

PAUL SCHERRER INSTITUT



D. Rochman and E. Bauge

# Fission yields and cross sections: correlated or not?

CSEWG meeting, BNL, online, 30 November 2020



# Summary

- Motivation/examples
- Considered system and results
- Conclusion

- Motivation 1: integral data are already used during adjustment
- Motivation 2: This should be done at the evaluation level
- Motivation 3: It leads to uncertainty reduction and cross-isotope correlations
- Motivation 4: nothing new: already done with GLLS by SG... at the OECD
- BFMC:
  - Generate  $n=5000$  random FY and XS libraries based on ENDF/B-VIII.0 covariance
  - Calculate  $n$  times the benchmark
  - Assign weights to all realizations  $i$  with a  $\chi^2$  and update the parameter distributions

For a random file  $i$  and a set of  $p$  benchmarks:

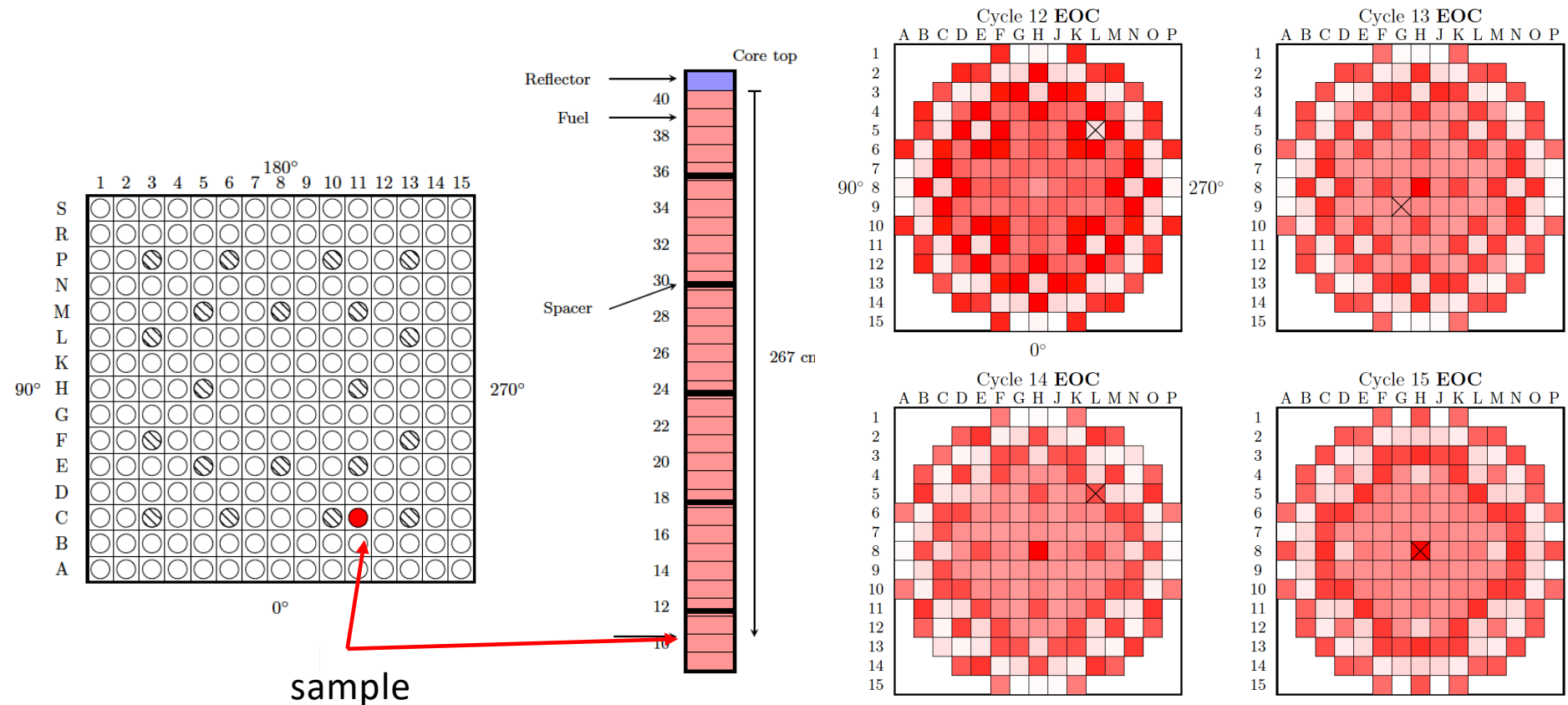
$$\chi_i = \sum_j^p \left( \frac{k_{\text{eff},i}^{(j)} - k_{\text{exp}}^{(j)}}{\Delta k^{(j)}} \right)^2 \quad (1)$$

