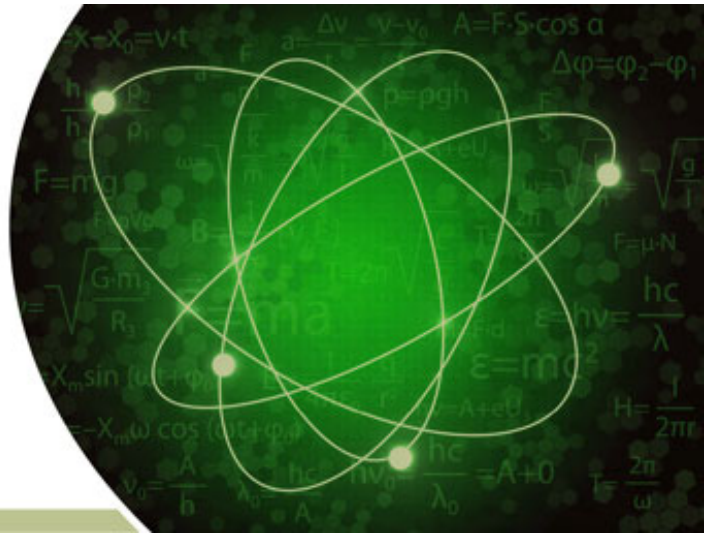
ANS Annual Meeting

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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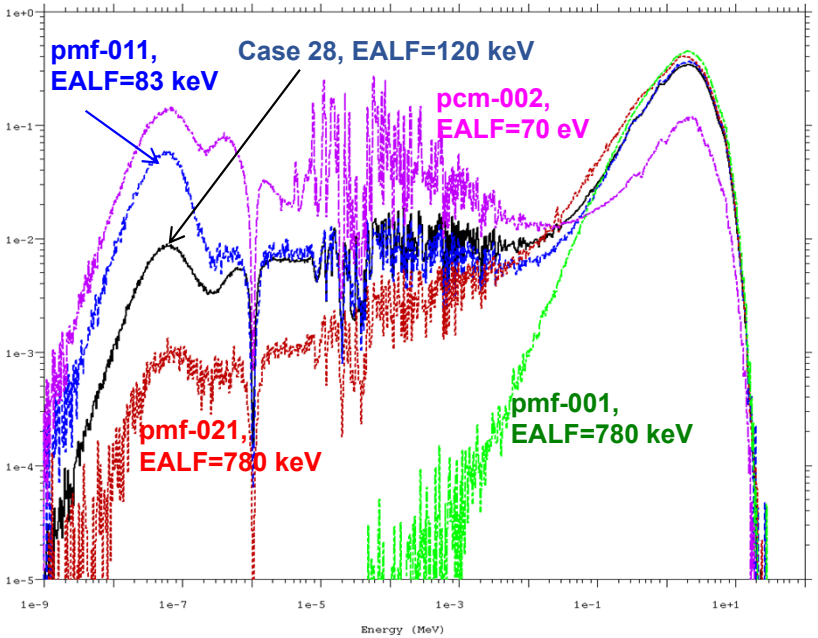
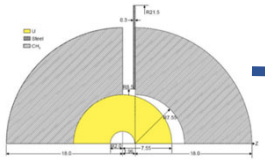
# Using Sensitivity-Uncertainty Methods to Improve Traditional Validation

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

$\nu\Sigma_F\Phi$ production spectrum

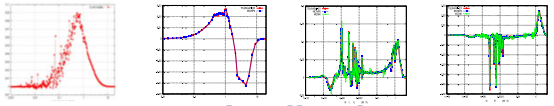



Which benchmarks are similar to the application?



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

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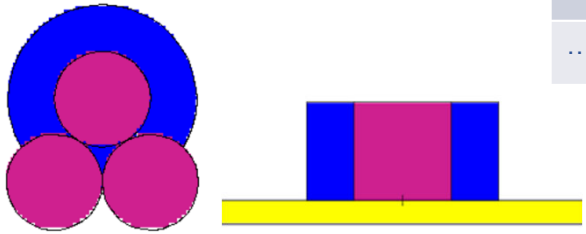
# Selection of Benchmarks

- 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 |
| … | | |

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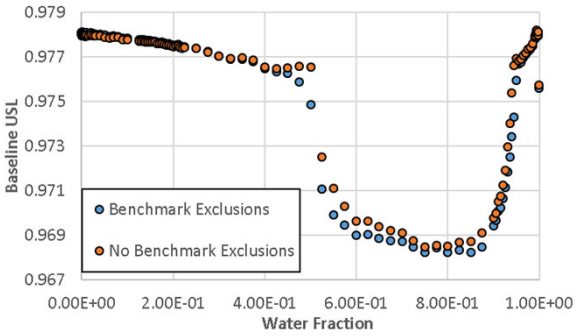
# Rejection of Statistical Outliers

- 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 $\chi^2_{min}$< 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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