LANL Covariance Work

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Evaluations & Methodologies

Covariance Evaluations

- Complete new evaluations + UQ for ^{238,240}Pu, ^{241}Am (ORNL at low energies)
- New light nuclei R-matrix evaluations for ^{4}He, ^{9}Be, and ^{16}O
- Covariance evaluation of PFNS for n(0.5 MeV)+^{238,239,240}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

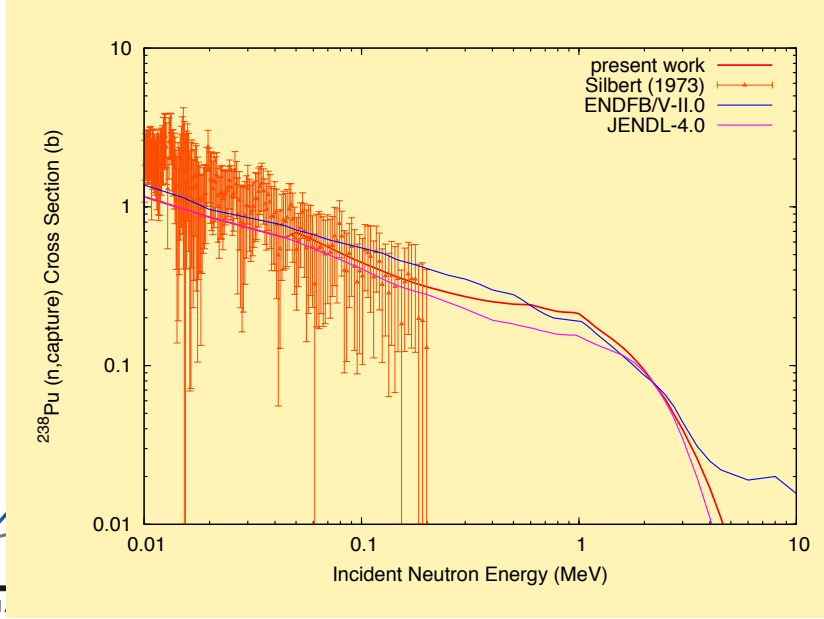
- Develop PFNS evaluation and UQ toolkit
- Advanced statistical tools
- Testing covariance matrices

