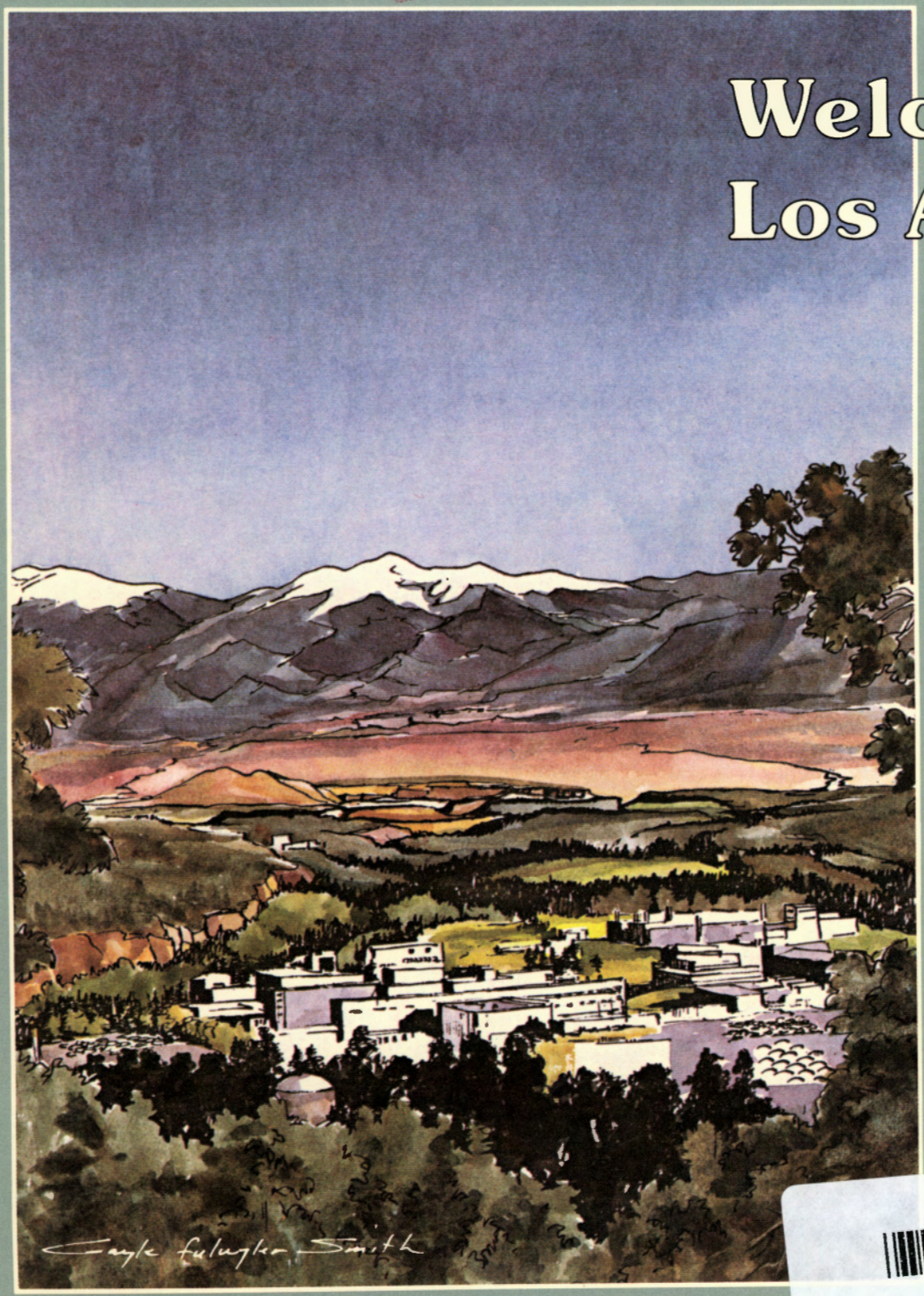
LALP-81-36

10/1/81

General

LIBRARY COPY

Welcome to Los Alamos



12183

LALP-81-36
October 1981
40 M

The following pages provide a capsule summary of the Laboratory's history, setting, organization, and programs. This booklet is designed to answer most of the nontechnical questions that visitors and new and prospective employees ask.

Contents

Foreword **1**
History and Culture of the Pajarito Plateau **3**
The Birth of the Laboratory **5**
Los Alamos County Today **7**
Employment and Educational Opportunities **9**
Organization of the Laboratory **14**
Maps **16**
Facilities **19**
Mission and Programs **21**
- National Security Programs **24**
- Energy Programs **30**
- Basic Research **40**

Some Los Alamos Firsts **47**

Cover: Watercolor of Los Alamos National Laboratory, Los Alamos, New Mexico.
By Gayle Fulwyler Smith

Foreword

Scientists at Los Alamos National Laboratory investigate an astounding range of phenomena that extend from the earth's interior through its atmosphere and magnetosphere into outer space, from subnuclear particles to galaxies, from events occurring in trillionths of a second to those that take thousands of centuries, from temperatures near absolute zero to those measured in tens of millions of degrees, and from the energy of a single photon to that of a supernova.

The research efforts at the Laboratory have as a primary mission the application of science and technology to problems of national security, that is, to the maintenance of a strong defense, the fulfillment of arms control commitments, and the guarantee of a secure energy supply for the future. In carrying out this mission, the Laboratory serves as a liaison between research programs in academia and industry and complements the activities of both. The interplay between fundamental research in the basic sciences and directed research in energy and defense programs creates a vital and exciting working environment.

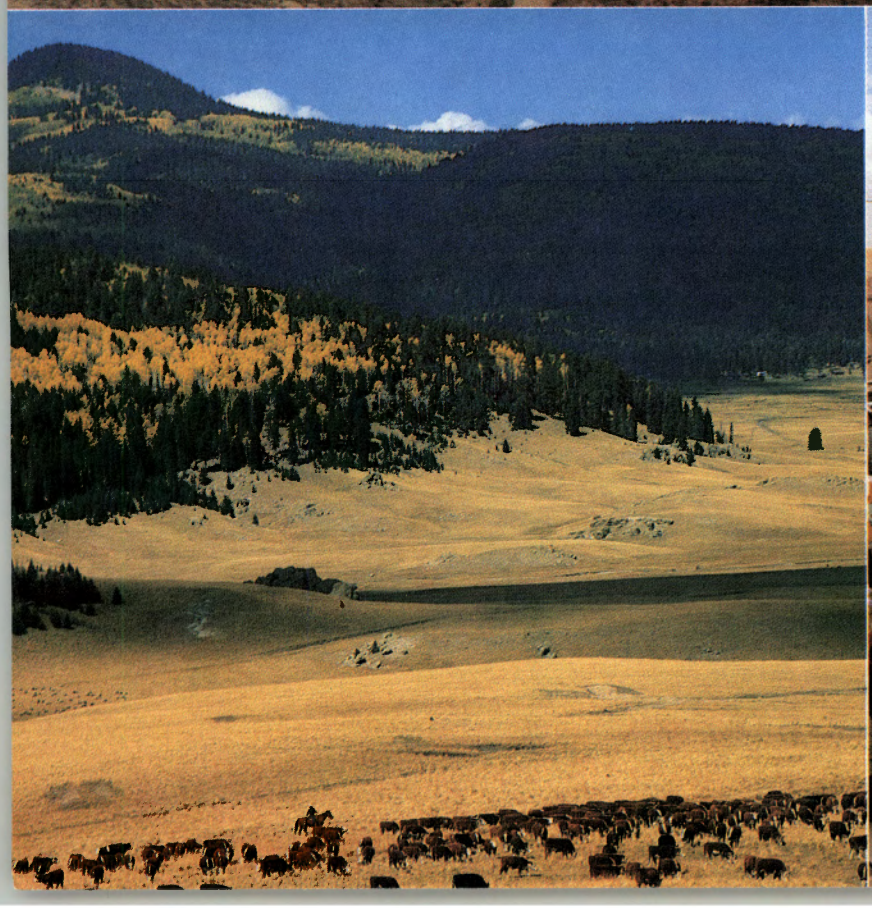
In staff and technical facilities, Los Alamos is one of the largest multidisciplinary, multiprogram national laboratories in the United States. It is also internationally recognized as one of the most prestigious scientific institutions in the world.

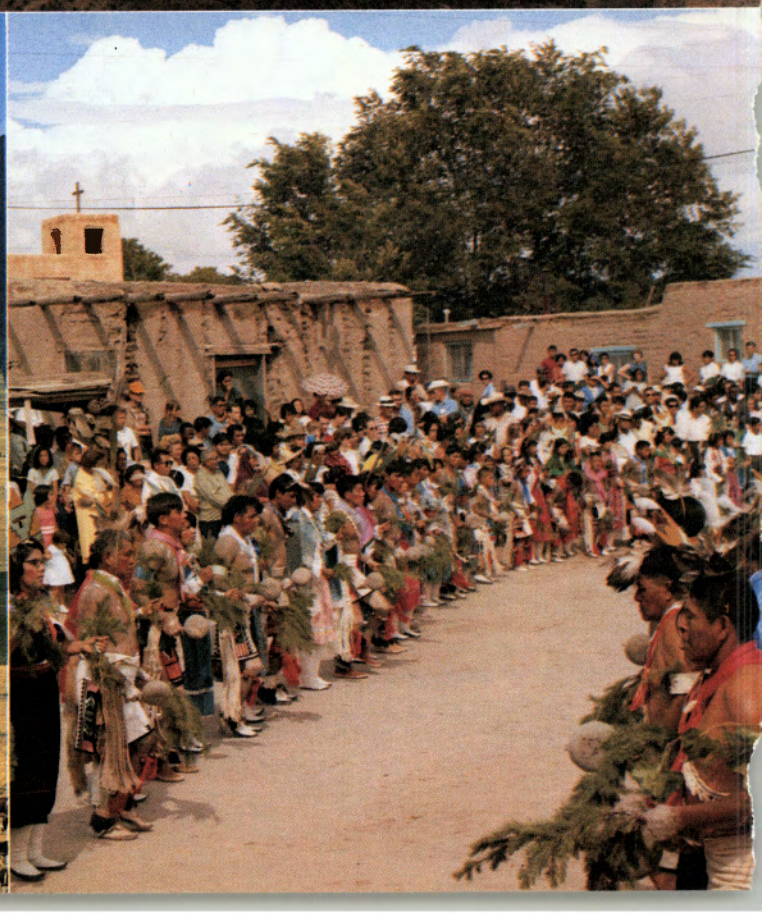
The Laboratory is managed by the University of California for the United States Department of Energy. In fact, all the national laboratories are managed for the Government by universities or private industry. Laboratory employees are employees of the University and consequently share in many benefits that are available to faculty members. Full-time research schedules combined with substantial individual freedom encourage first-rate contributions in basic and applied sciences.

For those of us who live and work here, Los Alamos is a place of challenge and discovery in a setting of great natural beauty. We welcome you to Los Alamos!

Donald M. Kerr

Donald M. Kerr
Director
Los Alamos National Laboratory





History and Culture of the Pajarito Plateau

Twelve million years ago a series of volcanic eruptions southwest of Los Alamos began to build the Jemez Mountains. This activity climaxed over a million years ago with two gigantic explosions that deposited a hundred cubic miles of tuff (ashfall and ashflow) and pumice around the mountain flanks.

The center of the highlands collapsed to form a caldera, a basin-shaped depression, 12 to 20 miles across and from 500 to 3,000 feet deep. Then, except for the building of the central peaks in the caldera, the volcanoes became dormant, as they are today.

Wind, water, heat, and cold have shaped and changed what the volcanoes so magnificently created. The central caldera, once a lake, is now covered with lush grasses for grazing cattle.

The Pajarito (Little Bird) Plateau, where Los Alamos and the Laboratory sites are located, is capped by a pocked and jointed layer of Bandelier Tuff. The plateau has been dissected by erosion into 15 or so finger mesas separated by steep-sided canyons that run southeast to the Rio Grande. Deer, elk, and bear, small mammals and birds, fish and reptiles thrive in the forests and streams of these mountains, mesas, and canyons.

People came here at least 8,000 years ago (Sandia Man perhaps much earlier) to hunt the abundant wildlife. Artifacts show that they continued to hunt here for thousands of years. Eventually, Indians built houses and dry-farmed on the mesas. Villages evolved by 1100 A.D.

Two major periods of migration followed. The first peaked in the 1100s. About 1300 the Anasazi people left their great cities at Chaco Canyon, Mesa Verde, and Kayenta in the Four Corners area, moving southwest in Arizona and southeast in New Mexico. They may have joined the expanding populations along the Rio Grande. The ruins of several hundred of their settlements sprinkle the mesa tops around Los Alamos (a well-preserved one is near Fuller Lodge).

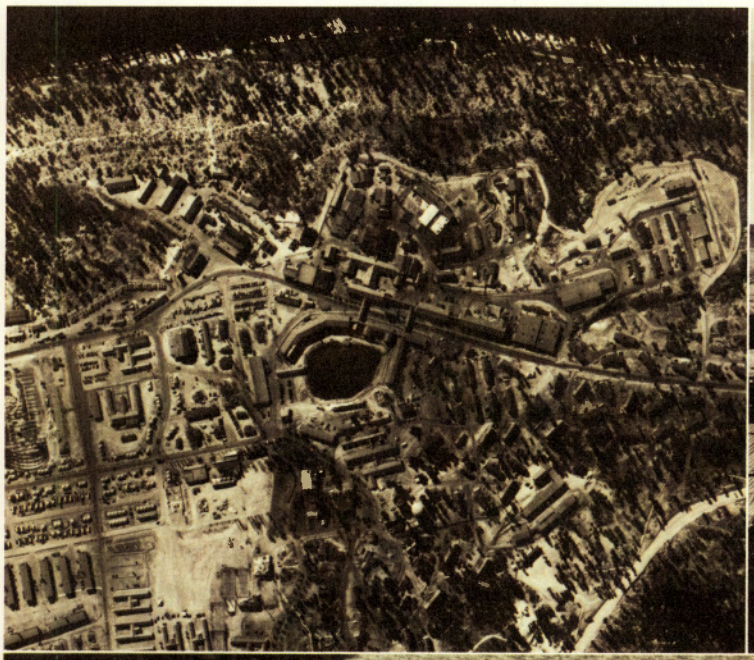
Top: The Jemez Mountains and their finger plateaus were sculpted by volcanic eruptions, winds, and erosion. Bottom right: Pueblo Indians dance near Los Alamos. Bottom left: Herds of cattle graze on the lush grasses of the Valle Grande.

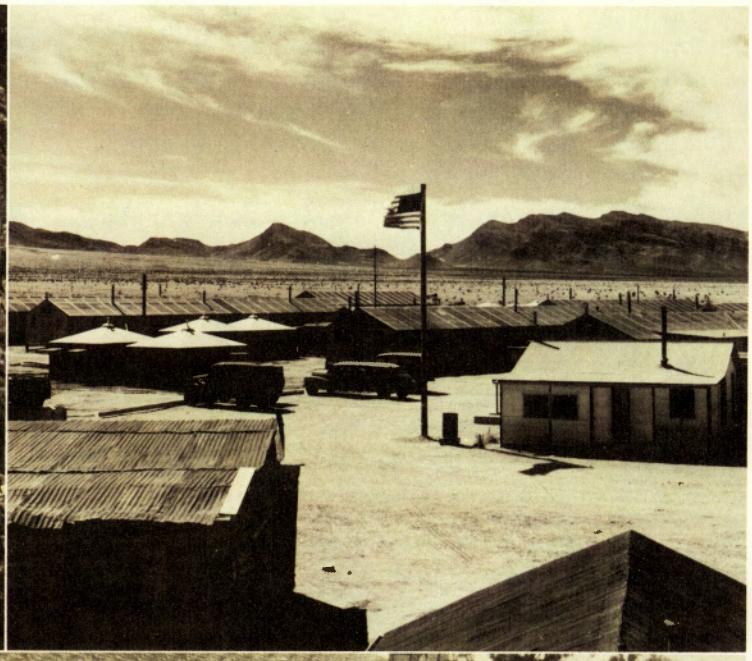
In the second major migration, about the end of the 14th century, these people gradually abandoned the high mesa tops to build large villages in canyons and on low mesas at Otowi, Tyuonyi, Tsankawi (now in the Bandelier National Monument), and Tshirege (near White Rock). By the end of the 16th century the Indians had left the Pajarito Plateau.

Legends say they moved to the Tewa village of San Ildefonso, though many moved to other villages along the Rio Grande (for example, the Keres Pueblos at Cochiti, San Felipe, and Santo Domingo). Today about 31,500 Pueblo Indians, some descendants of the early Pajarito Plateau culture, live in the 19 Pueblo groups in New Mexico. The modern Indian Pueblo culture is influential in this area today.

The first Europeans to extensively explore New Mexico came with Francisco Vásquez de Coronado in 1540 seeking the gold and silver of the fabled Seven Cities of Cíbola. Part of the expedition passed near Los Alamos, as did another expedition led by Antonio de Espejo in 1582. In 1598, eight years after an unsuccessful attempt to colonize New Mexico, Don Juan de Oñate and 140 settlers established the Spanish capital where the Rio Chama and the Rio Grande meet at what is now known as San Juan Pueblo. The capital was moved across the Rio Grande the following year. In 1610 the capital was moved to Santa Fe, only three years after the English settled Jamestown, Virginia. The Spanish continued colonization efforts, despite a pueblo revolt in 1680 that drove them out of the area for a dozen years. A gradual influx of people from Spain and Mexico eventually established a permanent Spanish-American population.

The best land along the rivers had long since been settled when the first Anglo Americans arrived to homestead the Pajarito Plateau in the late 1880s. They started cattle ranches, dry-farmed, mined, and lumbered. During this time, Adolph Bandelier's excavations of prehistoric ruins in Frijoles Canyon generated national interest. In 1916 Bandelier National Monument was established, four years after New Mexico, the tricultural "Land of Enchantment," became a state. The Los Alamos Ranch School for boys (opened by Ashley Pond II in 1918) flourished for nearly a quarter of a century before its facilities were appropriated and expanded in 1943 to accommodate scientists who came to build the first atomic bomb.





The Birth of the Laboratory

In March 1943 a small group of scientists came to the remote Los Alamos Mesa high above the Rio Grande, northwest of Santa Fe. Their mission was to design and build the world's first atomic bomb. The Los Alamos effort was the Project Y part of the United States Army's secret World War II crash program — code named the Manhattan Engineer District. The project was to develop and produce a weapon that harnessed the huge amounts of energy released during nuclear fission (splitting the nucleus of an atom).

Although radioactivity had been known since 1896, nuclear fission was not discovered until early 1939. Immediately, scientists all over the world began investigating nuclear fission and the possibility of a chain reaction that would release useful amounts of nuclear energy by fissioning uranium.

The results of these first investigations, and the early recognition of the military applications of uranium fission, led a group of American scientists, including several refugees from Nazi Germany, to consult the President. They persuaded Roosevelt in 1939 to support a uranium research program to investigate atomic power and atomic weapons.

The United States' entry into World War II in 1941 and the belief that the Germans were working on an atomic bomb project spurred the expansion of this uranium research program into the massive Manhattan Project, a wartime effort carried out with the utmost secrecy and urgency by the finest scientific and engineering talent available.

This vast effort included research laboratories at Columbia University, the University of California, and the University of Chicago, and enormous production and separation plants at Oak Ridge, Tennessee, and Hanford, Washington, for the manufacture of plutonium metal, the fuel for the nuclear weapon.

Top left: The main technical area of the Laboratory was located near Ashley Pond (near center of photo) until the 1950s when the Laboratory expanded and moved to its present location. Top right: Trinity Site, near Alamogordo, New Mexico, was the base camp for more than 200 scientists who made final preparations for testing the atomic bomb. At 5:29 a.m. on July 16, 1945, the world's first nuclear device was detonated 17,000 yards away. Bottom: Fuller Lodge, the hub of the Los Alamos Ranch School, later served as an inn for scientists visiting the Laboratory.

Experimental work on nuclear fission culminated at the University of Chicago when, on December 2, 1942, Enrico Fermi and his coworkers achieved the world's first nuclear chain reaction.

Theoretical possibilities of an atomic bomb were being investigated by Dr. J. Robert Oppenheimer and a small group of well-known physicists at the University of California at Berkeley. By late 1942 their theoretical studies had progressed to the point where design and construction of an actual weapon could begin.

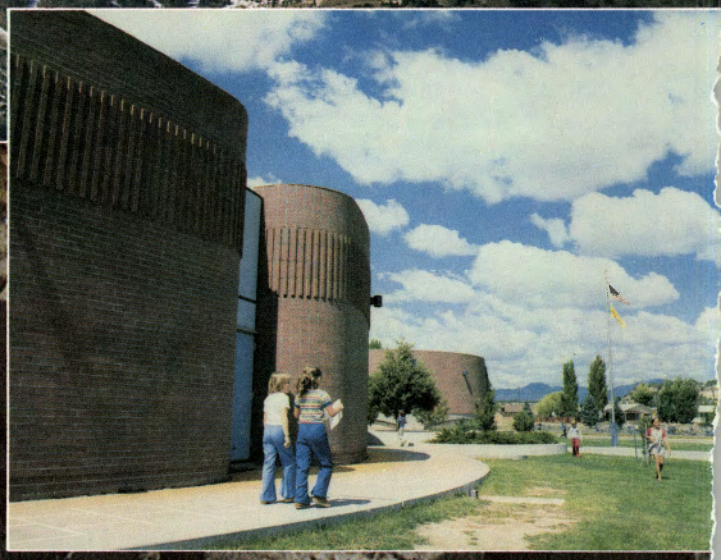
Several sites in the western United States were surveyed as possible locations for the new laboratory. Los Alamos was chosen because it offered isolation, a good climate, and because it was the site of Anchor Ranch and the Los Alamos Ranch School, whose buildings could be used to house the 100 or so scientists then believed needed to develop the weapon. However, more than 3,000 civilian and military personnel were working at Los Alamos in July 1945, when the first atomic device was successfully exploded at Trinity Site in southern New Mexico.

