

REPORT

**Processing of the new JEFF-3.2T4
Cross Section Library with the NJOY
Code System into Various Formats
for Testing Purposes**

NEA-2014

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1. Introduction.

The objective of this work is to process the updated files to be included in the new version of JEFF-3.2T4/February 2014.

According with the new data and corrections of these updates, this report has been focused on processing of Cu63, Cu65 and Mn55.

Table 1. JEFF-3.2 Updates in February 2014.

• Mn-55 :	New IAEA evaluation (Trkov)
• Cu-63 :	New KIT evaluation (Fischer)
• Cu-65 :	New KIT evaluation (Fischer)
• Y-89 :	MF10 Q values updated, MF 14 fixs (Mattoon)
• Nb-93 :	Minor fix (Cabellos)
• Mo-95 :	MF14 fix (Mattoon)
• Pd-105 :	MF14 fix (Mattoon)
• U-235 :	New CEA evaluation, MF12 fix (Duarte)
• U-238 :	New CEA evaluation, MF12 fix (Duarte)
• Pu-239 :	New CEA evaluation, MF12 fix (Duarte)
• Pu-240 :	New CEA evaluation, MF12 fix (Duarte)

Last update: 19 February 2014.

The report includes:

- An extensive criticality validation suite of 123 cases from ICSBEP has been used to test JEFF-3.2T4.
- An additional Benchmark proposed by A.Trkov, PU-MET-INT-002 is included in this work.
- A preliminary analysis of HEU–MET-FAST-73 Benchmark has been performed, concluding the importance of Cu63 and Cu65 evaluation. It is recommended a revision of this Benchmark.
- A comparison with total, elastic, capture and damage energy cross-sections ENDF/B-VII.1 has been done.
- Calculations with INTER code are shown, and these values are compared with ATLAS data.
- NJOY [NJOY99_up393] and PREPRO [PREPRO2010] Warnings are also included in the report.

2. Criticality Validation

An extensive criticality validation suite of 123 cases [ICSBEP, LA-UR-11-04170, NEA/JEFF-3.1.1] is used from the *International Handbook of Evaluated Criticality Safety Benchmark Experiments* from the OECD-NEA project ICSBEP, September 2010 Edition.

➤ ^{233}U	: 18
➤ highly enriched uranium (HEU)	: 40
➤ intermediate-enriched uranium (IEU)	: 17
➤ low-enriched uranium (LEU)	: 8
➤ plutonium	: 36

For each type of fuel, there are cases with a variety of:

- moderators
- reflectors
- spectra
- geometries

In addition, 4 cases also included in ICSBEP are included for testing purposes:

- Np237
- heavy-Water solutions
- very thermal Pu solution
- unmoderated ZEUS benchmark

MCNP inputs uses (`kcode 10000 1.0 100 600`). A statistical uncertainty between 0.00020 and 0.00040 is obtained. For simplicity, this statistical uncertainty is not shown in the following tables.

Table 2. ^{233}U Benchmarks

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEF Benchmark name	Benchmark	keff			
						ENDF/B-VII.1 293.6K	JEFF-3.1.2 293.6K	JEFF-3.2T3 293.6K	JEFF-3.2T4 293.6K
Fast	Metal	Spheres	Unreflected	u233-met-fast-001	1.0000±0.0010	0.99994	1.00444	0.99961	0.99961
			HEU	u233-met-fast-002-CASE_1	1.0000±0.0010	0.99850	1.00252	0.99902	0.99902
				u233-met-fast-002-CASE_2	1.0000±0.0011	1.00014	1.00379	1.00061	1.00061
			Normal Uranium	u233-met-fast-003-CASE_1	1.0000±0.0010	0.99808	1.00528	0.99881	0.99881
				u233-met-fast-003-CASE_2	1.0000±0.0010	0.99778	1.00466	0.99977	0.99977
				u233-met-fast-006	1.0000±0.0014	0.99902	1.00586	1.00105	1.00105
			Tungsten	u233-met-fast-004-CASE_1	1.0000±0.0007	0.99895	1.00584	0.99924	0.99856
				u233-met-fast-004-CASE_2	1.0000±0.0008	0.99505	1.00466	0.99713	0.99753
			Beryllium	u-233-met-fast-005-CASE_1	1.0000±0.0030	0.99626	BeO STL+	BeO STL+	BeO STL+
				u-233-met-fast-005-CASE_2	1.0000±0.0030	0.99504	BeO STL+	BeO STL+	BeO STL+
Intermediate	Solution	Sphere	Beryllium	u233-sol-inter-001-case1	1.0000±0.0083	0.98521	0.98438	0.98563	0.98563
Thermal	UO ₂ +ZrO ₂	Lattice	Water	u233-comp-therm-001-case3	1.0000±0.0024	1.00163	0.99795	1.00348	1.00364
	Solution	Sphere	Unreflected	u233-sol-therm-001-case1	1.0000±0.0031	1.00137	0.99844	1.00195	1.00201
				u233-sol-therm-001-case2	1.0000±0.0033	1.00101	0.99846	1.00192	1.00179
				u233-sol-therm-001-case3	1.0000±0.0033	1.00039	0.99835	1.00114	1.00135
				u233-sol-therm-001-case4	1.0000±0.0033	1.00016	0.99806	1.00146	1.00135
				u233-sol-therm-001-case5	1.0000±0.0033	1.00026	0.99802	1.0005	1.00039
				u233-sol-therm-008	1.0000±0.0029	1.00136	0.99805	1.00121	1.00133

$$\sigma < |\Delta k| \leq 2\sigma \quad 2\sigma < |\Delta k| \leq 3\sigma \quad 3\sigma < |\Delta k|$$

(σ is the experimental uncertainty)

Table 3. HEU Benchmarks

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEP Benchmark name	Benchmark	keff			
						This work			
						ENDF/B-VII.1 293.6K	JEFF-3.1.2 293.6K	JEFF-3.2T3 293.6K	JEFF-3.2T4 293.6K
Fast	Metal	Spheres	Unreflected	heu-met-fast-001	1.0000±0.0010	0.99983	0.99612	0.99985	0.99985
				heu-met-fast-008	0.9989±0.0016	0.99522	0.99246	0.99585	0.99547
				heu-met-fast-018-case2	1.0000±0.0014	0.99950	0.99565	0.9993	0.9993
			Normal Uranium	heu-met-fast-003-case1	1.0000±0.0050	0.99476	0.99366	0.99614	0.99614
				heu-met-fast-003-case2	1.0000±0.0050	0.99440	0.99300	0.9957	0.9957
				heu-met-fast-003-case3	1.0000±0.0050	0.99868	0.99723	0.99993	0.99993
				heu-met-fast-003-case4	1.0000±0.0030	0.99738	0.99627	0.99928	0.99928
				heu-met-fast-003-case5	1.0000±0.0030	1.00097	1.00010	1.00402	1.00402
				heu-met-fast-003-case6	1.0000±0.0030	1.00129	0.99980	1.00369	1.00369
				heu-met-fast-003-case7	1.0000±0.0030	1.00194	1.00167	1.00486	1.00486
				heu-met-fast-028	1.0000±0.0030	1.00259	1.00161	1.00512	1.00512
			Depleted Uranium	heu-met-fast-014	0.9989±0.0017	0.99798	0.99613	0.99905	0.99873
			Tungsten carbide	heu-met-fast-003-case8	1.0000±0.0050	1.00167	1.00144	1.0028	1.0028
				heu-met-fast-003-case9	1.0000±0.0050	1.00190	1.00254	1.00417	1.00417
				heu-met-fast-003-case10	1.0000±0.0050	1.00560	1.00820	1.00747	1.00747
				heu-met-fast-003-case11	1.0000±0.0050	1.01019	1.01385	1.0137	1.0137
			Nickel	heu-met-fast-003-case12	1.0000±0.0030	1.00879	1.00174	1.00523	1.00523
			Steel	heu-met-fast-013	0.9990±0.0015	0.99734	0.99314	0.99528	0.99484
				heu-met-fast-021-case2	1.0000±0.0024	0.99744	0.99328	0.99629	0.99651
			Duralumin	heu-met-fast-022-case2	1.0000±0.0019	0.99755	0.99427	0.9969	0.99718
			Aluminium	heu-met-fast-012	0.9992±0.0018	0.99839	0.99494	0.99816	0.99813
			Graphite	heu-met-fast-019-case2	1.0000±0.0028	1.00740	1.00282	1.00663	1.00663
			Beryllium	heu-met-fast-009-case1	0.9992±0.0015	0.99745	0.99385	0.99699	0.99652
			Beryllium Oxide	heu-met-fast-009-case2	0.9992±0.0015	0.99684	0.99257	0.99522	0.99553
			Polyethylene	heu-met-fast-011	0.9989±0.0015	0.99826	0.99510	0.99884	0.99801
				heu-met-fast-020-case2	1.0000±0.0028	1.00080	0.99738	1.00103	1.00103
			Water	heu-met-fast-004-case1	1.0020±0.0010	1.00050	0.99536	0.99806	0.99806
		Cylinder	Unreflected	heu-met-fast-015	0.9996±0.0017	0.99409	0.99069	0.99449	0.99449
		Lattice	Paraffin	heu-met-fast-026-case9	1.0000±0.0038	0.99036	0.98730	0.98902	0.98862
Intermediate	UH3	Cylinder	Natural U	heu-comp-inter-003-case7	1.0000±0.0047	0.99666	0.99556	0.99951	1.00019
	Metal	Cylinder	Graphite, copper	heu-met-inter-006-case1	0.9977±0.0008	0.99422	0.99293	0.99696	0.99811
				heu-met-inter-006-case2	0.9997±0.0008	0.99665	0.99481	1.00034	1.00197

				heu-met-inter-006-case3	1.0015±0.0009	0.99926	0.99843	1.00372	1.00545
				heu-met-inter-006-case4	1.0016±0.0008	1.00777	1.00479	1.01115	1.01525
Thermal	UO ₂ +ZrO ₂	Lattice	Water, ThO ₂	u233-comp-therm-001-case6	1.0015±0.0028	0.99889	0.99755	1.00276	1.00311
	Solution	Sphere	Unreflected	heu-sol-therm-013-case1	1.0012±0.0026	0.99828	0.99903	0.99959	0.99859
				heu-sol-therm-013-case2	1.0007±0.0036	0.99709	0.99819	0.9977	0.99798
				heu-sol-therm-013-case3	1.0009±0.0036	0.99475	0.99502	0.99384	0.99427
				heu-sol-therm-013-case4	1.0003±0.0036	0.99626	0.99638	0.99578	0.99541
				heu-sol-therm-032	1.0015±0.0026	0.99921	0.99924	0.99936	0.99856

$$\sigma < |\Delta k| \leq 2\sigma \quad 2\sigma < |\Delta k| \leq 3\sigma \quad 3\sigma < |\Delta k|$$

(σ is the experimental uncertainty)

Table 4. IEU Benchmarks

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEP Benchmark name	Benchmark	keff			
						ENDF/B-VII.1 293.6K	JEFF-3.1.2 293.6K	JEFF-3.2T3 293.6K	JEFF-3.2T4 293.6K
Fast	Metal	Spheres	Unreflected	ieu-met-fast-003-case2	1.0000±0.0017	1.00255	0.99983	1.00281	1.00261
			Steel	ieu-met-fast-005-case2	1.0000±0.0021	1.00193	0.99787	1.00092	1.00157
			Duralumin	ieu-met-fast-006-case2	1.0000±0.0023	0.99659	0.99230	0.99482	0.99475
			Graphite	ieu-met-fast-004-case2	1.0000±0.0030	1.00739	1.00424	1.00706	1.00706
		Cylinder	Unreflected	ieu-met-fast-001-case1	0.9989±0.0010	0.99997	0.99756	1.00134	1.00033
				ieu-met-fast-001-case2	0.9997±0.0010	1.00053	0.99750	1.00152	1.00069
				ieu-met-fast-001-case3	0.9993±0.0005	1.00109	0.99802	1.00043	1.00154
				ieu-met-fast-001-case4	1.0002±0.0005	1.00130	0.99799	1.00122	1.0013
			Normal U	ieu-met-fast-002	1.0000±0.0030	0.99872	0.99192	0.99711	0.99711
			Depleted U	ieu-met-fast-007-case1	1.0049±0.0008	1.00463	0.99820	1.00443	1.0047
Intermediate	Plate	Lattice	Normal U, steel	mix-met-fast-008-case7	1.0030±0.0025	1.01911	1.01594	1.02326	1.02337
Thermal	UO2	Lattice	Water	ieu-comp-therm-002-CASE_3	1.0017±0.0044	1.00451	1.00114	1.00078	1.00038
	Solution	Cylinder	Unreflected	ieu-sol-therm-007-CASE14	0.9961±0.0009	0.99473	0.99558	0.99551	0.99452
				ieu-sol-therm-007-CASE30	0.9973±0.0009	0.99724	0.99816	0.99691	0.99753
				ieu-sol-therm-007-CASE32	0.9985±0.0010	0.99611	0.99654	0.99672	0.99636
				ieu-sol-therm-007-CASE36	0.9988±0.0011	0.99860	0.99867	0.99848	0.99876
				ieu-sol-therm-007-CASE49	0.9983±0.0011	0.99746	0.99742	0.9974	0.99709

$$\sigma < |\Delta k| \leq 2\sigma \quad 2\sigma < |\Delta k| \leq 3\sigma \quad 3\sigma < |\Delta k|$$

(σ is the experimental uncertainty)

Table 5. LEU Benchmarks

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEP Benchmark name	Benchmark	keff			
						This work			
						ENDF/B-VII.1 293.6K	JEFF-3.1.2 293.6K	JEFF-3.2T3 293.6K	JEFF-3.2T4 293.6K
Thermal	UO2	Lattice	UO2 rods, Water	leu-comp-ther-008-CASE_1	1.0007±0.0016	1.00152	1.00040	1.00088	1.00057
				leu-comp-therm-008-CASE_2	1.0007±0.0016	1.00122	1.00085	1.00038	0.99977
				leu-comp-therm-008-CASE_5	1.0007±0.0016	1.00149	1.00111	1.00049	1.00036
				leu-comp-therm-008-CASE_7	1.0007±0.0016	1.00105	1.00028	0.99996	1.0001
				leu-comp-therm-008-CASE_8	1.0007±0.0016	1.00094	1.00014	0.99937	0.99989
				leu-comp-therm-008-CASE_11	1.0007±0.0016	1.00179	1.00135	1.00153	1.00197
	Solution	Sphere	Water	leu-sol-therm-002-case1	1.0038±0.0040	1.00020	1.00040	0.99977	0.99985
			Unreflected	leu-sol-therm-002-case2	1.0024±0.0037	0.99590	0.99661	0.9963	0.99676

$$\sigma < |\Delta k| \leq 2\sigma \quad 2\sigma < |\Delta k| \leq 3\sigma \quad 3\sigma < |\Delta k|$$

(σ is the experimental uncertainty)

