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Title: Sharing of Good Industry Practives and/or Lessons Learned in Nuclear Criticality Safety: Using Sensitivity-Uncertainty Methods to Improve Traditional Validation

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ANS Annual Meeting

2019 THE VALUE OF NUCLEAR

Sharing of Good Industry Practices and/or Lessons Learned in Nuclear Criticality Safety

Using Sensitivity-Uncertainty Methods to Improve Traditional Validation

Jennifer Alwin

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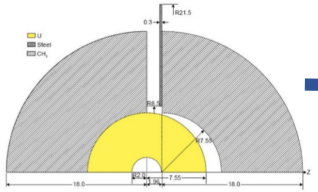
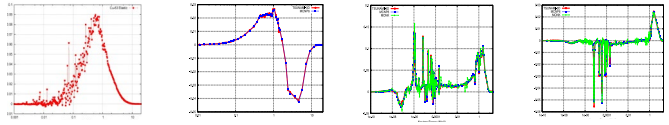
Using Sensitivity-Uncertainty Methods to Improve Traditional Validation

- Selection of Benchmarks
- Rejection of Outliers
- Basis for Margin of Subcriticality
- Quantification of Missing Uncertainties



Application + Nuclear Data

Monte Carlo Criticality Calculation



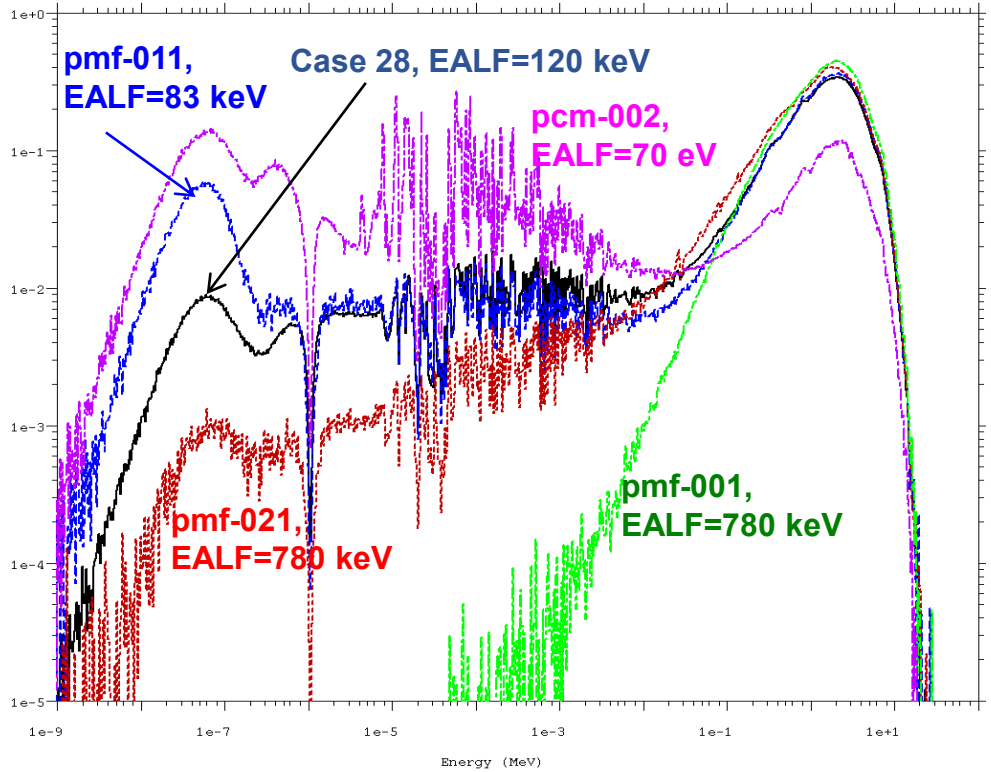
Application Sensitivity Profile

SU-based Analysis

Pattern matching select similar benchmarks

Bias, Bias Uncertainty
Margin of Subcriticality
Upper Subcritical Limit

$v\Sigma_F\Phi$ production spectrum



Which benchmarks are similar to the application?

