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DHS HS-STEM Summer Report

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DHS HS-STEM Internship Summary Report

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Project Outline

I had the opportunity to work at Lawrence Livermore National Laboratory within the MEMS, Electronics, and Photonics Technologies group. I worked under the direct supervision of Dr. Adam Conway and Dr. Erik Swanberg on a semiconductor based gamma ray detector. My work involved automating the experimental setup and data analysis portion of the project to alleviate the researcher's busy schedules.

A semiconductor is a material that has conductivity in between a metal and ceramic. In layman's terms, if you provide it with just enough energy, charge can flow inside of the material. If we impose some form of ionizing radiation such as a gamma ray, we can detect the amount of energy imparted on the system by measuring the amount of charge produced in the material. Figure 1 outlines the process that a semiconductor undergoes to allow us to detect ionizing radiation. Certain materials properties make them ideal for gamma ray detection such as the average atomic number, carrier properties, resistivity, and bandgap energy. I was working with Thallium Bromide (TlBr) detectors for room temperature detection of gamma rays, specifically looking at how different metal electrodes affected the stability of our system.

My work involved automating the stress and voltage tests applied to the TlBr detectors and allowing for easy analysis of the data to determine if the system was still functional.

Achievements

I presented a poster at the Lawrence Livermore National Laboratory poster symposium. With almost 400 posters presented, it was a great opportunity to network with other students across the lab and understand the diversity of the work that a National Laboratory undertakes. The poster symposium convinced me that working in a National Laboratory setting would be an ideal environment. With a large emphasis on research and development, Lawrence Livermore National Laboratory has the unique ability to leverage ties across an academic and industry setting. With a wide variety of disciplines, most of the employees have the ability to shift focus throughout their career to whatever they feel is best suited for them and the nation.

The opportunity to participate in research is priceless as I had the ability to work with some of the brightest scientists in the field of radiation detection. I was able to complete the majority of my goals for this internship. I automated the data analysis by using a program called ROOT maintained by European Organization for Nuclear Research. I also got to test the effect of different contact metals on the stability of TlBr gamma detectors to determine which provided the longest viability. I was lucky enough to work with some of Dr. Conway's longest running gamma detectors. The sample I performed radiation measurements on held the record for longest stability relative to any of their other detectors they have created.

Skills

Coming into this internship, I had a limited background in solid state physics, so I knew I had my work cut out for me. I began to study the different forms of radiation detection that exist specifically looking at semiconductor based systems. High Purity Germanium detectors have been around for over 30 years so why was Dr. Conway trying to look into TlBr? It turns out, that those systems require extensive cooling through mechanical or cryogenic means. TlBr has the potential to be used for room temperature applications. As I continued my background research, I identified the past problems that had prevented the use of TlBr detectors and how Dr. Conway's team had mitigated those problems. From their current state, I went over the analysis on which future pathways TlBr could be utilized.

Arriving at the internship, I was exposed to many analytical techniques that I had never utilized before. To determine the electrical characteristics of each semiconductor, I was able to produce Current vs. Voltage (IV) curves to determine if the semiconductor was made from a viable material as seen in Figure 2. I had the opportunity to use sealed radiation sources to determine each semiconductors ability to identify a specific gamma ray as seen in Figure 3. I worked with both planar and pixelated semiconductors to determine which was best in a specific application. I had the chance to run my own experiment and test how oxygen and humidity affect the semiconductors physical appearance as seen in Figure 4. Due to preliminary results from that portion of the project, Dr. Conway plans on expanding testing in oxygen deficit environments via dry nitrogen. I also had almost no experience utilizing C++ for data analysis, but due to project specifications, I learned to use ROOT, which is a C++ based programming language. ROOT was used to fit our radiation testing data to determine the stability of our system over time and potentially find indicators for future failure as shown in Figure 5. An overview of my main test station is shown in Figure 6.

Career Planning

After having the chance to collaborate with some of the brightest scientists in the field of radiation detection, I decided that pursuing doctoral work in the future is not the right path for me at the moment. All the lab employees have diverse backgrounds in how they arrived at the lab with industry and academic roots; however they all hold the ability to shift between multiple disciplines. A prime example of this unique ability is Scott Perfect, the Chief Mechanical Engineer for the Engineering Directorate. Scott came on from the Oil Industry with a MS in Petroleum Engineering. After years of work at the lab, he has been able to shift between multiple projects to truly understand the breath of diversity that Lawrence Livermore National Laboratory offers. As of now, I am content with pursuing my masters; if I do pursue doctoral studies, it would be in a skillset that can be applied to multiple disciplines such as rare events detection or imaging.

