Building bridges between nuclear reactions and statistical models

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Connecting the Dots, or Nuclear Data in the Age of Supercomputing

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BFMC   Models   Massive computing

Two examples of Eric's work

Two of his achievements linking physics and statistics:

BFMC + TMC

correlations due to integral constraints
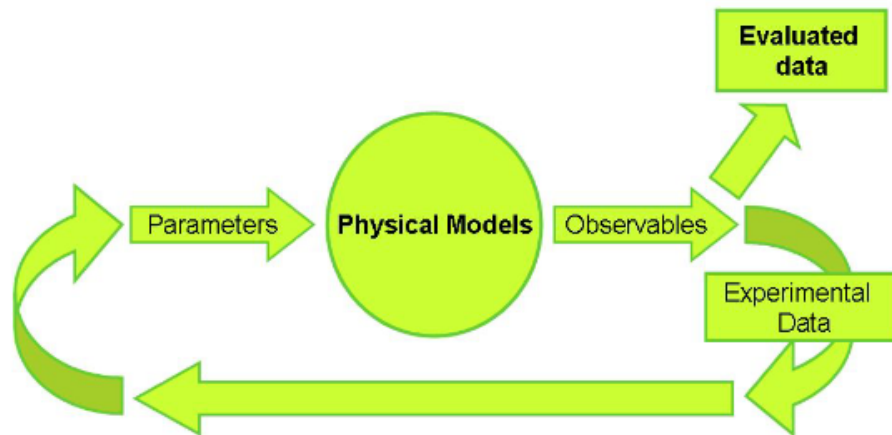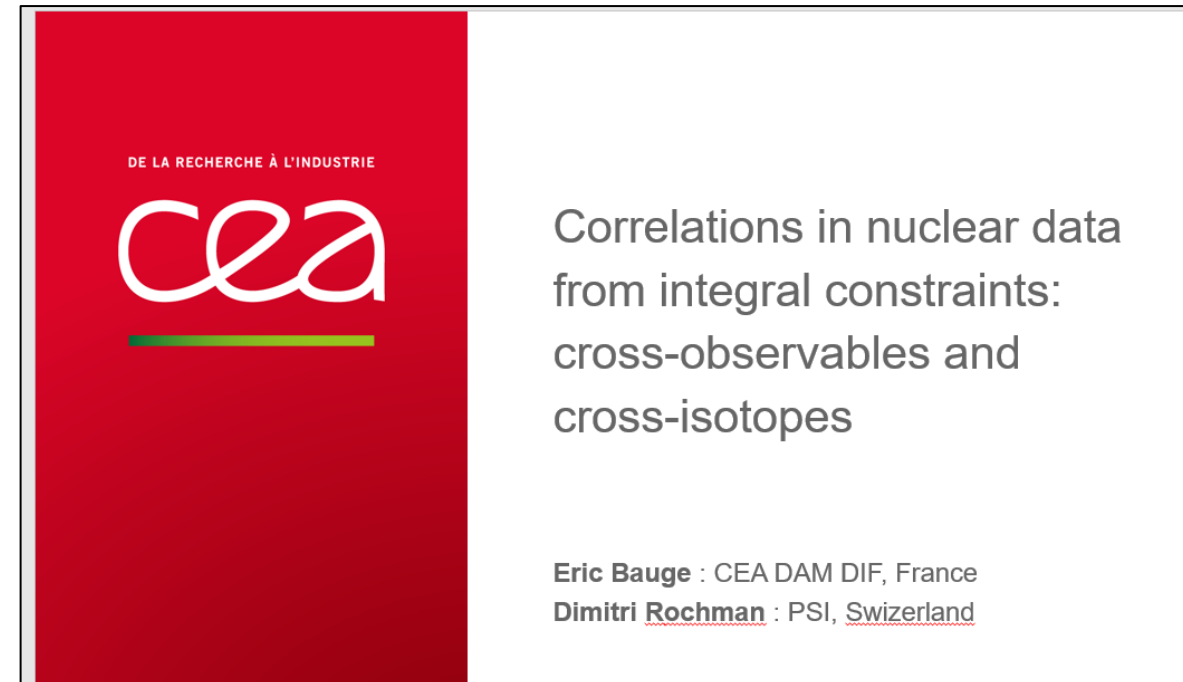

Fig. 1. (Color online) Schematic view of the "all model" evaluation method.

The   Backward-Forward   Monte-Carlo   (BFMC)

Correlations in nuclear data from integral constraints: cross-observables and cross-isotopes

Eric Bauge : CEA DAM DIF, France
Dimitri Rochman : PSI, Swizerland

Example 1: BFMC + TMC

- First applications of BFMC:

  - on ^{89}Y, Chadwick et al., Nucl.Data Sheets 108 (2007) 2742

  - on ^{239}Pu, E. Bauge et al., J. Korean Phys. Soc. 59 (2011) 1218

  - on covariance + TMC, E. Bauge, Nucl.Data Sheets 123 (2015) 201

  - Followed by others

- BFMC: "inspired from Bayesian methods"

