NEEDS AND APPLICATION OF COVARIANCE DATA

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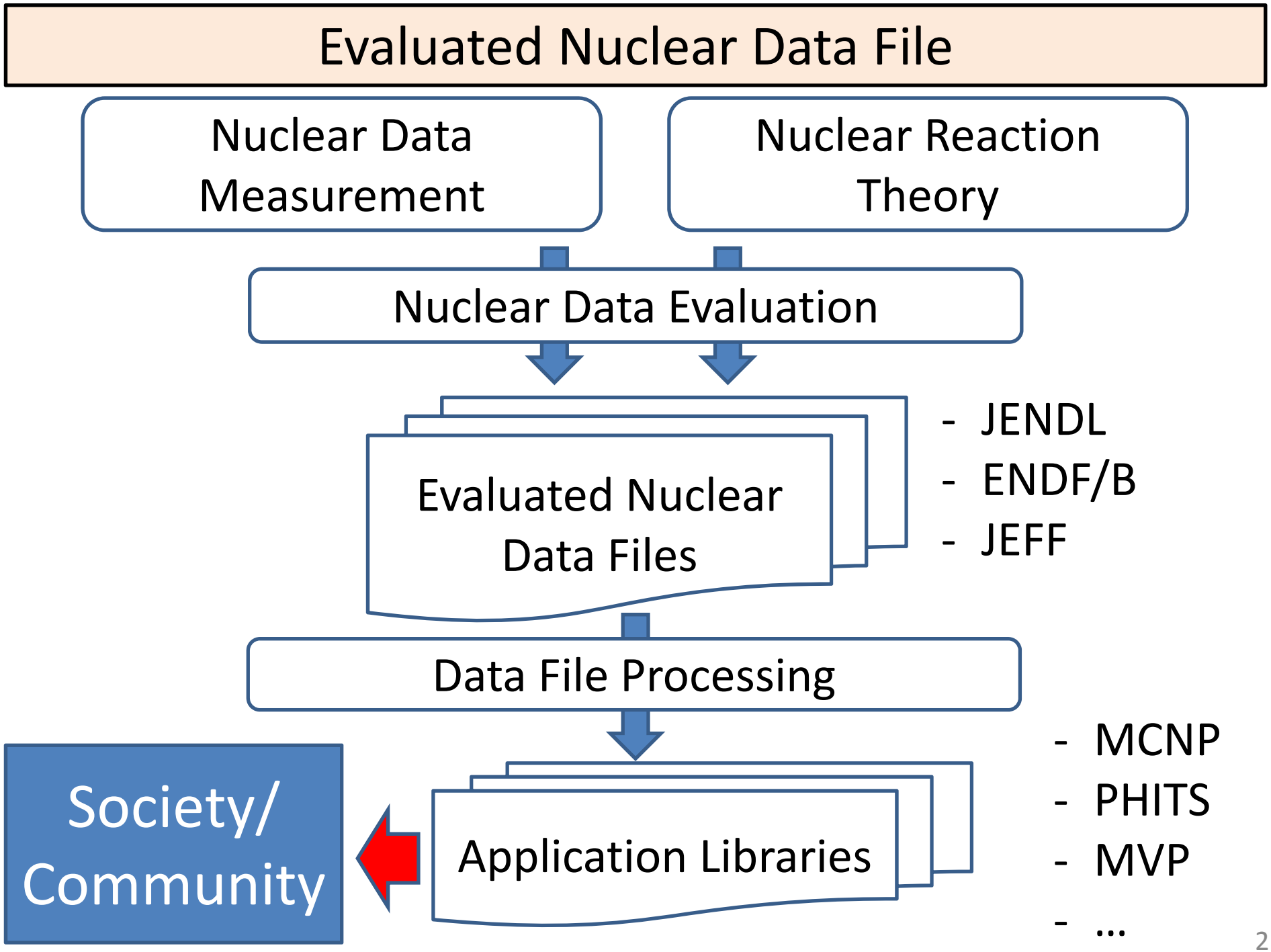
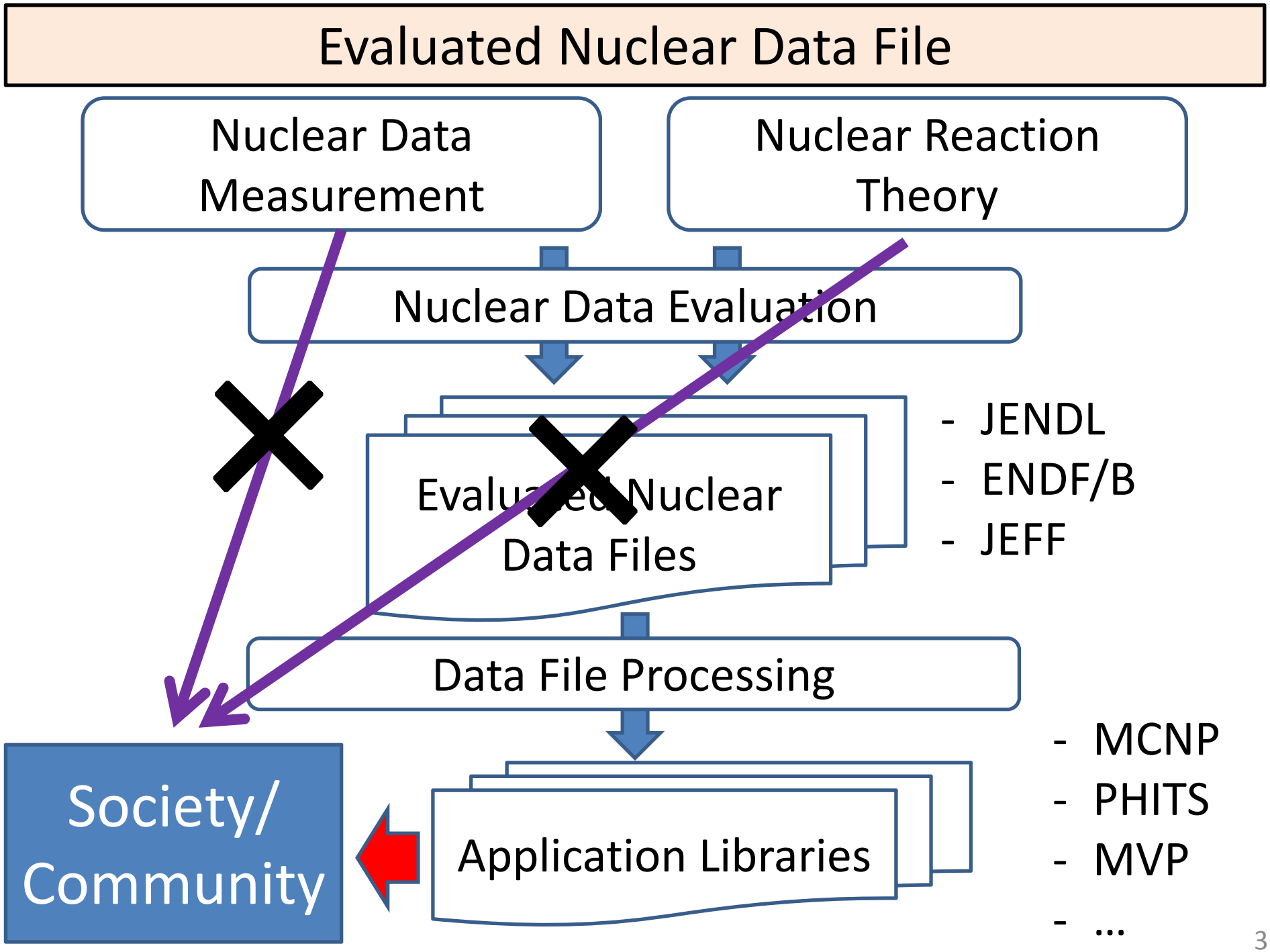

