

CIELO: Collaborative International Evaluation Library Organization

Rationale, Progress, and Plans

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Overview

- CIELO: (1) initially, a focused collaboration to advance key evaluations & individual projects may later decide to adopt them
(2) eventually, an internationally-maintained library, perhaps
- WPEC proposal for a new subgroup on a a CIELO pilot project that will focus on (1), and would set the stage for the possibility of (2) which, if realized, would go beyond a WPEC subgroup.

CIELO Discussed at IAEA & WPEC in 2012.

Rationale

- **Nuclear data are physical constants – there’s only one correct answer! And they are used as a trusted repository for scientific data**
 - Existing ENDF, JENDL, JEFF, have reached a level of maturity enabling us to contemplate this next step – *they’re already converging!*
- **Quality: advances will benefit from closer collaboration of world’s experts**
 - Evaluations are extremely complex, with very broad scope
 - We are relying more on complementary expertises. e.g. Japan identified a 1 keV $^{235}\text{U}(n,g)$ problem from reactor simulations; US confirmed it in physics experiments at LANL and RPI
- **Computational & sensitivity/covariance advances enable us to identify correct solutions from large phase space of incorrect compensating-error solutions**
- **Previously, differences in evaluated libraries were useful to communicate uncertainties and ambiguities. But now, covariances convey this information**
- **We have experts in place to do this (including key retirees who may help)**
- **Build on initial steps already taken through international collaborations**

Pilot Project – Is CIELO Feasible? Can the Community Make this Work? Will They Value the Results?

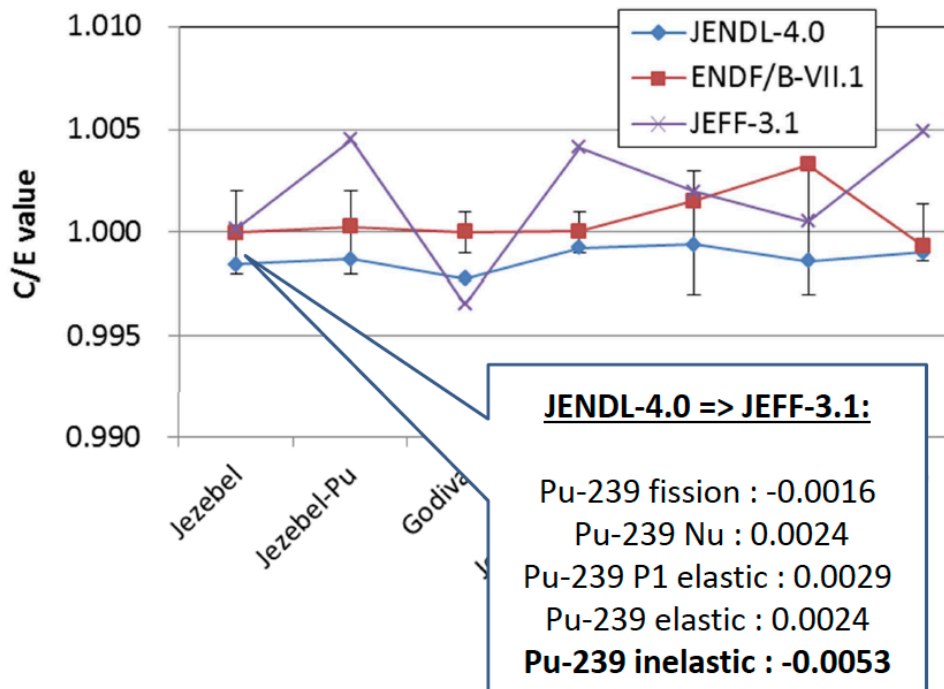
- ✓ Initial Pilot Project Focus on 1H, 16O, 56Fe ^{235,8}U and ²³⁹Pu, with a goal to make substantive advances within 2-3 years
- ✓ Identify discrepancies – see report www.oecd-nea.org/science/wpec/cielo , and this presentation
- Establish teams of ENDF, JEFF, JENDL, IAEA, WPEC ... specialists
- Resolve discrepancies and create new CIELO files: Insights come from experiment (cross sections, spectra, integral experiments), nuclear theory, and simulation of benchmark experiments
- Goal: evaluate best physically-justifiable cross sections, while maintaining good integral performance (k-eff criticality, reaction rates, etc)

Proposal: Create a new WPEC Subgroup, with 3 teams (^{235,8}U, ²³⁹Pu; 16O, and 56Fe). Many details to work out: collaborative technical team participants? Organization/coordination participants and leaders?

