

# Standard comparison between Serpent 1.1.19 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

- JEFF-3.1 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  $k_{\infty}$ . Relative statistical errors are in per cent.

Case	MCNP		Serpent		$\Delta$ (%)
PWR pin-cell, 1 MWd/kgU burnup	1.28165	(0.013)	1.28136	(0.013)	-0.023
PWR pin-cell, 20 MWd/kgU burnup	1.06963	(0.017)	1.06984	(0.016)	0.020
PWR pin-cell, 40 MWd/kgU burnup	0.91316	(0.021)	0.91282	(0.018)	-0.037
VVER-440 assembly	1.26892	(0.016)	1.26885	(0.014)	-0.006
BWR+Gd Assembly, 25% void fraction	1.07701	(0.018)	1.07649	(0.021)	-0.048
BWR+Gd Assembly, 50% void fraction	1.06168	(0.018)	1.06170	(0.021)	0.002
BWR+Gd Assembly, 75% void fraction	1.04151	(0.019)	1.04176	(0.021)	0.024
Mixed PWR MOX/UOX lattice	1.06897	(0.019)	1.06904	(0.018)	0.007
SCWR assembly	1.14169	(0.016)	1.14166	(0.017)	-0.003
CANDU fuel cluster	0.92060	(0.016)	0.92070	(0.017)	0.010
SFR assembly	1.76631	(0.009)	1.76639	(0.007)	0.005
Prismatic HTGR fuel block	1.44974	(0.016)	1.44975	(0.016)	0.001
Prismatic HTGR fuel block + BP	1.13849	(0.023)	1.13800	(0.021)	-0.043
PBMR fuel pebble	1.43474	(0.015)	1.43439	(0.017)	-0.024

**Table 2.** Comparison of prompt neutron lifetimes (in  $\mu$ s). Relative statistical errors are in per cent.

Case	MCNP		Serpent		$\Delta$ (%)
PWR pin-cell, 1 MWd/kgU burnup	21.61	(0.039)	21.59	(0.025)	-0.057
PWR pin-cell, 20 MWd/kgU burnup	19.33	(0.045)	19.34	(0.029)	0.083
PWR pin-cell, 40 MWd/kgU burnup	19.93	(0.048)	19.92	(0.030)	-0.032
VVER-440 assembly	18.12	(0.046)	18.13	(0.027)	0.015
BWR+Gd Assembly, 25% void fraction	29.05	(0.043)	29.02	(0.033)	-0.091
BWR+Gd Assembly, 50% void fraction	27.92	(0.044)	27.93	(0.034)	0.050
BWR+Gd Assembly, 75% void fraction	26.40	(0.048)	26.39	(0.034)	-0.029
Mixed PWR MOX/UOX lattice	14.22	(0.058)	7.27	(0.068)	-48.906
SCWR assembly	15.22	(0.038)	15.22	(0.032)	-0.026
CANDU fuel cluster	188.55	(0.055)	188.50	(0.034)	-0.028
SFR assembly	0.34	(0.022)	0.34	(0.018)	-0.071
Prismatic HTGR fuel block	322.40	(0.036)	322.71	(0.033)	0.096
Prismatic HTGR fuel block + BP	257.08	(0.036)	256.98	(0.034)	-0.040
PBMR fuel pebble	574.30	(0.034)	573.89	(0.035)	-0.071

**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	776.8	24.5	31.7
PWR pin-cell, 20 MWd/kgU burnup	767.5	22.9	33.6
PWR pin-cell, 40 MWd/kgU burnup	759.4	23.2	32.7
VVER-440 assembly	260.2	18.3	14.2
BWR+Gd Assembly, 25% void fraction	247.5	24.9	9.9
BWR+Gd Assembly, 50% void fraction	268.3	23.8	11.3
BWR+Gd Assembly, 75% void fraction	307.1	23.5	13.1
Mixed PWR MOX/UXO lattice	142.3	17.7	8.0
SCWR assembly	396.1	19.3	20.5
CANDU fuel cluster	319.9	35.6	9.0
SFR assembly	1412.3	26.1	54.1
Prismatic HTGR fuel block	6070.7	104.5	58.1
Prismatic HTGR fuel block + BP	5712.3	93.0	61.5
PBMR fuel pebble	3877.8	117.0	33.2

**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		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	2.28856E-01	(0.057)	2.28856E-01	(0.010)	-0.000
	2	5.63631E-01	(0.028)	5.63551E-01	(0.006)	-0.014
	3	8.80141E-01	(0.028)	8.80040E-01	(0.007)	-0.011
	4	1.42115E+00	(0.042)	1.42113E+00	(0.010)	-0.001
$\Sigma_{\text{fiss}}$	1	2.86703E-03	(0.064)	2.86479E-03	(0.044)	-0.078
	2	3.41442E-04	(0.028)	3.41546E-04	(0.023)	0.030
	3	4.92406E-03	(0.036)	4.92552E-03	(0.042)	0.030
	4	5.38586E-02	(0.042)	5.38637E-02	(0.024)	0.009
$\Sigma_{\text{abs}}$	1	3.67419E-03	(0.064)	3.67218E-03	(0.039)	-0.055
	2	2.19203E-03	(0.036)	2.19312E-03	(0.031)	0.050
	3	2.37259E-02	(0.045)	2.37236E-02	(0.041)	-0.010
	4	8.36031E-02	(0.042)	8.36100E-02	(0.021)	0.008
$\Sigma_{\text{capt}}$	1	8.07151E-04	(0.081)	8.07390E-04	(0.061)	0.030
	2	1.85059E-03	(0.036)	1.85158E-03	(0.033)	0.053
	3	1.88019E-02	(0.054)	1.87980E-02	(0.048)	-0.021
	4	2.97445E-02	(0.042)	2.97463E-02	(0.017)	0.006
$\Sigma_{\text{scatt}}$	1	2.25182E-01	(0.057)	2.25183E-01	(0.010)	0.000
	2	5.61439E-01	(0.028)	5.61358E-01	(0.006)	-0.014
	3	8.56415E-01	(0.028)	8.56316E-01	(0.007)	-0.012
	4	1.33754E+00	(0.042)	1.33752E+00	(0.011)	-0.002
$\nu\Sigma_{\text{fiss}}$	1	8.04818E-03	(0.064)	8.04404E-03	(0.047)	-0.051
	2	8.38377E-04	(0.028)	8.38509E-04	(0.026)	0.016
	3	1.20188E-02	(0.036)	1.20218E-02	(0.042)	0.025
	4	1.32144E-01	(0.042)	1.32155E-01	(0.024)	0.008
$\bar{\nu}$	1	2.80715E+00	(0.071)	2.80790E+00	(0.015)	0.027
	2	2.45540E+00	(0.028)	2.45504E+00	(0.012)	-0.015
	3	2.44084E+00	(0.042)	2.44072E+00	(0.003)	-0.005
	4	2.45354E+00	(0.042)	2.45350E+00	(0.002)	-0.002
$1/\nu$	1	5.26097E-10	(0.057)	5.26107E-10	(0.010)	0.002
	2	2.63110E-09	(0.028)	2.63084E-09	(0.014)	-0.010
	3	1.82660E-07	(0.036)	1.82665E-07	(0.022)	0.003
	4	2.45372E-06	(0.042)	2.45353E-06	(0.009)	-0.008

**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		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	2.28816E-01	(0.057)	2.28813E-01	(0.009)	-0.001
	2	5.64293E-01	(0.028)	5.64244E-01	(0.006)	-0.009
	3	8.88882E-01	(0.028)	8.88822E-01	(0.007)	-0.007
	4	1.43732E+00	(0.057)	1.43764E+00	(0.011)	0.022
$\Sigma_{\text{fiss}}$	1	2.80490E-03	(0.064)	2.80588E-03	(0.041)	0.035
	2	2.21399E-04	(0.028)	2.21389E-04	(0.022)	-0.005
	3	3.21867E-03	(0.036)	3.21681E-03	(0.041)	-0.058
	4	4.79810E-02	(0.057)	4.79572E-02	(0.026)	-0.050
$\Sigma_{\text{abs}}$	1	3.62261E-03	(0.064)	3.62353E-03	(0.039)	0.025
	2	2.06509E-03	(0.036)	2.06437E-03	(0.030)	-0.035
	3	2.77543E-02	(0.045)	2.77313E-02	(0.038)	-0.083
	4	8.96711E-02	(0.057)	8.96316E-02	(0.023)	-0.044
$\Sigma_{\text{capt}}$	1	8.17705E-04	(0.081)	8.17652E-04	(0.060)	-0.006
	2	1.84369E-03	(0.036)	1.84298E-03	(0.031)	-0.039
	3	2.45356E-02	(0.045)	2.45144E-02	(0.041)	-0.087
	4	4.16901E-02	(0.057)	4.16744E-02	(0.020)	-0.038
$\Sigma_{\text{scatt}}$	1	2.25193E-01	(0.057)	2.25190E-01	(0.010)	-0.001
	2	5.62228E-01	(0.028)	5.62179E-01	(0.006)	-0.009
	3	8.61127E-01	(0.028)	8.61091E-01	(0.007)	-0.004
	4	1.34765E+00	(0.057)	1.34800E+00	(0.012)	0.026
$\nu\Sigma_{\text{fiss}}$	1	7.93455E-03	(0.064)	7.93792E-03	(0.046)	0.043
	2	5.72455E-04	(0.028)	5.72369E-04	(0.050)	-0.015
	3	8.27880E-03	(0.036)	8.27394E-03	(0.043)	-0.059
	4	1.27257E-01	(0.057)	1.27194E-01	(0.026)	-0.049
$\bar{\nu}$	1	2.82881E+00	(0.071)	2.82903E+00	(0.016)	0.008
	2	2.58562E+00	(0.028)	2.58536E+00	(0.045)	-0.010
	3	2.57212E+00	(0.042)	2.57210E+00	(0.014)	-0.001
	4	2.65223E+00	(0.057)	2.65223E+00	(0.005)	-0.000
$1/\nu$	1	5.24387E-10	(0.057)	5.24383E-10	(0.009)	-0.001
	2	2.63178E-09	(0.028)	2.63095E-09	(0.014)	-0.031
	3	1.75844E-07	(0.036)	1.75873E-07	(0.020)	0.016
	4	2.49062E-06	(0.057)	2.49070E-06	(0.011)	0.003

**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		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	2.29133E-01	(0.057)	2.29133E-01	(0.009)	-0.000
	2	5.64928E-01	(0.028)	5.64957E-01	(0.006)	0.005
	3	8.94873E-01	(0.028)	8.94823E-01	(0.007)	-0.006
	4	1.43838E+00	(0.057)	1.43821E+00	(0.011)	-0.012
$\Sigma_{\text{fiss}}$	1	2.74228E-03	(0.064)	2.74134E-03	(0.043)	-0.034
	2	1.46224E-04	(0.028)	1.46251E-04	(0.021)	0.019
	3	2.14124E-03	(0.036)	2.14115E-03	(0.043)	-0.004
	4	3.85045E-02	(0.057)	3.84979E-02	(0.026)	-0.017
$\Sigma_{\text{abs}}$	1	3.56562E-03	(0.064)	3.56648E-03	(0.041)	0.024
	2	1.99247E-03	(0.036)	1.99225E-03	(0.032)	-0.011
	3	2.99834E-02	(0.045)	2.99986E-02	(0.036)	0.051
	4	8.45715E-02	(0.057)	8.45626E-02	(0.023)	-0.010
$\Sigma_{\text{capt}}$	1	8.23340E-04	(0.081)	8.25146E-04	(0.061)	0.219
	2	1.84624E-03	(0.036)	1.84600E-03	(0.033)	-0.013
	3	2.78422E-02	(0.045)	2.78574E-02	(0.038)	0.055
	4	4.60670E-02	(0.057)	4.60647E-02	(0.020)	-0.005
$\Sigma_{\text{scatt}}$	1	2.25568E-01	(0.057)	2.25566E-01	(0.010)	-0.001
	2	5.62936E-01	(0.028)	5.62965E-01	(0.006)	0.005
	3	8.64890E-01	(0.028)	8.64824E-01	(0.007)	-0.008
	4	1.35381E+00	(0.057)	1.35364E+00	(0.012)	-0.012
$\nu\Sigma_{\text{fiss}}$	1	7.79101E-03	(0.064)	7.79071E-03	(0.048)	-0.004
	2	3.98957E-04	(0.028)	3.99115E-04	(0.067)	0.040
	3	5.80662E-03	(0.036)	5.80774E-03	(0.047)	0.019
	4	1.06810E-01	(0.057)	1.06792E-01	(0.027)	-0.017
$\bar{\nu}$	1	2.84107E+00	(0.071)	2.84193E+00	(0.018)	0.030
	2	2.72840E+00	(0.028)	2.72897E+00	(0.064)	0.021
	3	2.71180E+00	(0.042)	2.71244E+00	(0.016)	0.024
	4	2.77396E+00	(0.057)	2.77396E+00	(0.004)	-0.000
$1/\nu$	1	5.23635E-10	(0.057)	5.23621E-10	(0.009)	-0.003
	2	2.63245E-09	(0.028)	2.63268E-09	(0.014)	0.009
	3	1.72090E-07	(0.036)	1.72091E-07	(0.020)	0.000
	4	2.52525E-06	(0.057)	2.52497E-06	(0.010)	-0.011

