MCNP 6.1.1 Validation for Shielding Applications

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PANTEX PLANT | Y-12 NATIONAL SECURITY COMPLEX

Disclaimer

Outline

- Motivation
- Approach
- Benchmark Discussion
- Results

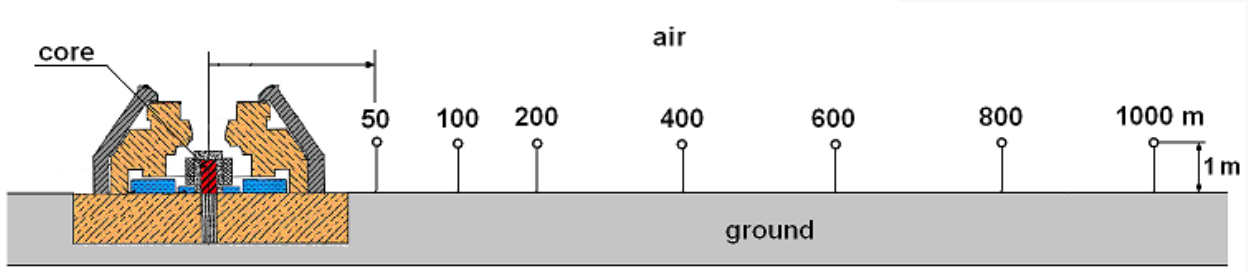
Motivation

- ANSI/ANS-8.3 requires that CAAS coverage be demonstrated
- Multiple shielding applications for MCNP
  - Verifying existing CAAS detector coverage
  - Design of new CAAS installations
  - Dose rates for evacuation planning
  - Shipping container dose profiles
- MCNP criticality safety calculations require validation (ANSI/ANS 8.24)
  - NCS validation quantifies uncertainty in calculation
- Different approach than NCS validation
  - Limited literature on technical approach
  - Few shielding benchmarks exist and they are of diverse quality
  - Different applications require different conservativism

Approach

- Benchmarks selected
  - 12 sets of benchmark experiments
    - Conference proceedings, journal articles, OECD, and SINBAD
    - 5 directly applicable to CAAS
  - Area of Applicability
    - Primary gamma-ray, primary fission neutron, coupled photon/neutron transport
    - Concrete mazes
    - Large quantities of water
    - Skyshine
  - Use automated variance reduction (e.g. ADVANTG) where appropriate
  - Analysis
    - No normality tests, unlike criticality validations
    - Range of C/E values calculated

