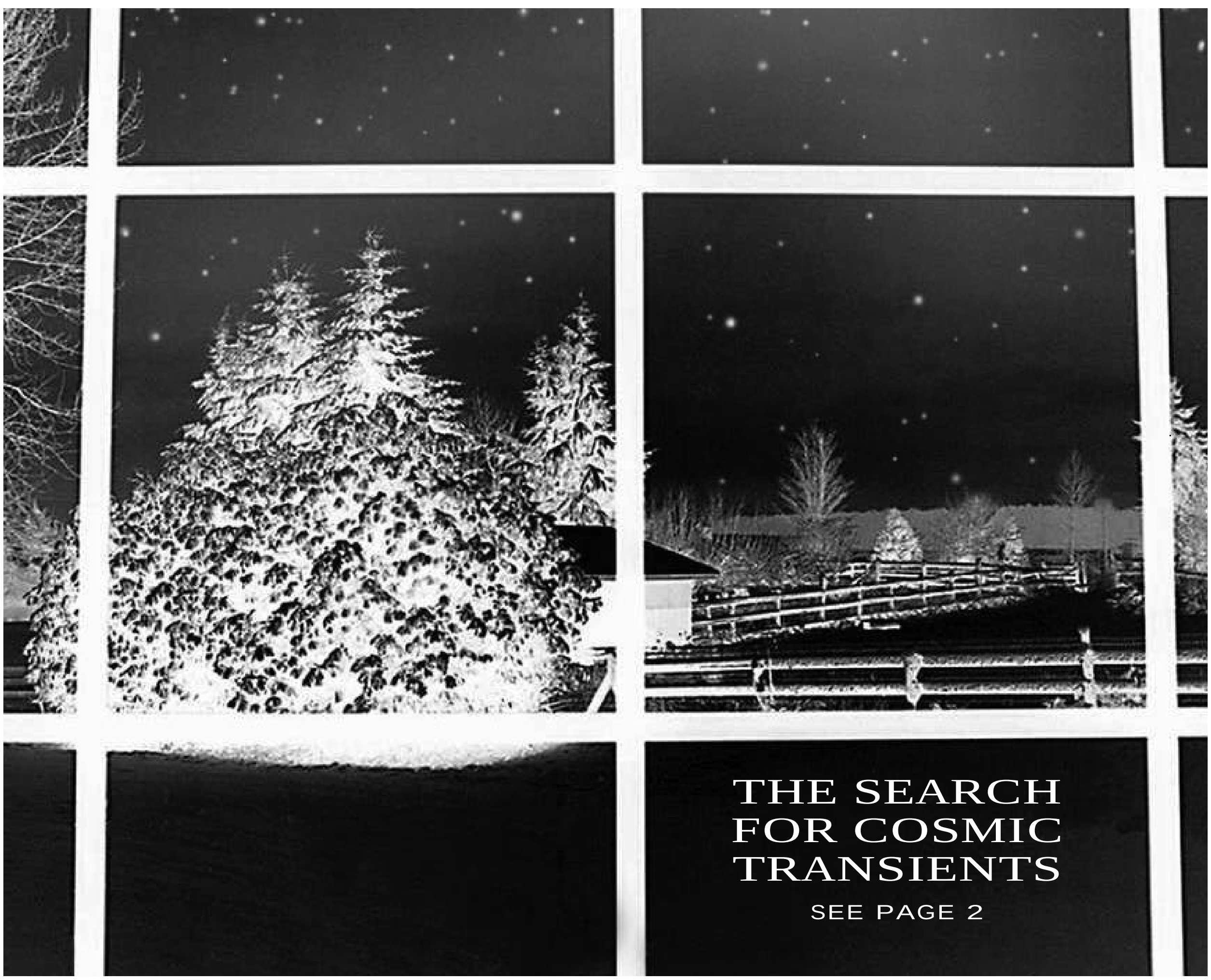
JANUARY ISSUE 2000

LOS ALAMOS NATIONAL LABORATORY
WHERE SCIENCE MAKES A DIFFERENCE

# DATELINE LOS ALAMOS

U.S. DEPARTMENT OF ENERGY
UNIVERSITY OF CALIFORNIA



THE SEARCH FOR COSMIC TRANSIENTS

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# Dateline: Los Alamos

There is something almost mystical about winter nights in northern New Mexico. The cold, clear skies seem to let the stars shine brighter, the snow-laden land and trees make the world a much quieter place. During this season, as we hurry through the chilled nights that carry us toward the next millennium, some of us may stop and gaze upward to ponder the beguiling constancy of the universe. Yet even then, in the cold and the dark, as we consider the universe to be permanent and unchanging, nothing could be further from the truth. Scattered amid the stars that have kept their places in our skies for millions of years are the astrophysical phenomena scientists call cosmic transients — short-duration, one-time astrophysical events lasting anywhere from less than a second to as long as a few years. They include such diverse phenomena as quasars, comets, asteroids and supernovae. These heavenly events often come and go completely unseen, but leave behind a changed and changing universe. As part of the Lab's high-energy and space science programs, Los Alamos researchers have studied cosmic transients for decades. Today, this work is the focus of research at the Laboratory's Fenton Hill Observatory.


