

Battery Powered Radiation Detector

Kyle Kercher
University of Texas at Austin
BS Mechanical Engineer, Spring 2018

Monitoring radioactive materials requires constant collection of data. This detector aims to provide a time dependent radiation spectrum, while being able to run on a minimal amount of power. The purpose of these experiments is to establish a baseline count rate for certain check sources in order to establish efficiency and a noise floor. In addition, during these tests we also aim to validate a new software package, Attila, to insure accuracy on future models.

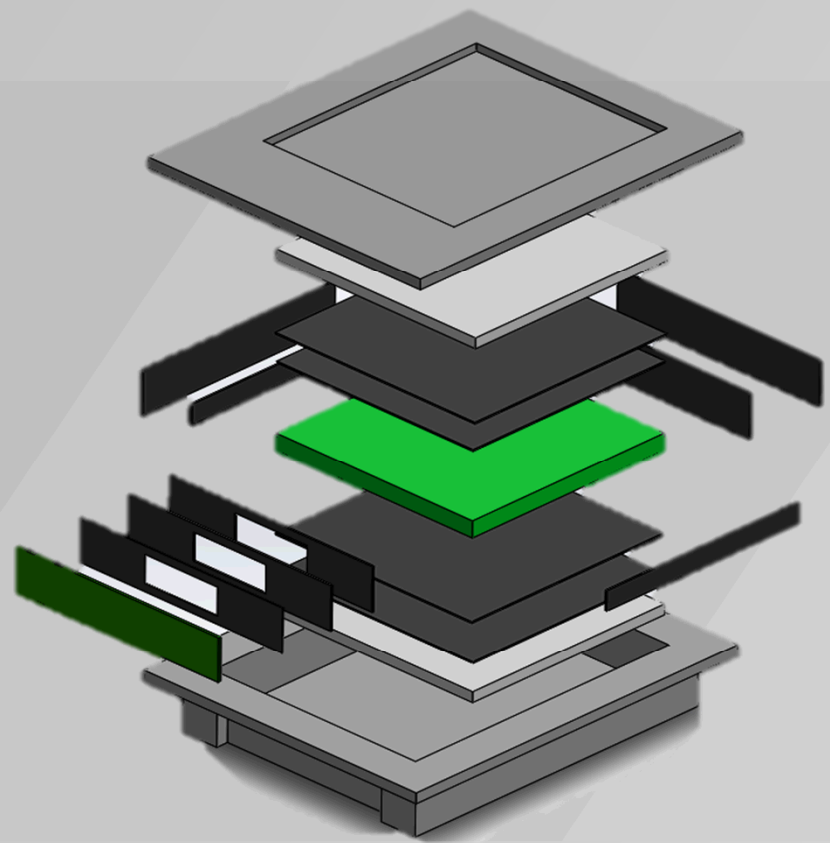


Figure 1: Exploded view of detector

How it Works

The detector utilizes Compton scattering and fluorescence to convert Gamma-rays to optical photons. When radiation is absorbed in the scintillator, the green part in Figure 1, optical photons are emitted. These photons are then reflected by the Teflon wrapping towards a photodiode. The photodiode generates a signal for every photon it sees. However, the photodiodes also see inherent noise from their design. These false counts are normally low energy and can be ignored by creating a noise floor. For the purpose of this report, I established a floor of 50 KeV to both simulate noise reduction and produce easier to read graphs

Modeling efforts

For implementation into MCNP, the design had to be simplified to reduce simulation time. MCNP is capable of handling complicated geometries, however, small details slow down the calculations but effect the calculations a negligible amount. The changes can be seen in Figure 2. The main changes made were to the housing. The screws were removed, as well as their corresponding holes; the O-ring and its corresponding groove was removed; the components from the circuit board and all fillets were removed.

