$^{238}_{94}\mathrm{Pu}_{144}$

1 Decay Scheme

Pu-238 decays 100% by alpha transitions to U-234. Most of the alpha decay populates the U-234 ground state (71.04 %) and the U-234 first excited level with energy of 43.50 keV (28.85 %). Branching of Pu-238 decay by spontaneous fission is 1.85 (5)E-7 %.
Le plutonium 238 se désintègre par émission alpha vers les niveaux fondamental (71,04 %) et excité de 43,5 keV (28,85 %). Le nombre de désintegrations par fission spontanée est de 1,85 (5)E-7 %

2 Nuclear Data

$T_{1/2}(^{238}\mathrm{Pu})$	:	87,74	(3)	a
$T_{1/2}(^{234}\mathrm{U})$	:	2,455	(6)	10^5 a
$Q^{\alpha}(^{238}\mathrm{Pu})$	:	5593,20	(19)	keV

2.1 α Transitions

	Energy keV	Probability × 100	F
$\alpha_{0,14}$	4507,94 (20)	∼ 0,0000012	3,5
$\alpha_{0,13}$	4548,66 (20)	0,00000117 (7)	7,5
$\alpha_{0,12}$	4569,43 (20)	∼ 0,0000002	64
$\alpha_{0,11}$	4603,77 (20)	0,000000150 (16)	155
$\alpha_{0,10}$	4645,56 (20)	0,00000023	21
$\alpha_{0,9}$	4666,48 (20)	0,00000130 (5)	53
$\alpha_{0,8}$	4741,46 (20)	0,0000081	30,5
$\alpha_{0,7}$	4743,93 (20)	0,000000075 (22)	3400
$\alpha_{0,6}$	4783,29 (20)	0,0001	5
$\alpha_{0,5}$	4806,91 (20)	0,00000821 (16)	89
$\alpha_{0,4}$	5096,16 (20)	0,00000680 (23)	10000
$\alpha_{0,3}$	5297,13 (19)	0,00292 (4)	440
$\alpha_{0,2}$	5449,85 (19)	0,104 (3)	102
$\alpha_{0,1}$	5549,70 (19)	28,85 (6)	1,39
$\alpha_{0,0}$	5593,20 (19)	71,04 (6)	1

