International Criticality Benchmark Comparison for Nuclear Data Validation

Summary of the work 2019 - 2022

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Two objectives of the intercomparison exercise:

- Cross-validation of Monte Carlo codes:

  - for the same model, Monte Carlo codes shall provide the same results (± calculation uncertainty)

  - source of discrepancies: error or differences in the benchmark model (e.g. revision), processing of nuclear data, …

- Feedback on nuclear data libraries: rigorous methodology to assess the quality and validation of libraries

Codes	MORET 5	COG11	MCNP6	KENO
Nuclear data librairies	ENDF/B-VII.1 ENDF/B-VIII.0 JEFF-3.3	ENDF/B-VII.1 ENDF/B-VIII.0 JEFF-3.3	ENDF/B-VII.1 ENDF/B-VIII.0	ENDF/B-VII.1 ENDF/B-VIII.0
Processing tool	GAIA 1 (based on NJOY)	PREPRO (except for TSL and JEFF lib.)	NJOY	AMPX

Identification of common benchmarks between the MORET, MCNP, COG and KENO codes

|	MORET	COG	MCNP	KENO	Common benchmarks
Pu	248	766	261	93	63
HEU	450	1044	386	102	37
IEU	167	199	13	13	7
LEU	554	801	204	159	32
MIX	219	352	73	61	4
U233	191	193	155	190	128
SPEC	10	10	0	0	10 *(2 codes)*

Number of benchmarks cases avalable for each category

- **Good agreement between codes**

- **Discrepancies between nuclear data libraries**

  – Better results for B8.0 and JEFF 3.3 than B7.1 thanks to new evaluations of ^{239}Pu and ^{16}O for PST benchmarks

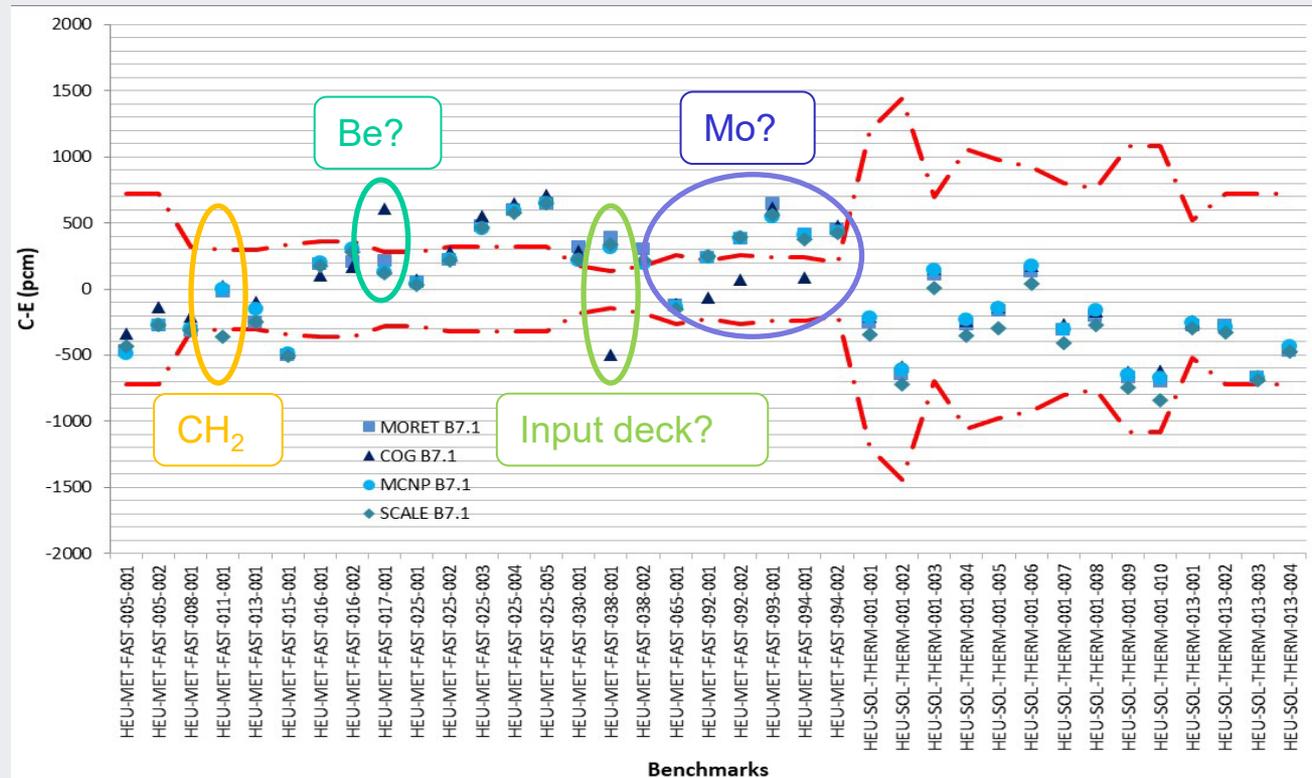 – For PST-041: Pu solution with 3% ^{240}Pu

