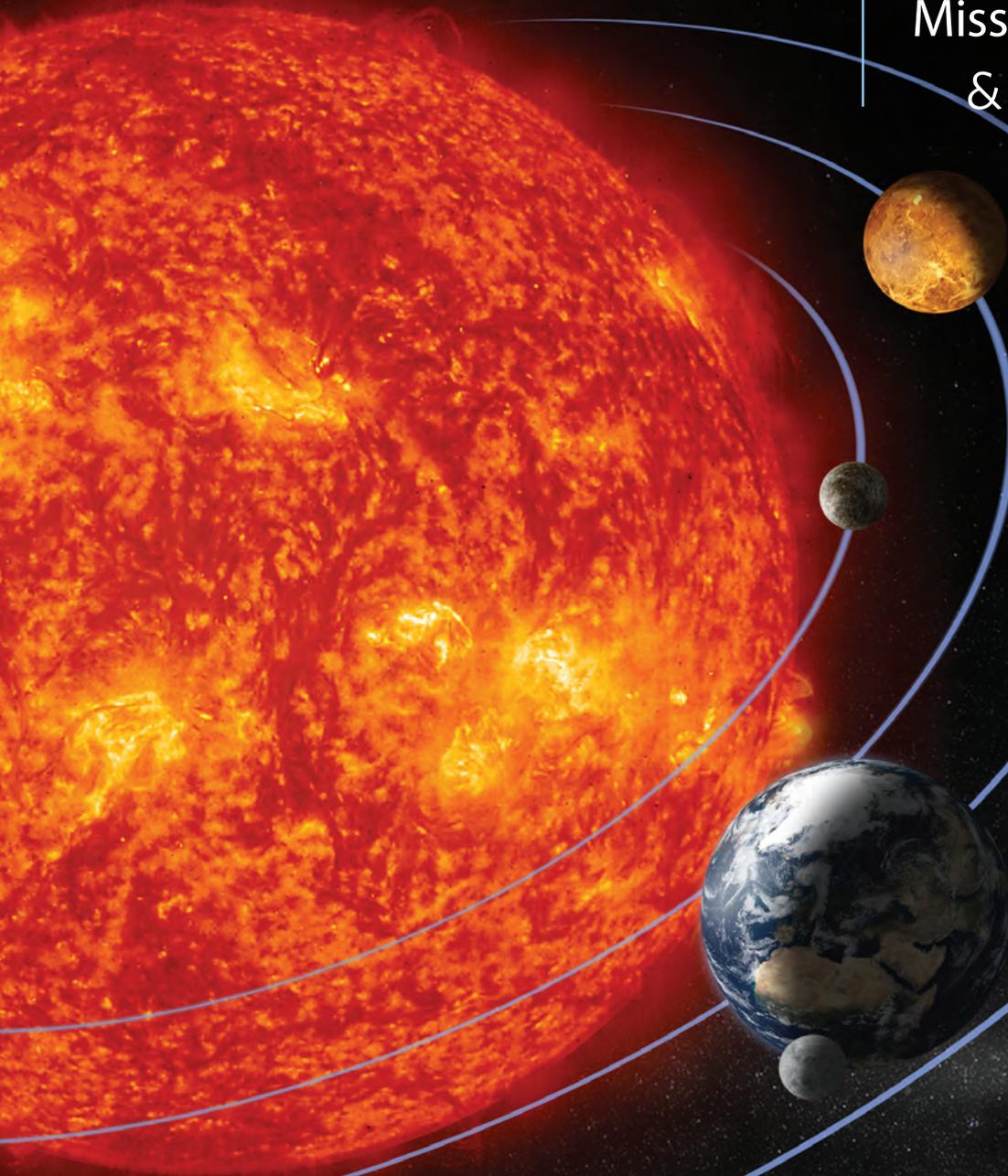




LASP

Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**

Planetary Science
Space Physics
Solar Influences
Atmospheric Science
Engineering
Mission Operations
& Data Systems



A message from the Director



At the Laboratory for Atmospheric and Space Physics (LASP), we bring together space science, space technology, and the education of the next generation of space professionals.

LASP is the world's only space research institute to have sent instruments to all eight planets and Pluto. This is only one aspect of what we do, but it's the kind of success that comes from our commitment to asking and answering the most exciting questions in planetary science, space physics, solar influences, and atmospheric science.

