Project ID: **60141**

Project Title: **Gamma Ray Imaging for Environmental Remediation**

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1999 Technical Progress Report

Gamma Ray Imaging for Environmental Remediation, EMSP Project 60141

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Research Objective. The goal of this project is the development of field portable gamma-ray detectors that can both image gamma rays from radioactive emission and determine the isotopic composition by the emitted spectrum. Most instruments to date have had either very good imaging with no spectroscopy, or very good spectroscopy with no imaging. The only instruments with both imaging and spectroscopy have had rather poor quality imaging and spectroscopy (e.g. NaI Anger Cameras). The technology would have widespread applications, from laboratory nuclear physics, to breast cancer imaging, to astronomical research. For this project, we focus on the applications in the field of fissile materials, spent nuclear fuels and decontamination and decommissioning.

Research Progress. The project consists of developing an array of double-sided germanium strip detectors. The project has been progressing on three fronts:

- the development of a prototype system using existing germanium detector technology;
- the development of a new contact technology on germanium strip detectors to allow for finer strips (and better imaging) in the future;
- and survey and simulation work to prepare for a field trial.

Figure 1. Ge detector array in test. Four detectors are mounted in 2 x 2 array. Preamps are enclosed in housing and readout by connectors on sides.

The main hardware effort consists of a developing a gamma ray detector with 100 square centimeters of active area with 2-mm pixellization and 2 keV energy resolution. The detector consists of a 2×2 array of germanium wafers (Figure 1), each with 5×5 cm of active area. The germanium crystals have 2mm wide strips, orthogonal on each side, generating the 2×2-mm pixellization. The electronics from adjacent detectors are daisy-chained together, thereby cutting the required electronics in half. Figure 2 shows the detector during final assembly at the factory. After some delays, it is now undergoing final testing and should be in our hands soon.

We have successfully fabricated, for the first time, a double-sided orthogonal strip Ge detector using the amorphous contact process. The detector has an active area of 16 mm x 16 mm and a thickness of 10 mm. The entire detector was coated with a layer of amorphous Ge. The strip electrodes were formed by evaporating Au on top of the amorphous layer through a shadow mask. The present design has 5 linear strips at 3-mm pitch on

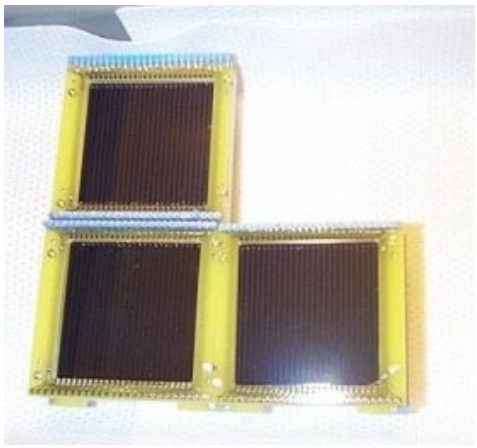

Figure 2. Three of the four Ge strip detectors are shown during assembly.

Figure 3. Prototype amorphous contact Ge detector in test cryostat at NRL.

each side of the detector. The strip width is 2.5 mm and the gap between strips is 0.5 mm. Electrical connections to the strips were made using ultrasonic wire bonding. Figure 4 shows results obtained by scanning collimated 60 keV gamma rays along the length of a strip electrode on one side of the detector. Plotted are the integrated photo-peak counts from that strip and from a strip on the opposite side of the detector. These results will be presented at the IEEE Nuclear Science Symposium in the fall of 1999.

A preliminary field investigation of a possible test site for our prototype imaging system was performed. The Defense Nuclear Weapons School at Kirtland Air Force Base has multiple sites that were seeded with radioactive thorium to simulate a nuclear accident. Of the eight seeded sites, four are no longer active. Two of these four are available for surveys. They are sites TS-7 and TS-8. These sites were surveyed, three different ways:

- A large number of activity measurements were taken on a two-dimensional grid and activity maps were generated.
- A geo-magnetic survey was performed using a Portable Surface Towed Ordnance/Object Locator (STOLS) system to locate buried metallic objects.
- Several soil samples were taken and the emitted radiation was analyzed with Germanium detectors to determine the radioactive isotopes. As expected, the isotopes were Th-232 decay products. The survey also showed that most of the contamination was in the top 6 inches of soil.

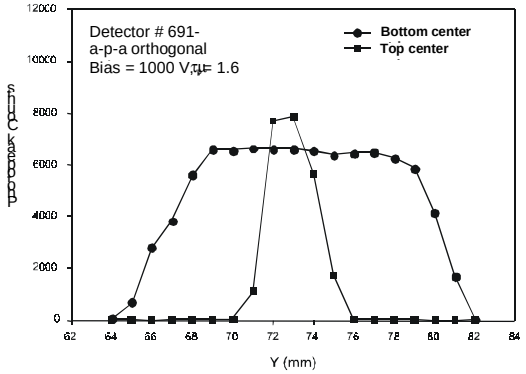

Figure 4. Position sensitivity of amorphous Ge detector. The count response from orthogonal strips is shown.

A preliminary field test plan was also prepared.

We have also been in contact with a group at Lawrence Livermore National Laboratory to discuss the possibility of using our new detector array to demonstrate the imaging of a plutonium button.

Planned Activities: As soon as the 2x2 array detector is delivered, we will test its performance, in terms of energy resolution and imaging resolution. We will instrument it with preamplifiers, shaping amplifiers, analog to digital converters, and readout the data into a PC. We will then test the array with collimators and coded apertures to demonstrate imaging at low energies. We will also combine the array with an existing germanium strip detector to demonstrate a Compton telescope configuration. This will allow us to demonstrate a large field of view, MeV energy imager with good spatial resolution.

We will also manufacture a larger detector with the amorphous technology. We are planning to manufacture a detector identical to the ones in the 2×2 array, i.e. 5×5×1 cm active area, with 2 mm strips orthogonal on each side of the detector. If this detector works, it will prove unambiguously that the new contact technology is interchangeable with the standard technology

We will demonstrate the imaging capabilities of the system with simple uranium and plutonium pieces available at the Naval Research Laboratory. We then plan to image pieces of interest to the environmental remediation program such as plutonium buttons and spent fuel rods.