$^{169}_{70}\mathrm{Yb}_{99}$

1 Decay Scheme

The Yb-169 disintegrates 100 % by electron capture to excited levels of Tm-169.
L'ytterbium 169 se désintègre à 100 % par capture électronique vers des niveaux excités du thulium 169.

2 Nuclear Data

$T_{1/2}(^{169}\mathrm{Yb})$	:	32,018	(5)	d
$Q^+(^{169}\mathrm{Yb})$	:	909	(5)	keV

2.1 Electron Capture Transitions

	Energy keV	Probability × 100	Nature	lg ft	P_K	P_L	P_M
$\epsilon_{0,19}$	31 (5)	0,000004 (1)	Allowed	10,8			
$\epsilon_{0,18}$	77 (5)	0,0000175 (5)	Allowed	11,2			
$\epsilon_{0,17}$	127 (5)	0,0045 (3)	Allowed	10,5	0,623 (15)	0,280 (11)	0,0743 (32)
$\epsilon_{0,16}$	190 (5)	0,0037 (2)	Allowed	10,3	0,725 (5)	0,2073 (35)	0,0526 (13)
$\epsilon_{0,15}$	262 (5)	0,00013 (7)	1st forbidden	12			
$\epsilon_{0,14}$	276 (5)	0,0109 (4)	Allowed	10,3	0,7692 (25)	0,1750 (18)	0,0432 (9)
$\epsilon_{0,13}$	338 (5)	0,00030 (6)	(2nd Forbidden)	12			
$\epsilon_{0,12}$	434 (5)	0,000344 (7)	Unique 1st forbidden	12			
$\epsilon_{0,11}$	436 (5)	12,6 (3)	1st forbidden	7,6	0,7980 (19)	0,1540 (13)	0,0372 (7)
$\epsilon_{0,10}$	474 (5)	0,121 (14)	Allowed	9,9	0,8017 (18)	0,1513 (13)	0,0365 (7)
$\epsilon_{0,9}$	479 (5)	0,0044 (1)	1st forbidden	11,2	0,8020 (18)	0,1511 (13)	0,0364 (7)
$\epsilon_{0,8}$	530 (5)	82,2 (18)	1st forbidden	7	0,8057 (18)	0,1484 (12)	0,0356 (7)
$\epsilon_{0,6}$	564 (5)	0,0138 (13)	1st forbidden	11	0,8078 (18)	0,1469 (12)	0,0352 (7)
$\epsilon_{0,5}$	577 (5)	0,0142 (16)	Allowed	10,9	0,8085 (18)	0,1463 (12)	0,0350 (7)
$\epsilon_{0,4}$	593 (5)	5,1 (19)	Allowed	8,33	0,8093 (17)	0,1457 (12)	0,0349 (7)

