AWE NUCLEAR SECURITY TECHNOLOGIES

Testing ENDF/B-VIII.1 and the INDEN p44 file

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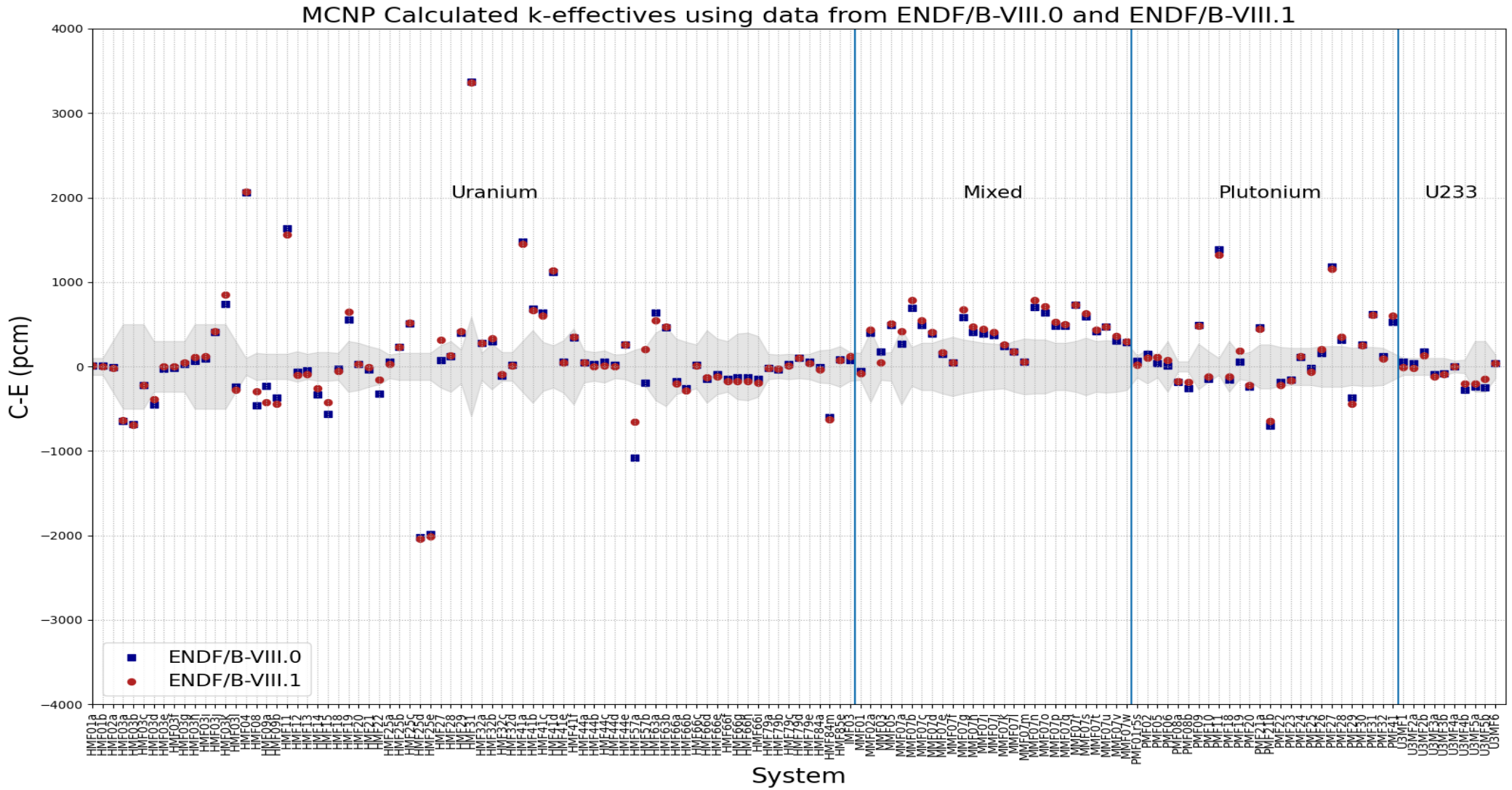
ENDF/B-VIII.1 Fast Criticality Testing

- Comparing NNDC released versions of ENDF/B-VIII.0 and ENDF/B-VIII.1.
- ~ 90 Fast Metal ICSBEP Benchmarks.
  - HMF,MMF,PMF,U3MF
  - MCNP
- Average Chi-Squared like parameter, calculated per case and plotted cumulatively.

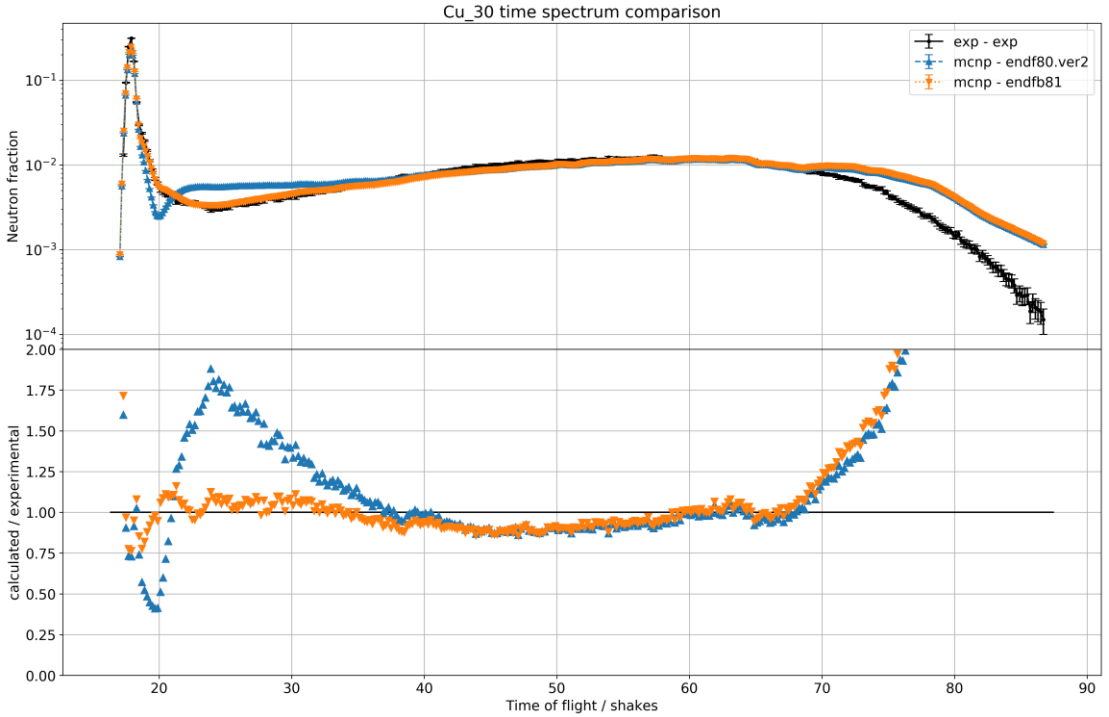
$$\chi^2 = \sum \frac{((k_{calc} - k_{exp})/\delta k_{exp})^2}{n}$$

