The European Commission's science and knowledge service

Joint Research Centre

European Commission

JEFF-3.3

Arjan Plompen

OECD-NEA, 17 May 2018

European Commission

The JEFF-3.3 release is now official

- Many thanks to all contributors
  - For providing (parts of) the files
  - For fixing files
  - For testing
  - For providing feedback
  - For lively discussions
  - For the support given by NEA

Contents

- JEFF – 3.3 http://www.oecd-nea.org/dbdata/jeff/jeff33/
  - Short history
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Information collected from the last two JEFF-CHANDA meetings, November 2017, April 2018. Full presentations are on the JEFF webpage.

European Commission

Short history

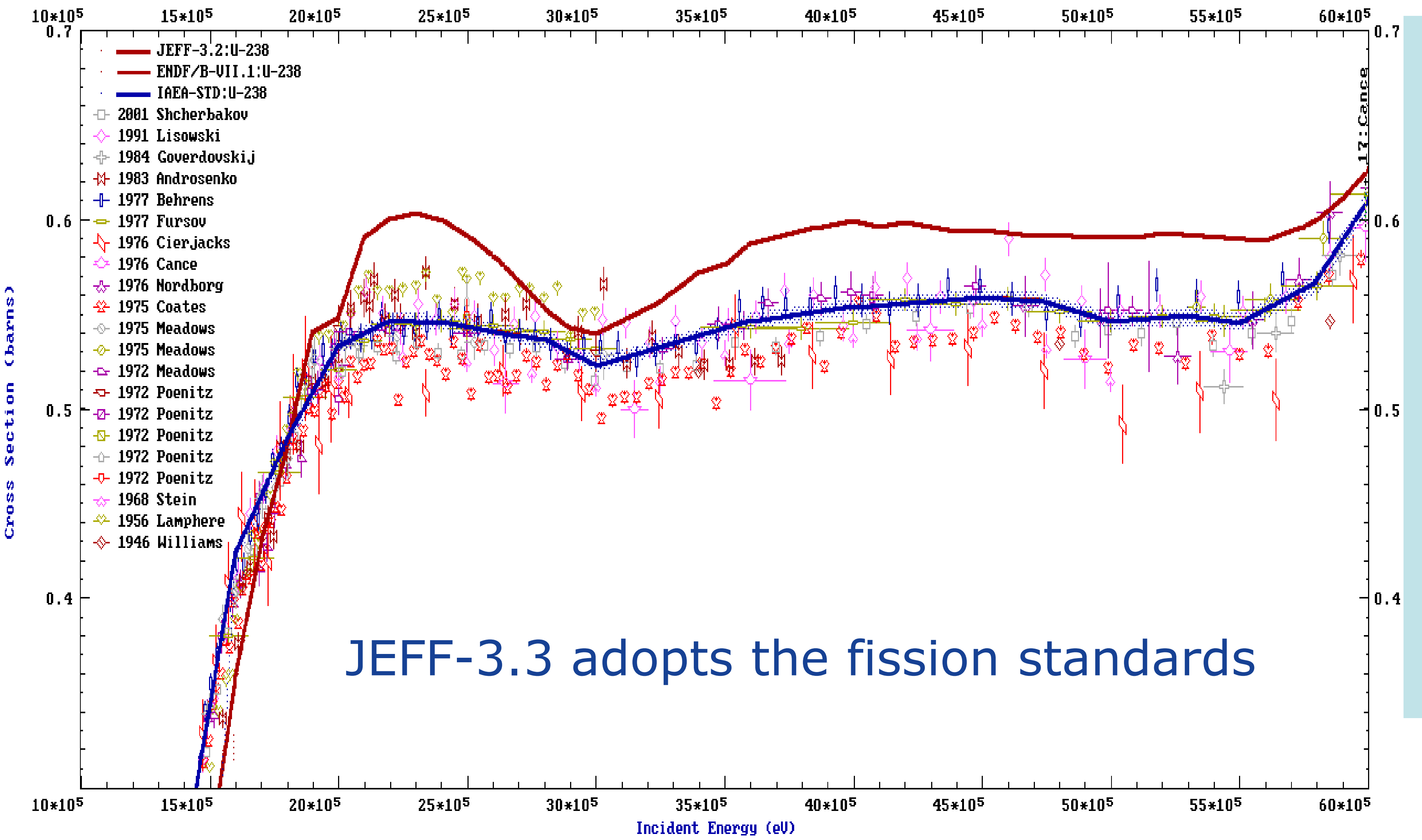
- JEFF – 3.2, 5 March 2014.
- JEFF – 3.3T0/T1, 19 Feb 2016 (Decision Nov. 2015).
- JEFF – 3.3T2, June 2016
- JEFF – 3.3T3, March 2017
- JEFF – 3.3T4, June 2017
- JEFF – 3.3, 20 November 2017

Short history

- New major actinides (Morillon, Romain, De Saint Jean, Leal)
- New thermal scattering data (April 2017, Cantargi, Granada , Marquez Damian, Noguere)
- Radioactive Decay Data File (Oct. 2016, M. Kellett & O. Bersillon, JEF/DOC-1792)
- FY beta file UKFY3.7, adjustment to new RDD pending (Wednesday)
- New covariances, larger subset of MTs, some proposals still not ENDF format
- Removal of legacy files, update of adopted files to latest release.
- Increased reliance on TENDL for completeness and decay heat (D. Rochman, M. Flemming)
- Improved gamma-data and energy balance for emission (C. Jouanne, R. Perry, G. Noguere, O. Serot, …)
- Restoration of 8 group structure for delayed neutrons (P. Leconte)
- New Cu files (Pereslavtsev, Leal)
- Many issues resolved (many contributors)

Evaluated $^{238}U(n,f)$ & standard cross section

R. Capote

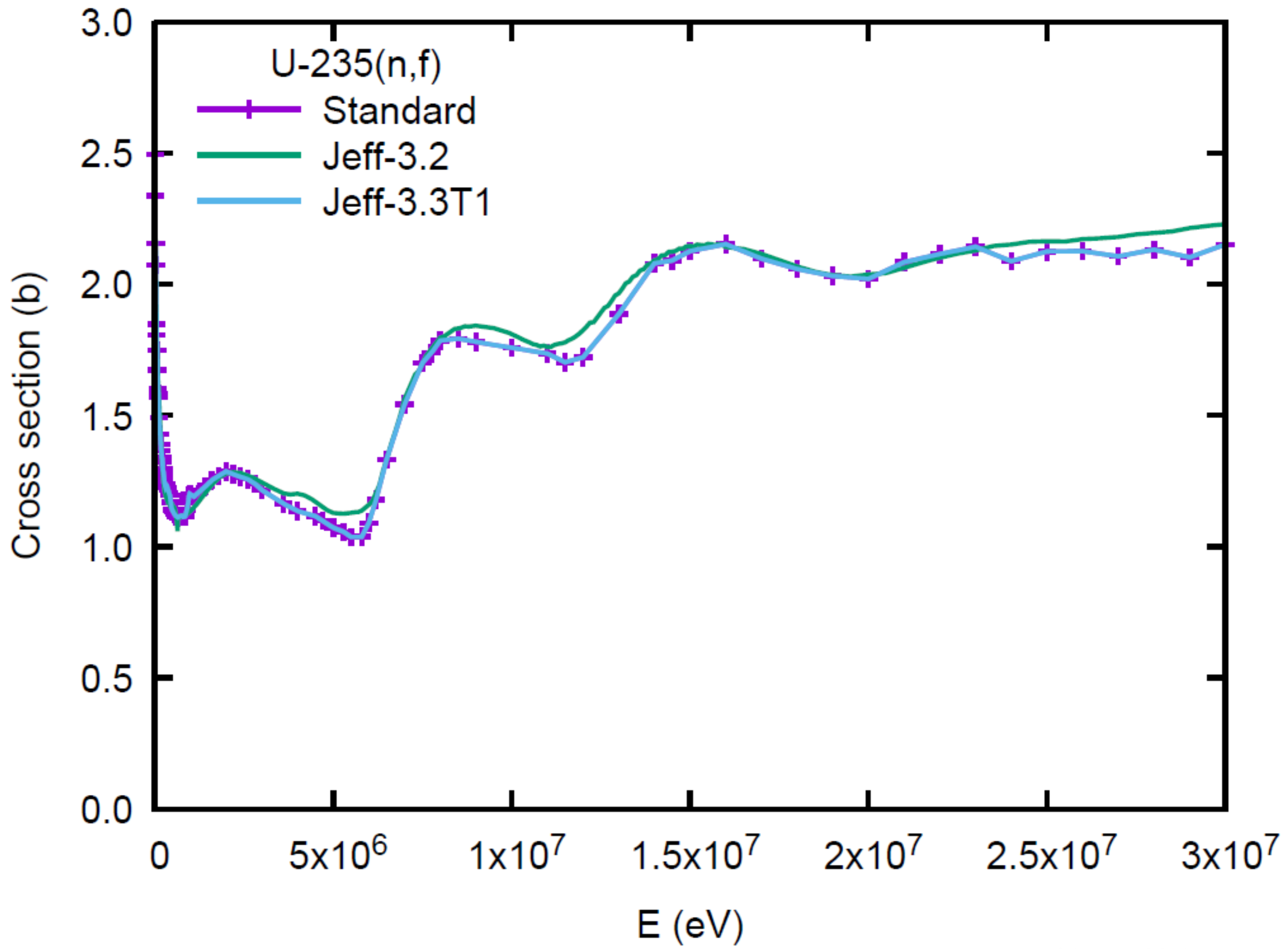


JEFF 3.3 T1

- March 2016, 559 materials
  - Impose the fission standards: new CEA-IRSN actinide files
  - Covariances for all important nuclides.
  - Many specific issues with nuclides Cr, Cu, Cd, Ta, W, Hf, Au, Pb, Bi, …
  - Replacement of legacy files
  - New TENDL files; includes replacing earlier TENDL.
  - Activation library performance upgrade (Sublet)
  - Many bug-fixes (Jouanne, Haeck, Rochman, a.o.)

Fission standards

Adopted for U-235 & U-238



JEFF 3.3 T2

- T2 June 2016, 559 materials
  - 44 changes from T1
  - 40 photoproduction from TENDL: Y89, Zr93, Nb95, Mo, Ru, Pd, In, I, Xe, Cs, Ba134, La139, Ce, Pr, Nd, Pm, Sm, Eu, Gd157, Dy, Hf (Perry)
  - 304 changes to covariances from TENDL
  - Restore 2H, 0C, Cd, W, Au
  - Restore and mod INL of Cr Pb-206,206,208, Bi-209
  - Cu-63,65: KIT+3.2-RR
  - Add 81Br, remove 80Br
  - Recoil data Sauvan 54,56,57,58Fe
  - Ni-59 Helgesson
  - MF1 updates Noguere, Plompen, …
  - Many bugfixes discovered in processing Jouanne, Haeck, NDEC/Diez, …

JEFF 3.3 T3

- New Radioactive Decay Data file (Kellett)
- Adjustment of the new Fission Yields file to new RDD UKFY3.7 (Mills)
  - *So far the old RDD*
  - *Still needs covariances (several options)*
- Covariances U-235
- Updates to gamma-emission: capture, inelastic, pfgs
- Restoration of 8 group structure delayed neutron data
- New cases (Rochman, Fleming, decay heat)
- O-16
- TSL H, D, O
- ^{54,56,57,58}Fe CIELO/ENDF/B-VIII.0beta
- ^{63,65}Cu KIT + ORNL/IRSN resonance parameters
- Zr chain, fusion (KIT and partners)
- Corrections Jouanne, Rochman

JEFF 3.3 **(former JEFF-3.3T4)**

- Turn back Fe
- Improve Cu files (merge resonance file with KIT fast range)
- Improve covariances nu-bar for Pu-239
- UK FY3.7 adopted after verification against new RDD file; still working on covariances.
- DPA files adopted

New Radioactive Decay Data

- Oct. 2016, M. Kellett & O. Bersillon
- This week: JEF/DOC-1792, M. Kellett

JEFF-3.3: Improvements

From JEFF-3.1.1 to JEFF-3.3

JEFF-3.3 (released October 2016):

Complete re-assessment and update to all 900 evaluations coming from ENSDF

Assessment of IAEA actinide decay data (85 nuclei)

Assessment of IRDFF decay data library (~80 nuclei)

Inclusion of updated UKPADD-6.12 library (~50 additional nuclei)

Assessment of new DDEP evaluations (~30 additional nuclei)

Inclusion of initial TAGS results from University of Valencia *(2010)*

Inclusion of first TAGS results from University of Nantes *(2015)*

Inclusion of further TAGS results from University of Valencia *(2016)*

Corrections based on limited feedback to JEFF-3.1.1

JEFF-3.3: Source libraries

Contents of JEFF-3.2 (March 2015) and JEFF-3.3 (October 2016)

Library	JEFF-3.2	JEFF-3.3
NUBASE	2 297	2 295
ENSDF	861	849
UKPADD-6.x	441	441
UKHEDD-2.x	46	59
DDEP	128	140
IAEA	79	66
IRDFF	-	2
Total	3 852	3 852

JEFF-3.3: Some remarks

It was found that ~100 or so evaluations, from the 900 evaluations coming from ENSDF, were less consistent than before, i.e. energy balance is now worse than 2%. Original files from JEFF-3.1.1 have been kept for JEFF-3.3.

Many issues were identified with the ENSDF formatted files coming from DDEP and IAEA – these were all recreated and tested, before conversion to the ENDF format.

Very limited manpower available for producing new evaluations. However, I have managed to recruit three new part-time DDEP evaluators from the metrology community: NIST (USA), NIM (China) and PTB (Germany) and CTBTO are currently funding a fourth person to produce new/updated evaluations for Xe-133, Xe-133m, Xe-135 and Xe-135m.

A new UK fission yield evaluation – UKFY3.7

Dr Robert W Mills, NNL

(From his contribution to ND2016)

Important fissioning systems

NATIONAL NUCLEAR LABORATORY

Max. Fraction of Fission Rate			
>10%	1-10%	0.1%-1%	Spont. fission
nuclides: 5	2	12	3
*^{233}U TFH *^{235}U TFH *^{238}U FH *^{239}Pu TF *^{241}Pu TF	*^{240}Pu F ^{245}Cm TF	*^{232}Th FH ^{234}U F ^{236}U F ^{237}Np TF ^{238}Np TF ^{238}Pu TF ^{242}Pu F ^{241}Am TF ^{242m}Am TF ^{243}Am TF ^{243}Cm TF ^{244}Cm TF	^{252}Cf Sp ^{242}Cm Sp ^{244}Cm Sp

* Nuclides in UKFY1 and previous UK libraries.
T Thermal fission.
F Fast fission.
H 14Mev Fission.
Sp Spontaneous fission.

New data

NATIONAL NUCLEAR LABORATORY

- New data split into systems:

Neutron spectra	Fissioning nuclide	UKFY3.6	New data	UKFY3.7
Thermal	Th229	337	72	409
Thermal	U233	757	188	945
Thermal	U235	2390	151	2541
Thermal	Np238	115	63	178
Thermal	Pu239	861	225	1086
Thermal	Pu241	334	63	397
Thermal	Cm245	161	219	380
Thermal	Cf249	305	239	544
Fast	U235	724	5	729
Fast	Pu239	390	5	395
Fast	Pu241	111	5	116

- Fast yields refer to Neodymium cumulative yields.

Covariances

- Overview: O. Cabellos, CW2017, Aix-en-Provence
- Major nuclides: U-235, U-238, Pu-239 (CEA)
- TENDL-2015 + updates (D. Rochman)
- TSL: H in H_2O (G. Noguere)
- Processing w. NJOY2012.99 (O. Cabellos, J. Dyrda)
- Accessible through JANIS
- Verified through NDaST (chi, nubar, …)

I. JEFF-3.3T4 (562 files)

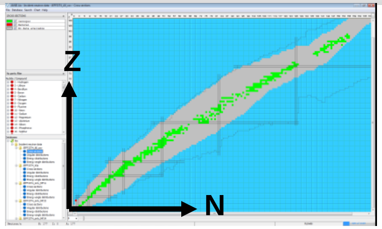


Table 1: List of isotopes with covariances in JEFF-3.3T4

MFs	Isotopes	#ENDF Files	#Processed Files
MF31	89-Ac-225 89-Ac-226 89-Ac-227 …	50	50
MF32	6-C-13 8-O-17 8-O-18 …	352	
MF33	1-H-1 1-H-2 3-Li-6 3-Li-7 …	442	
MF32/MF33			446
MF34	6-C-13 8-O-17 8-O-18 …	359	346
MF35	89-Ac-225 89-Ac-226 89-Ac-227 …	35	35
MF40	13-Al-26 15-P-31 17-Cl-36 …	286	0
MF31…MF40		**447**	
No Covariance	1-H-3 2-He-3 2-He-4 6-C-0 …	115	

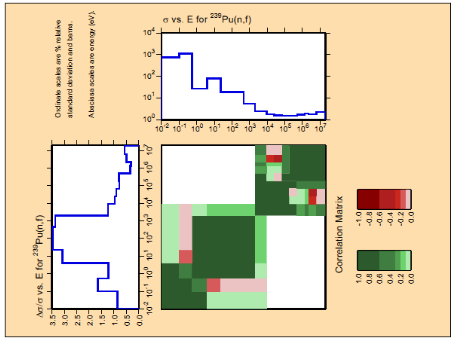
- MF31: U235, U238, Pu239, …
- MF35 - Chi(E) : U235, U238, Pu239, …

U233 MF31-only delayed and prompt
U233: No MF35

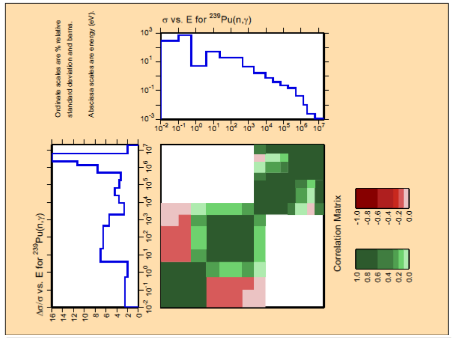
De Saint Jean, JEFF April 2016

^{239}Pu

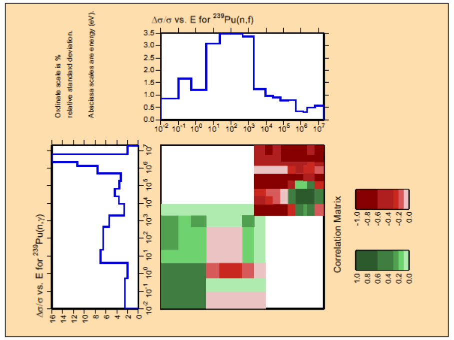
(n,f)



(n,g)

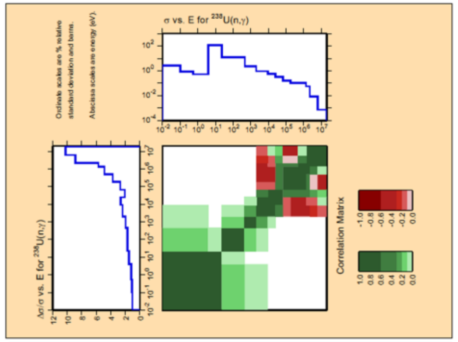


(n,f) x (n,g)

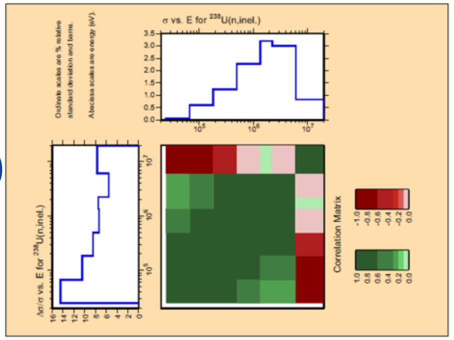


^{238}U

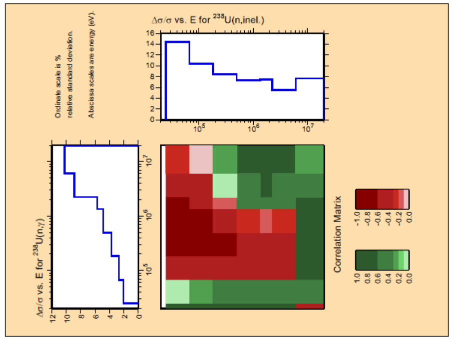
(n,g)



(n,inl)

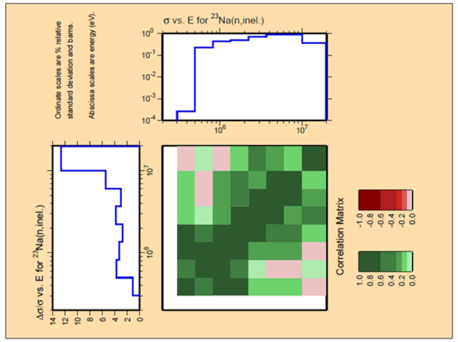


(n,g) x (n,inl)



