The European Commission's science and knowledge service

Joint Research Centre

The Status of JEFF

The final steps to JEFF-3.3

Arjan Plompen

European Commission

JEFF

Joint Evaluated Fission and Fusion
nuclear data library

Originated as a European initiative
Hosted by the OECD-NEA Data Bank

All NEA member states (may) contribute
Example: KAERI
Files from ENDF/B, JENDL, CENDL, BROND

JEFF-3 history

JEFF-2.2, JEFF Report 17, April 2000

JEFF-3.0 33 MB, 340 materials, TSL: H/H2O, D/D20, Be, C, H/CH2

JEFF report 19, April 2005

JEFF-3.1 RDD+FY JEFF Report 20, September 2009

JEFF-3.1 381 materials, activation library from EAF/EFF 774 materials

RDD: 852 (226 stable)

FY: 19 nuclides n+A, 3 nuclides SF

Proton library: 26 materials

JEFF Report 21, November 2006

JEFF-3.1.1 Feedback from user validation: in use at AREVA

JEFF Report 22, May 2009

JEFF-3.1.2 Hf, Gamma production for FPs, bug-fixes, October 2011

European Commission

JEFF-3 history

JEFF-3.2 release, 5 March 2014

General purpose incident neutron energy data, 472 materials.

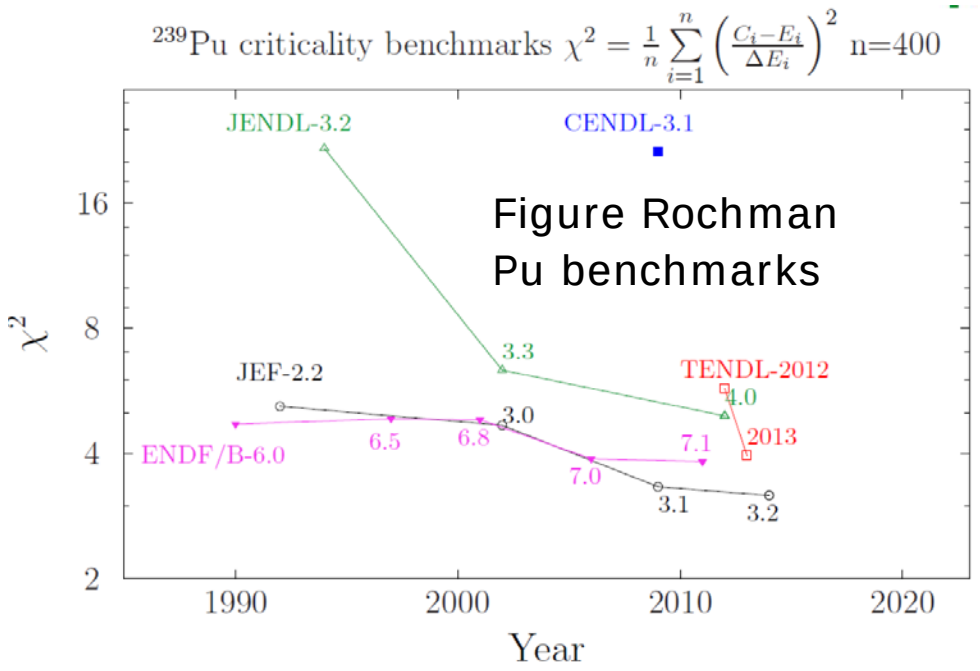
Thermal scattering data (9 cases for H, D, Be, C, Mg)

Incident proton library (Jan. 2009)

n-Induced and spontaneous fission yields library - 2006

Radioactive decay data - 2006

Activation library (Nov. 2003)



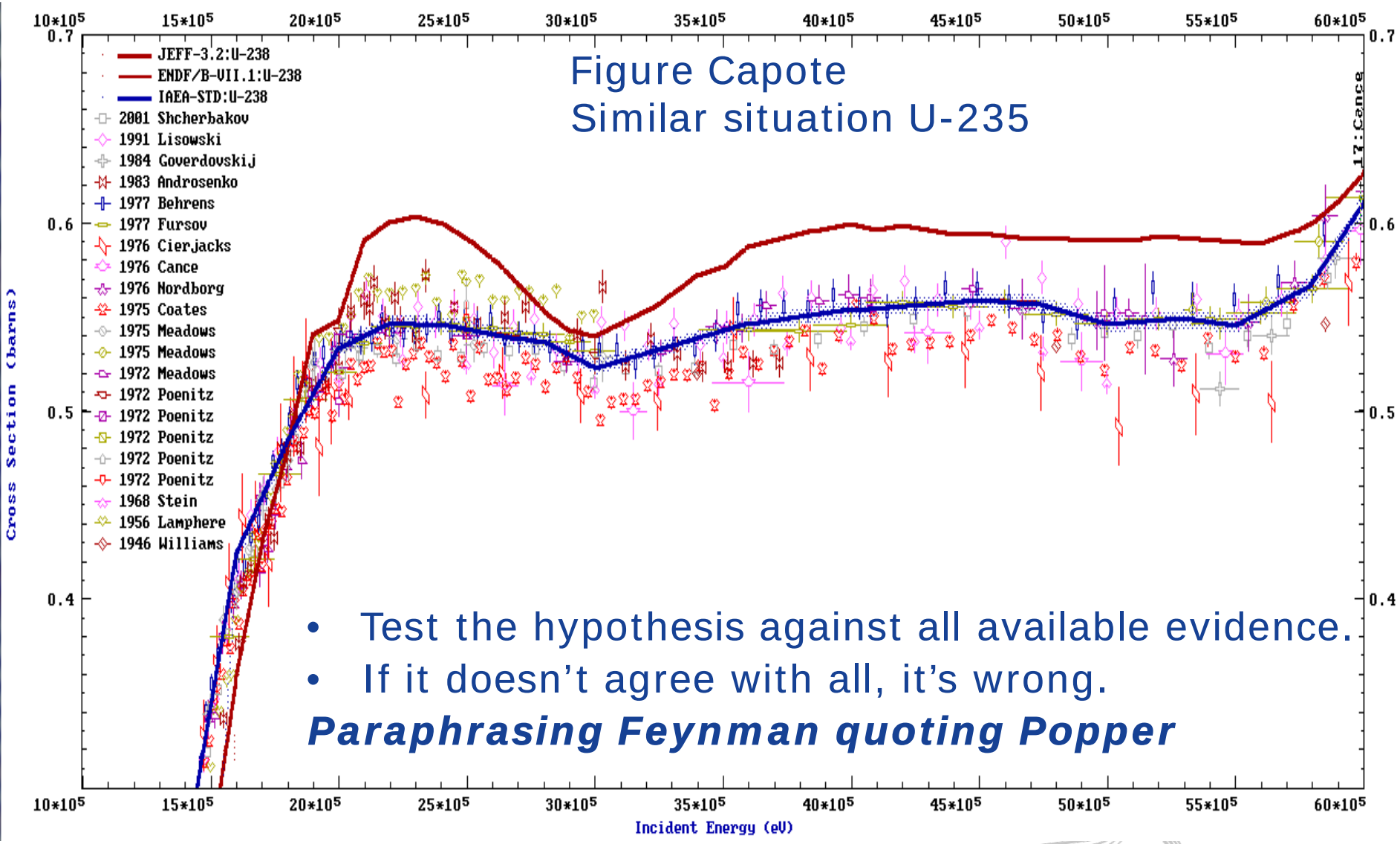
Example of performance

Clear continuous improvement

Still discrepant
How to do better?

European Commission

^{238}U(n,f) Data, JEFF-3.2, IAEA Standard eval.



- Test the hypothesis against all available evidence.
- If it doesn't agree with all, it's wrong.

