Testing JEFF-3.3T3 in ICSBEP Benchmarks

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Data Bank

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I. Benchmarking and Validation Activities

- Paper in ND2016

Benchmarking and Validation Activities within JEFF Project

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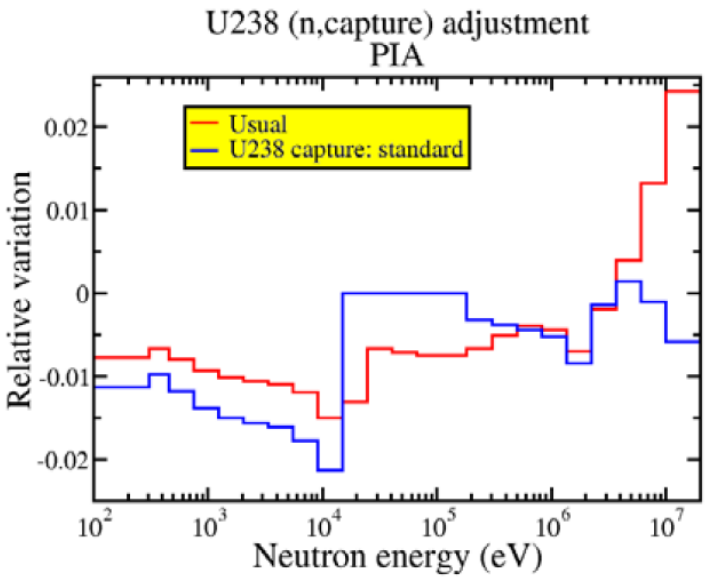
- 14 Institutions !!!

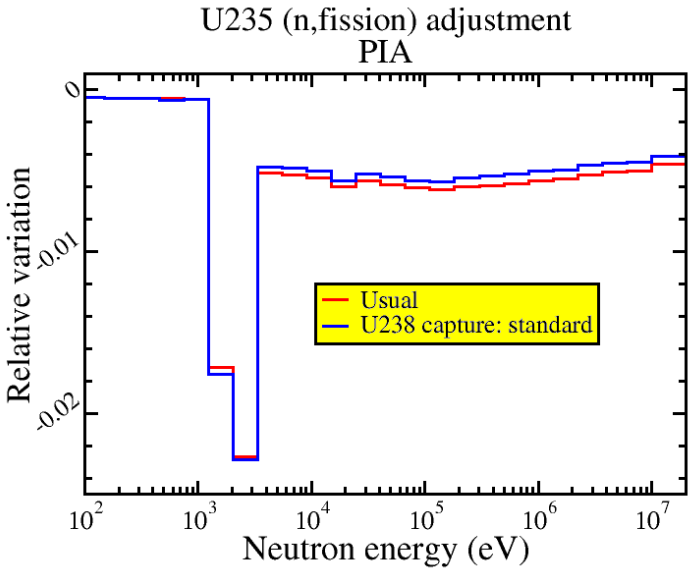
Abstract. The challenge for any nuclear data evaluation project is to periodically release a revised, fully consistent and complete library, with all needed data and covariances, and ensure that it is robust and reliable for a variety of applications. Within an evaluation effort, benchmarking activities play an important role in validating proposed libraries. The Joint Evaluated Fission and Fusion (JEFF) Project aims to provide such a nuclear data library, and thus, requires a coherent and efficient benchmarking process. The aim of this paper is to present the activities carried out by the new JEFF Benchmarking and Validation Working Group, and to describe the role of the NEA Data Bank in this context. The paper will also review the status of preliminary benchmarking for the next JEFF-3.3 candidate cross-section files.

I. Recent discussions on U235-U238

- Arjan PLOMPEN's presentation in WPEC/SG39 meeting (December 2016)

- **See Sandro PELONI's work in WPEC/SG39 (May 2017):** *"The idea is that the 238U capture cross-section is a standard data set in the unresolved energy region between 20keV and 149keV"*
  - current uncertainty of the order of only 2% => put the standard deviation to zero
  - cross correlations available in COMMARA-2.0





- See **Luiz LEAL's presentation**: "Testing of the RR+UR of the JEFF-3.3T library" in JEFF-April 2017
- See **Bor KOS's presentation**: "Analysis of recent U-235 and U-238 evaluations using the BigTen and LMT-006 benchmarks" in JEFF/April 2017

I. Some ideas…. before results

- Nuclear Data Evaluation needs a closer collaboration between experimentalist, evaluators and validation experts
  - Tracking changes in evaluated files are needed …. **NDTracker is coming soon!**

- Processing & Verification + Benchmarking & Validation activities are required for this task
  - Automatizing procedures … **NDEC works!**
  - Sharing experiences in processing … **New NJOY open versions! NEA Tutorials!**
  - Extended validation suites … **New WPEC-SG45 VaNDAL project**
    - Criticality (ICSBEP, IRPhEP,…) **… DICE**
    - Shielding, ….SINBAD …**New Tool**
  - ….
- New tools in generation of future evaluated libraries
  - Sensitivities and covariances play an essential work … **NDaST tool**
  - Assessing trends on nuclear data…**SENDIS tool**
  - **How to build new files?** It requires expertise on evaluation, processing and familiarity with ND format.

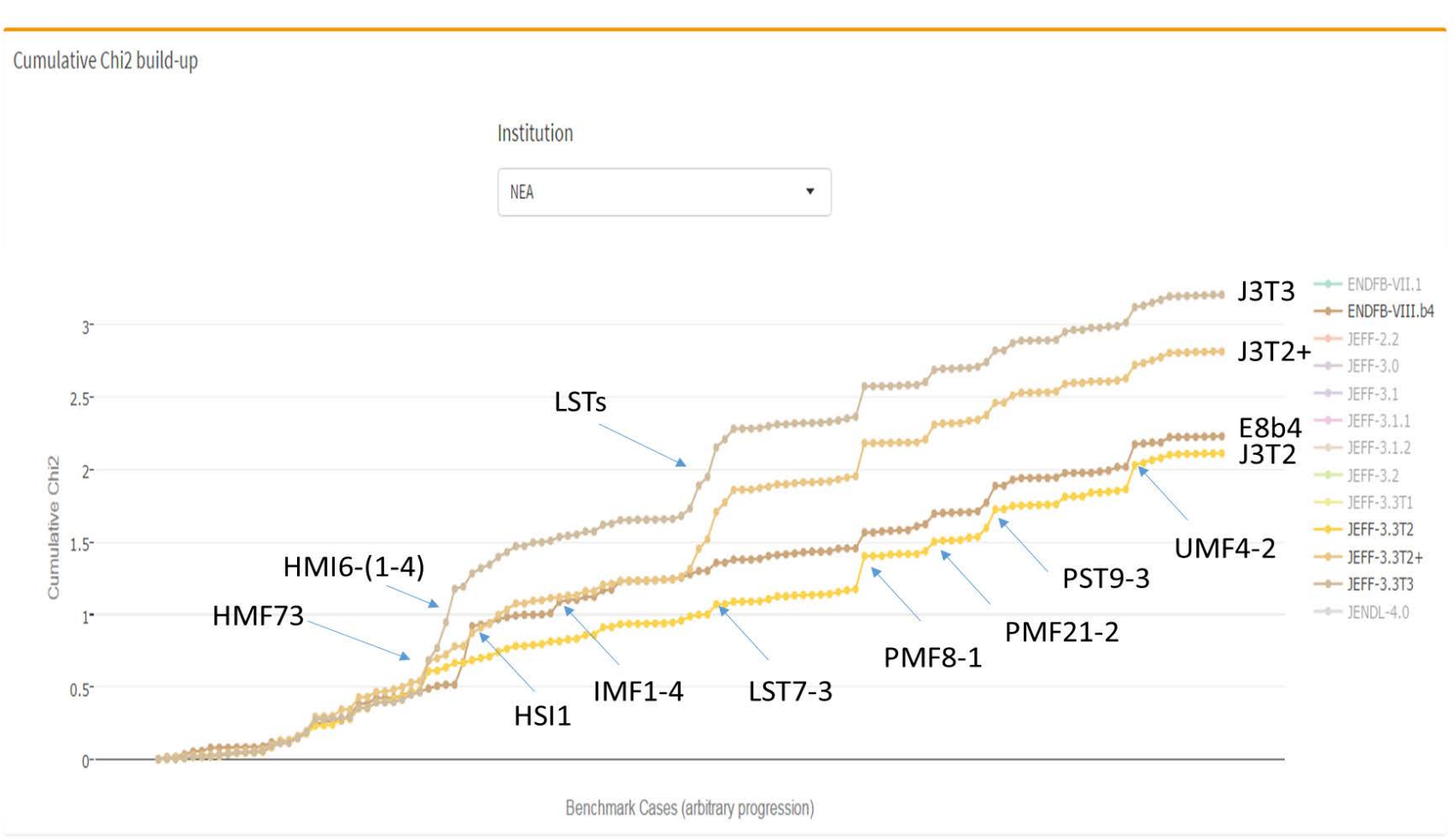
II. Results of criticality benchmarking using ICSBEP

Table 1. Evaluation of general performance for extended validation suites.
Values are "*reduced*" Chi-squared, number of cases in brackets

	NEA							
	ENDF/B-VII.1	ENDF/B-VIIIb4	JEFF-3.1.1	JEFF-3.2	JEFF-3.3.T2	JEFF-3.3T2+		JEFF-3.3T3
PU	4.2 (29)	2.2 (29)	2.9 (29)	3.6 (29)	2.8 (29)	2.4 (29)		2.4 (29)
HEU	6.1 (42)	4.1 (42)	5.3 (42)	11.8 (42)	2.2 (42)	3.5 (42)		3.9 (42)
IEU	5.0 (12)	1.9 (12)	11.3 (12)	4.9 (12)	2.7 (12)	2.1 (12)		2.2 (12)
LEU	0.9 (13)	1.4 (13)	1.4 (13)	0.9 (13)	1.8 (13)	3.7 (13)		4.0 (13)
U233	1.7 (18)	2.1 (18)	9.5 (18)	1.2 (18)	1.7 (18)	1.9 (18)		1.7 (18)
MIX	0.7 (8)	1.0 (8)	1.2 (8)	0.9 (8)	0.9 (8)	1.0 (8)		0.8 (8)
SPEC (C/E)	0.99249 (1)	0.99338 (1)	0.98719 (1)	0.98847 (1)	0.99142 (1)	0.99145 (1)		0.99118 (1)
Total	3.7 (123)	2.22 (123)	6.5 (123)	5.6 (123)	2.02 (123)	2.9 (123)		3.1 (123)

II. Results of criticality benchmarking using ICSBEP

Figure 1. Cumulative Chi-2 build-up (SENDIS output)



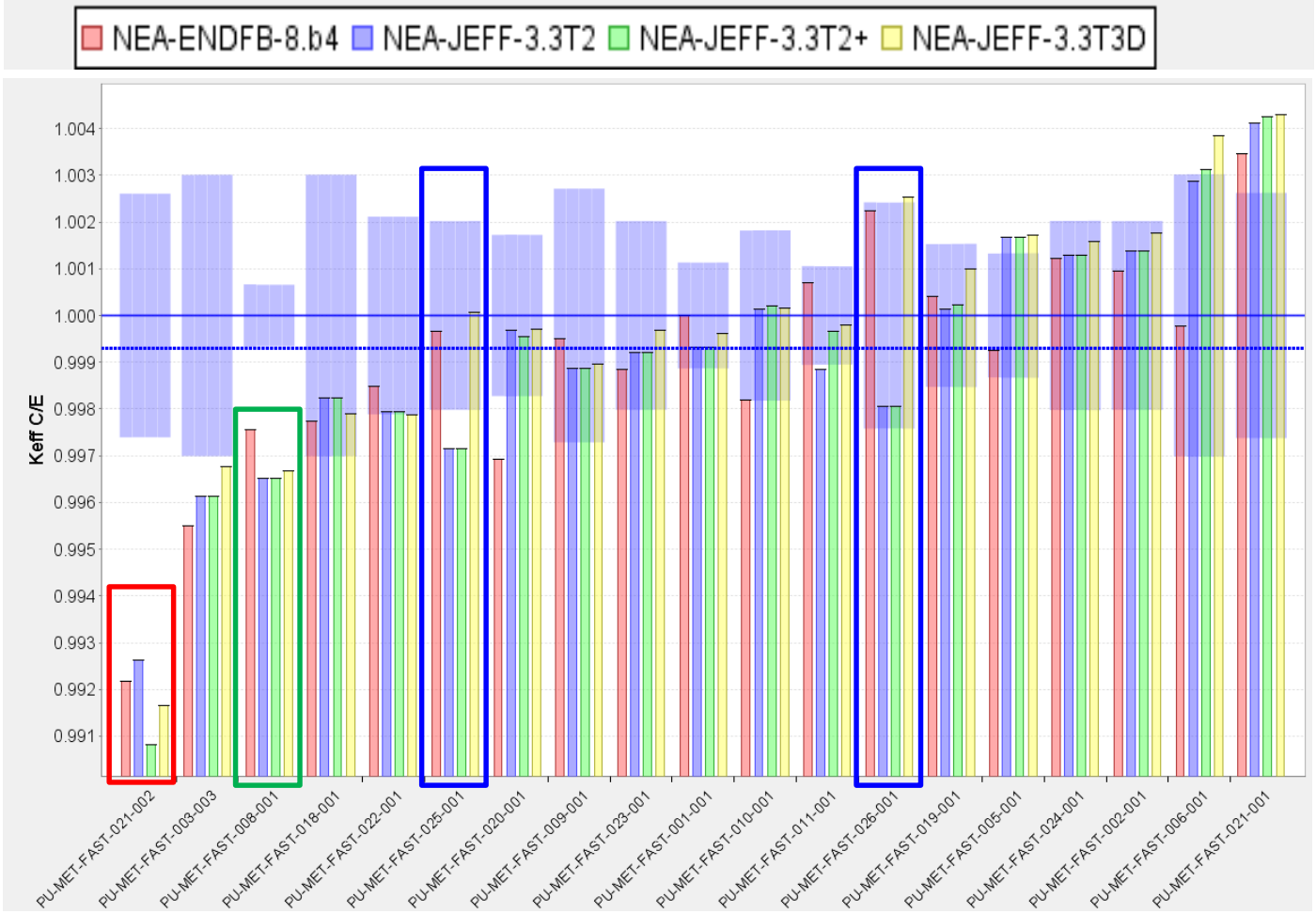
II. Main changes in JEFF-3.3 beta for criticality

Table 2. Main changes in JEFF3.3 beta files for criticality

	JEFF-3.3T2	JEFF-3.3T2P	JEFF-3.3T3	T4 ?
Pu239	JEFF-3.3T2	JEFF-3.3T2	JEFF-3.3T2	
U235	JEFF-3.3T2	JEFF-3.3T2	JEFF-3.3T2	
U238	JEFF-3.3T2	JEFF-3.3T2+RR/JRC	JEFF-3.3T2+RR-JRC	
O16	ENDF/B-VII.1	O16-Luiz	O16-Luiz	
TSLs	JEFF-3.1	H2O Bariloche D2OBariloche	H2O Bariloche D2OBariloche	H2O – ENDF/B-VIIIb4 D2O – ENDF/B-VIIIb4
Cu	ENDF/B-VII.1+RR/JRC	ENDF/B-VII.1+RR/JRC	KIT-revised + RR/Sobes&Luiz	
Zr	TENDL-2015	JEFF-3.3T2=TENDL-2015	KIT	
Fe54/56	JEFF-3.2	JEFF-3.2	ENDF/B-VIIIb4	
W	JEFF-3.2	JEFF-3.2	JEFF-3.2	
Be	JEFF-3.2	JEFF-3.2	JEFF-3.2	
C	JEFF-3.2	JEFF-3.2	JEFF-3.2	
Ni	JEFF-3.2	JEFF-3.2	JEFF-3.2	
Al	JEFF-3.2	JEFF-3.2	JEFF-3.2	
Th232	JEFF-3.2	JEFF-3.2	JEFF-3.2	

II.1 PU-FAST

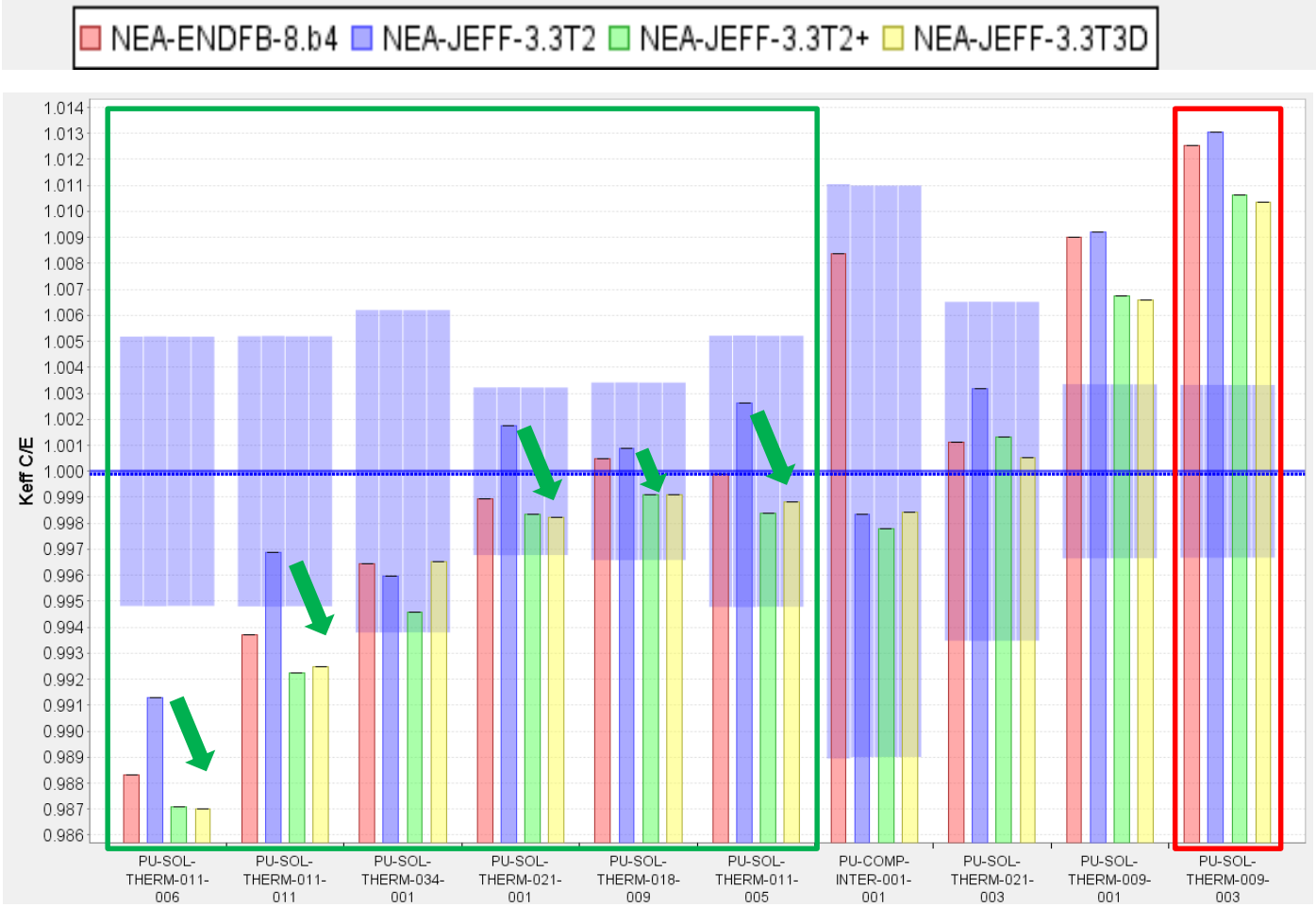
ENDF/B-VIII.b4	JEFF-3.3.T2	JEFF-3.3T2+		JEFF-3.3T3
1.5	2.2	2.4		2.6



- Case with highest contribution in Chi-2
  - PMF8-1
  - PMF21-2
- JEFFvsENDFB8b4
  - **PMF8-1 (Th232)**
  - **PMF26-1 and PMF25-1(Fe)**
- JEFF
  - **PMF21-2 (O16)**

