

Variations in Computed Neutron Multiplication of Deuterium Moderated Highly Enriched Uranium Systems

R. G. Taylor and D. F. Hollenbach

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Data Analysis in Nuclear Criticality Safety - II

Methodology and Observations

- Performing comprehensive, general validation of SCALE6.1/KENO V.a
 - v7-238 (ENDF/B-VII) cross sections
 - Execute each case specifying $\sigma = 0.0001$
- Noticed ~1% or more difference between v5-238 (ENDF/B-V) and v7-238 (ENDF/B-VII) cross sections for heavy water moderated and reflected high ^{235}U enrichment systems

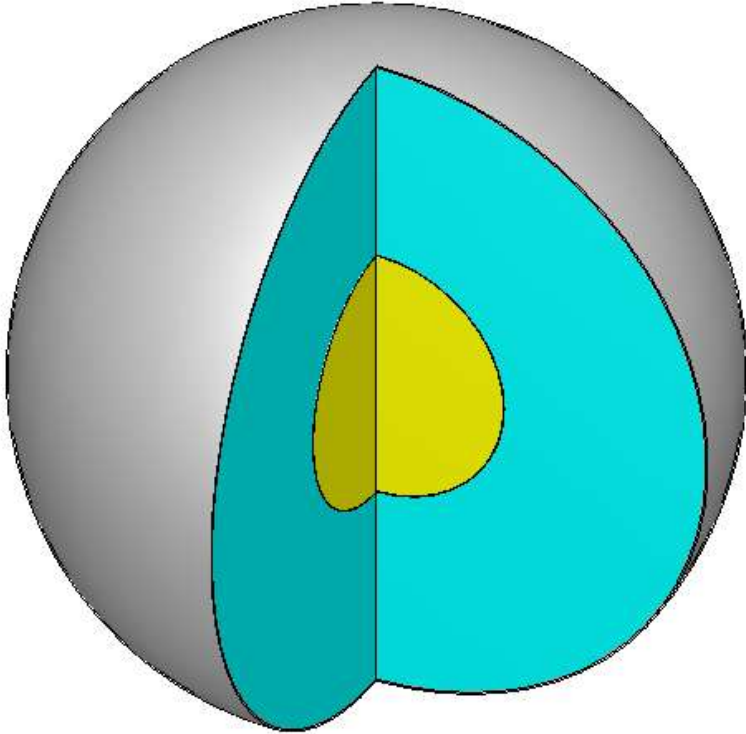
Reference Evaluations

- International Handbook of Evaluated Criticality Safety Benchmark Experiments
 - HEU-SOL-THERM-004:
 - Reflected Uranyl-Fluoride Solutions in Heavy Water
 - HEU-SOL-THERM-020:
 - Unreflected Cylinders of Uranyl-Fluoride Solutions in Heavy Water
- Both evaluations remark upon differences in results between ENDF/B-V and ENDF/B-VI cross sections
- Various reports of issues with and changes to ENDF/B cross sections for deuterium

Piqued Curiosity

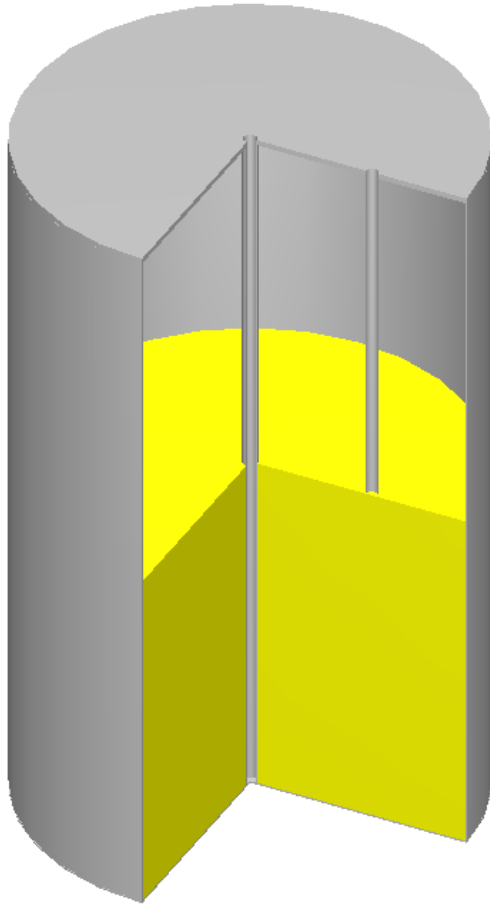
- Explore using various codes
 - SCALE6.1/KENO V.a
 - The code being validated
 - Various ENDF/B cross section sets available
 - MCNP5
 - Used for various previous works
 - Various ENDF/B cross section sets available
 - $S(\alpha, \beta)$ scattering available
 - Easy to select/mix cross sections

HEU-SOL-THERM-004



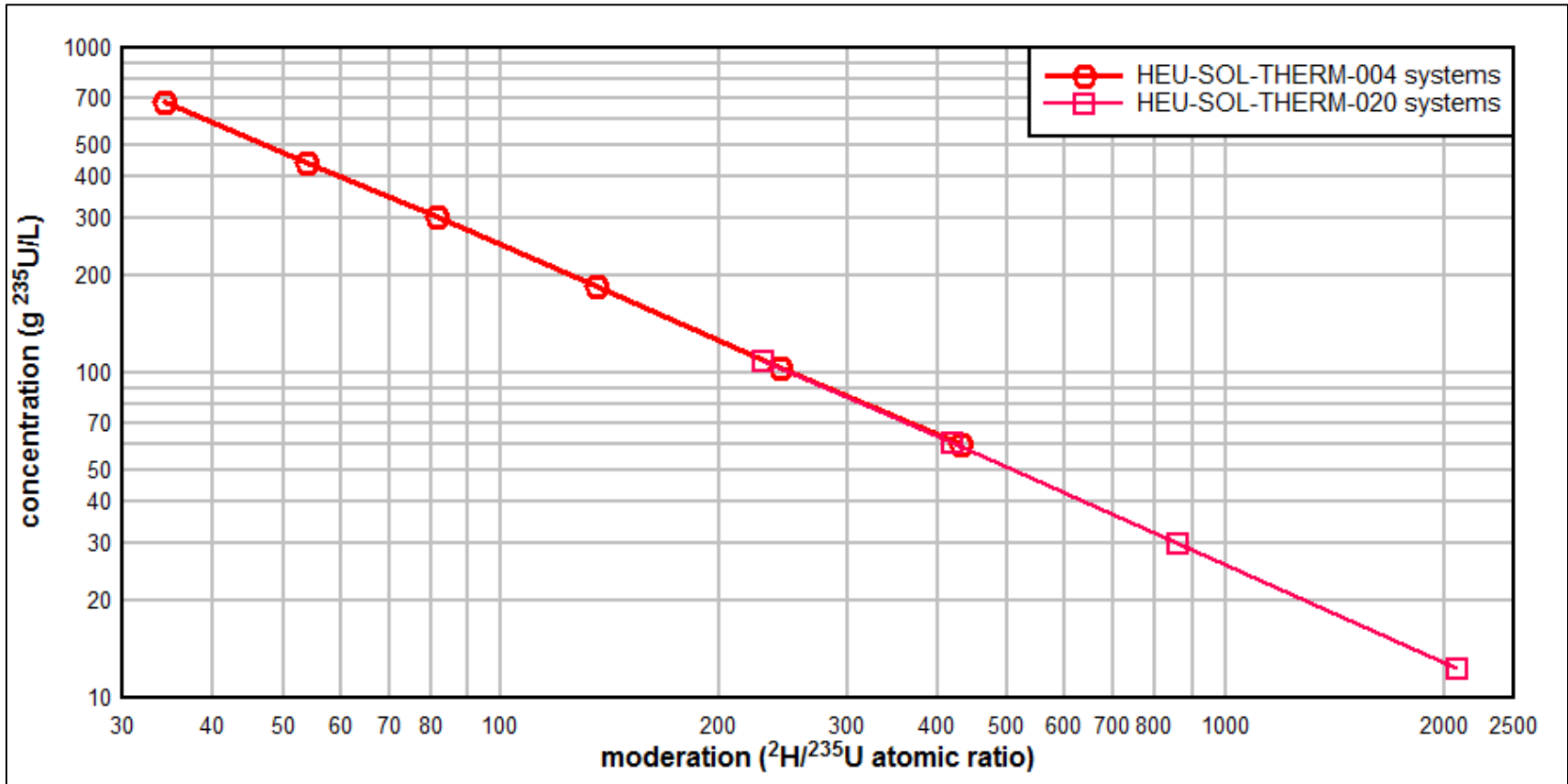
concentration (g ²³⁵ U/L)	moderation (² H/ ²³⁵ U)
679	34.2
443	53.7
302	81.2
185	135.3
104	243
60	431

HEU-SOL-THERM-020



concentration	moderation
(g ²³⁵U/L)	(²H/²³⁵U)
109.4	230
61	419
30.1	856
12.4	2081

Concentration/Moderation Span



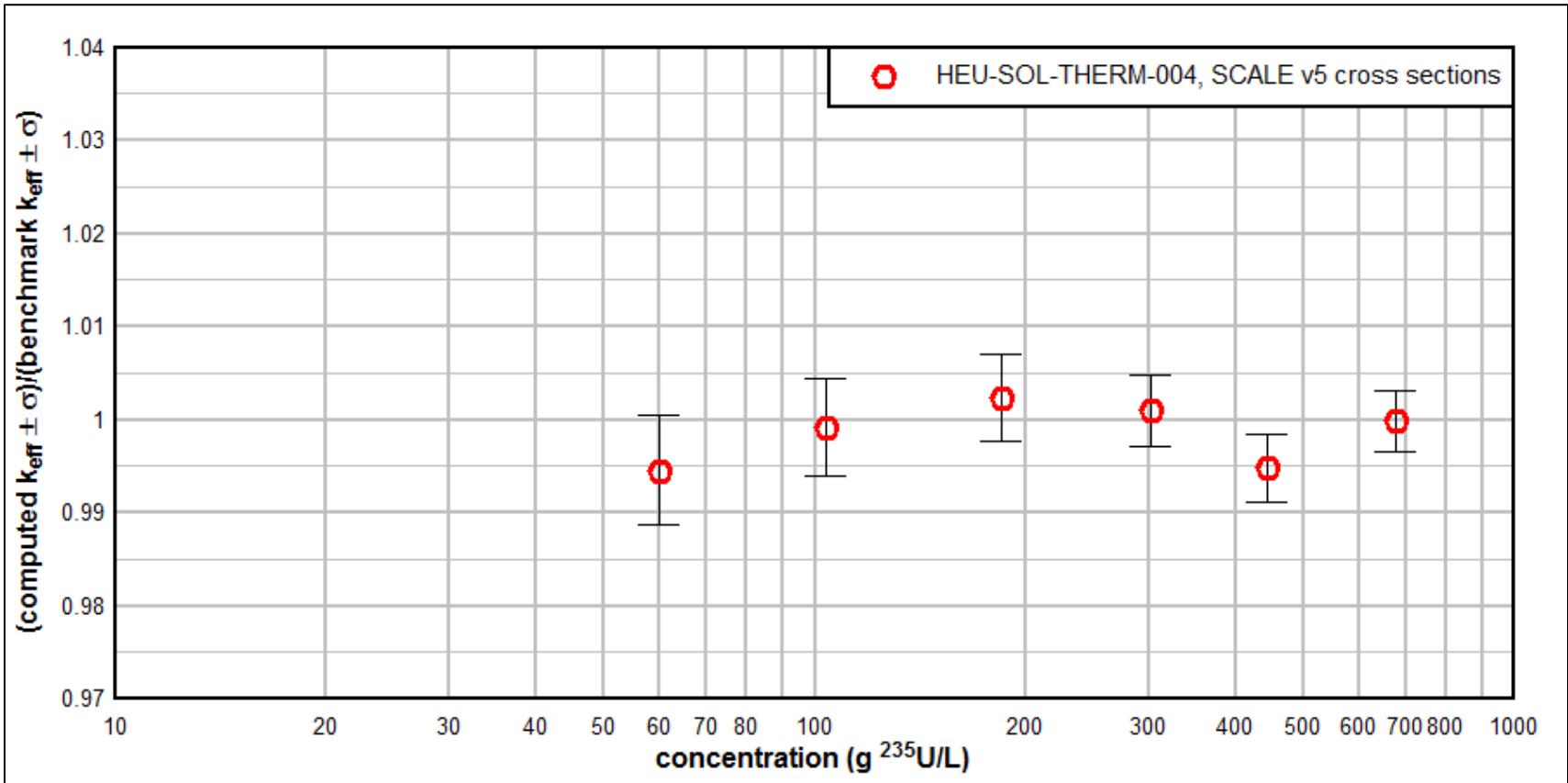
Benchmark Particulars

	HEU-SOL-THERM-004						HEU-SOL-THERM-020				
case no.	1	2	3	4	5	6	1	2	3	4	5
concentration (g ²³⁵ U/L)	679	443	302	185	104	60	109.4	61	30.1	30.1	12.4
² H/ ²³⁵ U atom ratio	34.2	53.7	81.2	135.3	243	431	230	419	856	856	2081
benchmark k _{eff}	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9966	0.9956	0.9957	0.9955	0.9959
benchmark uncertainty	0.0033	0.0036	0.0039	0.0046	0.0052	0.0059	0.0058	0.0047	0.0040	0.0039	0.0039