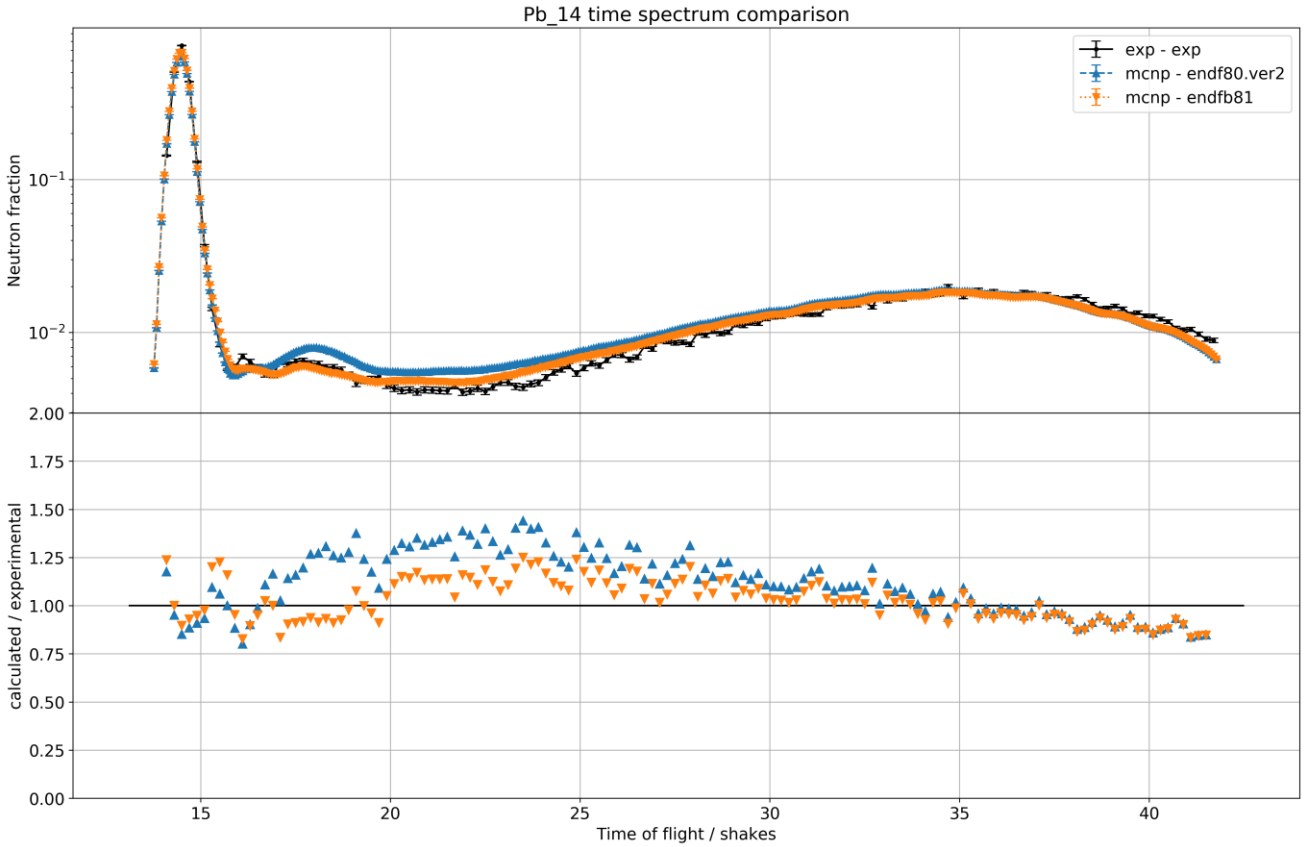
- LLNL Pulsed Spheres in MCNP
  - Compared to measured data.
- Not shown here, groupwise processing and Sn Deterministic transport results.
- Goal is to understand whether we broke things.