LOS ALAMOS NATIONAL LABORATORY • WHERE SCIENCE MAKES A DIFFERENCE

DATELINE LOS ALAMOS

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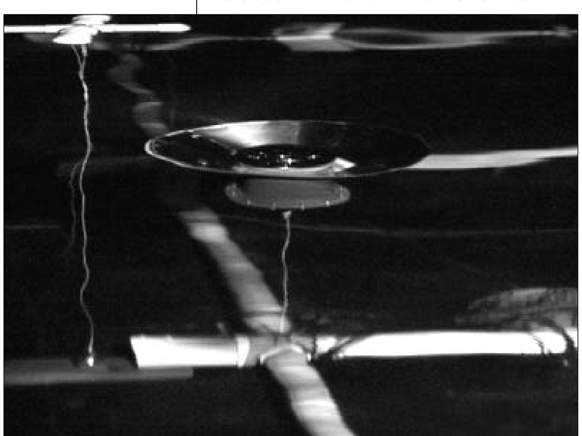
# Dateline: Los Alamos

Cosmic transients exist in numerous forms. Some of the most active known transients are galactic nuclei and quasars. These mysterious phenomena are observable for periods lasting anywhere from seconds to years and emit massive amounts of radiation at nearly every wavelength of the electromagnetic spectrum. This wide range of radiation means scientists can study them using a number of different types of instruments — from optical and radio telescopes to gamma ray detectors.

Scientists navigate the Milagro pool at Fenton Hill Observatory in a raft to check and repair photomultiplier tubes.

Supernovae, the sudden, unpredictable explosions of stars that produce in seconds as much energy as our sun will release in its lifetime, are often only visible for a short time and are best discovered through a program of continuous sky monitoring. Other visitors to our region of space, such as comets and asteroids, are somewhat better known transients of great interest to science. The telescopes and instruments at Fenton Hill Observatory are used to study many types of cosmic transients.



The photomultiplier tubes float tethered to a framework of PVC tubing visible in the depths.

Once home to the Department of Energy's innovative Hot Dry Rock Project, Fenton Hill is located 35 miles west of the Laboratory in the pine-forested Jemez Mountains of northern New Mexico. The Fenton Hill Observatory, which sits at an elevation of 8,680 feet and is without a direct line of sight to any city lights, has several unique telescopes.

The largest and perhaps the best-known telescope at Fenton Hill is Milagro. Not a typical telescope, Milagro is actually a gamma ray detector constructed of more than 700 light-sensitive photomultiplier devices submerged in a six-million-gallon pool of highly purified water.

Milagro detects bursts of cosmic gamma rays by the tiny flashes of blue Cherenkov light that occur when the high-energy particles strike and interact with the water. Acting somewhat like a camera whose shutter is always open, Milagro stares continuously at the sky, day and night, from horizon to horizon, waiting for the high-energy particles produced by gamma ray bursts that continually bombard our planet from outer space.

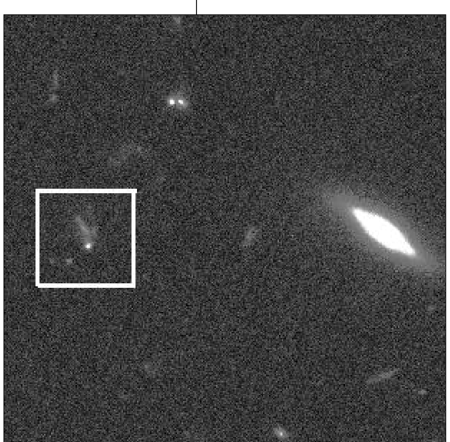
Last year, during one of the nearly 50 gamma ray bursts detected by Milagrito, Milagro's prototype predecessor at Fenton Hill, a cone-shaped shower of particles appeared from the direction of a gamma ray burst. This discovery was seen by many researchers as a step toward proving the existence of what astrophysicists refer to as TeV, or trillion electron volt, radiation. This was the most energetic radiation ever recorded from a gamma ray burst, and Milagro will no doubt record more such bursts in the coming years.

Discoveries like this, along with the original find of cosmic gamma ray bursts by Los Alamos scientists in the 1960s, has the international scientific community turning to Los Alamos for leadership in this area of transient research.

Like Milagro, ROTSE-I, the Robotic Optical Transient Search Experiment, is crucial in the continuing quest to broaden science's overall understanding of gamma ray bursts.

In January 1999 the visible light component of a gamma ray burst from space was observed by ROTSE-I coming from a galaxy nine billion light years away in a part of the sky near the constellation Corona Borealis.

History was made in January 1999 when ROTSE-I captured this image of the optical counterpart of gamma ray burst GRB990123.



Awakened by a detection signal provided by NASA's Compton Gamma Ray Observatory, ROTSE-I responded in less than 22 seconds to capture the visible light from the burst while the gamma rays were still arriving on Earth. This was the first time in history that such an observation had ever been made.

Before that, the optical counterparts of gamma ray bursts had only been caught as the faint, fading afterglow of the event. At its peak, the brightness of the object now known as GRB 990123 was an estimated six million times brighter than a typical supernova with an estimated energy release almost 10 million billion times that of our sun.