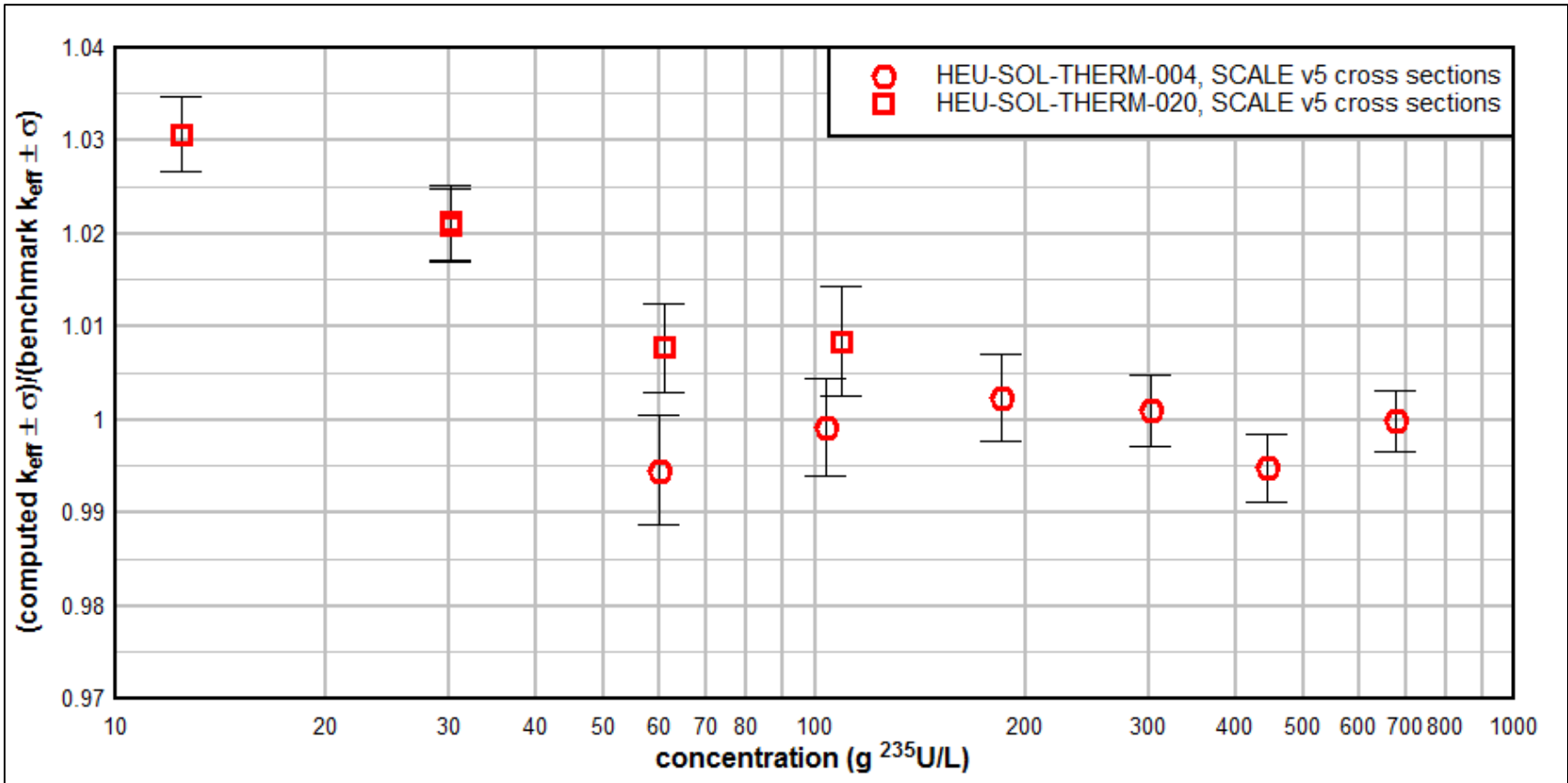
Correspondences

SCALE6.1	MCNP5
V5-238 ENDF/B-V	.50c B-V.0 (^2H & ^{235}U) .01t endf5
V6-238 ENDF/B-VI release 8	.60c B-VI.0 (^2H), B-VI.2 (^{235}U) .60t endf6.3
V7-238 ENDF/B-VII release 0	.70c B-VII.0 (^2H & ^{235}U) .10t endf7.0

