Monaco/MAVRIC: Computational Resources for Radiation Protection and Shielding in SCALE

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INTRODUCTION

SCALE (Standardized Computer Analyses for Licensing Evaluation) [1] is a widely used computational code system that has been developed and maintained by Oak Ridge National Laboratory. The purpose of SCALE is to provide a comprehensive collection of easy-to-use automated calculational sequences for performing accurate analyses of nuclear facilities and transport/storage package designs. The primary shielding analysis sequence included in SCALE has been the SAS4 sequence that uses the three-dimensional (3-D) Monte Carlo shielding code, MORSE-SGC, along with automated variance reduction techniques specifically designed for spent fuel cask analyses. The SAS4 sequence uses a one-dimensional adjoint XSDRNPM calculation to generate the biasing parameters for MORSE-SGC. SAS4 automatically passes the biasing parameters to MORSE-SGC to perform axial or radial shielding calculations for cylindrical cask-type geometry models.

The SAS4 sequence was created to reduce long computational times. SAS4 is quite successful for a specific class of cask problems, but more complex problems, such as thick shields with streaming paths, demand general 3-D variance reduction.

MONACO

Monaco is a new 3-D Monte Carlo code being developed within SCALE for shielding calculations.[2] Monaco is the result of a modernization effort combining the multi-group neutron and photon physics of MORSE with the flexibility of the second-order surface SCALE general geometry package (SGGP), which is shared with KENO-VI. Monaco uses the same cross section package as other SCALE modules. Major efforts have been made in bringing the coding style up to modern Fortran 95 standards so that future development can be more easily continued.

Available tallies in Monaco include point detectors, region-based flux tallies and mesh tallies. Any Monaco tally can be convoluted with a response function, either user-entered or from a standard list available with each SCALE cross section library. Mesh tally values and uncertainties can be viewed with a special viewer on either Windows or Unix platforms, as shown in Fig. 1.

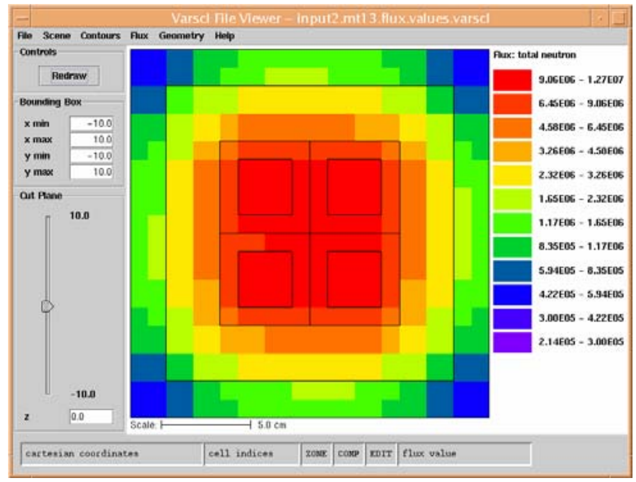

Fig. 1. Example of a Monaco mesh tally showing dose.

MAVRIC

The MAVRIC sequence[2] (Monaco with Automated Variance Reduction using Importance Calculations) combines the results of an adjoint calculation from the 3-D deterministic code TORT with Monaco. Both an importance map (shown in Fig. 2) for weight windows and a biased source are automatically generated from the adjoint flux using the CADIS methodology.[3] MAVRIC is completely automated — from a simple user input, it creates the cross sections (forward and adjoint), calculates the first collision source using GRTUNCL3-D, computes the adjoint fluxes using TORT, creates the importance map and biased source and then executes Monaco. Users can start and stop the calculation at various points so that progress can be monitored and importance maps can be reused for similar problems.

For simple problems that do not require the advanced variance reduction, the MAVRIC sequence is an easy way to compute problem-dependent cross sections and execute Monaco with a common user input. Standard region-based weight windows for particle splitting and roulette are available when not using the TORT-based importance maps.

