IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

Summary, state-of-the art review, step towards science-driven V&UQ

Semi-annual meeting
OECD-NEA/NSC/WPEC-SG46
May 12, 2021

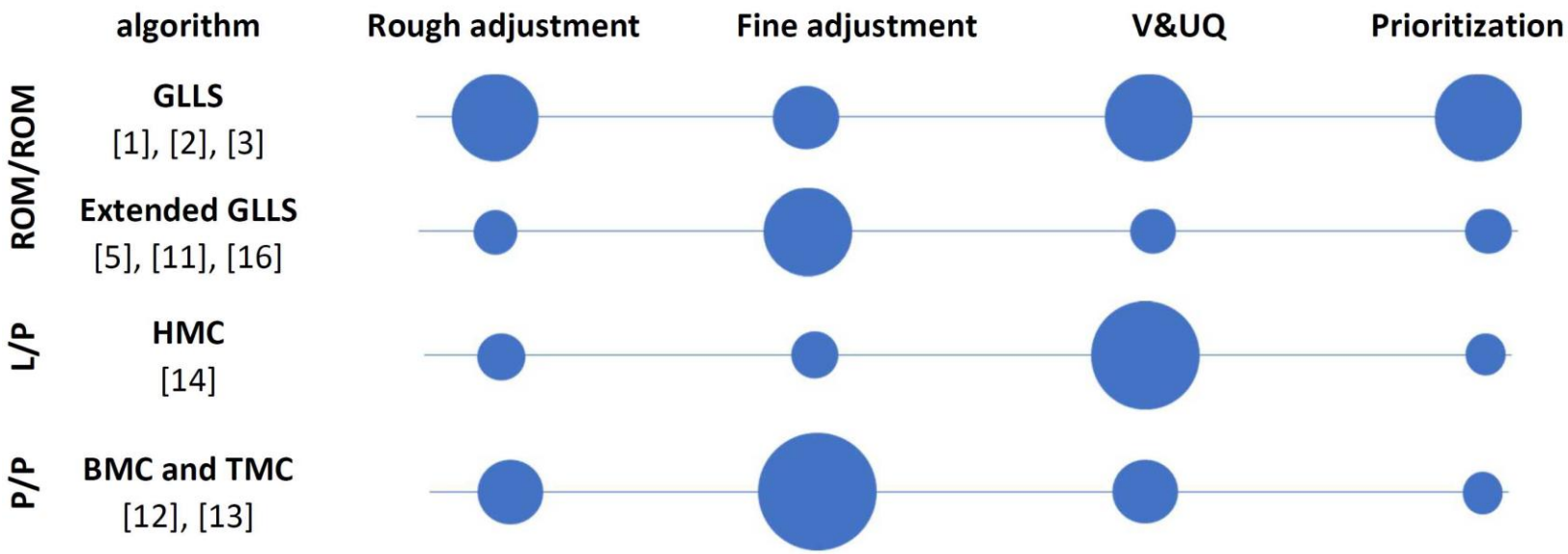
MEMBRE DE
ETSON
EUROPEAN
TECHNICAL SAFETY
ORGANISATIONS
NETWORK

Outline

- Introduction
  - Topics to be discussed
- V&UQ
  - Validation through science-driven UQP
  - Current status and TRLs
- Discussion
  - Some newly identified potential challenges
  - Paradigm-shift examples & stress tests ideas
- Summary

IRSN MEMBRE DE ETSON

TRLs for the adjustment methodologies (by groups)



E. Ivanov, C. De Saint-Jean and V. Sobes, ***NUCLEAR DATA ASSIMILATION, SCIENTIFIC BASIS AND CURRENT STATUS,*** *EPJ-N (2021)*

