

Some Results on One-Step- Target Radioactivity Production and Decay

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for the MSU-LANL-LBNL-LLNL-ORNL RIA R&D collaboration

Purpose

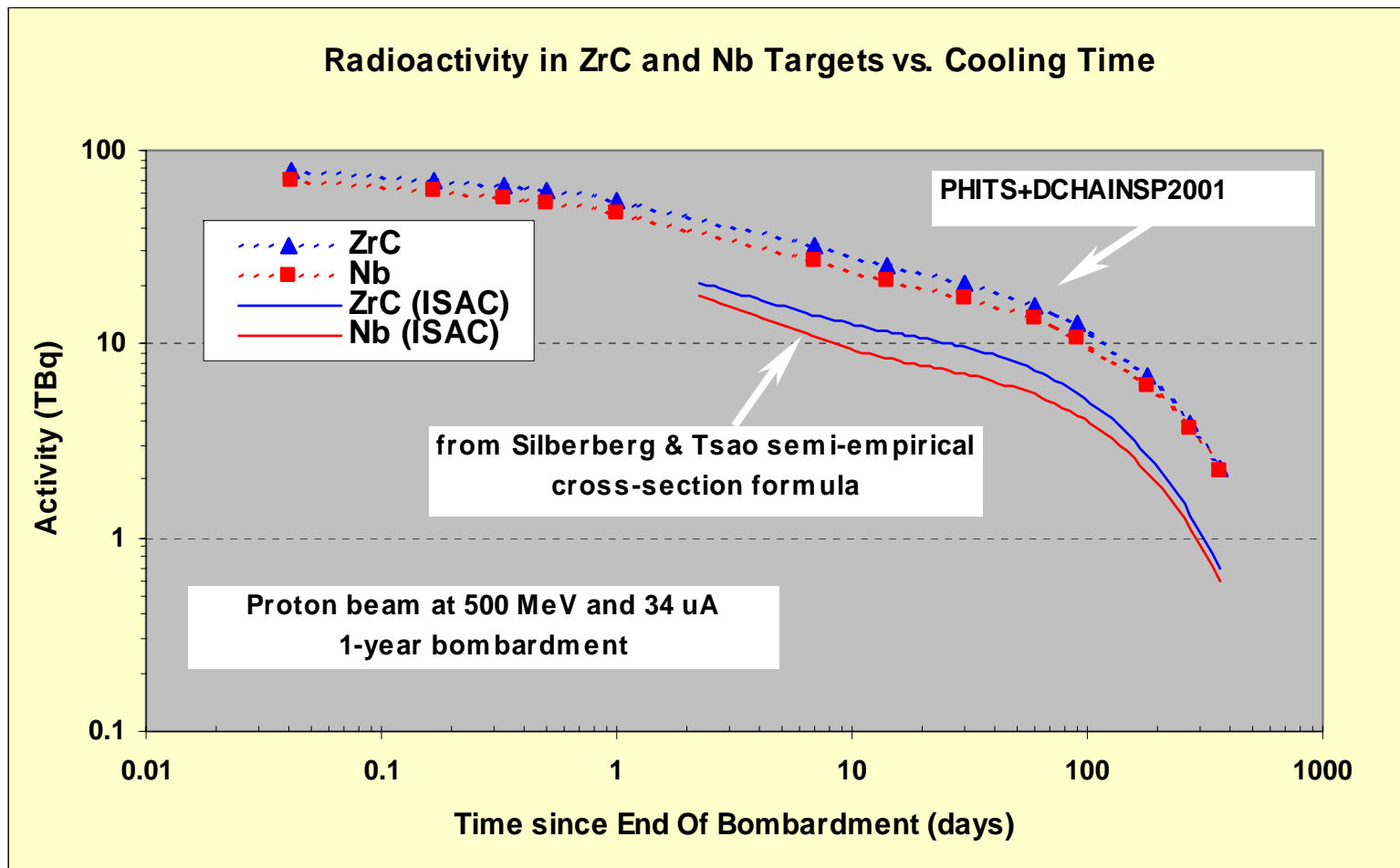
- Obtain some understanding of radioisotope inventories expected from irradiating one-step targets
 - Total Activity and Decay Heat vs. Cooling Time
 - Purposes of inventory, storage, disposal, accidental release, doses, etc

Target Geometry

- Chose 5 “typically used” one-step targets
 - Choices from targets ISAC is using or is considering
 - CaO, Nb, SiC, UC₂, ZrC
 - One-interaction length $\lambda = \rho / (N\sigma_{inelastic}) = 38.5 \times A^{0.31} \text{ g/cm}^2$
 - Geometric approximation
 - Conservative inventories
 - Target material enclosed in 0.05 cm-thick Ta

