Standard comparison between Serpent 1.1.17 and MCNP5

Date: February 29, 2012

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-3.1.1 based cross section libraries
- With 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 MeV
2. 5.5 keV $< E <$ 0.821 MeV
3. 0.625 eV $< E <$ 5.5 keV
4. $E <$ 0.625 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	1.28345	(0.013)	1.28306	(0.014)	-0.030
PWR pin-cell, 20 MWd/kgU burnup	1.07228	(0.018)	1.07164	(0.016)	-0.060
PWR pin-cell, 40 MWd/kgU burnup	0.91649	(0.019)	0.91629	(0.019)	-0.021
VVER-440 assembly	1.27020	(0.016)	1.27023	(0.014)	0.002
BWR+Gd Assembly, 25% void fraction	1.07847	(0.019)	1.07792	(0.021)	-0.051
BWR+Gd Assembly, 50% void fraction	1.06275	(0.019)	1.06267	(0.019)	-0.008
BWR+Gd Assembly, 75% void fraction	1.04246	(0.018)	1.04297	(0.021)	0.049
Mixed PWR MOX/UOX lattice	1.06921	(0.019)	1.06954	(0.017)	0.031
SCWR assembly	1.14255	(0.015)	1.14253	(0.016)	-0.002
CANDU fuel cluster	0.92151	(0.016)	0.92151	(0.017)	0.000
SFR assembly	1.76858	(0.008)	1.76824	(0.008)	-0.019
Prismatic HTGR fuel block	1.44935	(0.015)	1.44944	(0.017)	0.006
Prismatic HTGR fuel block + BP	1.13835	(0.021)	1.13774	(0.022)	-0.054
PBMR fuel pebble	1.43467	(0.016)	1.43455	(0.016)	-0.008

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

Case	MCNP		Serpent		Δ (%)
PWR pin-cell, 1 MWd/kgU burnup	21.62	(0.043)	21.62	(0.025)	0.006
PWR pin-cell, 20 MWd/kgU burnup	19.38	(0.047)	19.38	(0.029)	-0.016
PWR pin-cell, 40 MWd/kgU burnup	20.02	(0.049)	20.01	(0.031)	-0.052
VVER-440 assembly	18.15	(0.043)	18.15	(0.029)	-0.017
BWR+Gd Assembly, 25% void fraction	29.06	(0.043)	29.06	(0.035)	-0.021
BWR+Gd Assembly, 50% void fraction	27.96	(0.049)	27.93	(0.034)	-0.109
BWR+Gd Assembly, 75% void fraction	26.40	(0.048)	26.43	(0.032)	0.117
Mixed PWR MOX/UOX lattice	14.24	(0.054)	7.26	(0.064)	-49.048
SCWR assembly	15.23	(0.036)	15.23	(0.032)	-0.039
CANDU fuel cluster	188.86	(0.058)	188.78	(0.033)	-0.040
SFR assembly	0.34	(0.021)	0.34	(0.018)	-0.125
Prismatic HTGR fuel block	322.62	(0.037)	322.45	(0.032)	-0.051
Prismatic HTGR fuel block + BP	257.15	(0.036)	256.83	(0.034)	-0.125
PBMR fuel pebble	574.29	(0.036)	574.11	(0.033)	-0.032

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	1000.7	63.5	15.8
PWR pin-cell, 20 MWd/kgU burnup	1008.2	73.5	13.7
PWR pin-cell, 40 MWd/kgU burnup	971.2	74.6	13.0
VVER-440 assembly	257.9	19.1	13.5
BWR+Gd Assembly, 25% void fraction	249.0	33.3	7.5
BWR+Gd Assembly, 50% void fraction	271.6	32.7	8.3
BWR+Gd Assembly, 75% void fraction	313.1	32.7	9.6
Mixed PWR MOX/UOX lattice	152.1	35.6	4.3
SCWR assembly	400.6	21.9	18.3
CANDU fuel cluster	319.1	36.1	8.8
SFR assembly	1413.8	38.3	36.9
Prismatic HTGR fuel block	6128.1	104.7	58.5
Prismatic HTGR fuel block + BP	5499.4	98.2	56.0
PBMR fuel pebble	3799.4	108.0	35.2

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		Δ (%)
Σ_{tot}	1	2.28780E-01	(0.057)	2.28729E-01	(0.010)	-0.022
	2	5.63506E-01	(0.028)	5.63503E-01	(0.006)	-0.001
	3	8.80073E-01	(0.028)	8.80014E-01	(0.007)	-0.007
	4	1.42116E+00	(0.042)	1.42098E+00	(0.010)	-0.013
Σ_{fiss}	1	2.86564E-03	(0.064)	2.86563E-03	(0.042)	-0.000
	2	3.41492E-04	(0.028)	3.41415E-04	(0.024)	-0.022
	3	4.92434E-03	(0.036)	4.92656E-03	(0.042)	0.045
	4	5.38630E-02	(0.042)	5.38702E-02	(0.023)	0.013
Σ_{abs}	1	3.59033E-03	(0.064)	3.59002E-03	(0.038)	-0.009
	2	2.18898E-03	(0.036)	2.18938E-03	(0.031)	0.018
	3	2.36779E-02	(0.045)	2.37057E-02	(0.042)	0.117
	4	8.36025E-02	(0.042)	8.36100E-02	(0.020)	0.009
Σ_{capt}	1	7.24689E-04	(0.081)	7.24387E-04	(0.054)	-0.042
	2	1.84749E-03	(0.036)	1.84796E-03	(0.033)	0.026
	3	1.87536E-02	(0.054)	1.87791E-02	(0.050)	0.136
	4	2.97394E-02	(0.042)	2.97398E-02	(0.016)	0.001
Σ_{scatt}	1	2.25190E-01	(0.057)	2.25139E-01	(0.010)	-0.022
	2	5.61317E-01	(0.028)	5.61314E-01	(0.006)	-0.001
	3	8.56395E-01	(0.028)	8.56308E-01	(0.007)	-0.010
	4	1.33756E+00	(0.042)	1.33737E+00	(0.011)	-0.014
$\nu\Sigma_{\text{fiss}}$	1	8.04421E-03	(0.064)	8.04437E-03	(0.046)	0.002
	2	8.38494E-04	(0.028)	8.38306E-04	(0.026)	-0.022
	3	1.20193E-02	(0.036)	1.20249E-02	(0.042)	0.047
	4	1.32143E-01	(0.042)	1.32155E-01	(0.023)	0.009
$\overline{\nu}$	1	2.80713E+00	(0.071)	2.80719E+00	(0.016)	0.002
	2	2.45539E+00	(0.028)	2.45539E+00	(0.011)	0.000
	3	2.44079E+00	(0.042)	2.44082E+00	(0.003)	0.001
	4	2.45332E+00	(0.042)	2.45321E+00	(0.002)	-0.004
$1/v$	1	5.26085E-10	(0.057)	5.26004E-10	(0.010)	-0.015
	2	2.63106E-09	(0.028)	2.63119E-09	(0.014)	0.005
	3	1.82683E-07	(0.036)	1.82719E-07	(0.021)	0.020
	4	2.45377E-06	(0.042)	2.45338E-06	(0.010)	-0.016

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	2.28659E-01	(0.057)	2.28653E-01	(0.009)	-0.003
	2	5.64154E-01	(0.028)	5.64181E-01	(0.006)	0.005
	3	8.88772E-01	(0.028)	8.88835E-01	(0.006)	0.007
	4	1.43743E+00	(0.057)	1.43760E+00	(0.011)	0.012
Σ_{fiss}	1	2.80593E-03	(0.064)	2.80565E-03	(0.041)	-0.010
	2	2.21411E-04	(0.028)	2.21328E-04	(0.023)	-0.038
	3	3.22106E-03	(0.036)	3.21915E-03	(0.042)	-0.059
	4	4.80129E-02	(0.057)	4.80013E-02	(0.025)	-0.024
Σ_{abs}	1	3.53819E-03	(0.064)	3.53915E-03	(0.037)	0.027
	2	2.06190E-03	(0.036)	2.06184E-03	(0.031)	-0.003
	3	2.76515E-02	(0.045)	2.76821E-02	(0.038)	0.111
	4	8.96352E-02	(0.057)	8.96162E-02	(0.022)	-0.021
Σ_{capt}	1	7.32269E-04	(0.081)	7.33495E-04	(0.057)	0.167
	2	1.84049E-03	(0.036)	1.84052E-03	(0.032)	0.001
	3	2.44304E-02	(0.045)	2.44630E-02	(0.041)	0.133
	4	4.16223E-02	(0.057)	4.16149E-02	(0.019)	-0.018
Σ_{scatt}	1	2.25121E-01	(0.057)	2.25113E-01	(0.010)	-0.004
	2	5.62092E-01	(0.028)	5.62119E-01	(0.006)	0.005
	3	8.61120E-01	(0.028)	8.61153E-01	(0.007)	0.004
	4	1.34779E+00	(0.057)	1.34798E+00	(0.012)	0.014
$\nu\Sigma_{\mathrm{fiss}}$	1	7.93768E-03	(0.064)	7.93458E-03	(0.045)	-0.039
	2	5.72494E-04	(0.028)	5.72376E-04	(0.055)	-0.021
	3	8.28348E-03	(0.036)	8.27902E-03	(0.043)	-0.054
	4	1.27227E-01	(0.057)	1.27202E-01	(0.026)	-0.019
$\overline{\nu}$	1	2.82890E+00	(0.071)	2.82806E+00	(0.016)	-0.030
	2	2.58566E+00	(0.028)	2.58609E+00	(0.048)	0.017
	3	2.57166E+00	(0.042)	2.57180E+00	(0.013)	0.005
	4	2.64984E+00	(0.057)	2.64996E+00	(0.004)	0.004
$1/v$	1	5.24180E-10	(0.057)	5.24166E-10	(0.009)	-0.003
	2	2.63232E-09	(0.028)	2.63233E-09	(0.013)	0.000
	3	1.75982E-07	(0.036)	1.75987E-07	(0.022)	0.003
	4	2.49078E-06	(0.057)	2.49099E-06	(0.011)	0.008

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	2.28964E-01	(0.057)	2.28991E-01	(0.010)	0.012
	2	5.64864E-01	(0.028)	5.64796E-01	(0.006)	-0.012
	3	8.94652E-01	(0.028)	8.94648E-01	(0.006)	-0.000
	4	1.43839E+00	(0.057)	1.43854E+00	(0.010)	0.010
Σ_{fiss}	1	2.74327E-03	(0.064)	2.74259E-03	(0.043)	-0.025
	2	1.46165E-04	(0.028)	1.46118E-04	(0.022)	-0.032
	3	2.14291E-03	(0.036)	2.14217E-03	(0.042)	-0.035
	4	3.85535E-02	(0.057)	3.85539E-02	(0.027)	0.001
Σ_{abs}	1	3.48208E-03	(0.064)	3.48186E-03	(0.038)	-0.006
	2	1.98883E-03	(0.036)	1.98761E-03	(0.032)	-0.061
	3	2.98572E-02	(0.045)	2.98462E-02	(0.038)	-0.037
	4	8.45047E-02	(0.057)	8.45033E-02	(0.023)	-0.002
Σ_{capt}	1	7.38816E-04	(0.081)	7.39273E-04	(0.053)	0.062
	2	1.84266E-03	(0.036)	1.84149E-03	(0.034)	-0.064
	3	2.77143E-02	(0.045)	2.77040E-02	(0.040)	-0.037
	4	4.59512E-02	(0.057)	4.59494E-02	(0.020)	-0.004
Σ_{scatt}	1	2.25482E-01	(0.057)	2.25509E-01	(0.010)	0.012
	2	5.62876E-01	(0.028)	5.62808E-01	(0.006)	-0.012
	3	8.64795E-01	(0.028)	8.64802E-01	(0.006)	0.001
	4	1.35389E+00	(0.057)	1.35404E+00	(0.011)	0.011
$\nu\Sigma_{\mathrm{fiss}}$	1	7.79576E-03	(0.064)	7.79071E-03	(0.048)	-0.065
	2	3.98830E-04	(0.028)	3.98737E-04	(0.065)	-0.023
	3	5.80940E-03	(0.036)	5.80656E-03	(0.047)	-0.049
	4	1.06814E-01	(0.057)	1.06806E-01	(0.028)	-0.008
$\overline{\nu}$	1	2.84177E+00	(0.071)	2.84063E+00	(0.018)	-0.040
	2	2.72863E+00	(0.028)	2.72886E+00	(0.061)	0.008
	3	2.71098E+00	(0.042)	2.71058E+00	(0.017)	-0.015
	4	2.77054E+00	(0.057)	2.77029E+00	(0.004)	-0.009
$1/v$	1	5.23412E-10	(0.057)	5.23491E-10	(0.010)	0.015
	2	2.63302E-09	(0.028)	2.63226E-09	(0.014)	-0.029
	3	1.72320E-07	(0.036)	1.72335E-07	(0.021)	0.008
	4	2.52591E-06	(0.057)	2.52548E-06	(0.011)	-0.017

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	2.21785E-01	(0.057)	2.21816E-01	(0.010)	0.014
	2	5.17230E-01	(0.028)	5.17194E-01	(0.006)	-0.007
	3	7.75161E-01	(0.028)	7.75163E-01	(0.008)	0.000
	4	1.20629E+00	(0.050)	1.20633E+00	(0.014)	0.003
Σ_{fiss}	1	2.82516E-03	(0.064)	2.82345E-03	(0.041)	-0.061
	2	4.10645E-04	(0.028)	4.10615E-04	(0.022)	-0.007
	3	5.79119E-03	(0.036)	5.78987E-03	(0.039)	-0.023
	4	5.98777E-02	(0.050)	5.99023E-02	(0.027)	0.041
Σ_{abs}	1	3.53542E-03	(0.064)	3.53341E-03	(0.037)	-0.057
	2	2.33103E-03	(0.036)	2.33111E-03	(0.026)	0.003
	3	2.47031E-02	(0.036)	2.46921E-02	(0.035)	-0.044
	4	8.94696E-02	(0.050)	8.95023E-02	(0.023)	0.037
Σ_{capt}	1	7.10263E-04	(0.072)	7.09959E-04	(0.052)	-0.043
	2	1.92039E-03	(0.036)	1.92049E-03	(0.028)	0.005
	3	1.89119E-02	(0.045)	1.89022E-02	(0.043)	-0.051
	4	2.95919E-02	(0.050)	2.96000E-02	(0.017)	0.027
Σ_{scatt}	1	2.18249E-01	(0.057)	2.18282E-01	(0.010)	0.015
	2	5.14899E-01	(0.028)	5.14862E-01	(0.006)	-0.007
	3	7.50458E-01	(0.028)	7.50471E-01	(0.008)	0.002
	4	1.11682E+00	(0.050)	1.11682E+00	(0.015)	-0.000
$\nu\Sigma_{\mathrm{fiss}}$	1	7.90578E-03	(0.064)	7.90116E-03	(0.045)	-0.058
	2	1.00526E-03	(0.028)	1.00518E-03	(0.023)	-0.008
	3	1.40949E-02	(0.036)	1.40917E-02	(0.039)	-0.023
	4	1.45874E-01	(0.050)	1.45934E-01	(0.027)	0.041
$\overline{\nu}$	1	2.79834E+00	(0.071)	2.79840E+00	(0.015)	0.002
	2	2.44801E+00	(0.028)	2.44798E+00	(0.004)	-0.001
	3	2.43385E+00	(0.042)	2.43385E+00	(0.000)	-0.000
	4	2.43620E+00	(0.057)	2.43620E+00	(0.000)	-0.000
$1/v$	1	5.31022E-10	(0.057)	5.31117E-10	(0.009)	0.018
	2	2.63268E-09	(0.028)	2.63277E-09	(0.014)	0.003
	3	1.76379E-07	(0.036)	1.76405E-07	(0.023)	0.015
	4	2.35566E-06	(0.050)	2.35591E-06	(0.013)	0.011

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	2.02426E-01	(0.057)	2.02445E-01	(0.010)	0.010
	2	4.93014E-01	(0.028)	4.93028E-01	(0.006)	0.003
	3	7.69065E-01	(0.028)	7.69080E-01	(0.007)	0.002
	4	1.35439E+00	(0.050)	1.35417E+00	(0.012)	-0.016
Σ_{fiss}	1	2.36023E-03	(0.064)	2.36048E-03	(0.045)	0.011
	2	3.17845E-04	(0.036)	3.17669E-04	(0.029)	-0.055
	3	4.24692E-03	(0.045)	4.24420E-03	(0.049)	-0.064
	4	3.30662E-02	(0.050)	3.30698E-02	(0.036)	0.011
Σ_{abs}	1	2.98046E-03	(0.064)	2.98080E-03	(0.041)	0.011
	2	1.84723E-03	(0.036)	1.84577E-03	(0.034)	-0.079
	3	1.87334E-02	(0.045)	1.87414E-02	(0.041)	0.043
	4	6.53859E-02	(0.042)	6.54062E-02	(0.030)	0.031
Σ_{capt}	1	6.20232E-04	(0.081)	6.20315E-04	(0.058)	0.013
	2	1.52939E-03	(0.036)	1.52810E-03	(0.036)	-0.084
	3	1.44865E-02	(0.054)	1.44972E-02	(0.050)	0.074
	4	3.23197E-02	(0.050)	3.23364E-02	(0.039)	0.052
Σ_{scatt}	1	1.99445E-01	(0.057)	1.99464E-01	(0.011)	0.009
	2	4.91166E-01	(0.028)	4.91182E-01	(0.006)	0.003
	3	7.50332E-01	(0.028)	7.50339E-01	(0.007)	0.001
	4	1.28900E+00	(0.050)	1.28876E+00	(0.013)	-0.019
$\nu\Sigma_{\text{fiss}}$	1	6.61245E-03	(0.064)	6.61052E-03	(0.049)	-0.029
	2	7.78350E-04	(0.036)	7.77944E-04	(0.029)	-0.052
	3	1.03365E-02	(0.045)	1.03299E-02	(0.049)	-0.063
	4	8.05560E-02	(0.050)	8.05647E-02	(0.036)	0.011
$\overline{\nu}$	1	2.80161E+00	(0.071)	2.80049E+00	(0.017)	-0.040
	2	2.44883E+00	(0.042)	2.44892E+00	(0.005)	0.004
	3	2.43387E+00	(0.057)	2.43387E+00	(0.000)	0.000
	4	2.43620E+00	(0.057)	2.43620E+00	(0.000)	-0.000
$1/v$	1	5.28073E-10	(0.057)	5.28138E-10	(0.009)	0.012
	2	2.61504E-09	(0.028)	2.61503E-09	(0.014)	-0.000
	3	1.84194E-07	(0.036)	1.84112E-07	(0.021)	-0.045
	4	2.52129E-06	(0.050)	2.52111E-06	(0.010)	-0.007