This ROTSE-I observation represents the most luminous optical object ever detected in the universe. If you had been gazing at that spot with binoculars, you would have seen a 'star' appear suddenly, brighten and then fade away within minutes — a true transient event.

ROTSE-I has four wide-field 200 millimeter lenses mounted on electronic cameras that can respond automatically to a transient event signal. The four-inch-diameter lenses are each connected to chargecoupled imaging devices — basically the same technology found in digital cameras on the consumer market. The four lenses, strapped to a single mount, point to slightly different, but overlapping, sections of the sky and together they capture 250 square degrees of the sky at once. That field is about what would be covered by a dinner plate held out at arm's length.

The fast-moving cameras on ROTSE-I are capable of reacting to transient alerts in seconds.

In addition to responding to transient events, ROTSE-I automatically scans the sky each night from horizon to horizon, taking a series of digital snapshots that jointly cover the entire visible night sky. In clear weather ROTSE can compile a complete photographic record of the sky twice each night.

Presently located at the Los Alamos Neutron Science Center, ROTSE-I soon will be relocated to become a part of the Fenton Hill Observatory. A second ROTSE device currently is being debugged. Located alongside ROTSE-I, ROTSE-II uses a set of twin 0.45-meter aperture telescopes that will be operated in stereo mode to perform similar sky-watching functions. The next-generation ROTSE telescope is being built. It will have characteristics similar to the ROTSE-II instrument, but is being designed so it can be easily replicated and shipped to distant locations.

After the Laboratory receives and debugs the first of these units, probably in the summer of 2000, the ROTSE team will order six to eight more of them to be stationed at various sites around the world to give more complete coverage of the sky. The ROTSE team has already begun negotiations for locating the telescopes at sites in Australia, the Canary Islands and Israel. ROTSE telescopes are operated through a collaboration of astrophysicists from Los Alamos and Lawrence Livermore national laboratories and the University of Michigan.

REACT, Research and Education Automatically Controlled Telescope, is a robotic telescope with a one-half-degree field of view. When running in event alert mode, REACT will automatically respond to a signal by swinging around to take a series of one-minute, high-resolution photos that might capture any optical signals that coincide with gamma ray transients detected by other sky-watching instruments. REACT, however, will soon have another important use as an educational outreach tool.

If plans go as expected, REACT could someday provide northern New Mexico middle- and high-school-level teachers and students the opportunity to strengthen their knowledge of fundamental astronomy and build skills in collecting science information. With Laboratory and

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university researchers acting as subject-matter experts, students will use the Internet to remotely control the REACT telescope for scientific research. REACT will allow teachers and students to participate in a variety of science experiences that permit hands-on discovery such as the search for undiscovered asteroids and other Near Earth Objects.

A Laboratory student employee makes adjustments to the REACT telescope.

The future of Fenton Hill Observatory for astronomical transient research continues to shine. The Radio Interferometer Transient Experiment, or RITE, will eventually place 16 to 20 surplus satellite television dishes at Fenton Hill. These stationary dishes will be aimed at the heavens and use the rotation of Earth to repeatedly monitor a narrow region of the sky.

By combining the radio wave signals received from all the dishes, an image of radio sources coming from space will be created. Comparing each day's image with the previous day's image will allow the detection of transient radio sources. Private citizens are donating the satellite dish antennas, making this an extremely low-cost scientific research project.

Funding for work at Fenton Hill Observatory comes from a variety of sources, including NASA, the National Science Foundation and several major universities. Los Alamos Laboratory-Directed Research and Development funds and the University of California's Institute for Nuclear and Particle Astrophysics and Cosmology have also provided support.

As the facilities and capabilities of Fenton Hill Observatory grow in the years to come, so too will our knowledge of cosmic transients. In the meantime, the instruments and telescopes at Fenton Hill will be waiting and watching to capture those celestial events that eyes might otherwise miss.

Two of the several small telescopes located at Fenton Hill. The dome on the left houses the REACT telescope.

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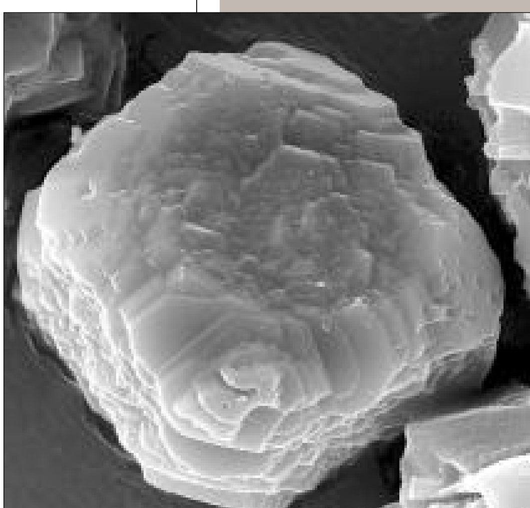
# SHIFTING THE THEORY OF PLATE TECTONICS

## OR: DIAMONDS AREN'T ALWAYS A GEOPHYSICIST'S BEST FRIEND

You won't find these diamonds adorning a piece of jewelry. They're too tiny — ranging in size from a mere micron (0.000039 of an inch) to 100 microns — and can't be seen with the naked eye. But researchers from Los Alamos and the University of California at Riverside have studied them and come up with evidence that could force a revision of the theory of plate tectonics, which explains how continents were formed.