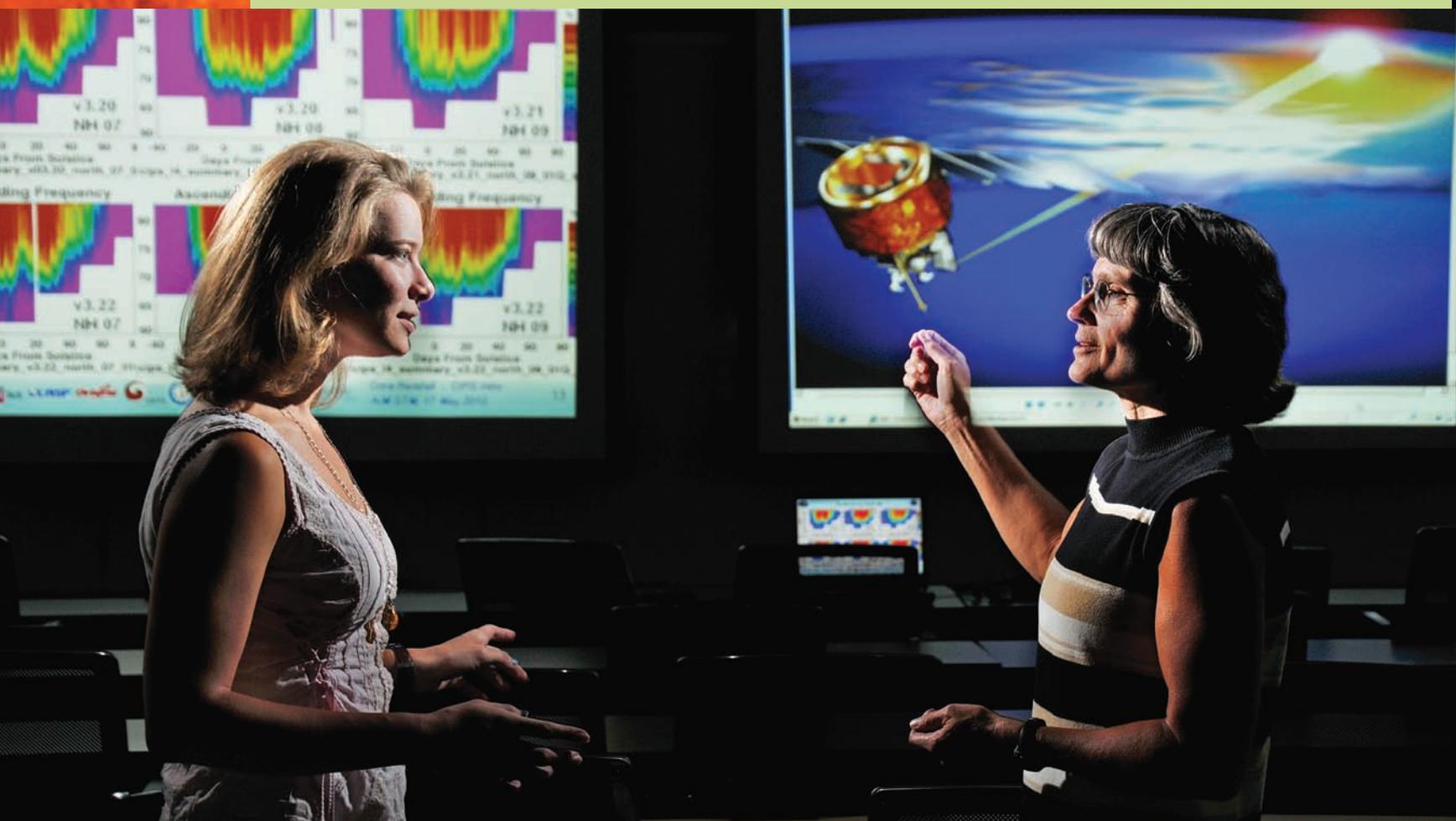
LASP has emerged as one of an elite group of space centers able to meet the increasingly stringent requirements of space exploration in the new millennium. Our ability to blend space science with hardware design, development, implementation, mission operations, and data management is almost one-of-a-kind among university-based space centers. With up to a dozen space science flight programs in development at any given time, the capability to build multiple space instruments simultaneously in our state-of-the-art facilities, and the demonstrated experience to operate as many as eleven space instruments concurrently, LASP is a leader in space exploration.

Add the deep and abiding integration of undergraduate and graduate students into our organization, and we further grow our capacities: we embrace the enthusiasm of our nation's future scientists and engineers, while training them for life after graduation.

A handwritten signature in black ink that reads "Daniel N. Baker". The signature is fluid and cursive, with a long, sweeping underline.

DR. DANIEL N. BAKER
Director

LASP scientist and CU-Boulder professor Cora Randall (*below right*) engages in a lively exchange with a student in our National Science Foundation Research Experiences for Undergraduates program; they are discussing the Aeronomy of Ice in the Mesosphere (AIM) satellite, shown in the background. AIM is a perfect example of LASP's full-cycle capabilities. The mission was conceived to answer scientific questions about noctilucent clouds, including whether climate change could be influencing the clouds' appearance at lower latitudes. Two of the three instruments on AIM, plus the Instrument Pallet Assembly, were built on-site at LASP. LASP Mission Operations & Data Systems has operated the satellite since its launch in 2007 and continues to manage and archive AIM data. The ongoing use of the scientific data brings the mission full circle: AIM is advancing our scientific understanding of why noctilucent clouds form and why they are so varied.



Bringing space science and exploration full circle

The Laboratory for Atmospheric and Space Physics (LASP) is a full-cycle space institute, combining all aspects of space exploration through our expertise in science, engineering, mission operations, data analysis, and education. LASP has been a part of the University of Colorado Boulder (CU-Boulder) since the laboratory's inception as the Upper Air Laboratory in 1948.

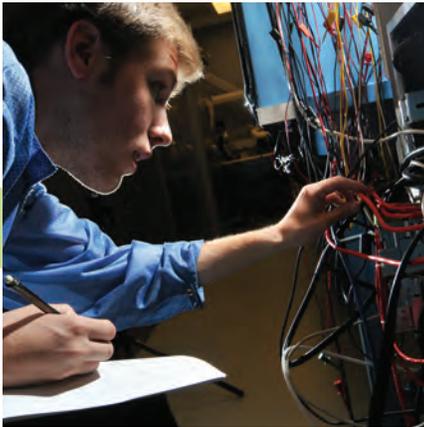
Science drives exploration

LASP scientists develop areas of focus for space and aircraft missions; our researchers define the technology required to collect data and answer scientific questions.



