Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

Preliminary evaluation of ALFRED S/U analysis

Meeting of the OECD/NEA-NSC-WPEC-SG46
NEA Headquarters - 25-26 November 2019

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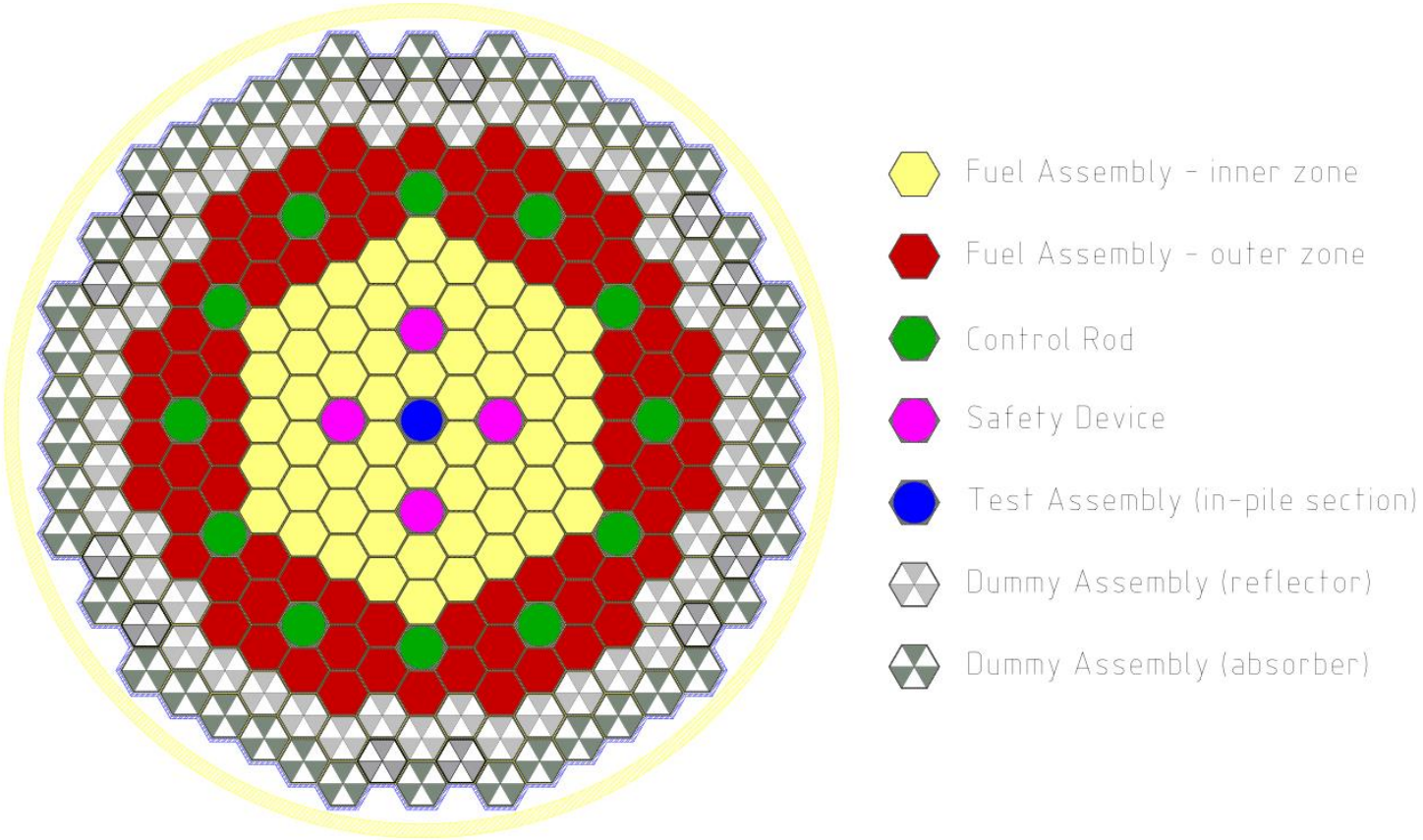
The ALFRED core configuration

Actual model – core map



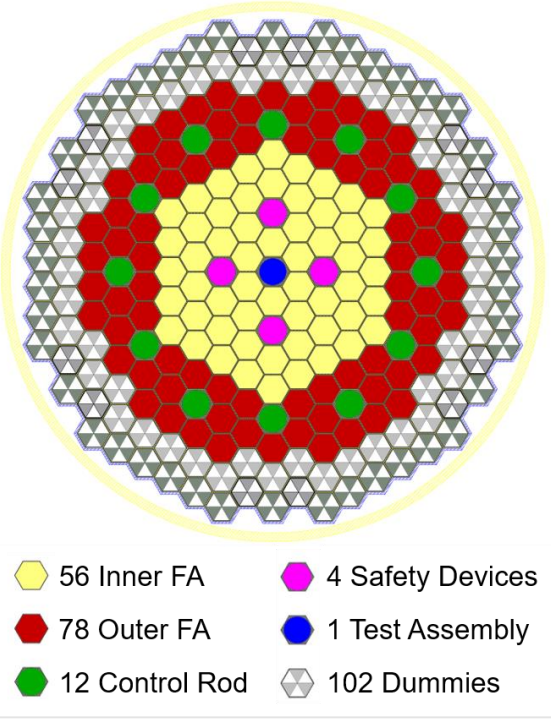
The ALFRED core configuration

Actual model – core layout

Core data

- 300 MWth power (in final operational stage).
- 400 / 520 °C lead inlet / outlet temperatures (in final operational stage).
- 253 hexagonal S/As all with same external shape and size.
- 167 mm of triangular pitch among the S/As.