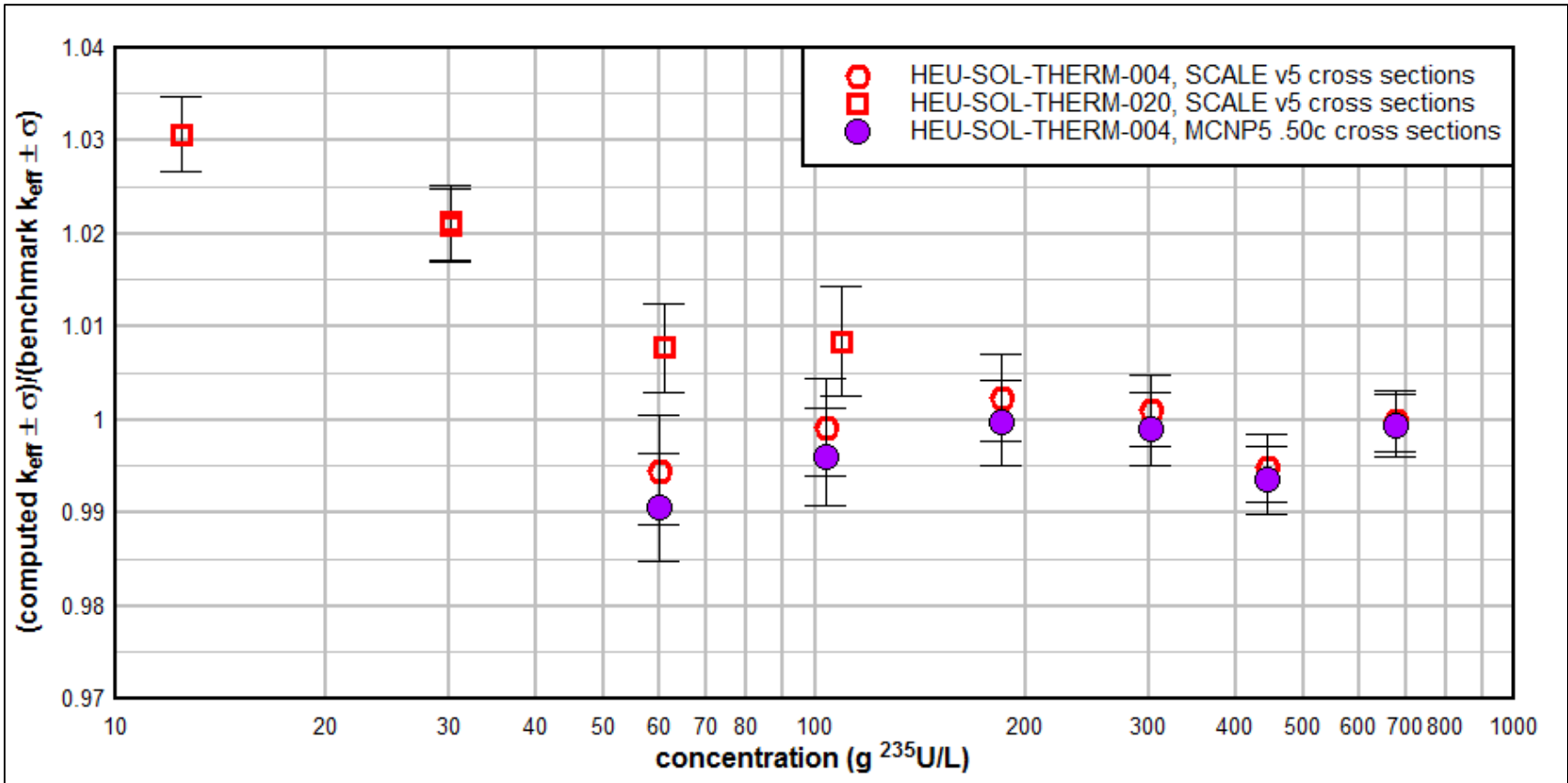
ENDF/B-V



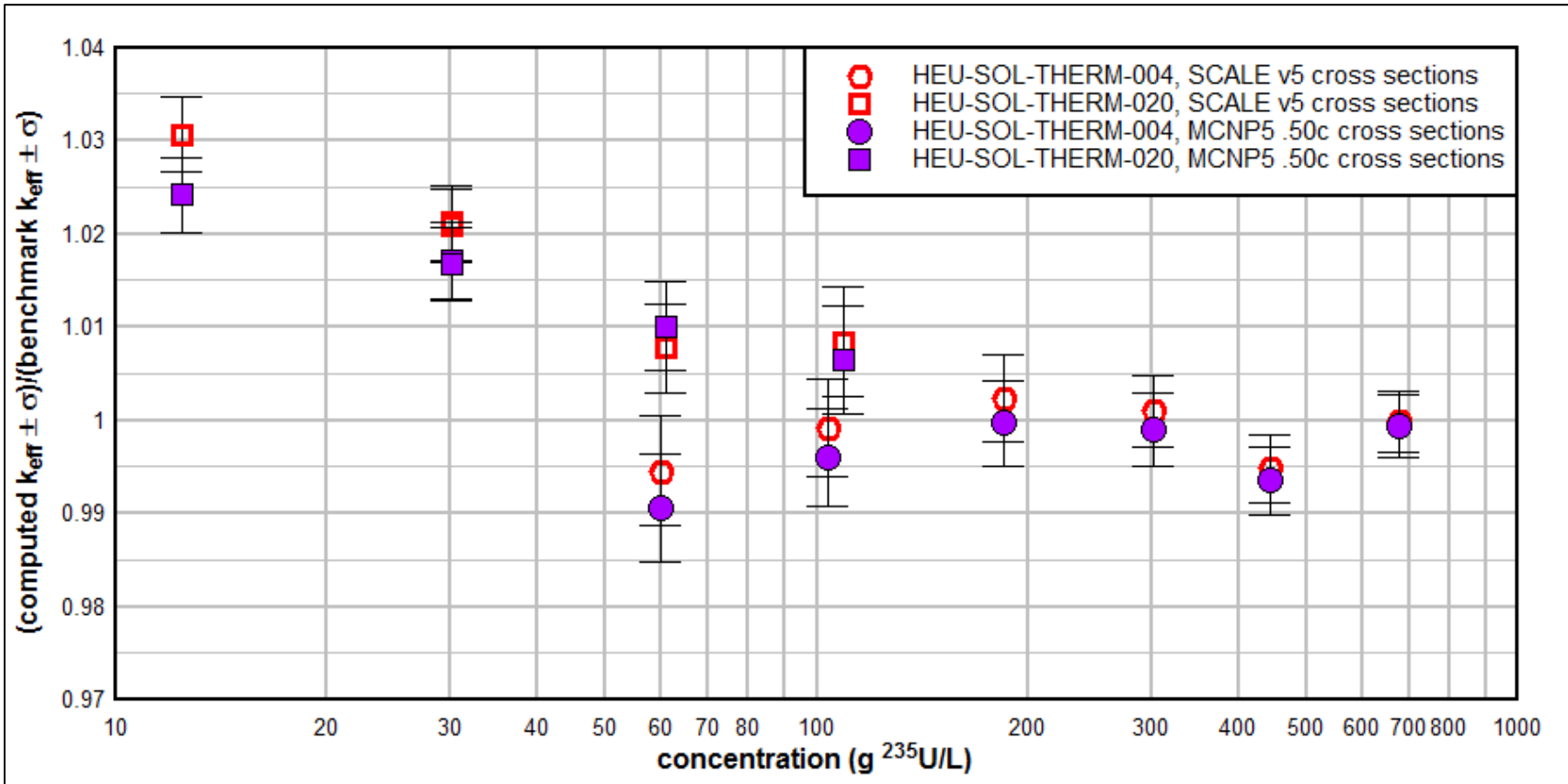
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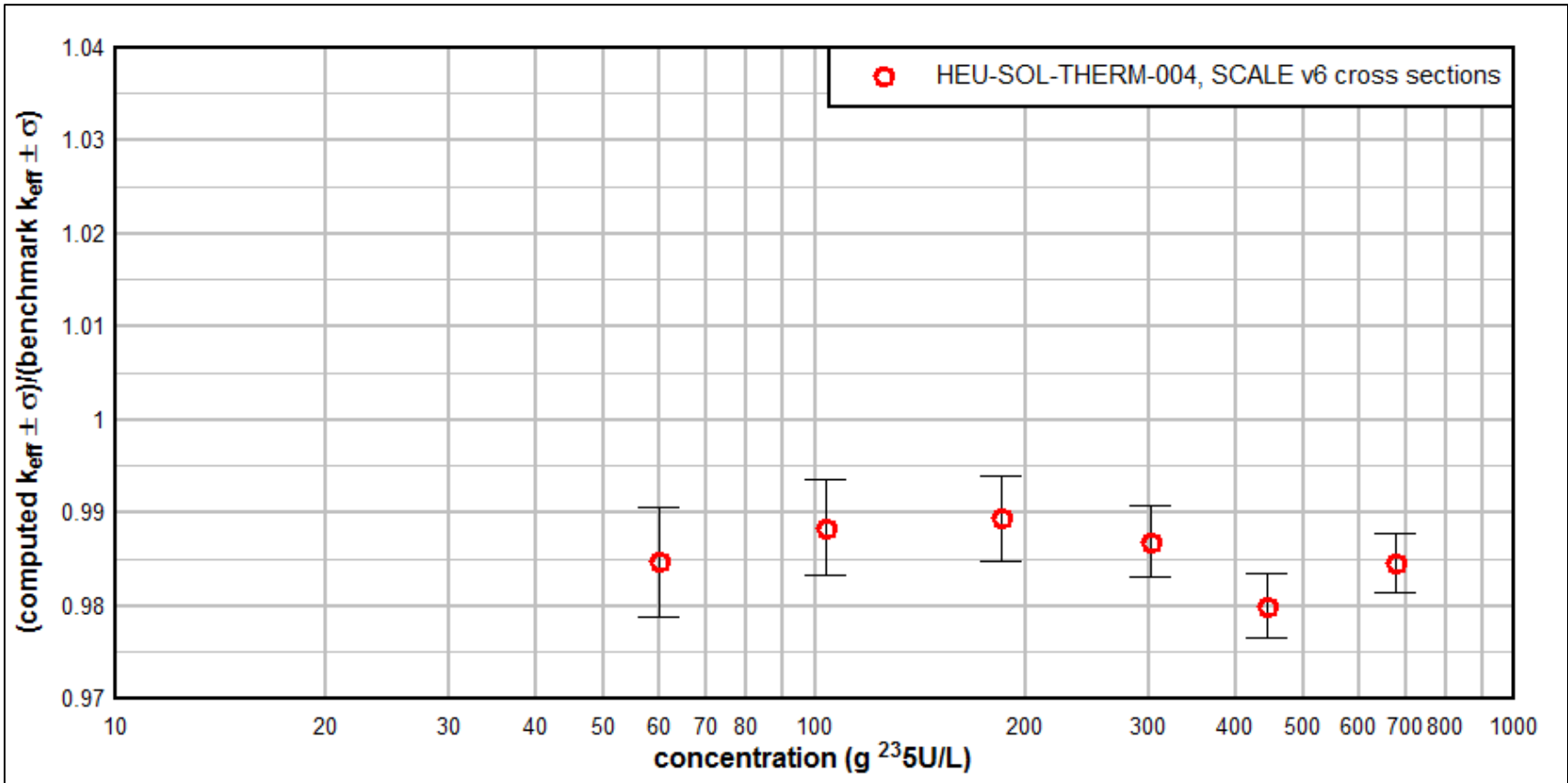
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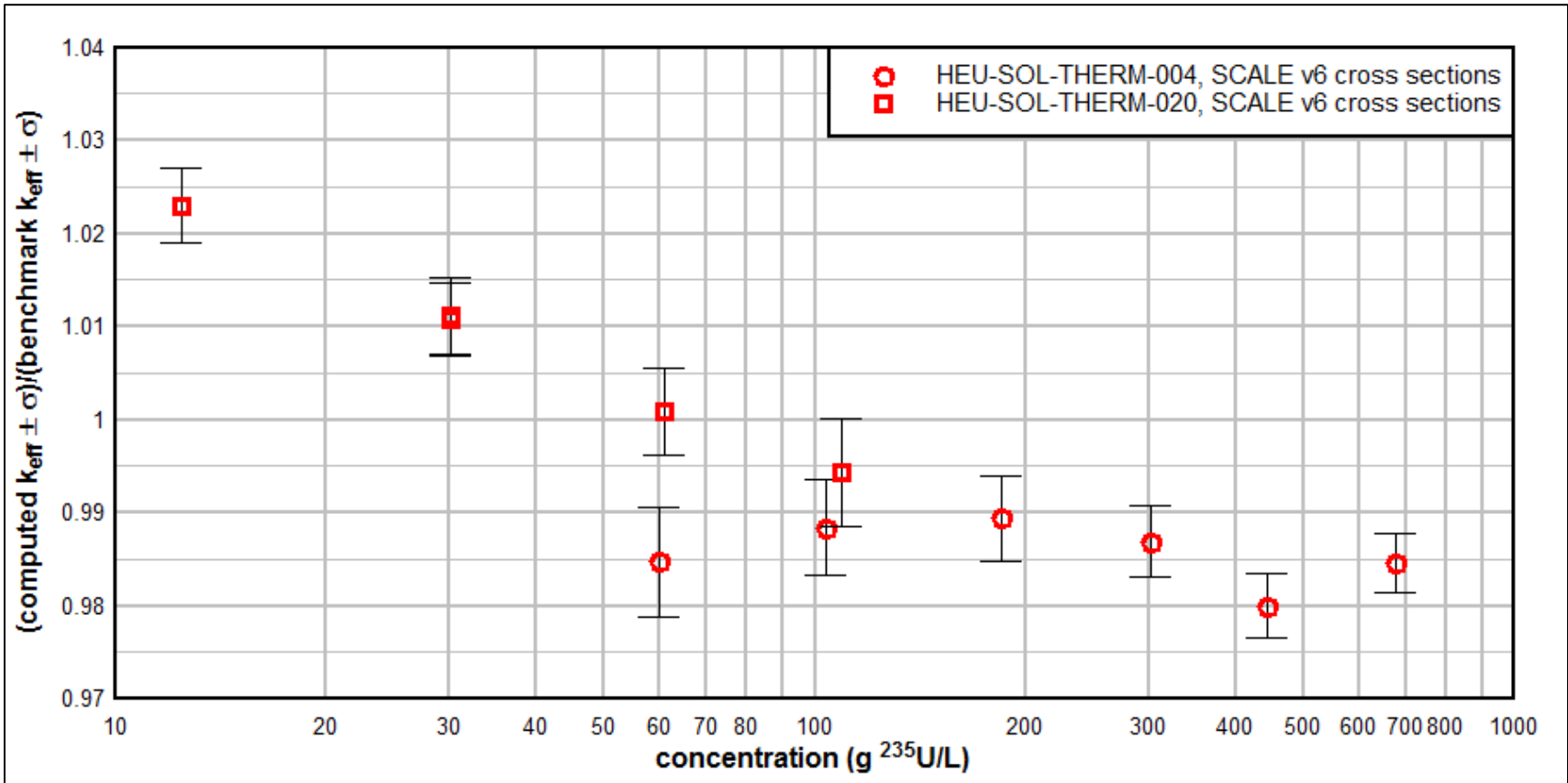