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

param.	$g$	MCNP		Serpent		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	2.21901E-01	(0.057)	2.21903E-01	(0.010)	0.001
	2	5.17307E-01	(0.028)	5.17335E-01	(0.006)	0.005
	3	7.75170E-01	(0.028)	7.75236E-01	(0.007)	0.008
	4	1.20634E+00	(0.050)	1.20623E+00	(0.013)	-0.009
$\Sigma_{\text{fiss}}$	1	2.82424E-03	(0.064)	2.82490E-03	(0.039)	0.024
	2	4.10630E-04	(0.028)	4.10694E-04	(0.021)	0.016
	3	5.78866E-03	(0.036)	5.79374E-03	(0.038)	0.088
	4	5.99003E-02	(0.050)	5.98795E-02	(0.027)	-0.035
$\Sigma_{\text{abs}}$	1	3.60513E-03	(0.064)	3.60628E-03	(0.036)	0.032
	2	2.33329E-03	(0.036)	2.33402E-03	(0.027)	0.031
	3	2.47099E-02	(0.036)	2.47037E-02	(0.034)	-0.025
	4	8.94987E-02	(0.050)	8.94714E-02	(0.023)	-0.030
$\Sigma_{\text{capt}}$	1	7.80891E-04	(0.081)	7.81382E-04	(0.052)	0.063
	2	1.92265E-03	(0.036)	1.92333E-03	(0.029)	0.035
	3	1.89212E-02	(0.045)	1.89100E-02	(0.041)	-0.059
	4	2.95983E-02	(0.050)	2.95919E-02	(0.016)	-0.022
$\Sigma_{\text{scatt}}$	1	2.18296E-01	(0.057)	2.18296E-01	(0.010)	-0.000
	2	5.14974E-01	(0.028)	5.15001E-01	(0.006)	0.005
	3	7.50461E-01	(0.028)	7.50532E-01	(0.007)	0.010
	4	1.11684E+00	(0.050)	1.11676E+00	(0.014)	-0.007
$\nu\Sigma_{\text{fiss}}$	1	7.90141E-03	(0.064)	7.90284E-03	(0.044)	0.018
	2	1.00523E-03	(0.028)	1.00537E-03	(0.021)	0.014
	3	1.40887E-02	(0.036)	1.41011E-02	(0.038)	0.088
	4	1.45929E-01	(0.050)	1.45878E-01	(0.027)	-0.035
$\bar{\nu}$	1	2.79772E+00	(0.071)	2.79755E+00	(0.015)	-0.006
	2	2.44802E+00	(0.028)	2.44797E+00	(0.004)	-0.002
	3	2.43384E+00	(0.042)	2.43385E+00	(0.000)	0.000
	4	2.43620E+00	(0.057)	2.43620E+00	(0.000)	0.000
$1/\nu$	1	5.31237E-10	(0.057)	5.31204E-10	(0.009)	-0.006
	2	2.63199E-09	(0.028)	2.63250E-09	(0.014)	0.019
	3	1.76385E-07	(0.036)	1.76382E-07	(0.023)	-0.002
	4	2.35594E-06	(0.050)	2.35559E-06	(0.012)	-0.015



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

param.	$g$	MCNP		Serpent		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	2.02500E-01	(0.057)	2.02529E-01	(0.010)	0.014
	2	4.93163E-01	(0.028)	4.93063E-01	(0.006)	-0.020
	3	7.69045E-01	(0.028)	7.69017E-01	(0.007)	-0.004
	4	1.35464E+00	(0.050)	1.35444E+00	(0.012)	-0.015
$\Sigma_{\text{fiss}}$	1	2.36102E-03	(0.064)	2.35994E-03	(0.043)	-0.046
	2	3.17957E-04	(0.036)	3.17852E-04	(0.029)	-0.033
	3	4.24248E-03	(0.045)	4.24471E-03	(0.048)	0.053
	4	3.30541E-02	(0.050)	3.30558E-02	(0.035)	0.005
$\Sigma_{\text{abs}}$	1	3.04938E-03	(0.064)	3.04796E-03	(0.039)	-0.046
	2	1.85079E-03	(0.036)	1.84912E-03	(0.034)	-0.090
	3	1.87287E-02	(0.045)	1.87256E-02	(0.043)	-0.016
	4	6.53712E-02	(0.042)	6.54277E-02	(0.030)	0.086
$\Sigma_{\text{capt}}$	1	6.88351E-04	(0.081)	6.88015E-04	(0.059)	-0.049
	2	1.53283E-03	(0.036)	1.53127E-03	(0.036)	-0.102
	3	1.44862E-02	(0.054)	1.44809E-02	(0.051)	-0.037
	4	3.23172E-02	(0.050)	3.23719E-02	(0.040)	<b>0.169</b>
$\Sigma_{\text{scatt}}$	1	1.99450E-01	(0.057)	1.99481E-01	(0.011)	0.015
	2	4.91312E-01	(0.028)	4.91214E-01	(0.006)	-0.020
	3	7.50316E-01	(0.028)	7.50292E-01	(0.007)	-0.003
	4	1.28927E+00	(0.050)	1.28901E+00	(0.013)	-0.020
$\nu\Sigma_{\text{fiss}}$	1	6.61427E-03	(0.064)	6.61307E-03	(0.048)	-0.018
	2	7.78624E-04	(0.036)	7.78415E-04	(0.029)	-0.027
	3	1.03257E-02	(0.045)	1.03311E-02	(0.048)	0.053
	4	8.05264E-02	(0.050)	8.05305E-02	(0.035)	0.005
$\bar{\nu}$	1	2.80144E+00	(0.071)	2.80220E+00	(0.016)	0.027
	2	2.44883E+00	(0.042)	2.44898E+00	(0.005)	0.006
	3	2.43388E+00	(0.057)	2.43388E+00	(0.000)	0.000
	4	2.43620E+00	(0.057)	2.43620E+00	(0.000)	0.000
$1/\nu$	1	5.28108E-10	(0.057)	5.28242E-10	(0.009)	0.025
	2	2.61552E-09	(0.028)	2.61439E-09	(0.014)	-0.043
	3	1.84109E-07	(0.036)	1.84195E-07	(0.022)	0.047
	4	2.52168E-06	(0.050)	2.52094E-06	(0.010)	-0.029

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

param.	$g$	MCNP		Serpent		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	1.81795E-01	(0.057)	1.81796E-01	(0.013)	0.001
	2	4.26482E-01	(0.028)	4.26510E-01	(0.007)	0.007
	3	6.57787E-01	(0.028)	6.57896E-01	(0.007)	0.017
	4	1.18008E+00	(0.050)	1.18005E+00	(0.014)	-0.003
$\Sigma_{\text{fiss}}$	1	2.31124E-03	(0.064)	2.31116E-03	(0.042)	-0.004
	2	3.15863E-04	(0.036)	3.15894E-04	(0.027)	0.010
	3	4.16435E-03	(0.045)	4.16015E-03	(0.049)	-0.101
	4	3.23068E-02	(0.050)	3.23144E-02	(0.036)	0.024
$\Sigma_{\text{abs}}$	1	2.95773E-03	(0.064)	2.95724E-03	(0.039)	-0.016
	2	1.83265E-03	(0.036)	1.83291E-03	(0.034)	0.014
	3	1.79334E-02	(0.045)	1.79258E-02	(0.043)	-0.043
	4	6.37962E-02	(0.050)	6.38034E-02	(0.030)	0.011
$\Sigma_{\text{capt}}$	1	6.46484E-04	(0.081)	6.46079E-04	(0.056)	-0.063
	2	1.51679E-03	(0.036)	1.51701E-03	(0.036)	0.014
	3	1.37690E-02	(0.054)	1.37656E-02	(0.050)	-0.025
	4	3.14894E-02	(0.058)	3.14890E-02	(0.039)	-0.001
$\Sigma_{\text{scatt}}$	1	1.78837E-01	(0.057)	1.78839E-01	(0.013)	0.001
	2	4.24649E-01	(0.028)	4.24677E-01	(0.007)	0.007
	3	6.39854E-01	(0.028)	6.39970E-01	(0.007)	0.018
	4	1.11629E+00	(0.050)	1.11625E+00	(0.015)	-0.003
$\nu\Sigma_{\text{fiss}}$	1	6.46841E-03	(0.064)	6.46703E-03	(0.046)	-0.021
	2	7.73493E-04	(0.036)	7.73580E-04	(0.028)	0.011
	3	1.01354E-02	(0.045)	1.01253E-02	(0.049)	-0.100
	4	7.87059E-02	(0.050)	7.87244E-02	(0.036)	0.024
$\bar{\nu}$	1	2.79867E+00	(0.071)	2.79816E+00	(0.015)	-0.018
	2	2.44882E+00	(0.042)	2.44886E+00	(0.004)	0.001
	3	2.43386E+00	(0.057)	2.43387E+00	(0.000)	0.000
	4	2.43620E+00	(0.057)	2.43620E+00	(0.000)	-0.000
$1/\nu$	1	5.30690E-10	(0.057)	5.30820E-10	(0.010)	0.024
	2	2.60544E-09	(0.028)	2.60558E-09	(0.014)	0.006
	3	1.80239E-07	(0.036)	1.80258E-07	(0.023)	0.010
	4	2.46869E-06	(0.050)	2.46864E-06	(0.011)	-0.002

