

$^{165}\text{Ho}(\text{n},\gamma)$ E=thermal: $\gamma\gamma$ coin 2000Pr10

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 109, 1103 (2008)	1-Mar-2008

2000Pr10: 99% purity Ho metal target; Ge x-ray detector ($E_\gamma=20\text{--}465$ keV; FWHM=1.39 keV At 305 keV), Ge detector ($E_\gamma=59\text{--}760$ keV; FWHM=2.2 keV At 305 keV); measured $\gamma\gamma$ coin (resolving time 23 ns). Additional data taken using 99.99% purity Ho oxide target; HPGE and Ge(Li) detectors (FWHM=1.9 and 2.1 keV, respectively, At 1332 keV). Measured E_γ , I_γ , $\gamma\gamma$ coin; deduced intermediate level energies for two-photon cascades to known low-energy states. See also 2000Pr03 (included In $^{165}\text{Ho}(\text{n},\gamma)$ E=thermal data set) which incorporates some of these results.

 ^{166}Ho Levels

E(level) [†]	Comments
0.0	
54.3 [‡]	
82.6 [‡]	
171.1 [‡]	
180.5 [‡]	
191.7 [‡]	
262.1 [‡]	E(level): probably includes both the 260.7 and 263.8 levels from Adopted Levels.
329.9 [‡]	
348.4 [‡]	
372.1 [‡]	E(level): probably includes both the 372.0 and 373.1 levels from Adopted Levels.
416.2 [‡]	
430.1 10	
453.9 [‡]	
475.9 12	
483.1 11	
522.2 [‡]	
543.0 8	
548.1 [‡]	
563.7 11	
593.8 7	corresponds to adopted level At 592.5.
599.5 18	E(level): probably a multiplet including the adopted 597.0 and 598.4 levels.
651.5 8	
658.1 5	
668.3 4	
683.3 15	
701.5 16	No other evidence exists for this level.
717.0 14	
719.7 15	
757.7 10	
770.3 7	
790.1 20	possibly a doublet including the adopted 788.6 and 792.8 levels, but γ deexcitation pattern agrees with neither.
807.9 20	probable multiplet; levels adopted At 806.6 and 807.0 could not have been resolved In this experiment and the presence of an additional level cannot Be ruled out. A 434 γ and 546 γ are known to deexcite the adopted 806.6 level but they should Be accompanied by much stronger 336 γ and 325 γ , neither of which is seen here.
816.0 10	
826.1 16	
832.7 12	
873.6 24	probable multiplet including levels adopted At 870 and 876.
881.9 9	possible multiplet including levels adopted At 881.2 and 884.0.
891 5	possible multiplet including levels adopted At 885.4, 891.1 and 895.5.
906.0 10	

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$^{165}\text{Ho}(\text{n},\gamma)$ E=thermal: $\gamma\gamma$ coin 2000Pr10 (continued) ^{166}Ho Levels (continued)

E(level) [†]	Comments
947.1 6	
953.4 11	
960.3 18	
973.7 18	
996.8 8	
1004.9 9	
1010.5 6	
1014.6 19	
1023.3 7	
1028.7 15	
1029.0 12	
1030.2 7	
1035.8 6	
1053.9 7	
1060.8 6	
1062.7 9	adopted J=2,4 for this level but the proposed deexciting gammas feed levels with J ^π including 5 ⁺ and 4 ⁻ and 1 ⁻ , so some placements are presumably incorrect.
1087.8 10	
1099.8 11	
1115.3 12	possible doublet; levels are adopted At 1114.7 and 1118.7.
1121.2 7	
1134.3 15	this May Be a doublet; levels are adopted At 1131.0 and 1135.0.
1137.9 5	
1143.4 16	
1155.5 27	
1161.5 10	
1166.2 18	possible doublet; E _γ values for deexciting transitions consistent with levels At 1164 and 1167 keV.
1189.9 11	

[†] Authors' values. these have larger and more realistic uncertainties than would Be obtained from a least-squares fit to the E_γ data. Further, it should Be noted that the level density is high and, In some cases, the energies are for multiplets.

[‡] Difference between capture state energy and energy of gate for sum spectrum (2000Pr10).

