LA-UR-06-4324

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Title: ENDF/B-VII β-2 Results for the MCNP Criticality Validation Suite and Other Criticality Benchmarks

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Submitted to: Validation Meeting on ENDF/B-VII β-2
Brookhaven National Laboratory
June 27, 2006

Los Alamos
NATIONAL LABORATORY

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ENDF/B-VII β-2 Results for the MCNP Criticality Validation Suite and Other Criticality Benchmarks

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To Be Presented at the Validation Meeting on ENDF/B-VII β-2
Brookhaven National Laboratory June 27, 2006

The initial release of the ENDF/B-VII data library is imminent. An assessment of the reactivity behavior produced by the latest pre-release candidate, ENDF/B-VII β-2, has been made using the MCNP5 Monte Carlo code and the benchmarks in the MCNP criticality validation suite. In addition, analyses have been performed for several other criticality benchmarks that have produced problematic results in the past. The results obtained with ENDF/B-VII β-2 are compared with ENDF/B-VI and JENDL-3.3 results for the same cases.

The results from the calculations demonstrate that the ENDF/B-VII changes produce substantial overall improvements relative to ENDF/B-VI and JENDL-3.3. In particular, the calculated ENDF/B-VII results differ from the corresponding benchmark values by more than two standard deviations for only five of the 31 cases in the suite, compared to nine cases for both the ENDF/B-VI and JENDL-3.3 data. Furthermore, ENDF/B-VII β-2 produces improved results relative to ENDF/B-VI for some of the other cases studied. However, improvements still are needed in a number of specific areas, including:

- ^{235}U cross sections in the unresolved resonance range
- neptunium cross sections
- fast copper cross sections
- thermal ^{239}Pu cross sections
- angular scattering distribution for deuterium (probably)

ENDF/B-VII β-2 Results for the MCNP Criticality Validation Suite and Other Criticality Benchmarks

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OVERVIEW OF PRESENTATION

Succinct Description of MCNP Criticality Validation Suite

MCNP5 Results for the Criticality Validation Suite Using ENDF/B-VII β-2, ENDF/B-VI, and JENDL-3.3 Nuclear Data Libraries

MCNP5 Results for Other Criticality Benchmarks Using ENDF/B-VII β-2, ENDF/B-VI, and JENDL-3.3 Nuclear Data Libraries

Conclusions

MCNP Criticality Validation Suite

Cases were selected to encompass a wide variety of

Fissile isotopes	:	^{233}U, ^{235}U, and ^{239}Pu
Spectra	:	Fast, intermediate, and thermal
Compositions	:	Metals, oxides, and solutions
Configurations	:	Bare and reflected spheres and cylinders, 2-D and 3-D lattices, and infinite homogeneous and heterogeneous regions

^{235}U Cases were subdivided into HEU, IEU, AND LEU

Input specifications for all 31 cases are taken from the *International Handbook of Evaluated Criticality Safety Benchmark Experiments*

CASES IN THE MCNP CRITICALITY VALIDATION SUITE

Spectrum	Fast			Intermed	Thermal	
Geometry	Bare	Heavy Reflector	Light Reflector	Any	Lattice of Fuel Pins	Solution
^{233}U	Jezebel-233	Flattop-23	U233-MF-05	Falstaff-1*	SB-2½	ORNL-11
HEU	Godiva Tinkertoy-2	Flattop-25	Godiver	Zeus-2 UH_3	SB-5	ORNL-10
IEU	IEU-MF-03	BIG TEN	IEU-MF-04	Zebra-8H†	IEU-CT-02	STACY-36
LEU					B&W XI-2	LEU-ST-02
Pu	Jezebel Jezebel-240 Pu Buttons	Flattop-Pu THOR	Pu-MF-11	HISS/HPG†	PNL-33	PNL-2

