

WHAT TO EXPECT IN 2026 FROM MICROSCOPIC NUCLEAR MODELLING FOR K_{EFF} CALCULATIONS?

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MOTIVATION AND GOALS

Motivation

- Nuclear data of relevance for criticality-safety can be adjusted in existing libraries
- What happens if we consider non-adjusted nuclear data ?
- What happens if we consider microscopic models ?
- What is the impact on criticality-safety benchmarks ?

Goals

- Quantify the impact of today's microscopic modelling on integral k_{eff} benchmarks
- Update parameters of microscopic models with integral information

METHOD

- 1st step: nominal calculations
 - Produce ENDF-6 (and ACE) files for ^{235}U , ^{238}U and ^{239}Pu with TALYS 2.0 microscopic models
 - Use these files with 134 fast criticality benchmarks
- 2nd step: perturbed calculations
 - Produce 10 000 “random” ENDF-6 (ACE) files for ^{235}U , ^{238}U and ^{239}Pu with TALYS microscopic models
 - Use these files with 134 fast criticality benchmarks
- 3rd step: Bayesian update
 - Select the best files
 - Apply BFMC to obtain posterior distributions

1ST STEP: NOMINAL ²³⁵U, ²³⁸U AND ²³⁹PU ENDF / ACE FILES

	Microscopic (theoretical)
E1 strength	Gogny D1M HFB+QRPA
Level density	Gogny-Hartree-Fock-Bogoluybov level densities
OMP	JLM microscopic optical model potential
M1 strength	Hartree-Fock BCS tables
Width fluctuation mode	Moldauer
Mass model	Goriely HFB-Skyrme table, no Exp. masses
Fission barriers	Theoretical, WKB approximation for fission path model
Discrete level	Theoretical levels

The most recent option, invoked with **ldmodel 6**, is based on temperature-dependent Hartree-Fock-Bogoliubov calculations using the Gogny force [46].

Since these microscopical level densities, which we will call ρ_{HFM} , have not been adjusted to experimental data, we add adjustment flexibility through a scaling function, i.e.

