

IRSN

INSTITUT
DE RADIOPROTECTION
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Enhancing nuclear safety



Benchmark Inter-comparison Study

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MEMBER OF

ETSON

EUROPEAN
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NETWORK

Benchmark Intercomparison Study: COG, KENO, MCNP, MORET



- New benchmark intercomparison using various nuclear data libraries
 - ↳ JEFF-3.1.1, JEFF-3.3, ENDF/B-VII.1 and ENDF/B-VIII.0
- Use of codes validations suites benchmark → independent modeling

Provide a rigorous basis for quality and validating nuclear data libraries



ADVANCE, VaNDaL, ICSBEP/DICE

Data available at IRSN

2019 : HEU and Pu systems

MCNP (ENDF/B-VII.1) received in June 2017

- HEU: 386
- PU: 261
- LEU: 209
- IEU: 13
- MIX: 73
- U233: 158

COG (ENDF/B-VII.1 and B-8) received in March 2018/last update on Feb. 2019

- HEU: 761
- PU: 526
- LEU: 366
- IEU: 188
- MIX: 28
- U233: 193

MORET (JEFF3.1.1/ JEFF3.3/ ENDF/B-VII.1/ENDF/B-VIII.0)

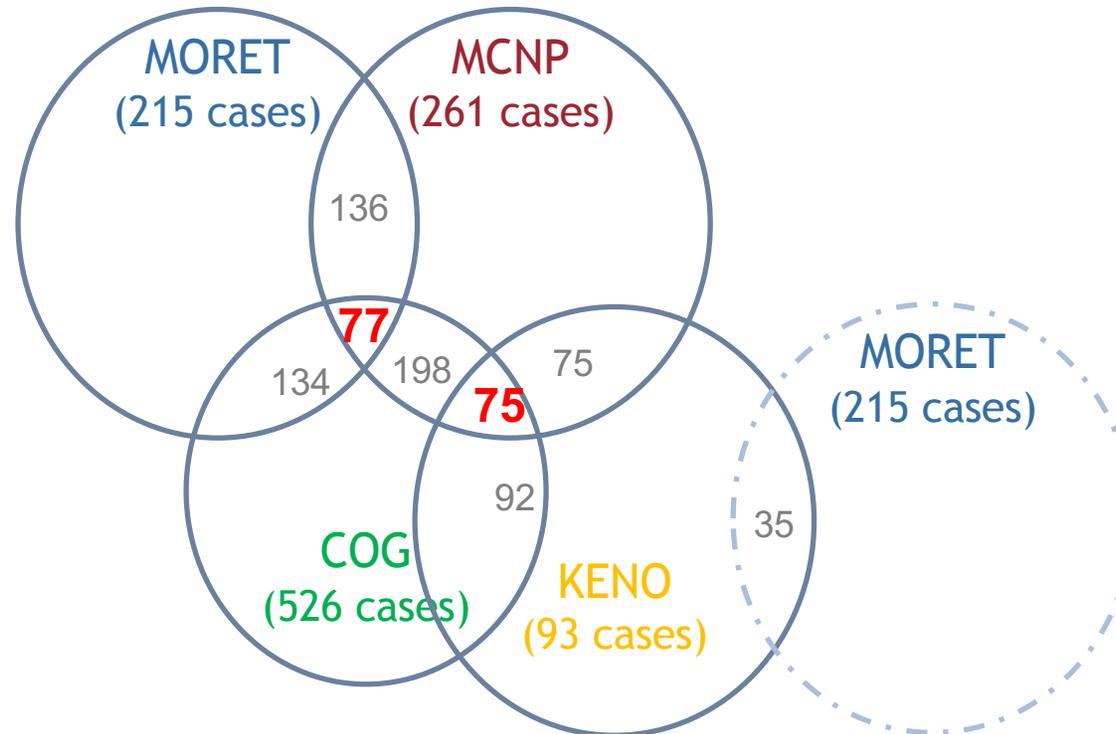
- HEU: 457
- PU: 215
- LEU: 449
- IEU: 18
- MIX: 164
- U233: 32