* Extrapolated to critical   † k_∞ measurement

CASES IN THE CRITICALITY VALIDATION SUITE

Name	Spectrum	*Handbook* ID	Description
Jezebel-233	Fast	U233-MET-FAST-001	Bare sphere of ^{233}U
Flattop-23	Fast	U233-MET-FAST-006	Sphere of ^{233}U reflected by normal U
U233-MF-05	Fast	U233-MET-FAST-005, case 2	Sphere of ^{233}U reflected by beryllium
Falstaff-1	Intermediate	U233-SOL-INTER-001, case 1	Sphere of uranyl fluoride solution enriched in ^{233}U
SB-2½	Thermal	U233-COMP-THERM-001, case 3	Lattice of ^{233}U fuel pins in water
ORNL-11	Thermal	U233-SOL-THERM-008	Large sphere of uranyl nitrate solution enriched in ^{233}U
Godiva	Fast	HEU-MET-FAST-001	Bare HEU sphere
Tinkertoy-2	Fast	HEU-MET-FAST-026, case C-11	3 x 3 x 3 array of HEU cylinders in paraffin box
Flattop-25	Fast	HEU-MET-FAST-028	HEU sphere reflected by normal U
Godiver	Fast	HEU-MET-FAST-004	HEU sphere reflected by water
Zeus-2	Intermediate	HEU-MET-INTER-006, case 2	HEU platters moderated by graphite and reflected by copper
UH_3	Intermediate	HEU-COMP-INTER-003, case 6	UH_3 cylinders reflected by depleted uranium
SB-5	Thermal	U233-COMP-THERM-001, case 6	Lattice of HEU fuel pins in water, with blanket of ThO_2 pins
ORNL-10	Thermal	HEU-SOL-THERM-032	Large sphere of HEU nitrate solution
IEU-MF-03	Fast	IEU-MET-FAST-003	Bare sphere of IEU (36 wt.%)
BIG TEN	Fast	IEU-MET-FAST-007	Cylinder of IEU (10 wt.%) reflected by normal uranium
IEU-MF-04	Fast	IEU-MET-FAST-004	Sphere of IEU (36 wt.%) reflected by graphite
Zebra-8H	Intermediate	MIX-MET-FAST-008, case 7	IEU (37.5 wt.%) reflected by normal U and steel
IEU-CT-02	Thermal	IEU-COMP-THERM-002, case 3	Lattice of IEU (17 wt.%) fuel rods in water
STACY-36	Thermal	LEU-SOL-THERM-007, case 36	Cylinder of IEU (9.97 wt.%) uranyl nitrate solution
B&W XI-2	Thermal	LEU-COMP-THERM-008, case 2	Large lattice of LEU (2.46 wt.%) fuel pins in borated water
LEU-ST-02	Thermal	LEU-SOL-THERM-002, case 2	Sphere of LEU (4.9 wt.%) uranyl fluoride solution
Jezebel	Fast	PU-MET-FAST-001	Bare sphere of plutonium
Jezebel-240	Fast	PU-MET-FAST-002	Bare sphere of plutonium (20.1 at.% ^{240}Pu)
Pu Buttons	Fast	PU-MET-FAST-003, case 103	3 x 3 x 3 array of small cylinders of plutonium
Flattop-Pu	Fast	PU-MET-FAST-006	Plutonium sphere reflected by normal U
THOR	Fast	PU-MET-FAST-008	Plutonium sphere reflected by thorium
PU-MF-11	Fast	PU-MET-FAST-011	Plutonium sphere reflected by water
HISS/HPG	Intermediate	PU-COMP-INTER-001	Infinite, homogeneous mixture of plutonium, hydrogen, and graphite
PNL-33	Thermal	MIX-COMP-THERM-002, case 4	Lattice of mixed-oxide fuel pins in borated water
PNL-2	Thermal	PU-SOL-THERM-021, case 3	Sphere of plutonium nitrate solution

PURPOSE AND USE OF THE MCNP CRITICALITY VALIDATION SUITE

The MCNP Criticality Validation Suite was developed to assess the reactivity impact of future improvements to MCNP as well as changes to its associated nuclear data libraries

Suite is *not* an absolute indicator of the accuracy or reliability of a given nuclear data library, nor is it intended to be

Suite can provide a general indication of the overall performance of a nuclear data library

Suite can provide an early warning of unexpected or unintended consequences resulting from changes to nuclear data

MCNP5 CALCULATIONS

Each calculation employed 550 generations with 10,000 neutrons per generation (350 generations for SB-5 and Zebra-8H)

Results from first 50 generations were excluded from the statistics

Results therefore are based on 5,000,000 active histories for each case (3,000,000 for SB-5 and Zebra-8H)

ENDF/B-VI thermal scattering kernels (from SAB2002 library) were used where needed for JENDL-3.3 calculations, since they are not included in the JENDL-3.3 library distributed for MCNP

RESULTS FOR ^{233}U BENCHMARKS

Case	Benchmark k_{eff}	Calculated k_{eff}		
		ENDF/B-VII β-2	ENDF/B-VI	JENDL-3.3
Jezebel-233	1.0000 ± 0.0010	0.9996 ± 0.0003	0.9926 ± 0.0003	1.0041 ± 0.0003
Flattop-23	1.0000 ± 0.0014	0.9990 ± 0.0003	1.0003 ± 0.0003	0.9985 ± 0.0003
U233-MF-05	1.0000 ± 0.0030	0.9977 ± 0.0003	0.9972 ± 0.0003	1.0019 ± 0.0003
Falstaff-1	1.0000 ± 0.0083	0.9910 ± 0.0005	0.9895 ± 0.0005	0.9879 ± 0.0005
SB-2½	1.0000 ± 0.0024	1.0045 ± 0.0005	0.9964 ± 0.0005	0.9979 ± 0.0005
ORNL-11	1.0006 ± 0.0029	1.0046 ± 0.0002	0.9974 ± 0.0002	0.9989 ± 0.0002

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

k_{eff} for Jezebel-233 improves dramatically, and reactivity swing from Jezebel-233 to Flattop-23 is eliminated

k_{eff} is high for SB-2½ and ORNL-11 (reduce $\bar{\nu}$?)

