

# Summary of ENDF/B-VII.0 Validation Work at VNIIEF

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# VNIEF ENDF/B-VII.0 Validation Summary

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- **VNIEF STATIC NEUTRONICS SIMULATIONS OF BENCHMARK EXPERIMENTS, TO VALIDATE NEW ENDF/B-VII NUCLEAR CROSS SECTION DATA**
  - Report on Contract 37713-000-35-02 TO # 036 between RFNC-VNIEF, Sarov, Russia, and Los Alamos National Laboratory (LANL), USA

# VNIEF ENDF/B-VII.0 Validation Summary

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- Objectives:
  - The objective of this work was to perform neutronics simulations of a number of published benchmarks using VNIEF codes (the C-95 Monte Carlo code [1] and the group  $S_n$  code from the BEND suite) to provide validation data testing for the new ENDF/B-VII cross section database[3].
  - For the neutronics simulations (criticality parameter  $k_{\text{eff}}$  and ratio of fission rates for different isotopes, there were chosen 120 benchmarks (test assemblies) from the Nuclear Energy Agency International Criticality Benchmark Project (ICSBEP) Handbook [4] and 6 critical assemblies representing VNIEF open benchmarks [5,6] that have not yet been included in the Handbook.

# VNIEF ENDF/B-VII.0 Validation Summary

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- Many ICSBEP Benchmarks
  - Bare Uranium Spheres (4, all “xxx-met-fast”)
  - Reflected Uranium Assemblies (41, all “xxx-xxx-fast”)
  - Bare  $^{239}\text{Pu}$  and  $^{235}\text{U}$  Spheres (3, all “mix-met-fast”)
  - Reflected  $^{239}\text{Pu}$  and  $^{235}\text{U}$  Spheres (26, all “mix-met-fast”)
  - Bare  $^{233}\text{U}$  Spheres (3, all “u233-met-fast”)
  - Reflected  $^{233}\text{U}$  Spheres (7, all “u233-met-fast”)
  - Bare Plutonium Spheres (4, all “pu-met-fast”)
  - Uranium Reflected Plutonium Spheres (3, all “pu-met-fast”)
  - Reflected Plutonium Assemblies (2, all “pu-met-fast”)
  - Reflected Plutonium Spheres (16, all “pu-met-fast”)
- 45 benchmarks are in common with LANL MCNP results published in the “Big Paper”.

# VNIEF ENDF/B-VII.0 Validation Summary

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- Six “open” VNIEF Benchmarks
  - spherical configurations with a central void and/or non-fissile region surrounded by shells of plutonium and/or enriched uranium
    - central cavity plus  $^{239}\text{Pu}$  plus  $^{235}\text{U}$  plus Ni.
    - central cavity plus Ni plus  $^{235}\text{U}(90\%)$  plus  $^{235}\text{U}(36\%)$ .
    - central cavity plus Ni plus  $^{235}\text{U}(90\%)$ .
    - central cavity plus  $^{235}\text{U}(90\%)$  plus  $^{235}\text{U}(36\%)$ .
    - central “salt” (Na, F & Zr) plus  $^{235}\text{U}(90\%)$  plus  $^{235}\text{U}(36\%)$ .
    - central “salt” (Na, F, Zr & U) plus  $^{235}\text{U}(90\%)$  plus  $^{235}\text{U}(36\%)$ .
- No discussion of cross section processing.

# VNIIEF ENDF/B-VII.0 Validation Summary

- Comparison with MCNP (LANL, Big Paper)
  - VNIIEF report, Table 2.13:

Fast Uranium Assemblies				ENDF/B-VII.0 (NDS)		ENDF/B-VII.0 (VNIIEF)	
Name	Geometry	$k_{\text{expt}}$	$\sigma_{\text{expt}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$
hmf1-1	Sphere	1.0000	0.0010	1.0000	0.0001	1.0006	0.0005
hmf18	Sphere	1.0000	0.0014	1.0002	0.0001	0.9987	0.0005
hmf21	Sphere + Fe	1.0000	0.0024	0.9976	0.0001	0.9973	0.0005
hmf22	Sphere + Al	1.0000	0.0019	0.9977	0.0001	<b>0.9879</b>	<b>0.0005</b>
hmf27	Sphere + Pb	1.0000	0.0025	1.0007	0.0001	<b>1.0104</b>	<b>0.0005</b>
hmf28	Sphere + $^{238}\text{U}$	1.0000	0.0030	1.0028	0.0001	1.0023	0.0004
hmf41-1	Sphere + Be	1.0013	0.0030	1.0025	0.0001	<b>1.0083</b>	<b>0.0005</b>
hmf41-2	Sphere + Be	1.0022	0.0043	1.0003	0.0001	<b>1.0087</b>	<b>0.0005</b>

## $^{233}\text{U}$ Spheres

umf-1	Sphere	1.0000	0.0010	9.9996	0.0001	0.9991	0.0005
umf-6	Sphere + $^{238}\text{U}$	1.0000	0.0014	0.9991	0.0001	0.9985	0.0005