Core map



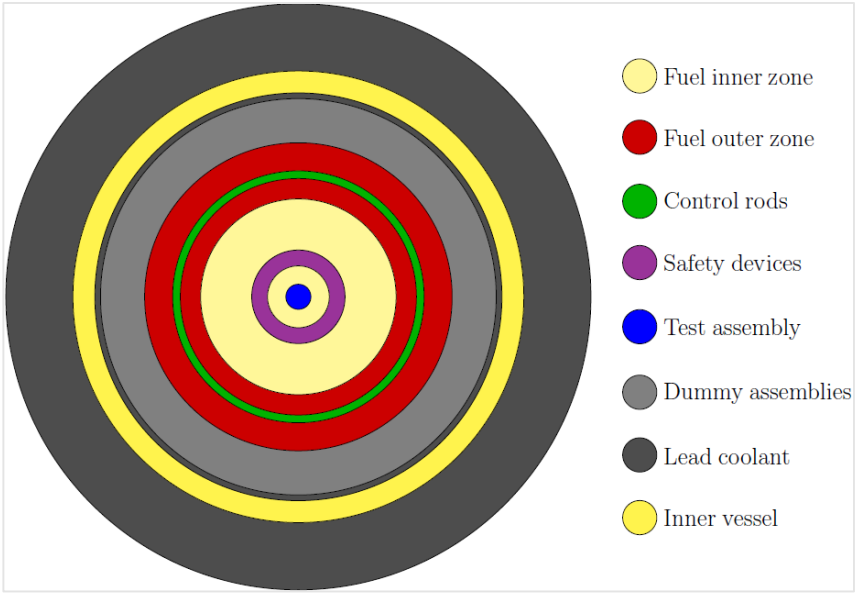
The ALFRED core configuration

Simulated model – core layout

Core data

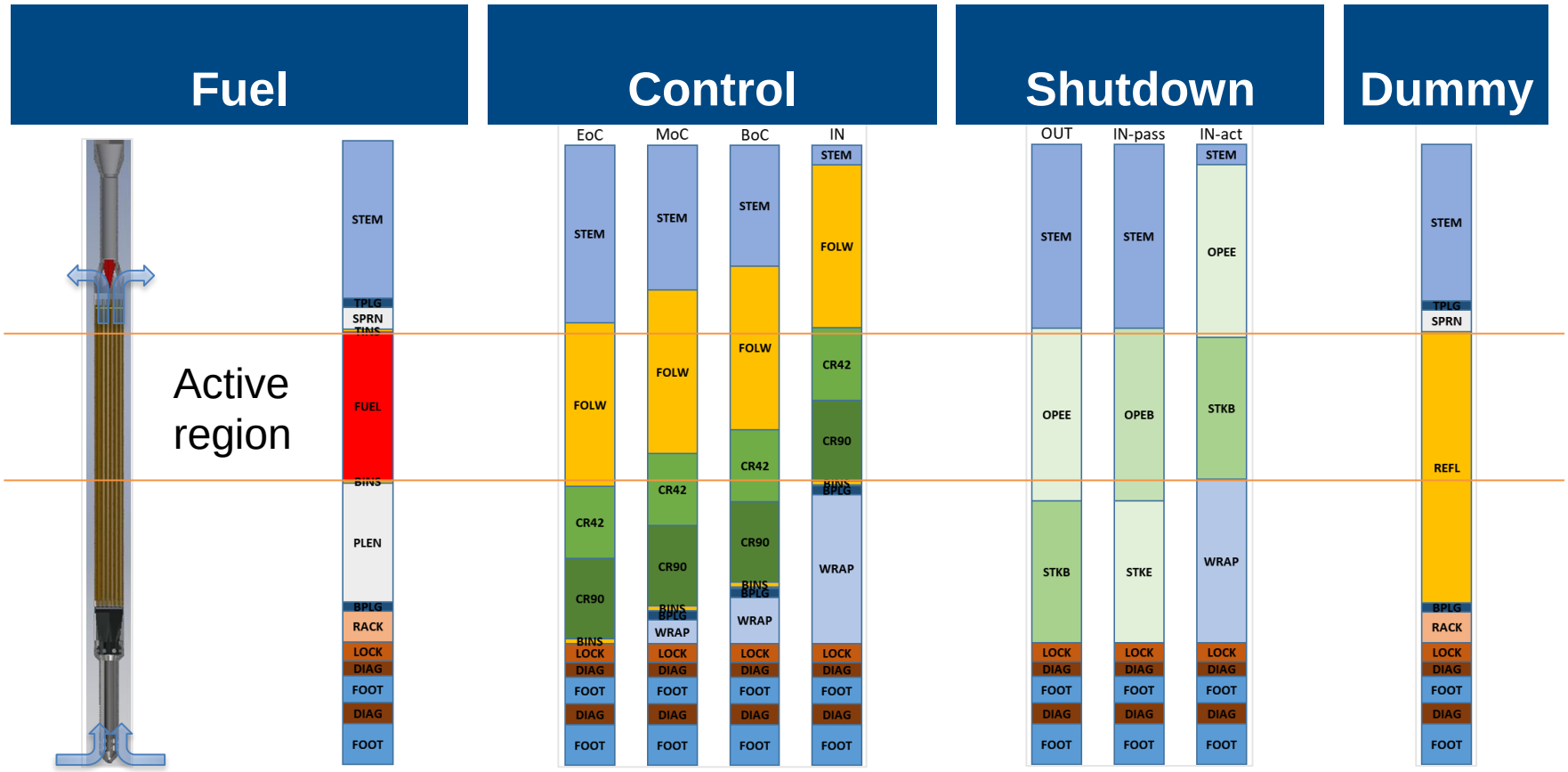
- R-Z model for S/U analysis.
- volumes of zones selected to preserve masses.
- radii of zones selected to be representative of direct / adjoint flux shapes.

