WPEC Sub group 34
"Coordinated evaluation of ^{239}Pu in the resonance region"

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Subgroup report

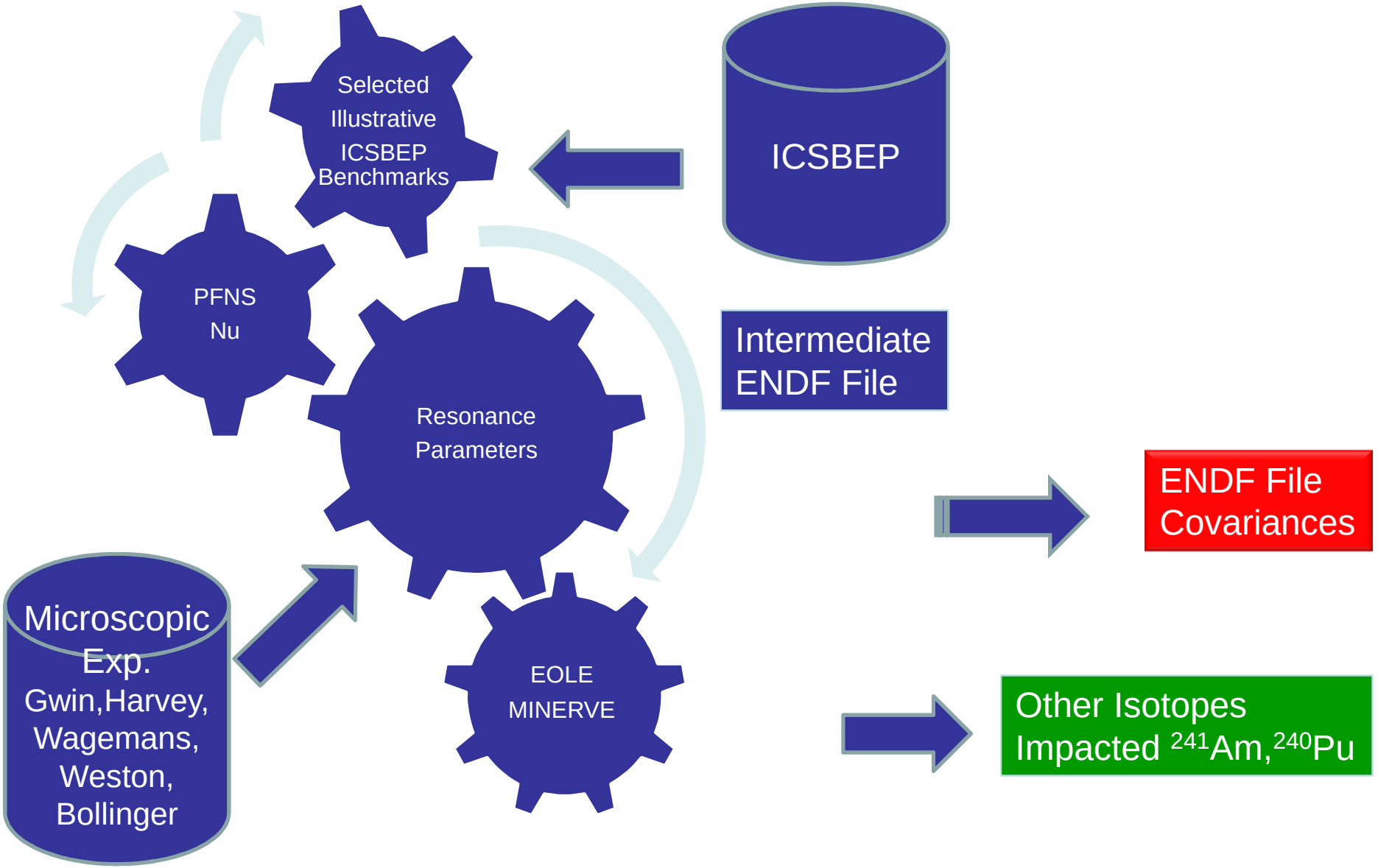
Based on Contributions from ORNL/LANL and CEA Cadarache

