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Application of MCNP, MERCURY and TART to Calculation of the National Ignition Facility (NIF) Shielding

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June 6, 2006

An invited paper to be presented at
The 2006 American Nuclear Society Winter Meeting
Nov. 12 – Nov. 16, Albuquerque, NM

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This paper is available on-line at http://www.llnl.gov/cullen1/NIF-Shield.htm

Abstract

The National Ignition Facility (NIF) is a multi-billion dollar laser project that is presently being constructed at Lawrence Livermore National Laboratory. In its use to investigate fusion this facility will produce radiation fields, and as such will require radiation shielding to protect the personnel who will be working in the vicinity. Physically, the facility is roughly the size of a major sports stadium and very complex. For example, the figure below illustrates a cut away view of only the portion of the facility within the target bay; it is ~35 m in diameter and ~40 m in height. Access requirements and laser beam transport make the shielding design challenging.

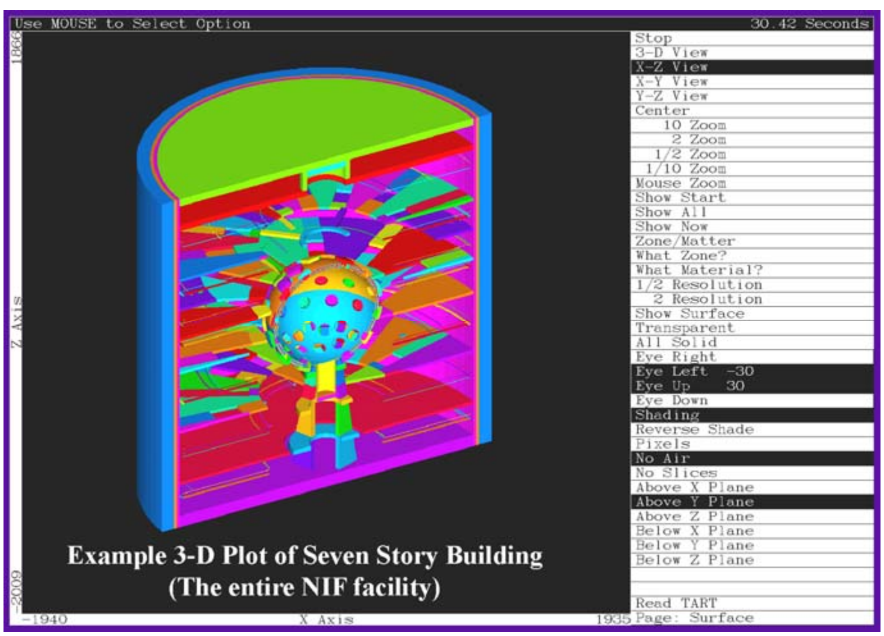

Fig. 1: NIF Facility

The shielding for NIF is being designed using three state-of-the-art Monte Carlo radiation transport codes, namely: MCNP (Los Alamos), MERCURY and TART (Livermore). All of these codes presently use the latest ENDF/B-VI neutron interaction data, including detailed energy dependent cross sections, i.e., not multi-group cross sections. They also all use the ENDF/B-VI photon interaction data, derived from the Livermore Evaluated Photon Data Library (EPDL). When available, these codes use ENDF/B neutron-induced photon production data. Often this data is not included in ENDF/B, in which case MERCURY and TART use the Livermore ENDL data, which has complete neutron induced photon production data. Using these data and their nuclear and atomic data we are able to perform complete coupled neutron-photon transport calculations.

There are several reasons why we are using three codes for this project. First, the utilization of multiple independent radiation transport codes provides quality assurance of the shielding design. Second, none of the codes is able to single-handedly meet all of our needs in terms of their ability to accurately model the full range of problems of interest. Finally, quality is further enhanced in that multiple people have generated models independently, which reduces the human factor, thereby giving greater confidence in the final results.

Previous analyses have relied entirely upon human-generated radiation transport models. To further reduce the effects of human factors and to reduce the effort required to generate such models, we are increasingly moving towards their automatic generation directly from computer-assisted design (CAD) tools such as Pro|Engineer.

Generally the calculated results are in good agreement, with most of the differences attributed to differences in nuclear data and models used by the codes, e.g., many ENDF/B evaluations used by MCNP do not include neutron induced photon production information, whereas all of the evaluations used by MERCURY and TART do include complete neutron induced photon production emission information. In this situation we expect generally good agreement between the three codes for neutron transport, and naturally somewhat less agreement for the neutron induced photons.

In this paper we discuss the various features of each code that we used to good advantage for this shielding problem, and we present results for the three codes.

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