# VNIIEF ENDF/B-VII.0 Validation Summary

- Comparison with MCNP (LANL, Big Paper)
  - VNIIEF report, Table 2.14:

Plutonium Spheres with Reflector				ENDF/B-VII.0 (NDS)		ENDF/B-VII.0 (VNIIEF)	
Name	Geometry	$k_{\text{expt}}$	$\sigma_{\text{expt}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$
Pmf1	Sphere	1.0000	0.0020	0.9999	0.0001	1.0001	0.0005
Pmf2	Sphere	1.0000	0.0020	1.0001	0.0001	0.9995	0.0005
Pmf6	Sphere + $^{238}\text{U}$	1.0000	0.0030	1.0002	0.0001	1.0017	0.0005
pmf-8	Sphere + $^{232}\text{Th}$	1.0000	0.0006	0.9980	0.0002	<b>1.0090</b>	<b>0.0005</b>
pmf-9	Sphere + Al	1.0000	0.0027	1.0052	0.0001	<b>0.9936</b>	<b>0.0005</b>
pmf11	Sphere + H <sub>2</sub> O	1.0000	0.0010	1.0004	0.0002	<b>1.0140</b>	<b>0.0005</b>
pmf22	Sphere	1.0000	0.0021	0.9987	0.0001	0.9987	0.0005
pmf23	Sphere + C	1.0000	0.0023	1.0001	0.0001	1.0003	0.0004
pmf24	Sphere + CH <sub>2</sub>	1.0000	0.0020	1.0020	0.0001	1.0023	0.0005
pmf25	Sphere + Fe	1.0000	0.0020	0.9990	0.0001	0.9992	0.0005
pmf26	Sphere + Fe	1.0000	0.0024	0.9986	0.0001	0.9991	0.0005
pmf35	Sphere + Pb	1.0000	0.0016	0.9979	0.0001	<b>1.0039</b>	<b>0.0005</b>

# VNIEF ENDF/B-VII.0 Validation Summary

- Comparison with MCNP (LANL, Big Paper)
  - VNIEF report, Table 2.15:

<sup>239</sup> Pu and <sup>235</sup> U Spheres with Reflector				ENDF/B-VII.0 (NDS)		ENDF/B-VII.0 (VNIEF)	
Name	Geometry	k <sub>expt</sub>	σ <sub>expt</sub>	k <sub>calc</sub>	σ <sub>calc</sub>	k <sub>calc</sub>	σ <sub>calc</sub>
mmf 7-1	Sphere + Be	1.0000	0.0045	1.0008	0.0002	<b>1.0083</b>	<b>0.0006</b>
mmf 7-2	Sphere + Be	1.0000	0.0023	1.0052	0.0002	<b>1.0124</b>	<b>0.0005</b>
mmf 7-3	Sphere + Be	1.0000	0.0028	1.0026	0.0001	<b>1.0092</b>	<b>0.0005</b>
mmf 7-4	Sphere + Be	1.0000	0.0028	1.0022	0.0001	<b>1.0079</b>	<b>0.0005</b>
mmf 7-5	Sphere + Be	1.0000	0.0032	1.0001	0.0001	<b>1.0037</b>	<b>0.0005</b>
mmf 7-6	Sphere + Be	1.0000	0.0035	0.9999	0.0001	1.0012	0.0005
mmf 7-7	Sphere + Be	1.0000	0.0032	1.0034	0.0002	<b>1.0110</b>	<b>0.0005</b>
mmf 7-8	Sphere + Be	1.0000	0.0030	1.0023	0.0002	<b>1.0092</b>	<b>0.0005</b>
mmf 7-9	Sphere + Be	1.0000	0.0028	1.0018	0.0002	<b>1.0088</b>	<b>0.0005</b>
mmf 7-10	Sphere + Be	1.0000	0.0027	1.0017	0.0001	<b>1.0076</b>	<b>0.0005</b>
mmf 7-11	Sphere + Be	1.0000	0.0026	1.0006	0.0001	<b>1.0058</b>	<b>0.0005</b>
mmf 7-12	Sphere + Be	1.0000	0.0030	1.0008	0.0001	<b>1.0035</b>	<b>0.0005</b>
mmf 7-13	Sphere + Be	1.0000	0.0033	1.0000	0.0001	<b>1.0018</b>	<b>0.0005</b>
mmf 7-14	Sphere + Be	1.0000	0.0032	1.0045	0.0001	<b>1.0125</b>	<b>0.0005</b>
mmf 7-15	Sphere + Be	1.0000	0.0032	1.0043	0.0001	<b>1.0116</b>	<b>0.0005</b>
mmf 7-16	Sphere + Be	1.0000	0.0028	1.0028	0.0001	<b>1.0086</b>	<b>0.0005</b>
mmf 7-17	Sphere + Be	1.0000	0.0028	1.0033	0.0001	<b>1.0072</b>	<b>0.0005</b>
mmf 7-18	Sphere + Be	1.0000	0.0030	1.0067	0.0001	<b>1.0086</b>	<b>0.0005</b>
mmf 7-19	Sphere + Be	1.0000	0.0034	1.0043	0.0001	<b>1.0093</b>	<b>0.0005</b>
mmf 7-20	Sphere + Be	1.0000	0.0030	1.0027	0.0001	<b>1.0054</b>	<b>0.0005</b>
mmf 7-21	Sphere + Be	1.0000	0.0031	1.0042	0.0001	1.0047	0.0005
mmf 7-22	Sphere + Be	1.0000	0.0030	1.0015	0.0001	<b>1.0064</b>	<b>0.0005</b>
mmf 7-23	Sphere + Be	1.0000	0.0028	1.0019	0.0001	<b>1.0049</b>	<b>0.0005</b>