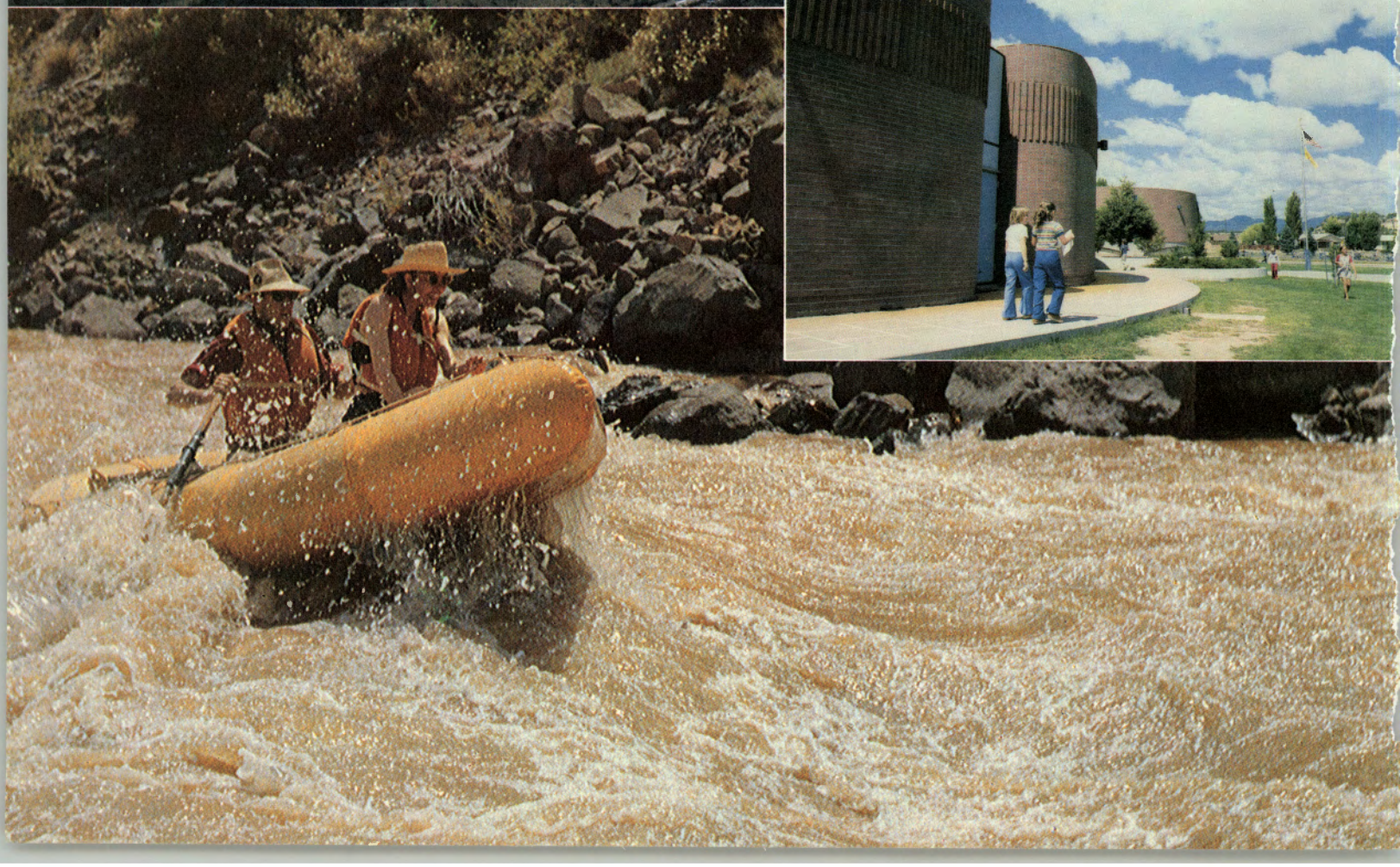
The future of the Laboratory, born of expediency and operated under military control, was suddenly in doubt. General Leslie R. Groves, who was in charge of the Manhattan Project, wrote: "It was particularly important to continue the Los Alamos Laboratory so that the nucleus of a staff for future weapon development would always be available. . . ." But "a number of people strongly urged that we abandon the Los Alamos site and reestablish the laboratory in southern California."*

Los Alamos was not abandoned. It became instead a permanent facility that has achieved recognition as one of the finest scientific research laboratories in the world. Today the Laboratory is a multiprogram national laboratory of the United States Department of Energy, still operated by the University of California, the original contractor to the wartime Manhattan Engineer District.

---

*Now It Can Be Told (Harper & Bros., New York, 1962), pp. 377, 378.





Los Alamos County Today

Until February 1957 Los Alamos was a closed community with strict security controls on residents and visitors. All residences and community facilities, including water, gas, and electric utilities, were federally owned, having been built exclusively to serve Laboratory facilities. Starting in 1958, however, federally owned land was sold to permit private residential development. Federally owned residences were first offered for sale to private individuals in 1965.

All residential property is now privately owned, and almost all community facilities and services are owned and operated by Los Alamos County. Los Alamos and White Rock have a combined population of about 20,000 distributed in an approximate ratio of 2:1. Most residents are Laboratory or contractor employees and their families.

About 35 percent of the employees of the Laboratory, its supporting contractors, and Los Alamos County live outside the county. They commute from Española and Santa Fe, from many small towns and villages in the mountains and valleys, and even from as far away as Taos and Albuquerque. Those who live "on the Hill" have houses or apartments along pleasant winding streets. Many locations offer superb views of the the Jemez Mountains to the west and the Rio Grande Valley and Sangre de Cristo Mountains to the east.

An exceptional school system offers strong academic, extracurricular, and special programs to meet the needs of all students. More than 4,500 students attend five conveniently located elementary schools, two junior high schools, and the high school. Teacher-student ratios compare favorably with national averages — about 1/20 for all grades. The current expenditure per student is about $2,150. About 62 percent of the high-school students go to college, and these college-bound students consistently score above state and national averages on the American College Testing Program and on the Scholastic Aptitude Test.

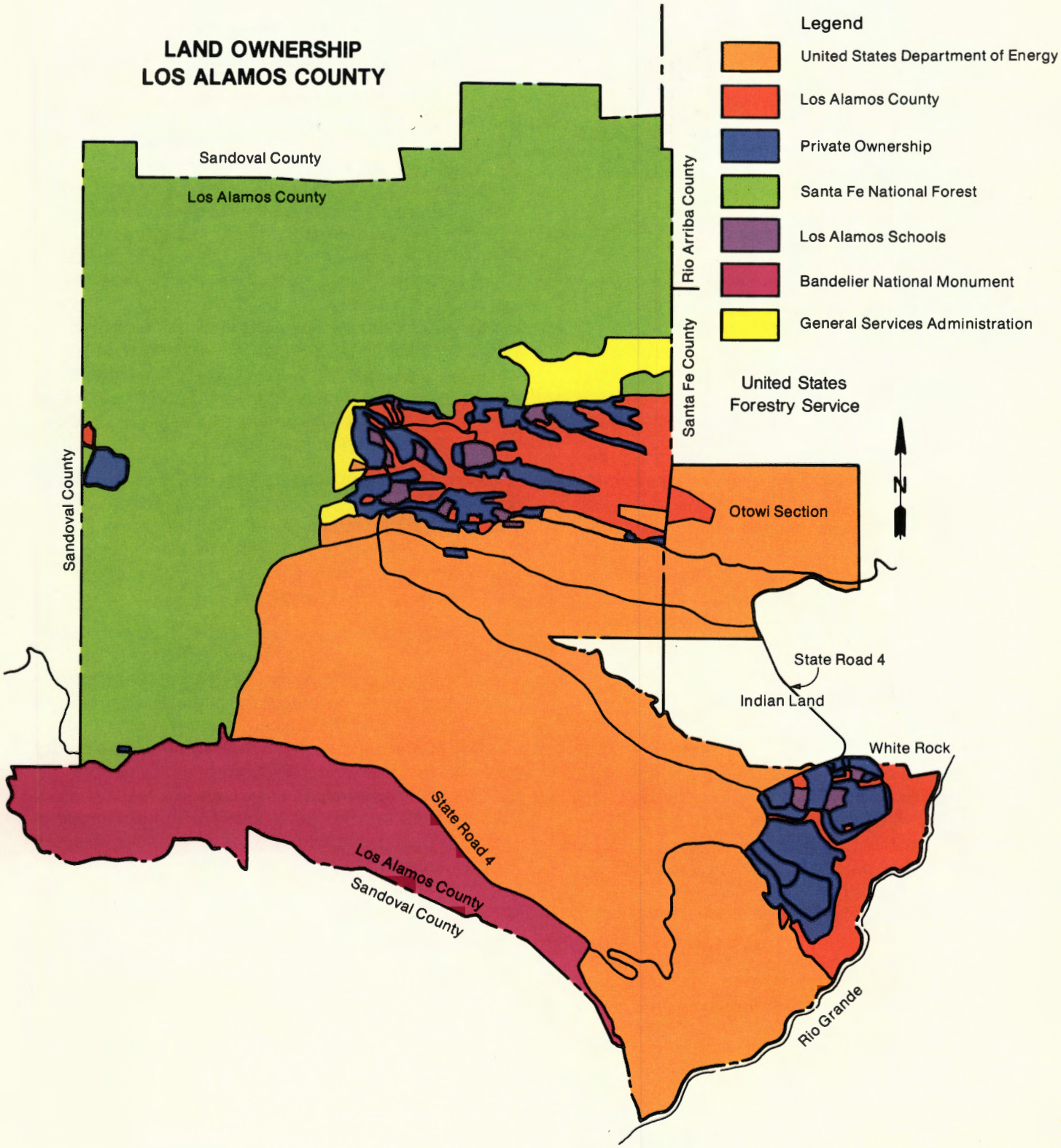
Summers in Los Alamos, at an altitude of 7,300 feet, are cool and pleasant; winters are cold and sunny. The air is generally fresh and clear, and although some days bring gusty winds, many days are calm and beautiful. Daytime highs average 72°F from April through September and 47°F from October through March. The average humidity is about 40 percent, and the total annual precipitation is about 18 inches (August is the rainy month). Snowfalls can be heavy for a total of about 50 inches each winter, but the snow often melts quickly leaving streets and sidewalks clear within a few days. White Rock, at an elevation of about 6,400 feet, experiences warmer temperatures, lower humidity, and less precipitation. It may be raining hard in Los Alamos while White Rock residents only 8 miles away are sunbathing.

For area information, the Los Alamos County Historical Museum in the Fuller Lodge Cultural Center downtown offers local history archives, exhibits, programs, and tours. The Chamber of Commerce in Fuller Lodge provides general information, maps, brochures, and self-guided walking and driving tours.

The Bradbury Science Hall and Museum is, for more than 70,000 visitors each year, a showcase for the Laboratory's varied research activities. Exhibits range from photographs and documents about the earliest days of Project Y to displays on the most recent work in geothermal energy, inertial fusion, and nuclear safeguards. The Science Hall features demonstrations of actual Laboratory devices, visitor-participation exhibits, nuclear fission and fusion models and mockups, and highlights of ongoing Laboratory programs in energy and biomedical research and development.

The museum is open to the public 9 to 5 Tuesdays through Fridays and 1 to 5 Saturdays, Sundays, and Mondays. It is closed on Laboratory holidays. Guided tours are available and cameras are welcome. There is no admission charge.

Clockwise from top left: Skiers tackle one of Pajarito Mountain's challenging slopes. The Pajarito Mountain Ski Area and the Valle Grande are just minutes away from Los Alamos. Chamisa Elementary School in White Rock is one of eight schools in the county. "River runners" challenge the white water of the Rio Grande.

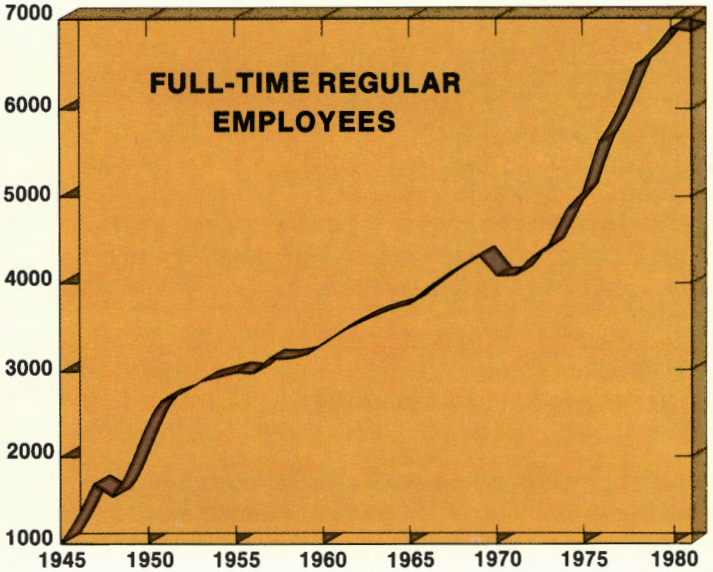

LAND OWNERSHIP
LOS ALAMOS COUNTY
Legend
United States Department of Energy
Los Alamos County
Private Ownership
Santa Fe National Forest
Los Alamos Schools
Bandelier National Monument
General Services Administration
Sandoval County
Los Alamos County
Rio Arriba County
Santa Fe County
Sandoval County
United States
Forestry Service
N
Otowi Section
State Road 4
Indian Land
White Rock
State Road 4
Los Alamos County
Sandoval County
Rio Grande

Employment and Educational Opportunities

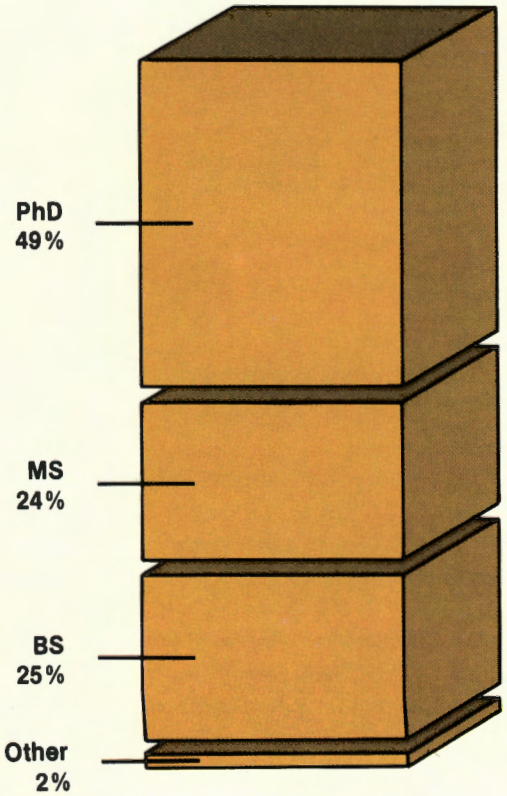
The Laboratory employs about 7,930 people; 7,215 full time, 300 part time, 345 as casuals, and 70 on leaves of absence. About 1,500 more employees of the Department of Energy's Los Alamos Operations Office and of the Zia Company and other contractors are supported by Laboratory operating, capital equipment, and construction funds, which currently total about $450 million, $31 million, and $44 million, respectively.

Regular employees are classified by series: staff member, administrative staff member, general, and technical. Staff members make up about 41 percent of the Laboratory personnel, technical series employees 36 percent, general series employees 15 percent, and administrative staff members 8 percent.

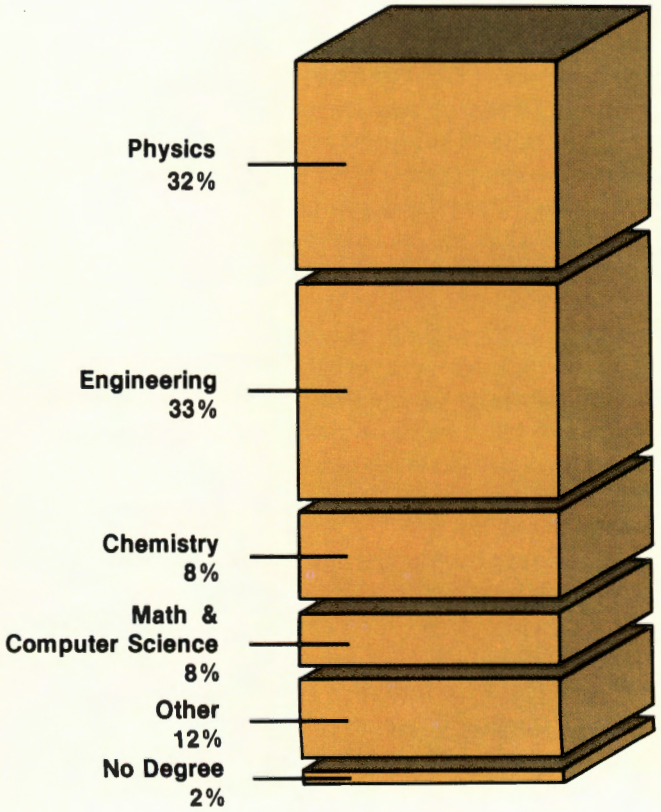
Regular employees are eligible for a comprehensive benefits program encompassing a variety of health and life insurance plans, a retirement program, and a liberal sick



TECHNICAL STAFF BY DEGREE



TECHNICAL STAFF BY DISCIPLINE



leave and vacation policy. Regular full-time employees earn 1-1/2 days of sick leave and 2 days of vacation per month (in addition to 11 paid holidays).

Special Employment Opportunities

The Laboratory offers a variety of special employment opportunities to researchers and students. These programs are briefly described here. For more information contact

Employment Group (PA-1)
Los Alamos National Laboratory
Los Alamos, NM 87545

J. Robert Oppenheimer Research Fellowship. Provides an opportunity for independent research to a select number of new Ph.D.'s who show promise of becoming outstanding leaders in science. One- to two-year appointments.

Postdoctoral Research Program. Provides work to deepen and broaden research experience of recent Ph.D. graduates in science and engineering. Many postdocs have subsequently become regular Laboratory employees. One- and two-year appointments.

Graduate Research Assistant Program. Provides jobs that contribute to students' graduate studies in science and engineering. Year-round program; most students participate during the summer.

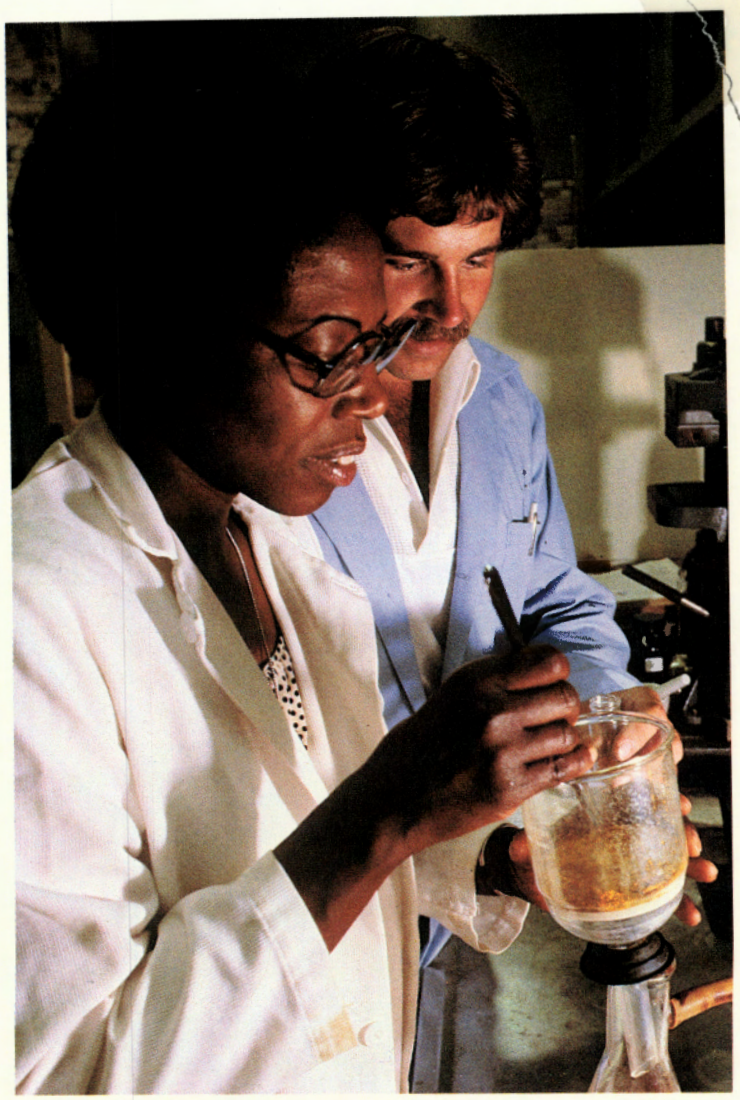
GEM Fellowship. As part of the Laboratory's membership in the National Consortium for Graduate Degrees for Minorities in Engineering (GEM), provides summer employment for recipients of stipends covering their graduate engineering education.

Summer Undergraduate Program. Gives work experience to full-time undergraduates and high-school seniors who plan to enter college the next fall semester. Preference given to students from economically disadvantaged families.

Skills Training Employment Program. Aids degreed and nondegreed participants who lack training or work experience to prepare for a career at Los Alamos. One-year appointments.

Undergraduate Cooperative Program. Provides New Mexico undergraduates an opportunity for six months of campus study and six months of work experience.

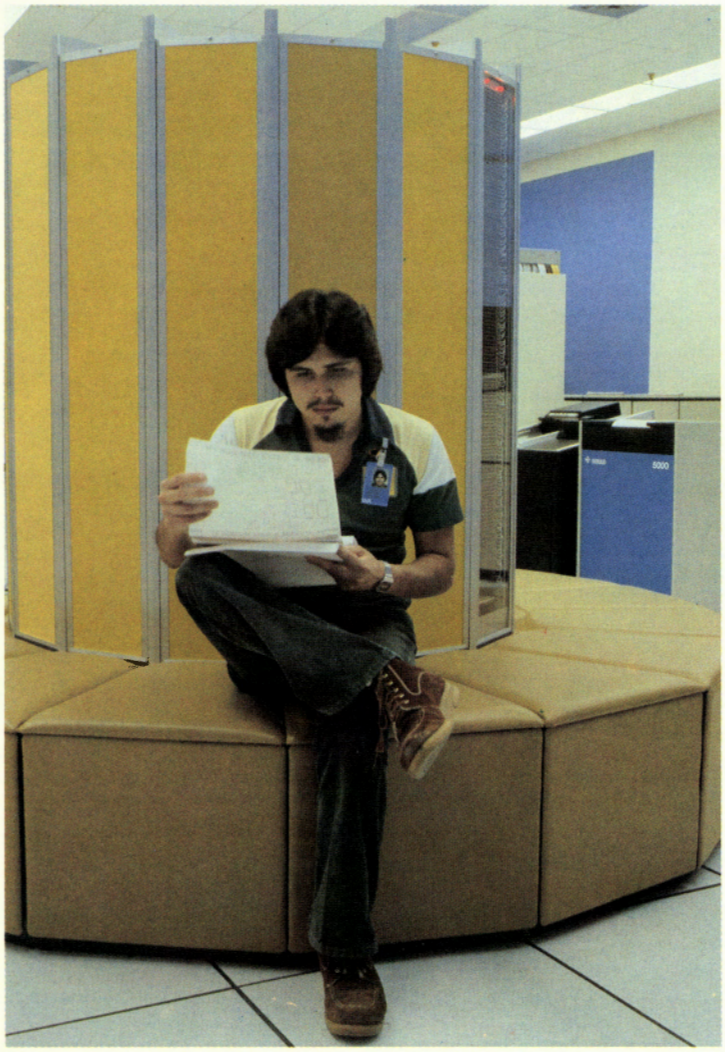
Machinist Apprenticeship Program. A four-year program involving 800 hours of classroom instruction and on-the-job training that leads to a Laboratory machinist rating. Graduates become Machinists II.



The following employment opportunities enhance the Laboratory's interaction with industry and the academic community. Participants in these programs are not Laboratory employees (except for long-term visiting staff members).

Visiting Staff Members. Professionals who come to the Laboratory for a specific assignment either under contract or as employees. Short- and long-term appointments.

Industrial Staff Members. Promotes collaborative technical research on projects of mutual interest to the



Laboratory and industry. One- and two-year appointments.

Military Staff Members. Improves interagency communication and gives the military a better understanding of work at a national weapons laboratory by assigning career scientific officers to staff member positions. Two- and three-year appointments.

Service Academy Research Appointees. Summer appointments of a limited number of the Service Academy faculty members and cadets to work with Laboratory employees in various programs.

Guest Scientists. Provides opportunities for specific research that uses unique Laboratory facilities, such as the Van de Graaff accelerators, Omega research reactor, and the Meson Physics Facility. Term of appointment varies.

