Revision to ENDF/B-VI U235 Thermal Delayed Nubar for ENDF/B-VII.0

CR Lubitz - KAPL, Inc.

CSEWG
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Background

- Longstanding puzzle about a possible difference between the thermal and fast values of delayed nubar for U235.
- Theory said “no”, not until the second-chance fission threshold at 4 MeV.
- Experiment was equivocal. Direct measurements of delayed nubar and beta-effective experience were consistent with “yes”.

Possible Resolution

- A possible resolution was provided by multimodal fission theory (Ohsawa and Oyama).
- Branching ratios to different fission modes may fluctuate in resonances.
- Hence precursor populations may fluctuate.
- Hence delayed nubar may fluctuate.

Possible Resolution (cont.)

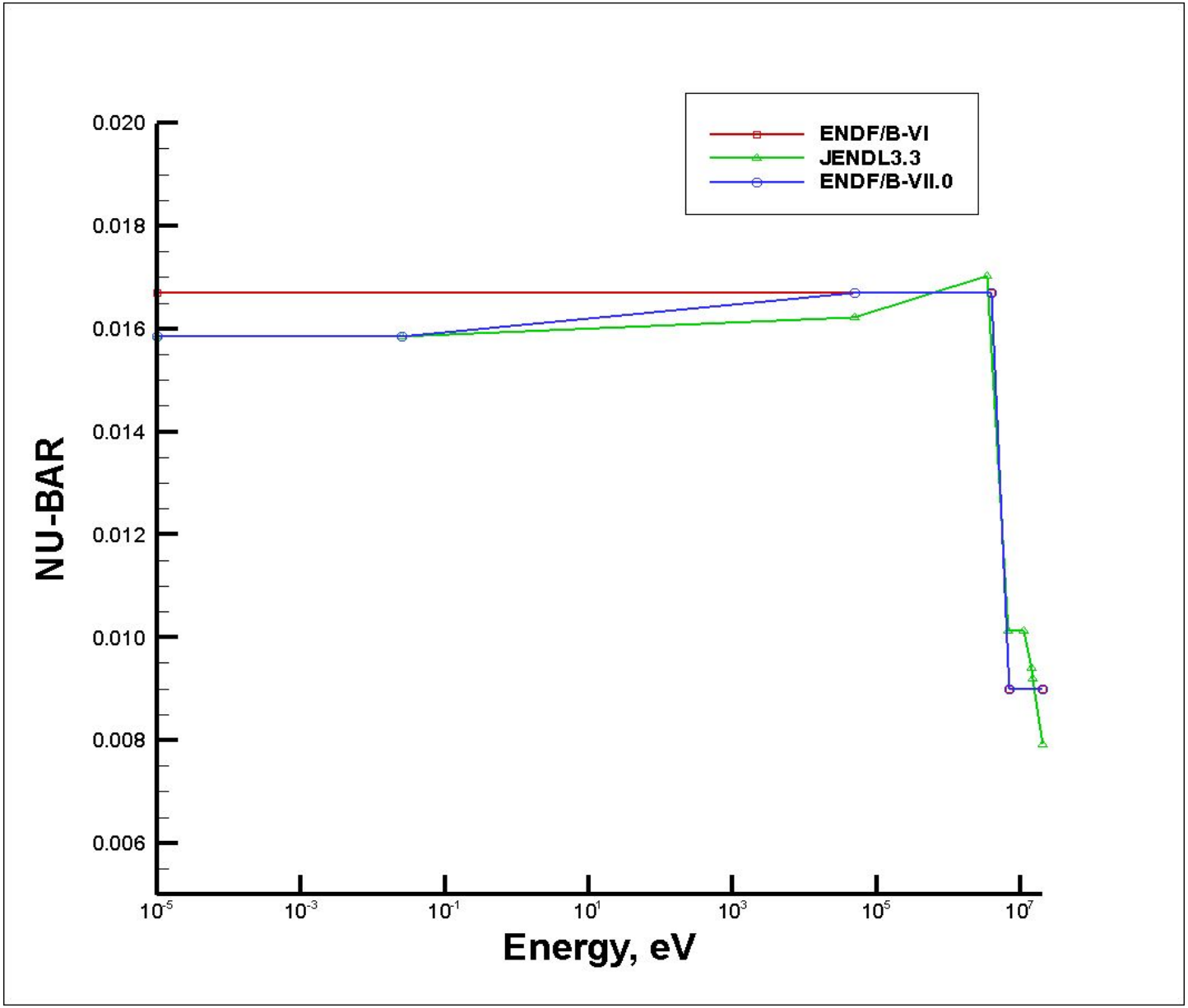
- Provides a rationale for allowing the thermal and fast values to differ.
- Idea accepted by JENDL3.3, WPEC Subgroup 6, JEFF3.1, and (probably) ANS19.9.
- Is consistent with the value used by commercial reactor vendors.