JENDL-3.3 produces best result for SB-2½ and ORNL-11

RESULTS FOR HEU BENCHMARKS

Case	Benchmark k_{eff}	Calculated k_{eff}		
		ENDF/B-VII β-2	ENDF/B-VI	JENDL-3.3
Godiva	1.0000 ± 0.0010	1.0004 ± 0.0003	0.9963 ± 0.0003	1.0033 ± 0.0003
Tinkertoy-2	1.0000 ± 0.0038	1.0006 ± 0.0004	0.9973 ± 0.0003	1.0042 ± 0.0003
Flattop-25	1.0000 ± 0.0030	1.0034 ± 0.0003	1.0021 ± 0.0003	0.9974 ± 0.0003
Godiver	0.9985 ± 0.0011	1.0005 ± 0.0004	0.9948 ± 0.0003	1.0019 ± 0.0004
UH_3	1.0000 ± 0.0047	0.9953 ± 0.0004	0.9914 ± 0.0003	0.9967 ± 0.0004
Zeus-2	0.9997 ± 0.0008	0.9966 ± 0.0003	0.9942 ± 0.0003	0.9956 ± 0.0003
SB-5	1.0015 ± 0.0028	0.9964 ± 0.0006	0.9965 ± 0.0005	0.9990 ± 0.0006
ORNL-10	1.0015 ± 0.0026	0.9996 ± 0.0002	0.9992 ± 0.0002	0.9999 ± 0.0002

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

k_{eff} improves substantially for Godiva and UH_3 and also improves for Godiver and Zeus-2

Reactivity swing from Godiva to Flattop-25 is reduced significantly

RESULTS FOR IEU BENCHMARKS

Case	Benchmark k_{eff}	Calculated k_{eff}		
		ENDF/B-VII β-2	ENDF/B-VI	JENDL-3.3
IEU-MF-03	1.0000 ± 0.0017	1.0022 ± 0.0003	0.9987 ± 0.0003	0.9969 ± 0.0002
BIG TEN	0.9948 ± 0.0013	0.9952 ± 0.0002	1.0071 ± 0.0003	0.9851 ± 0.0002
IEU-MF-04	1.0000 ± 0.0030	1.0078 ± 0.0003	1.0036 ± 0.0003	1.0024 ± 0.0003
Zebra-8H	1.0300 ± 0.0025	1.0189 ± 0.0002	1.0406 ± 0.0002	1.0152 ± 0.0002
IEU-CT-02	1.0017 ± 0.0044	1.0039 ± 0.0003	1.0004 ± 0.0003	1.0014 ± 0.0003
STACY-36	0.9988 ± 0.0013	0.9989 ± 0.0003	0.9986 ± 0.0003	0.9999 ± 0.0003

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

k_{eff} improves dramatically for BIG TEN

k_{eff} is worse for IEU-MF-03 and IEU-MF-04 and drops substantially for Zebra-8H

For IEU-CT-02 and STACY-36, changes to resonance parameters offset reactivity effects of other changes for uranium isotopes

RESULTS FOR LEU BENCHMARKS

Case	Benchmark k_{eff}	Calculated k_{eff}		
		ENDF/B-VII β-2	ENDF/B-VI	JENDL-3.3
B&W XI-2	1.0007 ± 0.0012	1.0012 ± 0.0003	0.9968 ± 0.0003	0.9991 ± 0.0003
LEU-ST-02	1.0024 ± 0.0037	0.9954 ± 0.0003	0.9953 ± 0.0003	0.9963 ± 0.0003

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

k_{eff} improves substantially for B&W XI-2, which eliminates need for *ad hoc* adjustment to ^{238}U resonance integral (used in many nuclear data libraries since early 1970s)

For LEU-ST-02, changes to resonance parameters for ^{235}U and ^{238}U offset reactivity effects of other changes

