

LA-UR-08-06963

Approved for public release;  
distribution is unlimited.

<i>Title:</i>	Some Areas of Concern for ENDF/B-VII
<i>Author(s):</i>	Russell D. Mosteller
<i>Intended for:</i>	2008 Meeting of the Cross Section Evaluation Working Group Brookhaven National Laboratory November 4 - 6, 2008



Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the Los Alamos National Security, LLC for the National Nuclear Security Administration of the U.S. Department of Energy under contract DE-AC52-06NA25396. By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

## Some Areas of Concern for ENDF/B-VII

Russell D. Mosteller

Improvised and Foreign Design Section (X-2-IFD)  
Applied Physics Division  
Los Alamos National Laboratory

To Be Presented at the 2008 CSEWG Meeting  
Brookhaven National Laboratory      November 4-6, 2008

ENDF/B-VII.0 was released in December 2006. Although it has shown major improvements relative to ENDF/B-VI, a number of areas with possible deficiencies have been identified. Those areas include:

- fast beryllium cross sections
- fast copper cross sections
- fast neptunium cross sections
- fast thorium cross sections
  
- $^{235}\text{U}$  data in the unresolved resonance range
  
- thermal  $^{113}\text{Cd}$  capture cross section
- thermal  $^{233}\text{U}$  cross sections
- thermal Pu cross sections
  
- angular scattering distribution for deuterium (possibly)

Calculated results for benchmarks that illustrate these possible deficiencies are presented.

# Some Areas of Concern for ENDF/B-VII

Russell D. Mosteller

Applied Physics Division  
Los Alamos National Laboratory  
mosteller@lanl.gov

Presented at the 2008 CSEWG Meeting  
Brookhaven National Laboratory                      November 4-6, 2008

# AREAS OF CONCERN

Fast cross sections for Be  
Fast cross sections for Cu  
Fast cross sections for Np  
Fast cross sections for Th

Unresolved resonance range for  $^{235}\text{U}$

Thermal capture cross section for  $^{113}\text{Cd}$

Thermal cross sections for  $^{233}\text{U}$

Thermal cross sections for Pu

Angular scattering distribution for  $^2\text{H}$  (possibly)

All results were obtained from MCNP5

All benchmark specifications are taken from the *International Handbook of Evaluated Criticality Safety Benchmark Experiments*

# MCNP5 RESULTS FOR FAST <sup>233</sup>U BENCHMARKS

Case	Benchmark k <sub>eff</sub>	Calculated k <sub>eff</sub>			
		ENDF/B-VII.0	ENDF/B-VI	JEFF-3.1	JENDL-3.3
Jezebel-233	1.0000 ± 0.0010	0.9995 ± 0.0003	0.9926 ± 0.0003	1.0038 ± 0.0003	1.0041 ± 0.0003
Flatop-23	1.0000 ± 0.0014	0.9994 ± 0.0003	1.0003 ± 0.0003	1.0062 ± 0.0003	0.9985 ± 0.0003
U233-MF-05	1.0000 ± 0.0030	0.9929 ± 0.0003	0.9972 ± 0.0003	1.0004 ± 0.0003	1.0019 ± 0.0003

Case	Benchmark k <sub>eff</sub>	Calculated k <sub>eff</sub> (ENDF/B-VII.0 + Indicated Be)		
		ENDF/B-VII β-3	ENDF/B-VII β-2	ENDF/B-VII β-1
U233-MF-05	1.0000 ± 0.0030	0.9925 ± 0.0003	0.9925 ± 0.0003	0.9977 ± 0.0003

$$|\Delta k| > 2\sigma$$

U233-MF-05 is a <sup>233</sup>U sphere encased in Be

Fast Be cross sections should be re-examined prior to the next interim release of ENDF/B-VII

# MCNP5 RESULTS FOR THE UNMODERATED ZEUS BENCHMARK

Copper cross section	Benchmark $k_{\text{eff}}$	Calculated $k_{\text{eff}}$			
		ENDF/B-VII.0	ENDF/B-VI	JEFF-3.1	JENDFL-3.3
As stated	1.0004 ± 0.0016	1.0116 ± 0.0003	1.0077 ± 0.0003	1.0084 ± 0.0003	1.0241 ± 0.0003
ENDF/B-V		1.0001 ± 0.0003	0.9971 ± 0.0003	0.9974 ± 0.0003	1.0000 ± 0.0003

$$\sigma < |\Delta k| \leq 2\sigma$$

$$|\Delta k| > 4\sigma$$

The unmoderated Zeus benchmark contains platters of HEU enclosed in copper

Other Zeus benchmarks with graphite moderator and an intermediate spectrum do not show similar sensitivity to the copper cross sections

