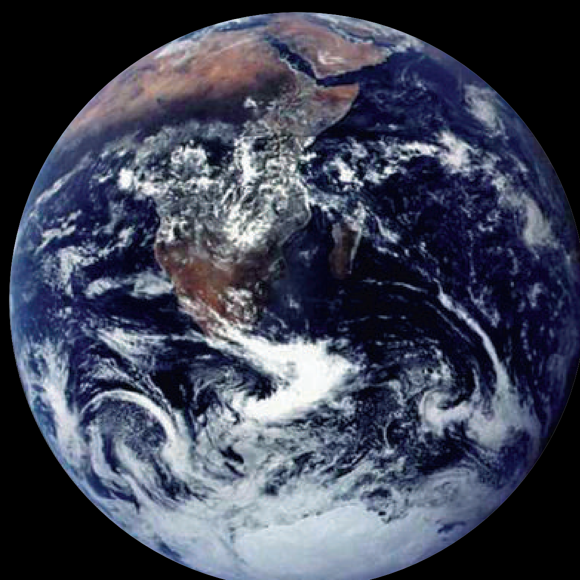
JANUARY/FEBRUARY/MARCH ISSUE 1998

LOS ALAMOS NATIONAL LABORATORY
WHERE SCIENCE MAKES A DIFFERENCE

DATELINE LOS ALAMOS



LOS ALAMOS IN SPACE

FUTURE SCIENCE AND TECHNOLOGY BASED ON 40 YEARS OF EXPERIENCE

When the Russians launched Sputnik in 1957, the race into space began. Today, more than 2,400 international satellites orbit Earth. Many U.S. satellites carry Los Alamos instrumentation, sensors or power generators.

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Los Alamos' contribution to the space program began in the late 1950s with the research and development of a nuclear rocket program called Rover that lasted 17 years. In that era, Los Alamos scientists also began development of radioactive batteries to power satellites, a grandfather technology of today's radioisotope thermoelectric generators.

President Kennedy and then-director Norris Bradbury (left) tour a mockup of the Kiwi-A reactor during the president's visit in December 1962. Eight Kiwi reactors were built and tested during Phase I of the Laboratory's Project Rover.

Los Alamos' contribution to nuclear test monitoring from space also began in the late 1950s with the Vela program. The United States had no capability to detect nuclear explosions in the upper atmosphere or in space.

The Laboratory was assigned the responsibility to develop sensors to do this type of monitoring. When President Kennedy and Russian President Khrushchev signed the Limited Test Ban Treaty in 1963, the first Vela satellites carrying Los Alamos instruments were ready for launch.

Los Alamos continues its treaty verification mission today. Los Alamos and Sandia national laboratories have supplied most of the nuclear test monitoring sensors deployed on U.S. satellite systems.

No treaty receives a favorable rating by the federal government until it can be proved that the terms of the treaty can be verified. Los Alamos satellite sensors have provided verification technology for the LTBT, the

DATELINE LOS ALAMOS

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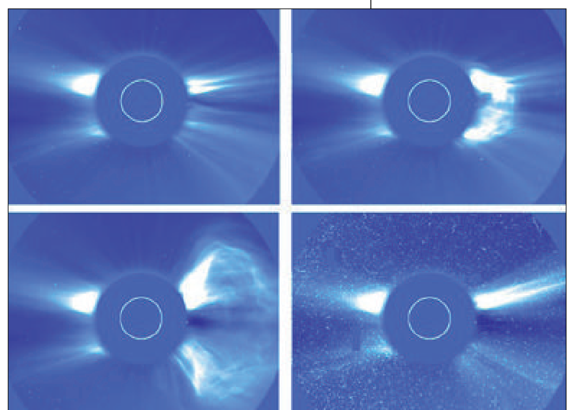
Nonproliferation Treaty and the Threshold Test Ban Treaty. To meet the latest Comprehensive Test Ban Treaty requirements, Los Alamos is developing new or improved technologies to detect clandestine nuclear tests.

Today, following the end of the Cold War, the proliferation of weapons of mass destruction, including nuclear, biological and chemical weapons, poses a major threat to national security.



The first signs of the January 1997 coronal mass ejection were seen from a coronagraph on board the SOHO satellite, part of the ISTP program detailed on Page 16. The coronagraph uses a blocking disk in front of the lens to shield it from the sun's glare. On Jan. 6, 1997, the coronal mass ejection appeared on the Naval Research Laboratory's Large Angle Spectrometric Coronagraph instrument three and a half hours after it happened. Coronal mass ejections can cause large fluctuations in Earth's magnetic field and have the potential to disrupt sensitive satellite equipment.

NASA

Laboratory scientists are developing new sensors and systems to detect proliferant activities of all kinds, including radiation, chemical and biological agent sensors. These sensors will be used across a spectrum of applications, from unattended ground-based instruments to space-based instruments.

Other sensor technology will predict space weather, an ever-increasing concern for sensitive satellite electronics that could be blasted by an electrical storm emanating from the sun.

Laboratory instruments detected such a phenomenon in January 1997 when a coronal mass ejection smashed into Earth's magnetosphere and may have damaged a sensitive satellite.

The sun often explodes with ionized gas several million degrees hot: so hot, it glows in X-rays. It was unusual for scientists to be watching the potentially disruptive mass ejection just as it left the sun. Scientists were able to alert other scientific teams of possible activity they might observe two to three days later, when the wave struck Earth.

This was not the first nor the largest event of this nature to be detected, but the complement of spacecraft and ground-based equipment was able to analyze this space storm on a scale never before accomplished.

In addition to the nonproliferation and test-ban verification roles, Los Alamos space scientists have sent instruments on NASA probes to the sun, Saturn and Jupiter to gain an understanding of the basic science of the universe.

Today, instead of competing as it did in the days of Sputnik, Russia is now collaborating with Los Alamos and other space agencies. The global threat of loose nuclear weapons, materials and the capability for rogue nations to acquire or build weapons of mass destruction makes the Los Alamos mission in space as important today as it was 40 years ago.

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PREFACE

During the past 40 years Los Alamos has played a significant role in the nation's space program by uniquely combining national security missions with leading-edge investigations of space science and space technology.

From verifying test-ban treaties to exploring the outer limits of the universe, Los Alamos scientists and engineers have made lasting contributions. This combination of mission and science has stirred the imagination of some of the Laboratory's finest and has attracted dozens of students and young researchers to Los Alamos.

Today we stand on the shoulders of the first space pioneers at the Laboratory 40 years ago and look forward to an exciting future involving Los Alamos in space. In 1997 alone, more than two dozen Los Alamos instruments have traveled into space on satellites and space probes, including the Laboratory's own FORTÉ research satellite.

Radioisotope thermoelectric generators pioneered at Los Alamos powered the Cassini mission to Saturn. Los Alamos' role in national security will continue in the future with satellite monitoring of the Comprehensive Test Ban Treaty, while our role in space science and technology will continue with space probes planned to visit Mars and the outer planets.

This special issue of *Dateline: Los Alamos* is dedicated to the men and women of the Laboratory — past, present and future — who established and continue the tradition of excellence of Los Alamos in space.

Don Cobb
Director
Nonproliferation and International Security

LOS ALAMOS' SPACE HISTORY

50 YEARS OF SCIENCE; 40 YEARS IN SPACE

In the 1950s, Los Alamos scientists built on their nuclear expertise by developing new methods for rocket propulsion into space. Based on their nuclear explosives experience, Laboratory scientists also developed sensors to go on Vela satellites to detect nuclear weapons tests. The programs discussed in this section represent some of the larger programs Los Alamos was involved with. In the 1970s and 1980s, the Laboratory also sent instruments into space on board satellites such NASA's Pioneer Venus Orbiter and Meteosat-3, and the Japanese GINGA Astro-C.

ROVER ROCKET PROGRAM • 1955-1972

Los Alamos became involved in Project Rover in 1955. The goal was to launch large payloads into deep space using nuclear-powered rockets. The basic technology involved passing hydrogen through a very high-temperature nuclear reactor, where it expanded and blasted out of the reactor at high velocity.

Nuclear reactors were built at the Laboratory's Pajarito Site, and tested at very low powers and then shipped to the Nevada Test Site. Laboratory work also included developing and testing the fuel elements that powered the reactors.

Phase one of Project Rover was called Kiwi and entailed building and testing eight reactors between 1959 and 1964. Phase two, called Phoebus, involved advanced nuclear reactors. The 1968 test of the Phoebus reactor convinced scientists that the concept of a nuclear-powered rocket was sound.

While most of the experiments were done at the Nevada Test Site in the Kiwi reactors, Rover was, at the time, the Laboratory's second largest program. It was phased out in 1972 in response to public concern about the cost of the nation's space program.

One of the eight Kiwi reactors designed and built at Los Alamos for Project Rover. The reactors were tested at very low powers at Los Alamos; full-scale testing like this was done at the Nevada Test Site.

