JEFF-3.1, ENDF/B-VII and JENDL-3.3 critical assemblies benchmarking with the Monte Carlo code TRIPOLI

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Codes, libraries and benchmarks versions

- TRIPOLI-4.4.1, Monte Carlo, pointwise mode with PT's
- NJOY-99.161(+) and CALENDF-2005 (build 69)
- 2006, ENDF/B-VII/GP (393) with **252 PT's in the URR** and /Th (20)
- 2005 JEFF-3.1/GP (381) **with 140 PT's in the URR** and /Th (9)
- 2002, JENDL-3.3 (337) **with 209 PT's in the URR** (+ JEFF-3.1/Th)
- International Handbook of Evaluated Criticality Benchmarks Experiment, ICSBEP **September 2006** edition
- Run on octo-pro SUN Blade workstation

Nuclear Data Libraries and Processing

NJOY-99.161(+)

1. Reconstruction at 0 K (RECONR)
2. Doppler Broadening at T K (BROADR)
3. Treatment of Unresolved Range (UNRESR)

Free Gas thermalisation is done within TRIPOLI-4.4.1

4. Treatment of Thermal Neutron scattering data for materials (➔ Thermr(+))

Modification: results in terms of equi-probable cosines instead of equi-probable angles (on 32 bins)
MT's 221 and 222 hard coded

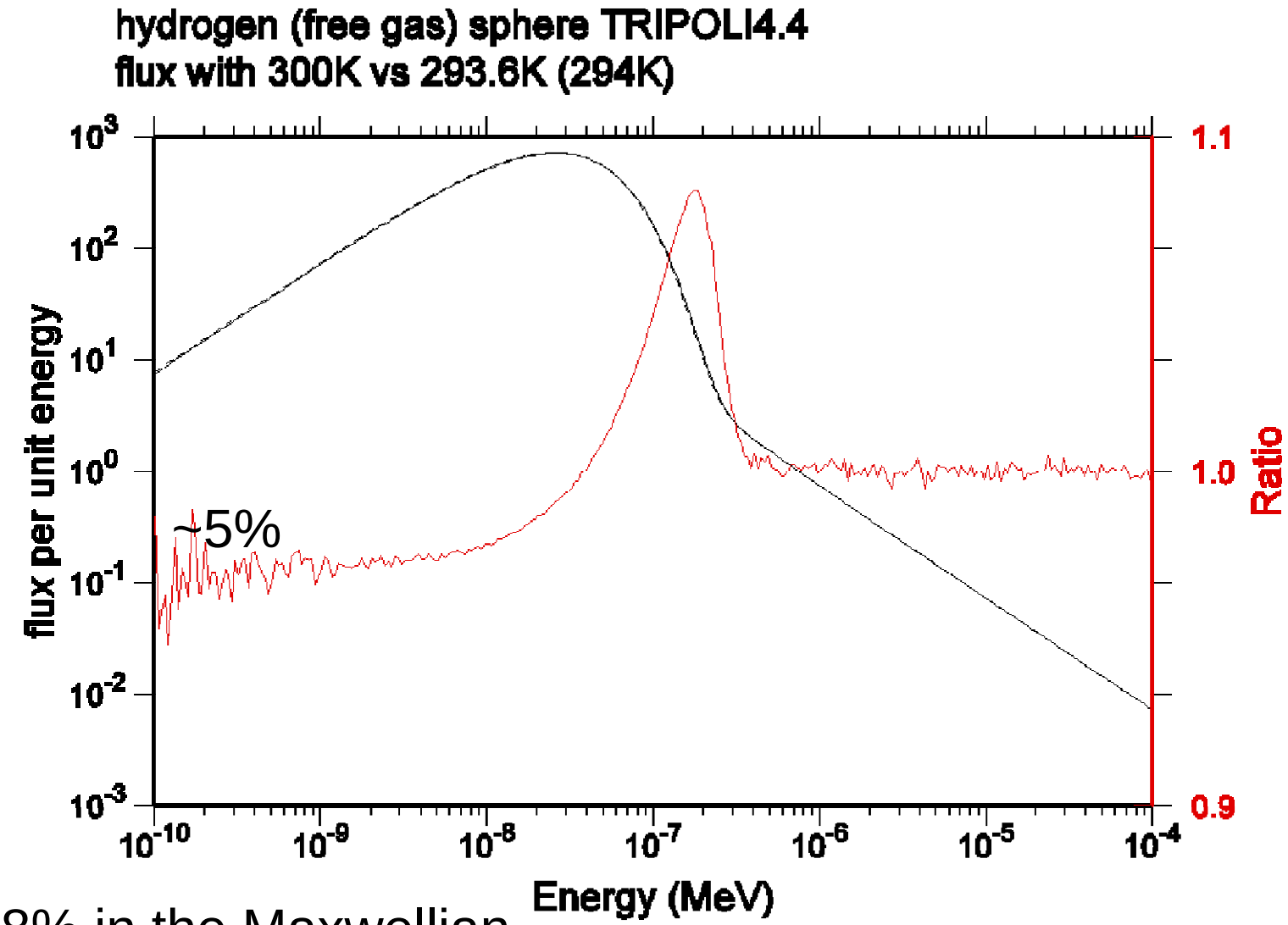
➔ Pointwise cross section

CALENDF-2005

1. Reconstruction, Doppler, URR

➔ Probability tables

Temperatures 294K versus 300K: neutron spectra



-5% to + 8% in the Maxwellian

NJOY-99.161(+) modules processing scheme

Evaluations

NJOY-99.161(+)

Modules	Main parameters	Outputs
moder		
reconr	err = 0.001 (0.1%)	
broadr	errthn = 0.001	**Thermal quantities**
unresr		
moder		**pendf files**
thermr	nbin = 32 tol = 0.001 emax = 4.95	
moder		

Tripoli-4.4.1 library

Tripoli-4.4.1 Libraries

TRIPOLI-4.4.1 generates XDR portable binary and angular distribution files the first time it reads in a PENDF and and an ENDF file

Seven File Types are used :

1. Evaluation (ascii)
2. **PENDF (binary)**
3. Dictionary of cross sections (ascii)*
4. Binary XDR pointwise file*
5. Anisotropy file (ascii)*
6. **Probability tables (ascii)**
7. **Thermal file (ascii)**

*: generated by TRIPOLI the first time it access the data file.

Tests for evaluations :

140 URR JEFF-3.1
252 URR ENDF/B-VII
209 URR JENDL-3.3

ENDF-102 format

Normalization (angular and energetic distribution)

T4XS-4.4.1 library files

jeff3.neutron.H1_H2O.bcd
jeff3.neutron.H1_H2O.bcd.therm
jeff3.neutron.H1_H2O.bcd.therm.294 (only at the file temperature)
jeff3.neutron.H1_H2O.bcd.aniso

jeff3.gamma.H1_H2O.bcd

Evaluation

jeff3.neutron.U238.bcd
jeff3.neutron.U238.bin.pendf.294
jeff3.neutron.U238.xdr.pendf.294.dictio
jeff3.neutron.U238.xdr.pendf.294
jeff3.neutron.U238.bcd.aniso
jeff3.neutron.U238.bcd.tp.294

Angular distribution

CALENDF PT's

jeff3.gamma.U238.bcd

For each of the 390 JEFF-3.1 isotopes in a single directory

TRIPOLI-4.4.1 libraries

file t4path.jeff3_1

/export/opt/CODE/TRIPOLI4.4.1/Env-4.4/jeff3_1.dictionary
/export/opt/CODE/TRIPOLI4.4.1/mass_rmd.mas95
/export/opt/CODE/TRIPOLI4.4.1/JEFF31/Qfission
/export/opt/CODE/TRIPOLI4.4.1/Mott_rutherford

Isotopic dictionary
Atomic mass
Fission Q values
Mott - Rutherford electron-positrons cross section

