

MCNP 6.1.1 Validation for Shielding Applications

Timothy D. Jackson



Disclaimer

This work of authorship and those incorporated herein were prepared by Consolidated Nuclear Security, LLC (CNS) as accounts of work sponsored by an agency of the United States Government under Contract DE-NA0001942. Neither the United States Government nor any agency thereof, nor CNS, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility to any non-governmental recipient hereof for the accuracy, completeness, use made, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency or contractor thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency or contractor (other than the authors) thereof.

Outline

- Motivation
- Approach
- Benchmark Discussion
- Results

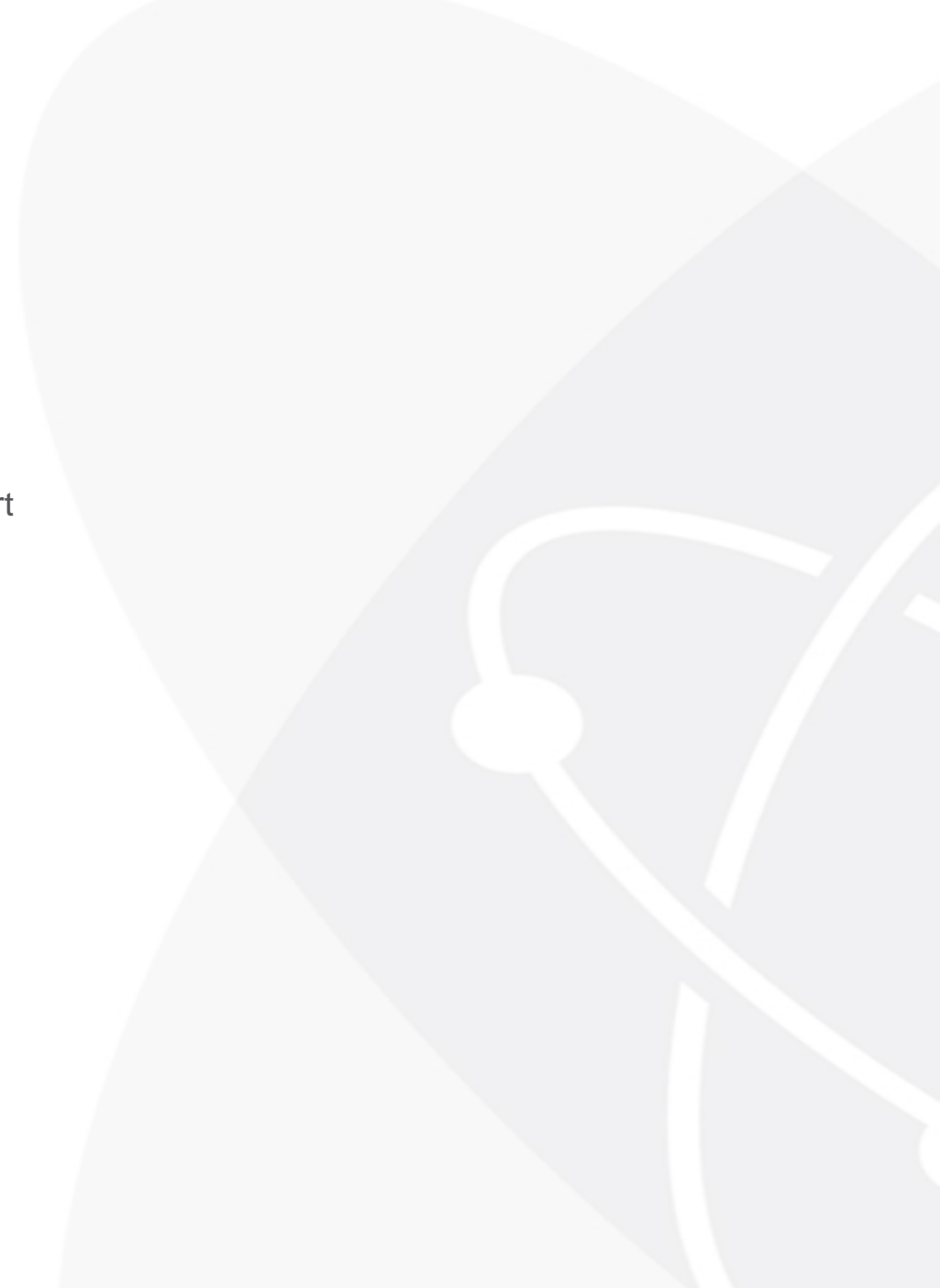


Motivation

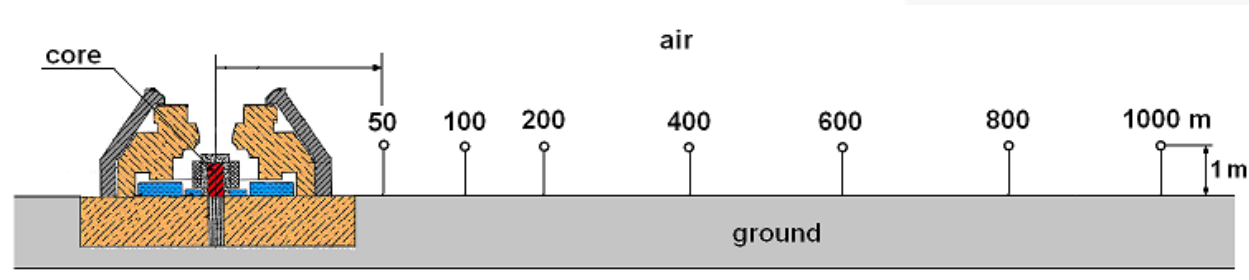
- ANSI/ANS-8.3 requires that CAAS coverage be demonstrated
- Multiple shielding applications for MCNP
 - Verifying existing CAAS detector coverage
 - Design of new CAAS installations
 - Dose rates for evacuation planning
 - Shipping container dose profiles
- MCNP criticality safety calculations require 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 conservatism

