



# Spent fuel characterization in Lithuania

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- Nuclear power in Lithuania
- Spent fuel management
- Geological disposal
- Lithuanian energy institute
- Modelling of RBMK-1500



# Nuclear power in Lithuania

- There are two units with RBMK-1500 reactors at the Ignalina NPP. The first unit began commercial operation at 1985, the second – at 1987.
- In order to join the EU, Lithuania had to shut down the first unit at the end of 2004 and the second unit at the end of 2009.
- In 2006 the feasibility study for construction of the new nuclear power plant in Lithuania to replace existing Ignalina Nuclear Power Plant was carried out.
- On 14 October 2012 an advisory referendum on constructing a new nuclear plant found 62.7% of the participating Lithuanian electorate against and 34.1% for.
- The revised National Energy Independence Strategy does not foresee development of nuclear power in Lithuania.



# Spent fuel management

- Both reactors are defueled.
- Ignalina NPP has plans to defuel both units' spent fuel pools until 2022.
- Ignalina NPP operates two dry type spent nuclear fuel storage facilities: the first facility contains 98 CONSTOR RBMK-1500 type and 20 CASTOR RBMK containers. This facility is fully loaded; the second facility was put in operation on 4 May 2017 and will contain about 190 CONSTOR RBMK-1500/M2 type containers. Common design capacity of two facilities is about 2400 tons of heavy metal – all spent fuel of Ignalina NPP.
- Approximately 22,000 SNF assemblies are due for geological disposal. Currently it is envisaged that SNF will be stored in dry interim storage facilities for at least 50 y prior to possible deep geological disposal.



# Geological disposal

## THE DEVELOPMENT PROGRAM OF RADIOACTIVE WASTE MANAGEMENT:

- Site selection – 2033.
- The begin of construction – 2039/2040.
- The begin of operation – 2066.
- The closing of deep repository – 2072.

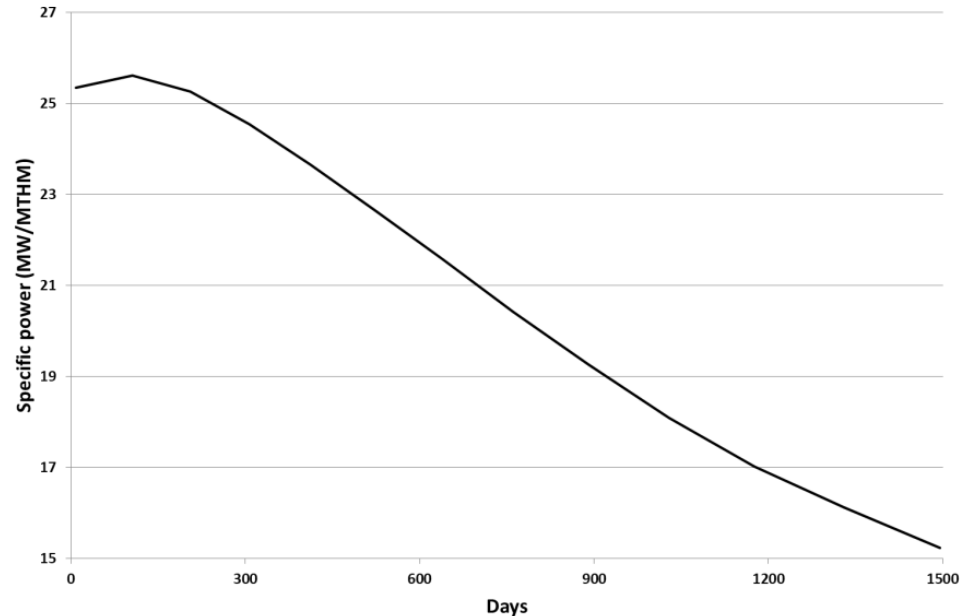
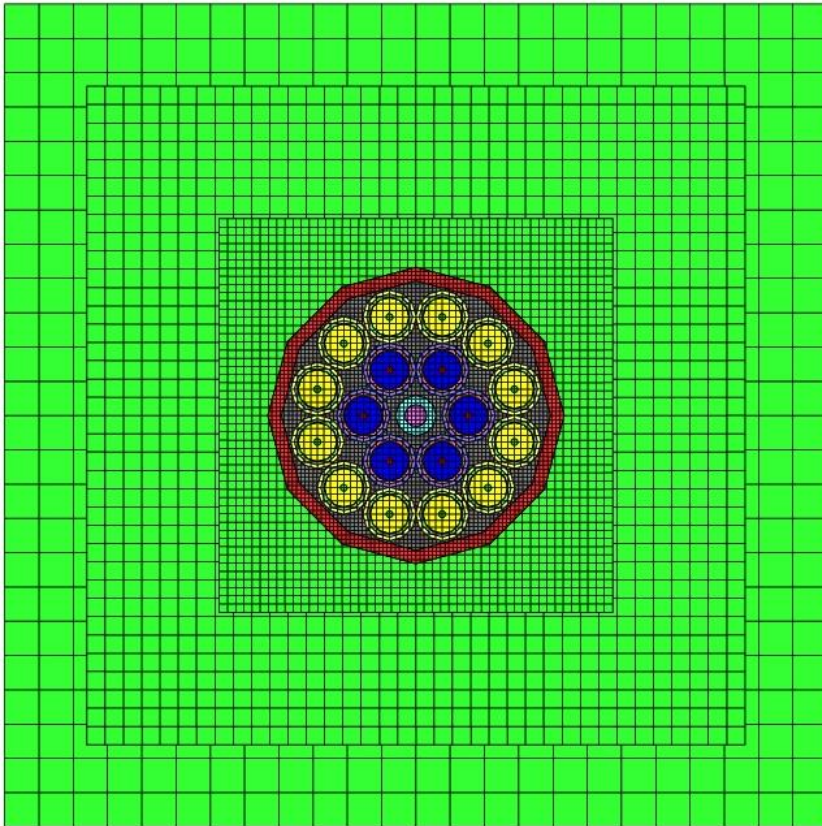


# Lithuanian energy institute

- R&D&I Directions
- I. Thermal physics, gas and liquid dynamics and metrology research;
- II. Research of materials, processes and technologies, devoted to use renewable energy sources, to develop hydrogen energy, to efficiently use energy sources and reduce environmental pollution;
- III. Safety and reliability research of nuclear and thermal nuclear power engineering and other industrial objects;
- **IV. Methods of nuclear waste management, also terminating the operation of Ignalina nuclear power plant;**
- V. Simulation and management of power systems, energy economy.



# RBMK-1500 fuel assembly



SCALE 6.1 code package (TRITON/T-NEWT sequence) was used to perform the neutron transport and depletion calculations.

SCALE developers performed the verification and validation of the code package based on the experimental investigations of RBMK-1000 fuel.



# Dancoff factor

- With the correct geometry model for the fuel assemblies established, it is important to determine the Dancoff factors for multi-group transport calculations (like T-NEWT).
- The Dancoff factor is the probability that a neutron emitted isotropically from the surface of one absorber lump will pass through the external media and enter a nearby absorber lump.
- Dancoff factors have a significant impact on transport calculation (including for isotopic calculations), given the relatively heterogeneous environment of BWR or CANDU fuel assembly.





# Dancoff factor

- Two materials (graphite and water) are used as a neutron moderator of the RBMK reactor. However, only one material can be determined as a moderator in SCALE XS processing. Therefore, water is considered as a moderator, while the influence of graphite on resonant neutron absorption cross-sections is not evaluated. Therefore, approximation is not correct.
- Some studies show that differences in Dancoff factors can have large impacts in the effective cross-sections, and thus, the isotopic calculations. It was also noted that at higher burnups Dancoff factors are particularly important. Deviations of 8% for U-235 and 3-5% in plutonium isotopes were seen when Dancoff factors were not used.

