

File: http://lise.nsci.msu.edu/9_10/radiation/238U_CoulombFission.radlist

This file has been produced by LISE⁺⁺ with next settings and Coulomb Fission mechanism

P rojectile	$^{238}\text{U}^{92+}$
	1000 MeV/u 1 pA
F ragment	$^{130}\text{Te}^{52+}$
T arget	^{207}Pb 1 nm
St ripper	
M aterial 1	Si 100 nm
A FaradayCup 1	☒ enable

Radiation residue calculator

Mode to implant:

- ☐ 1. One nucleus to implant. Chose manually here
- ☒ 2. List of isotopes to implant from file
- ☐ 3. Select detector to obtain the list of isotopes stopped in

designations:

Yield = Number of atoms; N of DI = Number of Different Isotopes;
Final Time (FT) = Irradiation Time (IT) + Decay Time (DT)

"238U_CoulombFission.radlist" N of isotopes = 490

FP_PPAC0 Refresh N of isotopes = 0

Press "Escape" to interrupt calculations

Total Irradiation Rate

Rate = 7.569e+07 pps

Irradiation (Implantation)

IT : Irradiation Time [sec] = 1

N of DI @ time (IT) = 542

Radiation Residues as Function of time (DT)

DT : Decay Time after irradiation (sec) = 1e10

N of DI @ time (FT) = 89

Total Yield @ time (FT) = 7.42e+7

CAUTION RADIATION AREA

Calculate

Options

1D : Residues as function of time

1D : Activity as function of time

2D : Final Residues (@ TF)

View Results (Text)

Quit Link

Elapsed time is 00:01:52.25 or 112.25 sec

→ Decay time 317 years

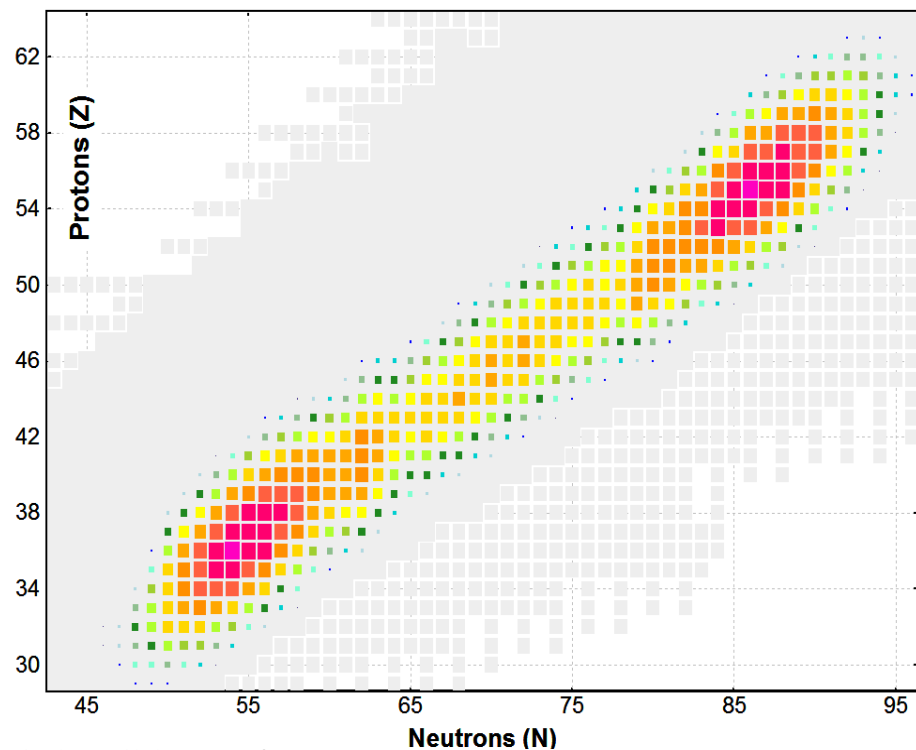
→ Takes 2 minutes

Implanted isotopes

(number of different isotopes is 490)

[3] Total: All reactions (pps)

^{238}U (1000 MeV/u) + Pb (1 mm); Settings on ^{130}Te ; Config: MA
dp/p=100.00%
N=0-200

