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iSAFE

Interns for Security, Arms control and Force protection Engineering

Validation of Gamma Detector Analysis Software

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MS Mechanical Engineering, Spring 2020

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The best form of validation for modeling and simulation software is experimental; however, funding and time, limit experimental availability. One of the more efficient ways to catch errors is by implementing a set of unit tests. This project aims to use experimentally validated detector responses to create unit tests to catch bugs before they adversely effect users.

What is GADRAS?

Gamma Detector Response and Analysis Software, or GADRAS, is a software suite capable of modeling response signals from gamma-ray and neutron detectors. GADRAS is capable of displaying measured or computed spectra, characterizing detectors and analyzing spectra to identify isotopes and estimate flux profiles. These capabilities are performed in a matter of minutes and provide users with accurate data quickly.

Figure 1: GADRAS Logo

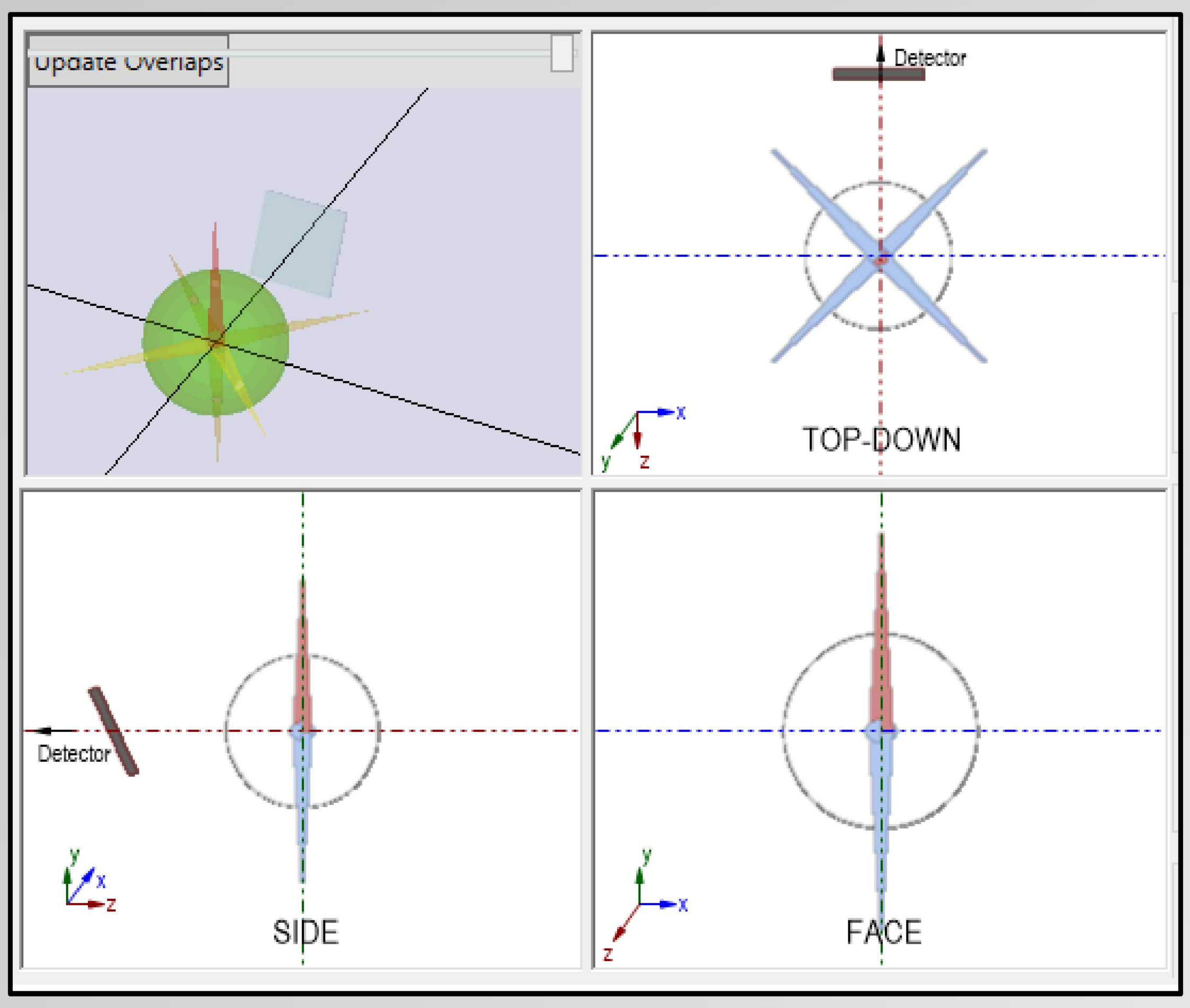

Figure 2: Complex Geometry Modeled in GADRAS

Modeling in GADRAS

GADRAS is able to model 6 shape primitives accurately: spheres, sphere caps, cylinders, round end cylinders, cones, and boxes. These shape's radiation transport responses are relatively easy to solve for using conventional methods; coupled with their abundance of experimental data, these shape primitives are used as the basis for all GADRAS models. In addition to basic shapes, GADRAS uses its adaptive mesher to simulate multiple primitives as a composite model, resulting in unique and hard to solve geometries.

