

Neutron Cross Section Covariances for the ENDF/B-VII Library

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What is a Covariance Matrix?



- Quantifying Uncertainties
- Correlations, e.g., model, experimental systematic errors, etc.

Example: ^{237}Np (n,fission) Cross Section Correlation Matrix
(Tovesson *et al.*, LA-UR-06-7318)

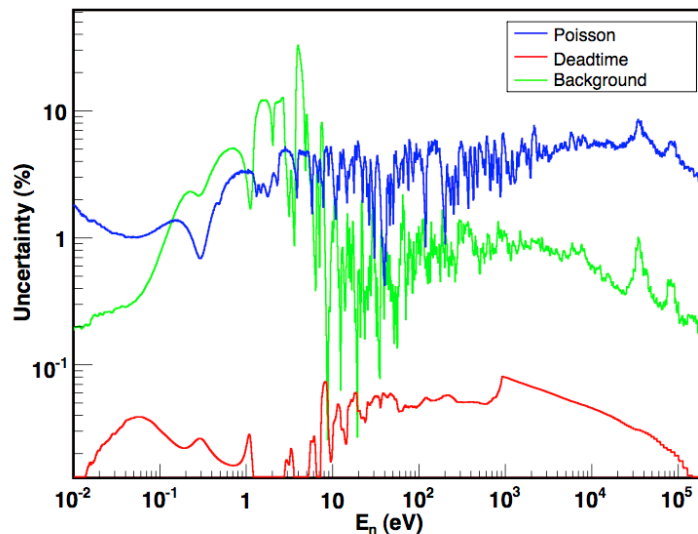


Figure 5: Uncertainties in the ^{237}Np cross section ratio due to counting statistics (blue line), dead-time correction (red line) and the background correction (green line).

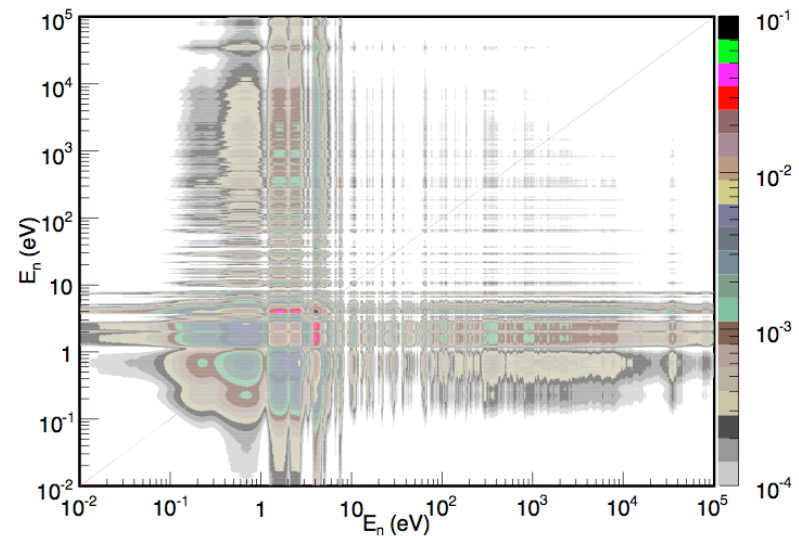
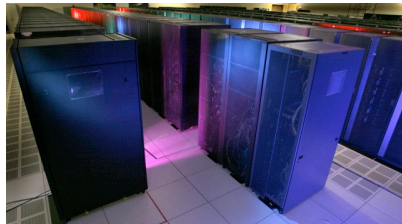
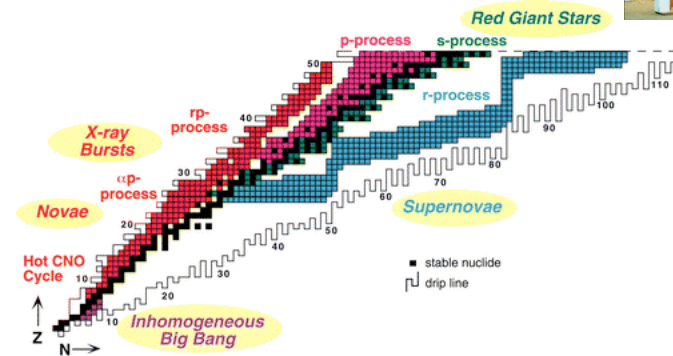


Figure 7: The relative covariance matrix when considering statistical, dead-time, and background uncertainties for the ^{237}Np to ^{235}U cross-section ratio measurement.

