

Recent LANL Uncertainty Quantification Activities for FCR&D

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Evaluations & Methodologies

■ Covariance Evaluations

- Complete new evaluations + UQ for $^{238,240}\text{Pu}$, ^{241}Am (ORNL at low energies)
 - ^{241}Pu (n,fission)
 - New light nuclei R-matrix evaluations for ^4He , ^9Be , and ^{16}O
 - Covariance evaluation of PFNS for $n(0.5 \text{ MeV})+^{238,239,240}\text{Pu}$
 - Systematic study of minor actinides PFNS
- “**AFCI-2.0 Covariance Library: BNL & LANL Report FY2010**”,
M.Herman et al. (BNL) and P.Talou et al. (LANL), Oct. 14, 2010.

■ UQ Methodologies

- Develop PFNS evaluation and UQ toolkit
- Advanced statistical tools
- Testing covariance matrices

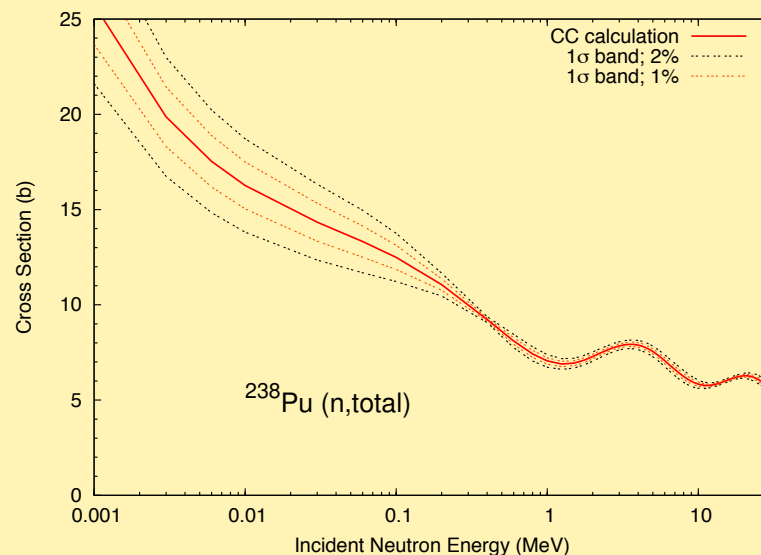
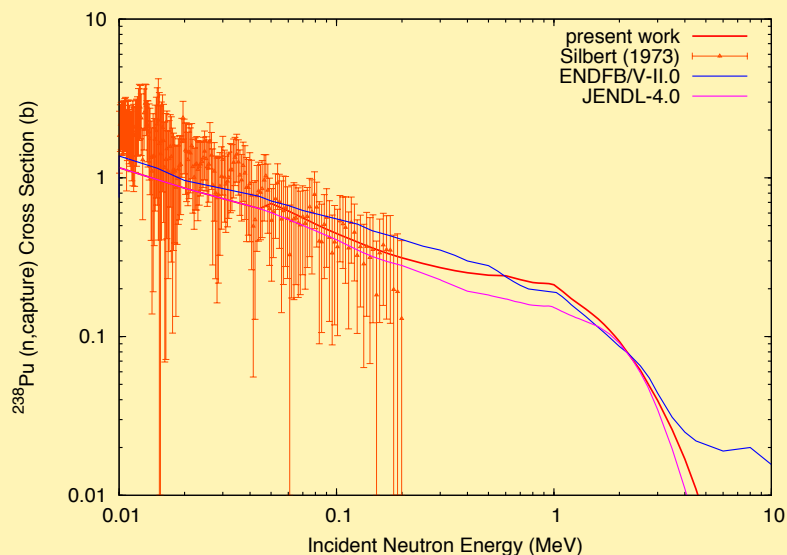
■ Advanced modeling of PFNS and fission cross section

Actinide Evaluations

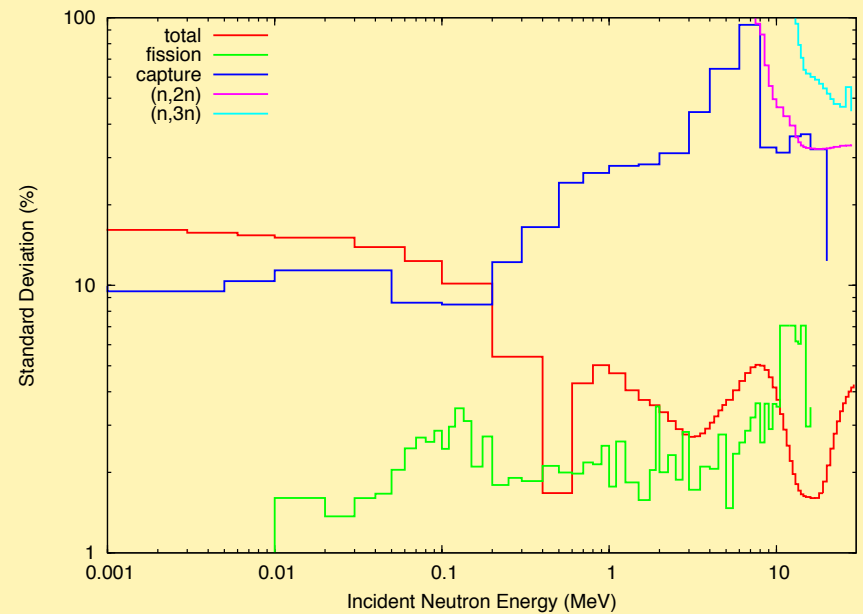
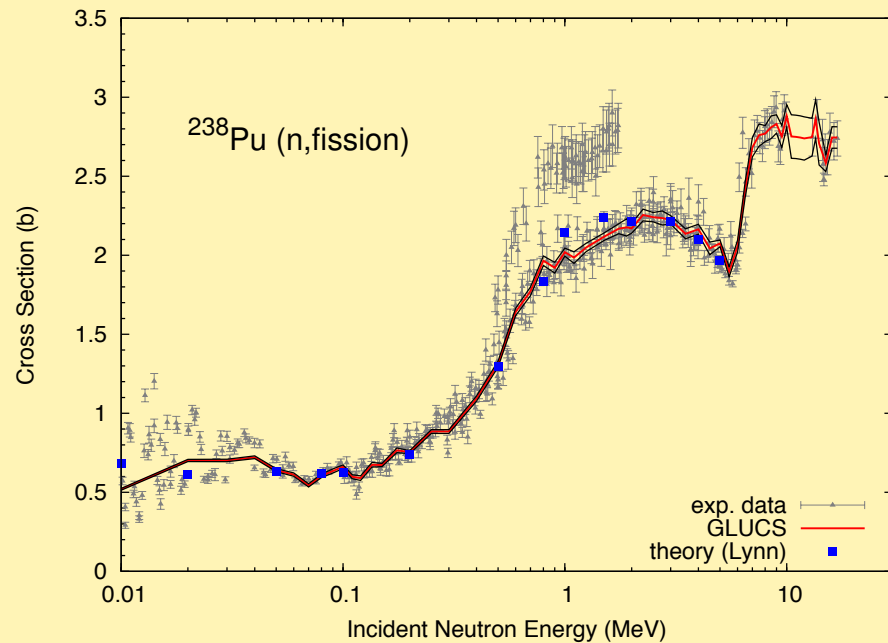
- **n+^{238,240}Pu**
 - New evaluations
 - Covariance evaluation performed simultaneously, but retrofitted to ENDF/B-VII.0 files for AFCI-2.0 covariance library
 - Includes PFNS and $\langle v \rangle$ covariance matrices
- **n+²⁴¹Am**
 - Covariance evaluation on top of ENDF/B-VII.0 evaluation

