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ENDF/B-VIII.0 Testing with AMPX and SCALE

Andrew Holcomb
D. Wiarda
V. Sobes
W. J. Marshall

SCALE USERS' GROUP WORKSHOP
Oak Ridge, Tennessee
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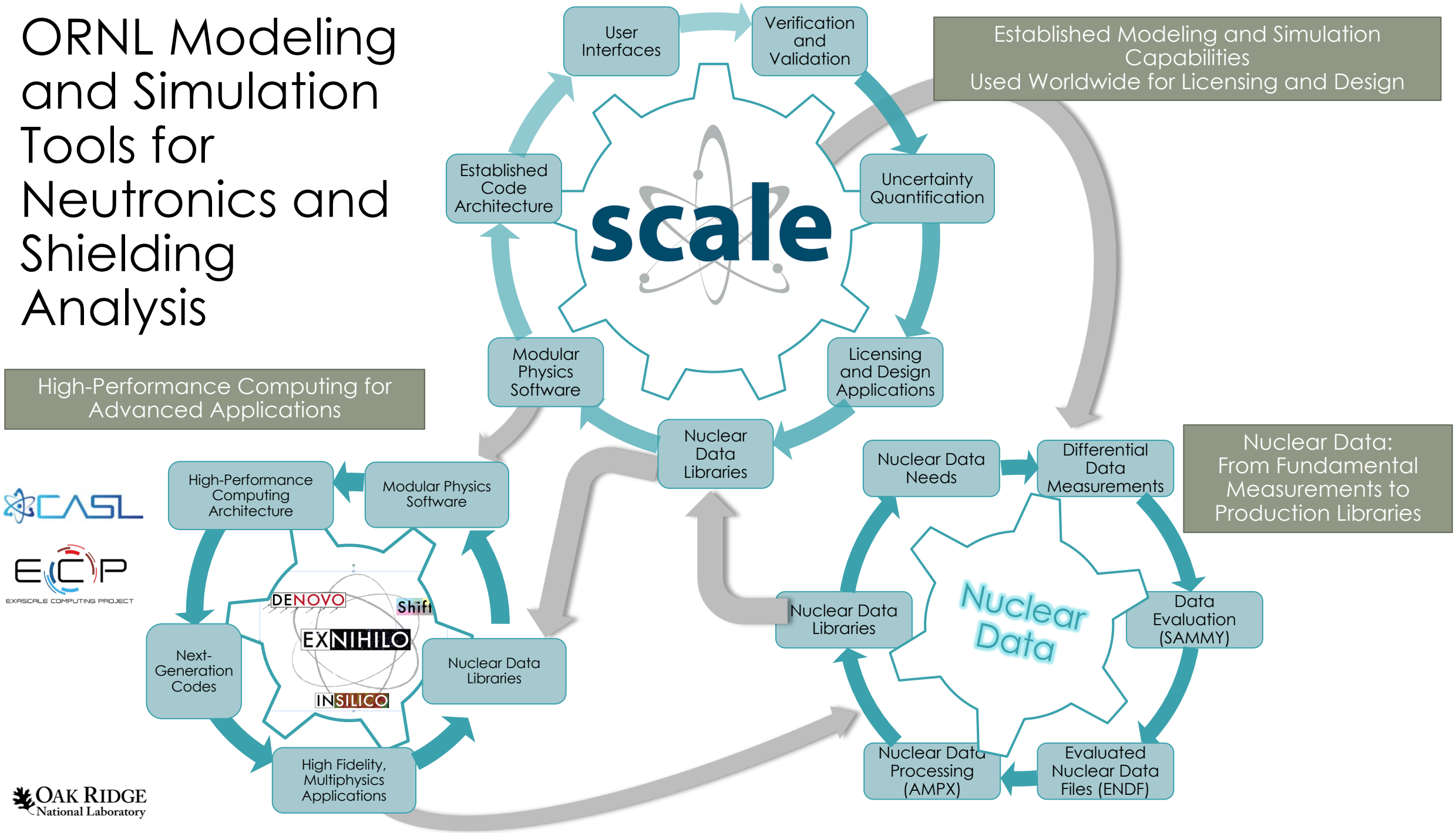
U.S. DEPARTMENT OF ENERGY

Outline

1. Brief overview of AMPX
2. Synopsis of VALID
3. ENDF/B-VIII testing

ORNL Modeling and Simulation Tools for Neutronics and Shielding Analysis



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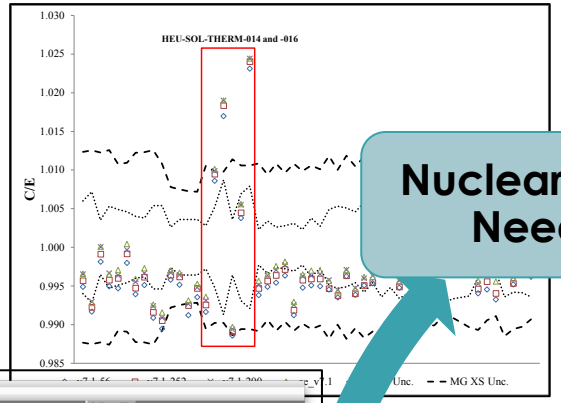
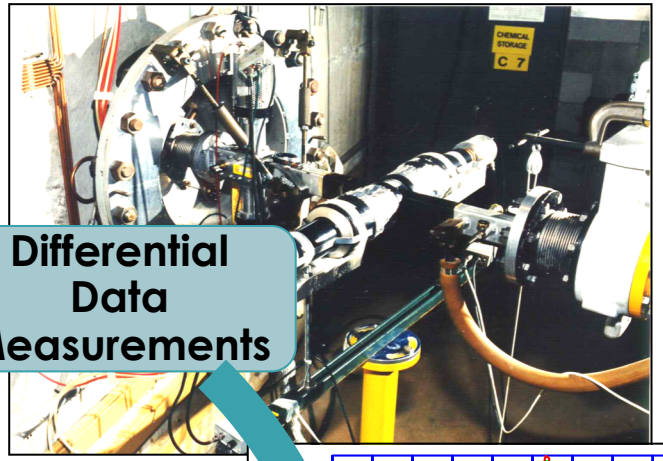
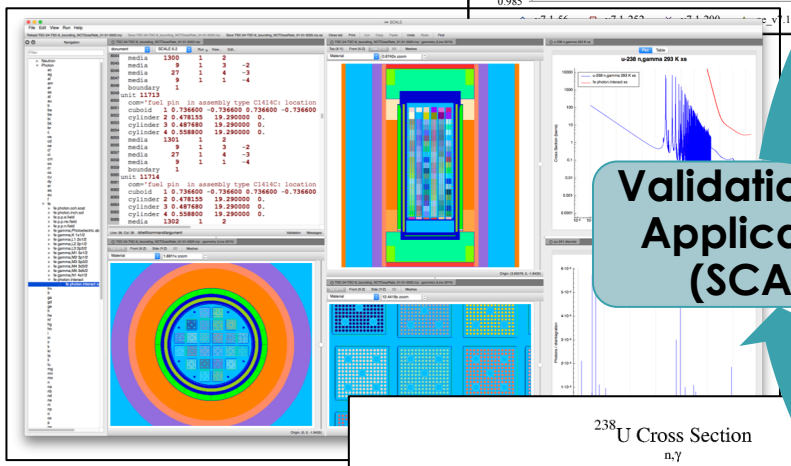
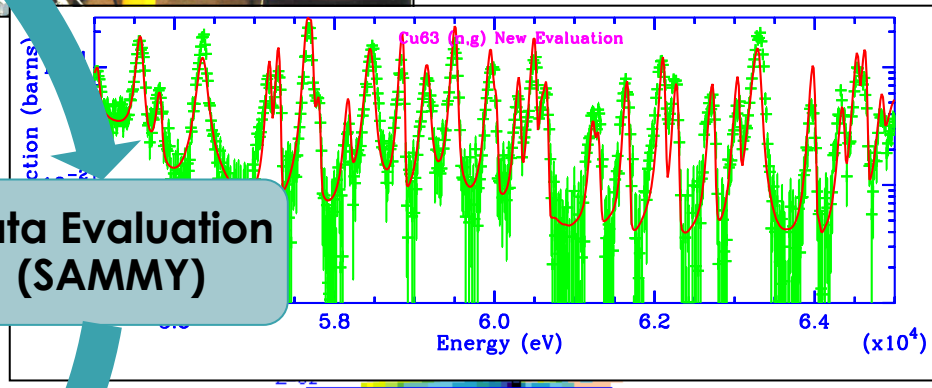
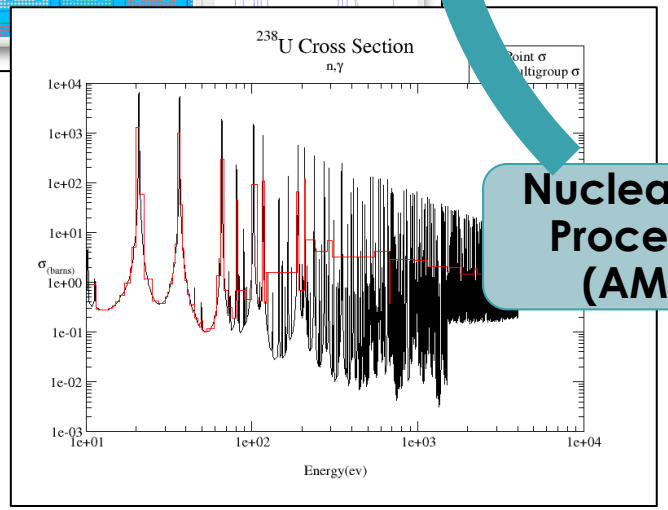
Nuclear Data Lifecycle

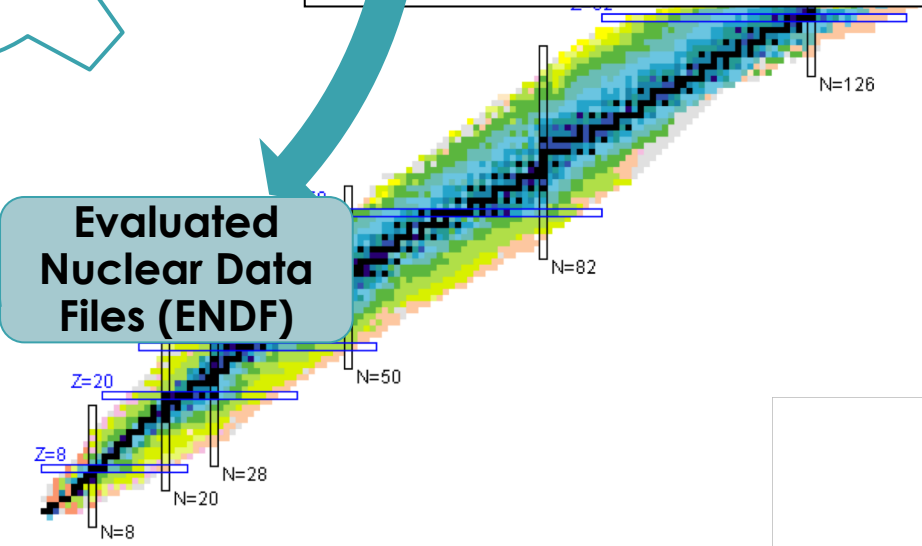












Nuclear Data Needs

Differential Data Measurements

Data Evaluation (SAMMY)