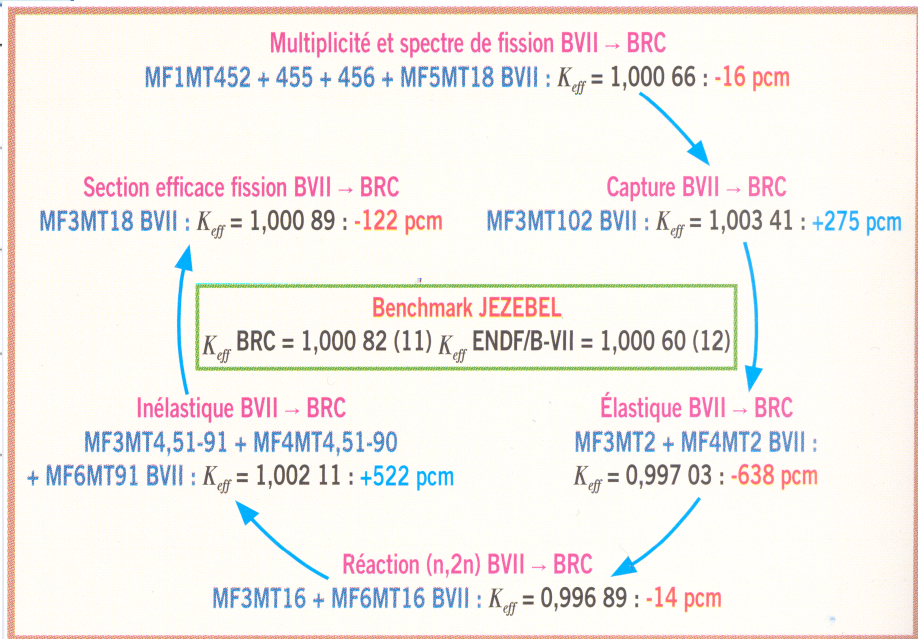
Differences in Reasons for Fast Plutonium Criticality: Existing Evaluations Have Compensating Errors

Japanese analysis

Very small fast systems: Now



CEA analysis

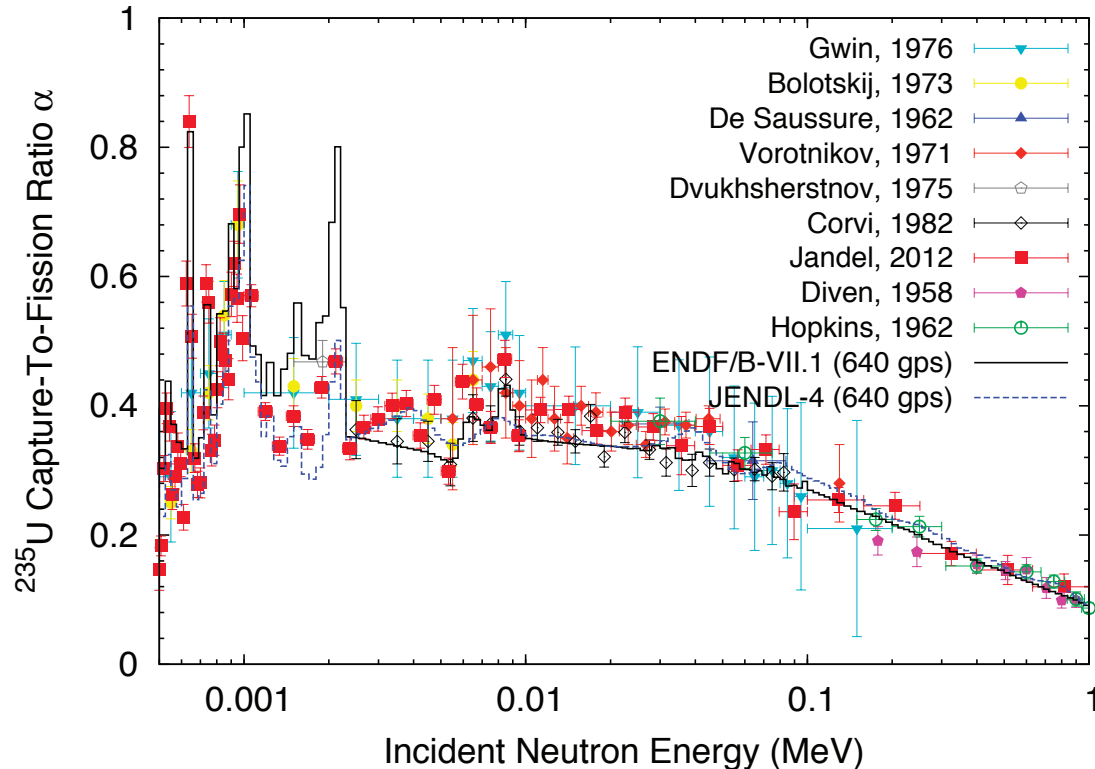
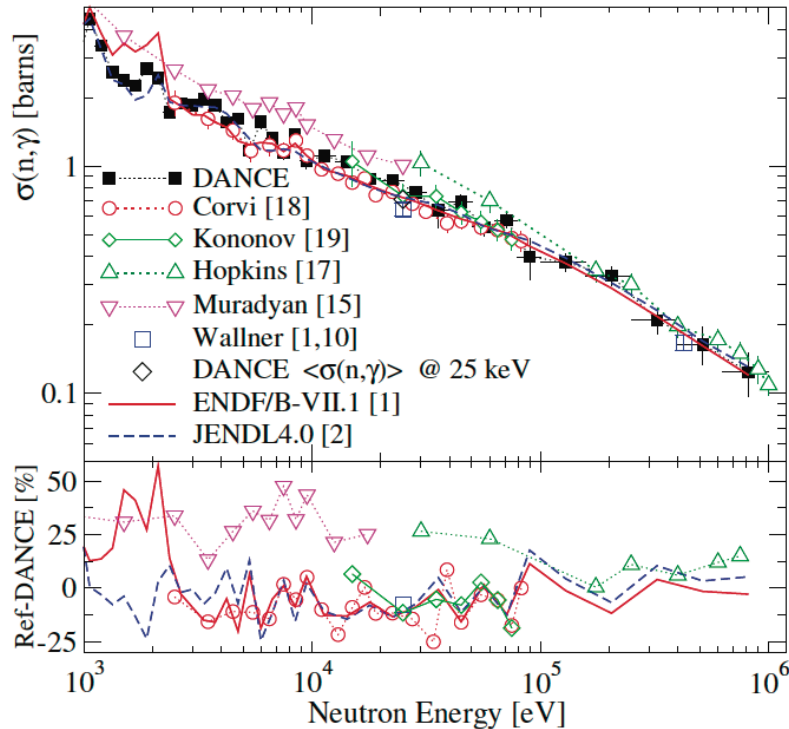