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	1.81704E-01	(0.057)	1.81744E-01	(0.012)	0.022
	2	4.26421E-01	(0.028)	4.26394E-01	(0.007)	-0.006
	3	6.57830E-01	(0.028)	6.57741E-01	(0.007)	-0.013
	4	1.18016E+00	(0.050)	1.17990E+00	(0.013)	-0.022
Σ_{fiss}	1	2.31099E-03	(0.064)	2.31071E-03	(0.043)	-0.012
	2	3.15886E-04	(0.036)	3.15818E-04	(0.026)	-0.021
	3	4.16521E-03	(0.045)	4.16407E-03	(0.044)	-0.027
	4	3.23188E-02	(0.050)	3.23447E-02	(0.035)	0.080
Σ_{abs}	1	2.89806E-03	(0.064)	2.89758E-03	(0.039)	-0.016
	2	1.83026E-03	(0.036)	1.83000E-03	(0.032)	-0.014
	3	1.79270E-02	(0.045)	1.79317E-02	(0.040)	0.026
	4	6.38254E-02	(0.050)	6.38602E-02	(0.030)	0.055
Σ_{capt}	1	5.87068E-04	(0.072)	5.86872E-04	(0.057)	-0.033
	2	1.51438E-03	(0.036)	1.51418E-03	(0.034)	-0.013
	3	1.37618E-02	(0.054)	1.37677E-02	(0.048)	0.043
	4	3.15066E-02	(0.058)	3.15155E-02	(0.039)	0.028
Σ_{scatt}	1	1.78806E-01	(0.057)	1.78846E-01	(0.012)	0.022
	2	4.24591E-01	(0.028)	4.24564E-01	(0.007)	-0.006
	3	6.39903E-01	(0.028)	6.39810E-01	(0.007)	-0.014
	4	1.11633E+00	(0.050)	1.11604E+00	(0.014)	-0.026
$\nu\Sigma_{\text{fiss}}$	1	6.46743E-03	(0.064)	6.46527E-03	(0.046)	-0.033
	2	7.73544E-04	(0.036)	7.73369E-04	(0.027)	-0.023
	3	1.01375E-02	(0.045)	1.01348E-02	(0.044)	-0.027
	4	7.87351E-02	(0.050)	7.87981E-02	(0.035)	0.080
$\overline{\nu}$	1	2.79856E+00	(0.071)	2.79795E+00	(0.015)	-0.022
	2	2.44881E+00	(0.042)	2.44878E+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
$1/v$	1	5.30600E-10	(0.057)	5.30675E-10	(0.009)	0.014
	2	2.60625E-09	(0.028)	2.60575E-09	(0.014)	-0.019
	3	1.80287E-07	(0.036)	1.80200E-07	(0.022)	-0.048
	4	2.46860E-06	(0.050)	2.46857E-06	(0.010)	-0.001

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	1.60793E-01	(0.057)	1.60838E-01	(0.014)	0.028
	2	3.59384E-01	(0.028)	3.59363E-01	(0.009)	-0.006
	3	5.47743E-01	(0.028)	5.47761E-01	(0.009)	0.003
	4	1.01236E+00	(0.050)	1.01200E+00	(0.019)	-0.035
Σ_{fiss}	1	2.25169E-03	(0.064)	2.25128E-03	(0.038)	-0.018
	2	3.13084E-04	(0.036)	3.13110E-04	(0.023)	0.008
	3	4.05248E-03	(0.045)	4.05106E-03	(0.042)	-0.035
	4	3.13176E-02	(0.050)	3.13345E-02	(0.033)	0.054
Σ_{abs}	1	2.80676E-03	(0.064)	2.80638E-03	(0.034)	-0.013
	2	1.80264E-03	(0.036)	1.80244E-03	(0.029)	-0.011
	3	1.68051E-02	(0.045)	1.67976E-02	(0.037)	-0.045
	4	6.19598E-02	(0.050)	6.19710E-02	(0.029)	0.018
Σ_{capt}	1	5.55071E-04	(0.072)	5.55094E-04	(0.046)	0.004
	2	1.48955E-03	(0.036)	1.48933E-03	(0.031)	-0.015
	3	1.27526E-02	(0.045)	1.27466E-02	(0.044)	-0.047
	4	3.06422E-02	(0.058)	3.06365E-02	(0.041)	-0.019
Σ_{scatt}	1	1.57986E-01	(0.057)	1.58031E-01	(0.014)	0.028
	2	3.57581E-01	(0.028)	3.57561E-01	(0.009)	-0.006
	3	5.30938E-01	(0.028)	5.30964E-01	(0.010)	0.005
	4	9.50398E-01	(0.050)	9.50028E-01	(0.021)	-0.039
$\nu\Sigma_{\text{fiss}}$	1	6.29337E-03	(0.064)	6.29321E-03	(0.043)	-0.002
	2	7.66714E-04	(0.036)	7.66805E-04	(0.023)	0.012
	3	9.86316E-03	(0.045)	9.85970E-03	(0.042)	-0.035
	4	7.62959E-02	(0.050)	7.63371E-02	(0.033)	0.054
$\overline{\nu}$	1	2.79495E+00	(0.071)	2.79538E+00	(0.014)	0.015
	2	2.44891E+00	(0.042)	2.44900E+00	(0.004)	0.004
	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
$1/v$	1	5.34121E-10	(0.057)	5.34300E-10	(0.010)	0.033
	2	2.58610E-09	(0.028)	2.58551E-09	(0.015)	-0.023
	3	1.75295E-07	(0.036)	1.75208E-07	(0.025)	-0.049
	4	2.39591E-06	(0.050)	2.39585E-06	(0.012)	-0.002

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	2.17899E-01	(0.092)	2.18001E-01	(0.016)	0.047
	2	5.31158E-01	(0.071)	5.31202E-01	(0.012)	0.008
	3	8.41319E-01	(0.071)	8.41265E-01	(0.013)	-0.006
	4	1.46024E+00	(0.127)	1.45998E+00	(0.027)	-0.018
Σ_{fiss}	1	3.18164E-03	(0.106)	3.18137E-03	(0.075)	-0.008
	2	4.38235E-04	(0.078)	4.38185E-04	(0.039)	-0.012
	3	5.93890E-03	(0.103)	5.93911E-03	(0.093)	0.004
	4	1.14049E-01	(0.127)	1.14210E-01	(0.070)	0.141
Σ_{abs}	1	3.90406E-03	(0.106)	3.90312E-03	(0.069)	-0.024
	2	2.28061E-03	(0.078)	2.28048E-03	(0.053)	-0.006
	3	3.46759E-02	(0.094)	3.46818E-02	(0.068)	0.017
	4	2.02854E-01	(0.127)	2.03124E-01	(0.065)	0.133
Σ_{capt}	1	7.22426E-04	(0.130)	7.21747E-04	(0.091)	-0.094
	2	1.84238E-03	(0.086)	1.84230E-03	(0.060)	-0.004
	3	2.87371E-02	(0.103)	2.87427E-02	(0.077)	0.020
	4	8.88048E-02	(0.127)	8.89134E-02	(0.060)	0.122
Σ_{scatt}	1	2.13995E-01	(0.099)	2.14098E-01	(0.016)	0.048
	2	5.28878E-01	(0.071)	5.28921E-01	(0.012)	0.008
	3	8.06644E-01	(0.071)	8.06583E-01	(0.014)	-0.008
	4	1.25738E+00	(0.127)	1.25686E+00	(0.033)	-0.042
$\nu\Sigma_{\text{fiss}}$	1	9.22151E-03	(0.106)	9.22303E-03	(0.085)	0.017
	2	1.26975E-03	(0.078)	1.26909E-03	(0.052)	-0.052
	3	1.69351E-02	(0.103)	1.69355E-02	(0.094)	0.002
	4	3.25745E-01	(0.127)	3.26201E-01	(0.070)	0.140
$\overline{\nu}$	1	2.89835E+00	(0.113)	2.89904E+00	(0.032)	0.024
	2	2.89741E+00	(0.085)	2.89625E+00	(0.034)	-0.040
	3	2.85155E+00	(0.127)	2.85152E+00	(0.008)	-0.001
	4	2.85618E+00	(0.127)	2.85615E+00	(0.003)	-0.001
$1/v$	1	5.23069E-10	(0.092)	5.23216E-10	(0.015)	0.028
	2	2.61569E-09	(0.078)	2.61668E-09	(0.028)	0.038
	3	1.62840E-07	(0.086)	1.62758E-07	(0.043)	-0.051
	4	2.31143E-06	(0.135)	2.30997E-06	(0.030)	-0.063

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

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	1.76995E-01	(0.057)	1.77011E-01	(0.012)	0.009
	2	3.84365E-01	(0.028)	3.84351E-01	(0.007)	-0.004
	3	6.33692E-01	(0.028)	6.33730E-01	(0.005)	0.006
	4	9.48523E-01	(0.057)	9.48521E-01	(0.012)	-0.000
Σ_{fiss}	1	2.42131E-03	(0.064)	2.42242E-03	(0.039)	0.046
	2	4.72592E-04	(0.028)	4.72590E-04	(0.023)	-0.000
	3	6.13241E-03	(0.036)	6.13363E-03	(0.037)	0.020
	4	5.51719E-02	(0.057)	5.51852E-02	(0.035)	0.024
Σ_{abs}	1	3.16892E-03	(0.064)	3.16994E-03	(0.034)	0.032
	2	2.10259E-03	(0.036)	2.10161E-03	(0.027)	-0.047
	3	2.25650E-02	(0.036)	2.25780E-02	(0.031)	0.057
	4	9.00054E-02	(0.057)	9.00307E-02	(0.027)	0.028
Σ_{capt}	1	7.47609E-04	(0.072)	7.47518E-04	(0.046)	-0.012
	2	1.63001E-03	(0.036)	1.62902E-03	(0.030)	-0.060
	3	1.64327E-02	(0.045)	1.64443E-02	(0.038)	0.071
	4	3.48336E-02	(0.057)	3.48455E-02	(0.022)	0.034
Σ_{scatt}	1	1.73826E-01	(0.057)	1.73841E-01	(0.012)	0.009
	2	3.82262E-01	(0.028)	3.82249E-01	(0.007)	-0.003
	3	6.11127E-01	(0.028)	6.11152E-01	(0.005)	0.004
	4	8.58517E-01	(0.057)	8.58490E-01	(0.014)	-0.003
$\nu\Sigma_{\text{fiss}}$	1	6.74057E-03	(0.064)	6.74369E-03	(0.043)	0.046
	2	1.15698E-03	(0.028)	1.15693E-03	(0.023)	-0.005
	3	1.49251E-02	(0.036)	1.49281E-02	(0.037)	0.020
	4	1.34410E-01	(0.057)	1.34442E-01	(0.035)	0.024
$\overline{\nu}$	1	2.78385E+00	(0.071)	2.78385E+00	(0.014)	-0.000
	2	2.44817E+00	(0.028)	2.44806E+00	(0.003)	-0.004
	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
$1/v$	1	5.38870E-10	(0.057)	5.38877E-10	(0.009)	0.001
	2	2.61344E-09	(0.028)	2.61235E-09	(0.014)	-0.042
	3	1.64532E-07	(0.036)	1.64551E-07	(0.025)	0.012
	4	2.20592E-06	(0.057)	2.20592E-06	(0.015)	-0.000

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	2.10344E-01	(0.057)	2.10354E-01	(0.012)	0.005
	2	3.16091E-01	(0.028)	3.16092E-01	(0.006)	0.000
	3	3.20482E-01	(0.014)	3.20505E-01	(0.005)	0.007
	4	3.76168E-01	(0.042)	3.76197E-01	(0.005)	0.008
Σ_{fiss}	1	2.10377E-03	(0.064)	2.10164E-03	(0.050)	-0.101
	2	5.09232E-05	(0.036)	5.09051E-05	(0.033)	-0.035
	3	4.77650E-04	(0.041)	4.77356E-04	(0.051)	-0.062
	4	4.61099E-03	(0.042)	4.61100E-03	(0.029)	0.000
Σ_{abs}	1	2.73473E-03	(0.064)	2.73196E-03	(0.044)	-0.101
	2	1.25705E-03	(0.045)	1.25640E-03	(0.040)	-0.052
	3	5.12898E-03	(0.041)	5.12961E-03	(0.047)	0.012
	4	9.08795E-03	(0.042)	9.08782E-03	(0.028)	-0.001
Σ_{capt}	1	6.30958E-04	(0.081)	6.30314E-04	(0.059)	-0.102
	2	1.20613E-03	(0.045)	1.20549E-03	(0.040)	-0.053
	3	4.65133E-03	(0.041)	4.65225E-03	(0.050)	0.020
	4	4.47695E-03	(0.042)	4.47683E-03	(0.026)	-0.003
Σ_{scatt}	1	2.07609E-01	(0.057)	2.07622E-01	(0.012)	0.006
	2	3.14834E-01	(0.028)	3.14836E-01	(0.006)	0.001
	3	3.15353E-01	(0.014)	3.15376E-01	(0.004)	0.007
	4	3.67080E-01	(0.042)	3.67109E-01	(0.005)	0.008
$\nu\Sigma_{\text{fiss}}$	1	5.90321E-03	(0.064)	5.89830E-03	(0.054)	-0.083
	2	1.24384E-04	(0.036)	1.24350E-04	(0.034)	-0.028
	3	1.16256E-03	(0.041)	1.16184E-03	(0.051)	-0.062
	4	1.12333E-02	(0.042)	1.12333E-02	(0.029)	-0.000
$\overline{\nu}$	1	2.80602E+00	(0.071)	2.80651E+00	(0.017)	0.018
	2	2.44259E+00	(0.042)	2.44277E+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
$1/v$	1	5.28570E-10	(0.057)	5.28634E-10	(0.010)	0.012
	2	3.53528E-09	(0.028)	3.53488E-09	(0.010)	-0.011
	3	1.84970E-07	(0.022)	1.85004E-07	(0.018)	0.018
	4	2.55956E-06	(0.042)	2.55984E-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		Δ (%)
Σ_{tot}	1	1.87313E-01	(0.042)	1.87303E-01	(0.009)	-0.005
	2	2.84703E-01	(0.014)	2.84703E-01	(0.006)	-0.000
	3	5.57646E-01	(0.099)	5.57448E-01	(0.023)	-0.035
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
Σ_{fiss}	1	6.28958E-03	(0.050)	6.28962E-03	(0.022)	0.001
	2	4.45556E-03	(0.014)	4.45579E-03	(0.009)	0.005
	3	1.38819E-02	(0.106)	1.38812E-02	(0.045)	-0.005
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
Σ_{abs}	1	7.19556E-03	(0.042)	7.19509E-03	(0.021)	-0.007
	2	7.03657E-03	(0.014)	7.03728E-03	(0.011)	0.010
	3	2.87460E-02	(0.106)	2.87437E-02	(0.041)	-0.008
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
Σ_{capt}	1	9.05957E-04	(0.050)	9.05468E-04	(0.033)	-0.054
	2	2.58102E-03	(0.022)	2.58149E-03	(0.016)	0.018
	3	1.48641E-02	(0.106)	1.48624E-02	(0.044)	-0.011
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
Σ_{scatt}	1	1.80117E-01	(0.042)	1.80108E-01	(0.009)	-0.005
	2	2.77667E-01	(0.014)	2.77666E-01	(0.006)	-0.000
	3	5.28900E-01	(0.099)	5.28704E-01	(0.024)	-0.037
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$\nu\Sigma_{\text{fiss}}$	1	1.83167E-02	(0.050)	1.83164E-02	(0.025)	-0.002
	2	1.17877E-02	(0.014)	1.17885E-02	(0.010)	0.007
	3	3.57619E-02	(0.106)	3.57599E-02	(0.047)	-0.006
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$\overline{\nu}$	1	2.91223E+00	(0.057)	2.91216E+00	(0.009)	-0.002
	2	2.64561E+00	(0.014)	2.64566E+00	(0.004)	0.002
	3	2.57616E+00	(0.113)	2.57613E+00	(0.012)	-0.001
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$1/v$	1	5.61617E-10	(0.042)	5.61677E-10	(0.009)	0.011
	2	2.51636E-09	(0.022)	2.51653E-09	(0.015)	0.007
	3	1.61747E-08	(0.106)	1.61751E-08	(0.032)	0.002
	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	1.37510E-01	(0.042)	1.37531E-01	(0.008)	0.016
	2	2.76018E-01	(0.014)	2.76015E-01	(0.004)	-0.001
	3	3.11259E-01	(0.014)	3.11252E-01	(0.003)	-0.002
	4	3.20235E-01	(0.057)	3.20200E-01	(0.003)	-0.011
Σ_{fiss}	1	6.61555E-05	(0.050)	6.60373E-05	(0.138)	-0.179
	2	2.94903E-05	(0.014)	2.94894E-05	(0.057)	-0.003
	3	4.06426E-04	(0.022)	4.06792E-04	(0.054)	0.090
	4	3.82071E-03	(0.057)	3.82195E-03	(0.030)	0.032
Σ_{abs}	1	1.18047E-04	(0.163)	1.18100E-04	(0.171)	0.045
	2	8.27108E-05	(0.014)	8.27221E-05	(0.061)	0.014
	3	1.98639E-03	(0.041)	1.98853E-03	(0.043)	0.108
	4	4.83272E-03	(0.057)	4.83415E-03	(0.029)	0.030
Σ_{capt}	1	5.18913E-05	(0.341)	5.20627E-05	(0.331)	0.330
	2	5.32206E-05	(0.022)	5.32327E-05	(0.068)	0.023
	3	1.57996E-03	(0.051)	1.58174E-03	(0.051)	0.113
	4	1.01200E-03	(0.057)	1.01220E-03	(0.025)	0.019
Σ_{scatt}	1	1.37392E-01	(0.042)	1.37413E-01	(0.008)	0.016
	2	2.75935E-01	(0.014)	2.75932E-01	(0.004)	-0.001
	3	3.09273E-01	(0.014)	3.09264E-01	(0.003)	-0.003
	4	3.15402E-01	(0.057)	3.15365E-01	(0.003)	-0.012
$\nu\Sigma_{\text{fiss}}$	1	1.80741E-04	(0.050)	1.80394E-04	(0.153)	-0.192
	2	7.19529E-05	(0.014)	7.19466E-05	(0.057)	-0.009
	3	9.89183E-04	(0.022)	9.90074E-04	(0.054)	0.090
	4	9.30804E-03	(0.057)	9.31103E-03	(0.030)	0.032
$\overline{\nu}$	1	2.73206E+00	(0.057)	2.73157E+00	(0.051)	-0.018
	2	2.43989E+00	(0.014)	2.43975E+00	(0.005)	-0.006
	3	2.43386E+00	(0.028)	2.43386E+00	(0.000)	0.000
	4	2.43621E+00	(0.057)	2.43620E+00	(0.000)	-0.000
$1/v$	1	5.69086E-10	(0.042)	5.69184E-10	(0.006)	0.017
	2	3.39245E-09	(0.014)	3.39240E-09	(0.004)	-0.002
	3	1.83203E-07	(0.022)	1.83206E-07	(0.012)	0.002
	4	2.13723E-06	(0.057)	2.13706E-06	(0.009)	-0.008