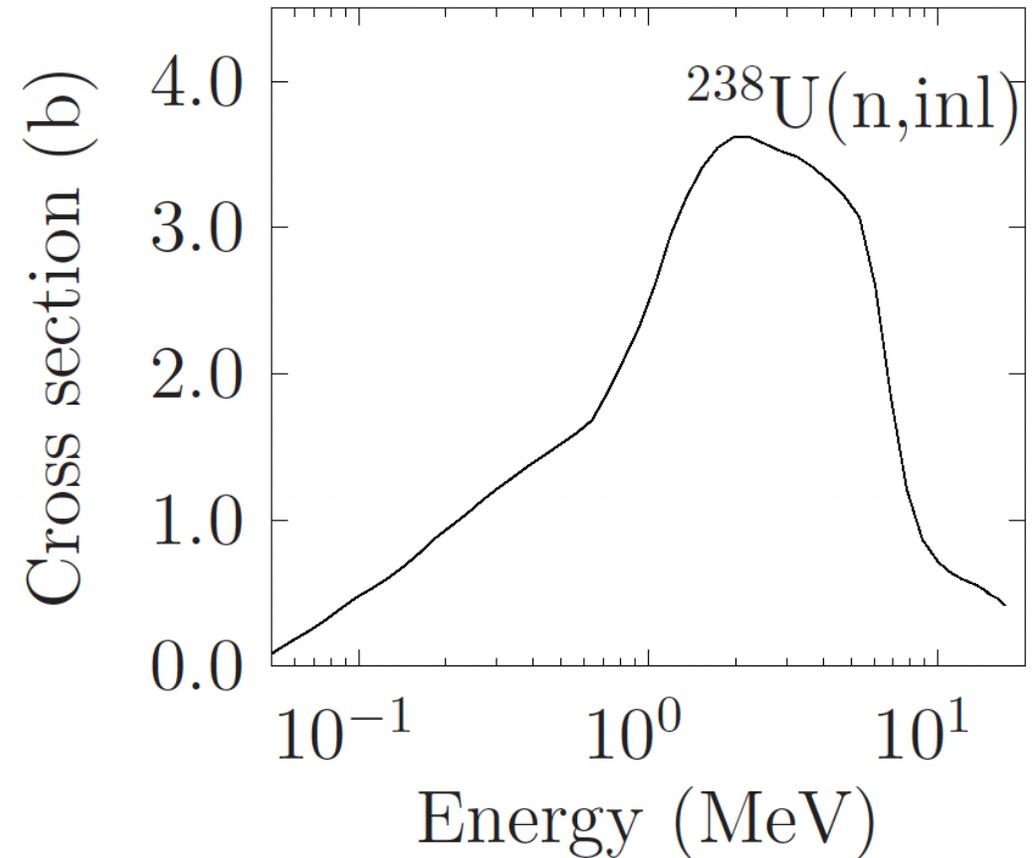
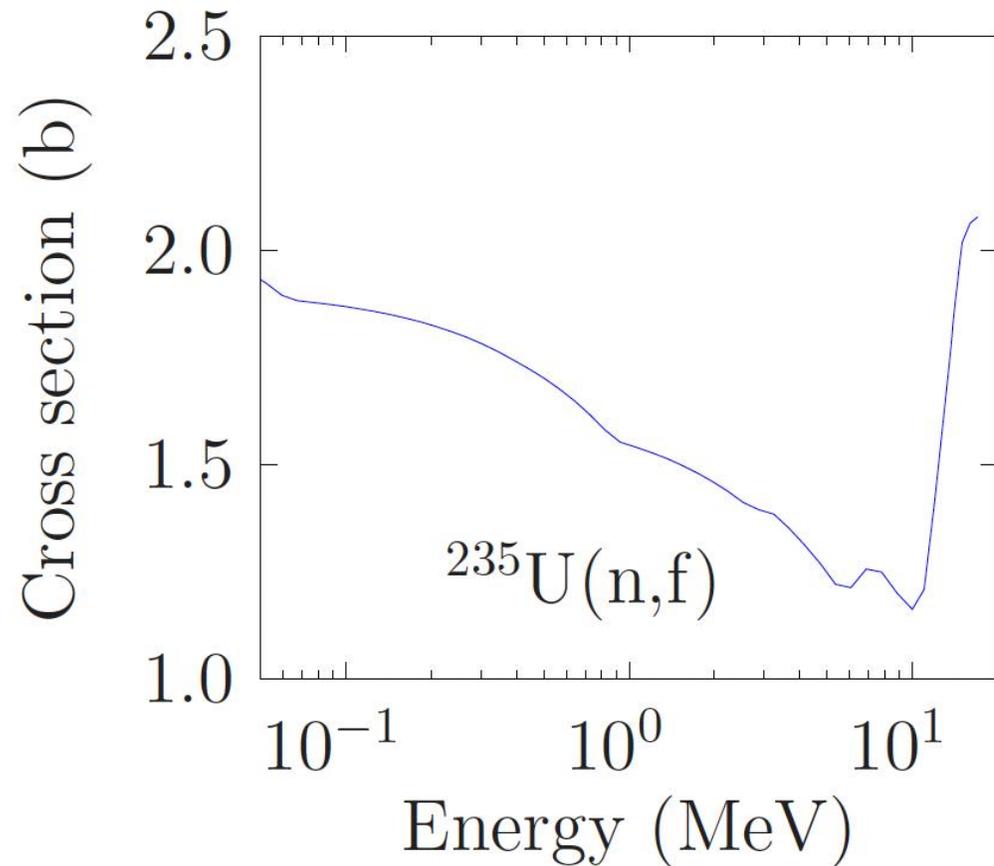
$$\rho(E_x, J, \pi) = \exp(c\sqrt{E_x - \delta})\rho_{HFM}(E_x - \delta, J, \pi) \quad (9.94)$$

where by default $c = 0$ and $\delta = 0$ (i.e. unaltered values from the tables). The “pairing shift” δ simply implies obtaining the level density from the table at a different energy. The constant c plays a role similar to that of the level density parameter a of phenomenological models. Adjusting c and δ together gives adjustment flexibility at both low and higher energies.

