D	
		407.2		3276.0+y	(18$^+$)		
3752.2+y	(21$^-$)	325.5	65 *9*	3426.7+y	(20$^-$)	D	
		711.7	100	3040.8+y	(19$^-$)	E2	
3975.0+y	(21$^+$)	292.0	100	3682.9+y	(20$^+$)	D	
		318.0		3657.0+y	(20$^+$)		
		558.3	51 *10*	3416.6+y	(19$^+$)	E2	
4175.5+y	(22$^-$)	423.1	100	3752.2+y	(21$^-$)	D	
		748.4	83 *12*	3426.7+y	(20$^-$)	E2	
4287.9+y	(22$^+$)	312.9	100	3975.0+y	(21$^+$)	D	
		605.3	59 *14*	3682.9+y	(20$^+$)	E2	
4392.0+y	(22$^+$)	735.0	100	3657.0+y	(20$^+$)		
4520.1+y	(23$^-$)	344.2	65 *13*	4175.5+y	(22$^-$)	D	
		768.5	100	3752.2+y	(21$^-$)	E2	
4608.8+y	(23$^+$)	320.5	100	4287.9+y	(22$^+$)	D	

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Adopted Levels, Gammas (continued)

$\gamma(^{160}Lu)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.[#]
4608.8+y	(23^+)	633.6	87 *27*	3975.0+y	(21^+)	E2
4961.4+y	(24^+)	352.3	100	4608.8+y	(23^+)	D
		674.0	69 *21*	4287.9+y	(22^+)	E2
5001.8+y	(24^-)	481.7		4520.1+y	(23^-)	
		826.2		4175.5+y	(22^-)	
5311.7+y	(25^+)	349.8	100	4961.4+y	(24^+)	D
		702.6	94 *19*	4608.8+y	(23^+)	E2
5379.8+y	(25^-)	859.7	100	4520.1+y	(23^-)	E2
5695.0+y	(26^+)	382.5	100	5311.7+y	(25^+)	D
		734.4	87 *26*	4961.4+y	(24^+)	E2

[†] From 2012Wa17 ($^{144}Sm(^{19}F,3n\gamma)$).

[‡] From 2001Yi03 ($^{144}Sm(^{19}F,3n\gamma)$) who give measured I$\gamma$ values with no unc as well as branching ratio values with unc (adopted conventionally by evaluator with the smaller intensity).

