

Standard comparison between Serpent 1.1.17 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

- JEF-2.2 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	1.28540	(0.014)	1.28547	(0.013)	0.005
PWR pin-cell, 20 MWd/kgU burnup	1.07197	(0.018)	1.07137	(0.016)	-0.056
PWR pin-cell, 40 MWd/kgU burnup	0.91748	(0.019)	0.91763	(0.019)	0.017
VVER-440 assembly	1.27441	(0.015)	1.27431	(0.015)	-0.008
BWR+Gd Assembly, 25% void fraction	1.08275	(0.018)	1.08274	(0.020)	-0.001
BWR+Gd Assembly, 50% void fraction	1.06791	(0.019)	1.06769	(0.020)	-0.021
BWR+Gd Assembly, 75% void fraction	1.04851	(0.017)	1.04809	(0.020)	-0.040
Mixed PWR MOX/UOX lattice	1.06915	(0.017)	1.06879	(0.017)	-0.034
SCWR assembly	1.14877	(0.015)	1.14849	(0.016)	-0.024
CANDU fuel cluster	0.91957	(0.016)	0.91931	(0.016)	-0.029
SFR assembly	1.75952	(0.008)	1.75961	(0.007)	0.005
Prismatic HTGR fuel block	1.45696	(0.016)	1.45684	(0.016)	-0.008
Prismatic HTGR fuel block + BP	1.14531	(0.022)	1.14562	(0.023)	0.027
PBMR fuel pebble	1.44105	(0.016)	1.44088	(0.015)	-0.012

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	21.54	(0.041)	21.53	(0.024)	-0.028
PWR pin-cell, 20 MWd/kgU burnup	19.29	(0.047)	19.28	(0.028)	-0.043
PWR pin-cell, 40 MWd/kgU burnup	19.92	(0.048)	19.92	(0.030)	-0.011
VVER-440 assembly	18.08	(0.042)	18.08	(0.030)	0.001
BWR+Gd Assembly, 25% void fraction	29.07	(0.041)	29.10	(0.032)	0.113
BWR+Gd Assembly, 50% void fraction	27.95	(0.046)	27.97	(0.036)	0.059
BWR+Gd Assembly, 75% void fraction	26.42	(0.044)	26.42	(0.034)	-0.016
Mixed PWR MOX/UOX lattice	14.18	(0.055)	7.25	(0.067)	-48.917
SCWR assembly	15.18	(0.036)	15.19	(0.032)	0.056
CANDU fuel cluster	187.59	(0.053)	187.58	(0.030)	-0.004
SFR assembly	0.33	(0.019)	0.33	(0.017)	-0.073
Prismatic HTGR fuel block	321.12	(0.038)	321.07	(0.034)	-0.017
Prismatic HTGR fuel block + BP	256.09	(0.036)	256.17	(0.033)	0.032
PBMR fuel pebble	571.38	(0.038)	571.52	(0.032)	0.024

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	807.8	20.5	39.4
PWR pin-cell, 20 MWd/kgU burnup	777.1	18.5	42.0
PWR pin-cell, 40 MWd/kgU burnup	794.0	18.8	42.3
VVER-440 assembly	257.2	17.4	14.8
BWR+Gd Assembly, 25% void fraction	247.7	23.8	10.4
BWR+Gd Assembly, 50% void fraction	270.8	22.7	11.9
BWR+Gd Assembly, 75% void fraction	306.3	22.3	13.8
Mixed PWR MOX/UOX lattice	145.9	16.9	8.6
SCWR assembly	395.3	17.7	22.3
CANDU fuel cluster	319.5	33.0	9.7
SFR assembly	1324.2	22.0	60.3
Prismatic HTGR fuel block	6206.7	98.5	63.0
Prismatic HTGR fuel block + BP	5498.1	89.9	61.2
PBMR fuel pebble	3817.8	101.7	37.5

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	2.28027E-01	(0.057)	2.28030E-01	(0.009)	0.001
	2	5.64933E-01	(0.028)	5.64948E-01	(0.006)	0.003
	3	8.80691E-01	(0.028)	8.80646E-01	(0.007)	-0.005
	4	1.44269E+00	(0.042)	1.44260E+00	(0.010)	-0.006
Σ_{fiss}	1	2.87278E-03	(0.064)	2.87349E-03	(0.041)	0.025
	2	3.41771E-04	(0.028)	3.41806E-04	(0.023)	0.010
	3	4.97230E-03	(0.036)	4.97270E-03	(0.041)	0.008
	4	5.40675E-02	(0.042)	5.40687E-02	(0.023)	0.002
Σ_{abs}	1	3.71327E-03	(0.064)	3.71379E-03	(0.038)	0.014
	2	2.17014E-03	(0.036)	2.16961E-03	(0.030)	-0.024
	3	2.37010E-02	(0.045)	2.36880E-02	(0.041)	-0.055
	4	8.37842E-02	(0.042)	8.37867E-02	(0.021)	0.003
Σ_{capt}	1	8.40492E-04	(0.089)	8.40306E-04	(0.058)	-0.022
	2	1.82836E-03	(0.036)	1.82781E-03	(0.032)	-0.030
	3	1.87287E-02	(0.054)	1.87153E-02	(0.050)	-0.072
	4	2.97168E-02	(0.042)	2.97180E-02	(0.017)	0.004
Σ_{scatt}	1	2.24314E-01	(0.057)	2.24316E-01	(0.009)	0.001
	2	5.62763E-01	(0.028)	5.62778E-01	(0.006)	0.003
	3	8.56990E-01	(0.028)	8.56958E-01	(0.007)	-0.004
	4	1.35890E+00	(0.042)	1.35881E+00	(0.011)	-0.007
$\nu\Sigma_{\text{fiss}}$	1	7.99641E-03	(0.064)	7.99860E-03	(0.045)	0.027
	2	8.42267E-04	(0.028)	8.42277E-04	(0.025)	0.001
	3	1.21419E-02	(0.036)	1.21397E-02	(0.041)	-0.018
	4	1.32772E-01	(0.042)	1.32765E-01	(0.023)	-0.005
$\bar{\nu}$	1	2.78351E+00	(0.071)	2.78358E+00	(0.017)	0.003
	2	2.46442E+00	(0.028)	2.46420E+00	(0.011)	-0.009
	3	2.44190E+00	(0.042)	2.44126E+00	(0.003)	-0.026
	4	2.45566E+00	(0.042)	2.45548E+00	(0.002)	-0.007
$1/v$	1	5.24145E-10	(0.057)	5.24162E-10	(0.009)	0.003
	2	2.63895E-09	(0.028)	2.63856E-09	(0.014)	-0.015
	3	1.83554E-07	(0.036)	1.83576E-07	(0.023)	0.012
	4	2.45121E-06	(0.042)	2.45105E-06	(0.009)	-0.006

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	2.27923E-01	(0.057)	2.27903E-01	(0.009)	-0.009
	2	5.65783E-01	(0.028)	5.65853E-01	(0.006)	0.012
	3	8.89393E-01	(0.028)	8.89413E-01	(0.006)	0.002
	4	1.45864E+00	(0.057)	1.45842E+00	(0.011)	-0.015
Σ_{fiss}	1	2.81476E-03	(0.064)	2.81623E-03	(0.043)	0.052
	2	2.22268E-04	(0.028)	2.22213E-04	(0.021)	-0.025
	3	3.23568E-03	(0.036)	3.23385E-03	(0.042)	-0.057
	4	4.81088E-02	(0.057)	4.80981E-02	(0.024)	-0.022
Σ_{abs}	1	3.67938E-03	(0.064)	3.68126E-03	(0.040)	0.051
	2	2.04745E-03	(0.036)	2.04698E-03	(0.029)	-0.023
	3	2.78312E-02	(0.045)	2.78347E-02	(0.038)	0.013
	4	8.95996E-02	(0.057)	8.95816E-02	(0.021)	-0.020
Σ_{capt}	1	8.64627E-04	(0.089)	8.65031E-04	(0.056)	0.047
	2	1.82518E-03	(0.036)	1.82476E-03	(0.031)	-0.023
	3	2.45955E-02	(0.045)	2.46008E-02	(0.041)	0.021
	4	4.14907E-02	(0.057)	4.14836E-02	(0.018)	-0.017
Σ_{scatt}	1	2.24244E-01	(0.057)	2.24222E-01	(0.009)	-0.010
	2	5.63735E-01	(0.028)	5.63806E-01	(0.006)	0.013
	3	8.61562E-01	(0.028)	8.61579E-01	(0.006)	0.002
	4	1.36904E+00	(0.057)	1.36884E+00	(0.012)	-0.014
$\nu\Sigma_{\text{fiss}}$	1	7.90468E-03	(0.064)	7.90951E-03	(0.048)	0.061
	2	5.76007E-04	(0.028)	5.75777E-04	(0.052)	-0.040
	3	8.32242E-03	(0.036)	8.31558E-03	(0.044)	-0.082
	4	1.27690E-01	(0.057)	1.27653E-01	(0.024)	-0.029
$\bar{\nu}$	1	2.80830E+00	(0.071)	2.80853E+00	(0.018)	0.008
	2	2.59150E+00	(0.028)	2.59110E+00	(0.047)	-0.015
	3	2.57207E+00	(0.042)	2.57142E+00	(0.014)	-0.025
	4	2.65420E+00	(0.057)	2.65401E+00	(0.004)	-0.007
$1/v$	1	5.22056E-10	(0.057)	5.22042E-10	(0.009)	-0.003
	2	2.64126E-09	(0.028)	2.64115E-09	(0.014)	-0.004
	3	1.76573E-07	(0.036)	1.76536E-07	(0.021)	-0.021
	4	2.48768E-06	(0.057)	2.48713E-06	(0.010)	-0.022

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	2.28167E-01	(0.057)	2.28206E-01	(0.009)	0.017
	2	5.66647E-01	(0.028)	5.66580E-01	(0.006)	-0.012
	3	8.95393E-01	(0.028)	8.95312E-01	(0.006)	-0.009
	4	1.45908E+00	(0.057)	1.45876E+00	(0.011)	-0.022
Σ_{fiss}	1	2.75314E-03	(0.064)	2.75524E-03	(0.041)	0.076
	2	1.46897E-04	(0.028)	1.46911E-04	(0.023)	0.010
	3	2.14411E-03	(0.036)	2.14539E-03	(0.042)	0.060
	4	3.86822E-02	(0.057)	3.86743E-02	(0.026)	-0.021
Σ_{abs}	1	3.63017E-03	(0.064)	3.63243E-03	(0.039)	0.062
	2	1.97708E-03	(0.036)	1.97670E-03	(0.032)	-0.019
	3	3.01040E-02	(0.045)	3.01042E-02	(0.037)	0.001
	4	8.42859E-02	(0.057)	8.42669E-02	(0.022)	-0.022
Σ_{capt}	1	8.77031E-04	(0.089)	8.77186E-04	(0.062)	0.018
	2	1.83017E-03	(0.036)	1.82979E-03	(0.034)	-0.021
	3	2.79599E-02	(0.045)	2.79588E-02	(0.039)	-0.004
	4	4.56036E-02	(0.057)	4.55926E-02	(0.019)	-0.024
Σ_{scatt}	1	2.24537E-01	(0.057)	2.24573E-01	(0.009)	0.016
	2	5.64670E-01	(0.028)	5.64603E-01	(0.006)	-0.012
	3	8.65289E-01	(0.028)	8.65208E-01	(0.006)	-0.009
	4	1.37479E+00	(0.057)	1.37449E+00	(0.012)	-0.022
$\nu\Sigma_{\text{fiss}}$	1	7.77038E-03	(0.064)	7.77812E-03	(0.046)	0.100
	2	4.00896E-04	(0.028)	4.01140E-04	(0.066)	0.061
	3	5.81530E-03	(0.036)	5.81798E-03	(0.046)	0.046
	4	1.07386E-01	(0.057)	1.07365E-01	(0.026)	-0.020
$\bar{\nu}$	1	2.82237E+00	(0.071)	2.82302E+00	(0.019)	0.023
	2	2.72909E+00	(0.028)	2.73050E+00	(0.064)	0.052
	3	2.71222E+00	(0.042)	2.71185E+00	(0.017)	-0.014
	4	2.77612E+00	(0.057)	2.77613E+00	(0.004)	0.000
$1/v$	1	5.21040E-10	(0.057)	5.21103E-10	(0.009)	0.012
	2	2.64322E-09	(0.028)	2.64225E-09	(0.013)	-0.037
	3	1.72789E-07	(0.036)	1.72821E-07	(0.022)	0.019
	4	2.52207E-06	(0.057)	2.52162E-06	(0.011)	-0.018

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	2.21070E-01	(0.057)	2.21106E-01	(0.010)	0.016
	2	5.19455E-01	(0.028)	5.19474E-01	(0.006)	0.004
	3	7.75870E-01	(0.028)	7.75904E-01	(0.007)	0.004
	4	1.22375E+00	(0.050)	1.22364E+00	(0.013)	-0.009
Σ_{fiss}	1	2.83684E-03	(0.064)	2.83512E-03	(0.040)	-0.061
	2	4.10844E-04	(0.028)	4.10965E-04	(0.021)	0.030
	3	5.85108E-03	(0.036)	5.85048E-03	(0.039)	-0.010
	4	6.01436E-02	(0.050)	6.01353E-02	(0.028)	-0.014
Σ_{abs}	1	3.63653E-03	(0.064)	3.63490E-03	(0.038)	-0.045
	2	2.29659E-03	(0.036)	2.29740E-03	(0.026)	0.035
	3	2.46546E-02	(0.036)	2.46409E-02	(0.038)	-0.056
	4	8.96964E-02	(0.050)	8.96849E-02	(0.024)	-0.013
Σ_{capt}	1	7.99688E-04	(0.081)	7.99774E-04	(0.056)	0.011
	2	1.88575E-03	(0.036)	1.88643E-03	(0.028)	0.036
	3	1.88035E-02	(0.045)	1.87904E-02	(0.045)	-0.070
	4	2.95528E-02	(0.050)	2.95496E-02	(0.017)	-0.011
Σ_{scatt}	1	2.17434E-01	(0.057)	2.17471E-01	(0.010)	0.017
	2	5.17158E-01	(0.028)	5.17177E-01	(0.006)	0.004
	3	7.51215E-01	(0.028)	7.51263E-01	(0.007)	0.006
	4	1.13406E+00	(0.050)	1.13395E+00	(0.013)	-0.009
$\nu\Sigma_{\text{fiss}}$	1	7.86926E-03	(0.064)	7.86257E-03	(0.044)	-0.085
	2	1.00947E-03	(0.028)	1.00977E-03	(0.021)	0.030
	3	1.42477E-02	(0.036)	1.42452E-02	(0.039)	-0.017
	4	1.46658E-01	(0.050)	1.46609E-01	(0.028)	-0.034
$\bar{\nu}$	1	2.77396E+00	(0.071)	2.77326E+00	(0.015)	-0.025
	2	2.45706E+00	(0.028)	2.45707E+00	(0.003)	0.000
	3	2.43505E+00	(0.042)	2.43489E+00	(0.000)	-0.006
	4	2.43847E+00	(0.057)	2.43798E+00	(0.000)	-0.020
$1/v$	1	5.28844E-10	(0.057)	5.28955E-10	(0.010)	0.021
	2	2.64156E-09	(0.028)	2.64235E-09	(0.015)	0.030
	3	1.77275E-07	(0.036)	1.77320E-07	(0.025)	0.026
	4	2.35260E-06	(0.050)	2.35235E-06	(0.012)	-0.010

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	2.01799E-01	(0.057)	2.01791E-01	(0.010)	-0.004
	2	4.94952E-01	(0.028)	4.94964E-01	(0.006)	0.002
	3	7.69656E-01	(0.028)	7.69607E-01	(0.007)	-0.006
	4	1.37695E+00	(0.050)	1.37705E+00	(0.011)	0.007
Σ_{fiss}	1	2.36835E-03	(0.064)	2.36626E-03	(0.044)	-0.088
	2	3.18038E-04	(0.036)	3.17946E-04	(0.029)	-0.029
	3	4.28833E-03	(0.045)	4.28785E-03	(0.049)	-0.011
	4	3.31116E-02	(0.050)	3.31062E-02	(0.035)	-0.016
Σ_{abs}	1	3.07774E-03	(0.064)	3.07472E-03	(0.041)	-0.098
	2	1.82167E-03	(0.036)	1.82152E-03	(0.035)	-0.008
	3	1.87057E-02	(0.045)	1.86933E-02	(0.044)	-0.066
	4	6.52369E-02	(0.042)	6.52372E-02	(0.029)	0.001
Σ_{capt}	1	7.09386E-04	(0.081)	7.08461E-04	(0.058)	-0.130
	2	1.50363E-03	(0.036)	1.50357E-03	(0.037)	-0.004
	3	1.44174E-02	(0.054)	1.44055E-02	(0.051)	-0.083
	4	3.21253E-02	(0.050)	3.21310E-02	(0.037)	0.018
Σ_{scatt}	1	1.98721E-01	(0.057)	1.98717E-01	(0.010)	-0.002
	2	4.93130E-01	(0.028)	4.93143E-01	(0.006)	0.003
	3	7.50950E-01	(0.028)	7.50913E-01	(0.007)	-0.005
	4	1.31172E+00	(0.050)	1.31181E+00	(0.013)	0.007
$\nu\Sigma_{\text{fiss}}$	1	6.57762E-03	(0.064)	6.57211E-03	(0.048)	-0.084
	2	7.81677E-04	(0.036)	7.81453E-04	(0.029)	-0.029
	3	1.04427E-02	(0.045)	1.04407E-02	(0.049)	-0.019
	4	8.07419E-02	(0.050)	8.07126E-02	(0.035)	-0.036
$\bar{\nu}$	1	2.77730E+00	(0.071)	2.77742E+00	(0.016)	0.004
	2	2.45781E+00	(0.042)	2.45782E+00	(0.004)	0.000
	3	2.43515E+00	(0.057)	2.43496E+00	(0.000)	-0.008
	4	2.43848E+00	(0.057)	2.43799E+00	(0.000)	-0.020
$1/v$	1	5.26094E-10	(0.057)	5.26119E-10	(0.009)	0.005
	2	2.62382E-09	(0.028)	2.62307E-09	(0.013)	-0.029
	3	1.85052E-07	(0.036)	1.85052E-07	(0.020)	-0.000
	4	2.52018E-06	(0.050)	2.52065E-06	(0.009)	0.019