Why? and why Now?

■ Applications

- Nuclear Energy
- Stockpile stewardship
- Astrophysics, e.g., nucleosynthesis
- Medical
- ...



■ Why now?

- Reliable and robust nuclear reaction codes
- Access to large computers
- Consistent request from users

BNL-LANL Collaboration



- **BNL National Nuclear Data Center coordinates the project**
 - Responsible for the ENDF/B library
 - Check final files
 - Produce covariance matrices for **structural materials**, **fission products** and **some light nuclei and actinides**
 - Library releases, e.g., **COMMARA-2.0** and **ENDF/B-VII.1**

- **LANL Expertise used for**
 - **Actinides** (fission)
 - **Light nuclei** (R-matrix)
 - **Prompt fission neutrons and gamma rays**



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Our Methodology: Bayesian Inference

- Nuclear Data Evaluation: **Experiments** + Theory + **Benchmarks**
- Uncertainty Quantification to **reflect all sources of uncertainties!**

Experiments

Theory

Statistical uncertainties
Systematic errors

Model parameter uncertainties
Model errors

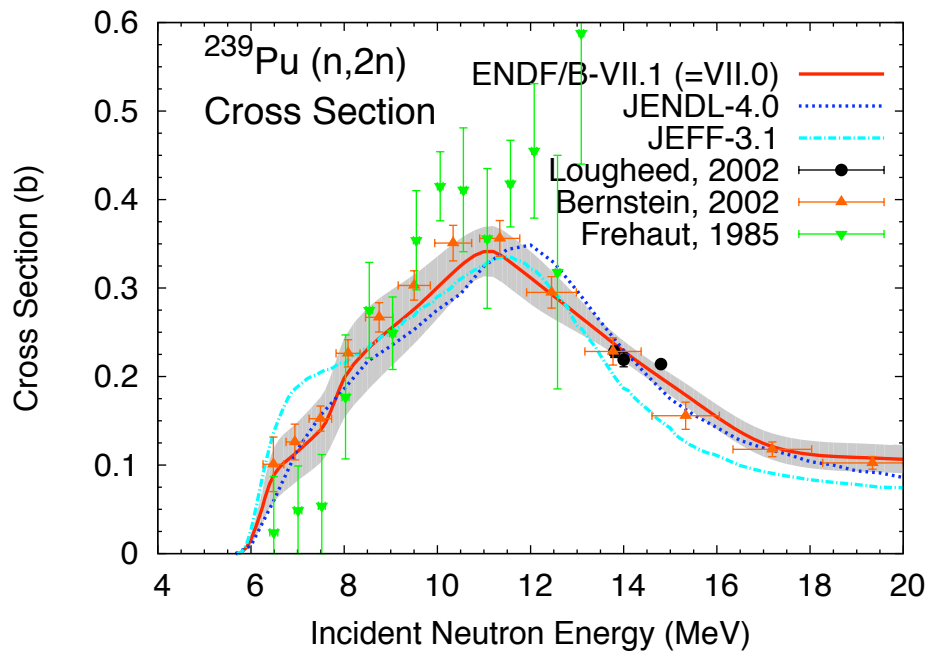


**Probability Distribution Functions
and Covariance Matrices**

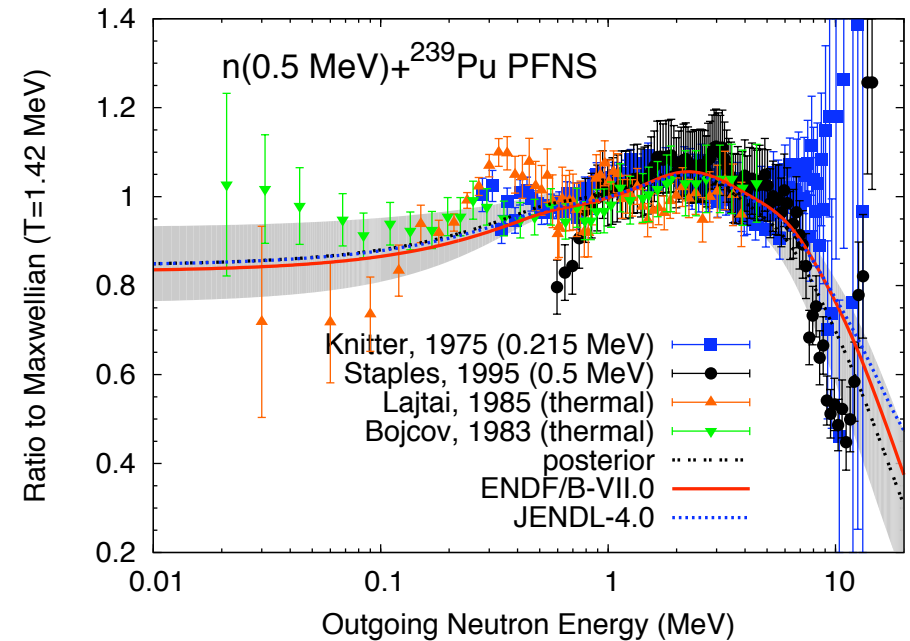
Benchmarks
& Adjustments?