I would not have been able to acquire such insight if it had not been for the programming that Lawrence Livermore National Laboratory offers. Through events such as the Engineering Capability Leadership Brown Bag Luncheon, I learned about how systems engineering is essential to maximizing productivity within a multi-disciplinary team; employees constantly need to be influencing the vision of the lab to introspect on where we are and where we should be.

One of the best parts about Lawrence Livermore National Laboratory's is that each of the employees takes ownership of their workplaces. When they see something that can be improved or is being utilized in an improper way, they will speak up. The unity within such an organization makes it a natural place for collaboration. The National Laboratory system would be an ideal place to work because they strive for innovation without fostering an overly competitive environment.

Potential Expansion

I think the Department of Homeland Security did a great job in determining areas that are critical for their mission. With a wide range of fields from Electrical Engineering to Epidemiology, they are able to strive for technical innovation. However I believe Department of Homeland Security can expand their focus by looking into safeguards policy. Coming from Lawrence Livermore National Laboratory, nuclear safety is of prime importance. From stockpile stewardship to treaty verification, there seems to be a large gap left between R&D and the actual implementations of new technologies. If we can bring together future policymakers and technical experts, we would be able to generate more viable solutions. By reflecting on current IAEA and CTBTO programs, the Department of Homeland Security should attempt to bridge the gap by bringing researchers into the policy setting; be it by expanding host sites or by incorporating new programs such as the Summer Internships in International Nuclear Safeguards Policy from the Monterey Institute of International Studies.

On top of safeguard studies, I think there needs to be a greater push towards computational physics for Homeland Security research. The Terascale Simulation Facility and National Atmospheric Release Advisory Center at Lawrence Livermore National Laboratory work on mixed threat modeling. However there was no opportunity to work with such facilities through the DHS HS-STEM program. If the program could expand to utilize such critical facilities, it would be invaluable to students.

Images

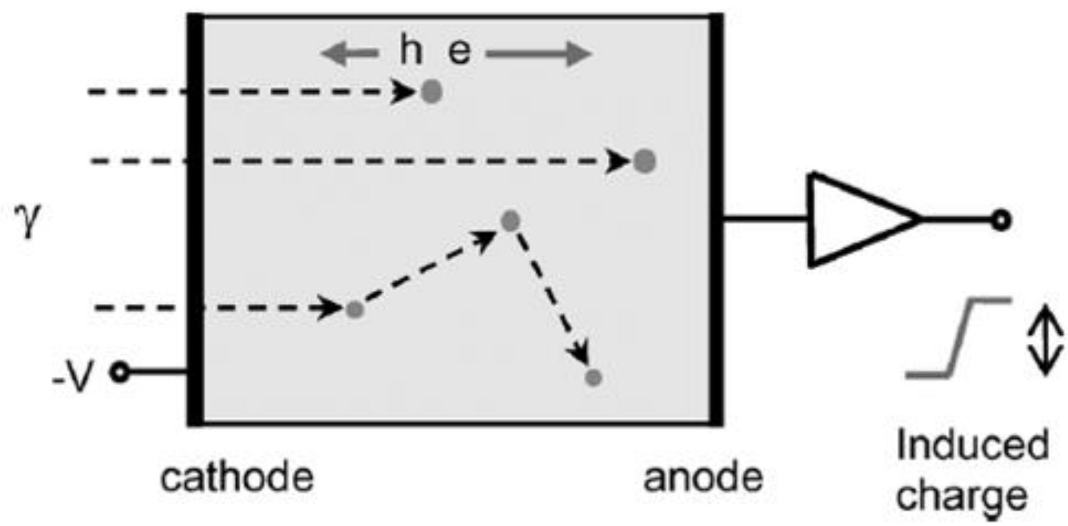

Figure 1: Electron- Hole pairs are excited in a semiconductor detector by ionizing radiation and carried away by an internal electric field created by an applied voltage. The induced charge is measured to determine the amount of energy deposited