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	1.81148E-01	(0.057)	1.81131E-01	(0.012)	-0.010
	2	4.28353E-01	(0.028)	4.28401E-01	(0.007)	0.011
	3	6.58327E-01	(0.028)	6.58411E-01	(0.008)	0.013
	4	1.20004E+00	(0.050)	1.20021E+00	(0.014)	0.014
Σ_{fiss}	1	2.31973E-03	(0.064)	2.32032E-03	(0.043)	0.025
	2	3.16094E-04	(0.036)	3.16055E-04	(0.026)	-0.012
	3	4.20728E-03	(0.045)	4.20910E-03	(0.045)	0.043
	4	3.23730E-02	(0.050)	3.23719E-02	(0.036)	-0.004
Σ_{abs}	1	2.98259E-03	(0.064)	2.98312E-03	(0.040)	0.018
	2	1.80646E-03	(0.036)	1.80587E-03	(0.032)	-0.033
	3	1.78951E-02	(0.045)	1.79005E-02	(0.041)	0.030
	4	6.36753E-02	(0.050)	6.36852E-02	(0.031)	0.016
Σ_{capt}	1	6.62863E-04	(0.081)	6.62802E-04	(0.056)	-0.009
	2	1.49037E-03	(0.036)	1.48981E-03	(0.034)	-0.038
	3	1.36878E-02	(0.054)	1.36914E-02	(0.049)	0.026
	4	3.13023E-02	(0.058)	3.13133E-02	(0.041)	0.035
Σ_{scatt}	1	1.78166E-01	(0.057)	1.78148E-01	(0.012)	-0.010
	2	4.26546E-01	(0.028)	4.26595E-01	(0.007)	0.011
	3	6.40431E-01	(0.028)	6.40510E-01	(0.008)	0.012
	4	1.13636E+00	(0.050)	1.13653E+00	(0.015)	0.015
$\nu\Sigma_{\text{fiss}}$	1	6.43624E-03	(0.064)	6.43826E-03	(0.048)	0.031
	2	7.76891E-04	(0.036)	7.76788E-04	(0.027)	-0.013
	3	1.02453E-02	(0.045)	1.02489E-02	(0.045)	0.035
	4	7.89415E-02	(0.050)	7.89225E-02	(0.036)	-0.024
$\bar{\nu}$	1	2.77457E+00	(0.071)	2.77471E+00	(0.016)	0.005
	2	2.45779E+00	(0.042)	2.45776E+00	(0.004)	-0.001
	3	2.43514E+00	(0.057)	2.43495E+00	(0.000)	-0.008
	4	2.43850E+00	(0.057)	2.43800E+00	(0.000)	-0.020
$1/\nu$	1	5.28442E-10	(0.057)	5.28423E-10	(0.010)	-0.004
	2	2.61557E-09	(0.028)	2.61570E-09	(0.014)	0.005
	3	1.81154E-07	(0.036)	1.81183E-07	(0.023)	0.016
	4	2.46757E-06	(0.050)	2.46736E-06	(0.011)	-0.008

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	1.60261E-01	(0.057)	1.60254E-01	(0.014)	-0.005
	2	3.61346E-01	(0.028)	3.61349E-01	(0.009)	0.001
	3	5.48323E-01	(0.028)	5.48259E-01	(0.010)	-0.012
	4	1.02970E+00	(0.050)	1.02972E+00	(0.019)	0.002
Σ_{fiss}	1	2.26540E-03	(0.064)	2.26522E-03	(0.037)	-0.008
	2	3.13553E-04	(0.036)	3.13544E-04	(0.024)	-0.003
	3	4.09029E-03	(0.045)	4.09333E-03	(0.041)	0.074
	4	3.14191E-02	(0.050)	3.14067E-02	(0.034)	-0.040
Σ_{abs}	1	2.88317E-03	(0.064)	2.88303E-03	(0.035)	-0.005
	2	1.78239E-03	(0.036)	1.78229E-03	(0.031)	-0.005
	3	1.67621E-02	(0.045)	1.67704E-02	(0.036)	0.050
	4	6.18945E-02	(0.050)	6.19002E-02	(0.029)	0.009
Σ_{capt}	1	6.17767E-04	(0.072)	6.17810E-04	(0.053)	0.007
	2	1.46883E-03	(0.036)	1.46874E-03	(0.033)	-0.006
	3	1.26718E-02	(0.045)	1.26770E-02	(0.043)	0.041
	4	3.04755E-02	(0.058)	3.04935E-02	(0.040)	0.059
Σ_{scatt}	1	1.57378E-01	(0.057)	1.57371E-01	(0.014)	-0.005
	2	3.59563E-01	(0.028)	3.59567E-01	(0.009)	0.001
	3	5.31561E-01	(0.028)	5.31489E-01	(0.010)	-0.014
	4	9.67804E-01	(0.050)	9.67817E-01	(0.021)	0.001
$\nu\Sigma_{\text{fiss}}$	1	6.27699E-03	(0.064)	6.27704E-03	(0.041)	0.001
	2	7.70661E-04	(0.036)	7.70635E-04	(0.024)	-0.003
	3	9.96040E-03	(0.045)	9.96716E-03	(0.041)	0.068
	4	7.66160E-02	(0.050)	7.65696E-02	(0.034)	-0.061
$\bar{\nu}$	1	2.77081E+00	(0.071)	2.77104E+00	(0.014)	0.008
	2	2.45783E+00	(0.042)	2.45782E+00	(0.003)	-0.001
	3	2.43514E+00	(0.057)	2.43497E+00	(0.000)	-0.007
	4	2.43852E+00	(0.057)	2.43800E+00	(0.000)	-0.021
$1/v$	1	5.31647E-10	(0.057)	5.31700E-10	(0.010)	0.010
	2	2.59796E-09	(0.028)	2.59808E-09	(0.015)	0.004
	3	1.76108E-07	(0.036)	1.76163E-07	(0.026)	0.031
	4	2.39445E-06	(0.050)	2.39429E-06	(0.013)	-0.007

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	2.17170E-01	(0.099)	2.17218E-01	(0.017)	0.022
	2	5.33017E-01	(0.071)	5.33024E-01	(0.011)	0.001
	3	8.41751E-01	(0.071)	8.41793E-01	(0.013)	0.005
	4	1.47800E+00	(0.127)	1.47723E+00	(0.028)	-0.052
Σ_{fiss}	1	3.19223E-03	(0.106)	3.18856E-03	(0.072)	-0.115
	2	4.44235E-04	(0.078)	4.44284E-04	(0.046)	0.011
	3	5.90184E-03	(0.103)	5.89536E-03	(0.096)	-0.110
	4	1.13907E-01	(0.127)	1.14015E-01	(0.067)	0.095
Σ_{abs}	1	4.05268E-03	(0.106)	4.04820E-03	(0.067)	-0.111
	2	2.27820E-03	(0.078)	2.27740E-03	(0.054)	-0.035
	3	3.48647E-02	(0.094)	3.48461E-02	(0.068)	-0.053
	4	2.02321E-01	(0.127)	2.02493E-01	(0.063)	0.085
Σ_{capt}	1	8.60450E-04	(0.139)	8.59646E-04	(0.100)	-0.093
	2	1.83396E-03	(0.086)	1.83311E-03	(0.061)	-0.046
	3	2.89628E-02	(0.103)	2.89508E-02	(0.075)	-0.042
	4	8.84146E-02	(0.127)	8.84781E-02	(0.057)	0.072
Σ_{scatt}	1	2.13117E-01	(0.099)	2.13170E-01	(0.017)	0.025
	2	5.30738E-01	(0.071)	5.30747E-01	(0.011)	0.002
	3	8.06886E-01	(0.071)	8.06947E-01	(0.013)	0.008
	4	1.27568E+00	(0.127)	1.27473E+00	(0.035)	-0.074
$\nu\Sigma_{\text{fiss}}$	1	9.19783E-03	(0.106)	9.18902E-03	(0.079)	-0.096
	2	1.28439E-03	(0.078)	1.28470E-03	(0.056)	0.024
	3	1.68527E-02	(0.103)	1.68317E-02	(0.097)	-0.124
	4	3.26115E-01	(0.127)	3.26423E-01	(0.067)	0.094
$\bar{\nu}$	1	2.88132E+00	(0.113)	2.88188E+00	(0.034)	0.019
	2	2.89123E+00	(0.085)	2.89161E+00	(0.031)	0.013
	3	2.85549E+00	(0.127)	2.85507E+00	(0.009)	-0.015
	4	2.86301E+00	(0.127)	2.86299E+00	(0.003)	-0.001
$1/v$	1	5.20705E-10	(0.099)	5.20845E-10	(0.017)	0.027
	2	2.62827E-09	(0.078)	2.62816E-09	(0.028)	-0.004
	3	1.63508E-07	(0.086)	1.63250E-07	(0.045)	-0.158
	4	2.30406E-06	(0.135)	2.30199E-06	(0.034)	-0.090

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

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	1.76551E-01	(0.057)	1.76611E-01	(0.012)	0.034
	2	3.84613E-01	(0.028)	3.84669E-01	(0.008)	0.015
	3	6.33756E-01	(0.028)	6.33678E-01	(0.005)	-0.012
	4	9.60261E-01	(0.057)	9.60217E-01	(0.013)	-0.005
Σ_{fiss}	1	2.42597E-03	(0.064)	2.42663E-03	(0.037)	0.027
	2	4.72960E-04	(0.028)	4.72918E-04	(0.022)	-0.009
	3	6.19030E-03	(0.036)	6.19319E-03	(0.038)	0.047
	4	5.54364E-02	(0.057)	5.54277E-02	(0.035)	-0.016
Σ_{abs}	1	3.25192E-03	(0.064)	3.25236E-03	(0.035)	0.014
	2	2.10519E-03	(0.036)	2.10532E-03	(0.026)	0.006
	3	2.24877E-02	(0.036)	2.24855E-02	(0.032)	-0.010
	4	9.01170E-02	(0.057)	9.01078E-02	(0.027)	-0.010
Σ_{capt}	1	8.25957E-04	(0.072)	8.25729E-04	(0.051)	-0.028
	2	1.63223E-03	(0.036)	1.63240E-03	(0.028)	0.010
	3	1.62973E-02	(0.045)	1.62923E-02	(0.038)	-0.031
	4	3.46807E-02	(0.057)	3.46801E-02	(0.023)	-0.002
Σ_{scatt}	1	1.73299E-01	(0.057)	1.73358E-01	(0.012)	0.034
	2	3.82508E-01	(0.028)	3.82563E-01	(0.008)	0.014
	3	6.11269E-01	(0.028)	6.11192E-01	(0.005)	-0.013
	4	8.70144E-01	(0.057)	8.70109E-01	(0.015)	-0.004
$\nu\Sigma_{\text{fiss}}$	1	6.69694E-03	(0.064)	6.69700E-03	(0.040)	0.001
	2	1.16214E-03	(0.028)	1.16207E-03	(0.022)	-0.006
	3	1.50735E-02	(0.036)	1.50796E-02	(0.038)	0.040
	4	1.35185E-01	(0.057)	1.35133E-01	(0.035)	-0.038
$\bar{\nu}$	1	2.76052E+00	(0.071)	2.75979E+00	(0.014)	-0.027
	2	2.45717E+00	(0.028)	2.45724E+00	(0.003)	0.003
	3	2.43503E+00	(0.042)	2.43487E+00	(0.000)	-0.006
	4	2.43855E+00	(0.057)	2.43801E+00	(0.000)	-0.022
$1/\nu$	1	5.37322E-10	(0.057)	5.37357E-10	(0.010)	0.007
	2	2.62014E-09	(0.028)	2.62086E-09	(0.014)	0.028
	3	1.65408E-07	(0.036)	1.65485E-07	(0.023)	0.047
	4	2.20242E-06	(0.057)	2.20250E-06	(0.015)	0.004

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	(0.050)	2.09536E-01	(0.012)	-0.027
	2	3.17294E-01	(0.028)	3.17302E-01	(0.006)	0.003
	3	3.21433E-01	(0.014)	3.21446E-01	(0.005)	0.004
	4	3.81843E-01	(0.042)	3.81839E-01	(0.005)	-0.001
Σ_{fiss}	1	2.13379E-03	(0.064)	2.13470E-03	(0.053)	0.042
	2	5.16291E-05	(0.036)	5.16621E-05	(0.036)	0.064
	3	4.81777E-04	(0.041)	4.81311E-04	(0.047)	-0.097
	4	4.62374E-03	(0.042)	4.62006E-03	(0.029)	-0.080
Σ_{abs}	1	2.87202E-03	(0.064)	2.87216E-03	(0.046)	0.005
	2	1.28422E-03	(0.045)	1.28557E-03	(0.042)	0.105
	3	5.14995E-03	(0.041)	5.15215E-03	(0.042)	0.043
	4	9.12302E-03	(0.042)	9.11637E-03	(0.028)	-0.073
Σ_{capt}	1	7.38217E-04	(0.089)	7.37460E-04	(0.064)	-0.102
	2	1.23259E-03	(0.045)	1.23391E-03	(0.042)	0.107
	3	4.66819E-03	(0.041)	4.67084E-03	(0.045)	0.057
	4	4.49928E-03	(0.042)	4.49631E-03	(0.027)	-0.066
Σ_{scatt}	1	2.06721E-01	(0.057)	2.06663E-01	(0.012)	-0.028
	2	3.16010E-01	(0.028)	3.16017E-01	(0.006)	0.002
	3	3.16283E-01	(0.014)	3.16294E-01	(0.005)	0.003
	4	3.72720E-01	(0.042)	3.72723E-01	(0.005)	0.001
$\nu\Sigma_{\text{fiss}}$	1	5.93300E-03	(0.064)	5.93551E-03	(0.058)	0.042
	2	1.26639E-04	(0.036)	1.26714E-04	(0.037)	0.059
	3	1.17332E-03	(0.041)	1.17208E-03	(0.047)	-0.106
	4	1.12749E-02	(0.042)	1.12640E-02	(0.029)	-0.097
$\bar{\nu}$	1	2.78049E+00	(0.071)	2.78047E+00	(0.018)	-0.001
	2	2.45287E+00	(0.042)	2.45275E+00	(0.007)	-0.005
	3	2.43540E+00	(0.057)	2.43518E+00	(0.000)	-0.009
	4	2.43849E+00	(0.042)	2.43805E+00	(0.000)	-0.018
$1/\nu$	1	5.25080E-10	(0.057)	5.25062E-10	(0.010)	-0.003
	2	3.58894E-09	(0.028)	3.58974E-09	(0.010)	0.022
	3	1.85026E-07	(0.022)	1.85091E-07	(0.017)	0.035
	4	2.55796E-06	(0.042)	2.55838E-06	(0.008)	0.016

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

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	1.83808E-01	(0.042)	1.83815E-01	(0.010)	0.004
	2	2.84869E-01	(0.014)	2.84860E-01	(0.006)	-0.003
	3	5.58120E-01	(0.099)	5.58151E-01	(0.021)	0.006
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
Σ_{fiss}	1	6.31239E-03	(0.050)	6.31298E-03	(0.021)	0.009
	2	4.49707E-03	(0.014)	4.49718E-03	(0.010)	0.003
	3	1.40841E-02	(0.106)	1.40963E-02	(0.043)	0.087
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
Σ_{abs}	1	7.29224E-03	(0.050)	7.29308E-03	(0.020)	0.012
	2	7.14180E-03	(0.014)	7.14208E-03	(0.012)	0.004
	3	2.87723E-02	(0.106)	2.88006E-02	(0.040)	0.098
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
Σ_{capt}	1	9.79827E-04	(0.058)	9.80099E-04	(0.034)	0.028
	2	2.64474E-03	(0.022)	2.64490E-03	(0.017)	0.006
	3	1.46882E-02	(0.106)	1.47043E-02	(0.044)	0.109
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
Σ_{scatt}	1	1.76516E-01	(0.042)	1.76522E-01	(0.010)	0.003
	2	2.77727E-01	(0.014)	2.77718E-01	(0.006)	-0.003
	3	5.29348E-01	(0.099)	5.29350E-01	(0.022)	0.000
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$\nu\Sigma_{\text{fiss}}$	1	1.82808E-02	(0.050)	1.82832E-02	(0.023)	0.013
	2	1.19212E-02	(0.014)	1.19217E-02	(0.011)	0.004
	3	3.63242E-02	(0.106)	3.63580E-02	(0.045)	0.093
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$\bar{\nu}$	1	2.89602E+00	(0.057)	2.89613E+00	(0.010)	0.004
	2	2.65089E+00	(0.014)	2.65093E+00	(0.004)	0.002
	3	2.57910E+00	(0.113)	2.57926E+00	(0.011)	0.006
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	–
$1/\nu$	1	5.60998E-10	(0.042)	5.61011E-10	(0.008)	0.002
	2	2.53620E-09	(0.022)	2.53633E-09	(0.015)	0.005
	3	1.62186E-08	(0.106)	1.62230E-08	(0.032)	0.027
	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	1.37483E-01	(0.042)	1.37464E-01	(0.008)	-0.014
	2	2.75971E-01	(0.014)	2.75978E-01	(0.004)	0.002
	3	3.11176E-01	(0.014)	3.11171E-01	(0.003)	-0.002
	4	3.19413E-01	(0.057)	3.19396E-01	(0.004)	-0.005
Σ_{fiss}	1	6.61998E-05	(0.050)	6.63438E-05	(0.144)	0.218
	2	2.94789E-05	(0.014)	2.94950E-05	(0.057)	0.055
	3	4.10388E-04	(0.022)	4.10334E-04	(0.055)	-0.013
	4	3.85316E-03	(0.057)	3.85416E-03	(0.030)	0.026
Σ_{abs}	1	1.22001E-04	(0.173)	1.22080E-04	(0.174)	0.065
	2	8.26052E-05	(0.014)	8.26596E-05	(0.061)	0.066
	3	1.98217E-03	(0.041)	1.98235E-03	(0.043)	0.009
	4	4.85750E-03	(0.057)	4.85866E-03	(0.029)	0.024
Σ_{capt}	1	5.58014E-05	(0.351)	5.57366E-05	(0.328)	-0.116
	2	5.31263E-05	(0.014)	5.31646E-05	(0.066)	0.072
	3	1.57178E-03	(0.051)	1.57201E-03	(0.050)	0.015
	4	1.00434E-03	(0.057)	1.00450E-03	(0.026)	0.016
Σ_{scatt}	1	1.37361E-01	(0.042)	1.37342E-01	(0.008)	-0.014
	2	2.75889E-01	(0.014)	2.75895E-01	(0.004)	0.002
	3	3.09194E-01	(0.014)	3.09189E-01	(0.003)	-0.002
	4	3.14556E-01	(0.057)	3.14537E-01	(0.003)	-0.006
$\nu\Sigma_{\text{fiss}}$	1	1.79503E-04	(0.050)	1.79897E-04	(0.159)	0.219
	2	7.22105E-05	(0.014)	7.22496E-05	(0.057)	0.054
	3	9.99293E-04	(0.022)	9.99047E-04	(0.055)	-0.025
	4	9.39637E-03	(0.057)	9.39734E-03	(0.030)	0.010
$\bar{\nu}$	1	2.71154E+00	(0.057)	2.71146E+00	(0.052)	-0.003
	2	2.44956E+00	(0.014)	2.44956E+00	(0.004)	-0.000
	3	2.43500E+00	(0.028)	2.43472E+00	(0.000)	-0.011
	4	2.43861E+00	(0.057)	2.43823E+00	(0.000)	-0.016
$1/v$	1	5.68998E-10	(0.042)	5.69076E-10	(0.007)	0.014
	2	3.39198E-09	(0.014)	3.39189E-09	(0.005)	-0.003
	3	1.83442E-07	(0.022)	1.83435E-07	(0.012)	-0.004
	4	2.13673E-06	(0.057)	2.13655E-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	1.37326E-01	(0.042)	1.37314E-01	(0.008)	-0.008
	2	2.75836E-01	(0.014)	2.75835E-01	(0.004)	-0.000
	3	3.11133E-01	(0.014)	3.11139E-01	(0.003)	0.002
	4	3.19584E-01	(0.057)	3.19564E-01	(0.004)	-0.006
Σ_{fiss}	1	6.47153E-05	(0.050)	6.46462E-05	(0.154)	-0.107
	2	2.86874E-05	(0.014)	2.86893E-05	(0.061)	0.007
	3	3.98268E-04	(0.022)	3.98097E-04	(0.059)	-0.043
	4	3.68334E-03	(0.057)	3.68391E-03	(0.034)	0.015
Σ_{abs}	1	1.20006E-04	(0.173)	1.20091E-04	(0.177)	0.071
	2	8.32098E-05	(0.014)	8.32340E-05	(0.064)	0.029
	3	2.08206E-03	(0.041)	2.08045E-03	(0.040)	-0.077
	4	5.96395E-03	(0.057)	5.96416E-03	(0.029)	0.004
Σ_{capt}	1	5.52907E-05	(0.351)	5.54450E-05	(0.319)	0.279
	2	5.45225E-05	(0.014)	5.45448E-05	(0.069)	0.041
	3	1.68380E-03	(0.041)	1.68235E-03	(0.047)	-0.086
	4	2.28060E-03	(0.064)	2.28025E-03	(0.043)	-0.016
Σ_{scatt}	1	1.37206E-01	(0.042)	1.37194E-01	(0.008)	-0.008
	2	2.75753E-01	(0.014)	2.75751E-01	(0.004)	-0.001
	3	3.09051E-01	(0.014)	3.09058E-01	(0.003)	0.002
	4	3.13620E-01	(0.057)	3.13600E-01	(0.004)	-0.006
$\nu\Sigma_{\text{fiss}}$	1	1.75482E-04	(0.050)	1.75387E-04	(0.167)	-0.054
	2	7.02721E-05	(0.014)	7.02781E-05	(0.061)	0.009
	3	9.69768E-04	(0.022)	9.69255E-04	(0.059)	-0.053
	4	8.98230E-03	(0.057)	8.98222E-03	(0.034)	-0.001
$\bar{\nu}$	1	2.71160E+00	(0.057)	2.71292E+00	(0.055)	0.049
	2	2.44958E+00	(0.014)	2.44963E+00	(0.004)	0.002
	3	2.43496E+00	(0.028)	2.43472E+00	(0.000)	-0.010
	4	2.43863E+00	(0.057)	2.43823E+00	(0.000)	-0.016
$1/v$	1	5.69043E-10	(0.042)	5.69061E-10	(0.006)	0.003
	2	3.39150E-09	(0.014)	3.39181E-09	(0.004)	0.009
	3	1.82043E-07	(0.022)	1.82115E-07	(0.012)	0.040
	4	2.08735E-06	(0.057)	2.08711E-06	(0.010)	-0.012