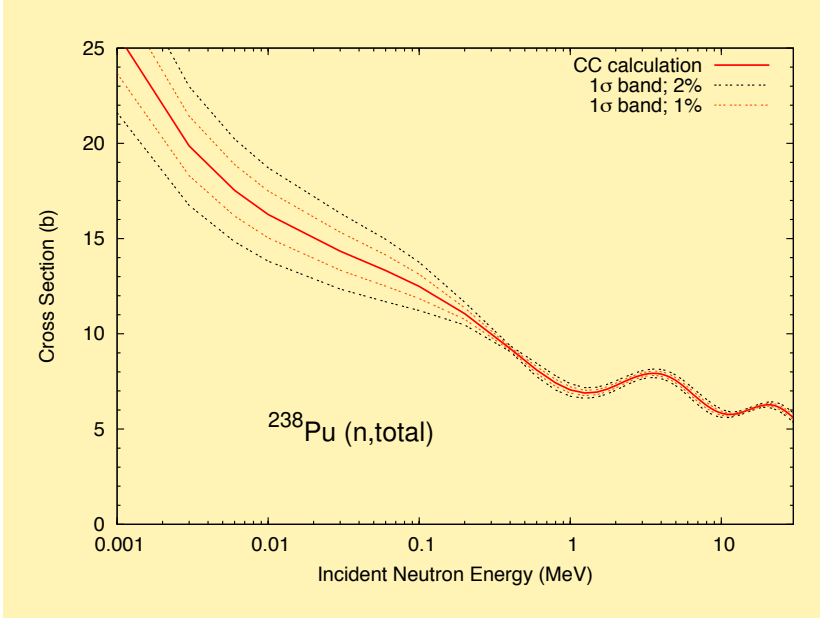
Actinide Evaluations

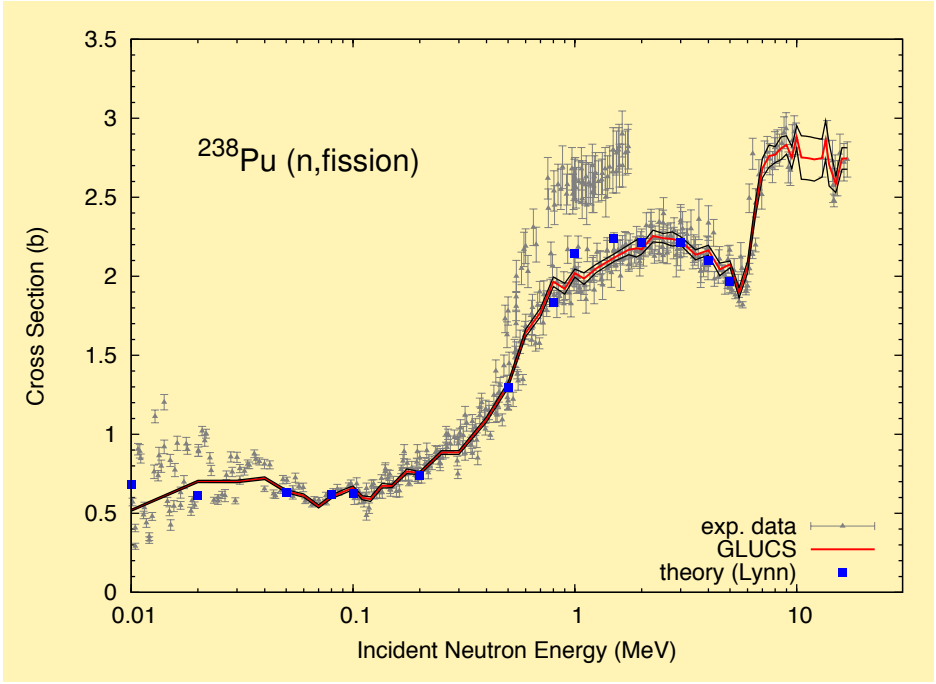
- **n+^{238,240}Pu**
  - New evaluations
  - Covariance evaluation performed simultaneously, but retrofitted to ENDF/B-VII.0 files for AFCI-2.0 covariance library
  - Includes PFNS and <ν> covariance matrices
- **n+^{241}Am**
  - Covariance evaluation on top of ENDF/B-VII.0 evaluation

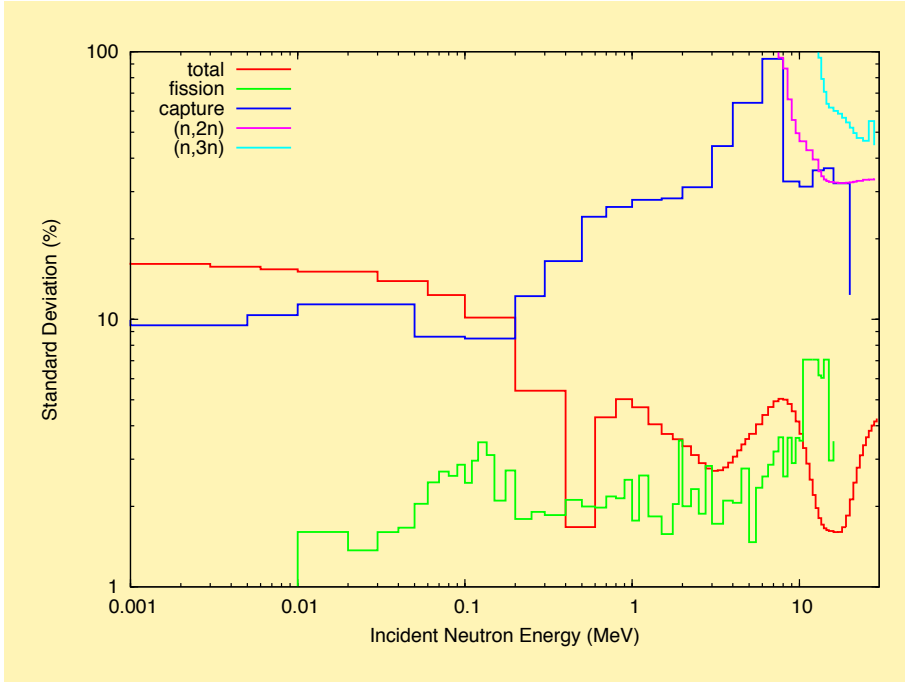
n+^{238}Pu Evaluation and UQ

- **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)**



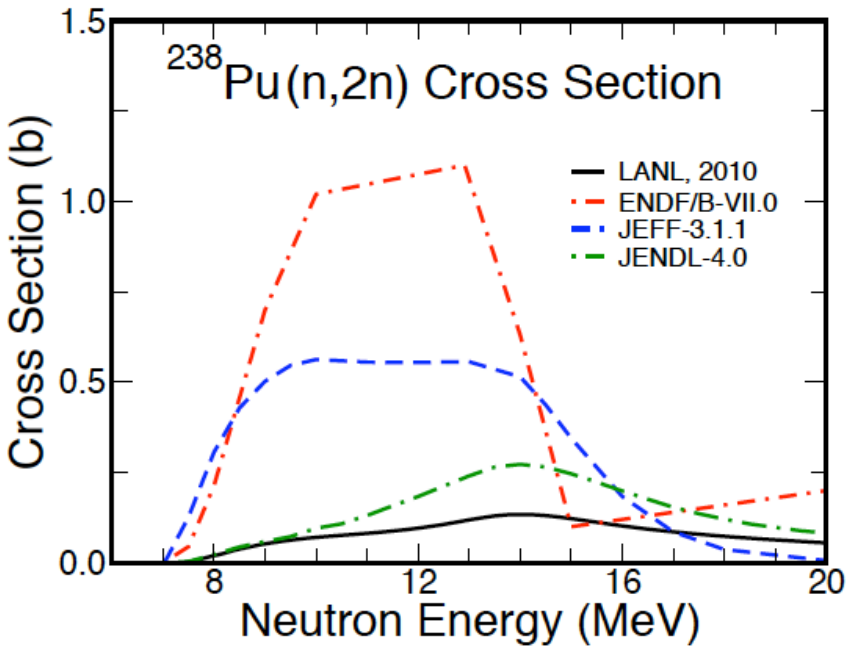



^{238}Pu (n,fission)
Cross Section (b)
Incident Neutron Energy (MeV)
exp. data
GLUCS
theory (Lynn)
0
0.5
1
1.5
2
2.5
3
3.5
0.01
0.1
1
10


