Science.

Technology.

Innovation.

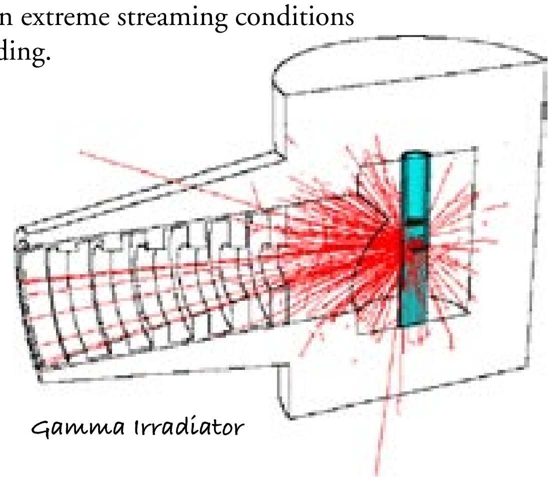
Radiological Science and Engineering Group

Radiation Transport and Shielding Analysis

Pacific Northwest National Laboratory (PNNL) and its Radiological Science and Engineering Group (RSEG) are leaders in performing advanced radiation transport and shielding analysis to solve challenging environmental, safety, and health problems. We develop and use state-of-the-art methods and codes for monitoring and calculating doses and dose equivalents in a wide range of circumstances.

Example Applications

- Calculation of the effective dose and effective dose equivalent resulting from external radiation incident on male and female anthropomorphic phantom models.
- Calculation of neutron and photon dose rates due to single and multiple configurations of spent fuel storage casks to support licensing and operational activities.
- Calculating direct and scattered radiation components in collimated irradiators and calibration facilities to provide correction factors for the interpretation of dosimeter/instrument response.
- Modeling detector response in chest and whole body counters, to generate "virtual calibration factors" for the facilities.
- Performing shielding calculations for a proposed plutonium plant, to determine the required shield thicknesses for vaults and glovebox walls, and to estimate the doses that will be received by workers.
- Calculating radiation transport in extreme streaming conditions to recommend appropriate shielding.



Gamma Irradiator

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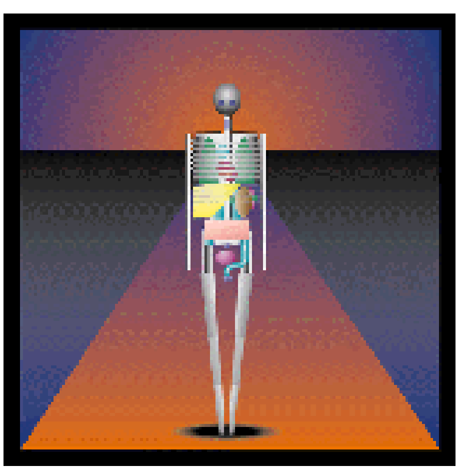
Modeling Capabilities

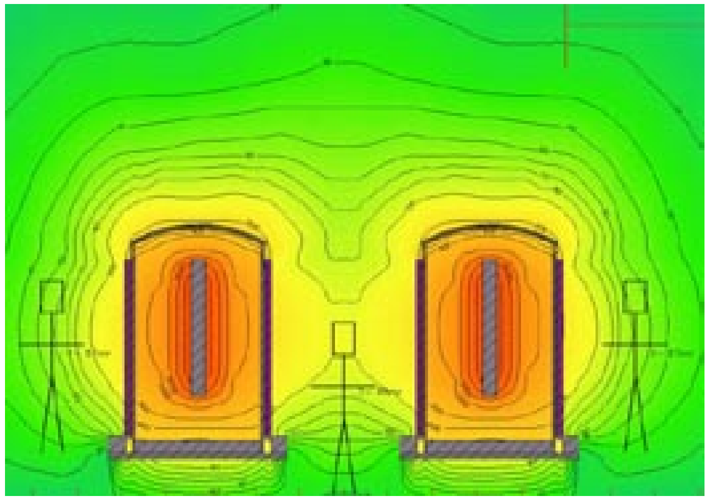
RSEG staff are experienced at modeling radiation detection devices, calibration facilities, radiation sources, and spent-fuel storage casks. We also use male and female anthropomorphic "phantom" models to evaluate the effective dose and effective dose equivalent for workplace, environmental, and accidental radiation exposures. Advanced visualization techniques allow us to construct model geometries, illustrate radiation streaming through filters, shields and duct work, and show dose contours around hot spots and sources. Among our available software resources, we use MCNP, ORIGEN, SOURCES, and SCALE software packages to support both applied and fundamental research projects.

MCNP is a general-purpose Monte Carlo N-Particle code that can be used for neutron, photon, electron, or coupled neutron/photon/electron transport. It is used for radiation protection and dosimetry, radiation shielding, radiography, medical physics, nuclear criticality safety, detector design and analysis, accelerator target design, fission and fusion reactor design, and in decontamination and decommissioning.

ORIGEN solves equations of radioactive growth and decay that involve continuous first-order chemical processing and neutron flux, described by a three-region spectrum. It can treat complex decay and transmutation schemes.



Anthropomorphic "phantom" model



Dose rate contours near an RTG

SOURCES is used to determine neutron production rates and spectra from (alpha,n) reactions, spontaneous fission, and delayed neutron emission due to radionuclide decay.

SCALE determines whether designs of nuclear facilities and transportation or storage packages meet nuclear safety standards. It has been used in problems of criticality safety and radiation shielding for nuclear facilities and containers for fissile and radioactive materials, including assessments of the safety of transporting nuclear material in casks.

Some Past and Current Projects

Hot Cell Characterization. RSEG staff designed a neutron detector pod for assessing transuranic contents of a hot cell in the 327 Building at the Hanford Site and modeled the measurement conditions to evaluate the measurement data and modeled the experimental conditions to evaluate the measurement data.

Pit Disassembly and Conversion Facility Design. RSEG staff performed shielding calculations to support the design of a new plutonium facility, intended for construction at the Savannah River Site. Calculations were performed to determine optimal thicknesses for vault walls and glove boxes and to estimate the doses received by facility workers.

Radiation Portal Monitor Project. PNNL has the responsibility to select radiation detection instruments to monitor incoming cargo at all U.S. Ports of Entry to detect radioactive shipments. PNNL and RSEG staff have been modeling candidate detector systems to evaluate their performance to detect illicit radioactive shipments.

Mayak (Russia) Worker Dose Reconstruction. RSEG staff participate in reconstructing doses received by workers at Russia's Mayak Production Association plutonium production facility. In the first years of Mayak's operation (1949-1954), radiation monitoring instruments and personnel dosimeters were primitive, and monitoring was not comprehensive, but worker doses were very high by today's standards. Consequently, the modeling plays an important role in re-evaluating doses. RSEG staff are collaborating with Russian colleagues in these radiation transport studies.

W-464 Shielding Calculation. RSEG staff are performing shielding calculations to aid in designing modifications to a canister storage building on the Hanford Site. This building will provide temporary storage of canisters of vitrified (solidified) radioactive waste. Our staff performed calculations to determine the dose rates inside the building (for movement of the vitrified waste into storage locations) and outside the building (for times when the building is filled with vitrified waste).