$n+^{238}\text{Pu}$ Evaluation and UQ

- Modern coupled-channels reaction calculation
- Fission cross section evaluation using experimental data
 - Including recent LANSCE data
- Capture cross section calculated using CoH code
- Covariance evaluation using GNASH/CoH+KALMAN (Bayesian filter)

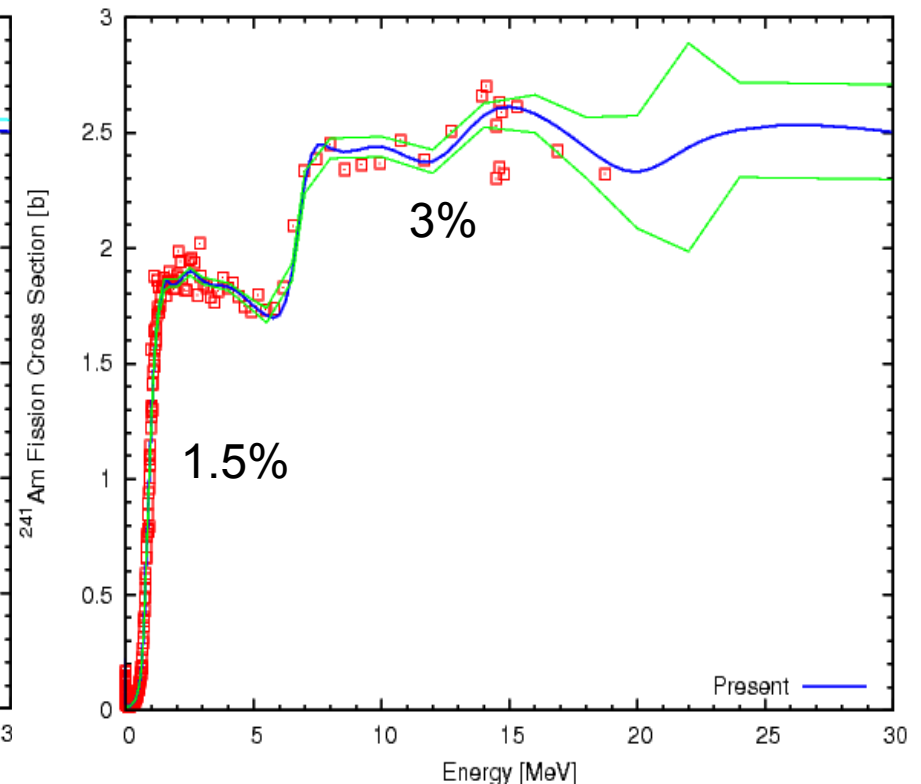
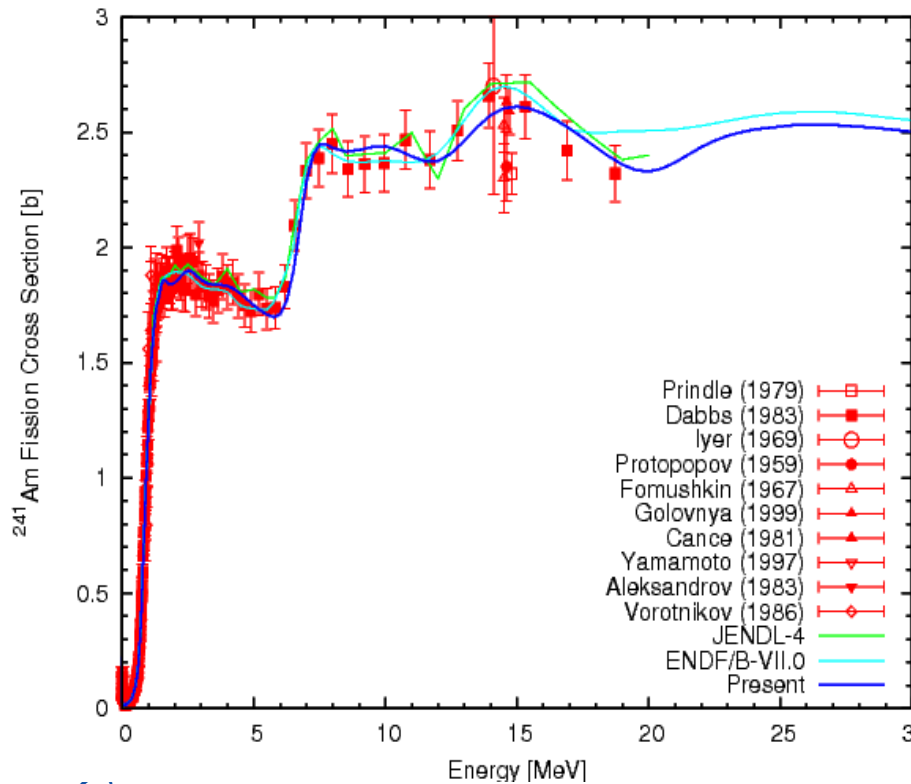


