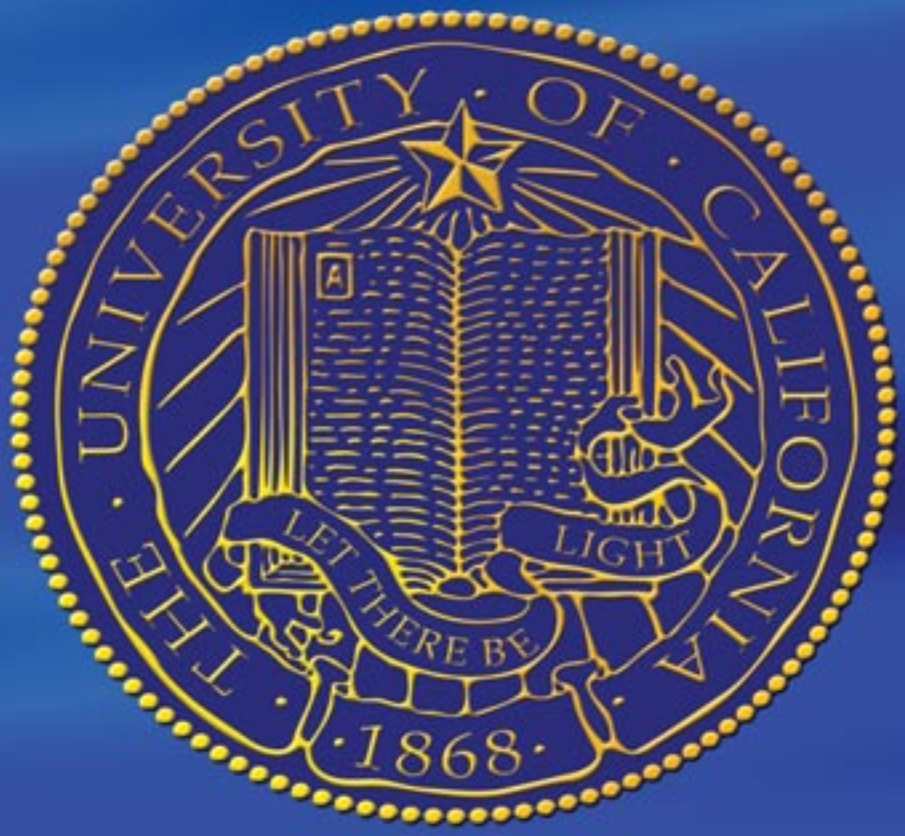
DATELINE LOS ALAMOS



R&D 100

Los Alamos
NATIONAL LABORATORY

R&D 100: AWARD-WINNING TRADITION AT UNIVERSITY OF CALIFORNIA-MANAGED LABORATORIES

FROM THE DIRECTOR

The national laboratories managed by the University of California – Lawrence Livermore, Lawrence Berkeley and Los Alamos – have demonstrated through the years tremendous benefit to the country by supplying great science that underlies innovative research and development. Discoveries in science, and the applications that result, play an important role in shaping the future of our country and also can be used to address problems that confront us worldwide.

Recognition by R&D Magazine in an annual, international competition reinforces and brings awareness to the broad scope of achievements from these three national institutions. We are pleased to profile in this issue of Dateline: Los Alamos technologies with broad application that have matured from the wellspring of cutting-edge research at Los Alamos and its sister labs. Examples include the Lasershot Marking System, which uses laser pulses to safely, and permanently, impress identification markings on metal components; AirLiner, an inexpensive, advanced insulating material now licensed to San Diego's Cargo Technology Inc. for use as thermal packaging to ship perishable cargo such as seafood, meats, fruits and pharmaceuticals; and Free-Space Quantum Cryptography technology, a communication system that uses tiny bits of light to send "quantum keys" through the air over long distances.

The University of California has managed all three labs for the nation since their inceptions, in keeping with its mission of public service. UC rightly shares in the honor the three laboratories receive through the distinguished R&D 100 awards, which recognize science that serves society.

I hope you enjoy learning more about these latest accomplishments.

DATELINE LOS ALAMOS

A MONTHLY PUBLICATION OF THE PUBLIC AFFAIRS OFFICE OF LOS ALAMOS NATIONAL LABORATORY

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R&D 100: AWARD-WINNING TRADITION AT UNIVERSITY OF CALIFORNIA-MANAGED LABORATORIES

This year Los Alamos National Laboratory, Lawrence Livermore National Laboratory and Lawrence Berkeley National Laboratory captured a total of seven of R&D Magazine's prestigious R&D 100 Awards. While this is not nearly the largest number of R&D 100 Awards ever received by the trio in a given year, this latest round of winners brings to 191 the total R&D 100 awards received since 1963. Perhaps most importantly, the awards signal the continuing ability of these three University of California laboratories to apply cutting-edge science and technology to challenges of global consequence.