SCALE (KENO V and VI with ENDF/B-VII.0 and .1) received in March 2018

- HEU: 102 (27 K6)
- PU: 93
- LEU: 159
- IEU: 13
- MIX: 61
- U233: 190

Common set of PU benchmarks

- ❑ PU: **748** cases available (95 evaluations) in ICSBEP Handbook (2018)

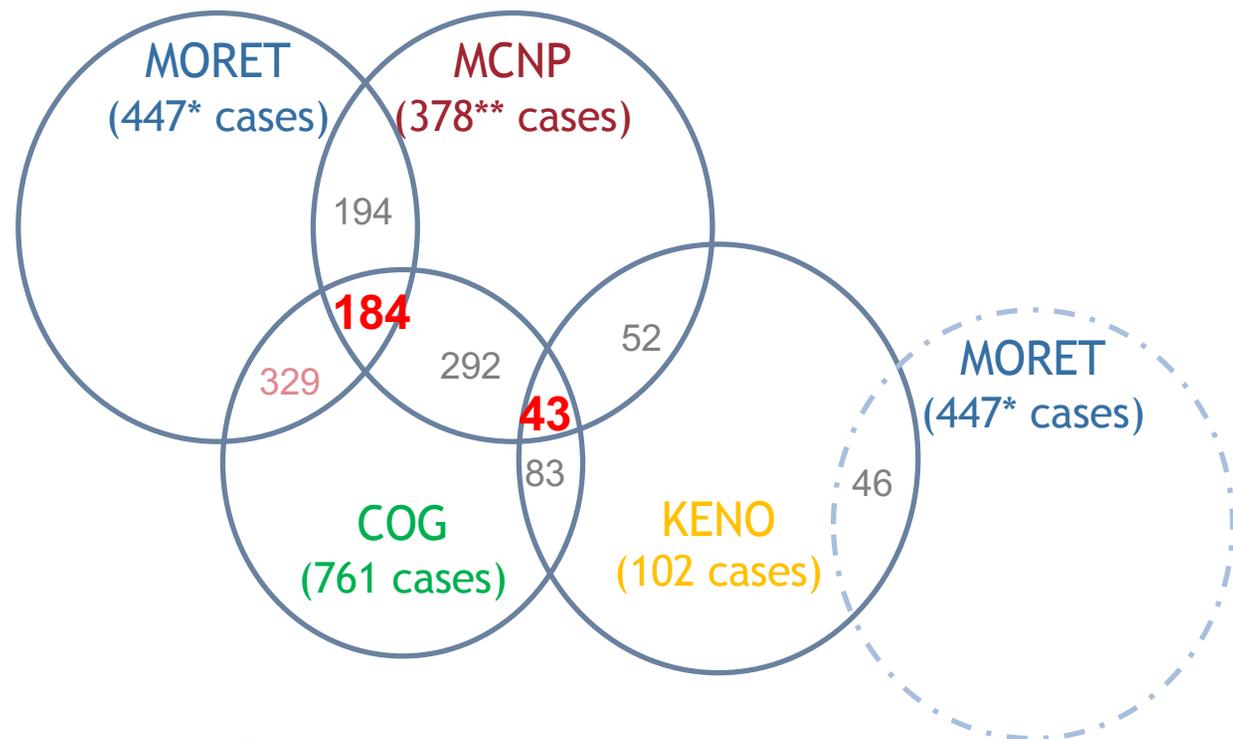


- Only 33 common cases for PU in KENO, MCNP, COG and MORET validation suites

No more benchmarks with polystyrene-moderated plutonium oxide in MORET validation suites (quality of the 61 experiments)

Common set of HEU benchmarks

❑ HEU: **1426** cases available (225 evaluations) in ICSBEP Handbook (2018)



➤ Only 35 common cases for HEU systems

* HST014 to 018 were suppressed from the MORET validation suites because of inconsistencies