Table 6. Plutonium Benchmarks

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEF Benchmark name	Benchmark	Keff			
						This work			
Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEF Benchmark name	Benchmark	ENDF/B-VII.1 293.6K	JEFF-3.1.2 293.6K	JEFF-3.2T3 293.6K	JEFF-3.2T4 293.6K
Fast	Metal	Spheres	Unreflected	pu-met-fast-001-CASE_1	1.0000±0.0020	0.99982	0.99999	1.00012	1.00012
				pu-met-fast-002-CASE_1	1.0000±0.0020	0.99984	1.00413	1.00249	1.00249
				pu-met-fast-022	1.0000±0.0021	0.99841	0.99778	0.9989	0.9989
			HEU	mix-met-fast-001-CASE_1	1.0000±0.0016	0.99885	0.99837	0.99905	0.99905
				mix-met-fast-003	0.9993±0.0016	1.00105	1.00059	1.00099	1.00026
			Normal Uranium	pu-met-fast-006	1.0000±0.0030	1.00083	1.00237	1.00275	1.00275
				pu-met-fast-010-CASE_1	1.0000±0.0018	0.99969	1.00109	1.00102	1.00102
			Depleted Uranium	pu-met-fast-020	0.9993±0.0017	0.99852	0.99998	0.99974	1.00041
			Thorium	pu-met-fast-008-case2	1.0000±0.0006	0.99744	1.00234	0.99731	0.99731
			Tungsten	pu-met-fast-005-CASE_1	1.0000±0.0013	0.99993	1.00395	1.00183	1.00186
			Steel	pu-met-fast-025	1.0000±0.0020	0.99832	0.99729	0.99712	0.99772
				pu-met-fast-026	1.0000±0.0024	0.99983	0.99806	0.99886	0.9988
			Aluminium	pu-met-fast-009-CASE_1	1.0000±0.0027	1.00027	0.99917	0.99936	0.99936
			Graphite	pu-met-fast-023	1.0000±0.0020	1.00037	0.99863	0.99896	0.99896
			Beryllium	pu-met-fast-018-CASE_1	1.0000±0.0030	0.99908	BeO STL+	BeO STL+	BeO STL+
				pu-met-fast-019	0.9992±0.0015	1.00117	0.99941	0.99852	0.99876
			Polyethylene	pu-met-fast-024	1.0000±0.0020	1.00208	0.99958	1.00038	1.00038
			Water	pu-met-fast-011-CASE_1	1.0000±0.0010	0.99998	0.99688	0.99786	0.99786
		Cylinder	Beryllium	pu-met-fast-021-case1	1.0000±0.0026	1.00417	1.00311	1.00333	1.00306
			Beryllium Oxide	pu-met-fast-021-case2	1.0000±0.0026	0.99387	BeO STL+	BeO STL+	BeO STL+
		Lattice	Unreflected	pu-met-fast-003-case103	1.0000±0.0030	0.99568	0.99679	0.99614	0.99614
Intermediate	Mixture	Homog	Hydrogen, graphite	pu-comp-inter-001	1.0000±0.0110	1.01127	1.00735	1.00577	1.00577
Thermal	MOX	Lattice	Water	mix-comp-therm-002-case-pnl30	1.0024±0.0060	1.00181	0.99945	1.00055	1.0012
				mix-comp-therm-002-case-pnl31	1.0009±0.0047	1.00252	1.00225	1.00297	1.00308
				mix-comp-therm-002-case-pnl32	1.0042±0.0031	1.00323	1.00137	1.00255	1.00181
				mix-comp-therm-002-case-pnl33	1.0024±0.0021	1.00703	1.00612	1.00683	1.00647
				mix-comp-therm-002-case-pnl34	1.0038±0.0025	1.00427	1.00255	1.00268	1.00286
				mix-comp-therm-002-case-pnl35	1.0029±0.0027	1.00648	1.00480	1.00515	1.00544
	Solution	Sphere	Unreflected	pu-sol-therm-009-case3a	1.0000±0.0033	1.01870	1.01414	1.01551	1.01592
				pu-sol-therm-011-CASE_5.16	1.0000±0.0052	1.00669	1.00244	1.0027	1.0027

				pu-sol-therm-011-CASE_1.18	1.0000±0.0052	0.99372	0.99082	0.99196	0.99196
				pu-sol-therm-011-CASE_6.18	1.0000±0.0052	1.00000	0.99755	0.99759	0.99759
				pu-sol-therm-021-case_1.t9a	1.0000±0.0032	1.00550	1.00224	1.00168	1.00226
				pu-sol-therm-021-CASE_3.T9A	1.0000±0.0065	1.00458	1.00424	1.00337	1.00289
		Cylinder	Water	pu-sol-therm-018-case_9	1.0000±0.0034	1.00343	1.00262	1.00168	1.00168
				pu-sol-therm-034-case_01	1.0000±0.0062	1.00002	0.99817	0.99818	0.99818

$$\sigma < |\Delta k| \leq 2\sigma \quad 2\sigma < |\Delta k| \leq 3\sigma \quad 3\sigma < |\Delta k|$$

(σ is the experimental uncertainty)

Table 7. Additional criticality validation tests taken from ICSBEP.

		Case	Benchmark	This work			
				ENDF/B-VII.1 293.6K	JEFF-3.1.2 293.6K	JEFF-3.2T3 293.6K	JEFF-3.2T4 293.6K
PU	Thermal	PU-SOL-THERM-009 (48-inch sphere of plutonium nitrate solution)	1.00030 (330)	1.01528	1.01072	1.01157	1.01327
			- Same sphere as for ORNL-10 (HEU) and ORNL-11 (U233) Benchmarks - Very thermal spectra with vey little leakage - Cross sections for Pu239 should be re-examined in the deep thermal range				
HEU	Fast	HEU-MET-FAST-73 (Unmoderated ZEUS benchmark)	1.00120 (150)	1.01152	1.00840	1.01042	1.01673
			- Benchmark contains no moderator and therefore has a fast spectrum - Fast cross sections for Cu should be reviewed				
HEU	Thermal	HEU-SOL-THERM-004_case1 (Heavy water solutions, reflected spheres)	1.00000 (330)	0.98590	0.98500	0.99438	0.99356
			Improvement for cases with deuterium				
SPEC	Thermal	SPEC-MET-FAST-08 (Neptunium sphere reflected by HEU)	1.00190 (360)	0.99493	0.98912	0.99129	0.99063
			Fast cross sections for Np-237 should be reviewed				

$$\sigma < |\Delta k| \leq 2\sigma \quad 2\sigma < |\Delta k| \leq 3\sigma \quad 3\sigma < |\Delta k|$$

(σ is the experimental uncertainty)

These results show:

1. Improvement from JEFF-3.2T3 to JEFF-3.2.T4 in:

- ieu-met-fast-001-case (1.00134 -> 1.00033)

Materials in : Ieu-met-fast-001-case1					
Al27.ACE	Cr50.ACE	Cr52.ACE	Cr53.ACE	Cr54.ACE	Cu63.ACE
Cu65.ACE	Fe54.ACE	Fe56.ACE	Fe57.ACE	Fe58.ACE	Mg24.ACE
Mg25.ACE	Mg26.ACE	Mn55.ACE	Ni58.ACE	Ni60.ACE	Ni61.ACE
Ni62.ACE	Ni64.ACE	U234.ACE	U235.ACE	U238.ACE	

2. Worse prediction using JEFF-3.2T4 in:

- heu-met-inter-006-case2 (1.00034 -> 1.00197)

Materials in: heu-met-inter-006-case2					
Al27.ACE	C0.ACE	Cr50.ACE	Cr52.ACE	Cr53.ACE	Cr54.ACE
Cu63.ACE	Cu65.ACE	Fe54.ACE	Fe56.ACE	Fe57.ACE	Fe58.ACE
Gra-293.ACE	Mg24.ACE	Mg25.ACE	Mg26.ACE	Mn55.ACE	Si28.ACE
Si29.ACE	Si30.ACE	Ti46.ACE	Ti47.ACE	Ti48.ACE	Ti49.ACE
Ti50.ACE	U234.ACE	U235.ACE	U236.ACE	U238.ACE	

- heu-met-inter-006-case3 (1.00372 -> 1.00545)

Materials in: heu-met-inter-006-case3					
Al27.ACE	C0.ACE	Cr50.ACE	Cr52.ACE	Cr53.ACE	Cr54.ACE
Cu63.ACE	Cu65.ACE	Fe54.ACE	Fe56.ACE	Fe57.ACE	Fe58.ACE
Gra-293.ACE	Mg24.ACE	Mg25.ACE	Mg26.ACE	Mn55.ACE	Si28.ACE
Si29.ACE	Si30.ACE	Ti46.ACE	Ti47.ACE	Ti48.ACE	Ti49.ACE
Ti50.ACE	U234.ACE	U235.ACE	U236.ACE	U238.ACE	

- heu-met-fast-73 (1.01042 -> 1.01673)

Materials in:heu-met-fast-73					
Al27.ACE	C0.ACE	Cr50.ACE	Cr52.ACE	Cr53.ACE	Cr54.ACE
Cu63.ACE	Cu65.ACE	Fe54.ACE	Fe56.ACE	Fe57.ACE	Fe58.ACE
Mg24.ACE	Mg25.ACE	Mg26.ACE	Mn55.ACE	Mo100.ACE	Mo92.ACE
Mo94.ACE	Mo95.ACE	Mo96.ACE	Mo97.ACE	Mo98.ACE	N14.ACE
N15.ACE	Ni58.ACE	Ni60.ACE	Ni61.ACE	Ni62.ACE	Ni64.ACE
P31.ACE	S32.ACE	S33.ACE	S34.ACE	S36.ACE	Ti46.ACE
Ti47.ACE	Ti48.ACE	Ti49.ACE	Ti50.ACE	U234.ACE	U235.ACE
U236.ACE	U238.ACE	Si28.ACE	Si29.ACE	Si30.ACE	

- ieu-met-fast-001-case3 (1.00043 -> 1.00154)

Materials in:ieu-met-fast-001-case3					
Al27.ACE	Cr50.ACE	Cr52.ACE	Cr53.ACE	Cr54.ACE	Cu63.ACE
Cu65.ACE	Fe54.ACE	Fe56.ACE	Fe57.ACE	Fe58.ACE	Mg24.ACE
Mg25.ACE	Mg26.ACE	Mn55.ACE	Ni58.ACE	Ni60.ACE	Ni61.ACE
Ni62.ACE	Ni64.ACE	U234.ACE	U235.ACE	U238.ACE	

- leu-sol-therm-007-CASE14 (0.99551 -> 0.99452)

Materials in:leu-sol-therm-007-CASE14					
Cr50.ACE	Cr52.ACE	Cr53.ACE	Cr54.ACE	Fe54.ACE	Fe56.ACE
Fe57.ACE	Fe58.ACE	H1.ACE	H2O-293.ACE	Mn55.ACE	N14.ACE
Ni58.ACE	Ni60.ACE	Ni61.ACE	Ni62.ACE	Ni64.ACE	O16.ACE
P31.ACE	S32.ACE	S33.ACE	S34.ACE	S36.ACE	Si28.ACE
Si29.ACE	Si30.ACE	U234.ACE	U235.ACE	U236.ACE	U238.ACE
C0.ACE					

- u233-met-fast-004-CASE_1 (0.99924 - > 0.99856)

Materials in:u233-met-fast-004-CASE_1					
Cu63.ACE	Cu65.ACE	Ni58.ACE	Ni60.ACE	Ni61.ACE	Ni62.ACE
Ni64.ACE	U233.ACE	U234.ACE	U238.ACE	W182.ACE	W183.ACE
W184.ACE	W186.ACE	Zr90.ACE	Zr91.ACE	Zr92.ACE	Zr94.ACE
Zr96.ACE					

3. Additional Benchmark: PU-MET-INT-002

WPEC SG33 (<https://www.oecd-nea.org/science/wpec/sg33/>) included additional benchmark experiments for "stress" tests [ICSBEP]. One of them, ZPR-6/10 - Pu/C/SS assembly with SS/Fe reflectors (PU-MET-INTER-002) is considered as a "tricky" Benchmark and it should be used with caution in any data adjustment.

This Benchmark is proposed by A. Trkov to assess the status of JEFF-3.2T4.

Table 8. PU-MET-INTER-002 Benchmark Calculations.

Exp.	0.98690 ± 0.00260
ENDF/B-VII.1	1.01480 ± 0.00027
JEFF-3.2T3	1.01608 ± 0.00028
JEFF-3.2T4	1.00937 ± 0.00029

Figure 1. MCNP5 Input

```

PU-MET-INTER-002 - ZPR-6/10 L024 - RZ Benchmark Model - V5 XS
c
c Version 5 XS - MCNP5
c
1 1 7.750309e-2 -1 5 -6 imp:n=1 $ core
2 2 8.098731e-2 (-1 6 -8):(-1 -5 7) imp:n=1 $ ss ax refl
3 4 8.023073e-2 1 -2 7 -8 imp:n=1 $ ss radial refl
4 5 8.041246e-2 2 -3 7 -8 imp:n=1 $ fe radial refl
5 3 6.157238e-3 (3 -4 9 -10):(-3 8 -10):
(-3 -7 9) imp:n=1 $ empty matrix
6 0 (4:-9:10) imp:n=0 $ external void

1 cz 41.93313
2 cz 86.88175
3 cz 104.17047
4 cz 115.32402
5 pz -38.17874
6 pz 38.17874
7 pz -92.08008
8 pz 92.08008
9 pz -121.92000
10 pz 121.92000

mode n
kcode 20000 1.0 100 600
sdef erg=d1 rad=d2 ext=d3 pos 0 0 0.0 axs 0 0 1
sp1 -2
si2 0.0 41.93
si3 -38.0 38.0
m001 94240.03c 5.03037E-05 94241.03c 1.70034E-06 $ Core
      94239.03c 1.06299E-03 94238.03c 1.69380E-09
      94242.03c 1.15592E-07 95241.03c 2.98613E-06
      24050.03c 4.27634E-04
      24052.03c 8.24650E-03
      24053.03c 9.35087E-04
      24054.03c 2.32763E-04
      28058.03c 2.78114E-03
      28060.03c 1.07128E-03
      28061.03c 4.65722E-05
      28062.03c 1.48459E-04
      28064.03c 3.78297E-05
c      24000.03c 9.84199E-03 28000.03c 4.08528E-03
      26054.03c 2.06099E-03
      26056.03c 3.23531E-02
      26057.03c 7.47174E-04
      26058.03c 9.94352E-05
c      26000.03c 3.52607E-02

