

ACE file perturbation tool

Japan Atomic Energy Agency (JAEA)

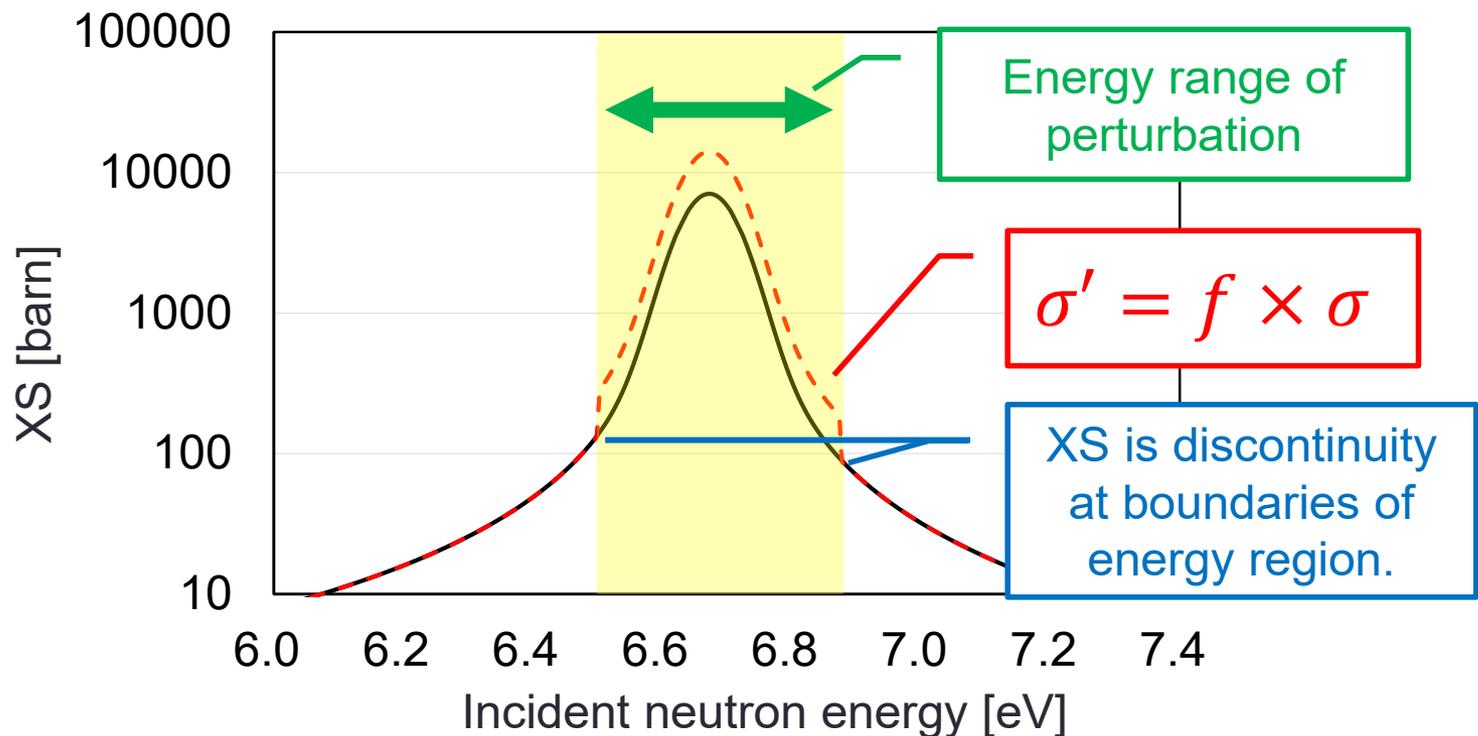
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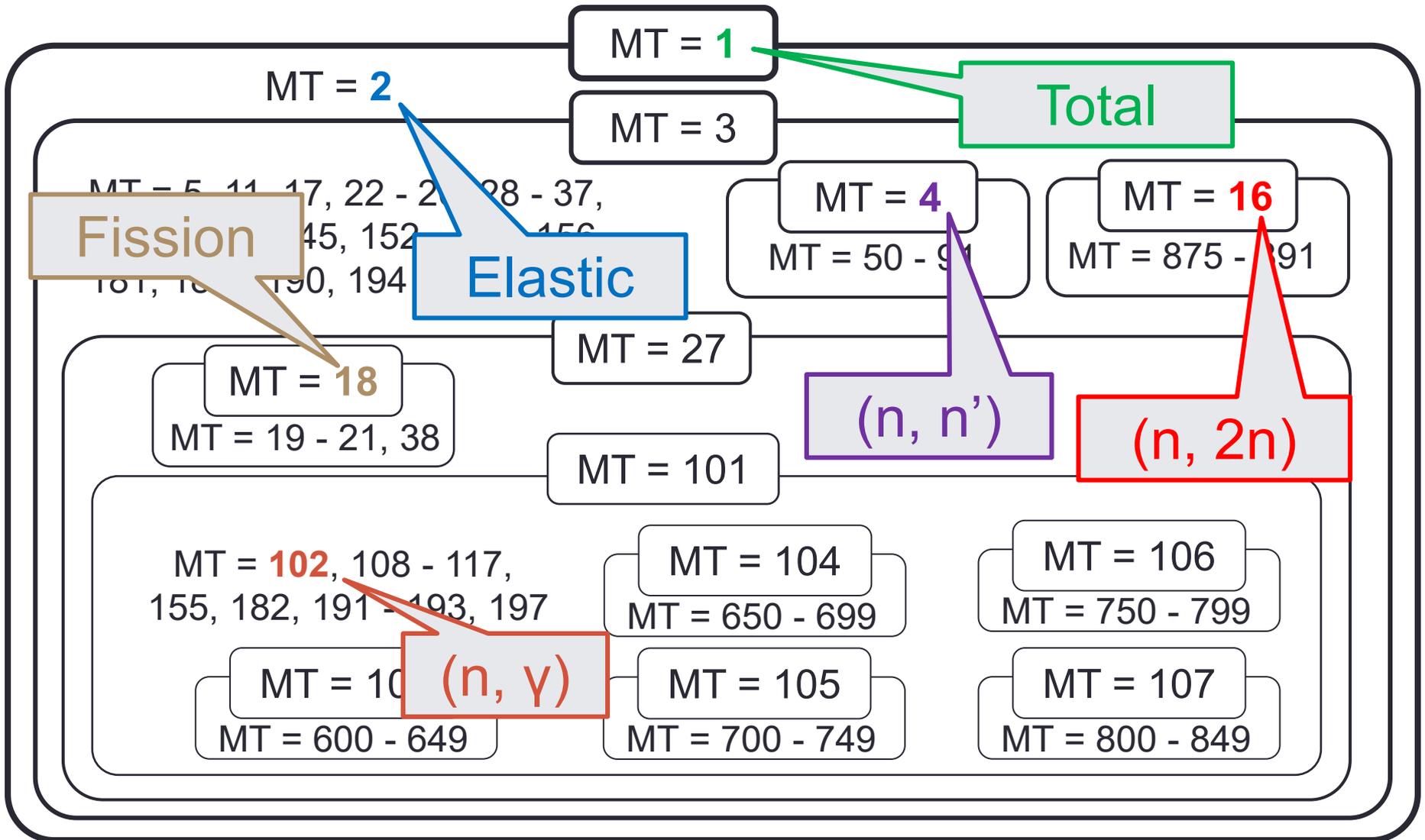
Ref: R. Kondo, T. Endo, A. Yamamoto, K. Tada, “Implementation of random sampling for ACE-format cross sections using FRENDY and application to uncertainty reduction,” *Proc. M&C2019*, Aug. 25-29, Portland, USA (2019).