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	1.37344E-01	(0.042)	1.37354E-01	(0.008)	0.007
	2	2.75871E-01	(0.014)	2.75891E-01	(0.004)	0.007
	3	3.11216E-01	(0.014)	3.11213E-01	(0.003)	-0.001
	4	3.20422E-01	(0.057)	3.20383E-01	(0.004)	-0.012
Σ_{fiss}	1	6.46923E-05	(0.050)	6.47685E-05	(0.150)	0.118
	2	2.86857E-05	(0.014)	2.86812E-05	(0.056)	-0.016
	3	3.94240E-04	(0.022)	3.94203E-04	(0.058)	-0.009
	4	3.65286E-03	(0.057)	3.65272E-03	(0.035)	-0.004
Σ_{abs}	1	1.16805E-04	(0.163)	1.16558E-04	(0.165)	-0.211
	2	8.32725E-05	(0.014)	8.32655E-05	(0.061)	-0.008
	3	2.08602E-03	(0.041)	2.08684E-03	(0.041)	0.039
	4	5.94036E-03	(0.057)	5.94256E-03	(0.030)	0.037
Σ_{capt}	1	5.21126E-05	(0.341)	5.17898E-05	(0.317)	-0.619
	2	5.45868E-05	(0.014)	5.45842E-05	(0.067)	-0.005
	3	1.69177E-03	(0.041)	1.69263E-03	(0.046)	0.051
	4	2.28750E-03	(0.064)	2.28983E-03	(0.043)	0.102
Σ_{scatt}	1	1.37227E-01	(0.042)	1.37237E-01	(0.008)	0.007
	2	2.75788E-01	(0.014)	2.75808E-01	(0.004)	0.007
	3	3.09130E-01	(0.014)	3.09126E-01	(0.003)	-0.001
	4	3.14482E-01	(0.057)	3.14440E-01	(0.004)	-0.013
$\nu\Sigma_{\text{fiss}}$	1	1.76760E-04	(0.050)	1.76998E-04	(0.163)	0.134
	2	6.99903E-05	(0.014)	6.99788E-05	(0.056)	-0.016
	3	9.59520E-04	(0.022)	9.59431E-04	(0.058)	-0.009
	4	8.89909E-03	(0.057)	8.89876E-03	(0.035)	-0.004
$\overline{\nu}$	1	2.73233E+00	(0.057)	2.73271E+00	(0.053)	0.014
	2	2.43991E+00	(0.014)	2.43988E+00	(0.005)	-0.001
	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
$1/v$	1	5.69084E-10	(0.042)	5.69112E-10	(0.007)	0.005
	2	3.39200E-09	(0.014)	3.39194E-09	(0.004)	-0.002
	3	1.81836E-07	(0.022)	1.81840E-07	(0.012)	0.002
	4	2.08837E-06	(0.057)	2.08750E-06	(0.010)	-0.042

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	9.68945E-02	(0.042)	9.68910E-02	(0.012)	-0.004
	2	1.94204E-01	(0.014)	1.94215E-01	(0.006)	0.006
	3	2.18662E-01	(0.014)	2.18653E-01	(0.005)	-0.004
	4	2.24345E-01	(0.057)	2.24284E-01	(0.005)	-0.027
Σ_{fiss}	1	4.43033E-05	(0.050)	4.42834E-05	(0.146)	-0.045
	2	1.63865E-05	(0.014)	1.63994E-05	(0.059)	0.079
	3	2.27288E-04	(0.022)	2.27254E-04	(0.058)	-0.015
	4	2.18389E-03	(0.057)	2.18415E-03	(0.029)	0.012
Σ_{abs}	1	8.00572E-05	(0.163)	8.00524E-05	(0.168)	-0.006
	2	5.30223E-05	(0.014)	5.30772E-05	(0.064)	0.103
	3	1.31252E-03	(0.041)	1.31317E-03	(0.044)	0.050
	4	2.79482E-03	(0.057)	2.79511E-03	(0.028)	0.010
Σ_{capt}	1	3.57538E-05	(0.351)	3.57690E-05	(0.317)	0.043
	2	3.66359E-05	(0.022)	3.66778E-05	(0.070)	0.114
	3	1.08523E-03	(0.051)	1.08591E-03	(0.050)	0.062
	4	6.10934E-04	(0.057)	6.10960E-04	(0.024)	0.004
Σ_{scatt}	1	9.68144E-02	(0.042)	9.68109E-02	(0.013)	-0.004
	2	1.94151E-01	(0.014)	1.94162E-01	(0.006)	0.006
	3	2.17350E-01	(0.014)	2.17339E-01	(0.005)	-0.005
	4	2.21550E-01	(0.057)	2.21489E-01	(0.005)	-0.028
$\nu\Sigma_{\mathrm{fiss}}$	1	1.21283E-04	(0.050)	1.21279E-04	(0.158)	-0.003
	2	3.99817E-05	(0.014)	4.00168E-05	(0.059)	0.088
	3	5.53185E-04	(0.022)	5.53105E-04	(0.058)	-0.015
	4	5.32039E-03	(0.057)	5.32102E-03	(0.029)	0.012
$\overline{\nu}$	1	2.73756E+00	(0.057)	2.73863E+00	(0.052)	0.039
	2	2.43992E+00	(0.014)	2.44014E+00	(0.005)	0.009
	3	2.43385E+00	(0.028)	2.43386E+00	(0.000)	0.000
	4	2.43620E+00	(0.057)	2.43620E+00	(0.000)	0.000
$1/v$	1	5.69619E-10	(0.042)	5.69720E-10	(0.006)	0.018
	2	3.39161E-09	(0.014)	3.39209E-09	(0.006)	0.014
	3	1.85172E-07	(0.022)	1.85135E-07	(0.013)	-0.020
	4	2.18412E-06	(0.057)	2.18341E-06	(0.008)	-0.033

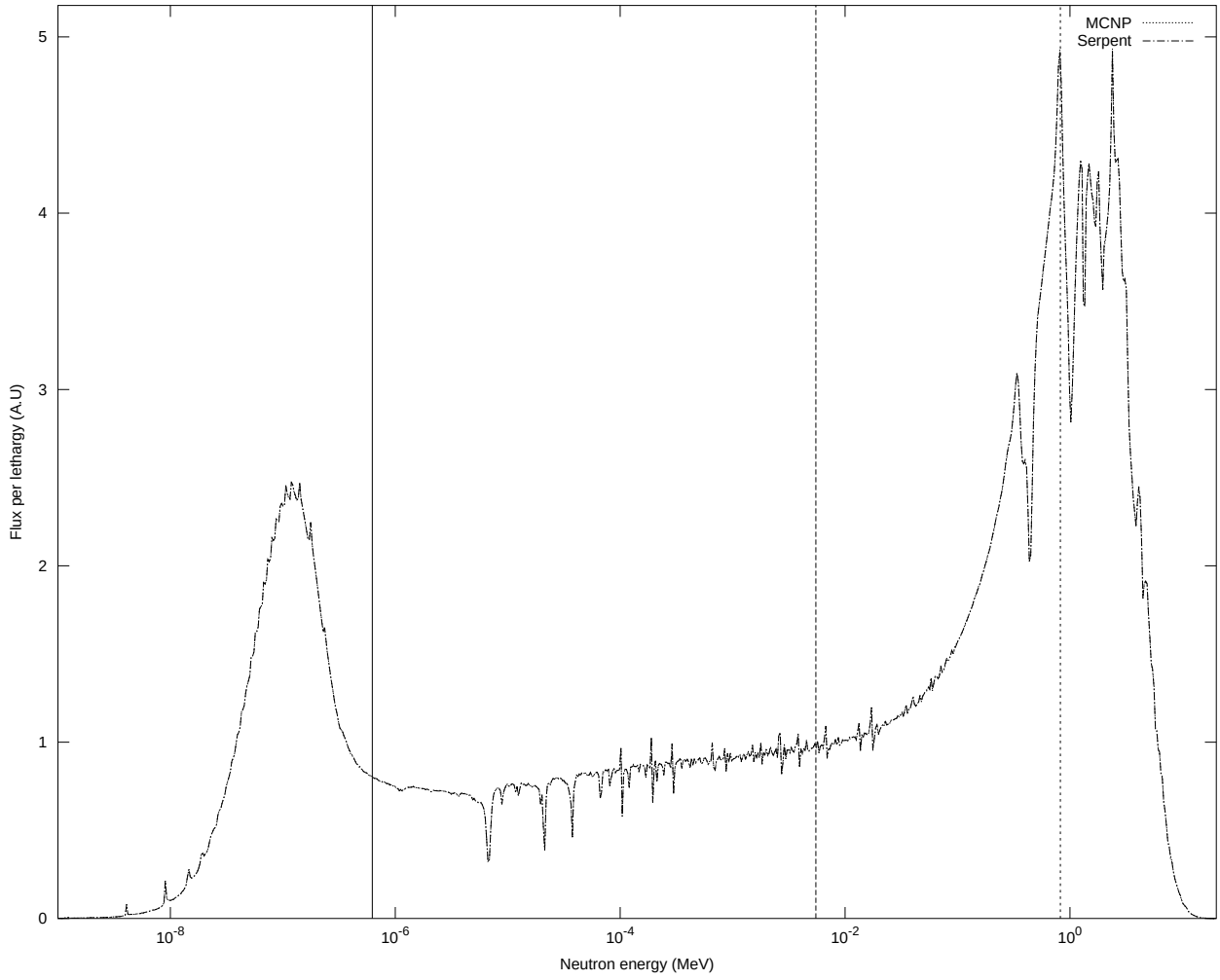

Figure 1. *Flux spectra integrated over the entire geometry PWR pin-cell, 1 MWd/kgU burnup.*

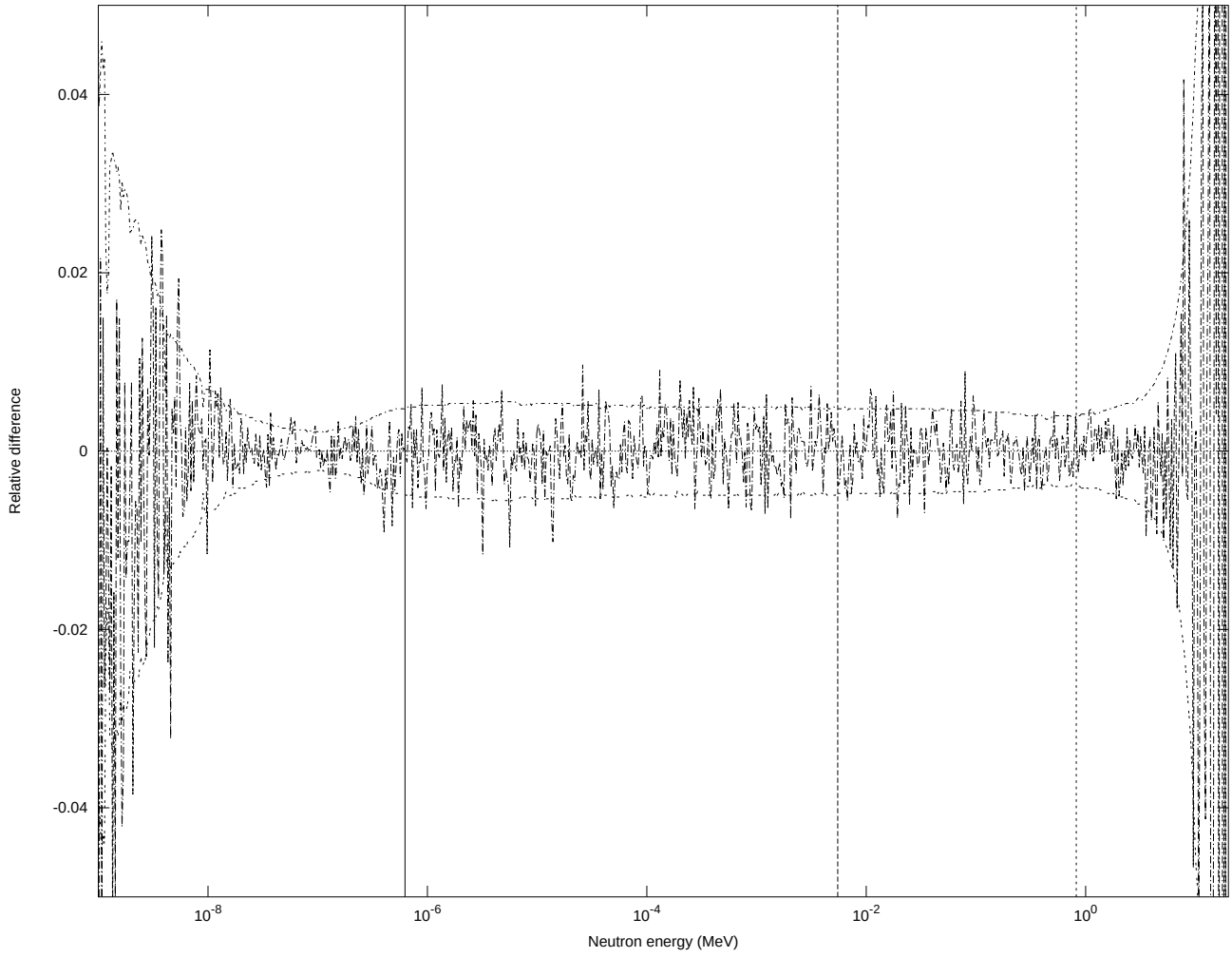

Figure 2. *Relative differences between the two spectra Figure 1.*

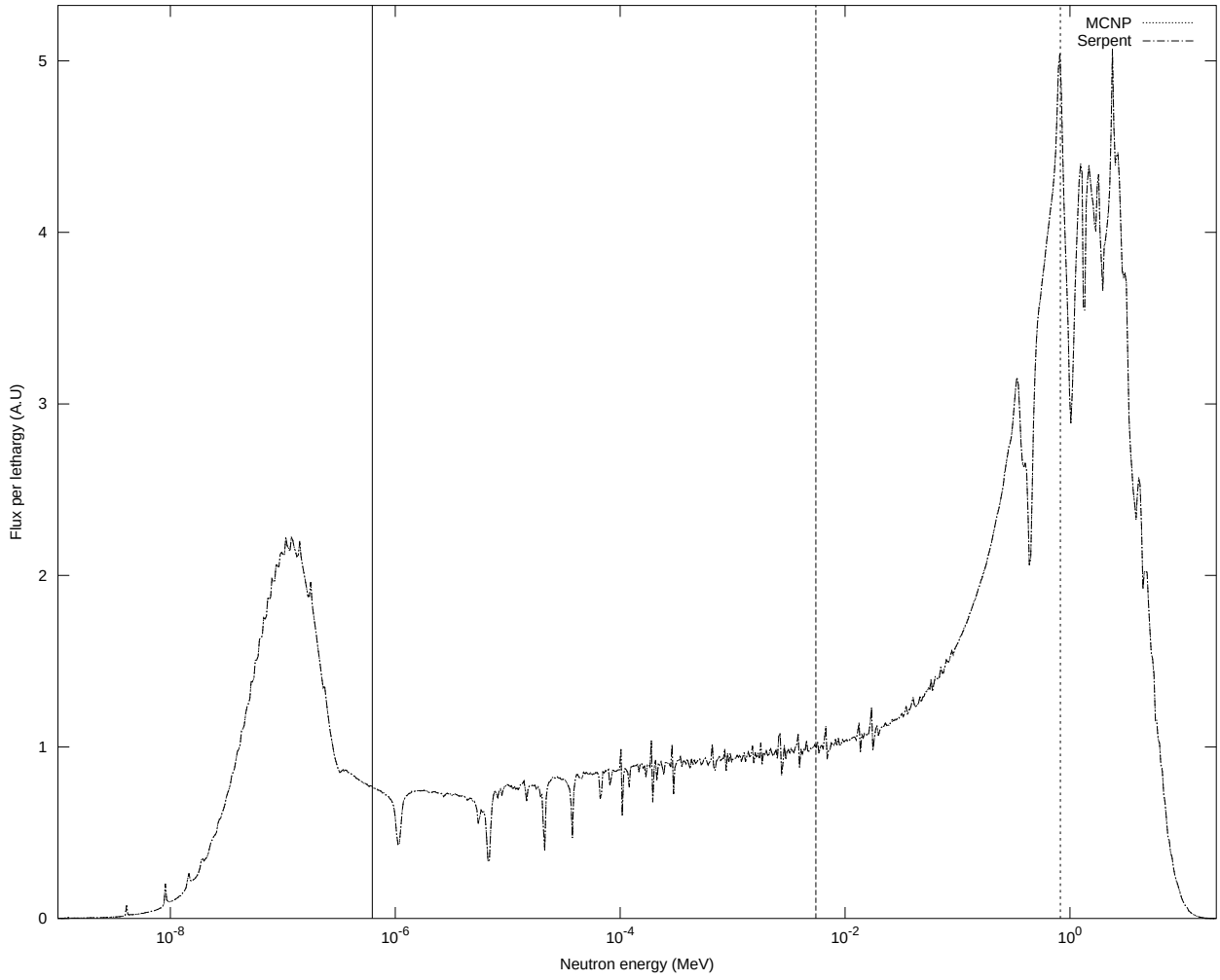

Figure 3. *Flux spectra integrated over the entire geometry PWR pin-cell, 20 MWd/kgU burnup.*

