

^{239}Pu Evaluations in the Fast Energy Range

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Nuclear Data Evaluations

- **Evaluations are based on a combination of**
 - Model calculations
 - Experimental differential data
 - Integral benchmark (adjustments?)
- **Strengths and Weaknesses**
 - Experiments → often precise, but partial only
 - Theory → complete, but not accurate or predictive enough
- **Uncertainty Quantification**
 - First large-scale effort for ENDF/B-VII.1
 - A lot remains to be done for better quantifying uncertainties and correlations
- **Integral feedback provides some external constraints, but compensating errors may (do !) happen**

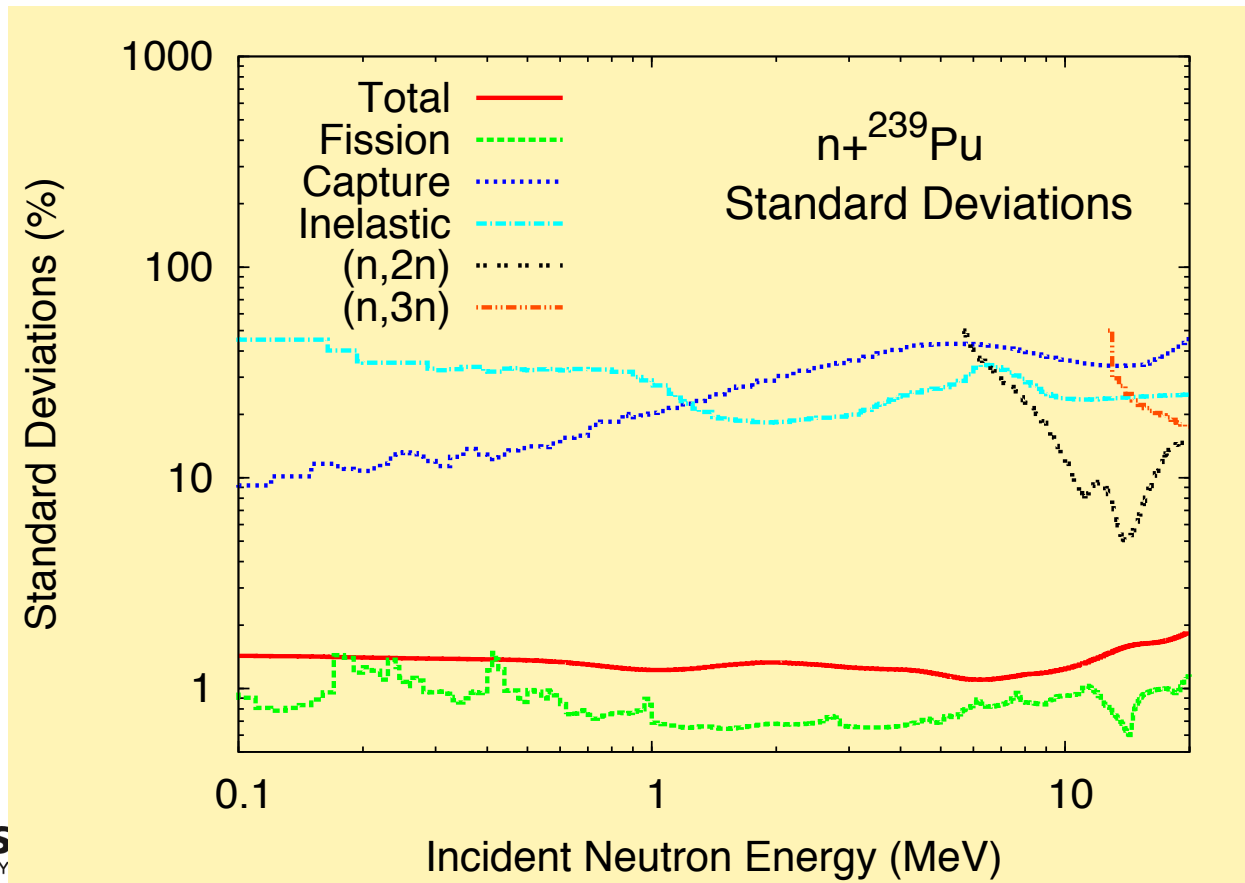