Comparison to some ISAC calculations

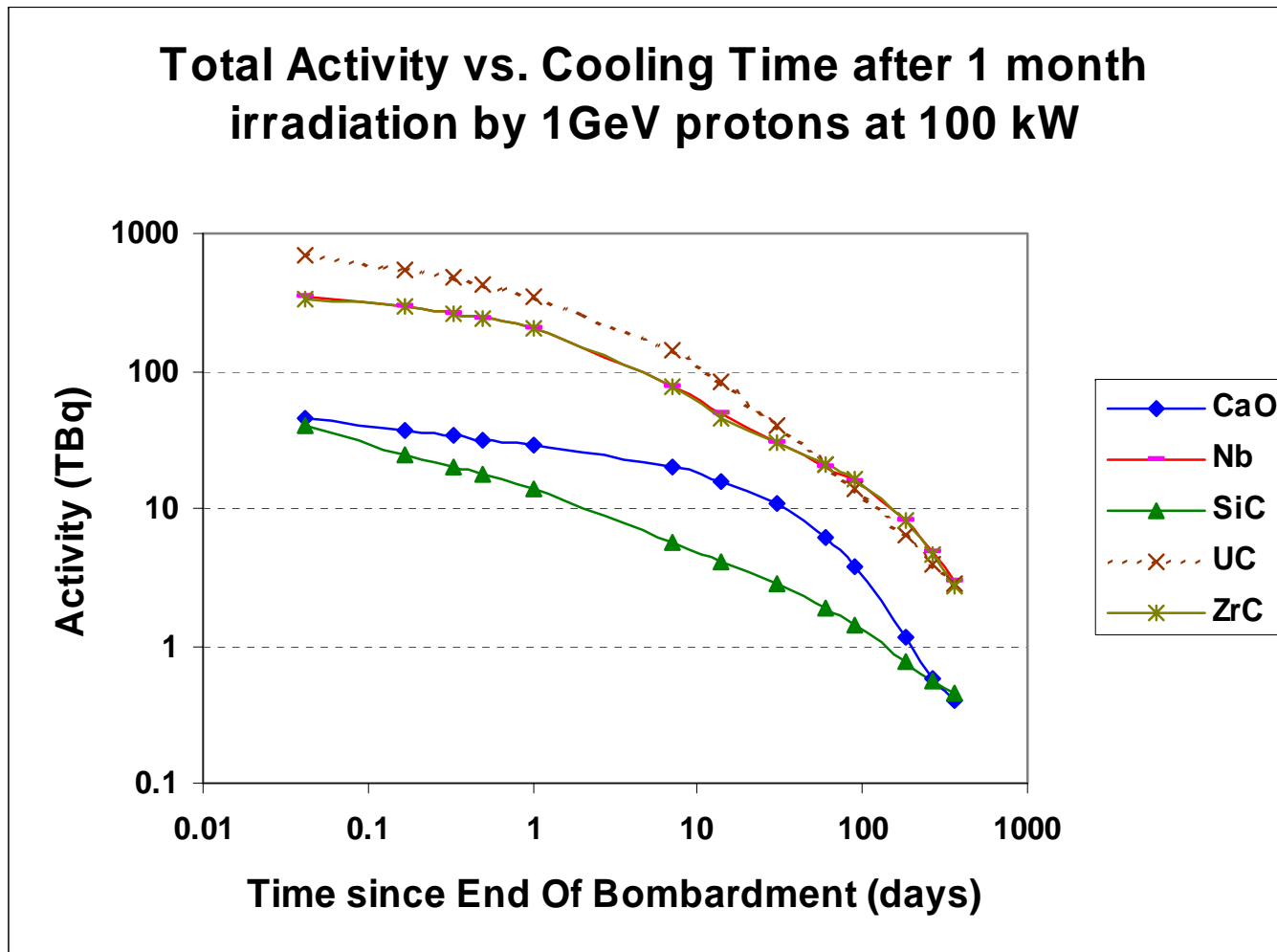
See TRIUMF ISAC Extension Safety Report (Lutz Moritz)