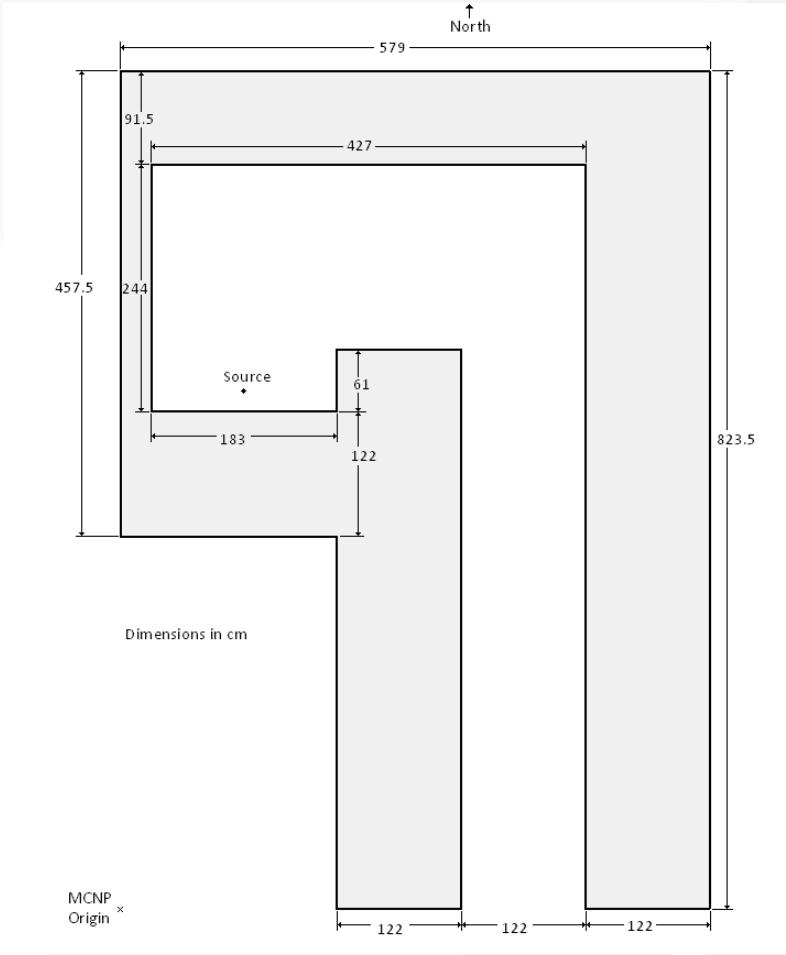
Baikal-1 Skyshine



- Primary and coupled neutron/photon skyshine experiment
- Representative of leakage from a critical assembly
- Neutron C/E 0.72-0.93, Photon C/E 0.45-0.73
  - Almost all photon dose at 1500m due to secondary photons
  - Bias in neutron results leads to bias in photon results
  - High experimental uncertainty in neutron results

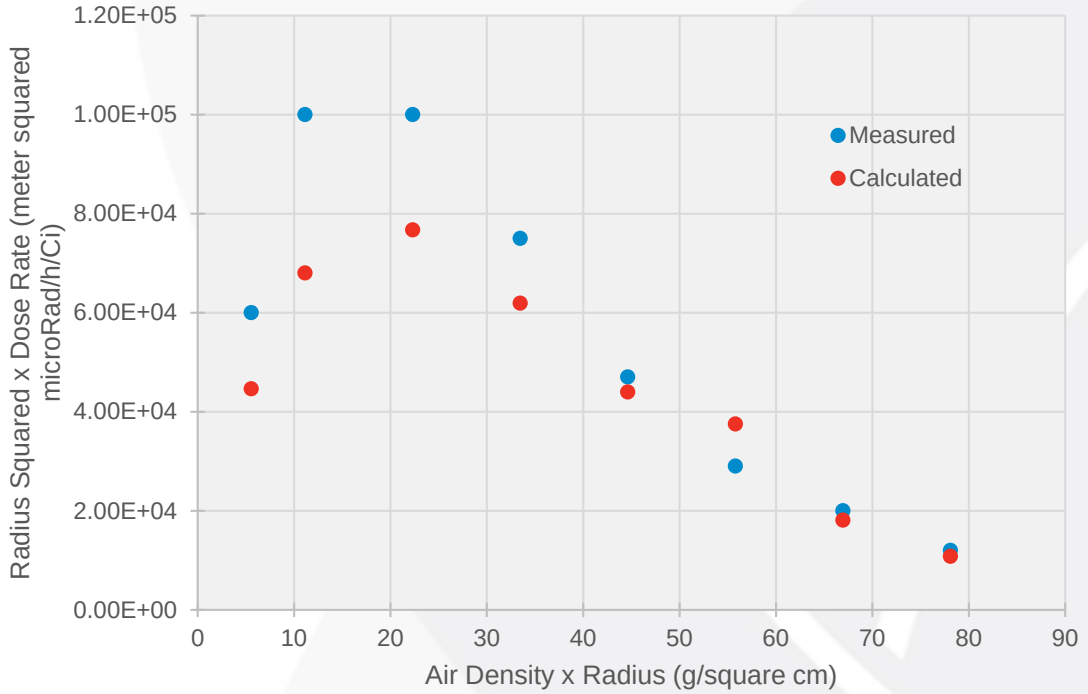
Stanford Concrete Maze

- Measures neutron and photon dose at maze entrance
- Source position estimated from figures presented by benchmark authors
- Concrete type not specified
  - Modeled Oak Ridge concrete, Reg. Concrete, Hanford-Wet, and SLAC concrete
- Wet concrete has opposite bias from dry concrete
- 0.86-1.05 neutron C/E, 0.63-0.72 photon C/E.