Adjustment Procedure for Delayed Nubar in ENDF/B-VII.0

- Used JENDL3.3 thermal value 0.01585, replacing ENDF/B-VI value, 0.0167. Close to the thermal Keepin value, 0.0158.
- Used JENDL3.3 linear ramp to 50 keV, then flat to 4 MeV.
- Kept ENDF/B-VI “fast” value (0.0167) from 50 keV to 4 MeV.

Adjustment Procedure for Delayed Nubar in ENDF/B-VII.0

- No change to ENDF/B-VI delayed nubar above 50 keV.
- Adjusted *prompt* nubar to preserve ENDF/B-VI *total* nubar, which was “tuned” to K1 by ORNL/Subgroup 18.


ENDF/B-VI
JENDL3.3
ENDF/B-VII.0
NU-BAR
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
10-5
10-3
10-1
101
103
105
107
Energy, eV

- A plot of what the fluctuating delayed nubar for U235 “really” looks like can be found in their Fort-Courcelle WONDER 2006 paper.

Effect on $\bar{\nu}$-Effective Calculations

- To a good approximation, $\bar{\nu}$-effective is proportional to

$$\bar{\nu} = \nu_d / \nu_t = \nu_d / [\nu_p + \nu_d]$$

- Steven van der Marck's calculations are consistent with this change.