# VNIEF ENDF/B-VII.0 Validation Summary

- Comparison among ENDF/B-VII.0, -VI.8, JEF-3, JENDL-3.3 & CENDL
  - Tables 2.1, 2.3, 2.7 & 2.8: Bare Uranium and Plutonium Spheres

Table 2.1: Bare Uranium Spheres				JENDL-3.3		JEF-3		CENDL		ENDF/B-VI.8		ENDF/B-VII.0	
Name	Geometry	$k_{\text{expt}}$	$\sigma_{\text{expt}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$
hmf-1/1	Sphere	1.0000	0.0010	1.0030	0.0005	0.9970	0.0005	0.9982	0.0005	0.9974	0.0005	1.0006	0.0005
hmf-1/2	Sphere	1.0000	0.0010	1.0030	0.0005	0.9960	0.0005	0.9974	0.0005	0.9984	0.0005	0.9996	0.0003
hmf-018	Sphere	1.0000	0.0014	1.0030	0.0005	0.9980	0.0005	0.9994	0.0005	0.9976	0.0005	0.9987	0.0005
imf3	Sphere	1.0000	0.0018	0.9984	0.0005	0.9956	0.0005	1.0060	0.0005	1.0008	0.0005	1.0012	0.0005

Table 2.3: Bare $^{239}\text{Pu}$ and $^{235}\text{U}$ Spheres													
Name	Geometry	$k_{\text{expt}}$	$\sigma_{\text{expt}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$
mmf-1	Sphere	1.0000	0.0016	0.9970	0.0005	0.9980	0.0005	1.0002	0.0005	0.9969	0.0005	0.9996	0.0005
mmf-9	Sphere	1.0000	0.0015	0.9962	0.0005	0.9990	0.0005	1.0021	0.0005	0.9972	0.0005	1.0012	0.0005
mmf-10	Sphere	1.0000	0.0014	0.9980	0.0005	0.9960	0.0005	0.9995	0.0005	0.9969	0.0005	1.0006	0.0004

Table 2.7: Bare $^{239}\text{Pu}$ Spheres													
Name	Geometry	$k_{\text{expt}}$	$\sigma_{\text{expt}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$
Pmf 1	Sphere	1.0000	0.0020	0.9971	0.0005	1.0008	0.0005	1.0010	0.0005	0.9973	0.0005	1.0001	0.0005
Pmf 2	Sphere	1.0000	0.0020	1.0017	0.0005	1.0052	0.0005	1.0009	0.0005	0.9975	0.0005	0.9995	0.0005
Pmf 22	Sphere	1.0000	0.0037	0.9958	0.0003	0.9990	0.0005	1.0006	0.0005	0.9955	0.0005	0.9987	0.0005
Pmf 29	Sphere	1.0000	0.0019	0.9949	0.0005	0.9972	0.0005	0.9973	0.0005	0.9927	0.0005	0.9959	0.0005

Table 2.8: Plutonium Spheres with Uranium Reflector													
Name	Geometry	$k_{\text{expt}}$	$\sigma_{\text{expt}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$
Pmf 41	Sphere+ $^{238}\text{U}$	1.0000	0.0016	0.9987	0.0005	1.0015	0.0005	1.0019	0.0005	1.0075	0.0005	1.0054	0.0005
pmf-10	Sphere+ $^{238}\text{U}$	1.0000	0.0018	0.9920	0.0005	0.9966	0.0005	0.9975	0.0005	1.0001	0.0005	1.0009	0.0005
Pmf 6	Sphere+ $^{238}\text{U}$	1.0000	0.0030	0.9913	0.0005	0.9950	0.0005	0.9968	0.0005	1.0038	0.0005	1.0017	0.0005