II.2 PU- INTER & THERM

ENDF/B-VIII.b4	JEFF-3.3.T2	JEFF-3.3T2+		JEFF-3.3T3
3.4	2.9	3.3		3.1

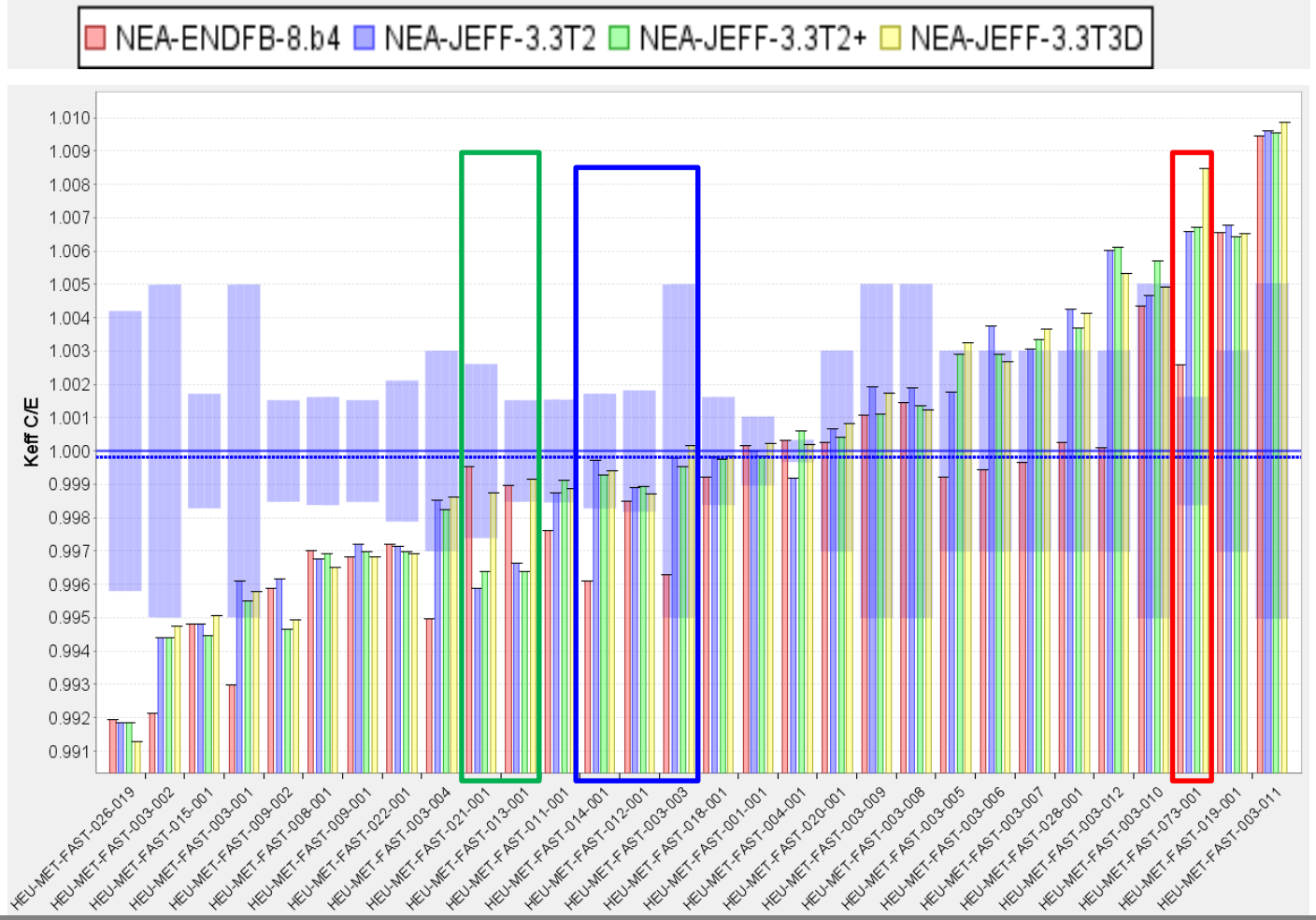


- Case with highest contribution in Chi-2
  - PST9-3

- JEFF-3.3T2vsT3
  - **PSTs(O16& H2O)**

II.3 HEU - FAST

ENDF/B-VIII.b4	JEFF-3.3.T2	JEFF-3.3T2+		JEFF-3.3T3
2.3	2.2	2.5		2.5



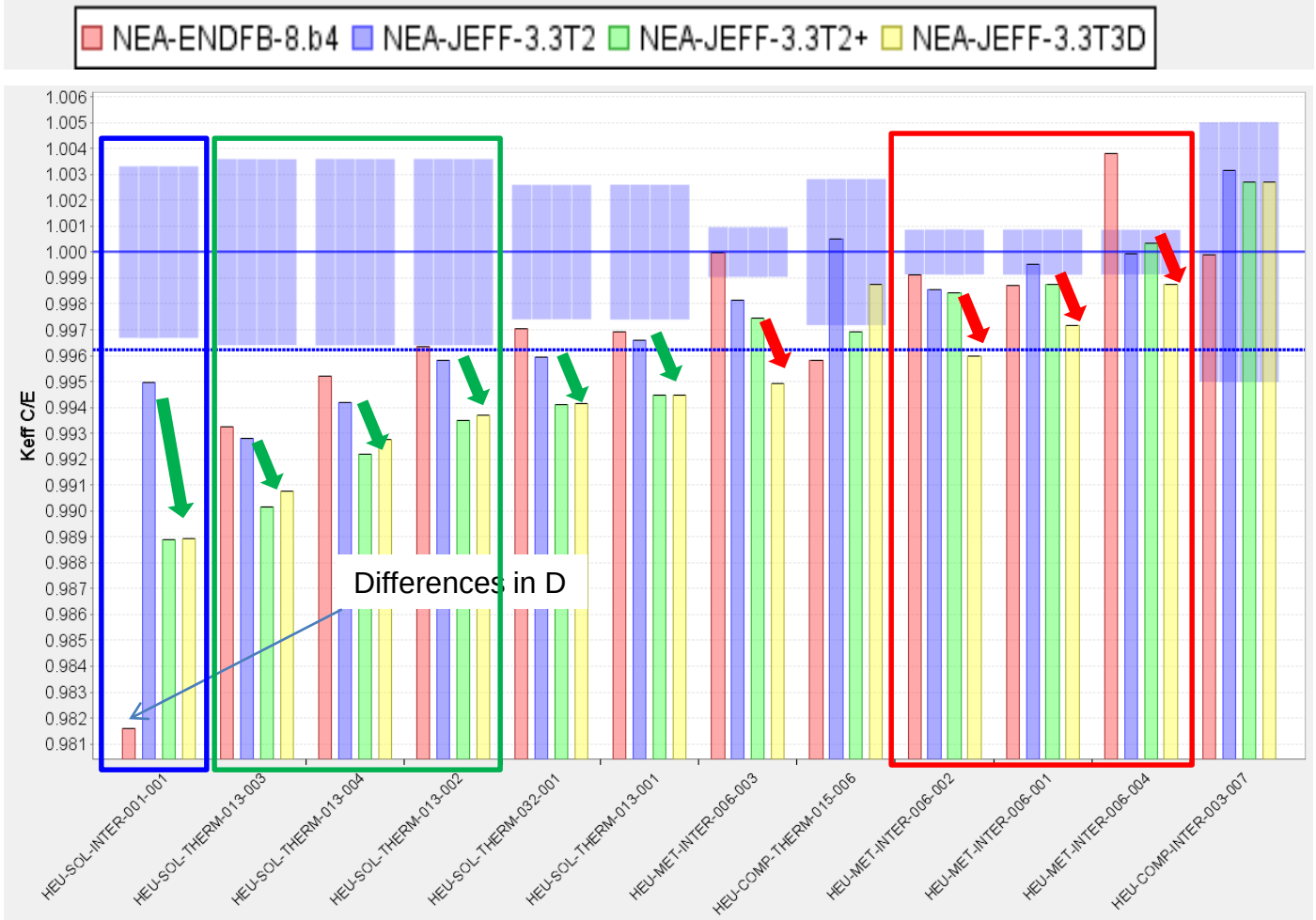
- Case with highest contribution in Chi-2
  - HMF73-1

- JEFF T3vs T2
  - **HMF73-1 (Cu?)**
  - **HMF13-1 (Fe?)**
  - **HMF21-1 (Fe?)**

- ENDF/B-VIIIb4 Lower values
  - **HMF3**
  - **HMF11**
  - **HMF14**
  - **HMF73-1**

II.4 HEU- INTER & THERM

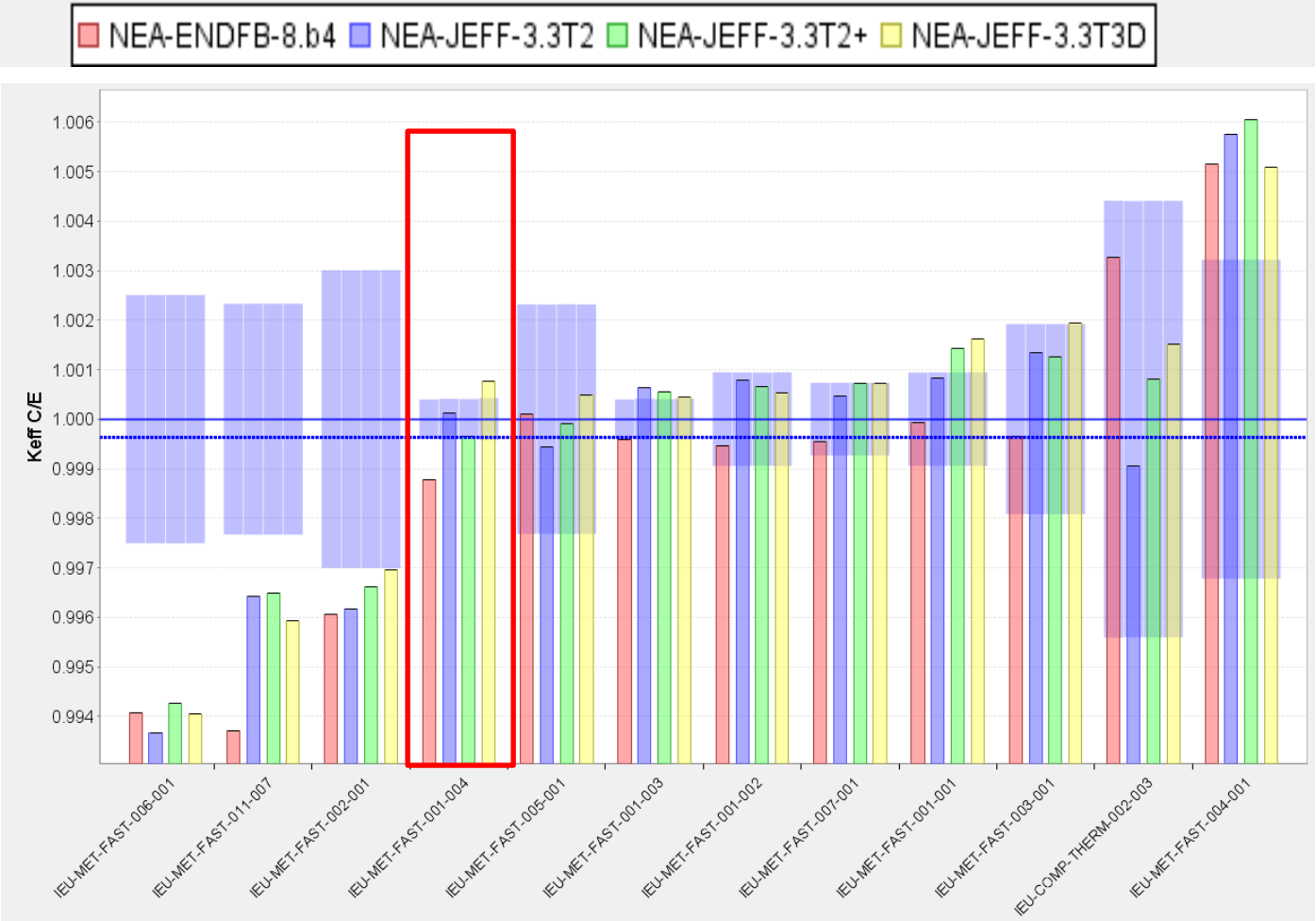
ENDF/B-VIII.b4	JEFF-3.3.T2	JEFF-3.3T2+		JEFF-3.3T3
12.3	2.2	6.6		3.2



- Case with highest contribution in Chi-2
  - HMI6-1/4
- JEFF-3.3T3
  - **HMI6-1-1(Cu)**
- JEFF-3.3T2vsT3
  - **HST13-1/4, HST32 and HSI1(O16& H2O)**
- ENDF/B-VIIIb4
  - **HSI1-1 (D!!!)**

II.5 IEU

ENDF/B-VIII.b4	JEFF-3.3.T2	JEFF-3.3T2+		JEFF-3.3T3
1.9	2.7	2.1		2.2

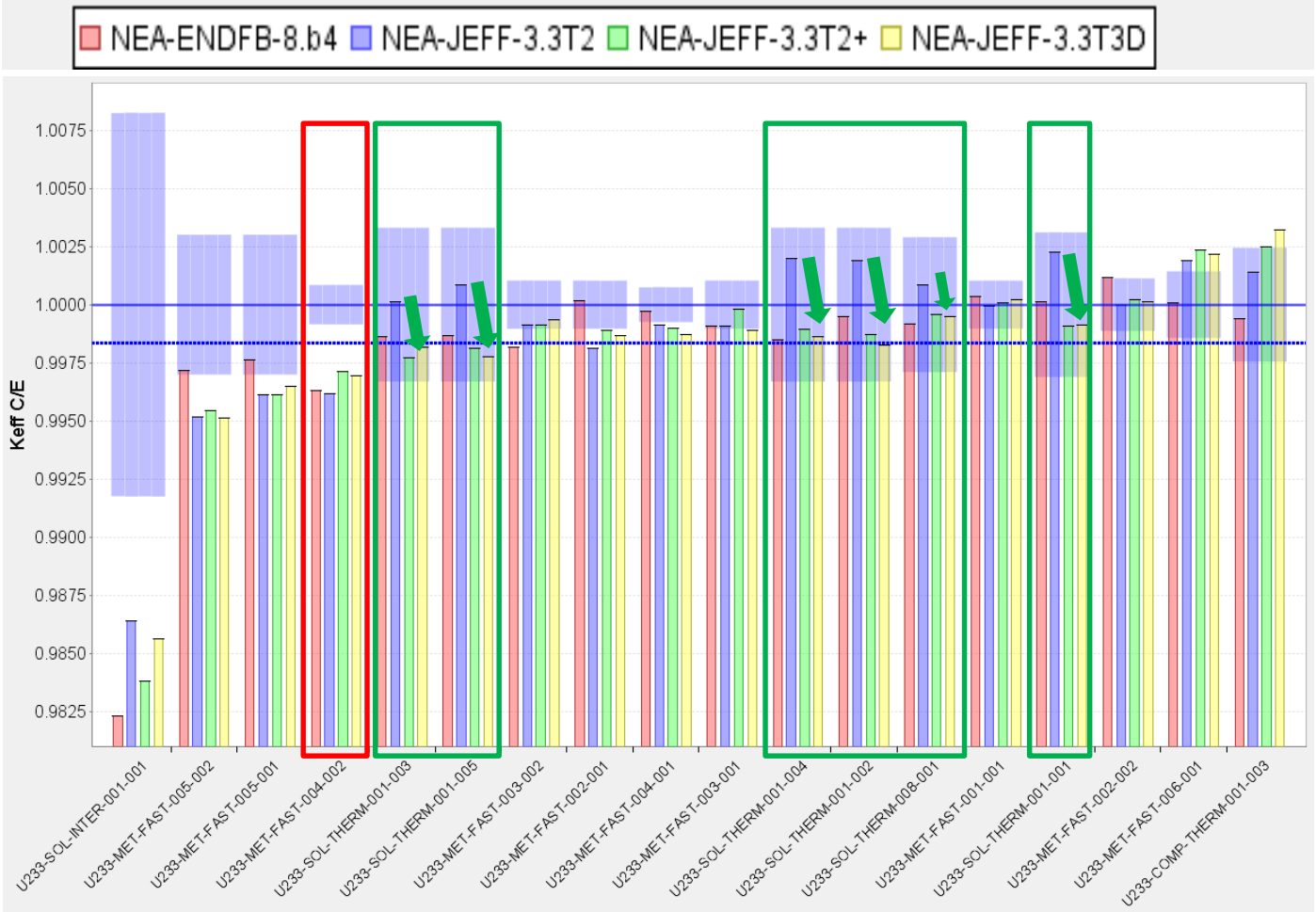


- Case with highest contribution in Chi-2
  - IMF1-4

- JEFF
  - **IMF1-4(Cu, Fe)**

II.6 U233

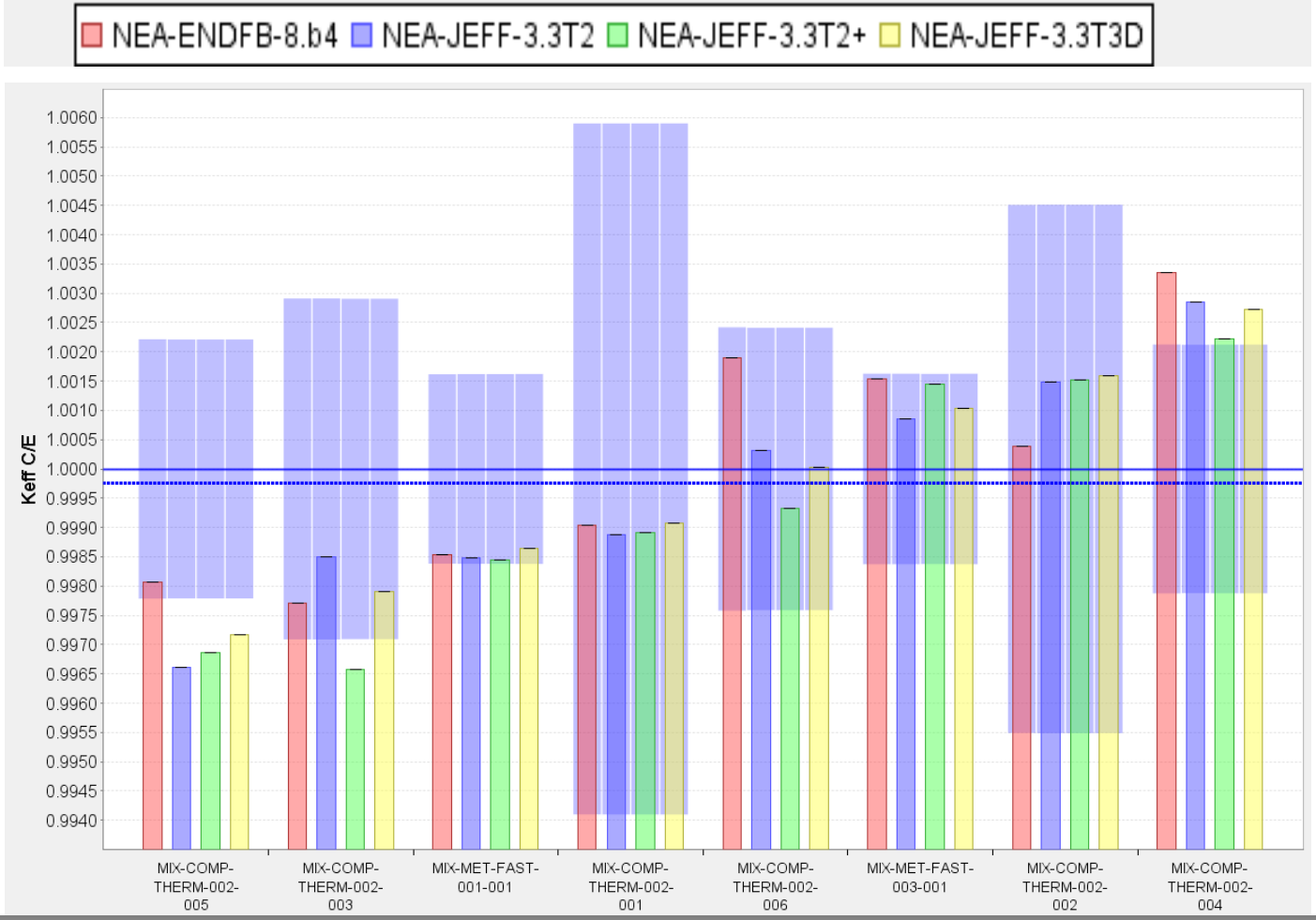
ENDF/B-VIII.b4	JEFF-3.3.T2	JEFF-3.3T2+		JEFF-3.3T3
2.1	1.7	1.9		1.7



- Case with highest contribution in Chi-2
  - UMF4-2
- JEFF
  - **UMF4-2(Cu, Zr, W)**
- JEFF
  - **USTs (O16&H2O)**