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	9.68933E-02	(0.042)	9.68817E-02	(0.013)	-0.012
	2	1.94189E-01	(0.014)	1.94172E-01	(0.007)	-0.009
	3	2.18607E-01	(0.014)	2.18608E-01	(0.005)	0.000
	4	2.23752E-01	(0.057)	2.23712E-01	(0.005)	-0.018
Σ_{fiss}	1	4.43211E-05	(0.050)	4.43314E-05	(0.144)	0.023
	2	1.63892E-05	(0.014)	1.63785E-05	(0.056)	-0.065
	3	2.29501E-04	(0.022)	2.29610E-04	(0.061)	0.048
	4	2.20189E-03	(0.057)	2.20144E-03	(0.029)	-0.020
Σ_{abs}	1	8.28142E-05	(0.173)	8.27312E-05	(0.176)	-0.100
	2	5.29769E-05	(0.014)	5.29413E-05	(0.063)	-0.067
	3	1.31119E-03	(0.041)	1.31080E-03	(0.041)	-0.029
	4	2.80923E-03	(0.057)	2.80865E-03	(0.028)	-0.021
Σ_{capt}	1	3.84933E-05	(0.351)	3.83998E-05	(0.318)	-0.243
	2	3.65877E-05	(0.014)	3.65627E-05	(0.069)	-0.068
	3	1.08168E-03	(0.051)	1.08119E-03	(0.047)	-0.046
	4	6.07346E-04	(0.057)	6.07212E-04	(0.024)	-0.022
Σ_{scatt}	1	9.68105E-02	(0.042)	9.67990E-02	(0.013)	-0.012
	2	1.94136E-01	(0.014)	1.94119E-01	(0.007)	-0.009
	3	2.17296E-01	(0.014)	2.17297E-01	(0.005)	0.000
	4	2.20943E-01	(0.057)	2.20903E-01	(0.005)	-0.018
$\nu\Sigma_{\text{fiss}}$	1	1.20375E-04	(0.050)	1.20393E-04	(0.156)	0.015
	2	4.01470E-05	(0.014)	4.01242E-05	(0.056)	-0.057
	3	5.58839E-04	(0.022)	5.59041E-04	(0.061)	0.036
	4	5.36954E-03	(0.057)	5.36760E-03	(0.029)	-0.036
$\bar{\nu}$	1	2.71598E+00	(0.057)	2.71567E+00	(0.050)	-0.011
	2	2.44961E+00	(0.014)	2.44980E+00	(0.005)	0.008
	3	2.43502E+00	(0.028)	2.43474E+00	(0.000)	-0.011
	4	2.43861E+00	(0.057)	2.43822E+00	(0.000)	-0.016
$1/v$	1	5.69669E-10	(0.042)	5.69648E-10	(0.006)	-0.004
	2	3.39175E-09	(0.014)	3.39173E-09	(0.006)	-0.000
	3	1.85373E-07	(0.022)	1.85408E-07	(0.013)	0.019
	4	2.18356E-06	(0.057)	2.18319E-06	(0.009)	-0.017

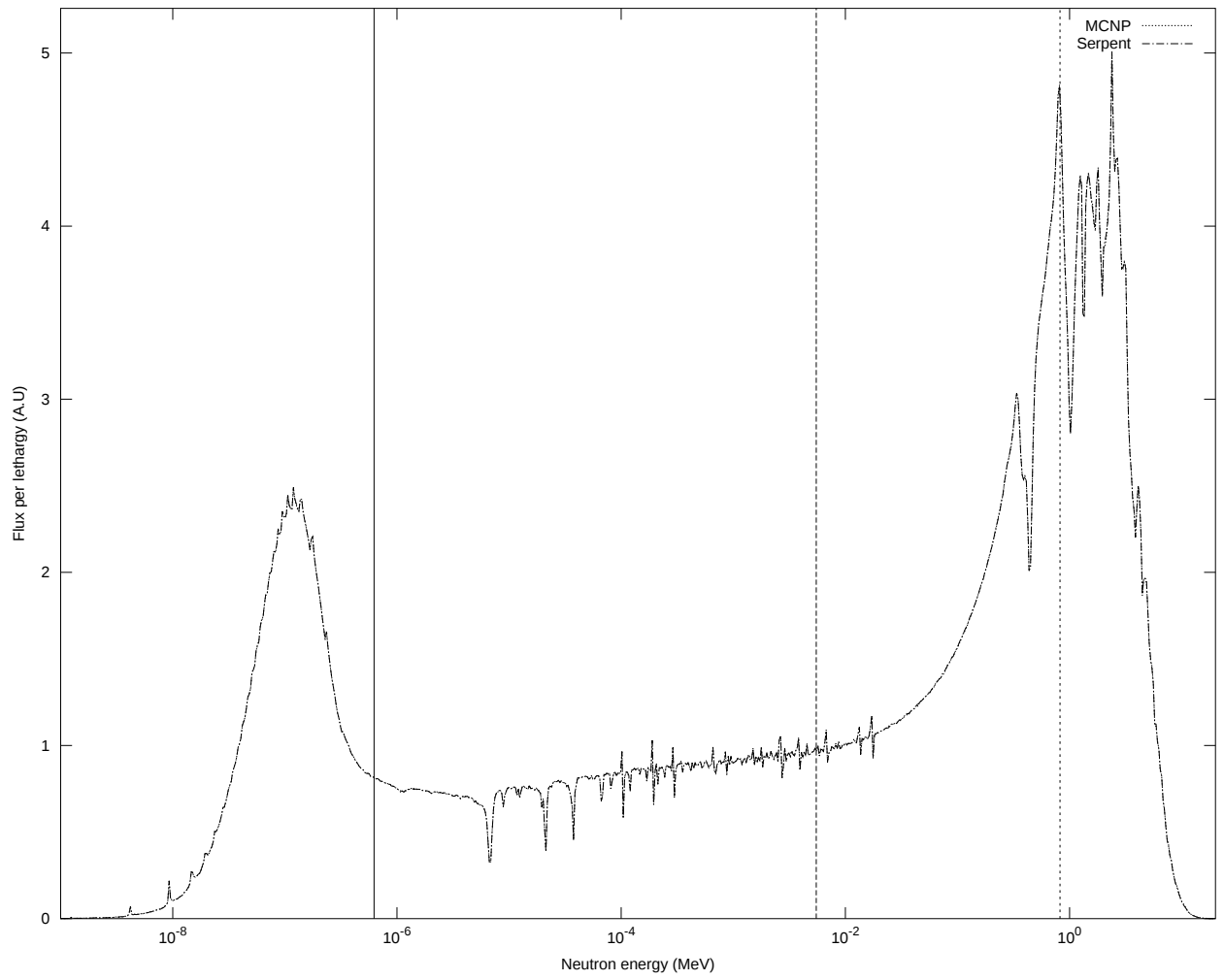


Figure 1. Flux spectra integrated over the entire geometry PWR pin-cell, 1 MWd/kgU burnup.

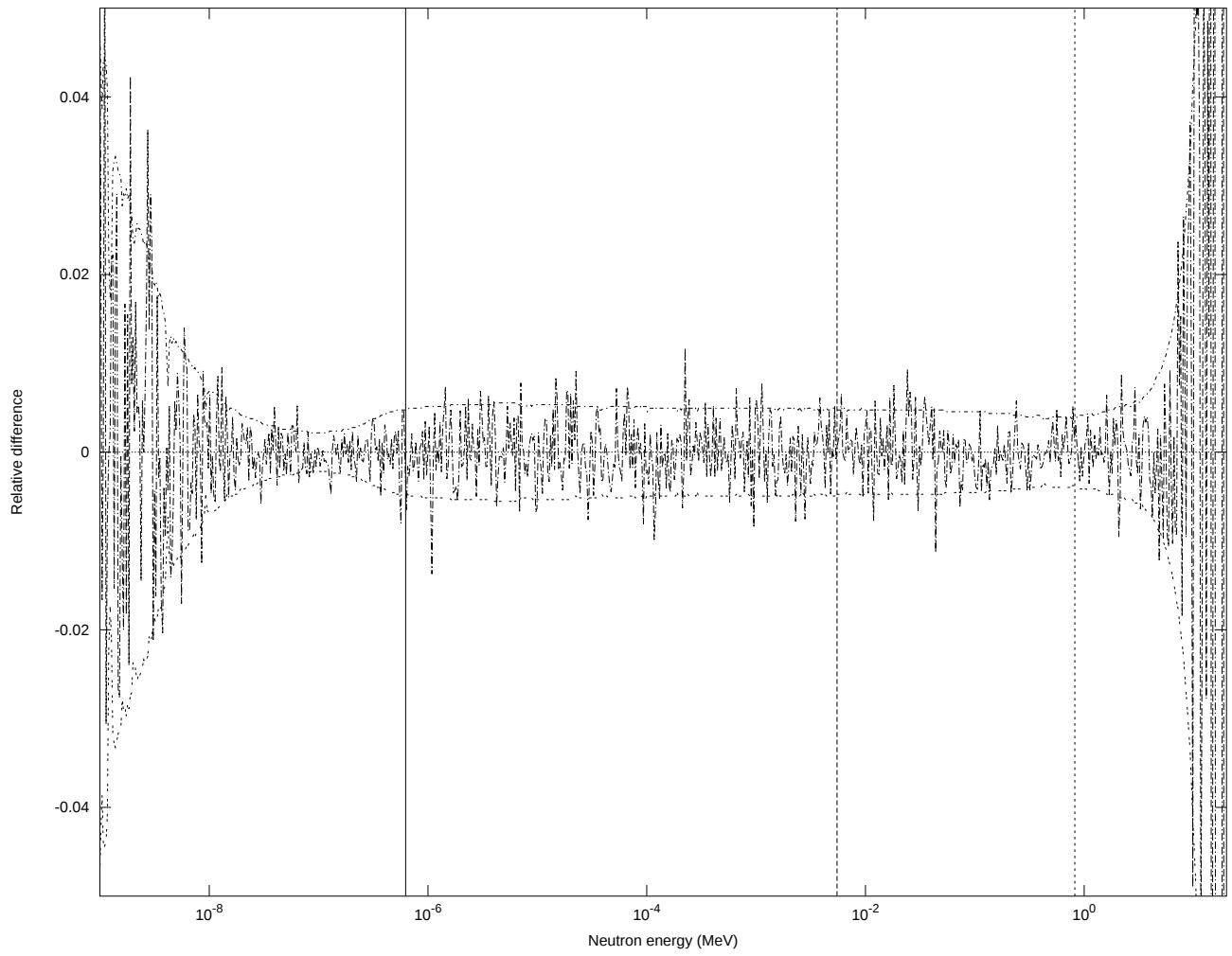


Figure 2. Relative differences between the two spectra Figure 1.

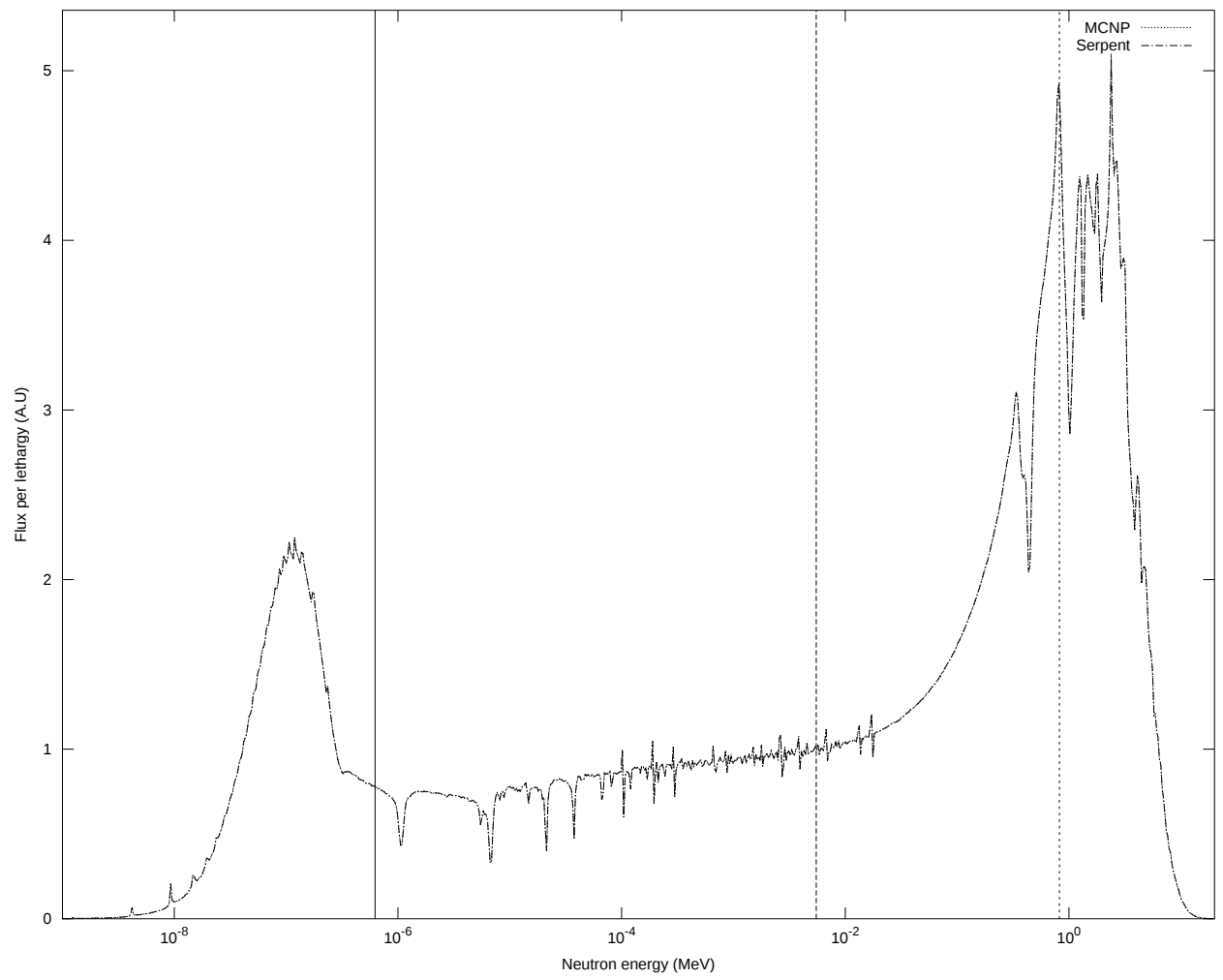


Figure 3. Flux spectra integrated over the entire geometry PWR pin-cell, 20 MWd/kgU burnup.