TRIPOLI-4.4.1 dictionary

File jeff3_1.dictionary

/export/opt/CODE/TRIPOLI4.4.1/JEFF31/T4XS-4.4
390

```
AC225  8925     8900     -1      jeff3.neutron.Ac225.bcd
AC226  8928     8900     -1      jeff3.neutron.Ac226.bcd
AC227  8931     8900     -1      jeff3.neutron.Ac227.bcd
AG107  4725     4700     -1      jeff3.neutron.Ag107.bcd
***
H1 125 100 -1 jeff3.neutron.H1.bcd
H1_H2O 125 100 1250001 jeff3.neutron.H1_H2O.bcd
***
U238   9237     9200     -1      jeff3.neutron.U238.bcd
V      2300     2300     -1      jeff3.neutron.V.bcd
**
ZR95   4040     4000     -1      jeff3.neutron.Zr95.bcd
ZR96   4043     4000     -1      jeff3.neutron.Zr96.bcd
```

TRIPOLI-4.4.1 input sequence

static_tripoli4-4.4 -d hmf001c2 -s TABPROB –c
~/Env-4.4/t4path.jeff3_1 -p graphe -t bsd >& hmf001c2.out

static_tripoli4-4.4 -d lct006c13 -s NJOY -c
~/Env-4.4/t4path.jeff3_1 -o lct006c13.res >& lct006c13.out

TRIPOLI use BSD socket under the GNU C library Lesser General Public License and so can access any CPU on a network without the need of message passing libraries

File graphe in the ./ directory

```
PROCESS
4
process  monitor  static_tripoli4-4.4   cade
process  scorer   static_tripoli4-4.4   cade
process  tache1   static_tripoli4-4.4   cade
process  tache2   static_tripoli4-4.4   cade
GRAPH
scorer <-> tache1
scorer <-> tache2
FIN
```

Sun dual-core
or
workstation

TRIPOLI-4.4.1 program and multi-processing

Networking Services Library Functions xdr(3NSL)

NAME

xdr - library routines for external data representation

DESCRIPTION

XDR routines allow C programmers to describe arbitrary data structures in a machine-independent fashion. Data for remote procedure calls (RPC) are transmitted using these routines.

Sockets Library Functions socket(3SOCKET)

NAME

socket - create an endpoint for communication

SYNOPSIS

```
cc [ flag ... ] file ... -lsocket -lnsl [ library ... ]
#include <sys/types.h>
#include <sys/socket.h>

int socket(int domain, int type, int protocol);
```

DESCRIPTION

socket() creates an endpoint for communication and returns a descriptor.

Angular distribution

- The angular distribution is computed by TRIPOLI-4.4.1 the first time a pendf file is accessed and the code require to be linked to the original endf file

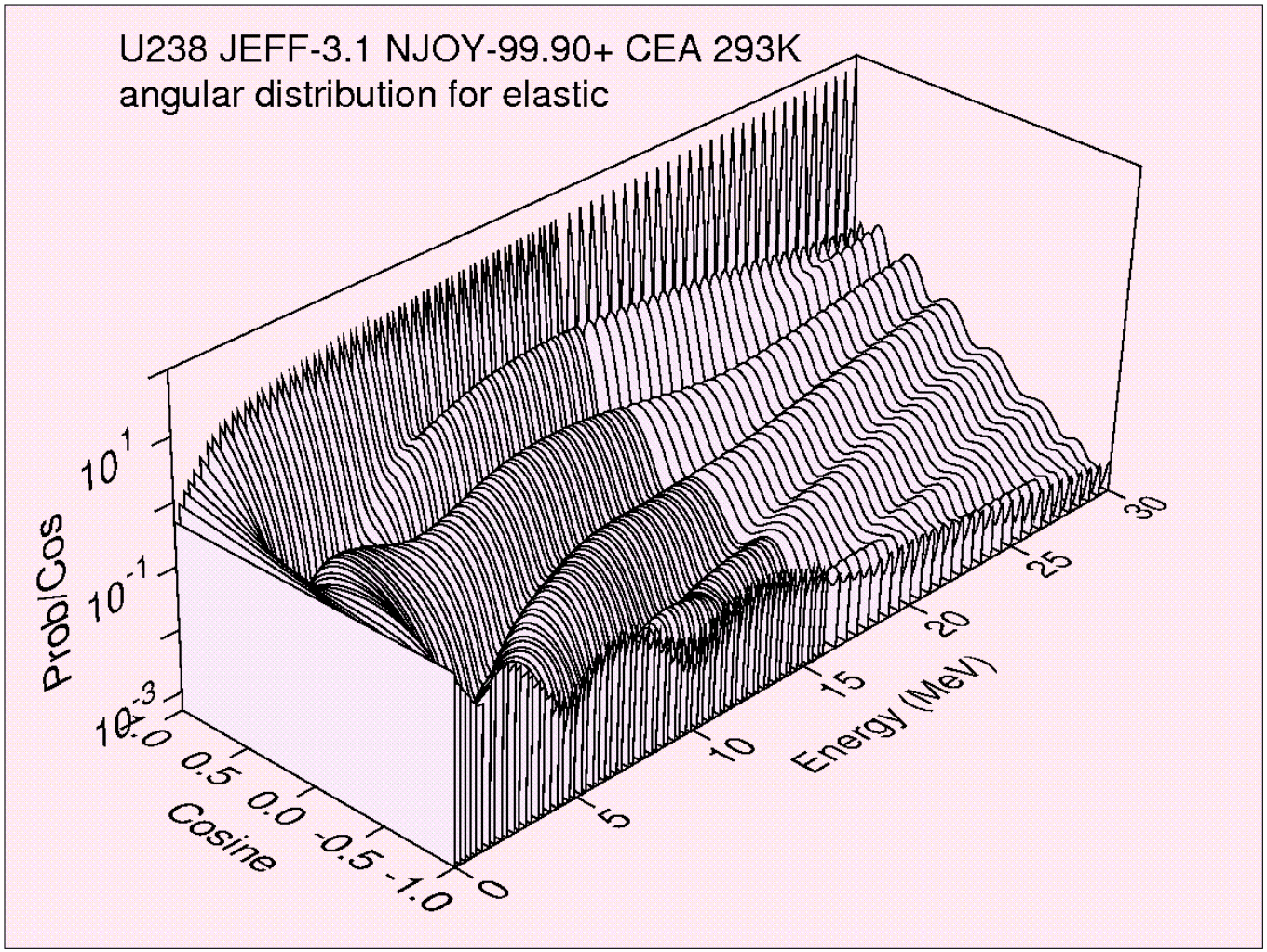
- The computed angular distribution is variable, file dependant and can contain up to 256 equally probable cosine bins

- For the JEFF-3.1 U238 the angular distribution have been produced by the ECIS optical model code and tabulated in 91 bins from 0 to 180 degree. It is used as such by TRIPOLI-4.4.1

- Elastic and inelastic channels structures are preserved

- It is a much better representation than in Legendre coefficients

QA: MT=2 Angular distribution



TRIPOLI-4.4.1 & JEFF-3.1 + Probability Table

- The probability table have been produced by CALENDF-2005 in 11276 groups, with IPRECI =4 (~0.002 accuracy)
- They can be used by TRIPOLI-4.4.1:
  - in the **U**nresolved **R**esonance **R**ange, **for ALL isotopes with one**
  - in the entire energy range, “PT sampling mode”
- The CALENDF probability table order vary from group to group

NOR vary from 1 to 11

NOR = table order; NPAR number of partials (four + (n.xn))
I = first negative moment

