

Evaluating and adjusting nuclear data with a Monte Carlo technique

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Nuclear Research and Consultancy Group,

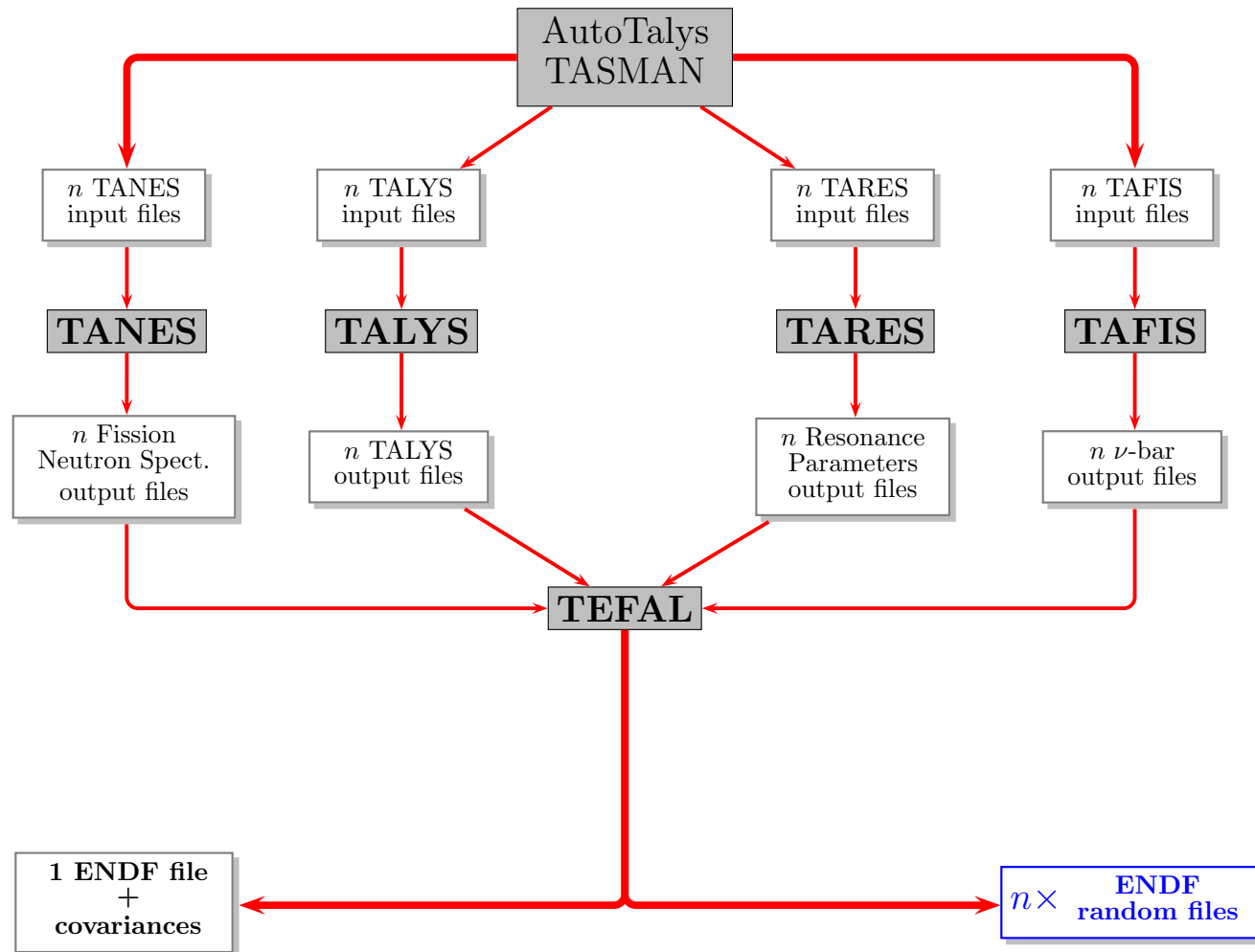
NRG, Petten, The Netherlands

PHYSOR conference, Knoxville, USA, April 2012

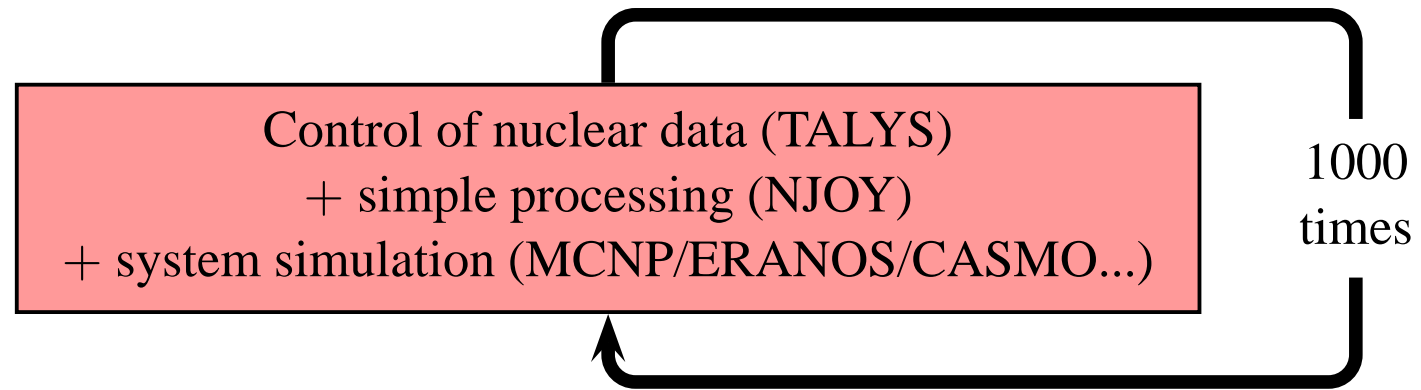
Contents



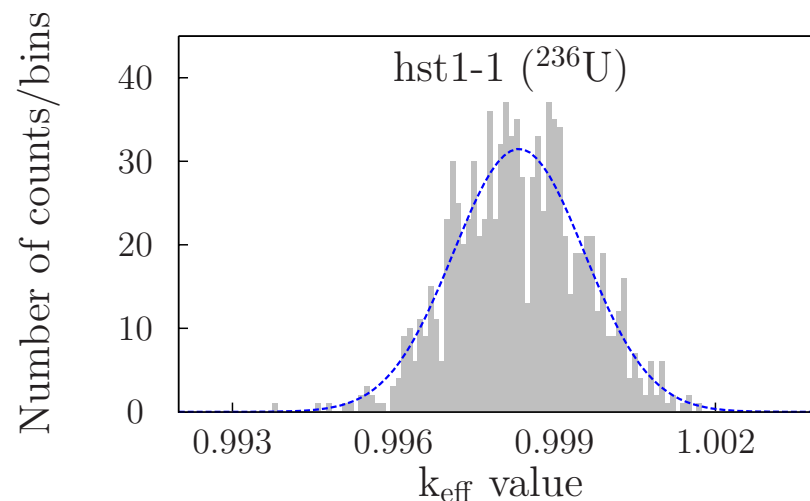
- ① Method of work: REPRODUCIBILITY
- ② Applications: TMC and TMC⁻¹
- ③ Conclusions



TMC: Total Monte Carlo



For each random ENDF file, the benchmark calculation is performed with MCNP. At the end of the n calculations, n different k_{eff} values are obtained. In the obtained probability distribution of k_{eff} , the standard deviation σ_{total} reflects two different effects: $\sigma_{\text{total}}^2 = \sigma_{\text{statistics}}^2 + \sigma_{\text{nuclear data}}^2$.