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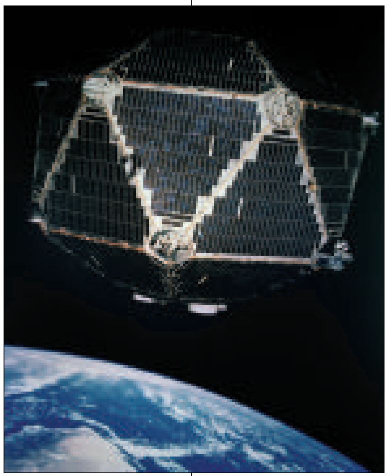
VELA SATELLITE PROGRAM • 1963-1984

Conceived in the early years of the space age, the Vela Satellite Program provided a technical way of monitoring nuclear explosions in Earth's atmosphere. Los Alamos was a major player in the Vela program because of its expertise in detecting nuclear explosions.

The Vela satellites carried Los Alamos-designed and Laboratory-built sensors for detecting X-rays, gamma rays, neutrons and the natural background radiation of space.

Although their primary function was to provide technical means for monitoring treaties, the Vela satellites contributed significantly to astrophysics, interplanetary physics and physics of Earth's magnetosphere.



The Vela satellites were an early technology for monitoring nuclear explosions.

Cosmic gamma-ray bursts, an unexpected phenomenon in astrophysics, were discovered with instrumentation aboard the Vela satellites. These blasts of extreme high energy, which seem to originate from all parts of the universe, are still poorly understood, but their discovery showed astrophysicists that the cosmos is more chaotic and transient than previously believed.

In the solar wind, the presence of iron, silicon and other ions heavier than hydrogen and helium was discovered with plasma analyzers aboard the Velas. The existence of a plasma sheet in Earth's magnetosphere and its dynamics associated with magnetospheric activity were other discoveries made with Vela instrumentation.

From 1963 to 1970, the Vela Satellite Program launched six pairs of satellites into space to an orbit of more than 60,000 miles above Earth. In 1984, the last satellite was turned off and left to drift in space, signaling the end of one of the most successful space programs.

As a result of the concepts, approaches and data developed for the Vela program, numerous NASA scientific satellite flights have used similar instruments developed at Los Alamos.

INTERPLANETARY MONITORING PROGRAM • 1971-1979

The space plasma team at Los Alamos has been directly involved in NASA space exploration programs since the early 1970s. This involvement began in 1971 when a Laboratory plasma experiment was launched aboard the Interplanetary Monitoring Program Six spacecraft. That experiment was designed to study the plasmas found in the solar wind and within Earth's magnetosphere.

Similar instrumentation was subsequently launched on IMP-7 and IMP-8 in 1972 and 1973. The IMP experiments provided fundamental information on the nature of the solar wind and its long-term variations. These data also provided valuable insights about the solar wind's interaction with Earth's magnetosphere and were the foundation from which current Los Alamos-NASA participation was built.

The IMP-8 experiment continues to return high-quality solar wind measurements more than 25 years after its launch.

INTERNATIONAL SUN-EARTH EXPLORER • 1977-1991

The International Sun-Earth Explorer One and Two satellites were launched into highly elliptical Earth orbit in October 1977. Each spacecraft carried a new type of plasma experiment designed primarily to study the physical nature of the major boundaries found within Earth's near-space environment.

Analysis of the data returned from these experiments provided important information into previously mysterious processes and demonstrated for the first time that mass and energy are transferred from the solar wind to Earth's magnetosphere.

ISEE-3, which was launched in August 1978, carried solar wind plasma experiments designed and built at Los Alamos. Both the ISEE-1 and ISEE-3 solar wind experiments provided new physical insights on solar wind disturbances driven by transient events on the sun, known as coronal mass ejections. The experiments demonstrated that virtually all of Earth's large geomagnetic storms are caused by such disturbances.

After nearly four years orbiting Earth, ISEE-3 was diverted deep into the geomagnetic tail for the first-ever exploration of that region. When deep in the geomagnetic tail, the Los Alamos plasma experiment discovered gigantic plasmoids ejected from the near-Earth magnetosphere.

After a year exploring the nature of the geomagnetic tail, ISEE-3 was sent off for the first spacecraft encounter with a comet in September 1985. When it was near Comet Giacobini-Zinner, the Los Alamos experiment provided the first direct measurements of the solar wind's interaction with a comet.

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CURRENT MISSIONS

IT'S NOT JUST ROCKET SCIENCE

Los Alamos plays a key role in monitoring treaty compliance with satellite sensors. Based on this sensor technology, Los Alamos instrumentation also has been placed on space missions touring the solar system, giving the Laboratory a dual role in space research. This instrumentation provides scientific data on the interactions between the sun and the planets and the makeup of space beyond Earth's boundaries.

NUCLEAR TEST MONITORING MISSIONS

Three ongoing space missions carry Los Alamos-designed instruments for detecting atmospheric nuclear tests. The missions are: Defense Support Program, Global Positioning System and Fast On-orbit Recording of Transient Events.

DEFENSE SUPPORT PROGRAM: CATCHING THE RAYS

The Air Force's DSP satellites provide early warning of ballistic missile launches or nuclear explosions. Los Alamos' technology on the DSP is an extension of the work that began on Vela satellites in the 1960s. The first two DSP radiation detection instrument (RADEC) suites were launched in 1975. The Air Force launched additional satellites beginning in 1989 with advanced radiation monitoring equipment.

The current Los Alamos technology complements the Global Positioning System and addresses the need for verifying compliance with the Limited Test Ban Treaty and the Comprehensive Test Ban Treaty.

The Laboratory's instruments on these satellites provide increased X-ray sensitivity and provide the sole source of neutron and gamma-ray measurements.

A DSP satellite is deployed from the Space Shuttle bay before being boosted into its operational orbit. The technology on the DSP satellite is an extension of work that began with the Vela satellite program.

NASA

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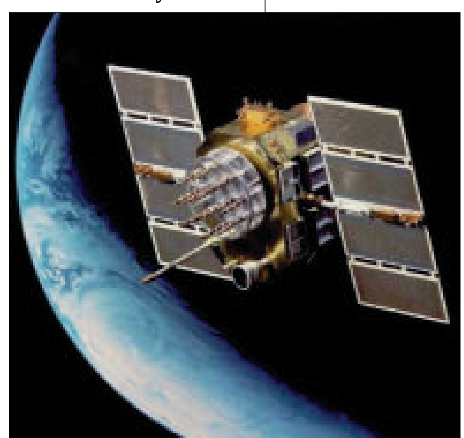
GLOBAL POSITIONING SYSTEM: EYES AND EARS IN SPACE

Campers, hunters and military forces have used GPS as a pinpoint location service but very few people are aware of the role GPS plays in treaty monitoring. In addition to carrying the navigation and timing payload, the satellites carry sensors that can detect and pinpoint nuclear weapons tests anywhere in the world.

The detection system is a joint program between the Air Force and the Department of Energy.

Starting in the mid-1980s, the GPS satellites have monitored emissions from nuclear tests by measuring light, radio waves and X-rays. The bhangmeter, developed by Sandia National Laboratories, measures the distinct, visible light signature of a nuclear test. When a flash of light within the sensor's field of view exceeds a preset level and shows other characteristics of a nuclear explosion, the bhangmeter triggers and records the optical intensity history.



Global Positioning System satellites carry sensors that can pinpoint nuclear weapons tests anywhere in the world.

Air Force Space Command

A nuclear detonation in the atmosphere also triggers intense radio waves. Energized electrons radiate an intense electromagnetic pulse. The GPS satellites carry a special antenna and electronics to detect and measure EMP from a nuclear detonation.

Because X-rays are absorbed by Earth's atmosphere, the instruments detect X-rays from detonations occurring in space. A ground-based antenna at Los Alamos is used to simulate and calibrate the EMP detectors in space.

Los Alamos' X-ray instruments are sensors designed to measure the intense burst of X-rays that also accompany a nuclear detonation. Because the X-rays travel at the speed of light in all directions from a nuclear detonation, the GPS navigation system provides information to pinpoint the location of an explosion in space. The sensor also measures the intensity of the X-rays and can be used to estimate the yield of the device that was detonated.

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FORTÉ:
PLASTIC FANTASTIC TESTS NEW TECHNOLOGIES

A radically different satellite jettisoned into orbit Aug. 29, 1997. The plastic fantastic — the first all-composite launch vehicle and satellite — rocketed into space to test improved ways of identifying clandestine nuclear tests and to teach scientists more about lightning and the top layer of the atmosphere that propagates, disperses and distorts radio waves called the ionosphere.

FORTÉ, Fast On-orbit Recording of Transient Events, is a lightweight satellite built for the Department of Energy to test new technologies to monitor international treaty compliance. The satellite's graphite-reinforced epoxy structure weighs only 90 pounds and was snapped together like a model airplane kit.

