

Standard comparison between Serpent 1.1.15 and MCNP5

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This report presents a set of standard test cases for the validation of the Serpent code in group constant generation. All geometries are infinite in the x-, y- and z- directions. Reference results are calculated using MCNP5.

Libraries and options

- ENDF/B-VII based cross section libraries
- No unresolved resonance probability table treatment
- 10 million neutron histories run (20 inactive and 500 active cycles of 20000 source neutrons)

Test cases

1. PWR pin-cell model, 1 MWd/kgU burnup
2. PWR pin-cell model, 20 MWd/kgU burnup
3. PWR pin-cell model, 40 MWd/kgU burnup
4. VVER-440 assembly, 650 ppm boron
5. Mixed UOX / MOX PWR lattice
6. BWR assembly with burnable absorber, 25% void fraction
7. BWR assembly with burnable absorber, 50% void fraction
8. BWR assembly with burnable absorber, 75% void fraction
9. Conceptual SCWR assembly
10. CANDU cluster
11. Sodium-cooled fast reactor assembly
12. Prismatic HTGR fuel block
13. Prismatic HTGR fuel block with burnable absorber
14. PBMR fuel pebble

Results

- Effective multiplication factors
- Prompt neutron lifetimes

- Running times
- Homogenized multi-group reaction cross sections
- Flux spectra

Energy group structure

All homogenized parameters are calculated using the same four energy group structure:

1. $E > 0.821 \text{ MeV}$
2. $5.5 \text{ keV} < E < 0.821 \text{ MeV}$
3. $0.625 \text{ eV} < E < 5.5 \text{ keV}$
4. $E < 0.625 \text{ eV}$

Notes

- The MCNP running times are significantly affected by the number of tallies in the calculation.
- All homogenized reaction cross sections for MCNP are calculated using a tallyx-subroutine that essentially makes a summation over all the constituent nuclides in the material where the track length is scored.
- The mixed UOX/MOX lattice consists of a PWR MOX assembly surrounded by UOX assemblies. All group constants are calculated for the central assembly only, but the MCNP result for prompt neutron lifetime is for the whole geometry. The result is an unrealistically large difference in the values.

Table 1. Comparison of k_{∞} . Relative statistical errors are in per cent.

Case	MCNP		Serpent		Δ (%)
PWR pin-cell, 1 MWd/kgU burnup	1.28408	(0.014)	1.28375	(0.012)	-0.026
PWR pin-cell, 20 MWd/kgU burnup	1.07312	(0.018)	1.07331	(0.016)	0.018
PWR pin-cell, 40 MWd/kgU burnup	0.91798	(0.021)	0.91787	(0.018)	-0.012
VVER-440 assembly	1.27059	(0.015)	1.27094	(0.014)	0.028
BWR+Gd Assembly, 25% void fraction	1.07737	(0.018)	1.07756	(0.020)	0.018
BWR+Gd Assembly, 50% void fraction	1.06291	(0.019)	1.06294	(0.019)	0.003
BWR+Gd Assembly, 75% void fraction	1.04325	(0.018)	1.04304	(0.020)	-0.020
Mixed PWR MOX/UOX lattice	1.07134	(0.020)	1.07126	(0.016)	-0.007
SCWR assembly	1.14347	(0.016)	1.14357	(0.016)	0.009
CANDU fuel cluster	0.92194	(0.016)	0.92165	(0.018)	-0.032
SFR assembly	1.76872	(0.008)	1.76871	(0.008)	-0.001
Prismatic HTGR fuel block	1.44995	(0.016)	1.44980	(0.017)	-0.010
Prismatic HTGR fuel block + BP	1.13840	(0.022)	1.13859	(0.022)	0.017
PBMR fuel pebble	1.43459	(0.016)	1.43469	(0.016)	0.007

Table 2. Comparison of prompt neutron lifetimes (in μ s). Relative statistical errors are in per cent.

Case	MCNP		Serpent		Δ (%)
PWR pin-cell, 1 MWd/kgU burnup	21.59	(0.041)	21.58	(0.025)	-0.037
PWR pin-cell, 20 MWd/kgU burnup	19.17	(0.046)	19.17	(0.031)	-0.020
PWR pin-cell, 40 MWd/kgU burnup	19.70	(0.046)	19.70	(0.029)	-0.049
VVER-440 assembly	18.10	(0.046)	18.12	(0.029)	0.062
BWR+Gd Assembly, 25% void fraction	28.71	(0.044)	28.74	(0.034)	0.107
BWR+Gd Assembly, 50% void fraction	27.67	(0.047)	27.66	(0.033)	-0.025
BWR+Gd Assembly, 75% void fraction	26.19	(0.049)	26.19	(0.032)	-0.007
Mixed PWR MOX/UOX lattice	14.08	(0.054)	7.19	(0.068)	-48.944
SCWR assembly	15.18	(0.038)	15.17	(0.032)	-0.026
CANDU fuel cluster	187.90	(0.052)	187.74	(0.032)	-0.084
SFR assembly	0.34	(0.021)	0.34	(0.018)	-0.089
Prismatic HTGR fuel block	322.62	(0.036)	322.53	(0.033)	-0.028
Prismatic HTGR fuel block + BP	256.94	(0.035)	257.01	(0.034)	0.029
PBMR fuel pebble	574.28	(0.036)	574.05	(0.033)	-0.040

Table 3. Comparison of running times (in minutes). The last column shows the ratio between Serpent and MCNP.

Case	MCNP	Serpent	M/S
PWR pin-cell, 1 MWd/kgU burnup	817.4	22.4	36.6
PWR pin-cell, 20 MWd/kgU burnup	781.0	21.8	35.8
PWR pin-cell, 40 MWd/kgU burnup	779.1	22.2	35.1
VVER-440 assembly	260.4	18.2	14.3
BWR+Gd Assembly, 25% void fraction	248.1	24.6	10.1
BWR+Gd Assembly, 50% void fraction	269.6	23.7	11.4
BWR+Gd Assembly, 75% void fraction	306.8	23.2	13.2
Mixed PWR MOX/UOX lattice	142.7	17.6	8.1
SCWR assembly	398.5	18.6	21.4
CANDU fuel cluster	320.9	34.3	9.3
SFR assembly	1369.9	23.5	58.4
Prismatic HTGR fuel block	6127.4	104.3	58.8
Prismatic HTGR fuel block + BP	5488.5	94.8	57.9
PBMR fuel pebble	3812.9	104.3	36.5

Table 4. Comparison of 4-group constants PWR pin-cell, 1 MWd/kgU burnup. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	2.27463E-01	(0.057)	2.27440E-01	(0.009)	-0.010
	2	5.63221E-01	(0.028)	5.63230E-01	(0.006)	0.002
	3	8.79170E-01	(0.028)	8.79206E-01	(0.007)	0.004
	4	1.39783E+00	(0.042)	1.39775E+00	(0.009)	-0.006
Σ_{fiss}	1	2.88884E-03	(0.064)	2.88950E-03	(0.041)	0.023
	2	3.39782E-04	(0.028)	3.39871E-04	(0.022)	0.026
	3	4.92551E-03	(0.036)	4.92833E-03	(0.041)	0.057
	4	5.32877E-02	(0.042)	5.32957E-02	(0.022)	0.015
Σ_{abs}	1	3.60416E-03	(0.064)	3.60510E-03	(0.036)	0.026
	2	2.17541E-03	(0.036)	2.17589E-03	(0.030)	0.022
	3	2.36937E-02	(0.045)	2.37138E-02	(0.039)	0.085
	4	8.27323E-02	(0.042)	8.27444E-02	(0.020)	0.015
Σ_{capt}	1	7.15318E-04	(0.081)	7.15602E-04	(0.049)	0.040
	2	1.83563E-03	(0.036)	1.83602E-03	(0.033)	0.021
	3	1.87682E-02	(0.054)	1.87855E-02	(0.046)	0.092
	4	2.94446E-02	(0.042)	2.94487E-02	(0.016)	0.014
Σ_{scatt}	1	2.23859E-01	(0.057)	2.23835E-01	(0.009)	-0.011
	2	5.61046E-01	(0.028)	5.61054E-01	(0.006)	0.001
	3	8.55476E-01	(0.028)	8.55492E-01	(0.007)	0.002
	4	1.31510E+00	(0.042)	1.31501E+00	(0.010)	-0.007
$\nu\Sigma_{\text{fiss}}$	1	8.05323E-03	(0.064)	8.05552E-03	(0.043)	0.028
	2	8.35938E-04	(0.028)	8.36158E-04	(0.022)	0.026
	3	1.20317E-02	(0.036)	1.20385E-02	(0.041)	0.057
	4	1.30792E-01	(0.042)	1.30811E-01	(0.022)	0.015
$\bar{\nu}$	1	2.78771E+00	(0.071)	2.78785E+00	(0.007)	0.005
	2	2.46022E+00	(0.028)	2.46022E+00	(0.000)	0.000
	3	2.44272E+00	(0.042)	2.44271E+00	(0.000)	-0.000
	4	2.45445E+00	(0.042)	2.45443E+00	(0.000)	-0.001
$1/v$	1	5.24856E-10	(0.057)	5.24850E-10	(0.009)	-0.001
	2	2.63390E-09	(0.028)	2.63397E-09	(0.014)	0.003
	3	1.82840E-07	(0.036)	1.82806E-07	(0.021)	-0.019
	4	2.42430E-06	(0.042)	2.42442E-06	(0.009)	0.005

Table 5. Comparison of 4-group constants PWR pin-cell, 20 MWd/kgU burnup. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	2.27427E-01	(0.057)	2.27417E-01	(0.010)	-0.005
	2	5.63969E-01	(0.028)	5.63976E-01	(0.006)	0.001
	3	8.88167E-01	(0.028)	8.88066E-01	(0.006)	-0.011
	4	1.41406E+00	(0.057)	1.41391E+00	(0.010)	-0.011
Σ_{fiss}	1	2.82614E-03	(0.064)	2.82851E-03	(0.042)	0.084
	2	2.20259E-04	(0.028)	2.20223E-04	(0.022)	-0.017
	3	3.22125E-03	(0.036)	3.22204E-03	(0.038)	0.024
	4	4.78566E-02	(0.057)	4.78744E-02	(0.026)	0.037
Σ_{abs}	1	3.54709E-03	(0.064)	3.54890E-03	(0.038)	0.051
	2	2.04913E-03	(0.036)	2.04838E-03	(0.030)	-0.037
	3	2.77919E-02	(0.045)	2.77707E-02	(0.040)	-0.076
	4	8.93416E-02	(0.057)	8.93717E-02	(0.023)	0.034
Σ_{capt}	1	7.20951E-04	(0.081)	7.20384E-04	(0.048)	-0.079
	2	1.82887E-03	(0.036)	1.82816E-03	(0.032)	-0.039
	3	2.45707E-02	(0.045)	2.45486E-02	(0.043)	-0.090
	4	4.14849E-02	(0.057)	4.14973E-02	(0.020)	0.030
Σ_{scatt}	1	2.23880E-01	(0.057)	2.23868E-01	(0.010)	-0.006
	2	5.61920E-01	(0.028)	5.61928E-01	(0.006)	0.001
	3	8.60375E-01	(0.028)	8.60296E-01	(0.007)	-0.009
	4	1.32472E+00	(0.057)	1.32454E+00	(0.011)	-0.014
$\nu\Sigma_{\text{fiss}}$	1	7.93826E-03	(0.064)	7.94609E-03	(0.045)	0.099
	2	5.70143E-04	(0.028)	5.70046E-04	(0.022)	-0.017
	3	8.29470E-03	(0.036)	8.29735E-03	(0.038)	0.032
	4	1.27118E-01	(0.057)	1.27166E-01	(0.026)	0.038
$\bar{\nu}$	1	2.80887E+00	(0.071)	2.80927E+00	(0.007)	0.014
	2	2.58851E+00	(0.028)	2.58849E+00	(0.001)	-0.001
	3	2.57499E+00	(0.042)	2.57518E+00	(0.002)	0.007
	4	2.65622E+00	(0.057)	2.65623E+00	(0.001)	0.001
$1/v$	1	5.23093E-10	(0.057)	5.23080E-10	(0.010)	-0.003
	2	2.63575E-09	(0.028)	2.63545E-09	(0.014)	-0.011
	3	1.75915E-07	(0.036)	1.75897E-07	(0.021)	-0.010
	4	2.45868E-06	(0.057)	2.45854E-06	(0.010)	-0.006