Target Cases

There are four major categories targeted at testing GADRAS radiation transport:

- Symmetry – Every model should maintain its symmetry throughout the 4 Pi field of view
- Composite models – multiple shapes added or subtracted together to create other simple shapes
- Shielding – Simple shielding should have similar spectra at great distances
- Trace Sources – all geometries should look the same under point source conditions with void shells

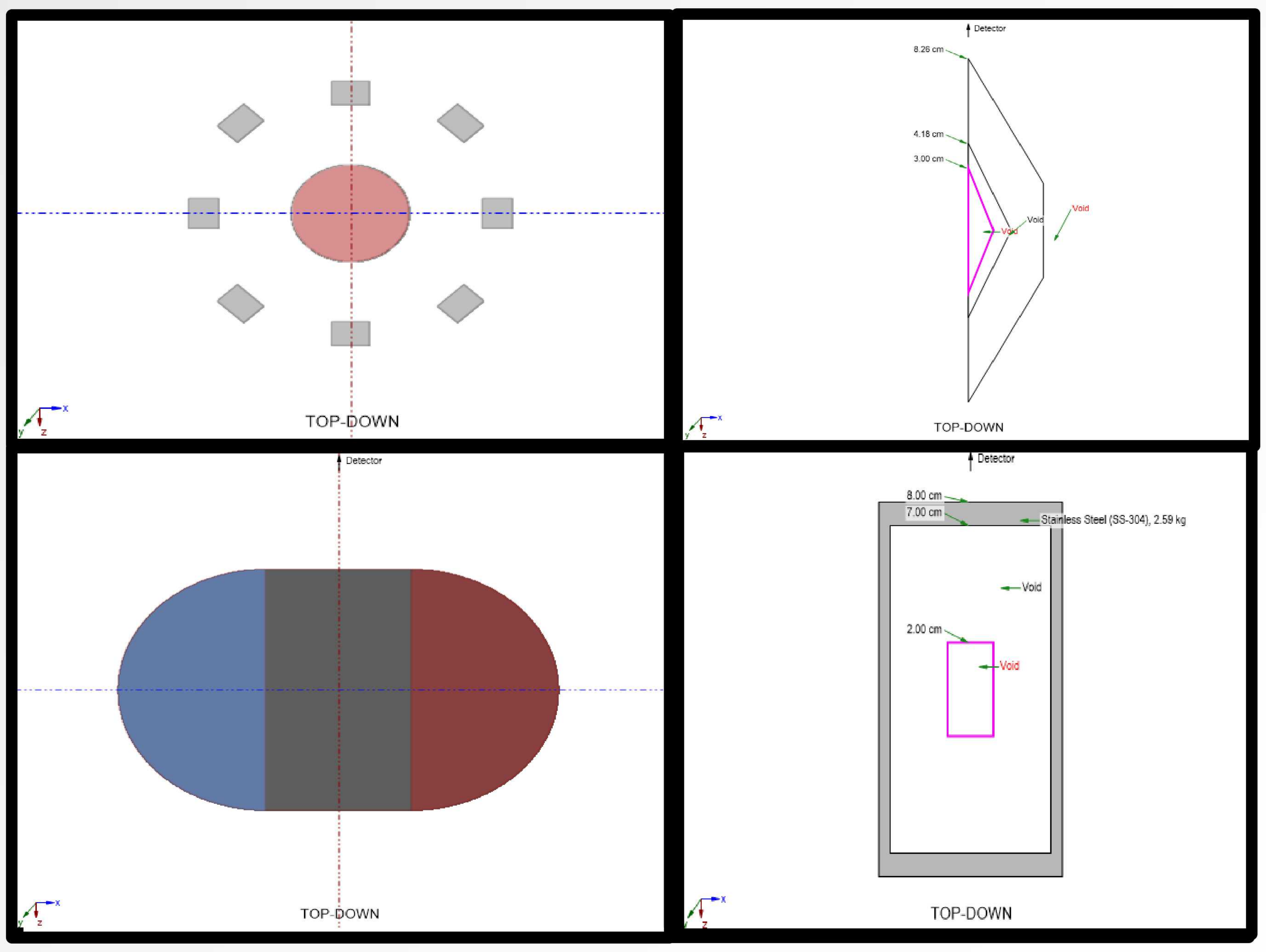

Figure 3: Symmetry (Top Left), Composite models (Bottom Left), Shielding (Bottom Right), and Trace Sources (Top Right) modeled in GADRAS

