DECEMBER ISSUE 1997

LOS ALAMOS NATIONAL LABORATORY
WHERE SCIENCE MAKES A DIFFERENCE

DATELINE
LOS ALAMOS

ELK USING MILITARY TECHNOLOGY

COLLARS ACCESS GLOBAL POSITIONING SYSTEM TO PINPOINT LOCATION

St. Nick's yearly sleigh ride might be easier if his reindeer wore the same collars as some Los Alamos elk. The Rocky Mountain elk are using the global positioning system satellites to communicate their locations with Laboratory wildlife biologists.

Originally deployed for military use, the GPS satellites orbit Earth providing accurate map coordinates to users on the ground. Los Alamos researchers are using this technology to develop a master land-use plan that includes tracking movements of the elk herds around the Laboratory.

The first goal of the research is to test the GPS technology to track wildlife, the second goal is to determine the impact of the growing herd on Laboratory resources. Los Alamos researchers trapped six elk last winter to study the movements and resource use habits and how these habits may affect Laboratory property and future land-use plans.

Because Los Alamos is a weapons laboratory, its land is used for diverse missions and research. For example, in one of the canyons, researchers

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Laboratory researchers bait a large pen with alfalfa or other tasty elk treats. Once the elk steps into the pen, it triggers a trap door. Researchers then collar the animal with the special GPS device.

routinely set off high explosives to determine the effects of aging on weapons components. Wildlife biologists research how the elk are impacted by Laboratory activities such as these that may cause the animals to alter their movement and habits.

Before GPS, wildlife biologists primarily tracked animals using very high-frequency radio telemetry collars. Researchers hiked in the back country armed with a radio receiver, antenna and headphones to listen for the low-frequency signals emitted from the collared critter. The estimated location of a signal was written on a map.

But tracking the elk on Laboratory land with conventional methods is not practical and is cost prohibitive. Laboratory property encompasses more than 43 square miles with steep, 600-foot deep canyons. The conventional method requires at least two people on foot trying to find a collared animal. On a good day, a researcher may find all the animals. On a bad day, researchers could hike all day with no contact.

Using GPS, researchers receive location data from all the animals without any of the legwork.

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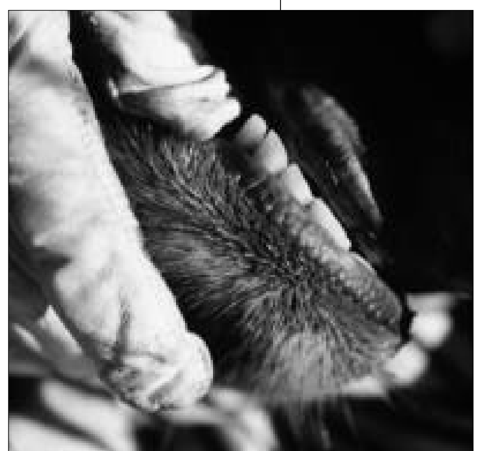
"If we had to do this using regular telemetry, we'd break the bank," Laboratory biologist Kathy Bennett said.

Researchers estimate that the elk herd in the Jemez Mountains near Laboratory property numbers between 8,000 to 10,000, although the Los Alamos herd is much less, probably between 100 to 200 animals. Two large, recent forest fires created more grassland and better elk habitat. No hunting is allowed on Laboratory property and adjacent National Park Service land, allowing the elk population to grow.

"There are estimates by area biologists that the herd is doubling every three to five years," Laboratory biologist James Biggs said. "They're increasing almost exponentially."

However, researchers are unsure if the population is actually increasing or if there is a shift of animals from the Jemez Mountains to the Pajarito Plateau, where the Laboratory is located.

The GPS collar turns itself on every 23 hours. Once it obtains a signal from a GPS satellite, the location is stored in a small memory unit located on the collar, which then shuts off. On the third day, the collar transmits the collected data to a telecommunications satellite. The data then is downloaded and sent to the researchers via an e-mail message.



Researchers rope the feet of the trapped elk to bring him or her down. They place a hood over the head to calm it and examine the teeth and draw blood samples. By looking at the teeth, the biologists can estimate the age and general health of the animal.

