Workshop on Neutron Cross Section Covariances
Port Jefferson, NY, June 24-27, 2008

Neutron Cross Section Covariances: Status, Issues, Questions

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CSEWG Perspective

US covariance activities during 1966-2008

CSEWG, Cross Section Evaluation Working Group, maintains US Evaluated Nuclear Data File, ENDF/B

1966	CSEWG founded
1972 - 1980	Error Quantities Subcommittee, chair M. Drake (GA), F. Perey (ORNL) *ENDF/B-V released in 1978, golden era of covariances*
1980 - 1994	Covariance Subcommittee, chair R. Peelle (ORNL), D. Muir (LANL) *ENDF/B-VI released in 1990, decline*
1995 - 2004	Virtually no covariance activities
2005	Covariances re-appeared on CSEWG Agenda
2006	ENDF/B-VI.8 covariances were reviewed, mostly rejected by VII.0 *ENDF/B-VII.0 released, revival begins*
2007	Covariance Committee established, chair D. Smith (ANL) *Low fidelity covariance project, new golden era begins?*
2008	Many activities: GNEP covariance project, major actinides, advances in methodology, processing & visualization, …

Local Perspective
Covariance meetings in Long Island

Symposium on Nuclear Data Evaluation Methodology, 1992
BNL, October 1992, organized by C. Dunford (BNL)
9 talks on covariances, main speaker H. Vonach:

"It would be highly desirable if the intuitive method for qualitative generation of covariances could be formalized to allow mass production of covariances.''

"More work is necessary on the problem … of combining our knowledge from both accurate measurements and model calculations."

Nuclear Data Covariance Workshop, 1999
BNL, April 1999, organized by D. Smith (ANL) and L. Leal (ORNL)
28 attendees, 7 of them present also today

Workshop on Nuclear Data Needs for Gen-IV, 2003
BNL, April 2003, organized by T. Taiwo (ANL), 25 participants

"M. Salvatores reiterated the importance of covariance data on a multi-group structure for use in conjunction with deterministic core design tools. He strongly recommended an application-oriented approach to covariance data generation."

Covariance Workshop 2008

Where are we with covariances today?

Main topics

User's perspective
Evaluation methodology
Status of evaluations

Main questions

Do we understand user's needs and how to meet them?
Do we have sound evaluation procedures? *Still major issue.*
What is the quality of our results?

Covariance Evaluation Methodology

Different perspectives

Energy
- Low energy region
- Fast neutron region

Type of material
- Actinides (~70)
- Structural and FPs (~310)
- Light nuclei (~15)

Type of data
- Cross sections
- nubars
- Neutron fission spectra
- mubars

Quality of results
- Modest (estimate, educated guess)
- Intermediate (estimate/evaluation)
- High (evaluation)
- Very high (standards)

Covariance Evaluation Methodology

Low energies: from simple to sophisticated methods

Simple method

- Uses thermal and RI uncertainties
- Proposed by M. Williams (ORNL), MF33
- Simple, used in low-fidelity project

Is it good enough?

Intermediate method (Atlas)

- Uncertainties from Atlas of Neutron Resonances
- Developed by BNL-KAERI, MF32
- Fairly straightforward, example 55-Mn

Discrepant uncertainties (thermal, RRR, RI)

Sophisticated method (SAMMY)

- Based on full analysis by code SAMMY
- Developed by ORNL, retroactive by SG20, MF32
- Applied to fake (retroactive) or real experiments
- Sophisticated approach, used for major actinides