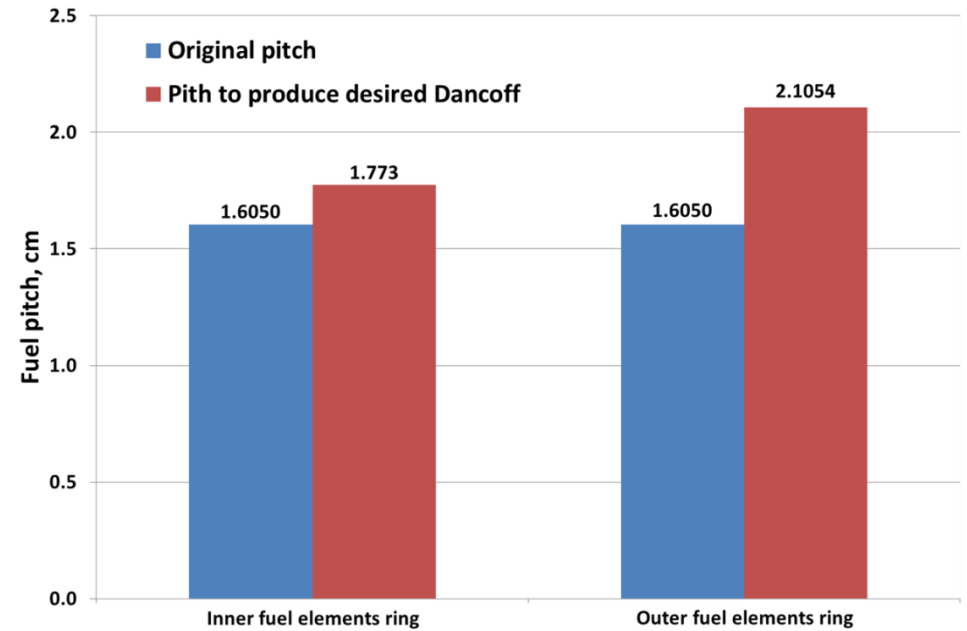
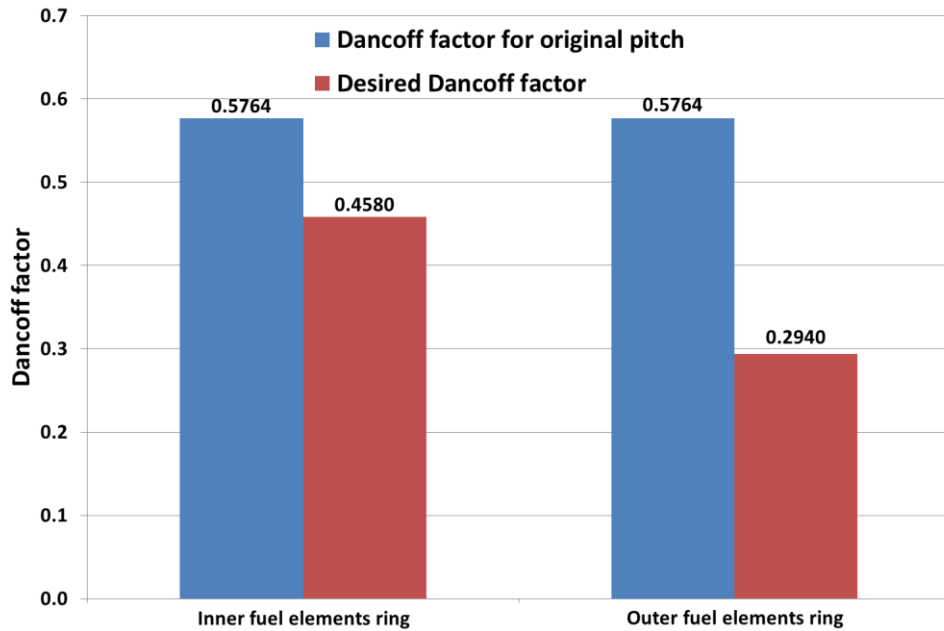
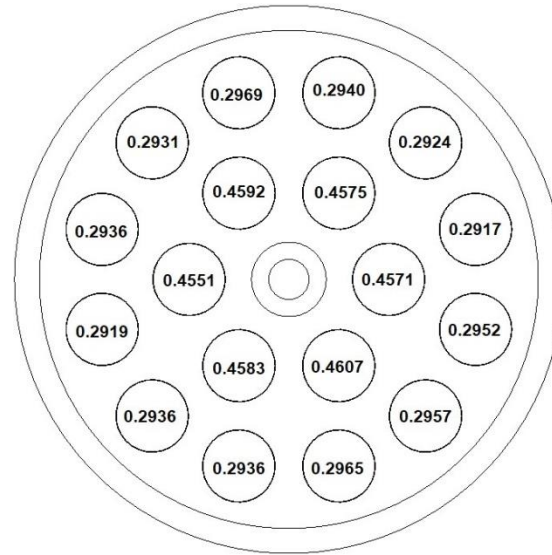


# Dancoff factor

- The lattice treatment assumes an infinite lattice which consists of identical fuel pin cells with segregated inside the regions for fuel, gap, cladding and moderator. The region of graphite block outside fuel assembly and fuel pin cells was not included during the estimation of spatial resonance self-shielding effects and the preparation of problem-specific multigroup XS.
- The MCDancoff module within SCALE code was used to calculate Dancoff factors for specific locations in the fuel assembly. The calculation within MCDancoff module involves the following of neutrons paths through all system regions and materials till they are absorbed or have exited the system. Thus all system details of geometry and materials were considered in the estimation of spatial resonance self-shielding effects in this case.



# Dancoff factor





# The experimental data

Makarova, T.P., Bibichev, B.A., Domkin, V.D., 2008. Destructive analysis of the nuclide composition of Spent fuel of WWER-440, WWER-1000, and RBMK-1000 reactors. Radiochemistry 50 (4), 414–426.

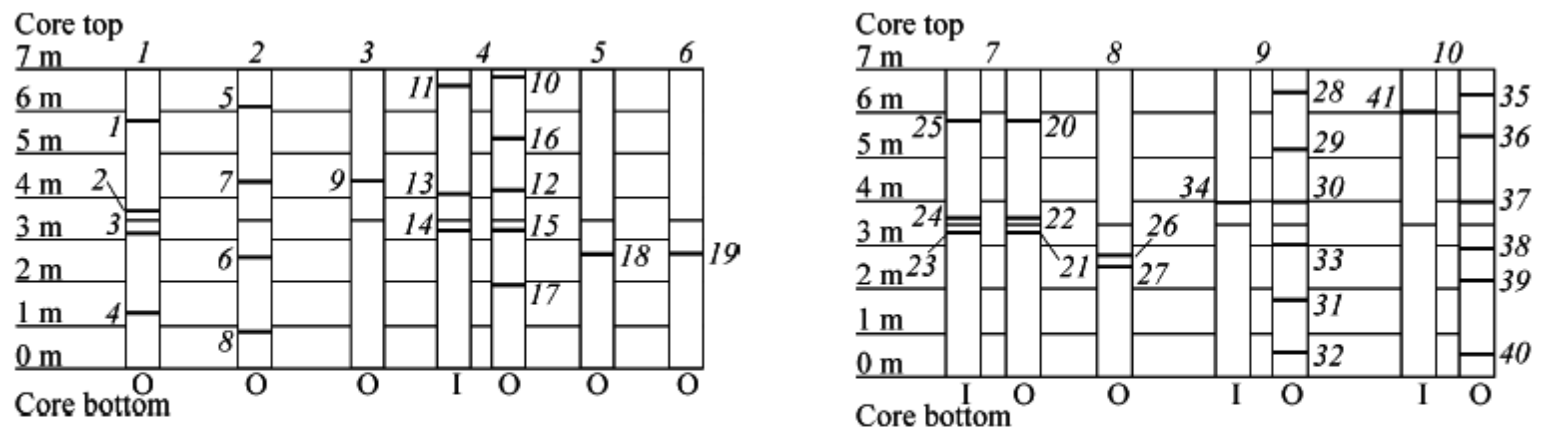


Fig. 2. Cutting schemes for the samples of the SNF from RBMK-1000 reactor: (O) outer and (I) inner row. (1) R-1029, (2) REV-34, (3) R-870, (4) RG-221, (5) REA-35-74, (6) REB-01-74, (7) R1-20-2603, (8) IG-12-2, (9) R1-20-7788, and (10) 4-20-3675-85.