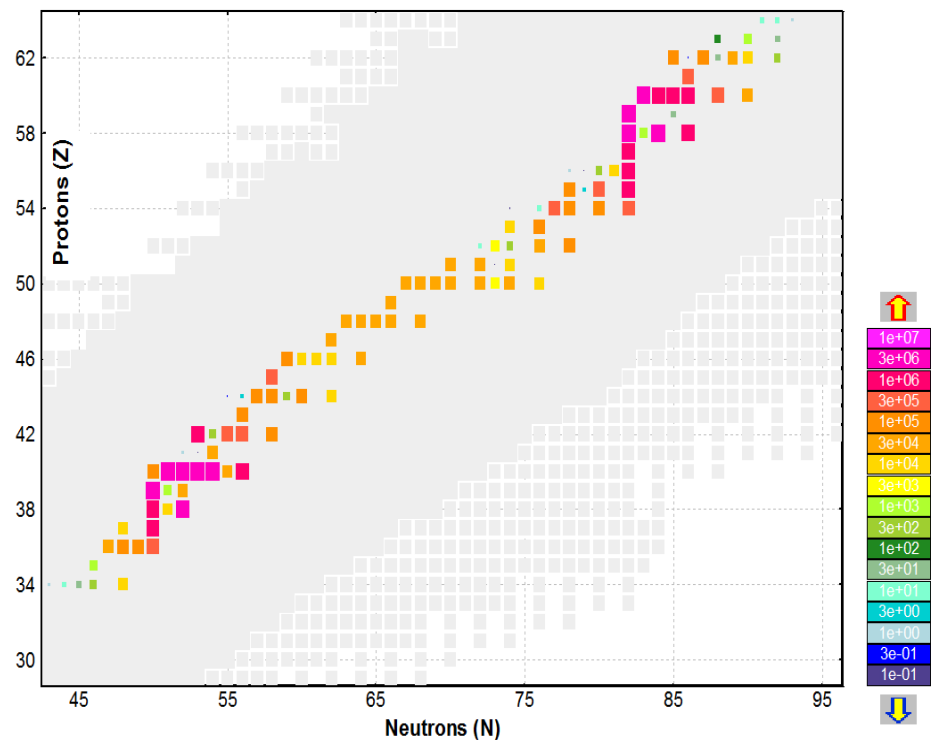


Radiation Residues after 1000 year decay time

(number of different isotopes is 122)

Radioactive decay residues

Implanted isotopes file: "G:\238U_CoulombFission.radlist" (490 different isotopes)
Irradiation Time (IT) = 1.00e+00 sec; Decay Time (DT) = 3.15e+07 sec; Plot All isotopes
N_Implant=100, N_Resid=1000, Abs.Error=1.0e-05, Rel.Error=1.0e-03, Threshold=1.0e-04, Model="RKF4"



https://en.wikipedia.org/wiki/Long-lived_fission_product

Actinides and fission products by half-life								V · T · E
Actinides ^[3] by decay chain				Half-life range (y)	Fission products of ²³⁵ U by yield ^[4]			
4n	4n+1	4n+2	4n+3		4.5–7%	0.04–1.25%	<0.001%	
²²⁸ Ra ^{Ne}				4–6	†	¹⁵⁵ Eu ^b		
²⁴⁴ Cm ^f	²⁴¹ Pu ^f	²⁵⁰ Cf	²²⁷ Ac ^{Ne}	10–29	⁹⁰ Sr	⁸⁵ Kr	^{113m} Cd ^b	
²³² U ^f		²³⁸ Pu ^{fNe}	²⁴³ Cm ^f	29–97	¹³⁷ Cs	¹⁵¹ Sm ^b	^{121m} Sn	
²⁴⁸ Bk ^[5]	²⁴⁹ Cf ^f	^{242m} Am ^f		141–351	No fission products have a half-life in the range of 100–210 k years ...			
	²⁴¹ Am ^f		²⁵¹ Cf ^{f[6]}	430–900				
		²²⁶ Ra ^{Ne}	²⁴⁷ Bk	1.3 k – 1.6 k				
²⁴⁰ Pu ^{fNe}	²²⁸ Th ^{Ne}	²⁴⁵ Cm ^f	²⁴³ Am ^f	4.7 k – 7.4 k				
	²⁴² Cm ^f	²⁵⁰ Cm		8.3 k – 8.5 k				
			²³⁹ Pu ^{fNe}	24.1 k				
		²³⁰ Th ^{Ne}	²³¹ Pa ^{Ne}	32 k – 76 k				
²³⁶ Np ^f	²³³ U ^{fNe}	²³⁴ U ^{Ne}		150 k – 250 k	†	⁹⁹ Tc ^c	¹²⁶ Sn	
²⁴⁸ Cm		²⁴² Pu ^f		327 k – 375 k		⁷⁹ Se ^c		
				1.53 M		⁹³ Zr		
	²³⁷ Np ^{fNe}			2.1 M – 6.5 M		¹³⁵ Cs ^c	¹⁰⁷ Pd	
²³⁸ U ^{Ne}			²⁴⁷ Cm ^f	15 M – 24 M		¹²⁹ I ^c		
²⁴⁴ Pu ^{Ne}				80 M				
²³² Th ^{Ne}		²³⁸ U ^{Ne}	²³⁵ U ^{fNe}	0.7 G – 14.1 G				

... nor beyond 15.7 M years^[7]