^{23}Na

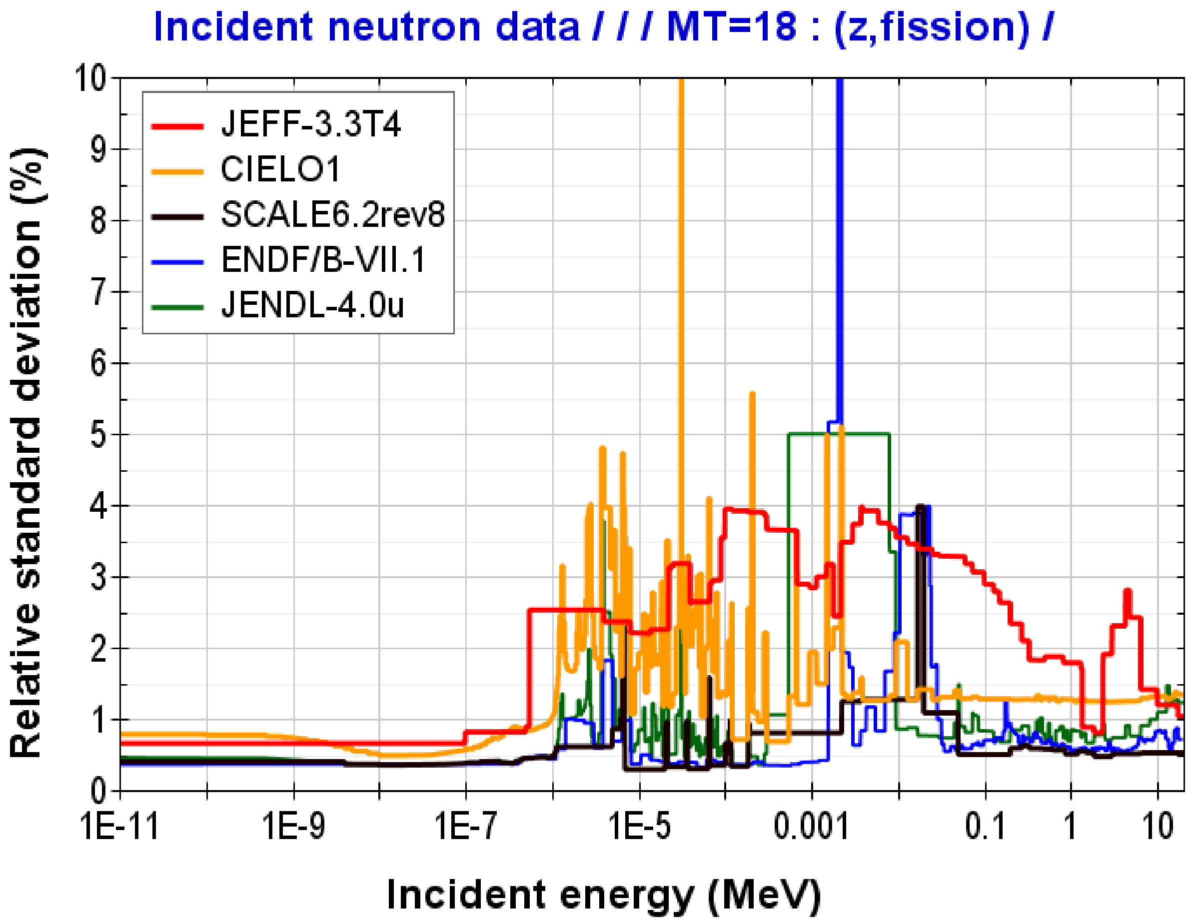
(n,inl)

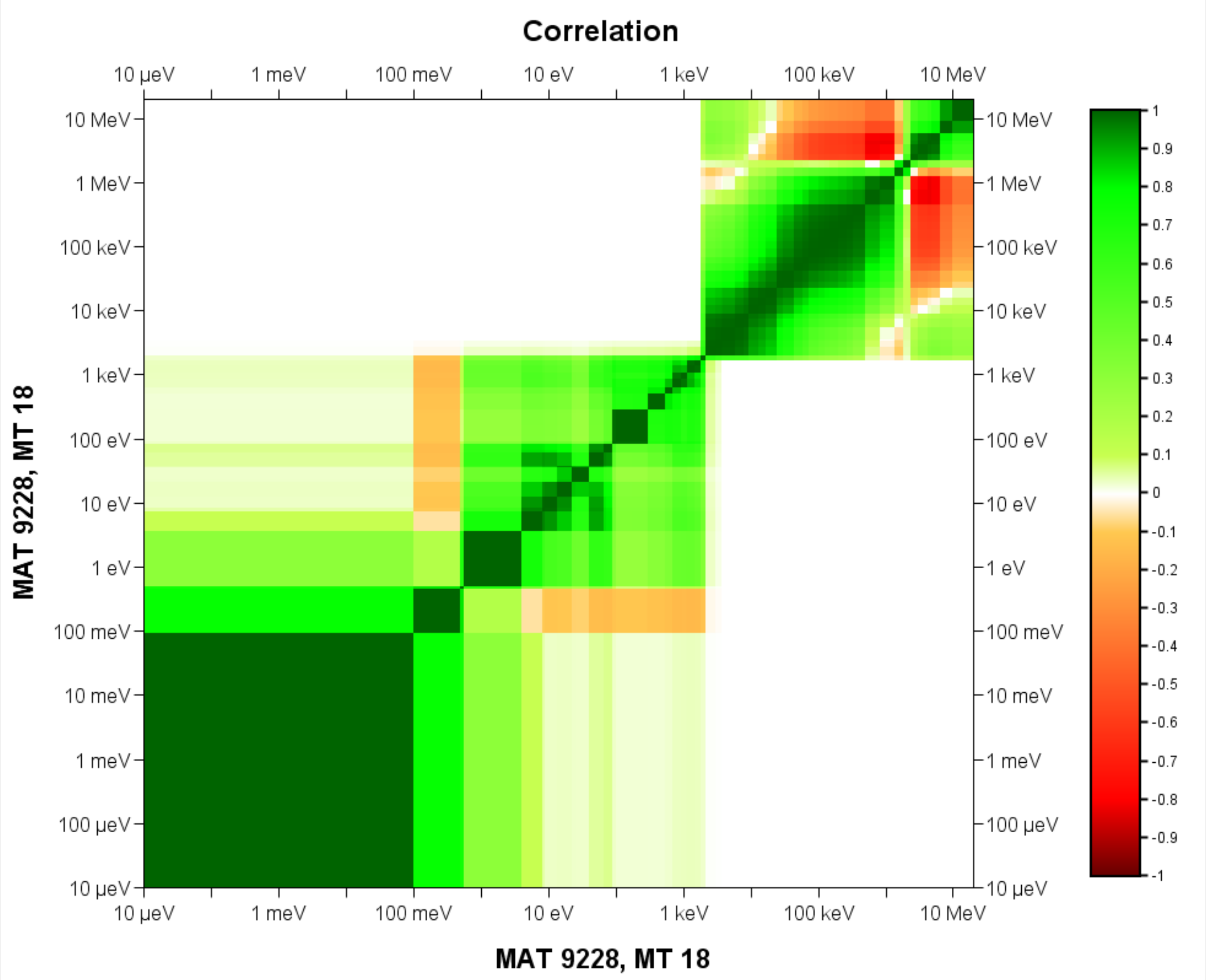


Further covariances for Hf

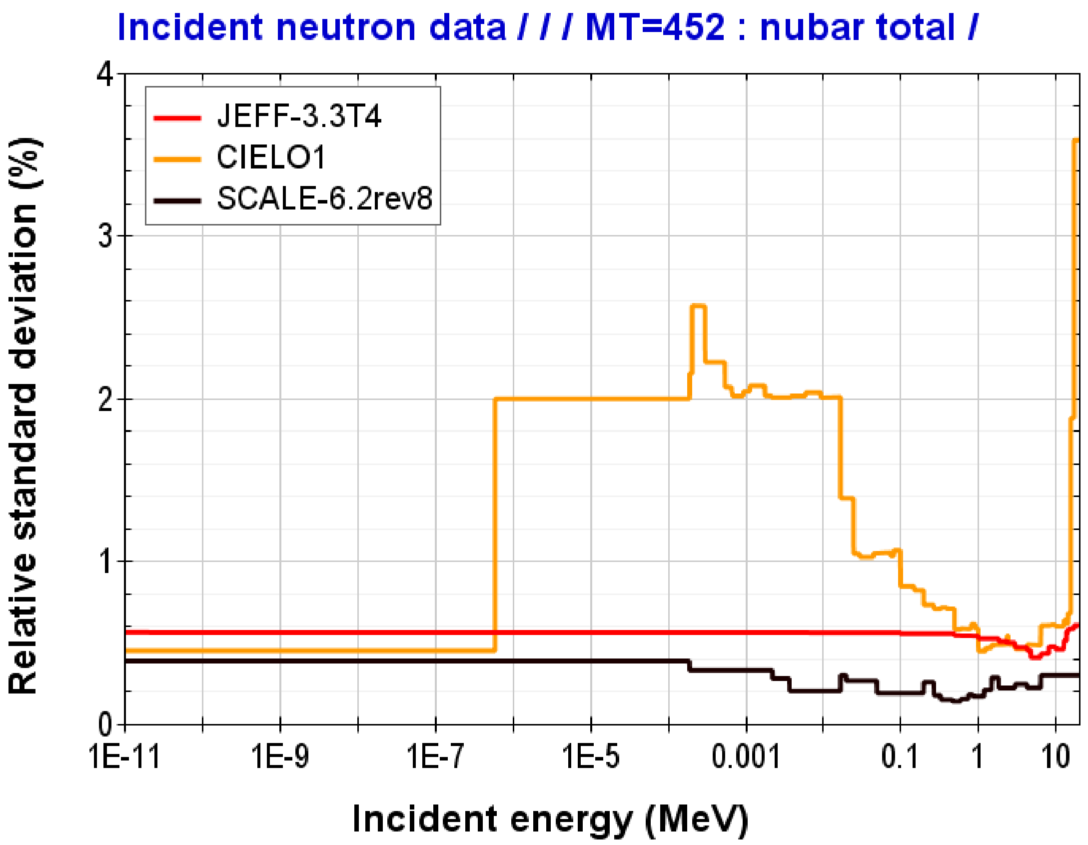
Many from TENDL (D. Rochman)

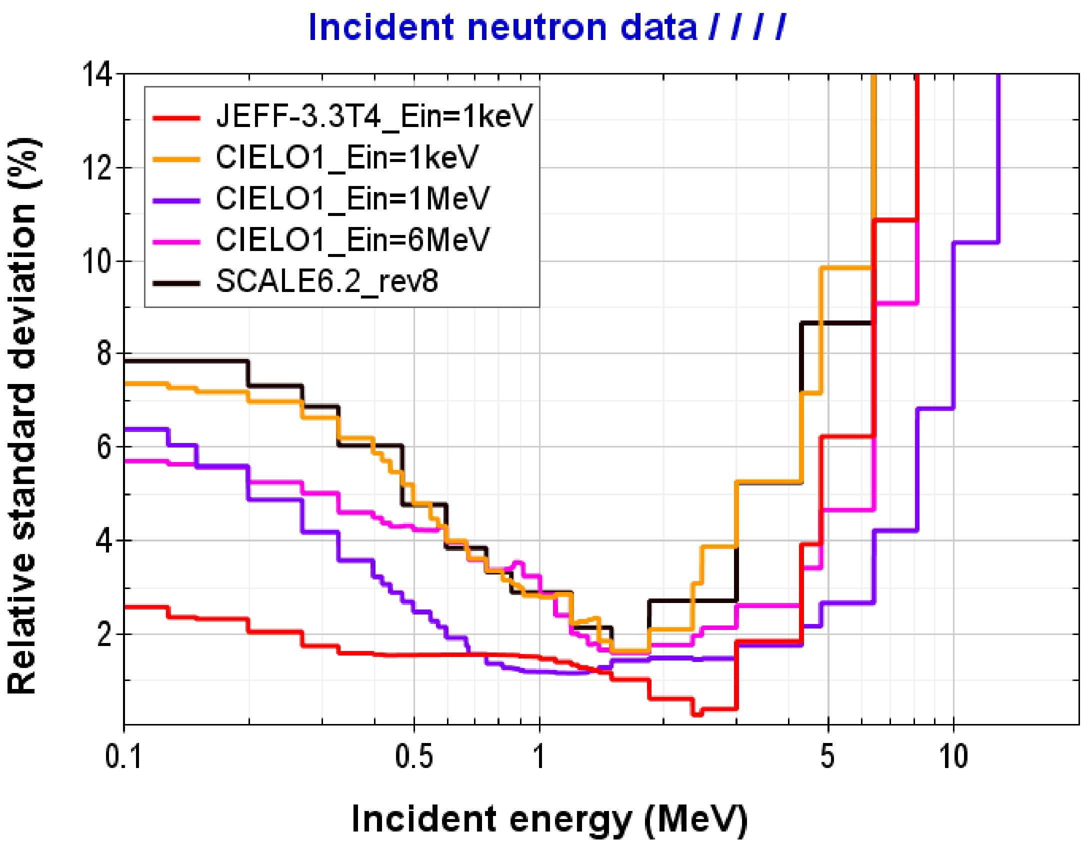
❑ U-235, MT18


Incident neutron data / / / MT=18 : (z,fission) /
JEFF-3.3T4
CIELO1
SCALE6.2rev8
ENDF/B-VII.1
JENDL-4.0u
Relative standard deviation (%)
Incident energy (MeV)
1E-11
1E-9
1E-7
1E-5
0.001
0.1
1
10

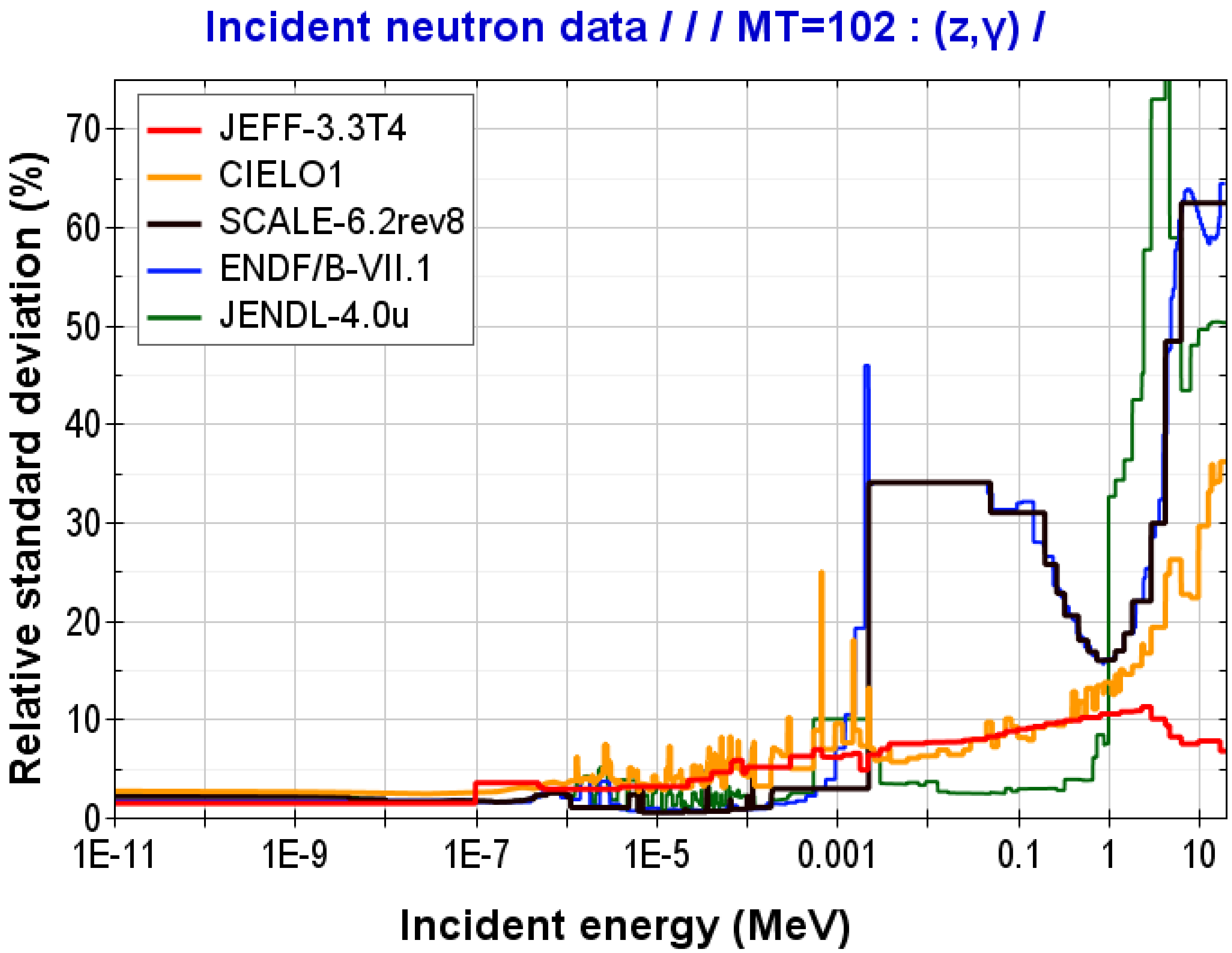

Correlation
MAT 9228, MT 18
MAT 9228, MT 18
10 μeV
1 meV
100 meV
10 eV
1 keV
100 keV
10 MeV

- U-235, MT452
- U-235, MT1018





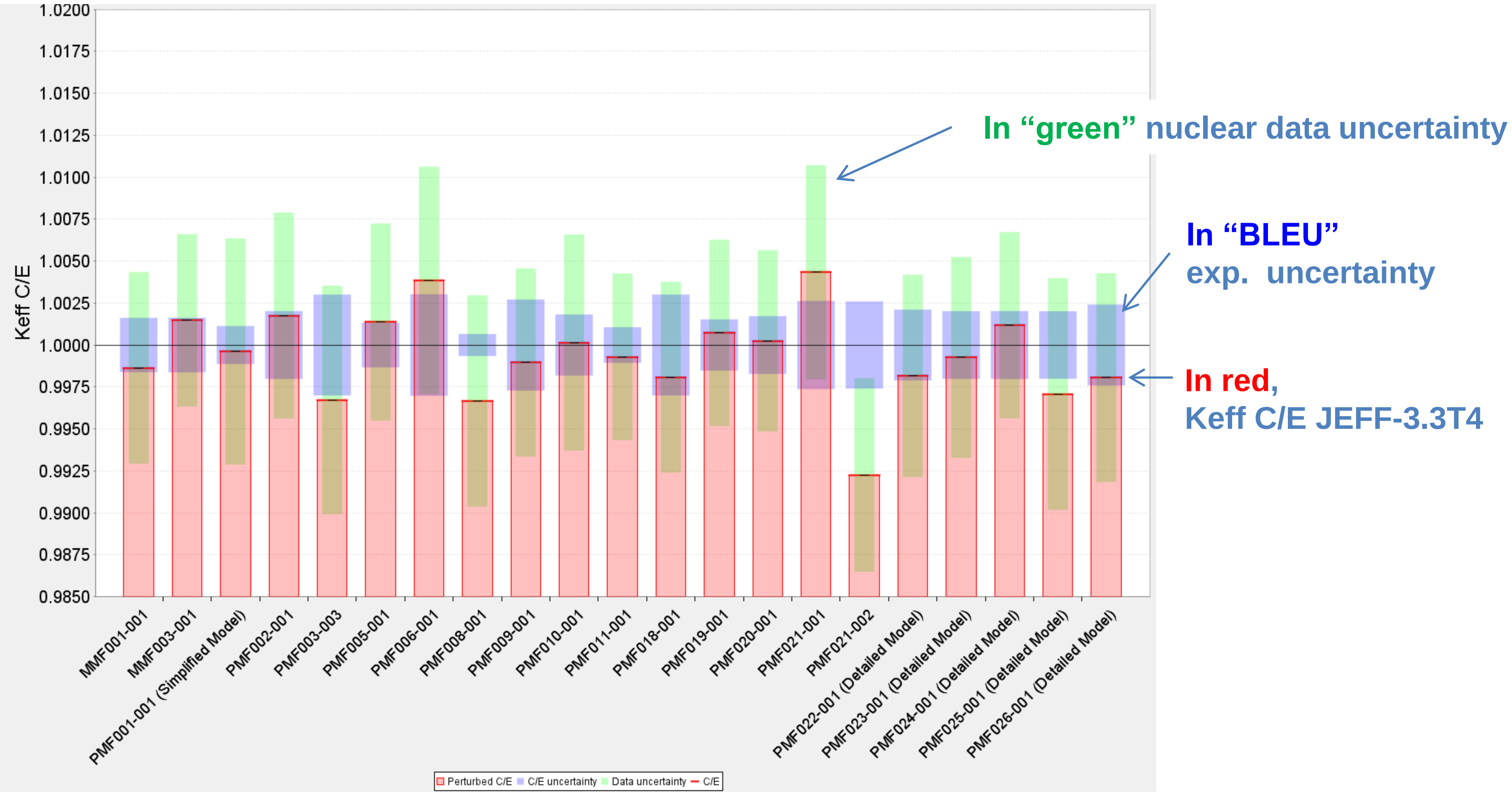
❑ U-235, MT102


Incident neutron data / / / MT=102 : (z,γ) /
JEFF-3.3T4
CIELO1
SCALE-6.2rev8
ENDF/B-VII.1
JENDL-4.0u
Relative standard deviation (%)
0
10
20
30
40
50
60
70
1E-11
1E-9
1E-7
1E-5
0.001
0.1
1
10
Incident energy (MeV)

