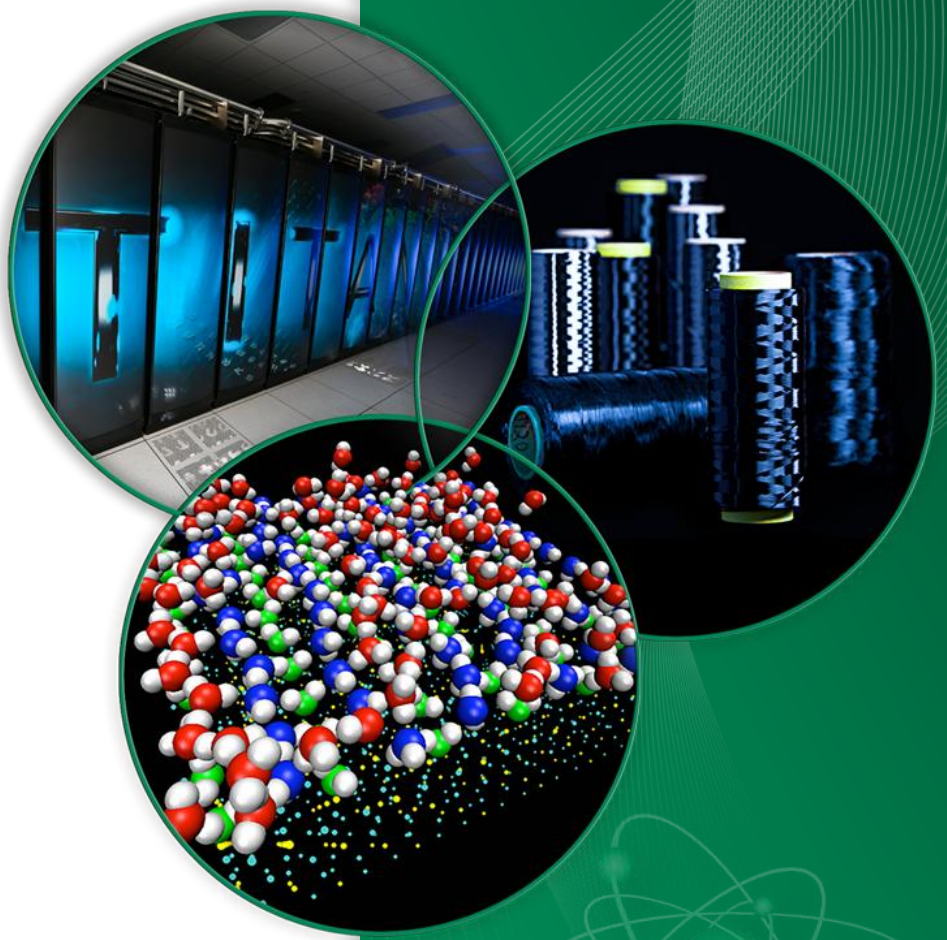
Status Report on ORNL Nuclear Data Evaluations



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Nuclear Data & Criticality Safety Group

CSEWG Evaluation Session
Brookhaven National Laboratory
November 20, 2013

ORNL Resonance Evaluations and deliverables

	Energy Range	Resonance Covariance Evaluation	Target date for delivery the evaluation
$^{63,65}Cu$	Thermal to 300 keV	Yes	Completed
^{182}W	Thermal to 10 keV	Yes	FY2014
^{183}W	Thermal to 5 keV	Yes	FY2014
^{184}W	Thermal to 10 keV	Yes	FY2014
^{186}W	Thermal to 10 keV	Yes	FY2014
^{56}Fe	Thermal to 2 MeV	Yes	CIELO
^{16}O	Thermal to 6.3 MeV LRF=7; includes (n,α)	Yes	CIELO
^{239}Pu	Thermal to 2.5 keV	Use ENDF/B-VII.1 (FILE33)	Completed
^{235}U	Thermal to 2.25 keV	Use ENDF/B-VII.1 (FILE33)	CIELO

ORNL Planned Evaluations

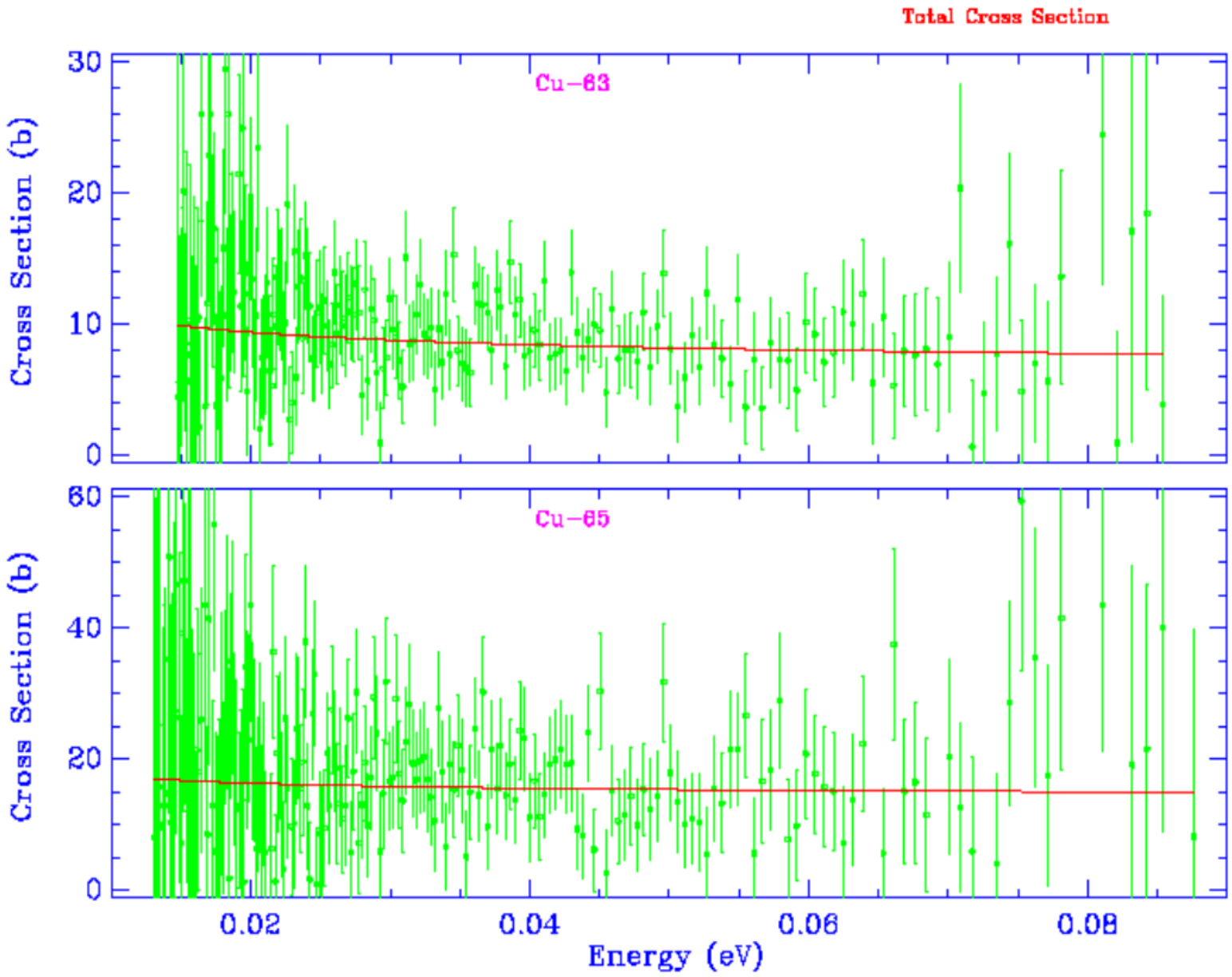
	Energy Range	Resonance Covariance Evaluation	Target date for delivery the evaluation
Ca	^{40}Ca (96.95 %) ^{44}Ca (2.086 %)	Yes	FY2015
Ce	^{140}Ce (88.450 %) ^{142}Ce (11.114 %)	Yes	FY2015
Dy	^{161}Dy (18.889 %) ^{162}Dy (25.475 %) ^{163}Dy (24.896 %) ^{164}Dy (28.260 %)	Yes	FY2015
Gd	^{155}Gd (14.80 %) ^{156}Gd (20.47 %) ^{157}Gd (15.65 %) ^{158}Gd (24.84 %) ^{160}Gd (21.86 %)	Yes	FY2015
CH_2	Thermal Scattering S(α,β)	-	FY2015