- Select the calculation with the smallest weight: this is the new evaluation

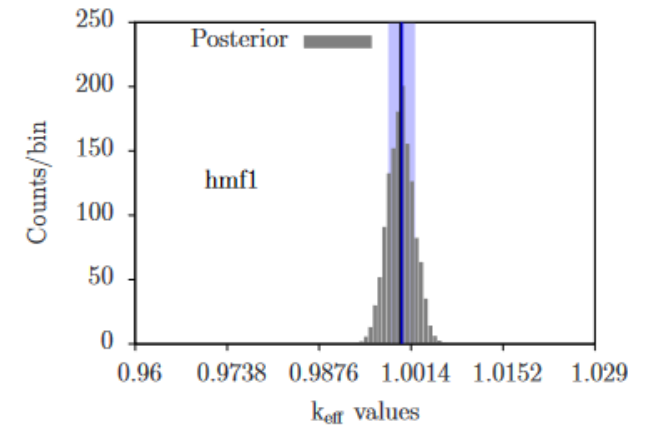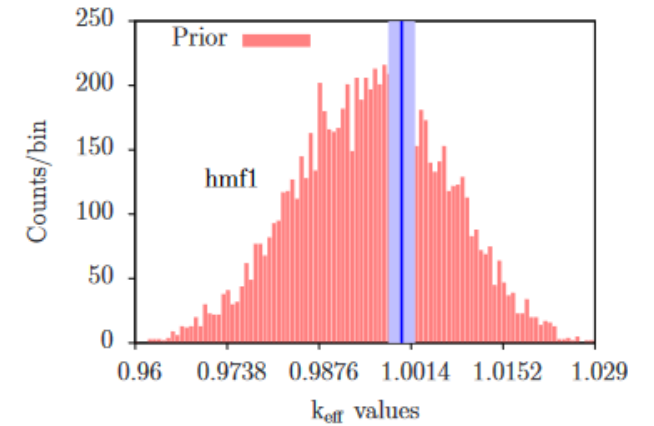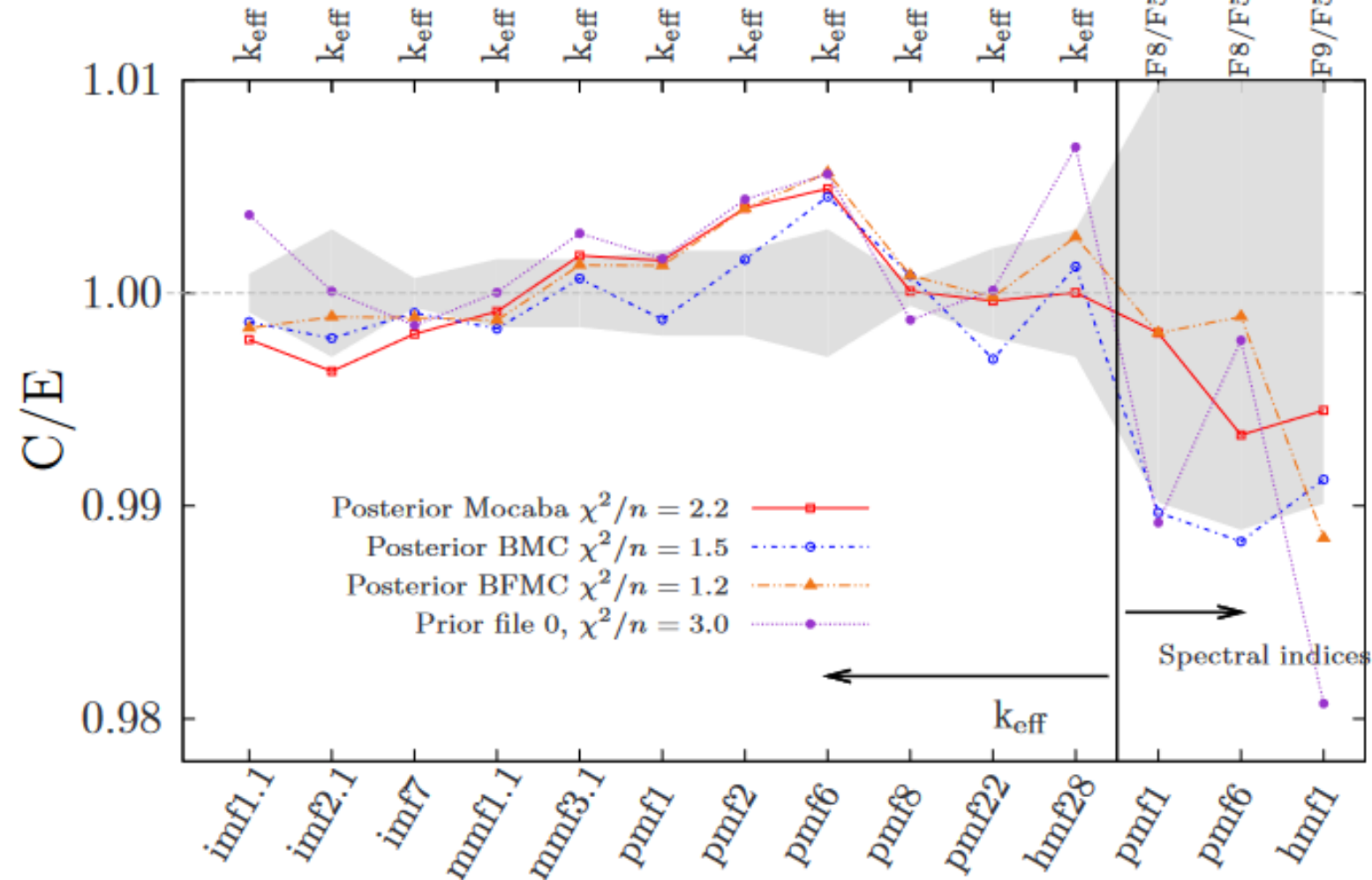$$\chi_I^2 = \sum_{l,l'=1,..,m} (e_i^l - s_l)(\nu^{-1})_{ll'}(e_j^{l'} - s_{l'}).$$