Table 6. Comparison of 4-group constants PWR pin-cell, 40 MWd/kgU burnup. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	2.27705E-01	(0.057)	2.27720E-01	(0.010)	0.006
	2	5.64755E-01	(0.028)	5.64664E-01	(0.006)	-0.016
	3	8.94410E-01	(0.028)	8.94404E-01	(0.007)	-0.001
	4	1.41446E+00	(0.057)	1.41437E+00	(0.010)	-0.007
Σ_{fiss}	1	2.76400E-03	(0.064)	2.76177E-03	(0.040)	-0.081
	2	1.45089E-04	(0.028)	1.45119E-04	(0.023)	0.020
	3	2.14249E-03	(0.036)	2.14234E-03	(0.044)	-0.007
	4	3.85962E-02	(0.057)	3.85961E-02	(0.025)	-0.000
Σ_{abs}	1	3.48800E-03	(0.064)	3.48574E-03	(0.036)	-0.065
	2	1.97649E-03	(0.036)	1.97672E-03	(0.032)	0.011
	3	3.00837E-02	(0.045)	3.00882E-02	(0.038)	0.015
	4	8.44194E-02	(0.057)	8.44148E-02	(0.022)	-0.006
Σ_{capt}	1	7.23993E-04	(0.081)	7.23962E-04	(0.052)	-0.004
	2	1.83140E-03	(0.036)	1.83160E-03	(0.033)	0.011
	3	2.79413E-02	(0.045)	2.79458E-02	(0.040)	0.016
	4	4.58232E-02	(0.057)	4.58188E-02	(0.019)	-0.010
Σ_{scatt}	1	2.24217E-01	(0.057)	2.24234E-01	(0.010)	0.007
	2	5.62779E-01	(0.028)	5.62687E-01	(0.006)	-0.016
	3	8.64326E-01	(0.028)	8.64316E-01	(0.007)	-0.001
	4	1.33004E+00	(0.057)	1.32996E+00	(0.011)	-0.006
$\nu\Sigma_{\text{fiss}}$	1	7.79804E-03	(0.064)	7.79101E-03	(0.042)	-0.090
	2	3.95810E-04	(0.028)	3.95896E-04	(0.023)	0.022
	3	5.81965E-03	(0.036)	5.81926E-03	(0.045)	-0.007
	4	1.07243E-01	(0.057)	1.07244E-01	(0.025)	0.001
$\bar{\nu}$	1	2.82129E+00	(0.071)	2.82101E+00	(0.007)	-0.010
	2	2.72804E+00	(0.028)	2.72807E+00	(0.001)	0.001
	3	2.71630E+00	(0.042)	2.71631E+00	(0.002)	0.000
	4	2.77858E+00	(0.057)	2.77861E+00	(0.001)	0.001
$1/\nu$	1	5.22189E-10	(0.057)	5.22273E-10	(0.010)	0.016
	2	2.63671E-09	(0.028)	2.63616E-09	(0.014)	-0.021
	3	1.72080E-07	(0.036)	1.72102E-07	(0.019)	0.013
	4	2.49106E-06	(0.057)	2.49058E-06	(0.010)	-0.019

Table 7. Comparison of 4-group constants VVER-440 assembly. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	2.20577E-01	(0.057)	2.20578E-01	(0.010)	0.000
	2	5.16945E-01	(0.028)	5.16881E-01	(0.006)	-0.012
	3	7.74335E-01	(0.028)	7.74370E-01	(0.007)	0.005
	4	1.18919E+00	(0.050)	1.18905E+00	(0.013)	-0.012
Σ_{fiss}	1	2.84795E-03	(0.064)	2.85037E-03	(0.041)	0.085
	2	4.08798E-04	(0.028)	4.08918E-04	(0.022)	0.029
	3	5.79871E-03	(0.036)	5.79188E-03	(0.039)	-0.118
	4	5.93746E-02	(0.050)	5.93700E-02	(0.027)	-0.008
Σ_{abs}	1	3.55295E-03	(0.064)	3.55510E-03	(0.037)	0.061
	2	2.31858E-03	(0.036)	2.31920E-03	(0.029)	0.027
	3	2.47204E-02	(0.036)	2.46962E-02	(0.035)	-0.098
	4	8.87308E-02	(0.050)	8.87234E-02	(0.023)	-0.008
Σ_{capt}	1	7.04992E-04	(0.072)	7.04726E-04	(0.046)	-0.038
	2	1.90979E-03	(0.036)	1.91029E-03	(0.031)	0.026
	3	1.89216E-02	(0.045)	1.89044E-02	(0.042)	-0.091
	4	2.93561E-02	(0.050)	2.93535E-02	(0.016)	-0.009
Σ_{scatt}	1	2.17024E-01	(0.057)	2.17023E-01	(0.010)	-0.001
	2	5.14626E-01	(0.028)	5.14561E-01	(0.006)	-0.013
	3	7.49614E-01	(0.028)	7.49674E-01	(0.007)	0.008
	4	1.10046E+00	(0.050)	1.10033E+00	(0.014)	-0.012
$\nu\Sigma_{\text{fiss}}$	1	7.91527E-03	(0.064)	7.92173E-03	(0.043)	0.082
	2	1.00269E-03	(0.028)	1.00298E-03	(0.022)	0.029
	3	1.41238E-02	(0.036)	1.41073E-02	(0.039)	-0.117
	4	1.44678E-01	(0.050)	1.44667E-01	(0.027)	-0.008
$\bar{\nu}$	1	2.77929E+00	(0.071)	2.77918E+00	(0.006)	-0.004
	2	2.45277E+00	(0.028)	2.45276E+00	(0.000)	-0.000
	3	2.43569E+00	(0.042)	2.43570E+00	(0.000)	0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	-0.000
$1/v$	1	5.29817E-10	(0.057)	5.29870E-10	(0.009)	0.010
	2	2.63685E-09	(0.028)	2.63717E-09	(0.014)	0.012
	3	1.76559E-07	(0.036)	1.76569E-07	(0.024)	0.005
	4	2.33255E-06	(0.050)	2.33236E-06	(0.012)	-0.008

Table 8. Comparison of 4-group constants BWR+Gd Assembly, 25% void fraction. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	2.01340E-01	(0.057)	2.01362E-01	(0.011)	0.011
	2	4.92812E-01	(0.028)	4.92837E-01	(0.006)	0.005
	3	7.68249E-01	(0.028)	7.68261E-01	(0.007)	0.002
	4	1.32690E+00	(0.050)	1.32713E+00	(0.011)	0.017
Σ_{fiss}	1	2.37923E-03	(0.064)	2.38051E-03	(0.046)	0.054
	2	3.16459E-04	(0.036)	3.16428E-04	(0.029)	-0.010
	3	4.24944E-03	(0.045)	4.24516E-03	(0.048)	-0.101
	4	3.29073E-02	(0.050)	3.29025E-02	(0.039)	-0.015
Σ_{abs}	1	2.99029E-03	(0.064)	2.99157E-03	(0.042)	0.043
	2	1.83284E-03	(0.036)	1.83253E-03	(0.034)	-0.017
	3	1.87397E-02	(0.045)	1.87340E-02	(0.042)	-0.030
	4	6.51839E-02	(0.042)	6.51857E-02	(0.032)	0.003
Σ_{capt}	1	6.11063E-04	(0.072)	6.11062E-04	(0.053)	-0.000
	2	1.51638E-03	(0.036)	1.51610E-03	(0.036)	-0.018
	3	1.44902E-02	(0.054)	1.44888E-02	(0.050)	-0.010
	4	3.22766E-02	(0.050)	3.22833E-02	(0.039)	0.021
Σ_{scatt}	1	1.98349E-01	(0.057)	1.98371E-01	(0.011)	0.011
	2	4.90979E-01	(0.028)	4.91005E-01	(0.006)	0.005
	3	7.49510E-01	(0.028)	7.49527E-01	(0.007)	0.002
	4	1.26172E+00	(0.050)	1.26194E+00	(0.012)	0.018
$\nu\Sigma_{\text{fiss}}$	1	6.61951E-03	(0.064)	6.62318E-03	(0.048)	0.055
	2	7.76489E-04	(0.036)	7.76418E-04	(0.029)	-0.009
	3	1.03504E-02	(0.045)	1.03400E-02	(0.048)	-0.101
	4	8.01852E-02	(0.050)	8.01734E-02	(0.039)	-0.015
$\bar{\nu}$	1	2.78221E+00	(0.071)	2.78224E+00	(0.007)	0.001
	2	2.45368E+00	(0.042)	2.45369E+00	(0.000)	0.001
	3	2.43572E+00	(0.057)	2.43572E+00	(0.000)	0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	0.000
$1/\nu$	1	5.26974E-10	(0.057)	5.27015E-10	(0.009)	0.008
	2	2.61829E-09	(0.028)	2.61804E-09	(0.014)	-0.010
	3	1.84251E-07	(0.036)	1.84255E-07	(0.022)	0.002
	4	2.48285E-06	(0.050)	2.48352E-06	(0.010)	0.027

Table 9. Comparison of 4-group constants BWR+Gd Assembly, 50% void fraction. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	1.80714E-01	(0.057)	1.80683E-01	(0.012)	-0.017
	2	4.26194E-01	(0.028)	4.26211E-01	(0.007)	0.004
	3	6.57180E-01	(0.028)	6.57141E-01	(0.008)	-0.006
	4	1.15652E+00	(0.050)	1.15602E+00	(0.014)	-0.043
Σ_{fiss}	1	2.32936E-03	(0.064)	2.33040E-03	(0.042)	0.044
	2	3.14540E-04	(0.036)	3.14409E-04	(0.028)	-0.042
	3	4.16593E-03	(0.045)	4.16489E-03	(0.044)	-0.025
	4	3.21629E-02	(0.050)	3.21787E-02	(0.033)	0.049
Σ_{abs}	1	2.90981E-03	(0.064)	2.91110E-03	(0.038)	0.044
	2	1.81693E-03	(0.036)	1.81536E-03	(0.032)	-0.086
	3	1.79206E-02	(0.045)	1.79247E-02	(0.039)	0.023
	4	6.36180E-02	(0.050)	6.36158E-02	(0.029)	-0.003
Σ_{capt}	1	5.80448E-04	(0.072)	5.80702E-04	(0.048)	0.044
	2	1.50239E-03	(0.036)	1.50096E-03	(0.034)	-0.095
	3	1.37547E-02	(0.054)	1.37599E-02	(0.047)	0.038
	4	3.14552E-02	(0.058)	3.14371E-02	(0.038)	-0.057
Σ_{scatt}	1	1.77804E-01	(0.057)	1.77772E-01	(0.012)	-0.018
	2	4.24377E-01	(0.028)	4.24396E-01	(0.007)	0.004
	3	6.39259E-01	(0.028)	6.39217E-01	(0.008)	-0.007
	4	1.09290E+00	(0.050)	1.09240E+00	(0.015)	-0.046
$\nu\Sigma_{\text{fiss}}$	1	6.47460E-03	(0.064)	6.47774E-03	(0.044)	0.048
	2	7.71779E-04	(0.036)	7.71457E-04	(0.028)	-0.042
	3	1.01469E-02	(0.045)	1.01444E-02	(0.044)	-0.025
	4	7.83713E-02	(0.050)	7.84099E-02	(0.033)	0.049
$\bar{\nu}$	1	2.77956E+00	(0.071)	2.77966E+00	(0.006)	0.004
	2	2.45367E+00	(0.042)	2.45367E+00	(0.000)	-0.000
	3	2.43569E+00	(0.057)	2.43570E+00	(0.000)	0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	-0.000
$1/v$	1	5.29434E-10	(0.057)	5.29407E-10	(0.010)	-0.005
	2	2.61039E-09	(0.028)	2.60976E-09	(0.014)	-0.024
	3	1.80429E-07	(0.036)	1.80388E-07	(0.023)	-0.023
	4	2.43378E-06	(0.050)	2.43353E-06	(0.010)	-0.010