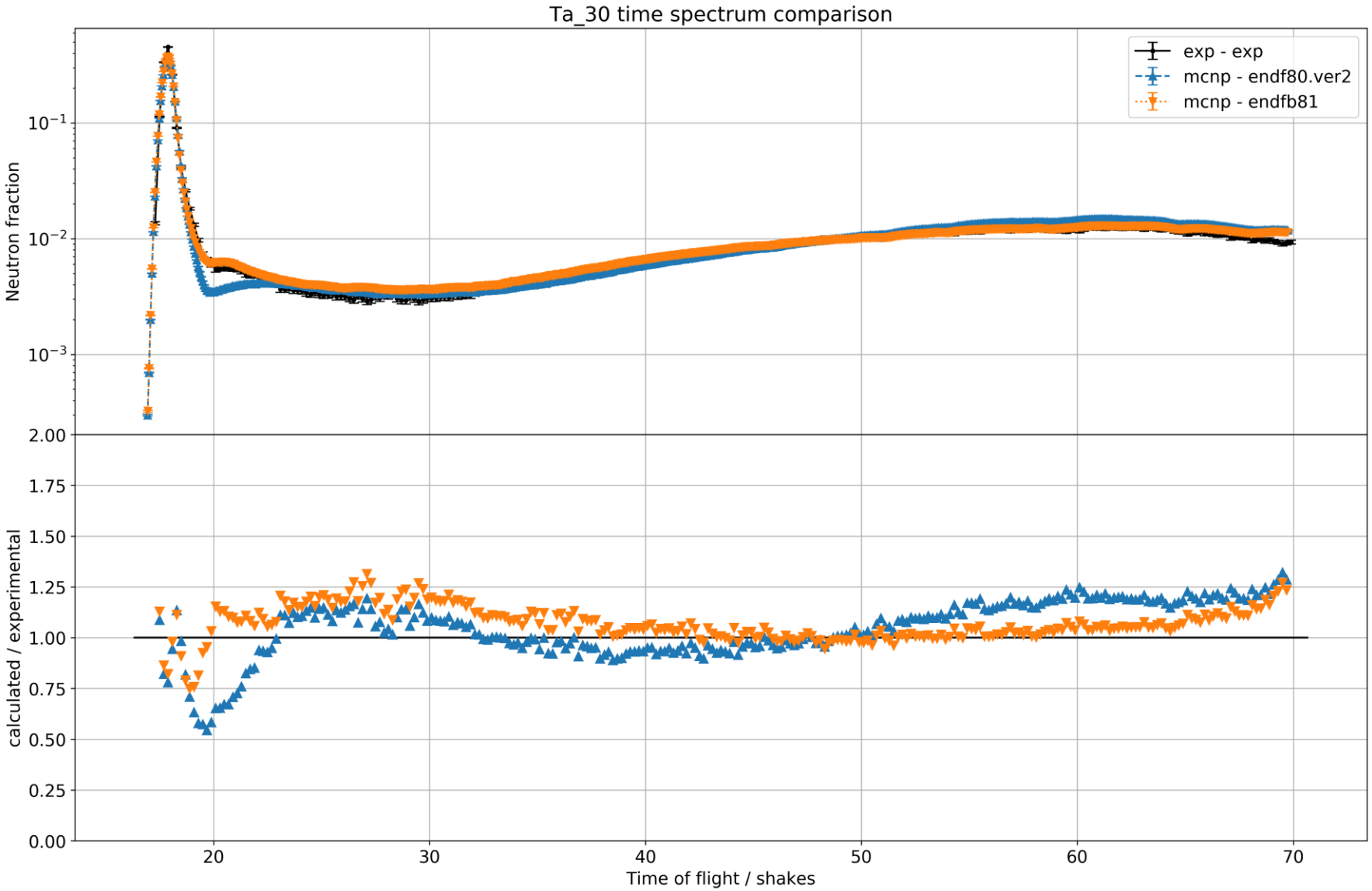
ENDF/B-VIII.1 vs ENDF/B-VIII.0



Pulsed Spheres



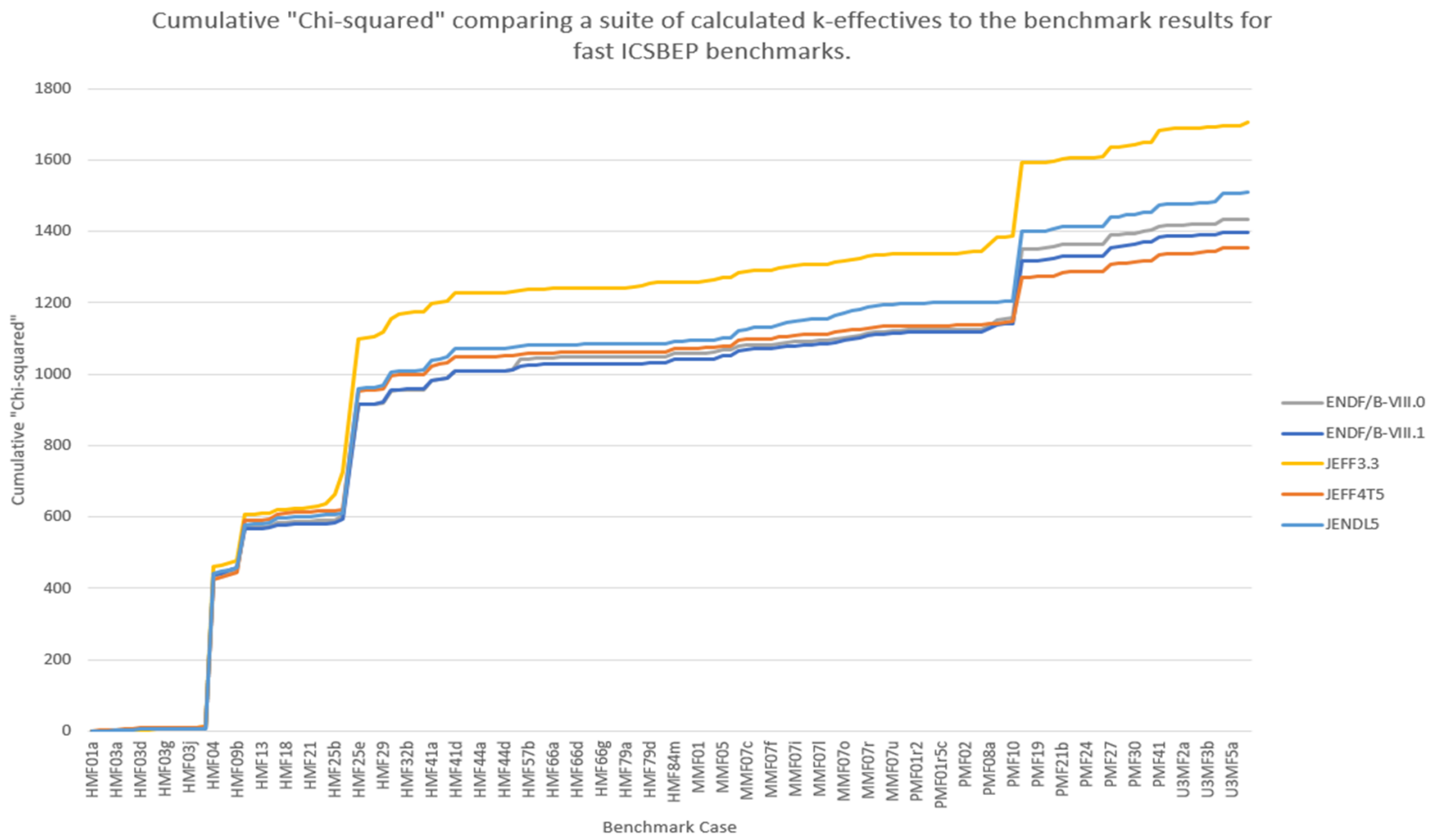



Ta_30 time spectrum comparison
exp - exp
mcnp - endf80.ver2
mcnp - endfb81
Neutron fraction
10^{-1}
10^{-2}
10^{-3}
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
calculated / experimental
20
30
40
50
60
70
Time of flight / shakes

- No Change in criticality using final beta test version compared to the final release.
- Changes between VIII.0 and VIII.1 are generally small for our suite, across the whole suite VIII.1 shows a slightly better fit to benchmark results.
  - Be Systems do worse with VIII.1 than VII.1
  - Shown in “Chi squared” calculations coming up
- Some improvements in fit to measured data in LLNL pulsed spheres, Copper is a good example.