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

param.	$g$	MCNP		Serpent		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	1.60864E-01	(0.057)	1.60876E-01	(0.014)	0.008
	2	3.59488E-01	(0.028)	3.59555E-01	(0.009)	0.019
	3	5.47811E-01	(0.028)	5.47888E-01	(0.010)	0.014
	4	1.01265E+00	(0.050)	1.01233E+00	(0.020)	-0.032
$\Sigma_{\text{fiss}}$	1	2.25223E-03	(0.064)	2.25187E-03	(0.041)	-0.016
	2	3.13134E-04	(0.036)	3.13135E-04	(0.024)	0.000
	3	4.05136E-03	(0.045)	4.05262E-03	(0.042)	0.031
	4	3.13161E-02	(0.050)	3.13446E-02	(0.035)	0.091
$\Sigma_{\text{abs}}$	1	2.85739E-03	(0.064)	2.85698E-03	(0.036)	-0.014
	2	1.80648E-03	(0.036)	1.80621E-03	(0.030)	-0.015
	3	1.67988E-02	(0.045)	1.68116E-02	(0.035)	0.076
	4	6.19621E-02	(0.050)	6.19988E-02	(0.030)	0.059
$\Sigma_{\text{capt}}$	1	6.05157E-04	(0.072)	6.05110E-04	(0.051)	-0.008
	2	1.49334E-03	(0.036)	1.49308E-03	(0.032)	-0.018
	3	1.27475E-02	(0.045)	1.27590E-02	(0.042)	0.091
	4	3.06461E-02	(0.058)	3.06542E-02	(0.042)	0.027
$\Sigma_{\text{scatt}}$	1	1.58006E-01	(0.057)	1.58019E-01	(0.014)	0.008
	2	3.57681E-01	(0.028)	3.57749E-01	(0.009)	0.019
	3	5.31012E-01	(0.028)	5.31076E-01	(0.010)	0.012
	4	9.50691E-01	(0.050)	9.50327E-01	(0.022)	-0.038
$\nu\Sigma_{\text{fiss}}$	1	6.29467E-03	(0.064)	6.29401E-03	(0.045)	-0.011
	2	7.66835E-04	(0.036)	7.66860E-04	(0.024)	0.003
	3	9.86045E-03	(0.045)	9.86350E-03	(0.042)	0.031
	4	7.62923E-02	(0.050)	7.63617E-02	(0.035)	0.091
$\bar{\nu}$	1	2.79486E+00	(0.071)	2.79500E+00	(0.014)	0.005
	2	2.44891E+00	(0.042)	2.44897E+00	(0.004)	0.003
	3	2.43386E+00	(0.057)	2.43386E+00	(0.000)	-0.000
	4	2.43620E+00	(0.057)	2.43620E+00	(0.000)	0.000
$1/\nu$	1	5.34254E-10	(0.057)	5.34394E-10	(0.010)	0.026
	2	2.58579E-09	(0.028)	2.58629E-09	(0.015)	0.019
	3	1.75299E-07	(0.036)	1.75206E-07	(0.025)	-0.053
	4	2.39609E-06	(0.050)	2.39577E-06	(0.013)	-0.013

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

param.	$g$	MCNP		Serpent		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	2.18083E-01	(0.085)	2.18061E-01	(0.017)	-0.010
	2	5.31306E-01	(0.071)	5.31362E-01	(0.012)	0.011
	3	8.41431E-01	(0.071)	8.41389E-01	(0.012)	-0.005
	4	1.45950E+00	(0.127)	1.45977E+00	(0.026)	0.019
$\Sigma_{\text{fiss}}$	1	3.17983E-03	(0.100)	3.17970E-03	(0.071)	-0.004
	2	4.38293E-04	(0.078)	4.38556E-04	(0.043)	0.060
	3	5.93428E-03	(0.103)	5.92976E-03	(0.091)	-0.076
	4	1.13868E-01	(0.127)	1.13821E-01	(0.067)	-0.041
$\Sigma_{\text{abs}}$	1	3.98355E-03	(0.100)	3.98320E-03	(0.066)	-0.009
	2	2.28442E-03	(0.078)	2.28545E-03	(0.054)	0.045
	3	3.46714E-02	(0.094)	3.46879E-02	(0.067)	0.048
	4	2.02673E-01	(0.127)	2.02580E-01	(0.062)	-0.046
$\Sigma_{\text{capt}}$	1	8.03728E-04	(0.125)	8.03494E-04	(0.097)	-0.029
	2	1.84612E-03	(0.086)	1.84689E-03	(0.061)	0.042
	3	2.87370E-02	(0.103)	2.87582E-02	(0.076)	0.074
	4	8.88039E-02	(0.127)	8.87583E-02	(0.057)	-0.051
$\Sigma_{\text{scatt}}$	1	2.14099E-01	(0.092)	2.14078E-01	(0.017)	-0.010
	2	5.29022E-01	(0.071)	5.29077E-01	(0.012)	0.010
	3	8.06760E-01	(0.071)	8.06701E-01	(0.012)	-0.007
	4	1.25682E+00	(0.127)	1.25719E+00	(0.032)	0.029
$\nu\Sigma_{\text{fiss}}$	1	9.21548E-03	(0.100)	9.21539E-03	(0.079)	-0.001
	2	1.26991E-03	(0.078)	1.27071E-03	(0.052)	0.063
	3	1.69310E-02	(0.103)	1.69198E-02	(0.092)	-0.066
	4	3.25819E-01	(0.127)	3.25695E-01	(0.067)	-0.038
$\bar{\nu}$	1	2.89811E+00	(0.113)	2.89818E+00	(0.032)	0.003
	2	2.89741E+00	(0.085)	2.89751E+00	(0.032)	0.003
	3	2.85309E+00	(0.127)	2.85336E+00	(0.009)	0.009
	4	2.86137E+00	(0.127)	2.86146E+00	(0.003)	0.003
$1/\nu$	1	5.23332E-10	(0.085)	5.23357E-10	(0.016)	0.005
	2	2.61584E-09	(0.078)	2.61671E-09	(0.026)	0.033
	3	1.62939E-07	(0.086)	1.62794E-07	(0.046)	-0.089
	4	2.31028E-06	(0.135)	2.31022E-06	(0.032)	-0.003

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

param.	$g$	MCNP		Serpent		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	1.77067E-01	(0.057)	1.77069E-01	(0.012)	0.001
	2	3.84471E-01	(0.028)	3.84454E-01	(0.007)	-0.004
	3	6.33740E-01	(0.028)	6.33713E-01	(0.005)	-0.004
	4	9.48372E-01	(0.057)	9.48430E-01	(0.012)	0.006
$\Sigma_{\text{fiss}}$	1	2.42025E-03	(0.064)	2.41951E-03	(0.039)	-0.031
	2	4.72638E-04	(0.028)	4.72595E-04	(0.022)	-0.009
	3	6.13033E-03	(0.036)	6.12841E-03	(0.035)	-0.031
	4	5.51719E-02	(0.057)	5.51788E-02	(0.033)	0.013
$\Sigma_{\text{abs}}$	1	3.21712E-03	(0.064)	3.21575E-03	(0.035)	-0.043
	2	2.10572E-03	(0.036)	2.10513E-03	(0.026)	-0.028
	3	2.25692E-02	(0.036)	2.25526E-02	(0.031)	-0.073
	4	9.00064E-02	(0.057)	9.00125E-02	(0.026)	0.007
$\Sigma_{\text{capt}}$	1	7.96872E-04	(0.072)	7.96245E-04	(0.048)	-0.079
	2	1.63308E-03	(0.036)	1.63253E-03	(0.028)	-0.034
	3	1.64389E-02	(0.045)	1.64242E-02	(0.039)	-0.089
	4	3.48345E-02	(0.057)	3.48337E-02	(0.023)	-0.002
$\Sigma_{\text{scatt}}$	1	1.73850E-01	(0.057)	1.73853E-01	(0.012)	0.002
	2	3.82366E-01	(0.028)	3.82349E-01	(0.007)	-0.004
	3	6.11171E-01	(0.028)	6.11161E-01	(0.005)	-0.002
	4	8.58366E-01	(0.057)	8.58418E-01	(0.014)	0.006
$\nu\Sigma_{\text{fiss}}$	1	6.73792E-03	(0.064)	6.73408E-03	(0.042)	-0.057
	2	1.15710E-03	(0.028)	1.15701E-03	(0.022)	-0.007
	3	1.49200E-02	(0.036)	1.49154E-02	(0.035)	-0.031
	4	1.34410E-01	(0.057)	1.34427E-01	(0.033)	0.013
$\bar{\nu}$	1	2.78397E+00	(0.071)	2.78324E+00	(0.013)	-0.026
	2	2.44816E+00	(0.028)	2.44821E+00	(0.003)	0.002
	3	2.43381E+00	(0.042)	2.43382E+00	(0.000)	0.001
	4	2.43620E+00	(0.057)	2.43620E+00	(0.000)	-0.000
$1/\nu$	1	5.39046E-10	(0.057)	5.39086E-10	(0.010)	0.007
	2	2.61272E-09	(0.028)	2.61214E-09	(0.013)	-0.022
	3	1.64582E-07	(0.036)	1.64550E-07	(0.024)	-0.019
	4	2.20556E-06	(0.057)	2.20584E-06	(0.015)	0.013

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

param.	$g$	MCNP		Serpent		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	2.10495E-01	(0.057)	2.10480E-01	(0.012)	-0.007
	2	3.16300E-01	(0.028)	3.16282E-01	(0.005)	-0.006
	3	3.20465E-01	(0.014)	3.20490E-01	(0.005)	0.008
	4	3.76192E-01	(0.042)	3.76208E-01	(0.005)	0.004
$\Sigma_{\text{fiss}}$	1	2.10375E-03	(0.064)	2.10347E-03	(0.049)	-0.013
	2	5.09474E-05	(0.036)	5.09561E-05	(0.033)	0.017
	3	4.77332E-04	(0.041)	4.77711E-04	(0.048)	0.079
	4	4.61202E-03	(0.042)	4.61276E-03	(0.031)	0.016
$\Sigma_{\text{abs}}$	1	2.81342E-03	(0.064)	2.81171E-03	(0.043)	-0.061
	2	1.26148E-03	(0.045)	1.26159E-03	(0.038)	0.009
	3	5.12786E-03	(0.041)	5.12868E-03	(0.042)	0.016
	4	9.08974E-03	(0.042)	9.09101E-03	(0.030)	0.014
$\Sigma_{\text{capt}}$	1	7.09659E-04	(0.089)	7.08237E-04	(0.062)	-0.200
	2	1.21053E-03	(0.045)	1.21064E-03	(0.038)	0.009
	3	4.65053E-03	(0.051)	4.65097E-03	(0.045)	0.009
	4	4.47773E-03	(0.042)	4.47825E-03	(0.028)	0.012
$\Sigma_{\text{scatt}}$	1	2.07682E-01	(0.057)	2.07668E-01	(0.012)	-0.007
	2	3.15039E-01	(0.028)	3.15020E-01	(0.005)	-0.006
	3	3.15337E-01	(0.014)	3.15361E-01	(0.005)	0.008
	4	3.67102E-01	(0.042)	3.67117E-01	(0.005)	0.004
$\nu\Sigma_{\text{fiss}}$	1	5.90247E-03	(0.064)	5.89924E-03	(0.052)	-0.055
	2	1.24443E-04	(0.036)	1.24473E-04	(0.033)	0.024
	3	1.16178E-03	(0.041)	1.16271E-03	(0.048)	0.080
	4	1.12358E-02	(0.042)	1.12376E-02	(0.031)	0.016
$\bar{\nu}$	1	2.80569E+00	(0.071)	2.80453E+00	(0.017)	-0.041
	2	2.44259E+00	(0.042)	2.44275E+00	(0.007)	0.007
	3	2.43391E+00	(0.057)	2.43391E+00	(0.000)	0.000
	4	2.43620E+00	(0.042)	2.43620E+00	(0.000)	-0.000
$1/\nu$	1	5.28815E-10	(0.057)	5.28775E-10	(0.010)	-0.008
	2	3.53507E-09	(0.028)	3.53488E-09	(0.010)	-0.005
	3	1.85012E-07	(0.022)	1.84995E-07	(0.019)	-0.009
	4	2.55957E-06	(0.042)	2.55929E-06	(0.008)	-0.011