V.1 Verifying Covariance Data: Pu cases (21 Benchmarks)

- NDaST (Nuclear Data Sensitivity Tool) tool

Figure. PU's Mosteller Benchmark Suite (**21 Benchmarks**): ….. **only Pu239/JEFF-3.3-T4**



V.2 Verifying Covariance Data: Pu cases (21 Benchmarks)

- The impact of evaluations: JENDL-4.0u, ENDF/B-VII.1 and JEFF-3.3T4

Fig. **Pu's Mosteller** Benchmark Suite (21 Benchmarks) …only **Pu239 cross-sections covariance**

	ENDF/B-VII.1					JENDL4					JEFF-3.3T4				
	All	Elastic	Inel.	Fission	Gamma	All	Elastic	Inel.	Fission	Gamma	All	Elastic	Inel.	Fission	Gamma
PMF001-001	**780**	439	797	331	74	**542**	197	250	434	60	**294**	90	150	305	30
PMF002-001	628	382	629	281	62	453	171	194	369	50	250	78	118	262	25
PMF003-003	457	272	346	317	77	447	119	93	416	61	277	55	62	293	31
PMF005-001	579	257	539	315	111	471	107	181	411	92	286	51	103	301	45
PMF006-001	401	175	292	286	113	396	68	74	371	95	275	32	52	280	46
PMF008-001	588	276	553	316	105	470	115	176	412	87	286	54	105	302	42
PMF009-001	664	326	652	321	91	498	141	215	420	73	284	65	124	300	36
PMF010-001	514	252	460	304	97	439	107	132	397	80	275	50	85	291	39
…															
PMF022-001	852	467	884	339	76	571	210	284	445	61	306	95	168	312	31
PMF023-001	683	340	673	329	91	510	149	215	432	75	290	68	128	305	37
PMF024-001	777	379	799	319	97	527	163	263	419	81	291	75	153	297	56
PMF025-001	678	381	663	334	81	515	169	203	438	66	292	77	124	309	33
PMF026-001	584	279	541	325	100	481	122	170	425	82	287	56	102	304	41
MMF001-001	449	221	407	262	72	382	97	122	344	59	230	45	75	244	29
MMF003-001	408	195	363	245	70	350	86	94	321	58	216	39	64	228	28

#Lower values JEFF-3.3T4

V.3 Verifying Covariance Data

❑ H in H2O covariances

- H in H2O covariances
- CONRAD calculations, by G. Noguere

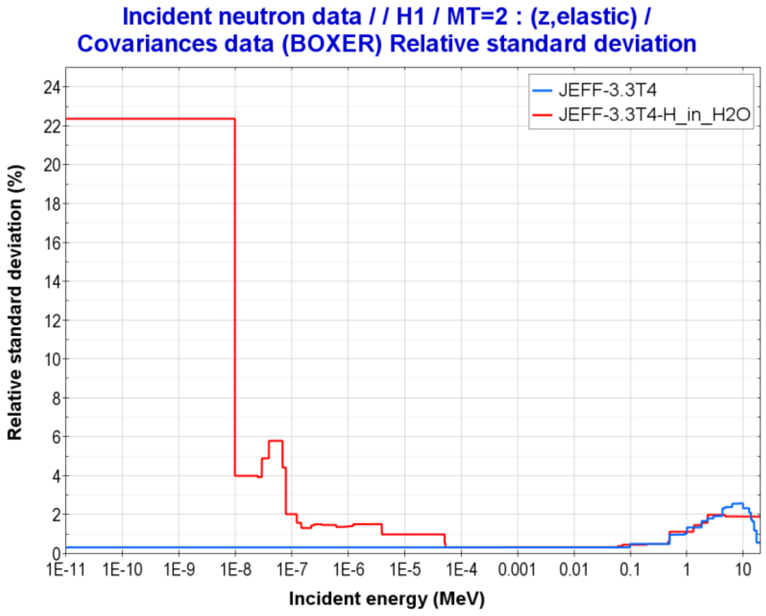


Figure. H in H2O correlation matrix

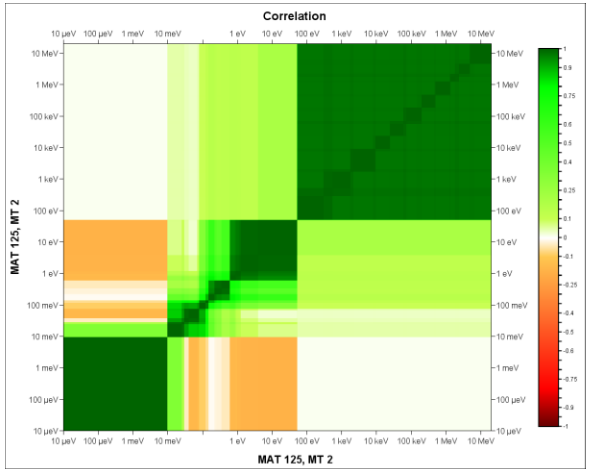
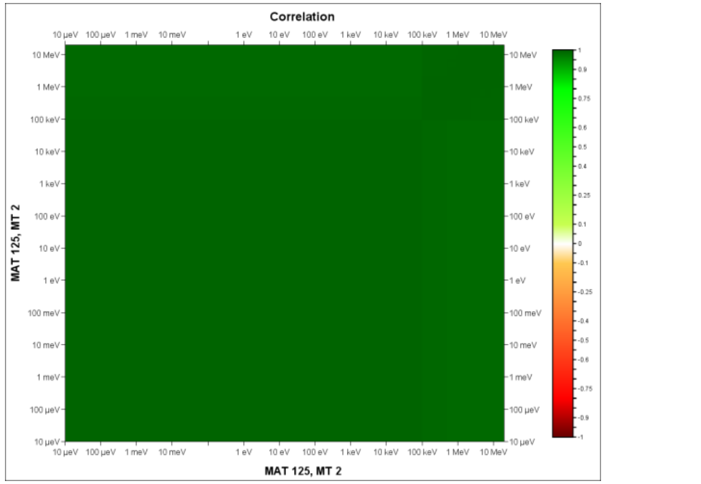


Figure. H (JEFF-3.3T4) correlation matrix



Thermal scattering

- 20 files, 14 new, first covariances for H in H_2O.
- Cantargi, Granada, Marquez Damian
    - D in D_2O, Ortho D_2, Para D_2
    - H in ice, mesitylene, Ortho H_2, Para H_2, toluene
    - O-16 in D_2O, Al_2O_3
    - Al in $Al2O_3$
    - Si in Si
- Mg in Mg (Mounier)
- H in CaH_2, Ca in CaH_2 (Serot)
- Keinert, Mattes
    - H in H_2O, CH_2, ZrH (Keinert, Mattes)
    - Be in Be (Keinert, Mattes)
    - C in graphite (Keinert, Mattes)

Benchmarking

- Mosteller suite
- ICSBEP
- Institute dependent subsets of ICSBEP
- Institute dependent proprietary benchmarks

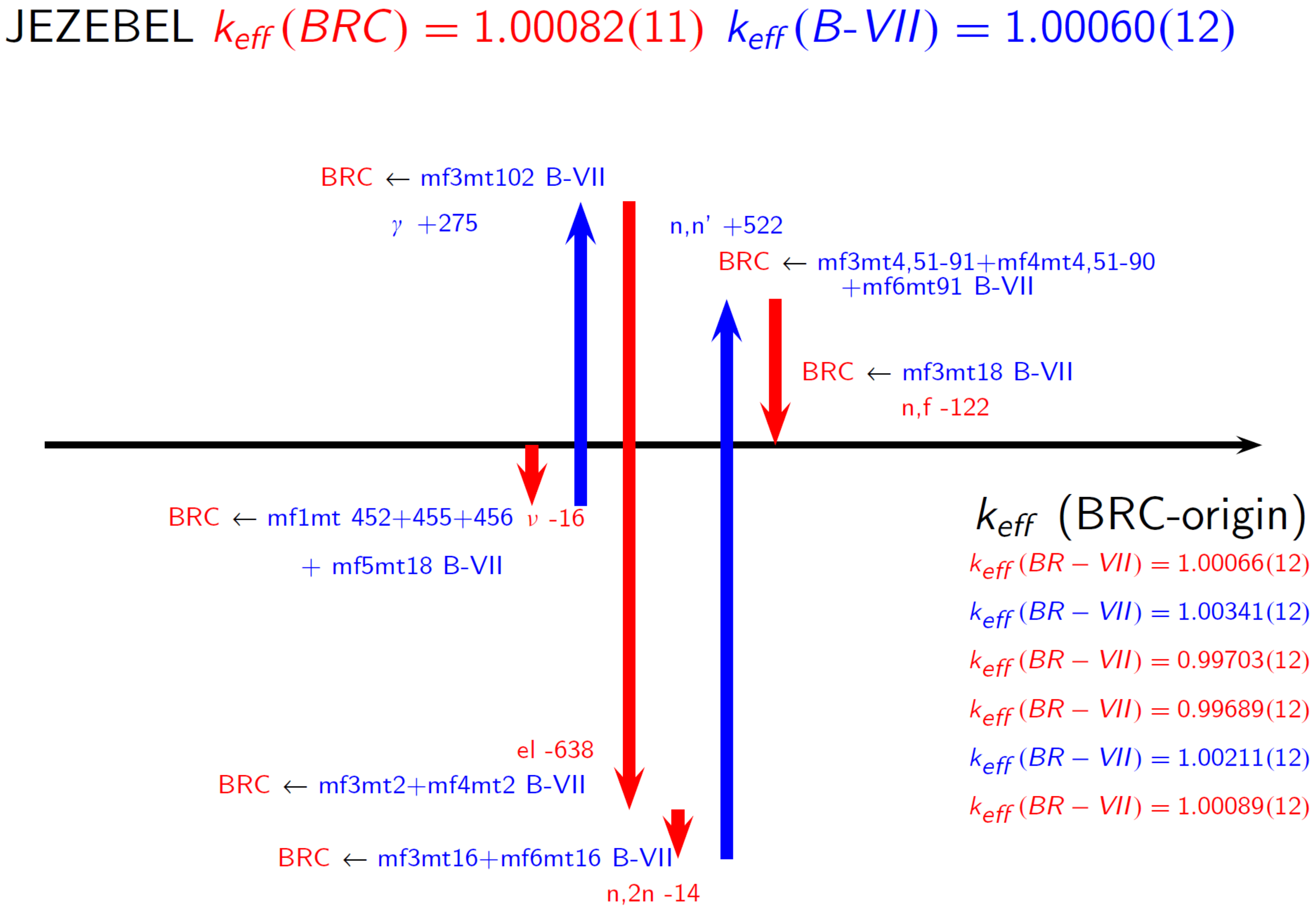
- Criticality
- Some decay heat

An example of a critical assembly

- JEZEBEL criticality benchmark, modeled as a Pu sphere
  - k=1
  - 1 nuclide: ^{239}Pu
- One of the Mosteller suite of 123 cases used for nuclear data library development.
- Much wider suite: ICSBEP

www.oecd-nea.org/science/wpncs/icsbep/

K-eff is a balance



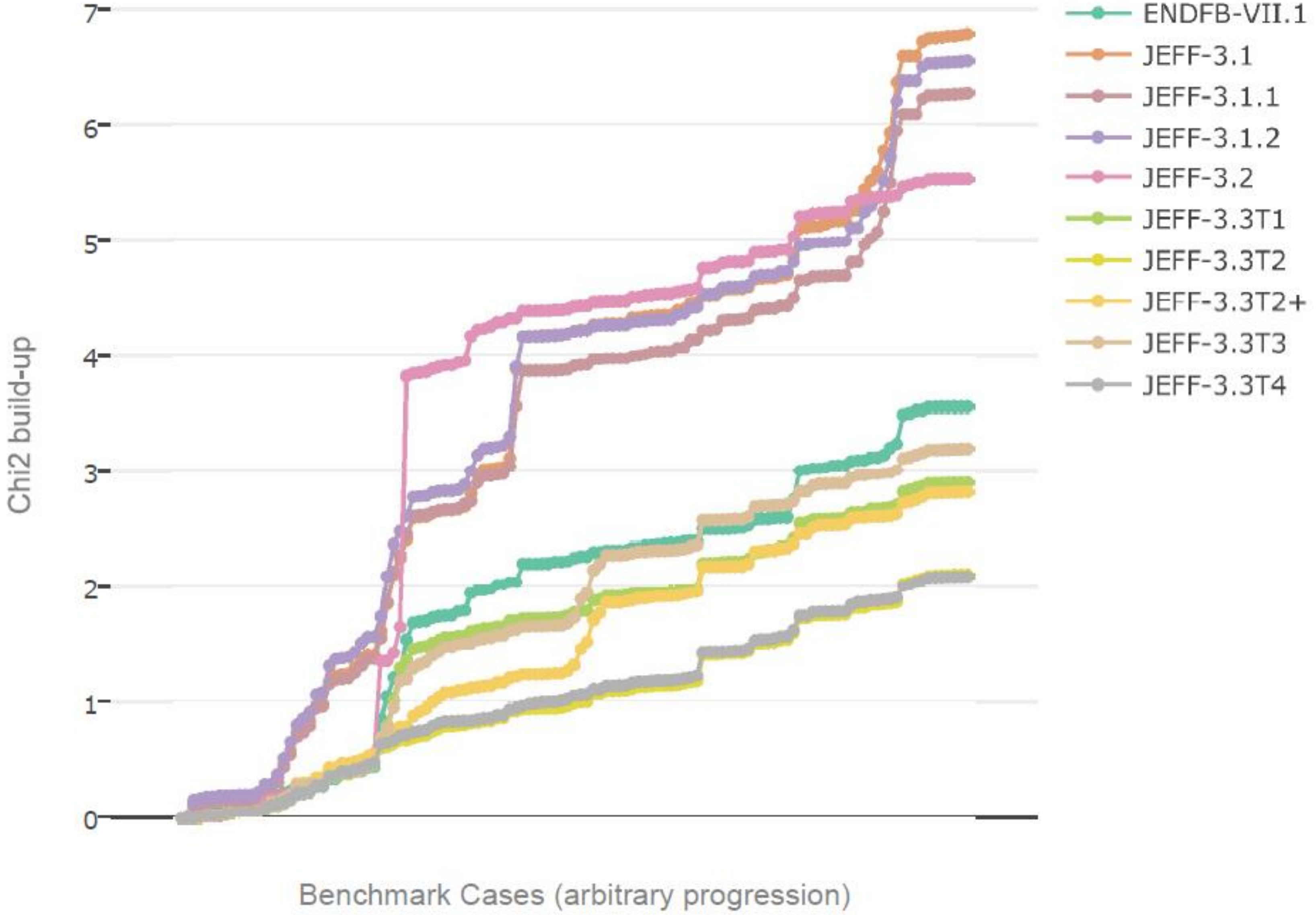
B. Morillon, P. Romain (CEA)
INDC(NDS)-0597

K-eff is a balance, a ratio of two integrals

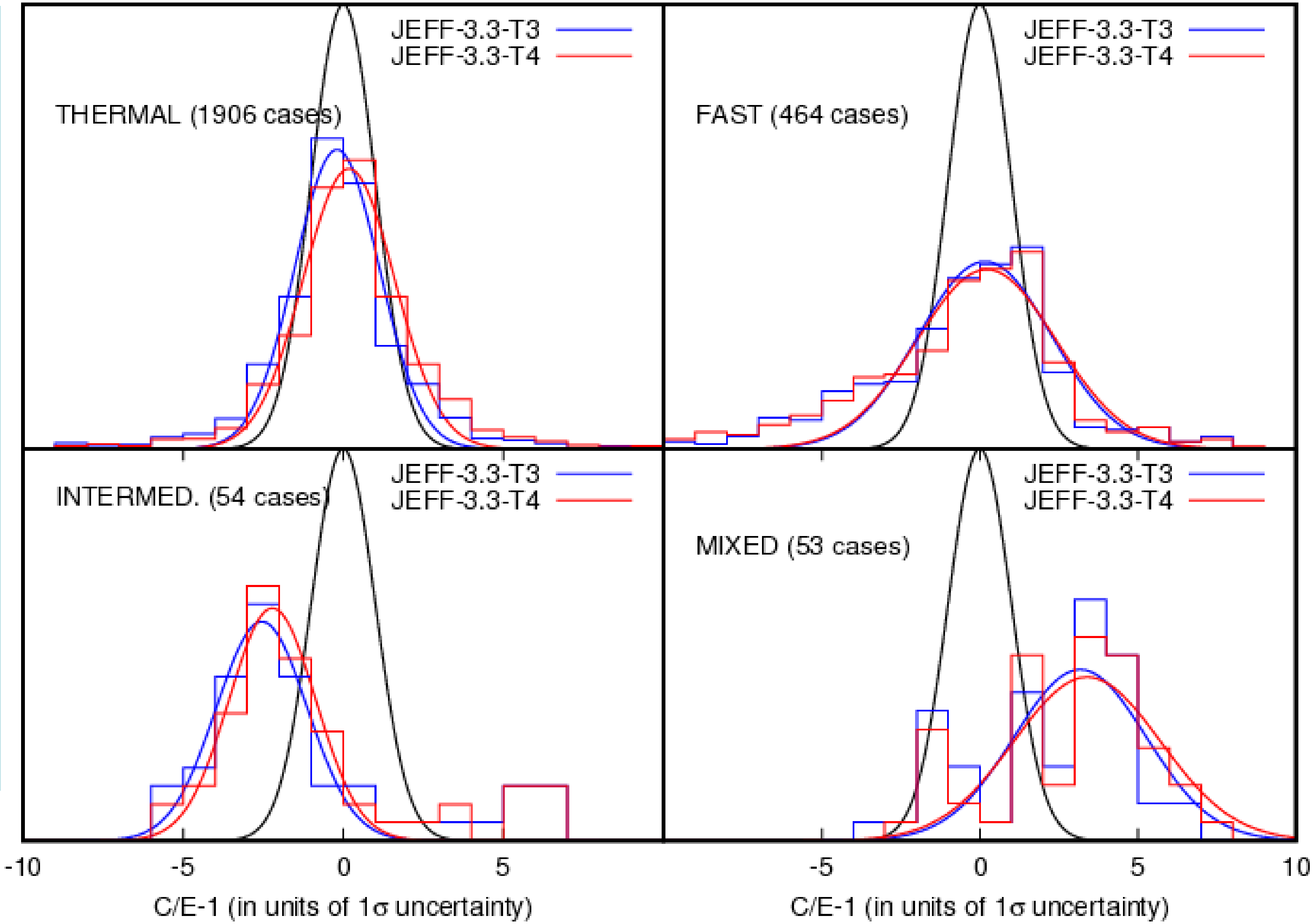
- Partial cross section differences between evaluations have k-eff impacts well beyond the desired uncertainty.
- Fortuitous cancellations must be expected!
- How cancellations affect predictability out of the benchmarking domain is even less clear than within.
- There is no substitute for understanding.
- We must continue to improve our understanding despite the ability for & with the aid of massive computation and comparison.