The R&D 100 awards program, now in its 39th year, is designed to honor significant commercial promise in products, materials or processes developed by the international scientific research and development community. Each year, R&D Magazine recognizes the world's top 100 scientific and technological advances with awards for innovations showing the most significant commercial potential. Over the years, the R&D 100 awards have become one measure of a scientific institution's contribution to society. Technologies are nominated in open competition and then judged by technical experts selected by the Illinois-based magazine. While not part of the UC laboratories' mission, each laboratory's ability to compete in what is essentially an industrial research and development competition is perhaps a testament to their versatility.

Standing alone, or as a group, these seven award-winning technologies exemplify the very best in American cutting-edge scientific research and development. They also represent the sort of scientific leadership the nation has come to expect from its national laboratories and the kind of excellence the University of California laboratories will continue to deliver.

Also in this issue are the Los Alamos National Laboratory's innovative research and development projects nominated for the R&D 100 Award.

THE UNIVERSITY OF CALIFORNIA-MANAGED LABORATORIES

LAWRENCE LIVERMORE NATIONAL LABORATORY

In September 1952, America's second nuclear weapons laboratory opened its doors at the site of the former Livermore Naval Air Station in the then small town of Livermore, California. The purpose was to diversify America's nuclear and scientific expertise and to help handle the large volume of work that Congress believed would eventually arise from future scientific discoveries. In the years since, Lawrence Livermore has more than lived up to its charter to become one of a America's scientific powerhouses.

Lasershot Marking System

This year, Lawrence Livermore received three R&D 100 awards. One award was for the Lasershot Marking System, which uses laser pulses to safely and permanently impress identification markings on metal components. The process does not remove material or change surface chemistry, but increases the marked area's resistance to fatigue and corrosion failure. The award was shared with Metal Improvement Company Inc. of Paramus, New Jersey.

R&D 100: AWARD-WINNING TRADITION AT UNIVERSITY OF CALIFORNIA-MANAGED LABORATORIES

Manufacturing Laser Glass by Continuous Melting technology

Lawrence Livermore also received an award for a novel, continuous melting process that currently is being used to manufacture meter-sized plates of laser glass at a rate 20 times faster, five times less expensive and with two to three times better optical quality than with other one-at-a-time or discontinuous processes. With the Manufacturing Laser Glass by Continuous Melting technology, it is now possible to construct high-energy, high-peak-power lasers for use in fusion energy development, national defense and basic physics research that would have been impractical, or even impossible, to build using the old melting technology. The award was received jointly with Schott Glass Technologies Inc. of Duryea, Pennsylvania, and Hoya Corporation USA of Fremont, California.

Gene Recovery Microdissection process

Lawrence Livermore's third 2001 R&D 100 award was for the Gene Recovery Microdissection process that can be used to produce libraries of all of the genes expressed in any chromosomal region of any tissue. It also can be used to clone the entire DNA in any organism, including bacteria, even those that can't be cultured. GRM can be used to provide enough DNA for sequencing from one bacterium, eliminating the need for cultures and allowing all bacteria to be screened for new genes.

ERNEST ORLANDO BERKELEY NATIONAL LABORATORY

Founded in 1931, Ernest Orlando Lawrence Berkeley National Laboratory is the oldest of America's national laboratories. Today, seven decades later, the scientific achievements of Berkeley Lab are still truly world class.

AirLiner

This year Berkeley captured an R&D 100 Award for a technology called AirLiner. AirLiner is an inexpensive, advanced insulating material developed by Berkeley researchers and licensed to San Diego's Cargo Technology Inc. for use as thermal packaging to ship perishable cargo such as seafood, meats, fruits and pharmaceuticals. The product is essentially an inflatable, insulating bag that converts an ordinary corrugated box into a cooler to keep perishables cold during shipping. AirLiner can be inflated with ordinary air, or to further prolong its thermal performance, with inert gases. The product is designed to replace expanded polystyrene foam containers, a bulky and cumbersome 30-year-old technology that is prone to cracking and leaking.

AirLiner is produced from plastic films with internal baffles that create a construction that inhibits heat transfer. AirLiner can be transported to shippers in flat, space-efficient packages, saving warehouse space and delivery expenses for shippers who use foam boxes. About fifty AirLiner bags will fit into the space now taken up by only one similarly sized foam container.

Researchers in Berkeley Lab's Environmental Energy Technologies Division developed the gas-filled panel technology in the 1980s as part of a research program into more energy-efficient windows.