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

param.	$g$	MCNP		Serpent		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	1.87351E-01	(0.042)	1.87366E-01	(0.009)	0.008
	2	2.84920E-01	(0.014)	2.84942E-01	(0.006)	0.008
	3	5.57675E-01	(0.099)	5.57609E-01	(0.021)	-0.012
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$\Sigma_{\text{fiss}}$	1	6.28907E-03	(0.050)	6.28987E-03	(0.021)	0.013
	2	4.45611E-03	(0.014)	4.45607E-03	(0.009)	-0.001
	3	1.38935E-02	(0.106)	1.38994E-02	(0.044)	0.043
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$\Sigma_{\text{abs}}$	1	7.22692E-03	(0.042)	7.22771E-03	(0.020)	0.011
	2	7.04231E-03	(0.014)	7.04227E-03	(0.011)	-0.001
	3	2.87633E-02	(0.106)	2.87680E-02	(0.040)	0.016
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$\Sigma_{\text{capt}}$	1	9.37840E-04	(0.050)	9.37839E-04	(0.033)	-0.000
	2	2.58620E-03	(0.022)	2.58620E-03	(0.017)	0.000
	3	1.48698E-02	(0.106)	1.48686E-02	(0.045)	-0.008
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$\Sigma_{\text{scatt}}$	1	1.80124E-01	(0.042)	1.80138E-01	(0.009)	0.008
	2	2.77878E-01	(0.014)	2.77899E-01	(0.006)	0.008
	3	5.28912E-01	(0.099)	5.28841E-01	(0.022)	-0.013
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$\nu\Sigma_{\text{fiss}}$	1	1.83134E-02	(0.050)	1.83156E-02	(0.023)	0.012
	2	1.17894E-02	(0.014)	1.17899E-02	(0.010)	0.004
	3	3.57924E-02	(0.106)	3.58067E-02	(0.046)	0.040
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$\bar{\nu}$	1	2.91194E+00	(0.057)	2.91192E+00	(0.009)	-0.001
	2	2.64567E+00	(0.014)	2.64580E+00	(0.004)	0.005
	3	2.57621E+00	(0.113)	2.57612E+00	(0.011)	-0.003
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$1/\nu$	1	5.61777E-10	(0.042)	5.61779E-10	(0.009)	0.000
	2	2.51477E-09	(0.022)	2.51499E-09	(0.015)	0.009
	3	1.61721E-08	(0.106)	1.61761E-08	(0.031)	0.025
	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		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	1.37513E-01	(0.042)	1.37524E-01	(0.008)	0.008
	2	2.76014E-01	(0.014)	2.76021E-01	(0.004)	0.002
	3	3.11257E-01	(0.014)	3.11258E-01	(0.003)	0.000
	4	3.20251E-01	(0.057)	3.20208E-01	(0.003)	-0.014
$\Sigma_{\text{fiss}}$	1	6.61460E-05	(0.050)	6.61382E-05	(0.136)	-0.012
	2	2.94856E-05	(0.014)	2.94870E-05	(0.058)	0.005
	3	4.06399E-04	(0.022)	4.06384E-04	(0.054)	-0.004
	4	3.82162E-03	(0.057)	3.82031E-03	(0.031)	-0.034
$\Sigma_{\text{abs}}$	1	1.18806E-04	(0.163)	1.18625E-04	(0.166)	-0.152
	2	8.26989E-05	(0.014)	8.26950E-05	(0.064)	-0.005
	3	1.98736E-03	(0.041)	1.98651E-03	(0.044)	-0.043
	4	4.83383E-03	(0.057)	4.83209E-03	(0.030)	-0.036
$\Sigma_{\text{capt}}$	1	5.26602E-05	(0.341)	5.24871E-05	(0.319)	-0.329
	2	5.32133E-05	(0.022)	5.32080E-05	(0.071)	-0.010
	3	1.58095E-03	(0.051)	1.58013E-03	(0.050)	-0.052
	4	1.01220E-03	(0.057)	1.01179E-03	(0.026)	-0.041
$\Sigma_{\text{scatt}}$	1	1.37394E-01	(0.042)	1.37406E-01	(0.008)	0.009
	2	2.75932E-01	(0.014)	2.75938E-01	(0.004)	0.002
	3	3.09270E-01	(0.014)	3.09272E-01	(0.003)	0.001
	4	3.15417E-01	(0.057)	3.15375E-01	(0.003)	-0.013
$\nu\Sigma_{\text{fiss}}$	1	1.80719E-04	(0.050)	1.80743E-04	(0.145)	0.013
	2	7.19414E-05	(0.014)	7.19426E-05	(0.058)	0.002
	3	9.89115E-04	(0.022)	9.89081E-04	(0.054)	-0.003
	4	9.31027E-03	(0.057)	9.30703E-03	(0.031)	-0.035
$\bar{\nu}$	1	2.73212E+00	(0.057)	2.73278E+00	(0.045)	0.024
	2	2.43988E+00	(0.014)	2.43981E+00	(0.005)	-0.003
	3	2.43385E+00	(0.028)	2.43386E+00	(0.000)	0.000
	4	2.43621E+00	(0.057)	2.43620E+00	(0.000)	-0.000
$1/\nu$	1	5.69128E-10	(0.042)	5.69124E-10	(0.006)	-0.001
	2	3.39235E-09	(0.014)	3.39231E-09	(0.004)	-0.001
	3	1.83199E-07	(0.022)	1.83215E-07	(0.012)	0.009
	4	2.13757E-06	(0.057)	2.13723E-06	(0.009)	-0.016

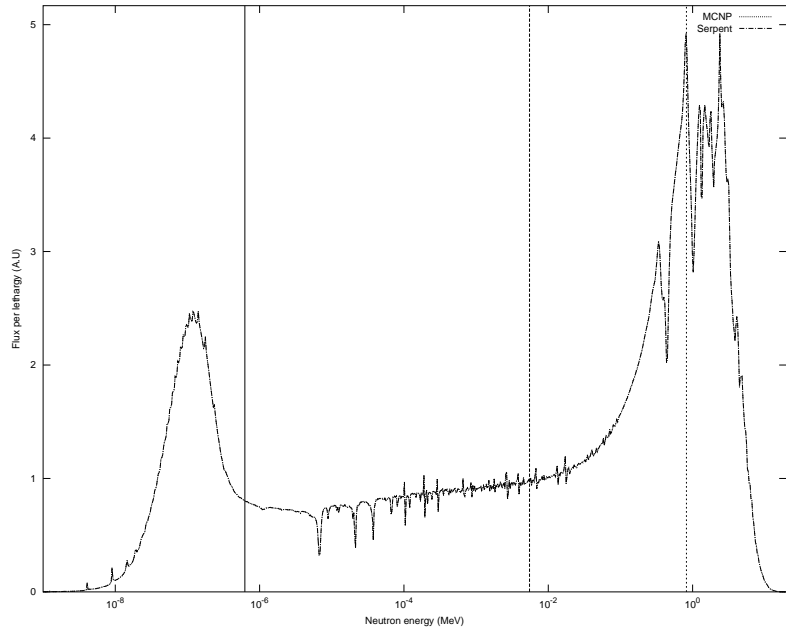


**Table 16.** Comparison of 4-group constants Prismatic HTGR fuel block + BP. Relative statistical errors are in per cent.

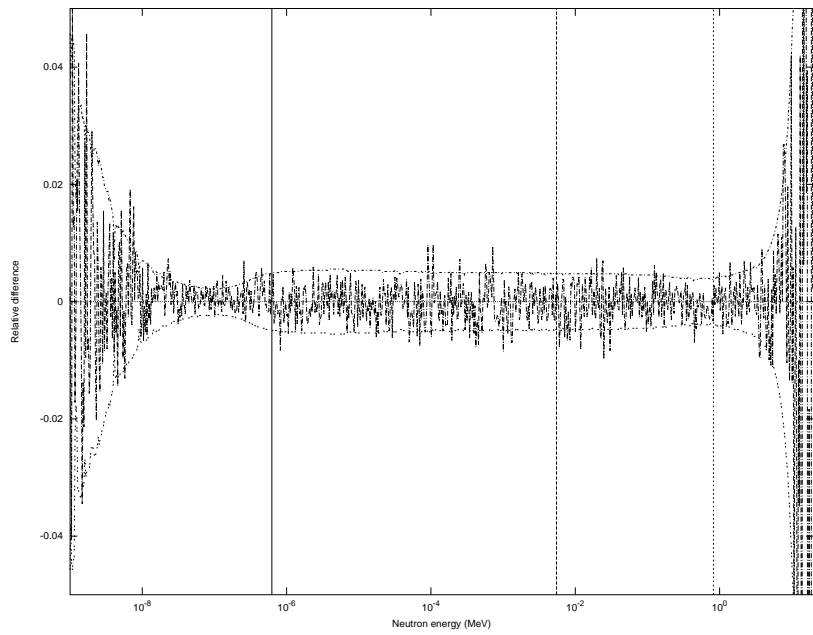
param.	$g$	MCNP		Serpent		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	1.37346E-01	(0.042)	1.37360E-01	(0.008)	0.010
	2	2.75875E-01	(0.014)	2.75852E-01	(0.004)	-0.008
	3	3.11211E-01	(0.014)	3.11202E-01	(0.003)	-0.003
	4	3.20412E-01	(0.057)	3.20403E-01	(0.004)	-0.003
$\Sigma_{\text{fiss}}$	1	6.47140E-05	(0.050)	6.47384E-05	(0.137)	0.038
	2	2.86841E-05	(0.014)	2.86985E-05	(0.058)	0.050
	3	3.94248E-04	(0.022)	3.94230E-04	(0.058)	-0.004
	4	3.65282E-03	(0.057)	3.65133E-03	(0.035)	-0.041
$\Sigma_{\text{abs}}$	1	1.17296E-04	(0.163)	1.17095E-04	(0.172)	-0.171
	2	8.32786E-05	(0.014)	8.33072E-05	(0.060)	0.034
	3	2.08762E-03	(0.041)	2.08501E-03	(0.039)	<b>-0.125</b>
	4	5.94070E-03	(0.057)	5.94099E-03	(0.030)	0.005
$\Sigma_{\text{capt}}$	1	5.25824E-05	(0.341)	5.23570E-05	(0.334)	-0.429
	2	5.45946E-05	(0.014)	5.46087E-05	(0.065)	0.026
	3	1.69337E-03	(0.041)	1.69078E-03	(0.044)	<b>-0.153</b>
	4	2.28788E-03	(0.064)	2.28966E-03	(0.042)	0.078
$\Sigma_{\text{scatt}}$	1	1.37229E-01	(0.042)	1.37242E-01	(0.008)	0.010
	2	2.75792E-01	(0.014)	2.75769E-01	(0.004)	-0.008
	3	3.09123E-01	(0.014)	3.09117E-01	(0.003)	-0.002
	4	3.14471E-01	(0.057)	3.14462E-01	(0.004)	-0.003
$\nu\Sigma_{\text{fiss}}$	1	1.76814E-04	(0.050)	1.76830E-04	(0.154)	0.009
	2	6.99864E-05	(0.014)	7.00234E-05	(0.058)	0.053
	3	9.59540E-04	(0.022)	9.59497E-04	(0.058)	-0.004
	4	8.89899E-03	(0.057)	8.89537E-03	(0.035)	-0.041
$\bar{\nu}$	1	2.73224E+00	(0.057)	2.73131E+00	(0.053)	-0.034
	2	2.43990E+00	(0.014)	2.43997E+00	(0.005)	0.003
	3	2.43385E+00	(0.028)	2.43385E+00	(0.000)	-0.000
	4	2.43620E+00	(0.057)	2.43620E+00	(0.000)	0.000
$1/\nu$	1	5.69093E-10	(0.042)	5.69116E-10	(0.006)	0.004
	2	3.39180E-09	(0.014)	3.39191E-09	(0.005)	0.003
	3	1.81827E-07	(0.022)	1.81833E-07	(0.012)	0.003
	4	2.08815E-06	(0.057)	2.08759E-06	(0.010)	-0.027