# VNIIEF ENDF/B-VII.0 Validation Summary

Table 2.2: Fast Uranium Assemblies with Reflector				JENDL-3.3		JEF-3		CENDL		ENDF/B-VI.8		ENDF/B-VII.0	
Name	Geometry	$k_{\text{expt}}$	$\sigma_{\text{expt}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$
hmf28	Sphere+ <sup>238</sup> U	1.0000	0.0030	0.9991	0.0005	0.9940	0.0005	1.0004	0.0005	1.0033	0.0005	1.0023	0.0004
hmf3-1	Sphere+ <sup>238</sup> U	1.0000	0.0050	0.9928	0.0005	0.9876	0.0005	0.9927	0.0005	0.9944	0.0005	0.9952	0.0005
hmf3-3	Sphere+ <sup>238</sup> U	1.0000	0.0050	0.9956	0.0005	0.9901	0.0005	0.9964	0.0004	0.9989	0.0005	1.0001	0.0005
hmf31	Sphere+CH <sub>2</sub>	1.0000	0.0059	1.0030	0.0005	0.9988	0.0005	1.0136	0.0005	1.0034	0.0005	1.0028	0.0005
hmf3-11	Sphere+WC	1.0000	0.0050	1.0141	0.0005	1.0183	0.0005	1.0123	0.0005	1.0107	0.0005	<b>1.0125</b>	0.0005
hmf3-8	Sphere+WC	1.0000	0.0050	1.0022	0.0005	1.0070	0.0005	1.0087	0.0005	1.0070	0.0005	<b>1.0100</b>	0.0005
hmf3-12	Sphere+Ni	1.0000	0.0050	1.0092	0.0005	1.0018	0.0005	1.0142	0.0005	1.0041	0.0005	<b>1.0083</b>	0.0005
hmf41-1	Sphere+Be	1.0013	0.0030	1.0114	0.0005	1.0071	0.0005	1.0084	0.0005	1.0081	0.0005	<b>1.0083</b>	0.0005
hmf41-2	Sphere+Be	1.0022	0.0043	1.0093	0.0005	1.0062	0.0005	1.0114	0.0005	1.0084	0.0005	<b>1.0087</b>	0.0005
hmf41-6	Sphere+C	1.0006	0.0045	1.0063	0.0005	1.0009	0.0005	1.0027	0.0005	1.0030	0.0005	<b>1.0061</b>	0.0005
imf5	Sphere+Fe	1.0000	0.0025	1.0032	0.0005	1.0025	0.0005	1.0101	0.0005	1.0038	0.0005	1.0003	0.0005
imf6	Sphere+Al	1.0000	0.0022	0.9939	0.0005	0.9751	0.0005	1.0016	0.0005	0.9920	0.0005	<b>0.9796</b>	0.0005
imf8	Cylinder+ <sup>238</sup> U	1.0000	0.0023	0.9986	0.0003	0.9980	0.0005	1.0093	0.0005	1.0052	0.0005	<b>1.0057</b>	0.0005
hcf 903	Cylinder+ <sup>238</sup> U	1.0000	0.0028	0.9888	0.0005	0.9941	0.0005	1.0217	0.0005	1.0009	0.0005	<b>0.9916</b>	0.0005
icf 904	Cylinder+ <sup>238</sup> U	1.0000	0.0015	0.9921	0.0005	0.9875	0.0005	1.0059	0.0005	1.0002	0.0005	<b>0.9900</b>	0.0005
lcf 905	Cylinder+ <sup>238</sup> U	1.0000	0.0025	0.9894	0.0005	0.9917	0.0005	1.0129	0.0005	1.0055	0.0005	<b>0.9908</b>	0.0005
hmf 16-1	Cylinder+Be	0.9996	0.0018	1.0057	0.0005	1.0014	0.0005	1.0042	0.0005	1.0021	0.0005	<b>1.0176</b>	0.0005
hmf 16-2	Cylinder+BeO	0.9996	0.0018	1.0070	0.0005	1.0003	0.0005	1.0048	0.0005	1.0030	0.0005	<b>1.0155</b>	0.0005
hmf 17	Cylinder+Be	0.9993	0.0014	1.0033	0.0005	1.0005	0.0005	1.0083	0.0005	1.0017	0.0005	1.0025	0.0005
hmf 2-2	Cylinder+ <sup>238</sup> U	1.0000	0.0030	0.9975	0.0005	0.9936	0.0005	0.9993	0.0005	1.0027	0.0005	1.0046	0.0005
hmf 35	Cylinder+Fe	0.9966	0.0028	0.9852	0.0005	0.9929	0.0005	1.0524	0.0005	0.9986	0.0005	1.0046	0.0005
hmf 37-2	Cylinder+Cd+CH <sub>2</sub>	0.9997	0.0011	0.9827	0.0005	0.9809	0.0005	1.0082	0.0005	0.9859	0.0005	<b>0.9806</b>	0.0005
hmf-17	Cylinder+Be	0.9993	0.0014	1.0100	0.0005	1.0040	0.0005	1.0063	0.0005	1.0044	0.0005	<b>1.0072</b>	0.0005
hmf-19	Sphere+C	1.0000	0.0028	0.9974	0.0005	0.9940	0.0005	0.9981	0.0005	1.0024	0.0005	1.0012	0.0005
hmf-2	Sphere+ <sup>238</sup> U	1.0000	0.0030	1.0030	0.0005	0.9970	0.0005	0.9990	0.0005	0.9988	0.0005	1.0011	0.0005
hmf-20	Sphere+CH <sub>2</sub>	1.0000	0.0028	1.0040	0.0005	1.0040	0.0005	1.0005	0.0005	0.9947	0.0005	0.9973	0.0005
hmf-21	Sphere+Fe	1.0000	0.0023	1.0001	0.0005	0.9850	0.0005	0.9964	0.0005	0.9939	0.0005	<b>0.9879</b>	0.0005
hmf-22	Sphere+Al	1.0000	0.0018	1.0090	0.0005	1.0004	0.0005	1.0027	0.0005	1.0120	0.0005	<b>1.0104</b>	0.0005
hmf-27	Sphere+Pb	1.0000	0.0025	1.0200	0.0005	1.0130	0.0005	1.0173	0.0005	1.0050	0.0005	<b>1.0067</b>	0.0005
hmf-29	Sphere+ <sup>238</sup> U	1.0000	0.0028	0.9990	0.0005	0.9930	0.0005	0.9979	0.0005	0.9994	0.0005	1.0011	0.0005
hmf-32/3	Sphere+ <sup>238</sup> U	1.0000	0.0017	1.0020	0.0005	0.9960	0.0005	0.9980	0.0005	0.9999	0.0005	1.0013	0.0005
hmf-32/4	Sphere+ <sup>238</sup> U	1.0000	0.0017	1.0096	0.0005	1.0070	0.0005	1.0069	0.0005	1.0082	0.0005	<b>1.0083</b>	0.0005
hmf-41/1	Sphere+Be	1.0013	0.0030	1.0060	0.0005	0.9980	0.0005	1.0005	0.0005	1.0005	0.0005	1.0038	0.0005
hmf-41/3	Sphere+C	1.0006	0.0029	1.0100	0.0005	1.0040	0.0005	1.0063	0.0005	1.0044	0.0005	<b>1.0072</b>	0.0005