Measured Data Used In Copper Evaluation

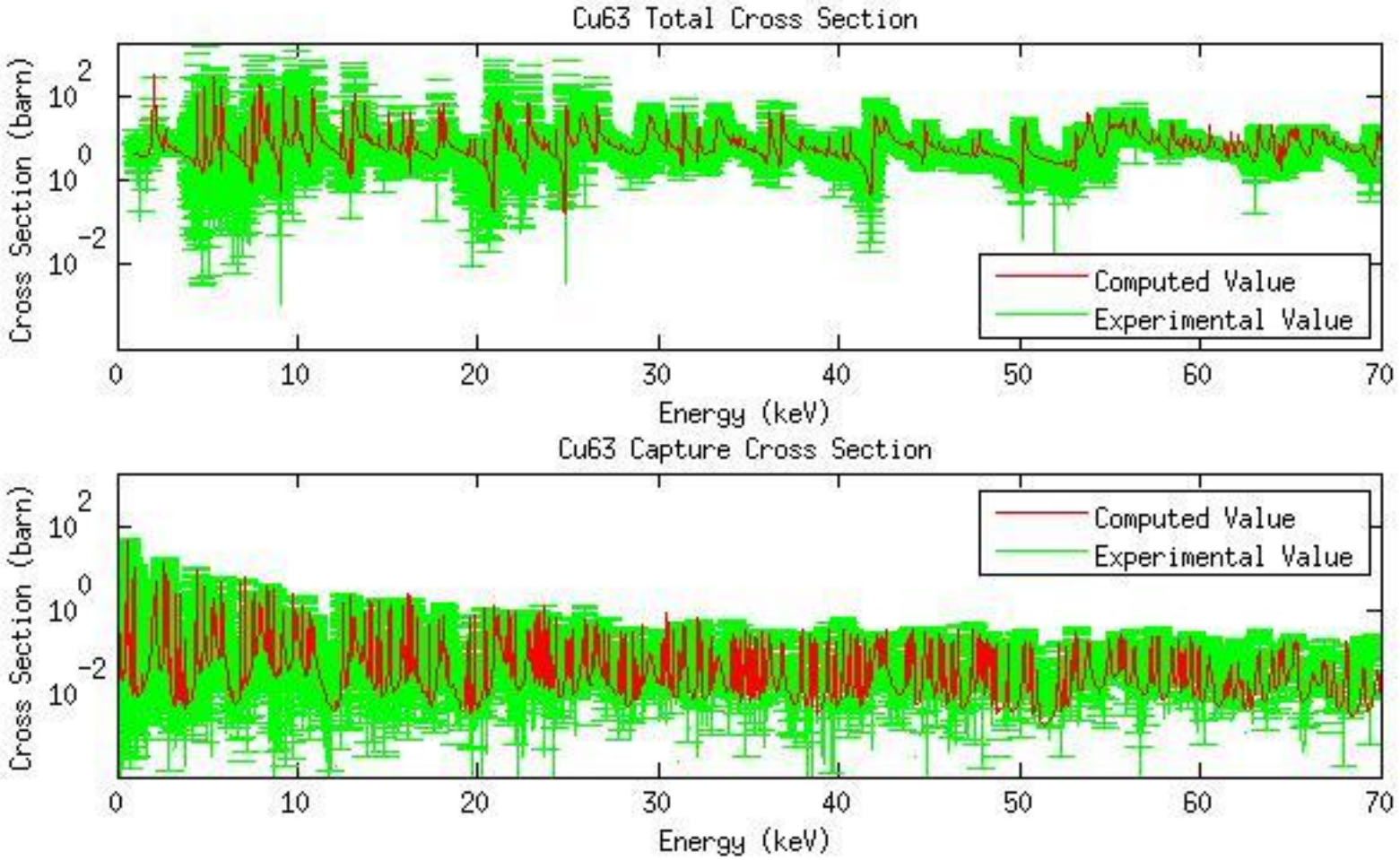
Transmission and capture data:

- ORELA: 32 eV – 185 keV
- ORELA: 1 keV – 1.4 MeV
- MITR: 0.01 eV – 0.1 eV
- GELINA: Capture Cross-section 1 keV – 200 keV

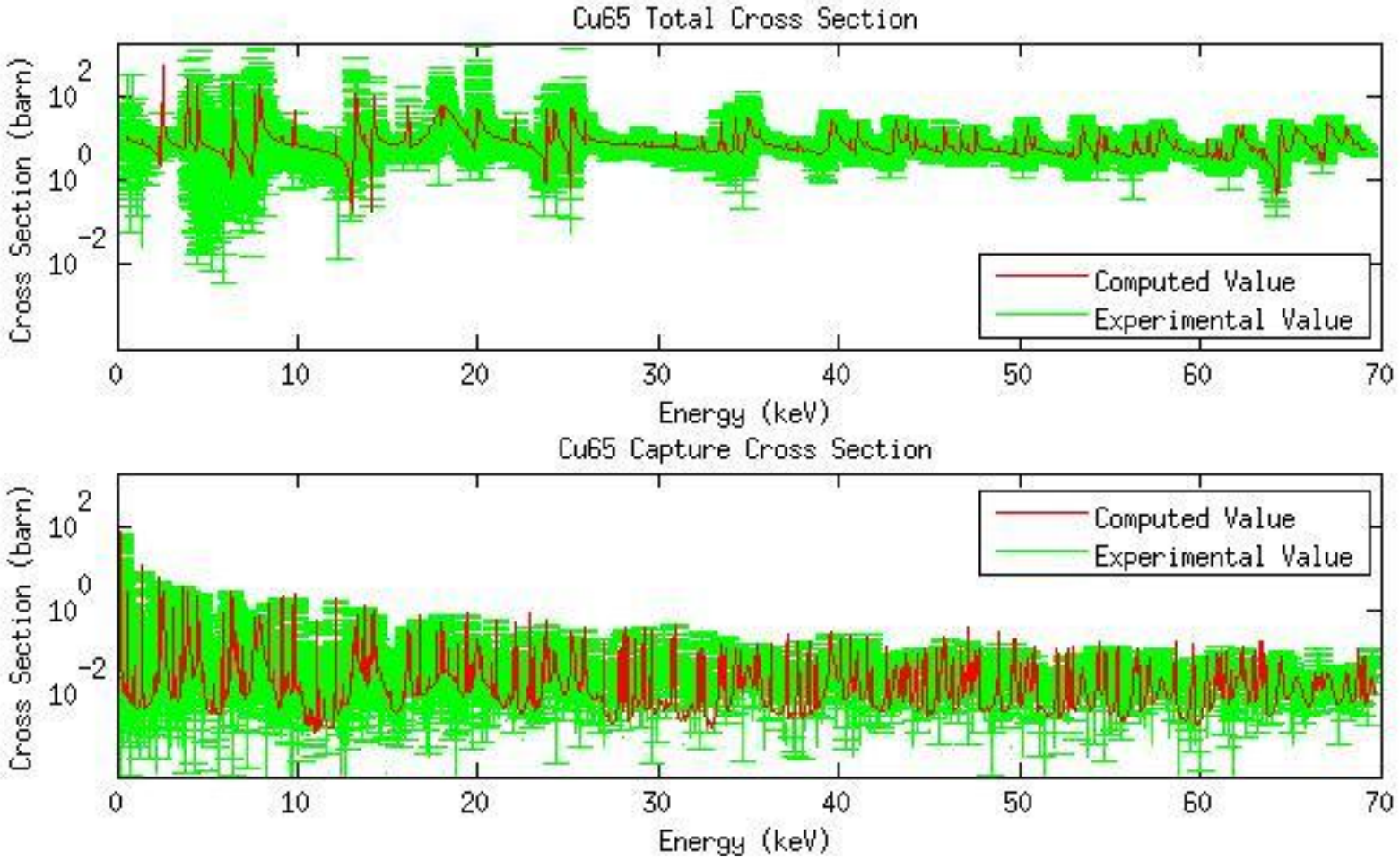
SAMMY fit at low energy (MIT data) (Vladimir update)



Resolved Resonance Region for ^{63}Cu



Resolved Resonance Region for ^{65}Cu



Tungsten Resolved Resonance

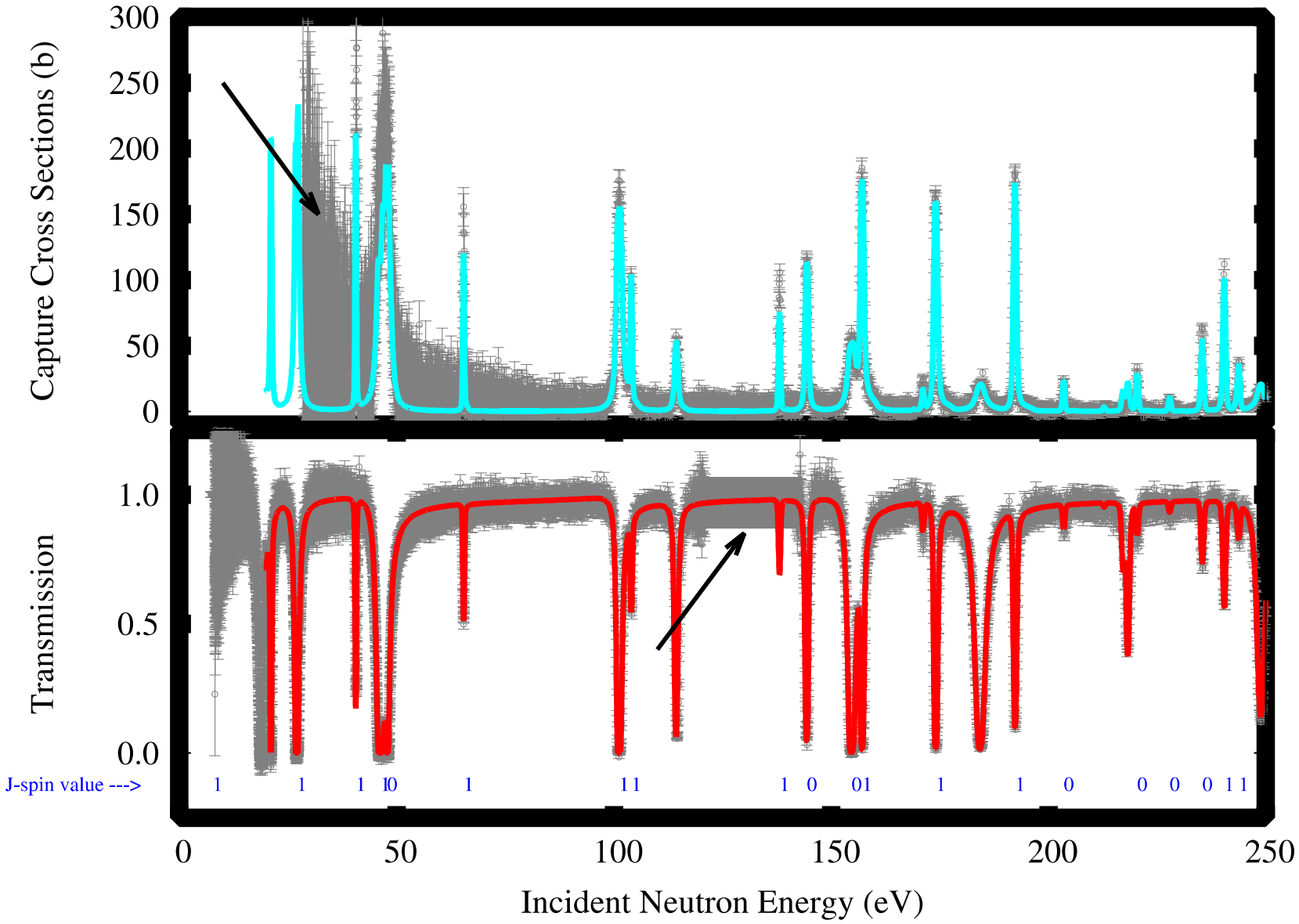
Isotope	Energy Range (old)	Energy Range (new)
^{182}W	10^{-5} eV – 5 keV	10^{-5} eV – 10 keV
^{183}W	10^{-5} eV – 2.2 keV	10^{-5} eV – 5 keV
^{184}W	10^{-5} eV – 4 keV	10^{-5} eV – 10 keV
^{186}W	10^{-5} eV – 8 keV	10^{-5} eV – 10 keV