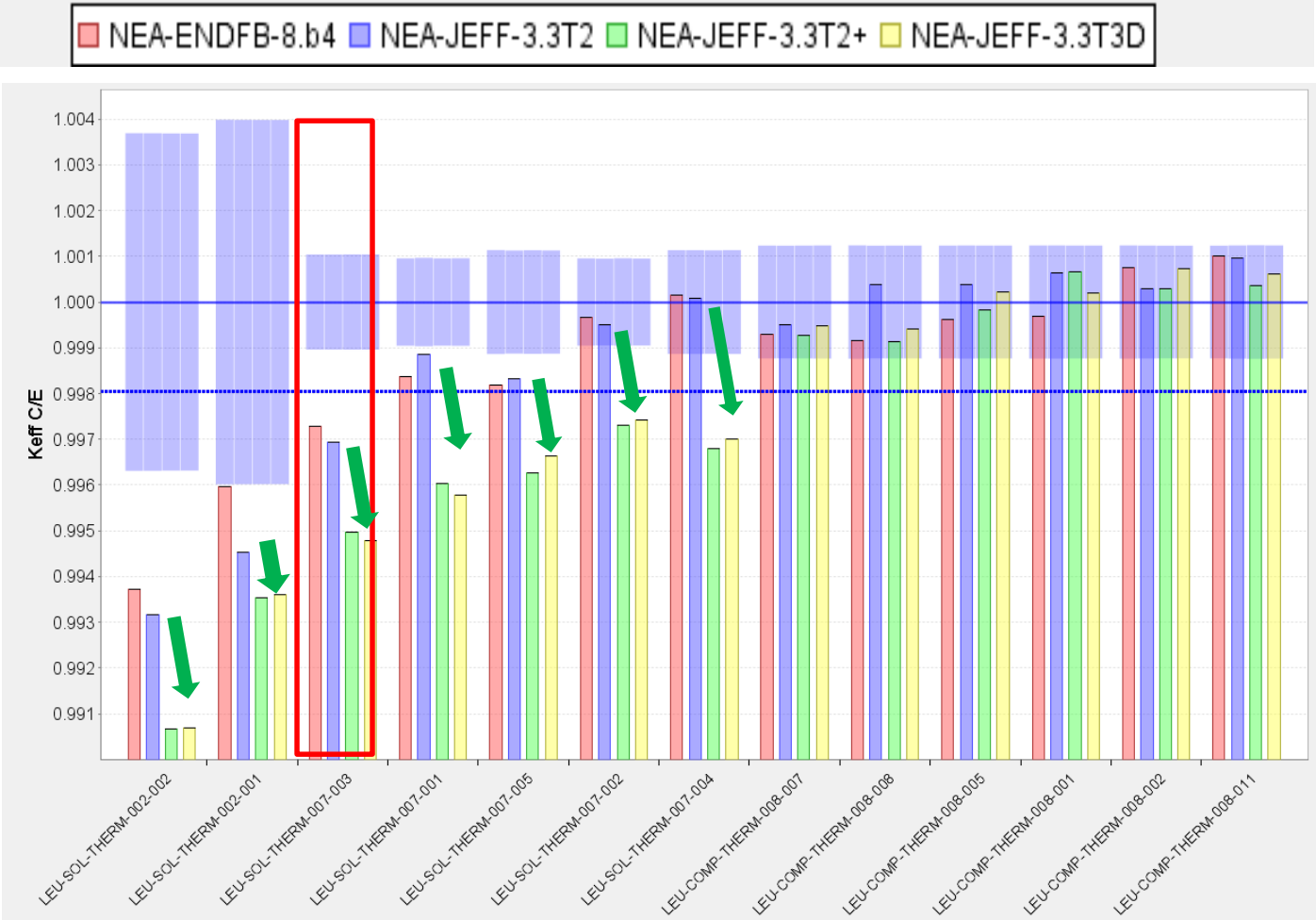
II.7 MIX

ENDF/B-VIII.b4	JEFF-3.3.T2	JEFF-3.3T2+		JEFF-3.3T3
1.0	0.9	1.0		0.8



II.8 LEU

ENDF/B-VIII.b4	JEFF-3.3.T2	JEFF-3.3T2+		JEFF-3.3T3
1.4	1.8	3.7		4.0



- Case with highest contribution in Chi-2
  - LST7-1/5

- JEFF3.3T3
  - **LSTs(O16&H2O)**

III. S/U analysis

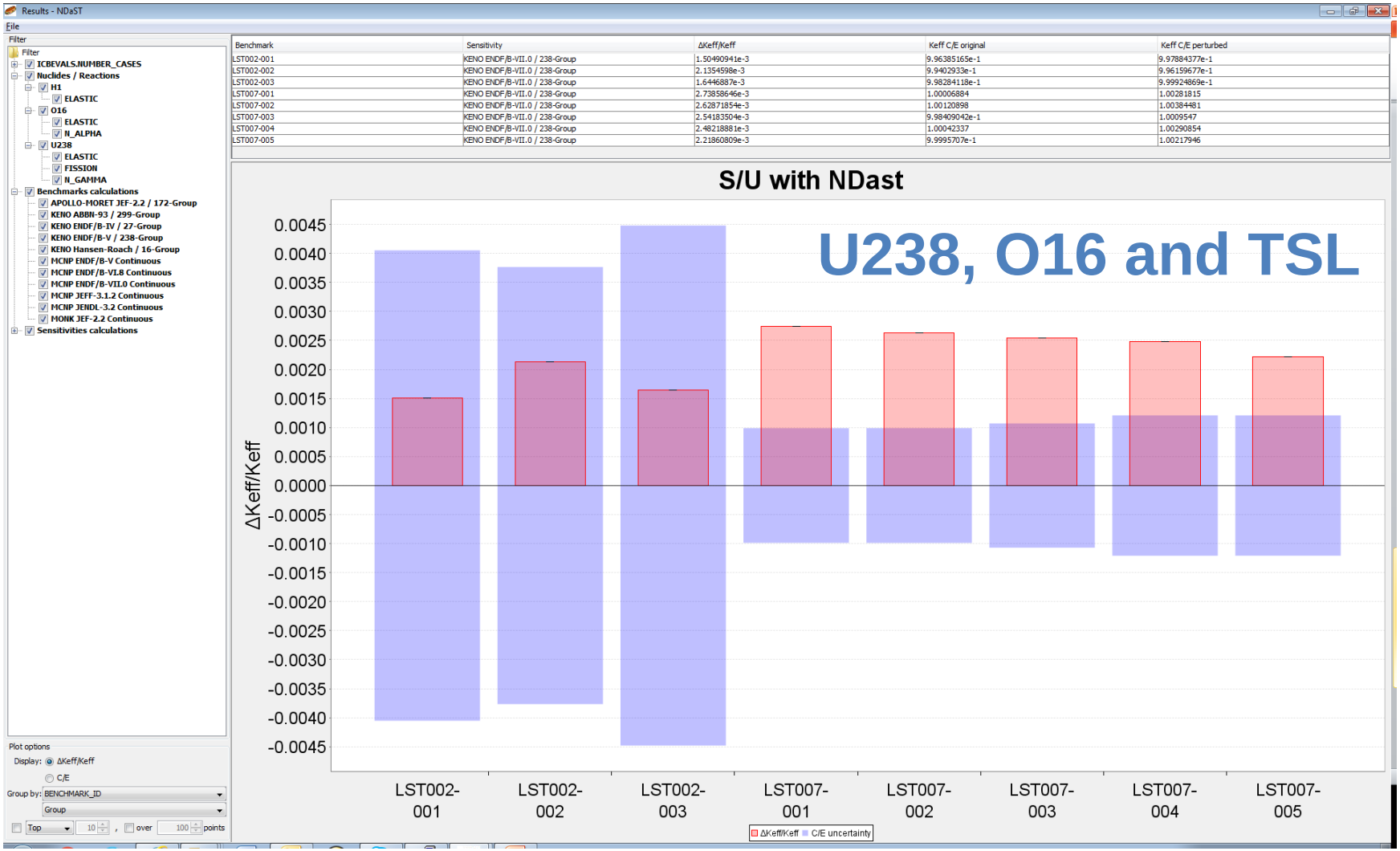
III.1 LST cases

See Annex I

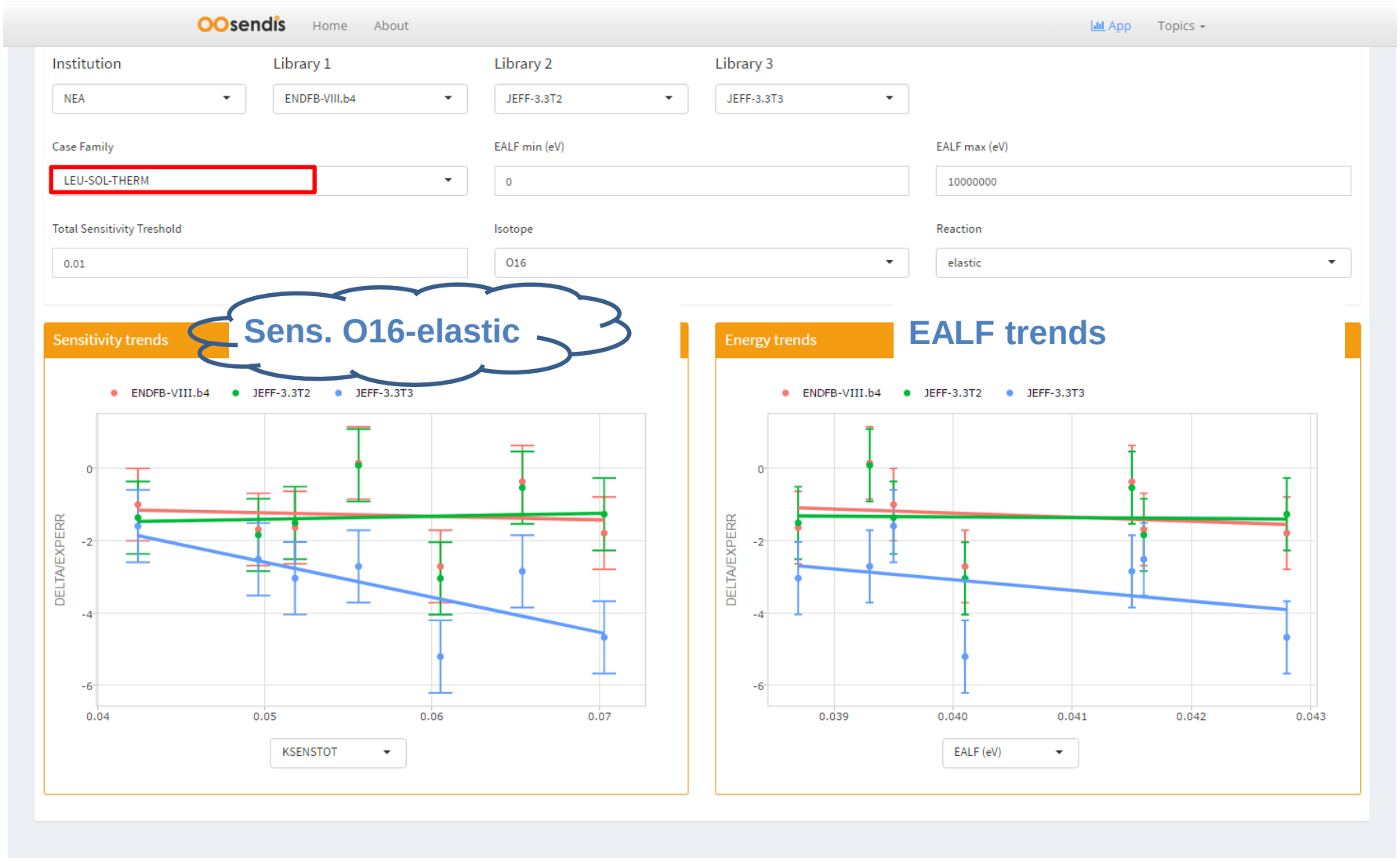
III.2 HMI6-1/4 and HMF73-1

See Annex II

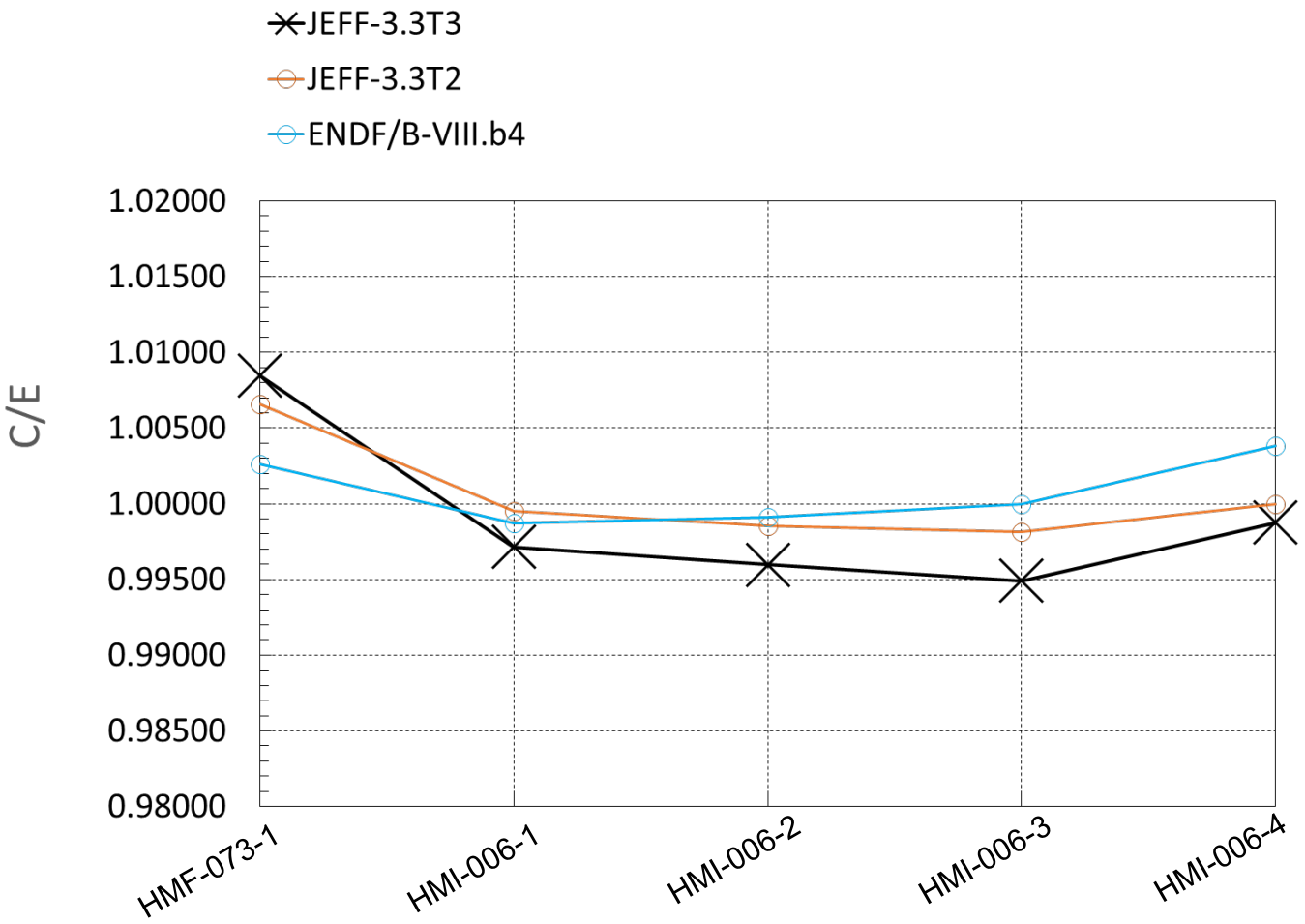
III.1 LST cases: T2 versus T3



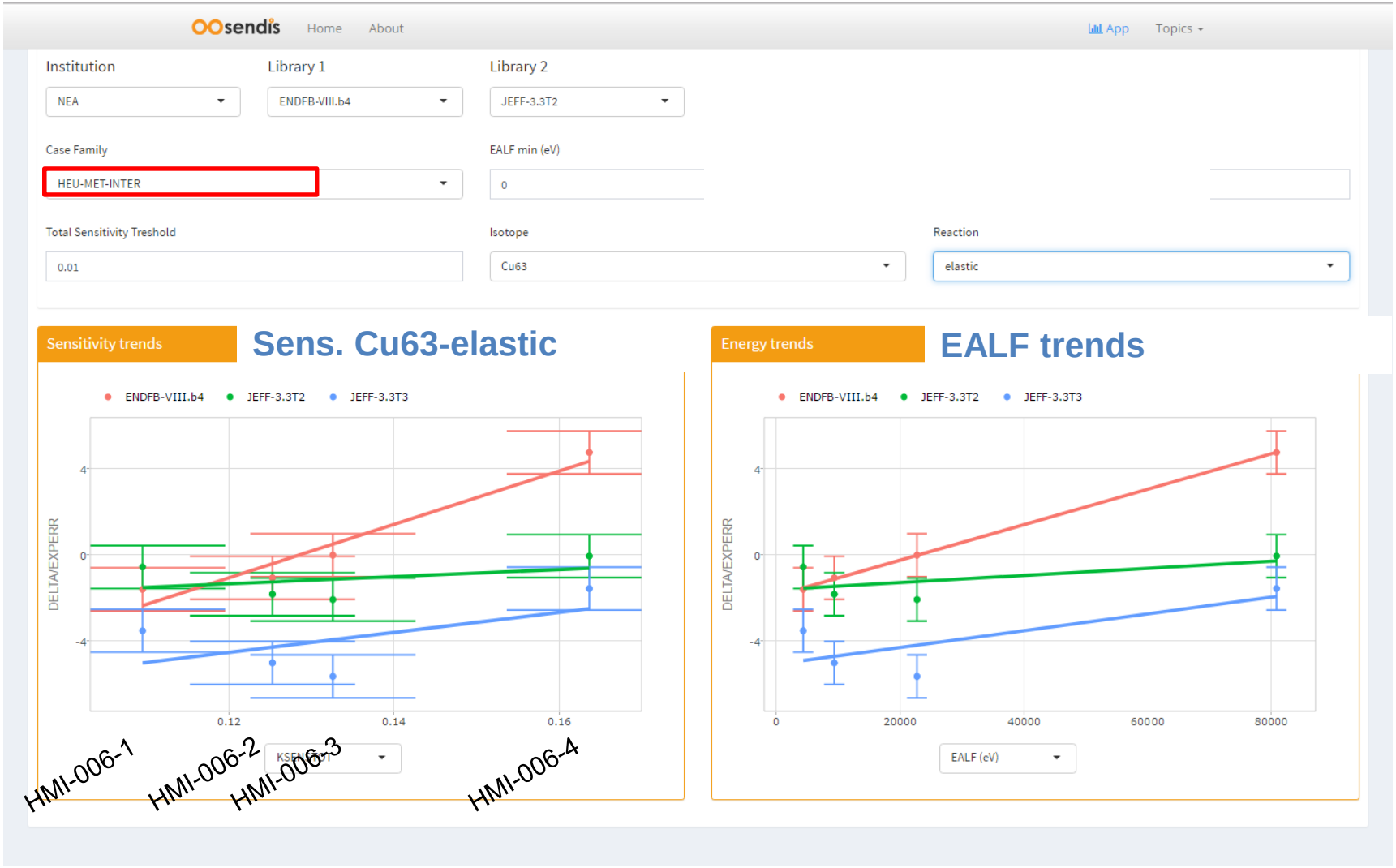
III.1 LST cases: T2 versus T3



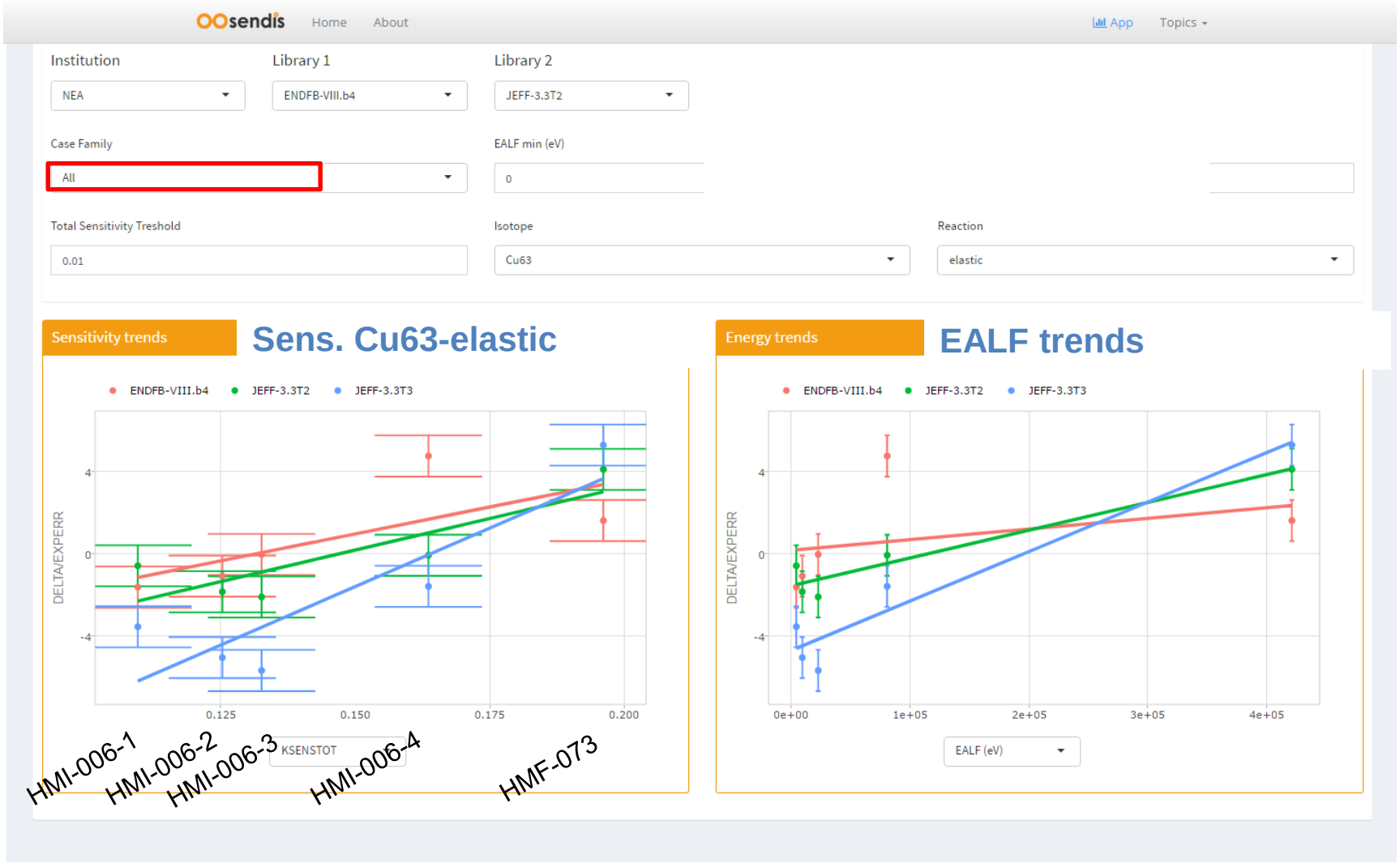
III.2 HMI6-1/4 and HMF-73 cases



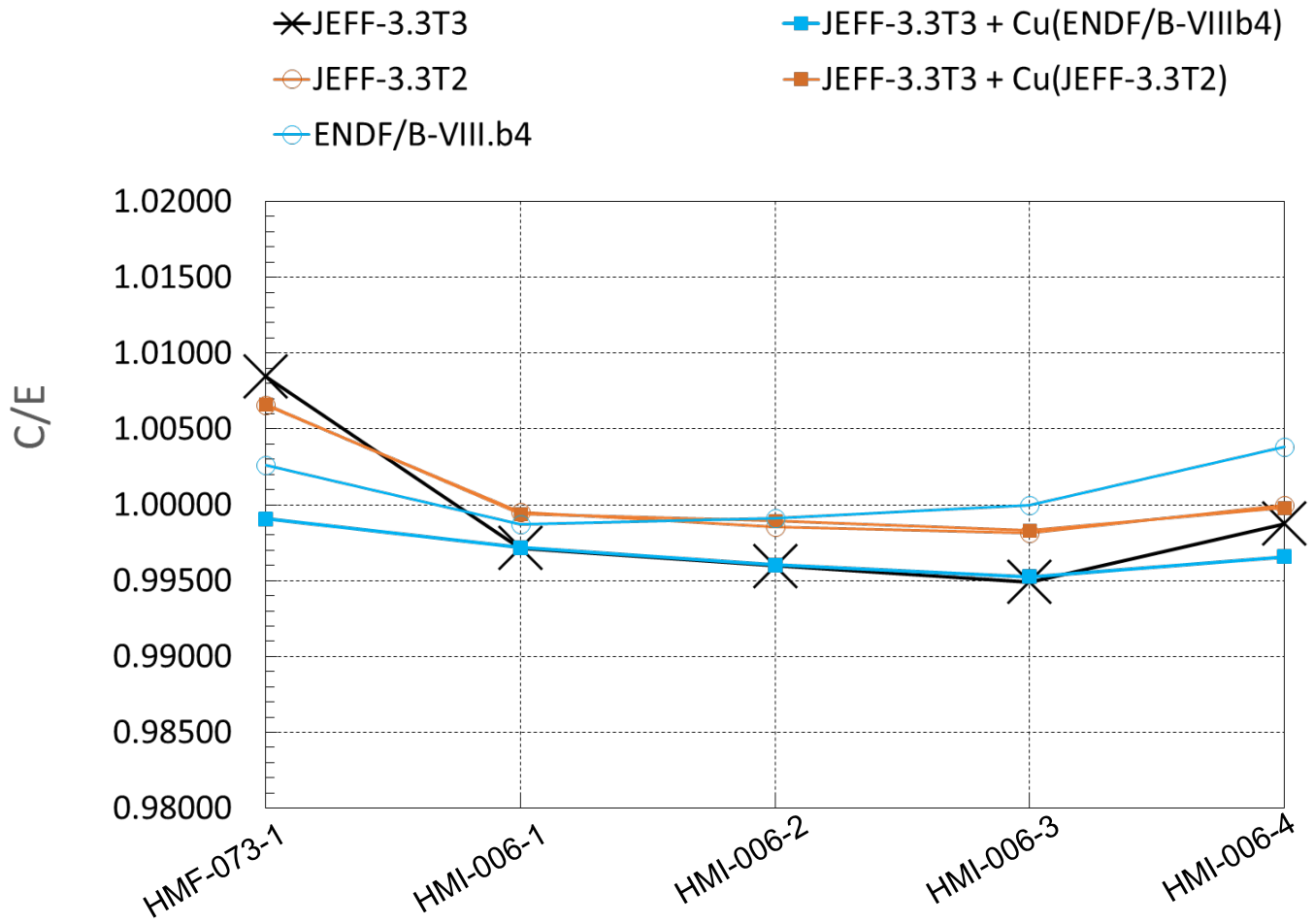
III.2 HMI6-1/4 and HMF-73 cases



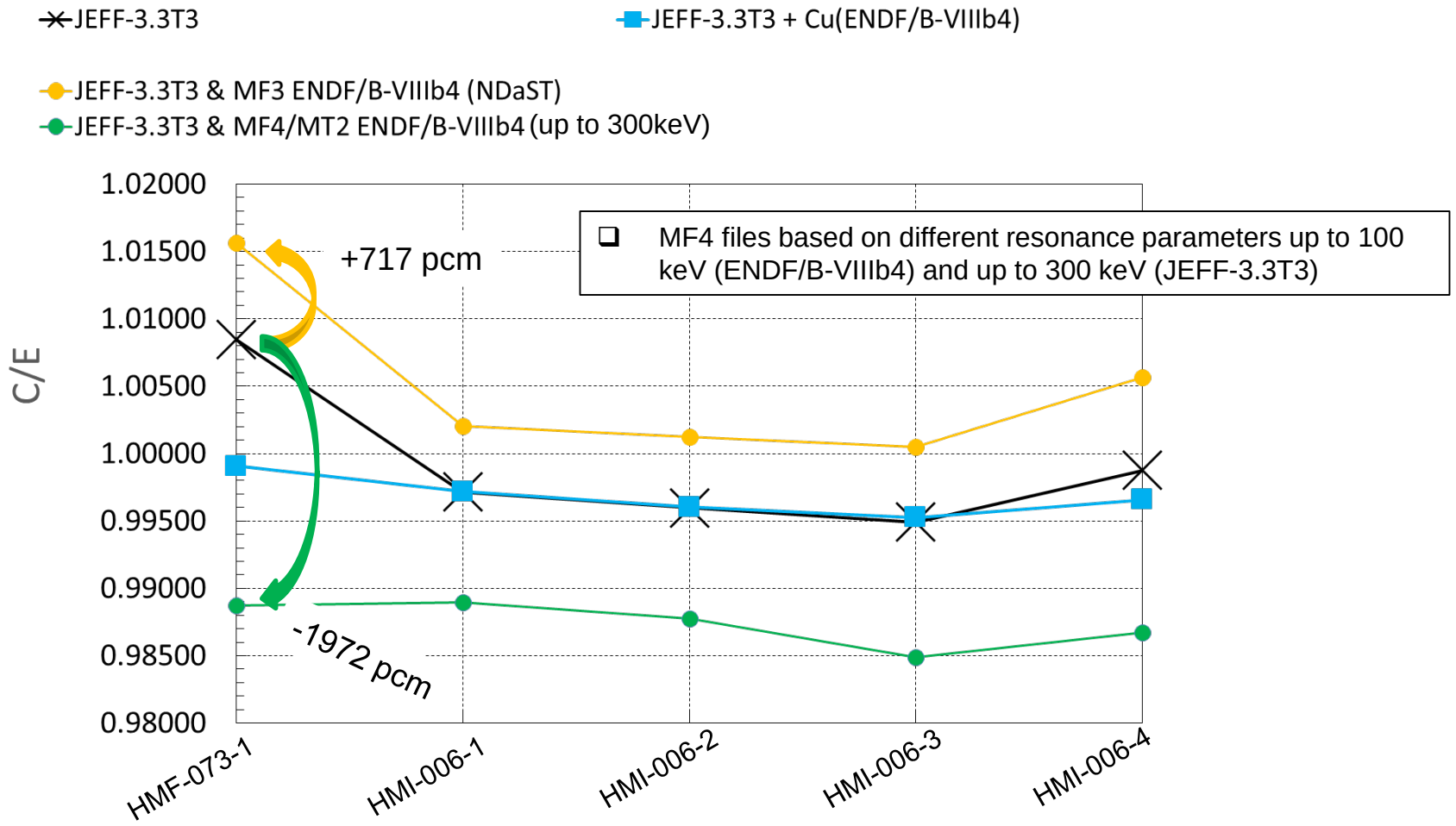
III.2 HMI6-1/4 and HMF-73 cases



III.2 HMI6-1/4 and HMF-73 cases

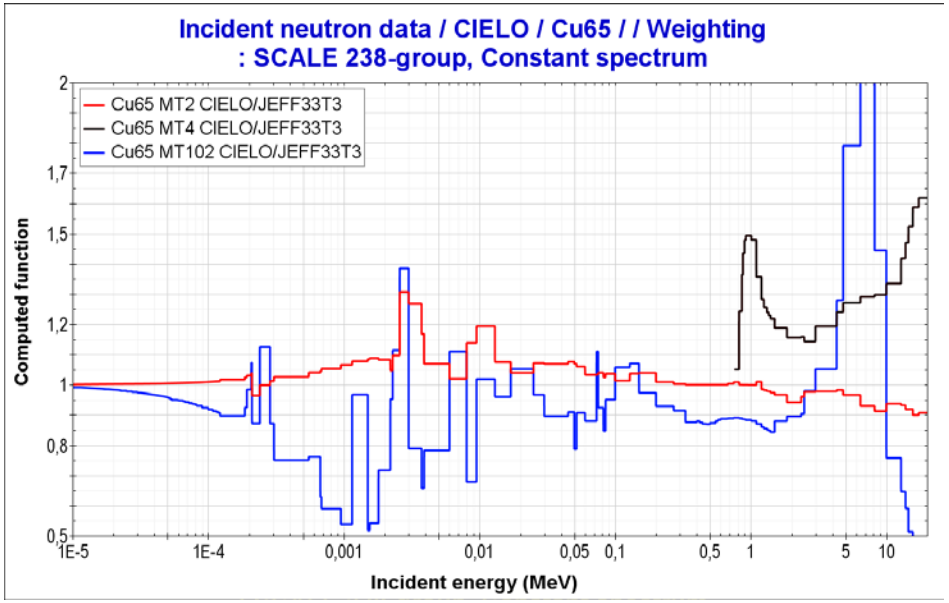


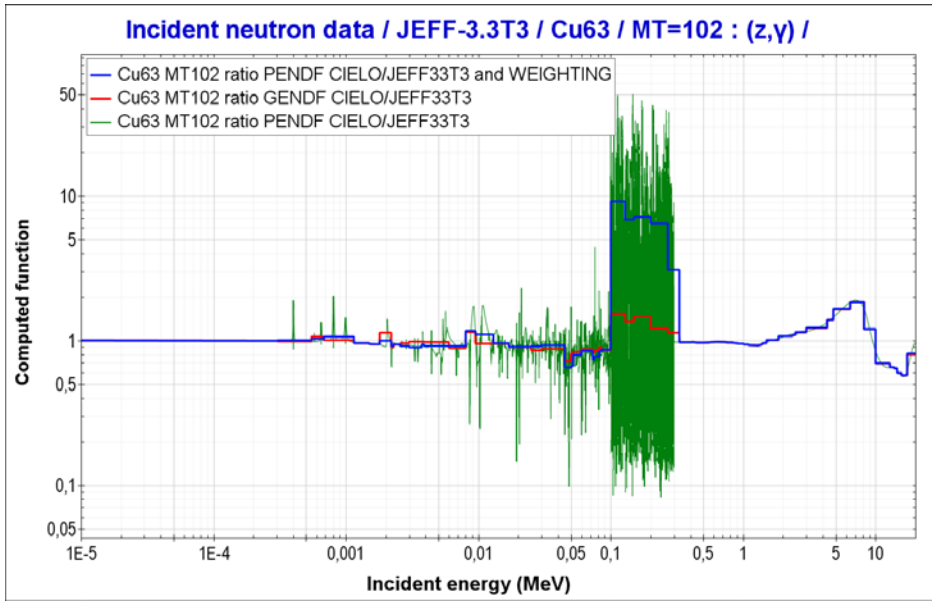
III.2 HMI6-1/4 and HMF-73 cases

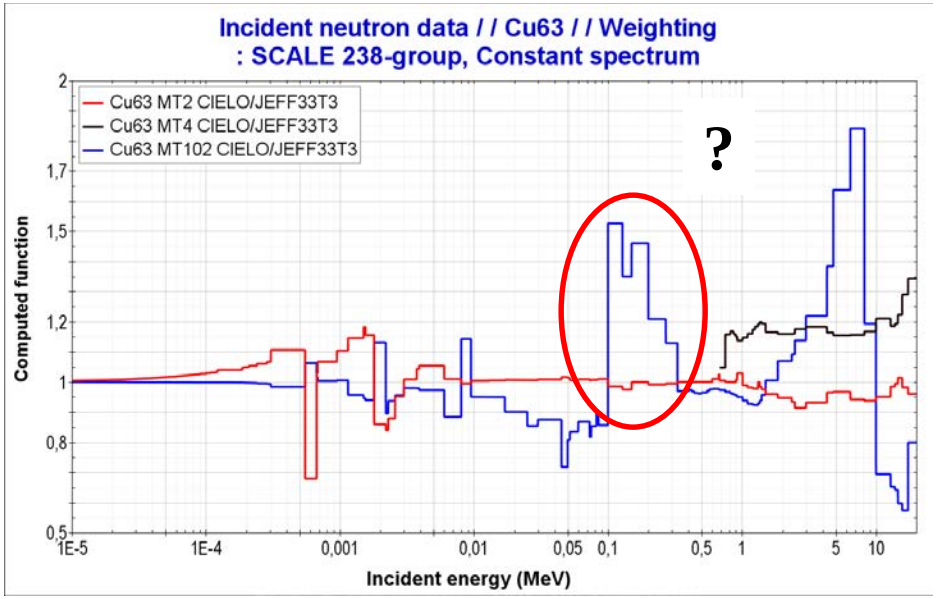


III.2 HMI6-1/4 and HMF-73

- JEFF-3.3T3 versus ENDF/B-VIIIb4





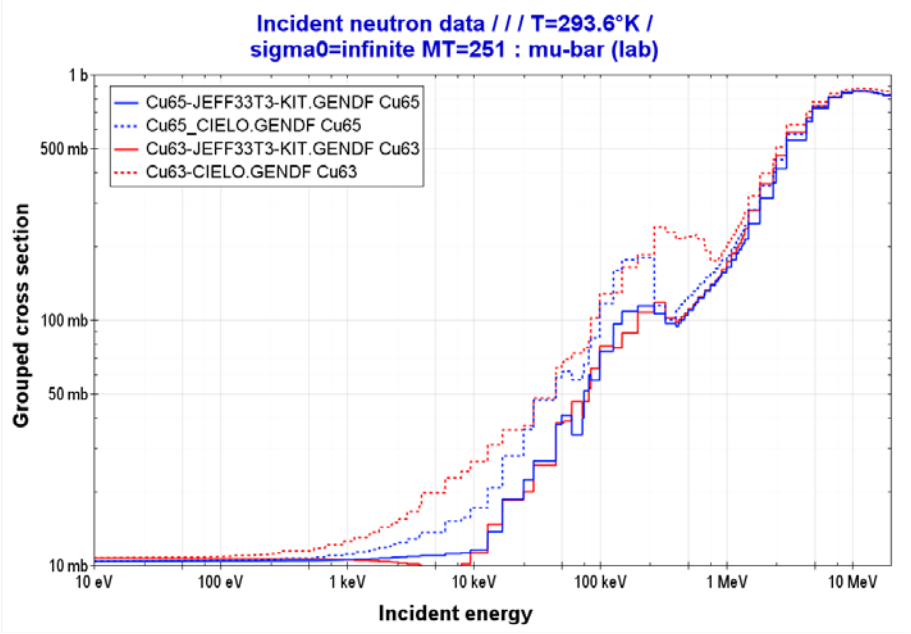


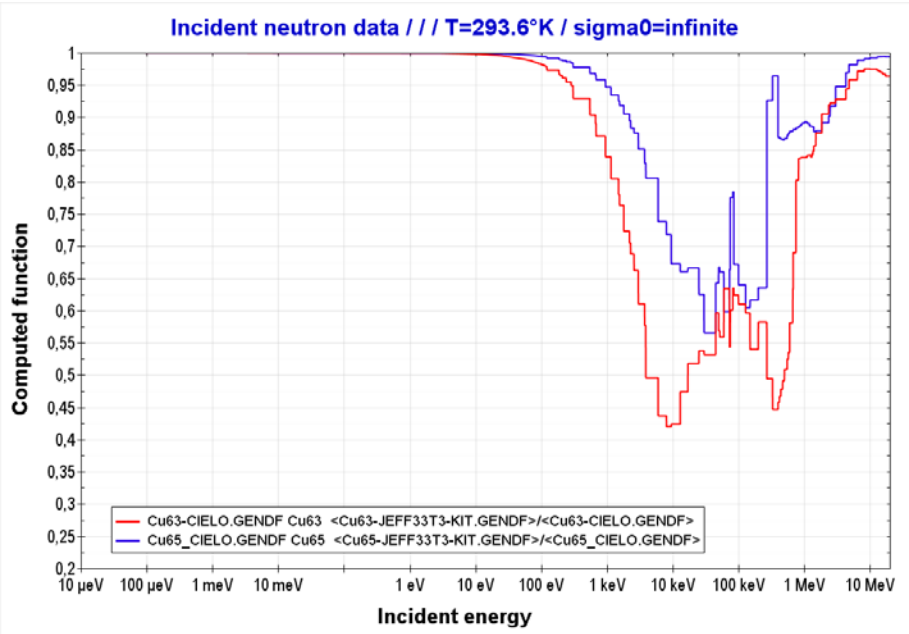
Change in angular distributions

- JEFF-3.3T3 versus ENDF/B-VIIIb4: MT251 mu-bar
- MF4/MT2 produced by T. Kawano based on different resonance parameters:
  - JEFF-3.3T3 resonance parameters up to 100 keV

    + smoothly transition from the MF4 based on the resonance parameters to the MF4 based on Kawano's model calculations above 300 keV

  - ENDF/B-VIIIb4 up to 300 keV





IV. Re-evaluation of T3 criticality benchmarking

Table 3. Evaluation of general performance for extended validation suites.