Inelastic & elastic are modeled very differently. (PFNS effect would be larger except all evals use a similar approach)

Major Actinides. Much Work is Needed As We Seek To Improve Cross Section Understanding and Improve Integral Benchmark Performance

Reaction channel	Issues
✓ Capture	239Pu 10%+ discrepancies in the 1keV – MeVs region. Few data exist and they are discrepant; PROFIL suggests ENDF/B-VII.1 capture is overall ~ 10% low. 235U : Recent work points to upgrades needed near 1 keV and above; 238U – OK?
✓ Inelastic, xs; ang dist	Significant differences in the keV – MeV region, with less measured data than we would like. Theory/modeling advances will likely contribute importantly. Inelastic/preequilibrium scattering work is also needed near 14 MeV to replace pseudo-levels.
Elastic, xs; ang dist	Significant differences between evaluations
(n,2n)	Notable differences between many of the evaluations
Fission – cross section	Significant differences, outside the Standards assessed uncertainties. Future Standards work coordinated by the IAEA will be valuable
Fission – nu _{bar}	239Pu - ENDF should remove the tweak we made to match Jezebel. Consider if thermal changes warranted (Koning/Rochman search gave a 3-sigma lower value)
✓ Fission – PFNS	LANSCCE data (LANL, LLNL, CEA), with theory, dosimetry, and nu _{ex} data, and with IAEA CRP, will determine the PFNS more accurately by ~ 2014
✓ PFGS for γ & multiplicity	DANCE data (in 2012-2013) should be used to replace/update the existing PFGS. Also, fission gammas should be represented at all energies, not just up to 1.09 MeV
✎ P(nu), Chi(nu) for n, γ	Could be added for detection applications, based on measured data (incl new DANCE data for g), Lestone's routines; and on model calculations such as FREYA, CGM, ...
Resonance region	239Pu : ORNL/CEA WPEC subgroup updates should be adopted if possible. 235U – updates needed to better represent capture.

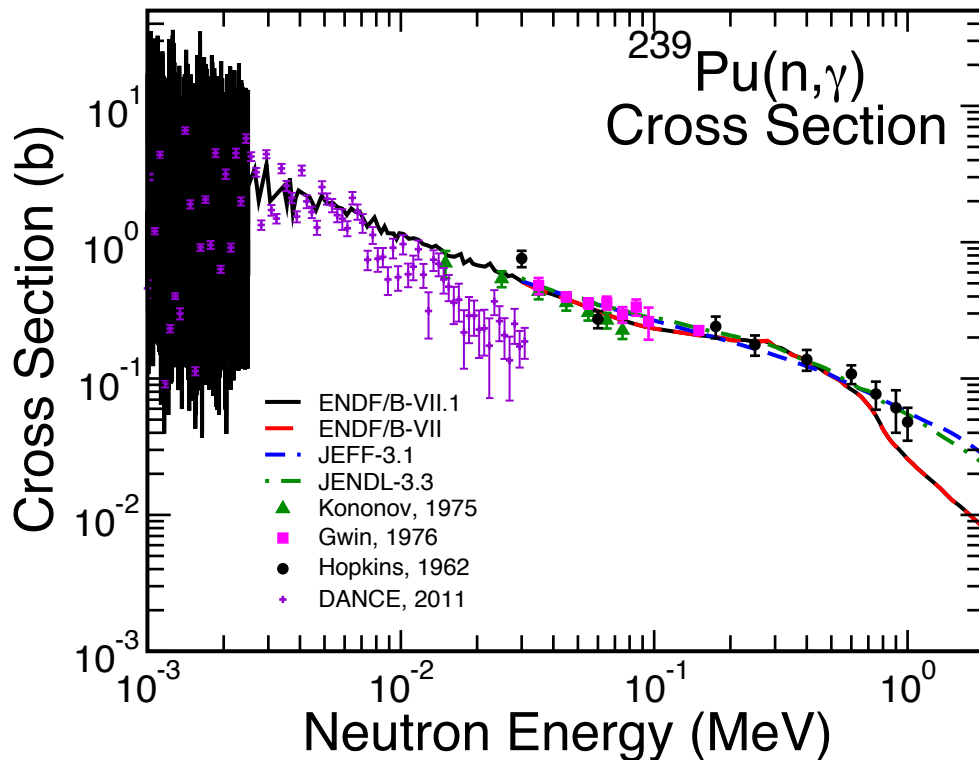
^{235}U radiative capture advances – Evaluations need upgrading in the resonance & fast regions. It appears the Japanese were right near 1 keV