LOS ALAMOS NATIONAL LABORATORY

Like Lawrence Livermore, Los Alamos National Laboratory also was the recipient of three R&D 100 Awards this year, but for three quite different technologies. These latest winners give Los Alamos a total of 79 awards won since 1978, the year the Laboratory began counting its awards. The technologies recognized this year span a diverse range of scientific and technical areas – from innovative manufacturing techniques and personal safety to revolutionary advances in the application of quantum physics.

R&D 100: AWARD-WINNING TRADITION AT UNIVERSITY OF CALIFORNIA-MANAGED LABORATORIES

Supercritical Carbon diOxide Resist Remover — SCORR

One technology for which Los Alamos received an R&D 100 award is the Supercritical Carbon diOxide Resist Remover, or SCORR. SCORR is a novel method for processing computer chips that uses supercritical carbon dioxide to remove a coating called photoresist. The SCORR system works without the use of toxic chemicals and has the potential to save the semiconductor manufacturing industry tens of millions of gallons of water per day.

↑ Using a Supercritical Carbon diOxide Resist Remover or SCORR-based instrument, the semiconductor industry can remove photoresists, residues and particles from the smallest features in integrated circuits.

The technology will be of special interest to integrated circuit manufacturers who rely heavily on photolithography to create the desired features in chip circuitry. The photolithography process requires the selective removal of hardened coatings, or resist, from a wafer, while leaving the intricate circuitry intact. Current wet-stripping technologies apply either corrosive combinations of sulfuric acid and hydrogen peroxide or other organic solvents to remove resist, producing profuse amounts of waste.

Los Alamos' SCORR system is actually a mixture of supercritical carbon dioxide and a nontoxic, nonhazardous organic solvent modifier that flows over the chip surface through a novel, pulsed-flow system. Under moderate pressure and temperature, carbon dioxide gas can be converted into its liquid, or supercritical, phase in which it has the properties of both a gas and a liquid. Supercritical carbon dioxide diffuses into the tiniest pores of a material like a gas, but because it has a high density like a liquid, it can dissolve substances and carry them away. These combined properties make supercritical carbon dioxide an excellent solvent for many applications like resist removal. In tests, SCORR typically strips photoresist from wafers in less than half the time required for wet-stripping. The carbon dioxide in the SCORR system also is a closed-loop system, which means that no waste, other than the waste resist, is generated. Members of the Los Alamos SCORR team include Craig Taylor, Jerry Barton, Leisa Davenhall, Kirk Hollis, Gunilla Jacobson, Jim Rubin and Laurie Williams.

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R&D 100: AWARD-WINNING TRADITION AT UNIVERSITY OF CALIFORNIA-MANAGED LABORATORIES

Although simple in appearance, the tandem-configured solid-state optical limiters shown at right are designed to reduce by 400-fold intense beams of light from devices such as lasers. The U.S. Army has plans to place optical limiters on its tank periscopes and perhaps on other equipment such as rifle scopes and aircraft windows.

Solid-state Optical Limiter

A second R&D 100 Award was received for the product of a Los Alamos collaboration with GEL-TECH Inc. of Orlando, Fla.; the Center for Research and Education in Optics and Lasers in Orlando, Fla.; and the U.S. Army. This collaboration developed a high-performance, solid-state optical limiter, a device capable of protecting the human eye from concentrated beams of intense light, such as those produced by lasers.

The optical limiter device looks like a simple colored lens, but it is capable of reducing, by as much as 400 times, the intensity of beams of light from devices like lasers. The limiter consists of a special dye embedded onto a polymer matrix. Because it is made from solid materials, optical limiters can be designed in many colors or shapes.

The optical limiter works much like photochromic eyeglass lenses, which automatically darken or lighten in response to changing daylight conditions. Unlike conventional photochromic devices, however, they respond to intense light much faster — a reaction time of less than a picosecond — and take only a millisecond to recover. The device offers protection from light even more intense than concentrated sunlight. The Army Research Office funded the work under a Small Business Technology Transfer grant. Members of the Tandem-Configured Solid-State Optical Limiter team at Los Alamos include Hsing-Lin Wang, originally of Chemistry Division but currently in the Bioscience Division; Duncan McBranch, formerly with the Laboratory but now with QTLBiosystems in Santa Fe; and Sam Xu, formerly with the Laboratory and currently with Lumenis Inc. of Santa Clara, CA. Team members at GEL-TECH Inc. are William Moreshead and Jean-Luc Nogues and at the University of Central Florida's School of Optics, David J. Hagan and Eric W. Van Stryland. The team member from the Army Research Office is Mikael Ciftan.

