The Scintillator-Layered Imaging Microscope for Environmental Research

G. Buchanan[1], M. F. Kidd[1], S. R. Elliott[2], K. Rielage[2], J. N. Murdock[1], R. S. Pirkle[1]

[1]Tennessee Tech University, [2]Los Alamos National Laboratory

Objectives

- Pinpoint, with high position resolution, radioactive decay events with a wide range of energies.
- Develop a Monte Carlo simulation to accurately model the experiment.
- Ultimately, apply the results from SLIMER in environmental research fields, particularly with algae blooms–both preventing their formation, and developing their uses in mitigating atmospheric carbon dioxide.

Introduction

SLIMER's main potential is in the field of microbial ecology: identifying the microbes that process different nutrients within ecosystems in order to gain an understanding of those ecosystems. To this end, SLIMER incorporates a microcolumnar scintillator in a standard fluorescence microscope coupled with an EMCCD camera.

Figure 1: Microscope and camera inside dark box.

A radioactive event interacts with the cesium iodide to create photons, which the camera detects. Events are displayed on a computer screen (see Figure 3).

Materials

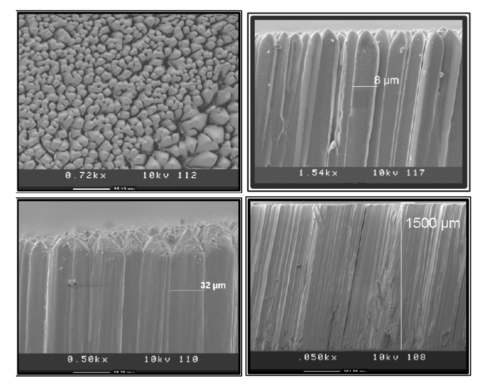

Figure 2: Microcolumnar CsI structure. Photo from [2].

A new EMCCD camera and new objectives were purchased, in order to reduce background noise and improve light collection efficiency. The camera and microscope are set up in a dark box. The camera software are Micro-Manager and ImageJ, an open source camera manager and image analyzer, respectively. The simulation, as well as various macros for image analysis, are written in C++ with GEANT4 and ROOT.

Experiment

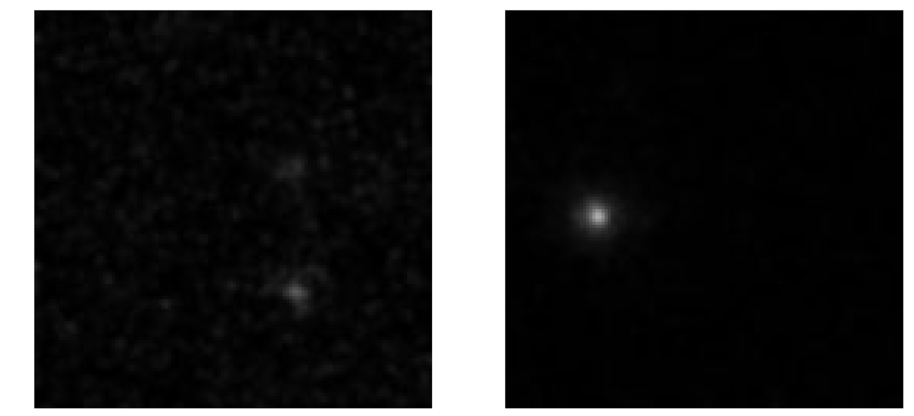

Figure 3: Left: ^{14}C beta event. Right: ^{241}Am alpha event.

Events in the CsI show up in grayscale on the computer screen. Bright, distinct events, such as ^{241}Am alpha particles, are much easier to detect than lower-energy, less distinct events, such as betas from ^{14}C.

Future Work

Being able to determine the position of events is highly important. In the near future, work will go towards determining the spatial resolution for various sources.

Simulation

Simulations are used to find problems with the experiment, and to try different things before changing the physical setup. Data from the simulation can be compared to data collected from the experiment (see Figure 5) and, if needed, changes can be made to the experiment or the simulation.

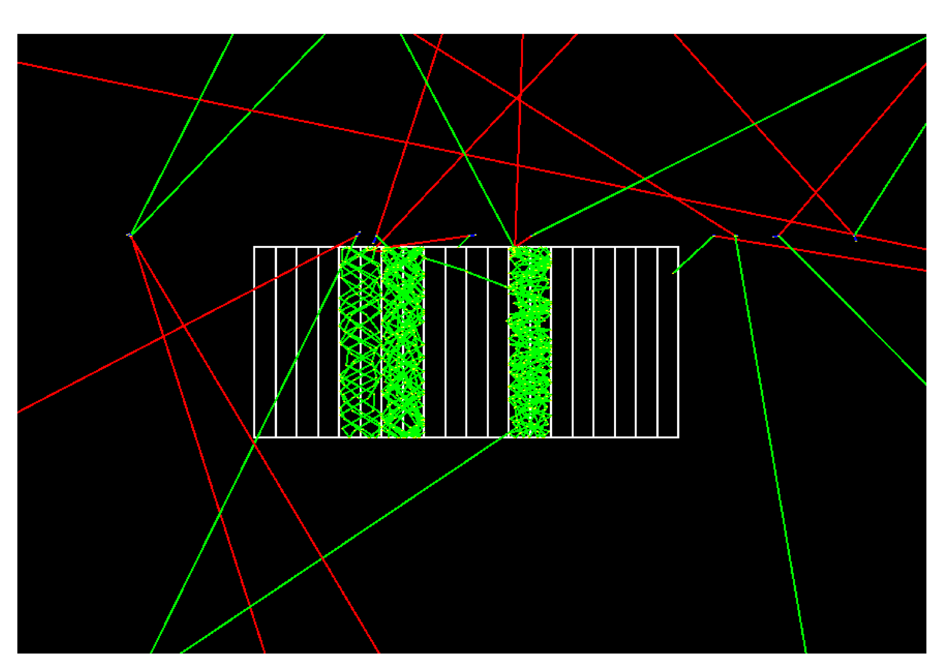

Figure 4: Initial radioactive decay events occurring outside the CsI. Three electrons interact with the CsI to generate photons.