```

	13027.03c	1.11659E-04	
	42092.03c	1.10230E-05	
	42094.03c	6.87083E-06	
	42095.03c	1.18252E-05	
	42096.03c	1.23898E-05	
	42097.03c	7.09366E-06	
	42098.03c	1.79236E-05	
	42100.03c	7.15309E-06	
c	42000.03c	7.42792E-05	
	6000.03c	2.58213E-02	
	29063.03c	7.00215E-05	
	29065.03c	3.12095E-05	
c	29000.03c	1.01231E-04	
	25055.03c	8.05254E-04	
	14028.03c	2.57854E-04	
	14029.03c	1.30562E-05	
	14030.03c	8.66689E-06	
c	14000.03c	2.79577E-04	
	27059.03c	3.71924E-06	
m002	24050.03c	6.83369E-04	
	24052.03c	1.31781E-02	
	24053.03c	1.49429E-03	
	24054.03c	3.71960E-04	
	28058.03c	4.72902E-03	
	28060.03c	1.82160E-03	
	28061.03c	7.91909E-05	
	28062.03c	2.52438E-04	
	28064.03c	6.43252E-05	
c m002	24000.03c	1.57277E-02	28000.03c 6.94657E-03 \$ Axial refl
	26054.03c	3.24527E-03	
	26056.03c	5.09437E-02	
	26057.03c	1.17651E-03	
	26058.03c	1.56572E-04	
c	26000.03c	5.55221E-02	6000.03c 2.35948E-04
	6000.03c	2.35948E-04	
	42092.03c	2.25746E-06	
	42094.03c	1.40711E-06	
	42095.03c	2.42175E-06	
	42096.03c	2.53736E-06	
	42097.03c	1.45275E-06	
	42098.03c	3.67066E-06	
	42100.03c	1.46492E-06	
c	42000.03c	1.52120E-05	25055.03c 1.56081E-03
	25055.03c	1.56081E-03	
	29063.03c	2.06206E-05	
	29065.03c	9.19089E-06	
	14028.03c	8.72025E-04	
	14029.03c	4.41544E-05	
	14030.03c	2.93102E-05	
c	29000.03c	2.98115E-05	14000.03c 9.45490E-04
	27059.03c	3.73582E-06	
m003	24050.03c	5.15869E-05	
	24052.03c	9.94802E-04	
	24053.03c	1.12803E-04	
	24054.03c	2.80789E-05	
	28058.03c	3.26456E-04	
	28060.03c	1.25750E-04	
	28061.03c	5.46674E-06	
	28062.03c	1.74264E-05	
	28064.03c	4.44053E-06	
c m003	24000.03c	1.18727E-03	28000.03c 4.79539E-04 \$ Matrix
	26054.03c	2.49724E-04	
	26056.03c	3.92013E-03	
	26057.03c	9.05328E-05	
	26058.03c	1.20483E-05	
c	26000.03c	4.27243E-03	6000.03c 1.87078E-05
	6000.03c	1.87078E-05	
	42092.03c	1.22237E-06	
	42094.03c	7.61920E-07	
	42095.03c	1.31133E-06	
	42096.03c	1.37393E-06	
	42097.03c	7.86631E-07	
	42098.03c	1.98758E-06	
	42100.03c	7.93220E-07	
c	42000.03c	8.23697E-06	25055.03c 1.05699E-04
	25055.03c	1.05699E-04	
	29063.03c	1.18868E-05	

```

29065.03c 5.29810E-06
14028.03c 6.28775E-05
14029.03c 3.18376E-06
14030.03c 2.11342E-06
c 29000.03c 1.71849E-05 14000.03c 6.81747E-05
m004 24050.03c 6.79063E-04
24052.03c 1.30950E-02
24053.03c 1.48487E-03
24054.03c 3.69616E-04
28058.03c 4.61841E-03
28060.03c 1.77899E-03
28061.03c 7.73387E-05
28062.03c 2.46534E-04
28064.03c 6.28208E-05
c m004 24000.03c 1.56286E-02 28000.03c 6.78410E-03 $ SS rad refl
26054.03c 3.22623E-03
26056.03c 5.06449E-02
26057.03c 1.16961E-03
26058.03c 1.55654E-04
c 26000.03c 5.51964E-02 13027.03c 1.00000E-20
13027.03c 1.00000E-20
42092.03c 6.88610E-06
42094.03c 4.29221E-06
42095.03c 7.38725E-06
42096.03c 7.73990E-06
42097.03c 4.43142E-06
42098.03c 1.11969E-05
42100.03c 4.46854E-06
c 6000.03c 2.37106E-04 42000.03c 4.64023E-05
6000.03c 2.37106E-04
29063.03c 3.48653E-05
29065.03c 1.55399E-05
c 25055.03c 1.42057E-03 29000.03c 5.04052E-05
25055.03c 1.42057E-03
14028.03c 7.96277E-04
14029.03c 4.03189E-05
14030.03c 2.67642E-05
c 14000.03c 8.63360E-04 27059.03c 3.77932E-06
27059.03c 3.77932E-06
m005 24050.03c 7.94084E-05
24052.03c 1.53131E-03
24053.03c 1.73638E-04
24054.03c 4.32223E-05
28058.03c 5.18362E-04
28060.03c 1.99671E-04
28061.03c 8.68036E-06
28062.03c 2.76705E-05
28064.03c 7.05089E-06
c m005 24000.03c 1.82758E-03 28000.03c 7.61435E-04 $ Fe rad refl
26054.03c 4.48038E-03
26056.03c 7.03324E-02
26057.03c 1.62428E-03
26058.03c 2.16162E-04
c 26000.03c 7.66532E-02 6000.03c 4.27315E-04
6000.03c 4.27315E-04
42092.03c 2.17013E-06
42094.03c 1.35267E-06
42095.03c 2.32806E-06
42096.03c 2.43920E-06
42097.03c 1.39654E-06
42098.03c 3.52865E-06
42100.03c 1.40824E-06
c 42000.03c 1.46235E-05 25055.03c 5.50350E-04
25055.03c 5.50350E-04
29063.03c 2.00909E-05
29065.03c 8.95479E-06
14028.03c 1.33870E-04
14029.03c 6.77841E-06
14030.03c 4.49959E-06
c 29000.03c 2.90457E-05 14000.03c 1.45148E-04
27059.03c 3.77222E-06
totnu
phys:n 20.0 0.0
prdmp J 40
ctme 9000.0

```

4. Impact of ^{63}Cu and ^{65}Cu cross-sections in HEU-MET-FAST-73.

4.1. Sensitivity Analysis

A sensitivity analysis is done with MCNP/PERT card, for a perturbation of only 1% in different cross-sections. Despite the well known limitation of this methodology for scattering cross-sections, it is interesting to see the large sensitivity in the range 0.183MeV-1.35MeV.

Table 9. Sensitivities for ^{63}Cu .

#	Ei (MeV)		Ei+1 (MeV)	$\Delta k/\Delta XS(+1\%)$				
				Total	Elastic	Inelastic MT91	Inelastic MT51-70	Capture (n,g)
1	6.06E+00	-	1.96E+01	0.00002	0.00001	0.00002	0	0
2	2.23E+00	-	6.06E+00	0.00029	0.00012	0.00005	0.00015	0
3	1.35E+00	-	2.23E+00	0.00030	0.00018	0	0.00013	-0.00001
4	4.98E-01	-	1.35E+00	0.00073	0.00070	0	0.00009	-0.00005
5	1.83E-01	-	4.98E-01	0.00048	0.00058	0	0	-0.00011
6	6.74E-02	-	1.83E-01	0.00016	0.00026	0	0	-0.00010
7	2.48E-02	-	6.74E-02	0.00002	0.00008	0	0	-0.00006
8	9.12E-03	-	2.48E-02	-0.00001	0.00002	0	0	-0.00004
9	2.04E-03	-	9.12E-03	-0.00001	0.00001	0	0	-0.00002
10	4.54E-04	-	2.04E-03	0	0	0	0	0
11	2.26E-05	-	4.54E-04	0	0	0	0	0
12	4.00E-06	-	2.26E-05	0	0	0	0	0
13	5.40E-07	-	4.00E-06	0	0	0	0	0
14	1.00E-07	-	5.40E-07	0	0	0	0	0
15	1.00E-11	-	1.00E-07	0	0	0	0	0

Table 10. Sensitivities for ^{65}Cu .

#	Ei (MeV)		Ei+1 (MeV)	$\Delta k/\Delta XS(+1\%)$				
				Total	Elastic	Inelastic MT91	Inelastic MT51-70	Capture (n,g)
1	6.06E+00	-	1.96E+01	0.00001	0	0.00001	0	0
2	2.23E+00	-	6.06E+00	0.00015	0.00006	0.00003	0.00006	0
3	1.35E+00	-	2.23E+00	0.00013	0.00009	0	0.00005	0
4	4.98E-01	-	1.35E+00	0.00034	0.00033	0	0.00002	-0.00001
5	1.83E-01	-	4.98E-01	0.00028	0.00030	0	0	-0.00002
6	6.74E-02	-	1.83E-01	0.00012	0.00015	0	0	-0.00003
7	2.48E-02	-	6.74E-02	0.00003	0.00005	0	0	-0.00002
8	9.12E-03	-	2.48E-02	0.00001	0.00001	0	0	-0.00001
9	2.04E-03	-	9.12E-03	0	0	0	0	-0.00001
10	4.54E-04	-	2.04E-03	0	0	0	0	0
11	2.26E-05	-	4.54E-04	0	0	0	0	0
12	4.00E-06	-	2.26E-05	0	0	0	0	0
13	5.40E-07	-	4.00E-06	0	0	0	0	0
14	1.00E-07	-	5.40E-07	0	0	0	0	0
15	1.00E-11	-	1.00E-07	0	0	0	0	0

4.2. *Keff Comparison with different ENDF evaluations.*

In Table 11. MCNP criticality calculation is done with different ENDF files.

In this work a comparison of different Cu evaluations is shown in the following Table. A comparison with Cu-Nat from ENDF/B-V is shown in the last line of this table.

Table 11. PU-MET-INTER-002 Benchmark Calculations.

Exp.	1.00120 ± 0.00150
ENDF/B-VII.1	1.01152 ± 0.00027
JEFF-3.2T3	1.01042 ± 0.00027
JEFF-3.2T3 + Cu63-KIT	1.01394 ± 0.00027
JEFF-3.2T3 + Cu65-KIT	1.01373 ± 0.00027
JEFF-3.2T3 + Cu63&65-KIT	1.01673 ± 0.00027
JEFF-3.2T3 + CuNat-ENDF/B-V	0.99951 ± 0.00027

As it is reported in ICSBEP and R.D. Mosteller, P. J. Jaegers, “*Analysis of the Unmoderated Zeus Critical Experiment*”, PHYSOR-2006, a revision of copper cross –section is recommended:

“All four calculated values for keff differ from the experimental value by at least three standard deviations. However, JENDL-3.3 and ENDF/B-VII β -2 produce excellent agreement with the experimental value when their cross sections for copper are replaced with ENDF/B-V data. This behavior suggests that the copper cross sections are the principal cause of the disagreement between the reference and calculated values for keff. Therefore, it is strongly recommended that the fast cross sections for copper be reviewed prior to the first formal release of ENDF/B-VII.” R.D Mosteller, P.J. Jaegers. PHYSOR2006, LA-UR-06-3902.

4.3. *Reaction rates and cross-sections*

Tables 12 and 13 show a comparison of reaction rates and cross-sections at different zones of this Benchmark. Front, Left, Back, Right, Top and Bottom blocks of Copper material between JEFF-3.2T4 (KIT evaluation) and ENDF/B-V.

It can be seen in the range of 0.1MeV to 1 MeV higher value of total an elastic cross-section, and lower value for capture cross-section.

Figures 2, 3 4 and 5 show a comparison with ENDF/B-VII.1 and EXFOR data.

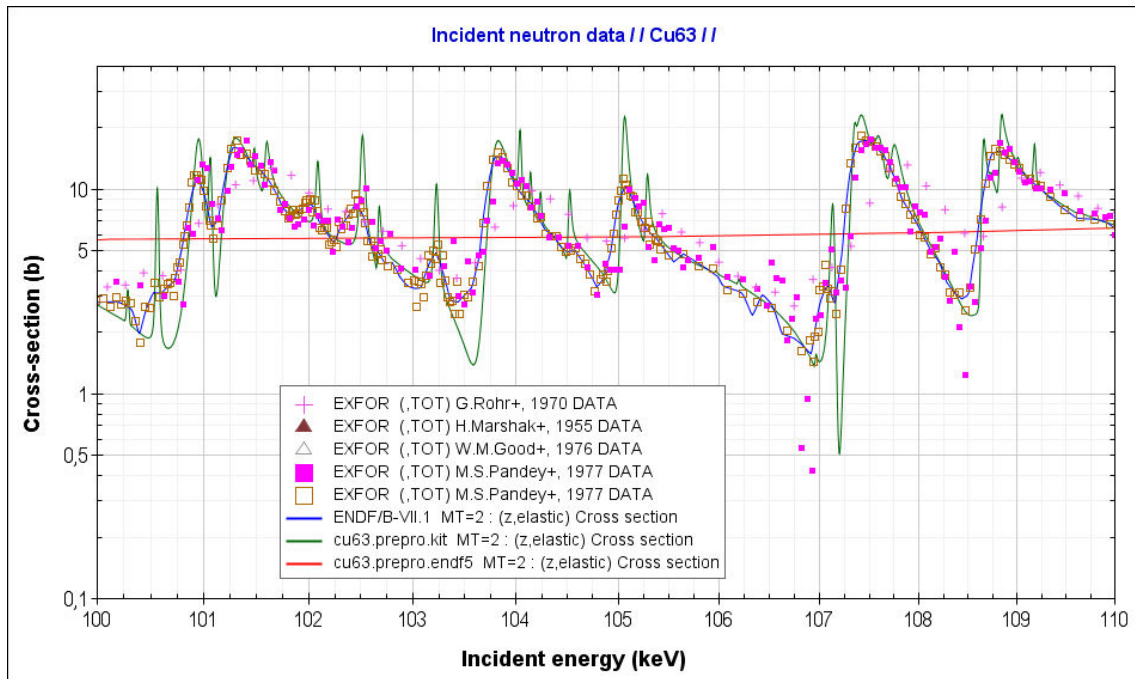
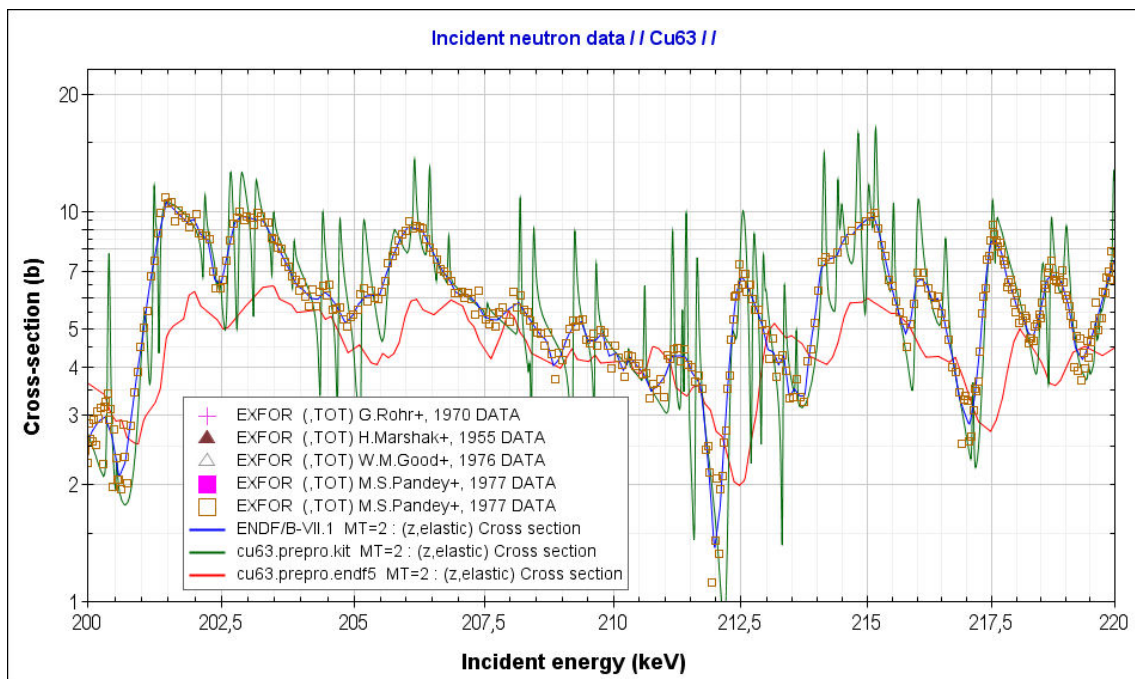
Figure 2. Comparison of elastic-cross section in the energy range 100-110 keV**Figure 3.** Comparison of elastic-cross section in the energy range 200-220 keV

