NEA
NUCLEAR ENERGY AGENCY

# NEA Nuclear Science Committee activities in connection with the NCSP

Julie-Fiona Martin (NEA)

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# 1. The Nuclear Science Committee of the NEA

# 2. WPNCS Working Party on Nuclear Criticality Safety

# 3. WPEC … on nuclear data Evaluation Cooperation

# 4. WPRS … on scientific issues and uncertainty analysis of Reactor Systems

# 5. NEA tools

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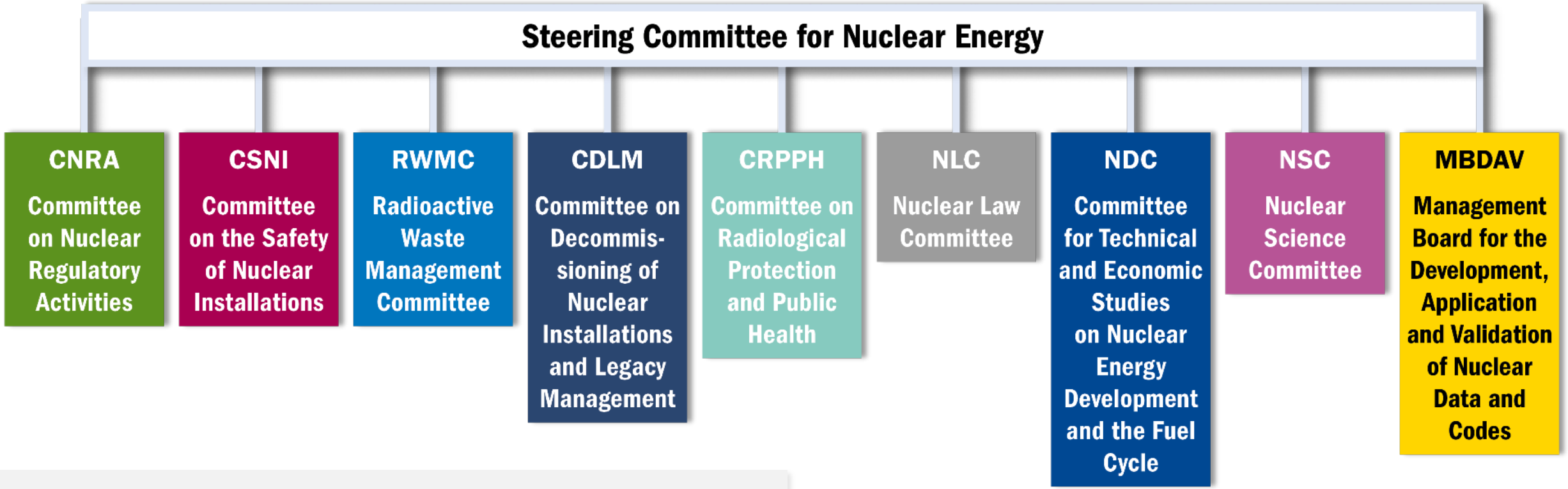
# NEA committees (as of 1 January 2022)