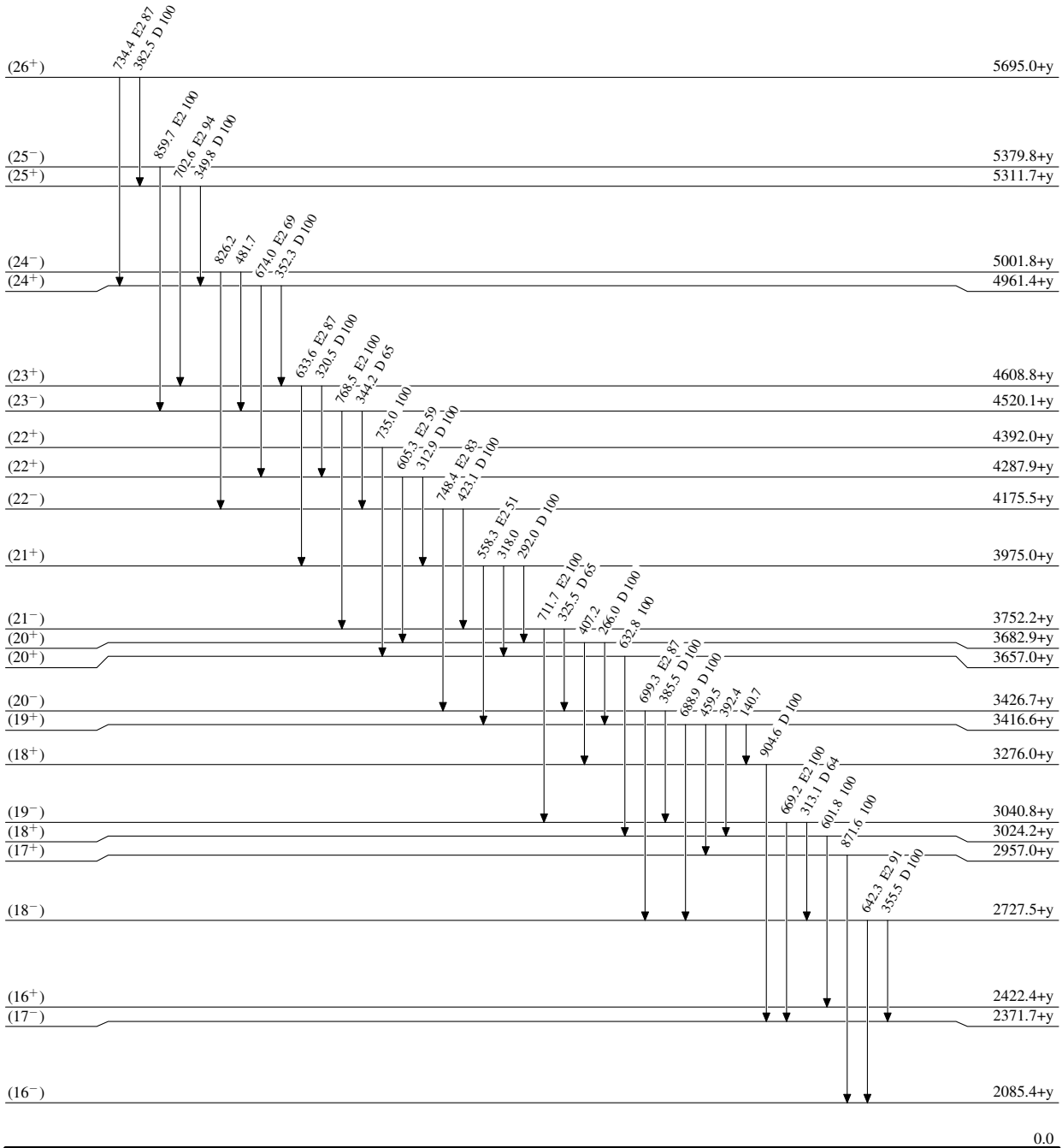
[#] Adopted by evaluator based on measured DCO ratio values by 2001Yi03 (with one exception of measurement done by 2012Wa17 noted separately). Based on the level scheme J^π assignments most of the D values are rather M1 (with possible admixture of E2) while the Q values are E2.

[@] From DCO ratio measured by 2012Wa17.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level