Values are "*reduced*" Chi-squared, number of cases in brackets

	NEA							
	ENDF/B-VIIIb4	JEFF-3.3.T2	JEFF-3.3T2+	JEFF-3.3T3 +TSL/JEFF3.1 +O16&Cu&Fe T2	JEFF-3.3T3 +TSL/JEFF3.1 +O16&Cu T2	JEFF-3.3T3 +TSL/JEFF3.1 +O16 T2	JEFF-3.3T3 +TSL-JEFF3.1	JEFF-3.3T3
PU	2.2 (29)	2.8 (29)	2.4 (29)	2.8 (29)	2.9 (29)	2.9 (29)	2.7 (29)	2.4 (29)
HEU	4.1 (42)	2.2 (42)	3.5 (42)	2.2 (42)	2.1 (42)	3.4 (42)	3.7 (42)	3.9 (42)
IEU	1.9 (12)	2.7 (12)	2.1 (12)	2.5 (12)	2.8 (12)	2.7 (12)	3.0 (12)	2.2 (12)
LEU	1.4 (13)	1.8 (13)	3.7 (13)	2.1 (13)	1.8 (13)	2.0 (13)	2.8 (13)	4.0 (13)
U233	2.1 (18)	1.7 (18)	1.9 (18)	1.4 (18)	1.4 (18)	1.7 (18)	1.6 (18)	1.7 (18)
MIX	1.0 (8)	0.9 (8)	1.0 (8)	1.0 (8)	1.0 (8)	1.0 (8)	1.2 (8)	0.8 (8)
Total	2.22 (123)	2.02 (123)	2.9 (123)	2.03 (123)	1.95 (123)	2.5 (123)	2.9 (123)	3.1 (123)

IV. Re-evaluation of T3 criticality benchmarking

Table 4. Evaluation of general performance for extended validation suites.
Values are "*reduced*" Chi-squared, number of cases in brackets

	NEA							
	ENDF/B-VIIIb4	JEFF-3.3.T2	JEFF-3.3T2+	JEFF-3.3T3 +TSL/JEFF3.1 +O16&Cu&Fe T2	JEFF-3.3T3 +TSL/JEFF3.1 +O16&Cu T2	JEFF-3.3T3	JEFF-3.3.T3 +LuizU5*	JEFF-3.3T3 +TSL/JEFF3.1+Cu T2 +LuizO16&U5*
PU	2.2 (29)	2.8 (29)	2.4 (29)	2.8 (29)	2.9 (29)	2.4 (29)	2.4 (29)	2.6 (29)
HEU	4.1 (42)	2.2 (42)	3.5 (42)	2.2 (42)	2.1 (42)	3.9 (42)	3.6 (42)	2.3 (42)
IEU	1.9 (12)	2.7 (12)	2.1 (12)	2.5 (12)	2.8 (12)	2.2 (12)	2.5 (12)	2.5 (12)
LEU	1.4 (13)	1.8 (13)	3.7 (13)	2.1 (13)	1.8 (13)	4.0 (13)	3.1 (13)	2.0 (13)
U233	2.1 (18)	1.7 (18)	1.9 (18)	1.4 (18)	1.4 (18)	1.7 (18)	1.9 (18)	1.4 (18)
MIX	1.0 (8)	0.9 (8)	1.0 (8)	1.0 (8)	1.0 (8)	0.8 (8)	0.8 (8)	1.3 (8)
Total	2.22 (123)	2.02 (123)	2.9 (123)	2.03 (123)	1.95 (123)	3.1 (123)	2.8 (123)	2.05 (123)