Quantifying uncertainties

- **Current Status**
 - ENDF/B-VII.1, JENDL-4.0
 - Cross sections, Spectra, Multiplicities, ...
- **Remaining issues**
 - Lack of systematic uncertainties
 - Angular distributions
 - Fission fragment yields?
 - Prompt fission gamma rays
 - Are quantified uncertainties realistic?
- **Where should the efforts be focused?**
 - Prompt fission neutrons and gamma rays
 - Capture cross-section
 - Inelastic cross-section
 - Angular distributions?

ENDF/B-VII.1

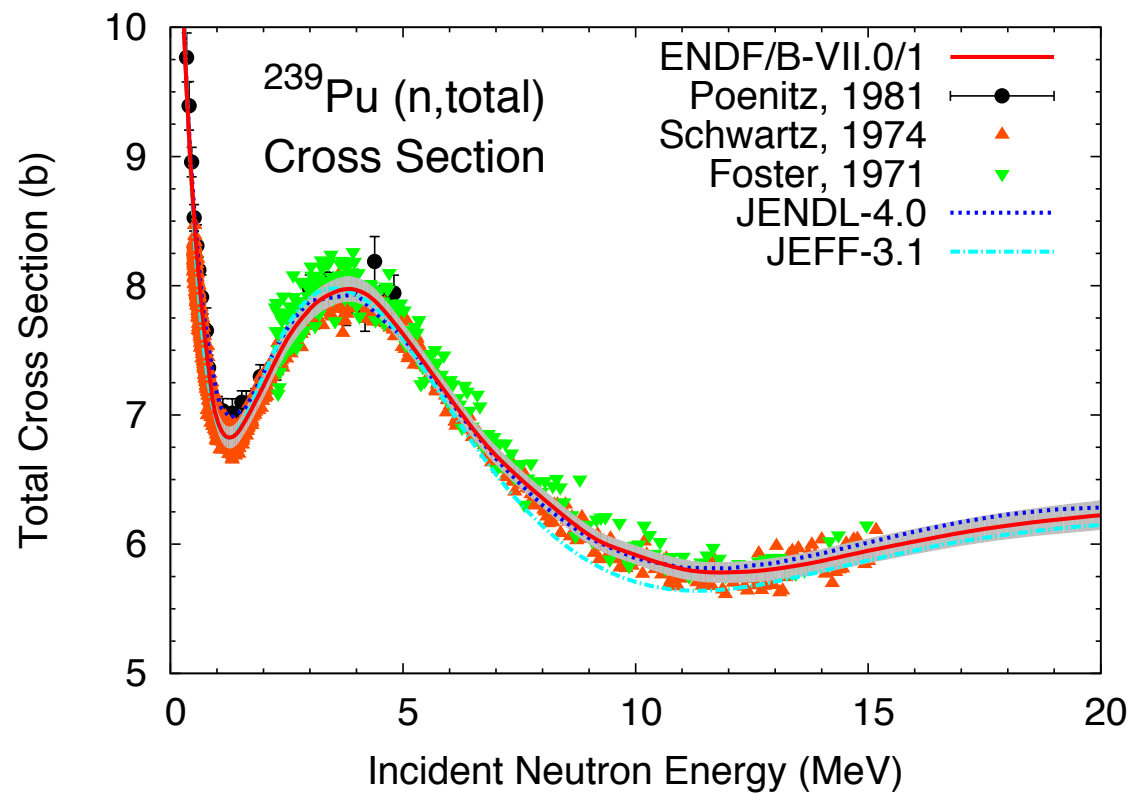
Covariance Matrices for $n+^{239}\text{Pu}$ Cross Sections

- Covariance matrices were evaluated for all important reaction cross sections, prompt fission neutron spectrum (at 0.5 MeV) and multiplicity