Evaluated Nuclear Data Files (ENDF)

Nuclear Data Processing (AMPX)

Validation and Applications (SCALE)

Nuclear Data

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AMPX - Capabilities

- Modular code system that takes basic cross section data in Evaluated Nuclear Data File (ENDF) format to provide:
  - Multigroup (MG) libraries
    - Requires point cross section data, weighting functions, energy bounds, etc
  - Continuous energy (CE) libraries
    - In resolved resonance region, 1-D data comes from POLIDENT
      - Supports single-level Breit-Wigner (SLBW), multilevel Breit-Wigner (MLBW), Adler-Adler (AA), Reich-Moore (RM), and R-Matrix Limited (RML) formats
    - In unresolved resonance region, PRUDE or PURM
      - Only SLBW in unresolved resonance region (only ENDF supported format)

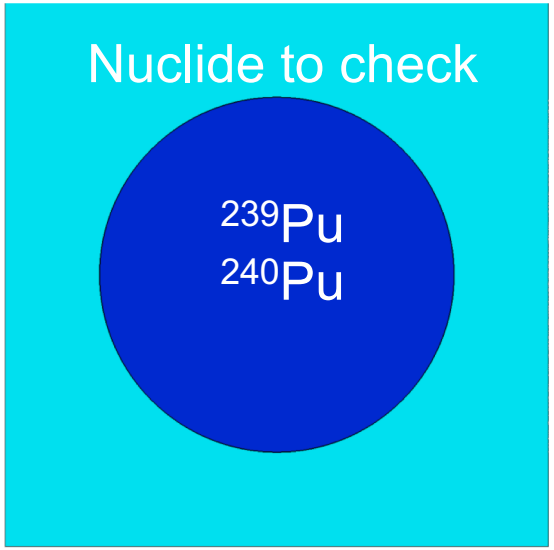
AMPX – Capabilities (con't)

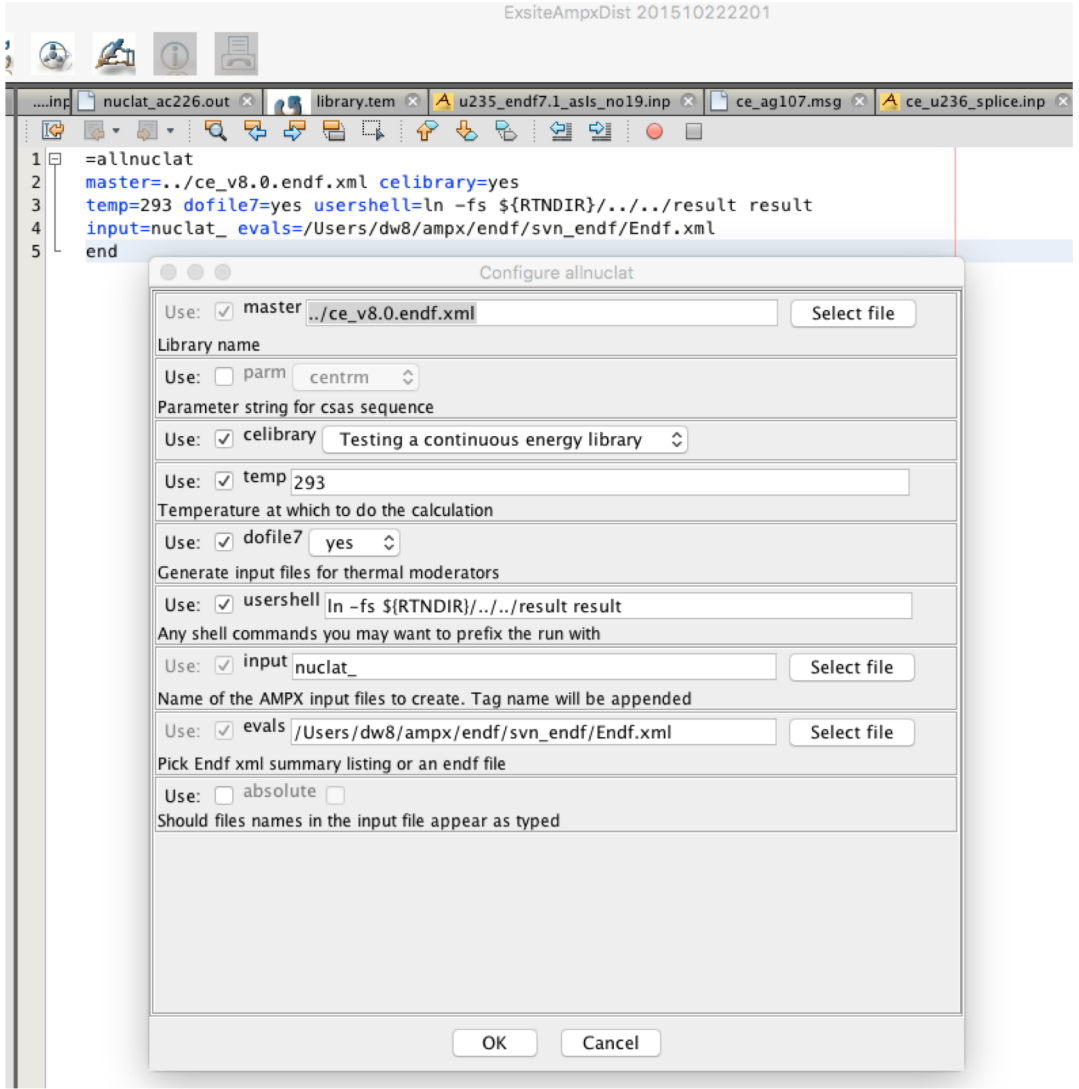
- Cross section uncertainty or covariance data
  - Used in SCALE sensitivity and uncertainty analysis tools
- Depletion and decay libraries
  - Used by ORIGEN
- In short, if you are using SCALE, you are using AMPX processed libraries

- Greatly simplified input file generation
  - ExSITE provides templates to generate all input files needed for successful library build
  - ExSITE also allows for user defined templates

Testing of ENDF Data

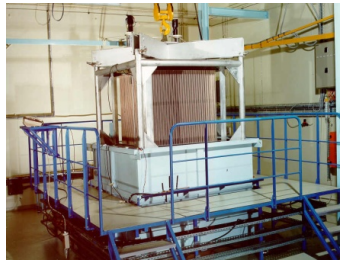
- Generate ENDF/B-VIII.0 libraries with AMPX (MG & CE)
- Run KENO for a pin-cell with a moderator substituted by each nuclide in the library (ExSITE can generate the input files)
- Note that the hard spectrum for most nuclides allows testing for anomalies for the threshold reactions
- Run the VALID suite
- Compare results to ENDF/B-VII.1

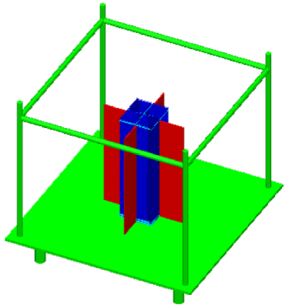


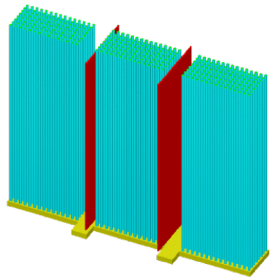


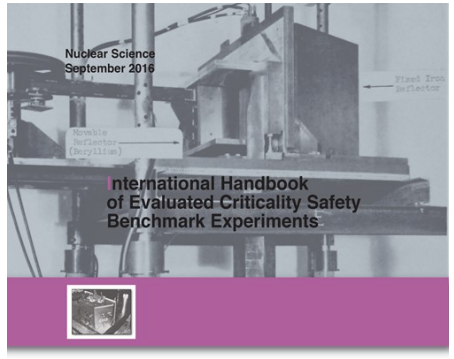
SCALE criticality validation: Verified, Archived Library of Inputs and Data (VALID)

- 611 configurations from International Criticality Safety Benchmark Evaluation Project (ICSBEP)