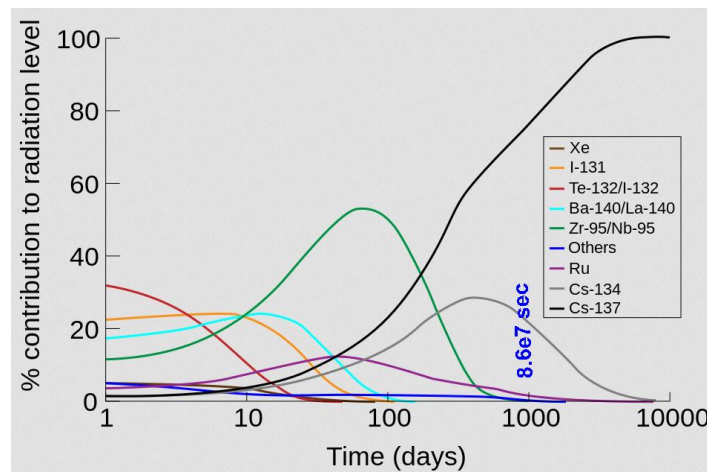
Legend for superscript symbols
^c has thermal neutron capture cross section in the range of 8–50 barns
^f fissile
^m metastable isomer
^{Ne} naturally occurring radioactive material (NORM)
^b neutron poison (thermal neutron capture cross section greater than 3k barns)
† range 4–97 y: Medium-lived fission product
‡ over 200,000 y: Long-lived fission product

https://en.wikipedia.org/wiki/Long-lived_fission_product

Medium-lived fission products				
Prop:	t _{1/2}	Yield	Q *	βγ *
Unit:	(a)	(%)	(keV)	
¹⁵⁵ Eu	4.76	0.0803	252	βγ
⁸⁵ Kr	10.76	0.2180	687	βγ
^{113m} Cd	14.1	0.0008	316	β
⁹⁰ Sr	28.9	4.505	2826	β
¹³⁷ Cs	30.23	6.337	1176	βγ
^{121m} Sn	43.9	0.00005	390	βγ
¹⁵¹ Sm	96.6	0.5314	77	β

Long-lived fission products				
Prop:	t _{1/2}	Yield	Q *	βγ *
Unit:	(Ma)	(%)	(keV)	
⁹⁹ Tc	0.211	6.1385	294	β
¹²⁶ Sn	0.230	0.1084	4050	βγ
⁷⁹ Se	0.327	0.0447	151	β
⁹³ Zr	1.53	5.4575	91	βγ
¹³⁵ Cs	2.3	6.9110	269	β
¹⁰⁷ Pd	6.5	1.2499	33	β
¹²⁹ I	15.7	0.8410	194	βγ