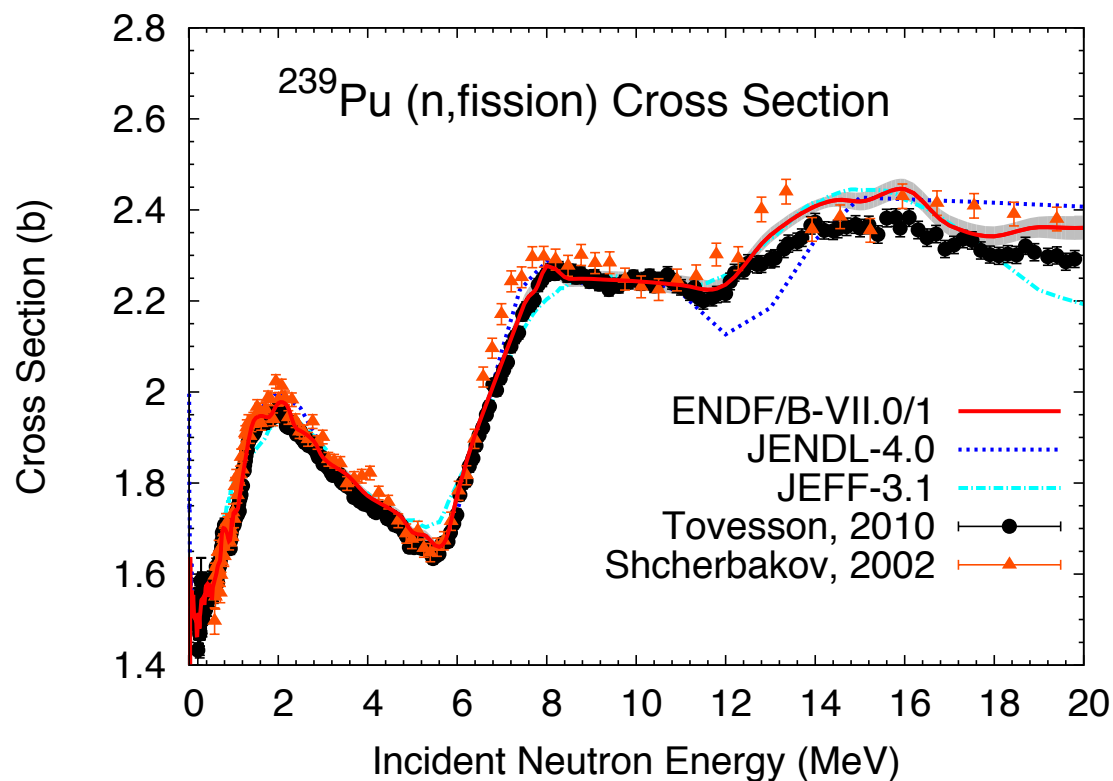
^{239}Pu (n,total) Cross Section

- Very precise measurements
- Well understood model calculations



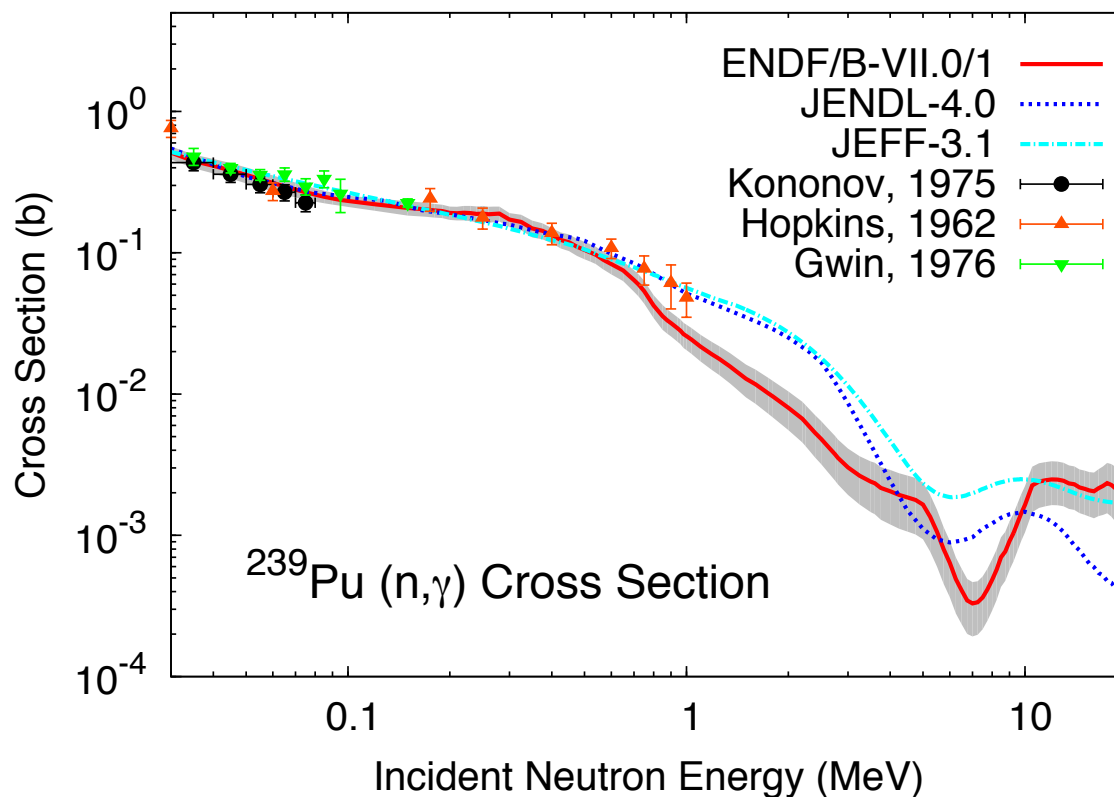
^{239}Pu (n,fission) Cross Section

- Small uncertainties driven by ^{235}U (n,f) Cross Section standard
- Systematic uncertainties? New TPC measurement should help.