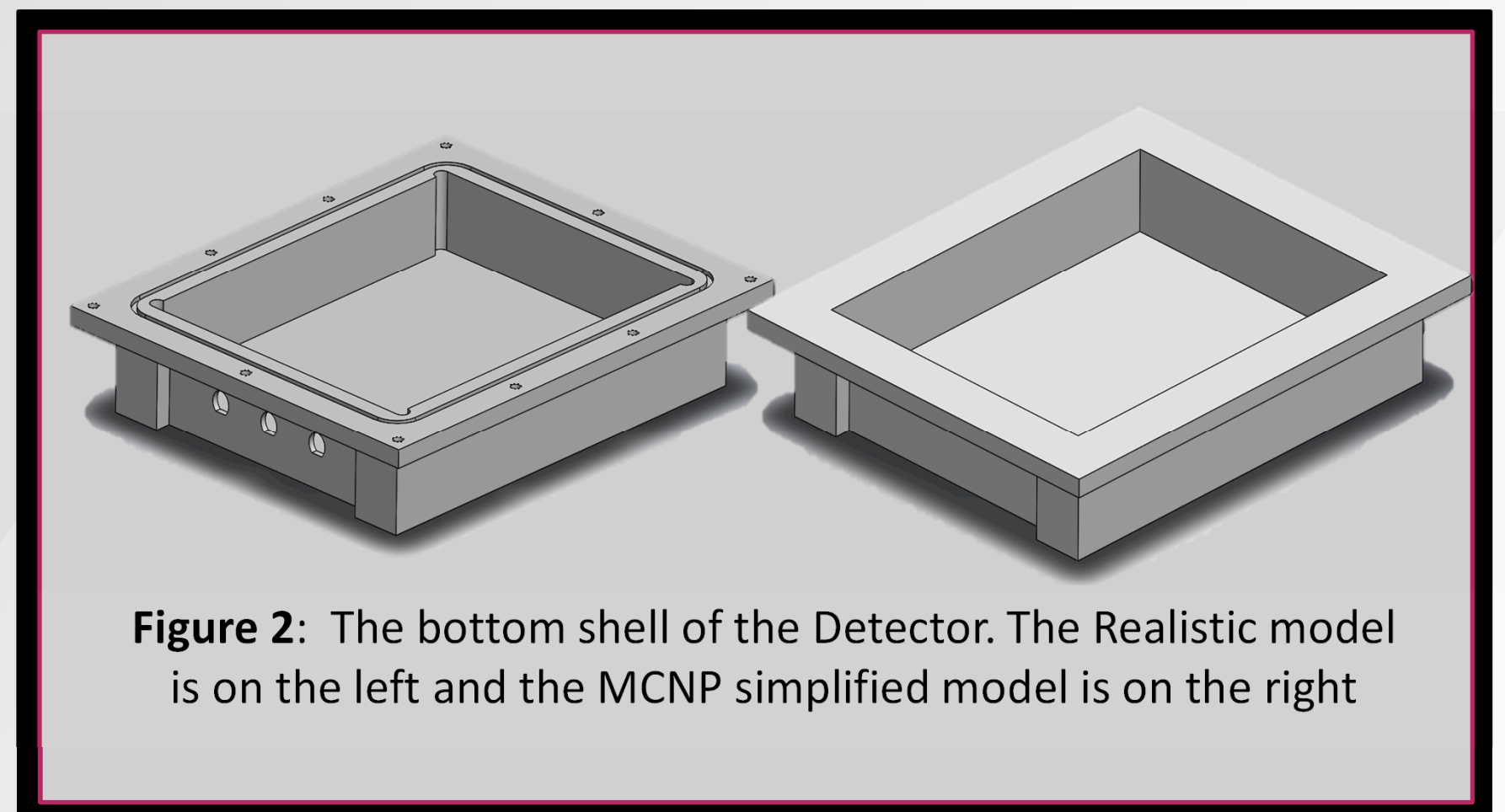


Figure 2: The bottom shell of the Detector. The Realistic model is on the left and the MCNP simplified model is on the right

MCNP Runs

The energy deposition of three one millicurie check sources, Cesium-137, Cobalt-57, and Americium-241 were modeled. The sources were limited to their emissions greater than 30 KeV with a yield of greater than 1% per decay. The sources were modeled in two separate positions: one meter away from the gamma detector window,

located on the back side of the above models, and one meter away from the lid of the detector. The outputs were then converted to counts per second and plotted against their corresponding energy bins as seen in Figure 3.

