$^{239}_{93}$Np $_{146}$

1 Decay Scheme

Np-239 decays by beta minus emission to levels in Pu-239.
Le neptunium 239 se désintègre par émissions bêta moins vers le plutonium 239.

2 Nuclear Data

$T_{1/2}(^{239}$Np)	:	2,356	(3)	d
$T_{1/2}(^{239}$Pu)	:	24100	(11)	a
$Q^{-}(^{239}$Np)	:	722,5	(10)	keV

2.1 β^- Transitions

	Energy keV	Probability × 100	Nature	lg ft
$\beta^-_{0,13}$	166,3 (5)	0,0026	1st forbidden	9,7
$\beta^-_{0,12}$	210,7 (5)	1,56 (16)	Allowed	7,3
$\beta^-_{0,11}$	217,3 (5)	0,0074	1st forbidden	9,7
$\beta^-_{0,10}$	230,3 (5)	0,02	1st forbidden	9,3
$\beta^-_{0,9}$	252,7 (5)	0,0027	1st forbidden unique	9,9
$\beta^-_{0,8}$	330,9 (5)	38,8 (9)	1st forbidden	6,3
$\beta^-_{0,7}$	335,1 (5)		2nd forbidden	
$\beta^-_{0,6}$	392,4 (5)	9,4 (14)	Allowed	7,4
$\beta^-_{0,5}$	437,0 (5)	43,0 (22)	Allowed	6,9
$\beta^-_{0,4}$	558,7 (5)		2nd forbidden	
$\beta^-_{0,3}$	646,8 (5)		Allowed	
$\beta^-_{0,2}$	665,2 (5)	0,4 (72)	Allowed	
$\beta^-_{0,1}$	714,6 (5)	6,5 (10)	Allowed	8,4
$\beta^-_{0,0}$	722,5 (5)		2nd forbidden unique	