**HMF077 cases (8 exp.) are from a preliminary version of the ICSBEP evaluation

Main issues for the intercomparison

ICSBEP revisions

- Not indicated in MCNP, COG and SCALE Excel files
- Always the last revision in the MORET 5 validation suites (check each year)
- Could impact geometrical or materials data (*sometimes revisions are issued to add new calculations in section 4*)
- Benchmark k_{eff} and uncertainty could sometimes help to solve this issue

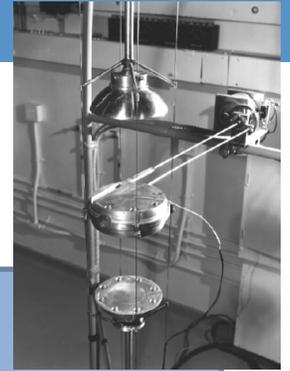
HEU systems (225 evaluations)

- 148 revisions 0
- 37 revisions 1
- 28 revisions 2
- 9 revisions 3
- 3 revisions 4

Pu systems (95 evaluations)

- 50 revisions 0
- 32 revisions 1
- 9 revisions 2
- 3 revisions 3
- 1 revisions 4

Main issues



JEZEBEL experiment (PMF001-001)

4 releases since 1995 - Last one in September 2016 by J. Favorite LANL

Revisions 0 to 2

A solely simplified model based on 2 configurations

Bare sphere of Delta phase Plutonium alloy
17.02 kg with density of
15.61 g/cm³
R= 6.3849 cm

Simplified Benchmark
keff = 1.0000+/- 0.002

MCNP; KENO

Revision 3 (2013)

4 detailed configurations and a simplified model

Bare sphere of Delta phase Plutonium alloy
17.073 kg with density of
15.61 g/cm³
R= 6.39157 cm

Simplified Benchmark
keff = 1.0000+/- 0.00129

Revision 4 (2016)

4 detailed configurations and a simplified model

Mass, densities and dimensions have been reviewed for detailed configurations

Simplified Benchmark
keff = 1.0000+/- 0.0011

COG; MORET

Main issues

■ Simplified or detailed model ?

- Not always indicated in MCNP and SCALE Excel files
- Benchmark k_{eff} and uncertainty could sometimes help to solve this issue
- Could explained small significant discrepancies observed between codes

■ Cross references in ICSBEP

- Example: HEU-MET-FAST-007
 - Cases 11, 12, 14 and 31 are referenced as HEU-MET-INTER-007
 - Cases 13, 15, 16, 17, 18, and 36 to 43 as HEU-MET-MIXED-009



Some cases referenced differently in validation suites

Main issues

Benchmark and DICE numbering

- PU-SOL-THERM-07: Numbering in DICE (1 to 8) doesn't correspond to numbering in the benchmark (2, 3, 5 to 10, cases 1, 4 and 11 being unacceptable)
- KENO uses DICE numbering, whereas MCNP, COG and MORET use benchmarks one

	MORET	COG	MCNP	KENO	
Case 3	1.00382 +/- 0.00010	1.00406 +/- 0.00018	1.00361 +/- 0.00013	1.00901 +/- 0.00010	Corresponds to case 5

↳ 1.00376
+/- 0.00010
(PST007-002 in KENO validation suite)