2013, May 23-24, NEA Headquarters

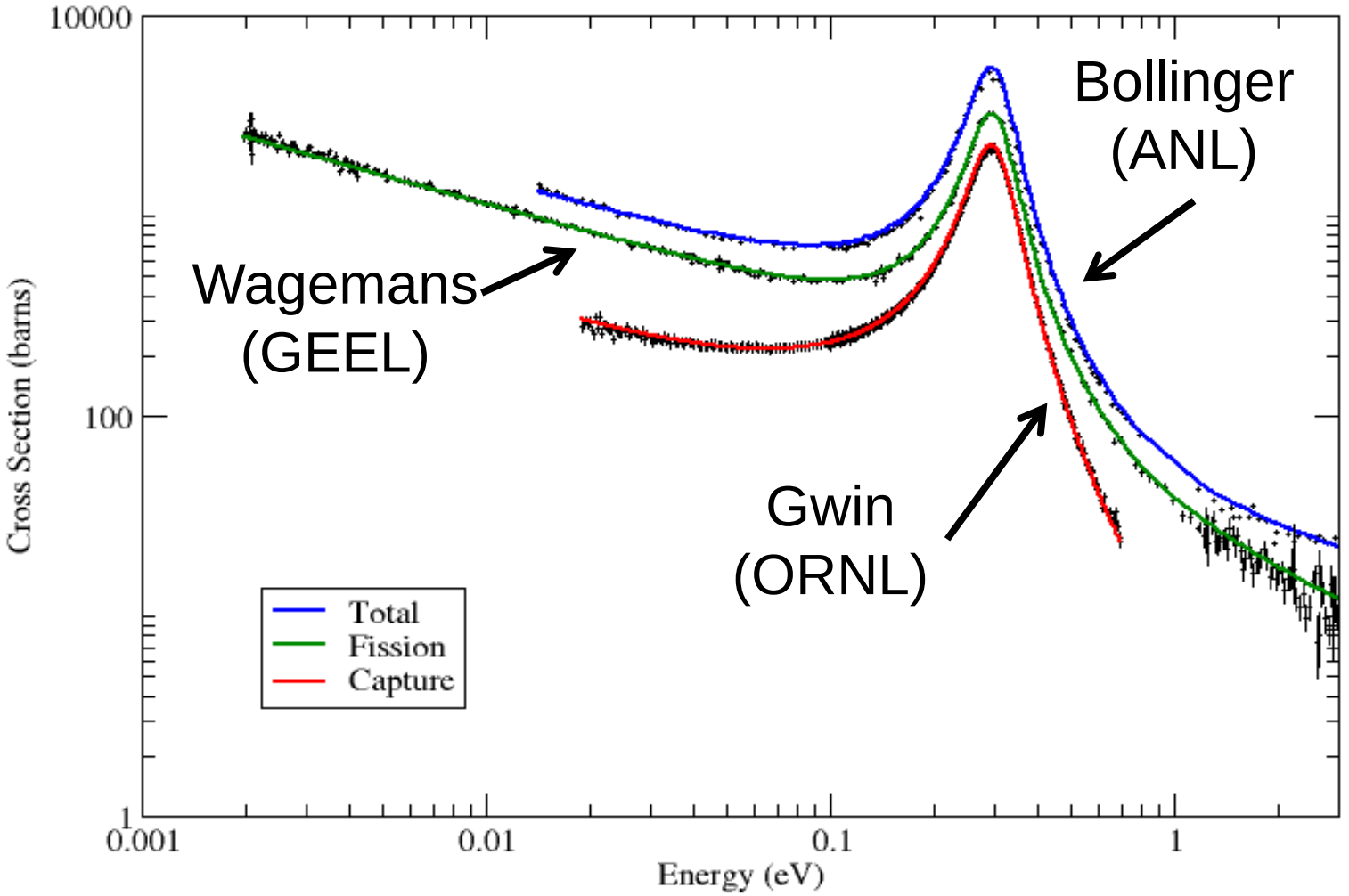
History

- Sub-group proposition by McKnight/Dunn/Chadwick on June 2009. Justification :
  - General discrepancies on Pu-SOL-THERMAL assemblies and Pu-INTER assemblies
  - JEFF 3.1.1 thermal part
  - New Derrien/Leal ENDF resonance files :
    - With covariances
    - Using new microscopic data sets
- Goal → obtain an improved ^{239}Pu resonance evaluation :
  - including covariances
  - consistent with our fundamental cross section data,
  - leading to improvements in calculations of integral data

Work Strategy



Resonance Analysis



Thermal values and Integral quantities

Quantity	ANR	ENDF/B-VII.1 (JEFF3.1)	JEFF3.1.1	ORNL CEA
σ_γ	269.3 ± 2.9	270.64	272.72	270.06
σ_f	748.1 ± 2.0	747.65	747.08	747.19
g_f	1.0553 ± 0.0013	1.0544	1.0495	1.0516
g_a	1.0770 ± 0.0030	1.0784	1.0750	1.0771
$\bar{\nu}$	2.879 ± 0.006	2.873	2.873	2.873
I_γ	180 ± 20	181.44	181.50	180.09
I_f	303 ± 10	302.60	303.58	309.09
$K1$	1177.25	1166.62	1156.35	1161.30