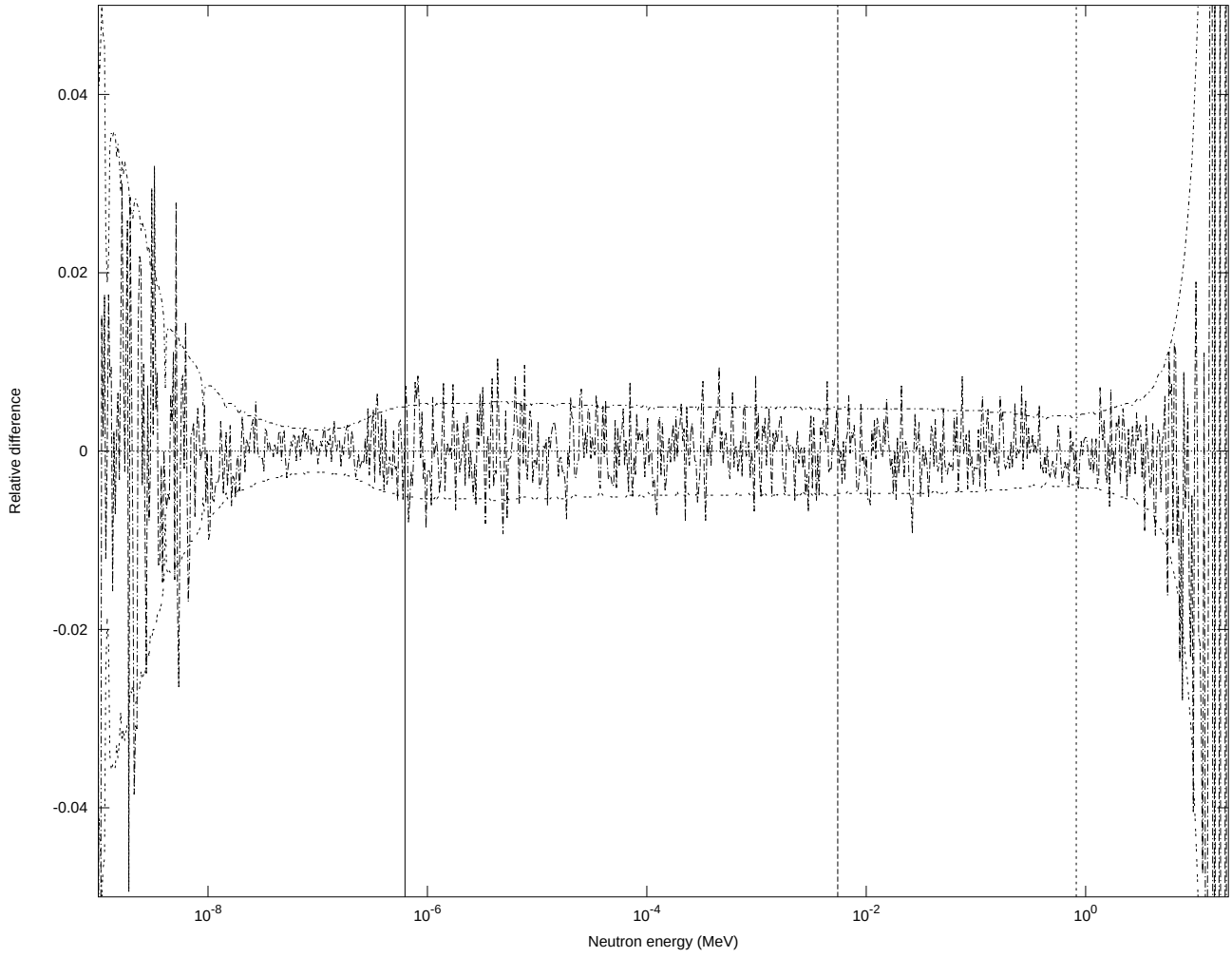

Figure 4. *Relative differences between the two spectra Figure 3.*

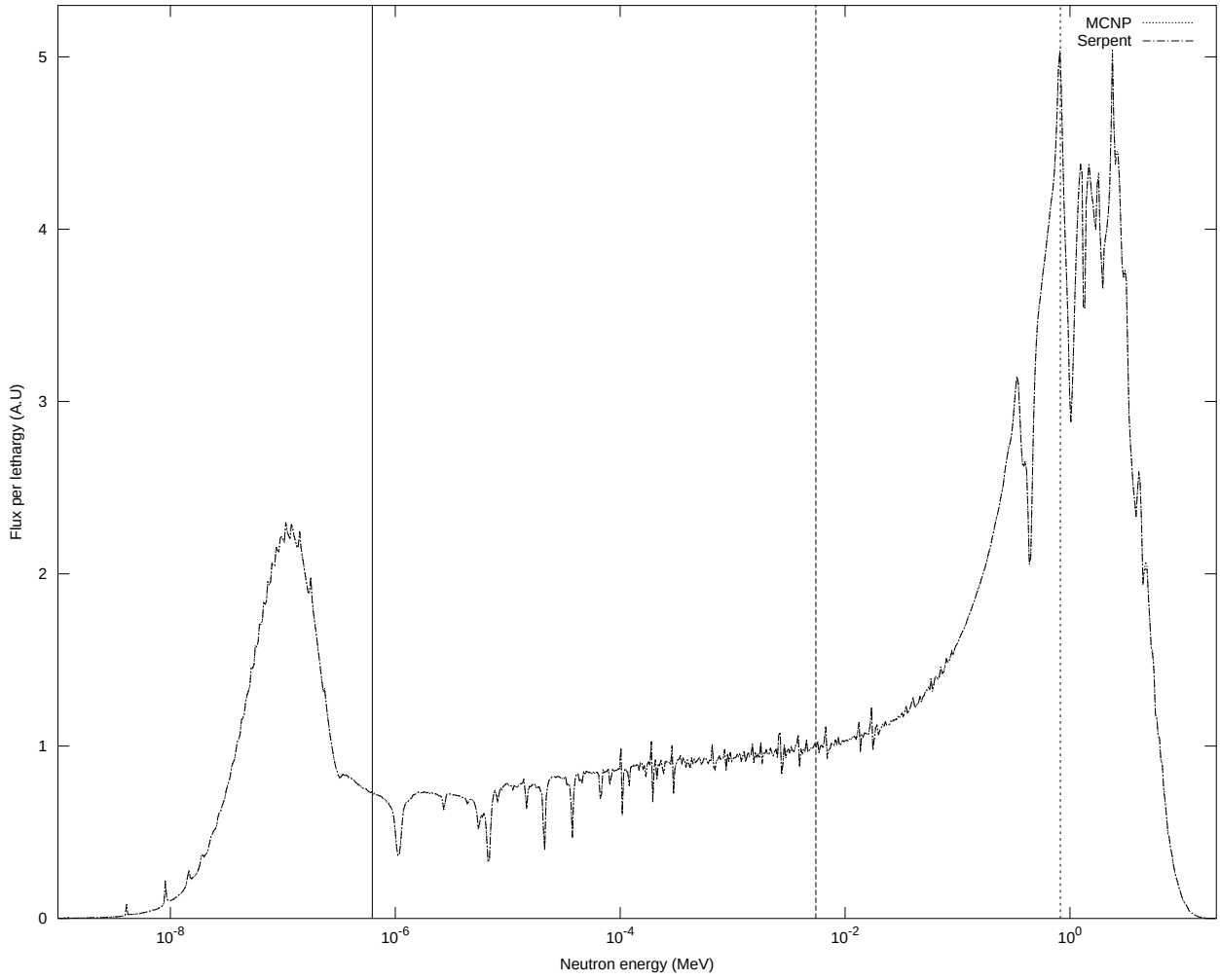

Figure 5. *Flux spectra integrated over the entire geometry PWR pin-cell, 40 MWd/kgU burnup.*

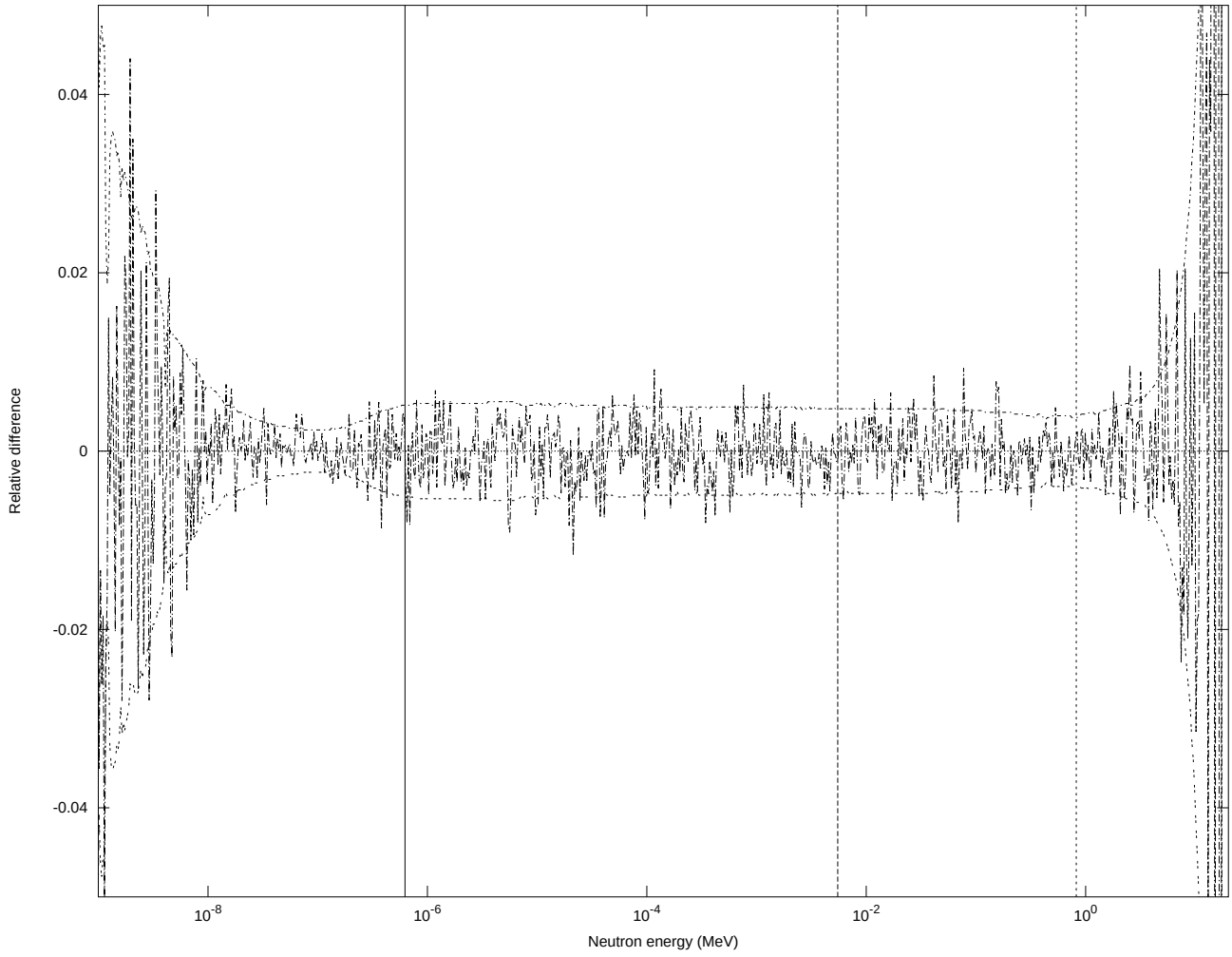

Figure 6. *Relative differences between the two spectra Figure 5.*

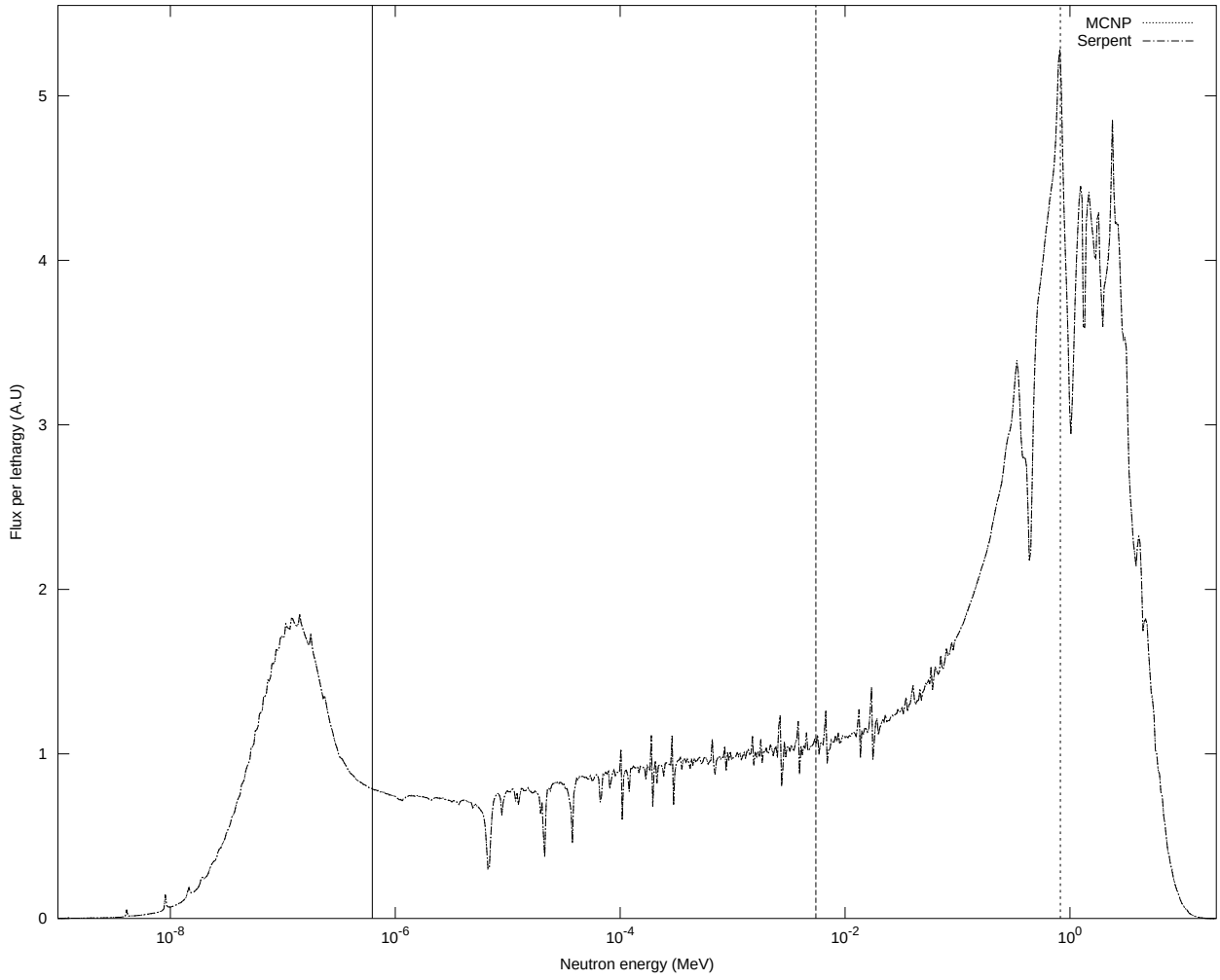

Figure 7. *Flux spectra integrated over the entire geometry VVER-440 assembly.*

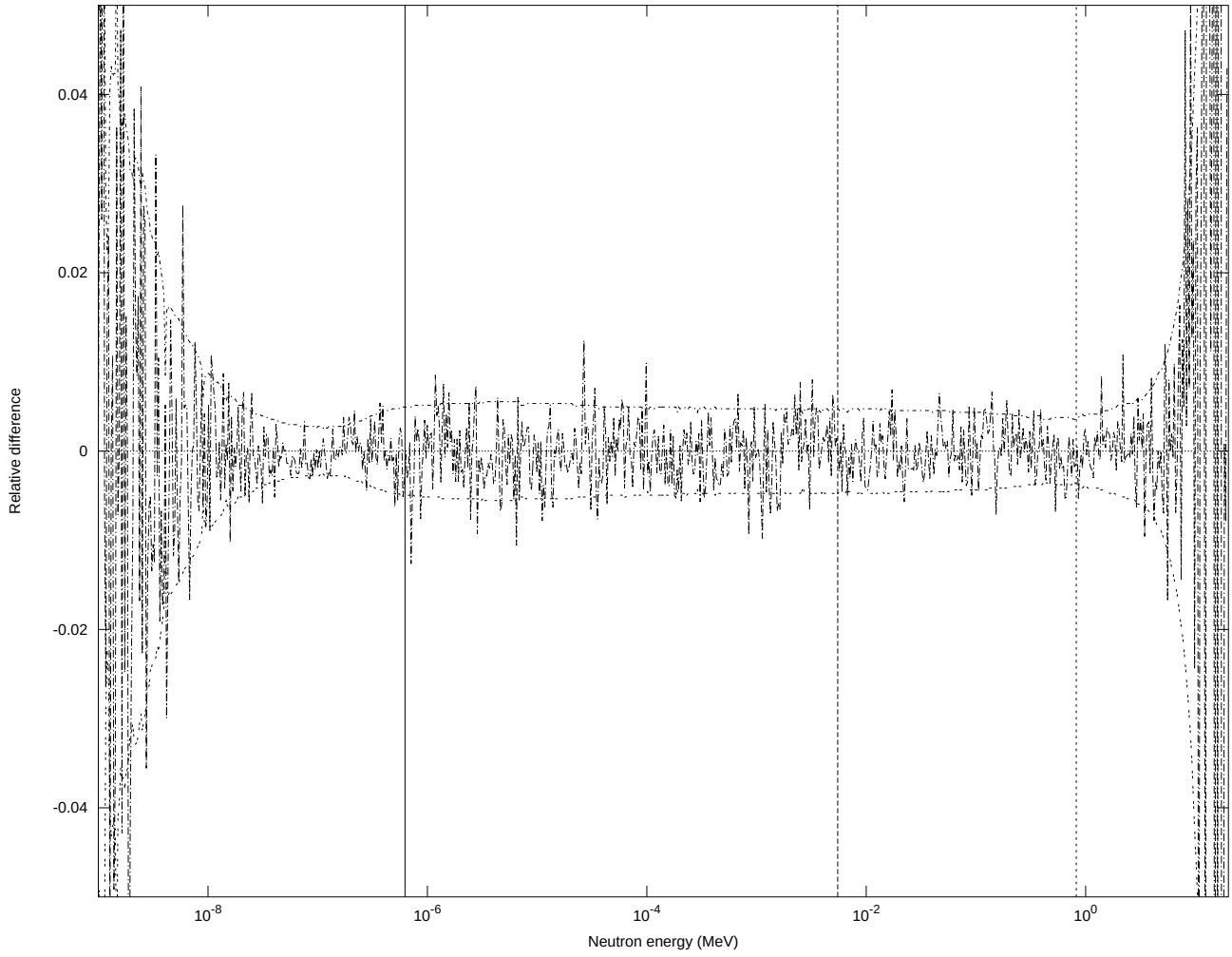

Figure 8. *Relative differences between the two spectra Figure 7.*

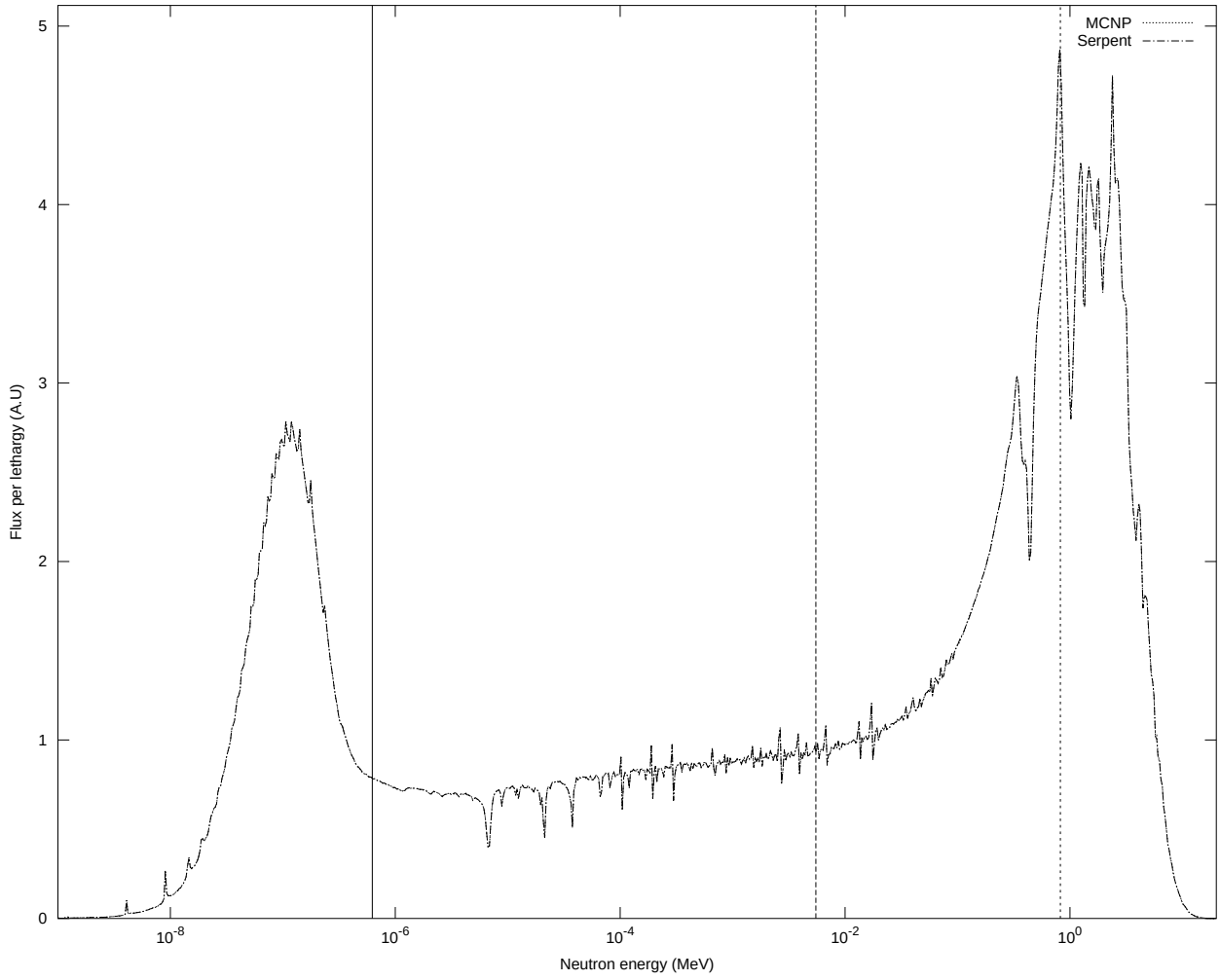

Figure 9. *Flux spectra integrated over the entire geometry BWR+Gd Assembly, 25% void fraction.*