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

- Application of BFMC + TMC

Monte Carlo nuclear data adjustment via integral information

D. Rochman[1,a], E. Bauge[2], A. Vasiliev[1], H. Ferroukhi[1], S. Pelloni[1], A.J. Koning[3], and J.Ch. Sublet[3]

PSI

- Based on pmf1 : ^{239}Pu (EPJ/N 3 (2017) 14)

Summary

● A first attempt at the rigorous quantification of the $\sigma-\chi-\nu$ correlations existing in all the present evaluated nuclear data files

● These correlation allow nuclear data files to reach target integral performance. (Evaluators have known that for a long time, but never advertised it).

● A first demonstration is limited to a few PMFs (Eur. Phys. J. N **3**, 14 (2017))

● Cross isotopes correlations (IMF7: BIGTEN known to strongly depend on both ^{235}U and ^{238}U) can be quantified (submitted to EPJ N).

● The posterior (weighted) distributions are not inconsistent with the best differential experiments.

● Adjusting for one integral exp. seems to improve agreement with other integral expt. (including with different neutronic spectra).

● Do we learn anything about the fission process ? NO !

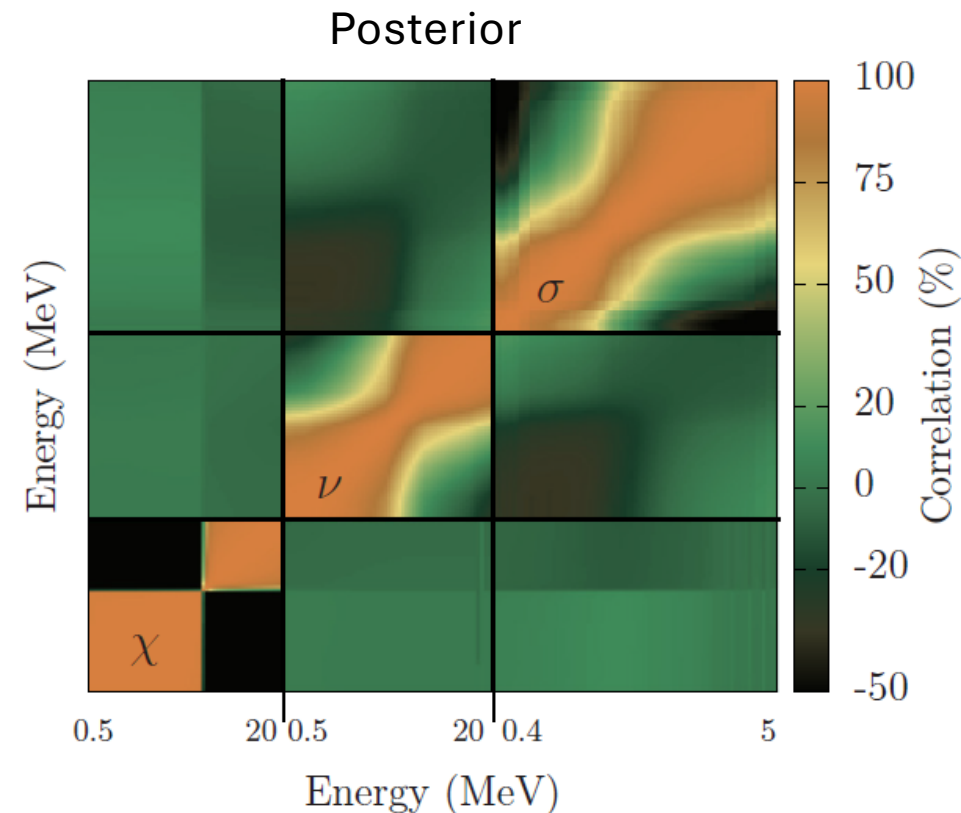● The ENDF6 format does not allow for storage or processing of such correlations