Status of ^{183}W Resolved Resonance (RR) Evaluation (Marco Pigni)

- **M.T. Pigni et al., "*^{183}W Resonance Parameter Evaluation in the Neutron Energy Range Up to 5 keV*," PHYSOR 2012 – Advances in Reactor Physics – Knoxville, TN April 15-20 2012**

- **What is improved and new in this evaluation?**
  - **Energy range in RR region extended up to 5 keV (2.2 keV in ENDF/B-VII.1)**
  - **Evaluation based on recent experimental data (2007, Lampoudis et al.) for both reaction channels (capture and transmission)**
  - **In the thermal region corrected value of elastic scattering cross section (value in ATLAS, 2.4 barn, underestimated)**
  - **Improved systematics of resonance parameters.**
- **What is necessary to be done?**
  - **Include corrections of experimental data in the energy range 130-150 eV, 2.5-3.3 keV (transmission) and below 50 eV (capture)**
  - **Benchmarks and validation of ^{183}W cross section evaluation along with new A-even tungsten evaluations (Leal)**
  - **Cross section covariance evaluation**

Status of ^{183}W Resolved Resonance (RR) Evaluation



^{56}Fe Resonance Evaluation up to 2.0 MeV

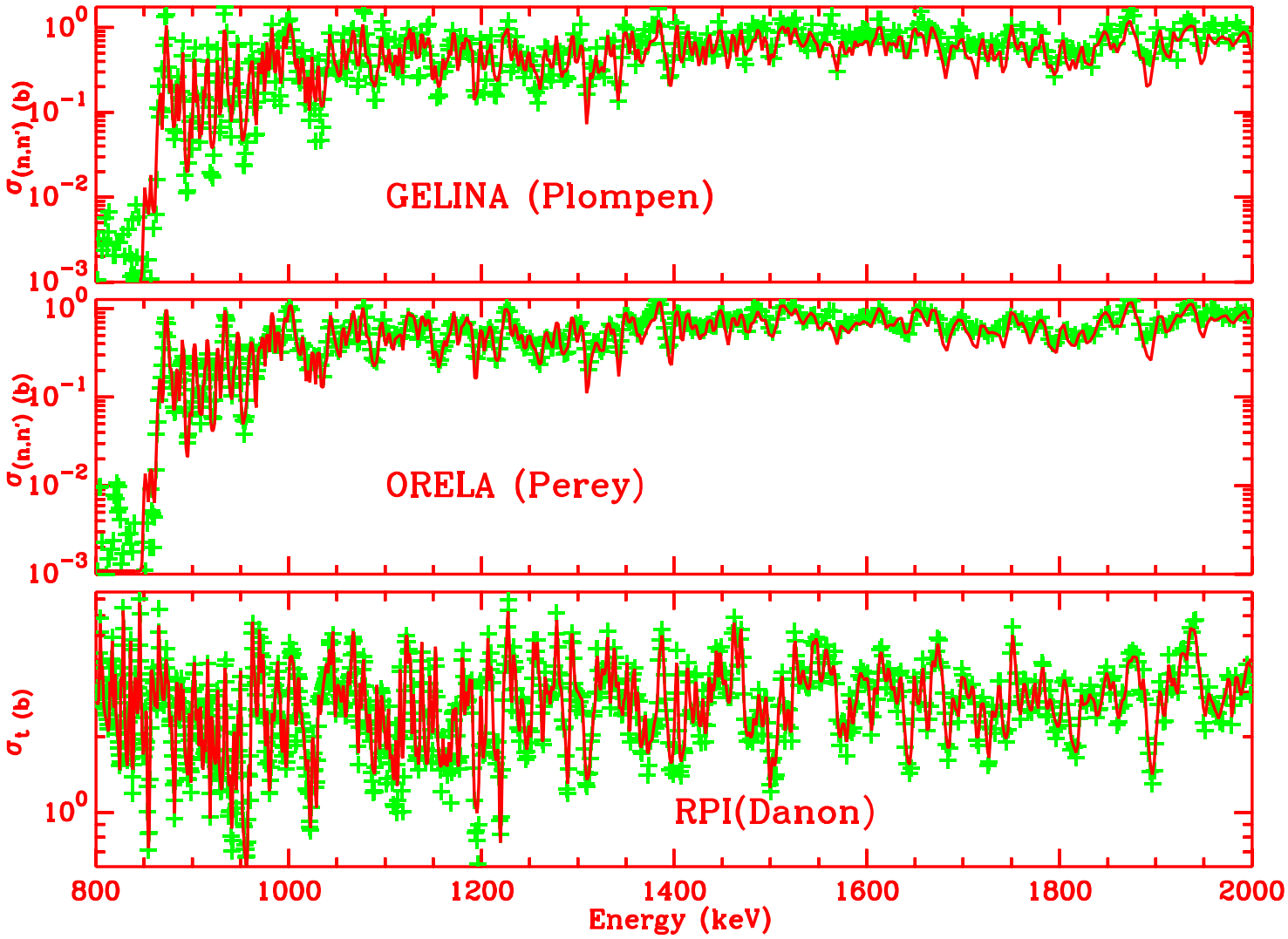
- Motivation for evaluating ^{56}Fe in the resolved resonance Region
- Evaluation description
- Use RML option of the SAMMY code (R-matrix Limited Format)
- Experimental Data
- Preliminary results

Motivation for evaluating ^{56}Fe in the Resolved Resonance Region

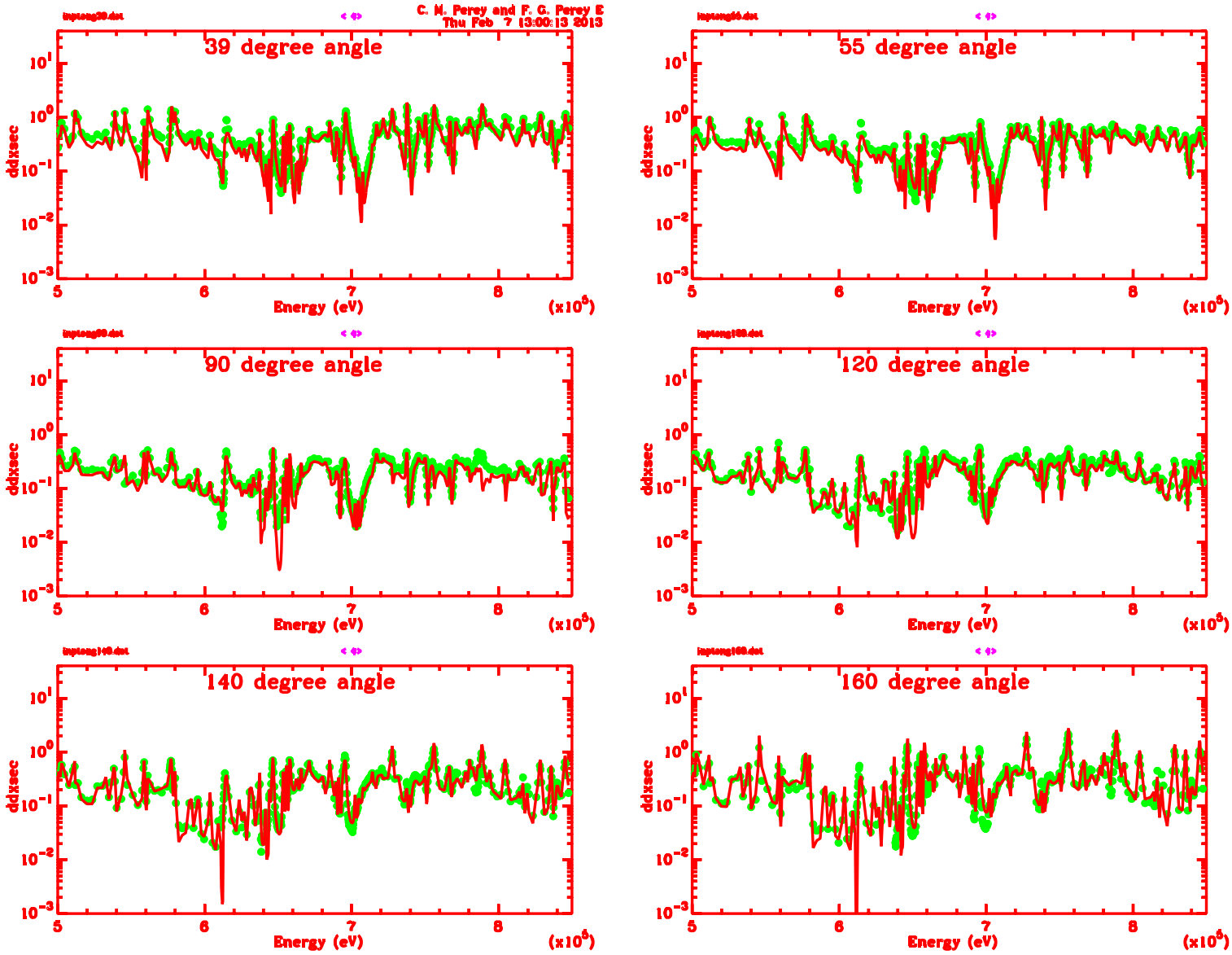
- New high resolution transmission measurements done at the RPI extending the resonance region up to 5 MeV (Yaron Danon)
- New inelastic cross-section measurements done at GEEL (Arjan Plompen)
- Use the SAMMY/RML feature to include inelastic channel in the R-matrix analysis
- Improve the results of benchmark systems calculations