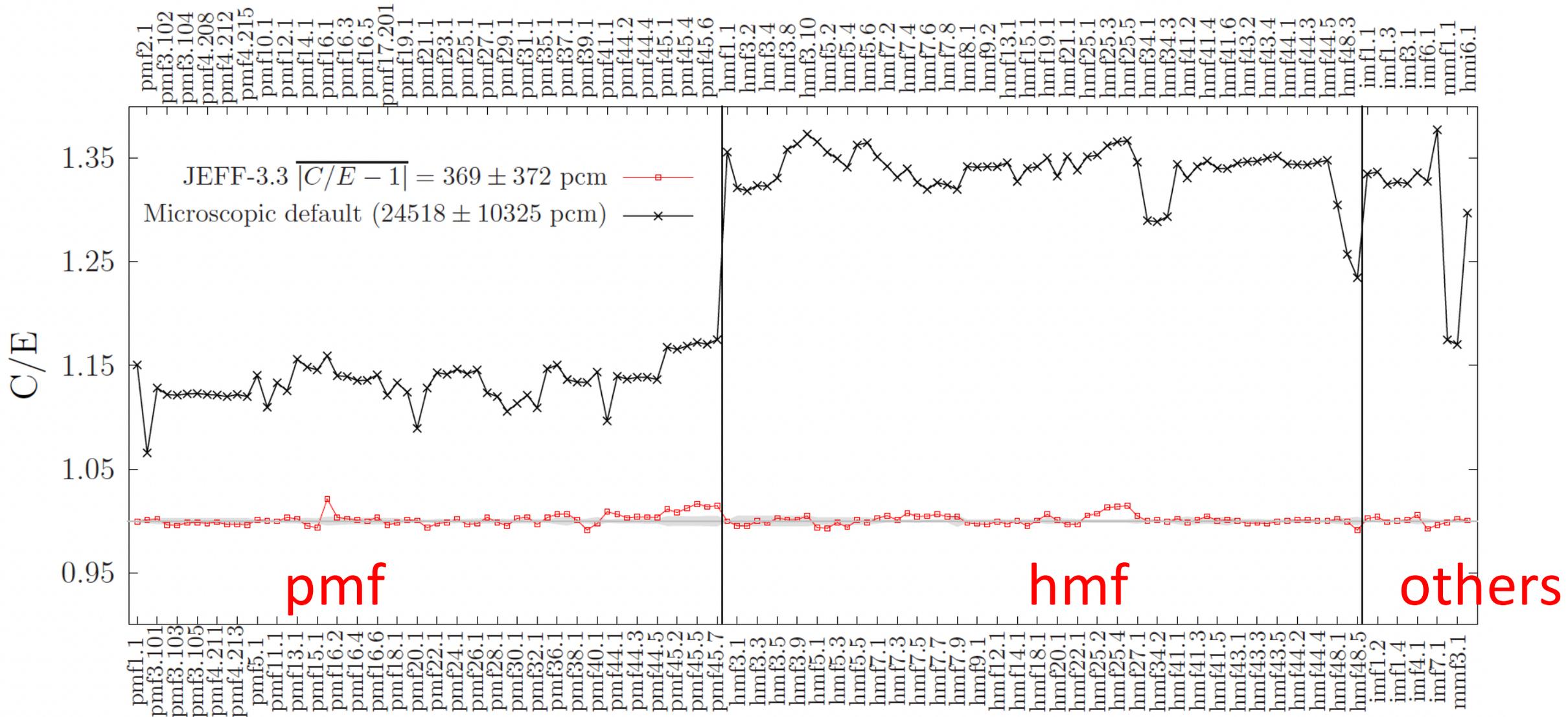
1ST STEP: NOMINAL ²³⁵U, ²³⁸U AND ²³⁹PU ENDF / ACE FILES

TALYS microscopic models: examples