*** (April 2017) Luiz Leal, U235 thermal cross section according to the latest IAEA-2016 thermal values**

Conclusion

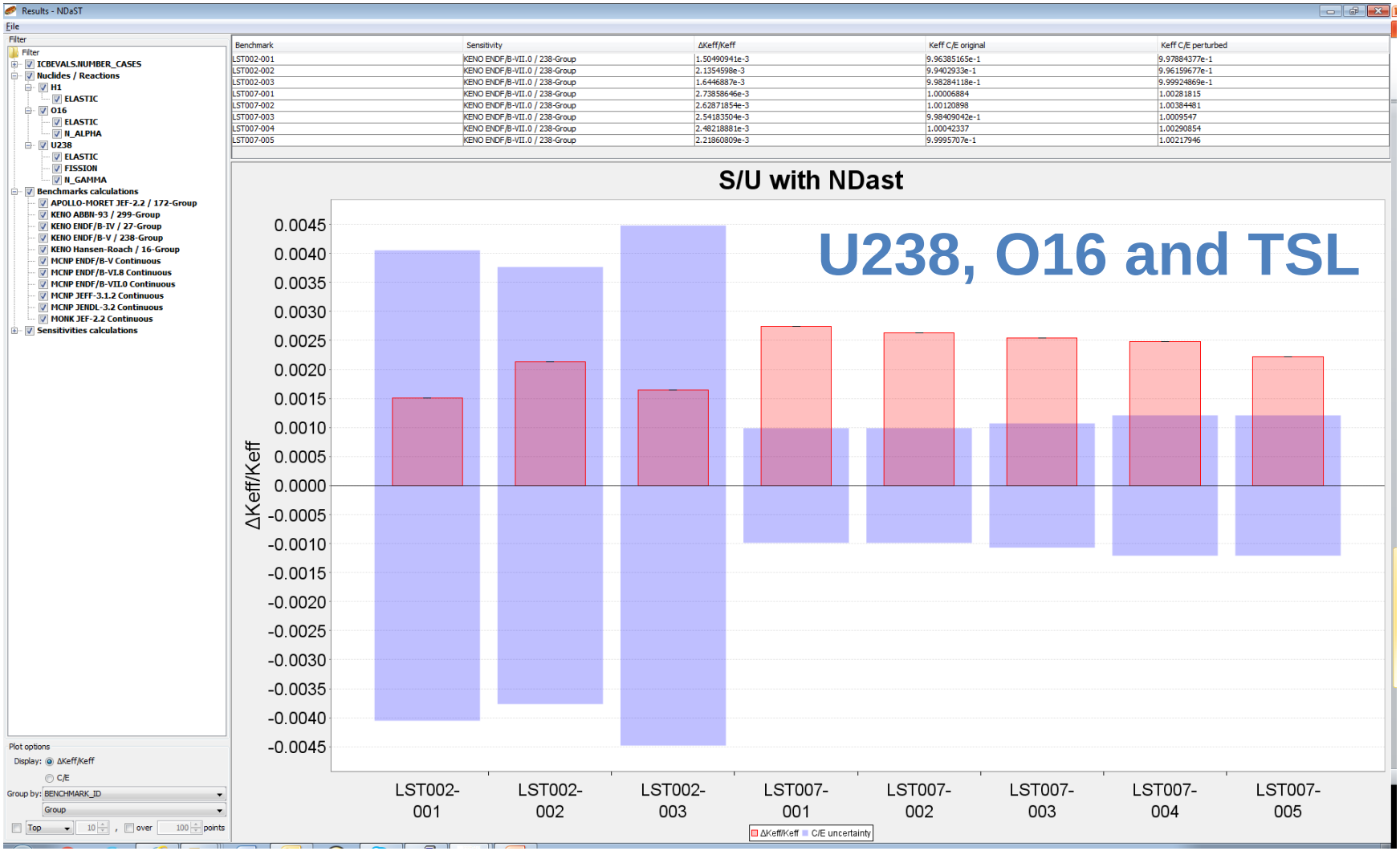
- Testing JEFF-3.3T2, T2+ and T3
  - Comparison with ENDF/B-VIIIb4

- Assessing the main contributors of Chi-squared
  - HMI6-1/4, HMF73
  - IMF1-4
  - LSTs
  - PMF8-1, PMF21-2, PST9-3
  - UMF4-2

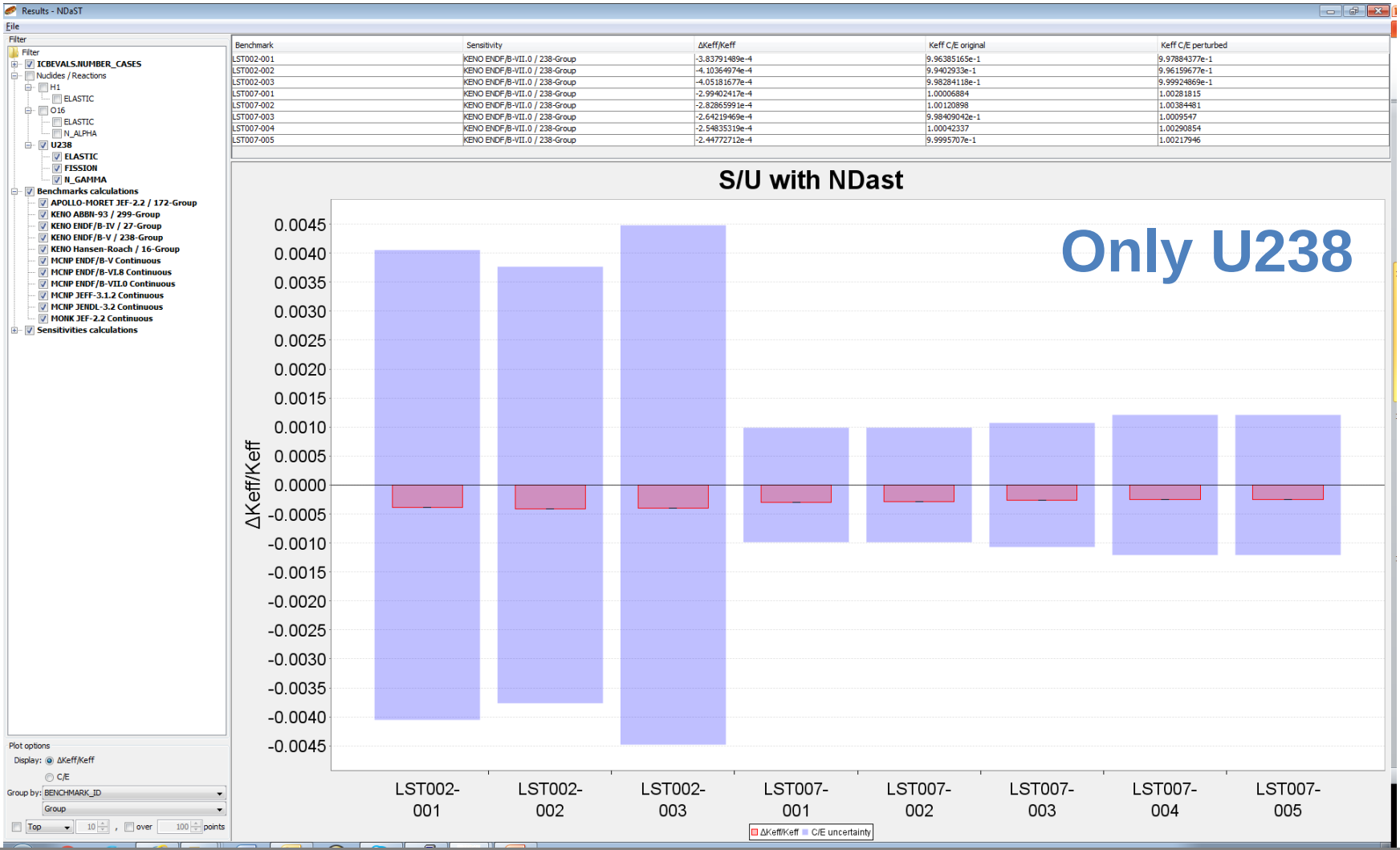
- Assessing the main changes in T3
  - TSL- H in H2O
  - O16
  - Cu63 and Cu65
  - Fe
- Re-evaluation of T3: **JEFF-3.3T3 can be improved for criticality benchmarking**