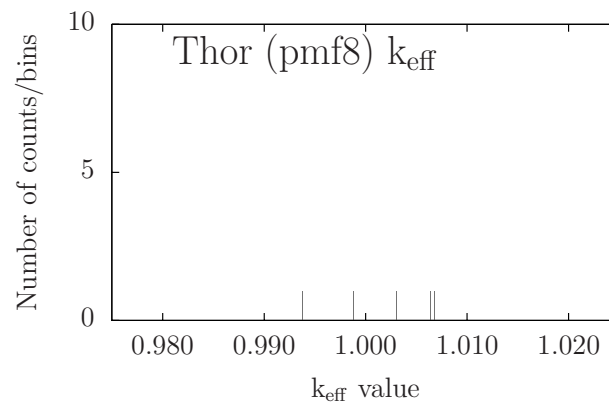
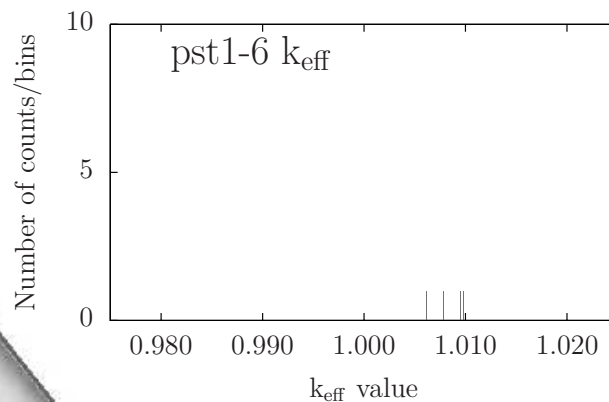
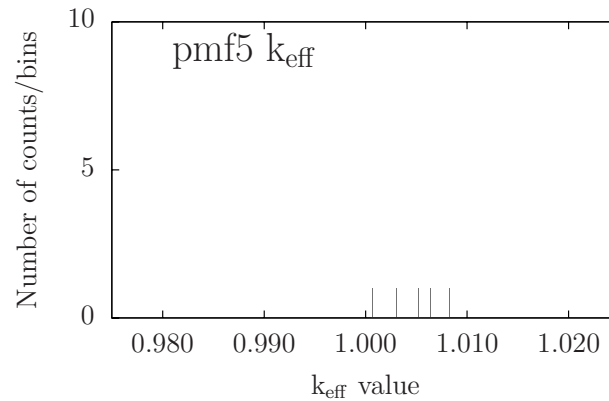
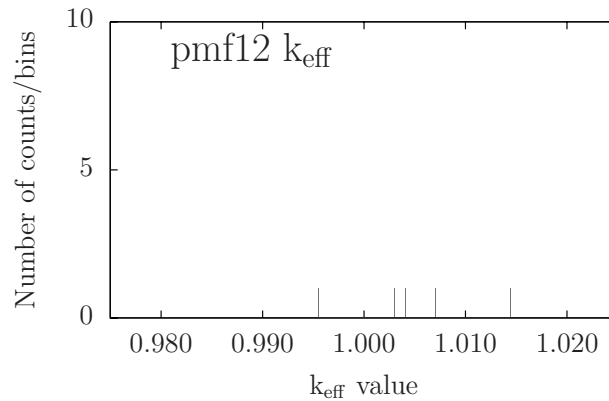
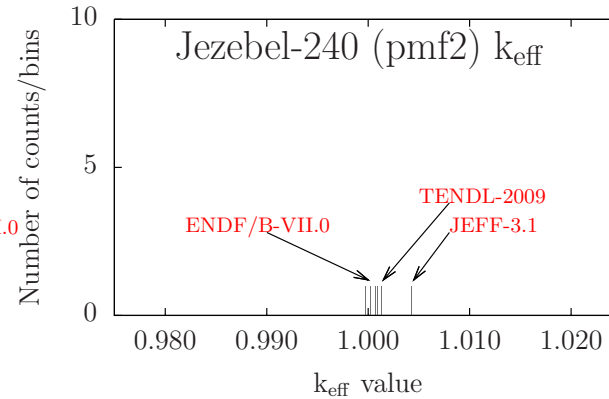
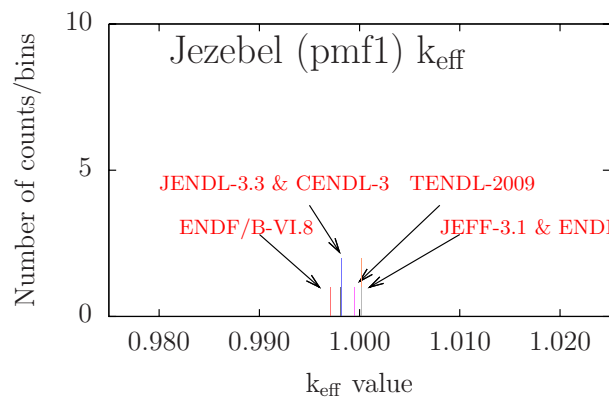


Total Monte Carlo + selection
 $\implies \frac{1}{TMC}$

- ① Use TALYS to create a single ^{239}Pu evaluation close or equal to ENDF/B-VII.0 or JEFF-3.1.1
- ② Randomize all model parameters (resonances, nubar, fission neutron spectrum, TALYS parameters) to create 500 random ^{239}Pu evaluations
- ③ Benchmarks the $n \geq 500$ files with the same set of criticality benchmarks
- ④ Select the best random file

Example: 100 benchmarks, 500 random files \implies 500 TALYS + NJOY and $100 \times 500 = 5 \cdot 10^4$ MCNP loops,
1.4 years on a single processor, or 5 days on 100 processors (3 GHz)