 $\gamma(^{166}\text{Ho})$

E _i (level)	E _γ [†]	I _γ [‡]	E _f	Comments
430.1	238.5 1	5.7 4	191.7	
475.9	304.2 2	2.5 3	171.1	
	420.5 6	0.5 2	54.3	
483.1	220.1 4	0.6 1	262.1	probably feeds the adopted 260.7 level.
	303.6 5	0.5 1	180.5	placement not adopted; E _γ expected from Adopted Gammas is 301.4 and I(304γ)/I(220γ) here is much too large for the 304γ to have been unnoticed In independent studies In which the 220γ was observed.
543.0	488.0 8	0.3 1	54.3	
	543.8 7	5.0 15	0.0	I(544γ)/I(488γ) is much larger than the adopted value; possibly, γ is contaminated In this experiment.
563.7	391.6 6	0.4 1	171.1	
	508.2 8	0.3 1	54.3	
593.8	401.5 2	2.3 3	191.7	
	414.0 6	0.3 1	180.5	
599.5	408.8 6	0.5 1	191.7	based on E _γ , this γ probably deexcites the 598.4 level.
	421.7 7	0.3 1	180.5	not included In Adopted Gammas; this E _γ implies a level At 602.2 7 for which No other evidence exists.

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$^{165}\text{Ho}(n,\gamma)$ E=thermal: $\gamma\gamma$ coin 2000Pr10 (continued) $\gamma(^{166}\text{Ho})$ (continued)

$E_i(\text{level})$	$E_\gamma^\dagger$	$I_\gamma^\ddagger$	E_f	Comments
599.5	426.7 4	0.9 2	171.1	probably a doublet deexciting both the adopted 597.0 and 598.4 levels. from adopted branching for 597 level, $I(427\gamma)/I(543\gamma)=0.069\ 27$, so $I(427\gamma)$ from 597 level expected here is 0.07 3 leaving 0.83 20 to deexcite the 598 level.
	543.1 4	1.0 2	54.3	deexcites 597.0 level.
651.5	304.1 7	0.8 3	348.4	
	596.6 6	0.4 1	54.3	
658.1	328.2 4	1.3 3	329.9	
	477.5 7	0.3 1	180.5	
668.3	488.0 5	0.3 1	180.5	
	613.9 6	0.5 1	54.3	I_γ : $I(614\gamma)/I(488\gamma)$ is much larger than the adopted value; possibly, γ is contaminated In this reaction.
683.3	491.6 7	0.3 1	191.7	not included In Adopted Gammas; none of the previously-known transitions from the 683 level is present and No γ with this energy has been reported In (n,γ) E=thermal.
701.5	369.6 10	0.7 3	329.9	
717.0	456.0 1	7.1 5	262.1	probably deexcites the 719.7 level instead; see comment on 347.6 γ . E_γ would Be consistent with placement from the 719.7 level if γ fed the 263.8 (rather than the 260.7) member of the 262.1-keV doublet.
	715.4 8	3.3 11	0.0	
719.7	347.6 7	0.8 3	372.1	based on Adopted Gammas, this γ should Be accompanied by an order of magnitude stronger 455.6 γ ; probably the 456.0 γ which 2000Pr10 place from a separate 717.0 level.
757.7	426.9 9	0.6 3	329.9	omitted from Adopted Gammas; I_γ too large for transition to have been missed In (n,γ) E=thermal.
	578.1 7	0.3 1	180.5	
770.3	421.9 5	1.9 5	348.4	
790.1	598.4 7	0.2 1	191.7	May deexcite the adopted 788.6 or 792.8 level but other gammas known to deexcite those levels are not seen here and No γ with the appropriate energy for the former placement has been reported In (n,γ) E=thermal. Not included In Adopted Gammas.
807.9	394.8 9	0.9 3	416.2	presumably does not deexcite either 806.6 or 807.0 level because those placements would imply E3 or M4 multipolarity, respectively. omitted from Adopted Levels, Gammas.
	433.1 8	0.3 1	372.1	deexcites the 806.6 level In Adopted Levels, Gammas.
	479.2 11	0.4 2	329.9	not included In Adopted Gammas because it is unclear which member of a probable 808 multiplet is deexcited by IT.
	545.4 5	0.5 1	262.1	deexcites the 806.6 level In Adopted Levels, Gammas.
	628.4 8	0.4 2	180.5	not included In Adopted Gammas because it is unclear which member of a probable 808 multiplet is deexcited by IT.
816.0	401.4 2	5.8 8	416.2	not included In Adopted Gammas; E_γ fits placement poorly and γ is far too strong to have been overlooked In other studies that excited this level.
	442.6 2	2.4 3	372.1	
	485.2 10	0.5 2	329.9	the evaluator considers this placement to Be doubtful since it implies M2 multipolarity for the 485 γ .
	554.4 3	1.1 2	262.1	
	624.1 1	3.9 3	191.7	
826.1	456.3 4	0.7 2	372.1	placement not adopted. this E_γ would imply the existence of a level for which No other evidence exists.
	563.3 5	0.5 1	262.1	
	633.2 3	1.4 2	191.7	
832.7	652.2 7	0.3 1	180.5	
873.6	546.6 5	1.5 3	329.9	
	614.6 9	0.3 1	262.1	
	692.4 7	0.3 1	180.5	
	790.0 10	0.5 2	82.6	
	816.1 4	1.0 2	54.3	based on E_γ , this γ probably deexcites the 870 level In Adopted Levels.
881.9	511.5 2	4.9 5	372.1	not included In Adopted Levels, Gammas. presumably does not deexcite 882 level because it is too strong to have been overlooked In other studies; also E_γ fits placement poorly.
	620.5 7	0.6 2	262.1	
	690.2 4	0.7 2	191.7	