paradigm shift

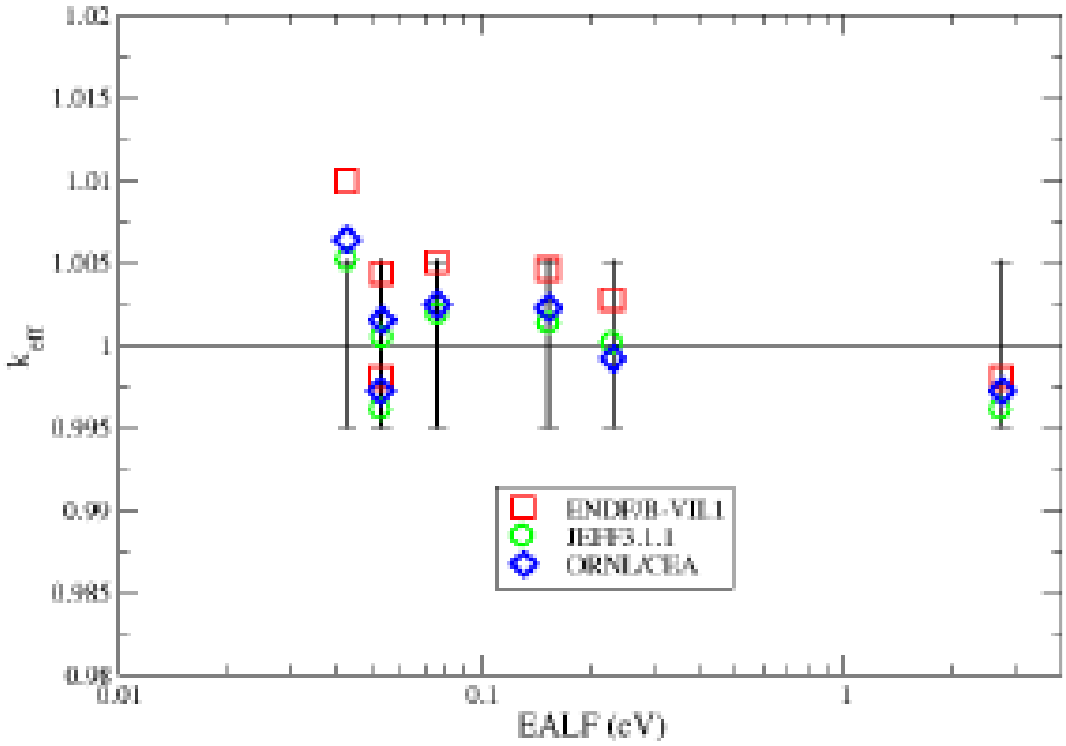
SG34 related talk in 2013

TABLE II. ICSBEP ^{239}Pu thermal benchmark.

Benchmark	Experimental k_{eff}	EALF (eV)	Contents
PST12.13	1.0000±0.0050	0.0428	19.5 % ^{240}Pu
PST4.1	1.0000±0.0047	0.0531	0.5 % ^{240}Pu
PST12.10	1.0000±0.0033	0.0535	25 % ^{240}Pu
PST18.6	1.0000±0.0047	0.0761	43 % ^{240}Pu
PST1.4	1.0000±0.0047	0.154	5 % ^{240}Pu
PST34.4	1.0000±0.0047	0.231	116g Pu/L, 1.42 Gd/L
PST34.15	1.0000±0.0047	2.730	363g Pu/L, 20.25 Gd/L

L.C. Leal (ORNL) et al. (LANL/CEA), *^{239}Pu Resonance Evaluation for Thermal Benchmark System Calculations*, ND2013, New York , US, March 2013

New Resonance evaluation
reproduces existing microscopic data very well
Exhibits reasonable keff for Integral Experiment



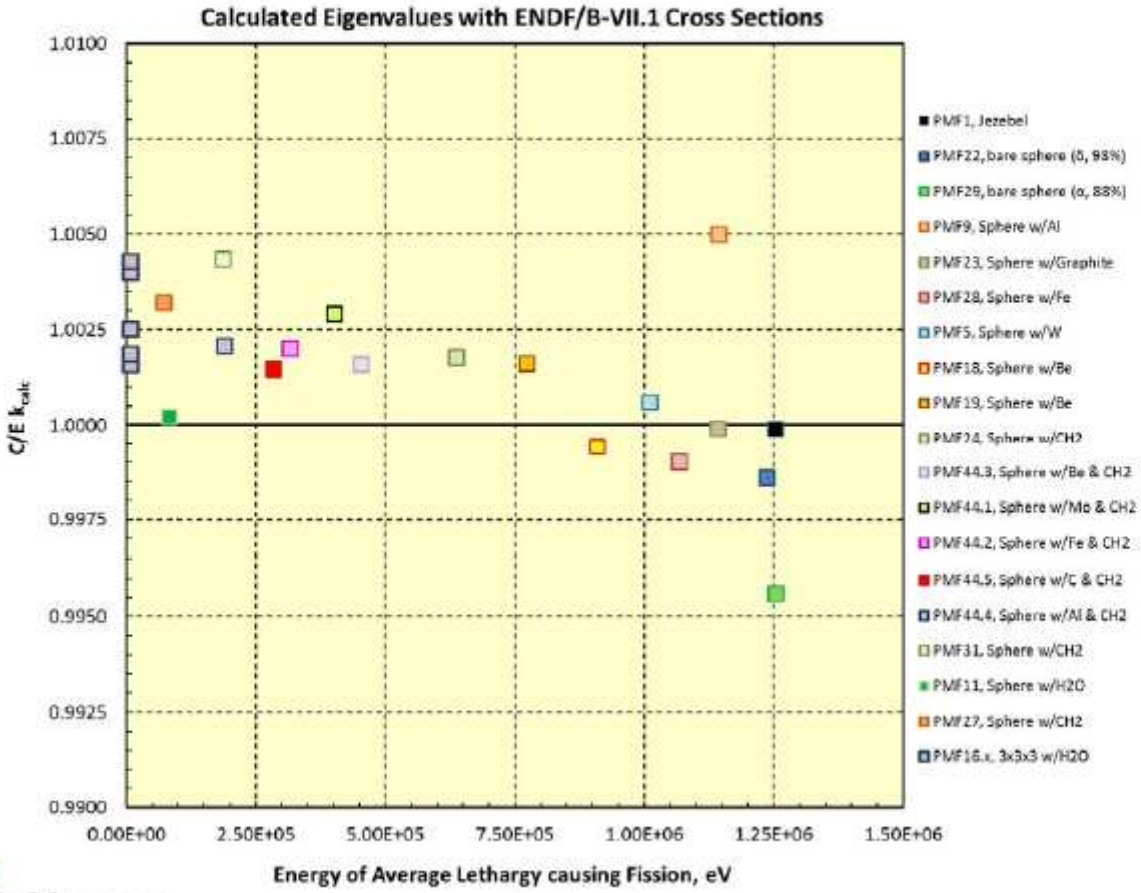
Related Additional Work/Talk in 2012-2013