Engineering supports scientific endeavors

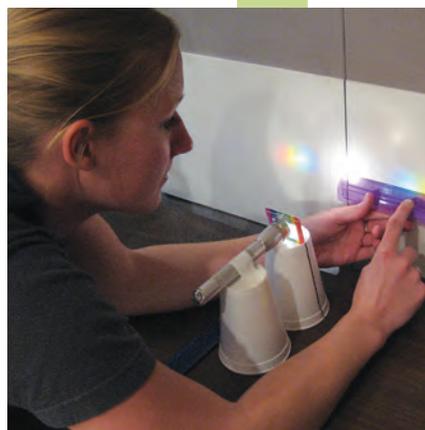
LASP has the in-house engineering capabilities and facilities to support the design and manufacture of space-based and suborbital instruments and small spacecraft.



Students are involved at all levels

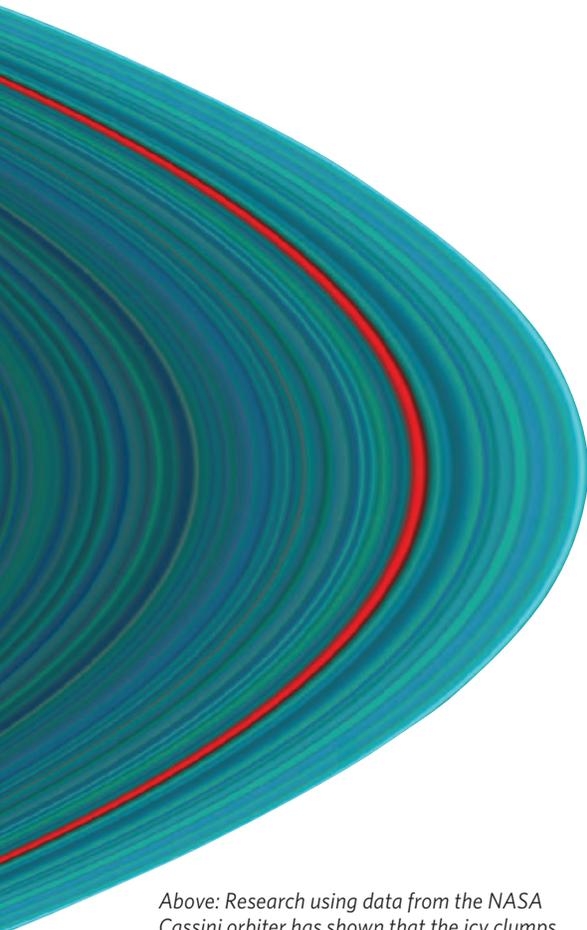
Throughout this process, undergraduate and graduate students are integrated into working teams at LASP. Students take this unique experience with them into government, industry, or academia. They are the next generation of space scientists, engineers, and mission operators—the future experts of space exploration.

(Courtesy LASP)



Mission Operations & Data Systems

After launch, LASP manages day-to-day mission and science operations for spacecraft and instruments. In addition, LASP mission control is responsible for the delivery of scientific data to scientists and the public, continuing the cycle of space exploration.



Discovering new frontiers in planetary science

Researchers in the Planetary Science group at LASP study space objects ranging in size from small meteoroids to gas giant planets; LASP has provided instruments for numerous NASA missions and has studied every planet in our solar system. LASP scientists use telescopes and data from spacecraft and space-based instruments to study the characteristics, dynamics, formation, interrelations, and history of planetary objects. The LASP Planetary Science group studies the following areas:

- Planetary surfaces and their evolution
- Atmospheres and exospheres
- Magnetospheres
- Planetary rings
- Dusty plasmas
- The solar system
- Comets
- Astrobiology and the search for life in the universe

