SAND2014-17592R

GADRAS Development FY14 Annual Report

PROJECT TITLE: GADRAS Development **REQUIREMENTS:** Ka
***webPMIS* PROJECT NUMBER:** SL12-GADRAS-PD2Ka **LAB/CONTRACTOR:** SNL
B&R CODE: NN2001-03 **DATE:** September 9, 2014
PRINCIPAL INVESTIGATOR(S): Dean J. Mitchell, Org 6633, (505) 844-8868
LAB PROGRAM/PORTFOLIO MANAGERS: Craig R. Tewell, Org. 8127, (925) 294-2310
Rob Tachau, Org. 5737, (505) 845-7157
HQ OFFICE/PROGRAM MANAGER: David Beach, NA-221, (202) 586-1928

Project Summary

The GADRAS Development project comprises several elements that are all related to the Detector Response Function (DRF), which is the core of GADRAS. An ongoing activity is implementing continuous improvements in the accuracy and versatility of the DRF. The ability to perform rapid computation of the response of gamma-ray detectors for 3-D descriptions of source objects and their environments is a good example of a recent utilization of this versatility. The 3-D calculations, which execute several orders of magnitude faster than competing techniques, compute the response as an extension of the DRF so the radiation transport problem is never solved explicitly, thus saving considerable computational time. Maintenance of the Graphic User Interface (GUI) and extension of the GUI to enable construction of the 3-D source models is included in tasking for the GADRAS Development project. Another aspect of this project is application of the isotope identification algorithms for search applications. Specifically, SNL is tasked with development of an isotope-identification based search capability for use with the RSL-developed AVID system, which supports simultaneous operation of numerous radiation search assets. A Publically Available (PA) GADRAS-DRF application, which eliminates sensitive analysis components, will soon be available so that the DRF can be used by researchers at universities and corporations.

GADRAS/RayTrace3D

The approach that GADRAS uses to compute the detector response for macroscopic radiation sources is to use the DRF to combine the output of discrete ordinates calculations (using the LANL code PARTISN) with a unique implementation of ray trace calculations that are performed within GADRAS. In addition to compiling a tally of gamma ray energies and intensities, the GADRAS implementation computes leakage-weighted atomic numbers and areal densities for intervening materials. Utilization of this information by the DRF enables reasonably accurate estimation of the detector response, including the continuum produced by scattered radiation. The discrete ordinates calculations are used primarily to compute leakages of neutron and gamma rays produced by neutron capture reactions; the discrete ordinates calculations are also applied as correction terms for spectra that are derived from the ray-trace method.

The computational methodology that has been applied for 1-D models has recently been extended to accommodate 3-D source descriptions. When models are saved, the volumetric source terms are stored for subsequent use by GADRAS/RayTrace3D. Storing these source terms relieves any re-computation of the gamma-ray and neutron flux by discrete ordinates methods. The resulting computation time ranges from about 2 seconds for a single 3-D object such as a cylinder or a slab, to about 30 seconds for a scenario that comprises a dozen objects. Figure 1 compares measured and computed spectra for a 4.5-kg plutonium ball within 3 inches of polyethylene. Representations of the tables that support the detector and the source are essential in order to replicate capture gamma rays emitted by these steel structures. The 3-D visualizer that was used to create and display the measurement scenario shown in Figure 1 has been incorporated into the GADRAS GUI. Benchmark measurements of cylindrical depleted uranium (DU) castings and DU plates, which were acquired during FY14, have been used to refine the 3-D calculations.

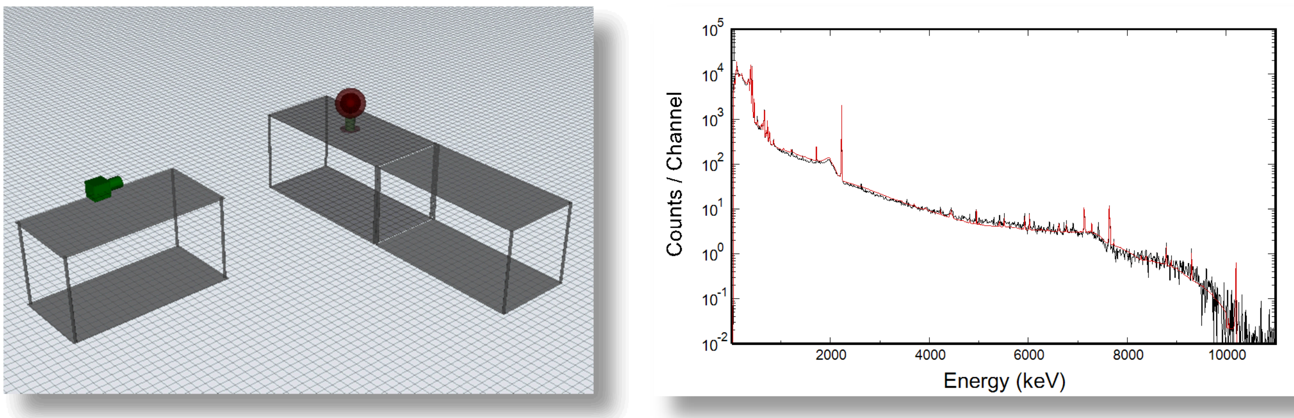

Figure 1. The 3-D model describing measurements of a 4.5-kg plutonium ball inside 3 inches of polyethylene (left) was used to compute the spectrum given by the red curve (right). The computed spectrum agrees well with the measured spectrum (black).