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$^{165}\text{Ho}(n,\gamma)$ E=thermal: $\gamma\gamma$ coin 2000Pr10 (continued) $\gamma(^{166}\text{Ho})$ (continued)

$E_i(\text{level})$	$E_\gamma^\dagger$	$I_\gamma^\ddagger$	E_f	Comments
881.9	708.9 6	0.5 1	171.1	deexcites level adopted At 881.1 keV.
	798.3 4	3.0 5	82.6	deexcites level adopted At 881.1 keV.
	826.9 3	2.0 3	54.3	deexcites level adopted At 881.1 keV.
891	519.0 7	0.6 2	372.1	
	545.7 6	1.2 4	348.4	E_γ suggests that this γ deexcites the level adopted At 895.5. Not included In Adopted Gammas.
	626.6 7	0.4 1	262.1	
	708.6 10	0.3 2	191.7	not included In Adopted Gammas; E_γ implies that it deexcites a level At 899.5 keV.
	714.7 5	0.7 2	171.1	E_γ suggests that this γ deexcites the level adopted At 885.4. Not included In Adopted Gammas.
	716.1 7	0.8 3	180.5	E_γ suggests that this γ deexcites the level adopted At 895.5. Not included In Adopted Gammas.
	805.4 7	1.2 3	82.6	not included In Adopted Gammas; E3 multipolarity required if γ deexcites the 891.1 level.
906.0	714.3 1	5.1 4	191.7	
	734.4 3	0.6 1	171.1	
947.1	774.9 3	0.7 1	171.1	
	892.4 5	1.3 3	54.3	
953.4	624.6 10	0.5 2	329.9	
	898.1 10	0.4 2	54.3	
960.3	542.6 7	1.0 3	416.2	
	700.1 3	1.3 2	262.1	
	875.9 9	0.5 2	82.6	from Adopted Levels, Gammas, this placement implies M2 multipolarity and that seems unlikely.
973.7	889.2 10	0.5 2	82.6	
	921.1 9	0.3 1	54.3	
996.8	543.5 10	1.2 5	453.9	
	624.2 5	0.6 2	372.1	
	736.1 10	0.2 1	262.1	
1004.9	634.3 8	0.3 1	372.1	
	824.3 4	1.0 2	180.5	
	950.0 4	2.5 5	54.3	
1010.5	679.9 8	0.7 2	329.9	
	838.1 6	0.5 1	171.1	
1014.6	596.1 7	1.0 3	416.2	
	825.1 11	0.2 1	191.7	
	961.2 5	1.6 3	54.3	
1023.3	831.3 12	0.2 1	191.7	
	842.8 7	0.3 1	180.5	
1028.7	552.6 9	0.6 3	475.9	
1029.0	599.5 4	2.6 5	430.1	
	765.3 11	0.4 2	262.1	
1030.2	614.5 4	1.9 4	416.2	not included In Adopted Levels, Gammas because proposed placement implies M2 multipolarity.
	657.5 4	0.9 2	372.1	not included In Adopted Levels, Gammas because proposed placement implies E3 multipolarity.
	681.1 6	1.1 3	348.4	
	700.8 4	1.7 3	329.9	
	769.9 4	1.4 3	262.1	
	838.9 7	2.2 9	191.7	
	849.2 7	0.4 1	180.5	
	857.3 4	0.9 2	171.1	
	947.7 2	13.5 13	82.6	not included In Adopted Levels, Gammas because proposed placement implies E3 multipolarity.
	975.4 6	0.8 2	54.3	not included In Adopted Levels, Gammas because proposed placement implies M2 multipolarity.
1035.8	664.3 8	0.4 1	372.1	