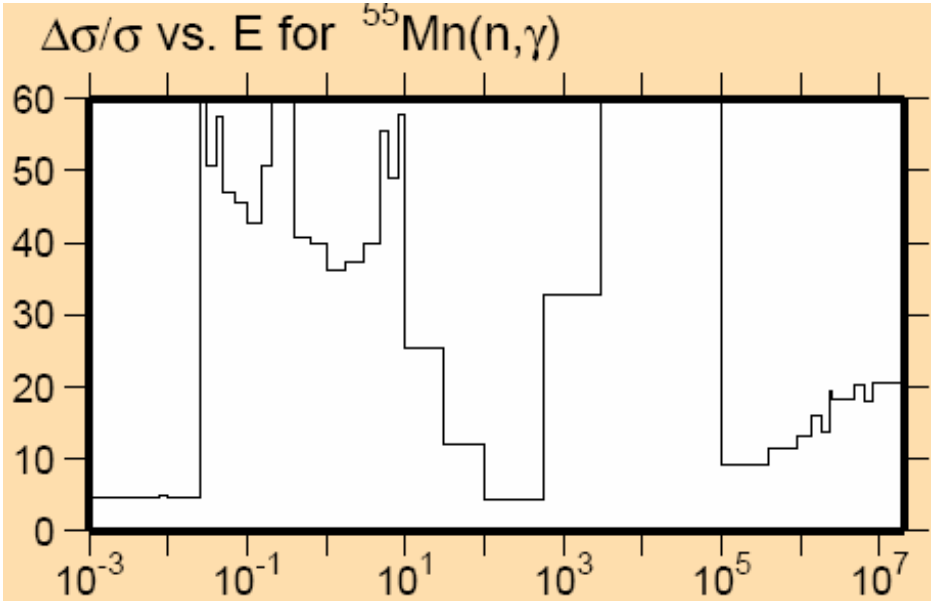
Are thermal values overestimated?

Covariance Evaluations

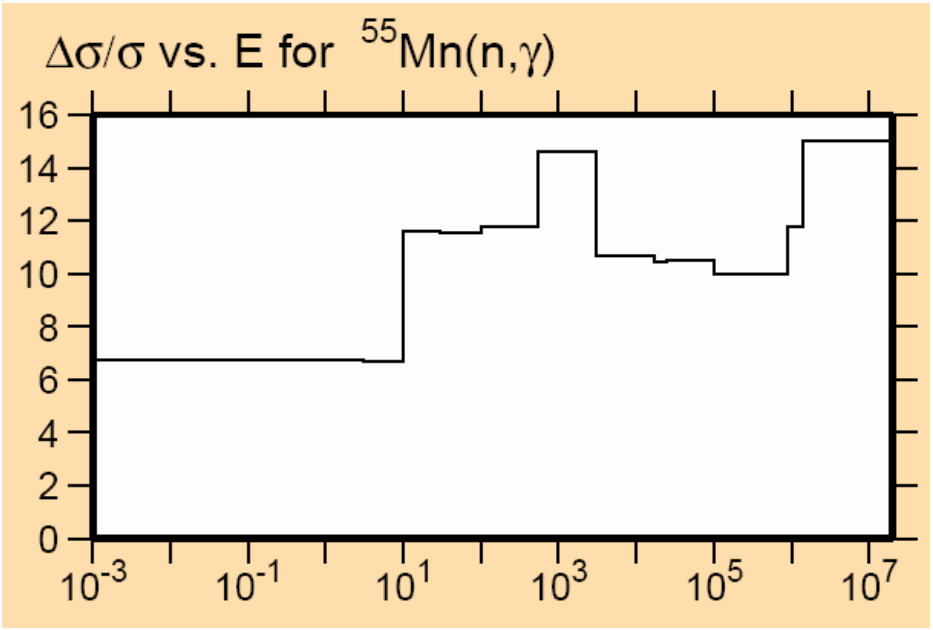
Example: 55-Mn capture in evaluated libraries

Release	Library	Evaluator	Covariances
1) 2001	ENDF/B-VI.8	Shibata 88	MF33 by ORNL (LB=8)
2) 2002	JENDL-3.3	Shibata 87	MF33 estimate, MF32 added for 3.3
3) 2005	IRDF-2002	Shibata 88	dosimetry, identical with ENDF/B-VI.8
4) 2005	JEFF-3.1	Shibata 87	taken over from JENDL-3.3
5) 2006	ENDF/B-VII.0	Shibata 88	VI.8 considered poor, MF33 removed

