WANDA session on Covariances/ Sensitivity/ Uncertainties/ Validation and its Impact on Application

Denise Neudecker  WANDA 2020

The gist of this session:

Nuclear data uncertainties limit the precision and/or accuracy of predictive application simulations. **If nuclear data uncertainties are wrong, so are the economic, safety and performance margins of our application simulations.**

Questions here:

• Where do we have problematic nuclear data uncertainties affecting many application areas leading to $$$ lost, too large or small margins, etc.?

• How can we solve these problems such that we provide more reliable application margins?
Structure of this introduction:

• What are covariances, uncertainties and sensitivities?
• Pipeline of nuclear data (covariances)
• Example: issues at the beginning of the nuclear data pipeline can impact applications at the end
• Session Structure
• Charge
What are covariances: the diagonal contains uncertainties, the off-diagonal correlations.

Nuclear data covariances provide an estimate of fidelity of nuclear data mean values.
What are sensitivities: how does a simulated response change due to differences in nuclear data

Sensitivities enable:

- Assessing impact of changes in nuclear data on application simulations.
- Forward-propagate nuclear data covariances to application quantity uncertainties.

Example

Sensitivity of criticality of Jezebel to nuclear data.

\[
\text{Sensitivity} = \frac{\sigma}{k} \frac{dk}{d\sigma}
\]
The nuclear data (covariance) pipeline.

- Differential Experiment
- Nuclear Theory
- Evaluation
- Processing Sensitivity
- Validation
- Tuning Corrections
- General-purpose Library
- Adjusted Libraries
- Application
- Integral Experiment
There are some leaks in the (covariance) pipeline

- Losses to large performance margins
- Unreliable safety margins
- Funding spent on issues inconsequential to applications
Problems at the beginning of the pipeline: EXFOR uncertainties can be misleading.

**Taking Unc. from our ND experimental database**

EXFOR is great but data should not be blindly adopted!

**PFNS: energy distribution of prompt neutrons released after fission.**

Experimentalists and evaluators analyzed unc.
Lesson learned: Issue in any part of pipeline can critically impact application simulations!

Change in Jezebel $k_{\text{eff}}$ 195 pcm!!!
(2/3rd of difference between delayed and prompt critical)

Drop in Jezebel $k_{\text{eff}}$ unc. due to PFNS uncertainty: -69% !!!
Topic 1: Which covariances in current US libraries are unrealistic and impact various applications?

T. Bailey: Various covariance needs
B. Rearden: Covariance needs for nuclear energy, reactor physics, etc.
K. Parsons: angular distribution covariances.
Topic 1: Which tools are missing to find problematic covariances early on and correct?

Differential Experiment

Nuclear Theory

Evaluation

Processing Sensitivity

Validation

Tuning Corrections

General-purpose Library

Adjusted Libraries

Application

Integral Experiment

BJ Marshall: Tools for finding problematic covariances
K. Wendt: Correcting covariances
Topic 2: How do we deliver nuclear data and covariances tailored to the needs of applications?

M. Rising: missing sensitivity tools to propagate covariances to applications.
F. Bostelmann: ENDF/B-VIII.0, the tuned general-purpose library
BJ Marshall: Adjusting nuclear data to application needs
V. Sobes: Missing integral experiments representing applications
Charge: discuss the following questions

• Which nuclear data covariances/uncertainties are clearly wrong in the current US-library and impact many application areas?

• Which tools are missing that help us pinpoint such wrong covariances/uncertainties early on and correct them?

• Which tools are missing enabling us to propagate nuclear data covariances to application bounds?

• Which tools and validation experiments are missing to produce nuclear data libraries representing specific application spaces?

Reminder: discussion should be collaborative.
Next talk by A. Sonzogni:

Example how FOA funds are currently enabling critically advancing our fission yield covariance capabilities:

- **Before the FOA**, we had no fission yield covariances in US nuclear data libraries.
- **Now**, we can even predict their impact on applications.