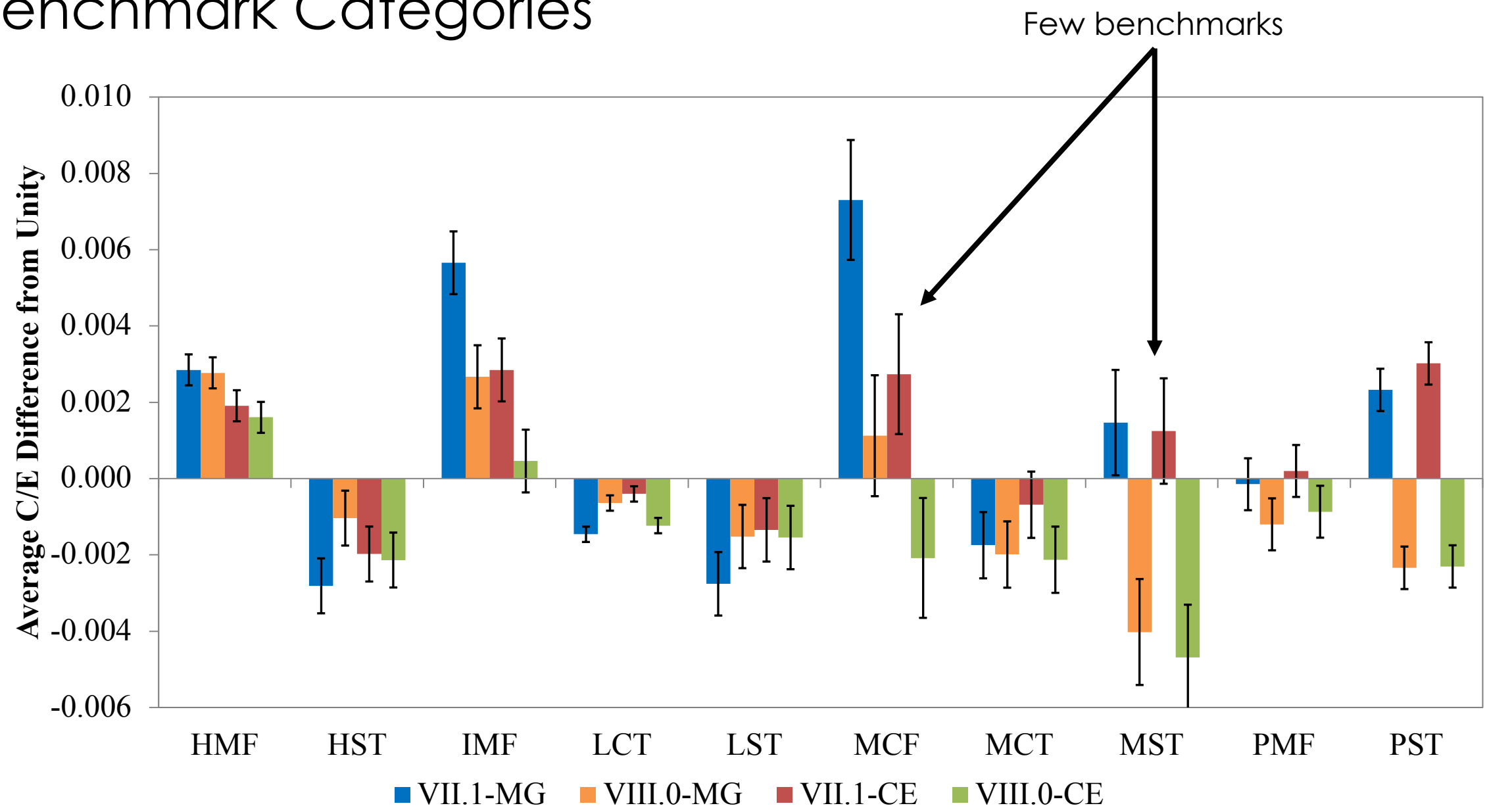




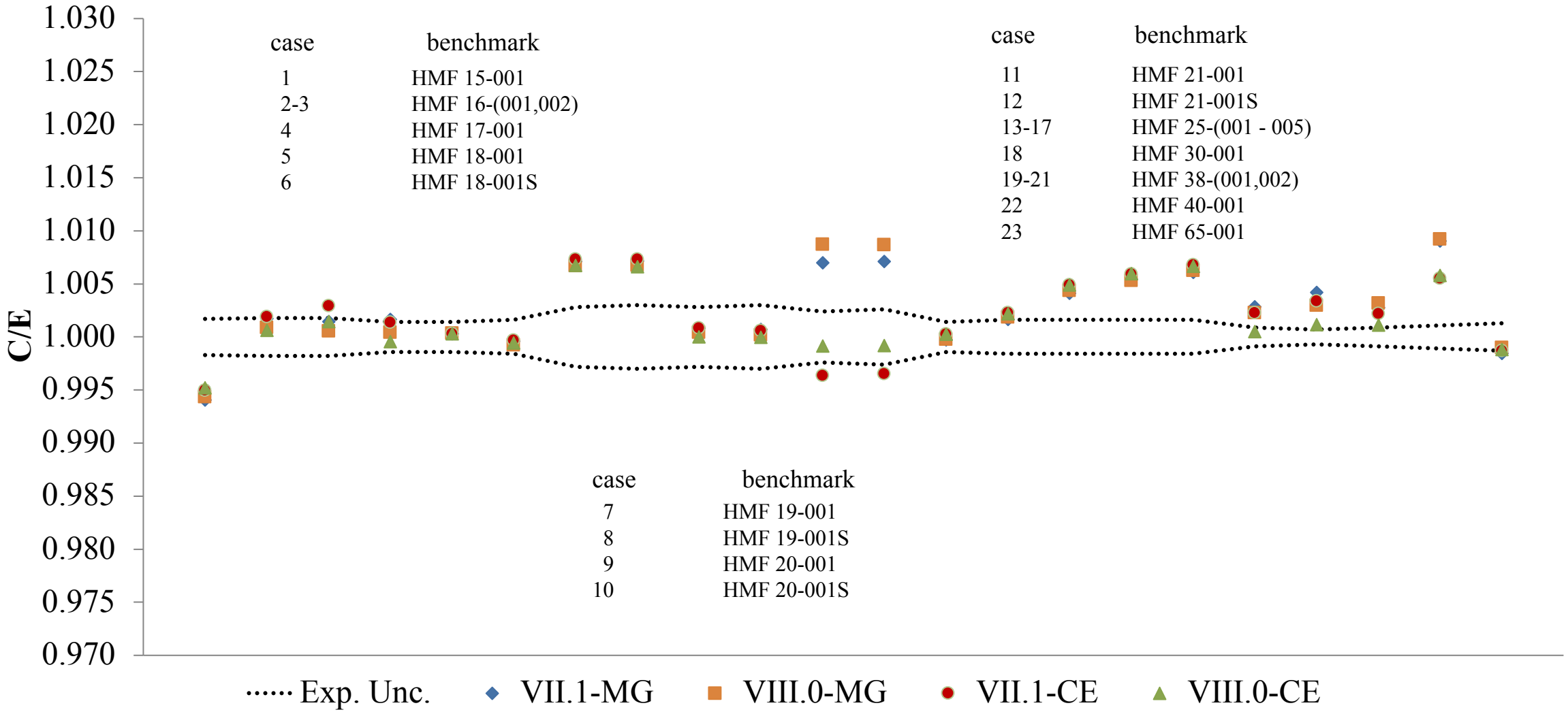
Sequence / Geometry	Experiment class	ICSBEP case numbers	Number of configurations
CSAS5 / KENO V.a	HEU-MET-FAST	15, 16, 17, 18, 19, 20, 21, 25, 30, 38, 40, 52, 65	19
	HEU-SOL-THERM	1, 13, 14, 16, 28, 29, 30	52
	IEU-MET-FAST	2, 3, 4, 5, 6, 7, 8, 9	8
	LEU-COMP-THERM	1, 2, 8, 10, 17, 42, 50, 78, 80	140
	LEU-SOL-THERM	2, 3, 4	19
	MIX-MET-FAST	5, 6	2
	MIX-COMP-THERM	1, 2, 4	21
	MIX-SOL-THERM	2, 7	10
	PU-MET-FAST	1, 2, 5, 6, 8, 10, 18, 22, 23, 24, 25, 26	12
	PU-SOL-THERM	1, 2, 3, 4, 5, 6, 7, 11, 20	81
	U233-COMP-THERM	1	3
	U233-MET-FAST	1, 2, 3, 4, 5, 6	10
	U233-SOL-INTER	1	29
	U233-SOL-MIXED	1, 2	8
	U233-SOL-THERM	1, 2, 3, 4, 5, 8, 9, 11, 12, 13, 15, 16, 17	140
CSAS6 / KENO-VI	HEU-MET-FAST	5, 8, 9, 10, 11, 13, 24, 80, 86, 92, 93, 94	27
	IEU-MET-FAST	19	2
	MIX-COMP-THERM	8	28

- **Fissile materials**
  - High-enriched uranium (HEU),
  - Intermediate-enriched uranium (IEU)
  - Low-enriched uranium (LEU)
  - Plutonium (Pu)
  - Mixed uranium/plutonium oxides (MOX)
  - Uranium-233 (U233)
- **Fuel form**
  - Metal (MET),
  - Fissile solution (SOL)
  - Multi-material composition (e.g. fuel pins – COMP)
- **Neutron spectra**
  - Fast
  - Intermediate (INTER)
  - Thermal
  - Mixed

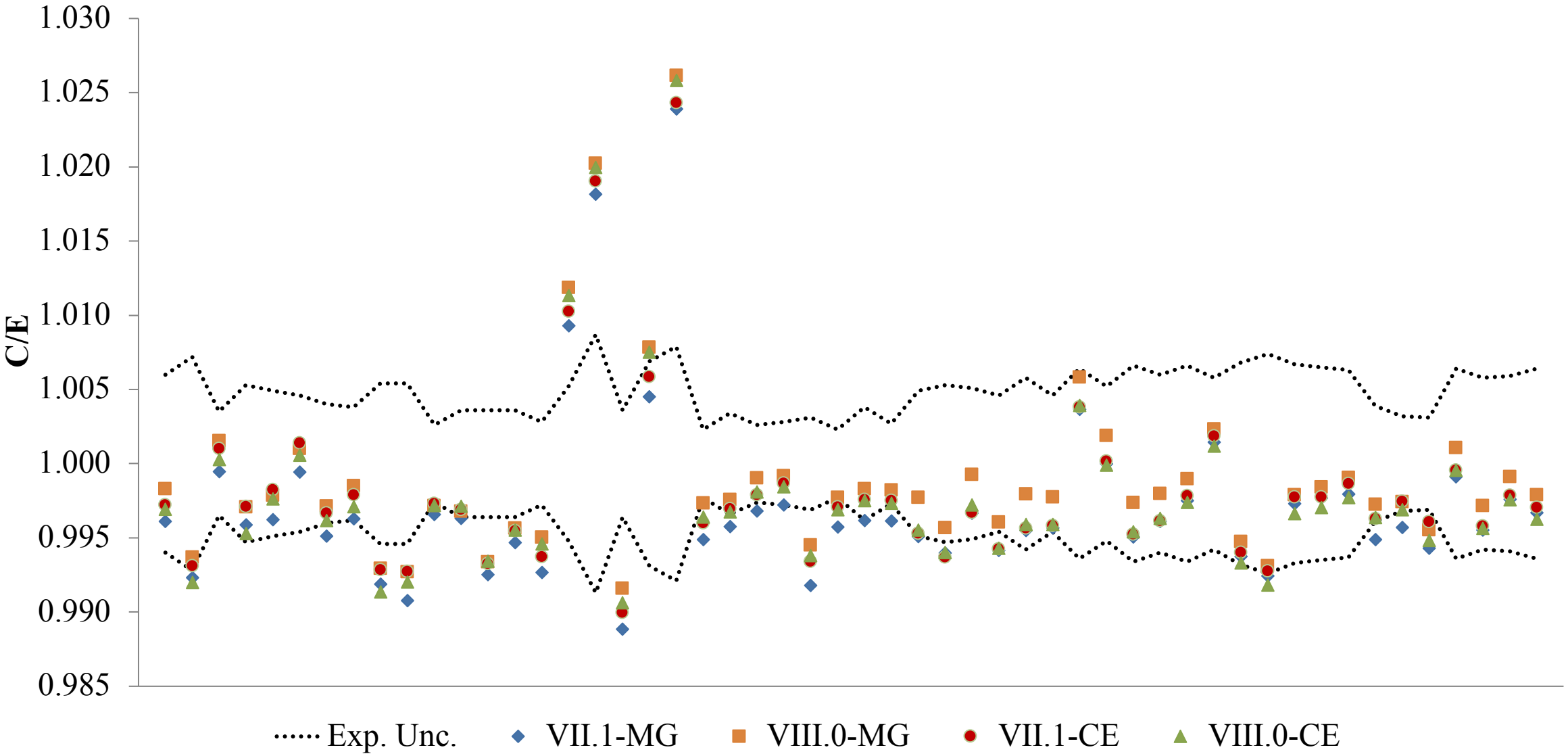
Benchmark Categories



HMF Results


1.030
1.025
1.020
1.015
1.010
1.005
1.000
0.995
0.990
0.985
0.980
0.975
0.970
C/E
case benchmark
1 HMF 15-001
2-3 HMF 16-(001,002)
4 HMF 17-001
5 HMF 18-001
6 HMF 18-001S
case benchmark
11 HMF 21-001
12 HMF 21-001S
13-17 HMF 25-(001 - 005)
18 HMF 30-001
19-21 HMF 38-(001,002)
22 HMF 40-001
23 HMF 65-001
case benchmark
7 HMF 19-001
8 HMF 19-001S
9 HMF 20-001
10 HMF 20-001S
Exp. Unc.
VII.1-MG
VIII.0-MG
VII.1-CE
VIII.0-CE