The satellite was launched by a Pegasus launch vehicle shortly after taking off mounted to the underside of an L-1011 aircraft from Vandenberg Air Force Base, Calif. This new satellite assembly method was two-thirds faster and 60 percent less expensive than conventional methods.

One of the instruments is a broad-bandwidth radio receiver that receives signals via a 35-foot-long antenna. The antenna, coiled up inside the satellite, occupied no more room than a small office trash can and expanded into space like a child's Slinky™ toy.

The second instrument was designed by Sandia National Laboratories to locate lightning flashes and pinpoint global lightning distribution. These data may help explain the atmospheric breakdown mechanisms that lead to lightning discharges.

Los Alamos researcher Steve Knox inspects the final FORTÉ assembly before launch.

The third major instrument is an event classifier, a set of adaptive processors that distinguish between lightning and man-made electromagnetic signals, such as a nuclear detonation. The event classifier will be a key instrument on future treaty verification satellites.

The technology on FORTÉ is the first step toward an independently existing radio-frequency monitoring system that performs reliably in the electromagnetically noisy environment of near-Earth space. A Los Alamos operations center and a ground station at Sandia in Albuquerque control the satellite and receive data.

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ASTROPHYSICS, SPACE PHYSICS AND PLANETARY SCIENCE STUDIES

ULYSSES: VOYAGE OVER THE SOLAR POLES

Launched by the space shuttle Discovery in October 1990, the Ulysses satellite flew by Jupiter in 1992 where the giant planet's immense gravitational pull served as a sling shot to propel Ulysses out of the ecliptic plane — the plane in which the planets orbit. The satellite then traced an arc back over the south pole of the sun in 1994 and over the solar north pole in 1995.

At the time of its polar passages, the spacecraft was more than twice as far from the sun as the average distance from the sun to Earth. Although Ulysses is the first spacecraft to probe the sun's polar regions, it does not travel near the sun. The spacecraft, like the legendary Greek adventurer for whom it is named, is exploring regions over the sun's poles never before visited.

The Ulysses mission is designed to study three major topics: the sun, the solar wind and interstellar space. Ulysses' five European and four American instruments are studying those phenomena at nearly all solar latitudes, but the most important work will be done at high solar latitudes near the sun's north and south poles.

Ulysses is a joint project of the European Space Agency and NASA's Jet Propulsion Laboratory. Los Alamos researchers developed the Solar Wind Observations Over the Poles of the Sun experiment to study protons, electrons and heavy ions in the solar wind and their dependence on distance from the sun and heliospheric latitude.

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The Los Alamos team of scientists reported in 1994 that near the south pole the solar wind is flowing away from the sun at nearly twice the speed that is typically observed near the sun's equator; the wind continuously is arriving at Earth.

The solar wind flow also is much smoother than at low latitudes, causing a marked reduction in the variability of "space weather" that typically exists near the sun's equator and affects Earth by causing magnetic storms and the beautiful aurora borealis, or northern lights, as well as its southern counterpart, the aurora australis.

Scientists expect to take advantage of the simplicity of the solar wind flow in the polar regions to better understand the physical conditions under which the solar wind originates. Such knowledge should also clarify the high-speed emission of gas from other stars, known as the stellar winds, which are thought to be prevalent throughout the universe.

Scientists had expected to see the magnetic fields embedded in the solar wind increase in strength as Ulysses traveled toward the pole, but there were more surprises awaiting them.

The solar wind fields bear the imprint of magnetic fields originating on the sun, which increase in strength toward the poles, just like the magnetic field of Earth. But Ulysses' observations have not revealed the expected increase from the equator to the poles in interplanetary space.

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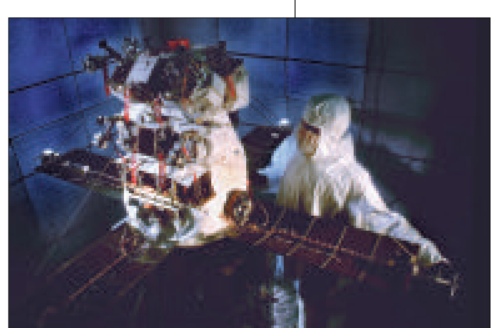
ALEXIS: THE LITTLE SATELLITE THAT COULD

ALEXIS, which stands for Array of Low Energy X-ray Imaging Sensors, is a small research satellite designed and built by a laboratory-industry team led by Los Alamos and sponsored by the U.S. Department of Energy.



In a clean room, Los Alamos technician Greg Obbink assembles part of the Alexis satellite prior to its April 1993 launch. The footlocker-sized satellite carries six X-ray telescopes.

The $17-million satellite was launched April 25, 1993, by a U.S. Air Force Pegasus booster rocket from Edwards Air Force Base in California. Due to the vibrations that ALEXIS encountered

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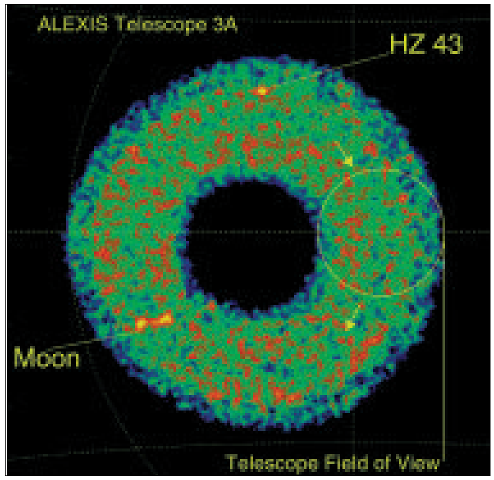
during the launch phase, one of its four solar panels and its magnetometer were damaged, leaving the satellite with a misaligned spin and unable to communicate for six weeks.

But a dedicated ground team continued to listen 24 hours a day for signs of life from the ailing satellite. Finally, their patience and dedication were rewarded by a brief radio contact. The team slowly nursed the crippled spacecraft back to life. After five years, the satellite continues to operate at nearly full potential.



This composite image is a sky-view returned by one of the six soft-X-ray telescopes on the ALEXIS satellite. The image combines eight hours of data from April 25-27,1994. The moon, which reflects X-rays from the sun, is seen as a yellow streak because of its motion during the three days (lower left). The star HZ 43 is the yellow object at the top.

The footlocker-sized satellite carries six sophisticated X-ray telescopes, each about the size of a 2-pound coffee can.

A major objective of the project was to develop the capability at Los Alamos to design, construct, integrate, launch and fly cost-effective and reliable satellites. Besides demonstrating new technologies, the experiments are performing state-of-the-art measurements relevant to astrophysics and ionospheric physics.

ALEXIS is providing a wealth of data in three narrow bands of “soft,” or low-energy X-ray light. The telescopes do not collect visible light but rather count the photons that are released by soft X-ray sources. Some types of stars radiate a lot of these X-rays and ALEXIS is making a map of the sky, identifying where these X-ray sources are located.

The background of low-energy X-rays discovered in earlier studies is thought to emanate from an interstellar gas with a temperature of about one million degrees. Data from ALEXIS will help scientists identify what the hot gas is and how it emits soft X-rays.

ALEXIS’ six telescopes — each with a 30-degree-wide field of view — will scan the entire sky every six months. This long-term monitoring will enable it to search for variations in soft-X-ray emission from sources such as white dwarfs, cataclysmic variable stars and flare stars. The spacecraft also searches nearby space for such exotic objects as isolated neutron stars and gamma-ray bursters.

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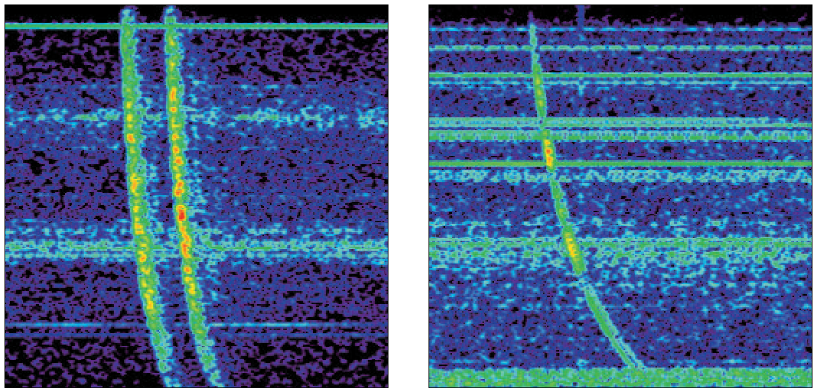

The Blackbeard experiment on ALEXIS was the first instrument to detect Trans-Ionospheric Pulse Pairs. The spectrograph measures radio frequency. TIPPs signals (left) are similar to a pulse generated by the Los Alamos Portable Pulser (right). The LAPP device creates a pulse that resembles one coming from a nuclear weapon detonation and is used to calibrate orbiting satellites that monitor for such pulses.