Evaluation Features

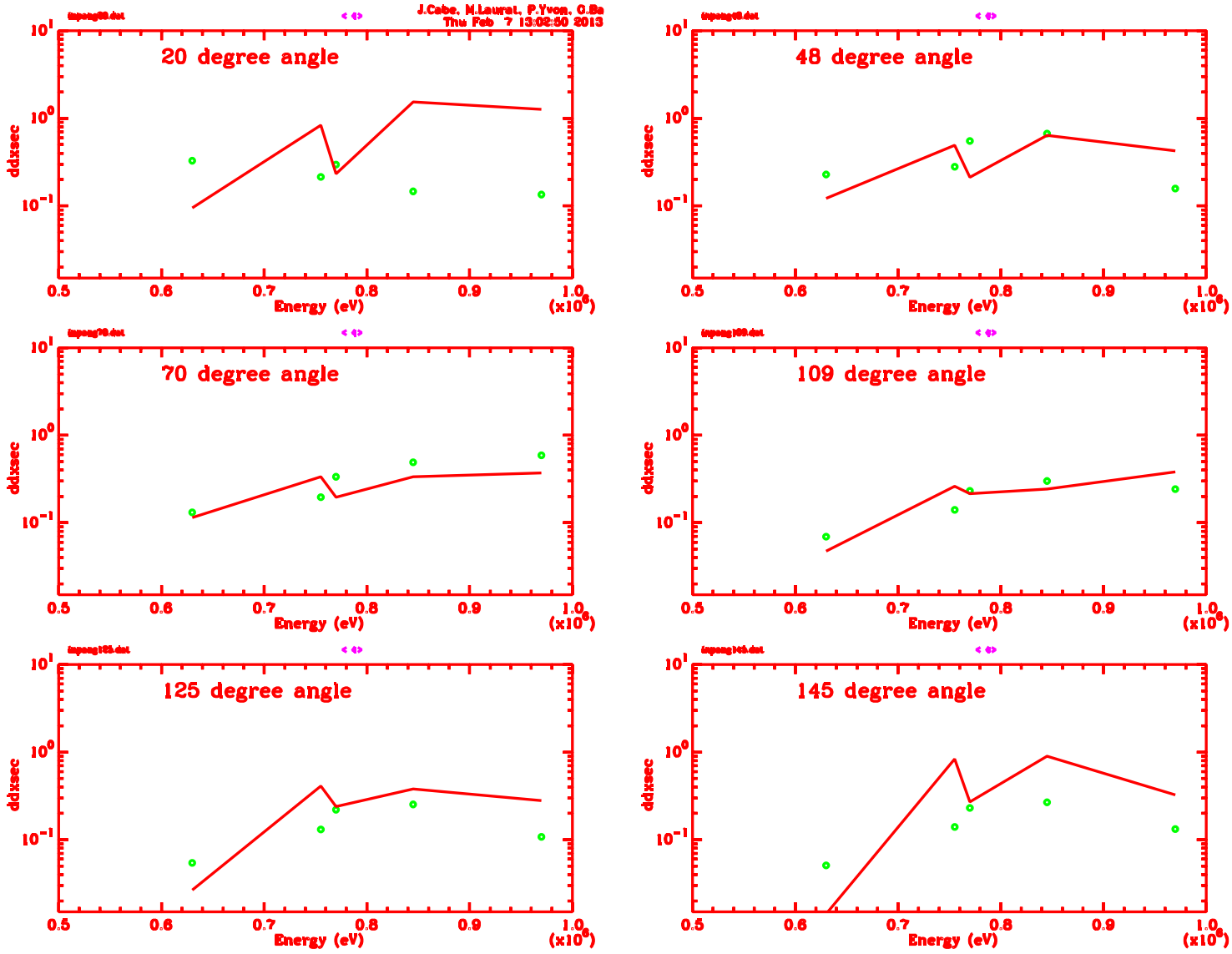
- Extend the resolved resonance region from 850 keV to 2.0 MeV
- Include new transmission measurements and inelastic cross section data
- Use the extended R-matrix formalism in the SAMMY code for fitting the experimental data
- Compare the cross section processed with SAMMY, NJOY, AMPX and PREPRO using the evaluated iron resonance parameters



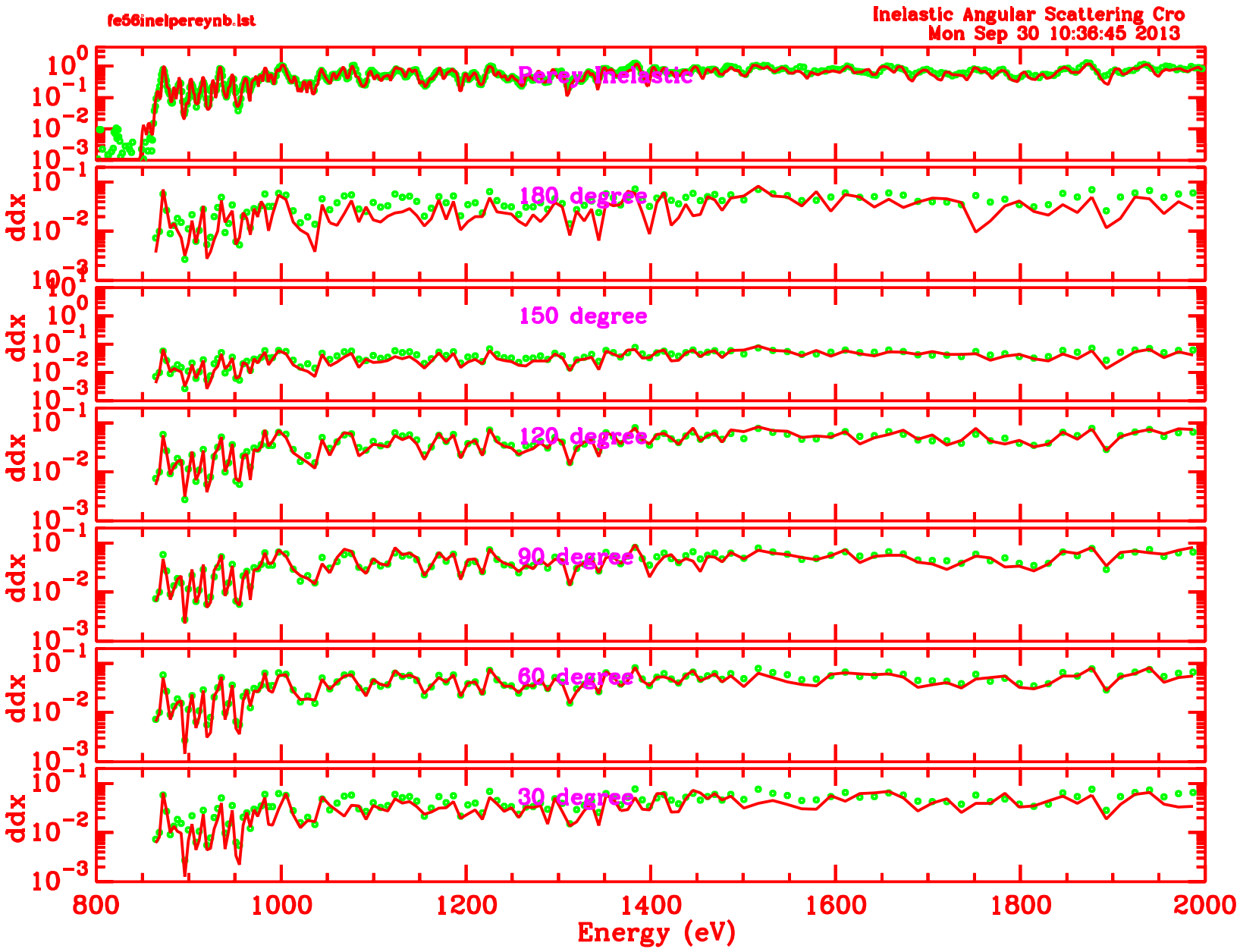
Comparison of SAMMY predictions of Total and inelastic data.