Full ENDF-6 files produced

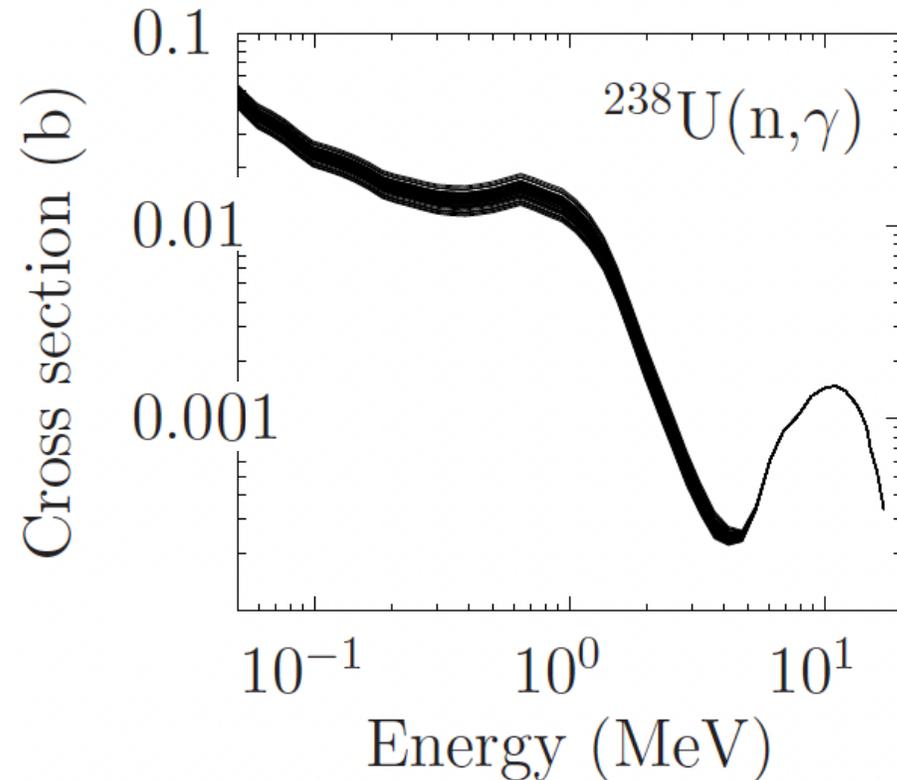
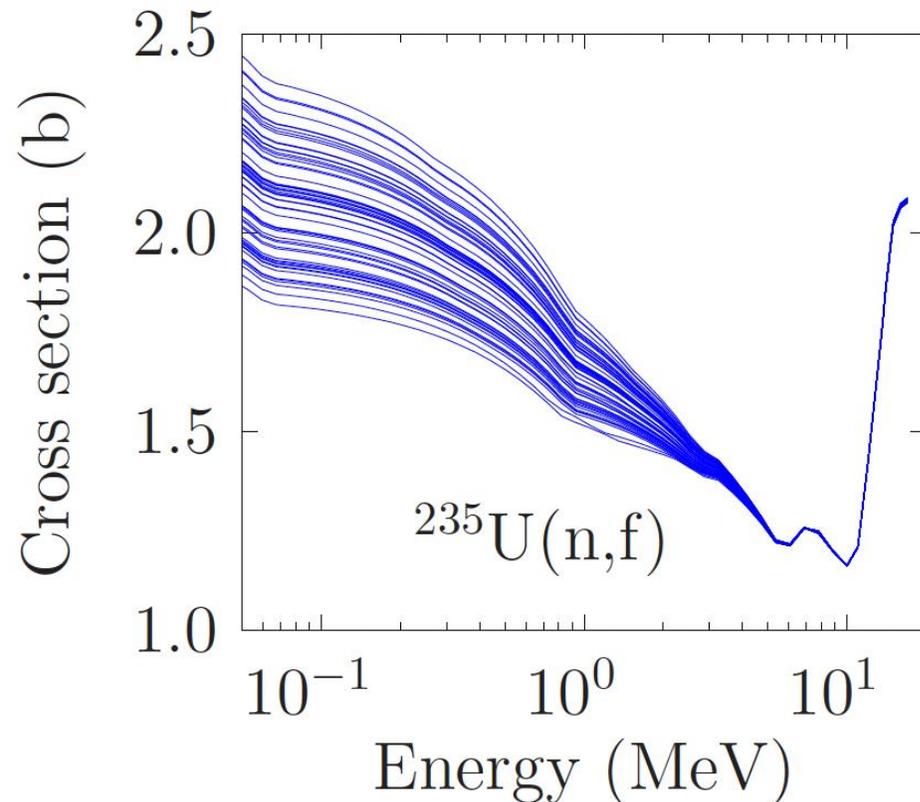