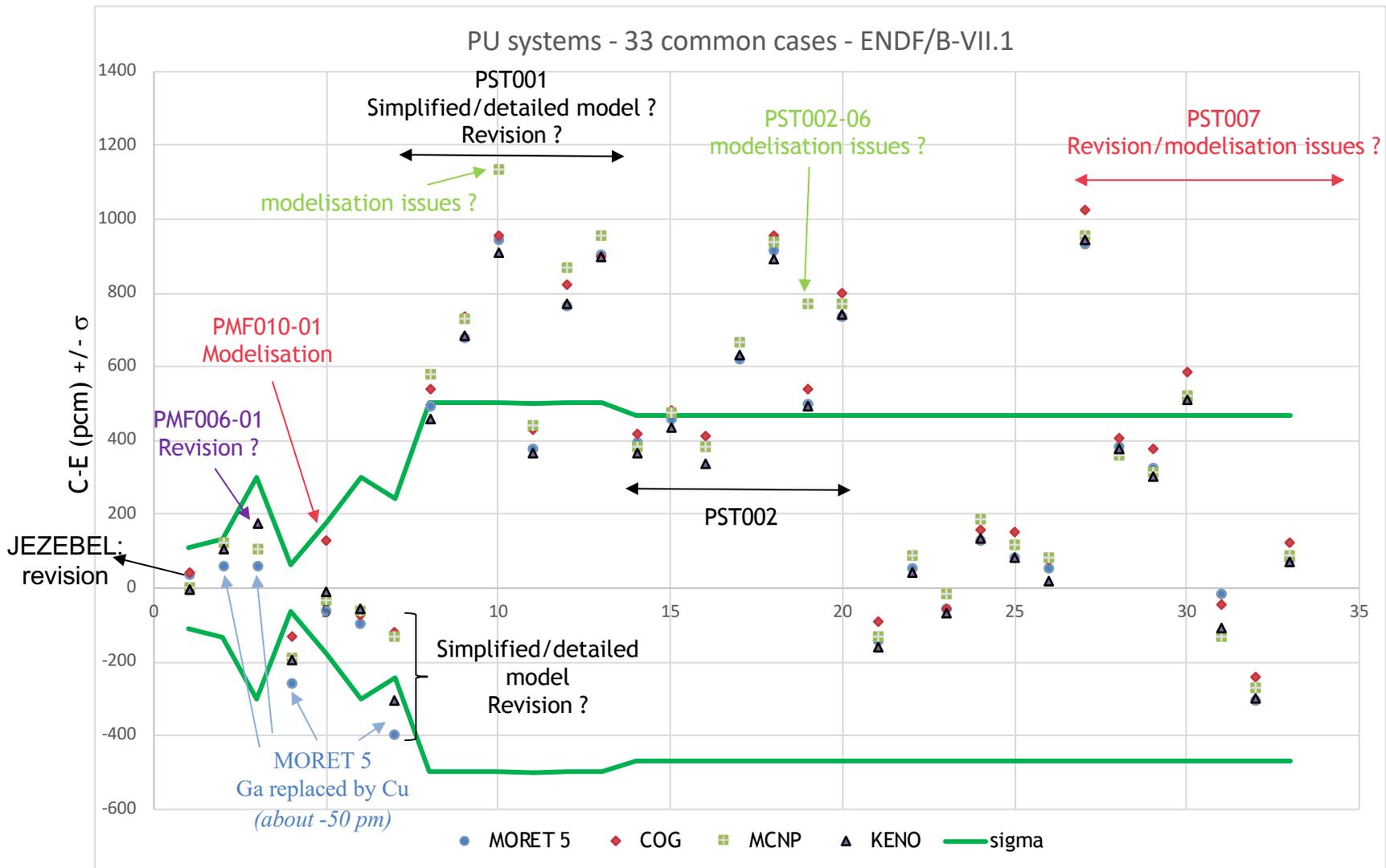
ICSBEP/DICE issues

- HCM-003 - sigma = **0 !**
- HMF004-01 - sigma = **0 !**