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$^{165}\text{Ho}(\text{n},\gamma) \text{E=thermal: } \gamma\gamma \text{ coin}$ **2000Pr10** (continued) $\gamma(^{166}\text{Ho})$ (continued)

$E_i(\text{level})$	$E_\gamma^\dagger$	$I_\gamma^\ddagger$	E_f	Comments
1035.8	952.4 9	1.9 8	82.6	
	981.6 9	0.4 2	54.3	
	1036.2 8	3.5 3	0.0	
1053.9	999.6 11	0.3 1	54.3	
1060.8	689.1 1	5.3 4	372.1	
	798.1 9	0.2 1	262.1	
1062.7	586.1 2	4.0 5	475.9	
	646.1 2	7.3 9	416.2	
	716.0 7	1.0 3	348.4	
	734.0 7	0.6 2	329.9	
	871.8 9	0.2 1	191.7	
	881.1 9	0.5 2	180.5	
	979.3 7	0.9 3	82.6	
	1008.5 4	1.1 2	54.3	
1087.8	715.6 3	1.0 2	372.1	
	826.8 9	0.3 1	262.1	
	894.0 9	0.2 1	191.7	
	906.9 7	0.4 1	180.5	
	916.1 7	0.4 1	171.1	
	1034.3 7	0.5 2	54.3	
1099.8	623.6 8	0.5 2	475.9	May Be misplaced; Adopted Levels, Gammas implies that this would Be an E3 transition.
	753.1 10	0.6 3	348.4	
	836.8 8	0.3 1	262.1	
1115.3	567.5 5	1.6 5	548.1	
	595.9 14	0.8 4	522.2	tentatively placed from a 1118.7 level In Adopted Levels, Gammas.
	661.3 2	14.5 15	453.9	
	743.1 10	0.2 1	372.1	
	765.9 3	3.2 5	348.4	
	853.7 3	2.5 3	262.1	
	943.2 9	0.4 1	171.1	
1121.2	704.4 9	0.8 3	416.2	
	791.9 11	0.5 2	329.9	
	940.0 6	0.8 2	180.5	
	949.2 6	0.6 2	171.1	
1134.3	761.5 6	0.4 1	372.1	
	873.9 6	0.8 2	262.1	
	942.2 7	0.3 1	191.7	
	951.4 12	0.4 1	180.5	
1137.9	957.4 3	1.4 2	180.5	
1143.4	816.2 10	0.5 2	329.9	not included In Adopted Levels, Gammas; fits placement from known 1141.3 level very poorly.
	950.3 6	0.4 1	191.7	
1155.5	683.4 4	1.8 3	475.9	
	701.7 9	1.2 5	453.9	
	787.1 4	1.4 3	372.1	
	806.5 7	0.8 3	348.4	
	825.5 11	0.5 2	329.9	
	892.1 8	0.4 2	262.1	
	959.0 7	0.3 1	191.7	not included In Adopted Levels, Gammas; fits placement very poorly.
	983.3 6	0.6 2	171.1	
	1099.0 5	0.8 2	54.3	
1161.5	612.7 6	1.5 4	548.1	
	732.1 5	1.8 4	430.1	
	813.3 6	1.0 3	348.4	
	831.3 7	1.1 3	329.9	
	898.8 5	1.0 2	262.1	

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$^{165}\text{Ho}(\text{n},\gamma) \text{E=thermal: } \gamma\gamma \text{ coin } 2000\text{Pr10 (continued)}$ $\gamma(^{166}\text{Ho})$ (continued)

$E_i(\text{level})$	$E_\gamma^\dagger$	$I_\gamma^\ddagger$	E_f	Comments
1161.5	981.0 7	0.5 1	180.5	
	989.6 3	1.5 3	171.1	
1166.2	689.1 5	1.4 3	475.9	not included In Adopted Levels, Gammas; fits placement from known 1168.4 level very poorly.
	713.6 6	2.4 6	453.9	
	791.8 7	0.8 2	372.1	not included In Adopted Levels, Gammas; fits placement from known 1168.4 level very poorly.
	976.9 7	0.4 1	191.7	
1189.9	712.6 7	0.5 2	475.9	
	928.7 5	0.8 2	262.1	

[†] From [2000Pr10](#), uncertainties May have been underestimated. This experiment reports a number of transitions with energies above the 735 keV cutoff for data from the (n, γ) E=thermal study In [1967Mo05](#) but is insensitive to the lowest energy transitions.