Evaluated Nuclear Data File
Nuclear Data Measurement
Nuclear Reaction Theory
Nuclear Data Evaluation
Evaluated Nuclear Data Files
- JENDL
- ENDF/B
- JEFF
Data File Processing
Application Libraries
- MCNP
- PHITS
- MVP
- …
Society/ Community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Role of evaluated nuclear data library

- In order to utilize achievements of research and developments on the nuclear physics field to the public and society, nuclear data evaluation and development of the evaluated nuclear data libraries/files are essential.

- Japanese evaluated nuclear data library, JENDL, has played an important role as a “bridge” between the nuclear physics research and the real world in Japan.

Application fields of nuclear data

- Fast neutron fission reactors
- Thermal neutron fission reactors
- Fusion reactors
- Medical application and accelerator shielding design
- Fissile material detection / Support on Fukushima-Daiichi NPP decommissioning
- Decommissioning and nuclear waste disposal

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Nuclear data in nuclear fission reactors application

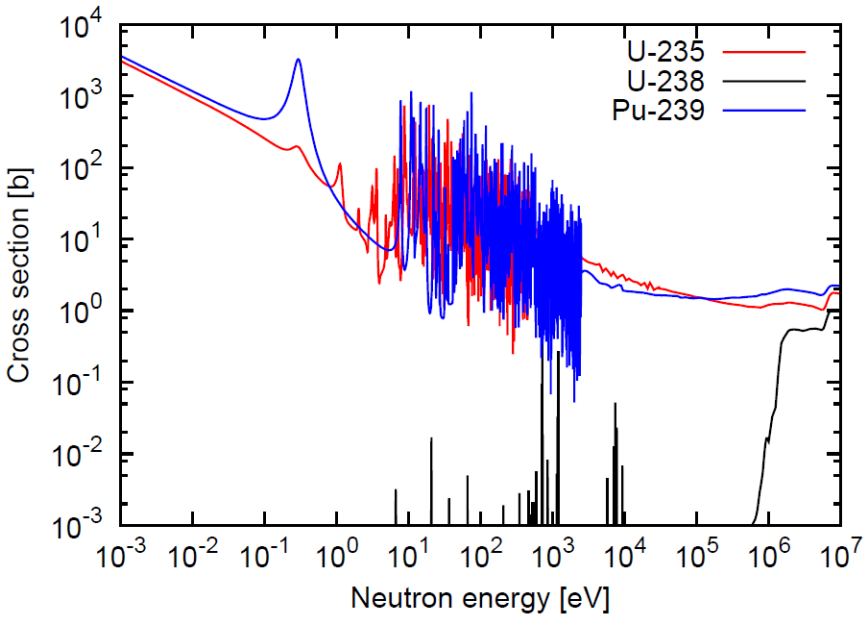
- In fast neutron reactors, uncertainties induced by nuclear data are dominant, especially in future nuclear systems such as accelerator-driven systems (ADS) for actinoid management.

- Experiences of fast reactor operations are limited, so effective use of integral data has been important.

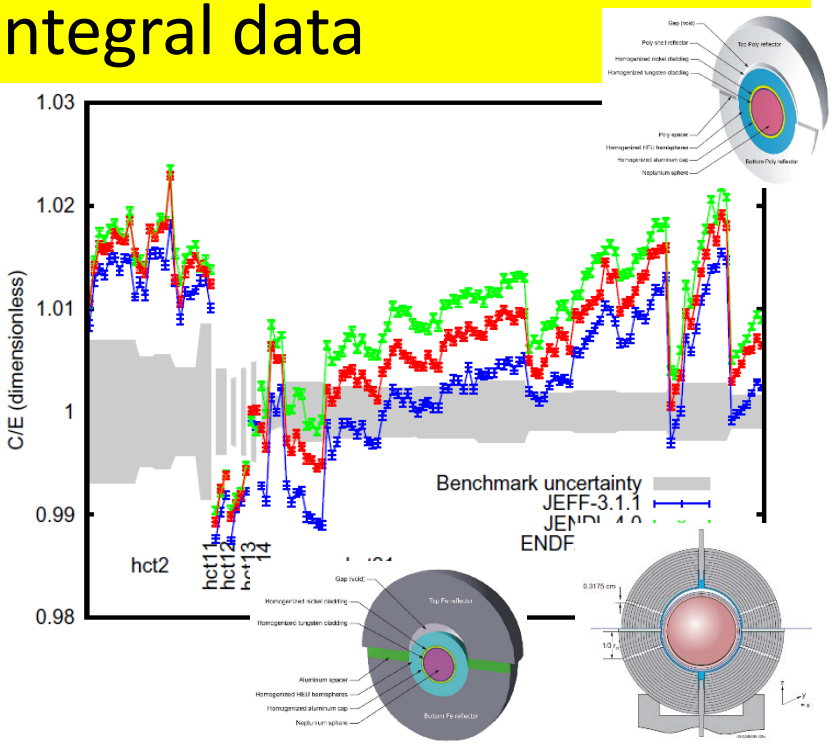
- Nuclear data adjustment (or data assimilation) has been generally adopted, and covariance data of nuclear data are used to define primary bands of the adjusted parameters (nuclear data).