Comparison of SAMMY predictions to differential elastic data of Perey.



Comparison of SAMMY predictions to differential elastic data of Cabé .



Comparison of SAMMY predictions to differential inelastic with ENDF

^{239}Pu Resonance Evaluation Discussion

- Status of resonance evaluation presented at November 2012 CSEWG Meeting—resonance parameters have not changed in past year
- Issues to discuss: ENDF/A (SVN repository) ^{239}Pu evaluation versus WPEC SG34 ^{239}Pu
  - Resonance parameters the same in ENDF/A and SG34
  - Resonance region covariance data
    - SG34 file has File 32
    - ENDF/A File 33 does not include resonance region uncertainty—need to either provide File 33 or adopt File 32
  - SG34 File 4 data differs from ENDF/A evaluation
  - SG34 nu-bar data differs from ENDF/A evaluation (nu-bar covariance data provided in ENDF/A)

^{235}U Evaluation

- Working Party on International Nuclear Data Evaluation Co-operation (WPEC) subgroup 29 (SG 29)
- Problem Description: ^{235}U data issue in the energy range 0.1 to 2.25 keV
- Issues and Resolutions
- Method of Evaluation: SAMMY code
- ZEUS Benchmark Results
- Conclusions

WPEC subgroup 29:

"Uranium-235 Capture Cross-section in the keV to MeV Energy Region"

Mission:

- Investigate C/E discrepancies in uranium-core integral parameters observed with all major evaluated libraries (ENDF, JENDL, JEFF)
- Perform sensitivity analyses of integral parameters with respect to differential data
- Review the ^{235}U capture cross-section to determine recommended values in the energy region from 100 eV to 1 MeV
- Perform Benchmark calculations for the FCA-IX-1, -2 and -3 cores and the ZEUS-1, -2, -3, and -4

^{235}U Issues and Resolutions:

Issues:

Overestimation of ^{235}U capture cross-section in the resonance region range (0.1 to 2.5 keV).

Recommend:

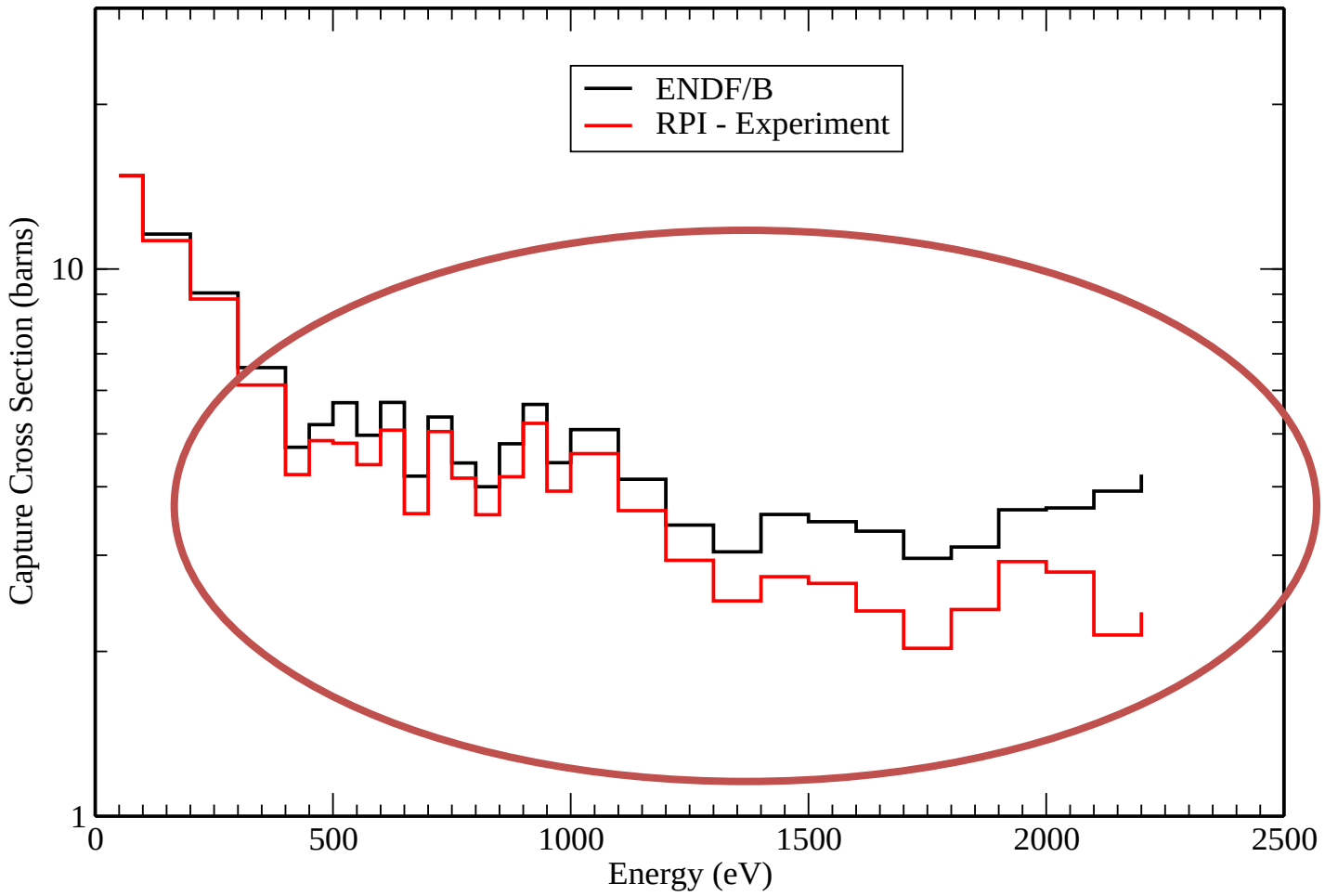
1. New measurements of capture and fission cross-section in the keV region
2. Perform new resonance analysis in the 0.1 to 2.5 keV region
3. Investigate the reason for the overestimation of criticalities for some benchmarks

^{235}U Issues and Resolutions:

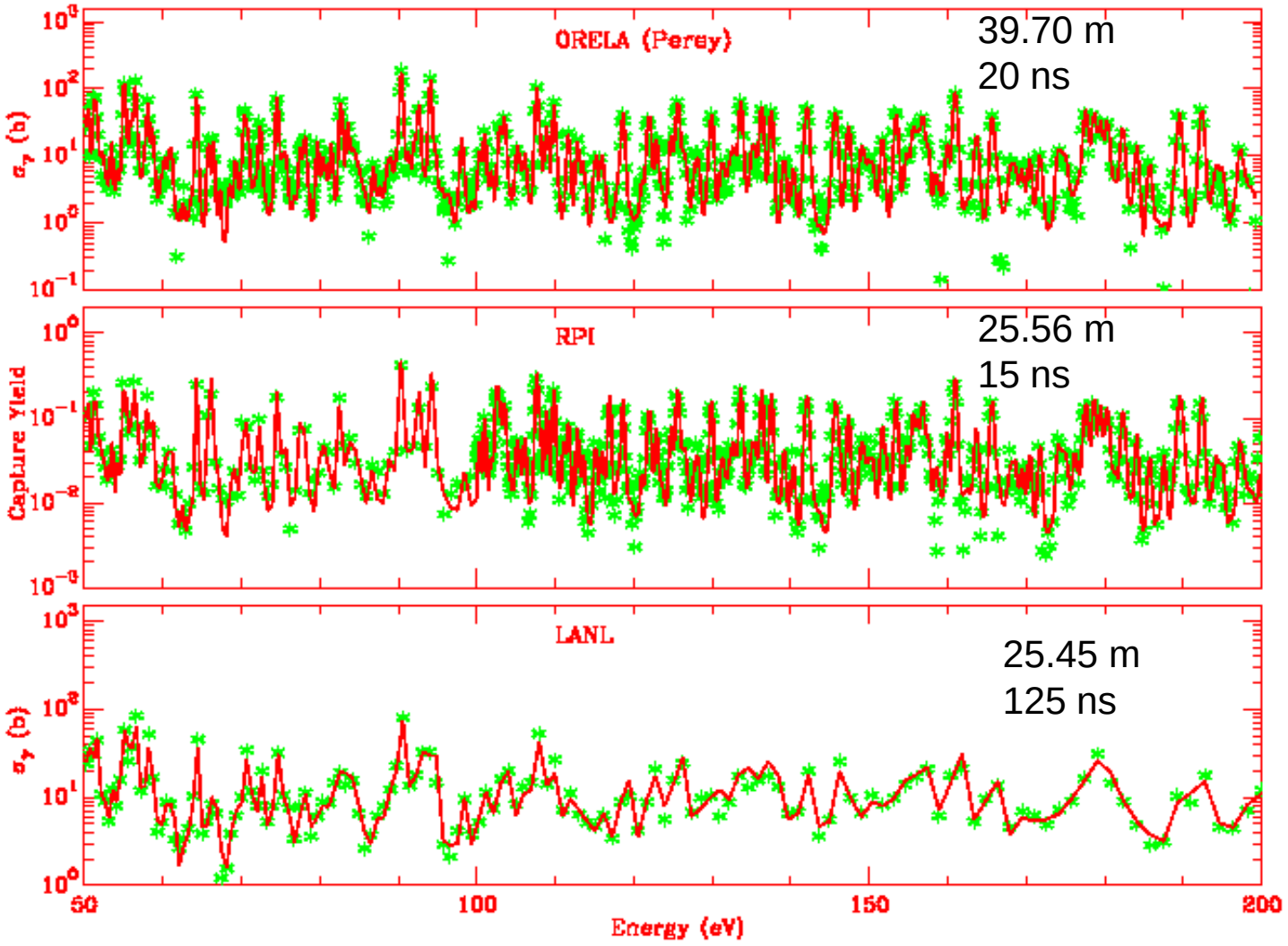
Resolution:

- ✓ New data measurements from RPI (capture and fission yields) (kind of alpha measurements)
- ✓ New capture data from LANL
- ✓ Use SAMMY code for fitting the new data
- ✓Test the new evaluation in benchmark calculations: ZEUS benchmarks (FCA not available)
- ✓ Use JENDL4 as the template
- ✓ Benchmark Calculations done with MCNP with everything else from ENDF/B-VII.0

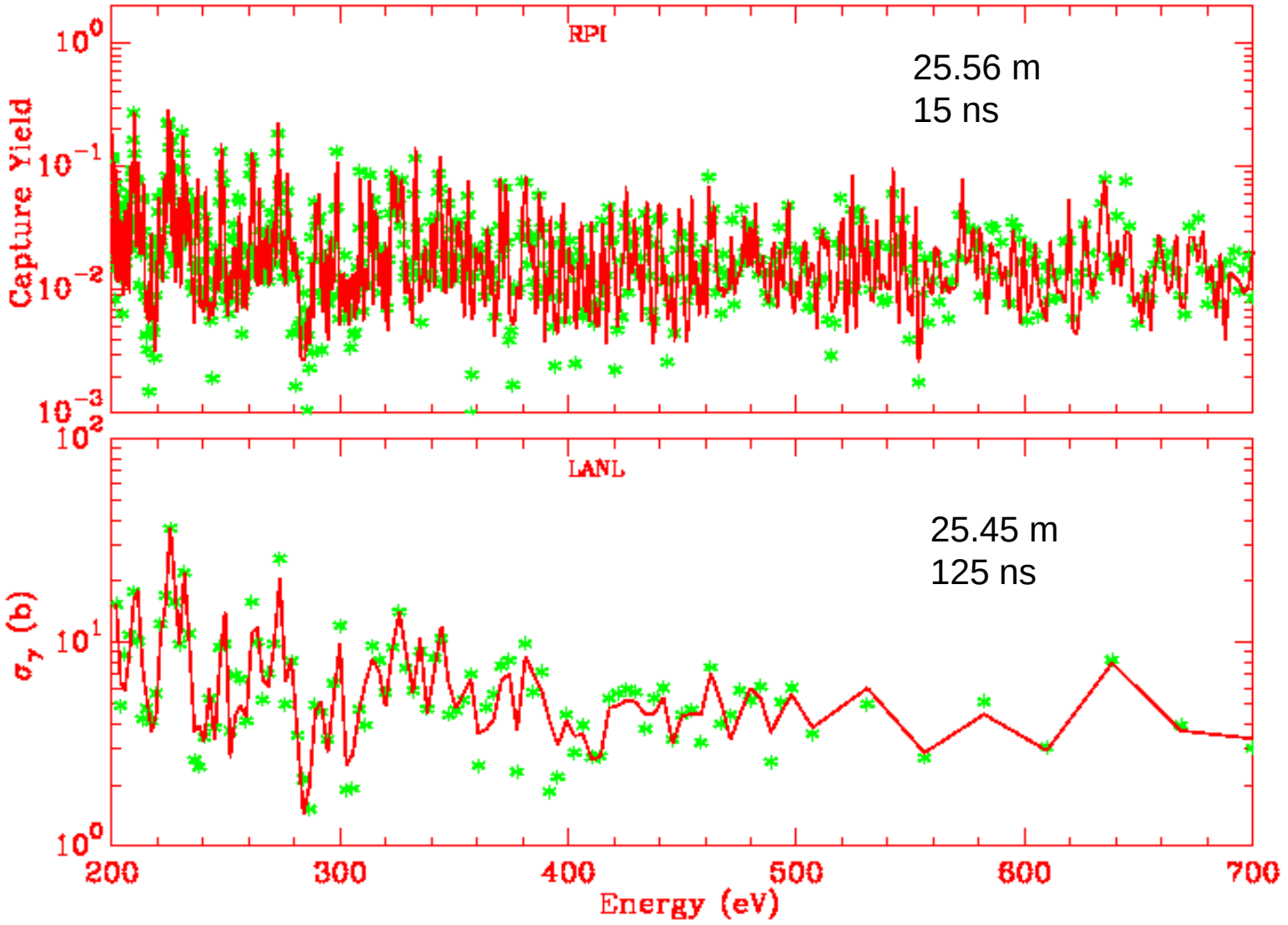
RPI capture data and ENDF evaluation (SG29 prediction confirmed)



ORNL, RPI and LANL Capture Data



RPI and LANL Capture Data



Selected Measurements ^{235}U

- Four transmission measurements, eight fission cross section measurements and four capture cross section measurements were used in the evaluation
- Evaluation performed up 2250 eV with 3197 resonances with 3168 in the energy range analyzed and 29 external resonances
- Evaluation done using SAMMY with the Reich-Moore formalism
- Fitted also integral data such as K1, Westcott factor, capture resonance integral

Selected Measurements

Author	Energy (eV)	Data
De Saussure (RPI/1967)	0.01 - 2250.0	Fission and Capture at 25.2 meters
Perez (ORNL/1972)	0.01 - 200.0	Fission and Capture at 39.7 meters
Weston (ORNL/1984)	14.0 - 2250.0	Fission at 18.9 meters
Gwin (ORNL/1984)	0.01 - 20.0	Fission at 25.6 meters
Spencer (ORNL/1984)	0.01 - 1.0	Transmission at 18 meters and sample thickness of 0.001468 atom/barn
Harvey (ORNL/1986)	0.4 - 68.0	Transmission at 18 meters and sample thickness of 0.03269 atom/barn