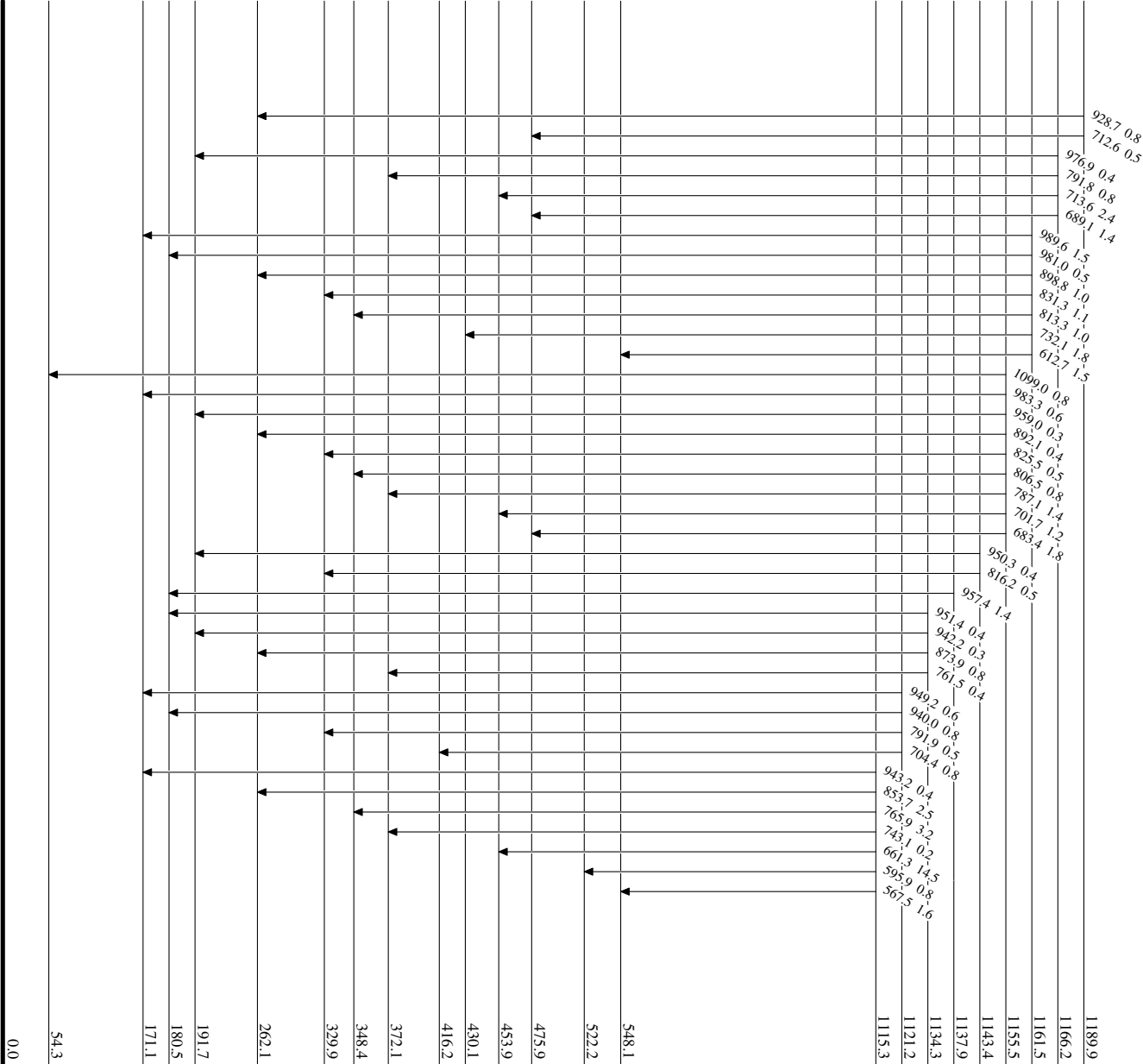
[‡] Two-photon cascade intensity normalized so that area of experimental spectrum In range $520 < E_\gamma < (\text{cascade energy} - 520)$ was 100% for each final level.