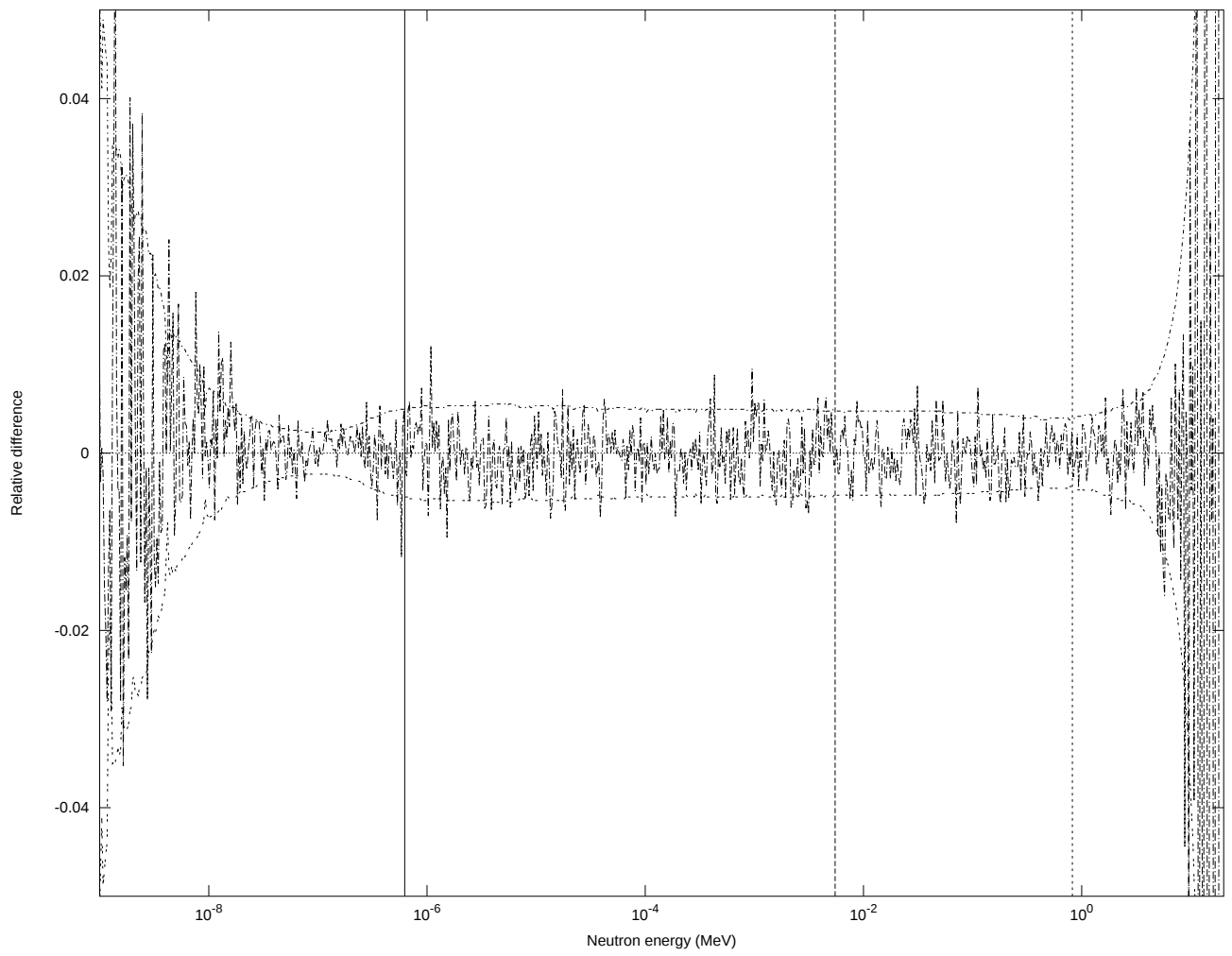


Figure 4. Relative differences between the two spectra Figure 3.

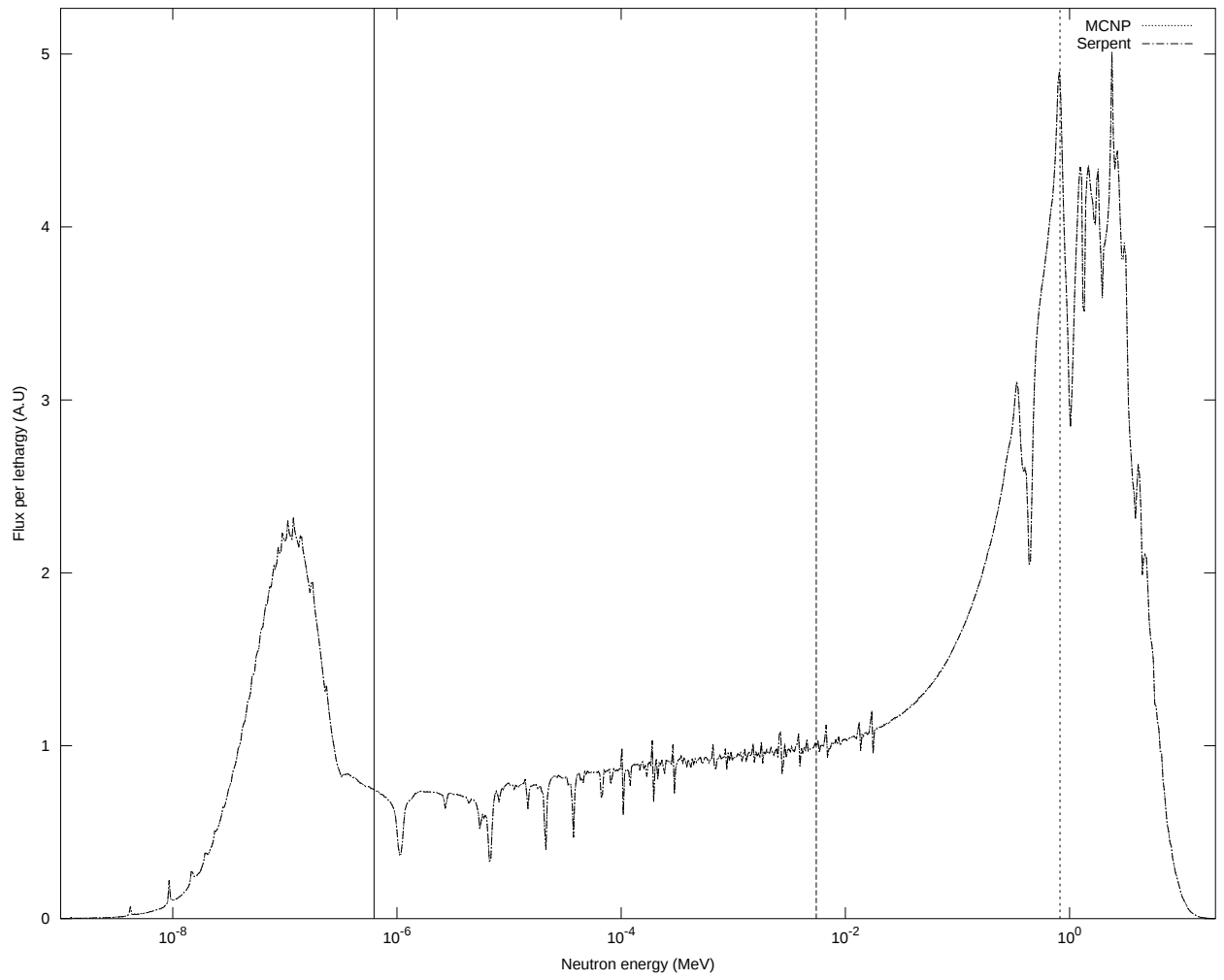


Figure 5. Flux spectra integrated over the entire geometry PWR pin-cell, 40 MWd/kgU burnup.

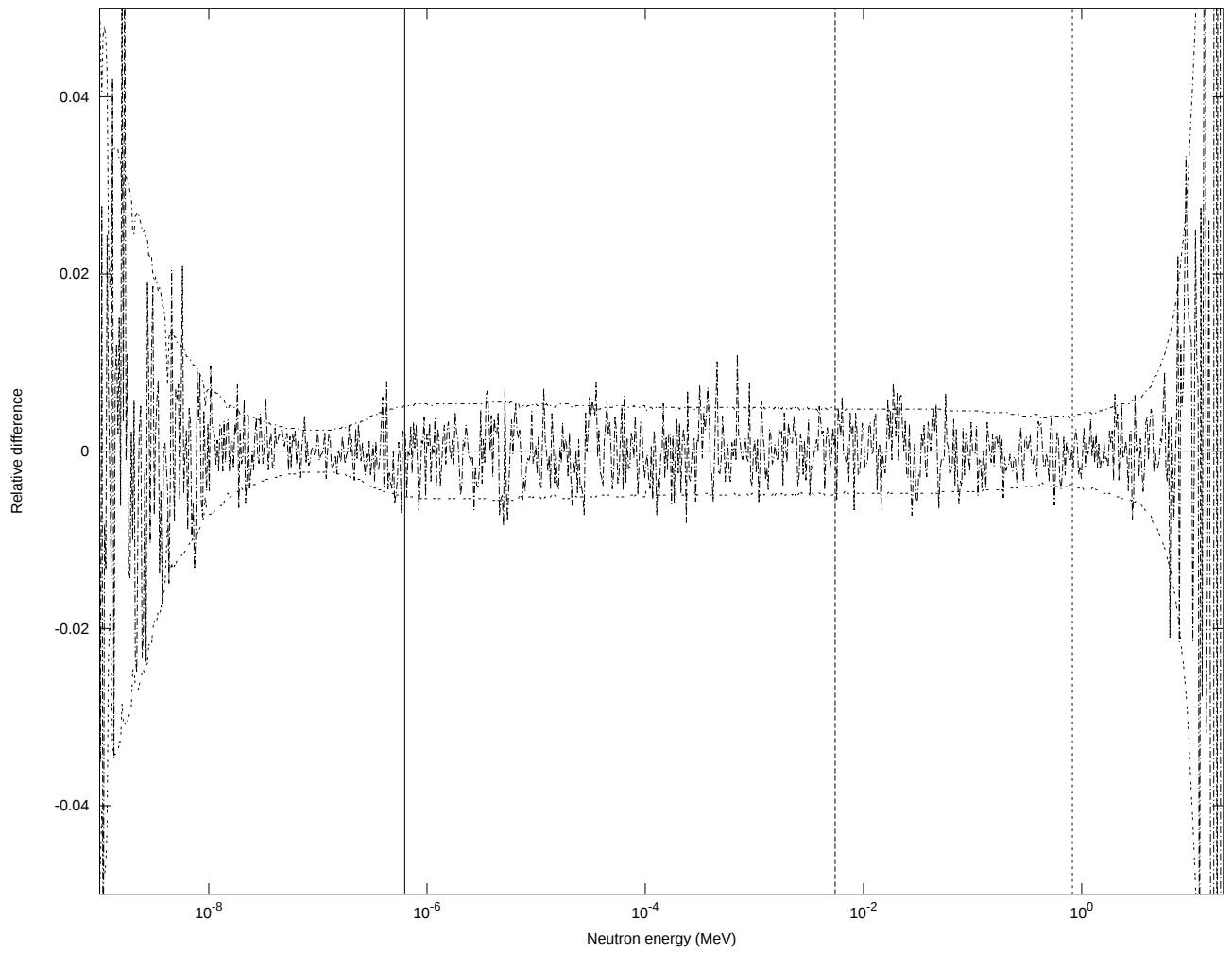


Figure 6. Relative differences between the two spectra Figure 5.

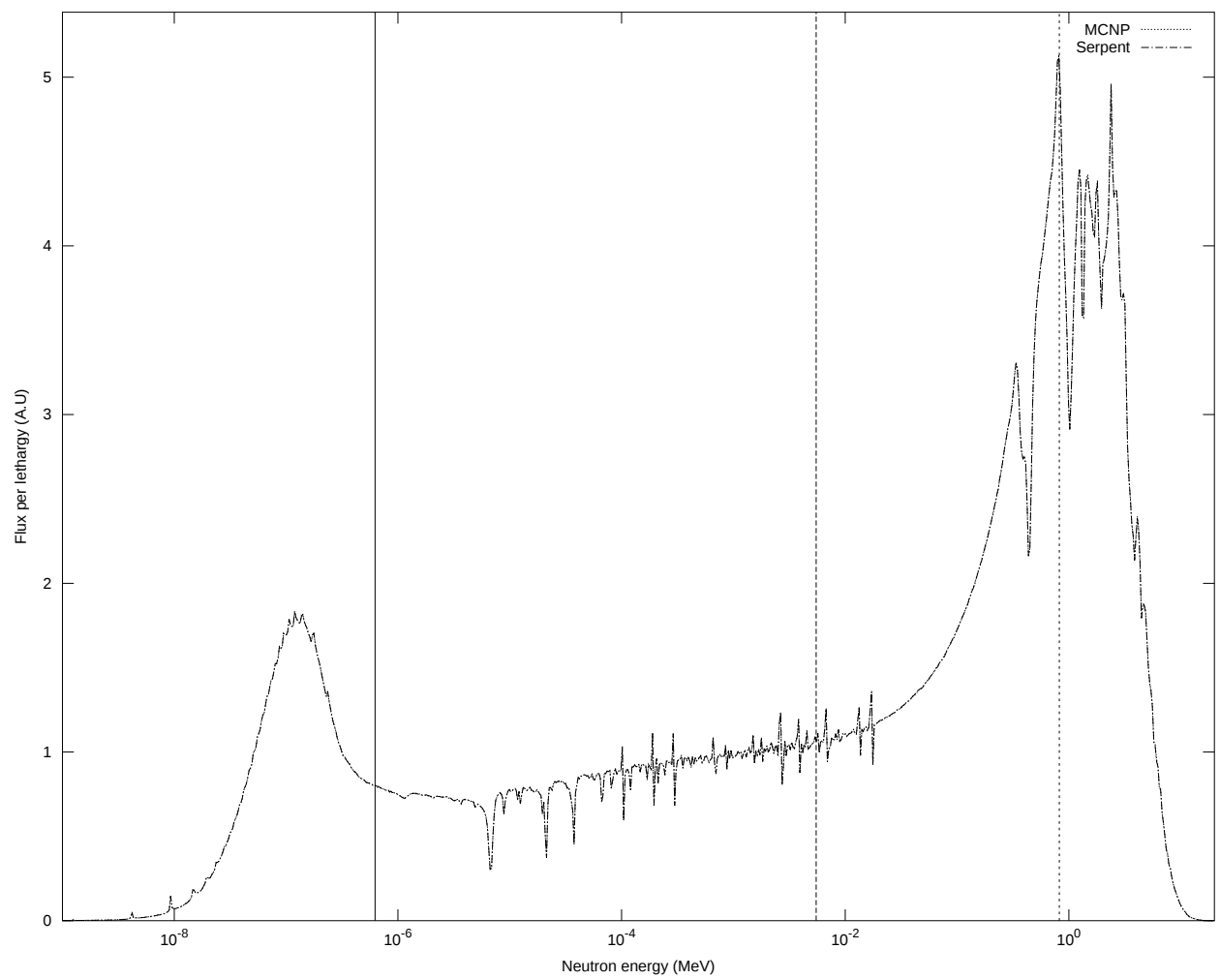


Figure 7. Flux spectra integrated over the entire geometry VVER-440 assembly.

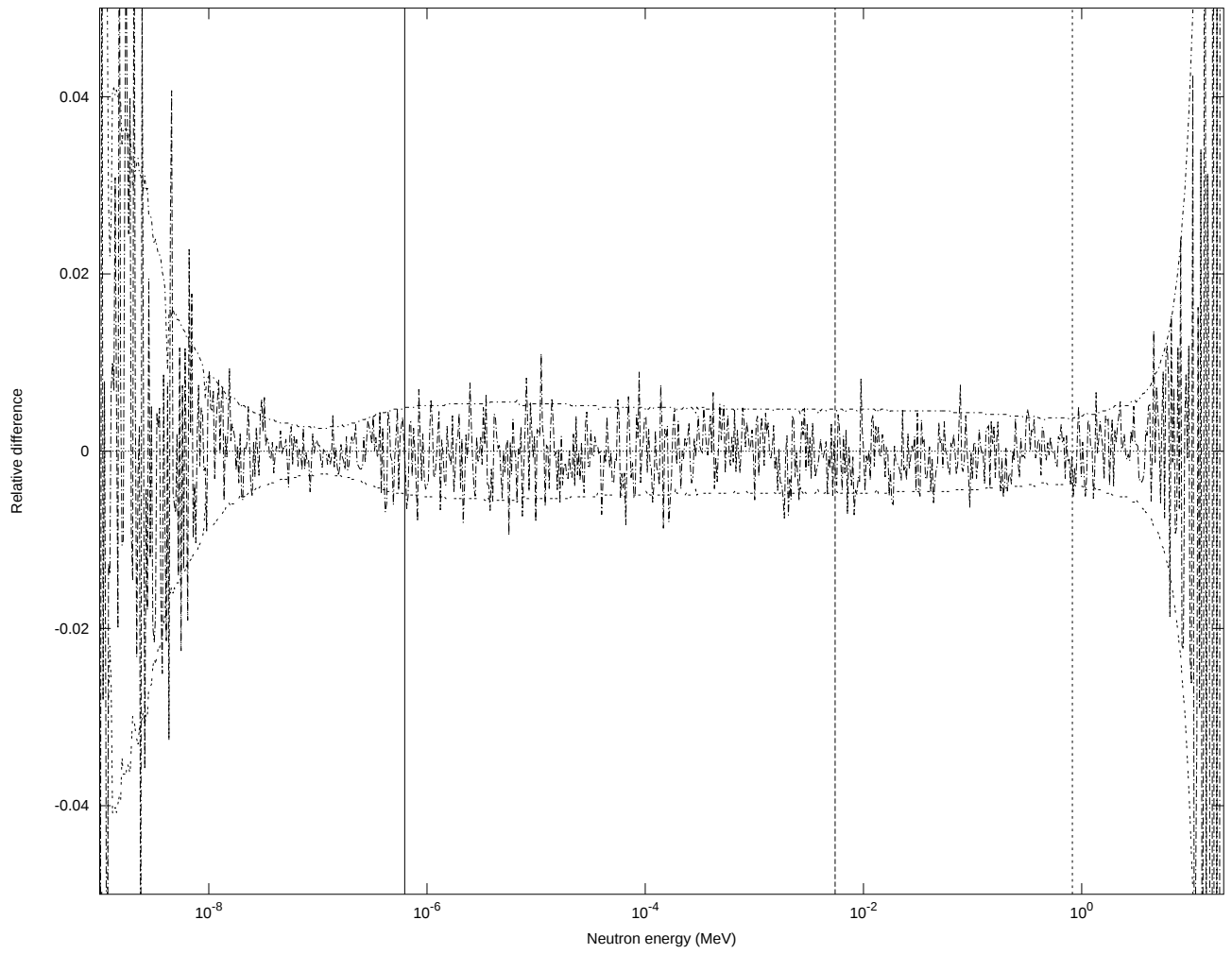


Figure 8. Relative differences between the two spectra Figure 7.