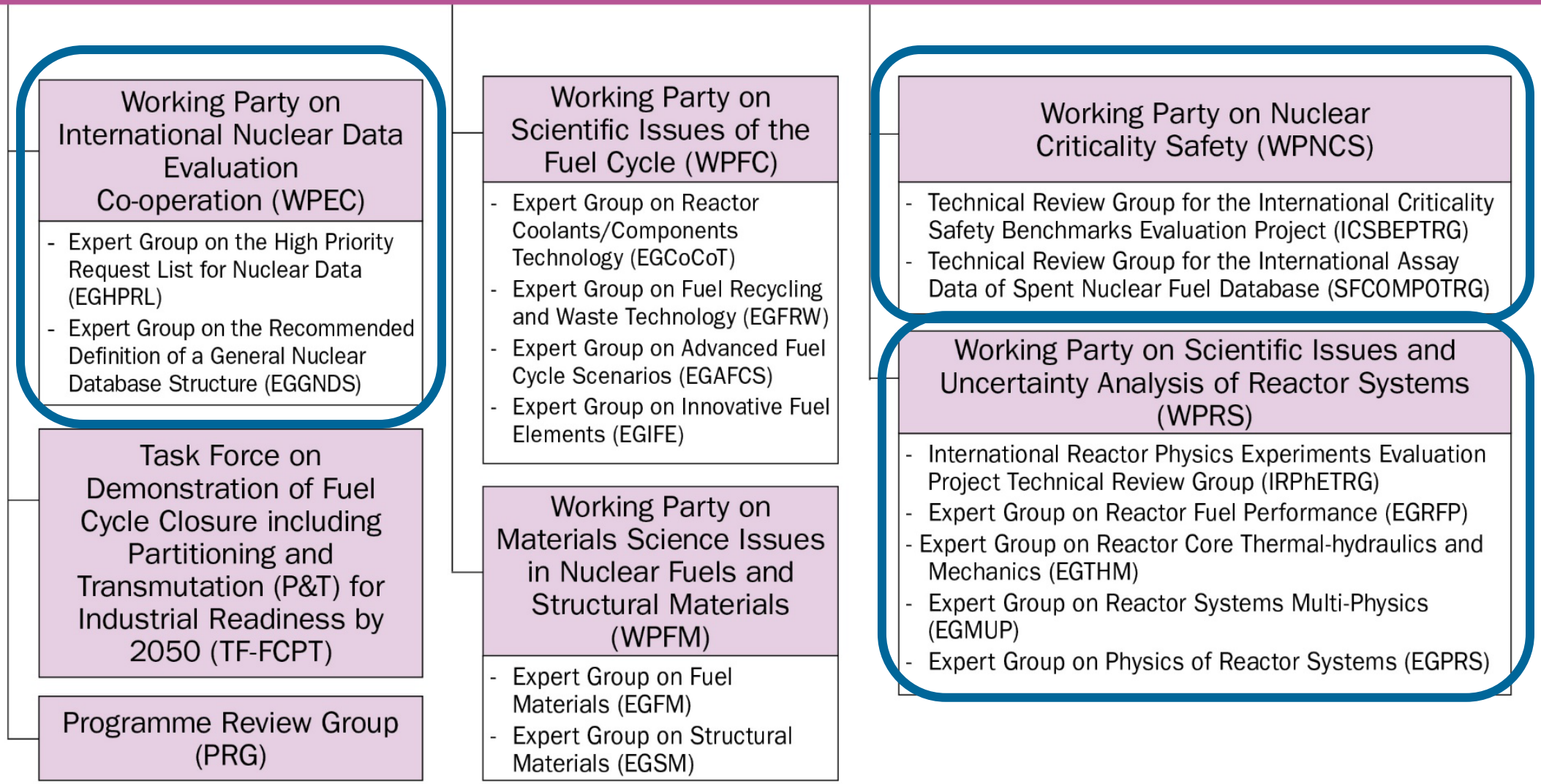



**8** standing technical committees

**1** management board

**74** working parties and expert groups

# Nuclear Science Committee (NSC)



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1. The Nuclear Science Committee of the NEA
2. **WPNCS** **Working Party on Nuclear Criticality Safety**
3. WPEC … on nuclear data Evaluation Cooperation
4. WPRS … on scientific issues and uncertainty analysis of Reactor Systems
5. NEA tools

# Working Party on Nuclear Criticality Safety (WPNCS) – Highlights since last NCSP presentation (Feb. 2022)

***Chair: A. Vasiliev (CH)***
***Vice-chair: G. O'Connor (UK)***
***Secretariat: J.-F. Martin***

*US leadership highlighted*

| Domain | Published | Finalized | On-going | Launching |
|---|---|---|---|---|
| **IPD Information preservation and dissemination** | SFCOMPO Evaluations, databases and tools *Chair: G. Ilas (ORNL)* | | | |
| | ICSBEP Handbooks, databases and tools *Chair: C. Percher (LLNL) Vice-chair: W.J. Marshall (ORNL)* | | | |
| **IE Integral experiments** | Experimental needs (SG5) | Expert knowledge (SG8) | | |
| **AM Analytical methods / calculation** | Temperature effect (SG3)<br>Source convergence (SG6) | Random geometries (SG9) | | |
| **AM Analytical methods /uncertainties** | Integral experiments uncertainty and covariance (SG1) | Bias and correlated data (SG11) | | Error recovery and exp. Coverage (SG14) |
| **ND Nuclear data** | | ND uncertainty on spent fuel inventory calculations Part A (SG10) | | ND uncertainty on spent fuel inventory calculations Part B (SG15) |
| **CSE Criticality Safety Evaluations** | | | CSE and BUC (SG13) | Ref values (SG17) |
| **DH Decay heat** | | DH review (SG12) | | Blind benchmark (SG16) |

# Data preservation and dissemination

## **SFCOMPO TRG** Technical Review Group for the International Assay Data of Spent Nuclear Fuel Database

Chair G. Ilas (ORNL)

Nuclide inventory of used fuels experiments and decay heat measurements

24k measurements on 750 samples from 44 reactors, DH addition in progress

## Focus of the TRG

**Collection** of experimental data incl. decay heat data

**Evaluation** of the experimental data and the development of benchmarks and benchmark models

Revision of **guidance** documents

**Maintenance** of the database & GUI


**oe.cd/nea-sfcompo**

## **ICSBEP TRG** Technical Review Group for the International Criticality Safety Benchmarks Evaluation Project

Chair: C. Percher (LLNL); Vice Chair: B.J. Marshall (ORNL)

Critical, subcritical, alarm/shielding and fundamental physics experiments

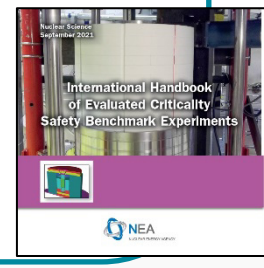
587 experimental series from 19 countries, Handbook of ~70000 pages

### 2022 Edition
Annual meeting in Oct. + Dec ’21 (remote)
**6 new** evaluations approved + 1 update

### 2023 Edition
Meeting in April 2023 (NEA HQ)
**7 new** evaluations approved + 1 update

>> Joint 2022/2023 publication scheduled in ‘24

### 2024 Edition
Meeting in April 2024 (LLNL)
**5 candidate new evaluations**




**oe.cd/nea-icsbep**

# IE Integral experiments

## Experimental needs (SG5)

- Coord. I. Duhamel (FR), then C. Percher (LLNL) & G. McKenzie (LANL)
- Report published in 2022
- Review of needs, proprietary experiments, experimental facilities
- Needs ranked by usage / level of knowledge

## Expert knowledge (SG8)

- Coord. W. Wieselquist (ORNL)
- Brief conclusions in preparation
- Acknowledge variation in quality expectations of ICSBEP benchmarks with time
- Capture tacit knowledge on quality/reliability/suitability of ICSBEP cases
- Template to be used for robust and long-lasting repository of feedback

1. **Intermediate: $^{240}$Pu and $^{238}$U, Chlorine, Criticality safety training**
2. **Structural materials: Fe, Intermediate: $^{239}$Pu and $^{235}$, Molybdenum, TSL: UZrH, Polyethylene at low temp, Solution reactor, Criticality studies and neutron source**
3. **Structural materials: Ta, Ni, Cr, Mn, Ni, F. TSL: HF, Lucite. Low and high temperature**
4. **Slab fuels, Structural materials: Si, W, Nb, Al**
5. **Structural materials: Zr**

**oe.cd/wpncsexpneeds**

# AM Analytical methods - calculations

## Temperature effect (SG3)

- Coord. S. Gan, A. R. Wilson (UK)
- Report published in 2023
- Comparison exercise assessing impact of temperature on $k_{eff}$, notably integrating TSL of H in water & ice, at various BU
- Experiment to confirm findings needed!