Posterior

Fig. 5. Posterior correlation matrix for ^{239}Pu ν, σ and χ (for the incident neutron energy of 750 keV). The energy axis is for the incident neutrons for ν and σ, and for the outgoing neutron for χ. The X- and Y-axis are in linear scale.
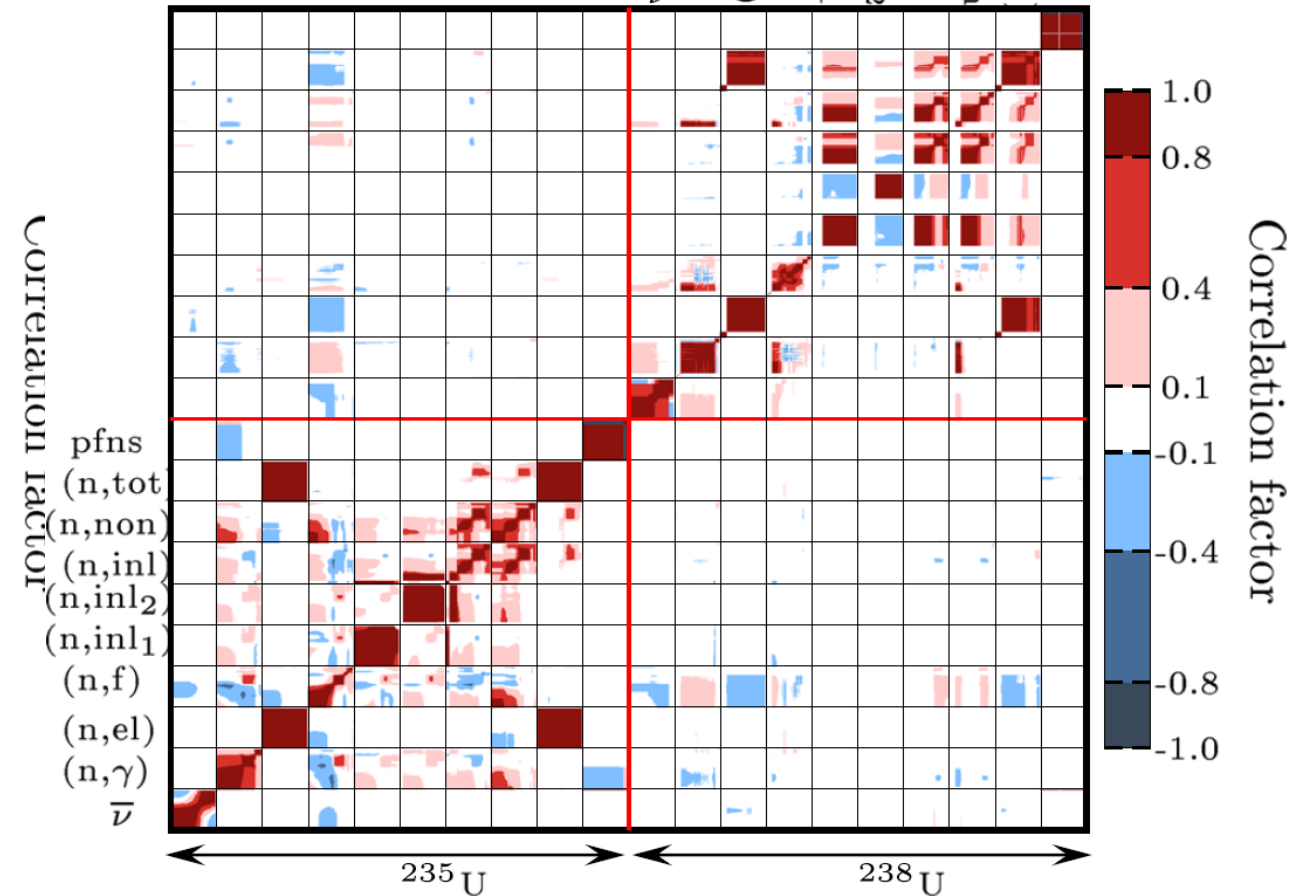
Example 2: Correlations from BFMC + TMC