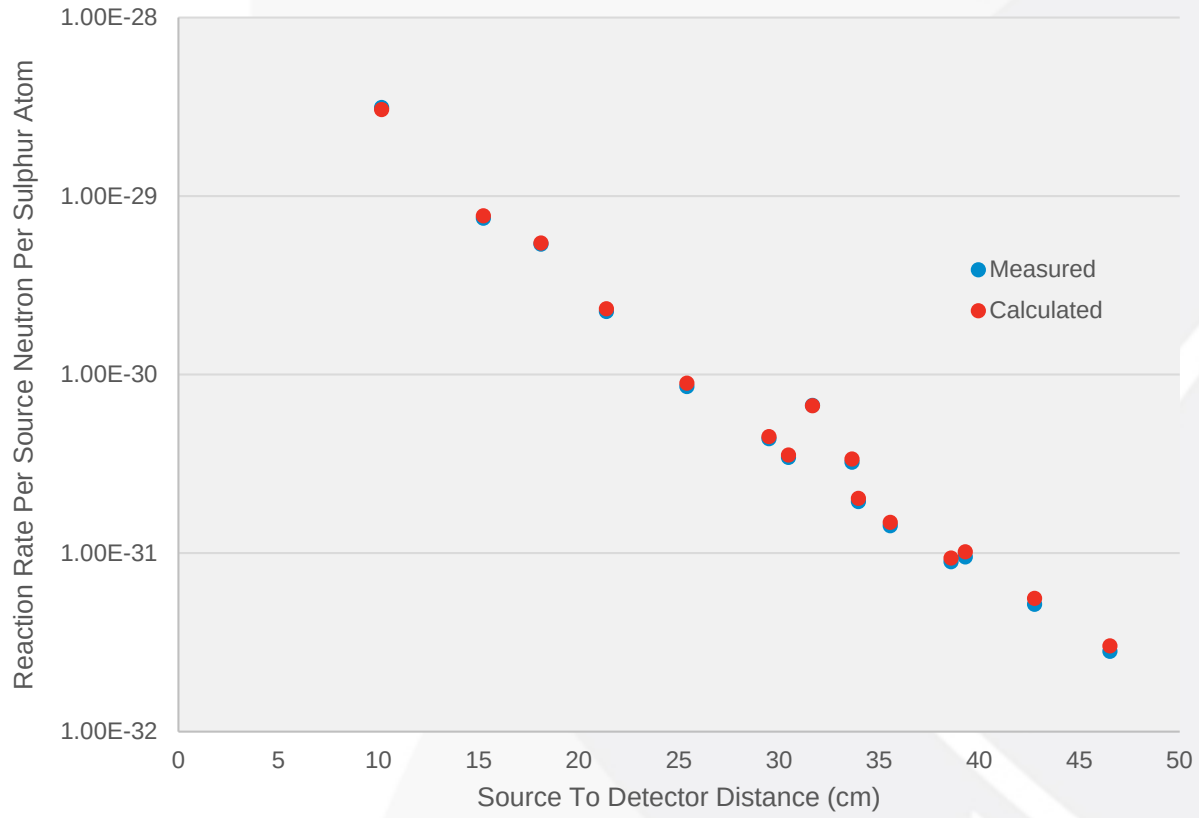
Gamma-Ray Skyshine

- Direct measurements of primary photon skyshine
- All materials compositions were assumed
  - Used the Baikal-1 ground material composition
- C/E < 0.77 within 200 ft of the source, 0.9-1.29 up to 700 ft.
- Could not replicate MCNP V&V results