Nuclear data adjustment

Original nuclear data

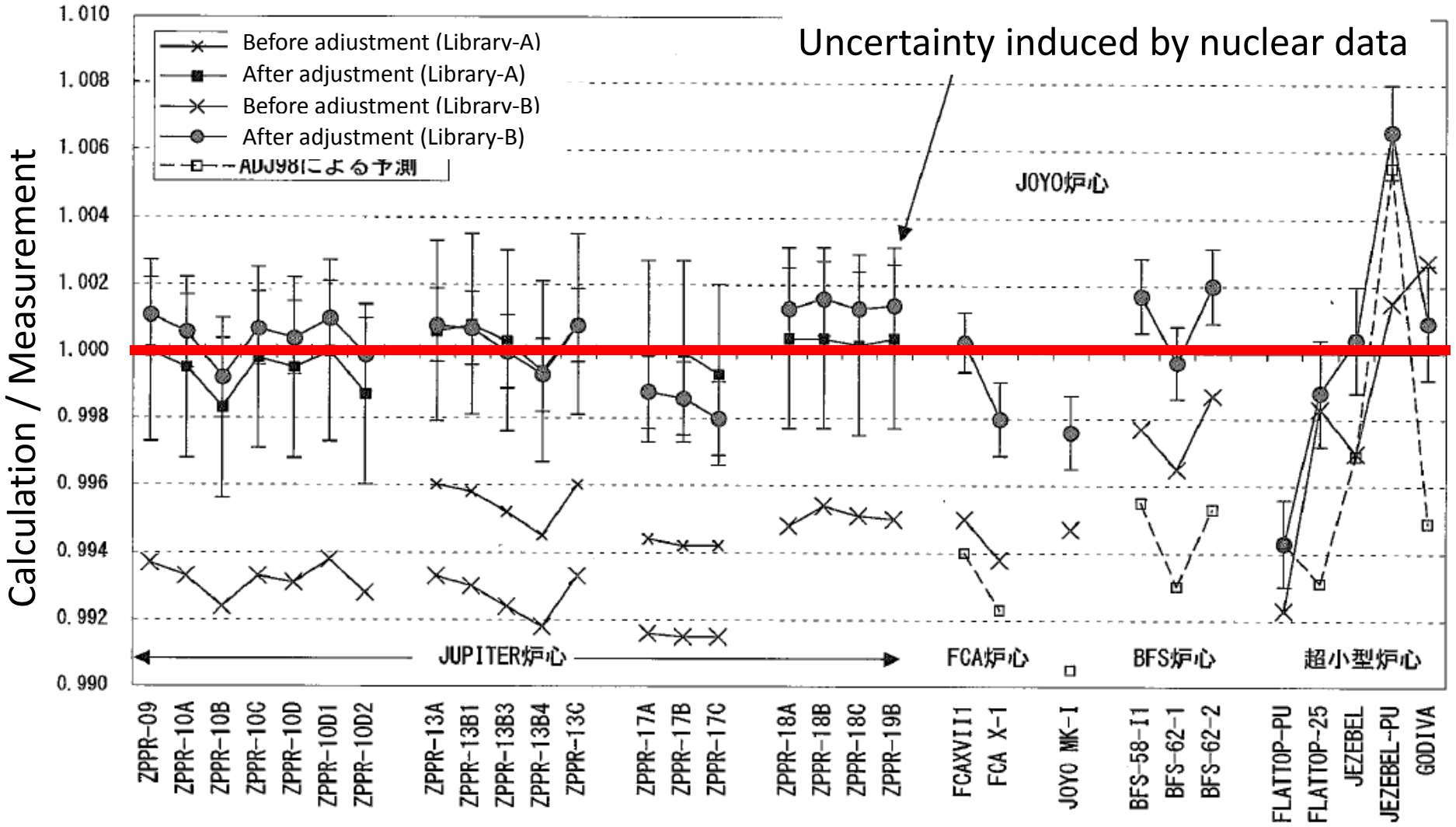


Additional information on integral data



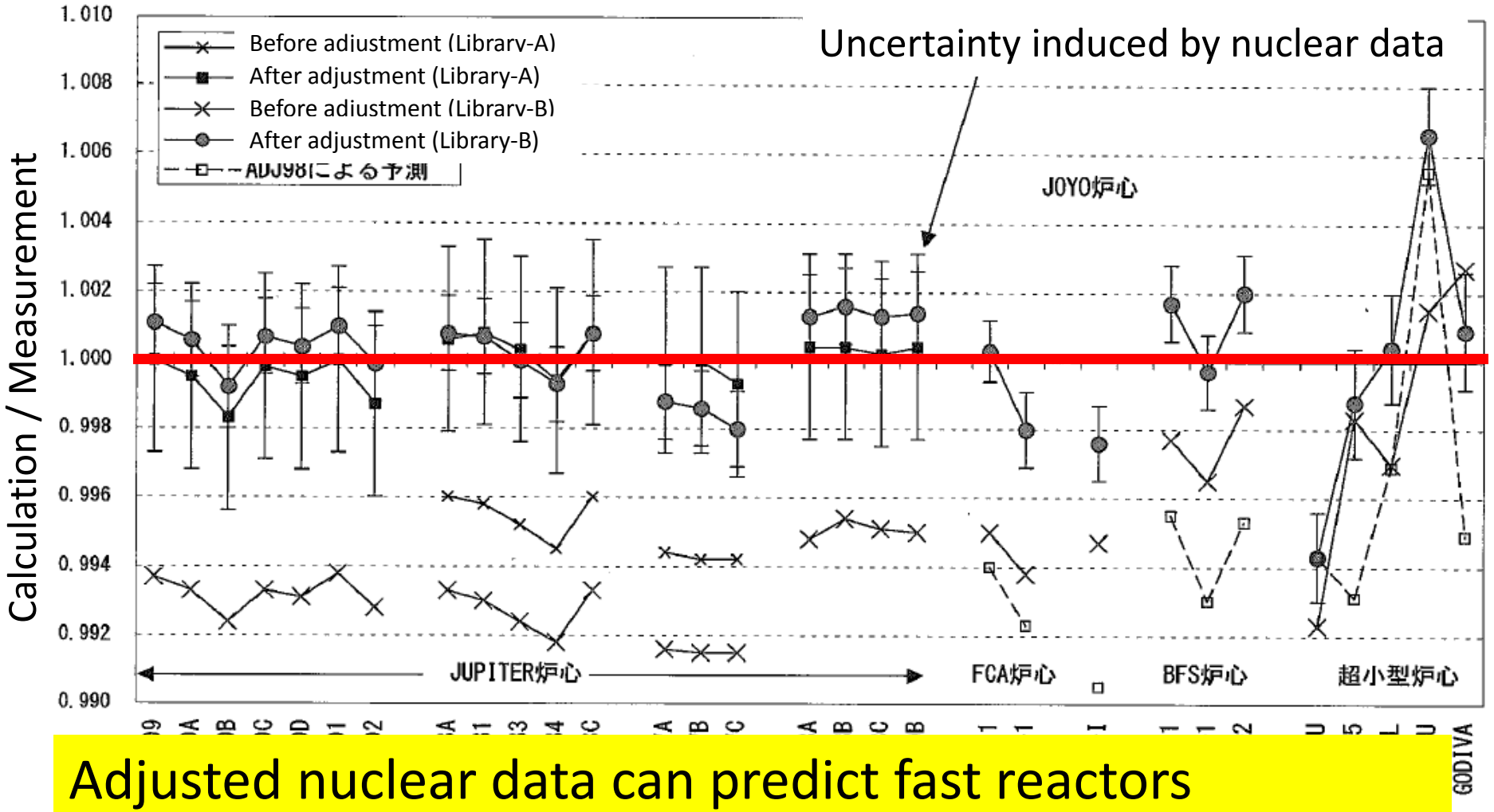
Since integral data are functions dependent on the nuclear data, consideration of the information on integral data can result in revised probability distribution of the nuclear data with smaller variances.