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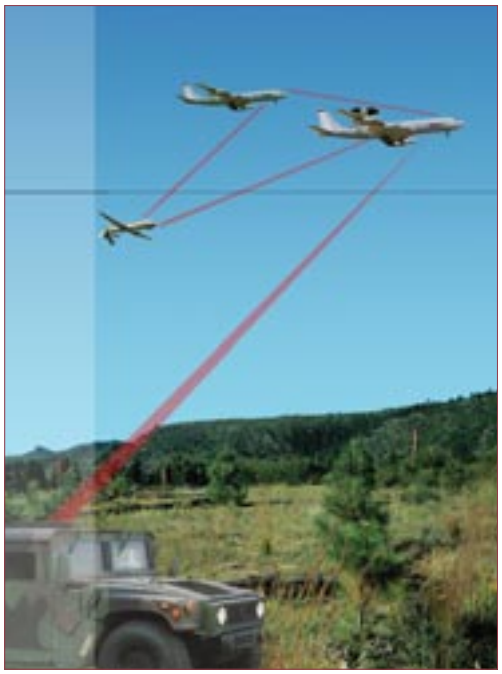
R&D 100: AWARD-WINNING TRADITION AT UNIVERSITY OF CALIFORNIA-MANAGED LABORATORIES



This illustration shows how Free-Space Quantum Cryptography can provide secure communications on the battle field. Using a high-speed laser communication channel, the drone (lower left) generates a quantum cryptographic key through free space with the plane with the large radome on top (far right). The drone uses the key to randomize the reconnaissance photo, then sends the completely secure, encrypted image over the laser channel to the radome plane. The radome plane uses its copy of the key to decrypt the laser transmission and recover the photo. The keys can be easily, quickly and securely shared by various air and ground vehicles.

Free-Space Quantum Cryptography

The third R&D 100 Award Los Alamos received was for the Free-Space Quantum Cryptography technology, a communication system that uses tiny bits of light to send "quantum keys" through the air over long distances. Quantum cryptographic keys are transmitted by photons randomly polarized to states representing ones and zeroes.

These polarized photon transmissions create a random string of numbers known only to the sender and receiver. This string of numbers becomes the quantum cryptographic key that locks or unlocks the encrypted messages that are sent via normal communication channels. Because the photons cannot be intercepted without being destroyed, and therefore tipping off the receiver, the quantum cryptographic key is perhaps the most practicable means available for creating unbreakable data encryption systems.

In 1999, Los Alamos researchers set a world record sending a quantum key through a 31-mile-long optical fiber. While this distance proved far enough to create networks connecting closely spaced government offices or local branches of a bank, at greater distances the signal loss in optical fiber increases until the photons are absorbed. To achieve longer distances, Los Alamos researchers developed a free-space, quantum cryptography system that would allow keys to be sent through the air. The 2001 R&D Award is based on an initial 1.6-kilometer free-space transmission distance in daylight, but plans are under way to test the system at distances of up to 10 kilometers.

The success of the Los Alamos free-space system could accelerate the development of new systems for secure satellite transmissions as well as encryption support for so-called "last mile" wireless or optical ground-based communications of special interest to the financial community. The Los Alamos technology is intended to serve as a model on which to base a global satellite, quantum key distribution system. Members of the Free-Space Quantum Cryptography team include Richard Hughes, Jane Nordholt, Charles Peterson, George Morgan and William Buttlers, all of the Neutron Science and Technology Group at Los Alamos.

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R&D 100: AWARD-WINNING TRADITION AT UNIVERSITY OF CALIFORNIA-MANAGED LABORATORIES

The following are Los Alamos National Laboratory's nominated projects.

LECIS

Plug and play — easily connecting and working with new pieces of equipment — is common for personal computer users but has been a dream for researchers using different kinds of laboratory equipment.

Laboratory personnel use a variety of equipment – most connected to an external control system such as a local controller PC. To have a device perform an operation, the lab researcher uses the controller to issue a command through the device's control interface. The device may return data. For both operations the exchange requires both the controller and device to use the same communications protocol or language. However, a variety of different laboratory devices generally use proprietary protocols that prevent communication between products from different manufacturers.

The Laboratory Equipment Control Interface Specification was developed and adopted by the American Society for Testing and Materials that made LECIS a formal standard. Equipment manufacturers can now use it when writing the programs that control their equipment. LECIS defines a uniform remote-control interface for lab equipment, a common way of describing a device's idiosyncrasies and behavior.

However, many laboratories are stocked with noncompliant devices that may be too expensive for immediate replacement or manufacturers are slow to implement the new standard. Whatever the reason, LECIS-compliant devices are rare. Los Alamos researchers have developed the Laboratory Equipment Control Interface Specification, or LECIS, Protocol Converter Box. The box is a hardware/software combination that allows lab researchers to implement the LECIS standard with existing devices.

The laboratory researcher must first program his or her device controller according to the LECIS standard or purchase the third-party controller software. Even after doing this, however, the device remains noncompliant. The Los Alamos developed converter box bridges this gap. The converter box communicates between the LECIS standard and the proprietary device via either a parallel, Ethernet or serial computer port.