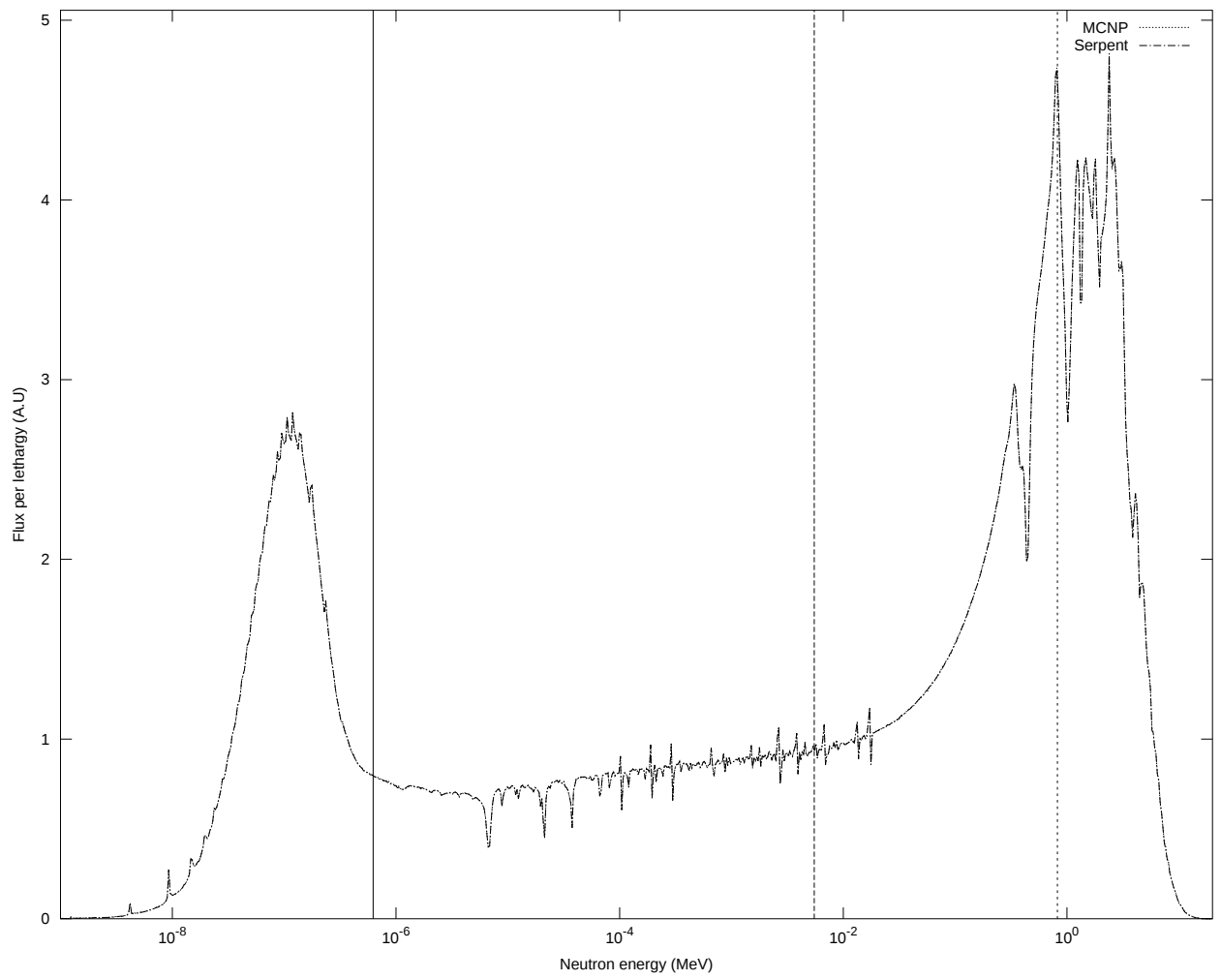


Figure 9. Flux spectra integrated over the entire geometry BWR+Gd Assembly, 25% void fraction.

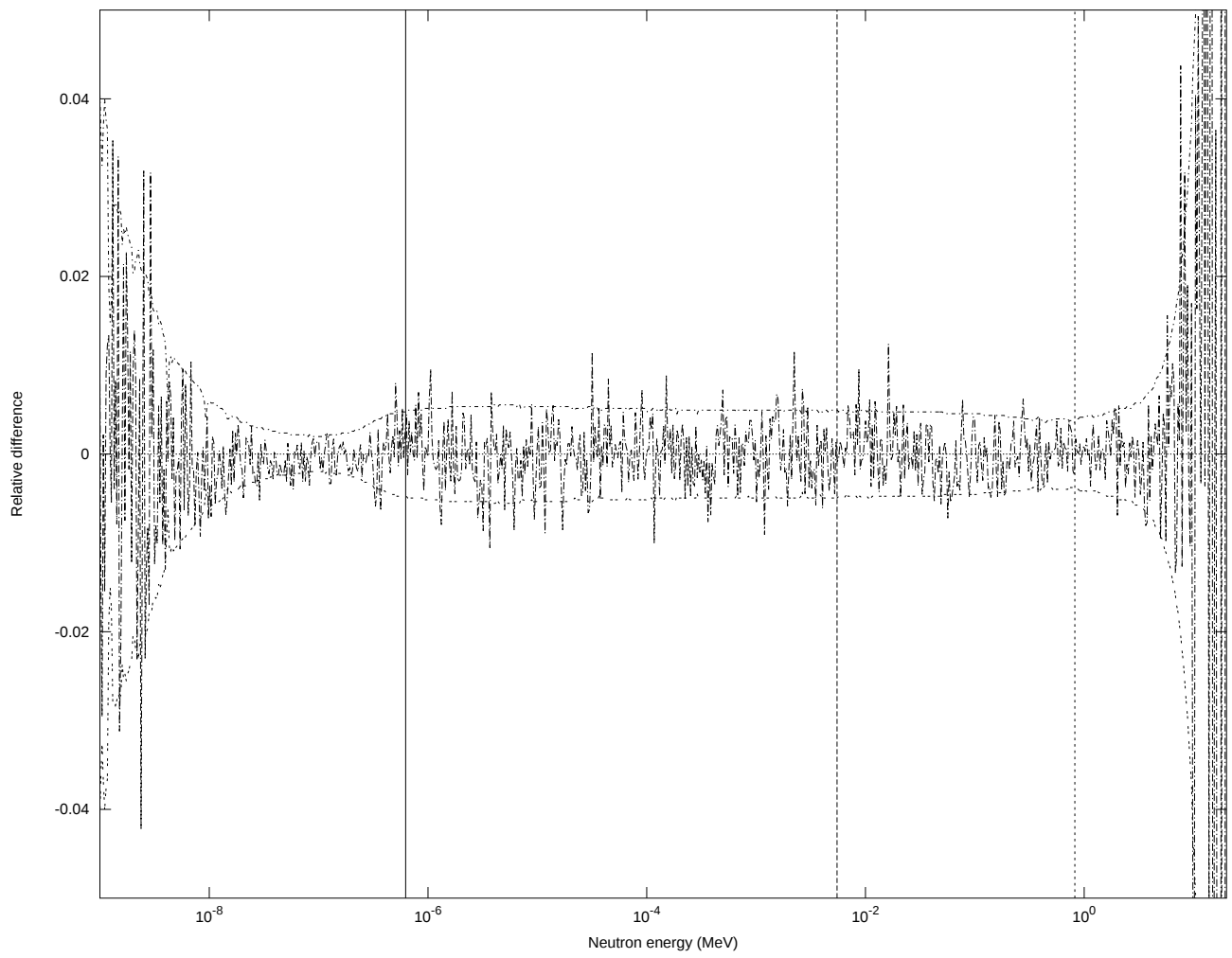


Figure 10. Relative differences between the two spectra Figure 9.

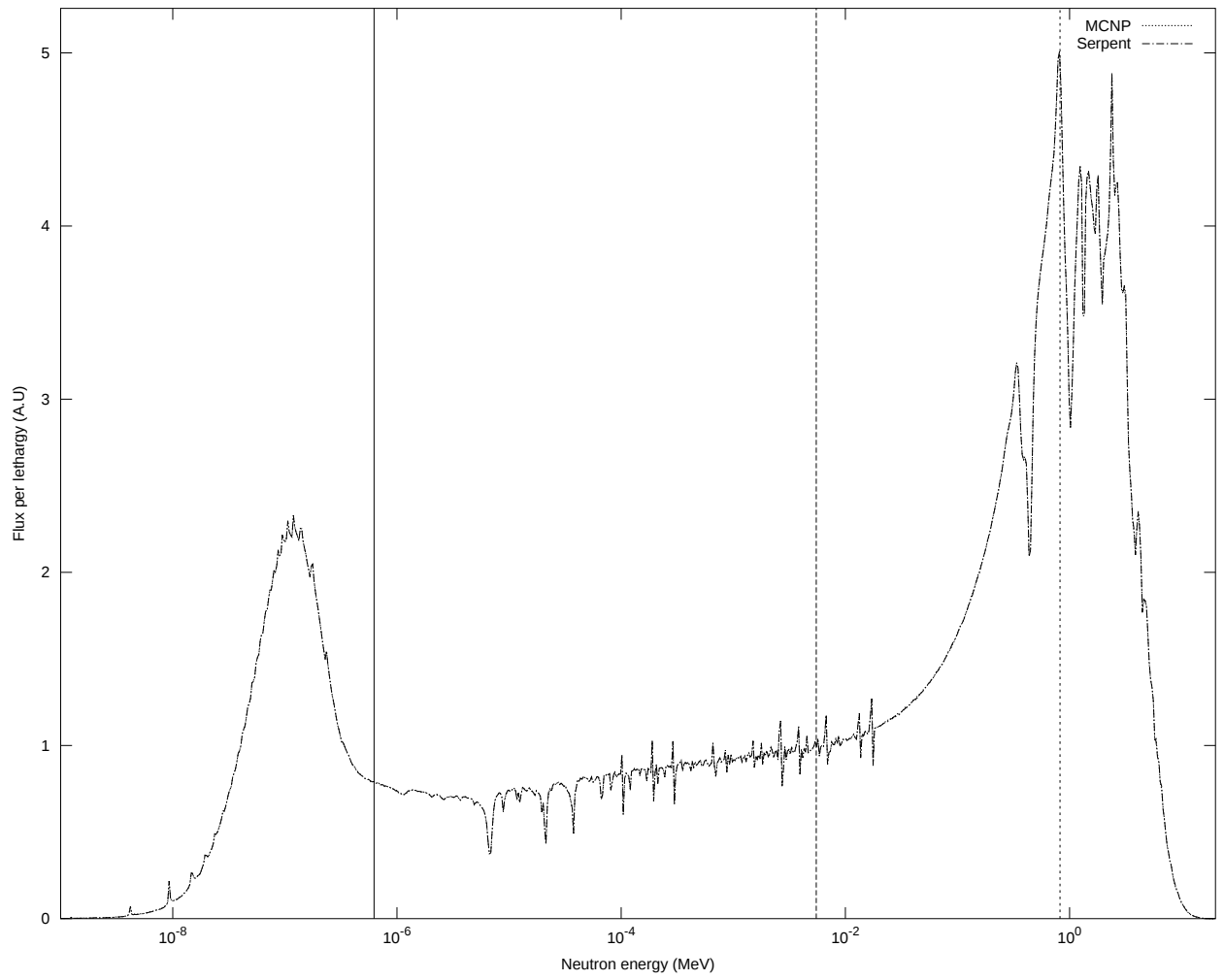


Figure 11. Flux spectra integrated over the entire geometry BWR+Gd Assembly, 50% void fraction.

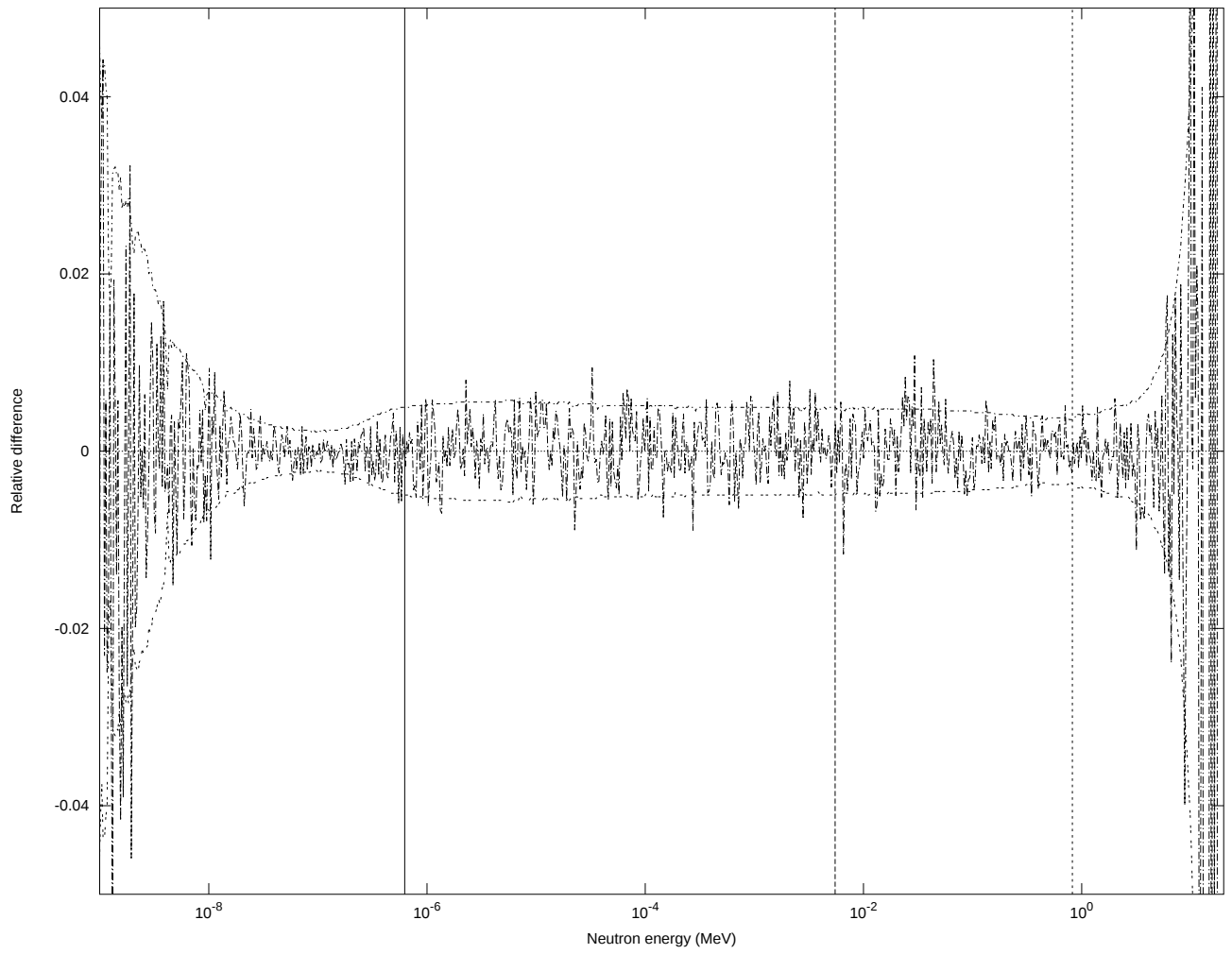


Figure 12. Relative differences between the two spectra Figure 11.

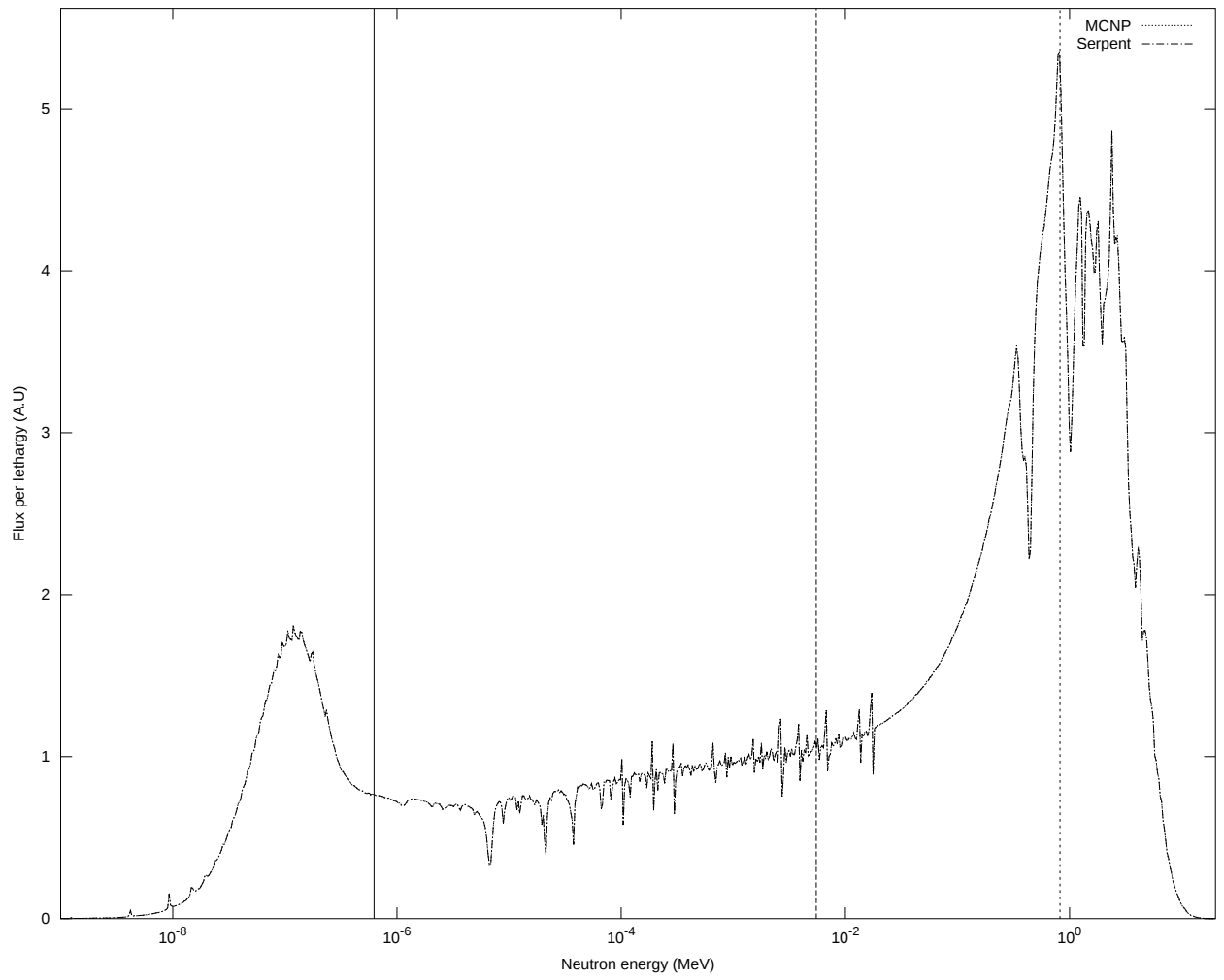


Figure 13. Flux spectra integrated over the entire geometry BWR+Gd Assembly, 75% void fraction.