Laboratory researchers are currently tracking four elk and hope to trap six to 10 more this winter. When the animal is trapped, biologists place the collar around the neck, take a blood sample and check the teeth. The blood samples provide information on any diseases that have the potential of infecting livestock and researchers can estimate the animal's age from its teeth.

The research team has found that the collared elk migrate very little off Laboratory property.

"There are many issues that affect the elk herd and how the herd may affect current and future operations on Laboratory property," Biggs said. "We're only scratching at the surface. We're just beginning to evaluate the elk population at Los Alamos."

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A COAT OF MANY COLORS

LAB TECHNOLOGY HELPS LOCAL ARTISTS

A penny for their thoughts and nickel for the sculpture, that's an accomplishment of a recent nuclear weapons technology transfer activity.

Metallurgists using their nuclear weapons know-how are sharing their technology with a Santa Fe sculptor and all are receiving rave reviews.

➔

Stockpile stewardship meets the art world. A technology used to spray corrosive-resistant coatings on nuclear weapons storage containers was used by Santa Fe sculptor Tom Bollinger to create "New Life."

Los Alamos researchers are developing metal spray technology to spray corrosive-resistant coatings on nuclear weapons storage containers protecting them for long-term storage. Now this technique is being used in the art community to coat sculptures and create corrosion-resistant, highly polished artistic surfaces.

Laboratory metallurgists Kendall Hollis and Richard Castro contacted Santa Fe sculptor Tom Bollinger who was managing a nearby art foundry. With the help of the Laboratory's technology transfer office, the three researchers, with very different backgrounds, formed a partnership to develop metal spray technology to address the needs of the sculpture art community

Using the metal spray technology, the team can coat nearly any surface to any thickness. Hollis and Castro used a wire-arc spray process to coat an aluminum casting of Bollinger's sculpture called "New Life." The sculpture represents the bond between a pregnant woman and her unborn child. But it also represents a new way of achieving a highly polished and corrosion-resistant surface.

The technique uses a commercially available device that produces a fine metal spray pattern. The device resembles an arc welder. Two wires, made of the metal that serves as the coating, receive opposite electrical

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charges. A small arc forms and melts the wires. A pressurized gas breaks the melted wire tips into a fine metal spray that can coat the object from thousandths of an inch to several inches thick.

The metal spray technique is more efficient than conventional casting processes because it requires less energy to melt the tips of the wires than to heat a large pot of casting material. This technique also improves the time it takes to finish the sculpture. It's easier to achieve a final form of the sculpture when casting in a more workable material. A metal sprayed coating is then precisely applied over the final form, reducing the time it takes for finishing the sculpture.

Another advantage of metal spraying is that it allows the artist to use different metals on a single sculpture. On Bollinger's sculpture, the baby's hand touching the mother's hand is bronze while the surrounding material is nickel. Conventional techniques would have made the combination of nickel and bronze metals extremely difficult. The two metals would have to be separately cast, precisely shaped to fit each other and welded into place.

Bollinger says the metal spray technology will enhance sculptors' works because fewer casting and metal working steps will be required to achieve the desired result.

"Metal sprayed coatings offer a new way of combining different metals that could never be done before," Bollinger said.

The researchers at Los Alamos spray different metals on cast pieces and can fill in flaws and smooth out the sculpture. Bollinger then uses conventional polishing techniques to buff and shine the finished product. If a mistake occurs, it can be sprayed again and buffed away.

There is a trend in the art community for large-scale, outdoor, cast stainless steel sculptures. To achieve these forms, artists and foundry workers must cast the sculpture in small stainless steel sections and weld the pieces together.

Stainless steel welds cause distortion of the sculpture's form requiring extensive finishing to regain the original shape. The spray technology allows the use of larger cast sections of aluminum, which are subsequently joined and coated with stainless steel. This process reduces the number of welds needed thereby reducing the distortion. Reduced distortion improves the ability to reproduce the original and decreases finishing labor requirements.

Bollinger believes this technology could significantly impact the large-scale sculpture community.

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The art community may be slow to accept change, but the team believes once artists see what the metal spray technology can do when expertly applied, it will have a better chance of acceptance.