Fast copper cross sections should be re-examined prior to the next interim release of ENDF/B-VII

# MCNP5 RESULTS FOR A NEPTUNIUM SPHERE REFLECTED BY HEU

Benchmark $k_{\text{eff}}$	Calculated $k_{\text{eff}}$			
	ENDF/B-VII.0	ENDF/B-VI	JEFF-3.1	JENDFL-3.3
$1.0019 \pm 0.0036$	$0.9951 \pm 0.0003$	$0.9889 \pm 0.0003$	$0.9918 \pm 0.0003$	$0.9967 \pm 0.0002$

$$\sigma < |\Delta k| \leq 2\sigma$$

$$|\Delta k| > 2\sigma$$

More than 85% of the fissions occur in the HEU reflector

ENDF/B-VII.0 produces accurate values of  $k_{\text{eff}}$  for fast HEU systems

Improvements still are needed in the fast  $^{237}\text{Np}$  cross sections

# MCNP5 RESULTS FOR FAST PU BENCHMARKS

Case	Benchmark $k_{\text{eff}}$	Calculated $k_{\text{eff}}$			
		ENDF/B-VII.0	ENDF/B-VI	JEFF-3.1	JENDL-3.3
Jezebel	$1.0000 \pm 0.0020$	$1.0002 \pm 0.0003$	$0.9971 \pm 0.0003$	$1.0000 \pm 0.0003$	$0.9966 \pm 0.0004$
Jezebel-240	$1.0000 \pm 0.0020$	$0.9998 \pm 0.0003$	$0.9980 \pm 0.0003$	$1.0043 \pm 0.0003$	$1.0009 \pm 0.0004$
Pu Buttons	$1.0000 \pm 0.0030$	$0.9984 \pm 0.0003$	$0.9962 \pm 0.0003$	$0.9996 \pm 0.0003$	$0.9958 \pm 0.0004$
Flattop-Pu	$1.0000 \pm 0.0030$	$1.0003 \pm 0.0003$	$1.0016 \pm 0.0003$	$1.0019 \pm 0.0003$	$0.9904 \pm 0.0003$
THOR	$1.0000 \pm 0.0006$	$0.9977 \pm 0.0003$	$1.0057 \pm 0.0003$	$1.0020 \pm 0.0003$	$1.0066 \pm 0.0003$
Pu-MF-11	$1.0000 \pm 0.0010$	$1.0005 \pm 0.0004$	$0.9966 \pm 0.0004$	$0.9970 \pm 0.0003$	$0.9982 \pm 0.0003$

Case	Benchmark $k_{\text{eff}}$	Calculated $k_{\text{eff}}$ (ENDF/B-VII.0 + Indicated Th)		
		ENDF/B-VII $\beta$ -3	ENDF/B-VII $\beta$ -2	ENDF/B-VII $\beta$ -1
THOR	$1.0000 \pm 0.0006$	$0.9979 \pm 0.0003$	$0.9979 \pm 0.0003$	$0.9995 \pm 0.0003$