Beam Parameters

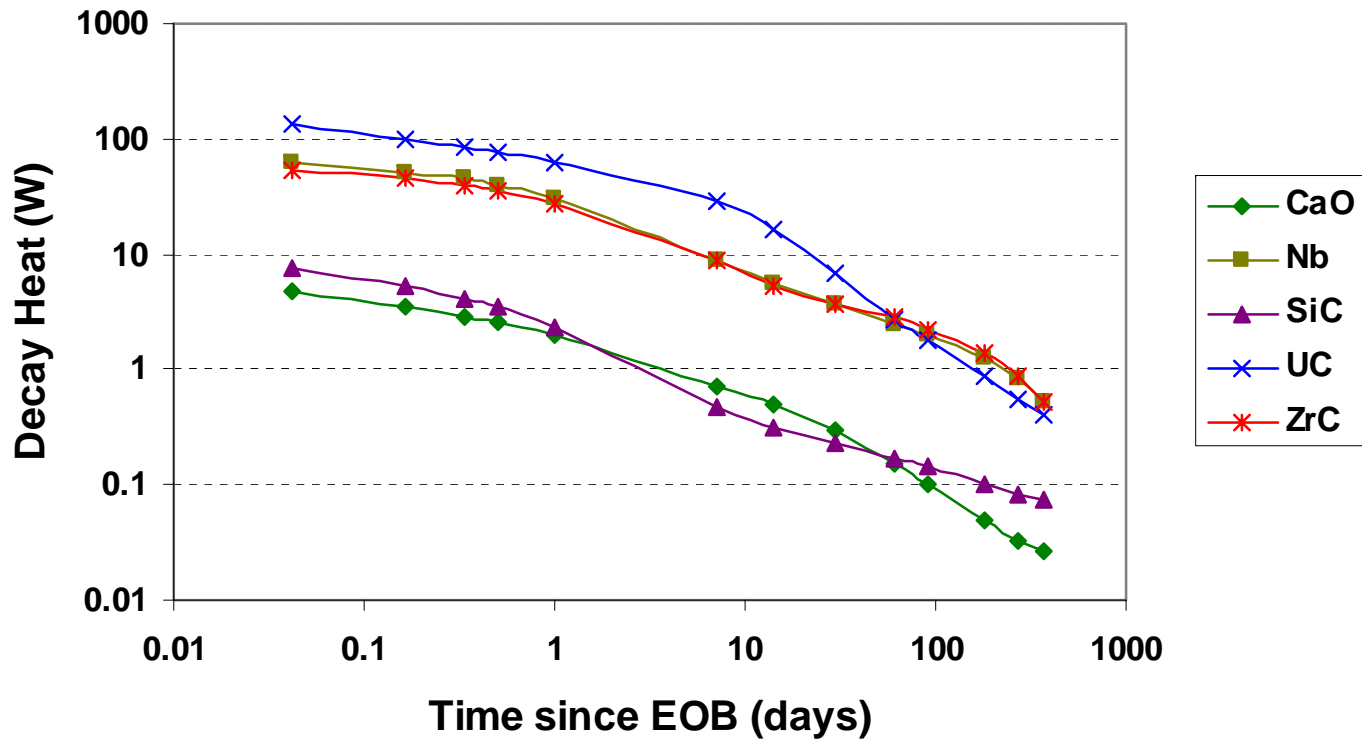
- 1 GeV p's, 622A MeV d's,
777A MeV ^3He 's
- Flat or “pencil” beam
- 1 cm radius (2 cm diameter)
- Target size is 2.54 cm diameter