Paraphrasing Feynman quoting Popper

European Commission

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

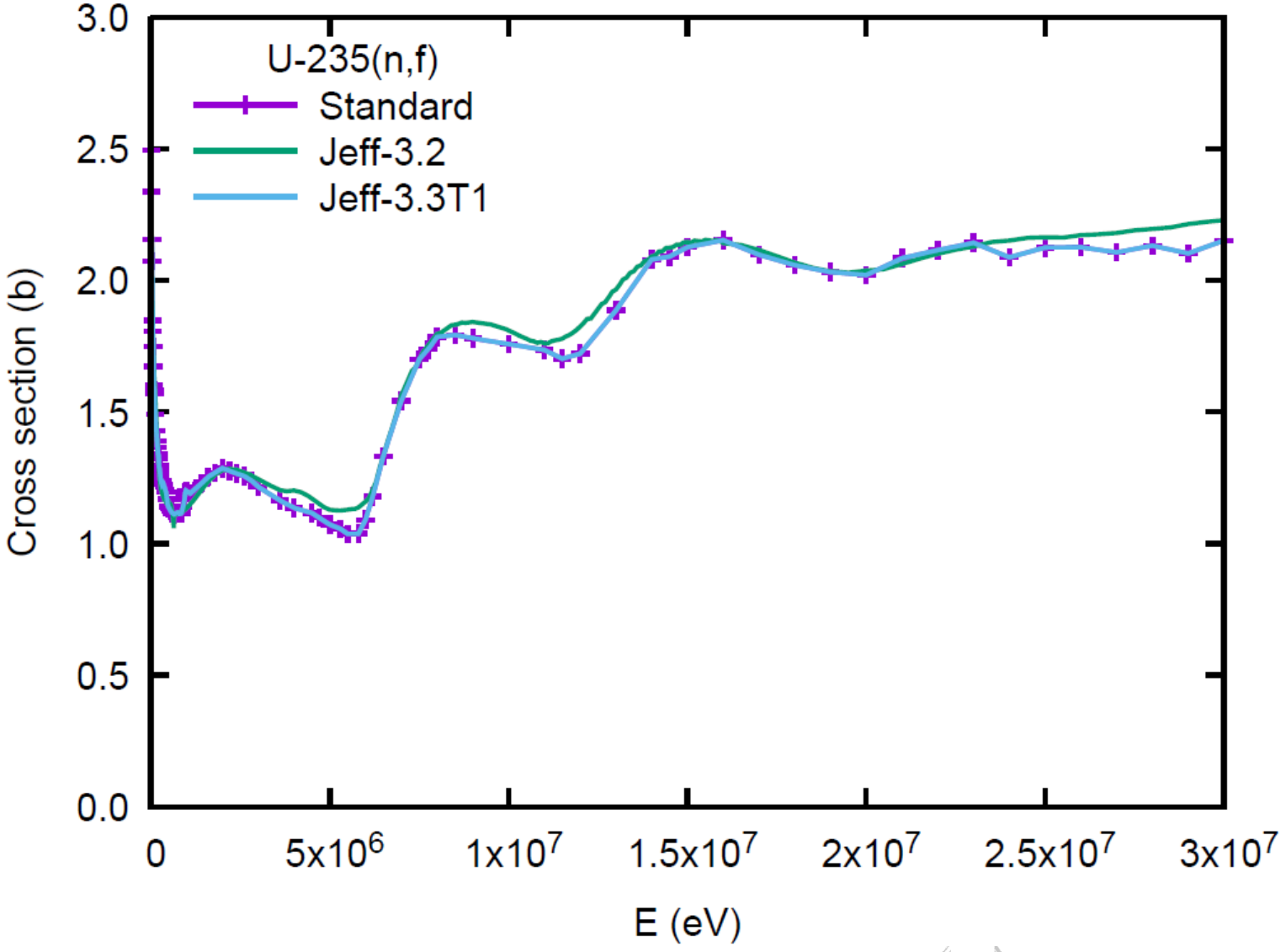
    Cr, Cu, Cd, Ta, W, Hf, Au, Pb, Bi, …
  - Replacement of legacy files
  - New TENDL files; includes replacing earlier TENDL.
  - Activation library performance upgrade (Sublet)
  - Many bug-fixes (Jouanne, Haeck, Rochman, a.o.)

European Commission

Fission standards

Adopted!
U-235

Also
U-238



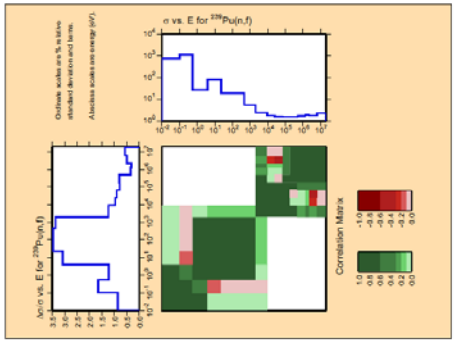
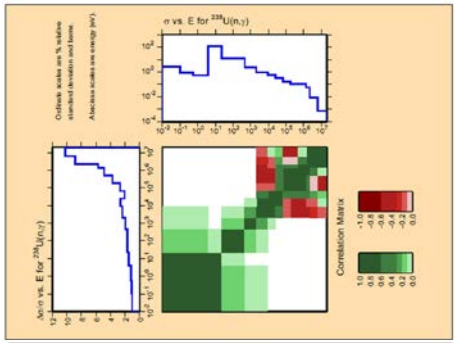
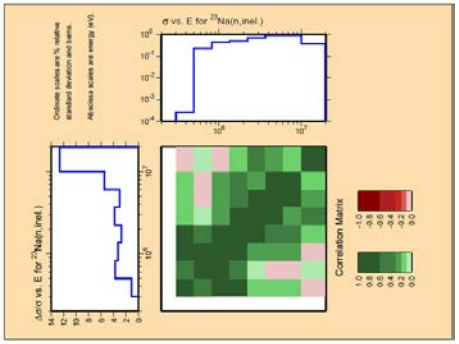
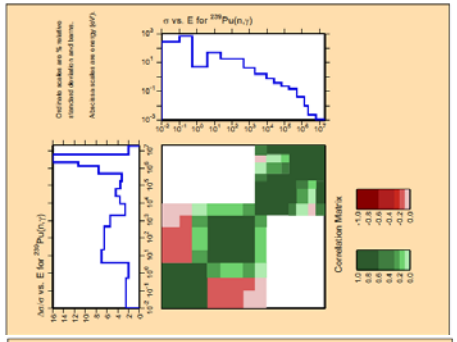
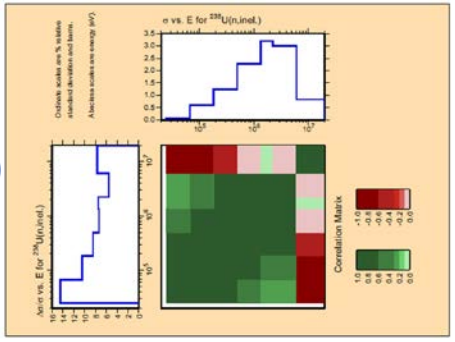
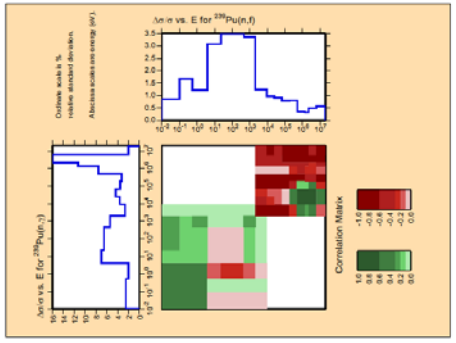
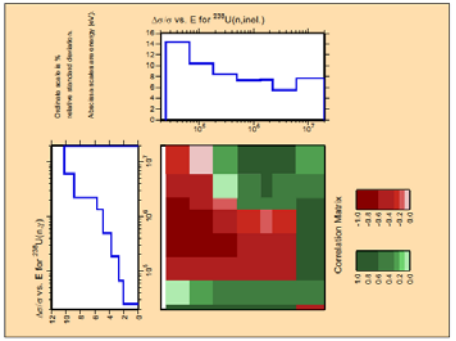
European Commission

JEFF 3.3 T2

- T2 June 2016, 559 materials
  - 44 changes from T1
  - 40 got 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, …

European Commission

Covariances (De Saint Jean, JEFF April)

	^{239}Pu	^{238}U	^{23}Na
(n,f)			
(n,g)			
(n,g)			
(n,inl)			
(n,f) x (n,g)			
(n,g) x (n,inl)			

Further covariances for Hf

Many from TENDL (Rochman)