Standard Deviation (%)
Incident Neutron Energy (MeV)
total
fission
capture
(n,2n)
(n,3n)
100
10
1
0.001
0.01
0.1
1
10

Retrofit to ENDF/B-VII.0 files for AFCI-2.0 library

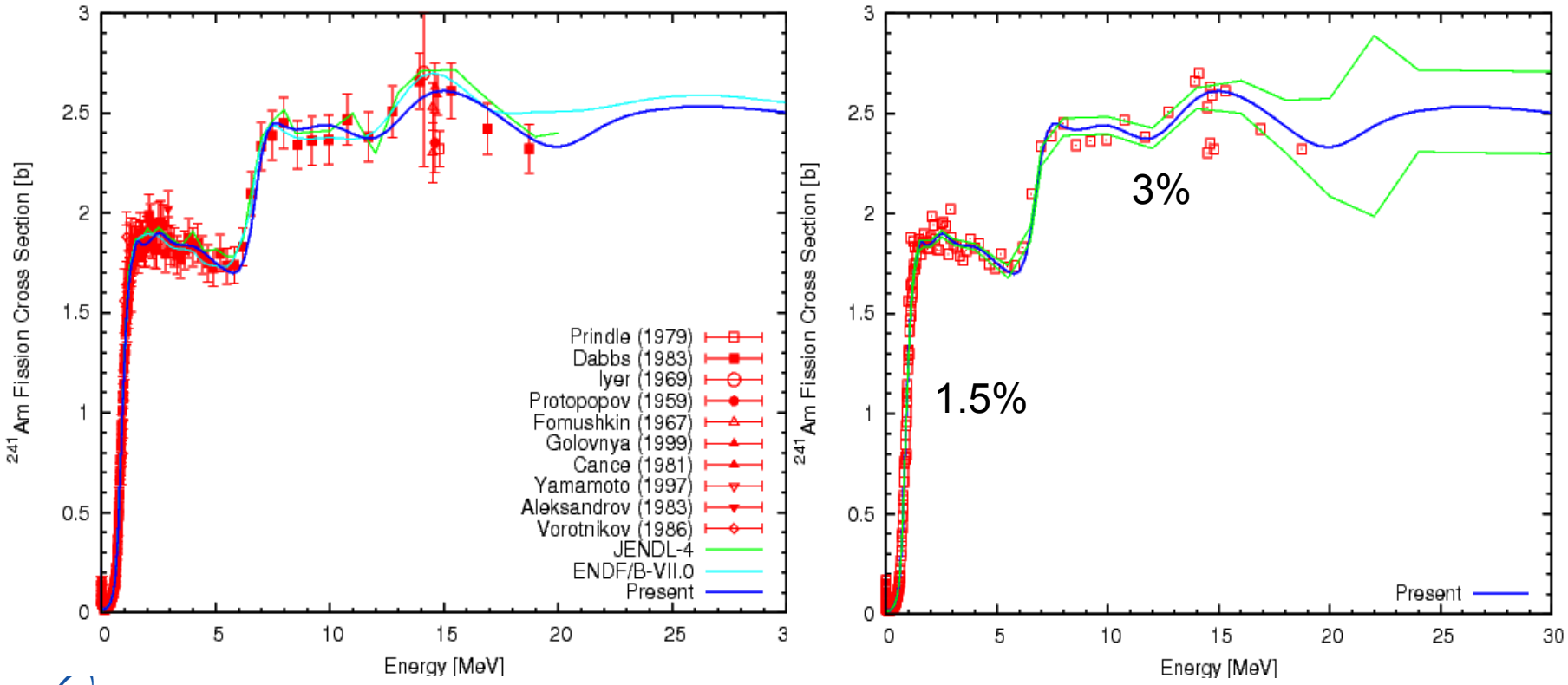
- **AFCI-2.0 Covariance Library requires covariance matrices associated with ENDF/B-VII.0 files, NOT VII.1**
- **Retrofit new matrices to old files → "fuzzy business"**