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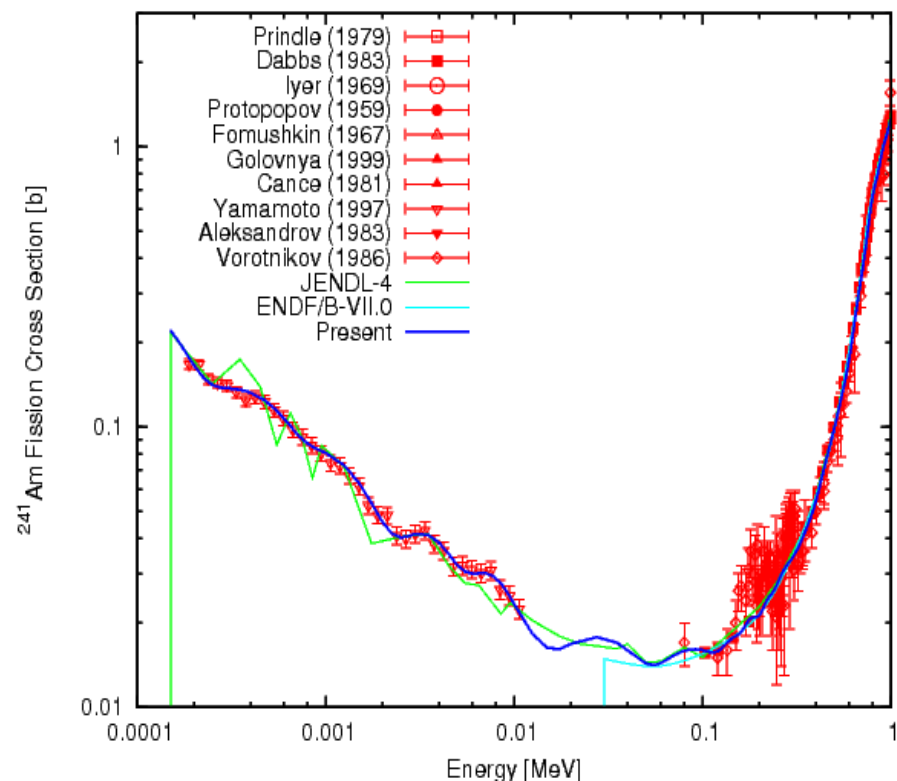
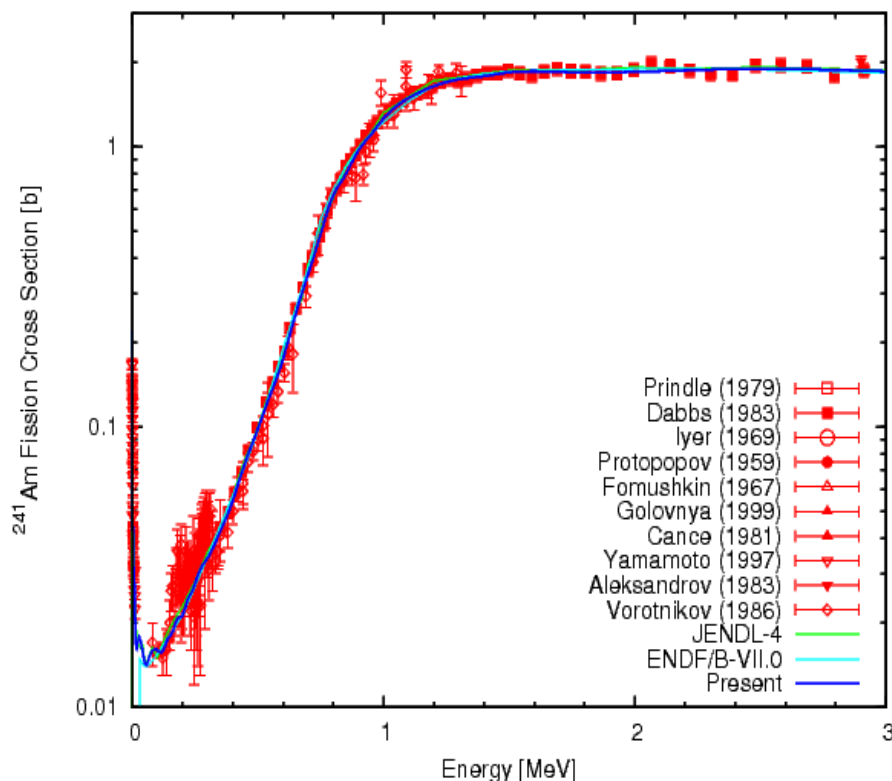