Table 10. Comparison of 4-group constants BWR+Gd Assembly, 75% void fraction. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	1.59915E-01	(0.057)	1.59905E-01	(0.013)	-0.006
	2	3.59111E-01	(0.028)	3.59165E-01	(0.008)	0.015
	3	5.47263E-01	(0.028)	5.47231E-01	(0.010)	-0.006
	4	9.91749E-01	(0.050)	9.91985E-01	(0.019)	0.024
Σ_{fiss}	1	2.27101E-03	(0.064)	2.26886E-03	(0.039)	-0.095
	2	3.11839E-04	(0.036)	3.11856E-04	(0.024)	0.006
	3	4.05127E-03	(0.045)	4.05708E-03	(0.043)	0.143
	4	3.12019E-02	(0.050)	3.11805E-02	(0.036)	-0.069
Σ_{abs}	1	2.82194E-03	(0.064)	2.81990E-03	(0.035)	-0.072
	2	1.78997E-03	(0.036)	1.79050E-03	(0.031)	0.029
	3	1.67869E-02	(0.045)	1.67943E-02	(0.037)	0.044
	4	6.18296E-02	(0.050)	6.17773E-02	(0.030)	-0.085
Σ_{capt}	1	5.50929E-04	(0.064)	5.51042E-04	(0.045)	0.021
	2	1.47814E-03	(0.036)	1.47864E-03	(0.033)	0.034
	3	1.27356E-02	(0.045)	1.27373E-02	(0.043)	0.014
	4	3.06277E-02	(0.058)	3.05969E-02	(0.040)	-0.100
Σ_{scatt}	1	1.57093E-01	(0.057)	1.57085E-01	(0.013)	-0.005
	2	3.57321E-01	(0.028)	3.57375E-01	(0.008)	0.015
	3	5.30476E-01	(0.028)	5.30436E-01	(0.010)	-0.008
	4	9.29920E-01	(0.050)	9.30208E-01	(0.021)	0.031
$\nu\Sigma_{\text{fiss}}$	1	6.30339E-03	(0.064)	6.29750E-03	(0.041)	-0.094
	2	7.65187E-04	(0.036)	7.65224E-04	(0.024)	0.005
	3	9.86755E-03	(0.045)	9.88169E-03	(0.043)	0.143
	4	7.60296E-02	(0.050)	7.59774E-02	(0.036)	-0.069
$\bar{\nu}$	1	2.77559E+00	(0.071)	2.77561E+00	(0.006)	0.001
	2	2.45379E+00	(0.042)	2.45377E+00	(0.000)	-0.001
	3	2.43567E+00	(0.057)	2.43567E+00	(0.000)	0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	-0.000
$1/v$	1	5.32997E-10	(0.057)	5.33020E-10	(0.009)	0.004
	2	2.59123E-09	(0.028)	2.59177E-09	(0.015)	0.021
	3	1.75355E-07	(0.036)	1.75417E-07	(0.025)	0.035
	4	2.36421E-06	(0.050)	2.36431E-06	(0.013)	0.004

Table 11. Comparison of 4-group constants Mixed PWR MOX/UOX lattice. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	2.16661E-01	(0.085)	2.16654E-01	(0.016)	-0.003
	2	5.30905E-01	(0.071)	5.30978E-01	(0.011)	0.014
	3	8.40633E-01	(0.071)	8.40684E-01	(0.013)	0.006
	4	1.44140E+00	(0.127)	1.44111E+00	(0.027)	-0.020
Σ_{fiss}	1	3.19921E-03	(0.100)	3.19759E-03	(0.077)	-0.051
	2	4.37350E-04	(0.078)	4.37524E-04	(0.044)	0.040
	3	5.93241E-03	(0.103)	5.93514E-03	(0.099)	0.046
	4	1.14198E-01	(0.127)	1.14255E-01	(0.069)	0.050
Σ_{abs}	1	3.90674E-03	(0.100)	3.90531E-03	(0.070)	-0.037
	2	2.26625E-03	(0.078)	2.26946E-03	(0.055)	0.142
	3	3.48763E-02	(0.094)	3.48484E-02	(0.069)	-0.080
	4	2.03055E-01	(0.127)	2.03159E-01	(0.064)	0.051
Σ_{capt}	1	7.07531E-04	(0.117)	7.07717E-04	(0.084)	0.026
	2	1.82890E-03	(0.086)	1.83193E-03	(0.062)	0.166
	3	2.89439E-02	(0.103)	2.89133E-02	(0.077)	-0.106
	4	8.88573E-02	(0.127)	8.89044E-02	(0.059)	0.053
Σ_{scatt}	1	2.12755E-01	(0.092)	2.12749E-01	(0.017)	-0.003
	2	5.28639E-01	(0.071)	5.28708E-01	(0.011)	0.013
	3	8.05757E-01	(0.071)	8.05835E-01	(0.013)	0.010
	4	1.23834E+00	(0.127)	1.23795E+00	(0.033)	-0.032
$\nu\Sigma_{\text{fiss}}$	1	9.21254E-03	(0.100)	9.20691E-03	(0.080)	-0.061
	2	1.26548E-03	(0.078)	1.26598E-03	(0.044)	0.040
	3	1.69525E-02	(0.103)	1.69602E-02	(0.099)	0.045
	4	3.27027E-01	(0.127)	3.27190E-01	(0.069)	0.050
$\bar{\nu}$	1	2.87963E+00	(0.113)	2.87930E+00	(0.010)	-0.011
	2	2.89352E+00	(0.085)	2.89350E+00	(0.001)	-0.001
	3	2.85762E+00	(0.127)	2.85758E+00	(0.001)	-0.001
	4	2.86370E+00	(0.127)	2.86369E+00	(0.000)	-0.000
$1/\nu$	1	5.21952E-10	(0.085)	5.21918E-10	(0.015)	-0.007
	2	2.61910E-09	(0.078)	2.62118E-09	(0.027)	0.080
	3	1.62643E-07	(0.086)	1.62628E-07	(0.044)	-0.009
	4	2.28763E-06	(0.135)	2.28719E-06	(0.032)	-0.019

Table 12. Comparison of 4-group constants SCWR assembly. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	1.76160E-01	(0.057)	1.76173E-01	(0.012)	0.008
	2	3.84176E-01	(0.028)	3.84144E-01	(0.008)	-0.008
	3	6.33172E-01	(0.028)	6.33133E-01	(0.005)	-0.006
	4	9.36986E-01	(0.057)	9.37200E-01	(0.012)	0.023
Σ_{fiss}	1	2.43991E-03	(0.064)	2.43957E-03	(0.037)	-0.014
	2	4.70889E-04	(0.028)	4.70835E-04	(0.023)	-0.011
	3	6.13096E-03	(0.036)	6.13405E-03	(0.039)	0.050
	4	5.49268E-02	(0.057)	5.49407E-02	(0.034)	0.025
Σ_{abs}	1	3.18940E-03	(0.064)	3.18909E-03	(0.034)	-0.010
	2	2.09238E-03	(0.036)	2.09216E-03	(0.028)	-0.010
	3	2.25679E-02	(0.036)	2.25717E-02	(0.032)	0.017
	4	8.95744E-02	(0.057)	8.96032E-02	(0.026)	0.032
Σ_{capt}	1	7.49487E-04	(0.072)	7.49518E-04	(0.044)	0.004
	2	1.62149E-03	(0.036)	1.62132E-03	(0.031)	-0.011
	3	1.64370E-02	(0.045)	1.64377E-02	(0.038)	0.004
	4	3.46476E-02	(0.057)	3.46625E-02	(0.023)	0.043
Σ_{scatt}	1	1.72970E-01	(0.057)	1.72984E-01	(0.012)	0.008
	2	3.82084E-01	(0.028)	3.82052E-01	(0.008)	-0.008
	3	6.10604E-01	(0.028)	6.10562E-01	(0.005)	-0.007
	4	8.47412E-01	(0.057)	8.47597E-01	(0.013)	0.022
$\nu\Sigma_{\text{fiss}}$	1	6.74870E-03	(0.064)	6.74766E-03	(0.039)	-0.015
	2	1.15503E-03	(0.028)	1.15491E-03	(0.023)	-0.010
	3	1.49325E-02	(0.036)	1.49402E-02	(0.039)	0.051
	4	1.33840E-01	(0.057)	1.33874E-01	(0.034)	0.025
$\bar{\nu}$	1	2.76596E+00	(0.071)	2.76591E+00	(0.006)	-0.002
	2	2.45287E+00	(0.028)	2.45289E+00	(0.000)	0.001
	3	2.43560E+00	(0.042)	2.43561E+00	(0.000)	0.001
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	0.000
$1/\nu$	1	5.37774E-10	(0.057)	5.37903E-10	(0.009)	0.024
	2	2.61819E-09	(0.028)	2.61740E-09	(0.014)	-0.030
	3	1.64667E-07	(0.036)	1.64665E-07	(0.024)	-0.001
	4	2.18737E-06	(0.057)	2.18797E-06	(0.015)	0.028

Table 13. Comparison of 4-group constants CANDU fuel cluster. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	2.09593E-01	(0.057)	2.09626E-01	(0.012)	0.016
	2	3.15739E-01	(0.028)	3.15694E-01	(0.006)	-0.014
	3	3.20359E-01	(0.014)	3.20378E-01	(0.005)	0.006
	4	3.75752E-01	(0.042)	3.75755E-01	(0.005)	0.001
Σ_{fiss}	1	2.11665E-03	(0.064)	2.11735E-03	(0.048)	0.033
	2	5.04019E-05	(0.036)	5.04312E-05	(0.034)	0.058
	3	4.77979E-04	(0.041)	4.78120E-04	(0.051)	0.030
	4	4.56794E-03	(0.042)	4.56642E-03	(0.030)	-0.033
Σ_{abs}	1	2.73538E-03	(0.064)	2.73698E-03	(0.042)	0.058
	2	1.25694E-03	(0.045)	1.25753E-03	(0.039)	0.047
	3	5.12287E-03	(0.041)	5.12727E-03	(0.046)	0.086
	4	9.00970E-03	(0.042)	9.00676E-03	(0.028)	-0.033
Σ_{capt}	1	6.18734E-04	(0.081)	6.19631E-04	(0.053)	0.145
	2	1.20654E-03	(0.045)	1.20710E-03	(0.039)	0.047
	3	4.64490E-03	(0.051)	4.64915E-03	(0.048)	0.092
	4	4.44176E-03	(0.042)	4.44033E-03	(0.027)	-0.032
Σ_{scatt}	1	2.06858E-01	(0.057)	2.06889E-01	(0.013)	0.015
	2	3.14482E-01	(0.028)	3.14437E-01	(0.005)	-0.014
	3	3.15236E-01	(0.014)	3.15251E-01	(0.004)	0.005
	4	3.66743E-01	(0.042)	3.66748E-01	(0.005)	0.001
$\nu\Sigma_{\text{fiss}}$	1	5.89240E-03	(0.064)	5.89482E-03	(0.050)	0.041
	2	1.23364E-04	(0.036)	1.23436E-04	(0.034)	0.058
	3	1.16425E-03	(0.041)	1.16460E-03	(0.051)	0.030
	4	1.11307E-02	(0.042)	1.11270E-02	(0.030)	-0.033
$\bar{\nu}$	1	2.78383E+00	(0.071)	2.78405E+00	(0.007)	0.008
	2	2.44761E+00	(0.042)	2.44761E+00	(0.000)	0.000
	3	2.43579E+00	(0.057)	2.43578E+00	(0.000)	-0.000
	4	2.43670E+00	(0.042)	2.43670E+00	(0.000)	-0.000
$1/\nu$	1	5.27616E-10	(0.057)	5.27626E-10	(0.010)	0.002
	2	3.53813E-09	(0.028)	3.53877E-09	(0.010)	0.018
	3	1.85335E-07	(0.022)	1.85297E-07	(0.017)	-0.020
	4	2.52224E-06	(0.042)	2.52226E-06	(0.008)	0.001