2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ × 100	Multipolarity	α_K	α_L	α_M	α_T
$\gamma_{8,6}$(U)	41,82 (11)	0,0000026 (14)	[E2]		630 (13)	174 (4)	863 (18)
$\gamma_{1,0}$(U)	43,498 (1)	28,3 (8)	E2		520 (11)	143,5 (29)	713 (15)
$\gamma_{11,9}$(U)	62,70 (1)	0,000000016 (4)	E1		0,320 (7)	0,0791 (16)	0,426 (9)
$\gamma_{2,1}$(U)	99,852 (3)	0,1060 (23)	E2		9,77 (20)	2,71 (6)	13,42 (27)
$\gamma_{11,7}$(U)	140,15 (2)	0,000000021 (7)	M1 + 63% E2	2,6 (8)	1,79 (5)	0,48 (14)	5,1 (15)
$\gamma_{3,2}$(U)	152,719 (2)	0,00292 (4)	E2	0,217 (4)	1,404 (28)	0,388 (8)	2,14 (4)
$\gamma_{13,8}$(U)	192,91 (7)	0,0000000012 (4)	[E2]	0,1635 (33)	0,505 (10)	0,1391 (28)	0,856 (17)
$\gamma_{4,3}$(U)	200,97 (3)	0,00000680 (23)	E2	0,1534 (31)	0,424 (9)	0,1166 (23)	0,734 (15)
$\gamma_{11,5}$(U)	203,12 (3)	0,000000021 (5)	M1 + 66% E2	0,90 (17)	0,423 (9)	0,1113 (23)	1,5 (3)
$\gamma_{14,8}$(U)	233,6 (2)	0,00000041	(E0 + E2)				
$\gamma_{13,6}$(U)	234,6 (2)	0,0000001	E0				
$\gamma_{14,7}$(U)	235,9 (3)	0,000000010 (5)	[E1]	0,0532 (11)	0,01067 (21)	0,00258 (5)	0,0673 (14)
$\gamma_{13,5}$(U)	258,227 (3)	0,000000074 (12)	(E1)	0,0434 (9)	0,00859 (17)	0,00207 (4)	0,0548 (11)
$\gamma_{14,5}$(U)	299,1 (2)	0,000000046 (3)	[E1]	0,0314 (6)	0,00608 (12)	0,001466 (29)	0,0395 (8)
$\gamma_{7,2}$(U)	705,9 (1)	0,000000050 (13)	[E1]	0,00568 (12)	0,000987 (20)	0,000235 (5)	0,00698 (14)
$\gamma_{8,2}$(U)	708,3 (2)	0,00000050 (3)	[E2]	0,01537 (31)	0,00489 (10)	0,001246 (25)	0,0219 (5)
$\gamma_{12,3}$(U)	727,8 (2)	0,0000000028 (3)	(E2)	0,01464 (29)	0,00454 (9)	0,001156 (23)	0,0207 (4)
$\gamma_{5,1}$(U)	742,813 (5)	0,00000513 (13)	E1	0,00518 (10)	0,000895 (18)	0,000213 (4)	0,00636 (13)
$\gamma_{6,1}$(U)	766,38 (2)	0,0000223 (5)	E2	0,01336 (27)	0,00396 (8)	0,001003 (20)	0,0187 (4)
$\gamma_{9,2}$(U)	783,4 (1)	0,000000022 (3)	[E2]	0,01285 (26)	0,00374 (8)	0,000946 (19)	0,0179 (4)
$\gamma_{5,0}$(U)	786,27 (3)	0,00000322 (9)	E1	0,00467 (9)	0,000804 (16)	0,000191 (4)	0,00573 (12)
$\gamma_{10,2}$(U)	804,4 (3)	0,00000017	E0 + E2				0,57
$\gamma_{7,1}$(U)	805,80 (5)	0,000000056 (15)	[E1]	0,00447 (9)	0,000768 (16)	0,000183 (4)	0,00549 (11)
$\gamma_{8,1}$(U)	808,2 (1)	0,0000041	E0 + 17% E2	3,31	0,94		4,3
$\gamma_{6,0}$(U)	810,0 (5)	≥ 0,000077	E0	≥ 60			
$\gamma_{8,0}$(U)	851,7 (1)	0,00000129 (4)	[E2]	0,01109 (22)	0,00302 (6)	0,000759 (16)	0,01513 (30)
$\gamma_{12,2}$(U)	880,5 (1)	≥ 0,00000015	(E0 + E2)				
$\gamma_{9,1}$(U)	883,24 (4)	0,00000073 (4)	E2	0,01040 (21)	0,00276 (6)	0,000692 (14)	0,01409 (28)
$\gamma_{10,1}$(U)	904,37 (15)	0,000000062 (11)	[E2]	0,00998 (20)	0,00260 (5)	0,000652 (13)	0,01346 (27)
$\gamma_{9,0}$(U)	926,72 (1)	0,000000565 (25)	(E2)	0,00956 (20)	0,00245 (5)	0,000613 (12)	0,01284 (26)
$\gamma_{14,2}$(U)	941,94 (10)	0,000000472 (23)	[E2]	0,00929 (20)	0,00236 (5)	0,000589 (12)	0,01244 (25)
$\gamma_{11,1}$(U)	946,00 (3)	0,000000092 (13)	(E1)	0,00337 (7)	0,000571 (12)	0,0001355 (27)	0,00412 (8)
$\gamma_{12,1}$(U)	980,3 (1)	0,000000042	(E2)	0,00866 (18)	0,00214 (4)	0,000534 (11)	0,01152 (23)
$\gamma_{13,1}$(U)	1001,03 (3)	0,00000099 (4)	E2	0,00835 (17)	0,00204 (4)	0,000507 (11)	0,01107 (22)
$\gamma_{14,1}$(U)	1041,7 (2)	≥0,0000002	(E0 + E2)				
$\gamma_{14,0}$(U)	1085,4 (2)	0,000000078 (9)	(E2)	0,00725 (15)	0,00169 (3)	0,000418 (8)	0,00950 (19)