- Consistent with others testing results.
- For ND2025 compared recent ENDF performance to recent JEFF (JEFF4T5, final test version) and JENDL5 evaluations.

Cumulative “Chi-Squared”



Per case

- JEFF data fit to benchmarks has improved significantly.
- Now provides a Chi-squared value slightly lower than VIII.1 (for this suite).
  - Slightly is ~10 pcm on average for this suite.
- JEFF seem to be doing better for low Z reflectors Be, Li, Water.
- VIII.1 is worse than VIII.0 for Be cases.

- Can we learn from the differences?

	ENDF/B-VIII.1	JEFF4T5	JENDL5	ENDF/B-VIII.0	JEFF3.3
TOTAL	10.1	9.7	10.8	10.3	12.3
HEU	14.1	14.5	14.8	14.3	17.0
MIX	2.8	2.4	3.9	2.4	2.9
PU	10.2	7.5	10.5	11.1	13.2
U233	1.1	1.8	3.1	1.8	1.7
ALL					
None	1.4	2.6	2.2	2.2	2.1
Beryllium	2.7	2.4	3.6	2.2	2.7
Steel	0.6	0.8	0.4	0.4	1.8
Tungsten	2.4	3.7	9.2	3.9	2.3
Lead	4.3	3.2	3.2	10.0	3.5
HEU	0.6	0.7	0.5	1.1	0.5
Nat U	0.8	0.9	0.8	0.7	2.3
HEU					
None	1.9	4.5	4.0	3.8	3.0
Beryllium	3.0	2.9	3.2	2.6	2.8
Steel	0.2	0.2	0.7	0.1	2.9
WC	0.9	0.4	0.4	0.7	0.9
Lead	4.3	3.2	3.2	10.0	3.5
Nat U	0.8	0.9	0.9	0.8	2.3
Aluminium	0.5	0.8	1.2	0.7	0.7
LiD	1.4	0.7	0.3	1.8	0.6
Titanium	1.8	1.6	1.4	1.6	2.7
MIX					
None	0.1	0.1	1.0	1.2	1.2
Beryllium	2.9	2.5	4.3	2.4	3.0
Aluminium	9.1	5.1	4.7	8.4	6.1
HEU	0.3	1.7	0.3	0.1	0.4
Nat U	1.1	0.3	1.4	0.9	2.8
PU					
None	0.1	0.9	0.1	0.4	0.2
Beryllium	0.9	0.6	0.7	0.2	0.5
Steel	0.8	1.1	0.2	0.6	1.3
Tungsten	0.8	0.7	0.9	0.1	4.4
DU	7.9	7.2	10.1	6.4	15.8
Nat U	0.1	0.1	0.6	0.0	1.7
U233					
None	0.0	1.0	0.1	0.3	0.9
Beryllium	3.5	5.6	11.4	6.1	0.9
Tungsten	0.4	1.1	2.5	0.3	1.9
HEU	0.0	0.6	0.4	0.2	0.5
Nat U	1.1	1.0	0.7	1.6	1.2

Testing the “INDEN p44” file

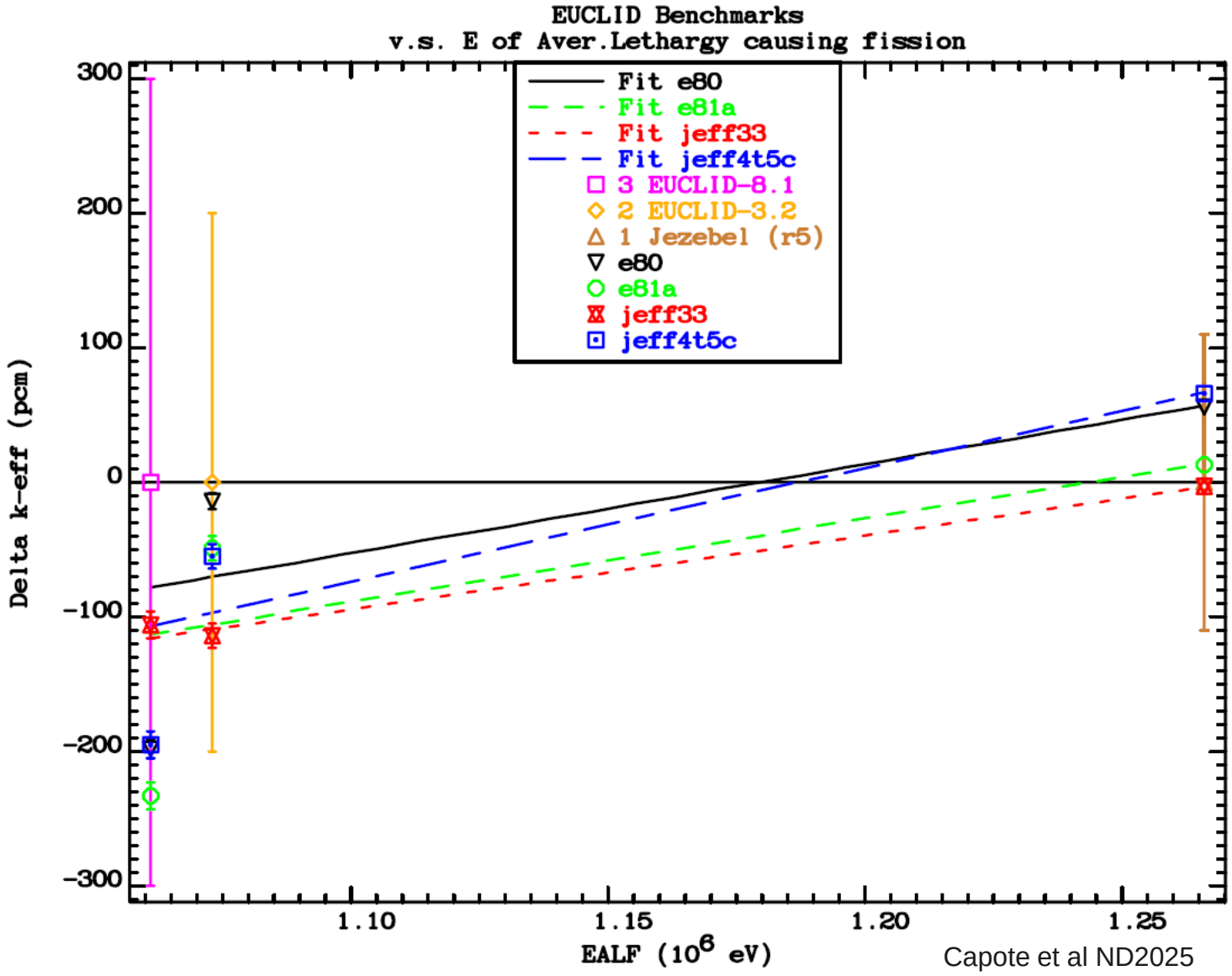
- Firstly thank you Roberto for the file, and copy of your ND2025 talk.
  - I have used some of those slides here but all of the credit should go to Roberto and INDEN.