The converter box, based on an industrial PC, translates the researcher's LECIS commands into the language of the assigned device using software as a dictionary. Users can purchase the box already programmed for the device they own or they can configure it themselves. The box also can be reconfigured later for a different piece of equipment.

↑ The LECIS Protocol box, left center above on the tabletop, a hardware/software combination, can make any laboratory instrument compliant with ASTM E1989-98 LECIS, the standard for laboratory device control. As a result, it enables communication between a controlling computer and devices from different manufacturers in spite of their separate control protocols or languages.

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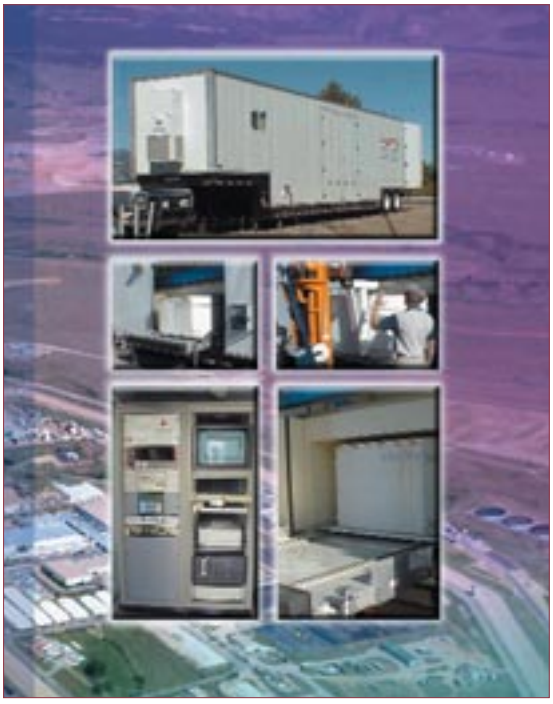
SUPERHENC

SuperHENC, the "Super-High-Efficiently Neutron-Coincidence Counting System," was developed to meet a specific need at Rocky Flats Environmental Technology Center. Rocky Flats needed a mobile, accurate, fast system to measure the amount of plutonium in 1,900-liter standard waste boxes bound for the Waste Isolation Pilot Plant in Carlsbad. SuperHENC was the answer.The picture collage below shows a standard truck trailer that SuperHENC fits entirely into; the middle two pictures and the one on the lower right show the device in operation, loading a standard waste box into a trailer that contains an assay chamber. The box is typical of those containing transuranic waste resulting from deactivation and decommissioning of radioactively contaminated nuclear weapons complex facilities at Rocky Flats. SuperHENC detects neutrons from spontaneous fission of plutonium-240. It also corrects for neutron absorption by waste materials and for the effects of cosmic rays so that it can determine accurately the quantity of plutonium in a waste box.The lower left photo shows the instrument console that controls operation of SUPERHENC and gathers and reduces the data.



SuperHENC, which stands for Super-High-Efficiency Neutron-Coincidence counter, allows nuclear workers to load nuclear waste without having to segregate the different materials. Use of SuperHENC not only reduces the potential for worker radiation exposure, but the device may help speed up the dismantlement schedule and save an estimated $100 million in the cost of remediation of the Rocky Flats Environmental Technology Site near Denver.

SuperHENC is a trailer-mounted passive neutron counter that can measure the trace amounts of plutonium present in mixtures of metals, combustibles and debris packed in standard waste boxes. The instrument provides accurate measurements of transuranic waste and certification of waste for disposal at the Waste Isolation Pilot Plant in Carlsbad, N.M. Scientists must know how much plutonium is in each waste shipment bound for WIPP to ensure they meet shipping requirements.

The system includes a waste-box handling capability and weight indicator device or load cell that can handle and measure loads up to 5,000 pounds and is more accurate than currently used technology for smaller packages.

The device works by counting the neutrons produced by the spontaneous fission of the plutonium isotopes. The neutron counting process, called coincidence counting, uses special electronic circuitry to distinguish between the neutrons emitted two or three at a time by the fission process and the typically single, random neutrons emitted by alpha particle reactions. By analyzing the number of double or triple neutrons recorded by a counter within a specified period — usually around 128 microseconds — workers can determine the plutonium content of the material in the waste container. Currently, three commercial vendors have begun the licensing procedure to manufacture more SuperHENC devices. Funding was provided by the Department of Energy through Rocky Flats.

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PRESCILA

The possibility of neutron exposure is a serious risk for people who work around gloveboxes containing transuranic materials or near nuclear reactors, particle accelerators, isotopic sources and fusion reactors. For health physicists who protect these workers, the neutron rem meter is an indispensable tool for obtaining real-time measurements of neutron dose equivalent or the equivalent biological effect of a particular measure of neutron radiation.