Consultants. Provides expert knowledge not available within the Laboratory or independent second opinions. Term of appointment varies.

Visiting Scientists. Provides interaction with Laboratory staff members and promotes exchange of information between the Laboratory and international scientific community. Short-term visits.

Laboratory Fellows. Awarded to outstanding scientists to pursue research of their choice for an indefinite period.

Information on these programs may be obtained from
Official Visitor Liaison (PA-1)
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Educational Opportunities

There are many opportunities for advanced training, both formal and informal, at the Laboratory. Some of these special programs are indicated below.

Tuition Assistance Program. Provides reimbursement for tuition to employees pursuing career development.

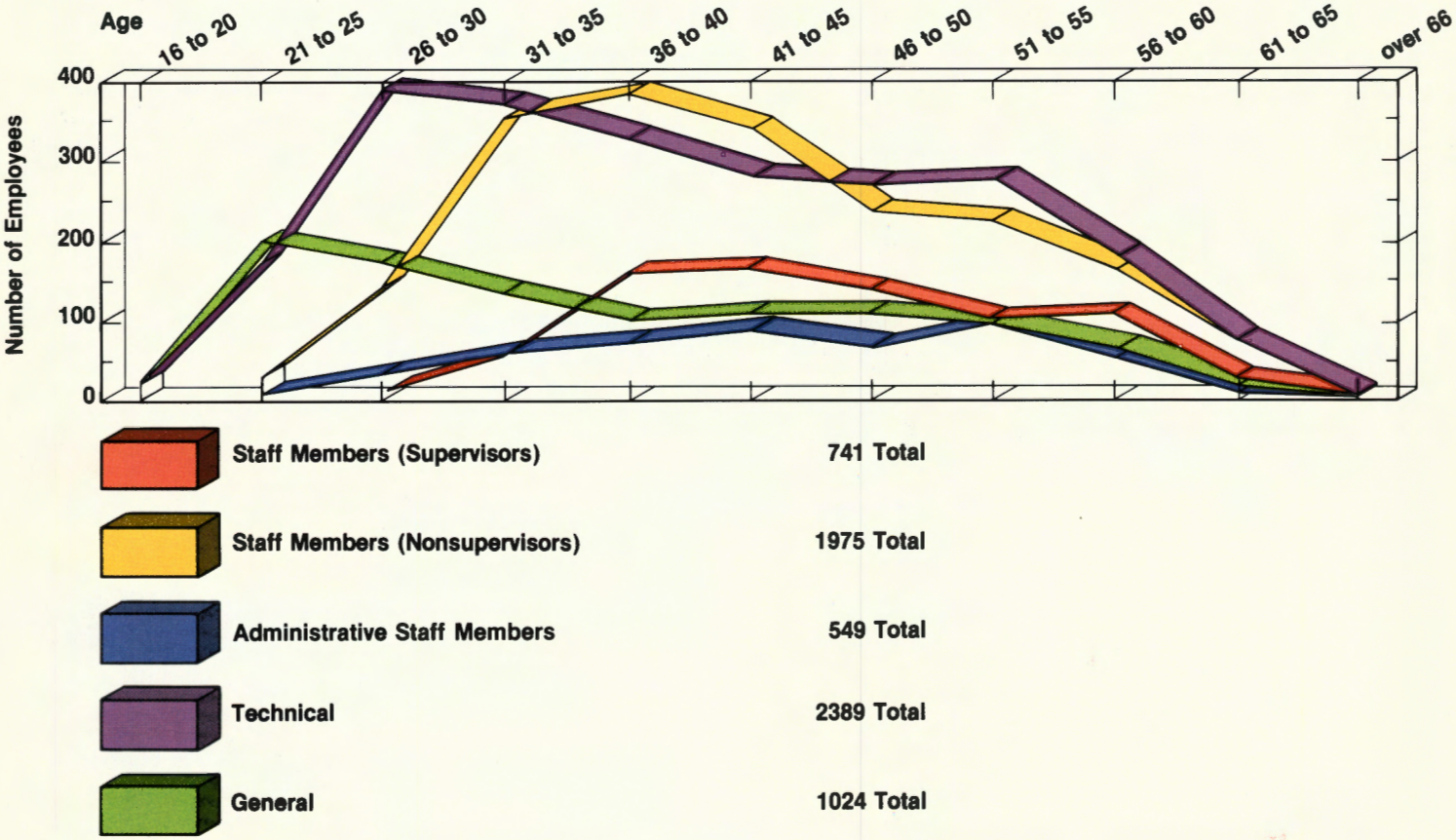
Academic Tuition Program. Operated by the Laboratory's training office with the Los Alamos Center for Graduate Studies of the University of New Mexico. Provides opportunities for employees to enroll in evening courses that can lead to master's and doctoral degrees in technical fields.

Continuing Education. Nearly 200 courses offered each year specifically to assist employees in personal upgrading of skills to be used on the job.

Consortia Appointments. In cooperation with Associated Western Universities, Inc., and University Association for Science, offers research opportunities at the Laboratory for graduate students and faculty members. The sponsoring institution pays the appointees.

Graduate Thesis Program. Regular employees of two years or more who have essentially completed all course requirements, have thesis proposals acceptable to the Laboratory and the University, and arrange to have a Laboratory staff member supervise their thesis research, are eligible. Provides facilities for research, thesis supervision, and typing support.

FULL-TIME REGULAR EMPLOYEES



Professional Research and Teaching Leave. Leave for scientific staff members who have been Laboratory employees for at least four years. Provides part payment of salary for up to one year to persons of outstanding professional ability with a firm plan for study, teaching, or research relevant to Laboratory interest.

Advanced Study Program. Allows staff members who have been employees for at least three years to pursue graduate scientific study at a recognized college or university when it will enhance the Laboratory's objectives.

Summer Science Student Program. Joint program of the Department of Energy and Department of Labor aimed at motivating high-school students to pursue science-related education and careers by allowing them to work with Laboratory staff who serve as their tutors and mentors.

DISCIPLINES EMPLOYED IN LABORATORY RESEARCH PROGRAMS

Biosciences

Biochemists
Biologists
Biophysicists
Health Physicists
Physicians
Veterinarians

Chemistry

Inorganic Chemists
Nuclear Chemists
Organic Chemists
Physical Chemists
Theoretical Chemists

Computer Science and Math

Code Developers
Computer Designers
Computer Programmers
Mathematicians
Systems Engineers

Engineering

Aeronautical Engineers
Architectural Engineers
Chemical Engineers
Civil Engineers
Electrical and Electronic Engineers
Environmental Scientists and Engineers
Materials Scientists
Mechanical Engineers
Mining Engineers
Nuclear Engineers

Geosciences

Geochemists
Geologists
Geophysicists
Hydrologists
Seismologists

Physics

Astronomists and Astrophysicists
Atomic/Molecular Physicists
Medium-Energy Physicists
Nuclear Physicists
Particle Physicists
Plasma Physicists

Systems Science

Economists
Statisticians
Systems Analysts

Technical Support

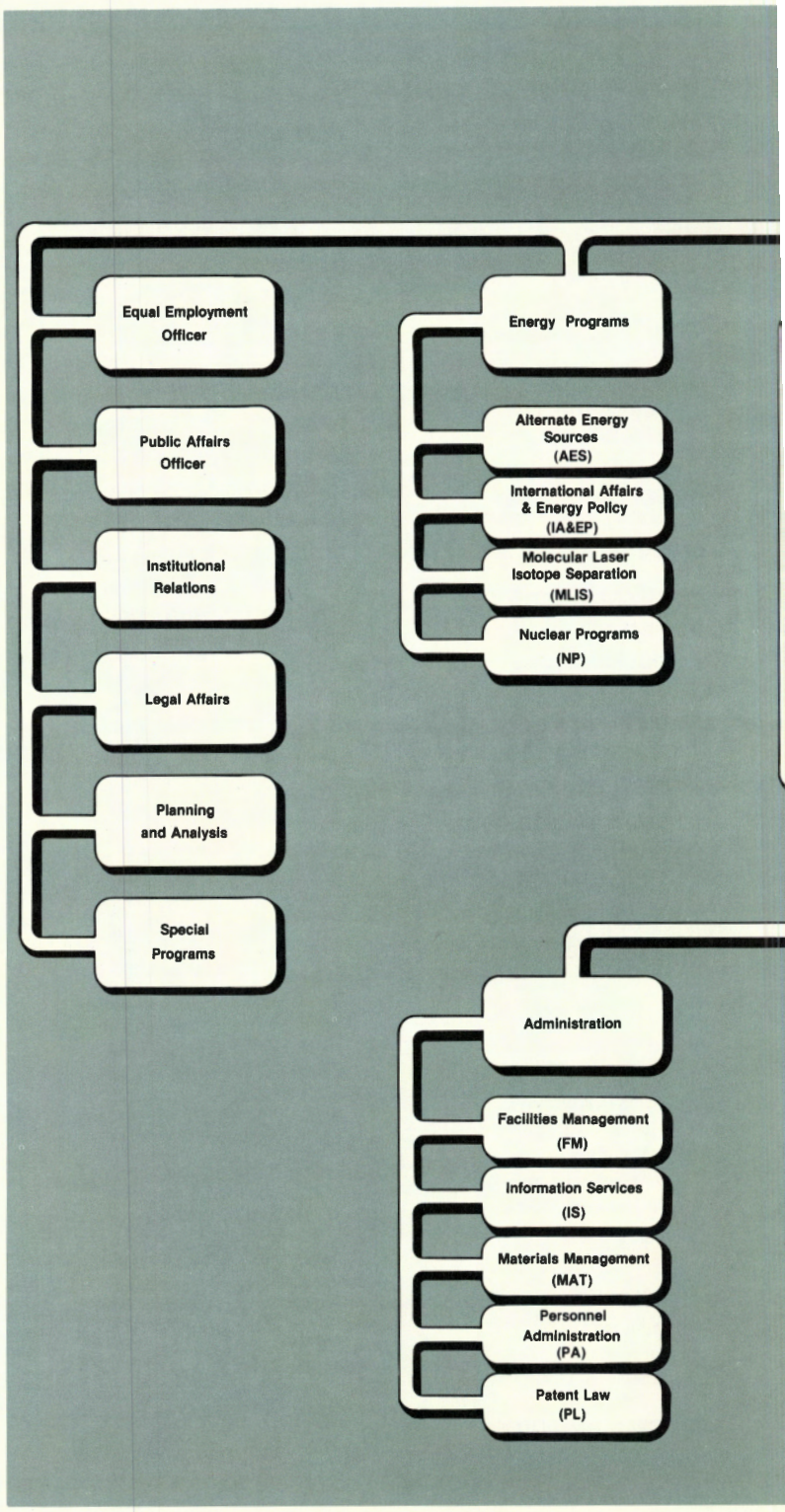
Biological Technicians
Chemical Technicians
Design Technicians
Electronic Technicians
Machinists
Materials Technicians
Mechanical Technicians
Optical Technicians

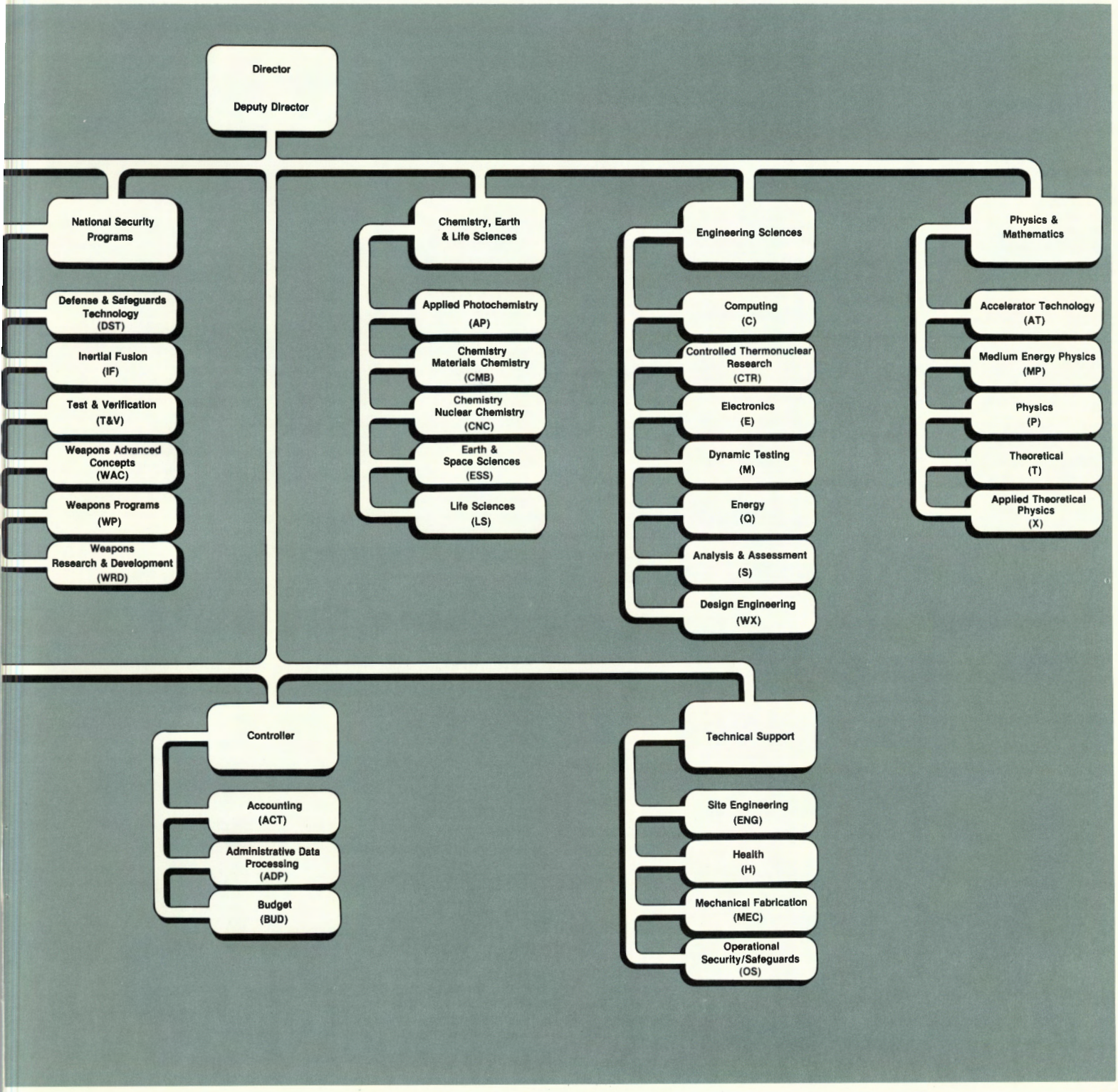
Organization of the Laboratory

The Laboratory land and facilities are owned by the Department of Energy and operated under contract by the University of California. The Albuquerque Operations Office of the Department of Energy oversees the administrative and budgetary aspects of the contract assisted by its branch, the Los Alamos Area Office.

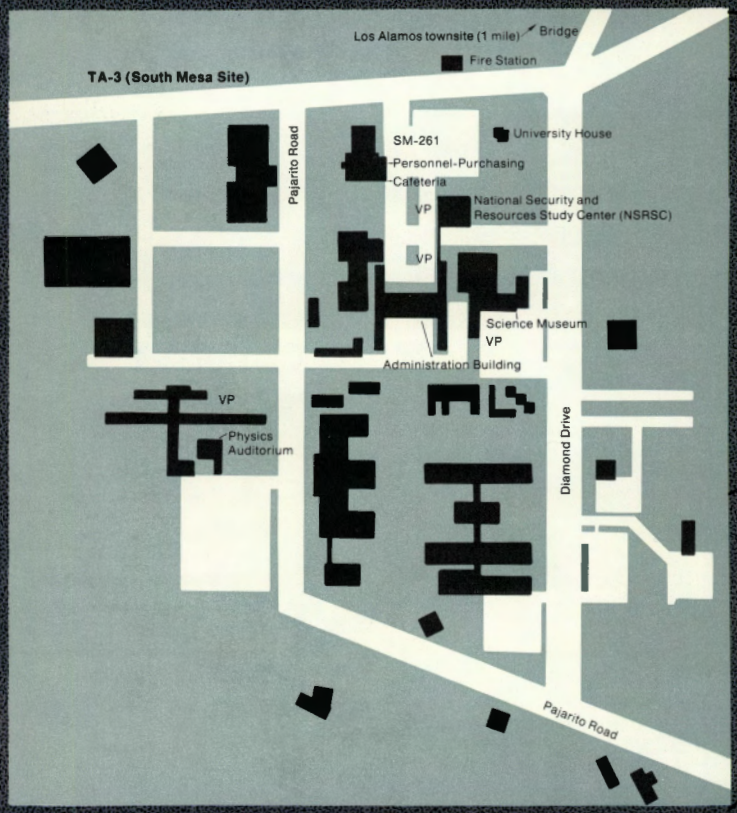
While the official channel for the Laboratory's relationship with the Department of Energy is through Albuquerque, substantive discussions on programmatic work are carried out directly between the Laboratory and Department of Energy Headquarters personnel in Washington, D. C. In the Headquarters organization structure, the Laboratory falls under the managerial purview of the Assistant Secretary for Defense Programs, along with the other two weapons laboratories, Sandia National Laboratories and Lawrence Livermore National Laboratory.

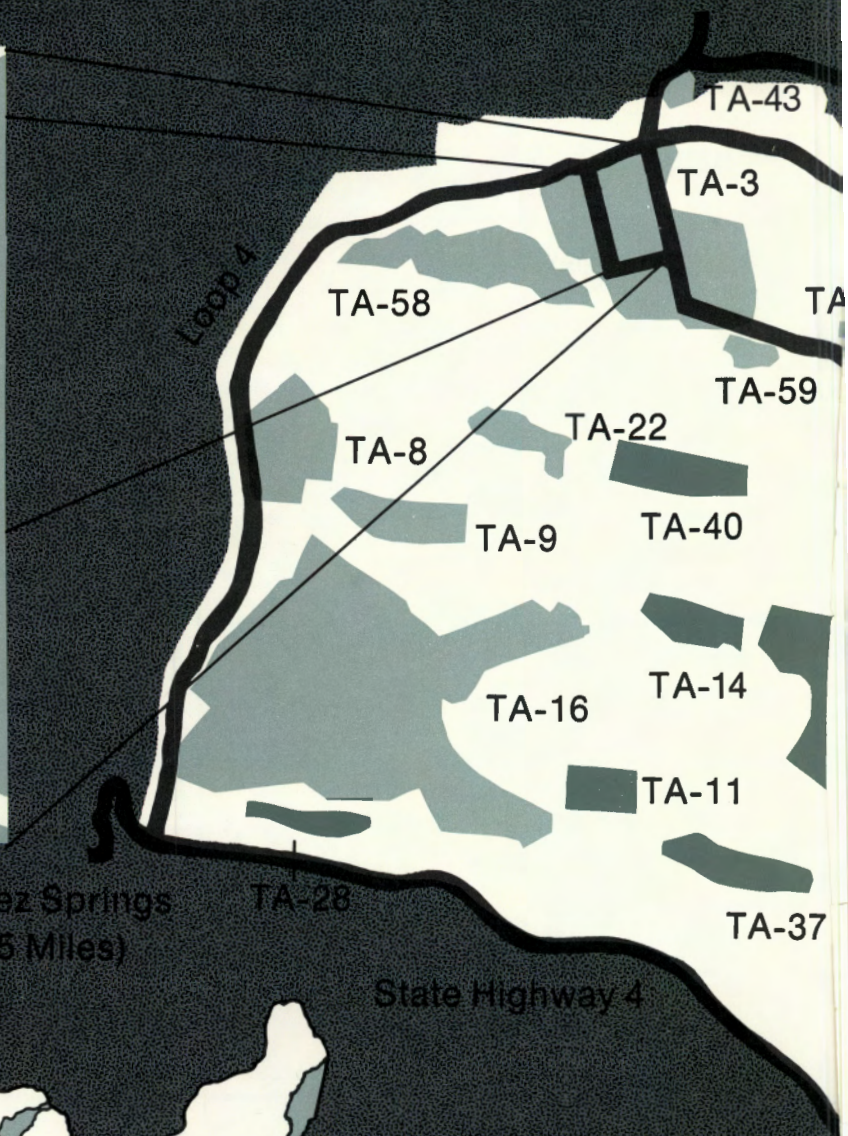
The Laboratory's organizational structure is given in the following chart. Programmatic and functional management is the responsibility of seven associate directors and the Controller. Scientific and technical programs are guided by the two program associate directors and three discipline associate directors. Division leaders report to the discipline associate directors and are responsible for providing the capabilities necessary to carry out the Laboratory's research programs. Services and support are provided by the Associate Directors for Administration and Technical Support and by the Controller.