- File is named Pu239e80p57empJa.endf
  - On Roberto’s instruction included MF5 MT455 from ENDF/B-VIII.0 which was missing in the file provided.
  - Processed using NJOY 2016.76 without error.
  - Referred to as the p44 file.

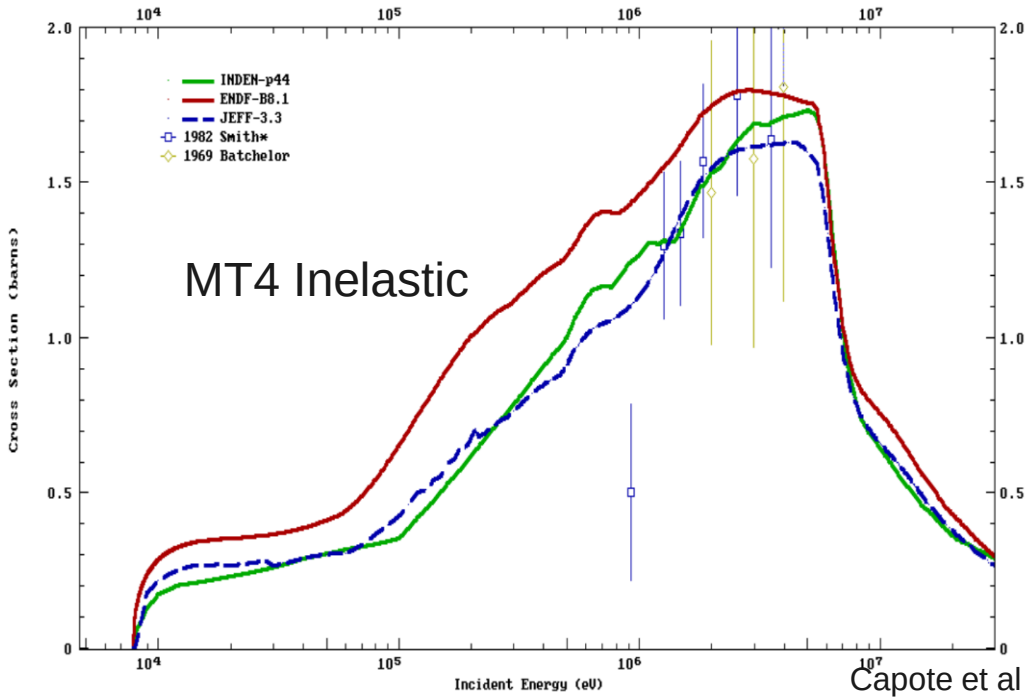
- Not a formal beta version but a candidate for inclusion, I wanted to understand the impacts of these changes in isolation.

- MCNP models of the EUCLID experiments show a trend in their fit to “benchmark” keff with EALF

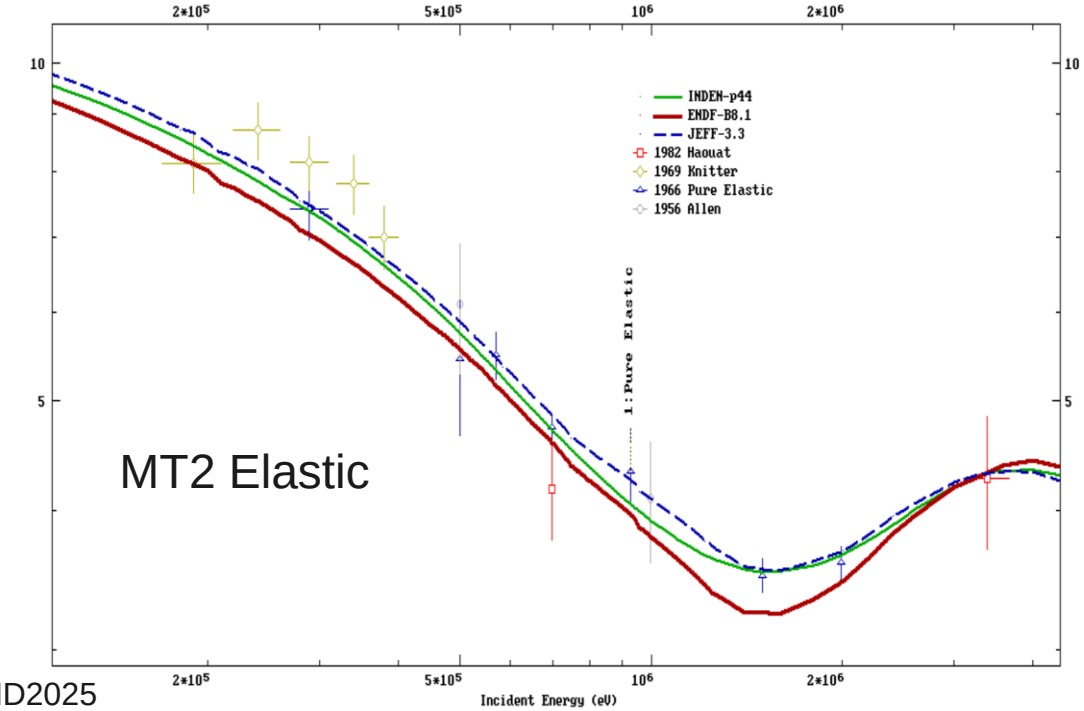
- As I understand the intention of the p44 file was to correct this trend by subtly changing the neutrons spectrum by changing the balance of Elastic and inelastic cross sections.