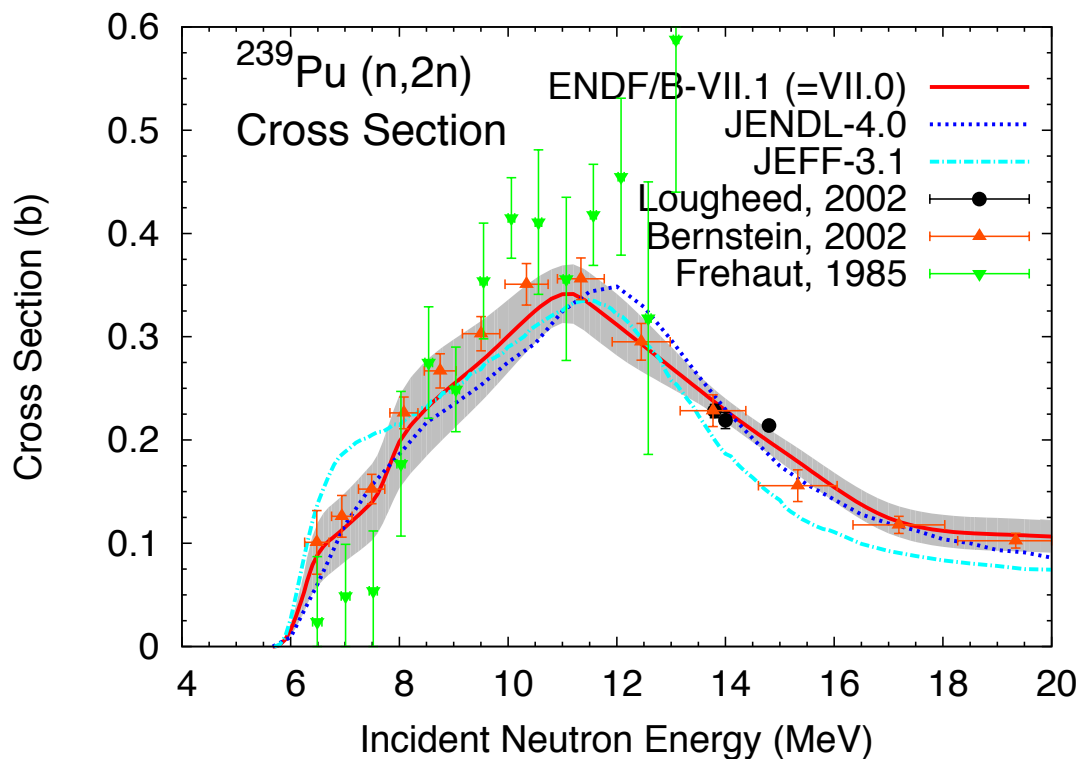
^{239}Pu Capture Cross Section

- Based mostly on α measurement



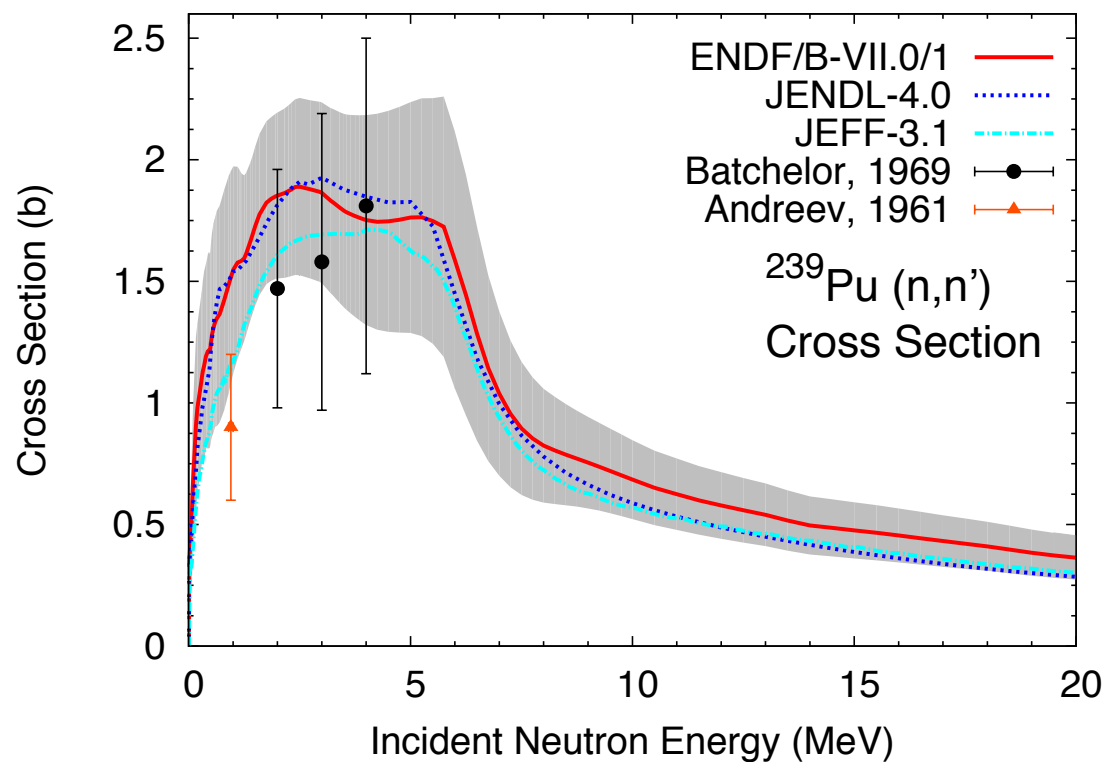
^{239}Pu (n,2n) Cross Section

- Chadwick, McNabb *et al.* analysis of GEANIE experimental data (2002)
- Good agreement with other experimental data and evaluated files, except JEFF-3.1