Some results

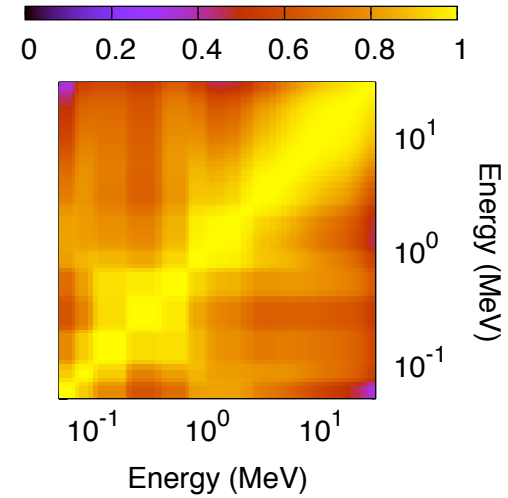
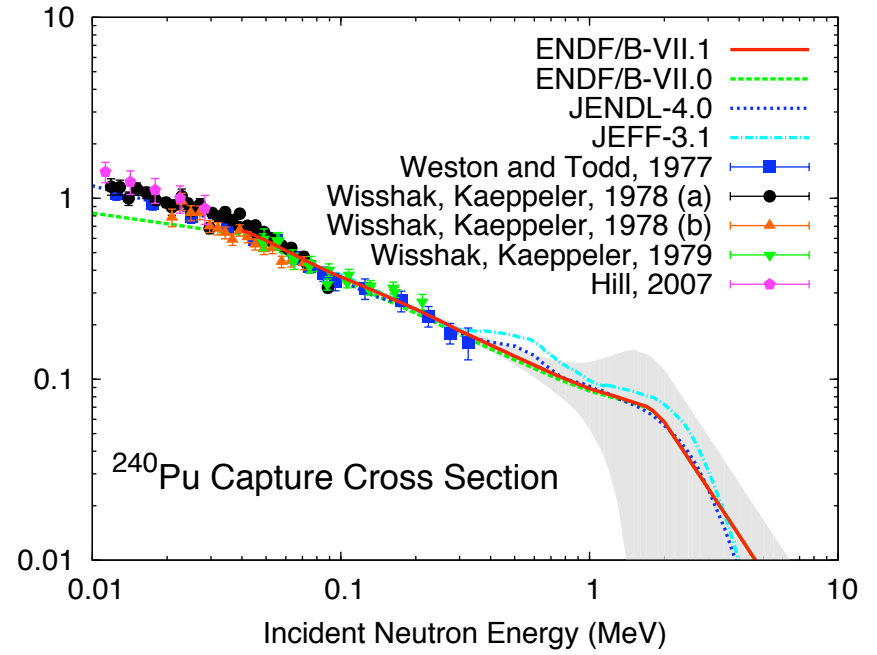