The Blackbeard radio frequency instrument aboard ALEXIS uses a broadband receiver to detect radio signals from Earth, including bursts of radio energy triggered by lightning. The instrument measures how the ionosphere — an electrically conducting region in the atmosphere — disperses and distorts such signals.

Blackbeard's radio receiver listens to thousands of frequencies simultaneously and takes 150 million measurements each second. It sees signals from standard communications carriers and from small sources of radio noise such as car ignitions and kids' walkie-talkies.

Other satellites have taken many measurements at specific frequencies, but Blackbeard provides a detailed characterization of the background at many frequencies simultaneously.

Among other things, the Blackbeard experiment has observed strange radio bursts called Trans-Ionospheric Pulse Pairs, or TIPPs. These strange signals are the most intense radio sources from Earth, which can be much stronger than typical lightning.

In 1996, Los Alamos researchers reported the first simultaneous Blackbeard observations and multiple ground station measurements of TIPPs. The new evidence suggests that TIPPs come from thunderstorms and probably comprise an atmospheric event and its reflection off Earth. TIPPs were an important discovery because the signals look very similar to a signal from a nuclear weapons test.

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FAST:
WHAT LIGHTS UP THE SKY?

The Fast Auroral Snapshot Explorer is one of three small explorer satellites developed by NASA. Its purpose is to understand the physical processes that give rise to the northern and southern lights.

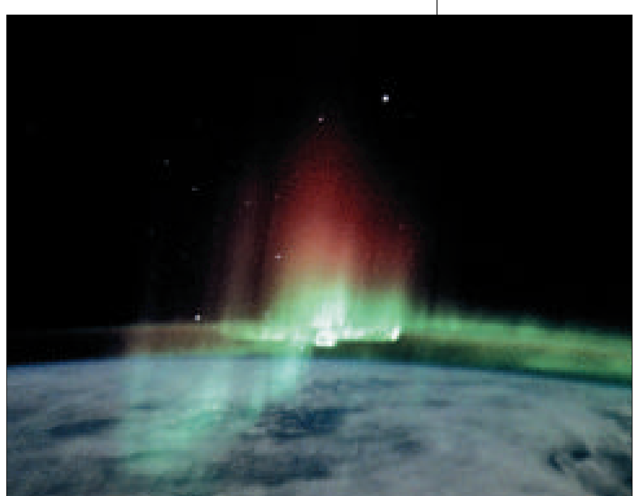
The instruments aboard FAST measure the charged particles and electric and magnetic fields associated with these phenomena. The instruments are more sensitive and capable of better time resolution than instruments on board any previous satellite missions.

The satellite has two magnetometers, one for low-frequency magnetic field measurements, and one for high-frequency observations. The measurements will help scientists study the interaction of the magnetic fields and how they may affect life on Earth by disrupting satellites, radio waves or electrical power grids.

Scientists can directly observe high-frequency radio waves, called auroral kilometric radiation, that make Earth a bright radio source to other planets in the solar system. Scientists also have been able to tie the magnetic field signatures to observations of the current carriers, the electrons.

The electrical currents produce a lot of plasma turbulence, similar to white noise or static. The static is so loud it disrupts the way the electrons flow. This disruption, in turn, threatens to turn off the electric current. However, the current must flow to sustain Earth's magnetosphere, therefore, a large electric field develops that can keep the electrons flowing in spite of the static.

This electric field produces electrical potentials far greater than the 120 volts used by household appliances. Scientists have observed up to 10,000 electron volts of energy.



Auroras are caused by high-energy particles from the solar wind that are trapped in Earth's magnetic field. The delicate colors are caused by energetic electrons colliding with oxygen and nitrogen molecules. FAST will use instrumentation to further scientific understanding of these processes.

NASA

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ISTP

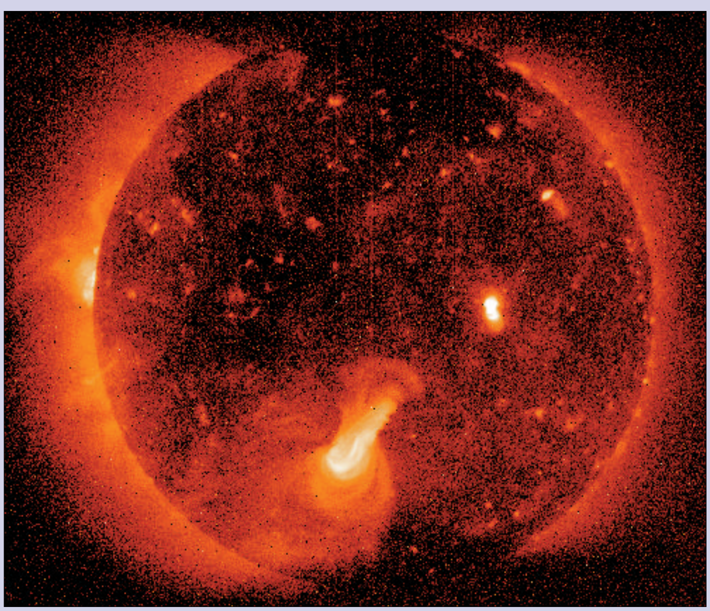
BETWEEN EARTH AND SUN

The International Solar-Terrestrial Physics program is a collaboration of NASA, the European Space Agency, the Russian Space Institute and the Japanese Institute for Space and Astronautical Sciences.

The ISTP program coordinates observation and analysis from more than 10 satellites in Earth orbit including POLAR, WIND, GEOTAIL, SOHO, Interball, IMP-8, FAST, and five or six geosynchronous satellites.

The goal of the program is to simultaneously observe conditions on the sun, in interplanetary space and in critical parts of Earth's magnetosphere to build a comprehensive picture of the influences of the sun on Earth.

A remarkable opportunity for such observations was provided in January 1997 when a large solar eruption, called a coronal mass ejection, exploded from the sun, hurled through space and hit the magnetosphere. The resulting geomagnetic storm, while by no means the most intense event ever observed, was certainly the best-documented space weather event ever.



The January 1997 event as seen by the Yohkoh Soft X-ray Telescope.

Japanese Institute for Space and Astronautical Sciences

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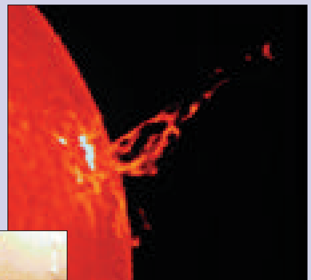


Large coronal mass ejections can cause damage on Earth. A large space storm in March 1989 created intense electrical currents on the ground causing severe internal damage in a transformer in the Hydro-Quebec electric power system in Canada. Nearly six million people in Canada and the United States were without electricity for more than nine hours.

National Solar Observatory

Minnesota Power and Light

The event began Jan. 6, 1997, when the SOHO satellite observed the coronal mass ejection leaving the sun. Four days later, on Jan. 10, the solar wind carrying the eruption passed SOHO and WIND, which were positioned between Earth and the sun. An hour later it reached Earth's magnetosphere and the magnetic coupling between the solar wind and the magnetosphere transferred a tremendous amount of energy into the magnetosphere.

Even traveling at several hundred miles per second, the coronal mass ejection took a day to completely pass by Earth. During that time tremendous auroral displays were observed, not just near the north pole but as far south as Boston and the northern United States.

At the same time electrons in Earth's Van Allen radiation belts increased in intensity by 100 to 1,000 times their previous levels. These electrons are known to affect sensitive electronics on satellites and may have contributed to the failure of a telecommunications satellite that went dead on Jan. 11, temporarily disrupting communications and television broadcasts.

While the radiation belt electrons decreased on Jan. 12, the intensity of electrons at geosynchronous orbit, where many communications satellites operate, began to increase again on Jan. 13 and finally peaked on Jan. 15, at nearly the same intensity as during the magnetic storm.

Using Los Alamos instruments on three geosynchronous satellites, three Global Positioning Satellites and NASA's POLAR satellite, Laboratory scientists recently discovered that this one-two punch only occurred in the outer edges of the radiation belts while closer to Earth the intensity jumped up but remained high for weeks.

Detailed analysis of this event has overturned many ideas about the radiation belts that have remained virtually unchallenged for 20 years.

POLAR

Part of the ISTP program, the POLAR satellite was launched into Earth's orbit in late February 1996. The satellite spends much of its orbit over the northern geographic pole. Three Los Alamos instruments on the satellite are conducting experimental research.

The Comprehensive Energetic Particle and Pitch Angle Distribution experiment aboard the POLAR satellite originated at Los Alamos. The Charge and Mass Magnetospheric Ion Composition Experiment consists of two Los Alamos-designed sensor systems designed to measure the charge and mass composition of Earth's magnetosphere.

Los Alamos researchers recently generated the first-ever images of changes in the radiation belts that surround Earth. The researchers produced images using data from the Imaging Proton Spectrometer, another instrument aboard the POLAR satellite.