3 Atomic Data

3.1

ω_K : 0,970 (4)
$\bar{\omega}_L$: 0,500 (19)
n_{KL} : 0,794 (5)

3.1.1 X Radiations

		Energy keV		Relative probability
X_K				
	$K\alpha_2$	94,666		62,47
	$K\alpha_1$	98,440		100
	$K\beta_3$	110,421	}	
	$K\beta_1$	111,298	}	
	$K\beta_5''$	111,964	}	36,08
	$K\beta_2$	114,407	}	
	$K\beta_4$	115,012	}	12,34
	$KO_{2,3}$	115,377	}	
X_L				
	$L\ell$	11,619		
	$L\alpha$	13,438 – 13,615		
	$L\eta$	15,399		
	$L\beta$	15,727 – 18,206		
	$L\gamma$	19,507 – 20,714		

3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	71,78 – 80,95	100
KLX	88,15 – 98,43	59,6
KXY	104,51 – 115,59	8,88
Auger L	5,9 – 21,6	

4 α Emissions

	Energy keV	Probability × 100
$\alpha_{0,14}$	4432,1 (2)	∼ 0,0000012
$\alpha_{0,13}$	4472,1 (2)	0,00000117 (7)
$\alpha_{0,12}$	4492,5 (2)	∼ 0,0000002

	Energy keV	Probability × 100
$\alpha_{0,11}$	4526,3 (2)	0,000000150 (16)
$\alpha_{0,10}$	4567,4 (2)	0,00000023
$\alpha_{0,9}$	4587,9 (2)	0,00000130 (5)
$\alpha_{0,8}$	4661,7 (2)	0,0000081
$\alpha_{0,7}$	4664,1 (2)	0,000000075 (22)
$\alpha_{0,6}$	4702,8 (2)	0,0001
$\alpha_{0,5}$	4726,0 (2)	0,00000821 (16)
$\alpha_{0,4}$	5010,4 (2)	0,00000680 (23)
$\alpha_{0,3}$	5208,0 (2)	0,00292 (4)
$\alpha_{0,2}$	5358,1 (2)	0,104 (3)
$\alpha_{0,1}$	5456,3 (2)	28,85 (6)
$\alpha_{0,0}$	5499,03 (20)	71,04 (6)

5 Electron Emissions

		Energy keV	Electrons per 100 disint.
e_{AL}	(U)	5,9 - 21,6	10,6 (4)
e_{AK}	(U)		0,0000110 (15)
	KLL	71,78 - 80,95 }	
	KLX	88,15 - 98,43 }	
	KXY	104,51 - 115,59 }	
$ec_{1,0\ L}$	(U)	21,74 - 26,33	20,6 (6)
$ec_{1,0\ M}$	(U)	37,95 - 39,95	5,7 (12)
$ec_{1,0\ N}$	(U)	42,057 - 43,119	1,544 (39)
$ec_{2,1\ L}$	(U)	78,095 - 82,685	0,0718 (17)

6 Photon Emissions

6.1 X-Ray Emissions

		Energy keV	Photons per 100 disint.
XL	(U)	11,619 — 20,714	10,63 (8)

		Energy keV		Photons per 100 disint.	
$XK\alpha_2$	(U)	94,666		0,000106 (3)	} Kα
$XK\alpha_1$	(U)	98,440		0,000169 (5)	}
$XK\beta_3$	(U)	110,421	}		
$XK\beta_1$	(U)	111,298	}	0,0000609 (22)	$K'\beta_1$
$XK\beta_5''$	(U)	111,964	}		
$XK\beta_2$	(U)	114,407	}		
$XK\beta_4$	(U)	115,012	}	0,0000208 (6)	$K'\beta_2$
$XKO_{2,3}$	(U)	115,377	}		

