

Representation of Future Continuous Energy Yields with Correlations

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Continuous energy yields will require a new understanding of the interpolation procedures

Outreach

- Some application codes interpolate previous FPY evaluations

Fission yields are interpolated differently between ORIGIN and Serpent

SCALE/ORIGEN:

- For each actinide j , an average energy of fission is calculated

$$E_{avg,j} = \frac{\sum_g E^g \sigma_j^g \phi^g}{\sum_g \sigma_j^g \phi^g}$$

E^g average group energy (simple midpoint)
 σ_j^g multigroup fission XS of actinide j
 ϕ^g flux in energy group g

- The FPY of actinide j resulting in FP i is then calculated by linearly interpolating the FPYs at this average energy

$$\gamma_{ij}(E_{avg}) = \gamma_{ij}(E_1) + \left(\frac{E_{avg} - E_1}{E_2 - E_1} \right) \cdot (\gamma_{ij}(E_2) - \gamma_{ij}(E_1))$$

with $E_1 < E_{avg} < E_2$, and E_1 and E_2 the respective adjacent energy points

- Then the production rate $R_{f,i}$ of FP i is:

$$R_{f,i} = \sum_j \gamma_{ij}(E_{avg,j}) \sigma_j \phi N_j$$

N_j nuclide density of actinide j

ORIGEN considers the FPY of 2 adjacent energy points to E_{avg} per fissioning actinide

Serpent:

- The production rate of FP i is the sum of partial rates corresponding to the available FPY energies E_k

$$R_{f,i} = \sum_j \sum_k \gamma_{ij}(E_k) \cdot R_{f,j}^k$$

- Partial fission rates: When the fission event occurs at neutron energy E , the corresponding fission rate contribution is distributed between the two adjacent E_k , thereby incrementing the associated partial fission rates according to linear interpolation weights:

$$R_{f,j}^1 + = \frac{E_2 - E}{E_2 - E_1} R_{f,j}(E) \quad R_{f,j}^2 + = \frac{E - E_1}{E_2 - E_1} R_{f,j}(E)$$

Serpent considers energy-dependent FPY using partial fission rates across the whole energy range

OAK RIDGE National Laboratory

Slide from [F. Bostelmann, Nuclear Data Week 2025](#)

- Need to determine, document, and advertise best practices for spectrum-averaged and continuous energy FPY evaluations

Code Updates

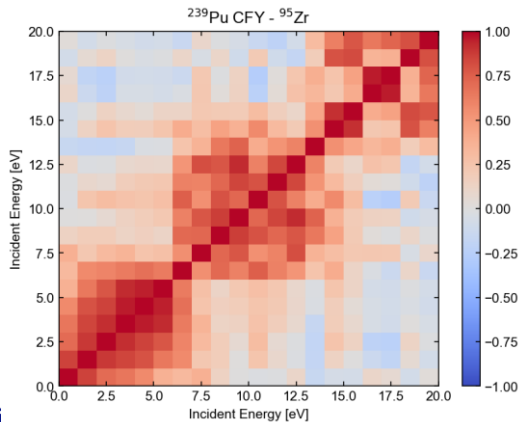
- Application codes may need to be updated to follow the best practices
 - Decay heat calculations
 - Inventory calculations
 - R-value calculations
- Community meetings and discussions
- Verification and validation
 - Identification of continuous energy evaluations
 - Inter-comparison exercises



Cross-product and cross-energy FPY correlations will be included in the new LANL FPY evaluation

Formats

- The ENDF-6 format needs an update for FPY covariances
 - New format will require testing
- Looking into the trade-off between detail and file size
 - Is 3 energy groups enough?



Code Updates

- Application codes will need to be updated to make use of the new covariances available
 - Decay heat, inventory calculations
 - R-value calculations
 - Anti-neutrino spectrum calculations
- Need to determine best practices for UQ with FPY covariances
 - Non-linear calculations
 - Gaussian uncertainties > 30% or non-Gaussian uncertainties