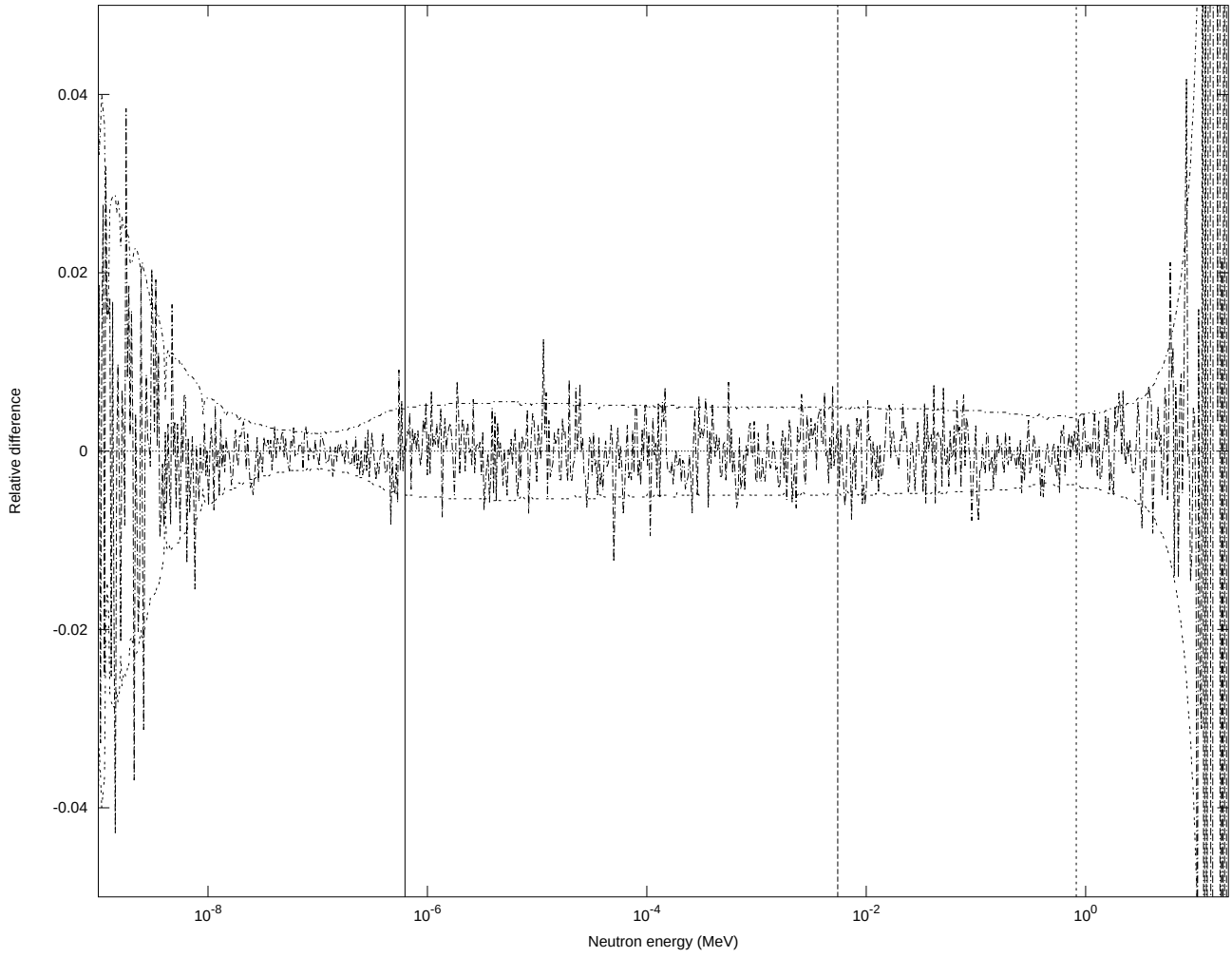

Figure 10. *Relative differences between the two spectra Figure 9.*

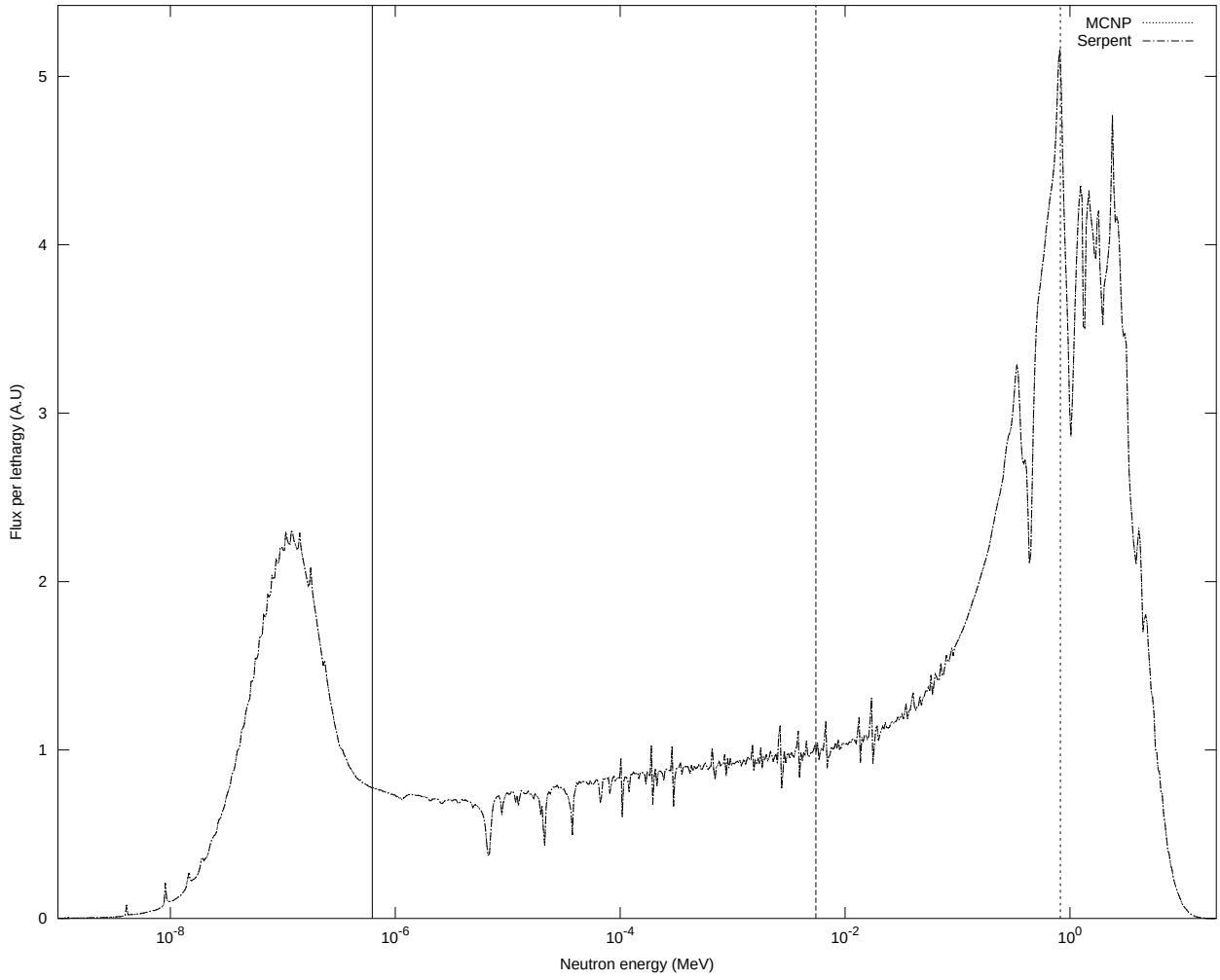

Figure 11. *Flux spectra integrated over the entire geometry BWR+Gd Assembly, 50% void fraction.*

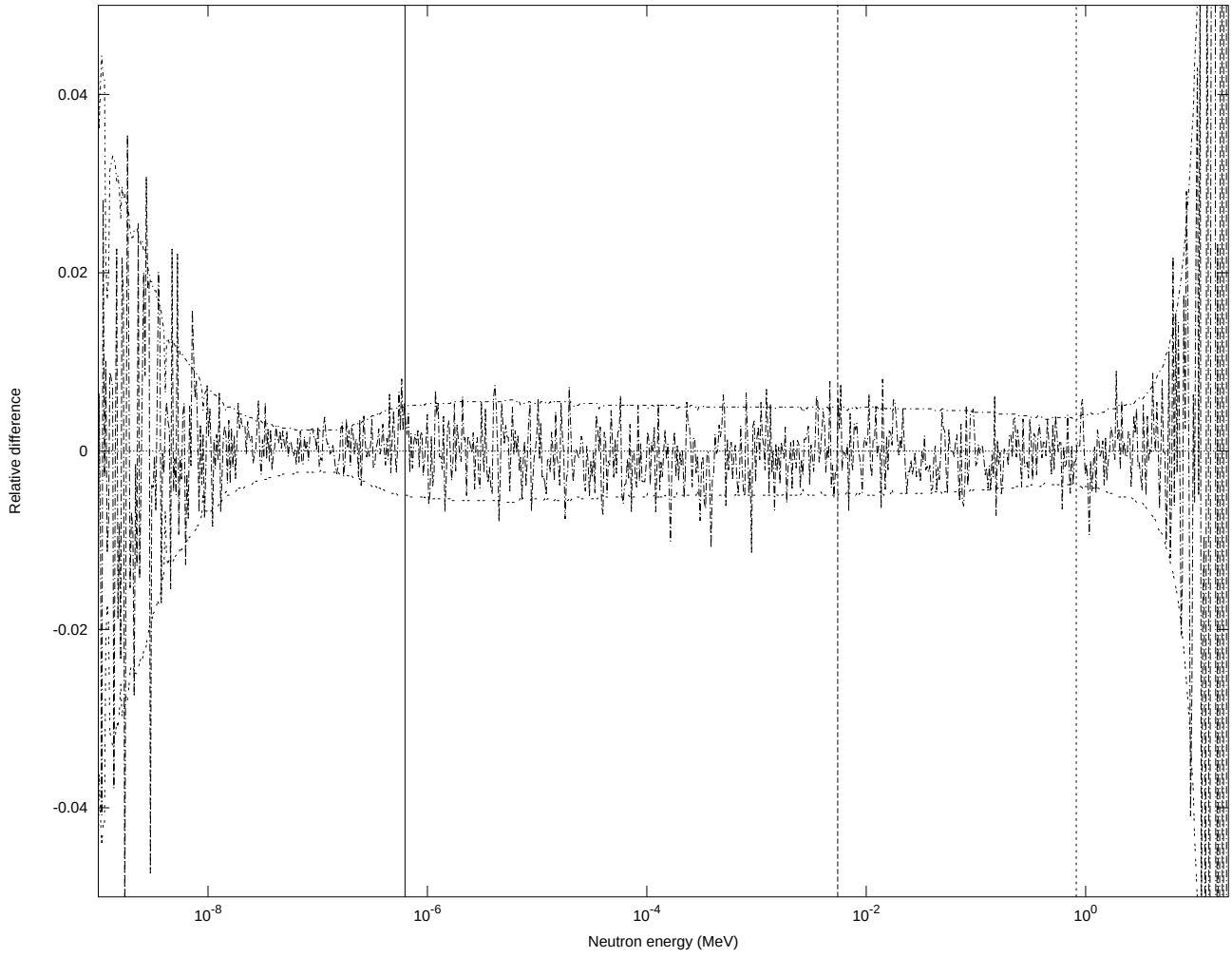

Figure 12. *Relative differences between the two spectra Figure 11.*

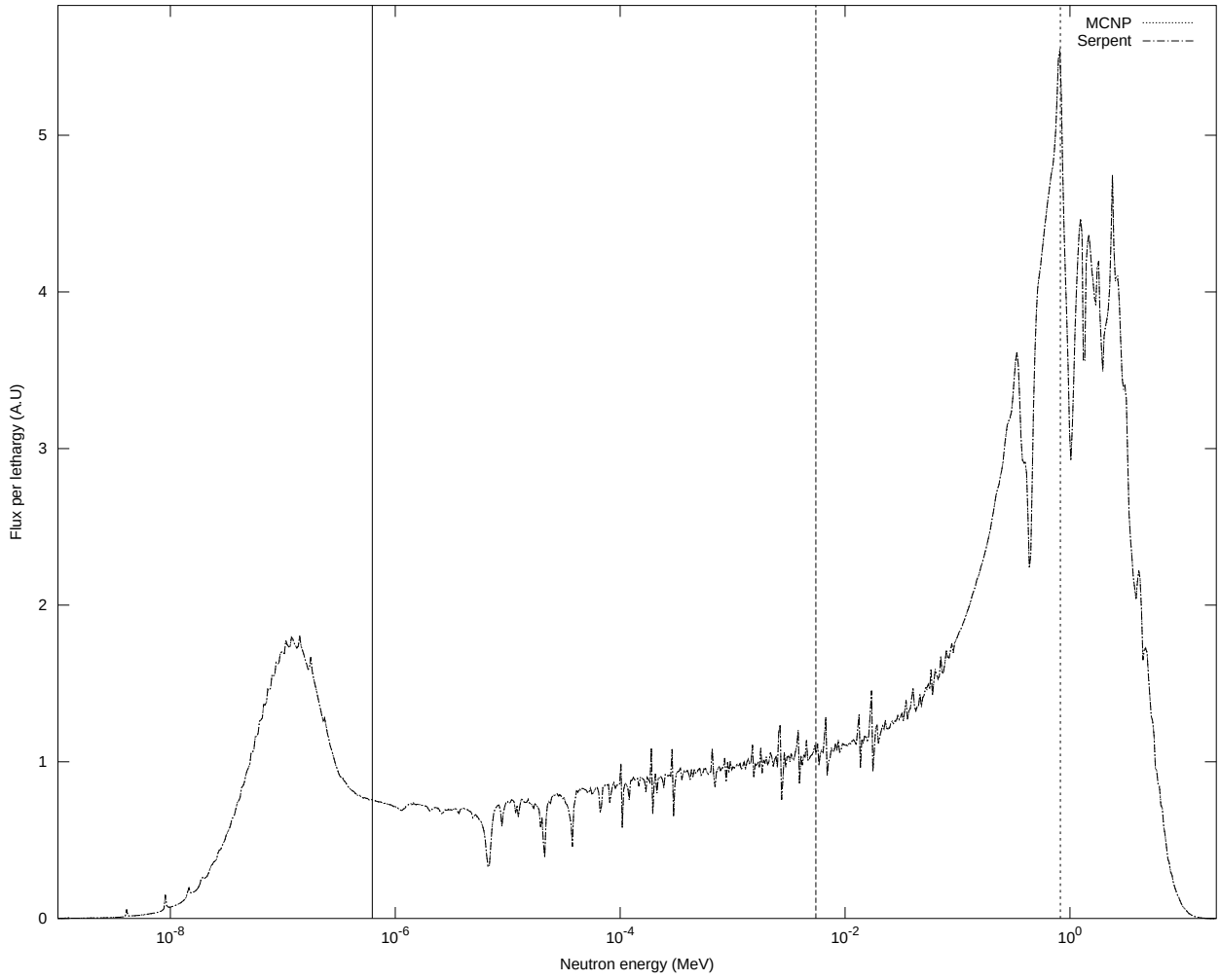

Figure 13. *Flux spectra integrated over the entire geometry BWR+Gd Assembly, 75% void fraction.*