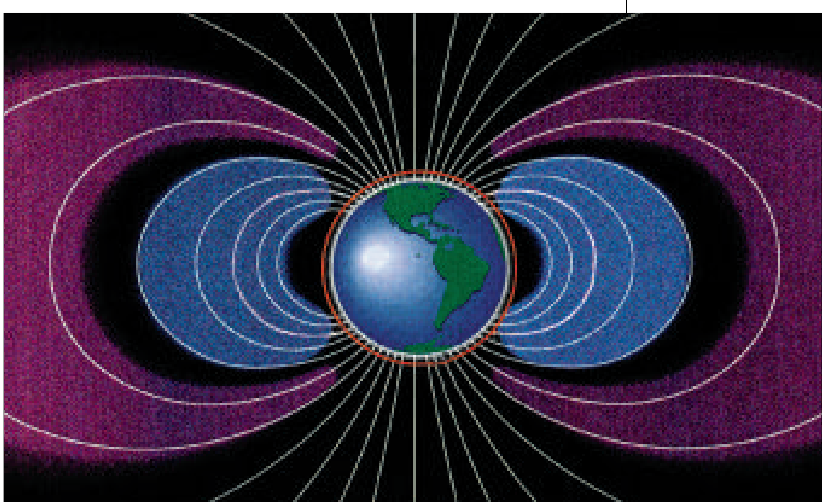
When the images of radiation belts, viewed from above the poles, are combined with measurements from satellites passing through the belts, it gives scientists an important new tool for studying and predicting changes in the space weather out in the magnetosphere. Space weather is important to satellites that orbit in the upper atmosphere where their sensitive electronics are vulnerable to high-energy electron fluctuations.

The POLAR images show a buildup of particles in the radiation belts when Earth is hit by a disturbance in the solar wind — a stream of magnetic fields and electrified subatomic particles pouring in from the sun — and the subsequent migration of those particles to other regions in the belts. The solar wind can potentially affect electronically sensitive satellites and disrupt radio waves.

The radiation belts are created because electrically charged particles are constrained by magnetic fields

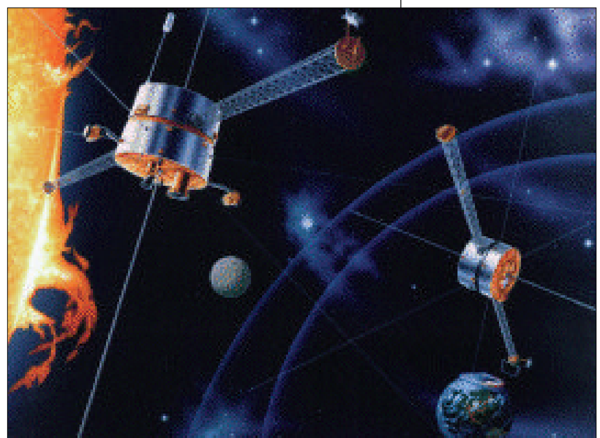
Earth has two radiation belts with different origins. The inner belt (blue) is a byproduct of cosmic radiation and contains high-energy protons that can damage electronic equipment. Spacecraft tend to stay out of this region. The outer belt (purple) contains part of the plasma trapped in the magnetosphere.

NASA



DATELINE: LOS ALAMOS

in the magnetosphere. The particles travel in a repetitious spiral along a field line, cycling from the north pole to the south pole, and over again. The particles cannot be set free of their magnetic trap unless their electric charge is removed. As long as the particles have a charge, their motion is constrained by the magnetic field.



Los Alamos' experiments on the POLAR satellite (right) — CEPPAD, CAMMICE and TIDE — are designed to further scientists' understanding of the solar wind. The WIND satellite is pictured on the left. Together, these two satellites comprise NASA's contribution to the ISTP program.

Uncharged atoms, however, continually float spaceward from Earth's atmosphere crossing magnetic field lines. When they encounter an ionized atom in the radiation belts, they can lose an electron to the ionized atom. Now electrically neutral, the newly formed atom from the radiation belt shoots off into space at high speed, leaving the now charged atmospheric ion trapped in its place.

The energetic neutral atoms spray out from the radiation belts in all directions. When POLAR is above the poles, the background of charged particles is sufficiently small enough that the signature of the neutral atoms can be detected. By using the Imaging Proton Spectrometer to map the direction from which the energetically neutral atoms came, researchers can calculate the structure of the radiation belts.

Most previous measurements of the magnetosphere have been from satellites that take samples only at their location. Neutral atom imaging provides a way to take global measurements of the magnetosphere. The leap in technology is akin to putting a finger in the air to detect wind direction versus using a satellite image to see where a storm is moving.

The third Laboratory experiment on POLAR, the Thermal Ion Dynamics Experiment, was built jointly by Los Alamos, the Southwest Research Institute in San Antonio, and NASA's Marshall Space Flight Center in Huntsville, Ala. TIDE is a highly sensitive instrument that detects trace amounts of low-energy ions.

In the polar regions of Earth's ionosphere, ionized particles flow up away from the poles, then swing away from the sun. TIDE measures trace amounts of these particles, quantifying how much is coming away from Earth. The particles represent mass lost by Earth to space. These systematic measurements will help scientists refine their models of the space environment.

The broad focus of this research is directed toward improved understanding of the mechanisms that couple solar processes into the terrestrial environment.

These include investigations of phenomena associated with short-term environmental effects such as auroras, induced electrical currents and radio-wave communications interference, as well as those associated with longer-term effects such as changes in the ozone layer, atmospheric composition studies, stratospheric winds, weather and climate.

THE MAGNETOSPHERIC PLASMA ANALYZER AND THE SYNCHRONOUS ORBIT PARTICLE ANALYZER

The Magnetospheric Plasma Analyzer and the Synchronous Orbit Particle Analyzer fly aboard the geosynchronous satellites that orbit as part of the ISTP program.

Satellites placed in geostationary orbit appear to remain above fixed points on Earth's geographic equator because the satellites have an orbital speed exactly matched to Earth's rotational speed.

Knowledge of the radiation environment at geostationary orbit is important to spacecraft design, communications and satellite operations. Such knowledge also is important for scientific purposes such as understanding the structure and dynamics of the magnetosphere.

As plasma wind from the sun blows past Earth's magnetic field, the field distorts into a long magnetotail. The MPA instruments flying aboard three Los Alamos satellites are monitoring the leakage of this solar-wind material into and through the magnetosphere. The solar wind can affect the operation of satellites that orbit in the magnetosphere.

These studies have found that, as scientists suspected, the flow of plasma through the magnetosphere is backward. In other words, wind material appears to enter the magnetosphere in the magnetotail and the material is later exhausted from the magnetosphere on the upwind end.

This backward movement is caused by the complex electrical interaction between the solar wind and Earth's magnetic field.

The studies determined that material flows quite rapidly through the magnetosphere. The movement of material between pairs of satellites exceeded 23,000 miles per hour. Solar-wind plasma can reach deep within the magnetosphere to geosynchronous orbit, where most communications satellites reside. This plasma interacts with spacecraft and can cause a number of electronic problems and even complete shut-down of electronically sensitive equipment.

These sensors are primarily environmental monitors for individual spacecraft and their orbits. However, they constitute a series of instruments that can measure particle background. They provide data on particle distributions every 10 seconds. MPAs monitor only electrons. SOPAs monitor electrons and protons as well as ions from helium, carbon, oxygen and nitrogen.

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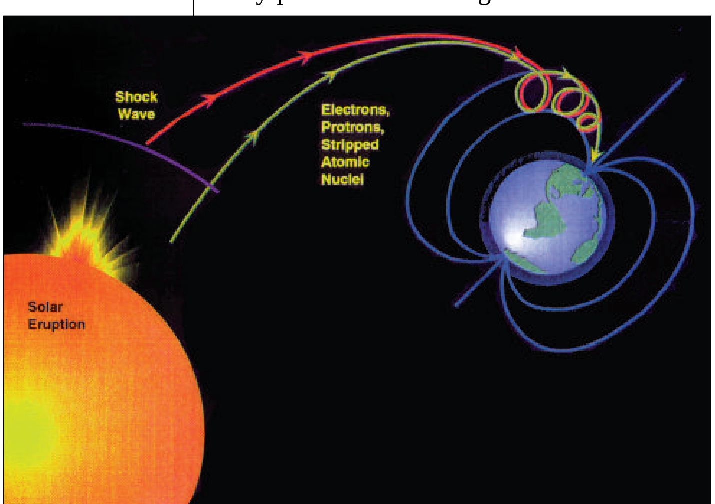
ACE:
SURFING THE SOLAR WIND

Two Los Alamos-designed sensors are on NASA's Advanced Composite Explorer, a satellite that will study various astrophysical processes that may provide some insight into the formation and evolution of the solar system. Launched from Cape Canaveral Aug. 24, 1997, the satellite will orbit one-hundredth the distance from Earth to the sun at a point where the gravitational pull of Earth and the sun are balanced.

