

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

- ENDF/B-VI.8 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	1.27925	(0.014)	1.27917	(0.012)	-0.006
PWR pin-cell, 20 MWd/kgU burnup	1.06973	(0.017)	1.06954	(0.016)	-0.018
PWR pin-cell, 40 MWd/kgU burnup	0.91451	(0.021)	0.91515	(0.019)	0.070
VVER-440 assembly	1.26630	(0.016)	1.26592	(0.015)	-0.030
BWR+Gd Assembly, 25% void fraction	1.07479	(0.018)	1.07540	(0.021)	0.057
BWR+Gd Assembly, 50% void fraction	1.05969	(0.019)	1.06011	(0.021)	0.040
BWR+Gd Assembly, 75% void fraction	1.04018	(0.019)	1.03971	(0.021)	-0.045
Mixed PWR MOX/UOX lattice	1.06815	(0.020)	1.06774	(0.017)	-0.038
SCWR assembly	1.13975	(0.015)	1.13966	(0.016)	-0.008
CANDU fuel cluster	0.91499	(0.016)	0.91495	(0.018)	-0.004
SFR assembly	1.77431	(0.008)	1.77415	(0.008)	-0.009
Prismatic HTGR fuel block	1.44810	(0.016)	1.44789	(0.016)	-0.015
Prismatic HTGR fuel block + BP	1.13686	(0.022)	1.13664	(0.021)	-0.019
PBMR fuel pebble	1.43272	(0.016)	1.43225	(0.016)	-0.033

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	21.50	(0.042)	21.51	(0.026)	0.044
PWR pin-cell, 20 MWd/kgU burnup	19.07	(0.045)	19.07	(0.029)	-0.014
PWR pin-cell, 40 MWd/kgU burnup	19.58	(0.047)	19.58	(0.032)	-0.021
VVER-440 assembly	18.05	(0.043)	18.05	(0.029)	-0.018
BWR+Gd Assembly, 25% void fraction	28.87	(0.042)	28.86	(0.033)	-0.008
BWR+Gd Assembly, 50% void fraction	27.75	(0.046)	27.74	(0.034)	-0.001
BWR+Gd Assembly, 75% void fraction	26.19	(0.047)	26.19	(0.033)	0.020
Mixed PWR MOX/UOX lattice	14.03	(0.049)	7.15	(0.071)	-48.993
SCWR assembly	15.13	(0.040)	15.14	(0.031)	0.030
CANDU fuel cluster	186.48	(0.048)	186.43	(0.034)	-0.025
SFR assembly	0.33	(0.021)	0.33	(0.019)	-0.122
Prismatic HTGR fuel block	322.13	(0.035)	322.09	(0.035)	-0.014
Prismatic HTGR fuel block + BP	256.69	(0.036)	256.53	(0.032)	-0.062
PBMR fuel pebble	573.64	(0.037)	573.02	(0.032)	-0.108

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	807.4	21.0	38.4
PWR pin-cell, 20 MWd/kgU burnup	780.2	18.7	41.7
PWR pin-cell, 40 MWd/kgU burnup	786.1	19.0	41.3
VVER-440 assembly	261.7	17.8	14.7
BWR+Gd Assembly, 25% void fraction	255.6	24.2	10.6
BWR+Gd Assembly, 50% void fraction	269.6	23.1	11.7
BWR+Gd Assembly, 75% void fraction	307.9	22.6	13.6
Mixed PWR MOX/UOX lattice	142.7	17.1	8.4
SCWR assembly	404.7	17.7	22.8
CANDU fuel cluster	320.8	33.7	9.5
SFR assembly	1367.1	22.5	60.9
Prismatic HTGR fuel block	6108.8	99.6	61.4
Prismatic HTGR fuel block + BP	5485.4	89.0	61.6
PBMR fuel pebble	3826.9	101.3	37.8

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	2.28513E-01	(0.057)	2.28506E-01	(0.009)	-0.003
	2	5.61687E-01	(0.028)	5.61705E-01	(0.006)	0.003
	3	8.79383E-01	(0.028)	8.79404E-01	(0.006)	0.002
	4	1.43547E+00	(0.042)	1.43548E+00	(0.010)	0.001
Σ_{fiss}	1	2.84330E-03	(0.064)	2.84246E-03	(0.041)	-0.029
	2	3.40263E-04	(0.028)	3.40337E-04	(0.024)	0.022
	3	4.93110E-03	(0.036)	4.92688E-03	(0.041)	-0.086
	4	5.30724E-02	(0.042)	5.30852E-02	(0.024)	0.024
Σ_{abs}	1	3.66722E-03	(0.064)	3.66541E-03	(0.037)	-0.049
	2	2.17809E-03	(0.036)	2.17868E-03	(0.034)	0.027
	3	2.37690E-02	(0.045)	2.37780E-02	(0.038)	0.038
	4	8.25076E-02	(0.042)	8.25245E-02	(0.022)	0.021
Σ_{capt}	1	8.23931E-04	(0.081)	8.22946E-04	(0.051)	-0.120
	2	1.83782E-03	(0.036)	1.83835E-03	(0.036)	0.029
	3	1.88379E-02	(0.054)	1.88511E-02	(0.044)	0.070
	4	2.94352E-02	(0.042)	2.94393E-02	(0.017)	0.014
Σ_{scatt}	1	2.24846E-01	(0.057)	2.24841E-01	(0.010)	-0.002
	2	5.59509E-01	(0.028)	5.59526E-01	(0.006)	0.003
	3	8.55614E-01	(0.028)	8.55626E-01	(0.006)	0.001
	4	1.35296E+00	(0.042)	1.35296E+00	(0.011)	0.000
$\nu\Sigma_{\text{fiss}}$	1	7.91213E-03	(0.064)	7.90736E-03	(0.046)	-0.060
	2	8.35856E-04	(0.028)	8.35869E-04	(0.028)	0.002
	3	1.20387E-02	(0.036)	1.20282E-02	(0.041)	-0.087
	4	1.30268E-01	(0.042)	1.30301E-01	(0.024)	0.025
$\bar{\nu}$	1	2.78273E+00	(0.071)	2.78186E+00	(0.016)	-0.031
	2	2.45650E+00	(0.028)	2.45600E+00	(0.012)	-0.020
	3	2.44137E+00	(0.042)	2.44134E+00	(0.003)	-0.001
	4	2.45454E+00	(0.042)	2.45457E+00	(0.002)	0.001
$1/v$	1	5.27099E-10	(0.057)	5.27172E-10	(0.009)	0.014
	2	2.62381E-09	(0.028)	2.62396E-09	(0.014)	0.006
	3	1.83680E-07	(0.036)	1.83679E-07	(0.023)	-0.001
	4	2.41600E-06	(0.042)	2.41594E-06	(0.010)	-0.002

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	2.28453E-01	(0.057)	2.28468E-01	(0.009)	0.007
	2	5.62598E-01	(0.028)	5.62578E-01	(0.006)	-0.004
	3	8.87853E-01	(0.028)	8.87786E-01	(0.007)	-0.008
	4	1.45185E+00	(0.057)	1.45194E+00	(0.011)	0.006
Σ_{fiss}	1	2.78204E-03	(0.064)	2.77980E-03	(0.043)	-0.080
	2	2.20506E-04	(0.028)	2.20527E-04	(0.022)	0.009
	3	3.22139E-03	(0.036)	3.22250E-03	(0.039)	0.034
	4	4.77871E-02	(0.057)	4.77674E-02	(0.025)	-0.041
Σ_{abs}	1	3.61193E-03	(0.064)	3.61069E-03	(0.039)	-0.034
	2	2.05179E-03	(0.036)	2.05131E-03	(0.031)	-0.023
	3	2.78561E-02	(0.045)	2.78390E-02	(0.037)	-0.061
	4	8.92699E-02	(0.057)	8.92375E-02	(0.022)	-0.036
Σ_{capt}	1	8.29898E-04	(0.081)	8.30893E-04	(0.053)	0.120
	2	1.83128E-03	(0.036)	1.83079E-03	(0.033)	-0.027
	3	2.46347E-02	(0.045)	2.46165E-02	(0.040)	-0.074
	4	4.14829E-02	(0.057)	4.14701E-02	(0.019)	-0.031
Σ_{scatt}	1	2.24841E-01	(0.057)	2.24857E-01	(0.009)	0.007
	2	5.60546E-01	(0.028)	5.60527E-01	(0.006)	-0.003
	3	8.59997E-01	(0.028)	8.59947E-01	(0.007)	-0.006
	4	1.36258E+00	(0.057)	1.36270E+00	(0.012)	0.009
$\nu\Sigma_{\text{fiss}}$	1	7.79507E-03	(0.064)	7.78717E-03	(0.048)	-0.101
	2	5.70242E-04	(0.028)	5.70703E-04	(0.052)	0.081
	3	8.29187E-03	(0.036)	8.29478E-03	(0.041)	0.035
	4	1.26960E-01	(0.057)	1.26900E-01	(0.026)	-0.047
$\bar{\nu}$	1	2.80193E+00	(0.071)	2.80133E+00	(0.018)	-0.021
	2	2.58606E+00	(0.028)	2.58791E+00	(0.047)	0.072
	3	2.57400E+00	(0.042)	2.57402E+00	(0.013)	0.001
	4	2.65678E+00	(0.057)	2.65662E+00	(0.005)	-0.006
$1/v$	1	5.25371E-10	(0.057)	5.25399E-10	(0.009)	0.005
	2	2.62645E-09	(0.028)	2.62624E-09	(0.014)	-0.008
	3	1.76743E-07	(0.036)	1.76729E-07	(0.021)	-0.008
	4	2.44998E-06	(0.057)	2.45031E-06	(0.010)	0.013

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	2.28777E-01	(0.057)	2.28811E-01	(0.009)	0.015
	2	5.63426E-01	(0.028)	5.63321E-01	(0.006)	-0.019
	3	8.93606E-01	(0.028)	8.93591E-01	(0.007)	-0.002
	4	1.45290E+00	(0.057)	1.45290E+00	(0.010)	0.000
Σ_{fiss}	1	2.71801E-03	(0.064)	2.71917E-03	(0.042)	0.043
	2	1.45182E-04	(0.028)	1.45293E-04	(0.022)	0.077
	3	2.13945E-03	(0.036)	2.14189E-03	(0.044)	0.114
	4	3.85767E-02	(0.057)	3.85815E-02	(0.026)	0.013
Σ_{abs}	1	3.55252E-03	(0.064)	3.55368E-03	(0.040)	0.033
	2	1.97902E-03	(0.036)	1.97918E-03	(0.032)	0.008
	3	3.01737E-02	(0.045)	3.01461E-02	(0.038)	-0.091
	4	8.44293E-02	(0.057)	8.44231E-02	(0.022)	-0.007
Σ_{capt}	1	8.34511E-04	(0.081)	8.34509E-04	(0.056)	-0.000
	2	1.83384E-03	(0.036)	1.83389E-03	(0.033)	0.003
	3	2.80342E-02	(0.045)	2.80042E-02	(0.040)	-0.107
	4	4.58528E-02	(0.057)	4.58417E-02	(0.019)	-0.024
Σ_{scatt}	1	2.25225E-01	(0.057)	2.25257E-01	(0.009)	0.014
	2	5.61447E-01	(0.028)	5.61342E-01	(0.006)	-0.019
	3	8.63432E-01	(0.028)	8.63445E-01	(0.007)	0.001
	4	1.36847E+00	(0.057)	1.36848E+00	(0.011)	0.001
$\nu\Sigma_{\text{fiss}}$	1	7.64770E-03	(0.064)	7.65146E-03	(0.049)	0.049
	2	3.95869E-04	(0.028)	3.96158E-04	(0.068)	0.073
	3	5.80854E-03	(0.036)	5.81777E-03	(0.048)	0.159
	4	1.07189E-01	(0.057)	1.07220E-01	(0.026)	0.029
$\bar{\nu}$	1	2.81372E+00	(0.071)	2.81388E+00	(0.018)	0.006
	2	2.72671E+00	(0.028)	2.72661E+00	(0.064)	-0.004
	3	2.71497E+00	(0.042)	2.71618E+00	(0.017)	0.044
	4	2.77859E+00	(0.057)	2.77905E+00	(0.004)	0.017
$1/v$	1	5.24623E-10	(0.057)	5.24727E-10	(0.009)	0.020
	2	2.62824E-09	(0.028)	2.62786E-09	(0.015)	-0.015
	3	1.72850E-07	(0.036)	1.72810E-07	(0.021)	-0.023
	4	2.48324E-06	(0.057)	2.48336E-06	(0.010)	0.005

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	2.21578E-01	(0.057)	2.21568E-01	(0.010)	-0.005
	2	5.15538E-01	(0.028)	5.15549E-01	(0.006)	0.002
	3	7.74396E-01	(0.028)	7.74437E-01	(0.008)	0.005
	4	1.21818E+00	(0.050)	1.21791E+00	(0.013)	-0.022
Σ_{fiss}	1	2.80175E-03	(0.064)	2.80399E-03	(0.037)	0.080
	2	4.09258E-04	(0.028)	4.09223E-04	(0.021)	-0.009
	3	5.79856E-03	(0.036)	5.79505E-03	(0.038)	-0.060
	4	5.90497E-02	(0.050)	5.90672E-02	(0.026)	0.030
Σ_{abs}	1	3.59959E-03	(0.064)	3.60136E-03	(0.033)	0.049
	2	2.32012E-03	(0.036)	2.32025E-03	(0.026)	0.006
	3	2.47555E-02	(0.036)	2.47761E-02	(0.037)	0.083
	4	8.83789E-02	(0.050)	8.83977E-02	(0.022)	0.021
Σ_{capt}	1	7.97841E-04	(0.072)	7.97368E-04	(0.050)	-0.059
	2	1.91086E-03	(0.036)	1.91103E-03	(0.028)	0.009
	3	1.89570E-02	(0.045)	1.89810E-02	(0.046)	0.127
	4	2.93292E-02	(0.050)	2.93304E-02	(0.016)	0.004
Σ_{scatt}	1	2.17978E-01	(0.057)	2.17966E-01	(0.010)	-0.006
	2	5.13218E-01	(0.028)	5.13228E-01	(0.006)	0.002
	3	7.49641E-01	(0.028)	7.49661E-01	(0.008)	0.003
	4	1.12980E+00	(0.050)	1.12951E+00	(0.014)	-0.026
$\nu\Sigma_{\text{fiss}}$	1	7.77168E-03	(0.064)	7.77657E-03	(0.040)	0.063
	2	1.00228E-03	(0.028)	1.00215E-03	(0.021)	-0.013
	3	1.41158E-02	(0.036)	1.41073E-02	(0.038)	-0.060
	4	1.43887E-01	(0.050)	1.43929E-01	(0.026)	0.030
$\bar{\nu}$	1	2.77387E+00	(0.071)	2.77339E+00	(0.015)	-0.017
	2	2.44901E+00	(0.028)	2.44891E+00	(0.004)	-0.004
	3	2.43436E+00	(0.042)	2.43437E+00	(0.000)	0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	-0.000
$1/\nu$	1	5.32224E-10	(0.057)	5.32229E-10	(0.009)	0.001
	2	2.62546E-09	(0.028)	2.62570E-09	(0.014)	0.009
	3	1.77311E-07	(0.036)	1.77306E-07	(0.023)	-0.003
	4	2.32273E-06	(0.050)	2.32248E-06	(0.012)	-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	2.02227E-01	(0.057)	2.02262E-01	(0.010)	0.017
	2	4.91719E-01	(0.028)	4.91741E-01	(0.006)	0.004
	3	7.68589E-01	(0.028)	7.68590E-01	(0.007)	0.000
	4	1.36756E+00	(0.050)	1.36762E+00	(0.011)	0.004
Σ_{fiss}	1	2.34345E-03	(0.064)	2.34508E-03	(0.045)	0.070
	2	3.16297E-04	(0.036)	3.16180E-04	(0.028)	-0.037
	3	4.24676E-03	(0.045)	4.25007E-03	(0.048)	0.078
	4	3.25824E-02	(0.050)	3.26010E-02	(0.037)	0.057
Σ_{abs}	1	3.04414E-03	(0.064)	3.04579E-03	(0.041)	0.054
	2	1.83320E-03	(0.036)	1.83224E-03	(0.033)	-0.052
	3	1.87794E-02	(0.045)	1.87669E-02	(0.043)	-0.066
	4	6.45818E-02	(0.042)	6.45951E-02	(0.029)	0.021
Σ_{capt}	1	7.00697E-04	(0.081)	7.00709E-04	(0.055)	0.002
	2	1.51690E-03	(0.036)	1.51606E-03	(0.035)	-0.055
	3	1.45326E-02	(0.054)	1.45168E-02	(0.051)	-0.109
	4	3.19992E-02	(0.050)	3.19941E-02	(0.038)	-0.016
Σ_{scatt}	1	1.99183E-01	(0.057)	1.99216E-01	(0.010)	0.017
	2	4.89886E-01	(0.028)	4.89909E-01	(0.006)	0.005
	3	7.49809E-01	(0.028)	7.49823E-01	(0.007)	0.002
	4	1.30298E+00	(0.050)	1.30303E+00	(0.012)	0.004
$\nu\Sigma_{\text{fiss}}$	1	6.50831E-03	(0.064)	6.51115E-03	(0.050)	0.044
	2	7.74874E-04	(0.036)	7.74528E-04	(0.029)	-0.045
	3	1.03383E-02	(0.045)	1.03463E-02	(0.048)	0.077
	4	7.93936E-02	(0.050)	7.94389E-02	(0.037)	0.057
$\bar{\nu}$	1	2.77723E+00	(0.071)	2.77650E+00	(0.017)	-0.026
	2	2.44983E+00	(0.042)	2.44964E+00	(0.005)	-0.008
	3	2.43440E+00	(0.057)	2.43439E+00	(0.000)	-0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	-0.000
$1/v$	1	5.29087E-10	(0.057)	5.29130E-10	(0.009)	0.008
	2	2.60890E-09	(0.028)	2.60913E-09	(0.013)	0.009
	3	1.85103E-07	(0.036)	1.85148E-07	(0.022)	0.024
	4	2.47859E-06	(0.050)	2.47841E-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	1.81517E-01	(0.057)	1.81549E-01	(0.011)	0.018
	2	4.25246E-01	(0.028)	4.25272E-01	(0.007)	0.006
	3	6.57406E-01	(0.028)	6.57352E-01	(0.007)	-0.008
	4	1.19143E+00	(0.050)	1.19159E+00	(0.014)	0.013
Σ_{fiss}	1	2.29373E-03	(0.064)	2.29351E-03	(0.041)	-0.010
	2	3.14256E-04	(0.036)	3.14245E-04	(0.027)	-0.004
	3	4.16616E-03	(0.045)	4.16872E-03	(0.041)	0.061
	4	3.18803E-02	(0.050)	3.18808E-02	(0.034)	0.002
Σ_{abs}	1	2.95205E-03	(0.064)	2.95247E-03	(0.038)	0.014
	2	1.81688E-03	(0.036)	1.81676E-03	(0.032)	-0.007
	3	1.79667E-02	(0.045)	1.79605E-02	(0.041)	-0.034
	4	6.30755E-02	(0.050)	6.30814E-02	(0.028)	0.009
Σ_{capt}	1	6.58317E-04	(0.072)	6.58961E-04	(0.051)	0.098
	2	1.50262E-03	(0.036)	1.50252E-03	(0.034)	-0.007
	3	1.38005E-02	(0.054)	1.37918E-02	(0.050)	-0.063
	4	3.11953E-02	(0.058)	3.12006E-02	(0.039)	0.017
Σ_{scatt}	1	1.78565E-01	(0.057)	1.78597E-01	(0.012)	0.018
	2	4.23430E-01	(0.028)	4.23455E-01	(0.007)	0.006
	3	6.39439E-01	(0.028)	6.39392E-01	(0.007)	-0.007
	4	1.12836E+00	(0.050)	1.12851E+00	(0.015)	0.014
$\nu\Sigma_{\text{fiss}}$	1	6.36344E-03	(0.064)	6.36333E-03	(0.045)	-0.002
	2	7.69878E-04	(0.036)	7.69866E-04	(0.027)	-0.002
	3	1.01421E-02	(0.045)	1.01483E-02	(0.041)	0.061
	4	7.76827E-02	(0.050)	7.76838E-02	(0.034)	0.001
$\bar{\nu}$	1	2.77428E+00	(0.071)	2.77449E+00	(0.017)	0.008
	2	2.44984E+00	(0.042)	2.44989E+00	(0.005)	0.002
	3	2.43439E+00	(0.057)	2.43439E+00	(0.000)	-0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	-0.000
$1/v$	1	5.31731E-10	(0.057)	5.31790E-10	(0.009)	0.011
	2	2.59928E-09	(0.028)	2.59967E-09	(0.014)	0.015
	3	1.81194E-07	(0.036)	1.81260E-07	(0.023)	0.037
	4	2.42844E-06	(0.050)	2.42811E-06	(0.011)	-0.014