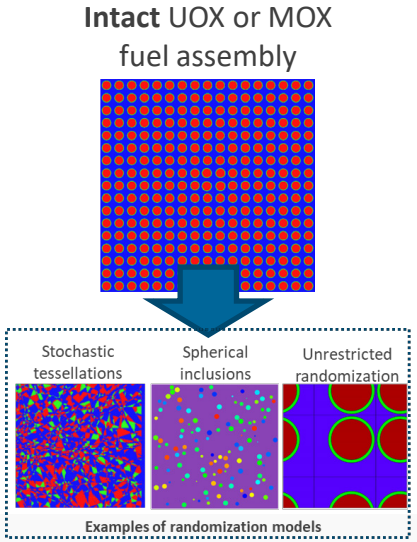
## Neutron source convergence (SG6)

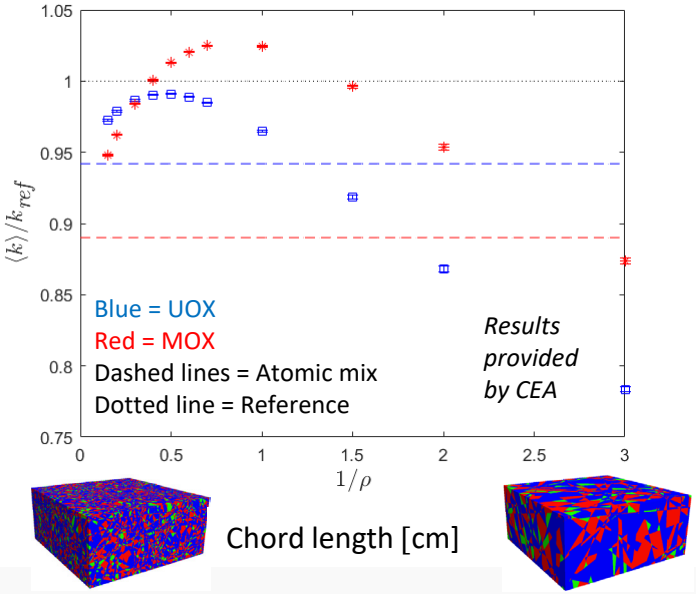
- Coord. F. Brown (LANL, UNM)
- Report published in 2023
- Recommended series of statistical tests to enhance reliability and robustness of source convergence assessments in MC calculations
- Checked against a series of problems

## Random geometries (SG9)

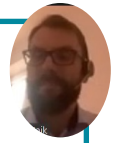
- Coord. A. Zoia (FR)
- Report pending publication
- Application cases : randomly arranged fuels (e.g. TRISO), severe accident recovery, dismantling, radwaste repositories
- Impact of randomization model on multiplication factor calculations

Left: Initial geometry, and randomized geometries. Right: Impact on randomization chord length on $k_{eff}$
*Court. A. Zoia, CEA (FR), Nov. 2022*



# AM Analytical methods - uncertainties



## Integral experiments uncertainty and covariance (SG1)

- Coord. M. Stuke (GER)
- Report published in 2023
- Derive covariance between benchmarks and assess impact on application case

## Bias and correlated data (SG11)

- Coord. A. Hoefer (GER)
- Report in preparation
- Using pre-defined correlations between criticality benchmark experiments, assess role of methodology to derive impact on application case
- Families of methods provide consistent results

## Error recovery and experimental coverage (SG14)

- Coord. U. Mertyurek (ORNL) & H. Abdel-Khalik (Purdue U.)
- Kick-off in Sept. 2024
- Explore modern data assimilation techniques and capabilities to spot (and correct for) embedded errors and to quantify experimental coverage

