Wir schaffen Wissen – heute für morgen

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Why do we need more covariances in JEFF and how to achieve it

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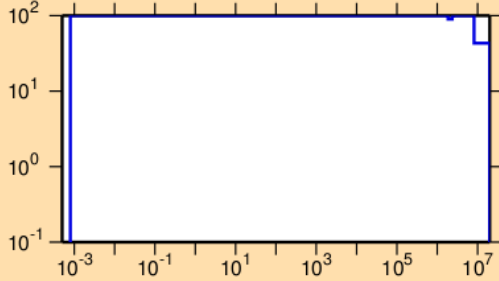5. Conclusion

- In JEFF-3.2, 217 isotopes contain covariances,
- Many covariances come from TENDL-2012 (for exotic isotopes),
- But JEFF-3.2 lacks ^{235}U, ^{239}Pu, and contains "only" 3 reactions for ^{238}U.

- Out of 217 isotopes with covariances, 45 are original (not directly taken from another library):
  - 11 from IRK/IAEA
  - 11 from KAERI
  - 10 from NRG/ECN (not in TENDL)
  - 10 from FZK/KIT
  - 3 from CEA

- In ENDF/B-VII.1, 180 isotopes, all uranium and plutonium (93 originals)
- In JENDL-4.0, 88 isotopes, all uranium and plutonium (88 originals, but fission products are missing)
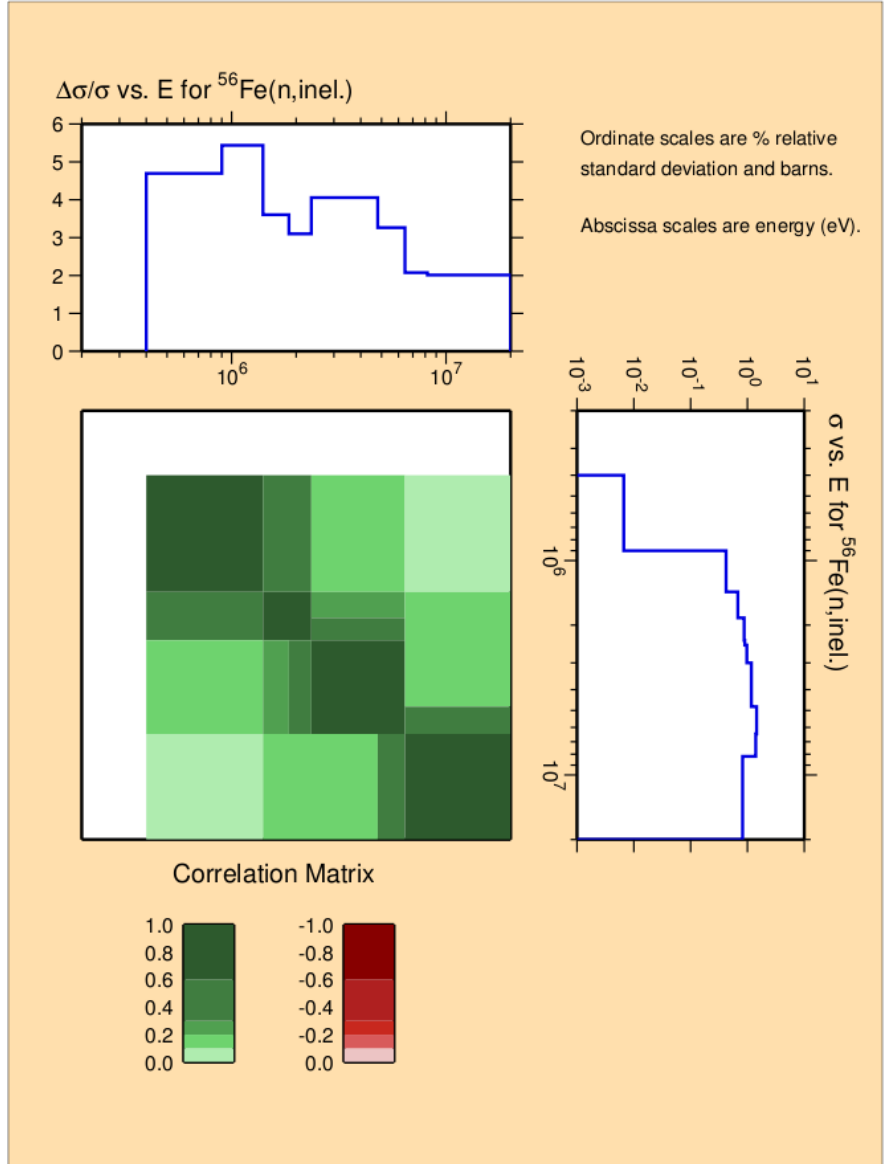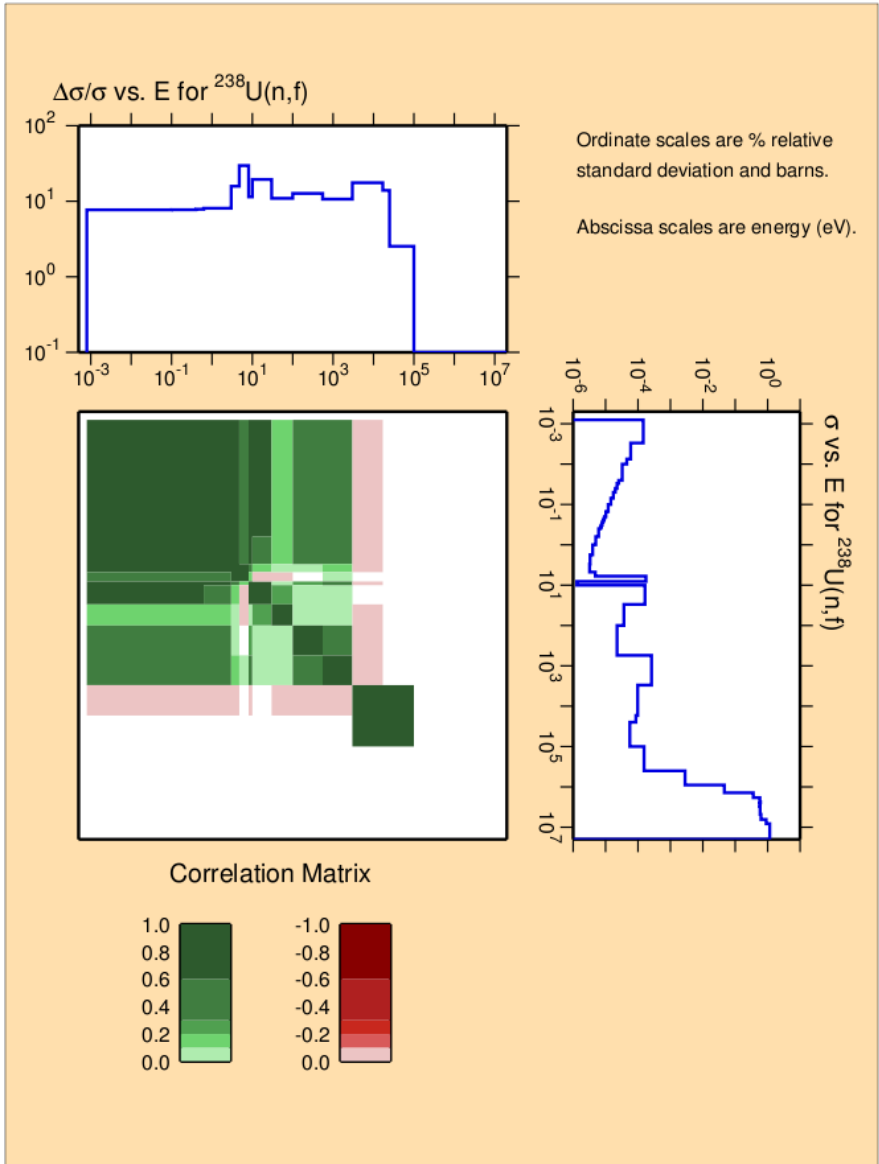
$\Delta\sigma/\sigma$ vs. E for ^{238}U(n,f)

Ordinate scales are % relative standard deviation and barns.

Abscissa scales are energy (eV).

σ vs. E for ^{238}U(n,f)

Correlation Matrix

$\Delta\sigma/\sigma$ vs. E for ^{56}Fe(n,inel.)

Ordinate scales are % relative standard deviation and barns.

Abscissa scales are energy (eV).
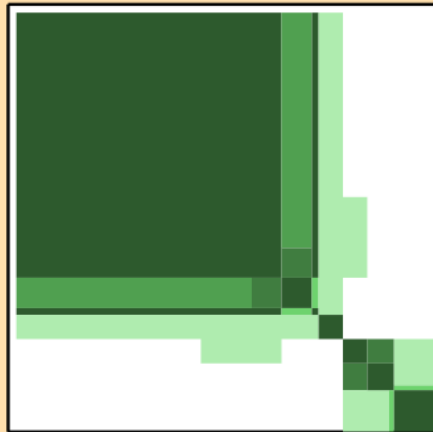
σ vs. E for ^{56}Fe(n,inel.)