Capote et al ND2025

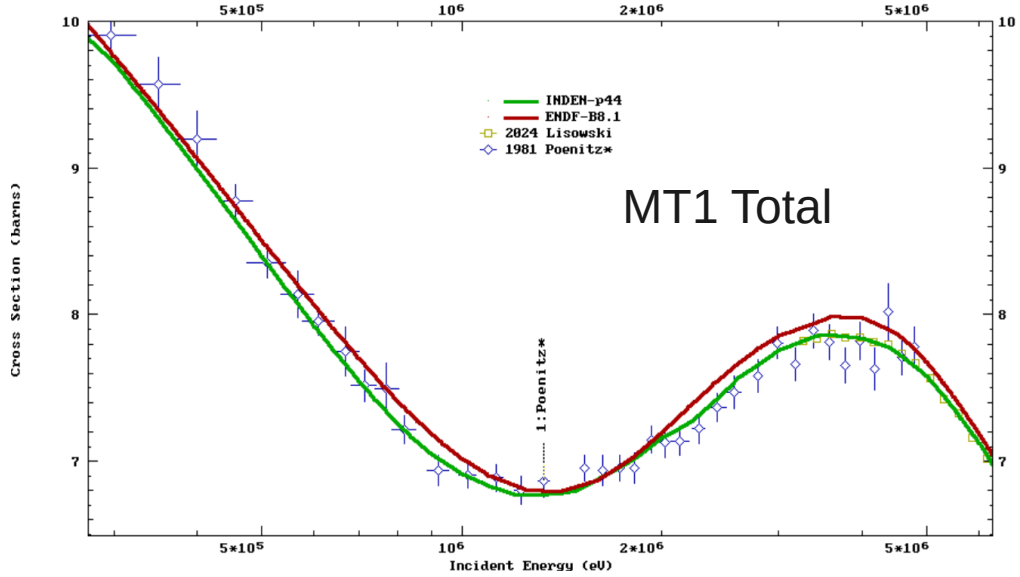


MT4 Inelastic



MT2 Elastic

Capote et al ND2025



MT1 Total

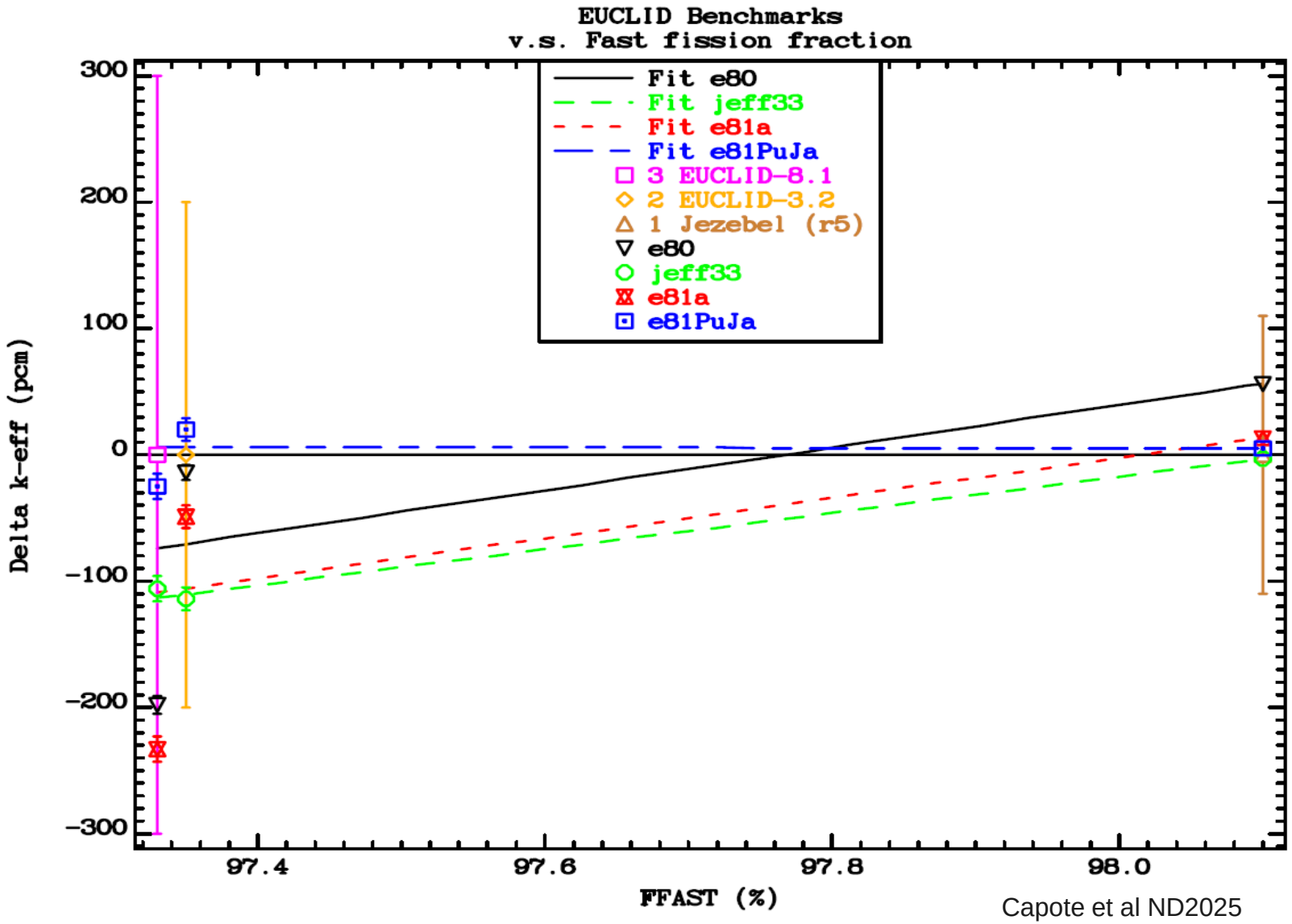
Ignoring the outgoing spectra.

Increase in high energy neutrons from elastic.

Decrease in lower energy neutrons from Inelastic

- Observed trend dissapears using the p44 file.