Still far from complete

European Commission

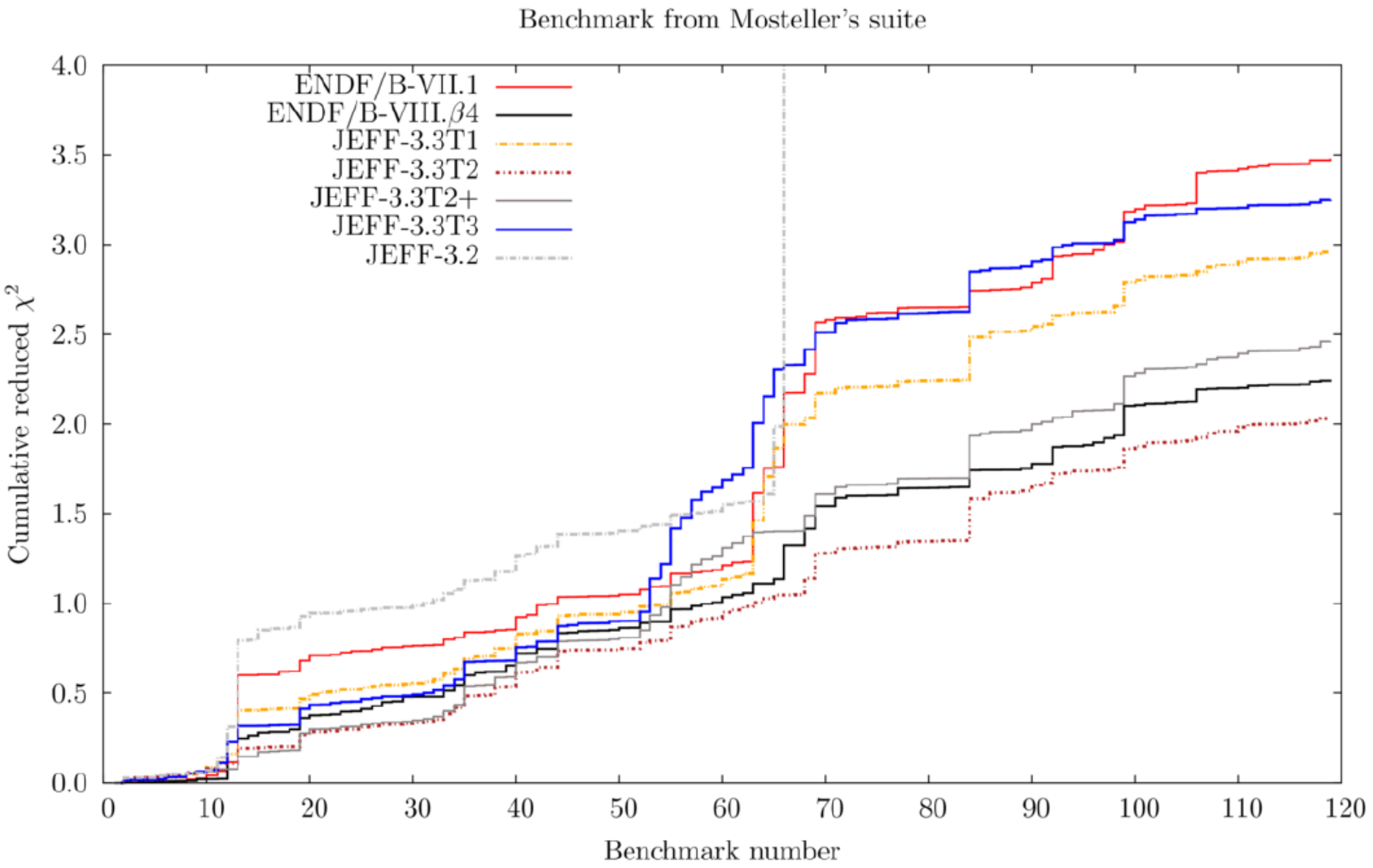
JEFF 3.3T3

- 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

NEA
NUCLEAR ENERGY AGENCY

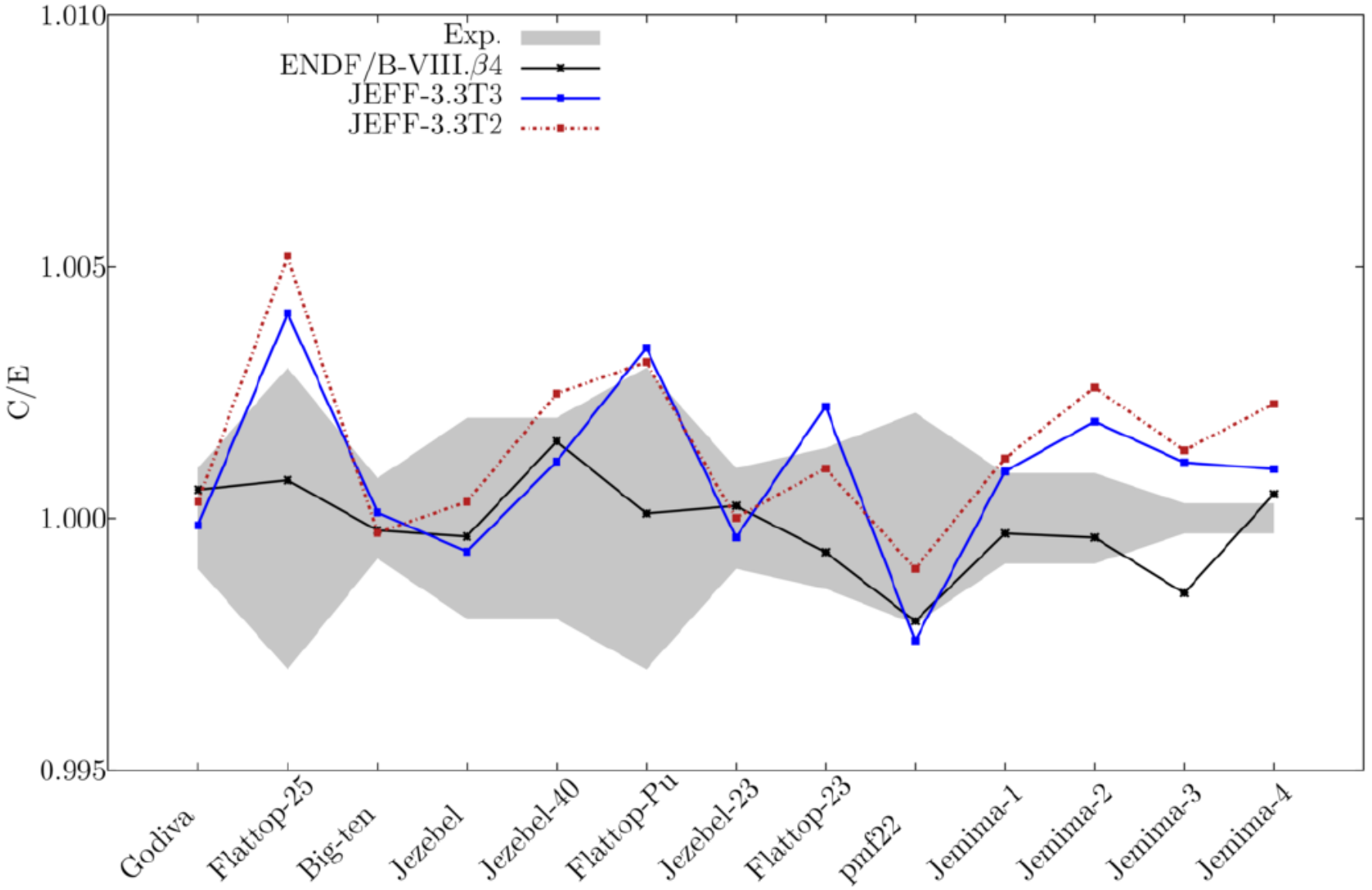
European Commission

Results in terms of reduced χ^2 Mosteller suite



European Commission

Results in terms of C/E for some fast benchmarks



European Commission

Results in terms of reduced χ^2 Mosteller suite

Type	JEFF-3.3T3	JEFF-3.3T2	JEFF-3.3T2p	JEFF-3.3T1	JEFF-3.2	ENDF/B-VII.1	ENDF/B-VIII.beta4	JENDL-4.0
119 all	**3.2**	**2.0**	**2.6**	**2.9**	**5.4**	**3.5**	**2.2**	**10.1**
13 LEU	6.5	1.5	4.0	1.4	1.1	1.2	1.4	5.7
39 HEU	3.9	2.1	2.3	4.2	10.7	4.7	2.7	4.4
28 PU	2.4	2.5	2.7	2.5	2.3	2.5	1.9	3.8
19 U233	1.5	1.6	2.1	1.9	1.8	2.0	1.7	1.9
20 other	2.7	2.0	1.8	3.1	5.8	5.4	2.8	40.8
41 Thermal	3.2	1.4	2.5	1.4	1.5	1.7	1.3	3.6
7 Inter	10.3	1.5	0.9	14.6	48.8	16.7	5.3	2.5
71 fast	2.6	2.4	2.6	2.7	3.4	3.1	2.5	14.6

European Commission

JEFF 3.3

- Adjustment of the new Fission Yields file to new RDD UKFY3.7 (Mills)
- TSL: Back to JEFF-3.1 (but keep Bariloche for ice).
- O-16: Back to T1 (B-VII.1)
- Fe: back to T2 (=JEFF-3.2 + dpa changes).
- Update fission and nu-bar uncertainties U-235 (U-238)
- Update nu-bar uncertainties Pu-239
- Cu-63, 65: improve criticality benchmarking preserve shielding performance (resonance range vs fast)
- Al-27 covariances: replace to fix processing problem
- Ni-58: adopt IRDFF channels
- Rh-103: improve branchings in capture (Jouanne, Rochman)
- Correct error leading to high dpa values
- Adopt 30 proposals Jouanne for gamma-emission n,inl
- Provide updated special purpose file for dpa (Konobeev, KIT)
- Store proposals for covariances, even if not endf-format (FY, TSL)

Timing

Corrections/changes to NEA end of June.
Processing, benchmarking and validation before end of September.
Report by November meeting of JEFF

JEFF meeting 20-24 November 2017

European Commission

Thermal cross section uncertainties

Thermal constants		GMA fit with Axton ALL	**GMA fit with Axton MIC**	GMA fit with CONRAD-AGS	GMA fit with CONRAD-AGS & marginal.
^{233}U	σ_s	12.1(0.1)	**12.2(0.7)**	12.3(0.7)	12.3(0.7)
	σ_f	531.2(1.3)	**534.5(2.4)**	530.4(2.2)	530.2(2.1)
	σ_γ	45.6(0.7)	**45.9(1.7)**	44.9(0.8)	45.1(0.9)
	υ_t	2.4968 (0.0035)	**2.485 (0.005)**	2.4908 (0.0049)	2.4927 (0.0050)
^{235}U	σ_s	14.09(0.22)	**14.09(0.22)**	14.07(0.22)	14.05(0.22)
	σ_f	584.3(1.0)	**587.2(1.4)**	585.5(1.1)	586.4(1.5)
	σ_γ	99.4(0.7)	**99.3(2.0)**	99.0(2.0)	99.1(2.1)
	υ_t	2.4355 (0.0023)	**2.425 (0.005)**	2.4289 (0.0047)	2.4257 (0.0047)
^{239}Pu	σ_s	7.80(0.96)	**7.82(1.00)**	7.98(0.98)	8.0(1.0)
	σ_f	750.0(1.8)	**752.1(2.2)**	750.3(2.5)	747.4(2.5)
	σ_γ	271.5(2.1)	**270.4(3.1)**	271.0(2.7)	272.6(2.9)
	υ_t	2.8836 (0.0047)	**2.877 (0.006)**	2.8809 (0.0057)	2.8868 (0.0057)
^{241}Pu	σ_s	12.1(2.6)	**11.95(2.6)**	12.0(2.5)	12.1(2.6)
	σ_f	1014(7)	**1024(11)**	1018(11)	1014(14)
	σ_γ	361.8(5.0)	**361.8(6.2)**	364.2(6.0)	362.0(7.0)
	υ_t	2.9479 (0.0054)	**2.940 (0.006)**	2.9430 (0.0058)	2.9427 (0.0058)
^{252}Cf	υ_t	3.7692 (0.0047)	**3.7635 (0.0049)**	3.7660 (0.0049)	3.7609 (0.0053)

V. Pronyaev, R. Capote, A. Trkov, G. Noguere and A. Wallner, New fit of Thermal Neutron Constants (TNC) for ^{233,235}U, ^{239,241}Pu and ^{252}Cf(sf), ND2016.

