Nuclear Data Benchmark for Sodium Voided Reactivity Worth with Improved Neutronics Simulation Method

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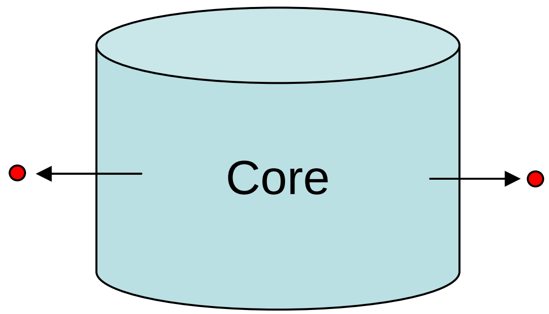
[Background]

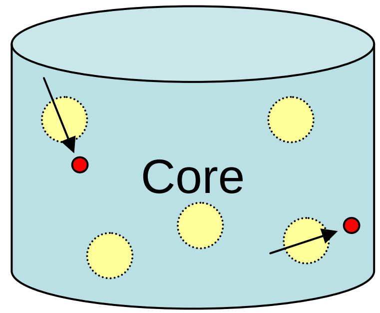
- Sodium voided reactivity worth (SVRW) is one of the most important core parameters in fast reactor design.

- The purpose of the present work is to assess the nuclear data files for SVRW calculations,

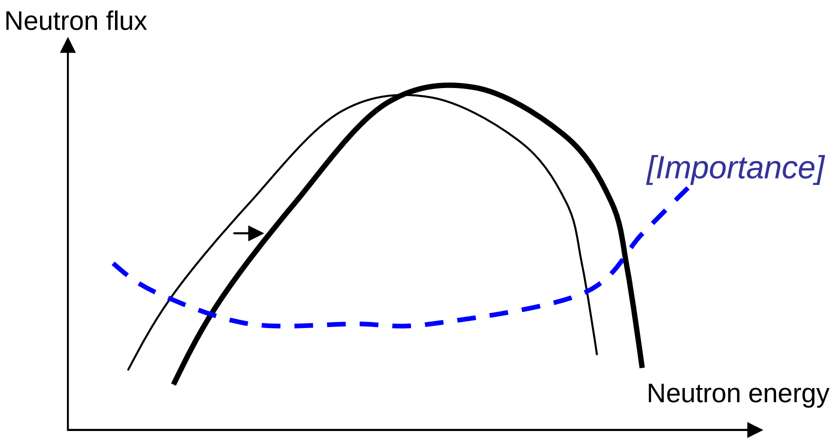
What does sodium voiding do?



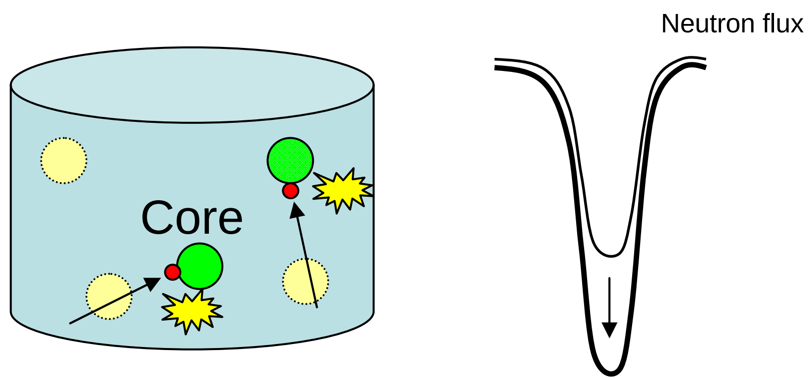
(1) Promoting neutron leakage
… negative reactivity