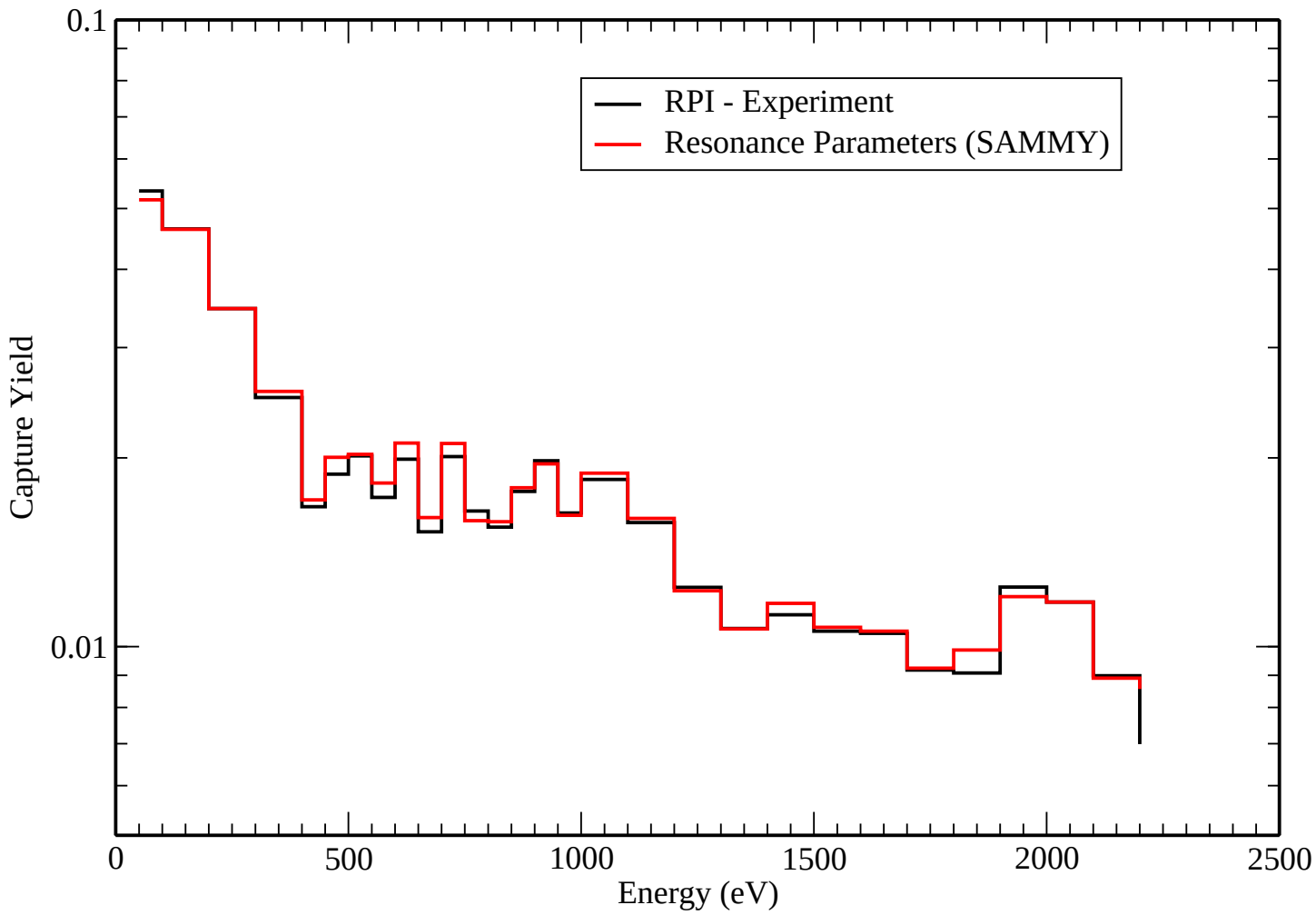
Selected Measurements

Author	Energy (eV)	Data
Harvey (ORNL/1986)	4.0 - 2250.0	Transmission at 80 meters and sample thickness of 0.00233 atom/barn cooled to 77 K
Harvey (ORNL/1986)	4.0 - 2250.0	Transmission at 80 meters and sample thickness of 0.03269 atom/barn cooled to 77 K
Wartena (Geel/1987)	0.0018 - 1.0	Eta at 8 meters
Wagemans (Geel/1988)	0.001 – 0.4	Fission at 18 meters
Schrack (RPI/1988)	0.02 - 20.0	Fission at 8.4 meters
Weigman (ILL/1990)	0.0015 – 0.15	Eta (Chopper)

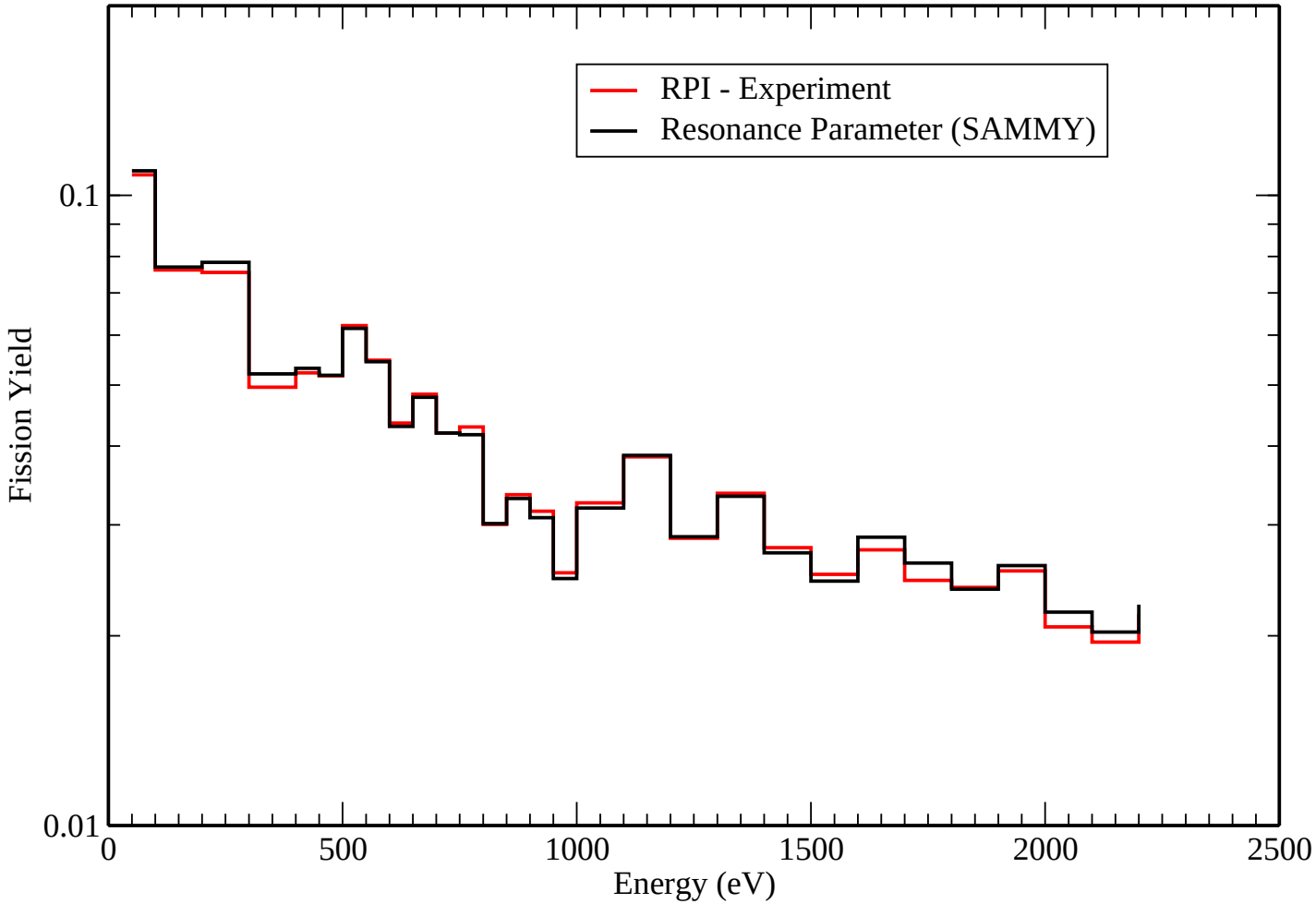
Selected Measurements

Author	Energy (eV)	Data
Weston (ORNL/1992)	100.0 - 2000.0	Fission at 86.5 meters
Moxon (ORNL/1992)	0.01 - 50.0	Fission Yield
Gwin (ORNL/1996)	0.01 - 4.0	Absorption and fission at 21.68 meters
Danon (RPI/2012)	100.0 – 5000	Fission and capture yield at 25.56 meters (burst 15 ns)
Jandel (LANL/2012)	100.0 - 5000	Capture at 25.45 meters (burst 125 ns)

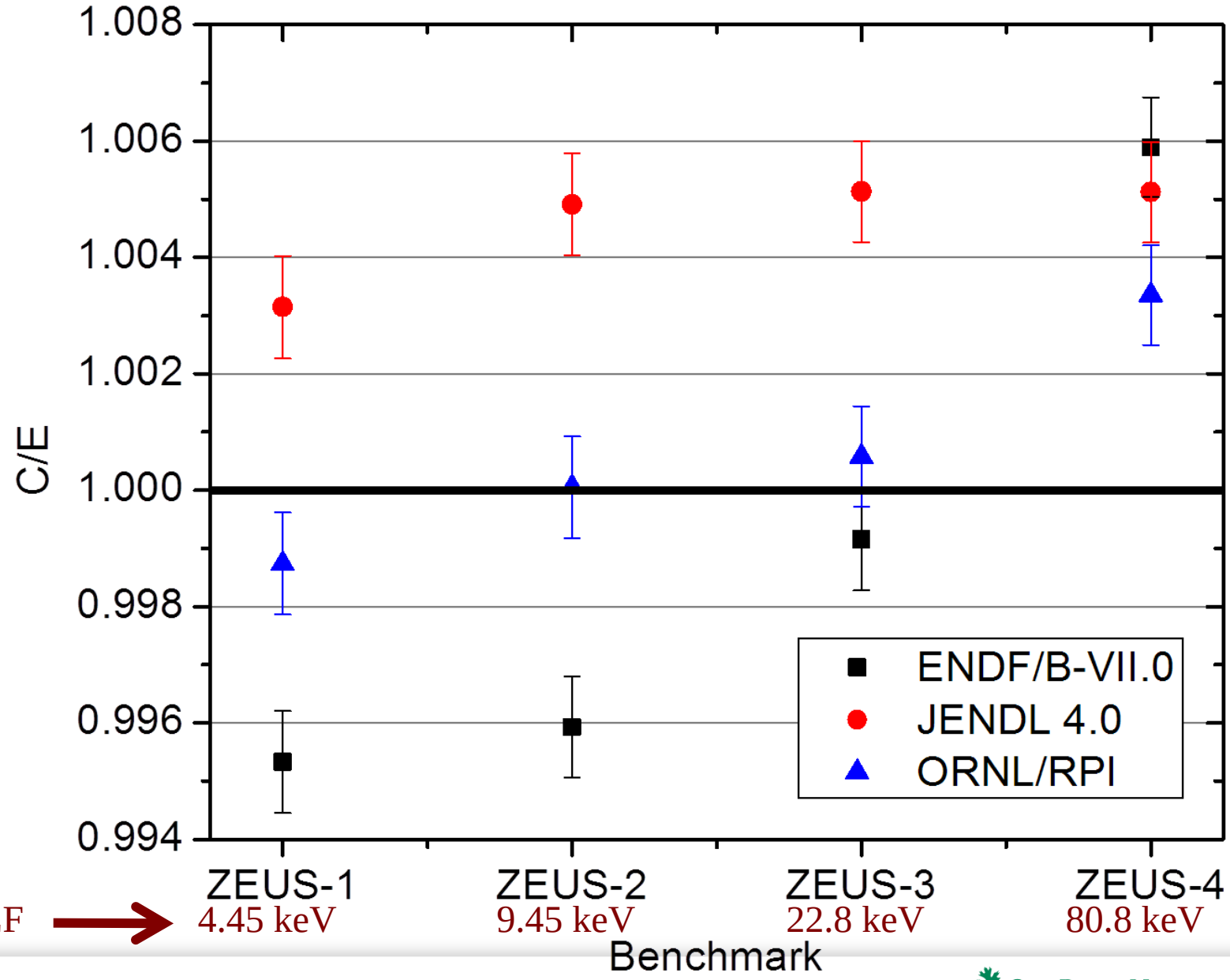
Fit of the RPI Capture Data



Fit of the RPI Fission data



The HEU-MET-INTER-006 cases (ZEUS)