2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ × 100	Multipolarity	α_K	α_L	α_M	α_T
$\gamma_{1,0}$(Pu)	7,861 (2)	70 (8)	M1+0,3%E2			4220 (270)	5716 (400)
$\gamma_{3,2}$(Pu)	18,430 (4)	5,5 (30)	[M1+E2]				
$\gamma_{6,5}$(Pu)	44,663 (5)	11,3 (14)	M1+4%E2		64 (6)	16,3 (16)	86 (8)
$\gamma_{2,1}$(Pu)	49,415 (3)	18 (5)	M1+20%E2		92 (6)	24,8 (15)	126 (8)
$\gamma_{2,0}$(Pu)	57,273 (4)	27 (7)	E2		161 (3)	45,0 (9)	222 (5)
$\gamma_{7,6}$(Pu)	57,3	≈ 0,2	M1(+E2)				
$\gamma_{8,6}$(Pu)	61,460 (2)	1,900 (32)	E1		0,354 (7)	0,0881 (18)	0,473 (10)
$\gamma_{3,1}$(Pu)	67,841 (7)	9,9 (30)	E2		71,3 (14)	20,0 (4)	98,3 (20)
$\gamma_{4,3}$(Pu)	88,06 (3)	0,078 (44)	M1+20%E2		9 (4)	2,4 (13)	12 (6)
$\gamma_{7,5}$(Pu)	101,96 (2)	0,12 (3)	E2		10,5 (2)	2,93 (6)	14,4 (3)
$\gamma_{8,5}$(Pu)	106,125 (2)	32,6 (9)	E1(+M2)		0,19 (3)	0,050 (8)	0,26 (3)
$\gamma_{4,2}$(Pu)	106,50 (3)	0,63 (10)	E2		8,55 (17)	2,39 (5)	11,8 (3)
$\gamma_{12,7}$(Pu)	124,4	0,15	E2	10,4 (2)	2,39 (5)	0,591 (12)	13,6 (3)
$\gamma_{6,4}$(Pu)	166,39 (6)	0,12 (5)	M1(+20%E2)	4,92 (10)	0,987 (20)	0,240 (5)	6,23 (13)
$\gamma_{12,6}$(Pu)	181,70 (3)	0,497 (14)	M1	3,76 (8)	0,768 (15)	0,187 (4)	4,78 (10)
$\gamma_{5,3}$(Pu)	209,753 (2)	13,47 (24)	M1+2%E2	2,27 (5)	0,501 (10)	0,123 (25)	2,94 (6)
$\gamma_{12,5}$(Pu)	226,38 (2)	0,91 (5)	M1+12%E2	2,04 (7)	0,411 (12)	0,100 (3)	2,58 (8)
$\gamma_{8,4}$(Pu)	227,83	0,54 (11)	M1+1,7%E2	0,0597 (12)	0,0125 (3)	0,00303 (6)	0,0762 (15)
$\gamma_{5,2}$(Pu)	228,183 (1)	38,6 (12)	M1+7,3%E2	1,89 (6)	0,396 (12)	0,097 (3)	2,41 (8)
$\gamma_{6,3}$(Pu)	254,40 (3)	0,314 (10)	M1+2,5%E2	1,46 (3)	0,295 (6)	0,0718 (15)	1,85 (4)
$\gamma_{6,2}$(Pu)	272,84 (3)	0,194 (8)	M1+2,6%E2	1,20 (3)	0,242 (5)	0,0589 (12)	1,52 (3)
$\gamma_{5,1}$(Pu)	277,599 (1)	34,8 (9)	M1+5%E2	1,12 (5)	0,228 (6)	0,0556 (12)	1,42 (6)
$\gamma_{5,0}$(Pu)	285,460 (2)	0,973 (13)	E2	0,0843 (17)	0,119 (3)	0,0327 (7)	0,248 (5)
$\gamma_{7,3}$(Pu)	311,70 (2)	0,002 (2)	(M1+E2)				
$\gamma_{8,3}$(Pu)	315,880 (3)	1,649 (10)	E1(+0,006%M2)	0,0295 (6)		0,00141 (4)	0,0372 (8)
$\gamma_{6,1}$(Pu)	322,3 (2)	0,006	(E2)	0,0680 (14)		0,0203 (4)	0,170 (4)
$\gamma_{8,2}$(Pu)	334,310 (3)	2,107 (21)	E1(+0,004%M2)	0,0261 (5)		0,0012 (3)	0,0329 (7)
$\gamma_{13,4}$(Pu)	392,4 (5)	0,0016	(E1)				
$\gamma_{11,3}$(Pu)	429,5 (5)	0,0039					
$\gamma_{10,2}$(Pu)	434,7 (5)	0,013	E1(+M2)				
$\gamma_{11,2}$(Pu)	447,6 (5)	0,00026					
$\gamma_{12,2}$(Pu)	454,2 (5)	0,00082	(M1)				
$\gamma_{9,1}$(Pu)	461,9 (5)	0,0016	(E1)				
$\gamma_{9,0}$(Pu)	469,8 (5)	0,0011	(E1)				
$\gamma_{10,1}$(Pu)	484,3 (5)	0,001	(E1)				
$\gamma_{10,0}$(Pu)	492,3 (5)	0,006	(E1)				
$\gamma_{11,1}$(Pu)	497,8 (5)	0,0032					
$\gamma_{13,2}$(Pu)	498,7	0,001	(E1)				
$\gamma_{12,1}$(Pu)	504,2 (5)	0,00078	(E2)				

3 Atomic Data

3.1 Pu

ω_K : 0,971 (4)
$\bar{\omega}_L$: 0,521 (20)
n_{KL} : 0,790 (5)

3.1.1 X Radiations

		Energy keV		Relative probability
X_K				
	$K\alpha_2$	99,525		63,17
	$K\alpha_1$	103,734		100
	$K\beta_3$	116,244	}	
	$K\beta_1$	117,228	}	
	$K\beta_5''$	117,918	}	36,7
	$K\beta_2$	120,54	}	
	$K\beta_4$	120,969	}	12,74
	$KO_{2,3}$	121,543	}	
X_L				
	$L\ell$	12,125		
	$L\alpha$	14,083 – 14,279		
	$L\eta$	16,334		
	$L\beta$	16,499 – 19,331		
	$L\gamma$	20,708 – 21,984		

3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	75,26 – 85,36	100
KLX	92,61 – 103,73	60,6
KXY	109,93 – 121,78	9,18
Auger L	6,1 – 23,0	

4 Electron Emissions

		Energy keV		Electrons per 100 disint.
e_{AL}	(Pu)	6,1 - 23,0		47,9 (26)
e_{AK}	(Pu)			1,36 (19)
	KLL	75,26 - 85,36	}	
	KLX	92,61 - 103,73	}	
	KXY	109,93 - 121,78	}	