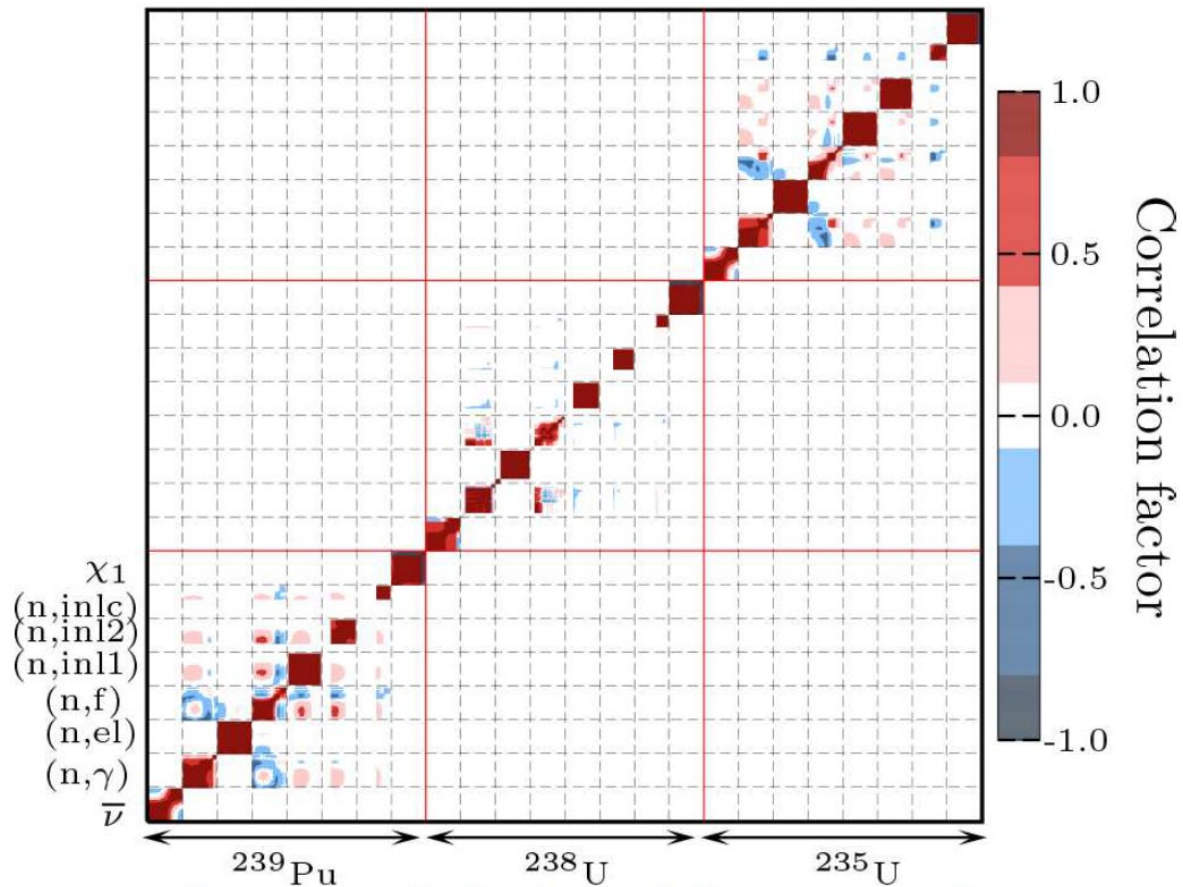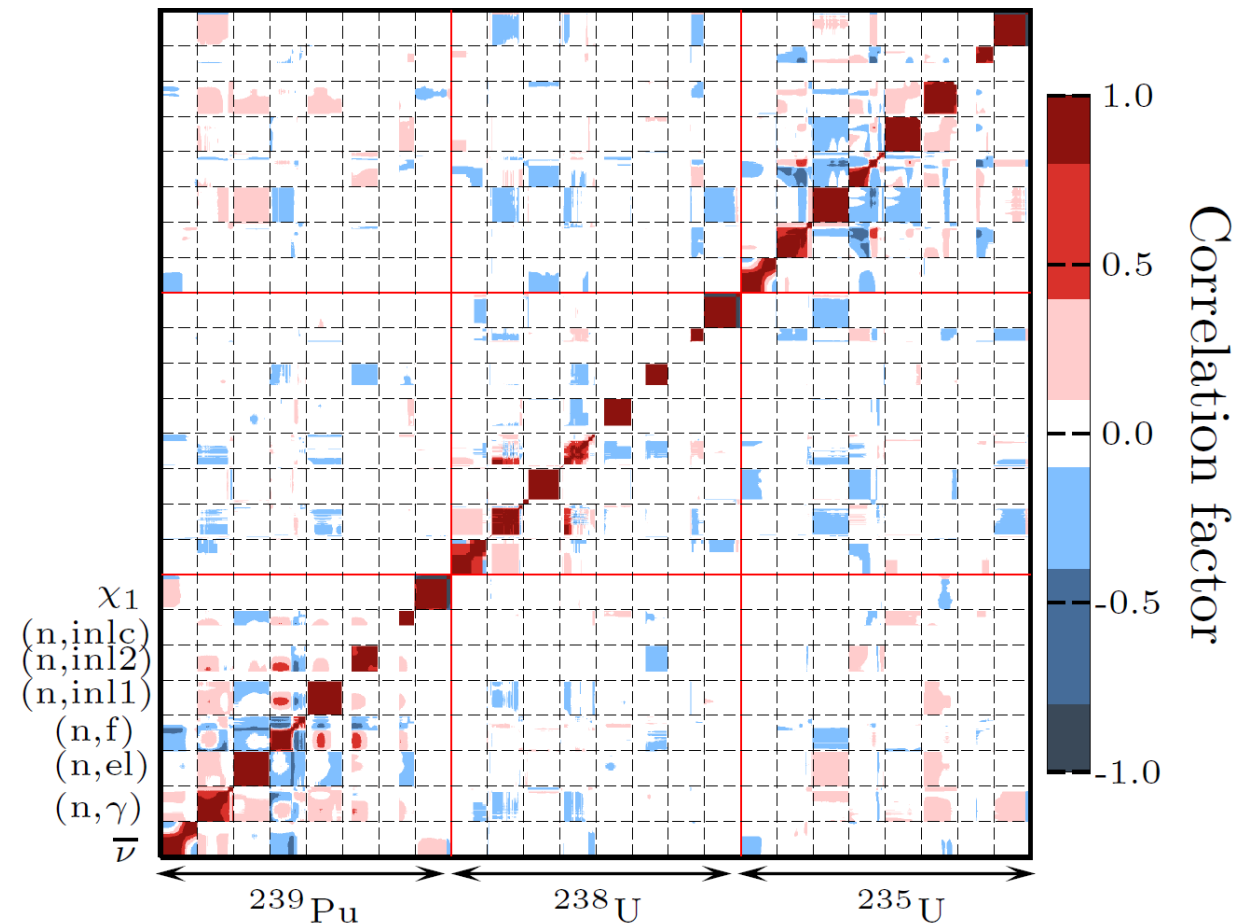- Based on imf7 : ^{235}U - ^{238}U (EPJ/N 4 (2018) 7)
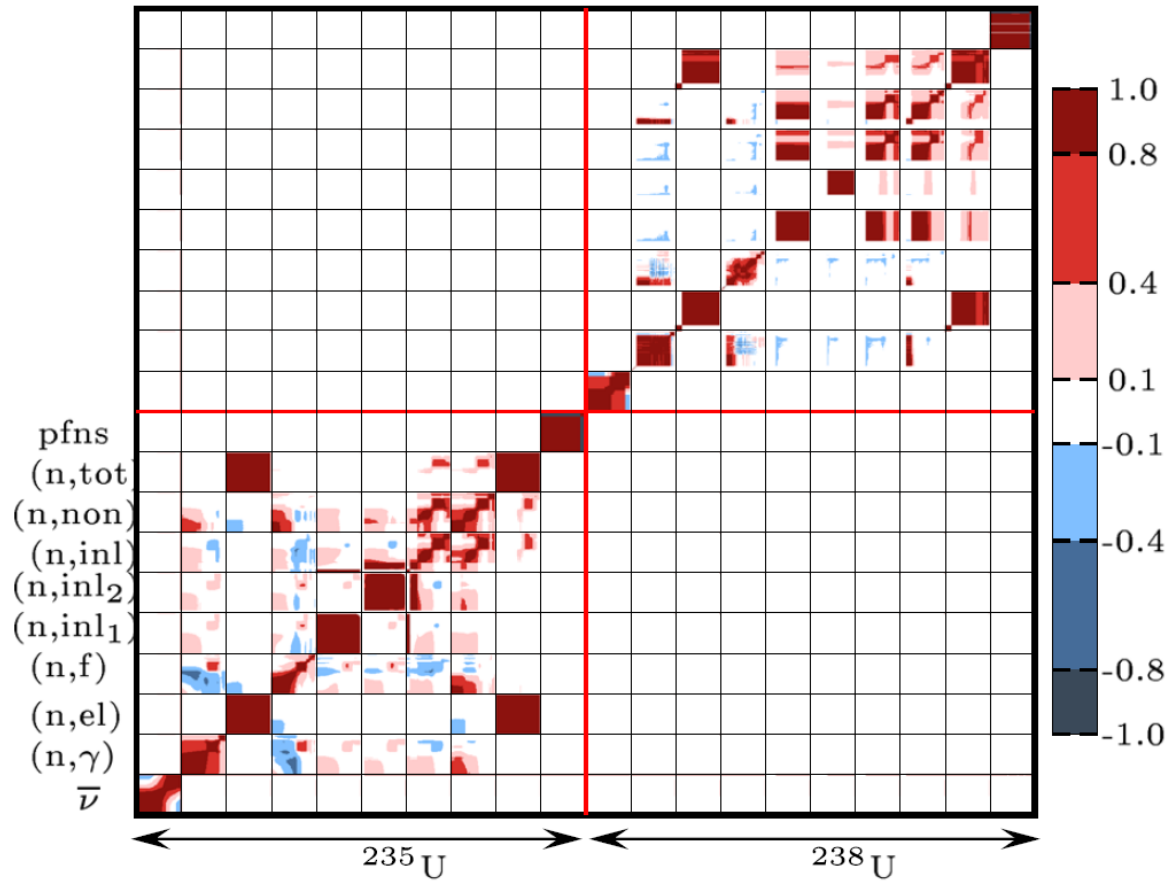
Example 2: Correlations from BFMC + TMC