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	1.60587E-01	(0.057)	1.60605E-01	(0.013)	0.011
	2	3.58387E-01	(0.028)	3.58398E-01	(0.008)	0.003
	3	5.47262E-01	(0.028)	5.47259E-01	(0.010)	-0.001
	4	1.02193E+00	(0.050)	1.02209E+00	(0.019)	0.015
Σ_{fiss}	1	2.23415E-03	(0.064)	2.23254E-03	(0.039)	-0.072
	2	3.11553E-04	(0.036)	3.11607E-04	(0.024)	0.017
	3	4.05647E-03	(0.045)	4.05519E-03	(0.042)	-0.032
	4	3.09240E-02	(0.050)	3.09180E-02	(0.037)	-0.019
Σ_{abs}	1	2.85143E-03	(0.064)	2.84947E-03	(0.035)	-0.069
	2	1.79154E-03	(0.036)	1.79200E-03	(0.029)	0.026
	3	1.68286E-02	(0.045)	1.68422E-02	(0.038)	0.081
	4	6.13435E-02	(0.050)	6.13317E-02	(0.029)	-0.019
Σ_{capt}	1	6.17271E-04	(0.072)	6.16928E-04	(0.045)	-0.056
	2	1.47998E-03	(0.036)	1.48039E-03	(0.031)	0.028
	3	1.27721E-02	(0.045)	1.27870E-02	(0.044)	0.117
	4	3.04195E-02	(0.058)	3.04138E-02	(0.038)	-0.019
Σ_{scatt}	1	1.57735E-01	(0.057)	1.57755E-01	(0.013)	0.013
	2	3.56595E-01	(0.028)	3.56606E-01	(0.008)	0.003
	3	5.30434E-01	(0.028)	5.30416E-01	(0.010)	-0.003
	4	9.60589E-01	(0.050)	9.60754E-01	(0.020)	0.017
$\nu\Sigma_{\text{fiss}}$	1	6.18882E-03	(0.064)	6.18238E-03	(0.043)	-0.104
	2	7.63290E-04	(0.036)	7.63440E-04	(0.024)	0.020
	3	9.87498E-03	(0.045)	9.87186E-03	(0.042)	-0.032
	4	7.53525E-02	(0.050)	7.53378E-02	(0.037)	-0.019
$\bar{\nu}$	1	2.77009E+00	(0.071)	2.76920E+00	(0.015)	-0.032
	2	2.44995E+00	(0.042)	2.45001E+00	(0.004)	0.002
	3	2.43438E+00	(0.057)	2.43438E+00	(0.000)	0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	0.000
$1/\nu$	1	5.35447E-10	(0.057)	5.35623E-10	(0.009)	0.033
	2	2.57886E-09	(0.028)	2.57868E-09	(0.015)	-0.007
	3	1.76194E-07	(0.036)	1.76110E-07	(0.025)	-0.048
	4	2.35819E-06	(0.050)	2.35809E-06	(0.012)	-0.004

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

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	2.17774E-01	(0.085)	2.17765E-01	(0.016)	-0.004
	2	5.29755E-01	(0.071)	5.29759E-01	(0.012)	0.001
	3	8.40732E-01	(0.071)	8.40735E-01	(0.013)	0.000
	4	1.47546E+00	(0.127)	1.47530E+00	(0.028)	-0.011
Σ_{fiss}	1	3.14994E-03	(0.100)	3.15203E-03	(0.071)	0.066
	2	4.36479E-04	(0.078)	4.36522E-04	(0.046)	0.010
	3	5.92795E-03	(0.103)	5.92442E-03	(0.096)	-0.059
	4	1.14090E-01	(0.127)	1.13960E-01	(0.074)	-0.114
Σ_{abs}	1	3.95997E-03	(0.100)	3.96253E-03	(0.066)	0.065
	2	2.26923E-03	(0.078)	2.27038E-03	(0.057)	0.051
	3	3.49761E-02	(0.094)	3.49552E-02	(0.068)	-0.060
	4	2.02822E-01	(0.127)	2.02612E-01	(0.069)	-0.103
Σ_{capt}	1	8.10044E-04	(0.125)	8.10502E-04	(0.094)	0.057
	2	1.83275E-03	(0.086)	1.83385E-03	(0.064)	0.060
	3	2.90482E-02	(0.103)	2.90308E-02	(0.077)	-0.060
	4	8.87327E-02	(0.127)	8.86514E-02	(0.064)	-0.092
Σ_{scatt}	1	2.13814E-01	(0.085)	2.13802E-01	(0.017)	-0.006
	2	5.27486E-01	(0.071)	5.27489E-01	(0.012)	0.001
	3	8.05756E-01	(0.071)	8.05779E-01	(0.013)	0.003
	4	1.27264E+00	(0.127)	1.27269E+00	(0.033)	0.004
$\nu\Sigma_{\text{fiss}}$	1	9.04894E-03	(0.100)	9.05559E-03	(0.081)	0.073
	2	1.26402E-03	(0.078)	1.26458E-03	(0.056)	0.045
	3	1.69399E-02	(0.103)	1.69282E-02	(0.097)	-0.069
	4	3.26717E-01	(0.127)	3.26350E-01	(0.074)	-0.112
$\bar{\nu}$	1	2.87274E+00	(0.113)	2.87292E+00	(0.033)	0.006
	2	2.89594E+00	(0.085)	2.89695E+00	(0.032)	0.035
	3	2.85763E+00	(0.127)	2.85734E+00	(0.009)	-0.010
	4	2.86369E+00	(0.127)	2.86372E+00	(0.003)	0.001
$1/v$	1	5.24516E-10	(0.085)	5.24437E-10	(0.015)	-0.015
	2	2.61294E-09	(0.078)	2.61353E-09	(0.027)	0.023
	3	1.63323E-07	(0.086)	1.63293E-07	(0.044)	-0.018
	4	2.27690E-06	(0.135)	2.27617E-06	(0.031)	-0.032

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

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	1.76714E-01	(0.057)	1.76721E-01	(0.011)	0.004
	2	3.82864E-01	(0.028)	3.82866E-01	(0.007)	0.000
	3	6.33117E-01	(0.028)	6.33122E-01	(0.005)	0.001
	4	9.56668E-01	(0.057)	9.57035E-01	(0.012)	0.038
Σ_{fiss}	1	2.40128E-03	(0.064)	2.40046E-03	(0.039)	-0.034
	2	4.70867E-04	(0.028)	4.70826E-04	(0.024)	-0.009
	3	6.13010E-03	(0.036)	6.13541E-03	(0.036)	0.087
	4	5.46177E-02	(0.057)	5.45722E-02	(0.034)	-0.083
Σ_{abs}	1	3.20924E-03	(0.064)	3.20824E-03	(0.035)	-0.031
	2	2.09185E-03	(0.036)	2.09219E-03	(0.029)	0.016
	3	2.26172E-02	(0.036)	2.26224E-02	(0.030)	0.023
	4	8.91685E-02	(0.057)	8.91305E-02	(0.026)	-0.043
Σ_{capt}	1	8.07951E-04	(0.072)	8.07782E-04	(0.048)	-0.021
	2	1.62098E-03	(0.036)	1.62136E-03	(0.031)	0.024
	3	1.64871E-02	(0.045)	1.64870E-02	(0.036)	-0.000
	4	3.45508E-02	(0.057)	3.45584E-02	(0.022)	0.022
Σ_{scatt}	1	1.73504E-01	(0.057)	1.73513E-01	(0.011)	0.005
	2	3.80773E-01	(0.028)	3.80773E-01	(0.007)	0.000
	3	6.10500E-01	(0.028)	6.10500E-01	(0.005)	0.000
	4	8.67500E-01	(0.057)	8.67905E-01	(0.014)	0.047
$\nu\Sigma_{\text{fiss}}$	1	6.62908E-03	(0.064)	6.62593E-03	(0.042)	-0.047
	2	1.15319E-03	(0.028)	1.15310E-03	(0.024)	-0.008
	3	1.49226E-02	(0.036)	1.49356E-02	(0.036)	0.087
	4	1.33087E-01	(0.057)	1.32976E-01	(0.034)	-0.083
$\bar{\nu}$	1	2.76064E+00	(0.071)	2.76027E+00	(0.014)	-0.013
	2	2.44909E+00	(0.028)	2.44909E+00	(0.003)	0.000
	3	2.43432E+00	(0.042)	2.43433E+00	(0.000)	0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	-0.000
$1/\nu$	1	5.40162E-10	(0.057)	5.40236E-10	(0.009)	0.014
	2	2.60400E-09	(0.028)	2.60372E-09	(0.013)	-0.011
	3	1.65258E-07	(0.036)	1.65404E-07	(0.023)	0.088
	4	2.17822E-06	(0.057)	2.17903E-06	(0.014)	0.037

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	2.10188E-01	(0.050)	2.10254E-01	(0.011)	0.032
	2	3.15748E-01	(0.028)	3.15739E-01	(0.005)	-0.003
	3	3.20136E-01	(0.014)	3.20124E-01	(0.005)	-0.004
	4	3.77465E-01	(0.042)	3.77438E-01	(0.005)	-0.007
Σ_{fiss}	1	2.09024E-03	(0.064)	2.09207E-03	(0.049)	0.088
	2	5.04977E-05	(0.036)	5.04572E-05	(0.033)	-0.080
	3	4.76936E-04	(0.041)	4.77097E-04	(0.048)	0.034
	4	4.56694E-03	(0.042)	4.56424E-03	(0.032)	-0.059
Σ_{abs}	1	2.81211E-03	(0.064)	2.81462E-03	(0.043)	0.089
	2	1.26445E-03	(0.045)	1.26349E-03	(0.039)	-0.076
	3	5.15252E-03	(0.041)	5.15449E-03	(0.047)	0.038
	4	9.05192E-03	(0.042)	9.04679E-03	(0.030)	-0.057
Σ_{capt}	1	7.21866E-04	(0.081)	7.22556E-04	(0.056)	0.096
	2	1.21395E-03	(0.045)	1.21303E-03	(0.040)	-0.076
	3	4.67558E-03	(0.041)	4.67739E-03	(0.050)	0.039
	4	4.48497E-03	(0.042)	4.48255E-03	(0.029)	-0.054
Σ_{scatt}	1	2.07376E-01	(0.057)	2.07440E-01	(0.012)	0.031
	2	3.14484E-01	(0.028)	3.14476E-01	(0.005)	-0.002
	3	3.14984E-01	(0.014)	3.14970E-01	(0.005)	-0.004
	4	3.68413E-01	(0.042)	3.68391E-01	(0.005)	-0.006
$\nu\Sigma_{\text{fiss}}$	1	5.81067E-03	(0.064)	5.81569E-03	(0.054)	0.086
	2	1.23440E-04	(0.036)	1.23350E-04	(0.034)	-0.073
	3	1.16108E-03	(0.041)	1.16147E-03	(0.048)	0.033
	4	1.11283E-02	(0.042)	1.11217E-02	(0.032)	-0.059
$\bar{\nu}$	1	2.77990E+00	(0.071)	2.77987E+00	(0.018)	-0.001
	2	2.44447E+00	(0.042)	2.44464E+00	(0.007)	0.007
	3	2.43446E+00	(0.057)	2.43446E+00	(0.000)	-0.000
	4	2.43670E+00	(0.042)	2.43670E+00	(0.000)	-0.000
$1/\nu$	1	5.29655E-10	(0.050)	5.29720E-10	(0.010)	0.012
	2	3.53320E-09	(0.028)	3.53301E-09	(0.010)	-0.005
	3	1.84591E-07	(0.022)	1.84619E-07	(0.018)	0.015
	4	2.52510E-06	(0.042)	2.52546E-06	(0.008)	0.014

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

param.	g	MCNP		Serpent		Δ (%)
Σ_{tot}	1	1.84595E-01	(0.042)	1.84611E-01	(0.009)	0.009
	2	2.83167E-01	(0.014)	2.83159E-01	(0.006)	-0.003
	3	5.41406E-01	(0.099)	5.41389E-01	(0.024)	-0.003
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
Σ_{fiss}	1	6.22739E-03	(0.042)	6.22931E-03	(0.021)	0.031
	2	4.45573E-03	(0.014)	4.45535E-03	(0.009)	-0.009
	3	1.38247E-02	(0.106)	1.38177E-02	(0.045)	-0.050
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
Σ_{abs}	1	7.14115E-03	(0.042)	7.14302E-03	(0.020)	0.026
	2	7.03219E-03	(0.014)	7.03121E-03	(0.011)	-0.014
	3	2.85029E-02	(0.106)	2.84897E-02	(0.041)	-0.046
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
Σ_{capt}	1	9.13789E-04	(0.050)	9.13710E-04	(0.032)	-0.009
	2	2.57646E-03	(0.022)	2.57586E-03	(0.018)	-0.023
	3	1.46783E-02	(0.106)	1.46720E-02	(0.045)	-0.043
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
Σ_{scatt}	1	1.77454E-01	(0.042)	1.77468E-01	(0.009)	0.008
	2	2.76134E-01	(0.014)	2.76128E-01	(0.006)	-0.002
	3	5.12903E-01	(0.099)	5.12900E-01	(0.025)	-0.001
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
$\nu\Sigma_{\text{fiss}}$	1	1.80489E-02	(0.042)	1.80531E-02	(0.024)	0.023
	2	1.17944E-02	(0.014)	1.17931E-02	(0.010)	-0.011
	3	3.57043E-02	(0.106)	3.56943E-02	(0.047)	-0.028
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
$\bar{\nu}$	1	2.89832E+00	(0.042)	2.89809E+00	(0.009)	-0.008
	2	2.64703E+00	(0.014)	2.64695E+00	(0.004)	-0.003
	3	2.58265E+00	(0.113)	2.58322E+00	(0.012)	0.022
	4	0.00000E+00	(0.000)	0.00000E+00	(0.000)	—
$1/\nu$	1	5.66155E-10	(0.042)	5.66144E-10	(0.008)	-0.002
	2	2.50850E-09	(0.022)	2.50828E-09	(0.016)	-0.009
	3	1.59227E-08	(0.106)	1.59205E-08	(0.034)	-0.014
	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	1.37509E-01	(0.042)	1.37518E-01	(0.008)	0.007
	2	2.75976E-01	(0.014)	2.75959E-01	(0.004)	-0.006
	3	3.11268E-01	(0.014)	3.11276E-01	(0.003)	0.003
	4	3.19871E-01	(0.057)	3.19822E-01	(0.004)	-0.015
Σ_{fiss}	1	6.61603E-05	(0.050)	6.60206E-05	(0.139)	-0.211
	2	2.94854E-05	(0.014)	2.94767E-05	(0.060)	-0.029
	3	4.06326E-04	(0.022)	4.06227E-04	(0.055)	-0.024
	4	3.82115E-03	(0.057)	3.82065E-03	(0.030)	-0.013
Σ_{abs}	1	1.18463E-04	(0.163)	1.18671E-04	(0.175)	0.176
	2	8.25999E-05	(0.014)	8.26074E-05	(0.065)	0.009
	3	1.99034E-03	(0.041)	1.99155E-03	(0.041)	0.061
	4	4.83565E-03	(0.057)	4.83490E-03	(0.029)	-0.016
Σ_{capt}	1	5.23022E-05	(0.341)	5.26499E-05	(0.342)	0.665
	2	5.31145E-05	(0.014)	5.31307E-05	(0.071)	0.030
	3	1.58402E-03	(0.051)	1.58533E-03	(0.048)	0.083
	4	1.01450E-03	(0.057)	1.01426E-03	(0.025)	-0.024
Σ_{scatt}	1	1.37390E-01	(0.042)	1.37399E-01	(0.008)	0.006
	2	2.75894E-01	(0.014)	2.75876E-01	(0.004)	-0.006
	3	3.09277E-01	(0.014)	3.09285E-01	(0.003)	0.002
	4	3.15035E-01	(0.057)	3.14987E-01	(0.004)	-0.015
$\nu\Sigma_{\text{fiss}}$	1	1.79761E-04	(0.050)	1.79435E-04	(0.150)	-0.181
	2	7.19569E-05	(0.014)	7.19406E-05	(0.060)	-0.023
	3	9.89145E-04	(0.022)	9.88902E-04	(0.055)	-0.025
	4	9.31104E-03	(0.057)	9.30977E-03	(0.030)	-0.014
$\bar{\nu}$	1	2.71705E+00	(0.057)	2.71783E+00	(0.051)	0.029
	2	2.44043E+00	(0.014)	2.44059E+00	(0.005)	0.007
	3	2.43436E+00	(0.028)	2.43436E+00	(0.000)	-0.000
	4	2.43671E+00	(0.057)	2.43670E+00	(0.000)	-0.000
$1/v$	1	5.69239E-10	(0.042)	5.69198E-10	(0.006)	-0.007
	2	3.39149E-09	(0.014)	3.39128E-09	(0.004)	-0.006
	3	1.83162E-07	(0.022)	1.83157E-07	(0.012)	-0.003
	4	2.13731E-06	(0.057)	2.13638E-06	(0.009)	-0.043