DANCE suggests ENDF too high near 1-2 keV and too low 10-40 keV

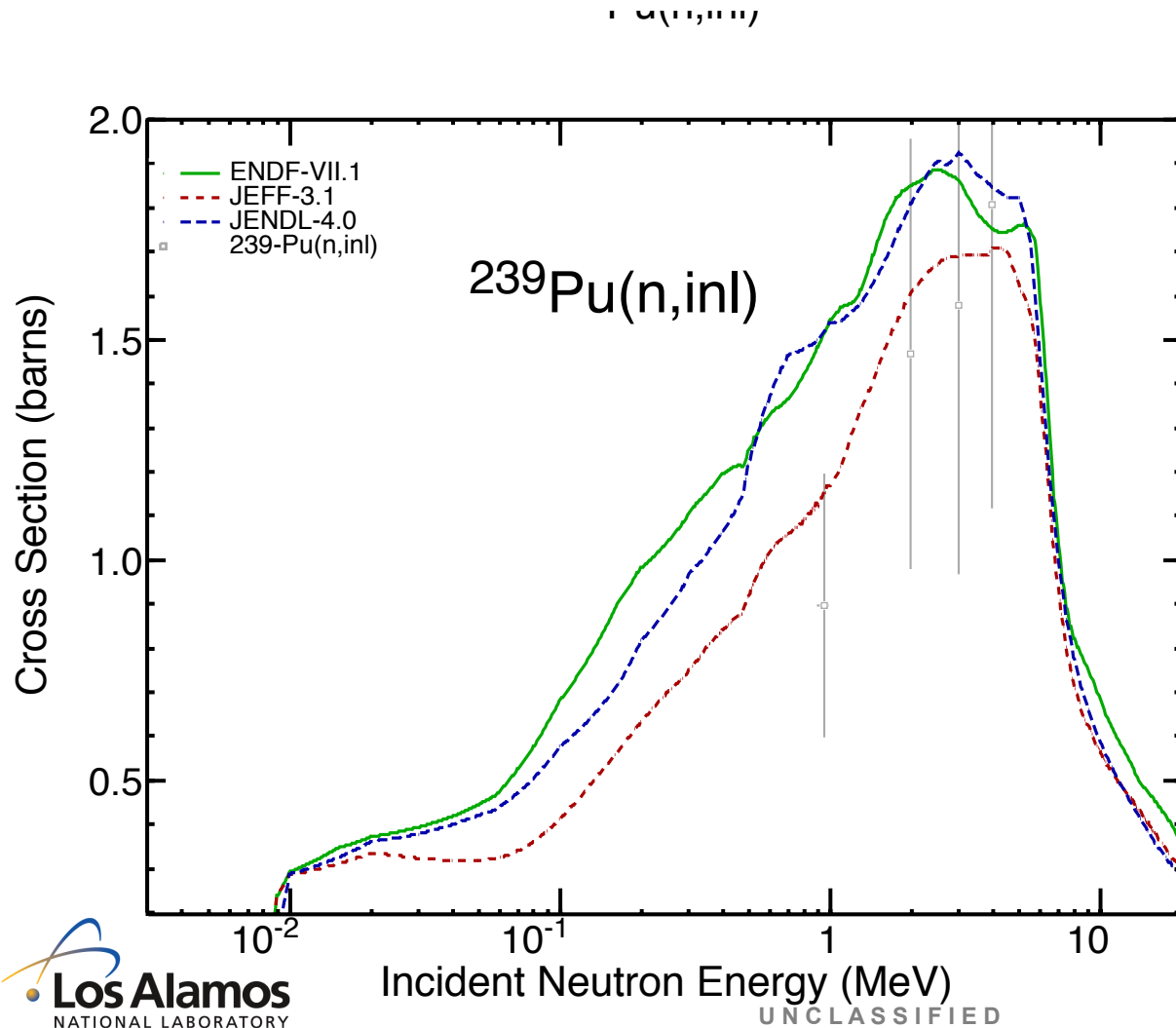
- But Wallner AMS 25 keV has ENDF high by 5% (+/- 6%); 423 keV ENDF high by 8% +/- 8%
- PROFIL fast reactor has ENDF low by 3-5%

Plutonium Capture: We need smaller uncertainties at 1 keV and in the fast (100-1000 keV) range