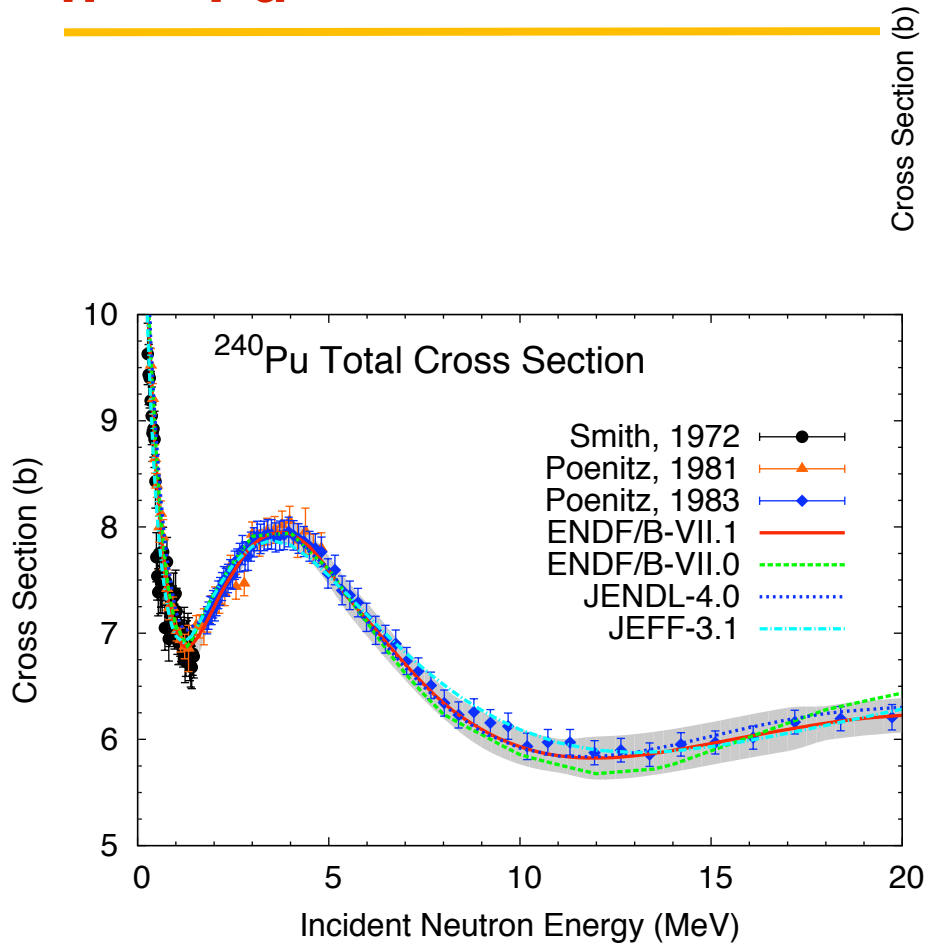
^{239}Pu (n,2n) Cross Section