(3) Decreasing neutron capture by sodium … positive reactivity

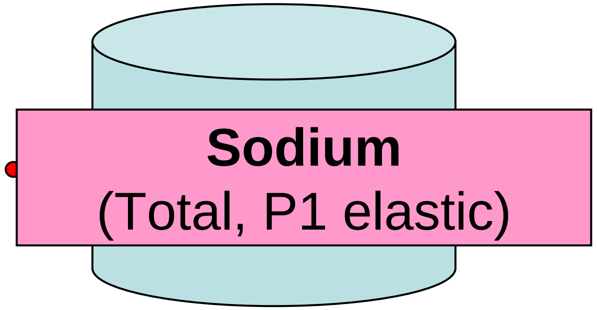


(2) Hardening neutron spectrum
… (normally) positive reactivity

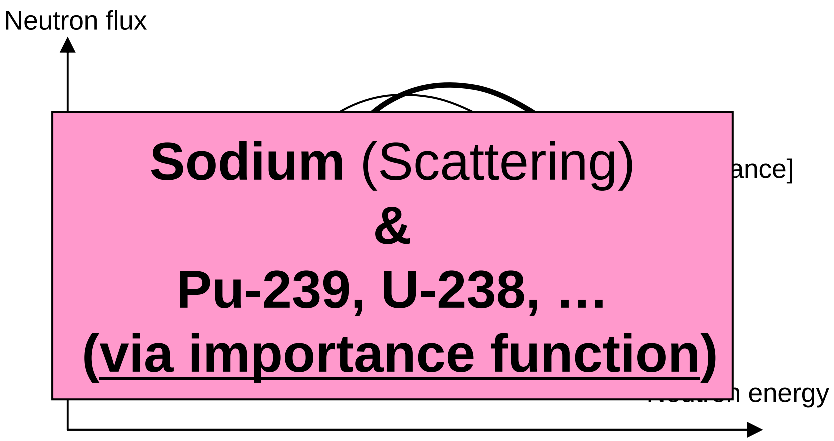


(4) Promoting self-shielding of U, Pu
… positive or negative reactivity

Which nuclear data is important for SVRW calculations?



(1) Promoting neutron leakage
… negative reactivity



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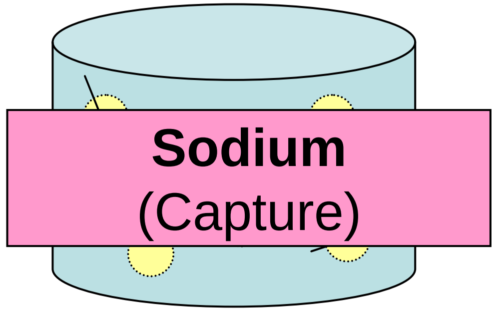
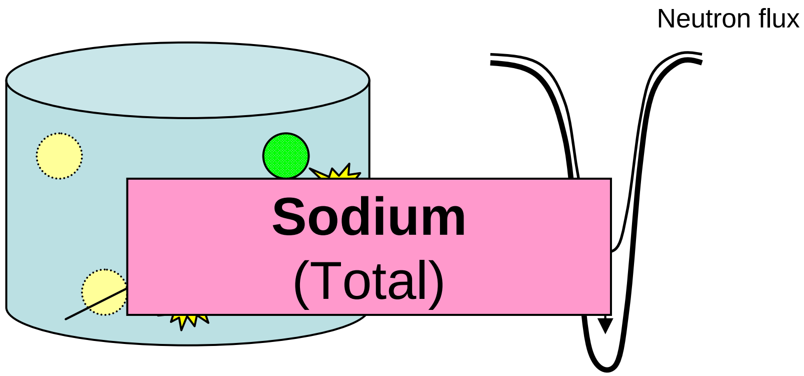


(3) Decreasing neutron capture by sodium … positive reactivity

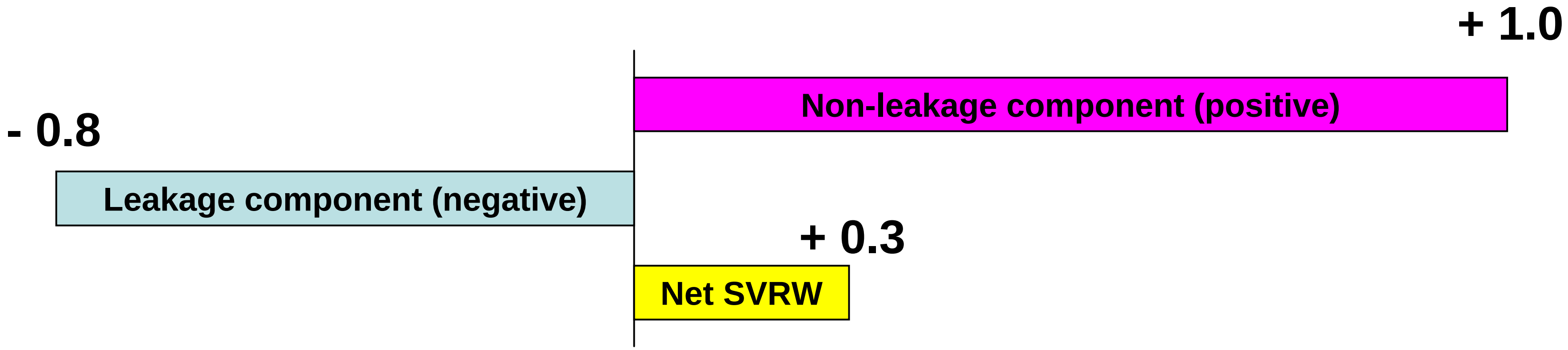


(4) Promoting self-shielding of U, Pu
… positive or negative reactivity

SVRW is difficult to be well predicted … Why?