Decay of Radioactivity after Production

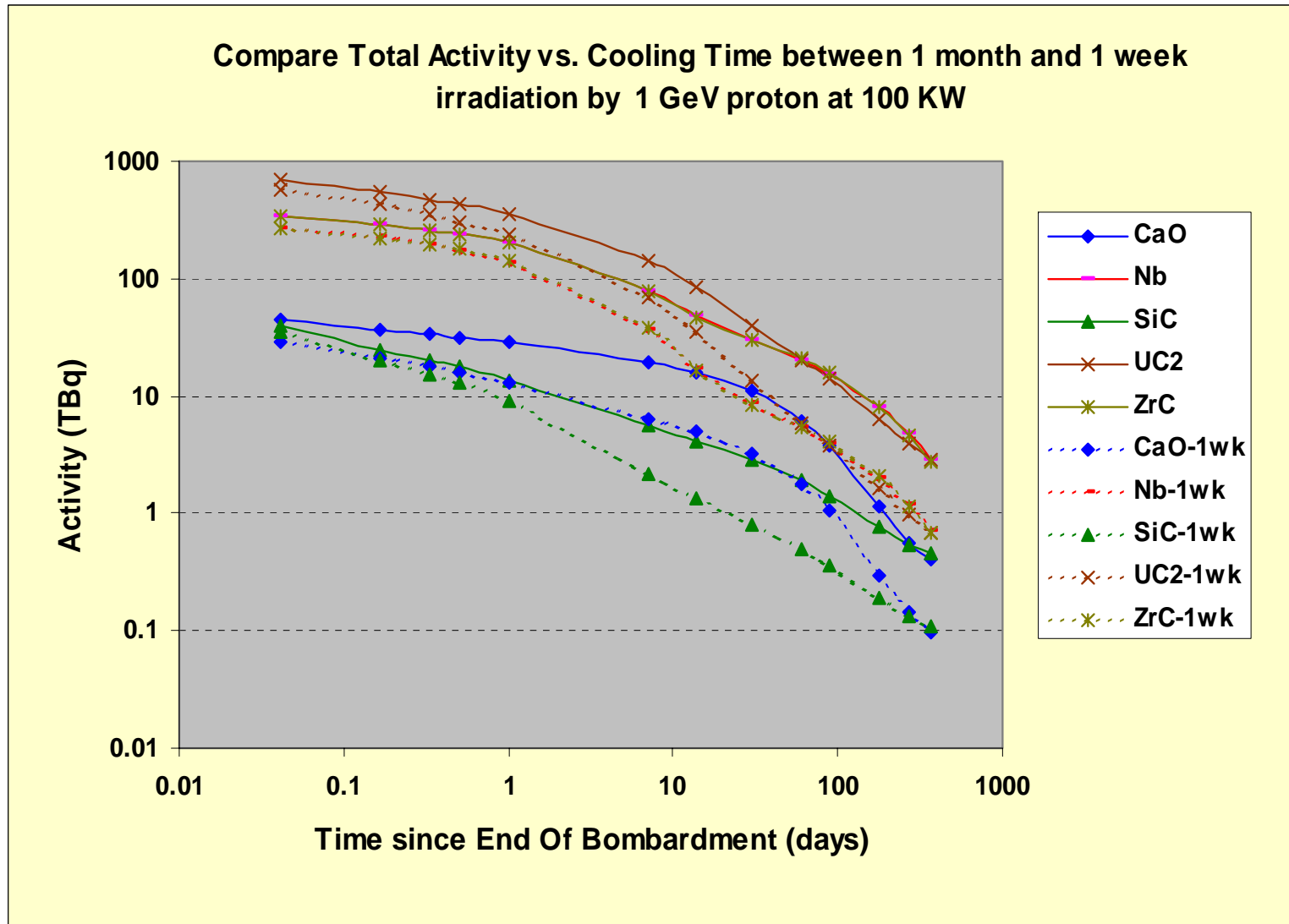


Decay Heat

Decay Heat vs. Cooling Time after 1 month irradiation by 1 GeV protons at 100 kW

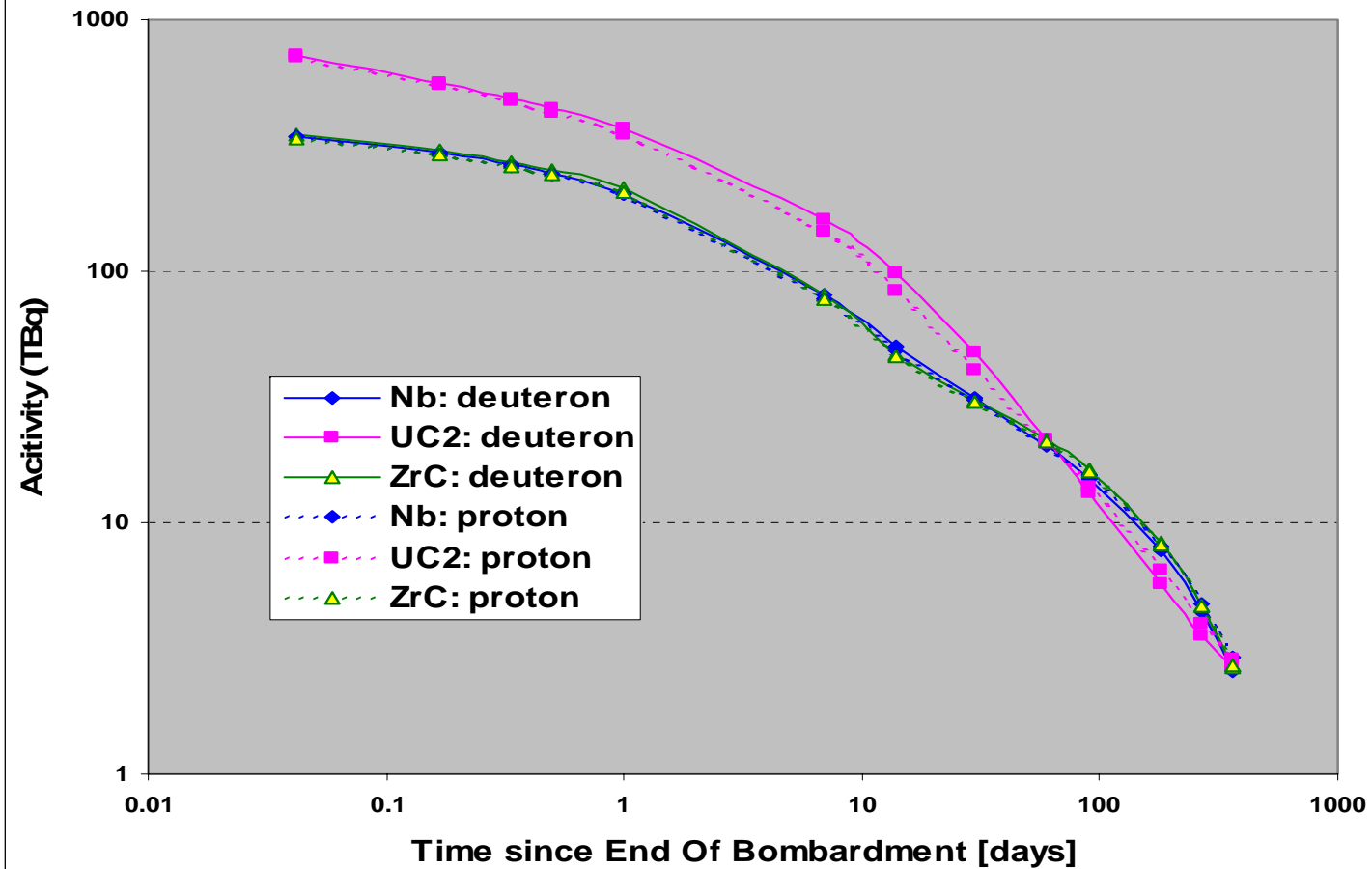