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

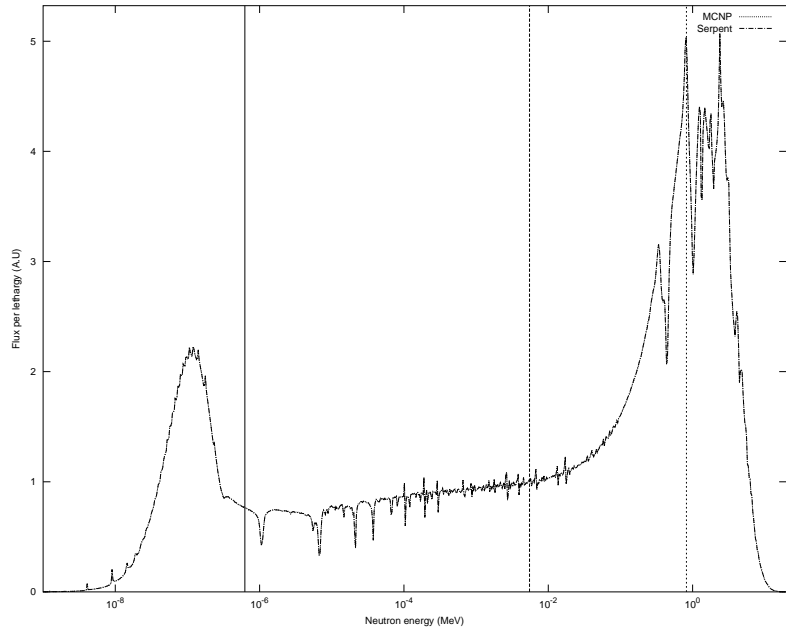
param.	$g$	MCNP		Serpent		$\Delta$ (%)
$\Sigma_{\text{tot}}$	1	9.68850E-02	(0.042)	9.69072E-02	(0.012)	0.023
	2	1.94209E-01	(0.014)	1.94221E-01	(0.006)	0.006
	3	2.18657E-01	(0.014)	2.18653E-01	(0.005)	-0.002
	4	2.24330E-01	(0.057)	2.24295E-01	(0.005)	-0.016
$\Sigma_{\text{fiss}}$	1	4.42970E-05	(0.050)	4.42333E-05	(0.149)	-0.144
	2	1.63902E-05	(0.014)	1.63862E-05	(0.058)	-0.024
	3	2.27240E-04	(0.022)	2.27402E-04	(0.056)	0.071
	4	2.18376E-03	(0.057)	2.18488E-03	(0.032)	0.051
$\Sigma_{\text{abs}}$	1	8.06231E-05	(0.163)	8.03916E-05	(0.179)	-0.287
	2	5.30386E-05	(0.014)	5.30479E-05	(0.067)	0.017
	3	1.31305E-03	(0.041)	1.31330E-03	(0.044)	0.019
	4	2.79466E-03	(0.057)	2.79607E-03	(0.031)	0.050
$\Sigma_{\text{capt}}$	1	3.63262E-05	(0.341)	3.61583E-05	(0.333)	-0.462
	2	3.66484E-05	(0.022)	3.66617E-05	(0.075)	0.036
	3	1.08581E-03	(0.051)	1.08590E-03	(0.051)	0.008
	4	6.10903E-04	(0.057)	6.11192E-04	(0.027)	0.047
$\Sigma_{\text{scatt}}$	1	9.68043E-02	(0.042)	9.68268E-02	(0.012)	0.023
	2	1.94156E-01	(0.014)	1.94168E-01	(0.006)	0.006
	3	2.17344E-01	(0.014)	2.17339E-01	(0.005)	-0.002
	4	2.21535E-01	(0.057)	2.21499E-01	(0.005)	-0.016
$\nu\Sigma_{\text{fiss}}$	1	1.21266E-04	(0.050)	1.21071E-04	(0.158)	-0.161
	2	3.99907E-05	(0.014)	3.99809E-05	(0.059)	-0.024
	3	5.53073E-04	(0.022)	5.53465E-04	(0.056)	0.071
	4	5.32009E-03	(0.057)	5.32280E-03	(0.032)	0.051
$\bar{\nu}$	1	2.73757E+00	(0.057)	2.73709E+00	(0.051)	-0.018
	2	2.43992E+00	(0.014)	2.43991E+00	(0.005)	-0.000
	3	2.43387E+00	(0.028)	2.43386E+00	(0.000)	-0.000
	4	2.43621E+00	(0.057)	2.43620E+00	(0.000)	-0.000
$1/\nu$	1	5.69644E-10	(0.042)	5.69732E-10	(0.006)	0.015
	2	3.39198E-09	(0.014)	3.39186E-09	(0.006)	-0.004
	3	1.85156E-07	(0.022)	1.85145E-07	(0.013)	-0.006
	4	2.18406E-06	(0.057)	2.18359E-06	(0.008)	-0.021



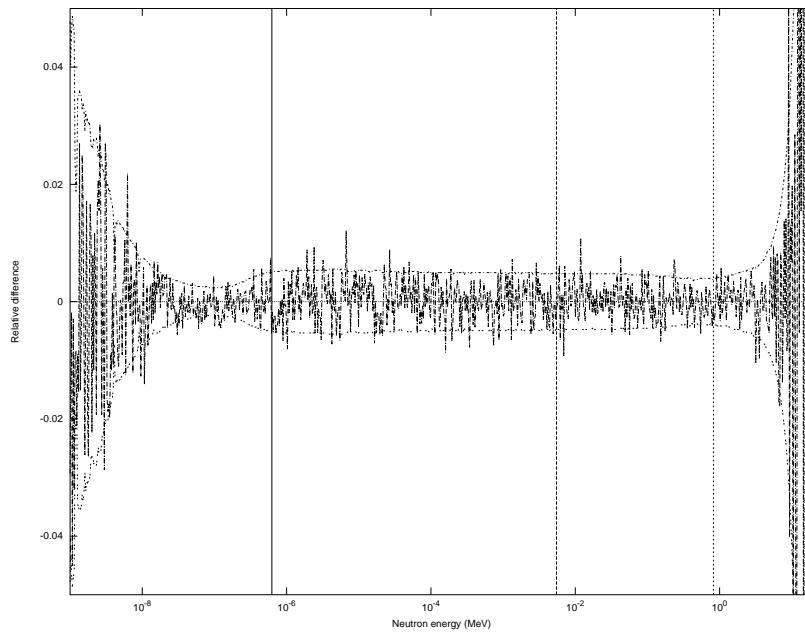
*Figure 1. Flux spectra integrated over the entire geometry PWR pin-cell, 1 MWd/kgU burnup.*



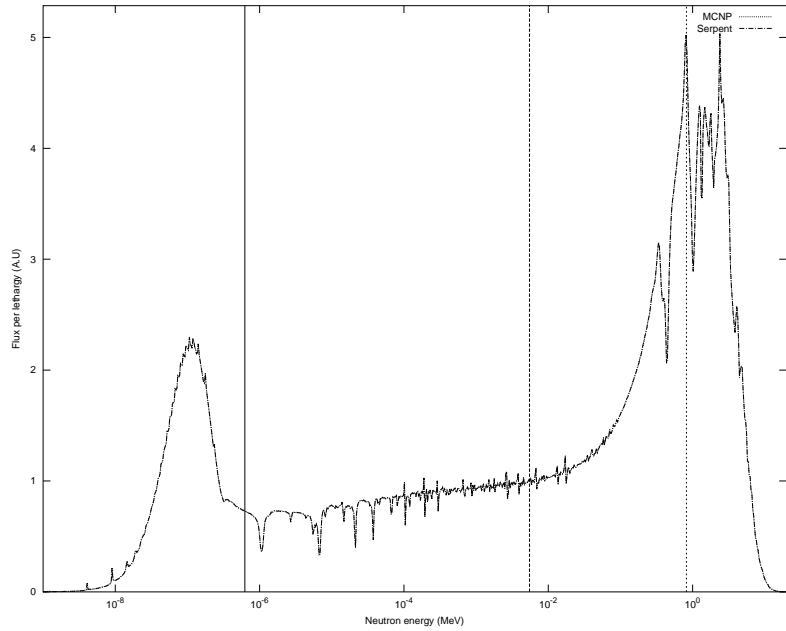
*Figure 2. Relative differences between the two spectra Figure 1.*



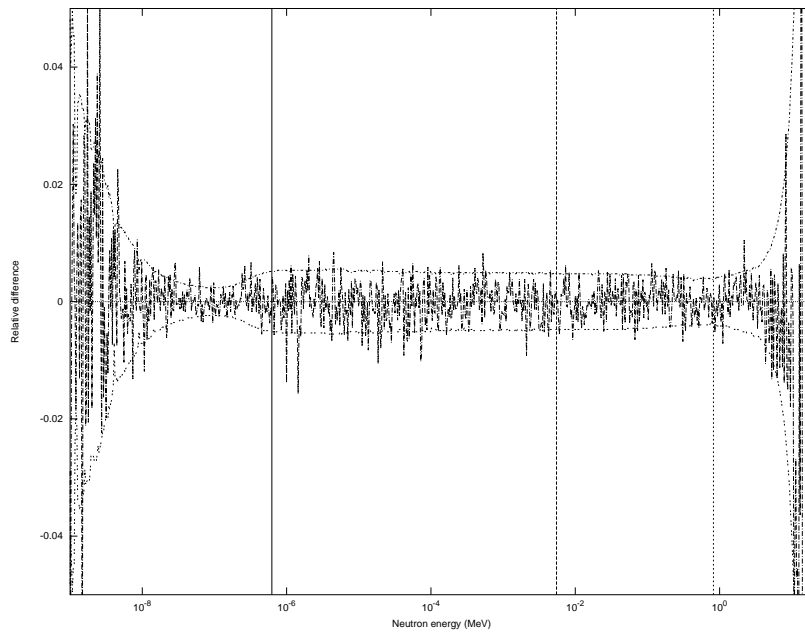
*Figure 3. Flux spectra integrated over the entire geometry PWR pin-cell, 20 MWd/kgU burnup.*



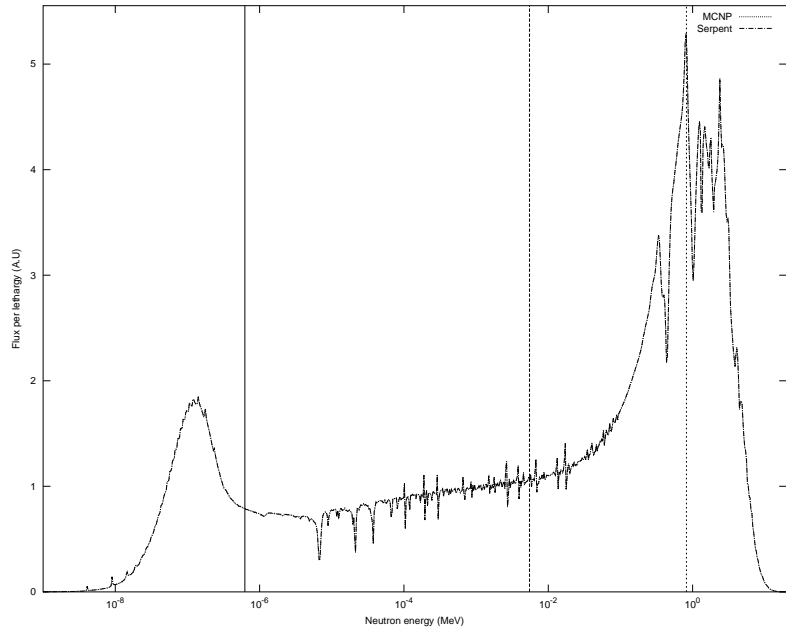
*Figure 4. Relative differences between the two spectra Figure 3.*