$$w_i = \exp\left(-\frac{\chi_i}{2}\right) \quad (2)$$

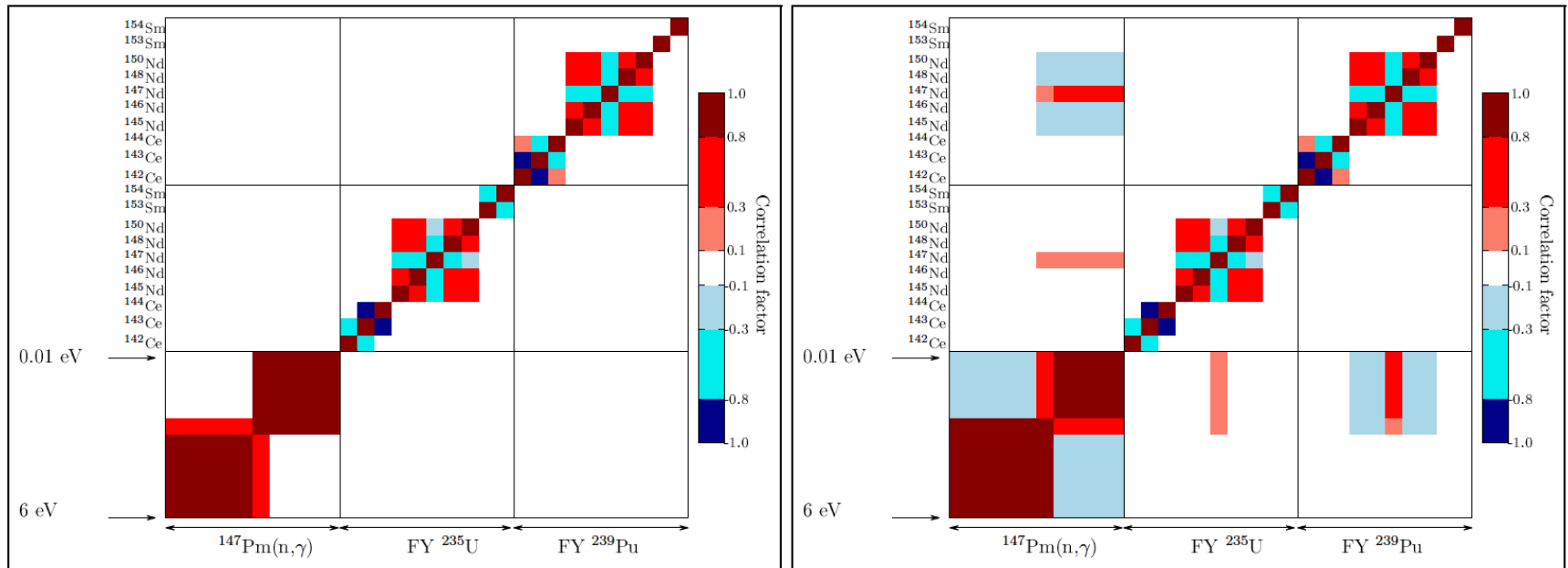
- Update the cross sections with the weights.
- System: PIE sample called GU1, simulated with CASMO (18 actinides, 32 fission products measured)

# PIE data: GU1 sample

- PIE data: isotopic concentrations from irradiated samples in a specific reactor
- Measured actinides and fission products (e.g. in mg/gU)
- Used for transport and depletion code validation