1ST STEP: USE 134 FAST BENCHMARKS

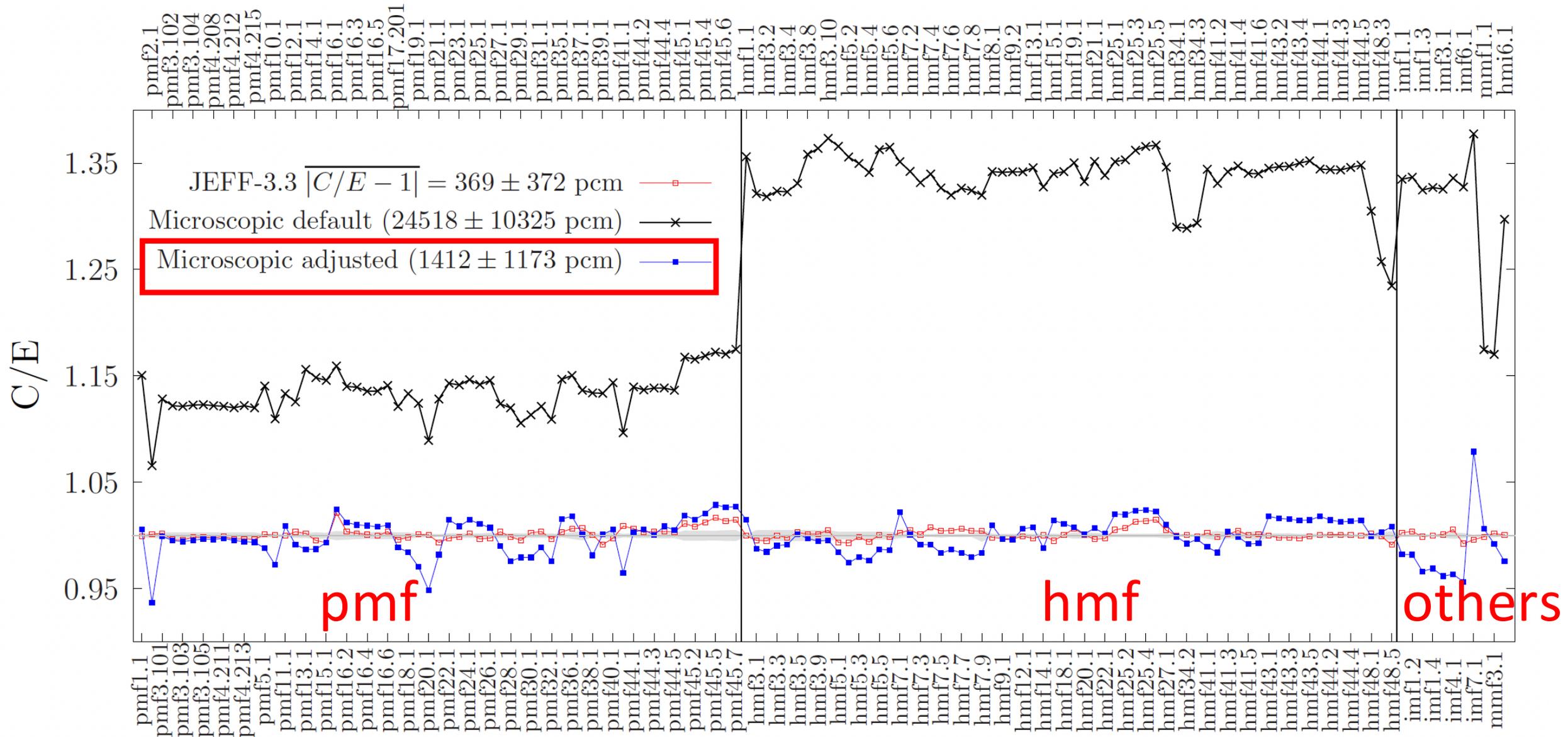


2ND STEP: PERTURBED CALCULATIONS FOR ²³⁵U, ²³⁸U AND ²³⁹Pu

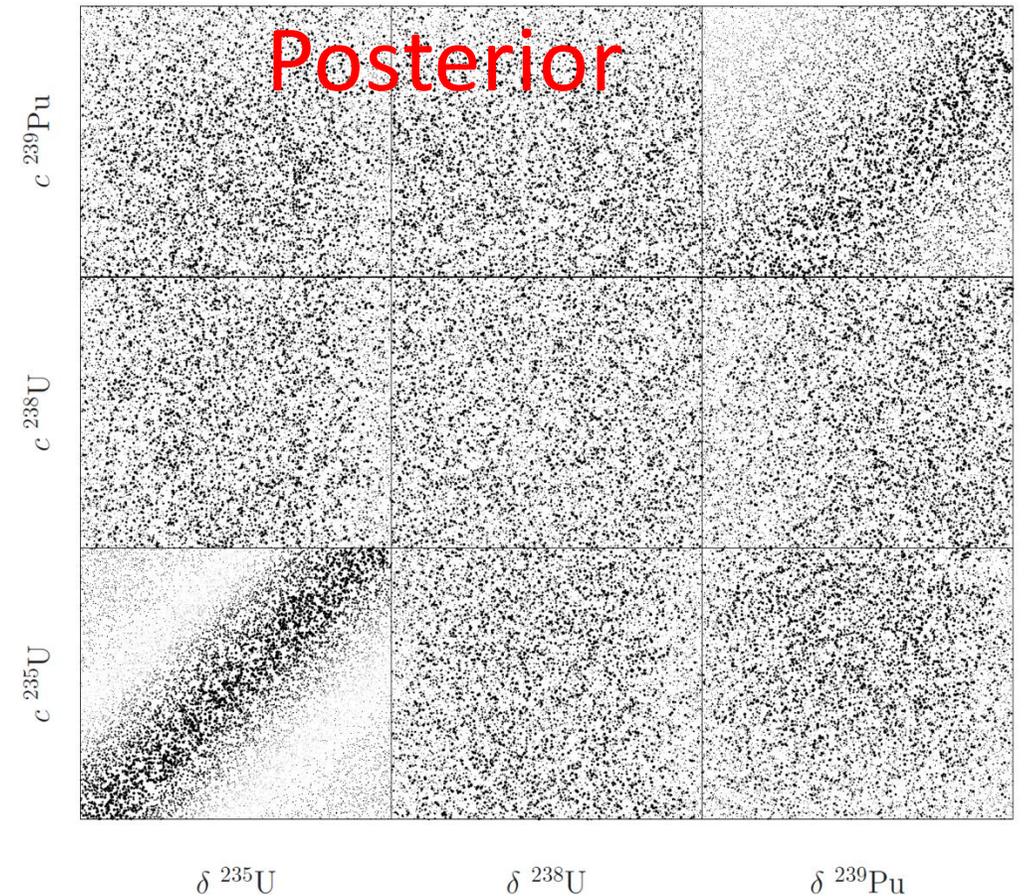