Compare Decay Activity 1 week versus 1 month irradiation

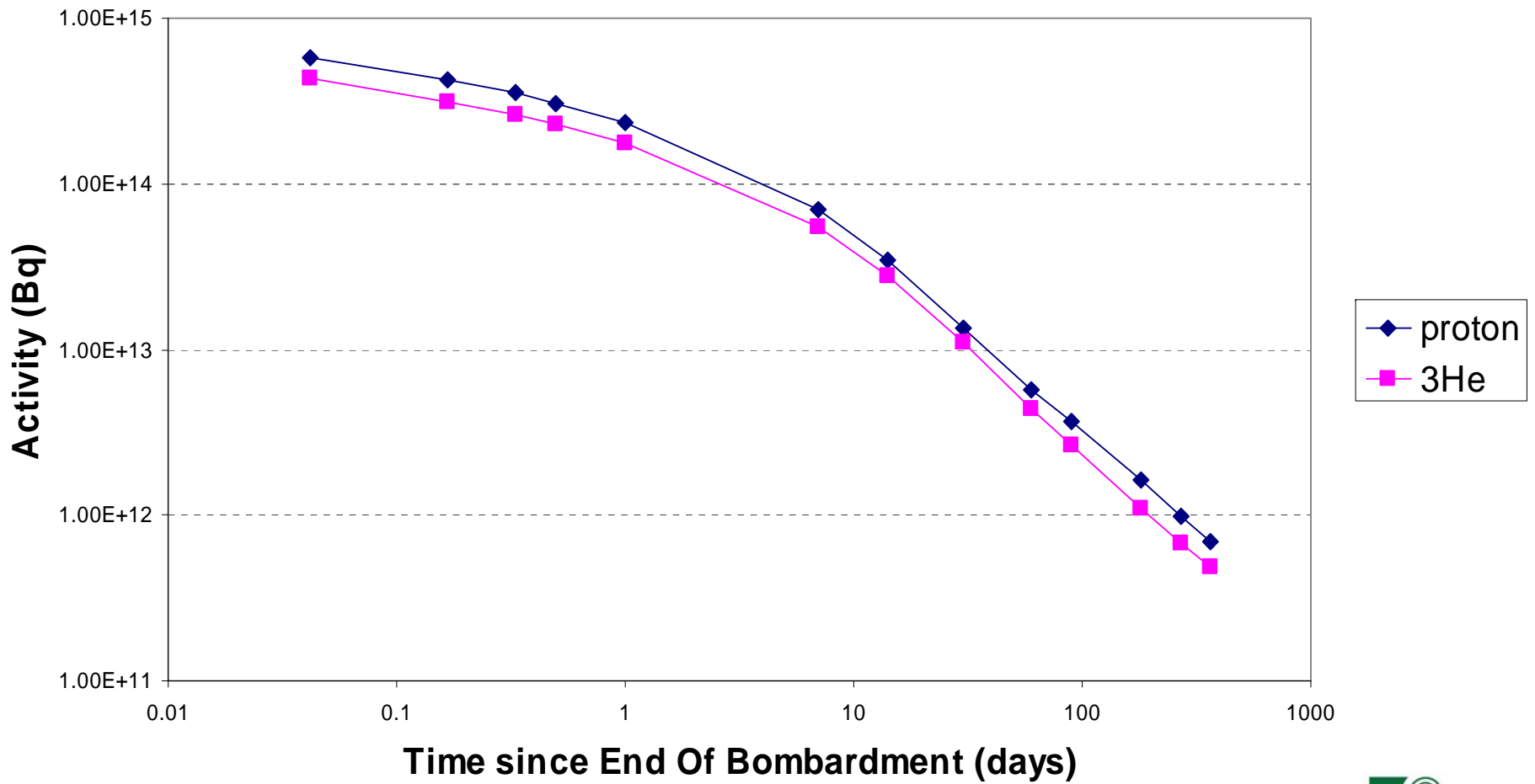


Compare Decay Activity: 622 MeV/u deuterons vs. 1 GeV protons

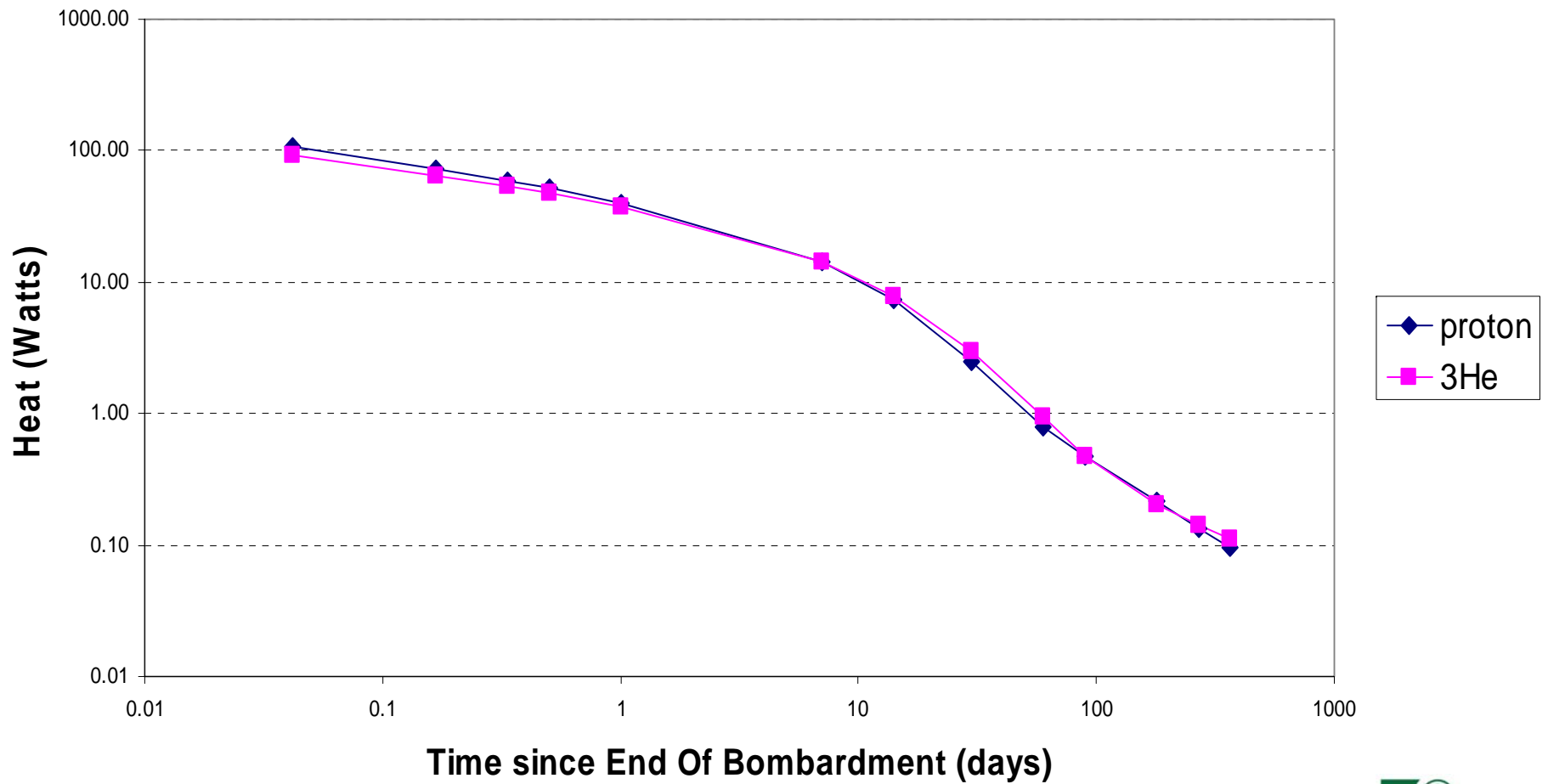
Compare Total Activity after 1 month irradiation at