An imperfect cube-octahedral diamond crystal from the Kokchetav Massif in Kazakhstan magnified 2,859 times. The natural size of the crystal is about 28 microns. Researcher Larissa Dobrzhinetskaya took the image with a scanning electron microscope at the University of California at Riverside.

Known as microdiamonds, the tiny gems first were discovered — albeit in very small quantities — in the mid-1970s by Anton Zayachkovsky, chief of geology for the Kokchetav Geological Survey, within crustal metamorphic rocks in an area of northern Kazakhstan called Kokchetav Massif.

However, because most geophysicists thought at that time that diamonds could not form in these types of rocks, they disputed and ultimately dismissed the discovery.

Years later, another team of geophysicists not only confirmed the original finding, but discovered that the microdiamonds were quite abundant. Now microdiamonds also have been discovered where plates collide in Norway, China and Germany.

The problem is, based on geophysicists' current understanding of plate tectonics, these microdiamonds aren't supposed to be there.

The theory of plate tectonics states that Earth's outer shell, the lithosphere, consists of about a dozen large plates and several smaller ones that move relative to each other and either diverge, converge or slip past each other. These interactions explain the

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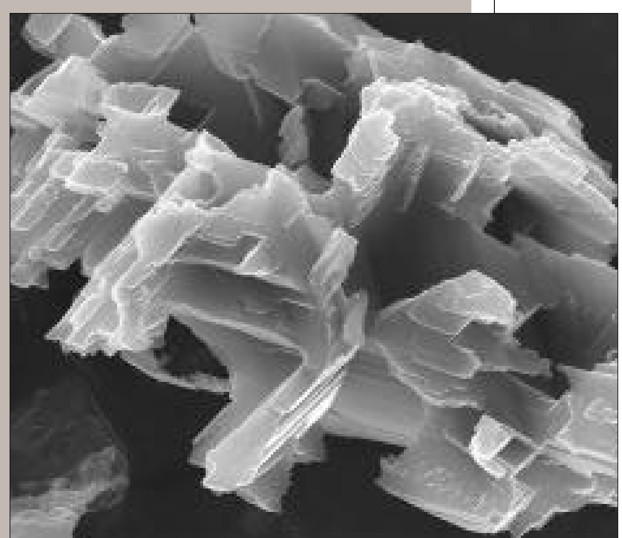
present-day positions of Earth's continents, as well as the formation of mountains and volcanoes.

Until recently, geophysicists thought that diamonds could develop only in Earth's mantle at depths of 60 to 186 miles or deeper, where pressures and temperatures are high enough to stabilize carbon into the ultracompact crystalline structure of a diamond. The diamonds reach Earth's surface when volcanic eruptions force them through the mantle and crust up narrow conduits called kimberlitic pipes.

However, microdiamonds were discovered within ultrahigh-pressure, sedimentary crustal rocks in the continental collision zones. Crustal rock is considered too buoyant, or light, to be forced under the mantle during a continental plate collision. It is instead the heavier mantle rock that is subducted under the mantle during these collisions.

So how could microdiamonds have formed within crustal rocks?



➔ The "house of cards" morphology is evident in this diamond, shown at a magnification of 2,851. This 35-micron crystal is very rich in impurities — or solid inclusions — and has large channels. In contrast to regular diamonds, which display perfect crystallographic form, microdiamonds have imperfect crystallographic form, most likely the result of being formed from media oversaturated with impurities and during very short periods of geological time.

Larissa Dobrzhinetskaya, a visiting scientist from UC Riverside, and a team of Los Alamos researchers have studied the mineral inclusions found inside the microdiamonds. These inclusions serve as environmental records of the conditions under which the microdiamonds formed.

Using a variety of analytical tools, including scanning, optical and tunneling electron microscopes and neutron diffraction at Los Alamos' Neutron Science Center, the Los Alamos-UC Riverside team discovered that microdiamonds have imperfect, skeletal crystalline structures, much like the shape of a form of gypsum called desert rose, which is commonly found in the Southwest. Conversely, typical diamonds have perfect crystalline structures.

The microdiamonds' imperfect structure suggests that they most likely formed in an oversaturated, impure environment. In other

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words, drops of fluid oversaturated with carbon and water eventually turned into diamonds in an environment laden with other minerals.

Those mineral inclusions included several types of silicates, carbonates and oxides, some of which are associated only with crustal rock. Therefore, continental collisions may have forced at least some of Earth's crustal rock down a subduction zone, where it "mixed" with mantle rock, then slowly rose back to the surface over tens of millions of years.

Researchers now are investigating the chemical compositions and crystalline structures of the mineral inclusions to learn the pressures and temperature stability fields of such structures and more precisely determine the depth at which the micro-diamonds formed.

In addition, Dobrzhinetskaya is performing high-pressure experiments at UC Riverside to confirm the pressures and temperature conditions in which the mineral inclusions may have been formed.

