Argonne NATIONAL LABORATORY

ANL-Gen-IV-084

Results of Calculations for the OSMOSE Samples in the MINERVE Reactor R1-UO2, R2-UO2 and R1-MOX Configurations

Topical Report

Nuclear Engineering Division

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Topical Report

by
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract

The design of nuclear systems has shifted over the years from a "test and build" approach to a much more analytical methodology based on the many advances in computational techniques and nuclear data. To a large extent current reactors can be calculated almost as well as they can be measured. This is due in particular to the high quality nuclear data available for the few major isotopes which dominate the neutronics of these systems. Nevertheless, most of the future nuclear systems concepts and advanced fuels development programs currently underway use significant quantities of minor actinides to address modern day issues such as proliferation resistance and low cost. For example, high burnup fuels contain large quantities of americium and curium. Systems designed for plutonium and minor actinide burning are very sensitive to uncertainties in americium and curium data. There are also several other programs where the minor actinide data are essential. These include the Accelerator Transmutation of Waste concepts and Burnup Credit programs [1].

The need for better nuclear data on minor actinides have been stressed by various organizations throughout the world, and results of studies have been published which demonstrate that current data are inadequate for designing the projects under consideration. The first step in obtaining better nuclear data consists of measuring accurate integral data and comparing it to integrated energy dependent data: this comparison provides a direct assessment of the effect of deficiencies in the differential data.

In this report, the comparisons between calculated and experimental reactivity of different OSMOSE samples in the CEA MINERVE reactor R1-UO2 configuration are performed. It has been demonstrated that for major actinides, i.e., U235, U238, Pu239, the current data sets ENDF/B-VI and JEFF3.1 provide good agreement between calculations and experiments which validates these integral cross-sections in this spectrum. However, for some minor actinides, Np237 specifically, there exists a large discrepancy between the calculated and experimental results. This discrepancy is still being investigated, but at this point, the cross-sections have not been validated for this energy spectrum.

The reactivity worths of the OSMOSE samples in the R2-UO2 and R1-MOX configurations have also been reported, although there is no experimental data currently. The trend of reactivity worth behavior of different configurations is consistent with the spectral analysis, i.e., the samples have the largest reactivity-worths in the R2-UO2 configuration because it is the softest as it is a overmoderated spectrum.

The comparison to NGNP/VHTR spectra have also been performed. The MORGANE/S configuration represents an under-moderated spectrum, which is comparable to that of DBMHR/VHTR. However, the MORGANE/S spectrum is still harder due to the small volume ratio between moderator and fuel. The cross section behavior and reaction rates of the OSMOSE samples are also reported, which can explain the behavior of reactivity worth for the OSMOSE samples. Additional development of sensitivity analysis based on spectral weighting is necessary for a more detailed assessment of spectral comparisons between MINERVE spectra and other relevant spectra.

1.0 Introduction

An ambitious program between the Commissariat à l'Energie Atomique (CEA) and the U.S. Department of Energy (DOE) has been launched with the aim of measuring the integral absorption rate parameters of actinide isotopes in the MINERVE experimental facility located at the CEA Cadarache Research Center. The OSMOSE Program (OScillation in Minerve of isOtopes in "Eupraxic" Spectra) includes a complete analytical program associated with the experimental measurement program and aims at understanding and resolving potential discrepancies between calculated and measured values for the studied actinides.

The objective of the OSMOSE program is to measure very accurate integral reaction rates in representative spectra for the actinides important to future nuclear system designs and to provide the experimental data for improving the basic nuclear data files. These data will support advanced reactors designed for transmutation of waste or plutonium burning, sub-critical systems such as found in advanced accelerator applications, and waste disposal and treatment programs in the area of criticality safety. The OSMOSE program is very generic, in the sense that it will measure these reaction rates over a broad range of isotopes and spectra and will be used to provide guidance to all nuclear data programs in the world. The data will provide information valuable to a large number of projects as noted above.

The experimental reactor MINERVE is devoted to neutronic studies of lattices of different reactor types. MINERVE is a pool type reactor operating at a maximum power of 100 W. The core, submerged under 3 meters of water, is used as a driver zone for the different experiments located in a central square cavity with a size of about 70 cm x 70 cm[2]. The coupled lattices in this cavity are built in such a way that they can reproduce the neutronic spectra of a fast reactor, a light water reactor, a RSM reactor and a heavy water reactor. MINERVE achieved its first criticality in 1959 in CEA Fontenay-aux-Roses (near Paris). The reactor was then transferred to Cadarache in 1977. The driver zone consists of enriched metallic uranium/aluminium plates cladded with aluminium and gathered in *MTR* elements of 9, 12 and 18 plates. About 30 elements compose the driver zone which is surrounded by a graphite reflector. The thermal flux is about 10^9 n/cm²-s^{-1} at a power level of 100 Watts. The reactor is controlled using 4 hafnium rods.

MINERVE provides a large experimental basis for the improvement of the cross section databases. An oscillation technique is used to determine the reactivity worth of samples containing the material of interest: actinides, absorbers, poisons, spent fuel, structural materials, etc.

The Argonne National Laboratory has developed Monte Carlo and deterministic calculation models of the MINERVE facility to determine core and safety parameters such as axial and radial fission rate distributions, control rod worth, spectral indices, and the reactivity worth of oscillated samples[3]. Oscillation samples include calibration samples with different uranium enrichments and boron concentrations and the OSMOSE samples - separated actinides including 232Th, 233U, 234U, 235U, 236U, 238U, 237Np, 238Pu, 239Pu, 240Pu, 241Pu, 242Pu, 241Am, 243Am, 244Cm and 245Cm. Seven different neutron spectra can be created in the MINERVE facility: an over moderated UO2 matrix (representative of a fuel processing plant or flooded storage cask), a UO2 matrix in water (representative of LWRs), a mixed oxide fuel matrix (representative of cores containing MOX fuels), two epithermal spectra (representative of under-moderated reactors), a moderated fast spectrum (representative of fast reactors which have some slowing down due to moderators such as lead-bismuth or sodium), and a very hard spectrum (representative of fast reactors with little moderation from reactor coolant). The different spectra are achieved by changing the experimental lattice within the MINERVE reactor. The currently investigated core configurations are R1-UO2, R2-UO2 and R1-MOX, representative of a LWR loaded with UO2, an overmoderated LWR loaded with UO2 and a LWR loaded with mixed oxide matrix, respectively.

The goal of this report is to synthesize the reactor analysis work performed within the framework of the OSMOSE program by Argonne National Laboratory in 2006. The results of the reactivity worth of the OSMOSE samples in the R1-UO2, R2-UO2 and R1-MOX configuration are reported. Comparisons to the experimental results for R1UO2 are also shown. In addition, spectral calculation have been performed

for the R1-UO2, R2-UO2, R1-MOX and MORGANE/S configurations, and these are also compared to representive spectra from some Gen-IV reactor design. Deterministic codes, REBUS and DRAGON, were used for the reactivity worth calculation, with the model of the samples based on the specifications for fabrication of the samples.

2.0 Calculation Model

2.1 REBUS Model

The first deterministic model is based on the REBUS code system [4]. REBUS has been used to solve the diffusion equation in XYZ geometry with the finite difference method. The self-shielded cross sections used in REBUS are provided by the one-dimensional-transport-code-system WIMS-ANL 5.07 [5]. The WIMS and REBUS models are fully described in [3] .

The REBUS model describes the MINERVE core surrounded by at least 30 cm of water and/or structural material, resulting in a 271.5 cm by 271.5 cm by 220 cm region. The core can be schematically described as an experimental zone surrounded by a driver zone (in 4 quadrants). Fuel pins in the experimental zone are used to generate the appropriate flux spectrum in the center and the driver zone feeds the experimental zone with neutrons. The experimental fuel pin lattice is surrounded by an aluminum buffer within a chimney. The driver zone is located outside the chimney and graphite is used as reflector around it. Fig.1 and Fig.2 show a radial and an axial view of the complete geometry of the REBUS model for the R1-UO2 configuration. For the R2-UO2 configuration, the geometry is almost exactly the same as that of R1-UO2, the only difference is that in the experimental zone, the eight fuel pins surrounding the sample channel have been removed, thus softening the spectrum in the sample channel. The geometry for R1-MOX is also similar with those in R1-UO2 and R2-UO2, except that in the experimental zone some UO2 pins are replaced by MOX pins and more aluminum pins are added at the boundary of the experimental zone . The configuration of R1-UO2, R2UO2 and R1-MOX are shown in Appendix 1.

The number of mesh used in the R1-UO2, R2-UO2 and R1-MOX configurations is 190×190×116, and 202×202×116, respectively. In the XY plan, one mesh is used for each cell of the experimental fuel pin lattice (every 1.26 cm) and the mesh size is roughly the same in all the driver elements. The graphite blocks (large and medium) are mapped using a mesh every 2 cm in the X and Y dimension and an approximate 5cm-mesh-size is used for the surrounding water in the XY plan. Axially, the mesh size is defined by the fuel elements and pins of the geometry. The surrounding water is mapped with a 10 cm mesh size, the structural material around the fuel (grid plate of the driver regions, lower and upper end plug and stainless steel spacers) is mapped using a 1-2 cm mesh size, and the fuel and the Plexiglas spacers of the experimental zone are mapped with a 1 cm mesh size.

Microscopic cross sections for the different homogenized regions have been calculated using the one-dimensional-transport-code-system WIMS-ANL 5.07. The starting 69 group structure of the ENDF/B-VI library was collapsed to 7 groups , and the group structure is shown in Table 1.

Table 1. REBUS group structure

Group	Energy
1	500 keV – 10 MeV
2	9.118 keV – 500 keV
3	1.123 eV – 9.118 keV
4	0.4 eV – 1.123 eV
5	0.14 eV – 0.4 eV
6	0.05 eV – 0.4 eV
7	0 - 0.05 eV

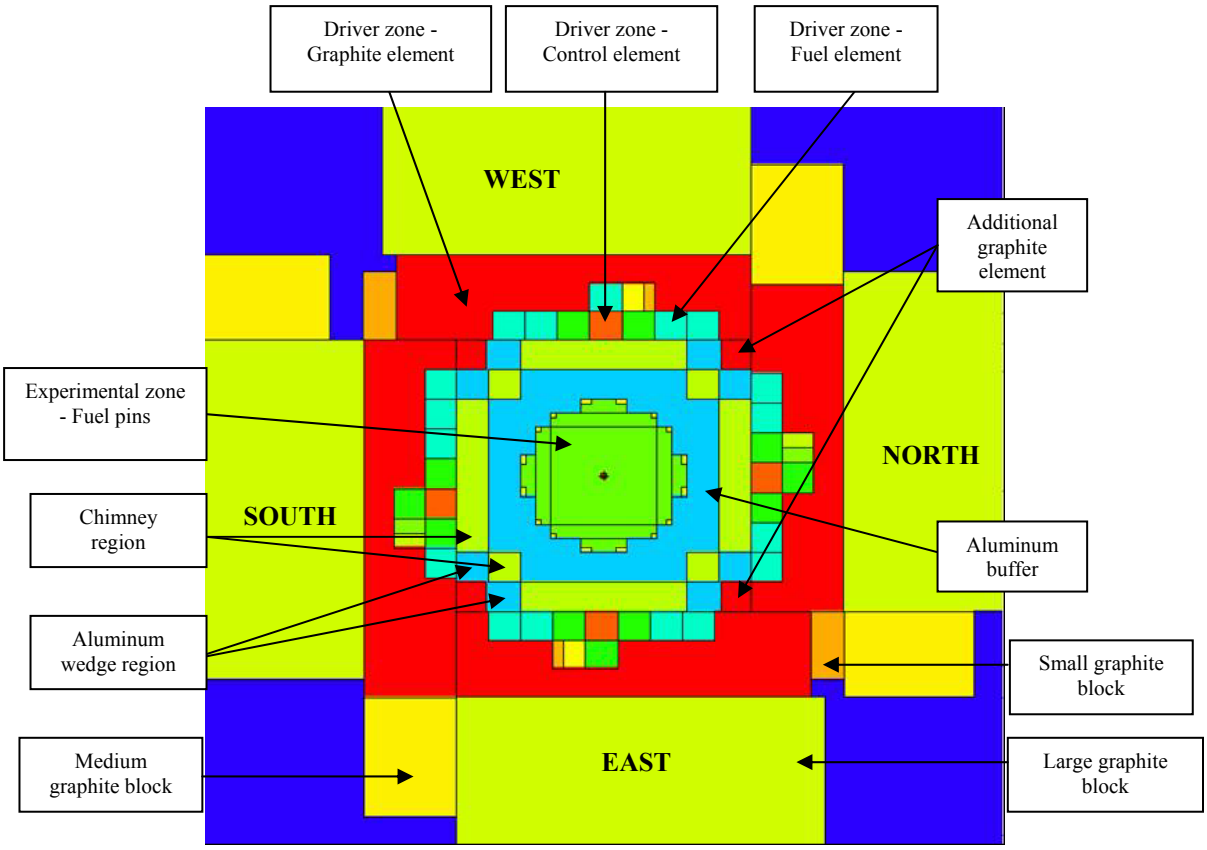

Figure 1. Radial view of the REBUS model in the R1-UO2 configuration

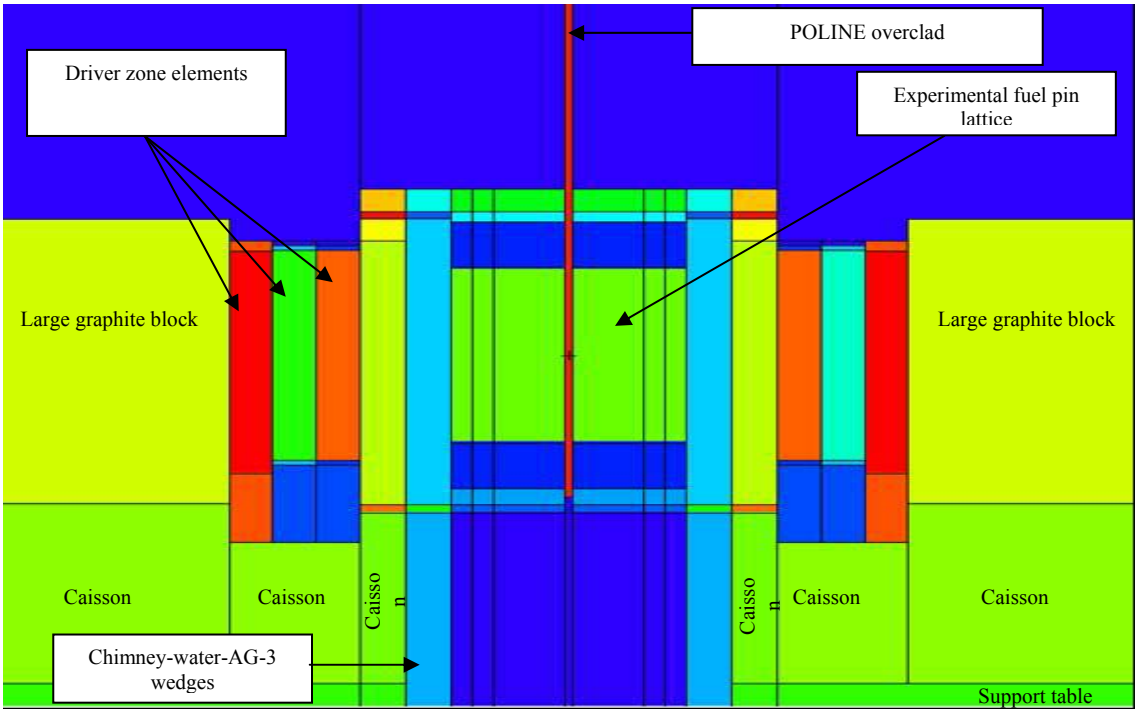

Figure 2. Axial view of the REBUS model in the R1-UO2 configuration

2.2 DRAGON Model

The deterministic transport code DRAGON [6] is also used for reactivity worth calculations. DRAGON is a lattice physics code based on the collision probability method. The two main components of the DRAGON code are its multigroup flux solver and its one group collision probability (CP) tracking modules. The different CP tracking modules perform the same tasks but with different levels of approximation.

The JPM tracking option uses the interface current technique at the level of each homogeneous zone associated with a geometry ($J\pm$ method). With this option, one can either build the complete collision probabilities matrix or generate a response matrix both of which can be processed by the general multigroup solver. The last method permits a non-iterative calculation of the one group neutron flux to be carried out using sparse matrix algebra.

The SYBIL tracking option emulates the main flux calculation option available in the APOLLO-1 code, and includes a new version of the EURYDICE-2 code which performs reactor assembly calculations in both rectangular and hexagonal geometries using the interface current method. SYBIL is slightly more accurate than JPM due to the fact that it performs a complete calculation of the collision probabilities on the whole or a large part of the domain therefore avoiding a large number of interfaces for the angular flux approximation.

The EXCELL tracking option is used to generate the collision probability matrices for the cases having cluster, two dimensional or three dimensional mixed rectangular and cylindrical geometries. A cyclic tracking option is also available for treating specular boundary conditions in two dimensional rectangular geometries. After the collision probability or response matrices associated with a given cell have been generated, the multigroup solution module can be activated. This module uses the power iteration method and requires a number of iteration types. The thermal iterations are carried out by DRAGON so as to rebalance the flux distribution only in cases where neutrons undergo upscattering. The power iterations are performed by DRAGON to solve the fixed source or eigenvalue problem in the cases where a multiplicative medium is analyzed. The effective multiplication factor (k_{eff}) is obtained during the power iterations. A search for the critical buckling may be superimposed upon the power iterations so as to force the multiplication factor to take on a fixed value.

The calculation model consists of a two-dimensional (11×11) multi-cell mini-lattice corresponding to the experimental zone of the MINERVE reactor. The model for R1-UO2 is shown in Fig.3, the sample pin is located in the center, surrounded with UO2 pins. Because of the symmetry of the geometry in the experimental region, only a one-eighth model is used in the calculation. For R2-UO2 and R1-MOX configurations, the models are similar to that shown in Fig.3.

A 172-group ENDF/B-VI based WIMS-D4 format neutron library is used for the DRAGON calculation. The surface net current coupling option -SYBLIT is used for the calculation.

3.0 Composition of the Oscillation Samples

There are several different kinds of oscillation samples: uranium calibration samples, boron loaded calibration samples, OSMOSE separated actinide samples, and absorber samples. The samples are composed of fuel pellets (height~9.35 cm, diameter ~ 0.81cm) clad with zirconium-4 (inner diameter = 0.836, outer diameter = 0.956 cm) and terminated by two zirconium-4 end plugs (same outer diameter, height of 0.2 cm). The sample has a second clad (inner diameter = 1.02 cm, outer diameter = 1.06 cm) with a lower end plug of 0.2 cm height and two upper end plug of 0.2 cm height. The external diameter of the entire sample is 1.06 cm with a total height of 10.35 cm .

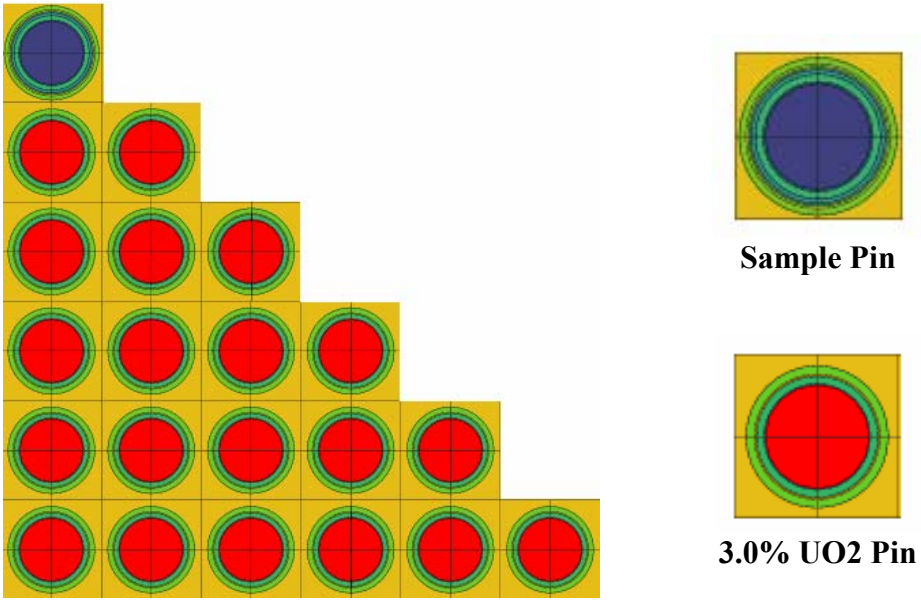

Figure 3. DRAGON calculation model for R1-UO2 configuration

Table 2. Geometry and material specification of the U-235 calibration sample

Sample	F0025	F0050	N0071	S0100	S0200	S0300	S0400	S0495
U235 enrichment (%)	0.25	0.49	0.71	1.00	2.01	3.01	4.00	4.93
Height (mm)	94.08	94.1	94.06	94.04	94.1	94.08	94.06	94.1
Diameter (mm)	8.0943	8.0946	8.0943	8.1114	8.0986	8.1032	8.0999	8.1036
Density (g/cc)	10.442	10.464	10.515	10.594	10.606	10.62	10.629	10.648

Table 3. Volume fraction of the homogenized U-235 calibration sample inserted in the oscillation cane

Sample		F0025	F0050	N0071	S0100	S0200	S0300	S0400	S0495
Volume fractions (%)	Sample	29.46	29.47	29.46	29.58	29.50	29.53	29.50	29.53
	Void	7.9	7.89	7.89	7.76	7.87	7.83	7.85	7.83
	Zr4	18.23	18.22	18.24	18.24	18.22	18.23	18.24	18.22
	SS	11.38	11.38	11.38	11.38	11.38	11.38	11.38	11.38
	Water	33.04	33.04	33.04	33.04	33.04	33.04	33.04	33.04

The total height of the fuel pellets is often larger than 9.35 cm. In order to keep the total height constant (10.35 cm) the upper end plug of the outer clad was modeled with a smaller height to accommodate the different fuel pellet heights.

The characteristics of the U-235 calibration sample fuel pellets are reported in Table 2. The associated volume fractions of the homogenized oscillation sample in the oscillation cane (1.26 cm × 1.26 cm) are shown in Table 3.

The characteristics of the borated UO_2 calibration sample fuel pellets are reported in Table 4. The associated volume fractions of the homogenized borated samples in the oscillation cane are shown in Table 5.

Table 4. Geometry and material specification of the borated UO_2 calibration sample

Sample	1B0000	1B0071	1B0150	1B0419	2B0000	2B0333	2B1062	2B2360
U235 enrichment (%)	0.25	0.25	0.25	0.25	0.53	0.53	0.53	0.53
Boron fraction (ppm)	0	71	150	419	0	333	1062	2360
Height (mm)	99.96	100	99.98	99.82	99.7	99.5	99.62	98.7
Diameter (mm)	8.079	8.08	8.106	8.084	8.203	8.2	8.202	8.2
Density (g/cc)	9.551	9.545	9.380	9.523	2.854	9.801	9.701	9.504

Table 5. Volume fraction of the homogenized boron calibration sample inserted in the oscillation cane

Sample		1B0000	1B0071	1B0150	1B0419	2B0000	2B0333	2B1062	2B2360
Volume fractions (%)	Sample	31.19	31.21	31.40	31.18	32.07	31.98	32.03	31.72
	Void	8.49	8.49	8.28	8.44	7.51	7.52	7.51	7.46
	Zr4	15.91	15.89	15.90	15.96	16.01	16.09	16.04	16.41
	SS	11.38	11.38	11.38	11.38	11.38	11.38	11.38	11.38
	Water	33.04	33.04	33.04	33.04	33.04	33.04	33.04	33.04

Table 6. Atom number density of the Calibration Samples

Isotope	**Calibration Sample**					
	F0025	**F0050**	**N0071**	**S0100**	**S0200**	**S0300**
U234	2.3282E-07	7.9332E-07	1.2896E-06	1.9133E-06	4.2575E-06	6.5134E-06
U235	5.8485E-05	1.1538E-04	1.6656E-04	2.3673E-04	4.7450E-04	7.1242E-04
U236	6.9846E-08	6.9999E-08	1.1723E-07	1.1811E-07	1.1826E-07	9.4740E-08
U238	2.3223E-02	2.3217E-02	2.3279E-02	2.3382E-02	2.3174E-02	2.2966E-02
O	4.6632E-02	4.6722E-02	4.6947E-02	4.7335E-02	4.7355E-02	4.7470E-02
	S0400	**S0495**	**1B0150**	**2B0333**		
U234	8.7733E-06	1.0925E-05				
U235	9.4792E-04	1.1713E-03	5.3560E-05	1.1730E-04		
U236	1.1856E-07	1.1875E-07				
U238	2.2755E-02	2.2569E-02	2.1100E-02	2.1730E-02		
O	4.7466E-02	4.7616E-02	4.2310E-02	4.3700E-02		
B10			1.5780E-05	3.6180E-05		
B11			6.3500E-05	1.4560E-04		

Table 7. Atom number density of the OSMOSE Samples

Isotope	OSMOSE Sample					
	AM41_1	**AM41_2**	**AM43**	**NP37_1**	**NP37_2**	**Unat**
U234	1.3790E-06	1.3750E-06	1.2740E-06	1.3870E-06	1.3880E-06	1.3890E-06
U235	1.6600E-04	1.6550E-04	1.6680E-04	1.6690E-04	1.6700E-04	1.6720E-04
U236	4.5980E-07	4.5840E-07		4.6230E-07	4.6260E-07	4.6310E-06
U238	2.2820E-02	2.2750E-02	2.3000E-02	2.2950E-02	2.2960E-02	2.2980E-02
NP237	1.3350E-10	4.4510E-10		5.2460E-05	3.1530E-04	
AM241	3.0430E-05	1.0150E-04	6.2250E-09			
AM243			5.4170E-05			
O	4.6060E-02	4.6050E-02	4.6340E-02	4.6350E-02	4.6910E-02	4.6320E-02
	PU38	**PU39**	**PU40**	**PU41**	**PU42**	**U233**
U233						2.6980E-04
U234	4.8350E-06	1.3210E-06	1.3770E-06	1.3780E-06	1.3411E-06	7.3930E-06
U235	1.6450E-04	1.5870E-04	1.6570E-04	1.6580E-04	1.6138E-04	1.6570E-04
U236	4.5670E-07	4.4030E-07	4.6390E-07	4.5930E-07		
U237					4.4700E-07	
U238	2.2610E-02	2.1820E-02	2.2780E-02	2.2800E-02	2.2189E-02	2.2820E-02
NP237	4.5900E-11	3.2050E-12	3.3900E-12	1.5650E-14		
PU238	2.0010E-04	3.6180E-07	2.2880E-08			
PU239	3.5200E-05	2.9670E-04	1.2260E-07			
PU240	4.5110E-06	6.6840E-06	7.6190E-05		3.9170E-08	
PU241	2.3510E-07	8.1100E-08	2.2320E-07	5.4150E-05		
PU242	3.7810E-07	3.0380E-08	5.3660E-08		2.4468E-04	
AM241	2.5890E-08	3.9820E-09	6.7750E-09	7.1370E-09		
O	4.6060E-02	4.4580E-02	4.6050E-02	4.6050E-02	4.5207E-02	4.5960E-02
	U234	**URE**	**TH232**	**U-TH232**		
U234	1.6890E-04	1.7210E-05		1.3130E-06		
U235	1.6630E-04	9.4170E-04		1.5800E-04		
U236	5.1240E-07	2.1240E-04		4.3760E-07		
U238	2.2850E-02	2.2350E-02		2.1720E-02		
Th232			2.3540E-02	1.1150E-03		
O	4.6390E-02	4.7050E-02	4.7100E-02	4.6010E-02		

The cross sections used in the REBUS code for the materials are calculated in two steps. First microscopic cross sections for different elements (such as Al-27, U-235, Fe-54, etc.) are calculated using WIMS. The macroscopic cross sections of the materials are then generated in REBUS from the microscopic cross sections and the atom densities of the different elements.

Because the self shielding and energy group condensation of the microscopic cross sections is performed in WIMS, it is often necessary to define different sets of cross sections for a given element. It is particularly important for the constituents of the fuel and the absorber.

In this section, the compositions of the materials used in REBUS in terms of atom density, and the minor adjustments to be able to use the WIMS 69-group library are addressed. The WIMS models are described and related to the different REBUS regions for the R1UO2 and the R1MOX configurations.

The atom densities of the Oscillation Samples used in the deterministic models (WIMS-ANL/REBUS and DRAGON) are reported in Table 6 and Table 7.

4.0 Reactivity Worth Calculation

4.1 WIMS/REBUS Results

An initial series of calculations of the reactivity-worth of the OSMOSE samples in the MINERVE reactor with the R1-UO2 , R2-UO2 and R1-MOX core configuration were completed. The results are shown in Table 8 and Figure 4.

The results for the reactivity-worth of the samples are compared to the natural uranium sample by subtracting the reactivity of the natural uranium sample value from that of the OSMOSE sample. In this manner, the natural uranium sample shows a zero value for the reactivity-worth and is considered to be a reference. The samples that show a positive reactivity-worth have a postive reactivity effect compared to natural uranium. That is, replacing the natural uranium sample with the OSMOSE samples causes a net increase in the number of neutrons per cycle and hence a positive effect. This effect can be due to an increase of ν (the average number of neutrons per fission) or Σ_f (macroscopic fission cross section) or by a decrease of Σ_a since $k \sim (\nu \Sigma_f - \Sigma_a)$. Samples with a negative reactivity produce a net loss in the number of neutrons per cycle.

Fig.4 indicates a range of reactivity effect from -8 pcm to +8 pcm compared to the natural uranium sample for the R1-UO2 configuration, -25 pcm to + 25 pcm for the R2-UO2 configuration, and -3 pcm to + 3 pcm for the R1-MOX configuration. The trend for the reactivity effect is the same for each sample in all three configurations, however, the net effect is different. This is due to the spectra effect of the R2-UO2 configuration, with larger water region surrounding the sample, the spectrum is much softer so that both the k-eff and the reactivity worth are the largest among the three kind of core configurations. For the R1-MOX configuration, with the strong absorption from MOX pins, the spectrum is harder, which makes the k-eff and the reactivity worth smaller.

It can also be observed from Fig.4 that some samples have positive reactivity worth compared with that of the Unat sample, and other samples have negative value of reactivity worth. In this case, all the three spectra have large thermal neutron fractions. (The neutron spectra are shown in Section 5.) The samples that have positive reactivity worth have a larger thermal fission cross section than the Unat sample, and the samples that have negative reactivity worth have a smaller thermal fission cross section.

Table 8. Reactivity Worth of OSMOSE Samples calculated by WIMS/REBUS

Samples	R1UO2		R2UO2		R1MOX	
	k-eff	reactivity worth (pcm)	k-eff	reactivity worth (pcm)	k-eff	reactivity worth (pcm)
AM41_1	1.000798	-1.50	1.001276	-2.39	0.997427	-0.50
AM41_2	1.000769	-4.39	1.001224	-7.58	0.997418	-1.41
AM43	1.000806	-0.70	1.001290	-1.00	0.997429	-0.30
NP37_1	1.000806	-0.70	1.001288	-1.17	0.997429	-0.30
NP37_2	1.000776	-3.69	1.001233	-6.68	0.997420	-1.21
PU38	1.000776	-3.69	1.001237	-6.28	0.997423	-0.90
PU39	1.000856	4.29	1.001473	17.25	0.997443	1.11
PU40	1.000782	-3.10	1.001258	-4.19	0.997396	-1.11
PU41	1.000820	0.70	1.001357	5.68	0.997433	0.10
PU42	1.000800	-1.30	1.001283	-1.70	0.997426	-0.60
U233	1.000851	3.79	1.001421	12.07	0.997444	1.21
U234	1.000806	-0.70	1.001284	-1.60	0.997430	-0.20
Unat	1.000813	0	1.001300	0	0.997432	0
URE	1.000878	6.49	1.001548	24.73	0.997450	1.81
U-TH232	1.000809	-0.40	1.001289	-1.10	0.997431	-0.10
TH232	1.000738	-7.49	1.001113	-18.65	0.997409	-2.31

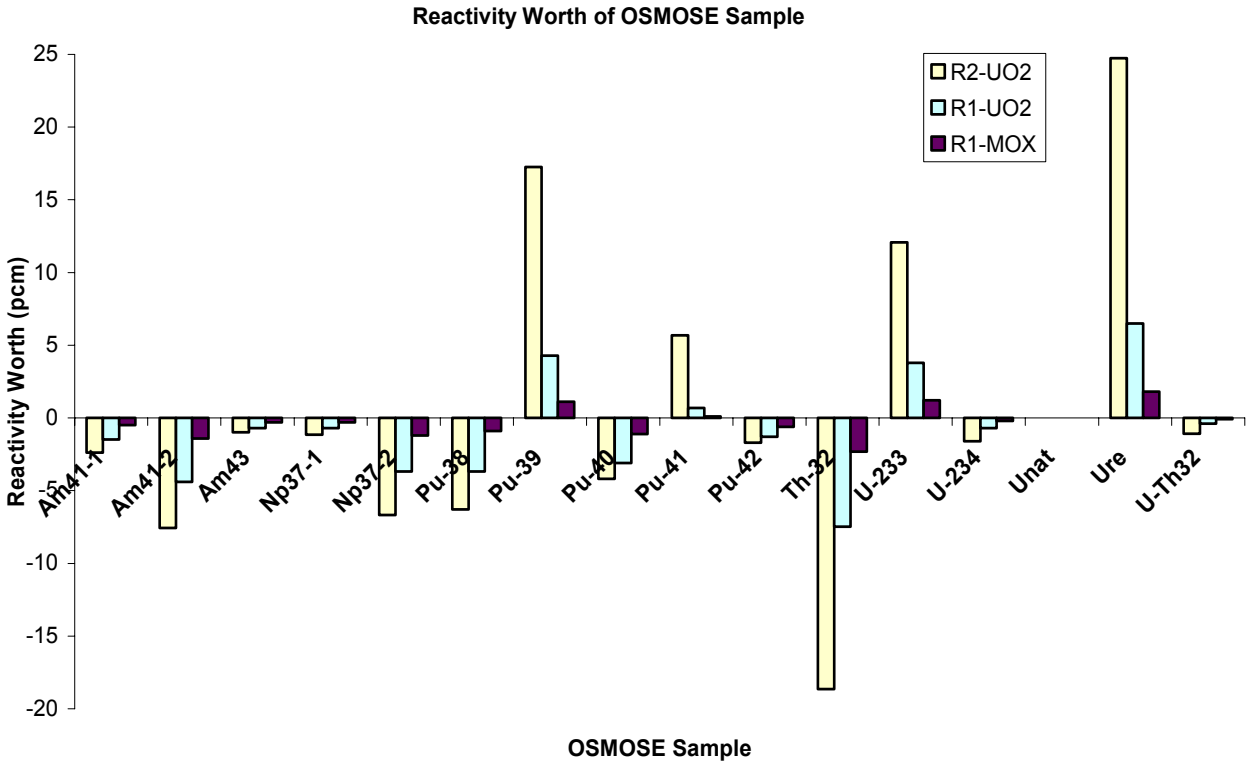

Figure 4. Reactivity Worth of OSMOSE Samples calculated by REBUS

4.2 DRAGON Results

From the results shown in Table 8 and Fig.4, it can be seen that the magnitude of reactivity worth for the OSMOSE samples are very small, (for some samples, the value is even less than 1 pcm) , which is difficult to be distinguished from the numerical error in the calculations, i.e, the truncation and convergence error. This introduces non-trivial uncertainty for the results, especially if we want to compare the reactivity with the experimental signal, which should be proportional to the minor reactivity difference of the core loaded with different samples. To fix this problem, a two–dimensional miniature lattice model was introduced using the lattice physics code DRAGON, as shown in Fig.3, in which the sample should have much larger effect to the reactivity of the system, and the effect of numerical error is significantly reduced and is practically neglible.

DRAGON calculations were performed to obtain reactivity worths of the OSMOSE samples in R1-UO2, R2-UO2 and R1-MOX configurations. The results are shown in Table 9 and Fig.5. As before, the reactivity-worth of a sample is referenced to the natural uranium sample.

In the DRAGON calculations, the critical buckling search is superimposed upon the iteration so that the effective multiplication factor (k_{eff}) is forced to 1.0, and using the calculated flux, the infinite multiplication factor (k_{inf}) can be obtained. This value is used as the calculation result for analysis.