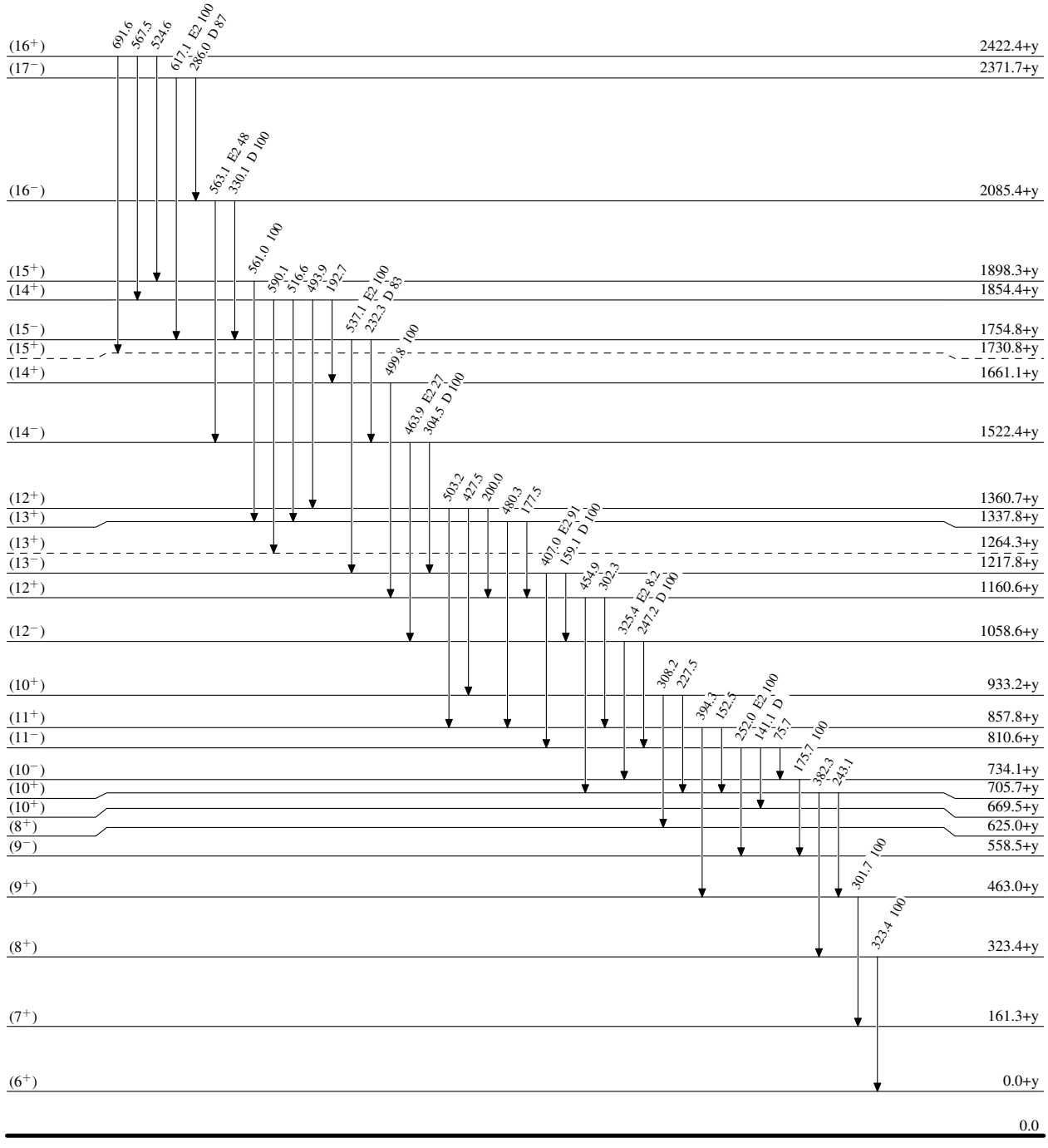


$^{160}_{71}Lu_{89}$

Adopted Levels, Gammas

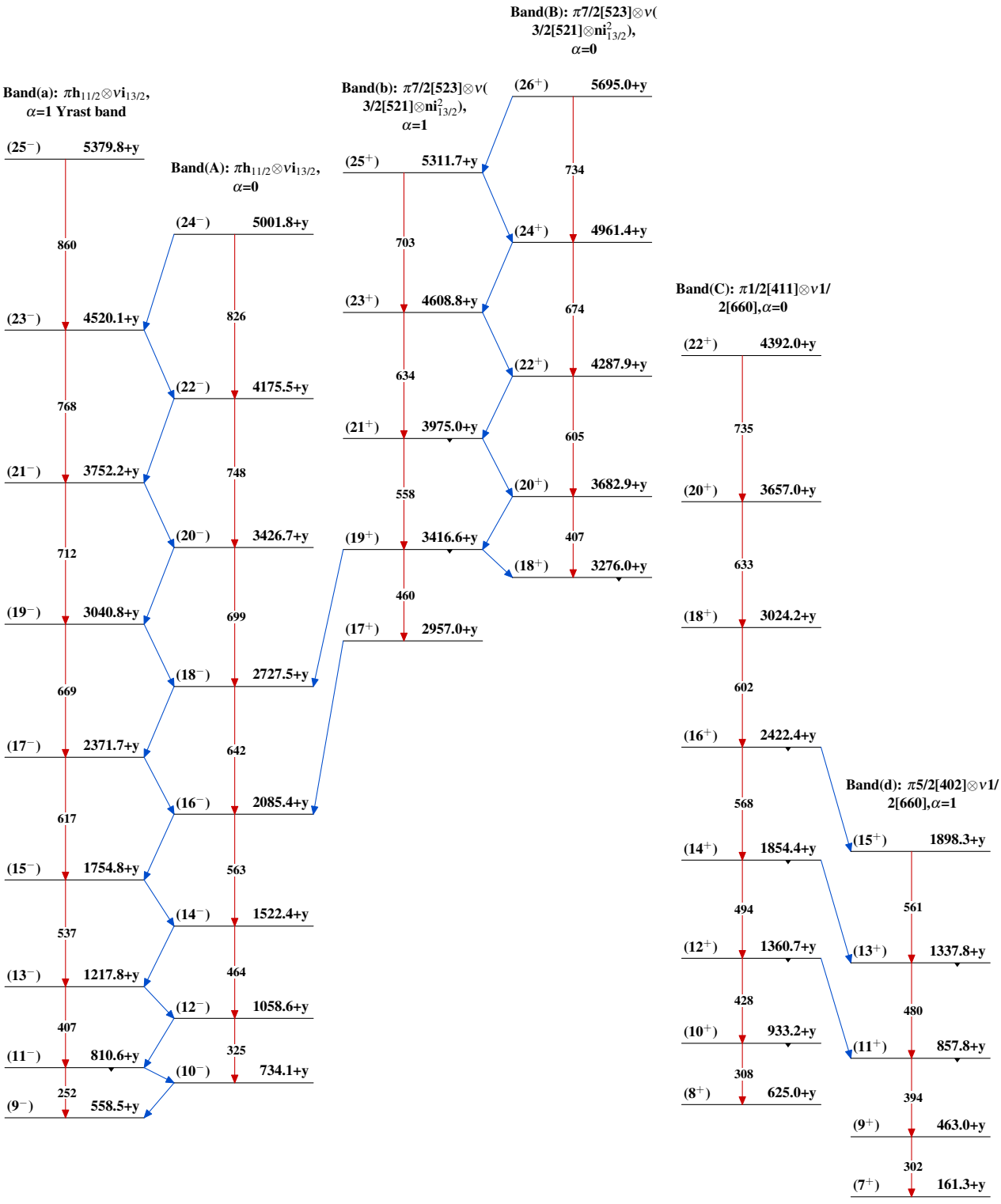
Level Scheme (continued)

Intensities: Relative photon branching from each level