    Overestimation with B7.1
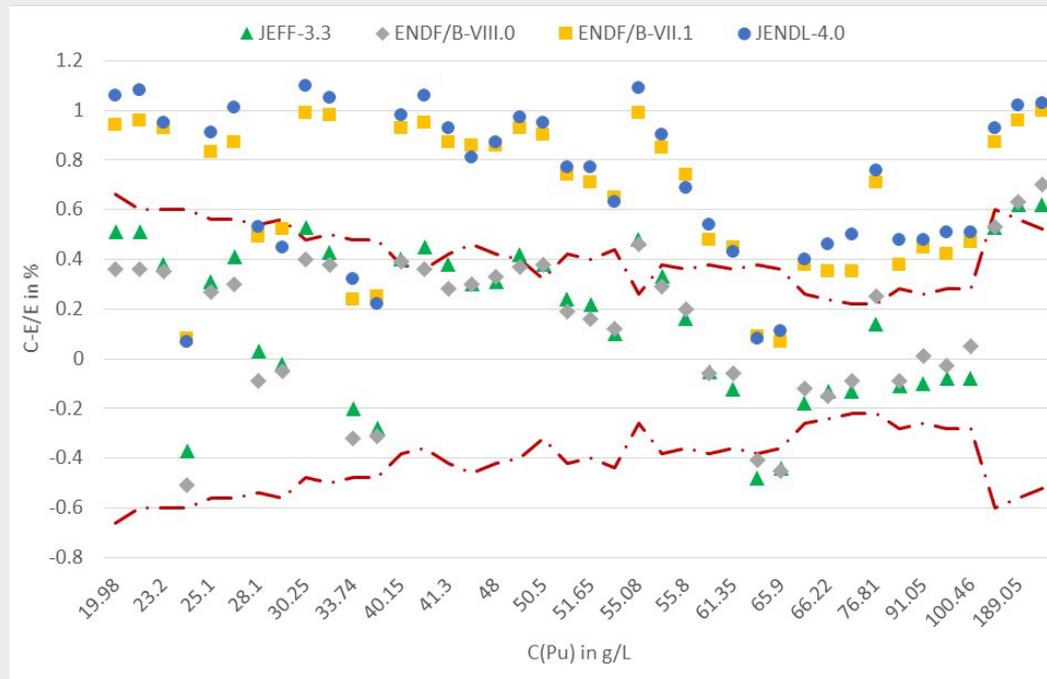
PST-041 results (MORET calculations)