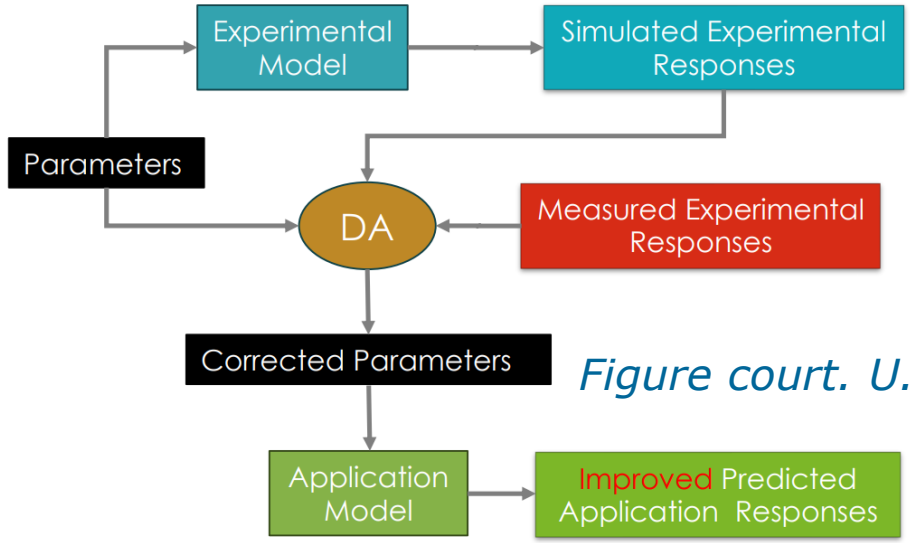
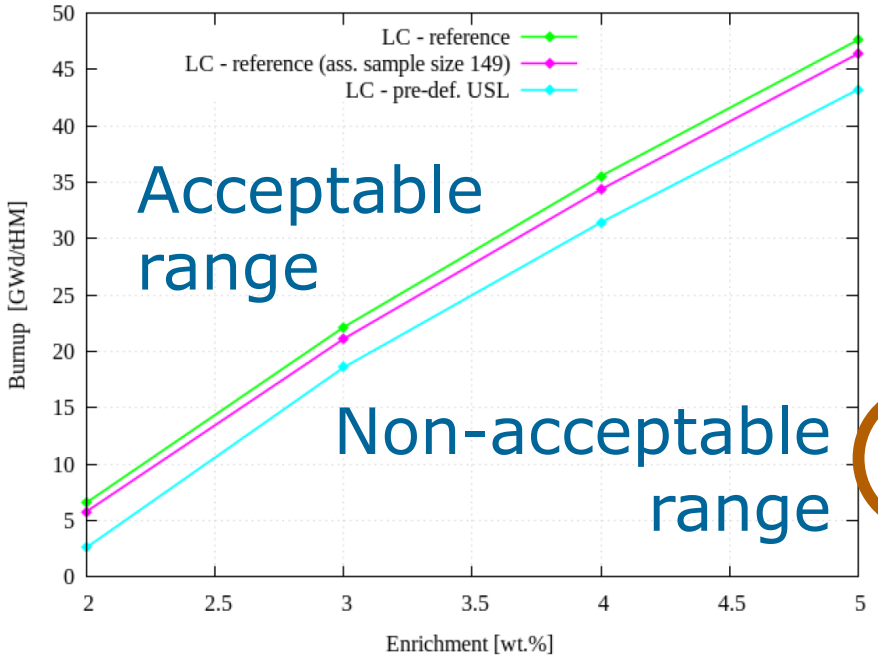



*Figure court. U. Mertyurek*

# CSE Criticality Safety Evaluations




*Results court. PSI (CH)*
*LC = loading curve*
*USL = Upper Subcritical Limit*

*Blue = pre-defined USL*
*Green = with user-defined USL*
*Pink = with user-defined USL, relying on a larger validation base*

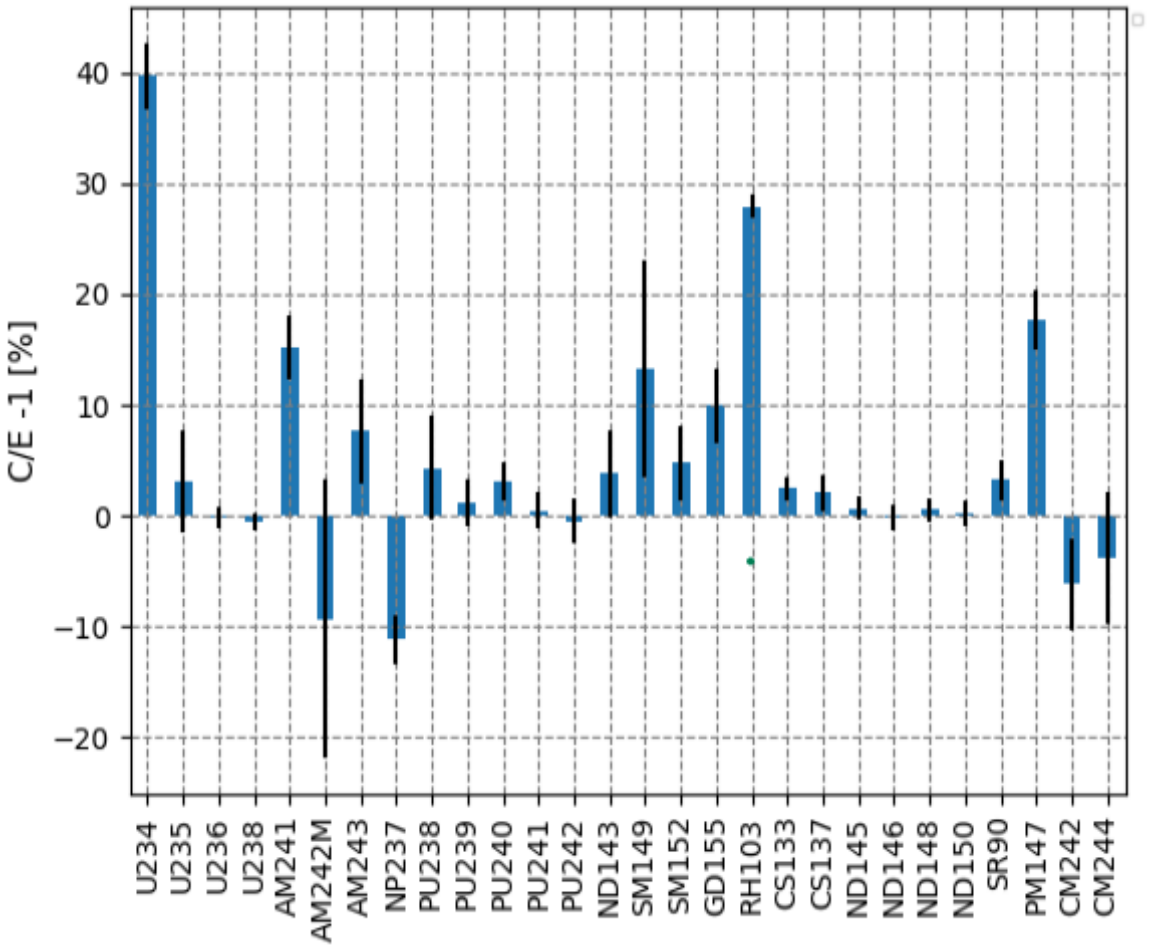
## CSE + BUC, pseudo application case with user defined NCS criteria (SG13)