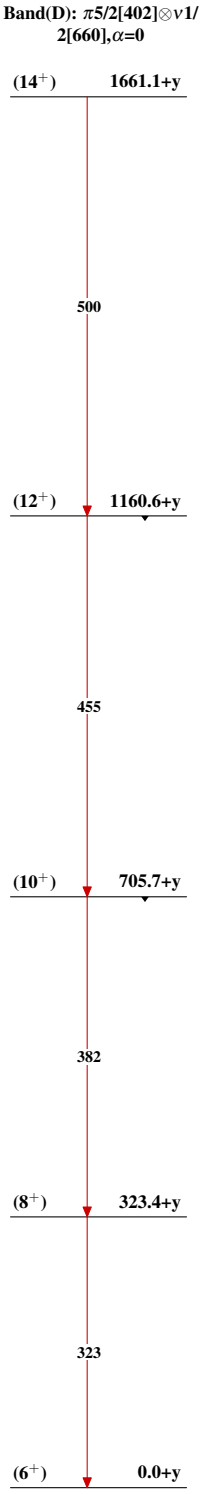
$^{160}_{71}Lu_{89}$

Adopted Levels, Gammas



$^{160}_{71}Lu_{89}$

Adopted Levels, Gammas (continued)



$^{160}_{71}Lu_{89}$