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



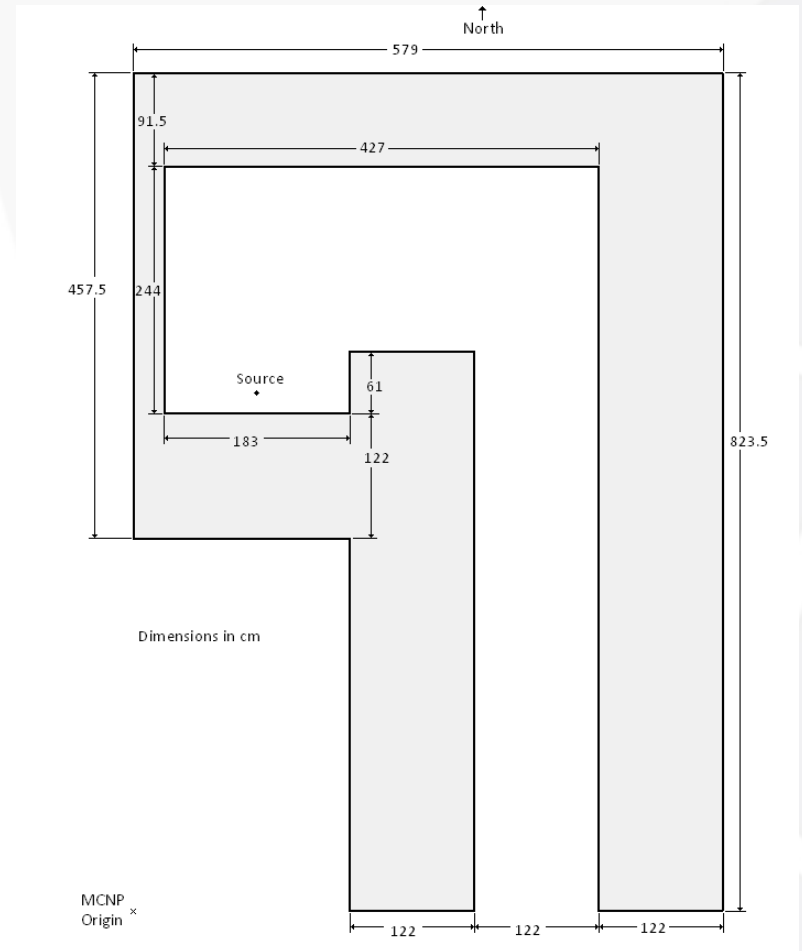
Baikal-1 Skyshine



- 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

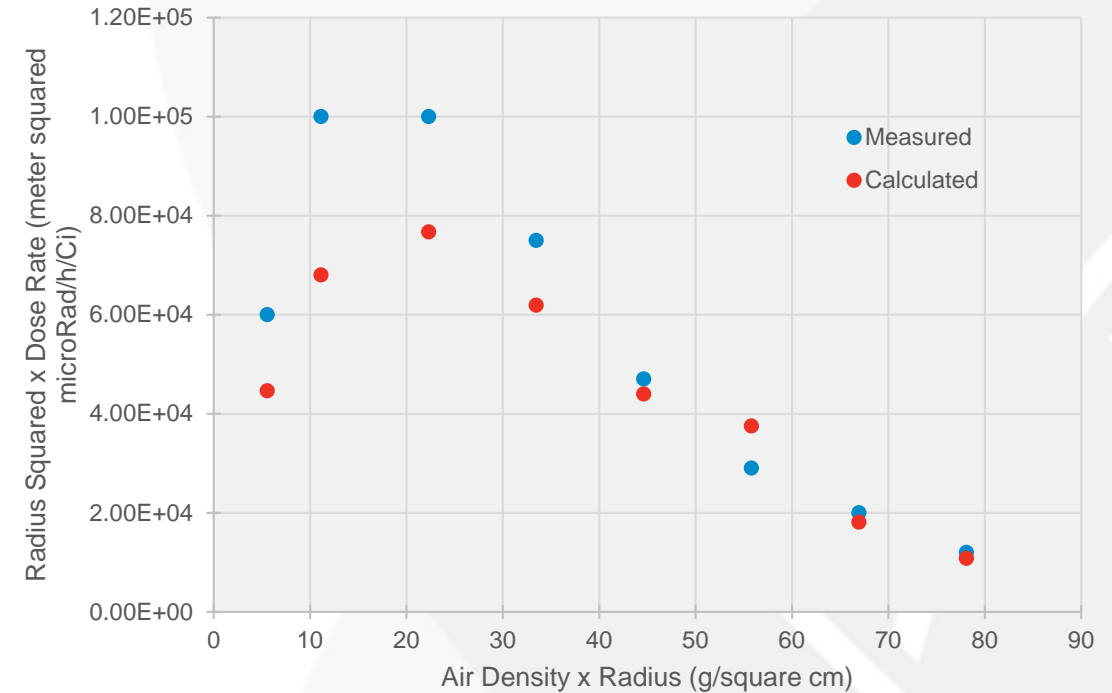
Stanford Concrete Maze

- 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.