Bollinger believes the process is a creative resource as well as a technological resource.

Los Alamos researcher Richard Castro sprays a fine mist of nickel on an aluminum cast of the sculpture.

Metal spraying is not new to the sculpture art community. The knowledge and expertise gained in developing this technology for weapons applications can be used to bring state-of-the-art metallurgy techniques to sculpture production. The application of an outer corrosion-resistant coating to an underlying, easily cast and worked material opens up many new possibilities in fine art production, the researchers said.

Hollis and Castro were interested in how their technology could be commercialized and how it could benefit surrounding communities in northern New Mexico. The three collaborators formed a small northern New Mexico business called Scintilla Artworks to commercialize the sculpture spraying technique.

"This is a perfect example of how a technology that's being developed for stockpile stewardship applications can be applied to the local art community," Castro said.

Stockpile stewardship is a national program designed to maintain a high level of confidence in the safety, reliability and storage of the nuclear stockpile without testing.

"It's well known that there's some animosity between local artists and Los Alamos. Hopefully, we're using this technology to narrow that gap," Castro said.

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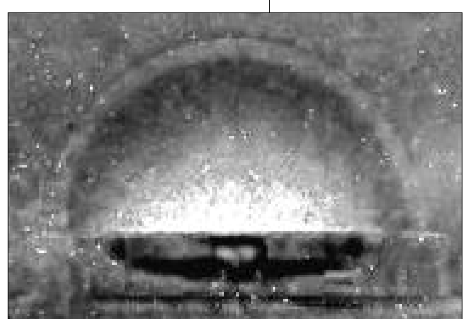
SCIENTISTS PHOTOGRAPH SHOCK WAVE WITH PROTONS

NEW TECHNOLOGY HAS POTENTIAL TO SUPPORT SCIENCE-BASED STOCKPILE STEWARDSHIP

Researchers have used protons from a linear accelerator to "photograph" the detonation wave from a small-scale explosion — demonstrating for the first time a potentially important technology to support science-based stockpile stewardship.



An early proton radiograph produced by Los Alamos scientists. The crude image shows the burn hemisphere of a small piece of high explosive that was detonated in a specially designed containment vessel that allowed the proton beam at LANSCE to pass through and make an image of the explosion.

The scientists detonated a small amount of high explosives inside a chamber specially designed to contain the explosion and let the proton beam at the Los Alamos Neutron Science Center (LANSCE) enter and exit to produce a clear, high-resolution image of the explosion's shock wave.

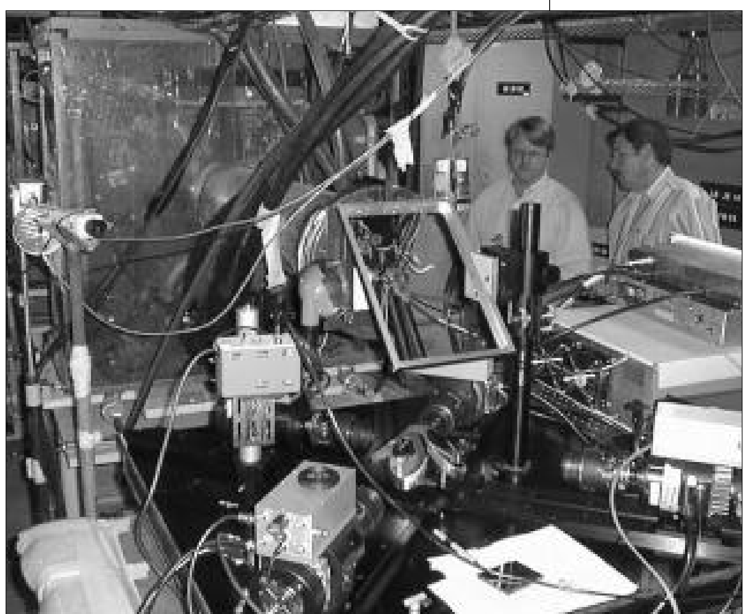
With the September 1996 Comprehensive Test Ban Treaty heralding an end to nuclear weapons tests, the United States is refining ways to ensure that the nation's nuclear weapons stockpile remains safe and reliable in the absence of weapons tests.