- A. C. Kahler (LANL) et al., *Critical Eigenvalue Calculations of Selected ICSBEP Benchmarks with Various ^{239}Pu Evaluated Data Files*, WONDER 2012, Aix en Provence, France, September 25-28, 2012 : add PST + Pu Metal; Fast & Intermediate Spectrum
- R.D MckKnight / Kahler/ Lell additional calculations with new resonance file on Pu Metal; Fast & Intermediate Spectrum →almost no effect
- Y. Peneliau (CEA) et al.,*^{239}Pu Prompt Fission Neutron Spectra impact on a set of criticality and experimental reactor benchmarks*, ND2013, New York , US, March 2013.
- *Tested in the framework of JEFF project with CEA/DAM high energy file (merged file proposed to Jeff3.2beta) : JEFF-DOC 1439,1481,1485,1505*

Related Additional Work/Talk in 2012-2013

- *Taken from Skip Khaler Wonder 2012 talk*

Pu Metal; Fast & Intermediate Spectrum



Can couple these with PST to cover the entire energy range from unmod-erated to fully-moderated.

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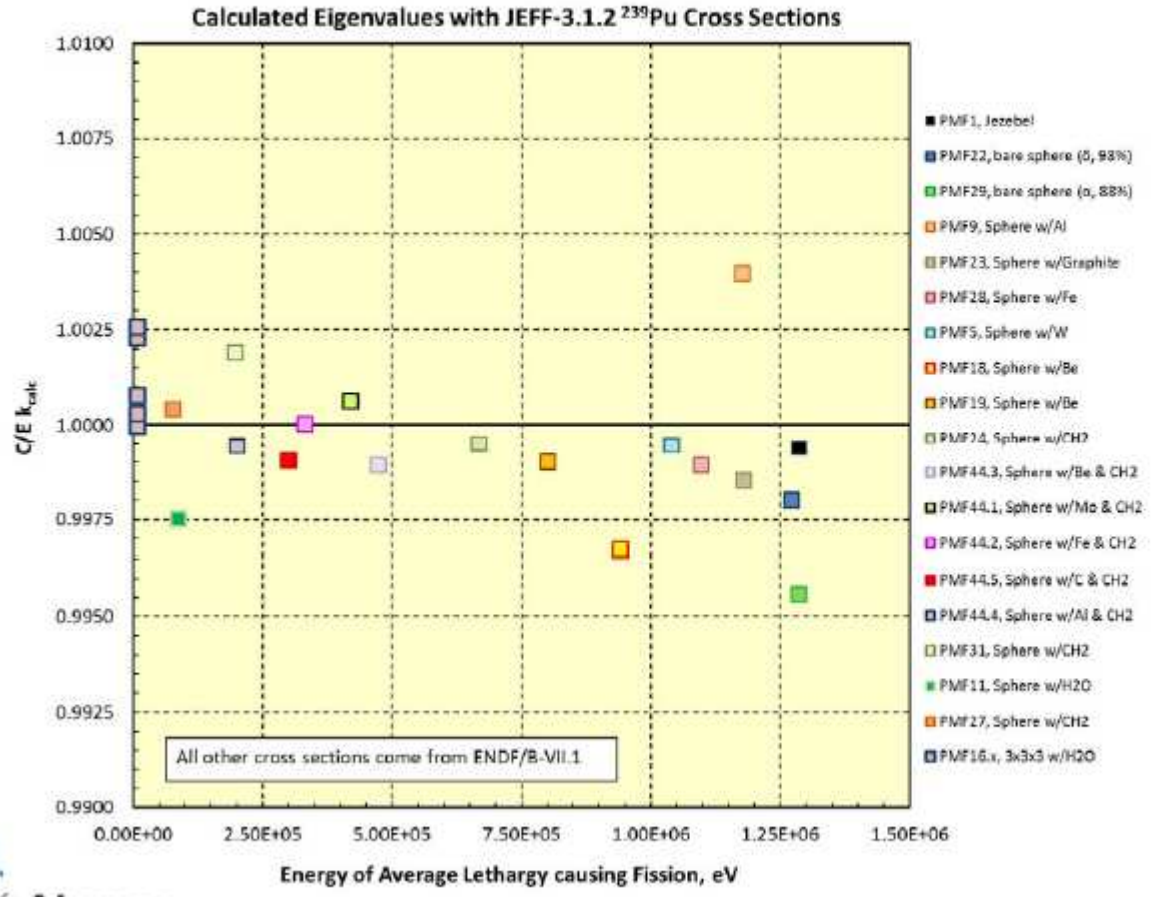
Related Additional Work/Talk in 2012-2013