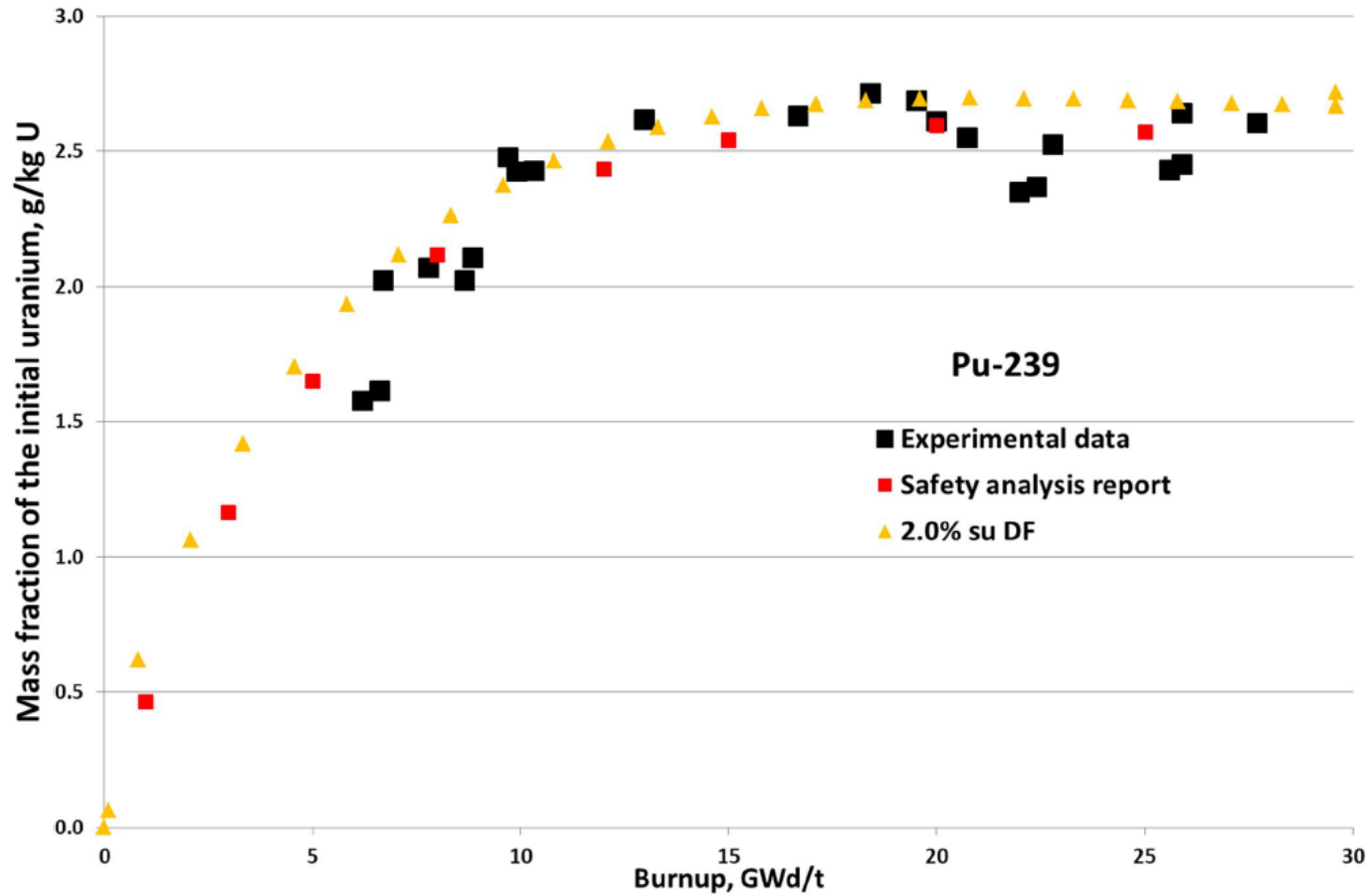


# The experimental data

Sample no.	Cutting place	Enrichment	Burnup	Row	Burnup	U-234	U-235	U-236	U-238	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242	Np-237	Am-241	Am-243	Cm-242	Cm-244
20	5.85	2	6.29	O	6.2	1.47E-01	1.38E+01	1.18E+00	9.76E+02	1.43E-03	1.58E+00	3.36E-01	7.50E-02	6.90E-03	2.90E-02	1.00E-06	5.00E-04	1.92E-04	1.50E-05
21	3.3	2	6.29	O	8.65	1.42E-01	1.18E+01	1.49E+00	9.75E+02	2.94E-03	2.02E+00	5.88E-01	1.42E-01	1.89E-02	4.30E-02	6.00E-06	1.00E-03	4.80E-04	3.60E-05
22	3.7	2	6.29	O	8.86	1.40E-01	1.17E+01	1.50E+00	9.75E+02	3.32E-03	2.11E+00	6.41E-01	1.55E-01	2.29E-02	4.50E-02	6.00E-06	1.10E-03	5.40E-04	1.13E-04
23	3.3	2	6.29	I	6.7	1.43E-01	1.28E+01	1.34E+00	9.77E+02	2.62E-03	2.02E+00	4.95E-01	1.13E-01	1.32E-02	3.30E-02	4.00E-06	1.20E-03	3.30E-04	5.60E-05
24	3.7	2	6.29	I	7.79	1.44E-01	1.27E+01	1.34E+00	9.75E+02	2.86E-03	2.07E+00	5.18E-01	1.21E-01	1.41E-02	4.30E-02	4.00E-06	1.20E-03	3.30E-04	3.10E-05
25	5.85	2	6.29	I	6.62	1.46E-01	1.37E+01	1.20E+00	9.76E+02	2.00E-03	1.61E+00	3.55E-01	8.00E-02	1.00E-02	3.00E-02	1.00E-06	1.80E-03	2.19E-04	4.20E-05
26	2.71	2	22	O	22	1.08E-01	3.41E+00	2.70E+00	9.67E+02	4.46E-02	2.35E+00	1.92E+00	5.78E-01	3.69E-01	1.85E-01	2.50E-05	3.64E-02	6.33E-03	6.24E-03
27	2.56	2	-	O	22.4	1.08E-01	3.42E+00	2.72E+00	9.67E+02	4.35E-02	2.37E+00	1.93E+00	5.68E-01	3.66E-01	2.04E-01	2.50E-05	3.70E-02	7.25E-03	7.10E-03
28	6.5	2.02	20.32	O	10.33	1.84E-01	1.06E+01	2.88E+00	9.74E+02	1.49E-02	2.43E+00	8.04E-01	2.16E-01	3.80E-02	1.49E-01	1.50E-05	5.00E-04	1.25E-03	1.50E-04
29	5.25	2.02	20.32	O	25.9	1.44E-01	3.42E+00	3.84E+00	9.63E+02	1.03E-01	2.64E+00	2.23E+00	7.02E-01	4.71E-01	3.00E-01	4.00E-05	6.10E-02	1.00E-02	1.14E-02
30	4	2.02	20.32	O	27.7	1.39E-01	2.97E+00	3.91E+00	9.62E+02	1.12E-01	2.60E+00	2.31E+00	7.20E-01	5.32E-01	3.70E-01	4.00E-05	5.60E-02	9.80E-03	1.21E-02
31	1.75	2.02	20.32	O	25.6	1.38E-01	2.78E+00	3.91E+00	9.64E+02	8.98E-02	2.43E+00	2.07E+00	6.24E-01	4.62E-01	2.70E-01	3.00E-05	5.30E-02	8.60E-03	9.10E-03
32	0.5	2.02	20.32	O	16.67	1.63E-01	6.28E+00	3.40E+00	9.68E+02	3.92E-02	2.63E+00	1.42E+00	4.24E-01	1.52E-01	2.00E-01	2.00E-05	-	2.50E-03	3.00E-03
33	3	2.02	20.32	O	25.9	1.32E-01	2.60E+00	3.80E+00	9.61E+02	1.02E-01	2.45E+00	2.19E+00	6.67E-01	5.25E-01	2.66E-01	3.00E-05	6.30E-02	7.40E-03	8.30E-03
34	4	2.02	20.32	I	20.72	1.48E-01	4.59E+00	3.66E+00	9.65E+02	7.21E-02	2.55E+00	1.84E+00	5.39E-01	2.90E-01	2.46E-01	2.50E-05	2.70E-02	9.30E-03	6.70E-03
35	6.5	2.09	17.52	O	9.91	2.55E-01	1.18E+01	5.10E+00	9.70E+02	2.14E-02	2.42E+00	7.24E-01	2.02E-01	3.08E-02	1.63E-01	1.50E-05	4.00E-04	1.18E-03	1.20E-04
36	5.5	2.09	17.52	O	18.4	2.19E-01	6.68E+00	5.81E+00	9.64E+02	7.46E-02	2.71E+00	1.54E+00	4.99E-01	1.84E-01	3.14E-01	2.50E-05	1.30E-02	4.40E-03	2.30E-03
37	4	2.09	17.52	O	20	2.07E-01	4.96E+00	5.96E+00	9.62E+02	1.01E-01	2.61E+00	1.81E+00	5.80E-01	2.96E-01	3.27E-01	2.50E-05	2.20E-02	6.60E-03	4.90E-03
38	3	2.09	17.52	O	22.8	1.97E-01	4.13E+00	5.97E+00	9.61E+02	1.01E-01	2.53E+00	1.88E+00	5.78E-01	3.40E-01	3.40E-01	2.50E-05	3.10E-02	8.10E-03	6.30E-03
39	2.25	2.09	17.52	O	19.51	2.14E-01	5.98E+00	5.80E+00	9.64E+02	8.22E-02	2.69E+00	1.67E+00	4.90E-01	2.09E-01	3.46E-01	2.50E-05	1.25E-02	5.20E-03	3.10E-03
40	0.5	2.09	17.52	O	12.98	2.22E-01	9.40E+00	4.89E+00	9.68E+02	3.89E-02	2.62E+00	1.10E+00	3.23E-01	7.70E-02	2.60E-01	1.00E-05	1.30E-03	2.40E-03	6.00E-04
41	6	2.09	17.52	I	9.7	2.39E-01	1.15E+01	4.64E+00	9.70E+02	2.28E-02	2.48E+00	7.69E-01	2.14E-01	3.50E-02	1.06E-01	1.50E-05	4.00E-04	1.20E-03	1.40E-04