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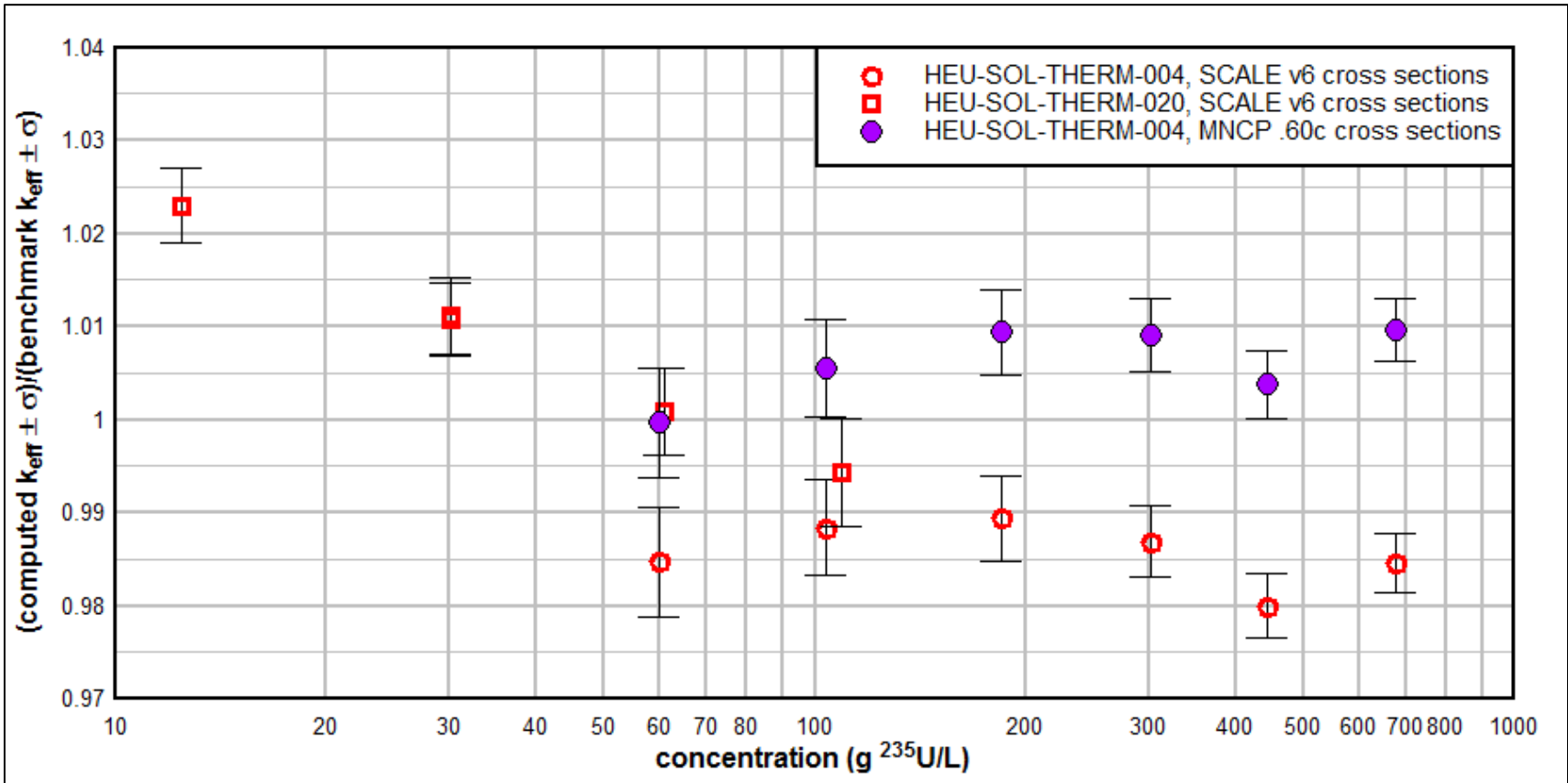
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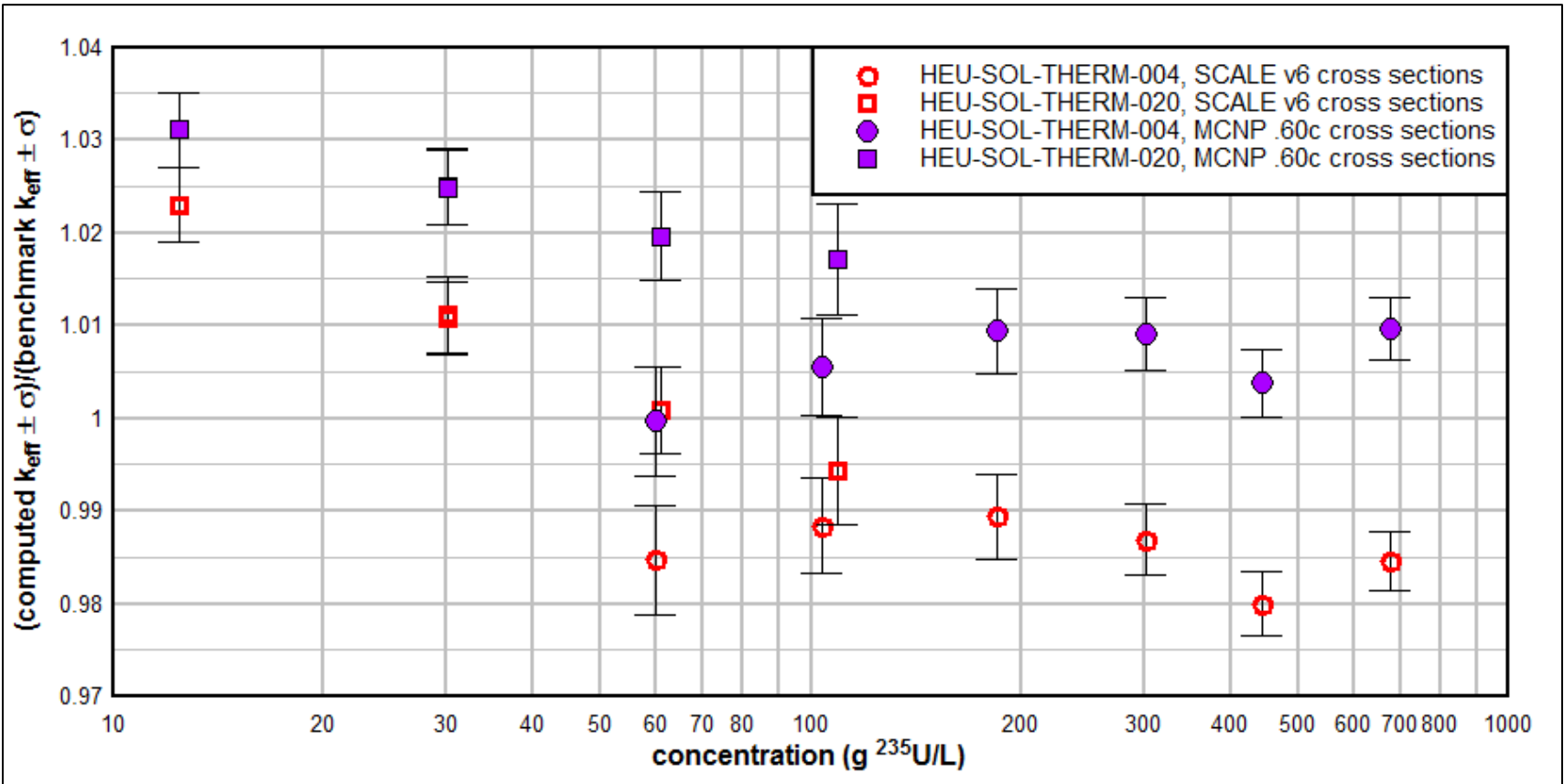
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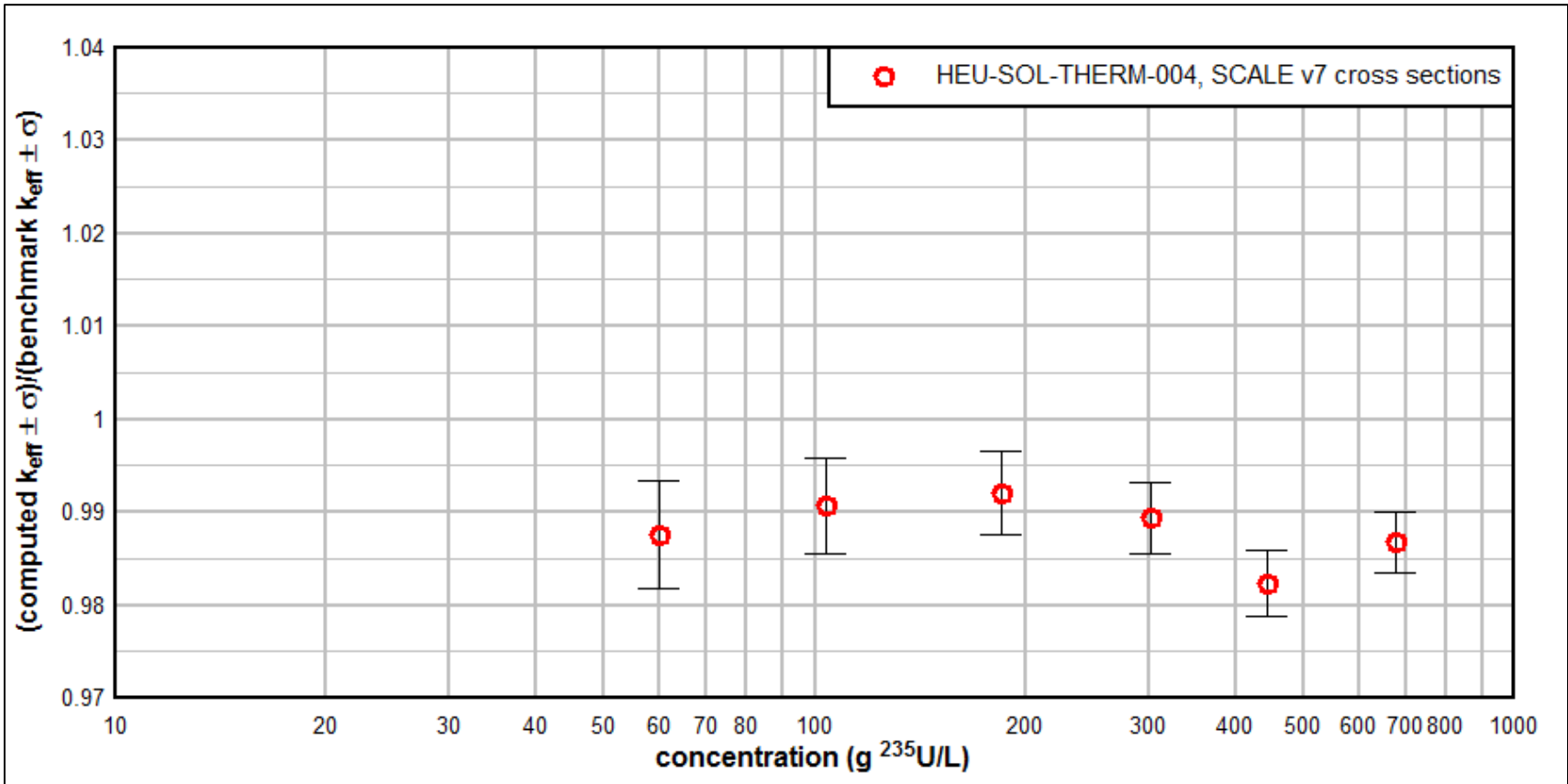