^{239}Pu Prompt Fission Neutron Spectrum

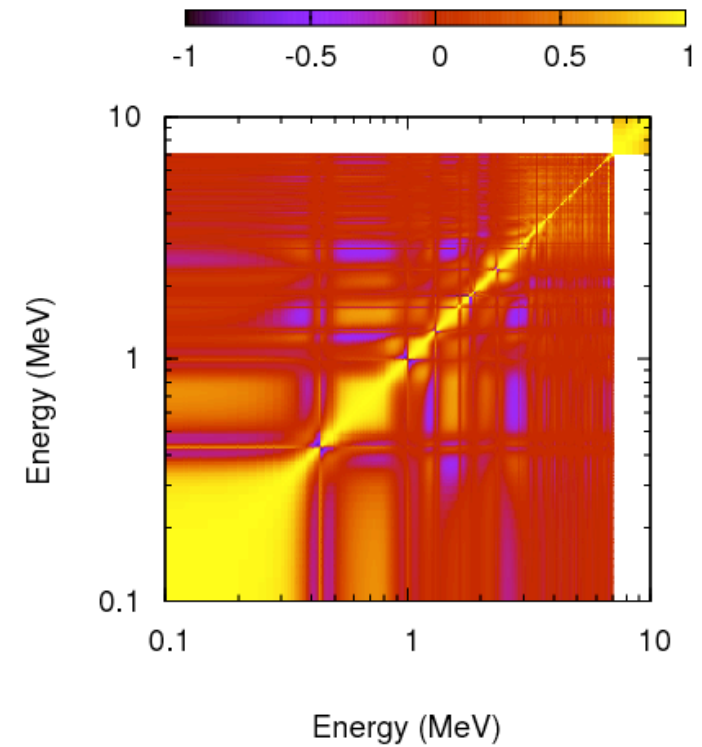
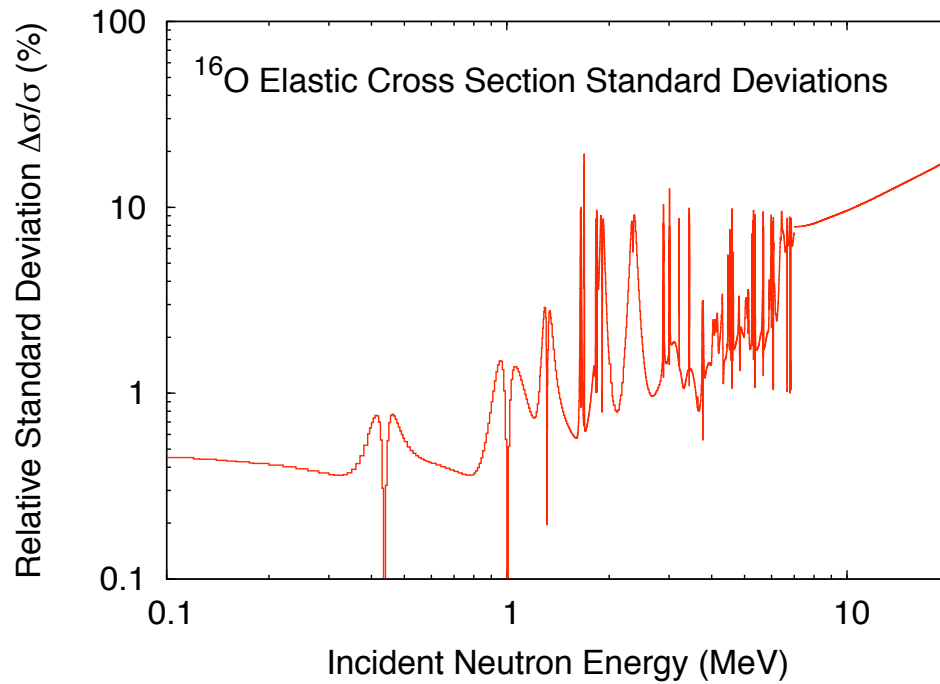