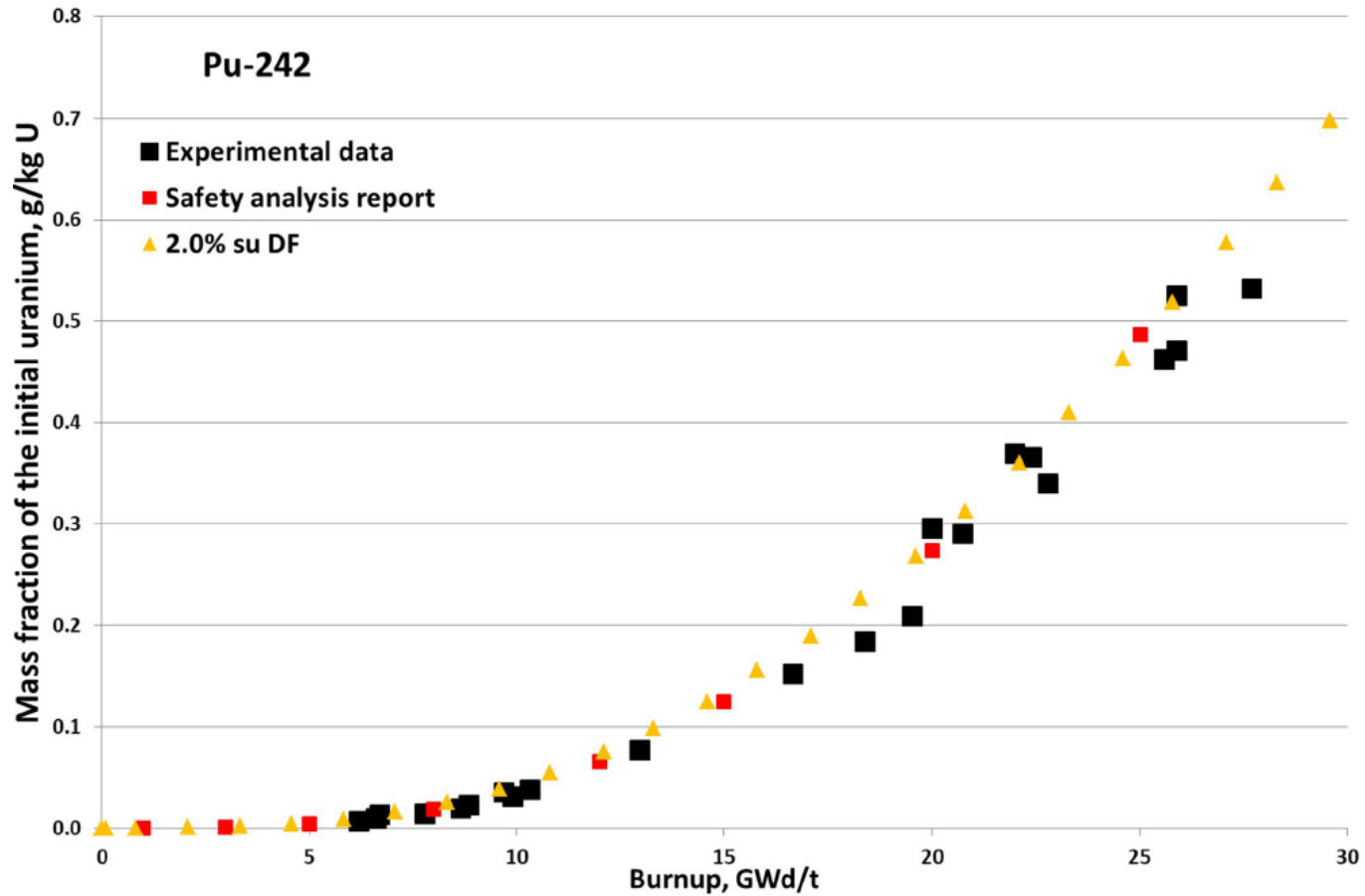
# Pu-239



Safety analysis report for decommissioning project for Ignalina NPP Unit 2 final shut down and defuelling phase.