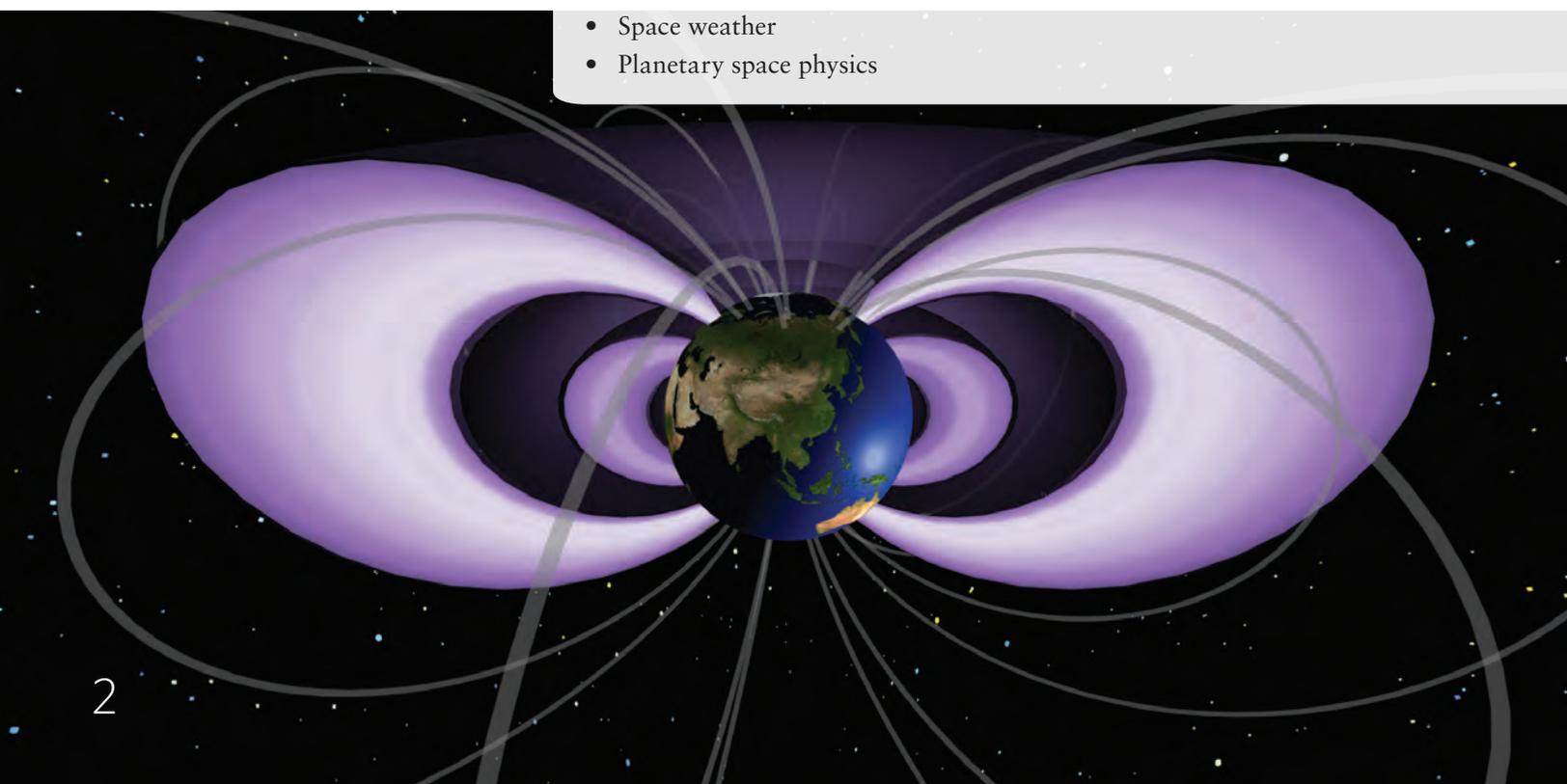
Understanding plasmas and space weather

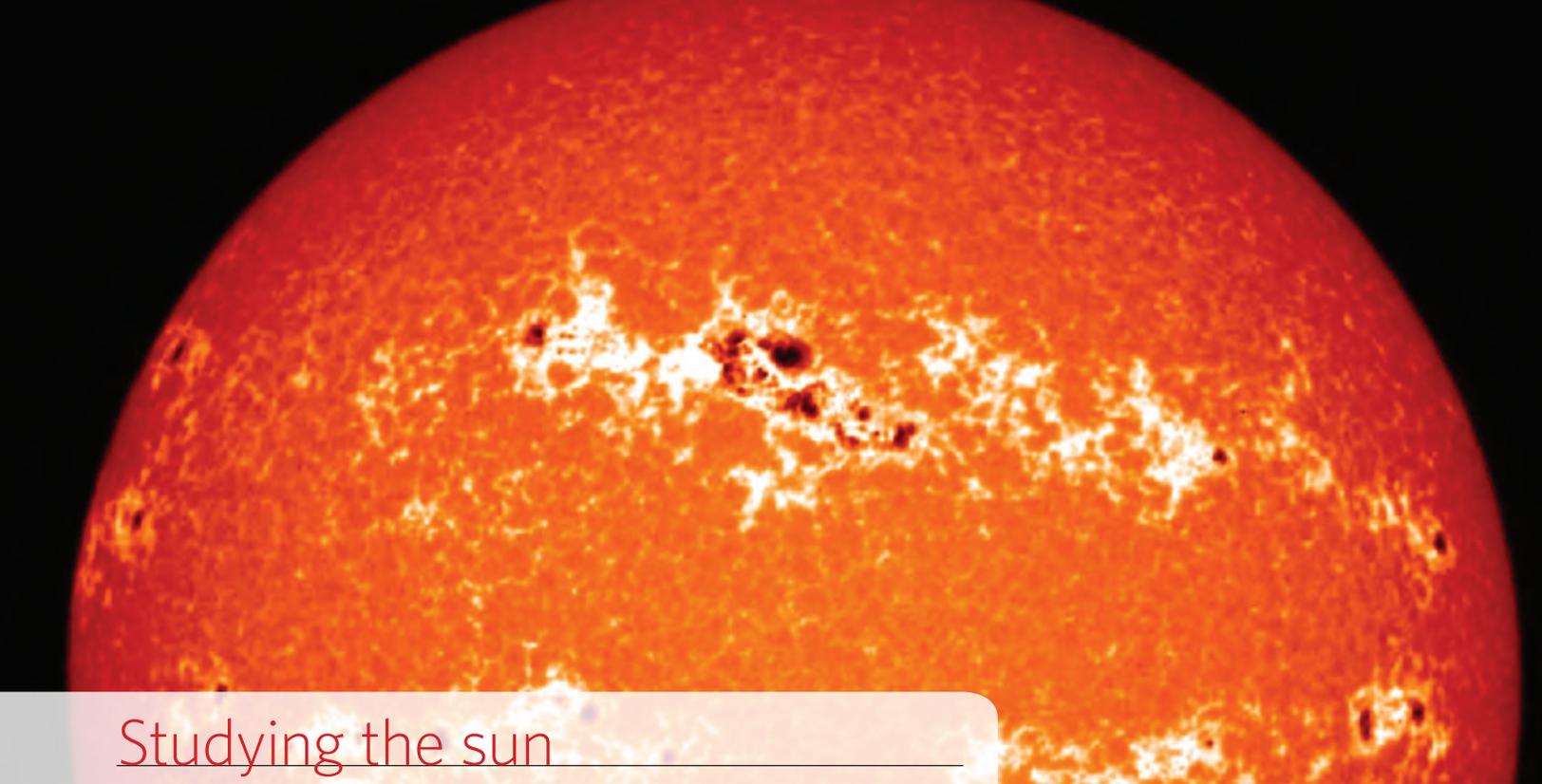
Scientists in the Space Physics group at LASP seek to understand the fundamental processes of the fourth and least understood state of matter: plasma. Plasmas, partially ionized gasses that fill much of the known cosmos, impact technology in space and on Earth. Plasma interactions guide the behavior of matter within our solar-terrestrial system; improving our understanding of plasma helps us explore the underlying physics occurring in various situations on Earth. The researchers associated with the Space Physics group at LASP investigate several areas:

- Space plasmas
- Earth's magnetosphere
- Earth's electrical fields, waves, and currents
- Aurora
- Space weather
- Planetary space physics

Above: Research using data from the NASA Cassini orbiter has shown that the icy clumps in Saturn's outermost F-ring continually collide and disperse. LASP guided the underlying science and engineering for the LASP-built Cassini Ultra-Violet Imaging Spectrograph. (Courtesy NASA/JPL)

Below: Scientists continue to advance the study of physics in space. This image shows how Earth's radiation belts, in purple, tremble under the impact of a solar storm in fall 2003. Translucent gray arcs represent Earth's magnetic field. (Courtesy NASA/Goddard Space Flight Center Scientific Visualization Studio)





Studying the sun

LASP scientists in the Solar Influences group measure the sun's irradiance over an ever-widening wavelength range, from soft X-rays through the near infrared, and strive to understand the sun's effects on the Earth's atmosphere. Using various space-based, suborbital, and ground-based instruments, researchers measure irradiance with a high degree of precision. The group's focus is to improve our understanding of solar variability and its influence on the terrestrial environment and climate, as well as the impact of solar storms for a variety of space weather applications. Scientists and students also model solar irradiance variations, convection in the solar atmosphere, and flare processes.

We have established a long-term solar record since the 1980s; advanced scientific understanding of solar variations throughout the spectrum; improved our understanding of solar variation on time scales ranging from minutes to years; and developed the technology for improved accuracy of irradiance measurements.

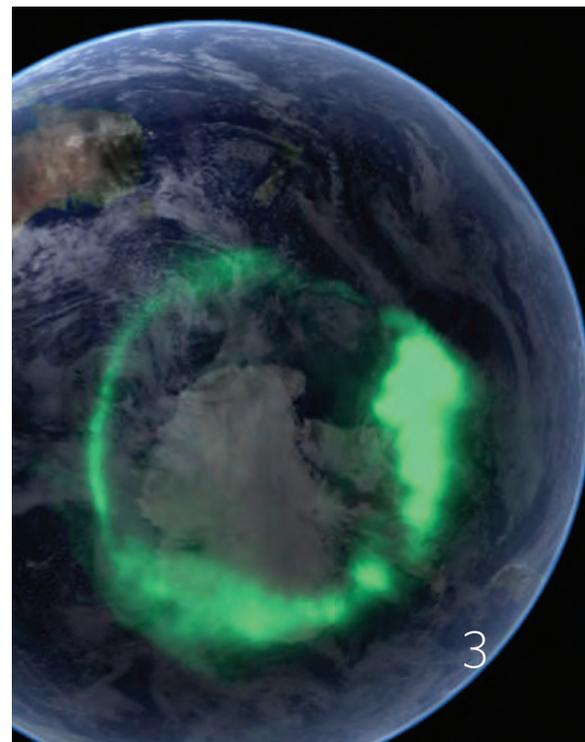
Examining Earth's atmosphere

Scientists in the LASP Atmospheric Science group study the composition, chemistry, dynamics, and radiative budget of the Earth's atmosphere, from the troposphere to the thermosphere. The group uses a wide variety of observations, including measurements from space-based instrumentation, rocket experiments, and aircraft field campaigns. Scientists analyze this data in conjunction with a number of different types of models, such as microphysical models, general circulation models, and coupled chemistry climate models, to investigate the Earth's weather and climate. Specific areas of interest include:

- Clouds and aerosols
- Boundary layer chemistry
- Stratospheric ozone depletion
- Impacts of energetic particle precipitation and solar irradiance
- Dynamical coupling of different atmospheric regions
- Noctilucent clouds

Above: LASP solar irradiance measurements from several NASA missions, along with solar images such as this one from the NSF Precision Solar Photometric Telescope (PSPT), are used to improve our understanding of solar variations that shape Earth's climate and atmosphere. Solar variations are primarily caused by magnetic activity on the sun, shown as dark sunspots and bright faculae in this solar image. This false-color image of solar Calcium-K emissions highlights the sunspots as red-black regions and the faculae as white regions. (Courtesy NASA/GSFC Scientific Visualization Studio; source data courtesy of HAO and LASP PSPT project team).