Fission $\Rightarrow \approx 0.3\%$
Capture $\Rightarrow \approx 2.0\ \%$

Additional sources of uncertainties can be taken into account …

Thermal cross section uncertainties

Thermal constants		Sources of uncertainties (in %)				Total (in %)
		fitting model (a)	rolled metal (b)	mac. data (c)	EXFOR data (d)	
U233	σ_s	-	0.05	0.98	-	0.98
	σ_f	0.04	0.21	0.09	0.01	0.23
	σ_γ	0.50	0.36	0.89	0.17	1.20
	υ_t	0.05	-	0.07	-	0.09
U235	σ_s	1.36	3.04	2.93	0.03	4.44
	σ_f	0.16	0.51	0.11	0.01	0.55
	σ_γ	0.47	0.04	0.51	0.01	0.69
	υ_t	0.10	0.02	0.07	-	0.12
Pu239	σ_s	0.04	0.22	0.06	-	0.23
	σ_f	0.05	0.19	0.18	0.01	0.27
	σ_γ	0.11	0.17	0.23	-	0.31
	υ_t	0.02	-	0.02	-	0.03
Pu241	σ_s	0.19	0.10	0.96	-	0.98
	σ_f	0.34	-	0.45	-	0.56
	σ_γ	0.02	0.10	0.25	0.01	0.27
	υ_t	0.04	-	0.06	-	0.07
Cf252	υ_t	0.02	-	0.02	-	0.03

N. Otuka, R. Capote, V. Semkova, T. Kawai and G. Noguere, Experiments in the EXFOR library for evaluation of thermal neutron constants, ND2016.

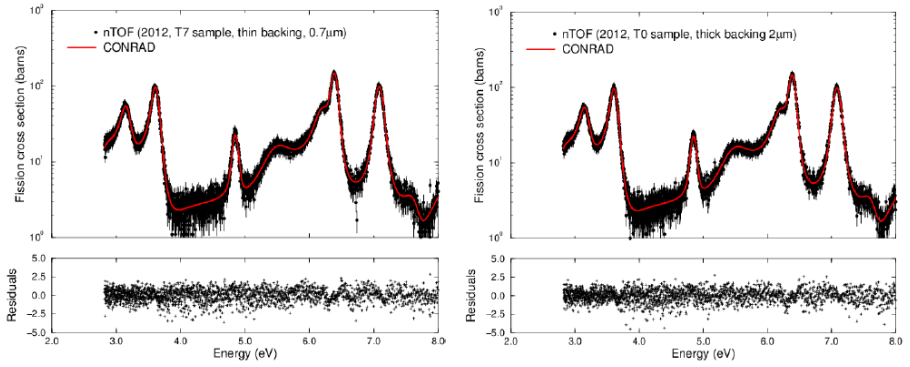
Final uncertainties obtained by Marginalization

Fission ⇒ ≈ **0.6%**

Capture ⇒ ≈ **2.2 %**

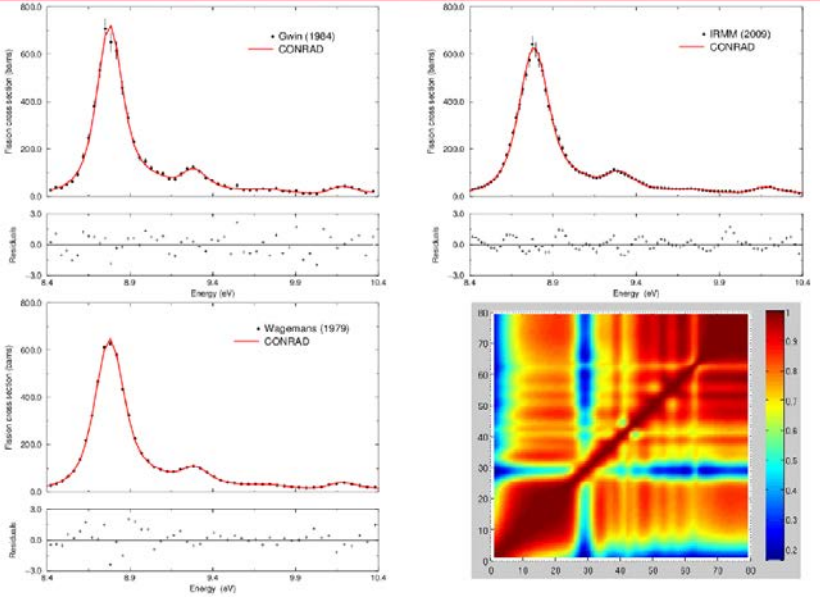
Comparison with nTOF data : fission cross section

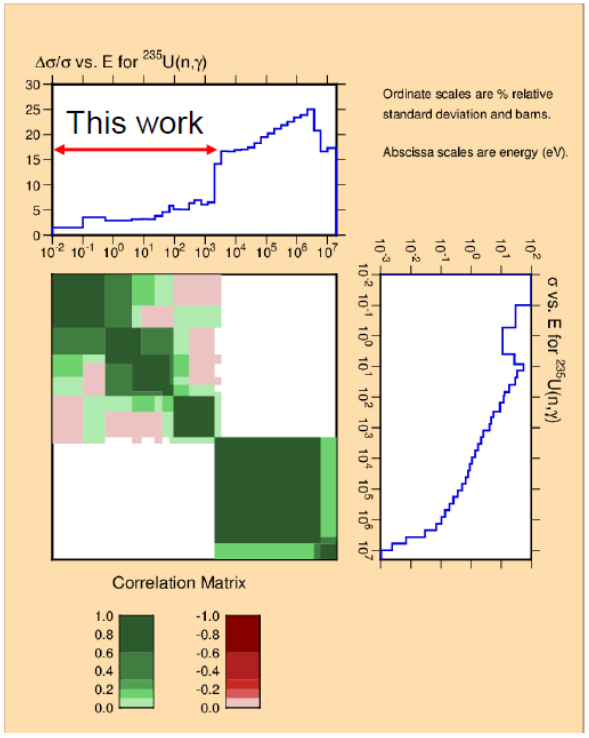
L. Leal, G. Noguere, C. Paradela, I. Durán, L. Tassan-Got, Y. Dannon and M. Jandel, Evaluation of the U235 resonance parameters to fit the standard recommended values, ND2016.

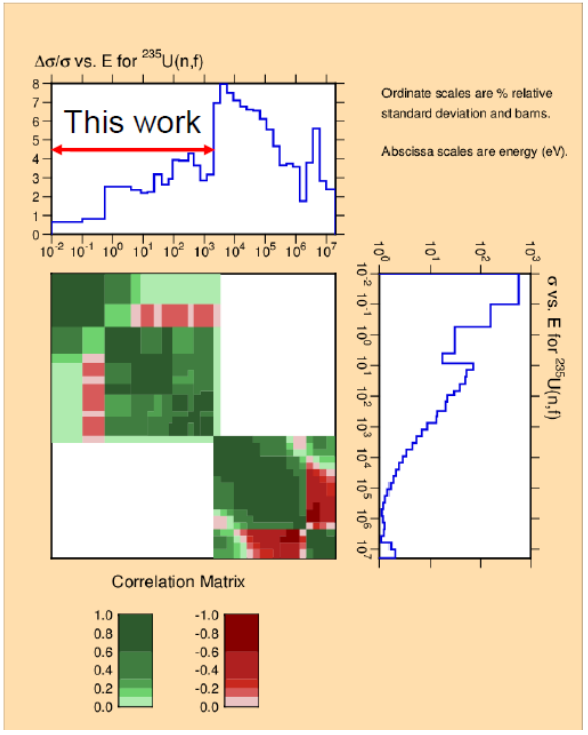


New data processing : E. Leal-Cidoncha and C. Paradela

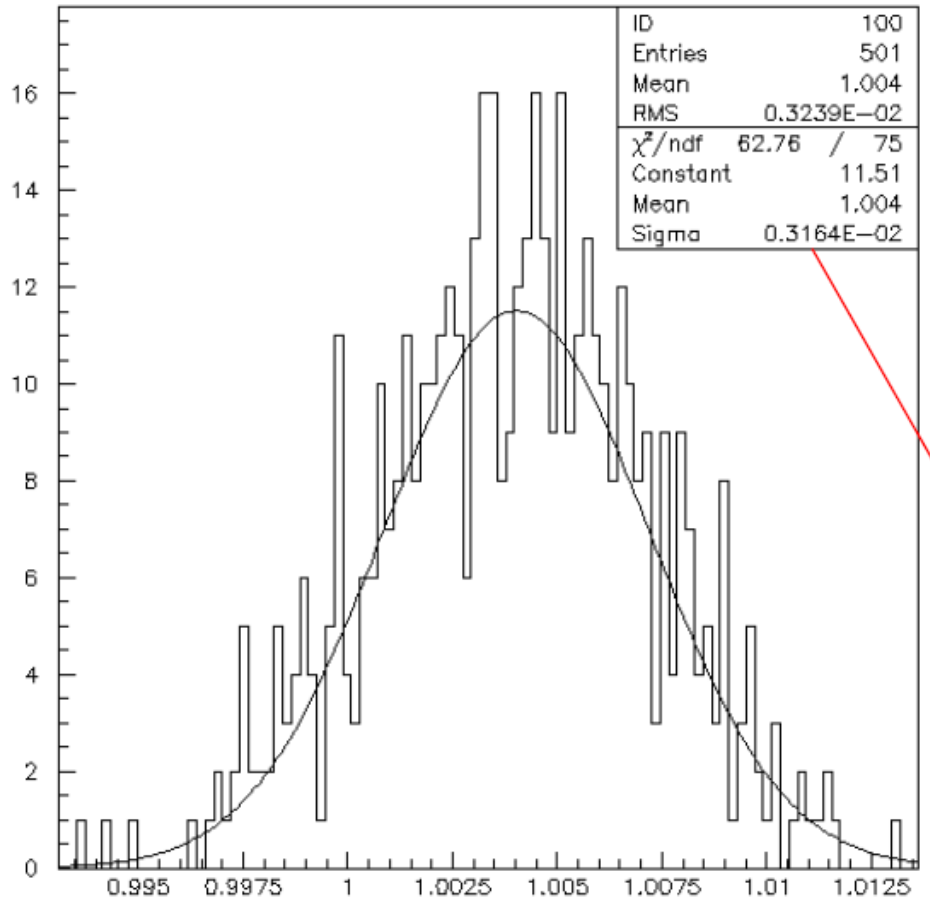
Uncertainty on the fission integral [7.8 eV – 11 eV] ⇒ ≈ 2.0%







