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Project Title

Automated Variance Reduction for Highly Angle-Dependent Calculations

Project Objective

Develop a tool to optimize Monte Carlo calculations using DXTRAN variance reduction for computational efficiency.

Project Description

The DXTRAN variance reduction technique available in the MCNP® code system is useful in calculations with a low probability of particles making enough scattering collisions to be directed toward regions of interest (e.g., tally regions representing radiation detectors). These situations can be characterized as highly angle-dependent problems. DXTRAN operates by splitting collided particles, transporting a portion of the split particle to the surface of the region of interest, and continuing sampling. DXTRAN is the only variance reduction technique available in the MCNP code system that permits directly biasing direction and allowing continued sampling.

However, no rigorous study of DXTRAN's unbiasedness and its effect on tally variance has been performed before. Moreover, there is no guidance available for a user to choose DXTRAN parameters while attempting to construct an efficient calculation. This work performs such a study of DXTRAN's behavior. Using that information, a pre-existing computational cost-optimized radiation transport software tool is modified to deterministically predict DXTRAN tally response and variance behavior, and estimate computational time, to then iteratively optimize DXTRAN parameters that an end user can directly apply. Such work is expected to

produce Monte Carlo calculations more efficient, with more reproducible variance reduction parameters, than are otherwise available.

Project Relevance to Nuclear Nonproliferation

Nuclear nonproliferation situations can often be characterized as highly angle-dependent problems. On a small scale, one can have a radioactive source in a room with a detector across the room or in an adjoining room separated from the source by a wall and potentially streaming paths. On a larger scale, urban environments provide similar shielding/streaming complications.

Products and Outcomes of Project

This work will produce a radiation transport software tool that predicts Monte Carlo tally response and variance, the expected Monte Carlo computational time, and ultimately optimized Monte Carlo variance reduction parameters for DXTRAN. This capability can then be applied to nuclear nonproliferation problems to yield more efficient solutions than was previously possible.

Publications and Reports

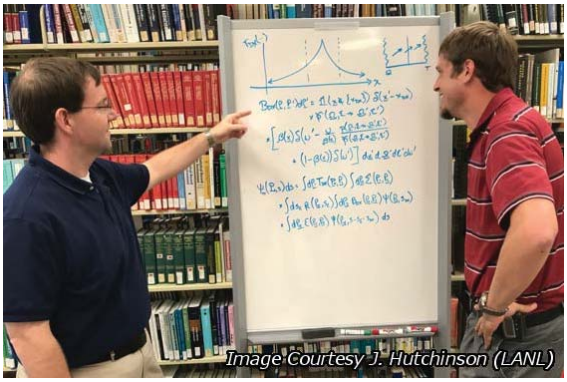
Image Courtesy J. Hutchinson (LANL)

J. A. KULESZA, C. J. SOLOMON, B. C. KIEDROWSKI, and E. W. LARSEN, "Performance Assessment of Cost-Optimized Variance Reduction Parameters in Radiation Shielding Scenarios," in Proceedings of *International Conference on Mathematics & Computational Methods Applied to Nuclear Science & Engineering*, American Nuclear Society, Jeju, South Korea; April 16–20 (2017).

C. J. SOLOMON, C. R. BATES, and J. A. KULESZA, "The MCNPTools Package: Installation and Use," Tech. Rep. LA-UR-17-21779, Los Alamos National Laboratory, Los Alamos, NM, USA (March 30, 2017).

J. A. KULESZA, B. C. KIEDROWSKI, and E. W. LARSEN, "Application of Automated Weight Window Generation Techniques to Modeling the Detection of Shielded Nuclear Material," in Proceedings of *Advances in Nuclear Nonproliferation Technology and Policy Conference (ANTPC)*, American Nuclear Society, Santa Fe, NM, USA; September 25–30 (2016).

Presentations

J. A. KULESZA, C. J. SOLOMON, B. C. KIEDROWSKI, "Initial Work to Deterministically Predict Tally Variance with MCNP6 DXTRAN Regions," Submitted to *25th International Conference on Transport Theory (ICTT25)*, Monterey, CA, USA (October 2017).

J. A. KULESZA, C. J. SOLOMON, and B. C. KIEDROWSKI, "Optimizing Monte Carlo for Computational Cost," *National Nuclear Security Administration NA-22 University Program Review*, Walnut Creek, CA, USA (June 7, 2017).

J. A. KULESZA, "Recent Work in Hybrid Radiation Transport Methods with Applications to Commercial Nuclear Power Reactors," *ASTM International Seminar*, West Conshohocken, PA, USA (March 24, 2017).