Perturbation of ACE file

- Perturbation tool decreases or increases cross section (XS) or number of neutron per fission (ν) or fission spectrum (χ).
 - XS or χ is multiplied by perturbation factor f within arbitrary energy range.
- This tools can be adopted to two analyses.
 - Sensitivity analysis with direct perturbation method
 - Uncertainty analysis with random sampling method



Relations of each reaction type



Example of fission XS perturbation

Perturbed fission XS (MT=18): $\sigma_{18}' = f \times \sigma_{18}$ (Perturbation factor: f)

MT18 contains MT=19-21 and 38.

MT=19-21 and 38 are also perturbed.

$$\sigma_{19}' = f \times \sigma_{19}, \sigma_{20}' = f \times \sigma_{20},$$

$$\sigma_{21}' = f \times \sigma_{21}, \sigma_{38}' = f \times \sigma_{38}$$

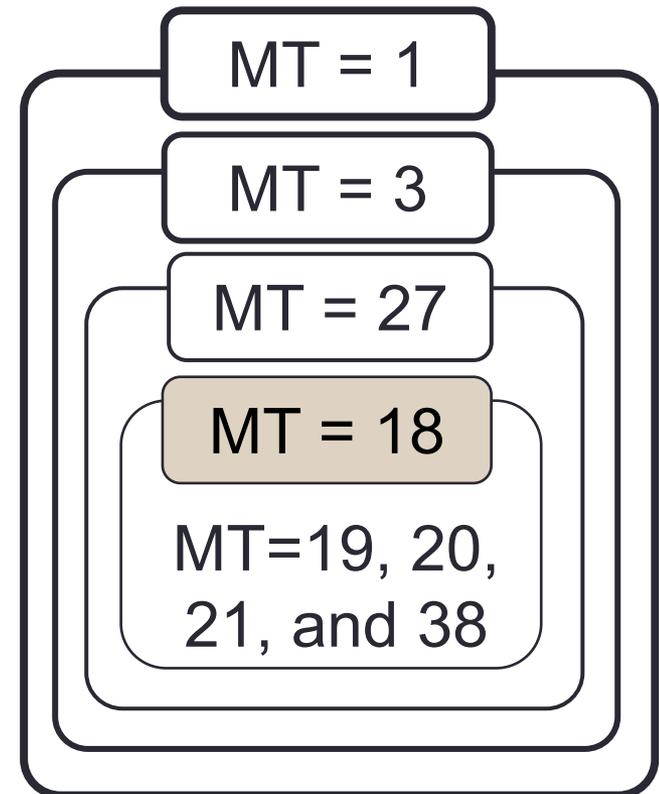
MT=1, 3, and 27 contain MT=18.