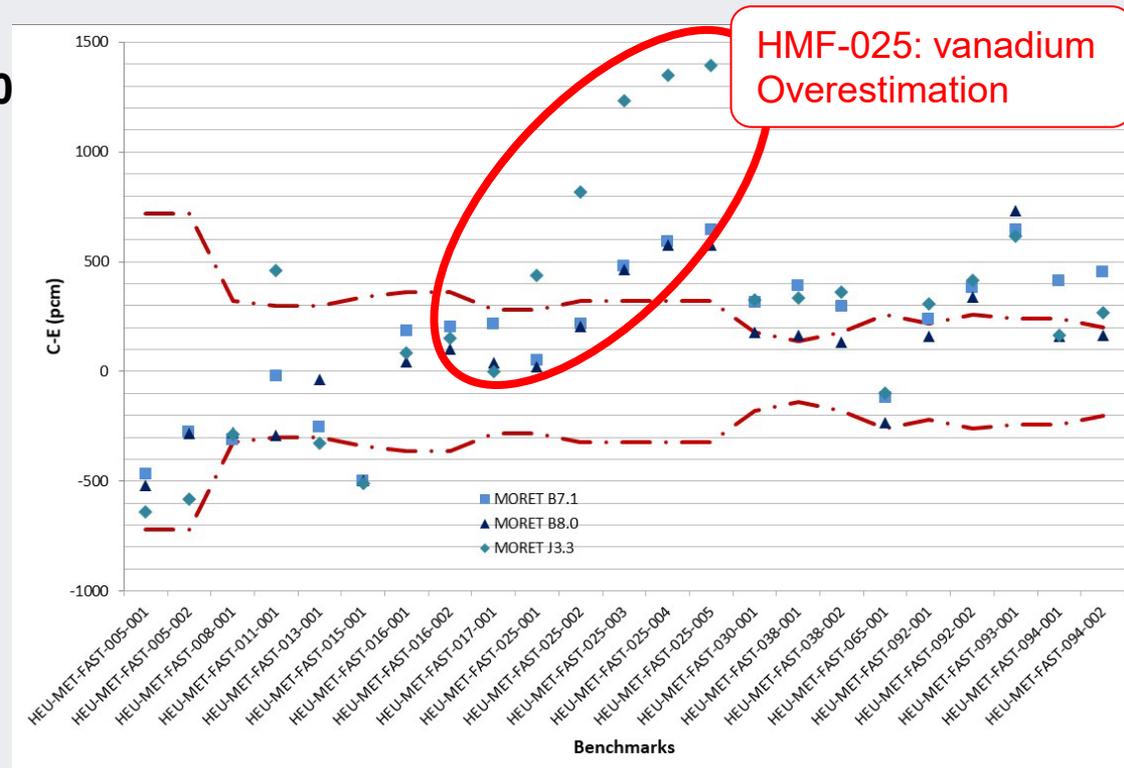- Significant discrepancies between codes for some cases due to **nuclear data processing**

HEU results for all codes and ENDF/B-VII.1

- Significant discrepancies between nuclear data libraries for specific reflectors and bias observed

- **In general, better results with B8.0** compared to B7.1 and JEFF3.3

| Benchmarks	Reflector
005	Be-Mo
011	CH_2
013	Steel
017	Be
030&038	U
092&093	Mo
94	U

HMF-025: vanadium Overestimation

- **Good agreement between codes** (except IMF-009 with KENO due to CH_2 TSL processing, correction done in the last version of SCALE)