Table 9. Reactivity Worth of OSMOSE Samples calculated by DRAGON

Samples	R1UO2		R2UO2		R1MOX	
	k-eff	reactivity worth (pcm)	k-eff	reactivity worth (pcm)	k-eff	reactivity worth (pcm)
AM41_1	1.316891	-38.50	1.329203	-59.61	1.146963	-26.14
AM41_2	1.315435	-122.55	1.326929	-188.54	1.146197	-84.41
AM43	1.317082	-27.49	1.329687	-32.22	1.146989	-24.17
NP37_1	1.317201	-20.63	1.329705	-31.21	1.147089	-16.56
NP37_2	1.315478	-120.07	1.327088	-179.51	1.146065	-94.46
PU38	1.316010	-89.34	1.327332	-165.66	1.146723	-44.39
PU39	1.318823	72.74	1.334336	229.80	1.148068	57.77
PU40	1.316013	-89.16	1.328228	-114.84	1.146601	-53.67
PU41	1.318219	38.00	1.331816	88.00	1.147663	27.04
PU42	1.317106	-26.10	1.329607	-36.75	1.146955	-26.75
U233	1.319016	83.84	1.333591	187.93	1.148303	75.60
U234	1.317085	-27.31	1.329403	-48.29	1.146993	-23.86
Unat	1.317559	0.00	1.330257	0.00	1.147307	0.00
URE	1.319550	114.52	1.336010	323.70	1.148401	83.03
U-TH232	1.317279	-16.13	1.325062	-24.53	1.147115	-14.59
TH232	1.315153	-138.85	1.325062	-294.72	1.146250	-80.37

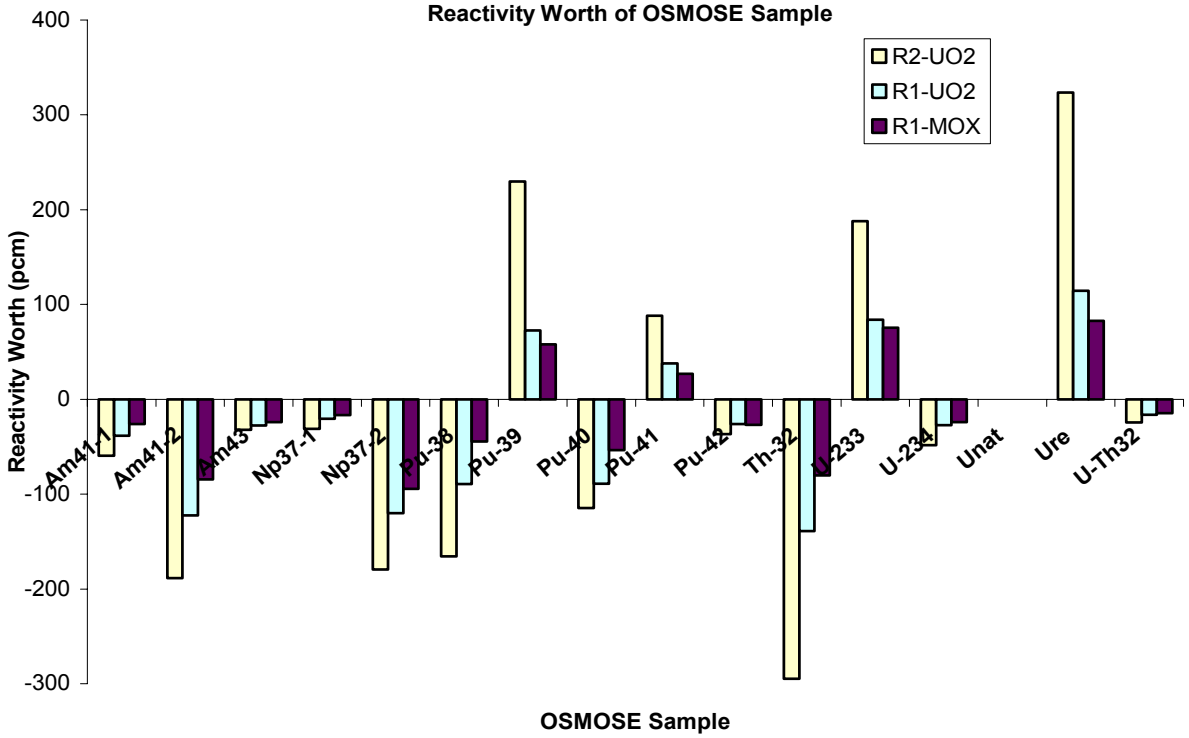

Figure 5. Reactivity Worth of OSMOSE Samples calculated by DRAGON

To validate the ANL ENDF/B-VI library, a comparison was performed between experimental and calculated results for the R1-UO2 configuration loaded with calibration and oscillation samples. The calculation model is based on lattice physics code DRAGON using ANL 172-group ENDF/B-VI library. The process can be summarized as following:

1) Perform calibration measurements, to obtain the experimental signal for
   i) calibration samples with well-known cross section
   ii) oscillation samples with less well known cross section.
2) Calculate the k_{inf} for the calibration samples with well known cross section using the validated model, compare it to the experimental signal obtained from step 1) to generate the calibration curve (linear function).
3) Calculate the k_{inf} for the oscillation samples with less well known cross sections using the validated model, compare it to the calibration curve obtained from step 2), if there exist apparent difference, it is generally due to the cross section.

For the R1-UO2 configuration, the comparison of calculated results and experimental data has also been performed. Table 10 shows the calculated k_{inf} of the B-10 and U-235 calibration samples, as well as the experimental signal (in pilot unit).

Fig.6 is the calibration curve, which shows the relation between the experimental signal (in pilot unit) of the B-10 and U-235 calibration samples, and their calculated eigenvalue (given by the DRAGON 2D model). It has been observed that for the calibration samples, (the composition is UO2 fuel with different enrichments in ^{235}U and with a range of boron concentrations), the calculated reactivity worth is almost perfectly linear with the value of experimental signal, as shown in Fig.6, with RMS less than 0.02, which shows that the data of major actinides - ^{235}U and ^{238}U, in the ANL ENDF/B-VI library is sufficiently accurate.

Table 11 shows the experimental results and the associated uncertainties obtained in the R1-UO2 core configuration, for the first 6 OSMOSE samples oscillated in MINERVE between October 2005 and March 2006. An excellent accuracy, better than 1.3% in every case, is obtained on the experimental results, that rely to the difference of the signal given by the OSMOSE samples (containing the natural uranium matrix and the doping actinide *X*) and the signal of the Unat sample (only containing the natural uranium matrix).

Using the function between k_{inf} and experimental signal determined in Fig.6, as well as the experimental signal shown in Table 11 for the OSMOSE samples, the "experimental" k_{inf} and reactivity worth of the OSMOSE samples can be predicted, and the comparison to the calculated results is shown in Table.12.

Table 10. Calculated eigenvalue and Experimental signal of the calibration samples

Sample	Enrichment of U235 (wt. %)	Boron Density (ppm)	*k-eff*	Experimental Signal
F0025	0.25	0	1.317135	11,126
F0050	0.50	0	1.317345	41,846
N0071	0.71	0	1.317518	72,001
S0100	1.00	0	1.317765	108,544
S0200	2.01	0	1.318487	218,290
S0300	3.01	0	1.319121	315,012
S0400	4.00	0	1.319715	391,359
S0495	4.93	0	1.320190	463,613
1B0150	0.25	150	1.316166	-135,504
2B0333	0.53	333	1.314937	-317,174

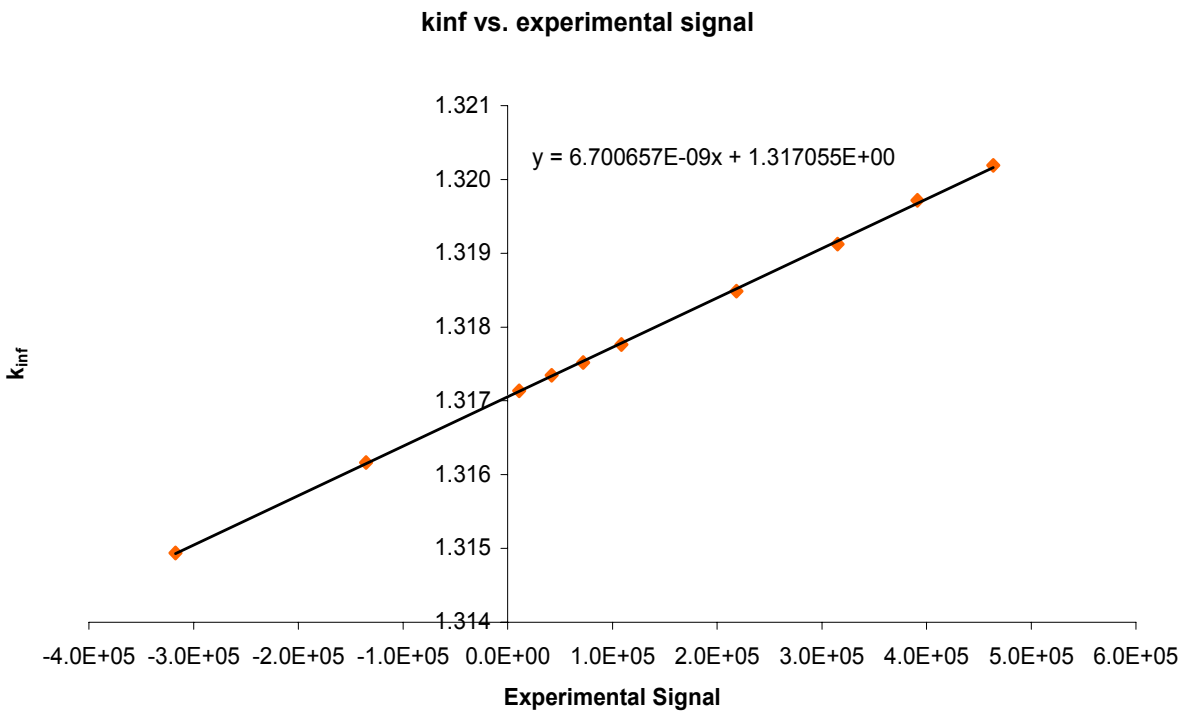

Figure 6. Calibration curve obtained with the DRAGON 2D model

Table 11. First experimental results in the R1-UO2 core configuration

Sample	Experimental signal (p.u.)	Mean overall uncertainty (p.u.)	Relative uncertainty on (*X* sample signal – Unat sample) (%)
Unat	62 444	451	/
U-234	-5 343	507	1.0%
Pu-239	250 028	700	0.4%
Pu-242	-2 801	526	1.1%
Np-237/1	11 727	484	1.3%
Np-237/2	-211 132	731	0.3%

Table 12. Comparison of experimental and calculation results for OSMOSE Samples in R1-UO2 configuration

Sample	Calculated reactivity worth (pcm)	Experimental reactivity worth (pcm)	(C-E)/E in %	σ_d (%) (a)	σ_e (%) (b)	σ_{tot} (%) (c)
			ENDF-B/VI			
U-234	-27.31	-26.18	4.3 %	2.3 %	1.0%	2.5 %
Pu-239	72.74	72.34	0.5 %	2.3 %	0.4%	2.3 %
Pu-242	-26.10	-25.20	3.6 %	2.3 %	1.0%	2.5 %
Np-237/1	-20.63	-19.58	5.3 %	2.3 %	1.3%	2.6 %
Np-237/2	-120.07	-105.76	13.53 %	2.3 %	0.3%	2.3 %

(a) uncertainty on the data analysis
(b) experimental uncertainty
(c) total uncertainty on (C-E)/E

It can be seen that for the U-234, Pu-239 and Pu-242 samples, the calculation result agrees well with that of the experimental result. However, for the Np-237 samples there exists relatively large error. As the experimental signal of Np-237 is mainly due to both thermal and epithermal captures, it is difficult to identify whether the thermal part of the Np-237 radiative capture cross section or the integral resonance are underestimated. It can also be observed that the calculated results always over-estimates the reactivity worth for the samples, (although for some samples it only over estimate the reactivity worth slightly), which might be due to the error of the ENDF/B-VI data set.

Although this discrepancy between the calculated and experimental results is observed, it is still difficult to conclude whether this problem is caused by the ENDF/B-VI data itself or is inherent in the processing of the data for the multi-group calculations. The DRAGON library is not raw ENDF/B data, a lot of pre-processing has been performed, especially for the resonance region, some approximations have been introduced to calculate the resonance integrals. New WIMSD format 172-group libraries based on ENDF/B-VI rev.8 and JEFF3.1 were downloaded from the IAEA website, and these were transformed into a binary format that could be used by the lattice physics code DRAGON. These new libraries provide us a chance for further validation of the nuclear data set. Using the new IAEA library, a similiar comparison between calculated and experimental reactivity worth was performed, which is shown in Table 13.

From the results shown in Table 13, the results using ANL ENDF/B-VI library are consistent with that using IAEA ENDF/B-VI library. The ANL library appears even to be a little better, the possibily due to the more detailed treatment of anisotropic scattering. It can also be seen that the agreement between calculated and experimental results using the JEFF3.1 library is apparently better than that using ENDF/B-VI library. However there still exists relatively large difference between the calculated and experimental results for N_P samples.

Based on this, it is concluded that the large discrepancy between calculated and experimental results for the Np sample is not library specific. The possible sources of error are 1) sample composition and geometry, 2) raw data in ENDF and JEFF, 3) self-shielding parameters in the processed library. It is suspected to be due to the ENDF/VI and JEFF data set. Some more study will be performed to figure out the source of error.

Table 13. Comparison of the Calculated (C) and Experimental (E) Results

	IAEA- ENDF/B-VI REV.8 172-g library			IAEA- JEFF3.1 172-g library		
Sample	C (pcm)	E (pcm)	(C-E)/E in %	C (pcm)	E (pcm)	(C-E)/E in %
U-234	-27.36	-26.06	5.0%	-26.26	-25.99	1.1%
Pu-239	72.60	72.02	0.8%	71.96	71.82	0.2%
Pu-242	-26.50	-25.08	5.7%	-25.12	-25.01	0.4%
Np-237/1	-21.12	-19.50	8.3%	-19.98	-19.44	2.8%
Np-237/2	-122.25	-105.29	16.1%	-115.47	-104.99	10.0%
U-TH32	-15.91	-16.10	-1.2%	-16.04	-16.05	-0.1%

5.0 Spectra Calculation

Within the MINERVE reactor, different spectra are achieved by changing the experimental lattice. The R1-UO2 configurations corresponds to an LWR loaded with UO2, the R1-MOX corresponds to LWR loaded with a mixed oxide matrix, the R2-UO2 corresponds to an over-moderated LWR spectrum, and MORGANE/S corresponds to an epithermal spectrum representive of under-moderated reactors. The spectra in the central sample channel of the R1-UO2 and R2-UO2 configuration have been calculated by both CEA and ANL with MCNP, using a 99 energy group structures, and the comparison of results is shown in Fig.7 and Fig.8.

The ANL MCNP[7] calculation model is a two-dimensional mini-lattice (11x11 pins) to reduce the computation time, the rest of the experimental zone and the whole driver region are ignored because their contribution to the spectra in the sample region is trivial.

From Fig.7 and Fig.8, it can be seen that the global spectral shape agrees reasonably well between ANL and CEA result, for both R1UO2 and R1MOX configuration, with the thermal peak located approximately at 0.08 eV. It is also observed that the ANL spectra is over-thermalized compared with that of the CEA result, for both R1UO2 and R1MOX. There also exists some difference for the local flux peak, which should be due to the library difference, (in ANL MCNP calculation, ENDF-VI based library is used.)

Deterministic code DRAGON was also used to calculate the spectra, using the same two-dimensional mini-lattice (11x11 pins) model and 172-group library. The DRAGON solution can be used to validate the MCNP results, because MCNP results have relative large standard deviation for detailed solution. Using the same MCNP model, a 172 energy group tally structure was implemented to match the same energy structure as the DRAGON library. The comparison of the 172-group spectra calculated by MCNP and DRAGON is shown in Fig.9 for R1-UO2 , and Fig.10 for R1-MOX (In Fig.9, Fig.10 and Fig.11, the total flux is normalized to 1.0).

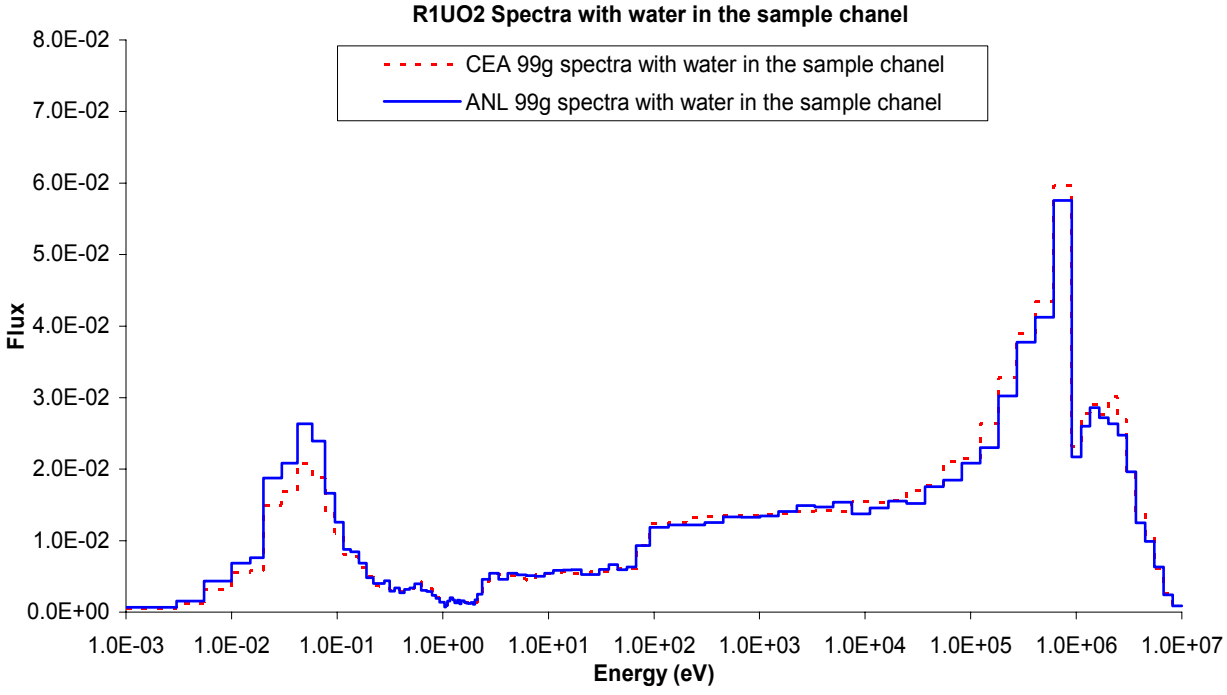

Figure 7. Comparison of 99-group spectra calculated by CEA and ANL for R1-UO2

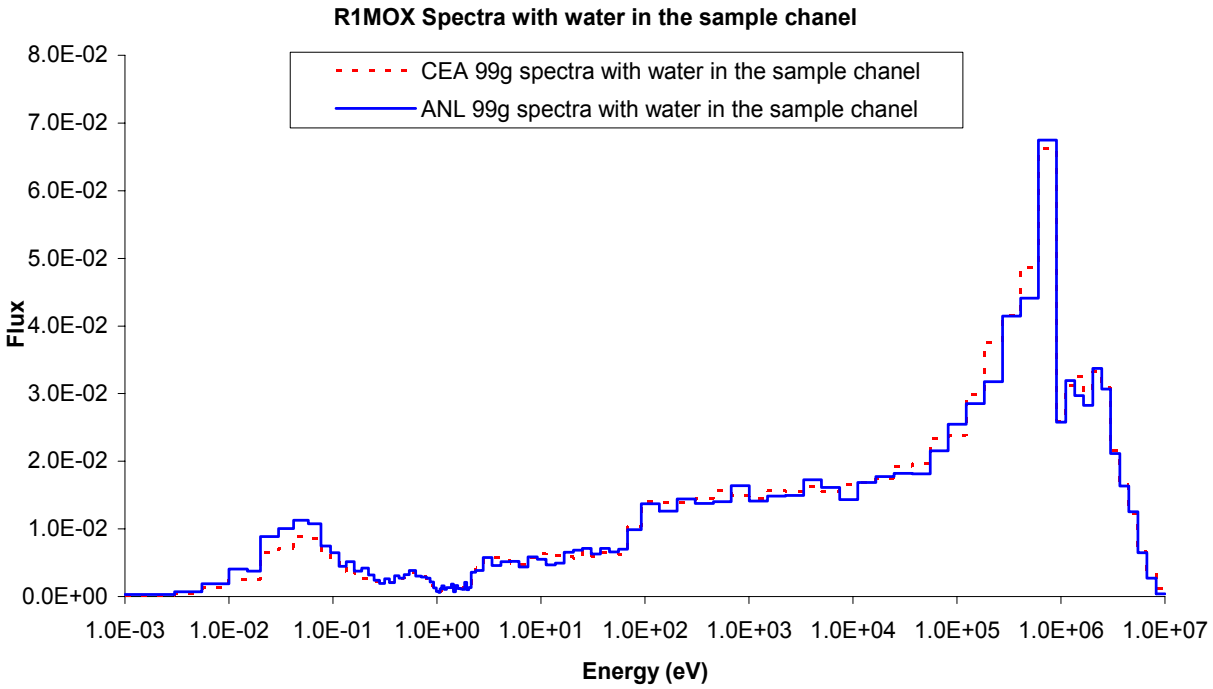

Figure 8. Comparison of 99-group spectra calculated by CEA and ANL for R1-MOX

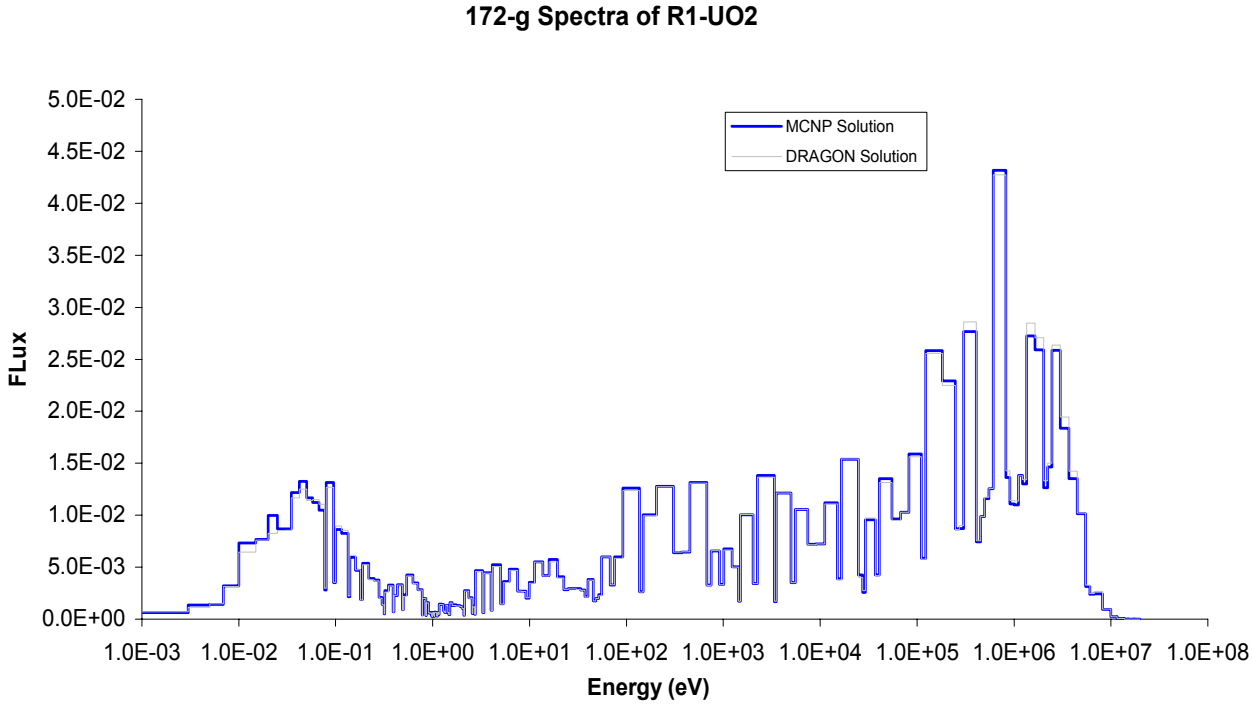

Figure 9. Comparison of 172-group spectra calculated by DRAGON and MCNP for R1-UO2

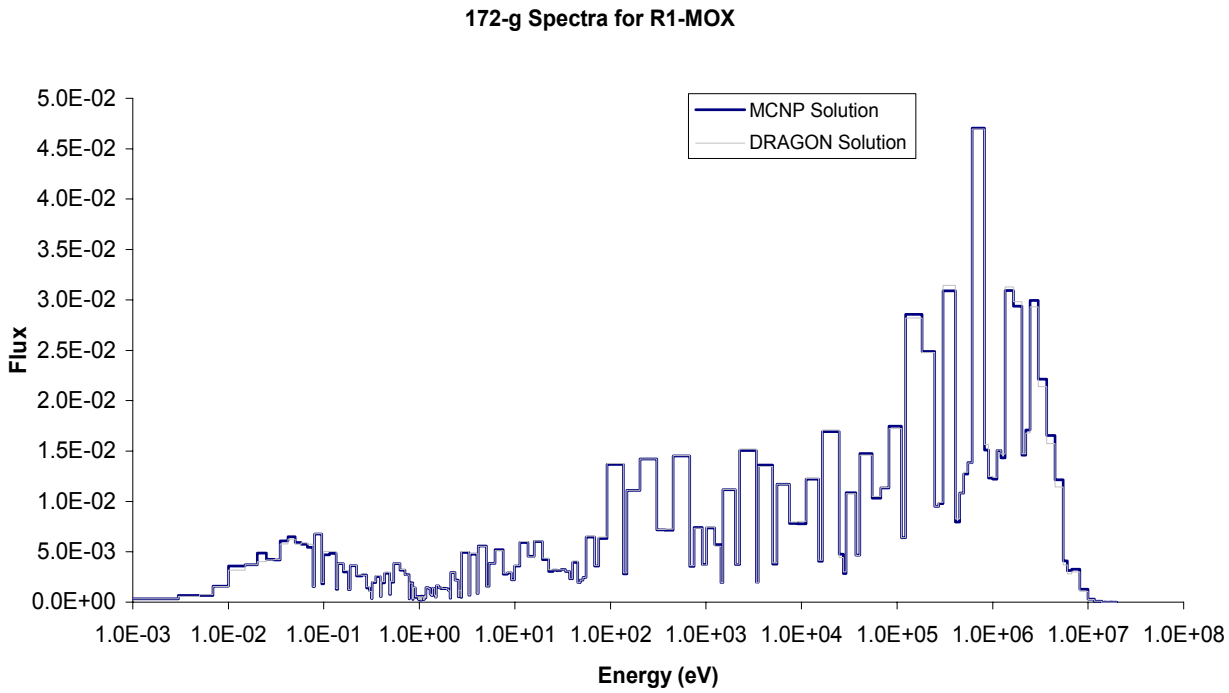

Figure 10. Comparison of 172-group spectra calculated by DRAGON and MCNP for R1-MOX

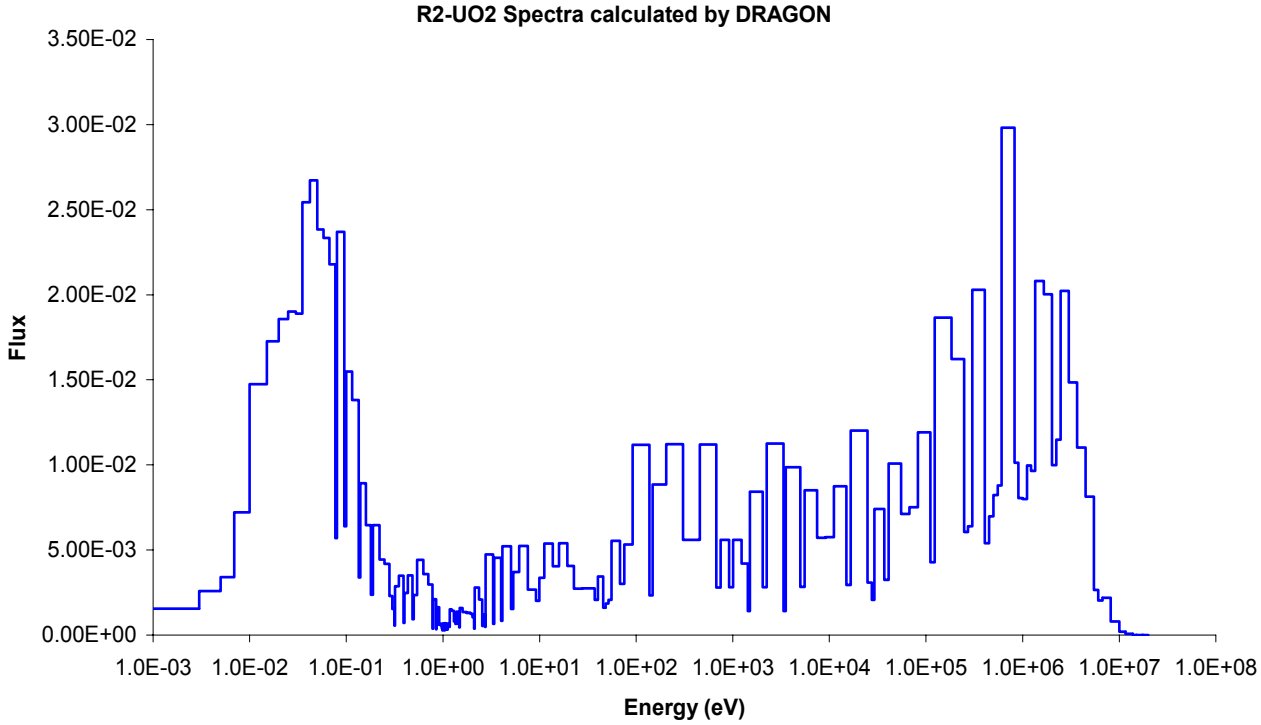

Figure 11. 172-group spectra calculated by DRAGON for R2-UO2

It can be seen that the spectra calculated by DRAGON and MCNP agree well for the R1-UO2 R1-MOX and the R2-UO2 configurations, which shows that MCNP can produce correct spectra with detailed energy structure, although in some tally bins the standard deviation is relatively large (especially for the fast region).

The 172-group spectra of the R2-UO2 configuration calculated by DRAGON is shown in Fig.11. Compared with Fig.9 and Fig.10, it is observed that the R2-UO2 spectra is much more thermalized, because eight fuel pins surrounding the sample channel are replaced by water, thus softening the spectrum near the sample region.

6.0 Comparison to Spectra from Gen-IV systems

It is interesting to compare OSMOSE spectra to that obtained from Gen-IV systems, to determine whether the results from the OSMOSE program can be used to validate cross sections of interest to the Gen-IV initiative. The prismatic Very High Temperature Reactor (VHTR) is one of the leading candidates for the Next Generation Nuclear Plant (NGNP) in the U.S. [8, 9] In this design, fuel rods (compacts) are contained in fuel holes in the hexagonal-prismatic fuel elements. Fuel elements also have holes for coolant and control rod material movements, and fuel element handling. The cylindrical fuel compacts contain coated fuel particles (CFPs) dispersed in a graphite matrix. The CFPs give an additional level of heterogeneity within the fuel element.

The 172-group spectrum of VHTR loaded with oxy-carbide ($UC_{0.5}O_{1.5}$) coated (TRISO) fuel particles (U235 enrichment 10.4%, packing fraction of 0.289, and fuel kernel radius of 385 μm) is shown in Fig.12. Compared with that for R1-UO2, R2-UO2 and R1-MOX, it can be seen that the shape of the spectrum is very different, for VHTR spectrum, the epithermal flux is much higher.

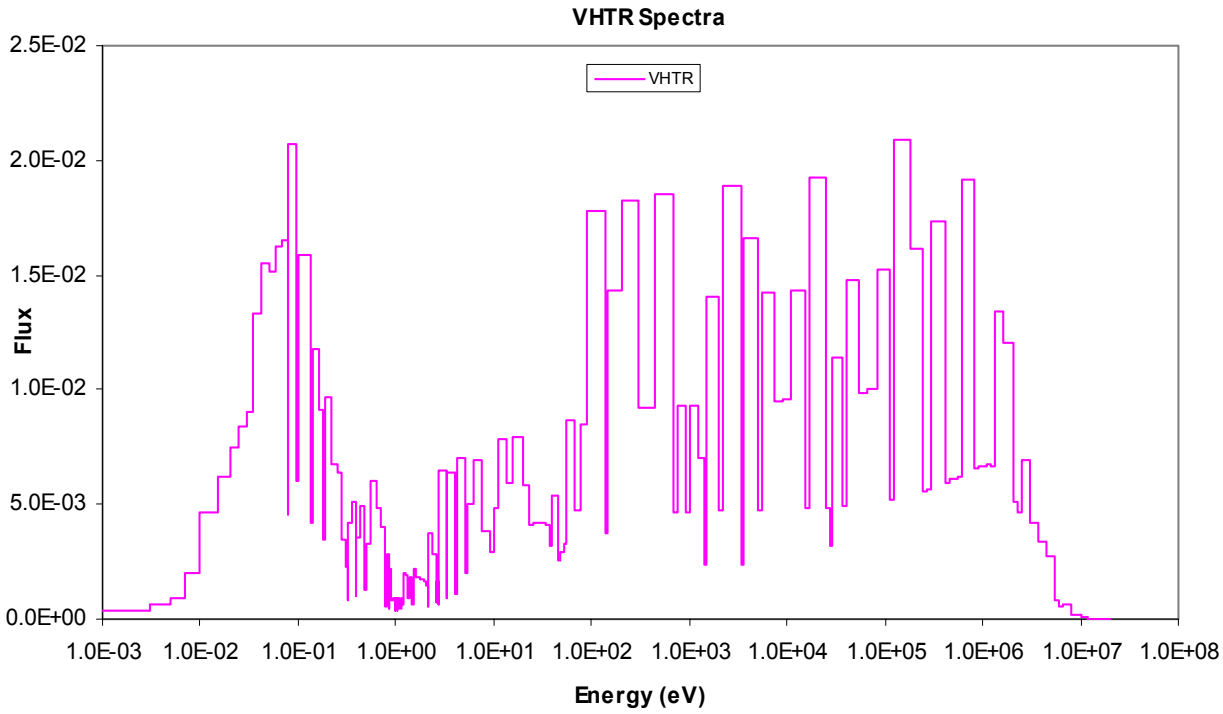

Figure 12. 172-group VHTR/Uranium Spectra

The spectra of MINERVE reactor loaded with MORGANE/S configuration has been calculated to compare with the spectra of VHTR reactor. For the MORGANE/S configuration, the hexagonal lattice is composed of 11.0% plutonium mixed oxide fuel pins with a moderating ratio 0.5, and the radius of fuel pellet is 0.475 cm. A Deep Burn Modular Helium Cooled Reactor (DBMHR) design of VHTR is selected, which is loaded with plutonium oxide fuel particles (packing fraction of 0.20, and fuel kernel radius of 360 μm).

The comparison of MORGANE/S and DBMHR spectra is shown in Fig.13. In both spectra the thermal flux is very low. Compared with the DBMHR spectrum, the fast flux in the MORGANE/S spectrum is higher but the lower range of the epithermal flux is lower. (Note that in Fig.12 and Fig.13, the total flux is normalized to 1.0). The comparison of the spectral composition is shown in Table 14, it can be seen that at the energy range (>110 keV), the MORGAN/S flux is apparently higher than that of VHTR/DBMHR, which means that MORGANE/S spectra is harder, this should be due to the small volume ratio between moderator and fuel in the MORGANE/S configuration.

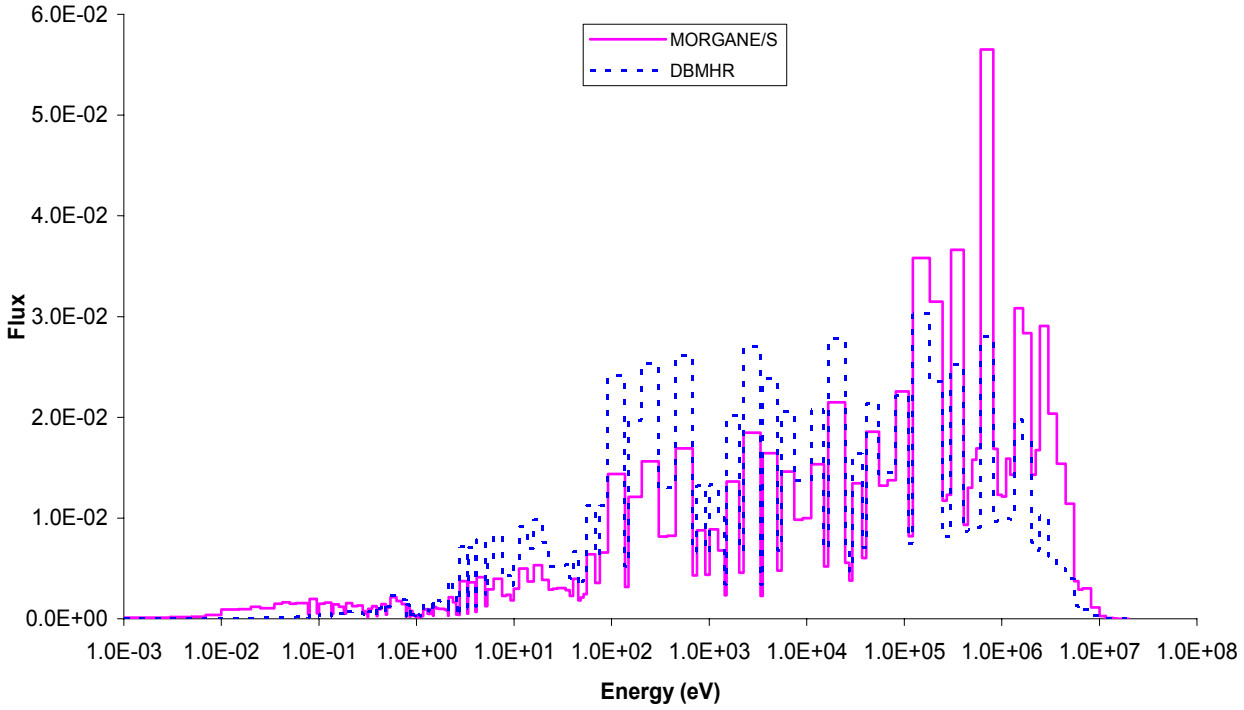

Figure 13. Comparison of 172-group MORGANE/S and DBMHR Spectra

Table 14. Comparison of the Spectral Composition

Energy Range	MINERVE Reactor				VHTR	
	R1-UO2	R2-UO2	R1-MOX	MORGANE/S	Uranium	DBMHR
< 1 eV	0.2045	0.3645	0.1232	0.0444	0.2851	0.0240
1-10 eV	0.0598	0.0620	0.0638	0.0467	0.0845	0.0856
10 eV – 1 keV	0.1408	0.1281	0.1561	0.1607	0.2021	0.2687
1 keV - 110keV	0.1823	0.1440	0.2022	0.2515	0.2260	0.3257
> 110 keV	0.4125	0.3014	0.4548	0.4967	0.2023	0.2960
Total	1.0	1.0	1.0	1.0	1.0	1.0

7.0 Cross Section Behavior & Reaction Rate

The reactivity worth of the OSMOSE Samples has been studied in Section 4. In this section, the cross section behavior and reaction rate of the OSMOSE samples are studied. Effort has been focused on understanding the behavior of cross sections ($\nu\Sigma_f - \Sigma_a$), which plays a significant factor for the reactivity, for the OSMOSE samples.