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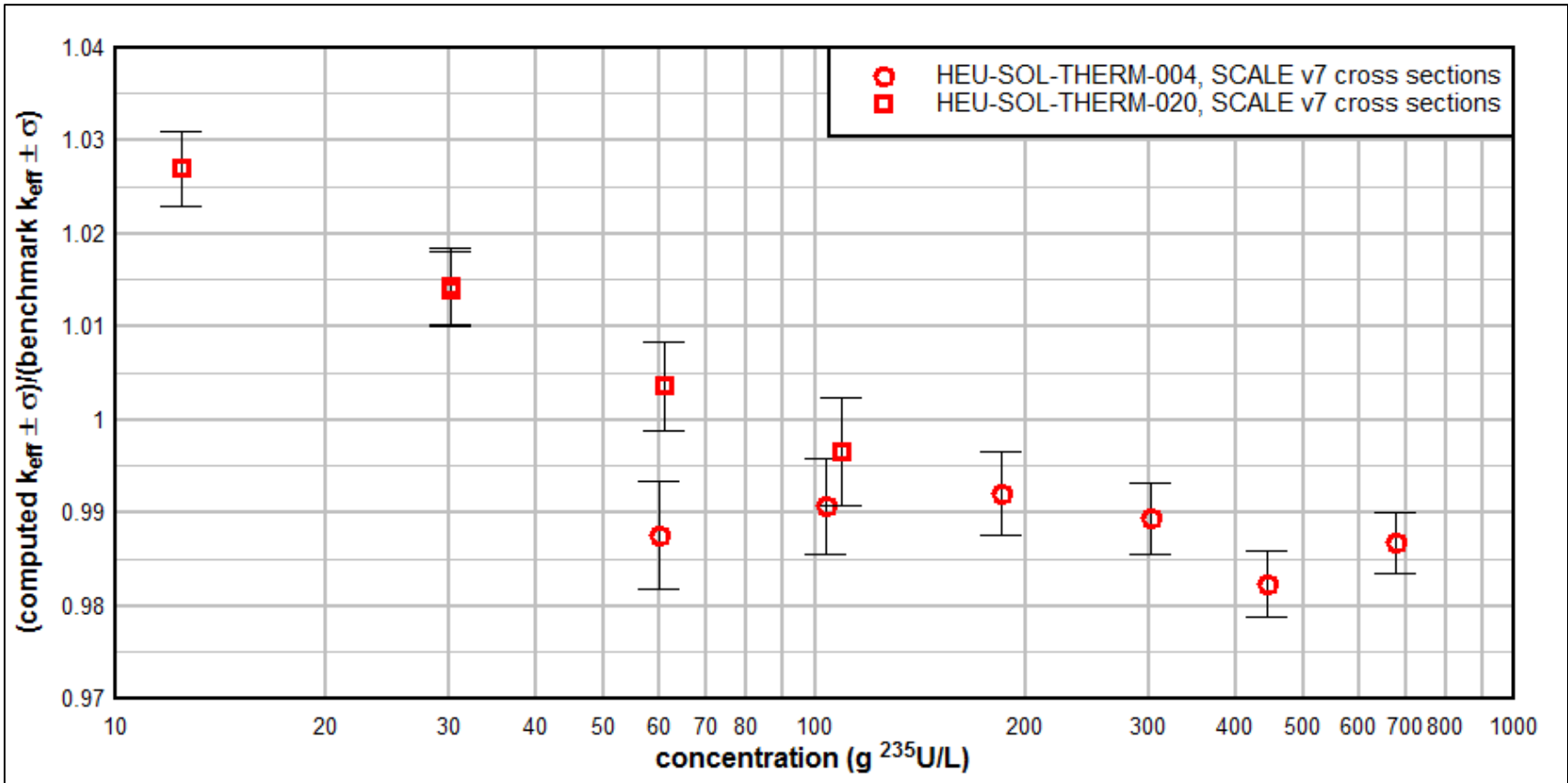
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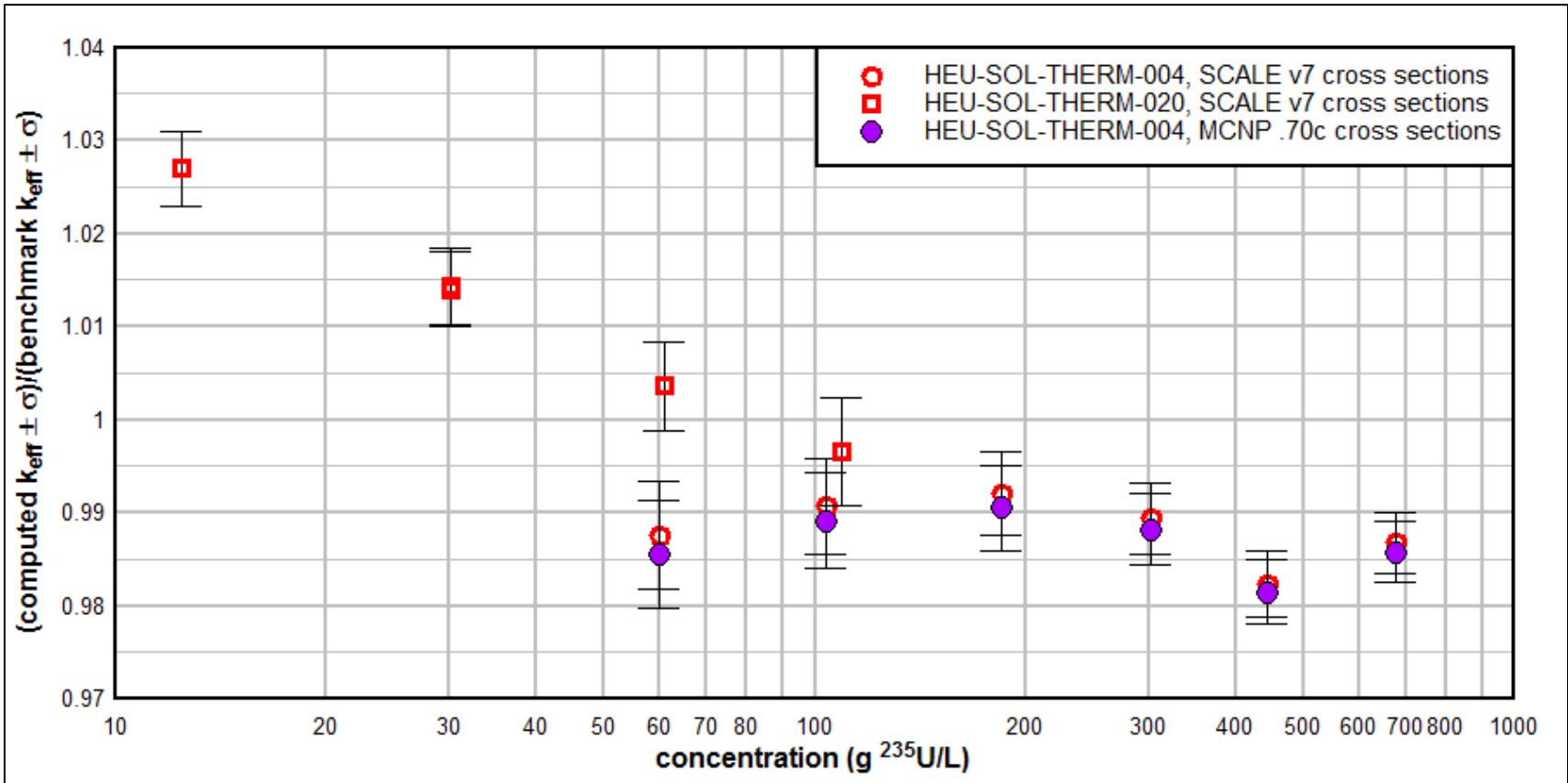
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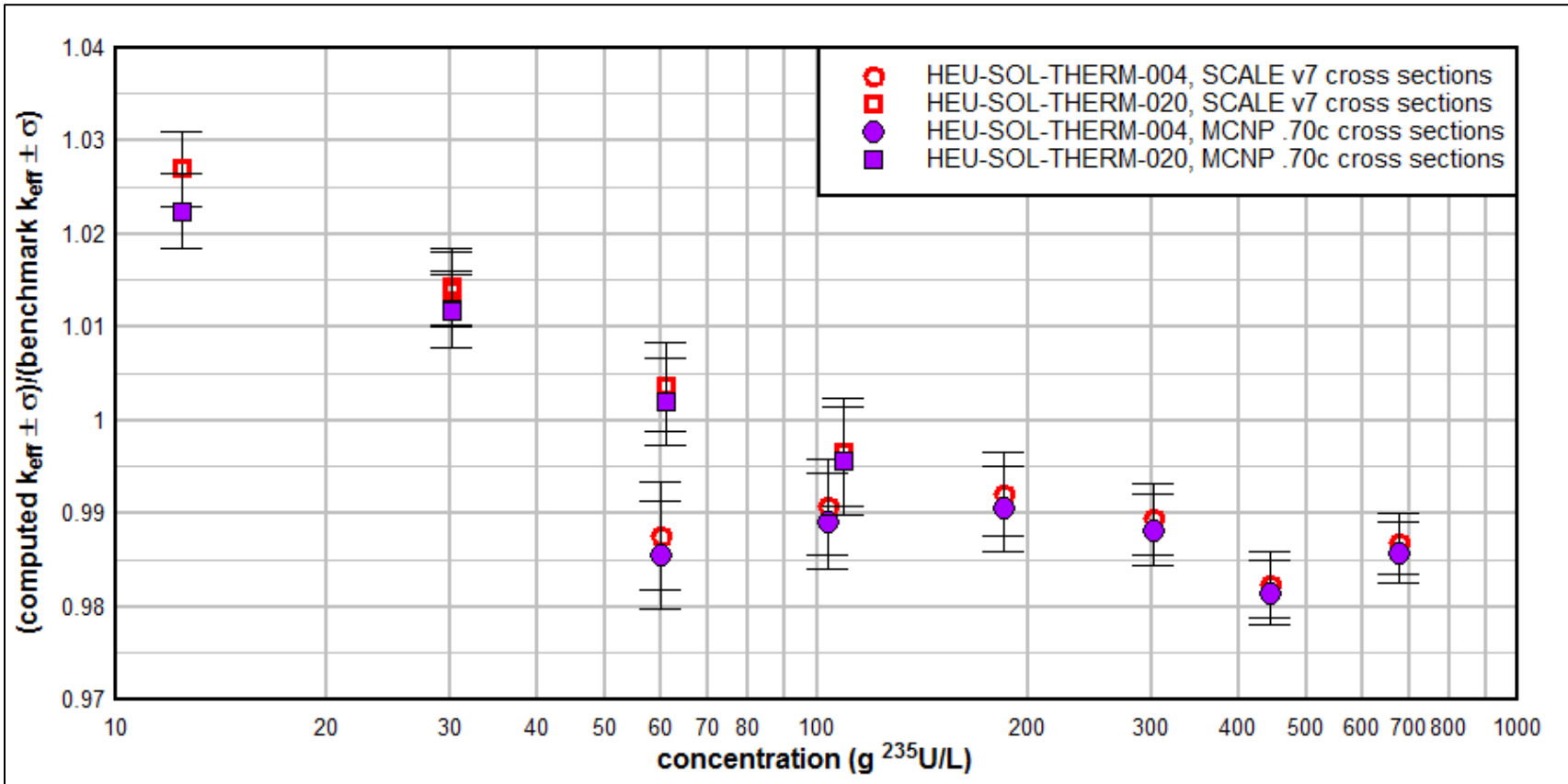