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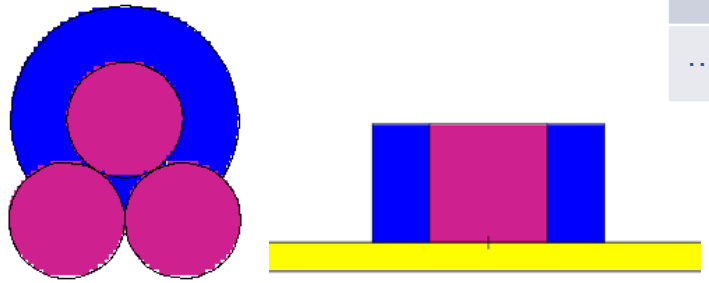
Selection of Benchmarks

- ANSI/ANS-8.24-2007:
  - *"Appropriate system or process parameters that correlate the experiments to the system(s) or process(es) under consideration shall be identified. Automated selection systems that consider isotopes, their abundances, energy ranges, cross-section uncertainties, or other parameters may be used."*

- Neutronic similarity based upon specific energy, isotope & reaction
  - Correlation of application to benchmarks
    - Example: Pu oxide-water mixture
      - 3 cylinders
      - Water, steel reflection
      - H/D variation

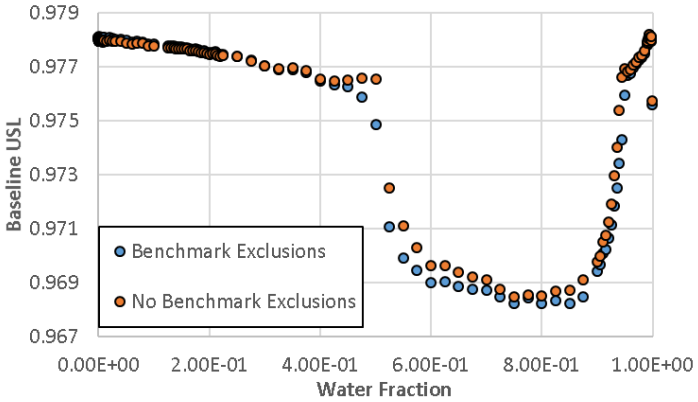
Case 1: Dry Oxide	EALF= 0.606	ANECF= 1.70
Bias		0.00852
Bias Uncertainty		0.00620
Nuclear Data Unc. Margin		0.00092
Software/method margin		0.00500
Benchmark	Ck	weight
PMF011-001	0.9905	1.0000
PMF021-002	0.9884	0.9462
PMF036-001	0.9855	0.8753
PMF044-005	0.9847	0.8552
…		

Case 67: 60% Water	EALF= 0.009	ANECF= 0.969
Bias		0.00797
Bias Uncertainty		0.01299
Nuclear Data Unc. Margin		0.00173
Software/method margin		0.00500
Benchmark	Ck	weight
PCM001-002	0.9383	1.0000
PCM002-006	0.8911	0.8455
PCM002-005	0.8850	0.8258
PCM002-007	0.8849	0.8254
…		



Rejection of Statistical Outliers

- ANSI/ANS-8.24-2017:
  - "*Identification of data outliers may be based on established statistical rejection methods; rejection of outliers shall be based on the inconsistency of the data with known physical behavior in the experimental data.*"
    - Iterative diagonal chi-squared method until χ^2_{min}< 1.2
    - 10% of Whisper-1.1 library identified as outliers
    - Include or exclude identified outliers to determine impact on USL



Basis for Margin of Subcriticality

- ANSI/ANS-8.24-2017:
  - "*The margin of subcriticality and its basis shall be documented.*"
- ANSI/ANS-8.24-2017:
  - "*Margin of subcriticality: an allowance beyond the calculational margin to ensure subcriticality.*"
    - S/U tools help support MOS basis: neutronic similarity, nuclear data uncertainties, validation weaknesses

Quantification of Missing Experimental Uncertainties

- Based upon neutronically similar benchmarks

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