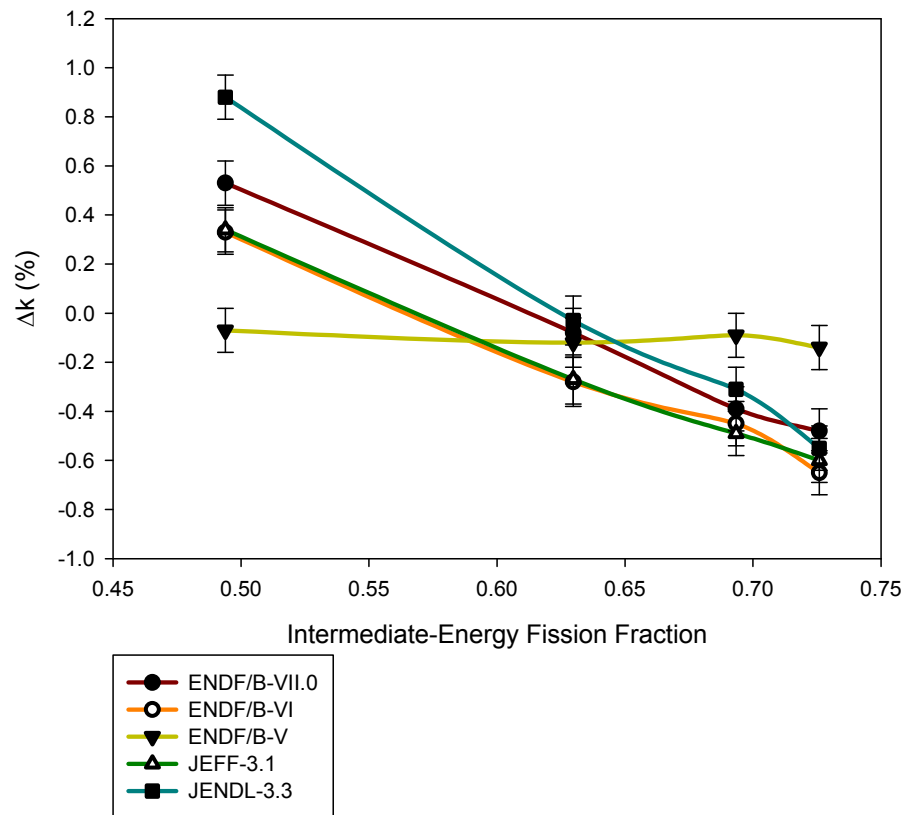
$$\sigma < |\Delta k| \leq 2\sigma$$

$$|\Delta k| > 2\sigma$$

Fast cross sections for thorium should be re-examined prior to the next interim release of ENDF/B-VII



# MCNP5 RESULTS FOR ZEUS GRAPHITE BENCHMARKS



Improvements still are needed to the  $^{235}\text{U}$  data in the unresolved resonance region

# MCNP RESULTS FOR CADMIUM SOLUTION BENCHMARKS

Case	In-Vessel Cd Conc. (mg/g)	Benchmark $k_{\text{eff}}$	Calculated $k_{\text{eff}}$	
			ENDF/B-VII.0	ENDF/B-VII.0 + Revised $^{113}\text{Cd}$
9	0	1.0012 ± 0.0020	0.9976 ± 0.0001	0.9976 ± 0.0001
10*	0	1.0012 ± 0.0024	0.9891 ± 0.0002	0.9895 ± 0.0002
11*	1.240	1.0012 ± 0.0022	0.9908 ± 0.0001	0.9943 ± 0.0001
12*	2.250	1.0012 ± 0.0021	0.9924 ± 0.0001	0.9971 ± 0.0001
13*	3.362	1.0012 ± 0.0021	0.9919 ± 0.0001	0.9983 ± 0.0001
14*	4.189	1.0012 ± 0.0020	0.9923 ± 0.0001	0.9993 ± 0.0001
15*	4.577	1.0012 ± 0.0021	0.9941 ± 0.0001	1.0018 ± 0.0001
16*	4.897	1.0012 ± 0.0020	0.9921 ± 0.0001	1.0006 ± 0.0001
17*	5.047	1.0012 ± 0.0021	0.9915 ± 0.0001	0.9994 ± 0.0001
18	5.032	1.0012 ± 0.0020	0.9936 ± 0.0001	1.0014 ± 0.0001
19	5.937	1.0012 ± 0.0020	0.9939 ± 0.0001	1.0023 ± 0.0001
20	6.626	1.0012 ± 0.0019	0.9918 ± 0.0001	1.0007 ± 0.0001

\* Reflector contained Cd

$\sigma < |\Delta k| \leq 2\sigma$

$|\Delta k| > 2\sigma$

# MCNP5 RESULTS FOR THERMAL <sup>233</sup>U BENCHMARKS

Case	Benchmark k <sub>eff</sub>	Calculated k <sub>eff</sub>			
		ENDF/B-VII.0	ENDF/B-VI	JEFF-3.1	JENDL-3.3
ORNL-11	1.0006 ± 0.0029	1.0015 ± 0.0002	0.9974 ± 0.0002	0.9975 ± 0.0002	0.9989 ± 0.0002
SB-2½	1.0000 ± 0.0024	1.0038 ± 0.0005	0.9977 ± 0.0005	0.9966 ± 0.0005	0.9980 ± 0.0005
SB-6	0.9995 ± 0.0027	1.0033 ± 0.0004	1.0000 ± 0.0005	0.9971 ± 0.0004	1.0033 ± 0.0004