Annex I. S/U analysis: LST cases

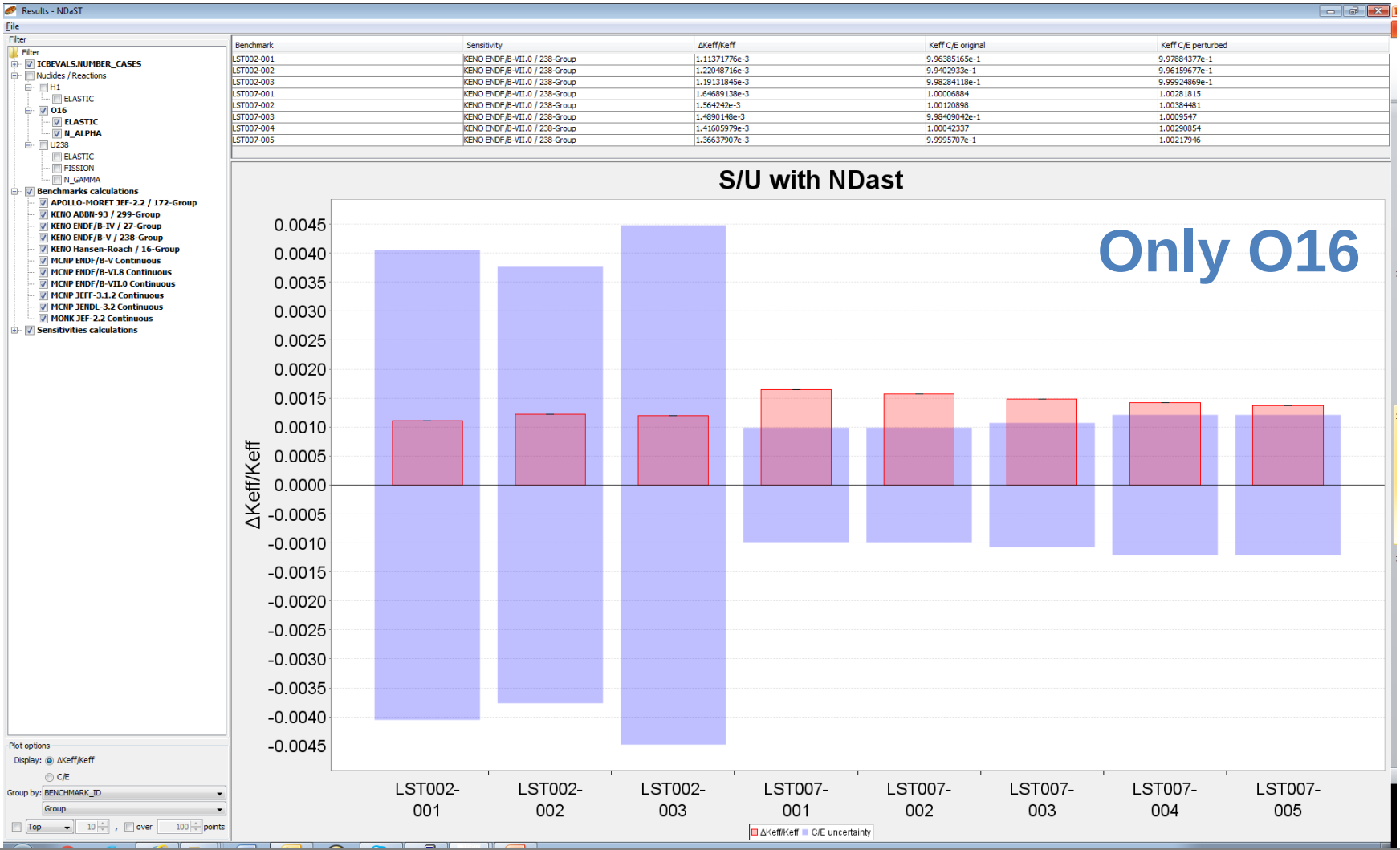
III.1 LST cases: T2 versus T3



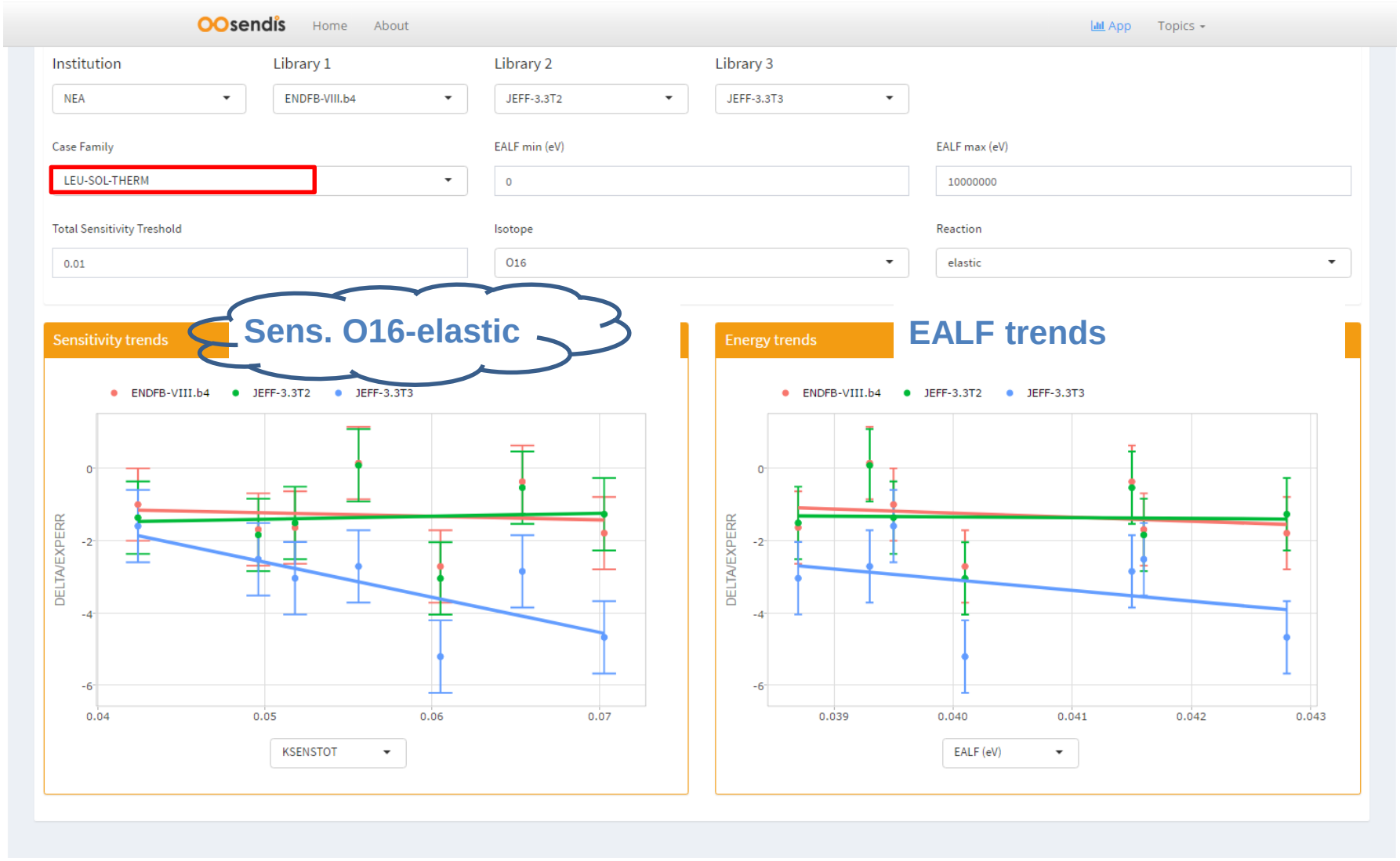
III.1 LST cases: T2 versus T3



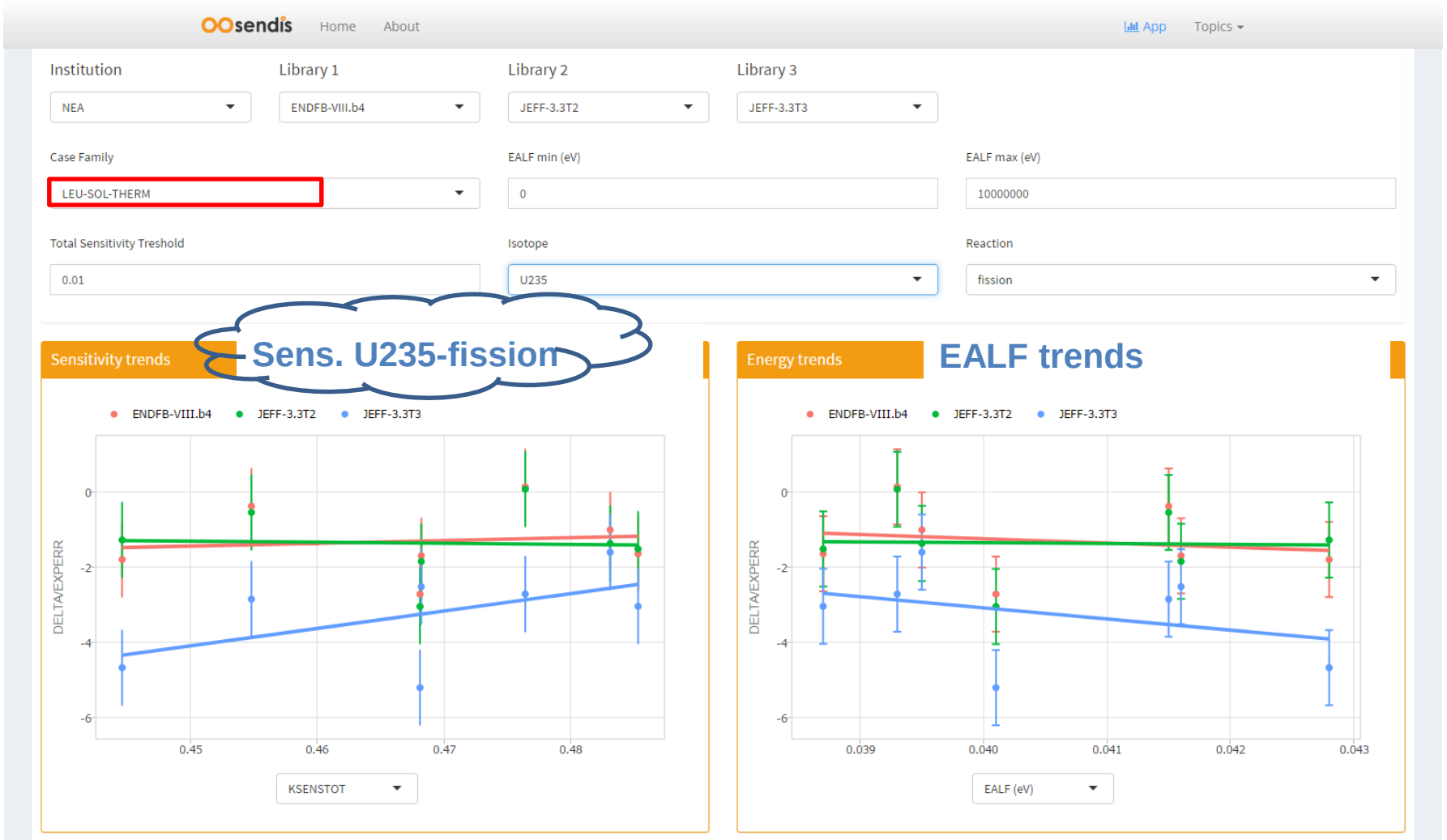
III.1 LST cases: T2 versus T3



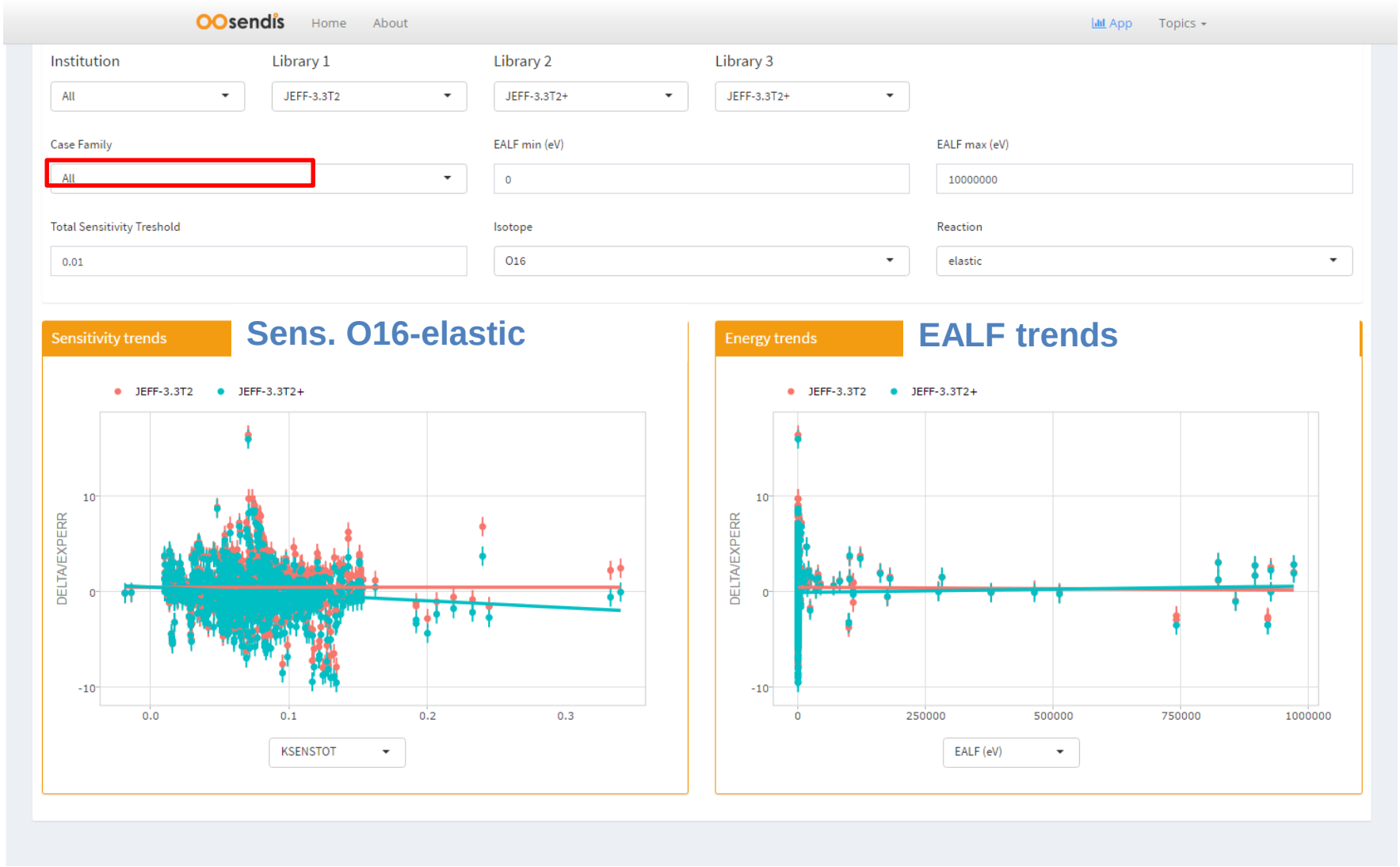
III.1 LST cases: T2 versus T3



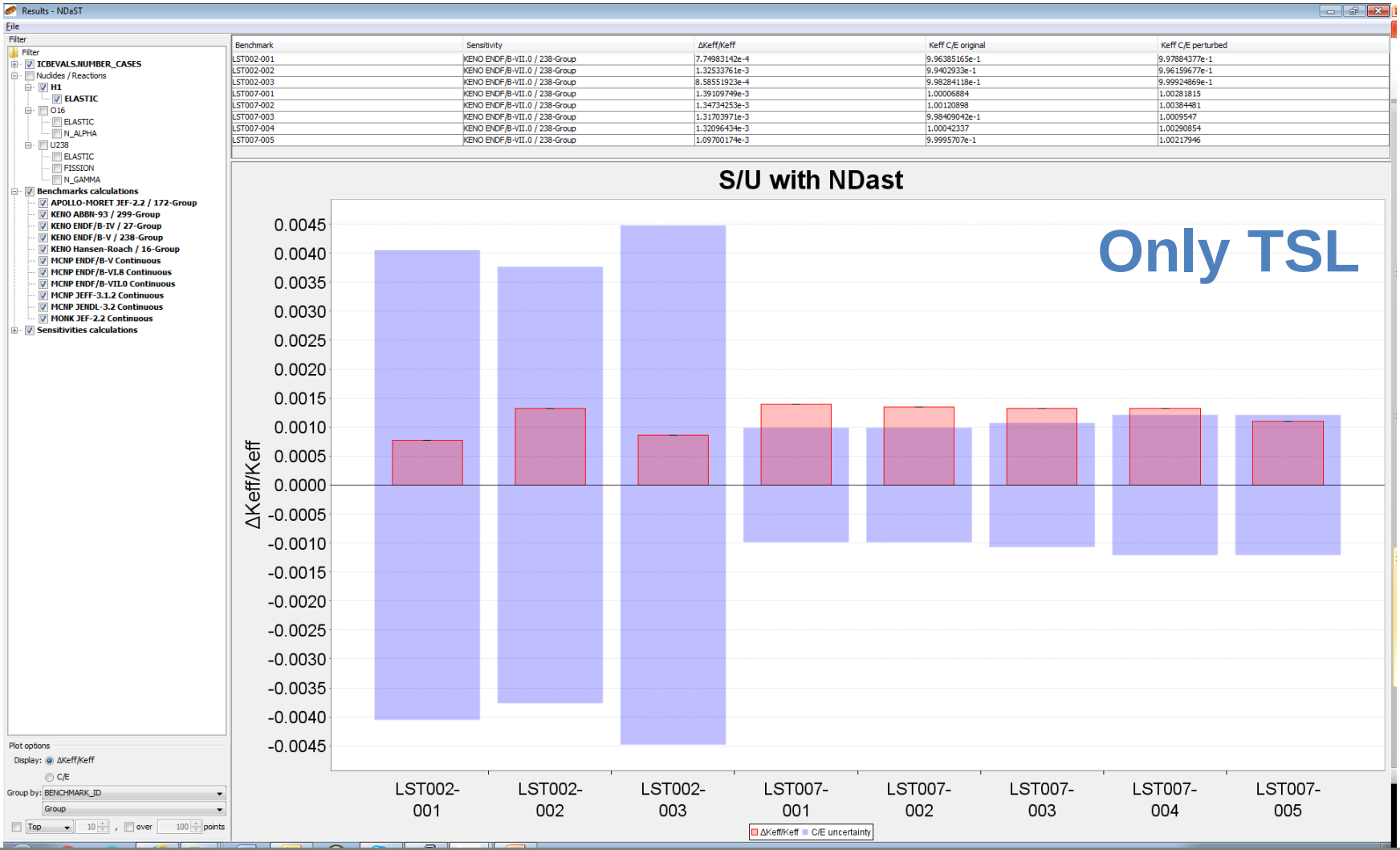
III.1 LST cases: T2 versus T3



III.1 LST cases: T2 versus T3

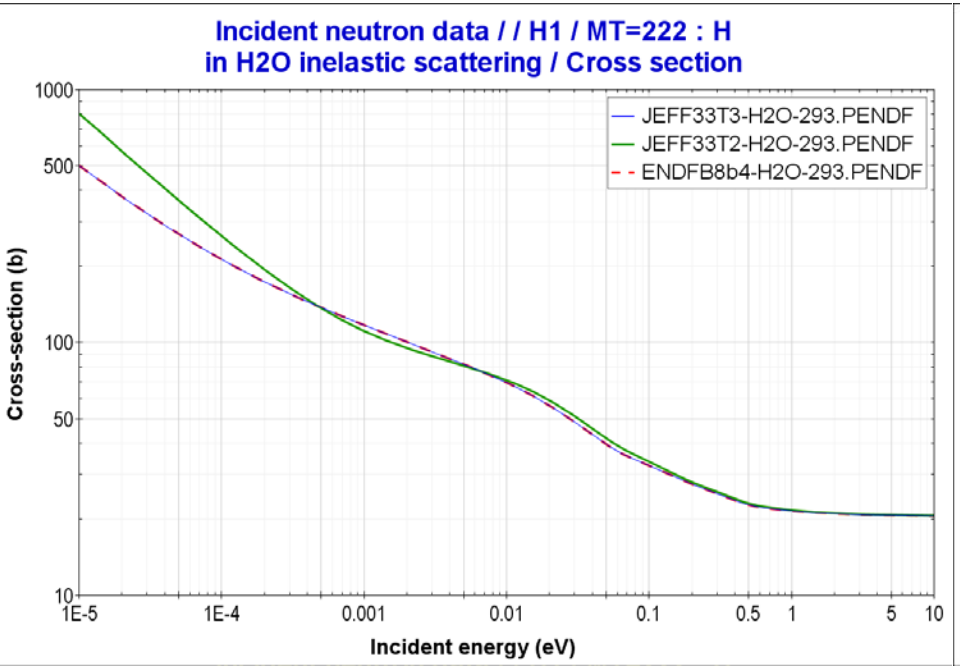


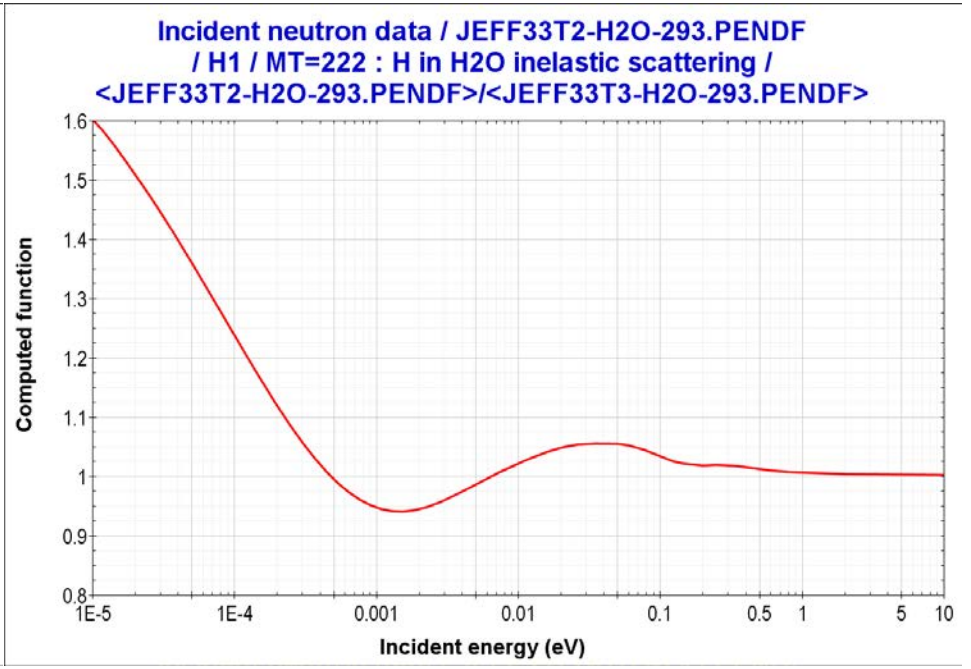
III.1 LST cases: T2 versus T3



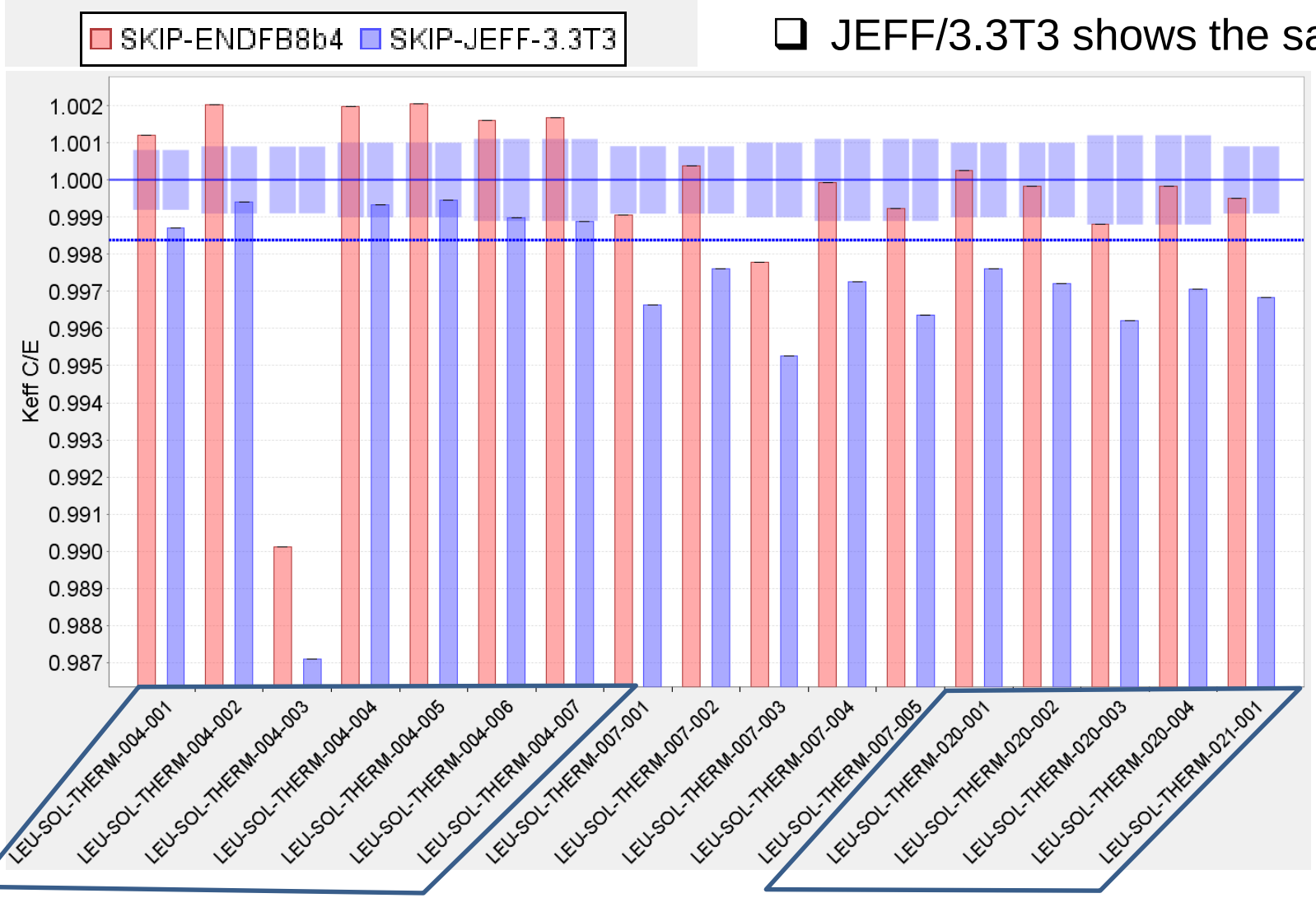
III.1 LST cases: T2 versus T3

- TSLs H in H2O





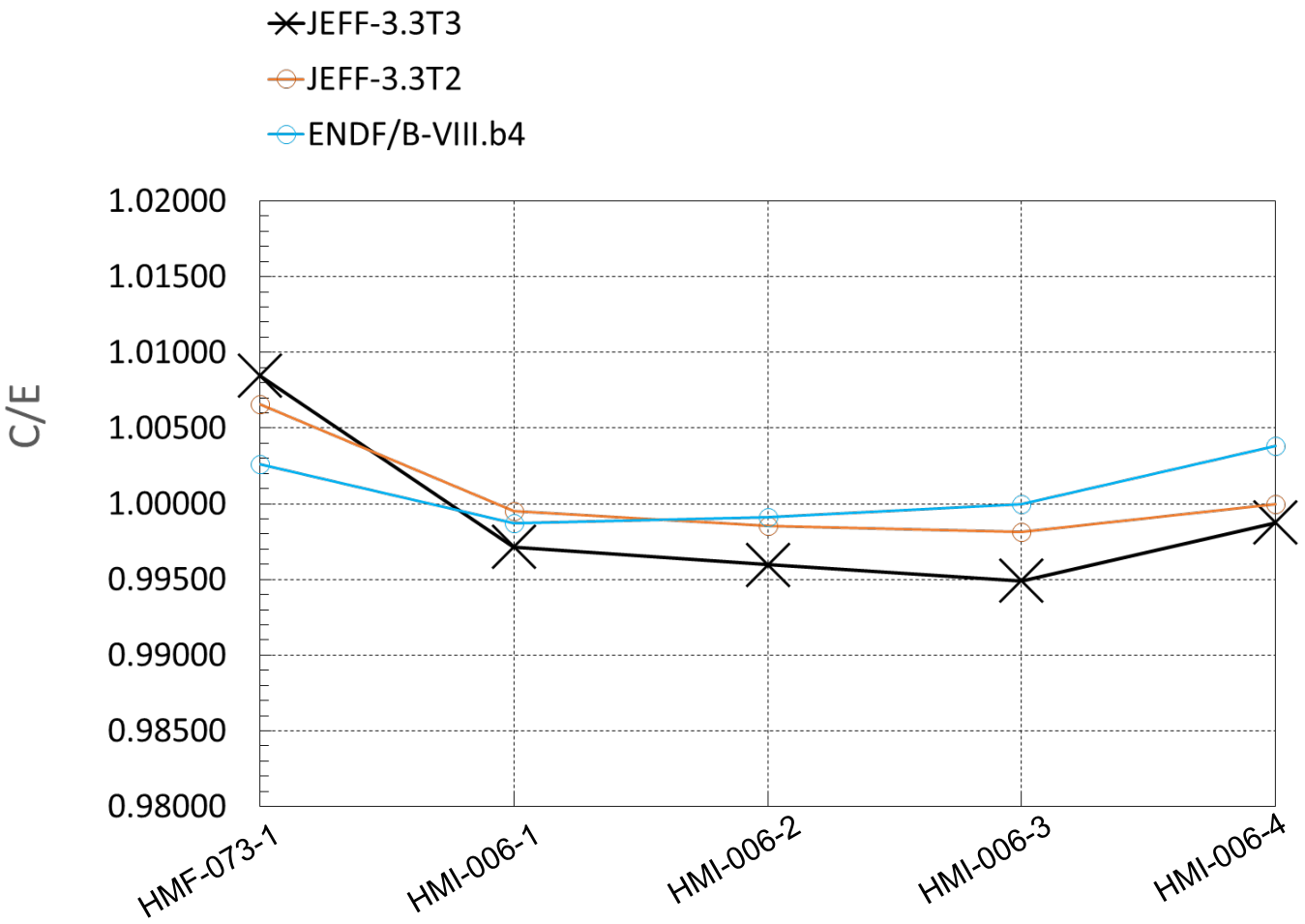
III.1 LEU cases: ENDF/B-VIIIb4 versus JEFF-3.3T3