ACE will provide scientists with information about the high-speed particles coming from the sun and outside the solar system. ACE will be able to warn

ACE will study accelerated particles arriving from the sun, interstellar and galactic sources and contribute to the understanding of the formation and evolution of the solar system and the astrophysical processes involved. ACE will provide near-real-time solar wind information. When a solar event occurs, the highly energetic particles can become trapped in Earth's magnetosphere and disrupt power grids and communications and may be a hazard to astronauts.

NASA



scientists of potential geomagnetic storms caused by coronal mass ejections that can destroy satellites and disrupt electronic communications and electrical power grids.

Los Alamos' Solar Wind Electron Proton Alpha Monitor provides the context for elemental and isotopic composition measurements for the other experiments on ACE. The data also will provide researchers an opportunity to study solar wind phenomena.

The solar wind is part of the sun's corona that cannot be contained by the star's gravity. It flows away in all directions in a constant stream of particles moving at roughly a million miles an hour. Scientists will measure the solar wind with two ACE instruments that measure in three dimensions the density, energies and directions of travel for electrons and ions.

The detection units are recycled, refurbished and enhanced versions of the solar wind instruments from the Ulysses project.

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Cassini launch

NASA

CASSINI:
INSIGHT INTO SATURN SPACE SCIENCE

The Cassini mission blasted off from Cape Canaveral on Oct. 15, 1997. The mission caused much media attention because it carries 72 pounds of plutonium that will power the space craft during its seven-year, 2.2 billion-mile trip to Saturn, where it will spend another four years orbiting.

The plutonium-powered batteries, called radioisotopic thermal generators, use heat from elemental decay and produce electricity. Los Alamos produced the plutonium heat sources used in the RTGs and has provided heat sources for the Mars Pathfinder, Pioneer, Voyager, Ulysses and other space missions. The totally encapsulated sources are designed and tested at Los Alamos to withstand any conceivable accident.

In addition to the power generators, Los Alamos has two sensors on the satellite. One is a completely new technology, the other is an improvement of a 1970s Los Alamos technology. Together, the sensors will measure the solar wind on their way to Saturn, measure the interaction of the solar wind with Saturn's magnetosphere, search for ion beams within the planet's magnetosphere and sample atmospheric constituents from Titan, Saturn's largest moon.

Los Alamos' ion mass spectrometer, never flown in space before, will measure energy and mass from ions emanating from Saturn's rings and moons. The Los Alamos mass spectrometer, unlike others, provides both high mass resolution and high-sensitivity measurements in three dimensions from a single package.

The ion beam spectrometer is a modern rendition of a design that flew on the first International Sun-Earth Explorer spacecraft in the 1970s. The spectrometer will sample ions of different energies or speeds.

Timing the arrival of ions that reach a detector as the instrument scans the sky provides data that can be decoded to reveal the distribution of the ions, especially intense, narrow beams of particles similar to those that cause the auroras.

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LUNAR PROSPECTOR:
MINING FOR MOON WATER

The Lunar Prospector, which was launched Jan. 6, is designed for low-polar orbit of Earth's moon, including mapping of surface composition and possible polar ice deposits. This mission carries three Los Alamos instruments. The neutron spectrometer is searching for water by detecting hydrogen on the moon's surface.

The question of whether water exists in some polar craters was first raised in the 1970s and hinted at more recently during the 1994 Clementine mission. The neutron spectrometer will give a clear and definite answer to the question of whether water exists in usable quantities. The neutron spectrometer is sensitive enough to detect one cup of water in a cubic yard of soil.

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Since the spacecraft is orbiting 63 miles above the moon's surface, the instrument looks at cool neutrons — neutrons that have bounced off a hydrogen atom somewhere on the lunar surface.

When cosmic rays collide with atoms on the moon's surface, they violently dislodge neutrons and other subatomic particles such as gamma rays. Hot or fast neutrons shoot off into space. Warm neutrons collide with other atoms and bounce around like pinballs.

To create a cool neutron, the subatomic particle must collide with an atom of hydrogen, which has a similar mass. This collision causes the neutron to slow down significantly. If the moon's crust contains a lot of hydrogen at a certain location, any neutron that bounces around in that section of crust will cool off rapidly.

The neutron spectrometer aboard the Lunar Prospector will search for water on the surface of the moon.

NASA/National Space Science Data Center

The neutron spectrometer, if it encounters water, will detect a surge in the number of cool neutrons and a decline of warm ones.

The second Los Alamos instrument on board is the gamma-ray spectrometer. A gamma ray is a very energetic photon originating from either natural sources like thorium and uranium or induced sources emitted by elements like iron, silicon and oxygen that are bombarded by cosmic rays and the solar wind.

The energy of a gamma ray serves as a distinctive signature of the atom it came from. This data will help scientists determine the elemental makeup of the moon.

The third instrument will detect alpha particles. Like a gamma ray, alpha particles also are emitted from radioactive elements as they decay and give an exact fingerprint of the element they came from. While the moon lacks volcanoes, it does appear to vent gases such as radon, nitrogen and carbon dioxide. In addition to more elemental information, the alpha particle spectrometer will search for these outgassing events.

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SPACE PLASMA THEORY PROGRAM:
CATCH A CURRENT BY THE TAIL

The magnetosphere occupies a region of roughly 40,000 to 60,000 miles above Earth's surface on the dayside and extends into a long tail, 400,000 miles long, on the nightside. Scientists are interested in its structure, its charged-particle population and the dynamic processes operating within it.

The magnetotail processes cause the spectacular auroras, perturb the Earth's magnetic field and affect the performance and reliability of space-borne and ground-based technological systems.

Understanding the magnetosphere is important because the underlying processes are characteristic of plasma behavior in many other areas such as laboratory plasma confinement experiments, solar flares and astrophysical phenomena.

The NASA Space Plasma Theory Program at Los Alamos supports theoretical and computational research into the processes that govern the dynamic behavior of the magnetotail, concentrating on the coupling of microscopic processes with large-scale dynamic effects.

The major focus of interest is the magnetospheric substorm. The substorm is a process that involves the rapid release of previously stored magnetotail energy. This magnetic energy is converted into particle energy and disrupts electric currents in the tail and diverts them through the ionosphere.

The consequences are injections of energetic ions and electrons into the inner magnetosphere where many scientific and programmatic satellites reside. Perturbations of Earth's magnetic field also may induce damaging currents in long-distance power grids on Earth.

Los Alamos researchers have investigated the formation and structure of thin current sheets in the tail that appear to be a necessary first step in the tail disruption. Scientists also are studying the tail stability and onset mechanisms of tail disruptions. The research team has developed computer models of the dynamic changes that result from the disruption process.

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FUTURE MISSIONS

SMALLER, BETTER, FASTER, LIGHTER

One of the biggest challenges to our national security is to detect hidden activities. Examples include manufacturing work for nuclear, chemical or biological weapons; pollution of the environment; and development and use of resources.

Recent events surrounding the international inspection team touring Iraq highlight the need for future technologies to detect weapons of mass destruction. While the United States, Russia and other countries search for a diplomatic solution, the risk grows that the weapons inspectors will never be able to do their jobs effectively.

Some weapons experts warn that since the Gulf War, Iraq has been actively designing nuclear weapons and could build an atomic bomb in three to five years that would weigh less than a ton and could be carried by a Scud missile.

It is essential to understand and characterize the nuclear threat. A major research and development effort at Los Alamos involves building new sensors to be flown on satellites into the next century that can image possible weapons plants and detect clandestine nuclear activities. Los Alamos is developing new instruments to detect proliferation of all kinds.

The nation needs timely warning and advanced detection technology that requires the application of leading-edge science and technology across a broad spectrum. Future methods of monitoring and detection in space could help international inspectors identify nuclear weapons capabilities.

Los Alamos is developing sensors for new satellites that will fly after the year 2000 to verify international compliance with the Comprehensive Test Ban Treaty and monitor for nuclear

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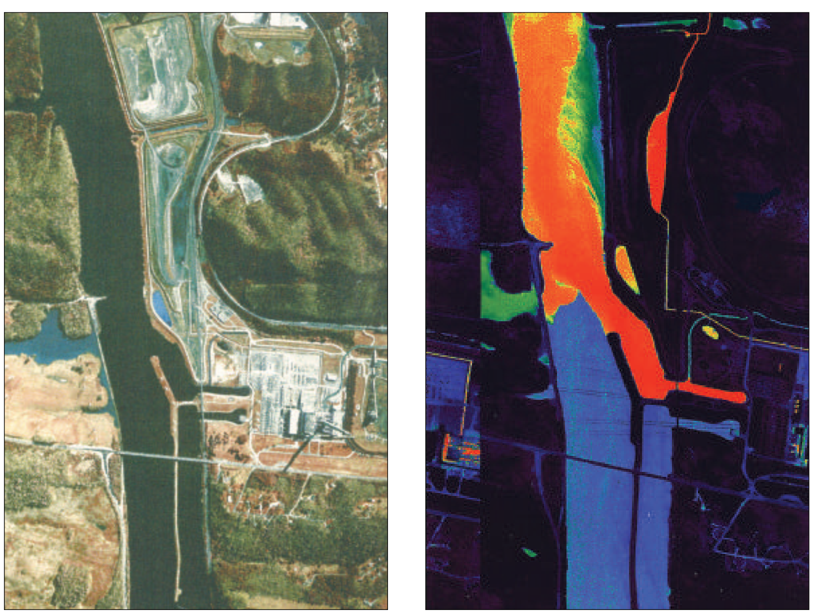
activities worldwide. Future detection systems will provide all-weather, continuous global coverage to monitor for nuclear explosions in the atmosphere or in space. Los Alamos also will support the Department of Defense in interpreting data from these sensors.