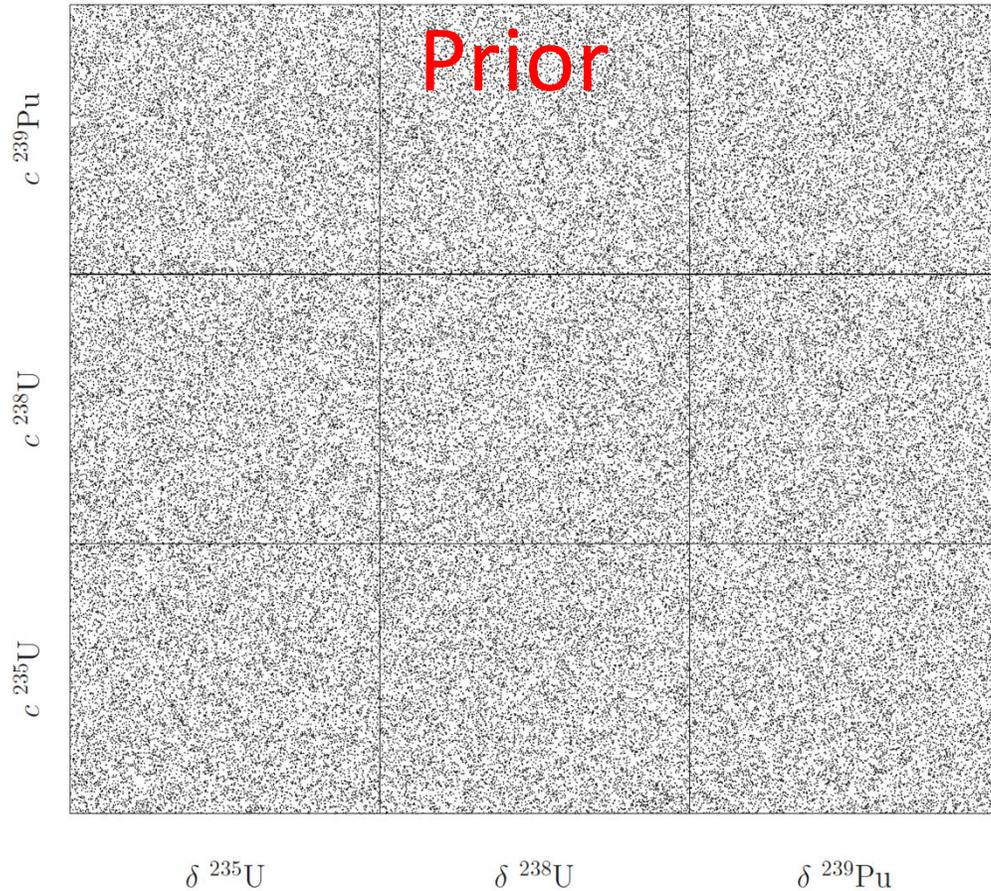
- Randomly vary 2 parameter $\rho(E_x, J, \pi) = \exp(c\sqrt{E_x - \delta})\rho_{HFM}(E_x - \delta, J, \pi)$
- 10 000 random ENDF/ACE files for ²³⁵U, ²³⁸U and ²³⁹Pu