- SVRW is composed of several different components.
- These components take both positive and negative values.

For example,



5% error in non-leakage component ***-> 17% error*** *in net SVRW*

5% error in leakage component ***-> 13% error*** *in net SVRW*

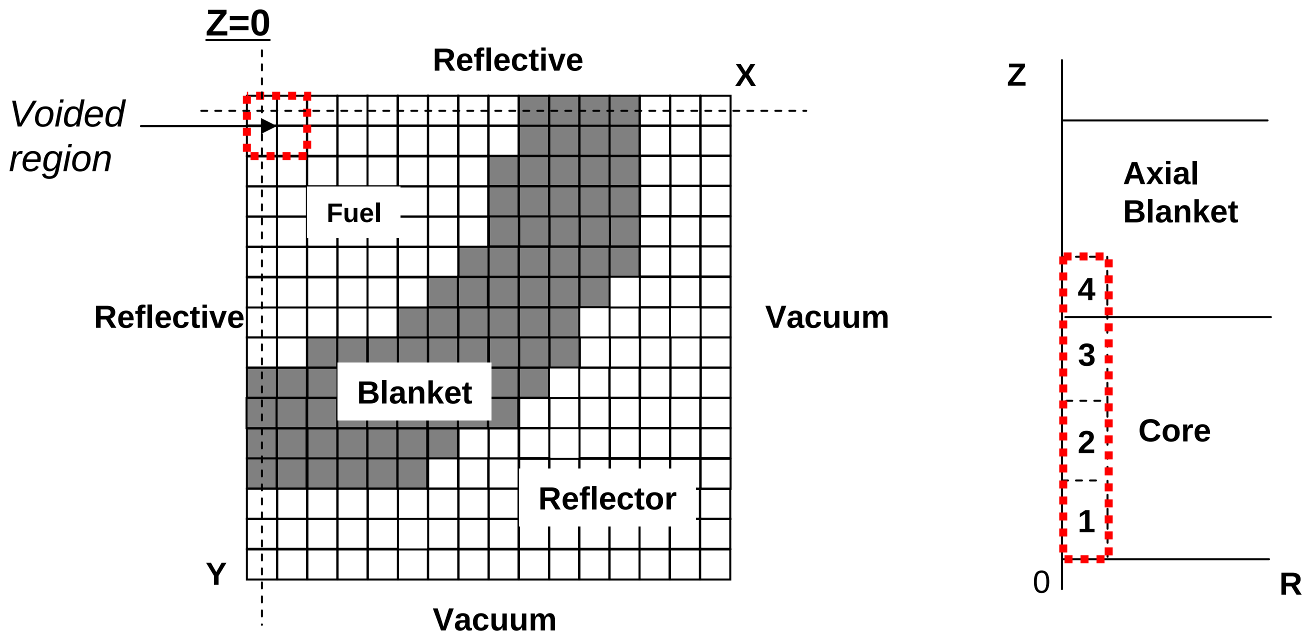
Error in each component is seriously propagated to net SVRW.

Benchmark calculations for nuclear data

The following nuclear data files are assessed.