6.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{8,6}$(U)	41,82 (11)	0,0000000030 (16)
$\gamma_{1,0}$(U)	43,498 (1)	0,0397 (8)
$\gamma_{11,9}$(U)	62,70 (1)	0,000000011 (3)
$\gamma_{2,1}$(U)	99,852 (3)	0,00735 (8)
$\gamma_{11,7}$(U)	140,15 (2)	0,0000000035 (7)
$\gamma_{3,2}$(U)	152,719 (2)	0,000930 (7)
$\gamma_{13,8}$(U)	192,91 (7)	0,00000000066 (20)
$\gamma_{4,3}$(U)	200,97 (3)	0,00000392 (13)
$\gamma_{11,5}$(U)	203,12 (3)	0,0000000085 (15)
$\gamma_{14,7}$(U)	235,9 (3)	0,000000009 (5)
$\gamma_{13,5}$(U)	258,227 (3)	0,000000070 (11)
$\gamma_{14,5}$(U)	299,1 (2)	0,000000044 (3)
$\gamma_{7,2}$(U)	705,9 (1)	0,000000050 (13)
$\gamma_{8,2}$(U)	708,3 (2)	0,00000049 (3)
$\gamma_{12,3}$(U)	727,8 (2)	0,0000000027 (3)
$\gamma_{5,1}$(U)	742,813 (5)	0,00000510 (13)
$\gamma_{6,1}$(U)	766,38 (2)	0,0000219 (5)
$\gamma_{9,2}$(U)	783,4 (1)	0,000000022 (3)
$\gamma_{5,0}$(U)	786,27 (3)	0,00000320 (9)
$\gamma_{10,2}$(U)	804,4 (3)	0,00000011 (5)
$\gamma_{7,1}$(U)	805,80 (5)	0,000000056 (15)
$\gamma_{8,1}$(U)	808,2 (1)	0,000000767 (25)
$\gamma_{8,0}$(U)	851,7 (1)	0,00000127 (4)
$\gamma_{12,2}$(U)	880,5 (1)	0,00000015 (4)
$\gamma_{9,1}$(U)	883,24 (4)	0,00000072 (4)
$\gamma_{10,1}$(U)	904,37 (15)	0,000000061 (11)
$\gamma_{9,0}$(U)	926,72 (1)	0,000000558 (25)
$\gamma_{14,2}$(U)	941,94 (10)	0,000000466 (23)
$\gamma_{11,1}$(U)	946,00 (3)	0,000000092 (13)

	Energy keV	Photons per 100 disint.
$\gamma_{12,1}$(U)	980,3 (1)	0,000000042
$\gamma_{13,1}$(U)	1001,03 (3)	0,00000098 (4)
$\gamma_{14,1}$(U)	1041,7 (2)	0,000000197 (16)
$\gamma_{14,0}$(U)	1085,4 (2)	0,000000077 (9)