EALF → 4.45 keV 9.45 keV 22.8 keV 80.8 keV

^{235}U Future Work

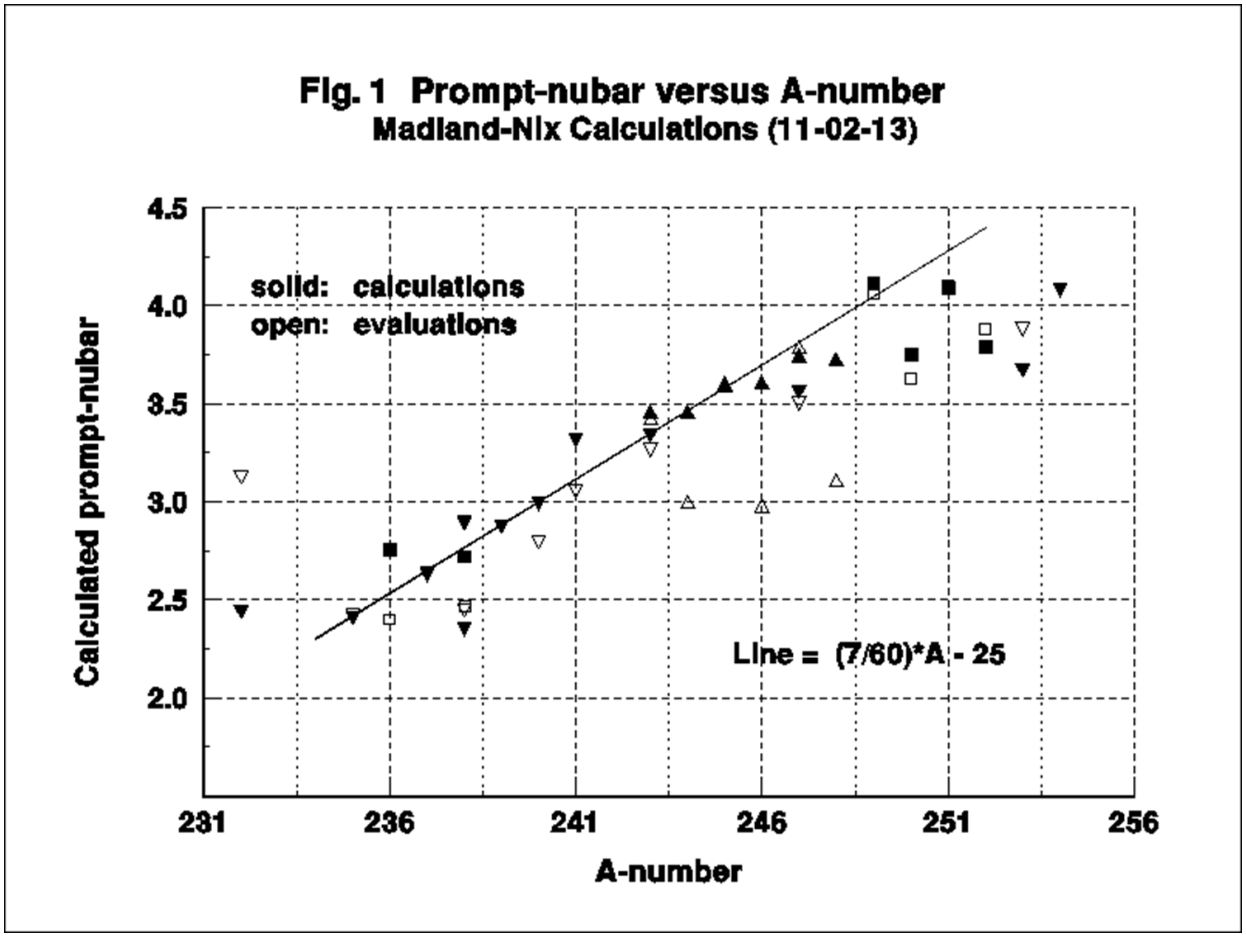
- Perform further benchmark testing;
- Temperature effects?
- Na-void reactivity of BFS and FCA;
- Revise the unresolved resonance region evaluation
- High energy data? What is going on?Investigate other parameters such as PFNS and nubar: any need for improvements?
- How about fast systems? Anything wrong with the GODIVA model, calculations?
- Continue work under the CIELO project

The Following Slides on Minor Actinide Recommendations are provided by RQ Wright (ORNL Retired)

Introduction

- Madland–Nix calculations were done for 24 actinides, including
  - Cm-243, Cm-244, Cm-245, Cm-246, Cm-247,
  - Cm-248, Cf-249, Cf-250, Cf-251, and Cf-252.
  - Results for all 24 actinides are shown on next slide
- The curium calculations agree with ENDF/B–VII.1 values with the exception of Cm-244, Cm-246, and Cm-248.
- The Cm-246 calculations agree with ENDF/B-VII.0.
- Changes to the ENDF/B–VII.1 prompt nubar values are recommended for neptunium, curium, californium, berkelium, and einsteinium (13 actinides).
- Nubar for U-232 should also be reviewed; Maslov et al. evaluation is recommended.

Madland–Nix Calculations



Recommendation for ENDF/B–VII.1

Considering the good agreement for Cm-243, Cm-245, and Cm-246, Madland-Nix calculations with ENDF/B-VII.0, we recommend the following changes for ENDF/B–VII.1:

1. **Use ENDF/B-VII.0 prompt-nubar for Cm-246.**
2. **Use the following for Cm-244, Cm-247, and Cm-248:**

Cm-244

1.0000e−05 3.4592e+00 1.0000e+06 3.5879e+00 2.0000e+06 3.7158e+00
5.0000e+06 4.0956e+00 9.0000e+06 4.5929e+00 2.0000e+07 5.9138e+00

Cm-247

1.0000e−05 3.7472e+00 1.0000e+06 3.8811e+00 2.0000e+06 4.0142e+00
5.0000e+06 4.4091e+00 9.0000e+06 4.9261e+00 2.0000e+07 6.2981e+00

Cm-248

1.0000e−05 3.7259e+00 1.0000e+06 3.8610e+00 2.0000e+06 3.9954e+00
5.0000e+06 4.3940e+00 9.0000e+06 4.9156e+00 2.0000e+07 6.2994e+00

Changes for Cf isotopes

No change to prompt−nubar at 0 MeV but revise the slope as shown:

Nuclide	VII.1	slope
Cf-249	4.0600	0.1225
Cf-250	3.6300	0.1256
Cf-251	4.1000	0.1250
Cf-252	3.8840	0.1301

Nubar revisions to ENDF/B-VII.1

MeV	Bk-247	Es-253	Es-254
0	3.5591	3.6735	4.0796
1	3.6880	3.8001	4.2059
2	3.8161	3.9260	4.3317
5	4.1963	4.3000	4.7052
9	4.6944	4.7903	5.1952
20	6.0181	6.0952	6.5007

Nu-bar Revisions for U–232, Np–236, and Np–238

MeV	U–232	Np–236	Np–238
0	2.4387	2.7545	2.7205
1	2.5895	2.8948	2.8621
2	2.7391	3.0341	3.0027
5	3.1817	3.4467	3.4191
9	3.7585	3.9851	3.9622
20	5.2789	5.4071	5.3962

Maslov Evaluations

The Maslov et al. evaluations are described in the IAEA reports INDC(BLR)-xx, where xx = 2, 3, 4, 5, 6, 9, 11, 14, 15, and 21. Values from these reports are compared with ENDF/B-VII.1 and with our calculations in Table I.

Table I. Prompt-nubar values

Nuclide	MADNIX	VII.1	Maslov
U-232	2.4387	3.12563	2.506 ± 0.24
U-238	2.3468	2.4481	2.3400
Np-236	2.7545	2.4000	2.7160
Np-237	2.5835	2.6250	2.6343
Np-238	2.7205	2.4700	2.7350
Pu-238	2.8883	2.8962	2.8400
Cm-243	3.4593	3.4290	3.4290
Cm-245	3.6048	3.5900	3.5900
Cm-246	3.6075	2.9800	3.6050

Comments on Madland–Nix Calculations

- Agreement with the Maslov evaluations is very good; in some cases < 1.0%.
- Our calculated value for Np−237 is 1.9% lower than the Maslov et al. value.
- I estimate that the uncertainty in our calculated values may be on the order of 3.5%.
- The calculated $v_p(E)$ agrees with the Maslov et al. evaluations for most actinides. One exception is U-232 which differs by 4.3% at 5 MeV.

RQ's Concluding Remarks - November 2013

Maslov has done Madland-Nix calculations for Cm-243, Cm-245, and Cm-246 (see Maslov et al., BNL-81884-2008-IR). Our results for Cm-245 and Cm-246 agree well with Maslov up to 9 MeV. At 20 MeV our value for Cm-245 is 4.3% higher and the value for Cm-246 is 3.1% higher. Maslov's treatment is more rigorous and accounts for pre-equilibrium pre-fission neutrons. In addition, our basic input data may be somewhat different from Maslov.

Logically the covariances for Cm-244, Cm-247, and Cm-248 may also need to be changed.