HST Results



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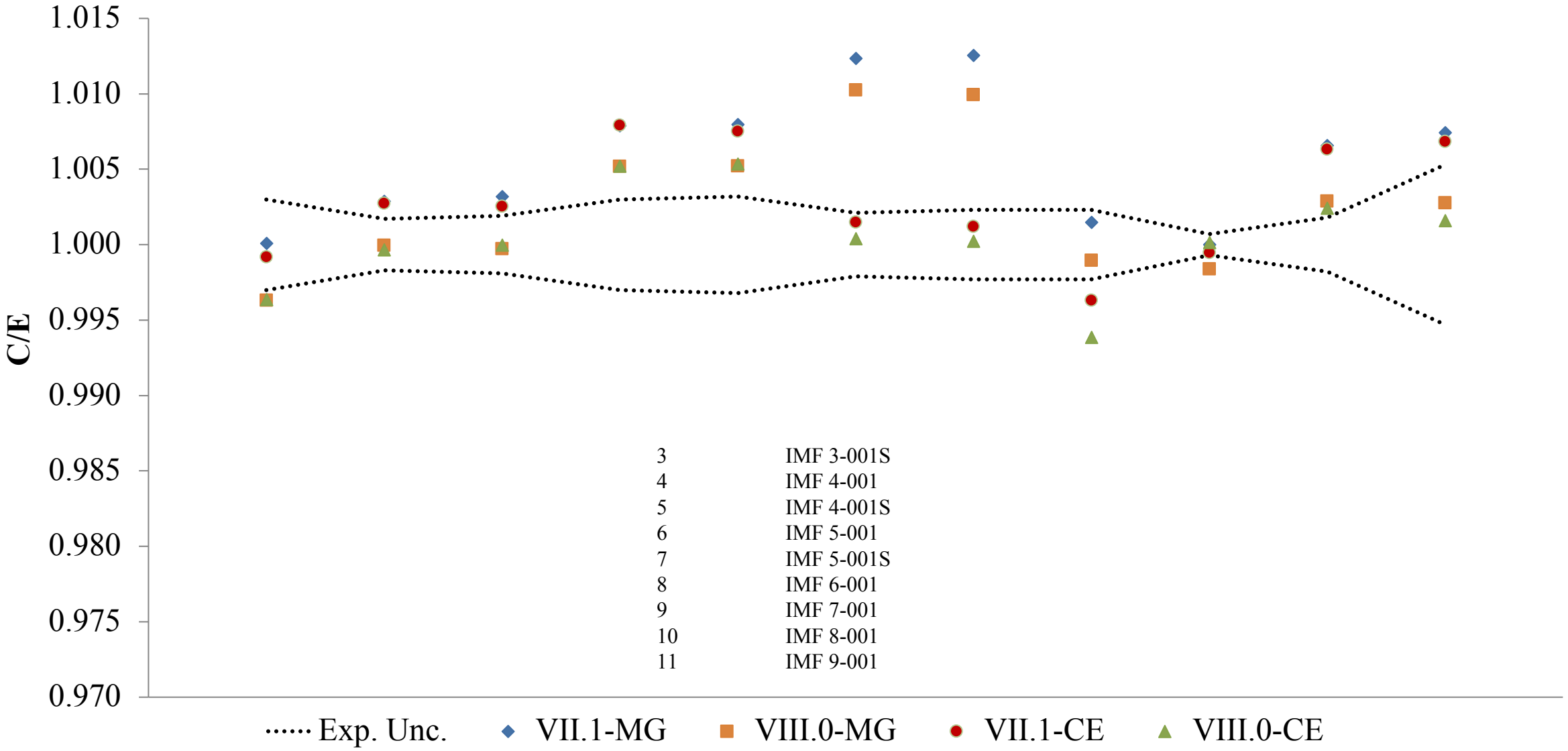
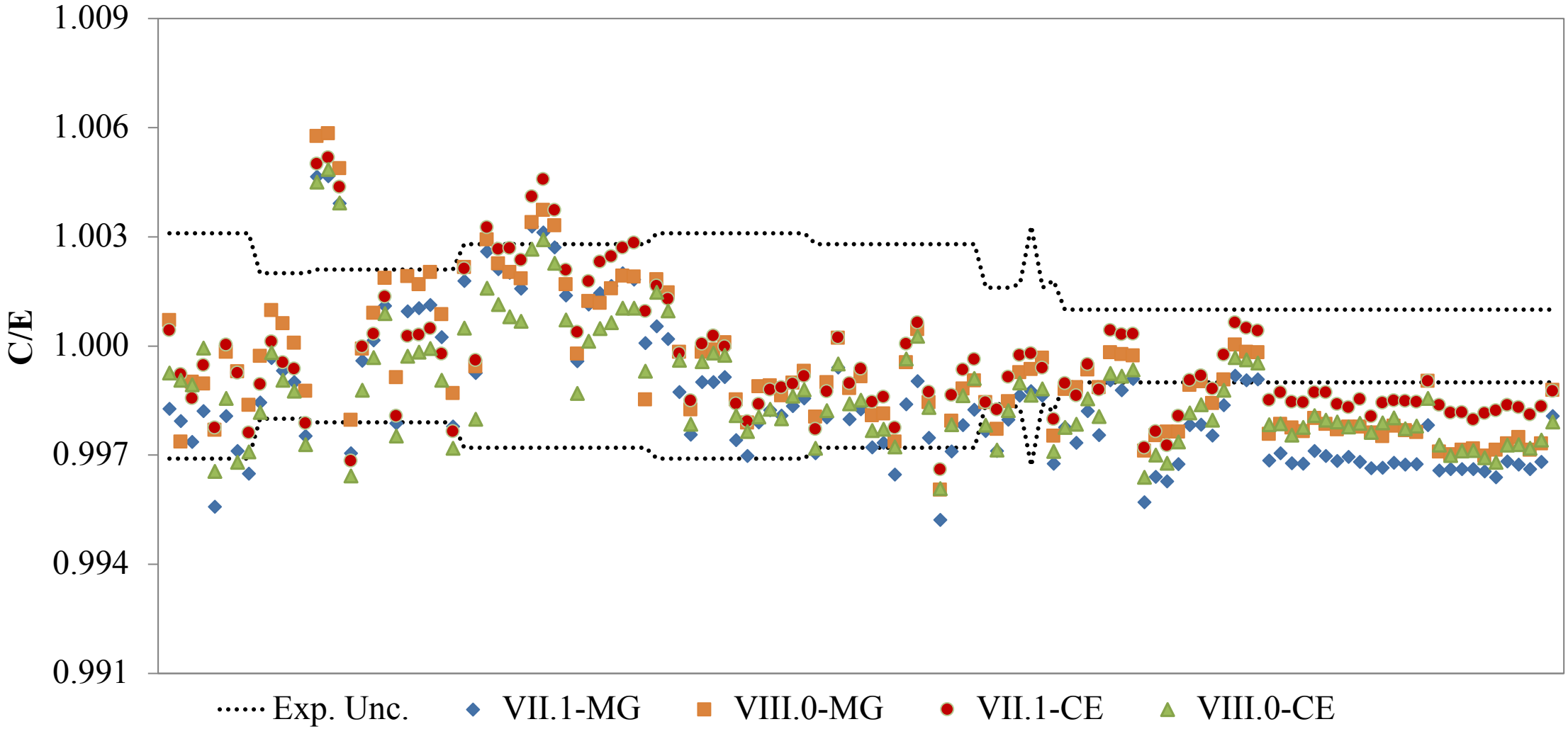
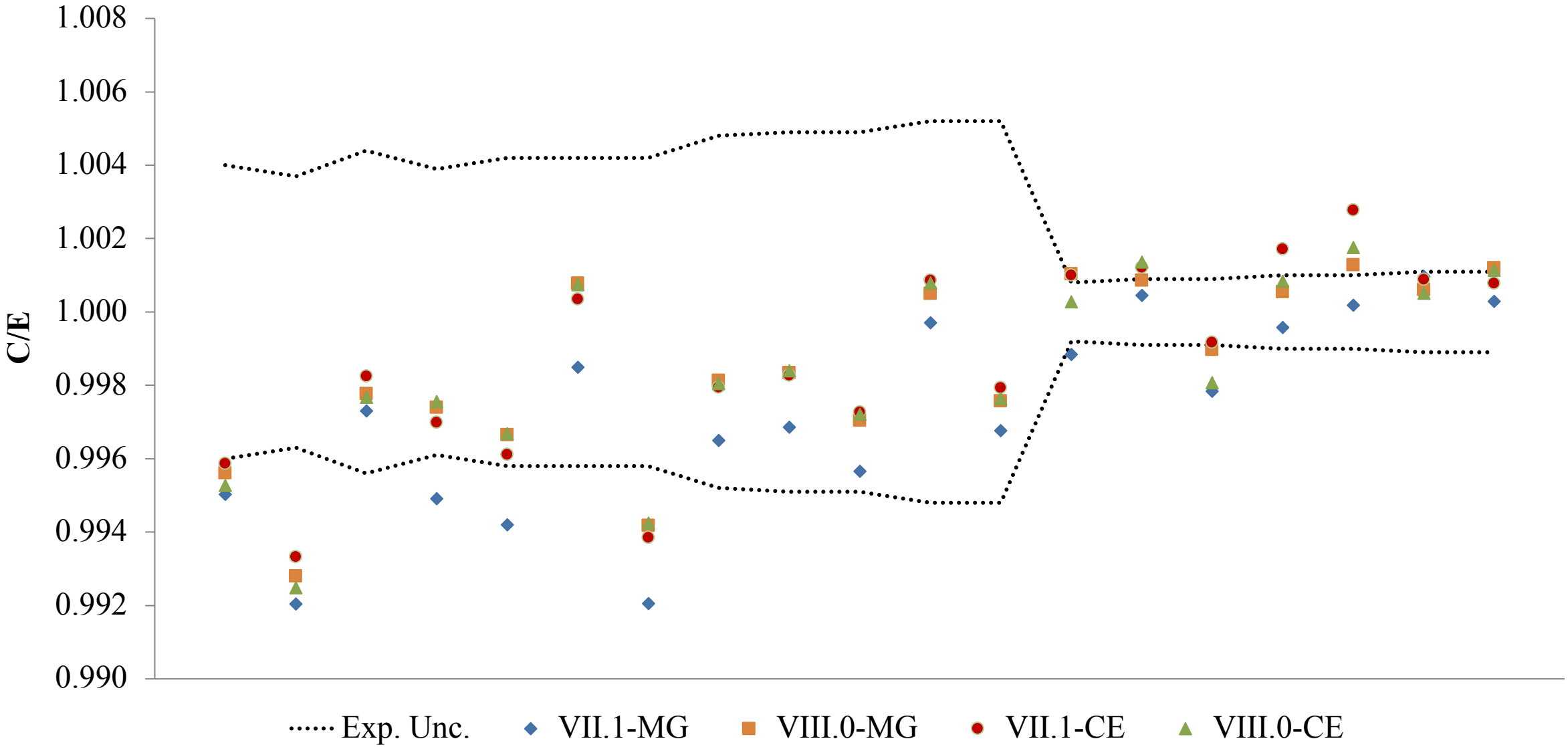
IMF Results