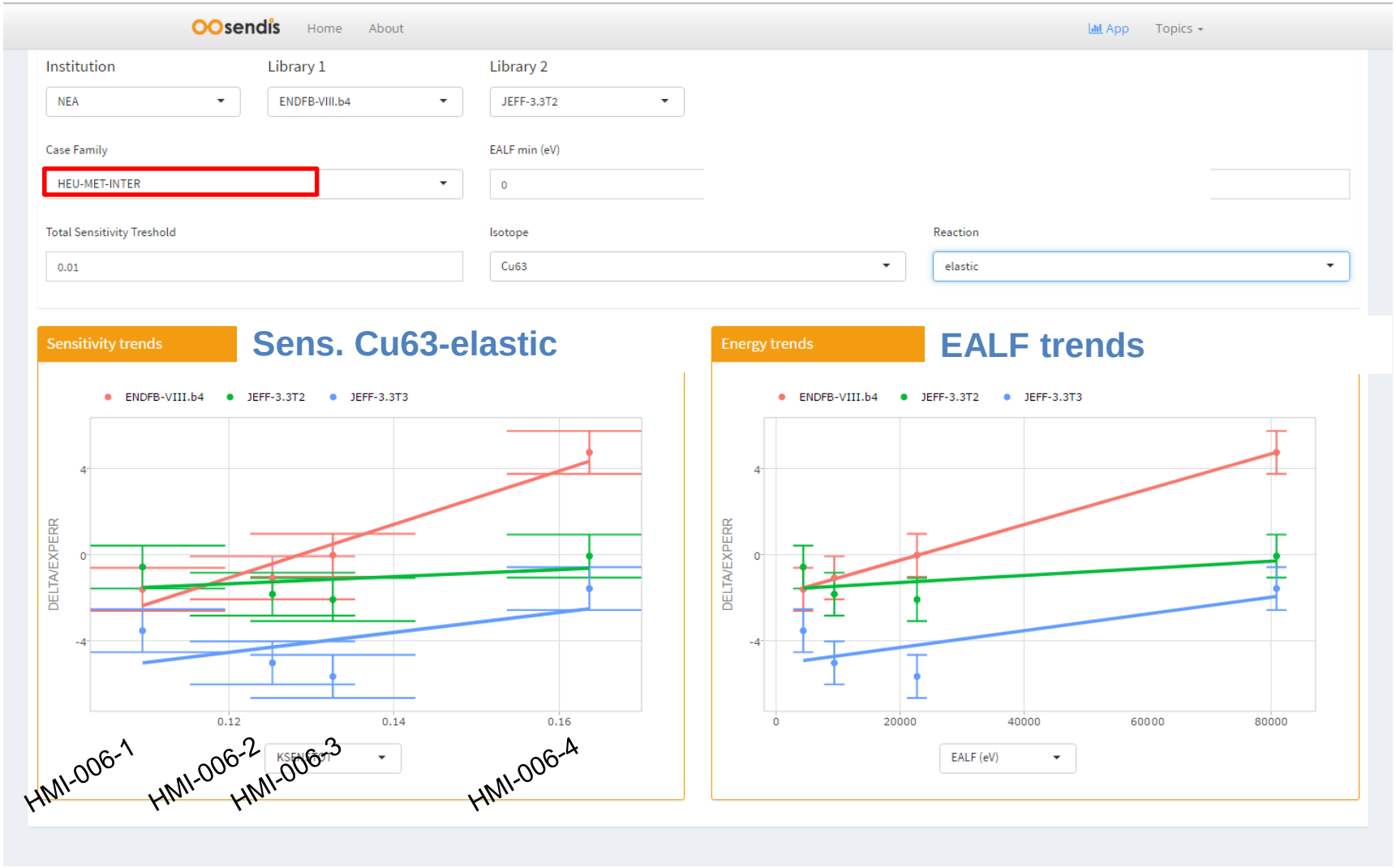
- JEFF/3.3T3 shows the same trends

Annex II. S/U analysis: HMI6-1/4 and HMF73-1

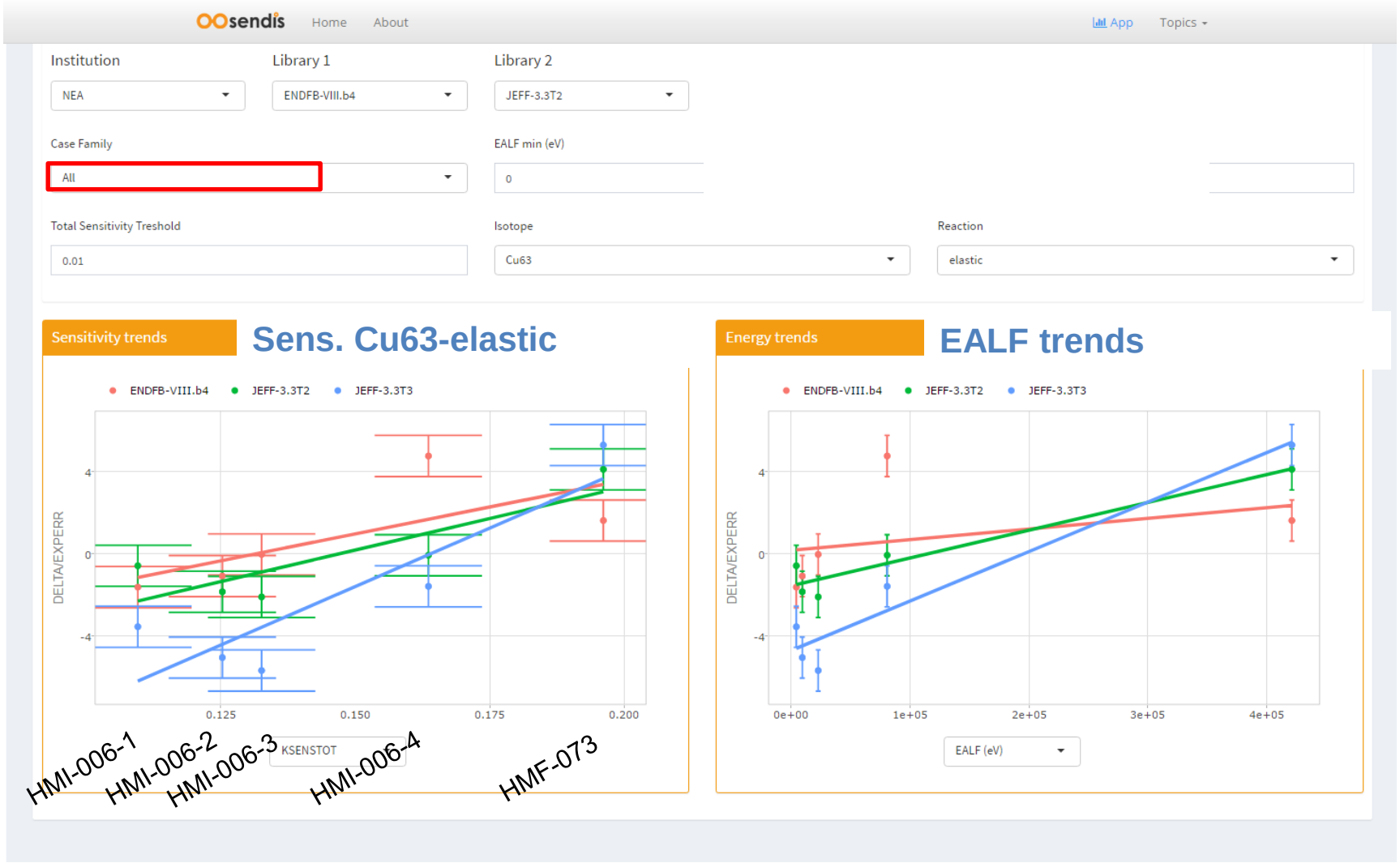
III.2 HMI6-1/4 and HMF-73 cases



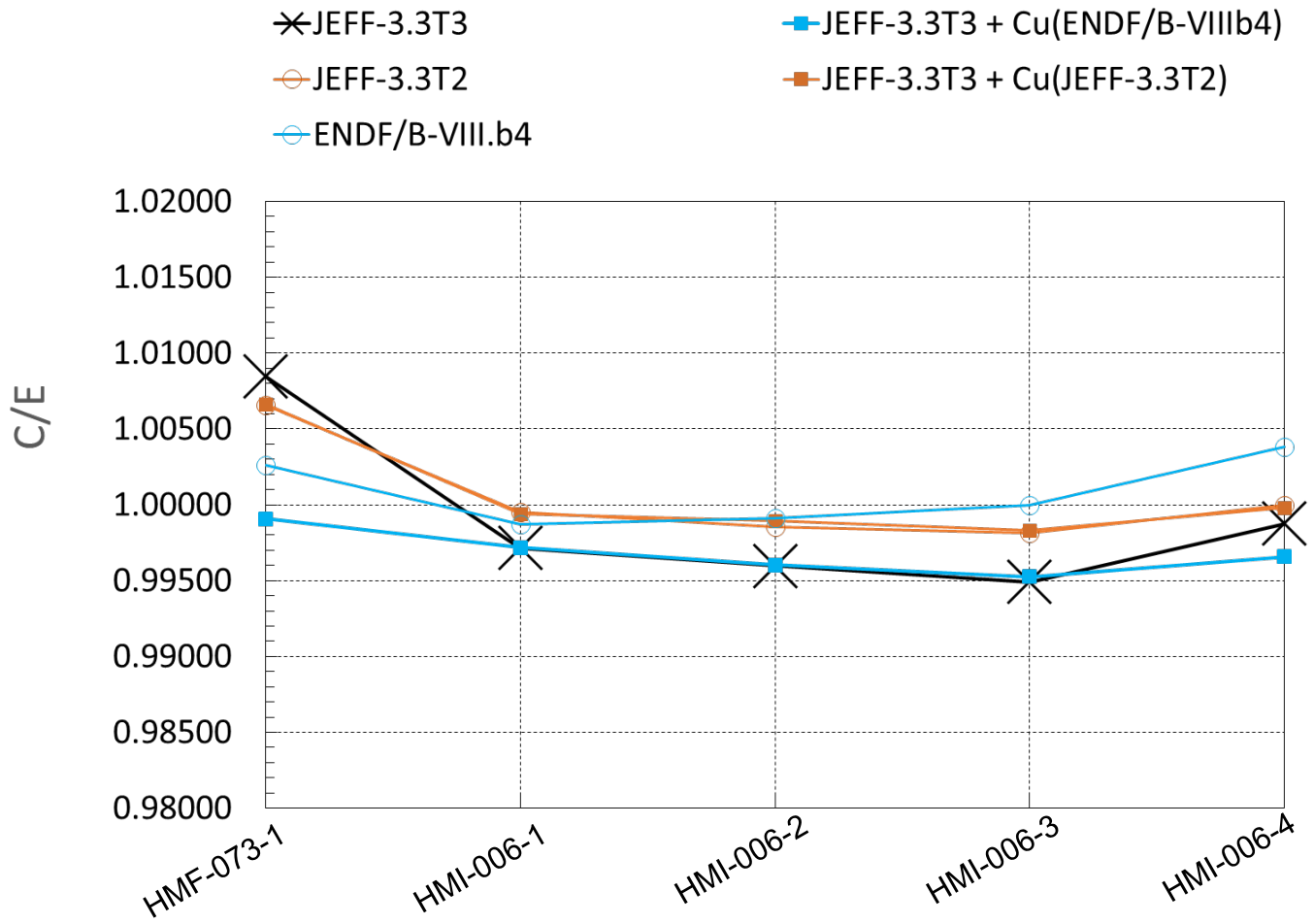
III.2 HMI6-1/4 and HMF-73 cases



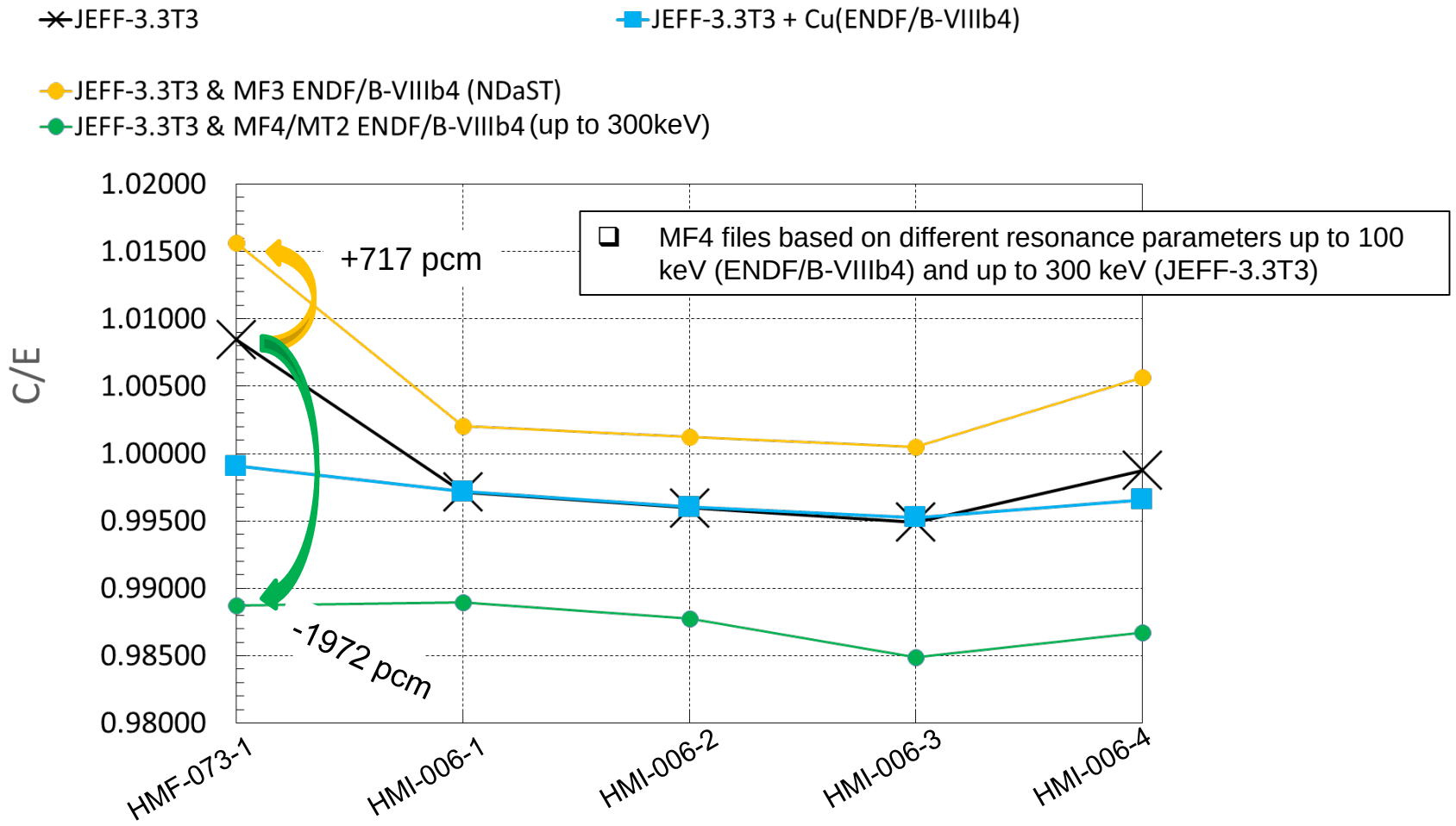
III.2 HMI6-1/4 and HMF-73 cases



III.2 HMI6-1/4 and HMF-73 cases



III.2 HMI6-1/4 and HMF-73 cases



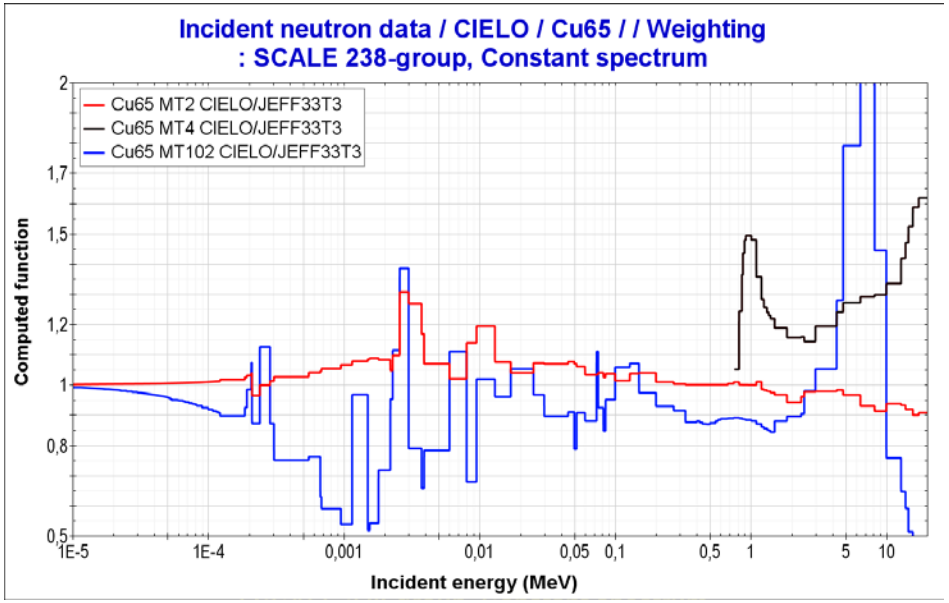
III.2 HMI6-1/4 and HMF-73 cases

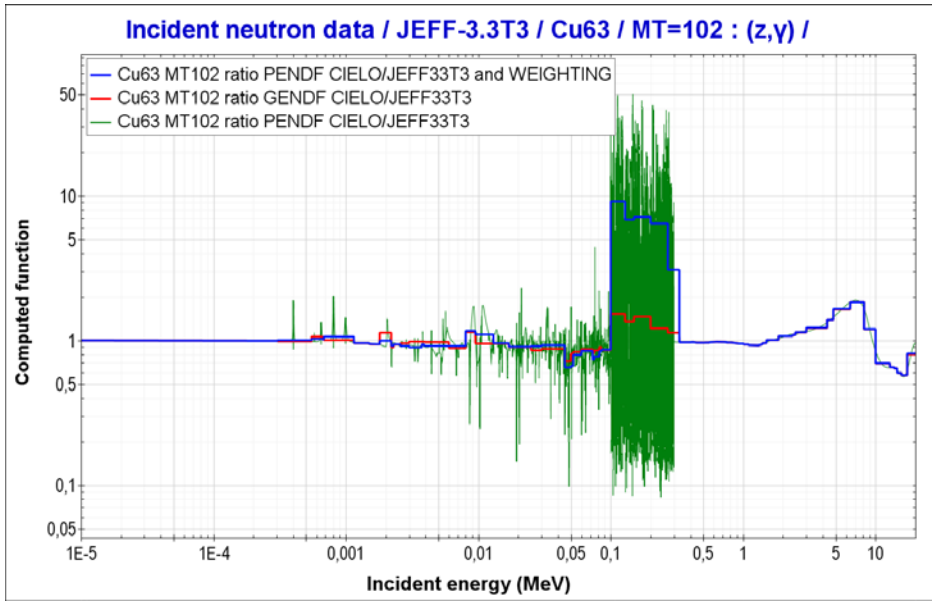
- ΔkeffCIELO/JEFF-3.3T3 with NDaST

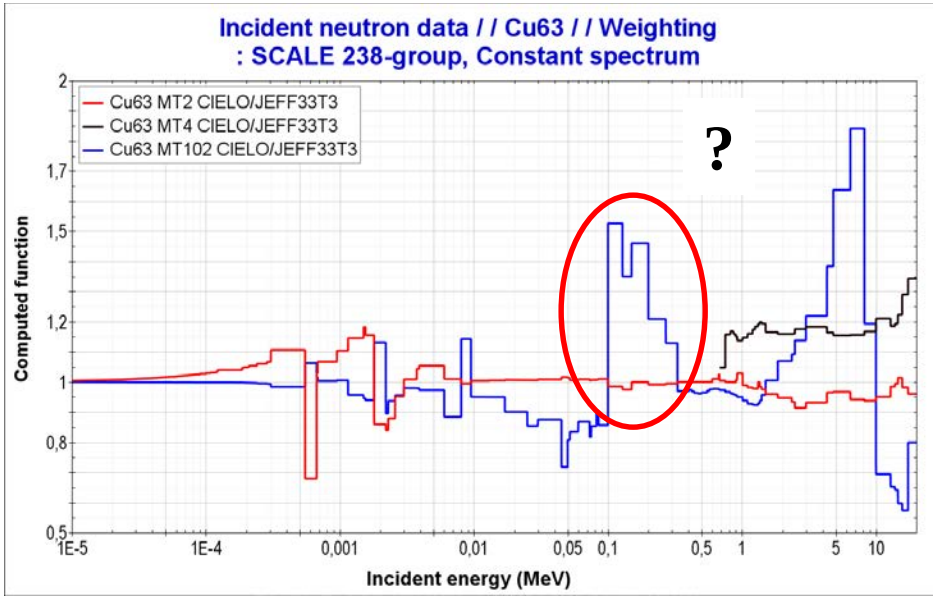
		HMF73-1	HMI6-1	HMI6-2	HMI6-3	HMI6-4
Cu63	MT2	-165	-72	-81	-85	-94
	MT4	701	235	265	308	413
	MT102	-258	-86	-86	-90	-113
	All	279	78	98	133	206
Cu65	MT2	37	228	244	225	234
	MT4	342	113	126	146	201
	MT102	58	66	61	57	54
	All	438	406	432	428	489
Cu63+Cu65	All	717	484	529	561	695

III.2 HMI6-1/4 and HMF-73

- JEFF-3.3T3 versus ENDF/B-VIIIb4



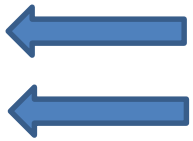




Sensitivity analysis with NDaST

- ΔkeffJEFF-3.3T2/JEFF-3.3T3 with NDaST

		HMF73-1	HMI6-1	HMI6-2	HMI6-3	HMI6-4
Cu63	MT2	126	232	210	166	146
	MT4	106	38	42	48	64
	MT102	-352	-570	-534	-501	-463
	All	-121	-300	-282	-288	-253
Cu65	MT2	86	350	362	322	266
	MT4	187	60	66	78	107
	MT102	-66	-4	-13	-24	-48
	All	207	407	416	376	325
Cu63+Cu65	All	87	107	134	89	72

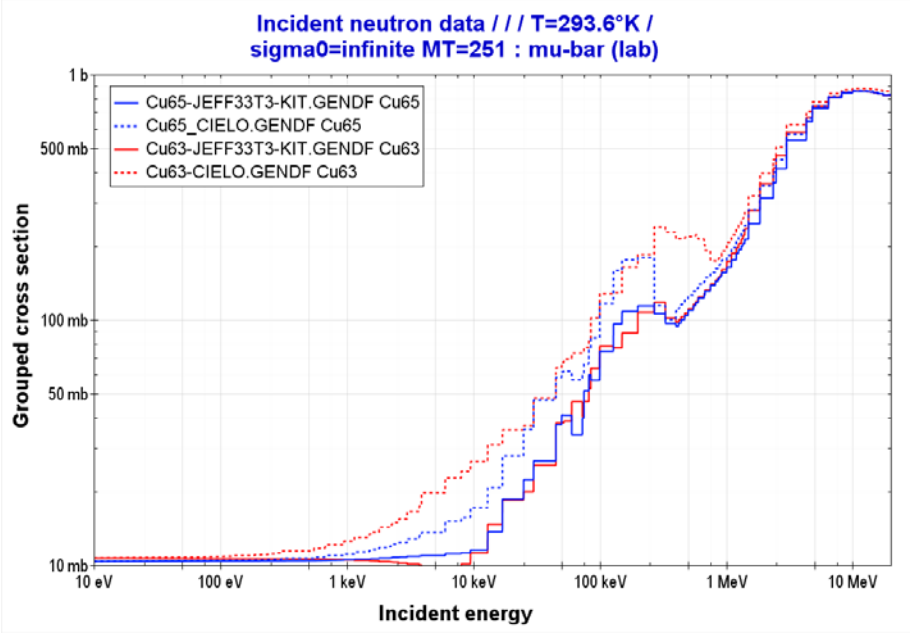


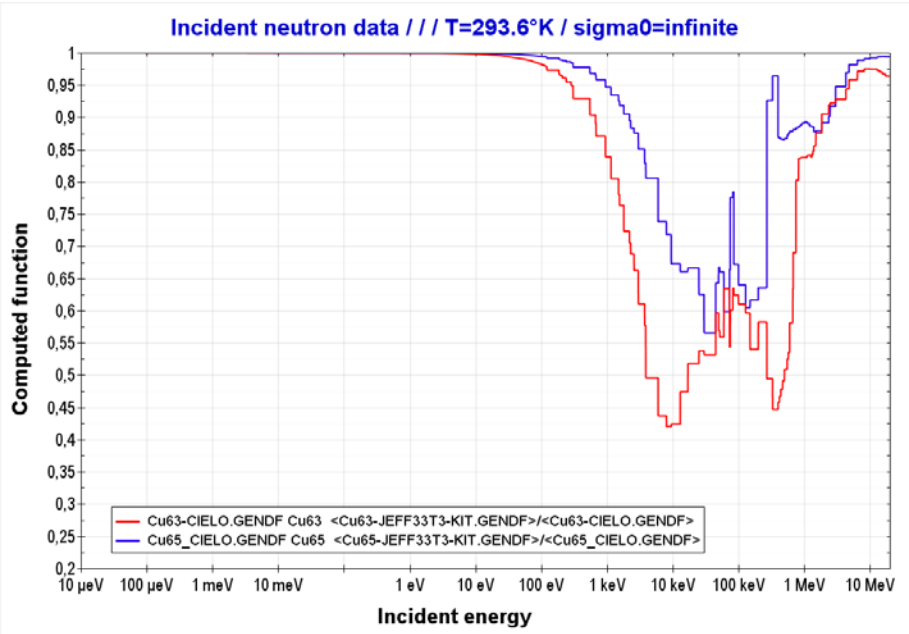
Change in angular distributions

- JEFF-3.3T3 versus ENDF/B-VIIIb4: MT251 mu-bar
- MF4/MT2 produced by T. Kawano based on different resonance parameters:
  - JEFF-3.3T3 resonance parameters up to 100 keV

    + smoothly transition from the MF4 based on the resonance parameters to the MF4 based on Kawano's model calculations above 300 keV