2ND AND 3RD STEPS: USE 134 FAST BENCHMARKS AND KEEP THE BEST



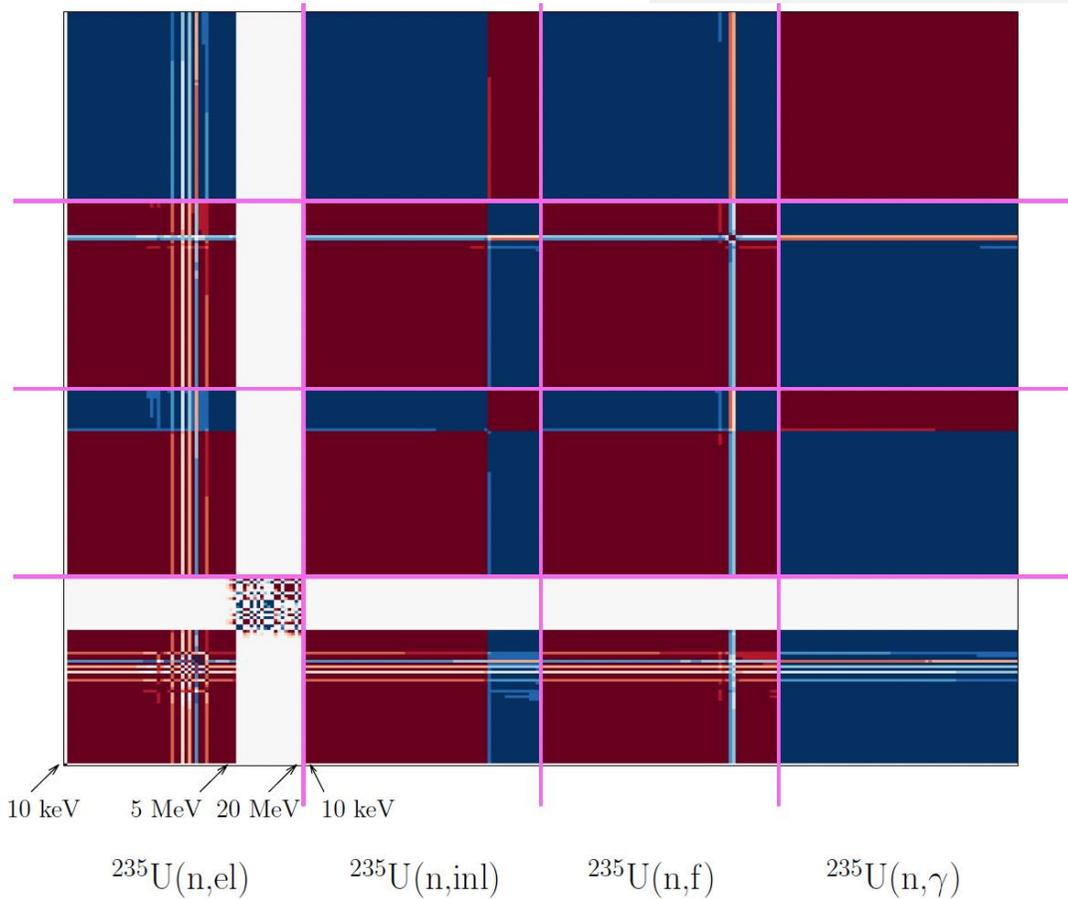
3RD STEP: APPLY BFMC



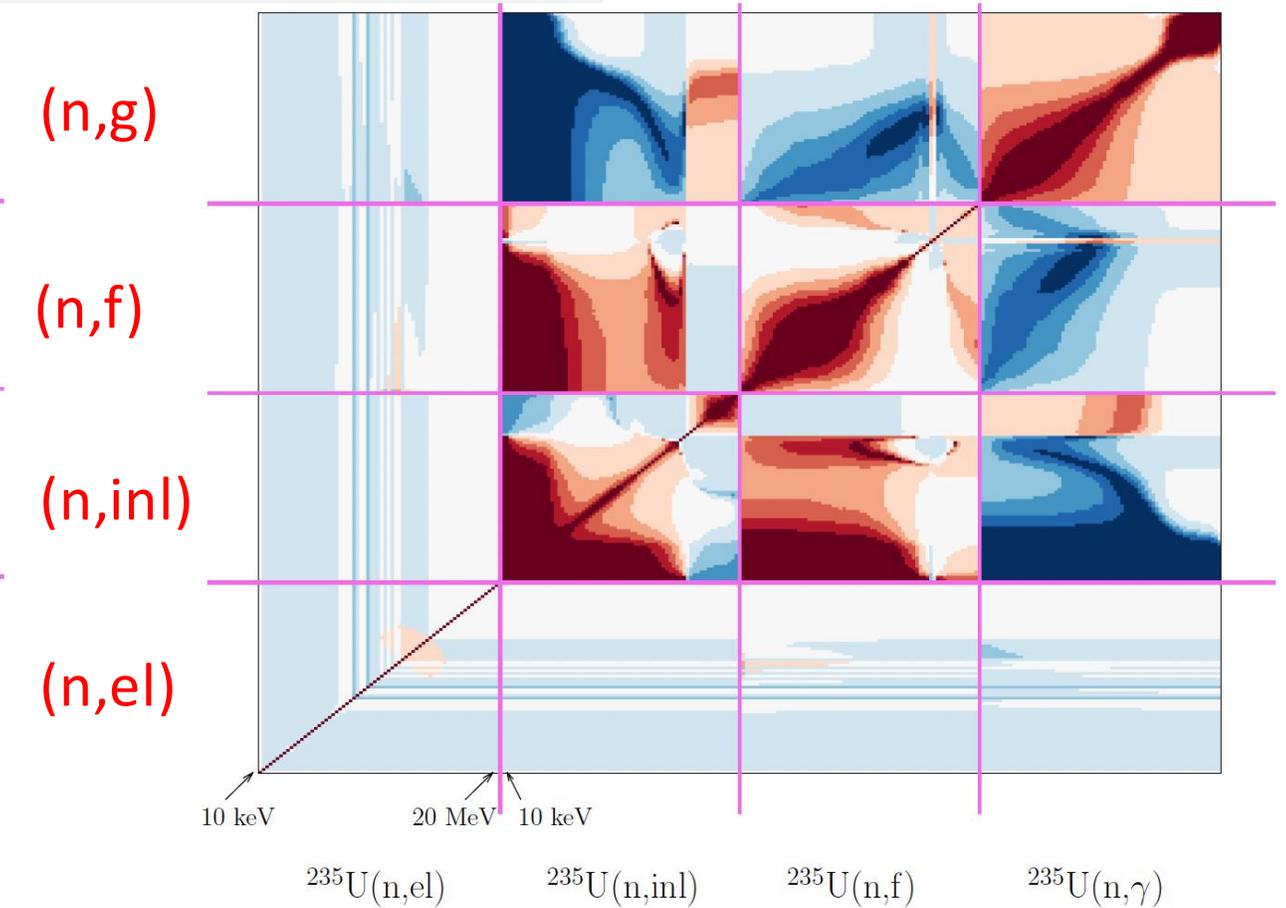
$$\chi_I^2 = \sum_{l,l'=1,\dots,m} (e_i^l - s_l)(\nu^{-1})_{ll'}(e_j^{l'} - s_{l'}).$$