RESULTS FOR PU BENCHMARKS

Case	Benchmark k_{eff}	Calculated k_{eff}		
		ENDF/B-VII β-2	ENDF/B-VI	JENDL-3.3
Jezebel	1.0000 ± 0.0020	1.0001 ± 0.0003	0.9971 ± 0.0003	0.9966 ± 0.0004
Jezebel-240	1.0000 ± 0.0020	0.9996 ± 0.0003	0.9980 ± 0.0003	1.0009 ± 0.0004
Pu Buttons	1.0000 ± 0.0030	0.9988 ± 0.0003	0.9962 ± 0.0003	0.9958 ± 0.0004
Flattop-Pu	1.0000 ± 0.0030	0.9999 ± 0.0003	1.0016 ± 0.0003	0.9904 ± 0.0003
THOR	1.0000 ± 0.0006	0.9993 ± 0.0003	1.0057 ± 0.0003	1.0066 ± 0.0003
Pu-MF-11	1.0000 ± 0.0010	1.0003 ± 0.0003	0.9966 ± 0.0004	0.9982 ± 0.0003
HISS/HPG	1.0000 ± 0.0110	1.0116 ± 0.0002	1.0106 ± 0.0003	1.0134 ± 0.0003
PNL-33	1.0024 ± 0.0021	1.0066 ± 0.0003	1.0029 ± 0.0003	1.0069 ± 0.0003
PNL-2	1.0000 ± 0.0065	1.0045 ± 0.0005	1.0033 ± 0.0005	1.0062 ± 0.0005

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

Striking improvement in k_{eff} for fast cases but PNL-33 gets worse

Reactivity increases for HISS/HPG, PNL-33, and PNL-2

SUMMARY OF RESULTS FOR MCNP CRITICALITY VALIDATION SUITE

Range	ENDF/B-VII	ENDF/B-VI	JENDL-3.3
$\|\Delta k\| \leq \sigma$	18	13	13
$\sigma < \|\Delta k\| \leq 2\sigma$	10	9	9
$\|\Delta k\| > 2\sigma$	3	9	9

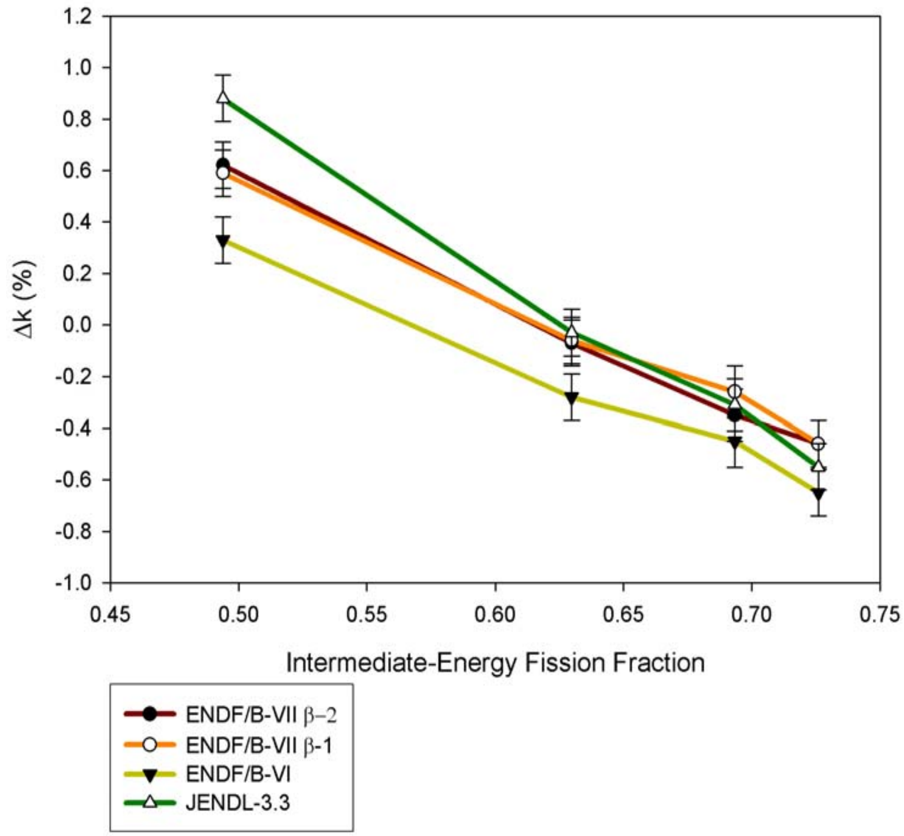
Substantial improvements for bare metal spheres (Jezebel-233, Godiva, and Jezebel), BIG TEN, UH_3, THOR, Pu metal sphere in water (Pu-MF-011), and LEU lattice (B&W XI-2)

ORNL resonance parameters improve results for Godiver, ORNL-10, IEU-CT-03, STACY-36, B&W XI-2, and LEU-ST-02