Core map



The ALFRED core configuration

Simulated model – assemblies axial layout



S/U analysis

Objectives

To retrieve sensitivities and uncertainties to the key isotopes and to the main cross sections (capture, fission, ν, χ, elastic, inelastic, μ) for the following integral parameters of interest:

system	k_{eff}	β_{eff}	Δk_{eff} Doppler	Δk_{eff} CR worth	$\Delta\rho_{coolant}$	BU	ΔM_{MAs} BR

S/U analysis

Methodology

- GPT (k_{eff}, β_{eff})
- EGPT (Δk_{eff} (Doppler, CR worth, $\Delta\rho_{coolant}$, BU), ΔM_{MAs})

- code: ERANOS v. 2.2N
- cross-sections: JEFF-3.1.1
- covariances: BNL-LANL (BOLNA)

Preliminary results

Current status

A preliminary set of sensitivities and uncertainties has been retrieved, for some of the integral parameters of interest.

system	k_{eff}	β_{eff}	Δk_{eff} Doppler	Δk_{eff} CR worth	$\Delta\rho_{coolant}$	BU	ΔM_{MAs} BR
ALFRED	(✓)	(✓)	(✓)	(✓)	(✓)		

Not all identified cross sections were investigated though, because of the available tools.

Preliminary results

k_{eff}

Sensitivities		
Isotope	**Reaction**	**Value**
Pu-239	ν	$6.86 \cdot 10^{-1}$
Pu-239	fission	$4.83 \cdot 10^{-1}$
U-238	capture	$-1.76 \cdot 10^{-1}$
Pu-241	ν	$1.04 \cdot 10^{-1}$
U-238	ν	$8.50 \cdot 10^{-2}$
Pu-241	fission	$7.42 \cdot 10^{-2}$
Pu-240	ν	$7.27 \cdot 10^{-2}$
Pu-239	capture	$-5.12 \cdot 10^{-2}$
U-238	fission	$5.06 \cdot 10^{-2}$
Pu-240	fission	$4.90 \cdot 10^{-2}$
U-238	inelastic	$-3.84 \cdot 10^{-2}$
O-16	elastic	$-3.75 \cdot 10^{-2}$
TOTAL		**1.27**

Uncertainties		
Isotope	**Reaction**	**Value**
Pu-241	fission	$6.99 \cdot 10^{-3}$
U-238	inelastic	$5.64 \cdot 10^{-3}$
U-238	capture	$3.48 \cdot 10^{-3}$
Pu-239	capture	$3.00 \cdot 10^{-3}$
Pu-240	ν	$2.24 \cdot 10^{-3}$
Pu-240	capture	$2.00 \cdot 10^{-3}$
Pu-239	fission	$1.92 \cdot 10^{-3}$
Pu-240	fission	$1.87 \cdot 10^{-3}$
O-16	capture	$1.77 \cdot 10^{-3}$
Pu-242	fission	$1.62 \cdot 10^{-3}$
Pu-238	fission	$1.50 \cdot 10^{-3}$
Pu-242	capture	$1.45 \cdot 10^{-3}$
TOTAL		**$1.19 \cdot 10^{-2}$**

Preliminary results

k_{eff} - Detailed breakdown of sensitivity contributions

Group	capture	fission	ν	elastic	inelastic	(n,xn)	SUM
1	-1.5878E-03	5.8828E-03	8.8887E-03	6.2982E-07	-4.5629E-03	-8.9117E-04	**7.73E-03**
2	-5.1409E-03	5.7047E-02	9.0784E-02	6.7664E-03	-2.9810E-02	-9.1311E-03	**1.11E-01**
3	-3.5108E-03	5.4761E-02	8.7551E-02	3.2239E-03	-2.5496E-02	-4.8692E-03	**1.12E-01**
4	-2.4784E-02	1.1628E-01	1.7307E-01	1.5225E-02	-1.8177E-02	-1.1647E-02	**2.50E-01**
5	-3.2924E-02	1.0563E-01	1.5231E-01	1.2471E-03	-3.0335E-03	-5.0040E-03	**2.18E-01**
6	-4.5644E-02	1.0642E-01	1.4886E-01	-6.3300E-03	-3.4376E-03	-1.5980E-03	**1.98E-01**
7	-5.2247E-02	7.8359E-02	1.0626E-01	1.0167E-03	-3.9725E-04	-4.4333E-04	**1.33E-01**
8	-5.2156E-02	5.9124E-02	7.9338E-02	7.9123E-03	9.3379E-05	-1.3333E-04	**9.42E-02**
9	-5.9092E-02	5.9541E-02	8.1043E-02	6.4952E-03	1.5470E-05	-3.5901E-05	**8.80E-02**
10	-4.1499E-02	3.7920E-02	5.2988E-02	2.4330E-03	1.4828E-11	7.0146E-06	**5.18E-02**
11	-1.4452E-02	1.1092E-02	1.7105E-02	-3.1679E-03	-3.6306E-08	3.0922E-05	**1.06E-02**
12	-1.2107E-03	8.4915E-04	1.3965E-03	-1.3453E-03	0.0000E+00	1.0581E-05	**-3.00E-04**
13	-4.1689E-04	1.8203E-04	2.2733E-04	-7.6644E-05	1.4765E-05	-2.8527E-08	**-6.94E-05**
14	-1.4677E-04	7.6406E-05	1.6889E-04	-5.8329E-05	-8.5204E-06	-2.3235E-09	**3.17E-05**
15	-1.9980E-05	1.1281E-05	2.6905E-05	-2.7551E-06	1.8131E-06	1.0303E-09	**1.73E-05**
PART >0	***0.000E+00***	***6.932E-01***	***1.000E+00***	***4.432E-02***	***1.254E-04***	***4.852E-05***	***1.738E+00***
PART <0	***-3.348E-01***	***0.000E+00***	***0.000E+00***	***-1.098E-02***	***-8.492E-02***	***-3.375E-02***	***-4.645E-01***
SUM	**-3.3483E-01**	**6.9318E-01**	**1.0000E+00**	**3.3339E-02**	**-8.4798E-02**	**-3.3704E-02**	**1.27**

