IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Enhancing nuclear safety

Nuclear Data at IRSN: From safety assessment to research

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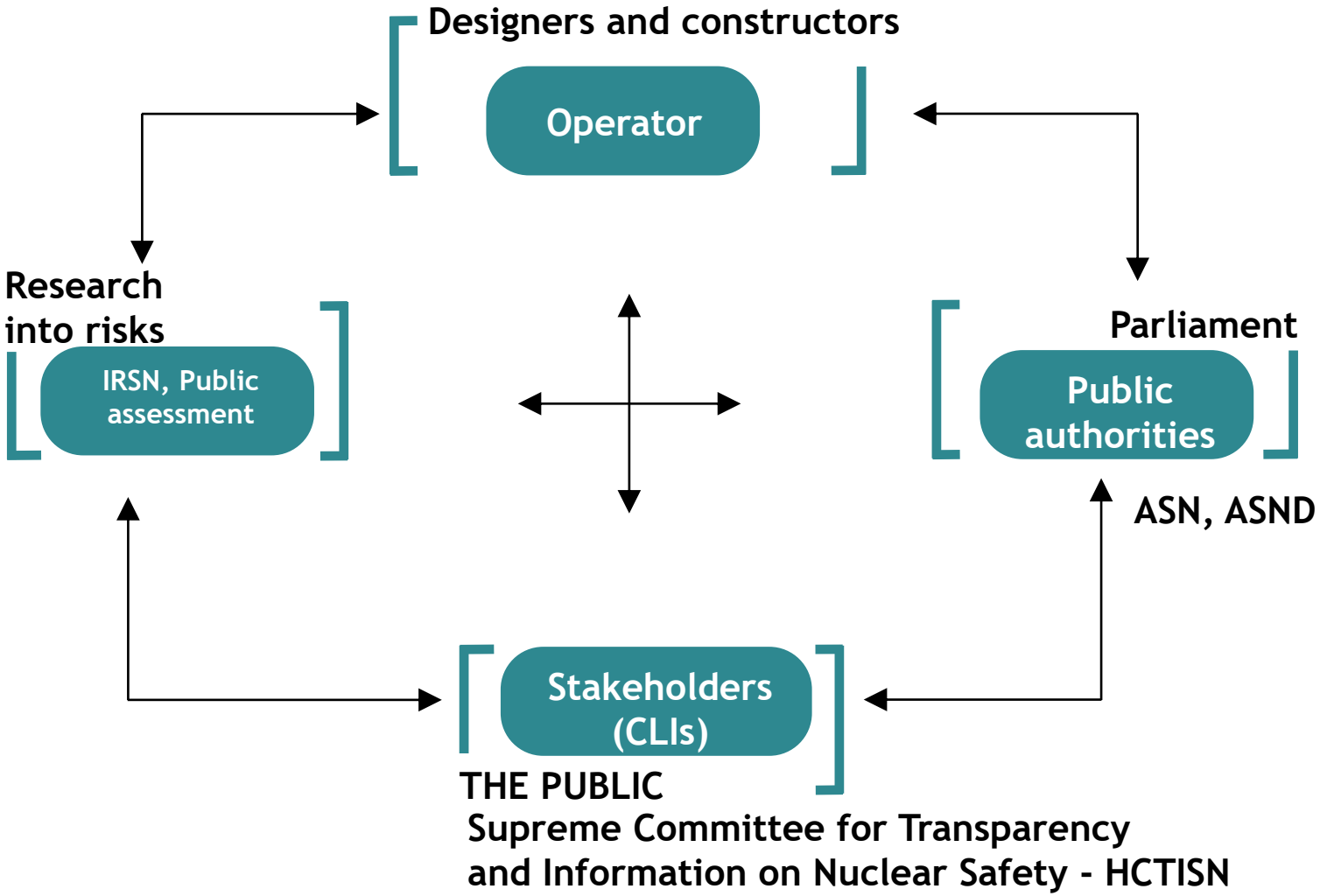
IRSN presentation

- **A public body with industrial and commercial activities**, placed under the joint authority of the Ministries of Defense, Environment, Energy, Research, and Health.
- National public expert for research and technical support on radiation protection and nuclear safety risks
- 1800 employees, including more than 1000 specialists: researchers, Ph.D. students, post-docs and engineers
- A budget of €280 million, with 40% devoted to research

Three main missions

- Research and services of public interest, including public transparency.
- Support and technical assistance to the public authorities for civil or defense-related activities.
- Contractual assessment, study and measurement services for public and private organizations, both French and foreign

Institutional environment



What is the interest of IRSN for ND?
Example of the criticality-safety assessment

- The strategy to overcome the criticality risk is to define some provisions allowing to ensure the respect of subcritical limits (mass, geometry, fissile concentration, etc.)