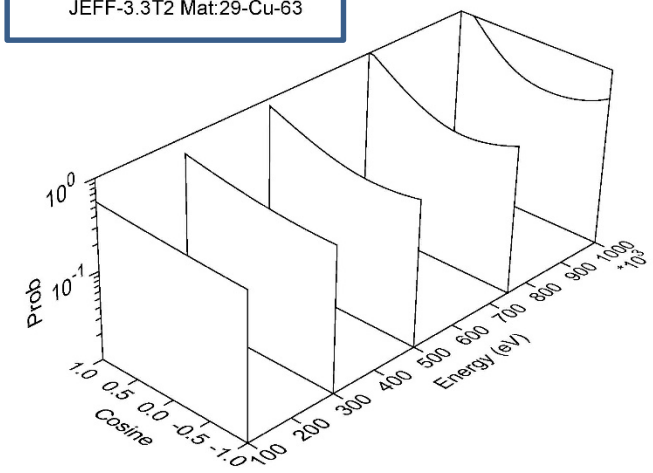
  - ENDF/B-VIIIb4 up to 300 keV





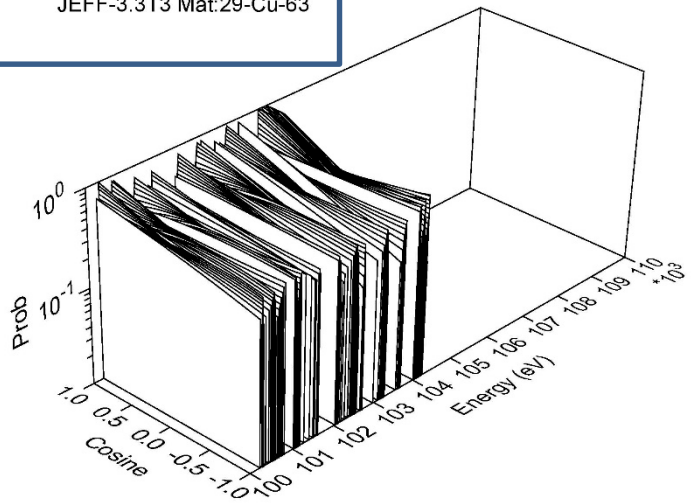
MF4/MT2 distributions

JEFF-3.3T2 Mat:29-Cu-63

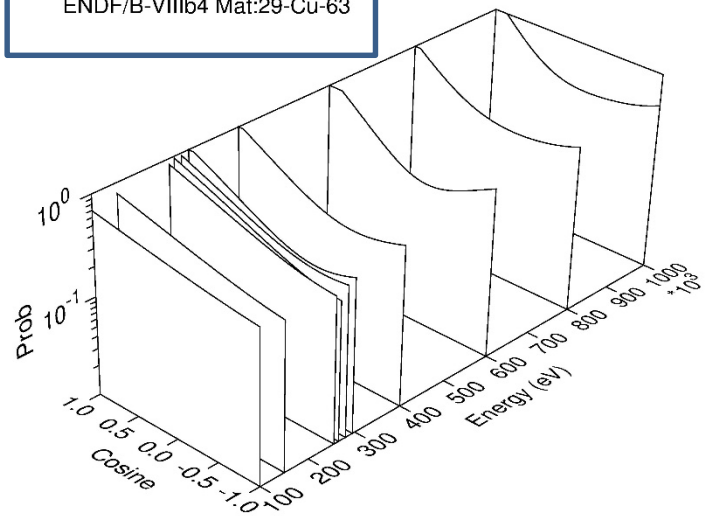


- Processing MF4/MT2 LRF7 option

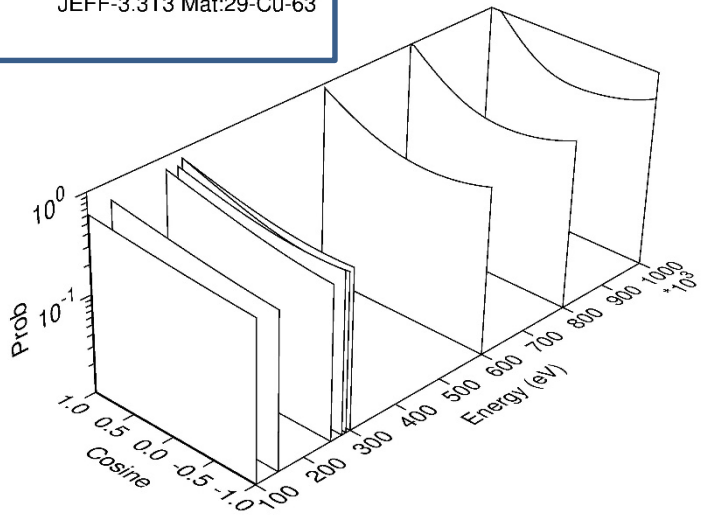
JEFF-3.3T3 Mat:29-Cu-63



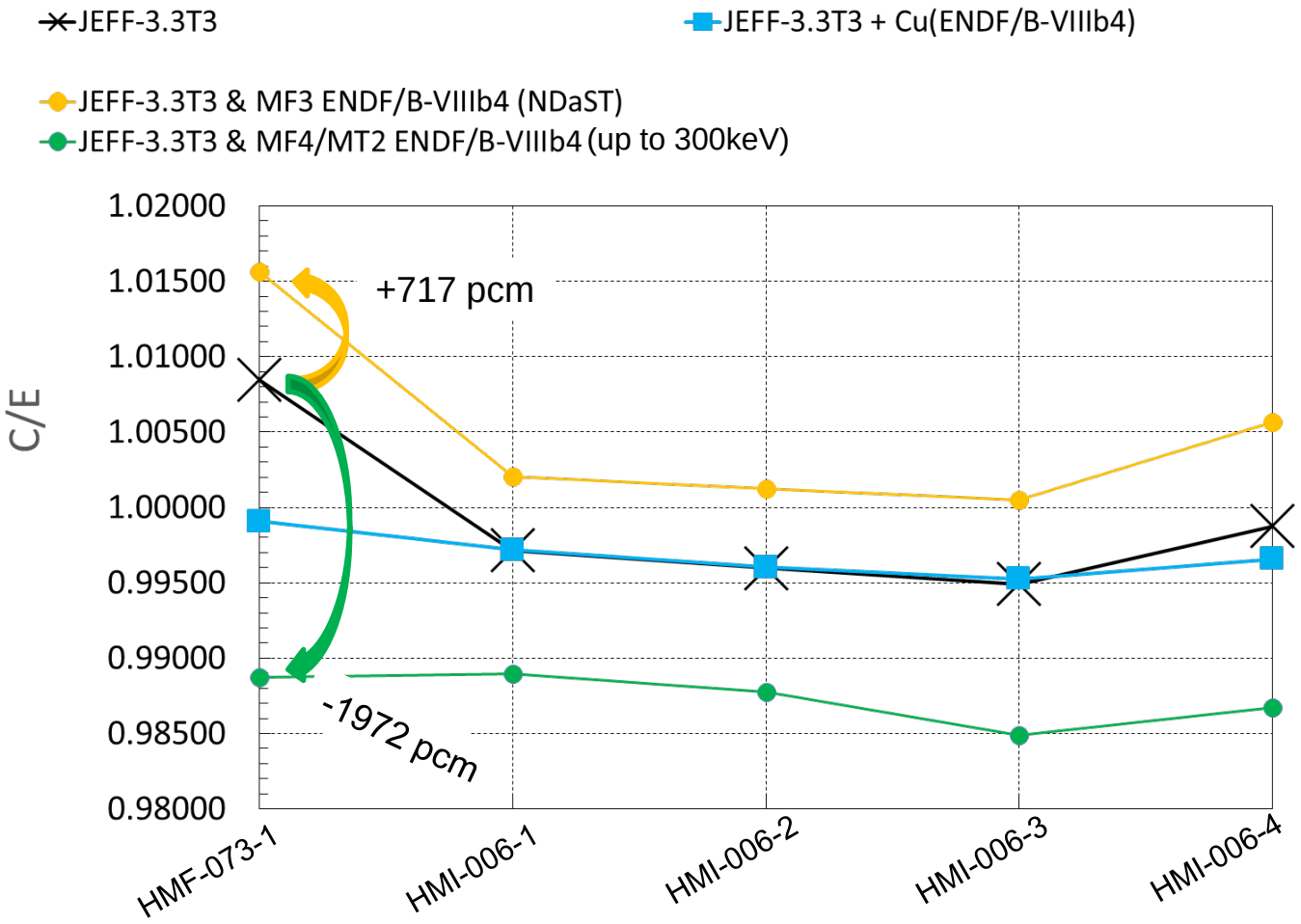
ENDF/B-VIIIb4 Mat:29-Cu-63



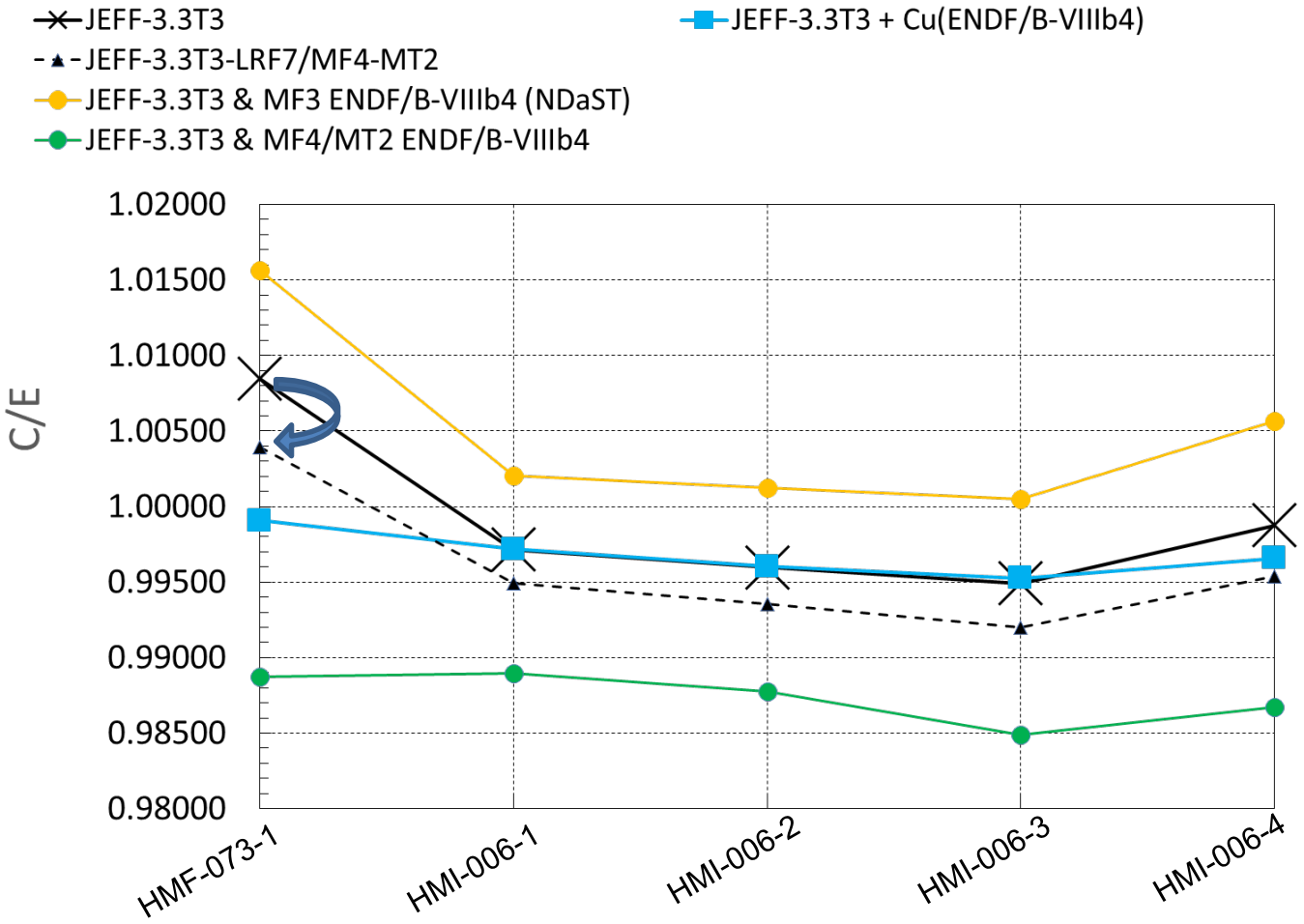
JEFF-3.3T3 Mat:29-Cu-63



III.2 HMI6-1/4 and HMF-73 cases



III.2 HMI6-1/4 and HMF-73 cases



Annex III. NEA Validation Suite (=R.Mosteller)

NEA Validation Suite

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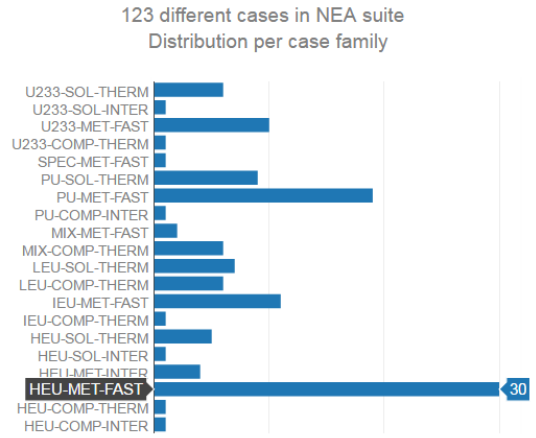
Results from this institution are only available for the following libraries:
ENDFB-VII.1 ; ENDFB-VIII.b4 ; JEFF-2.2 ; JEFF-3.0 ; JEFF-3.1 ; JEFF-3.1.1 ; JEFF-3.1.2 ; JEFF-3.2 ; JEFF-3.3T1 ; JEFF-3.3T2 ; JEFF-3.3T2+ ; JEFF-3.3T3 ; JENDL-4.0 ;



Show 10 entries Search:

FULLID	MODEL	EXPVAL	EXPERR	CALCVAL	CALCERR	COVERE
HEU-COMP-INTER-003-007		1	0.005	1.00272	0.00037	1.00272
HEU-COMP-THERM-015-006		1.0015	0.0028	1.00026	0.00041	0.998761857214179
HEU-MET-FAST-001-001	Shell Model	1	0.001	1.00023	0.00028	1.00023
HEU-MET-FAST-003-001		1	0.005	0.99578	0.00029	0.99578
HEU-MET-FAST-003-002		1	0.005	0.99476	0.0003	0.99476
HEU-MET-FAST-003-003		1	0.005	1.00016	0.00028	1.00016
HEU-MET-FAST-003-004		1	0.003	0.99862	0.00028	0.99862
HEU-MET-FAST-003-005		1	0.003	1.00325	0.0003	1.00325
HEU-MET-FAST-003-006		1	0.003	1.00267	0.00027	1.00267
HEU-MET-FAST-003-007		1	0.003	1.00365	0.00029	1.00365

Showing 1 to 10 of 123 entries Previous 1 2 3 4 5 … 13 Next

Annex III. NEA Validation Suite (=R.Mosteller)

U233 Benchmarks

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEP Benchmark name
Fast	Metal	Spheres	Unreflected	u233-met-fast-001
			HEU	u233-met-fast-002-CASE_1
				u233-met-fast-002-CASE_2
			Normal Uranium	u233-met-fast-003-CASE_1
				u233-met-fast-003-CASE_2
				u233-met-fast-006
			Tungsten	u233-met-fast-004-CASE_1
				u233-met-fast-004-CASE_2
			Beryllium	u-233-met-fast-005-CASE_1
				u-233-met-fast-005-CASE_2
Intermediate	Solution	Sphere	Beryllium	u233-sol-inter-001-case1
Thermal	UO2+ZrO2	Lattice	Water	u233-comp-therm-001-case3
	Solution	Sphere	Unreflected	u233-sol-therm-001-case1
				u233-sol-therm-001-case2
				u233-sol-therm-001-case3
				u233-sol-therm-001-case4
				u233-sol-therm-001-case5
				u233-sol-therm-008

Annex III. NEA Validation Suite (=R.Mosteller)

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEP Benchmark name
Fast	Metal	Spheres	Unreflected	heu-met-fast-001
				heu-met-fast-008
				heu-met-fast-018-case2
			Normal Uranium	heu-met-fast-003-case1
				heu-met-fast-003-case2
				heu-met-fast-003-case3
				heu-met-fast-003-case4
				heu-met-fast-003-case5
				heu-met-fast-003-case6
				heu-met-fast-003-case7
				heu-met-fast-028
			Depleted Uranium	heu-met-fast-014
			Tungsten carbide	heu-met-fast-003-case8
				heu-met-fast-003-case9
				heu-met-fast-003-case10
				heu-met-fast-003-case11
			Nickel	heu-met-fast-003-case12
			Steel	heu-met-fast-013
				heu-met-fast-021-case2
			Duralumin	heu-met-fast-022-case2
			Aluminium	heu-met-fast-012
			Graphite	heu-met-fast-019-case2
			Beryllium	heu-met-fast-009-case1
			Beryllium Oxide	heu-met-fast-009-case2
			Polyethylene	heu-met-fast-011
				heu-met-fast-020-case2
			Water	heu-met-fast-004-case1
		Cylinder	Unreflected	heu-met-fast-015
		Lattice	Paraffin	heu-met-fast-026-case9

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEP Benchmark name
Intermediate	UH3	Cylinder	Natural U	heu-comp-inter-003-case7
	Metal	Cylinder	Graphite, copper	heu-met-inter-006-case1
				heu-met-inter-006-case2
				heu-met-inter-006-case3
				heu-met-inter-006-case4
Thermal	UO2+ZrO2	Lattice	Water, ThO2	u233-comp-therm-001-case6
	Solution	Sphere	Unreflected	heu-sol-therm-013-case1
				heu-sol-therm-013-case2
				heu-sol-therm-013-case3
				heu-sol-therm-013-case4
				heu-sol-therm-032

HEU Benchmarks

Annex III. NEA Validation Suite (=R.Mosteller)

IEU Benchmarks

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEP Benchmark name
Fast	Metal	Spheres	Unreflected	ieu-met-fast-003-case2
			Steel	ieu-met-fast-005-case2
			Duralumin	ieu-met-fast-006-case2
			Graphite	ieu-met-fast-004-case2
		Cylinder	Unreflected	ieu-met-fast-001-case1
				ieu-met-fast-001-case2
				ieu-met-fast-001-case3
				ieu-met-fast-001-case4
			Normal U	ieu-met-fast-002
			Depleted U	ieu-met-fast-007-case1
Intermediate	Plate	Lattice	Normal U, steel	mix-met-fast-008-case7
Thermal	UO2	Lattice	Water	ieu-comp-therm-002-CASE_3
	Solution	Cylinder	Unreflected	leu-sol-therm-007-CASE14
				leu-sol-therm-007-CASE30
				leu-sol-therm-007-CASE32
				leu-sol-therm-007-CASE36
				leu-sol-therm-007-CASE49

Annex III. NEA Validation Suite (=R.Mosteller)

LEU Benchmarks

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEP Benchmark name
Thermal	UO2	Lattice	UO2 rods, Water	leu-comp-ther-008-CASE_1
				leu-comp-therm-008-CASE_2
				leu-comp-therm-008-CASE_5
				leu-comp-therm-008-CASE_7
				leu-comp-therm-008-CASE_8
				leu-comp-therm-008-CASE_11
	Solution	Sphere	Water	leu-sol-therm-002-case1
			Unreflected	leu-sol-therm-002-case2

Annex III. NEA Validation Suite (=R.Mosteller)

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEP Benchmark name
Fast	Metal	Spheres	Unreflected	pu-met-fast-001-CASE_1
				pu-met-fast-002-CASE_1
				pu-met-fast-022
			HEU	mix-met-fast-001-CASE_1
				mix-met-fast-003
			Normal Uranium	pu-met-fast-006
				pu-met-fast-010-CASE_1
			Depleted Uranium	pu-met-fast-020
			Thorium	pu-met-fast-008-case2
			Tungsten	pu-met-fast-005-CASE_1
			Steel	pu-met-fast-025
				pu-met-fast-026
			Aluminium	pu-met-fast-009-CASE_1
			Graphite	pu-met-fast-023
			Beryllium	pu-met-fast-018-CASE_1
				pu-met-fast-019
			Polyethylene	pu-met-fast-024
			Water	pu-met-fast-011-CASE_1
		Cylinder	Beryllium	pu-met-fast-021-case1
			Beryllium Oxide	pu-met-fast-021-case2
		Lattice	Unreflected	pu-met-fast-003-case103

Spectrum	Form	Shape	Moderator and/or Reflector	ICSBEP Benchmark name
Intermediate	Mixture	Homog	Hydrogen, graphite	pu-comp-inter-001
Thermal	MOX	Lattice	Water	mix-comp-therm-002-case-pnl30
				mix-comp-therm-002-case-pnl31
				mix-comp-therm-002-case-pnl32
				mix-comp-therm-002-case-pnl33
				mix-comp-therm-002-case-pnl34
				mix-comp-therm-002-case-pnl35
	Solution	Sphere	Unreflected	pu-sol-therm-009-case3a
				pu-sol-therm-011-CASE_5.16
				pu-sol-therm-011-CASE_1.18
				pu-sol-therm-011-CASE_6.18
				pu-sol-therm-021-case_1.t9a
				pu-sol-therm-021-CASE_3.T9A
		Cylinder	Water	pu-sol-therm-018-case_9
				pu-sol-therm-034-case_01

PU Benchmarks

Annex III. NEA Validation Suite (=R.Mosteller)

Additional Benchmarks

		Case
PU	**Thermal**	PU-SOL-THERM-009 (48-inch sphere of plutonium nitrate solution)
HEU	**Fast**	HEU-MET-FAST-73 (Unmoderated ZEUS benchmark)
HEU	**Thermal**	HEU-SOL-THERM-004_case1 (Heavy water solutions, reflected spheres)
SPEC	**Thermal**	SPEC-MET-FAST-08 (Neptunium sphere reflected by HEU)