1.015
1.010
1.005
1.000
0.995
0.990
0.985
0.980
0.975
0.970
C/E
3 IMF 3-001S
4 IMF 4-001
5 IMF 4-001S
6 IMF 5-001
7 IMF 5-001S
8 IMF 6-001
9 IMF 7-001
10 IMF 8-001
11 IMF 9-001
Exp. Unc.
VII.1-MG
VIII.0-MG
VII.1-CE
VIII.0-CE

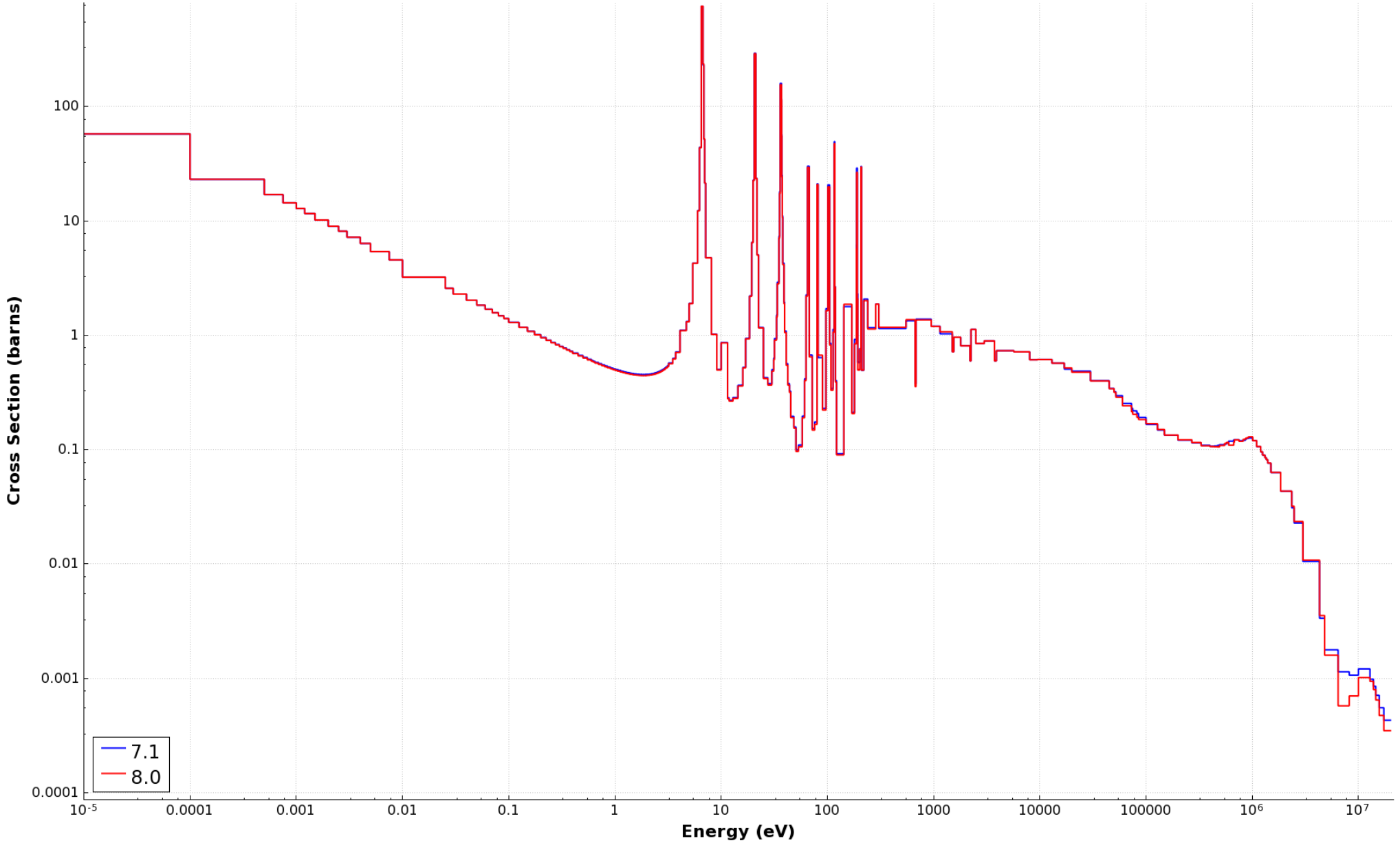
LCT Results


1.009
1.006
1.003
1.000
0.997
0.994
0.991
C/E
Exp. Unc.
VII.1-MG
VIII.0-MG
VII.1-CE
VIII.0-CE

LST Results


1.008
1.006
1.004
1.002
1.000
0.998
0.996
0.994
0.992
0.990
C/E
Exp. Unc.
VII.1-MG
VIII.0-MG
VII.1-CE
VIII.0-CE

U-238 Capture



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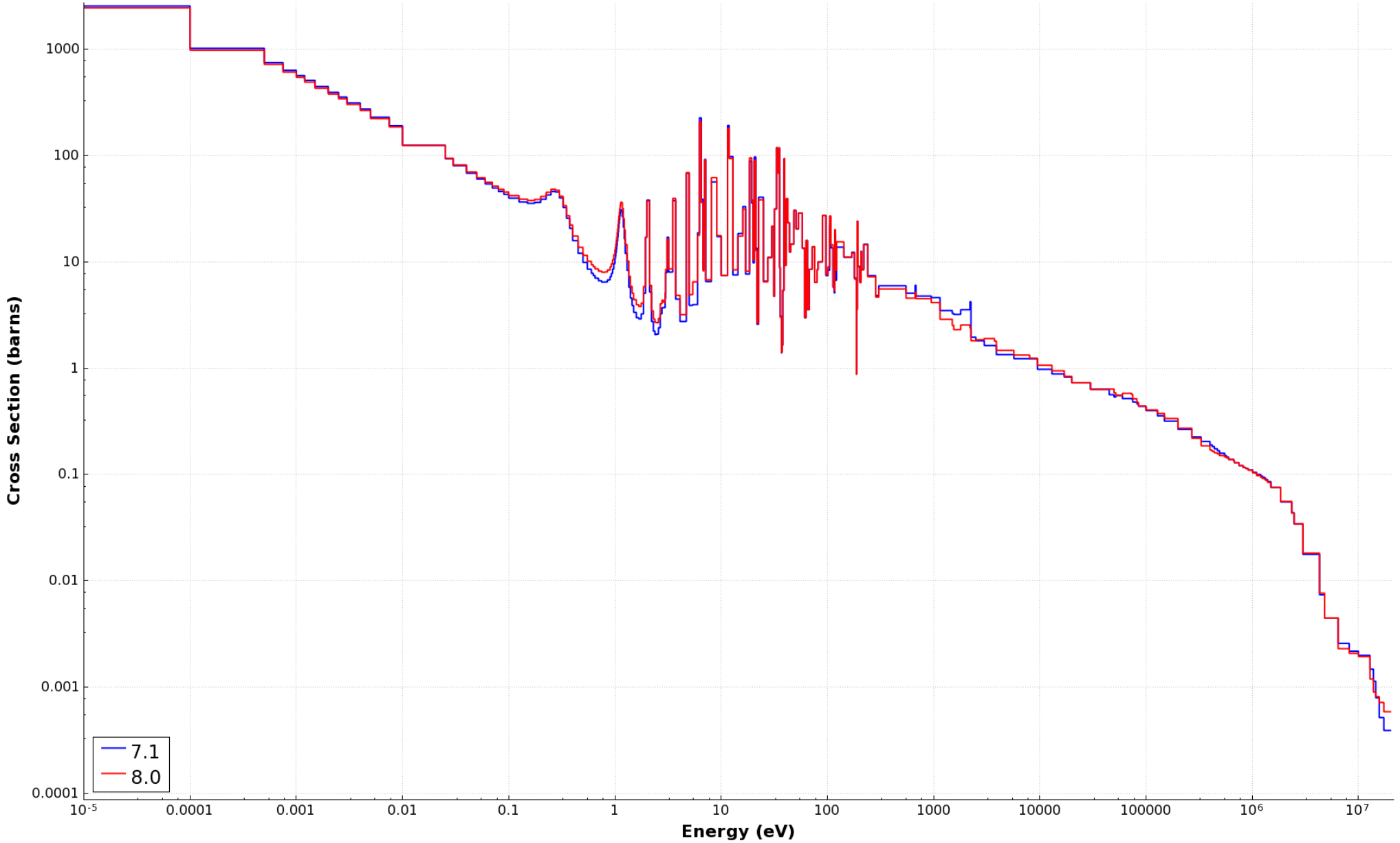
U-235 Capture



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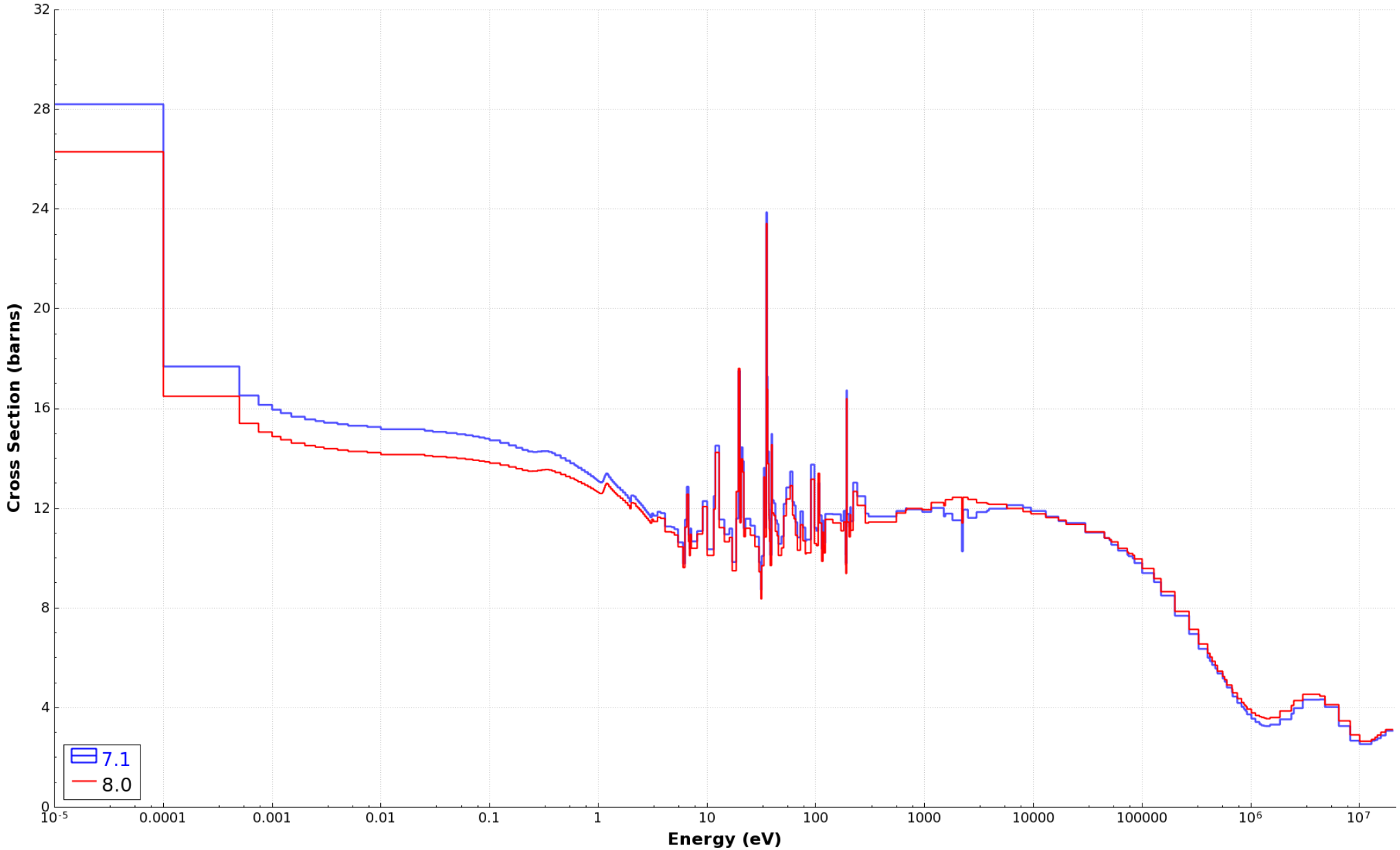
U-235 Elastic