- **Discrepancies between nuclear data libraries: identification of isotopes**

X Discrepancy due to **reflector** X

U Discrepancy due to **U**
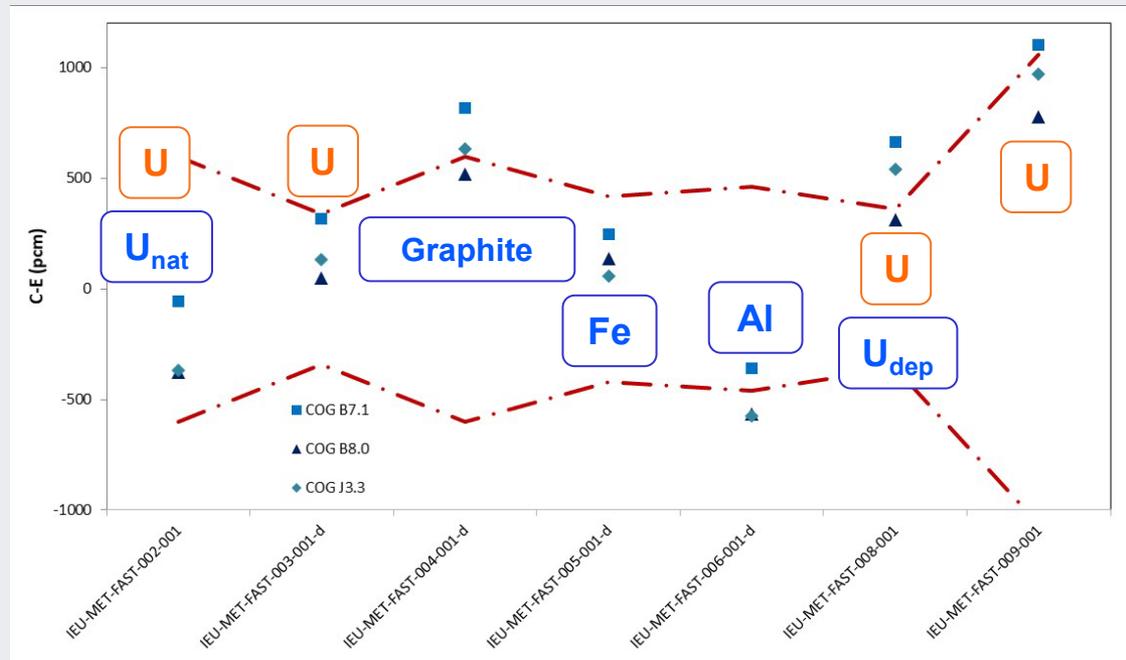
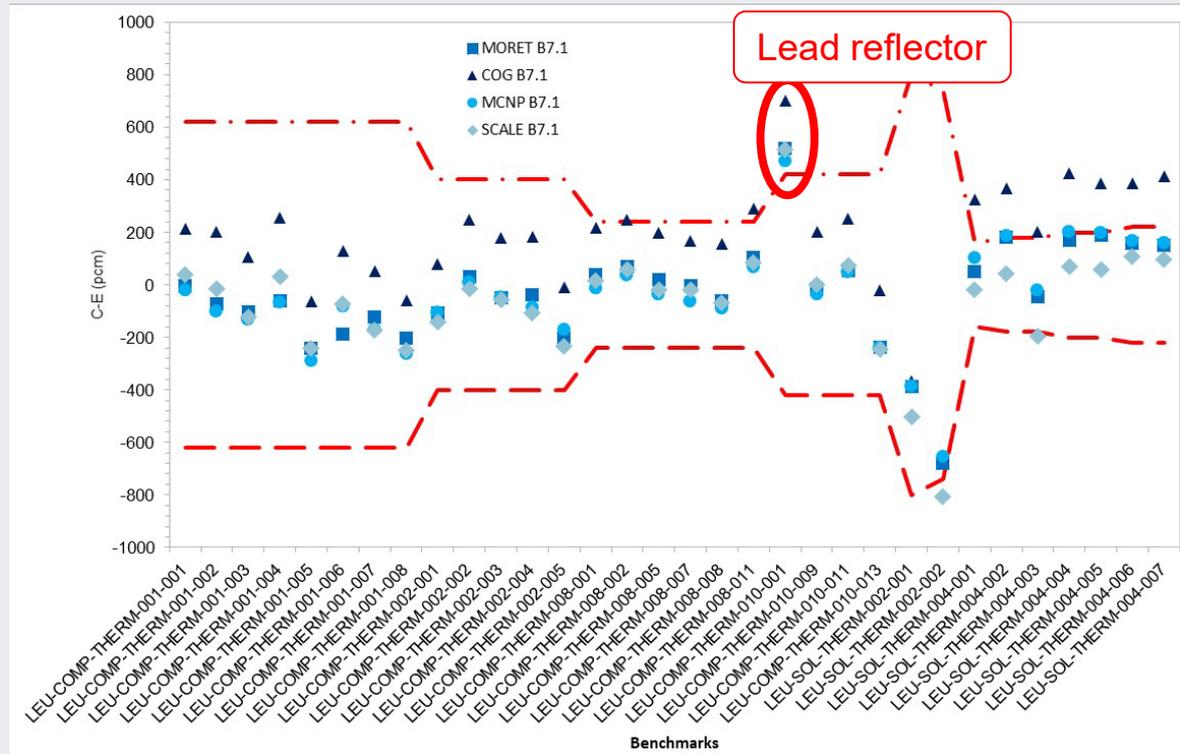
IEU results with COG and all nuclear data libraries