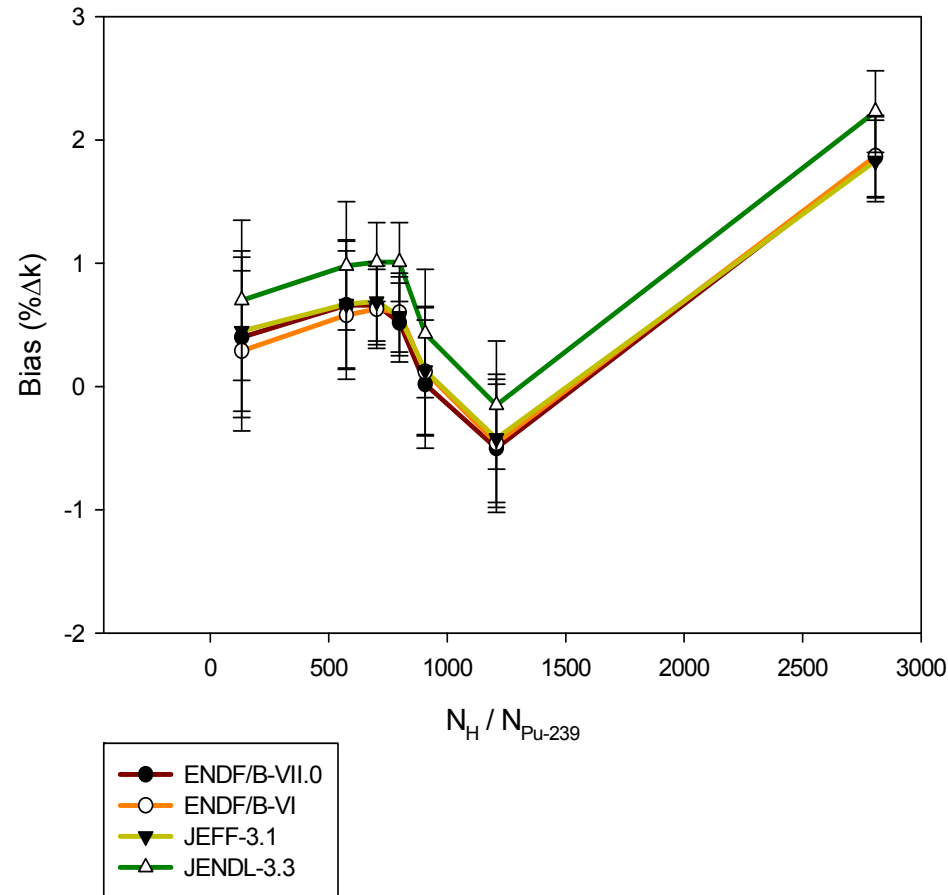
$$\sigma < |\Delta k| \leq 2\sigma$$

ENDF/B-VII.0 value for k<sub>eff</sub> is reasonable for ORNL-11 (water solution), but its values for the thermal lattices of fuel pins in water are high

SB-2½ and SB-6 have harder spectra than ORNL-11

Thermal <sup>233</sup>U cross sections should be re-examined prior to release of the next interim version of ENDF/B-VII