Mosteller suite testing of JEFF-3.3Tn

F. Michel Sendis (NEA)



JEFF-3.3Tn testing against ICSBEP



S. van der Marck (NRG)

Benchmarking & Validation Activities

- Reference Paper in ND2016. Published: *EPJ Web of Conferences* **146**, 06004 (2017)

Benchmarking and Validation Activities within JEFF Project

O. Cabellos[1,], F. Alvarez-Velarde[2], M. Angelone[3], C.J. Diez[1], J. Dyrda[1], L. Fiorito[4], U. Fischer[5], M. Fleming[6], W. Haeck[7], I. Hill[1], R. Ichou[7], D. H. Kim[8], A. Klix[5], I. Kodeli[9], P. Leconte[10], F. Michel-Sendis[1], E. Nunnenmann[5], M. Pecchia[11], Y. Peneliau[10], A. Plompen[12], D. Rochman[11], P. Romojaro[13], A. Stankovskiy[4], J.Ch Sublet[6], P. Tamagno[10], S. van der Marck[14]*

[1] NEA, OECD, Paris, France
[2] CIEMAT, Madrid, Spain
[3] ENEA, Frascati, Italy
[4] SCK·CEN, Mol, Belgium
[5] KIT, Eggenstein-Leopoldshafen, Germany
[6] UKAEA, Abingdon, Oxfordshire, United Kingdom
[7] IRSN, Paris, France
[8] KAERI, Daejeon, South Korea
[9] JSI, Ljubljana, Slovenia
[10] CEA, DEN, DER, SPRC, Cadarache, France
[11] PSI, Villigen, Switzerland
[12] JRC, Geel, Belgium
[13] UPM, Madrid, Spain
[14] NRG, Petten, The Netherlands

- 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. Main changes in JEFF-3.3T4

Table: Main changes in JEFF3.3T4 beta files for criticality + uncertainty assessment

	JEFF-3.3T2	JEFF-3.3T2+	JEFF-3.3T3	JEFF-3.3T4
Pu239	JEFF-3.3T2	JEFF-3.3T2	JEFF-3.3T2	nubar uncertainties
U235	JEFF-3.3T2	JEFF-3.3T2	JEFF-3.3T2	fission and nubar uncertainties
U238	JEFF-3.3T2	JEFF-3.3T2+RR/JRC	JEFF-3.3T2+RR-JRC	JEFF-3.3T2+RR-JRC
O16	ENDF/B-VII.1	O16-Luiz	O16-Luiz	ENDF/B-VII.1
TSLs	JEFF-3.1.1	H2O Bariloche D2OBariloche	H2O Bariloche D2OBariloche	H2O – JEFF-3.1.1 D2O – ENDF/B-VIIIb4
Cu	KIT1+Sobes/Luiz	ENDF/B-VII.1+RR/JRC	KIT1-rev+Sobes/Luiz	KIT2-rev+Sobes+RR/JRC
Fe54/56	JEFF-3.2	JEFF-3.2	ENDF/B-VIIIb4	JEFF-3.2
Al27	JEFF-3.2	JEFF-3.2	JEFF-3.2	Generate and add covariances using TENDL approach

II. XSs, PFNS and nubar Uncertainties

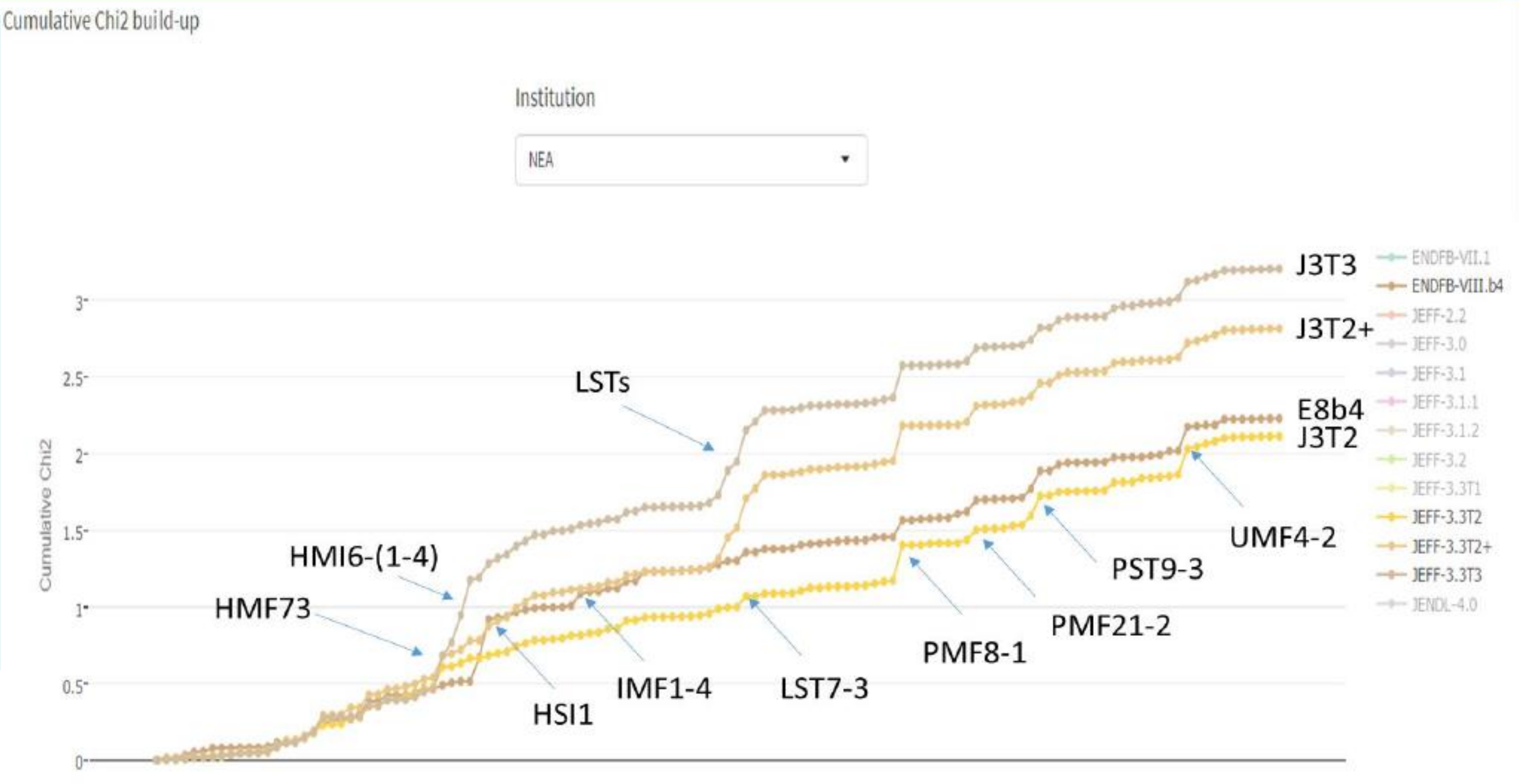
Table: Jezebel (PMF1) and Godiva (HMF1) criticality k-eff uncertainty (in pcm), based on NDaST and MCNP simulations

Jezebel	CIELO-1	B-VII.1	JEFF-3.3	JENDL-4.0u1
fission	903	331	305	434
nubar	241	81	413	209
PFNS E_{av}	185	186	443	286
elastic	463	438	90	198
inelastic	797	797	150	250
capture	67	74	30	59
Summed	1025	562	645	648
Exp. unc.	110	110	110	110
|C-E|	15	12	68	185

Godiva	CIELO-1	B-VII.1	JEFF-3.3	JENDL-4.0u1
fission	788	269	648	320
nubar	540	545	510	274
PFNS E_{av}	132	276	364	176
elastic	276	294	109	426
inelastic	698 (est.)	616	698	681
capture	281	873	375	269
Summed	1039 (est.)	1220	1342	962
Exp. unc.	100	100	100	100
|C-E|	6	8	16	167

III. Results of criticality benchmarking

Figure: Cumulative Chi-2 build-up (SENDIS output)



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ission

Results of criticality benchmarking using ICSBEP

Table: Evaluation of general performance for extended validation suites.

Values are "*reduced*" Chi-squared, number of cases in brackets

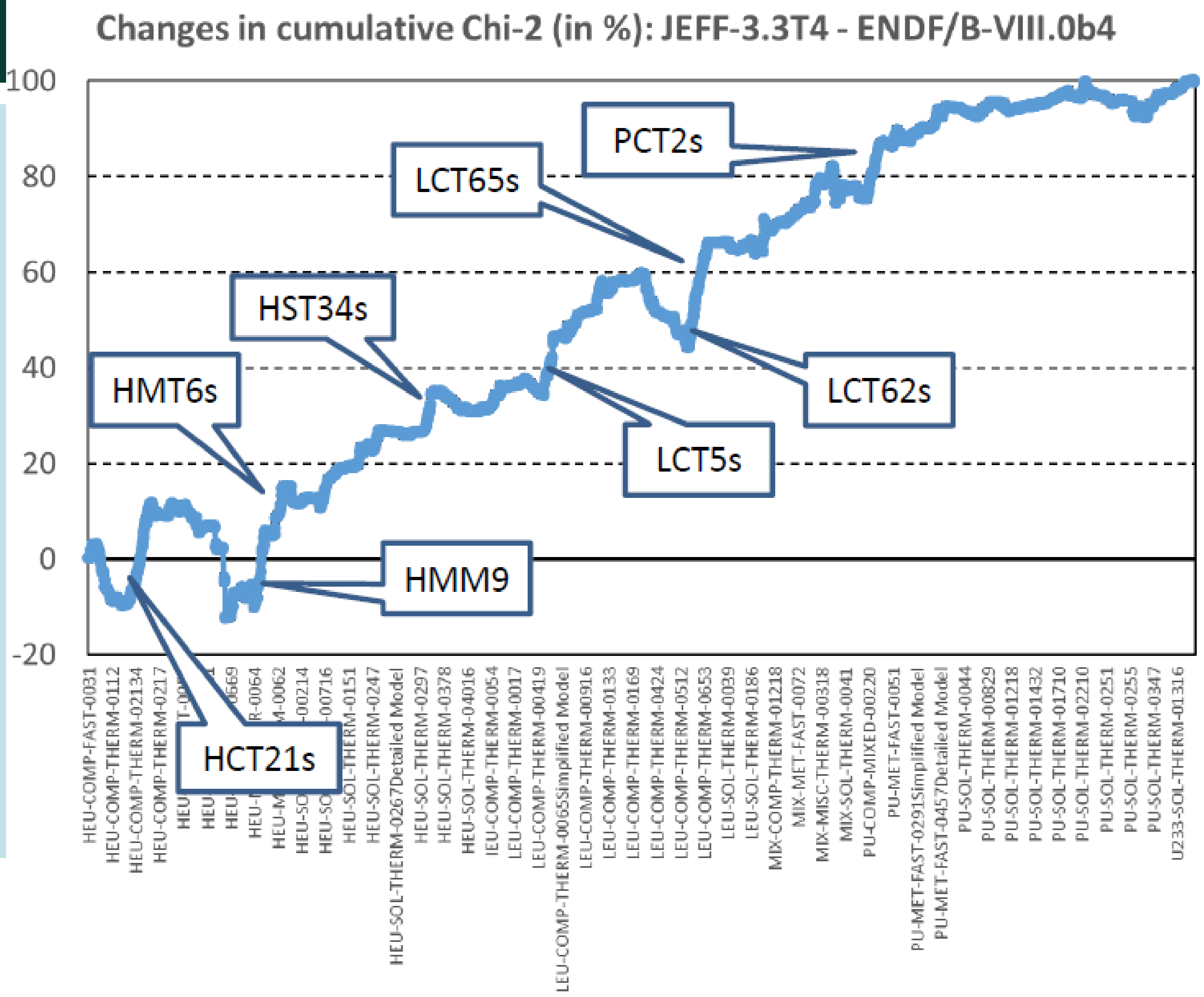
	NEA (based on Mosteller´s suite … "Expert Judgement")							
	ENDF/B-VII.1	ENDF/B-VIIIb4	JEFF-3.1.1	JEFF-3.2	JEFF-3.3.T2	JEFF-3.3T2+	JEFF-3.3T3	JEFF-3.3T4
PU	4.2 (29)	2.2 (29)	2.9 (29)	3.6 (29)	2.8 (29)	2.4 (29)	2.4 (29)	2.7 (29)
HEU	6.1 (42)	3.4 (42)	5.3 (42)	11.8 (42)	2.2 (42)	3.5 (42)	3.9 (42)	2.8 (42)
IEU	5.0 (12)	1.9 (12)	11.3 (12)	4.9 (12)	2.7 (12)	2.1 (12)	2.2 (12)	2.4 (12)
LEU	0.9 (13)	1.4 (13)	1.4 (13)	0.9 (13)	1.8 (13)	3.7 (13)	4.0 (13)	2.3 (13)
U233	1.7 (18)	2.1 (18)	9.5 (18)	1.2 (18)	1.7 (18)	1.9 (18)	1.7 (18)	1.6 (18)
MIX	0.7 (8)	1.0 (8)	1.2 (8)	0.9 (8)	0.9 (8)	1.0 (8)	0.8 (8)	1.0 (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)	0.99107 (1)
Total	3.7 (123)	2.0 (123)	6.5 (123)	5.6 (123)	2.0 (123)	2.9 (123)	3.1 (123)	2.2 (123)

Results of criticality benchmarking using ICSBEP

Table: Evaluation of general performance for extended validation suites.
Values are "*reduced*" Chi-squared, <u>number of cases in brackets</u>

	NRG – Steven van der Mark (based on ICSBEP … "brute force" .. we rely on statistical analysis)				
	JENDL-4.0	ENDF/B-VII.1	ENDF/B-VIIIb4	JEFF-3.1.1	JEFF-3.3T4
PU	6.4 (479)	6.0 (479)	5.2 (479)	5.6 (479)	6.3 (479)
HEU	9.0 (653)	6.0 (653)	5.9 (653)	6.3 (653)	6.2 (653)
IEU	8.7 (43)	1.8 (43)	1.2 (43)	5.2 (43)	2.0 (43)
LEU	3.4 (415)	3.3 (415)	3.7 (415)	4.0 (415)	3.9 (415)
U233	2.2 (66)	6.5 (66)	2.6 (66)	2.0 (66)	4.4 (66)
MIX	7.9 (168)	6.5 (168)	7.0 (168)	5.5 (168)	7.0 (168)
Total	7.4 (1824)	5.1 (1824)	4.8 (1824)	5.2 (1824)	5.3 (1824)

III. NRG-results: ENDF/B-VIII.0b4 versus JEFF-3.3T4



- **NRG – Steven van der Mark**
  - 2348 – JEFF-3.3T4
  - 2348 – ENDF/B-VIII.0b4
  - 2445 – JENDL-4.0
  - 2445 – ENDF/B-VII.1
  - 1908 – JEFF-3.1.1

common set of benchmarks …**1824 !!**

- **Analysis of χ^2 …..**
  - Exp. Correl. in Eval. Cases ?
    - None
  - Cases with large C/E bias!!
    - LCT5s
    - HCT21s
    - PCT2s

Results of criticality benchmarking using ICSBEP

Table: Evaluation of general performance for extended validation suites.

Values are "*reduced*" Chi-squared, number of cases in brackets

	NRG – Steven van der Mark (based on ICSBEP … "excluding benchmarks with large bias")				
	JENDL-4.0	ENDF/B-VII.1	ENDF/B-VIIIb4	JEFF-3.1.1	JEFF-3.3T4
PU	4.6 (444)	3.8 (444)	3.1 (444)	3.1 (444)	3.6 (444)
HEU	6.7 (595)	3.7 (595)	3.5 (595)	4.0 (595)	3.6 (595)
IEU	8.4 (37)	1.8 (37)	1.2 (37)	4.6 (37)	1.4 (37)
LEU	3.1 (407)	3.1 (407)	3.5 (407)	3.8 (407)	3.6 (407)
U233	2.2 (66)	6.5 (66)	2.6 (66)	2.0 (66)	4.4 (66)
MIX	7.0 (165)	5.7 (165)	6.2 (165)	4.7 (165)	6.1 (165)
Total	6.1 (1714)	3.8 (1714)	3.3 (1714)	3.8 (1714)	3.6 (1714)

Only common cases, except for cases with $(k_C - k_E) > 5^* \Delta k_{exp}$

Results of criticality benchmarking using ICSBEP

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

	NRG – Steven van der Mark (based on ICSBEP ... "excluding benchmarks with large bias")				
	JENDL-4.0	ENDF/B-VII.1	ENDF/B-VIIIb4	JEFF-3.1.1	JEFF-3.3T4
FAST	4.3 (256)	3.0 (255)	2.8 (255)	5.0 (255)	2.8 (255)
INTER	7.3 (26)	9.6 (21)	4.7 (21)	11.2 (21)	6.8 (21)
THERM	5.6 (1399)	3.7 (1367)	3.4 (1367)	3.3 (1367)	3.6 (1367)
MIXED	3.6 (33)	4.3 (33)	5.5 (33)	4.7 (33)	5.4 (33)
Total	6.1 (1714)	3.8 (1714)	3.3 (1714)	3.8 (1714)	3.6 (1714)

Only common cases, except for cases with $(k_C - k_E) > 5^* \Delta k_{exp}$

JEFF-3.3 is available for GEANT4,
courtesy CIEMAT, Emilio Mendoza Cembranos, Daniel Cano Ott

Summary and conclusions

JEFF-3.3, together with other nuclear data libraries, will be soon available for download from the IAEA nuclear data service: https://www-nds.iaea.org/geant4/

A comparison between Geant4 and MCNP6 when using JEFF-3.3 has been performed concerning the neutron transport. Some of the differences have been quantified. According to our comparison, JEFF-3.3 is the library that yields more similar results between both codes.

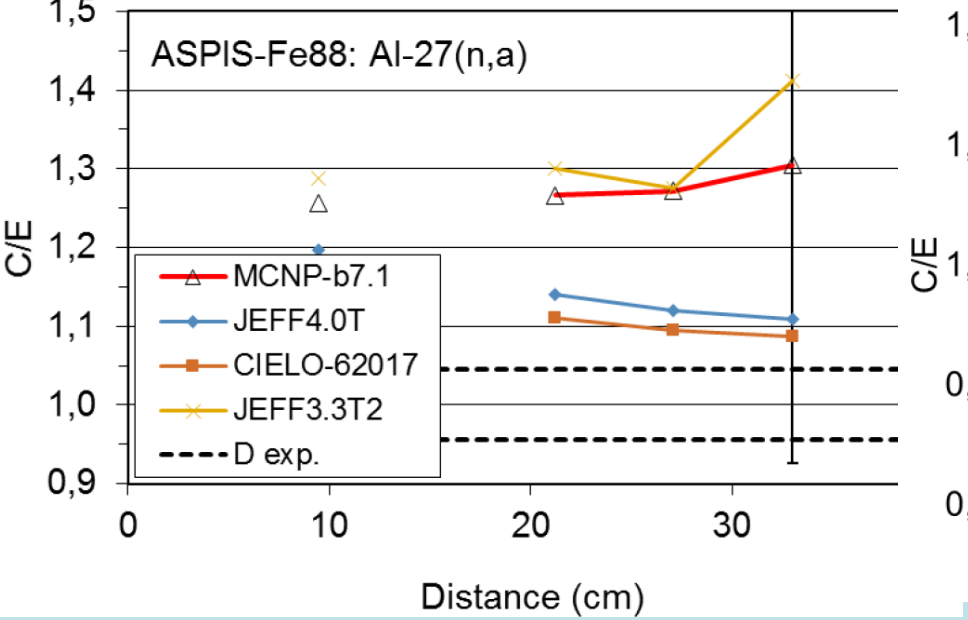
A large set of plots containing energy distributions from Geant4 and MCNP6 simulations of the secondary neutrons, γ-rays, p, d, t, ^{3}He and α will be available from the IAEA nuclear data service together with the libraries.

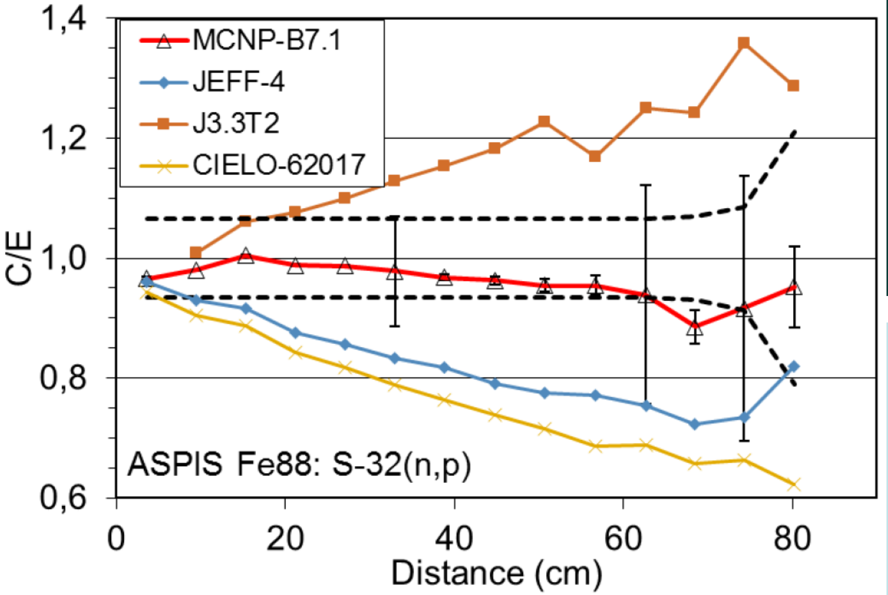
Future work ("CHANDA2" EOI):
- Systematic comparison between Geant4 and MCNP6 concerning the charged particle production.
- Convert to the G4NDL format the TENDL-2017 library (JEFF-3.3) for incident charged particles.