7 Main Production Modes

$\mathrm{Np-237(n,\gamma)Np-238}$

$\mathrm{Np-238(\beta^-)Pu-238}$

$\mathrm{Cm-242(\alpha)Pu-238}$

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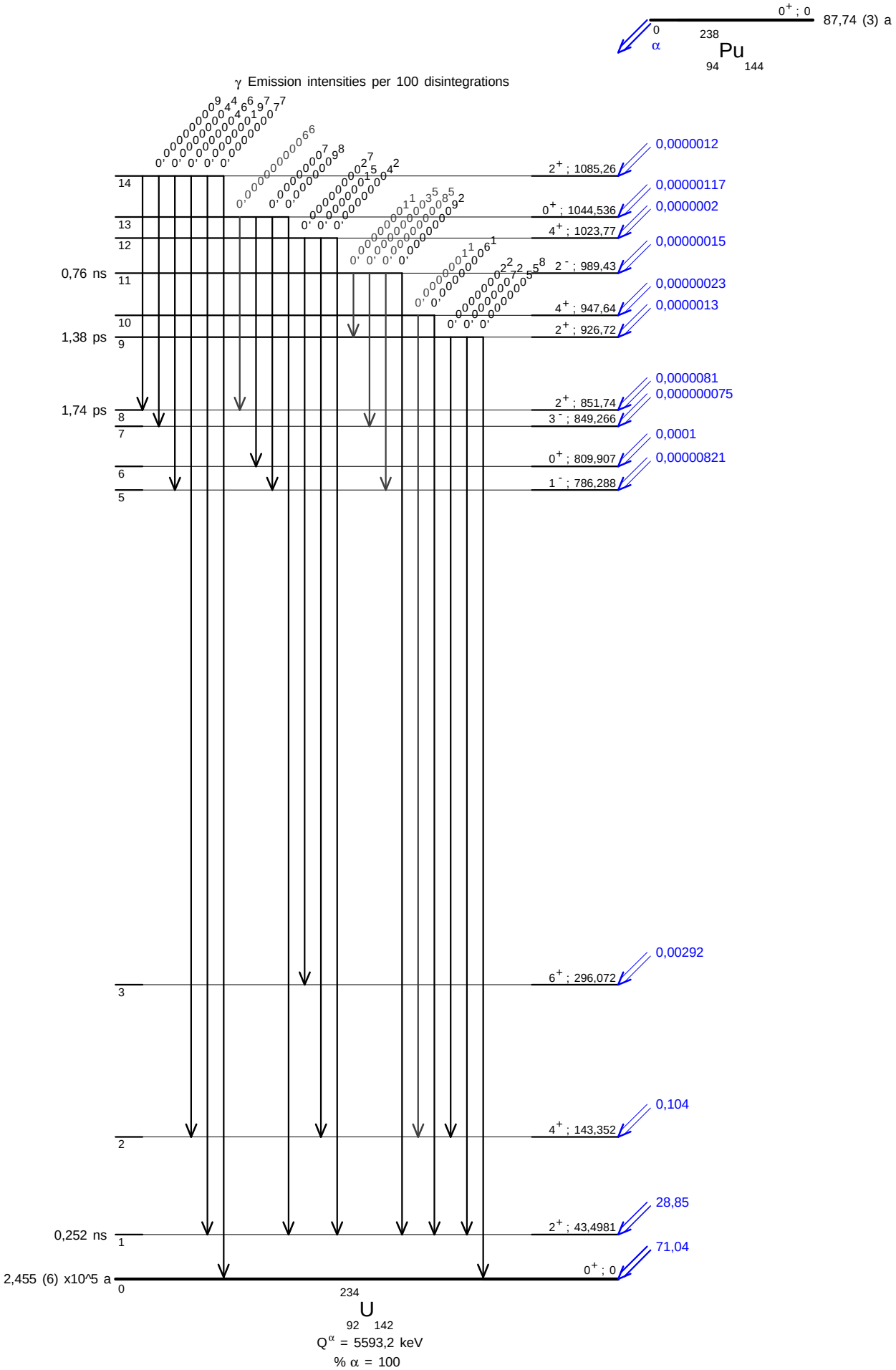
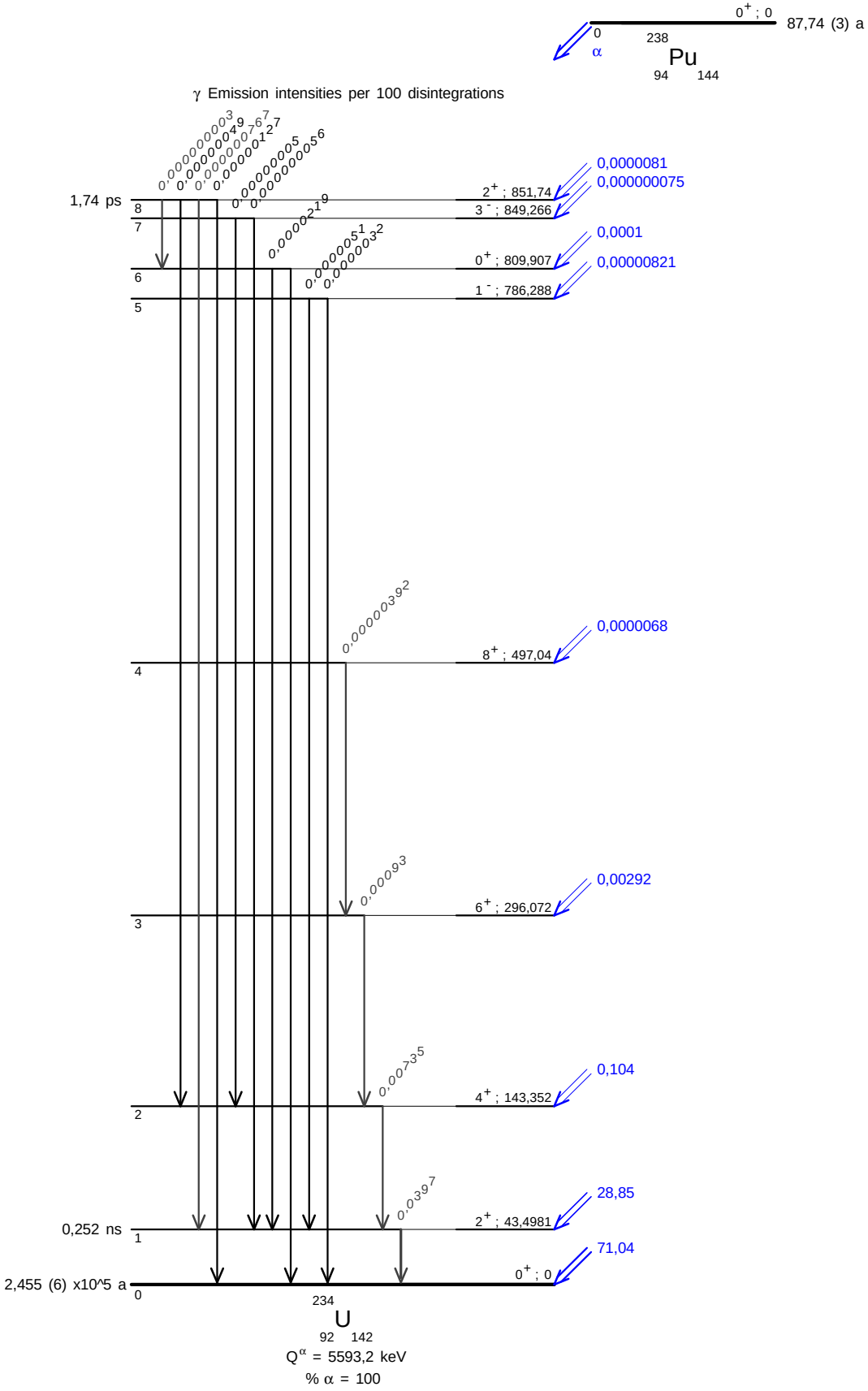