The 172-group microscopic cross sections ($\nu\sigma_f - \sigma_a$) of the separated actinides and the difference of macroscopic cross sections ($\nu\Sigma_f - \Sigma_a$) to that of the natural uranium sample for the OSMOSE samples are plotted in Fig. 14 to 20, respectively. The composition of the OSMOSE sample is based on natural UO_2 with separated actinides smeared in (i.e, U233 sample is with concentrated U233 smeared into natural UO2 material) The URE sample contains U236 from processed spent fuel and also contains U235 smeared into natural UO2 material).

Because the cross section ($\nu\sigma_f - \sigma_a$) of the actinides varies mostly in the thermal and epithermal region, and that the spectra of the OSMOSE R1-UO2 configuration is highly thermal, only the energy range (< 1 keV) is plotted, as shown in Fig.14, Fig.15, Fig.16 and Fig.17 for the microscopic cross-sections. The values of ($\nu\sigma_f - \sigma_a$) in tabular format are included in Appendix 3.

It can be seen that the ($\nu\sigma_f - \sigma_a$) of U238, which is the major composition of natural uranium sample, is almost zero everywhere, and it is used as the reference. It can also be seen that only the isotopes U233, U235, Pu239 and Pu241 have apparent positive values of ($\nu\sigma_f - \sigma_a$) in the thermal region. This should be apparently obvious as these are the only isotopes that are considered fissile, i.e. that they have a thermal neutron fission cross-section.

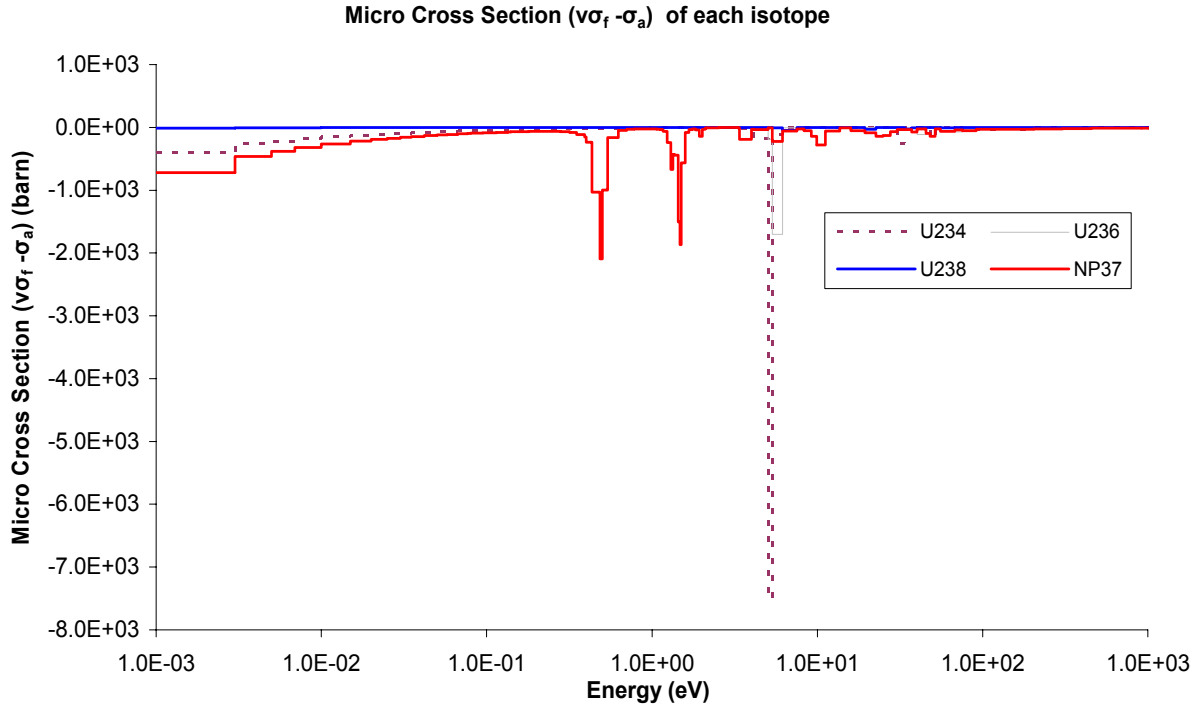

Figure 14. Plot of ($\nu\sigma_f - \sigma_a$) of separated Actinides in OSMOSE Samples

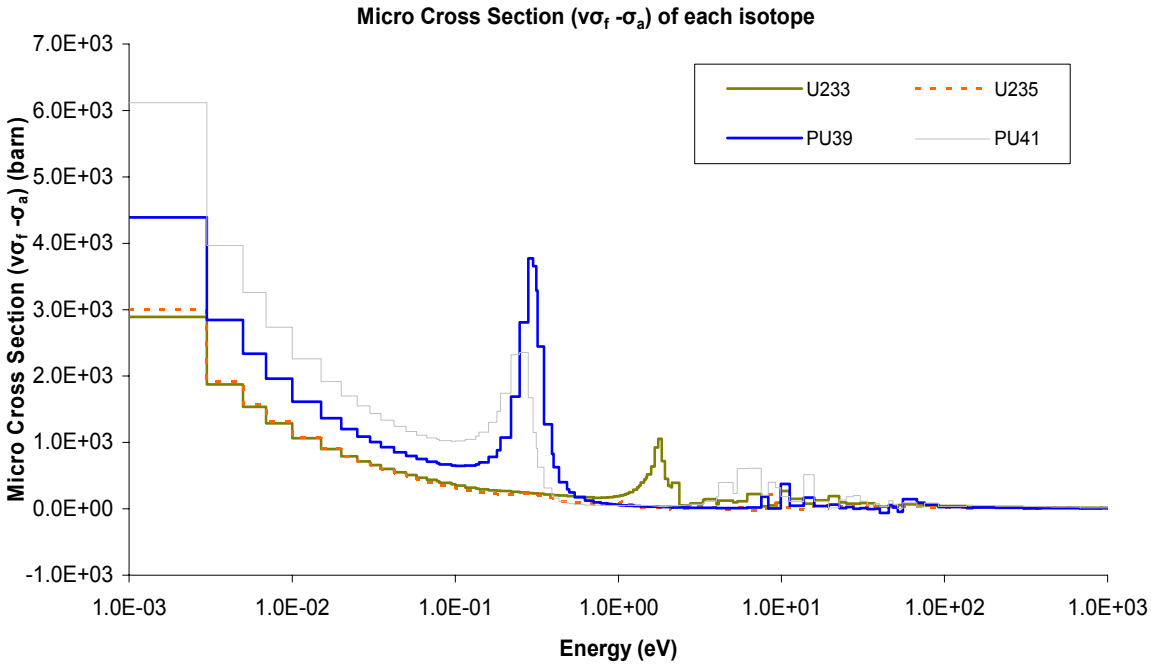

Figure 15. Plot of $(v\sigma_f - \sigma_a)$ of separated Actinides in OSMOSE Samples

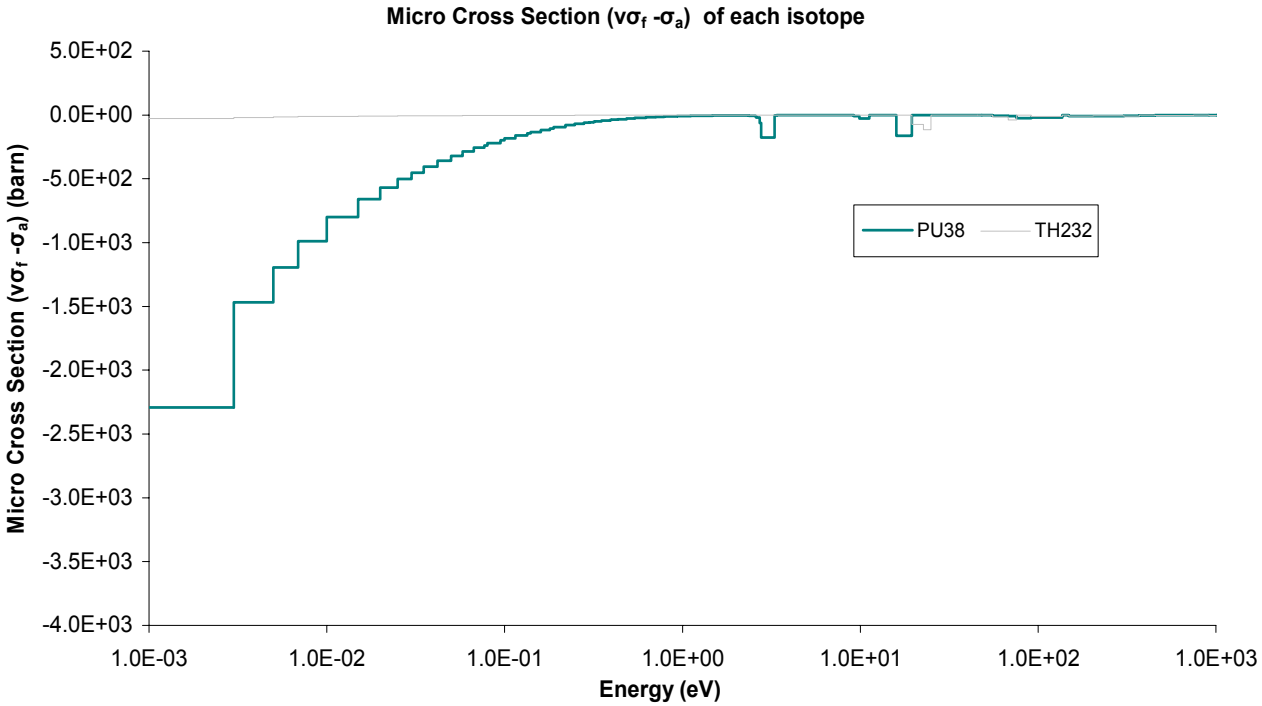

Figure 16. Plot of $(v\sigma_f - \sigma_a)$ of separated Actinides in OSMOSE Samples

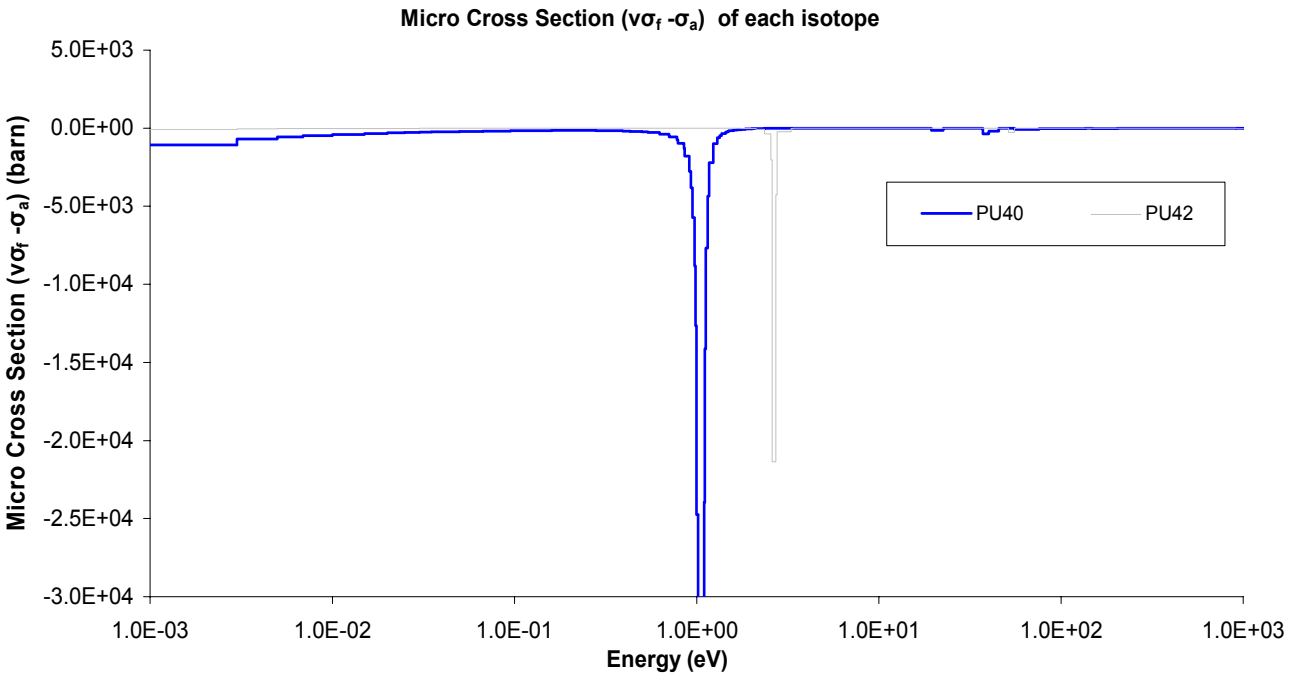

Figure 17. Plot of $(\nu\sigma_f - \sigma_a)$ of separated Actinides in OSMOSE Samples

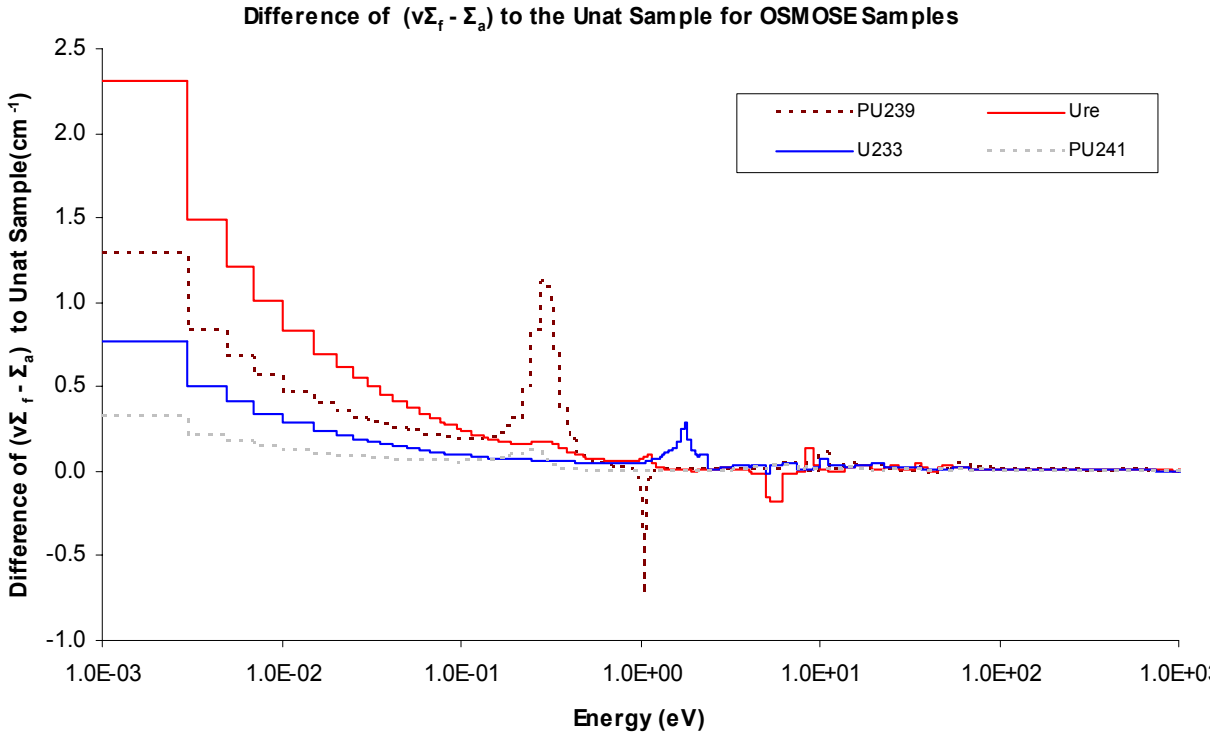

Figure 18. Difference of $(\nu\Sigma_f - \Sigma_a)$ to the Unat Sample for OSMOSE Samples

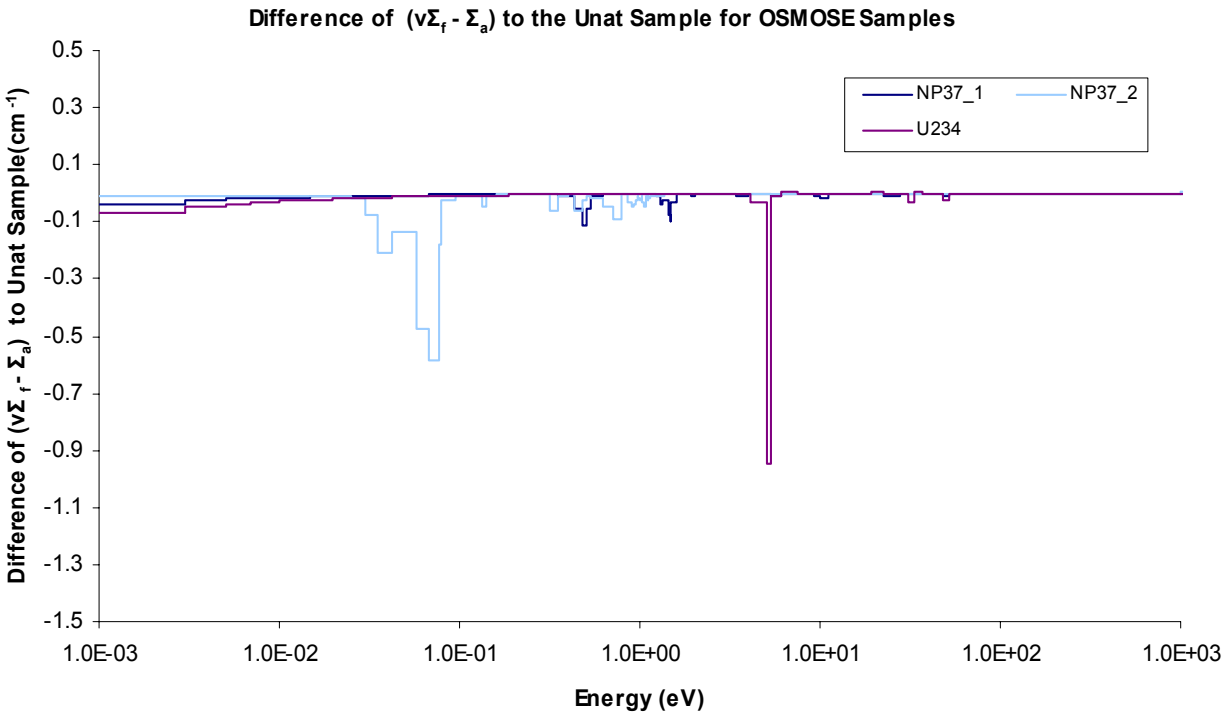

Figure 19. Difference of $(\nu\Sigma_f - \Sigma_a)$ to the Unat Sample for OSMOSE Samples

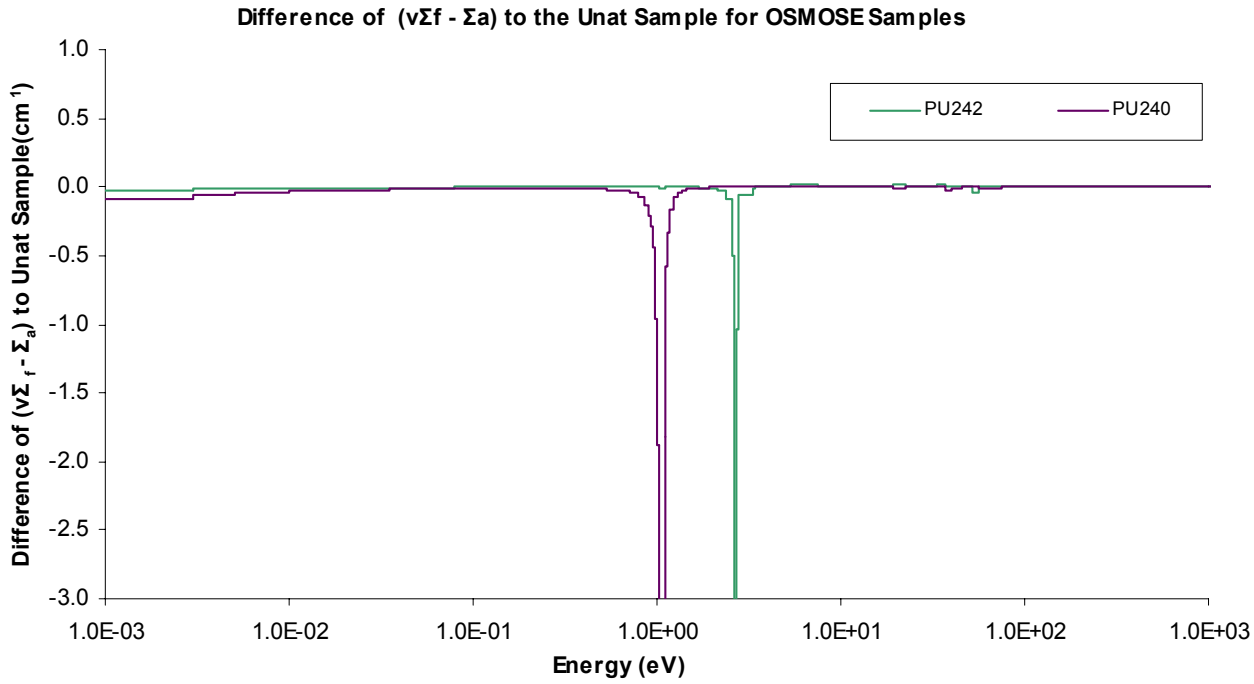

Figure 20. Difference of $(\nu\Sigma_f - \Sigma_a)$ to the Unat Sample for OSMOSE Samples

Fig.18, Fig.19 and Fig.20 show $\Delta(\nu\Sigma_f - \Sigma_a)$ which is the difference of macroscopic cross sections to that of natural uranium sample for each OSMOSE sample. The natural uranium sample is the reference and therefore $\Delta(\nu\Sigma_f - \Sigma_a)$ is zero everywhere for this sample. Note that the cross-section term $(\nu\Sigma_f - \Sigma_a)$ is not zero everywhere (because it does contain U235 and U238 and have a physical cross-section), but the cross-section difference is zero. Only for the samples U233, URE, Pu239 and Pu241, the value of $\Delta(\nu\Sigma_f - \Sigma_a)$ is apparently larger than that of natual uranium sample everywhere, which is consistent with Fig.15. This explains why these samples have a positive reactivity worth compared to the natual uranium sample.

Fig.18, Fig.19 and Fig.20 also help to explain the total reactivity worth of the OSMOSE samples shown in Fig.5. The samples U233, URE, Pu239 and Pu241 have positive reactivity worth because their $(\nu\Sigma_f - \Sigma_a)$ is larger than that of the natural uranium sample, the other OSMOSE samples have negative reactivity worth because of their smaller value of $(\nu\Sigma_f - \Sigma_a)$ compared to that of natural sample.

The reaction rate $(\nu\Sigma_f - \Sigma_a)\Phi$ of the sample pin for each OSMOSE sample has been calculated by DRAGON using the 11x11 mini lattice model. The comparison of reactivity worth and difference of reaction rate to the natural uranium sample is shown in Fig.21 and Table 15. Note that the $(\nu\Sigma_f - \Sigma_a)\Phi$ term shown in Fig.21 and Table 14 is the difference of $(\nu\Sigma_f - \Sigma_a)\Phi_{sample}$ to the value of $(\nu\Sigma_f - \Sigma_a)\Phi_{natU\text{-}sample}$. which is not strictly the same as $\Delta(\nu\Sigma_f - \Sigma_a)\Phi$ because the flux acting on the sample volume is not the same due to the difference of neutron source introduced by the sample.

From Fig.21, it can also be observed that the difference of $(\nu\Sigma_f - \Sigma_a)\Phi_{sample}$ in the sample pin rate to the natural uranium sample is not proportional to that of reactivity worth, especially for the 4 samples with positive reactivity worth.

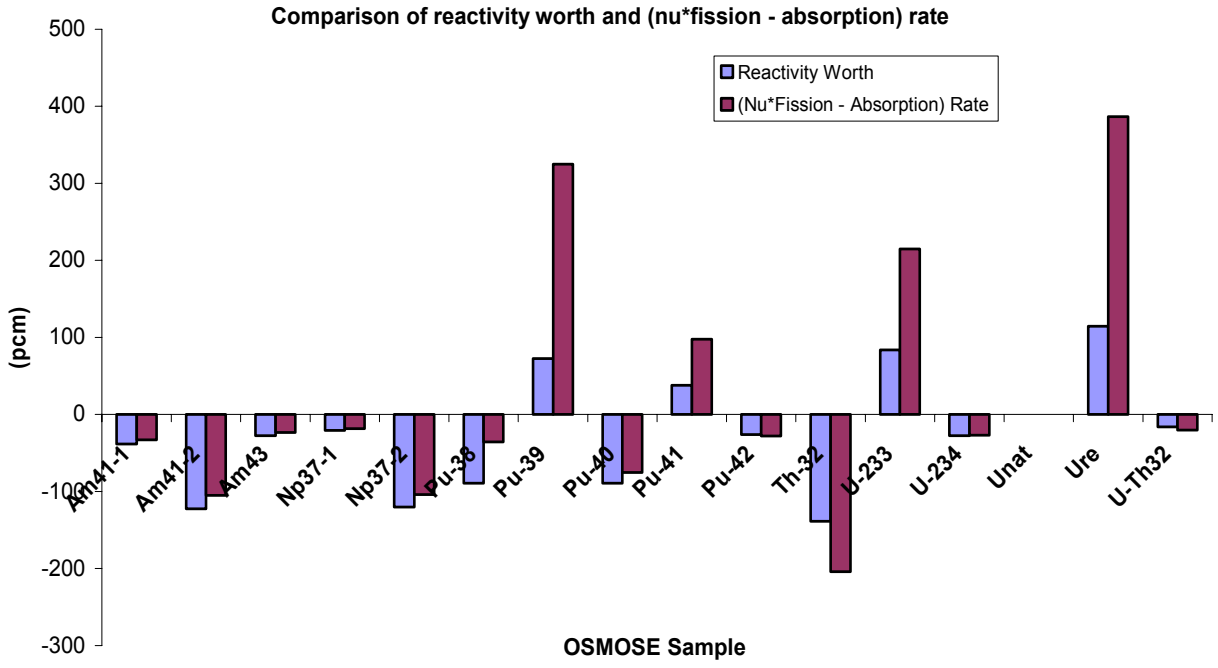

Figure 21. Comparison of reactivity worth and $(\nu\Sigma_f - \Sigma_a)\Phi_{sample}$

Table 15. Comparison of reactivity worth and $(\nu\Sigma_f - \Sigma_a)\Phi_{sample}$ for OSMOSE Samples in R1-UO2 configuration

Samples	k-eff	reactivity worth (pcm)	System (Nu*Fission –Absorption) rate	Sample (Nu*Fission –Absorption) rate
AM41_1	1.316891	-38.50	-38.00	-33.009
AM41_2	1.315435	-122.55	-122.00	-105.132
AM43	1.317082	-27.49	-27.00	-23.415
NP37_1	1.317201	-20.63	-21.00	-18.274
NP37_2	1.315478	-120.07	-121.00	-103.991
PU38	1.316010	-89.34	-89.00	-35.440
PU39	1.318823	72.74	73.00	324.753
PU40	1.316013	-89.16	-89.00	-75.010
PU41	1.318219	38.00	38.00	97.634
PU42	1.317106	-26.10	-31.00	-28.117
U233	1.319016	83.84	84.00	214.906
U234	1.317085	-27.31	-28.00	-26.803
Unat	1.317559	0.00	0.00	0.00
URE	1.319550	114.52	115.00	386.688
U-TH232	1.317279	-16.13	-16.00	-20.151
TH232	1.315153	-138.85	-139.00	-204.244

From the definition, the *k-inf* of the system can be expressed as

$$k_{\inf} = \frac{R\left(\nu\Sigma_f\right)_{system}}{R\left(\Sigma_a\right)_{system}} \qquad \text{Reactivity} = \frac{R\left(\nu\Sigma_f - \Sigma_a\right)_{system}}{R\left(\nu\Sigma_f\right)_{system}} \qquad (1)$$

In DRAGON calculation, the total $(\nu\Sigma_f-\Sigma_a)\Phi_{system}$ is normalized to a constant value of 1.0, so that the reactivity difference (Reactivity Worth) of each OSMOSE sample to the natural uranium sample can be expressed as:

$$\text{Reactivity Worth} = \Delta R\left(\nu\Sigma_f - \Sigma_a\right)_{system} \qquad (2)$$

Eq. (2) is consistent with the data shown in Table 15.

$$\begin{aligned} R\left(\nu\Sigma_f\right)_{system} &= R\left(\nu\Sigma_f\right)_{sample} + R\left(\nu\Sigma_f\right)_{other} \\ R\left(\nu\Sigma_f - \Sigma_a\right)_{system} &= R\left(\nu\Sigma_f - \Sigma_a\right)_{sample} + R\left(\nu\Sigma_f - \Sigma_a\right)_{other} \\ \Delta R\left(\nu\Sigma_f - \Sigma_a\right)_{system} &= \Delta R\left(\nu\Sigma_f - \Sigma_a\right)_{sample} + \Delta R\left(\nu\Sigma_f - \Sigma_a\right)_{other} \end{aligned} \qquad (3)$$

For different sample pins, there always exists a perturbation of the system flux, so that the term $\Delta R(\nu\Sigma_f-\Sigma_a)_{other}$ in Eq. (3) always changes, although the value for the rest of system besides sample pin does not change. For example, for the samples with positive reactivity worth, i.e. URE sample, the fission rate in the sample pin is larger than that of the natural uranium sample because the fission cross section increases, $\Delta R(\nu\Sigma_f)_{sample}>0$, due to the fact that $\nu\Sigma_f$ rate of the whole system is normalized to constant $R(\nu\Sigma_f)_{system}=1.0$. The flux perturbation makes $\Delta R\ (\nu\Sigma_f)_{other} <0$. Furthermore, when URE

sample is added, $R(\nu\Sigma_f - \Sigma_a)_{system}$ increases but $R(\nu\Sigma_f - \Sigma_a)_{other}$ decreases, leading to the following conclusion: $\Delta R(\nu\Sigma_f - \Sigma_a)_{sample} > \Delta R(\nu\Sigma_f - \Sigma_a)_{system}$.

The group-wise reaction rate $R(\nu\Sigma_f-\Sigma_a)$ of the OSMOSE sample is also shown in Fig.22 to Fig.24. It is observed that only 4 samples (U233, Ure, PU239, and PU241) have larger value of $R(\nu\Sigma_f-\Sigma_a)$ rate, compared with that of natural UO_2 (Unat) sample, which is consistent with the results shown in Fig.14 and Fig.18. It it also observed that the peak value of $R(\nu\Sigma_f-\Sigma_a)$ rate exists approximately at 0.05 eV, (the peak flux occurs approximately at 0.1 eV). Most of the difference of the $R(\nu\Sigma_f-\Sigma_a)$ rate among the OSMOSE samples exists in the thermal range (< 1eV).

This approach is being pursued as a means to understand the spectral effects of the different configurations on the reactivity worth of the OSMOSE samples. Understanding the energy response of the reactivity worth of the samples will allow an assessment to be performed to determine the portion of the spectra that contributes most significantly to the reactivity effect of the samples. Conversely, if differences between the calculated and experimentally measured values determine that there are errors in the cross-section evaluations, this approach will allow us to assess over which energy range the cross-section evaluations are most likely in error and suggest corrections. Put in another way, this approach will allow us to perform sensitivity studies of the results accounting for spectral weighting effects based on the configurations that are measured. Taking the results in combination with the results from the different configurations will allow a detailed assessment of the cross-sections over the entire energy range and a direct comparison and relevance for the energy regions and isotopes of importance to the Generation IV Initiative.

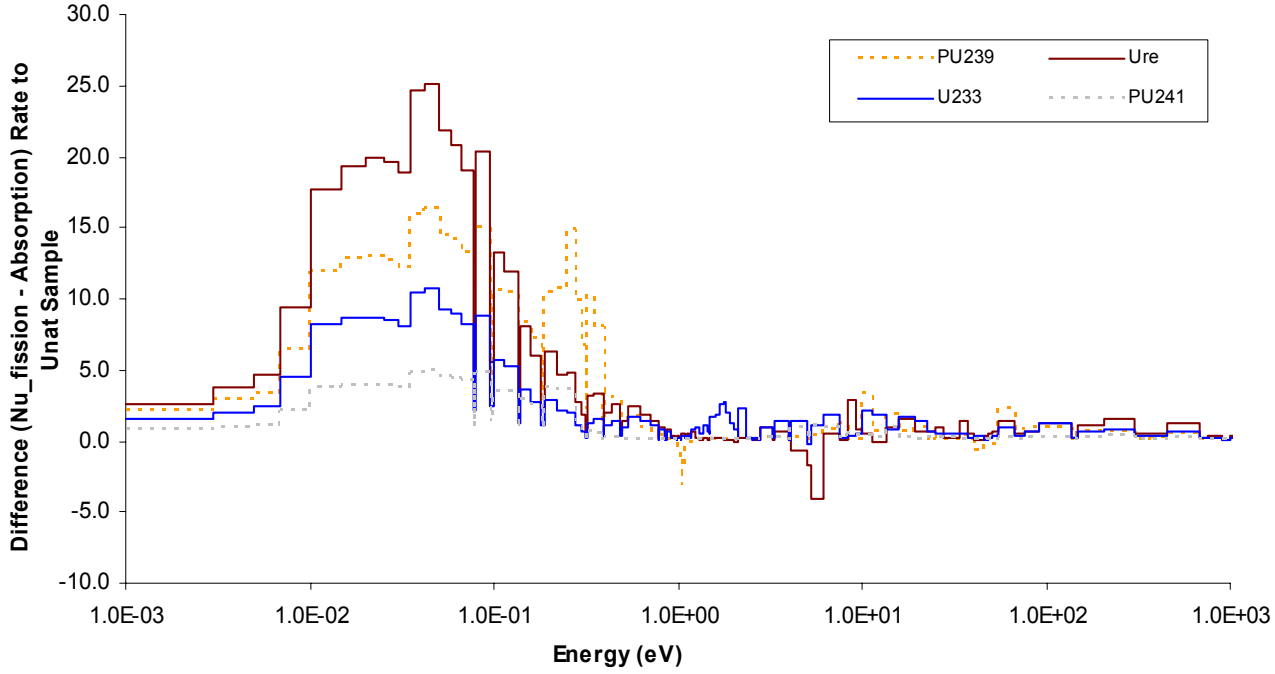

Figure 22. Difference of $(\nu\Sigma_f-\Sigma_a)\Phi_{sample}$ to Unat Samples for the OSMOSE Samples

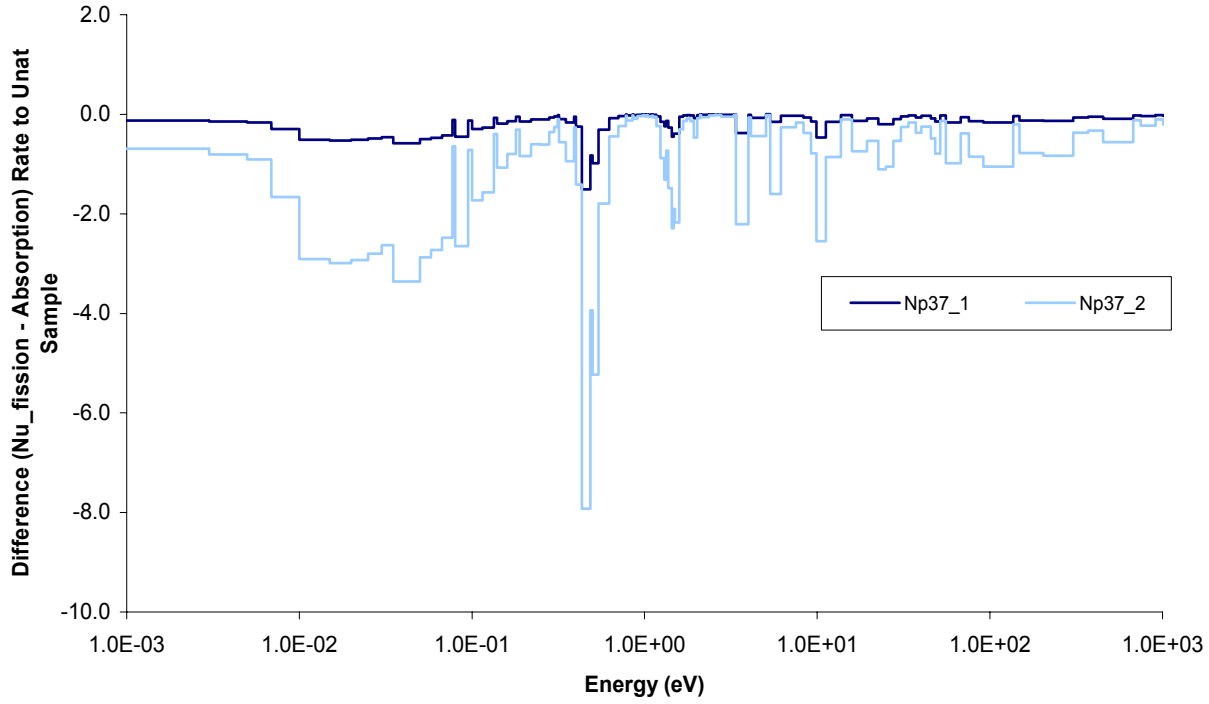

Figure 23. Difference of $(\nu\Sigma_f - \Sigma_a)\Phi_{sample}$ to Unat Samples for the OSMOSE Samples

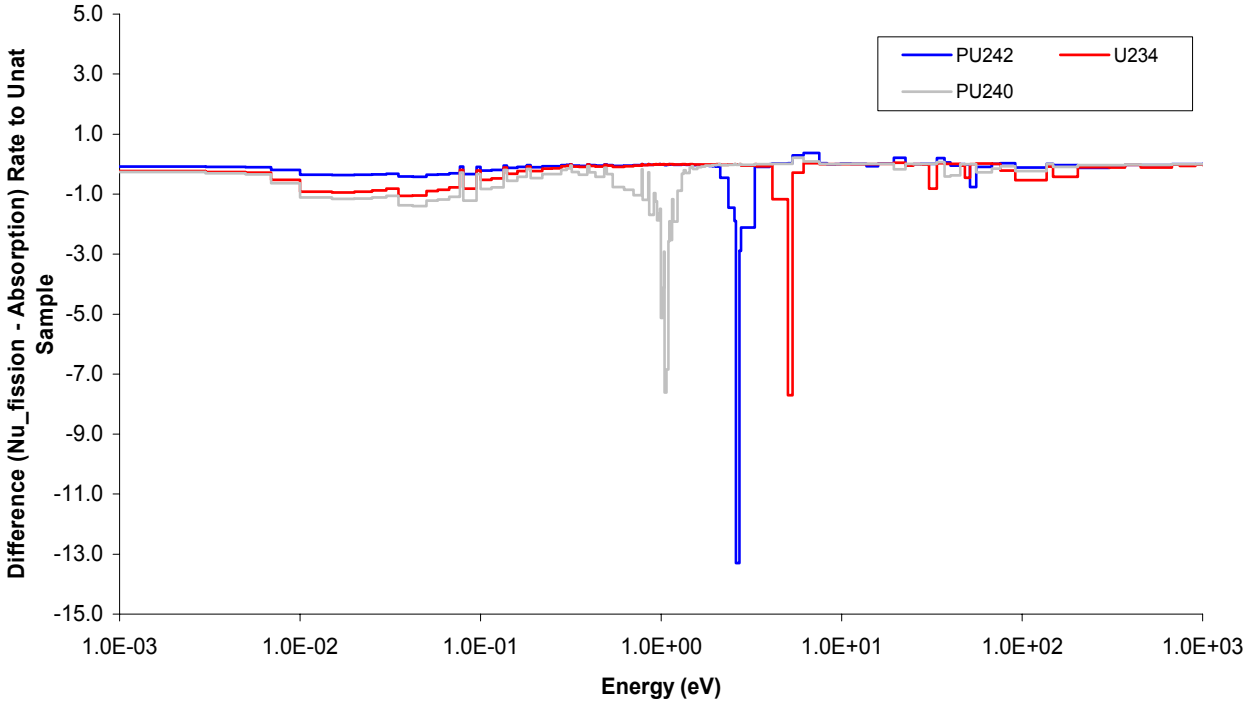

Figure 24. Difference of $(\nu\Sigma_f - \Sigma_a)\Phi_{sample}$ to Unat Samples for the OSMOSE Samples

8.0 Conclusions

Significant previous work has been performed using WIMS-ANL/REBUS for 3-D full core modeling of the MINERVE reactor configurations. In the latest effort, the two-dimensional lattice physics code DRAGON has been introduced for both reactivity worth and spectra calculations to reduce the error introduced in the group condensing process by WIMS-ANL and to enhance the range of utility for assessing the oscillation measurement results.