# VNIEF ENDF/B-VII.0 Validation Summary

- Comparison among ENDF/B-VII.0, -VI.8, JEF-3, JENDL-3.3 & CENDL

**Table 2.4: <sup>239</sup>Pu and <sup>235</sup>U Spheres with Reflector**

Table 2.4: <sup>239</sup> Pu and <sup>235</sup> U Spheres with Reflector				JENDL-3.3		JEF-3		CENDL		ENDF/B-VI.8		ENDF/B-VII.0	
Name	Geometry	k <sub>expt</sub>	σ <sub>expt</sub>	k <sub>calc</sub>	σ <sub>calc</sub>	k <sub>calc</sub>	σ <sub>calc</sub>	k <sub>calc</sub>	σ <sub>calc</sub>	k <sub>calc</sub>	σ <sub>calc</sub>	k <sub>calc</sub>	σ <sub>calc</sub>
mmf 2-1	Sphere+ <sup>235</sup> U	1.0000	0.0042	0.9997	0.0005	0.9984	0.0005	1.0026	0.0005	1.0058	0.0005	1.0054	0.0005
mmf 2-2	Sphere+ <sup>235</sup> U	1.0000	0.0044	0.9994	0.0005	0.9987	0.0005	1.0021	0.0005	1.0053	0.0005	1.0048	0.0005
mmf 2-3	Sphere+ <sup>235</sup> U	1.0000	0.0048	0.9997	0.0005	0.9994	0.0005	1.0023	0.0005	1.0051	0.0005	1.0044	0.0005
mmf7-21	Sphere+Be	1.0000	0.0031	1.0021	0.0005	1.0026	0.0005	1.0033	0.0005	1.0021	0.0005	1.0047	0.0005
mmf7-13	Sphere+Be	1.0000	0.0033	1.0004	0.0005	0.9981	0.0005	1.0005	0.0005	1.0004	0.0005	1.0018	0.0005
mmf7-18	Sphere+Be	1.0000	0.0030	1.0066	0.0005	1.0055	0.0005	1.0074	0.0005	1.0066	0.0005	1.0086	0.0005
mmf7-6	Sphere+Be	1.0000	0.0035	1.0018	0.0005	0.9974	0.0005	1.0023	0.0005	1.0018	0.0005	1.0012	0.0005
mmf7-23	Sphere+Be	1.0000	0.0028	1.0022	0.0005	1.0020	0.0005	1.0031	0.0005	1.0022	0.0005	1.0049	0.0005
mmf7-12	Sphere+Be	1.0000	0.0030	1.0021	0.0005	1.0011	0.0005	1.0016	0.0005	1.0021	0.0005	1.0035	0.0005
mmf7-20	Sphere+Be	1.0000	0.0030	1.0026	0.0005	1.0044	0.0005	1.0037	0.0005	1.0026	0.0005	1.0054	0.0005
mmf7-22	Sphere+Be	1.0000	0.0030	1.0018	0.0005	1.0043	0.0005	1.0048	0.0005	1.0018	0.0005	1.0064	0.0005
mmf7-5	Sphere+Be	1.0000	0.0032	1.0039	0.0005	1.0006	0.0005	1.0029	0.0005	1.0039	0.0005	1.0037	0.0005
mmf7-17	Sphere+Be	1.0000	0.0028	1.0047	0.0005	1.0046	0.0005	1.0051	0.0005	1.0047	0.0005	1.0072	0.0005
mmf7-19	Sphere+Be	1.0000	0.0034	1.0061	0.0005	1.0059	0.0005	1.0067	0.0005	1.0061	0.0005	1.0093	0.0005
mmf7-11	Sphere+Be	1.0000	0.0026	1.0037	0.0005	1.0025	0.0005	1.0036	0.0005	1.0037	0.0005	1.0058	0.0005
mmf7-16	Sphere+Be	1.0000	0.0028	1.0055	0.0005	1.0063	0.0005	1.0066	0.0005	1.0055	0.0005	1.0086	0.0005
mmf7-4	Sphere+Be	1.0000	0.0028	1.0054	0.0005	1.0040	0.0005	1.0052	0.0005	1.0054	0.0005	1.0079	0.0005
mmf7-10	Sphere+Be	1.0000	0.0027	1.0035	0.0005	1.0050	0.0005	1.0051	0.0005	1.0035	0.0005	1.0076	0.0005
mmf7-15	Sphere+Be	1.0000	0.0032	1.0082	0.0005	1.0077	0.0005	1.0084	0.0005	1.0082	0.0005	1.0116	0.0005
mmf7-3	Sphere+Be	1.0000	0.0028	1.0074	0.0005	1.0061	0.0005	1.0069	0.0005	1.0074	0.0005	1.0092	0.0005
mmf7-14	Sphere+Be	1.0000	0.0032	1.0091	0.0005	1.0077	0.0005	1.0098	0.0005	1.0091	0.0005	1.0125	0.0005
mmf7-9	Sphere+Be	1.0000	0.0028	1.0066	0.0005	1.0060	0.0005	1.0063	0.0005	1.0066	0.0005	1.0088	0.0005
mmf7-8	Sphere+Be	1.0000	0.0030	1.0062	0.0005	1.0067	0.0005	1.0072	0.0005	1.0062	0.0005	1.0092	0.0005
mmf7-2	Sphere+Be	1.0000	0.0023	1.0111	0.0005	1.0101	0.0005	1.0098	0.0005	1.0111	0.0005	1.0124	0.0005
mmf7-7	Sphere+Be	1.0000	0.0032	1.0089	0.0005	1.0076	0.0005	1.0095	0.0005	1.0089	0.0005	1.0110	0.0005
mmf7-1	Sphere+Be	1.0000	0.0045	1.0069	0.0005	1.0066	0.0005	1.0072	0.0005	1.0069	0.0005	1.0083	0.0006