Ironically, the neutron rem meter can produce its own health risk. Conventional rem emitters rely on a gas detector such as boron trifluoride to detect low-energy or thermal neutrons. To detect higher-energy particles, the gas detector requires a 20-pound plastic shell to slow the fast-moving neutrons. By adding lead or tungsten as a shield to get a more accurate measurement, manufacturers have increased the device's weight. Thus a worker who must lift the device many times a day may strain muscles in his or her back, shoulders or arms.

The PRESCILA Neutron Rem Meter is a new lightweight tool for safeguarding those who work around radiation fields. PRESCILA, in the left hand of the worker shown below, can be maneuvered into tight spaces. It is light enough to be lifted from knee level to above the shoulder repeatedly without the strain injuries that can occur with conventional meters. Its innovative use of multiple scintillators makes PRESCILA sensitive to a wide range of neutron energies and gives it the uniform response needed for superior accuracy. It can be used with existing commercial counters, such as the one in the worker's right hand, allowing it to replace thousands of conventional meters now in use.

Los Alamos researchers have developed PRESCILA — Proton Recoil Scintillator Los Alamos — as the first neutron rem meter to combine sensitivity, accuracy and wide-energy detection in a package that weighs only four pounds.

For high-energy response, PRESCILA replaces the gas detector with fast-neutron scintillators, which emit light in the presence of neutrons. The mechanism is proton recoil. The neutrons strike protons, which recoil and strike grains of scintillating material and the collision releases light.

PRESCILA features four fast-neutron scintillators, one on each side, where they are held in polyethylene frames. Each scintillator is a Lucite disk with concentric grooves filled with a special mixture of epoxy and the phosphor. The scintillators are positioned around a Lucite block that serves as a light guide, directing the light pulses to a photomultiplier tube in the meter's handle. Deep inside the central Lucite block, PRESCILA has a thermal-neutron scintillator.

By developing a device that teams fast and thermal neutron scintillators, researchers have created a tool that is more sensitive, portable and user-friendly than conventional meters. Because it is small, PRESCILA can be used in tight spots behind gloveboxes, between storage drums or around radiotherapy accelerators in cancer treatment facilities. Because it weighs only four pounds, technicians can lift it repeatedly and lessen injuries.

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GAMMARRAYS

Diabetes, Alzheimer's and cancer are all typical diseases that are caused by genetic variations. Since the successful sequencing of the human genome, scientists are beginning to focus on genetic variations to identify genes associated with diseases. If successful, researchers hope to develop new pharmaceuticals and gene therapies to treat individual patients.

To develop these applications, researchers will require rapid analyses of individual genetic variations. The most common type of variation is a single nucleotide polymorphism or SNP. Between any two chromosomes, there is an average of one SNP for every 1,000 DNA base-pairs. Variation among the 12 billion human genomes is estimated to be one SNP for every 100 to 300 base-pairs. In the human genome with about 3 billion base-pairs, there are, therefore, approximately 10 to 30 million SNPs.

Once the SNPs are identified, researchers must rapidly analyze or genotype the SNPs in individual samples. Los Alamos researchers have developed a tool to rapidly conduct such high-throughput genotyping. Called GAMMArrays, the technology uses flow cytometry to measure the fluorescence of micro-spheres — tiny balls that that serve as solid supports for nucleic acids in DNA.

Flow cytometry passes fluorescently stained particles single file through the path of a laser beam. The laser-induced fluorescence from each particle is collected, spectrally filtered and detected.

Because there is no need to wash away the free-dye molecules, researchers can measure thousands of particles per second. Los Alamos researchers now can

Biomedical research in the new genomic era will increasingly focus on DNA sequence-level variation among individuals. To analyze such variation, researchers will require more sensitive and higher throughput tools. Below, a research technician is using such a tool. Known as GAMMArrays technology this tool is designed to run a multiplexed analysis of any genetic material. Unlike traditional methods, GAMMArrays allow such analyses to be run quickly, accurately and cost effectively.

determine exactly how many molecules of DNA are immobilized on each microsphere, allowing them to maximize sensitivity and avoid potential fluorescence artifacts.

GAMMArrays is well suited for screening multiple mutations in a single sample. Such mutations may exist in diseases like breast cancer and cystic fibrosis. Genetic information also is an important tool in pharmacogenomics, the study of genetic factors that affect how an individual may respond to a specific drug. Genetic studies also are valuable in determining the genetic basis for transplant rejection.

Gene recognition also is important in agriculture. Traits such as insect and disease resistance have a large economic impact and many genetic markers for such traits have been identified in livestock and crops. DNA fingerprinting also can be valuable in helping to solve crimes. GAMMArrays can help forensics experts identify plant and animal material or help solve crimes such as rape and murder.