Hover underlined: more info

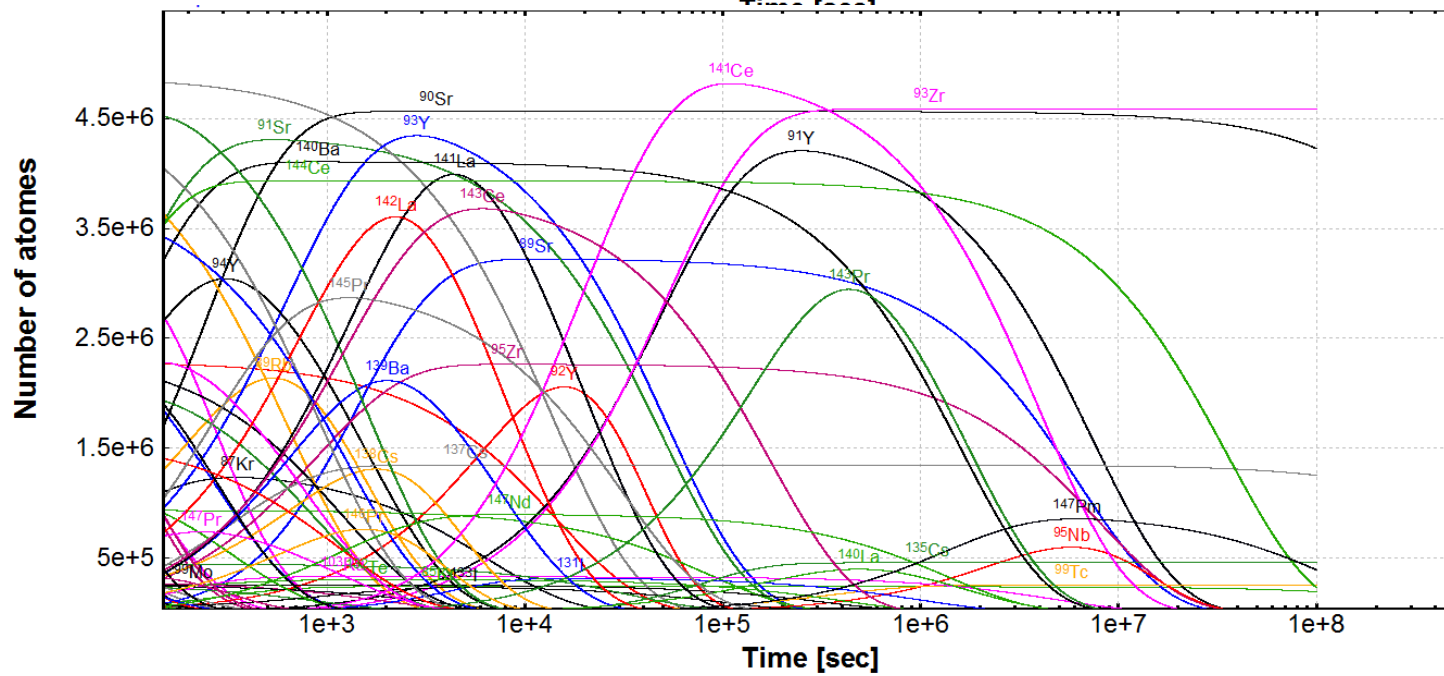


RKF45

ODE method

step	decay time , s	N of Isotopes	atoms	elapsed time, s	Implantation Steps	Decay steps	AbsErr	RelErr	Threshold	T1/2 MIN	T1/2 MAX		decay time , years
1	1E+10	82	7.42E+07	201.8	100	1000	1E-01	1E-04	1E-01	1E-01	1E+15	STIFFNESS622	3.2E+02
2	1E+10	89	7.42E+07	112.3	100	1000	1E-01	1E-04	1E-01	1E-01	1E+15		3.2E+02
3	1E+10	89	7.44E+07	676.1	100	1000	1E-02	1E-04	1E-02	1E-01	1E+15		3.2E+02
4	1E+11	91	7.44E+07	946.2	100	10000	1E-04	1E-04	1E-05	1E-01	1E+15	STIFFNESS 812	3.2E+03
5	1E+11	85	7.42E+07	115.5	100	1000	1E-01	1E-04	1E-01	1E+00	1E+15		3.2E+03
6	1E+11	87	7.44E+07	1193.5	100	3000	1E-03	1E-04	1E-03	1E+00	1E+15		3.2E+03
7	1E+11	94	7.46E+07	1468.6	100	10000	1E-04	1E-04	1E-05	1E-01	1E+15		3.2E+03
8	1E+11	91	7.46E+07	1328.6	100	10000	1E-04	1E-04	1E-05	1E-01	1E+15		3.2E+03
9	1E+12	97	7.48E+07	2406.4	100	10000	1E-05	1E-04	1E-06	1E-01	1E+15		3.2E+04
10	1E+08	118	7.52E+07	433.9	100	10000	1E-05	1E-04	1E-06	1E-01	1E+15		3.2E+00

Only
radioactive
residues



^{238}U fission case calculation : 3.2 years decay time

step	decay time , s	N of Isotopes	atoms	elapsed time, s	Implantation Steps	Decay steps	AbsErr	RelErr	Threshold	T1/2 MIN	T1/2 MAX	decay time , years
10	1E+08	118	7.52E+07	433.9	100	10000	1E-05	1E-04	1E-06	1E-01	1E+15	3.2E+00

Zoom Z=40 region

Only radioactive residues

Medium-lived fission products

Prop:	$t_{1/2}$	Yield	Q^*	$\beta\gamma^*$
Unit:	(a)	(%)	(keV)	
^{155}Eu	4.76	0.0803	252	$\beta\gamma$
^{85}Kr	10.76	0.2180	687	$\beta\gamma$
$^{113\text{m}}\text{Cd}$	14.1	0.0008	316	β
^{90}Sr	28.9	4.505	2826	β
^{137}Cs	30.23	6.337	1176	$\beta\gamma$
$^{121\text{m}}\text{Sn}$	43.9	0.00005	390	$\beta\gamma$
^{151}Sm	96.6	0.5314	77	β