# VNIEF ENDF/B-VII.0 Validation Summary

- Comparison among ENDF/B-VII.0, -VI.8, JEF-3, JENDL-3.3 & CENDL
  - Tables 2.9 & 2.10: Fast, Reflected Plutonium Assemblies

Table 2.9: Plutonium Assemblies with Reflector				JENDL-3.3		JEF-3		CENDL		ENDF/B-VI.8		ENDF/B-VII.0	
Name	Geometry	$k_{\text{expt}}$	$\sigma_{\text{expt}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$
Pmf21-1	Cylinder+Be	1.0000	0.0026	1.0035	0.0005	1.0050	0.0005	1.0066	0.0005	1.0041	0.0005	1.0046	0.0005
Pmf21-2	Cylinder+BeO	1.0000	0.0026	0.9921	0.0005	0.9928	0.0005	0.9962	0.0005	0.9921	0.0005	0.9910	0.0005

Table 2.10: Plutonium Spheres with Reflector				JENDL-3.3		JEF-3		CENDL		ENDF/B-VI.8		ENDF/B-VII.0	
Name	Geometry	$k_{\text{expt}}$	$\sigma_{\text{expt}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$
Pmf 32	Sphere+Fe	1.0000	0.0020	0.9992	0.0005	1.0036	0.0005	0.9997	0.0005	1.0000	0.0005	0.9991	0.0005
pmf-35	Sphere+Pb	1.0000	0.0017	1.0020	0.0005	1.0010	0.0005	1.0086	0.0005	1.0124	0.0005	<b>1.0039</b>	0.0005
pmf-11	Sphere+H <sub>2</sub> O	1.0000	0.0010	0.9980	0.0005	0.9970	0.0005	1.0014	0.0005	0.9971	0.0005	<b>1.0140</b>	0.0005
pmf-5	Sphere+BHM	1.0000	0.0013	0.9900	0.0005	0.9990	0.0005	1.0012	0.0005	1.0108	0.0005	<b>1.0117</b>	0.0005
pmf-8	Sphere+ <sup>232</sup> Th	1.0000	0.0006	1.0007	0.0005	1.0020	0.0005	1.0110	0.0005	1.0068	0.0005	<b>1.0090</b>	0.0005
pmf-18	Sphere+Be	1.0000	0.0030	0.9978	0.0005	1.0010	0.0005	1.0056	0.0005	0.9995	0.0005	<b>1.0025</b>	0.0005
pmf-23	Sphere+C	1.0000	0.0029	0.9960	0.0005	0.9970	0.0005	1.0003	0.0005	0.9984	0.0005	1.0003	0.0005
pmf-24	Sphere+CH <sub>2</sub>	1.0000	0.0018	1.0002	0.0005	0.9990	0.0005	1.0044	0.0005	1.0002	0.0005	1.0023	0.0005
pmf-25	Sphere+Fe	1.0000	0.0019	0.9960	0.0005	1.0020	0.0005	1.0007	0.0005	0.9961	0.0005	0.9992	0.0005
pmf-26	Sphere+Fe	1.0000	0.0017	0.9994	0.0005	1.0099	0.0005	1.0045	0.0005	0.9956	0.0005	0.9991	0.0005
pmf-27	Sphere+CH <sub>2</sub>	1.0000	0.0018	1.0020	0.0005	1.0020	0.0005	1.0050	0.0005	1.0015	0.0005	<b>1.0111</b>	0.0005
pmf-28	Sphere+Fe	1.0000	0.0020	1.0020	0.0005	1.0100	0.0005	1.0048	0.0005	0.9967	0.0005	0.9995	0.0005
pmf-30	Sphere+C	1.0000	0.0021	1.0002	0.0005	1.0040	0.0005	1.0035	0.0005	1.0013	0.0005	1.0045	0.0005