2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ × 100	Multipolarity	α_K	α_L	α_M	α_T
$\gamma_{1,0}$(Tm)	8,41016 (15)	95,1 (8)	M1+0,108%E2			218 (11)	273 (13)
$\gamma_{3,2}$(Tm)	20,74370 (21)	11,2 (4)	M1+0,085%E2		44,5 (13)	10,0 (3)	57,3 (17)
$\gamma_{7,4}$(Tm)	51,51 (40)	0,1686 (1)	E2		37,1 (15)	9,1 (4)	48,6 (22)
$\gamma_{8,4}$(Tm)	63,12044 (4)	92,9 (18)	E1+0,01%M2	0,899 (27)	0,163 (6)	0,0366 (12)	1,11 (4)
$\gamma_{11,8}$(Tm)	93,61450 (8)	12,6 (3)	M1+3,25%E2	3,18 (10)	0,55 (2)	0,124 (4)	3,89 (12)
$\gamma_{11,7}$(Tm)	105,19 (10)	0,0034 (10)	[E1]	0,24 (1)	0,039 (3)		0,293 (15)
$\gamma_{2,1}$(Tm)	109,77928 (4)	59,9 (7)	M1+2,17%E2	2,03 (3)	0,327 (5)	0,0730 (11)	2,45 (4)
$\gamma_{10,4}$(Tm)	117,377 (18)	0,121 (14)	(M1+E2)	1,70 (17)	0,257 (26)	0,057 (6)	2,03 (20)
$\gamma_{2,0}$(Tm)	118,18944 (14)	4,97 (9)	E2	0,697 (21)	0,734 (22)	0,179 (6)	1,66 (5)
$\gamma_{3,1}$(Tm)	130,52293 (6)	24,5 (5)	E2	0,538 (17)	0,470 (15)	0,115 (4)	1,15 (4)
$\gamma_{11,4}$(Tm)	156,73495 (9)	0,0109 (3)	(E1)	0,0853 (26)	0,0132 (4)	0,0029 (1)	0,102 (3)
$\gamma_{4,3}$(Tm)	177,21317 (6)	35,49 (26)	M1+15,8%E2	0,484 (7)	0,0868 (13)	0,0197 (3)	0,590 (9)
$\gamma_{5,3}$(Tm)	193,15 (5)	0,0111 (16)	M1+1,1%E2	0,42 (2)	0,063 (5)		0,50 (3)
$\gamma_{4,2}$(Tm)	197,95687 (7)	52,03 (31)	M1+9%E2	0,370 (6)	0,0603 (9)	0,0136 (2)	0,448 (7)
$\gamma_{6,3}$(Tm)	205,99 (6)	0,0036 (8)	(E1)	0,042 (2)	0,0020 (2)		0,050 (2)
$\gamma_{5,2}$(Tm)	213,936 (17)	0,0035 (3)	E2	0,135 (7)	0,072 (6)		0,21 (1)
$\gamma_{6,2}$(Tm)	226,3 (7)	0,00025 (18)					
$\gamma_{8,3}$(Tm)	240,33362 (12)	0,120 (6)	E1+0,9%M2	0,037 (4)	0,0065 (7)	0,0009 (1)	0,045 (5)
$\gamma_{8,2}$(Tm)	261,07734 (9)	1,735 (9)	E1+0,1%M2	0,0237 (7)	0,00355 (11)	0,00079 (3)	0,0283 (9)
$\gamma_{9,3}$(Tm)	291,1909	0,0044 (1)	[E1]	0,018 (1)	0,0026 (2)		0,021 (2)
$\gamma_{10,3}$(Tm)	294,54 (11)	0,0011 (5)					
$\gamma_{4,1}$(Tm)	307,73616 (9)	10,72 (5)	E2	0,0482 (15)	0,0141 (4)	0,00333 (10)	0,0666 (20)
$\gamma_{4,0}$(Tm)	316,1463	0,0033 (3)	M3+E4				