$n+^{240}\text{Pu}$



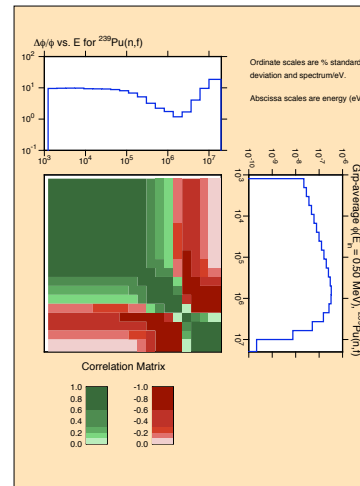
Light Nuclei

- R-Matrix Fits to Experimental Data

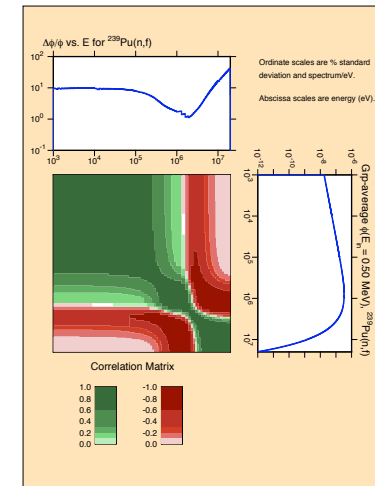


NJOY Processing & Propagation of Uncertainties

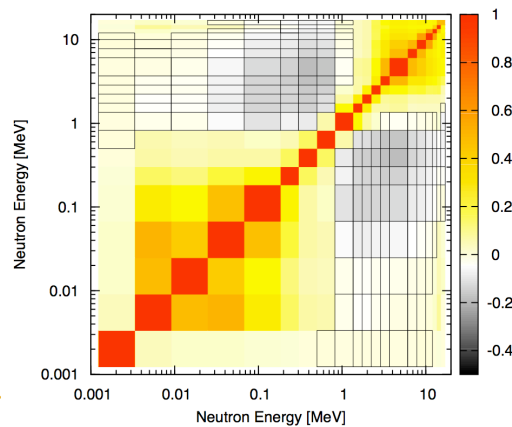
Continuous Development of NJOY Processing Code



33 groups

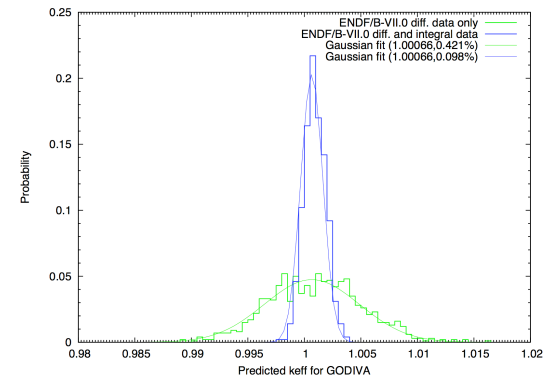


590 groups



Testing Covariance Matrices in Critical Assemblies

(e.g., ^{235}U (n,f) cross section in GODIVA)

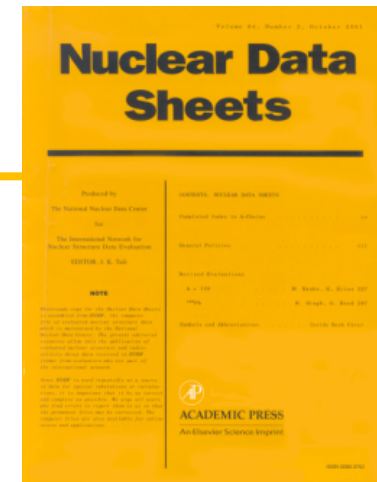


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Documenting this work

- Special Issue in Nuclear Data Sheets
- Large publication on ENDF/B-VII.1 release
- Contribution on LANL UQ work (20 pages, 53 figures)



**Quantification of Uncertainties
for Evaluated Neutron-Induced Reactions on Actinides
in the Fast Energy Range**

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Los Alamos National Laboratory, Los Alamos, NM 87545, USA*