Covariance Evaluation for Am241 Fission

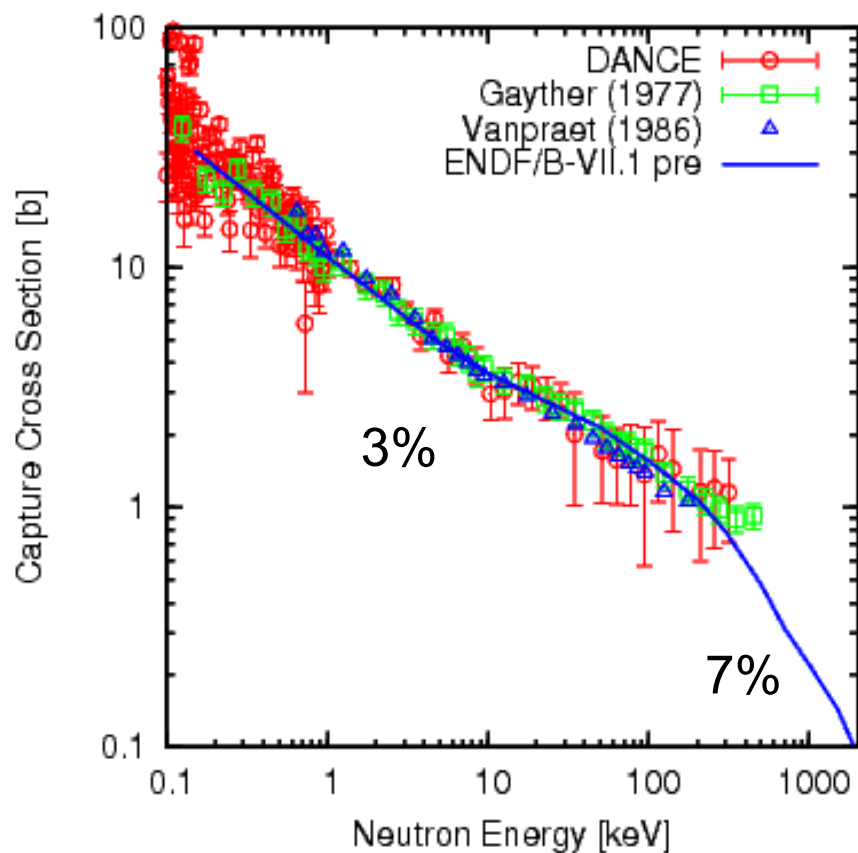
T.Kawano, Oct. 2010



Am241 Fission Cross Section in Fast Range



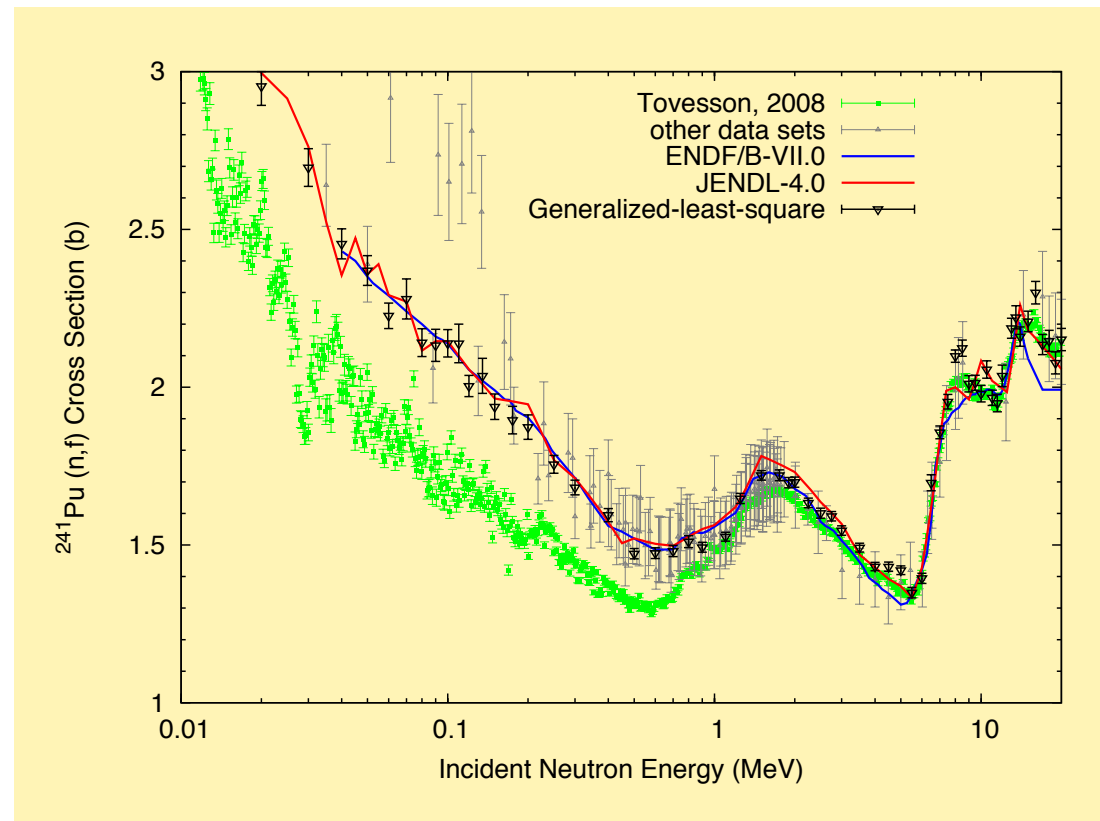
Am241 Capture Cross Section



- **Statistical model calculation**
 - DANCE experimental data
- **Benchmark Calculations**
 - LANL reaction rate measurements in the critical assemblies
- **Resonance Range**
 - LSSF=1 Used
 - JENDL-4 Resolved/unresolved resonance parameters adopted

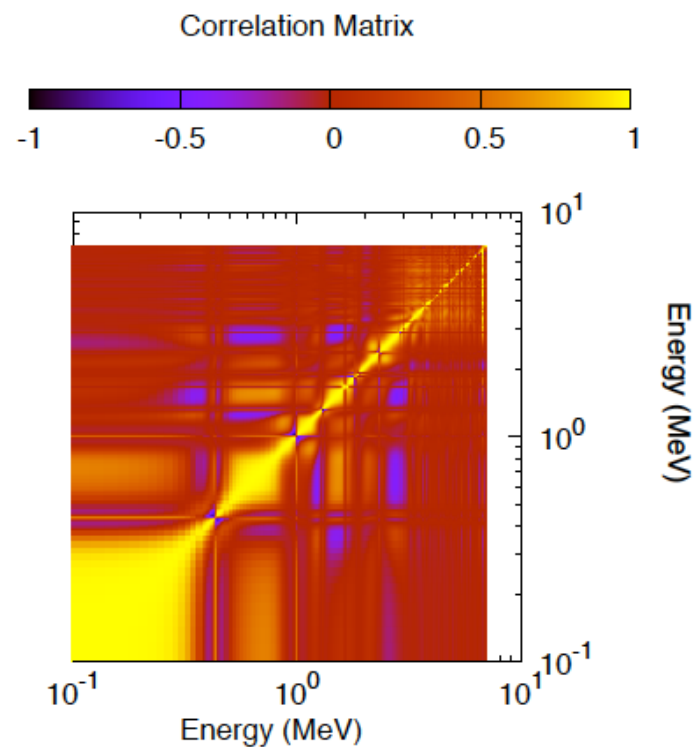
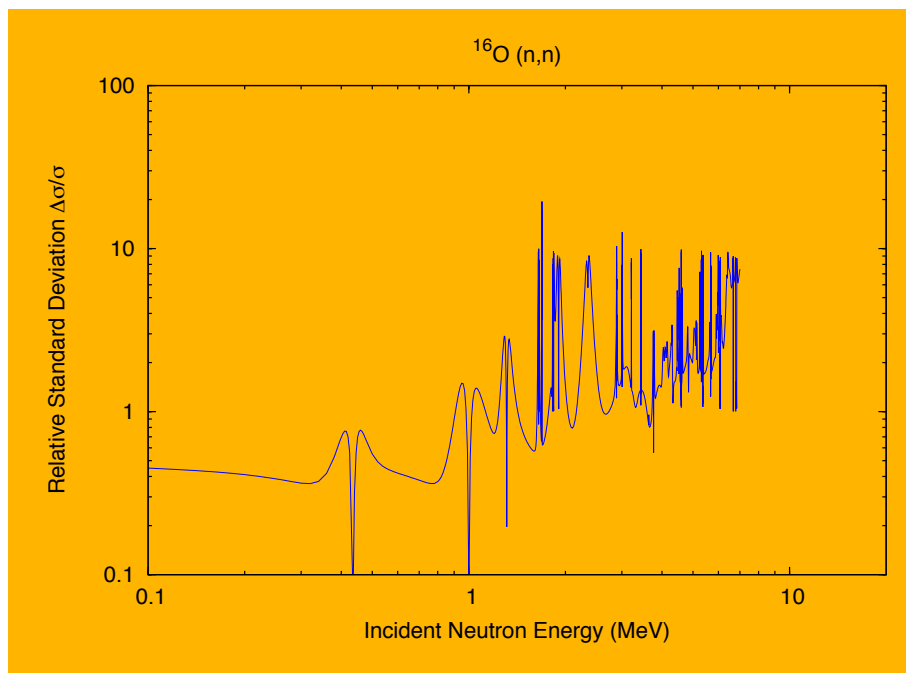
^{241}Pu (n,fission) Cross Section