- 1 KeV needs to be better determined
- 100-1000 keV: needs to be better understood:
 - Existing uncertainties >15%
 - SG33 & PROFIL (PHENIX) $^{239}\text{Pu}(n,g)$ integral testing suggests B-VII is ~ 10% low over this fast reactor spectrum. Also, Ishikawa's ADJ work suggests JENDL should be raised 5-10%
 - JEFF, JENDL and ENDF evaluations different
 - DANCE measurements are planned
 - O. Bouland (CEA) interested

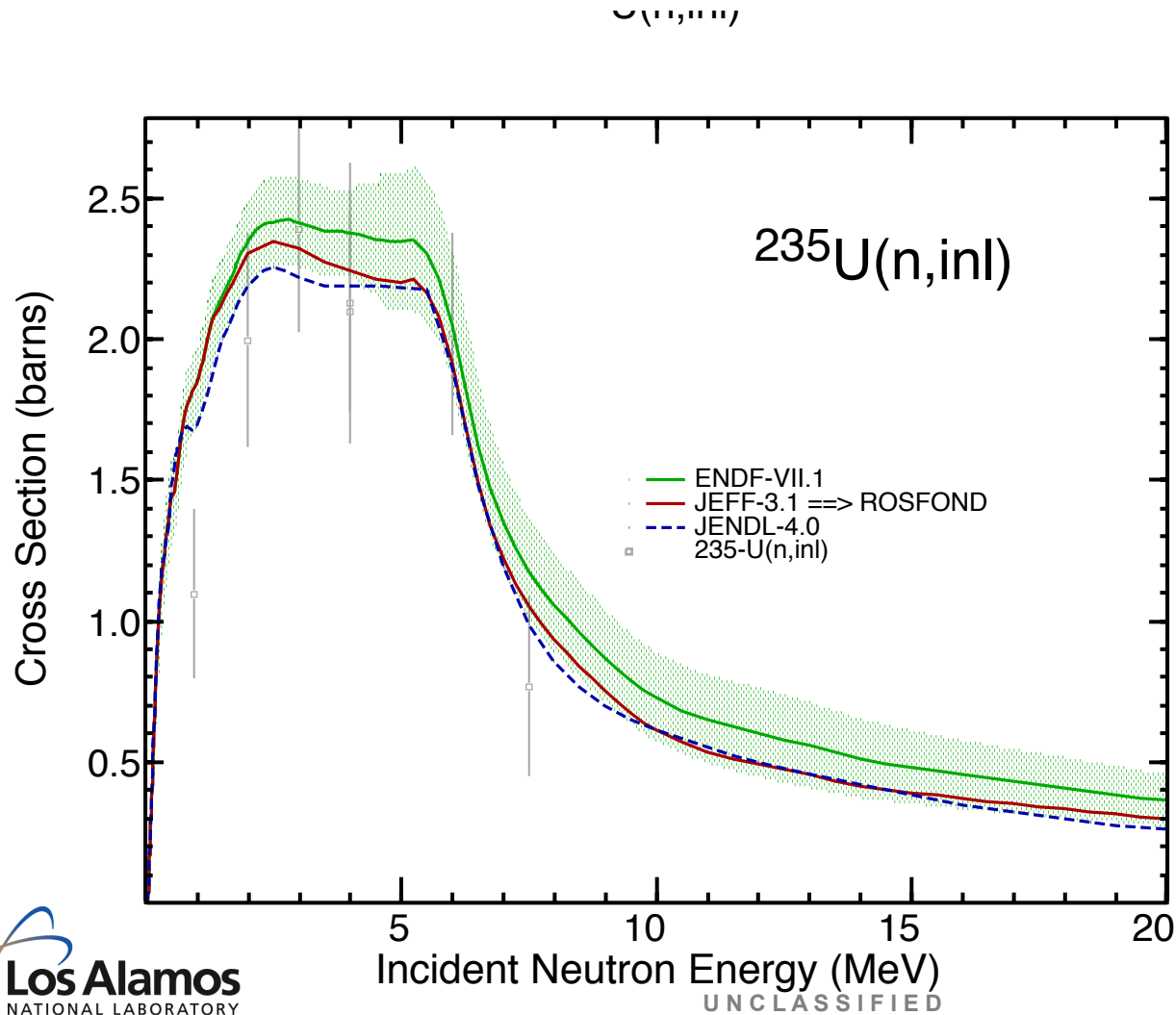
Plutonium Inelastic Scattering: Large discrepancies need to be resolved



ENDF, JEFF, JENDL need to collaborate to investigate resolution of these discrepancies. Insights from CC scattering theory, KKM, *etc* will be beneficial

In the 14 MeV region, would be good to update the present pseudo-state analyses, for all the major actinides