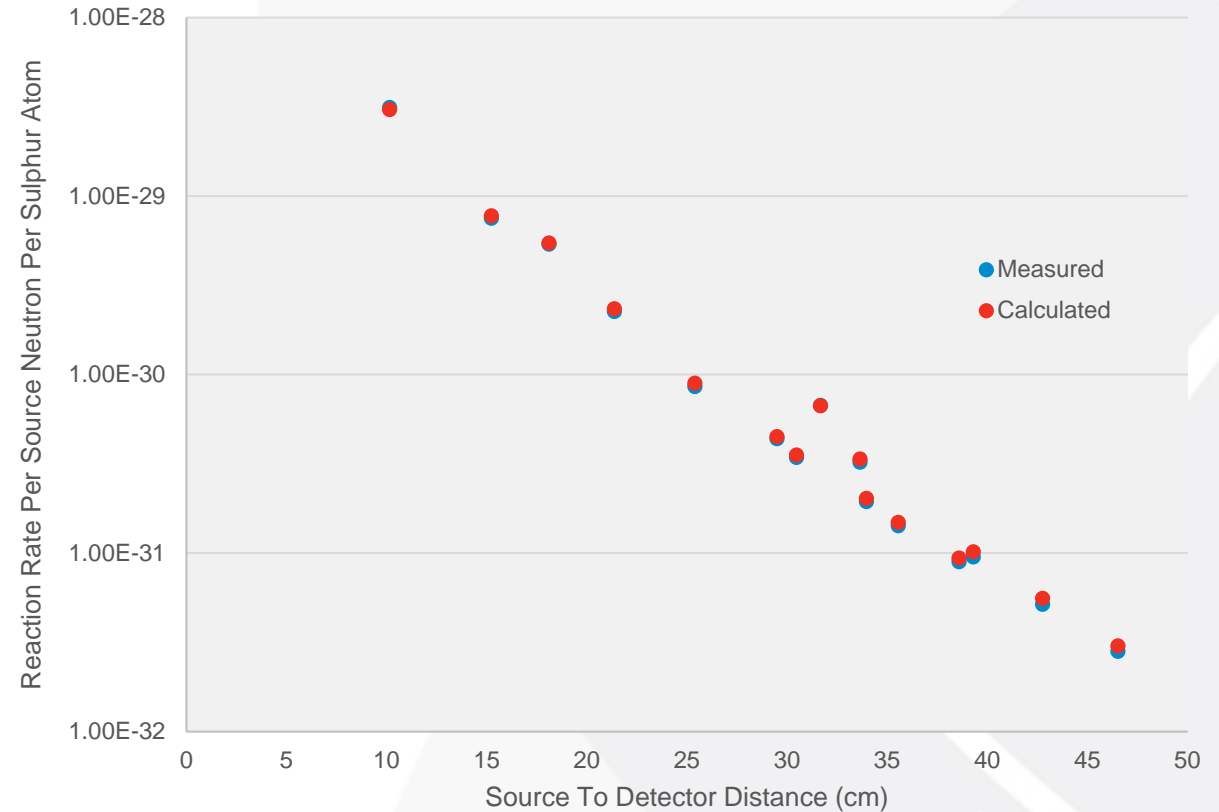
Gamma-Ray Skyshine

- 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