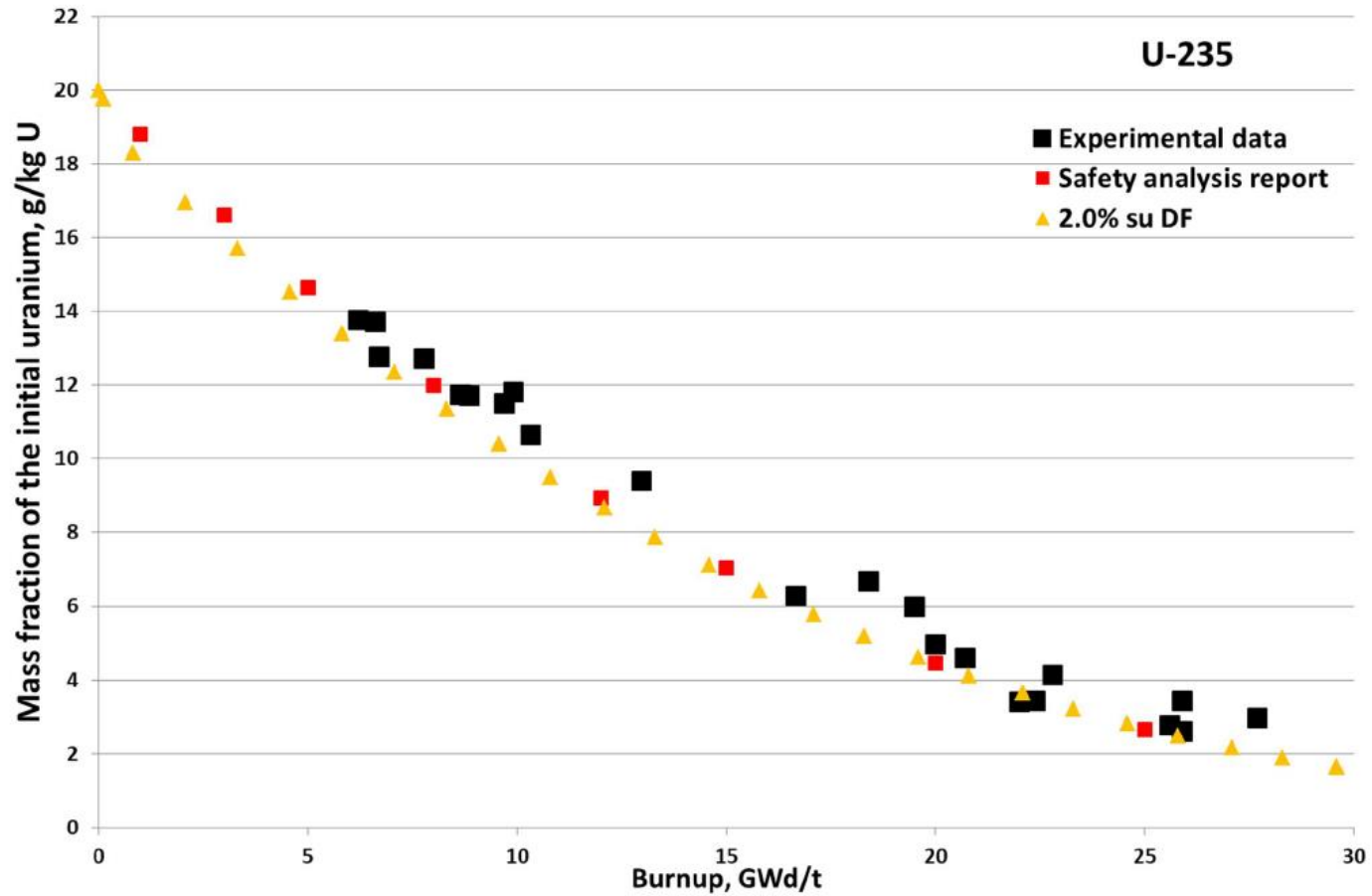
# Pu-242



Safety analysis report for decommissioning project for Ignalina NPP Unit 2 final shut down and defuelling phase.



# U-235

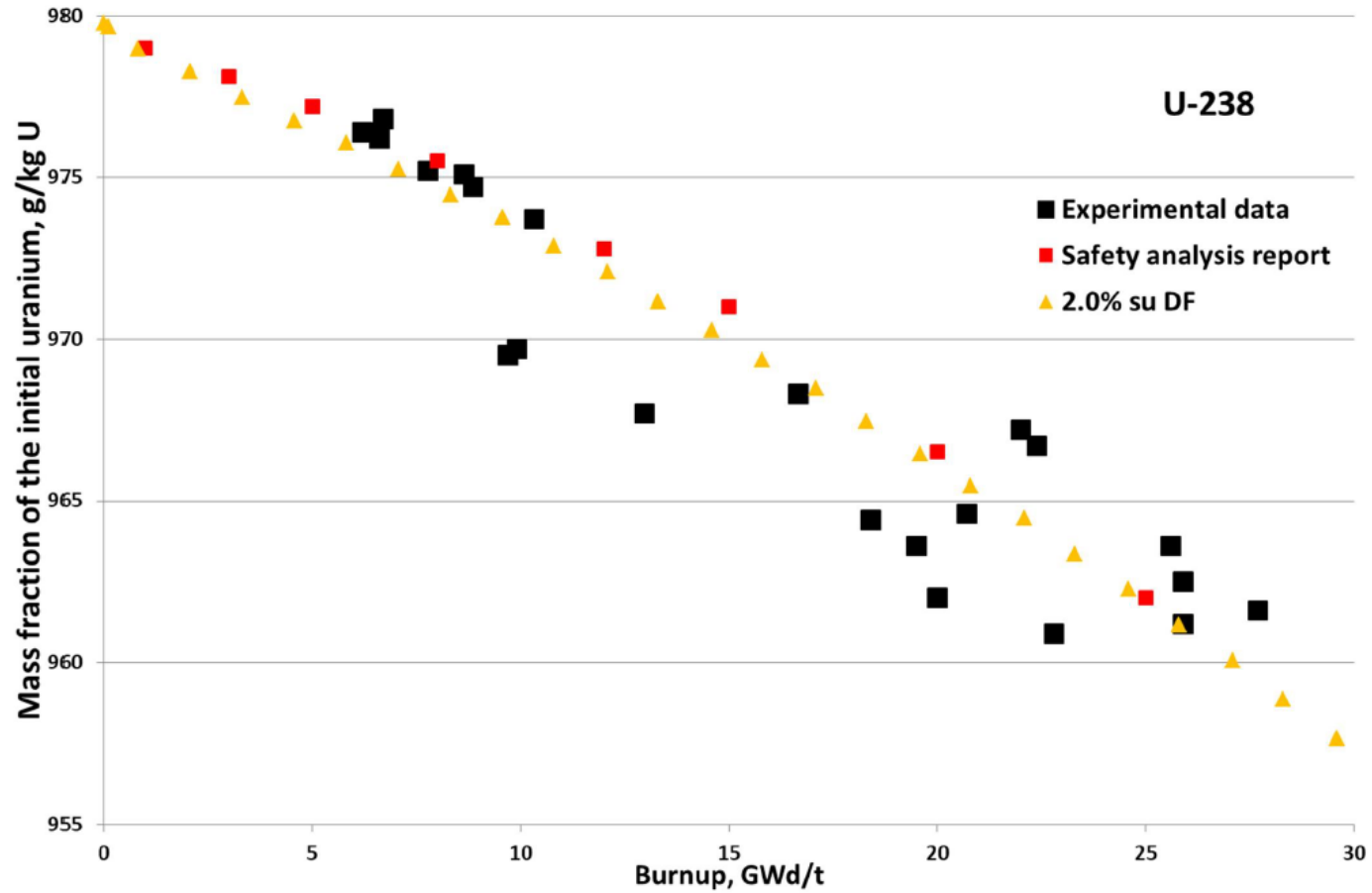


Safety analysis report for decommissioning project for Ignalina NPP Unit 2 final shut down and defuelling phase.