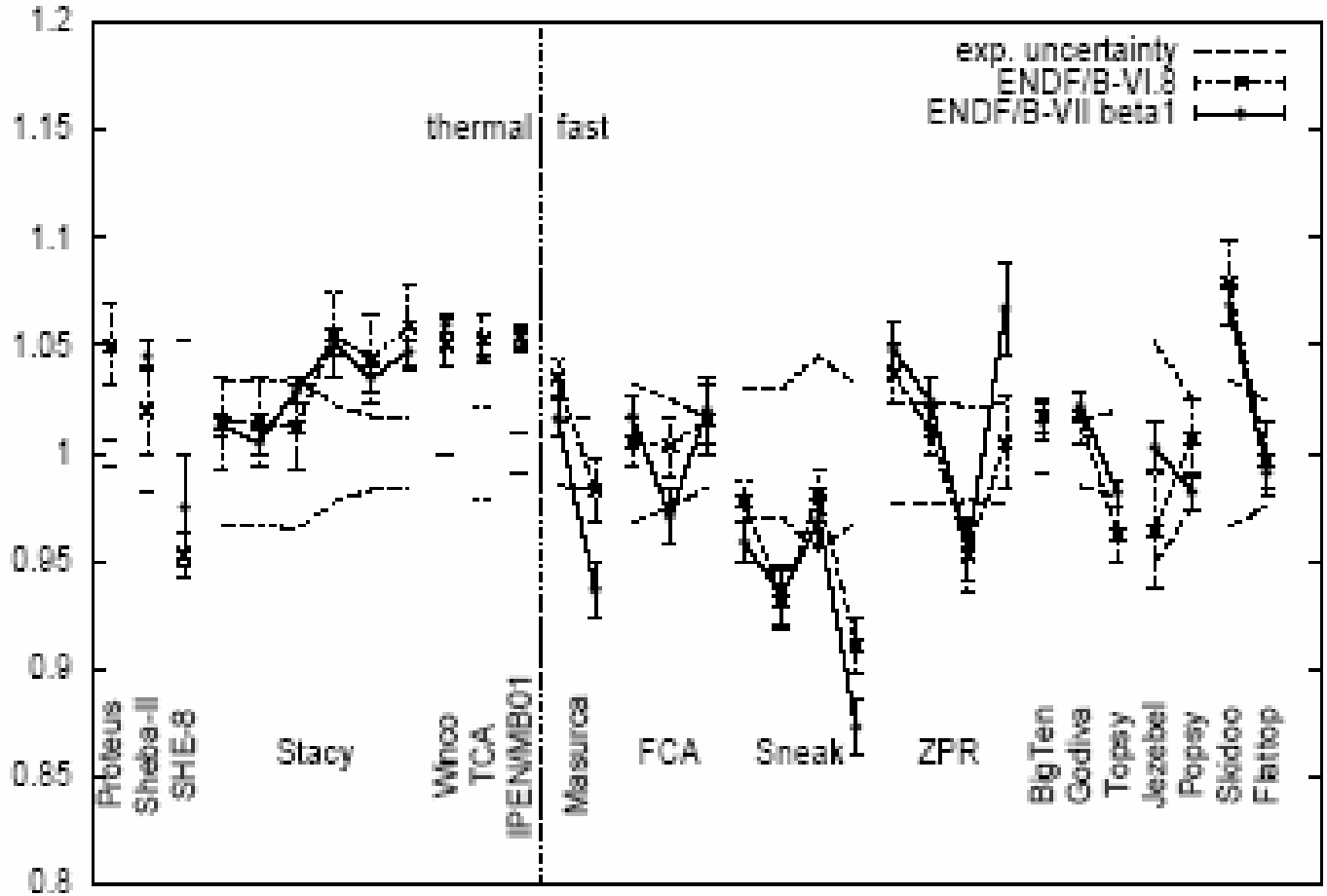


Figure 3.1 C/E for β_{eff} (or β_{eff}/l, see text) for many benchmark systems. The systems are roughly ordered with respect to the average energy at which fission takes place, from low energy (left) to high (right).

S. vanderMarck beta-effective calculations

We expect (0.0167-0.01585)/(0.0167)=5.4% reduction for thermal systems

The thermal cases are consistent with this expectation:

System	Expt	ENDF/B-VII.0	ENDF/B-VI.8	DIFF %
TCA	771pm17	0.998pm0.002	1.053pm0.011	5.2
IPEN/MB-01	742pm 7	1.008pm0.005	1.054pm0.005	4.4

S. vanderMarck beta-effective calculations

We expect a smaller change for fast systems

The fast cases are consistent (?) with this expectation:

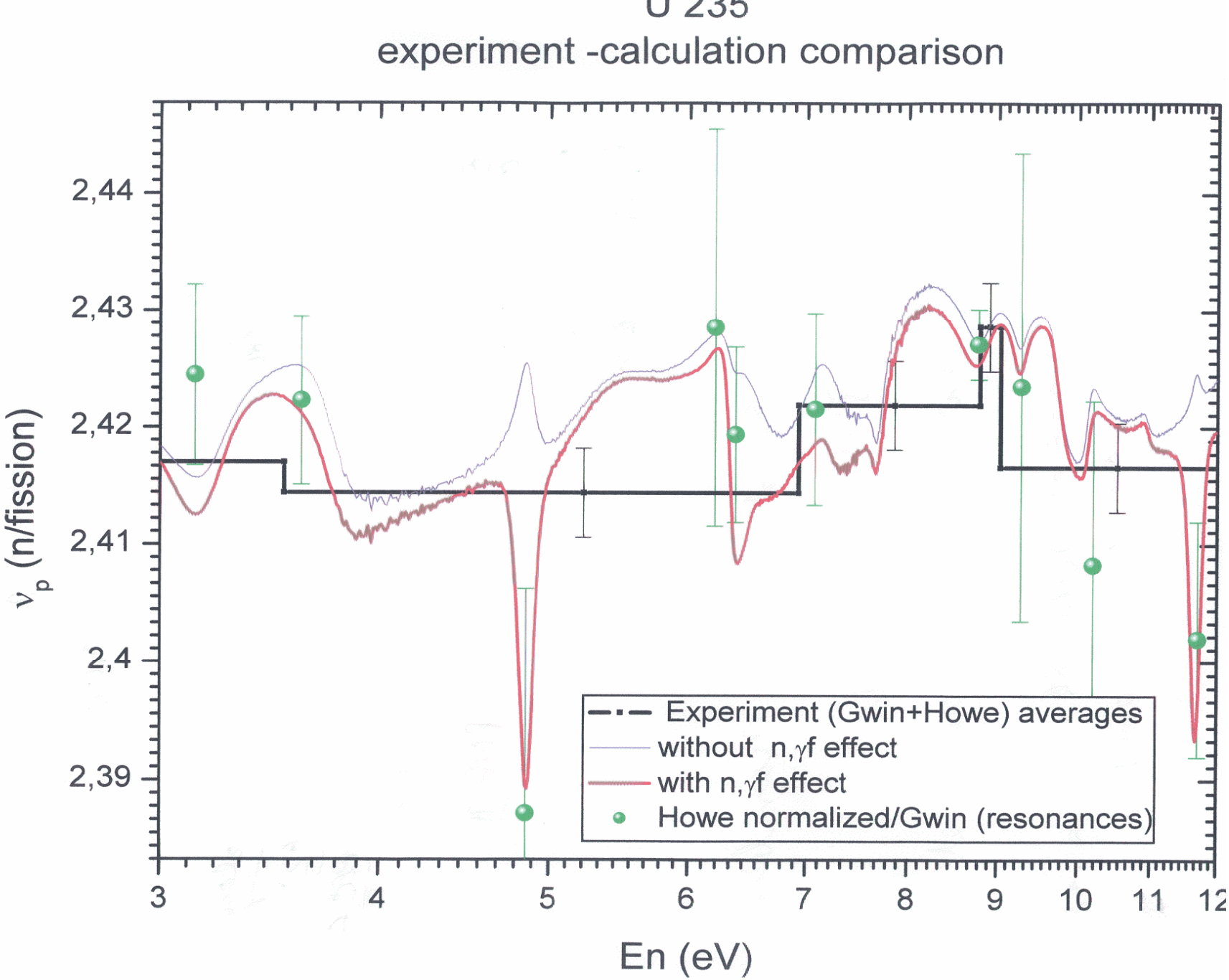
System	Expt	ENDF/B-VII.0	ENDF/B-VI.8	DIFF %
Masurca R2	721pm11	1.012pm0.009	1.035pm0.009	2.2
Masurca ZONA2	349pm 6	0.973pm0.013	0.983pm0.015	10.2
FCA XIX-1	742pm24	0.987pm0.010	1.005pm0.011	1.8
FCA XIX-2	364pm 9	1.010pm0.013	1.003pm0.014	-0.7
FCA XIX-3	251pm 4	0.981pm0.017	1.016pm0.016	3.4

Conclusions and Recommendation

- Reduction of thermal delayed nubar improves thermal k-effective calculations and brings ENDF into closer alignment with other databases and commercial experience.
- Let's wait for ANS19.9 to finish before tackling any mods to the higher energy values.

A Related Issue

- At WONDER-2006, Fort and Courcelle presented an energy-dependent *prompt* nubar calculation for U235, based on the same multimodal theory, plus n,γf.
- This has potential significance for reactivity calculations of thermal benchmarks. Could reduce some of the spread in the C/E data.


U 235
experiment -calculation comparison
2,44
2,43
2,42
2,41
2,4
2,39
ν_p (n/fission)
3
4
5
6
7
8
9
10
11
12
En (eV)
Experiment (Gwin+Howe) averages
without n,γf effect
with n,γf effect
Howe normalized/Gwin (resonances)

An Unrelated Issue

- At WONDER-2006, Ron Dagan (KFK) showed a significant effect on fuel-cycle burnup, from using the free-gas model for the heavy nuclides and allowing them to upscatter.
- If you want to follow this thread, sign up for the UEVAL mailing list.