In addition to the treaty verification and nonproliferation role, Los Alamos scientists are providing instrumentation to study and sample materials in outer space. As researchers apply their knowledge and expertise on better sensors and systems, these same technologies will provide new opportunities in science.

NONPROLIFERATION DETECTION AND TREATY MONITORING TECHNOLOGIES:

MULTISPECTRAL THERMAL IMAGER

Los Alamos is collaborating with Sandia National Laboratories and the Savannah River Technology Center to develop and fly a Multispectral Thermal Imager (MTI) satellite later this decade. This satellite will demonstrate the ability to measure subtle attributes of objects located



The photograph on the left is an aerial shot of an industrial plant in Tennessee taken with a conventional camera. The image on the right uses an infrared camera that provides colors indicating the temperatures of effluent and exhaust. The images are representative of the differences between conventional satellite imagery and technologies expected with the MTI.

on the ground while correcting for interference from nearby sources and effects of the intervening atmosphere.

An ordinary satellite photograph of an industrial plant does not provide the wealth of information that can be obtained by MTI. For example, a thermal image details hot and cold portions of buildings such as smoke stacks, intakes, valves and exhausts. This information gives scientists additional insights of what type of activity might be occurring in the facility. MTI also can identify materials and effluents.

The atmosphere modifies these signatures by absorbing some of the signals and emitting light that is detected by the satellite instruments. The MTI payload is designed to measure the major variable quantities in the atmosphere, such as water vapor content and cloudiness. This allows scientists to correct for the atmospheric effects and improve the fidelity of the signatures as they exist near the ground.

Los Alamos has developed a science-based computer model to predict the performance of the MTI instrument and help in its design. This model includes all of the major engineering and atmospheric science effects. Los Alamos also is using its state-of-the-art optical and infrared calibration facility to calibrate the MTI instrument. The main objective of MTI is to demonstrate the efficacy of these techniques for a variety of applications in remote sensing.

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SABRS

When a nuclear weapon detonates, it gives off radiation in the form of gamma rays, X-rays and neutrons, uncharged subatomic particles found in the nucleus of atoms, as well as radio-frequency waves and visible light. No naturally occurring phenomenon gives off such a brief “flash” of these types of radiation.

Los Alamos X-ray, gamma-ray and neutron sensors have been flown on Air Force satellites for more than 30 years to monitor nuclear test-ban treaties and to provide critical information in the event of a nuclear war. However, the current fleet of Defense Support Program satellites that carry these radiation sensors is scheduled to discontinue operations

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sometime after 2005. The follow-on satellites, the Space-Based InfraRed System, will not carry these radiation sensors because the project cannot afford to accommodate the complex and expensive radiation sensor payload carried by today's DSP satellites.

Because of this, Los Alamos has undertaken a project to greatly reduce the complexity and cost of the radiation sensor package and provide a more-effective, less-expensive system. The project, the Space and Atmospheric Burst Reporting System, could fly on the SBIRS geosynchronous satellite constellation, which will replace the capabilities lost when the DSP satellites stop operating.

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CXD

The Los Alamos-developed CXD will monitor X-rays and charged particles that emanate from nuclear explosions. This photo is the Ivy Mike nuclear test in 1952, the first detonation of a U.S. thermonuclear device. The test was conducted at Eniwetok Atoll in the Pacific.

The Combined X-ray detector and Dosimeter is the newest instrument to monitor X-rays and charged particles that emanate from an atmospheric nuclear explosion. The CXD will be launched with the next round of Global Positioning System satellites in the next few years.

The improved sensors allow researchers to see deeper into the atmosphere to monitor for both atmospheric and exoatmospheric detonations. Since real estate aboard satellites is becoming expensive, the CXD has accomplished a size reduction: The new device replaces two sensors currently being flown on GPS satellites.

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V-SENSOR

The Comprehensive Test Ban Treaty, which bans all nuclear explosion testing, presents the U.S. monitoring community with an entirely new challenge. The emphasis must move from monitoring primarily known test sites to monitoring the entire world with the added worry of rogue nations taking steps to test, while avoiding detection and attribution.

To detect such potentially evasive testing, the United States and international monitoring systems will require significant technological upgrades.

One such upgraded system will be the V-sensor, or verification sensor, which is the next-generation satellite-borne system for detecting the electromagnetic pulse created by a nuclear explosion in the atmosphere. The operational concept and hardware for this new sensor is currently being tested aboard the FORTÉ satellite.

The availability of new forms of micro-electronic circuitry including space-hardened fast microprocessors and very compact large memory chips makes it possible for detectors like the V-sensor to achieve an entirely new level of performance and reliability. This greatly enhanced capability also will be achieved at reduced cost.

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FUTURE SPACE SCIENCE EXPERIMENTS

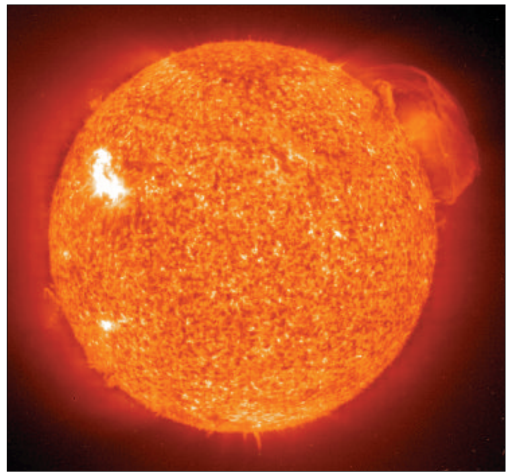
GENESIS

Bringing back a little piece of sunshine is what scientists are aiming for on the Genesis mission.

Los Alamos researchers will provide three key instruments as well as scientific input for the $216 million NASA mission scheduled for launch in 2001. Genesis will spend two years capturing material that blows off the sun and then return to Earth with the solar samples.

Genesis will travel about a million miles in space and orbit about a gravitationally stable point between Earth and the sun. There, it will collect charged atomic particles, or ions, traveling outward from the sun.

These particles form part of the solar wind, which blows at about a million miles an hour and carries occasional energetic disturbances that can create storms of activity in Earth's magnetosphere and knock out electrical systems on satellites.



Researchers are hoping Genesis will bring back a little bit of sunshine.

SOHO-EIT Consortium

Los Alamos will provide a concentrator to create an enhanced sample of oxygen ions, the mission's most important science goal. The Laboratory also will build an ion monitor and an electron monitor to determine what the ambient solar wind conditions are while particle collections are being made.

When the collected materials, which will total only a few millionths of a gram, are back on Earth, scientists can do detailed studies to gain more insight about the composition of the sun.

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MENA

Traditional instruments that analyze the plasma environment of Earth's magnetosphere only sample the plasma in the immediate vicinity of a spacecraft. This has provided an average global picture of the magnetosphere, which is typically highly structured and dynamic.

In collaboration with Southwest Research Institute in San Antonio, Los Alamos is developing the Medium Energy Neutral Atom Imager on NASA's IMAGE mission that promises to provide the next major advancement in the physics of the terrestrial magnetosphere.

Magnetospheric plasma ions that are neutralized by charge exchange when they pass close to atoms of Earth's extended atmosphere form the basis of the MENA Imager measurement technique. The imager acts like a camera by detecting these atoms and determining in what direction

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they were traveling. The subsequent images will reveal the global structure and dynamics of Earth's magnetosphere on a short timescale for the first time.

Results from the MENA Imager will resolve important, fundamental questions about Earth's magnetosphere, including identification of plasma sources and transport, global dynamics and energization processes, and global structures and their compositions.

Using sophisticated analysis of images from multiple viewpoints as the spacecraft moves around its orbit, MENA will facilitate the visualization of three-dimensional plasma structures.

An important aspect of the mission is to view the growth and evolution of geomagnetic storms, which can disrupt communications, satellite operations and power-grid distribution.

Since these storms are triggered by specific conditions of plasma emitted from the solar wind, Los Alamos will use the results from the MENA instrument, in conjunction with the ACE mission that monitors the solar wind, to predict the arrival of these storms and allow adequate preparation for these events.

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TWINS

Early next century, watching the "weather" in Earth's magnetosphere could be as commonplace as watching satellite imagery of cloud fronts marching across the landscape on the local news.