XS of MT=1, 3, and 27 are modified.

$$\Delta\sigma_{18} = \sigma_{18}' - \sigma_{18}$$

$$\sigma_1' = \sigma_1 + \Delta\sigma_{18}, \sigma_3' = \sigma_3 + \Delta\sigma_{18}$$

$$\sigma_{27}' = \sigma_{27} + \Delta\sigma_{18}$$



How to use perturbation tool

- Compile of perturbation tool
 - Run “make” command on
“frendy_20YYMMDD/tools/perturbation_ace_file”.
 - Executable file (**perturbation_ace_file.exe**) is generated.
- Manual of perturbation tool is
“frendy_20YYMMDD/tools/README_tools”.

./perturbation_ace_file.exe ace_file.ace perturbation_list.inp

Perturbation
ACE file name

Input file of
perturbation tool

Input of perturbation tool

- Following four parameters **must be set in one line.**
 - 1) Reaction type (MT number)
 - 2) Lower energy of perturbed energy range [MeV]
 - 3) Upper energy of perturbed energy range [MeV]
 - 4) Perturbation factor f ($\sigma' = f \times \sigma$)

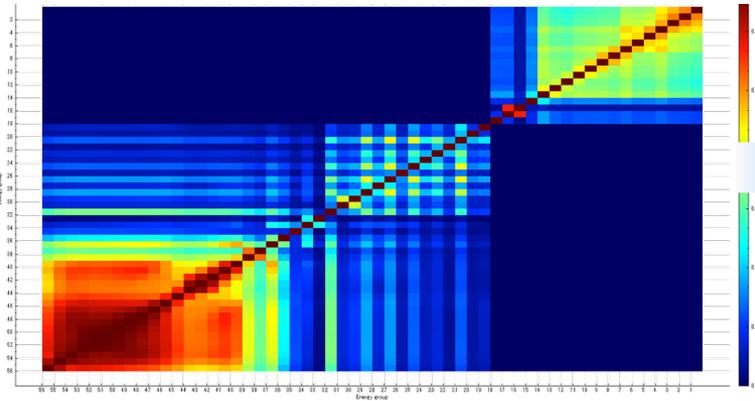
ACE file uses MeV
for unit of energy.

[Example of input of perturbation tool]

2	1.0e-11	1.0e-10	1.1
18	1.0e-6	1.0e-5	0.9

Random sampling

Covariance matrix of nuclear data



inp/Nddd_000x

102	2.00E+01	6.43E+00	8.78E-01
102	6.43E+00	4.30E+00	8.67E-01
102	4.30E+00	3.00E+00	8.62E-01
		...	

- User has to prepare covariance matrix.
 - We are now developing converter from GENDF file of NJOY/ERROR to input of random sampling tool.
- Generation of perturbation factors using random sampling method
 - See “/frendy_20ymmdd/tools/make_perturbation_factor/sample”

Uncertainty quantification using random sampling method

Godiva (HMF-001)

Geometry	Sphere Radius: 8.7 cm
Composition	U-235: 93.71 wt.% U-238: 5.27 wt.% U-234: 1.02 wt.%
k_{eff}	1.000 ± 0.001



Godiva [1]

- ◆ MCNP6.2
- ◆ Number of perturbed ACE file: 100
- ◆ Covariance data: 56groupcov7.1 (from SCALE6.2.3)
- ◆ MT=2,4,16,18,102,452, and 1018 (MT=452: ν , MT=1018: χ)

[1] ICSBEP NEA/NSC/DOC(95)03, Organization for Economic Co-operation and Development-Nuclear Energy Agency (OECD-NEA) (September 2016).

Calculation results (k-effective uncertainty)

k_{eff} -uncertainty due to all nuclides and reactions $\Delta k/k$ [%]

Sensitivity analysis (SA) of MCNP6.2	Random sampling method using perturbation tool
1.11	1.12 [0.98 – 1.24]

Comparison of k_{eff} -uncertainty due to individual nuclide and reaction $\Delta k/k$ [%]

		SA (TSUNAMI-1D)	SA (MCNP6.2)	RS
U-235	(n, γ)	0.880	0.880	0.833
U-235	(n,n')	0.615	0.617	0.664
U-235	Elastic	0.295	0.295	0.305
U-235	Fission	0.269	0.269	0.329
U-235	Fission spectrum	0.253	0.261	0.260
U-234	Fission	0.118	0.118	0.130
U-235	ν_{total}	0.085	0.085	0.093