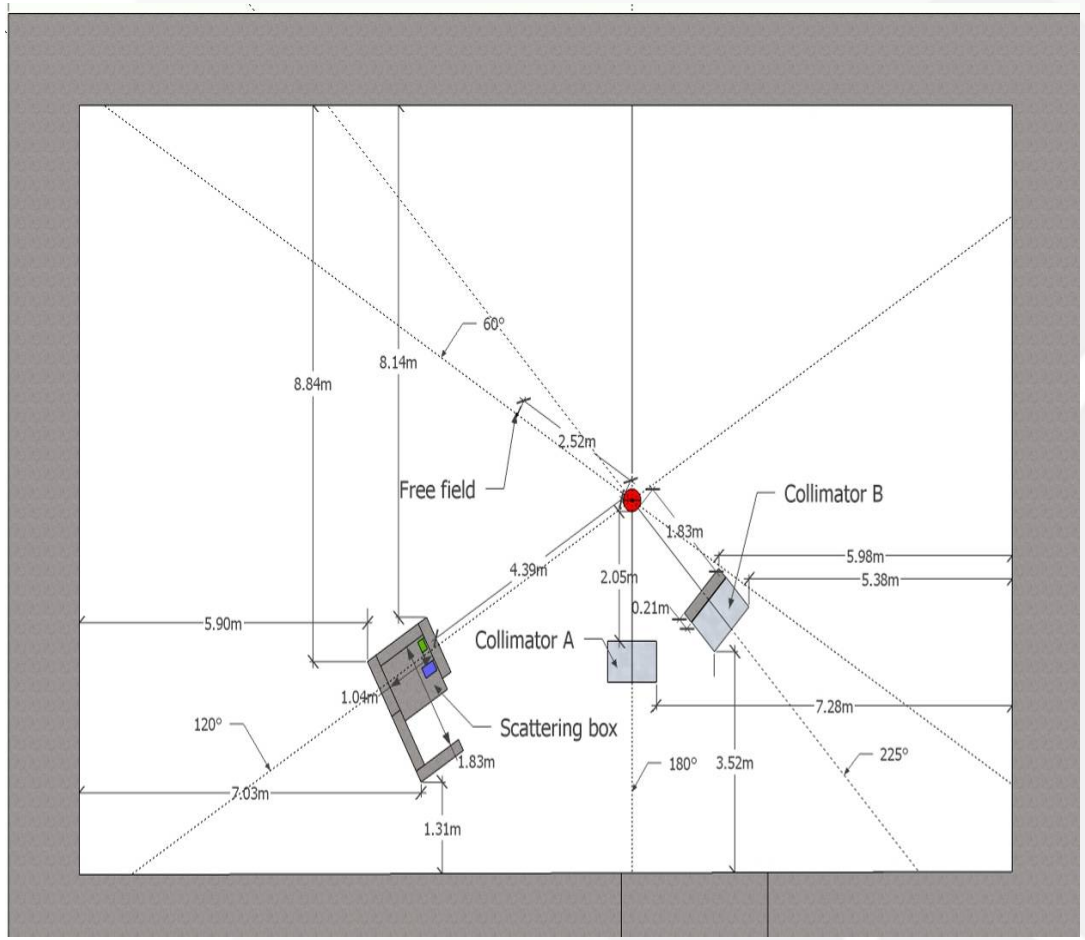
Winfrith Water Benchmark

- Transport of fission-energy neutrons in water
- Inconsistent stainless steel composition found in the associated documentation
- Good agreement with results C/E of 0.97-1.079
- Trend in results attributed to heterogeneity of experimental geometry



SILENE

- Neutron activation and TLD doses due to a bare critical assembly
- High-fidelity source presented by benchmark authors differs from typical Y-12 analysis techniques
  - Developed a low-fidelity model based on the benchmark source
  - Uniform line source equal to the leakage neutron energy distribution
  - Used SSR/SSW capabilities of MCNP
- TLD results C/E of 0.70 for all three sources
- C/E range of 1.18-1.97 for activation results for SSR and low-fidelity source.
- C/E range of 1.19-1.59 for leakage source



Conclusions

- Chose benchmarks directly applicable to CAAS analysis
  - Skyshine
  - Coupled neutron/photon
  - Concrete
- The selected benchmarks fell within the range of C/E for all benchmarks used in the validation
- All but one case has a C/E within a factor of two
  - Exception is a skyshine case with almost all of the dose due to secondary photons
- Results support a suggested factor of two conservative margin for calculations