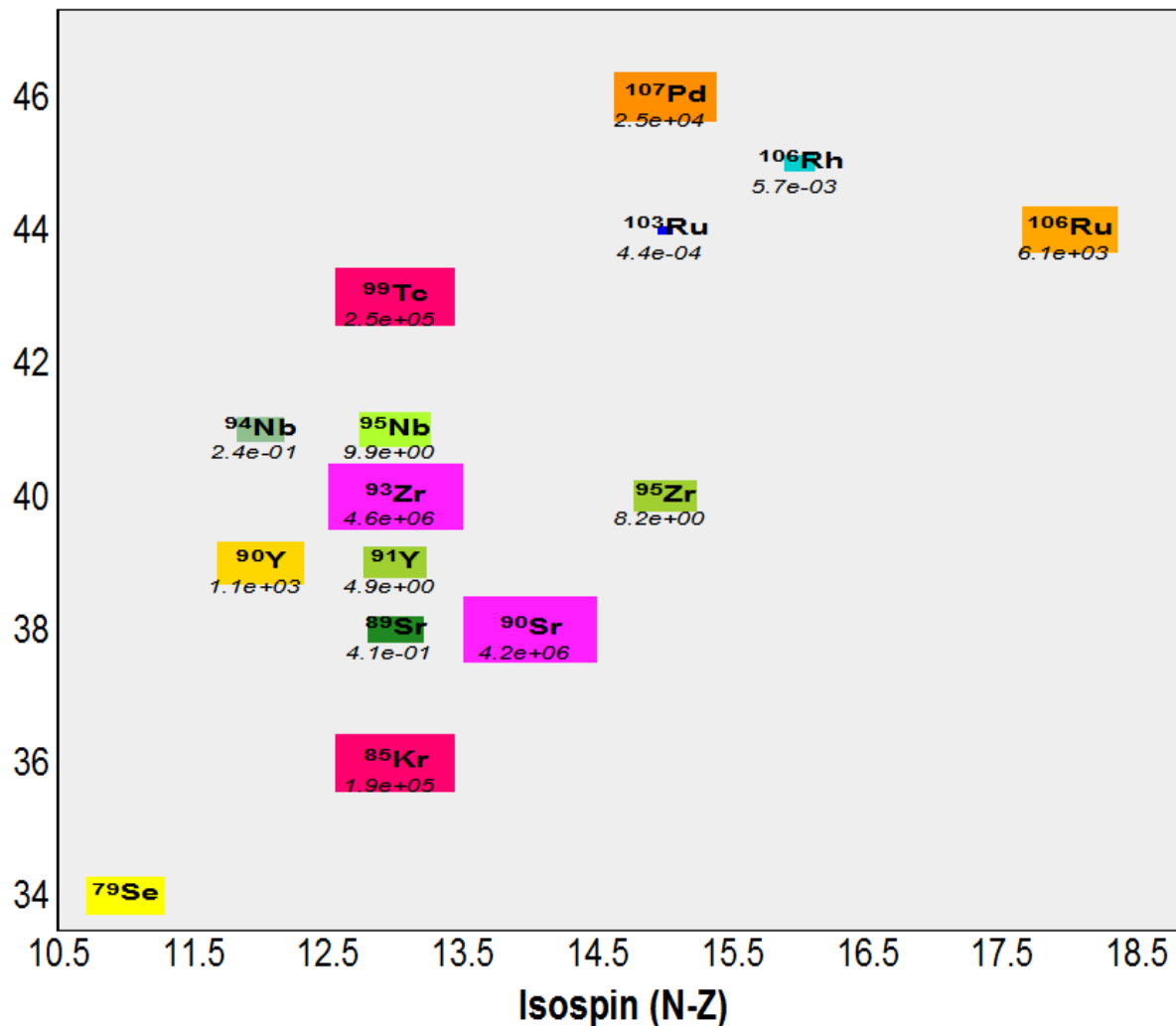
https://en.wikipedia.org/wiki/Long-lived_fission_product

Long-lived fission products

Prop:	$t_{1/2}$	Yield	Q^*	$\beta\gamma^*$
Unit:	(Ma)	(%)	(keV)	
^{99}Tc	0.211	6.1385	294	β
^{126}Sn	0.230	0.1084	4050	$\beta\gamma$
^{79}Se	0.327	0.0447	151	β
^{93}Zr	1.53	5.4575	91	$\beta\gamma$
^{135}Cs	2.3	6.9110	269	β
^{107}Pd	6.5	1.2499	33	β
^{129}I	15.7	0.8410	194	$\beta\gamma$

Hover underlined: more info

Protons (Z)



4e+06
8e+05
2e+05
3e+04
6e+03
1e+03
2e+02
5e+01
1e+01
2e+00
4e-01
8e-02
2e-02
3e-03
6e-04
1e-04
3e-05