Table 14. Comparison of 4-group constants SFR assembly. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	1.84380E-01	(0.042)	1.84380E-01	(0.009)	-0.000
	2	2.83897E-01	(0.014)	2.83897E-01	(0.005)	0.000
	3	5.42535E-01	(0.099)	5.42557E-01	(0.022)	0.004
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
Σ_{fiss}	1	6.28149E-03	(0.042)	6.28295E-03	(0.021)	0.023
	2	4.46358E-03	(0.014)	4.46324E-03	(0.008)	-0.008
	3	1.37949E-02	(0.106)	1.37964E-02	(0.044)	0.011
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
Σ_{abs}	1	7.16465E-03	(0.042)	7.16600E-03	(0.020)	0.019
	2	7.05683E-03	(0.014)	7.05644E-03	(0.010)	-0.006
	3	2.84064E-02	(0.106)	2.84121E-02	(0.041)	0.020
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
Σ_{capt}	1	8.83127E-04	(0.050)	8.83051E-04	(0.028)	-0.009
	2	2.59325E-03	(0.022)	2.59320E-03	(0.016)	-0.002
	3	1.46116E-02	(0.106)	1.46157E-02	(0.045)	0.028
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
Σ_{scatt}	1	1.77216E-01	(0.042)	1.77214E-01	(0.009)	-0.001
	2	2.76840E-01	(0.014)	2.76841E-01	(0.005)	0.000
	3	5.14128E-01	(0.099)	5.14144E-01	(0.023)	0.003
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
$\nu\Sigma_{\text{fiss}}$	1	1.82343E-02	(0.050)	1.82385E-02	(0.022)	0.023
	2	1.18178E-02	(0.014)	1.18169E-02	(0.008)	-0.008
	3	3.56314E-02	(0.106)	3.56364E-02	(0.045)	0.014
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
$\bar{\nu}$	1	2.90287E+00	(0.050)	2.90285E+00	(0.003)	-0.001
	2	2.64761E+00	(0.014)	2.64760E+00	(0.000)	-0.000
	3	2.58294E+00	(0.113)	2.58302E+00	(0.002)	0.003
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
$1/\nu$	1	5.63859E-10	(0.042)	5.63886E-10	(0.009)	0.005
	2	2.53400E-09	(0.022)	2.53392E-09	(0.015)	-0.003
	3	1.59235E-08	(0.106)	1.59254E-08	(0.032)	0.012
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—

Table 15. Comparison of 4-group constants Prismatic HTGR fuel block. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	1.37481E-01	(0.042)	1.37496E-01	(0.009)	0.011
	2	2.76004E-01	(0.014)	2.75991E-01	(0.004)	-0.005
	3	3.11261E-01	(0.014)	3.11270E-01	(0.003)	0.003
	4	3.19858E-01	(0.057)	3.19817E-01	(0.003)	-0.013
Σ_{fiss}	1	6.66568E-05	(0.050)	6.67301E-05	(0.142)	0.110
	2	2.93285E-05	(0.014)	2.93477E-05	(0.058)	0.065
	3	4.06191E-04	(0.022)	4.06424E-04	(0.056)	0.057
	4	3.81987E-03	(0.057)	3.82038E-03	(0.028)	0.013
Σ_{abs}	1	1.19100E-04	(0.163)	1.19139E-04	(0.169)	0.033
	2	8.24118E-05	(0.014)	8.24299E-05	(0.062)	0.022
	3	1.98685E-03	(0.041)	1.98771E-03	(0.045)	0.043
	4	4.83170E-03	(0.057)	4.83232E-03	(0.027)	0.013
Σ_{capt}	1	5.24430E-05	(0.341)	5.24092E-05	(0.326)	-0.064
	2	5.30832E-05	(0.022)	5.30822E-05	(0.068)	-0.002
	3	1.58066E-03	(0.051)	1.58129E-03	(0.052)	0.040
	4	1.01183E-03	(0.057)	1.01194E-03	(0.024)	0.011
Σ_{scatt}	1	1.37361E-01	(0.042)	1.37377E-01	(0.009)	0.011
	2	2.75922E-01	(0.014)	2.75908E-01	(0.004)	-0.005
	3	3.09274E-01	(0.014)	3.09282E-01	(0.003)	0.003
	4	3.15026E-01	(0.057)	3.14985E-01	(0.003)	-0.013
$\nu\Sigma_{\text{fiss}}$	1	1.81233E-04	(0.050)	1.81410E-04	(0.146)	0.098
	2	7.16655E-05	(0.014)	7.17128E-05	(0.058)	0.066
	3	9.89378E-04	(0.022)	9.89946E-04	(0.056)	0.057
	4	9.30789E-03	(0.057)	9.30911E-03	(0.028)	0.013
$\bar{\nu}$	1	2.71890E+00	(0.057)	2.71851E+00	(0.014)	-0.014
	2	2.44354E+00	(0.014)	2.44356E+00	(0.000)	0.001
	3	2.43575E+00	(0.028)	2.43575E+00	(0.000)	0.000
	4	2.43671E+00	(0.057)	2.43670E+00	(0.000)	-0.000
$1/v$	1	5.69081E-10	(0.042)	5.69067E-10	(0.007)	-0.002
	2	3.39239E-09	(0.014)	3.39242E-09	(0.005)	0.001
	3	1.83223E-07	(0.022)	1.83185E-07	(0.012)	-0.021
	4	2.13689E-06	(0.057)	2.13662E-06	(0.009)	-0.013

Table 16. Comparison of 4-group constants Prismatic HTGR fuel block + BP. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	1.37341E-01	(0.042)	1.37335E-01	(0.008)	-0.004
	2	2.75835E-01	(0.014)	2.75849E-01	(0.004)	0.005
	3	3.11225E-01	(0.014)	3.11233E-01	(0.003)	0.003
	4	3.20045E-01	(0.057)	3.20044E-01	(0.004)	-0.000
Σ_{fiss}	1	6.52103E-05	(0.050)	6.52405E-05	(0.137)	0.046
	2	2.85347E-05	(0.014)	2.85460E-05	(0.058)	0.040
	3	3.94237E-04	(0.022)	3.94213E-04	(0.056)	-0.006
	4	3.65069E-03	(0.057)	3.65140E-03	(0.034)	0.019
Σ_{abs}	1	1.17385E-04	(0.163)	1.17612E-04	(0.176)	0.193
	2	8.29894E-05	(0.014)	8.30165E-05	(0.061)	0.033
	3	2.08695E-03	(0.041)	2.08499E-03	(0.040)	-0.094
	4	5.93954E-03	(0.057)	5.94035E-03	(0.029)	0.014
Σ_{capt}	1	5.21746E-05	(0.341)	5.23715E-05	(0.336)	0.377
	2	5.44547E-05	(0.014)	5.44706E-05	(0.067)	0.029
	3	1.69271E-03	(0.041)	1.69078E-03	(0.046)	-0.114
	4	2.28884E-03	(0.064)	2.28894E-03	(0.046)	0.004
Σ_{scatt}	1	1.37223E-01	(0.042)	1.37217E-01	(0.008)	-0.005
	2	2.75752E-01	(0.014)	2.75766E-01	(0.004)	0.005
	3	3.09138E-01	(0.014)	3.09148E-01	(0.003)	0.003
	4	3.14106E-01	(0.057)	3.14104E-01	(0.004)	-0.001
$\nu\Sigma_{\text{fiss}}$	1	1.77305E-04	(0.050)	1.77451E-04	(0.142)	0.082
	2	6.97264E-05	(0.014)	6.97541E-05	(0.058)	0.040
	3	9.60258E-04	(0.022)	9.60202E-04	(0.056)	-0.006
	4	8.89564E-03	(0.057)	8.89738E-03	(0.034)	0.020
$\bar{\nu}$	1	2.71897E+00	(0.057)	2.71988E+00	(0.015)	0.033
	2	2.44357E+00	(0.014)	2.44357E+00	(0.000)	0.000
	3	2.43574E+00	(0.028)	2.43574E+00	(0.000)	0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	0.000
$1/v$	1	5.69106E-10	(0.042)	5.69120E-10	(0.006)	0.003
	2	3.39142E-09	(0.014)	3.39210E-09	(0.004)	0.020
	3	1.81847E-07	(0.022)	1.81890E-07	(0.012)	0.024
	4	2.08761E-06	(0.057)	2.08724E-06	(0.009)	-0.018

Table 17. Comparison of 4-group constants PBMR fuel pebble. Relative statistical errors are in per cent.

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	9.68831E-02	(0.042)	9.68808E-02	(0.013)	-0.002
	2	1.94198E-01	(0.014)	1.94205E-01	(0.006)	0.004
	3	2.18667E-01	(0.014)	2.18649E-01	(0.005)	-0.008
	4	2.24065E-01	(0.057)	2.24041E-01	(0.005)	-0.011
Σ_{fiss}	1	4.46392E-05	(0.050)	4.46240E-05	(0.147)	-0.034
	2	1.63013E-05	(0.014)	1.62986E-05	(0.058)	-0.017
	3	2.27183E-04	(0.022)	2.27183E-04	(0.060)	0.000
	4	2.18391E-03	(0.057)	2.18406E-03	(0.029)	0.007
Σ_{abs}	1	8.04703E-05	(0.163)	8.04144E-05	(0.163)	-0.069
	2	5.28522E-05	(0.014)	5.28376E-05	(0.064)	-0.028
	3	1.31391E-03	(0.041)	1.31296E-03	(0.045)	-0.072
	4	2.79487E-03	(0.057)	2.79504E-03	(0.028)	0.006
Σ_{capt}	1	3.58313E-05	(0.351)	3.57904E-05	(0.314)	-0.114
	2	3.65510E-05	(0.022)	3.65390E-05	(0.070)	-0.033
	3	1.08673E-03	(0.051)	1.08577E-03	(0.050)	-0.088
	4	6.10963E-04	(0.057)	6.10983E-04	(0.024)	0.003
Σ_{scatt}	1	9.68026E-02	(0.042)	9.68003E-02	(0.013)	-0.002
	2	1.94145E-01	(0.014)	1.94152E-01	(0.006)	0.003
	3	2.17353E-01	(0.014)	2.17336E-01	(0.005)	-0.008
	4	2.21270E-01	(0.057)	2.21246E-01	(0.005)	-0.011
$\nu\Sigma_{\text{fiss}}$	1	1.21550E-04	(0.050)	1.21519E-04	(0.151)	-0.025
	2	3.98337E-05	(0.014)	3.98269E-05	(0.058)	-0.017
	3	5.53360E-04	(0.022)	5.53364E-04	(0.060)	0.001
	4	5.32154E-03	(0.057)	5.32190E-03	(0.029)	0.007
$\bar{\nu}$	1	2.72293E+00	(0.057)	2.72311E+00	(0.015)	0.006
	2	2.44359E+00	(0.014)	2.44359E+00	(0.000)	0.000
	3	2.43575E+00	(0.028)	2.43576E+00	(0.000)	0.000
	4	2.43671E+00	(0.057)	2.43670E+00	(0.000)	-0.000
$1/v$	1	5.69632E-10	(0.042)	5.69693E-10	(0.006)	0.011
	2	3.39217E-09	(0.014)	3.39215E-09	(0.006)	-0.001
	3	1.85141E-07	(0.022)	1.85150E-07	(0.012)	0.005
	4	2.18404E-06	(0.057)	2.18340E-06	(0.008)	-0.029

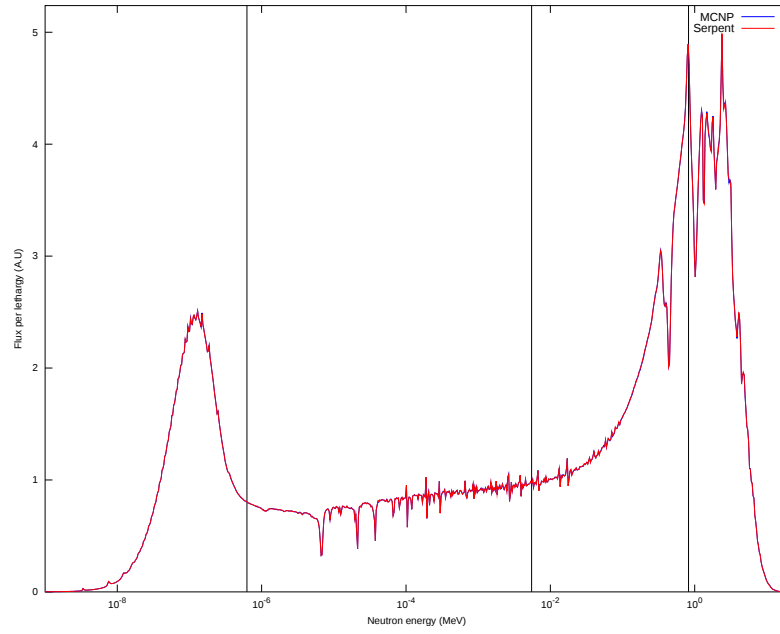


Figure 1. Flux spectra integrated over the entire geometry PWR pin-cell, 1 MWd/kgU burnup.