pmf-39	Sphere+Al	1.0000	0.0023	0.9866	0.0005	0.9820	0.0005	0.9924	0.0005	0.9877	0.0005	<b>0.9827</b>	0.0005
pmf-40	Sphere+Cu	1.0000	0.0039	0.9950	0.0005	1.0009	0.0005	1.0026	0.0005	0.9937	0.0005	0.9971	0.0005
pmf-9	Sphere+Al	1.0000	0.0027	1.0002	0.0005	0.9930	0.0005	1.0037	0.0005	1.0008	0.0005	<b>0.9936</b>	0.0005

# VNIEF ENDF/B-VII.0 Validation Summary

- Comparison among ENDF/B-VII.0, -VI.8, JEF-3, JENDL-3.3 & CENDL
  - Tables 2.5 & 2.6: Fast  $^{233}\text{U}$  Spherical Systems

Table 2.5: Bare $^{233}\text{U}$ Spheres				JENDL-3.3		JEF-3		CENDL		ENDF/B-VI.8		ENDF/B-VII.0	
Name	Geometry	$k_{\text{expt}}$	$\sigma_{\text{expt}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$
umf-1	Sphere	1.0000	0.0010	1.0037	0.0005	1.0130	0.0005	0.9920	0.0005	0.9932	0.0005	0.9991	0.0005
umf-2-1	Sphere	1.0000	0.0010	1.0030	0.0005	1.0090	0.0005	0.9954	0.0005	0.9948	0.0005	0.9998	0.0005
umf-2-2	Sphere	1.0000	0.0011	1.0052	0.0005	1.0090	0.0005	0.9981	0.0005	0.9983	0.0005	1.0003	0.0005

Table 2.6: $^{233}\text{U}$ Spheres with Reflector				JENDL-3.3		JEF-3		CENDL		ENDF/B-VI.8		ENDF/B-VII.0	
Umf	Geometry	$k_{\text{expt}}$	$\sigma_{\text{expt}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$	$k_{\text{calc}}$	$\sigma_{\text{calc}}$
Umf 5-1	Sphere+Be	1.0000	0.0009	1.0013	0.0005	1.0093	0.0005	0.9982	0.0005	0.9955	0.0005	0.9980	0.0005
Umf 5-2	Sphere+Be	1.0000	0.0006	1.0025	0.0005	1.0081	0.0005	1.0004	0.0005	0.9979	0.0005	0.9990	0.0005
umf-3-1	Sphere+ $^{238}\text{U}$	1.0000	0.0010	1.0020	0.0005	1.0090	0.0005	0.9958	0.0005	0.9968	0.0005	0.9995	0.0005
umf-3-2	Sphere+ $^{238}\text{U}$	1.0000	0.0010	1.0008	0.0005	1.0080	0.0005	0.9978	0.0005	0.9991	0.0005	1.0015	0.0005
umf-4-1	Sphere+W+Ni+Cu	1.0000	0.0007	1.0008	0.0005	1.0100	0.0005	0.9954	0.0005	1.0047	0.0005	<b>1.0066</b>	0.0005
umf-4-2	Sphere+W+Ni+Cu	1.0000	0.0008	0.9930	0.0005	1.0070	0.0005	0.9937	0.0005	1.0092	0.0005	<b>1.0079</b>	0.0005
umf 6	Sphere+ $^{238}\text{U}$	1.0000	0.0014	0.9997	0.0005	1.0050	0.0005	0.9983	0.0005	1.0004	0.0005	0.9985	0.0005

# VNIIEF ENDF/B-VII.0 Validation Summary

- Comparison among ENDF/B-VII.0, -VI.8, JEF-3, JENDL-3.3 & CENDL
  - Tables 2.11 & s.12: Other VNIIEF Benchmarks