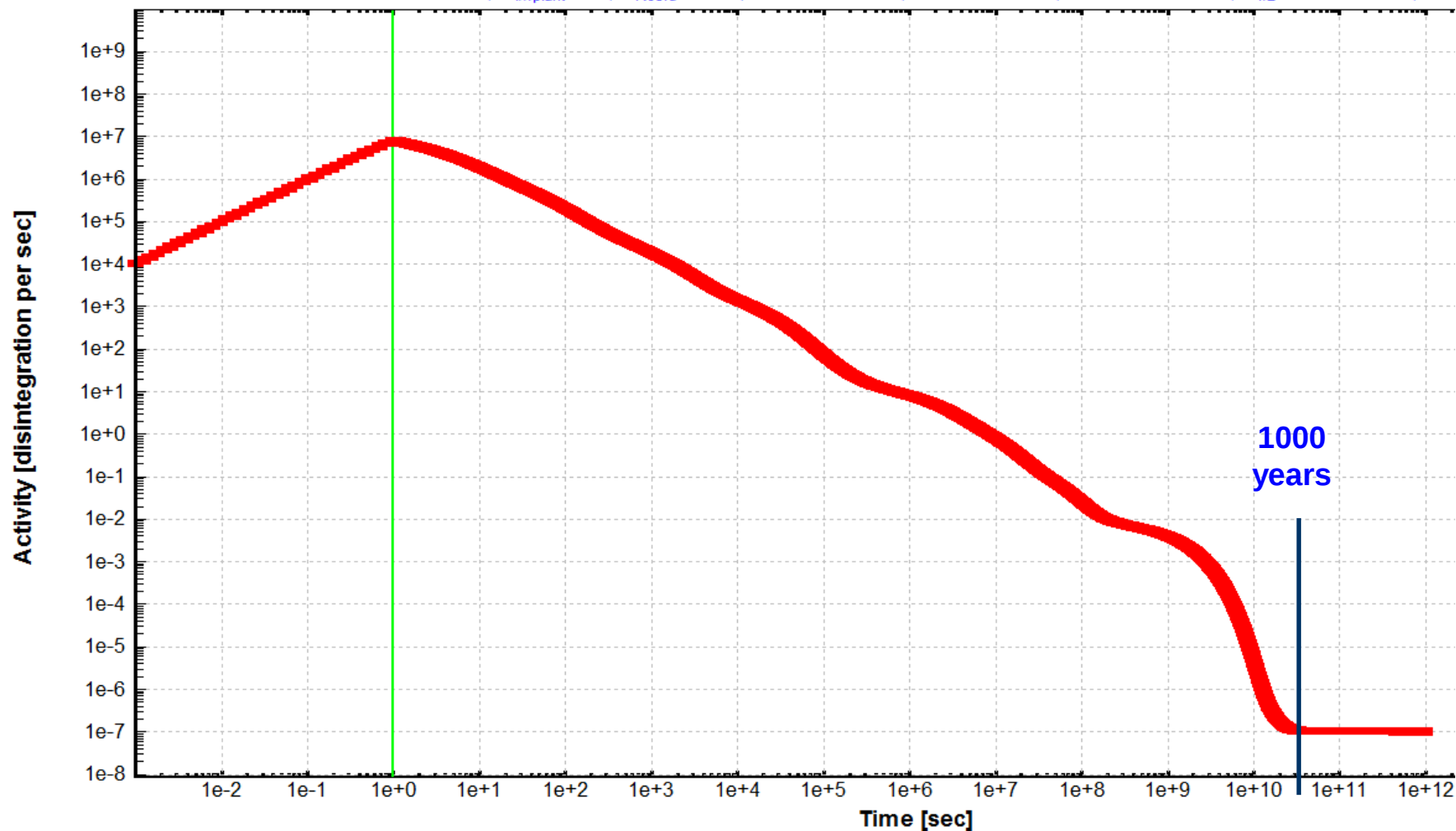


^{238}U fission case calculation : 3.2e4 years decay time

step	decay time , s	N of Isotopes	atoms	elapsed time, s	Implantation Steps	Decay steps	AbsErr	RelErr	Threshold	T1/2 MIN	T1/2 MAX	decay time , years
9	1E+12	97	7.48E+07	2406.4	100	10000	1E-05	1E-04	1E-06	1E-01	1E+15	3.2E+04

Activity

Implanted isotopes file : "G:\BeamDump\238U_CoulombFission.radlist" (490 different isotopes)
 Irradiation Time (IT) = 1.00e+00 sec; Decay Time (DT) = 1.00e+12 sec; Plot only Radioactive
 Model="ODE", N_{Implant}=100, N_{Resid}=10000, Abs.Err=1.0e-05, Rel.Err=1.0e-04, Threshold=1.0e-06, T_{1/2}^{bounds} = 1.0e-01, 1.0e