Total Monte-Carlo technique applied to **UH1.2** (Eole reactor, Cadarache)



Library	TRIPOLI-4 Calculated reactivity
JEFF-3.1.1	+407 (20) pcm
JEFF-3.1.1 + U235 from JEFF-3.3T3	+382 (20) pcm

Uncertainty on the calculated reactivity
(Resonance parameters only)
⇒ ± **316 pcm**

European Commission

Evaluation of n+^{238}U in URR: 20 keV - 150 keV

Extensive validation by IAEA and KAERI

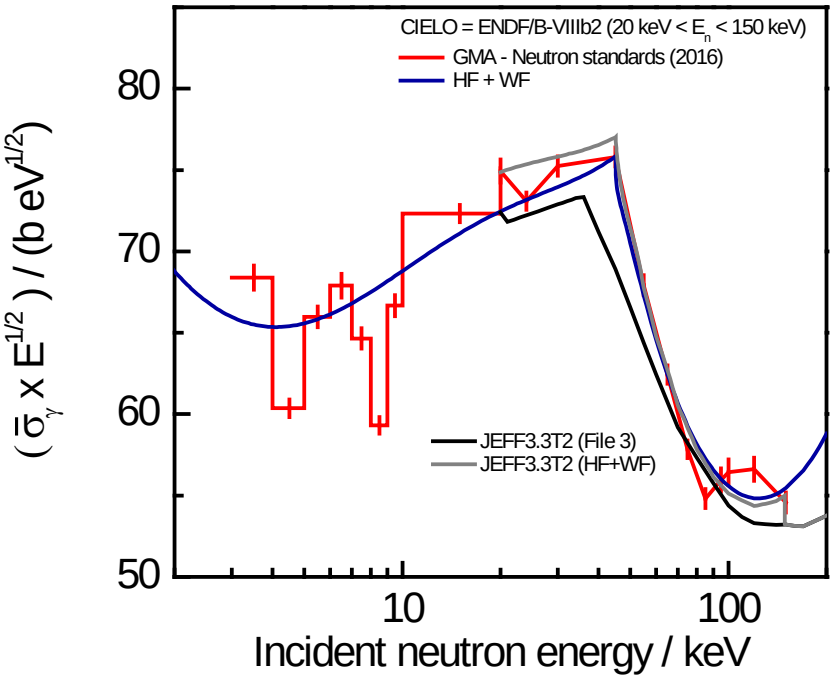
Example

Big-ten : k_{eff} = 1.0045 ± 0.0007 (experimental)

- CIELO
  - Big-ten : k_{eff} = 1.00446
- JEFF-3.3T2
  - Big-ten : k_{eff} = 1.00469
- JEFF-3.3T2 + RR of ^{238}U from CIELO
  - Big-ten : k_{eff} = 0.99994

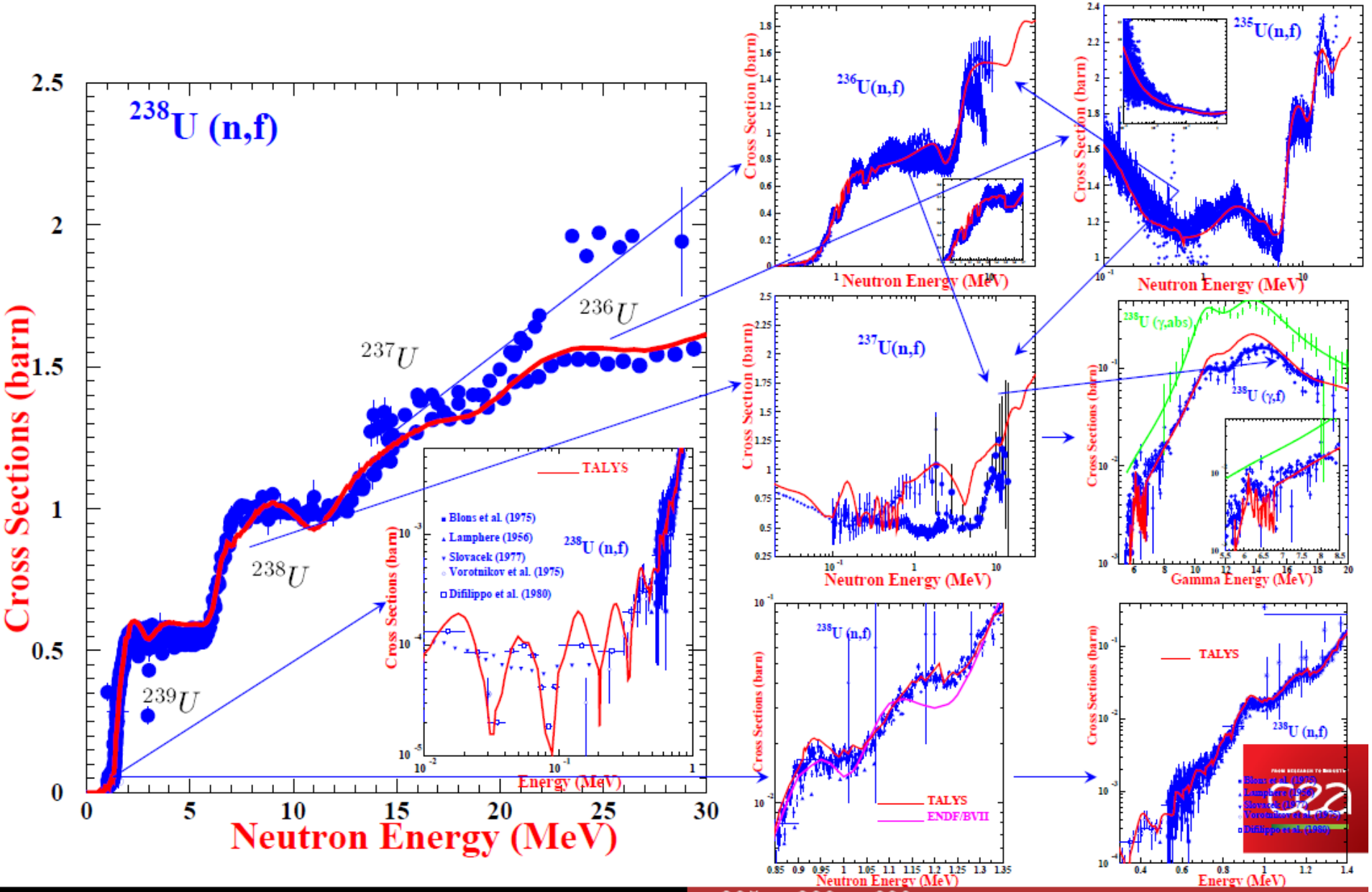
⇒ Compensating effects in JEFF-3.3T2
⇒ JEFF-3.3T2 is not a general purpose file