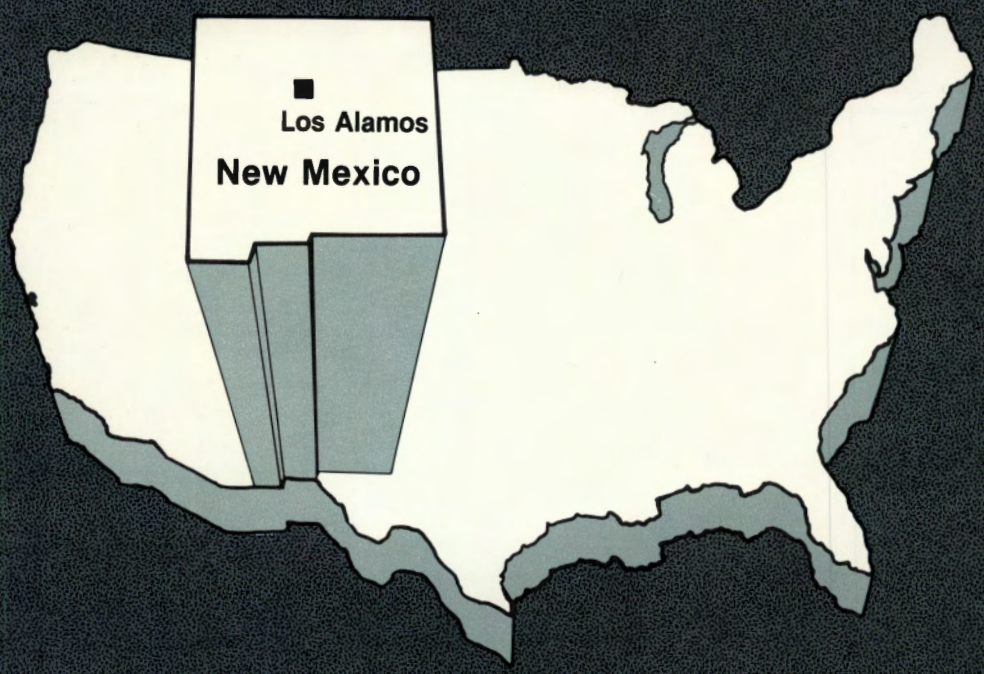


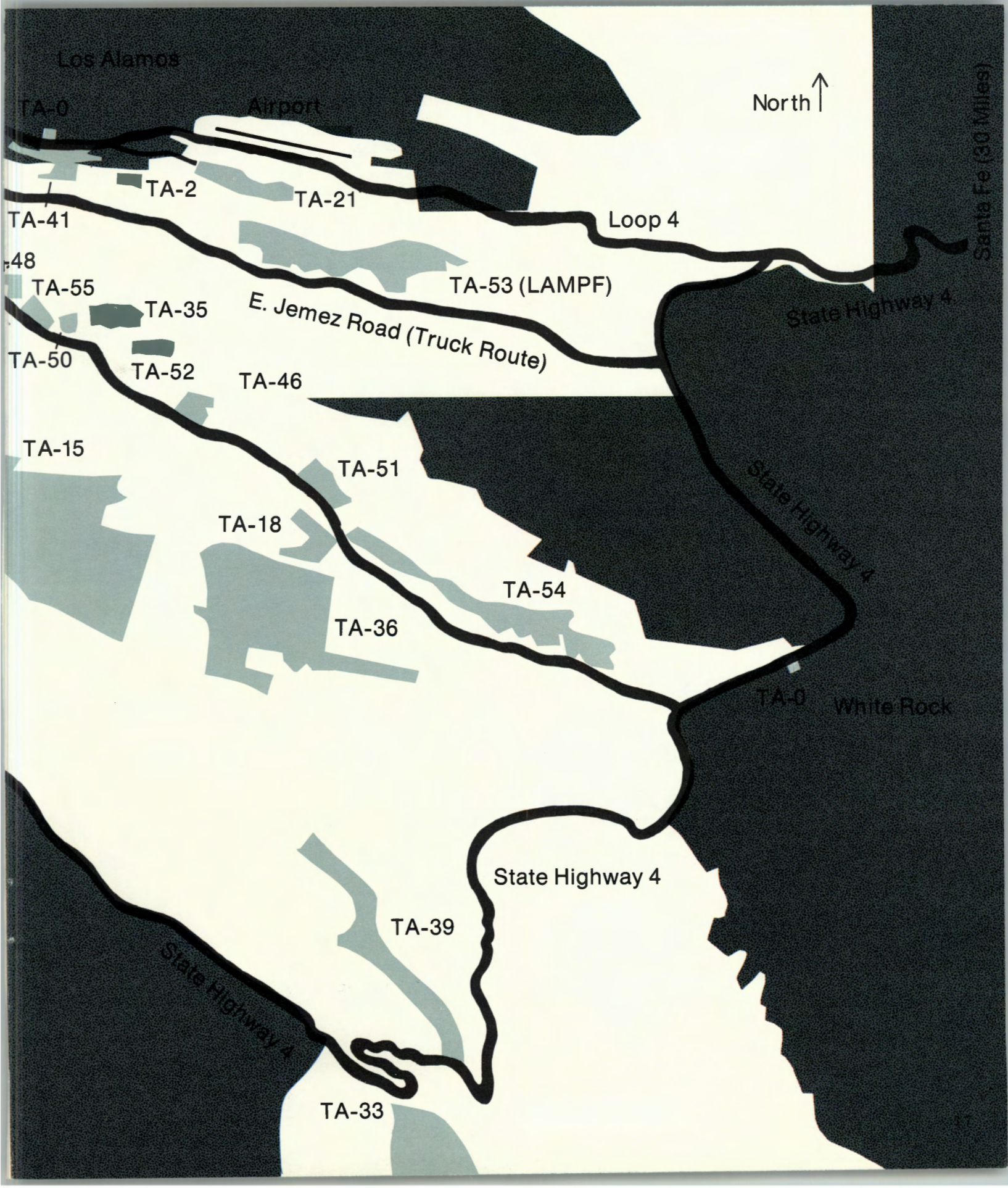

Director
Deputy Director
National Security Programs
Defense & Safeguards Technology (DST)
Inertial Fusion (IF)
Test & Verification (T&V)
Weapons Advanced Concepts (WAC)
Weapons Programs (WP)
Weapons Research & Development (WRD)
Chemistry, Earth & Life Sciences
Applied Photochemistry (AP)
Chemistry Materials Chemistry (CMB)
Chemistry Nuclear Chemistry (CNC)
Earth & Space Sciences (ESS)
Life Sciences (LS)
Engineering Sciences
Computing (C)
Controlled Thermonuclear Research (CTR)
Electronics (E)
Dynamic Testing (M)
Energy (Q)
Analysis & Assessment (S)
Design Engineering (WX)
Physics & Mathematics
Accelerator Technology (AT)
Medium Energy Physics (MP)
Physics (P)
Theoretical (T)
Applied Theoretical Physics (X)
Controller
Accounting (ACT)
Administrative Data Processing (ADP)
Budget (BUD)
Technical Support
Site Engineering (ENG)
Health (H)
Mechanical Fabrication (MEC)
Operational Security/Safeguards (OS)

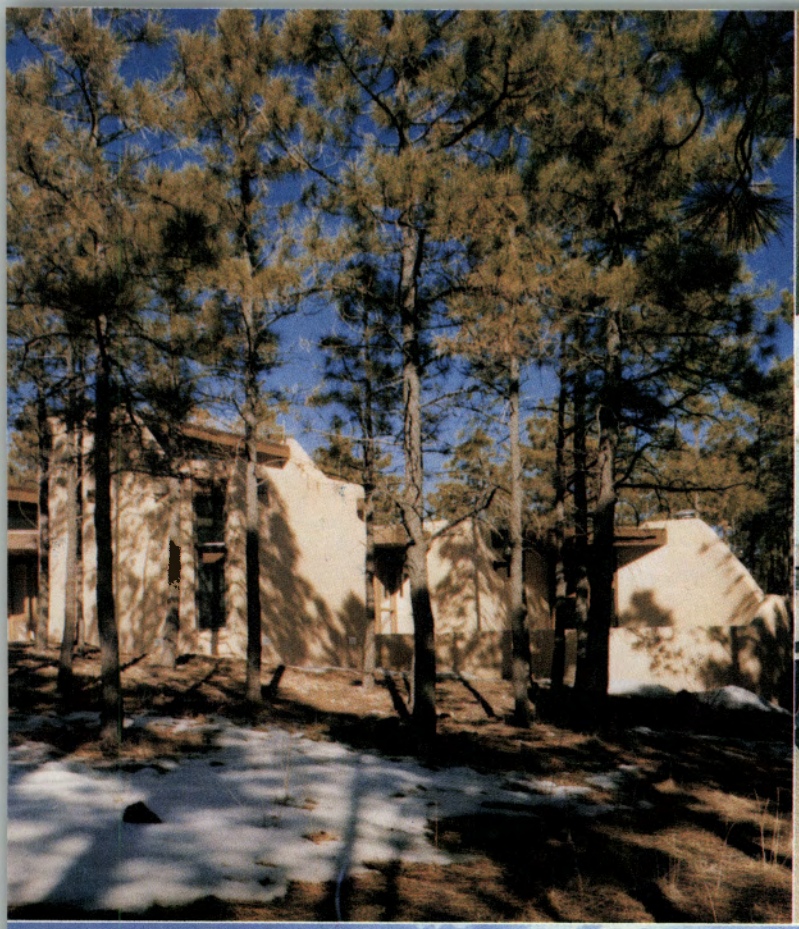
Laboratory Sites

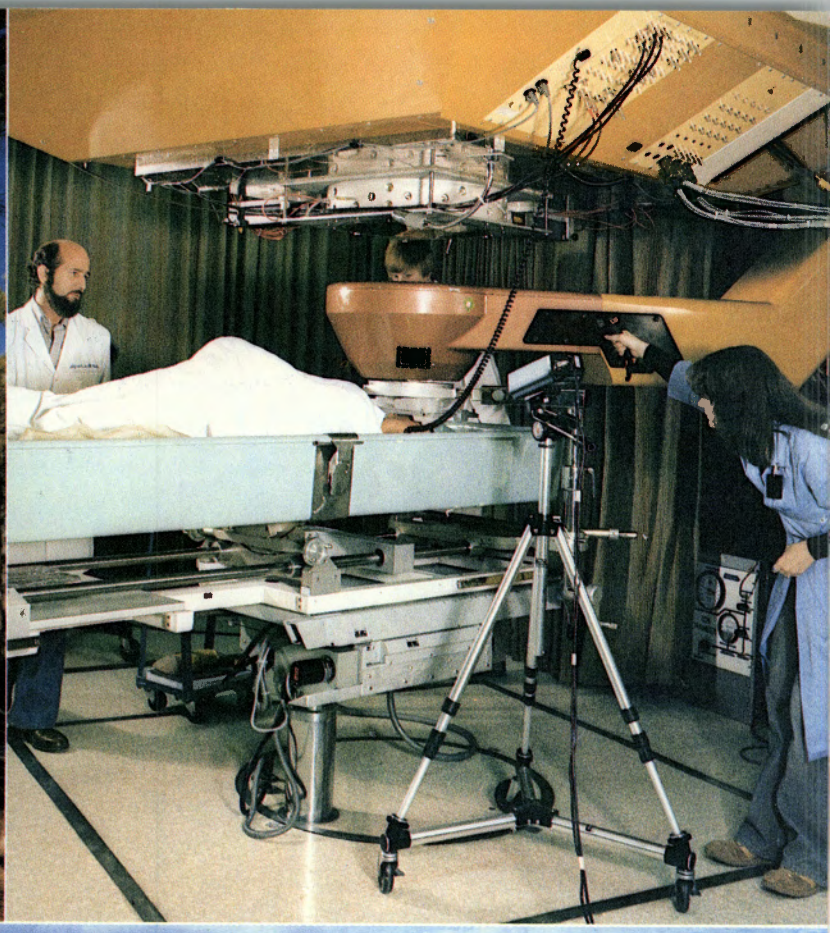







Los Alamos
TA-0
Airport
North
TA-2
TA-21
TA-41
Loop 4
Santa Fe (30 Miles)
48
TA-55
TA-53 (LAMPF)
TA-35
E. Jemez Road (Truck Route)
State Highway 4
TA-50
TA-52
TA-46
TA-15
TA-51
State Highway 4
TA-18
TA-54
TA-36
TA-0
White Rock
State Highway 4
TA-39
State Highway 4
TA-33





Facilities

Laboratory facilities consist of 33 technical areas (sites) distributed over about 43 square miles of the Pajarito Plateau. These facilities occupy nearly 4.5 million square feet of floor space in more than 125 principal buildings and would cost more than a billion dollars to replace.

Of the Laboratory's many unique facilities, visitors and new employees most often inquire about the Central Computing Facility and the National Security and Resources Study Center.

Central Computing Facility

The Laboratory's computing capabilities equal or exceed that of any computing center in the world. The Central Computing Facility offers more than 3,400 users throughout Los Alamos the most modern computing and processing equipment and a common file system for long-term storage of information.

The facility now consists of 10 major computers—three Cray-1s, four CDC 7600s, one CDC 6600, and two CDC Cyber-73s linked together in an integrated computer network. The Cray-1s and 7600s are used primarily for scientific computing; the 6600 and Cyber-73s are now used mainly for general-purpose computing.

With each decade since the Laboratory was established, the state of computing technology and the Laboratory's computing needs have grown dramatically. In the early 1940s, a few small desk calculators comprised the Laboratory's computing equipment. In the mid 1960s, when the CDC 6600 was installed, the machine offered the fastest execution speeds and largest memory available—two million operations per second and a main memory storage of more than 131,000 computer words. In the early 1970s, the CDC 7600 increased the processing speed to about 10 million operations per second with a memory of more than 500,000 words. The most recent additions to the facility are the Cray-1s, which execute 100 million operations per second and have memories of several million words.

Top left: The University House serves as an informal meeting area for visitors. Top right: Cancer patient being treated with pions at the Clinton P. Anderson Meson Physics Facility (LAMPF). Bottom: The National Security and Resources Study Center houses an extensive library and offers unique facilities for meetings.

The Laboratory has also kept abreast of developments in software and processing equipment to handle the volume of data processed by these supercomputers. To upgrade its line printers, the facility recently acquired laser printers that can produce two 8-1/2 by 11 pages of high-quality computer printout each second. Interactive systems are used on all our major computers. These systems support graphics terminals, which play an increasingly important role in scientific computation. All our major computers also have online access to an electronic filing system and to high-speed output processing equipment. Distributed processing facilities, including intelligent terminals, are under development.

National Security and Resources Study Center

The National Security and Resources Study Center houses an extensive technical library (nearly 300,000 books and journals) and offers excellent facilities for classified or unclassified meetings. The 66,000-square-foot building was designed as a research project to study energy-saving systems for large solar-heated and solar-cooled facilities.

The building's solar features provide more than 75 percent of its heat and 95 percent of its cooling requirements. The sun's energy is gathered by 400 black chrome collectors, designed and developed at Los Alamos. The collectors form an 8,000-square-foot array that serves as the roof for the south side of the building. The fluid in the collectors is a light paraffinic oil. After flowing through the collectors, it flows through a heat exchanger, where water in thermal storage tanks is heated. During the summer, water is chilled by circulating it through a cooling tower at night. During the day, the water is circulated through a chiller.

In addition to the solar energy features, the building incorporates such energy-saving designs as R-19 insulation; tinted, double-glazed windows; recovery of heat from electric lights; controlled, balanced air circulation; and variable temperature-humidity controls. Auxiliary heating is supplied by a conventional central steam system.

Experiments with the system's components and studies of the building's performance have provided valuable in-

formation for researchers. Members of the International Energy Agency have also run computer simulations of the Study Center and compared their calculated results with our measured data, thereby increasing their ability to assess performance and to improve the cost-effectiveness of solar heating and cooling systems.

From a viewing gallery that overlooks the equipment rooms, visitors can observe the plumbing and ventilation systems that form the heart of the Center's solar energy system.

Left: These disk pack drives are mass storage devices that provide local storage of jobs and data to be run on the Central Computing Facility's large worker computers. The devices can store 25 to 50 million words (60 or 64 bits) of data. Below: Black chrome collectors provide solar heating and cooling for the National Security and Resources Study Center. The Central Computing Facility is in the building on the right in the photograph.

Mission and Programs

The Laboratory's mission is the application of science and technology to solve national problems both in nuclear weapons development and in energy supply and conservation programs. Basic science research complements and strengthens the fundamental technical capabilities of the Laboratory.

National security programs account for about 50 percent of the Laboratory's operation. About 75 percent of the total effort is nuclear related. Nonnuclear programs (such as fossil, solar, and geothermal energy, electricity transmission and storage, and regional energy assessment and policy analysis) account for much of the remainder. Most of the recent growth in nonweapons work has been in nuclear-related energy research in such programs as magnetic confinement fusion, laser isotope separation, nuclear safeguards, and other research programs conducted for the Nuclear Regulatory Commission. This research often uses nuclear facilities paid for by the weapons program that are shared in cost-effective and staff-efficient ways between the weapons and energy programs. Major efforts of the Laboratory are categorized as follows:

National Security Programs

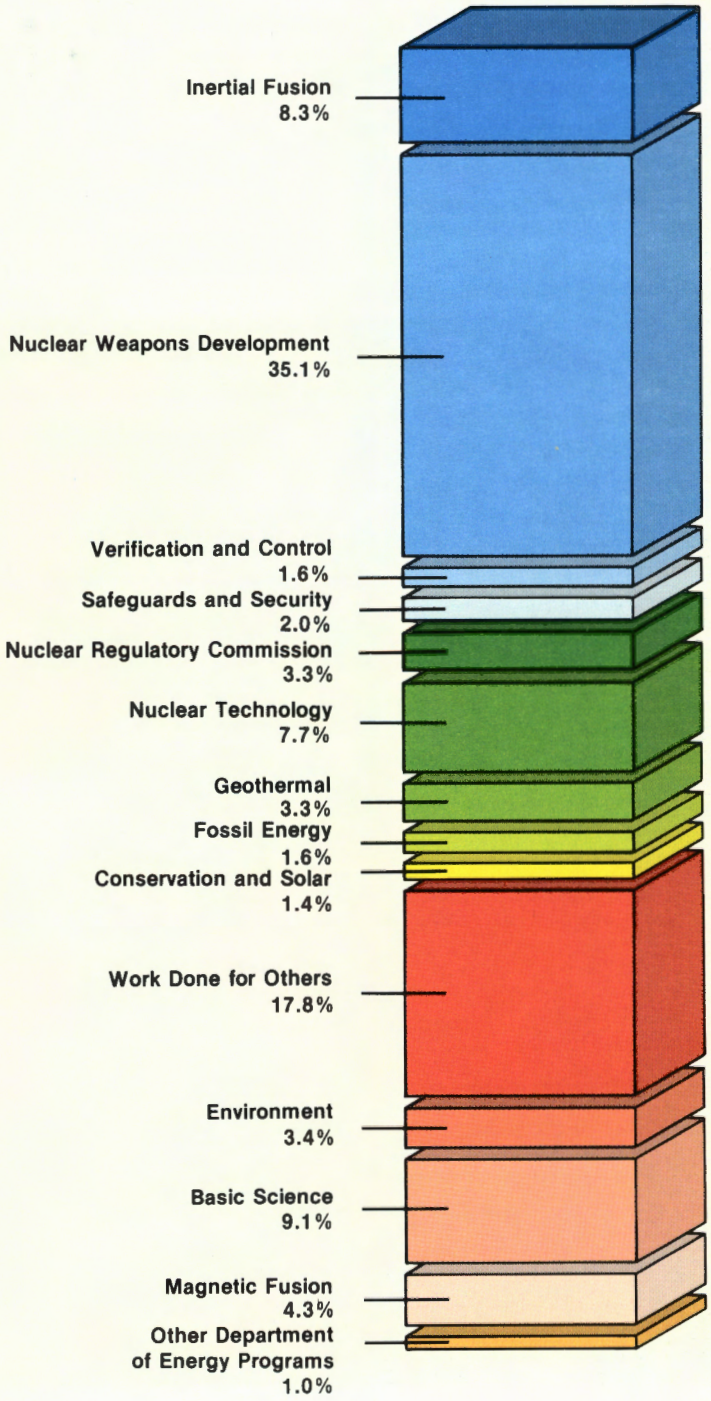
Weapons Programs
- Design and engineering development of nuclear weapons
- Technical liaison with Department of Energy, Department of Defense, and contractors
- Special studies and analysis to support nuclear weapons programs

Weapons Research and Development
- Weapons technology base
- Supporting technologies

Testing and Verification
- Nuclear testing at the Nevada Test Site
- Local nonnuclear testing
- Verification activities
- Vulnerability and effects
- Arms control

Safeguards and Security
- Research and development on instruments and techniques
- Nuclear materials management and security
- Nuclear emergency response capabilities

FY 81 OPERATING FUNDS (TOTAL~$450 MILLION)



Inertial Confinement Fusion
Department of Defense Programs (nonnuclear)

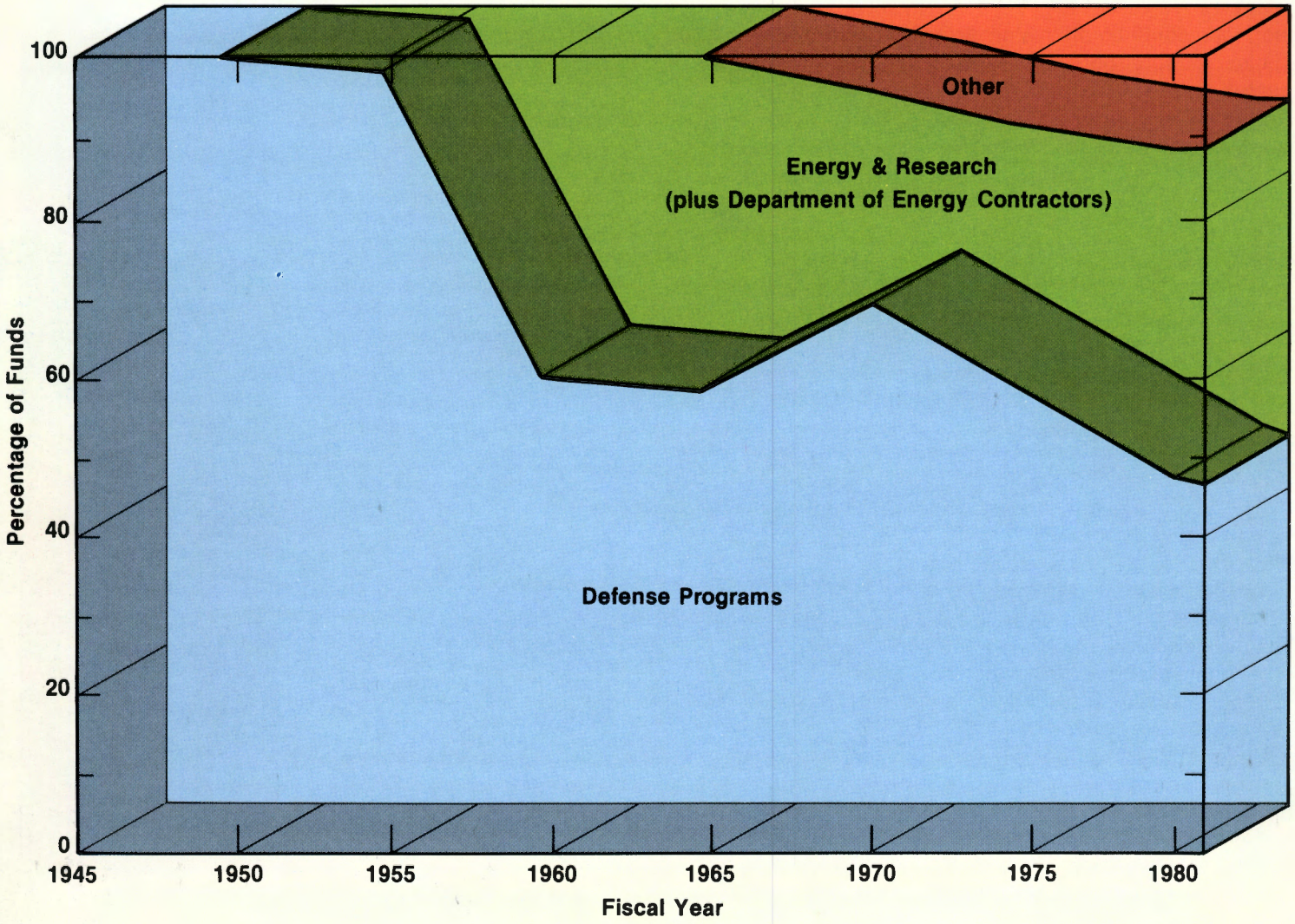
Energy Programs

Nuclear Programs
- Resource evaluation
- Laser isotope enrichment
- Nuclear fuels
- Reactor safety
- Waste management

Alternate Energy Sources
- Magnetic fusion
- Geothermal energy
- Fossil fuels
- Conservation and solar energy
- Energy transmission and storage

Environment and Biosciences
- Biosciences
- Energy systems analysis
- Environmental research

FUNDING MIX



Basic Research (Theoretical and Experimental)

Physics
Space Physics and Astrophysics
Chemistry
Materials Science
Mathematics and Computational Physics
Geosciences
Life and Environmental Science
Engineering

Left: The interior of the University House offers a relaxed living room atmosphere for informal meetings and social gatherings.
Below: The Laboratory's newest office building is partially earth sheltered and incorporates passive and active solar design elements. The 140,000-square-foot facility houses a cafeteria and offices for about 600 employees.