OTHER CRITICALITY BENCHMARKS

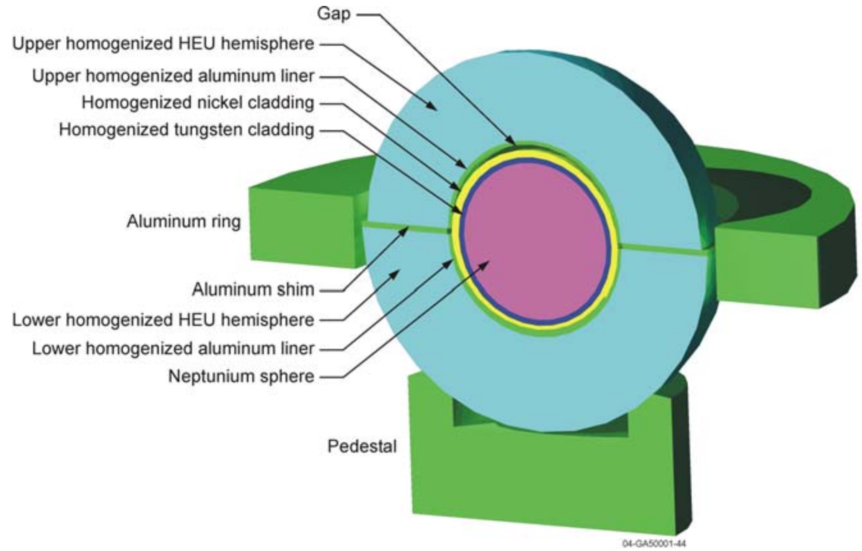
Name	Spectrum	*Handbook* ID	Description
Zeus-1	Intermediate	HEU-MET-INTER-006, case 1	HEU platters moderated by graphite and reflected by copper
Zeus-2	Intermediate	HEU-MET-INTER-006, case 2	HEU platters moderated by graphite and reflected by copper
Zeus-3	Intermediate	HEU-MET-INTER-006, case 3	HEU platters moderated by graphite and reflected by copper
Zeus-4	Intermediate	HEU-MET-INTER-006, case 4	HEU platters moderated by graphite and reflected by copper
Np Sphere	Fast	SPEC-MET-FAST-008	Neptunium sphere reflected by HEU shells
Unmod Zeus	Fast	HEU-MET-FAST-073	HEU platters reflected by copper
PNL-1	Thermal	PU-SOL-THERM-021, case 7	Unreflected 14-inch sphere of plutonium nitrate solution
PNL-3	Thermal	PU-SOL-THERM-011, case 18-1	Unreflected 18-inch sphere of plutonium nitrate solution
PNL-4	Thermal	PU-SOL-THERM-011, case 18-6	Unreflected 18-inch sphere of plutonium nitrate solution
PNL-5	Thermal	PU-SOL-THERM-011, case 16-5	Unreflected 16-inch sphere of plutonium nitrate solution
PNL-6	Thermal	PU-SOL-THERM-021, case 3	Unreflected 15.2-inch sphere of plutonium nitrate solution
PNL-8	Thermal	PU-SOL-THERM-021, case 2	Unreflected 15.2-inch sphere of plutonium nitrate solution
PST-9	Thermal	PU-SOL-THERM-009, case 3a	Unreflected 48-inch sphere of plutonium nitrate solution
PNL-30	Thermal	MIX-COMP-THERM-002, case 30	Lattice of 469 MOX pins (2 wt.% PuO_2) in water (1.7 PPM)
PNL-31	Thermal	MIX-COMP-THERM-002, case 31	Lattice of 761 MOX pins (2 wt.% PuO_2) in water (687.9 PPM)
PNL-32	Thermal	MIX-COMP-THERM-002, case 32	Lattice of 195 MOX pins (2 wt.% PuO_2) in water (0.9 PPM)
PNL-33	Thermal	MIX-COMP-THERM-002, case 33	Lattice of 761 MOX pins (2 wt.% PuO_2) in water (1090.4 PPM)
PNL-34	Thermal	MIX-COMP-THERM-002, case 34	Lattice of 161 MOX pins (2 wt.% PuO_2) in water (1.6 PPM)
PNL-35	Thermal	MIX-COMP-THERM-002, case 35	Lattice of 689 MOX pins (2 wt.% PuO_2) in water (767.2 PPM)
HST-4	Intermediate	HEU-SOL-THERM-004, cases 1-2	Reflected spheres of HEU solution in heavy water
HST-4	Thermal	HEU-SOL-THERM-004, cases 3-6	Reflected spheres of HEU solution in heavy water
HST-20	Thermal	HEU-SOL-THERM-020, cases 1-5	Unreflected cylinders of HEU solution in heavy water