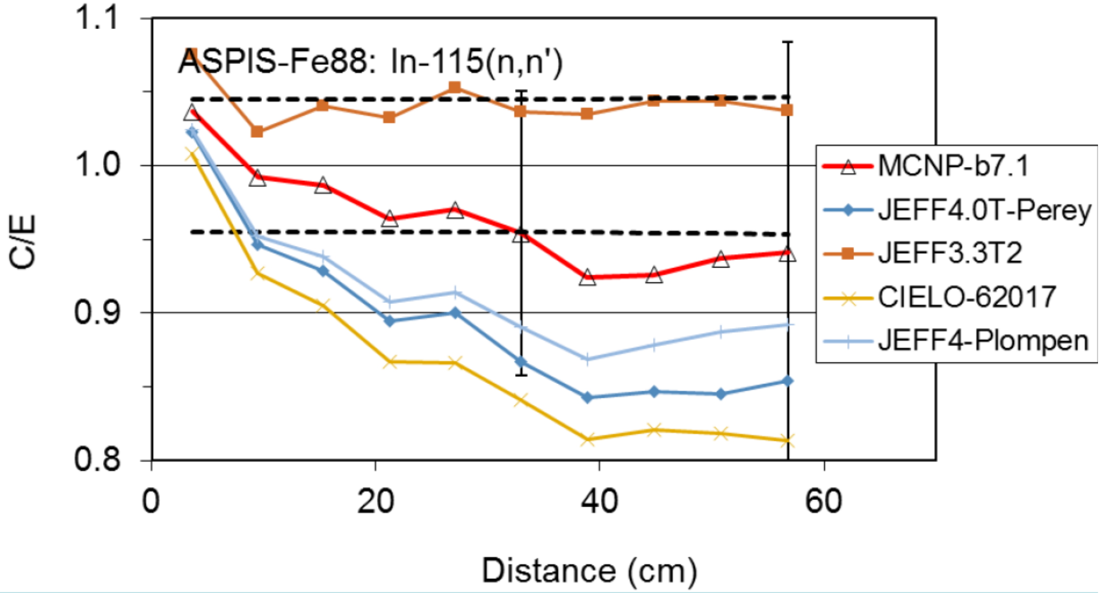
Iron Nuclear Data Testing Using SINBAD Shielding Experiments

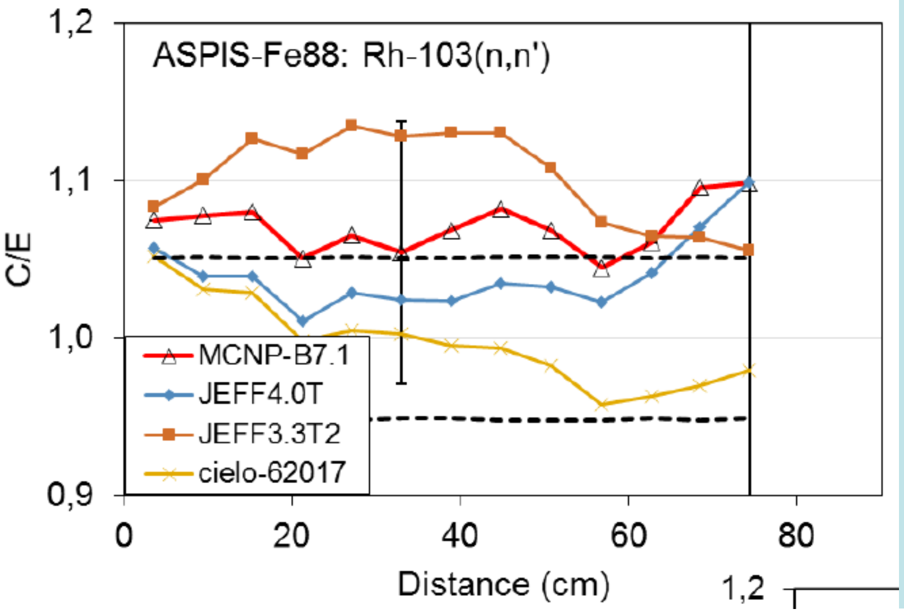
ASPIS IRON-88

I. Kodeli, B. Kos
JSI, Ljubljana, Slovenia





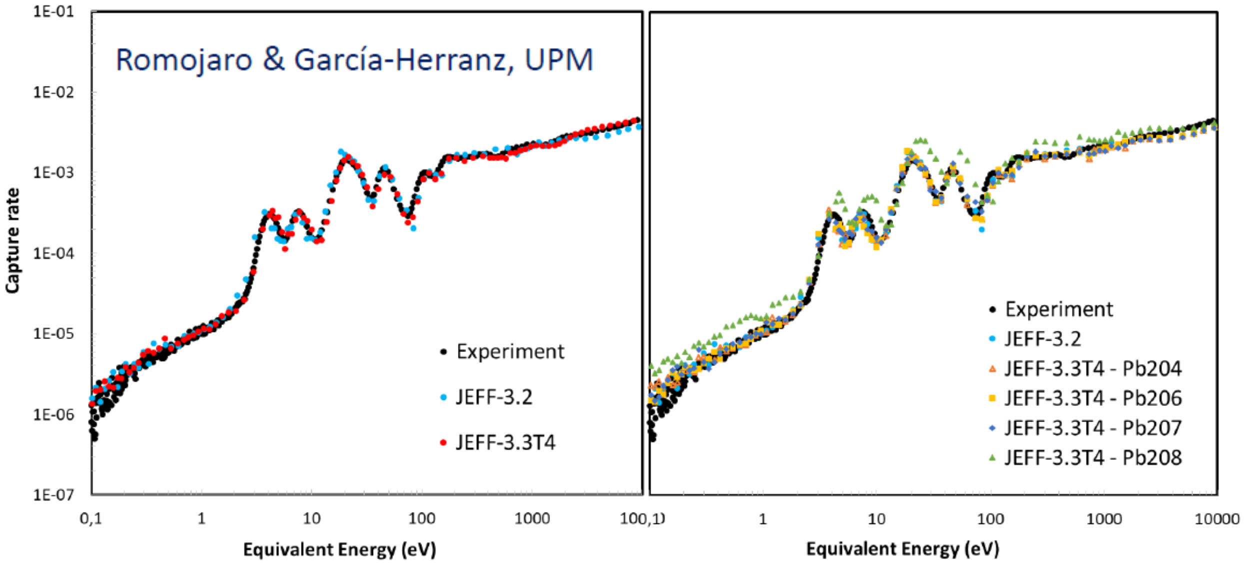


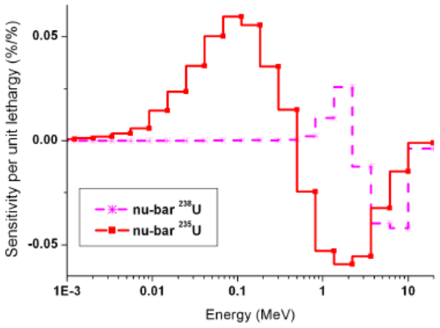


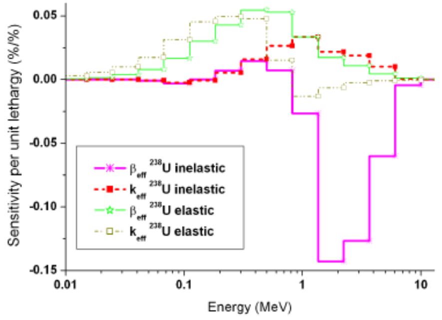
Institut "Jožef Stefan" Ljubljana, Slovenija

β_{eff} results (Big Ten)

Big Ten β_{eff} [pcm]	Benchmark	SUSD3D	MCNP6 p. k-ratio	MCNP6 (KOPTS)	C/E p. k-ratio	C/E KOPTS	C/E k_{eff}
Experiment	720 ± 7						
ENDF/B-VII.0		720	723 ± 4	725 ± 5	1.00	1.01	0.99969
ENDF/B-VII.1			719 ± 4	732 ± 5	1.00	1.02	0.99948
JEFF-3.2			752 ± 4	743 ± 5	1.04	1.03	0.99954
JEFF-3.3T2			752 ± 4	743 ± 5	1.04	1.03	1.00013
JEFF-3.3T4			728 ± 4	727 ± 5	1.01	1.01	0.99991
CIELO			720 ± 4	719 ± 5	1.00	1.00	1.00066



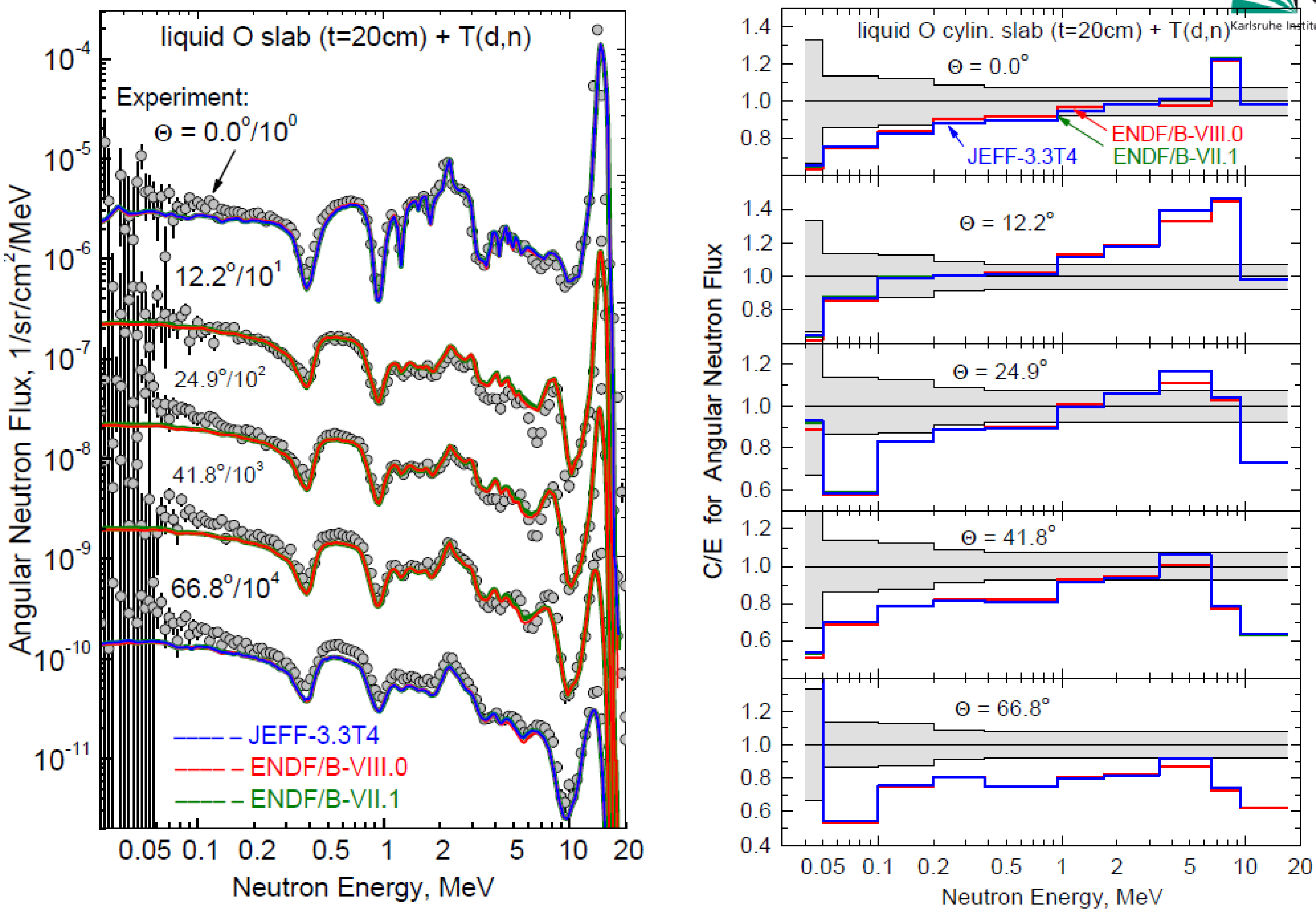




Prompt k-ratio -> prompt / (prompt + delayed)
KOPTS method -> based on iterated fission probability interpretation of adjoint flux

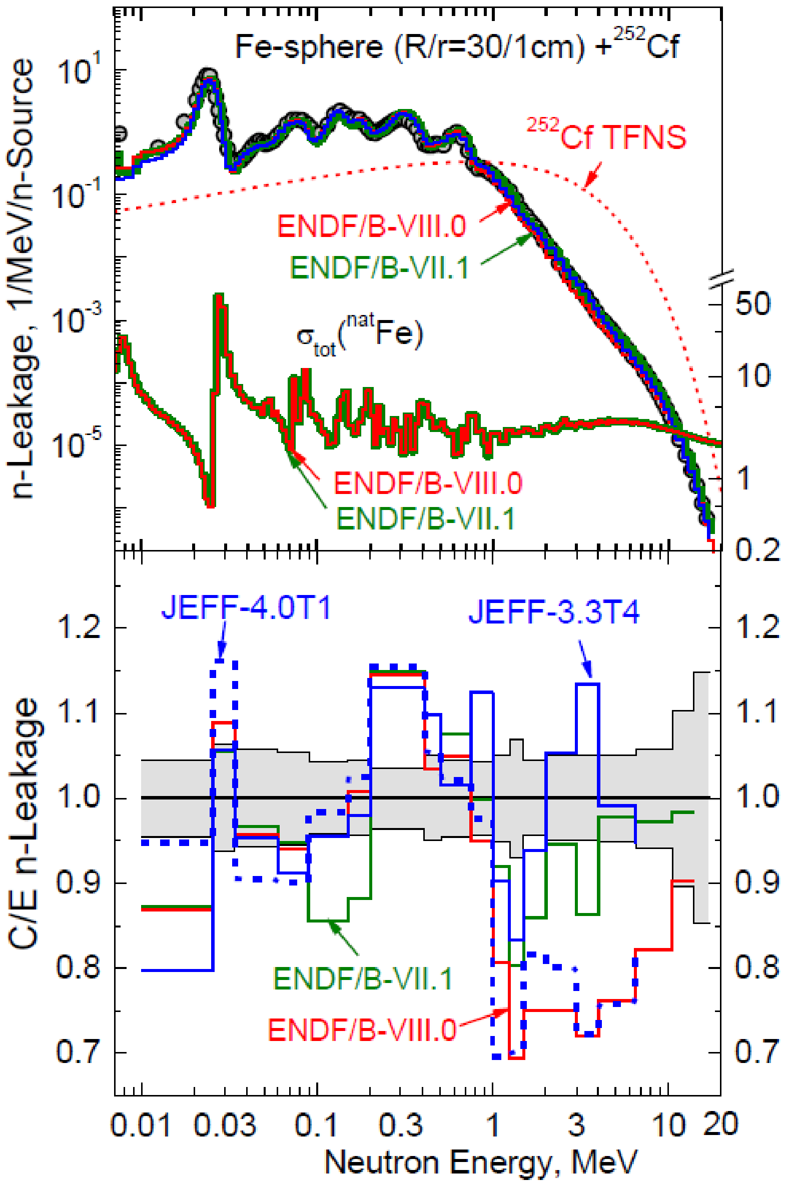
European Commission

I. Oxygen: Neutron Leakage from JAERI cylinder with D-T source



Findings: - ***JENDL-3.3T4 = ENDF/B-VII.1 and ENDF/B-VIII.0 are practically indistinguished***
- however among them, the ENDF/B-VIII.0 is slightly better

II a. Results for IPPE Fe sphere (Wall=29 cm) with ^{252}Cf(s.f.): Neutron Leakage



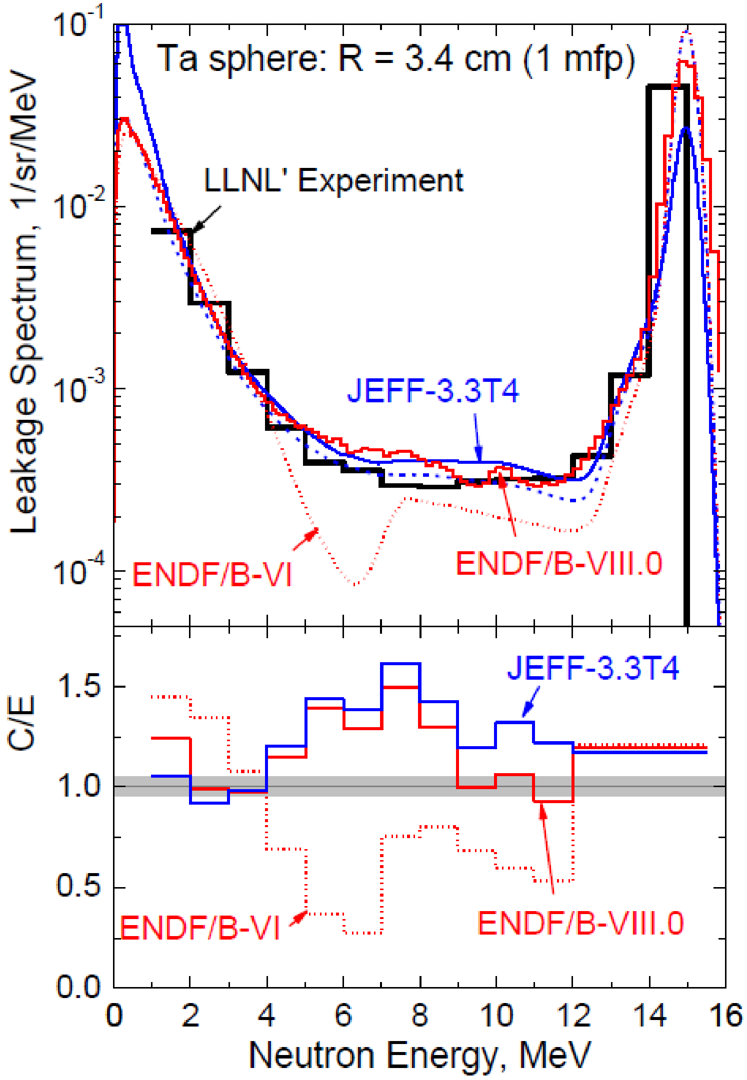
Before MCNP modelling we:

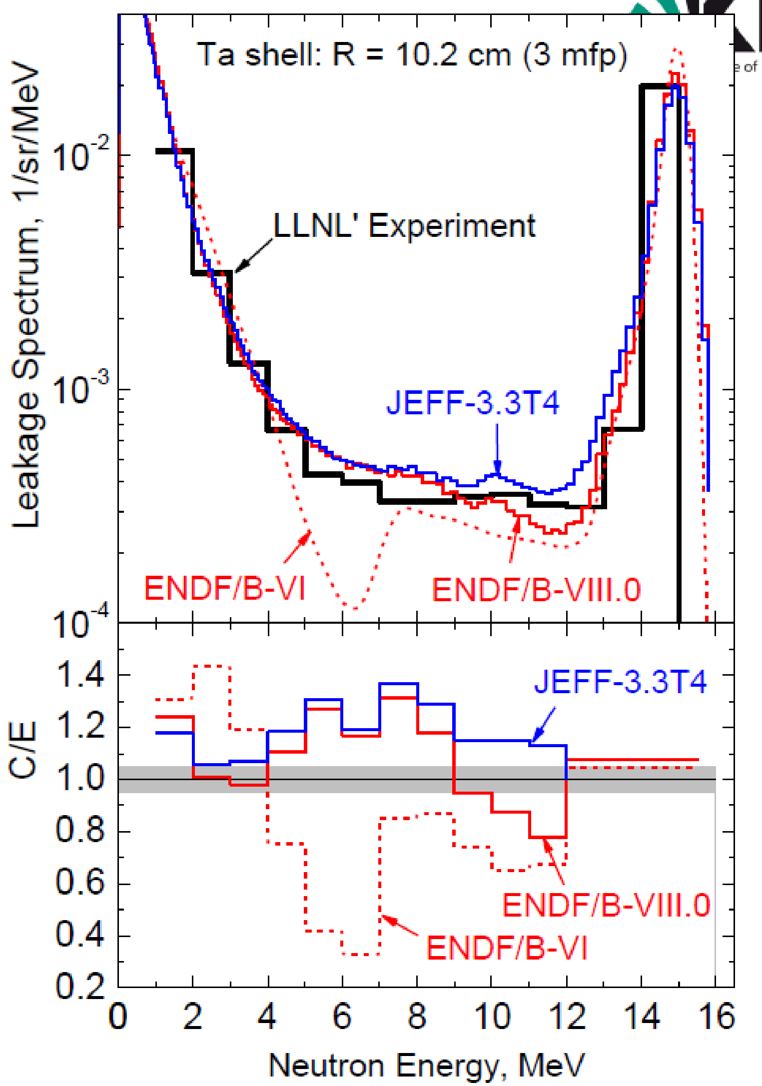
- **replaced ^{252}Cf(s.f.) neutron spectrum given in the ICSBEP MCNP input *(as Watt with Froehner parameters)* by PFNS Standard *(Mannhart evaluation), vp = 3.7590***
- **added delayed neutrons (*vd = 0.0086*) with DFNS spectrum from ENDF/B-VII.1**