Correlation Matrix
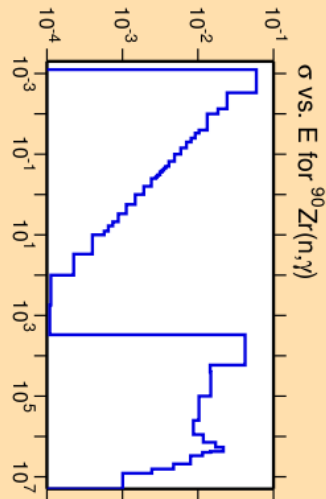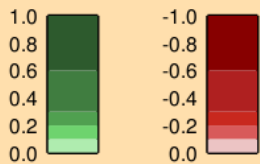
$\Delta\sigma/\sigma$ vs. E for ^{90}Zr(n,γ)

Ordinate scales are % relative standard deviation and barns.

Abscissa scales are energy (eV).

Warning: some uncertainty data were suppressed.

σ vs. E for ^{90}Zr(n,γ)

Correlation Matrix

1.0		-1.0	
0.8		-0.8	
0.6		-0.6	
0.4		-0.4	
0.2		-0.2	
0.0		0.0	

- Missing covariances for ^{235}U, ^{239}Pu and partially for ^{238}U prohibit users to get reasonable results on uncertainties,

- Users will then use ENDF/B-VII.1, JENDL-4.0, SCALE covariances (and even TENDL covariances) because they are complete,

- Sometimes, users mix and match evaluations and covariances (leads to heretic behavior…),

- A consequence is that JEFF-3.2 as a full library (not only covariances) is "left aside".

Example with a burn-up calculation

- A simple assembly, PWR UO_2 as presented in UAM Benchmark Phase II Exercise II-2 case 2a (up to 10 MWd/kg, 4.1 % ^{235}U, 2% Gd, CASMO-5 calculation (ENDF/B-VII.1 nuclear data),
- 500 random cross sections for all isotopes (TMC-like, but based on JEFF-3.2 covariances)

	keff uncertainties in pcm at 10 MWd/kg		
	scale6.0	endfb7.1	jeff3.2
u235	346	559	no covariance files -
u238	372	401	382
pu239	330	185	no covariance files -
light elements	44	32	27
heavy elements	8	6	0
minor actinides	26	33	5
fission products	55	99	0
Total uncertainty	610 pcm	720 pcm	380 pcm

	Cm244 number density uncertainty (%) at 10 MWd/kg		
	scale6.0	endfb7.1	jeff3.2
u235	1.3	1.2	no covariance files -
u238	1.5	1.5	1.1
pu239	1.3	1.3	no covariance files -
light elements	0.4	0.4	0.4
heavy elements	0.0	0.0	0.0
minor actinides	10.5	12.0	0.2
fission products	0.1	0.0	0.0
Total uncertainty	10.8	12.2	1.2

The following remarks should be integrated in the "Covariance activity roadmap for JEFF mandate" by Cyrille de Saint Jean,

- 1) need of covariances: as mentioned by Arjan Plompen, the lack of covariances in JEFF-3.2 lead to discard the whole library
  - Urgent need of (1) actinides, (2) fission products and (3) structural materials (0 to 20 MeV)
  - Light isotopes: covered by ENDF/B-VII.1, but is that enough (work by Helmut Leeb ?)
  - Fission yields: work is underway (Robert Mills/GEF) ?
  - Thermal scattering data: see SG42, but what to do in the meantime ?
  - Decay data: no covariance files exist.

- 2) Define the needed formats
  - ENDF,
  - plots,
  - COVERX,
  - AMPX,
  - tables,
  - random ENDF/ACE files.

- 3) Testing at the nuclear data level
  - Completeness,
  - Mathematically correct,
  - Reasonable uncertainties.

- 4) Testing at the application level
  - Methods: perturbation/sensitivity, TMC (based on covariances or random files)
  - Type of applications: fission (PWR/BWR), shielding (shielding benchmarks), burn-up
  - Quantities: k_{eff}, rates, number densities
  - Tools: MCNP, SERPENT, CASMO, APPOLO…

- 5) Provide scripts
  - NJOY scripts, testing (mathematics, format),
  - How to produce random files ?

- 6) A place to store them (website): NEA, IAEA, a dedicated webpage ?

- 7) Who will do the work ?

1. JEFF needs covariances for actinides, fission products and structural materials,

2. It needs them now,

3. Can we produce them for the next ND conference ?