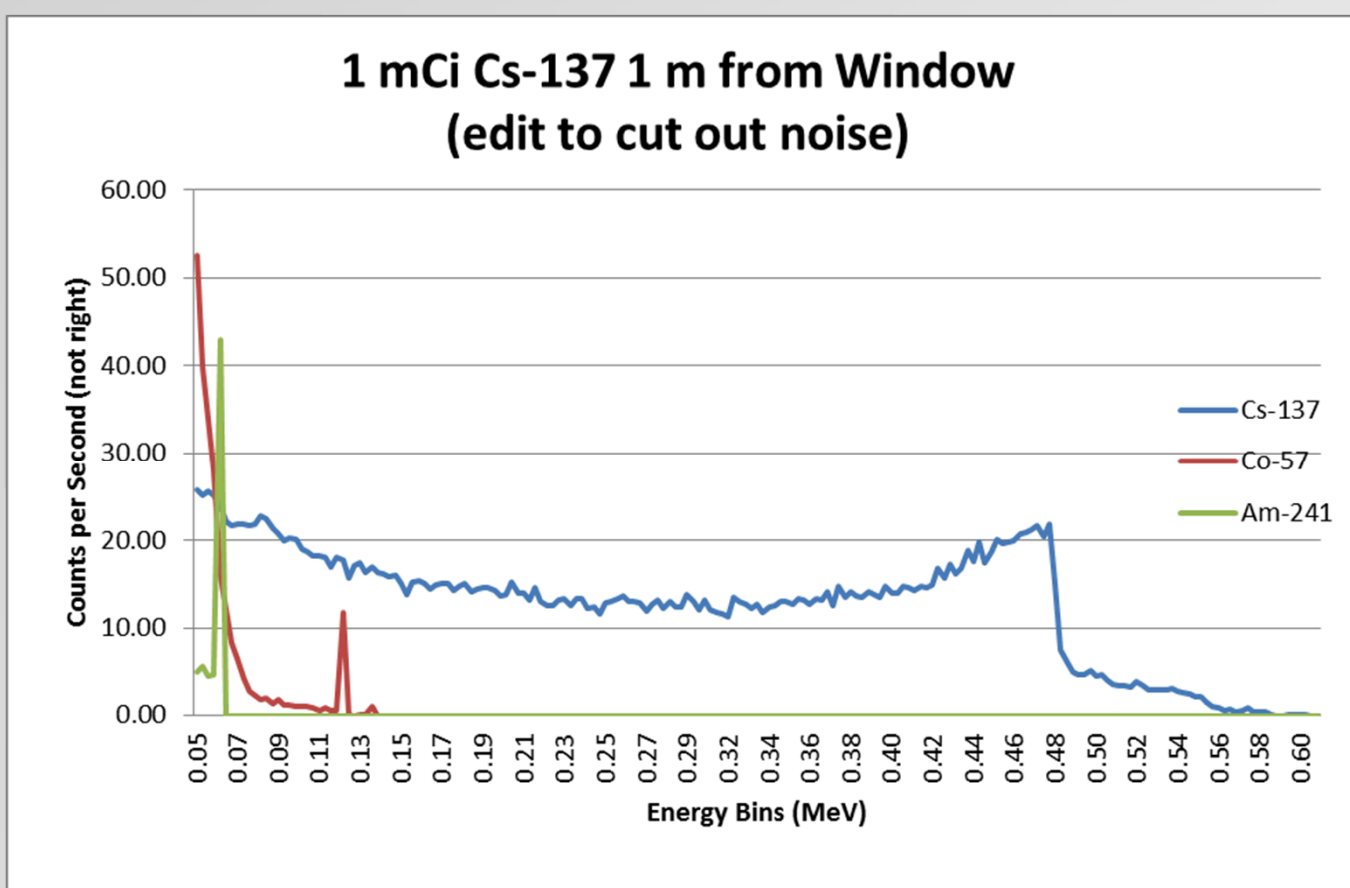