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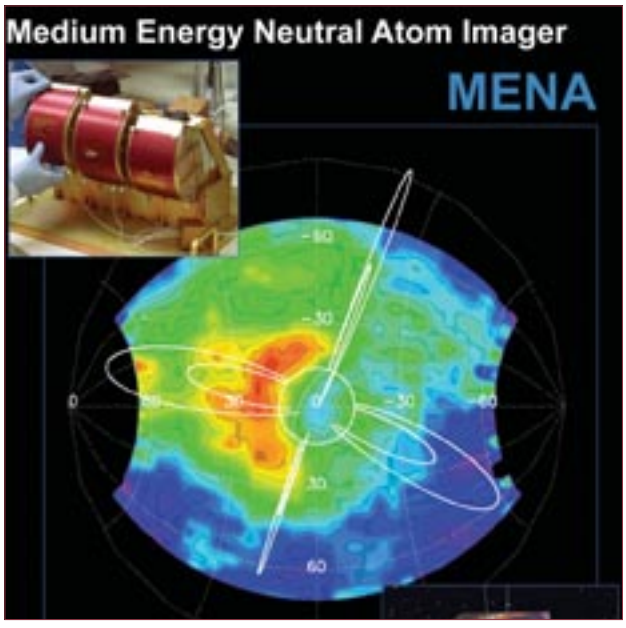
MEDIUM ENERGY NEUTRAL ATOM IMAGER

It has long been recognized that human society and economic life are vulnerable to Earth's weather. It also now is recognized that our dependence on a globally distributed and space-based, high-technology infrastructure and our permanent human presence in space have rendered us seriously vulnerable to another kind of weather as well – space weather.

Two examples of space weather's impact on Earth are the March 1989 disruption of a power grid by a severe geomagnetic storm that left 6 million people without power for nine hours. More recently on July 14, 2000, the Advanced Satellite for Cosmology and Astrophysics was disabled permanently as a direct result of the powerful "Bastille Day" storm.

The center image is a MENA picture of a magnetospheric disturbance. Earth is represented by the white circle in the center of the image. Pairs of representative geomagnetic-field lines extending to radial distances of four and eight Earth radii are shown at midnight, dusk, noon and dawn — moving clockwise from the left. The view is toward the North Pole. The false color shows an enormous injection of energy and "hot" plasma into near-Earth space environment, symmetrically distributed around local midnight (the yellow, orange, red region). Such global images of magnetospheric disturbances contribute to our understanding of "space weather" and to our effort to develop the capability to predict space storms and mitigate their effects on advanced technology systems. The MENA camera, inset photo, consists of three offset senor heads with removable covers.



The Medium Energy Neutral Atom Imager on NASA's Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) provides the first global images of the distribution and dynamics of the dominant ions in the region of the geospace where this critical space weathers occurs. MENA images plasmas that populate near-Earth space environment with sufficient time resolution to track the development and growth of geomagnetic storms and magnetospheric substorms. During these events, which cannot be observed with standard astronomical techniques, enormous amounts of energy are explosively released into near-Earth space and dissipated in the upper atmosphere, with potentially serious disruptive effects on spacecraft operations, telecommunications, navigation and ground-based power distribution systems. Using MENA, researchers will gain a better understanding of the space weather environment and will thereby contribute significantly to the development of the predictive capability needed to anticipate and mitigate the risks that space weather presents both to advanced technological systems and to astronauts in orbit.

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SAMi

Los Alamos researchers have developed SAMi, a SQUID Array Microscope, that possesses unsurpassed sensitivity and resolution to examine materials nondestructively and noninvasively. A SQUID is a superconducting quantum interference device — the most sensitive magnetic-field detector presently available. SQUIDs are able to detect magnetic fields one billion times smaller than that of Earth.

↑

The SQUID array microscope, SAMi, is a tool for nondestructive evaluation that uses an array of superconducting quantum interference devices, SQUIDs, shown above the dime. SQUIDs are magnetic-field detectors of unsurpassed sensitivities — able to detect magnetic fields one billion times smaller than that of Earth. SAMi uses a linear array of SQUIDS cooled by liquid nitrogen, a cheap, abundant cryogen.

Originally developed to noninvasively inspect nuclear weapons components, SAMi has to inspect weapons before and after disassembly to provide data on the parts. SAMi has industrial applications as well. Industries such as aviation, automotive and manufacturing could use the technology to inspect welds, assemblies or parts for flaws.

Researchers inject or induce currents into the conductive sample to produce magnetic fields. If the sample contains even a small feature or flaw, the SQUID detects a deviation in that magnetic field, even if the feature is buried beneath several centimeters of conductive or nonconductive materials.