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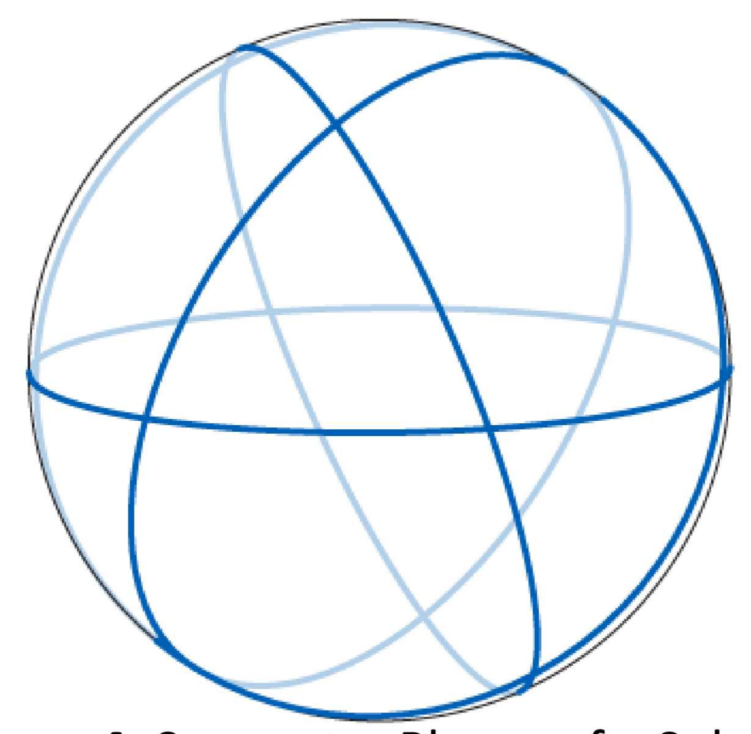


Figure 4: Symmetry Planes of a Sphere
https://11011110.github.io/blog/2007/03/08/visualizing-space-of.html

Symmetry

GADRAS moves the detector around a model using coordinate system transformations. Users can specify translations and rotations along the X, Y and Z axes. Using these six transformations on a shape primitive, one can make sure that the primitive is symmetrically consistent and from that, assume the transformations are being done correctly.

Composite Models

The adaptive mesher combines the shape primitives into complicated geometries and allows GADRAS to perform complex radiation transports quickly. The test suite aims to validate the adaptive mesher by checking the symmetry of composite models, and creating composite models that look like shape primitives, and comparing their results.

