Monaco/MAVRIC Evaluation for Facility Shielding and Dose Rate Analysis
(to support the Global Nuclear Energy Partnership)

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Monte Carlo methods are used to compute fluxes or dose rates over large areas using mesh tallies. For problems that demand that the uncertainty in each mesh cell be less than some set maximum, computation time is controlled by the cell with the largest uncertainty. This issue becomes quite troublesome in deep-penetration problems, and advanced variance reduction techniques are required to obtain reasonable uncertainties over large areas.[1]

Oak Ridge National Laboratory has developed a new sequence, MAVRIC, which will be available with the release of SCALE 6. In this sequence, a methodology called Consistent Adjoint-Driven Importance Sampling (CADIS) has been incorporated for effective variance reduction. The CADIS methodology was developed to quickly and automatically determine the biased source distribution, as well as all of the values for the weight windows over a rectangular mesh and a given energy group structure.[2-3] The method first determines the approximate adjoint particle flux, usually using a discrete ordinates code. The source for this calculation is the detector energy-group response for the process of interest (e.g., dose rate) at the location(s) of interest. The resulting adjoint flux at each location and energy is equated to the importance of particles and is combined with the source distribution to generate the biased source and weight windows values that control the splitting and particle rouletting at all locations. Very recently, a variation of the CADIS methodology, referred to as the Forward-Weighted CADIS (FW-CADIS) method has been developed, implemented in MAVRIC, and demonstrated for optimization of dose maps.[1,4]

In this project the MAVRIC sequence will be evaluated along with the Monte Carlo engine Monaco to investigate its effectiveness and usefulness in facility shielding and dose rate analyses. A previously MCNP-evaluated cask array from the Yucca Mountain Project's proposed aging pad and/or buffer area design will be utilized for evaluation and benchmarking purposes. In addition, dose mapping will be performed inside the surface facilities utilizing a transportation cask to evaluate the codes' effectiveness and also ability to calculate deep-penetration problems. Because of the dimensions and the large amount of shielding required for GNEP facilities, advanced variance reduction techniques beyond today's capabilities will certainly be required. Thus this evaluation will benefit the GNEP program. In addition, with the Generation IV Nuclear Energy System Initiative, it will become increasingly important to be able to accurately model advanced BWR and PWR facilities and to calculate dose rates at all locations within a containment (e.g., resulting from radiations from the reactor as well as the from the primary coolant loop) and adjoining structures (e.g., from the spent fuel pool).

References

[1] D.E. PEPLOW, E.D. BLAKEMAN, J.C. WAGNER, "Advanced Variance Reduction Strategies for Optimizing Mesh Tallies in MAVRIC," submitted to American Nuclear Society 2007 Winter Meeting, November 11-15, 2007, Washington, DC.

[2] Wagner, J. C. 1997. *Acceleration of Monte Carlo Shielding Calculations with an Automated Variance Reduction Technique and Parallel Processing*, Ph.D. dissertation, Pennsylvania State University, University Park.

[3] Haghighat, A., and J. C. Wagner. 2003. "Monte Carlo Variance Reduction with Deterministic Importance Functions," *Prog. Nucl. Energy* **42**(1), 25–53.

[4] J. C. Wagner, E. D. Blakeman, and D. E. Peplow, "Forward-Weighted CADIS Method for Global Variance Reduction," to be presented at the ANS Winter Meeting, Washington, DC, November 11-15, 2007.

Personnel:

Dr. Charlotta Sanders will be appointed as a Research Professor in the Mechanical Engineering Department at the University of Nevada, Las Vegas. She is currently employed by Bechtel-SAIC Corp., where she works on criticality and shielding analysis studies for the Yucca Mountain Project. She will serve as Principal Investigator for this project. In addition to her Yucca Mountain work, Dr. Sanders' experience includes nuclear engineering, reactor design, and other nuclear studies. She is well acquainted with computational reactor physics personnel working these issues at national laboratories.

Prof. Denis Beller is a Research Professor in the Mechanical Engineering Department at the University of Nevada, Las Vegas. He will serve as Co-Investigator for this project. Prof. Beller has a long career in nuclear engineering, reactor physics, systems analysis and radiation effects and currently supervises undergraduate, M.S., and Ph.D. students at UNLV.

Dr. Michael Dunn is the Nuclear Data (ND) Group Leader in the Nuclear Science & Technology Division (NSTD) at the Oak Ridge National Laboratory (ORNL). He oversees the development of cross-section processing and the ORNL cross-section measurement and evaluations for the U.S. Evaluated Nuclear Data File (ENDF/B) system. His expertise in the areas of nuclear criticality safety, radiation transport, and cross-section processing methods development will be invaluable for this project.

Dr. Douglas E. Peplow is a Senior R&D Staff member in the Radiation Transport and Criticality Group of the Nuclear Science and Technology Division of Oak Ridge National Laboratory. He is the developer for the Monaco shielding code and the MAVRIC sequence. Areas of research include advanced variance reduction methods, automating such methods and applying them to various problems in nuclear engineering.