National Security Programs

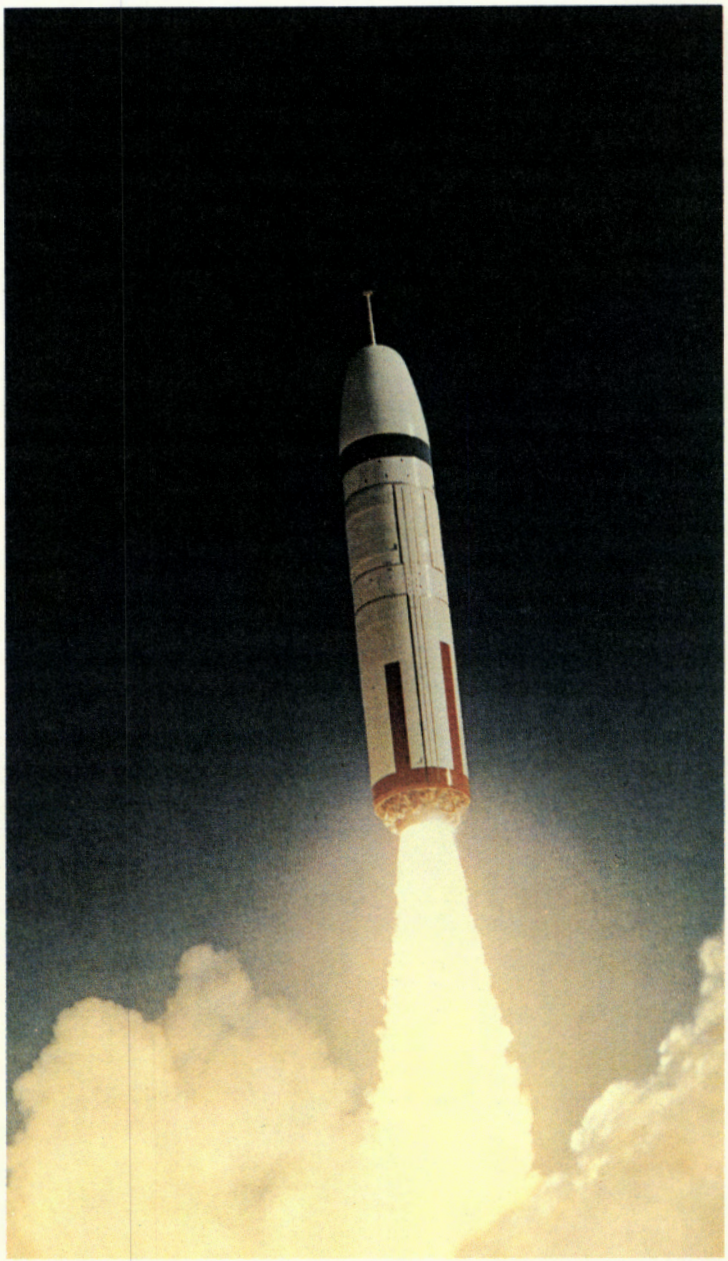
National Security Programs are the cornerstone of the Laboratory, accounting for more than half of the operating budget. Programs include the design, development, and testing of nuclear weapons; development of means to detect clandestine nuclear explosions; research and development for control and accountability of special nuclear materials; research on inertial confinement fusion for military and commercial applications; and research on advanced weapons for the Department of Defense.

Weapons

The world's first atomic weapons were produced at Los Alamos, and Los Alamos scientists conducted the first detonations of a fission weapon (atomic bomb) and a thermonuclear weapon (hydrogen bomb). Since the early 1940s, the Laboratory has concentrated on the design and development of nuclear devices. Today the responsibility for design and development of our nation's nuclear weapons rests with Los Alamos and the Lawrence Livermore National Laboratory in California. Department of Energy contractors do the actual production.

Development of nuclear weapons is one of the most difficult technical challenges facing our nation. The physical conditions generated in a nuclear explosion are beyond ordinary experimental means and involve temperatures more typical of stars. The Laboratory maintains a highly qualified staff and specialized facilities necessary to conduct broad-based research unique to the weapons program. Engineers, scientists, and others at Los Alamos participate in research, development, and testing of nuclear weapons. The weapons program is enhanced by continuing research programs, both theoretical and experimental, in areas such as mathematics, nuclear physics, nuclear chemistry, metallurgy, computer science, and fluid dynamics.

About two-thirds of the weapons in our nation's stockpile were designed at Los Alamos. The major recent contributions include the W78 warhead for the Minuteman III intercontinental ballistic missile, the W76 warhead for Trident and Poseidon submarine-launched ballistic missiles, and the B61, a multipurpose bomb carried by a variety of aircraft and called the workhorse of the arsenal. Weapons currently under development include the W80 warhead for air-and submarine-launched cruise missiles, the W81 warhead for the Navy SM-2 missile, and the W85 and W86 warheads for the Army Pershing II missile.



Above: This Lockheed C4 missile carries the W76 warhead for the Mark 4 reentry body. The missile can be launched from Trident I or retrofitted Poseidon nuclear submarines. Right: The Air Force air-launched cruise missile is equipped with the W80 warhead, developed at Los Alamos and designed for common application in the Navy's Tomahawk cruise missile.

The evolution of a nuclear weapon typically involves seven phases that span about 25 years: (1) weapon conception, (2) feasibility determination, (3) development engineering, (4) production and engineering, (5) first production, (6) quantity production, and (7) retirement.

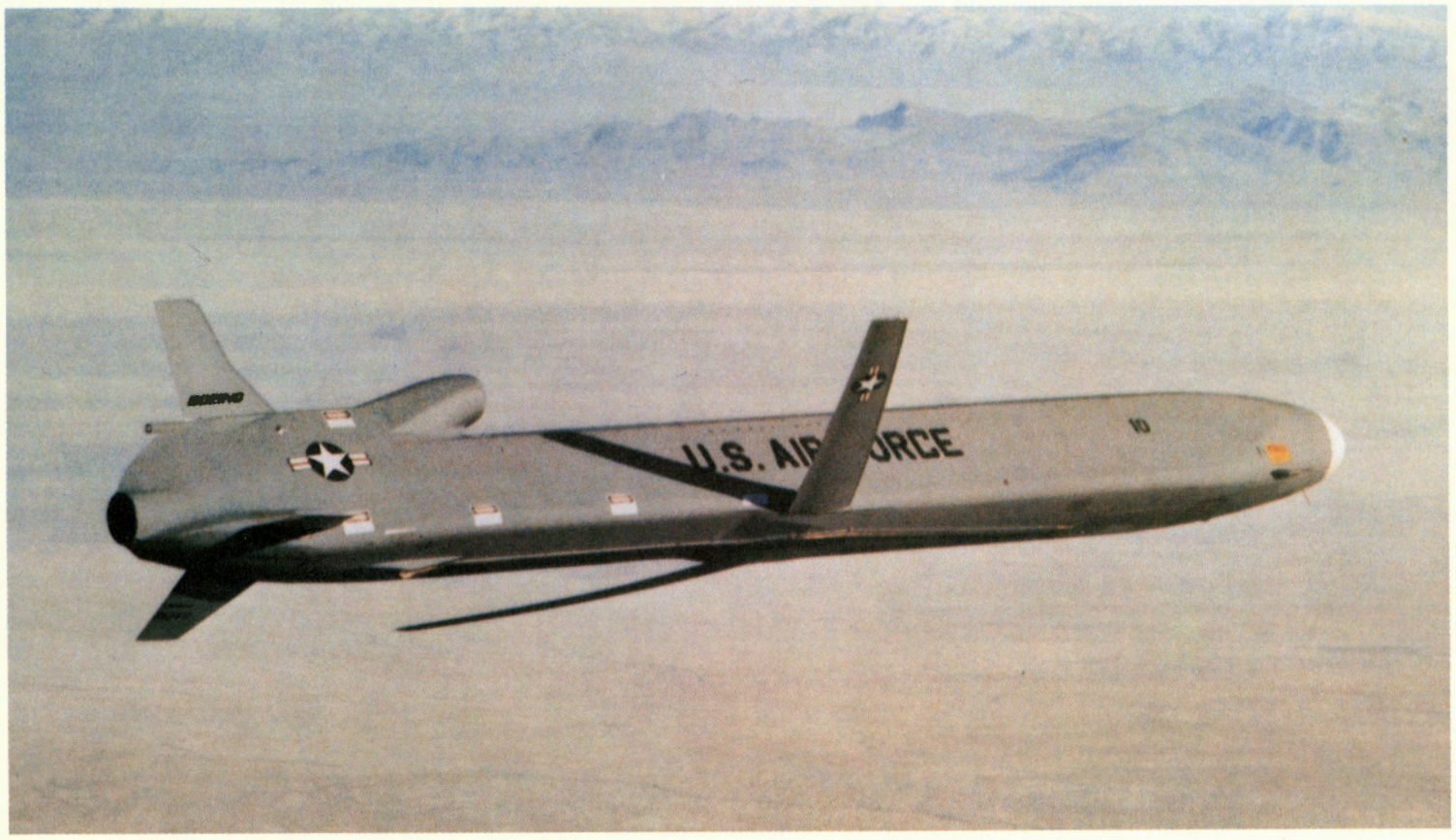
The Department of Defense generally initiates Phase 1 with a request to the weapons laboratories for conceptual studies. Phase 1 studies may result in a recommendation to use a modification of a current weapon or to develop a new system.

In Phase 2, the two competing design teams, Los Alamos National Laboratory/Sandia National Laboratories Albuquerque and Lawrence Livermore National Laboratory/Sandia National Laboratories Livermore, conduct studies to determine the feasibility of the proposed weapon system. Tradeoffs regarding size, weight, cost, nuclear yield, and packaging are identified. At the end of Phase 2 the design teams submit proposals for weapon development.

Phase 3 is initiated with the selection of a design team to develop a specific weapon. Throughout Phase 3 the weapon design is evaluated and tested using computer calculations and hydrodynamic experiments with mock-ups containing nonnuclear components. The development process culminates in underground nuclear tests.

The production and assembly of the weapons for our nation's nuclear stockpile, Phases 4 through 6, are done at Department of Energy weapons production facilities. An engineer from the design team supplies technical expertise during the production phases. During the life of a weapon, through Phase 7, the Laboratory ensures its integrity and provides advice regarding maintenance.

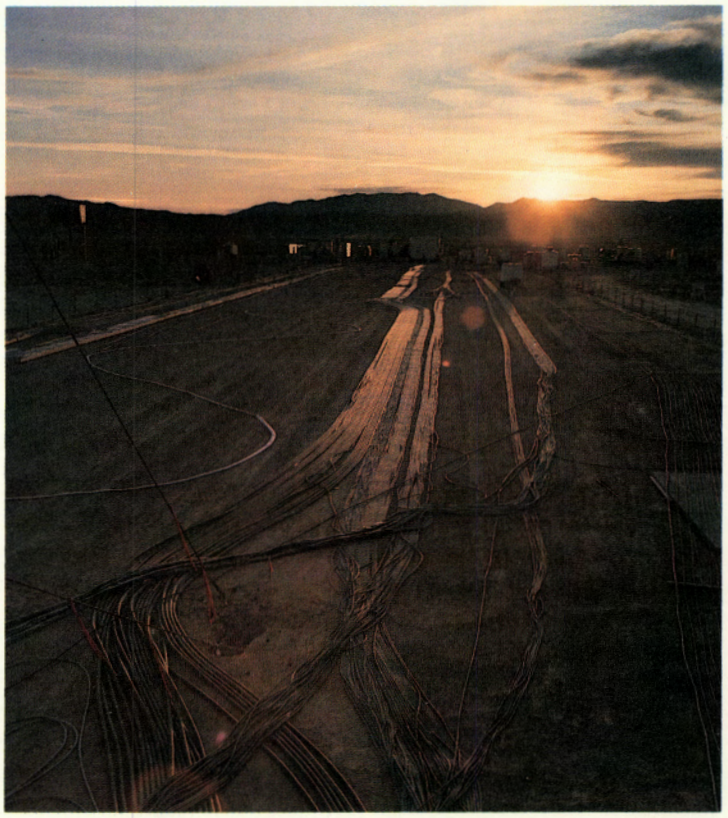
The benefits of the weapons program have extended beyond the nation's defense. This program has provided knowledgeable personnel and specialized facilities for other national programs, such as space reactor propulsion, nuclear safeguards, inertial fusion, and reactor safety.



Testing and Verification

Nuclear testing has been, and continues to be, an essential part of nuclear weapons development. The Laboratory conducted atmospheric nuclear tests in the Pacific, beginning in 1946 and continuing until 1963. In 1951 the Laboratory began testing at the Nevada Test Site, about 65 miles northwest of Las Vegas, Nevada. Over the past 30 years several hundred nuclear tests have been conducted, but all testing since 1963 has been underground, in accordance with the Threshold Test Ban Treaty. Knowledge gained from underground testing has been applicable to fossil fuels and hot, dry rock geothermal energy programs.

To verify that other countries are abiding by treaty regulations, Los Alamos developed sensing instruments carried aboard Vela satellites and their successors and is investigating other means to detect clandestine nuclear explosions. The Laboratory also responds to special requests for technical advice regarding arms control efforts; for example, Laboratory advisors participate on the United States negotiating teams for Strategic Arms Limitation Talks (SALT), Test Ban, and Nonproliferation Treaties.



Top: Diagnostic cables allow researchers to obtain detailed information on the performance of a nuclear test device.
Right: The Nevada Test Site is pocked with subsidence craters that form over the site of an underground nuclear explosion.

Safeguards and Security

Safeguards work at Los Alamos is concerned with developing instruments and techniques for detecting and measuring nuclear materials in many physical and chemical forms, developing accounting systems for monitoring nuclear materials, and providing expertise to the nuclear industry and to government and other research organizations.

Nondestructive assay technology, originated at Los Alamos, is being implemented throughout the nuclear industry for both active and passive assay. In active assay, external radiation sources are used to produce radioactivity in samples; the samples are then analyzed with detection devices to determine the amount of fissionable material present. In passive assay, the fissionable material in a sample is determined by detecting naturally occurring radiation.

DYMAC (for dynamic materials control) is the most sophisticated, comprehensive, and adaptable accounting system developed thus far by the Laboratory for monitoring nuclear materials. It is now in operation at the plutonium processing plant, where it accounts for the location, quantity, and chemical nature of all the radioactive material in the facility on a continuous (near real-time) basis. DYMAC registers statistical deviations and automatically computes discrepancies if material is determined to be missing.

Techniques, concepts, and designs developed in safeguards and security are transferred to the nuclear industry to provide safeguards for fuel fabrication plants, strategic nuclear materials storage sites, nuclear power plants, fuel reprocessing plants, and waste disposal facilities. As a part of this technology transfer, the Laboratory offers special training courses and workshops and provides staff to consult with and participate in international advisory groups.

The Laboratory also supplies trained personnel and equipment to our nation's Nuclear Emergency Search Team (NEST). This team provides scientific and technical assistance to federal, state, and local authorities who are faced with a nuclear emergency. For example, NEST helped track down and retrieve parts of the nuclear-powered Soviet satellite that fell in Canada in 1978.

DYMAC is a sophisticated and adaptable system for monitoring and accounting for nuclear materials. It is used at the Laboratory's plutonium processing facility, where it accounts for the location, quantity, and chemical nature of radioactive materials.

Department of Defense Programs

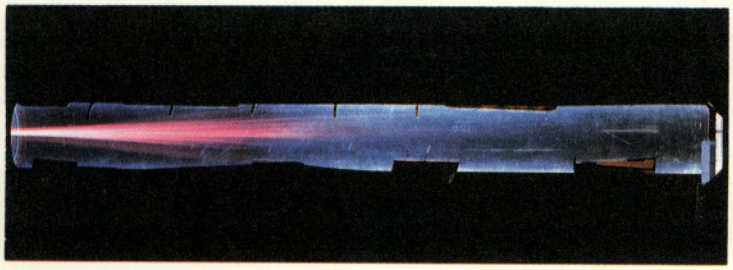
Our experience with nuclear weapons systems has created expertise that is being used by the Department of Defense for research on advanced conventional (nonnuclear) weapons systems. Defense programs draw on our experience with accelerators, lasers, high explosives, and in materials science.

Research accelerators at Los Alamos have spawned Department of Defense programs on directed-energy neutral-particle beams. The goal is the development of a powerful radiofrequency linear accelerator for use as an orbiting defense system. Another program involves possible application of free-electron lasers for satellite or ballistic missile defense.

Los Alamos work in laser isotope separation has led to military applications, such as the use of lasers to detect chemical warfare agents. Laser-based detectors developed here have demonstrated the ability to detect nerve gases more sensitively than any other detectors. Lasers can be tuned so that specific substances will fluoresce, or glow, when the laser light strikes it, facilitating clean-up of contaminated surfaces.

Our expertise in high explosives is being applied to a number of Department of Defense programs: nonnuclear warheads for defense against enemy ballistic missiles; nonnuclear warheads for cruise missiles; rail guns, electromagnetic projectile launchers driven by explosives; nonnuclear warheads for antisubmarine and antiarmor applications; kinetic-energy armor penetrators; and special armor to protect American tanks against enemy antitank missiles.

Right: A flash x-ray machine at the Laboratory's PHERMEX facility is used for pulsed high-energy experiments. Below: A directed-energy experiment conducted at the PHERMEX facility shows instabilities in the propagation of an electron beam in helium.



Materials scientists at Los Alamos have developed erosion-resistant materials that may be used for nose tips on reentry vehicles. Because of the speed at which these missiles travel, special high-temperature materials (more resistant than heat shields used on space reentry vehicles) are necessary to prevent the missile from overheating.

In addition to these research programs, the Laboratory conducts special studies for the Department of Defense and other government agencies. An energy options study is assessing the military's energy requirements and identifying possible solutions that could also help in commercializing new energy technologies. An antiballistic missile assessment study is reviewing our nation's ballistic missile defense system, in light of emerging technology, defense treaties, and proposed MX missile deployment.

Inertial Confinement Fusion

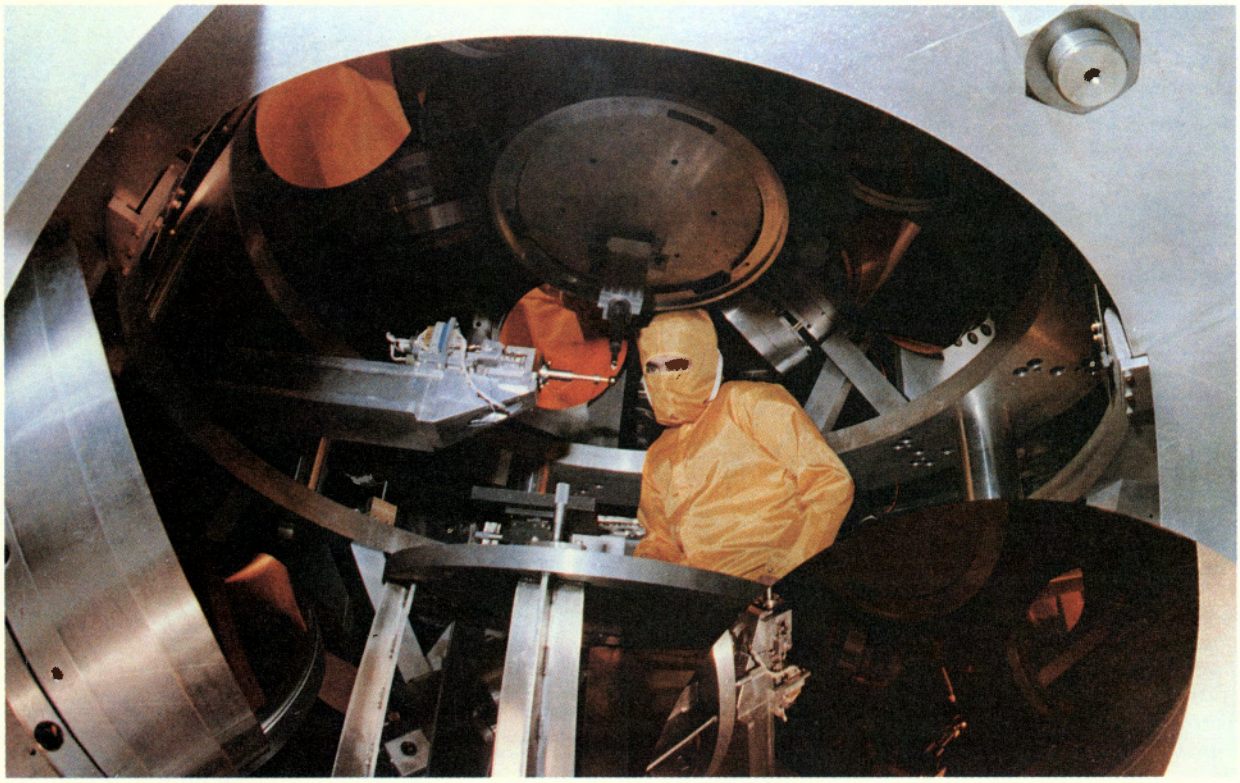
The inertial confinement fusion program grew out of the nuclear weapons program and remains closely tied to weapons physics studies. The goal of the program is to produce a laboratory source of thermonuclear reactions, similar to, but much smaller than, fusion explosions. The fusion fuel of interest is a mixture of the hydrogen isotopes, deuterium and tritium. Deuterium exists in abundance in water, and tritium is a by-product of the fusion reaction. Power limitations of available fusion drivers, which implode and heat the fusion fuel, have paced development of the program.

Since 1969, the Laboratory has emphasized development of the short-pulse carbon dioxide gas laser as a fusion driver. This gas laser is one of the most promising for military and commercial applications of inertial fusion because it is efficient and can be pulsed repetitively.

In 1977 Gemini, the Laboratory's two-beam carbon dioxide laser system, successfully compressed fuel pellets to produce thermonuclear neutrons. Today, the 10-kilojoule, eight-beam Helios laser is being used to further compress the fuel and to increase neutron yield. The larger Antares laser facility will begin operation in 1983 at an energy level of 40 kilojoules. It eventually can be enlarged to supply over 100 kilojoules to fusion targets.

Studies on Helios and Antares will allow researchers to determine the energy requirements to achieve scientific feasibility of inertial fusion. Scientific feasibility will show that inertial confinement fusion is possible, not necessarily practicable. Many engineering problems must be overcome before efficient energy production can be achieved. Then military and commercial applications can be developed. When commercially available, fusion could offer a limitless supply of energy for the production of electricity, fissile fuels, synthetic liquid fuels, and heat for industrial processing.

Inside the target chamber of Helios, our eight-beam carbon dioxide laser system, are turning and focusing mirrors that direct laser beams onto a tiny pellet, the target for inertial confinement fusion experiments.



Los Alamos is involved to some extent with development of all potential domestic energy resources. Our goals for energy-related programs are to maintain a base of research excellence to provide solutions for national problems and to use this scientific expertise to develop new methods for the generation, recovery, conversion, storage, and transportation of energy.