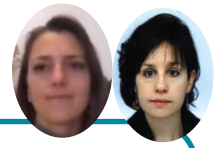
- Coord. A. Vasiliev & M. Wittel (CH)
- Started in 2023
- Simplified final disposal canister for used nuclear fuel
- Derive loading curve taking into account burn up credit with a user-defined nuclear criticality safety criteria (criticality aspects only – other metrics such as decay heat, radioprotection are not covered)
- Compare loading curves for various participants, covering variety of user-defined criticality safety criteria and methodologies

## Reference values for criticality (SG17)

- Coord. G. Frontier (FR)
- Kick off scheduled Sept 2024
- Provide reference values for Nuclear Criticality Safety (NCS) using state-of-the-art codes, methods and nuclear data

# ND Nuclear data

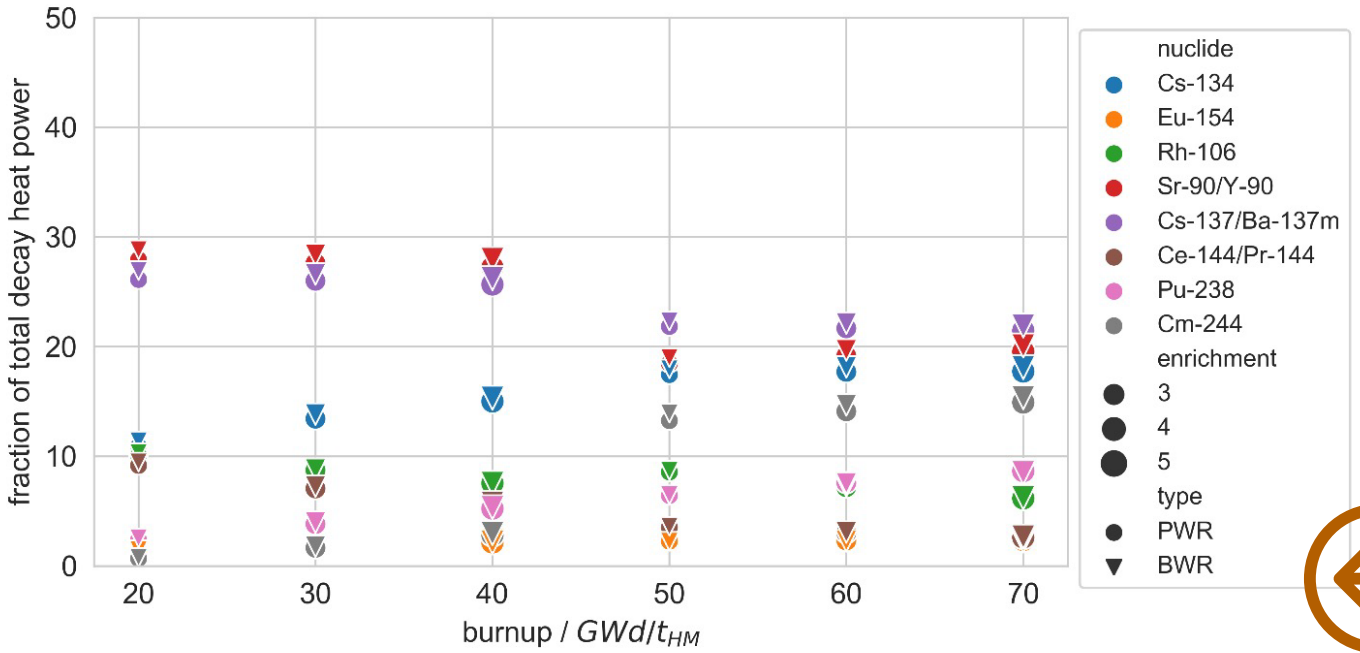


Nuclear data uncertainty for irradiated fuels inventory calculations (SG10 & 15)

- Coord. C. Carmouze & R. Ichou (FR)
- Part 1: Best estimate values (2020-2023)
- Part 2: Uncertainty propagation (2023-2026)
- ARIANE GU3 spent fuel nuclide inventory
- Nuclear data sensitivity/uncertainty analysis (cross-sections, decay data and fission yield) on fuel assembly depletion calculations
- ~35 nuclides important for criticality safety and decay heat

# DH Decay heat




Main nuclides contributing to DH for UOX fuels at 5 years cooling time. From SG12 paper, under review. Court. D. Rochman (CH)

## Assessing the confidence level in experimental and computational estimations (SG12)

- Coord. D. Rochman (CH)
- Journal article under review
- Review of experimental and simulation knowledge pertaining to DH assessments
- Incl. uncertainties, methods, standards.

## Decay heat comparison exercise (SG16)

- Coord. D. Rochman (CH)
- Kick off scheduled Sept 2024
- Pin-cell and assembly simulation with experimental data

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4. WPRS … on scientific issues and uncertainty analysis of Reactor Systems
5. NEA tools