$\gamma_{(-1,20)}$(Tm)	328 (2)	0,00672 (43)					
$\gamma_{11,3}$(Tm)	333,94777 (27)	0,00174 (9)	E1	0,0126 (13)	0,00182 (19)	0,00040 (4)	0,0149 (15)
$\gamma_{6,1}$(Tm)	336,621 (3)	0,0099 (9)	(E1)	0,0123 (13)	0,00179 (18)	0,00040 (4)	0,0146 (15)
$\gamma_{12,2}$(Tm)	356,74 (5)	0,000141 (6)					
$\gamma_{8,1}$(Tm)	370,85660 (29)	0,00111 (15)	[M2]	0,249 (8)	0,0460 (14)	0,0106 (3)	0,308 (9)
$\gamma_{8,0}$(Tm)	379,26676 (25)	0,00034 (14)	[E3]	0,0757 (23)	0,0401 (12)	0,0098 (3)	0,128 (4)
$\gamma_{16,5}$(Tm)	386,673 (13)	0,00038 (4)	[M1,E2]				
$\gamma_{10,1}$(Tm)	425,1138	0,00162 (29)					
$\gamma_{13,2}$(Tm)	452,62 (8)	0,000035 (19)	(M1+E2)				
$\gamma_{17,4}$(Tm)	465,657 (6)	0,000231 (24)					
$\gamma_{12,0}$(Tm)	474,973 (9)	0,000203 (9)					
$\gamma_{14,3}$(Tm)	494,360 (8)	0,00157 (12)					
$\gamma_{18,5}$(Tm)	500,35 (10)	0,0000088 (8)					
$\gamma_{15,3}$(Tm)	507,8 (3)	0,0000015 (8)					
$\gamma_{14,2}$(Tm)	515,108 (6)	0,00437 (16)	(M1)	0,0306 (30)	0,0045 (5)	0,00099 (10)	0,036 (4)
$\gamma_{15,2}$(Tm)	528,573 (10)	0,00013 (6)					
$\gamma_{19,5}$(Tm)	546,16 (22)	0,0000015 (4)					
$\gamma_{13,1}$(Tm)	562,414 (12)	0,00014 (4)	(M1+E2)				
$\gamma_{13,0}$(Tm)	570,89 (3)	0,000127 (26)	(M1+E2)				
$\gamma_{16,3}$(Tm)	579,855 (5)	0,00210 (17)	(M1)	0,023 (1)	0,0033 (3)		0,027 (2)
$\gamma_{16,2}$(Tm)	600,608 (8)	0,00114 (7)	(M1)				
$\gamma_{(-1,33)}$(Tm)	614,1 (5)	0,000097 (14)					
$\gamma_{14,1}$(Tm)	624,887 (4)	0,00495 (27)	(M1)	0,0187 (19)	0,0027 (3)	0,00060 (6)	0,0222 (22)
$\gamma_{14,0}$(Tm)	633,32 (10)	0,0000070 (5)					
$\gamma_{17,3}$(Tm)	642,878 (9)	0,000081 (5)					
$\gamma_{17,2}$(Tm)	663,604 (7)	0,00203 (15)					
$\gamma_{18,3}$(Tm)	693,46 (8)	0,0000087 (4)					
$\gamma_{16,1}$(Tm)	710,360 (15)	0,0000313 (22)					
$\gamma_{19,3}$(Tm)	739,42 (11)	0,00000183 (22)					
$\gamma_{19,2}$(Tm)	760,24 (24)	0,00000083 (22)					
$\gamma_{17,1}$(Tm)	773,390 (14)	0,00219 (11)					
$\gamma_{17,0}$(Tm)	781,64 (8)	0,0000030 (3)					