ZEUS HEU-GRAPHITE BENCHMARKS



⇒ Cross sections for ^{235}U in the unresolved resonance region should be re-examined

NEPTUNIUM SPHERE REFLECTED BY HEU



Benchmark k_{eff}	Calculated k_{eff}		
	ENDF/B-VII β-2	ENDF/B-VI	JENDL-3.3
1.0019 ± 0.0036	0.9954 ± 0.0003	0.9889 ± 0.0002	0.9967 ± 0.0002

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

⇒ Fast cross sections for ^{237}Np should be reviewed

UNMODERATED ZEUS BENCHMARK

Source	k_{eff}	Δk
Experiment	1.0008 ± 0.0015	—
ENDF/B-VII β-2	1.0119 ± 0.0003	0.0111 ± 0.0015
ENDF/B-VI	1.0080 ± 0.0003	0.0072 ± 0.0015
JENDL-3.3	1.0242 ± 0.0003	0.0234 ± 0.0015

$|\Delta k| > 4\sigma$

Benchmark contains no moderator and therefore has a fast spectrum

All of the calculated results differ from the experimental value for k_{eff} by more than 4 standard deviations

Results for k_{eff} with ENDF/B-V Cross Sections for Copper

Source	k_{eff}	Δk
Experiment	1.0008 ± 0.0015	—
ENDF/B-VII β-2	1.0007 ± 0.0003	-0.0001 ± 0.0015
ENDF/B-VI	0.9968 ± 0.0003	-0.0040 ± 0.0015
JENDL-3.3	1.0001 ± 0.0003	-0.0007 ± 0.0015

$|\Delta k| > 2\sigma$

Both JENDL-3.3 and ENDF/B-VII β-2 now produce results for k_{eff} that are within a single standard deviation of the experimental value

Differences between ENDF/B-V and ENDF/B-VI Cu cross sections have little net reactivity impact on previous Zeus benchmarks, which have intermediate spectra

⇒ Fast cross sections for Cu should be reviewed

Unreflected Spheres of Plutonium-Nitrate Solutions

Case	H / ^{239}Pu Atom Radio	Benchmark k_{eff}	Calculated k_{eff}		
			ENDF/B-VII β-2	ENDF/B-VI	JENDL-3.3
PNL-6	131.83	1.0000 ± 0.0065	1.0047 ± 0.0005	1.0029 ± 0.0005	1.0070 ± 0.0004
PNL-5	574.52	1.0000 ± 0.0052	1.0062 ± 0.0004	1.0058 ± 0.0004	1.0098 ± 0.0004
PNL-1	701.70	1.0000 ± 0.0032	1.0070 ± 0.0004	1.0066 ± 0.0004	1.0101 ± 0.0004
PNL-8	797.62	1.0000 ± 0.0032	1.0058 ± 0.0004	1.0060 ± 0.0004	1.0101 ± 0.0004
PNL-4	907.13	1.0000 ± 0.0052	1.0006 ± 0.0004	1.0012 ± 0.0004	1.0043 ± 0.0004
PNL-3	1207.8	1.0000 ± 0.0052	0.9939 ± 0.0004	0.9954 ± 0.0004	0.9985 ± 0.0004
PST-9	2806.8	1.0003 ± 0.0033	1.0188 ± 0.0002	1.0190 ± 0.0002	1.0226 ± 0.0002