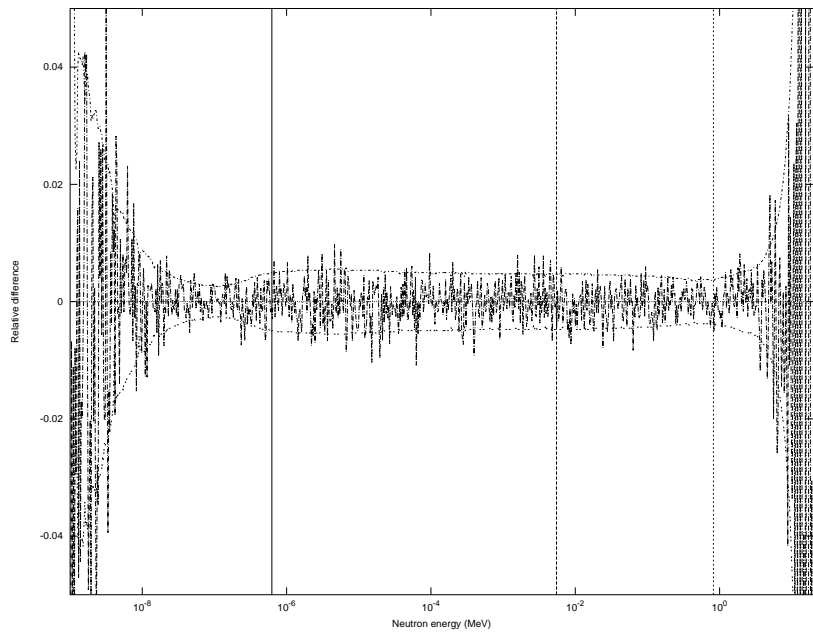
*Figure 5. Flux spectra integrated over the entire geometry PWR pin-cell, 40 MWd/kgU burnup.*



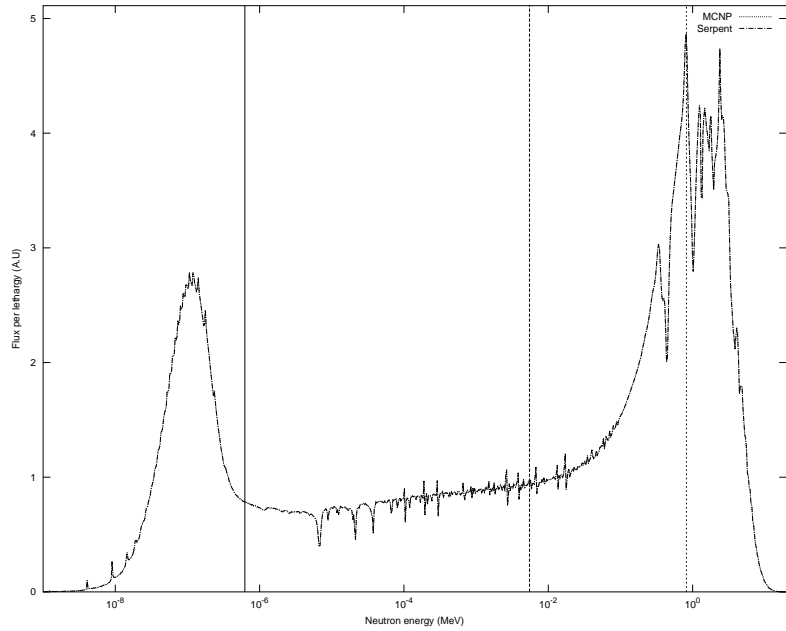
*Figure 6. Relative differences between the two spectra Figure 5.*



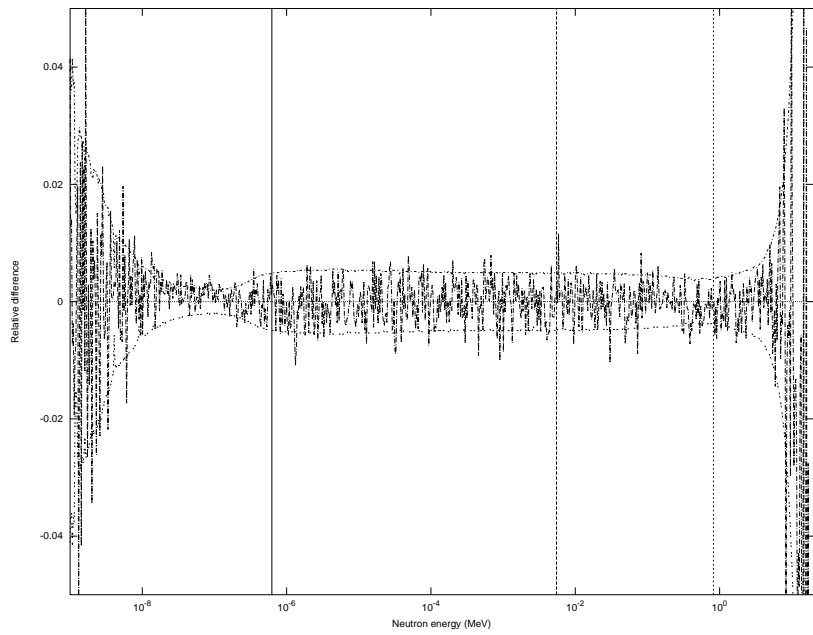
*Figure 7. Flux spectra integrated over the entire geometry VVER-440 assembly.*



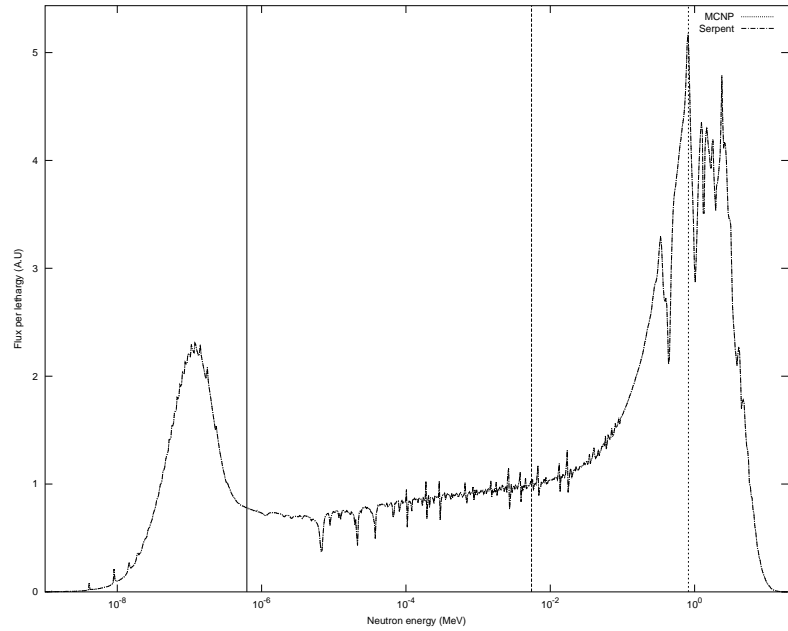
*Figure 8. Relative differences between the two spectra Figure 7.*



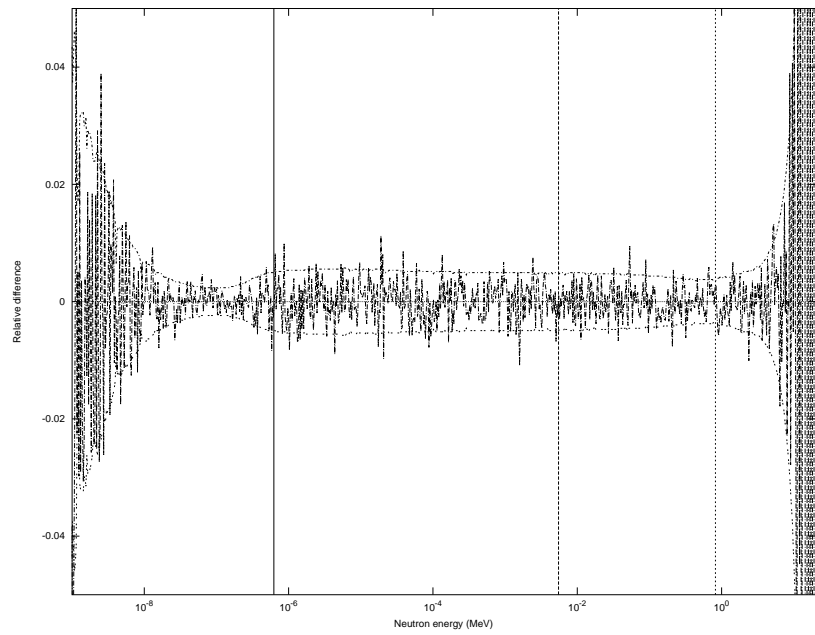
*Figure 9. Flux spectra integrated over the entire geometry BWR+Gd Assembly, 25% void fraction.*



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

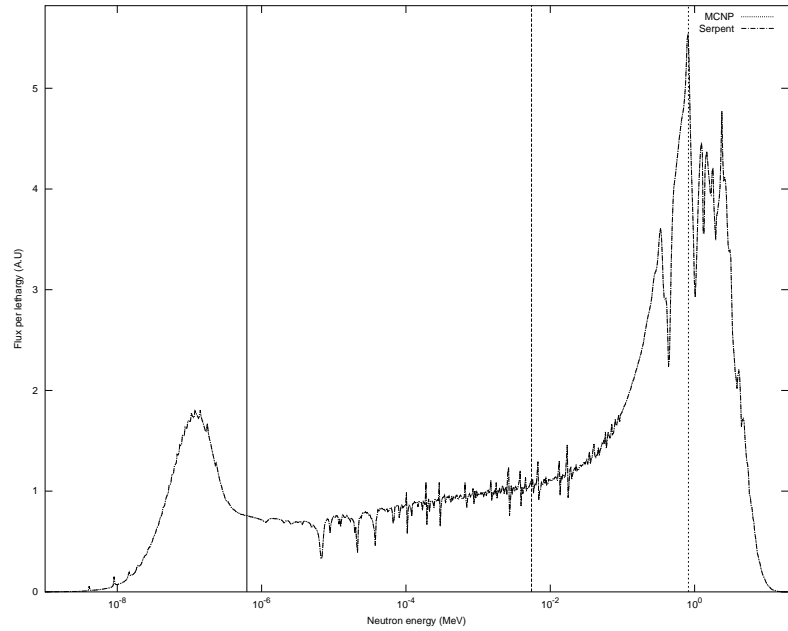


*Figure 11. Flux spectra integrated over the entire geometry BWR+Gd Assembly, 50% void fraction.*

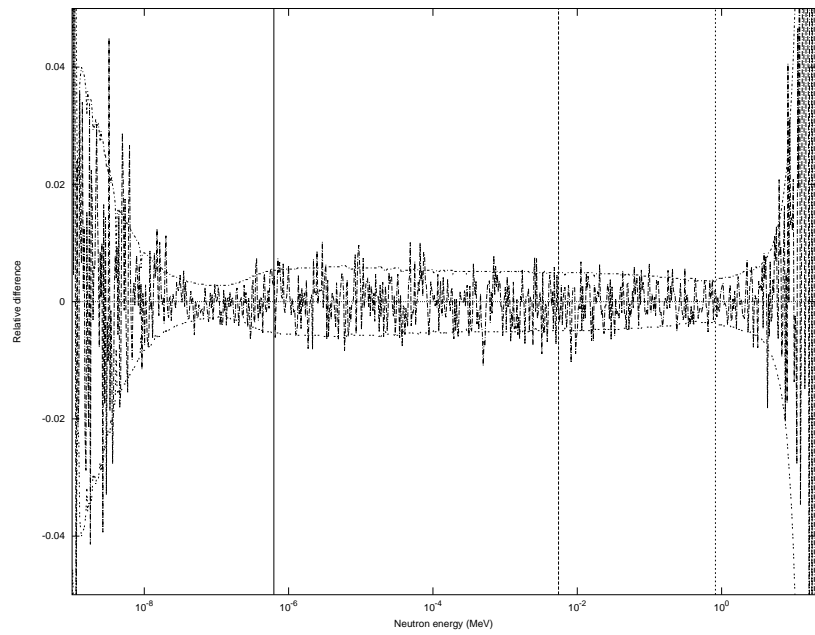


*Figure 12. Relative differences between the two spectra Figure 11.*





*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.*

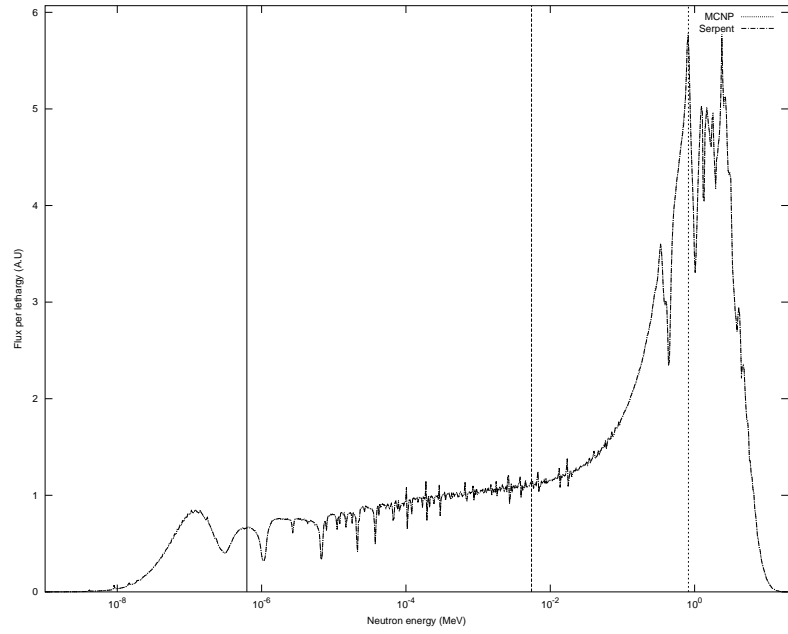


Figure 15. Flux spectra integrated over the entire geometry Mixed PWR MOX/UOX lattice.