Search Algorithm

A Search Algorithm project that NA-22 sponsored in FY12 concluded that all of the spectroscopic algorithms (including one provided by SNL) performed substantially better than the traditional count-rate-based detection method. SNL was subsequently tasked to integrate our isotope-identification based search algorithm into the RSL-developed AVID application, which can control dozens of search assets simultaneously. This integration required development of an Application Programming Interface (API) that is compatible with AVID and a variety of sensors systems. In order to accommodate the range of sensors, the API and underlying software components that were developed in FY14 supports the use of single or multiple detector elements, and input can be processed for either well calibrated instruments or sensors that only have nominal energy calibrations. A 32-bit version of the software was delivered to RSL for preliminary testing. In order to accommodate simultaneous processing of data from multiple assets, RSL requested a 64-bit version of the analysis program that utilizes parallel processing and references non-default detector folders. A version of the software that supports the new requirements is currently being tested.

As part of the GADRAS Development project, Sandia is participating in a search algorithm evaluation that is sponsored by DTRA and managed by APL. Data that is being used to evaluate the performance of various algorithms is exactly the kind of extensive field test data that is needed to optimize the performance of our search algorithm, and it also includes sensors of the types fielded by RSL, so this activity is directly applicable to the GADRAS Development project objectives. Many of the false alarms that were observed when search data were processed by GADRAS resulted from changes in the shapes of background spectra, which differ from characteristics of stationary detectors for which the GADRAS algorithms had been optimized. Relatively minor changes that were made to accommodate these background variations resulted in a 10-fold reduction in false alarm rates without impacting the sensitivity for threat materials. Figure 2 compares gamma-ray count rates with a Stuff-of-Interest (SOI) parameter, which expresses the confidence that one or more of the declared isotopes of interest is present. The isotope-identification based search algorithm can identify the presence of threat materials even when count rates are less than normal background variations.

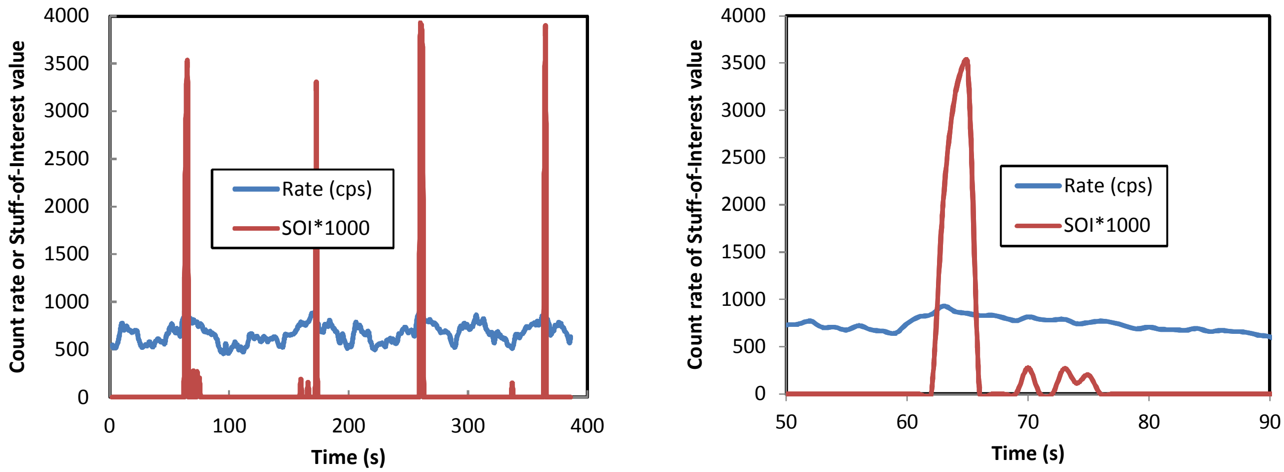

Figure 2. Count rates and the derived Stuff-of-Interest (SOI) parameter during a search trial that extends over four passes by a ^{137}Cs source, which was declared to be an isotope of interest. The right graph expands on the region associated with the first encounter with the source.

GADRAS-DRF

A Publically Available (PA) application called GADRAS-DRF was developed to enable researchers and sensors developers to access the DRF. This application uses the same detector response algorithm and much of the GUI components, but it does not include capabilities that are deemed to be sensitive. The application and associated documentation is being revised and tested for compatibility with the current version of GADRAS (18.5). We plan to make the application available through RSICC during the first quarter of FY15. A detailed User's Manual is also being written to assist users with no previous experience.

Technical Publications

1. D.J. Mitchell and L.T. Harding, "GADRAS Isotope ID Users' Manual for Analysis of Gamma-Ray Measurements and API for Linux and Android", Sandia National Laboratories report SAND2014-3933 (May 2014).
2. Dean Mitchell, "Rapid 3-D Gamma Response Calculations", Sandia National Laboratories presentation SAND2014-17192 PE, presented at the Fission Experiments and Theoretical Advances (FIESTA) conference (September 2014).
3. Release notes were prepared to describe changes in several versions of GADRAS that were released in FY14.
4. Several programmatic reports were prepared that did not receive SAND numbers.

Acknowledgments

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