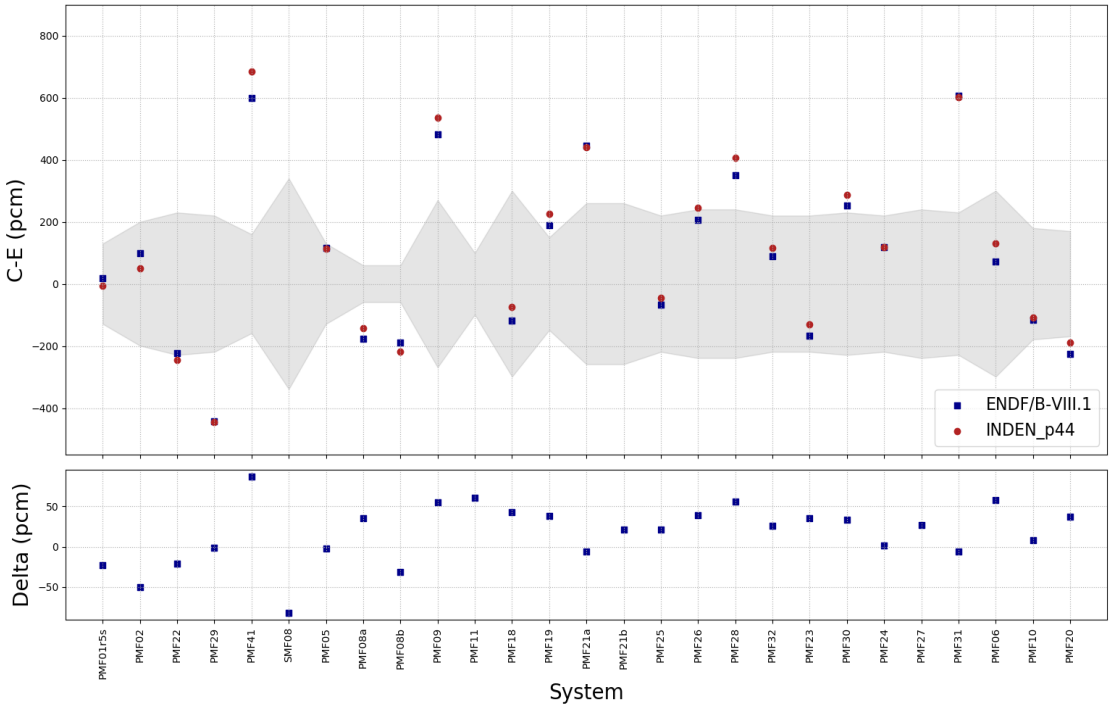
- LANL (Kleedtke) kindly given us mcnp inputs for the EUCLID models.
- In the process of replicating Roberto's finding