Schillebeeckx R103, Capote I102

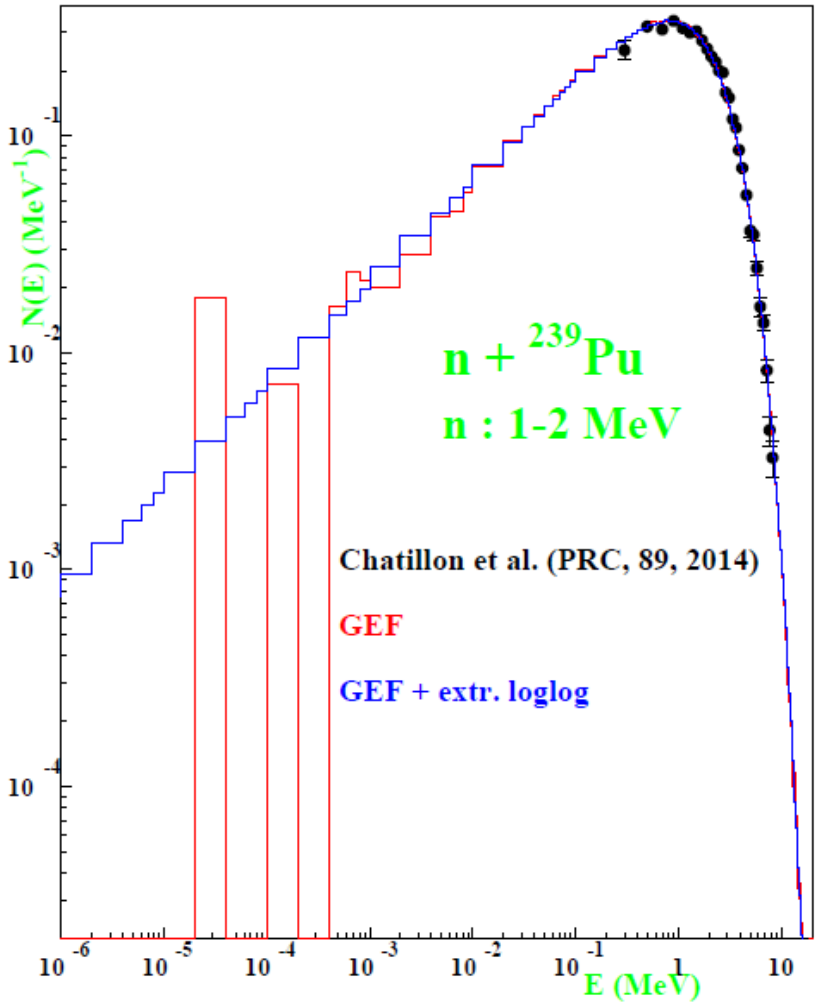


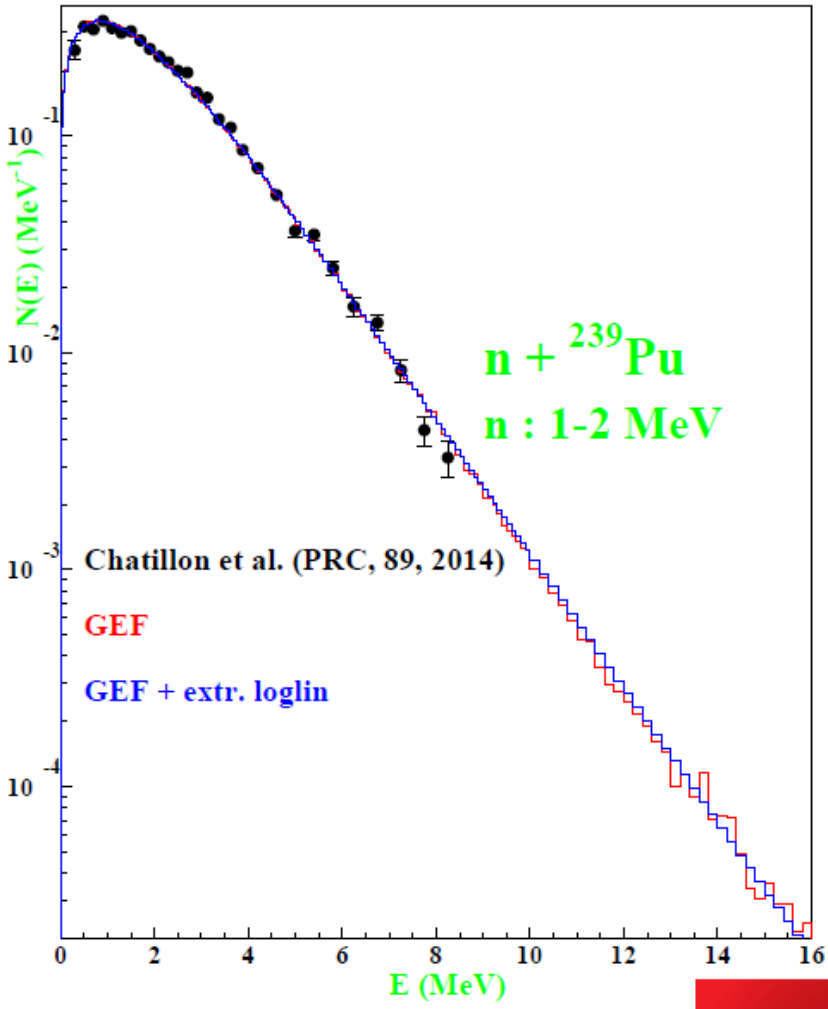
European Commission

Fission model ↔ from ^{233}U up ^{239}U, consistent parameters



PFNS : GEF[1], n + ^{239}Pu, E_n = 1-2 MeV

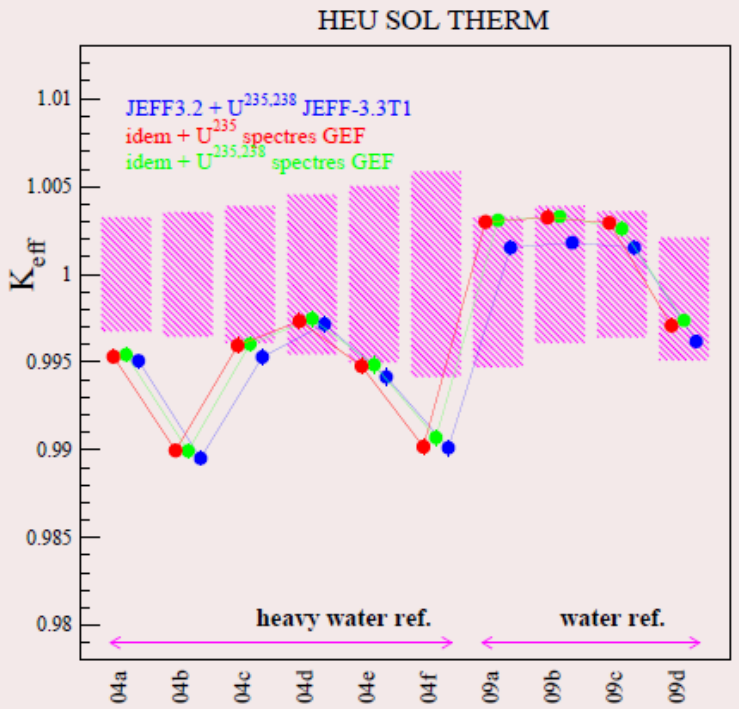




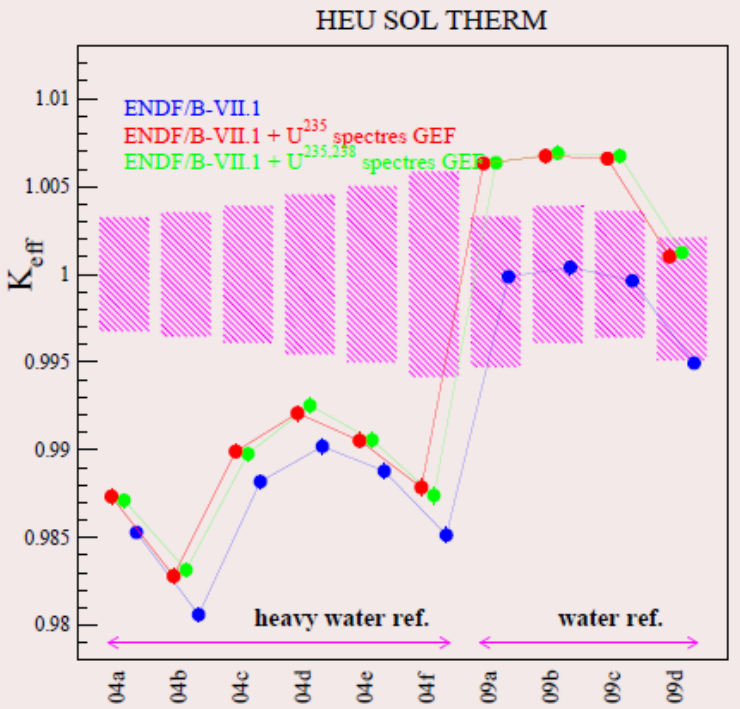
1. Karl-Heinz Schmidt et Beatriz Jurado, CENBG, CNRS/IN2P3.

Fission spectra : JEFF3.3T - GEF - ENDF/B-VII.1

JEFF3.3T - GEF



GEF - ENDF/B-VII.1



^{239}Pu and ^{235,238}U, GEF PFNS very close to JEFF3.3T PFNS but completly independant PFNS !