Preliminary results

k_{eff} - Detailed breakdown of uncertainty contributions

Group	capture	fission	ν	elastic	inelastic	(n,xn)	SUM
1	9.2635E-04	2.0053E-04	1.9835E-04	1.7928E-04	6.7104E-04	3.4056E-05	**1.16E-03**
2	1.5924E-03	8.4663E-04	9.5127E-04	2.3209E-04	3.6438E-03	1.1852E-05	**4.17E-03**
3	4.1982E-04	2.1945E-03	9.7946E-04	7.3520E-04	3.8495E-03	0.0000E+00	**4.62E-03**
4	1.1240E-03	3.5509E-03	1.7274E-03	1.1837E-03	2.5044E-03	0.0000E+00	**4.95E-03**
5	1.3703E-03	3.2749E-03	1.1031E-03	6.8941E-04	3.5298E-04	0.0000E+00	**3.80E-03**
6	1.6524E-03	4.1927E-03	1.0256E-03	5.4171E-04	5.0293E-04	0.0000E+00	**4.68E-03**
7	1.8417E-03	2.6744E-03	8.2442E-04	3.3586E-04	1.4096E-04	0.0000E+00	**3.37E-03**
8	3.4613E-03	1.8413E-03	6.7782E-04	2.5655E-04	8.8903E-05	0.0000E+00	**3.99E-03**
9	2.6557E-03	1.7719E-03	6.4073E-04	1.7522E-04	1.9806E-06	0.0000E+00	**3.26E-03**
10	8.1520E-04	8.8294E-04	4.2600E-04	2.1979E-05	0.0000E+00	0.0000E+00	**1.28E-03**
11	2.8027E-04	3.7795E-04	1.3172E-04	1.7070E-04	0.0000E+00	0.0000E+00	**4.58E-04**
12	1.0884E-04	5.4041E-05	2.4067E-05	4.1986E-05	0.0000E+00	0.0000E+00	**1.31E-04**
13	7.5023E-05	2.1777E-05	6.9608E-06	1.3590E-06	0.0000E+00	0.0000E+00	**7.21E-05**
14	4.6832E-05	1.1561E-05	4.1106E-06	3.9690E-06	0.0000E+00	0.0000E+00	**4.86E-05**
15	1.5235E-05	5.9380E-06	1.8749E-06	1.0050E-06	0.0000E+00	0.0000E+00	**1.65E-05**
TOTAL	**5.7123E-03**	**7.8111E-03**	**2.9842E-03**	**1.6944E-03**	**5.9336E-03**	**3.6059E-05**	**0.0119**

Preliminary results

Fuel Doppler coefficient

Sensitivities		
Isotope	**Reaction**	**Value**
Pu-239	fission	$-1.01 \cdot 10^{0}$
O-16	fission	$7.04 \cdot 10^{-1}$
Pu-239	ν	$-6.14 \cdot 10^{-1}$
Pu-239	capture	$-3.14 \cdot 10^{-1}$
U-238	capture	$1.97 \cdot 10^{-1}$
U-238	inelastic	$1.79 \cdot 10^{-1}$
U-238	ν	$-1.73 \cdot 10^{-1}$
Pu-240	ν	$-1.45 \cdot 10^{-1}$
Fe-56	elastic	$1.42 \cdot 10^{-1}$
TOTAL		**-1.20**

Uncertainties		
Isotope	**Reaction**	**Value**
U-238	inelastic	$2.11 \cdot 10^{-2}$
Pu-241	fission	$1.92 \cdot 10^{-2}$
O-16	elastic	$1.31 \cdot 10^{-2}$
Pu-239	capture	$1.23 \cdot 10^{-2}$
Pb-208	elastic	$6.42 \cdot 10^{-3}$
Fe-56	capture	$6.35 \cdot 10^{-3}$
Pu-239	fission	$5.25 \cdot 10^{-3}$
Fe-56	inelastic	$5.20 \cdot 10^{-3}$
Pu-240	fission	$4.95 \cdot 10^{-3}$
TOTAL		**$3.89 \cdot 10^{-2}$**

Preliminary results

Doppler effect - Detailed breakdown of sensitivity contributions

Group	capture	fission	ν	elastic	inelastic	(n,xn)	SUM
1	1.8629E-03	-1.4466E-02	-1.8193E-02	3.3528E-06	1.1054E-02	1.7035E-03	**-1.80E-02**
2	5.6844E-03	-1.4644E-01	-1.8668E-01	-1.1803E-02	9.7502E-02	1.7389E-02	**-2.24E-01**
3	3.8266E-03	-1.4276E-01	-1.7977E-01	2.1807E-03	8.4560E-02	8.7904E-03	**-2.23E-01**
4	2.1822E-02	-3.0098E-01	-3.5474E-01	4.4948E-02	9.8656E-02	1.8214E-02	**-4.72E-01**
5	1.5832E-02	-2.8282E-01	-3.0836E-01	1.6380E-01	2.2559E-02	6.1367E-03	**-3.83E-01**
6	-1.2281E-03	-2.9536E-01	-2.9352E-01	2.3867E-01	3.3339E-02	1.0789E-03	**-3.17E-01**
7	-3.6847E-02	-2.2490E-01	-1.9660E-01	2.6494E-01	1.4676E-02	-8.2875E-05	**-1.79E-01**
8	-7.1428E-02	-1.6579E-01	-1.1161E-01	2.7131E-01	9.7767E-03	-2.7905E-04	**-6.80E-02**
9	-8.6175E-02	-1.6206E-01	-3.6249E-02	3.1212E-01	6.5947E-04	-2.8967E-04	**2.80E-02**
10	-2.0678E-01	1.2329E-01	3.6758E-01	1.1177E-01	2.4753E-10	-1.4778E-04	**3.96E-01**
11	-1.7453E-01	1.4754E-01	3.1128E-01	-3.0820E-02	-3.6653E-07	3.7084E-04	**2.54E-01**
12	-3.4231E-03	2.4114E-03	5.2506E-03	-2.4047E-03	0.0000E+00	1.2455E-05	**1.85E-03**
13	-1.4874E-03	1.0733E-03	1.5582E-03	-8.6720E-04	4.2081E-05	-1.3870E-06	**3.18E-04**
14	-1.3841E-04	-4.7431E-06	-6.6083E-07	-7.2266E-05	9.9507E-05	-4.0085E-07	**-1.17E-04**
15	-3.6165E-05	1.9774E-05	5.4125E-05	-4.7927E-06	1.0679E-05	1.7477E-08	**4.36E-05**
PART >0	***4.903E-02***	***2.743E-01***	***6.857E-01***	***1.410E+00***	***3.729E-01***	***5.370E-02***	***2.845E+00***
PART <0	***-5.821E-01***	***-1.736E+00***	***-1.686E+00***	***-4.597E-02***	***-3.665E-07***	***-8.012E-04***	***-4.050E+00***
SUM	**-5.3304E-01**	**-1.4613E+00**	**-1.0000E+00**	**1.3638E+00**	**3.7294E-01**	**5.2895E-02**	**-1.20**