Dobrzhinetskaya and her colleagues postulate that the mineral inclusions were formed very deep inside the mantle. If they are correct, then the theory of plate tectonics must be reworked to account for how some crustal rocks managed to make a round trip from Earth's surface down into the mantle and back, and under what circumstances.

A paper detailing the team's work has been submitted to the science magazine *Nature* and was presented last month at the American Geophysical Union's annual meeting in San Francisco.

Los Alamos' Center for Materials Science, Institute of Geophysics and Planetary Physics and Neutron Science Center and UC Riverside collaborated on this project, with support from Los Alamos' Science and Technology Base Programs Office.

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# DARHT ON TARGET

## HYDRODYNAMICS FACILITY ACES FIRST TEST

The Dual-Axis Radiographic Hydrodynamic Test facility, a massive X-ray machine built to provide valuable freeze-frame photos of materials imploding at speeds of more than 10,000 miles an hour, has successfully performed its first hydrodynamic test.

DARHT, located at Los Alamos National Laboratory, is the newest and largest experimental facility to come on line in the U.S. stockpile stewardship program, which ensures the safety and reliability of the U.S. nuclear arsenal without nuclear testing.

"The recent test proves DARHT's technical capabilities and is a milestone we have been working toward for a decade," said Mike Burns, DARHT project director. "The facility and the equipment performed magnificently."

DARHT's experiments are called hydrodynamic tests because metals and other materials flow like liquids when driven by the high pressures and temperatures generated by the detonation of high explosives.

"We got a very high-resolution picture," said Todd Kauppila of Los Alamos' Dynamic Experimentation Division, who was the lead experimentalist for the hydrotest. "DARHT gives us an excellent new tool to use in investigating the dynamics of implosions."

The recent DARHT test marks the operational readiness of the first axis of the facility. When the second axis is completed in 2002, DARHT will have two giant X-ray machines set at right angles, providing a more complete picture of what materials are doing as they implode.

DARHT does not lead to a nuclear reaction. It only provides a nonnuclear replication of what occurs in a real nuclear weapon when the primary stage implodes. In a complete weapon, the primary stage acts as the trigger for the nuclear explosion.

"The DARHT project has served as an outstanding example of what we can achieve technologically," said John Browne, Los Alamos director.

"DARHT represents excellence in science, engineering and project management. It sets a standard that others will have to work hard to

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equal," Browne said. "It also gives us a tool that we need when every year we certify the safety and reliability of the nuclear stockpile to the secretary of energy and secretary of defense, who then certify to the president."

DARHT's team comprises about 150 Laboratory employees and subcontractors and includes staff from Lawrence Livermore and Lawrence Berkeley national laboratories.

"Simply put, DARHT's X-rays are as key to the U.S. nuclear stockpile stewardship program as hospital X-rays are to helping to assess the health of the human body," said Energy Secretary Bill Richardson.

"DARHT and the other tools of stockpile stewardship, including material science, and computer modeling and simulation, help to ensure the safety and reliability of our current weapons systems," Richardson said.

"I am tremendously proud of these men and women," said Richardson, who met with the DARHT team last summer. "They are among the best and the brightest from the U.S. science and engineering field."

DARHT is capable of generating a beam of power equivalent to 20,000 chest X-rays. The facility's walls, built of specially reinforced concrete, are more than five feet thick in the area facing the high-explosives test. DARHT is capable of handling explosive loads up to the equivalent of 150 pounds of TNT.

"Besides offering advanced optical and electronic diagnostics necessary for full-size hydrodynamic tests that are essential experimental confirmation of weapons computer codes, DARHT also will provide capabilities for experiments investigating shock physics, high-velocity impacts, and materials and high-explosives science," said Stephen Younger, Los Alamos' associate Laboratory director for nuclear weapons.

"These data will benchmark computer calculations that will serve as the basis for future nuclear stockpile decisions," Younger said.

The budget for the recently completed first phase of DARHT is about $105.7 million. The second phase, when completed in 2002, is estimated to cost $154 million.

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# LOS ALAMOS SHOOTS FIRST EVER 'MOTION PICTURE' OF IMPLOSION

The world's first "motion picture" of the dynamics of an implosion has provided a new tool to see what occurs during the inward burst of energy that triggers a nuclear weapon. Los Alamos researchers say that a recent test of a revolutionary new technical application called proton radiography was highly successful. The technology provides the image of an object's interior using high-energy protons, rather than the more traditional X-rays.

The experiment was conducted at the Los Alamos Neutron Science Center using an experimental device made of high explosives and aluminum. During the experiment, the implosion was triggered by a signal generated from a pulse of protons that was fired down the half-mile long, 800-million electron-volt LANSCE accelerator.

The accelerator fired multiple bursts of protons in an almost steady stream as special cameras designed at Los Alamos caught and separated the image made by each burst in the sequence, producing a "motion picture."

The experiment's multi-image picture lasted about one ten-thousandth of a second, but a time sequence of 11 photographic images was shot, constituting a "motion picture" of the implosion.

"This kind of tool will give us great insight into benchmarking computer codes that are being developed in the weapons program as part of the Accelerated Strategic Computing Initiative," said Mary Hockaday, leader of Los Alamos' Neutron Science and Technology Group.