$$w_I = C e^{-\left(\frac{\chi_I^2}{\chi_{\min}^2}\right)^2}$$

3RD STEP: APPLY BFMC



Prior

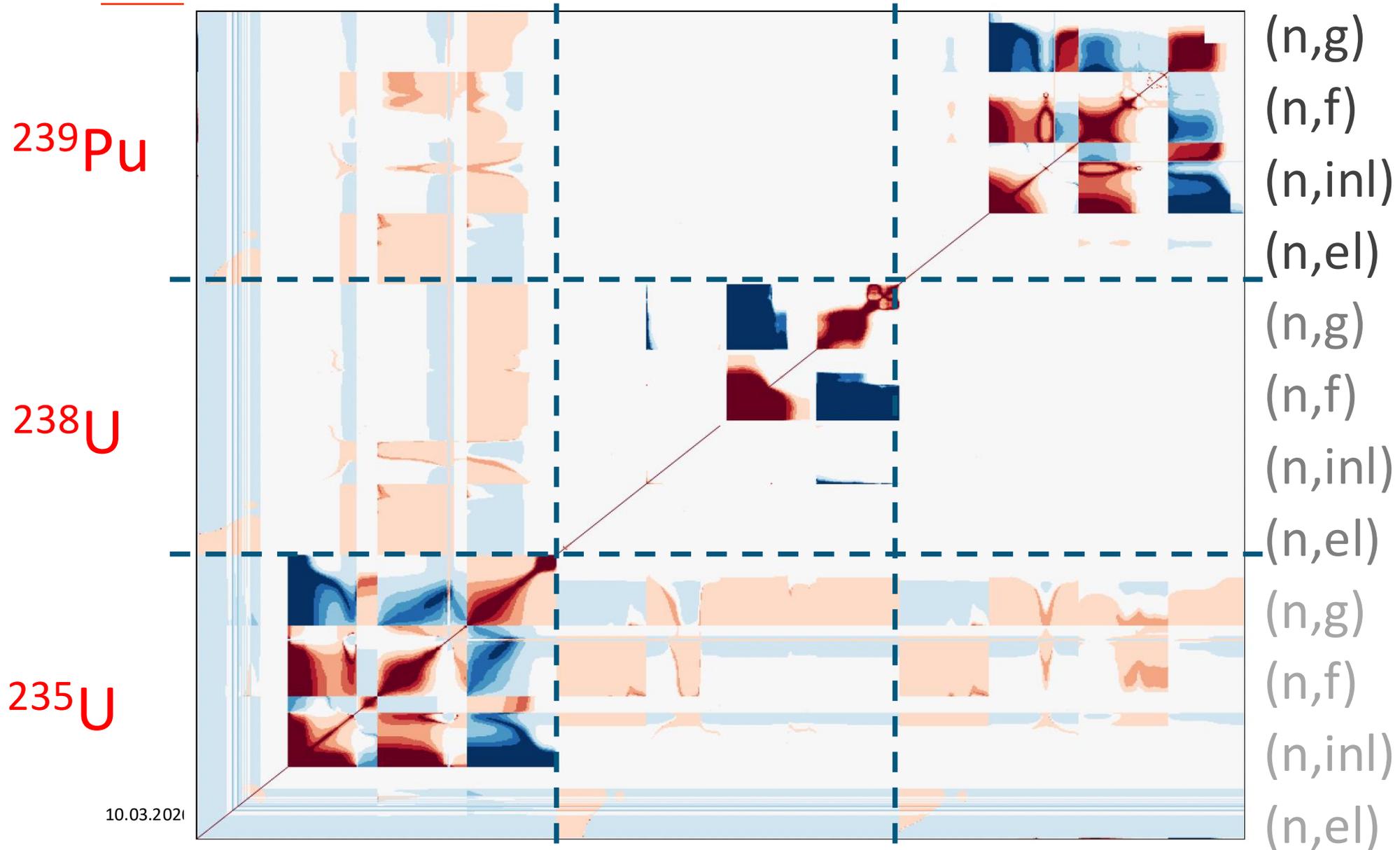


^{235}U

Posterior

3RD STEP: APPLY BFMC

Posterior



CONCLUSION

- Microscopic models for ^{235}U , ^{238}U , and ^{239}Pu
- 134 fast benchmarks considered (hmf, pmf, imf, mmf)
- Average C/E-1:
 - JEFF-3.3: C/E-1= 369 \pm 372 pcm
 - Microscopic models: C/E-1= 24518 \pm 10325 pcm
 - Adjusted microscopic models: C/E-1= 1412 \pm 1173 pcm
- Microscopic model can possibly be adjusted (new TALYS 2.2 even better with Idmodel=7: BSkG3+combinatorial)
- Correlations between actinides (and ultimately all nuclides)



**THANK YOU FOR YOUR ATTENTION –
QUESTIONS?**

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