Fission Data for Regulatory Needs

Workshop for Applied Nuclear Data Activities (WANDA) 2026

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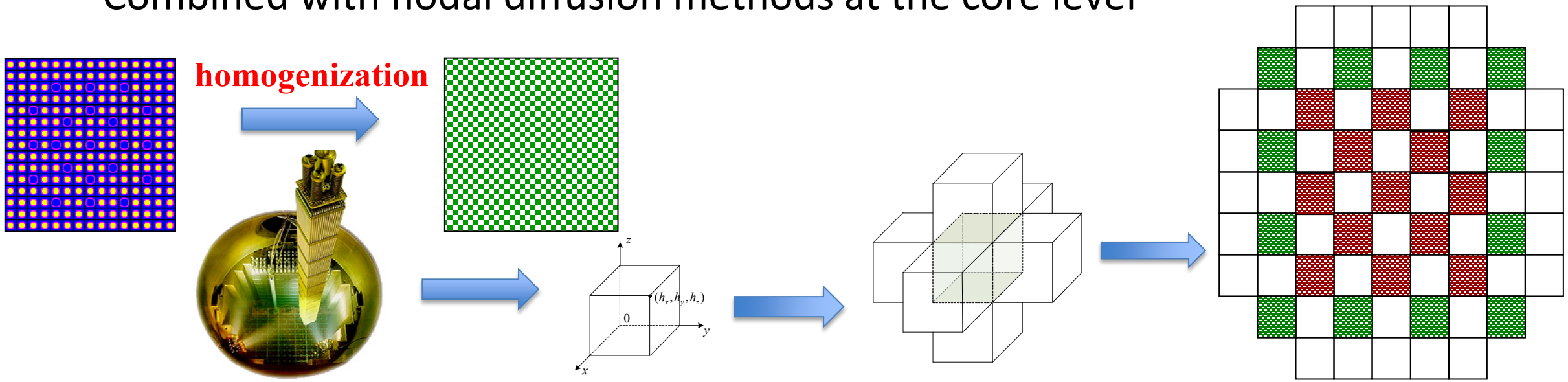
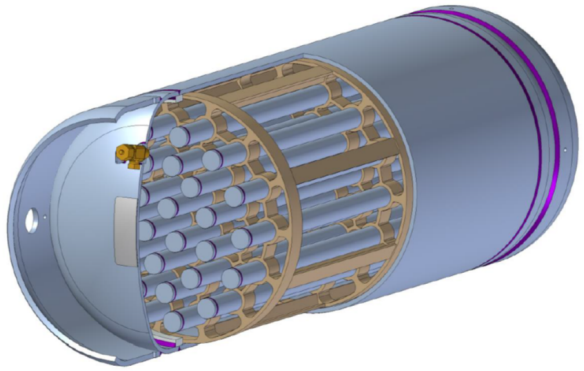
Fission Data – Reactor Physics

- Lattice/Nodal Methods (10 CFR Part 50/Part 52)
  - Tech Specs Limits, FSAR, and SE based on reactor physics calculations
  - Detailed neutron transport and depletion calculations at lattice level are condensed in energy and homogenized in space
  - Combined with nodal diffusion methods at the core level



Fission Data – Criticality Safety

- Fuel Facilities (10 CFR Part 70); Independent Storage of Spent Fuel (Part 72); Packaging and Transportation of Radioactive Material (Part 71)
  - Structural, thermal, criticality safety, radiation shielding analysis, (confinement/retrievability-Part 72)



ORANO's DN30-X
for UF6 up to 20 wt.%
U-235

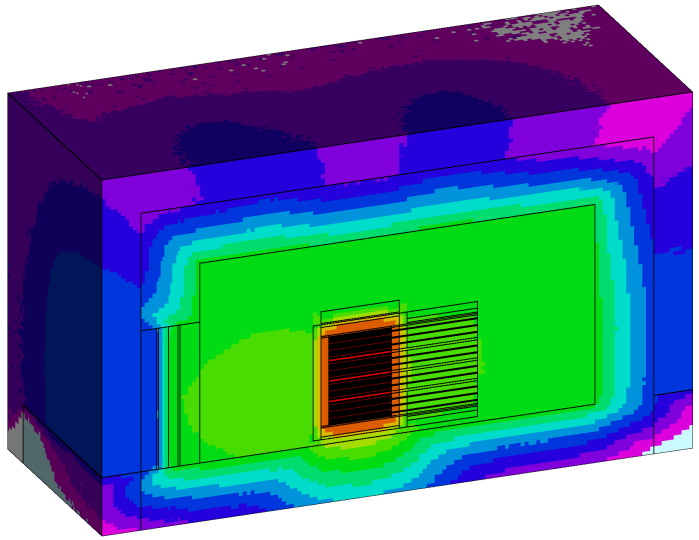
NAC's Optimus-L for
TRISO compacts

- Detailed models of critical configurations in facilities and packages transporting fresh and depleted fuel to calculate neutron multiplication factor (keff) and uncertainty (keff < 1 with margin)

Fission Data – Shielding/Dose

- Part 70, Part 71, Part 72, Part 73
  - 10 CFR Part 73.37 -- Physical protection of irradiated fuel during transit – 100 rad/h at 1m distance from any accessible surfaces without intervening shielding
  - Depletion to develop inventory for neutron and primary and secondary gamma sources to approximate dose