Example of nuclear data adjustment for FR



M. Ishikawa, et al., “Development of the unified cross-section set ADJ2000 for fast reactor analysis,” JNC TN9400 2001-071 (2001).

Example of nuclear data adjustment for FR



Adjusted nuclear data can predict fast reactors parameters much better than the original data, and covariance data play important roles in this procedure.

Nuclear data in nuclear fission reactors application

- In thermal neutron reactors, uncertainties induced by numerical modelling and methods had been dominant.

- Due to the advancement of computers, sophisticated numerical methods can be applied at present, so the uncertainties induced by numerical modelling and methods have been significantly reduced.

- Impact of nuclear data-induced uncertainties on reactor parameter predictions has become relatively large.

Nuclear data in nuclear fission reactors application

- Because of rich experiences of thermal reactor operations and accumulation of integral data, neutronics parameters of thermal reactors can be well predicted by the present technology.

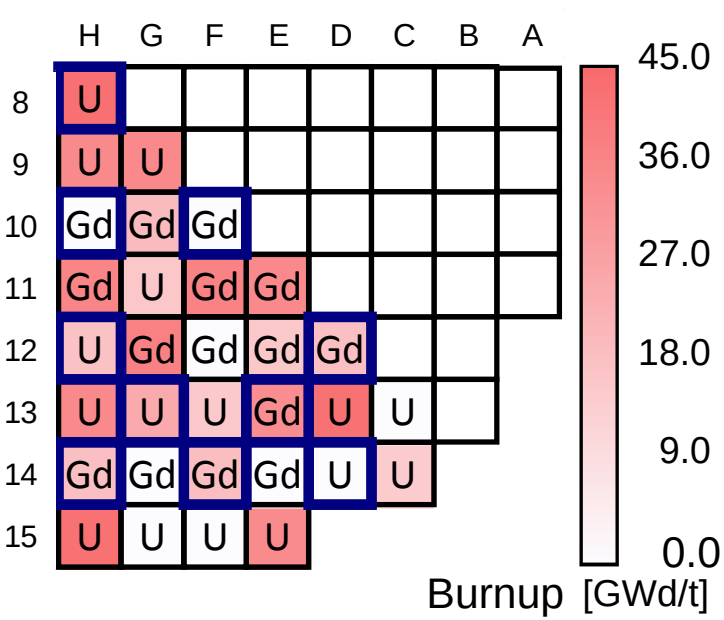
- The next concern is to show how reliable our estimations are. This is important in the future licensing procedure and from a viewpoint of the accountability to public.

- To do this, uncertainty information, that is covariance data of nuclear data, are required.

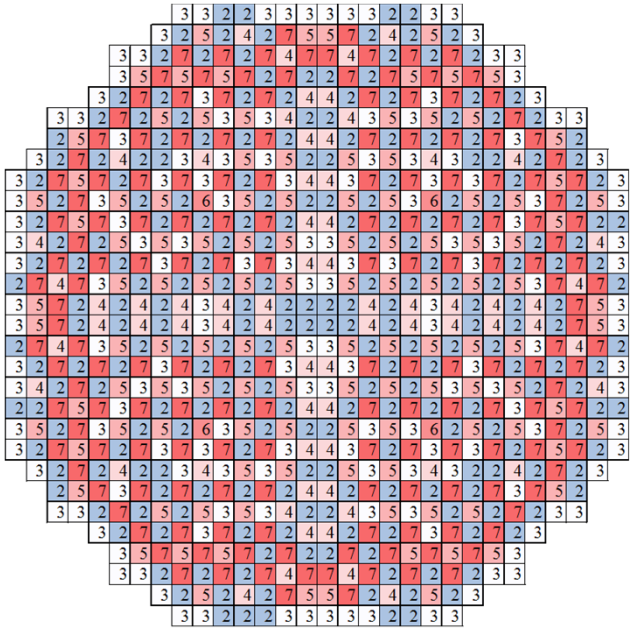
Works done by Nagoya Univ.

UQ of various reactor parameters of full-scale PWR and BWR have been done by the random sampling technique. Both of fuel depletion and thermal feedback have been taken into account.

PWR



BWR



- A widely-used design code system, CASMO/SIMULATE, is adopted.
- Covariance data of only actinoid nuclides cross section are used.

A. Yamamoto, et al., Nucl. Sci. Eng., 181, 160-174 (2015).

Validation of covariance data

- When we use covariance data of nuclear data in actual problems such as licensing, we have to consider how to validate the evaluated covariance data.

Validation of covariance data

When we use covariance data of nuclear data in actual problems such as licensing, we have to consider how to validate the evaluated covariance data.

This issue has been addressed by WPEC/SG-39 and its successor. This is one of the main issues discussed during the covariance workshop 2017 (CW2017).