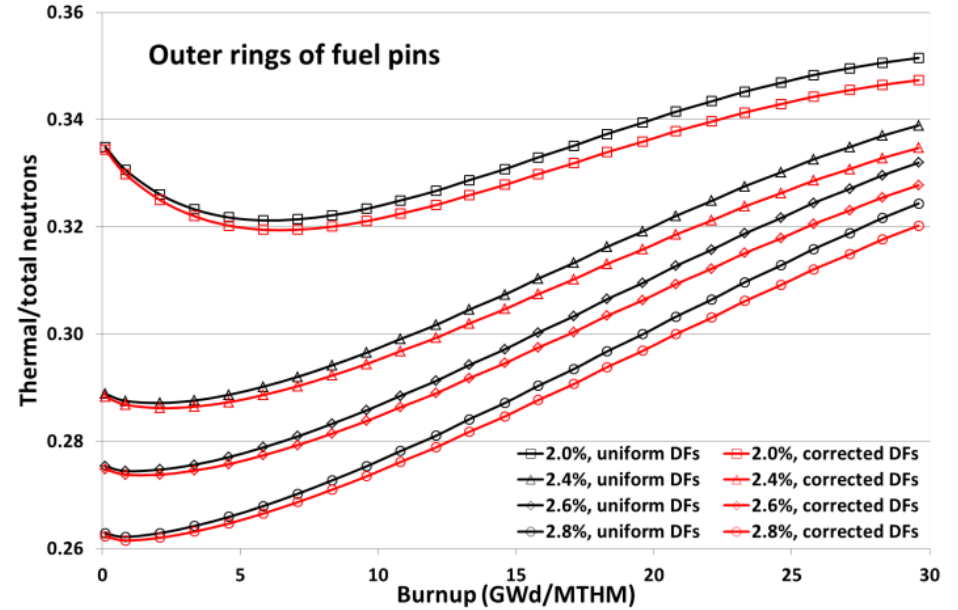
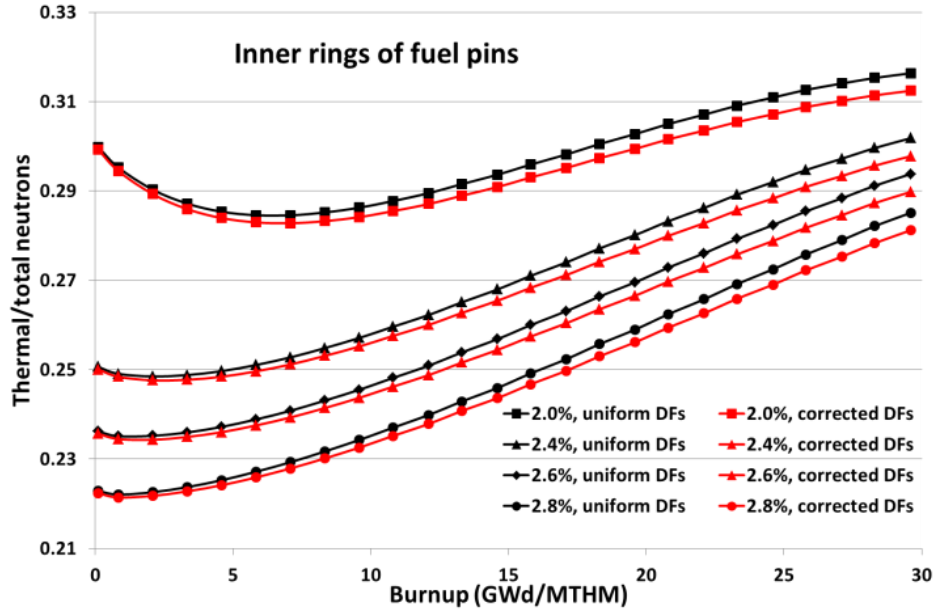
# U-238



Safety analysis report for decommissioning project for Ignalina NPP Unit 2 final shut down and defuelling phase.



# The ratio of thermal and total neutrons





# Pu-239

<b>Bp</b>	<b>2.0%, - DFs</b>	<b>2.0%, + DFs</b>	<b>2.4%, - DFs</b>	<b>2.4%, + DFs</b>	<b>2.6%, - DFs</b>	<b>2.6%, + DFs</b>	<b>2.8%, - DFs</b>	<b>2.8%, + DFs</b>		<b>2.0%</b>	<b>2.4%</b>	<b>2.6%</b>	<b>2.8%</b>
0	4.98E-16	4.98E-16	5.00E-16	5.00E-16	5.01E-16	5.01E-16	5.01E-16	5.01E-16		0.00%	0.00%	0.00%	0.00%
0.101	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.06		2.17%	2.39%	2.47%	2.53%
0.828	0.62	0.63	0.59	0.60	0.57	0.58	0.55	0.56		2.16%	2.39%	2.47%	2.55%
2.08	1.06	1.09	1.02	1.04	0.99	1.02	0.97	0.99		2.26%	2.36%	2.47%	2.54%
3.33	1.42	1.45	1.37	1.41	1.34	1.38	1.32	1.35		2.19%	2.40%	2.53%	2.59%
4.58	1.70	1.74	1.66	1.70	1.63	1.67	1.61	1.65		2.23%	2.40%	2.45%	2.55%
5.83	1.93	1.98	1.90	1.95	1.88	1.92	1.86	1.90		2.28%	2.42%	2.50%	2.53%
7.08	2.11	2.16	2.10	2.15	2.08	2.13	2.06	2.11		2.32%	2.48%	2.50%	2.57%
8.33	2.26	2.31	2.26	2.32	2.25	2.30	2.23	2.29		2.34%	2.48%	2.54%	2.64%
9.58	2.38	2.43	2.39	2.45	2.38	2.44	2.37	2.44		2.40%	2.55%	2.60%	2.65%
10.8	2.47	2.53	2.49	2.56	2.49	2.56	2.49	2.56		2.47%	2.57%	2.61%	2.65%
12.1	2.53	2.60	2.58	2.64	2.58	2.65	2.59	2.66		2.49%	2.60%	2.63%	2.71%
13.3	2.59	2.65	2.64	2.71	2.65	2.72	2.67	2.74		2.51%	2.65%	2.71%	2.74%
14.6	2.63	2.69	2.69	2.76	2.71	2.78	2.72	2.80		2.59%	2.68%	2.73%	2.79%
15.8	2.66	2.73	2.72	2.80	2.75	2.83	2.77	2.85		2.60%	2.75%	2.76%	2.81%
17.1	2.67	2.75	2.75	2.83	2.78	2.86	2.81	2.89		2.66%	2.76%	2.81%	2.85%
18.3	2.69	2.76	2.77	2.85	2.80	2.88	2.83	2.91		2.68%	2.82%	2.82%	2.86%
19.6	2.69	2.77	2.78	2.85	2.81	2.89	2.85	2.93		2.71%	2.81%	2.88%	2.88%
20.8	2.70	2.77	2.78	2.86	2.82	2.90	2.86	2.94		2.78%	2.84%	2.87%	2.94%
22.1	2.69	2.77	2.78	2.86	2.82	2.90	2.86	2.95		2.82%	2.88%	2.94%	2.94%
23.3	2.69	2.77	2.78	2.86	2.82	2.90	2.86	2.95		2.82%	2.88%	2.95%	2.97%
24.6	2.69	2.76	2.77	2.85	2.81	2.89	2.85	2.94		2.83%	2.93%	2.95%	3.01%
25.8	2.68	2.76	2.76	2.84	2.80	2.89	2.85	2.93		2.83%	2.93%	3.00%	3.02%
27.1	2.68	2.75	2.75	2.84	2.79	2.88	2.84	2.92		2.84%	2.94%	3.01%	3.00%
28.3	2.67	2.75	2.75	2.83	2.78	2.87	2.83	2.91		2.80%	2.95%	3.02%	3.04%
29.6	2.67	2.74	2.74	2.82	2.77	2.86	2.81	2.90		2.85%	2.96%	3.03%	3.06%
29.6	2.72	2.79	2.78	2.86	2.81	2.90	2.85	2.94		2.76%	2.95%	2.99%	3.02%