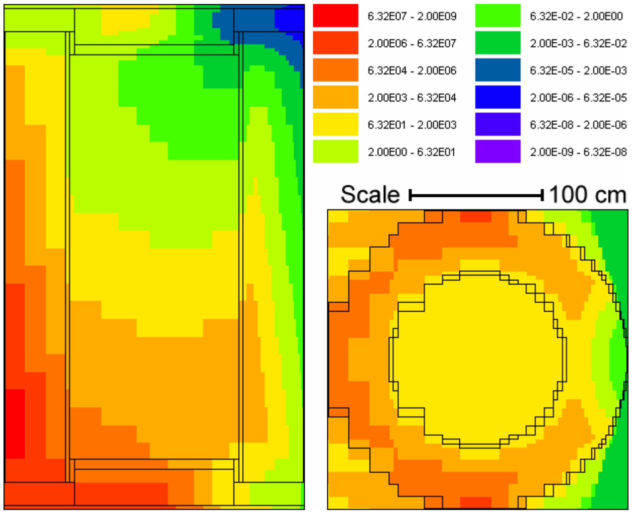

Fig. 2. Example of a MAVRIC-generated weight window target values map for a shipping cask calculation used to calculate dose at the upper right-hand corner of the cask.

GRAPHICAL USER INTERFACE

The SCALE Graphically Enhanced Editing Wizard (GeeWiz), the graphical user interface for many of the SCALE sequences[4], has been expanded to include the MAVRIC sequence. This allows the user to create/edit/view the geometry using the highly interactive KENO3D visualization tool, easily define the physical materials, set all of the calculational parameters, and set up the mesh planes for the discrete ordinates adjoint calculation. The GeeWiz user interface and a sample KENO3D visualization are shown in Fig. 3.

FUTURE DEVELOPMENT

The short-term future development of Monaco and MAVRIC will focus on easier user input (mostly for Unix users, because Windows users can already use GeeWiz) and enhanced user output, possibly moving to a set of HTML-formatted tables. Longer term development will include adding more capabilities, such as more tallies and tally options, a wider variety of source description options, more automation in determining the variance reduction parameters (especially for nested array problems) and possibly adding a differential sampling capability for sensitivity analysis. Rigorous testing and verification will be a part of the development of all new features.

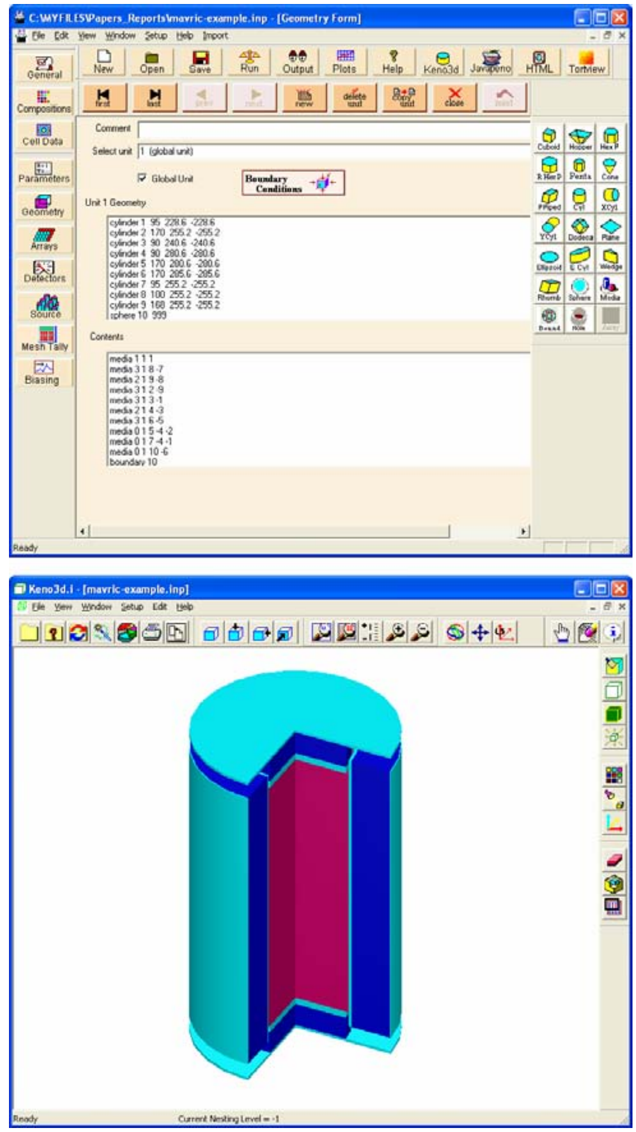

Fig. 3. Screen shots of the GeeWiz graphical user interface and KENO3D cutaway view of a shipping cask model.

SUMMARY

Monaco and MAVRIC will be valuable computational resources for radiation protection and shielding analysis. Both will be part of the SCALE version 6.0 release when it is available through RSICC (http://www-rsicc.ornl.gov/).

ACKOWLEDGEMENTS

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