We have three “unknowns”

- Known and considered unknown
- Known but unconsidered unknown
- Unknown unknown

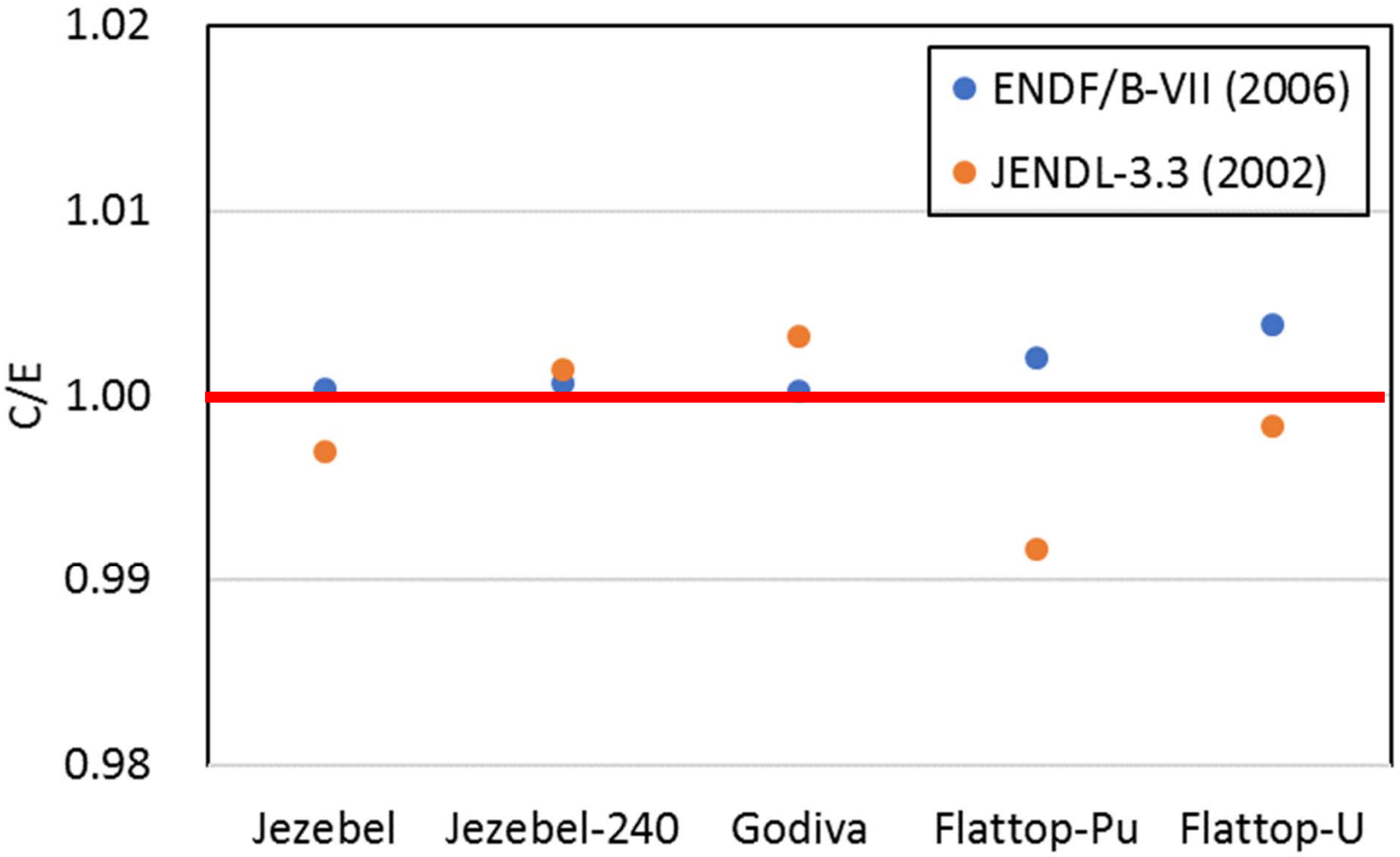
The second unknown can be the first unknown by our efforts, but how is the present situation?

Validation of covariance data

When we use covariance data of nuclear data in actual problems such as licensing, we have to consider how to validate the evaluated covariance data.

- We can test the covariance data through checking statistical consistency among C/E values and nuclear data-induced uncertainties in a set of integral data.

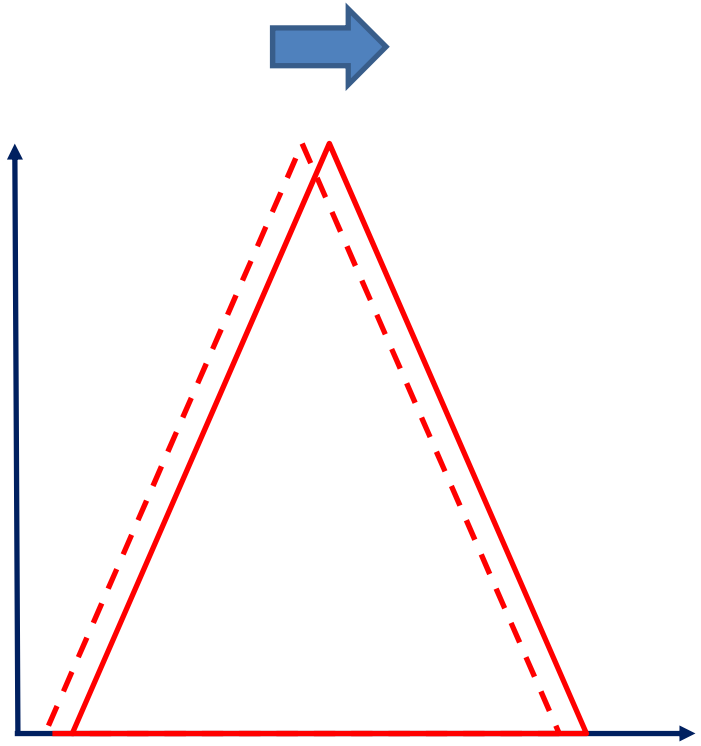
Performance of evaluated unclear data



Recent evaluated nuclear data files show much better performance than old ones. This is because of “final tuning”.