- Based on 14 fast benchmarks : ^{235}U - ^{238}U - ^{239}Pu (EPJ Plus 133 (2018) 537)
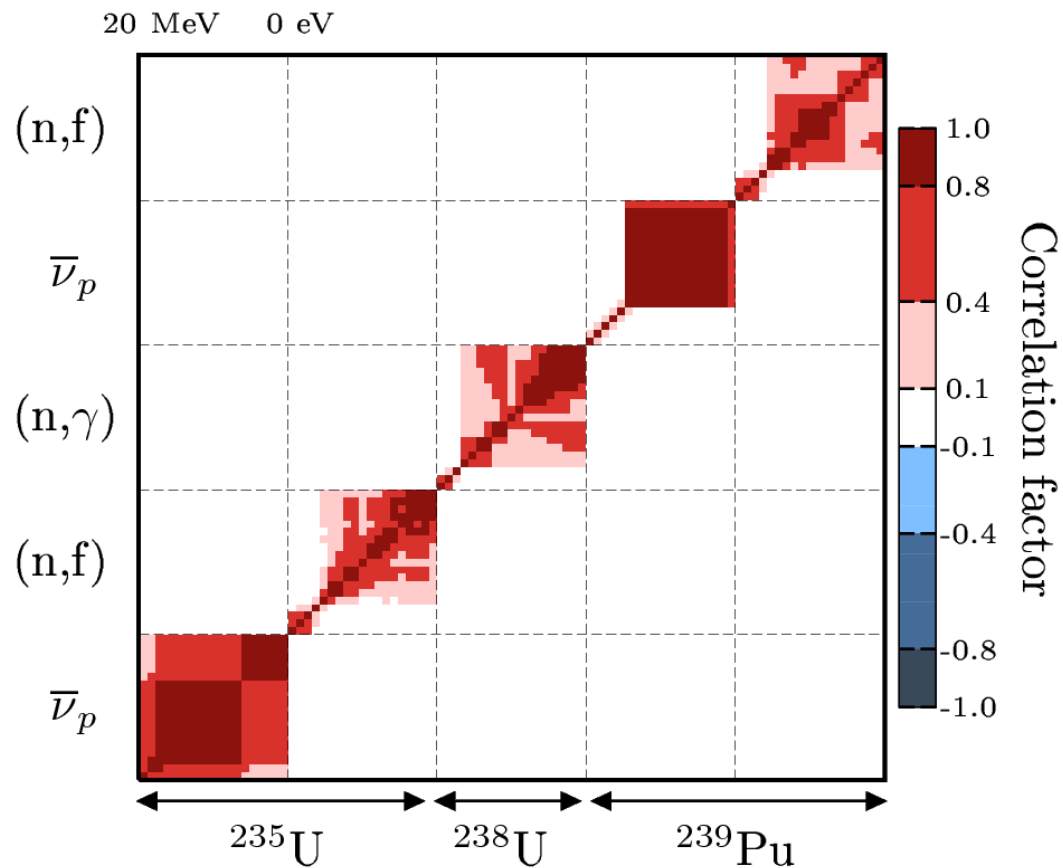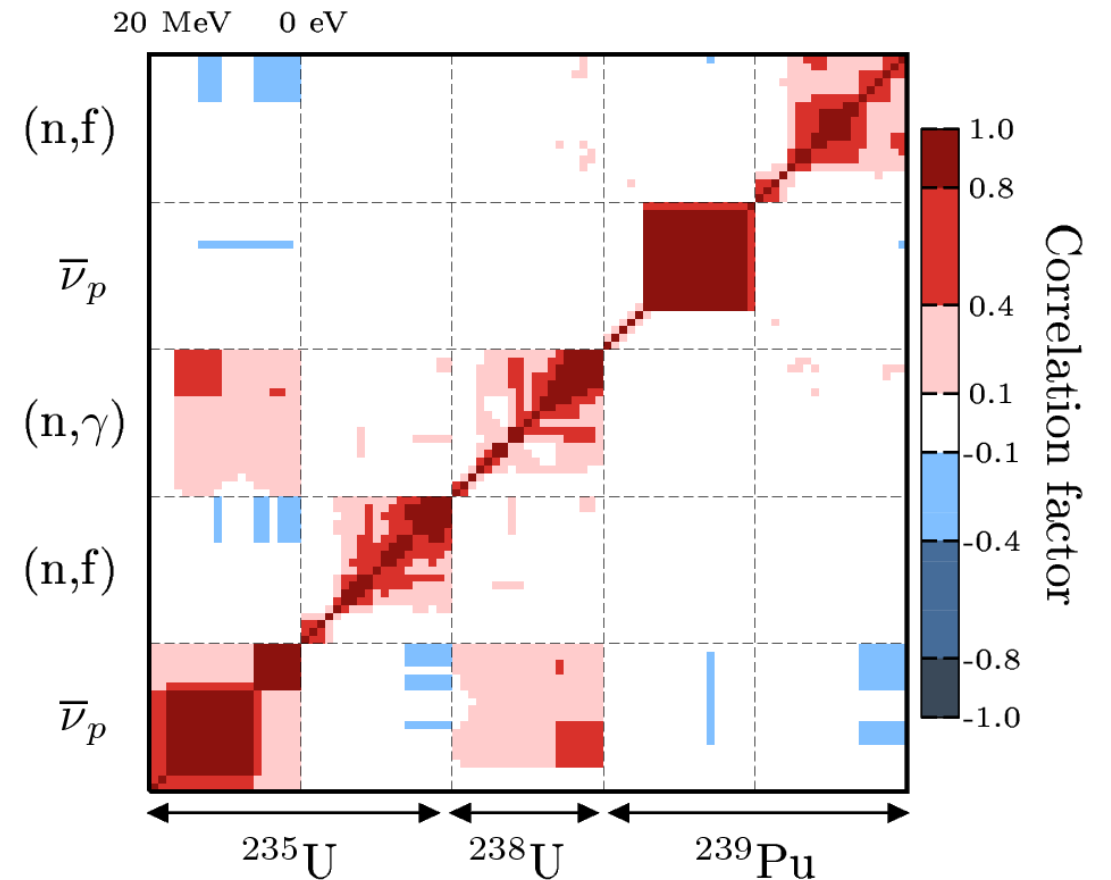