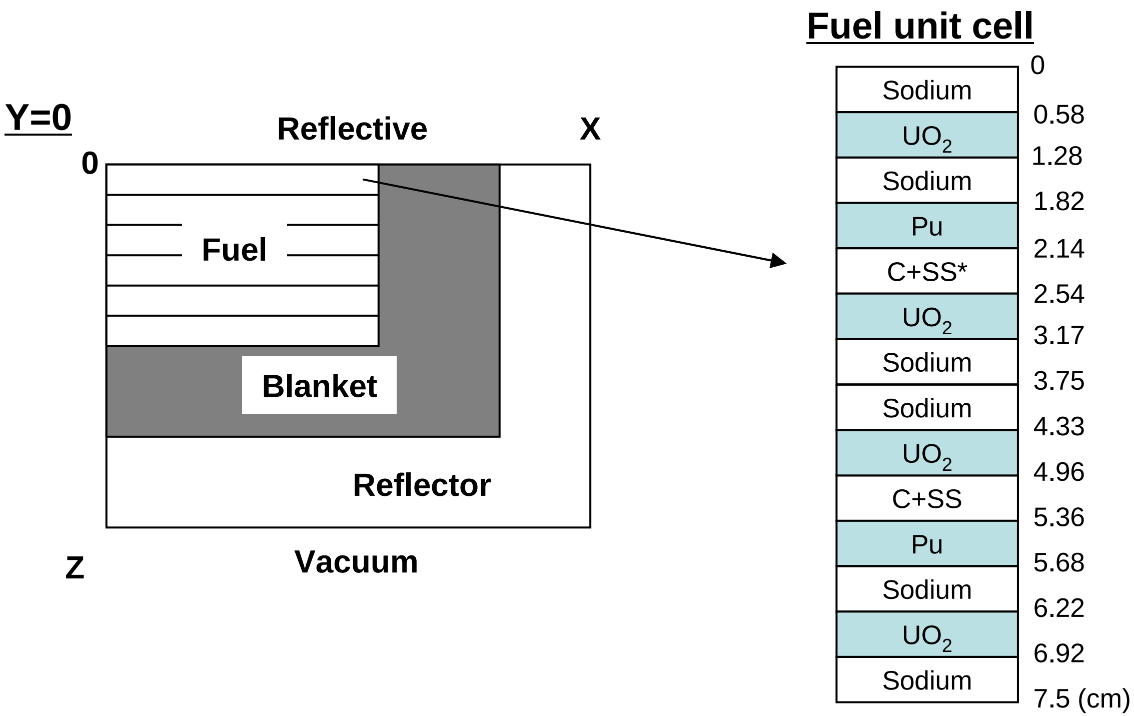
- **JEFF-3.1**
- **JENDL-3.3**
- **ENDF/B-VII.0**

SVRW experimental data obtained at MZA are utilized.



Numerical method

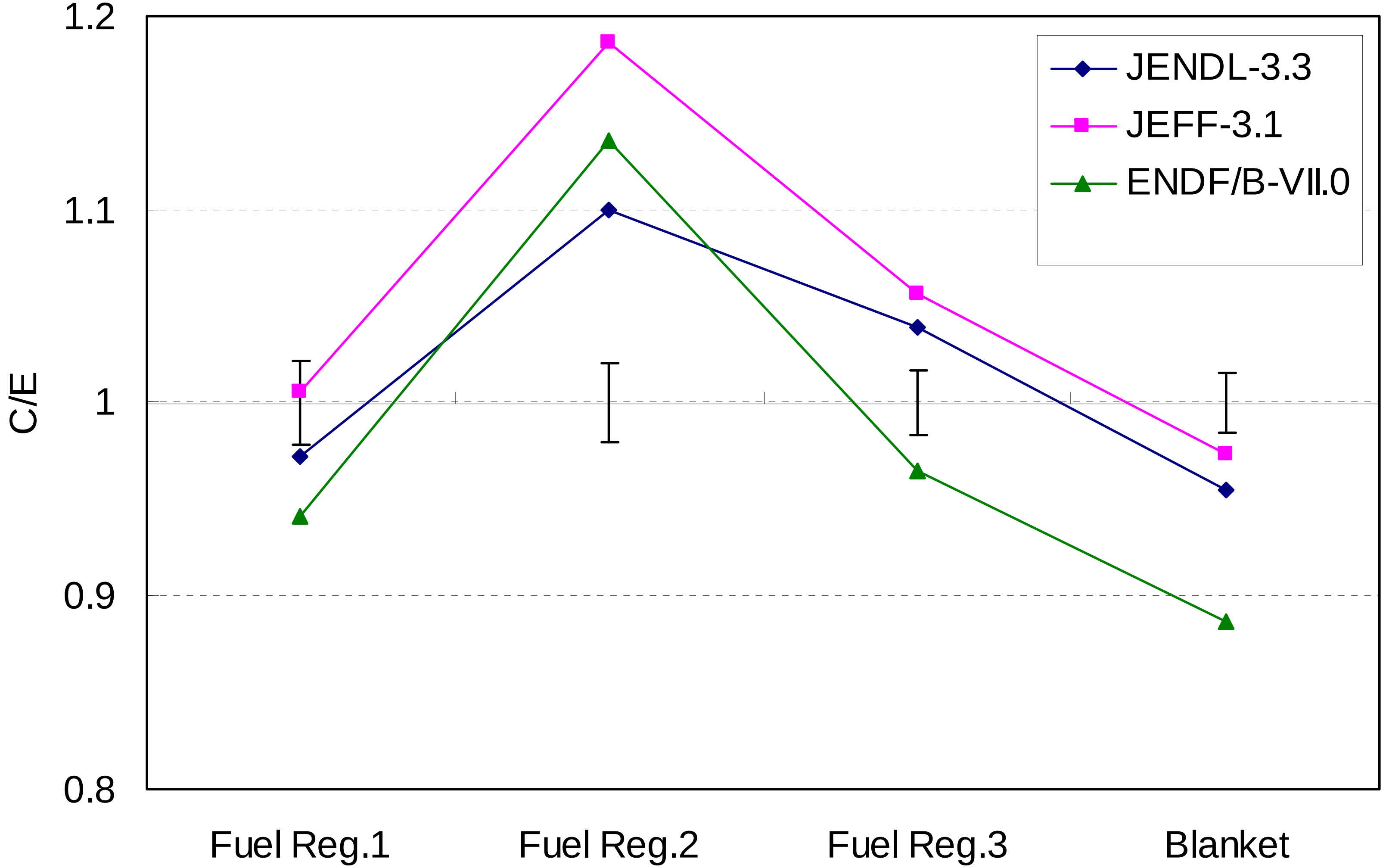
In order to reduce ambiguity caused by lattice homogenization,
only can regions are homogenized.