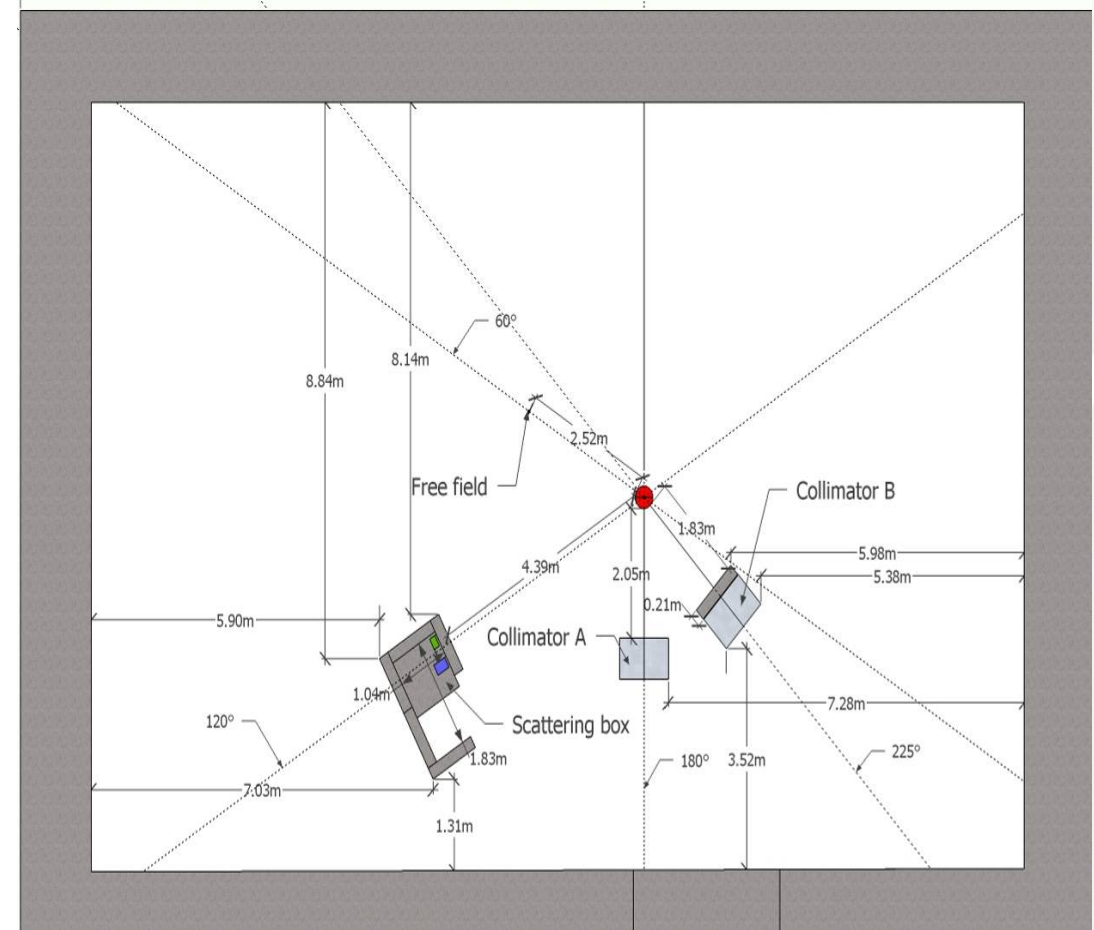
Winfrith Water Benchmark

- 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