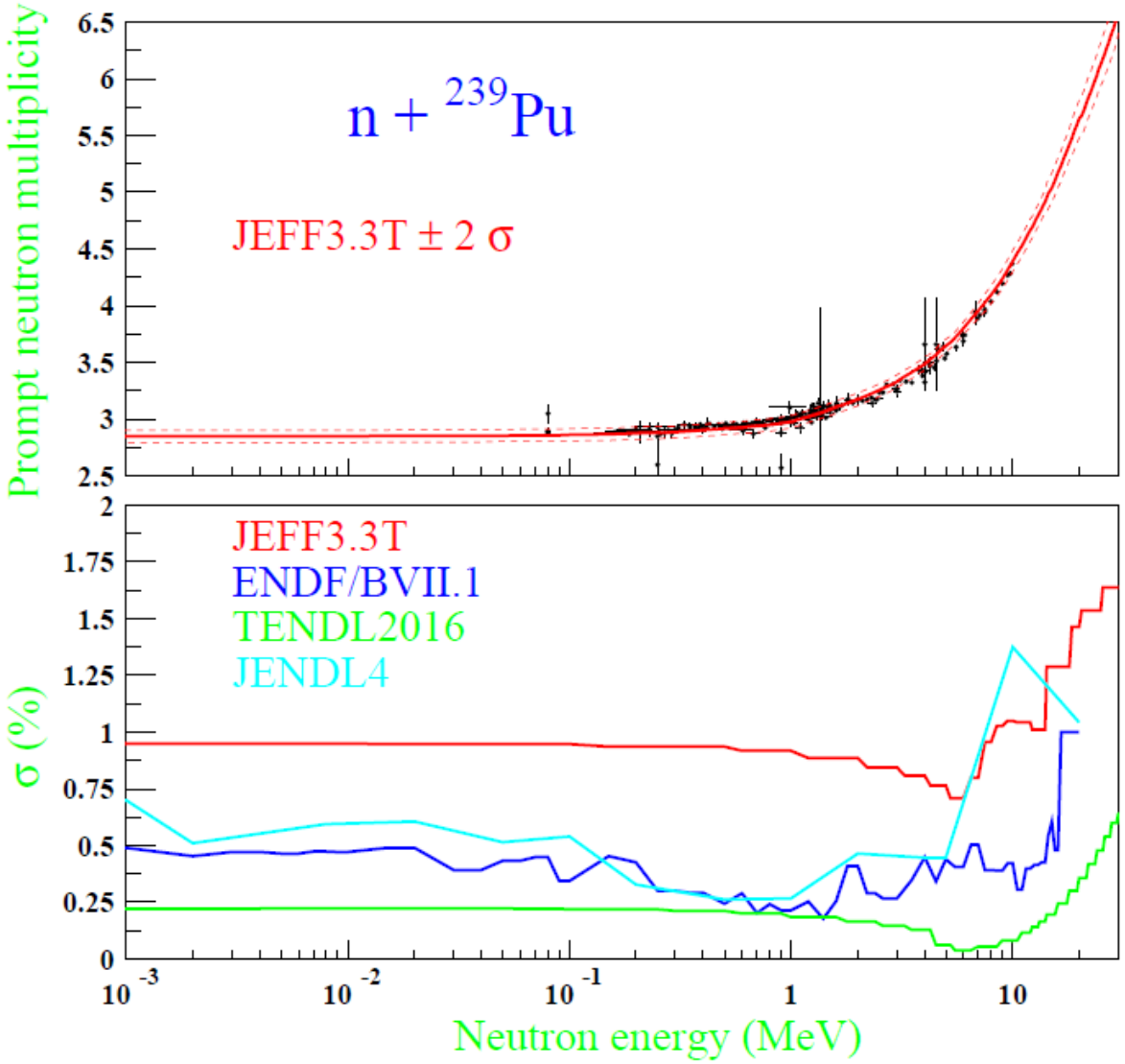
PFNS and ν covariances for ^{239}Pu and ^{235,238}U

- Modified Los Alamos model,
- Parameters are sampled,
- Covariances for PFNS and ν.
  - File 35 PFNS covariances.
  - File 31 for ν covariances.
- For JEFF3.3T, the thermal PFNS covariances are evaluated by CEA/Cadarache for ^{239}Pu and ^{235}U.

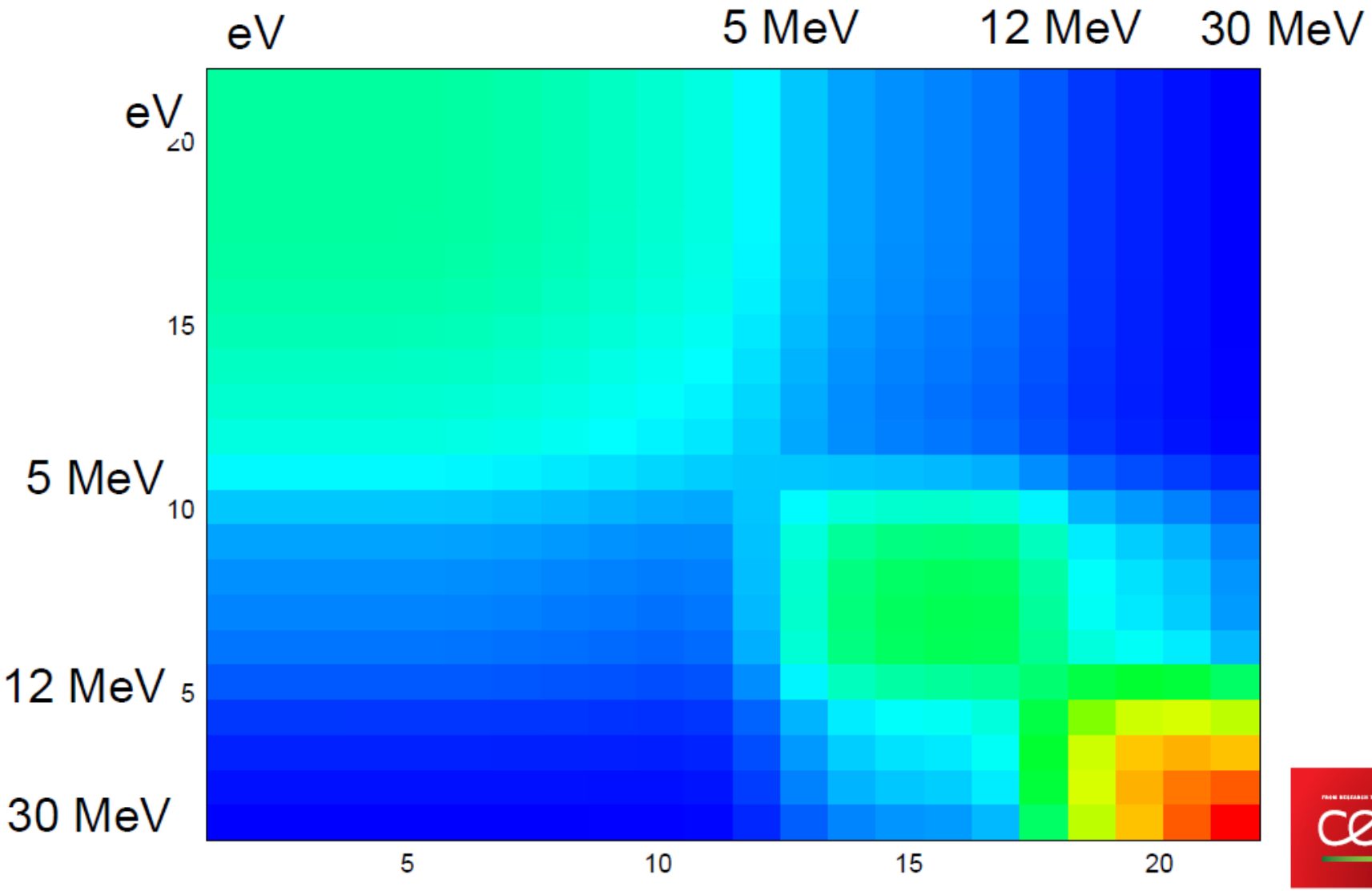
In the future...

- We want to try to run benchmarks with each sampled ν,
- And to associate a Chi-square test for every sampled ν,
- To reduce the covariances.