Results

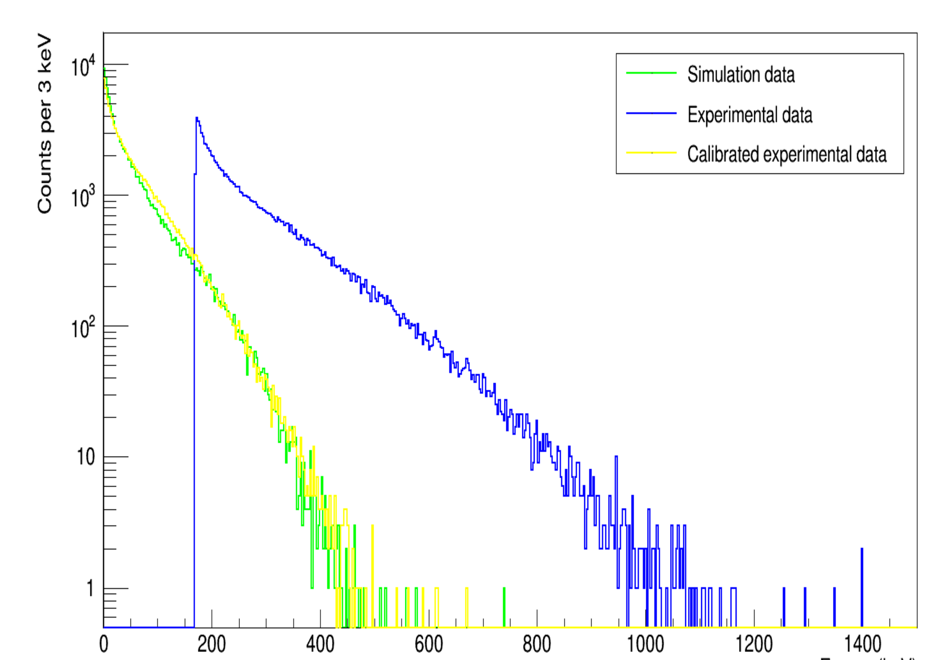

Figure 5: Data from a ^{137}Cs beta source, calibrated with a χ^2/ndf of 7.2.

The data most commonly used comes from ^{14}C, ^{90}Sr, and ^{137}Cs. Data from the simulation is used to characterize the system. A consistent calibration for all different sources has not yet been successful and needs to be explored.

Conclusion

SLIMER has shown its capability to detect different types of radioactive decay. Furthermore, the GEANT4 simulation has proven to be a useful tool in understanding and refining the experiment. The work in progress to calibrate data and demonstrate high position resolution will further the development of SLIMER as a useful tool in microbial ecology.

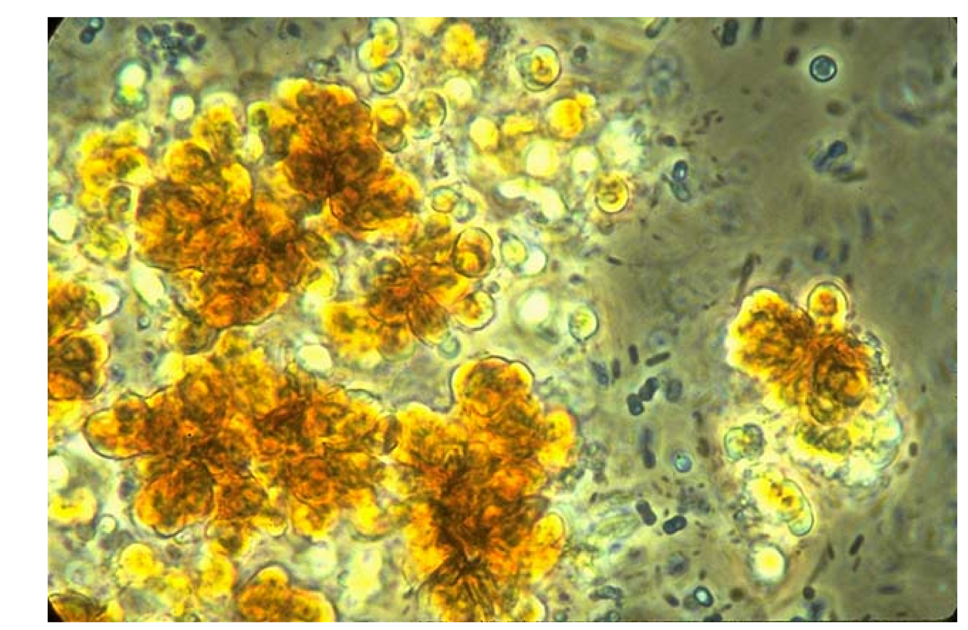

Figure 6: A microscopic view of a biofilm of the type SLIMER eventually plans to analyze. Photo from [3].

References

[1] S. Agostinelli et al. GEANT4 - a simulation toolkit. *Nuclear Instruments and Methods in Physics Research Section A*, 506, July 2003.

[2] S. Miller et al. Recent advances in columnar CsI(Tl) scintillator screens. *Proc. SPIE*, 5923, July 2005.

[3] J. Lennox. Biofilm primer.

Contact Information

- egbuchanan42@students.tntech.edu
- mkidd@tntech.edu
- elliotts@lanl.gov
- rielagek@lanl.gov