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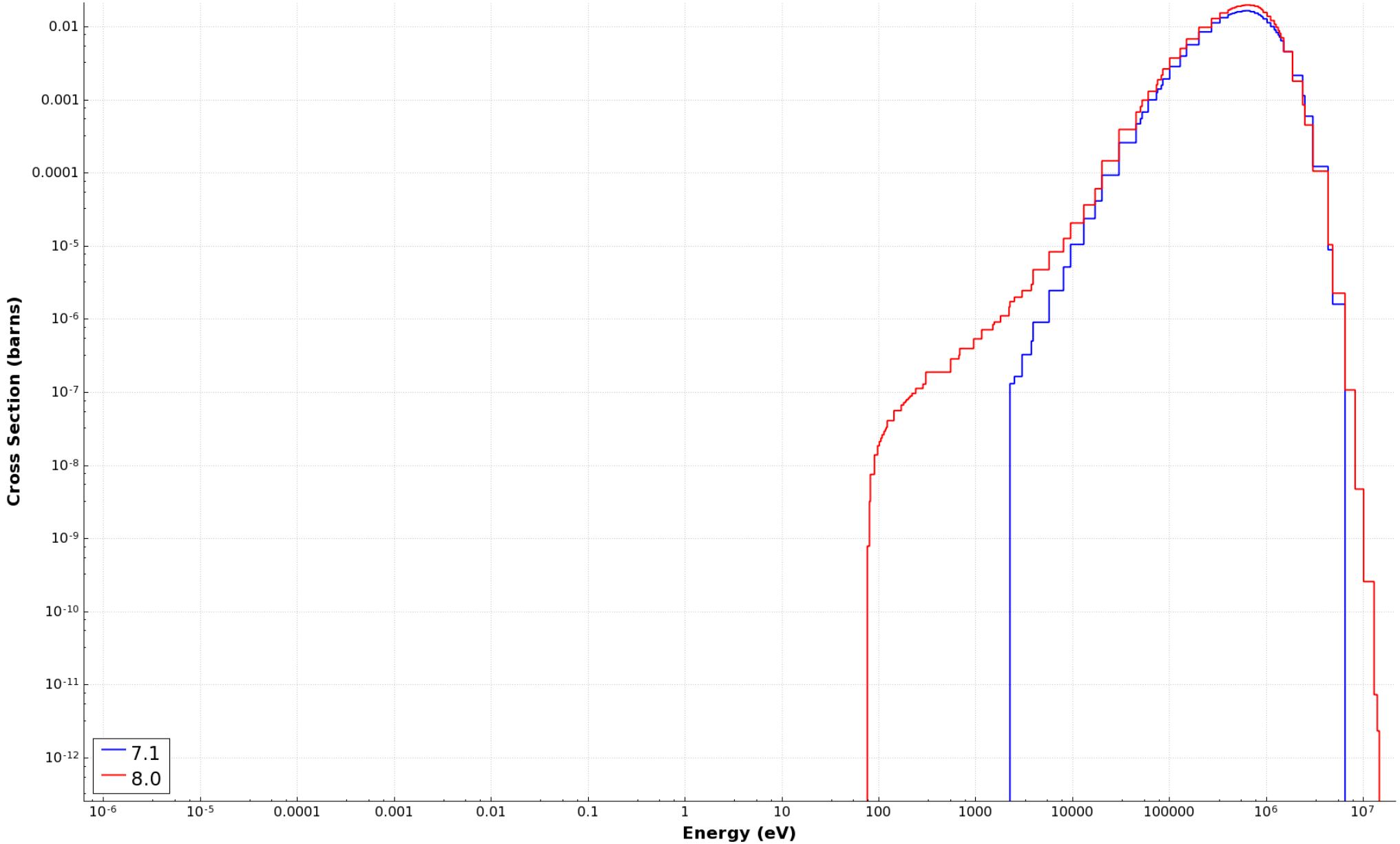
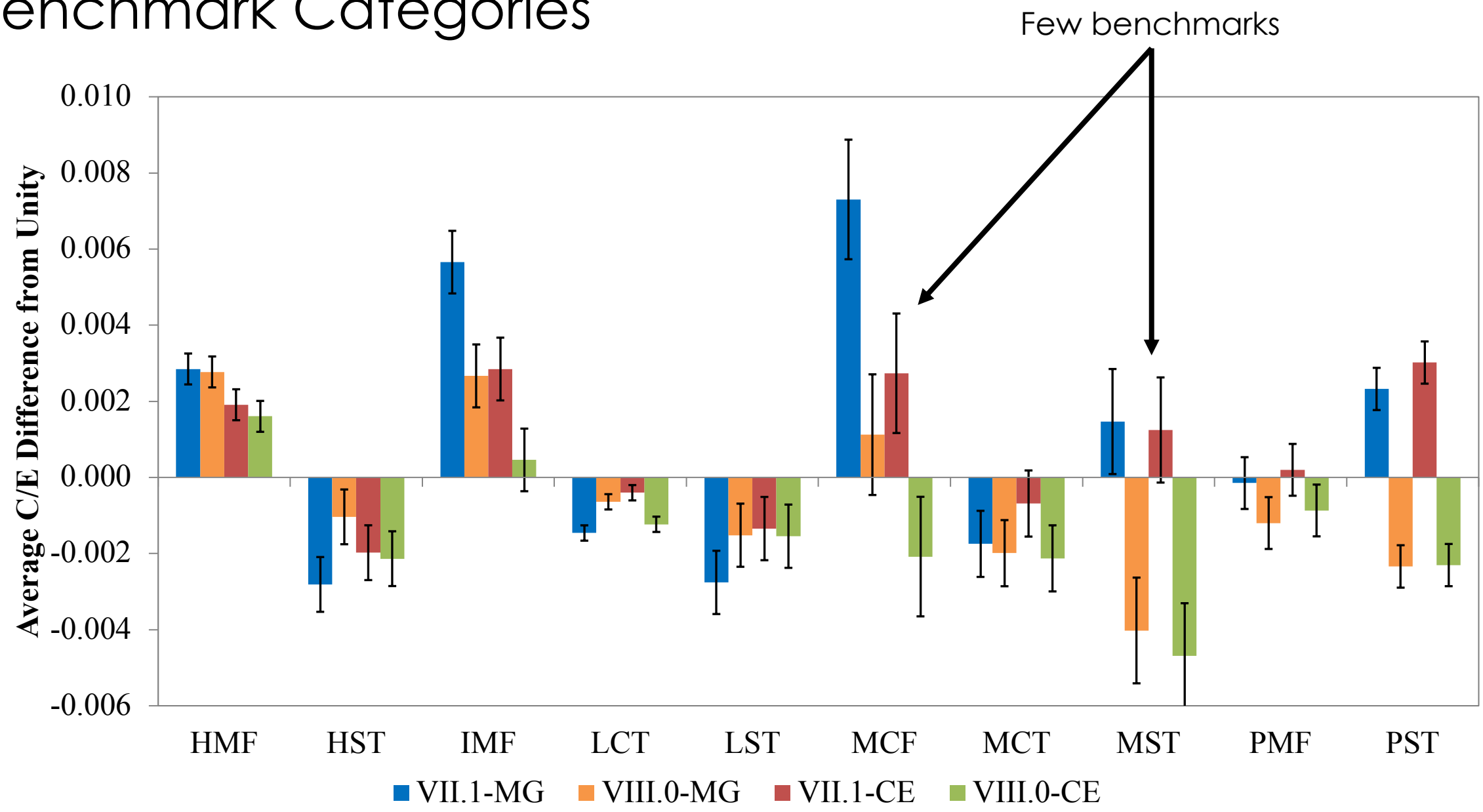
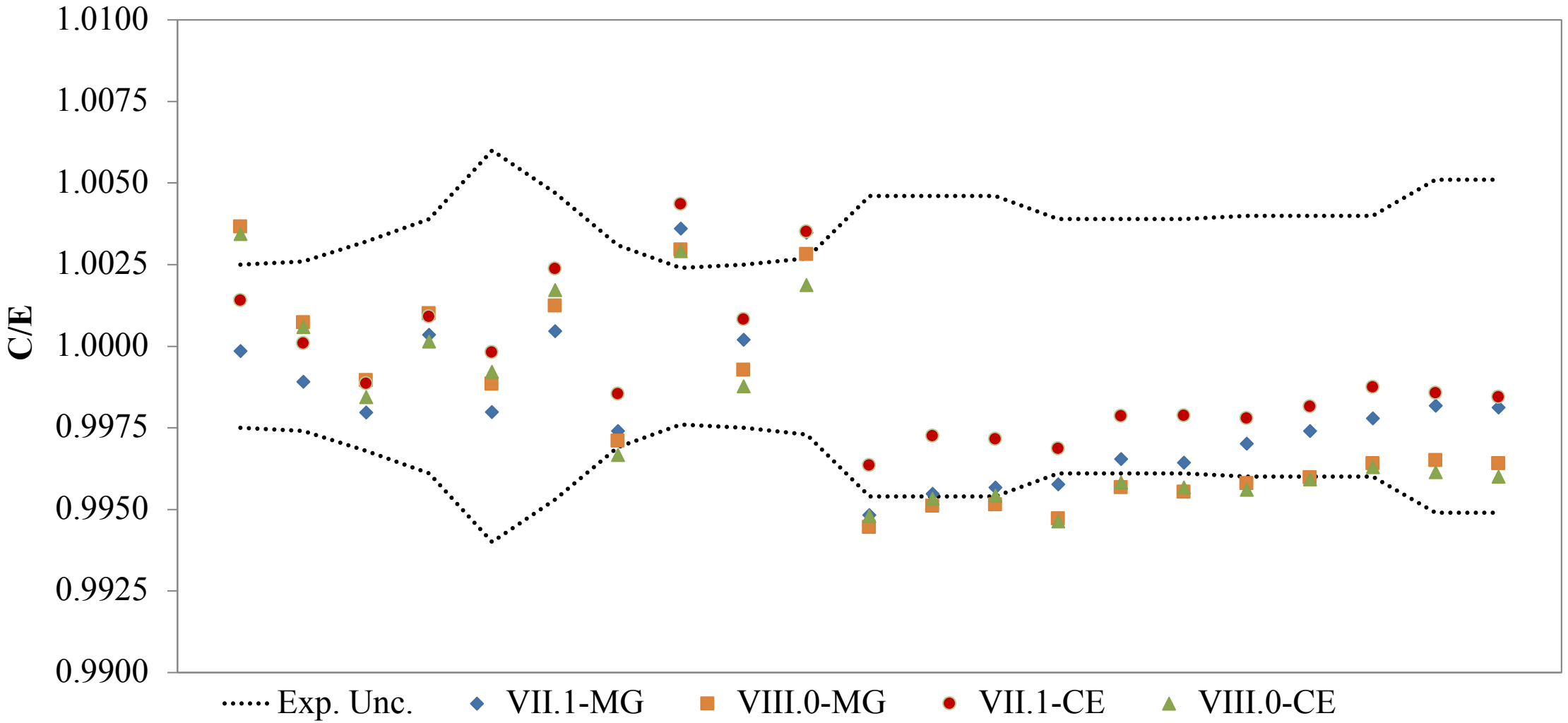
U-235 Inelastic



