

Verification and Testing of Covariance Libraries

Doro Wiarda and B.J. Marshall

WANDA Washington, D.C. March 4, 2020

ORNL is managed by UT-Battelle, LLC for the US Department of Energy



Purpose

- Present current verification and testing of covariance libraries
- Within this context:
 - <u>Verification</u> refers to automatic checks or corrections performed in the processing codes
 - <u>Testing</u> refers to inspections and calculations performed after the data have been processed
- This is a very high-level overview
 - Some additional details are available in published papers and reports



Verification

- Within the AMPX system:
 - PUFF-IV processes covariance data into a COVERX-formatted library
 - COGNAC performs checks and corrections
- COGNAC checks:
 - All redundant covariance matrices are removed
 - Cross section data without covariance information are removed
 - Relative uncertainties larger than 1 are set to 1
 - Correlation values with absolute values larger than 1 are set to +1 or -1
 - Diagonal elements of the covariance matrix are extended if a higher energy group has uncertainty data and the lower energy groups do not





• Visual inspection and comparison to prior evaluations

H-1 elastic scattering











Data-induced uncertainty propagated to measured critical experiments



Category	Avg C/E (CE_V7.1)	St. Dev. Of C/Es	Avg 1σ XS Unc	
			SCALE 6.2	E8+SCALE
HMF	1.00014	477	1366	1474
HST	0.99802	588	1050	1288
IMF	1.00329	367	1528	1591
LCT	0.99956	167	677	934
LST	0.99866	266	716	1180
MCT	0.99649	337	633	768
PMF	1.00020	128	586	584
PST	1.00302	420	850	995

What's missing?

- Improvements to verification
 - Does sampling from the covariances generate the mean values?
 - Detect and fix some data problems, e.g., matrices that are not positive definite
- Validation
 - Benchmark measurements of different systems allow comparison of calculated and measured results for mean values
 - Comparing variability of these results with covariance data prediction provides some insight, especially for major actinides
 - Substitution experiments and reactivity sensitivities may allow this approach to be expanded to other isotopes



References for further information

- W.J. Marshall, M.L. Williams, D. Wiarda, B.T. Rearden, M.E. Dunn, D.E. Mueller, J.B. Clarity, and E.L. Jones, "Development and Testing of Neutron Cross Section Covariance Data for SCALE 6.2," *Proceedings of International Conference on Nuclear Criticality Safety*, Charlotte, NC (2015).
- V. Sobes, W.J. Marshall, D. Wiarda, F. Bostelmann, A.M. Holcomb, B.T. Rearden, "Nuclear Data and Benchmarking Program: Nuclear Data and Covariance Assessment, ENDF/B-VIII.0 Covariance Data Development and Testing Report," ORNL/TM-2018/1037, Oak Ridge, TN (2019).
- W.J. Marshall, D. Wiarda, M.L. Williams, "Evaluation of ENDF/B-VIII Covariance Data," presentation at mini-CSEWG, Los Alamos, NM (2017).
- M.L. Williams, D. Wiarda, G. Ilas, W.J. Marshall, B.T. Rearden, "Covariance Applications in Criticality Safety, Light Water Reactor Analysis, and Spent Fuel Characterization," Nucl. Data Sheets, 123, 92 – 96 (2015).





Questions?

This work was supported by the Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy and by the US Nuclear Regulatory Commission (NRC); the presentation of the work is sponsored by the NRC.