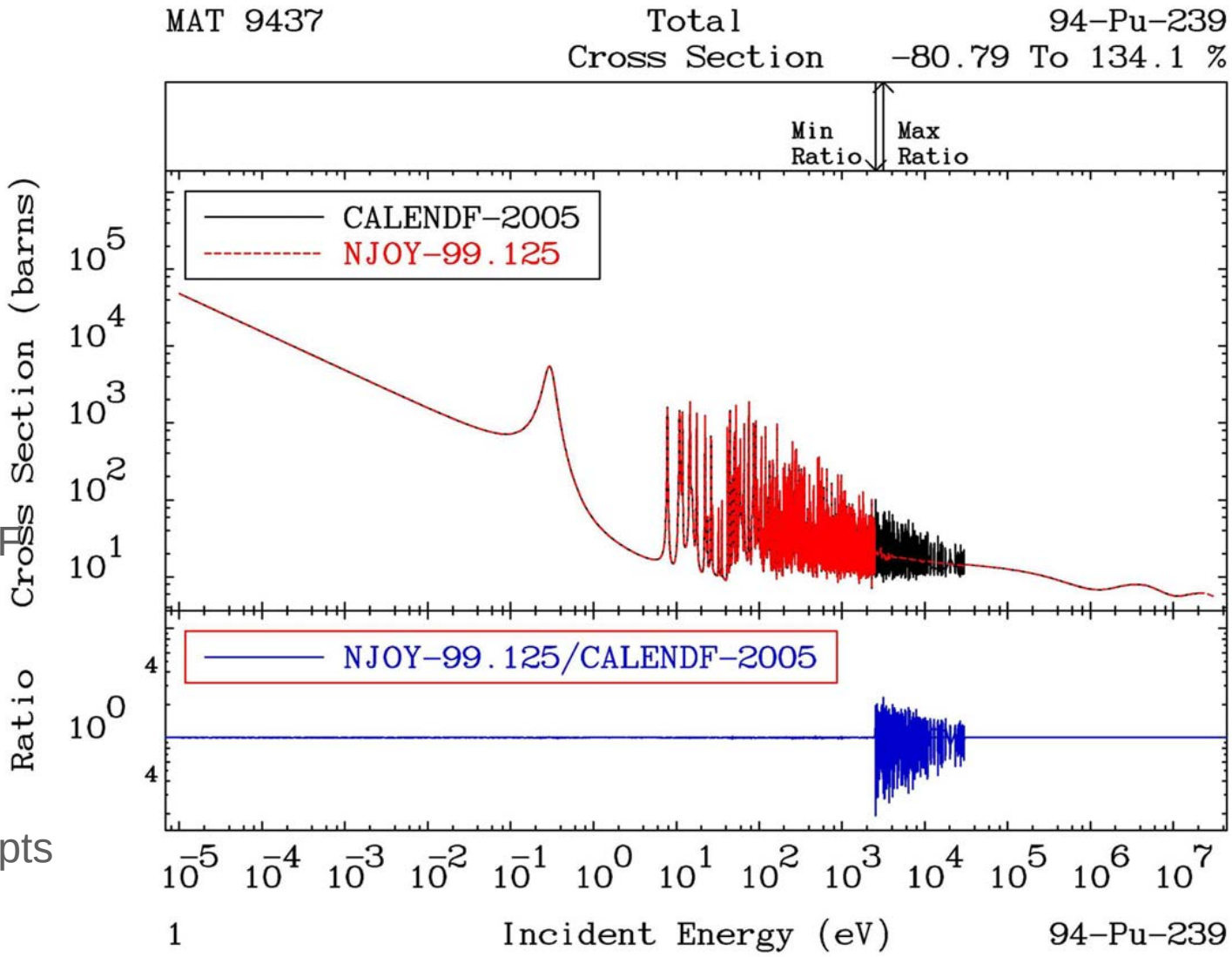
```
tables de probabilite pour  92-U -238 BRC,ORNL+  DIST-APR05
ZA=92238 MAT=9237 TEFF=294. 11276 groupes 1.0000E-5  1.9640E+7 IPRECI=4
IG 2148 ENG=2.237077E+5 2.241743E+5 NOR= 4 I= -3 NPAR=4 KP=2 101 18 4 0
1.094003-1  8.823080+0  8.196058+0  9.286816-2  1.266144-4  5.340267-1
4.538996-1  1.013560+1  9.196054+0  1.202600-1  1.263996-4  8.191575-1
4.029584-1  1.154104+1  1.023916+1  1.267343-1  1.261434-4  1.175020+0
3.374166-2  1.417834+1  1.326865+1  1.516819-1  1.255512-4  7.578883-1
Probability  Total       Elastic     Absorption  Fission     Inelastic
```

Pointwise cross section comparison: total

A Cubic interpolation requires less points than a linear one

But many more points exists in the CALENDF pointwise file in the URR, tenths of thousand …

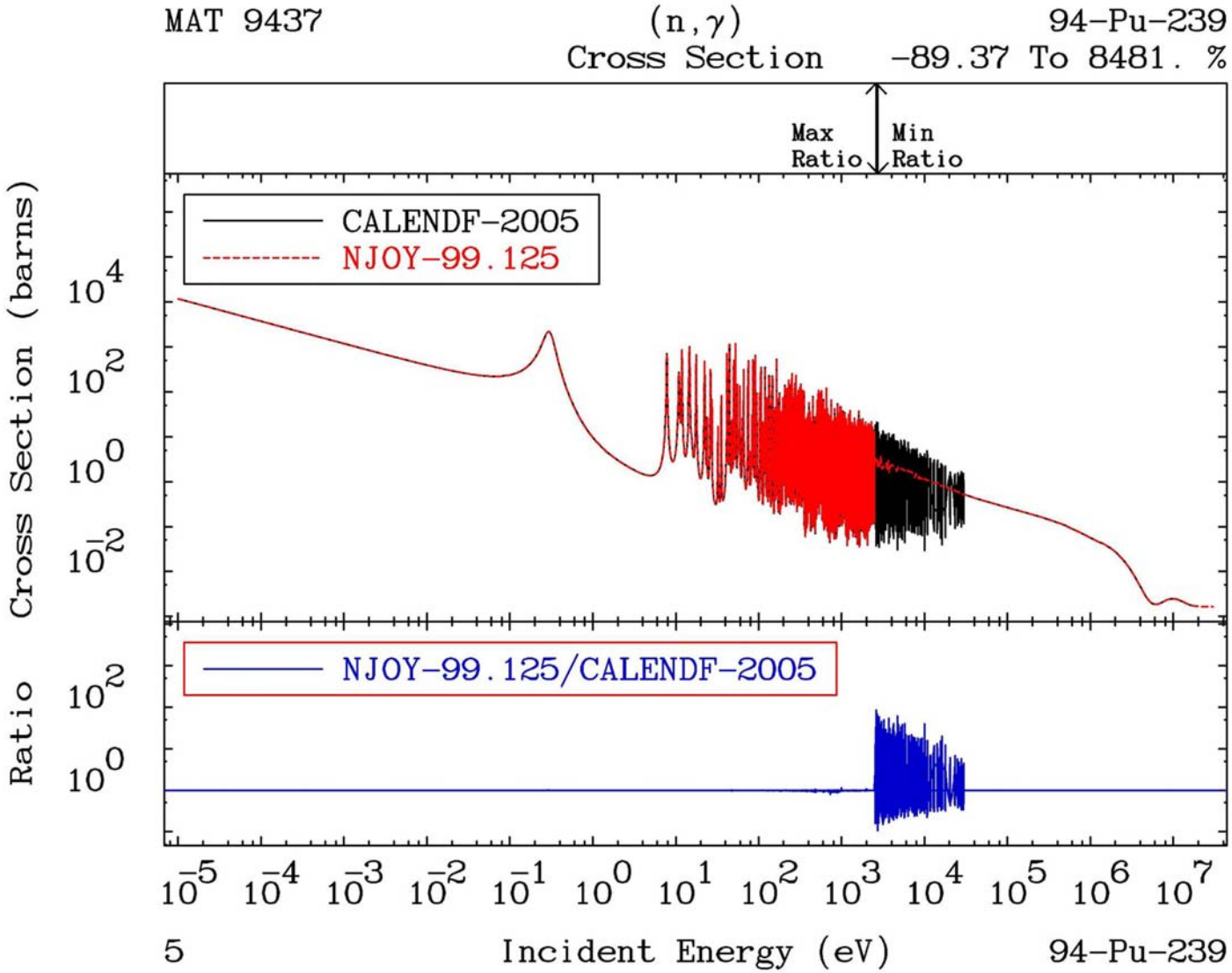
CALENDF 115156 pts
NJOY 72194 pts



Pointwise cross section comparison : capture

Reconstruction Criteria:

CALENDF 0.02%
NJOY 0.1%



CALENDF-NJOY comparison for U238 at 293.6K

COMPARISON ON CROSS SECTION MT= 101 (Abs.) in the **U**nresolved **R**esonance **R**ange

LIST OF DIFFERENCES GREATER THAN 0.0100

	CALENDF	NJOY	EINF	ESUP	SIGMA GENDF	SIGMA P.T.	DELTA	
16	833	1136	1.995887E+04	2.012589E+04	5.525137E-01	5.446610E-01	0.014418	
17	832	1137	2.012589E+04	2.029431E+04	5.106446E-01	4.612736E-01	0.107032	
18	831	1138	2.029431E+04	2.046413E+04	5.092291E-01	5.336834E-01	-0.045822	
19	830	1139	2.046413E+04	2.063538E+04	5.078018E-01	5.269383E-01	-0.036316	
20	829	1140	2.063538E+04	2.080806E+04	5.063609E-01	4.876923E-01	0.038279	
21	828	1141	2.080806E+04	2.098218E+04	5.049111E-01	5.345675E-01	-0.055477	
22	826	1143	2.115777E+04	2.133482E+04	5.019718E-01	4.831857E-01	0.038880	
23	825	1144	2.133482E+04	2.151335E+04	5.004830E-01	5.126722E-01	-0.023776	
24	824	1145	2.151335E+04	2.169338E+04	4.989832E-01	5.114362E-01	-0.024349	
25	823	1146	2.169338E+04	2.187491E+04	4.974701E-01	5.028943E-01	**-0.010786**	**Min.**
26	822	1147	2.187491E+04	2.205796E+04	4.959444E-01	5.031609E-01	-0.014342	
27	821	1148	2.205796E+04	2.224255E+04	4.944059E-01	4.763083E-01	0.037996	
28	820	1149	2.224255E+04	2.242868E+04	4.928544E-01	5.078373E-01	-0.029503	
29	819	1150	2.242868E+04	2.261636E+04	4.912901E-01	5.222933E-01	-0.059360	
30	817	1152	2.280562E+04	2.299646E+04	4.881219E-01	4.805247E-01	0.015810	
31	816	1153	2.299646E+04	2.318890E+04	4.865180E-01	4.499056E-01	0.081378	
32	815	1154	2.318890E+04	2.338295E+04	4.849005E-01	5.166270E-01	-0.061411	
33	814	1155	2.338295E+04	2.357862E+04	4.832695E-01	4.912039E-01	-0.016153	
34	813	1156	2.357862E+04	2.377593E+04	4.816249E-01	4.320517E-01	**0.114739**	**Max.**
35	811	1158	2.397489E+04	2.417552E+04	4.782943E-01	4.857236E-01	-0.015295	
36	810	1159	2.417552E+04	2.437782E+04	4.766081E-01	4.351625E-01	0.095242	

****

ICSBEP Leu-Comp-Therm-006 (JAERI) -007 (Valduc)

Code				Tripoli-4.4.1		Tripoli-4.4.1		Tripoli-4.4.1	
Library				JEFF-3.1		ENDF/B-VII		JENDL-3.3	
		Experiment		Calculation		Calculation		Calculation	
		Keff	Unc.	Kcalc	S.D.	Kcalc	S.D.	Kcalc	S.D.
ICSBEP	Name								
				Thermal range					
LCT-006									
	c-1	1.0000	200	0.99998	12	1.00058	12	0.99834	12
	c-3	1.0000	200	1.00051	9	1.00116	9	0.99866	9
	c-4	1.0000	200	0.99987	12	1.00083	12	0.99823	12
	c-8	1.0000	200	1.00059	12	1.00080	12	0.99837	12
	c-9	1.0000	200	1.00011	12	1.00076	12	0.99837	12
	c-13	1.0000	200	0.99994	12	1.00024	12	0.99810	12
	c-14	1.0000	200	0.99958	12	1.00050	12	0.99814	12
	c-18	1.0000	200	0.99978	12	1.00029	12	0.99782	12
Average				**1.00005**		**1.00065**		**0.99825**	
Δ (C-E)				**5**		**65**		**-175**	
LCT-007									
Valduc	c-1	1.0000	160	0.99780	10	0.99861	12	0.99653	10
	c-2	1.0000	160	0.99932	10	0.99993	14	0.99833	10
	c-3	1.0000	160	0.99749	10	0.99837	14	0.99720	10
	c-5	1.0000	160	0.99753	10	0.99828	14	0.99619	10
	c-6	1.0000	160	0.99915	10	0.99971	14	0.99845	10
	c-7	1.0000	160	0.99843	10	0.99963	14	0.99793	10
Average				**0.99829**		**0.99909**		**0.99744**	
Δ (C-E)				**-171**		**-91**		**-256**	

ICSBEP Leu-Comp-Therm-007 (Valduc)

Case 1

22 x 22 rods; 484 rods

pitch = 1.26 cm

critical water height = 90.69 cm

Grid plate:

60 x 60 cm, 0.25 cm thick

Case 4

(Case 1 grid, with one rod each 2 holes)

18 x 17 rods; 306 rods

pitch = 1.26 x 2 = 2.52 cm

critical water height = 79.85 cm

Case 2

16 x 17 rods; 272 rods

pitch = 1.60 cm

critical water height = 73.53 cm

Grid plate:

60 x 60 cm, 0.25 cm thick

Case 3

15 x 15 rods; 225 rods

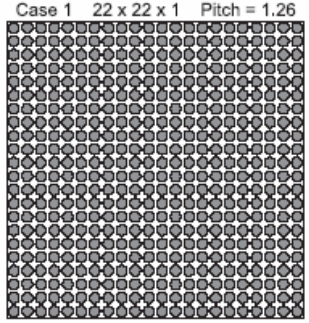
pitch = 2.10 cm

critical water height = 77.98 cm

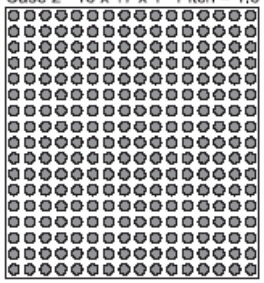
Grid plate:

60 x 60, 0.25 cm thick

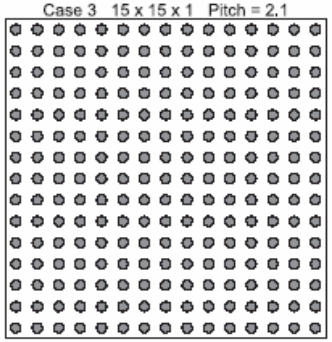
Case 1 22 x 22 x 1 Pitch = 1.26



Case 2 16 x 17 x 1 Pitch = 1.6



Case 3 15 x 15 x 1 Pitch = 2.1



Case 5

14 rods per side

547 rods

triangular pitch 1.35 cm

critical water height = 60.93 cm

Grid plate:

60 x 60 cm, 0.25 cm thick

Case 6

10 rods per side

271 rods

triangular pitch 1.72 cm

critical water height = 68.06 cm

Grid plate:

72 x 72 cm, 0.25 cm thick

Case 7

9 rods per side

217 rods

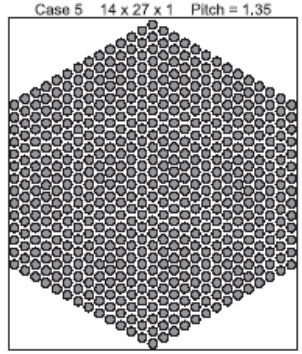
triangular pitch 2.26 cm

critical water height = 79.50 cm

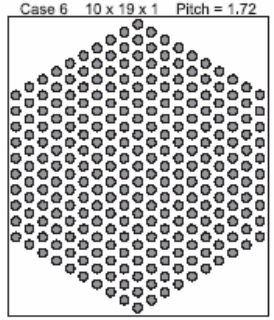
Grid plate:

92.5 x 92.5 cm, 0.25 cm thick

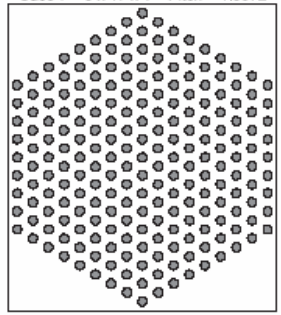
Case 5 14 x 27 x 1 Pitch = 1.35



Case 6 10 x 19 x 1 Pitch = 1.72



Case 7 9 x 17 x 1 Pitch = 1.9572



ICSBEP leu-comp-therm, continued

Code / Library		Experiment		Tripoli-4.4.1 JEFF-3.1 Calculation		Tripoli-4.4.1 ENDF/B-VII Calculation		Tripoli-4.4.1 JENDL-3.3 Calculation	
		Keff	Unc.	Kcalc	S.D.	Kcalc	S.D.	Kcalc	S.D.
ICSBEP	**Name**								
				Thermal range					
LCT-039									
Valduc	c-1	1.0000	140	0.99761	12	0.99824	14	0.99615	12
	c-4	1.0000	140	0.99665	12	0.99765	14	0.99525	12
	c-6	1.0000	140	0.99767	12	0.99801	14	0.99666	12
Average				**0.99731**		**0.99797**		**0.99602**	
Δ (C-E)				**-269**		**-203**		**-398**	
Hiss		1.0000	600	1.01003	13	1.01107	13	1.00580	13
Δ (C-E)				**1003**		**1107**		**580**	
Topsy-NI		1.0000	400	1.00201	17	1.00740	17	1.00593	17
Δ (C-E)				**201**		**740**		**593**	
Topsy-UR		1.0000	400	1.00687	16	1.00747	16	1.00454	16
Δ (C-E)				**687**		**747**		**454**	
LCT-027									
Pb refl.	c-1	1.0000	110	1.00757	12	1.00340	12	1.01003	12
Δ (C-E)				**757**		**340**		**1003**	
LCT-10									
Pb refl.	c-1	1.0000	210	1.00697	12	1.00597	12	1.00768	12
Δ (C-E)				**697**		**597**		**768**	
Pb refl.	c-20	1.0000	280	1.00538	12	1.00531	12	1.00536	12
Δ (C-E)				**538**		**531**		**536**	

$|\Delta k| > \sigma_{exp}$

U235, H1, O16, Pb208

PST = Pu-Solution-Thermal spectrum, Mix Compound

Code				Tripoli-4.4.1		Tripoli-4.4.1		Tripoli-4.4.1	
Library				JEFF-3.1		ENDF/B-VII		JENDL-3.3	
		Experiment		Calculation		Calculation		Calculation	
		Keff	Unc.	Kcalc	S.D.	Kcalc	S.D.	Kcalc	S.D.
ICSBEP	Name								
				Thermal range					
PST-009	48" sphere, Al vessel, bare								
9.54 gPu/l	c-2A	1.0003	330	1.01893	11	1.01923	11	1.02244	11
9.46 gPu/l	c-3A	1.0003	330	1.01927	11	1.01928	11	1.02224	11
Average				**1.01910**		**1.01926**		**1.02234**	
Δ (C-E)				**1880**		**1896**		**2204**	
MCT-004	Mox 3.01 wt% PuO2-UO2 fuel rods,								
2.4 w/f rati	c-1	1.0000	460	0.99683	13	0.99752	13	0.99760	13
2.9 w/f rati	c-4	1.0000	390	0.99707	13	0.99772	14	0.99795	13
4.2 w/f rati	c-7	1.0000	400	0.99779	13	0.99850	13	0.99822	13
5.5 w/f rati	c-10	1.0000	510	0.99783	13	0.99861	13	0.99899	13
Average				**0.99738**		**0.99809**		**0.99819**	
Δ (C-E)				**-262**		**-191**		**-181**	
PST-001	11.5" sphere, water reflected								
73.0 gPu/l	c-1	1.0000	500	1.00186	12	1.00622	12	1.00874	12
96.0 gPu/l	c-2	1.0000	500	1.00356	12	1.00829	12	1.01054	12
119.0 gPu/	c-3	1.0000	500	1.00665	12	1.01115	12	1.01305	12
132.0 gPu/	c-4	1.0000	500	1.00104	12	1.00526	12	1.00712	12
140.0 gPu/	c-5	1.0000	500	1.00505	17	1.00950	12	1.01117	12
268.7 gPu/	c-6	1.0000	500	1.00681	12	1.01057	12	1.01237	12
Average				**1.00416**		**1.00850**		**1.01050**	
Δ (C-E)				**416**		**850**		**1050**	

PST = Plutonium-Solution-Thermal spectrum

Code				Tripoli-4.4.1		Tripoli-4.4.1		Tripoli-4.4.1	
Library				JEFF-3.1		ENDF/B-VII		JENDL-3.3	
		Experiment		Calculation		Calculation		Calculation	
		Keff	Unc.	Kcalc	S.D.	Kcalc	S.D.	Kcalc	S.D.
ICSBEP	Name								
				Thermal range					
PST-011	16&18" sphere, bare								
34.9 gPu/l	16-1	1.0000	520	1.00669	13	1.01037	12	1.01408	13
43.4 gPu/l	16-5	1.0000	520	1.00337	13	1.00668	12	1.01041	13
Average				**1.00503**		**1.00853**		**1.01225**	
Δ (C-E)				**503**		**853**		**1225**	
22.3 gPu/l	18-1	1.0000	520	0.99134	13	0.99450	12	0.99893	13
27.5 gPu/l	18-6	1.0000	520	0.99708	13	1.00049	12	1.00435	13
Average				**0.99421**		**0.99750**		**1.00164**	
Δ (C-E)				**-579**		**-250**		**164**	
PST-013	256-mm cyl, in air								
115 gPu/l	c-1	0.9980	400	1.00169	12	1.00510	12	1.00823	12
115 gPu/l	c-2	0.9980	400	1.00157	12	1.00528	12	1.00774	12
Average				**1.00163**		**1.00519**		**1.00799**	
Δ (C-E)				**363**		**719**		**999**	
115 gPu/l	c-4	0.9965	520	0.99419	12	0.99747	12	1.00037	12
Δ (C-E)				**-231**		**97**		**386**	
		$\|\Delta k\| > \sigma$ exp.		Pu239 Pu24x		Pu239 Pu24x		Pu239 Pu24x	