Below: From space, the aurora appears as a ring of light encircling Earth's poles. This view of the Southern Lights, showing as green ultraviolet light, shows the aurora four days after a record-setting 2005 solar flare sent ionized gas flying towards Earth. (Courtesy NASA from IMAGE satellite)





Engineering for exploration

Above: LASP Engineering uses its cutting-edge mix of on-site facilities, skilled personnel, and close collaboration with scientists to build, test, and calibrate spacecraft, instruments, and components.

LASP's Engineering Division has demonstrated capabilities at both the instrument and mission levels, including expertise in the design of small spacecraft and flight instruments. LASP's engineers are proficient in the following areas:

- Project management and systems engineering
- Structure and mechanism design
- Stress and thermal analysis
- Space instrument optical designs and detector development for x-ray to infrared wavelengths
- Space electronics including microprocessors, FPGA, and ASIC acquisition
- Parts engineering and procurement expertise
- Extensive flight fabrication capability with certified assembly staff
- Flight software development
- Vacuum and thermal environmental testing facilities
- Verification and validation capability with NIST-traceable calibration standards
- Rigorous quality and safety assurance techniques
- ISO 9001 compliance

LASP's extensive test and calibration facilities include a fully equipped machine shop and metrology laboratory for mechanical fabrication; a NASA-qualified electrical assembly and polymeric lab for electronics and cable fabrication; multiple calibration labs for instrument characterization from the extreme ultraviolet to the infrared; several vacuum tanks for bake-out, thermal vacuum tests, and detector and instrument calibration; and various quality assurance inspection and cleaning laboratories, including four class-10,000 clean rooms for final instrument assembly. These facilities allow LASP engineers to develop and test spacecraft and instruments on-site, often with mission operations staff in "test-like-you-fly" scenarios. The full-cycle capability of LASP, combined with more than six decades of space research, has created a legacy of in-house knowledge. This experience, along with a focus on extensive testing before flight, is a key factor in LASP's superior on-orbit performance record.

Supporting space missions

The LASP Mission Operations & Data Systems (MO&DS) group is responsible for spacecraft and instrument operations. Our engineers also develop the computer, communications, and software systems necessary to operate spacecraft and process scientific data.

MO&DS staffs several Mission Operations Centers and Science Operations Centers for the day-to-day operations of NASA spacecraft and instrument missions. LASP is one of only a few university-based mission operations centers. We train and certify undergraduates to perform mission operations in concert with professional staff. Our mission operators are responsible for NASA satellites totaling more than \$1.5 billion in value.

Spacecraft and instruments run using specialized operational software, tailored to specific missions and instruments. Operational software ensures that temperature, energy levels, and other parameters on the spacecraft or instrument are running in an acceptable range. The software monitors the health of on-board systems; anything unusual is flagged and sent to mission operators who can look into potential causes and solutions.

Software engineers and data analysts in LASP Data Systems serve at the interface between software and science, focusing on the development of data systems that generate, display, and perform quality-control corrections on scientific data. Scientists around the world then use these high-quality data products to further scientific understanding of atmospheric and space science.

With our inclusive capabilities, from operations to data distribution, the MO&DS group both serves and supports LASP's scientific needs, helping make LASP a full-cycle space institute.

Below: Students participate in all facets of LASP operations, from pursuing scientific research to constructing real-life satellite instruments to supporting our education and public outreach program; here, students operate spacecraft.





Above: LASP supports education and public outreach to all age groups. Here, LASP atmospheric scientist Lars Kalnajs explains scientific weather balloons to a group of Colorado middle school students. (Courtesy Jenn Glaser)

Below: LASP informatics staff push the technological envelope in support of science operations as a matter of course; our operations represent the best in both technology and personnel know-how.

Supporting science with infrastructure

LASP receives extensive federal funding, and our administrative staff is key to managing complex programs and supporting the laboratory's scientific goals. Administrative, accounting, purchasing, and facilities personnel provide the infrastructure necessary to attract NASA and other government contracts.

Government agencies also value our emphasis on extending the reach of space science missions through education and public outreach. LASP provides educational development for kindergarten through high school, as well as opportunities for undergraduate and graduate students. LASP offers public tours, lectures, and events, and also provides professional development workshops for teachers and media who seek to learn more about space science.

Sustaining science through technology

LASP informatics experts work at the boundary between science and scientific data. Each day, more than 100 gigabytes of data come through LASP servers to support ongoing space missions, as well as the scientific data that scientists from all over the world rely on. LASP experts ensure fast and accurate data transfer, management, and archiving, as well as the development of software tools that support scientific data users.