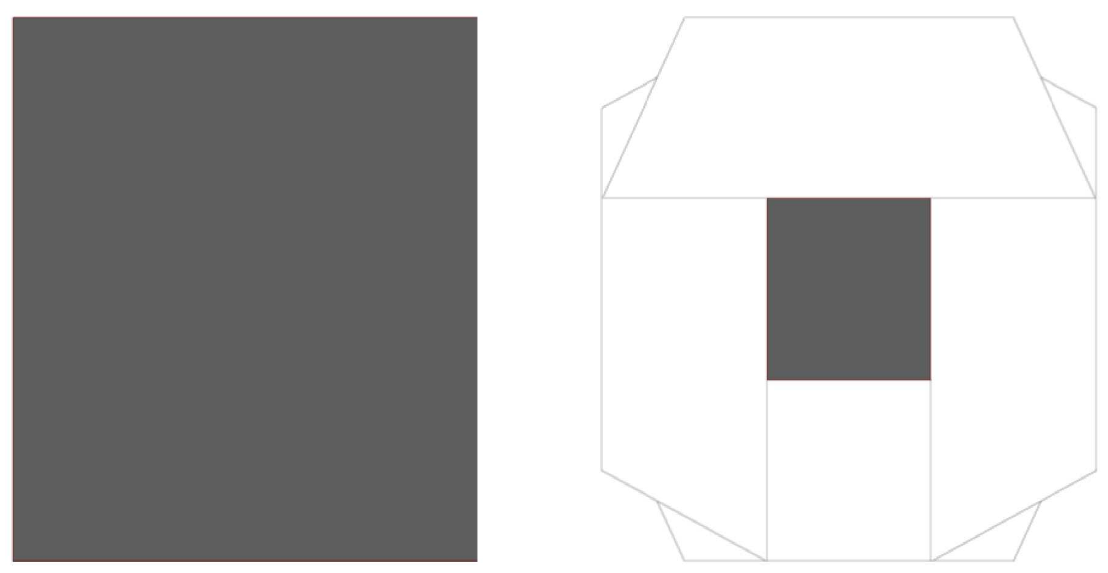


Figure 5: Composite Cube Compared to Primitive Cube

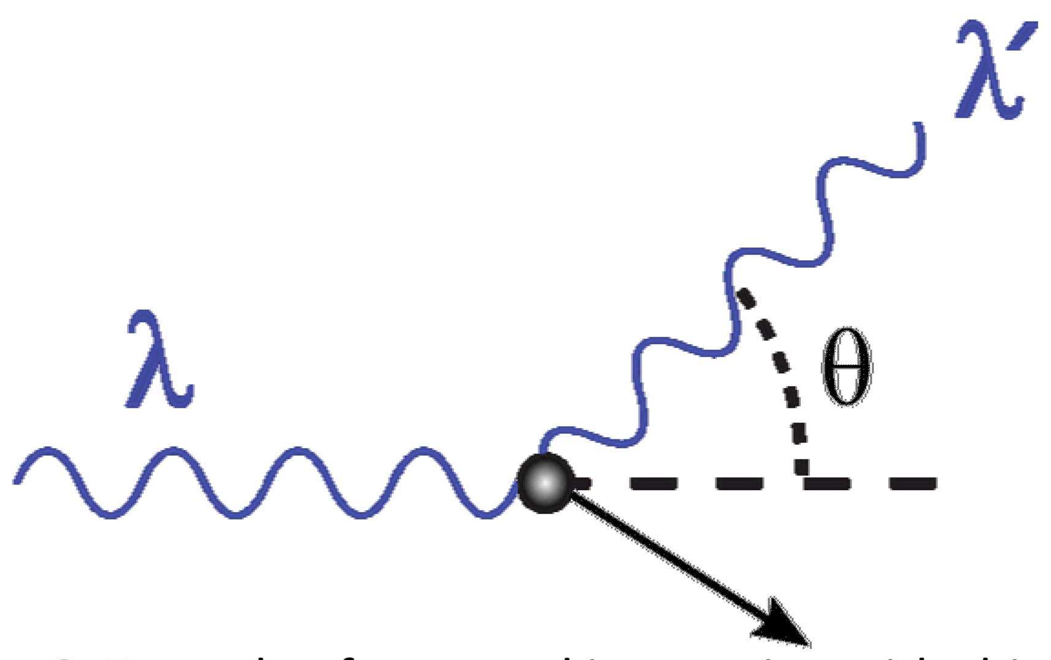


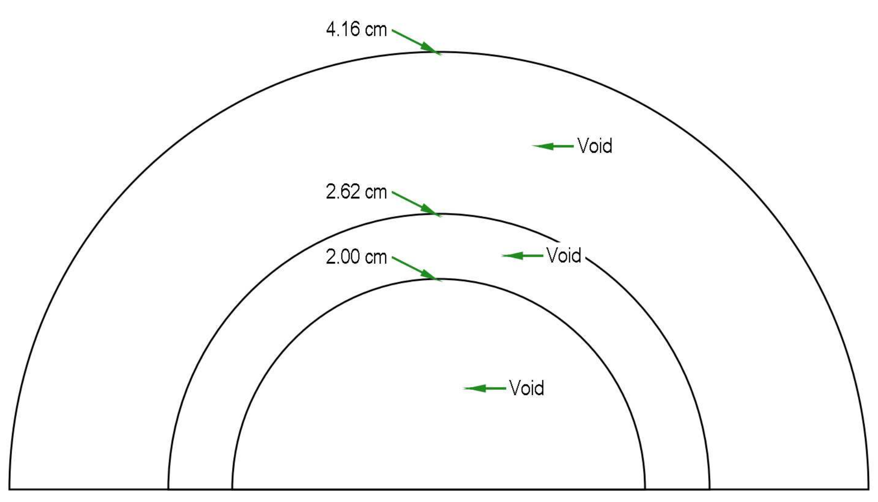
Figure 6: Example of expected interaction with shielding
(https://www.quora.com/What-is-Compton-scattering)

Shielding

Simple shielding models should be consistent across different shapes at great distances. These tests aim to validate the induced source terms, the cross section set and the ray tracer.

Trace sources

By creating simple models out of voids and populating them with trace sources, the test suite aims to validate the volume calculations of the mesher. This helps reinforce that the adaptive mesher is functioning properly for trace source calculations.



Material | Trace Sources

Isotope	Activity	Vary
Cs137	100 uCi	☐
Am241	100 uCi	☐
Co60	100 uCi	☐
Ba133	100 uCi	☐
U232	100 uCi	☐

Figure 7: Trace Source Model Geometry

Conclusion

The project resulted in many errors being found, and fixed, that would have gone unnoticed by manual testing. The test was able to analyze many models in a short period of time for every release since this project was started. This results in a more accurate radiation transport calculation and a more reliable project for the end user.

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