The comparisons between the calculated and experimental results show good agreement for the major actinides, i.e, U235 and U238. For the minor actinides, i.e. Np, there exists a relatively large discrepancy between the calculated and experimental results, possibly due to an error in ENDF/B-VI and JEFF-3.1 data sets. The source of this error is still being assessed based on the methodology and approach discussed in the previous section.

Spectra calculations are performed using both Monte Carlo code MCNP and Deterministic code DRAGON. Good agreement has been obtained between the ANL and CEA results for R1-UO2 and R1-MOX configurations. The spectral differences can explain the trends of reactivity worth among the R2-UO2, R1-UO2 and R1-MOX configurations - the R2-UO2 has the softest spectra thus the largest magnitude of reactivity worth, the R1-MOX configuration has the hardest spectra thus the smallest magnitude of reactivity worth, because the variation of cross sections among the OSMOSE samples exist mainly in the lower energy range (<10 eV).

Comparison to the Gen-IV spectra has also been performed. The DBMHR/VHTR has a similar spectral shape with that of the MORGANE/S configuration in the epithermal region. However, in the very fast region (>110 keV), the MORGANE/S flux is still much larger, which should be due to the small volume ratio between moderator and fuel.

The cross section behavior as well as reaction rates of the OSMOSE samples have also been studied, and it can explain the trend in reactivity worth for the samples. Some samples have larger values of $(\nu\Sigma_f - \Sigma_a)\Phi_{sample,}$ thus positive reactivity worth. It has also been observed that for some samples, the $(\nu\Sigma_f - \Sigma_a)\Phi_{sample}$ difference to the natual uranium sample is much larger than the reactivity worth. This might be due to the flux perturbation for the whole system. This approach is being pursued as a means to understand the spectral effects of the different configurations on the reactivity worth of the OSMOSE samples. Understanding the energy response of the reactivity worth of the samples will allow an assessment to be performed to determine the portion of the spectra that contributes most significantly to the reactivity effect of the samples. Conversely, if differences between the calculated and experimentally measured values determine that there are errors in the cross-section evaluations, this approach will allow us to assess over which energy range the cross-section evaluations are most likely in error and suggest corrections. Put another way, this approach will allow us to perform sensitivity studies of the results accounting for spectral weighting effects based on the configurations that are measured. Taking the results in combination with the results from the different configurations will allow a detailed assessment of the cross-sections over the entire energy range and a direct comparison and relevance for the energy regions and isotopes of importance to the Generation IV Program.

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Appendix 1 Configuration of R1-UO2, R2-UO2 and R1-MOX

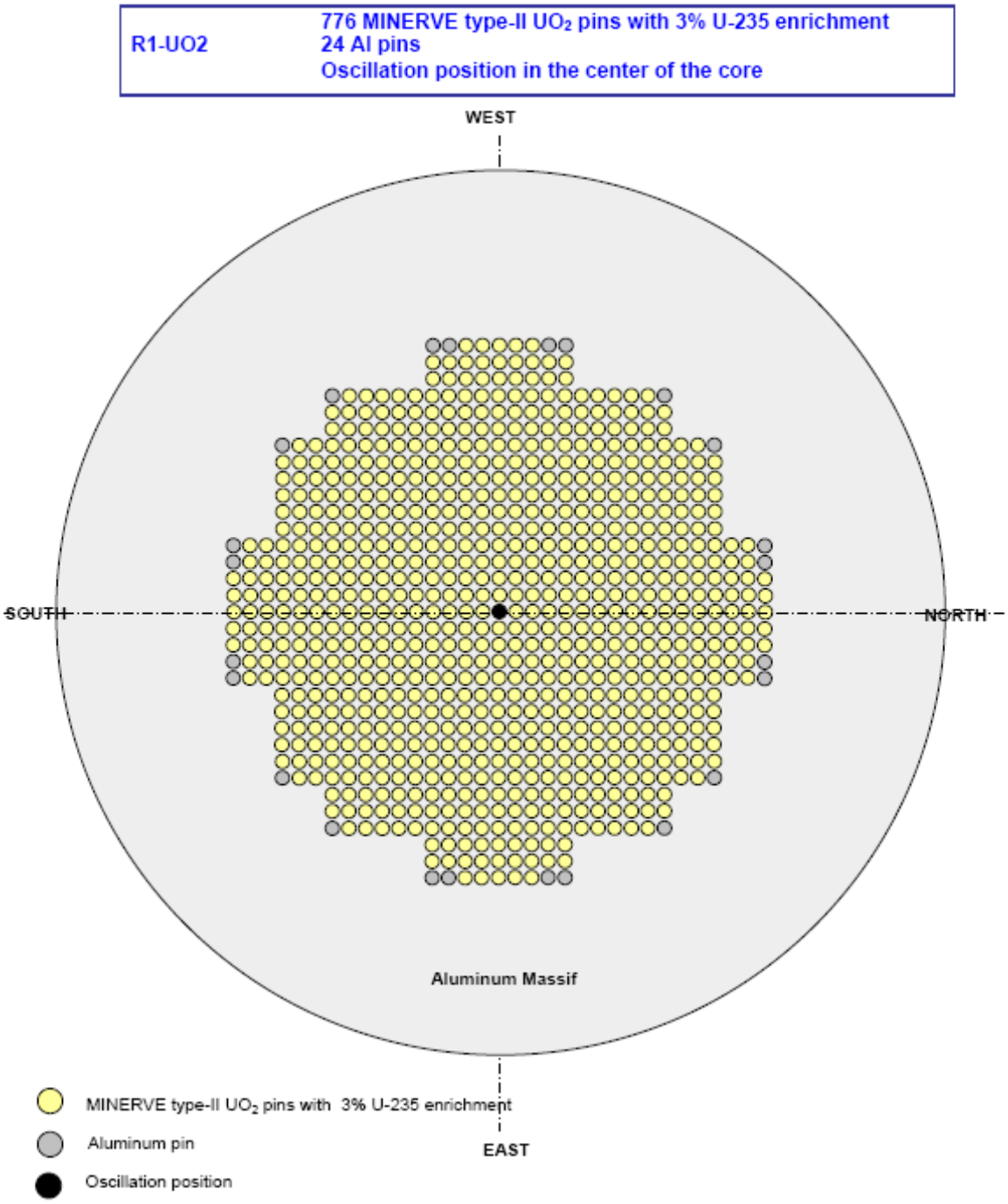

Figure 25. Experimental zone loading for the R1-UO2 configuration

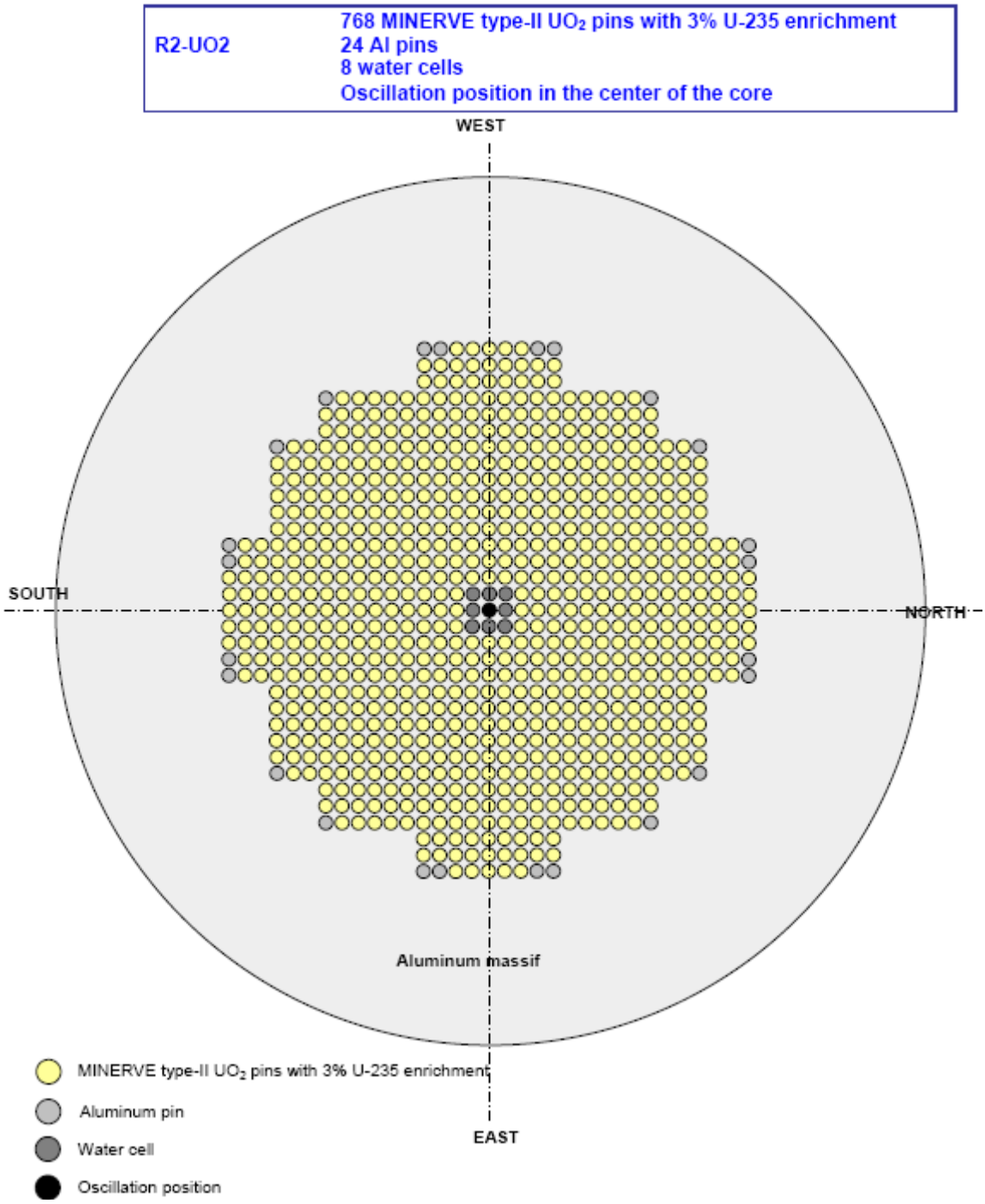

Figure 26. Experimental zone loading for the R2-UO2 configuration

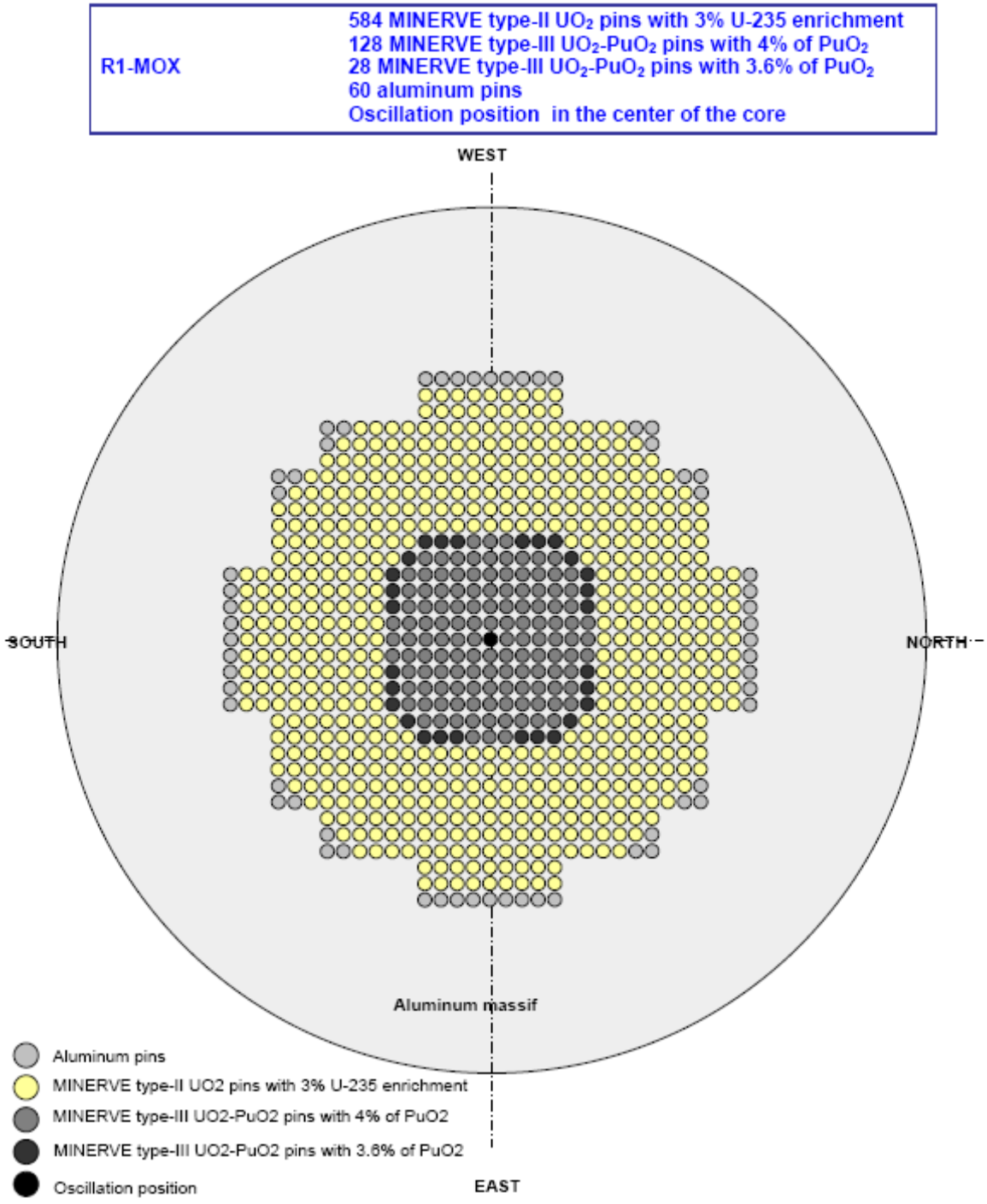

Figure 27. Experimental zone loading for the R1-MOX configuration

Appendix 2 Spectra of the MINERVE reactor loaded with different configuration

Comparison of the 99- group spectra calculated by ANL and CEA using MCNP

Group	Upper Energy, eV	R1-UO2		R1_MOX	
		CEA	ANL	CEA	ANL
1	1.0000E+07	1.0700E-03	8.6710E-04	1.1660E-03	4.3400E-04
2	8.1900E+06	2.6000E-03	2.4210E-03	3.5690E-03	2.7100E-03
3	6.7000E+06	6.0330E-03	6.3060E-03	6.6540E-03	6.5000E-03
4	5.4900E+06	1.0510E-02	9.8950E-03	1.2350E-02	1.2500E-02
5	4.4900E+06	1.3930E-02	1.2490E-02	1.6500E-02	1.6300E-02
6	3.6800E+06	1.9480E-02	1.9610E-02	2.1610E-02	2.1200E-02
7	3.0100E+06	2.7030E-02	2.4740E-02	3.0930E-02	3.0700E-02
8	2.4700E+06	3.0080E-02	2.6320E-02	3.3330E-02	3.3700E-02
9	2.0200E+06	2.7670E-02	2.7210E-02	3.0330E-02	2.8300E-02
10	1.6500E+06	2.9010E-02	2.8580E-02	3.2580E-02	2.9700E-02
11	1.3500E+06	2.7840E-02	2.6000E-02	3.1200E-02	3.1900E-02
12	1.1100E+06	2.3140E-02	2.1720E-02	2.5930E-02	2.5800E-02
13	9.0700E+05	5.9640E-02	5.7590E-02	6.6180E-02	6.7500E-02
14	6.0800E+05	4.3480E-02	4.1230E-02	4.8710E-02	4.4100E-02
15	4.0800E+05	3.8910E-02	3.7760E-02	4.1520E-02	4.1500E-02
16	2.7300E+05	3.2730E-02	3.0210E-02	3.7520E-02	3.1800E-02
17	1.8300E+05	2.6310E-02	2.2990E-02	2.9870E-02	2.8500E-02
18	1.2300E+05	2.1510E-02	2.0820E-02	2.3810E-02	2.5500E-02
19	8.2300E+04	2.1110E-02	1.8480E-02	2.3350E-02	2.1600E-02
20	5.5200E+04	1.7630E-02	1.7540E-02	1.9690E-02	1.8200E-02
21	3.7000E+04	1.7060E-02	1.5210E-02	1.9170E-02	1.8200E-02
22	2.4800E+04	1.5660E-02	1.5530E-02	1.7480E-02	1.7800E-02
23	1.6600E+04	1.5400E-02	1.4540E-02	1.6870E-02	1.6900E-02
24	1.1100E+04	1.5410E-02	1.3730E-02	1.6580E-02	1.4300E-02
25	7.4700E+03	1.4070E-02	1.5370E-02	1.5480E-02	1.6100E-02
26	5.0000E+03	1.4240E-02	1.4720E-02	1.6230E-02	1.7300E-02
27	3.3500E+03	1.4130E-02	1.4900E-02	1.5470E-02	1.4900E-02
28	2.2500E+03	1.3810E-02	1.4080E-02	1.5610E-02	1.4800E-02
29	1.5100E+03	1.3710E-02	1.3450E-02	1.4460E-02	1.4100E-02
30	1.0100E+03	1.3460E-02	1.3260E-02	1.4930E-02	1.6400E-02
31	6.7700E+02	1.3550E-02	1.3320E-02	1.5740E-02	1.4000E-02
32	4.5400E+02	1.3410E-02	1.2520E-02	1.4500E-02	1.3700E-02
33	3.0400E+02	1.3250E-02	1.2200E-02	1.3980E-02	1.4400E-02
34	2.0400E+02	1.2600E-02	1.2180E-02	1.3950E-02	1.2700E-02
35	1.3700E+02	1.2410E-02	1.1880E-02	1.4040E-02	1.3700E-02
36	9.1700E+01	9.2600E-03	9.3170E-03	1.0310E-02	9.9000E-03
37	6.7900E+01	6.0220E-03	6.3340E-03	6.2980E-03	7.0300E-03
38	5.5600E+01	6.0170E-03	5.9150E-03	6.4160E-03	6.5800E-03
39	4.5500E+01	5.9430E-03	6.6310E-03	6.5300E-03	7.1300E-03
40	3.7300E+01	5.6290E-03	5.9690E-03	5.9390E-03	6.2900E-03
41	3.0500E+01	5.7020E-03	5.2370E-03	6.7820E-03	7.1200E-03
42	2.5000E+01	5.4510E-03	5.2580E-03	5.6990E-03	6.8400E-03
43	2.0500E+01	5.4020E-03	5.9440E-03	5.8550E-03	6.5500E-03
44	1.6700E+01	5.7140E-03	5.8870E-03	6.1330E-03	4.9600E-03
45	1.3700E+01	5.6070E-03	5.8130E-03	6.0310E-03	4.6700E-03
46	1.1200E+01	5.4390E-03	5.4530E-03	6.4100E-03	5.5300E-03
47	9.1900E+00	5.2460E-03	4.9970E-03	5.7590E-03	5.8900E-03
48	7.5200E+00	4.4160E-03	5.1300E-03	4.7300E-03	4.4000E-03
49	6.1600E+00	4.7100E-03	5.2150E-03	4.9450E-03	5.1900E-03
50	5.0400E+00	5.1610E-03	5.4360E-03	5.3150E-03	5.1600E-03

Group	Upper Energy, eV	R1-UO2		R1_MOX	
		CEA	ANL	CEA	ANL
51	4.1300E+00	5.2670E-03	4.5650E-03	5.7090E-03	4.6000E-03
52	3.3800E+00	5.3420E-03	5.4560E-03	5.5310E-03	5.7700E-03
53	2.7700E+00	4.3480E-03	4.5610E-03	4.3050E-03	3.8800E-03
54	2.3600E+00	2.7140E-03	2.4970E-03	3.0220E-03	3.6300E-03
55	2.1300E+00	1.3630E-03	1.7200E-03	1.5250E-03	1.3600E-03
56	2.0200E+00	1.1060E-03	1.1090E-03	1.2650E-03	1.0200E-03
57	1.9300E+00	1.3290E-03	1.3310E-03	1.3540E-03	2.1100E-03
58	1.8400E+00	1.2960E-03	1.2260E-03	1.3000E-03	1.0700E-03
59	1.7600E+00	1.2960E-03	1.2360E-03	1.2630E-03	1.1100E-03
60	1.6700E+00	1.3850E-03	1.4050E-03	1.4740E-03	1.2100E-03
61	1.5900E+00	1.6410E-03	1.6070E-03	1.6090E-03	1.6700E-03
62	1.5000E+00	1.1010E-03	1.1380E-03	1.0540E-03	7.4100E-04
63	1.4400E+00	1.3270E-03	1.6920E-03	1.2710E-03	1.8800E-03
64	1.3700E+00	1.5280E-03	1.2940E-03	1.4150E-03	1.3600E-03
65	1.3000E+00	1.5470E-03	1.7250E-03	1.1930E-03	1.3600E-03
66	1.2400E+00	1.4400E-03	2.0300E-03	1.3750E-03	1.1100E-03
67	1.1700E+00	1.4070E-03	1.5400E-03	1.2600E-03	1.5900E-03
68	1.1100E+00	9.8020E-04	9.2180E-04	7.5640E-04	1.1500E-03
69	1.0700E+00	9.6340E-04	7.1220E-04	7.3070E-04	6.3800E-04
70	1.0400E+00	1.3570E-03	1.3960E-03	9.1640E-04	7.7600E-04
71	9.8600E-01	1.7710E-03	1.4200E-03	1.3360E-03	1.2800E-03
72	9.3000E-01	2.0840E-03	1.9210E-03	1.6680E-03	2.1600E-03
73	8.6000E-01	2.4140E-03	2.3850E-03	2.0660E-03	2.7400E-03
74	7.9000E-01	3.3550E-03	2.9070E-03	2.9350E-03	2.9100E-03
75	7.0500E-01	3.3420E-03	3.0150E-03	3.0120E-03	3.0300E-03
76	6.2500E-01	4.2450E-03	3.9510E-03	3.6180E-03	3.8400E-03
77	5.4000E-01	3.2620E-03	3.3900E-03	2.9590E-03	3.2600E-03
78	4.8500E-01	3.2670E-03	3.1920E-03	2.6630E-03	2.7200E-03
79	4.3300E-01	2.9650E-03	2.7230E-03	2.2170E-03	3.0700E-03
80	3.9100E-01	3.2560E-03	3.3640E-03	2.0610E-03	2.0900E-03
81	3.5000E-01	3.0550E-03	2.9450E-03	1.9570E-03	2.6500E-03
82	3.1500E-01	3.4140E-03	4.3950E-03	2.2090E-03	1.9700E-03
83	2.8000E-01	3.6370E-03	3.9960E-03	2.1690E-03	2.4100E-03
84	2.4800E-01	3.7440E-03	3.9880E-03	2.3800E-03	3.1900E-03
85	2.2000E-01	5.0010E-03	4.8160E-03	2.7300E-03	4.2200E-03
86	1.8900E-01	6.2770E-03	6.8590E-03	3.3660E-03	3.7900E-03
87	1.6000E-01	7.7410E-03	8.4580E-03	4.3970E-03	5.1500E-03
88	1.3400E-01	8.0700E-03	8.7960E-03	3.6890E-03	4.5000E-03
89	1.1500E-01	1.1050E-02	1.2600E-02	5.1880E-03	6.4800E-03
90	9.5000E-02	1.3980E-02	1.6650E-02	6.3400E-03	7.4600E-03
91	7.7000E-02	1.8800E-02	2.3910E-02	8.6350E-03	1.0800E-02
92	5.8000E-02	2.0830E-02	2.6310E-02	8.8960E-03	1.1300E-02
93	4.2000E-02	1.6810E-02	2.0830E-02	7.1910E-03	1.0100E-02
94	3.0000E-02	1.4930E-02	1.8740E-02	6.4760E-03	8.8500E-03
95	2.0000E-02	5.8340E-03	7.6320E-03	2.5490E-03	3.7800E-03
96	1.5000E-02	5.5710E-03	6.8570E-03	2.5090E-03	4.0800E-03
97	1.0000E-02	3.1890E-03	4.3620E-03	1.3040E-03	1.9200E-03
98	5.5000E-03	1.2770E-03	1.5200E-03	4.9130E-04	7.1700E-04
99	3.0000E-03	5.1520E-04	6.9080E-04	1.9740E-04	3.2500E-04

Comparison of the 172- group spectra calculated by MCNP and DRAGON

Group	Upper Energy, eV	R1-UO2		R1-MOX	
		MCNP	DRAGON	MCNP	DRAGON
1	1.9640E+07	1.1680E-06	1.3440E-06	0.0000E+00	1.5590E-06
2	1.7332E+07	5.5360E-06	7.2690E-06	1.0180E-05	8.3440E-06
3	1.4918E+07	7.9370E-06	1.0930E-05	1.3360E-05	1.2470E-05
4	1.3840E+07	6.9970E-05	8.3620E-05	8.8080E-05	9.4630E-05
5	1.1618E+07	2.4060E-04	2.4540E-04	3.0480E-04	2.7730E-04
6	1.0000E+07	9.3810E-04	9.6810E-04	1.2870E-03	1.0930E-03
7	8.1873E+06	2.4290E-03	2.6690E-03	3.2930E-03	3.0090E-03
8	6.7032E+06	2.3910E-03	2.4730E-03	3.1340E-03	2.7950E-03
9	6.0653E+06	3.1470E-03	3.2850E-03	4.0900E-03	3.6820E-03
10	5.4881E+06	1.0130E-02	1.0190E-02	1.2140E-02	1.1430E-02
11	4.4933E+06	1.3520E-02	1.4230E-02	1.6560E-02	1.5750E-02
12	3.6788E+06	1.8360E-02	1.9430E-02	2.2140E-02	2.1410E-02
13	3.0119E+06	2.5860E-02	2.6370E-02	2.9960E-02	2.9330E-02
14	2.4660E+06	1.4630E-02	1.5000E-02	1.7110E-02	1.6780E-02
15	2.2313E+06	1.2650E-02	1.3320E-02	1.4580E-02	1.4730E-02
16	2.0190E+06	2.5880E-02	2.7080E-02	2.9390E-02	2.9810E-02
17	1.6530E+06	2.7250E-02	2.8450E-02	3.0920E-02	3.1290E-02
18	1.3534E+06	1.3020E-02	1.3410E-02	1.4320E-02	1.4680E-02
19	1.2246E+06	1.3830E-02	1.3780E-02	1.5060E-02	1.5110E-02
20	1.1080E+06	1.0970E-02	1.1340E-02	1.2210E-02	1.2380E-02
21	1.0026E+06	1.1100E-02	1.1430E-02	1.2310E-02	1.2480E-02
22	9.0718E+05	1.3630E-02	1.4270E-02	1.5100E-02	1.5630E-02
23	8.2085E+05	4.3180E-02	4.2740E-02	4.7050E-02	4.6960E-02
24	6.0810E+05	1.2530E-02	1.2570E-02	1.3840E-02	1.3830E-02
25	5.5023E+05	1.1610E-02	1.1720E-02	1.2720E-02	1.2890E-02
26	4.9787E+05	9.8640E-03	9.8670E-03	1.0830E-02	1.0830E-02
27	4.5049E+05	7.4360E-03	7.5310E-03	7.9590E-03	8.2510E-03
28	4.0762E+05	2.7660E-02	2.8610E-02	3.0900E-02	3.1440E-02
29	3.0197E+05	8.7300E-03	9.0110E-03	9.7690E-03	9.9200E-03
30	2.7324E+05	8.6810E-03	8.6200E-03	9.5250E-03	9.4990E-03
31	2.4724E+05	2.2920E-02	2.2490E-02	2.4890E-02	2.4790E-02
32	1.8316E+05	2.5820E-02	2.5550E-02	2.8580E-02	2.8190E-02
33	1.2277E+05	5.8480E-03	5.7850E-03	6.3970E-03	6.3870E-03
34	1.1109E+05	1.5880E-02	1.5610E-02	1.7470E-02	1.7230E-02
35	8.2298E+04	1.0290E-02	1.0280E-02	1.1340E-02	1.1370E-02
36	6.7380E+04	9.6190E-03	9.4840E-03	1.0330E-02	1.0490E-02
37	5.5166E+04	1.3530E-02	1.3160E-02	1.4760E-02	1.4570E-02
38	4.0868E+04	4.2500E-03	4.1880E-03	4.6570E-03	4.6250E-03
39	3.6979E+04	9.5620E-03	9.7320E-03	1.0870E-02	1.0770E-02
40	2.9283E+04	2.5550E-03	2.7360E-03	2.8440E-03	3.0300E-03
41	2.7394E+04	4.2730E-03	4.0130E-03	4.7640E-03	4.4440E-03
42	2.4788E+04	1.5370E-02	1.5430E-02	1.6910E-02	1.7090E-02
43	1.6616E+04	3.8780E-03	3.7710E-03	4.0530E-03	4.1810E-03
44	1.5034E+04	1.1190E-02	1.1090E-02	1.2210E-02	1.2300E-02
45	1.1138E+04	7.2410E-03	7.2310E-03	7.8030E-03	8.0270E-03
46	9.1188E+03	7.1910E-03	7.1570E-03	7.8290E-03	7.9470E-03
47	7.4659E+03	1.0550E-02	1.0540E-02	1.1700E-02	1.1710E-02
48	5.5308E+03	3.5320E-03	3.5160E-03	3.8020E-03	3.9080E-03
49	5.0045E+03	1.2130E-02	1.2130E-02	1.3610E-02	1.3490E-02

Group	Upper Energy, eV	R1-UO2		R1-MOX	
		MCNP	DRAGON	MCNP	DRAGON
50	3.5266E+03	1.6860E-03	1.7230E-03	1.9910E-03	1.9160E-03
51	3.3546E+03	1.3830E-02	1.3660E-02	1.5050E-02	1.5190E-02
52	2.2487E+03	3.4090E-03	3.4180E-03	3.7620E-03	3.8050E-03
53	2.0347E+03	1.0040E-02	1.0060E-02	1.1180E-02	1.1210E-02
54	1.5073E+03	1.7160E-03	1.7360E-03	1.9590E-03	1.9270E-03
55	1.4338E+03	5.0500E-03	4.9950E-03	5.7100E-03	5.5640E-03
56	1.2341E+03	6.7510E-03	6.6710E-03	7.3680E-03	7.4350E-03
57	1.0104E+03	3.3400E-03	3.3240E-03	3.7620E-03	3.7020E-03
58	9.1424E+02	6.5660E-03	6.5950E-03	7.4240E-03	7.3550E-03
59	7.4852E+02	3.2890E-03	3.2460E-03	3.5390E-03	3.6300E-03
60	6.7729E+02	1.3150E-02	1.3070E-02	1.4520E-02	1.4570E-02
61	4.5400E+02	6.4510E-03	6.4800E-03	7.1520E-03	7.2340E-03
62	3.7170E+02	6.3990E-03	6.4620E-03	7.1650E-03	7.2100E-03
63	3.0433E+02	1.2770E-02	1.2740E-02	1.4210E-02	1.4210E-02
64	2.0399E+02	1.0050E-02	9.9510E-03	1.1100E-02	1.1100E-02
65	1.4862E+02	2.6400E-03	2.6180E-03	2.8100E-03	2.9180E-03
66	1.3674E+02	1.2610E-02	1.2380E-02	1.3690E-02	1.3770E-02
67	9.1661E+01	5.9810E-03	5.8440E-03	6.3240E-03	6.4740E-03
68	7.5674E+01	3.2740E-03	3.3060E-03	3.6000E-03	3.6490E-03
69	6.7904E+01	6.0010E-03	5.9890E-03	6.4580E-03	6.5740E-03
70	5.5595E+01	2.3780E-03	2.2590E-03	2.4770E-03	2.4860E-03
71	5.1578E+01	1.9820E-03	1.9990E-03	2.1940E-03	2.2110E-03
72	4.8252E+01	1.7460E-03	1.7550E-03	1.9470E-03	1.9420E-03
73	4.5517E+01	3.8330E-03	3.7410E-03	3.9640E-03	4.0960E-03
74	4.0169E+01	2.2110E-03	2.1420E-03	2.3230E-03	2.3600E-03
75	3.7266E+01	2.8090E-03	2.7740E-03	3.0350E-03	3.0830E-03
76	3.3720E+01	2.9500E-03	2.8830E-03	3.2470E-03	3.2130E-03
77	3.0511E+01	2.9540E-03	2.9050E-03	3.1600E-03	3.2300E-03
78	2.7608E+01	2.9490E-03	2.9030E-03	3.1950E-03	3.2080E-03
79	2.4980E+01	2.8270E-03	2.8700E-03	3.0480E-03	3.2010E-03
80	2.2603E+01	4.0780E-03	3.9540E-03	4.2380E-03	4.3620E-03
81	1.9455E+01	5.7430E-03	5.5100E-03	6.0300E-03	6.0960E-03
82	1.5928E+01	4.2060E-03	4.1740E-03	4.5700E-03	4.4980E-03
83	1.3710E+01	5.5260E-03	5.4920E-03	5.9180E-03	6.0120E-03
84	1.1224E+01	3.5590E-03	3.4410E-03	3.5940E-03	3.6680E-03
85	9.9056E+00	2.0280E-03	2.0490E-03	2.2380E-03	2.2430E-03
86	9.1898E+00	2.7020E-03	2.6580E-03	2.9130E-03	2.9630E-03
87	8.3153E+00	2.7100E-03	2.6960E-03	2.7730E-03	2.8650E-03
88	7.5240E+00	4.7990E-03	4.6860E-03	5.2150E-03	5.1270E-03
89	6.1601E+00	3.6310E-03	3.5280E-03	3.8500E-03	3.8520E-03
90	5.3464E+00	1.4780E-03	1.4670E-03	1.5890E-03	1.6050E-03
91	5.0435E+00	5.2430E-03	5.0720E-03	5.5870E-03	5.5390E-03
92	4.1293E+00	8.4370E-04	8.1370E-04	8.6860E-04	8.8620E-04
93	4.0000E+00	4.4470E-03	4.4180E-03	4.7640E-03	4.8390E-03
94	3.3807E+00	6.3260E-04	6.4160E-04	7.2220E-04	7.0260E-04
95	3.3000E+00	4.6570E-03	4.5910E-03	4.9480E-03	5.0280E-03
96	2.7679E+00	4.6310E-04	4.6800E-04	4.8190E-04	5.0300E-04
97	2.7200E+00	1.2560E-03	1.1840E-03	1.1980E-03	1.2160E-03
98	2.6000E+00	5.3340E-04	5.2570E-04	5.4690E-04	5.5850E-04
99	2.5500E+00	2.0650E-03	2.0270E-03	2.1980E-03	2.1830E-03
100	2.3600E+00	2.7470E-03	2.7170E-03	2.9320E-03	2.9350E-03
101	2.1300E+00	3.8520E-04	3.7860E-04	4.0140E-04	4.0980E-04
102	2.1000E+00	1.0600E-03	1.0210E-03	1.1840E-03	1.1080E-03