- Generalized-Least-Square study of existing experimental data sets
- Recent measurement at LANSCE (F.Tovesson)



^{16}O R-matrix Evaluation

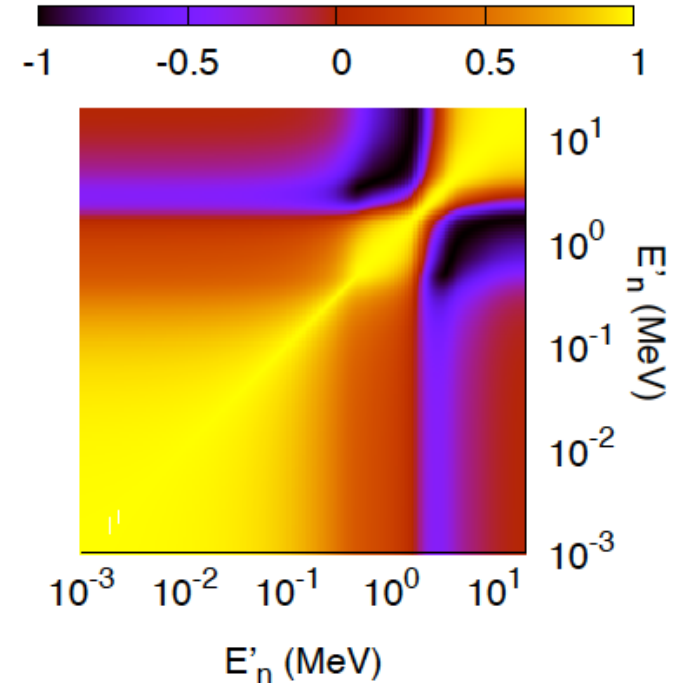
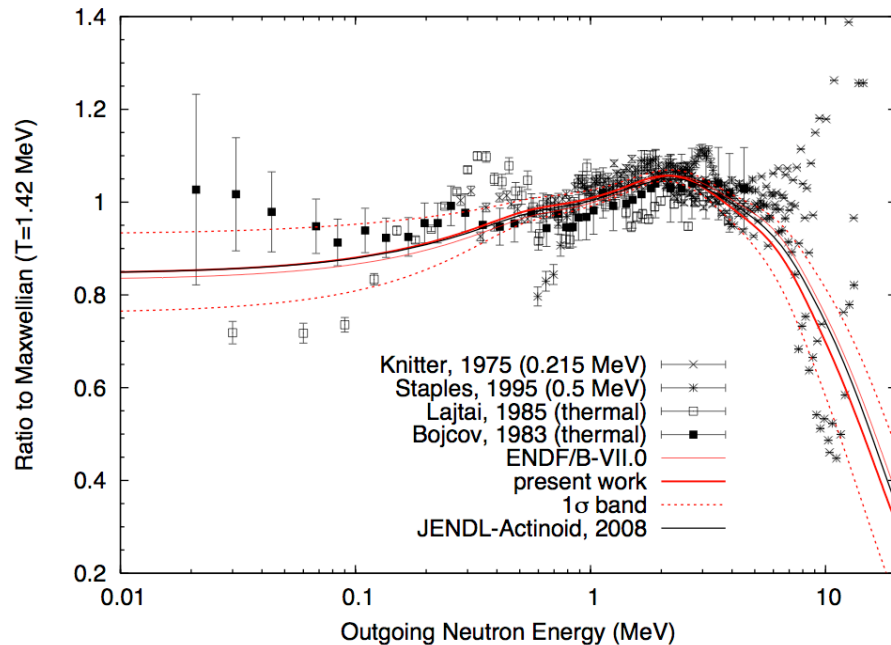
- New evaluation by G.M.Hale
- Covariance matrices evaluated for (n,n) , (n,α) and $\langle\mu\rangle$



Prompt Fission Neutron Spectrum $n+^{238,239,240}\text{Pu}$ Covariance Evaluations

■ Initial work on ^{239}Pu

- “Uncertainty Quantification of Prompt Fission Neutron Spectrum for $n(0.5 \text{ MeV}) + ^{239}\text{Pu}$ ”, P.Talou et al., Nucl. Sci. Eng. 166, 1-13 (2010).
- Part of ENDF/B-VII.1 β 0
- Methodology similar to cross section UQ \rightarrow Madland-Nix model + KALMAN



