



RADIATION DETECTION CENTER / Lawrence Livermore National Laboratory

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RADIATION DETECTION CENTER TECHNOLOGY FACT SHEET

Gamma Ray Imaging

Lawrence Livermore National Laboratory is developing several gamma ray imaging systems that can take “pictures” with gamma-ray light. These cameras can detect weak radioactive sources that would otherwise be hidden by the natural background of gamma-ray emissions. In addition to their use for detecting nuclear weapons, these instruments will also be used in space to search for black holes at the edge of the universe, and in hospitals for better detection, diagnosis and treatment of cancer. Two types of these detectors are being developed: the GRIS systems will be in use in the next year while the Compton Cameras are higher performance longer-term projects.

GRIS: the Gamma-Ray Imaging Spectrometer works like a high-efficiency pinhole camera to “photograph” radioactive sources. Developed to assist arms control inspectors unobtrusively verify nuclear warheads in missiles, this gamma-ray camera is now being used in counter terrorism applications. By taking “pictures” of the natural background while search for nuclear materials or weapons, the sensitivity of these instruments is about ten times better than non-imaging detectors. A very large version is under development that can detect nuclear materials or weapons up to 100 meters away.

Compton Cameras work without collimators or pinholes. Instead, they track the gamma rays as they scatter inside the detector like the ball in a pinball machine. By measuring the “pings” as the gamma-ray “balls” bounce through the detector, the system can figure out where the gamma rays came from. This results in a “photograph” with 100 times more sensitivity for dim gamma-ray sources than non-imaging systems. Compton cameras can measure gamma rays from nearly all directions at once, which is particularly useful when you are searching for nuclear materials or weapons that could be hidden anywhere. The Laboratory is testing Compton cameras made from different shapes of germanium, and is developing other solid state systems using silicon and compound semiconductors like cadmium zinc telluride. To detect nuclear materials at distances beyond 100 meters, a very large Compton Camera is required. Systems using gas or glass fibers as the detection medium are under investigation for this purpose.



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Cargo Container Screening

The Laboratory is developing techniques using neutron beams to unobtrusively probe large cargo containers for the presence of nuclear material or weapons. These techniques are intended to help screen shipping containers before they leave U.S. ports for their destinations further inland. Improvements to existing commercial systems are being tested, and new techniques are being evaluated that use advanced portable neutron generators and portable linear accelerators. Both radiation transport modeling and experimental measurements are being used to determine characteristics of special-purpose radiation detectors designed for screening these containers.



Long-term Neutron Monitoring

Neutron detectors using GaAs-based semiconductors are being developed to monitor cargo containers for nuclear materials during long ocean crossings. These solid-state devices are small, low costs, operate at low power so large numbers can be installed and little maintenance is required. Prior to reaching their destination, cargo ships with these detectors aboard would have the instruments report their measurements to determine if the ship requires further inspection before docking.

Electro-Mechanically Cooled Germanium Gamma-Ray Detectors

Laboratory gamma-ray detectors made from germanium are the mainstay of high resolution nuclear spectroscopic measurements. The spectrum of gamma radiation is a unique signature of nuclear species. High resolution measurements enable detecting these signatures in high background environments. Unfortunately, these germanium detectors require cooling to -300° F, which is typically done with liquid nitrogen. While this is not a problem in the laboratory, it can be very difficult in the field. The laboratory has developed several germanium detector systems cooled by compact low power refrigerators. A self-contained portable model will soon be manufactured commercially, and higher performance versions are under development.

Growth of AlSb Crystals for Room Temperature Gamma-Ray Detection

Techniques to grow high-purity crystals of aluminum antimonide (AlSb) are under development. When crystals of the desired quality are produced, they will be made into gamma-ray detectors. These AlSb detectors should operate at room temperature with nearly the same high performance that is only currently available in instruments that require cooling to -300° F, which is usually done with liquid nitrogen.



RadNet: Hand-held Cellular Phone Radiation Network

A low-cost handheld instrument that combines cellular telephones with recent breakthroughs in radiation sensor technology is being designed, built and tested. The instrument also includes a personal digital assistant (PDA e.g. Palm Pilot) and a global positioning satellite (GPS) receiver. They can be used to make calls,

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rowse the web, send and receive email, display maps showing where you are, and give directions. For U.S. Customs, other border inspectors, emergency response and law enforcement personnel, they can be used to detect and identify nuclear material. They can also be used as a “smart” radiation alarm that can tell the difference between a nuclear material and a person with a recent radiological medical treatment. When not in use by the user, the instrument constantly monitors the ambient radiation field and continuously communicates with a central processing system in real time. With very large numbers of these units in a given region, they can then all work together to watch for nuclear material either being moved into the region or hidden in an unknown location.

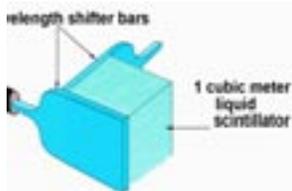


UltraSpec: Superconducting Gamma Ray and Neutron Spectrometers

Superconducting technology and low-temperature techniques are being exploited to provide major advancements in gamma-ray and neutron spectroscopy. These ultra-high resolution instruments provide increased sensitivity and selectivity in identifying the composition and possibly identifying the origin of nuclear materials.

Reactor Safeguards with Antineutrino Detectors

A new tool for detecting diversion of fissile materials from reactors in near-real time is being developed using scintillator-based antineutrino detectors. This instrument measures antineutrinos produced by the nuclear fission in the reactor. The number of antineutrinos detected is related to the composition of the nuclear fuel in the reactor. Unlike gamma-ray or neutrons produced by the reactor, antineutrinos are also impossible to shield. When installed at a reactor, this system would make it much more difficult to secretly remove plutonium produced in the reactor core.



Rad Sensor

The Laboratory is developing the world’s first X-ray sensor that uses optical light to measure the response of crystals to X ray flashes. Rad Sensor is capable of sub-picosecond resolution, single X-ray photon sensitivity, and imaging. These high-speed detectors will be used to help analyze the nuclear burning produced by the high-power lasers in the National Ignition Facility being constructed at the Laboratory, as well as the measurement of X rays associated with materials and biological experiments planned for new X ray light sources.



HEFT: High Energy Focusing Telescope

The High Energy Focusing Telescope uses a newly developed mirror system that focuses hard X-rays and gamma rays onto a high-performance detector six meters away. The telescope, developed jointly by LLNL, Caltech, Columbia University and the Danish Space Research Institute, will be released near Fort Sumner, N.M., this fall. It will ascend to 120,000 feet aboard a high-altitude scientific balloon to study how supernovae create and distribute most of the elements heavier than helium. With its mirror array and imaging detectors, the telescope system has 10

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to 100 times more sensitivity than is achievable with conventional non-focusing systems. The detectors use integrated circuits in conjunction with cadmium zinc telluride crystals to measure gamma ray signals at hundreds of different points, producing clear pictures with high spectral resolution, while operating at low power in a compact package that can be produced at low cost. This same detector technology is also being used on the ground in RadNet, the radiation detector cell phone network, where they will help find and identify nuclear weapons and materials.