Precise	***P***	$\boldsymbol{Lib_{ADJ} \approx fun(\alpha_1, \alpha_2, \dots, \alpha_K \mid \theta_1, \theta_2, \dots, \theta_L)}$
Reduced Order	***ROM***	$S_{R,\theta} = \frac{\theta}{R} \cdot \frac{\Delta R}{\Delta \theta} = \frac{\theta}{R} \cdot \left(\frac{\partial R}{\partial \theta} + \sum \frac{\partial R}{\partial \alpha} \cdot \frac{\partial \alpha}{\partial \theta} \right)$
Linear	***L***	$\boldsymbol{Lib_{syn} \approx a_1 \cdot Lib_1 + a_2 \cdot Lib_2 + \cdots + a_N \cdot Lib_N = \sum_n a_n \cdot Lib_n}$

still remained issue

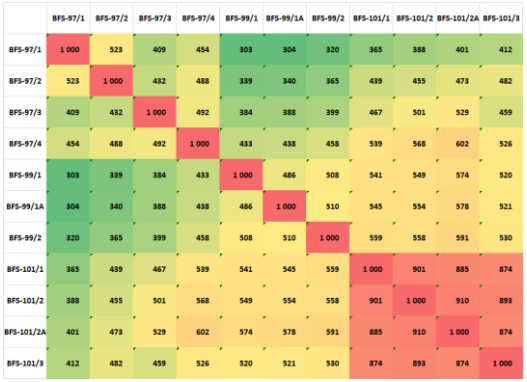
$\Rightarrow$ an adjustment of composed - non-linear – operators, including an operator of fission production

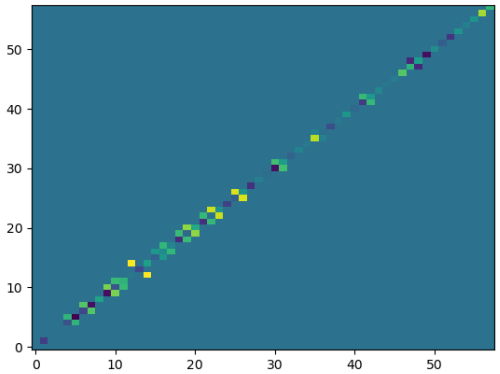
$\Rightarrow$ correlated ν-bar and PNFS ($\frac{1}{4\pi} \cdot \chi \cdot \nu \cdot \Sigma_{fiss} \leftarrow \cdots \chi(\nu) \cdot \nu \cdots \sim \cdots a_0 \cdot \nu + a_1 \cdot \nu^2 + \cdots$)

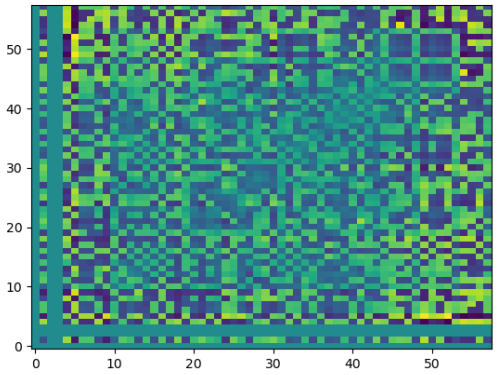
IRSN MEMBRE DE ETSON

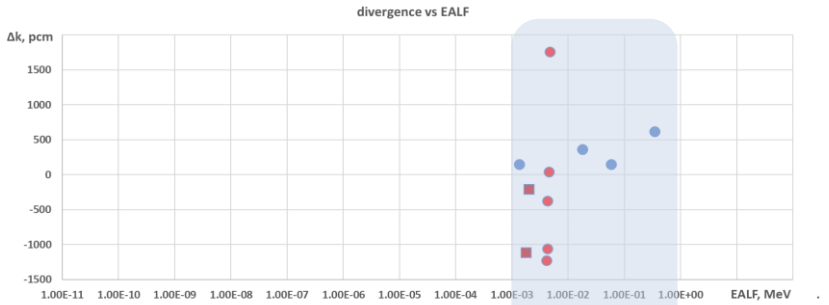
Involving IE in a scientific turnover using Data Assimilation

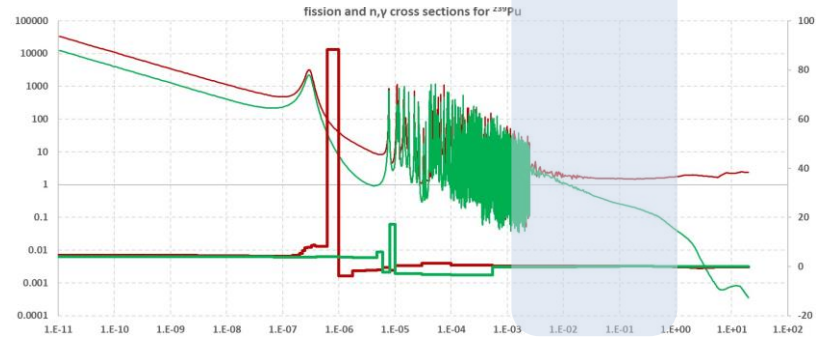
- Data assimilation to prioritize problem-oriented basic research programmes [C. De Saint-Jean, E. Ivanov, V. Sobes, Nuclear Data Assimilation, basis and status, *EPJ-N, 2021*]
- Data Assimilation and zero power experiments with EALF in keV allowed identifying an issue with the fission resonance of ^{239}Pu.