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	1.37345E-01	(0.042)	1.37336E-01	(0.009)	-0.007
	2	2.75822E-01	(0.014)	2.75819E-01	(0.004)	-0.001
	3	3.11237E-01	(0.014)	3.11235E-01	(0.003)	-0.001
	4	3.20059E-01	(0.057)	3.20019E-01	(0.004)	-0.013
Σ_{fiss}	1	6.47347E-05	(0.050)	6.46665E-05	(0.140)	-0.105
	2	2.86762E-05	(0.014)	2.86780E-05	(0.061)	0.006
	3	3.94189E-04	(0.022)	3.94150E-04	(0.053)	-0.010
	4	3.65023E-03	(0.057)	3.65149E-03	(0.034)	0.035
Σ_{abs}	1	1.17608E-04	(0.163)	1.17568E-04	(0.170)	-0.034
	2	8.31624E-05	(0.014)	8.31634E-05	(0.062)	0.001
	3	2.09089E-03	(0.041)	2.09023E-03	(0.039)	-0.032
	4	5.94018E-03	(0.057)	5.94397E-03	(0.028)	0.064
Σ_{capt}	1	5.28729E-05	(0.341)	5.29017E-05	(0.320)	0.054
	2	5.44863E-05	(0.014)	5.44854E-05	(0.066)	-0.002
	3	1.69670E-03	(0.041)	1.69608E-03	(0.044)	-0.037
	4	2.28995E-03	(0.064)	2.29248E-03	(0.040)	0.110
Σ_{scatt}	1	1.37227E-01	(0.042)	1.37218E-01	(0.009)	-0.007
	2	2.75739E-01	(0.014)	2.75736E-01	(0.004)	-0.001
	3	3.09146E-01	(0.014)	3.09144E-01	(0.003)	-0.001
	4	3.14119E-01	(0.057)	3.14076E-01	(0.004)	-0.014
$\nu\Sigma_{\text{fiss}}$	1	1.75921E-04	(0.050)	1.75836E-04	(0.148)	-0.048
	2	6.99825E-05	(0.014)	6.99853E-05	(0.062)	0.004
	3	9.59595E-04	(0.022)	9.59501E-04	(0.053)	-0.010
	4	8.89452E-03	(0.057)	8.89758E-03	(0.034)	0.034
$\bar{\nu}$	1	2.71757E+00	(0.057)	2.71915E+00	(0.050)	0.058
	2	2.44044E+00	(0.014)	2.44038E+00	(0.005)	-0.003
	3	2.43435E+00	(0.028)	2.43435E+00	(0.000)	0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	-0.000
$1/v$	1	5.69156E-10	(0.042)	5.69170E-10	(0.007)	0.002
	2	3.39076E-09	(0.014)	3.39091E-09	(0.005)	0.004
	3	1.81785E-07	(0.022)	1.81781E-07	(0.012)	-0.002
	4	2.08737E-06	(0.057)	2.08689E-06	(0.010)	-0.023

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	9.69151E-02	(0.042)	9.69021E-02	(0.013)	-0.013
	2	1.94160E-01	(0.014)	1.94176E-01	(0.007)	0.008
	3	2.18682E-01	(0.014)	2.18683E-01	(0.005)	0.001
	4	2.24077E-01	(0.057)	2.24030E-01	(0.005)	-0.021
Σ_{fiss}	1	4.43033E-05	(0.050)	4.43531E-05	(0.139)	0.112
	2	1.63844E-05	(0.014)	1.63798E-05	(0.060)	-0.028
	3	2.27224E-04	(0.022)	2.27196E-04	(0.062)	-0.012
	4	2.18375E-03	(0.057)	2.18437E-03	(0.028)	0.028
Σ_{abs}	1	8.08101E-05	(0.163)	8.09034E-05	(0.171)	0.116
	2	5.29506E-05	(0.014)	5.29597E-05	(0.066)	0.017
	3	1.31650E-03	(0.041)	1.31701E-03	(0.044)	0.038
	4	2.79643E-03	(0.057)	2.79719E-03	(0.027)	0.027
Σ_{capt}	1	3.65067E-05	(0.341)	3.65503E-05	(0.315)	0.119
	2	3.65662E-05	(0.014)	3.65799E-05	(0.071)	0.038
	3	1.08928E-03	(0.051)	1.08981E-03	(0.050)	0.049
	4	6.12678E-04	(0.057)	6.12821E-04	(0.024)	0.023
Σ_{scatt}	1	9.68343E-02	(0.042)	9.68212E-02	(0.013)	-0.014
	2	1.94107E-01	(0.014)	1.94123E-01	(0.007)	0.008
	3	2.17365E-01	(0.014)	2.17366E-01	(0.005)	0.000
	4	2.21281E-01	(0.057)	2.21232E-01	(0.005)	-0.022
$\nu\Sigma_{\text{fiss}}$	1	1.20578E-04	(0.050)	1.20693E-04	(0.145)	0.096
	2	3.99860E-05	(0.014)	3.99729E-05	(0.060)	-0.033
	3	5.53146E-04	(0.022)	5.53079E-04	(0.062)	-0.012
	4	5.32115E-03	(0.057)	5.32264E-03	(0.028)	0.028
$\bar{\nu}$	1	2.72164E+00	(0.057)	2.72124E+00	(0.054)	-0.015
	2	2.44049E+00	(0.014)	2.44038E+00	(0.005)	-0.004
	3	2.43436E+00	(0.028)	2.43437E+00	(0.000)	0.000
	4	2.43670E+00	(0.057)	2.43670E+00	(0.000)	0.000
$1/\nu$	1	5.69796E-10	(0.042)	5.69780E-10	(0.007)	-0.003
	2	3.39096E-09	(0.014)	3.39095E-09	(0.006)	-0.000
	3	1.85098E-07	(0.022)	1.85057E-07	(0.013)	-0.022
	4	2.18388E-06	(0.057)	2.18350E-06	(0.008)	-0.018

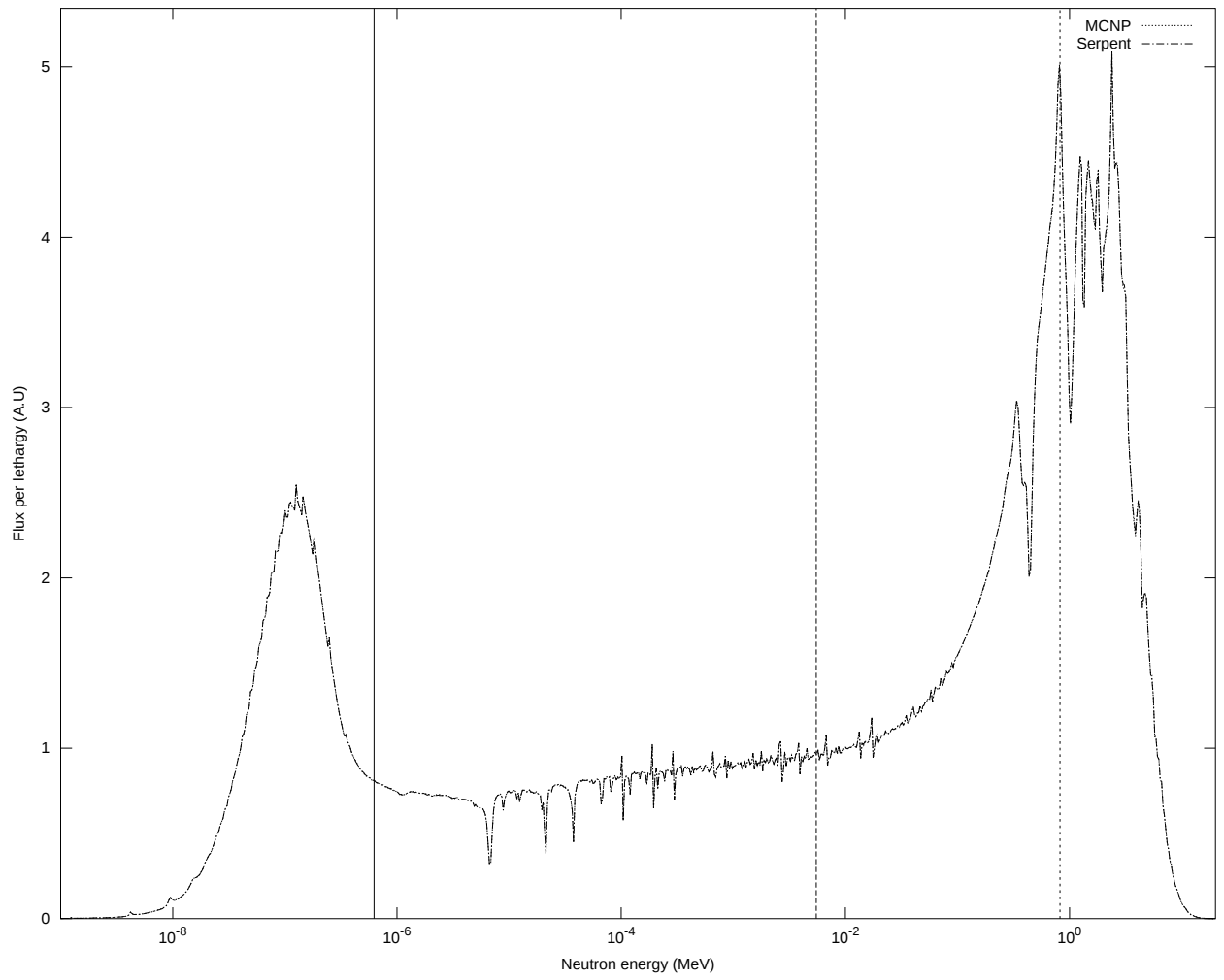


Figure 1. Flux spectra integrated over the entire geometry PWR pin-cell, 1 MWd/kgU burnup.

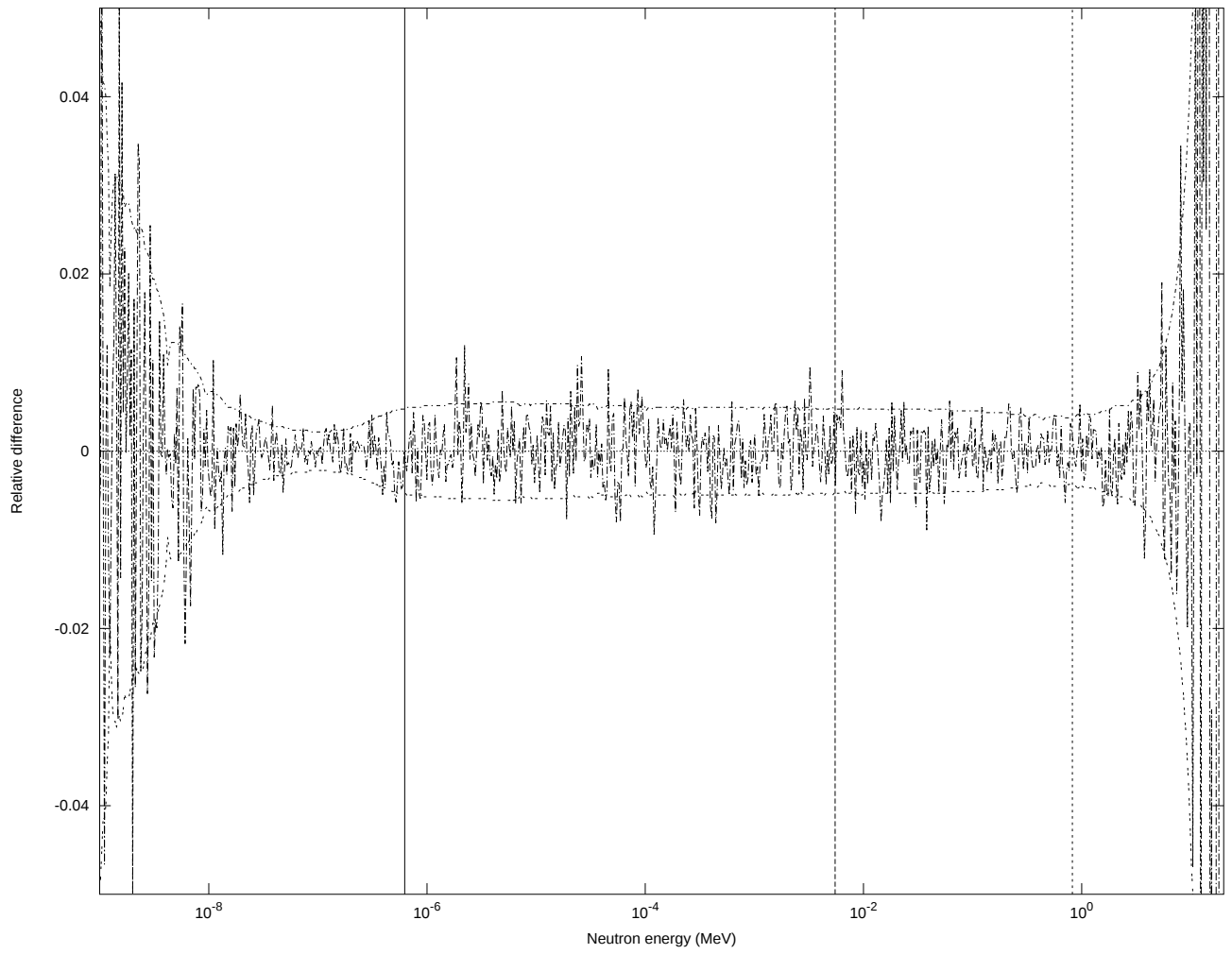


Figure 2. Relative differences between the two spectra Figure 1.

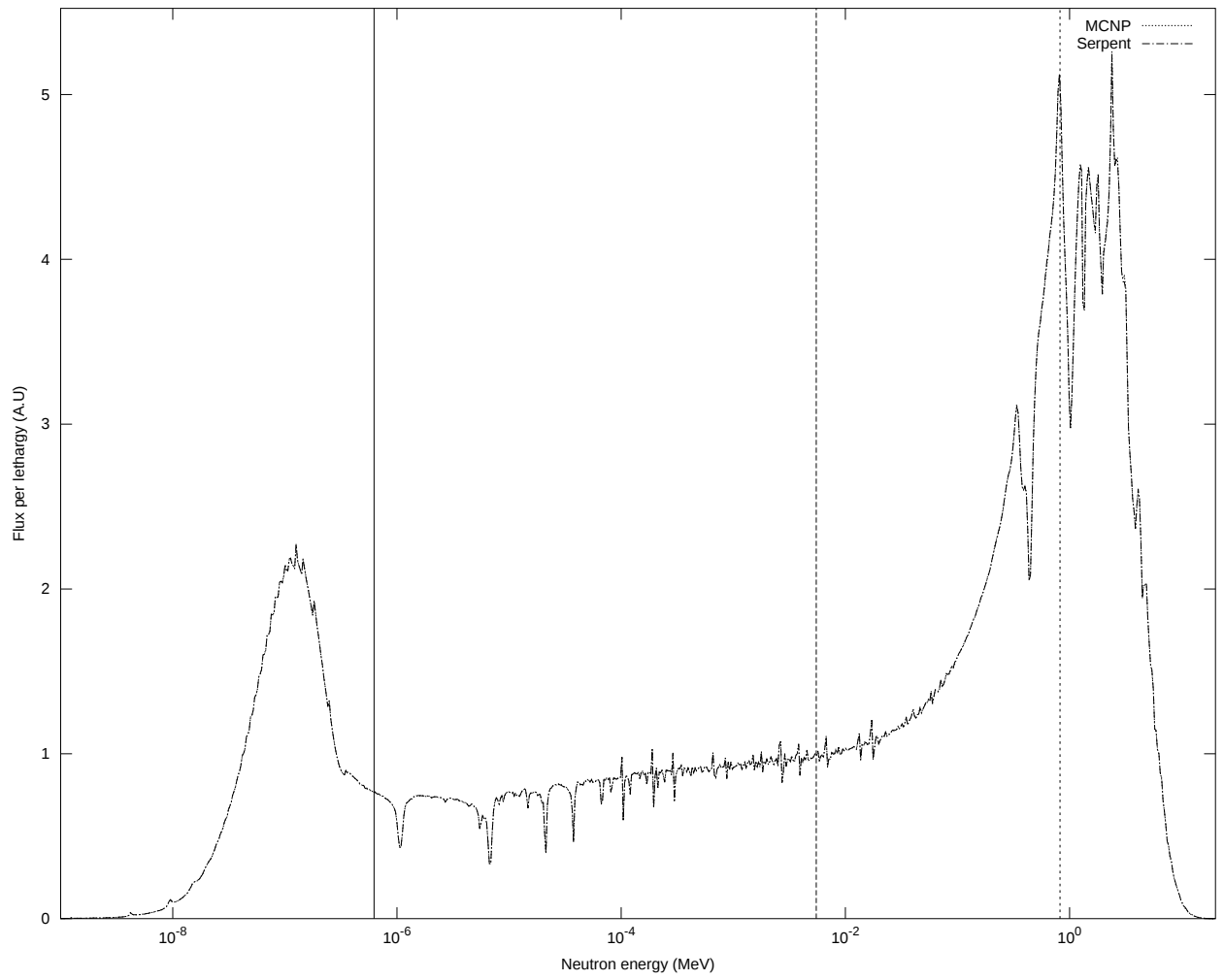


Figure 3. Flux spectra integrated over the entire geometry PWR pin-cell, 20 MWd/kgU burnup.