Prior

Posterior

Example 2: Correlations from BFMC + TMC

- Based on PWR cycles with boron concentration: (EPJ Plus 133 (2019) 453)

Prior

Posterior

Example 2: Correlations from BFMC + TMC

- Based on PWR nuclide concentration measurements:

- Production of some measured fission products depends on both FY and XS
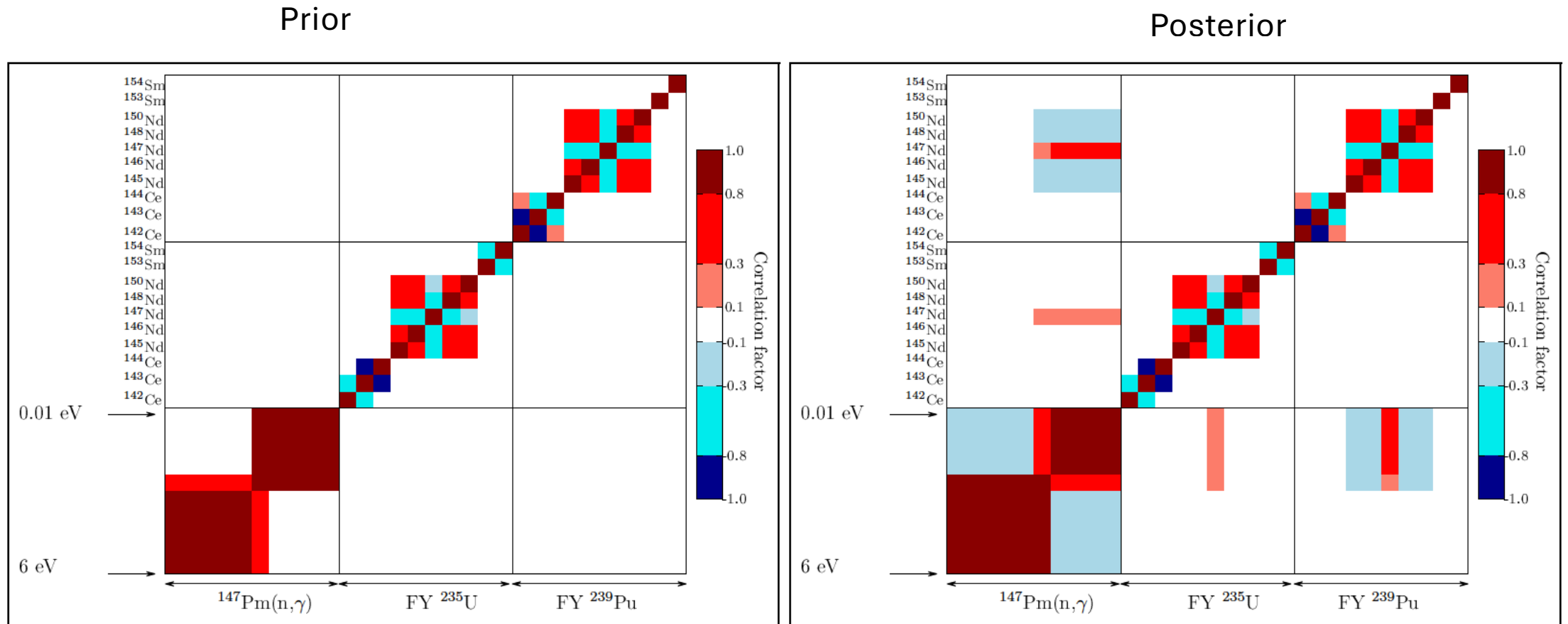

Fig. 4. Case of correlations between ^{147}Pm(n,γ) and fission yields from ^{235}U and ^{239}Pu. Left: prior correlation matrix without PIE data; Right: posterior correlation matrix using the PIE measurement from ^{147}Sm.

Eric's visions for the future

- <u>TENDL as a supporting library for JEFF</u>

  - Formal and informal help of Eric since 2015

  - How to combine in-depth evaluations and broad approaches (and motivate people) ?

  - Adept of the "soft power": let's convinced people and not force a solution

- <u>Varying models</u>

  - Produce libraries purely on model variations since 2019

  - Only recently applied to TENDL-Astro

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Eric's visions for the future

- <u>Acknowledging the adjustment</u>

  - From Eric's email (2018)

[...] One truth has to be hammered into ▓▓▓▓▓'s head :

benchmark data are already being used in the evaluation process of released libraries!

If the proposed file does not agree with the chosen benchmark suite (Mosteler for example) then the file in not accepted and evaluators go back to work. This part of the evaluation process is, at the time, not reflected in a mathematical way and barely acknowledged, but it doesn't mean it doesn't exist. There are two solutions : going on with denial (Roberto's) or try to model that existing process in a reproducible mathematical way (ours). [...]

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La Direction des applications militaires
du CEA fête ses 60 ans...

...et vous
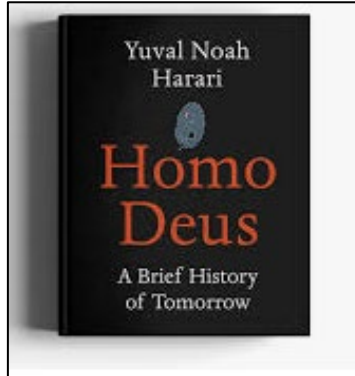
France and Nuclear Deterrence
A Spirit of Resistance

Edited by
Céline Jurgensen & Dominique Mongin
January 2020

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La patience est un plat qui se
mange sans sauce.

Kaamelott - Premier Volet
Perceval

Many thanks

- Questions ?

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