Researchers can probe various depths of the object by changing the frequency of the current they create. SAMi does not come in contact with the object — the technique is totally noninvasive.

SAMi uses a linear array of SQUIDs made of high-temperature superconducting material and operate at liquid nitrogen temperature — a cheap and abundant cryogen. The series of SQUIDs can be placed within a millimeter of the sample at room temperature.

SQUIDs can look deeply into samples and look at a wide range of depths with a uniform response. The SQUIDs are so sensitive that they can see the changes in conductivity associated with mechanical stress of a sample. Scientists and engineers can use the raw SAMi data to determine the presence and location of defects.

SAMi designers have built the microscope to be robust, affordable and user-friendly

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MASS TAGGING

Researchers at Los Alamos National Laboratory have developed a technique to enhance the accuracy and analysis of mass spectrometers that are used to sort and study DNA strands and map the human genome.

Mass spectrometry is a tool that provides rapid, rigorous and sensitive analyses to meet the challenge of understanding what is contained in the human genome. However, some advances would be beneficial to the research if the technique were more accurate and sensitive. With better data, researchers would be able to understand better how cells work and how diseases work at the cellular level.

Los Alamos scientists have developed a mass tagging technique that is fast, easy and inexpensive using commercially available materials that provide an enhancement to mass spectrometry. The mass-tagging technique uses stable-isotope-labeled nucleotides and amino acids, called monomers, to produce specific labeled DNA or protein fragments. Because the labeled molecules are chemically identical to nonlabeled counterparts, they are easily incorporated into larger molecules.

The mass of each labeled string in the DNA or protein fragment is greater than the mass of the nonlabeled counterpart. The difference, or mass tag, is the basis for the technique. This technique gathers information and more about masses through the use of different combinations of the labeled and unlabeled strands. Mass tagging allows for identification of the contents of the strands. For proteins, it allows relative locations in the protein as well. Data on monomer composition alone can be used directly for some applications. For example, by comparing the actual determined nucleotide with the expected composition from sequencing data, researchers can determine quickly the number and nature of sequencing errors in a particular region of genomic DNA.

Researchers also might use the information on partial amino acid composition and fragment masses as two parameters for a database search to identify a particular protein.

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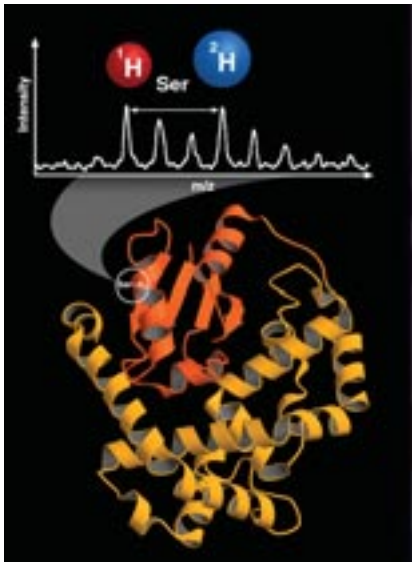
The orange portion of the model protein shown below contains a stable-isotope-labeled amino acid, serine (Ser-d_3), whose three ^1H atoms have been replaced with ^2H. The mass peak for the labeled protein fragment is 3 daltons higher than the peak from its unlabeled counterpart. Displayed through a characteristic pattern in mass spectra, this difference, the mass tag, enables researchers to determine the partial amino acid content of the protein fragment. This additional data greatly expands the specificity and accuracy of mass spectrometry for rapid, large-scale DNA and protein analyses.



R&D 100: AWARD-WINNING TRADITION AT UNIVERSITY OF CALIFORNIA-MANAGED LABORATORIES

BRIEFLY . . .

Nobel Laureate Hans Bethe and former Laboratory Director Harold Agnew received the first-ever Los Alamos Medal, deemed "the highest honor the Laboratory can bestow on an individual or small group."

Hans Bethe

Bethe, who headed the Theoretical (T) Group at Los Alamos from 1943-1946, was selected for his role as "scientific visionary and leader, mentor and role model to the Laboratory from its inception," said Laboratory Director John Browne. In 1967, Bethe won the Nobel Prize in physics for his contributions to the theory of nuclear reactions, especially his discoveries concerning energy production in stars. He is professor emeritus of physics at Cornell University.

Harold Agnew

Agnew, who was director of the Laboratory from 1970-1979, is cited "for leadership during the Laboratory's formative years and ascension to international stature." Agnew's association with the Laboratory began in 1943 when he joined the Laboratory's former Experimental Physics (W) Division. He was elected a New Mexico state senator in 1955 and in 1961 became science advisor to the NATO supreme allied commander in Europe. He returned to Los Alamos in 1964 to head the former W Division. Upon leaving Los Alamos, Agnew headed Gulf General Atomics in San Diego, a nuclear reactor builder.

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