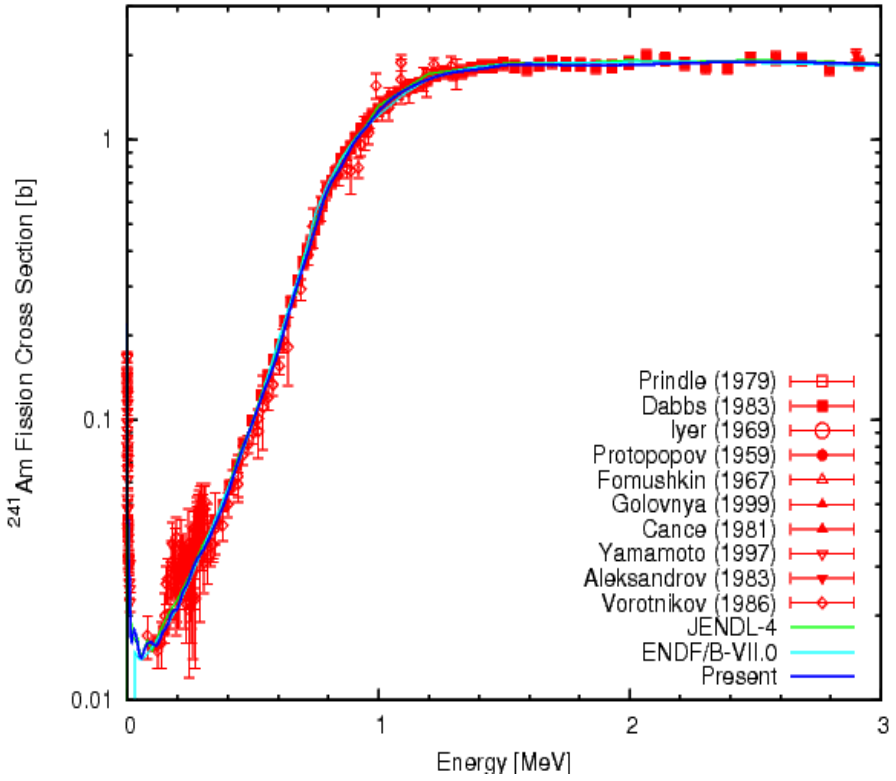
Reaction	Notes	UQ for VII.1	OK?
Total	Large differences (~20%) above 10 MeV and up to ~14%in 10-100 keV range	Above 10% in 10-100 keV range. Less than 5% above 10 MeV.	Uncertainties should be increased above 10 MeV
Elastic	Up to 20-30% differences above 3Mev	~8% above 3 MeV	Significant increase
Non-Elastic	Very large differences above 2 MeV	~10% above 1 MeV	Significant increase
Inelastic	Significant differences everywhere	~10% above 1 MeV	Significant increase
Fission	Both evaluations based on experimental data sets. Deviations 4-10% in places.	~1.5-2% in most energy range	Uncertainties to be increased above 5 MeV.
Capture	Up to 18% differences in 100-500 keV region	Less than 10-20% in 100-500 keV	Uncertainties should be increased in 100-500 keV and above 10 MeV should be max.
(n,2n)	1 order of magnitude different	30-100%	Significant increase
(n,3n)	1 order of magnitude different	50-100%	Significant increase
<ν>	Good agreement at thermal. Up to 5% difference at 20 MeV.	0.9% at thermal and 5-6% at 20 MeV	OK
Spectrum χ (at 0.5 MeV)	Large differences for spectra above second-chance fission threshold	Within error bands for low incident energies	OK (for low E_{inc} only!)