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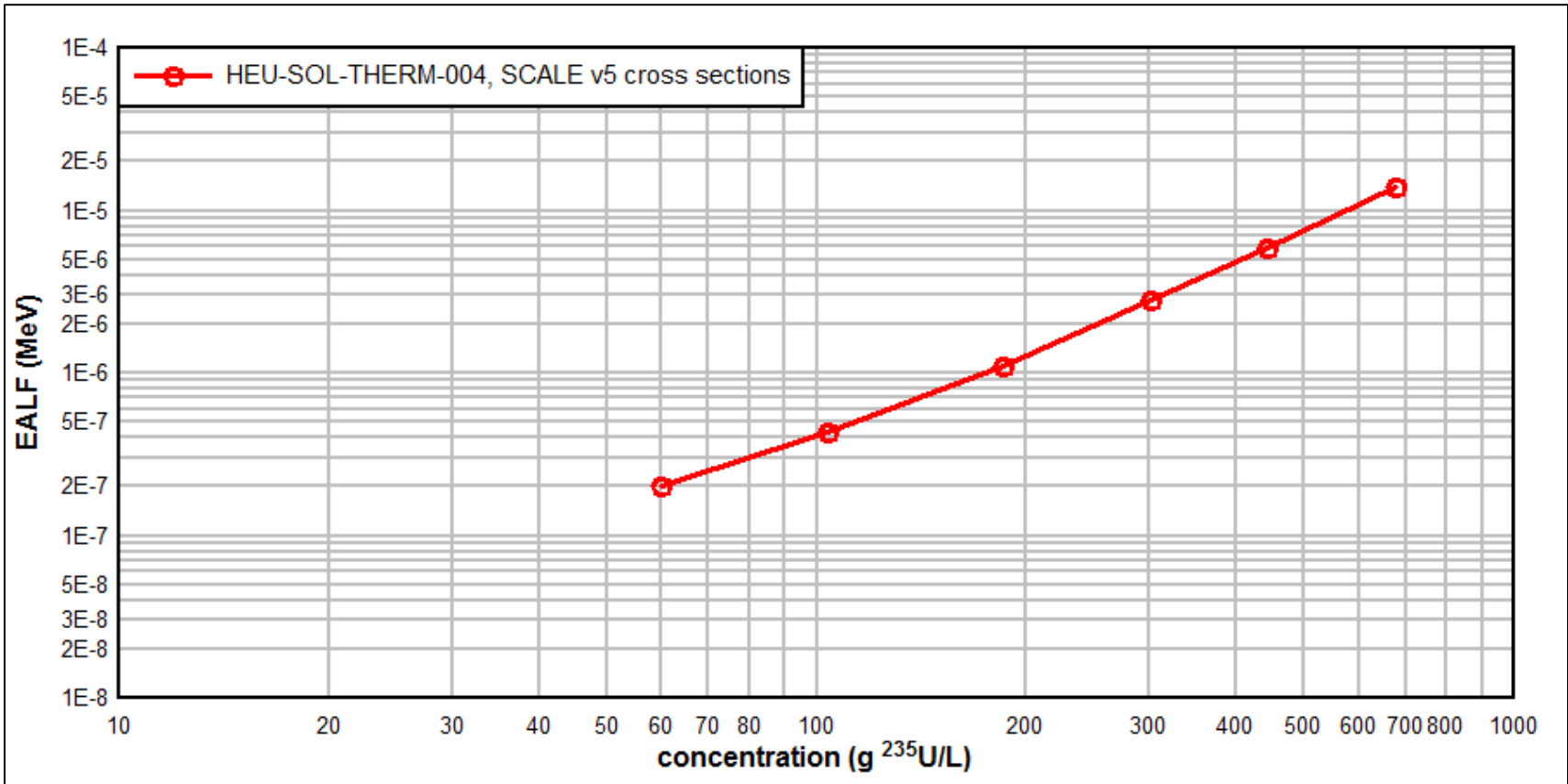
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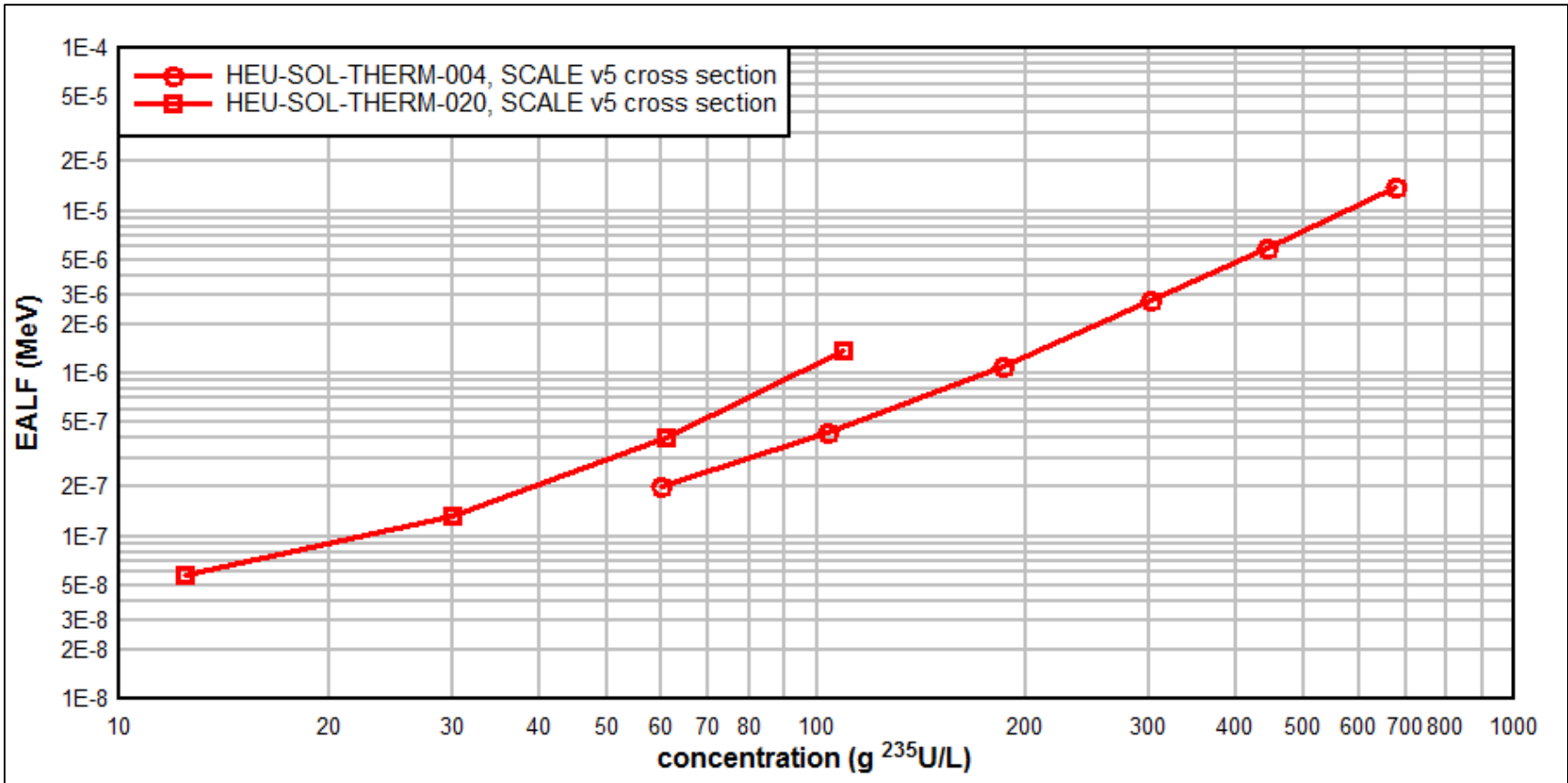
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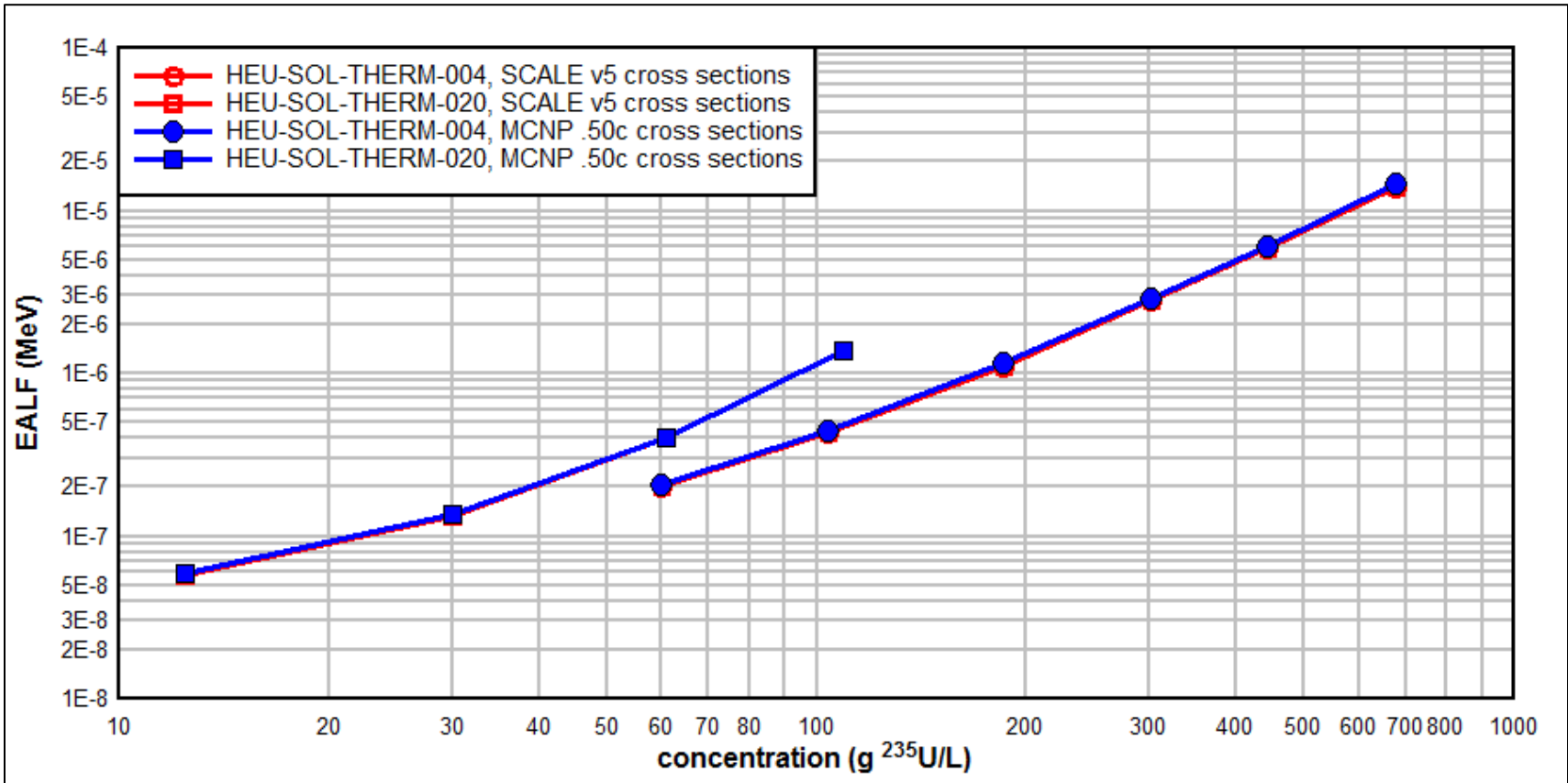
ENDF/B-V EALF