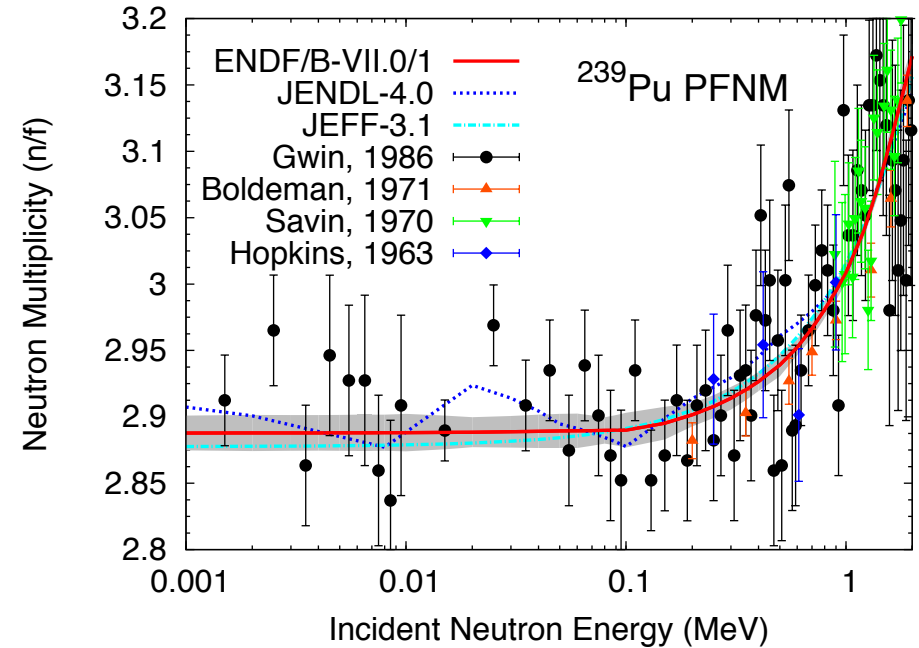
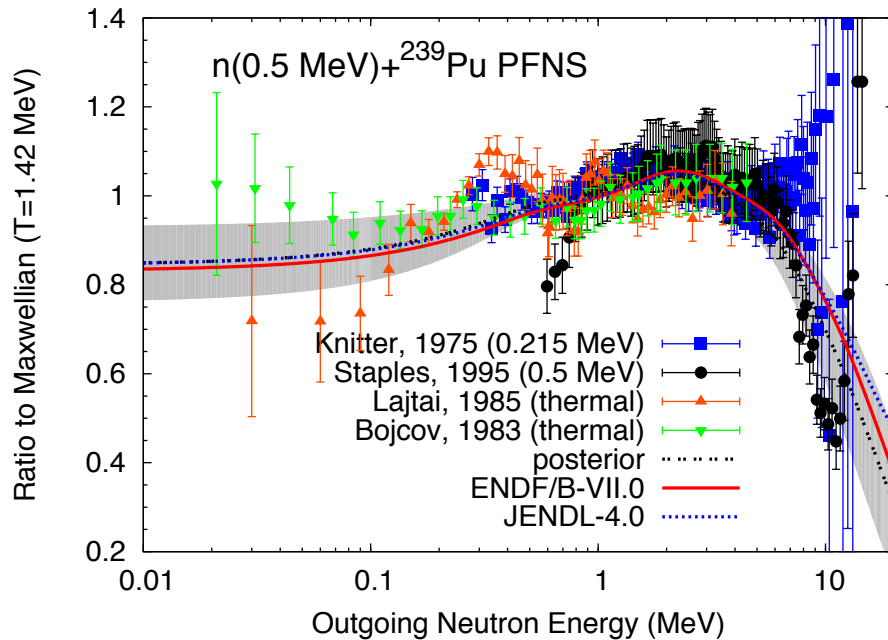
^{239}Pu Inelastic Cross Sections and Angular Distributions