3 Atomic Data

3.1 Tm

ω_K	:	0,945	(4)
$\bar{\omega}_L$	:	0,227	(9)
n_{KL}	:	0,835	(4)

3.1.1 X Radiations

		Energy keV		Relative probability
X_K				
	$K\alpha_2$	49,7731		56,64
	$K\alpha_1$	50,7417		100
	$K\beta_3$	57,304	}	
	$K\beta_1$	57,516	}	
	$K\beta_5''$	57,925	}	32,7
	$K\beta_2$	59,1	}	
	$K\beta_4$	59,21	}	8,5
	$KO_{2,3}$	59,357	}	
X_L				
	$L\ell$	6,34		
	$L\alpha$	7,13 – 7,18		
	$L\eta$	7,31		
	$L\beta$	8,18 – 8,64		
	$L\gamma$	9,15 – 9,78		

3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	38,96 – 41,88	100
KLX	46,88 – 50,71	52,6
KXY	54,78 – 59,32	6,92
Auger L	3,85 – 7,18	2450

4 Electron Emissions

		Energy keV	Electrons per 100 disint.
e_{AL}	(Tm)	3,85 - 7,18	168,2 (18)
e_{AK}	(Tm)		10,8 (8)
	KLL	38,96 - 41,88	}
	KLX	46,88 - 50,71	}
	KXY	54,78 - 59,32	}
$ec_{8,4\ T}$	(Tm)	3,7308 - 63,0881	48,9 (18)
$ec_{8,4\ K}$	(Tm)	3,7308 (4)	39,6 (12)
$ec_{1,0\ T}$	(Tm)	6,10 - 8,38	95 (6)
$ec_{1,0\ M}$	(Tm)	6,103 - 6,942	76 (5)
$ec_{3,2\ T}$	(Tm)	10,628 - 20,711	11,0 (4)
$ec_{3,2\ L}$	(Tm)	10,628 - 12,096	8,6 (3)
$ec_{3,2\ M}$	(Tm)	18,437 - 19,276	1,93 (7)
$ec_{11,8\ K}$	(Tm)	34,2249 (8)	8,18 (27)
$ec_{11,8\ T}$	(Tm)	34,225 - 93,582	10,0 (3)
$ec_{2,1\ K}$	(Tm)	50,3897 (4)	35,2 (6)
$ec_{2,1\ T}$	(Tm)	50,3897 - 109,7470	42,5 (7)
$ec_{8,4\ L}$	(Tm)	53,0047 - 54,4720	7,18 (27)
$ec_{10,4\ K}$	(Tm)	57,987 (18)	0,068 (9)
$ec_{2,0\ T}$	(Tm)	58,79 - 118,16	3,1 (1)
$ec_{2,0\ K}$	(Tm)	58,7998 (2)	1,30 (4)
$ec_{8,4\ M}$	(Tm)	60,8136 - 61,6527	1,61 (5)
$ec_{3,1\ T}$	(Tm)	71,133 - 130,491	13,1 (5)
$ec_{3,1\ K}$	(Tm)	71,1333 (1)	6,1 (2)
$ec_{11,8\ L}$	(Tm)	83,499 - 84,967	1,4 (5)
$ec_{11,8\ M}$	(Tm)	91,308 - 92,147	0,32 (1)
$ec_{2,1\ L}$	(Tm)	99,6636 - 101,1310	5,68 (9)
$ec_{2,1\ M}$	(Tm)	107,4725 - 108,3116	1,267 (20)
$ec_{2,0\ L}$	(Tm)	108,074 - 109,541	1,37 (4)
$ec_{2,0\ M}$	(Tm)	115,883 - 116,723	0,33 (1)
$ec_{4,3\ T}$	(Tm)	117,823 - 177,181	13,2 (2)
$ec_{4,3\ K}$	(Tm)	117,8235 (1)	10,8 (2)
$ec_{3,1\ L}$	(Tm)	120,407 - 121,875	5,3 (2)
$ec_{3,1\ M}$	(Tm)	128,216 - 129,055	1,31 (5)
$ec_{4,2\ T}$	(Tm)	138,567 - 197,924	16,1 (3)
$ec_{4,2\ K}$	(Tm)	138,5671 (1)	13,29 (22)
$ec_{4,3\ L}$	(Tm)	167,097 - 168,565	1,94 (3)
$ec_{4,3\ M}$	(Tm)	174,906 - 175,745	0,44 (1)
$ec_{4,2\ L}$	(Tm)	187,841 - 189,308	2,17 (3)
$ec_{4,2\ M}$	(Tm)	195,649 - 196,489	0,49 (1)
$ec_{4,1\ K}$	(Tm)	248,3479 (1)	0,484 (15)
$ec_{4,1\ L}$	(Tm)	297,621 - 299,089	0,142 (4)