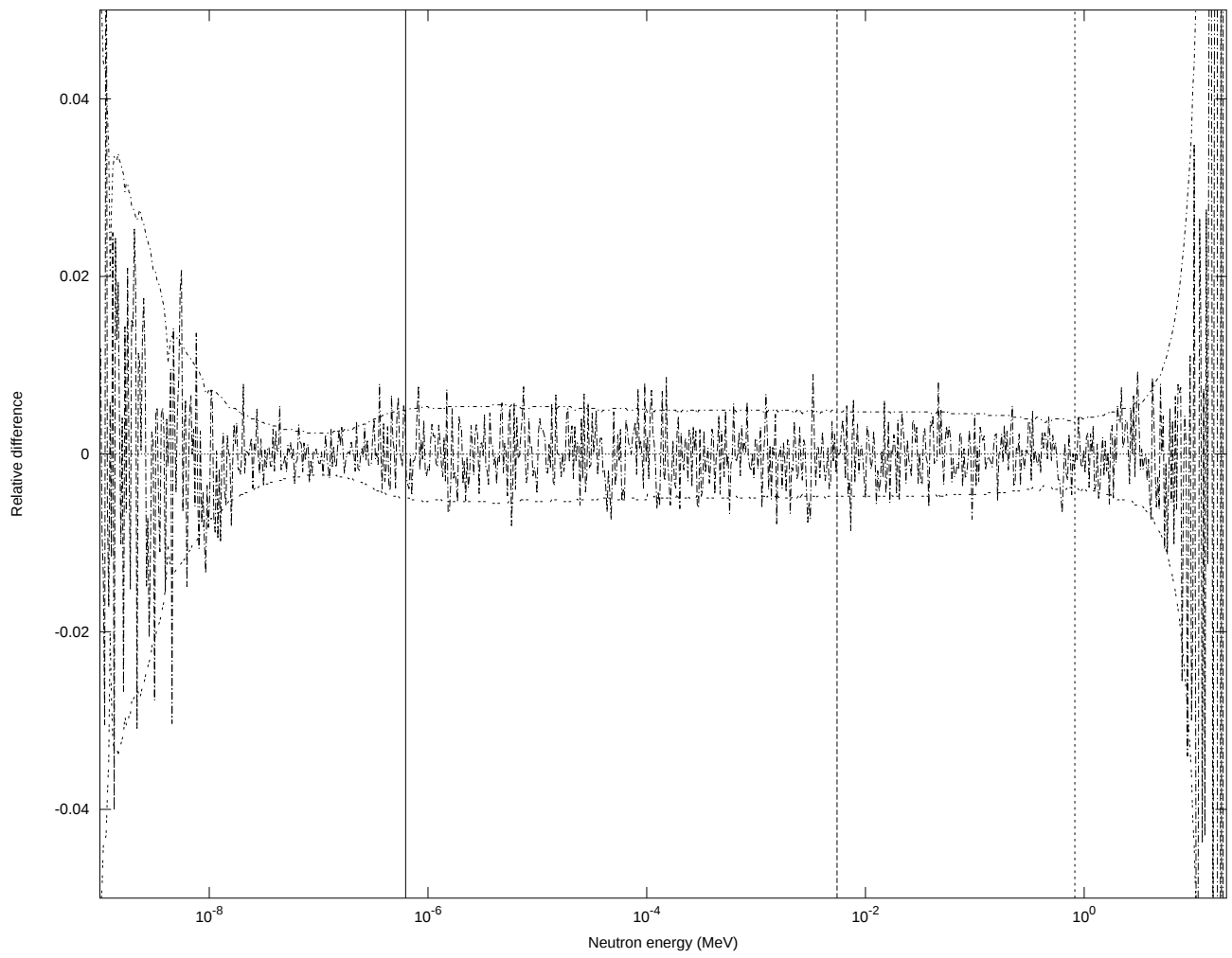


Figure 4. Relative differences between the two spectra Figure 3.

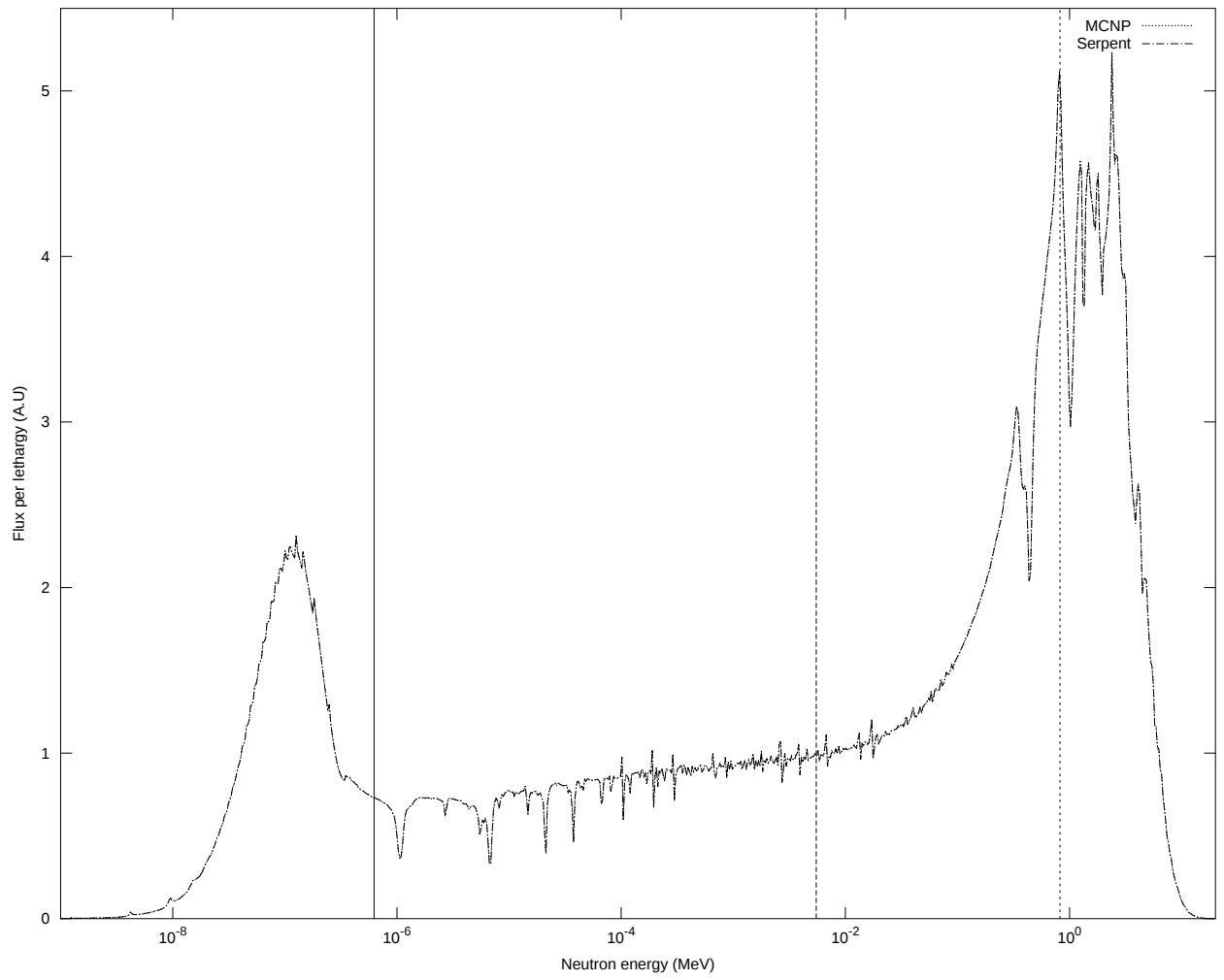


Figure 5. Flux spectra integrated over the entire geometry PWR pin-cell, 40 MWd/kgU burnup.

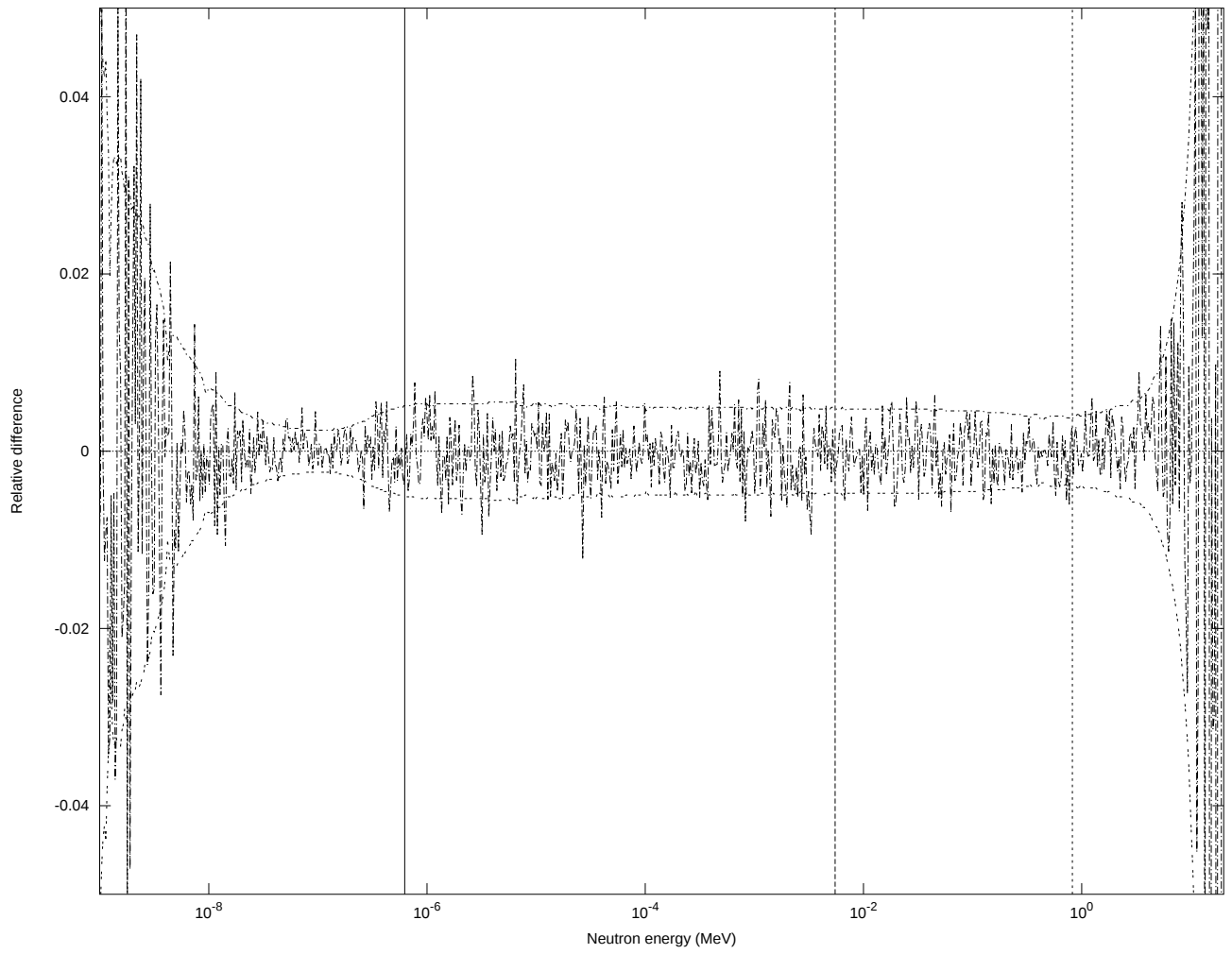


Figure 6. Relative differences between the two spectra Figure 5.

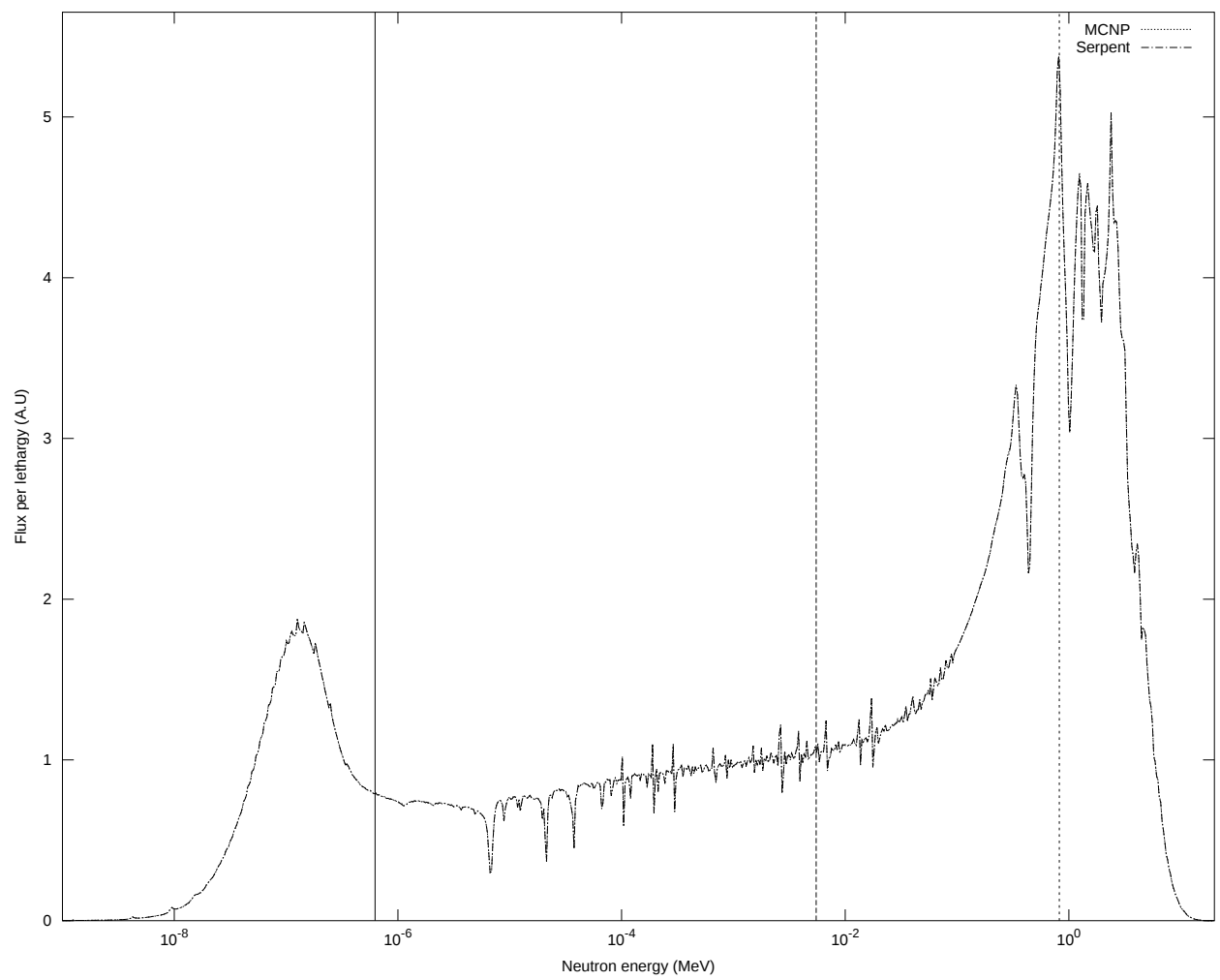


Figure 7. Flux spectra integrated over the entire geometry VVER-440 assembly.

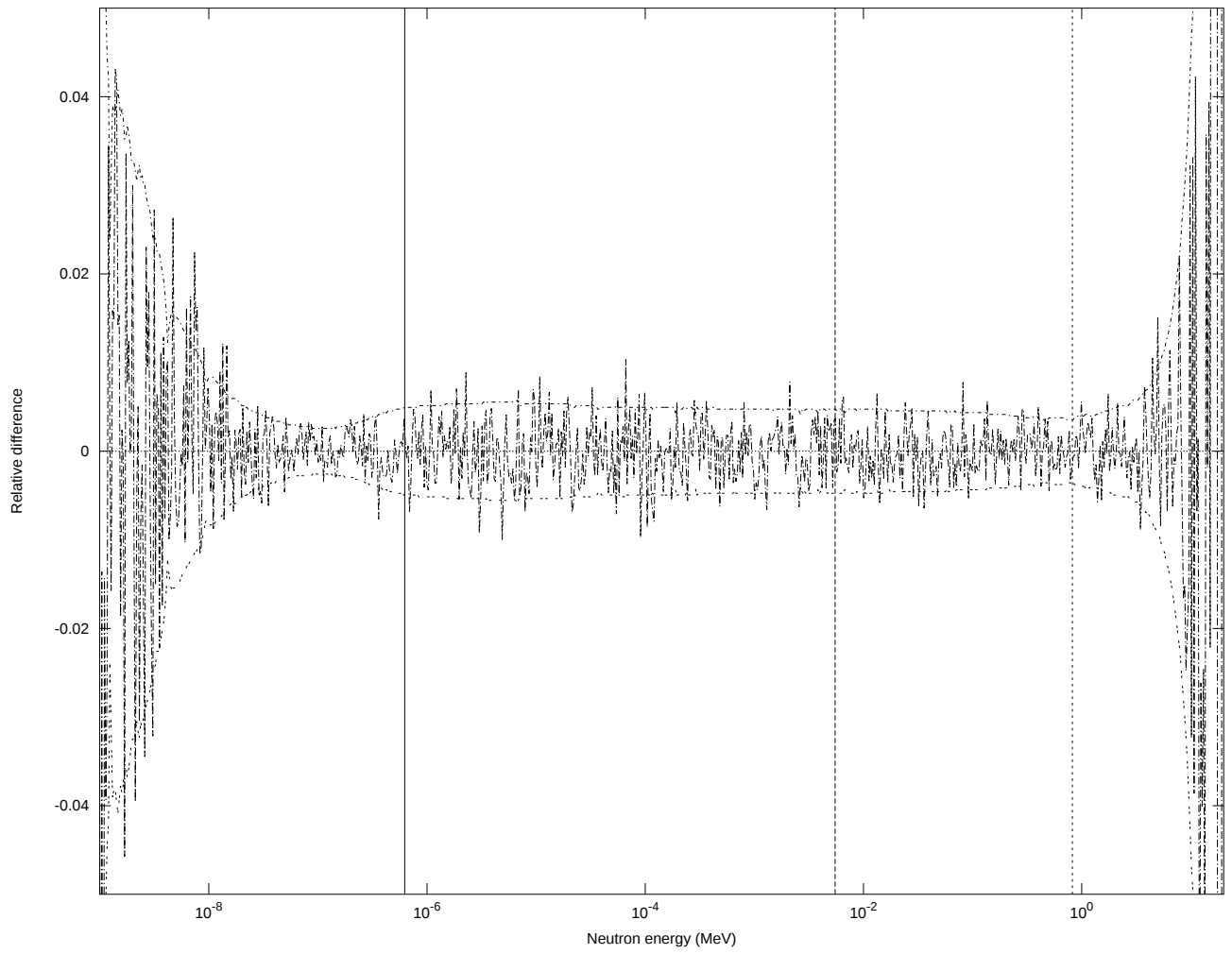


Figure 8. Relative differences between the two spectra Figure 7.