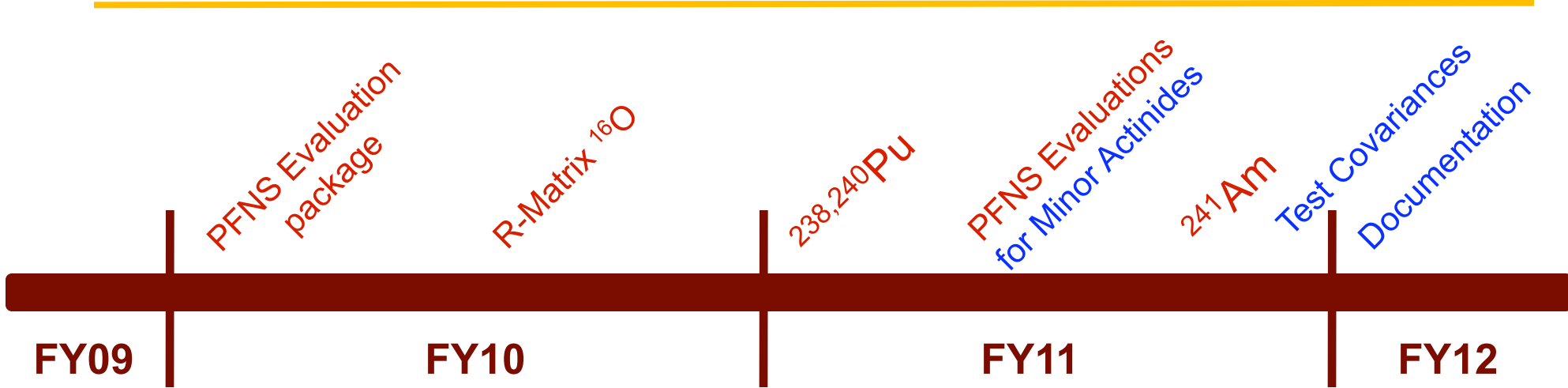
M. Rising
Department of Nuclear Engineering, University of New Mexico, Albuquerque, NM

M.B. Chadwick
X-CP, Los Alamos National Laboratory, Los Alamos, NM 87545, USA
(Dated: July 15, 2011)

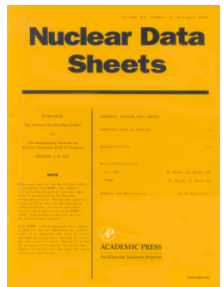
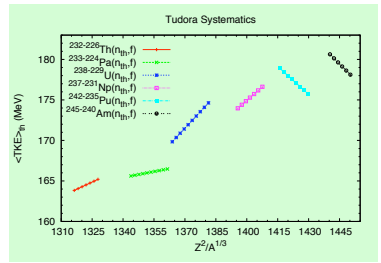
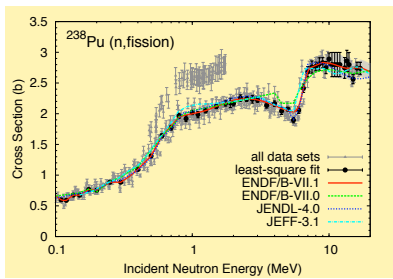
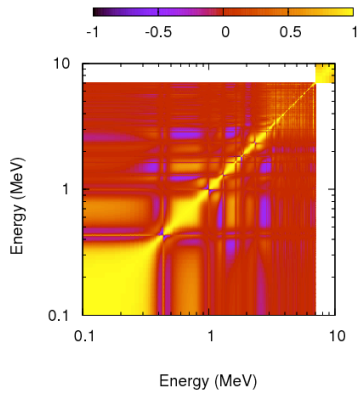
Covariance matrix evaluations in the fast energy range were performed for a large number of actinides, either using low-fidelity techniques or more sophisticated methods that rely on both experimental data as well as model calculations. The latter covariance evaluations included in the ENDF/B-VII.1 library are discussed for each actinide separately.

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Timeline & Deliverables



- PFNS
 - Accelerate.framework
 - Documents
 - tests
 - data
 - Source
 - accuracy.f90
 - mainO.f90
 - datatypes.f90
 - ripI2Masses.f90
 - numerical.f90
 - toolsENDF.f90
 - plotting.f90
 - kalman.f90
 - pfnsLosAlamosModel.f90
 - systematicsPFNS.f90
 - experimentalDataPFNS.f90
 - sensitivityPFNS.f90
 - pfnsDriver.f90
 - testingDriver.f90
 - pfnsTesting.f90
 - Documentation
 - Products



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