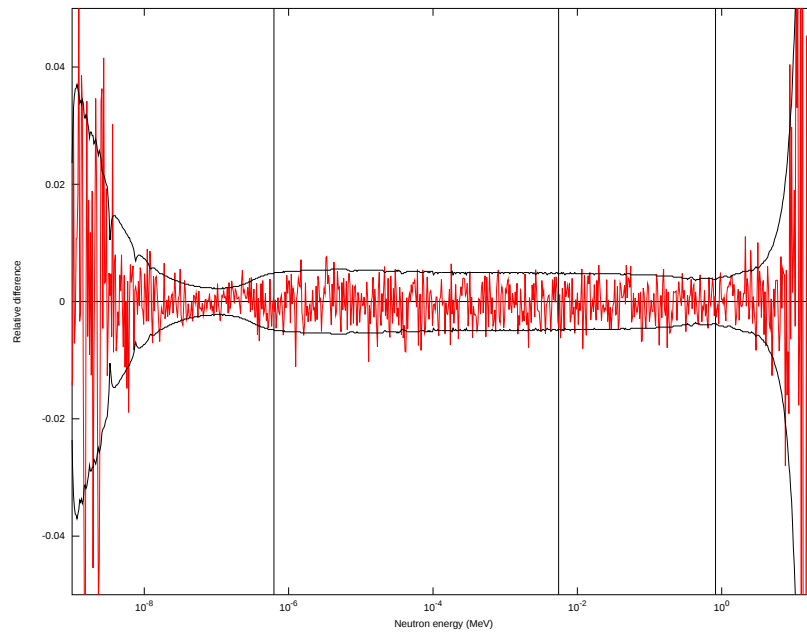


Figure 2. Relative differences between the two spectra Figure 1.

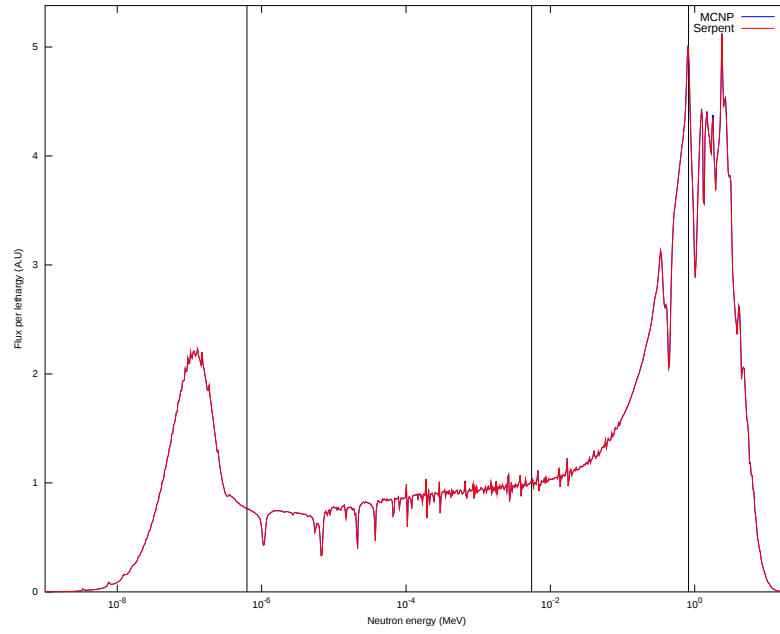


Figure 3. Flux spectra integrated over the entire geometry PWR pin-cell, 20 MWd/kgU burnup.

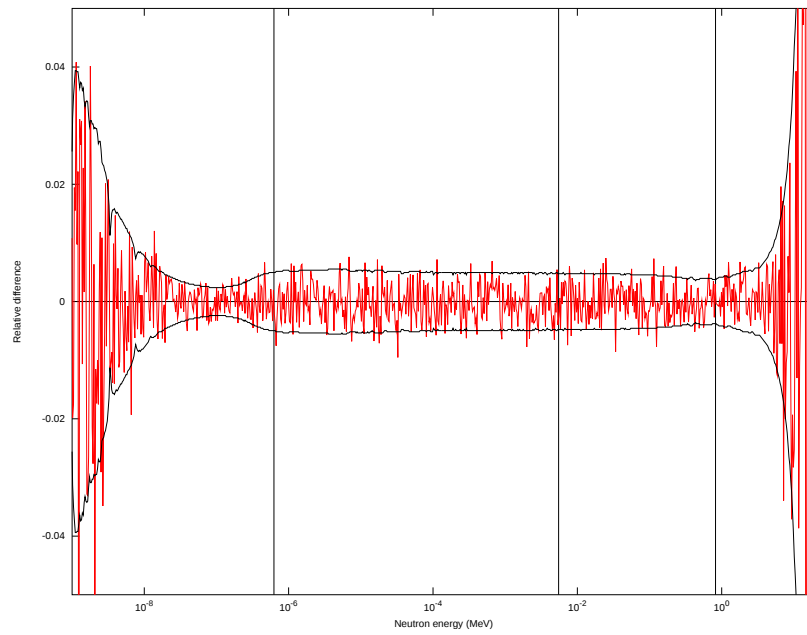


Figure 4. Relative differences between the two spectra Figure 3.

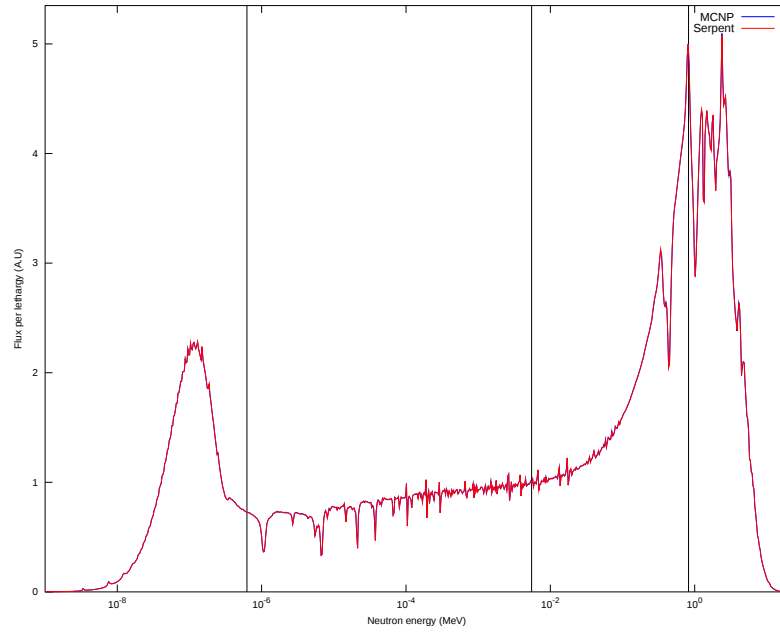


Figure 5. Flux spectra integrated over the entire geometry PWR pin-cell, 40 MWd/kgU burnup.

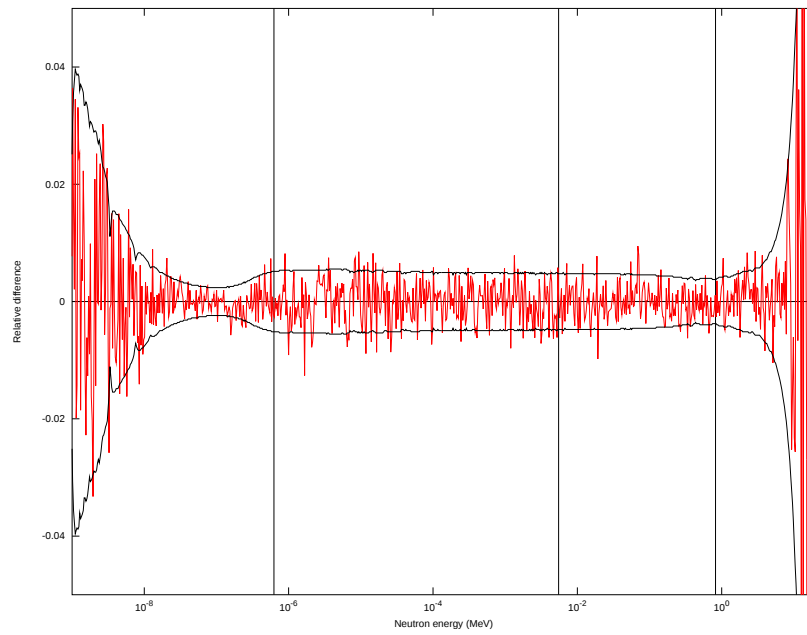


Figure 6. Relative differences between the two spectra Figure 5.

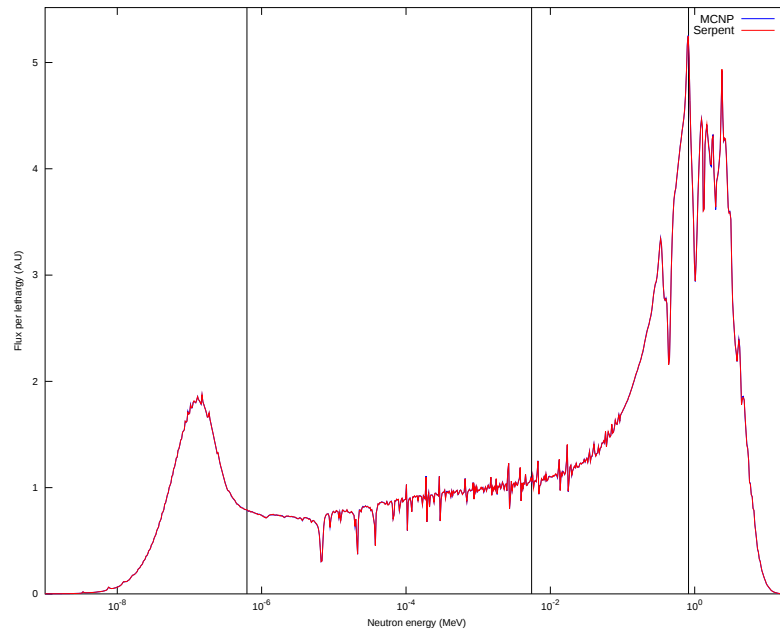


Figure 7. Flux spectra integrated over the entire geometry VVER-440 assembly.