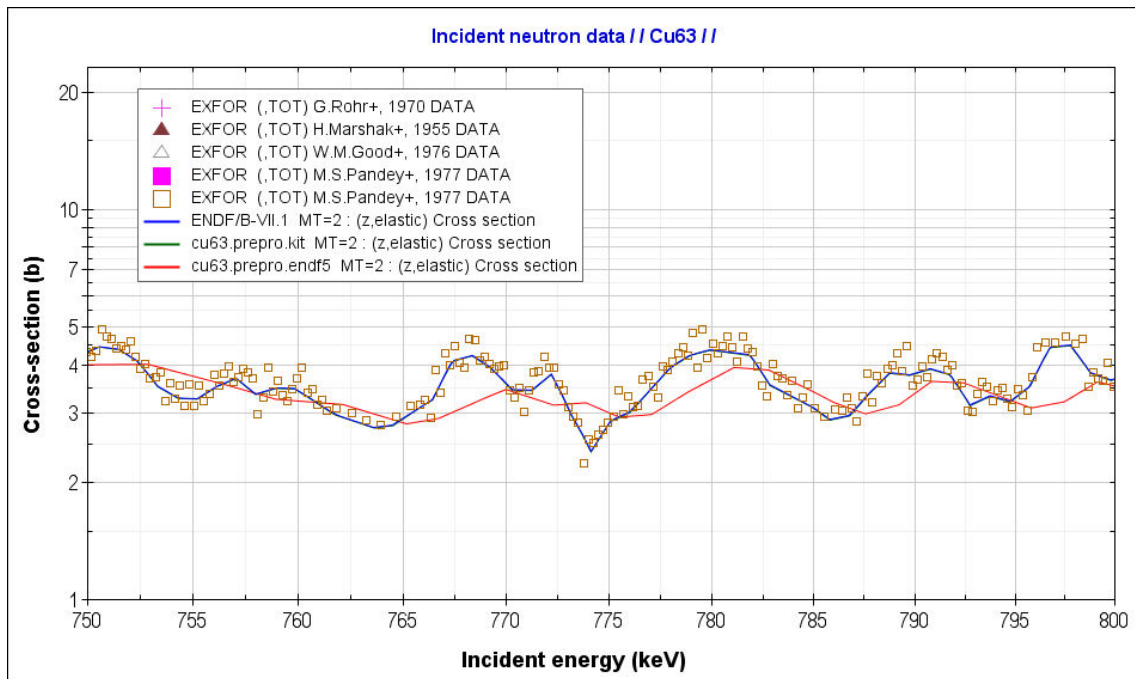
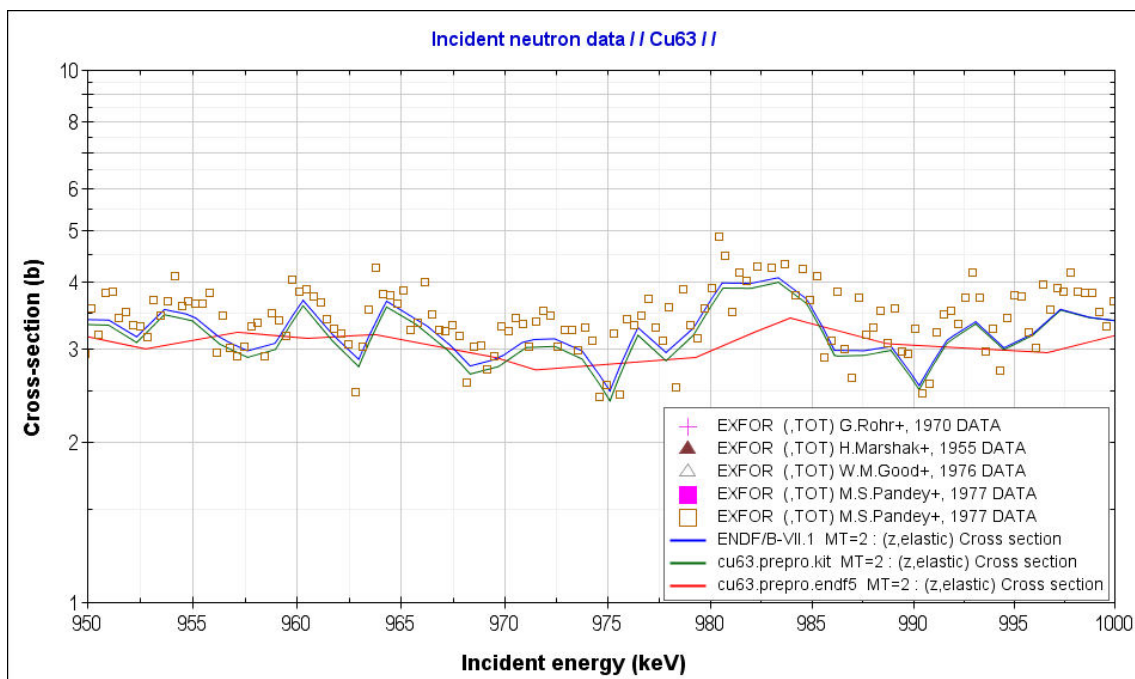
Figure 4. Comparison of elastic-cross section in the energy range 750-800 keV**Figure 5.** Comparison of elastic-cross section in the energy range 950-1000 keV

Table 12. Comparison of cross-sections between Cu63&65-KIT evaluation and ENDF/B-V at different Copper zones in the Benchmark.Values calculated as: $(\text{KIT} - \text{ENDF/B-V}) / \text{ENDF/B-V} * 100$

Total cross section						
Energy	Front	Left	Back	Right	Top	Bottom
1.0E-11 - 1.0E-06	-9.7	-7.9	-9.8	-8.8	-9.5	-9.4
1.0E-06 - 1.0E-05	-9.5	-9.5	-9.7	-9.3	-9.3	-9.7
1.0E-05 - 1.0E-04	-13.9	-14.0	-13.9	-13.9	-13.9	-13.8
1.0E-04 - 1.0E-03	-14.4	-14.4	-14.4	-14.4	-14.7	-14.4
1.0E-03 - 1.0E-02	-25.0	-25.0	-25.0	-25.0	-24.0	-23.6
1.0E-02 - 1.0E-01	-18.5	-18.4	-18.4	-18.4	-16.2	-16.3
1.0E-01 - 1.0E+00	7.9	7.9	8.0	7.9	9.0	8.9
1.0E+00 - 1.0E+01	2.0	2.0	2.0	2.0	1.2	1.1
1.0E+01 - 2.0E+01	-0.8	-0.6	-0.4	0.4	-0.2	-0.4
Total	-5.6	-5.6	-5.6	-5.7	0.2	-0.2
Elastic cross-section						
Energy	Front	Left	Back	Right	Top	Bottom
1.0E-11 - 1.0E-06	-9.7	-9.6	-9.7	-9.6	-9.7	-9.7
1.0E-06 - 1.0E-05	-9.7	-9.7	-9.7	-9.7	-9.7	-9.7
1.0E-05 - 1.0E-04	-13.9	-14.0	-13.9	-13.9	-13.9	-13.8
1.0E-04 - 1.0E-03	-14.5	-14.6	-14.5	-14.5	-14.8	-14.5
1.0E-03 - 1.0E-02	-24.8	-24.8	-24.8	-24.8	-23.8	-23.4
1.0E-02 - 1.0E-01	-18.2	-18.2	-18.2	-18.2	-16.0	-16.1
1.0E-01 - 1.0E+00	8.0	8.0	8.1	8.0	9.0	8.9
1.0E+00 - 1.0E+01	1.0	0.9	0.9	0.9	0.2	0.2
1.0E+01 - 2.0E+01	4.8	5.3	5.5	6.9	5.9	5.4
Total	-5.4	-5.4	-5.4	-5.5	0.2	-0.1
Capture cross-section						
Energy	Front	Left	Back	Right	Top	Bottom
1.0E-11 - 1.0E-06	-9.9	11.9	-11.1	0.6	-7.3	-6.1
1.0E-06 - 1.0E-05	-3.6	-3.8	-7.1	1.7	2.3	-7.4
1.0E-05 - 1.0E-04	-13.3	-15.7	-13.1	-14.2	-13.6	-13.5
1.0E-04 - 1.0E-03	-10.5	-9.8	-10.2	-8.9	-10.4	-9.2
1.0E-03 - 1.0E-02	-37.9	-37.7	-38.0	-37.8	-36.8	-36.7
1.0E-02 - 1.0E-01	-49.0	-48.9	-48.9	-48.9	-47.8	-47.6
1.0E-01 - 1.0E+00	-11.5	-11.6	-11.6	-11.7	-5.1	-5.4
1.0E+00 - 1.0E+01	7.7	7.7	7.4	7.6	3.3	3.3
1.0E+01 - 2.0E+01	-60.2	-60.3	-60.6	-60.4	-60.3	-60.2
Total	-35.6	-35.5	-35.6	-35.6	-26.3	-26.6

Table 13. Comparison of reaction rates between Cu63&65-KIT evaluation and ENDF/B- V at different Copper zones in the Benchmark.
Values calculated as: $(KIT - ENDF/B-V) / ENDF/B-V * 100$

Total cross section						
Energy	Front	Left	Back	Right	Top	Bottom
1.0E-11 - 1.0E-06	-92.6	-83.2	-69.9	-44.4	-86.1	-95.3
1.0E-06 - 1.0E-05	-61.0	-73.8	-64.2	-60.5	-61.5	-57.6
1.0E-05 - 1.0E-04	-56.2	-60.1	-55.2	-57.9	-64.8	-52.7
1.0E-04 - 1.0E-03	-50.3	-50.9	-50.8	-51.0	-57.0	-51.9
1.0E-03 - 1.0E-02	-31.1	-31.4	-31.3	-31.4	-43.8	-41.0
1.0E-02 - 1.0E-01	1.7	1.7	2.0	1.3	-12.2	-11.1
1.0E-01 - 1.0E+00	6.6	5.9	6.6	6.1	10.6	9.9
1.0E+00 - 1.0E+01	-1.7	-1.9	-1.1	-1.9	0.5	0.6
1.0E+01 - 2.0E+01	54.3	26.0	-8.4	18.1	7.5	10.3
Total	-0.3	-0.7	-0.2	-0.7	1.2	0.9
Elastic cross-section						
Energy	Front	Left	Back	Right	Top	Bottom
1.0E-11 - 1.0E-06	-92.6	-83.5	-69.8	-44.9	-86.1	-95.3
1.0E-06 - 1.0E-05	-61.0	-73.9	-64.3	-60.7	-61.7	-57.6
1.0E-05 - 1.0E-04	-56.2	-60.1	-55.2	-57.9	-64.8	-52.7
1.0E-04 - 1.0E-03	-50.3	-51.0	-50.8	-51.1	-57.1	-52.0
1.0E-03 - 1.0E-02	-30.9	-31.2	-31.2	-31.2	-43.6	-40.9
1.0E-02 - 1.0E-01	2.0	1.9	2.3	1.6	-12.0	-10.9
1.0E-01 - 1.0E+00	6.7	5.9	6.7	6.2	10.7	10.0
1.0E+00 - 1.0E+01	-2.7	-2.9	-2.2	-2.9	-0.5	-0.4
1.0E+01 - 2.0E+01	63.0	33.5	-3.0	25.7	14.0	16.8
Total	-0.1	-0.5	0.0	-0.5	1.3	1.0
Capture cross-section						
Energy	Front	Left	Back	Right	Top	Bottom
1.0E-11 - 1.0E-06	-92.6	-79.6	-70.3	-38.7	-85.7	-95.1
1.0E-06 - 1.0E-05	-58.4	-72.2	-63.2	-55.7	-56.6	-56.5
1.0E-05 - 1.0E-04	-55.9	-60.9	-54.8	-58.0	-64.7	-52.5
1.0E-04 - 1.0E-03	-48.1	-48.2	-48.3	-47.9	-54.9	-49.0
1.0E-03 - 1.0E-02	-43.0	-43.1	-43.3	-43.1	-53.2	-51.1
1.0E-02 - 1.0E-01	-36.4	-36.3	-36.1	-36.5	-45.3	-44.4
1.0E-01 - 1.0E+00	-12.6	-13.3	-12.7	-13.1	-3.7	-4.5
1.0E+00 - 1.0E+01	3.7	3.6	4.2	3.5	2.6	2.7
1.0E+01 - 2.0E+01	-38.1	-49.6	-63.8	-53.4	-57.2	-55.9
Total	-32.0	-32.2	-32.0	-32.2	-25.5	-25.8

5. CHECKR, FIZCON AND PSYCHE Pre-processing

CHECKR, FIZCON and PHYSICHE codes have been used in a pre-processing step of these ENDF files. An extract of these outputs are presented in Tables 14, 15 and 16.

It can be noted some Warnings in PHYSICHE code in MF6 section to be checked by evaluators.

Table 14. Mn55

PROGRAM CHECKR VERSION 8.20		Run on 19-Feb-2014
Input File Specification-----Output.stanef		
Check the Entire File		
No problems to report		
Done CHECKR		
PROGRAM FIZCON VERSION 8.14		Run on 19-Feb-2014
Input File Specification-----Output.stanef		
Check the Entire File		
Sum Up Tests will be Omitted		
Deviant Point Check will be Omitted		
Consecutive Equal Value Check will be Omitted		
TAPE BEING PROCESSED IS NUMBERED 7		
LABEL IS IAEA evaluation Mn55_ib22g4		
No problems to report		
Done FIZCON		
PROGRAM PSYCHE VERSION 8.08		Run on 19-Feb-2014
Input File Specification-----Output.stanef		
Check the Entire File		
TAPE BEING PROCESSED IS NUMBERED 7		
LABEL IS IAEA evaluation Mn55_ib22g4		
CHECK MATERIAL 2525		
(NO WARNINGS DETECTED IN SECTIONS WITHOUT COMMENTS)		

FILE 1		
SECTION 451		
25-Mn- 55 IAEA Eval-Oct13 IAEA Evaluation Consortium (ib22)		
----INDL/V-3 MATERIAL 2525		
-----INCIDENT NEUTRON DATA		
-----ENDF-6 FORMAT		

FILE 2		
SECTION 151		
...		
...		
FILE 4		
SECTION 2		
SECTION 51		
SECTION 52		
SECTION 53		
SECTION 54		
SECTION 55		
SECTION 56		
SECTION 57		
SECTION 58		
SECTION 59		

```

SECTION 60
SECTION 61
SECTION 62
SECTION 63
SECTION 64
SECTION 65
SECTION 66
SECTION 67
SECTION 68
SECTION 69
SECTION 70
SECTION 71
  DISTRIBUTION IS NEGATIVE                      SEQUENCE NUMBER 245
    FROM -8.7500E-01 TO -1.0000E+00 NEGATIVE PROBABILITY IS -2.7031E-05
  DISTRIBUTION IS NEGATIVE                      SEQUENCE NUMBER 245
    FROM -1.0000E+00 TO -1.0000E+00 NEGATIVE PROBABILITY IS 0.0000E+00
  DISTRIBUTION IS NEGATIVE                      SEQUENCE NUMBER 245
    FROM -1.0000E+00 TO -1.0000E+00 NEGATIVE PROBABILITY IS 0.0000E+00
...
...
-----
FILE 6
  SECTION 5
    DISTRIBUTION IS NEGATIVE                      SEQUENCE NUMBER 7135
      FROM -9.4948E-01 TO -1.0000E+00 NEGATIVE PROBABILITY IS 2.9802E-07
    DISTRIBUTION IS NEGATIVE                      SEQUENCE NUMBER 7595
      FROM -9.3750E-01 TO -1.0000E+00 NEGATIVE PROBABILITY IS 2.9802E-07
    DISTRIBUTION IS NEGATIVE                      SEQUENCE NUMBER 7595
      FROM -1.0000E+00 TO -1.0000E+00 NEGATIVE PROBABILITY IS 0.0000E+00
    DISTRIBUTION IS NEGATIVE                      SEQUENCE NUMBER 7595
      FROM -1.0000E+00 TO -1.0000E+00 NEGATIVE PROBABILITY IS 0.0000E+00
...
...
  SECTION 16

    ENERGY BALANCE SUMMARY: Q = -1.02260E+07

      TOTAL SECONDARY ENERGY BY EMITTED PARTICLE (CM)
      E      AVAIL  %DIFF    SUM      00001      25054      00000
1.04E+07  0.00E+00  *****  1.09E-05  6.67E-06  3.33E-06  9.43E-07
1.05E+07  8.47E+04  100.00  1.10E-05  6.67E-06  3.33E-06  9.70E-07
1.10E+07  5.76E+05   46.49  8.43E+05  4.71E+05  3.00E+05  7.24E+04
1.15E+07  1.07E+06   29.05  1.38E+06  9.23E+05  3.16E+05  1.38E+05
1.20E+07  1.56E+06   19.52  1.86E+06  1.34E+06  3.27E+05  1.91E+05
...