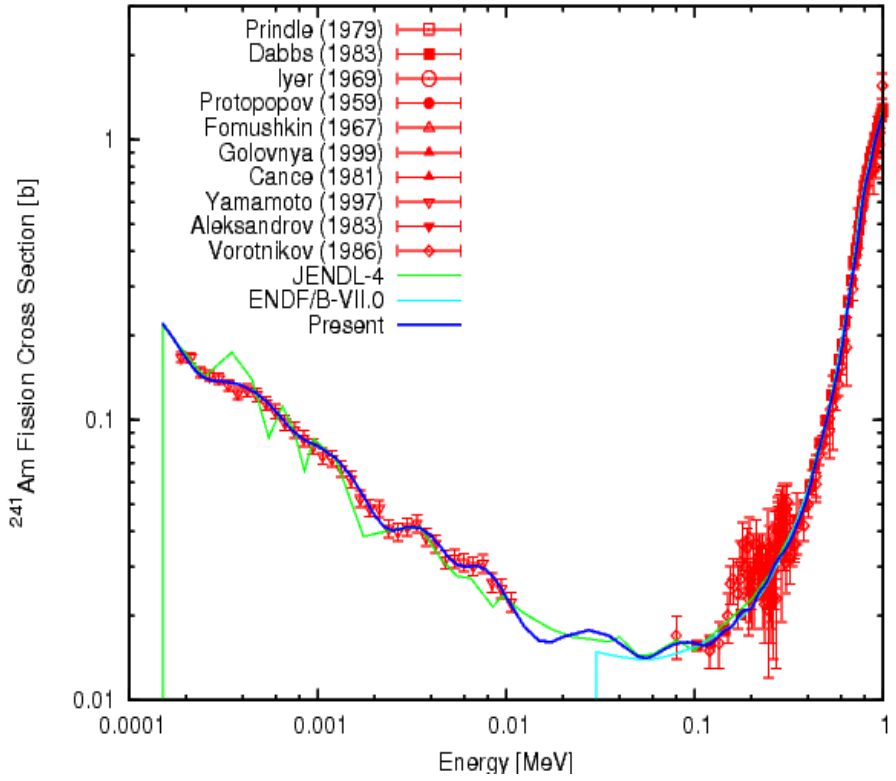
Covariance Evaluation for Am241 Fission

T.Kawano, Oct. 2010

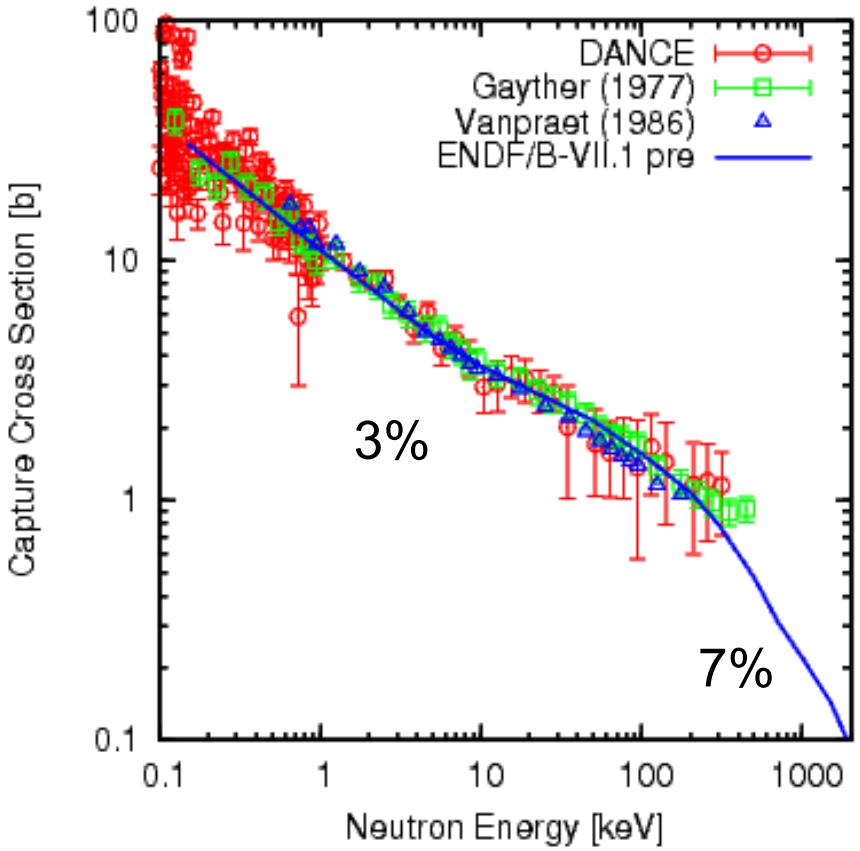


Am241 Fission Cross Section in Fast Range





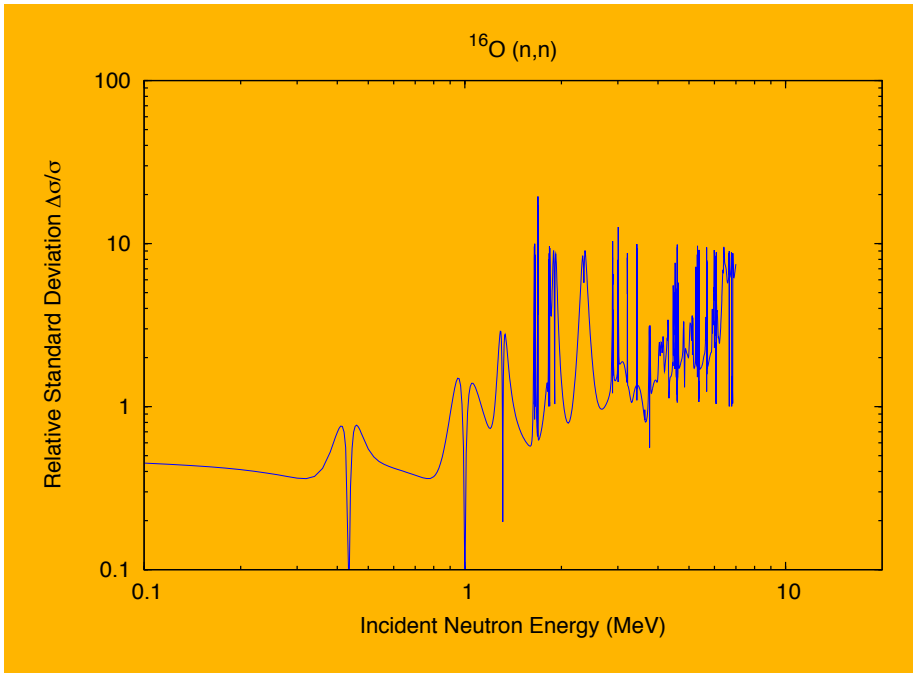
Am241 Capture Cross Section

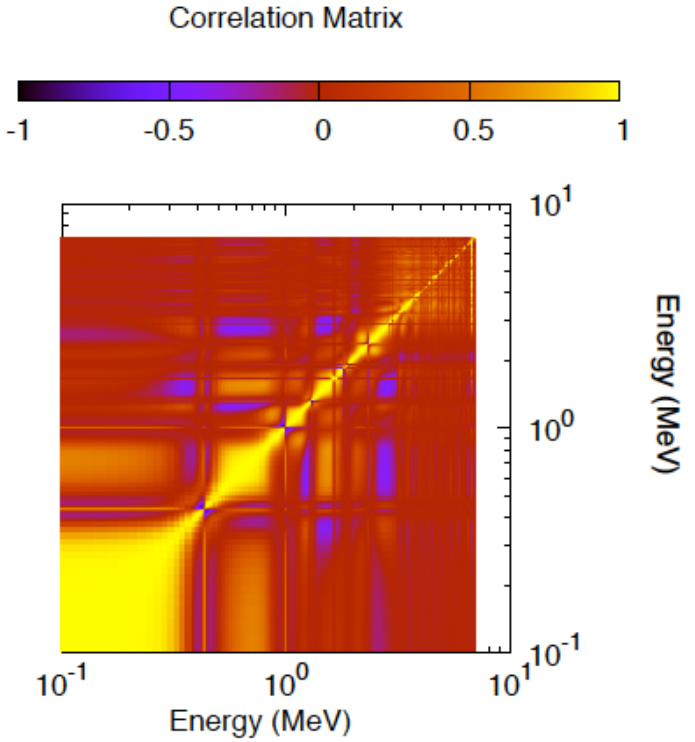


- **Statistical model calculation**
  - DANCE experimental data