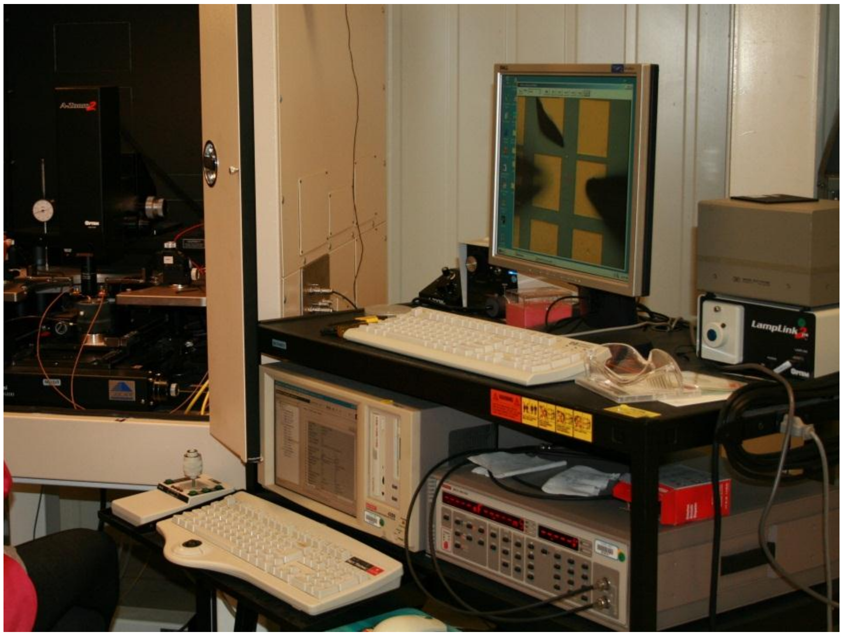

Figure 2: Keithley Semiconductor Characterization Station used to determine electrical properties of TlBr

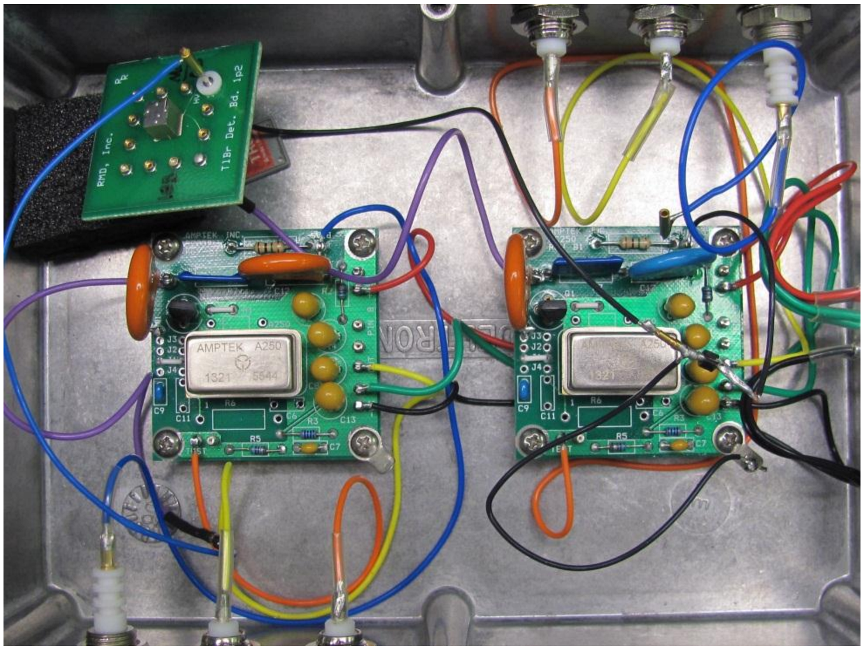

Figure 3: Radiation testing on pixelated TlBr detector to determine its ability to identify Americium-241 60 keV photopeak

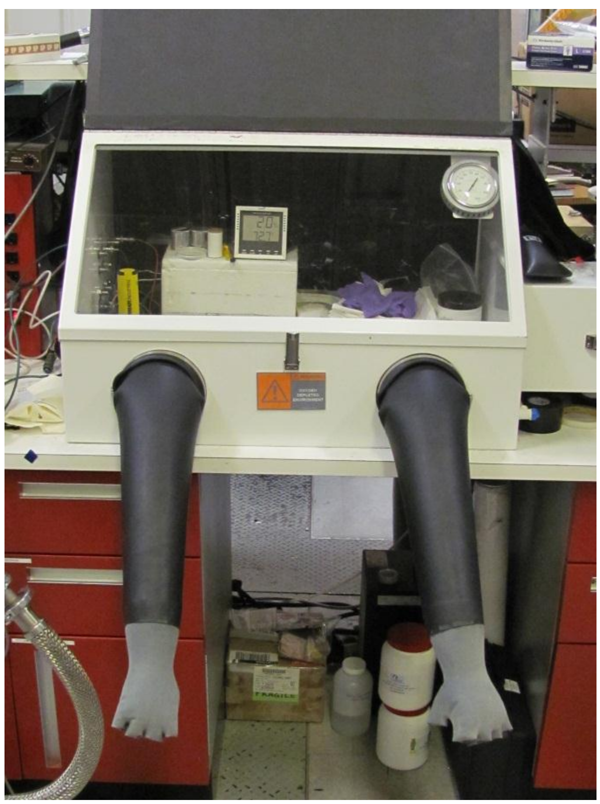

Figure 4: Oxygen Depleted Glove box used to determine the effects of oxygen and humidity on the performance of TlBr detectors