The British Atomic Weapons Establishment collaborated on the project, which was one of a series of hydrodynamic experiments driven by high explosives that allow researchers to study how materials behave. Solids and metals flow like liquids when driven by the detonation of high explosives.

"This experiment was another important step in developing proton radiography into a crucial diagnostic tool for ensuring the safety and reliability of our nuclear stockpile in the absence of nuclear testing," said Phil Goldstone, director of experimental programs at Los Alamos.

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# PRESERVING THE PAST

## LOS ALAMOS ANALYZES NEW ENCLOSURES FOR DOCUMENTS AT THE NATIONAL ARCHIVES

*"We the People of the United States, in Order to form a more perfect Union ..."*

Those are perhaps the most important words in the Constitution of the United States, which along with the Bill of Rights and the Declaration of Independence, is on display at the National Archives in the nation's capital. More than one million visitors every year file past the historic documents, which are housed in airtight enclosures to preserve the delicate parchment they were written on more than 200 years ago.

But as this century ends, officials from the National Institute of Standards and Technology have concerns about the enclosures and have embarked on a three-year project to design and build new ones. Los Alamos is assisting NIST by providing a scientific assessment of the proposed new encasements.

Last spring, Lance Hill of Engineering Analysis analyzed a model of the enclosure that was developed for NIST. Dick Rhorer at NIST, who is a former Laboratory employee, found some deficiencies in the prototype and asked the Laboratory to provide engineering structural analysis support to aid in the final design of the encasements. Rhorer oversees the mechanical design of the new encasements for NIST.

The current enclosures were built in 1952 and designed to have a 100-year life span. However, when conservators at NIST examined them recently, they observed changes that could affect the documents. Hazy areas near where the Bill of Rights made contact with an inner pane of glass revealed possible sites of unwanted chemical reactions. Similar reactions were observed with the Declaration of Independence. They are caused by humidity inside the enclosures, among other things.

While some humidity is needed to keep the parchment from becoming too brittle, too much humidity can make the parchment swell and contract, which can promote the growth of organisms.

The effect of the environment on the structural integrity of the encasement has been a central theme of Hill's work. Weather systems can

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More than a million people view the historic documents at the National Archives every year.

Cade Martin, National Archives and Records Administration

change the barometric pressure, thereby changing the difference between pressure inside and outside the encasements. Once the inert atmosphere is set, a seal must be created and maintained for varying weather conditions.

Hill also examined the C-seal that will bind the glass panes to the titanium encasements and the 72 bolts that will bind the C-seal to the encasements.

Hill's group leader, Steve Girrens, said Los Alamos benefits from collaborations like this. “For our effort, we get a chance to validate our analysis methodologies in an unclassified environment,” he said. “We have the very best engineering analysis talent, along with the very best analysis tools and computing power in the world, right here at Los Alamos.”

NIST plans to unveil a new prototype encasement next year. The rotunda of the National Archives Building is closing for two years beginning in July 2001. When it reopens in the summer of 2003, new encasements will hold and display all seven pages of the historical documents.

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# PEOPLE IN THE NEWS

## STUDENT RECEIVES AWARD FROM MEXICAN PRESIDENT

An former astrophysics student at Los Alamos has been awarded the highest academic youth honor in the nation of Mexico for his studies of cosmic gamma ray bursts. Enrico Ramirez-Ruiz traveled to the home of President Ernesto Zedillo to receive the Premio Nacional de la Juventud - Rama Academica from the president.

Enrico Ramirez-Ruiz (left) and Mexican President Ernesto Zedillo.

"Los Alamos prides itself on its population of world-class scientists in a variety of fields," said Laboratory Director John Browne. "And in the case of Enrico Ramirez-Ruiz, that description applies even before he starts on his first graduate degree."

A student of astrophysicist and Los Alamos Fellow Edward Fenimore, Ramirez-Ruiz has authored several scholarly papers, specifically in the study of gamma ray bursts, the largest cosmic explosions since the Big Bang. These titanic explosions flood the entire universe with gamma rays, and they are the brightest objects in the universe — many of them gleaming 1,000 times brighter than a supernova.

Among the conclusions Ramirez-Ruiz has reached is that the random flickering characteristic of gamma ray bursts is the same at the end of the burst as at the beginning, despite the fact that the burst's source should have used up much of its energy by the end of the event.

Another of his papers analyzed how the bulk-motion energy dissipates. As Ramirez-Ruiz explains, a substantial energy reservoir must power gamma ray bursts, and several theories suggest merging massive objects such as neutron stars and black holes are the source of the energy.

Observing very high-energy photons produced during the brief bursts gives researchers information about the interior structure of the bursts. Ramirez-Ruiz's interpretation is that the bursts of energy are carried on a set of thin spherical layers (rather like the layers of an onion); and these layers are moving at a speed very close to the speed of light. Current models don't explain where all this relativistic energy goes, and the Los Alamos student and his mentor have come up with a model that accounts for almost all this energy.

Ramirez-Ruiz presented a paper on "Filling Factors: A Hubble Relationship for Gamma Ray Bursts" at the Gamma Ray Burst Symposium conference in Huntsville, Ala., where he was among the few undergraduates ever invited to present a paper.