- Large uncertainties

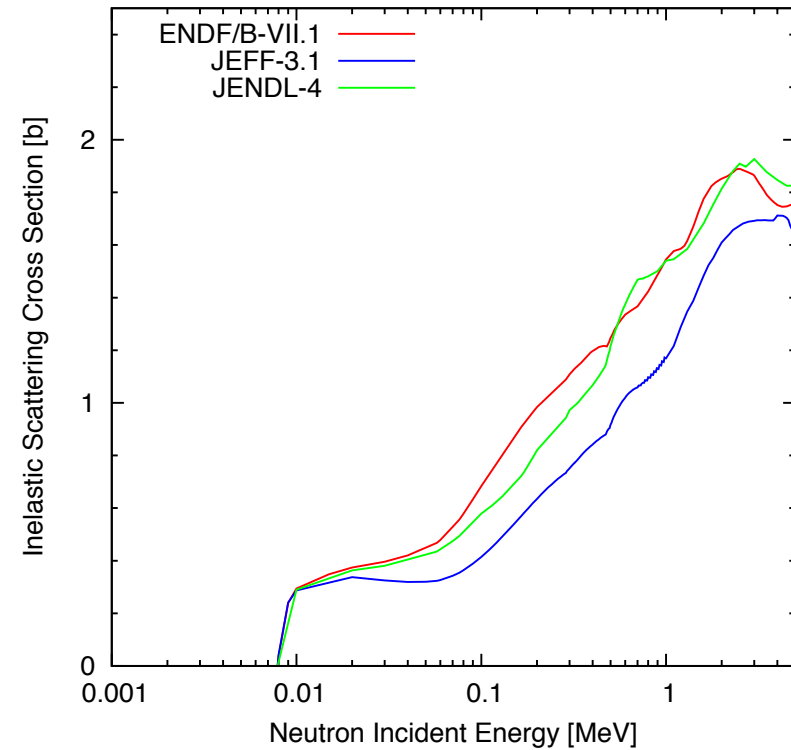
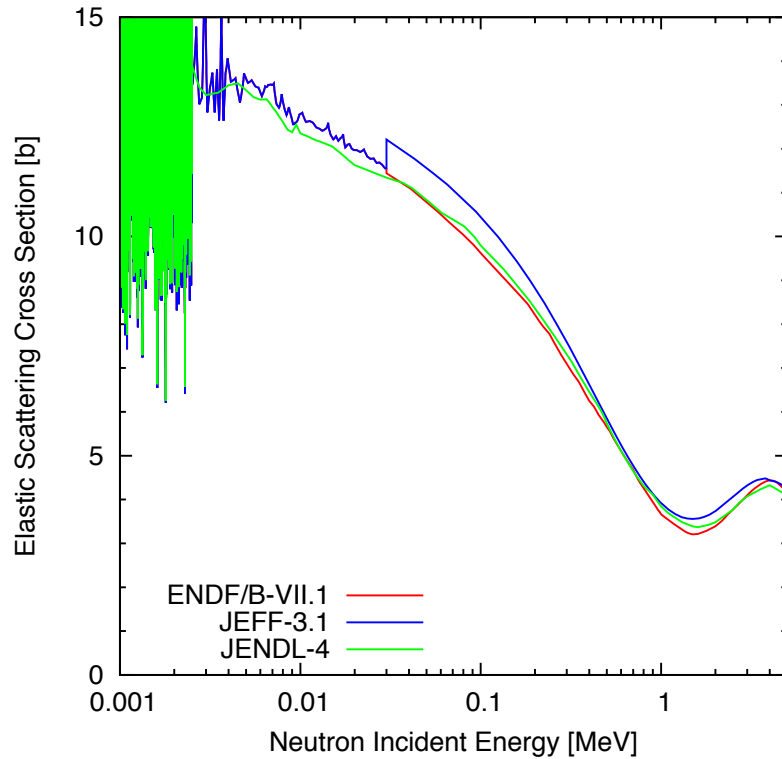


Prompt Fission Neutrons

- Spectrum: large uncertainties below ~500 keV and above 6 MeV
- Multiplicity: “optimist” error bars?



Significant Differences in the Scattering Cross Sections



Three evaluations give $k\text{-eff} = 1.0$ for Jezebel, which implies there are compensation effects

Present Experimental and Theoretical Efforts

- **Prompt Fission Neutron Spectrum and Multiplicity**
 - Chi-Nu experimental collaboration (R.C.Haight *et al.*)
 - Theory: Monte Carlo Hauser-Feshbach calculations
- **Prompt Fission Gamma-Ray Spectrum and Multiplicity**
 - DANCE recent measurements
 - EXOGAM @ GANIL
- **Capture**
 - Needs more attention to resolve model calculation differences above 1 MeV
 - Might be small impact on many applications
- **Inelastic / Elastic in the Fast Energy Range**
 - NEUP efforts (T.Kawano) and International efforts (WPEC, IAEA, WINS)
 - Nuclear reaction modeling essential
 - Optical model and fission competition