```

Table 15. Cu63

PROGRAM CHECKR VERSION 8.20		Run on 17-Feb-2014
Input File Specification-----Test.endf		
Check the Entire File		
Check material 29-Cu- 63 MAT 2925		
ERROR(S) FOUND IN MAT=2925, MF= 4, MT= 2		
NP2 = 77258 OUT OF RANGE	1 - 2000	SEQUENCE NUMBER 3
NE = 77258 OUT OF RANGE	1 - 2000	SEQUENCE NUMBER 3
Encountered 2 errors, 0 warnings		
Done CHECKR		
PROGRAM FIZCON VERSION 8.14		Run on 17-Feb-2014
Input File Specification-----Test.endf		
Check the Entire File		
Sum Up Tests will be Omitted		
Deviant Point Check will be Omitted		
Consecutive Equal Value Check will be Omitted		
TAPE BEING PROCESSED IS NUMBERED 1		
LABEL IS Cu- 63 INR/KIT		
No problems to report		
Done FIZCON		
PROGRAM PSYCHE VERSION 8.08		Run on 17-Feb-2014
Input File Specification-----Test.endf		
Check the Entire File		
TAPE BEING PROCESSED IS NUMBERED 1		
LABEL IS Cu- 63 INR/KIT		
CHECK MATERIAL 2925		
(NO WARNINGS DETECTED IN SECTIONS WITHOUT COMMENTS)		

FILE 1		
SECTION 451		
29-Cu- 63 KIT	EVAL-DEC13 P.Pereslavl'tsev, A. Konobeyev	
KIT-2013	DIST- REV1-	
----KIT-2013	Material 2425	REVISION 1
-----Incident neutron data		
-----ENDF-6 Format		

FILE 2		
SECTION 151		
AP NOT IN RANGE	2.78534E-01 TO 6.76440E-01	SEQUENCE NUMBER 4
CHECK ON ISOTOPE PROPERTIES		
SPIN OF ISOTOPE 29063. DISAGREES WITH 1.5		

FILE 3		
SECTION 1		
THERMAL CROSS SECTIONS AND RESONANCE INTEGRALS		
E = THERMAL	SIGMA =	0.00000E+00
...		
...		
FILE 4		
SECTION 2		
WICKS LIMIT AT 1.00000E-05 CANNOT BE TESTED DUE ZERO ELASTIC CROSS SECTION		
WICKS LIMIT AT 1.06250E-05 CANNOT BE TESTED DUE ZERO ELASTIC CROSS SECTION		

```
WICKS LIMIT AT 1.12500E-05 CANNOT BE TESTED DUE ZERO ELASTIC CROSS SECTION
...
...
FILE 6
SECTION 5
TOO MANY ENERGIES ( 3006)--UNION CHECK SUPRESSED
SECTION 16

ENERGY BALANCE SUMMARY: Q = -1.08530E+07

TOTAL SECONDARY ENERGY BY EMITTED PARTICLE (CM)
E      AVAIL  %DIFF  SUM      00001      29062      00000
1.10E+07 3.00E+00 -50.00 1.50E+00 1.00E+00 5.00E-01 0.00E+00
1.15E+07 4.66E+05 25.63 5.85E+05 3.43E+05 1.88E+05 5.39E+04
1.20E+07 9.58E+05 12.58 1.08E+06 6.55E+05 2.03E+05 2.20E+05
1.25E+07 1.45E+06 9.57 1.59E+06 1.01E+06 2.17E+05 3.63E+05
....
...
```

Table 16. Cu65

PROGRAM CHECKR VERSION 8.20		Run on 17-Feb-2014
Input File Specification-----Test.endf		
Check the Entire File		
Check material 29-Cu- 65 MAT 2931		
ERROR(S) FOUND IN MAT=2931, MF= 4, MT= 2		
NP2 = 77258 OUT OF RANGE	1 - 2000	SEQUENCE NUMBER 3
NE = 77258 OUT OF RANGE	1 - 2000	SEQUENCE NUMBER 3
Encountered 2 errors, 0 warnings		
Done CHECKR		
PROGRAM FIZCON VERSION 8.14		Run on 17-Feb-2014
Input File Specification-----Test.endf		
Check the Entire File		
Sum Up Tests will be Omitted		
Deviant Point Check will be Omitted		
Consecutive Equal Value Check will be Omitted		
TAPE BEING PROCESSED IS NUMBERED 1		
LABEL IS Cu- 65 INR/KIT		
No problems to report		
Done FIZCON		
PROGRAM PSYCHE VERSION 8.08		Run on 17-Feb-2014
Input File Specification-----Test.endf		
Check the Entire File		
TAPE BEING PROCESSED IS NUMBERED 1		
LABEL IS Cu- 65 INR/KIT		
CHECK MATERIAL 2931		
(NO WARNINGS DETECTED IN SECTIONS WITHOUT COMMENTS)		

FILE 1		
SECTION 451		
29-Cu- 65 KIT EVAL-DEC13 P.Pereslavl'tsev, A. Konobeyev		
KIT-2013 DIST- REV1-		
----KIT-2013 Material 2431 REVISION 1		
-----Incident neutron data		
-----ENDF-6 Format		

FILE 2		
SECTION 151		
AP NOT IN RANGE 2.81451E-01 TO 6.83523E-01 SEQUENCE NUMBER 4		
CHECK ON ISOTOPE PROPERTIES		
SPIN OF ISOTOPE 29065. DISAGREES WITH 1.5		

FILE 3		
SECTION 1		
THERMAL CROSS SECTIONS AND RESONANCE INTEGRALS		
E = THERMAL SIGMA = 0.00000E+00		
...		
....		

FILE 4		
SECTION 2		
WICKS LIMIT AT 1.00000E-05 CANNOT BE TESTED DUE ZERO ELASTIC CROSS SECTION		
WICKS LIMIT AT 1.06250E-05 CANNOT BE TESTED DUE ZERO ELASTIC CROSS SECTION		
WICKS LIMIT AT 1.12500E-05 CANNOT BE TESTED DUE ZERO ELASTIC CROSS SECTION		

```
...
...
-----
FILE 6
SECTION 5
TOO MANY ENERGIES ( 3032)--UNION CHECK SUPRESSED
SECTION 16

ENERGY BALANCE SUMMARY: Q = -9.91074E+06

TOTAL SECONDARY ENERGY BY EMITTED PARTICLE (CM)
E      AVAIL  %DIFF  SUM      00001      29064      00000
1.01E+07 0.00E+00 ***** 1.50E+00 1.00E+00 5.00E-01 0.00E+00
1.05E+07 4.29E+05 28.41 5.50E+05 3.16E+05 1.67E+05 6.78E+04
1.10E+07 9.21E+05 12.30 1.03E+06 6.61E+05 1.82E+05 1.92E+05
1.15E+07 1.41E+06 7.71 1.52E+06 1.03E+06 1.96E+05 3.00E+05
1.20E+07 1.91E+06 5.68 2.01E+06 1.38E+06 2.10E+05 4.22E+05
```

6. INTER Calculation

In this section, a comparison between JEFF-3.2T4 and ENDF/B-VII.1 is shown. Additional data from [Mughabghab-2003] and [Pritychenko-2013] is included.

PROGRAM INTER VERSION 8.06

Selected Integrations of ENDF File 3 and File 10 Cross Sections

Thermal cross section : Sig(2200) = Sig(Eth)
Thermal energy : Eth= 2.53000E-02 (eV)

Ezero cross section : Sig(Ezero)
Ezero energy (input) : E0 = 2.53000E-02 (eV)

Maxwellian average : Avg-Sigma = (2/sqrt(Pi)) Intg[E1:E2] Sig(E) Phi_m(E) dE / Intg[E1:E2] Phi_m(E) dE
Maxwellian spectrum : Phi_m(E) = (E/E0^2) exp(-E/E0)
Spectrum Temperature : E0 = 2.53000E-02 (eV)
Integration Limits : E1 = 1.00000E-05 (eV) E2 = 1.00000E+01 (eV)
Integral of Spectrum = 1.00000E+00

Westcott g-factor : G-fact = 2/sqrt(Pi) Avg-Sigma / Sig(2200)

Resonance Integral : Res.Integ = Intg[E3:E4] Sig(E)/E dE
Integration Limits : E3 = 5.00000E-01 (eV) E4 = 1.00000E+05 (eV)
Integral of Spectrum = 1.22061E+01

Fiss.spect. average : Sig(Fiss) = Intg[E1:E2] Sig(E) Phi_f(E) dE / Intg[E1:E2] Phi_f(E) dE
Fission spectrum : Phi_f(E) = sqrt(E/Ef)/Ef exp(-E/E0)
Spectrum Temperature : Ef = 1.35000E+06 (eV)
Integration Limits : E1 = 1.00000E+03 (eV) E2 = 2.00000E+07 (eV)
Integral of Spectrum = 1.00000E+00

E14 cross-section : Sig(E14)
Selected Energy : E14 = 1.40000E+07 eV

JEFF-32.T4

Z	A	LISO	LFS	MT	Reaction	Sig(2200)	Sig(Ezero)	Avg-Sigma	G-fact	Res Integ	Sig(Fiss)	Sig(E14)	MAT
25	55			1	Total	1.55017E+01	1.55017E+01	1.5794E+01	1.01882	6.32051E+02	3.63988E+00	2.52185E+00	2525
25	55			2	Elastic	2.22919E+00	2.22919E+00	2.5164E+00	1.12884	6.17761E+02	2.70843E+00	1.12280E+00	2525
25	55			4	Inelas	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	9.26695E-01	5.20816E-01	2525
25	55			16	n,2n	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	4.06746E-04	7.50948E-01	2525
25	55			17	n,3n	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	3.21173E-11	0.00000E+00	2525
25	55			102	n,gamma	1.32724E+01	1.32724E+01	1.3276E+01	1.00030	1.42553E+01	2.90399E-03	6.91988E-04	2525

ENDF/B-VII.1

Z	A	LISO	LFS	MT	Reaction	Sig(2200)	Sig(Ezero)	Avg-Sigma	G-fact	Res Integ	Sig(Fiss)	Sig(E14)
25	55	0		1	Total	1.53953E+01	1.53857E+01	1.5663E+01	1.01812	6.21807E+02	3.54946E+00	2.48845E+00
25	55	0		2	Elastic	2.11631E+00	2.11629E+00	2.3882E+00	1.12933	6.08281E+02	2.54776E+00	1.15420E+00
25	55	0		4	Inelas	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	9.98007E-01	5.46581E-01
25	55	0		16	n,2n	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	3.67080E-04	6.76280E-01
25	55	0		17	n,3n	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	3.42049E-11	0.00000E+00
25	55	0		102	n,gamma	1.32790E+01	1.32695E+01	1.3274E+01	1.00040	1.35250E+01	2.91788E-03	6.17986E-04

Data taken from [Mughabghab-2003] and [Pritychenko-2013]

Z	A	LISO	LFS	MT	Reaction	Sig(2200)	G-fact	Res Integ
25	55			2	Elastic	2.060E+0±3.000E-2		
25	55			102	n,gamma	1.336E+1±5.000E-2	1.0003	1.400E+1±3.000E-1

JEFF-32.T4

Z	A	LISO	LFS	MT	Reaction	Sig(2200)	Sig(Ezero)	Avg-Sigma	G-fact	Res Integ	Sig(Fiss)	Sig(E14)	MAT
29	63			1	Total	9.61319E+00	9.61319E+00	1.0276E+01	1.06894	9.61724E+01	3.64815E+00	2.94710E+00	2925
29	63			2	Elastic	5.14334E+00	5.14334E+00	5.8050E+00	1.12864	9.12292E+01	2.84918E+00	1.42277E+00	2925
29	63			4	Inelas	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	7.67574E-01	5.69999E-01	2925
29	63			16	n,2n	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	1.60907E-04	4.46239E-01	2925
29	63			102	n,gamma	4.46984E+00	4.46984E+00	4.4706E+00	1.00018	4.92512E+00	1.02175E-02	1.11720E-03	2925
29	63			103	n,p	1.80690E-13	1.80690E-13	6.9542E-13	3.84871	1.67332E-06	2.09688E-02	5.58853E-02	2925
29	63			104	n,d	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	4.73046E-05	3.52395E-02	2925
29	63			105	n,t	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	9.59234E-08	1.28137E-04	2925
29	63			106	n,He3	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	7.36204E-11	1.75249E-09	2925
29	63			107	n,alpha	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	5.93577E-04	4.29678E-02	2925

ENDF/B-VII.1

Z	A	LISO	LFS	MT	Reaction	Sig(2200)	Sig(Ezero)	Avg-Sigma	G-fact	Res Integ	Sig(Fiss)	Sig(E14)
29	63	0		1	Total	9.61350E+00	9.61009E+00	1.0271E+01	1.06922	1.01696E+02	3.66108E+00	2.90930E+00
29	63	0		2	Elastic	5.14332E+00	5.14326E+00	5.8032E+00	1.12914	9.67680E+01	2.87837E+00	1.47209E+00
29	63	0		4	Inelas	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	7.49754E-01	6.17037E-01
29	63	0		16	n,2n	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	1.59599E-04	4.38705E-01
29	63	0		102	n,gamma	4.47018E+00	4.46683E+00	4.4681E+00	1.00029	4.92798E+00	1.07539E-02	2.72000E-03
29	63	0		103	n,p	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	1.99397E-02	4.61667E-02
29	63	0		104	n,d	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	4.53648E-04	9.61429E-03
29	63	0		106	n,He3	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	2.46084E-09	3.76022E-06
29	63	0		107	n,alpha	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	5.99787E-04	4.30880E-02

Data taken from [Mughabghab-2003] and [Pritychenko-2013]

Z	A	LISO	LFS	MT	Reaction	Sig(2200)	G-fact	Res Integ
29	63			2	Elastic	5.100E+0±2.000E-1		
29	63			102	n,gamma	4.500E+0±2.000E-2	1.0002	4.970E+0±8.000E-2

JEFF-32.T4

Z	A	LISO	LFS	MT	Reaction	Sig(2200)	Sig(Ezero)	Avg-Sigma	G-fact	Res Integ	Sig(Fiss)	Sig(E14)	MAT
29	65			1	Total	1.60413E+01	1.60413E+01	1.7830E+01	1.11149	1.49436E+02	3.72379E+00	3.03767E+00	2931
29	65			2	Elastic	1.38923E+01	1.38923E+01	1.5680E+01	1.12868	1.47353E+02	3.03454E+00	1.47954E+00	2931
29	65			4	Inelas	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	6.83616E-01	5.85007E-01	2931
29	65			16	n,2n	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	5.44278E-04	8.84280E-01	2931
29	65			102	n,gamma	2.14896E+00	2.14896E+00	2.1495E+00	1.00025	1.99721E+00	6.77754E-03	1.01533E-03	2931
29	65			103	n,p	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	5.90690E-04	2.18717E-02	2931
29	65			104	n,d	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	1.25624E-05	1.86148E-02	2931
29	65			105	n,t	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	5.70976E-08	6.32036E-05	2931
29	65			106	n,He3	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	1.91141E-13	0.00000E+00	2931
29	65			107	n,alpha	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	4.53455E-05	1.36892E-02	2931

ENDF/B-VII.1

Z	A	LISO	LFS	MT	Reaction	Sig(2200)	Sig(Ezero)	Avg-Sigma	G-fact	Res Integ	Sig(Fiss)	Sig(E14)
29	65	0		1	Total	1.60414E+01	1.60397E+01	1.7823E+01	1.11191	1.52414E+02	3.74091E+00	2.95880E+00
29	65	0		2	Elastic	1.38923E+01	1.38922E+01	1.5675E+01	1.12917	1.50235E+02	3.04182E+00	1.40274E+00
29	65	0		4	Inelas	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	6.90733E-01	5.99293E-01
29	65	0		16	n,2n	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	5.40988E-04	8.95310E-01
29	65	0		102	n,gamma	2.14909E+00	2.14749E+00	2.1482E+00	1.00034	2.17876E+00	7.10295E-03	5.20000E-04
29	65	0		103	n,p	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	5.98870E-04	2.42603E-02
29	65	0		104	n,d	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	8.14238E-05	9.60000E-03
29	65	0		105	n,t	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	1.83241E-08	3.26250E-05
29	65	0		106	n,He3	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	1.01018E-09	2.33000E-06
29	65	0		107	n,alpha	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	1.76132E-05	9.91593E-03

Data taken from [Mughabghab-2003] and [Pritychenko-2013]

Z	A	LISO	LFS	MT	Reaction	Sig(2200)	G-fact	Res Integ
29	65			2	Elastic	1.410E+1±5.000E-1		
29	65			102	n,gamma	2.170E+0±3.000E-2	1.0002	2.190E+0±7.000E-2

OUTPUT INTER code for ENDF/B-V.