Understanding how weapons components age over time is an important part of the science-based stockpile stewardship program at Los Alamos and other national laboratories.

One way to study the behavior inside a weapon's non-nuclear, high-explosive components is to detonate them (so-called dynamic experiments) and look at the resultant shock waves using radiography. The radiography process is most often done with X-rays or neutrons, but in the recent Los Alamos experiment, researchers used protons — which have several potential advantages over X-rays — to take a picture of what happened shortly after detonation.

The idea of proton radiography has been around for a while, but scientists have had to invent new techniques to make radiographs of dynamic systems. For the recent experiments, researchers from many different divisions across the Laboratory assembled to figure out how to use Los Alamos' half-mile-long accelerator with its high-intensity, 800-million-electron-volt proton beam as a proton camera.

In principle, the idea of using protons to produce an image is somewhat similar to using X-rays — high-energy photons — to expose film. But instead of photons, protons are "shone" on the material to be studied.



➔ Researchers Nicholas King (left) and Steven Jaramillo stand next to an apparatus that can make four consecutive proton radiographs in rapid succession. Los Alamos researchers this year made the world's first images of an explosive shock wave using protons at the Laboratory's half-mile-long particle accelerator. The technology has applications for ensuring the safety and reliability of the nation's nuclear weapons stockpile.

As protons interact with the material from which an image is to be obtained, some of the protons are absorbed or scattered. Protons that exit the material strike a recording medium, such as a special type of film or electronic camera, and create an image much like conventional photographic film or a digital camera.

However, because protons are electrically charged, they undergo a large number of small-angle scatterings as they pass through the material. If not corrected, these scatterings would cause unacceptable blurring of the image as they pass from the object to be photographed to the recording medium.

To help overcome the proton scattering problem, Los Alamos researchers developed a magnetic lens to refocus scattered protons. The system uses a series of four quadrupoles — devices that produce magnetic fields — to focus the protons onto the image plane, a process somewhat analogous to a camera lens focusing light onto film.

This new focusing system was the key to overcoming many of the problems that researchers believed would limit the usefulness of protons as radiographic probes.

The complex interaction of the proton beam with the materials to be radiographed was calculated using the Blue Mountain supercomputer at Los Alamos. The Blue Mountain machine, part of the Department of

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Energy's Accelerated Strategic Computing Initiative and another key element of science-based stockpile stewardship, is scheduled to be fully installed at Los Alamos in 1998, and will be the world's most powerful supercomputer — capable of performing more than three trillion calculations a second.

"The ASCI Blue Mountain machine's role was vital to the project since two billion protons in a single burst from the accelerator had to be tracked through the radiography system to model the system's performance," said John McClelland, leader of the proton radiography project.

"This traditionally would have taken weeks of intense computing to model," said McClelland. "With a small fraction of the eventual capability of Blue Mountain, it can now be done in a couple of days. In this experiment, Blue Mountain already has demonstrated its usefulness in predictive modeling calculations."

With development of the magnetic lens, with calculations from Blue Mountain, and with data from proton radiography experiments on static objects performed in July 1996 at Brookhaven National Laboratory, the Los Alamos research team was ready to try proton radiography on a small explosion at LANSCE.

Scientists prepared a 4-foot-diameter containment vessel in which the explosion would occur. The chamber was specially designed to have relatively thin windows through which the proton beam could pass to minimize blurring effects while still safely containing the explosion.

The high-explosives system used in the dynamic experiment was designed to match experimental capabilities available at LANSCE with the interests of the science-based stockpile stewardship program at Los Alamos.

This breakthrough research recently was awarded a Los Alamos Distinguished Performance Award. The citation for the Los Alamos Proton Radiography team reads in part:

" … demonstrations at LANSCE and at Brookhaven's Alternating Gradient Synchroton facility have fundamentally changed how radiography is viewed within the weapons complex. … Additionally, the team's work has made proton radiography a contender for the next-generation advanced hydrotest facility. … Throughout its efforts, the team exemplified the strength inherent in the range of talents found at Los Alamos. Team members applied nuclear and particle physics skills and technologies to a stockpile stewardship problem; developed new codes and modified existing ones to incorporate the unique physics of protons; and introduced new capabilities at both LANSCE and Brookhaven. Their successes illustrate the Laboratory's ability to solve complex problems with a combination of computational and experimental expertise."