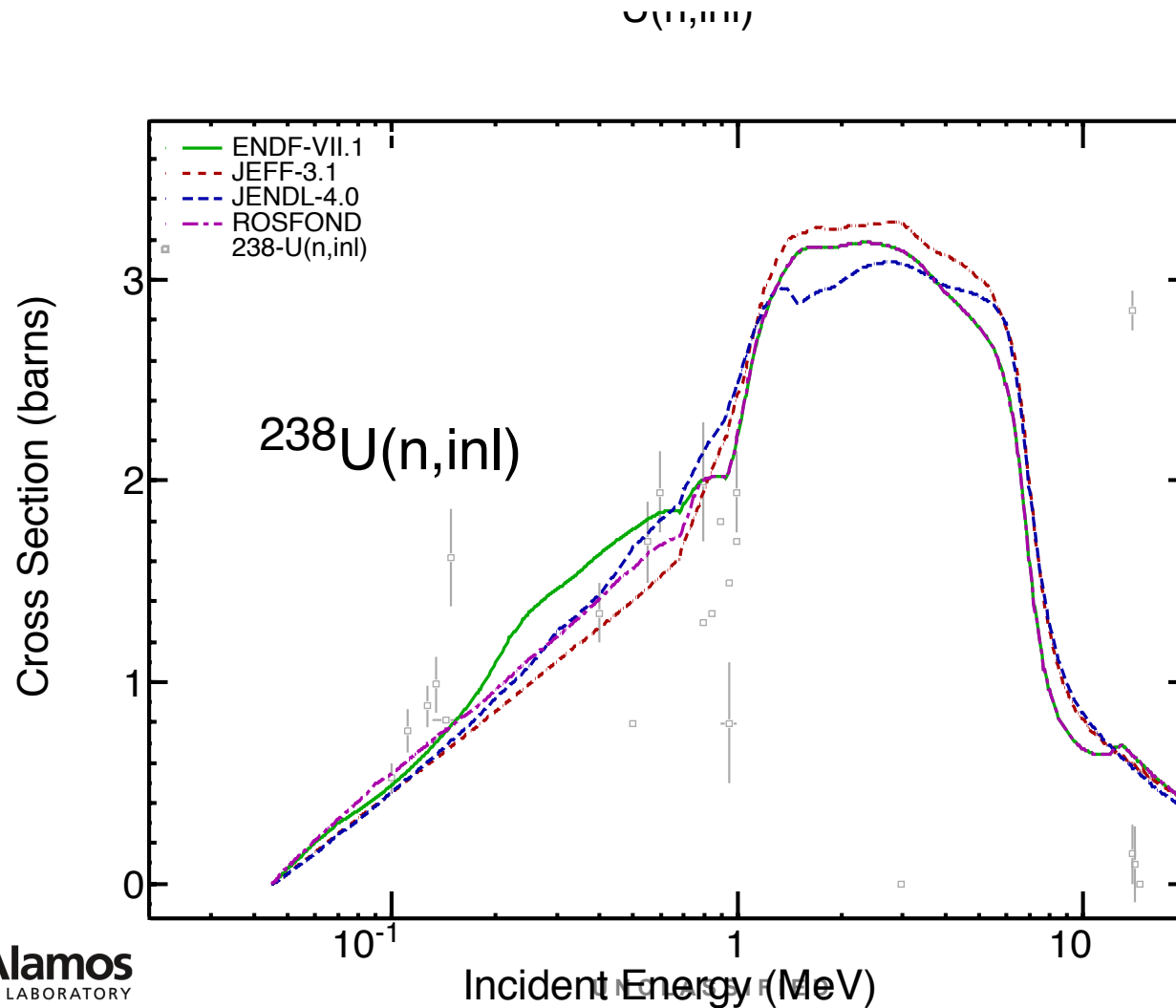
235U Inelastic Scattering: discrepancies need to be resolved, but differences are smaller than for 239Pu



Even though differences appear small, the ENDF-JENDL difference led to 540 pcm difference in Godiva criticality!

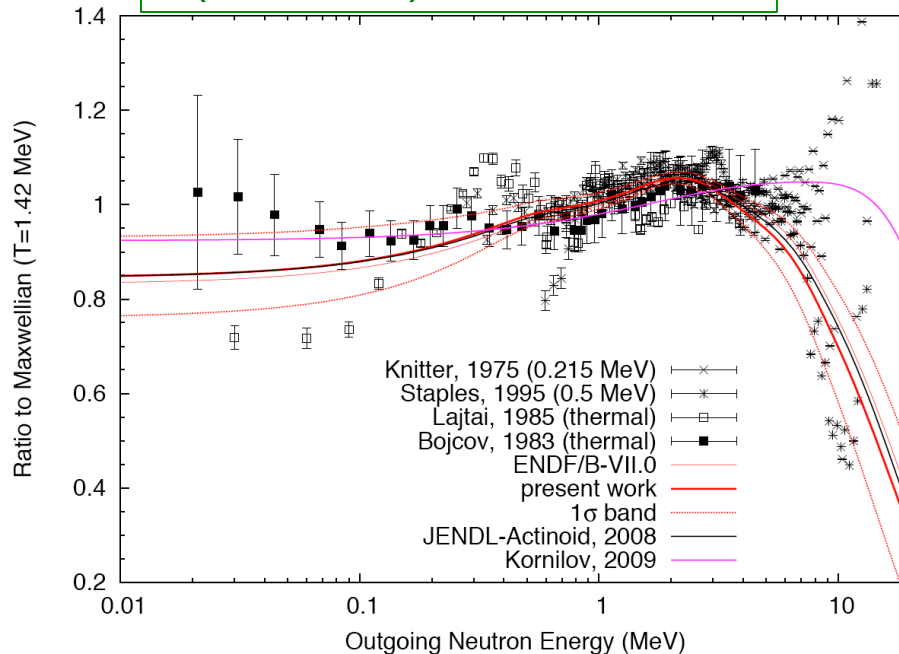
Angular differences, and individual inelastic channel cross section differences may also play a role