Resonance cross section of each plate is calculated with the ultra-fine group library.

The above 3D model is calculated by a Sn code (with the double-Gaussian Tchebyshev quadrature set).

Results (1) C/E values



How do you feel this?

Results (2) “normalized” (C-E) values

In order to grasp a degree of difference between C- and E-values, we introduce the following “normalized” absolute difference.

$(C\text{-}E)/C_{\text{Non-leakage}}$:

Relative error in the non-leakage component
under the assumption that there is no error in the leakage component

$(C\text{-}E)/C_{\text{leakage}}$:

Relative error in leakage component
under the assumption that there is no error in the Non-L component

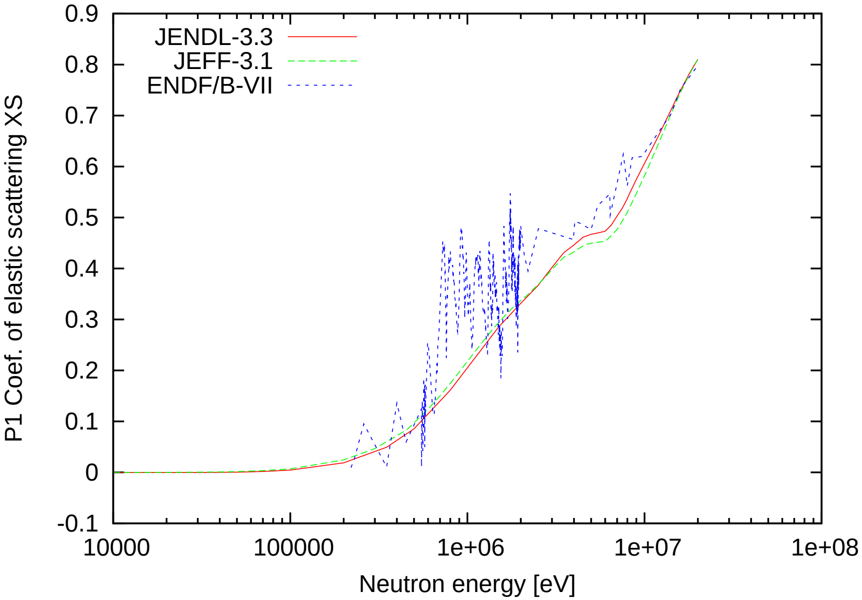
Results (3) “normalized” (C-E) values

		JENDL-3.3	JEFF-3.1	ENDF/B-VII.0	(Error)
Fuel Reg.1	Non-Leakage	-0.02	0	-0.05	0.05
Fuel Reg.2	Non-Leakage	0.02	0.03	0.02	0.06
	Leakage	-0.02	-0.04	-0.03	-0.08
Fuel Reg.3	Non-Leakage	-0.06	-0.09	0.06	0.09
	Leakage	0.02	0.03	-0.02	-0.03
Blanket	Leakage	-0.03	-0.02	-0.09	-0.04

- **All the libraries predict well SVRW within experimental uncertainties.**

- **However, ENDF/B-VII.0 clearly underestimates the leakage component.**

(It is found through a sensitivity study that this difference is caused by a difference in P1 component of elastic scattering of sodium.)



JENDL-3.3
JEFF-3.1
ENDF/B-VII
P1 Coef. of elastic scattering XS
Neutron energy [eV]
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
10000
100000
1e+06
1e+07
1e+08