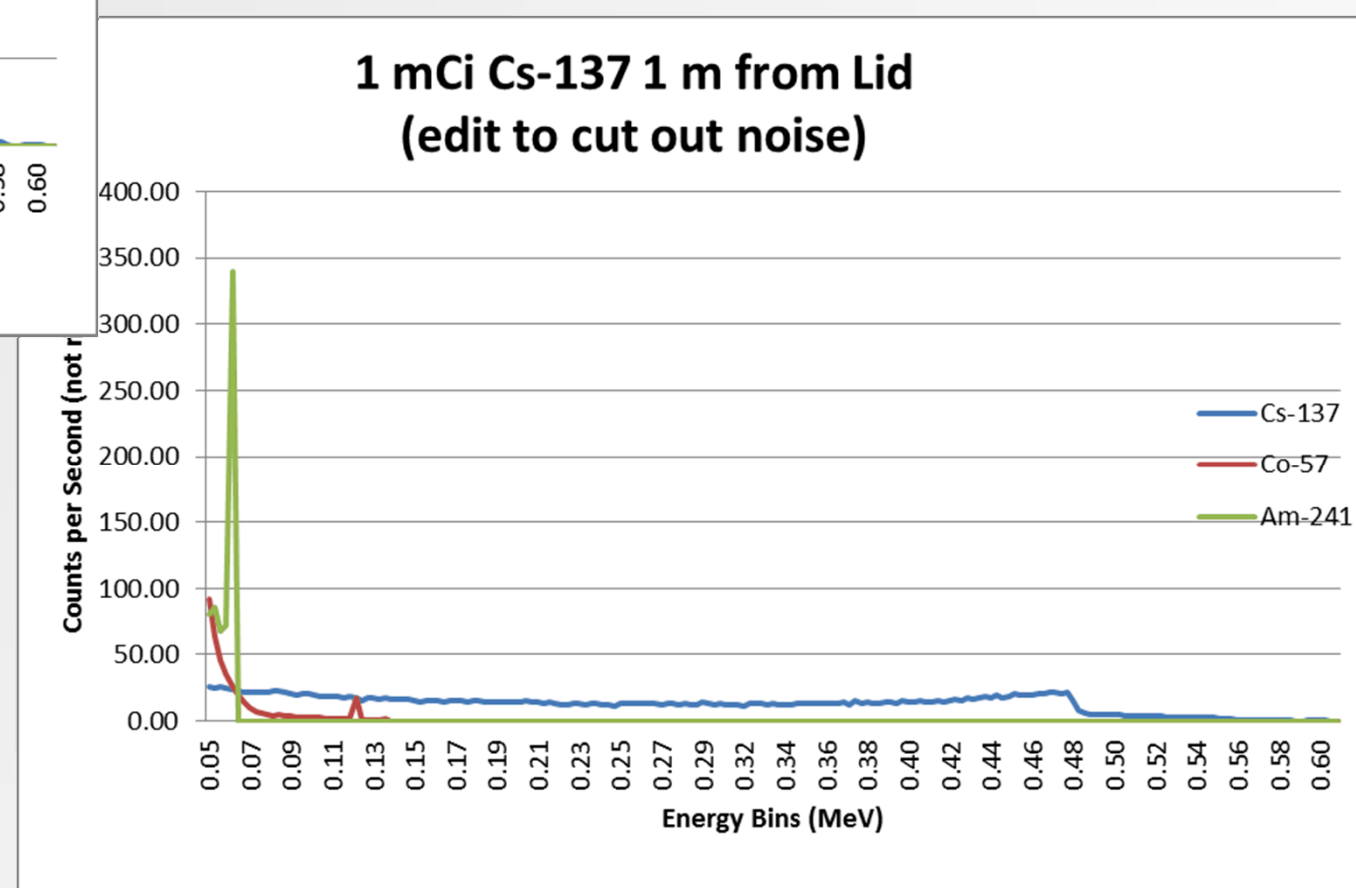