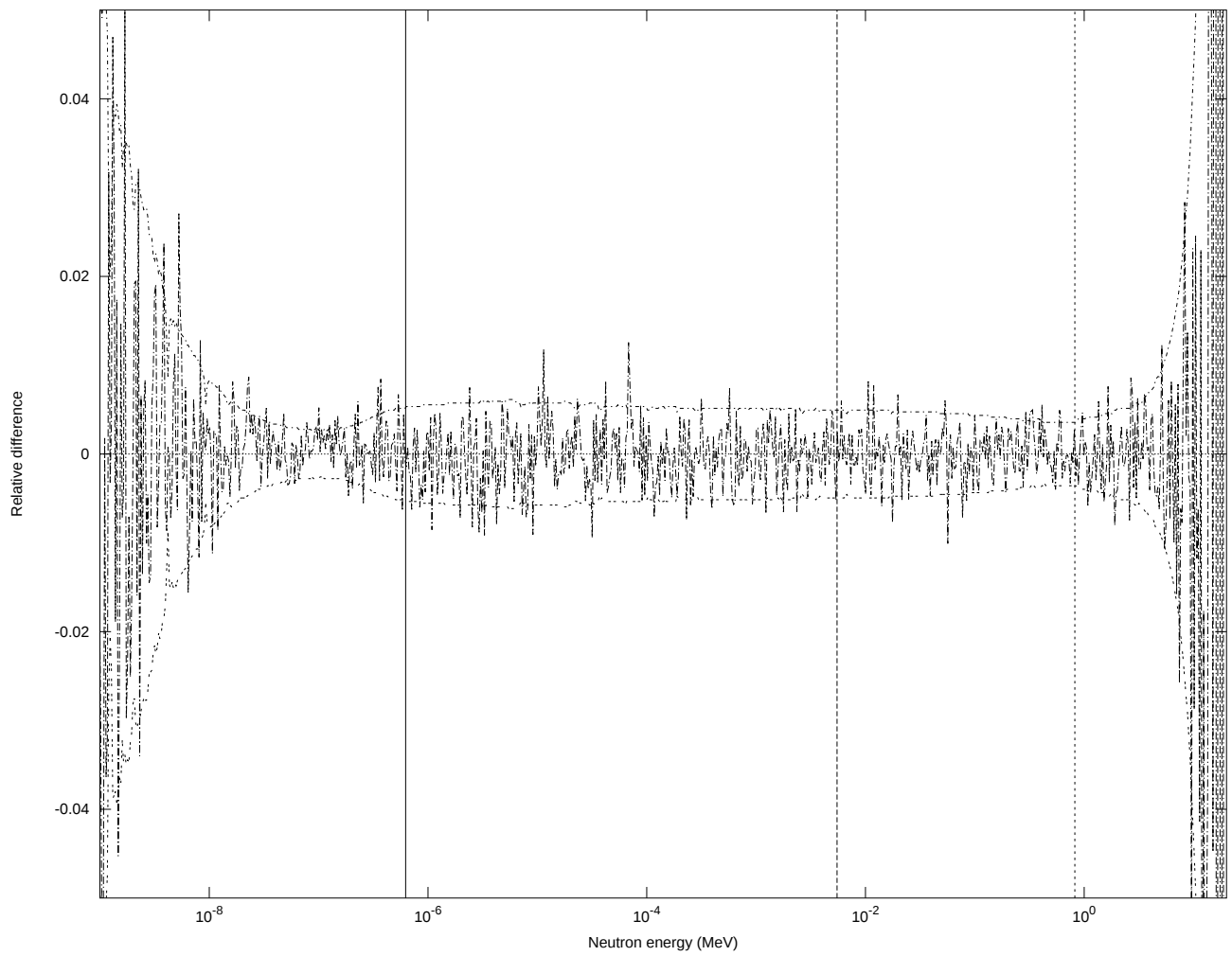


Figure 14. Relative differences between the two spectra Figure 13.

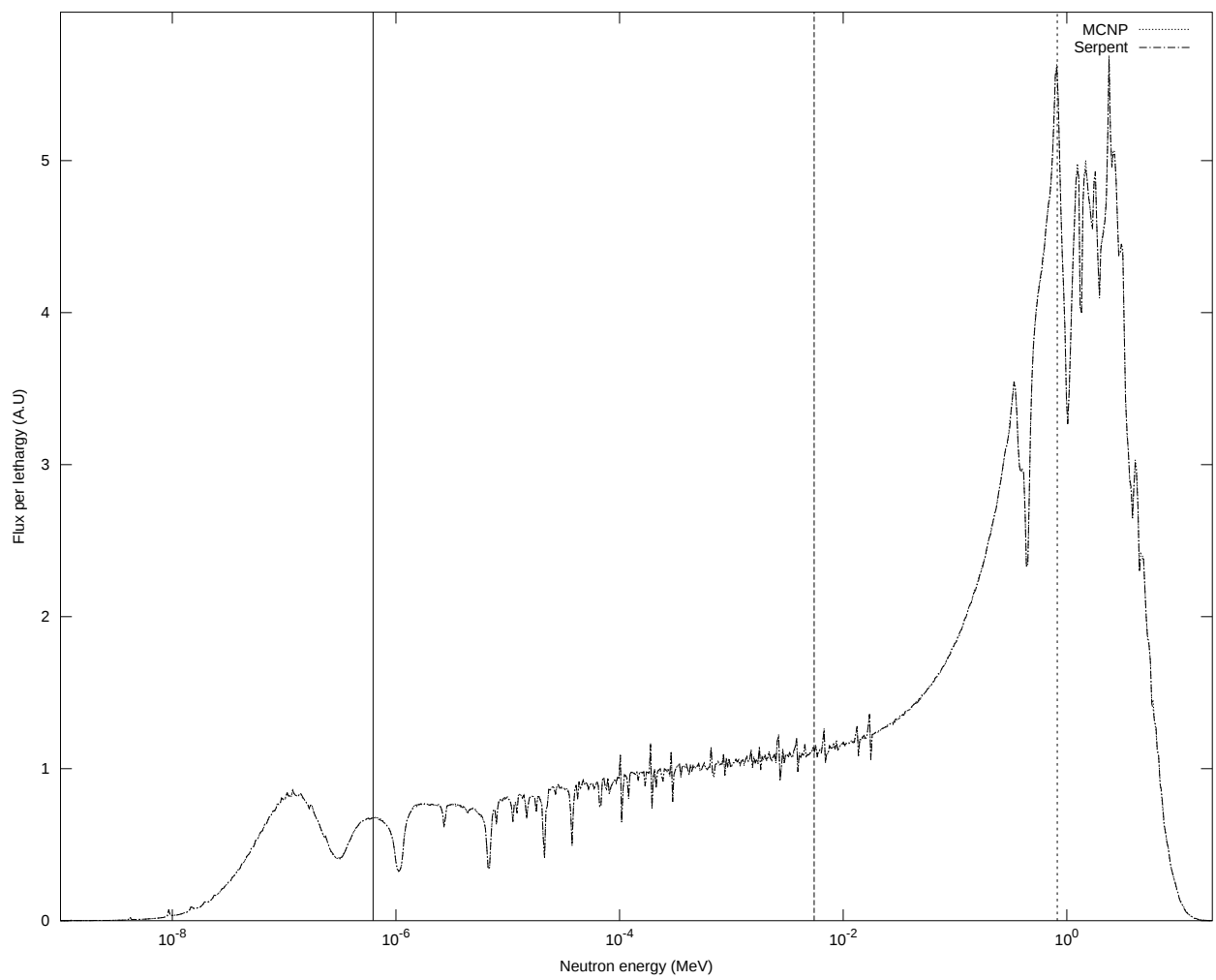


Figure 15. Flux spectra integrated over the entire geometry Mixed PWR MOX/UOX lattice.

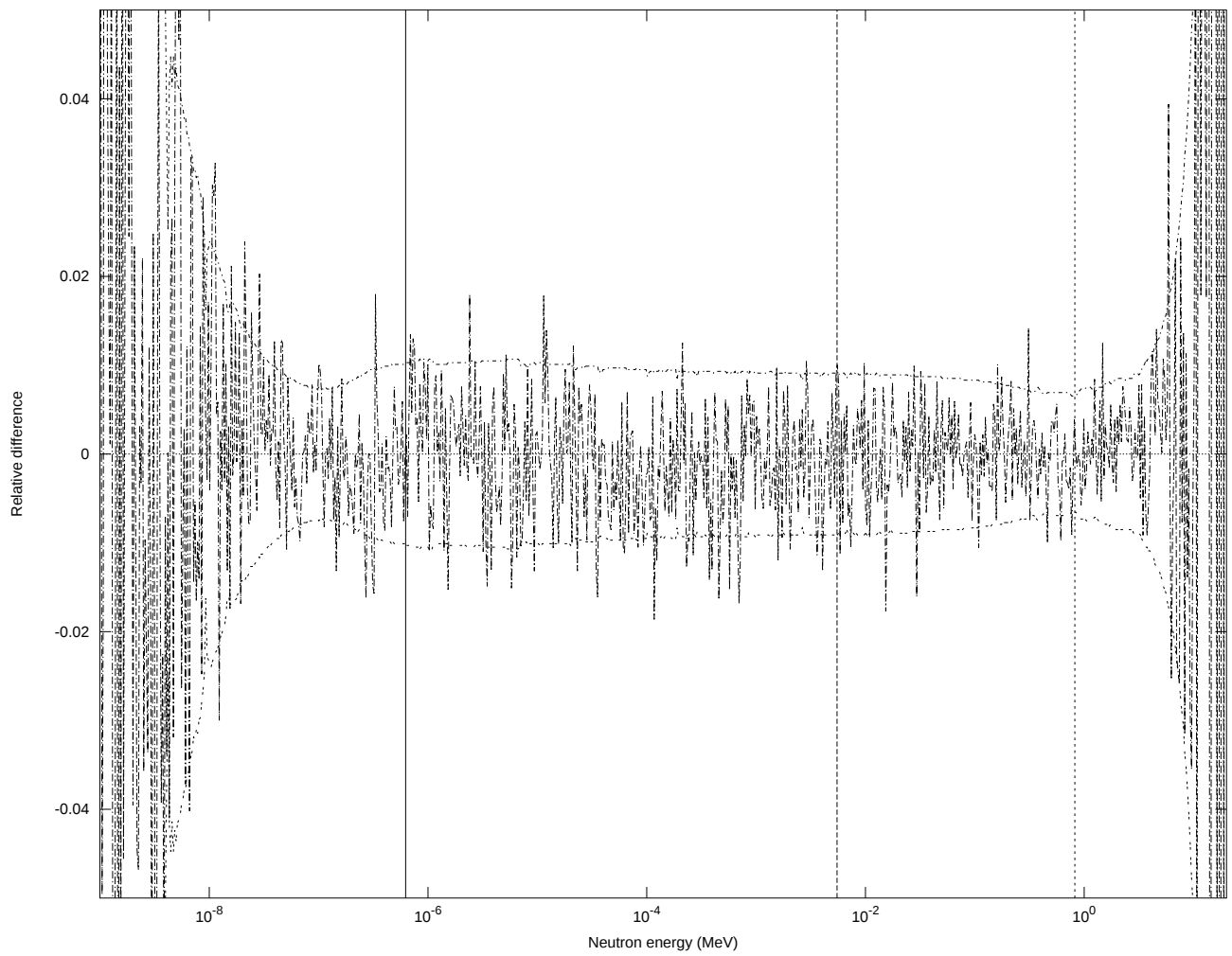


Figure 16. Relative differences between the two spectra Figure 15.

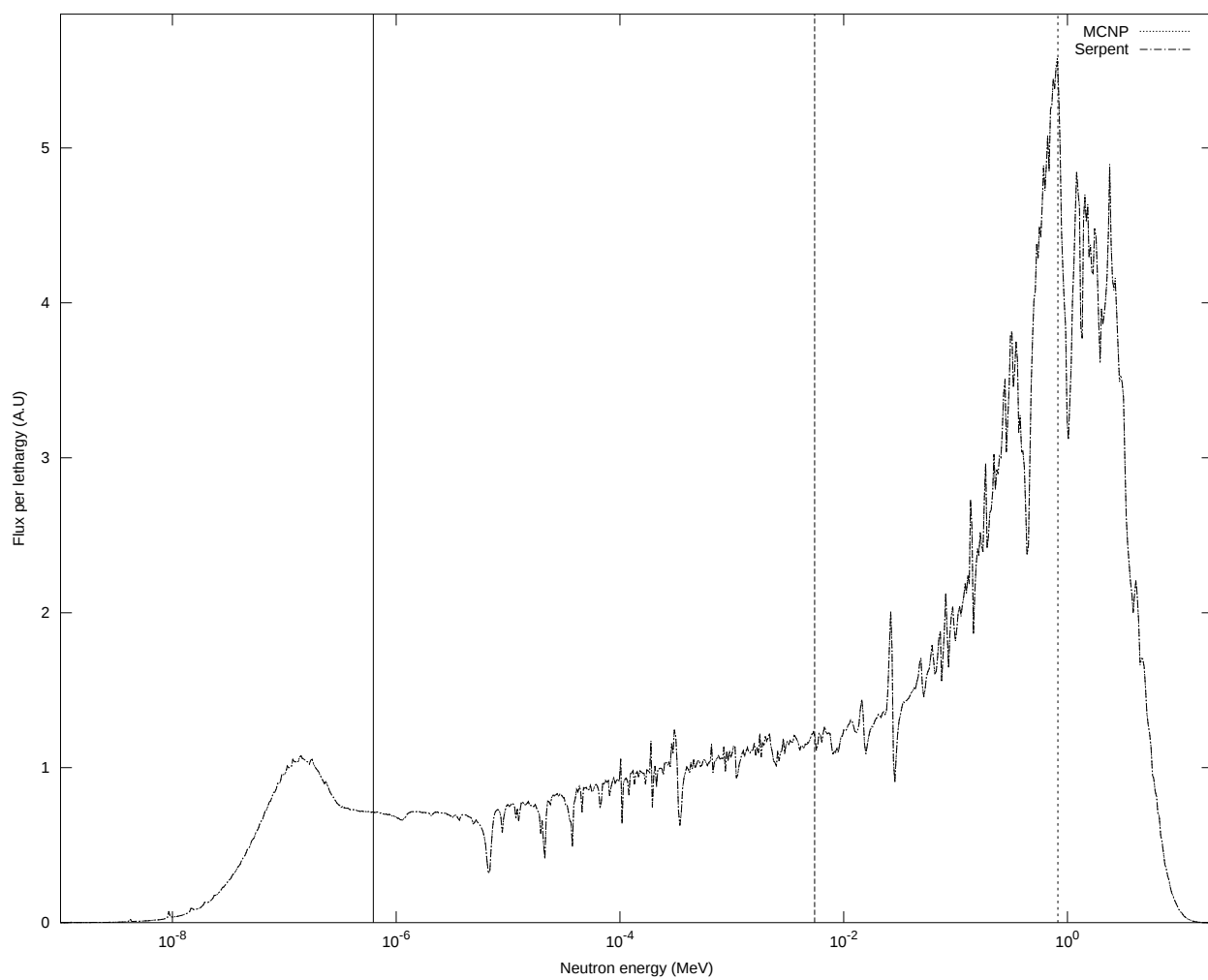


Figure 17. Flux spectra integrated over the entire geometry SCWR assembly.

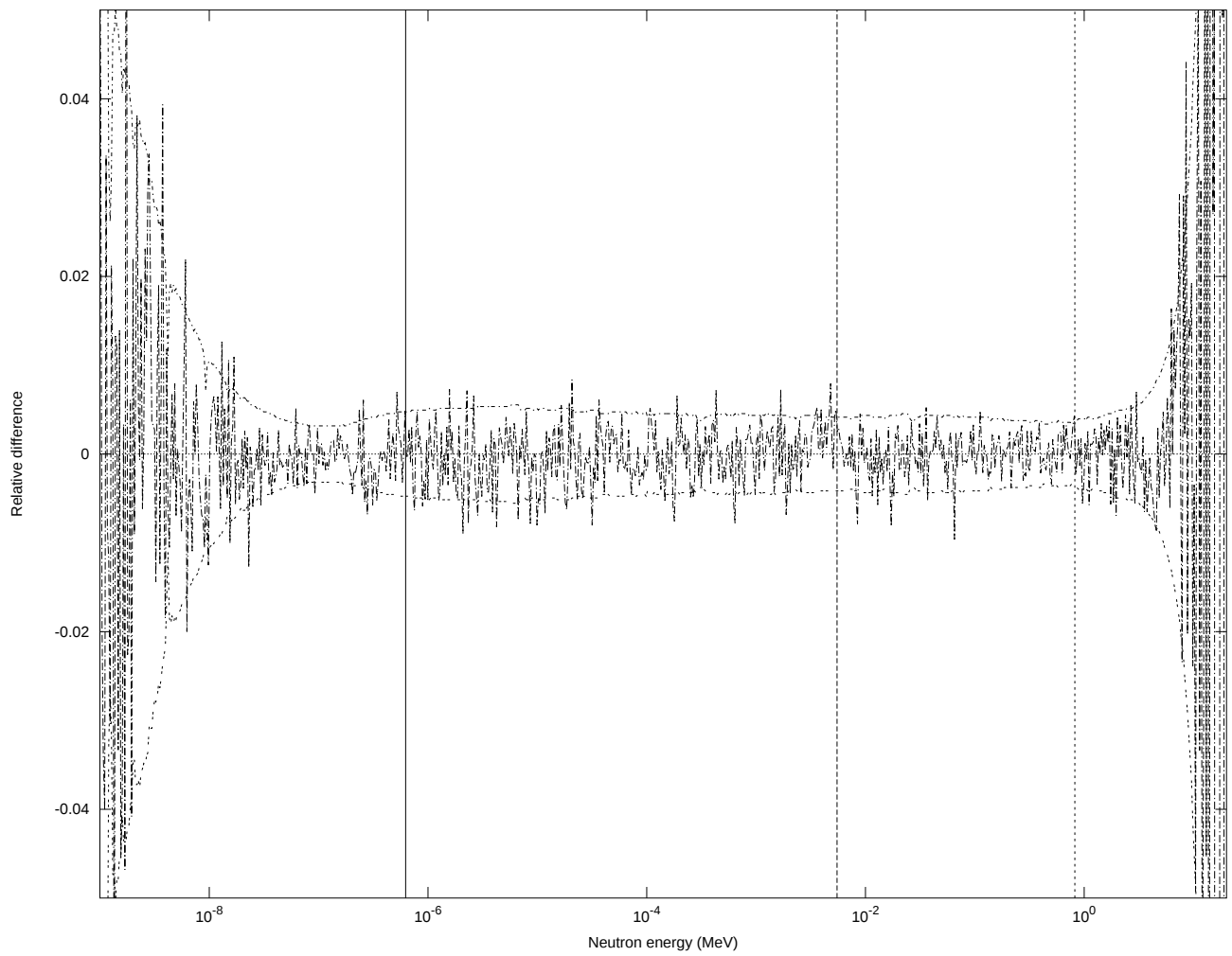


Figure 18. Relative differences between the two spectra Figure 17.