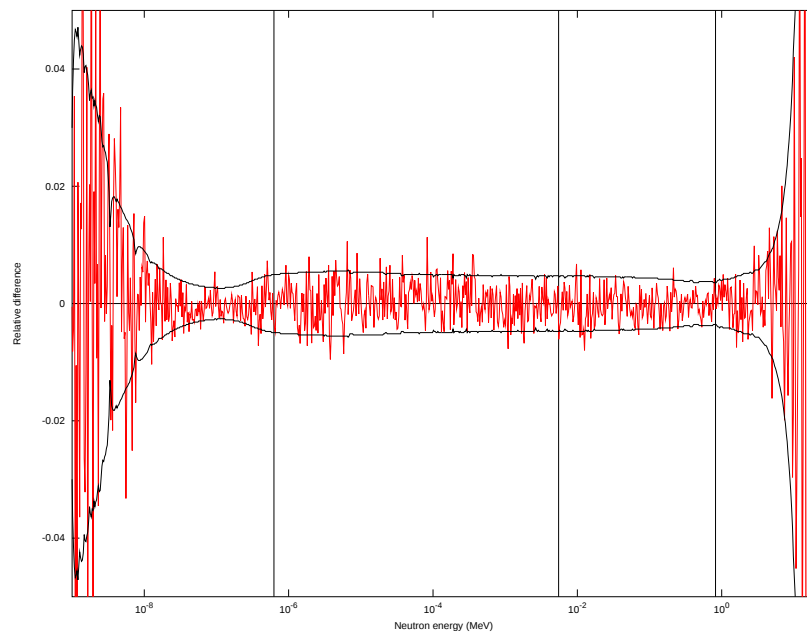


Figure 8. Relative differences between the two spectra Figure 7.

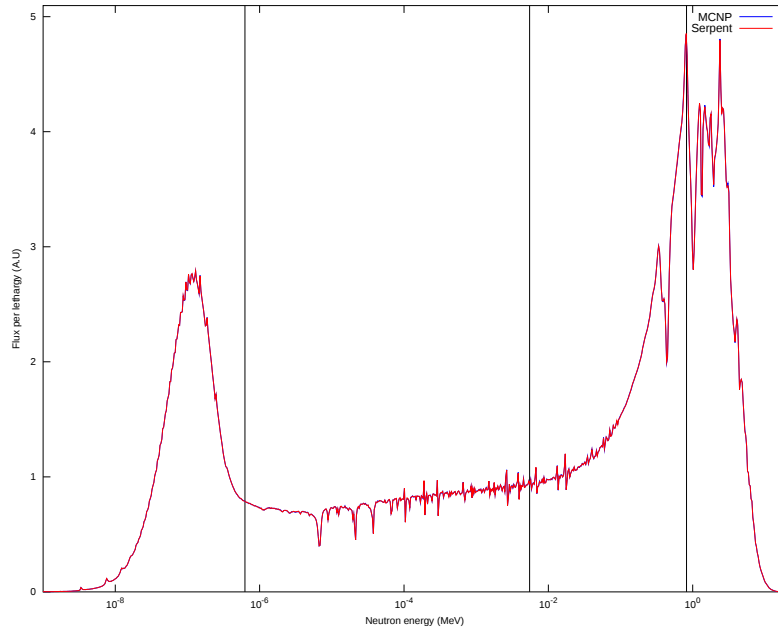


Figure 9. Flux spectra integrated over the entire geometry BWR+Gd Assembly, 25% void fraction.

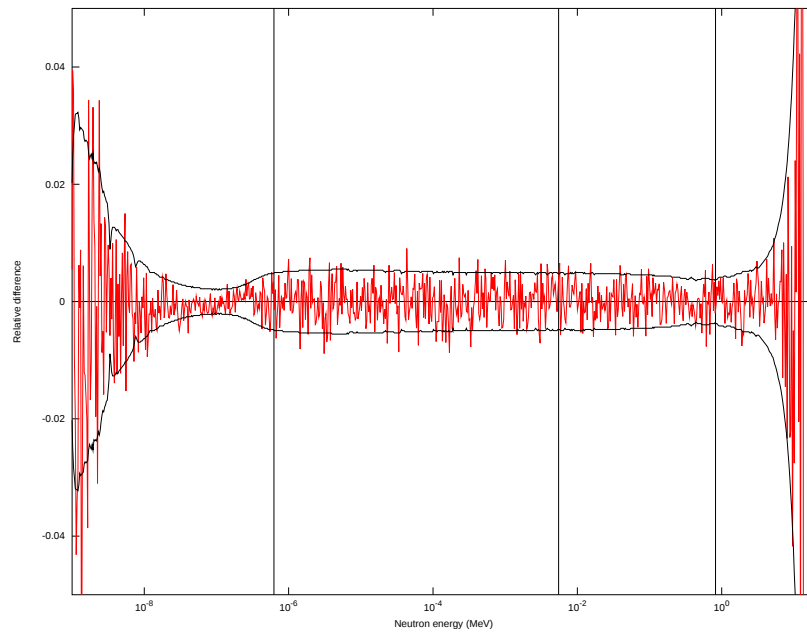


Figure 10. Relative differences between the two spectra Figure 9.

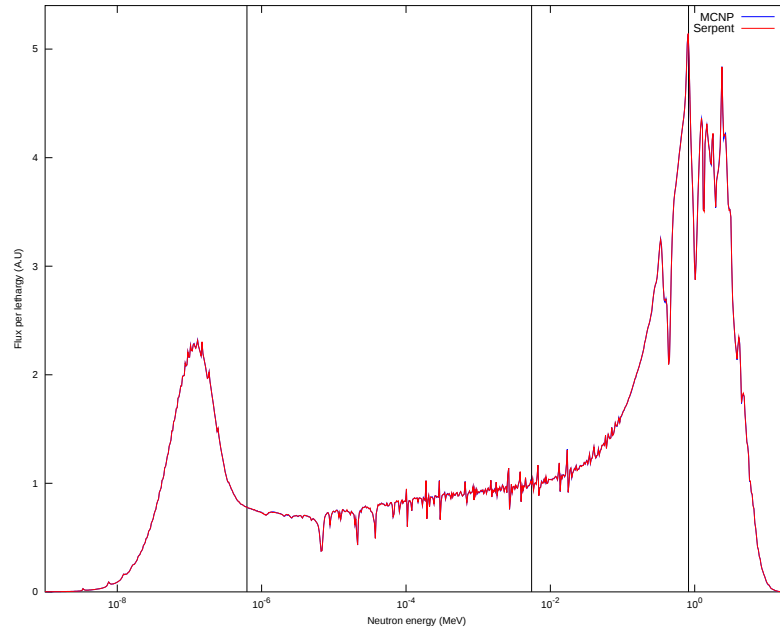


Figure 11. Flux spectra integrated over the entire geometry BWR+Gd Assembly, 50% void fraction.

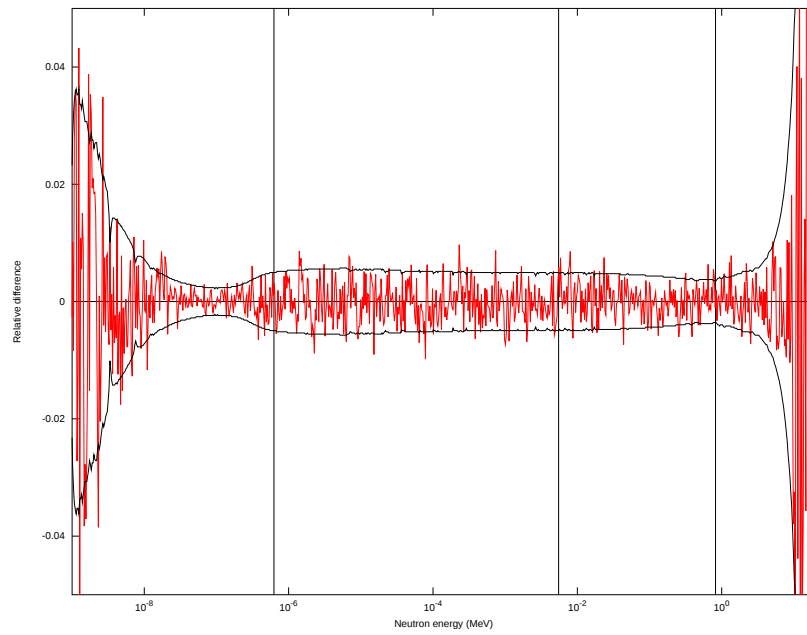


Figure 12. Relative differences between the two spectra Figure 11.

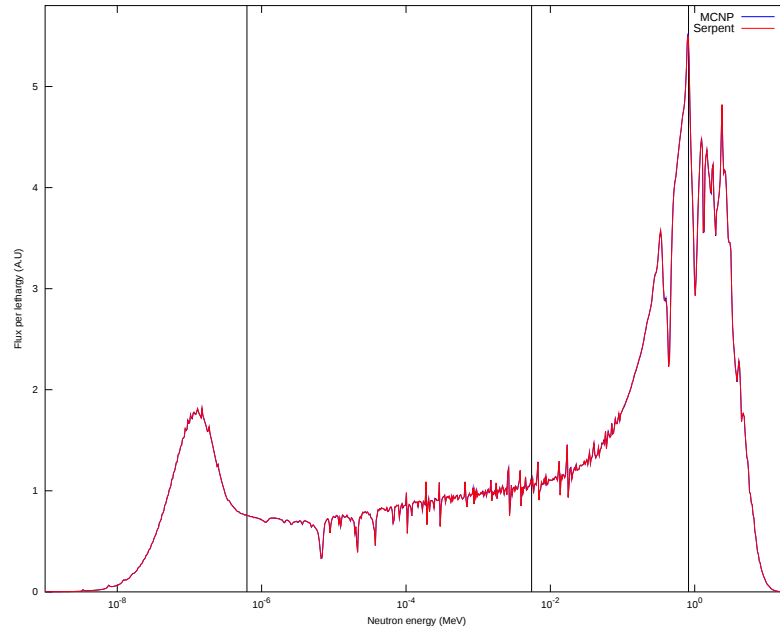


Figure 13. Flux spectra integrated over the entire geometry BWR+Gd Assembly, 75% void fraction.

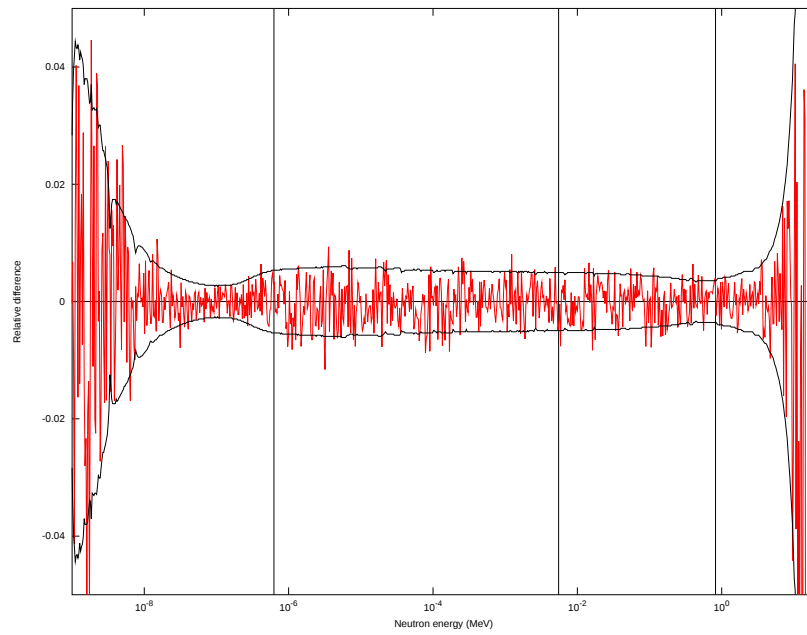


Figure 14. Relative differences between the two spectra Figure 13.