ICSBEP water criticality benchmarks with U and Pu

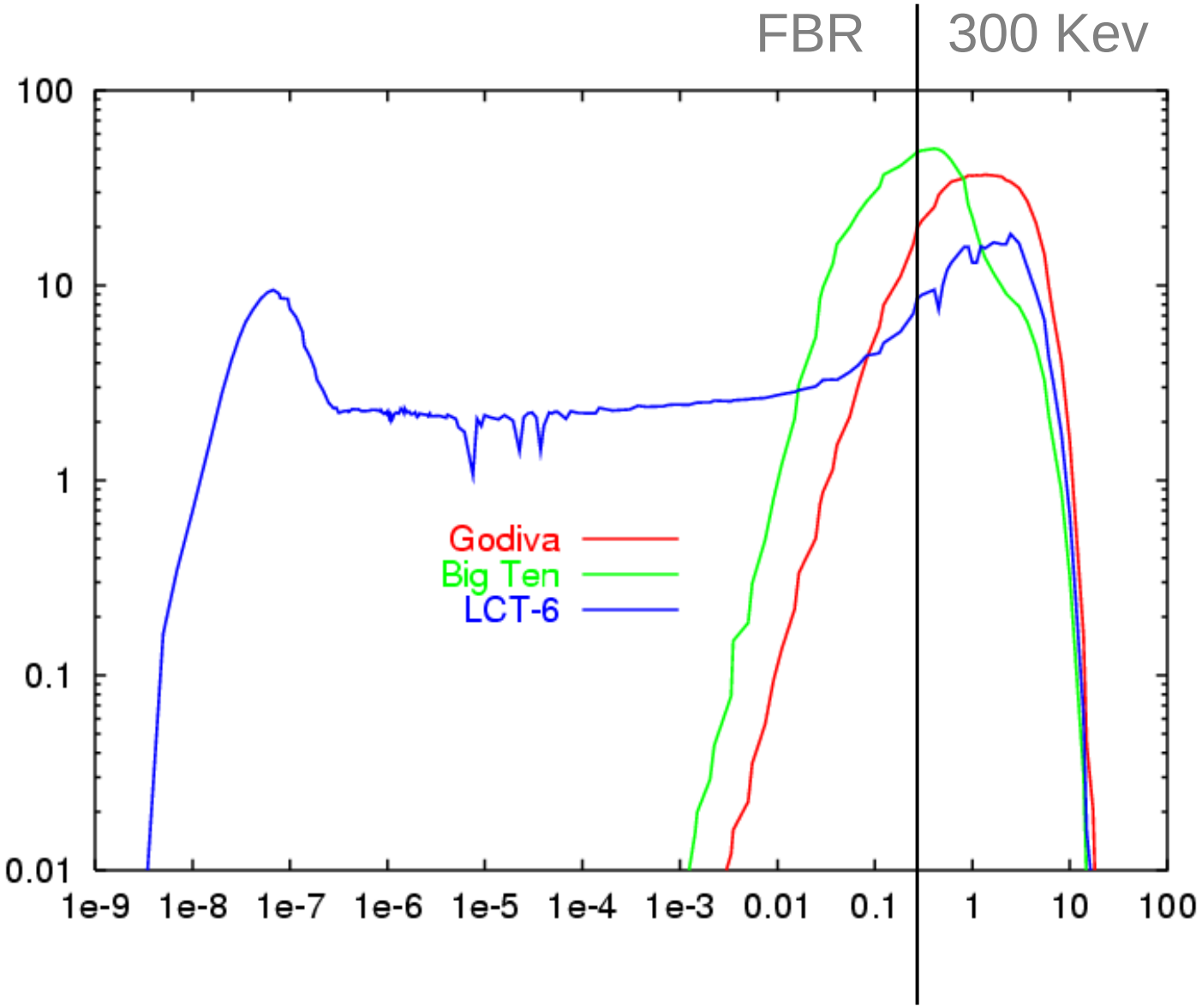
Comparison between JEF-2.2 and JEFF-3.1 **H and H in H_20** evaluations with JEFF-3.1 as base library

~ ±100 pcm swing

Name	Composition	Exp Res.	Old Res.	New Res.	Δ
HST011_C01	UO_2F_2 +H_2O	1.0000 ±(200)	1.00552 ±(20)	1.00549±(20)	**-3**
HST011_C02	UO_2F_2 +H_2O	1.0000 ±(200)	1.00235 ±(20	1.00180 ±(19)	**-55**
HSTO12_c01	UO_2F_2 +H_2O	0.9999 ±(580)	1.00228 ±(20)	1.00189 ±(20)	**-39**
PST001_c01_sph	Sol Pu. Nit.+H_2O	1.0000 ±(500)	1.00401 ±(19)	1.00494 ±(19)	**93**
PST004_C02	Sol Pu. Nit. H_2O	1.0000 ±(470)	0.99892 ±(19)	0.99854 ±(19)	**-38**
LCT006_c01	UO_2 + H_2O	1.0000 ±(200)	1.00164 ±(20)	1.00250 ±(20)	**86**
LCT007_c01	UO_2 + H_2O	1.0000 ±(200)	1.00162 ±(20)	1.00250 ±(20)	**88**
MCT004_c01	UPu + H_2O	1.0000 ±(460)	0.99615 ±(20)	0.99688 ±(19)	**73**
HMF004_c01_1D	$U_{enrich.}$ +H_2O	0.9985 ±	0.99854 ±(21)	0.99845 ±(21)	**-9**
PMF011_c01	Pu +H_2O	1.0000 ±(100)	0.99760 ±(20)	0.99730 ±(20)	**-30**

Well within the uncertainty bands

Thermal, Intermediate and Fast benchmarks spectra



Metal-Fast - Intermediate spectra

Code Library		Experiment		Tripoli-4.4.1 JEFF-3.1 Calculation		Tripoli-4.4.1 ENDF/B-VII Calculation		Tripoli-4.4.1 JENDL-3.3 Calculation	
		Keff	Unc.	Kcalc	S.D.	Kcalc	S.D.	Kcalc	S.D.
ICSBEP	**Name**								
				Fast range					
IMF-007									
Big Ten	deta.	1.0045	70	0.99863	13	1.00503	13	1.01040	13
	simp.	1.0045	70	0.99790	13	1.00417	13	1.00950	13
Δ (C-E)				**-623**		**10**		**545**	
	t.z.h.	0.9948	130	0.98830	12	0.99534	12	1.00188	13
Δ (C-E)				**-650**		**54**		**708**	
IMF-012									
ZPR(16%)	c-1	1.0007	270	1.00261	13	1.00408	13	1.00618	13
Δ (C-E)				**191**		**338**		**548**	
IMF-10									
ZPR-U9	c-1	0.9954	240	0.99181	12	0.99688	12	1.00373	13
Δ (C-E)				**-359**		**148**		**833**	
IMF-002									
	c-1	1.0000	300	0.99216	10	0.99923	10	1.00228	10
Δ (C-E)				**-784**		**-77**		**228**	
IMF-001									
Jemima	c-2	1.0000	120	0.99837	12	0.99902	12	1.00702	12
	c-3	1.0000	100	0.99741	12	1.00080	12	1.00526	12
	c-4	1.0000	100	0.99850	12	1.00166	12	1.00625	12
Average				**0.99809**		**1.00049**		**1.00618**	
Δ (C-E)				**-191**		**49**		**618**	

$|\Delta k| > \sigma$ exp.

U238
U235

U238
U235

High enriched -Metal-Fast-

Code				Tripoli-4.4.1		Tripoli-4.4.1		Tripoli-4.4.1	
Library				JEFF-3.1		ENDF/B-VII		JENDL-3.3	
		Experiment		Calculation		Calculation		Calculation	
		Keff	Unc.	Kcalc	S.D.	Kcalc	S.D.	Kcalc	S.D.
ICSBEP	Name								
				Fast range					
HMF-028									
Flattop-25		1.0000	300	1.00210	11	1.00321	11	1.00385	11
Δ (C-E)				**210**		**321**		**175**	
HMF-001									
Godiva	c1	1.0000	100	0.99645	11	1.00020	11	1.00717	11
	c2	1.0000	100	0.99660	11	1.00027	11	1.00723	11
Average				**0.99653**		**1.00023**		**1.00720**	
Δ (C-E)				**-347**		**23**		**720**	
PMF-001									
Jezebel	c-1	1.0000	200	1.00025	15	0.99963	15	0.99759	15
Δ (C-E)				**25**		**-37**		**-241**	
PMF-002									
Jez. 240	c-1	1.0000	200	1.00430	15	0.99986	15	1.00118	15
Δ (C-E)				**430**		**-14**		**118**	

U235
Pu240

$|\Delta k| > \sigma$ exp.