- **Benchmark Calculations**
  - LANL reaction rate measurements in the critical assemblies
- **Resonance Range**
  - LSSF=1 Used
  - JENDL-4 Resolved/ unresolved resonance parameters adopted

^{16}O R-matrix Evaluation

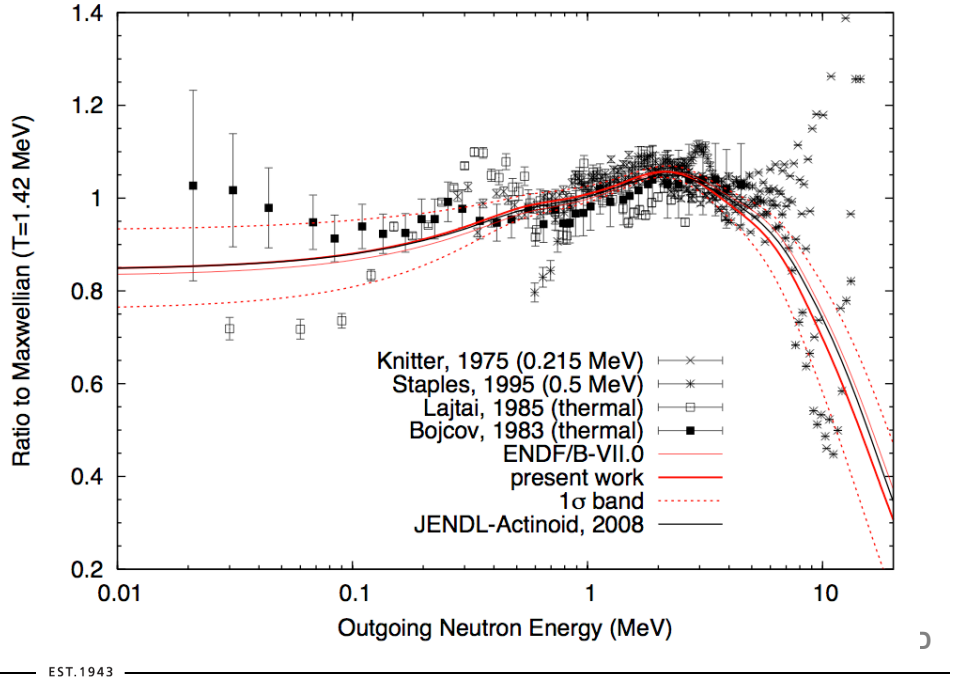
- **New evaluation by G.M.Hale**
- **Covariance matrices evaluated for (n,n), (n,α) and <μ>**

