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U.S. DEPARTMENT OF ENERGY | Office of SBIR/STTR Programs

DOE SBIR-STTR SUCCESS STORY

So, what *is* a germanium gamma ray detector and why is it important?

According to Ethan Hull, CEO of DOE SBIR awardee, PHDS Co., "High-purity germanium detectors provide the highest resolution (specificity), detection and identification of gamma rays for applications ranging from nuclear physics to nuclear forensics."

PHDS Co. FAST FACTS

PHASE III SUCCESS
After nearly 20 years, 20 DOE SBIRs, and support from DOE National Labs, PHDS Co. achieved 8-figure revenue in 2021 with continued expansion in 2022 and beyond.

IMPACT
PHDS Co.'s unique portable gamma ray detection products have fundamentally changed radiation detection for public safety, military, and industrial applications.

DOE PROGRAM OFFICE
Office of Nuclear Physics

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Germanium detectors are fragile, expensive, and complicated to make and use. However, the isotope identification results are worth the required effort: the detectors yield information that is extremely important to nuclear physicists for their research and for nuclear security missions. Germanium gamma ray detectors are also important to law enforcement, national security personnel, first responders and nuclear waste-management personnel in the identification of nuclear materials. The information from a germanium detector is the final word confirming the presence of fissile materials that may be used in the construction of nuclear weapons. Gamma ray signatures coming from the nuclei of the uranium and plutonium atoms can't be faked.

Prior to founding PHDS Co. with Dick Pehl nearly 20 years ago, Hull was a researcher at two national labs – Lawrence Berkeley National Laboratory and Lawrence Livermore National Laboratory. Hull reminisces, "I was at Berkeley Lab and I was lucky to work with the pioneers in the germanium detector instrumentation crystal field. I learned the art of semiconductor detector fabrication and electronics design from them. They were the wizards who originally invented this technology in the first place." For PHDS Co., the DOE National Labs were very accommodating places to be early on. In addition to the deep well of scientific talent at the labs, the labs also possess unique instruments and facilities, many of which are found nowhere else in the world. Here is how Hull views it: "The way it works at a lab is you make a few prototypes and then you need to commercialize your technology."

The SBIR program has been a critical piece in the advancement of PHDS Co.'s technology from lab to market. Per Hull, "the SBIR Program has been a very key resource, particularly in the early years. The Office of Nuclear Physics (NP) has been incredibly generous toward us and at the same time we've always tried to show the connection between the commercial products that we have developed and the program's mission." In the funding world, the SBIR program is considered 'patient' capital compared to private angel investors or venture capital firms. The SBIR program does emphasize return on investment for the SBIR program, but DOE does not take equity stakes or require certain rates of return. Hull sums it up, "the SBIR program understands new science is difficult; that science can take a long time. The easy stuff has all been done."

PHDS Co. has won 20 DOE SBIR grants over the past 20 years, totaling just over $8M. PHDS Co. has also won additional SBIR grants from Department of Defense and Department of Homeland Security. The most significant technical hurdle surpassed by PHDS Co. using an SBIR grant involved the development of germanium crystal and detector technology to commercialize large diameter planar germanium detectors having both excellent spatial and energy resolution. These detectors can be used for in-beam gamma ray spectroscopy and radiochemical separations at the frontier of nuclear physics research. At the same time, these detectors have been adapted to be gamma ray location, identification and quantification tools for non-nuclear physicists performing extremely important tactical missions.

Two of PHDS's early products were the Germanium Gamma Ray Imager and the NP Imager. According to Hull, "These two products have unique capabilities some of which we were working on when I was back at the labs." The original gamma ray detector prototypes were 500-lb. devices that had to be moved around on a cart. Although interesting as a science experiment and practical for lab use, the devices were impractical for wider market use in the field. PHDS Co. took the 500-lb. functional prototype from the lab and developed a 15-pound device you can carry in one hand. Per Hull, "We took the fundamentals that the Berkeley team came up with and packaged them in a compact way with additional features so that anybody can have access to this technology."

PHDS Co. is a vertically integrated manufacturer. However, the production processes are very challenging. Hull states, "Sometimes I say that we take rocks out of the ground and sell a software answer on the screen of a tablet or phone. We buy germanium metal. We refine the germanium.

We grow it into a crystal. We cut it up with a big saw, and then make it into a shape for a detector." From there, crystals are loaded into a cryogenic system including a compact cooler to maintain the germanium detector in the 77-100 K regions to allow it to perform as a gamma ray detector. Working around and with germanium detectors is challenging; yet they are the only spectroscopic gamma ray detector system that really works.

In 2021, the company shipped 55 detector units at an estimated selling price of $100,000 per unit. As for future growth, Hull says, "There may be more aggressive people out there who would say that we could be doing this faster. The technical details of our manufacturing process have given us enough of a challenge that I'm glad we haven't had to grow faster." Last year Hull estimates that the firm could have absorbed 1.5 times the orders we had the previous year. This year, if the firm had gotten 1.5 times the orders they had gotten, the company might have experienced greater difficulty and possible product delivery delays. PHDS Co. needed to scale certain functions around the manufacturing and delivery of the product, including sales support, supply chain, logistics, customer support, and finance functions which takes cash.

Hull states, "We've always managed ourselves in a cash conservative manner that we have never needed to do anything terribly sophisticated finance-wise. We are debt free and 100% founder-owned." Right now, Hull is happy growing with the orders the company gets. PHDS Co. is putting a lot of effort into their 2022 summer sales. As of August 2022, PHDS Co. is a revenue-generating employer of 15 personnel in Knoxville, TN. For the record, you do not need a deep-science PhD to work there. Four of the 15 employees are PhDs; the rest are manufacturing, sales and administrative personnel.