^x γ ray not placed in level scheme.

$^{165}\text{Ho}(n,\gamma)$ E=thermal: $\gamma\gamma$ coin 2000Pr10

Level Scheme

Intensities: Relative photon branching from each level

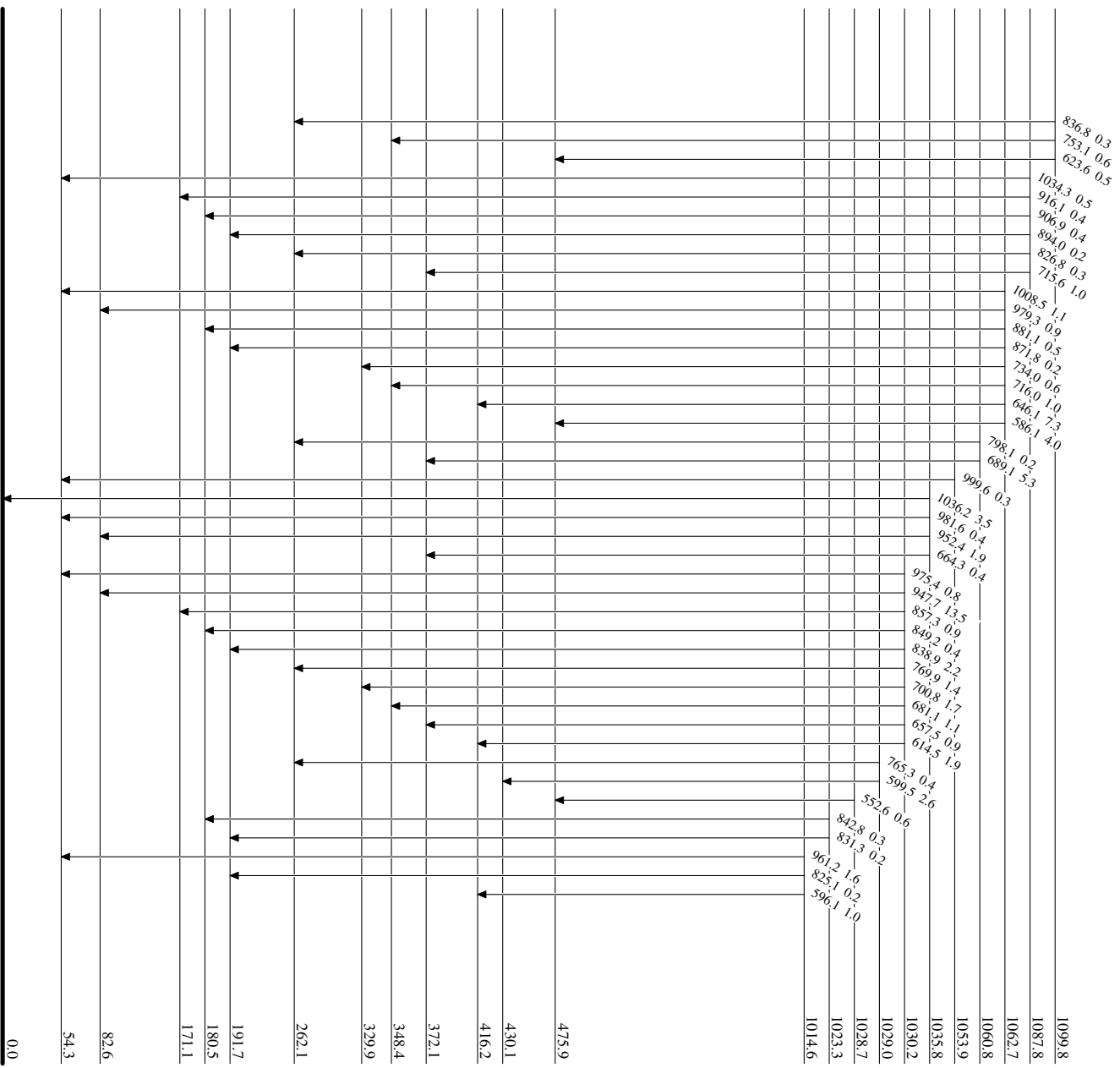


$^{166}_{67}\text{Ho}_{99}$

¹⁶⁵Ho(n,γ) E=thermal: γγ coin 2000Pr10

Level Scheme (continued)