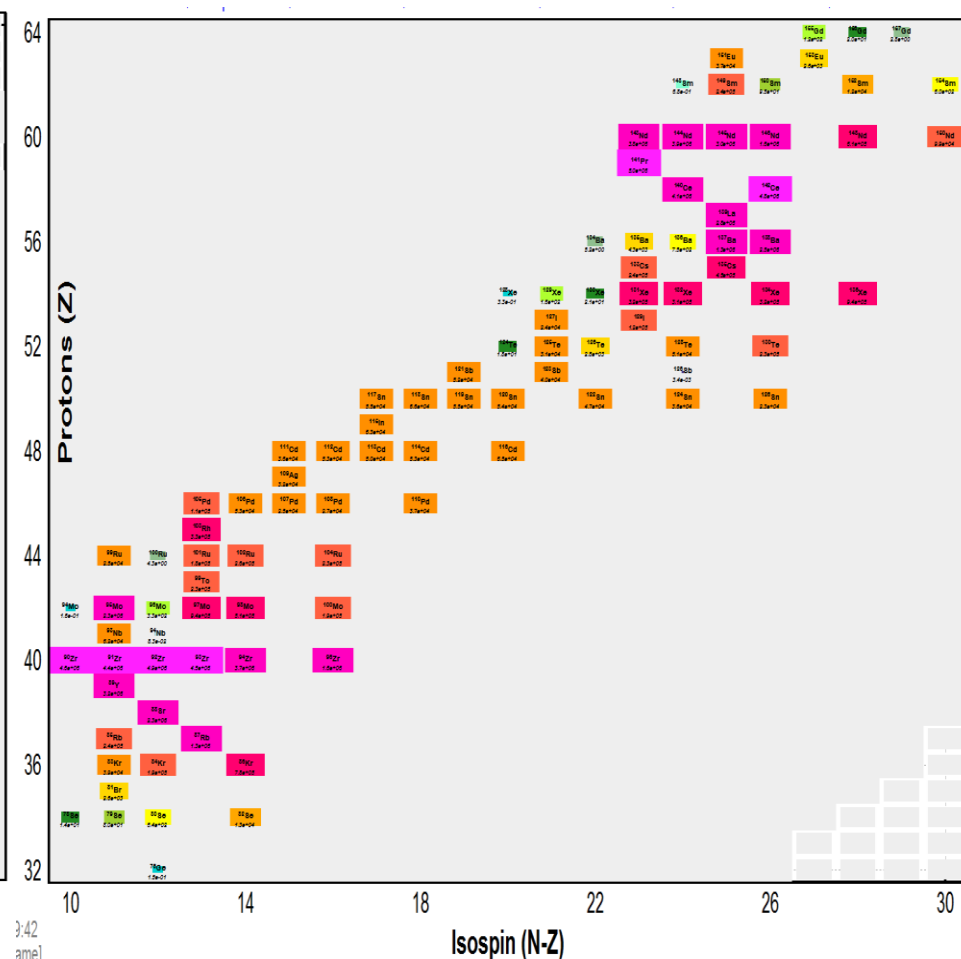
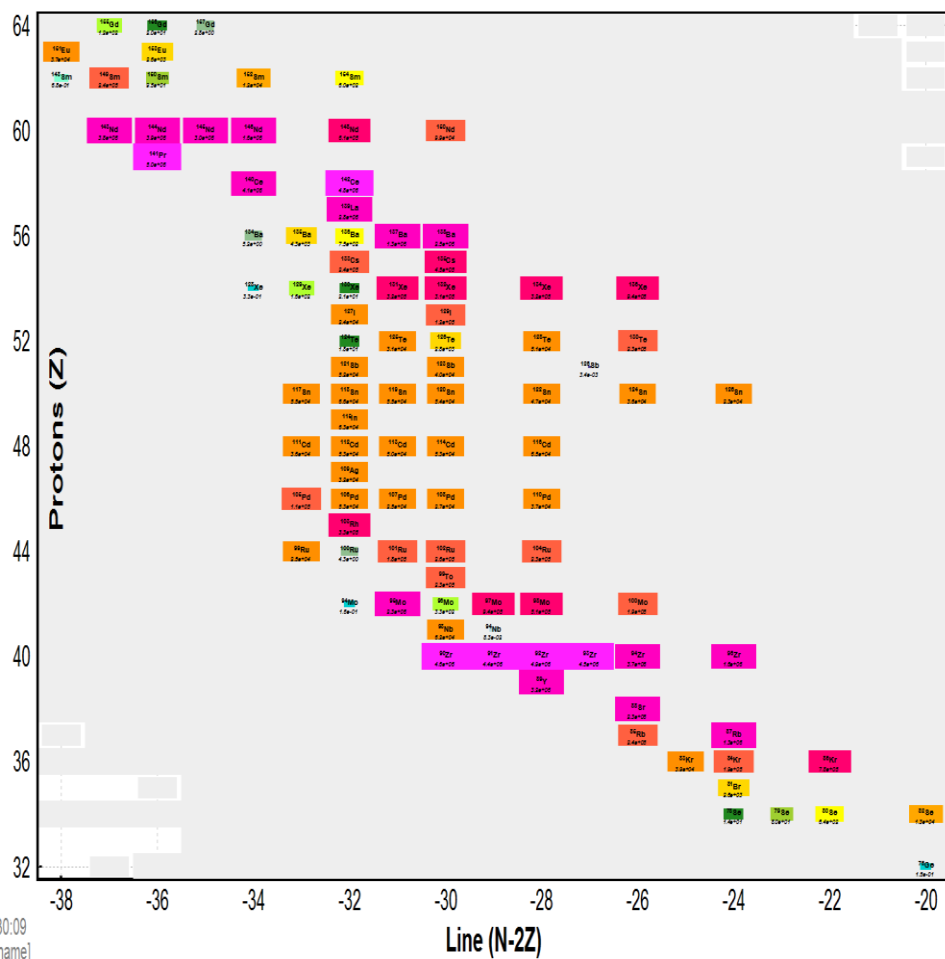


03-11-2016 12:25:41
LISE++ [Noname]

^{238}U fission case calculation : 3.2e4 years decay time

step	decay time , s	N of Isotopes	atoms	elapsed time, s	Implantation Steps	Decay steps	AbsErr	RelErr	Threshold	T1/2 MIN	T1/2 MAX		decay time , years
9	1E+12	97	7.48E+07	2406.4	100	10000	1E-05	1E-04	1E-06	1E-01	1E+15		3.2E+04