238U Inelastic Scattering: Smaller Discrepancies Here Compared to 239Pu



Prompt Fission Neutron Spectrum (PFNS) Needs to be Better Understood

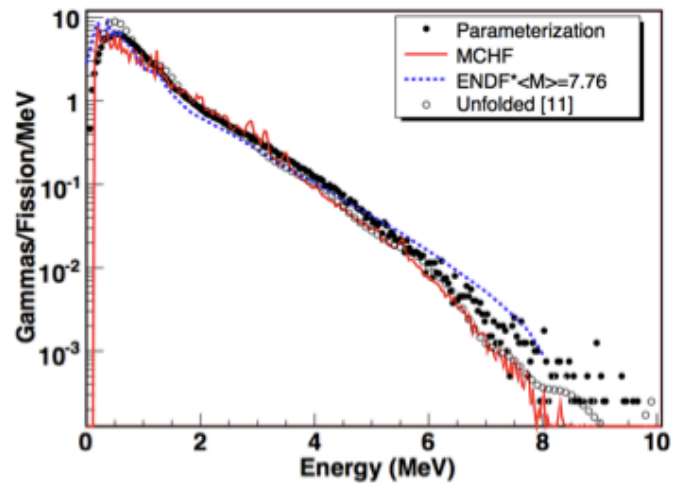
$n(0.5 \text{ MeV}) + {}^{239}\text{Pu}$, PFNS



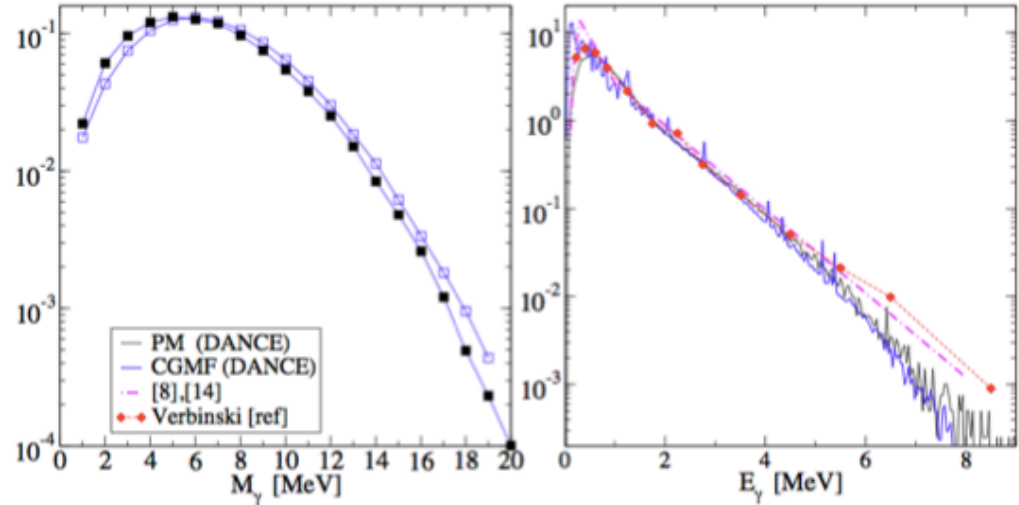
- ENDF, JENDL, JEFF, ... based on LANL Madland-Nix type approach
- Current solution works well in our applications
- Evidence in favor of the current solution: (a) some data agree with ENDF; (b) Lestone's NUEX work for Pu
- But: (a) n_2n activation in fission expts suggest the spectrum > 10 MeV should be 10-30% lower; (b) Some spectrum data suggest there should be more neutrons below ~ 1 MeV, e.g. 10-15% more at 0.1 MeV out
- IAEA CRP is helping solve this problem
- LANSCE (LANL-LLNL-CEA experiments will be available in 2013-2014)

Prompt Fission Gamma Spectra from DANCE Enable an ENDF-Update. (Additionally, Multiplicity Distributions and Spectra (nu) Could be Added for Detection Applications)

^{239}Pu (n,f)



Talou calc. Multiplicity distributions are needed for SNM detection applications ^{235}U (n,f)