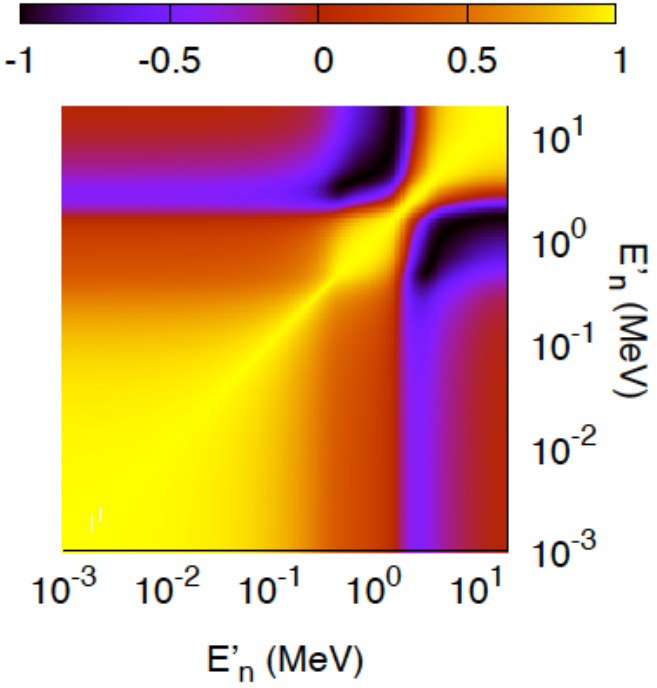




Prompt Fission Neutron Spectrum n+^{238,239,240}Pu Covariance Evaluations

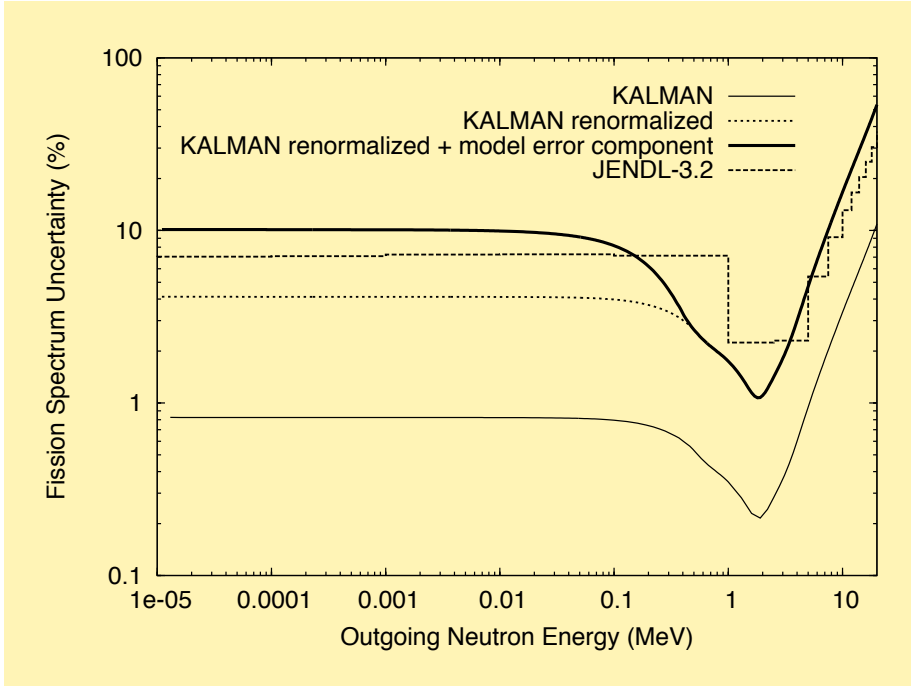
- **Initial work on ^{239}Pu**
  - "Uncertainty Quantification of Prompt Fission Neutron Spectrum for n(0.5 MeV) +^{239}Pu", P.Talou et al., Nucl. Sci. Eng. 166, 1-13 (2010).
  - Part of ENDF/B-VII.1β0
  - Methodology similar to cross section UQ ➔ Madland-Nix model + KALMAN

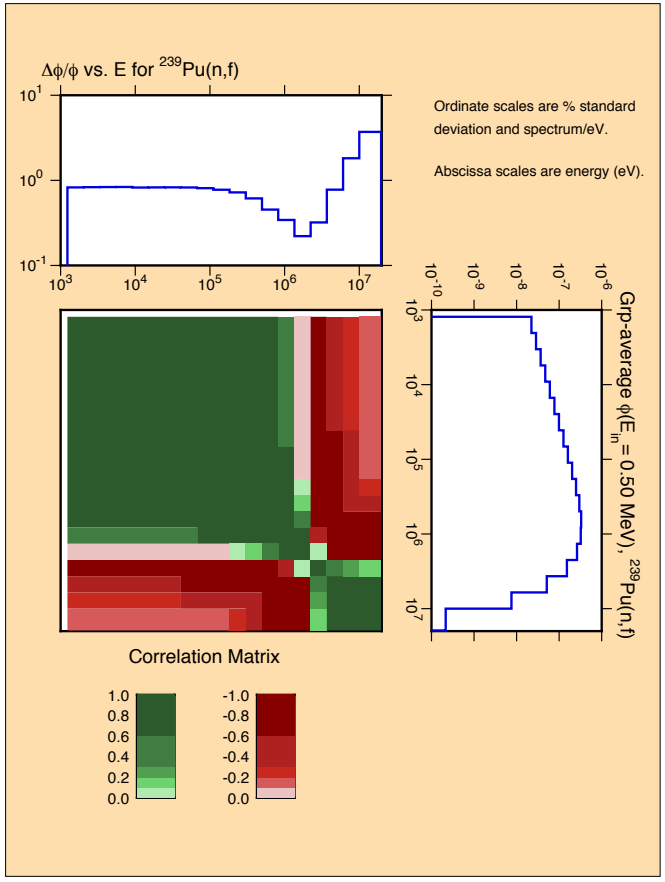




n(0.5 MeV)+^{239}Pu PFNS (cont'd)