# Pu-240

Bp	2.0%, - DFs	2.0%, + DFs	2.4%, - DFs	2.4%, + DFs	2.6%, - DFs	2.6%, + DFs	2.8%, - DFs	2.8%, + DFs		2.0%	2.4%	2.6%	2.8%
0	5.00E-16	5.00E-16	5.02E-16	5.02E-16	5.03E-16	5.03E-16	5.03E-16	5.03E-16		0.00%	0.00%	0.00%	0.00%
0.101	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		2.08%	2.31%	2.38%	2.45%
0.828	0.03	0.03	0.02	0.03	0.02	0.02	0.02	0.02		1.98%	2.20%	2.31%	2.34%
2.08	0.10	0.10	0.08	0.08	0.07	0.07	0.07	0.07		1.89%	2.14%	2.23%	2.30%
3.33	0.19	0.19	0.15	0.16	0.14	0.14	0.13	0.13		1.87%	2.08%	2.20%	2.24%
4.58	0.29	0.30	0.24	0.25	0.22	0.23	0.21	0.21		1.82%	2.07%	2.16%	2.24%
5.83	0.41	0.41	0.34	0.35	0.31	0.32	0.29	0.30		1.77%	2.00%	2.11%	2.21%
7.08	0.53	0.54	0.44	0.45	0.41	0.42	0.38	0.39		1.77%	1.98%	2.09%	2.17%
8.33	0.65	0.66	0.55	0.57	0.51	0.52	0.48	0.49		1.77%	1.99%	2.08%	2.17%
9.58	0.78	0.79	0.67	0.68	0.62	0.63	0.58	0.59		1.75%	1.98%	2.06%	2.16%
10.8	0.91	0.92	0.78	0.80	0.73	0.74	0.68	0.70		1.76%	1.97%	2.06%	2.16%
12.1	1.03	1.05	0.90	0.91	0.84	0.86	0.79	0.80		1.74%	1.97%	2.06%	2.15%
13.3	1.16	1.18	1.01	1.03	0.95	0.97	0.89	0.91		1.73%	1.98%	2.07%	2.14%
14.6	1.28	1.30	1.13	1.15	1.06	1.08	1.00	1.02		1.80%	1.95%	2.08%	2.10%
15.8	1.40	1.42	1.24	1.26	1.17	1.19	1.10	1.13		1.79%	2.02%	2.14%	2.18%
17.1	1.51	1.54	1.35	1.38	1.28	1.30	1.21	1.23		1.85%	1.93%	2.04%	2.15%
18.3	1.62	1.65	1.46	1.49	1.38	1.41	1.31	1.34		1.85%	1.99%	2.10%	2.21%
19.6	1.73	1.76	1.56	1.59	1.48	1.51	1.41	1.44		1.85%	1.99%	2.09%	2.20%
20.8	1.83	1.86	1.66	1.70	1.58	1.62	1.51	1.54		1.86%	1.99%	2.08%	2.12%
22.1	1.93	1.96	1.76	1.79	1.68	1.72	1.61	1.64		1.87%	1.99%	2.08%	2.12%
23.3	2.01	2.05	1.85	1.89	1.77	1.81	1.70	1.74		1.94%	2.05%	2.14%	2.18%
24.6	2.10	2.14	1.94	1.98	1.86	1.90	1.79	1.83		1.95%	2.06%	2.15%	2.18%
25.8	2.18	2.22	2.02	2.07	1.95	1.99	1.87	1.92		1.98%	2.13%	2.10%	2.24%
27.1	2.25	2.29	2.10	2.15	2.03	2.07	1.96	2.00		2.00%	2.14%	2.17%	2.20%
28.3	2.31	2.36	2.18	2.22	2.11	2.15	2.04	2.08		2.03%	2.16%	2.14%	2.26%
29.6	2.38	2.42	2.25	2.29	2.18	2.23	2.11	2.16		2.06%	2.14%	2.20%	2.23%
29.6	2.38	2.43	2.25	2.30	2.18	2.23	2.11	2.16		2.10%	2.13%	2.20%	2.22%



# Pu-241

<b>Bp</b>	<b>2.0%, - DFs</b>	<b>2.0%, + DFs</b>	<b>2.4%, - DFs</b>	<b>2.4%, + DFs</b>	<b>2.6%, - DFs</b>	<b>2.6%, + DFs</b>	<b>2.8%, - DFs</b>	<b>2.8%, + DFs</b>		<b>2.0%</b>	<b>2.4%</b>	<b>2.6%</b>	<b>2.8%</b>
0	5.02E-16	5.02E-16	5.04E-16	5.04E-16	5.05E-16	5.05E-16	5.05E-16	5.05E-16		0.00%	0.00%	0.00%	0.00%
0.101	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		1.95%	2.15%	2.19%	2.26%
0.828	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		1.80%	2.01%	2.08%	2.18%
2.08	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01		1.64%	1.90%	1.98%	2.08%
3.33	0.03	0.03	0.02	0.03	0.02	0.02	0.02	0.02		1.50%	1.79%	1.86%	1.91%
4.58	0.06	0.06	0.05	0.05	0.04	0.04	0.04	0.04		1.44%	1.67%	1.76%	1.83%
5.83	0.09	0.09	0.08	0.08	0.07	0.07	0.06	0.07		1.36%	1.59%	1.69%	1.76%
7.08	0.13	0.14	0.11	0.11	0.10	0.10	0.10	0.10		1.35%	1.51%	1.65%	1.70%
8.33	0.18	0.18	0.15	0.15	0.14	0.14	0.13	0.13		1.30%	1.45%	1.57%	1.62%
9.58	0.22	0.23	0.19	0.20	0.18	0.18	0.17	0.17		1.25%	1.45%	1.51%	1.62%
10.8	0.27	0.27	0.24	0.24	0.22	0.22	0.21	0.21		1.26%	1.44%	1.54%	1.60%
12.1	0.32	0.32	0.28	0.28	0.26	0.27	0.25	0.25		1.26%	1.43%	1.52%	1.58%
13.3	0.36	0.37	0.32	0.33	0.30	0.31	0.29	0.29		1.29%	1.42%	1.51%	1.56%
14.6	0.41	0.41	0.37	0.37	0.35	0.35	0.33	0.33		1.32%	1.47%	1.50%	1.58%
15.8	0.45	0.46	0.41	0.41	0.39	0.39	0.37	0.38		1.35%	1.47%	1.52%	1.59%
17.1	0.49	0.50	0.45	0.46	0.43	0.44	0.41	0.42		1.38%	1.49%	1.56%	1.61%
18.3	0.53	0.54	0.49	0.50	0.47	0.47	0.45	0.46		1.45%	1.54%	1.58%	1.63%
19.6	0.57	0.57	0.52	0.53	0.50	0.51	0.49	0.49		1.50%	1.58%	1.61%	1.65%
20.8	0.60	0.61	0.56	0.57	0.54	0.55	0.52	0.53		1.55%	1.63%	1.65%	1.69%
22.1	0.63	0.64	0.59	0.60	0.57	0.58	0.55	0.56		1.60%	1.67%	1.69%	1.71%
23.3	0.66	0.67	0.62	0.63	0.60	0.61	0.59	0.60		1.66%	1.72%	1.74%	1.76%
24.6	0.68	0.70	0.65	0.66	0.63	0.64	0.62	0.63		1.72%	1.75%	1.78%	1.78%
25.8	0.71	0.72	0.68	0.69	0.66	0.67	0.64	0.66		1.78%	1.82%	1.82%	1.85%
27.1	0.73	0.74	0.70	0.71	0.69	0.70	0.67	0.68		1.84%	1.87%	1.87%	1.88%
28.3	0.75	0.76	0.72	0.74	0.71	0.72	0.69	0.71		1.88%	1.91%	1.92%	1.93%
29.6	0.77	0.78	0.74	0.76	0.73	0.74	0.72	0.73		1.93%	1.97%	1.97%	1.98%
29.6	0.49	0.50	0.47	0.48	0.47	0.48	0.46	0.47		1.94%	1.96%	1.97%	1.99%