Los Alamos scientists are leading a national team developing a pair of unique instruments, based on MENA technology, that will provide three-dimensional imagery of changing conditions in the magnetosphere. The magnetosphere is a protective envelope generated by Earth's magnetic field that repels most charged particles — ions and electrons — emanating from the sun and traps and circulates those able to penetrate inside this magnetic shield.

A variety of solar eruptions and space disturbances can inject particles and energy into the magnetosphere, creating conditions for storms that can wipe out satellites and even knock out electrical power grids on the ground. When the trapped particles rain down along magnetic field lines and hit the atmosphere they create the glowing, shifting auroras.

The $18 million “TWINS” imagers funded by NASA will ride on two separate satellites to create stereoscopic, three-dimensional movies of the churning activity in Earth’s magnetosphere.

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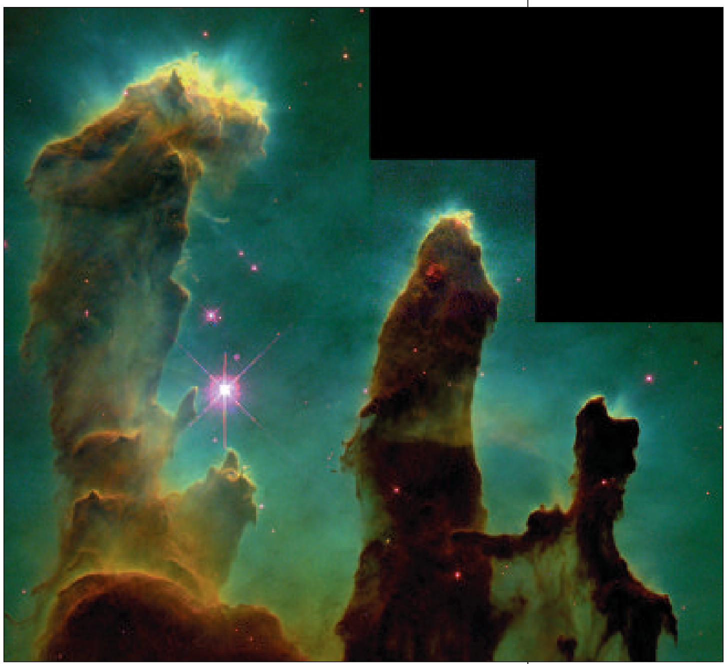
MOXE

The Monitoring X-ray Experiment is an X-ray monitor to be launched on the Russian Spectrum-X-Gamma satellite scheduled to fly in 1999. Spectrum-X-Gamma was originally planned for 1993, but has been delayed because of budgetary constraints on the Russian space science program.

Los Alamos built MOXE jointly with the Goddard Space Flight Center and the Russian Space Research Institute. MOXE will be the first X-ray camera to view almost all the sky almost all the time.

With a purely scientific mission, the instrument’s objective is to study new and variable X-ray stars and to better understand what physical processes are reacting to extreme conditions of matter and gravity.



MOXE will study new and variable X-ray stars. This Hubble Space Telescope image shows columns of cool interstellar hydrogen gas and dust that act as incubators for new stars. They are part of the Eagle Nebula, a nearby star-forming region 7,000 light-years away in the constellation Serpens.

Jeff Hester and Paul Scowen (Arizona State University), and NASA

Bright X-ray stars, in our galaxy and elsewhere, are usually associated with the fall of matter onto neutron stars and black holes.

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MOXE itself is a 250-pound package consisting of six pinhole cameras to detect and locate X-ray sources in the sky, along with a central electronics unit and mass memory.

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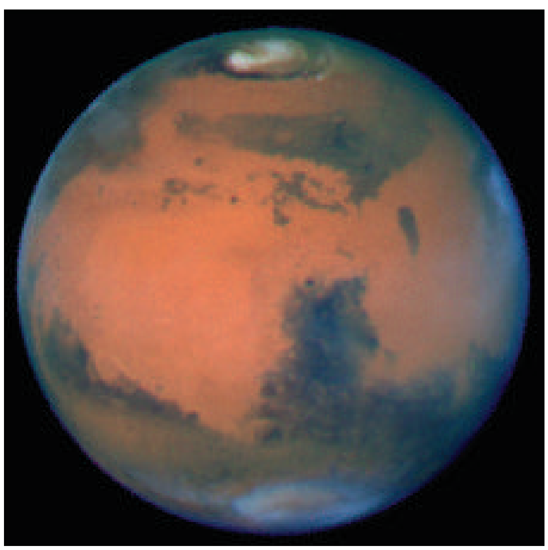
PEPÉ

The Plasma Experiment for Planetary Exploration contains Los Alamos instruments and will be launched in July 1998 on NASA's Deep Space 1. The spacecraft will conduct flybys of an asteroid, a comet and Mars.

The Los Alamos instruments will conduct state-of-the-art plasma measurements in support of the scientific investigation of an asteroid and a comet. These results will validate several new plasma sensor technologies needed for future space physics and planetary missions.



One of the PEPÉ missions will measure cosmic plasma near Mars. This view of Mars was taken by the Hubble Space Telescope on March 10, 1997, just before the red planet made one of its closest passes to Earth, 60 million miles away.

David Crisp and the WFPC2 Science Team (Jet Propulsion Laboratory/California Institute of Technology)

PEPÉ includes a very low-power, low-mass micro-calorimeter to help understand plasma-to-surface interactions and a plasma analyzer to identify the individual molecules and atoms that have eroded off the asteroid and comet.

The total instrument is an 18-inch-tall combination of three instruments that were placed on Cassini, innovations that make PEPÉ smaller, cheaper, faster and better than any other instrument of its kind.

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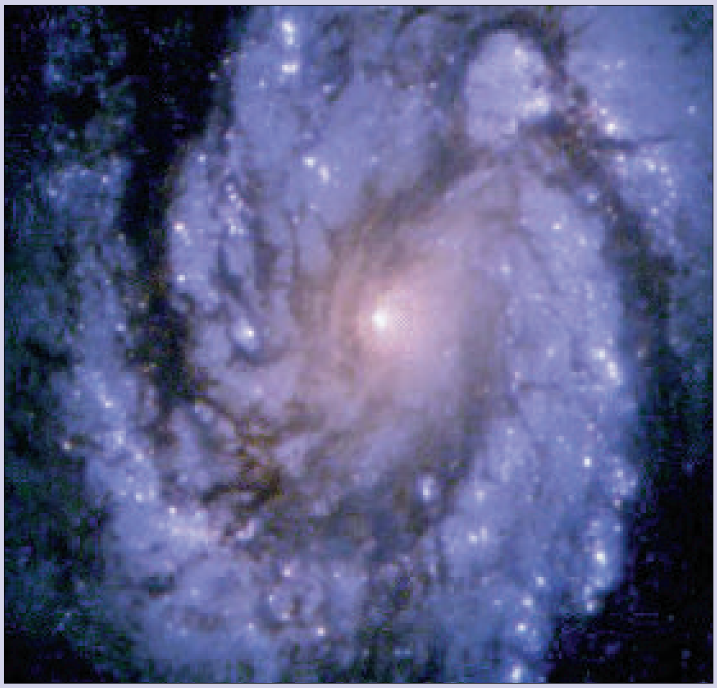
DATELINE: LOS ALAMOS



The future of space research is sure to discover previously unknown space physics and astrophysics phenomena. This galaxy, the M100, was discovered by the Hubble Space Telescope in 1993 and is tens of millions of light years from Earth.

Association of Universities for Research in Astronomy/ Space Telescope Science Institute

EPILOGUE

The next 40 years of Los Alamos in space promise to be at least as exciting as the first 40 years. Increasingly sophisticated instruments and innovative ways of extracting information from the large amounts of data produced by these instruments will help meet the challenge of controlling the proliferation of weapons of mass destruction, to effectively monitor the Comprehensive Test Ban Treaty, and to extend our knowledge of the universe in which we live. The unique ability to combine national security missions with space science and technology will continue to be the hallmark of Los Alamos in space.

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BRIEFLY ...

NIS DIVISION PROVIDES EDUCATION OPPORTUNITIES. Los Alamos National Laboratory's Nonproliferation and International Security Division, which also conducts research in nonproliferation and arms control, and international technologies, recently issued 25 educational scholarships ranging from $800 to $1,000. The scholarship program is funded through royalties received from patents held by employees in the NIS Division. "This is probably the most personally rewarding thing I've done here since coming to the Laboratory about nine years ago," said Terry Hawkins, deputy director of NIS Division. Hawkins came up with the idea for the program as a way to enhance the future workforce of the division. The NIS Student Education Scholarships Program was established with help from specialists in the Laboratory's human resources, business and legal offices. Nominations for the NIS scholarships were made by NIS group managers from among the students who worked in the division last summer. NIS Division employs about 100 high school, undergraduate and graduate students during the summer months.

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