- *Taken from Skip Khaler Wonder 2012 talk*

Pu Metal; Fast & Intermediate Spectrum



Results using JEFF-3.1.2 ^{239}Pu; remaining cross sections come from ENDF/B-VII.1.

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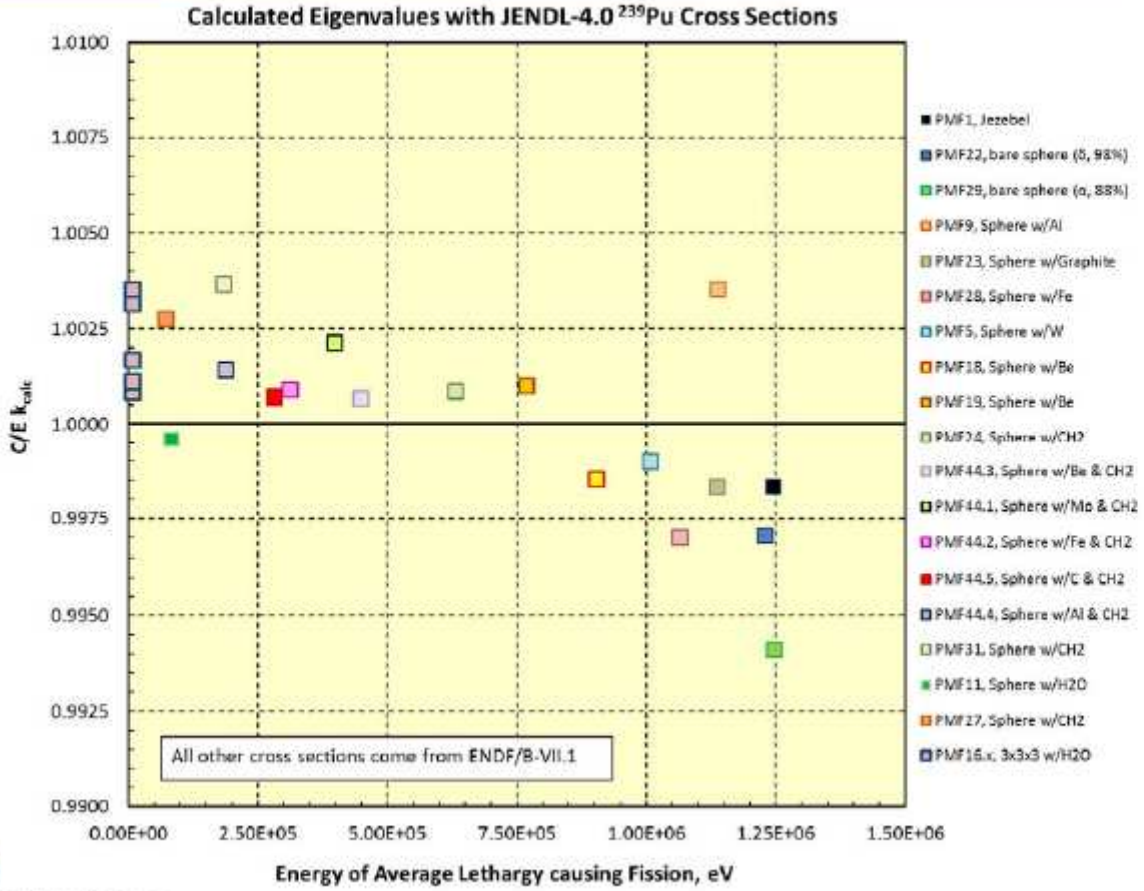
Related Additional Work/Talk in 2012-2013

- *Taken from Skip Khaler Wonder 2012 talk*

Pu Metal; Fast & Intermediate Spectrum



Results using JENDL-4.0 ^{239}Pu; remaining cross sections come from ENDF/B-VII.1.