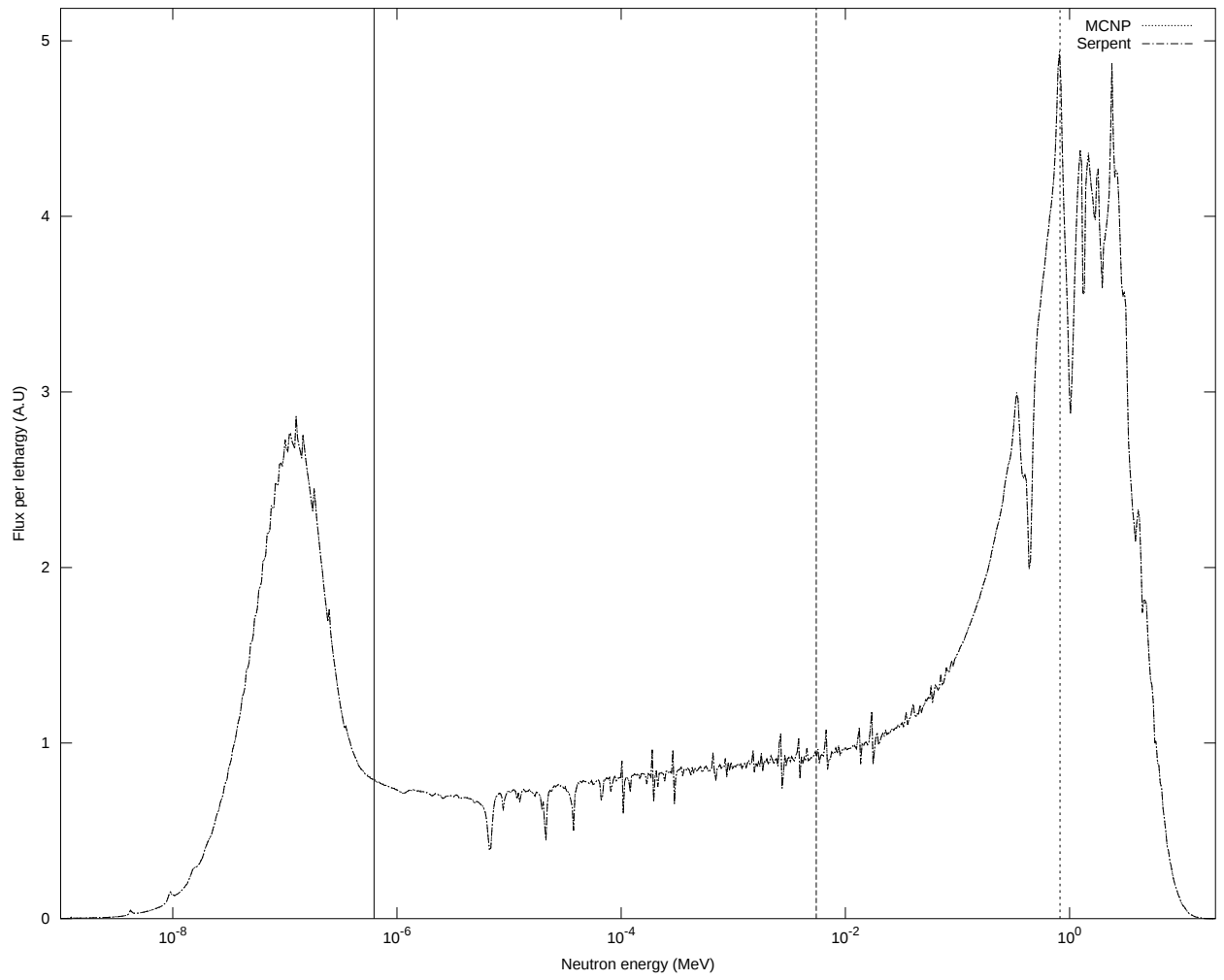


Figure 9. Flux spectra integrated over the entire geometry BWR+Gd Assembly, 25% void fraction.

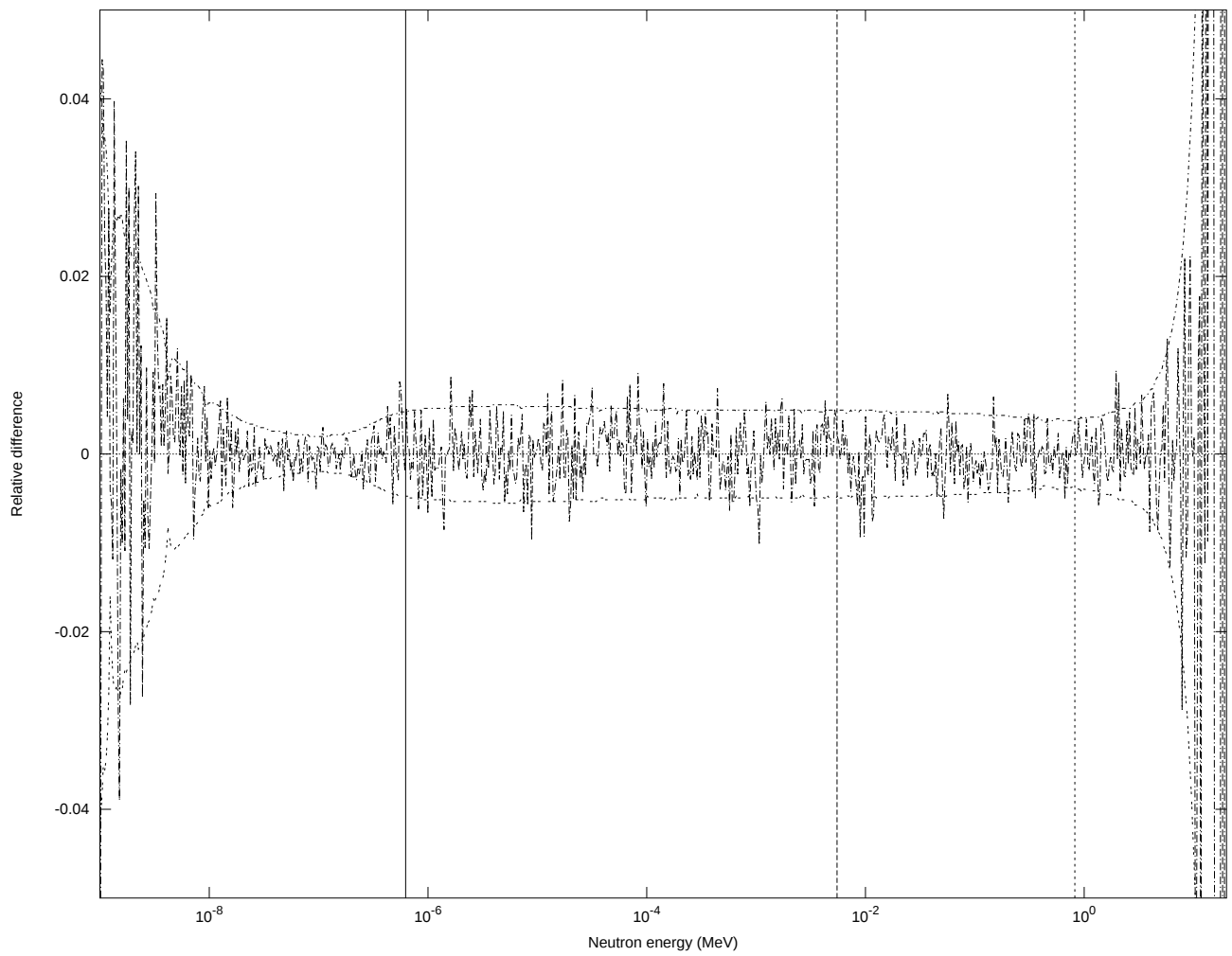


Figure 10. Relative differences between the two spectra Figure 9.

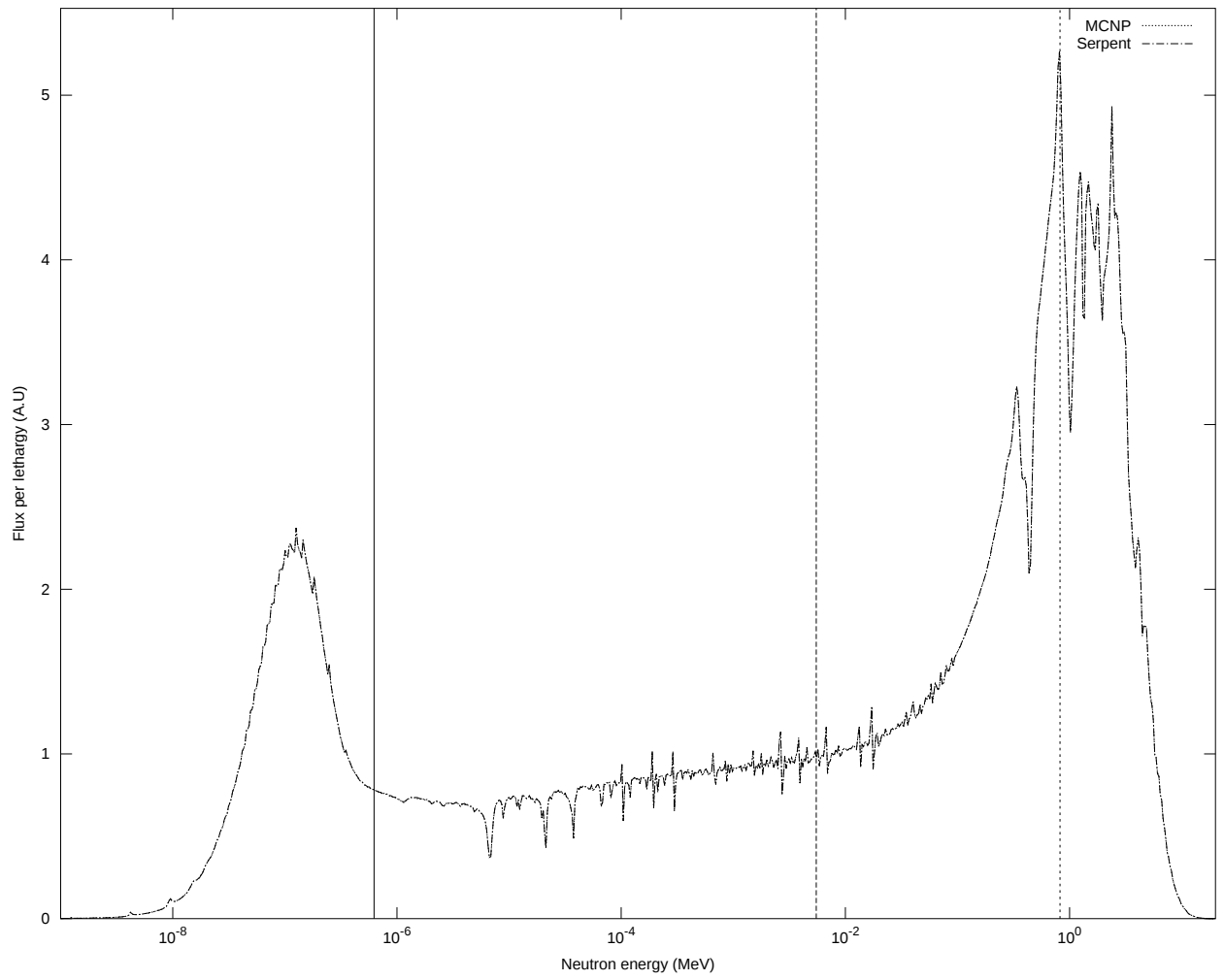


Figure 11. Flux spectra integrated over the entire geometry BWR+Gd Assembly, 50% void fraction.

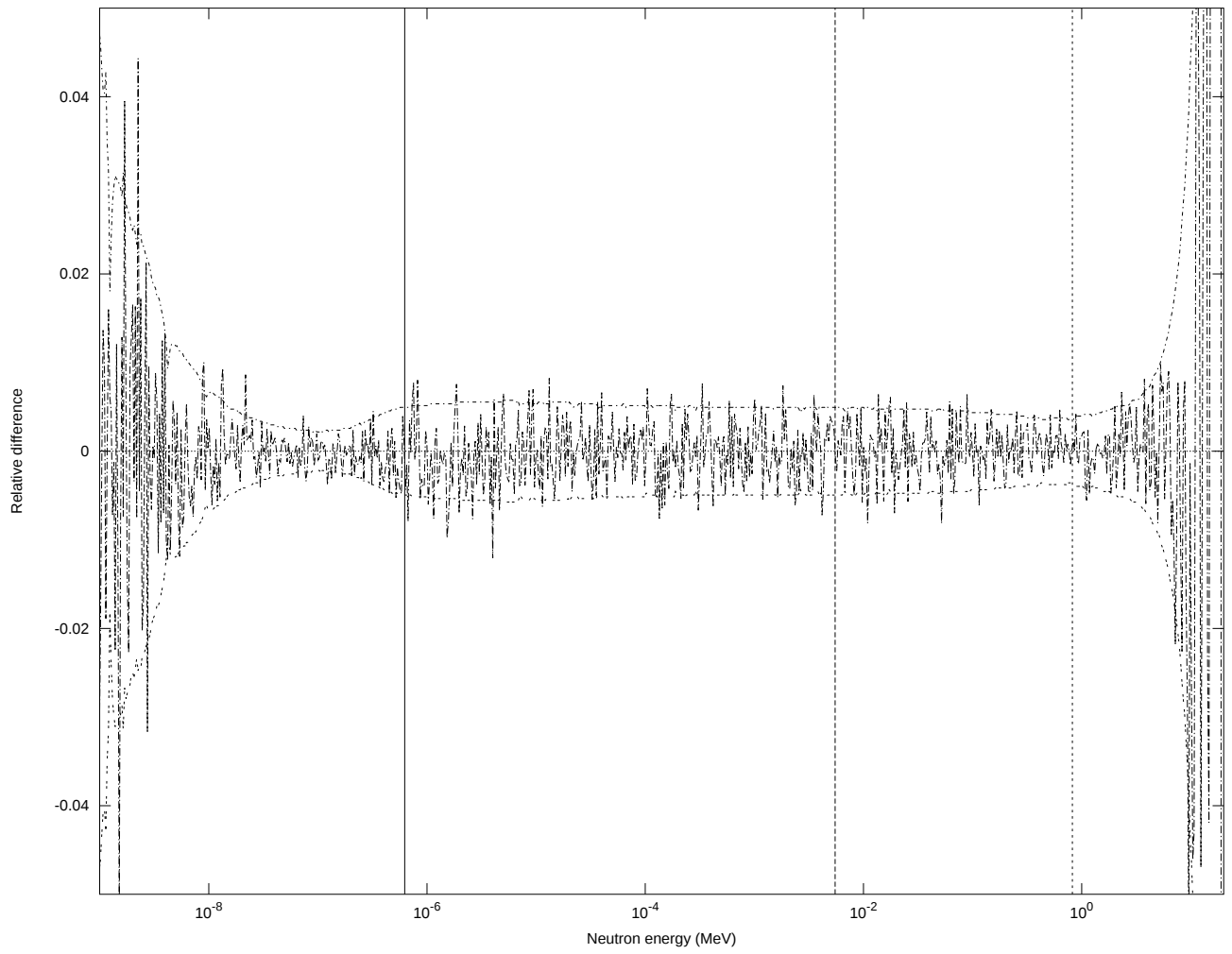


Figure 12. Relative differences between the two spectra Figure 11.

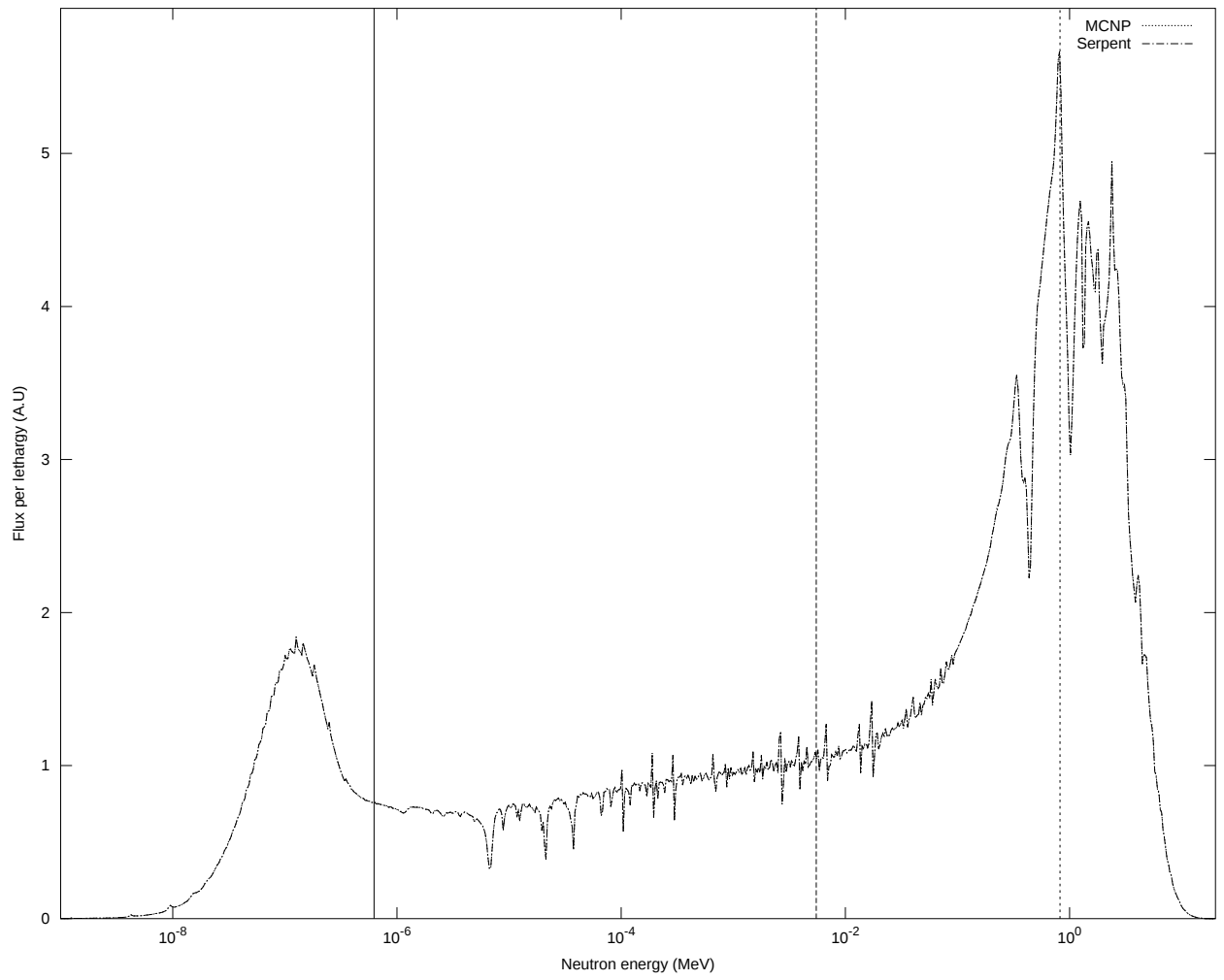


Figure 13. Flux spectra integrated over the entire geometry BWR+Gd Assembly, 75% void fraction.