Benchmark Categories



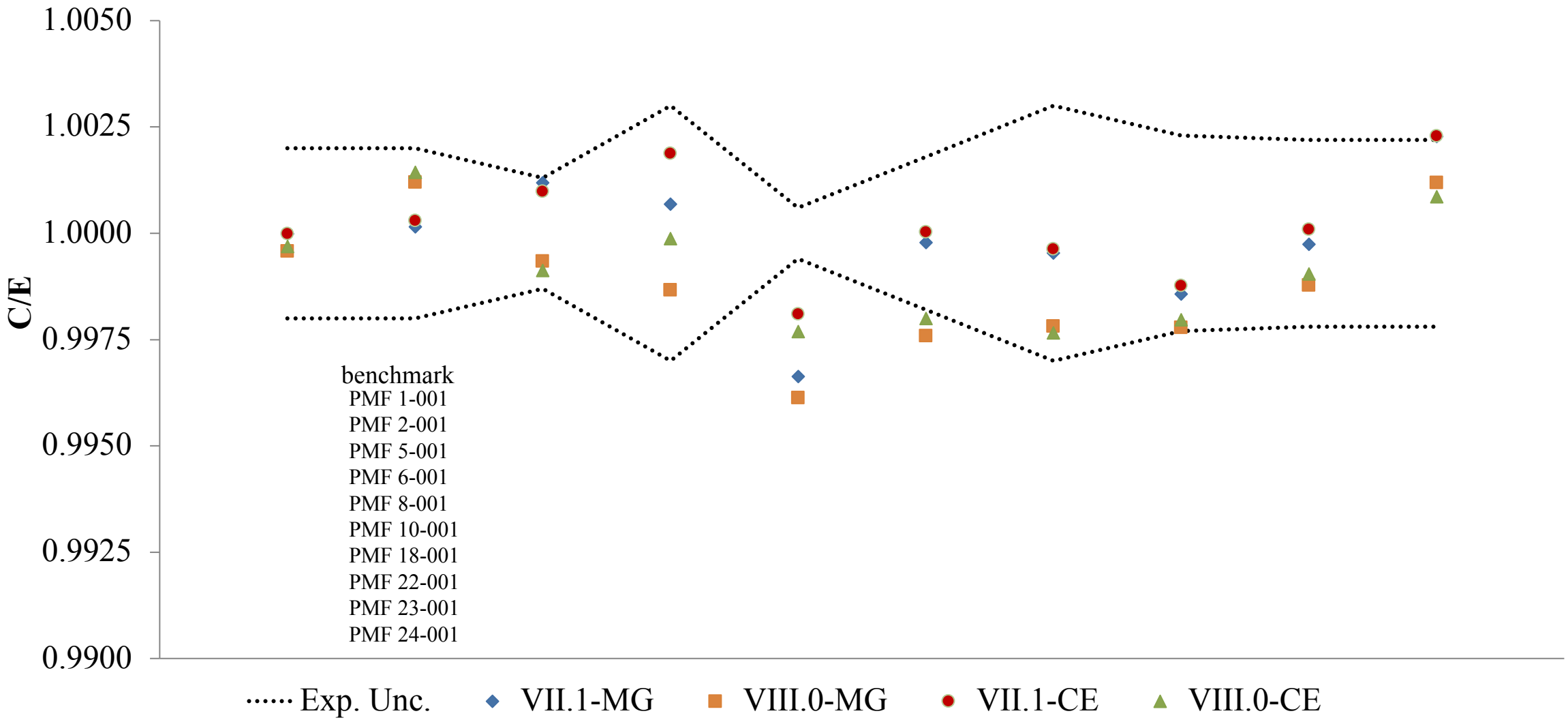
MCT Results


1.0100
1.0075
1.0050
1.0025
1.0000
0.9975
0.9950
0.9925
0.9900
C/E
Exp. Unc.
VII.1-MG
VIII.0-MG
VII.1-CE
VIII.0-CE

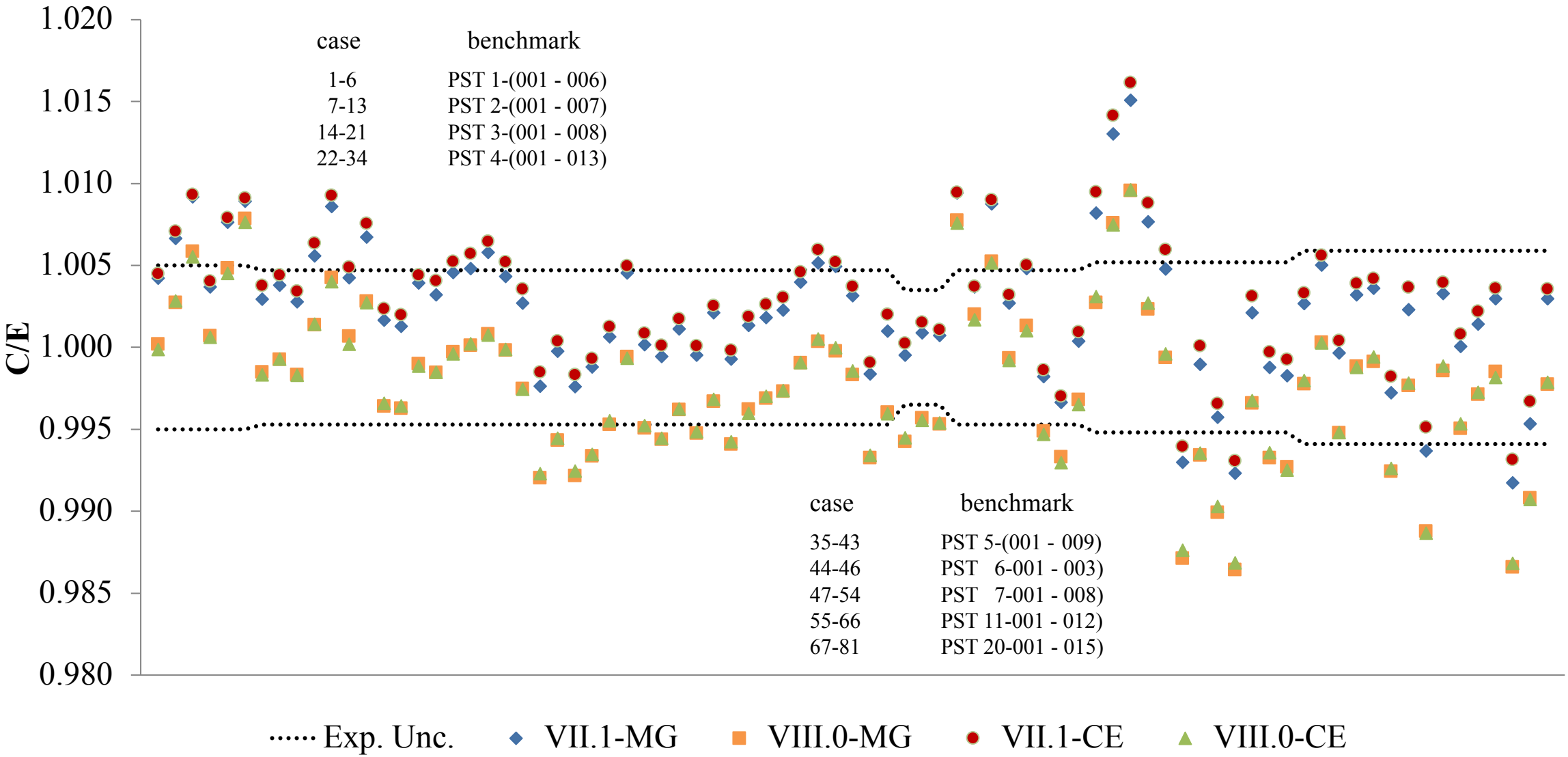
MST Results

Case	VII.1 MG	VIII.0 MG	$\Delta(MG)$	VII.1 CE	VIII.0 CE	$\Delta(CE)$
MST-002-001	1.00139	0.99601	-538	1.00116	0.99528	-589
MST-002-002	1.00154	0.99592	-561	1.00144	0.99545	-599
MST-002-003	1.00148	0.99601	-547	1.00113	0.99521	-592