Observations from C/E comparison:

JEFF-3.3T4 looks even more preferable than others

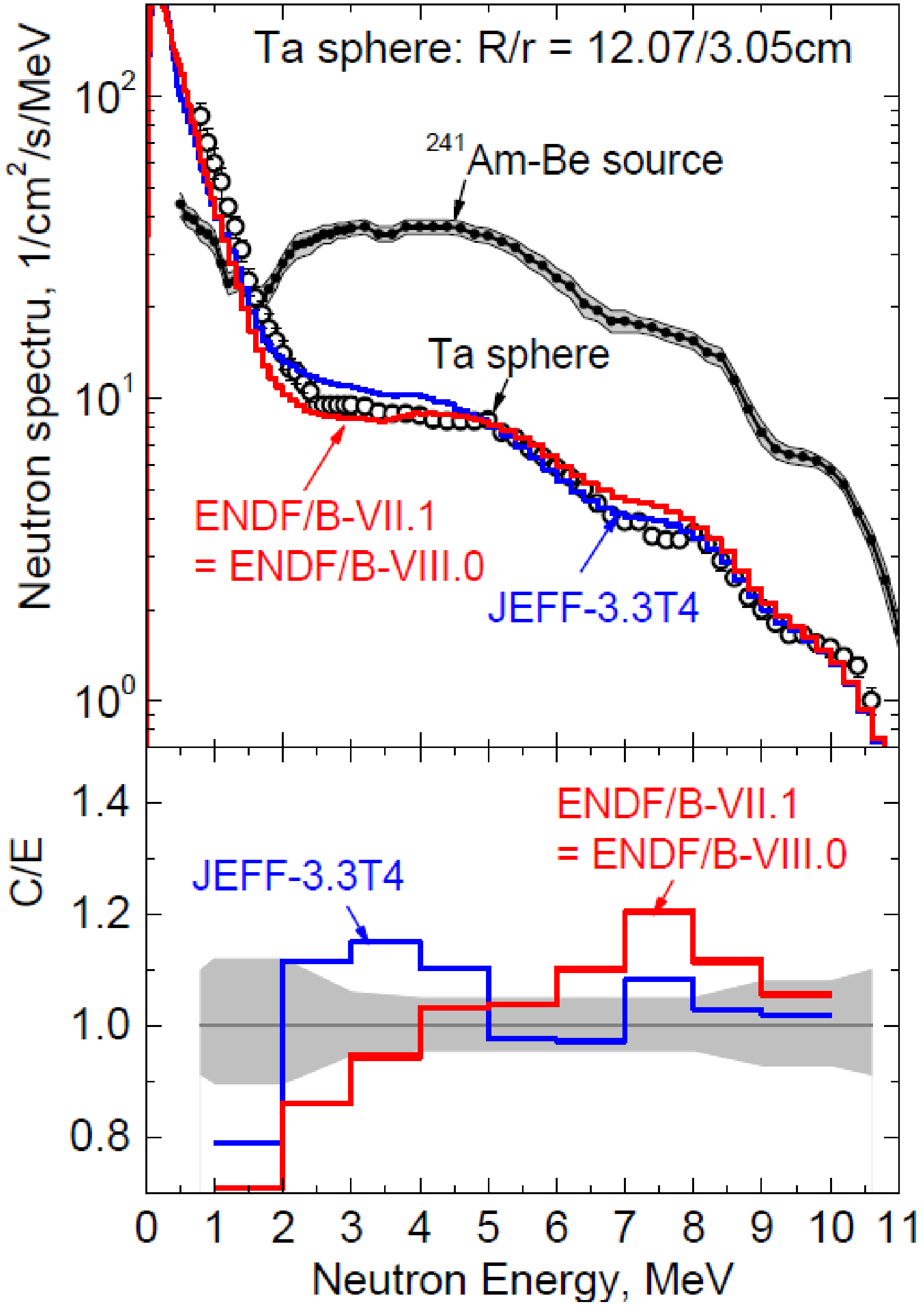
III. Ta: Results – Neutron Leakage from two LLNL Spheres with D-T source





Observations: *- ENDF/B-VIII.0 & JEFF-3.3T4 equally and nearly reasonable reproduce LLL spheres*
- essential progress is observed when comparing with previous versions (ENDF/B-VI)

III. Ta: Results - Neutron leakage from Lewis Sphere with Am-Be source



Observations:

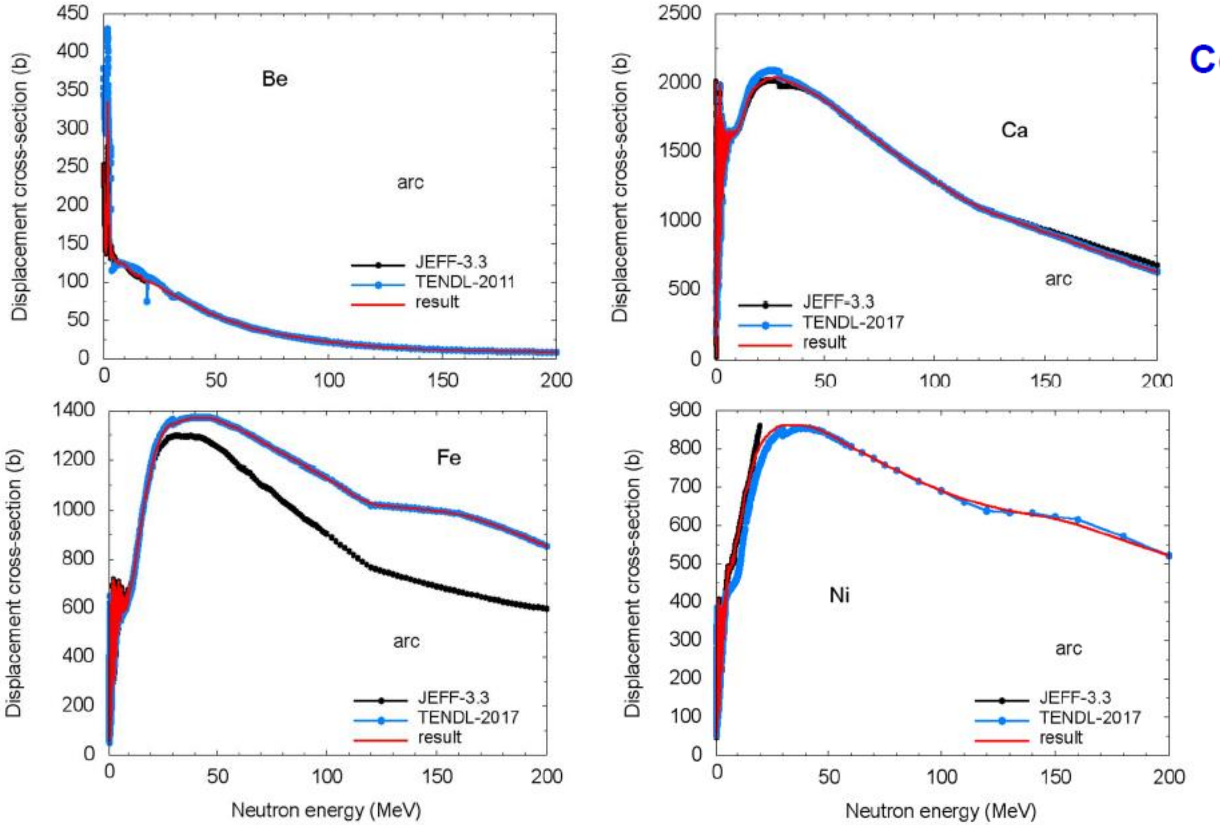
- ***JEFF-3.3T4** reasonably agrees with this benchmark*

- ***ENDF/B-VII.1 = ENDF/B-VIII.0** (both based on TALYS) seem behave a bit worse than **JEFF-3.3T4***

DPA, Konobeev

1. JEFF-3.3 extension using TENDL-2017

Karlsruhe Institute of Technology



Conclusion

Atomic displacement cross-sections were obtained for materials from Be to Bi using arc-dpa and NRT model

Main improvements compared to DXS-2017:

- JEFF-3.3 + TENDL-2017
- calculations applying CEM03 and ECIS at energies above 50 MeV
- arc-dpa model with BCA corrections for Al, Fe, Cu, and W

Analysis of the JEFF-3.3 library for the UQ of Gen-IV reactor concepts

P. Romojaro, F. Álvarez-Velarde

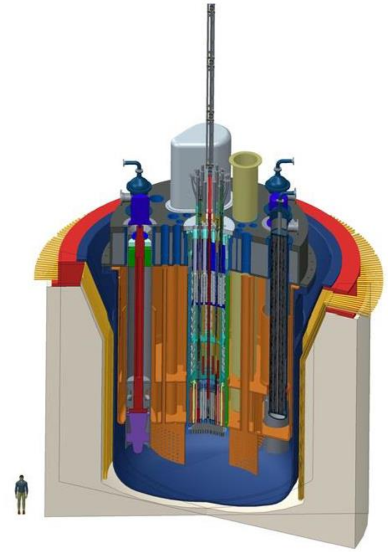
pablo.romojaro@ciemat.es, francisco.alvarez@ciemat.es

CIEMAT – Nuclear Innovation Unit

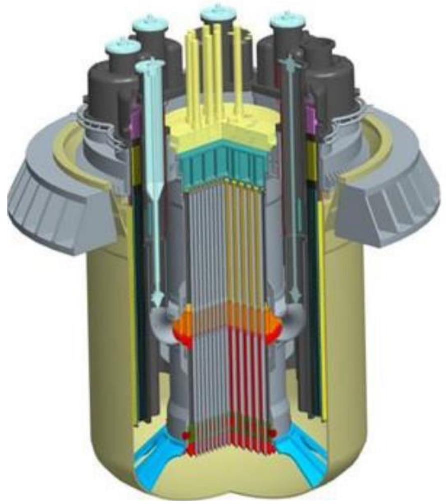
GOBIERNO DE ESPAÑA | MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD | Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

JEFF Meeting – CIEMAT (Madrid), April 18th – 20th, 2018

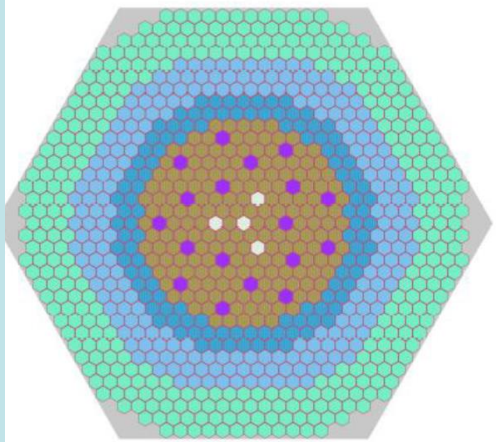
MYRRHA



ALFRED



ASTRID



- **Significant gaps between current uncertainties and target accuracies have been shown in the past**

Target accuracy for fast reactors k_{eff} = 300 pcm*

- **Objective: benchmarking and UQ analysis with state-of-the-art ND for Gen-IV reactor concepts**
  - **MYRRHA** (Multi-purpose hYbrid Research Reactor for High-tech Applications)
  - **ALFRED** (Advanced Lead Fast Reactor European Demonstrator)
  - **ASTRID** (Advanced Sodium Technological Reactor for Industrial Demonstration)

European Commission

	MYRRHA			ALFRED			ASTRID		
	JEFF-3.2	JEFF-3.3	Difference	JEFF-3.2	JEFF-3.3	Difference	JEFF-3.2	JEFF-3.3	Difference
k_{eff}	1.00475	1.00722	+247 pcm	0.99220	0.99937	+717 pcm	0.99838	1.00252	+414 cpm
ν	2.930	2.908	-0.8 %	2.937	2.914	-0.8 %	2.932	2.913	-0.7 %
Total fission probability	0.343	0.346	+1.0 %	0.338	0.343	+1.5 %	0.340	0.344	+1.1 %
Total capture probability	0.664	0.660	-0.5 %	0.635	0.632	- 0.4 %	0.657	0.654	-0.6 %

MYRRHA – ISC (%/%)

Quantity		JEFF-3.2	JEFF-3.3
^{239}Pu	ν	0.694	0.696
^{239}Pu	(n,f)	0.484	0.482
^{238}U	(n,γ)	-0.114	-0.112
^{240}Pu	ν	0.081	0.081
^{239}Pu	(n,γ)	-0.057	-0.053

- **Reactivity increase** in MYRRHA, ALFRED and ASTRID **with JEFF-3.3**
- **JEFF-3.2 and JEFF-3.3** yield **similar ISC and sensitivity profiles**
- **Good agreement** between **JEFF-3.3 and ENDF/B-VIII.0** for **total k_{eff} uncertainty** in reactor concepts
- Very **different magnitude and contributors to the total uncertainty**
- **k_{eff} target accuracy is exceeded at least by a factor of two for all considered reactors**

Calculation of Integral experiments with the MORET 5 code in support to the validation of JEFF-3.3 nuclear data

IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

Selection of 238 cases covering:

- FAST energy range,
- INTERMEDIATE energy range,
- THERMAL energy range,
- SPECIAL isotopes (^{233}U, ^{237}Np,..)

LECLAIRE Nicolas

April, 19th 2018

Conclusions (comparison 3.3t3/3.3)

Thermal energy spectrum

- No deterioration or improvement of results for Pu, LEU and MOX in lattices
- Slight improvement of results for LEU, HEU solutions in water due to 0_{16}, **<u>except for lead as reflector</u>**
- Improvement of results for solutions in heavy water: TSL of H_2-D_2O and O_{16}-D_2O
- Improvement of results for uranium when compared with JEFF-3.2

Intermediate energy spectrum

- Slight improvement of results with Cu JEFF-3.3 in ZEUS experiments
- Deterioration of results with ^{56}Fe JEFF-3.3 in the fissile

Fast energy spectrum

- Pu without reflector: no improvement of results
- HEU without reflector: good agreement and improvement when compared with JEFF-3.2

Conclusions (continued)

Fast energy spectrum

- Deterioration of k_{eff} results for systems with Fe (JEFF-3.3/JEFF-3.3t3)
- Still bad results for systems with CH_2 reflectors : evaluation?, processing?
  - Better results with JEFF-3.2

Analysis based on a restricted number of experiments

- Focus on few isotopes
  - Main tendencies highlighted
- Need to go more deeply to explain all the results (compensation between various isotopes)

To be done:

- Use of sensitivity coefficients to better understand trends

JEFF 3.3 processing

- Processed with NJOY 2016.03

- NOT every nuclide "passes":
  - Am243: small error in first lines of ENDF: "9549" instead of "9543", corrected.
  - BE-METAL: error of space in temperatures in ENDF, corrected
  - Zr92, Zr94, Sn116, Sn117: make NJOY crash
  - Be9, Ar39, Cs135 (run but no covariance produced)
  - D-D2O and O-D2O: Problem of numbering of lines (absent), but OK for NJOY

Raphaëlle ICHOU
Clément JEANNESSON

- The case of probability table with negative val
  - Ag109
  - Hf174
  - Np238
  - Cf252

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Faire avancer la sûreté nucléaire

Feedback on JEFF 3.3 processing with GAIA 1.1

Raphaëlle ICHOU
Clément JEANNESSON

- The case of non-positive elastic cross sections – RECONR:

---message from emerge---nonpositive elastic cross sections found.

  - JEF 2.2: 61Ni, 128Te, 152Eu, 154Eu, 157Gd, 176Lu, 185Re, 240Pu, 241Am, 244Cm
  - JEFF 3.1: 40Ar, 61Ni, 111Cd, 113Cd, 128Te, 157Gd, 182W, 244Cm
  - JEFF 3.2: 32Si, 36S, 40Ar, 61Ni, 128Te, 152Gd, 157Gd, 240U
  - JEFF 3.3: 40Ar, 61Ni, 152Gd, 157Gd, 240U

Validation of JEFF-3.3 and ENDF/B-VIII.0 on SCK•CEN projects

Alexey Stankovskiy

SCK•CEN, Belgium
astankov@sckcen.be

Contributions:
A. Krása, D. Gérard (SCK•CEN)
K.-H. Schmidt

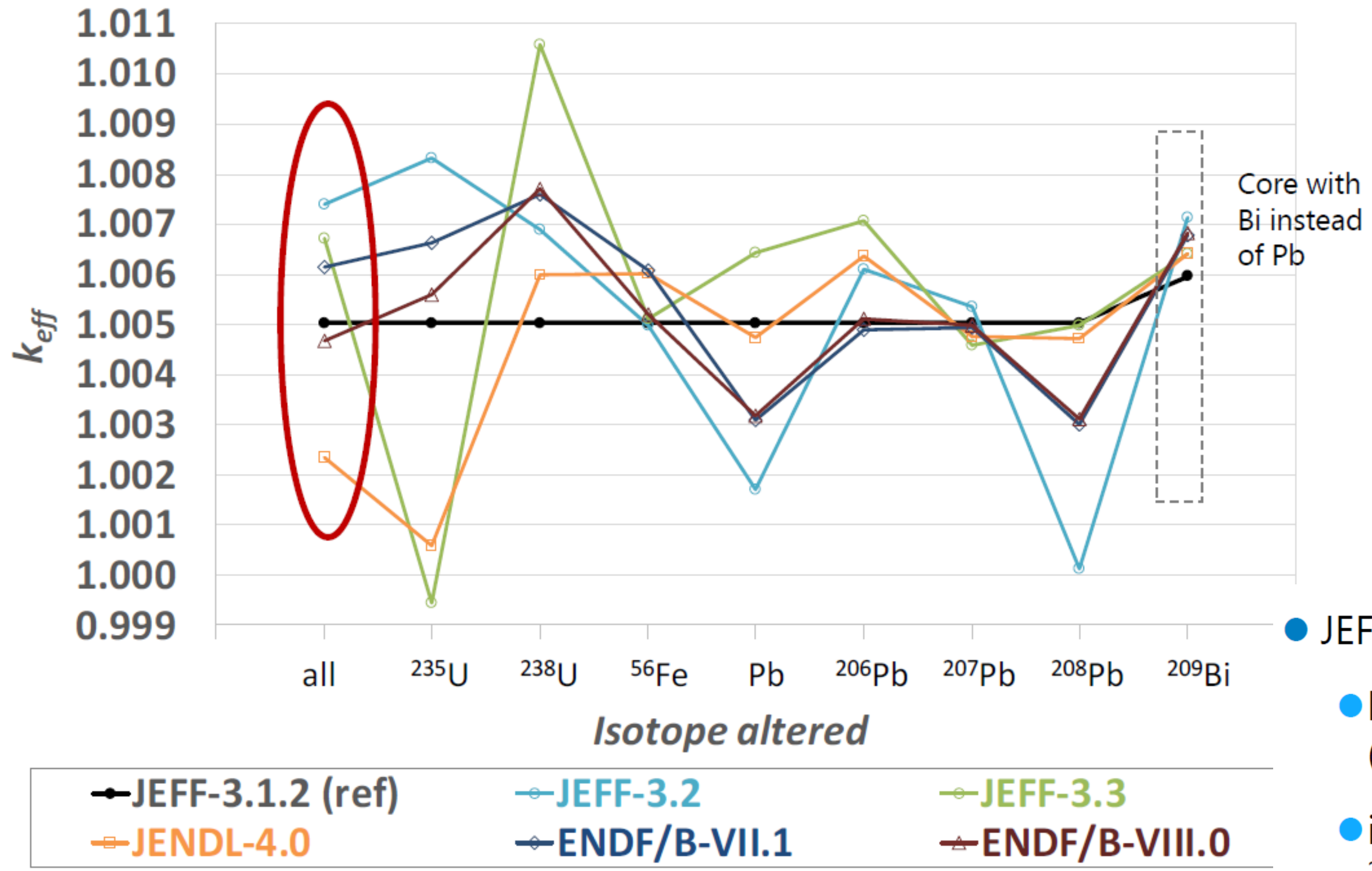
- VENUS-F fast spectrum zero power facility
- Decay heat benchmark