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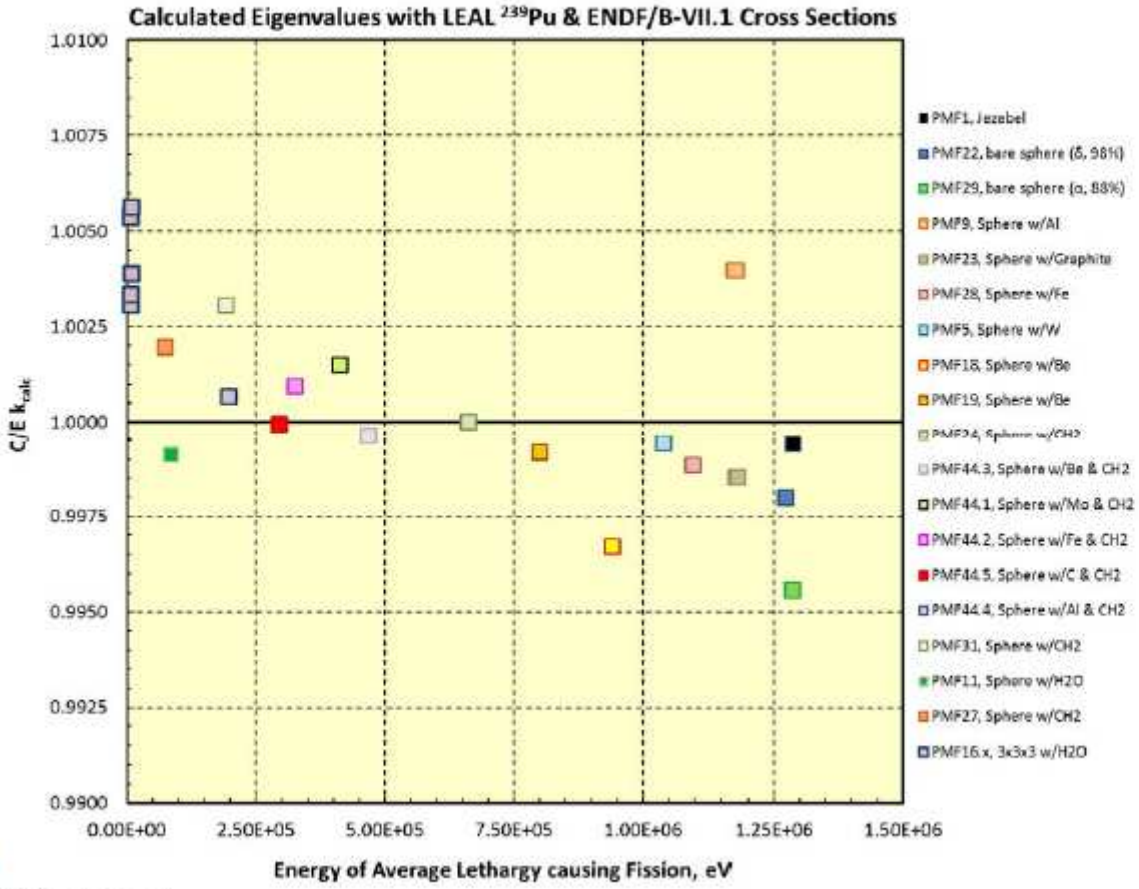
Related Additional Work/Talk in 2012-2013

- *Taken from Skip Khaler Wonder 2012 talk*

Pu Metal; Fast & Intermediate Spectrum



Results using the Leal/CEA ^{239}Pu; remaining cross sections come from ENDF/B-VII.1.

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Related Additional Work/Talk in 2012-2013

- *Taken from mail exchange between R.D. McKnight and SG members; work performed by McKnight/Kahler/Lell*

→Test Intermediate spectrum

Selected assemblies, in order of softest to hardest spectrum, included:

- ZPR-6/10 was a small, clean, cylindrical assembly consisting of plutonium, carbon, and stainless steel (no uranium) with intermediate spectrum.
- ZPR-3/53 was small clean core containing PuUMo, PuAl, and C plates with a DU reflector.
- ZPR-3/54 was identical to ZPR-3/53 except that the DU reflector was replaced by an iron reflector.
- ZPR6/7 was a large, cylindrical, single-zone plutonium / uranium oxide benchmark assembly that was part of the LMFBR Demonstration Reactor Benchmark Program.