Ramirez-Ruiz has begun his graduate work at Cambridge University, England, where he studies with the renowned astrophysicist Sir Martin Rees, Royal Astronomer to Queen Elizabeth II.

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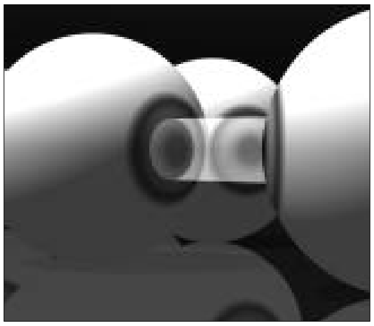
SCIENCE DIGEST

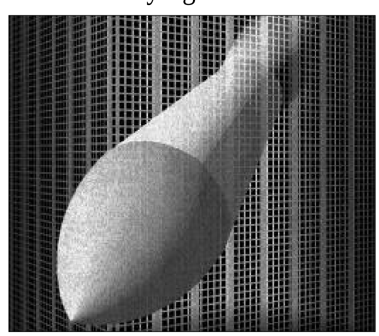
## SEEING EYE TO EYE



Researchers at Los Alamos have developed a novel device for determining the optical properties of the human eye. The instrument, which assesses the optical characteristics of the eye lens, uses fiber optics to rapidly and noninvasively determine the overall optical quality of the lens. The process directs modest levels of light into the eye for a few seconds and then measures the resulting backscatter and fluorescence spectra. The data is collected and compared to results in a database containing a reference set of data for normal human lenses. The measurements can serve to document accelerated optical aging or as indicators of cataracts or other disease processes. An industrial partner is sought to commercially develop the technology. CONTACT: IRVING BIGIO, (505) 667-7748, E-MAIL: ijb@lanl.gov

## MAKING SANS OF IT ALL

Using small-angle neutron scattering, researchers have gained a better understanding of the microstructural properties of the high-explosive material used inside nuclear weapons. Small-angle neutron scattering, or SANS, has been around since the 1960s for studying the microstructural properties of complex fluids, polymers and other materials, but only over the past few years has it been used for studying the properties of HE systems. As the neutrons strike the HE sample, they scatter at very small angles. By measuring the angles of scatter, researchers can detect defects such as pits or cracks within HE materials, and determine the material's porosity and surface area. This information can then be fed into a computer for modeling purposes to better predict weapon performance. Because neutrons are highly penetrating, researchers don't need to rely on special sample preparation techniques. Microstructural characterization of HE systems plays an important role in the Department of Energy's Science-based Stockpile Stewardship Program from both a safety and performance standpoint since cracks or pores in HEs caused by aging or damage can affect weapon reliability and performance. CONTACT: JOSEPH MANG, (505) 665-6856, E-MAIL: jtmang@lanl.gov



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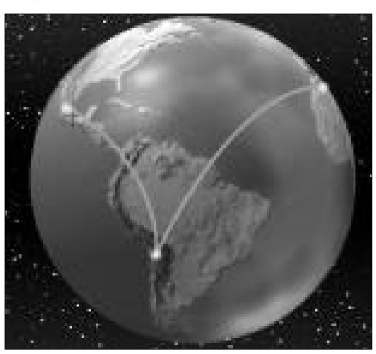
SCIENCE DIGEST

## WHEN BEAM MEETS TUMOR

Scientists recently discovered it is feasible to use the Monte Carlo transport method and powerful computers to calculate energy deposition and particle transport caused by radiotherapy beams in the human body. The Monte Carlo transport method is a process for obtaining an approximate solution to certain physics and mathematics problems by using statistical sampling techniques. The calculation facilitates the optimum radiation dose delivered to the tumor while minimizing the dose given to nearby organs. The knowledge is useful in reducing the risk inherent with radiotherapy. The process requires an accurate understanding of neutron, proton and photon behavior in biological materials. The knowledge came as a result of nuclear model calculations and experimental programs run at the Weapons Neutron Research Facility at the Los Alamos Neutron Science Center. CONTACT: MARK CHADWICK, (505) 667-9877, E-MAIL: mbchadwick@lanl.gov

## A WORLD OF WASTE

Radioactive wastes in the foothills of Peru, the outskirts of Mexico City, the Romanian countryside and even the Nile Delta are coming under the scrutiny of Los Alamos scientists. As part of a DOE effort to provide technical cooperation in peaceful uses of nuclear energy, Los Alamos is providing expert advice to effectively control and dispose of low-level nuclear wastes around the world. Laboratory geologist Dennis Newell is consulting with nuclear authorities to enable nations to develop responsible disposal practices and safety analyses for low-level radioactive waste — typically those generated by medical therapies, industrial applications and research, but not power reactors. Los Alamos nuclear physicist Kenneth Apt, coordinating the effort, says his team has logged trips to Cairo, Lima, Mexico City and Bucharest to help facility managers and government officials understand the comprehensive effort needed to develop and use low-level radioactive waste facilities in a socially responsible and economically sustainable fashion. CONTACT: KEN APT, (505) 667-5796, E-MAIL: kapt@lanl.gov



DATELINE: LOS ALAMOS

SCIENCE FOR THE 21ST Century

# DO NEUTRINOS HAVE MASS?

## RESEARCH PROBES THE MYSTERIOUS, SUBATOMIC WORLD OF MINISCULE PARTICLES

Learning more about neutrinos could have an enormous impact on our understanding of the composition and evolution of the universe.