		Energy keV		Electrons per 100 disint.
$ec_{1,0\ M}$	(Pu)	1,928 - 4,086		51 (6)
$ec_{12,7\ K}$	(Pu)	2,6		0,1
$ec_{6,5\ L}$	(Pu)	21,559 - 26,606		8,3 (10)
$ec_{2,1\ L}$	(Pu)	26,311 - 31,358		13,3 (3)
$ec_{2,0\ L}$	(Pu)	34,169 - 39,216		20,8 (32)
$ec_{8,6\ L}$	(Pu)	38,36 - 43,40		0,457 (11)
$ec_{6,5\ M}$	(Pu)	38,730 - 40,888		2,12 (26)
$ec_{2,1\ M}$	(Pu)	43,482 - 45,640		3,6 (9)
$ec_{6,4\ K}$	(Pu)	44,60	(6)	0,08 (3)
$ec_{3,1\ L}$	(Pu)	44,74 - 49,78		7,1 (21)
$ec_{2,0\ M}$	(Pu)	51,340 - 53,498		5,8 (9)
$ec_{8,6\ M}$	(Pu)	55,53 - 57,68		0,114 (3)
$ec_{12,6\ K}$	(Pu)	59,91	(3)	0,323 (10)
$ec_{3,1\ M}$	(Pu)	61,91 - 64,07		2,0 (6)
$ec_{4,3\ L}$	(Pu)	64,96 - 70,00		0,054 (30)
$ec_{7,5\ L}$	(Pu)	78,86 - 83,90		0,084 (21)
$ec_{8,5\ L}$	(Pu)	83,02 - 88,07		4,9 (8)
$ec_{4,2\ L}$	(Pu)	83,37 - 88,41		0,42 (7)
$ec_{5,3\ T}$	(Pu)	87,962 - 209,746		10,05 (22)
$ec_{5,3\ K}$	(Pu)	87,962	(2)	7,76 (18)
$ec_{8,5\ M}$	(Pu)	100,19 - 102,35		1,30 (21)
$ec_{4,2\ M}$	(Pu)	100,54 - 102,69		0,117 (19)
$ec_{12,5\ K}$	(Pu)	104,59	(2)	0,52 (3)
$ec_{5,2\ T}$	(Pu)	106,392 - 228,176		27,3 (10)
$ec_{5,2\ K}$	(Pu)	106,392	(1)	21,4 (8)
$ec_{6,3\ K}$	(Pu)	132,61	(3)	0,161 (6)
$ec_{6,2\ K}$	(Pu)	151,05	(3)	0,092 (4)
$ec_{5,1\ K}$	(Pu)	155,808	(1)	16,1 (7)
$ec_{5,1\ T}$	(Pu)	155,808 - 277,592		20,4 (9)
$ec_{12,6\ L}$	(Pu)	158,59 - 163,63		0,066 (2)
$ec_{5,0\ K}$	(Pu)	163,669	(2)	0,066 (2)
$ec_{5,3\ L}$	(Pu)	186,65 - 191,70		1,71 (4)
$ec_{12,5\ L}$	(Pu)	203,28 - 208,32		0,105 (7)
$ec_{5,3\ M}$	(Pu)	203,82 - 205,98		0,42 (9)
$ec_{5,2\ L}$	(Pu)	205,08 - 210,13		4,48 (16)
$ec_{8,2\ K}$	(Pu)	212,519	(3)	0,0532 (11)
$ec_{5,2\ M}$	(Pu)	222,25 - 224,41		1,10 (4)
$ec_{5,1\ L}$	(Pu)	254,50 - 259,54		3,28 (9)
$ec_{5,0\ L}$	(Pu)	262,36 - 267,40		0,093 (3)
$ec_{5,1\ M}$	(Pu)	271,67 - 273,82		0,801 (18)
$\beta^-_{0,13}$	max:	166,3	(5)	0,0026
$\beta^-_{0,13}$	avg:	44,2	(2)	
$\beta^-_{0,12}$	max:	210,7	(5)	1,56 (16)
$\beta^-_{0,12}$	avg:	56,8	(2)	
$\beta^-_{0,11}$	max:	217,3	(5)	0,0074
$\beta^-_{0,11}$	avg:	58,7	(2)	