Group	Upper Energy, eV	R1-UO2		R1-MOX	
		MCNP	DRAGON	MCNP	DRAGON
103	2.0200E+00	1.2190E-03	1.2060E-03	1.3090E-03	1.3000E-03
104	1.9300E+00	1.3060E-03	1.2710E-03	1.3610E-03	1.3650E-03
105	1.8400E+00	1.3060E-03	1.2460E-03	1.3770E-03	1.3450E-03
106	1.7550E+00	1.3700E-03	1.3260E-03	1.3710E-03	1.4300E-03
107	1.6700E+00	1.3260E-03	1.3150E-03	1.4510E-03	1.4160E-03
108	1.5900E+00	1.5780E-03	1.5410E-03	1.6210E-03	1.6560E-03
109	1.5000E+00	4.5220E-04	4.5310E-04	5.1810E-04	4.8520E-04
110	1.4750E+00	6.2670E-04	6.5010E-04	6.6130E-04	6.9470E-04
111	1.4400E+00	1.3100E-03	1.3280E-03	1.3750E-03	1.4130E-03
112	1.3700E+00	6.4340E-04	6.4580E-04	6.8030E-04	6.7970E-04
113	1.3375E+00	7.9530E-04	7.6720E-04	8.2420E-04	7.9100E-04
114	1.3000E+00	1.4080E-03	1.3770E-03	1.4050E-03	1.3820E-03
115	1.2350E+00	1.4650E-03	1.4340E-03	1.4600E-03	1.4390E-03
116	1.1700E+00	4.4580E-04	4.6160E-04	4.3950E-04	4.4760E-04
117	1.1500E+00	6.2700E-04	6.3350E-04	6.1840E-04	5.9300E-04
118	1.1230E+00	3.1950E-04	3.1110E-04	2.7880E-04	2.7980E-04
119	1.1100E+00	3.3020E-04	3.1520E-04	2.9660E-04	2.7620E-04
120	1.0970E+00	6.2540E-04	6.4090E-04	5.3830E-04	5.5040E-04
121	1.0710E+00	6.8800E-04	6.5750E-04	5.9830E-04	5.5810E-04
122	1.0450E+00	2.6940E-04	2.5810E-04	2.1530E-04	2.1720E-04
123	1.0350E+00	4.4420E-04	3.9200E-04	3.2530E-04	3.2940E-04
124	1.0200E+00	6.3710E-04	6.4120E-04	5.6350E-04	5.4220E-04
125	9.9600E-01	2.7350E-04	2.7200E-04	2.3530E-04	2.3470E-04
126	9.8600E-01	3.7930E-04	3.8630E-04	3.4840E-04	3.3870E-04
127	9.7200E-01	6.4780E-04	6.1830E-04	5.5930E-04	5.5370E-04
128	9.5000E-01	5.8740E-04	5.7720E-04	4.8320E-04	5.2610E-04
129	9.3000E-01	6.0300E-04	5.9400E-04	4.9640E-04	5.4790E-04
130	9.1000E-01	1.5980E-03	1.5470E-03	1.4050E-03	1.4490E-03
131	8.6000E-01	3.3850E-04	3.2660E-04	2.8500E-04	3.0760E-04
132	8.5000E-01	2.0070E-03	2.0020E-03	1.9370E-03	1.9080E-03
133	7.9000E-01	3.8960E-04	3.5800E-04	3.2830E-04	3.4150E-04
134	7.8000E-01	2.8470E-03	2.8200E-03	2.7400E-03	2.7070E-03
135	7.0500E-01	3.4770E-03	3.3980E-03	3.1910E-03	3.2510E-03
136	6.2500E-01	4.2620E-03	4.1580E-03	3.8100E-03	3.8640E-03
137	5.4000E-01	2.3370E-03	2.2110E-03	2.0100E-03	2.0490E-03
138	5.0000E-01	9.2550E-04	8.8640E-04	7.7460E-04	8.1470E-04
139	4.8500E-01	3.3280E-03	3.2780E-03	2.8690E-03	2.9700E-03
140	4.3300E-01	2.2490E-03	2.3010E-03	1.9400E-03	2.0180E-03
141	4.0000E-01	7.0860E-04	6.6350E-04	5.5930E-04	5.6770E-04
142	3.9100E-01	3.2940E-03	3.2150E-03	2.5480E-03	2.6530E-03
143	3.5000E-01	2.7340E-03	2.6100E-03	1.9650E-03	2.0400E-03
144	3.2000E-01	5.1700E-04	5.0780E-04	3.8680E-04	3.8670E-04
145	3.1450E-01	1.4160E-03	1.3860E-03	1.1420E-03	1.0440E-03
146	3.0000E-01	2.1070E-03	2.0450E-03	1.4160E-03	1.5160E-03
147	2.8000E-01	3.7610E-03	3.6850E-03	2.7130E-03	2.6800E-03
148	2.4800E-01	3.9360E-03	3.7900E-03	2.6110E-03	2.7100E-03
149	2.2000E-01	5.3870E-03	5.2470E-03	3.6090E-03	3.6530E-03
150	1.8900E-01	1.8960E-03	1.8480E-03	1.2460E-03	1.2490E-03
151	1.8000E-01	4.6970E-03	4.7790E-03	2.9960E-03	3.1470E-03
152	1.6000E-01	5.9580E-03	6.1450E-03	3.8320E-03	3.8710E-03
153	1.4000E-01	2.1740E-03	2.2180E-03	1.2900E-03	1.3540E-03
154	1.3400E-01	8.2530E-03	8.5420E-03	4.8430E-03	5.0420E-03
155	1.1500E-01	8.6200E-03	8.9460E-03	4.7180E-03	5.0550E-03

Group	Upper Energy, eV	R1-UO2		R1-MOX	
		MCNP	DRAGON	MCNP	DRAGON
156	1.0000E-01	3.5030E-03	3.5570E-03	1.8200E-03	1.9600E-03
157	9.5000E-02	1.3160E-02	1.2680E-02	6.7650E-03	6.8200E-03
158	8.0000E-02	2.8200E-03	2.9580E-03	1.5440E-03	1.5610E-03
159	7.7000E-02	1.0490E-02	1.1040E-02	5.4520E-03	5.7480E-03
160	6.7000E-02	1.1230E-02	1.1480E-02	5.7690E-03	5.8750E-03
161	5.8000E-02	1.1670E-02	1.1420E-02	5.9250E-03	5.7690E-03
162	5.0000E-02	1.3240E-02	1.2520E-02	6.4940E-03	6.2540E-03
163	4.2000E-02	1.2180E-02	1.1680E-02	6.0920E-03	5.7860E-03
164	3.5000E-02	8.6920E-03	8.5480E-03	4.2010E-03	4.2160E-03
165	3.0000E-02	8.6830E-03	8.5120E-03	4.2760E-03	4.1870E-03
166	2.5000E-02	9.9890E-03	8.2320E-03	4.8870E-03	4.0430E-03
167	2.0000E-02	7.6690E-03	7.5940E-03	3.7290E-03	3.7300E-03
168	1.5000E-02	7.3290E-03	6.4590E-03	3.6050E-03	3.1790E-03
169	1.0000E-02	3.1960E-03	3.1500E-03	1.5920E-03	1.5560E-03
170	6.9000E-03	1.4280E-03	1.4920E-03	6.9220E-04	7.4070E-04
171	5.0000E-03	1.3610E-03	1.1360E-03	6.7540E-04	5.6650E-04
172	3.0000E-03	6.3030E-04	6.9480E-04	3.2580E-04	3.5040E-04
Lower Bound	1.1000E-04				

Comparison of the 172- group spectra between MORGANE/S and VHTR

Group	Upper Energy, eV	MORGANE/S	VHTR/Uranium	VHTR/DBMHR
1	1.9640E+07	3.6920E-06	1.8410E-07	2.7060E-07
2	1.7332E+07	6.7810E-06	1.1620E-06	1.7110E-06
3	1.4918E+07	1.9710E-05	1.8900E-06	2.7850E-06
4	1.3840E+07	8.2060E-05	1.4650E-05	2.1610E-05
5	1.1618E+07	2.5730E-04	4.9310E-05	7.2830E-05
6	1.0000E+07	1.1230E-03	1.9230E-04	2.8400E-04
7	8.1873E+06	3.0300E-03	6.0770E-04	8.9810E-04
8	6.7032E+06	2.8760E-03	5.0520E-04	7.4590E-04
9	6.0653E+06	3.7360E-03	8.6210E-04	1.2750E-03
10	5.4881E+06	1.1430E-02	2.7320E-03	4.0380E-03
11	4.4933E+06	1.5400E-02	3.3710E-03	4.9710E-03
12	3.6788E+06	2.0350E-02	4.2060E-03	6.1940E-03
13	3.0119E+06	2.9050E-02	6.9160E-03	1.0190E-02
14	2.4660E+06	1.6750E-02	4.6190E-03	6.8020E-03
15	2.2313E+06	1.4300E-02	5.1390E-03	7.5710E-03
16	2.0190E+06	2.8370E-02	1.2040E-02	1.7750E-02
17	1.6530E+06	3.0830E-02	1.3430E-02	1.9770E-02
18	1.3534E+06	1.4290E-02	6.7000E-03	9.8530E-03
19	1.2246E+06	1.5870E-02	6.7540E-03	9.9200E-03
20	1.1080E+06	1.2120E-02	6.6730E-03	9.8030E-03
21	1.0026E+06	1.2300E-02	6.6160E-03	9.7170E-03
22	9.0718E+05	1.6880E-02	6.5930E-03	9.6610E-03
23	8.2085E+05	5.6500E-02	1.9160E-02	2.7990E-02
24	6.0810E+05	1.6920E-02	6.2080E-03	9.0690E-03
25	5.5023E+05	1.5780E-02	6.1540E-03	8.9780E-03
26	4.9787E+05	1.3000E-02	6.0700E-03	8.8510E-03
27	4.5049E+05	9.3310E-03	5.9460E-03	8.6760E-03
28	4.0762E+05	3.6640E-02	1.7330E-02	2.5240E-02
29	3.0197E+05	1.2290E-02	5.6370E-03	8.2040E-03

Group	Upper Energy, eV	MORGANE/S	VHTR/Uranium	VHTR/DBMHR
30	2.7324E+05	1.1710E-02	5.5770E-03	8.1170E-03
31	2.4724E+05	3.1470E-02	1.6150E-02	2.3540E-02
32	1.8316E+05	3.5800E-02	2.0880E-02	3.0280E-02
33	1.2277E+05	8.2120E-03	5.1670E-03	7.4910E-03
34	1.1109E+05	2.2550E-02	1.5270E-02	2.2130E-02
35	8.2298E+04	1.3770E-02	1.0040E-02	1.4540E-02
36	6.7380E+04	1.3210E-02	9.8440E-03	1.4300E-02
37	5.5166E+04	1.8580E-02	1.4780E-02	2.1390E-02
38	4.0868E+04	6.0470E-03	4.8930E-03	7.0790E-03
39	3.6979E+04	1.3460E-02	1.1370E-02	1.6450E-02
40	2.9283E+04	3.7810E-03	3.2370E-03	4.6790E-03
41	2.7394E+04	5.5510E-03	4.8470E-03	7.0060E-03
42	2.4788E+04	2.1470E-02	1.9260E-02	2.7830E-02
43	1.6616E+04	5.1780E-03	4.8010E-03	6.9310E-03
44	1.5034E+04	1.5340E-02	1.4360E-02	2.0720E-02
45	1.1138E+04	9.9900E-03	9.5470E-03	1.3770E-02
46	9.1188E+03	9.8380E-03	9.5280E-03	1.3730E-02
47	7.4659E+03	1.4610E-02	1.4250E-02	2.0520E-02
48	5.5308E+03	4.7900E-03	4.7430E-03	6.8260E-03
49	5.0045E+03	1.6430E-02	1.6560E-02	2.3810E-02
50	3.5266E+03	2.2700E-03	2.3620E-03	3.3940E-03
51	3.3546E+03	1.8470E-02	1.8850E-02	2.7030E-02
52	2.2487E+03	4.5850E-03	4.7060E-03	6.7410E-03
53	2.0347E+03	1.3630E-02	1.4080E-02	2.0150E-02
54	1.5073E+03	2.3260E-03	2.3470E-03	3.3490E-03
55	1.4338E+03	6.7710E-03	7.0200E-03	1.0030E-02
56	1.2341E+03	8.8610E-03	9.3500E-03	1.3330E-02
57	1.0104E+03	4.3840E-03	4.6660E-03	6.6410E-03
58	9.1424E+02	8.7600E-03	9.3150E-03	1.3240E-02
59	7.4852E+02	4.3050E-03	4.6490E-03	6.6070E-03
60	6.7729E+02	1.6890E-02	1.8500E-02	2.6140E-02
61	4.5400E+02	8.2400E-03	9.2210E-03	1.2990E-02
62	3.7170E+02	8.1540E-03	9.1980E-03	1.2890E-02
63	3.0433E+02	1.5630E-02	1.8220E-02	2.5300E-02
64	2.0399E+02	1.2090E-02	1.4320E-02	1.9710E-02
65	1.4862E+02	3.1620E-03	3.7600E-03	5.1390E-03
66	1.3674E+02	1.4370E-02	1.7800E-02	2.4130E-02
67	9.1661E+01	6.5610E-03	8.4750E-03	1.1280E-02
68	7.5674E+01	3.5550E-03	4.7820E-03	6.2580E-03
69	6.7904E+01	6.4120E-03	8.6980E-03	1.1250E-02
70	5.5595E+01	2.4330E-03	3.2630E-03	4.1590E-03
71	5.1578E+01	2.1130E-03	2.8880E-03	3.6740E-03
72	4.8252E+01	1.8310E-03	2.5270E-03	3.2150E-03
73	4.5517E+01	3.9480E-03	5.4040E-03	6.6990E-03
74	4.0169E+01	2.2670E-03	3.2140E-03	3.9850E-03
75	3.7266E+01	2.8530E-03	4.1060E-03	5.3500E-03
76	3.3720E+01	3.0380E-03	4.2050E-03	5.3120E-03
77	3.0511E+01	3.0330E-03	4.1860E-03	5.2880E-03
78	2.7608E+01	2.9800E-03	4.1600E-03	5.1960E-03
79	2.4980E+01	2.8960E-03	4.1510E-03	5.1960E-03
80	2.2603E+01	3.8470E-03	5.8750E-03	7.5820E-03
81	1.9455E+01	5.3030E-03	7.9220E-03	9.9000E-03
82	1.5928E+01	3.6760E-03	5.9040E-03	6.9900E-03

Group	Upper Energy, eV	MORGANE/S	VHTR/Uranium	VHTR/DBMHR
83	1.3710E+01	4.9780E-03	7.8070E-03	9.1590E-03
84	1.1224E+01	2.9660E-03	4.8790E-03	5.3990E-03
85	9.9056E+00	1.8220E-03	2.9140E-03	3.3000E-03
86	9.1898E+00	2.3800E-03	3.8330E-03	4.3460E-03
87	8.3153E+00	2.2660E-03	3.8630E-03	4.0930E-03
88	7.5240E+00	3.9810E-03	6.9400E-03	8.2930E-03
89	6.1601E+00	2.9260E-03	5.0130E-03	5.7000E-03
90	5.3464E+00	1.2540E-03	2.0400E-03	2.3550E-03
91	5.0435E+00	4.1430E-03	7.0050E-03	7.9040E-03
92	4.1293E+00	6.7460E-04	1.1210E-03	1.2570E-03
93	4.0000E+00	3.6280E-03	6.3830E-03	7.1280E-03
94	3.3807E+00	5.0670E-04	9.3820E-04	1.0470E-03
95	3.3000E+00	3.7240E-03	6.4540E-03	7.1440E-03
96	2.7679E+00	3.6870E-04	6.1870E-04	6.3520E-04
97	2.7200E+00	8.4230E-04	1.6160E-03	1.3970E-03
98	2.6000E+00	3.9840E-04	7.0370E-04	7.0750E-04
99	2.5500E+00	1.6120E-03	2.8170E-03	2.9010E-03
100	2.3600E+00	2.1220E-03	3.7570E-03	3.8370E-03
101	2.1300E+00	3.0910E-04	5.2090E-04	5.2920E-04
102	2.1000E+00	7.9690E-04	1.4230E-03	1.4440E-03
103	2.0200E+00	9.2990E-04	1.6750E-03	1.6640E-03
104	1.9300E+00	9.7850E-04	1.7610E-03	1.7350E-03
105	1.8400E+00	9.7190E-04	1.7460E-03	1.7260E-03
106	1.7550E+00	9.8110E-04	1.8390E-03	1.7990E-03
107	1.6700E+00	1.0090E-03	1.8240E-03	1.7800E-03
108	1.5900E+00	1.1400E-03	2.1690E-03	2.0770E-03
109	1.5000E+00	3.1670E-04	6.2850E-04	5.8150E-04
110	1.4750E+00	4.6330E-04	8.9970E-04	8.2650E-04
111	1.4400E+00	9.3580E-04	1.8680E-03	1.6660E-03
112	1.3700E+00	4.6270E-04	9.0330E-04	7.4900E-04
113	1.3375E+00	5.1290E-04	1.0720E-03	8.6570E-04
114	1.3000E+00	9.3270E-04	1.9380E-03	1.4800E-03
115	1.2350E+00	9.0210E-04	2.0430E-03	1.5050E-03
116	1.1700E+00	2.7820E-04	6.5290E-04	4.3530E-04
117	1.1500E+00	3.7050E-04	8.9970E-04	5.4430E-04
118	1.1230E+00	1.9320E-04	4.4120E-04	2.4340E-04
119	1.1100E+00	1.7040E-04	4.4730E-04	2.3320E-04
120	1.0970E+00	3.5090E-04	9.1200E-04	4.5000E-04
121	1.0710E+00	3.8080E-04	9.3690E-04	4.4060E-04
122	1.0450E+00	1.4270E-04	3.6720E-04	1.6760E-04
123	1.0350E+00	2.0960E-04	5.5790E-04	2.5030E-04
124	1.0200E+00	3.3320E-04	9.1230E-04	4.0500E-04
125	9.9600E-01	1.5590E-04	3.8740E-04	1.7560E-04
126	9.8600E-01	2.0720E-04	5.4950E-04	2.5410E-04
127	9.7200E-01	3.4850E-04	8.8150E-04	4.1850E-04
128	9.5000E-01	3.2430E-04	8.2100E-04	3.9850E-04
129	9.3000E-01	3.1270E-04	8.4140E-04	4.1290E-04
130	9.1000E-01	7.9370E-04	2.1980E-03	1.0820E-03
131	8.6000E-01	1.7130E-04	4.5800E-04	2.2410E-04
132	8.5000E-01	1.1080E-03	2.8710E-03	1.3930E-03
133	7.9000E-01	2.0340E-04	5.0370E-04	2.4050E-04
134	7.8000E-01	1.4650E-03	4.0230E-03	1.8860E-03
135	7.0500E-01	1.7630E-03	4.8740E-03	2.1680E-03

Group	Upper Energy, eV	MORGANE/S	VHTR/Uranium	VHTR/DBMHR
136	6.2500E-01	2.1440E-03	6.0460E-03	2.3390E-03
137	5.4000E-01	1.1080E-03	3.2480E-03	1.1890E-03
138	5.0000E-01	4.1800E-04	1.3010E-03	4.5130E-04
139	4.8500E-01	1.4680E-03	4.9230E-03	1.6050E-03
140	4.3300E-01	9.6290E-04	3.5230E-03	1.0080E-03
141	4.0000E-01	2.8550E-04	1.0250E-03	2.6520E-04
142	3.9100E-01	1.2450E-03	5.0820E-03	1.1130E-03
143	3.5000E-01	9.7610E-04	4.2350E-03	6.9930E-04
144	3.2000E-01	1.8080E-04	8.3480E-04	1.1880E-04
145	3.1450E-01	4.9130E-04	2.3000E-03	3.0300E-04
146	3.0000E-01	7.5490E-04	3.4490E-03	4.0160E-04
147	2.8000E-01	1.3090E-03	6.3590E-03	6.3330E-04
148	2.4800E-01	1.2630E-03	6.7070E-03	5.6920E-04
149	2.2000E-01	1.5590E-03	9.6470E-03	6.7990E-04
150	1.8900E-01	5.2030E-04	3.4650E-03	2.0890E-04
151	1.8000E-01	1.1740E-03	9.1340E-03	4.8230E-04
152	1.6000E-01	1.4120E-03	1.1750E-02	5.0330E-04
153	1.4000E-01	4.6790E-04	4.1900E-03	1.5470E-04
154	1.3400E-01	1.6090E-03	1.5870E-02	5.0010E-04
155	1.1500E-01	1.4850E-03	1.5870E-02	3.9720E-04
156	1.0000E-01	5.5490E-04	6.0620E-03	1.3130E-04
157	9.5000E-02	1.9530E-03	2.0740E-02	3.8660E-04
158	8.0000E-02	4.2470E-04	4.6080E-03	7.4450E-05
159	7.7000E-02	1.5490E-03	1.6520E-02	2.4020E-04
160	6.7000E-02	1.5490E-03	1.6210E-02	2.0110E-04
161	5.8000E-02	1.4980E-03	1.5180E-02	1.6200E-04
162	5.0000E-02	1.6380E-03	1.5490E-02	1.4290E-04
163	4.2000E-02	1.5020E-03	1.3330E-02	1.0650E-04
164	3.5000E-02	1.0530E-03	9.0600E-03	6.4730E-05
165	3.0000E-02	1.0620E-03	8.3980E-03	5.4680E-05
166	2.5000E-02	1.2010E-03	7.4560E-03	4.4470E-05
167	2.0000E-02	9.3980E-04	6.2000E-03	3.4090E-05
168	1.5000E-02	9.0760E-04	4.6410E-03	2.4100E-05
169	1.0000E-02	3.8850E-04	2.0060E-03	1.0490E-05
170	6.9000E-03	1.9510E-04	8.7310E-04	4.7120E-06
171	5.0000E-03	1.6790E-04	6.1690E-04	3.4910E-06
172	3.0000E-03	8.8880E-05	3.4670E-04	2.3640E-06
Lower Bound	1.1000E-04			

Appendix 3 Micro Scopic Cross Section ($\nu\sigma_f - \sigma_a$) of separate actinides

Group	Upper Energy, eV	Isotope			
		U233	U234	U235	U236
1	1.9640E+07	8.2753E+00	8.3440E+00	8.0599E+00	7.0235E+00
2	1.7332E+07	8.2811E+00	7.6852E+00	7.9383E+00	6.3416E+00
3	1.4918E+07	8.0642E+00	7.1271E+00	7.5881E+00	5.8065E+00
4	1.3840E+07	7.2004E+00	6.3461E+00	6.5044E+00	5.3547E+00
5	1.1618E+07	6.5558E+00	5.8768E+00	5.8708E+00	4.9600E+00
6	1.0000E+07	6.0881E+00	5.6229E+00	5.3667E+00	4.7240E+00
7	8.1873E+06	5.4303E+00	4.7010E+00	4.4042E+00	3.5926E+00
8	6.7032E+06	4.5068E+00	3.4376E+00	3.1691E+00	2.4381E+00
9	6.0653E+06	3.4706E+00	2.8342E+00	2.3670E+00	1.8920E+00
10	5.4881E+06	3.3038E+00	2.6767E+00	2.1766E+00	1.6545E+00
11	4.4933E+06	3.3537E+00	2.6954E+00	2.1279E+00	1.5883E+00
12	3.6788E+06	3.3893E+00	2.6538E+00	2.0950E+00	1.5135E+00
13	3.0119E+06	3.3850E+00	2.5690E+00	2.0970E+00	1.4299E+00
14	2.4660E+06	3.3479E+00	2.4705E+00	2.0810E+00	1.3728E+00
15	2.2313E+06	3.2979E+00	2.4497E+00	2.0569E+00	1.2763E+00
16	2.0190E+06	3.2112E+00	2.3738E+00	1.9852E+00	1.1284E+00
17	1.6530E+06	3.0754E+00	1.9814E+00	1.8723E+00	9.7213E-01
18	1.3534E+06	2.9751E+00	1.7083E+00	1.7931E+00	8.7531E-01
19	1.2246E+06	2.9185E+00	1.5609E+00	1.7560E+00	7.1059E-01
20	1.1080E+06	2.8746E+00	1.3911E+00	1.7327E+00	4.9193E-01
21	1.0026E+06	2.8454E+00	1.3919E+00	1.6885E+00	3.1170E-01
22	9.0718E+05	2.8287E+00	1.5372E+00	1.5871E+00	1.5039E-01
23	8.2085E+05	2.8330E+00	1.3103E+00	1.5422E+00	-6.9672E-02
24	6.0810E+05	2.8677E+00	8.2230E-01	1.5219E+00	-1.4095E-01
25	5.5023E+05	2.8972E+00	6.6566E-01	1.5251E+00	-1.4350E-01
26	4.9787E+05	2.9321E+00	4.7706E-01	1.5347E+00	-1.4766E-01
27	4.5049E+05	2.9703E+00	2.6795E-01	1.5629E+00	-1.5311E-01
28	4.0762E+05	3.0414E+00	2.2969E-02	1.5807E+00	-1.6246E-01
29	3.0197E+05	3.0980E+00	-1.1170E-01	1.5720E+00	-1.7305E-01
30	2.7324E+05	3.1064E+00	-1.3653E-01	1.6048E+00	-1.7851E-01
31	2.4724E+05	3.0631E+00	-1.7618E-01	1.6571E+00	-1.9063E-01
32	1.8316E+05	3.0251E+00	-2.5265E-01	1.7185E+00	-2.1239E-01
33	1.2277E+05	3.0551E+00	-3.0624E-01	1.7758E+00	-2.4264E-01
34	1.1109E+05	3.1027E+00	-3.3960E-01	1.7960E+00	-2.8556E-01
35	8.2298E+04	3.1952E+00	-3.8883E-01	1.9188E+00	-3.4386E-01
36	6.7380E+04	3.2917E+00	-4.2546E-01	1.9948E+00	-3.8846E-01
37	5.5166E+04	3.4469E+00	-4.8464E-01	2.0480E+00	-4.4379E-01
38	4.0868E+04	3.5992E+00	-5.3423E-01	2.1126E+00	-4.9101E-01
39	3.6979E+04	3.7522E+00	-6.0029E-01	2.2464E+00	-5.3427E-01
40	2.9283E+04	3.8814E+00	-6.5278E-01	2.3587E+00	-5.7572E-01
41	2.7394E+04	3.9569E+00	-6.7836E-01	2.3314E+00	-5.9906E-01
42	2.4788E+04	4.2094E+00	-7.9600E-01	2.5616E+00	-6.7341E-01
43	1.6616E+04	4.5270E+00	-9.0279E-01	2.6815E+00	-7.4985E-01
44	1.5034E+04	4.8748E+00	-1.0127E+00	2.9891E+00	-8.1344E-01
45	1.1138E+04	5.3927E+00	-1.1438E+00	3.2239E+00	-8.9367E-01
46	9.1188E+03	6.1529E+00	-1.2318E+00	3.0882E+00	-9.5959E-01
47	7.4659E+03	6.9882E+00	-1.3926E+00	3.7371E+00	-1.0482E+00
48	5.5308E+03	7.5342E+00	-1.5104E+00	4.4324E+00	-1.1252E+00
49	5.0045E+03	8.0133E+00	-1.7039E+00	4.8778E+00	-1.2239E+00
50	3.5266E+03	8.4846E+00	-1.8904E+00	5.3933E+00	-1.3241E+00
51	3.3546E+03	9.9982E+00	-2.2365E+00	5.7027E+00	-1.4682E+00

Group	Upper Energy, eV	Isotope			
		U233	U234	U235	U236
52	2.2487E+03	1.1403E+01	-2.6104E+00	3.8954E+00	-1.6581E+00
53	2.0347E+03	1.2262E+01	-2.8719E+00	5.6941E+00	-1.8457E+00
54	1.5073E+03	1.2988E+01	-4.2413E+00	5.4182E+00	-2.0165E+00
55	1.4338E+03	1.3330E+01	-3.8191E+00	7.6559E+00	-2.4019E+00
56	1.2341E+03	1.3098E+01	-4.0754E+00	7.7533E+00	-2.5358E+00
57	1.0104E+03	1.3246E+01	-2.3717E+00	5.5230E+00	-3.6678E+00
58	9.1424E+02	1.5839E+01	-6.9865E+00	8.3780E+00	-2.9651E+00
59	7.4852E+02	1.8486E+01	-3.7786E+00	1.1631E+01	-3.8869E+00
60	6.7729E+02	1.8380E+01	-6.3978E+00	1.3714E+01	-4.7699E+00
61	4.5400E+02	1.8619E+01	-3.1142E+00	1.2387E+01	-6.4914E+00
62	3.7170E+02	2.3526E+01	-1.2040E+01	1.3018E+01	-2.5745E+00
63	3.0433E+02	2.6911E+01	-6.3855E+00	1.9873E+01	-8.1805E+00
64	2.0399E+02	2.8625E+01	-3.2047E+01	1.7041E+01	-6.0702E+00
65	1.4862E+02	2.8234E+01	-2.3022E+01	1.0742E+01	-1.2320E+00
66	1.3674E+02	3.9522E+01	-3.6693E+01	1.8075E+01	-1.5359E+01
67	9.1661E+01	4.6647E+01	-2.9299E+01	2.3516E+01	-2.9933E+01
68	7.5674E+01	5.0787E+01	-2.6999E-01	3.8908E+01	-7.2120E+01
69	6.7904E+01	6.5572E+01	-8.2733E-02	3.5436E+01	-2.5100E-01
70	5.5595E+01	5.5384E+01	-2.6176E-01	4.6275E+01	-5.3912E-02
71	5.1578E+01	4.0211E+01	-1.7923E+02	4.8161E+01	-1.0260E-01
72	4.8252E+01	2.8529E+01	-1.7513E+01	3.1416E+01	-4.2575E-01
73	4.5517E+01	3.0943E+01	-1.7512E+00	2.4665E+01	-1.1001E+02
74	4.0169E+01	4.2864E+01	-1.9020E-01	3.2541E+01	-1.6468E-01
75	3.7266E+01	8.1677E+01	-4.3974E-01	8.5548E+01	-4.6328E+01
76	3.3720E+01	8.6393E+01	-2.5023E+02	1.4792E+01	-5.1767E-01
77	3.0511E+01	7.9613E+01	-2.9468E+00	1.7442E+01	-1.7707E+01
78	2.7608E+01	7.8694E+01	-3.9615E-01	5.2651E+01	-5.7700E-02
79	2.4980E+01	9.8124E+01	-1.3396E+01	3.1782E+01	-4.2889E-02
80	2.2603E+01	1.8847E+02	-2.9905E-01	1.3382E+01	-4.2014E-02
81	1.9455E+01	1.2931E+02	-1.8430E-01	5.2883E+01	-5.1569E-02
82	1.5928E+01	7.6546E+01	-2.4515E-01	3.7984E+01	-7.3762E-02
83	1.3710E+01	1.4791E+02	-3.9425E-01	8.7537E+00	-1.2287E-01
84	1.1224E+01	2.6835E+02	-6.6075E-01	1.8920E+01	-2.1818E-01
85	9.9056E+00	9.2147E+01	-9.7836E-01	5.6731E+01	-3.3430E-01
86	9.1898E+00	5.2784E+01	-1.4646E+00	2.1302E+02	-5.2454E-01
87	8.3153E+00	3.8257E+01	-2.4954E+00	2.9179E+00	-9.6336E-01
88	7.5240E+00	2.2202E+02	-8.1442E+00	1.9028E+01	-4.2384E+00
89	6.1601E+00	1.1584E+02	-1.1362E+02	2.2224E+01	-1.7045E+03
90	5.3464E+00	9.6220E+01	-7.7800E+03	8.1812E+00	-1.9128E+02
91	5.0435E+00	1.2465E+02	-1.7837E+02	1.4474E+01	-1.2732E+01
92	4.1293E+00	6.9228E+01	-2.0040E+01	2.0763E+00	-4.0257E+00
93	4.0000E+00	1.4417E+02	-1.2435E+01	2.1622E+01	-2.7014E+00
94	3.3807E+00	1.3349E+02	-8.9250E+00	2.1748E+01	-1.9714E+00
95	3.3000E+00	8.4757E+01	-7.3131E+00	3.2826E+01	-1.6119E+00
96	2.7679E+00	5.8487E+01	-6.3690E+00	1.0166E+01	-1.3714E+00
97	2.7200E+00	5.3445E+01	-6.2515E+00	9.2539E+00	-1.3189E+00
98	2.6000E+00	4.8430E+01	-6.1421E+00	1.0990E+01	-1.2707E+00
99	2.5500E+00	5.0827E+01	-5.9829E+00	1.2769E+01	-1.2120E+00
100	2.3600E+00	3.9002E+02	-5.8926E+00	1.3806E+01	-1.1276E+00
101	2.1300E+00	3.2591E+02	-5.9028E+00	9.9513E+00	-1.0868E+00
102	2.1000E+00	3.4583E+02	-5.9074E+00	1.0374E+01	-1.0712E+00
103	2.0200E+00	4.5199E+02	-5.9465E+00	3.5155E+00	-1.0492E+00
104	1.9300E+00	7.1736E+02	-6.0553E+00	1.5405E+01	-1.0300E+00