- **Some discrepancies between codes** ➔ TSL processing for water

Codes results for ENDF/B-VII.1

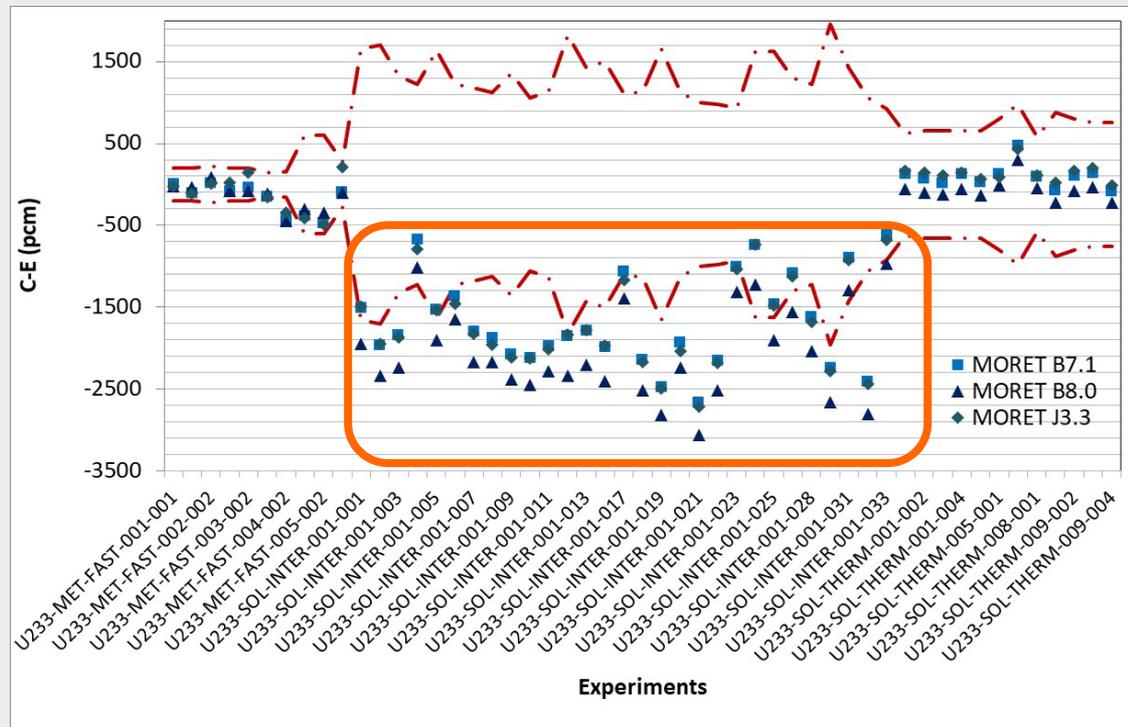- **Good agreement between nuclear data libraries**

  – For LCT-10-001 with Pb, better results with ENDF/B evaluations

- **Good agreement between codes**

- **Discrepancies between nuclear data libraries**

  - Overall underestimation in the intermediate energy range, higher with B8.0

U233 results with different librairies (MORET calculations)

- **MIX category**

  - General good agreement between codes, except with COG for cases sensitive to TSL

  - For some MST-001 and -003 cases the C-E are huge, however it can be due to an experimental bias

- **SPEC category: COG and MORET results**

  - Discrepancies between codes to be investigated (differences in benchmark modeling?)

  - Better results with B7.1 and B8.0

Conclusions

> For most experiments, **quite good agreement between codes** for similar libraries

>> Impact of nuclear data processing, especially $S(\alpha,\beta)$

>> Identification of differences between benchmark interpretation

> **Some discrepancies identified between JEFF-3.3, ENDF/B-VII.1 and ENDF/B-VIII.0**

>> Interesting feedback on nuclear data libraries, especially for reflectors

>> There is no "best" evaluations, however it is possible to identify improvement needs

>> Sometimes it is difficult to conclude because there are compensation effects

> Draft version of the final report sent to partners mid-January for review

> Extension of the work in progress for β_{eff} and shielding calculations (FY2024)

- ➢ Intercomparison exercises are very useful for the validation of our Monte Carlo codes, processing tools and nuclear data libraries

  - ➢ **IRSN would like to continue this work within the framework of the NCSP**
  - ➢ Investigate the origin of codes and libraries discrepancies by carrying out **simple cases** to avoid the effects of compensation
  - ➢ Perform an intercomparison exercise for **depletion codes** (VESTA for IRSN)
    - ➢ At first, with the same nuclear data library to compare codes and simulation options

- ➢ **Acknowledgment**

  IRSN thanks the NCSP for supporting this action on analytical methods and all the partners for this exercise

  And also, Nicolas Leclaire for the results analysis (281 benchmarks x 4 codes x 3 libraries)