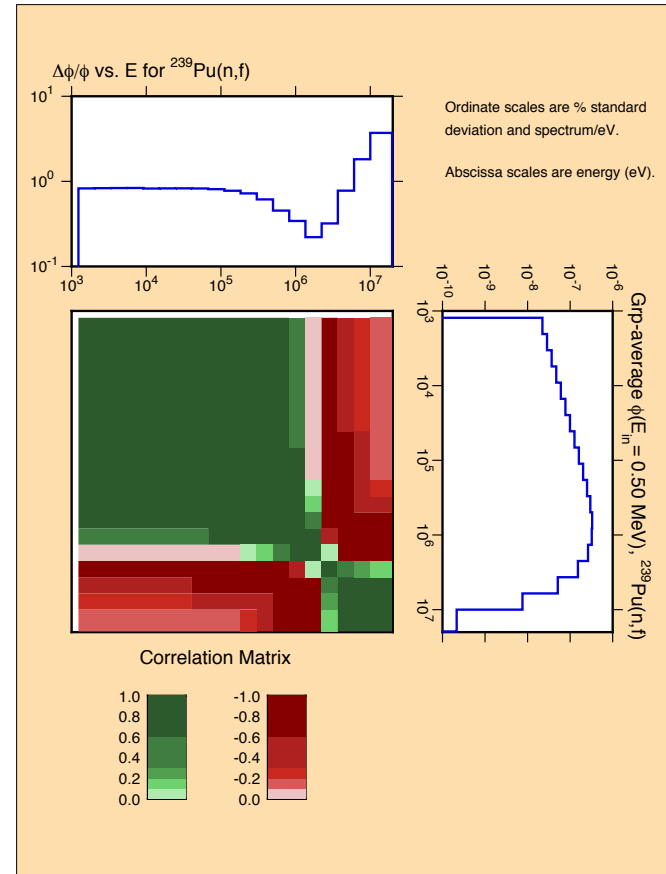
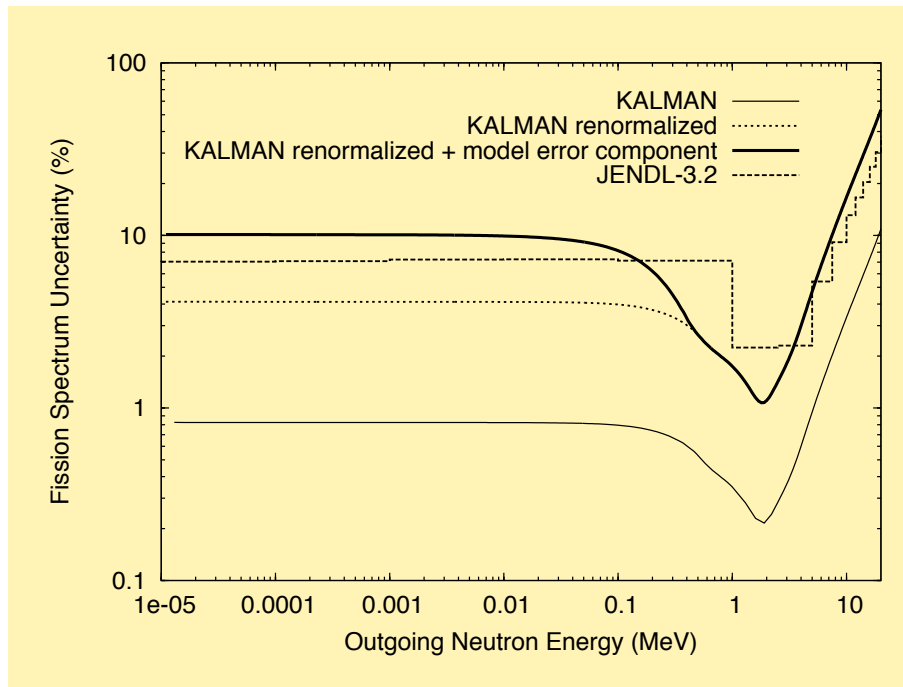
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Operated by Los Alamos National Security, LLC for NNSA