# U-235

Bp	2.0%, - DFs	2.0%, + DFs	2.4%, - DFs	2.4%, + DFs	2.6%, - DFs	2.6%, + DFs	2.8%, - DFs	2.8%, + DFs		2.0%	2.4%	2.6%	2.8%
0	20.00	20.00	24.00	24.00	26.00	26.00	28.00	28.00		0.00%	0.00%	0.00%	0.00%
0.101	19.75	19.75	23.75	23.75	25.75	25.75	27.76	27.76		0.00%	0.00%	0.00%	0.00%
0.828	18.30	18.31	22.29	22.29	24.28	24.28	26.28	26.28		0.05%	0.00%	0.00%	0.00%
2.08	16.96	16.97	20.91	20.91	22.88	22.89	24.87	24.88		0.06%	0.00%	0.04%	0.04%
3.33	15.70	15.71	19.60	19.61	21.55	21.56	23.52	23.53		0.06%	0.05%	0.05%	0.04%
4.58	14.52	14.53	18.35	18.37	20.28	20.29	22.22	22.24		0.07%	0.11%	0.05%	0.09%
5.83	13.40	13.42	17.16	17.18	19.06	19.08	20.98	21.00		0.15%	0.12%	0.10%	0.10%
7.08	12.34	12.37	16.02	16.05	17.88	17.91	19.77	19.80		0.24%	0.19%	0.17%	0.15%
8.33	11.34	11.37	14.93	14.96	16.75	16.79	18.60	18.63		0.26%	0.20%	0.24%	0.16%
9.58	10.39	10.43	13.89	13.93	15.67	15.71	17.48	17.52		0.38%	0.29%	0.26%	0.23%
10.8	9.50	9.55	12.89	12.93	14.62	14.67	16.40	16.45		0.51%	0.31%	0.34%	0.30%
12.1	8.66	8.71	11.93	11.99	13.62	13.68	15.36	15.41		0.62%	0.50%	0.44%	0.33%
13.3	7.87	7.93	11.02	11.08	12.66	12.72	14.35	14.41		0.78%	0.54%	0.47%	0.42%
14.6	7.12	7.19	10.15	10.22	11.74	11.80	13.38	13.45		0.93%	0.69%	0.51%	0.52%
15.8	6.43	6.50	9.32	9.39	10.85	10.93	12.45	12.52		1.11%	0.82%	0.74%	0.56%
17.1	5.78	5.85	8.53	8.61	10.01	10.09	11.55	11.63		1.32%	0.95%	0.80%	0.69%
18.3	5.18	5.25	7.79	7.87	9.20	9.29	10.69	10.78		1.51%	1.12%	0.97%	0.84%
19.6	4.62	4.70	7.08	7.17	8.43	8.53	9.87	9.97		1.75%	1.29%	1.11%	0.96%
20.8	4.11	4.19	6.42	6.51	7.71	7.80	9.08	9.18		2.02%	1.50%	1.29%	1.11%
22.1	3.64	3.72	5.80	5.90	7.02	7.12	8.33	8.44		2.31%	1.71%	1.48%	1.27%
23.3	3.21	3.30	5.22	5.32	6.37	6.48	7.62	7.73		2.62%	1.96%	1.70%	1.47%
24.6	2.83	2.91	4.68	4.78	5.76	5.87	6.95	7.06		2.94%	2.22%	1.91%	1.66%
25.8	2.48	2.56	4.18	4.28	5.19	5.30	6.31	6.43		3.31%	2.51%	2.18%	1.87%
27.1	2.16	2.24	3.72	3.82	4.66	4.77	5.71	5.83		3.70%	2.80%	2.45%	2.14%
28.3	1.89	1.96	3.30	3.40	4.17	4.28	5.15	5.27		4.03%	3.15%	2.76%	2.39%
29.6	1.64	1.71	2.91	3.02	3.71	3.83	4.63	4.75		4.45%	3.47%	3.07%	2.66%
29.6	1.64	1.71	2.92	3.02	3.71	3.83	4.63	4.75		4.45%	3.46%	3.07%	2.68%



# U-238

Bp	2.0%, - DFs	2.0%, + DFs	2.4%, - DFs	2.4%, + DFs	2.6%, - DFs	2.6%, + DFs	2.8%, - DFs	2.8%, + DFs		2.0%	2.4%	2.6%	2.8%
0	9.80E+02	9.80E+02	9.76E+02	9.76E+02	9.74E+02	9.74E+02	9.72E+02	9.72E+02		0.00%	0.00%	0.00%	0.00%
0.101	9.80E+02	9.80E+02	9.76E+02	9.76E+02	9.74E+02	9.74E+02	9.72E+02	9.72E+02		0.00%	0.00%	0.00%	0.00%
0.828	9.79E+02	9.79E+02	9.75E+02	9.75E+02	9.73E+02	9.73E+02	9.71E+02	9.71E+02		-0.01%	0.00%	0.00%	0.00%
2.08	9.78E+02	9.78E+02	9.74E+02	9.74E+02	9.72E+02	9.72E+02	9.70E+02	9.70E+02		-0.01%	0.00%	0.00%	0.00%
3.33	9.77E+02	9.77E+02	9.74E+02	9.74E+02	9.72E+02	9.72E+02	9.70E+02	9.70E+02		0.00%	0.00%	0.00%	0.00%
4.58	9.77E+02	9.77E+02	9.73E+02	9.73E+02	9.71E+02	9.71E+02	9.69E+02	9.69E+02		0.00%	-0.01%	-0.01%	0.00%
5.83	9.76E+02	9.76E+02	9.72E+02	9.72E+02	9.70E+02	9.70E+02	9.69E+02	9.68E+02		-0.01%	-0.01%	-0.01%	-0.01%
7.08	9.75E+02	9.75E+02	9.72E+02	9.71E+02	9.70E+02	9.70E+02	9.68E+02	9.68E+02		-0.01%	-0.01%	-0.01%	-0.01%
8.33	9.74E+02	9.74E+02	9.71E+02	9.71E+02	9.69E+02	9.69E+02	9.67E+02	9.67E+02		0.00%	-0.01%	-0.01%	-0.01%
9.58	9.74E+02	9.74E+02	9.70E+02	9.70E+02	9.68E+02	9.68E+02	9.67E+02	9.67E+02		-0.02%	-0.01%	-0.01%	-0.01%
10.8	9.73E+02	9.73E+02	9.69E+02	9.69E+02	9.68E+02	9.68E+02	9.66E+02	9.66E+02		-0.01%	-0.01%	-0.01%	-0.01%
12.1	9.72E+02	9.72E+02	9.69E+02	9.69E+02	9.67E+02	9.67E+02	9.65E+02	9.65E+02		-0.01%	-0.01%	-0.01%	-0.01%
13.3	9.71E+02	9.71E+02	9.68E+02	9.68E+02	9.66E+02	9.66E+02	9.65E+02	9.64E+02		-0.01%	-0.02%	-0.02%	-0.02%
14.6	9.70E+02	9.70E+02	9.67E+02	9.67E+02	9.66E+02	9.65E+02	9.64E+02	9.64E+02		-0.01%	-0.02%	-0.02%	-0.02%
15.8	9.69E+02	9.69E+02	9.66E+02	9.66E+02	9.65E+02	9.65E+02	9.63E+02	9.63E+02		-0.01%	-0.02%	-0.02%	-0.01%
17.1	9.68E+02	9.68E+02	9.66E+02	9.65E+02	9.64E+02	9.64E+02	9.62E+02	9.62E+02		-0.02%	-0.02%	-0.02%	-0.02%
18.3	9.67E+02	9.67E+02	9.65E+02	9.64E+02	9.63E+02	9.63E+02	9.62E+02	9.62E+02		-0.01%	-0.02%	-0.02%	-0.01%
19.6	9.66E+02	9.66E+02	9.64E+02	9.64E+02	9.62E+02	9.62E+02	9.61E+02	9.61E+02		-0.01%	-0.01%	-0.02%	-0.02%
20.8	9.65E+02	9.65E+02	9.63E+02	9.63E+02	9.62E+02	9.61E+02	9.60E+02	9.60E+02		-0.02%	-0.02%	-0.03%	-0.02%
22.1	9.64E+02	9.64E+02	9.62E+02	9.62E+02	9.61E+02	9.60E+02	9.59E+02	9.59E+02		-0.02%	-0.02%	-0.02%	-0.03%
23.3	9.63E+02	9.63E+02	9.61E+02	9.61E+02	9.60E+02	9.60E+02	9.58E+02	9.58E+02		-0.02%	-0.02%	-0.02%	-0.02%
24.6	9.62E+02	9.62E+02	9.60E+02	9.60E+02	9.59E+02	9.59E+02	9.58E+02	9.57E+02		-0.02%	-0.02%	-0.02%	-0.03%
25.8	9.61E+02	9.61E+02	9.59E+02	9.59E+02	9.58E+02	9.58E+02	9.57E+02	9.56E+02		-0.02%	-0.02%	-0.02%	-0.03%
27.1	9.60E+02	9.60E+02	9.58E+02	9.58E+02	9.57E+02	9.57E+02	9.56E+02	9.56E+02		-0.02%	-0.02%	-0.03%	-0.03%
28.3	9.59E+02	9.59E+02	9.57E+02	9.57E+02	9.56E+02	9.56E+02	9.55E+02	9.55E+02		-0.02%	-0.03%	-0.03%	-0.02%
29.6	9.58E+02	9.57E+02	9.56E+02	9.56E+02	9.55E+02	9.55E+02	9.54E+02	9.54E+02		-0.02%	-0.02%	-0.03%	-0.03%
29.6	9.58E+02	9.57E+02	9.56E+02	9.56E+02	9.55E+02	9.55E+02	9.54E+02	9.54E+02		-0.02%	-0.02%	-0.03%	-0.03%



Thank You for Your Attention

Questions ?