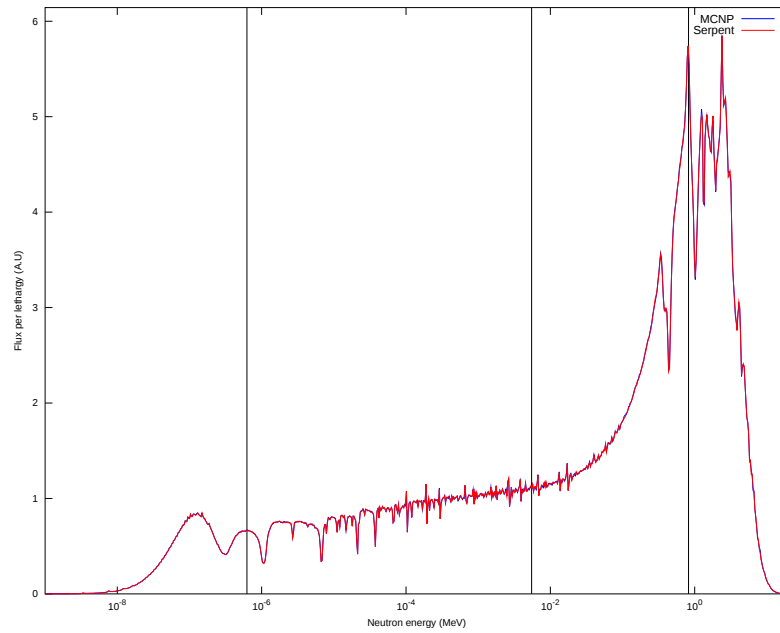


Figure 15. Flux spectra integrated over the entire geometry Mixed PWR MOX/UOX lattice.

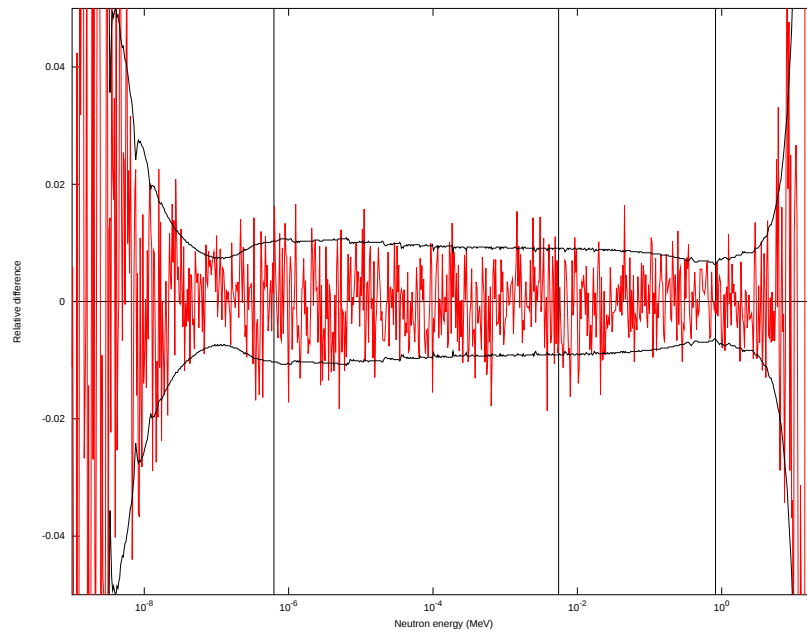


Figure 16. Relative differences between the two spectra Figure 15.

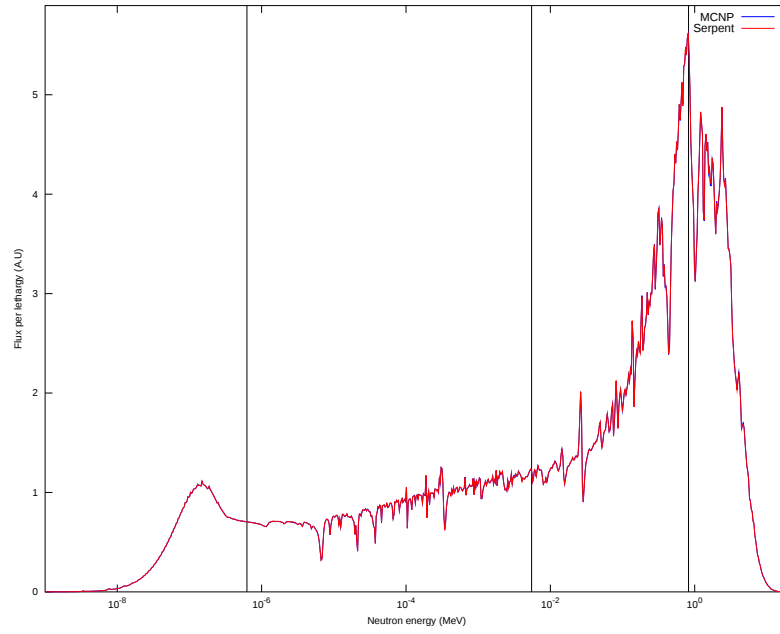


Figure 17. Flux spectra integrated over the entire geometry SCWR assembly.

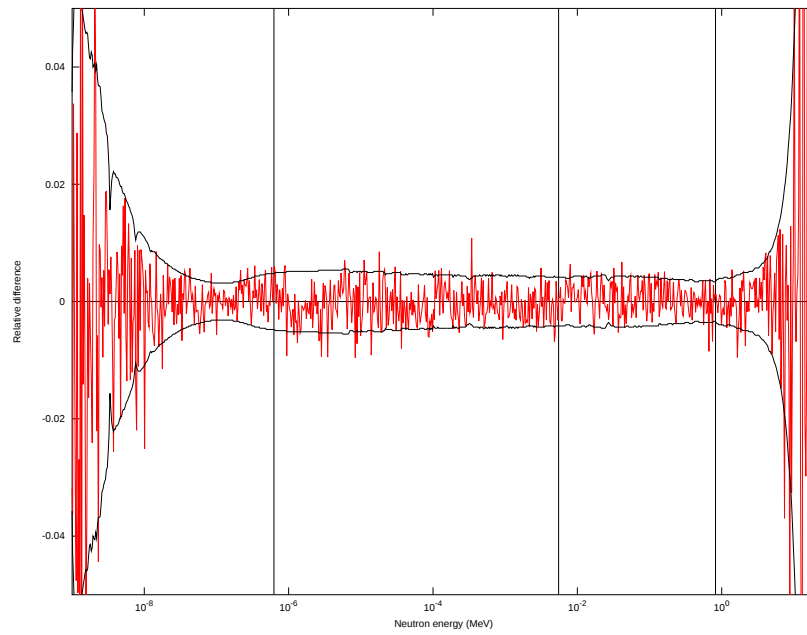


Figure 18. Relative differences between the two spectra Figure 17.

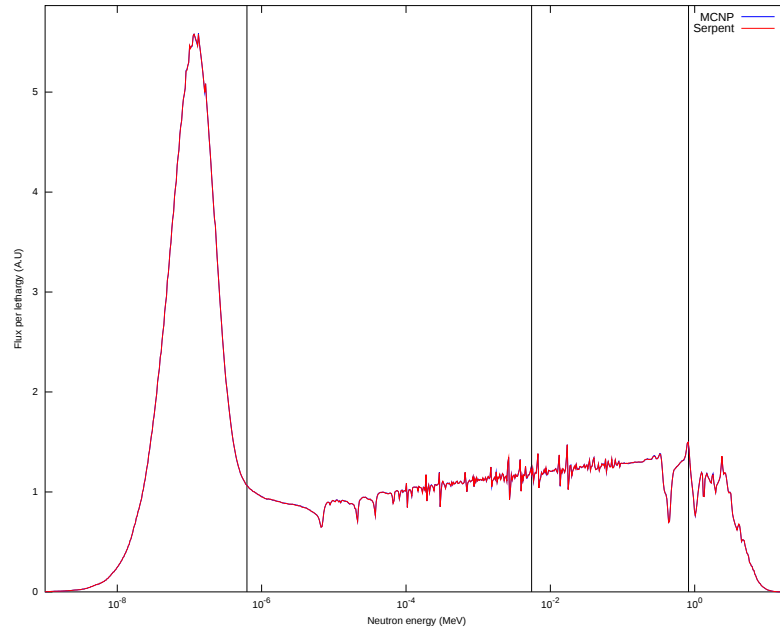


Figure 19. Flux spectra integrated over the entire geometry CANDU fuel cluster.

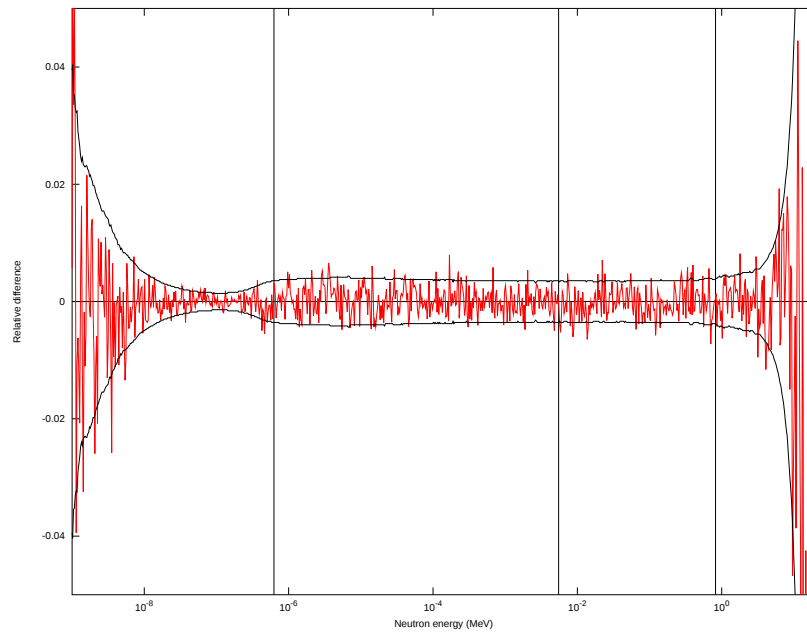


Figure 20. Relative differences between the two spectra Figure 19.

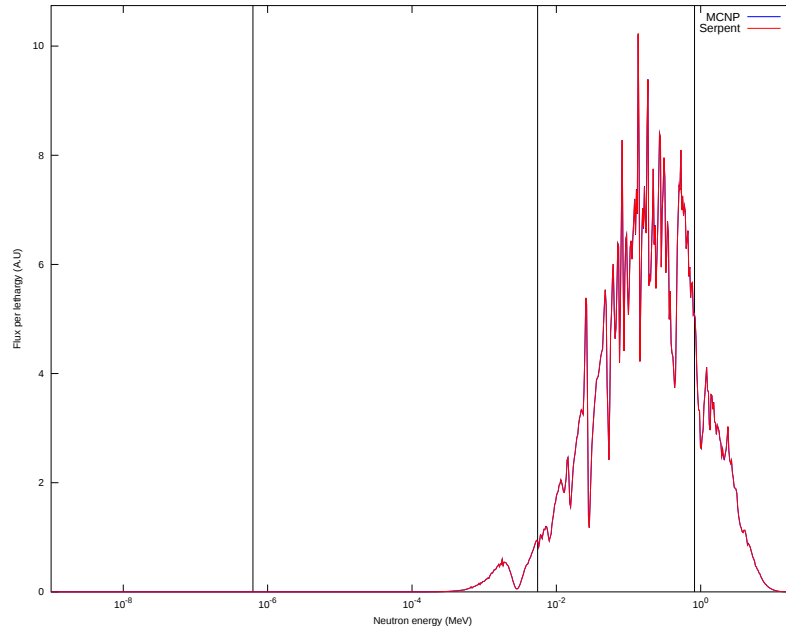


Figure 21. Flux spectra integrated over the entire geometry SFR assembly.