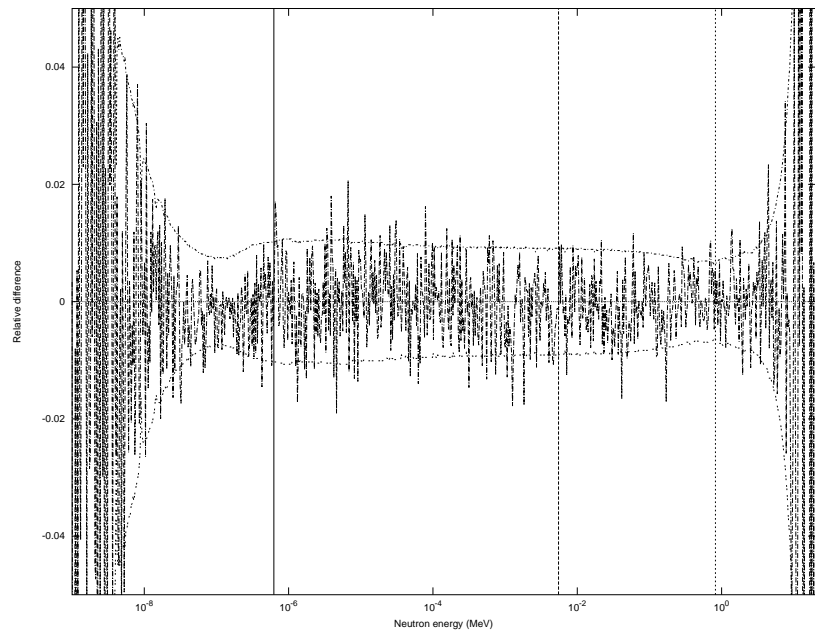
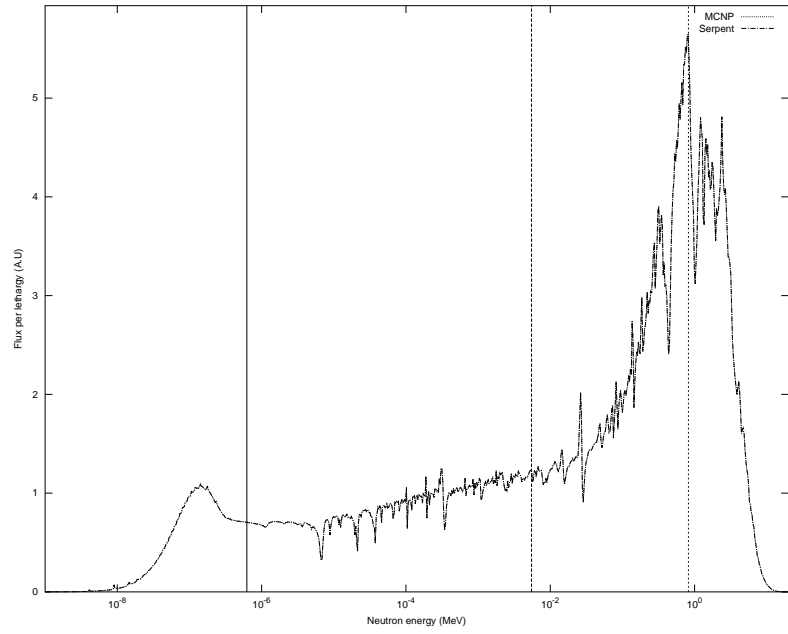
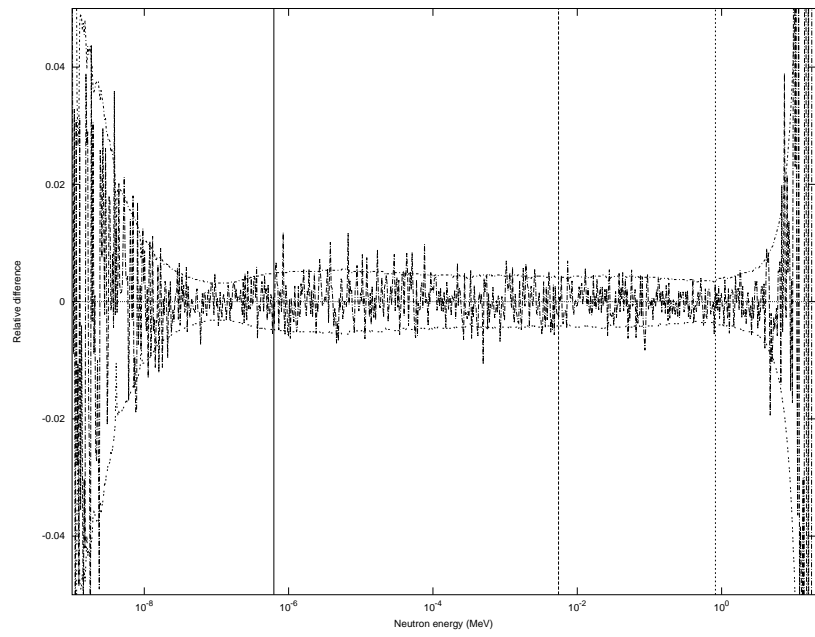


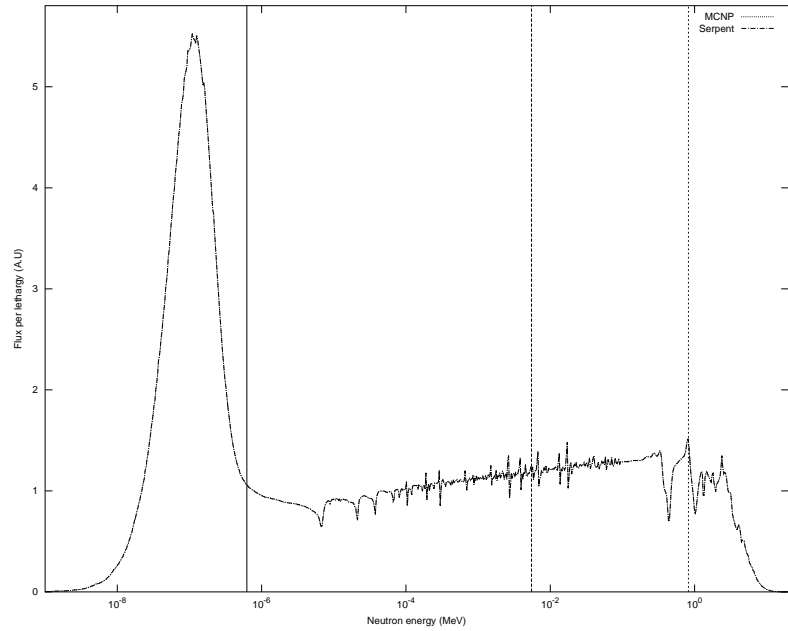
Figure 16. Relative differences between the two spectra Figure 15.



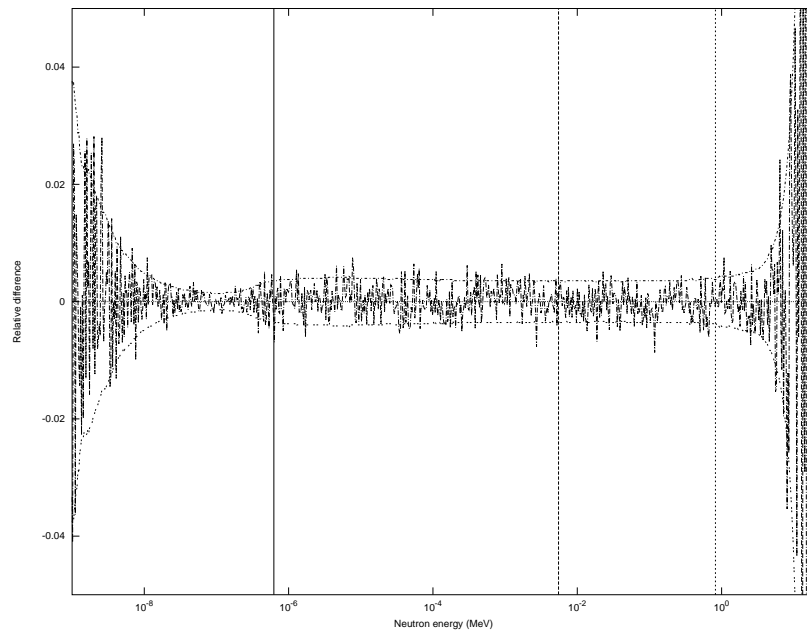
*Figure 17. Flux spectra integrated over the entire geometry SCWR assembly.*



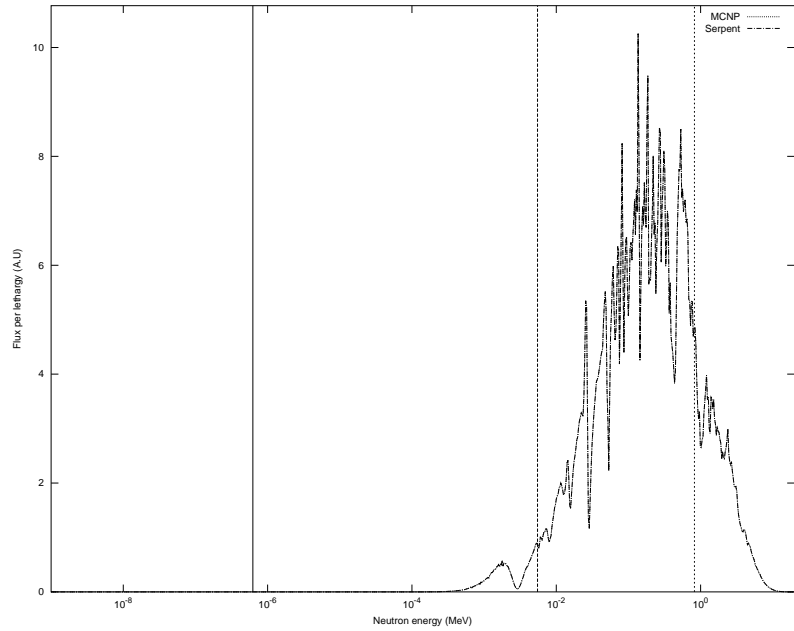
*Figure 18. Relative differences between the two spectra Figure 17.*