Figure 3: Graphic visualizations of MCNP output files converted to counts per second. The above graph is taken from the gamma window and the graph to the right is taken from the lid of the detector



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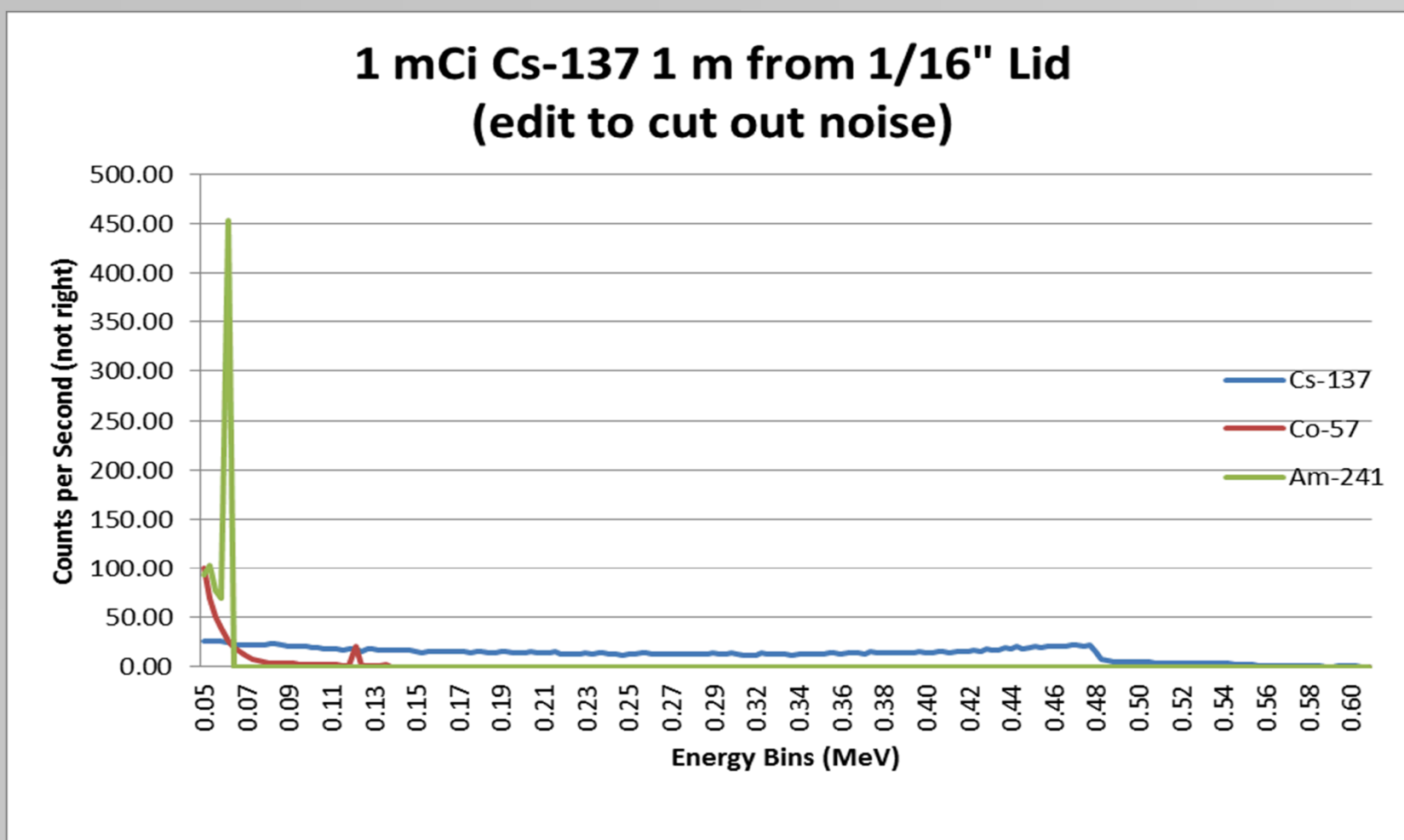