		Energy keV		Electrons per 100 disint.
$\beta^-_{0,10}$	max:	230,3	(5)	0,02
$\beta^-_{0,10}$	avg:	62,5	(2)	
$\beta^-_{0,9}$	max:	252,7	(5)	0,0027
$\beta^-_{0,9}$	avg:	74,7	(2)	
$\beta^-_{0,8}$	max:	330,9	(5)	38,8 (9)
$\beta^-_{0,8}$	avg:	98,3	(2)	
$\beta^-_{0,7}$	max:	335,1	(5)	
$\beta^-_{0,7}$	avg:			
$\beta^-_{0,6}$	max:	392,4	(5)	9,4 (14)
$\beta^-_{0,6}$	avg:	111,5	(2)	
$\beta^-_{0,5}$	max:	437,0	(5)	43,0 (22)
$\beta^-_{0,5}$	avg:	125,6	(2)	
$\beta^-_{0,4}$	max:	558,7	(5)	
$\beta^-_{0,4}$	avg:			
$\beta^-_{0,3}$	max:	646,8	(5)	
$\beta^-_{0,3}$	avg:			
$\beta^-_{0,2}$	max:	665,2	(5)	0,4 (72)
$\beta^-_{0,2}$	avg:			
$\beta^-_{0,1}$	max:	714,6	(5)	6,5 (10)
$\beta^-_{0,1}$	avg:	218,3	(2)	
$\beta^-_{0,0}$	max:	722,5	(5)	
$\beta^-_{0,0}$	avg:			

5 Photon Emissions

5.1 X-Ray Emissions

		Energy keV		Photons per 100 disint.	
XL	(Pu)	12,125 — 21,984		51,3 (24)	
XKα_2	(Pu)	99,525		13,5 (4)	} Kα
XKα_1	(Pu)	103,734		21,4 (6)	}
XKβ_3	(Pu)	116,244	}		
XKβ_1	(Pu)	117,228	}	7,84 (25)	K$'\beta_1$
XKβ_5''	(Pu)	117,918	}		
XKβ_2	(Pu)	120,54	}		
XKβ_4	(Pu)	120,969	}	2,72 (10)	K$'\beta_2$
XKO$_{2,3}$	(Pu)	121,543	}		

5.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{1,0}$(Pu)	7,861 (2)	0,0122 (12)
$\gamma_{3,2}$(Pu)	18,430 (4)	< 0,02
$\gamma_{6,5}$(Pu)	44,663 (5)	0,13 (1)
$\gamma_{2,1}$(Pu)	49,415 (3)	0,145 (35)
$\gamma_{2,0}$(Pu)	57,273 (4)	0,12 (3)
$\gamma_{7,6}$(Pu)	57,3	≈ 0,012
$\gamma_{8,6}$(Pu)	61,460 (2)	1,29 (2)
$\gamma_{3,1}$(Pu)	67,841 (7)	0,10 (3)
$\gamma_{4,3}$(Pu)	88,06 (3)	0,006 (2)
$\gamma_{7,5}$(Pu)	101,96 (2)	0,008 (2)
$\gamma_{8,5}$(Pu)	106,125 (2)	25,9 (3)
$\gamma_{4,2}$(Pu)	106,50 (3)	0,049 (8)
$\gamma_{12,7}$(Pu)	124,4	0,01
$\gamma_{6,4}$(Pu)	166,39 (6)	0,016 (7)
$\gamma_{12,6}$(Pu)	181,70 (3)	0,086 (2)
$\gamma_{5,3}$(Pu)	209,753 (2)	3,42 (3)
$\gamma_{12,5}$(Pu)	226,38 (2)	0,255 (14)
$\gamma_{8,4}$(Pu)	227,83	0,5 (1)
$\gamma_{5,2}$(Pu)	228,183 (1)	11,32 (22)
$\gamma_{6,3}$(Pu)	254,40 (3)	0,110 (3)
$\gamma_{6,2}$(Pu)	272,84 (3)	0,077 (3)
$\gamma_{5,1}$(Pu)	277,599 (1)	14,4 (1)
$\gamma_{5,0}$(Pu)	285,460 (2)	0,78 (1)
$\gamma_{7,3}$(Pu)	311,70 (2)	0,002 (2)
$\gamma_{8,3}$(Pu)	315,880 (3)	1,59 (1)
$\gamma_{6,1}$(Pu)	322,3 (2)	0,0052
$\gamma_{8,2}$(Pu)	334,310 (3)	2,04 (2)
$\gamma_{13,4}$(Pu)	392,4 (5)	0,0016
$\gamma_{11,3}$(Pu)	429,5 (5)	0,0039
$\gamma_{10,2}$(Pu)	434,7 (5)	0,013
$\gamma_{11,2}$(Pu)	447,6 (5)	0,00026
$\gamma_{12,2}$(Pu)	454,2 (5)	0,00082
$\gamma_{9,1}$(Pu)	461,9 (5)	0,0016
$\gamma_{9,0}$(Pu)	469,8 (5)	0,0011
$\gamma_{10,1}$(Pu)	484,3 (5)	0,001
$\gamma_{10,0}$(Pu)	492,3 (5)	0,006
$\gamma_{11,1}$(Pu)	497,8 (5)	0,0032
$\gamma_{13,2}$(Pu)	498,7	0,001
$\gamma_{12,1}$(Pu)	504,2 (5)	0,00078