100 kW: 622 MeV/u deuterons and 1 GeV protons



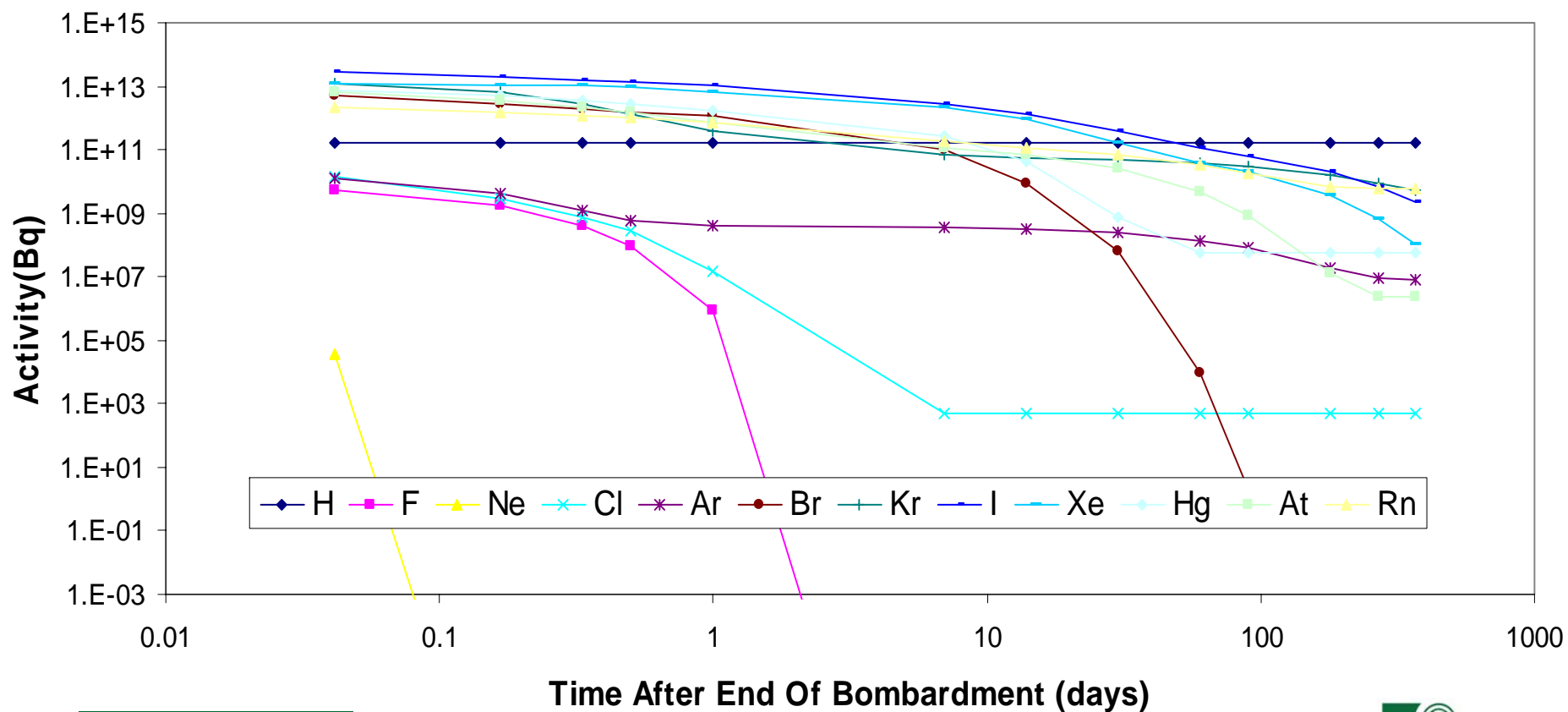
**Compare Activities and Cooling
1 GeV Protons vs 777 MeV/u 3He @ 100 kW
1-week irradiation of UC2 Target**