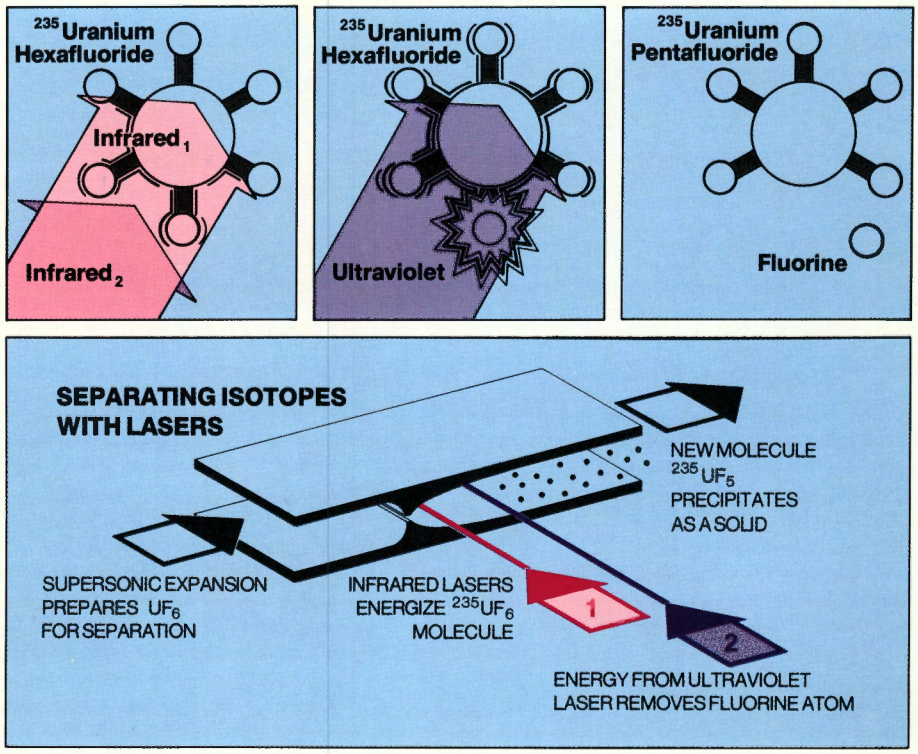
The objectives of each energy program are the same—to determine the technical potential of the program and to develop that potential to the extent warranted by its projected commercial application. Whether pursuing exotic approaches to fusion energy or near-term technologies for fossil fuel recovery, the Laboratory works closely with industry so that as new technologies are developed, they can be expeditiously transferred and applied to solving national problems.

Nuclear Programs

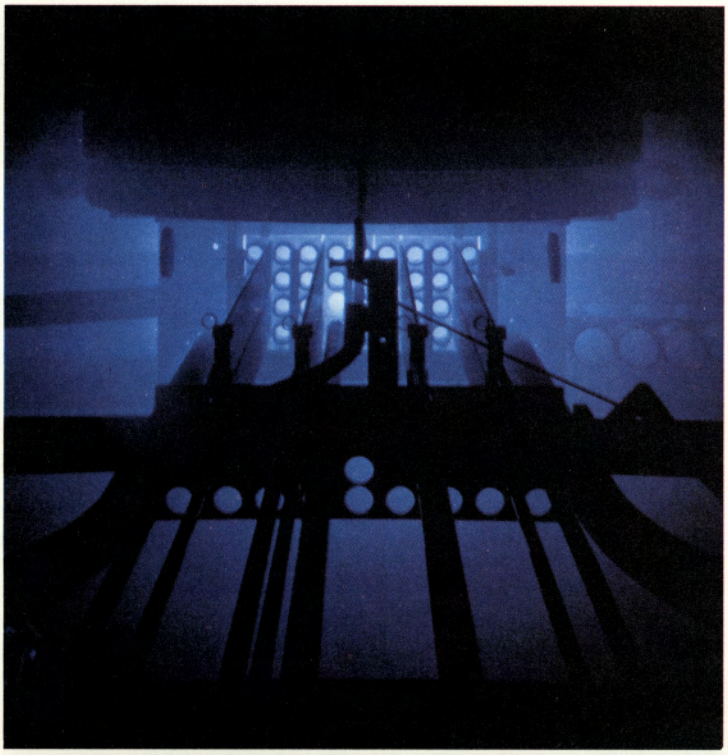
Our activities in nuclear fission energy span several aspects of the nuclear fuel cycle, including reactor and fuel cycle safety, nuclear fuels, reactors for space applications, advanced enrichment techniques, and nuclear waste.

Enrichment. Before uranium can be used as a reactor fuel, the concentration of its fissionable isotope, uranium-235, must be increased. The gaseous diffusion enrichment process cannot economically separate more than about 65 percent of the uranium-235 from natural uranium; the rest is lost in waste. Scientists here are developing a laser isotope separation process that will produce enriched uranium much more economically than the present technology. This process will also increase the extraction of uranium-235 from natural uranium to almost 100 percent, thereby significantly increasing our uranium reserves. Because this process requires much less electrical energy than gaseous diffusion, it will also contribute to national energy conservation.

Advanced Fuels. Our work on reactor fuels encompasses development, fabrication, and testing of advanced reactor fuel elements. In the development of breeder reactor fuels, emphasis has been on carbides, rather than oxides. Because carbide fuels have higher densities and higher thermal conductivities, they may prove to be more efficient and more economical than oxides. Our plutonium facility has unique capabilities for fabricating carbide fuels in quantity.

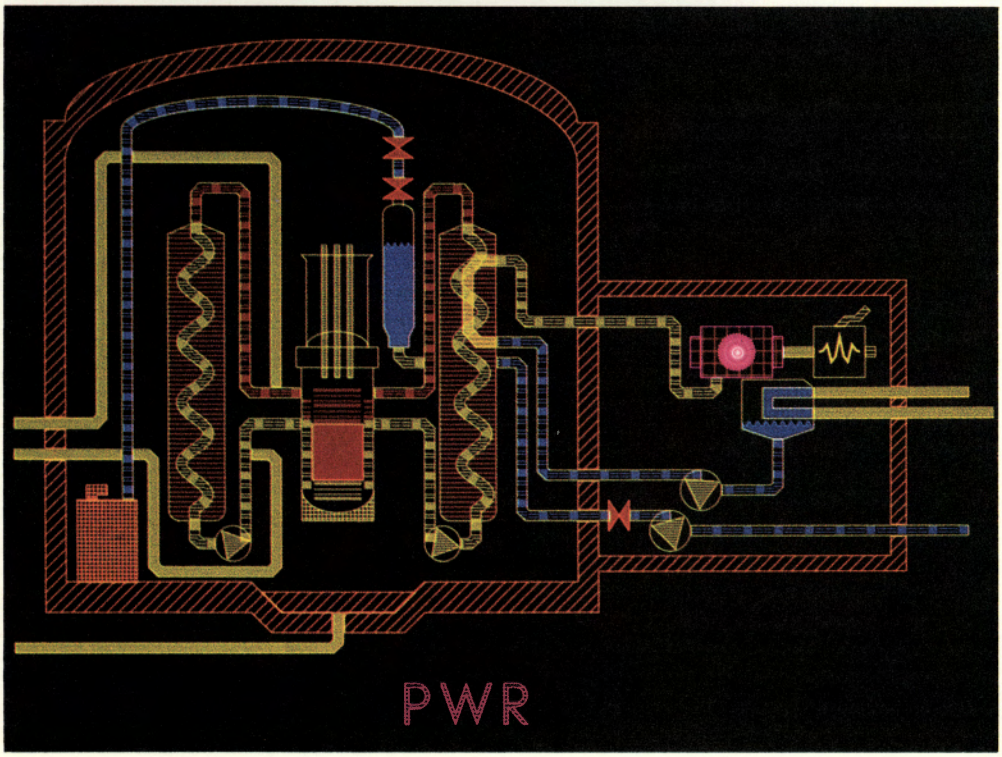


Laser energy can break apart molecules and separate isotopes. A two-stage process developed at Los Alamos can induce only those molecules containing the desired isotope to undergo chemical reactions. First, an infrared laser illuminates the gas, uranium hexafluoride. A second infrared laser is used to raise the already excited molecules to higher energy states. Finally, an ultraviolet laser harvests the highly excited molecules by providing even more energy to break the molecular bonds and produce UF_5, a powdery solid form of enriched uranium.



Reactor Safety. A key aspect in licensing nuclear power plants is an evaluation of their response to potential accident conditions. Because it is impractical to perform accident experiments on actual nuclear power plants, their accident response is evaluated analytically using complex computer code simulations. Most of the research effort conducted at Los Alamos for the Nuclear Regulatory Commission and for the Department of Energy is directed toward meeting the national need for more accurate and reliable safety analysis through the development, testing, and application of sophisticated reactor-safety computer codes. This extensive effort encompasses fuel cycle facilities and all major reactor types—conventional light-water reactors, liquid-metal fast breeder reactors, and high-temperature gas-cooled reactors.

Los Alamos code developers have completed versions of major new computer codes for light-water reactors and breeder reactors. The light-water reactor code, called TRAC, was used to analyze the early stages of the Three Mile Island accident. The Laboratory is also providing analytic support for a multinational (United States, Germany, and Japan) safety research program directed at



Above: A blue glow from Cerenkov radiation is emitted by the core of the Laboratory's research reactor. Left: A computer-generated schematic of a pressurized water reactor shows how a Laboratory computer code, TRAC, simulates accident conditions.

evaluating the performance of emergency core cooling in light-water reactors following a loss-of-coolant accident.

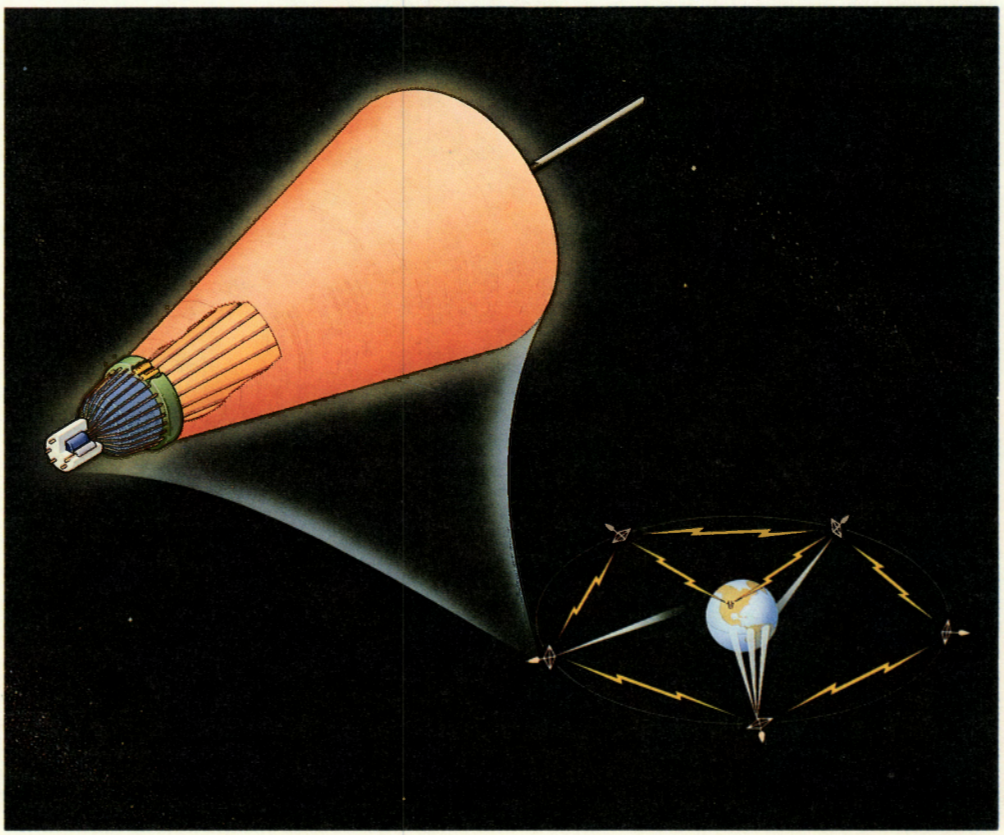
The Laboratory is on the forefront of the nation's effort to analyze the sequence of events that might lead to severe nuclear reactor accidents. Results of this effort will help operators to recognize the signals or signature of an accident on their instruments and to take corrective action to either terminate the accident or mitigate its consequences, thereby reducing the risk to the public.

Our breeder reactor safety code, SIMMER, is being used to study the potential consequences of postulated severe accidents in various breeder reactor designs. The results are showing that the potential damage from such accidents is significantly less than predicted by much simpler methods used earlier.

An integral part of the reactor safety effort involves establishing the predictive credibility of these new computer codes through analysis of hundreds of relevant experiments being performed throughout the world. The most significant safety experiments on light-water reactors to date were performed at the Loss of Fluid Test Facility in Idaho. They examined the behavior of a small-scale light-water reactor during a simulated loss-of-coolant accident. Successful predictions of the results of these experiments, using TRAC, contributed significantly to the code's credibility.

In addition to the reactor safety research program, Los Alamos carries out a number of technical assistance projects in direct support of the Nuclear Regulatory Commission's licensing activities. These apply unique Laboratory technical expertise to such licensing problems as physical security at nuclear power plants, performance of respirators, vulnerability of reactors to sabotage, and the response of containment structures during accidents.

Los Alamos is an ideal laboratory for performing these research activities for the Nuclear Regulatory Commission and Department of Energy because of our powerful computing capability and the technical compatability with the weapons research program.



SPAR, a space nuclear reactor developed here, could be used to power a satellite. The small reactor is at the left; its heat-dissipation cone is shown in orange.

Space Reactor. Researchers are studying concepts for advanced nuclear reactors for potential military and civilian applications in space. One such space reactor, called SPAR, is under study at Los Alamos. It is a high-temperature compact unit that can supply up to 100 kilowatts, enough to power a satellite for deep space missions or for an orbiting surveillance system. Space nuclear power has the potential of opening the door to space exploration as well as significantly strengthening our national defense.

Waste Management. Los Alamos activities in waste management are focused on safe methods of confining waste, assaying it, and reducing its volume. Geochemical studies are conducted to determine methods for underground disposal of high-level waste and shallow land burial of low-level wastes. Other work on the selection of the best form in which to store waste, including techniques for isolating and immobilizing it, will assist the national effort to design a permanent repository.

Through the use of instrumentation that evolved from the Laboratory's nuclear safeguards program, Los Alamos scientists are leading the national program to assay and sort wastes before storage. The effect of this program has been to reduce the volume of wastes committed to long-term storage.

Incineration of transuranic wastes at Los Alamos has proven to be an effective method for volume reduction. As a result of this success, Los Alamos is assisting the Department of Energy in transferring the technology to the commercial nuclear power program for low-level waste treatment.

Low-level radioactive waste is collected in special drums for burial at the Los Alamos disposal site. The surrounding rock, called tuff, is very stable; it has existed essentially unchanged for about a million years.

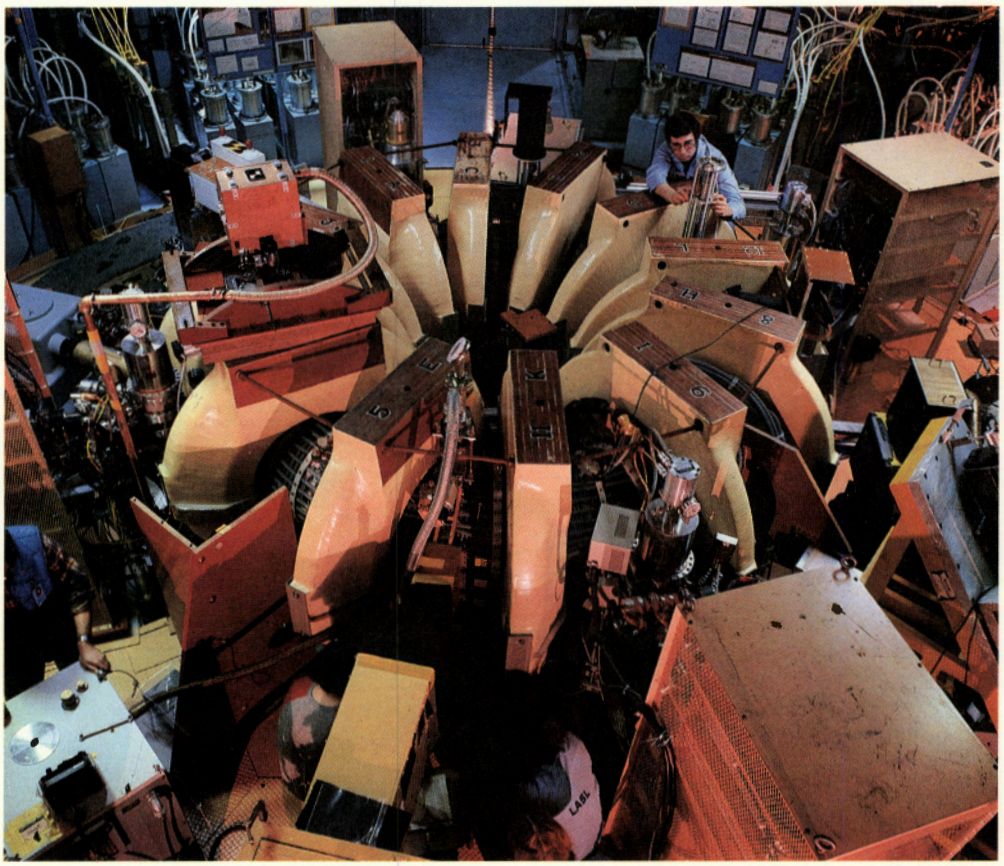
Alternate Energy Sources

Magnetic Fusion. Project Sherwood, established at Los Alamos in 1952, was the nation's first program in controlled thermonuclear research. In 1957 the first laboratory thermonuclear reaction (at a temperature of about 10 million degrees) was achieved here. Since then the Laboratory has been involved in nearly all aspects of the production, heating, and magnetic confinement of plasma (hot ionized gas).

A principal thrust of magnetic confinement fusion research at Los Alamos today is to study alternatives to the tokamak. Two alternatives are currently under study: the reversed field pinch and the compact toroid. The largest reversed field pinch device is the ZT-40M, a toroidal (doughnut-shaped) machine that uses magnetic fields to confine plasma while strong currents (up to 600,000 amperes) heat the plasma to millions of degrees. Experiments with the ZT-40M are providing important new information on this approach to magnetic confinement of fusion fuel. In a recent experiment, plasma heated to eight million degrees was contained for eight milliseconds—80 times longer than in previous experiments.

In a related program, the Laboratory is developing safe handling techniques for large quantities of tritium. The Tritium Systems Test Assembly (TSTA), which will be operational in 1982, is being built here as a national facility to develop tritium-handling technology. This facility will simulate tritium fuel cycles for first-generation fusion reactors and will be used to train people who design and operate fusion power plants.

Experiments with the ZT-40M are providing important data on the reversed-field-pinch approach to magnetic confinement fusion.



Geothermal Energy. Geothermal energy research at Los Alamos is directed toward tapping the natural heat of the earth found in hot, dry rock. The task of the national Hot Dry Rock (HDR) program, managed for the Department of Energy by Los Alamos, is to determine the potential of the resource, to determine the technical feasibility of extracting the heat, and to develop the commercial viability of the technology. The project, unique in this country, has demonstrated that heat can be extracted from hot rock by drilling two deep holes, connecting them through a heat transfer area of fractured rock, and circulating water through a closed-loop system.

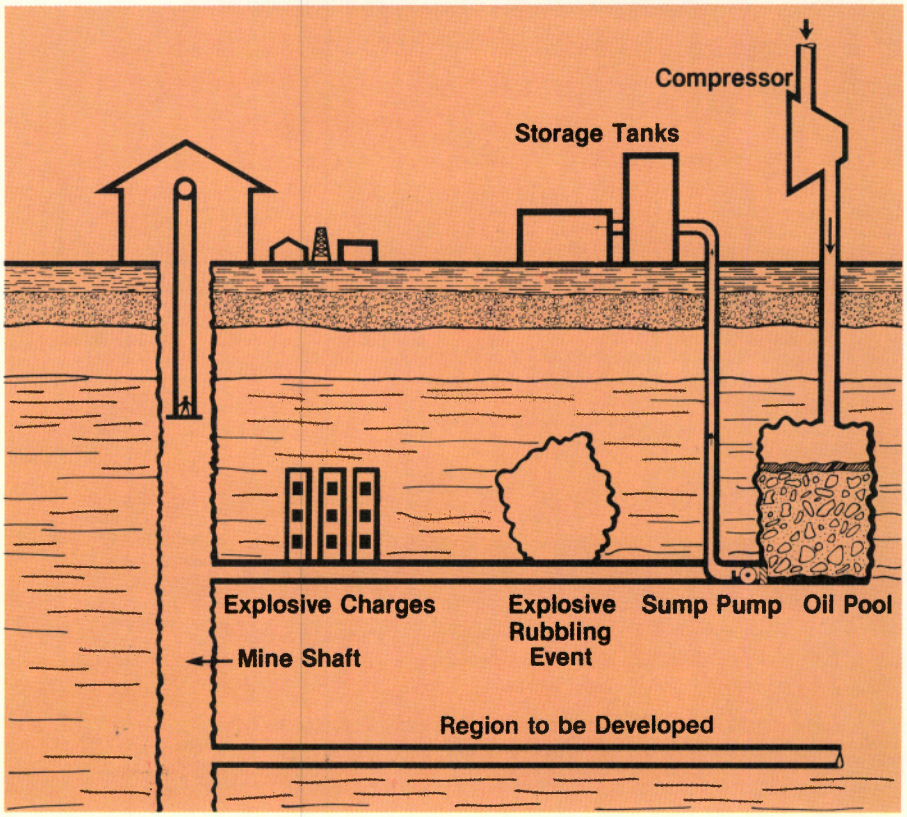
For this program the Laboratory, working with industry, designed and developed instruments that operate downhole at temperatures up to about 275°C (480°F).

In 1980 electricity was generated at the Fenton Hill geothermal site in the nearby Jemez Mountains. The hot geothermal fluid heated a secondary fluid (Freon) which, in turn, powered a small 60-kilowatt turbo alternator. In addition to field tests and exploratory work, the Laboratory is studying the economics, environmental effects, and institutional barriers related to development of this new resource.

Fenton Hill, in the Jemez Mountains of New Mexico, is the site of the first hot, dry rock geothermal energy experiment. Deep boreholes (covered with towers) circulate cold water underground through fractured granite and return hot water to the surface, where it can be used to heat buildings and generate electricity.

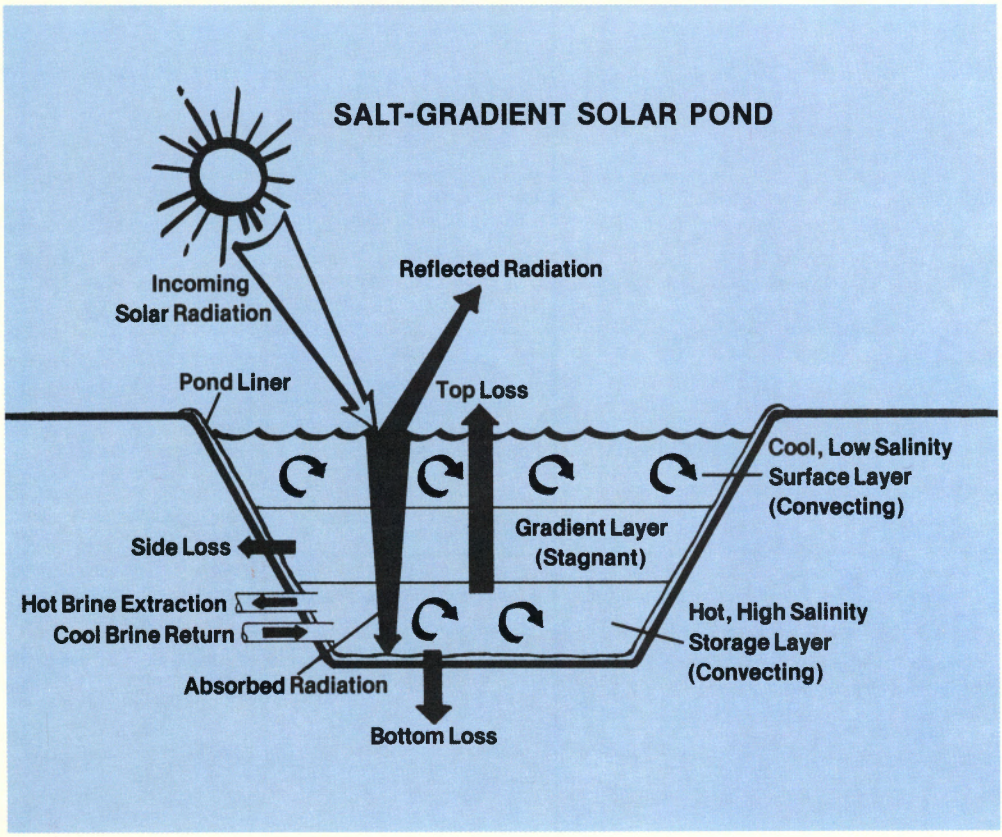
Fossil Energy Programs. Our expertise with high explosives and with materials under extreme temperature and pressure are being tapped for fossil energy research programs. The Laboratory's largest single effort in this area involves *in situ*, or underground, extraction of oil from shale. The *in situ* method involves blasting the shale to form a rubble pile and a chimney-like retort area where the rock can be heated underground to release oil vapor. The study involves a detailed analysis of how the rock fractures and how to achieve the proper size rubble. Although Los Alamos is involved in all aspects of *in situ* processing, the key issue is trying to understand the flow of the oil and gases through the complex permeable retort bed and being able to manipulate the properties of the bed to optimize production.