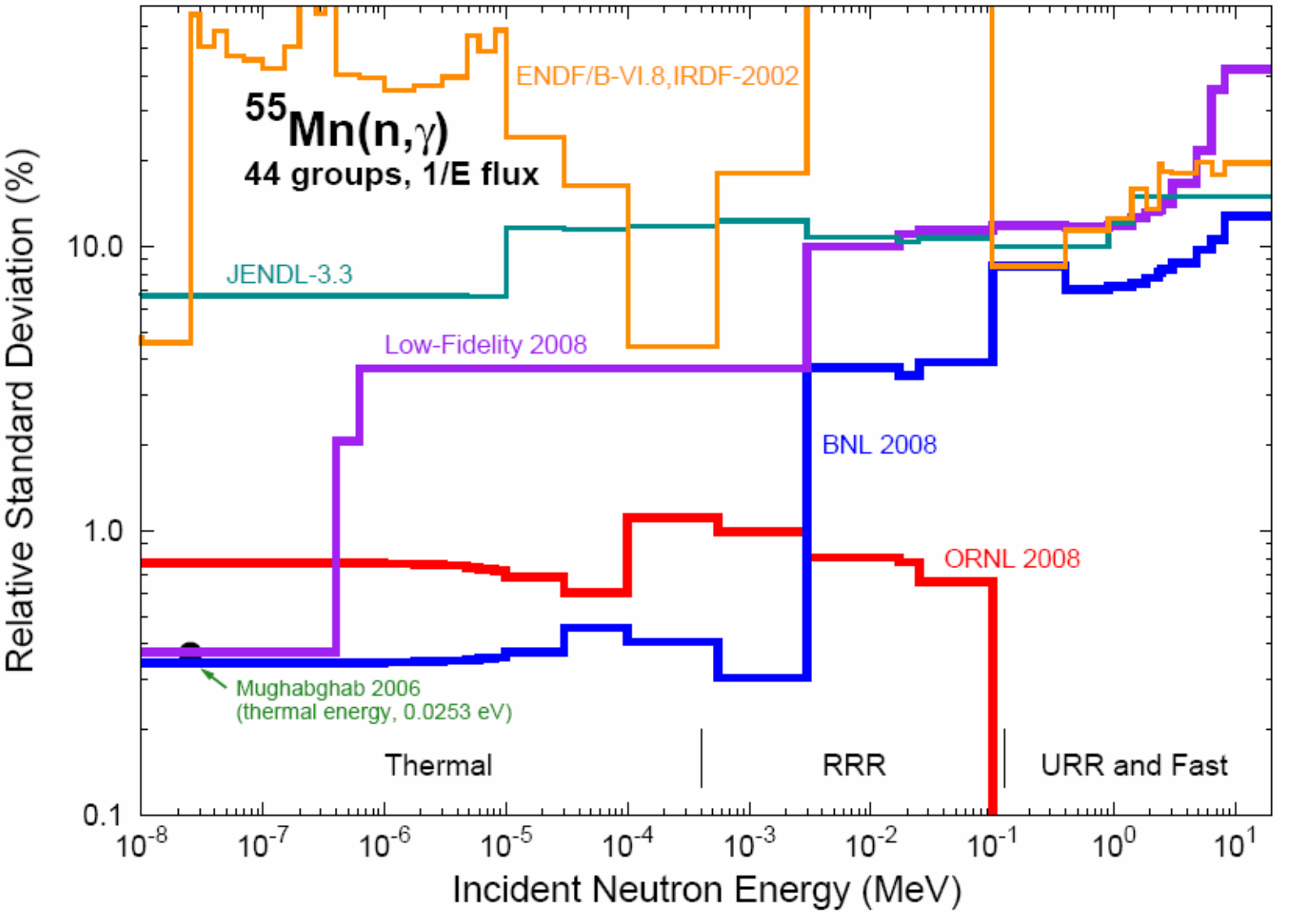
ENDF/B-VI.8 and IRDF-2002



JENDL-3.3 and JEFF-3.1



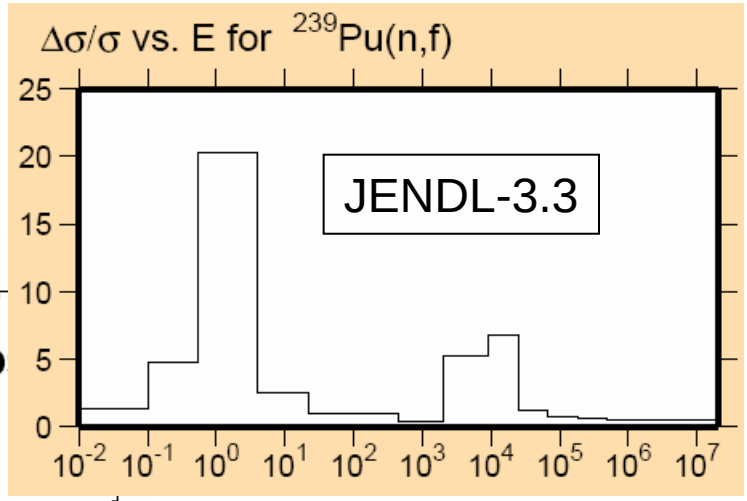
2008	Low fidelity	ORNL-BNL	Simple estimate, MF33
2008	Intermediate	BNL-KAERI	Atlas-Empire-Kalman, MF32 & MF33
2008	High fidelity	ORNL	SAMMY, MF32