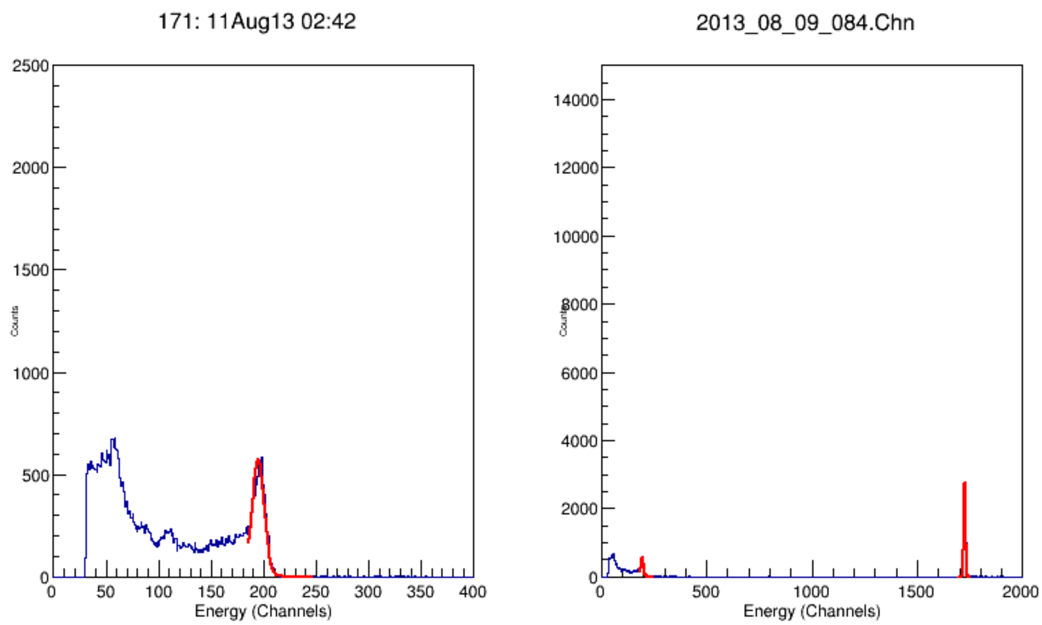

Figure 5: ROOT algorithm used to determine TlBr's ability to determine various sealed radiation sources

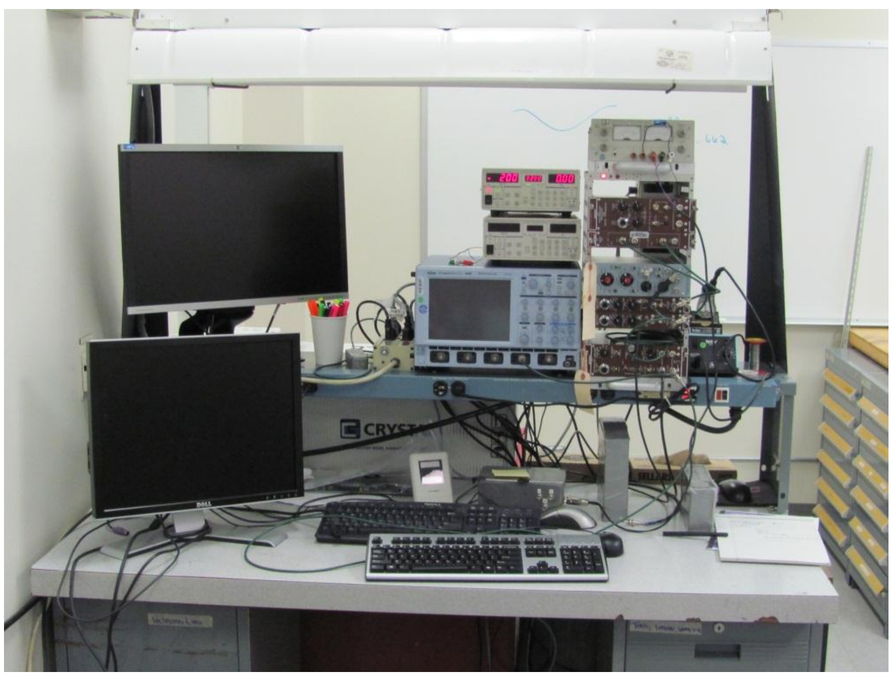

Figure 6: Workbench and storage for TlBr gamma ray testing.