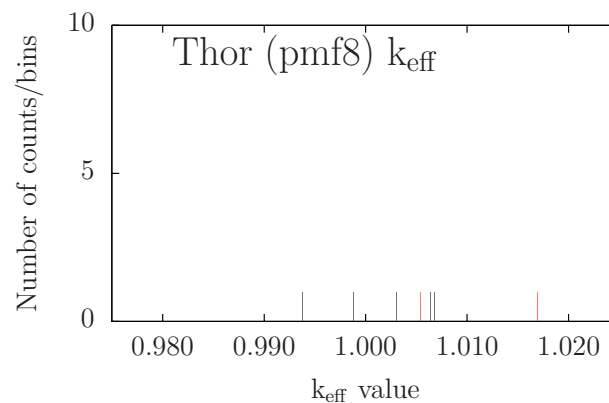
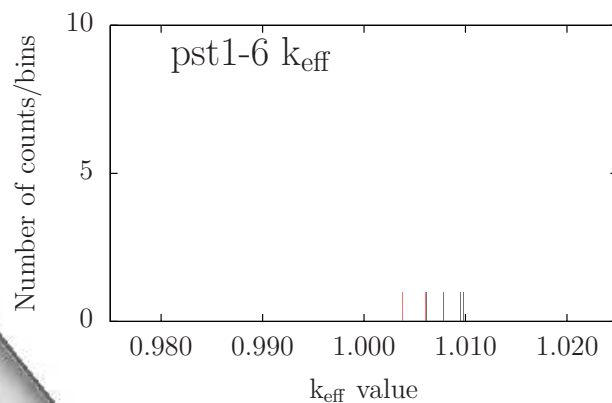
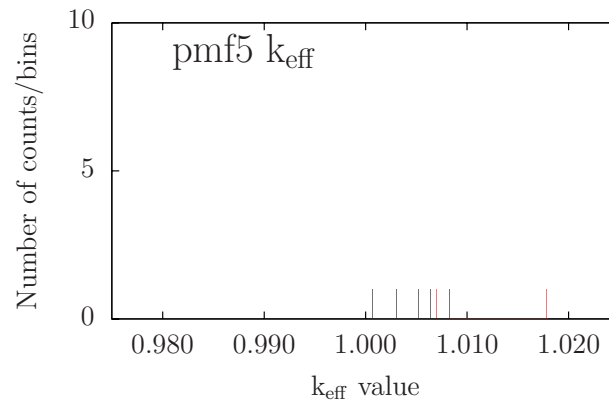
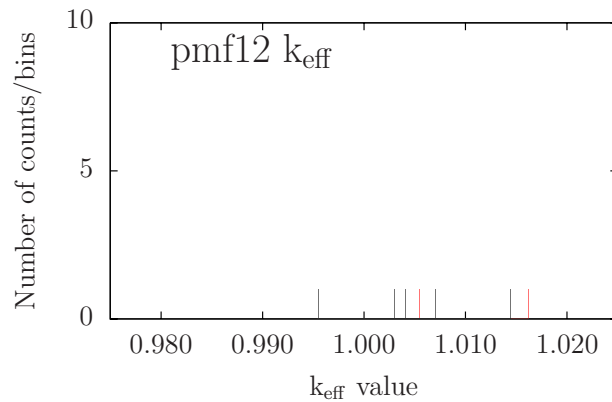
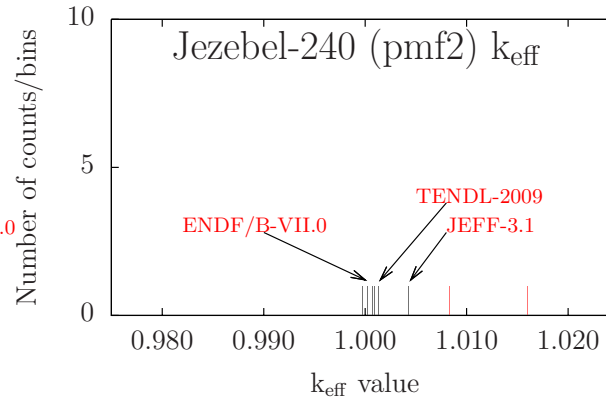
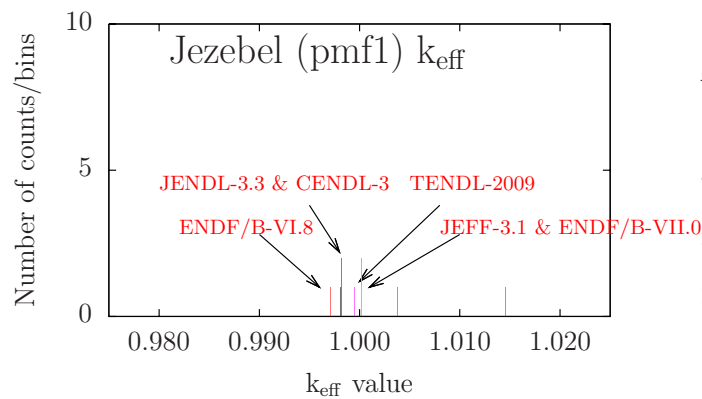
Inverse TMC: simple example with 6 k_{eff} benchmarks



	α
JEFF-3.1.1:	$1.14e^{-4}$
JENDL-3.3:	$1.71e^{-4}$
TENDL-2009:	$3.66e^{-4}$
ENDF/B-VI.8:	$1.72e^{-4}$
ENDF/B-VII.0:	$1.69e^{-4}$

$$\alpha = \sum_{i=0}^n \frac{(C_i - E_i)^2}{C_i}$$

Inverse TMC: simple example with 6 k_{eff} benchmarks



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JEFF-3.1.1:	$1.14e^{-4}$
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ENDF/B-VI.8:	$1.72e^{-4}$
ENDF/B-VII.0:	$1.69e^{-4}$
random 0:	$2.29e^{-4}$
random 1:	$13.4e^{-4}$