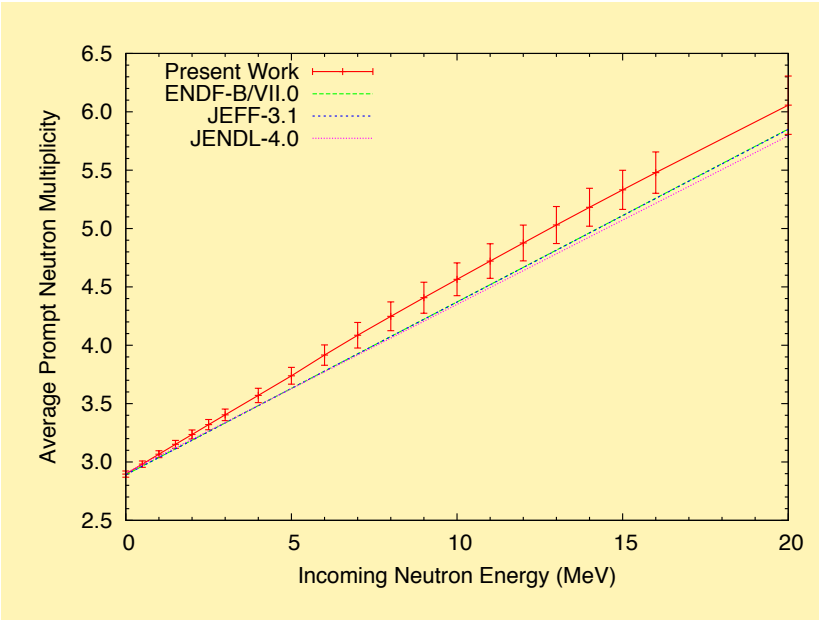
- **Processed through NJOY in 33 and 590 groups**
- **Verifies the zero-sum rule**

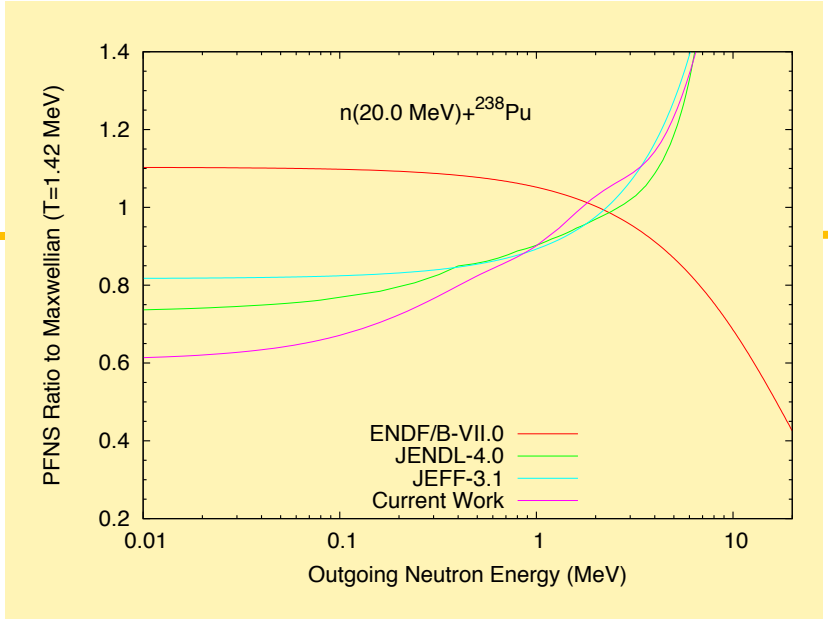


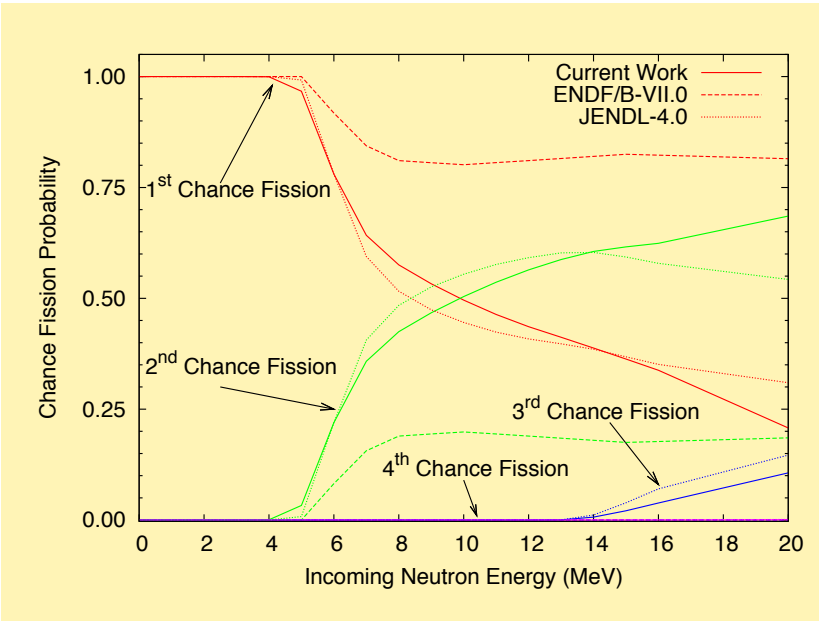


Similar work for ^{238,240}Pu

- **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)**
- **Collaboration with University of New Mexico (AFCI-NEUP project)**
- **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