SCK•CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

MYRRHA

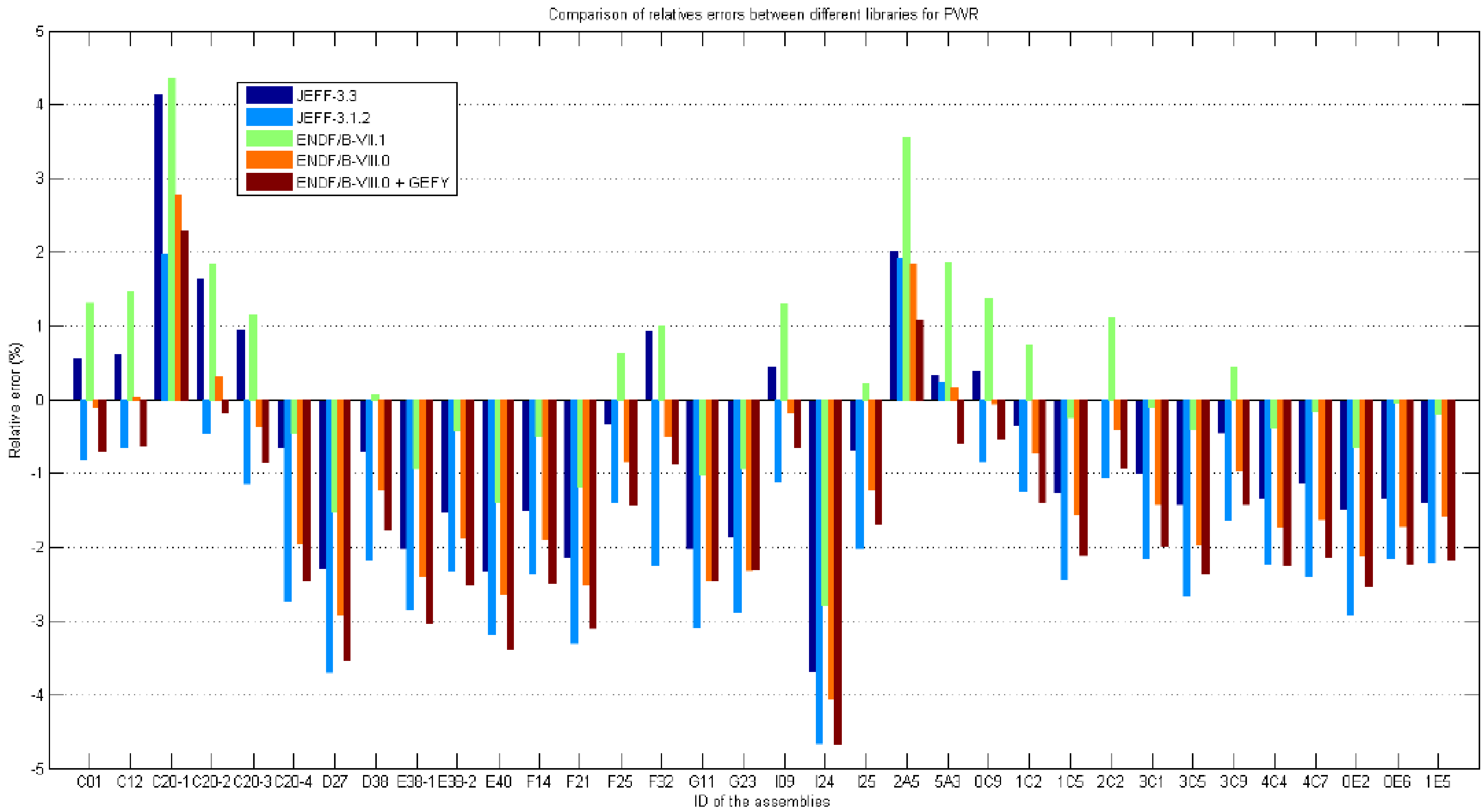
European Commission

ND validation at VENUS-F



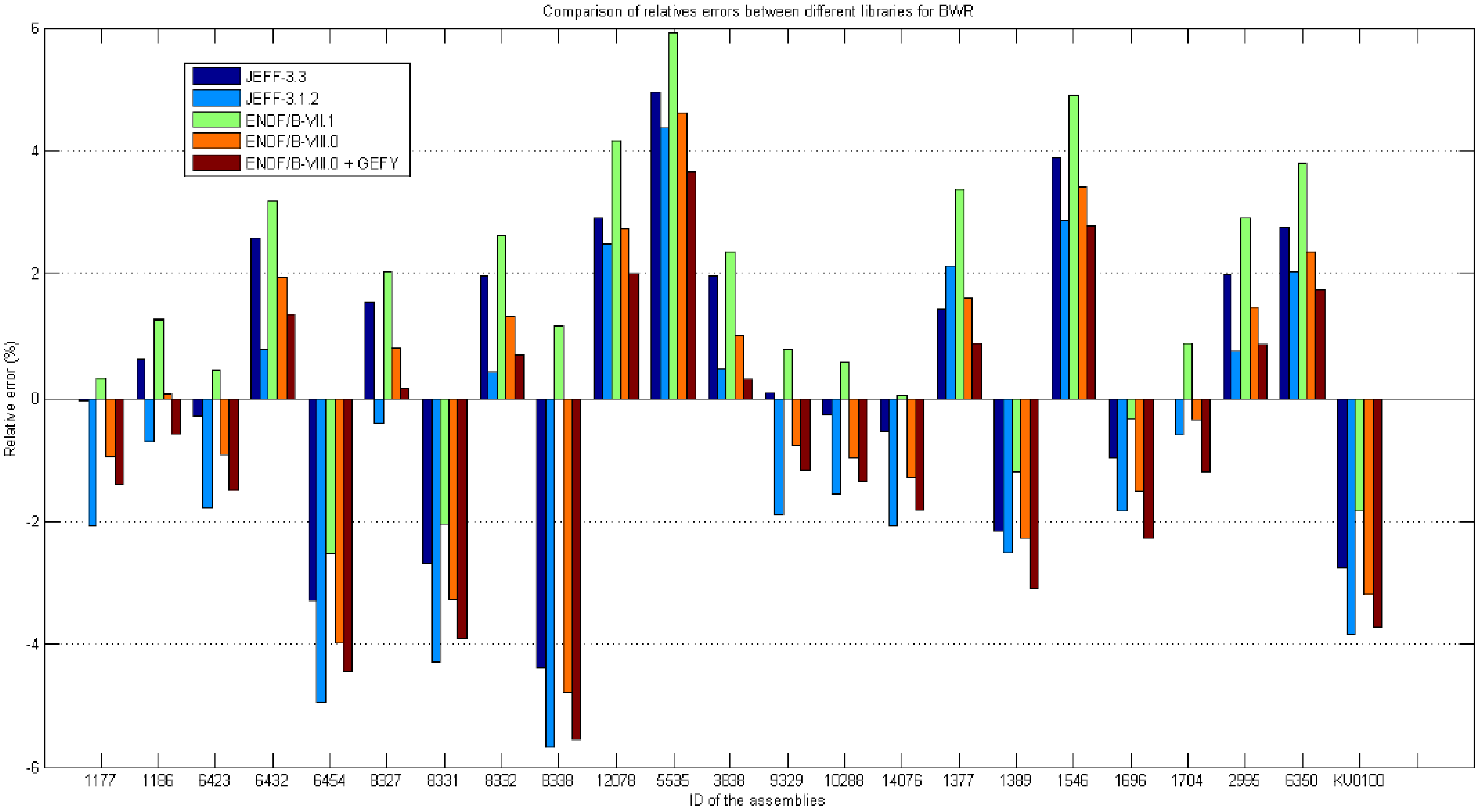
- JEFF-3.3 compared to JEFF-3.2
  - large change for ^{235}U (-890 pcm) and ^{238}U (+370 pcm), ^{208}Pb (+485 pcm)
  - intermediate change for ^{206}Pb (+100 pcm), ^{207}Pb (-80 pcm), ^{209}Bi (-70 pcm)
  - small change (-70 pcm) when altering all isotopes
- ENDF/B-VIII.0 compared to ENDF/B-VII.1
  - change only for ^{235}U (-100 pcm) and ^{56}Fe (-90 pcm)
  - -150 pcm when altering all isotopes

Decay heat of PWR assemblies



ENDF/B-VIII.0 vs ENDF/B-VII.1: consistent decrease → globally worsening
JEFF-3.3 vs JEFF-3.1.2: consistent increase → globally improvement

Decay heat of BWR assemblies



NDF/B-VIII.0 vs ENDF/B-VII.1: consistent decrease → globally worsening

EFF-3.3 vs JEFF-3.1.2: consistent increase → globally improvement

PWR and BWR

PWR assemblies

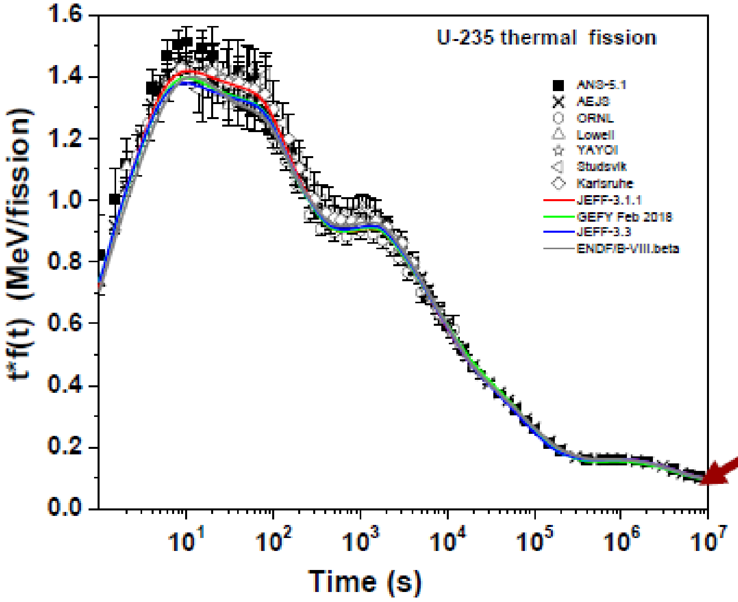
	C/E-1, %	χ^2
ENDF/B-VII.1	0.27	2.61
ENDF/B-VIII.0	-1.18	4.57
ENDF/B-VIII.0+GEFY	-1.70	6.79
JEFF-3.1.2	-1.85	7.97
JEFF-3.2	-1.75	7.72
JEFF-3.3	-0.61	3.64

BWR assemblies

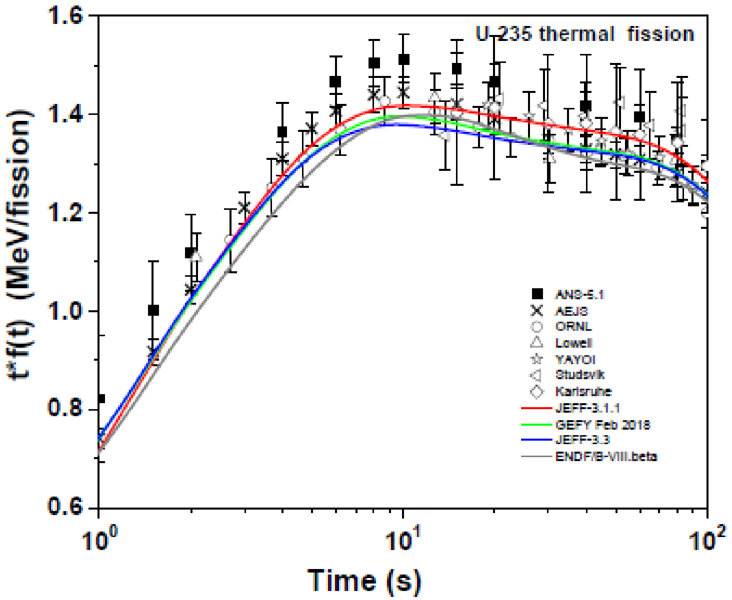
	C/E-1, %	χ^2
ENDF/B-VII.1	1.43	1.93
ENDF/B-VIII.0	-0.03	2.09
ENDF/B-VIII.0+GEFY	-0.76	2.14
JEFF-3.1.2	-0.77	2.50
JEFF-3.2	-0.61	2.40
JEFF-3.3	0.40	1.78

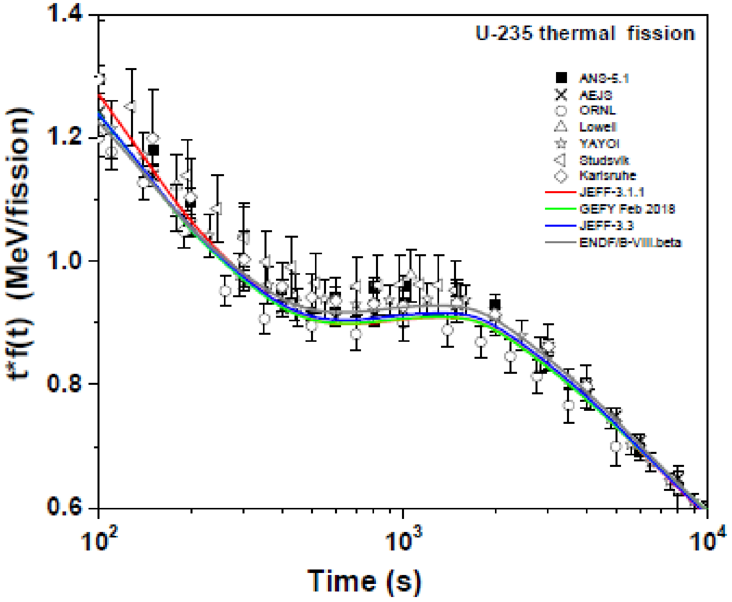
- ENDF/B-VII.1 wins
- BWR results better than PWR for all libs
- JEFF-3.3 better than JEFF-3.1.2 and JEFF-3.2

^{235}U FPDH

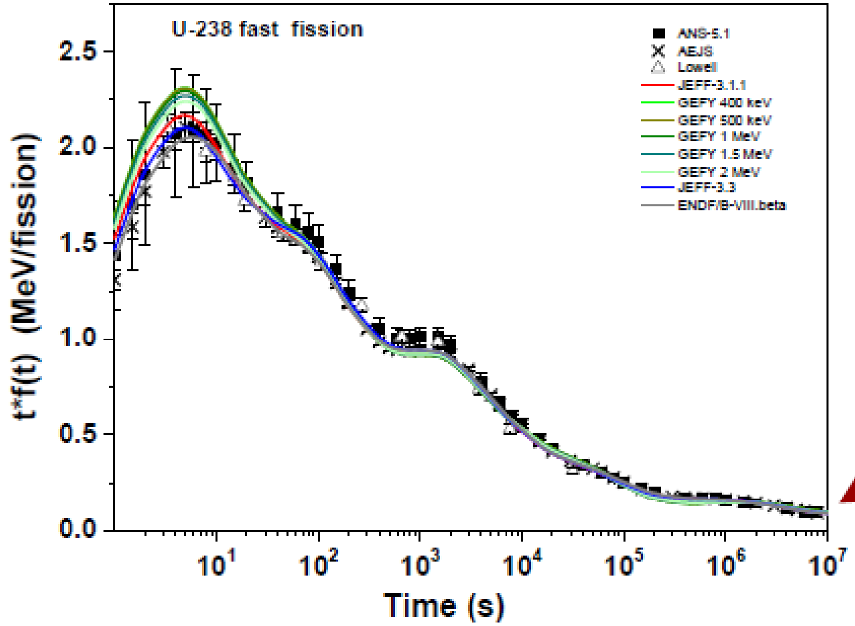


Differences < 6%

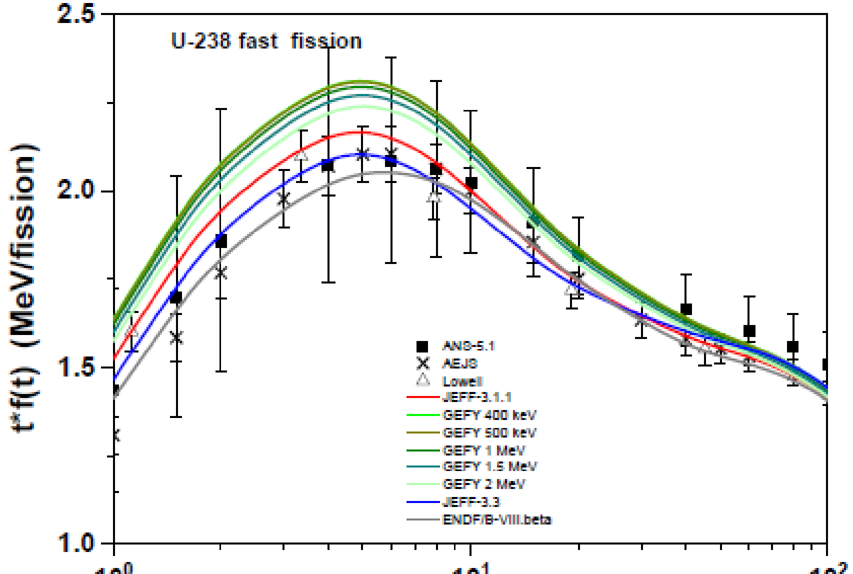


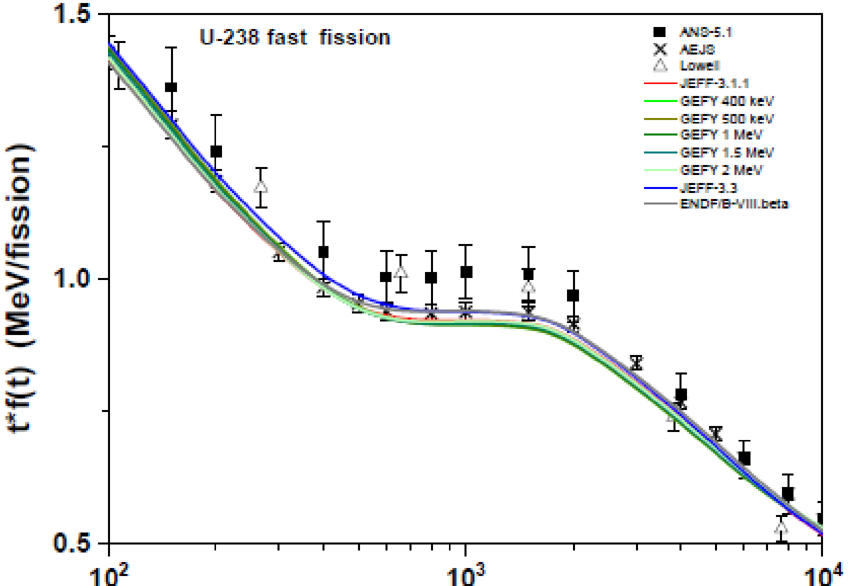


^{238}U FPDH



Differences < 4%





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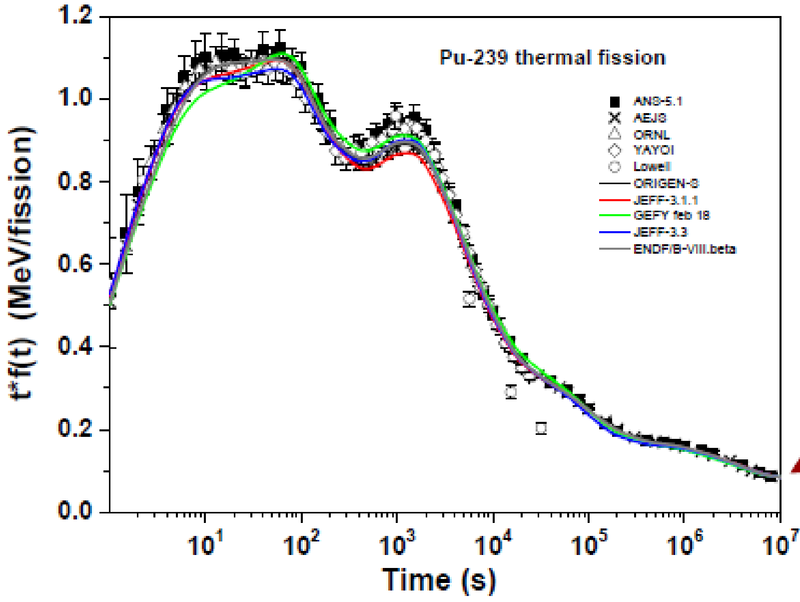
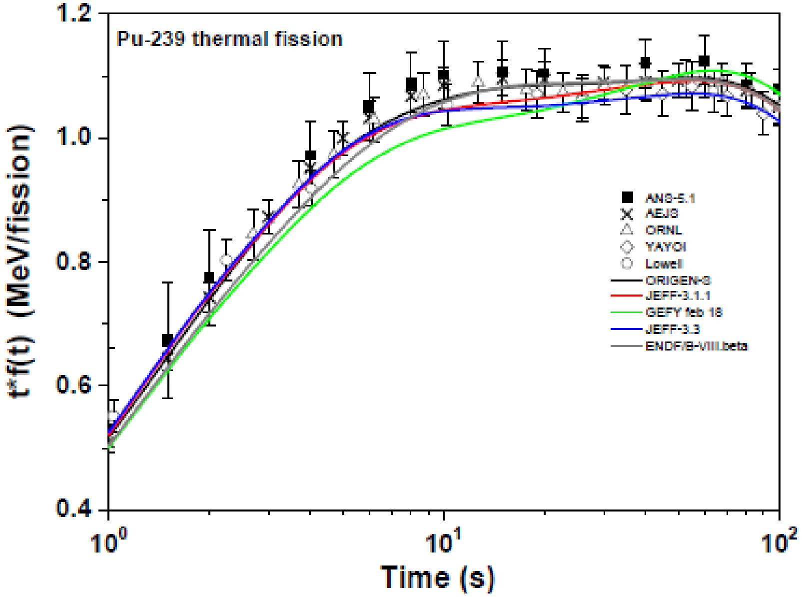
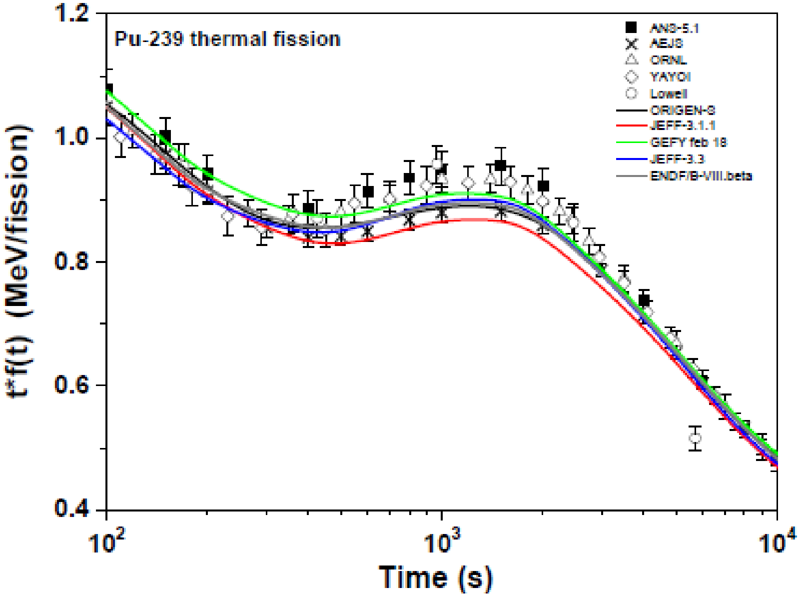
^{239}Pu FPDH