5 Photon Emissions

5.1 X-Ray Emissions

		Energy keV		Photons per 100 disint.	
XL	(Tm)	6,34 — 9,78		49,4 (8)	
XKα_2	(Tm)	49,7731		52,9 (8)	} Kα
XKα_1	(Tm)	50,7417		93,5 (13)	}
XKβ_3	(Tm)	57,304	}		
XKβ_1	(Tm)	57,516	}	30,6 (6)	Kβ_1'
XKβ_5''	(Tm)	57,925	}		
XKβ_2	(Tm)	59,1	}		
XKβ_4	(Tm)	59,21	}	7,95 (21)	Kβ_2'
XKO$_{2,3}$	(Tm)	59,357	}		

5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}$(Tm)	8,41016 (15)	0,347 (17)
$\gamma_{3,2}$(Tm)	20,74370 (21)	0,1925 (43)
$\gamma_{7,4}$(Tm)	51,51 (40)	0,0034 (1)
$\gamma_{8,4}$(Tm)	63,12044 (4)	44,05 (24)
$\gamma_{11,8}$(Tm)	93,61447 (8)	2,571 (17)
$\gamma_{11,7}$(Tm)	105,19 (10)	0,0026 (8)
$\gamma_{2,1}$(Tm)	109,77924 (4)	17,36 (9)
$\gamma_{10,4}$(Tm)	117,377 (18)	0,0398 (36)
$\gamma_{2,0}$(Tm)	118,18940 (14)	1,87 (1)
$\gamma_{3,1}$(Tm)	130,52293 (6)	11,38 (5)
$\gamma_{11,4}$(Tm)	156,73487 (9)	0,00990 (25)
$\gamma_{4,3}$(Tm)	177,21307 (6)	22,32 (10)
$\gamma_{5,3}$(Tm)	193,15 (5)	0,0074 (10)
$\gamma_{4,2}$(Tm)	197,95675 (7)	35,93 (12)
$\gamma_{6,3}$(Tm)	205,99 (6)	0,0034 (8)
$\gamma_{5,2}$(Tm)	213,936 (17)	0,00291 (22)
$\gamma_{6,2}$(Tm)	226,3 (7)	0,00025 (18)
$\gamma_{8,3}$(Tm)	240,33344 (12)	0,115 (5)
$\gamma_{8,2}$(Tm)	261,07712 (9)	1,687 (8)
$\gamma_{9,3}$(Tm)	291,190 (11)	0,00431 (14)
$\gamma_{10,3}$(Tm)	294,54 (11)	0,0011 (5)
$\gamma_{4,1}$(Tm)	307,73757 (9)	10,046 (45)
$\gamma_{4,0}$(Tm)	316,2 (7)	0,0033 (3)

	Energy keV	Photons per 100 disint.
$\gamma_{(-1,20)}$(Tm)	328 (2)	0,00672 (43)
$\gamma_{11,3}$(Tm)	333,94777 (27)	0,00171 (9)
$\gamma_{6,1}$(Tm)	336,621 (3)	0,0098 (9)
$\gamma_{12,2}$(Tm)	356,74 (5)	0,000141 (6)
$\gamma_{8,1}$(Tm)	370,85616 (29)	0,00085 (11)
$\gamma_{8,0}$(Tm)	379,26630 (25)	0,00030 (12)
$\gamma_{16,5}$(Tm)	386,673 (13)	0,00038 (4)
$\gamma_{10,1}$(Tm)	425,0 (2)	0,00162 (29)
$\gamma_{13,2}$(Tm)	452,62 (8)	0,000035 (19)
$\gamma_{17,4}$(Tm)	465,657 (6)	0,000231 (24)
$\gamma_{12,0}$(Tm)	474,973 (9)	0,000203 (9)
$\gamma_{14,3}$(Tm)	494,360 (8)	0,00157 (12)
$\gamma_{18,5}$(Tm)	500,35 (10)	0,0000088 (8)
$\gamma_{15,3}$(Tm)	507,8 (3)	0,0000015 (8)
$\gamma_{14,2}$(Tm)	515,107 (6)	0,00422 (16)
$\gamma_{15,2}$(Tm)	528,572 (10)	0,00013 (6)
$\gamma_{19,5}$(Tm)	546,16 (22)	0,0000015 (4)
$\gamma_{13,1}$(Tm)	562,413 (12)	0,00014 (4)
$\gamma_{13,0}$(Tm)	570,89 (3)	0,000127 (26)
$\gamma_{16,3}$(Tm)	579,854 (5)	0,00204 (16)
$\gamma_{16,2}$(Tm)	600,607 (8)	0,00114 (7)
$\gamma_{(-1,33)}$(Tm)	614,1 (5)	0,000097 (14)
$\gamma_{14,1}$(Tm)	624,886 (4)	0,00484 (27)
$\gamma_{14,0}$(Tm)	633,32 (10)	0,0000070 (5)
$\gamma_{17,3}$(Tm)	642,877 (9)	0,000081 (5)
$\gamma_{17,2}$(Tm)	663,603 (7)	0,00203 (15)
$\gamma_{18,3}$(Tm)	693,46 (8)	0,0000087 (4)
$\gamma_{16,1}$(Tm)	710,358 (15)	0,0000313 (22)
$\gamma_{19,3}$(Tm)	739,42 (11)	0,00000183 (22)
$\gamma_{19,2}$(Tm)	760,24 (24)	0,00000083 (22)
$\gamma_{17,1}$(Tm)	773,390 (14)	0,00219 (11)
$\gamma_{17,0}$(Tm)	781,64 (8)	0,0000030 (3)