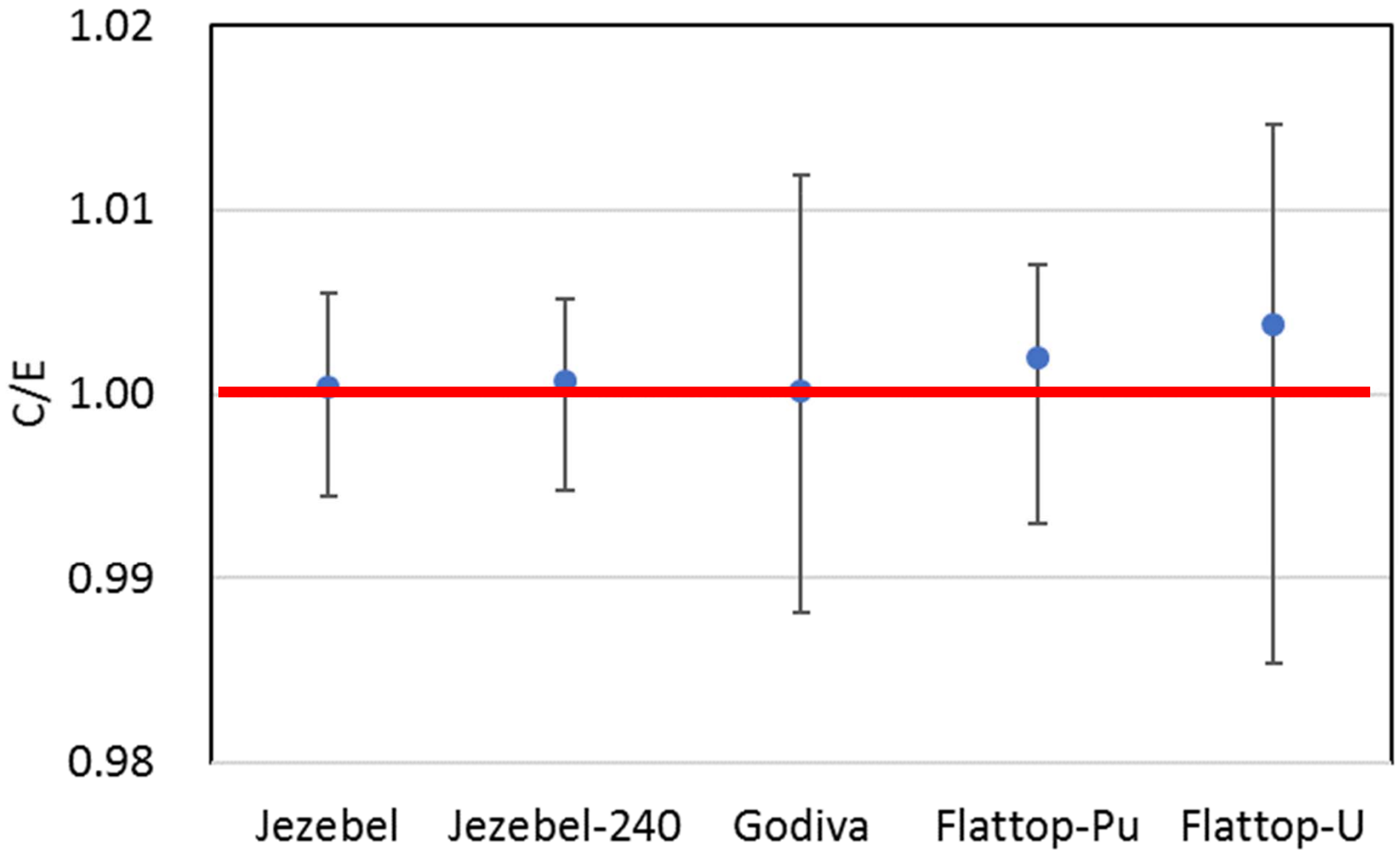
On feedback of integral testing to nuclear data evaluation

Correction/tuning



Correction is very small in comparison with the uncertainty.
Does it make sense to you?

Performance of evaluated unclear data



Since this final tuning is NOT considered in covariance data evaluation, chi-square values become close to zero.

Validation of covariance data

When we use covariance data of nuclear data in actual problems such as licensing, we have to consider how to validate the evaluated covariance data.

- We can test the covariance data through checking statistical consistency among C/E values and nuclear data-induced uncertainties in a set of integral data.

- If there is an evaluated nuclear data file which is developed WITHOUT any feedback from integral data, we can do this, but there are no such data files nowadays.

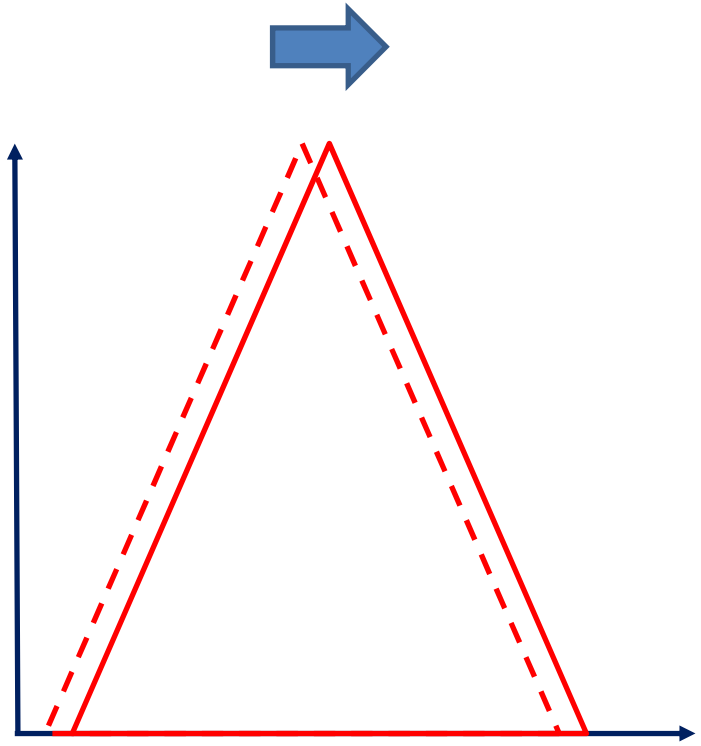
On feedback of integral testing to nuclear data evaluation

In the JENDL actinoid file-2008 development, we adopted "correction" (tuning) of nuclear data to reproduce integral data better.

- This was done with the maximum-likelihood method with the "constraining covariance matrix".
- Corrections on input parameters for nuclear data evaluation are quite small, but those improve significantly performance in integral testing.
- At that time we assumed that covariance data are unchanged because the correction is slight, and we believed that this treatment was not bad.
- This treatment was to make our library "high-performance", but now I am confused that this treatment was good or not.

On feedback of integral testing to nuclear data evaluation

Correction/tuning



Correction is very small in comparison with the uncertainty.

Does it make sense to you?