Z	A	LISO	LFS	MT	Reaction	Sig(2200)	Sig(Ezero)	Avg-Sigma	G-fact	Res	Integ	Sig(Fiss)	Sig(E14)	MAT
29	0			1	Total	1.24669E+01	1.24669E+01	1.3580E+01	1.08925	1.28673E+02	3.53543E+00	2.96167E+00	1329	
29	0			2	Elastic	8.67747E+00	8.67747E+00	9.7909E+00	1.12831	1.24221E+02	2.78754E+00	1.39651E+00	1329	
29	0			4	Inelas	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	7.25794E-01	6.63827E-01	1329	
29	0			16	n,2n	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	2.88588E-04	6.01480E-01	1329	
29	0			17	n,3n	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	5.04711E-08	0.00000E+00	1329	
29	0			102	n,gamma	3.78939E+00	3.78939E+00	3.7887E+00	0.99981	4.45242E+00	9.03517E-03	2.30000E-03	1329	
29	0			103	n,p	3.05022E-12	3.05022E-12	6.7291E-12	2.20610	1.15149E-05	1.19867E-02	2.81666E-02	1329	
29	0			104	n,d	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	1.46390E-05	5.38000E-03	1329	
29	0			106	n,He3	0.00000E+00	0.00000E+00	0.0000E+00	0.00000	0.00000E+00	7.90415E-07	2.27000E-03	1329	
29	0			107	n,alpha	2.72926E-15	2.72926E-15	6.2645E-15	2.29530	1.03033E-08	3.20324E-04	2.91030E-02	1329	

OUTPUT INTER calculated from JEFF-3.2T4 for Cu-Nat

	Sig(2200)	Sig(Ezero)	Avg-Sigma	G-fact	Res	Sig(Fiss)	Sig(E14)
Total	1.16E+01	1.16E+01	1.26E+01	1.08E+00	1.13E+02	3.67E+00	2.98E+00
Elastic	7.84E+00	7.84E+00	8.85E+00	1.13E+00	1.09E+02	2.91E+00	1.44E+00
Inelas	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.42E-01	5.75E-01
n,2n	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.79E-04	5.81E-01
n,gamma	3.75E+00	3.75E+00	3.76E+00	1.00E+00	4.02E+00	9.16E-03	1.09E-03
n,p	1.25E-13	1.25E-13	4.81E-13	2.66E+00	1.16E-06	1.47E-02	4.54E-02
n,d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.66E-05	3.01E-02
n,t	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.40E-08	1.08E-04
n,He3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.10E-11	1.21E-09
n,alpha	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.25E-04	3.39E-02

Data taken from [Mughabghab-2003] and [Pritychenko-2013]

Z	A	LISO	LFS	MT	Reaction	Sig(2200)	G-fact	Res	Integ
29	0			102	n,gamma	3.780E+0±2.000E-2		4.100E+0±1.000E-1	

Table 17. A comparison with ENDF/B-Vof CuNat. Values show: (KIT-ENDF5)/ENDF5*100

	Sig(2200)	Sig(Ezero)	Avg-Sigma	G-fact	Res	Sig(Fiss)	Sig(E14)
Total	-7.0	-7.0	-7.2	-0.7	-12.5	3.8	0.5
Elastic	-9.6	-9.6	-9.6	0.0	-12.6	4.3	3.1
Inelas						2.2	-13.4
n,2n						-3.3	-3.4
n,gamma	-0.9	-0.9	-0.9	0.0	-9.7	1.3	-52.8
n,p	-95.9	-95.9	-92.9	20.7	-89.9	22.5	61.2
n,d						150.0	459.8
n,t						-99.4	-98.0
n,He3						-100.0	-100.0
n,alpha	-100.0	-100.0	-100.0	-100.0	-100.0	32.5	16.6

7. Comparison with ENDFB-VII.1

Figures for comparison of Cu63, Cu65 and Mn55 with ENDF/B-VII.1 are included in this report.

Figure 6. Total cross-section for Cu63

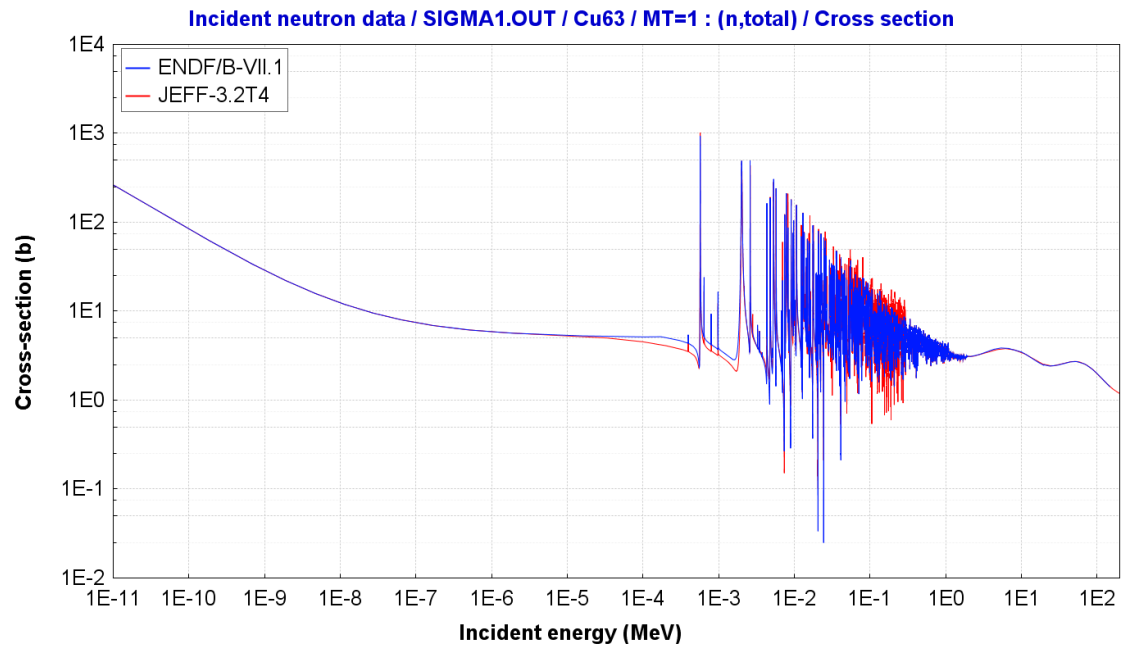


Figure 7. (n, γ) cross-section for Cu63

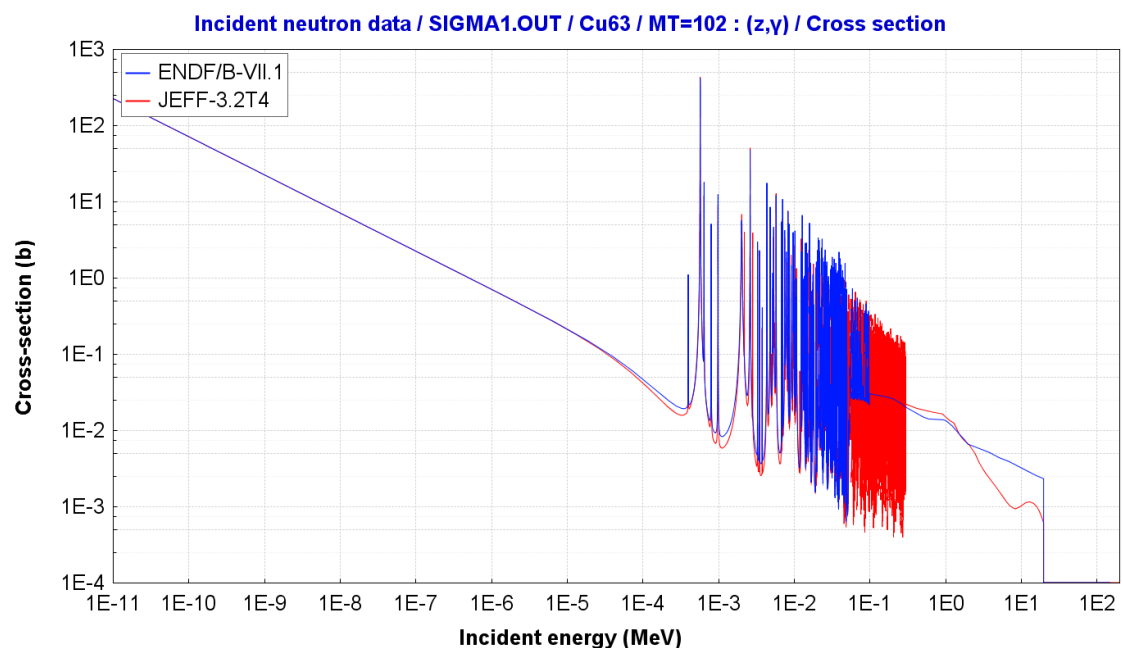


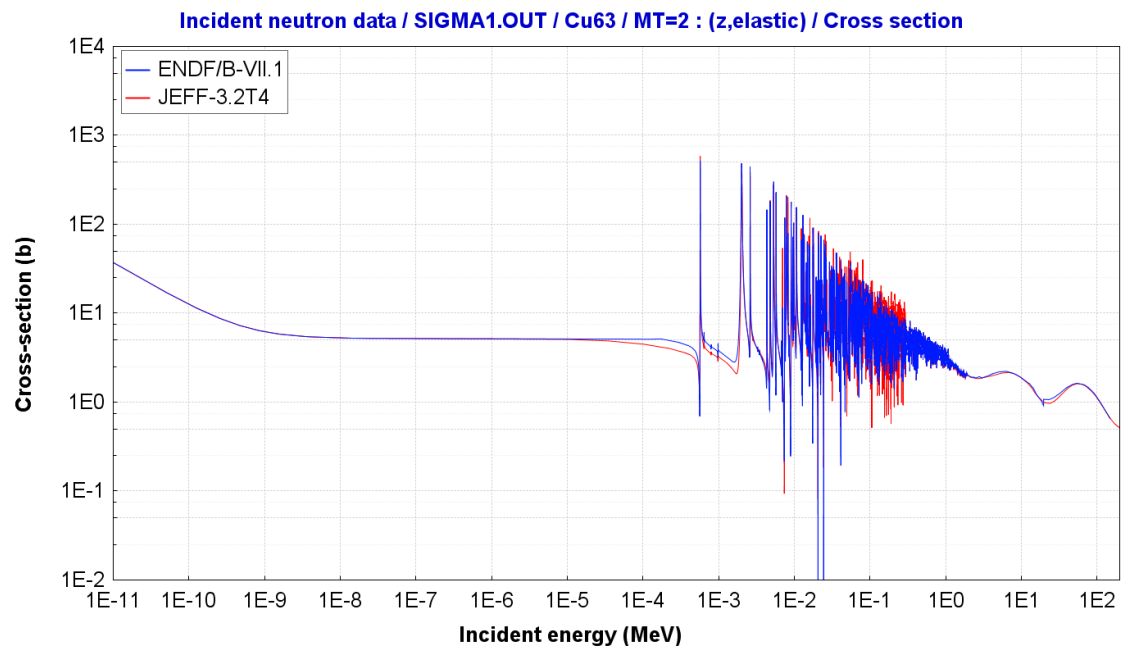
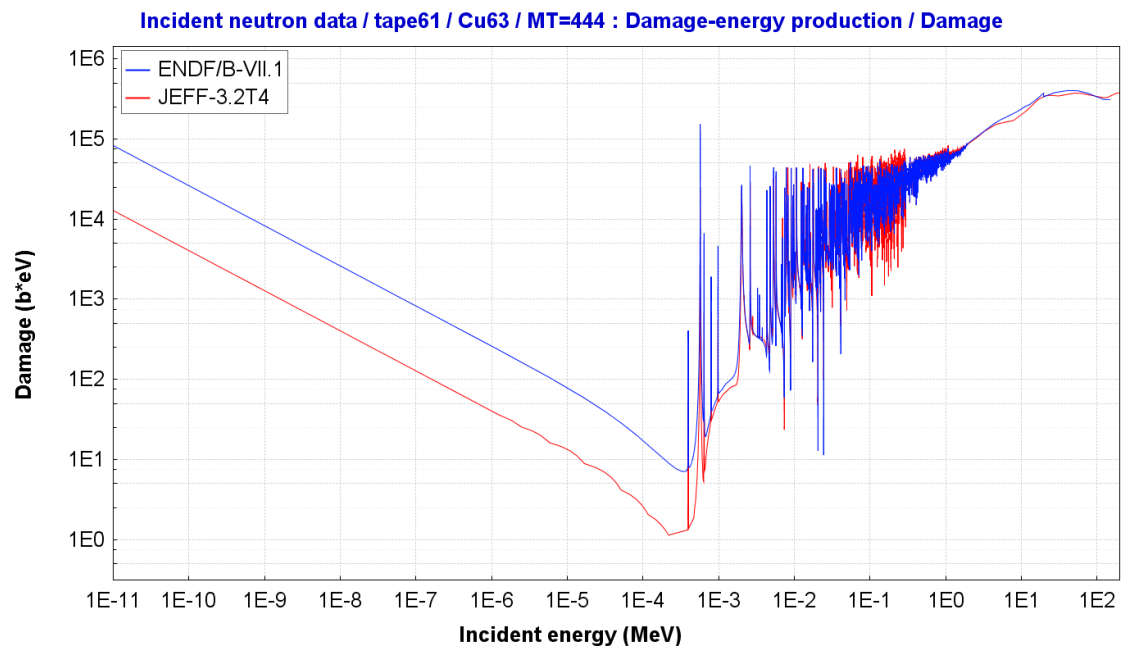
Figure 8. Elastic cross-section for Cu63**Figure 9.** Damage energy cross-section for Cu63