Group	Upper Energy, eV	Isotope			
		U233	U234	U235	U236
105	1.8400E+00	1.0539E+03	-6.1628E+00	1.6937E+01	-1.0145E+00
106	1.7550E+00	9.2400E+02	-6.3112E+00	1.7714E+01	-1.0022E+00
107	1.6700E+00	6.3543E+02	-6.5054E+00	1.8316E+01	-9.9274E-01
108	1.5900E+00	5.1982E+02	-6.7063E+00	1.8938E+01	-9.8596E-01
109	1.5000E+00	4.7024E+02	-6.8586E+00	1.9452E+01	-9.8250E-01
110	1.4750E+00	4.4305E+02	-6.9755E+00	1.9847E+01	-9.8180E-01
111	1.4400E+00	3.9461E+02	-7.1819E+00	2.1094E+01	-9.8058E-01
112	1.3700E+00	3.5019E+02	-7.3780E+00	2.3376E+01	-9.8053E-01
113	1.3375E+00	3.2300E+02	-7.5141E+00	2.4309E+01	-9.8157E-01
114	1.3000E+00	2.8873E+02	-7.7181E+00	2.9094E+01	-9.8321E-01
115	1.2350E+00	2.5380E+02	-8.0816E+00	6.6266E+01	-9.8790E-01
116	1.1700E+00	2.3540E+02	-8.3401E+00	1.0789E+02	-9.9160E-01
117	1.1500E+00	2.2667E+02	-8.4867E+00	1.2338E+02	-9.9369E-01
118	1.1230E+00	2.1988E+02	-8.6102E+00	1.2706E+02	-9.9606E-01
119	1.1100E+00	2.1579E+02	-8.6911E+00	1.2465E+02	-9.9813E-01
120	1.0970E+00	2.1008E+02	-8.8130E+00	1.1747E+02	-1.0012E+00
121	1.0710E+00	2.0317E+02	-8.9746E+00	1.0625E+02	-1.0054E+00
122	1.0450E+00	1.9882E+02	-9.0857E+00	9.9042E+01	-1.0082E+00
123	1.0350E+00	1.9601E+02	-9.1636E+00	9.4731E+01	-1.0102E+00
124	1.0200E+00	1.9194E+02	-9.2864E+00	8.9059E+01	-1.0134E+00
125	9.9600E-01	1.8866E+02	-9.4267E+00	8.5001E+01	-1.0168E+00
126	9.8600E-01	1.8650E+02	-9.5498E+00	8.2677E+01	-1.0198E+00
127	9.7200E-01	1.8348E+02	-9.7348E+00	7.9785E+01	-1.0243E+00
128	9.5000E-01	1.8027E+02	-9.9493E+00	7.7163E+01	-1.0295E+00
129	9.3000E-01	1.7751E+02	-1.0154E+01	7.5309E+01	-1.0345E+00
130	9.1000E-01	1.7335E+02	-1.0518E+01	7.3320E+01	-1.0435E+00
131	8.6000E-01	1.7033E+02	-1.0818E+01	7.2408E+01	-1.0530E+00
132	8.5000E-01	1.6763E+02	-1.1185E+01	7.2430E+01	-1.0661E+00
133	7.9000E-01	1.6614E+02	-1.1534E+01	7.2955E+01	-1.0785E+00
134	7.8000E-01	1.6741E+02	-1.2054E+01	7.4806E+01	-1.0960E+00
135	7.0500E-01	1.7291E+02	-1.3246E+01	8.0443E+01	-1.1355E+00
136	6.2500E-01	1.8124E+02	-1.4828E+01	9.0698E+01	-1.1915E+00
137	5.4000E-01	1.8897E+02	-1.6128E+01	1.0231E+02	-1.2380E+00
138	5.0000E-01	1.9273E+02	-1.6773E+01	1.0926E+02	-1.2636E+00
139	4.8500E-01	1.9831E+02	-1.7796E+01	1.2060E+02	-1.2996E+00
140	4.3300E-01	2.0599E+02	-1.9078E+01	1.3962E+02	-1.3506E+00
141	4.0000E-01	2.1016E+02	-1.9811E+01	1.5202E+02	-1.3791E+00
142	3.9100E-01	2.1556E+02	-2.0846E+01	1.7146E+02	-1.4184E+00
143	3.5000E-01	2.2439E+02	-2.2432E+01	2.0342E+02	-1.4802E+00
144	3.2000E-01	2.2964E+02	-2.3270E+01	2.1912E+02	-1.5144E+00
145	3.1450E-01	2.3282E+02	-2.3821E+01	2.2601E+02	-1.5360E+00
146	3.0000E-01	2.3862E+02	-2.4845E+01	2.3248E+02	-1.5758E+00
147	2.8000E-01	2.4820E+02	-2.6558E+01	2.2826E+02	-1.6440E+00
148	2.4800E-01	2.5931E+02	-2.8933E+01	2.1657E+02	-1.7353E+00
149	2.2000E-01	2.6983E+02	-3.1717E+01	2.1382E+02	-1.8579E+00
150	1.8900E-01	2.7401E+02	-3.3619E+01	2.1861E+02	-1.9353E+00
151	1.8000E-01	2.7838E+02	-3.5651E+01	2.2749E+02	-2.0161E+00
152	1.6000E-01	2.9062E+02	-3.8475E+01	2.4444E+02	-2.1390E+00
153	1.4000E-01	3.0253E+02	-4.0481E+01	2.5778E+02	-2.2247E+00
154	1.3400E-01	3.1985E+02	-4.3008E+01	2.7640E+02	-2.3379E+00
155	1.1500E-01	3.4829E+02	-4.6880E+01	3.0529E+02	-2.5059E+00
156	1.0000E-01	3.6771E+02	-4.9313E+01	3.2523E+02	-2.6183E+00
157	9.5000E-02	3.9278E+02	-5.2705E+01	3.5184E+02	-2.7669E+00

Group	Upper Energy, eV	Isotope			
		U233	U234	U235	U236
158	8.0000E-02	4.1579E+02	-5.5860E+01	3.7681E+02	-2.9064E+00
159	7.7000E-02	4.3636E+02	-5.8764E+01	4.0005E+02	-3.0367E+00
160	6.7000E-02	4.7007E+02	-6.3468E+01	4.3850E+02	-3.2535E+00
161	5.8000E-02	5.0693E+02	-6.8683E+01	4.8069E+02	-3.4948E+00
162	5.0000E-02	5.5046E+02	-7.4966E+01	5.3016E+02	-3.7821E+00
163	4.2000E-02	6.0274E+02	-8.2527E+01	5.8848E+02	-4.1277E+00
164	3.5000E-02	6.5664E+02	-9.0288E+01	6.4742E+02	-4.4841E+00
165	3.0000E-02	7.1461E+02	-9.8667E+01	7.0992E+02	-4.8714E+00
166	2.5000E-02	7.9040E+02	-1.0920E+02	7.9059E+02	-5.3824E+00
167	2.0000E-02	8.9653E+02	-1.2443E+02	9.0194E+02	-6.0980E+00
168	1.5000E-02	1.0610E+03	-1.4817E+02	1.0736E+03	-7.2095E+00
169	1.0000E-02	1.2893E+03	-1.8037E+02	1.3121E+03	-8.7531E+00
170	6.9000E-03	1.5357E+03	-2.1567E+02	1.5712E+03	-1.0422E+01
171	5.0000E-03	1.8714E+03	-2.6284E+02	1.9248E+03	-1.2694E+01
172	3.0000E-03	2.8887E+03	-4.0625E+02	2.9949E+03	-1.9586E+01
Lower Bound	1.1000E-04				

Group	Upper Energy, eV	Isotope			
		U238	NP237	Pu238	Pu239
1	1.9640E+07	5.3552E+00	9.6366E+00	1.2454E+01	1.0423E+01
2	1.7332E+07	5.0539E+00	9.1340E+00	1.1368E+01	1.0079E+01
3	1.4918E+07	4.7868E+00	8.5458E+00	1.1141E+01	9.7480E+00
4	1.3840E+07	4.5878E+00	7.8424E+00	1.1069E+01	8.8531E+00
5	1.1618E+07	4.3448E+00	7.3567E+00	1.0433E+01	8.2307E+00
6	1.0000E+07	3.9501E+00	6.8890E+00	9.2783E+00	7.7376E+00
7	8.1873E+06	2.9945E+00	6.0266E+00	7.7990E+00	6.7303E+00
8	6.7032E+06	1.7964E+00	4.7907E+00	6.9048E+00	5.5118E+00
9	6.0653E+06	1.2747E+00	3.8157E+00	6.2187E+00	4.6458E+00
10	5.4881E+06	1.1279E+00	3.4955E+00	5.6753E+00	4.4387E+00
11	4.4933E+06	1.0375E+00	3.4555E+00	5.6797E+00	4.3359E+00
12	3.6788E+06	9.1988E-01	3.4026E+00	5.4127E+00	4.2771E+00
13	3.0119E+06	8.6714E-01	3.3495E+00	5.0832E+00	4.2635E+00
14	2.4660E+06	8.5920E-01	3.2762E+00	4.8754E+00	4.2900E+00
15	2.2313E+06	8.3853E-01	3.2401E+00	4.7546E+00	4.3003E+00
16	2.0190E+06	7.3699E-01	3.0899E+00	4.5918E+00	4.1672E+00
17	1.6530E+06	4.4205E-01	2.8591E+00	4.3706E+00	3.9951E+00
18	1.3534E+06	1.2674E-02	2.6663E+00	4.2174E+00	3.8103E+00
19	1.2246E+06	-4.3412E-02	2.5231E+00	4.1254E+00	3.6369E+00
20	1.1080E+06	-8.4791E-02	2.4120E+00	4.0393E+00	3.5018E+00
21	1.0026E+06	-1.0100E-01	2.2970E+00	3.9393E+00	3.4054E+00
22	9.0718E+05	-1.0765E-01	2.0762E+00	3.8185E+00	3.3414E+00
23	8.2085E+05	-1.1436E-01	1.5372E+00	3.3911E+00	3.1797E+00
24	6.0810E+05	-1.0957E-01	8.4481E-01	2.9047E+00	3.0334E+00
25	5.5023E+05	-1.0892E-01	5.0123E-01	2.6136E+00	2.9725E+00
26	4.9787E+05	-1.0942E-01	1.8449E-01	2.3547E+00	2.9303E+00
27	4.5049E+05	-1.1071E-01	-8.2888E-02	2.0982E+00	2.8978E+00
28	4.0762E+05	-1.1316E-01	-4.1936E-01	1.7402E+00	2.8392E+00
29	3.0197E+05	-1.1536E-01	-5.8772E-01	1.4813E+00	2.7697E+00
30	2.7324E+05	-1.1719E-01	-6.4004E-01	1.3965E+00	2.7345E+00
31	2.4724E+05	-1.2415E-01	-7.3259E-01	1.1163E+00	2.6759E+00

Group	Upper Energy, eV	Isotope			
		U238	NP237	Pu238	Pu239
32	1.8316E+05	-1.4335E-01	-9.1327E-01	9.1935E-01	2.6503E+00
33	1.2277E+05	-1.6184E-01	-1.0775E+00	7.6476E-01	2.6717E+00
34	1.1109E+05	-1.8385E-01	-1.2149E+00	6.7031E-01	2.6703E+00
35	8.2298E+04	-2.2181E-01	-1.3911E+00	4.8371E-01	2.6554E+00
36	6.7380E+04	-2.6614E-01	-1.5558E+00	4.8703E-01	2.6221E+00
37	5.5166E+04	-3.4310E-01	-1.7428E+00	4.8721E-01	2.5169E+00
38	4.0868E+04	-3.9222E-01	-1.8882E+00	4.5994E-01	2.5099E+00
39	3.6979E+04	-4.2351E-01	-2.0253E+00	4.4367E-01	2.6043E+00
40	2.9283E+04	-4.5372E-01	-2.1423E+00	4.3920E-01	2.4202E+00
41	2.7394E+04	-4.7171E-01	-2.1982E+00	4.4465E-01	2.4237E+00
42	2.4788E+04	-5.2987E-01	-2.3883E+00	3.5027E-01	2.4292E+00
43	1.6616E+04	-5.9098E-01	-2.6093E+00	-8.9680E-02	2.5562E+00
44	1.5034E+04	-6.4368E-01	-2.8244E+00	-2.2192E-01	2.4345E+00
45	1.1138E+04	-6.6312E-01	-3.1318E+00	3.6457E-01	2.4219E+00
46	9.1188E+03	-5.9481E-01	-3.4213E+00	9.5228E-01	2.8522E+00
47	7.4659E+03	-7.3389E-01	-3.8586E+00	7.3205E-01	2.3224E+00
48	5.5308E+03	-7.7978E-01	-4.2616E+00	5.6042E-01	2.3589E+00
49	5.0045E+03	-7.4026E-01	-4.7997E+00	4.0045E-01	2.7126E+00
50	3.5266E+03	-7.5397E-01	-5.3292E+00	2.5511E-01	1.5710E+00
51	3.3546E+03	-9.4774E-01	-6.0457E+00	6.2216E-02	4.0231E+00
52	2.2487E+03	-7.4874E-01	-6.9410E+00	-1.8260E-01	8.4959E-01
53	2.0347E+03	-8.8350E-01	-7.7717E+00	6.2902E-02	3.7751E+00
54	1.5073E+03	-6.6491E-01	-8.5677E+00	3.5702E-01	6.0210E+00
55	1.4338E+03	-1.0030E+00	-9.0607E+00	2.0675E-01	7.3624E+00
56	1.2341E+03	-1.3376E+00	-1.0016E+01	-8.3986E-02	6.3100E+00
57	1.0104E+03	-1.0911E+00	-1.0891E+01	-3.5395E-01	1.0599E+01
58	9.1424E+02	-1.2968E+00	-1.1834E+01	-6.6348E-01	6.7596E+00
59	7.4852E+02	-1.3897E+00	-1.2873E+01	-1.0131E+00	3.9114E+00
60	6.7729E+02	-1.3319E+00	-1.4853E+01	-1.7785E+00	1.2580E+01
61	4.5400E+02	-1.4083E+00	-1.7511E+01	-4.3043E+00	1.0126E+01
62	3.7170E+02	-7.5873E-01	-1.9578E+01	-6.2953E+00	4.1856E+00
63	3.0433E+02	-1.8476E+00	-2.3094E+01	-8.5927E+00	1.5266E+01
64	2.0399E+02	-1.5838E+00	-2.7816E+01	-9.5021E+00	2.0547E+01
65	1.4862E+02	-1.2949E+00	-2.6763E+01	-2.6450E-02	1.2256E+01
66	1.3674E+02	-2.8172E+00	-3.0898E+01	-2.0330E+01	2.5574E+01
67	9.1661E+01	-2.1497E+00	-5.3034E+01	-2.6620E+01	6.1016E+01
68	7.5674E+01	-3.7180E-01	-4.1861E+01	-8.6917E+00	9.2408E+01
69	6.7904E+01	-4.7689E+00	-6.2224E+01	-6.6524E+00	1.4474E+02
70	5.5595E+01	-1.0129E-01	-2.0728E+01	-3.4986E-02	-4.3965E+01
71	5.1578E+01	-1.4438E-01	-1.4150E+02	-2.5223E-02	1.9806E+01
72	4.8252E+01	-1.7314E-01	-9.7144E+01	-2.3430E-02	5.6670E+01
73	4.5517E+01	-5.1733E-01	-2.4689E+01	-2.4189E-02	-6.1340E+01
74	4.0169E+01	-5.8536E+00	-7.6100E+01	-2.7346E-02	1.6580E+00
75	3.7266E+01	-2.6359E+01	-3.6641E+01	-3.2541E-02	-2.8261E+00
76	3.3720E+01	-8.7400E-01	-3.2199E+01	-4.2253E-02	1.1000E+01
77	3.0511E+01	-3.9855E-01	-6.6145E+01	-5.9510E-02	1.0530E+00
78	2.7608E+01	-4.5937E-01	-1.3079E+02	-9.4508E-02	2.4871E+01
79	2.4980E+01	-1.1562E+00	-1.4283E+02	-1.8461E-01	1.2244E+01
80	2.2603E+01	-2.8797E+01	-8.7270E+01	-1.2193E+00	6.2757E+01
81	1.9455E+01	-1.1737E+00	-5.1039E+01	-1.6356E+02	4.1352E+01
82	1.5928E+01	-3.4938E-01	-9.0138E+00	-4.5849E-01	1.7057E+02
83	1.3710E+01	-3.4290E-01	-5.6809E+01	-3.0677E-01	4.6509E+01
84	1.1224E+01	-8.5168E-01	-2.7668E+02	-2.7365E+01	3.7502E+02

Group	Upper Energy, eV	Isotope			
		U238	NP237	Pu238	Pu239
85	9.9056E+00	-5.0824E-01	-1.3994E+02	-8.1218E+00	7.4269E+00
86	9.1898E+00	-8.6936E-01	-5.1928E+01	-4.7011E-01	3.9653E+00
87	8.3153E+00	-2.4186E+00	-2.3613E+01	-3.7641E-01	1.8190E+02
88	7.5240E+00	-4.9220E+01	-5.5105E+01	-4.1564E-01	1.8797E+01
89	6.1601E+00	-5.2268E+00	-2.2441E+02	-5.2667E-01	1.1781E+01
90	5.3464E+00	-1.9092E+00	-7.9096E+00	-6.2489E-01	1.1740E+01
91	5.0435E+00	-1.2183E+00	-3.2977E+01	-8.3434E-01	1.2440E+01
92	4.1293E+00	-7.8458E-01	-2.8422E+01	-1.1287E+00	1.3351E+01
93	4.0000E+00	-6.6106E-01	-1.8913E+02	-1.8267E+00	1.4422E+01
94	3.3807E+00	-5.8175E-01	-5.4943E+00	-3.4442E+00	1.5579E+01
95	3.3000E+00	-5.3515E-01	-3.8813E+00	-1.7699E+02	1.7041E+01
96	2.7679E+00	-5.0248E-01	-3.6366E+00	-6.1947E+01	1.8570E+01
97	2.7200E+00	-4.9551E-01	-3.7872E+00	-2.0257E+01	1.9148E+01
98	2.6000E+00	-4.8880E-01	-4.0115E+00	-9.8541E+00	1.9720E+01
99	2.5500E+00	-4.8105E-01	-4.5745E+00	-6.0626E+00	2.0693E+01
100	2.3600E+00	-4.7086E-01	-7.1538E+00	-3.9827E+00	2.2586E+01
101	2.1300E+00	-4.6670E-01	-1.2286E+01	-3.6154E+00	2.3939E+01
102	2.1000E+00	-4.6537E-01	-2.8424E+01	-3.5744E+00	2.4607E+01
103	2.0200E+00	-4.6379E-01	-1.4152E+02	-3.5796E+00	2.5717E+01
104	1.9300E+00	-4.6315E-01	-3.9479E+01	-3.6619E+00	2.7011E+01
105	1.8400E+00	-4.6343E-01	-2.3788E+01	-3.8070E+00	2.8438E+01
106	1.7550E+00	-4.6446E-01	-3.5893E+01	-4.0072E+00	2.9941E+01
107	1.6700E+00	-4.6622E-01	-8.1607E+01	-4.2581E+00	3.1627E+01
108	1.5900E+00	-4.6909E-01	-5.6255E+02	-4.5813E+00	3.3622E+01
109	1.5000E+00	-4.7133E-01	-1.8655E+03	-4.8328E+00	3.5102E+01
110	1.4750E+00	-4.7295E-01	-1.5003E+03	-4.9830E+00	3.5961E+01
111	1.4400E+00	-4.7580E-01	-4.3810E+02	-5.2732E+00	3.7590E+01
112	1.3700E+00	-4.7898E-01	-4.3218E+02	-5.5841E+00	3.9307E+01
113	1.3375E+00	-4.8161E-01	-6.6859E+02	-5.8183E+00	4.0586E+01
114	1.3000E+00	-4.8551E-01	-2.4012E+02	-6.2079E+00	4.2697E+01
115	1.2350E+00	-4.9157E-01	-6.0822E+01	-6.7657E+00	4.5692E+01
116	1.1700E+00	-4.9574E-01	-4.0248E+01	-7.1756E+00	4.7841E+01
117	1.1500E+00	-4.9810E-01	-3.4749E+01	-7.4189E+00	4.9190E+01
118	1.1230E+00	-5.0037E-01	-3.1291E+01	-7.6392E+00	5.0389E+01
119	1.1100E+00	-5.0208E-01	-2.9531E+01	-7.7961E+00	5.1211E+01
120	1.0970E+00	-5.0468E-01	-2.7410E+01	-8.0328E+00	5.2508E+01
121	1.0710E+00	-5.0811E-01	-2.5245E+01	-8.3585E+00	5.4341E+01
122	1.0450E+00	-5.1047E-01	-2.4068E+01	-8.6101E+00	5.5692E+01
123	1.0350E+00	-5.1213E-01	-2.3425E+01	-8.7880E+00	5.6673E+01
124	1.0200E+00	-5.1472E-01	-2.2605E+01	-9.0663E+00	5.8307E+01
125	9.9600E-01	-5.1733E-01	-2.2051E+01	-9.3286E+00	5.9799E+01
126	9.8600E-01	-5.1943E-01	-2.1749E+01	-9.5299E+00	6.0912E+01
127	9.7200E-01	-5.2258E-01	-2.1415E+01	-9.8323E+00	6.2667E+01
128	9.5000E-01	-5.2625E-01	-2.1187E+01	-1.0186E+01	6.4845E+01
129	9.3000E-01	-5.2974E-01	-2.1130E+01	-1.0558E+01	6.7114E+01
130	9.1000E-01	-5.3603E-01	-2.1434E+01	-1.1276E+01	7.1544E+01
131	8.6000E-01	-5.4223E-01	-2.2007E+01	-1.1934E+01	7.5690E+01
132	8.5000E-01	-5.5062E-01	-2.3348E+01	-1.2820E+01	8.1577E+01
133	7.9000E-01	-5.5851E-01	-2.5233E+01	-1.3755E+01	8.8088E+01
134	7.8000E-01	-5.6945E-01	-2.9587E+01	-1.5139E+01	9.8537E+01
135	7.0500E-01	-5.9320E-01	-4.7665E+01	-1.8156E+01	1.2501E+02
136	6.2500E-01	-6.2459E-01	-1.6071E+02	-2.2498E+01	1.7569E+02
137	5.4000E-01	-6.5294E-01	-9.9829E+02	-2.6744E+01	2.4527E+02

Group	Upper Energy, eV	Isotope			
		U238	NP237	Pu238	Pu239
138	5.0000E-01	-6.6682E-01	-2.0939E+03	-2.8985E+01	2.9567E+02
139	4.8500E-01	-6.8704E-01	-1.0326E+03	-3.2308E+01	3.9874E+02
140	4.3300E-01	-7.1542E-01	-2.3416E+02	-3.7221E+01	6.2836E+02
141	4.0000E-01	-7.3122E-01	-1.5164E+02	-4.0050E+01	8.2876E+02
142	3.9100E-01	-7.5287E-01	-1.1018E+02	-4.4072E+01	1.2746E+03
143	3.5000E-01	-7.8676E-01	-8.0437E+01	-5.0619E+01	2.4432E+03
144	3.2000E-01	-8.0551E-01	-7.2630E+01	-5.4389E+01	3.2866E+03
145	3.1450E-01	-8.1732E-01	-6.9596E+01	-5.6786E+01	3.6556E+03
146	3.0000E-01	-8.3901E-01	-6.5793E+01	-6.1301E+01	3.7728E+03
147	2.8000E-01	-8.7611E-01	-6.2465E+01	-6.9277E+01	2.8091E+03
148	2.4800E-01	-9.2566E-01	-6.1264E+01	-8.0371E+01	1.6900E+03
149	2.2000E-01	-9.9199E-01	-6.2575E+01	-9.5539E+01	1.0716E+03
150	1.8900E-01	-1.0344E+00	-6.4252E+01	-1.0577E+02	8.8284E+02
151	1.8000E-01	-1.0772E+00	-6.6442E+01	-1.1639E+02	7.8232E+02
152	1.6000E-01	-1.1436E+00	-7.0239E+01	-1.3284E+02	6.9919E+02
153	1.4000E-01	-1.1898E+00	-7.3110E+01	-1.4442E+02	6.6834E+02
154	1.3400E-01	-1.2507E+00	-7.7056E+01	-1.5976E+02	6.5124E+02
155	1.1500E-01	-1.3410E+00	-8.3155E+01	-1.8278E+02	6.4697E+02
156	1.0000E-01	-1.4014E+00	-8.7346E+01	-1.9846E+02	6.5331E+02
157	9.5000E-02	-1.4813E+00	-9.2986E+01	-2.1916E+02	6.6976E+02
158	8.0000E-02	-1.5562E+00	-9.8261E+01	-2.3852E+02	6.8889E+02
159	7.7000E-02	-1.6261E+00	-1.0323E+02	-2.5652E+02	7.1004E+02
160	6.7000E-02	-1.7425E+00	-1.1158E+02	-2.8637E+02	7.4889E+02
161	5.8000E-02	-1.8720E+00	-1.2081E+02	-3.1928E+02	7.9578E+02
162	5.0000E-02	-2.0262E+00	-1.3182E+02	-3.5819E+02	8.5462E+02
163	4.2000E-02	-2.2116E+00	-1.4508E+02	-4.0458E+02	9.2794E+02
164	3.5000E-02	-2.4027E+00	-1.5867E+02	-4.5189E+02	1.0052E+03
165	3.0000E-02	-2.6105E+00	-1.7339E+02	-5.0263E+02	1.0902E+03
166	2.5000E-02	-2.8845E+00	-1.9273E+02	-5.6873E+02	1.2035E+03
167	2.0000E-02	-3.2682E+00	-2.1973E+02	-6.6001E+02	1.3631E+03
168	1.5000E-02	-3.8642E+00	-2.6146E+02	-7.9959E+02	1.6121E+03
169	1.0000E-02	-4.6918E+00	-3.1914E+02	-9.9026E+02	1.9585E+03
170	6.9000E-03	-5.5865E+00	-3.8120E+02	-1.1939E+03	2.3332E+03
171	5.0000E-03	-6.8046E+00	-4.6545E+02	-1.4683E+03	2.8434E+03
172	3.0000E-03	-1.0499E+01	-7.2042E+02	-2.2911E+03	4.3901E+03
Lower Bound	1.1000E-04				

Group	Upper Energy, eV	Isotope			
		Pu240	Pu241	Pu242	TH232
1	1.9640E+07	9.9504E+00	9.3690E+00	9.5389E+00	2.1010E+00
2	1.7332E+07	9.9407E+00	8.8914E+00	8.8709E+00	2.0899E+00
3	1.4918E+07	9.3340E+00	8.9193E+00	8.4472E+00	2.3817E+00
4	1.3840E+07	8.3086E+00	8.2128E+00	7.7844E+00	2.7017E+00
5	1.1618E+07	7.8607E+00	7.5822E+00	7.3201E+00	2.7182E+00
6	1.0000E+07	7.2910E+00	7.0568E+00	6.8181E+00	2.3651E+00
7	8.1873E+06	6.2217E+00	6.3062E+00	5.7846E+00	1.3227E+00
8	6.7032E+06	5.0233E+00	4.9703E+00	4.4096E+00	4.3367E-01
9	6.0653E+06	4.2009E+00	4.1459E+00	3.6045E+00	2.4242E-01
10	5.4881E+06	3.8541E+00	3.5069E+00	3.1606E+00	2.2377E-01
11	4.4933E+06	3.8263E+00	3.4426E+00	3.0898E+00	1.9900E-01

Group	Upper Energy, eV	Isotope			
		Pu240	Pu241	Pu242	TH232
12	3.6788E+06	3.8196E+00	3.4946E+00	3.0807E+00	1.7307E-01
13	3.0119E+06	3.7314E+00	3.5246E+00	3.0738E+00	1.2917E-01
14	2.4660E+06	3.6549E+00	3.5747E+00	3.0461E+00	1.0649E-01
15	2.2313E+06	3.6550E+00	3.6069E+00	3.0145E+00	9.8721E-02
16	2.0190E+06	3.4594E+00	3.6043E+00	2.9367E+00	4.1059E-02
17	1.6530E+06	3.1582E+00	3.5193E+00	2.7932E+00	-4.7769E-03
18	1.3534E+06	3.0267E+00	3.3132E+00	2.8018E+00	-8.9925E-02
19	1.2246E+06	2.9990E+00	3.1675E+00	2.9119E+00	-1.1606E-01
20	1.1080E+06	2.9479E+00	3.0884E+00	2.8616E+00	-1.2813E-01
21	1.0026E+06	2.8051E+00	3.0183E+00	2.5205E+00	-1.3972E-01
22	9.0718E+05	2.4774E+00	2.9780E+00	2.0308E+00	-1.5200E-01
23	8.2085E+05	1.7628E+00	2.8585E+00	1.1578E+00	-1.6331E-01
24	6.0810E+05	1.1549E+00	2.7997E+00	5.9536E-01	-1.6171E-01
25	5.5023E+05	8.1387E-01	2.8192E+00	3.9466E-01	-1.5354E-01
26	4.9787E+05	5.2313E-01	2.8414E+00	2.3647E-01	-1.4790E-01
27	4.5049E+05	3.2811E-01	2.8691E+00	1.3166E-01	-1.4430E-01
28	4.0762E+05	1.5297E-01	3.0090E+00	3.4135E-02	-1.4346E-01
29	3.0197E+05	5.5584E-02	3.1871E+00	-2.9613E-02	-1.4627E-01
30	2.7324E+05	1.9954E-02	3.2635E+00	-5.5608E-02	-1.4903E-01
31	2.4724E+05	-4.6343E-02	3.4295E+00	-9.9820E-02	-1.6147E-01
32	1.8316E+05	-1.4227E-01	3.6098E+00	-1.5978E-01	-1.8829E-01
33	1.2277E+05	-1.8795E-01	3.7252E+00	-1.9827E-01	-2.0951E-01
34	1.1109E+05	-2.1936E-01	3.8453E+00	-2.3639E-01	-2.3273E-01
35	8.2298E+04	-2.6617E-01	3.9535E+00	-2.9734E-01	-2.7664E-01
36	6.7380E+04	-3.2028E-01	4.0409E+00	-3.6499E-01	-3.2778E-01
37	5.5166E+04	-4.0097E-01	4.1645E+00	-4.6978E-01	-3.9928E-01
38	4.0868E+04	-4.6411E-01	4.2804E+00	-5.4805E-01	-4.2297E-01
39	3.6979E+04	-5.1819E-01	4.4913E+00	-5.9803E-01	-4.4045E-01
40	2.9283E+04	-5.7107E-01	4.7124E+00	-6.4316E-01	-4.6372E-01
41	2.7394E+04	-6.0072E-01	4.8224E+00	-6.6966E-01	-4.8187E-01
42	2.4788E+04	-6.9715E-01	5.2415E+00	-7.4582E-01	-5.4159E-01
43	1.6616E+04	-7.9895E-01	5.6128E+00	-8.3600E-01	-6.0408E-01
44	1.5034E+04	-8.9053E-01	5.9071E+00	-9.1217E-01	-6.5625E-01
45	1.1138E+04	-1.0172E+00	6.2454E+00	-1.0468E+00	-7.2641E-01
46	9.1188E+03	-1.1266E+00	6.7196E+00	-1.1589E+00	-7.2839E-01
47	7.4659E+03	-1.3032E+00	7.6923E+00	-1.2461E+00	-7.8609E-01
48	5.5308E+03	-1.1826E+00	8.5801E+00	-1.3269E+00	-8.2771E-01
49	5.0045E+03	-1.4140E+00	9.6339E+00	-1.4661E+00	-9.4891E-01
50	3.5266E+03	-8.4403E-01	1.0468E+01	-1.5878E+00	-7.7470E-01
51	3.3546E+03	-1.1764E+00	1.1624E+01	-1.6926E+00	-1.1901E+00
52	2.2487E+03	-1.0631E+00	1.2928E+01	-1.7896E+00	-1.2564E+00
53	2.0347E+03	-1.8245E+00	1.4038E+01	-2.0315E+00	-1.3201E+00
54	1.5073E+03	-1.2343E+00	1.4990E+01	-2.2911E+00	-6.3428E-01
55	1.4338E+03	-1.9930E+00	1.5634E+01	-2.4167E+00	-1.5184E+00
56	1.2341E+03	-3.0443E+00	1.6623E+01	-2.6091E+00	-1.2427E+00
57	1.0104E+03	-4.8435E+00	1.6912E+01	-2.9461E+00	-1.3267E+00
58	9.1424E+02	-3.2253E+00	1.6631E+01	-3.4411E+00	-1.1872E+00
59	7.4852E+02	-1.3340E+00	1.7362E+01	-4.1054E+00	-1.9088E+00
60	6.7729E+02	-5.0580E+00	2.5046E+01	-4.1383E+00	-1.6092E+00
61	4.5400E+02	-5.8663E+00	3.3242E+01	-4.5837E+00	-6.4980E-01
62	3.7170E+02	-1.0293E+01	3.7016E+01	-7.4104E+00	-2.9684E+00
63	3.0433E+02	-6.7268E+00	4.3811E+01	-8.5091E+00	-1.7236E+00
64	2.0399E+02	-1.7715E+01	5.2637E+01	-5.3013E+00	-2.3901E+00

Group	Upper Energy, eV	Isotope			
		Pu240	Pu241	Pu242	TH232
65	1.4862E+02	-2.2593E-01	5.6273E+01	-4.0933E-01	-3.1147E-01
66	1.3674E+02	-3.5210E+01	3.4329E+01	-1.1213E+01	-2.6900E+00
67	9.1661E+01	-2.4685E+01	8.7470E+01	-1.7825E+00	-1.6700E-01
68	7.5674E+01	-8.3775E+01	2.5114E+01	-7.5269E-01	-9.6581E+00
69	6.7904E+01	-8.0057E+01	9.0478E+01	-1.6798E+01	-3.6925E+00
70	5.5595E+01	-2.2110E-01	6.3772E+00	-2.6961E+02	-1.6731E-01
71	5.1578E+01	-2.6117E-01	6.6791E+01	-1.4221E+00	-1.2584E-01
72	4.8252E+01	-4.7189E-01	1.2308E+02	-3.6283E-01	-1.5363E-01
73	4.5517E+01	-1.9143E+02	3.6218E+01	-8.7913E+00	-1.1418E-01
74	4.0169E+01	-3.6230E+02	8.2581E+01	-1.5399E-01	-1.2891E-01
75	3.7266E+01	-1.9566E+00	5.8476E+01	-7.1940E-02	-1.4473E-01
76	3.3720E+01	-4.0546E-01	1.1471E+02	-5.6092E-02	-1.4266E-01
77	3.0511E+01	-2.5153E-01	2.0068E+02	-5.1635E-02	-2.1573E-01
78	2.7608E+01	-2.3835E-01	1.8088E+02	-5.9648E-02	-6.2364E-01
79	2.4980E+01	-4.0439E-01	1.3394E+02	-7.7796E+00	-2.5259E+01
80	2.2603E+01	-1.5097E+02	1.7883E+01	-1.0283E+01	-1.2594E+01
81	1.9455E+01	-7.3792E-01	1.1178E+02	-7.3855E-02	-3.5124E-01
82	1.5928E+01	-2.6631E-01	5.1430E+02	-7.8607E+00	-2.2533E-01
83	1.3710E+01	-2.6499E-01	1.0716E+02	-1.2045E-01	-2.3301E-01
84	1.1224E+01	-3.1493E-01	1.8691E+02	-1.4462E-01	-2.1077E-01
85	9.9056E+00	-3.6787E-01	3.1914E+02	-1.8271E-01	-2.1734E-01
86	9.1898E+00	-4.3139E-01	3.9990E+02	-2.3154E-01	-3.4269E-01
87	8.3153E+00	-5.2689E-01	2.0358E+02	-3.1048E-01	-2.7658E-01
88	7.5240E+00	-7.3951E-01	6.1028E+02	-5.1837E-01	-2.5507E-01
89	6.1601E+00	-1.1138E+00	6.0839E+02	-9.7671E-01	-2.8226E-01
90	5.3464E+00	-1.4384E+00	2.3024E+02	-1.4737E+00	-3.0067E-01
91	5.0435E+00	-2.0820E+00	3.9742E+02	-2.9052E+00	-3.2850E-01
92	4.1293E+00	-2.8722E+00	1.8154E+02	-5.3286E+00	-3.5638E-01
93	4.0000E+00	-3.9524E+00	1.1242E+02	-1.1742E+01	-3.8350E-01
94	3.3807E+00	-5.3112E+00	8.2942E+01	-2.5328E+01	-4.1118E-01
95	3.3000E+00	-7.5740E+00	6.8912E+01	-2.2355E+02	-4.4308E-01
96	2.7679E+00	-1.0477E+01	5.9134E+01	-4.2676E+03	-4.7511E-01
97	2.7200E+00	-1.1780E+01	5.6794E+01	-2.1366E+04	-4.8645E-01
98	2.6000E+00	-1.3289E+01	5.4530E+01	-2.0354E+03	-4.9793E-01
99	2.5500E+00	-1.6104E+01	5.1405E+01	-3.6741E+02	-5.1635E-01
100	2.3600E+00	-2.3354E+01	4.5748E+01	-8.1766E+01	-5.5215E-01
101	2.1300E+00	-2.9811E+01	4.1760E+01	-4.6245E+01	-5.7619E-01
102	2.1000E+00	-3.3643E+01	3.9690E+01	-3.8865E+01	-5.8740E-01
103	2.0200E+00	-4.0971E+01	3.6209E+01	-3.0565E+01	-6.0550E-01
104	1.9300E+00	-5.1489E+01	3.3141E+01	-2.4501E+01	-6.2683E-01
105	1.8400E+00	-6.5841E+01	3.4462E+01	-2.0297E+01	-6.4782E-01
106	1.7550E+00	-8.6095E+01	4.1645E+01	-1.7271E+01	-6.7055E-01
107	1.6700E+00	-1.1548E+02	4.8517E+01	-1.5033E+01	-6.9469E-01
108	1.5900E+00	-1.6408E+02	5.1875E+01	-1.3197E+01	-7.2180E-01
109	1.5000E+00	-2.1240E+02	5.2749E+01	-1.2172E+01	-7.4070E-01
110	1.4750E+00	-2.4826E+02	5.2878E+01	-1.1702E+01	-7.5170E-01
111	1.4400E+00	-3.3831E+02	5.2942E+01	-1.0950E+01	-7.7124E-01
112	1.3700E+00	-4.6985E+02	5.2885E+01	-1.0312E+01	-7.9151E-01
113	1.3375E+00	-6.1351E+02	5.2809E+01	-9.9148E+00	-8.0575E-01
114	1.3000E+00	-9.9035E+02	5.2681E+01	-9.3936E+00	-8.2865E-01
115	1.2350E+00	-2.2035E+03	5.2545E+01	-8.8157E+00	-8.5885E-01
116	1.1700E+00	-4.3392E+03	5.2486E+01	-8.4852E+00	-8.8020E-01
117	1.1500E+00	-7.6771E+03	5.2460E+01	-8.3111E+00	-8.9244E-01