Modeling issues and misunderstandings of benchmarks

Preliminary analyses

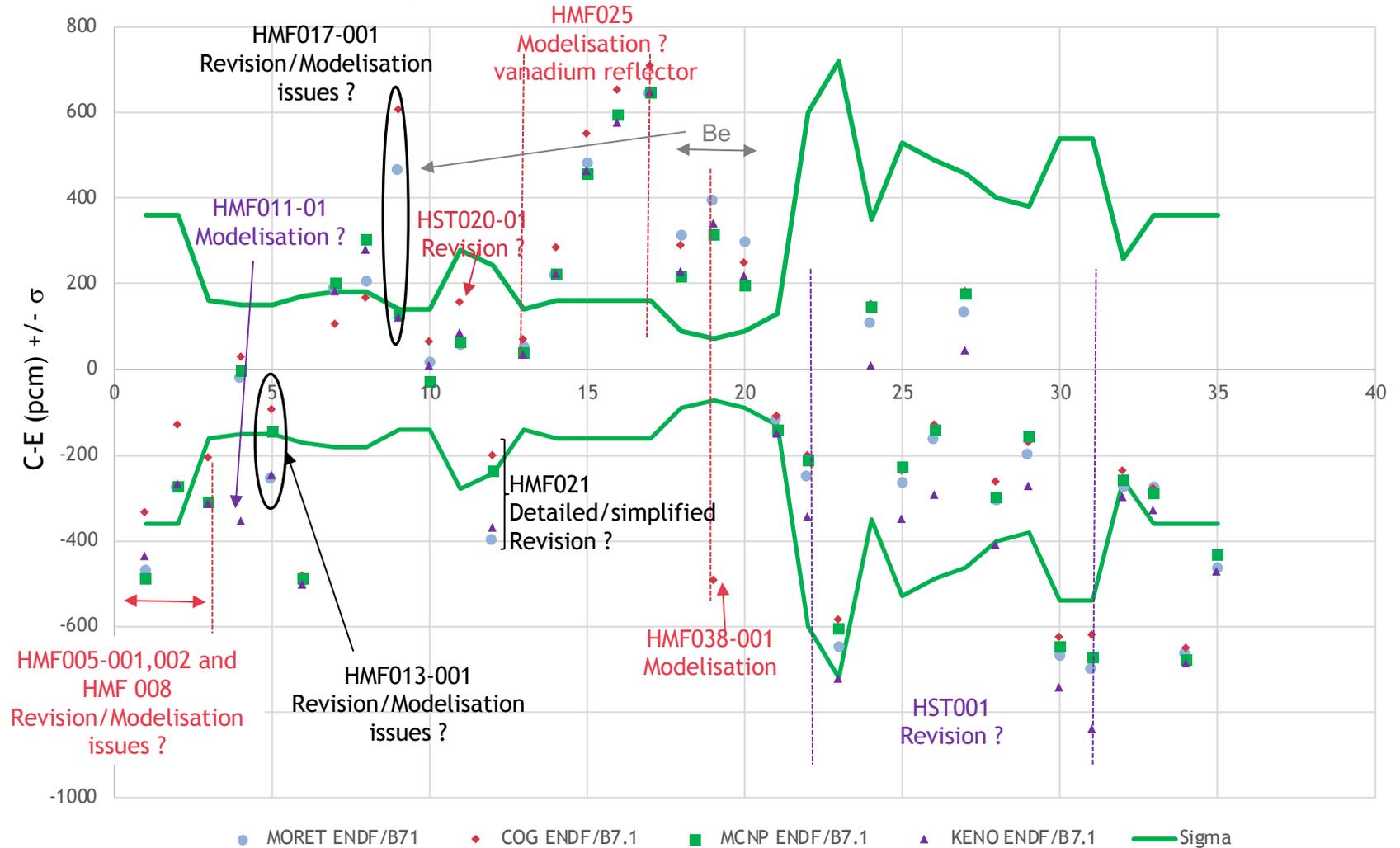
- MC Standard deviations
- Below 0.00020