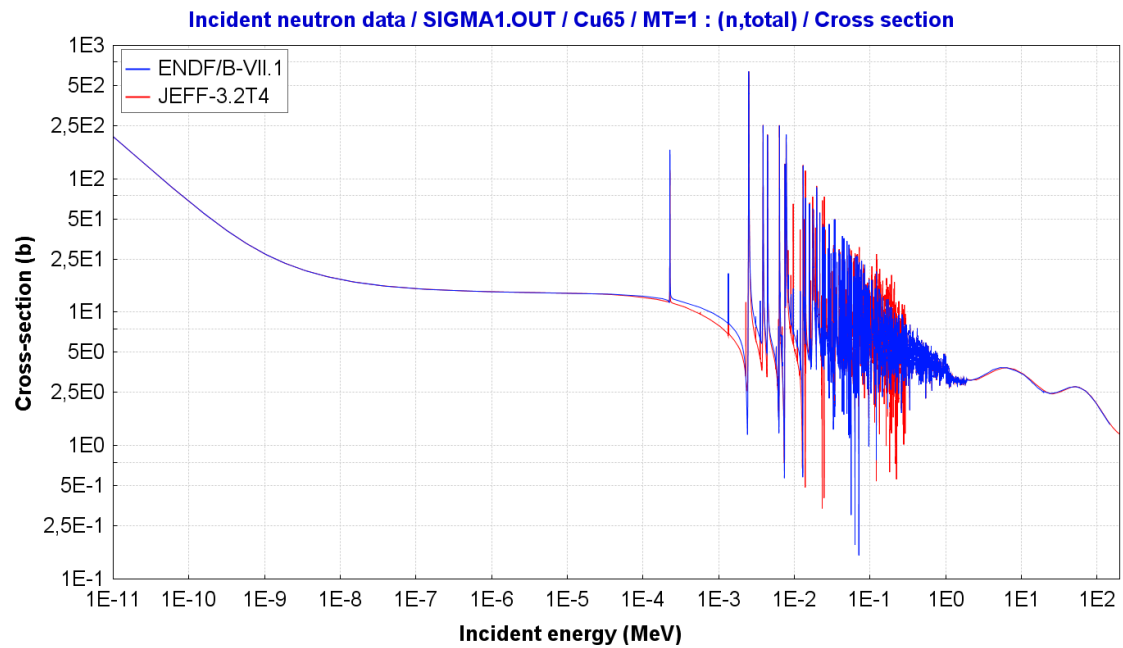
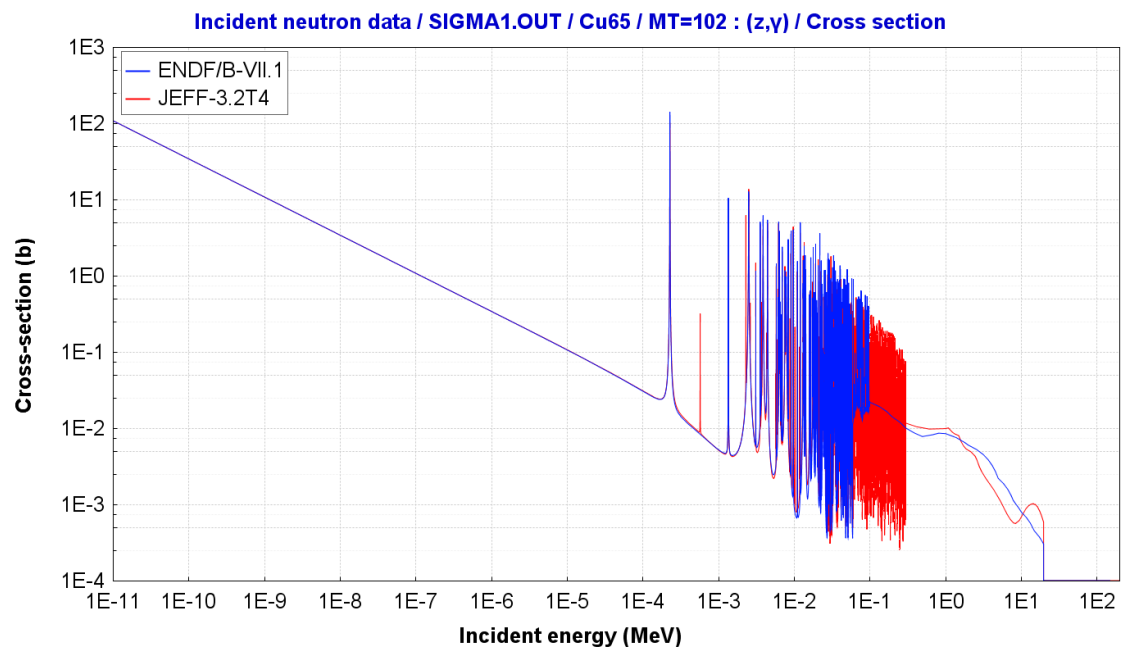
Figure 10. Total cross-section for Cu65**Figure 11.** (n, γ) cross-section for Cu65

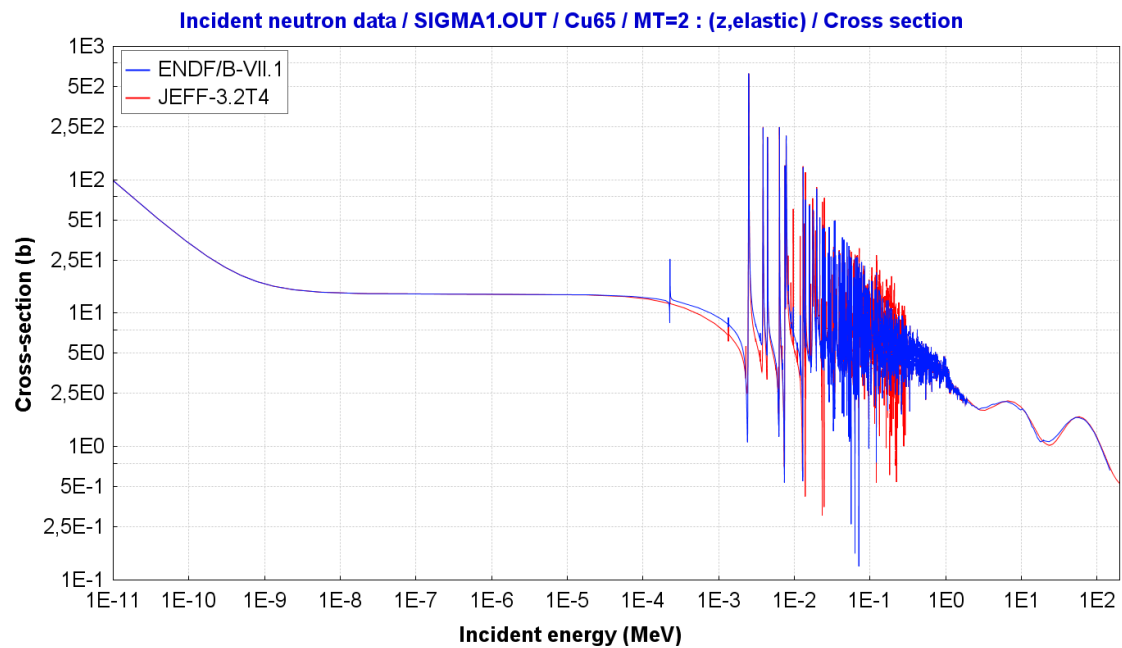
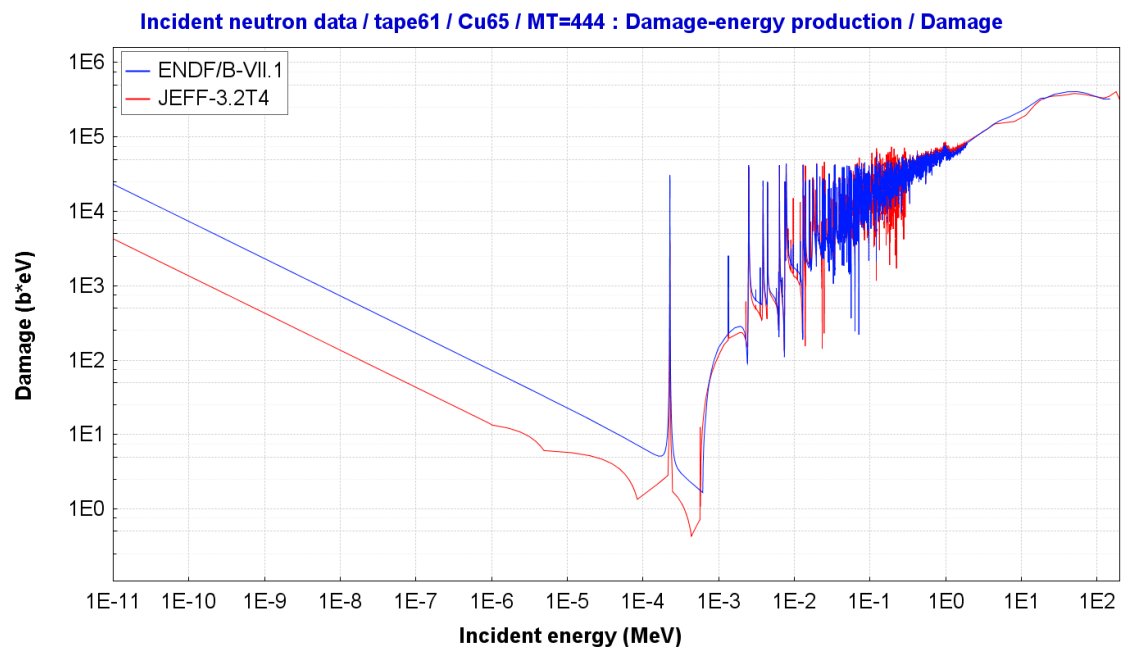
Figure 12. Elastic cross-section for Cu65**Figure 13.** Damage energy cross-section for Cu65

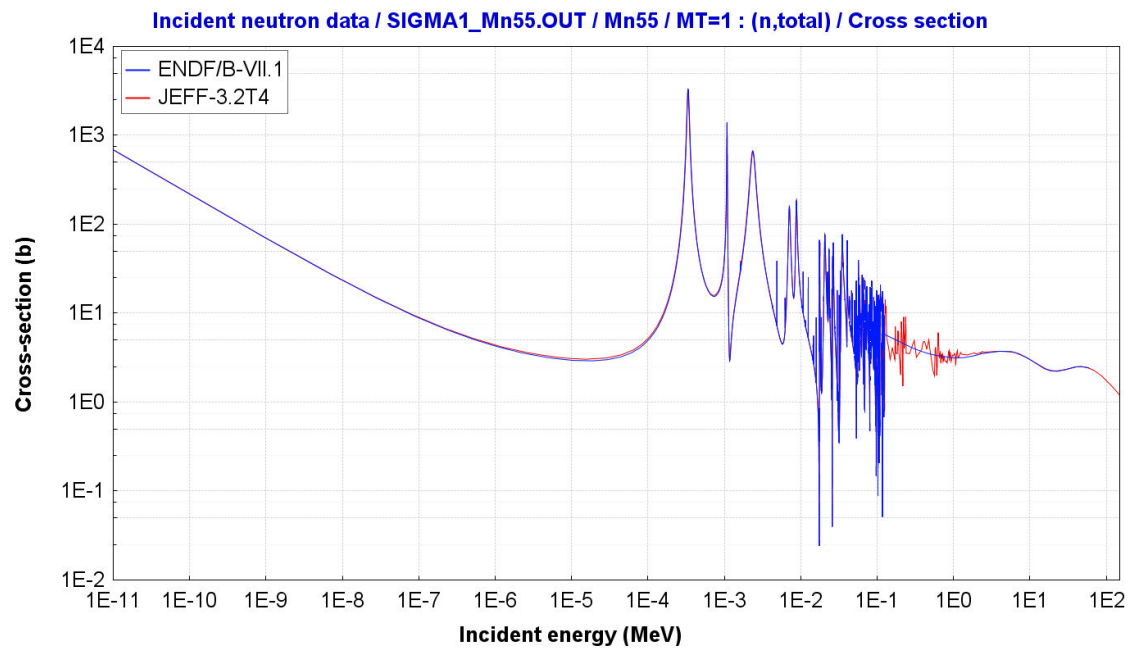
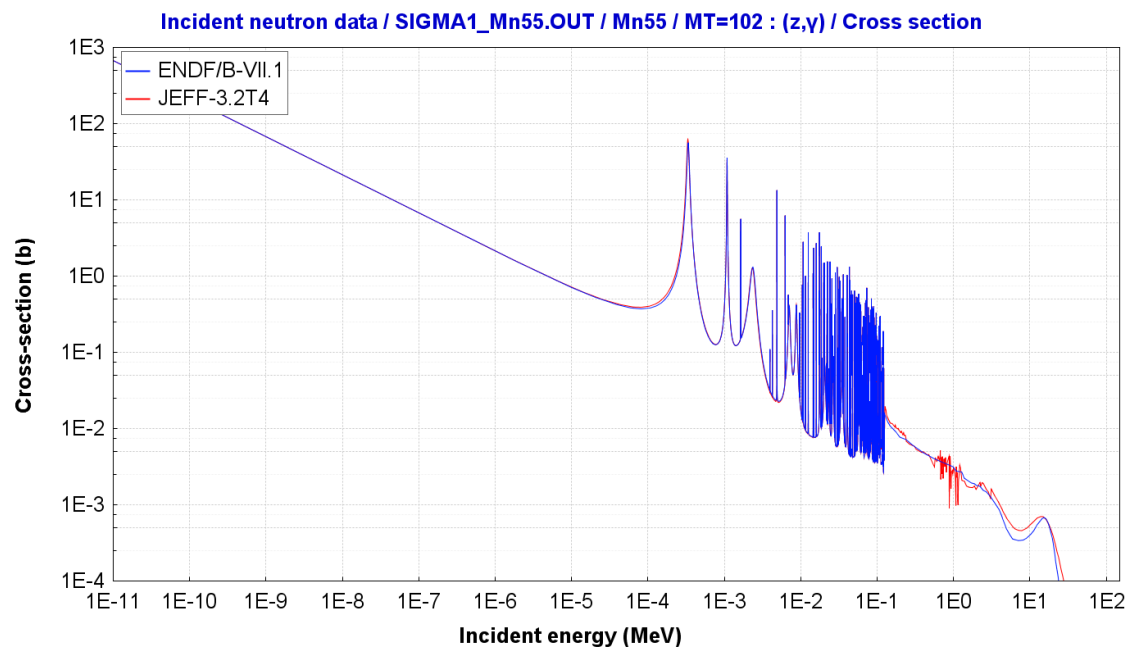
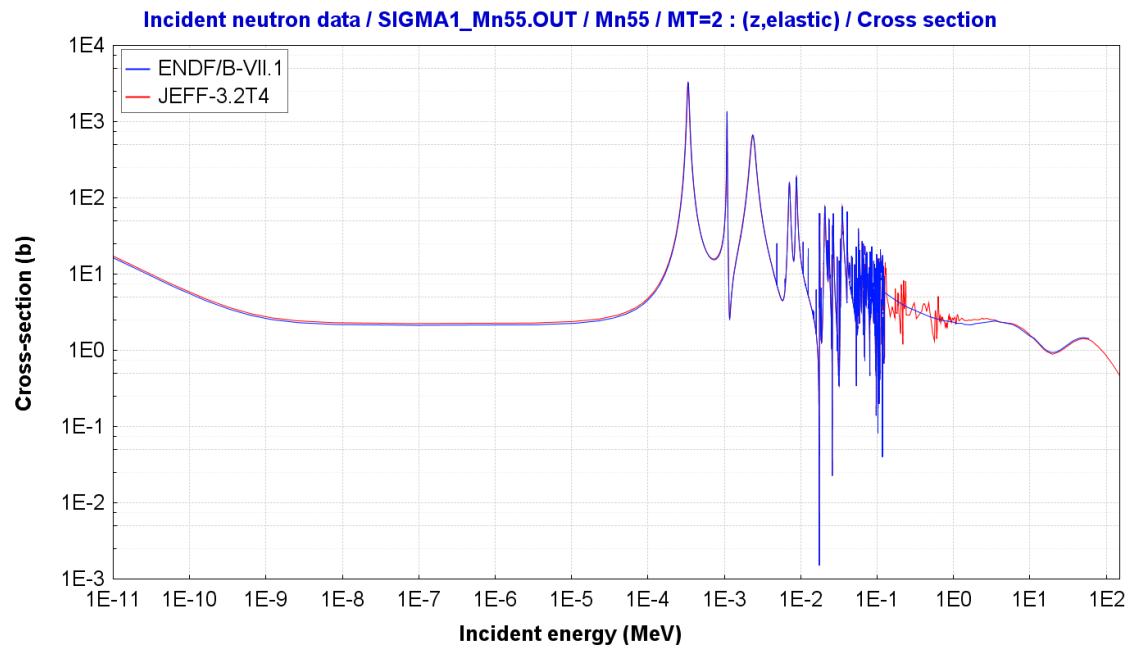
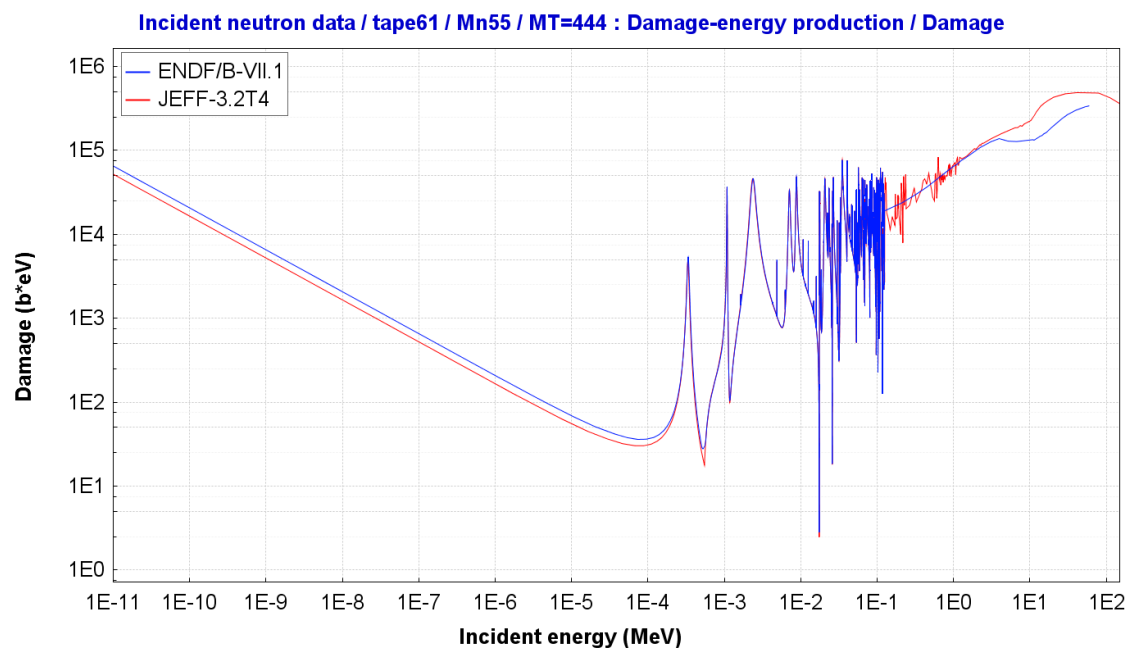
Figure 14. Total cross-section for Mn55**Figure 15.** (n, γ) cross-section for Mn55