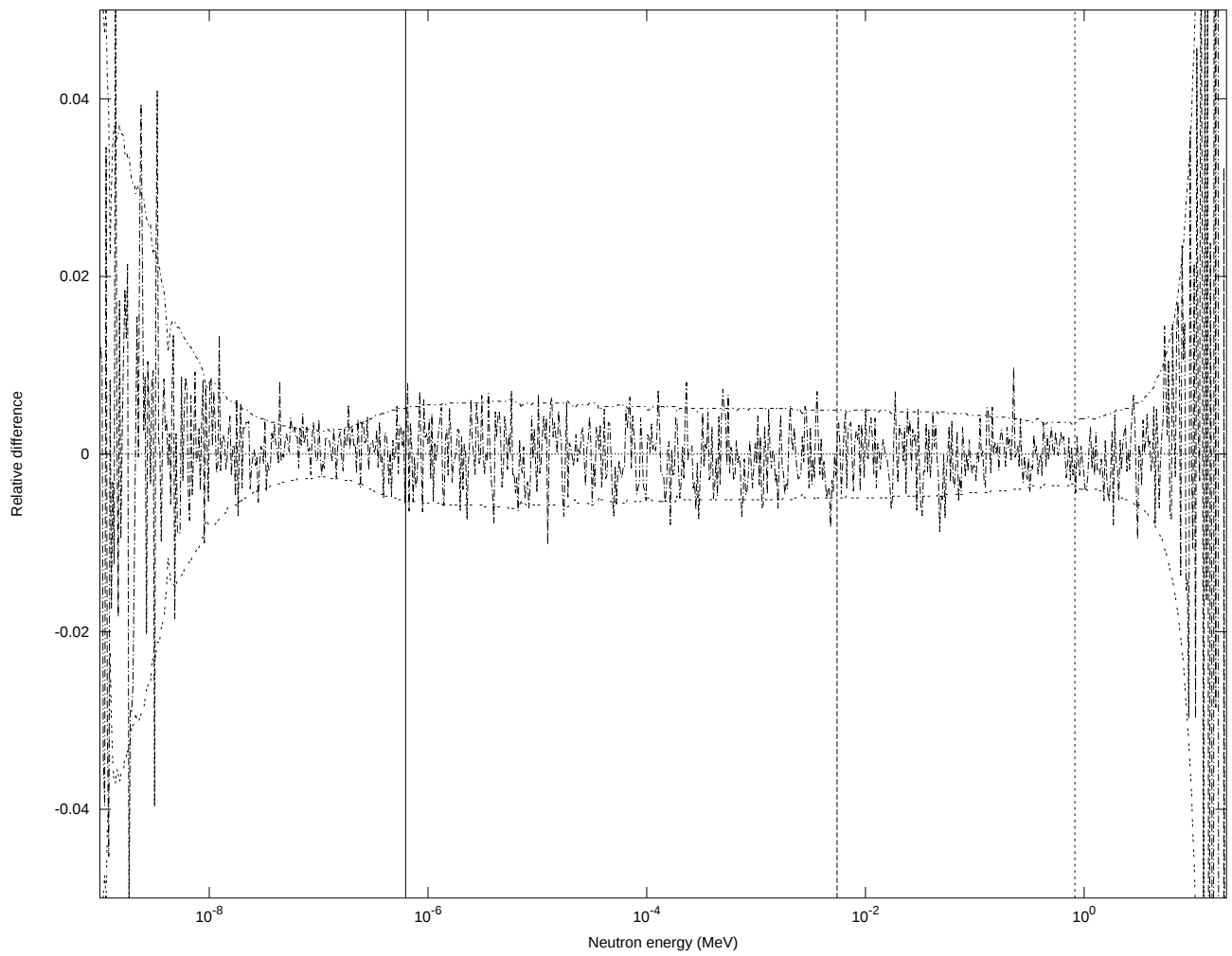


Figure 14. Relative differences between the two spectra Figure 13.

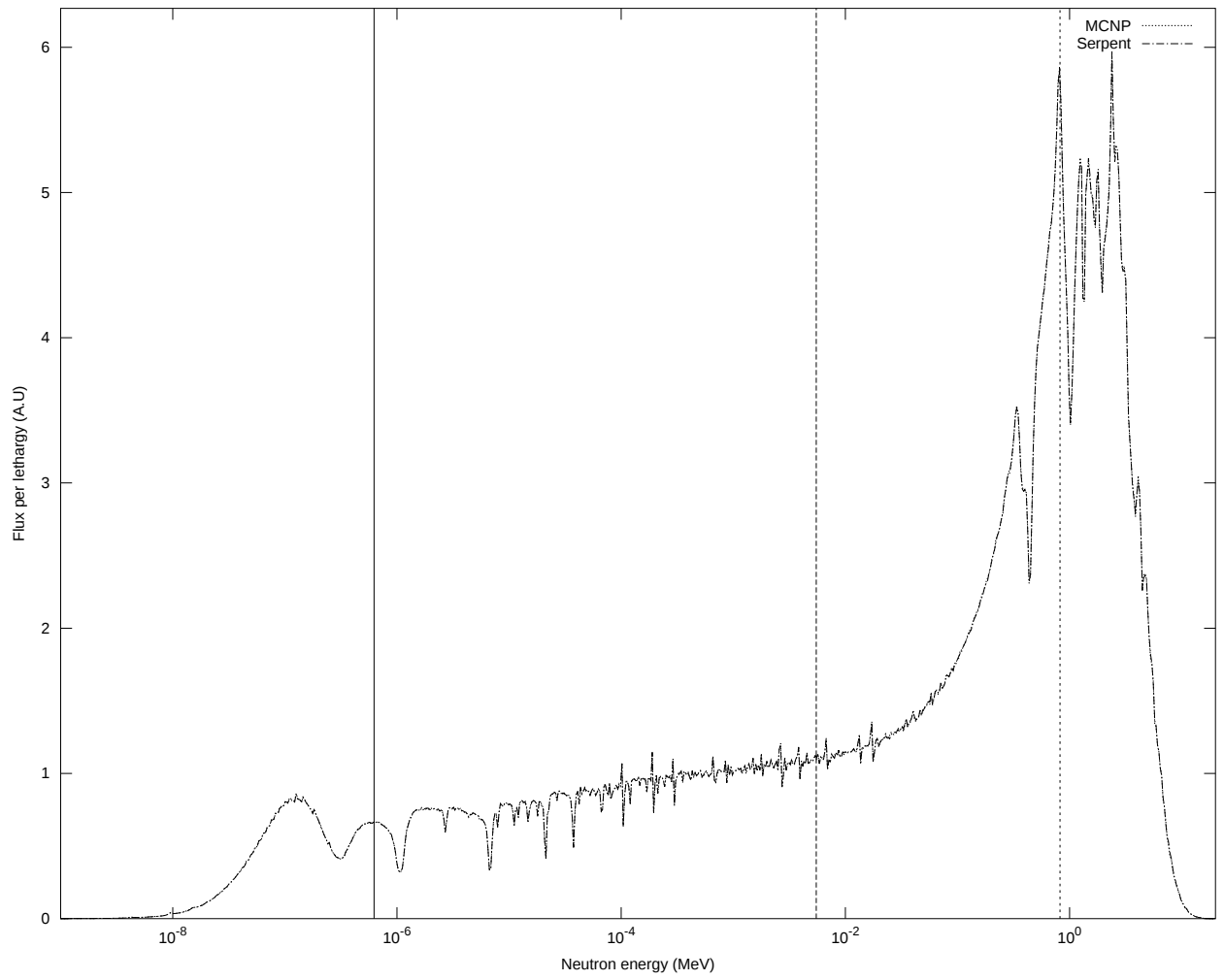


Figure 15. Flux spectra integrated over the entire geometry Mixed PWR MOX/UOX lattice.

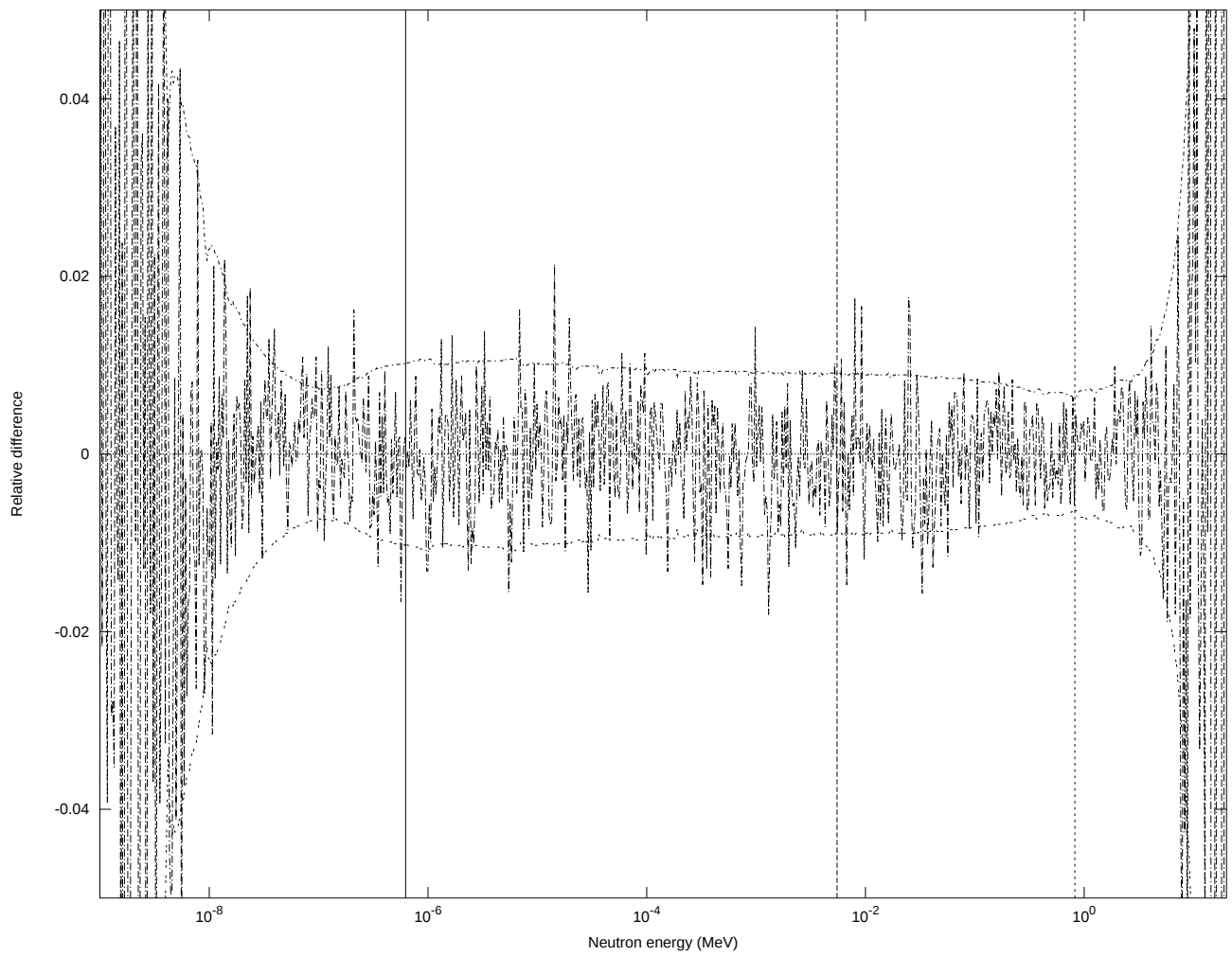


Figure 16. Relative differences between the two spectra Figure 15.

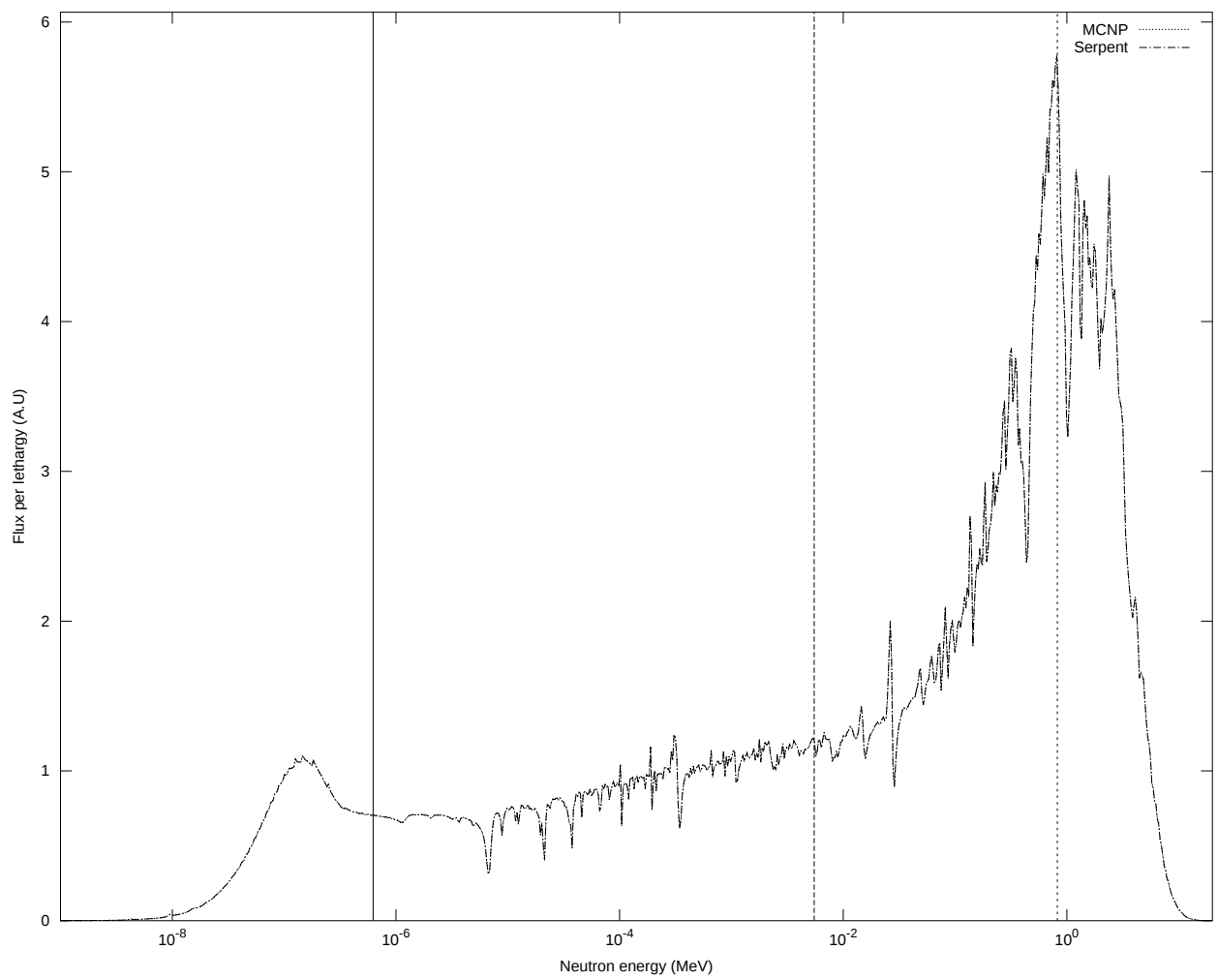


Figure 17. Flux spectra integrated over the entire geometry SCWR assembly.

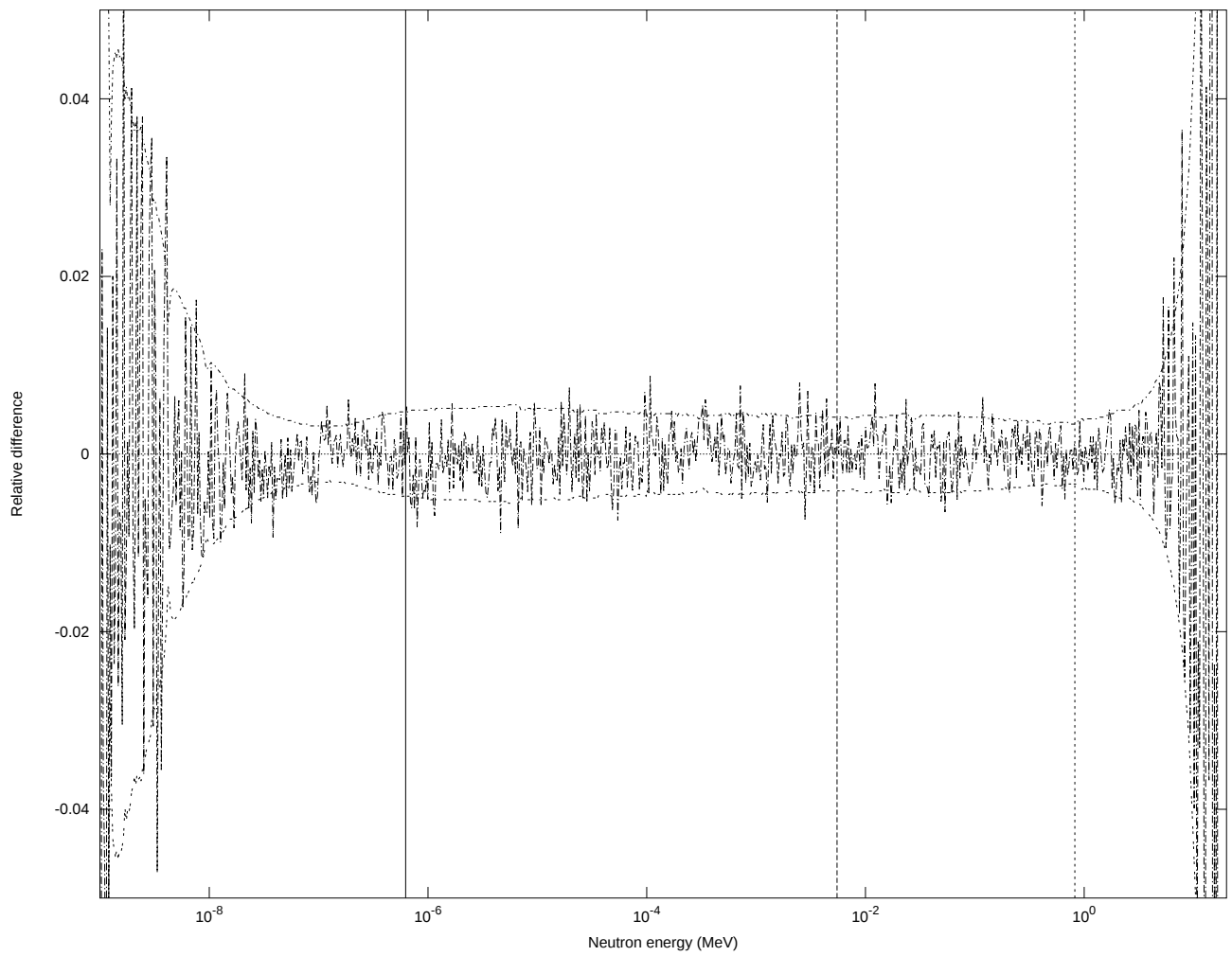


Figure 18. Relative differences between the two spectra Figure 17.