Inverse TMC: 6 k_{eff} benchmarks with random ^{239}Pu

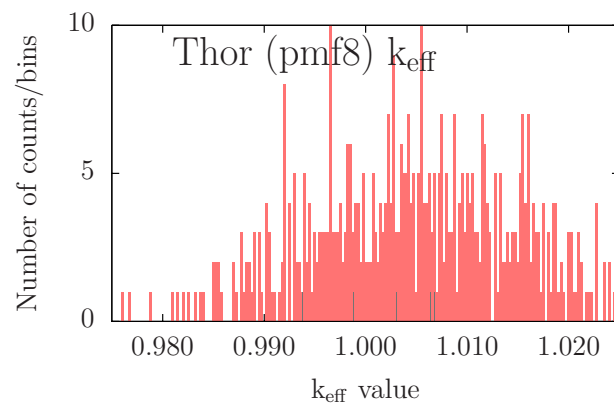
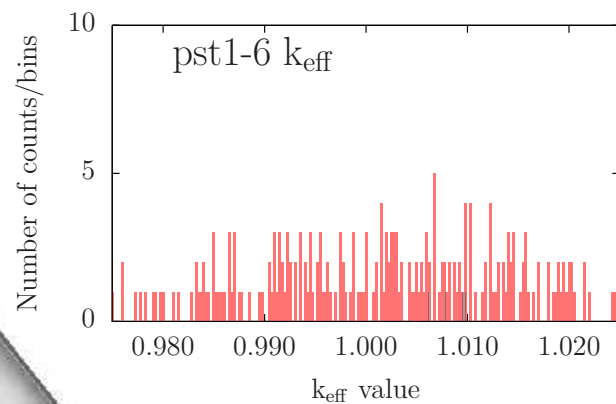
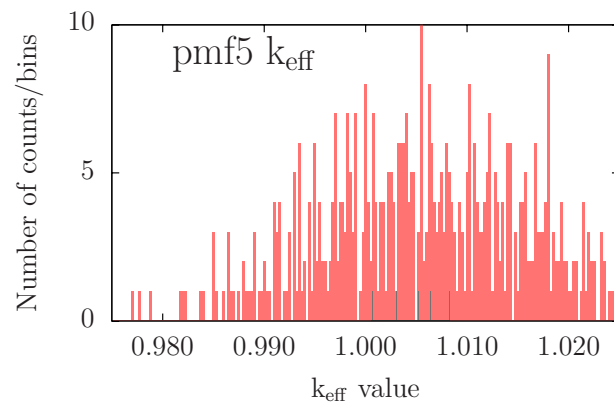
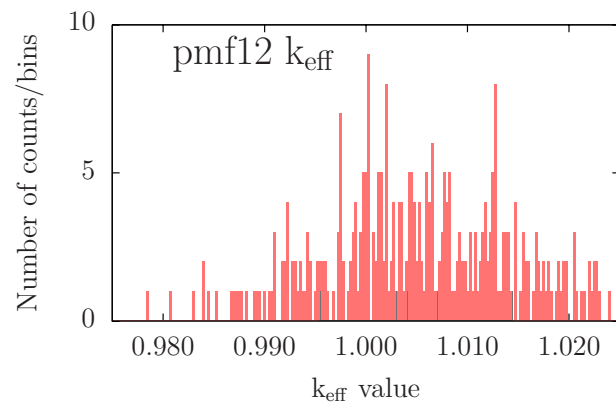
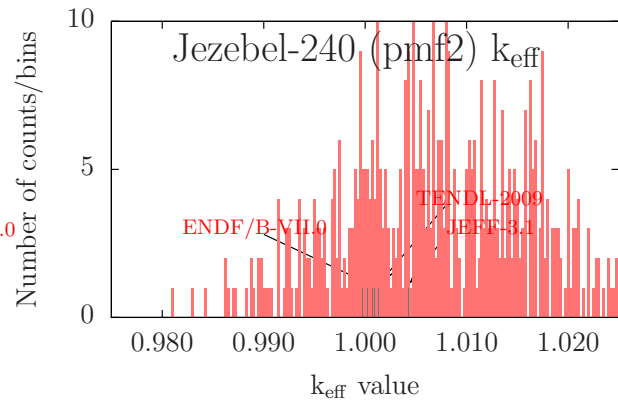
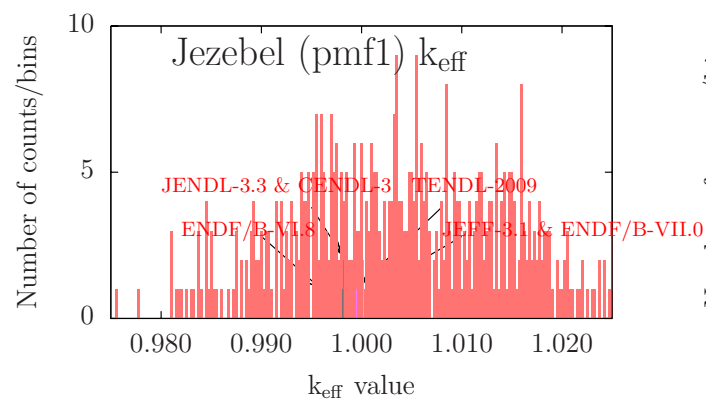


Table 1: List of plutonium benchmarks selected for the random search.

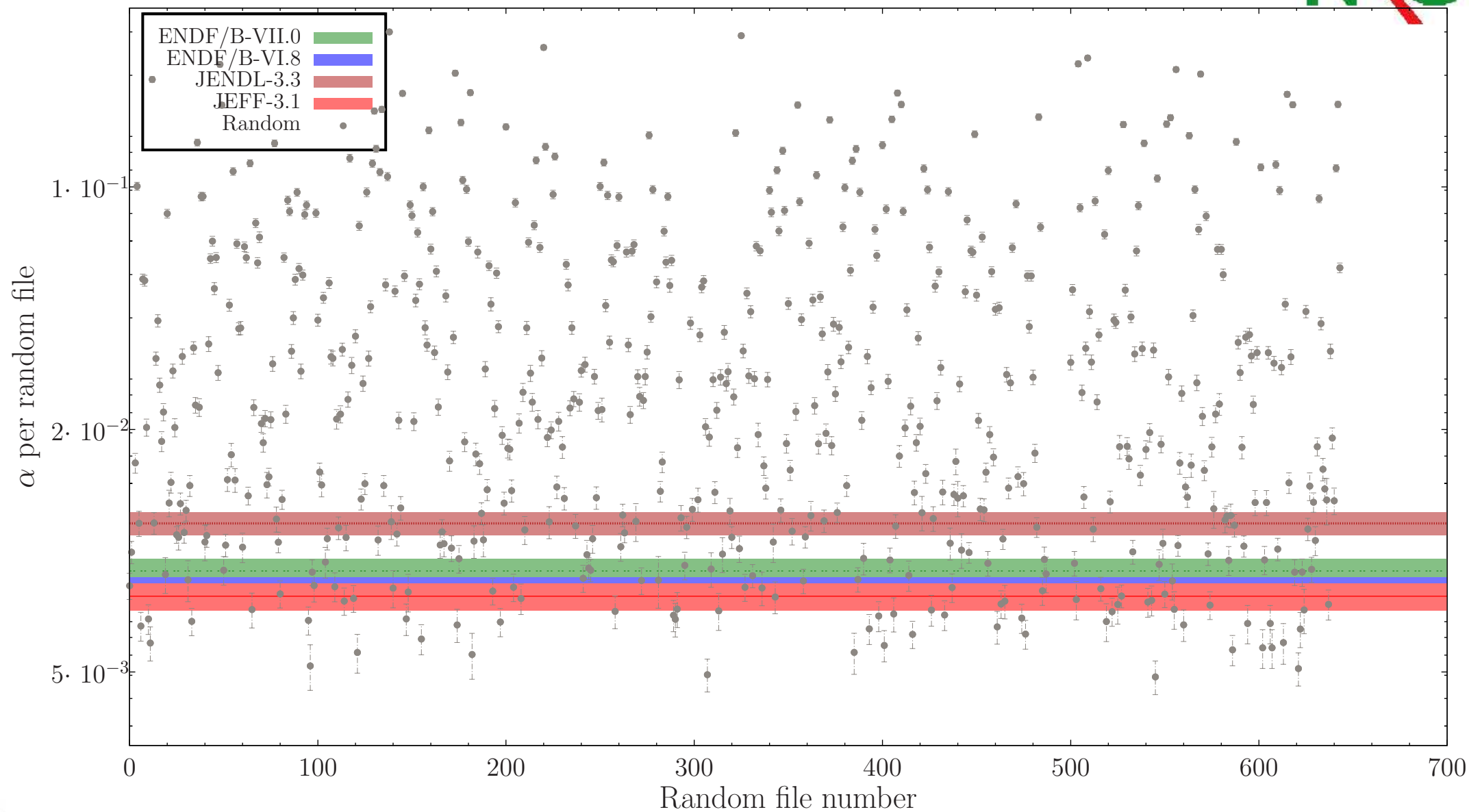
Name	Cases	Name	Cases	Name	Cases	Name	Cases
pmf1	1	pmf2	1	pmf5	1	pmf6	1
pmf8	1	pmf12	1	pmf13	1	pci1	1
pmi2	1	pst1	6	pst2	6	pst3	8
pst4	13	pst5	9	pst6	3	pst7	9
pst8	29	pst12	22	pmm1	6		