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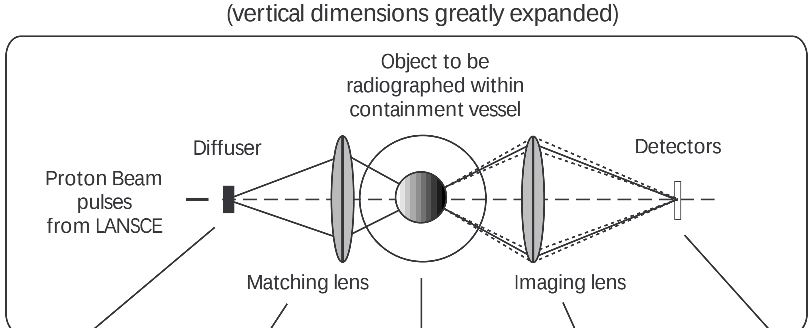
On April 19, teams from Los Alamos and Lawrence Livermore National Laboratory gathered at LANSCE for the first dynamic experiment. A portion of the proton beam was diverted to an experiment area where the containment vessel loaded with 92 grams — a little more than 3 ounces — of high explosive stood ready.

Three-and-one-quarter-millionths of a second after detonation, the proton beam snapped a picture of the explosion. The faint image on the plate shows the spherical burn edge — discernible because of density changes created by the explosive shock wave.

The dynamic experiment was a success on two levels. “First it succeeded in demonstrating on the very first attempt a new technology that may revolutionize how we probe the interior of rapidly changing objects,” McClelland said. “Second, it showed that we can integrate people from across the Laboratory and even from other laboratories, to achieve an objective.”

Radiography with Protons

Optical analogy of magnetic lens system
(vertical dimensions greatly expanded)

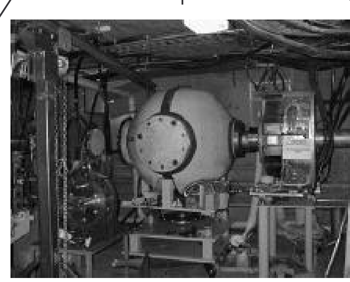


Diffuser spreads "pencil" beam to illuminate entire object

Matching lens prepares optics to eliminate blurring effects in imaging lens

Detector takes multiple "snapshots" during explosion

Imaging lens focuses protons onto detector, greatly reducing blurring effects due to scattering in object



Four-foot diameter vessel contains the small-scale explosive

From idea to implementation, the entire project took less than two years. Researchers didn't actually begin putting the experimental apparatus in place until December 1996, just five months before the first snapshot was made.

After the April experiment, researchers performed a series of small-scale explosive experiments. In the course of these experiments, another Los Alamos research team developed a new electronic camera system capable of taking up to six snapshots over the duration of the explosion to produce a "motion picture" of the explosion process.

Livermore researchers provided two of the cameras used in the new system and also are developing another system that can detect the amount of energy a proton loses as it passes through a material. This will provide a new way of processing the data to better interpret radiographic images.

The researchers plan to continue using LANSCE for additional experiments to develop proton radiography, understand its potential, and obtain scientific data on the behavior inside dynamic materials.

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BRIEFLY ...

LOS ALAMOS SCIENTIST NICHOLAS METROPOLIS HAS HAD A COMPUTATIONAL PHYSICS AWARD NAMED IN HIS HONOR. The prestigious American Physical Society award, sponsored by Academic Press, will recognize the best doctoral thesis research in the field. The winner will be awarded a $1,500 check and $500 for travel expenses to attend the annual meeting of the Division of Computational Physics and present the winning research. Metropolis first arrived in Los Alamos from the University of Chicago in 1943 as a member of the original team of scientists for the war-effort Manhattan Project. He is famous for his central role in the development of early electronic computers and for his advancement of a statistical sampling technique known as the Monte Carlo method.

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