6 Main Production Modes

$$\begin{cases} U-238(n,\gamma)U-239 \\ \text{Possible impurities : } Pu-239,\ Pu-240 \end{cases}$$

$$\begin{cases} U-239(\beta^-,)Np-239 \\ \text{Possible impurities : } T_{1/2}\ =\ 23{,}46\ \text{min} \end{cases}$$

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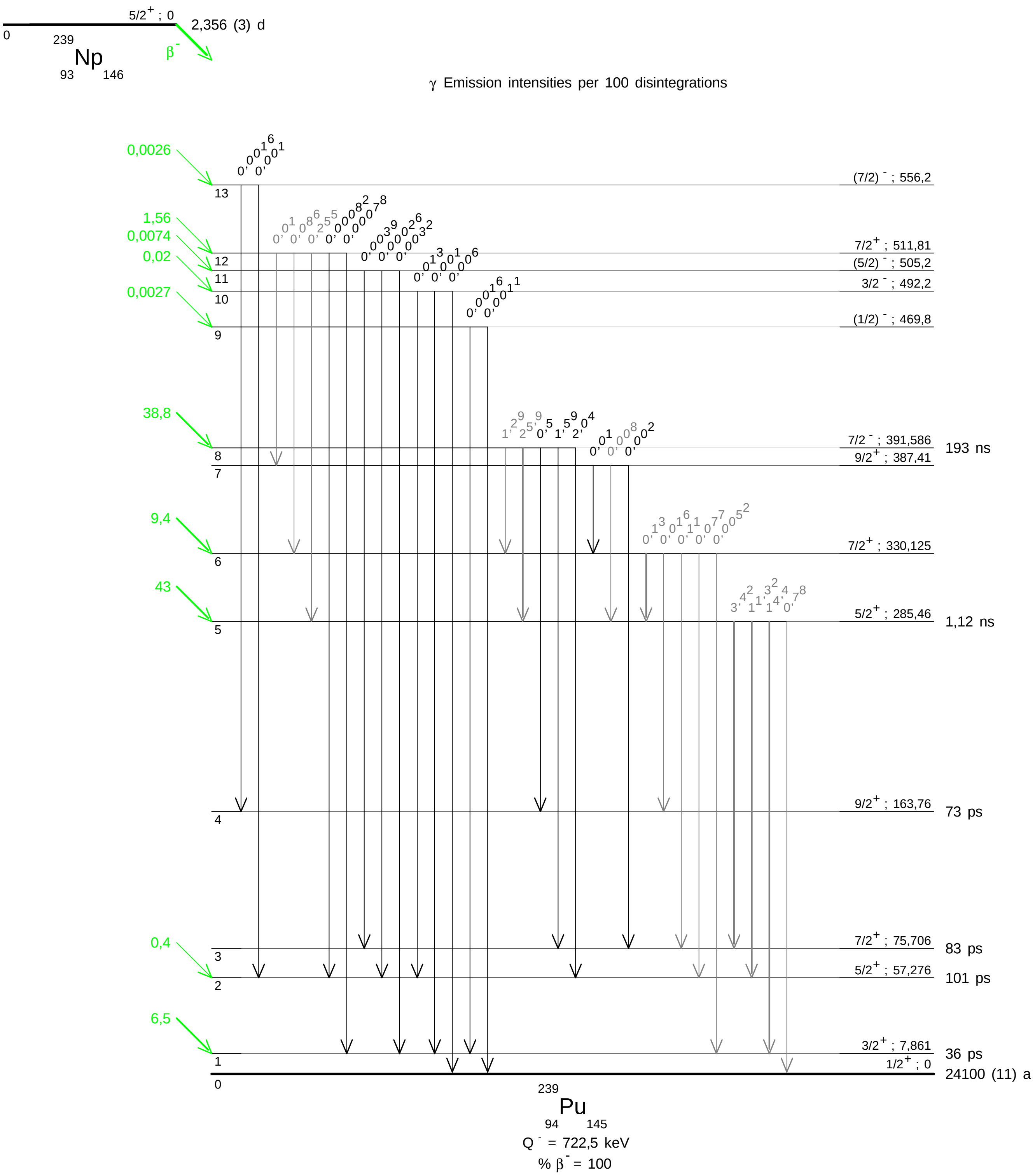
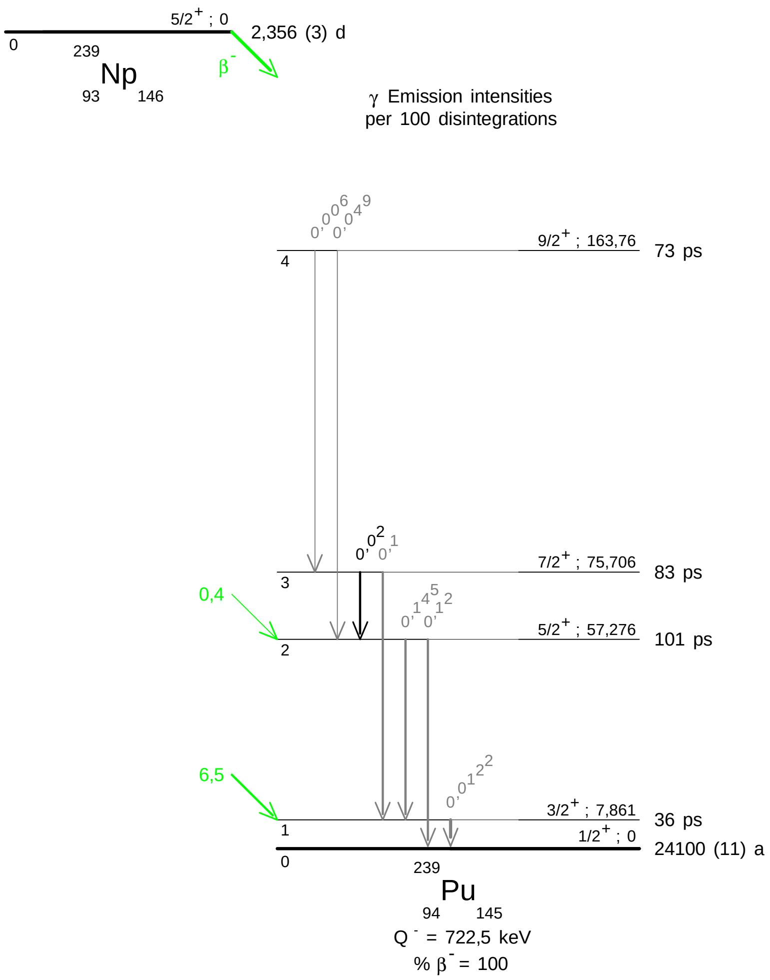