$$\alpha = \sum_{i=0}^n \frac{(C_i - E_i)^2}{C_i}, \quad (1)$$

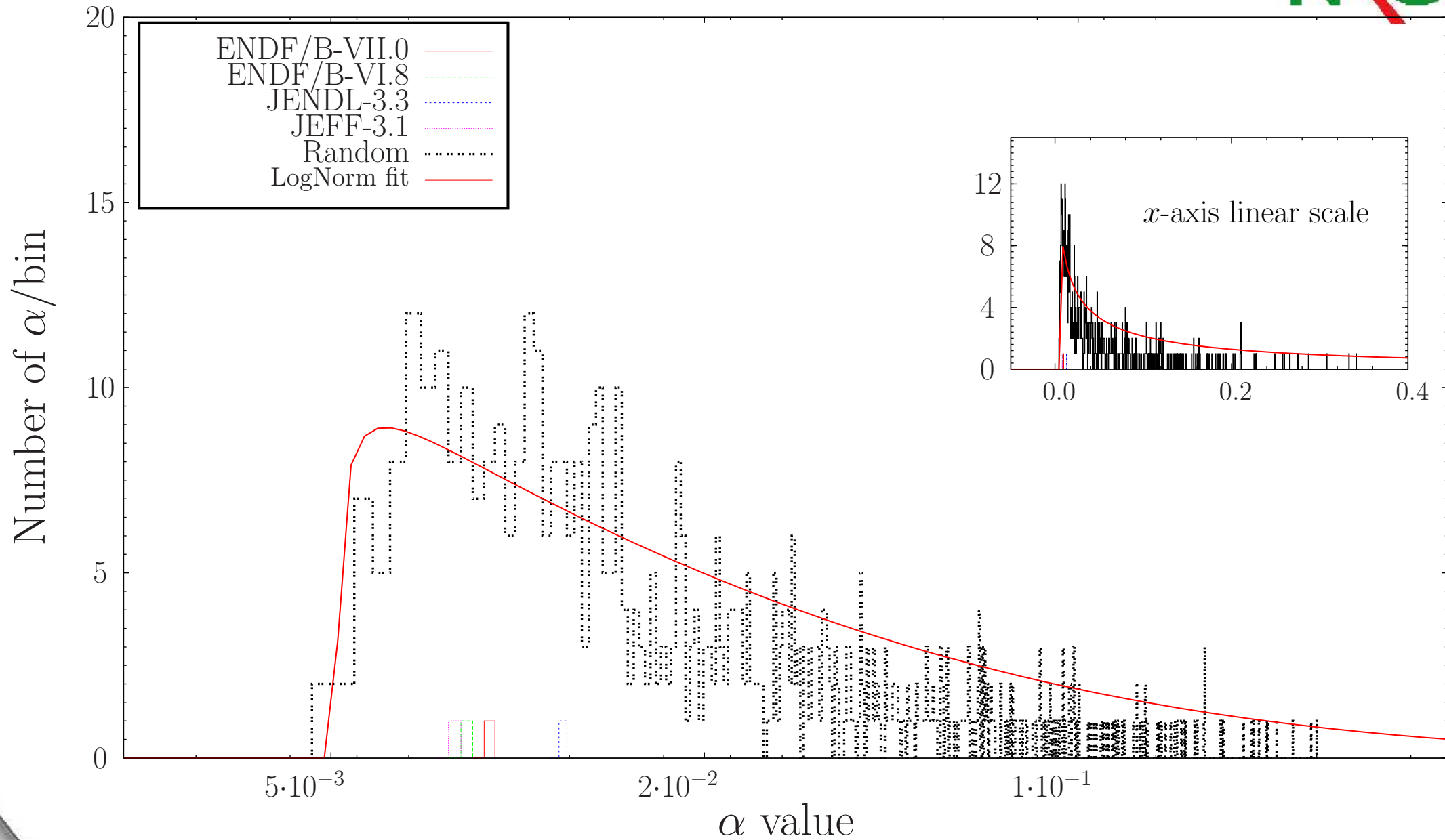
Results independent of the type of factor α , χ^2 ... or

$$F = 1 - 10\sqrt{\frac{1}{N} \sum (\log(E_i) - \log(C_i))^2} \quad (2)$$

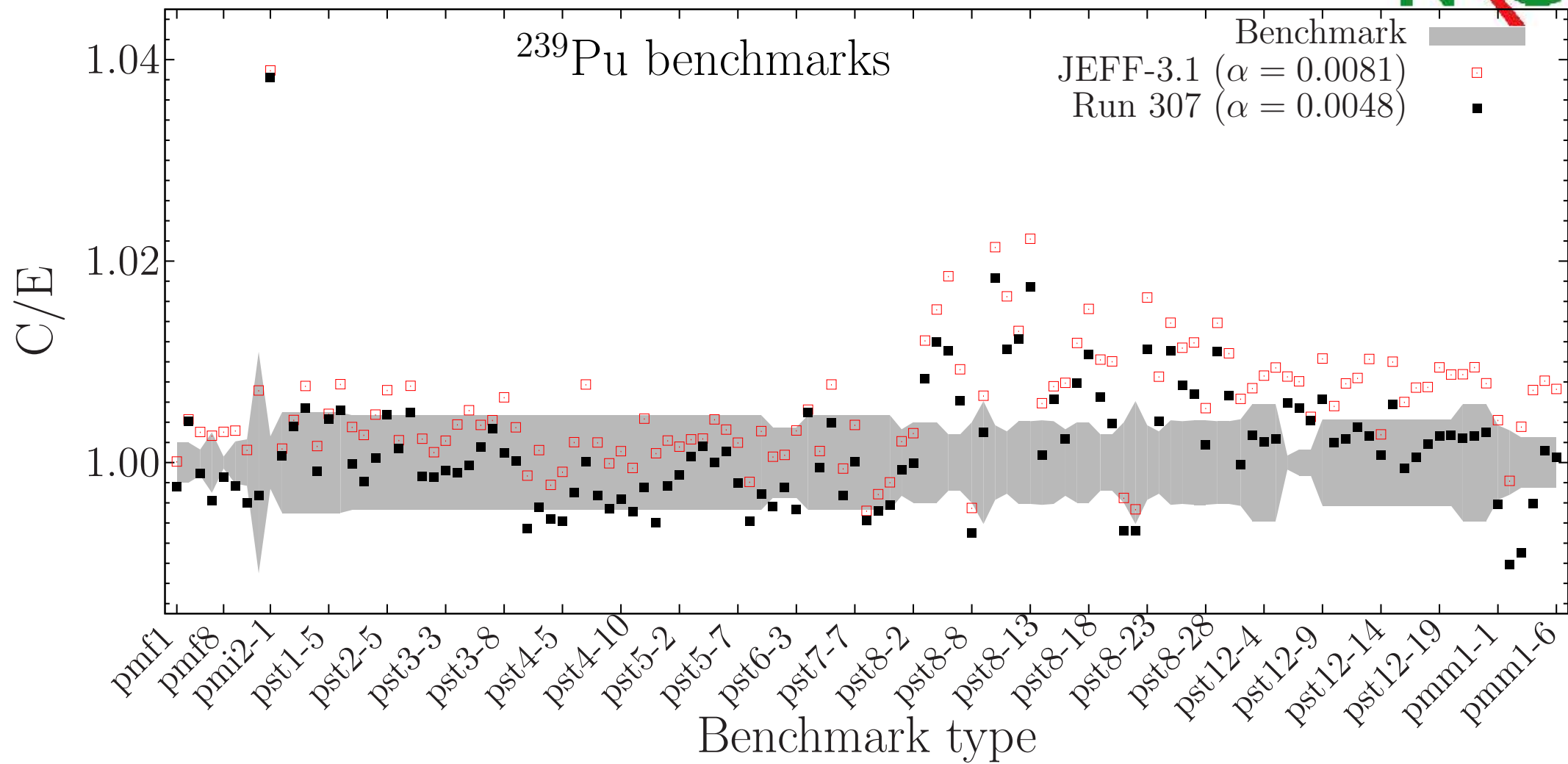
α values for random ^{239}Pu evaluations