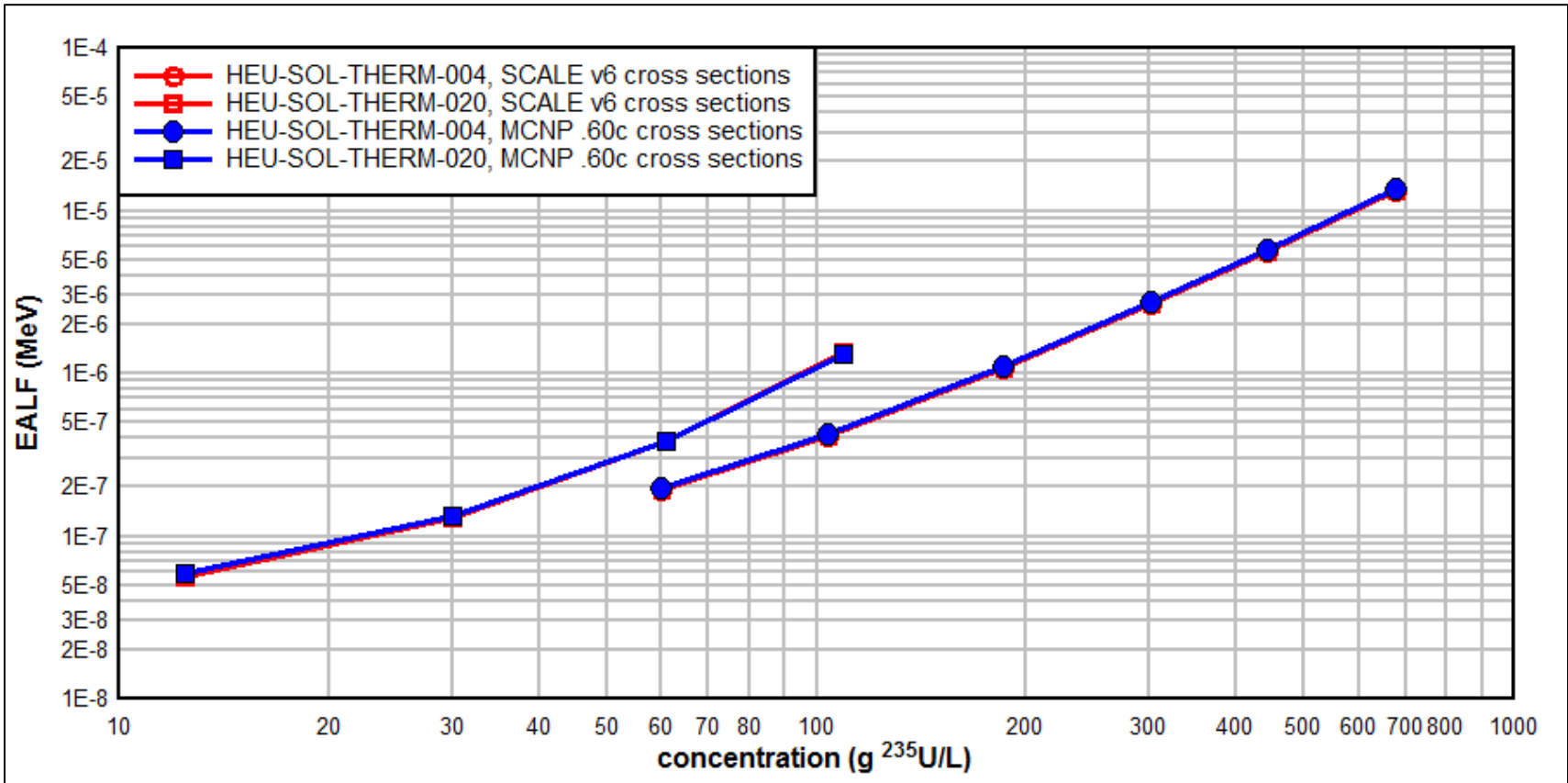
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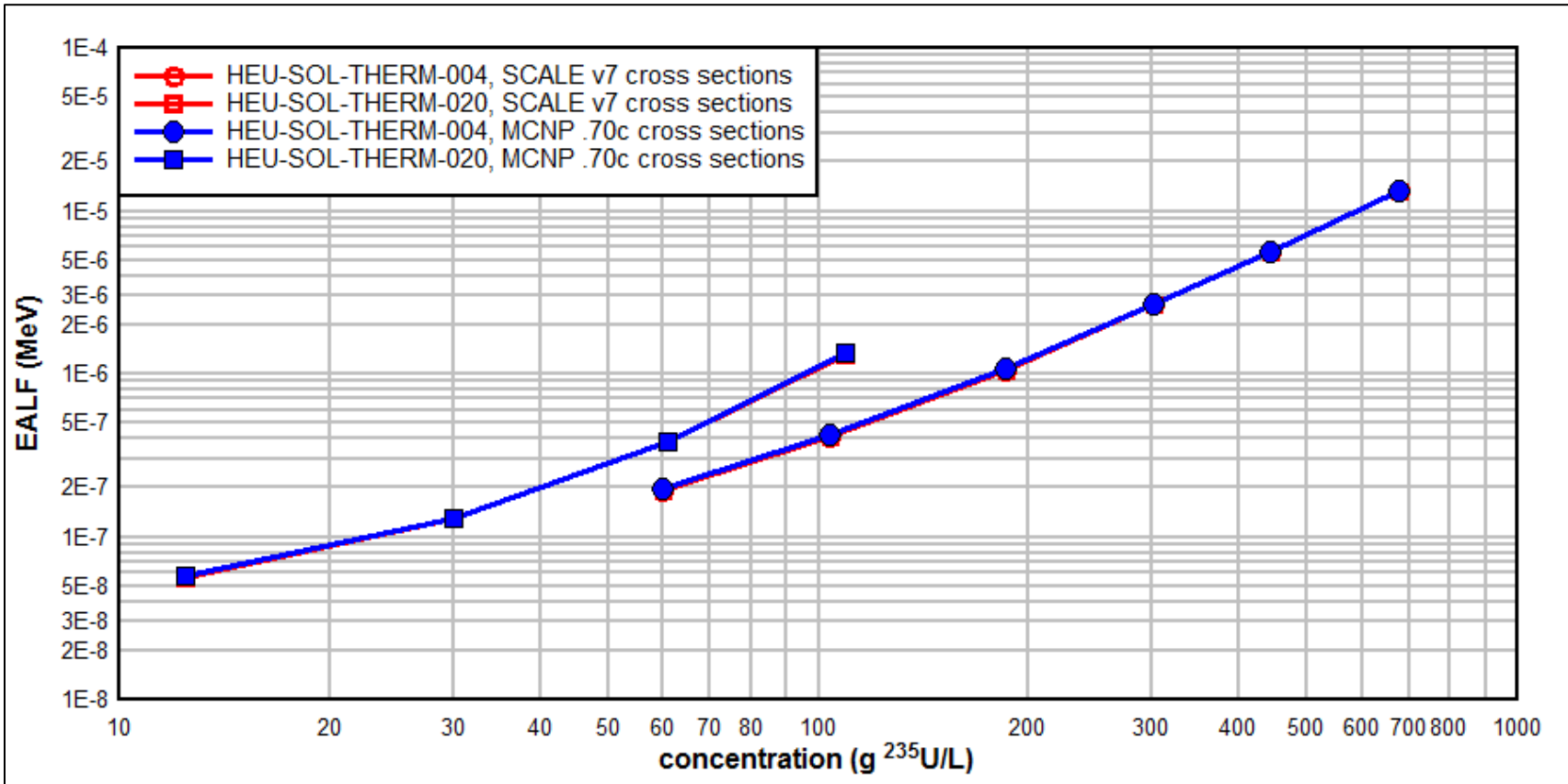
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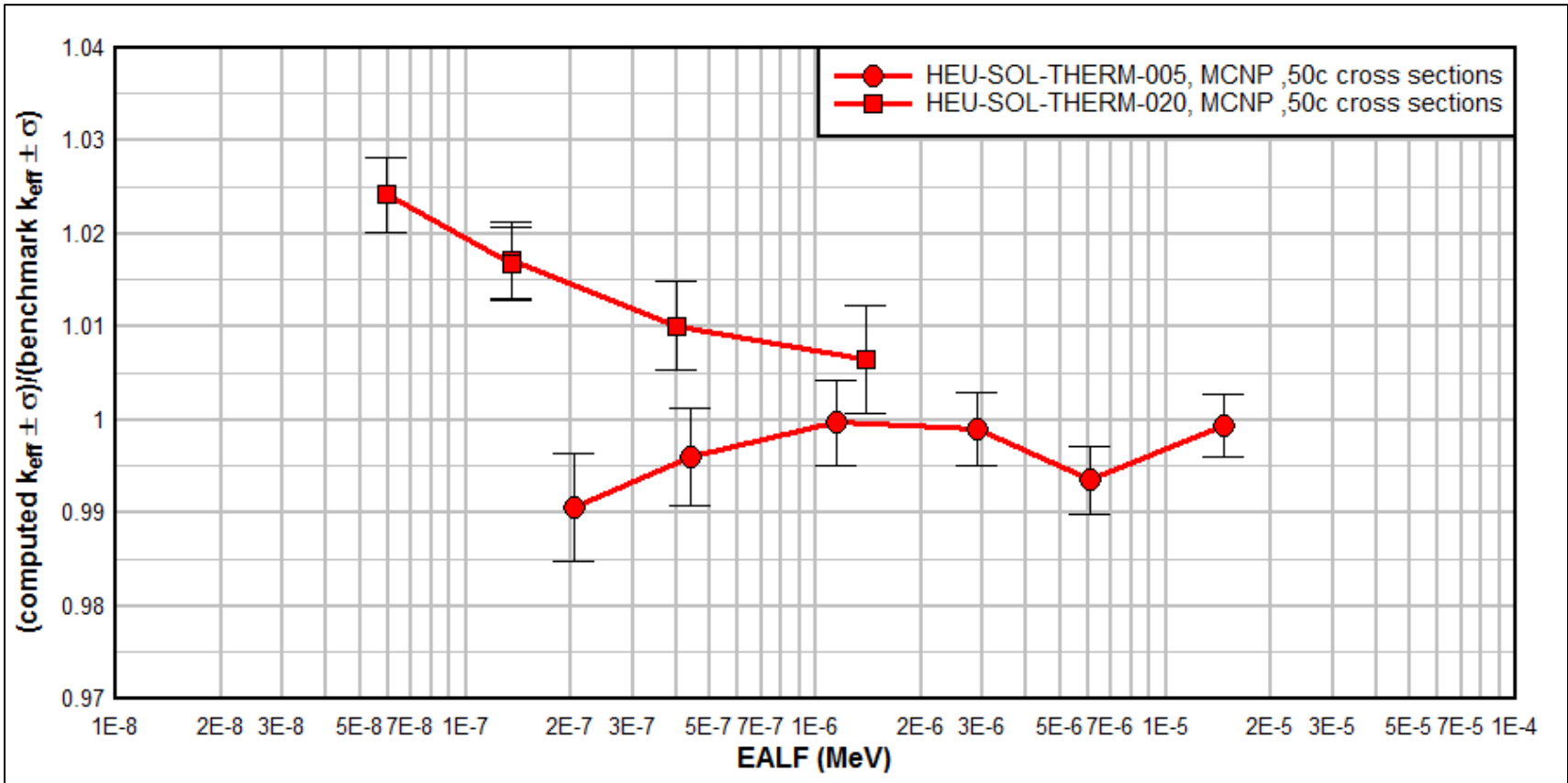
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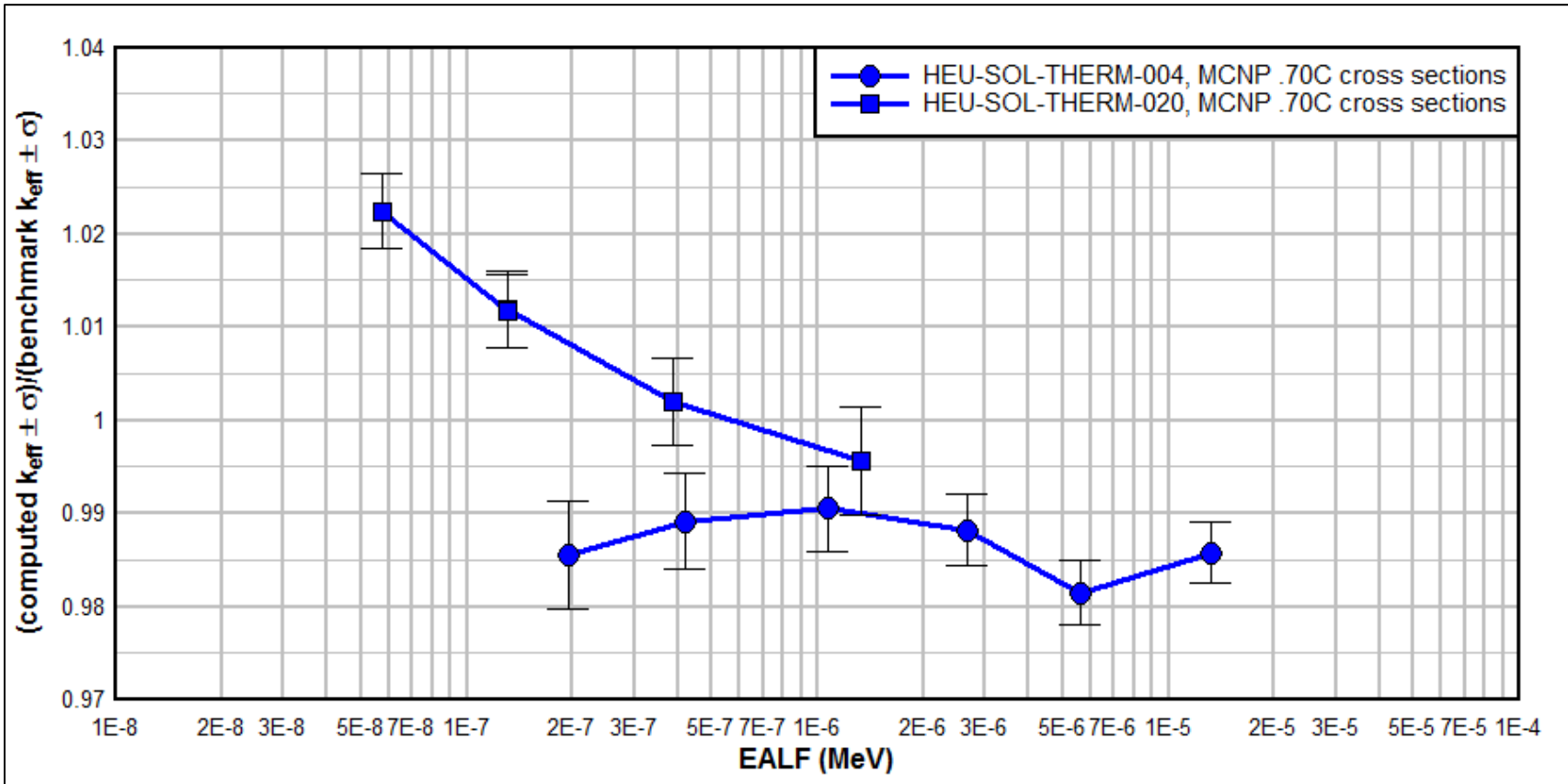
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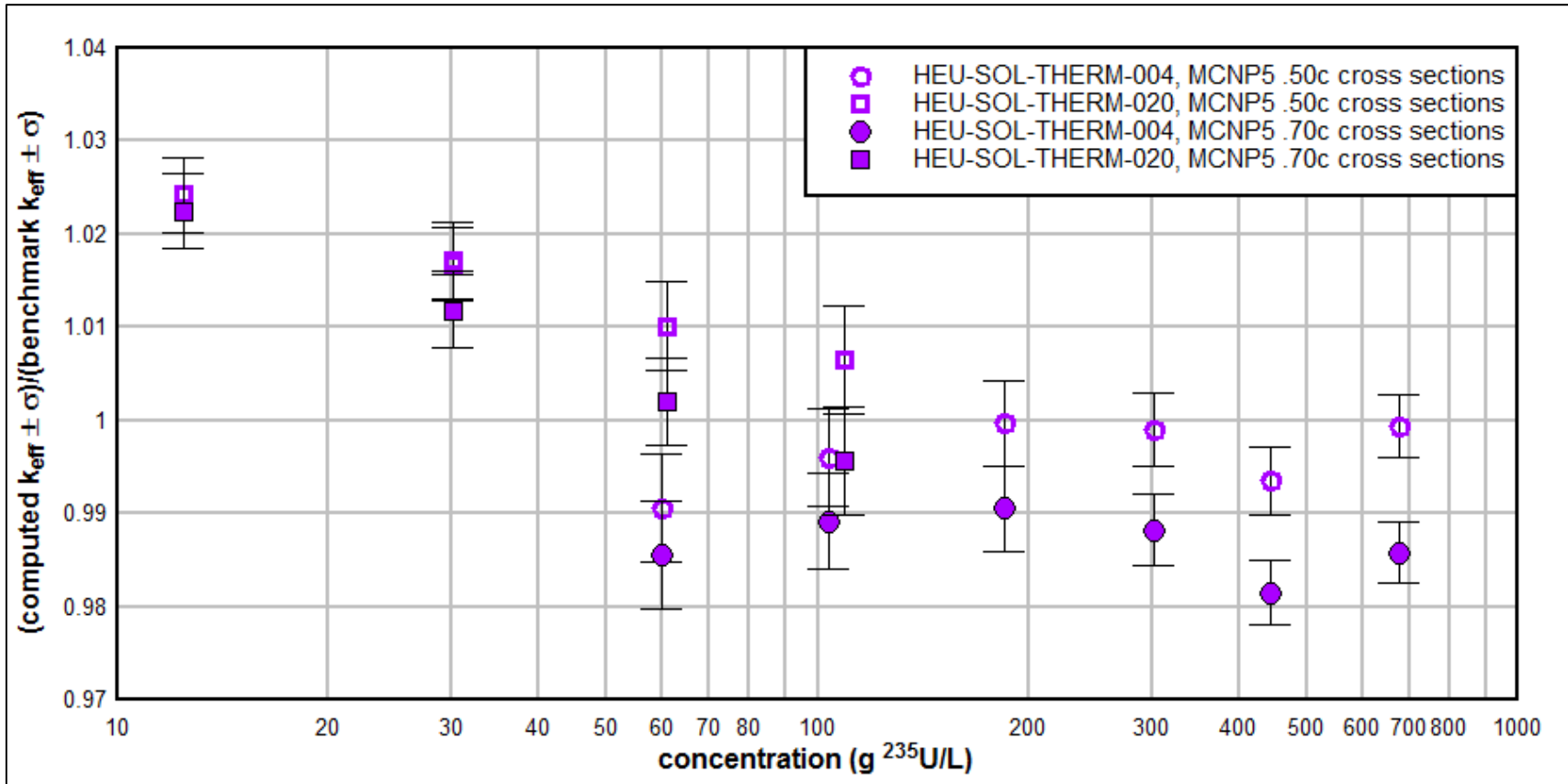
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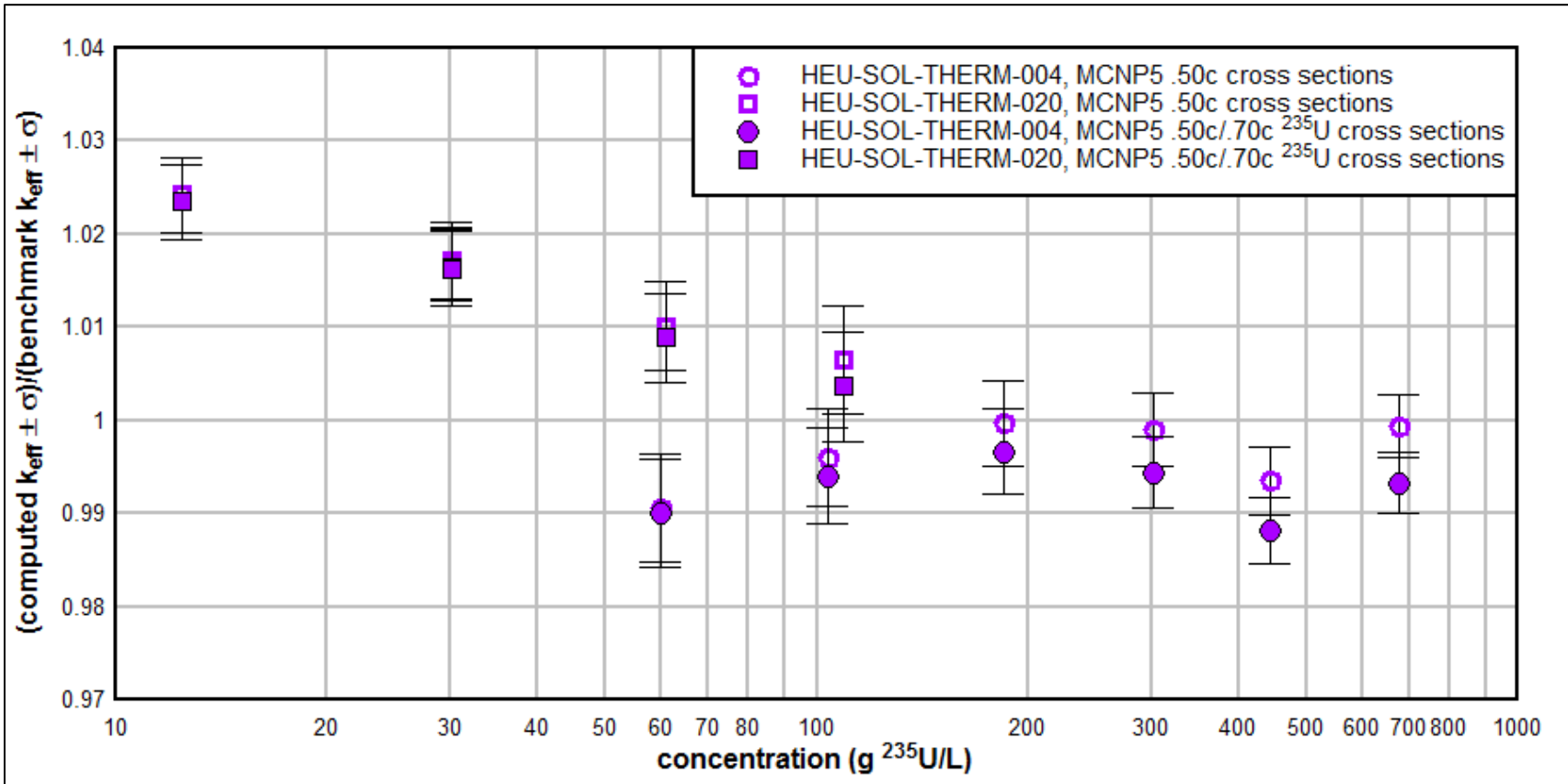
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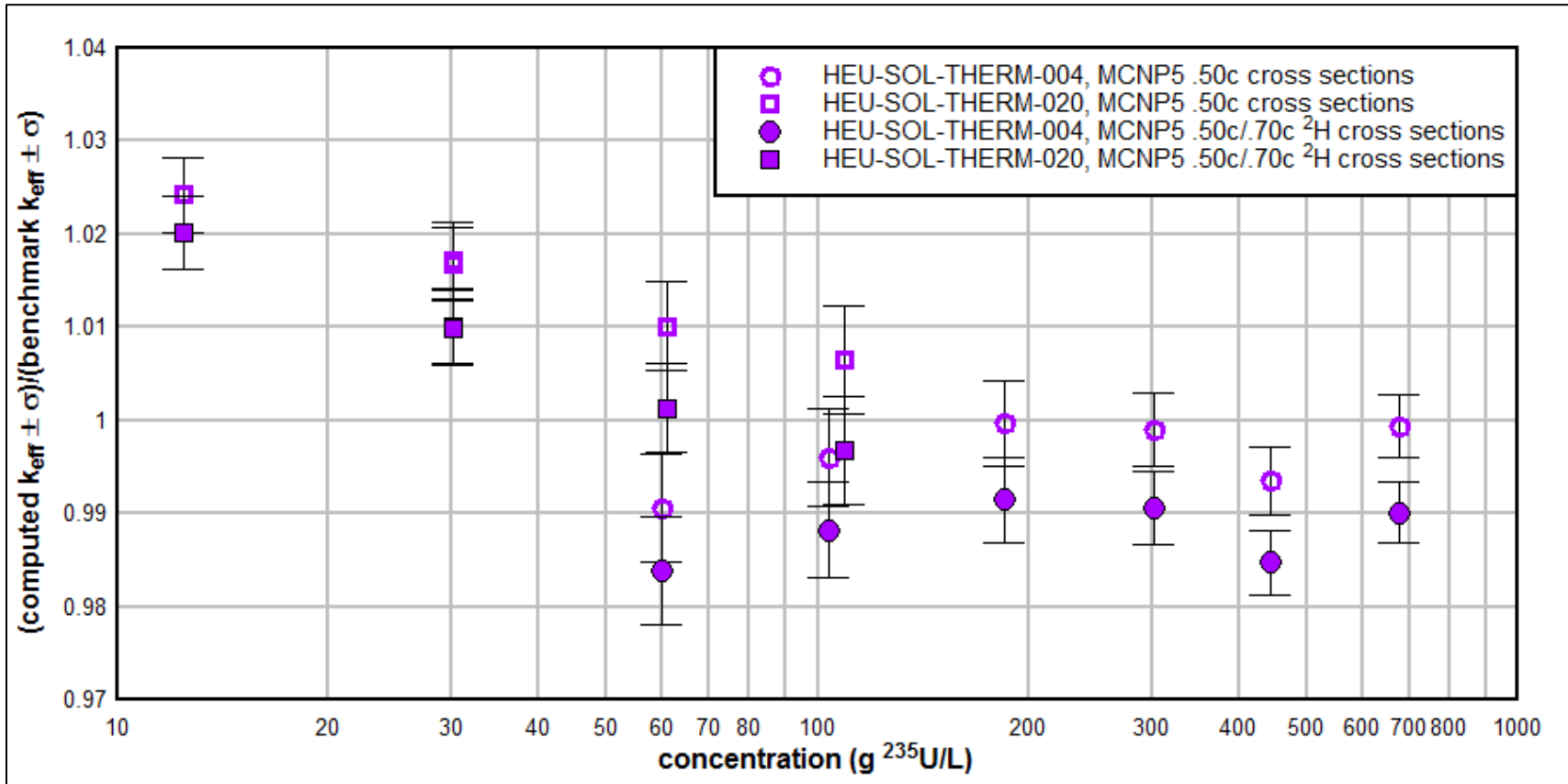
ENDF/B-V and -VII



ENDF/B-V with ENDF/B-VII ²³⁵U



ENDF/B-V with ENDF/B-VII ^2H



CONCLUSIONS

- There is a bias as a function of ^{235}U concentration ranging from about 3% high at lower concentrations to about 2% low at higher concentrations depending on the cross section set.
- In the 60 to 100 g $^{235}\text{U}/\text{L}$ range where the experimental systems overlap, results are indicated to diverge as concentration decreases - this may be related to presence/absence of a heavy water reflector.
- There are differences in results using ENDF/B-V cross sections compared to results using ENDF/B-VII cross sections and the differences become more pronounced as ^{235}U concentration increases.
- Changes in the ^2H cross sections are indicated to account for essentially all the difference in results between the ENDF/B-V and ENDF/B-VII cross sections.
- If HEU-SOL-THERM-004 systems are used in a general validation using ENDF/B-VII cross sections then expect a negative bias of about 2%.

FINIS

QUESTIONS

COMMENTS

OBSERVATIONS

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