# Working Party on international nuclear data Evaluation Cooperation (WPEC)

*Chair Dr Arjan PLOMPEN (EU),*
*Secretariat Dr Andrew Holcomb*

Working Party

Longer term Expert Groups

Recently closed subgroups

Currently running subgroups

*US leadership highlighted*

**WPEC**

**EG HPRL**

**EG GNDS**
*C. Mattoon (LLNL)*

**SG45 VaNDaL**
*W. Haeck (LANL)*

**SG46 IE for ND evaluation**

**SG47 SINBAD**

**SG48 TSL**

**SG49 Reproducibility**
*M. Herman (LANL)*

**SG50 EXFOR**
*A. Lewis (NNL), D. Neudecker (LANL)*

**SG51 URR**
*V. Sobes (UTK), J. Brown (ORNL)*

ND

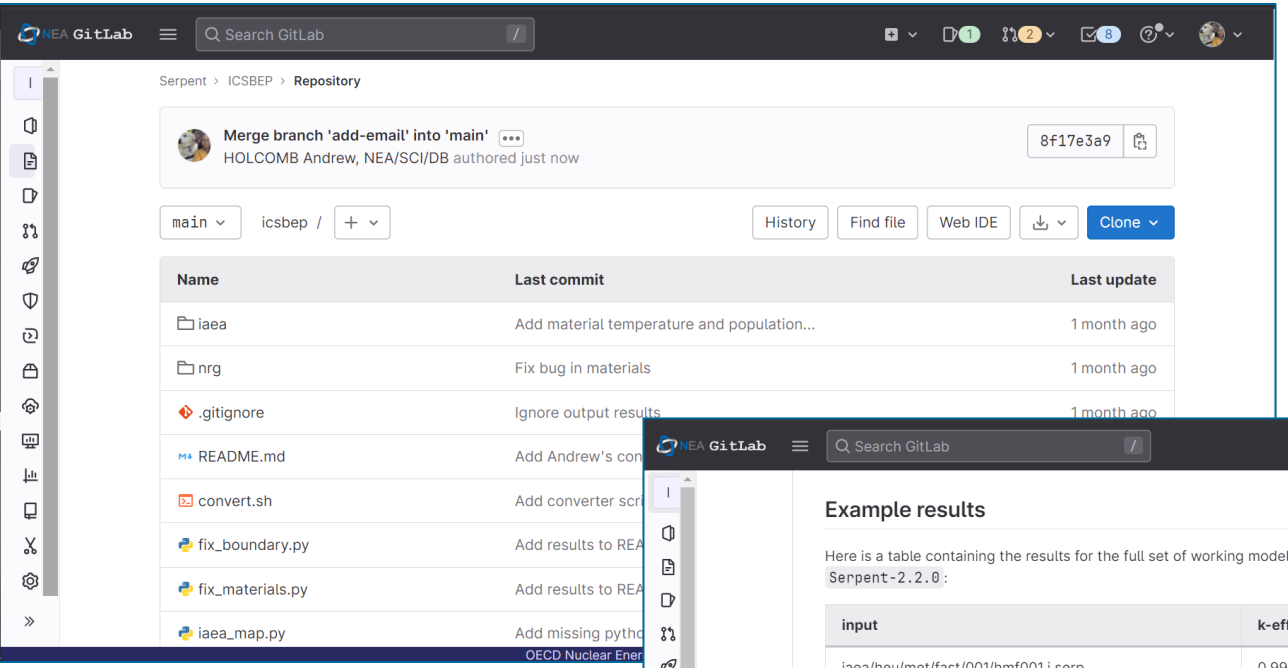
AM

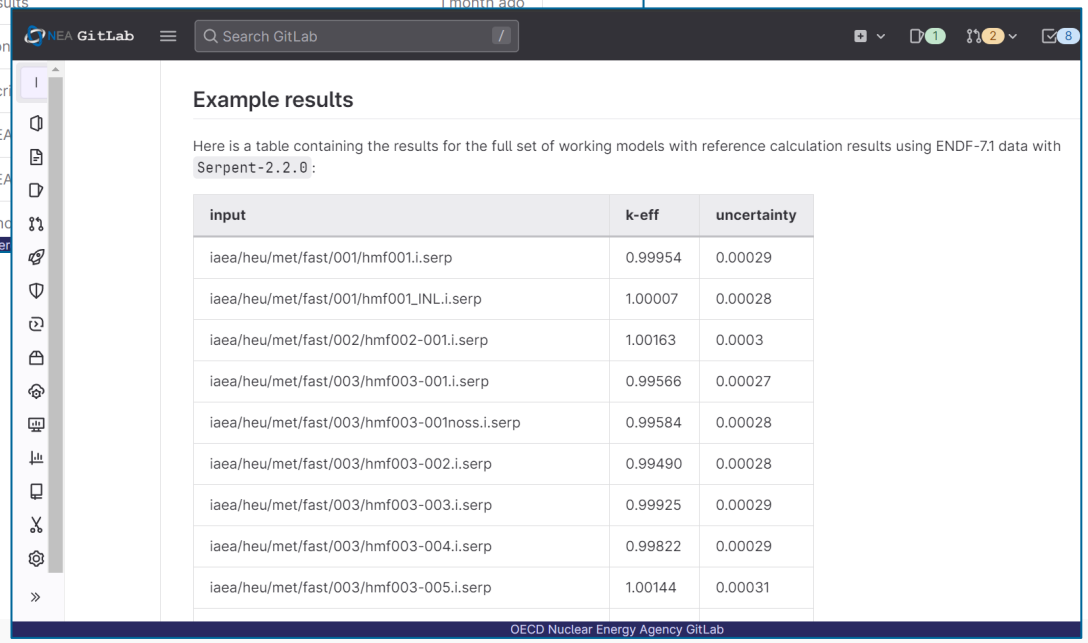
IE

Potential areas for new subgroups include gamma data, fission product yields, continuations of SG46 and SG48 work

# MCNP to Serpent-2

## WPEC SG45 contributions from Steven van der Marck and Andrej Trkov




- ~2400 functional inputs, ~4500 inputs with at least a starting point
- Upon request through the NEA Data Bank
- **Incentive to include in ICSBEP DVD**

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   **(input from O. Buss)**
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# Working Party on scientific issues and uncertainty analysis of Reactor Systems (WPRS)