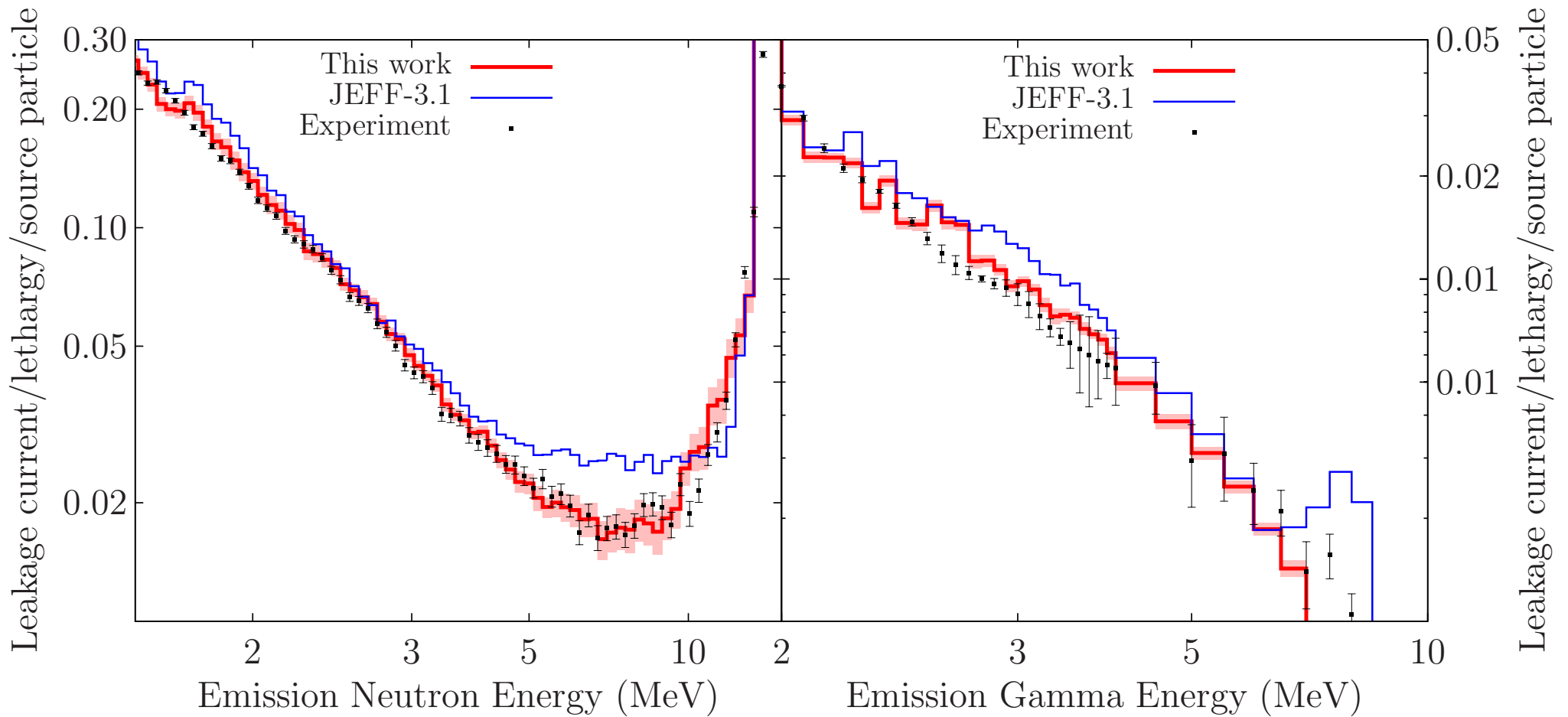
α values for random ^{239}Pu evaluations



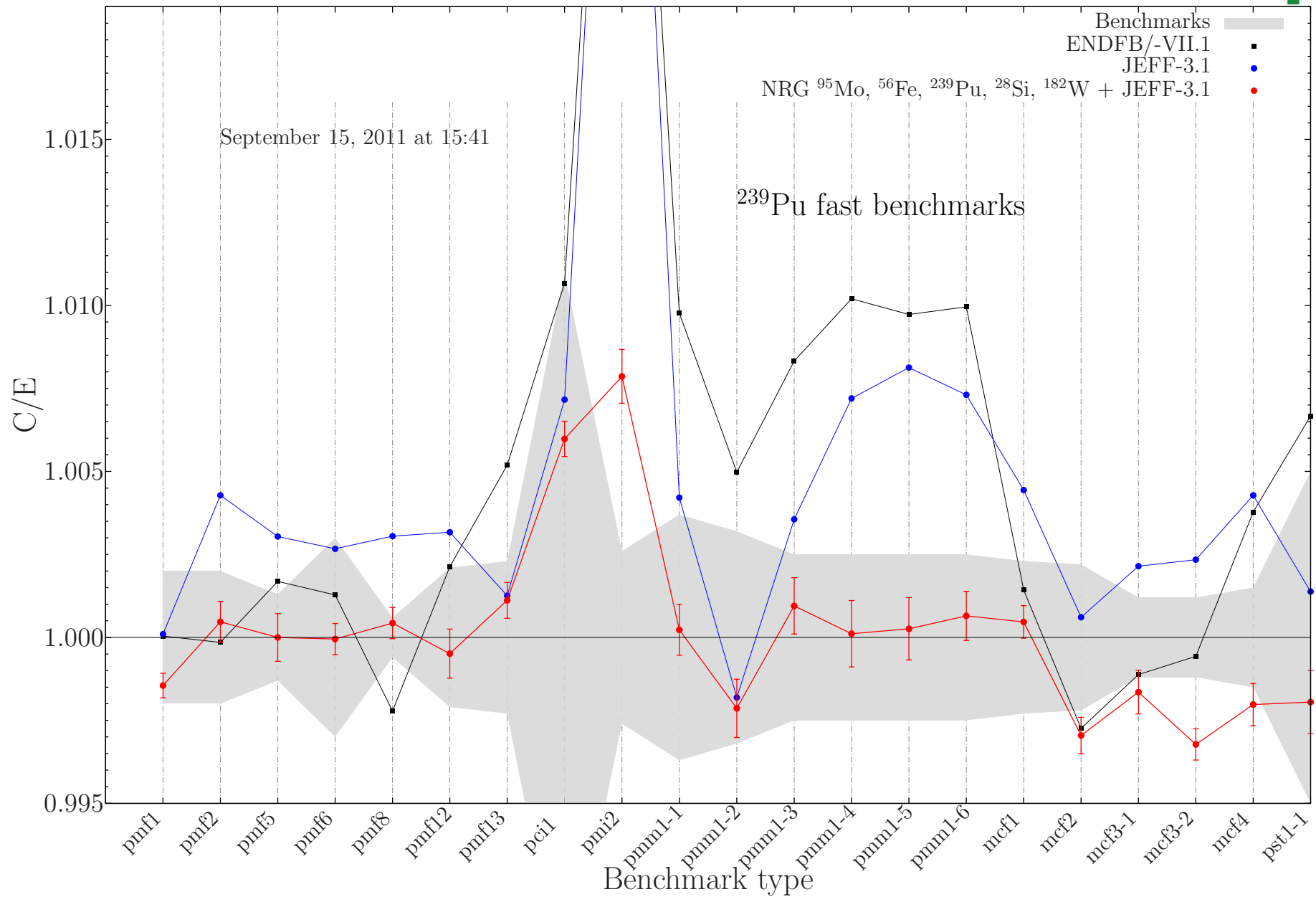
C/E values for the *best* ^{239}Pu (run 307)