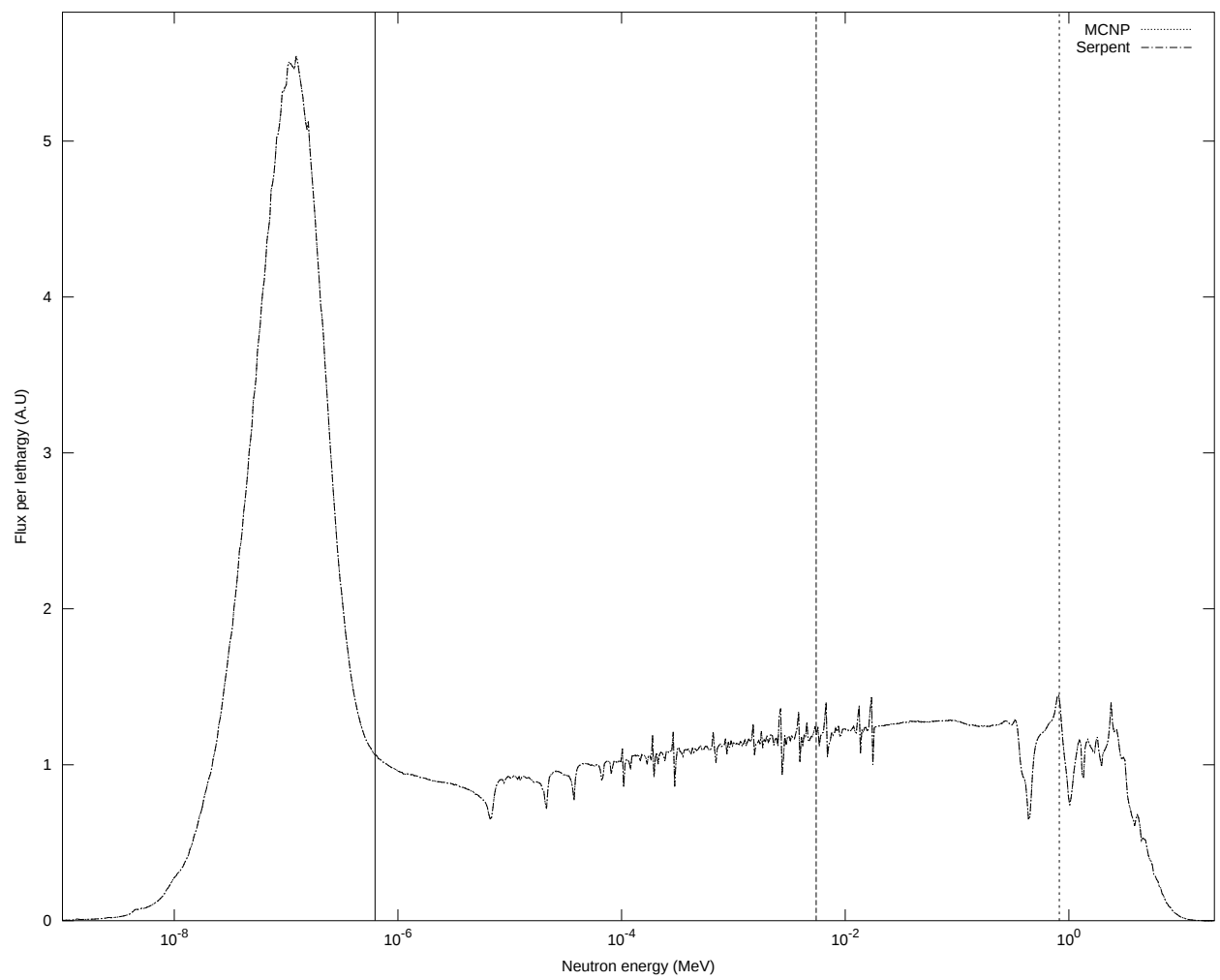


Figure 19. Flux spectra integrated over the entire geometry CANDU fuel cluster.

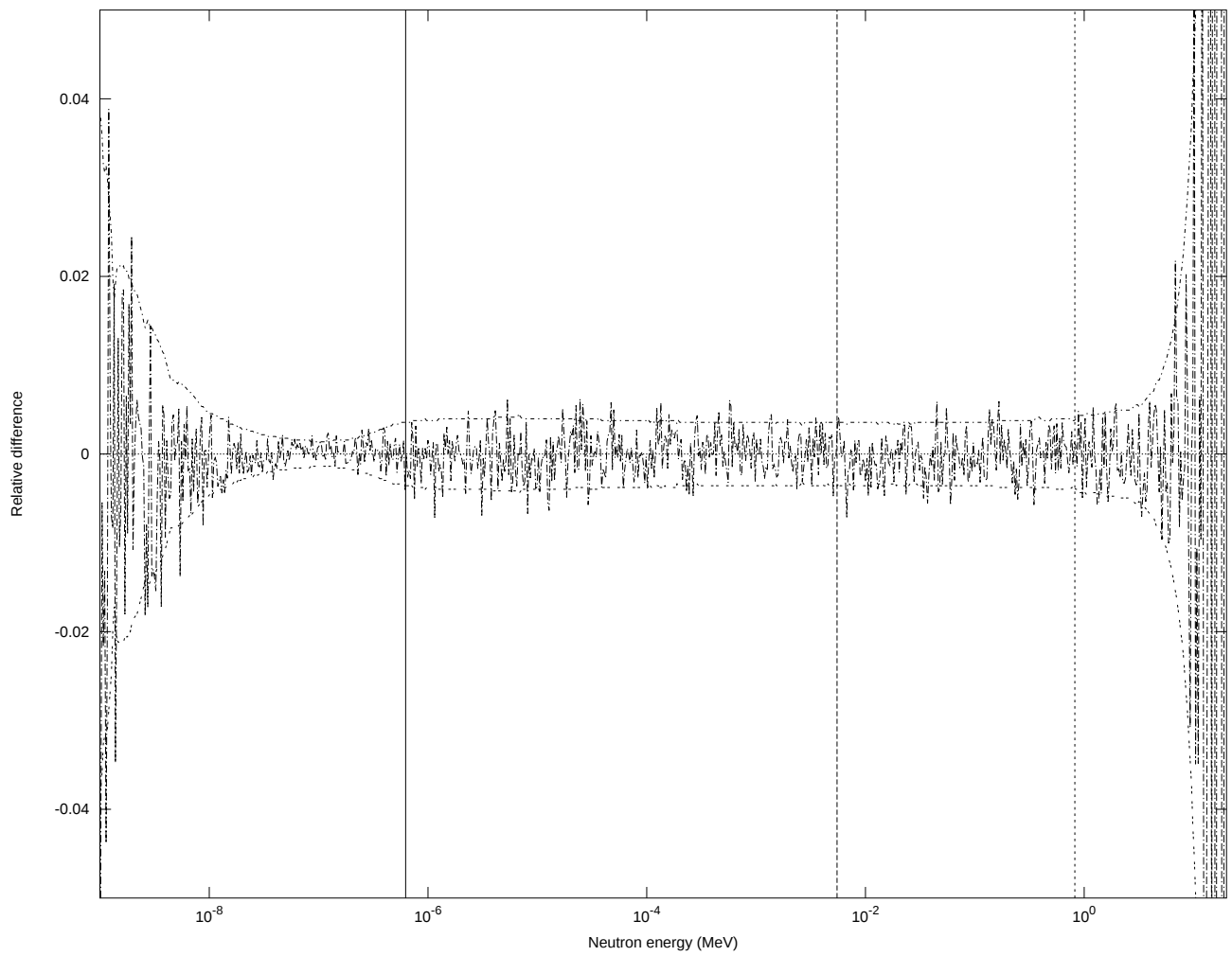


Figure 20. Relative differences between the two spectra Figure 19.

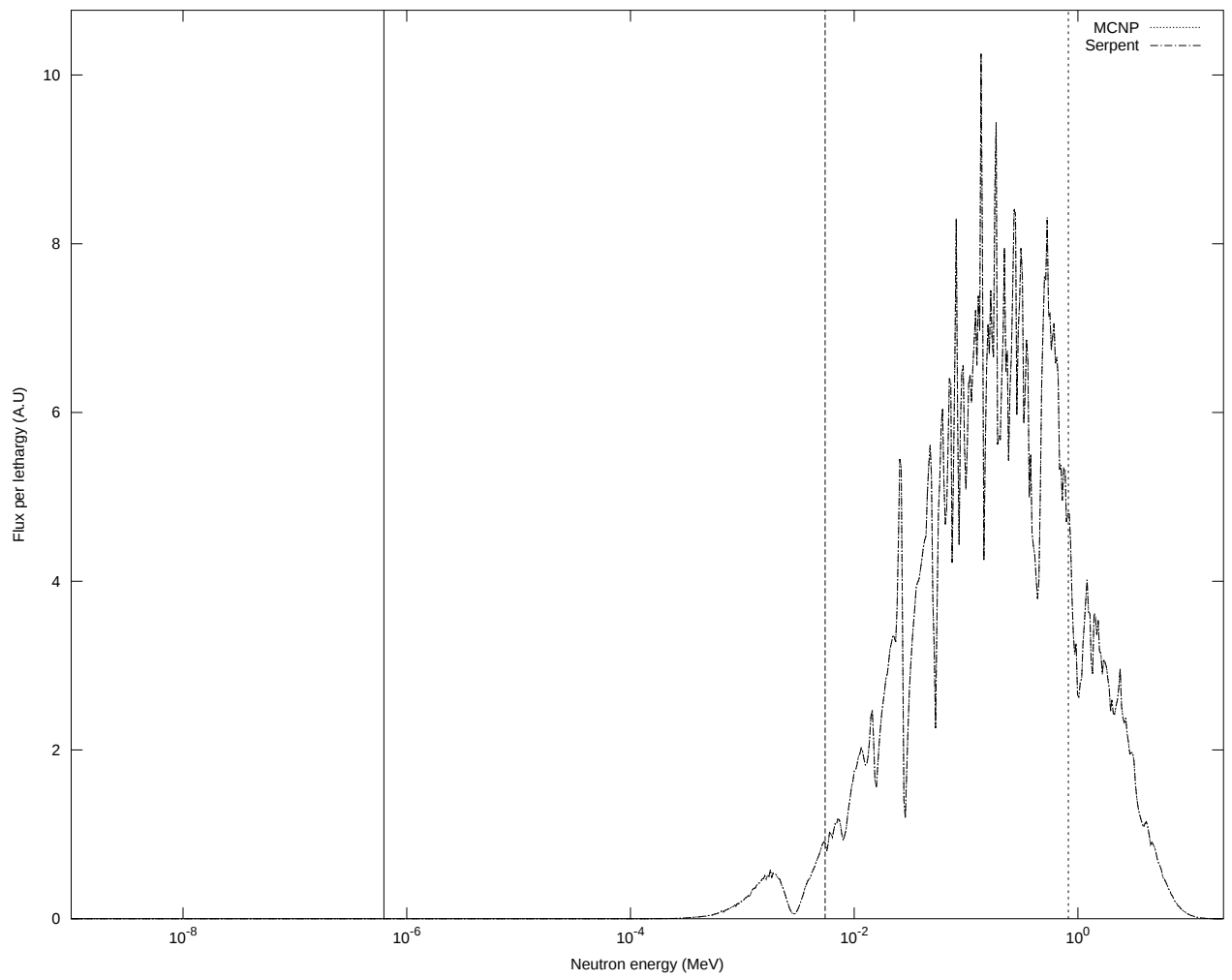


Figure 21. Flux spectra integrated over the entire geometry SFR assembly.

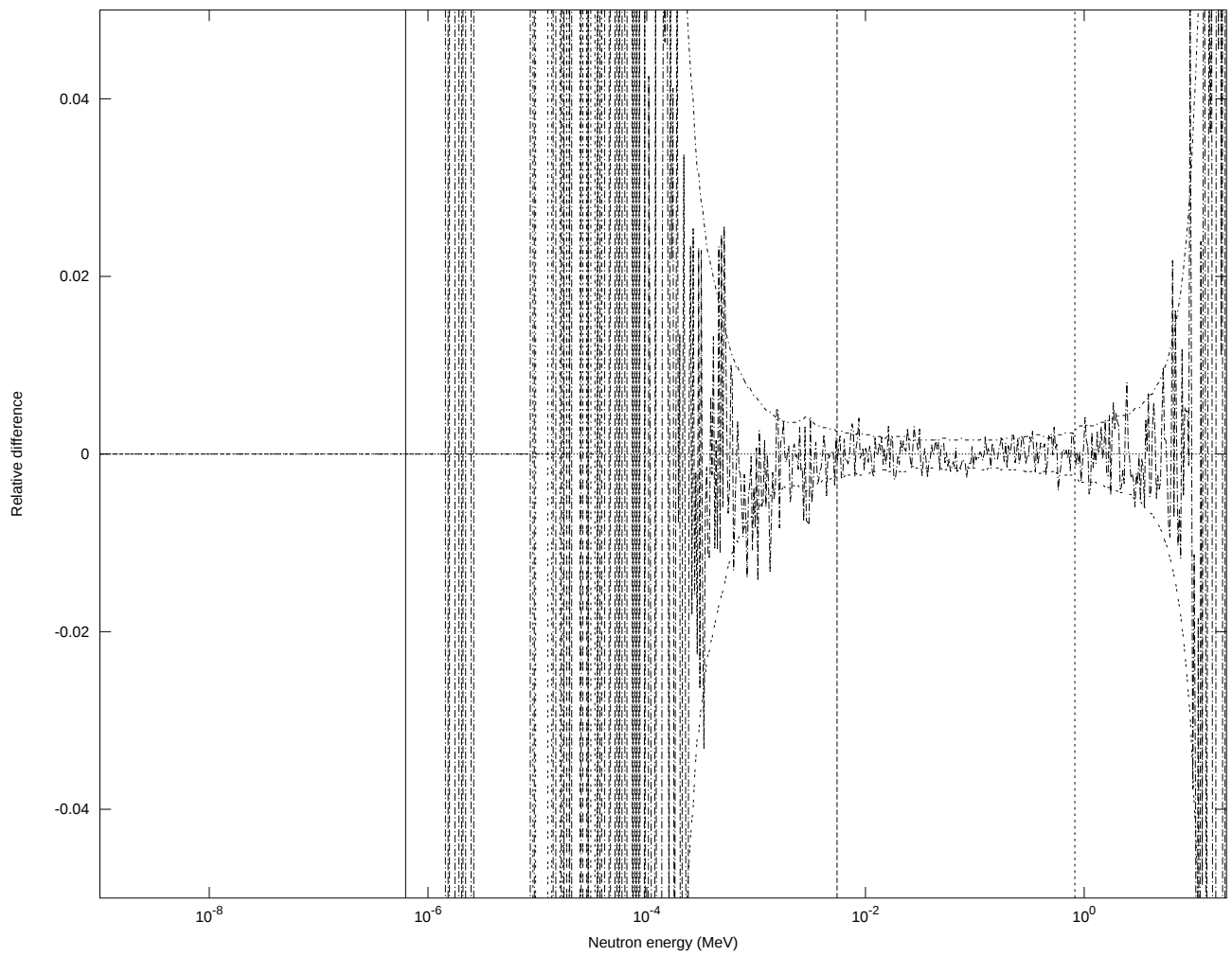


Figure 22. Relative differences between the two spectra Figure 21.

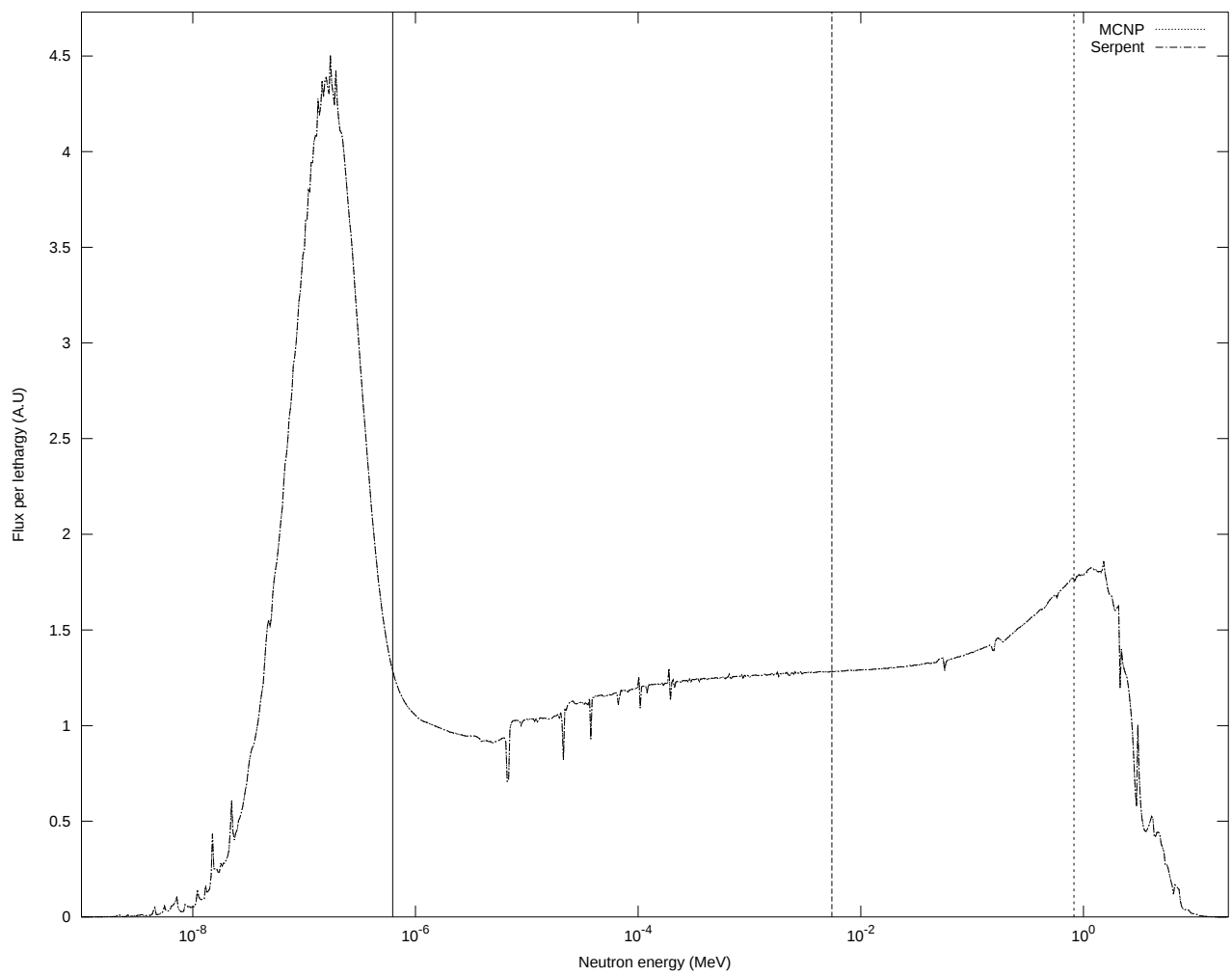


Figure 23. Flux spectra integrated over the entire geometry Prismatic HTGR fuel block.