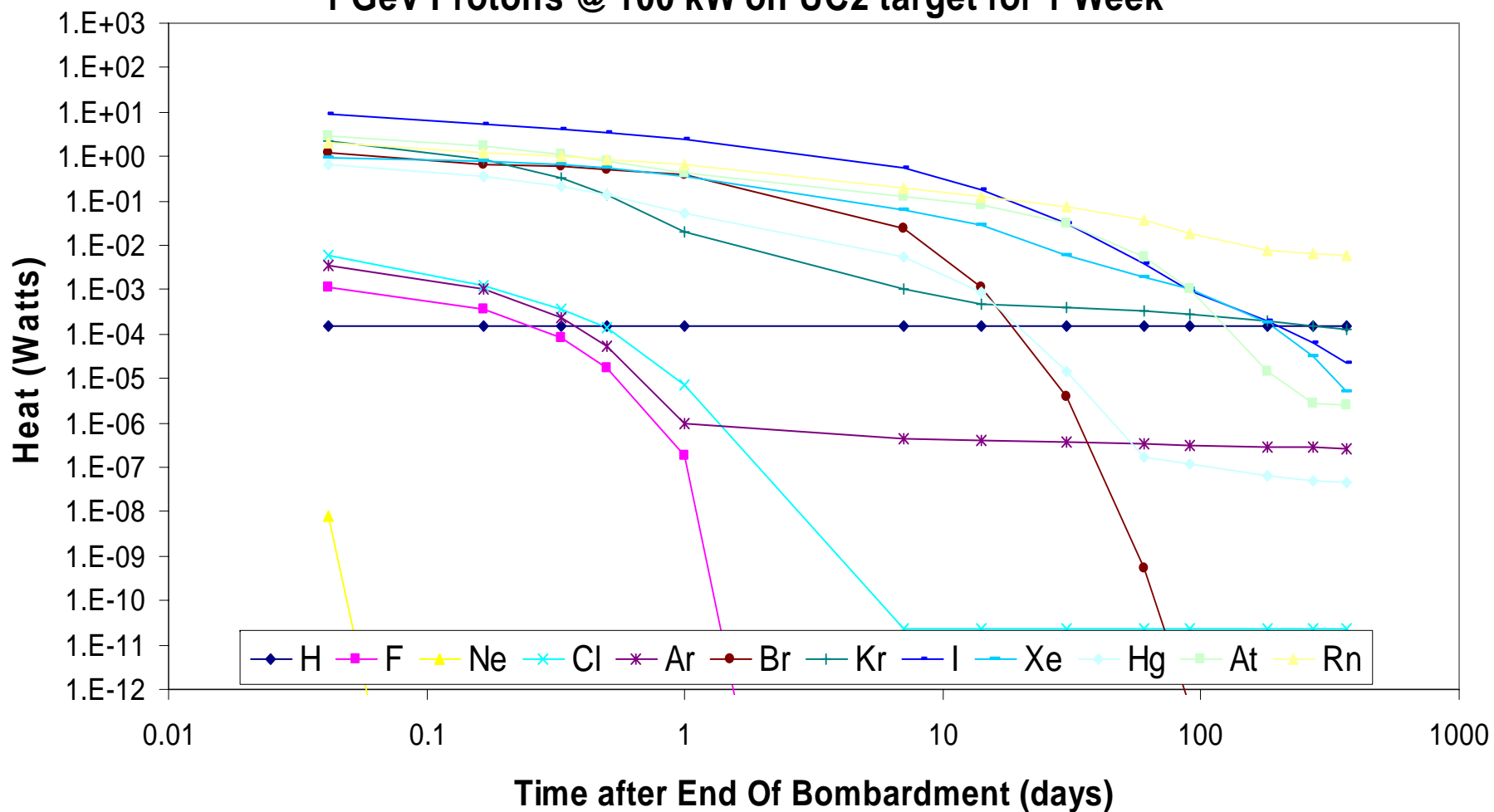
**Compare Radioactive Heat, Cooling
1 GeV Protons vs 777 MeV/u 3He @ 100 kW
1-week irradiation of UC2 Target**