0+ ; 0
87,74 (3) a
0
α
238
Pu
94 144
γ Emission intensities per 100 disintegrations
0,0000012
0,00000117
0,0000002
0,00000015
0,00000023
0,0000013
0,0000081
0,000000075
0,0001
0,00000821
0,00292
0,104
28,85
71,04
2+ ; 1085,26
0+ ; 1044,536
4+ ; 1023,77
2- ; 989,43
4+ ; 947,64
2+ ; 926,72
2+ ; 851,74
3- ; 849,266
0+ ; 809,907
1- ; 786,288
6+ ; 296,072
4+ ; 143,352
2+ ; 43,4981
0+ ; 0
0,76 ns
1,38 ps
1,74 ps
0,252 ns
2,455 (6) x10^5 a
14
13
12
11
10
9
8
7
6
5
3
2
1
0
234
U
92 142
Qα = 5593,2 keV
% α = 100


0+ ; 0
87,74 (3) a
0
α
238
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94 144
γ Emission intensities per 100 disintegrations
1,74 ps
8
7
2+ ; 851,74
3- ; 849,266
0,0000081
0,000000075
6
0+ ; 809,907
1- ; 786,288
0,0001
0,00000821
5
4
8+ ; 497,04
0,0000068
3
6+ ; 296,072
0,00292
2
4+ ; 143,352
0,104
0,252 ns
1
2+ ; 43,4981
28,85
2,455 (6) x10^5 a
0
0+ ; 0
71,04
234
U
92 142
Q^α = 5593,2 keV
% α = 100