Preliminary results

Doppler effect - Detailed breakdown of uncertainty contributions

Group	capture	fission	*v*	elastic	inelastic	(n,xn)	SUM
1	1.1015E-03	5.2448E-04	4.0338E-04	1.3292E-03	1.8327E-03	6.7927E-05	**2.50E-03**
2	1.7666E-03	2.1311E-03	1.9256E-03	2.8889E-03	1.2340E-02	2.7236E-05	**1.25E-02**
3	2.2916E-04	5.7067E-03	1.9799E-03	3.6610E-03	1.3339E-02	0.0000E+00	**1.51E-02**
4	8.1958E-04	9.2950E-03	3.3644E-03	3.0920E-03	1.1568E-02	0.0000E+00	**1.55E-02**
5	5.6523E-04	8.7502E-03	2.0809E-03	4.4701E-03	2.6247E-03	0.0000E+00	**1.04E-02**
6	4.9683E-04	1.1431E-02	1.9101E-03	5.8827E-03	4.5563E-03	0.0000E+00	**1.38E-02**
7	2.2535E-03	7.1317E-03	1.4623E-03	7.3674E-03	2.6365E-03	0.0000E+00	**1.09E-02**
8	4.7027E-03	3.9571E-03	1.1046E-03	8.0435E-03	2.2153E-03	0.0000E+00	**1.04E-02**
9	1.2505E-02	3.6748E-03	7.7576E-04	7.7856E-03	9.8092E-05	0.0000E+00	**1.52E-02**
10	7.1947E-03	3.1444E-03	6.9596E-04	5.3434E-03	0.0000E+00	0.0000E+00	**9.47E-03**
11	2.8113E-03	5.7454E-03	2.2975E-04	2.8484E-03	0.0000E+00	0.0000E+00	**5.72E-03**
12	7.7459E-04	3.6167E-04	8.9643E-05	4.5393E-04	0.0000E+00	0.0000E+00	**7.19E-04**
13	5.0579E-04	1.2598E-04	1.0388E-05	2.5753E-04	0.0000E+00	0.0000E+00	**4.17E-04**
14	2.1709E-04	1.1491E-05	3.7213E-06	6.1155E-05	0.0000E+00	0.0000E+00	**2.09E-04**
15	6.8989E-05	1.7384E-05	1.6339E-06	2.3754E-05	0.0000E+00	0.0000E+00	**6.70E-05**
TOTAL	**1.5738E-02**	**2.1296E-02**	**5.5230E-03**	**1.6454E-02**	**2.2514E-02**	**7.3184E-05**	**0.0389**

Preliminary results

Coolant density effect

Sensitivities		
Isotope	**Reaction**	**Value**
Pu-239	ν	$-2.64\cdot10^{0}$
Pu-239	fission	$-2.01\cdot10^{0}$
U-238	capture	$1.88\cdot10^{0}$
U-238	ν	$1.74\cdot10^{0}$
U-238	fission	$1.01\cdot10^{0}$
O-16	elastic	$8.14\cdot10^{-1}$
Pb-206	inelastic	$7.89\cdot10^{-1}$
U-238	inelastic	$-6.60\cdot10^{-1}$
TOTAL		**2.46**

Uncertainties		
Isotope	**Reaction**	**Value**
U-238	inelastic	$1.41\cdot10^{-1}$
O-16	capture	$7.43\cdot10^{-2}$
Pb-206	inelastic	$6.66\cdot10^{-2}$
Pb-206	capture	$6.08\cdot10^{-2}$
O-16	elastic	$5.74\cdot10^{-2}$
Pb-207	inelastic	$4.95\cdot10^{-2}$
U-238	capture	$4.82\cdot10^{-2}$
Pu-241	fission	$4.06\cdot10^{-2}$
TOTAL		**$2.29\cdot10^{-1}$**

Preliminary results

$\rho_{coolant}$ effect - Detailed breakdown of sensitivity contributions

Group	capture	fission	ν	elastic	inelastic	(n,xn)	SUM
1	-7.0843E-02	2.2245E-01	3.4967E-01	5.5687E-03	5.3999E-02	-5.8497E-02	**5.02E-01**
2	-1.8630E-01	1.5415E+00	2.5339E+00	3.0383E-01	-1.2551E-01	-4.4535E-01	**3.62E+00**
3	-3.2827E-02	5.2421E-01	8.5730E-01	1.3402E-01	1.3009E-01	-1.2962E-01	**1.48E+00**
4	7.5879E-02	2.8175E-01	3.4110E-01	4.7540E-01	3.4793E-01	-2.0653E-01	**1.32E+00**
5	2.0882E-01	-3.4596E-01	-5.6304E-01	5.6777E-01	4.6937E-02	-2.6587E-02	**-1.12E-01**
6	2.4208E-01	-3.1798E-01	-4.7681E-01	6.6356E-01	3.2337E-02	-2.1645E-02	**1.22E-01**
7	4.6960E-01	-5.9778E-01	-8.1842E-01	2.7241E-01	7.6492E-03	-5.5946E-03	**-6.72E-01**
8	7.1745E-01	-7.6920E-01	-1.0238E+00	1.2728E-02	2.5953E-03	-7.4169E-04	**-1.06E+00**
9	9.9386E-01	-1.0322E+00	-1.3572E+00	-7.5825E-02	-1.3851E-04	4.8894E-04	**-1.47E+00**
10	6.5296E-01	-6.3975E-01	-8.5066E-01	-1.6342E-01	3.9396E-10	1.1112E-03	**-1.00E+00**
11	-2.7483E-02	-4.7166E-02	-4.4443E-02	-1.3589E-01	-8.2390E-07	1.3170E-03	**-2.54E-01**
12	-3.5708E-02	2.3610E-02	4.1128E-02	-4.2319E-02	0.0000E+00	4.2054E-04	**-1.29E-02**
13	-1.2485E-02	6.0382E-03	7.4332E-03	-2.8499E-03	4.4769E-04	1.5684E-07	**-1.42E-03**
14	-3.6772E-03	1.6052E-03	3.5697E-03	-1.5833E-03	-1.0802E-04	1.5510E-07	**-1.93E-04**
15	-3.7817E-04	1.1345E-04	2.9864E-04	-7.0593E-05	5.2995E-05	4.3316E-08	**1.64E-05**
PART >0	**3.361E+00**	**2.601E+00**	**4.134E+00**	**2.435E+00**	**6.220E-01**	**3.338E-03**	**1.316E+01**
PART <0	**-3.697E-01**	**-3.750E+00**	**-5.134E+00**	**-4.220E-01**	**-1.258E-01**	**-8.946E-01**	**-1.070E+01**
SUM	**2.9909E+00**	**-1.1488E+00**	**-1.0000E+00**	**2.0133E+00**	**4.9628E-01**	**-8.9123E-01**	**2.46**