Group	Upper Energy, eV	Isotope			
		Pu240	Pu241	Pu242	TH232
118	1.1230E+00	-1.4146E+04	5.2451E+01	-8.1724E+00	-9.0276E-01
119	1.1100E+00	-2.3964E+04	5.2448E+01	-8.0893E+00	-9.0953E-01
120	1.0970E+00	-5.6696E+04	5.2456E+01	-7.9639E+00	-9.2101E-01
121	1.0710E+00	-1.0957E+05	5.2478E+01	-7.8034E+00	-9.3662E-01
122	1.0450E+00	-9.1724E+04	5.2502E+01	-7.7034E+00	-9.4735E-01
123	1.0350E+00	-5.7997E+04	5.2525E+01	-7.6343E+00	-9.5488E-01
124	1.0200E+00	-2.4753E+04	5.2570E+01	-7.5270E+00	-9.6663E-01
125	9.9600E-01	-1.2636E+04	5.2618E+01	-7.4406E+00	-9.7719E-01
126	9.8600E-01	-8.8248E+03	5.2657E+01	-7.3840E+00	-9.8500E-01
127	9.7200E-01	-5.7314E+03	5.2725E+01	-7.2988E+00	-9.9716E-01
128	9.5000E-01	-3.8060E+03	5.2819E+01	-7.2011E+00	-1.0117E+00
129	9.3000E-01	-2.7699E+03	5.2927E+01	-7.1184E+00	-1.0261E+00
130	9.1000E-01	-1.7959E+03	5.3165E+01	-6.9792E+00	-1.0527E+00
131	8.6000E-01	-1.2954E+03	5.3412E+01	-6.8731E+00	-1.0762E+00
132	8.5000E-01	-9.6792E+02	5.3808E+01	-6.7584E+00	-1.1062E+00
133	7.9000E-01	-7.4034E+02	5.4276E+01	-6.6595E+00	-1.1370E+00
134	7.8000E-01	-5.7328E+02	5.5145E+01	-6.5533E+00	-1.1791E+00
135	7.0500E-01	-3.8772E+02	5.7809E+01	-6.4099E+00	-1.2641E+00
136	6.2500E-01	-2.8183E+02	6.4600E+01	-6.3368E+00	-1.3727E+00
137	5.4000E-01	-2.3225E+02	7.6138E+01	-6.3210E+00	-1.4686E+00
138	5.0000E-01	-2.1590E+02	8.5601E+01	-6.3379E+00	-1.5165E+00
139	4.8500E-01	-1.9938E+02	1.0724E+02	-6.3819E+00	-1.5831E+00
140	4.3300E-01	-1.8247E+02	1.5862E+02	-6.4434E+00	-1.6754E+00
141	4.0000E-01	-1.7557E+02	2.0466E+02	-6.4924E+00	-1.7257E+00
142	3.9100E-01	-1.6849E+02	3.1354E+02	-6.5701E+00	-1.7942E+00
143	3.5000E-01	-1.6026E+02	6.2448E+02	-6.7061E+00	-1.9005E+00
144	3.2000E-01	-1.5690E+02	9.1076E+02	-6.7880E+00	-1.9585E+00
145	3.1450E-01	-1.5524E+02	1.1524E+03	-6.8420E+00	-1.9951E+00
146	3.0000E-01	-1.5273E+02	1.6713E+03	-6.9451E+00	-2.0607E+00
147	2.8000E-01	-1.4985E+02	2.3545E+03	-7.1308E+00	-2.1736E+00
148	2.4800E-01	-1.4787E+02	2.3209E+03	-7.3930E+00	-2.3240E+00
149	2.2000E-01	-1.4763E+02	1.7403E+03	-7.7650E+00	-2.5212E+00
150	1.8900E-01	-1.4836E+02	1.4678E+03	-8.0109E+00	-2.6479E+00
151	1.8000E-01	-1.4970E+02	1.3029E+03	-8.2656E+00	-2.7771E+00
152	1.6000E-01	-1.5256E+02	1.1537E+03	-8.6692E+00	-2.9718E+00
153	1.4000E-01	-1.5495E+02	1.0920E+03	-8.9547E+00	-3.1017E+00
154	1.3400E-01	-1.5863E+02	1.0495E+03	-9.3376E+00	-3.2764E+00
155	1.1500E-01	-1.6468E+02	1.0217E+03	-9.9139E+00	-3.5356E+00
156	1.0000E-01	-1.6906E+02	1.0187E+03	-1.0303E+01	-3.7081E+00
157	9.5000E-02	-1.7522E+02	1.0291E+03	-1.0824E+01	-3.9367E+00
158	8.0000E-02	-1.8118E+02	1.0458E+03	-1.1315E+01	-4.1499E+00
159	7.7000E-02	-1.8697E+02	1.0677E+03	-1.1777E+01	-4.3477E+00
160	6.7000E-02	-1.9691E+02	1.1111E+03	-1.2551E+01	-4.6761E+00
161	5.8000E-02	-2.0832E+02	1.1668E+03	-1.3418E+01	-5.0400E+00
162	5.0000E-02	-2.2227E+02	1.2400E+03	-1.4456E+01	-5.4726E+00
163	4.2000E-02	-2.3938E+02	1.3340E+03	-1.5711E+01	-5.9918E+00
164	3.5000E-02	-2.5735E+02	1.4355E+03	-1.7012E+01	-6.5269E+00
165	3.0000E-02	-2.7714E+02	1.5488E+03	-1.8430E+01	-7.1044E+00
166	2.5000E-02	-3.0357E+02	1.7013E+03	-2.0306E+01	-7.8689E+00
167	2.0000E-02	-3.4099E+02	1.9185E+03	-2.2943E+01	-8.9451E+00
168	1.5000E-02	-3.9970E+02	2.2603E+03	-2.7050E+01	-1.0608E+01
169	1.0000E-02	-4.8192E+02	2.7383E+03	-3.2768E+01	-1.2911E+01
170	6.9000E-03	-5.7136E+02	3.2575E+03	-3.8961E+01	-1.5397E+01

Group	Upper Energy, eV	Isotope			
		Pu240	Pu241	Pu242	TH232
171	5.0000E-03	-6.9364E+02	3.9657E+03	-4.7405E+01	-1.8781E+01
172	3.0000E-03	-1.0661E+03	6.1162E+03	-7.3050E+01	-2.9018E+01
Lower Bound	1.1000E-04				

Appendix 4 Difference of ($\nu\Sigma_f - \Sigma_a$) to natural uranium Sample for OSMOSE Samples

Group	Upper Energy, eV	OSMOSE Sample			
		U233	U234	URE	PU39
1	1.9640E+07	1.4207E-03	6.5768E-04	4.3793E-03	-2.9564E-03
2	1.7332E+07	1.4890E-03	5.8496E-04	4.2834E-03	-2.6098E-03
3	1.4918E+07	1.4885E-03	5.2638E-04	4.0300E-03	-2.3235E-03
4	1.3840E+07	1.3028E-03	4.2098E-04	3.1763E-03	-2.2746E-03
5	1.1618E+07	1.1669E-03	3.7656E-04	2.7512E-03	-2.1777E-03
6	1.0000E+07	1.0762E-03	3.9208E-04	2.6129E-03	-2.0005E-03
7	8.1873E+06	1.0381E-03	3.7026E-04	2.2506E-03	-1.2584E-03
8	6.7032E+06	9.8333E-04	3.1950E-04	1.7818E-03	-2.0639E-04
9	6.0653E+06	7.4849E-04	2.9645E-04	1.4450E-03	-4.2579E-05
10	5.4881E+06	7.4793E-04	2.8639E-04	1.2956E-03	1.6605E-04
11	4.4933E+06	7.6722E-04	3.0288E-04	1.3201E-03	1.9590E-04
12	3.6788E+06	7.7410E-04	3.1748E-04	1.3989E-03	2.0879E-04
13	3.0119E+06	7.8001E-04	3.0996E-04	1.4153E-03	2.6163E-04
14	2.4660E+06	7.7108E-04	2.9445E-04	1.3946E-03	2.7930E-04
15	2.2313E+06	7.6083E-04	2.9422E-04	1.3688E-03	3.0644E-04
16	2.0190E+06	7.5477E-04	2.9609E-04	1.3457E-03	3.8517E-04
17	1.6530E+06	7.6386E-04	2.6932E-04	1.4052E-03	6.7591E-04
18	1.3534E+06	8.0408E-04	2.7989E-04	1.5904E-03	1.1190E-03
19	1.2246E+06	7.9814E-04	2.6298E-04	1.5598E-03	1.1331E-03
20	1.1080E+06	7.9252E-04	2.4059E-04	1.5199E-03	1.1418E-03
21	1.0026E+06	7.8733E-04	2.4300E-04	1.4578E-03	1.1322E-03
22	9.0718E+05	7.8706E-04	2.6983E-04	1.3520E-03	1.1201E-03
23	8.2085E+05	7.8888E-04	2.3345E-04	1.2733E-03	1.0765E-03
24	6.0810E+05	7.9419E-04	1.5136E-04	1.2311E-03	1.0232E-03
25	5.5023E+05	8.0118E-04	1.2435E-04	1.2308E-03	1.0020E-03
26	4.9787E+05	8.0987E-04	9.2446E-05	1.2342E-03	9.8884E-04
27	4.5049E+05	8.1973E-04	6.0077E-05	1.2534E-03	9.7876E-04
28	4.0762E+05	8.3708E-04	1.7917E-05	1.2627E-03	9.6268E-04
29	3.0197E+05	8.5184E-04	-4.8842E-06	1.2519E-03	9.4360E-04
30	2.7324E+05	8.5455E-04	-7.8271E-06	1.2774E-03	9.3528E-04
31	2.4724E+05	8.4417E-04	-1.3609E-05	1.3199E-03	9.2561E-04
32	1.8316E+05	8.3622E-04	-2.3639E-05	1.3738E-03	9.3959E-04
33	1.2277E+05	8.4587E-04	-3.1273E-05	1.4212E-03	9.6460E-04
34	1.1109E+05	8.6348E-04	-3.3318E-05	1.4424E-03	9.9031E-04
35	8.2298E+04	8.9323E-04	-3.7017E-05	1.5489E-03	1.0297E-03
36	6.7380E+04	9.2580E-04	-3.7708E-05	1.6242E-03	1.0691E-03
37	5.5166E+04	9.8113E-04	-3.5884E-05	1.7033E-03	1.1271E-03
38	4.0868E+04	1.0305E-03	-3.7656E-05	1.7731E-03	1.1813E-03
39	3.6979E+04	1.0753E-03	-4.5767E-05	1.8862E-03	1.2445E-03
40	2.9283E+04	1.1158E-03	-4.9526E-05	1.9822E-03	1.2231E-03
41	2.7394E+04	1.1394E-03	-5.1836E-05	1.9682E-03	1.2456E-03
42	2.4788E+04	1.2151E-03	-6.3687E-05	2.1657E-03	1.3130E-03
43	1.6616E+04	1.3097E-03	-7.3405E-05	2.2790E-03	1.4192E-03
44	1.5034E+04	1.4115E-03	-8.5365E-05	2.5351E-03	1.4416E-03
45	1.1138E+04	1.5538E-03	-1.0390E-04	2.7115E-03	1.4582E-03
46	9.1188E+03	1.7409E-03	-1.3291E-04	2.5188E-03	1.4631E-03
47	7.4659E+03	1.9771E-03	-1.4895E-04	3.0656E-03	1.4270E-03
48	5.5308E+03	2.1341E-03	-1.5888E-04	3.6185E-03	1.4945E-03
49	5.0045E+03	2.2499E-03	-2.0148E-04	3.8952E-03	1.5180E-03
50	3.5266E+03	2.3710E-03	-2.3461E-04	4.2475E-03	1.1499E-03
51	3.3546E+03	2.8005E-03	-2.7294E-04	4.5477E-03	2.0572E-03

Group	Upper Energy, eV	OSMOSE Sample			
		U233	U234	URE	PU39
52	2.2487E+03	3.1513E-03	-3.5491E-04	2.9735E-03	9.2343E-04
53	2.0347E+03	3.3844E-03	-3.9272E-04	4.3345E-03	1.8359E-03
54	1.5073E+03	3.5468E-03	-6.4155E-04	3.9652E-03	2.3067E-03
55	1.4338E+03	3.6770E-03	-5.3881E-04	5.7576E-03	2.9871E-03
56	1.2341E+03	3.6499E-03	-5.4683E-04	5.9194E-03	2.9626E-03
57	1.0104E+03	3.6624E-03	-2.8665E-04	3.8431E-03	3.9166E-03
58	9.1424E+02	4.3500E-03	-1.0282E-03	6.1882E-03	2.9820E-03
59	7.4852E+02	5.0940E-03	-4.9975E-04	8.5746E-03	2.2250E-03
60	6.7729E+02	5.0210E-03	-9.4414E-04	9.7858E-03	4.5761E-03
61	4.5400E+02	5.1247E-03	-3.8382E-04	8.5655E-03	3.9560E-03
62	3.7170E+02	6.3270E-03	-1.8956E-03	9.4426E-03	1.6646E-03
63	3.0433E+02	7.3129E-03	-9.0481E-04	1.3690E-02	5.4755E-03
64	2.0399E+02	7.6361E-03	-4.7624E-03	1.2874E-02	7.0409E-03
65	1.4862E+02	7.5771E-03	-3.5559E-03	7.8946E-03	4.6283E-03
66	1.3674E+02	1.0586E-02	-5.0782E-03	1.0898E-02	9.1197E-03
67	9.1661E+01	1.2534E-02	-4.2311E-03	1.2796E-02	1.8980E-02
68	7.5674E+01	1.4035E-02	2.6437E-04	1.6727E-02	2.7254E-02
69	6.7904E+01	1.7536E-02	3.0589E-04	2.5668E-02	4.4115E-02
70	5.5595E+01	1.4889E-02	-7.1249E-05	3.5501E-02	-1.3326E-02
71	5.1578E+01	9.7248E-03	-2.5798E-02	3.3538E-02	5.6548E-03
72	4.8252E+01	7.5754E-03	-2.9210E-03	2.2738E-02	1.6760E-02
73	4.5517E+01	8.8924E-03	2.0541E-04	3.0460E-03	-1.8630E-02
74	4.0169E+01	1.2237E-02	6.2245E-04	2.7146E-02	3.8482E-03
75	3.7266E+01	2.1771E-02	2.2220E-03	4.5271E-02	1.7960E-02
76	3.3720E+01	2.1930E-02	-3.3600E-02	6.7820E-03	4.1764E-03
77	3.0511E+01	2.1582E-02	-3.8380E-04	9.3544E-03	7.1731E-04
78	2.7608E+01	2.1225E-02	-5.4388E-05	3.9617E-02	7.4803E-03
79	2.4980E+01	2.6535E-02	-2.1051E-03	2.5849E-02	4.7030E-03
80	2.2603E+01	4.5824E-02	2.3216E-03	1.2466E-02	3.4243E-02
81	1.9455E+01	3.4998E-02	7.7673E-05	3.4035E-02	1.3127E-02
82	1.5928E+01	2.0652E-02	-2.8493E-05	2.8266E-02	5.0735E-02
83	1.3710E+01	3.9966E-02	-1.3433E-05	-3.4428E-03	1.4268E-02
84	1.1224E+01	7.2477E-02	-1.8851E-05	1.4916E-02	1.1204E-01
85	9.9056E+00	2.4854E-02	-1.4700E-04	4.2159E-02	2.3366E-03
86	9.1898E+00	1.4082E-02	-3.1362E-04	1.4162E-01	4.6367E-04
87	8.3153E+00	1.0690E-02	-1.0211E-04	3.5090E-03	5.6716E-02
88	7.5240E+00	4.7692E-02	2.5631E-03	-1.3590E-02	4.3419E-02
89	6.1601E+00	3.9194E-02	-1.1104E-02	-1.7553E-01	1.6421E-02
90	5.3464E+00	1.9966E-02	-9.4829E-01	-1.5638E-01	6.9488E-03
91	5.0435E+00	3.2835E-02	-2.8154E-02	-1.4879E-02	5.3122E-03
92	4.1293E+00	1.8698E-02	-3.2413E-03	9.4718E-04	4.8653E-03
93	4.0000E+00	3.8909E-02	-2.0050E-03	1.6405E-02	4.8553E-03
94	3.3807E+00	3.6032E-02	-1.4309E-03	1.6660E-02	5.0901E-03
95	3.3000E+00	2.2866E-02	-1.1788E-03	2.5310E-02	5.2884E-03
96	2.7679E+00	1.5814E-02	-1.0042E-03	7.8050E-03	5.7954E-03
97	2.7200E+00	1.4454E-02	-9.8544E-04	7.1064E-03	5.4508E-03
98	2.6000E+00	1.3097E-02	-9.7009E-04	8.4586E-03	6.1772E-03
99	2.5500E+00	1.3741E-02	-9.4647E-04	9.8461E-03	6.4764E-03
100	2.3600E+00	1.0525E-01	-9.3408E-04	1.0662E-02	6.9776E-03
101	2.1300E+00	8.7959E-02	-9.3309E-04	7.6824E-03	7.3659E-03
102	2.1000E+00	9.3363E-02	-9.1460E-04	-8.0577E-03	7.7088E-03
103	2.0200E+00	1.2199E-01	-9.3445E-04	2.7032E-03	7.8676E-03
104	1.9300E+00	1.9356E-01	-9.6396E-04	1.1913E-02	8.0783E-03

Group	Upper Energy, eV	OSMOSE Sample			
		U233	U234	URE	PU39
105	1.8400E+00	2.8435E-01	-9.8271E-04	1.3101E-02	8.3960E-03
106	1.7550E+00	2.4931E-01	-1.0082E-03	1.3704E-02	8.7023E-03
107	1.6700E+00	1.7145E-01	-1.0413E-03	1.4170E-02	9.0030E-03
108	1.5900E+00	1.4026E-01	-1.0754E-03	1.4652E-02	9.2692E-03
109	1.5000E+00	1.2688E-01	-1.1009E-03	1.5050E-02	9.3830E-03
110	1.4750E+00	1.1954E-01	-1.1212E-03	1.5355E-02	9.3971E-03
111	1.4400E+00	1.0647E-01	-1.1560E-03	1.6320E-02	9.2703E-03
112	1.3700E+00	9.4483E-02	-1.1906E-03	1.8086E-02	8.8826E-03
113	1.3375E+00	8.7147E-02	-1.2141E-03	1.8808E-02	8.2922E-03
114	1.3000E+00	7.7891E-02	-1.2514E-03	2.2513E-02	6.3545E-03
115	1.2350E+00	6.8410E-02	-1.3463E-03	5.1299E-02	-1.1620E-03
116	1.1700E+00	6.3383E-02	-1.4255E-03	8.3532E-02	-1.5146E-02
117	1.1500E+00	6.1004E-02	-1.4638E-03	9.5533E-02	-3.7185E-02
118	1.1230E+00	5.9167E-02	-1.4876E-03	9.8377E-02	-8.0097E-02
119	1.1100E+00	5.8065E-02	-1.4984E-03	9.6509E-02	-1.4545E-01
120	1.0970E+00	5.6536E-02	-1.5123E-03	9.0948E-02	-3.6378E-01
121	1.0710E+00	5.4688E-02	-1.5288E-03	8.2257E-02	-7.1654E-01
122	1.0450E+00	5.3525E-02	-1.5404E-03	7.6677E-02	-5.9680E-01
123	1.0350E+00	5.2773E-02	-1.5497E-03	7.3337E-02	-3.7104E-01
124	1.0200E+00	5.1682E-02	-1.5651E-03	6.8943E-02	-1.4831E-01
125	9.9600E-01	5.0803E-02	-1.5840E-03	6.5799E-02	-6.6834E-02
126	9.8600E-01	5.0223E-02	-1.6024E-03	6.3998E-02	-4.1007E-02
127	9.7200E-01	4.9414E-02	-1.6302E-03	6.1756E-02	-1.9782E-02
128	9.5000E-01	4.8551E-02	-1.6635E-03	5.9723E-02	-6.2403E-03
129	9.3000E-01	4.7808E-02	-1.6958E-03	5.8284E-02	1.3782E-03
130	9.1000E-01	4.6688E-02	-1.7542E-03	5.6740E-02	9.2267E-03
131	8.6000E-01	4.5873E-02	-1.8019E-03	5.6032E-02	1.3818E-02
132	8.5000E-01	4.5142E-02	-1.8632E-03	5.6044E-02	1.7761E-02
133	7.9000E-01	4.4740E-02	-1.9206E-03	5.6450E-02	2.1219E-02
134	7.8000E-01	4.5079E-02	-2.0085E-03	5.7878E-02	2.5432E-02
135	7.0500E-01	4.6551E-02	-2.2093E-03	6.2232E-02	3.4506E-02
136	6.2500E-01	4.8780E-02	-2.4793E-03	7.0157E-02	5.0189E-02
137	5.4000E-01	5.0845E-02	-2.7033E-03	7.9137E-02	7.1106E-02
138	5.0000E-01	5.1846E-02	-2.8161E-03	8.4517E-02	8.6129E-02
139	4.8500E-01	5.3334E-02	-2.9949E-03	9.3289E-02	1.1675E-01
140	4.3300E-01	5.5373E-02	-3.2234E-03	1.0800E-01	1.8486E-01
141	4.0000E-01	5.6477E-02	-3.3541E-03	1.1760E-01	2.4428E-01
142	3.9100E-01	5.7901E-02	-3.5431E-03	1.3264E-01	3.7647E-01
143	3.5000E-01	6.0233E-02	-3.8326E-03	1.5738E-01	7.2304E-01
144	3.2000E-01	6.1624E-02	-3.9840E-03	1.6953E-01	9.7321E-01
145	3.1450E-01	6.2472E-02	-4.0809E-03	1.7487E-01	1.0827E+00
146	3.0000E-01	6.4024E-02	-4.2552E-03	1.7987E-01	1.1175E+00
147	2.8000E-01	6.6612E-02	-4.5334E-03	1.7658E-01	8.3170E-01
148	2.4800E-01	6.9619E-02	-4.9138E-03	1.6749E-01	4.9982E-01
149	2.2000E-01	7.2456E-02	-5.3696E-03	1.6534E-01	3.1639E-01
150	1.8900E-01	7.3572E-02	-5.6861E-03	1.6903E-01	2.6038E-01
151	1.8000E-01	7.4734E-02	-6.0278E-03	1.7588E-01	2.3050E-01
152	1.6000E-01	7.8004E-02	-6.5073E-03	1.8899E-01	2.0574E-01
153	1.4000E-01	8.1193E-02	-6.8501E-03	1.9930E-01	1.9650E-01
154	1.3400E-01	8.5834E-02	-7.2814E-03	2.1369E-01	1.9130E-01
155	1.1500E-01	9.3455E-02	-7.9426E-03	2.3603E-01	1.8985E-01
156	1.0000E-01	9.8659E-02	-8.3606E-03	2.5145E-01	1.9159E-01
157	9.5000E-02	1.0538E-01	-8.9415E-03	2.7203E-01	1.9629E-01

Group	Upper Energy, eV	OSMOSE Sample			
		U233	U234	URE	PU39
158	8.0000E-02	1.1154E-01	-9.4805E-03	2.9134E-01	2.0180E-01
159	7.7000E-02	1.1705E-01	-9.9795E-03	3.0930E-01	2.0791E-01
160	6.7000E-02	1.2608E-01	-1.0787E-02	3.3904E-01	2.1918E-01
161	5.8000E-02	1.3595E-01	-1.1680E-02	3.7166E-01	2.3280E-01
162	5.0000E-02	1.4761E-01	-1.2756E-02	4.0992E-01	2.4992E-01
163	4.2000E-02	1.6161E-01	-1.4049E-02	4.5501E-01	2.7127E-01
164	3.5000E-02	1.7605E-01	-1.5377E-02	5.0058E-01	2.9377E-01
165	3.0000E-02	1.9158E-01	-1.6807E-02	5.4890E-01	3.1858E-01
166	2.5000E-02	2.1190E-01	-1.8607E-02	6.1128E-01	3.5164E-01
167	2.0000E-02	2.4034E-01	-2.1205E-02	6.9738E-01	3.9824E-01
168	1.5000E-02	2.8442E-01	-2.5254E-02	8.3006E-01	4.7093E-01
169	1.0000E-02	3.4560E-01	-3.0749E-02	1.0145E+00	5.7207E-01
170	6.9000E-03	4.1162E-01	-3.6772E-02	1.2149E+00	6.8146E-01
171	5.0000E-03	5.0158E-01	-4.4824E-02	1.4883E+00	8.3040E-01
172	3.0000E-03	7.7422E-01	-6.9301E-02	2.3157E+00	1.2819E+00
Lower Bound	1.1000E-04				

Group	Upper Energy, eV	OSMOSE Sample			
		PU240	Pu241	PU242	NP237_1
1	1.9640E+07	-3.2122E-04	-4.6805E-04	-1.8554E-03	3.0956E-04
2	1.7332E+07	-2.4388E-04	-4.2114E-04	-1.7156E-03	2.9344E-04
3	1.4918E+07	-2.2228E-04	-3.5776E-04	-1.5571E-03	2.7204E-04
4	1.3840E+07	-2.4500E-04	-3.4448E-04	-1.5029E-03	2.4194E-04
5	1.1618E+07	-2.2883E-04	-3.3304E-04	-1.4216E-03	2.2572E-04
6	1.0000E+07	-2.1282E-04	-3.0972E-04	-1.3151E-03	2.1634E-04
7	8.1873E+06	-1.0840E-04	-1.8345E-04	-8.4830E-04	2.0599E-04
8	6.7032E+06	4.8465E-05	-3.1017E-05	-2.1455E-04	1.8216E-04
9	6.0653E+06	6.4340E-05	-8.1161E-06	-1.1241E-04	1.5215E-04
10	5.4881E+06	8.3413E-05	1.0381E-06	-3.9377E-05	1.3925E-04
11	4.4933E+06	9.2746E-05	6.2659E-06	-1.3992E-05	1.3995E-04
12	3.6788E+06	9.9654E-05	1.4778E-05	9.6438E-06	1.4409E-04
13	3.0119E+06	1.0303E-04	2.5601E-05	4.7846E-05	1.4292E-04
14	2.4660E+06	9.9273E-05	3.0387E-05	4.8101E-05	1.4030E-04
15	2.2313E+06	1.0347E-04	3.6575E-05	5.6799E-05	1.3900E-04
16	2.0190E+06	1.1049E-04	5.5608E-05	1.1965E-04	1.3548E-04
17	1.6530E+06	1.4700E-04	1.0517E-04	3.1918E-04	1.3213E-04
18	1.3534E+06	2.2347E-04	1.7149E-04	6.6172E-04	1.3568E-04
19	1.2246E+06	2.3284E-04	1.7376E-04	7.3342E-04	1.2965E-04
20	1.1080E+06	2.3847E-04	1.7778E-04	7.5545E-04	1.2639E-04
21	1.0026E+06	2.3049E-04	1.7804E-04	6.8467E-04	1.2051E-04
22	9.0718E+05	2.0863E-04	1.7799E-04	5.7283E-04	1.1194E-04
23	8.2085E+05	1.5653E-04	1.7361E-04	3.6573E-04	8.3734E-05
24	6.0810E+05	1.0832E-04	1.7010E-04	2.2408E-04	4.6896E-05
25	5.5023E+05	8.2408E-05	1.6982E-04	1.7405E-04	2.9392E-05
26	4.9787E+05	6.1099E-05	1.7184E-04	1.3603E-04	1.3468E-05
27	4.5049E+05	4.7292E-05	1.7401E-04	1.1298E-04	4.2430E-07
28	4.0762E+05	3.4198E-05	1.8192E-04	9.0449E-05	-1.8323E-05
29	3.0197E+05	2.6255E-05	1.9149E-04	7.5363E-05	-2.7480E-05
30	2.7324E+05	2.4626E-05	1.9661E-04	7.1335E-05	-2.9809E-05
31	2.4724E+05	2.0849E-05	2.0720E-04	6.5640E-05	-3.3444E-05

Group	Upper Energy, eV	OSMOSE Sample			
		PU240	Pu241	PU242	NP237_1
32	1.8316E+05	1.8210E-05	2.1979E-04	6.5720E-05	-4.2957E-05
33	1.2277E+05	1.7428E-05	2.2825E-04	6.9889E-05	-5.2188E-05
34	1.1109E+05	2.0022E-05	2.3957E-04	7.8642E-05	-5.7514E-05
35	8.2298E+04	2.2842E-05	2.5215E-04	9.3850E-05	-6.6075E-05
36	6.7380E+04	2.8543E-05	2.6486E-04	1.1060E-04	-7.3082E-05
37	5.5166E+04	3.8621E-05	2.8656E-04	1.4756E-04	-7.9168E-05
38	4.0868E+04	4.3933E-05	3.0142E-04	1.6706E-04	-8.5468E-05
39	3.6979E+04	4.5336E-05	3.1907E-04	1.7826E-04	-9.1994E-05
40	2.9283E+04	4.6964E-05	3.3617E-04	1.9027E-04	-9.7524E-05
41	2.7394E+04	4.9805E-05	3.4579E-04	1.9810E-04	-9.8851E-05
42	2.4788E+04	5.3112E-05	3.7824E-04	2.2544E-04	-1.0760E-04
43	1.6616E+04	5.9036E-05	4.1046E-04	2.5125E-04	-1.1643E-04
44	1.5034E+04	6.0817E-05	4.3510E-04	2.7208E-04	-1.2639E-04
45	1.1138E+04	5.5792E-05	4.5789E-04	2.5444E-04	-1.4128E-04
46	9.1188E+03	2.7496E-05	4.6399E-04	1.4276E-04	-1.6052E-04
47	7.4659E+03	3.1872E-05	5.3209E-04	2.0438E-04	-1.8233E-04
48	5.5308E+03	5.3622E-05	5.9218E-04	2.2306E-04	-1.9946E-04
49	5.0045E+03	2.1696E-05	6.3584E-04	1.3613E-04	-2.2767E-04
50	3.5266E+03	6.1492E-05	6.7765E-04	8.4019E-05	-2.5818E-04
51	3.3546E+03	6.8156E-05	7.6759E-04	1.8476E-04	-2.9085E-04
52	2.2487E+03	4.4027E-05	8.0899E-04	2.9332E-05	-3.4063E-04
53	2.0347E+03	-3.1536E-06	8.7790E-04	8.4230E-06	-3.8368E-04
54	1.5073E+03	8.0976E-06	8.9766E-04	-1.9139E-04	-4.2970E-04
55	1.4338E+03	3.4332E-06	9.7678E-04	-2.1103E-05	-4.4781E-04
56	1.2341E+03	-2.4876E-05	1.0768E-03	1.3787E-04	-4.9023E-04
57	1.0104E+03	-2.0602E-04	1.0510E-03	-1.4808E-04	-5.4015E-04
58	9.1424E+02	-5.6755E-05	1.0605E-03	-1.3026E-04	-5.8827E-04
59	7.4852E+02	1.0303E-04	1.1147E-03	-2.2447E-04	-6.3816E-04
60	6.7729E+02	-2.0068E-04	1.5028E-03	-3.3754E-04	-7.4417E-04
61	4.5400E+02	-2.2875E-04	1.9623E-03	-3.9228E-04	-8.7550E-04
62	3.7170E+02	-6.6707E-04	2.0775E-03	-1.1815E-03	-1.0095E-03
63	3.0433E+02	-2.5376E-04	2.5434E-03	-1.1782E-03	-1.1682E-03
64	2.0399E+02	-1.0771E-03	3.0149E-03	-4.2803E-04	-1.4232E-03
65	1.4862E+02	1.7980E-04	3.1732E-03	6.0132E-04	-1.3940E-03
66	1.3674E+02	-2.0575E-03	2.1870E-03	-1.0952E-03	-1.5559E-03
67	9.1661E+01	-1.3842E-03	4.9474E-03	5.5675E-04	-2.7291E-03
68	7.5674E+01	-5.1197E-03	1.6695E-03	1.9862E-04	-1.9367E-03
69	6.7904E+01	-5.5674E-03	5.1939E-03	-1.9521E-03	-3.3851E-03
70	5.5595E+01	-8.5113E-05	2.9909E-04	-3.7592E-02	-1.1025E-03
71	5.1578E+01	-4.3513E-05	3.5543E-03	-5.2448E-04	-7.9878E-03
72	4.8252E+01	-1.1392E-05	6.5866E-03	-1.5732E-04	-5.2328E-03
73	4.5517E+01	-1.1140E-02	2.4728E-03	-1.3564E-03	-8.7428E-04
74	4.0169E+01	-2.6467E-02	5.2893E-03	3.8729E-03	-3.9440E-03
75	3.7266E+01	3.3427E-03	5.9257E-03	1.3158E-02	-1.5844E-03
76	3.3720E+01	1.5519E-04	6.2968E-03	5.8244E-04	-1.6976E-03
77	3.0511E+01	1.5328E-04	1.0861E-02	2.5084E-04	-3.7463E-03
78	2.7608E+01	3.7938E-05	9.5841E-03	2.5346E-06	-7.5441E-03
79	2.4980E+01	1.8480E-04	7.3599E-03	-1.1334E-03	-8.0854E-03
80	2.2603E+01	-8.9509E-03	4.0826E-03	1.1801E-02	-5.0066E-03
81	1.9455E+01	1.2978E-04	6.1160E-03	5.6886E-04	-2.7653E-03
82	1.5928E+01	1.2837E-04	2.5671E-02	-1.9028E-03	-4.7719E-04
83	1.3710E+01	9.0753E-05	5.7241E-03	2.1917E-04	-3.1441E-03
84	1.1224E+01	2.0463E-04	1.0158E-02	5.0747E-04	-1.5442E-02

Group	Upper Energy, eV	OSMOSE Sample			
		PU240	Pu241	PU242	NP237_1
85	9.9056E+00	6.0986E-05	1.7144E-02	2.9569E-05	-7.7906E-03
86	9.1898E+00	-7.4007E-05	2.1008E-02	-5.7080E-04	-2.7859E-03
87	8.3153E+00	5.0880E-04	1.1400E-02	1.5705E-03	-1.1840E-03
88	7.5240E+00	6.8456E-03	3.3269E-02	2.6524E-02	-2.7064E-03
89	6.1601E+00	8.1652E-03	4.0429E-02	1.1572E-02	-5.8711E-03
90	5.3464E+00	1.2046E-03	1.3611E-02	2.3456E-03	4.5271E-04
91	5.0435E+00	2.5176E-04	2.0938E-02	4.0566E-04	-1.6457E-03
92	4.1293E+00	-8.0226E-06	9.9307E-03	-6.7796E-04	-1.4534E-03
93	4.0000E+00	-1.6380E-04	6.1875E-03	-2.4657E-03	-9.8963E-03
94	3.3807E+00	-2.9379E-04	4.5740E-03	-5.8578E-03	-2.6972E-04
95	3.3000E+00	-5.1161E-04	3.7880E-03	-5.4463E-02	-1.9126E-04
96	2.7679E+00	-9.2215E-04	3.2845E-03	-1.0439E+00	-1.7260E-04
97	2.7200E+00	-1.9410E-03	3.1541E-03	-5.2277E+00	-1.8056E-04
98	2.6000E+00	-1.0261E-03	3.0246E-03	-4.9772E-01	-1.9387E-04
99	2.5500E+00	-1.1523E-03	2.8557E-03	-8.9592E-02	-2.2441E-04
100	2.3600E+00	-1.6938E-03	2.5463E-03	-1.9716E-02	-3.6148E-04
101	2.1300E+00	-2.1789E-03	2.3355E-03	-1.1006E-02	-6.2850E-04
102	2.1000E+00	-2.4407E-03	2.2517E-03	-9.0833E-03	-1.4694E-03
103	2.0200E+00	-3.0239E-03	2.0399E-03	-7.1354E-03	-7.4074E-03
104	1.9300E+00	-3.8440E-03	1.8557E-03	-5.7232E-03	-2.0581E-03
105	1.8400E+00	-4.9354E-03	1.9297E-03	-4.7036E-03	-1.2356E-03
106	1.7550E+00	-6.4772E-03	2.3183E-03	-3.9682E-03	-1.8701E-03
107	1.6700E+00	-8.7145E-03	2.6889E-03	-3.4243E-03	-4.2686E-03
108	1.5900E+00	-1.2417E-02	2.8710E-03	-2.9785E-03	-2.9498E-02
109	1.5000E+00	-1.6099E-02	2.9176E-03	-2.7318E-03	-9.7853E-02
110	1.4750E+00	-1.8831E-02	2.9236E-03	-2.6189E-03	-7.8696E-02
111	1.4400E+00	-2.5694E-02	2.9254E-03	-2.4447E-03	-2.2970E-02
112	1.3700E+00	-3.5722E-02	2.9165E-03	-2.3050E-03	-2.2660E-02
113	1.3375E+00	-4.6677E-02	2.9026E-03	-2.2166E-03	-3.5062E-02
114	1.3000E+00	-7.5408E-02	2.8747E-03	-2.1295E-03	-1.2586E-02
115	1.2350E+00	-1.6787E-01	2.8382E-03	-2.2483E-03	-3.1927E-03
116	1.1700E+00	-3.3065E-01	2.7822E-03	-2.4900E-03	-2.1248E-03
117	1.1500E+00	-5.8499E-01	2.7602E-03	-2.6667E-03	-1.8409E-03
118	1.1230E+00	-1.0779E+00	2.7552E-03	-2.9061E-03	-1.6605E-03
119	1.1100E+00	-1.8259E+00	2.7590E-03	-3.2550E-03	-1.5674E-03
120	1.0970E+00	-4.3197E+00	2.7701E-03	-4.4628E-03	-1.4538E-03
121	1.0710E+00	-8.3480E+00	2.7879E-03	-6.4269E-03	-1.3370E-03
122	1.0450E+00	-6.9885E+00	2.7998E-03	-5.6602E-03	-1.2727E-03
123	1.0350E+00	-4.4188E+00	2.8073E-03	-4.2961E-03	-1.2378E-03
124	1.0200E+00	-1.8860E+00	2.8188E-03	-2.9327E-03	-1.1934E-03
125	9.9600E-01	-9.6274E-01	2.8273E-03	-2.4116E-03	-1.1624E-03
126	9.8600E-01	-6.7236E-01	2.8330E-03	-2.2337E-03	-1.1460E-03
127	9.7200E-01	-4.3667E-01	2.8414E-03	-2.0725E-03	-1.1272E-03
128	9.5000E-01	-2.8997E-01	2.8508E-03	-1.9555E-03	-1.1145E-03
129	9.3000E-01	-2.1102E-01	2.8599E-03	-1.8820E-03	-1.1108E-03
130	9.1000E-01	-1.3681E-01	2.8763E-03	-1.7933E-03	-1.1263E-03
131	8.6000E-01	-9.8670E-02	2.8926E-03	-1.7385E-03	-1.1552E-03
132	8.5000E-01	-7.3720E-02	2.9142E-03	-1.6926E-03	-1.2266E-03
133	7.9000E-01	-5.6378E-02	2.9414E-03	-1.6562E-03	-1.3237E-03
134	7.8000E-01	-4.3649E-02	2.9885E-03	-1.6273E-03	-1.5529E-03
135	7.0500E-01	-2.9511E-02	3.1269E-03	-1.6000E-03	-2.5014E-03
136	6.2500E-01	-2.1461E-02	3.4702E-03	-1.6164E-03	-8.4346E-03
137	5.4000E-01	-1.7673E-02	4.0959E-03	-1.6589E-03	-5.2376E-02