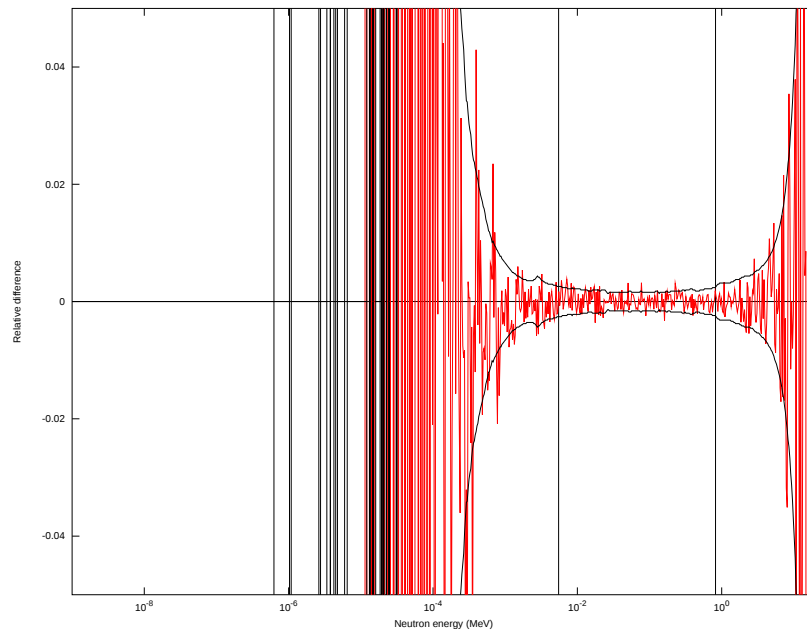


Figure 22. Relative differences between the two spectra Figure 21.

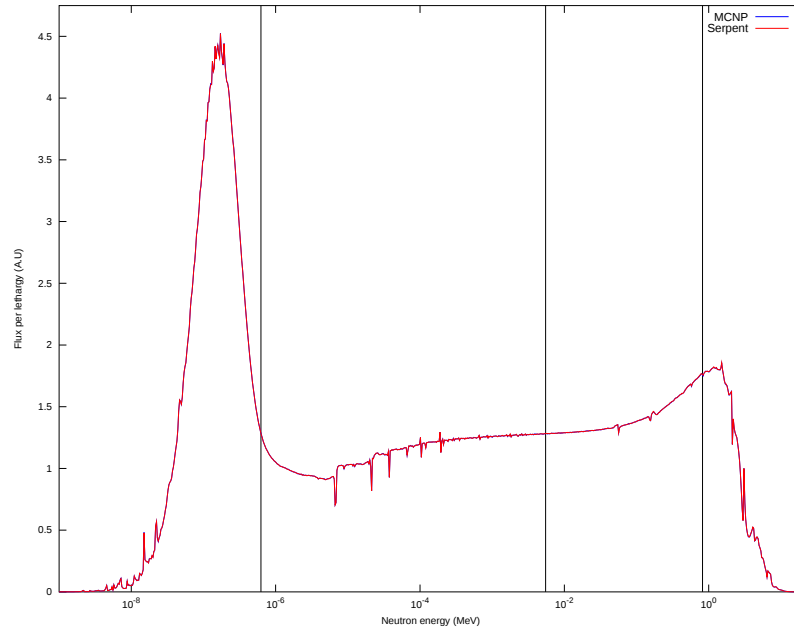


Figure 23. Flux spectra integrated over the entire geometry Prismatic HTGR fuel block.

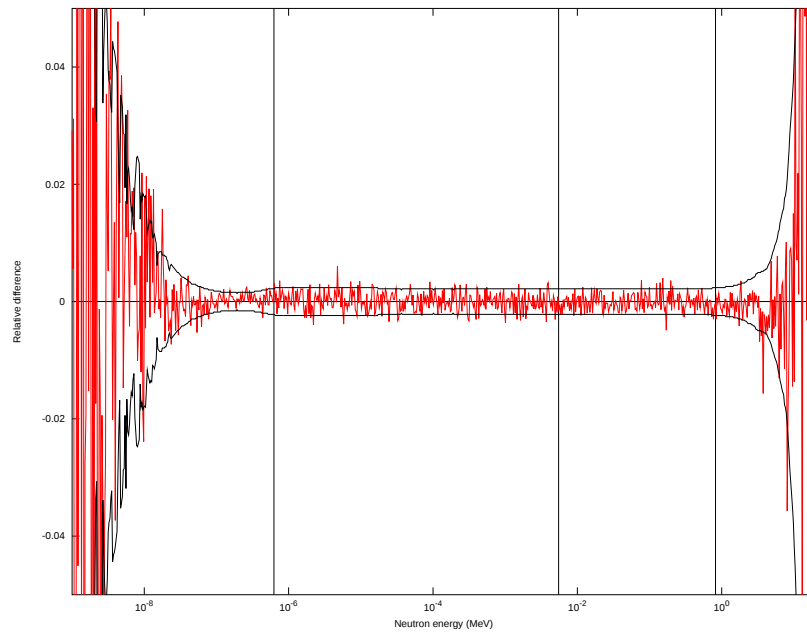


Figure 24. Relative differences between the two spectra Figure 23.

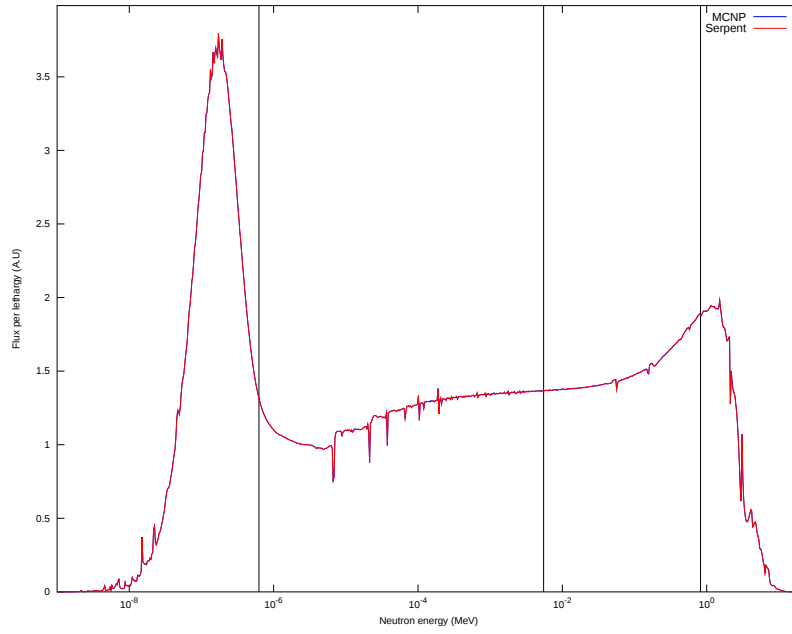


Figure 25. Flux spectra integrated over the entire geometry Prismatic HTGR fuel block + BP.

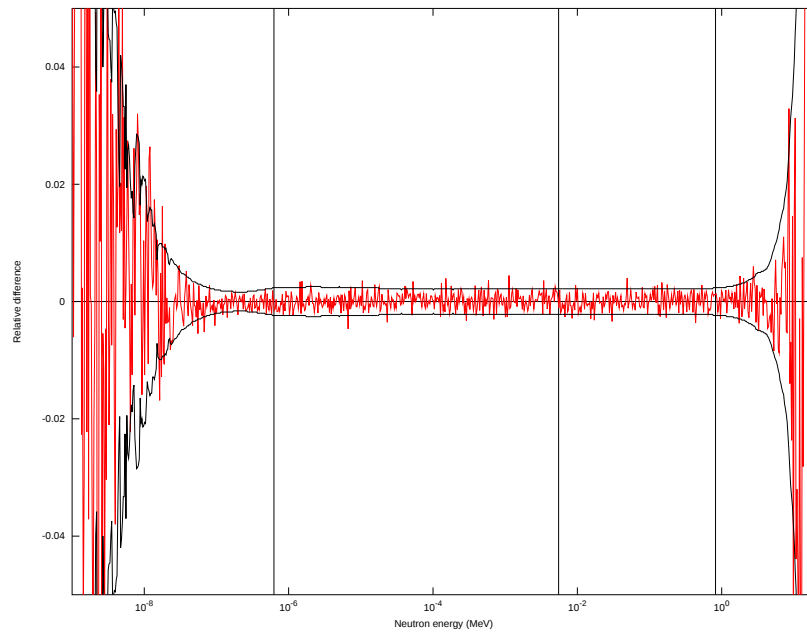


Figure 26. Relative differences between the two spectra Figure 25.

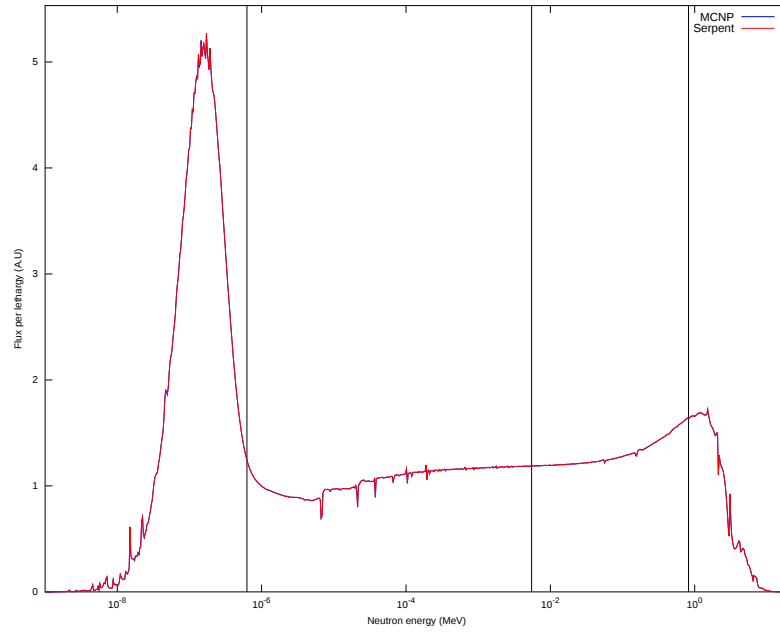


Figure 27. Flux spectra integrated over the entire geometry PBMR fuel pebble.

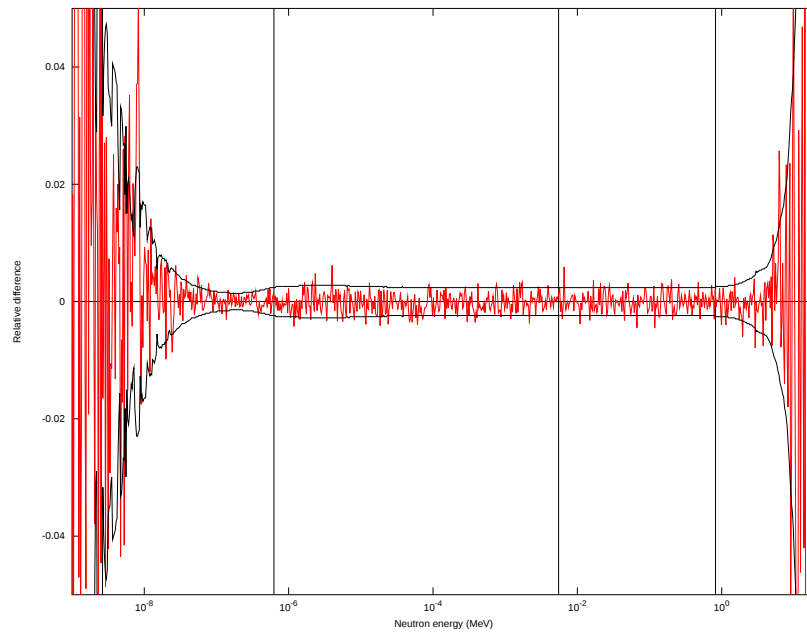


Figure 28. Relative differences between the two spectra Figure 27.