5/2+ ; 0
2,356 (3) d
239 Np 93 146
β-
γ Emission intensities per 100 disintegrations
(7/2) - ; 556,2
7/2+ ; 511,81
(5/2) - ; 505,2
3/2 - ; 492,2
(1/2) - ; 469,8
7/2 - ; 391,586
193 ns
9/2+ ; 387,41
7/2+ ; 330,125
5/2+ ; 285,46
1,12 ns
9/2+ ; 163,76
73 ps
7/2+ ; 75,706
83 ps
5/2+ ; 57,276
101 ps
3/2+ ; 7,861
36 ps
1/2+ ; 0
24100 (11) a
0,0026
1,56
0,0074
0,02
0,0027
38,8
9,4
43
0,4
6,5
239 Pu 94 145
Q - = 722,5 keV
% β - = 100


5/2+ ; 0
2,356 (3) d
0
239
Np
93
146
β-
γ Emission intensities
per 100 disintegrations
9/2+ ; 163,76
73 ps
4
7/2+ ; 75,706
83 ps
3
0,4
5/2+ ; 57,276
101 ps
2
6,5
3/2+ ; 7,861
36 ps
1
1/2+ ; 0
24100 (11) a
0
239
Pu
94
145
Q- = 722,5 keV
% β- = 100