Essential ingredients independent on the particular Bayesian technique used in Data Assimilation =>

- IEs covariance matrices
- prior CND

Output =>

- corrected ND, and
- posterior CND

Use of IEs related to one interval of a state-space helps improving knowledge in other intervals

DA equally allows separating application and validation domains

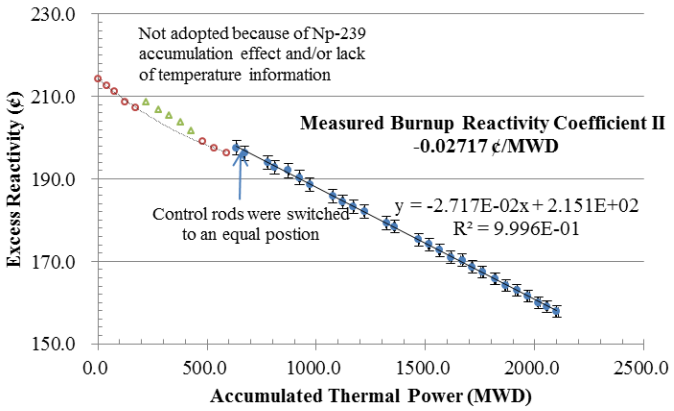
IEs covariance matrices (CovEx) are crucial to ND adjustments and validation

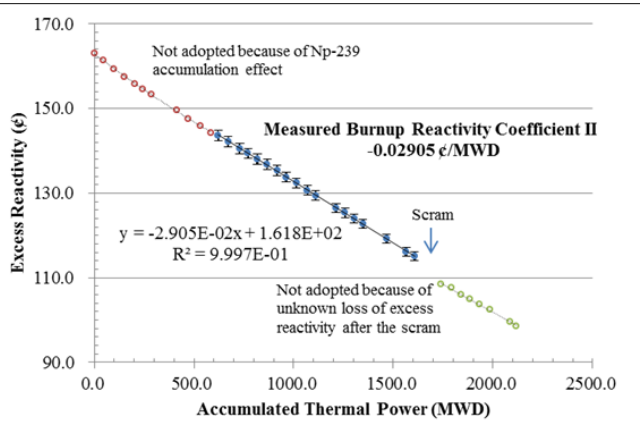
CovEx to be established between the cases, between different functionals in similar cases, etc.

IRSN MEMBRE DE ETSON

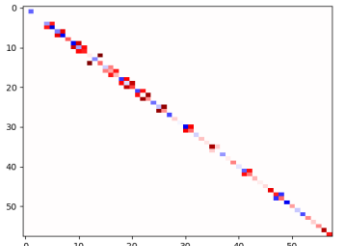
Slow transient IEs an ignorance of sufficient factors and AOs

Note: other physics (multi-physics) impact: JOYO evaluation example (IRPhE)



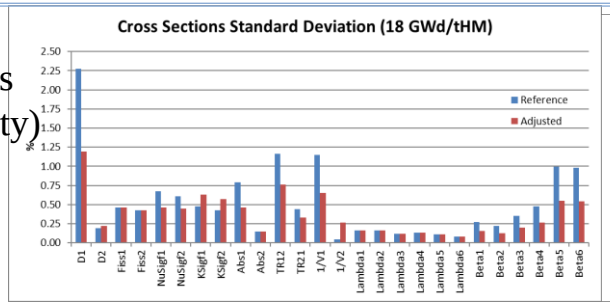


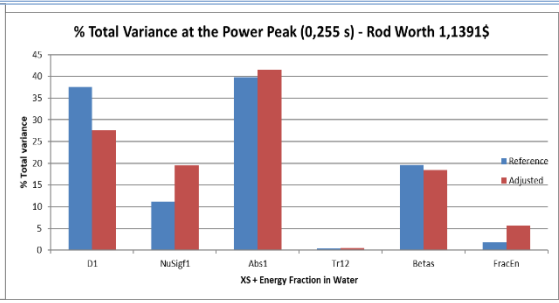
gases annealing / not Np-effect / as an impactive factors in a reactivity swing / dedicated IEs data