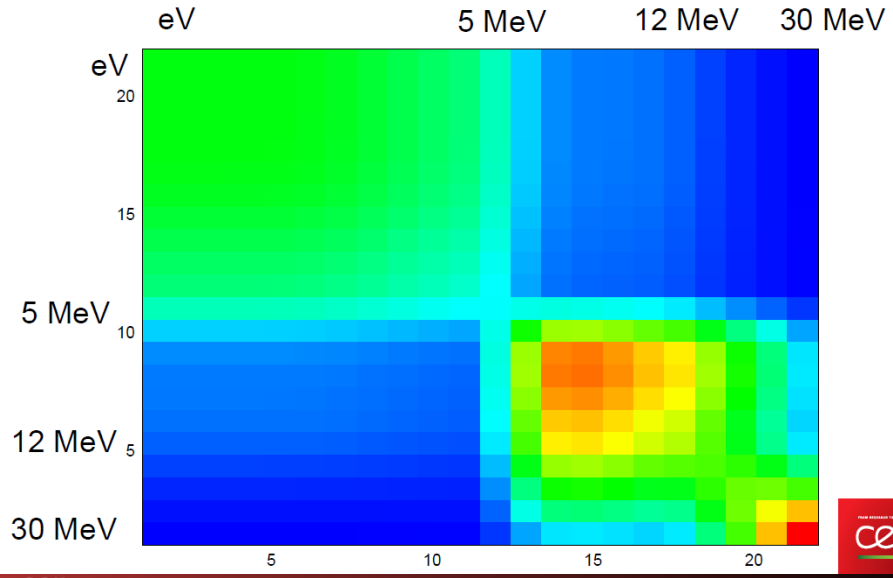
n+^{239}Pu, ν and standard deviation

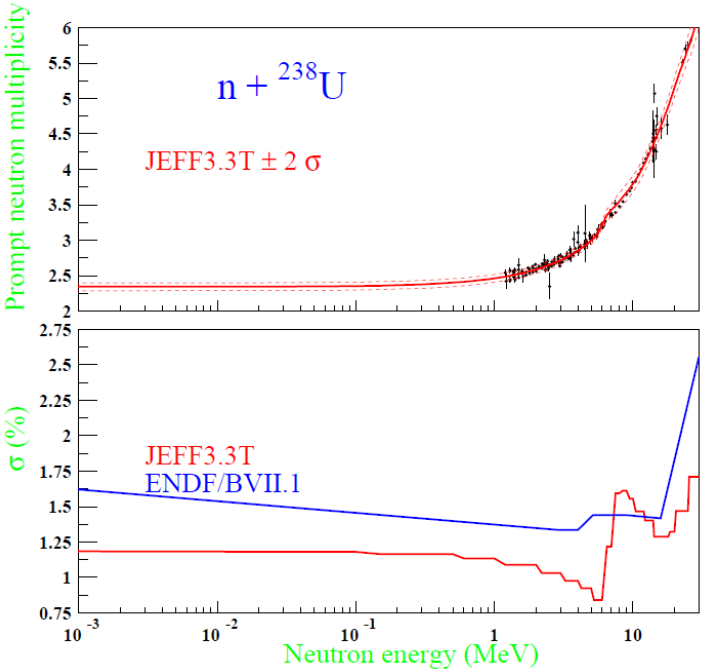


n+^{239}Pu, ν covariances

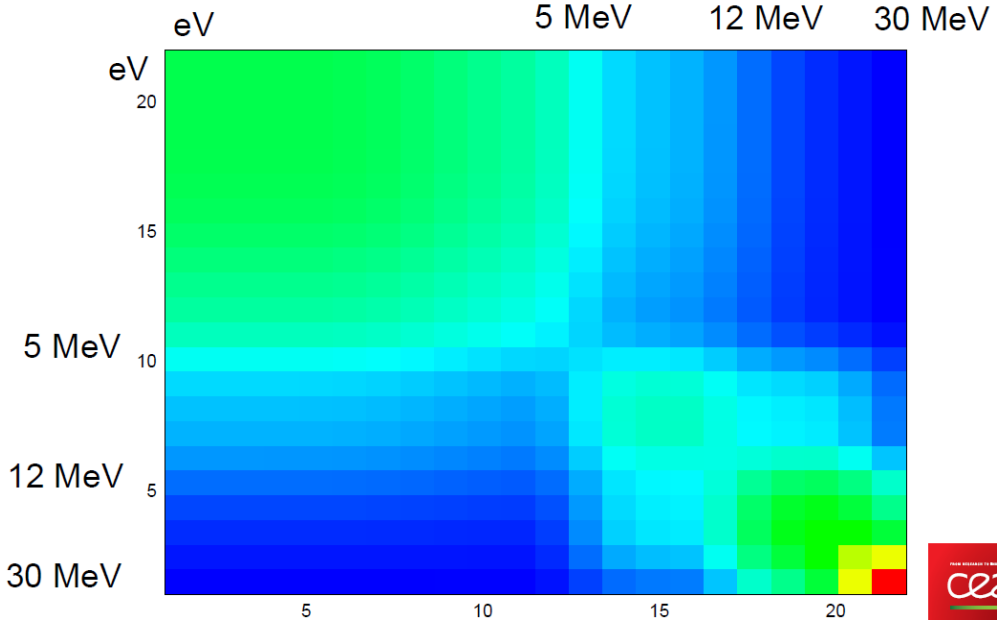


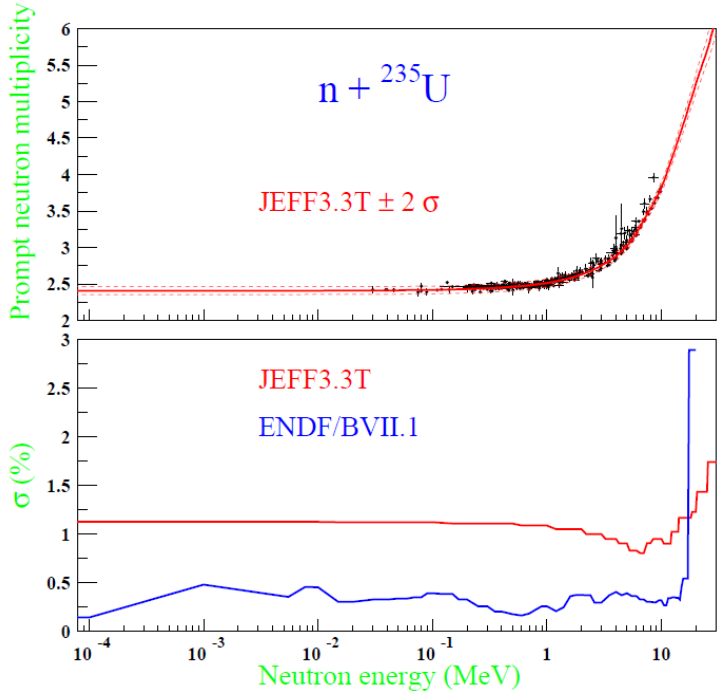
n+^{238}U, ν covariances



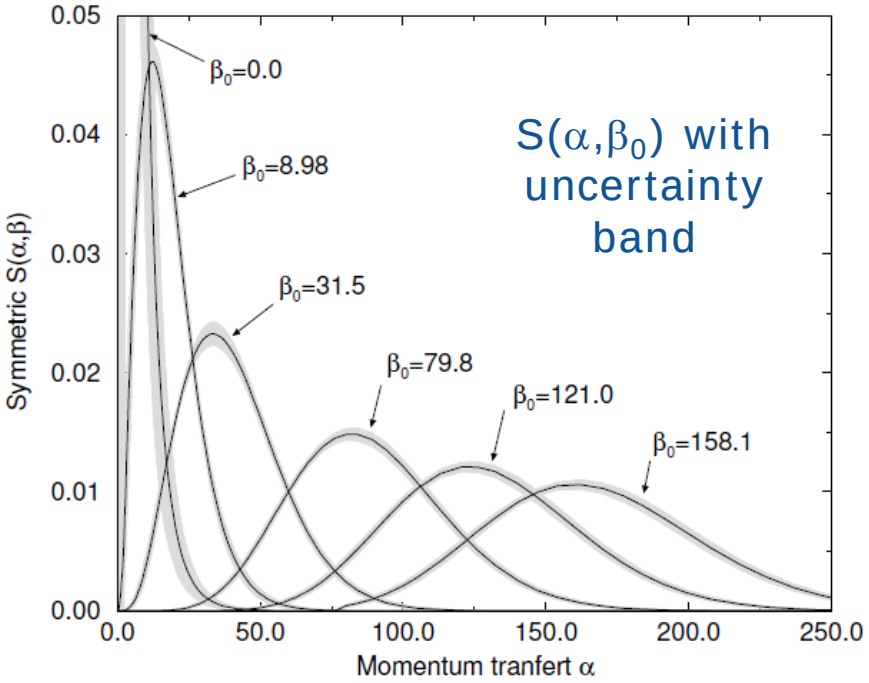


n+^{235}U, ν covariances



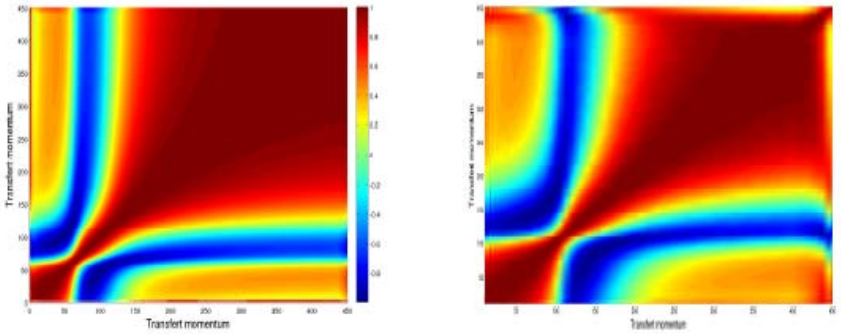


New covariance matrix for the S(αβ) of H in H_20



S(α,$β_0$) with uncertainty band

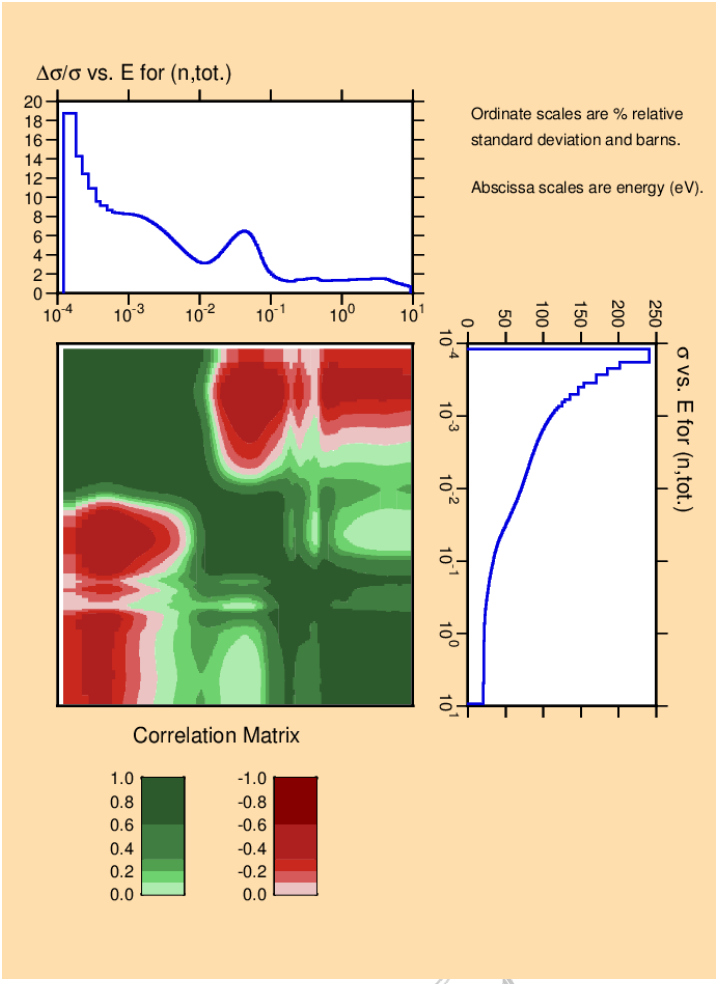
(a) $\beta_0 = 8.98$ (b) $\beta_0 = 31.15$



(c) $\beta_0 = 79.8$ (d) $\beta_0 = 121.0$

S(α,$β_0$) Correlation matrices

Calculated total cross section with relative uncertainty and correlation matrix



European Commission