AFCI Nuclear Physics Working Group, Nov 17, 2010

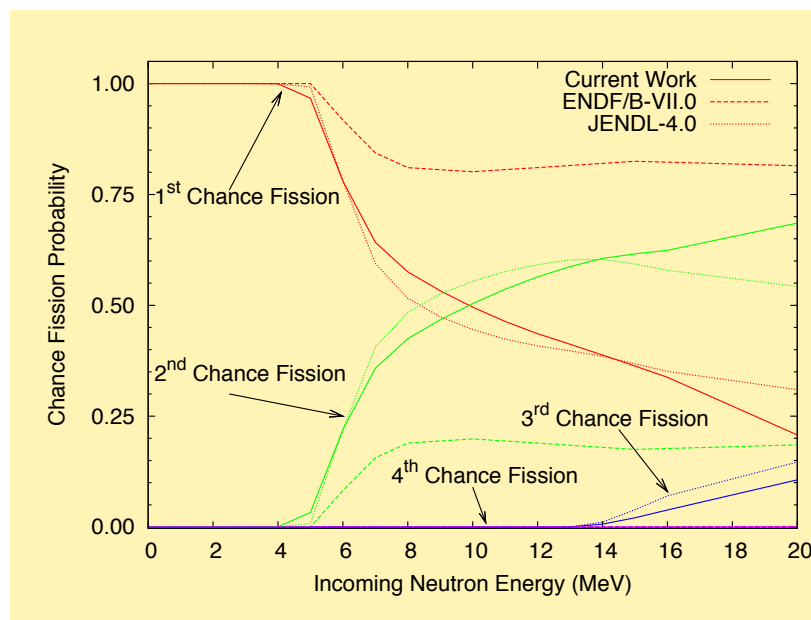
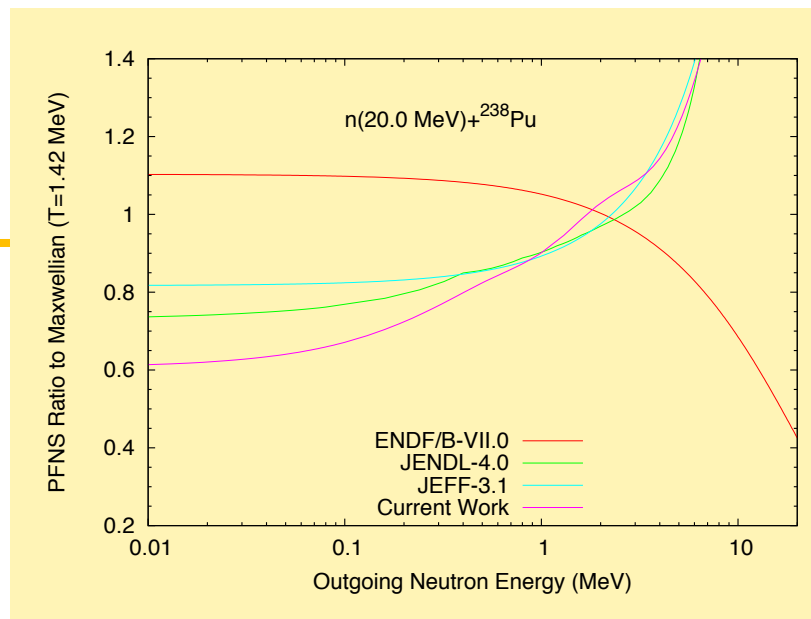
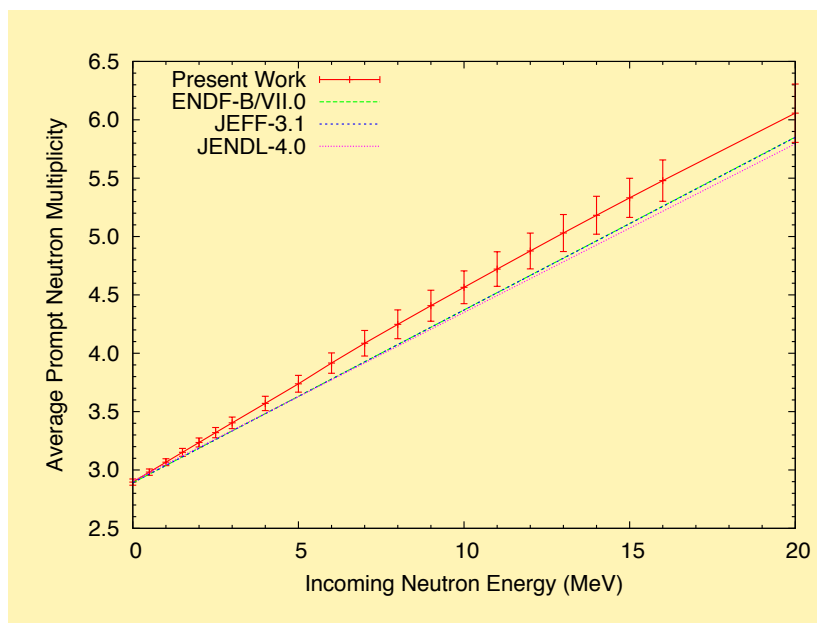
n(0.5 MeV)+²³⁹Pu PFNS (cont'd)

- Processed through NJOY in 33 and 590 groups
- Verifies the zero-sum rule



Similar work for $^{238,240}\text{Pu}$

- Lack of experimental data
- Use of systematics for model input parameters



PFNS Evaluation Package

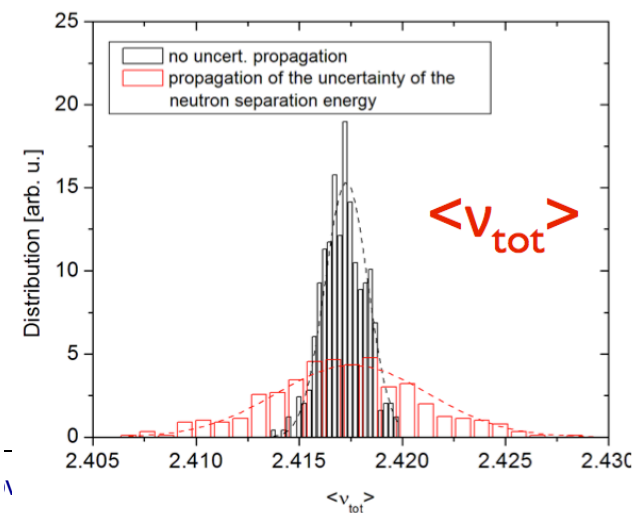
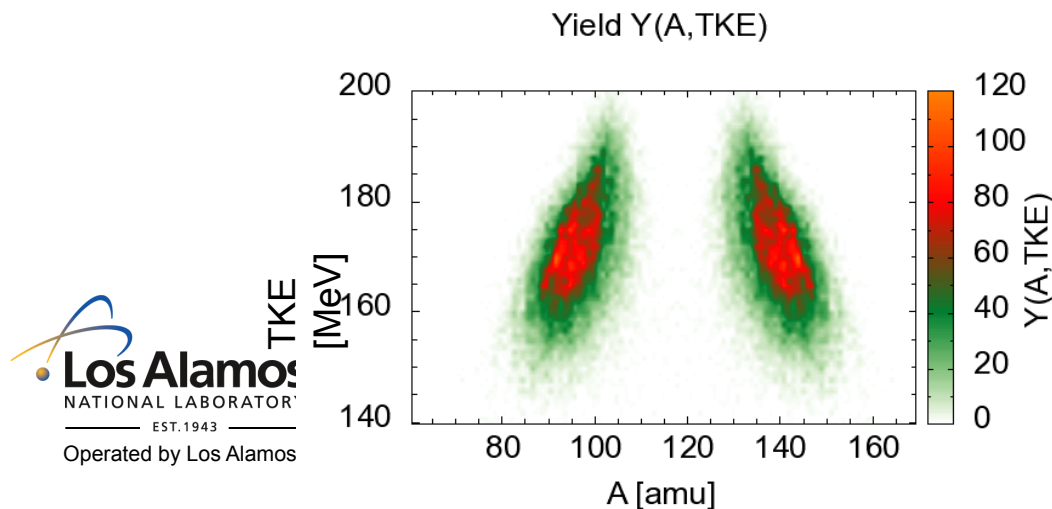
- **Complete code package to analyze, compute and evaluate prompt fission neutron spectrum and multiplicity**
 - Implementation of the Madland-Nix model
 - Model input parameter systematics included
 - Complete module to analyze various experimental data sets
 - Search for optimal model parameters
 - **Uncertainty Quantification** of spectrum and multiplicity
 - ENDF formatting for easy incorporation in evaluated libraries
- **Version 1.0 already released (internally)**
- **AFCI-NEUP collaboration with A.Prinja, M.Rising, UNM**
- **First application to suite of plutonium isotopes**
- **By end of this CY:**
large suite of actinides studied to replace values in ENDF/B-VII.0