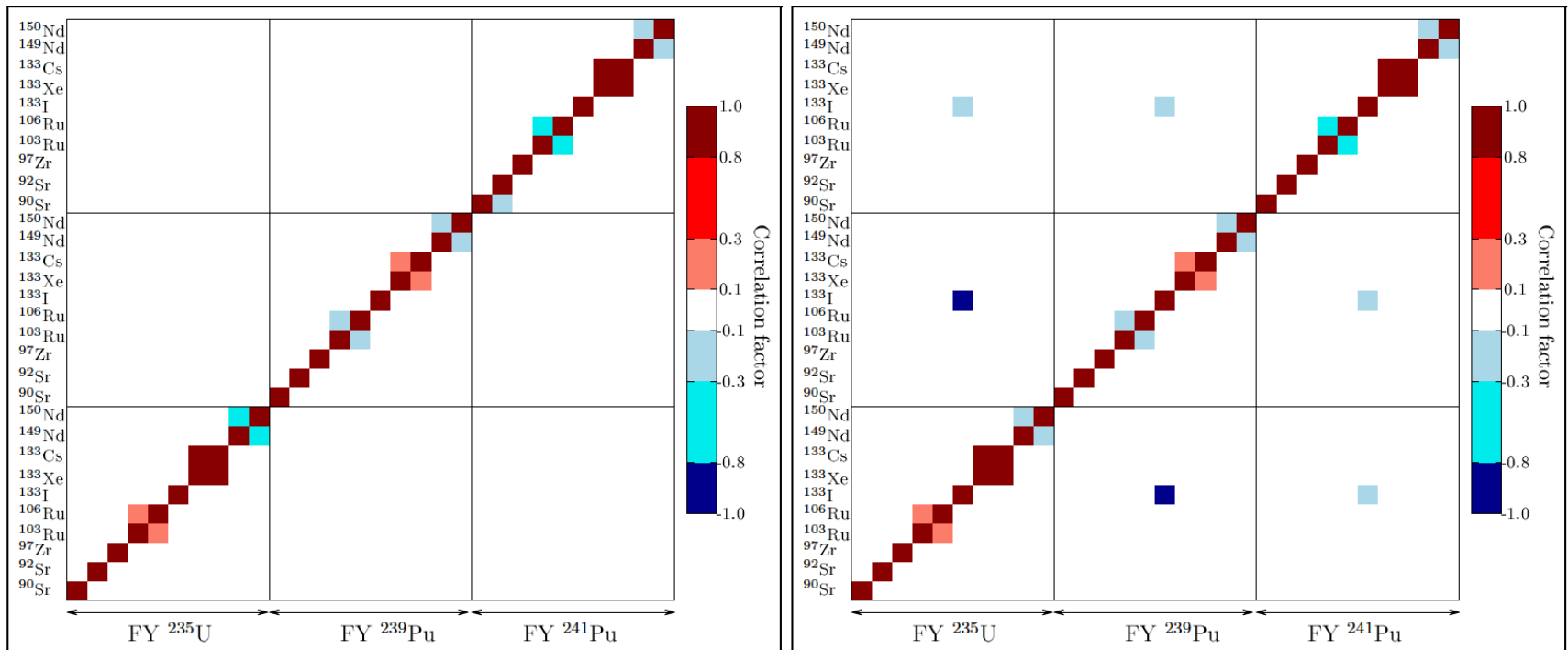


- Production of some measured fission products depends on both FY and XS



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

- Production of some measured fission products depends on FY from a few actinides



**Fig. 3.** Case of correlations between fission yields from  $^{235}\text{U}$ ,  $^{239}\text{Pu}$  and  $^{241}\text{Pu}$ . Left: prior correlation matrix without PIE data; Right: posterior correlation matrix using the PIE measurement from  $^{133}\text{Cs}$ .

# Conclusions

- Last example of correlations between nuclear data, after XS-XS, XS-nu, XS-nu-PFNS,
- Such correlations can improve calculations of integral quantities and answer requests from a number of users
- Because such correlations are constructed with specific measurements, and are case dependent, it is advocated that such correlations (and adjusted nuclear data) find their place in dedicated adjusted libraries
- This possibility can improve the user's satisfaction, but also emphasizes the fact that current nuclear data evaluations do not lead to a unique set of cross sections, nubar or fission yields.

# References on correlations

- E. Bauge, P. Dossantos-Uzarralde, “*Evaluation of the Covariance Matrix of  $^{239}\text{Pu}$  Neutronic Cross Sections in the Continuum Using the Backward-Forward Monte-Carlo Method*”, J. Kor. Phys. Soc. 59 (2011) 1218.
- D. Rochman, E. Bauge, A. Vasiliev and H. Ferroukhi, “*Correlation  $\nu$ -sigma- $\chi$  in the fast neutron range via integral information*”, EPJ/N 3 (2017) 14.
- D. Rochman, E. Bauge, A. Vasiliev, H. Ferroukhi and G. Perret, “*Nuclear data correlation between different isotopes via integral information*”, EPJ/N 4 (2018) 7.
- E. Bauge and D. Rochman, “*Cross-observables and cross-isotopes correlations in nuclear data from integral constraints*”, EPJ/ N 4 (2018) 35.
- D. Rochman, E. Bauge, A. Vasiliev, H. Ferroukhi, S. Pelloni, A.J. Koning and J.Ch. Sublet, “*Monte Carlo nuclear data adjustment via integral information*”, EPJ Plus 133 (2018) 537.
- D. Rochman, A. Vasiliev, H. Ferroukhi, S. Pelloni, E. Bauge and A.J. Koning, “*Correlation  $\nu$ -sigma for U-Pu in the thermal and resonance neutron range via integral information*”, EPJ Plus 133 (2019) 453.
- J.-Ch. Sublet et al., “*Neutron-induced damage simulations: Beyond defect production cross-section, displacement per atom and iron-based metrics*”, EPJ Plus 134 (2019) 350.
- D. Rochman and E. Bauge, “*Fission yields and cross sections: correlated or not ?*”, submitted to EPJ/N, July 2020.