*Chairs K. Ivanov (US NCSU) & H. Ferroukhi (CH),*
*Secretariat O. Buss*



*US leadership highlighted*

**WPRS**

IPD

**EG Physics of Reactor Systems (EGPRS)**
*H. Ferroukhi (CH), R. Grove (US ORNL)*

**EG Reactor System Multi Physics (EGMUP)**
*T. Valentine (US), E. Ivanov (FR)*

**International Reactor Physics Experiments Technical Review Group (IRPhE) ****
*M. DeHart (US INL), L. Buiron (FR)*

**EG Reactor Core Thermal Hydraulics and Mechanics (EGTHM)**
*M. Avramova (US NCSU), A. Petruzzi (IT)*

**EG Reactor Fuel Performance (EGRFP)***

**Task force Zero Power Reactors (ZPR)**

IE

* *Secretariat M. Bales*
** *Secretariat I. Hill*

# Task Force on Zero Power Reactors "The demise of ZPRs – From concern to action" [2022-...]

IE

Chair: Robert Jacqmin (FR)

- **Objectives**
  - Assess the projected needs for new reactor physics validation data, and elaborate on the motivations
  - Recommend a consensual course of action for acquiring such data, including minimal functional specifications of the needed facilities and expertise
- **Deliverables**
  - NSC/WPRS Workshop on Zero Power Reactors "The demise of zero power reactors: From concern to action"
  - "WPRS Zero Power Reactor Task Force - Interview Questionnaire" , including **representatives from the criticality safety community**

A dedicated activity under the WPNCS reported on "Experimental needs for criticality safety purposes" including needs for ZPR facilities (NEA/NSC/R(2022)6, Sept. 2023). These criticality-oriented needs will be further conveyed by this ZPR TF. [oe.cd/wpncsexpneeds]

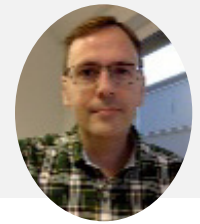
Tentative structure of report (January '23)

1. Motivation, scope and objectives
2. Method of work: questionnaire, interviews of ZPR data providers and users, workshops, brainstorming,
3. ZPRs: how they are/were used, purpose, contribution to the development of nuclear reactors, lessons learned from their operation, including difficulties they face(d)
4. How/why we got where we are
5. Needs and role/value of ZPRs. Projected needs for neutron physics data, esp. SOA simulations. Anticipated challenges
6. Conclusion. Recommendations on how to meet these needs with (new) ZPRs and possibly other facilities, required instrumentation and expertise. International cooperation and business model considerations + how to implement

# SINBAD - Shielding Integral Benchmark Archive and Database, a task force

IPD

Chair: T. Miller (US)



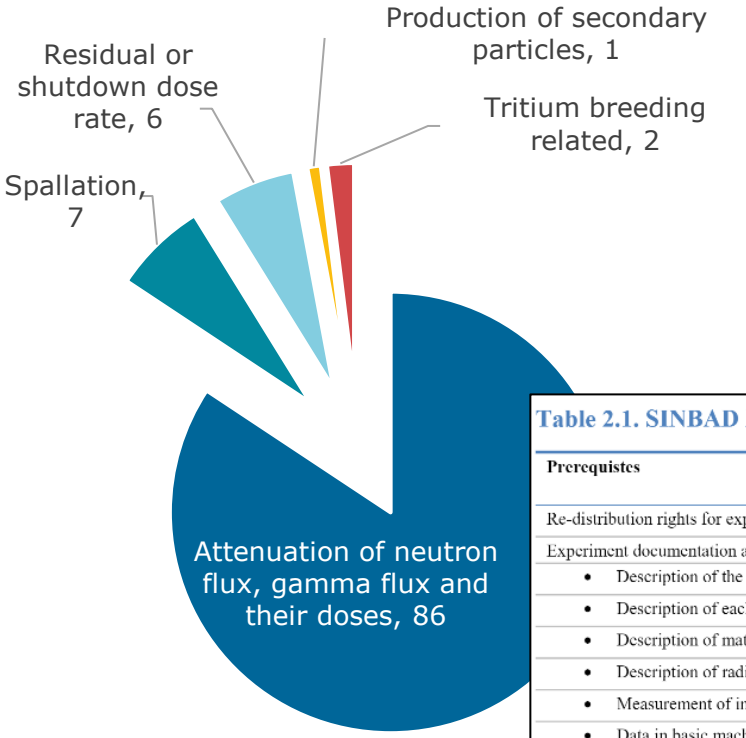



**Table 2.1. SINBAD Maturity Levels**

| Prerequistes | Maturity Level 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Re-distribution rights for experimental data and documentation has been obtained | ☒ | | | | |
| Experiment documentation according to Section 1 of Evaluation Guide (SINBAD TRG, 2019[3]) | | | | | |
| • Description of the measurement facility | | ☒ | | | |
| • Description of each measurement configuration | | ☒ | | | |
| • Description of materials | | ☒ | | | |
| • Description of radiation sources | | ☒ | | | |
| • Measurement of input and output variables | | ☒ | | | |
| • Data in basic machine-readable format (e.g. CSV) | | ☒ | | | |
| Evaluation of measurement data (Section 2 of Evaluation Guide (SINBAD TRG, 2019[3])) | | | | | |
| • Evaluation of measurement configuration | | | ☒ | | |
| • Evaluation of radiation source | | | ☒ | | |
| • Evaluation of the measured data | | | ☒ | | |
| • Provision of computation models which have been used for evaluations | | | ☒ | | |
| • Sensitivity and uncertainty analysis (including provision of computation models) | | | | ☒ | |
| • Definition of scientific relevance based on 1*-3* scheme | | | | ☒ | |
| Benchmark model (Section 3 of Evaluation Guide (SINBAD TRG, 2019[3])) | | | | ☒ | |
| Sample case results and input files for related computational models (Section 4 of Evaluation Guide (SINBAD TRG, 2019[3])) | | | | ☒ | |
| Geometry as CAD model | | | | | ☒ |
| Data in hierarchical machine readable data format (e.g. HDF5)[1] | | | | | ☒ |
| Provision of automatic pre- & post-processing chain for the benchmark models | | | | | ☒ |