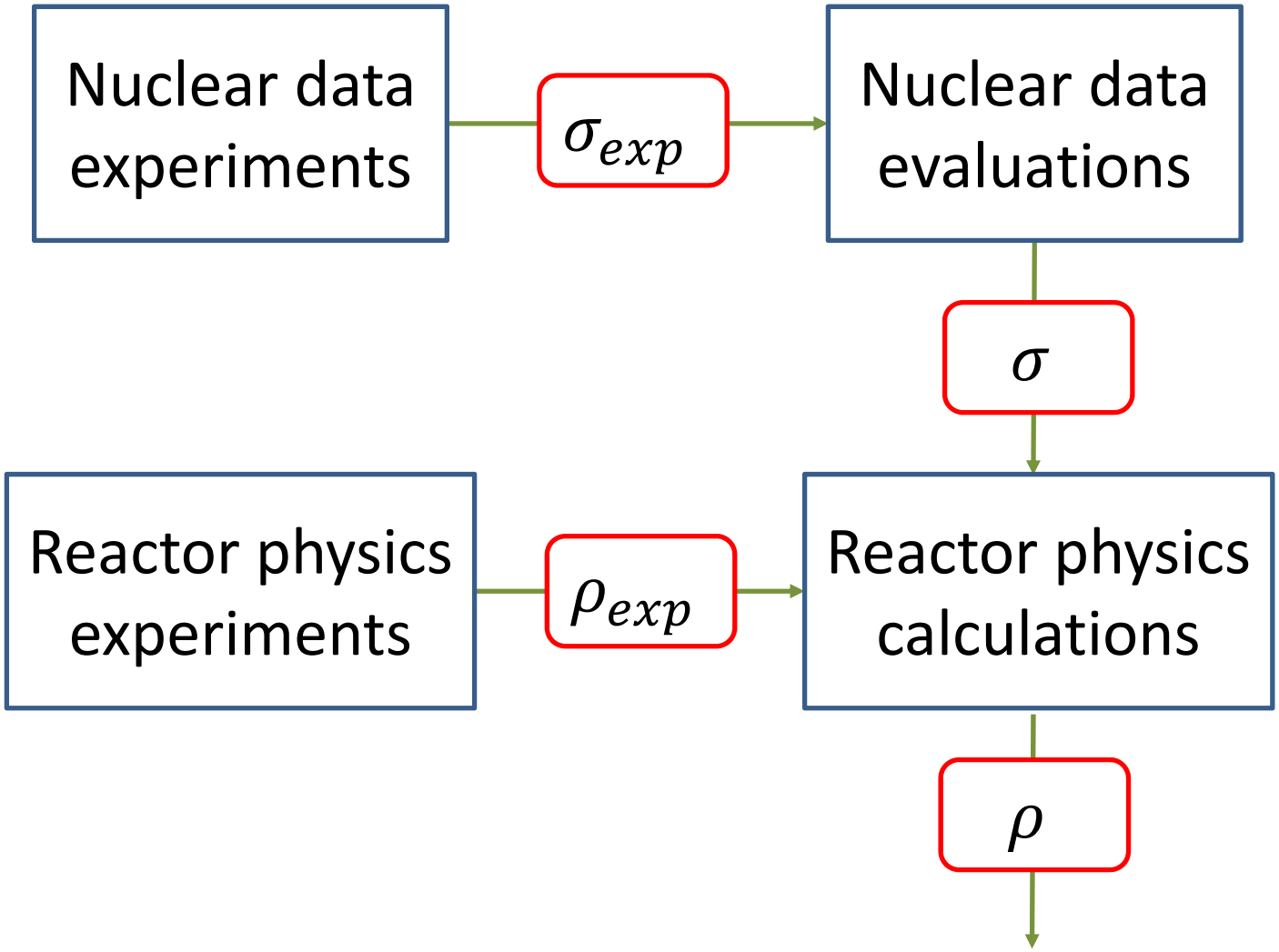
Do we have to prepare theoretically rigorous covariance matrix?

On feedback of integral testing to nuclear data evaluation

Should nuclear data evaluation be done WITHOUT any feedback from integral testing?

- If feedback from integral testing is considered, we have to consider a fully-correlated huge-size covariance matrix. In order to avoid this, we have to use information which are dependent on the small number of nuclear data as much as possible.
- Recent nuclear data files show quite high performance on integral testing. Is this really due to advancement of nuclear model and accumulation of experimental data? If we believe this, we do not have to rely on integral testing in nuclear data evaluation.
- Improvement of prediction accuracy is important in the nuclear data file developments. However, we have to know that we can produce "adjusted" nuclear data file which (perfectly?) reproduce the integral data because the dimension of "nuclear data space" is much larger than that of the integral data sub-space at present.