Related Additional Work/Talk in 2012-2013

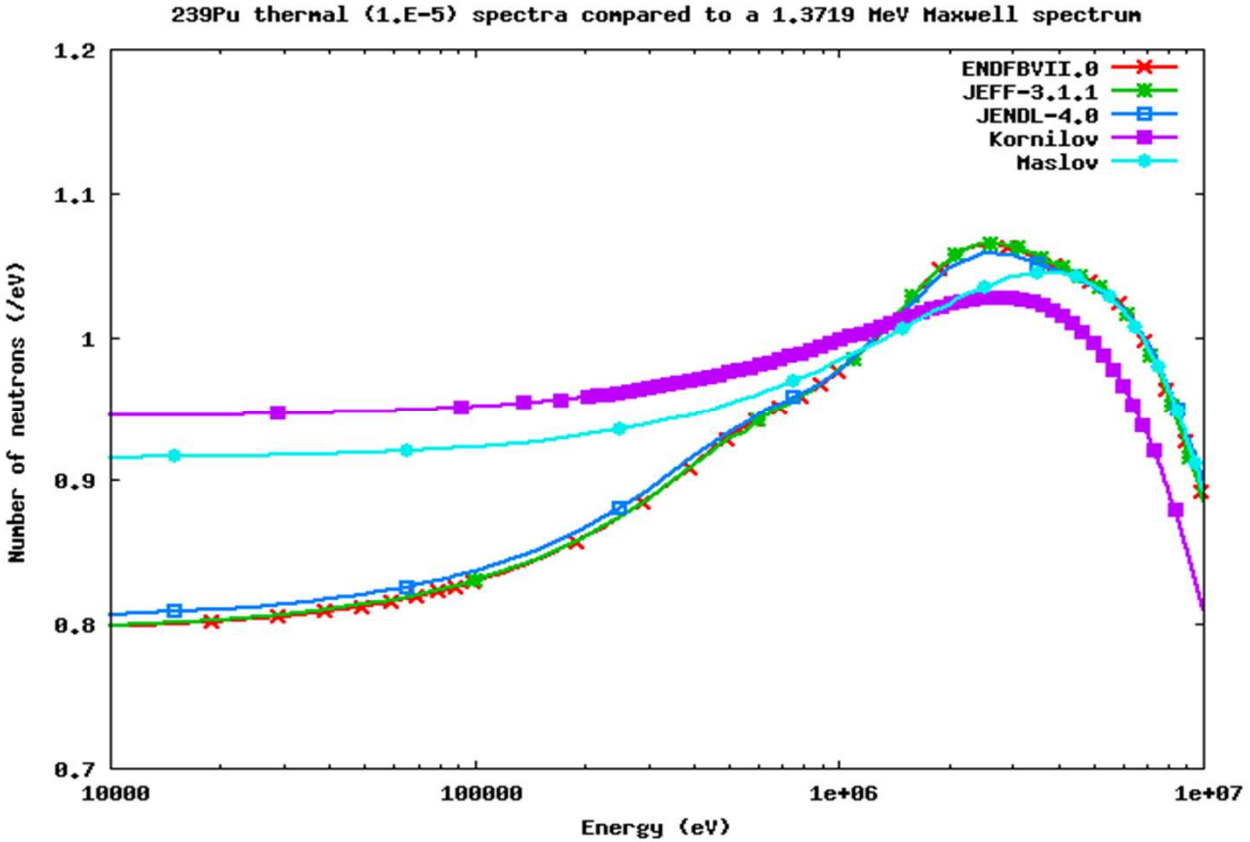
- *Taken from mail exchange between R.D. McKnight and SG members ; work performed by McKnight/Kahler/Lell*

Benchmark	Assembly	^{239}Pu Data	EALF,	Experiment [1]			Calculated			C/E - 1, %			
		Version	MeV	k_{eff}	±	σ	k_{eff}	±	σ	C/E - 1	±	σ	delta (C/E-1)$_{New-VII.1}$, %
PU-MET-INTER-002	ZPR-6/10	New	11.33	1.0016	±	0.0013	1.02893	±	0.00005	2.729	±	0.133	0.082 ± 0.189
PU-MET-INTER-002	ZPR-6/10	VII.1	11.48	1.0016	±	0.0013	1.02811	±	0.00005	2.647	±	0.133	
MIX-MET-INTER-003	ZPR-3/54	New	26.15	0.9981	±	0.0017	1.00838	±	0.00005	1.030	±	0.172	-0.009 ± 0.243
MIX-MET-INTER-003	ZPR-3/54	VII.1	26.27	0.9981	±	0.0017	1.00847	±	0.00004	1.039	±	0.172	
MIX-MET-INTER-004	ZPR-3/53	New	58.15	1.0017	±	0.0009	1.00872	±	0.00004	0.701	±	0.091	-0.063 ± 0.128
MIX-MET-INTER-004	ZPR-3/53	VII.1	58.12	1.0017	±	0.0009	1.00935	±	0.00004	0.764	±	0.091	
MIX-COMP-FAST-001	ZPR-6/7	New	120.56	1.0005	±	0.0009	1.00050	±	0.00003	0.000	±	0.090	-0.034 ± 0.127
MIX-COMP-FAST-001	ZPR-6/7	VII.1	120.30	1.0005	±	0.0009	1.00084	±	0.00003	0.034	±	0.090	

[1] **Benchmark k_{eff} for "as-built" Model with any Adjustments to Experiment**