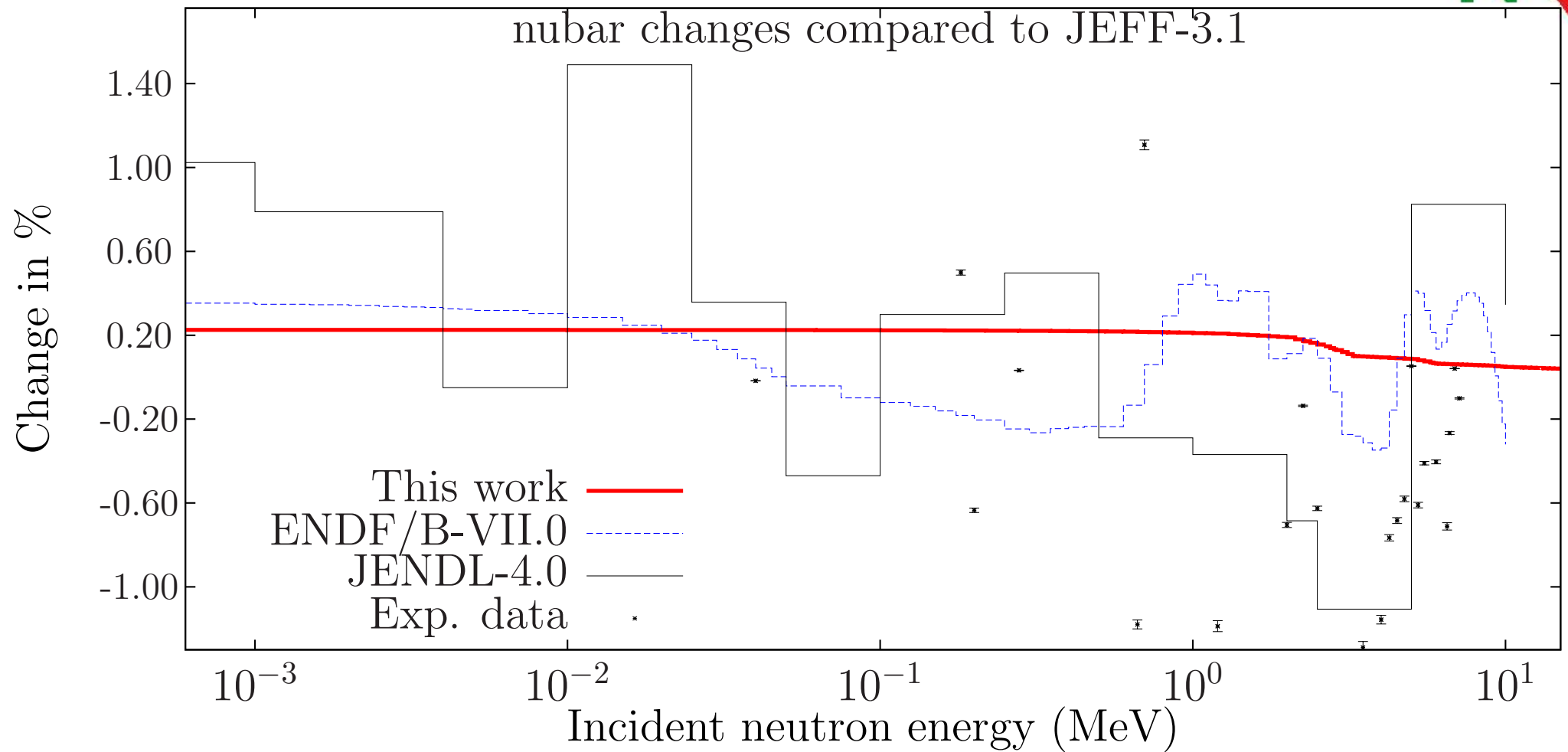
Example 2 on $^{63,65}\text{Cu}$ Oktavian shielding benchmark