Los Alamos is also involved in coal research and enhanced gas recovery programs, in particular methane hydrates and western gas sands. The emphasis of this research is on material properties, computer modeling, instrumentation, and process development. The coal research programs include studies of subsidence in mines, the use of laser diagnostic techniques for analyzing emissions from power plants, research related to ceramic heat pipes and drill bit designs, and catalytic coal gasification. Many researchers believe that coal gas can be used to produce electricity with less environmental impact than if the coal were burned directly.



Western pioneers learned from the Indians of "the rock that burns." Today, Los Alamos geoscientists are studying *In situ* rubblization and retorting of oil shale.

Solar Energy. Research here to capture the sun's energy for heating and cooling includes investigation of active and passive techniques for residential and light commercial buildings, the development of computer models applicable for large commercial buildings, technology assessment and evaluation, and salt-gradient solar ponds. The program on active solar techniques has concentrated on system modeling, materials, and reliability and maintainability. To establish an engineering basis for quantitatively predicting passive solar performance, solar experts are monitoring solar, climatic, and interior conditions of 14 laboratory test rooms, each outfitted with a different passive system. The "Passive Solar Design Handbook," which compiles results of some of these studies, provides quantitative design information applicable to any location in the United States. Programmers here are adding design capabilities to a large computer program being developed for determining energy management techniques in large commercial buildings. The Laboratory is also performing technology assessments and evaluations to provide the Department of Energy with information that can be used to help structure the national solar energy program. Los Alamos is using its expertise in hydrodynamics to study salt-gradient solar ponds that have potential for providing daily and seasonal solar energy storage.

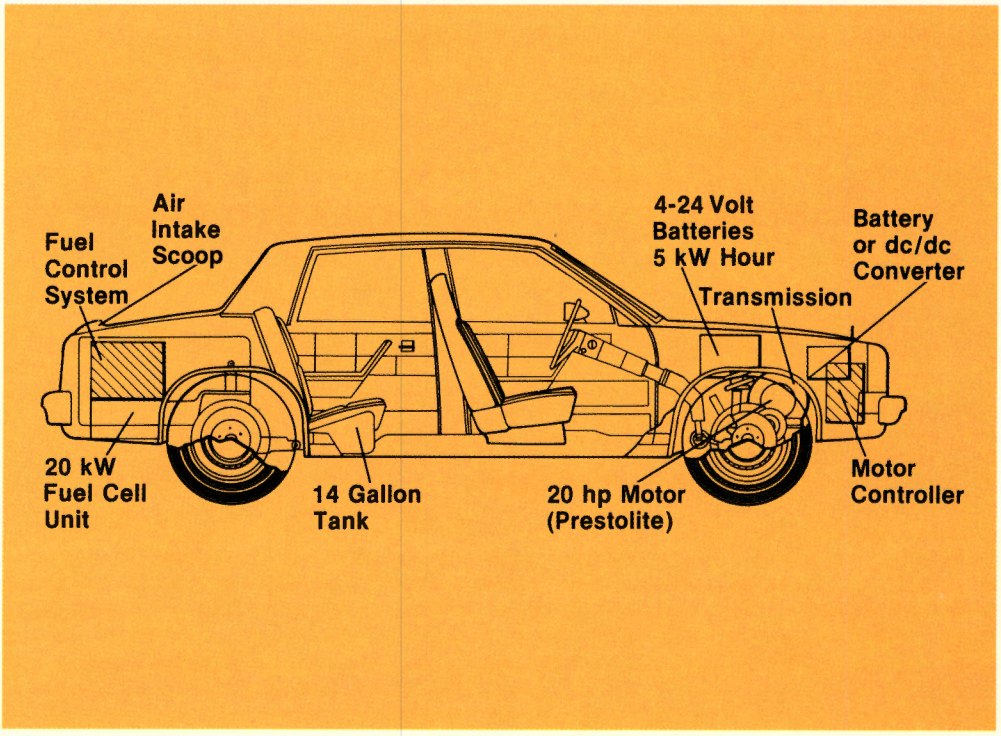


Above: These test rooms, each outfitted with a different solar heating system, are monitored by Laboratory researchers. Left: The Laboratory's pond will serve as a research tool for studying the basic hydrodynamics of salt-gradient solar ponds to obtain optimum operating conditions.

Conservation. At Los Alamos, the concept of conservation encompasses more than the reduction of energy consumption through lowered thermostat settings and enhanced fuel economy. Conservation programs here are focused on more efficient use of existing resources and the development of alternative transportation and fuels, such as hydrogen, that could replace dwindling petroleum reserves.

Since the early 1900s scientists have known that at very low temperatures many materials lose their resistance to the flow of electricity and become superconductors. Superconducting technology developed at Los Alamos is culminating in prototype energy storage devices that can offer transmission line stabilization as well as daily electricity storage, both of which can enhance the efficiency of utilities. Superconducting transmission lines are also under investigation as a more efficient means of distributing electricity.

Los Alamos researchers are adapting space-age fuel cells to power electric vehicles. This concept has been used to power a preprototype vehicle—a golf cart. Plans are to adapt this technology for use in an automobile. This automobile, as presently conceived, will use methanol as

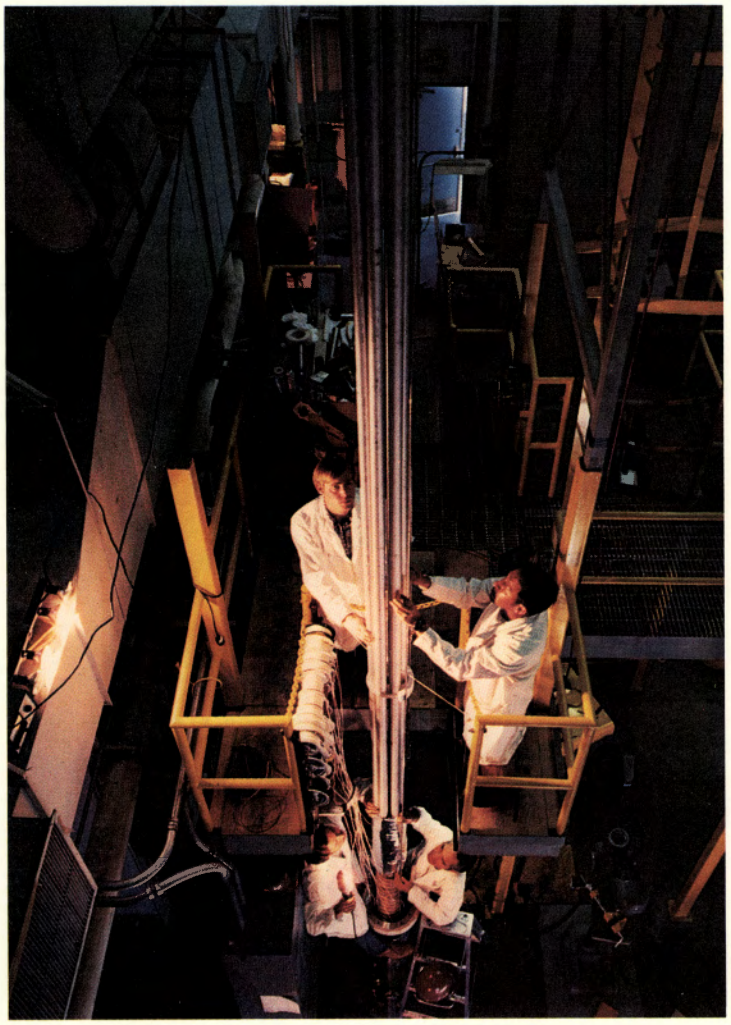


Above: A preprototype of the fuel-cell-powered car is the golf cart designed to run on methanol, or hydrogen, and air. Right: A fuel-cell-powered automobile, an alternative to gasoline-powered vehicles, is being studied at Los Alamos. The advantages of such vehicles include low noise and air pollution, reliability and long life, high energy efficiency, non-petroleum-based fuel, and long range.

fuel, stored in a conventional tank, which will then be reformed to hydrogen for use in the fuel cell.

Laboratory hydrodynamicists are modeling the combustion process that occurs in conventional internal combustion engines to better understand the engine's performance in an effort to increase fuel efficiency. Another transportation project involves the conversion of a conventional automobile to use liquid hydrogen fuel. Hydrogen is also being studied as an alternative fuel, for many possible applications besides transportation.

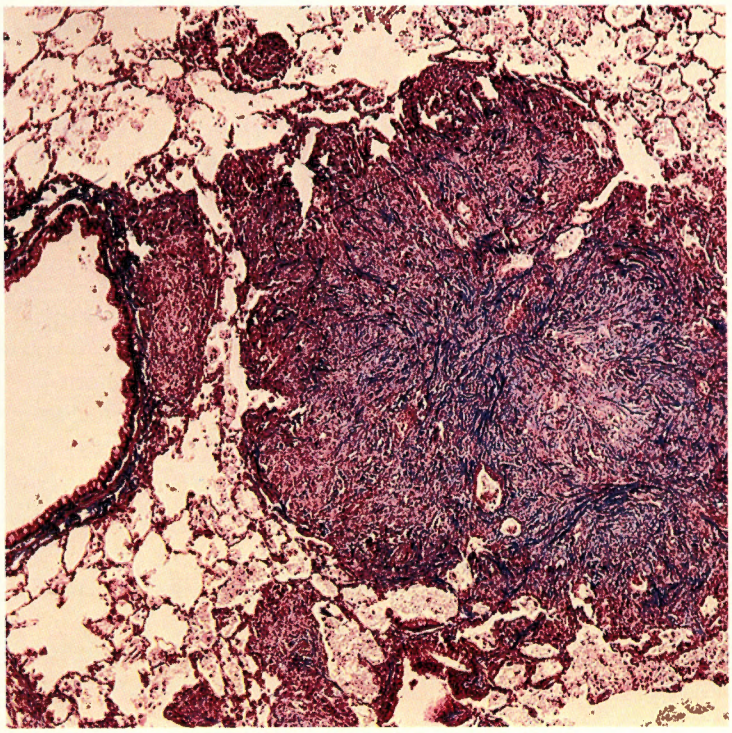
Energy-Related Programs. Our energy-related programs are concerned with health, safety, environmental, and economic studies related to development and use of various energy technologies.



Los Alamos economists and statisticians are evaluating, for example, the social, environmental, and institutional impacts on the Rocky Mountain states for various energy development scenarios.

Environmental and life sciences research focuses on the effects of technology on humans and their environment and on how to mitigate any harmful effects. For example, a comprehensive, multidisciplinary program is concerned with the effects of toxic substances, such as heavy metals and countermeasures related to energy production. The 27,500-acre Los Alamos National Environmental Research Park provides an outdoor laboratory for field studies of the interaction of effluents with the geology, meteorology, and biology of the local environs.

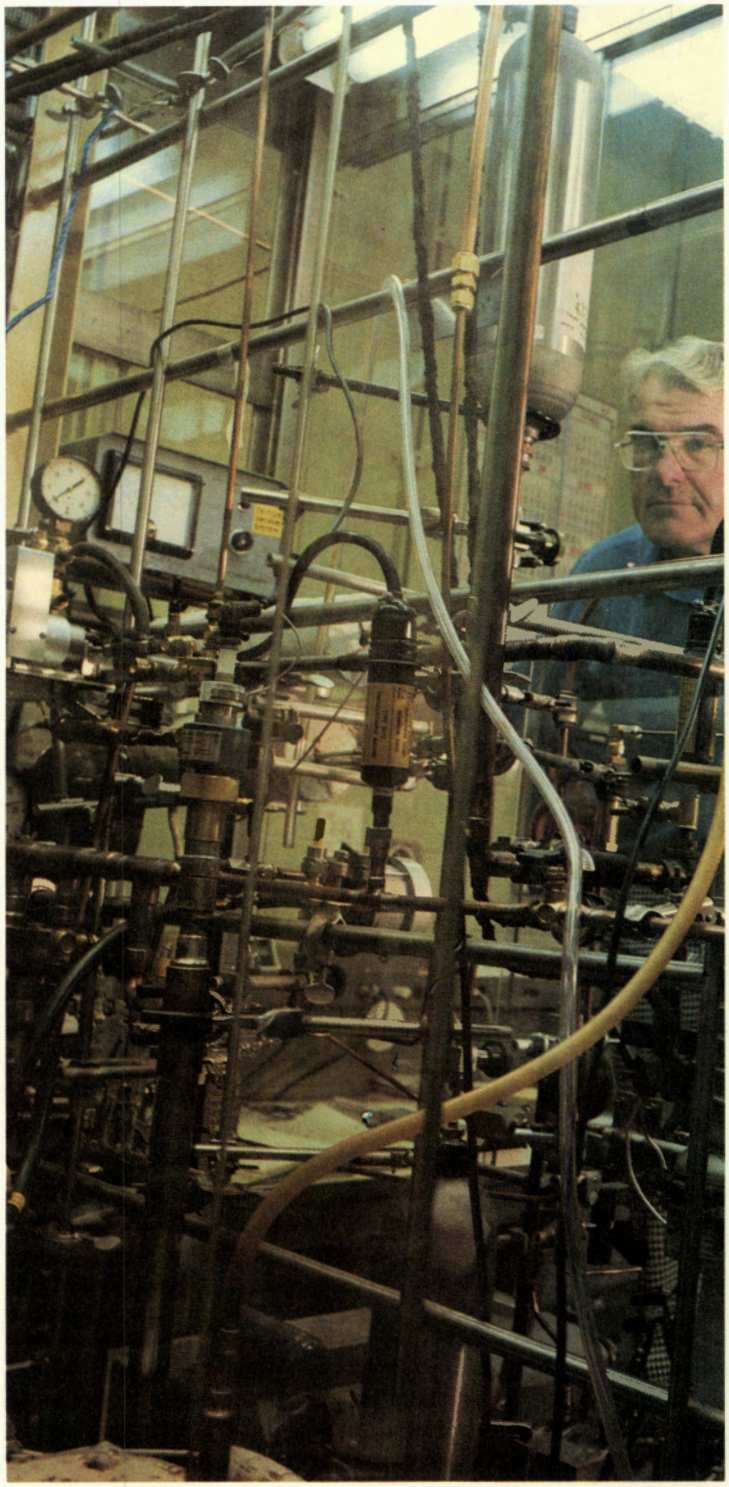
Left: The Stable Isotopes Production Facility uses cryogenic distillation to produce nonradioactive isotopes for biomedical, agricultural, and environmental research. Below: This thin section of a rat's lung shows damage resulting from the inhalation of quartz dust. The blue-stained central material is an abnormal deposit of collagen, a connective tissue protein formed during the healing of wounds. Normal air sacs in the lung, stained pink, are seen at the periphery. (Magnified 425 times.)



Basic Research

The search for new knowledge—basic research—leads to a fuller understanding of the nature of the world and the universe. Discoveries and advances in basic research often lead to new ideas or applications—the practical, often unpredictable consequences of fundamental inquiries.

Basic research provides support and guidance for the Laboratory's national security and energy programs while advancing the endless frontier of science. Our basic research programs cover every major branch of science—physics, chemistry, mathematics, biology, geology, engineering, and almost all of their subdisciplines—astrophysics, geochemistry, biophysics, to mention only a few.



Physics

Theoretical and experimental physics are major research areas at the Laboratory. Efforts include nuclear physics; plasma physics; materials science, including detonations; astrophysics; atomic and molecular physics; and space physics.

Methods for predicting the motion of free neutrons (neutron transport) were invented at Los Alamos, and data bases of nuclear cross sections, equations of state, and opacity were developed here. These data are routinely used, for example, by reactor physicists and weapons designers in their calculations. The basic numerical methods for studying time-dependent compressible and incompressible flows in several spatial dimensions and with large material distortions are Laboratory contributions. Current research in this area involves development of models for multiphase flows and fluid dynamic instabilities, which have applications in many of our energy programs. Hot, dense plasmas are also studied with lasers, relativistic electron beams, and magnetically confined plasma devices, such as the ZT-40M. These studies are designed to provide data on energy transport processes, loss mechanisms, instabilities, and laser beam plasma interactions.

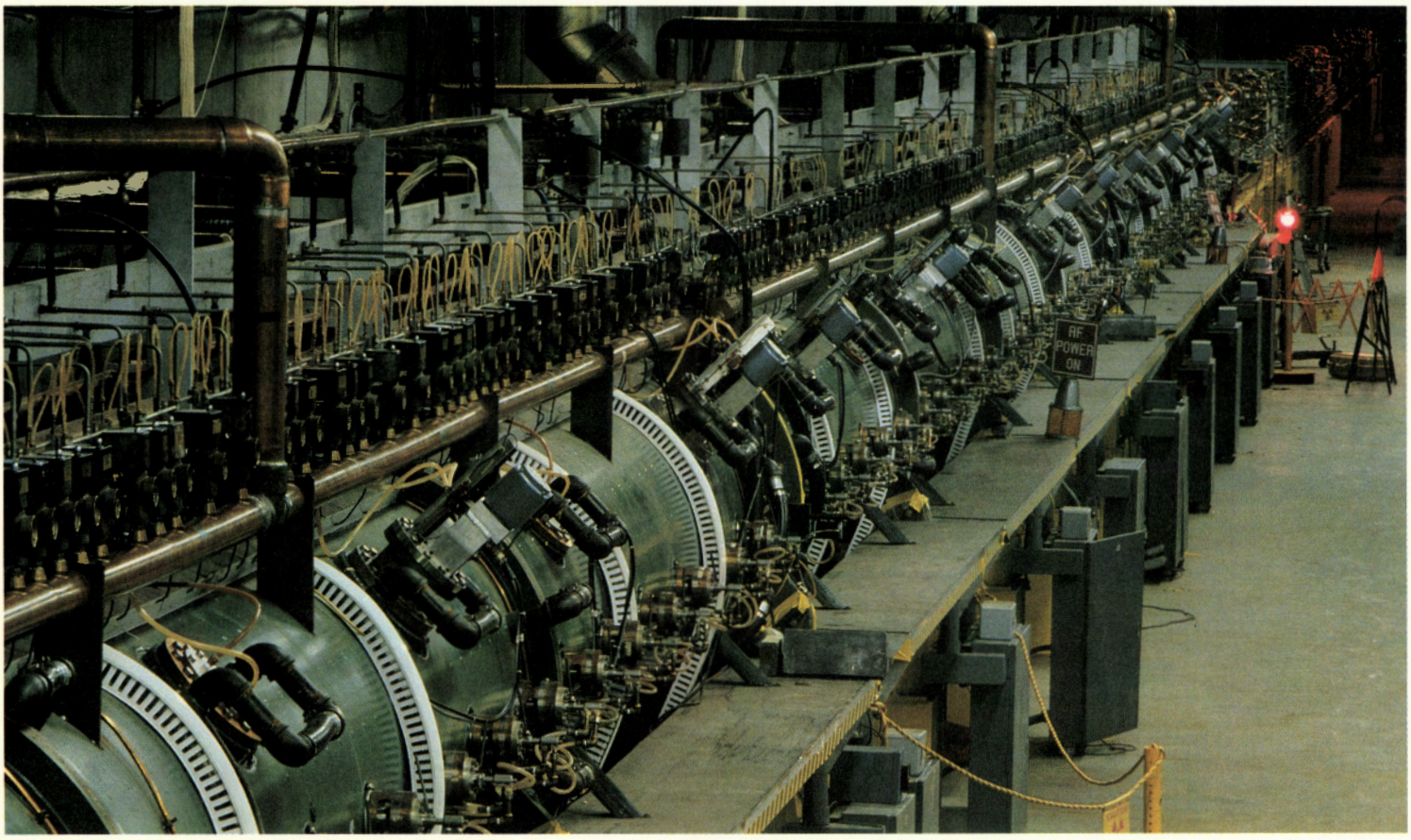
The Meson Physics Facility provides the world's most intense proton beams for nuclear science research. The heart of the facility is a linear accelerator designed to provide beams of protons with variable energies up to 800 million electron volts and a current of one milliampere.

The facility is designed to bridge the gap in studies between nuclear and subnuclear physics and to be used for practical applications as well. In addition to research on nuclear particles and condensed matter, the Meson Facility is used for studies in radiobiology, radiotherapy, and for the production of medical radioisotopes. One of its most interesting and promising practical applications is a clinical trial program based on the use of negative pions for treatment of deep-seated cancers. Pions, or pi-mesons, are subatomic particles that exist for only millionths of a second. Because they can easily be captured by a nucleus and as a result destroy it, they hold promise for eliminating cancerous cells by localized decay.

Left: Research on condensed-matter physics is an important part of many Laboratory programs. Below: In the drift-tube section of the Meson Facility, particles are accelerated to millions of electron volts.

Space Physics and Astrophysics

Basic research in space physics and astrophysics supports an interagency program to provide the United States with a satellite system for world wide surveillance of nuclear explosions conducted underground as well as in and above the atmosphere. It also supports a Laboratory program to assess the chemical and plasma effects of the detonation of nuclear weapons within and above the atmosphere. Our space physicists investigate fundamental processes, such as the properties and dynamics of cosmic plasmas (the highly energetic material that comprises most of the universe), as well as conduct research in solar, interplanetary, magnetospheric, ionospheric, planetary, and cometary physics. In the quest to try to unravel the complexities of black holes, white drawfs, and neutron stars our astrophysics efforts also cover basic research on the nature and origin of cosmic gamma-ray bursts, transient X-ray sources, and the astrophysical processes that occur near strong gravitational fields.