Differences up to 15%





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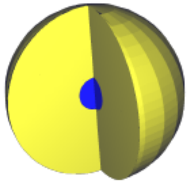
Summation calculations and validation with integral experiments

A. Sánchez, D. Cano-Ott, E. Mendoza, P. Romojaro

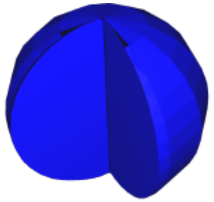
CIEMAT– Unidad de Innovación Nuclear

Type 1:

Natural U reflector



Type 2:



Name	Relative contribution to β_{eff} (%)	Description
POPSY	52.5% ^{239}Pu, 40.9% ^{238}U	Pu core
TOPSY	72.7% ^{235}U, 25.4% ^{238}U	HEU core
JEZEBEL	90.9 ^{239}Pu, 7.1% ^{240}Pu	Bare Pu sphere
SKIDOO	97.2% ^{233}U, 1.3% ^{238}U	Bare ^{233}U sphere
FLAT-TOP 23	65.7% ^{233}U, 30.3% ^{238}U	^{233}U core

Standard evaluated libraries **JEFF-3.3** and **ENDF/B-VIII.0**

In addition, **4 modified libraries** are used (for each *standard* library):

- **V01**: ν_d (and total) replaced with new values from **summation calculations** of the main fissioning systems using **fission yields and decay data from standard library**.
- **V02**: ν_d (and total) replaced with new values from **summation calculations** of the main fissioning systems using fission yields and decay data from standard library **complemented with new evaluated IAEA CRP P_n values (Oct. 2017)**.
- **V03**: ν_d (and total) replaced with new values from **summation calculations** of the main fissioning systems using **FY from JEFF-3.3** and **decay data from ENDF/B-VIII.0**.
- **V04**: same as V03 but also it **adds the new evaluated P_n values**.

Main fissioning systems: ^{233}U, ^{235}U, ^{238}U and ^{239}Pu

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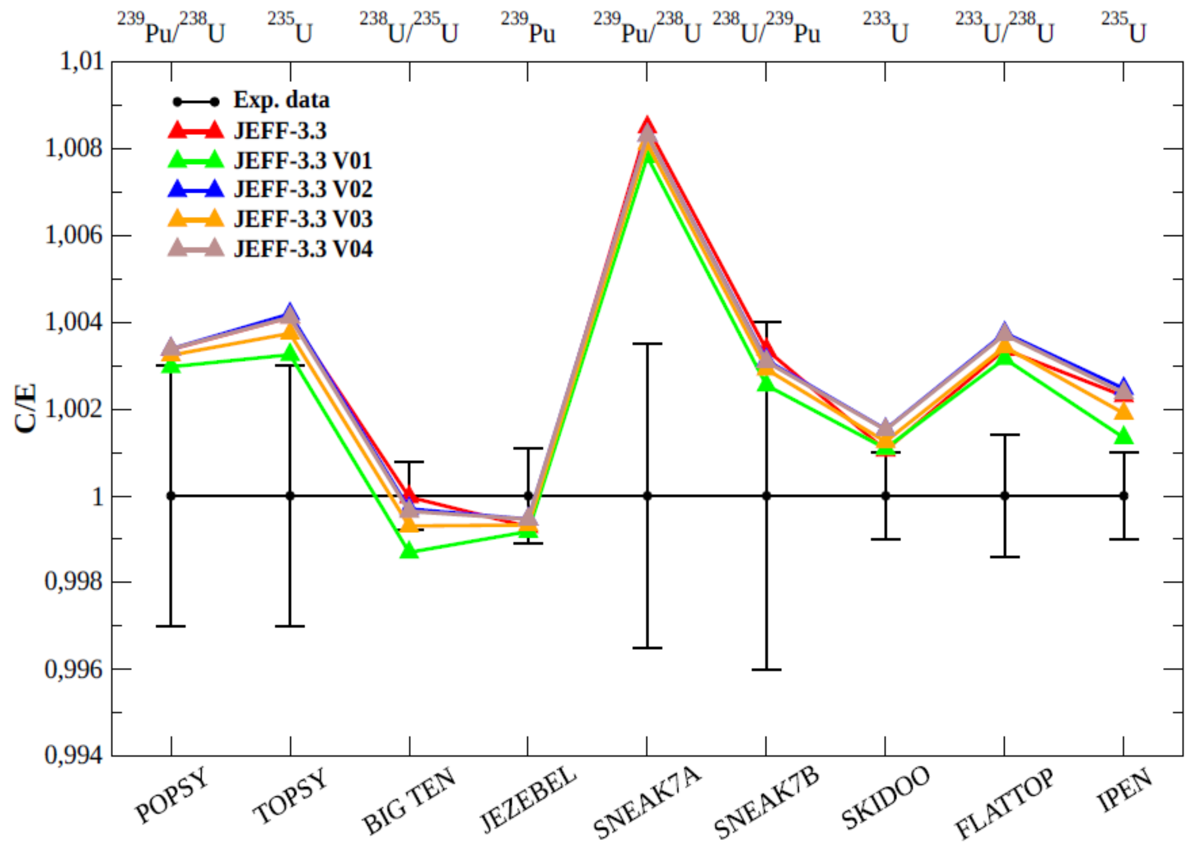
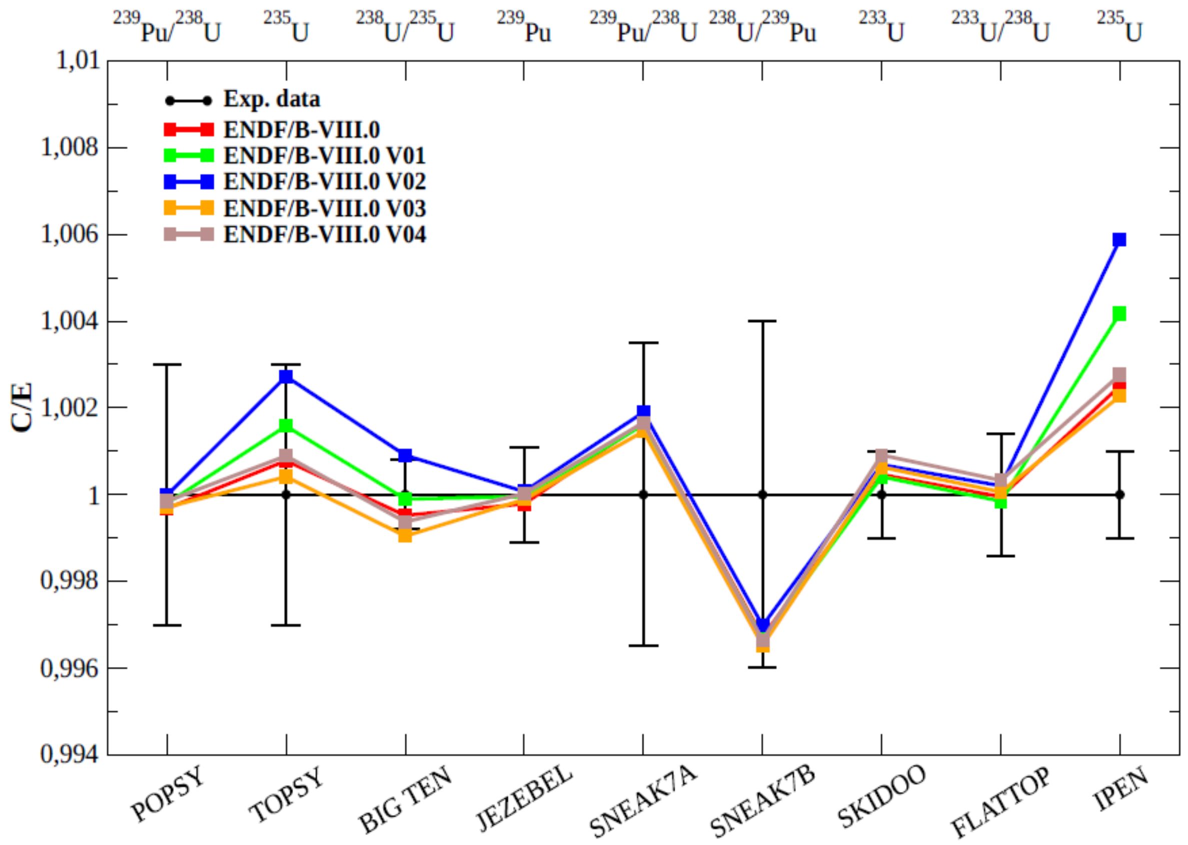
k_{eff} results (JEFF-3.3)



k_{eff} results (ENDF/B-VIII.0)



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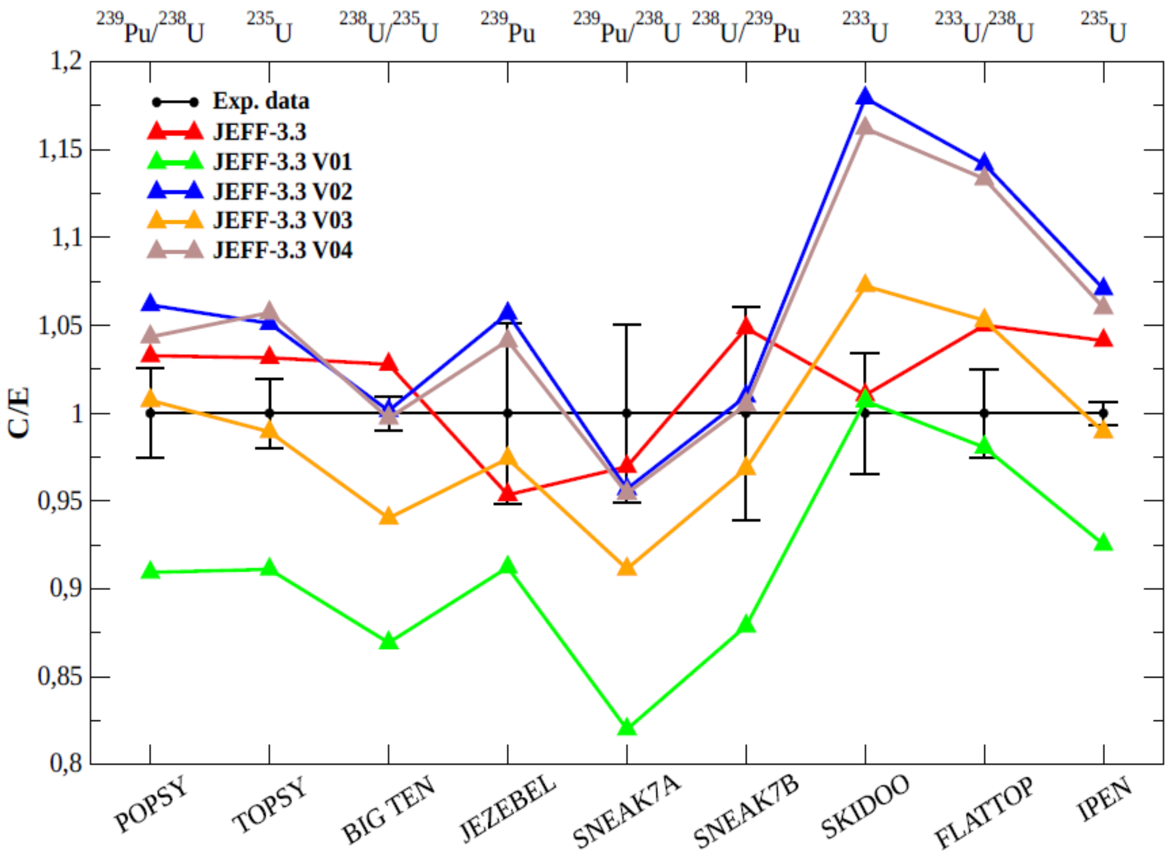
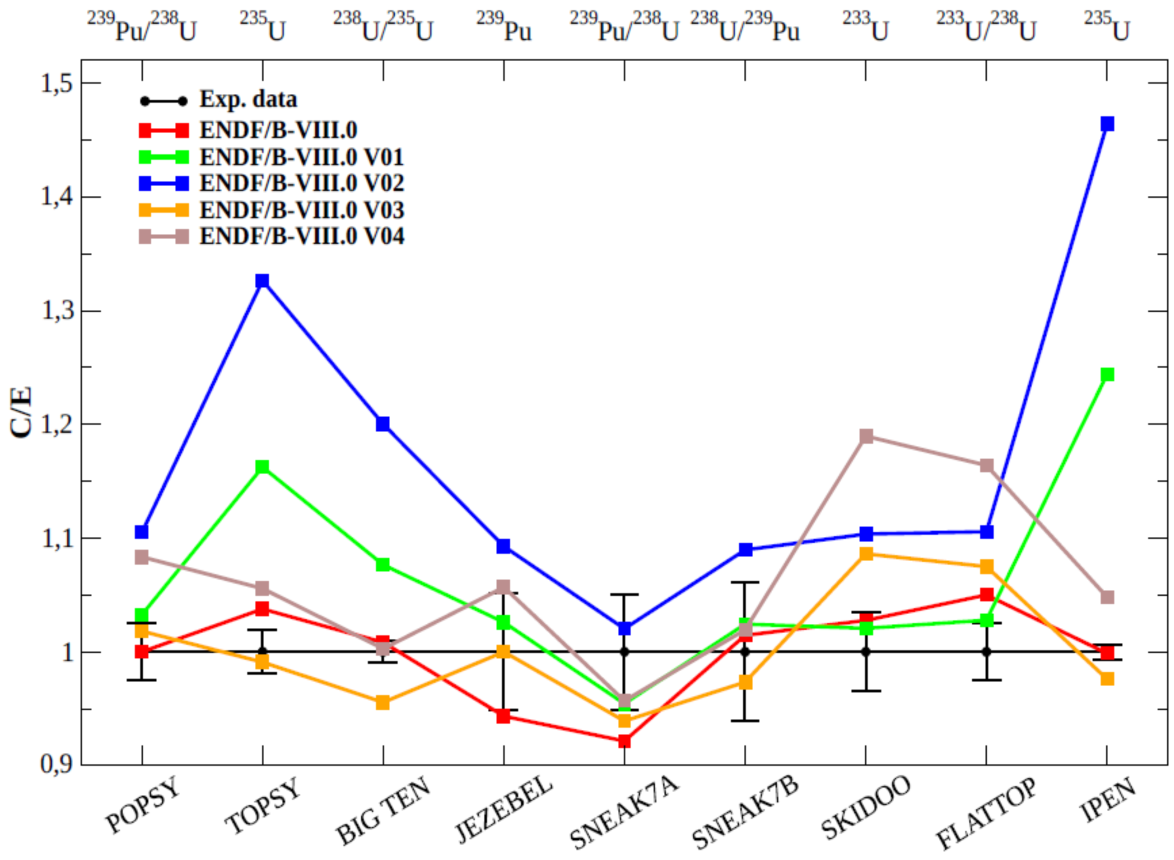
β_{eff} results (JEFF-3.3)



β_{eff} results (ENDF/B-VIII.0)



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Summary and conclusions

- k_{eff} shows **negligible effects** when modifying delayed neutron yields
- When new **P_n values** added, ν_d always incremented
- In both *standard* libraries, ν_d of **^{238}U seems to be overestimated**, when compared with experiment
- ENDF/B-VIII.0 shows slightly better agreement in β_{eff}
- Using **FY from JEFF-3.3** and **decay data from ENDF/B-VIII.0** in summation calculations seems to yield **good results**
- The β_{eff} benchmark should be extended to more **integral experiments**

The future

- Towards JEFF-4

Challenges for evaluated data libraries

• Evaluated	Best available knowledge for the user.
• Completeness	All required data should be available to the user.
• Reliability	Success should be independent of the application.
• Accuracy	Uncertainties less than 5%, 2%, … 0.3%.
• Covariances	Users need to know how good the data are. They need to handle that knowledge quantitatively for propagating uncertainty and safe margins.

Best available knowledge.

Best science, as complete as we can, for applications

- Either from models or from experiment.
- Evaluators must judge which should prevail.
- We must master assembling files with best input for its parts.

- Checking is absolutely essential.

- Automation will continue to mature further as a means.

JEFF-4.0

First **true** general purpose file

Serving all needs

Best physics estimates

completeness in sections and incident particles

Methods of production to be reconsidered.

Combination of model estimates and best data.

Take the TENDL approach as a starting point?

Variances, co-variances

Quality assurance of evaluations

automation of assembly, physics and format correctness, validation, transparency, traceability

Serving a wide-range of user codes

automation and quality assurance of processing

Knowledge management

Is the essence of what we are trying to achieve: bring scientific and technological key developments to the users!

Our goals must be realistic.

A lot of scientific and technology oriented work has not made it to the files and modeling codes yet, no matter how good it is.

Our goals should also be ambitious!

> ‘We shouldn’t have to put up with that.’

Why JEFF?

Harbor the interests in our community.

Large scale modeling

- Nuclear systems design, development and performance estimates.
- Emphasis on safety analyses
- Design and interpretation of experiments for cost effective development.

Recognized SNETP/SRIA & SRA

Recognized EUROSAFE

Trends

- Nuclear safety & economy
- Nuclear waste
- Security and emergencies
- Decommissioning

Sources of data needs

- Projects
- HPRL
- Sensitivity analyses
- Literature

Challenging needs require

- High quality experiments
- High quality calculations
- Good equipment & facilities

Your contributions to JEFF

We want to build the bridge across the gap between science and application.

This requires a joint work of experiments, evaluations, benchmarking and validation.

Your contributions are needed on all these aspects as the responsibility to build the bridge is a joint one.

It will be stronger if we can build it together.

Method development

- Rizzo Darwin PIE ND-adjustment (CEA)
- Voirin from FY experiments to new evaluations (CEA/CNRS)
- Rochmann, Correlations from integral constraints
- Noguere, NRA, thermal constants, thermal scattering
- Bauge, Identify and eliminate sources of uncertainty in nuclear modeling
- Bouland, Interpretation of surrogate reaction data to improve modeling
- De Saint Jean, Influence of systematic uncertainties on evaluations
- Schnabel, Modern statistical tools for global nuclear model assessments
- Jansky, understanding Fe shielding benchmark (Rez, IPPE)