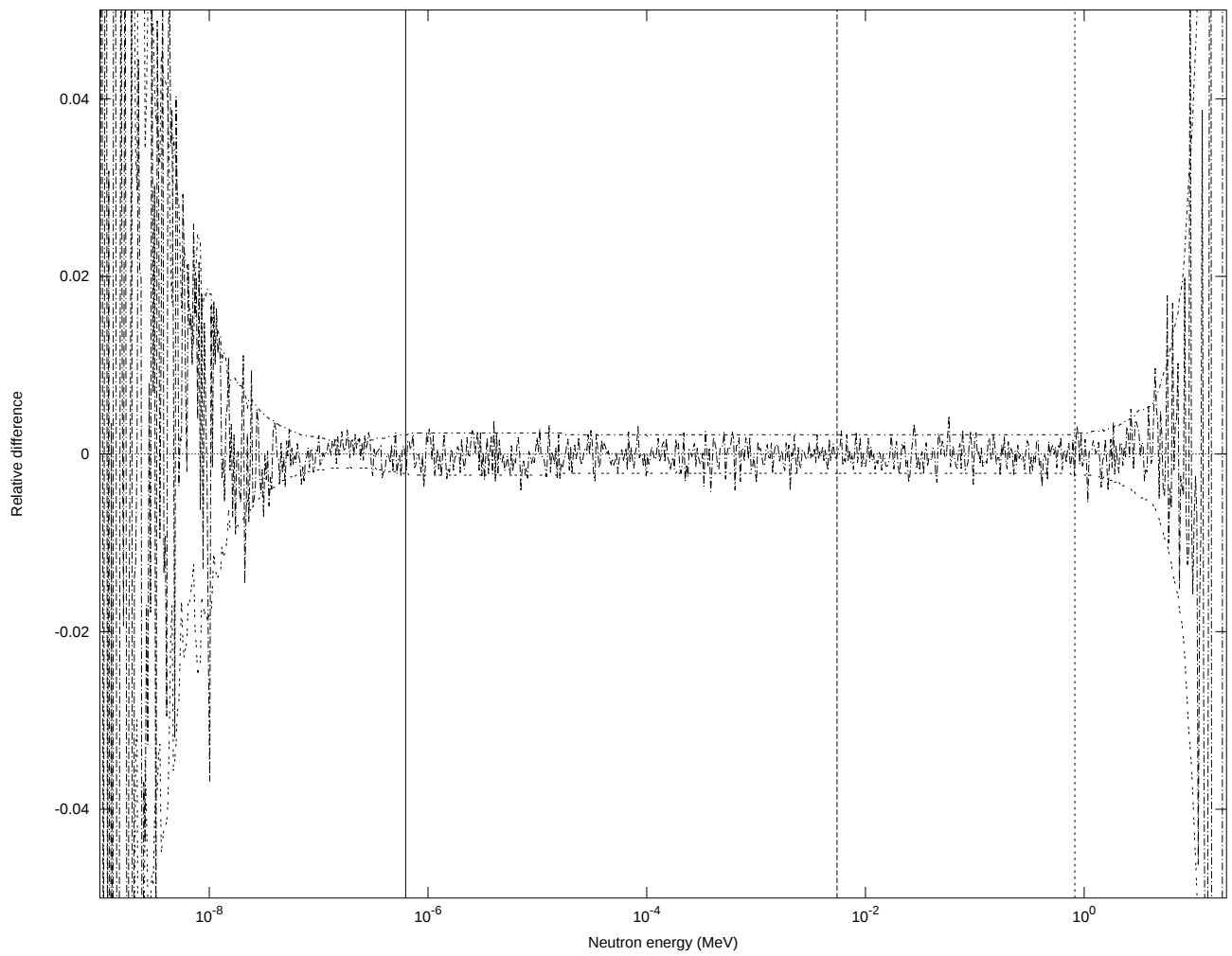


Figure 24. Relative differences between the two spectra Figure 23.

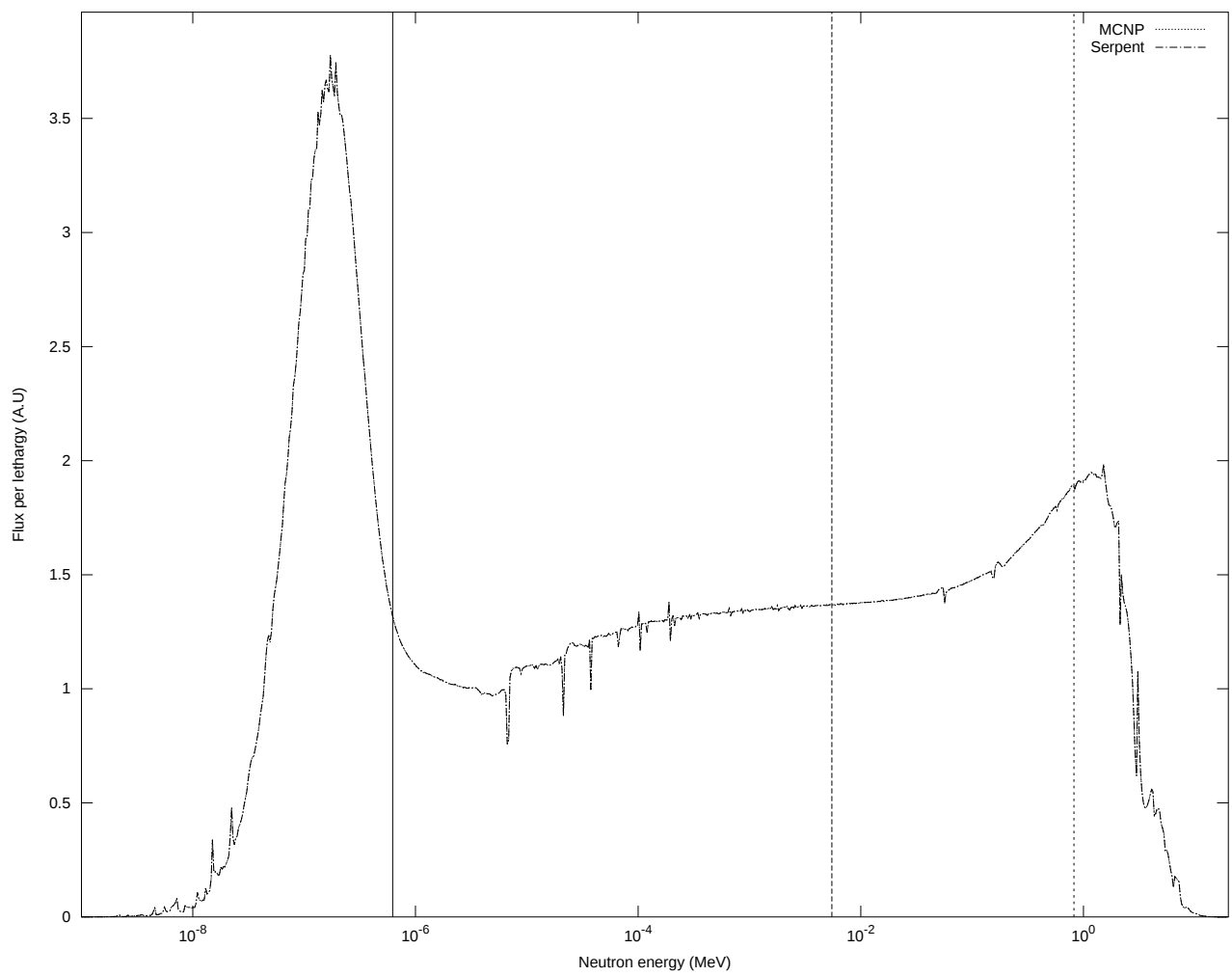


Figure 25. Flux spectra integrated over the entire geometry Prismatic HTGR fuel block + BP.

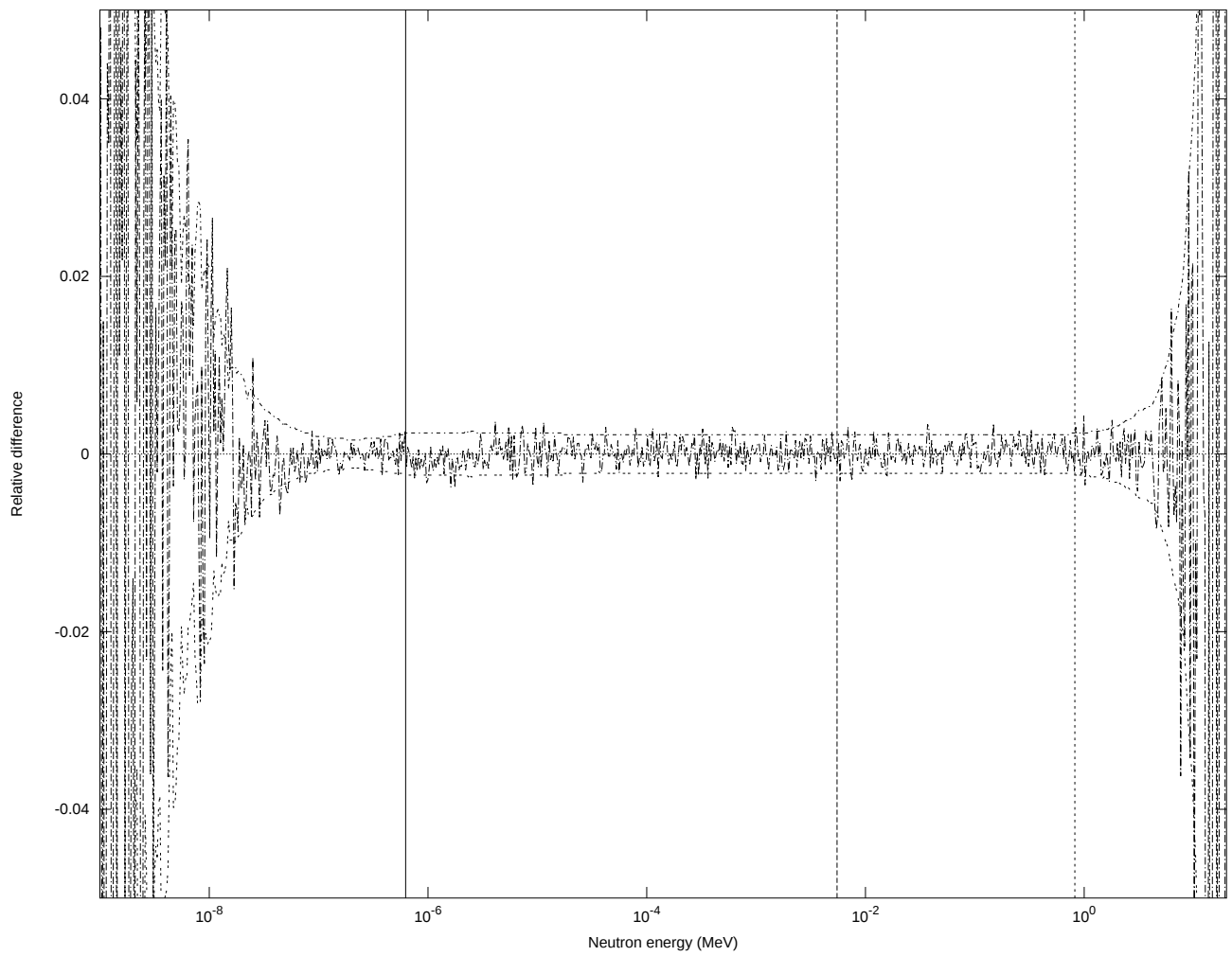


Figure 26. Relative differences between the two spectra Figure 25.

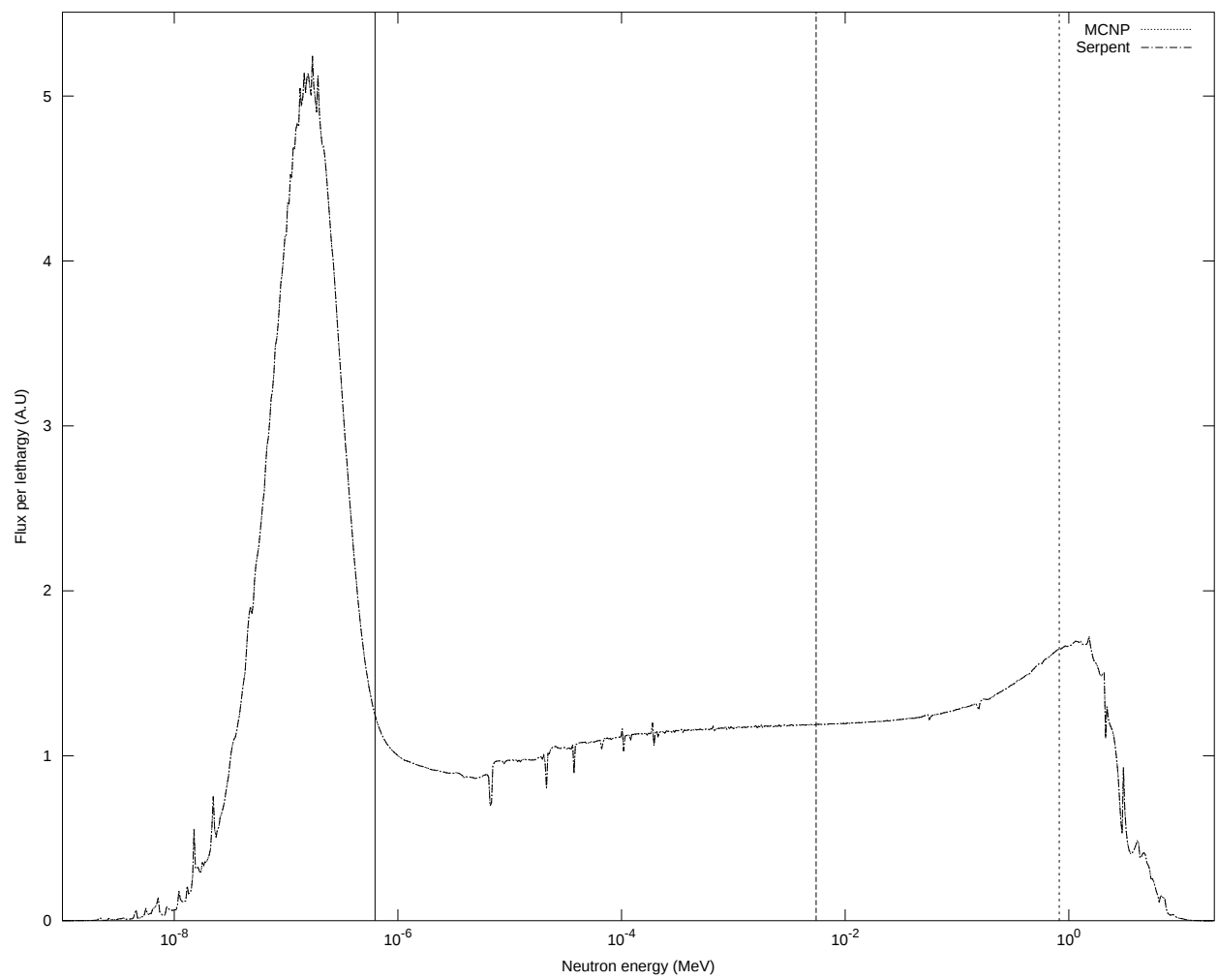


Figure 27. Flux spectra integrated over the entire geometry PBMR fuel pebble.

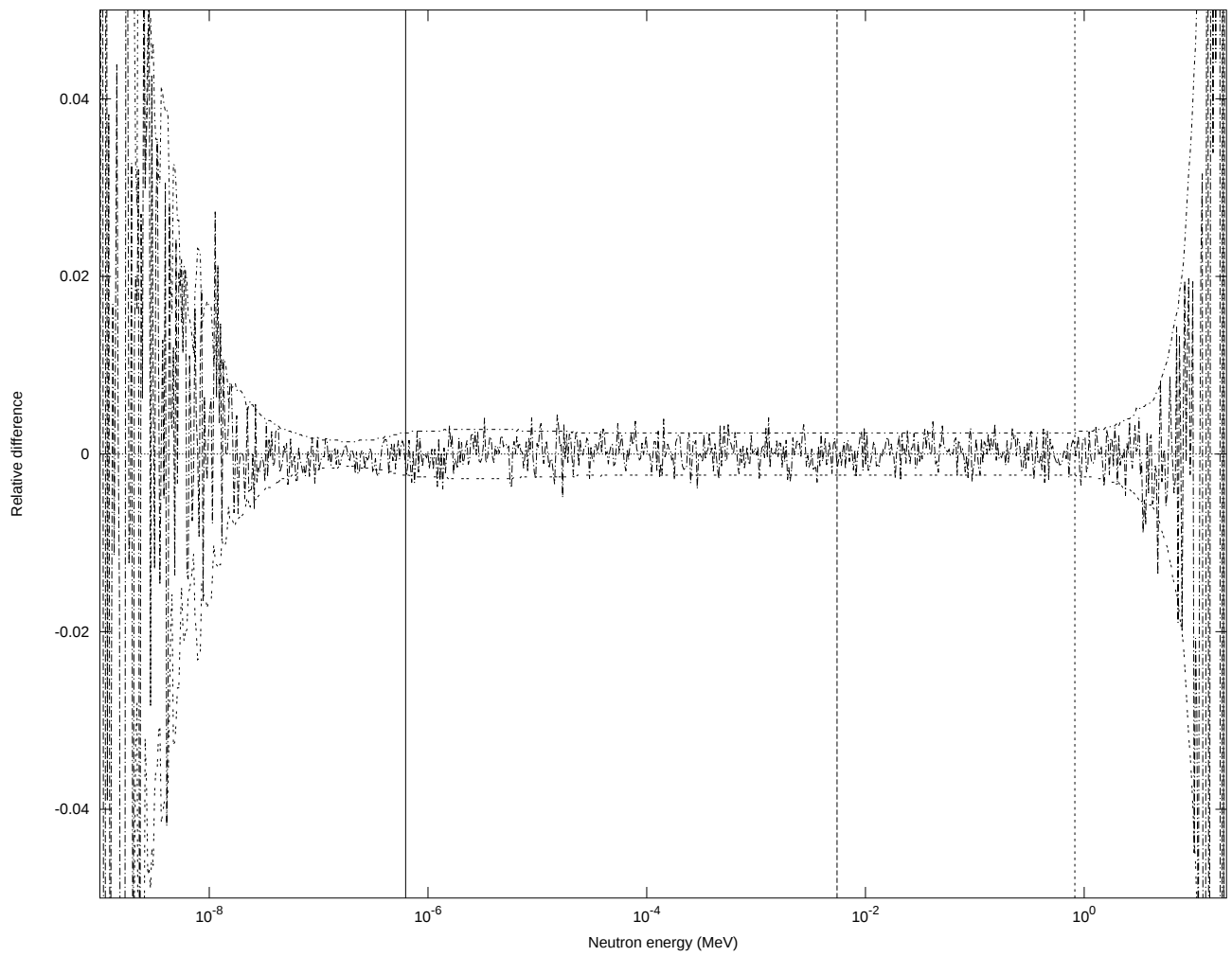


Figure 28. Relative differences between the two spectra Figure 27.