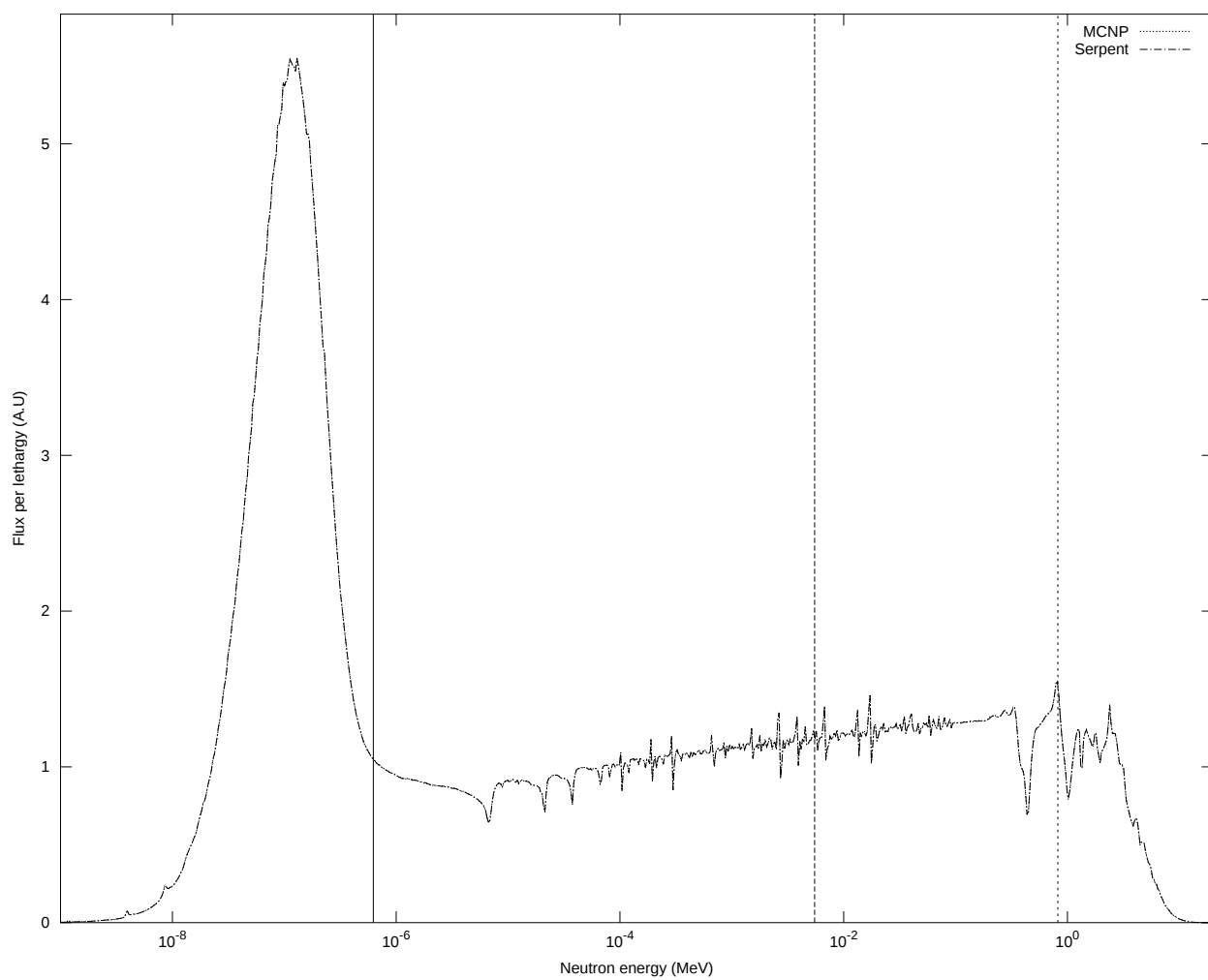


Figure 19. Flux spectra integrated over the entire geometry CANDU fuel cluster.

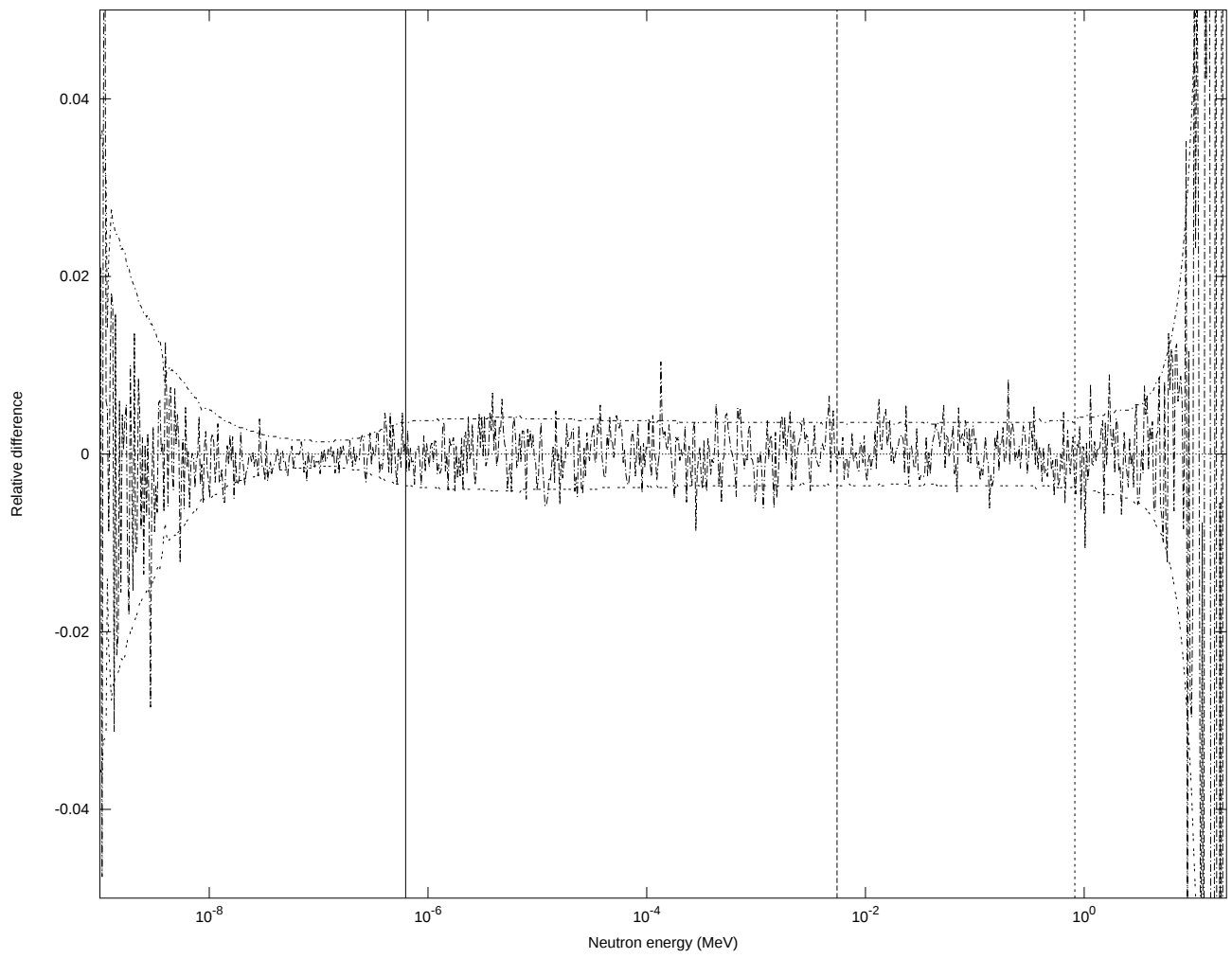


Figure 20. Relative differences between the two spectra Figure 19.

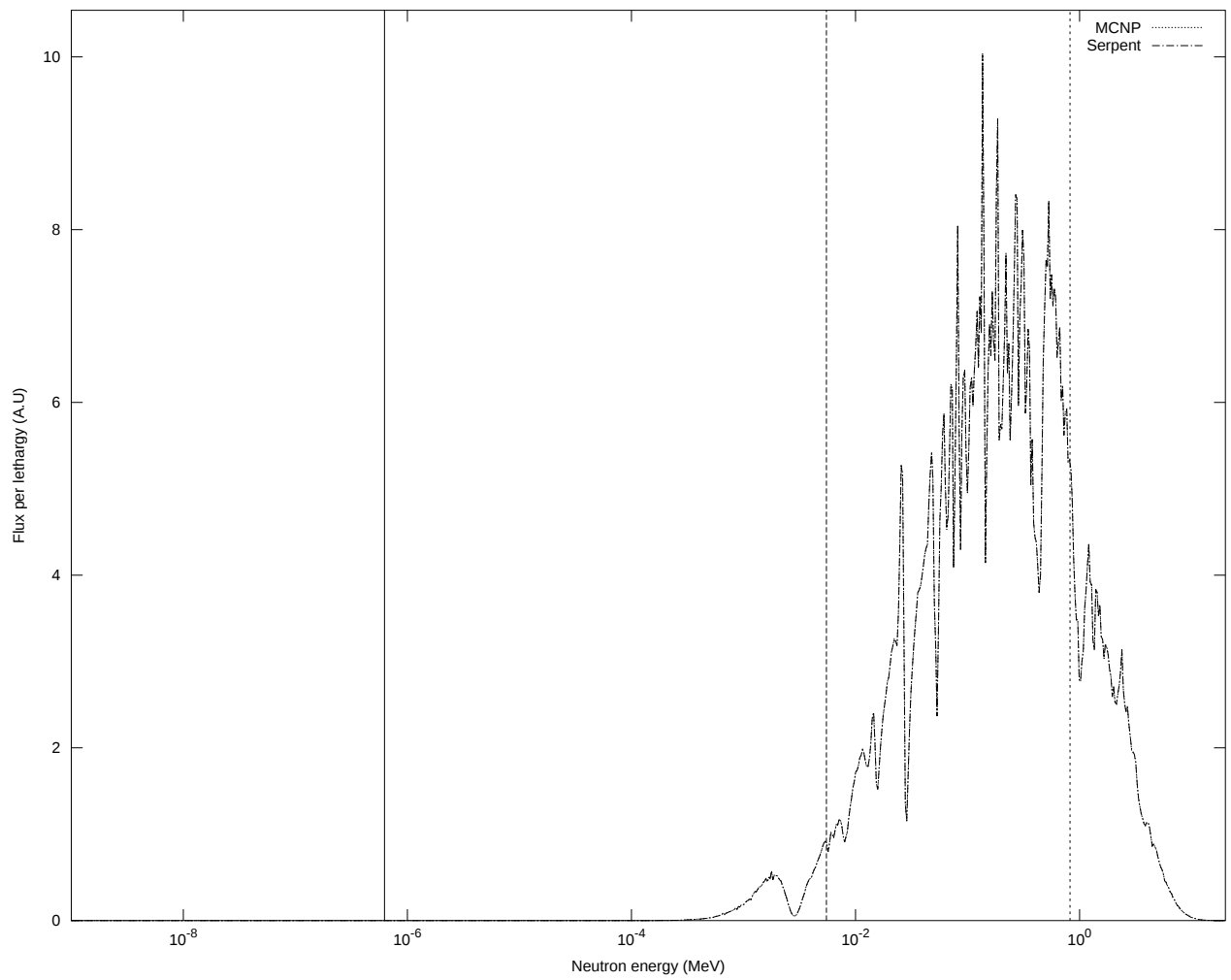


Figure 21. Flux spectra integrated over the entire geometry SFR assembly.

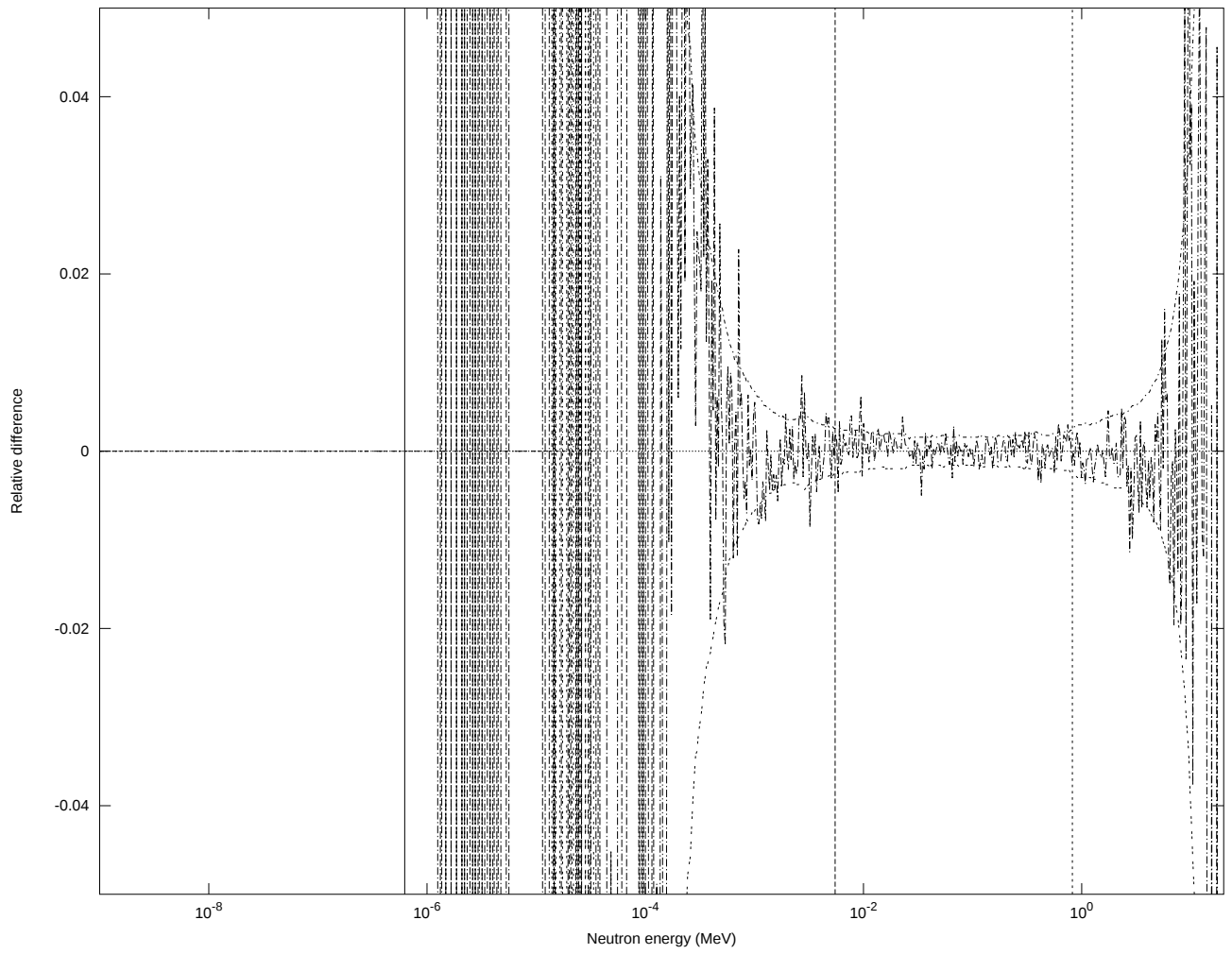


Figure 22. Relative differences between the two spectra Figure 21.

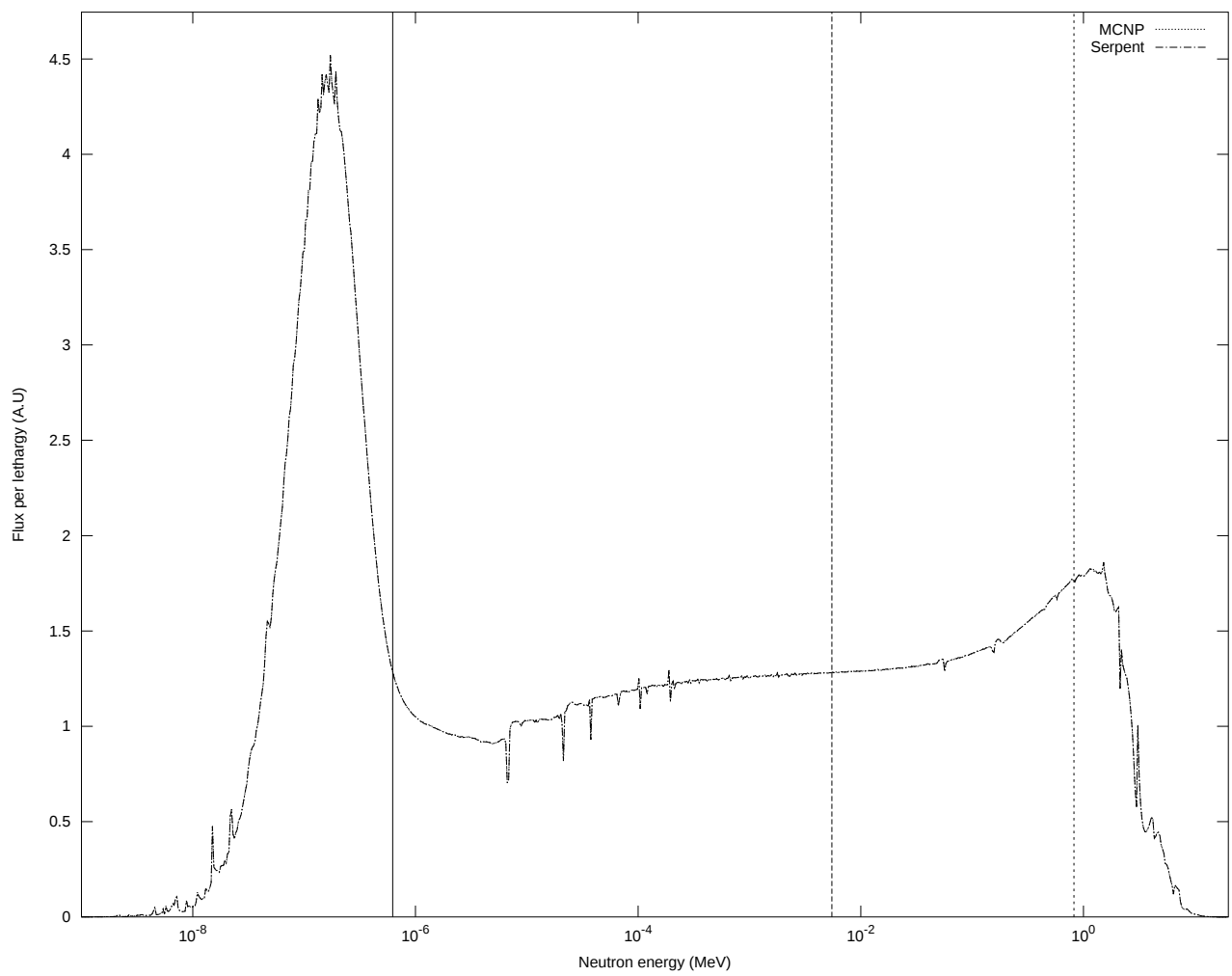


Figure 23. Flux spectra integrated over the entire geometry Prismatic HTGR fuel block.