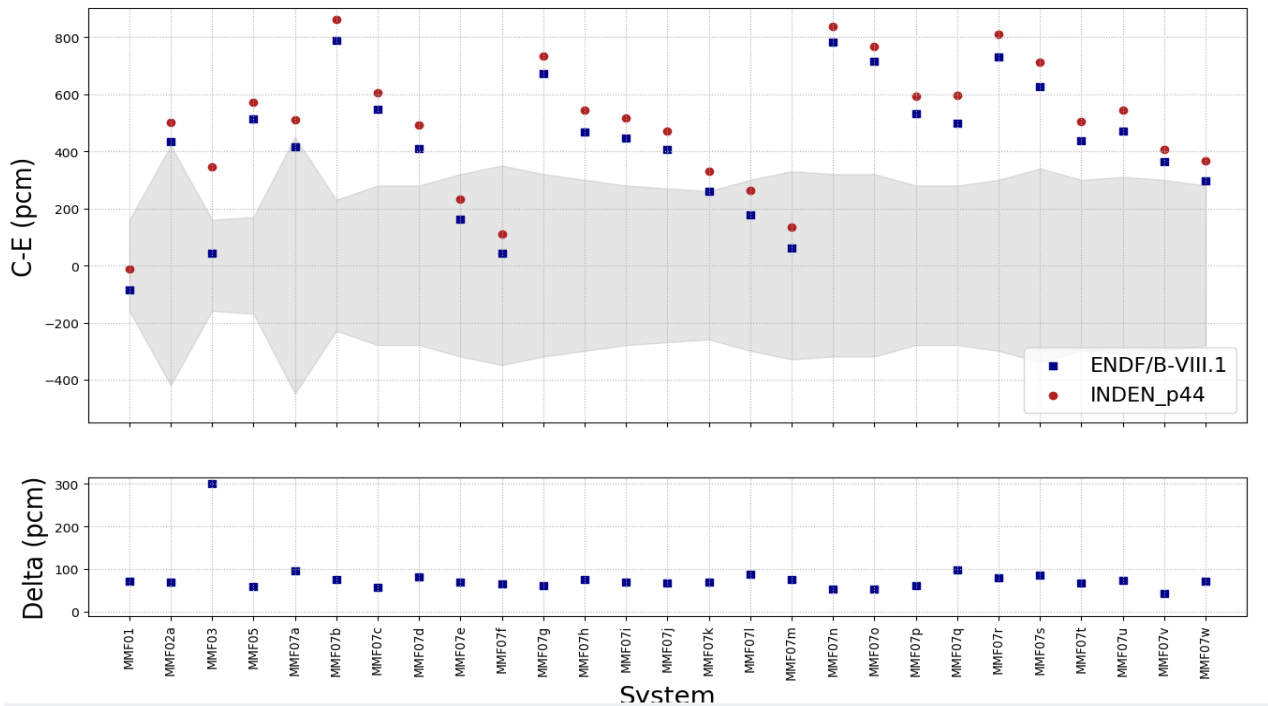
Capote et al ND2025

PMF and MMF Benchmarks

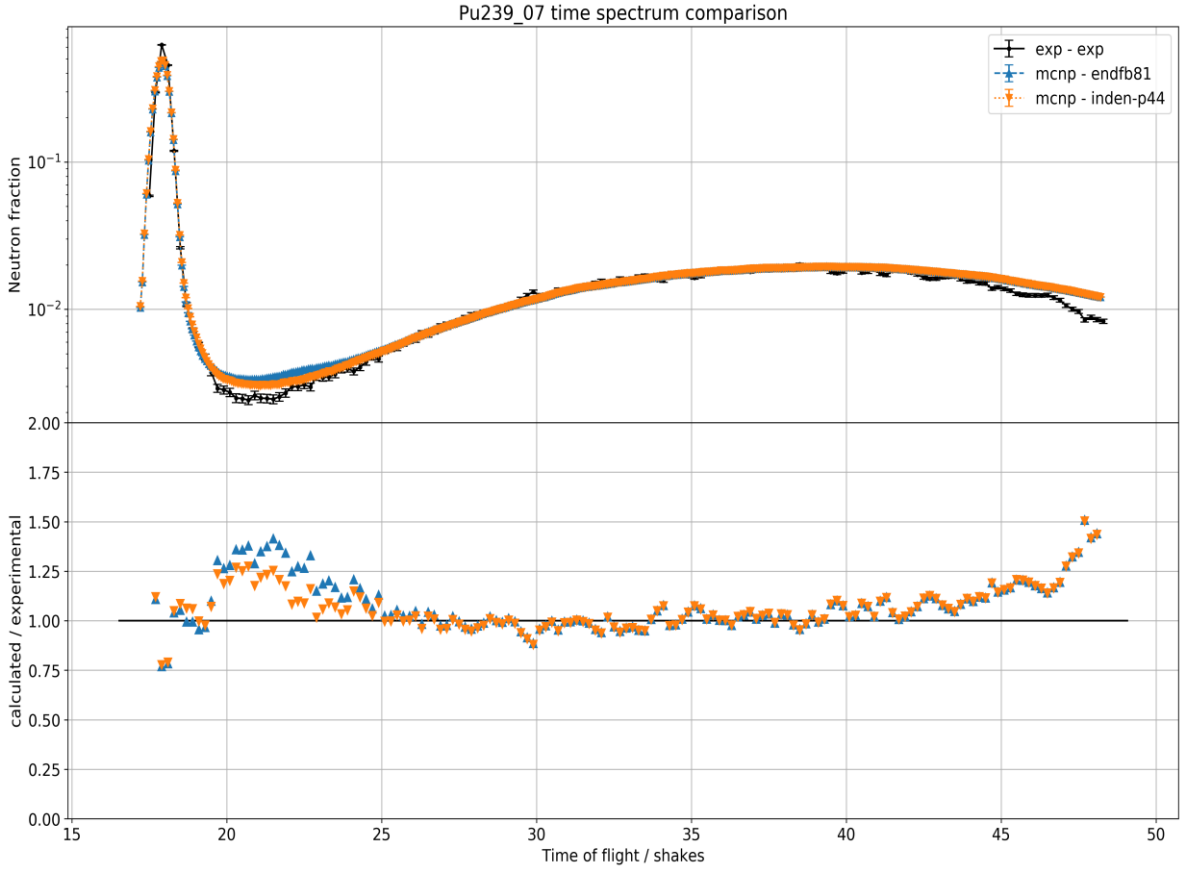
MCNP Calculated-Experimental (pcm) using data from ENDF/B-VIII.1 and the INDEN_p44 file

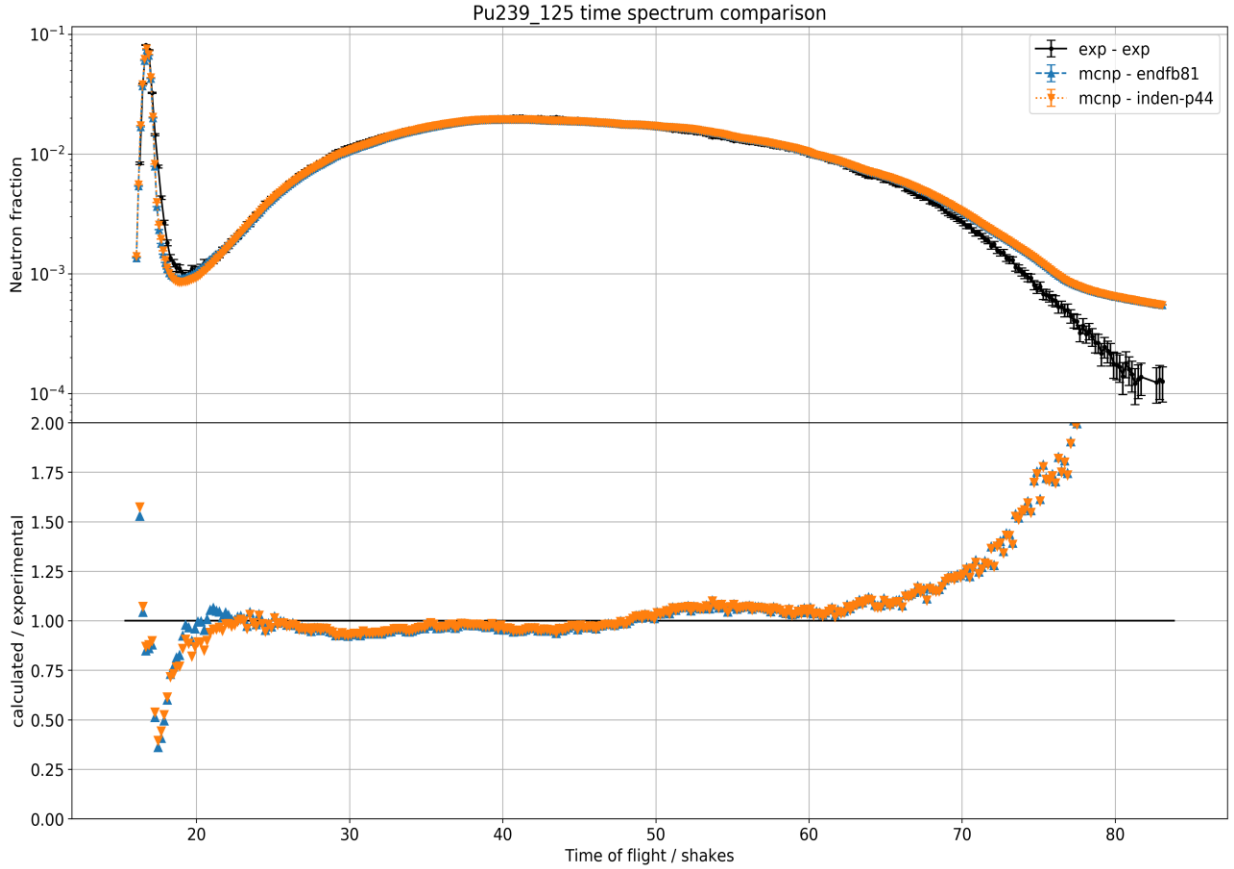


MCNP Calculated-Experimental (pcm) using data from ENDF/B-VIII.1 and the INDEN_p44 file



Plutonium Pulsed Spheres





Impact of p44 on our suite

- Does impact criticality, though changes are small.
  - MMF
    - Increase in k-eff of less than 100 pcm.
  - PMF
    - Change of less than 100pcm not always up or down.
- Change in balance if elastic and inelastic reactions is seen in the pulsed spheres.
  - Pu spheres show better fit to measurements.

To Summarise

- From my perspective:
- VIII.1 is an improvement on VIII.0.
- Compares well to latest JEFF and JENDL
  - Can we learn from the JEFF improvements in Beryllium modelling?

- New INDEN file seems to solve an issue in EUCLID modelling.
  - Improves Pu Pulsed Spheres.
  - Does not significantly impact criticality.
  - Seems appropriate for further testing.

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