Group	Upper Energy, eV	OSMOSE Sample			
		PU240	Pu241	PU242	NP237_1
138	5.0000E-01	-1.6422E-02	4.6041E-03	-1.6931E-03	-1.0985E-01
139	4.8500E-01	-1.5159E-02	5.7647E-03	-1.7547E-03	-5.4178E-02
140	4.3300E-01	-1.3854E-02	8.5256E-03	-1.8601E-03	-1.2299E-02
141	4.0000E-01	-1.3309E-02	1.1005E-02	-1.9322E-03	-7.9727E-03
142	3.9100E-01	-1.2719E-02	1.6874E-02	-2.0504E-03	-5.8030E-03
143	3.5000E-01	-1.1932E-02	3.3661E-02	-2.2446E-03	-4.2515E-03
144	3.2000E-01	-1.1539E-02	4.9133E-02	-2.3419E-03	-3.8451E-03
145	3.1450E-01	-1.1324E-02	6.2210E-02	-2.3867E-03	-3.6877E-03
146	3.0000E-01	-1.0999E-02	9.0307E-02	-2.4352E-03	-3.4903E-03
147	2.8000E-01	-1.0718E-02	1.2733E-01	-2.4287E-03	-3.3118E-03
148	2.4800E-01	-1.0680E-02	1.2554E-01	-2.3909E-03	-3.2434E-03
149	2.2000E-01	-1.0848E-02	9.4123E-02	-2.4198E-03	-3.3096E-03
150	1.8900E-01	-1.0986E-02	7.9367E-02	-2.4769E-03	-3.3966E-03
151	1.8000E-01	-1.1141E-02	7.0432E-02	-2.5596E-03	-3.5126E-03
152	1.6000E-01	-1.1414E-02	6.2346E-02	-2.7104E-03	-3.7146E-03
153	1.4000E-01	-1.1626E-02	5.8994E-02	-2.8259E-03	-3.8685E-03
154	1.3400E-01	-1.1933E-02	5.6675E-02	-2.9842E-03	-4.0788E-03
155	1.1500E-01	-1.2425E-02	5.5146E-02	-3.2289E-03	-4.4028E-03
156	1.0000E-01	-1.2777E-02	5.4967E-02	-3.3978E-03	-4.6273E-03
157	9.5000E-02	-1.3265E-02	5.5510E-02	-3.6228E-03	-4.9275E-03
158	8.0000E-02	-1.3736E-02	5.6396E-02	-3.8340E-03	-5.2080E-03
159	7.7000E-02	-1.4190E-02	5.7563E-02	-4.0333E-03	-5.4736E-03
160	6.7000E-02	-1.4968E-02	5.9877E-02	-4.3640E-03	-5.9197E-03
161	5.8000E-02	-1.5856E-02	6.2856E-02	-4.7286E-03	-6.4114E-03
162	5.0000E-02	-1.6939E-02	6.6781E-02	-5.1593E-03	-6.9984E-03
163	4.2000E-02	-1.8262E-02	7.1828E-02	-5.6731E-03	-7.7038E-03
164	3.5000E-02	-1.9649E-02	7.7276E-02	-6.1974E-03	-8.4279E-03
165	3.0000E-02	-2.1174E-02	8.3362E-02	-6.7595E-03	-9.2096E-03
166	2.5000E-02	-2.3205E-02	9.1555E-02	-7.4925E-03	-1.0238E-02
167	2.0000E-02	-2.6079E-02	1.0323E-01	-8.5109E-03	-1.1674E-02
168	1.5000E-02	-3.0582E-02	1.2161E-01	-1.0087E-02	-1.3892E-02
169	1.0000E-02	-3.6890E-02	1.4731E-01	-1.2279E-02	-1.6958E-02
170	6.9000E-03	-4.3751E-02	1.7524E-01	-1.4660E-02	-2.0259E-02
171	5.0000E-03	-5.3132E-02	2.1332E-01	-1.7908E-02	-2.4737E-02
172	3.0000E-03	-8.1705E-02	3.2896E-01	-2.7756E-02	-3.8295E-02
Lower Bound	1.1000E-04				

Group	Upper Energy, eV	OSMOSE Sample			
		NP37_2			
1	1.9640E+07	2.8359E-03			
2	1.7332E+07	2.6536E-03			
3	1.4918E+07	2.4514E-03			
4	1.3840E+07	2.2087E-03			
5	1.1618E+07	2.0637E-03			
6	1.0000E+07	1.9709E-03			
7	8.1873E+06	1.7477E-03			
8	6.7032E+06	1.3815E-03			
9	6.0653E+06	1.1499E-03			
10	5.4881E+06	1.0193E-03			
11	4.4933E+06	1.0237E-03			
12	3.6788E+06	1.0473E-03			

Group	Upper Energy, eV	OSMOSE Sample			
		NP37_2			
13	3.0119E+06	1.0317E-03			
14	2.4660E+06	1.0100E-03			
15	2.2313E+06	9.9922E-04			
16	2.0190E+06	9.5494E-04			
17	1.6530E+06	8.8867E-04			
18	1.3534E+06	8.3632E-04			
19	1.2246E+06	7.9296E-04			
20	1.1080E+06	7.6008E-04			
21	1.0026E+06	7.2458E-04			
22	9.0718E+05	6.5512E-04			
23	8.2085E+05	4.8756E-04			
24	6.0810E+05	2.6822E-04			
25	5.5023E+05	1.6020E-04			
26	4.9787E+05	6.0300E-05			
27	4.5049E+05	-2.2761E-05			
28	4.0762E+05	-1.2951E-04			
29	3.0197E+05	-1.8340E-04			
30	2.7324E+05	-1.9852E-04			
31	2.4724E+05	-2.2713E-04			
32	1.8316E+05	-2.8372E-04			
33	1.2277E+05	-3.3673E-04			
34	1.1109E+05	-3.7843E-04			
35	8.2298E+04	-4.3381E-04			
36	6.7380E+04	-4.8436E-04			
37	5.5166E+04	-5.4043E-04			
38	4.0868E+04	-5.8557E-04			
39	3.6979E+04	-6.2855E-04			
40	2.9283E+04	-6.6435E-04			
41	2.7394E+04	-6.8153E-04			
42	2.4788E+04	-7.3981E-04			
43	1.6616E+04	-8.0820E-04			
44	1.5034E+04	-8.7533E-04			
45	1.1138E+04	-9.7074E-04			
46	9.1188E+03	-1.0659E-03			
47	7.4659E+03	-1.2050E-03			
48	5.5308E+03	-1.3288E-03			
49	5.0045E+03	-1.5015E-03			
50	3.5266E+03	-1.6687E-03			
51	3.3546E+03	-1.8935E-03			
52	2.2487E+03	-2.1778E-03			
53	2.0347E+03	-2.4438E-03			
54	1.5073E+03	-2.6963E-03			
55	1.4338E+03	-2.8512E-03			
56	1.2341E+03	-3.1525E-03			
57	1.0104E+03	-3.4329E-03			
58	9.1424E+02	-3.7354E-03			
59	7.4852E+02	-4.0593E-03			
60	6.7729E+02	-4.6963E-03			
61	4.5400E+02	-5.5334E-03			
62	3.7170E+02	-6.1852E-03			
63	3.0433E+02	-7.3431E-03			
64	2.0399E+02	-8.8186E-03			
65	1.4862E+02	-8.4724E-03			

Group	Upper Energy, eV	OSMOSE Sample			
		NP37_2			
66	1.3674E+02	-9.8427E-03			
67	9.1661E+01	-1.6867E-02			
68	7.5674E+01	-1.2900E-02			
69	6.7904E+01	-2.0338E-02			
70	5.5595E+01	-6.5413E-03			
71	5.1578E+01	-4.4617E-02			
72	4.8252E+01	-3.0629E-02			
73	4.5517E+01	-7.3207E-03			
74	4.0169E+01	-2.4190E-02			
75	3.7266E+01	-1.3150E-02			
76	3.3720E+01	-1.0134E-02			
77	3.0511E+01	-2.0777E-02			
78	2.7608E+01	-4.1236E-02			
79	2.4980E+01	-4.5024E-02			
80	2.2603E+01	-3.2337E-02			
81	1.9455E+01	-1.6072E-02			
82	1.5928E+01	-2.8421E-03			
83	1.3710E+01	-1.7905E-02			
84	1.1224E+01	-8.7260E-02			
85	9.9056E+00	-4.4120E-02			
86	9.1898E+00	-1.6375E-02			
87	8.3153E+00	-7.3959E-03			
88	7.5240E+00	-2.1742E-02			
89	6.1601E+00	-6.3707E-02			
90	5.3464E+00	-1.6506E-03			
91	5.0435E+00	-1.0318E-02			
92	4.1293E+00	-8.9298E-03			
93	4.0000E+00	-5.9611E-02			
94	3.3807E+00	-1.7165E-03			
95	3.3000E+00	-1.2133E-03			
96	2.7679E+00	-1.1318E-03			
97	2.7200E+00	-1.1800E-03			
98	2.6000E+00	-1.2515E-03			
99	2.5500E+00	-1.4308E-03			
100	2.3600E+00	-2.2447E-03			
101	2.1300E+00	-3.8615E-03			
102	2.1000E+00	-8.9455E-03			
103	2.0200E+00	-4.4609E-02			
104	1.9300E+00	-1.2438E-02			
105	1.8400E+00	-7.4910E-03			
106	1.7550E+00	-1.1307E-02			
107	1.6700E+00	-2.5721E-02			
108	1.5900E+00	-1.7736E-01			
109	1.5000E+00	-5.8819E-01			
110	1.4750E+00	-4.7304E-01			
111	1.4400E+00	-1.3812E-01			
112	1.3700E+00	-1.3626E-01			
113	1.3375E+00	-2.1080E-01			
114	1.3000E+00	-7.5701E-02			
115	1.2350E+00	-1.9176E-02			
116	1.1700E+00	-1.2698E-02			
117	1.1500E+00	-1.0967E-02			
118	1.1230E+00	-9.8774E-03			

Group	Upper Energy, eV	OSMOSE Sample			
		NP37_2			
119	1.1100E+00	-9.3216E-03			
120	1.0970E+00	-8.6518E-03			
121	1.0710E+00	-7.9666E-03			
122	1.0450E+00	-7.5939E-03			
123	1.0350E+00	-7.3907E-03			
124	1.0200E+00	-7.1302E-03			
125	9.9600E-01	-6.9548E-03			
126	9.8600E-01	-6.8596E-03			
127	9.7200E-01	-6.7533E-03			
128	9.5000E-01	-6.6810E-03			
129	9.3000E-01	-6.6630E-03			
130	9.1000E-01	-6.7581E-03			
131	8.6000E-01	-6.9383E-03			
132	8.5000E-01	-7.3614E-03			
133	7.9000E-01	-7.9541E-03			
134	7.8000E-01	-9.3278E-03			
135	7.0500E-01	-1.5028E-02			
136	6.2500E-01	-5.0673E-02			
137	5.4000E-01	-3.1476E-01			
138	5.0000E-01	-6.6021E-01			
139	4.8500E-01	-3.2557E-01			
140	4.3300E-01	-7.3838E-02			
141	4.0000E-01	-4.7822E-02			
142	3.9100E-01	-3.4754E-02			
143	3.5000E-01	-2.5381E-02			
144	3.2000E-01	-2.2921E-02			
145	3.1450E-01	-2.1966E-02			
146	3.0000E-01	-2.0768E-02			
147	2.8000E-01	-1.9716E-02			
148	2.4800E-01	-1.9334E-02			
149	2.2000E-01	-1.9745E-02			
150	1.8900E-01	-2.0273E-02			
151	1.8000E-01	-2.0964E-02			
152	1.6000E-01	-2.2164E-02			
153	1.4000E-01	-2.3070E-02			
154	1.3400E-01	-2.4317E-02			
155	1.1500E-01	-2.6243E-02			
156	1.0000E-01	-2.7566E-02			
157	9.5000E-02	-2.9348E-02			
158	8.0000E-02	-3.1013E-02			
159	7.7000E-02	-3.2582E-02			
160	6.7000E-02	-3.5221E-02			
161	5.8000E-02	-3.8134E-02			
162	5.0000E-02	-4.1612E-02			
163	4.2000E-02	-4.5800E-02			
164	3.5000E-02	-5.0091E-02			
165	3.0000E-02	-5.4738E-02			
166	2.5000E-02	-6.0846E-02			
167	2.0000E-02	-6.9372E-02			
168	1.5000E-02	-8.2545E-02			
169	1.0000E-02	-1.0075E-01			
170	6.9000E-03	-1.2035E-01			
171	5.0000E-03	-1.4695E-01			

Group	Upper Energy, eV	OSMOSE Sample			
		NP37_2			
172 Lower Bound	3.0000E-03 1.1000E-04	-2.2746E-01			

Appendix 5 DRAGON Input deck for natural uranium Sample

```
*----
*  Define STRUCTURES and MODULES used
*----
LINKED_LIST
  ASSMBH ASSMBC DISCR1 DISCR2 LIBRARY CP CALC OUT COMPO
  TRACK TRACKS SYS FLUX BURNUP EDITION ;
SEQ_ASCII
  RES ;
MODULE
  GEO: JPMT: SYBILT: LIB: SHI: ASM: FLU: EVO: EDI: CPO: PSP:
  FREE: DELETE: END: ;
LIBRARY := LIB: ::
  NMIX 6 CTRA WIMS
  DEPL LIB: WIMSD4 FIL: WNEALIB
  MIXS LIB: WIMSD4 FIL: WNEALIB
  MIX  1  300.0                                          (* Sample Unat  *)
     U234      = '234'    1.3890E-06 1 SHIB '234.1'
     U235      = '235'    1.6720E-04 1 SHIB '235.1'
     U236      = '236'    4.6310E-06 1 SHIB '236.1'
     U238      = '2238'   2.2980E-02 1 SHIB '2238.1'
     O16       = '16'     4.6320E-02
  MIX  2  300.0                                            (* Air Gap *)
    O16       = '16'     1.0000E-06
  MIX  3  300.0                                            (* Zr-4    *)
    Zr        = '91'     4.2470E-02
    HZr       = '2191'   4.8990E-05
    Fe54      = '1054'   8.6830E-06
    Fe56      = '56'     1.3630E-04
    Fe57      = '57'     3.1480E-06
    Fe58      = '158'    4.1890E-07
    Cr50      = '50'     3.3010E-06
    Cr52      = '52'     6.3660E-05
    Cr53      = '53'     7.2190E-06
    Cr54      = '54'     1.7970E-06
    O16       = '16'     3.0860E-04
    C12       = '1212'   4.4400E-05
    Hf        = '178'    1.1070E-06
  MIX  4  300.0                                            (* AG-3    *)
    AL27      = '27'     5.4570E-02
    MG        = '24'     1.9590E-03
    MN        = '55'     6.9880E-05
    Fe54      = '1054'   3.2140E-06
    Fe56      = '56'     5.0460E-05
    Fe57      = '57'     1.1650E-06
    Fe58      = '158'    1.5510E-07
    CR50      = '50'     1.9250E-06
    CR52      = '52'     3.7120E-05
    CR53      = '53'     4.2090E-06
    CR54      = '54'     1.0480E-06
    Ti        = '48'     2.4050E-05
    Si        = '29'     1.0940E-04
    Cu63      = '63'     8.3580E-06
    Cu65      = '65'     3.7250E-06
  MIX  5  300.0                                          (* Water    *)
    H         = '2001'   6.6740E-02
    O16       = '16'     3.3370E-02
  MIX  6  300.0                                          (* U-235 3% *)
    U234      = '234'    4.6170E-06 1 SHIB '234.1'
    U235      = '235'    6.9000E-04 1 SHIB '235.1'
    U236      = '236'    5.4930E-06 1 SHIB '236.1'
    U238      = '2238'   2.2000E-02 1 SHIB '2238.1'
    O16       = '16'     4.6470E-02
```

```
  ;
*----
*  Geometry ASSMBH :  2-D Fuel Lattice
*----
ASSMBH := GEO: :: CAR2D  6  6
 X- DIAG  X+ REFL  Y- SYME  Y+ DIAG
 CELL  C1  C2  C2  C2  C2  C2
           C2  C2  C2  C2  C2
               C2  C2  C2  C2
                   C2  C2  C2
                       C2  C2
                           C2
 ::: C1 := GEO: CARCEL  7
  RADIUS  0.000 0.405 0.418 0.475 0.510 0.530 0.550 0.600
  MIX  1 2 3 2 3 5 4 5
  MESHX -0.63  0.63  SPLITX 2
  MESHY -0.63  0.63  SPLITY 2 ;
 ::: C2 := GEO: CARCEL  5
  RADIUS  0.000 0.4023 0.4100 0.4700 0.4850 0.5500
  MIX  6 2 3 5 4 5
  MESHX -0.63  0.63  SPLITX 2
  MESHY -0.63  0.63  SPLITY 2 ;
  ;
*----
*  Self-Shielding calculation JPM
*  Transport calculation      SYBIL
*  Flux calculation for B1 homogeneous leakage
*  Editing using SPH model for transport-diffusion
*----
DISCR1 := JPMT: ASSMBH ::
  TITLE 'HALF OF A HEXAGONAL ASSEMBLY WITH ER LBP'
  MAXR 2000 MAXZ 10200 ;
LIBRARY := SHI: LIBRARY DISCR1 :: ;
DISCR2 := SYBILT: ASSMBH ::
  TITLE 'TCWD03: MULTICELL HEXAGONAL ASSEMBLY WITH ER LBP'
  MAXR 2000 MAXZ 10200 ;
CP := ASM: LIBRARY DISCR2 :: ;
CALC := FLU: CP LIBRARY DISCR2 ::
 EXTE 60  1.0E-05
 THER 60  1.0E-05
 TYPE B B0 ;
 OUT := EDI: CALC LIBRARY DISCR2 ASSMBH ::
  EDIT 2
  MERG COMP
  COND
  SAVE
  ;
END: ;
```

Appendix 6 MCNP input deck for 11×11 lattice of R1-UO2 configuration

```
OSMOSE - R1-UO2 Lattice
c **********************
c CELL DEFINITIONS
c **********************
1    0  71 -72 73 -74 75 -76   fill=10    imp:n=1
2    0  (-71:72:-73:74:-75:76)            imp:n=0       $Out of system
c
100  0 -600 lat=1                    u=10 imp:n=1
      fill -10:10 -10:10 0:0
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 7 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
      2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
c
c UO2 fuel pin (U-235 3% wt.) - U=2 - Level 1
620  22  6.917e-2  -620                             u=2 imp:n=1 $Fuel pellets
621  10  -1.18     -621                             u=2 imp:n=1 $Plexiglas spacer (lower)
622  10  -1.18     -622                             u=2 imp:n=1 $Plexiglas spacer (upper)
623   6  -7.85     -623                             u=2 imp:n=1 $SS spacer (lower)
624   6  -7.85     -624                             u=2 imp:n=1 $SS spacer (upper)
625   0            -625 620 621 622 623 624         u=2 imp:n=1 $Void inside the clad
626   7  -6.56     -626 625                         u=2 imp:n=1 $Zr4 clad
627  32  6.468e-2  -627                             u=2 imp:n=1 $Lower end plug (Zr4 + water)
628  33  4.742e-2  -628                             u=2 imp:n=1 $Upper end plug (Zr4 + SS)
629  34  9.503e-2  -629                             u=2 imp:n=1 $Gripping head (SS + water)
630  3   -2.55     -610 611                         u=2 imp:n=1 $Lower grid plate
631  3   -2.55     -613 612                         u=2 imp:n=1 $Overclad
632  3   -2.55     -614 615                         u=2 imp:n=1 $Upper grid plate
633  1   -0.99823   626 627 628 629
                     #630 #631 #632                 u=2 imp:n=1 $Water
c
c Sample cell - Water
675   1  1.0010E-01    -675        681 -682    u=7 imp:n=1 vol=9.835934 $Water Gap
676  64  8.5420E-02    -676  675   681 -682    u=7 imp:n=1 vol=1.869640 $SS  Clad
677   1  1.0010E-01          676   681 -682    u=7 imp:n=1 vol=4.726086 $Water
c
678   1  1.0010E-01    -677                    u=7 imp:n=1 $Bottom Water ring
679  64  8.5420E-02    -678  677               u=7 imp:n=1 $Bottom SS  Clad
680  63  5.6840E-06    -679                    u=7 imp:n=1 $Lower AG-3 Rod
681   1  1.0010E-01    -675  678  -681  #680   u=7 imp:n=1 $Lower Water Gap
682  64  8.5420E-02    -676  675  -681         u=7 imp:n=1 $Lower  SS  Clad
683   1  1.0010E-01          676  -681         u=7 imp:n=1 $Water
c
684  63  5.6840E-06    -680                    u=7 imp:n=1 $Upper AG-3 Rod
685   1  1.0010E-01    -675        682  #684   u=7 imp:n=1 $Water Gap
686  64  8.5420E-02    -676  675   682         u=7 imp:n=1 $Upper  SS  Clad
687   1  1.0010E-01          676   682         u=7 imp:n=1 $Water

c **********************
c BOUNDARY DEFINITIONS
c **********************
c General
```

```
600 rpp -0.63 0.63 -0.63 0.63  73.04 161.2        $Experimental Zone Cell (Infinite in Z)
c
c Grid and overclad (level 1)
610 pz   75.2                                     $Lower grid plate (Infinite in X & Y)
611 rcc  0 0 74.7  0 0 0.5   0.485                $Lower grid plate
612 rcc  0 0 75.2  0 0 79.5  0.485                $Overclad ID
613 rcc  0 0 75.2  0 0 79.5  0.55                 $Overclad OD
614 rpp -1.0 1.0 -1.0 1.0  154.7 156.7            $Upper grid plate (Infinite in X & Y)
615 rcc  0 0 154.7 0 0 2.0   0.485                $Upper grid plate
c
c UO2 fuel pin (U-235 3% wt.) (level 1)
620 rcc  0 0 90.7   0 0 50.0   0.4023             $Fuel pellets
621 rcc  0 0 77.7   0 0 13.0   0.39               $Plexiglas spacer (lower)
622 rcc  0 0 140.7  0 0 13.0   0.39               $Plexiglas spacer (upper)
623 rcc  0 0 75.95  0 0 1.75   0.39               $SS spacer (lower)
624 rcc  0 0 153.7  0 0 1.5    0.39               $SS spacer (upper)
625 rcc  0 0 75.95  0 0 79.25  0.41               $Clad ID
626 rcc  0 0 75.95  0 0 79.25  0.47               $Clad OD
627 rcc  0 0 74.7   0 0 1.25   0.47               $Lower end plug
628 rcc  0 0 155.2  0 0 1.5    0.47               $Upper end plug
629 rcc  0 0 156.7  0 0 3.0    0.47               $Gripping head
c
c Sample cell
675 rcc  0 0  73.825 0 0 90.00 0.550              $Inner surface of SS  Clad
676 rcc  0 0  73.825 0 0 90.00 0.600              $Outer surface of SS  Clad
677 rcc  0 0  73.825 0 0  1.50 0.425              $Water
678 rcc  0 0  73.825 0 0  1.50 0.550              $SS  Clad
679 rcc  0 0  75.325 0 0 35.20 0.485              $Lower AG-3 Rod
680 rcc  0 0 120.875 0 0 42.95 0.485              $Upper AG-3 Rod
681  pz  110.525                                  $Lower surface of sample
682  pz  120.875                                  $Upper surface of sample
c
c  Boundary Surface
*71   pz    73.0405
*72   pz   161.19995
*73   px    -9.44999
*74   px     9.44999
*75   py    -9.44999
*76   py     9.44999

c **********************
c MATERIAL DEFINITIONS
c **********************
c
c Structural materials
m1    1001.60c  6.674E-02  $Water
      8016.60c  3.337E-02
c     tot 1.001E-01
mt1   lwtr.01t
c
m3    13027.60c 5.457E-02  $AG-3 (density = 2.55)
      12000.60c 1.959E-03
      25055.60c 6.988E-05
      26054.60c 3.214E-06
      26056.60c 5.046E-05
      26057.60c 1.165E-06
      26058.60c 1.551E-07
      24050.60c 1.925E-06
      24052.60c 3.712E-05
      24053.60c 4.209E-06
      24054.60c 1.048E-06
      22000.60c 2.405E-05
      14000.60c 1.094E-04
      29063.60c 8.358E-06
      29065.60c 3.725E-06
      30000.42c 2.348E-05 $add
c     tot 5.686E-02
c
m6    26054.60c 3.387E-03 $SS (density = 7.85)
      26056.60c 5.316E-02
      26057.60c 1.228E-03
      26058.60c 1.634E-04
```

```
      6000.60c  5.904E-05  $C-nat replace C-12
      24050.60c 7.111E-04
      24052.60c 1.371E-02
      24053.60c 1.555E-03
      24054.60c 3.870E-04
      28058.60c 6.031E-03
      28060.60c 2.323E-03
      28061.60c 1.010E-04
      28062.60c 3.220E-04
      28064.60c 8.200E-05
      25055.60c 8.605E-04
      14000.60c 8.416E-04
      16000.60c 2.221E-05 $add
      15031.60c 3.434E-05 $add
      42000.60c 4.927E-04
c     tot 8.548E-02
c
m7    40000.60c 4.247E-02 $Zr4 (density = 6.56)
      1001.60c  4.899E-05
      50000.42c 4.826E-04
      26054.60c 8.683E-06
      26056.60c 1.363E-04
      26057.60c 3.148E-06
      26058.60c 4.189E-07
      24050.60c 3.301E-06
      24052.60c 6.366E-05
      24053.60c 7.219E-06
      24054.60c 1.797E-06
      8016.60c  3.086E-04
      6000.60c  4.440E-05 $C-nat replace C-12
      72000.60c 1.107E-06
c mt7   zr/h.01t
c
m10   6000.60c  0.33333   $Plexiglas (C5H8O2 - methyl methacrylate) (density = 1.18)
      1001.60c  0.53334
      8016.60c  0.13333
c mt10  poly.60t
c
m22   92234.60c 4.617E-06 $UO2 pellet (U-235 3% wt.) (density = 6.917e-2 at/bcm)
      92235.60c 6.900E-04
      92236.60c 5.493E-06
      92238.60c 2.200E-02
       8016.60c 4.647E-02
c
m32   40000.60c 2.662E-02 $Zr4 (62.67%) + H2O (37.33%) (density = 6.468e-2 at/bcm)
       1001.60c 2.494E-02 $used for the lower end plug of the UO2 pins
      50000.42c 3.024E-04
      26054.60c 5.442E-06
      26056.60c 8.542E-05
      26057.60c 1.973E-06
      26058.60c 2.625E-07
      24050.60c 2.069E-06
      24052.60c 3.990E-05
      24053.60c 4.524E-06
      24054.60c 1.126E-06
       8016.60c 1.265E-02
       6000.60c 2.783E-05
      72000.60c 6.938E-07
c tot 6.468E-02
mt32   lwtr.01t
c
m33   40000.60c 3.858E-02 $Zr4 (90.83%)+ SS (9.17%) (density = 4.742e-2 at/bcm)
       1001.60c 4.450E-05 $used for the upper end plug of the UO2 pins
      50000.42c 4.383E-04
      26054.60c 3.185E-04
      26056.60c 4.999E-03
      26057.60c 1.155E-04
      26058.60c 1.536E-05
      24050.60c 6.821E-05
      24052.60c 1.315E-03
      24053.60c 1.492E-04
      24054.60c 3.712E-05
```

```
       8016.60c 2.803E-04
       6000.60c 4.574E-05
      72000.60c 1.005E-06
      28058.60c 5.530E-04
      28060.60c 2.130E-04
      28061.60c 9.262E-06
      28062.60c 2.953E-05
      28064.60c 7.519E-06
      25055.60c 7.891E-05
      14000.60c 7.717E-05
      16000.60c 2.037E-06
      15031.60c 3.149E-06
      42000.60c 4.518E-05
c tot 4.742E-02
c
m34   26054.60c 1.174E-03 $SS (34.67%) + H2O (65.33%)  (density = 9.503e-2 at/bcm)
      26056.60c 1.843E-02 $used for the gripping head of the UO2 pins
      26057.60c 4.257E-04
      26058.60c 5.665E-05
       6000.60c 2.047E-05
      24050.60c 2.465E-04
      24052.60c 4.753E-03
      24053.60c 5.391E-04
      24054.60c 1.342E-04
      28058.60c 2.091E-03
      28060.60c 8.054E-04
      28061.60c 3.502E-05
      28062.60c 1.116E-04
      28064.60c 2.843E-05
      25055.60c 2.983E-04
      14000.60c 2.918E-04
      16000.60c 7.700E-06
      15031.60c 1.191E-05
      42000.60c 1.708E-04
       1001.60c 4.360E-02
       8016.60c 2.180E-02
c tot 9.503E-02
mt34   lwtr.01t
c
c  OSMOSE Sample Unat
m60   92234.60c  1.2770E-06   $ Unat Sample
      92235.60c  1.6717E-04
      92238.60c  2.3050E-02
       8016.60c  4.6437E-02
c        SUM    6.9655E-02
c
m61    8016.60c  1.0000E-08   $ Air Gap
c
m62   40000.60c  4.2470E-02   $ Zr4 Clad
       1001.60c  4.8990E-05
      26054.60c  8.6830E-06
      26056.60c  1.3630E-04
      26057.60c  3.1480E-06
      26058.60c  4.1890E-07
      24050.60c  3.3010E-06
      24052.60c  6.3660E-05
      24053.60c  7.2190E-06
      24054.60c  1.7970E-06
       8016.60c  3.0860E-04
       6000.60c  4.4000E-05
      72000.60c  1.1070E-06
c        SUM    4.3097E-02
c
m63   13027.60c  5.4570E-02   $ AG-3
      12000.60c  1.9590E-03
      25055.60c  6.9880E-05
      26054.60c  3.2150E-06
      26056.60c  5.0460E-05
      26057.60c  1.1650E-06
      26058.60c  1.5510E-07
      24050.60c  1.9250E-06
      24052.60c  3.7120E-05
```

```
      24053.60c  4.2090E-06
      24054.60c  1.0480E-06
      22000.60c  2.4060E-05
      14000.60c  1.0940E-04
      29063.60c  8.3580E-06
      29065.60c  3.7250E-06
c         SUM    5.6840E-06
c
m64   26054.60c  3.3870E-03   $ Stainless Steel
      26056.60c  5.3160E-02
      26057.60c  1.2280E-03
      26058.60c  1.6340E-04
       6000.60c  5.9040E-05
      24050.60c  7.1110E-04
      24052.60c  1.3710E-02
      24053.60c  1.5550E-03
      24054.60c  3.8700E-04
      28058.60c  6.0310E-03
      28060.60c  2.3230E-03
      28061.60c  1.0100E-04
      28062.60c  3.2200E-04
      28064.60c  8.2010E-05
      25055.60c  8.6050E-04
      14000.60c  8.4160E-04
      42000.60c  4.9270E-04
c         SUM    8.5420E-02
c
c **********************
c TALLY DEFINITIONS
c **********************
f4:n   (675 < 100[0 0 0] < 1)
e4     3.0000E-09  5.5000E-09  1.0000E-08  1.5000E-08  2.0000E-08
       3.0000E-08  4.2000E-08  5.8000E-08  7.7000E-08  9.5000E-08
       1.1500E-07  1.3400E-07  1.6000E-07  1.8900E-07  2.2000E-07
       2.4800E-07  2.8000E-07  3.1450E-07  3.5000E-07  3.9100E-07
       4.3300E-07  4.8500E-07  5.4000E-07  6.2500E-07  7.0500E-07
       7.9000E-07  8.6000E-07  9.3000E-07  9.8600E-07  1.0350E-06
       1.0710E-06  1.1100E-06  1.1700E-06  1.2350E-06  1.3000E-06
       1.3700E-06  1.4400E-06  1.5000E-06  1.5900E-06  1.6700E-06
       1.7550E-06  1.8400E-06  1.9300E-06  2.0200E-06  2.1300E-06
       2.3600E-06  2.7679E-06  3.3808E-06  4.1293E-06  5.0435E-06
       6.1601E-06  7.5240E-06  9.1898E-06  1.1224E-05  1.3710E-05
       1.6745E-05  2.0452E-05  2.4980E-05  3.0511E-05  3.7267E-05
       4.5517E-05  5.5595E-05  6.7904E-05  9.1661E-05  1.3674E-04
       2.0400E-04  3.0432E-04  4.5400E-04  6.7729E-04  1.0104E-03
       1.5073E-03  2.2487E-03  3.3546E-03  5.0045E-03  7.4659E-03
       1.1138E-02  1.6616E-02  2.4788E-02  3.6979E-02  5.5166E-02
       8.2297E-02  1.2277E-01  1.8316E-01  2.7324E-01  4.0762E-01
       6.0810E-01  9.0718E-01  1.1080E+00  1.3534E+00  1.6530E+00
       2.0190E+00  2.4660E+00  3.0119E+00  3.6788E+00  4.4933E+00
       5.4881E+00  6.7032E+00  8.1873E+00  1.0000E+01
c
f14:n (675 < 100[0 0 0] < 1)
e14   0.30000E-08 0.50000E-08 0.69000E-08 0.10000E-07 0.15000E-07 0.20000E-07
      0.25000E-07 0.30000E-07 0.35000E-07 0.42000E-07 0.50000E-07 0.58000E-07
      0.67000E-07 0.77000E-07 0.80000E-07 0.95000E-07 0.10000E-06 0.11500E-06
      0.13400E-06 0.14000E-06 0.16000E-06 0.18000E-06 0.18900E-06 0.22000E-06
      0.24800E-06 0.28000E-06 0.30000E-06 0.31450E-06 0.32000E-06 0.35000E-06
      0.39100E-06 0.40000E-06 0.43300E-06 0.48500E-06 0.50000E-06 0.54000E-06
      0.62500E-06 0.70500E-06 0.78000E-06 0.79000E-06 0.85000E-06 0.86000E-06
      0.91000E-06 0.93000E-06 0.95000E-06 0.97200E-06 0.98600E-06 0.99600E-06
      0.10200E-05 0.10350E-05 0.10450E-05 0.10710E-05 0.10970E-05 0.11100E-05
      0.11230E-05 0.11500E-05 0.11700E-05 0.12350E-05 0.13000E-05 0.13375E-05
      0.13700E-05 0.14400E-05 0.14750E-05 0.15000E-05 0.15900E-05 0.16700E-05
      0.17550E-05 0.18400E-05 0.19300E-05 0.20200E-05 0.21000E-05 0.21300E-05
      0.23600E-05 0.25500E-05 0.26000E-05 0.27200E-05 0.27679E-05 0.33000E-05
      0.33807E-05 0.40000E-05 0.41293E-05 0.50435E-05 0.53464E-05 0.61601E-05
      0.75240E-05 0.83153E-05 0.91898E-05 0.99056E-05 0.11224E-04 0.13710E-04
      0.15928E-04 0.19455E-04 0.22603E-04 0.24980E-04 0.27608E-04 0.30511E-04
      0.33720E-04 0.37266E-04 0.40169E-04 0.45517E-04 0.48252E-04 0.51578E-04
      0.55595E-04 0.67904E-04 0.75674E-04 0.91661E-04 0.13674E-03 0.14862E-03
      0.20399E-03 0.30433E-03 0.37170E-03 0.45400E-03 0.67729E-03 0.74852E-03
```

```
      0.91424E-03 0.10104E-02 0.12341E-02 0.14338E-02 0.15073E-02 0.20347E-02
      0.22487E-02 0.33546E-02 0.35266E-02 0.50045E-02 0.55308E-02 0.74659E-02
      0.91188E-02 0.11138E-01 0.15034E-01 0.16616E-01 0.24788E-01 0.27394E-01
      0.29283E-01 0.36979E-01 0.40868E-01 0.55166E-01 0.67380E-01 0.82298E-01
      0.11109E+00 0.12277E+00 0.18316E+00 0.24724E+00 0.27324E+00 0.30197E+00
      0.40762E+00 0.45049E+00 0.49787E+00 0.55023E+00 0.60810E+00 0.82085E+00
      0.90718E+00 0.10026E+01 0.11080E+01 0.12246E+01 0.13534E+01 0.16530E+01
      0.20190E+01 0.22313E+01 0.24660E+01 0.30119E+01 0.36788E+01 0.44933E+01
      0.54881E+01 0.60653E+01 0.67032E+01 0.81873E+01 0.10000E+02 0.11618E+02
      0.13840E+02 0.14918E+02 0.17332E+02 0.20000E+02
c **********************
c RUN DEFINITIONS
c **********************
c
mode n
totnu
kcode  16000 1.0  20  1700 1500
ksrc  -1.26 -2.51 113.6
prdmp  5000  5000
lost 500 500
print
```

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