NEA & US RSICC, since 1992

Reactor (48), fusion neutronics (31), and accelerator (23) shielding experiments

TF: **Progressive**, well-defined **maintenance process**: subsequent updates to reach well-defined intermediate maturity levels

**Modular organization**: task force splits in several subgroups working on different entries/experiments

Q1 2024: Distributing SINBAD via NEA GitLab platform for SINBAD licensees

- Users can propose improvements to SINBAD via GitLab merge request workflows.
- Crowdsourcing, transparency and traceability

https://oe.cd/nea-sinbad

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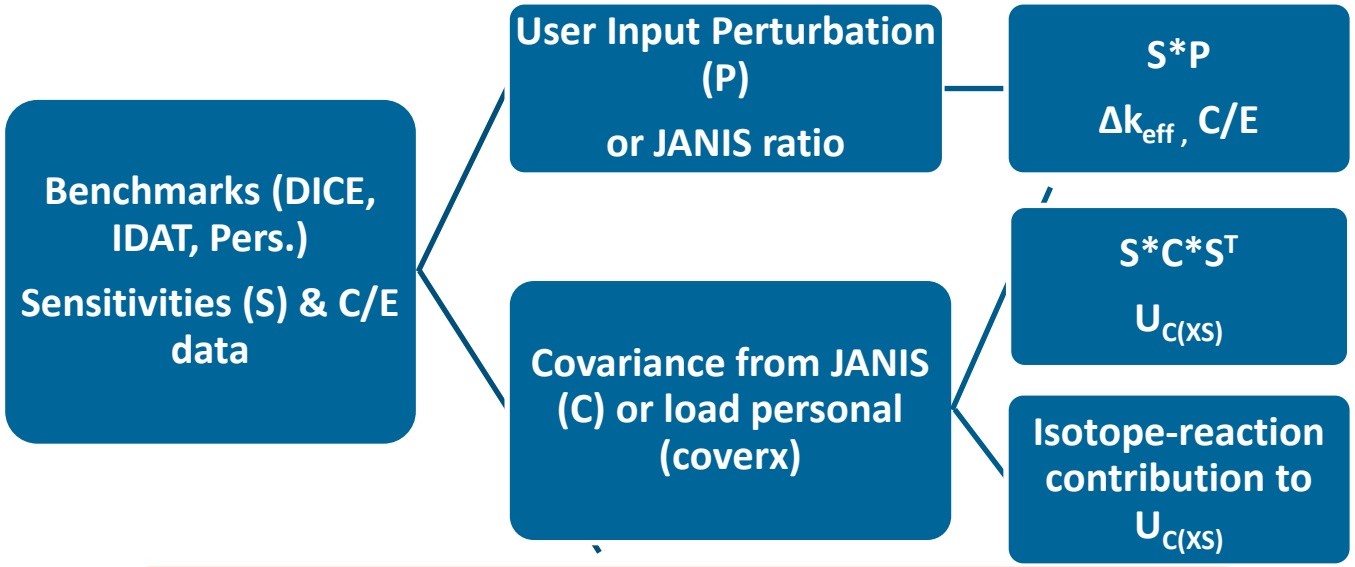
5. **NEA tools** (input from I. Hill)

*Nuclear Data Sensitivity Tool, Testing New Nuclear Data Libraries ENDF/B-VIII.1 (beta) and JEFF-4 Test Libraries*, I. Hill & N. Soppera, in M&C 2023

# NDaST Nuclear Data Sensitivity Tool



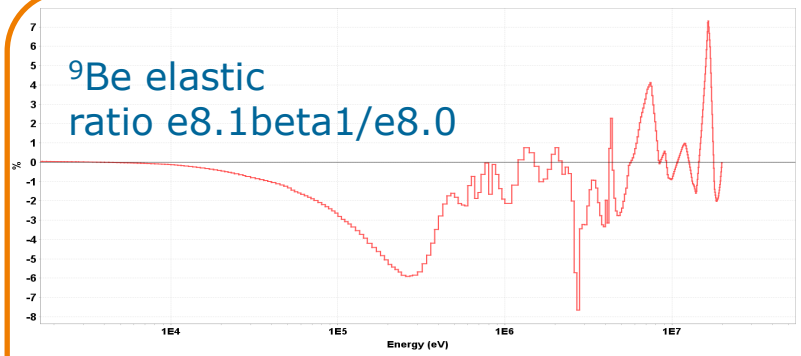





Figure 1. α-phase Plutonium Sphere Reflected by Beryllium.

| | Energy | Impact (pcm) (many groups/few groups) |
|---|---|---|
| $^{9}$Be (elastic) | Over 100 keV | -512 / -512 |
| $^{9}$Be (n.g) | Over 100 keV | -66 / -66 |

NDaST combines collections of sensitivity coefficients, with nuclear data tools.

Independent of response function, code, nuclear data library

Computations take of the order of **minutes**. Direct methods take multiple months to provide similar feedback.

Checked against direct perturbations in other work, found to be reliable in most cases, but accuracy is limited like other first order methods.

NDaST provides quick feedback to questions like, if I change from ENDF/B-VIII.0 to ENDF/B-VIII.1β1 how will my design calculations be impacted? Do the nuclear data changes improve the consistency of various benchmarks? Can filter what needs **additional checking**.


The NEA is grateful for the support of the NCSP for the US representation in NSC groups

**Thank you for your attention**

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