Intensities: Relative photon branching from each level

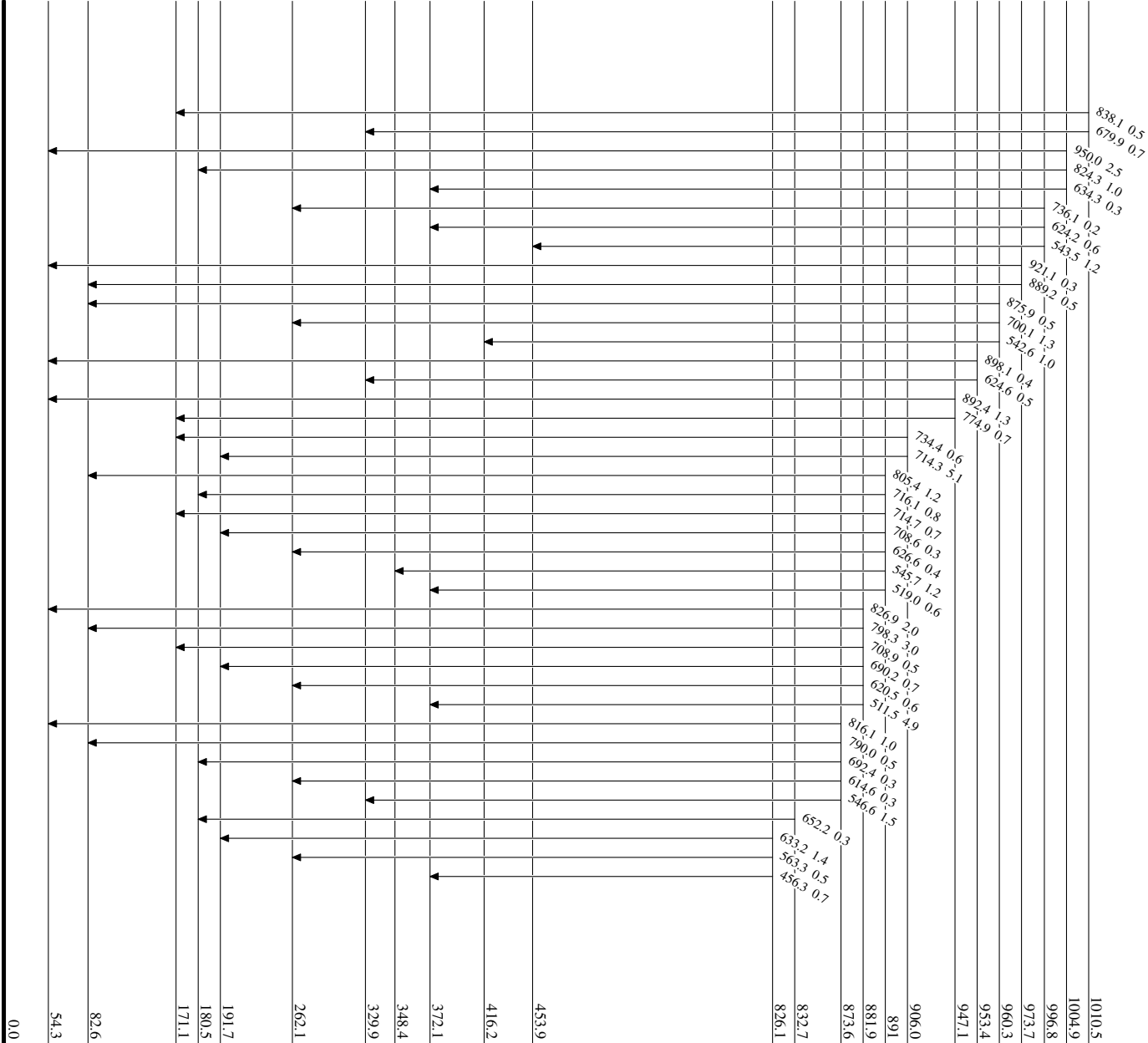


¹⁶⁶Ho₀₉
⁶⁷

¹⁶⁵Ho(u,γ) E=thermal: γγ coin 2000Pr10

Level Scheme (continued)

Intensities: Relative photon branching from each level



¹⁶⁶Ho₉₉

¹⁶⁵Ho(t,γ) E=thermal: γγ coin 2000Pr10

Level Scheme (continued)

Intensities: Relative photon branching from each level