# REACTIVITY BIASES FOR PLUTONIUM SOLUTION BENCHMARKS



Improvements still are needed to thermal plutonium cross sections

# MCNP5 RESULTS FOR PLUTONIUM BENCHMARKS

Case	Benchmark $k_{\text{eff}}$	Calculated $k_{\text{eff}}$		
		ENDF/B-VII.0	JEFF-3.1 + JEFF-3.2 $\beta$ $^{239}\text{Pu}$	JEFF-3.1
Jezebel	1.0000 $\pm$ 0.0020	1.0002 $\pm$ 0.0003	1.0001 $\pm$ 0.0003	1.0000 $\pm$ 0.0003
Jezebel-240	1.0000 $\pm$ 0.0020	0.9998 $\pm$ 0.0003	1.0045 $\pm$ 0.0003	1.0043 $\pm$ 0.0003
Pu Buttons	1.0000 $\pm$ 0.0030	0.9984 $\pm$ 0.0003	0.9994 $\pm$ 0.0003	0.9996 $\pm$ 0.0003
Flatop-Pu	1.0000 $\pm$ 0.0030	1.0003 $\pm$ 0.0003	1.0021 $\pm$ 0.0003	1.0019 $\pm$ 0.0003
THOR	1.0000 $\pm$ 0.0006	0.9977 $\pm$ 0.0003	1.0024 $\pm$ 0.0003	1.0020 $\pm$ 0.0003
PU-MF-11	1.0000 $\pm$ 0.0010	1.0005 $\pm$ 0.0003	0.9968 $\pm$ 0.0004	0.9970 $\pm$ 0.0003
HISS/HPG	1.0000 $\pm$ 0.0110	1.0120 $\pm$ 0.0002	1.0069 $\pm$ 0.0002	1.0073 $\pm$ 0.0002
PNL-33	1.0024 $\pm$ 0.0021	1.0068 $\pm$ 0.0003	1.0052 $\pm$ 0.0003	1.0072 $\pm$ 0.0003
PNL-2	1.0000 $\pm$ 0.0065	1.0044 $\pm$ 0.0005	1.0025 $\pm$ 0.0005	1.0045 $\pm$ 0.0004

$\sigma < |\Delta k| \leq 2\sigma$

$|\Delta k| > 2\sigma$

JEFF-3.2 $\beta$  evaluation for  $^{239}\text{Pu}$  has small impact on thermal cases

# MCNP5 RESULTS FOR REFLECTED SPHERES AND BARE CYLINDERS OF URANYL FLUORIDE IN HEAVY WATER

Type	Case	Benchmark $k_{\text{eff}}$	Calculated $k_{\text{eff}}$			
			ENDF/B-VII.0 + JENDL-3.3 $^2\text{H}$	ENDF/B-VII.0	ENDF/B-VI	JENDL-3.3
Reflected $\text{D}_2\text{O}$ Spheres	1	1.0000 ± 0.0033	0.9967 ± 0.0004	0.9847 ± 0.0004	0.9839 ± 0.0004	0.9918 ± 0.0004
	2	1.0000 ± 0.0036	0.9919 ± 0.0004	0.9815 ± 0.0004	0.9798 ± 0.0004	0.9873 ± 0.0004
	3	1.0000 ± 0.0039	0.9985 ± 0.0004	0.9883 ± 0.0004	0.9861 ± 0.0004	0.9979 ± 0.0004
	4	1.0000 ± 0.0046	1.0012 ± 0.0004	0.9904 ± 0.0004	0.9886 ± 0.0004	0.9971 ± 0.0004
	5	1.0000 ± 0.0052	0.9994 ± 0.0004	0.9891 ± 0.0004	0.9871 ± 0.0004	0.9956 ± 0.0004
	6	1.0000 ± 0.0059	0.9959 ± 0.0004	0.9854 ± 0.0004	0.9837 ± 0.0004	0.9913 ± 0.0004
Bare $\text{D}_2\text{O}$ Cylinders	1	0.9966 ± 0.0116	1.0039 ± 0.0005	0.9932 ± 0.0005	0.9918 ± 0.0005	1.0006 ± 0.0005
	2	0.9956 ± 0.0093	1.0105 ± 0.0005	0.9983 ± 0.0005	0.9967 ± 0.0005	1.0066 ± 0.0005
	3	0.9957 ± 0.0079	1.0185 ± 0.0005	1.0070 ± 0.0005	1.0055 ± 0.0005	1.0149 ± 0.0005
	4	0.9955 ± 0.0078	1.0162 ± 0.0005	1.0049 ± 0.0005	1.0029 ± 0.0005	1.0106 ± 0.0005
	5	0.9959 ± 0.0077	1.0234 ± 0.0005	1.0131 ± 0.0005	1.0114 ± 0.0005	1.0167 ± 0.0005

$$\sigma < |\Delta k| \leq 2\sigma$$

$$|\Delta k| > 2\sigma$$

Angular scattering distribution for  $^2\text{H}$  should be reviewed