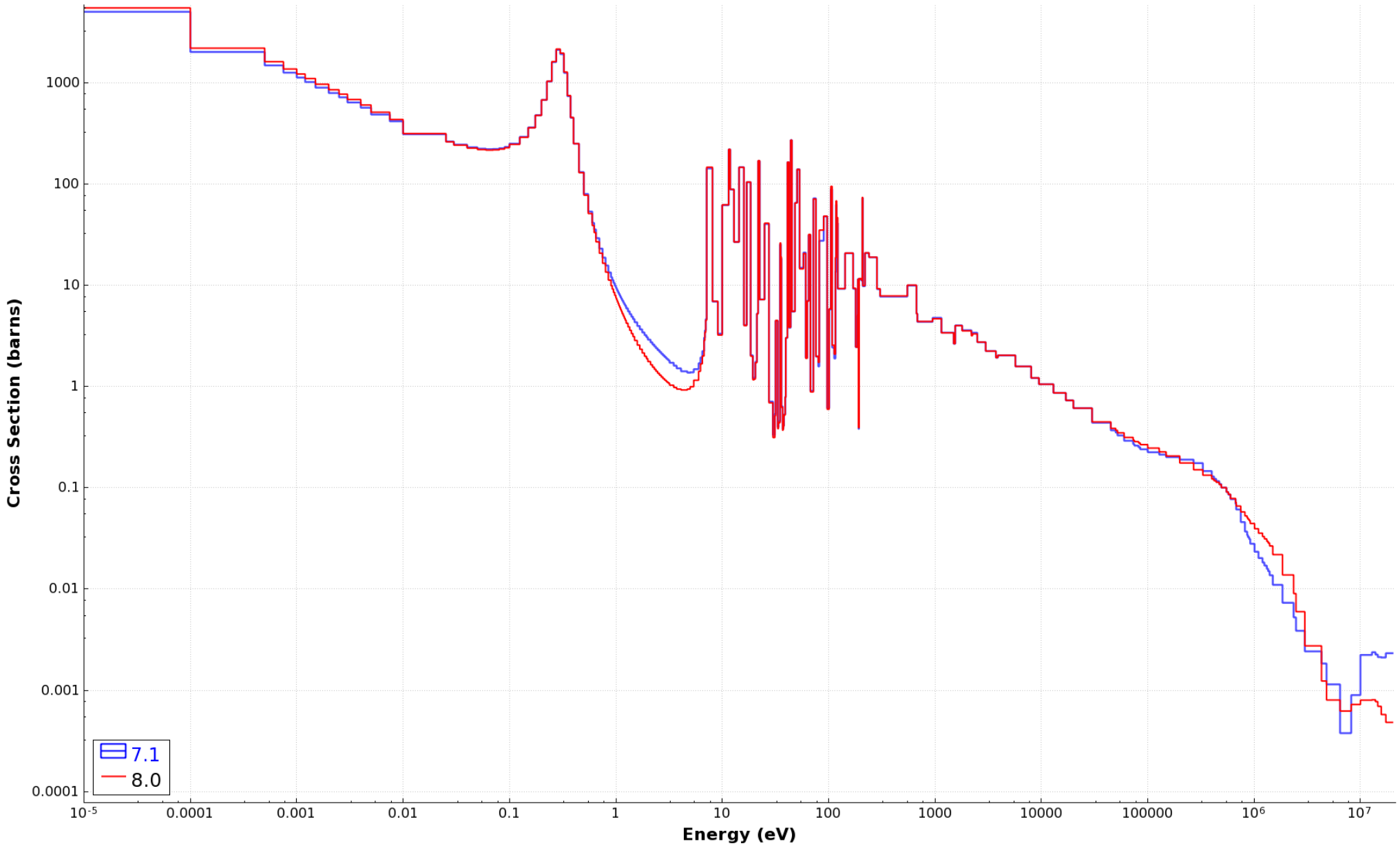
PMF Results


1.0050
1.0025
1.0000
0.9975
0.9950
0.9925
0.9900
C/E
benchmark
PMF 1-001
PMF 2-001
PMF 5-001
PMF 6-001
PMF 8-001
PMF 10-001
PMF 18-001
PMF 22-001
PMF 23-001
PMF 24-001
Exp. Unc.
VII.1-MG
VIII.0-MG
VII.1-CE
VIII.0-CE

PST Results


1.020
1.015
1.010
1.005
1.000
0.995
0.990
0.985
0.980
C/E
case
benchmark
1-6
PST 1-(001 - 006)
7-13
PST 2-(001 - 007)
14-21
PST 3-(001 - 008)
22-34
PST 4-(001 - 013)
case
benchmark
35-43
PST 5-(001 - 009)
44-46
PST 6-001 - 003)
47-54
PST 7-001 - 008)
55-66
PST 11-001 - 012)
67-81
PST 20-001 - 015)
Exp. Unc.
VII.1-MG
VIII.0-MG
VII.1-CE
VIII.0-CE

Pu-239 Capture



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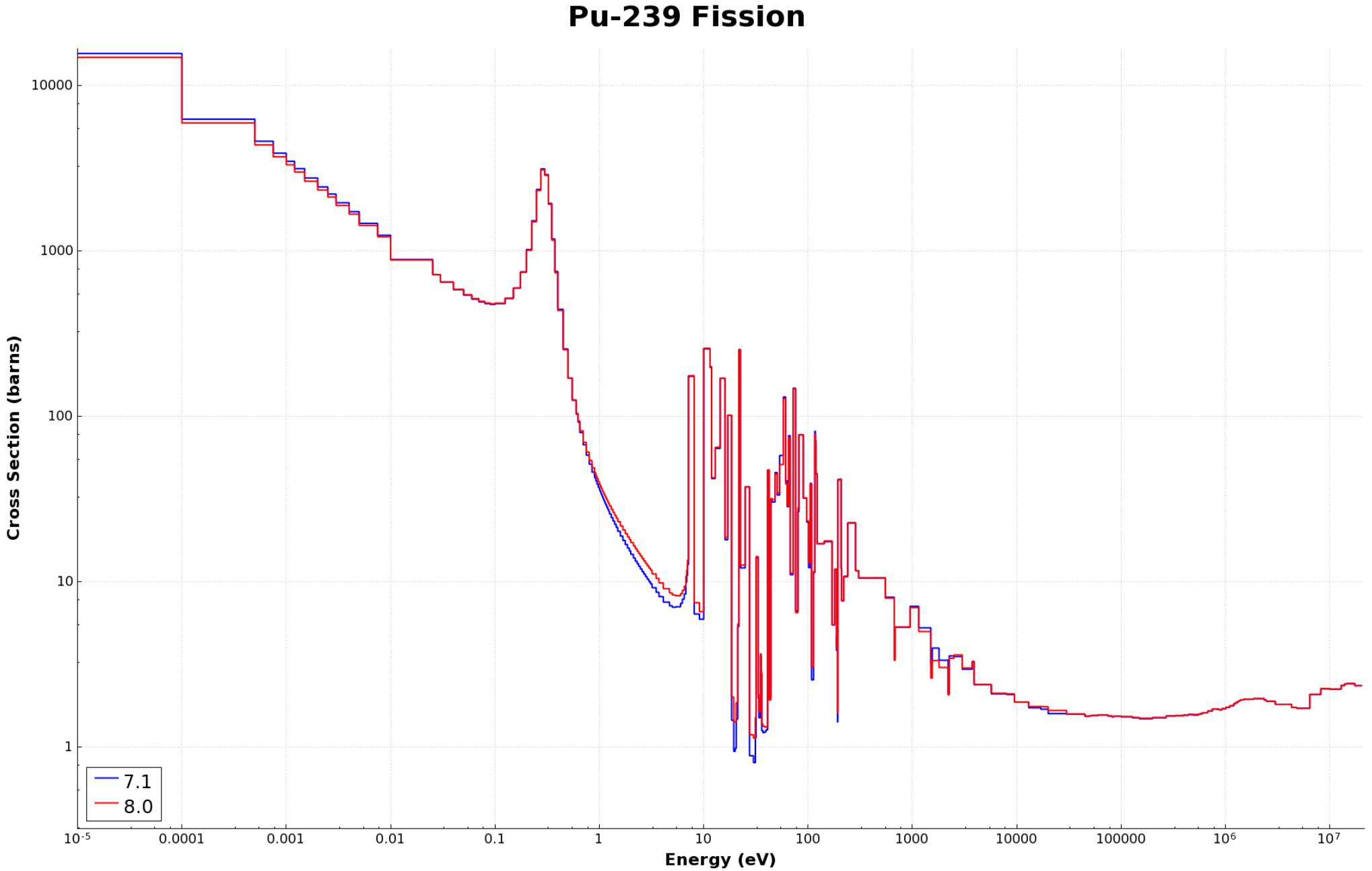

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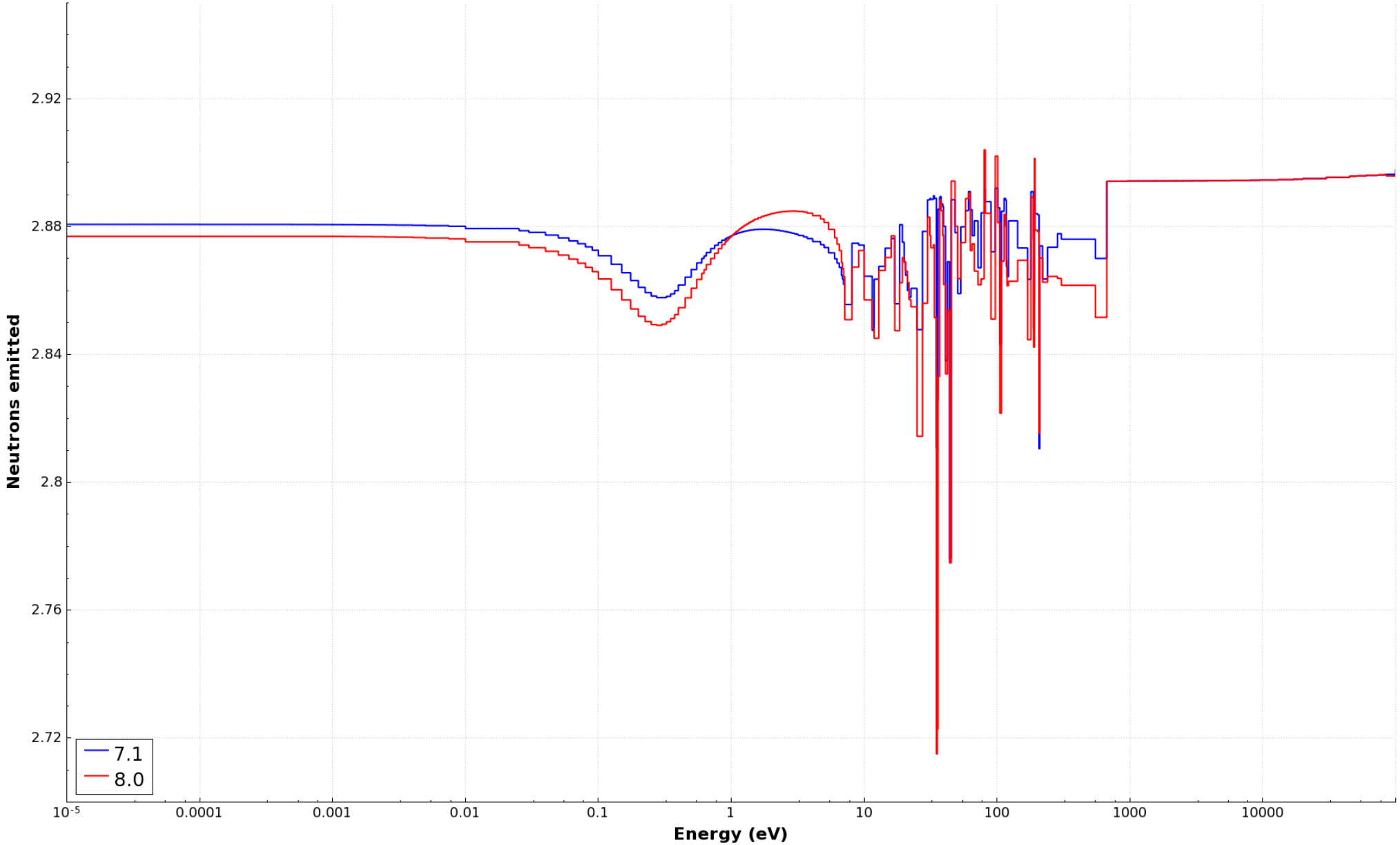
Pu-239 Nu-bar



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Summary

- New data give new answers
  - Flip in computational bias for PST and MST systems
  - Marginal decrease in average k_{eff} prediction quality for LCT cases (CE)
  - No significant change in HMF, HST, IMF, or LST results

- ENDF-VIII.0 libraries for SCALE in testing
  - Plan to release with 6.3. $\beta 1$