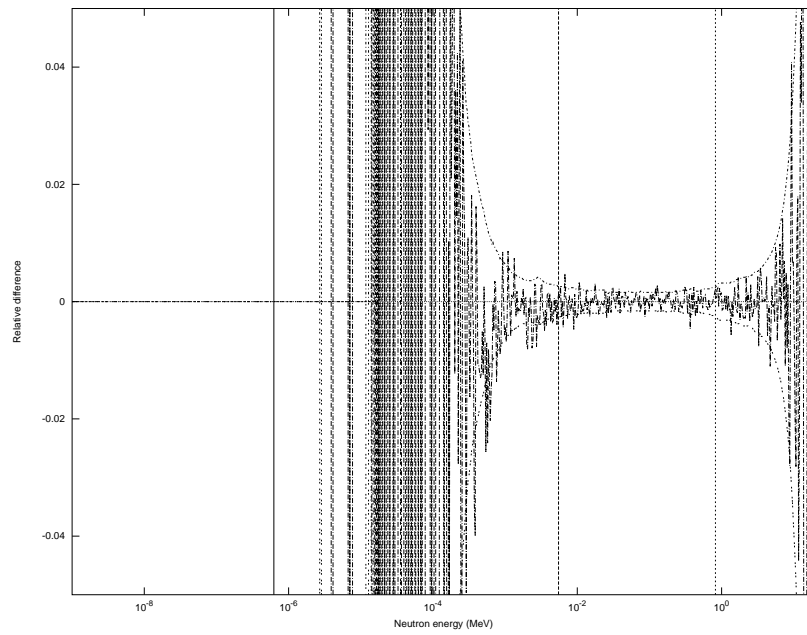
*Figure 19. Flux spectra integrated over the entire geometry CANDU fuel cluster.*



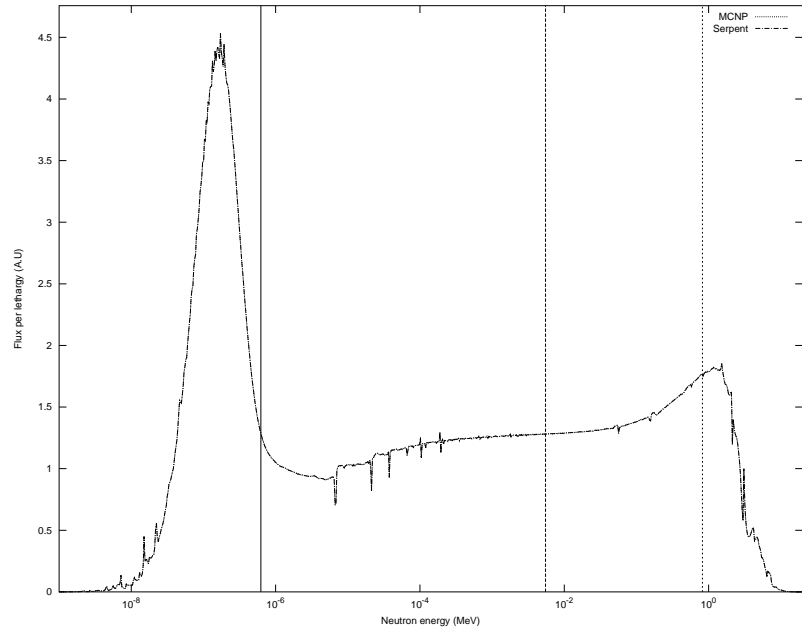
*Figure 20. Relative differences between the two spectra Figure 19.*



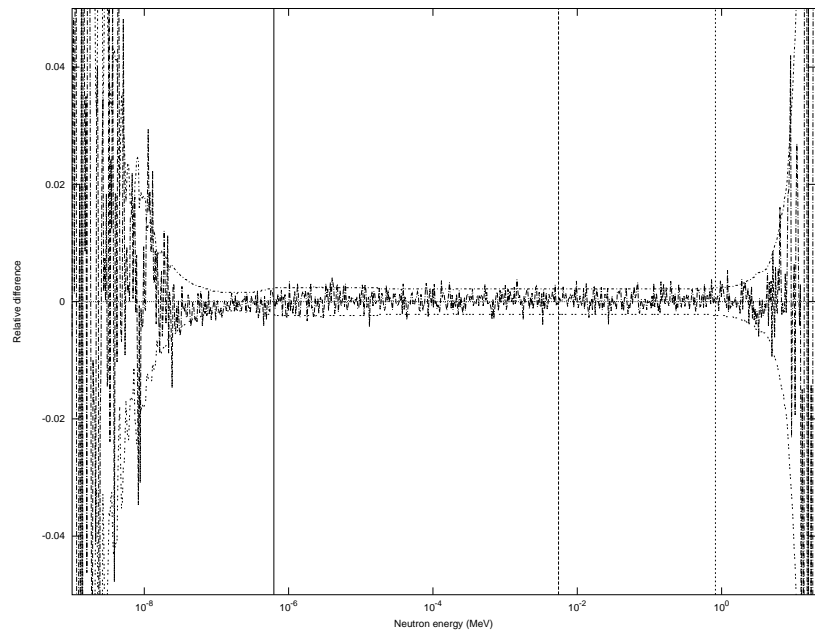
*Figure 21. Flux spectra integrated over the entire geometry SFR assembly.*



*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.*

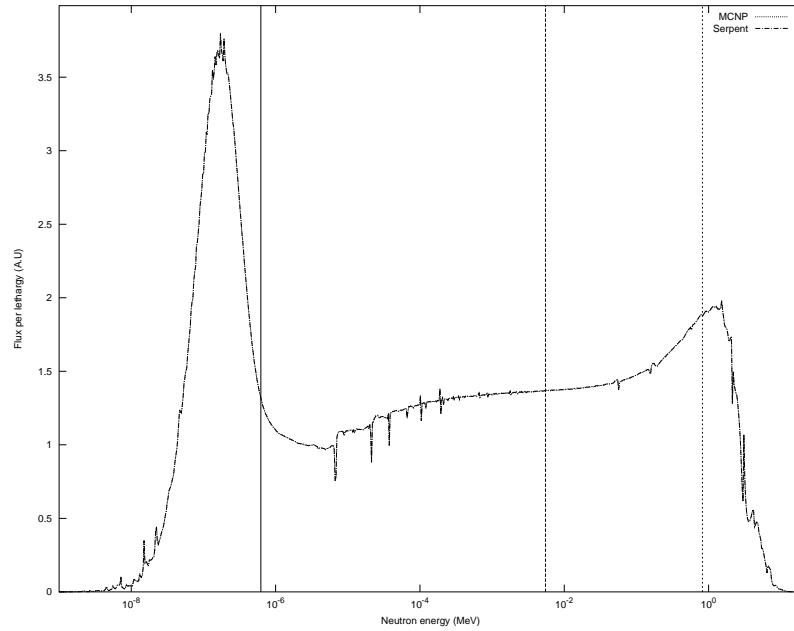


Figure 25. Flux spectra integrated over the entire geometry Prismatic HTGR fuel block + BP.

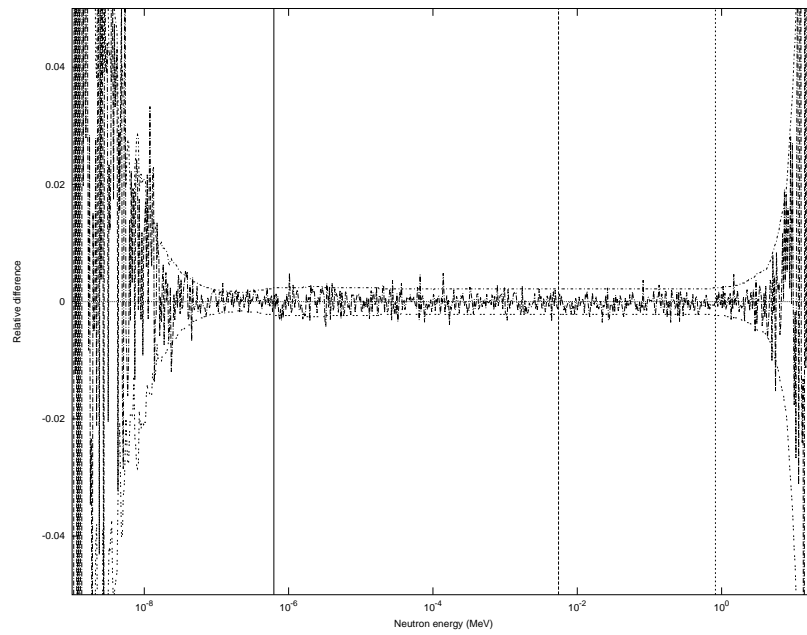


Figure 26. Relative differences between the two spectra Figure 25.

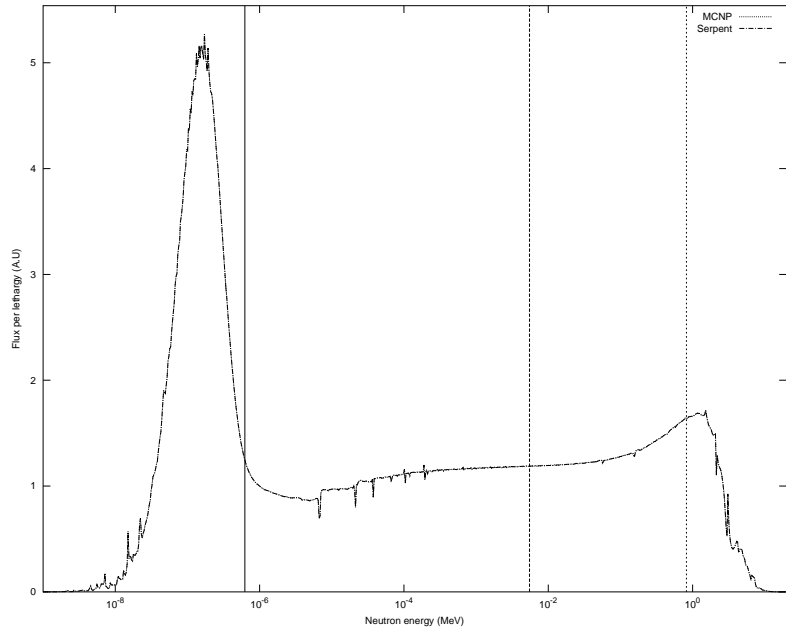


Figure 27. Flux spectra integrated over the entire geometry PBMR fuel pebble.

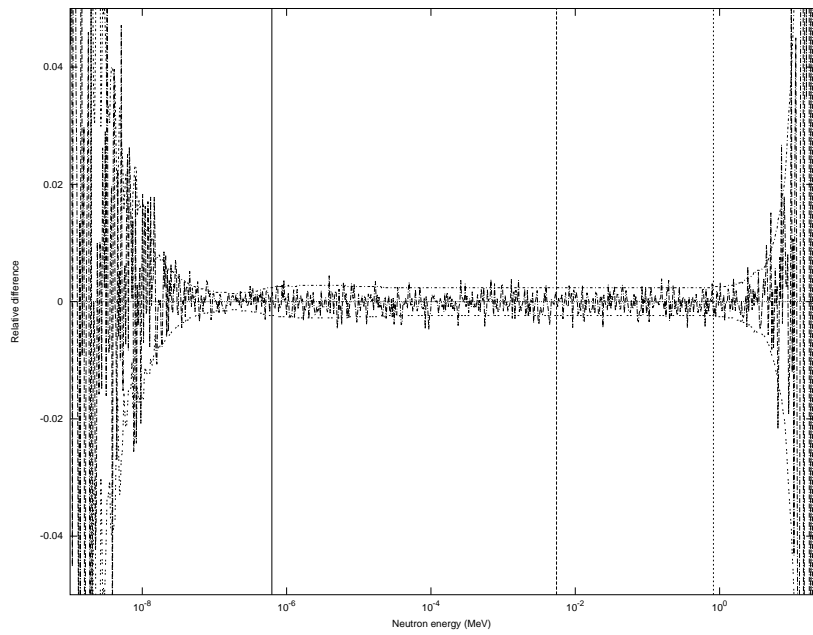


Figure 28. Relative differences between the two spectra Figure 27.