U235
Pu239

HST=High Enriched U-Solution-Thermal spectrum

Code				Tripoli-4.4.1		Tripoli-4.4.1		Tripoli-4.4.1	
Library				JEFF-3.1		ENDF/B-VII		JENDL-3.3	
		Experiment		Calculation		Calculation		Calculation	
		Keff	Unc.	Kcalc	S.D.	Kcalc	S.D.	Kcalc	S.D.
ICSBEP	Name								
				Solutions					
HST001									
Mid	c-1	1.0004	600	0.99908	16	0.99907	16	1.00026	16
Leakage	c-2	1.0021	720	0.99666	16	0.99700	17	0.99772	16
Nitrate	c-3	1.0003	350	1.00237	16	1.00208	17	1.00331	16
	c-4	1.0008	530	0.99929	16	0.99865	16	1.00002	16
	c-5	1.0001	490	0.99974	16	0.99925	16	1.00072	16
	c-6	1.0002	460	1.00314	16	1.00227	16	1.00406	16
	c-7	1.0008	400	0.99882	16	0.99853	16	0.99934	16
	c-8	0.9998	380	0.99890	16	0.99840	16	0.99957	16
	c-9	1.0008	540	0.99483	16	0.99480	16	0.99546	16
Average		**1.0006**		**0.99920**		**0.99890**		**1.00005**	
Δ (C-E)				**-139**		**-169**		**-54**	
HST009									
High	c-1	0.9990	430	1.00064	19	1.00238	17	1.00322	16
Leakage	c-2	1.0000	390	1.00144	16	1.00293	16	1.00309	16
Fluoride	c-3	1.0000	360	1.00099	16	1.00251	16	1.00191	16
	c-4	0.9986	350	0.99559	16	0.99700	16	0.99660	16
Average		**0.9994**		**0.99966**		**1.00120**		**1.00120**	
Δ (C-E)				**26**		**180**		**180**	
HST010									
Fluoride	c-1	1.0000	290	1.00104	16	1.00148	16	1.00192	16
	c-2	1.0000	290	1.00122	16	1.00221	16	1.00224	16
	c-3	1.0000	290	0.99872	16	0.99953	16	0.99973	16
	c-4	0.9992	290	0.99666	16	0.99773	16	0.99769	16
Average		**0.9998**		**0.99941**		**1.00024**		**1.00039**	
Δ (C-E)				**-39**		**44**		**59**	

$|\Delta k| > \sigma \exp.$

HST=High Enriched U-Solution-Thermal spectrum

Code				Tripoli-4.4.1		Tripoli-4.4.1		Tripoli-4.4.1	
Library				JEFF-3.1		ENDF/B-VII		JENDL-3.3	
		Experiment		Calculation		Calculation		Calculation	
		Keff	Unc.	Kcalc	S.D.	Kcalc	S.D.	Kcalc	S.D.
ICSBEP	Name								
				Solutions					
HST011									
Fluoride	c-1	1.0000	230	1.00473	16	1.00524	16	1.00595	16
	c-2	1.0000	230	1.00062	16	1.00110	16	1.00167	16
Average				**1.00267**		**1.00317**		**1.00381**	
Δ (C-E)				**267**		**317**		**381**	
HST012									
	c-1	0.9999	580	1.00115	16	1.00096	16	1.00193	15
Δ (C-E)				**125**		**106**		**203**	
HST013									
ORNL-1	c-1	1.0012	260	0.99880	16	0.99906	16	0.99982	16
ORNL-2	c-2	1.0007	360	0.99791	16	0.99766	16	1.00167	16
ORNL-3	c-3	1.0003	360	0.99416	16	0.99411	16	0.99519	16
ORNL-4	c-4	1.0003	360	0.99591	16	0.99593	16	0.99702	16
Average		**1.0006**		**0.99669**		**0.99669**		**0.99843**	
Δ (C-E)				**-393**		**-394**		**-220**	
HST018									
Nitrate	c-1	1.0000	340	0.98956	16	0.99093	16	0.99071	16
Gd	c-2	1.0000	460	0.98503	16	0.98570	16	0.98620	16
	c-3	1.0000	420	0.98832	16	0.98949	16	0.98969	16
Average				**0.98764**		**0.98871**		**0.98887**	
Δ (C-E)				**-1236**		**-1129**		**-1113**	
HST019									
	c-1	1.0000	410	0.99691	16	0.99835	17	0.99846	16
Δ (C-E)				**-309**		**-165**		**-154**	
HST032									
ORNL-10		1.0015	260	0.99881	16	0.99939	16	0.99990	16
Δ (C-E)				**-269**		**-211**		**-160**	

Gadolinium

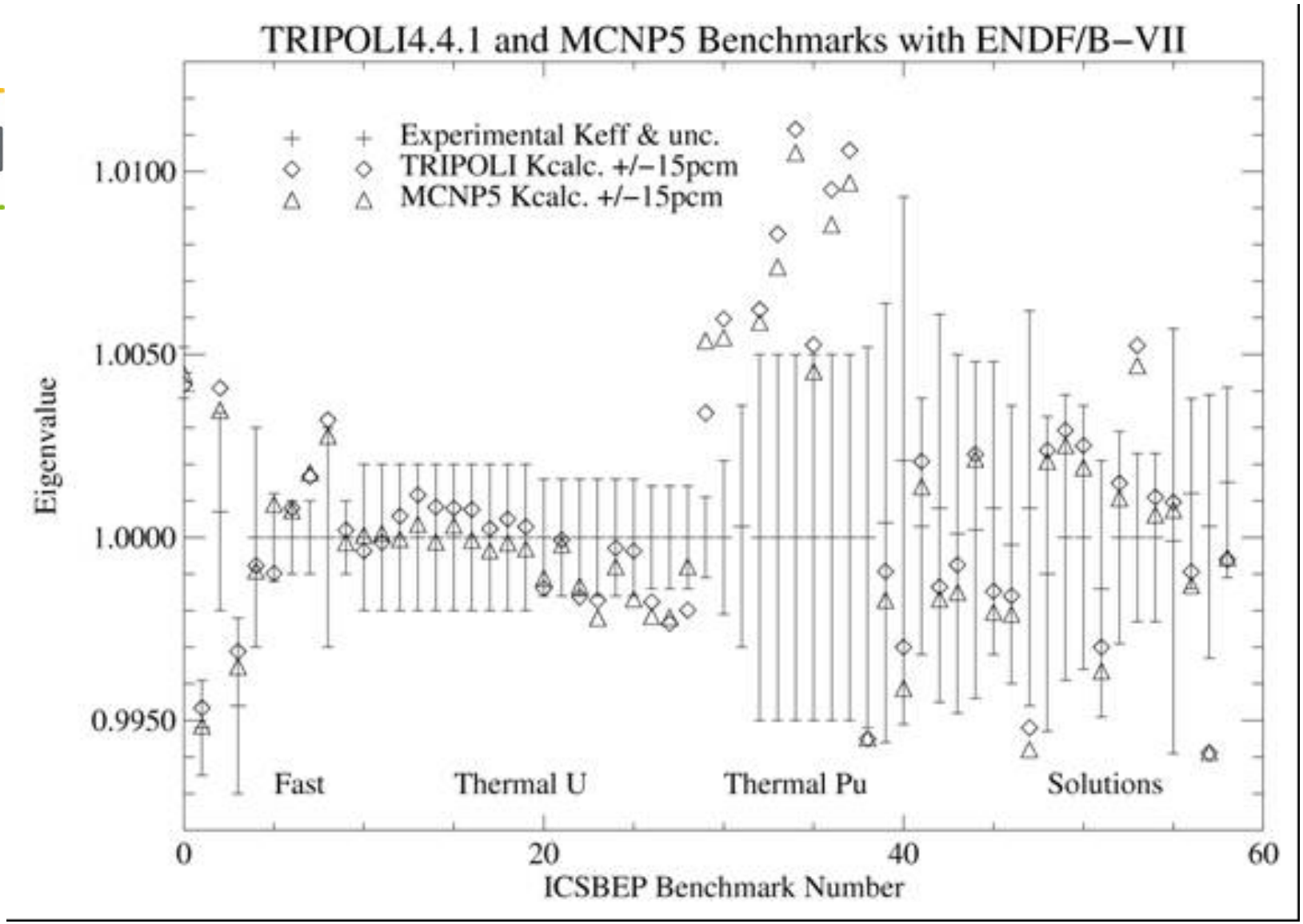
$|\Delta k| > \sigma$ exp.