- These subcritical limits are mostly based on calculations and are determined by an acceptability criterion, such as:

$$1 - \Delta keff_{admin} \geq keff_{calc} + 3\sigma_{calc} + \Delta k_{bias}$$

  - $\Delta keff_{admin}$: administrative margin
  - Δk_{bias} (≥ 0): calculation bias if there is a trend to underpredict $keff_{calc}$
  - $\Delta k_{bias} = \Delta k_{ND} + \Delta k_{scheme}$

What is the interest of IRSN for ND?
Example of the criticality-safety assessment

- Assessment of the criticality-safety provisions is an important part of the safety evaluation, but assessment of the criticality calculations is also another important part since there is no measurement of the Keff in fuel cycle facilities and in transport packages (≠ reactor cores)

- The safety margin may be significantly reduced (or even disappear) if the « real » Keff is underpredicted due to a bad estimates of the uncertainties

- The uncertainties come mainly from model description, ND libraries and calculation schemes

What is the interest of IRSN for ND?
Example of the criticality-safety assessment

- Uncertainties due to the model and the calculation scheme can be mastered by using:
  - bounding assumptions (for tolerance fabrication, etc.) and a rigourous QA procedure for the creation of the input deck,
  - reference codes such as continous energy MC codes.

- But, uncertainties due to ND libraries need a thorough knowledge of ND, in particular the covariance matrices.

What is the interest of IRSN for ND?
Example of the criticality-safety assessment

- Another specific issue related to criticality safety is the broad range of materials, configurations and neutron spectra that is not covered by reactor physics applications.
- In general (and it is quite understandable), a great deal of effort is devoted to nuclear reactors, but less to criticality safety.
- Nevertheless, there is a need of knowledge *a minima* since a criticality accident may lead to fatalities.

⇨ A relevant criticality-safety assessment requires a good knowledge of Nuclear data (out of other issues) regarding their possible impact on the safety margins.

IRSN's research activities on ND
Example of the criticality-safety assessment

- Determination of the Δk_{bias} in two steps:

1. Selection of representative integral experiments
   Engineers experience, specific tools (sensitivity analysis, etc.)

2. Calculation of a Δk_{bias} on the basis of the selected experiments
   Average of C-E values or more sophisticated statistical methods

⇒ Methods such as GLLSM require <u>covariance data</u>

IRSN's research activities on ND
Example of the criticality-safety assessment

- To have a better knowledge of the impact of ND on the safety margins, IRSN chose to focus on:

1. Tools to determine Δk_{bias} according to different methodologies (MACSENS)

2. Enhancing the quality of ND of interest by
   - ✓ performing new differential experiments,
   - ✓ re-evaluating ND of interest, including covariance data,
   - ✓ processing of ND,
   - ✓ validating them vs. Integral experiments.

IRSN's research activities on ND

- 2 IRSN projects support R&D activities on ND
  - **PRINCESS (Project for IRSN Neutron physics and Criticality Experimental data Supporting Safety)**
    - Following the closure of the CEA/Valduc facilities, search for collaborations for integral and differential experiments
    - With US-DOE (in the frame of the NCSP), with JAEA …

  - **INSIDER (Investigations in Neutronics for contributing to the Safety margin assessment based on data assimilation from Integral and Differential Experiment Researches)**
    - To have a better knowledge of Nuclear Data, including covariance matrices
    - To develop methods for estimating biases and uncertainties

IRSN's research activities on ND

ND processing tools

- GAIA 2: a IRSN Nuclear Data processing tool based on NJOY to generate MORET and VESTA code's libraries and test it's own evaluations
- Internal format for Monte Carlo applications…