Training the next generation in space exploration

CU-Boulder students gain knowledge and experience at LASP, making them attractive candidates for professional positions after graduation and helping them contribute in their fields throughout their careers. Professionals provide mentorship for student-based space missions awarded to CU by organizations such as NASA, the National Science Foundation, and the Universities Space Research Association. Undergraduate and graduate students work closely with LASP engineers, scientists, and experts in all aspects of our organization:

- Framing scientific questions and using data and models to develop answers
- Building actual space science instrumentation and hardware
- Planning spacecraft observation sequences
- Monitoring spacecraft performance
- Operating instruments and spacecraft
- Creating software tools for data analysis

Above: Professional staff and students work together in the LASP Mission Operations Center, where they send commands to multiple spacecraft and instruments.

Connecting academics, agencies, and industry

LASP employs scientific researchers, professional research support staff, and extensive numbers of students to implement our programs. Many of our scientists make teaching at CU-Boulder a priority; the laboratory shares faculty with five academic departments:

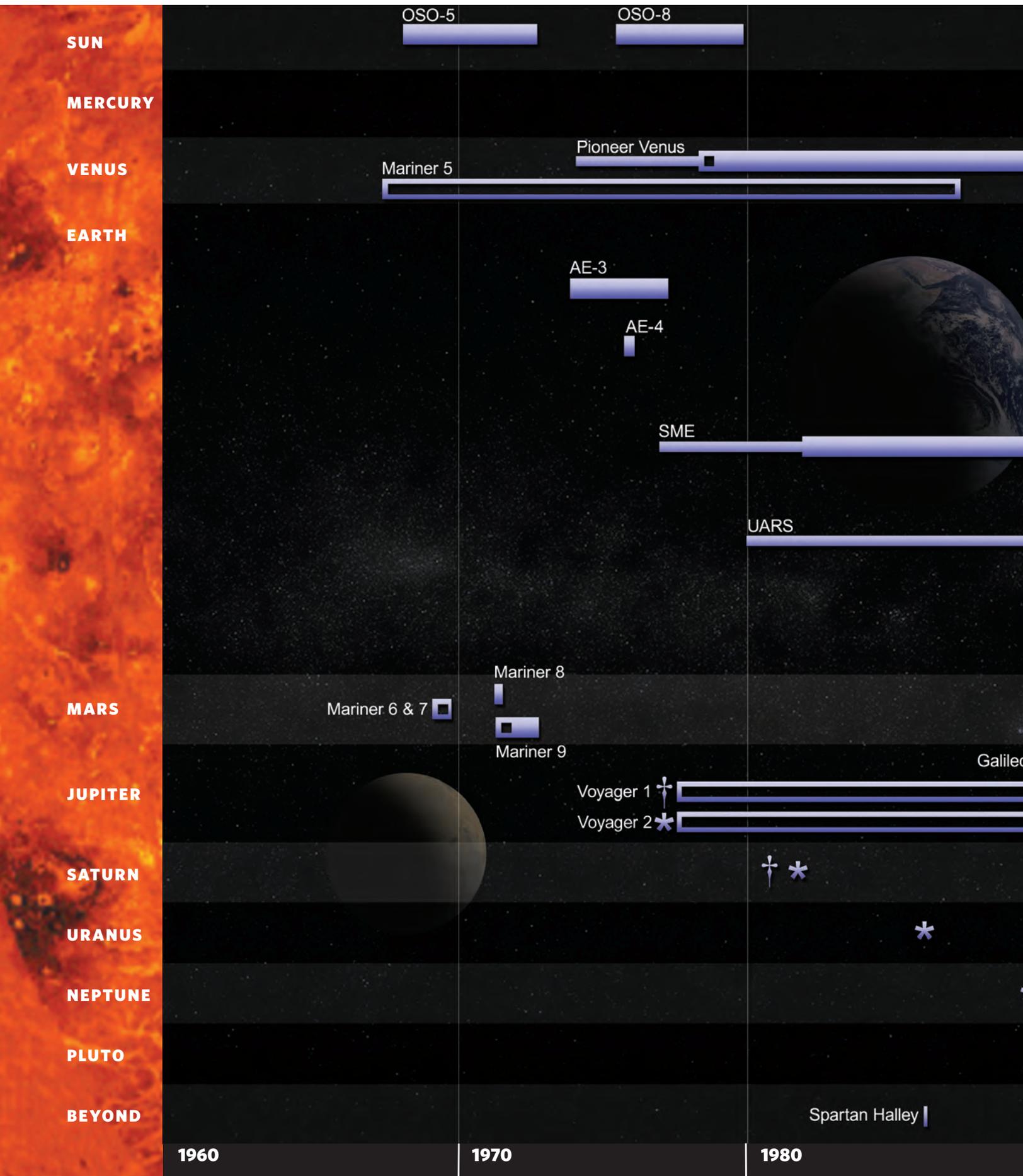
- Astrophysical and Planetary Sciences
- Atmospheric and Oceanic Sciences
- Geological Sciences
- Aerospace Engineering Sciences
- Physics

LASP earns considerable competitive research funding through the government's top science agencies, including NASA, NOAA, and NSF. LASP also has a long history of successful collaborations with space industry leaders, both at home in Colorado and all over the world.

LASP is a hub connecting CU-Boulder, government agencies, and the space science industry. LASP's proven success, appealing location, and neighboring science institutions allow us to attract leading researchers, develop full-cycle space science missions, and provide unequalled learning opportunities for the scientists and engineers of the future.