Reactive and Volatile Radioactive Nuclide Production 1 GeV Protons @ 100 kW on UC2 target for 1 Week



Heat, Cooling from Reactive and Volatile Nuclides 1 GeV Protons @ 100 kW on UC2 target for 1 Week



1 Hour After End of One-Month Bombardment (100 kW)

Top-Ten Dominant Nuclides								

no.	nuclide	[Bq/cc]	[Bq]	[%]	nuclide	[W/cc]	[W]	[%]
1	U237	9.48E+11	9.22E+13	17.13	U237	3.06E-01	2.98E+01	30.22
2	Np239	2.06E+11	2.01E+13	3.72	Ag112	3.05E-02	2.97E+00	3.02
3	Rh105	1.36E+11	1.32E+13	2.46	I132	2.08E-02	2.02E+00	2.06
4	Ag111	1.10E+11	1.07E+13	1.98	Y92	1.72E-02	1.67E+00	1.7
5	Mo 99	1.06E+11	1.03E+13	1.91	La140	1.43E-02	1.39E+00	1.41
6	Ag109m	9.84E+10	9.58E+12	1.78	Np239	1.41E-02	1.37E+00	1.39
7	Pd109	9.78E+10	9.51E+12	1.77	Y93	1.29E-02	1.26E+00	1.28
8	Tc 99m	9.50E+10	9.25E+12	1.72	Nb97	1.28E-02	1.24E+00	1.26
9	In115m	9.50E+10	9.24E+12	1.72	I135	1.25E-02	1.22E+00	1.24
10	Ag112	9.21E+10	8.96E+12	1.66	Nb96	1.09E-02	1.06E+00	1.08
total activity		5.54E+12	[Bq/cc]	5.38E+14	[Bq]			
total decay heat		1.01E+00	[W/cc]	9.85E+01	[W]			
(beta)		5.15E-01	[W/cc]	(50.0568 [W])	50.84%			
(gamma)		4.07E-01	[W/cc]	(39.5846 [W])	40.21%			
(alpha)		9.06E-02	[W/cc]	(8.81404 [W])	8.95%			
activated atoms		2.59E+22	[/cm**3]					
(A=60-180:all)		1.97E+19	[/cm**3]					
(A=60-180:activated)		6.38E+18	[/cm**3]					

1 Year After End of One-Month Bombardment (100 kW)

Top-Ten Dominant Nuclides								

no.	nuclide	[Bq/cc]	[Bq]	[%]	nuclide	[W/cc]	[W]	[%]
1	H3	7.08E+09	6.89E+11	25.23	Rh106	7.07E-04	6.88E-02	17.57
2	Rh106	2.72E+09	2.65E+11	9.71	Po210	4.14E-04	4.02E-02	10.28
3	Ru106	2.72E+09	2.65E+11	9.71	Po208	3.19E-04	3.11E-02	7.93
4	Nb95	1.12E+09	1.09E+11	4.01	Po216	2.65E-04	2.58E-02	6.59
5	Sb125	9.18E+08	8.93E+10	3.27	Rn220	2.46E-04	2.39E-02	6.11
6	Pr144	6.92E+08	6.73E+10	2.47	Ra224	2.22E-04	2.16E-02	5.52
7	Ce144	6.92E+08	6.73E+10	2.47	Po212	2.20E-04	2.14E-02	5.47
8	Au195	5.25E+08	5.11E+10	1.87	Th228	2.11E-04	2.05E-02	5.24
9	Zr95	5.23E+08	5.09E+10	1.87	Y88	1.69E-04	1.65E-02	4.21
10	Sn123	4.78E+08	4.65E+10	1.7	Nb95	1.46E-04	1.42E-02	3.62
total activity	2.80E+10	[Bq/cc]	2.73E+12	[Bq]				
total decay heat	4.03E-03	[W/cc]	3.92E-01	[W]				
(beta)	1.05E-03	[W/cc]	(1.02E-01 [W])	26.10%				
(gamma)	9.22E-04	[W/cc]	(8.97E-02 [W])	22.89%				
(alpha)	2.05E-03	[W/cc]	(2.00E-01 [W])	51.01%				
activated atoms	2.59E+22	[/cm**3]						
(A=60-180:all)	1.96E+19	[/cm**3]						
(A=60-180:activated)	4.06E+18	[/cm**3]						

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