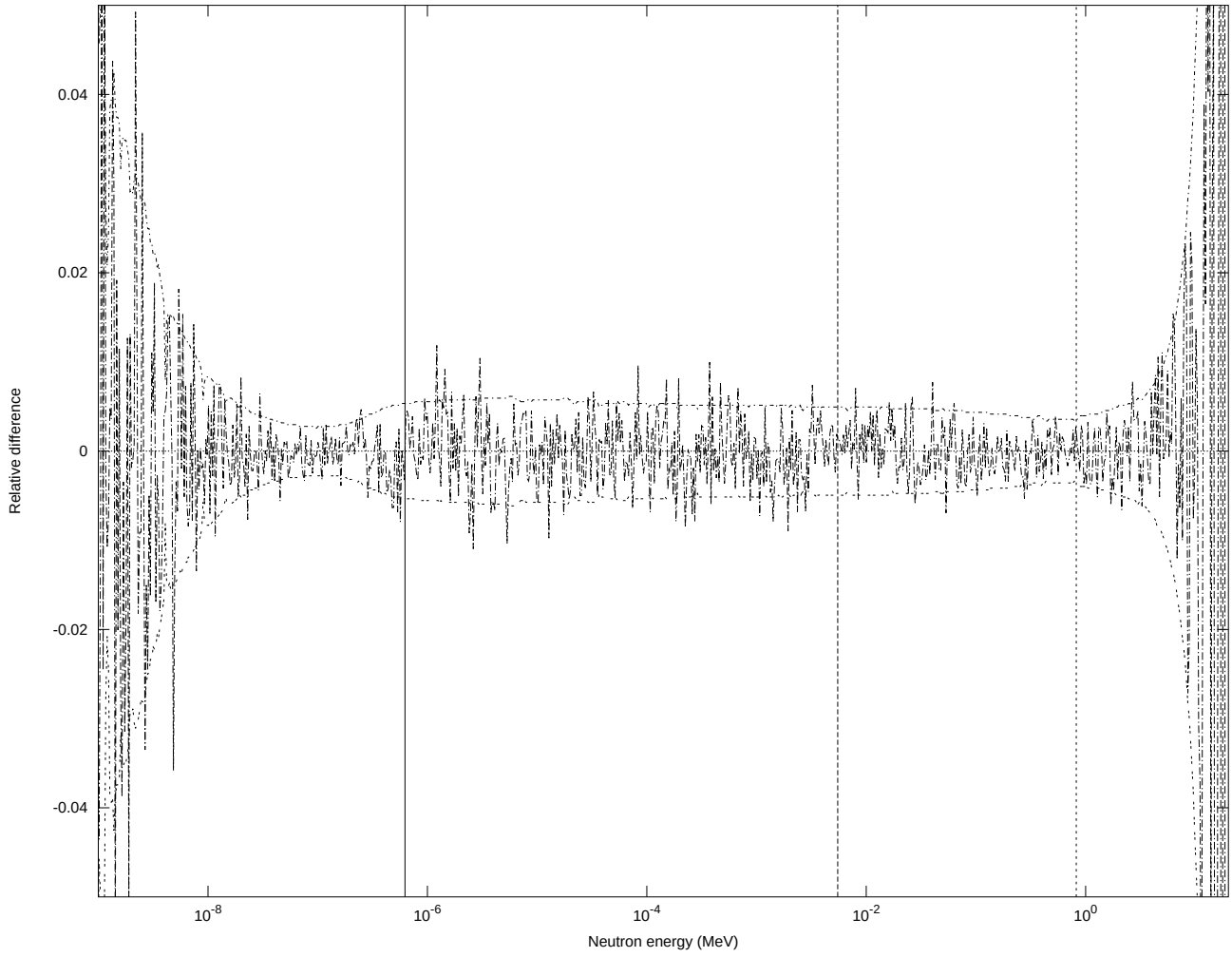

Figure 14. *Relative differences between the two spectra Figure 13.*

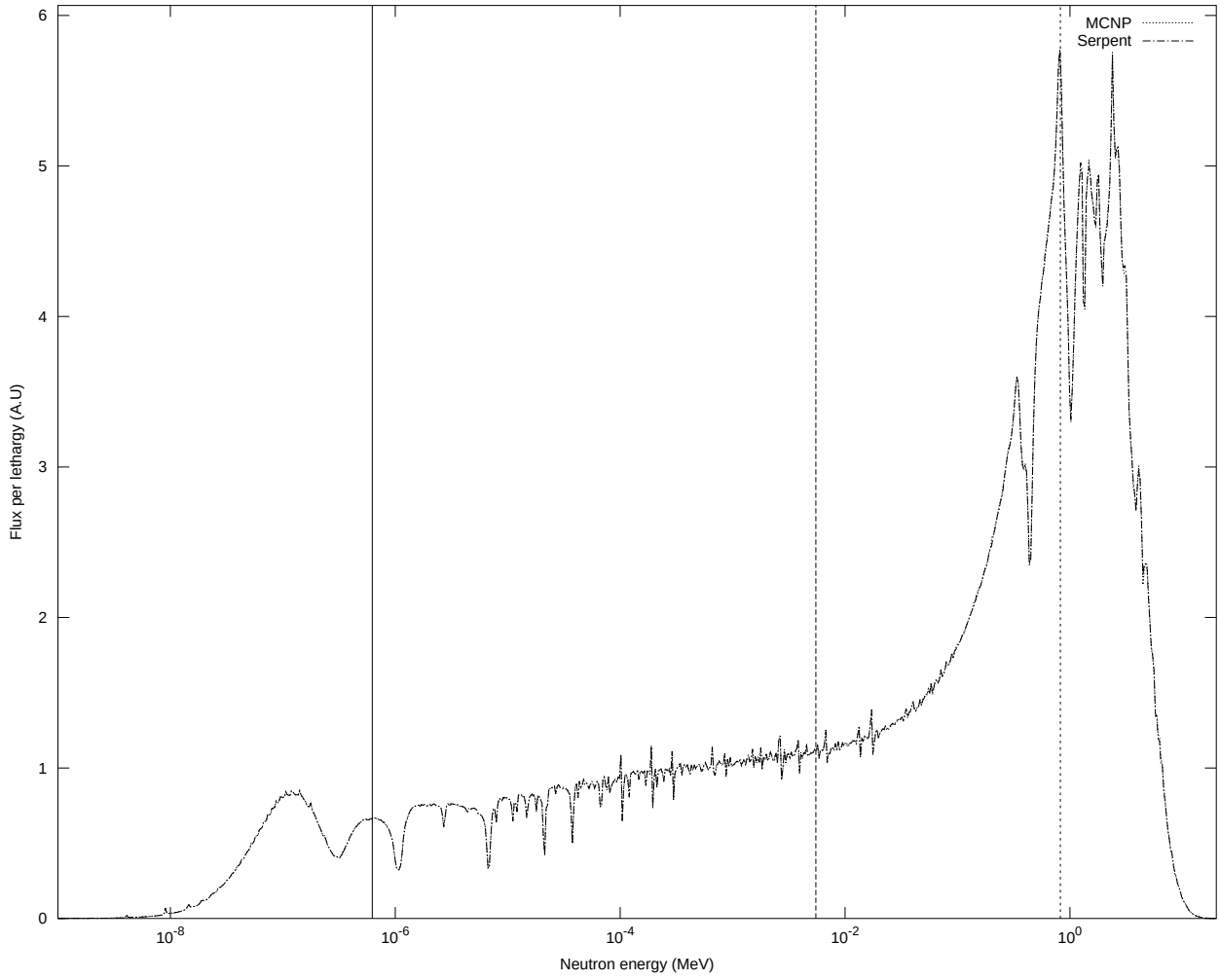

Figure 15. *Flux spectra integrated over the entire geometry Mixed PWR MOX/UOX lattice.*