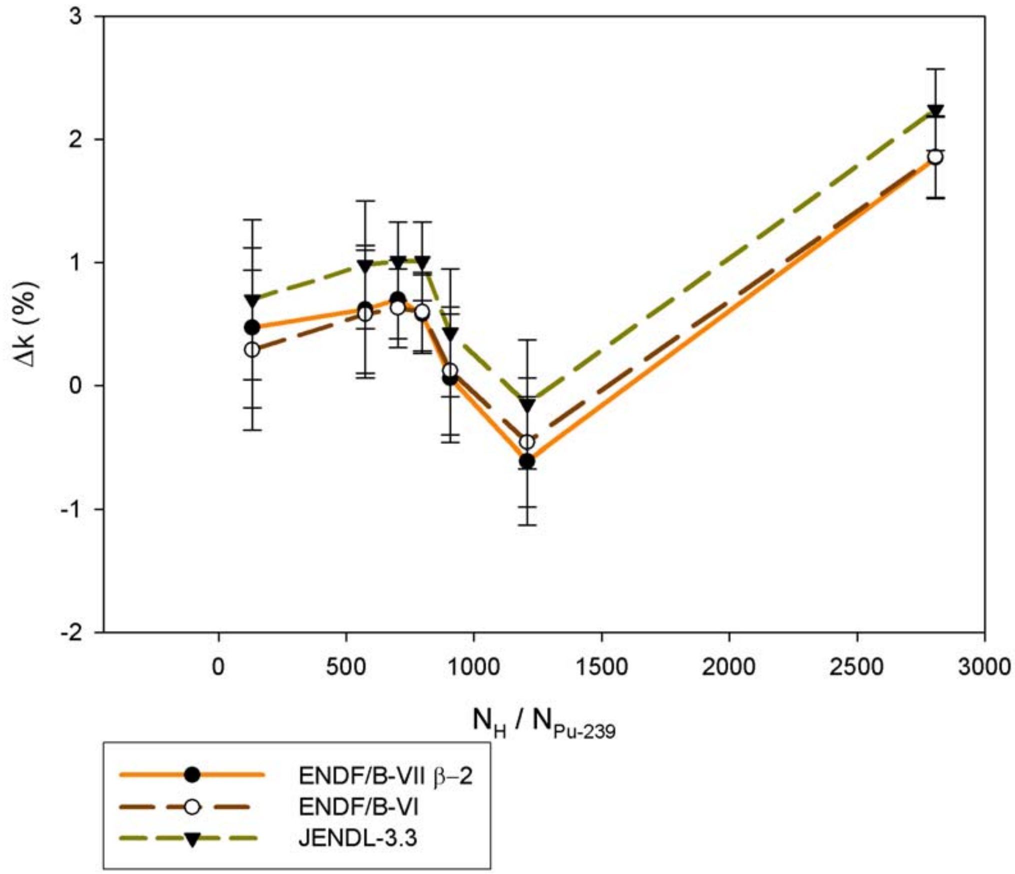
$\sigma < |\Delta k| \leq 2\sigma$ $\quad$ $|\Delta k| > 2\sigma$

ENDF/B-VII β-2 results are very similar to those from ENDF/B-VI

All differences greater than 1 σ are high, except for PNL-3

Is PST-9 (case 3a) a valid data point or an outlier?

Unreflected Spheres of Plutonium-Nitrate Solutions



⇒ Thermal cross sections for ^{239}Pu should be reviewed

PNL MOX Lattices

Case	Pitch (cm)	Soluble Boron (PPM)	Benchmark k_{eff}	Calculated k_{eff}		
				ENDF/B-VII β-2	ENDF/B-VI	JENDL-3.3
PNL-30	1.77800	1.7	1.0010 ± 0.0059	1.0010 ± 0.0003	0.9933 ± 0.0003	0.9987 ± 0.0003
PNL-31	1.77800	687.9	1.0009 ± 0.0045	1.0025 ± 0.0003	0.9960 ± 0.0004	1.0008 ± 0.0004
PNL-32	2.20914	0.9	1.0024 ± 0.0029	1.0028 ± 0.0003	0.9965 ± 0.0004	1.0018 ± 0.0003
PNL-33	2.20914	1090.4	1.0024 ± 0.0021	1.0066 ± 0.0003	1.0029 ± 0.0003	1.0069 ± 0.0003
PNL-34	2.51447	1.6	1.0038 ± 0.0022	1.0043 ± 0.0003	0.9989 ± 0.0003	1.0033 ± 0.0003
PNL-35	2.51447	767.2	1.0029 ± 0.0024	1.0067 ± 0.0003	1.0031 ± 0.0003	1.0062 ± 0.0004