What I have thought during CW2017



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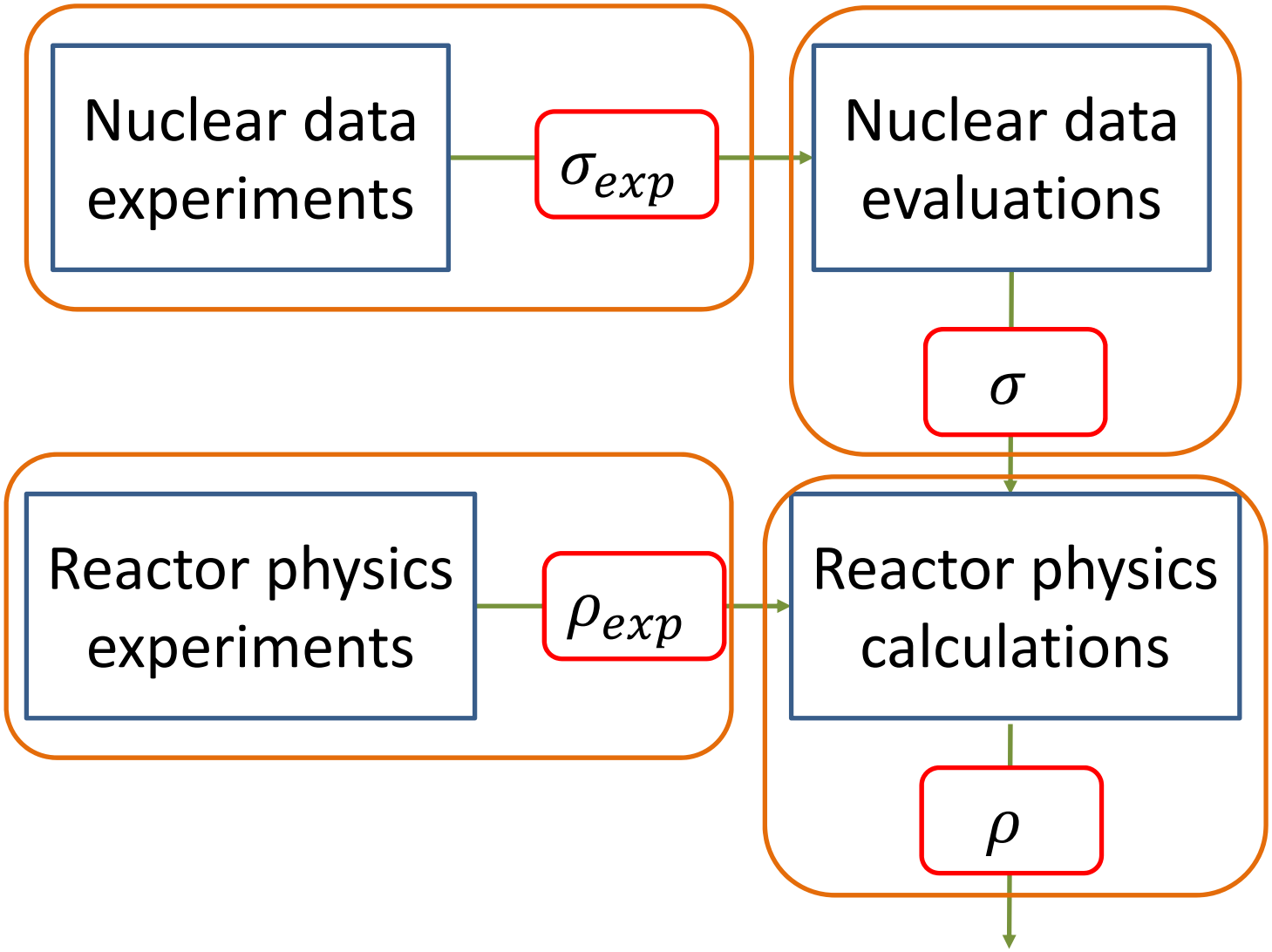
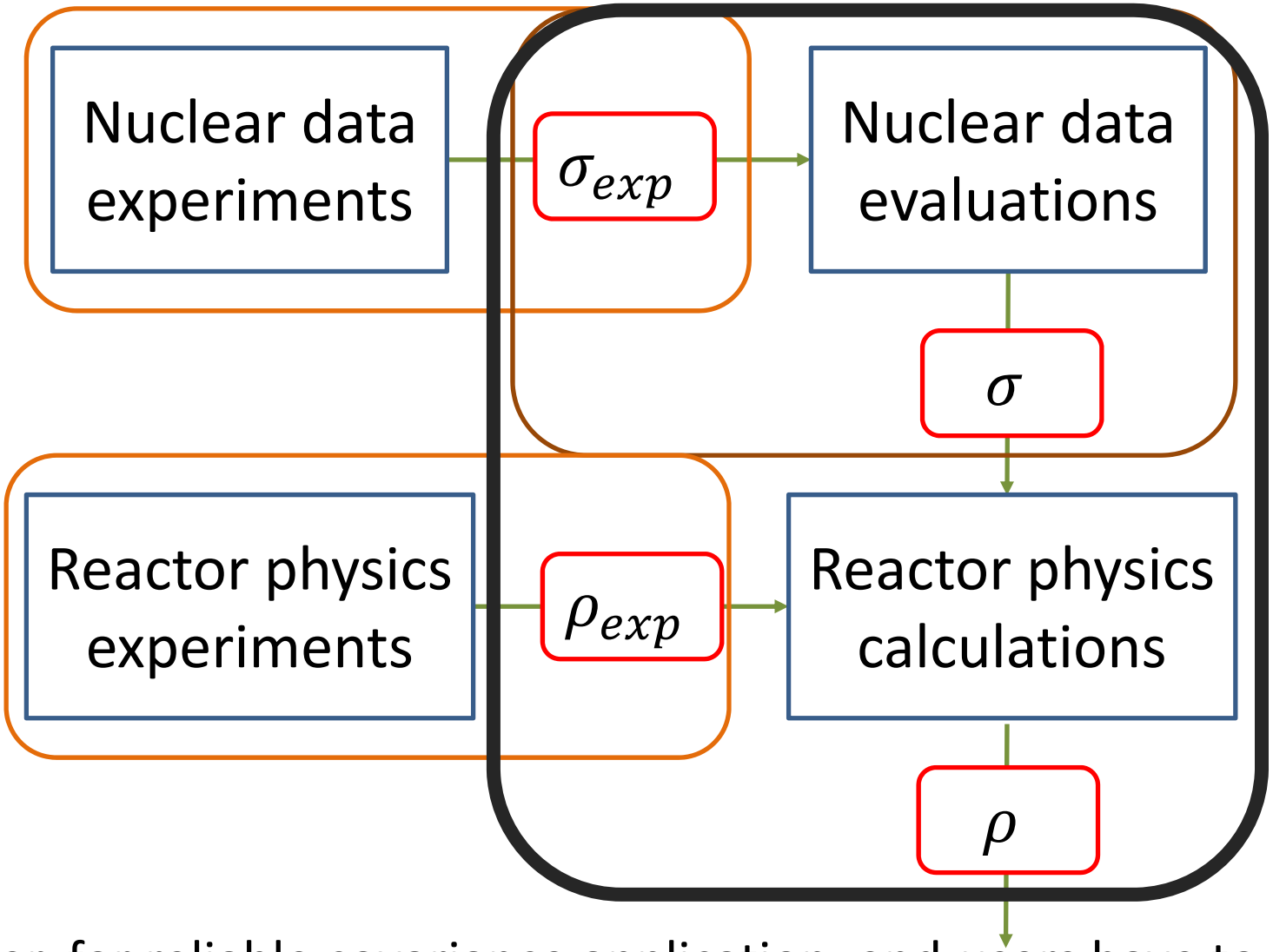


In the past, working areas are clearly defined and separated.
I like this world…

What I have thought during CW2017



However, for reliable covariance application, end-users have to pay attention to their upper-streaming areas. I realize this during the CW2017 workshop.

Establishment of the covariance data use promotion WG

The covariance data use promotion WG was established this year in the JENDL committee for the following purposes:

[1] To specify unquantified or difficult-to-quantify nuclear data uncertainty

[2] To specify nuclear data uncertainty which is quantified, but its reliability is low.

[3] To consider how to validate covariance data

[4] To consider which actions should be made to promote covariance data use in actual problems

[5] To discuss the best position of covariance data in evaluated nuclear data files.

Several open questions

[1] How to consider covariance data evaluated by expert judgement.

[2] How to consider unquantified (or unknown) uncertainty.

[3] How to assure reliability of covariance data.

[4] Should we use integral data information in nuclear data evaluation? If yes, how to prepare fully-correlated covariance matrix.

[5] What is necessary to promote covariance data use.