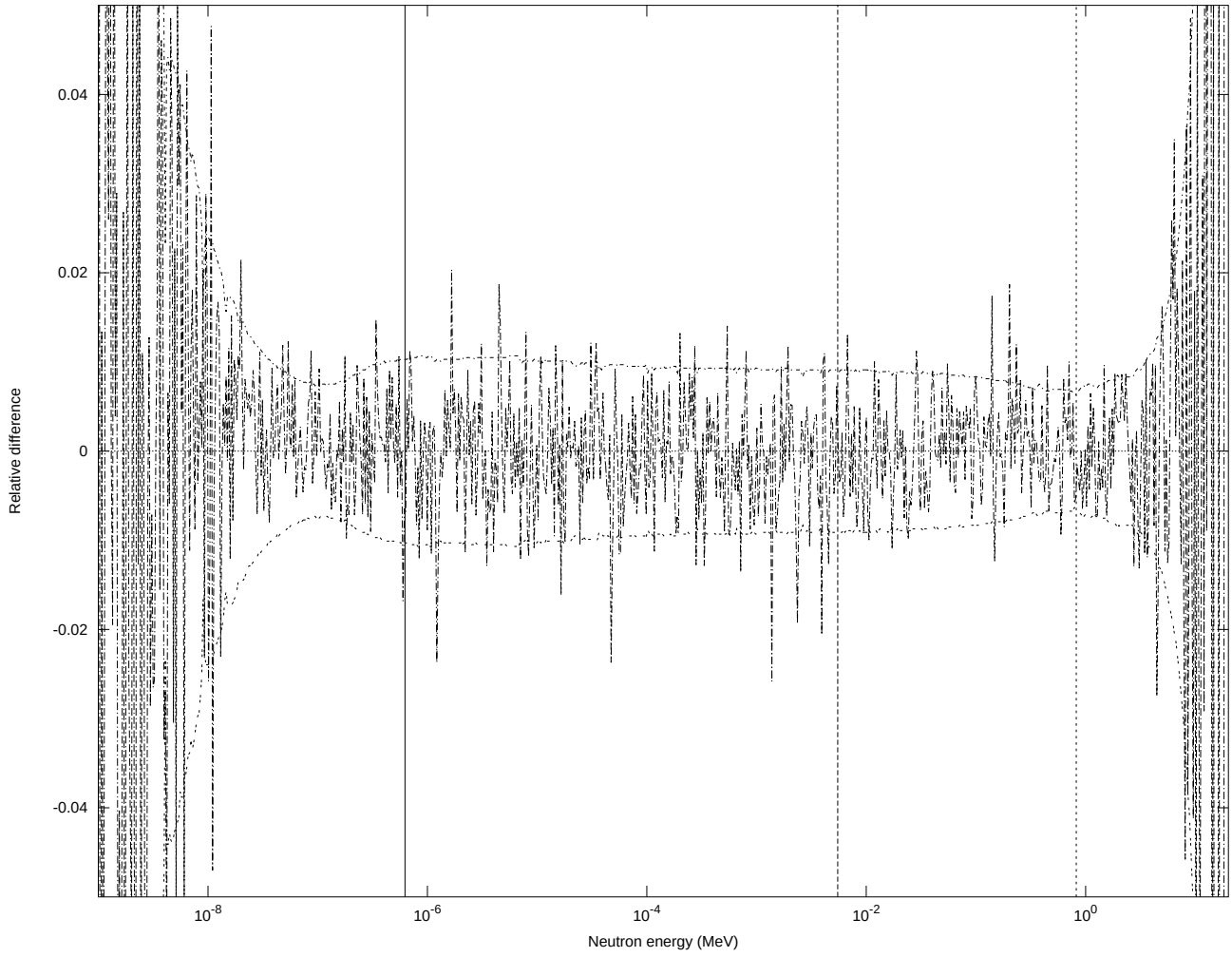

Figure 16. *Relative differences between the two spectra Figure 15.*

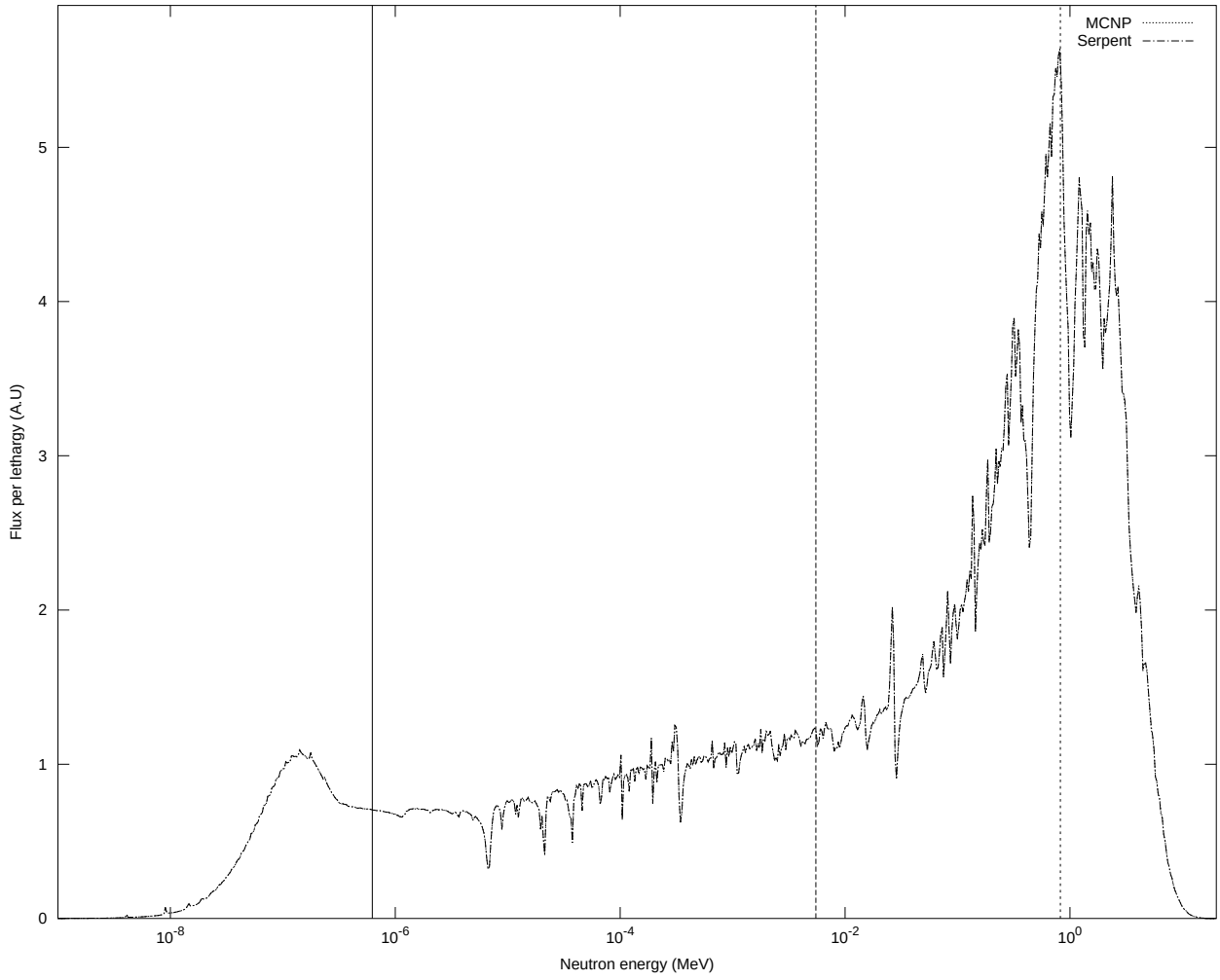

Figure 17. *Flux spectra integrated over the entire geometry SCWR assembly.*

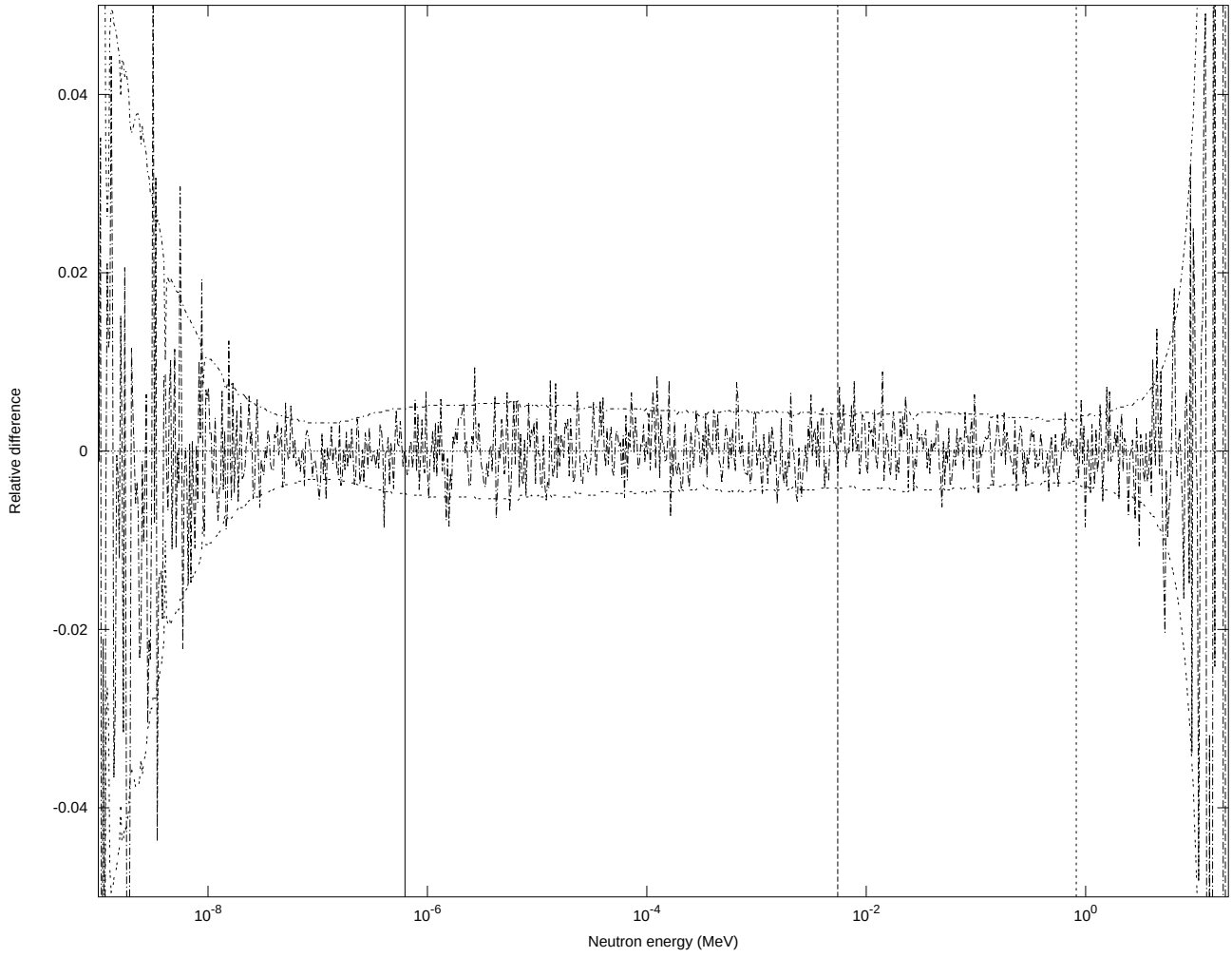

Figure 18. *Relative differences between the two spectra Figure 17.*

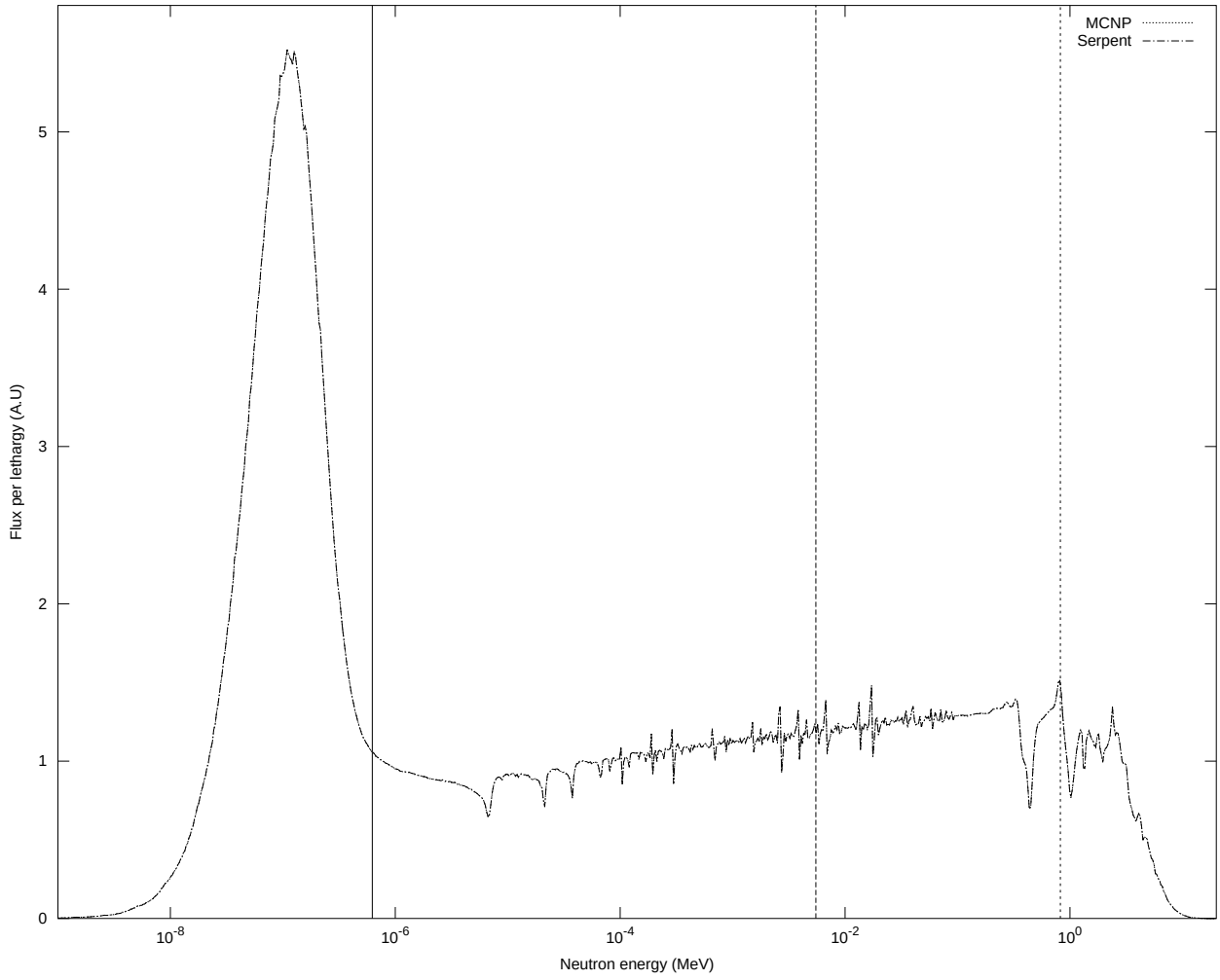

Figure 19. *Flux spectra integrated over the entire geometry CANDU fuel cluster.*

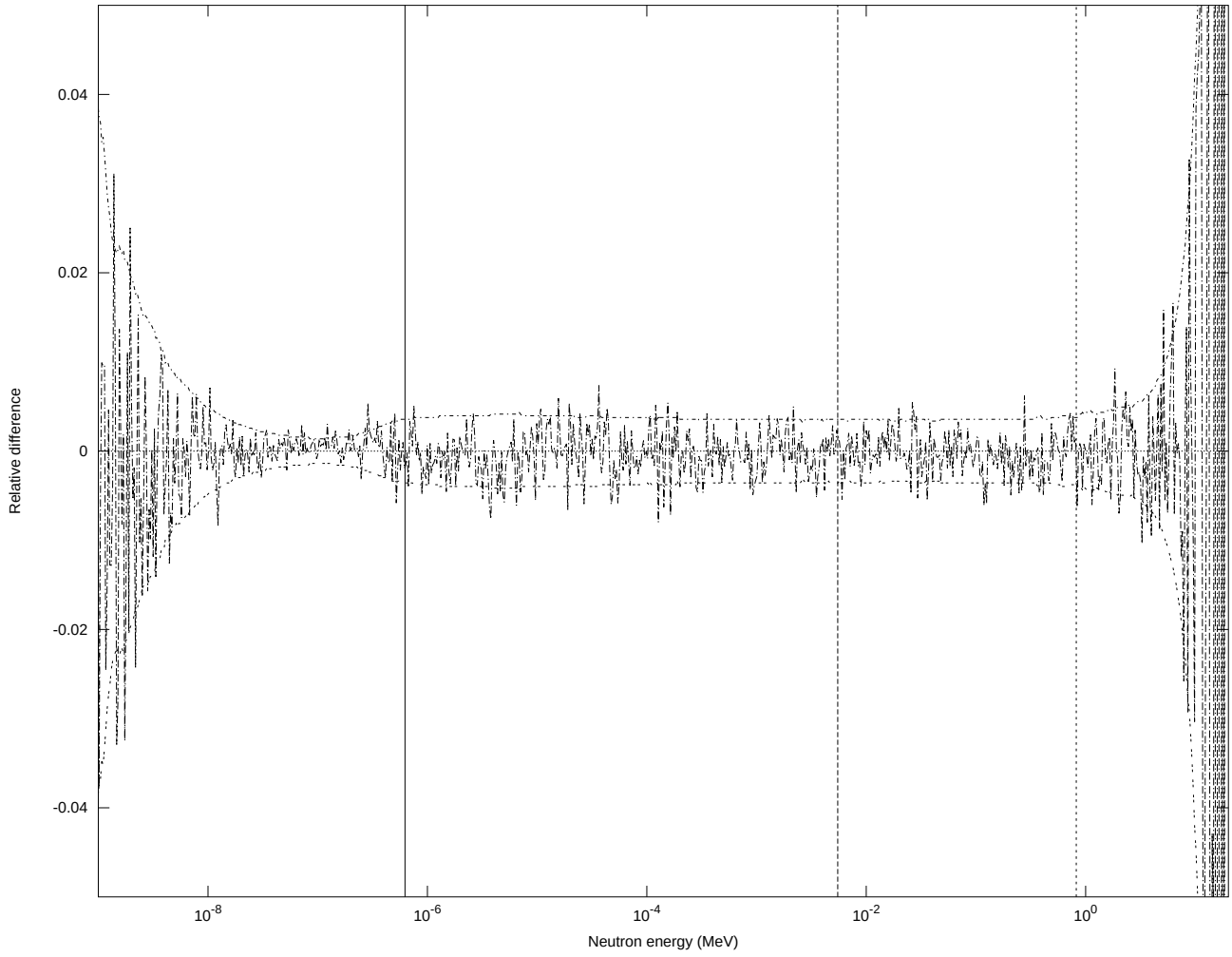

Figure 20. *Relative differences between the two spectra Figure 19.*

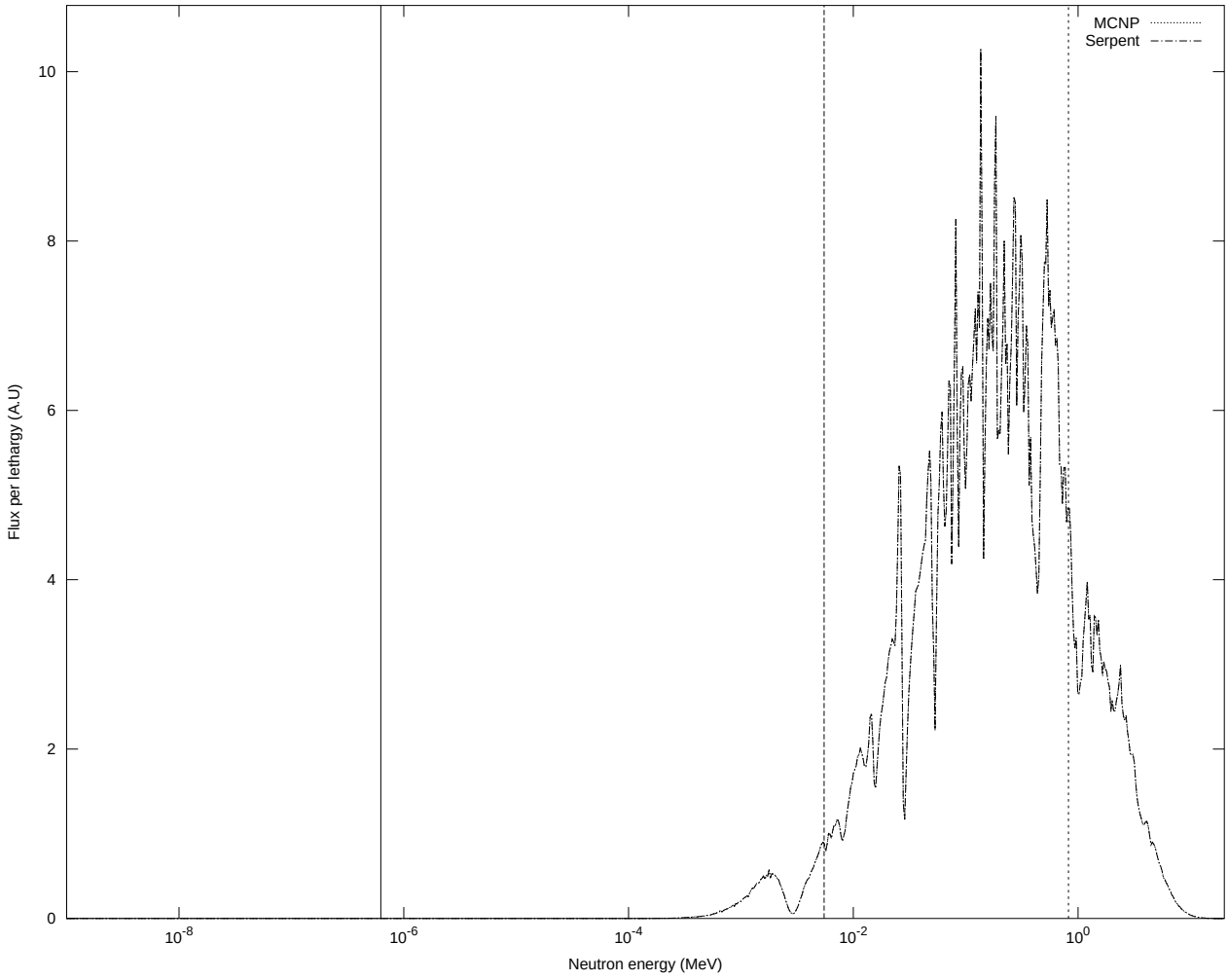

Figure 21. *Flux spectra integrated over the entire geometry SFR assembly.*

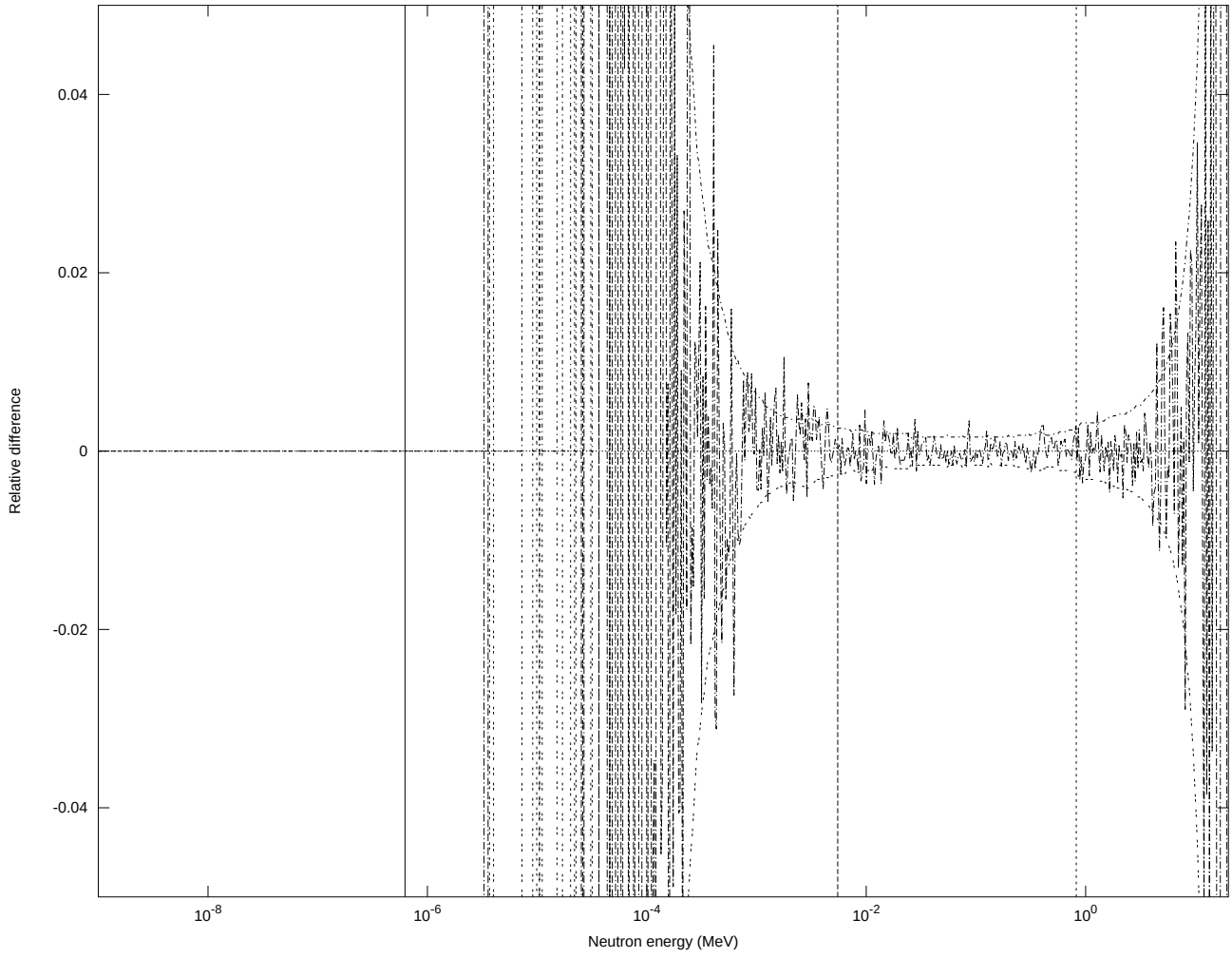

Figure 22. *Relative differences between the two spectra Figure 21.*

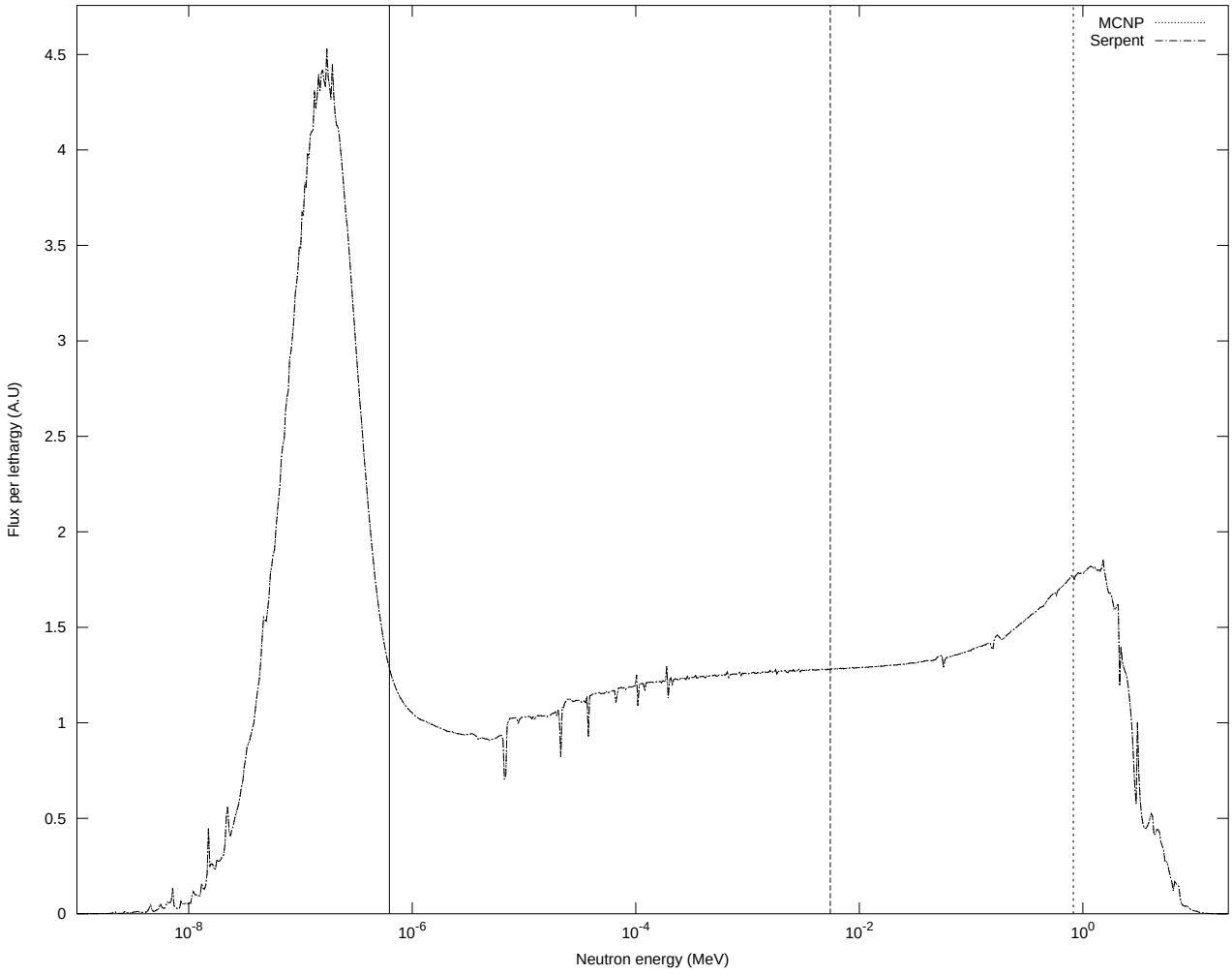

Figure 23. *Flux spectra integrated over the entire geometry Prismatic HTGR fuel block.*