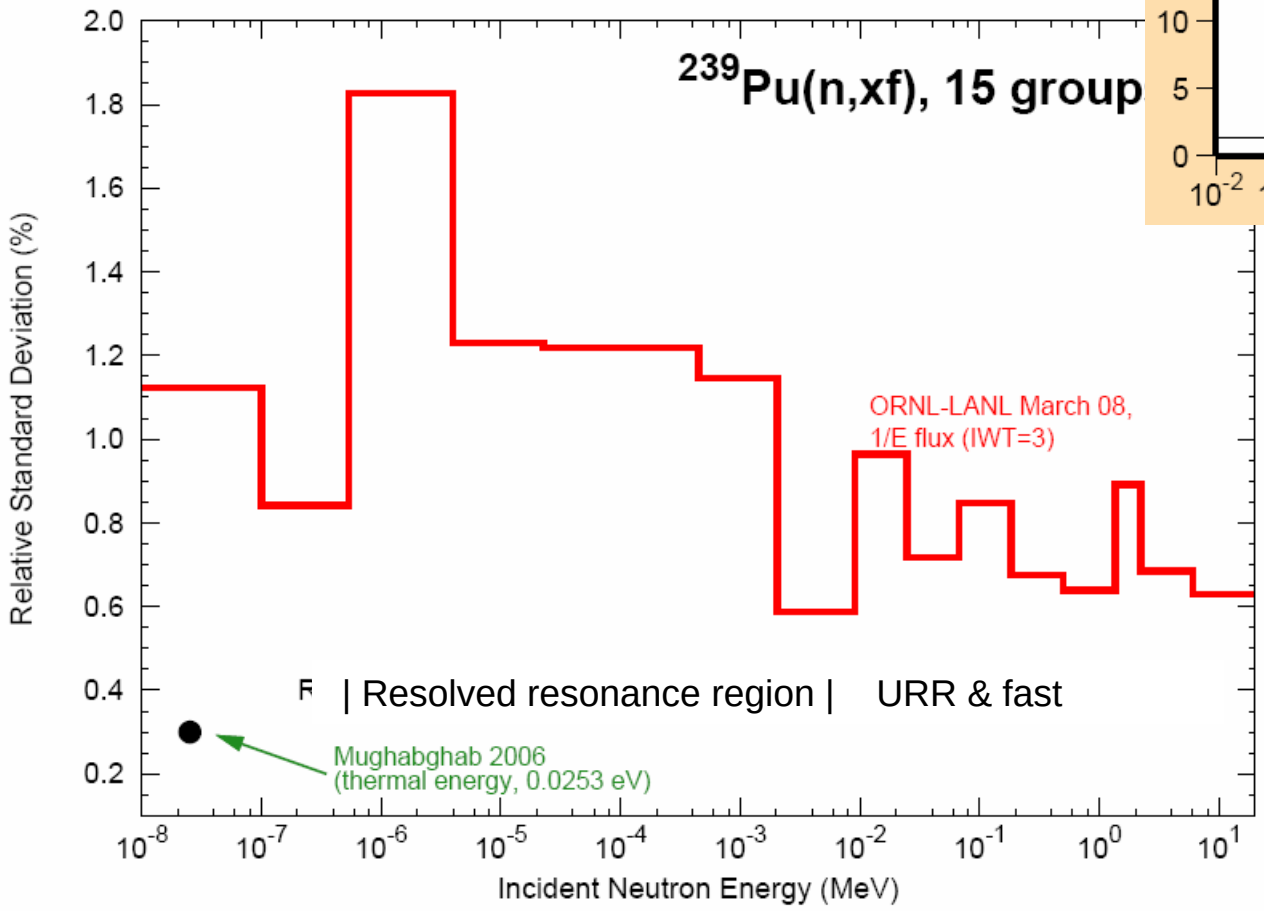


Covariance Evaluations

Example: 239-Pu(n,f)

2002 JENDL-3.3 Kawai MF32, MF33
2008 ORNL & LANL Leal et al MF33





Why such large difference in thermal uncertainty?
- ORNL 1.12%
- Standards 0.24%
- Mughabghab 0.27%

Covariance Evaluation Methodology

Fast region: ~10 methods in 3 groups

Simple methods

- Model-based, no experimental data
- Deterministic, Monte Carlo
- Propagates input parameter uncertainties