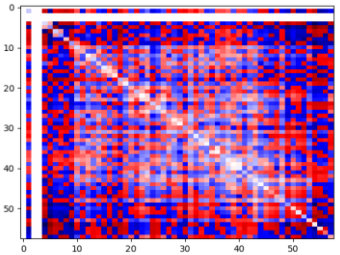


DBA and DEC transients
(non-adjusted/low-fidelity)

$\Delta\rho \sim 12 \div 15\%$
$\Delta Q \sim 30 \div 200\%$







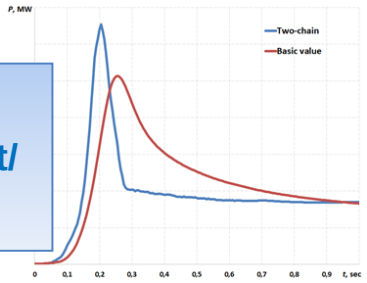
(adjusted/medium-fidelity)

$\Delta\rho_{ADJ} \sim 3 \div 5\%$
$\Delta Q_{ADJ} \sim 10 \div 50\%$

DA as a component of Multi-Physics V&UQ

1) low-fidelity prior CND /fundamental constraint/

2) evidence-based local posterior CND



Summary and Discussion

- Objectives?
  - Progress in methodology (Data Assimilation as informatics technology)
  - Validation via Uncertainty Quantification? science-driven/data-driven validation?

- Main statements
  - Uncertainty => fundamentally non-measurable/non-testable category (even theoretically impossible to confirm, but to be established)
  - DA allows separating the domains of validation and applications

- Key issues (to be somehow addressed)
  - Covariance matrices of IEs data (CovEx)
  - Non-linearities in the adjustment process

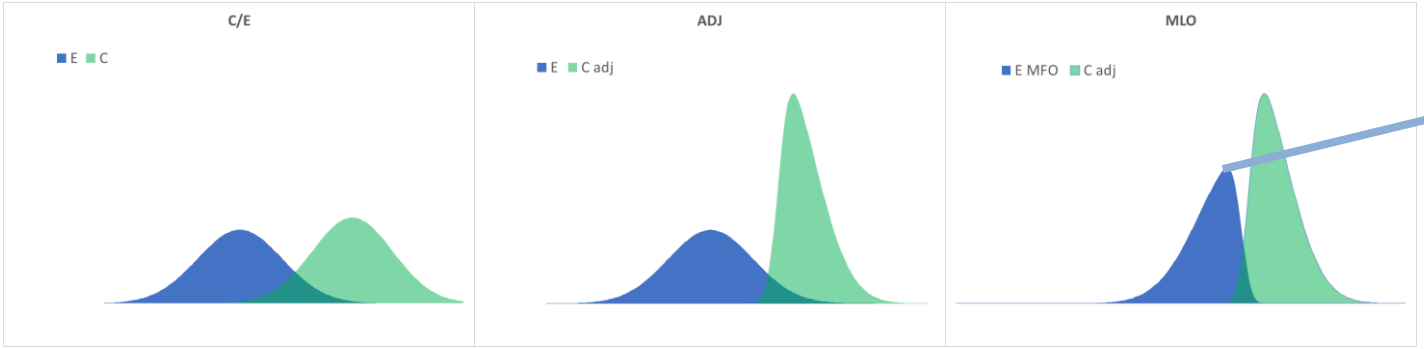
- Our contribution => characterizing TRLs /and SRLs/ for major groups of DA

IRSN MEMBRE DE ETSON

Thank you for your time

Questions?

Some qualitative considerations => MLO stress test



Stress test =>

using adjusted IEs data ($\tilde{E}$) to other functionals

PST-001-1-6
PST-002-1-7
PST-004-2,3,5,6,8,11
PST-007-2,3,6-10