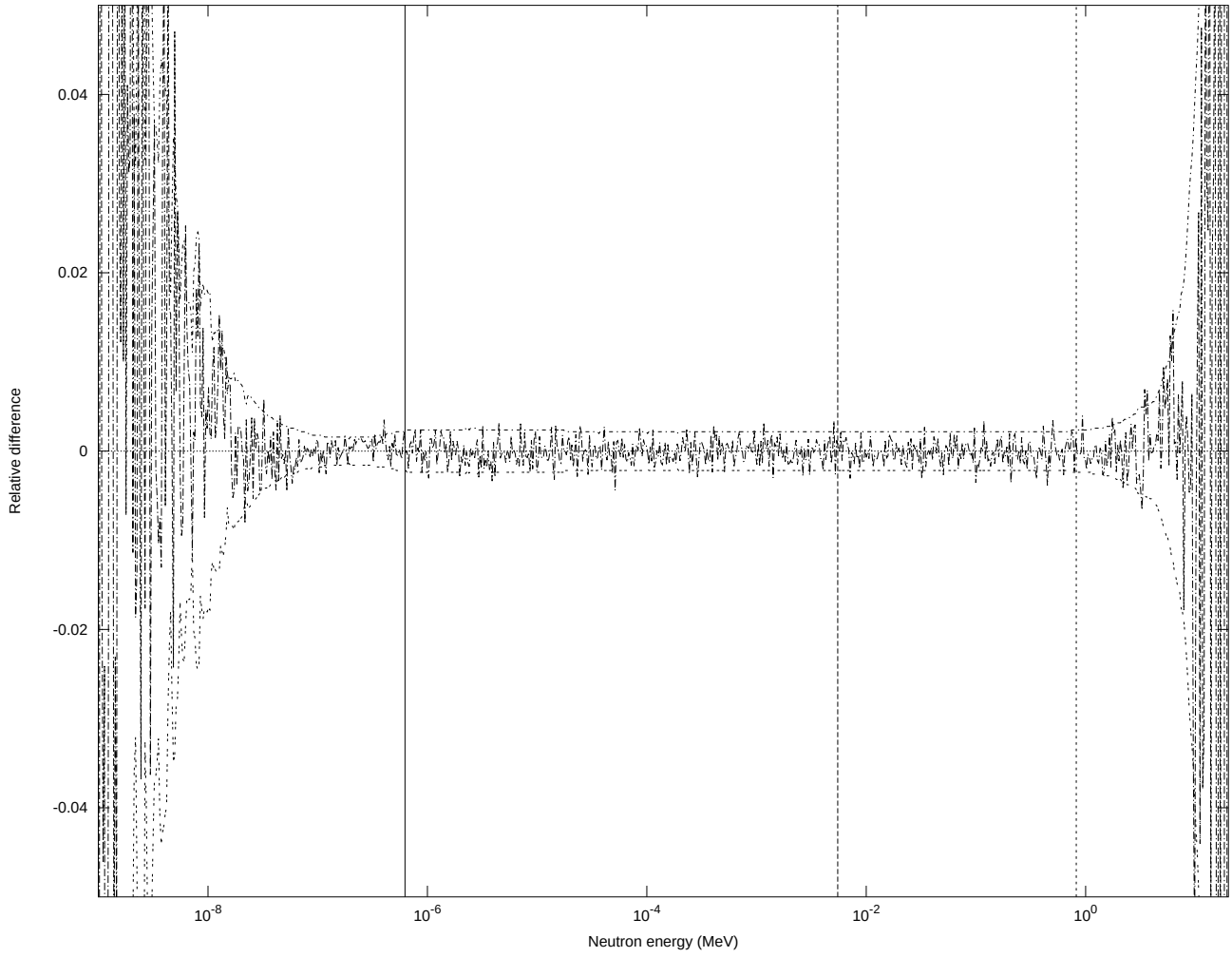

Figure 24. *Relative differences between the two spectra Figure 23.*

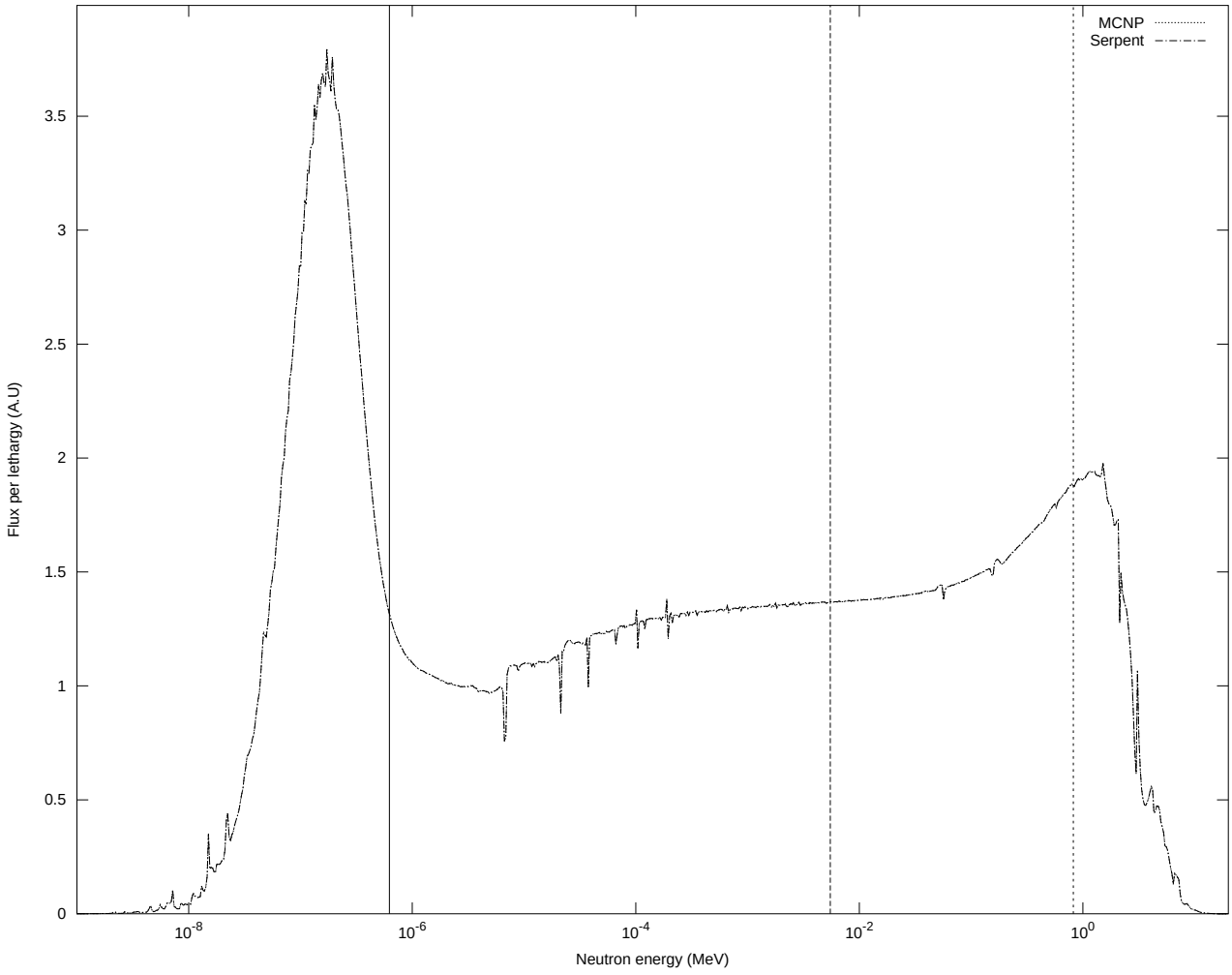

Figure 25. *Flux spectra integrated over the entire geometry Prismatic HTGR fuel block + BP.*

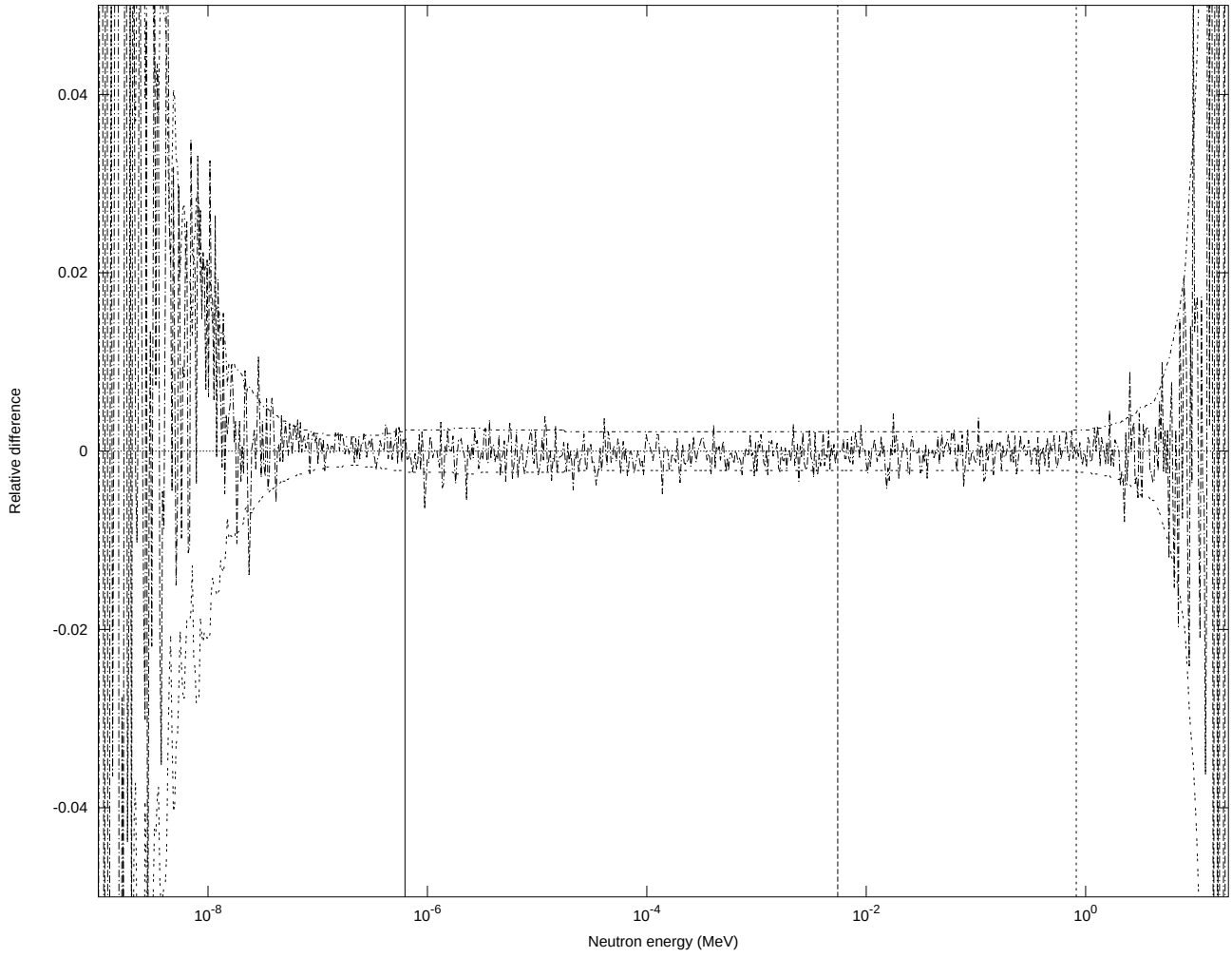

Figure 26. *Relative differences between the two spectra Figure 25.*

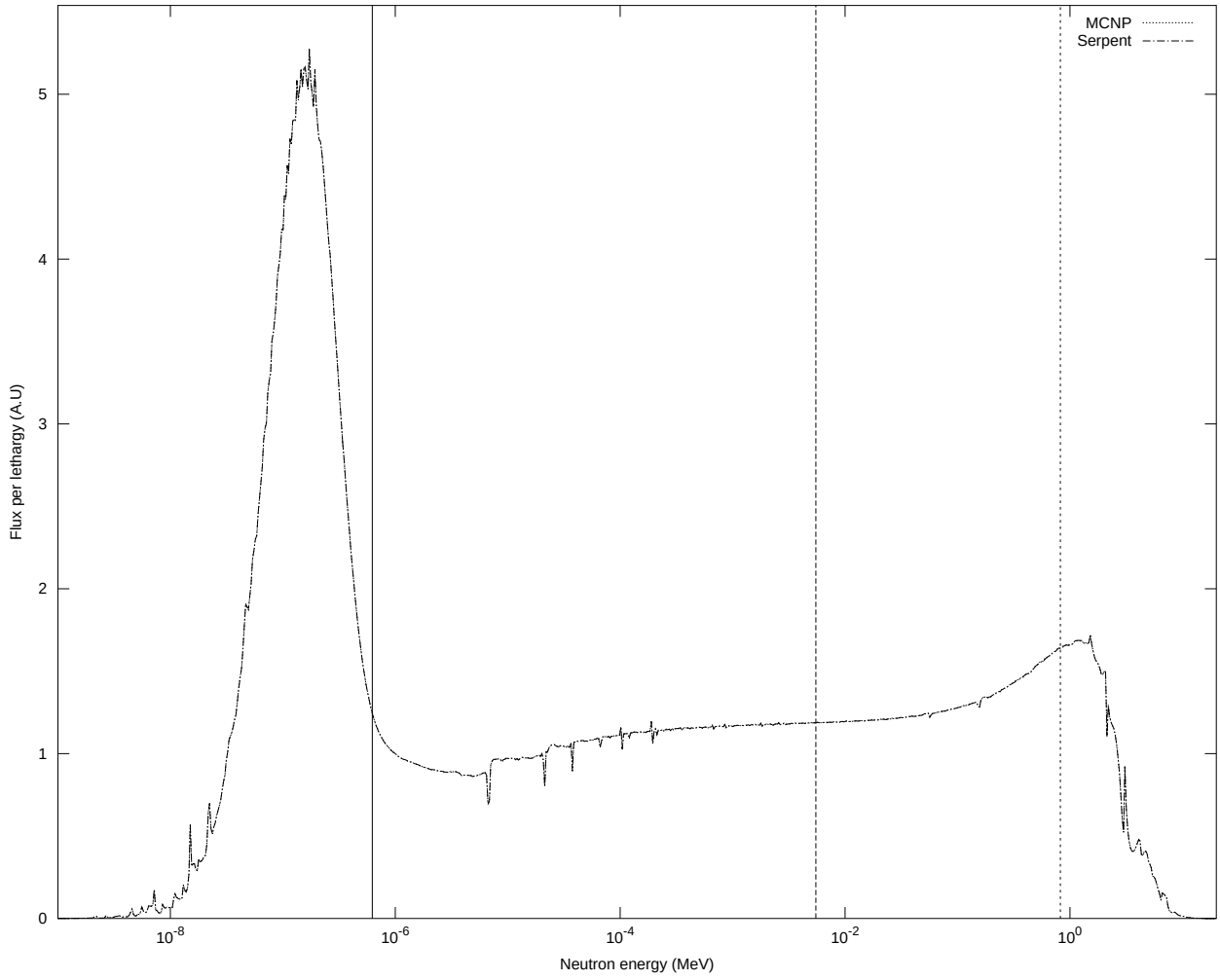

Figure 27. *Flux spectra integrated over the entire geometry PBMR fuel pebble.*

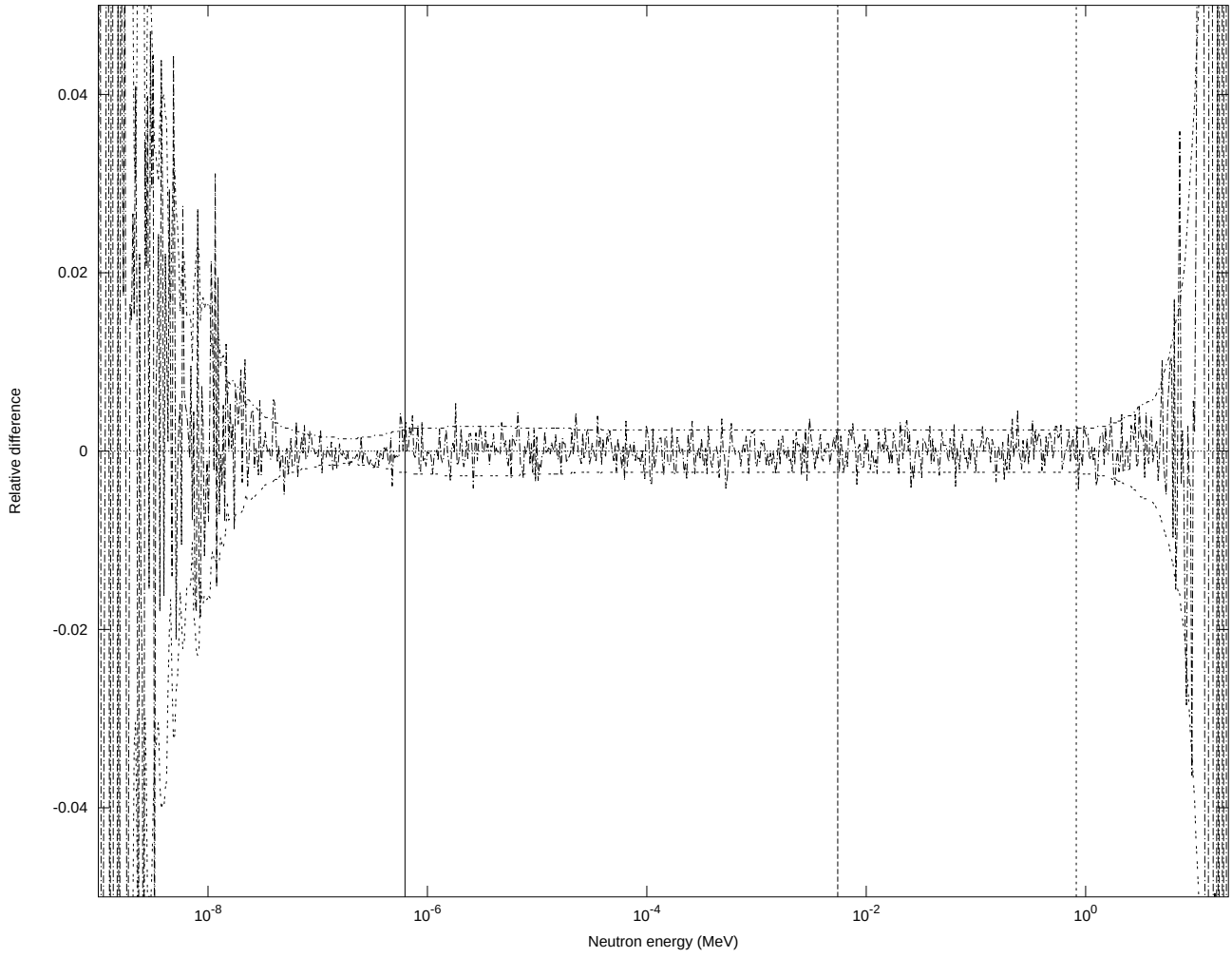

Figure 28. *Relative differences between the two spectra Figure 27.*