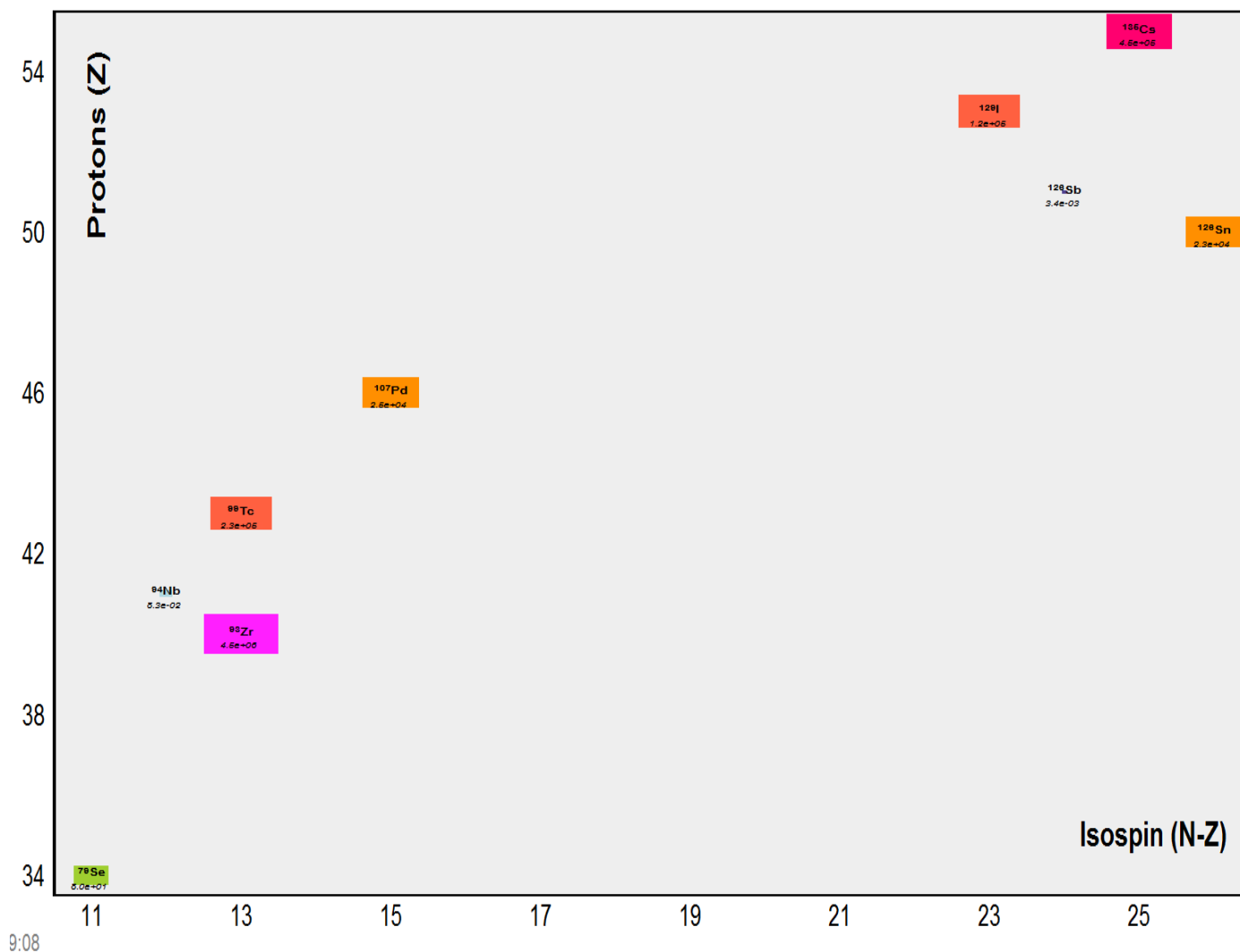
All residues



^{238}U fission case calculation : 3.2e4 years decay time

step	decay time , s	N of Isotopes	atoms	elapsed time, s	Implantation Steps	Decay steps	AbsErr	RelErr	Threshold	T1/2 MIN	T1/2 MAX	decay time , years
9	1E+12	97	7.48E+07	2406.4	100	10000	1E-05	1E-04	1E-06	1E-01	1E+15	3.2E+04

Only radioactive residues



https://en.wikipedia.org/wiki/Long-lived_fission_product

Long-lived fission products				
Prop:	$t_{1/2}$	Yield	Q_{β}	β_{γ}
Unit: (Ma)	(%)	(keV)	*	*
^{99}Tc	0.211	6.1385	294	β
^{126}Sn	0.230	0.1084	4050	$\beta\gamma$
^{79}Se	0.327	0.0447	151	β
^{93}Zr	1.53	5.4575	91	$\beta\gamma$
^{135}Cs	2.3	6.9110	269	β
^{107}Pd	6.5	1.2499	33	β
^{129}I	15.7	0.8410	194	$\beta\gamma$

Hover underlined: more info