Figure 4: Visualization of Counts per second of different energy groups for the revised lid

Attila Validation

Attila is a software package by Transpire, Inc. that converts SolidWorks files into meshes for use in LANL's MCNP. Attila creates a mesh from the SolidWorks assembly file, and uses the mesh to define the geometric data cards for MCNP. The mesh can be seen in Figure 5. For this experiment, MCNP geometries were created manually and through Attila. The results for a Cs-137 check source in the same two positions as before were compared. As seen in Figures 6 and 7 the Attila results match closely to the output from the manually created deck.

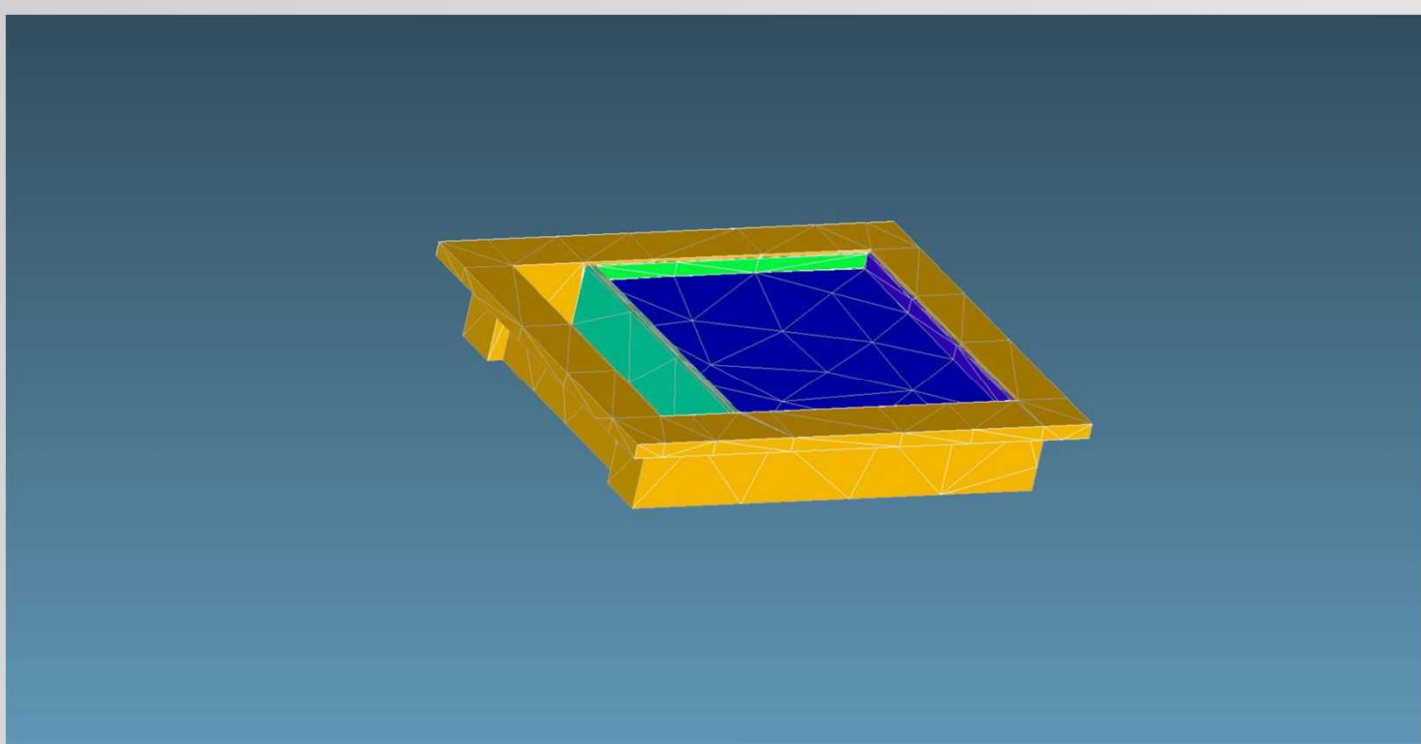


Figure 5: Attila Generated mesh for the detector

Testing & Going Forward

Initial testing of the device presented noise problems. After passing through filters and gain stages, the signal did not produce a prominent spectrum. The variance from the ideal distribution is largely due to large energy signals which caused "ringing" in the amplifier chain as shown in Figure 8. The oscillations cause multiple low energy counts to be recorded. Additionally, MCNP only models energy deposited which does not reflect the complete process. Although these results did not yield the anticipated spectrum, the counts can still be used for the device's intended purpose. The next step is to decrease noise by tuning the electronics and increase optical photon collection efficiency.

Model Revisions to Increase Counts

In order to increase the counts per second from the lid orientation, the lid of the detector was redesigned. Much like the gamma window on the side, the thickness was decreased to 1/16" over the PVT. The results can be seen to the left in Figure 4.