Comparison Between MCNP5 (LANL) and Tripoli 4.4.1 (Sublet)

- Excellent agreement is observed between MCNP5 and Tripoli eigenvalues for a variety of benchmarks.
  - Previous differences in LEU-COMP-THERM-006 have been attributed to slightly different fuel compositions.
  - Previous differences in selected HEU-SOL-THERM-001 eigenvalues are attributed to different normalizations.

Mcnp4c3 and MCNP5 use discrete thermal sampling versus the new continuous MCNP5-Bob, (or MCNP(X)2.6c) -20 to +30, (5o) pcm swing on HST,LST and LCT's

Comparison MCNP5 & TRIPOLI-4.4.1, 60 ICSBEP



Conclusions (Monte Carlo)

TRIPOLI-4.4 – MCNP5 & JEFF-3.1 - ENDF/B-VII - JENDL-3.3

The keff's prediction do **always** agree, even in the thermal range were the differences are within the experimental uncertainties if ALL (option, geometry, number density …) is identical ….

An excellent agreement exists in the fast range, when using Monte Carlo codes with CALENDF or PURR probability tables and the best data files; what about the deterministic codes ??

One cannot help noticing numerous and large compensation effects, arising not only from the major isotopes such as U's, Pu's but also from the minor ones including the structural isotopes

Times as come for the Monte Carlo benchmarking to probe further the basic data: angular distribution, emitted spectra, neutron spectrum and cross section ratio

Conclusions (libraries)

- The striking overall improvement of the predictions and simulation for many nuclear technologies (fission reactors, accelerator, transmutation, fusion technology, medicine, earth exploration, astrophysics, passive interrogation techniques etc..) has been the result of concerted, usually voluntary efforts on all the general but also the special purpose files

- The results presented show that while the most recent library ENDF/B-VII, which benefited from the timely development of JENDL-3.3 and JEFF-3.1, produces better overall results, it suggest clearly also that improvements are still needed

- Foreseen (majors) improvements (JEFF-3.1):
  - Thermal-epithermal: ^{239,241}Pu,^{235}U, Pb's
  - Fast, ^{238}U, ^{235}U, ^{240}Pu
  - Overall, Gd's, Hf's

This list is not exhaustive and will be impacted by the low Z data of ^{1}H, ^{16}O, ^{14}N, etc…that differs from one library to another…

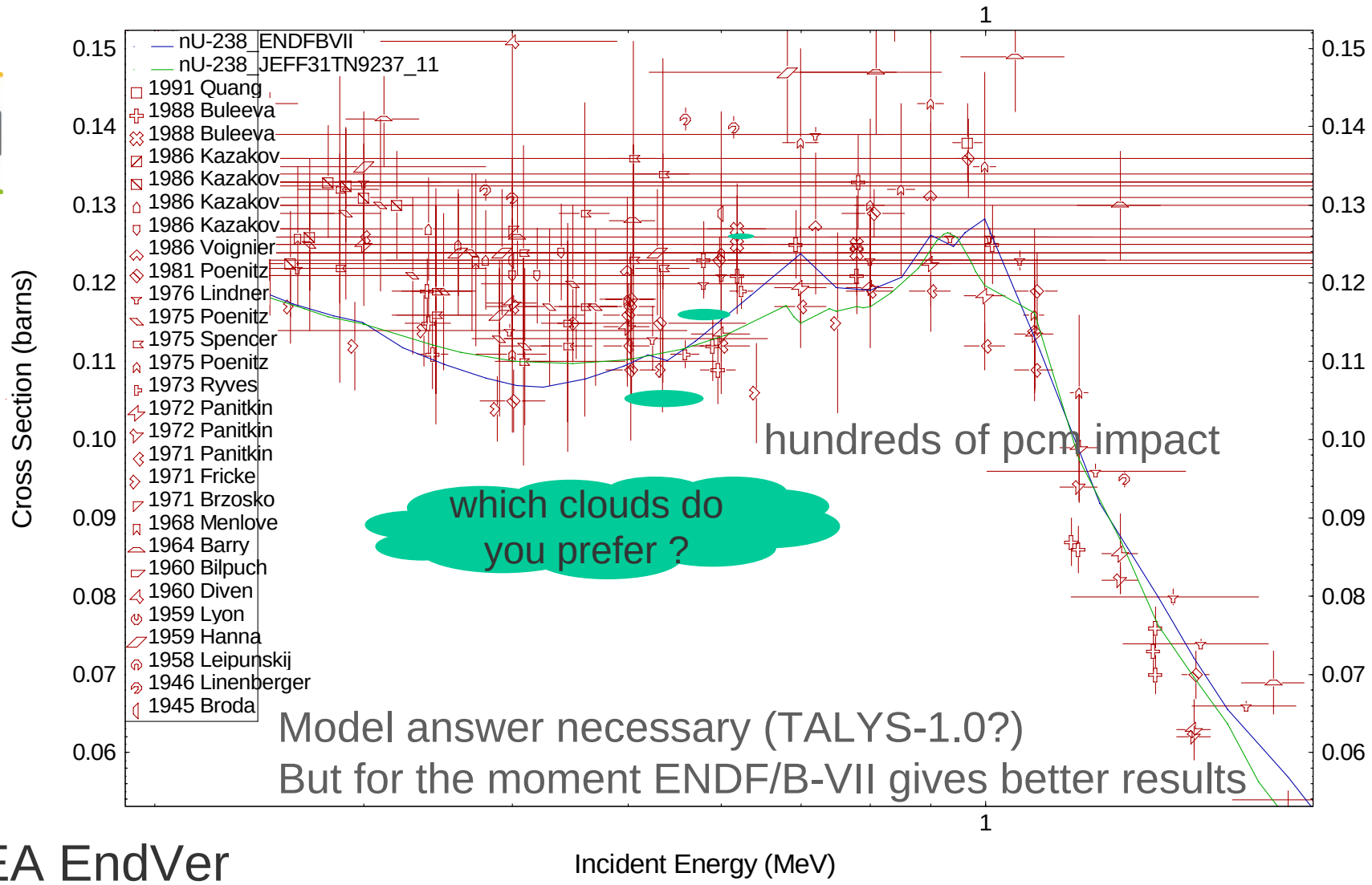
Conclusions

- The improvement does not always has to involve directly the cross sections themselves but also their angular distribution, particles emitted spectra, and other nuclear data such as yields, Q-values, emitted particles numbers and kinds, half-lives and decay data and schemes.

- The new JEFF-3.1, ENDF/B-VII and JENDL-3.3 libraries respectively produced by a handful of EU, US and Japanese laboratories represent common achievements. They all benefited from appreciable, substantial and timely input from the international nuclear data community that all those laboratories together represent so well.

- For the first time considerable efforts have been dedicated to the verification, processing and validation of all libraries prior to their open releases.

U-238 above URR capture region



IAEA EndVer