Preliminary results

$\rho_{coolant}$ effect - Detailed breakdown of uncertainty contributions

Group	capture	fission	ν	elastic	inelastic	(n,xn)	SUM
1	3.9586E-02	5.2326E-03	6.0577E-03	7.7583E-03	3.5206E-02	3.2247E-03	**5.31E-02**
2	6.5720E-02	1.7359E-02	1.9330E-02	5.6909E-02	1.2535E-01	1.1694E-03	**1.55E-01**
3	8.7175E-03	7.8933E-03	1.0445E-02	2.1070E-02	9.6195E-02	0.0000E+00	**9.97E-02**
4	3.0909E-02	3.2108E-03	2.7999E-03	2.9581E-02	3.9998E-02	0.0000E+00	**5.87E-02**
5	3.5972E-02	6.7288E-03	1.7490E-03	1.6114E-02	3.1868E-03	0.0000E+00	**3.99E-02**
6	3.7715E-02	9.9904E-03	2.8147E-03	1.1536E-02	4.3580E-03	0.0000E+00	**4.10E-02**
7	3.5604E-02	1.5814E-02	5.0966E-03	9.1265E-03	2.1284E-03	0.0000E+00	**4.04E-02**
8	5.3423E-02	2.3802E-02	5.9374E-03	1.1769E-02	3.9704E-04	0.0000E+00	**6.00E-02**
9	4.7488E-02	2.6803E-02	7.5411E-03	9.9073E-03	1.7956E-05	0.0000E+00	**5.59E-02**
10	1.6951E-02	1.3995E-02	2.1894E-03	4.6100E-03	0.0000E+00	0.0000E+00	**2.26E-02**
11	3.2086E-03	1.4856E-03	4.4126E-04	1.0916E-03	0.0000E+00	0.0000E+00	**3.73E-03**
12	1.0903E-03	8.9776E-04	3.2199E-04	3.1157E-03	0.0000E+00	0.0000E+00	**3.07E-03**
13	8.3038E-04	5.5436E-04	6.4914E-05	3.6967E-04	0.0000E+00	0.0000E+00	**9.25E-04**
14	5.0391E-04	1.9628E-04	4.0286E-05	3.7792E-04	0.0000E+00	0.0000E+00	**2.66E-04**
15	1.5952E-04	7.0995E-05	1.4809E-05	8.7340E-05	0.0000E+00	0.0000E+00	**1.12E-04**
TOTAL	**1.2771E-01**	**4.7738E-02**	**2.5715E-02**	**7.2268E-02**	**1.6679E-01**	**3.4302E-03**	**0.229**

Preliminary results

Control rods worth

Sensitivities		
Isotope	**Reaction**	**Value**
Pu-239	fission	$-6.07\cdot10^{-1}$
Pu-239	ν	$-5.65\cdot10^{-1}$
B-10	capture	$2.76\cdot10^{-1}$
U-238	ν	$-2.06\cdot10^{-1}$
U-238	fission	$-1.58\cdot10^{-2}$
Pb-208	elastic	$-1.04\cdot10^{-2}$
Pu-240	ν	$-9.79\cdot10^{-2}$
Pu-240	fission	$-9.17\cdot10^{-2}$
O-16	elastic	$-8.84\cdot10^{-2}$
TOTAL		**-1.92**

Uncertainties		
Isotope	**Reaction**	**Value**
B-10	capture	$2.06\cdot10^{-2}$
U-238	inelastic	$1.37\cdot10^{-2}$
Pu-241	inelastic	$1.11\cdot10^{-2}$
Pb-208	capture	$4.05\cdot10^{-3}$
U-238	capture	$3.79\cdot10^{-3}$
Pu-240	inelastic	$3.64\cdot10^{-3}$
Fe-56	inelastic	$3.48\cdot10^{-3}$
Pu-242	fission	$3.28\cdot10^{-3}$
Pu-240	ν	$2.91\cdot10^{-3}$
TOTAL		**$2.95\cdot10^{-2}$**