Figure 16. Elastic cross-section for Mn55**Figure 17.** Damage energy cross-section for Mn55

8. Warnings and Messages in PREPRO and NJOY.

8.1. PREPRO-2010 Warnings

- No warnings in: Cu63 and Cu63
- Mn55:

RECENT.LST

```

...
...
=====
Atomic Weight Ratio of Isotope----- 54.4661000
L Dependent Scattering Radius----- .536500000
Angular Momentum (L)----- 1
Number of Resonances----- 118
-----
WARNING...WARNING...WARNING...WARNING...WARNING...WARNING...WARNING...WARNING
L= 1 J = 2.000 Corresponds to 2 Resonance Sequences.
L= 1 J = 3.000 Corresponds to 2 Resonance Sequences.
-----
...
...

All Unresolved Parameters Energy Dependent
=====
Nuclear Spin of Target----- 2.50000000
Effective Scattering Radius (A+)----- .560628300
LSSF----- 1 (Included in File 3)
Number of L Values----- 3
=====
WARNING...WARNING...WARNING...WARNING...WARNING...WARNING...WARNING...WARNING
Note, LSSF= 1 Indicates that the Resonance Contribution
has Already been Added to the Cross Sections. This Section
will be Read, but Ignored in ALL Resonance Calculations.
=====
...
...

```

8.2. NJOY Warnings

- Cu63 and Cu65 were processed by KIT with NJOY2010.

A processing with PREPRO2010+NJO99.393 is also performed in this work. PREPRO2010 is used to obtain a PENDF file at 293.6K, following NJOY99.393 processing from HEATR module.

Cu63
HEATR
---message from hinit---mf6, mt102 has recoil with no spectrum photon momentum recoil used.
PURR
---message from purr---mat 2925 has no unresolved parameters copy as is to nout
ACER
---message from unionx---threshold error 53 1.3482490E+06 1.3482495E+06 9.9999967E-01 ---message from unionx---threshold error 56 1.8910420E+06 1.8910423E+06 9.9999982E-01 ---message from gamsum---file 12 not found. ---warning from acelod--- mf6/mt5 ep.gt.e mt= 5 e= 1.0000E-11 ep= 1.0000E-06 leaving it as is...
ACER
---message from consis---consistency problems found

Cu65
HEATR
---message from hinit---mf6, mt102 has recoil with no spectrum photon momentum recoil used.
PURR
---message from purr---mat 2931 has no unresolved parameters copy as is to nout
ACER
---message from unionx---threshold error 16 1.0064700E+07 1.0064705E+07 9.9999949E-01 ---message from unionx---threshold error 53 1.5048500E+06 1.5048505E+06 9.9999967E-01 ---warning from acelod--- mf6/mt5 ep.gt.e mt= 5 e= 1.0000E-11 ep= 1.0000E-06 leaving it as is...
ACER
---message from consis---consistency problems found

- Mn55 is processed with NJOY99.393.

RECONR
---message from rdf2bw---calculation of angular distribution not installed. changed threshold from 6.339291E+05 to 6.339292E+05 for mt 5. changed threshold from 1.041375E+07 to 1.041376E+07 for mt 16. ...
HEATR
---message from hinit---mf6, mt102 does not give recoil za= 25056 photon momentum recoil used.
ACER
---message from ptleg2---negative probs found 4 for mt= 62 e= 1.000E+08 ---message from ptleg2---negative probs found 4 for mt= 66 e= 1.000E+08 ...

9. Covariance Data processing

- Covariance data processing for Cu63 and Cu64 requires NJOY2010/12.
- For Mn55, processing is done with NJOY99.393.
 - o No problems to process MF33-MF32 in Mn55 (See an example in Figure 8)
 - o Problem in MF34/MT2. It is solved changing this line in the file:


```
"0.000000+0 0.000000+0      1      1      1      1252534  2  3"
```

 by


```
"0.000000+0 0.000000+0      1      0      1      1252534  2  3"
```
 - o Problem to process MF34/MT51 no solved.

Figure 18. MF33/32-MT1

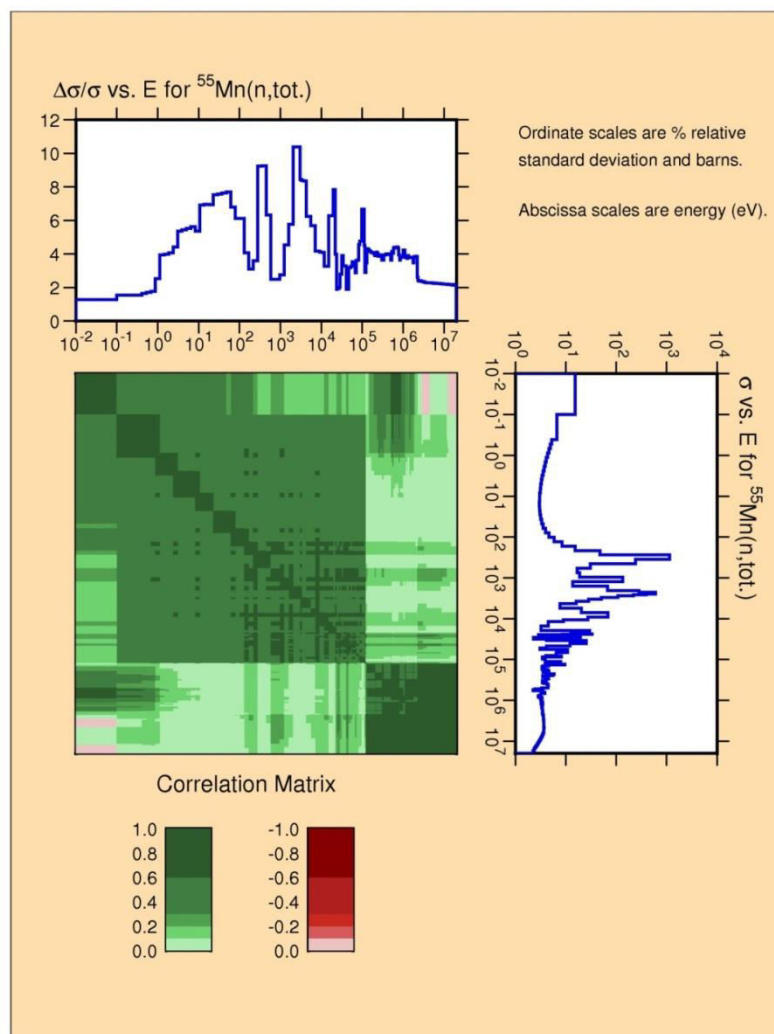
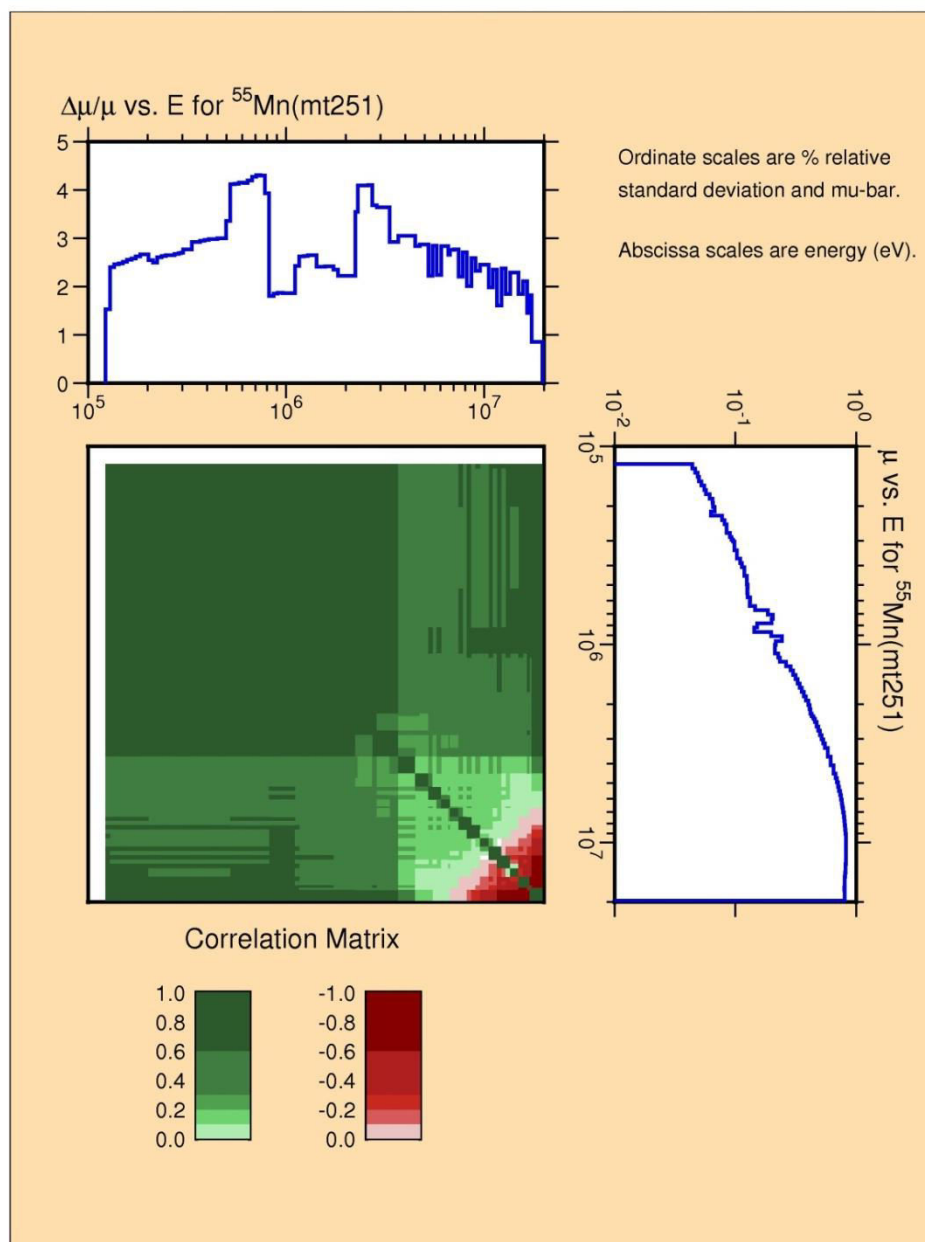


Figure 19. MF34-MT2

10. Conclusions

- Processing work of new updates files has been performed.
- The impact on criticality calculations has been revised using a suite of 124 cases from ICSBEP
- In some cases differences between keff calculations and experiment increase from JEFF-3.2T3:
 - o heu-met-inter-006-case2 (1.00034 -> 1.00197)
 - o heu-met-inter-006-case3 (1.00372 -> 1.00545)
 - o heu-met-fast-73 (1.01042 -> 1.01673)
 - o ieu-met-fast-001-case3 (1.00043 -> 1.00154)
 - o leu-sol-therm-007-CASE14 (0.99551 -> 0.99452)
 - o u233-met-fast-004-CASE_1 (0.99924 - > 0.99856)
- An explanation of these differences could be found in the Cu63 and Cu65 evaluation in the energy range between 0.1 MeV-1.35 MeV.

An extensive work should be performed to clarify this effect.

- For Cu63 and Cu65 some problems identified with PSYCHE code should be explained by the evaluators.
- NJOY2010/12 is required to process Cu63 and Cu65.

11. References

[NJOY99_up393] R. E. MacFARLANE, .up393 - NJOY version 99.393, Los Alamos National Laboratory, USA (2012)

[PREPRO2010] Cullen, D.E., PREPRO2010, Data Preparation and Management, Subsidiary Calculations (ENDF Format). IAEA1379 PREPRO2010, 2010

[ICSBEP] *International Handbook of Evaluated Criticality Safety Benchmark Experiments*, NEA/NSC/DOC(95)03/I, Nuclear Energy Agency, Paris (September 2010 Edition)

[LA-UR-11-04170] R.D. Mosteller, F. B. Brown and B.C. Kiedrowski, An Expanded Criticality Validation Suite for MCNP, International Conference on Nuclear Criticality 2011, Edinburgh, Scotland, September 19-22, 2011. LA-UR-11-04170.

[NEA/JEFF-3.1.1] O. Cabellos, in Processing of the JEFF-3.1.1 Cross Section Library into a Continuous Energy Monte Carlo Radiation Transport and Criticality Data Library (<http://www.nea.fr/dbdata/process>, NEA, 2009).

[Mughabghab-2003] S.F. Mughabghab , "THERMAL NEUTRON CAPTURE CROSS SECTIONS RESONANCE INTEGRALS AND G-FACTORS", INDIC(NDS)-440

[Pritychenko-2013] B. Pritychenko, S.F. Mughabghab, "Neutron Thermal Cross Sections, Westcott Factors, Resonance Integrals, Maxwellian Averaged Cross Sections and Astrophysical Reaction Rates Calculated from the ENDF/B-VII.1, JEFF-3.1.2, JENDL-4.0, ROSFOND-2010, CENDL-3.1 and EAF-2010 Evaluated Data Libraries", BNL REPORT