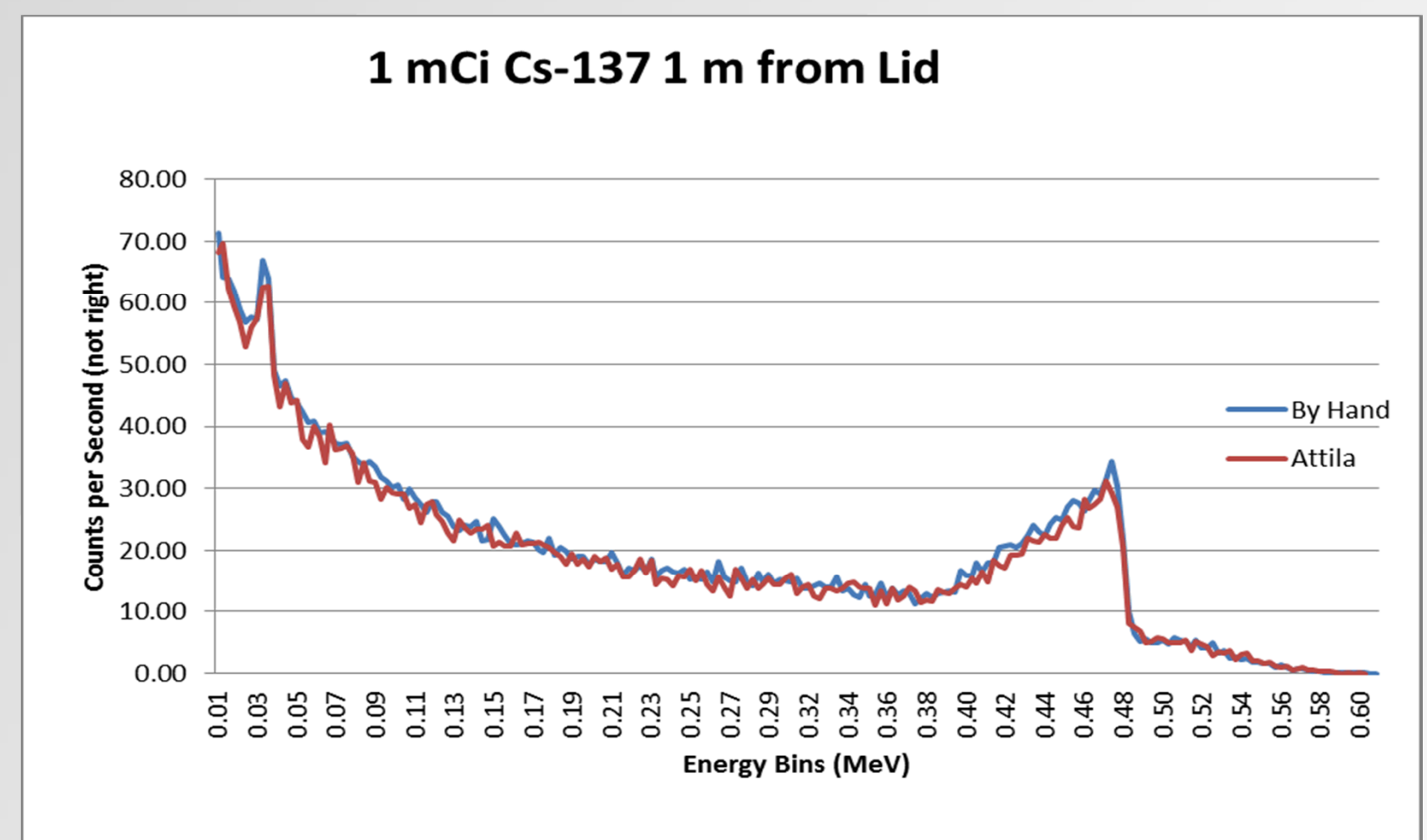


Figure 6: Energy deposition data visualization from MCNP output comparing Attila to hand model from lid

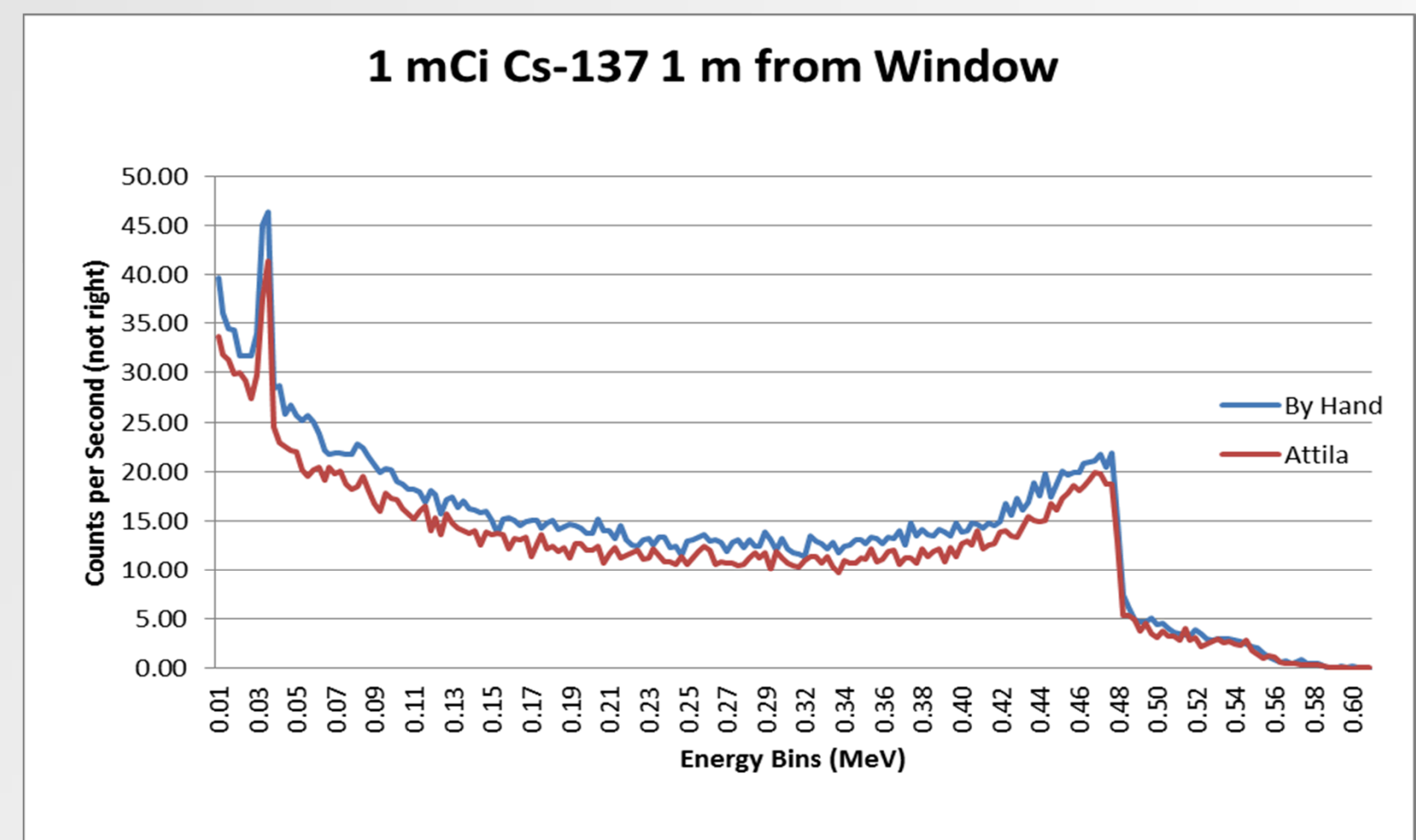


Figure 7: Energy deposition data visualization from MCNP output comparing Attila to hand model from gamma window