Advanced Statistical Tools

- **Better evaluation of experimental errors and correlations**
 - Work closely with LANSCE scientists measuring fission cross sections (F.Tovesson) and (χ, ν) (R.C.Haight)
- **Sampling model parameter space**
 - Beyond linear approximation (1st order KALMAN code)
 - Unified Monte Carlo (UMC) proposed by D.Smith
- **Advanced evaluation tools**
 - Better ways of checking consistency of experimental data sets (beyond χ^2/N)
 - Cross-correlations between experiments?
 - Model uncertainties?
- **Testing evaluated covariance matrices**
 - Propagation of uncertainties / consistency check in benchmarks and transport simulations

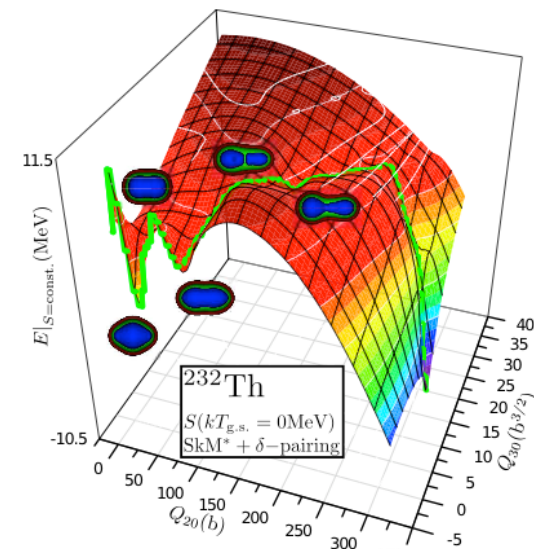
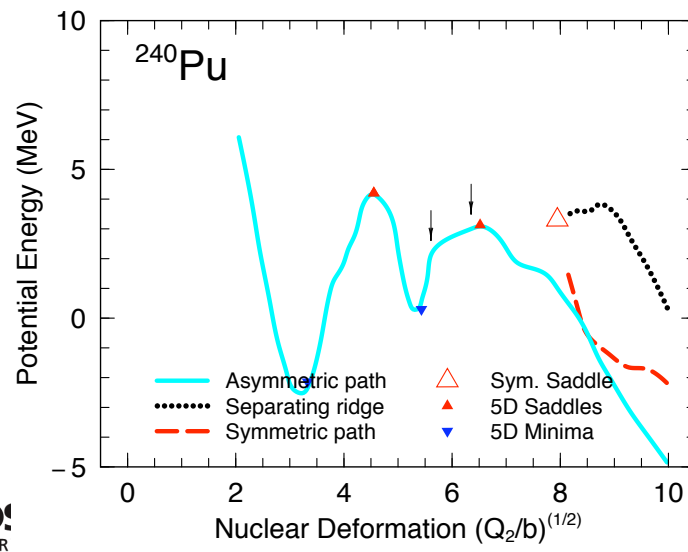
Advanced Modeling of Prompt Fission Neutrons

- **Based on earlier work:** S.Lemaire, P.Talou, T.Kawano, M.B.Chadwick and D.G.Madland, Phys. Rev. C **72**, 024601 (2005); Phys. Rev. C **73**, 014602 (2006)
- **Entirely new code written “FFD”**
- P.Talou, T.Kawano, O.Bouland, J.E.Lynn, P.Möller, and M.B.Chadwick, Proc. of the International Conference on Nuclear Data for Science & Technology ND2010, April 26-30, 2010, Jeju Island, Korea (2010). [LA-UR 10-03259]
- **AFCI-NEUP Collaboration with Y.Danon, B.Becker, RPI**
 - LSDS measurements of fission cross sections and fission fragment yields
 - Use FFD code with input from RPI measurements
 - Sensitivity calculations



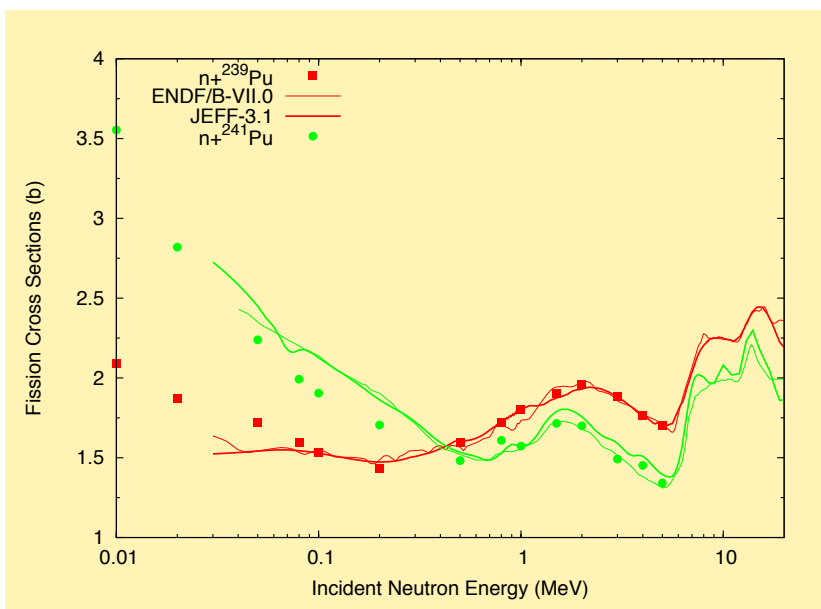
Advanced Modeling of Fission Cross Section

- R-matrix approach, based on original work by J.E.Lynn
- **Less phenomenology, more physics-based model parameters, better predictive capabilities**
- **Who:**
 - O.Bouland (long-term visit from CEA, France) - J.E.Lynn (LANL Consultant) - T.Kawano, P.Möller, P.Talou
 - **AFCI-NEUP** collaboration with W.Nazarewicz et al., UTK/ORNL



Preliminary Results for $n+^{239,241}\text{Pu}$ and $n+^{238,240}\text{Pu}$

Odd target



Even target