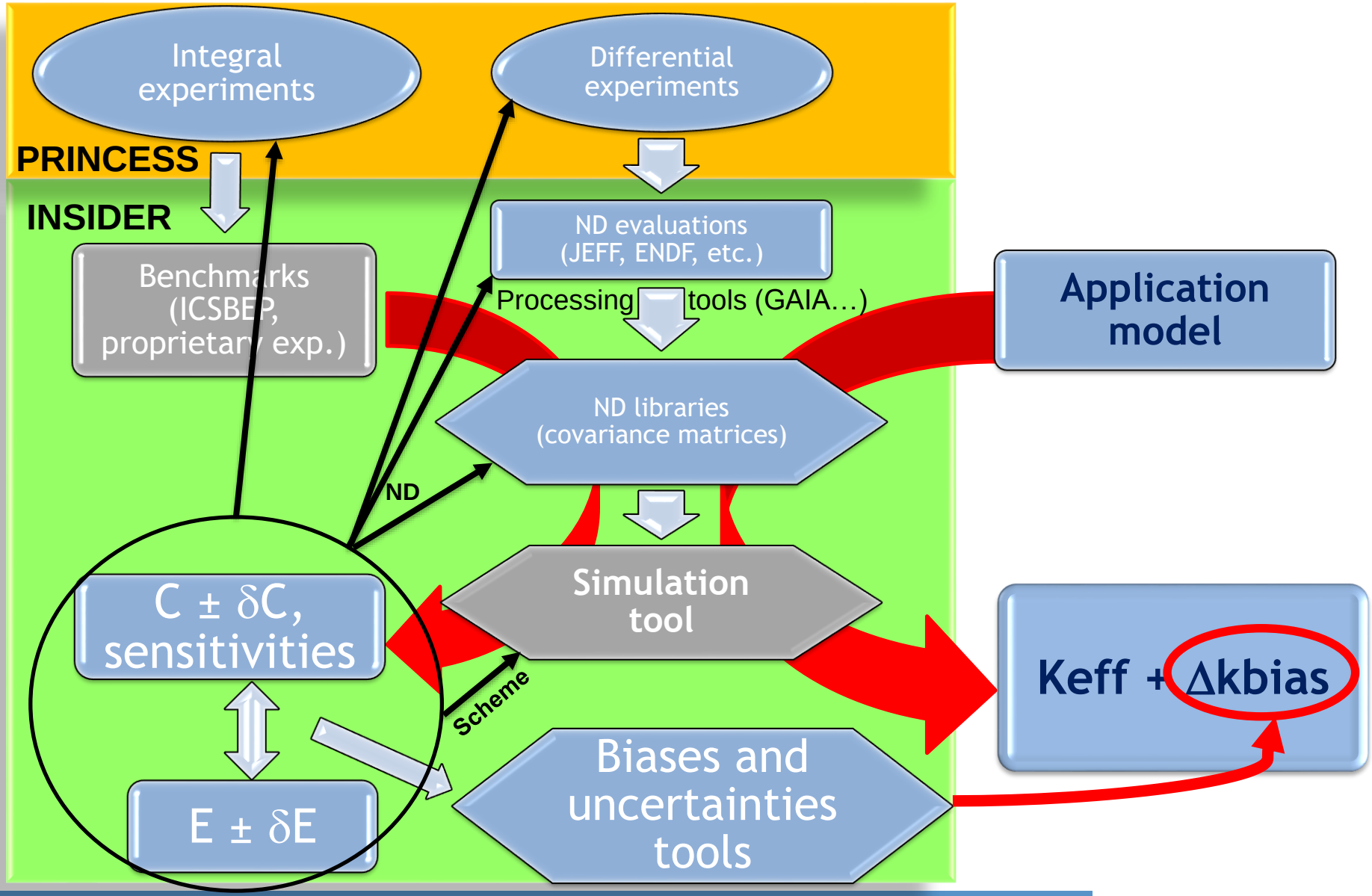
ND evaluation and validation

- Evaluation and validation of isotopes of interest (^{54}Fe, ^{56}Fe, ^{95}Mo, ^{96}Mo, ^{103}Rh, Gd, Pb, etc.) ➔ JEFF project
- Nuclear data at low temperature
- Benchmark testing of new libraries

MACSENS (bias and uncertainties)

- Statistical methods to determine the Δk_{bias}
- New methodologies as GLLSM

IRSN's research activities on ND



Final Remarks

- Over the years IRSN has been developing skills and tools for application on criticality safety
- Nuclear data remain a major source of uncertainties
- Nuclear data evaluation and uncertainties rely upon experimental data
- Methodologies for estimating biases and uncertainties
- Tight connections with experimental facilities around the world to help IRSN to address issues on ND and uncertainties

Final Remarks

- **Nuclear data needs** arise in several fields as:

  - Source Term of Radiation and Heating

  - Decay Heat Calculation
    → Fission Product & Minor Actinide Productions (Fission Product Yield, Activation)
    → Decay Data

  - Shielding Calculation for Fuel Cask
    → Neutron and Gamma-ray Productions, (α,n)

  - Calculation on Re-criticality Potential in case of severe accident
    → Neutron Production

  - LWR Safety
    → Thermal scattering cross sections, S(α,β)
    → Ageing

Thank you for your attention !

Back-up slides

Validation of Nuclear Data

Benchmarks Intercomparison Study: COG, KENO, MCNP, MORET

- New benchmarks intercomparison using various nuclear data libraries
  - JEFF-3.1.1, JEFF-3.3, ENDF/B-VII.1 and ENDF/B-VIII.0
- Use of codes validation suites ➔ independent modeling

Provide a rigorous basis for quality and validating nuclear data libraries

ADVANCE, VaNDaL, ICSBEP/DICE

Validation of Nuclear Data

Benchmarks Intercomparison Study: COG, KENO, MCNP, MORET

- Publication planned