Dose map from Microreactor Fuel Cycle Workshop (March 26, 2025)



- Non-LWR source term public workshop videos, slides, reports at the NRC
- https://www.nrc.gov/reactors/new-reactors/advanced/references/nuclear-power-reactor-source-term
- SCALE/MELCOR demonstrations

Fission Cross Sections

- Foundation for calculations to demonstrate design and safety
- Essential for predicting neutron multiplication and power

Fission Cross Sections - Probability of fission for each fissile isotope at different neutron energies

- Multiplication factor (keff)
- Integral power
- Node-wise flux/power shapes (r,z)
- Pin-wise power

- Shutdown Margin – Reactivity control mechanisms (boron, control rods) are sufficiently large to overcome postulated power rise

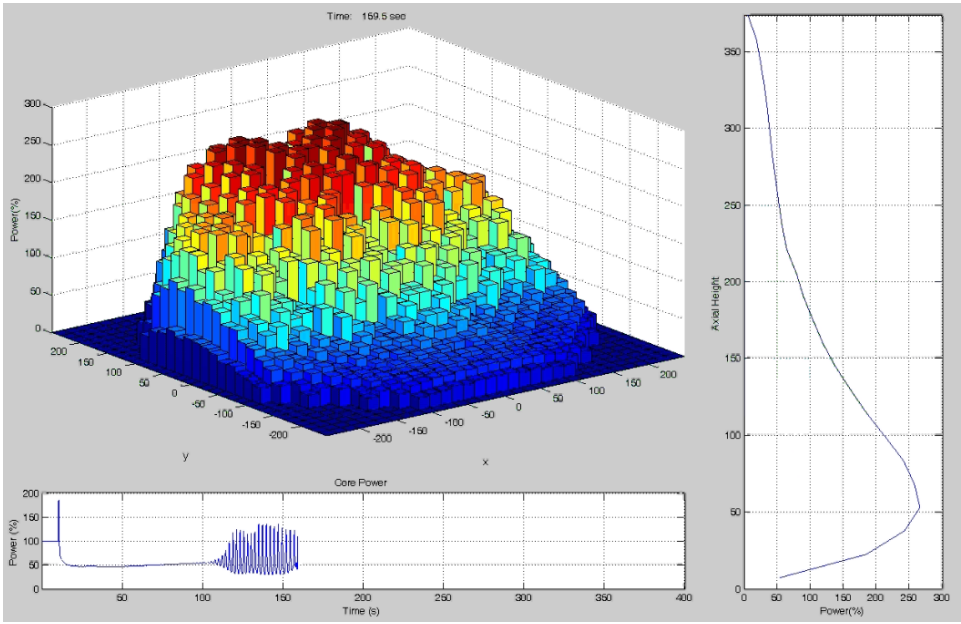
- Reactivity feedback coefficients (fuel temperature, moderator density, void coefficients, etc.)

- Neutron energy distribution, impacting fuel utilization and power distribution

Kinetics Inputs – Core Transient

- Prompt ν
- Prompt Spectrum χ(E)
- Delayed β
- Group fractions
- Decay constants

- Delayed neutron fractions
- Precursor yields
- Reactivity coefficients
- Reactivity control (reactor response)



- Energy release/fission

- Power normalization

- LOCA PCT
- Reactivity Insertion Accidents

- Stability Analysis
- ATWS

- Reactor Period Analysis

- Control Rod Eject

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Fission Product Yields

- Fission product yields (FPYs) define the distribution of nuclides produced in fission

Fission Product Yields

- Decay heat and isotopic inventories -- important for spent fuel evaluations and source term during reactor severe accidents
- Errors propagate throughout any calculation that depends on depletion (fuel cycle, source term, transient analysis)

- Burnup credit – accurate isotopic inventories determine how much reactivity credit can be taken for spent fuel
- Radiotoxicity and waste classification – depend on long-lived fission products

- Shielding calculations – require correct gamma-emitter inventories & neutron source terms
- Fuel performance (e.g., swelling, gas release) depends on noble gas yields

Energy-Dependent Fission Product Yields in SCALE

- Energy-dependent FPYs vary with incident neutron energy (thermal, epithermal, fast) and interpolated from discrete points (ENDF/B), depending on nuclide

- Transport solver (TRITON, Polaris, KENO, or Shift) computes flux

- Depletion module (ORIGEN) uses FPYs and decay data to develop isotopics

- Sources of Uncertainty

- More integral validations
- Sparse covariance data
  - Distorted uncertainties
- Mismatches between independent and cumulative yields

- Sparse experimental data above thermal (several non-LWR designs characterized by epithermal/fast spectra)
- Interpolations would benefit from a “denser” incident neutron energy grid for key actinides within current formats
  - Continuous energy representation of tabulations would be most ideal
- Fast-spectrum yields for Pu isotopes and U-238 have high uncertainties

Regulatory and Licensing Implications

- Regulatory Review Expectations:
  - Validation against critical experiments
  - Bias and uncertainty quantifications
  - Conservative margins
- Poor fission data sources:
  - Larger safety margins
  - More restrictive operating limits
  - Reduced fuel utilizations
  - Difficulty quantifying advanced reactor designs