Preliminary results

CRs worth - Detailed breakdown of sensitivity contributions

Group	capture	fission	ν	elastic	inelastic	(n,xn)	SUM
1	1.9027E-03	-1.4333E-02	-1.7751E-02	1.2940E-04	1.1394E-02	1.7662E-03	**-1.69E-02**
2	1.1702E-02	-1.3923E-01	-1.7199E-01	-8.6056E-03	8.2089E-02	1.8873E-02	**-2.07E-01**
3	1.3723E-02	-1.3372E-01	-1.6095E-01	2.0326E-03	6.3948E-02	8.9446E-03	**-2.06E-01**
4	5.2157E-02	-2.4198E-01	-2.5774E-01	-3.2305E-02	2.2432E-02	2.3528E-02	**-4.34E-01**
5	9.0061E-02	-2.1124E-01	-2.1806E-01	-8.1712E-02	-2.2052E-03	1.3986E-02	**-4.09E-01**
6	9.2416E-02	-1.6970E-01	-1.6563E-01	-9.4258E-02	-2.1111E-03	5.7271E-03	**-3.34E-01**
7	5.4343E-02	-8.8348E-02	-7.8428E-02	-7.4513E-02	-1.4272E-03	1.9159E-03	**-1.86E-01**
8	2.0026E-02	-3.6765E-02	-2.4155E-02	-5.9620E-02	-8.3056E-04	7.0251E-04	**-1.01E-01**
9	-1.5347E-02	-2.0484E-03	1.7941E-02	-3.7045E-02	-2.1874E-05	3.1095E-04	**-3.62E-02**
10	-3.1410E-02	1.8716E-02	3.7322E-02	-1.8419E-02	-2.6726E-10	1.6387E-04	**6.37E-03**
11	-2.9595E-02	1.7967E-02	3.0957E-02	-1.1517E-02	-5.3237E-09	1.3048E-04	**7.94E-03**
12	-5.0942E-03	3.8481E-03	6.4784E-03	-5.9703E-03	0.0000E+00	5.2578E-05	**-6.85E-04**
13	-2.2970E-03	1.0785E-03	1.3476E-03	-4.0120E-04	9.6710E-05	-1.7955E-07	**-1.76E-04**
14	-5.1043E-04	2.8112E-04	6.2920E-04	-1.9968E-04	-3.4783E-05	-4.3940E-08	**1.65E-04**
15	-3.5673E-05	8.3538E-06	2.1586E-05	-8.8053E-06	9.9493E-06	-1.0462E-09	**-4.59E-06**
PART >0	***3.363E-01***	***4.190E-02***	***9.470E-02***	***2.162E-03***	***1.800E-01***	***7.610E-02***	***7.312E-01***
PART <0	***-8.429E-02***	***-1.037E+00***	***-1.095E+00***	***-4.246E-01***	***-6.631E-03***	***-2.245E-07***	***-2.648E+00***
SUM	**2.5204E-01**	**-9.9547E-01**	**-1.0000E+00**	**-4.2241E-01**	**1.7334E-01**	**7.6101E-02**	**-1.92**

Preliminary results

CRs worth - Detailed breakdown of uncertainty contributions

Group	capture	fission	*v*	elastic	inelastic	(n,xn)	SUM
1	9.2568E-04	3.2945E-04	4.6669E-04	2.6241E-04	1.6800E-03	5.0660E-05	**1.93E-03**
2	2.9319E-03	1.6627E-03	1.8768E-03	8.8013E-04	9.4988E-03	3.9445E-05	**1.03E-02**
3	3.3876E-03	4.2328E-03	1.8616E-03	1.9437E-03	9.7787E-03	0.0000E+00	**1.15E-02**
4	6.0052E-03	6.8514E-03	2.3571E-03	3.9580E-03	4.2802E-03	0.0000E+00	**1.11E-02**
5	1.3643E-02	6.0756E-03	1.4505E-03	2.4430E-03	3.2073E-04	0.0000E+00	**1.52E-02**
6	1.1525E-02	6.8241E-03	1.1323E-03	2.4166E-03	2.5799E-04	0.0000E+00	**1.37E-02**
7	5.6884E-03	3.3301E-03	6.5396E-04	2.2072E-03	9.2320E-05	0.0000E+00	**6.98E-03**
8	3.9490E-03	1.0514E-03	3.2485E-04	2.0323E-03	1.1304E-04	0.0000E+00	**4.57E-03**
9	3.3583E-03	1.0405E-04	2.4290E-04	1.6358E-03	4.3134E-06	0.0000E+00	**3.73E-03**
10	7.3066E-04	4.5602E-04	3.5348E-04	1.4727E-03	0.0000E+00	0.0000E+00	**1.67E-03**
11	4.4747E-04	6.0436E-04	1.5362E-04	9.9610E-04	0.0000E+00	0.0000E+00	**1.24E-03**
12	2.5959E-04	1.3090E-04	4.5412E-05	2.9044E-04	0.0000E+00	0.0000E+00	**4.08E-04**
13	2.0535E-04	2.9900E-05	1.6825E-05	5.2428E-05	0.0000E+00	0.0000E+00	**2.09E-04**
14	1.0320E-04	1.8497E-05	6.3923E-06	4.8980E-05	0.0000E+00	0.0000E+00	**1.16E-04**
15	3.0020E-05	4.2641E-06	1.3540E-06	1.0177E-05	0.0000E+00	0.0000E+00	**3.20E-05**
TOTAL	**2.0881E-02**	**1.2798E-02**	**4.0584E-03**	**6.8474E-03**	**1.4381E-02**	**6.4206E-05**	**0.0295**

Preliminary results

Effective delayed neutrons fraction

Sensitivities		
Isotope	**Reaction**	**Value**
U-238	v	$8.44 \cdot 10^{-2}$
Pu-239	fission	$-8.43 \cdot 10^{-2}$
Pu-239	capture	$-6.56 \cdot 10^{-2}$
U-238	v	$5.71 \cdot 10^{-2}$
U-238	v	$5.27 \cdot 10^{-2}$
Pu-240	fission	$3.34 \cdot 10^{-2}$
U-238	v	$-2.61 \cdot 10^{-2}$
Pu-241	capture	$-2.39 \cdot 10^{-2}$
Pu-240	fission	$2.27 \cdot 10^{-2}$
Pu-239	fission	$2.03 \cdot 10^{-2}$
Indirect		$3.67 \cdot 10^{-3}$
Direct		$2.61 \cdot 10^{-2}$
TOTAL		**0.0298**