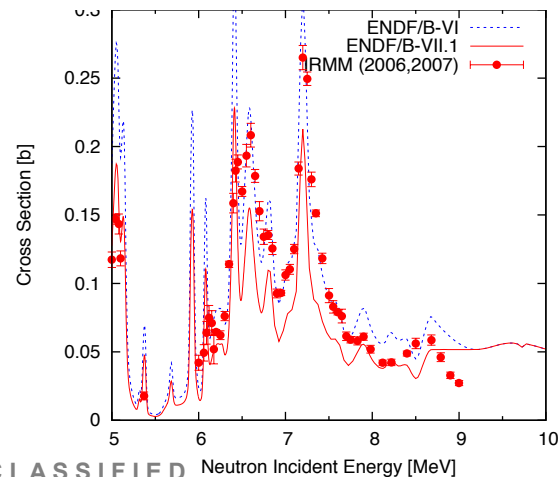
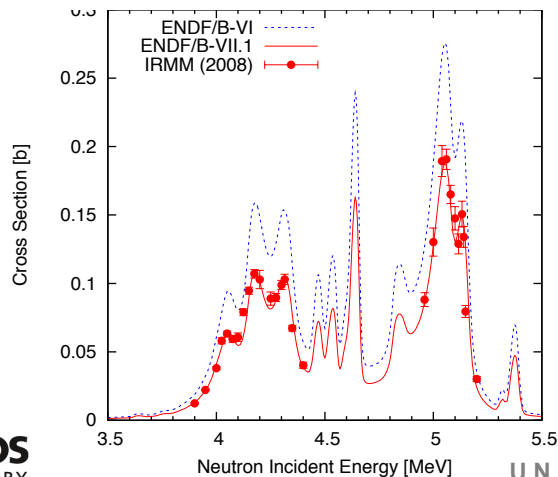


J.Ullmann et al.,
 "Prompt Gamma-Ray Production in Neutron-Induced Fission of ^{239}Pu ", to be submitted to PRC.

M.Jandel et al.,
 "Prompt Gamma-Ray Emission in Neutron-Induced Fission of ^{235}U ," to be submitted to PRC.

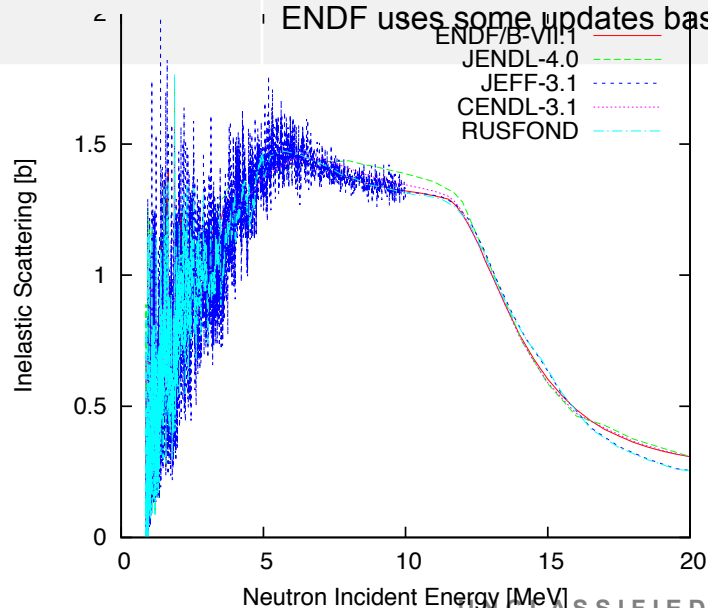
^{16}O . Much Work is Needed, As We Seek To Maintain Good Criticality and Transmission Performance

Reaction channel	Issues
Capture	JEFF will likely want to update to the JENDL/ENDF higher energy capture cross section that includes resonance effects for nuclear astrophysics applications
Inelastic, xs and ang dist	?
Elastic, xs and ang dist	At thermal the scattering evaluations differ from Dilg/Mughabghab. Resolve this. In general, it would be good to upgrade the present KAPL-LANL hybrid evaluation.
(n,a)	ENDF, JEFF, and JENDL are similar (adopted ENDF; in JENDL case below 6.5 MeV). ENDF looks good up to 6 MeV, though Hale has been considering changes. At higher energies the data suggest a change is needed (away from Davis data).



⁵⁶Fe.

Reaction channel	Issues
Resonances	JEFF, JENDL from Frohner's work, ENDF use an earlier Perey and Perey analysis
Inelastic, xs and ang dist	JEFF has high-resolution fluctuating effects up to 10 MeV. Note that experiments at Ohio University suggest significant changes to the total nonelastic cross section > few MeV (21% at 6.2 MeV increasing to 35% at 10.8 MeV – too large changes?)
Elastic, xs and ang dist	Below 0.85 MeV mubar is small; from 0.85-2.5 MeV JEFF follows Kinney data and other data accurately. At higher energies mubar uncertainties grow [Trkov, Dupont]. Caderache is performing a sensitivity study to RR scattering angular distributions
(n,a)	ENDF uses some updates based on Kunieda-Kawano's analysis of LANSCE data



Note that fast reactor simulation projects, eg SG33, Commara, JAEA ADJ, have pointed to the large sensitivity to iron inelastic scattering

Next Steps?

- Obtain feedback from evaluation projects & NEA and IAEA Communities
- Optimize to support (differing) goals of ENDF, JENDL, JEFF, BROND, CENDL..
- Create WPEC Subgroup
 - Identify technical participants, coordinators/leaders, organizational structure, goals
- Follow-on meeting Thursday morning