Preliminary analyses

MC Standard deviations
 Below 0.00020

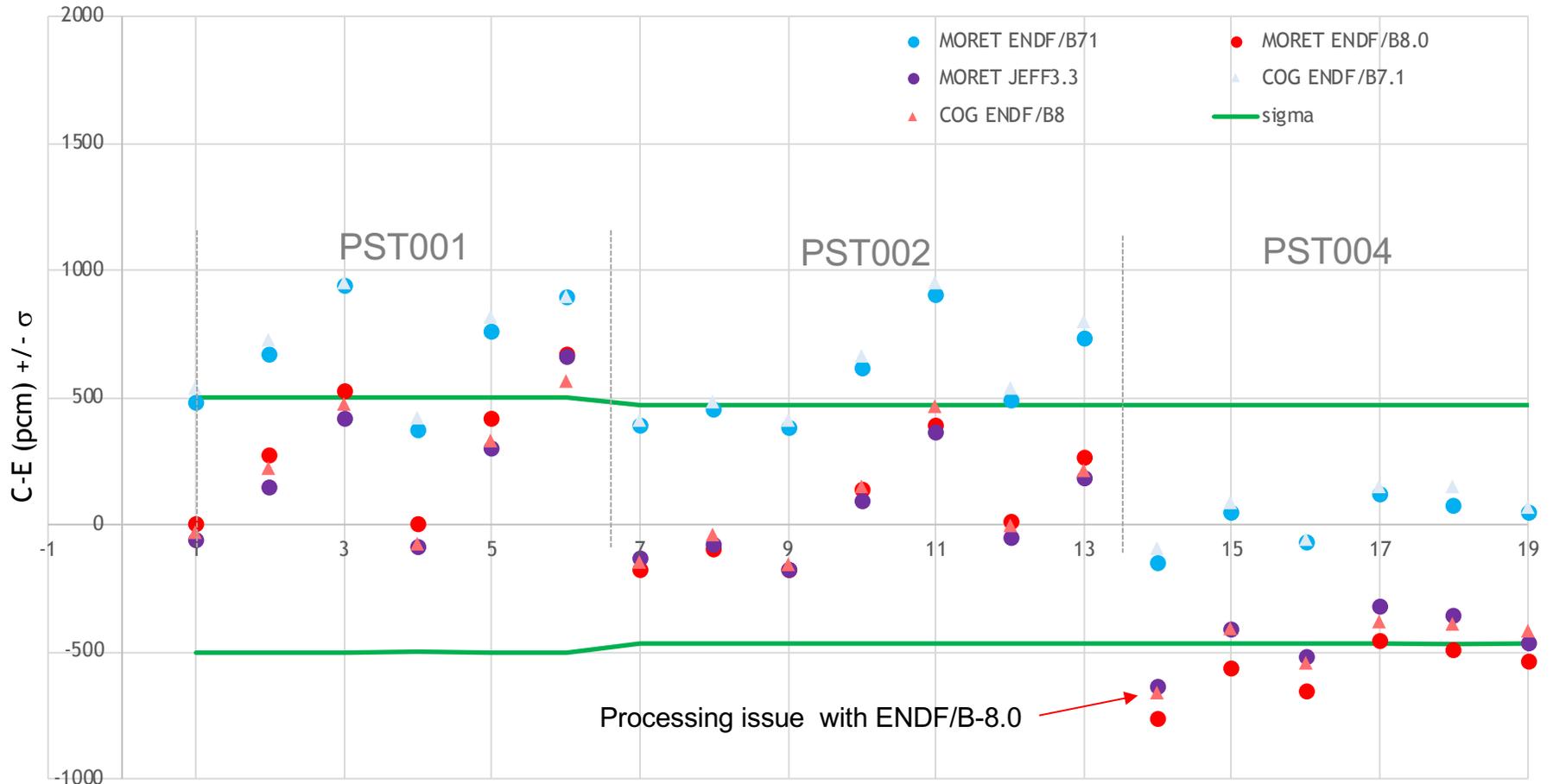
HEU systems - 35 common cases - ENDF/B-VII.1