Suitable for mass production, but how good is it?

Intermediate methods

- Model-based, approximate inclusion of data
- Deterministic, Monte Carlo
- Binary accept/reject, eye guided

Better results, to be treated with caution

Rigorous (?) methods

- Combines models and experimental data
- Deterministic (Kalman, least squares fit), Monte Carlo (backward-forward, unified)
- Requires detailed analysis of data

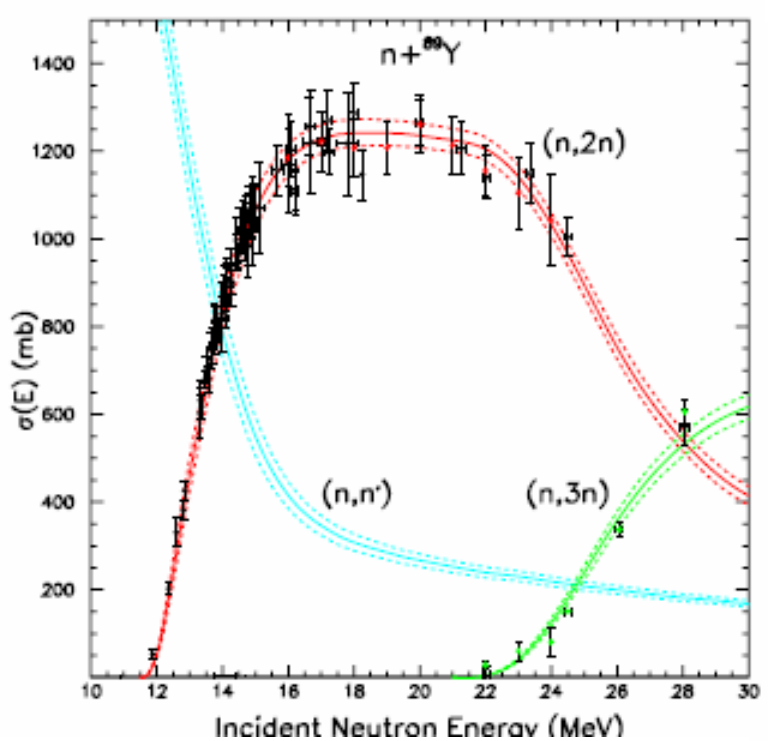
How big are hidden uncertainties (models, experiment)?