Example 3 on *best* ^{239}Pu for the ANDES project



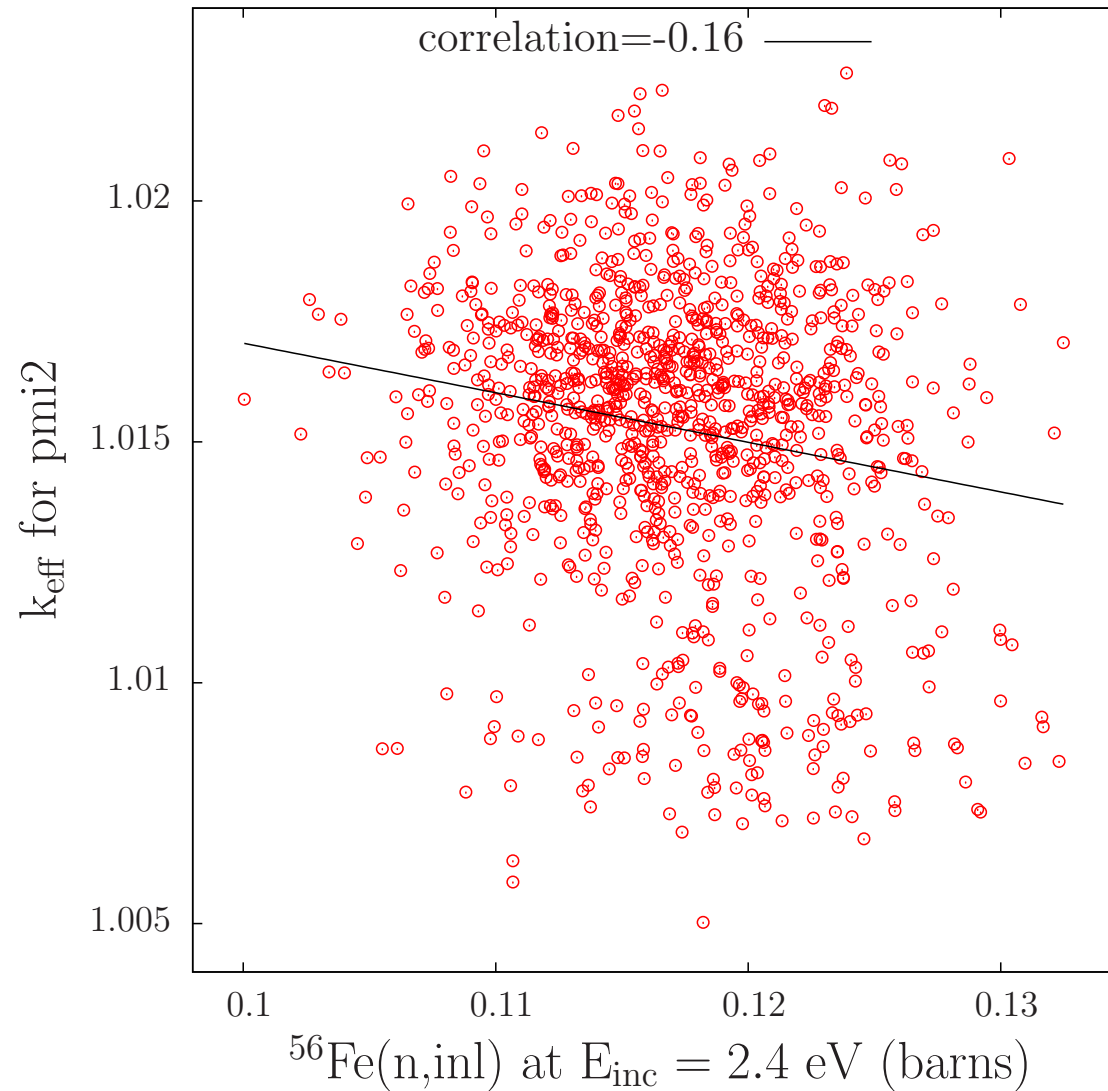
Inverse TMC: adjustment on FNS and $\bar{\nu}$



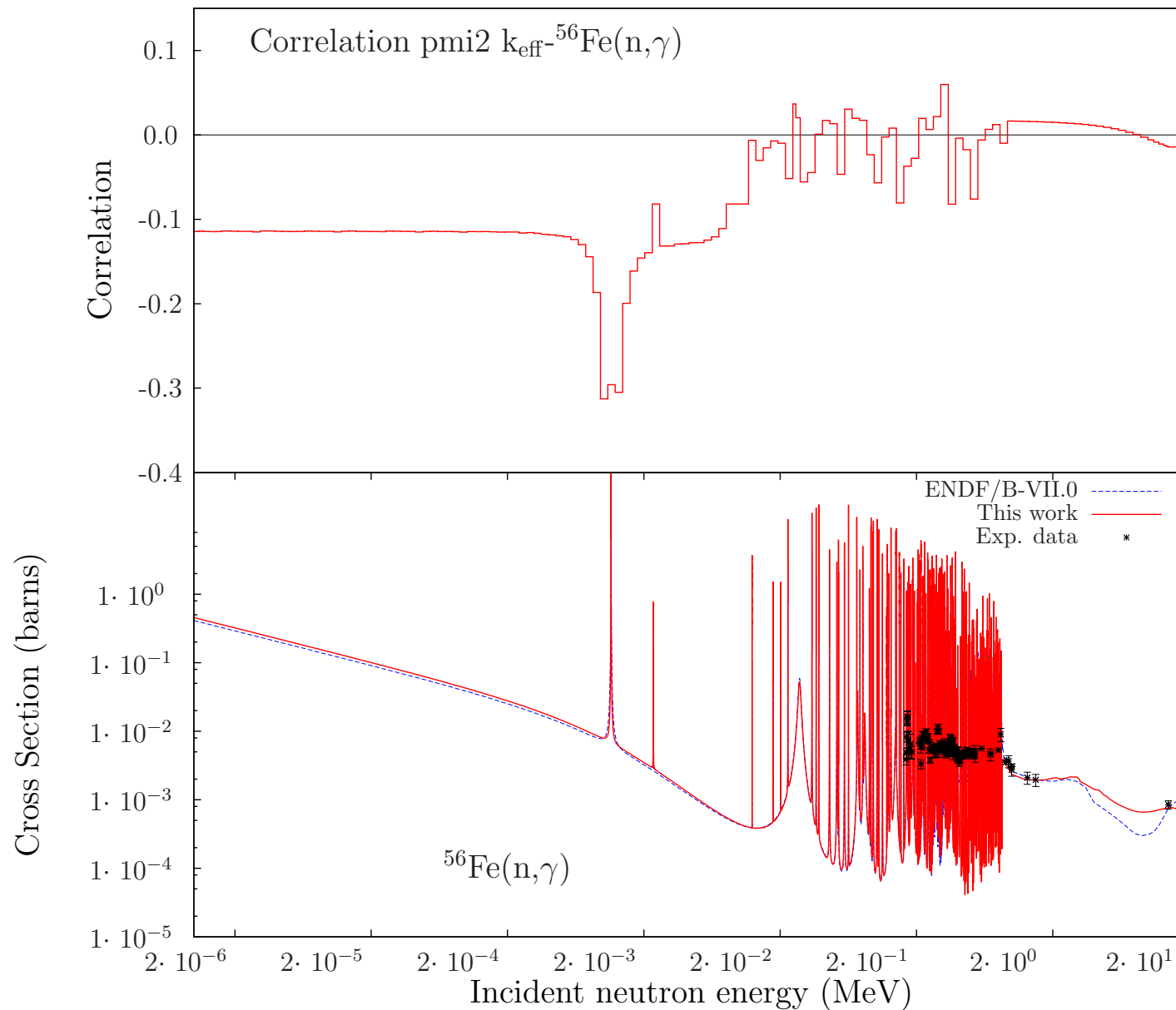
Correlation factors (instead of sensitivity)



$$\rho_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y}$$



Correlation factors (proportional to sensitivity)



Future work



- ⇒ Continue with TMC (more reactor calculations, applied to current reactors),
- ⇒ Apply TMC^{-1} to a large number of isotope (including crit-safety, reactor, dosimetry benchmarks)
 1. already applied to thermal scattering, selected isotopes,
 2. but how to combine many isotopes as ^{235}U , ^{238}U and ^{239}Pu ?

☺ **Long term goal:**

Apply this method to a large number of isotope
for the TENDL library

together with world domination (and world peace)