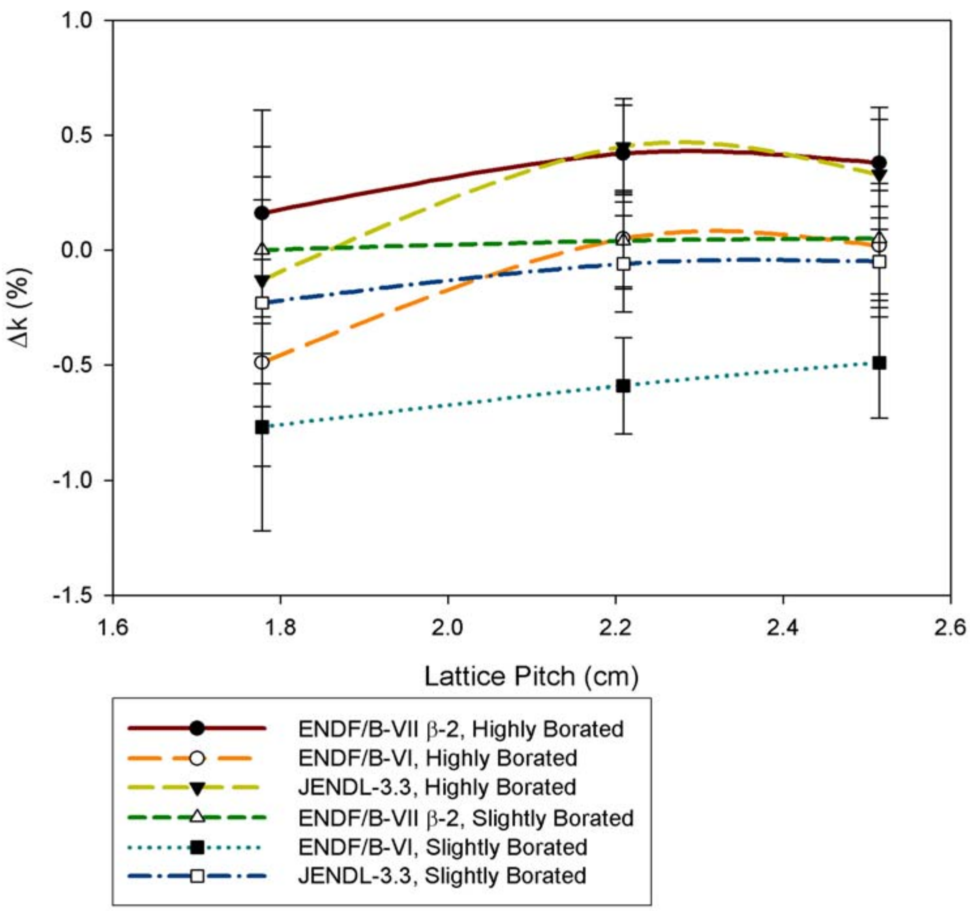
$\sigma < |\Delta k| \leq 2\sigma$ $|\Delta k| > 2\sigma$

Overall, ENDF/B-VII β-2 produces best results

None of the ENDF/B-VII β-2 values for k_{eff} are lower than the corresponding mean benchmark value, and two are higher by more than 1 standard deviation

All 3 libraries produce different shapes for borated and unborated cases

PNL MOX Lattices



⇒ Thermal cross sections for ^{239}Pu probably should be reviewed

RESULTS FOR HEAVY-WATER SOLUTIONS

Case	Benchmark k_{eff}	Calculated k_{eff}		
		ENDF/B-VII β-2 + JENDL-3.3 ^2H	ENDF/B-VII β-2	JENDL-3.3
Reflected Spheres (HEU-SOL-THERM-004)				
1	1.0000 ± 0.0033	0.9968 ± 0.0004	0.9861 ± 0.0004	0.9918 ± 0.0004
2	1.0000 ± 0.0036	0.9922 ± 0.0004	0.9812 ± 0.0004	0.9873 ± 0.0004
3	1.0000 ± 0.0039	0.9985 ± 0.0004	0.9886 ± 0.0004	0.9979 ± 0.0004
4	1.0000 ± 0.0046	1.0140 ± 0.0004	0.9911 ± 0.0004	0.9971 ± 0.0004
5	1.0000 ± 0.0052	0.9993 ± 0.0004	0.9886 ± 0.0004	0.9956 ± 0.0004
6	1.0000 ± 0.0059	0.9952 ± 0.0004	0.9847 ± 0.0005	0.9913 ± 0.0004
Unreflected Cylinders (HEU-SOL-THERM-020)				
1	0.9966 ± 0.0116	1.0036 ± 0.0005	0.9916 ± 0.0005	1.0006 ± 0.0005
2	0.9956 ± 0.0093	1.0103 ± 0.0005	0.9986 ± 0.0005	1.0066 ± 0.0005
3	0.9957 ± 0.0079	1.0186 ± 0.0005	1.0084 ± 0.0005	1.0149 ± 0.0005
4	0.9955 ± 0.0078	1.0161 ± 0.0005	1.0038 ± 0.0005	1.0160 ± 0.0005
5	0.9959 ± 0.0077	1.0230 ± 0.0005	1.0127 ± 0.0005	1.0167 ± 0.0005

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

CONCLUSIONS

Overall, ENDF/B-VII β-2 produces major reactivity improvements relative to ENDF/B-VI and JENDL-3.3

ENDF/B-VII β-2 produces dramatic improvements for bare metal spheres, BIG TEN, UH_3, THOR, and Pu sphere in water

Reactivity swings from bare spheres to corresponding systems reflected by normal uranium are eliminated or substantially reduced

Need for *ad hoc* adjustment to ^{238}U resonance integral may be eliminated

Improvements still are needed, particularly for:

- ^{235}U cross sections in the unresolved resonance region
- neptunium cross sections
- fast copper cross section
- thermal plutonium (^{239}Pu) cross sections
- angular scattering distribution for ^{2}H (probably)