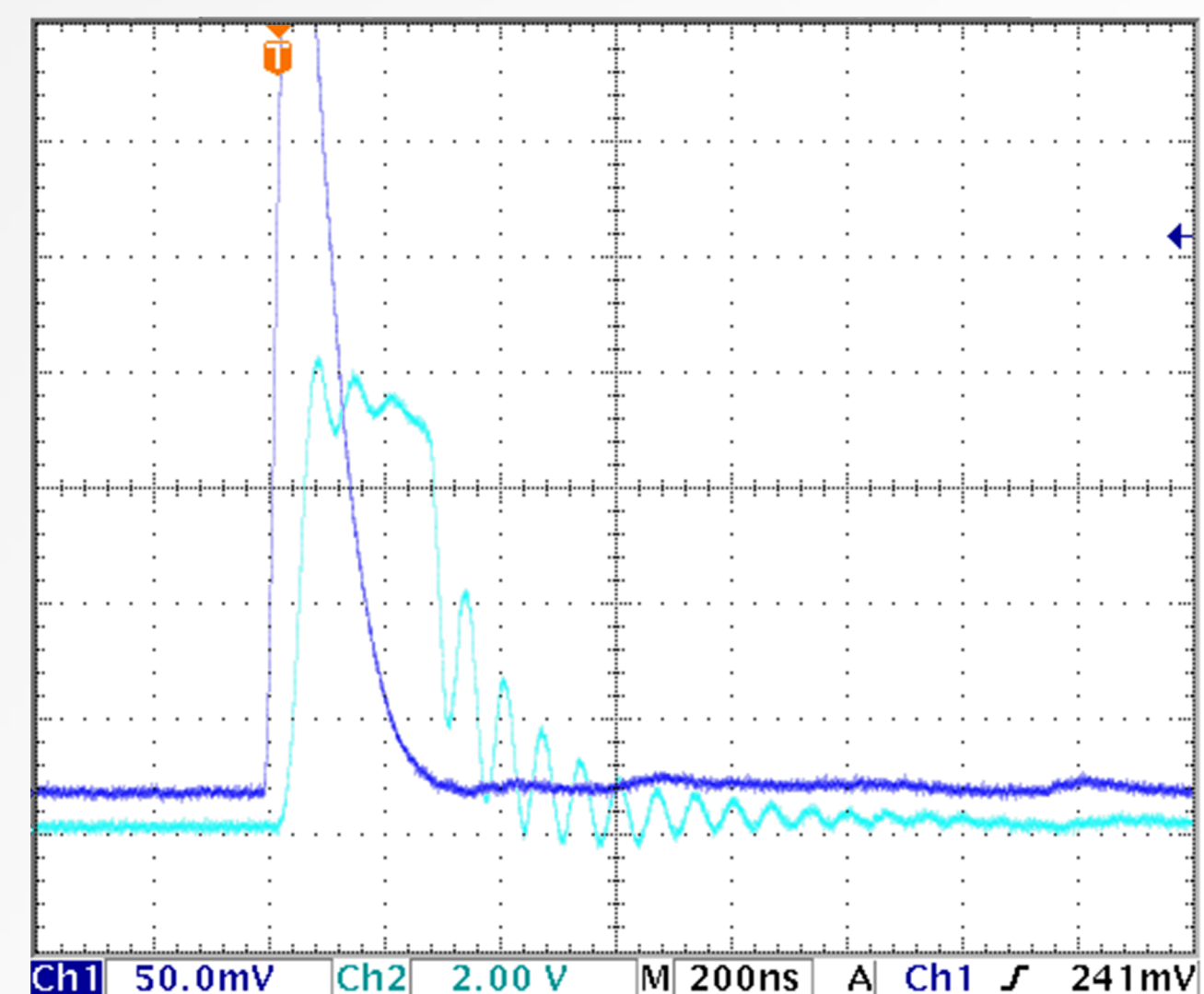


Figure 8: Signal oscillation visualization