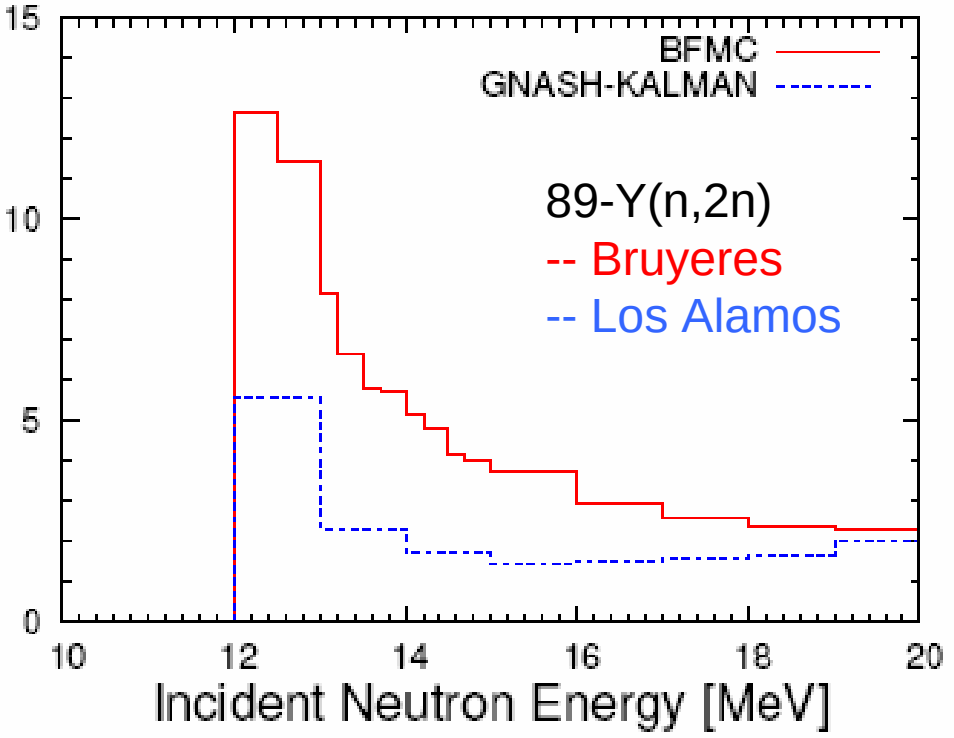
Covariance Evaluations

Example: 89-Y(n,2n), Chadwick 2007

Important radchem dosimetry reaction, to determine flux of 14 MeV neutrons, of special interest to weapon labs, carefully measured and evaluated.

Sophisticated methods, yet large differences in uncertainties and correlations:
- Bruyeres, backward-forward MC
- Los Alamos, GNASH-Kalman





CW2008: What is ahead of us?

User's perspective

Needs, applications, support
Advanced reactor systems
Criticality safety
Processing & visualization
…

Status of evaluations

Cross section standards
Low-fidelity project
Major actinides
Light nuclei
…

Evaluation methodology

Thermal and resonance region
Fast neutron region
Neutron fission spectra
Bypassing covariances?
…