Exploring our solar system and beyond

LASP has sent instruments on key space missions to all eight planets and Pluto. Our involvement has ranged from scientific oversight to instrument design and development to spacecraft operations. For some missions, our role has included all of these areas, with student participation key to our success.



Our vision

LASP's vision is to achieve and maintain world-leadership status in identifying and addressing the key questions in planetary science, space physics, solar influences, and atmospheric science.

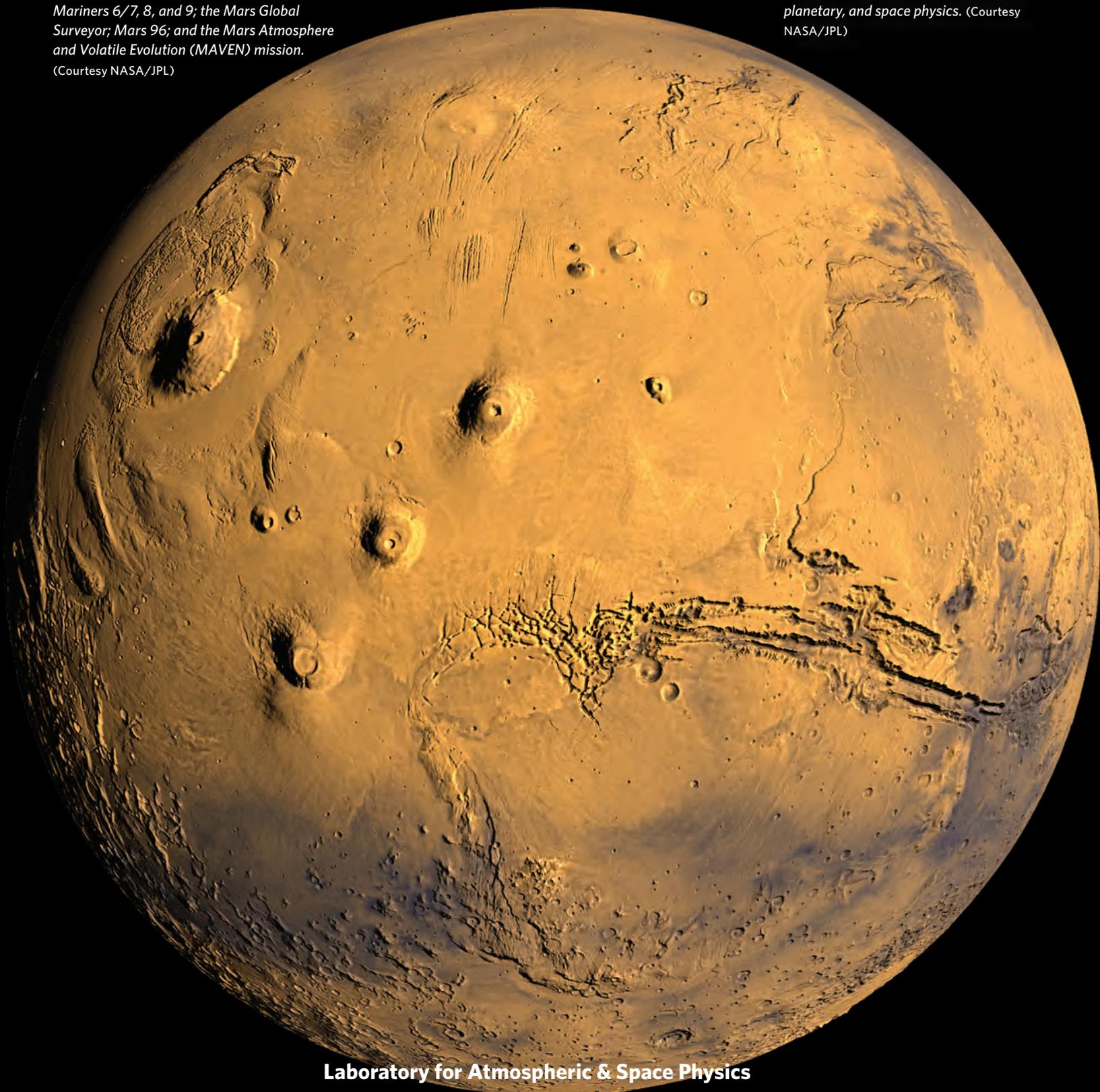
We seek to continuously maintain and improve our capability to pursue these questions using experimental, laboratory, theoretical, and information systems approaches. We are dedicated to building and maintaining a unique synergism of expertise in space science, engineering, and spacecraft operations. Through our projects, we participate actively in the training of the future leaders of space research and we help the University of Colorado to educate students with valued technical and scientific skills. The progressive development and use of innovative technologies and continuing participation in new research initiatives will help ensure a strong leadership role for LASP into the 21st century.

Below: The LASP Space Technology Research Center offers the cutting-edge laboratory space and clean room facilities needed to excel at space science and exploration in the 21st century.



Inside back cover: LASP has been involved with several missions targeting the red planet: Mariners 6/7, 8, and 9; the Mars Global Surveyor; Mars 96; and the Mars Atmosphere and Volatile Evolution (MAVEN) mission. (Courtesy NASA/JPL)

Cover: LASP's scientific focus is the solar system: solar influences, atmospheric, planetary, and space physics. (Courtesy NASA/JPL)



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