Preliminary analyses

- MC Standard deviations
 - Below 0.00020

Plutonium solutions - Thermal spectrum

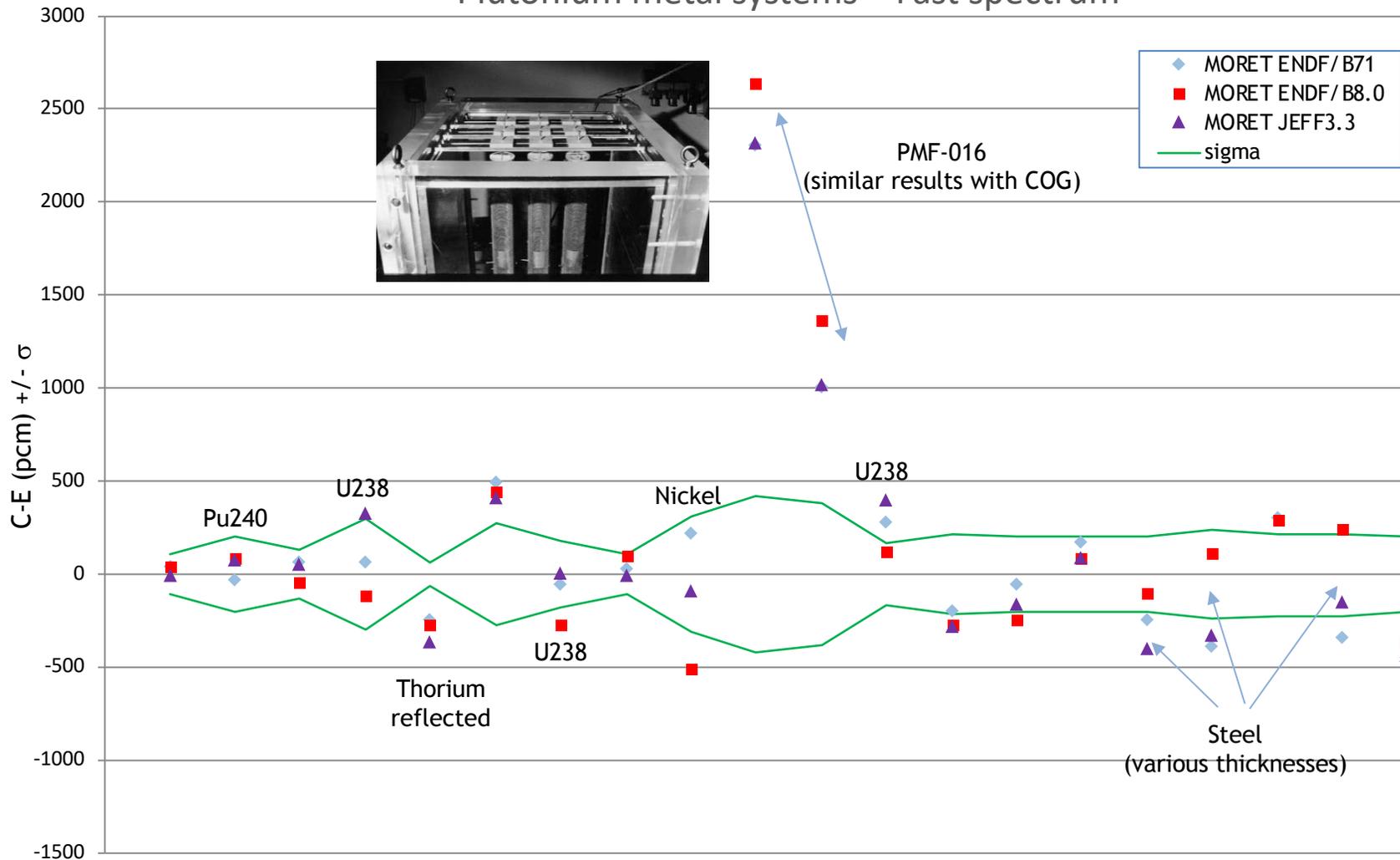


Pu improvement in thermal spectrum with ENDF/B-8.0 and JEFF3.3

Preliminary analyses

- MC Standard deviations
 - Below 0.00020

Plutonium metal systems – Fast spectrum



Conclusion

- ❑ Improvement of the codes validation suites
 - ❑ Use for sensitivity/uncertainty studies

- ❑ Feedback to ICSBEP
 - ❑ Experimental data quality
 - ❑ Misunderstanding in benchmark model
 - ❑ Suspicious data or experimental uncertainties

- ❑ Feedback to Nuclear Data
 - ❑ JEFF and ENDF
 - ❑ Processing tools
 - ❑ New evaluations need

- ❑ Need of additional uncorrelated experiments ?

Conclusion

- ❑ Common publication planned



- ❑ Other systems to be analyzed in FY2020 to FY2022
 - 2020 - IEU, LEU
 - 2021 - MIX, U233, SPEC
 - 2022 - Final report