Related Additional Work/Talk in 2012-2013

❑ *Taken from Y. Peneliau et al. ND2013 paper*



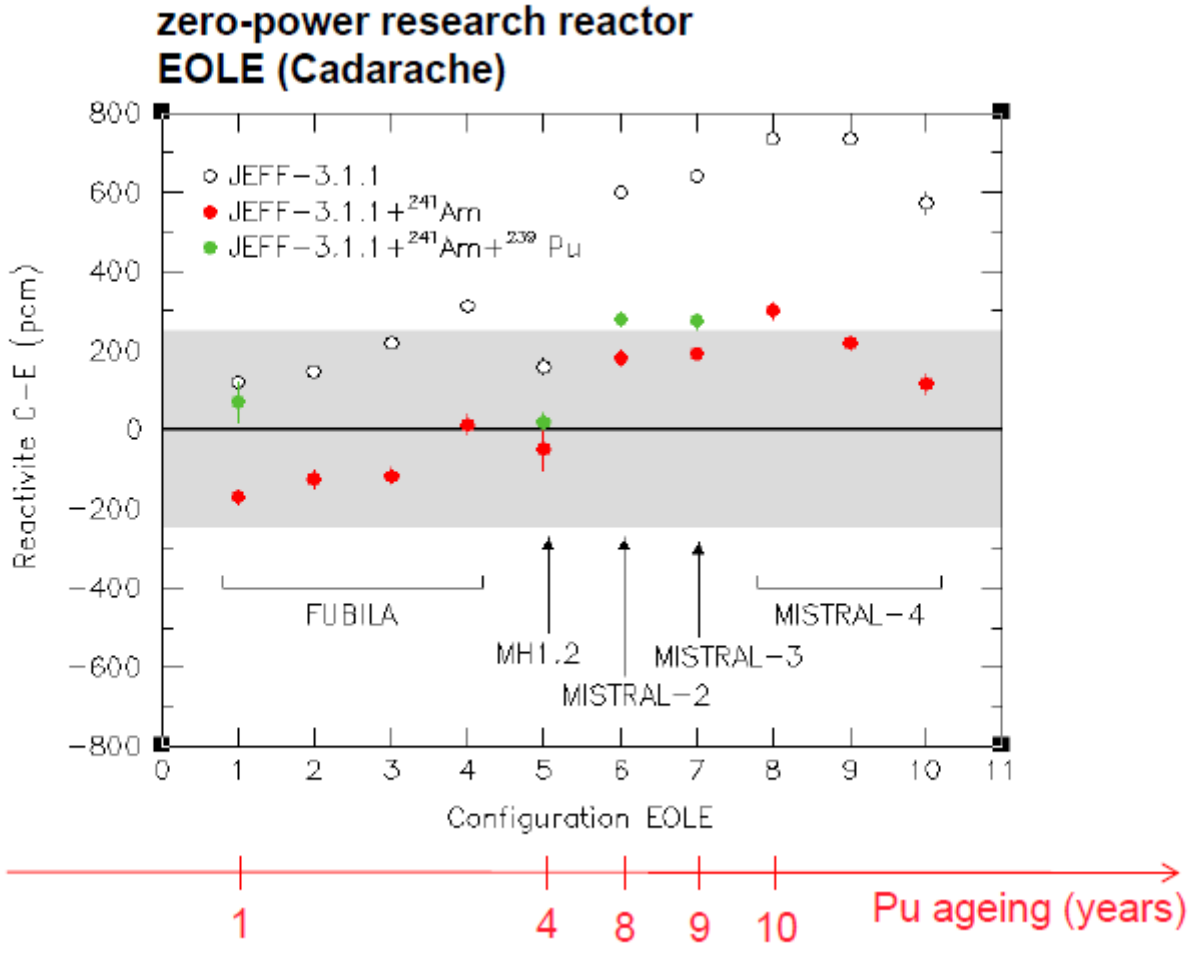
ENDF/JENDL/JEFF → Kornilov/Maslov :

- ~+800pcm on PU-SOL-THERM with high leakage
- -300pcm on Fast Benchmark (ICSBEP/MASURCA))

SG decided to wait for IAEA-CRP

Related Additional Work/Talk in 2012-2013

- *Taken from G. Noguere JEFF-DOC 1481*



Conclusions

- Resonance parameter evaluation including both microscopic and integral data : resolved resonance parameters in ENDF format
  →http://www.oecd-nea.org/science/wpec/sg34
- For prompt nu-bar (ν), new analysis similar to JEFF/ENDF
- For PFNS → no clear conclusion → Wait for IAEA-CRP
- Intermediate benchmark deviations →need a dedicated activity (URR/continuum) to investigate
- **Final Report** is underway (20 pages draft for time being)

→Resonance analysis, PFNS **OK**

→Nu, Covariance, benchmarks **OK**

→to be finalized before summer. **OK**

Conclusions/Comments/Propositions

For an additional improvement, one may need :

- Integral experiments :
  - → need of more precise measurements (500 pcm too high)
  - → support the refurbishment of existing Experimental reactors (in France/US)
- New microscopic data experiments :
  - ✓capture-to-fission ratio (alpha, eta)
  - ✓Transmission at low energy (~ 20 eV)
  - ✓Capture (3% normalization uncertainty for the time being…)