Although the sun and other stars generate and emit neutrinos constantly by fusing hydrogen into helium, Earth and other cosmic bodies are virtually transparent to a neutrino.

Scientists calculate that three trillion neutrinos pass through every square centimeter of Earth's surface every second, but only one in 10 billion ever interact with other matter. These weak and rare interactions with other particles make neutrinos difficult to detect and study.

In 1955, Los Alamos scientists Frederick Reines and Clyde Cowan Jr. used a detector called "Herr Auge," or Mr. Eye, to gather the first tangible evidence of the existence of neutrinos, which previously had been known only in theory. This discovery earned Reines the 1995 Nobel Prize in physics.

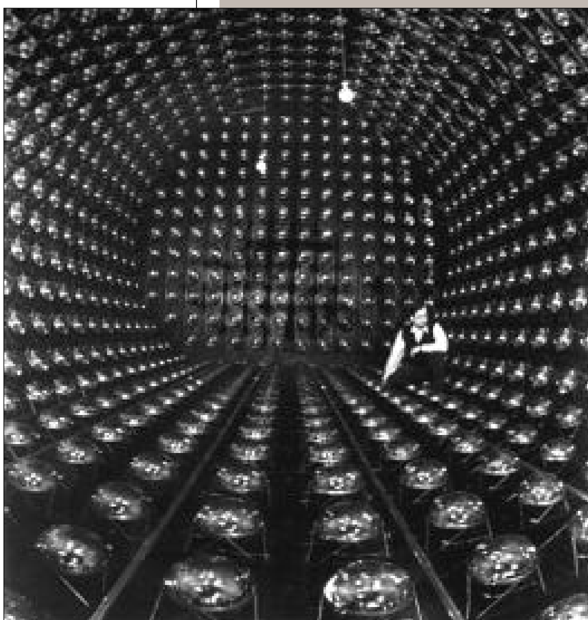
A researcher and the early neutrino detector "Herr Auge."

In 1996 a team of scientists at Los Alamos used the Liquid Scintillator Neutrino Detector — a chamber filled with about 60,000 gallons of pure mineral oil and 1,220 detectors — to demonstrate with a beam of neutrinos created by a linear accelerator that the tiny particles might indeed have mass.

At about the same time, Los Alamos researchers were leading SAGE, a joint Russian-American experiment using 55 tons of liquid gallium metal as a solar neutrino detector located deep underground at the Baksan Neutrino Observatory in the Caucasus Mountains of Russia.

## Dateline: Los Alamos

# Science for the 21st Century



The inside of the Liquid Scintillator Neutrino Detector.

Today, Los Alamos scientists are pursuing neutrino research in locations around the world. The Liquid Scintillator Neutrino Detector experiment is moving to Fermi National Accelerator Laboratory. The Fermi version of the Los Alamos experiment, called Boone, will provide further evidence to validate or refute the neutrino mass discovery.

In another project, Los Alamos scientists are among hundreds of international collaborators working together in Japan's Kamioka mine on Super-Kamiokande, or Super-K — a huge cylindrical tank of purified water surrounded by eleven thousand detectors called photomultiplier tubes.

Deep in the heart of Canada's Creighton mine lies the Sudbury Neutrino Observatory, another multinational collaboration involving researchers from Los Alamos. Located 6,800 feet below the surface, the Sudbury Neutrino Observatory contains 1,000 tons of heavy water in an acrylic vessel 12 meters in diameter. Interactions between incoming neutrinos and the heavy water are detected by the geodesic array of 9,600 photomultiplier tubes surrounding the vessel.

Neutrino research has come a long way since Reines' and Cowan's first measurements and the ongoing work demonstrates the neutrino's cosmological importance. The Standard Model, a model that has ruled particle physics for nearly three decades, has as its cornerstone massless neutrinos. Since neutrino oscillations can only occur if neutrinos are massive, any detected oscillations constitute the first definite evidence of new physics beyond the Standard Model.

The neutrino's mass could eventually enable cosmologists to determine the origins and ultimate fate of the universe, as the combined mass of the wispy neutrinos may surpass the mass of all other material in the universe.

DATELINE: LOS ALAMOS

## BRIEFLY ...

Beginning with this issue, we're adding a new feature to *Dateline: Los Alamos*: a monthly series titled Science for the 21st Century. The articles will be culled from Los Alamos National Laboratory Public Affairs Office's new weekly information series by the same name. The Science for the 21st Century series highlights some of the extraordinary and groundbreaking science the Laboratory will be exploring in the next century. This month we'll unravel Los Alamos' Nobel Prize-winning past, as well as its present role in the hunt for elusive neutrino particles. See pages 18 and 19 for the first installment. You can read the weekly releases at the following address on the World Wide Web: http://www.lanl.gov/orgs/pa/science21.



## IN THIS ISSUE:



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