Table 2.11: Ni Sphere Surrounded by Plutonium				JENDL-3.3		JEF-3		CENDL		ENDF/B-VI.8		ENDF/B-VII.0	
Name	Geometry	$k_{expt}$	$\sigma_{expt}$	$k_{calc}$	$\sigma_{calc}$	$k_{calc}$	$\sigma_{calc}$	$k_{calc}$	$\sigma_{calc}$	$k_{calc}$	$\sigma_{calc}$	$k_{calc}$	$\sigma_{calc}$
PuNi-1	Sphere+Ni	1.0000	0.0009	0.9967	0.0001	0.9987	0.0001	1.0057	0.0001	0.9980	0.0001	1.0017	0.0001
PuNi-2	Sphere+Ni	1.0000	0.0014		0.0001	1.0002	0.0001		0.0001	1.0046	0.0001	1.0068	0.0001
PuNi-3	Sphere+Ni	1.0000	0.0029	1.0046	0.0001	0.9985	0.0001	1.0009	0.0001	0.9997	0.0001	1.0017	0.0001

Table 2.12: Hollow Uranium Salt Spheres				JENDL-3.3		JEF-3		CENDL		ENDF/B-VI.8		ENDF/B-VII.0	
Name	Geometry	$k_{expt}$	$\sigma_{expt}$	$k_{calc}$	$\sigma_{calc}$	$k_{calc}$	$\sigma_{calc}$	$k_{calc}$	$\sigma_{calc}$	$k_{calc}$	$\sigma_{calc}$	$k_{calc}$	$\sigma_{calc}$
Psol-1	Sphere	1.0000	0.0013	0.9858	0.0001	0.9799	0.0001	0.9840	0.0001	0.9834	0.0001	0.9855	0.0001
Psol-2	Sphere	1.0000	0.0020	0.9980	0.0001	0.9937	0.0001	1.0000	0.0001	0.9994	0.0001	0.9990	0.0001
Psol-3	Sphere	1.0000	0.0020	0.9952	0.0001	0.9913	0.0001	0.9973	0.0001	0.9970	0.0001	0.9968	0.0001

# VNIEF ENDF/B-VII.0 Validation Summary

- Results for Spectral Indices in the Central Cavity.
  - The simulation data for  $(\sigma_{U-238f}/\sigma_{U-235f})$  (see Table 3.1) show satisfactory agreement to within  $\sigma_{exp}$  (i.e. ~4-5%). This difference was obtained in the simulations with all the libraries considered.
  - Table 3.2 for  $(\sigma_{U-233f}/\sigma_{U-235f})$  shows good agreement with experiment, and simulation results using ENDF/B-7 look credible.
  - The simulation data presented in Table 3.3 for  $(\sigma_{U-234f}/\sigma_{U-235f})$  suggest that the cross-sections of  $^{234}\text{U}$  seem to be somewhat improved in ENDF/B-7 as illustrated by the case of using JENDL-3.3 data.
  - The data in Table 3.4 for  $(\sigma_{U-236f}/\sigma_{U-235f})$  show satisfactory agreement with experiment.
  - The data in Table 3.5 for  $(\sigma_{Pu-240f}/\sigma_{U-235f})$  on average provide a satisfactory description of experiment, although there is a spread of (2-3)  $\sigma_{exp}$ .
  - For  $(\sigma_{Pu-239f}/\sigma_{U-235f})$  (see Table 3.6) one can observe definite agreement with experiment to within (1-2)  $\sigma_{exp}$  of simulations with the libraries considered.
  - For  $(\sigma_{Np-237f}/\sigma_{U-235f})$  (see Table 3.7), a wide spread of calculated values obtained using different libraries is observed (up to (3-5)  $\sigma_{exp}$ ), but the simulation data obtained using ENDF/B-7 look not bad compared to other libraries.

# VNIIEF ENDF/B-VII.0 Validation Summary

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- **Conclusions:**

- The objective of the work described was to perform neutronics simulations of a number of published benchmarks using VNIIEF codes (C-95 (Monte-Carlo) and  $S_n$  code (group) from the BEND suite[2]) to validate the new ENDF-B-VII evaluated neutron data library [3]. An attempt was made to perform a comparative quality assessment of ENDF/B-7 versus other evaluated neutron data libraries (ENDF/B-VI.8, JENDL-3.3, JEF-3, CENDL-2).
- The analysis was performed based on the comparative benchmark simulations using different libraries. Also, an attempt was made to supplement the library quality assessment with a comparison of calculated and experimental spectral indices for different nuclides.
- On the whole, the analysis demonstrated rather high quality of ENDF/B-7 data, although some elements and isotopes were revealed that probably require special attention (for example Ni, W, Np, probably  $^{234}\text{U}$  and  $^{236}\text{U}$ ); it is also noted that additional analysis is needed for the group of Pu- $\alpha$  critical assemblies with  $^{238}\text{U}$  reflector, for which the parameter is systematically overstated to  $\sim 0.5\%$ .