6 Main Production Modes

$$\begin{cases} \mathrm{Yb}-169\mathrm{m(I.T.)Yb}-169 \\ T_{1/2} = 46\ s \end{cases}$$

$$\begin{cases} \mathrm{Lu}-169\mathrm{(E.C.,)Yb}-169 \\ T_{1/2} = 34{,}06\ h \end{cases}$$

Er – 167(α,2nγ)Yb – 169

Yb – 168(n,γ)Yb – 169

Yb – 168(d,p)Yb – 169

Yb – 170(d,t)Yb – 169

Yb – 171(p,t)Yb – 169

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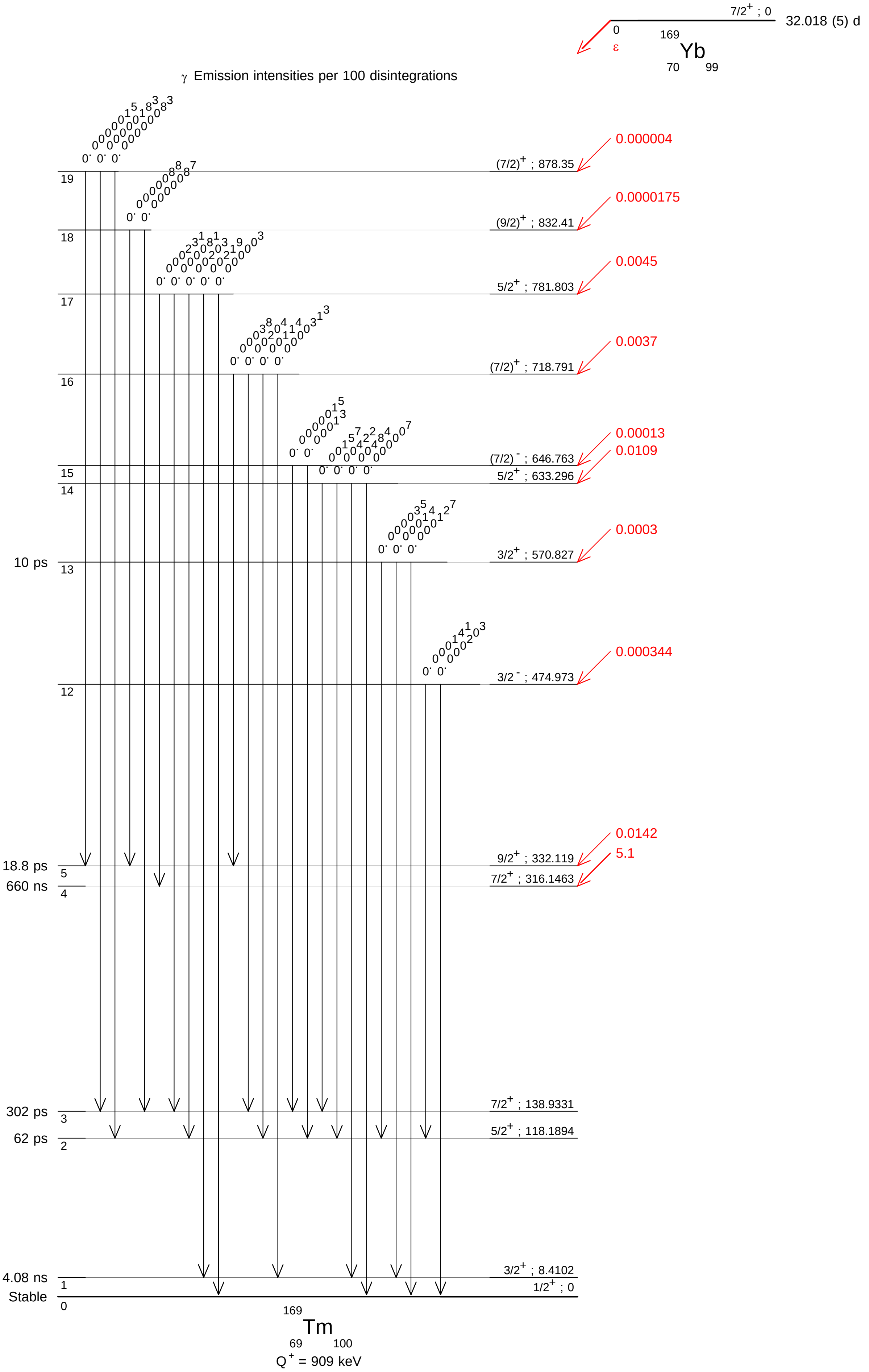
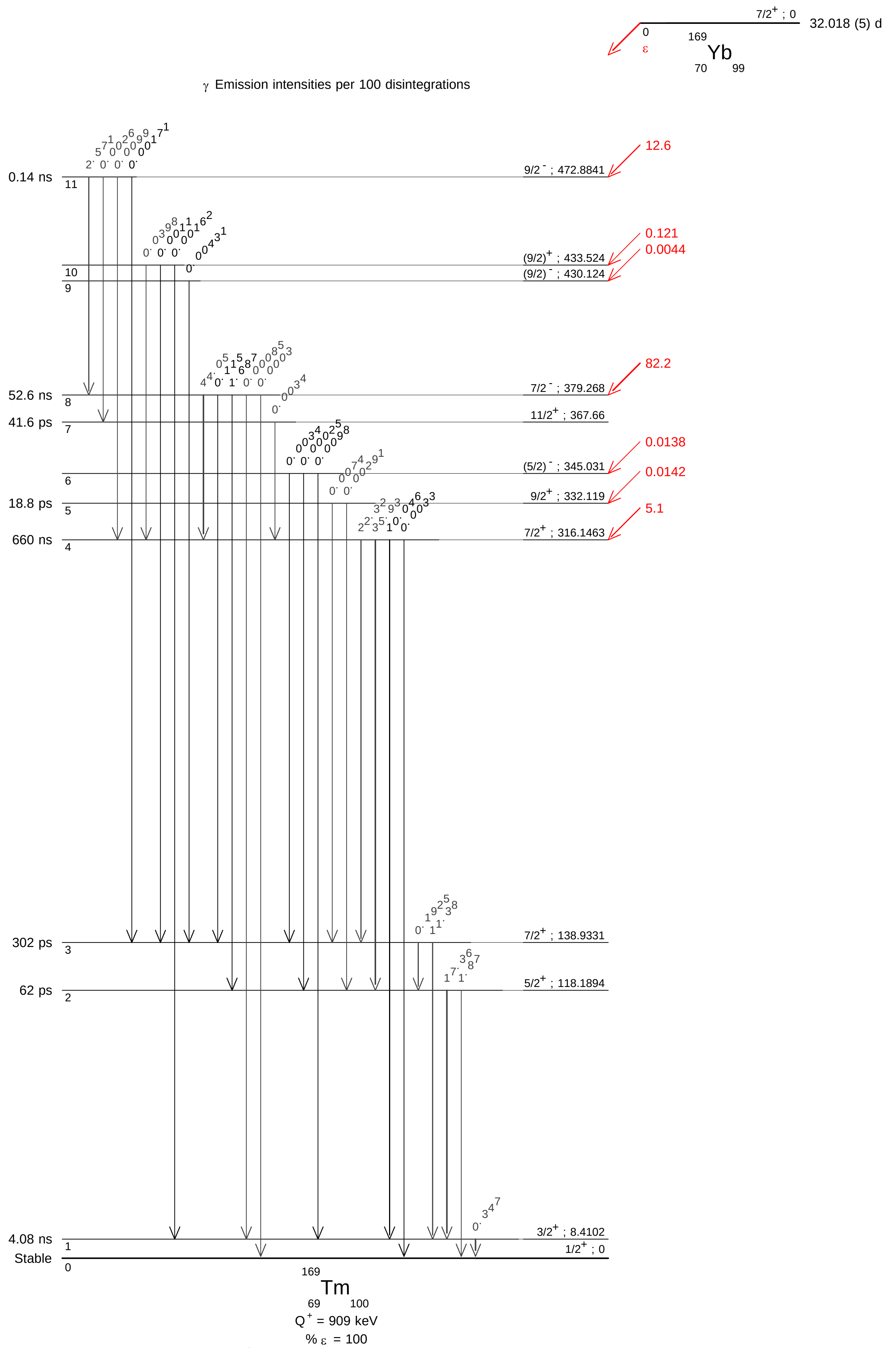