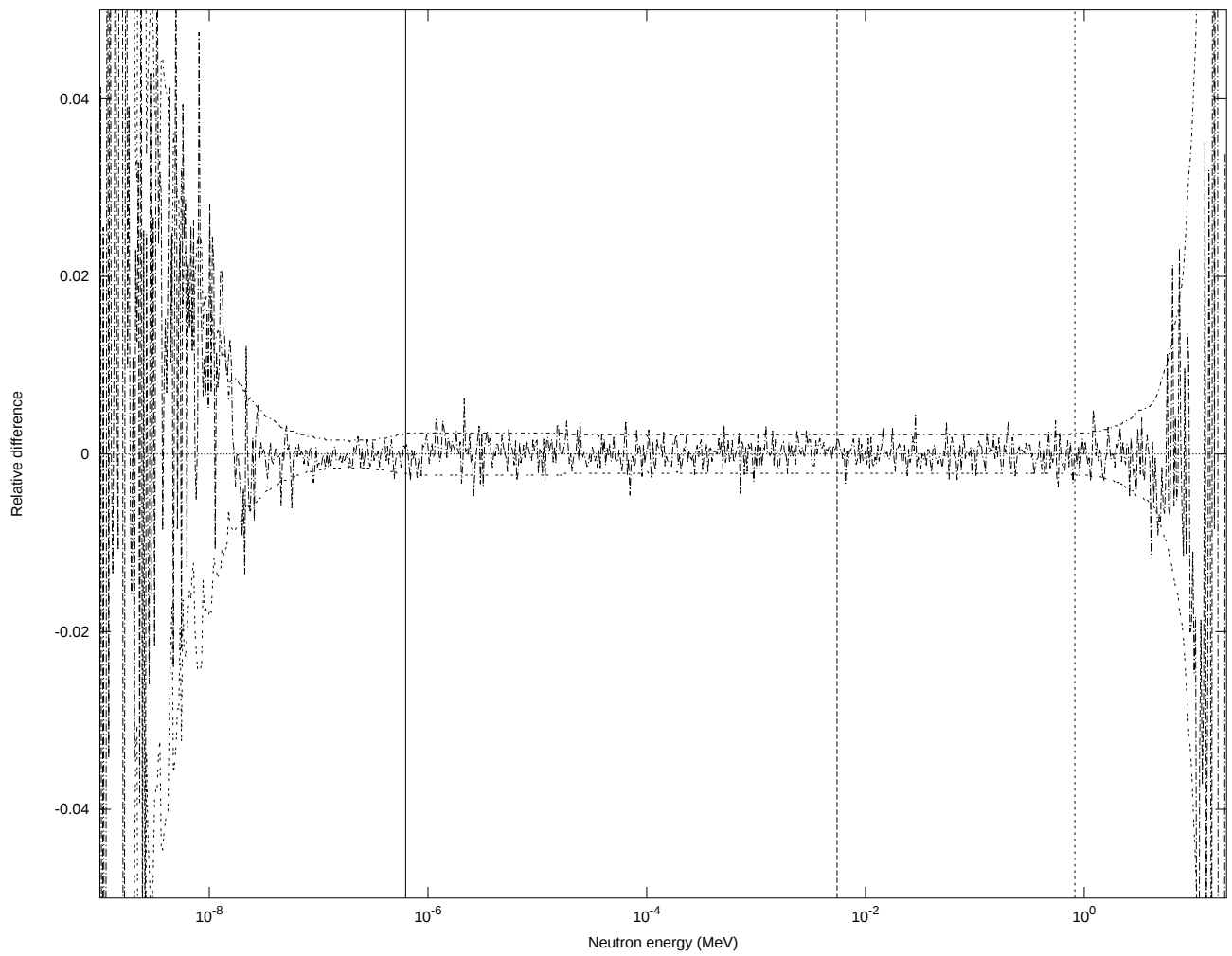


Figure 24. Relative differences between the two spectra Figure 23.

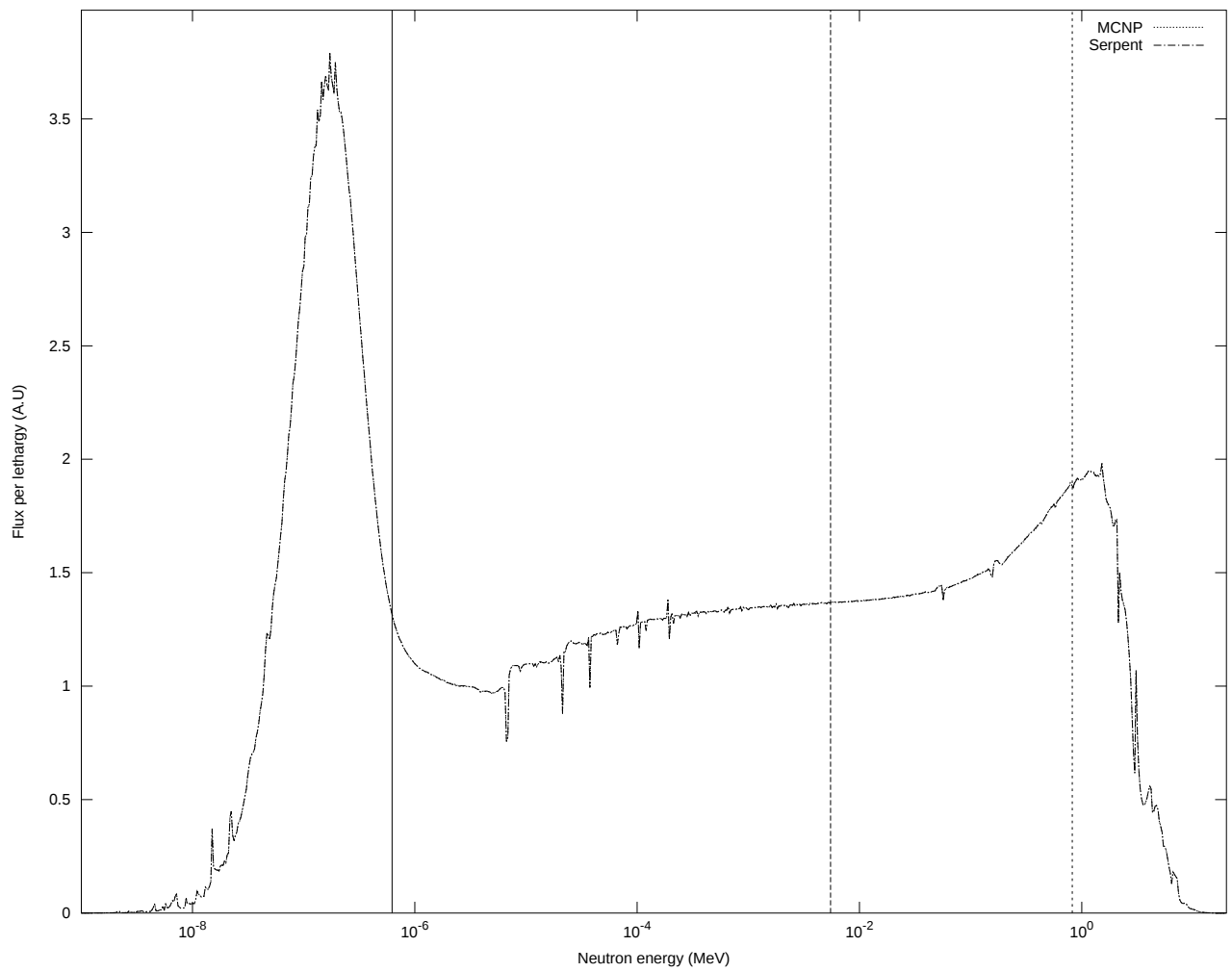


Figure 25. Flux spectra integrated over the entire geometry Prismatic HTGR fuel block + BP.

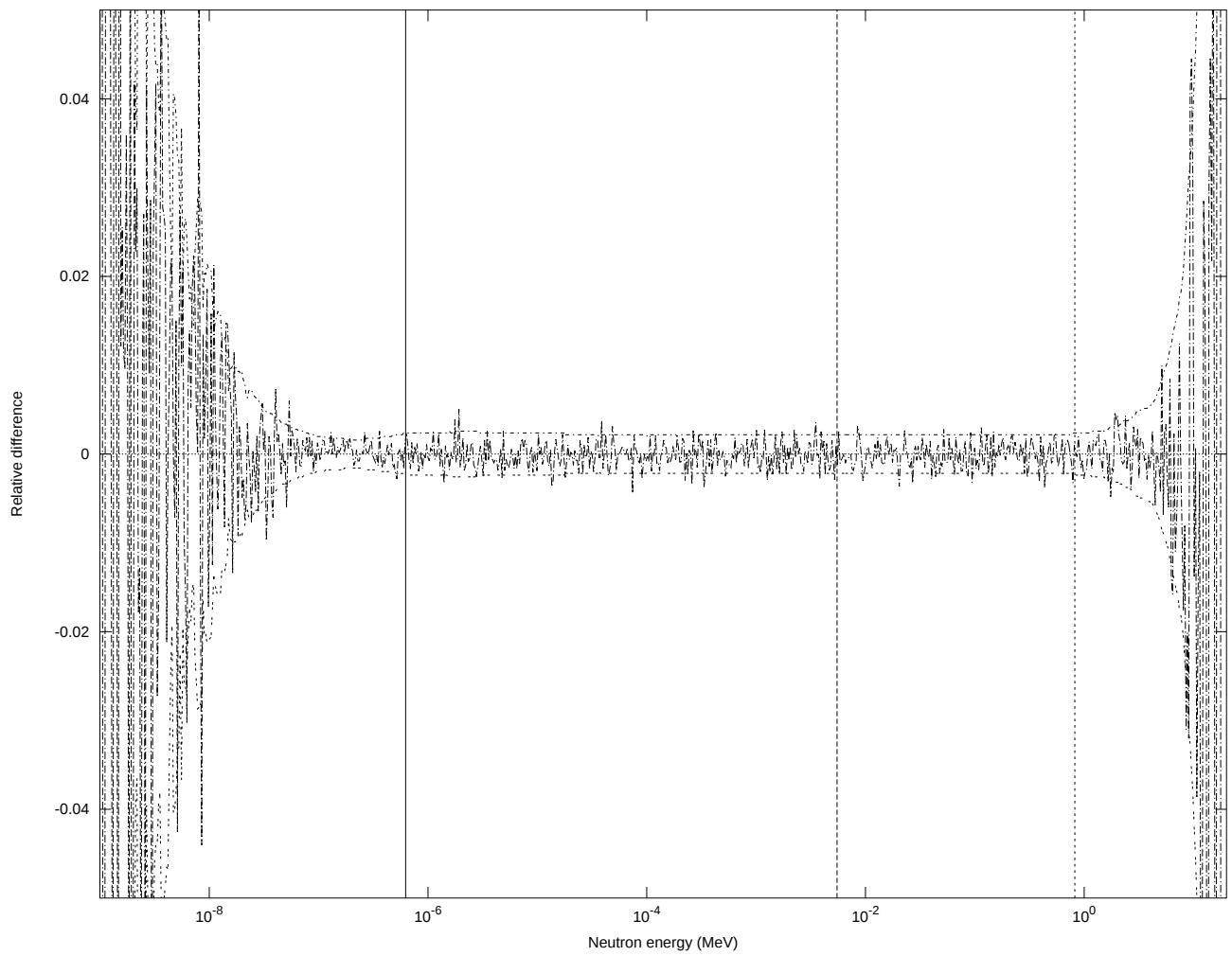


Figure 26. Relative differences between the two spectra Figure 25.

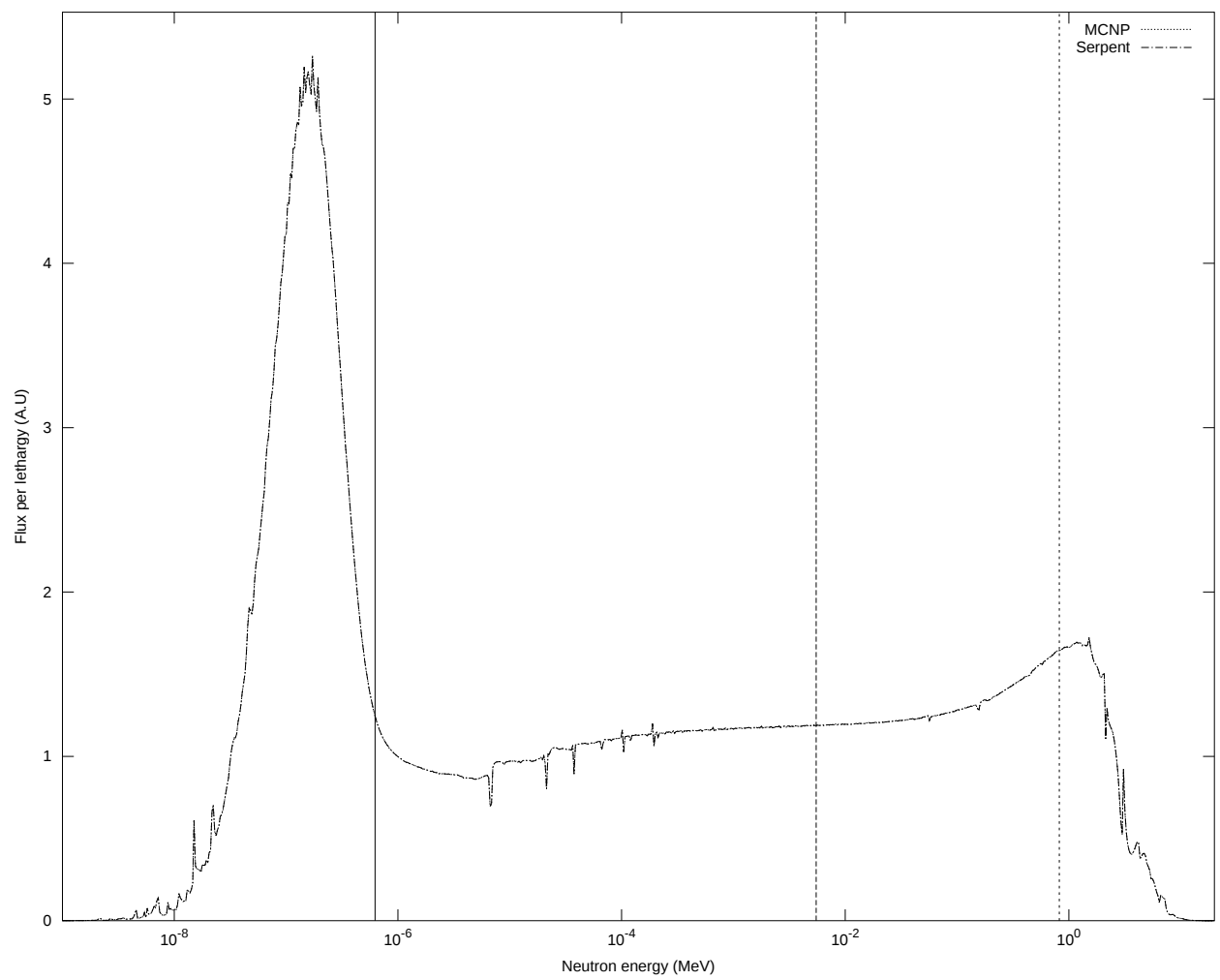


Figure 27. Flux spectra integrated over the entire geometry PBMR fuel pebble.

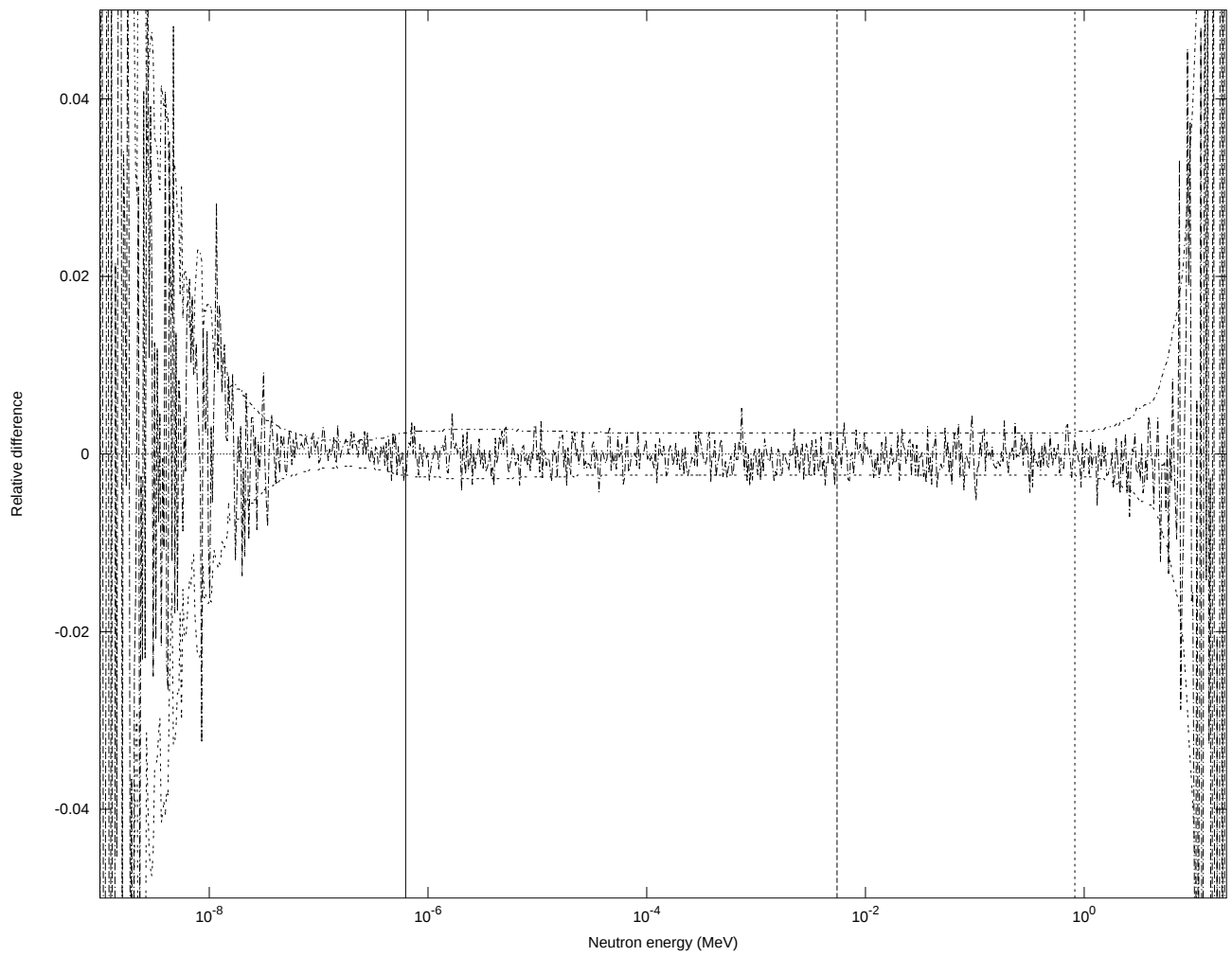


Figure 28. Relative differences between the two spectra Figure 27.