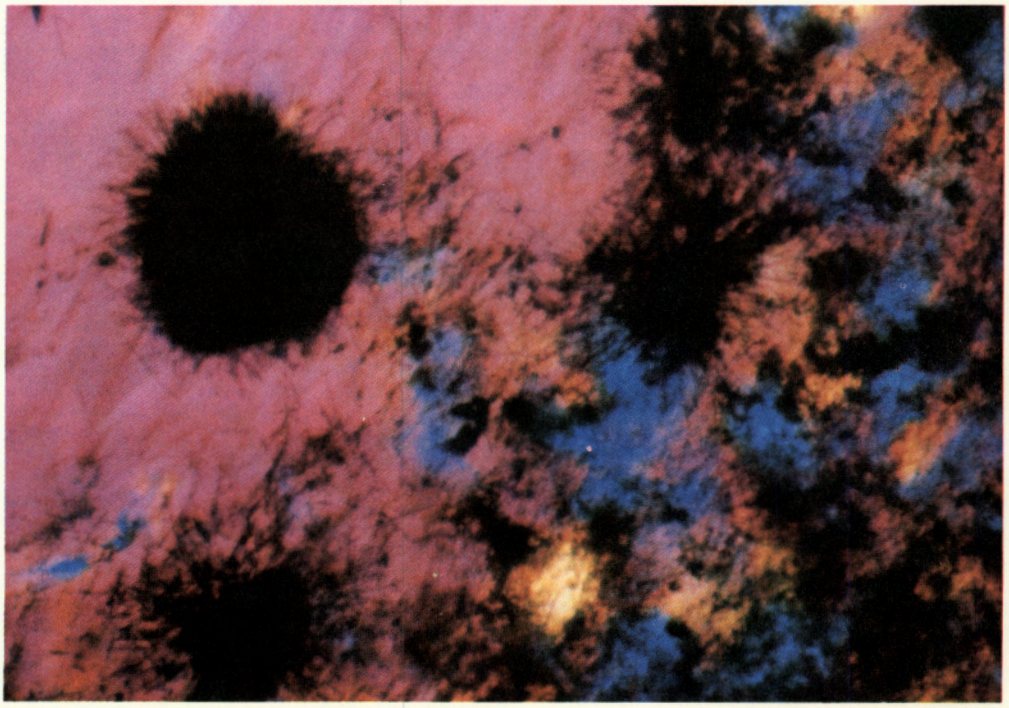
Chemistry

Chemistry research activities unite classical test-tube chemistry with advanced techniques using molecular jets, lasers, and ultrafast diagnostics to probe the nature of chemical structures and reactions. An extensive effort in laser photochemistry is researching fundamental molecular interactions in an effort to understand and control chemical reactions that are important in the synthesis of materials and for energy production. Another research project involves investigation of the synthesis, reactivity, structure, and bonding of transition metal complexes of interest in catalysis and the selective removal of heteroatoms, which is important in coal conversion and the basic chemistry of pollutants. These studies could be useful in converting sulfur dioxide and oxides of nitrogen into less harmful or even potentially useful by-products. Another important research activity focuses on theoretical and experimental studies of thermochemical cycles that appear to be potentially useful for dissociating water to produce hydrogen and oxygen.

Our experimental program in nuclear chemistry exploits the uniquely high fluxes of mesons and protons generated at the Meson Physics Facility to investigate nuclear and extranuclear phenomena. One of the main thrusts of this effort is to investigate the effects of chemical structure on the capture of negative muons.

Radiochemists and geologists are engaged in a research program to investigate the phenomena of migration and fixation of elements under various geologic conditions. The goal of the program is to determine the effectiveness of certain geologic formations as barriers to radionuclide migration under various hydrologic conditions. Uranium ore deposits, the natural reactor in Oklo, Gabon, and a nuclear explosion cavity at the Nevada Test Site serve as areas for field experiments. The results of these studies can provide information not only applicable to determining safe, permanent storage for nuclear wastes, but also relevant to understanding natural geochemical processes such as ore formation.

Below: This microautoradiograph shows the sorption of plutonium-239 on a thin section of tuff. The dark spot is about 60 to 70 micrometers in diameter (about two thousandths of an inch). At right: A materials technician casts a hemishell of glass at 1500°C. Laboratory technicians have the capabilities of working with a wide variety of plastics, metals, ceramics, and glass.



Materials Science

Research on mechanical behavior of materials emphasizes the response to multiaxial and high-rate loading and includes strain-induced transformation of stainless steel and brittle fracture of ceramics. Microscopic structural features are correlated with macroscopic response. A theoretical study of elastic-wave scattering relates ultrasonic measurements to microstructural defects. Research on the behavior of materials under severe environments, such as high pressure, high temperature, and high strain rates includes diamond anvil cell high-pressure experiments and dynamic flyer plate experiments.

Much of the materials research involves the behavior and properties of actinides, especially the role of their unique electronic structure. Theoretical efforts include band structure calculations and many-body effects. The study of superconductivity emphasizes new alloys and compounds. Research in surface science includes sophisticated surface analysis to understand the crystallography, electronic properties, catalysis, and reaction kinetics at surfaces. Research on actinide coatings includes electrochemical techniques and physical and chemical vapor deposition processes.

A major thrust in materials science research is the use of the pulsed neutron source at the Meson Physics Facility and Weapons Neutron Research Facility for neutron radiation and scattering damage studies. A proton storage ring is being constructed to increase greatly the intensity and flexibility of the pulsed neutron source. This unique facility will offer new approaches to studying many aspects of materials science.

Mathematics and Computational Physics

Mathematicians at Los Alamos are mainly concerned with two general areas of research that arise in the attempt to describe and understand complex phenomena of interest to Laboratory scientists.

The first area concerns the effect of nonlinearities on systems, as nonlinearities pervade the models associated with complex physical phenomena. Indeed, the importance of this area motivated the recent formation of the Laboratory's Center for Nonlinear Studies.

The second area is numerical analysis, which concerns the development and understanding of more efficient and effective ways to represent and calculate on a computer approximate solutions of complex problems (for example, finite difference methods, finite element and collocation methods, and multigrid methods). An important application is numerical fluid dynamics, which the Laboratory has helped develop into a powerful modern research tool. The Laboratory is pioneering in a variety of technical areas: toroidal confinement magnetic fusion, vapor-phase heat transfer as applied to heat pipes, multiphase flow to aid in the analysis of nuclear reactor safety, and chemically reacting flows in internal combustion engines and coal furnaces.

Other areas explored mathematically at Los Alamos include the application of group theoretic techniques to molecular and atomic spectroscopy, as well as the behavior of models of biological and energy systems.

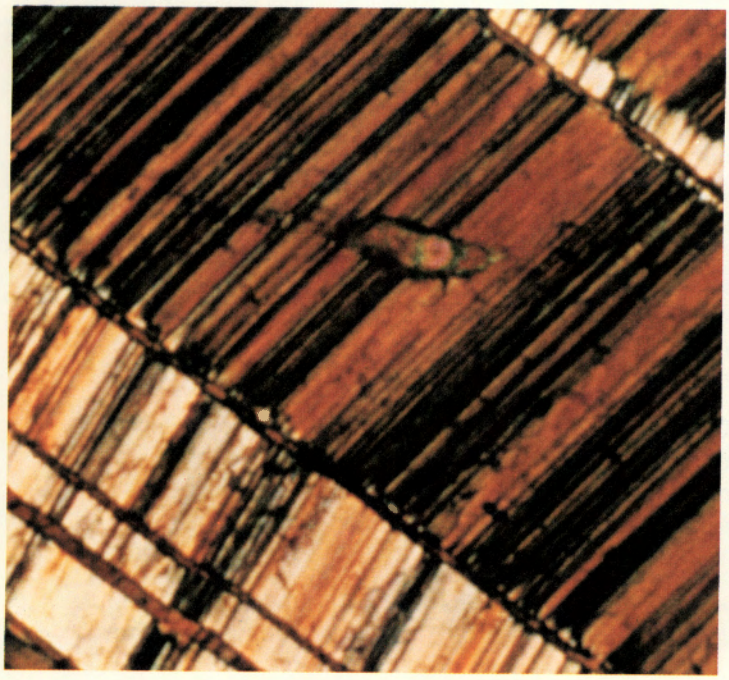
In addition to specific problem areas, Los Alamos is a leader in the development of computational techniques for ordinary and partial differential equations, integral equations, and approximation theory.

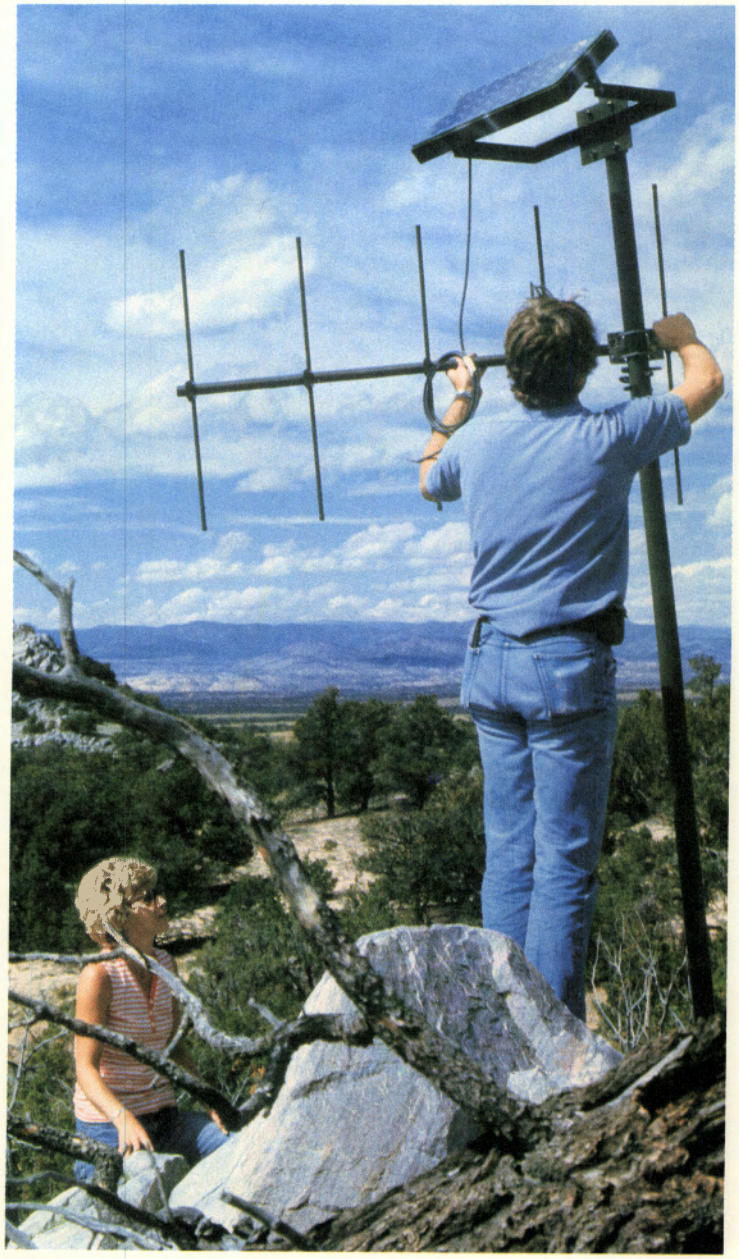
Geosciences

Geosciences research supports several Laboratory programs: underground nuclear testing; hot, dry rock geothermal energy; *in situ* energy extraction of fossil fuels; and radiological waste management. Research in the nuclear testing program centers on investigations of the flow of liquids and gases through porous and fractured rock to ensure that radioactivity from underground nuclear tests is not released to the atmosphere. Effort in support of the geothermal program emphasizes thermal conductivity, rock mechanics, and igneous processes. Work in fossil fuels centers on enhancing production by advancing the technology to model and control the flow of fluids through *in situ* georesource beds. In waste management, researchers study selected geologies as prospective waste storage sites and investigate volcanism and other conditions that may pose hazards to safe isolation.

Field geology and geophysics, rock physics, petrology, and geochemistry research are dedicated to the fundamental goal of understanding continental geodynamics. Seismologists here are studying the tectonics and structure of the earth's crust and source mechanisms for earthquakes. As part of the Continental Scientific Drilling Program, funded by the National Academy of Sciences, geologists are investigating the evolution of the Rio Grande rift, particularly in connection with its relevance to national energy and weapons technology needs.

Below: This magnified view shows a thin section of experimentally deformed pyroxene mineral under polarized light. Right: This solar-powered seismic station transmits data on the Rio Grande rift to the Laboratory.





Life and Environmental Sciences

Basic research in the life sciences seeks to understand general features of living systems so that researchers can decide if and why some environmental effects pose greater threats to society than others. Major advances in the art of measuring biochemical events have permitted experiments never possible before and have made important contributions to understanding cancer induction and progression, how genes function, why chromosomes become unstable in malignancy, and the nature of defense and repair mechanisms that have evolved in humans and other mammals. Our genetic research facilities offer means of isolating and cloning genes.

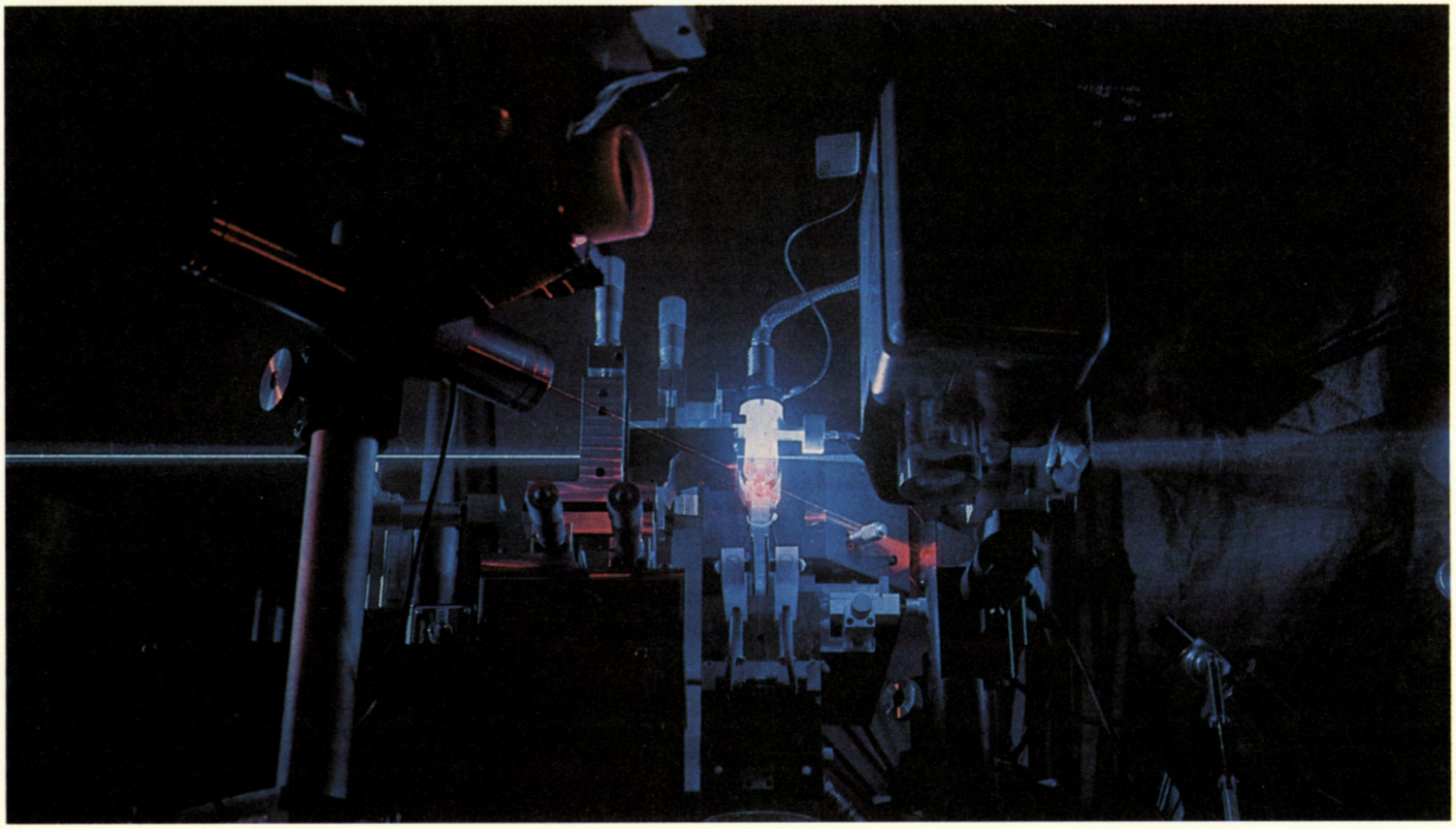
Theoreticians at Los Alamos with interests in cell biology, immunology, and genetics recently established a computer library for the storage and manipulation of nucleic acid sequences, the components of RNA and DNA.

Scientists here are producing stable and radioactive isotopes for medical researchers to use for imaging organs, diagnosing diseases, and monitoring physiological processes.

In molecular and cellular biology, we have developed instruments that use laser-induced fluorescence to rapidly sort and analyze individual biological cells for anomalies. This flow cytometry work is being applied to study biological effects of drugs and toxins, and to diagnose diseases (such as cancer) and monitor treatment.

Basic research in the life and environmental sciences also supports the Department of Energy's responsibility for identifying and minimizing potential problems associated with its energy programs. These efforts are described under Energy-Related Programs.

A cell sorter designed at the Laboratory can rapidly screen cells for anomalies by means of laser-induced fluorescence.



Engineering

Although engineering research at the Laboratory is often a partner with other scientific research projects, there are several projects oriented toward advancing the engineering disciplines. Some of these include research on advanced computers and computer networks; improved computer codes for static, dynamic, thermal, and fluid flow analyses; development of new materials and composites, and determination of their properties; heat- and radiation-resistant electronic circuits and instrumentation; and electromechanical devices for application in the weapons and energy programs.

Institute of Geophysics and Planetary Physics

In 1950 the University of California at Los Angeles formed an Institute of Geophysics and Planetary Physics to unite scientists in these related but different disciplines. The success of this venture spawned branches of the institute at other University of Calfornia campuses. In 1980 a branch was initiated at the Los Alamos National Laboratory.

The purpose of the Los Alamos branch is to foster stronger ties between Laboratory and University researchers by encouraging the exchange of information and ideas and by sharing facilities and equipment.

The breadth of research conducted by the Institute will encompass such disciplines as tectonophysics, seismology, planetary geology, atmospheric science, and geochemistry.

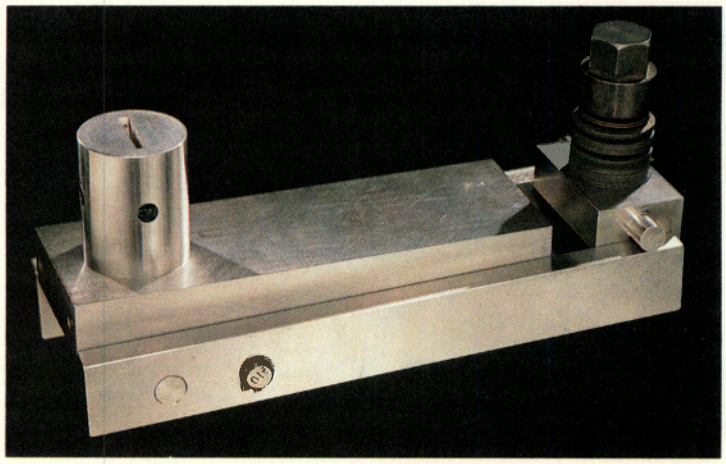
Center for Nonlinear Studies

Like the branch of the Institute of Geophysics and Planetary Physics, the purpose of the Center for Nonlinear Studies at Los Alamos stems from an attempt to encourage interdisciplinary research among many disciplines with common nonlinear problems and to increase interaction between Laboratory and University mathematicians and scientists. Toward that goal, the Center supports workshops and academic exchanges to stimulate research in areas such as turbulence, reaction diffusion processes, molecular dynamics, and biophysics.

The development of analytical methods for nonlinear systems would be applicable to many of the Laboratory's energy and defense programs, because most all of them involve complex nonlinear phenomena.

J. Robert Oppenheimer, the first director of the Laboratory, said of basic research: ". . .if the inquiry is well conceived it will not merely come up with a new answer, it will come up with something far more valuable, which is a new question, one which had not been thought of before. Out of such questions, and their progeny, the growth of science and the growth of practice both arise." Indeed, our basic and applied research programs have a synergistic effect on each other, an effect that helps keep the Laboratory in the forefront of scientific and technological discoveries.

This 8-inch-long diamond-anvil cell contains xenon at 460 kilobars (460,000 bars), the highest pressure ever obtained on this gas. Normal atmospheric pressure is about 775 millibars (0.775 bars).



Some Los Alamos Firsts

As an innovative Laboratory pursuing research on the frontiers of science, Los Alamos has, of course, generated many "firsts." The most well known is our development of the first atomic and thermonuclear weapons. Some other noteworthy but lesser known contributions to the history of science and technology include the following.

National Security Programs

Development of insensitive high explosives.
Development of many new special metal alloys, including several of plutonium.

Development of equipment and systems for safeguarding nuclear materials (for example, DYMAC).
Use of carbon dioxide lasers to produce thermonuclear reactions from deuterium-tritium mixtures in fusion fuel pellets.
Demonstration of uniformly frozen cryogenic laser fusion targets.

Energy Programs

Nuclear Programs
- Development of unique laser isotope separation process.

Alternate Energy Sources
- Laboratory demonstration of controlled thermonuclear reactions.
- Hot, dry rock geothermal energy: demonstration of deep drilling and hydraulic fracturing of granite, borehole connections, and heat extraction.
- Large-scale handling and use of liquid hydrogen, from which emerged much of the technology employed in the space program and in the nation's cryogenic engineering industry.
- Construction of first fast reactor (Clementine). The plutonium-core reactor demonstrated the characteristics of a fast neutron reactor.

Environment and Biosciences
- Development and application of flow cytometry for use in biological research, disease diagnosis, and therapy monitoring.
- Use of pion irradiation therapy for treatment of cancer.
- Development of enzyme-labeled antibody tests that permit rapid, automated mass screening for diseases.

Basic Research

Development of Monte Carlo computational techniques for neutral particle transport and other applications.
Direct detection of the neutrino.
Construction of a 800-million-electron-volt linear accelerator, one of the world's largest, most powerful medium-energy research facilities.
Verification of the Mössbauer effect.
Development of particle-in-cell method for numerical calculations of fluid flows now used extensively worldwide.
Discovery of cosmic gamma-ray bursts.

The University of California in compliance with Titles VI and VII of the Civil Rights Act of 1964, Title IX of the Education Amendments of 1972 (45 CFR 86), and Sections 503 and 504 of the Rehabilitation Act of 1973, does not discriminate on the basis of race, color, national origin, sex, religion, or handicap in any of its policies, procedures, or practices; nor does the University, in compliance with the Age Discrimination in Employment Act of 1967 and Section 402 of the Vietnam Era Veterans Readjustment Act of 1974, discriminate against any employees or applicants for employment on the basis of their age or because they are disabled veterans or veterans of the Vietnam era. This nondiscrimination policy covers admission, access, and treatment in University programs and activities, and application for and treatment in University employment.

In conformance with University policy and pursuant to Executive Order 11246 as amended, Section 503 of the Rehabilitation Act of 1973 and Section 402 of the Vietnam Era Veterans Readjustment Act of 1974, the University of California is an affirmative action/equal opportunity employer.

Inquiries regarding the University's equal opportunity and affirmative action policies may be directed to: Dimas M. Chavez, Equal Employment Opportunity Officer, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, telephone 505-667-3905.

The Los Alamos National Laboratory is operated by the University of California under contract W-7405-Eng. 36 for the U. S. Department of Energy. An affirmative action/equal opportunity employer.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1981 — 777-089/37