7/2+ ; 0
32.018 (5) d
0
ε
169 Yb 70 99
γ Emission intensities per 100 disintegrations
(7/2)+ ; 878.35
0.000004
(9/2)+ ; 832.41
0.0000175
5/2+ ; 781.803
0.0045
(7/2)+ ; 718.791
0.0037
(7/2)- ; 646.763
0.00013
5/2+ ; 633.296
0.0109
3/2+ ; 570.827
0.0003
3/2- ; 474.973
0.000344
9/2+ ; 332.119
0.0142
7/2+ ; 316.1463
5.1
7/2+ ; 138.9331
5/2+ ; 118.1894
3/2+ ; 8.4102
1/2+ ; 0
10 ps
18.8 ps
660 ns
302 ps
62 ps
4.08 ns
Stable
169 Tm 69 100
Q+ = 909 keV
% ε = 100


7/2+ ; 0
32.018 (5) d
ε
169 Yb 70 99
γ Emission intensities per 100 disintegrations
0.14 ns
9/2 - ; 472.8841
12.6
(9/2)+ ; 433.524
0.121
(9/2) - ; 430.124
0.0044
52.6 ns
7/2 - ; 379.268
82.2
41.6 ps
11/2+ ; 367.66
(5/2) - ; 345.031
0.0138
18.8 ps
9/2+ ; 332.119
0.0142
660 ns
7/2+ ; 316.1463
5.1
302 ps
7/2+ ; 138.9331
62 ps
5/2+ ; 118.1894
4.08 ns
3/2+ ; 8.4102
Stable
1/2+ ; 0
169 Tm 69 100
Q+ = 909 keV
% ε = 100