Uncertainties		
Isotope	**Reaction**	**Value**
U-238	elastic	$5.56 \cdot 10^{-3}$
U-238	capture	$3.30 \cdot 10^{-3}$
Pu-241	fission	$3.06 \cdot 10^{-3}$
Pu-239	capture	$2.57 \cdot 10^{-3}$
O-16	capture	$1.77 \cdot 10^{-3}$
Pu-242	fission	$1.66 \cdot 10^{-3}$
Pu-240	fission	$1.49 \cdot 10^{-3}$
Fe-56	elastic	$1.40 \cdot 10^{-3}$
Pu-240	n,xn	$1.36 \cdot 10^{-3}$
Pu-242	capture	$1.33 \cdot 10^{-3}$
TOTAL		**$9.00 \cdot 10^{-3}$**

Preliminary results

β_{eff} - Detailed breakdown of sensitivity contributions

Group	capture	fission	ν	elastic	inelastic	(n,xn)	SUM
1	-1.5860E-03	6.5619E-03	6.2886E-06	-4.5563E-03	-9.1335E-04	9.5636E-03	**9.08E-03**
2	-5.0888E-03	6.2874E-02	6.7213E-03	-2.9358E-02	-9.0950E-03	9.5937E-02	**1.22E-01**
3	-3.1049E-03	5.4122E-02	2.8221E-03	-2.2532E-02	-4.3024E-03	8.2868E-02	**1.10E-01**
4	-7.5272E-03	4.4466E-02	3.1954E-03	-8.8435E-03	-3.2254E-03	6.3460E-02	**9.15E-02**
5	4.4582E-03	-1.5820E-02	-4.1737E-03	3.3205E-04	1.0237E-03	-2.2951E-02	**-3.71E-02**
6	1.4788E-02	-3.7427E-02	-1.7436E-03	1.0887E-03	6.8870E-04	-5.1835E-02	**-7.44E-02**
7	2.1408E-02	-3.4301E-02	-2.6764E-03	1.3942E-04	2.3535E-04	-4.6042E-02	**-6.12E-02**
8	2.4432E-02	-2.9481E-02	-5.3710E-03	-6.0090E-05	8.3355E-05	-3.9149E-02	**-4.95E-02**
9	2.8459E-02	-3.0485E-02	-4.3463E-03	-7.7256E-06	2.7085E-05	-4.1058E-02	**-4.74E-02**
10	1.8948E-02	-1.8629E-02	-2.0831E-03	-4.8959E-12	5.3069E-06	-2.5763E-02	**-2.75E-02**
11	5.2799E-03	-4.3996E-03	3.6012E-04	9.3208E-09	-5.9812E-06	-6.7318E-03	**-5.50E-03**
12	2.9277E-04	-1.8139E-04	3.0850E-04	0.0000E+00	-1.9639E-06	-3.1105E-04	**1.07E-04**
13	8.6964E-05	-3.2072E-05	1.4730E-05	-2.7902E-06	5.5468E-09	-4.1136E-05	**2.57E-05**
14	2.2501E-05	-4.1841E-06	1.2070E-05	6.9226E-07	6.0856E-10	-1.3904E-05	**1.72E-05**
15	-8.3166E-07	3.6263E-06	5.8347E-07	-3.9515E-07	-2.2240E-10	7.3283E-06	**1.03E-05**
PART >0	***1.182E-01***	***1.680E-01***	***1.344E-02***	***1.561E-03***	***2.064E-03***	***2.518E-01***	***5.551E-01***
PART <0	***-1.731E-02***	***-1.708E-01***	***-2.039E-02***	***-6.536E-02***	***-1.754E-02***	***-2.339E-01***	***-5.253E-01***
SUM	**1.0087E-01**	**-2.7343E-03**	**-6.9530E-03**	**-6.3800E-02**	**-1.5481E-02**	**1.7940E-02**	**0.0298**

Preliminary results

β_{eff} - Detailed breakdown of uncertainty contributions

Group	capture	fission	ν	elastic	inelastic	(n,xn)	SUM
1	9.2558E-04	2.9438E-05	9.1868E-05	6.7953E-04	3.4363E-05	2.1332E-04	**1.17E-03**
2	1.5838E-03	7.8315E-04	4.6922E-04	3.6492E-03	1.1776E-05	9.4089E-04	**4.19E-03**
3	1.9509E-04	1.5176E-03	6.4545E-04	3.8391E-03	0.0000E+00	9.5645E-04	**4.29E-03**
4	2.0154E-04	2.0923E-03	8.6483E-04	2.3674E-03	0.0000E+00	1.1937E-03	**3.48E-03**
5	2.9766E-04	6.2799E-04	1.7252E-04	1.3365E-04	0.0000E+00	3.9992E-04	**7.16E-04**
6	7.1355E-04	3.7592E-04	1.6210E-04	1.4614E-04	0.0000E+00	1.7607E-04	**8.28E-04**
7	1.2938E-03	1.2445E-03	3.6217E-04	6.6605E-05	0.0000E+00	4.0190E-04	**1.87E-03**
8	3.3288E-03	1.8665E-03	4.5505E-04	7.7180E-05	0.0000E+00	3.8304E-04	**3.86E-03**
9	2.6002E-03	1.8377E-03	3.8534E-04	2.1148E-06	0.0000E+00	3.9866E-04	**3.23E-03**
10	6.9782E-04	8.7810E-04	2.8894E-04	0.0000E+00	0.0000E+00	2.1723E-04	**1.14E-03**
11	1.9520E-04	2.8646E-04	1.0683E-04	0.0000E+00	0.0000E+00	7.5211E-06	**3.30E-04**
12	4.8719E-05	2.6699E-05	2.0844E-05	0.0000E+00	0.0000E+00	5.5577E-06	**5.18E-05**
13	3.0566E-05	1.0316E-05	3.5091E-06	0.0000E+00	0.0000E+00	9.6359E-07	**2.85E-05**
14	1.8236E-05	3.1712E-06	4.6695E-06	0.0000E+00	0.0000E+00	7.4747E-07	**1.79E-05**
15	4.9424E-06	3.7701E-06	9.8146E-07	0.0000E+00	0.0000E+00	6.3885E-07	**2.97E-06**
TOTAL	**4.8814E-03**	**4.1343E-03**	**1.4169E-03**	**5.8412E-03**	**3.6325E-05**	**1.9701E-03**	**0.00899**

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