NSF Major Multi-User Facilities

DIRECTORATE FOR BIOLOGICAL SCIENCES:

Credit: © 2023 Battelle Memorial Institute. All Rights Reserved. Photo courtesy of NEON operated by Battelle.

National Ecological Observatory Network

The National Ecological Observatory Network, NEON, consists of geographically distributed field and lab infrastructure networked into an integrated platform enabling regional to continental scale ecological research. Cutting-edge sensor networks, instrumentation, observational sampling, natural history archive facilities and remote sensing are linked via the internet to computational, analytical and modeling capabilities to create NEON's integrated infrastructure. NEON is the first research platform, and only national facility, specifically designed to collect consistent and standardized sensor and observational measurements across 81 sites nationwide.

NEON enables research on the impacts of climate and land use change, water use, and invasive species on the Nation's living ecosystems at temporal and spatial scales. No other standalone system — federal or private — can provide the scientifically validated suite of data measurements that NEON is delivering.

The managing organization for NEON is Battelle Memorial Institute, Inc., funded under a cooperative agreement. The current Operations and Maintenance award to Battelle, which began in November 2017, is scheduled to end in October 2023. Following a delay due to COVID-19, the Competition for the Management of Operations and Maintenance of NEON is currently underway with a request for authorization by NSB scheduled for the spring of 2023. Oversight is provided by the BIO Division of Biological Infrastructure.

DIRECTORATE FOR GEOSCIENCES:

Credit: Oregon State University

U.S. Academic Research Fleet

The U.S. Academic Research Fleet, ARF, included 17 vessels in Calendar Year 2022. ARF ships range in size, endurance and capabilities and serve as the main platform for the collection of data, testing of hypotheses about the structure and dynamics of the ocean, and development and testing of novel oceanographic instrumentation. ARF vessels are owned by NSF, academic institutions, or the U.S. Navy. In Calendar Year 2022, NSF divested of R/V *Oceanus*, which is slated for replacement by the first Regional Class Research Vessel (RCRV), R/V *Taani*.

ARF is financially supported through an interagency partnership, principally with the Office of Naval Research, ONR and the National Oceanic and Atmospheric Administration. Oversight is provided to the ARF by the GEO Division of Ocean Sciences through cooperative agreements with each ship-operating institution and through a separate cooperative agreement with University- National Oceanographic Laboratory System, which schedules ship time for research cruises. NSF is the cognizant

agency for ship day-rate negotiations regardless of owner. All cooperative agreements for ship operations were renewed in 2018. Operators for NSF-owned vessels will be competed or renewed every ten years. A proposal from the University of Alaska Fairbanks to operate and maintain the R/V *Sikuliaq* will be reviewed for continued award through 2028.

CY 2022 NSF funding provided support for 2,409 ship operating days, which represents 66% of the total projected operating year of 3,650 days. This is a significant increase over the previous three years, marking recovery from the COVID-19 pandemic, while also confronting global challenges of fuel cost increases, supply chain delays and mariner shortages.

In CY 2021, ARF was able to safely accomplish 3,059 operational days which included both newly funded work as well as deferred cruises from CY 2020 The overhaul of the deep-submergence vehicle Alvin, including an upgrade to 6,500-meter depth capability, was accomplished, with testing off the Puerto Rico Trench.

Credit: Architectural design by Glosten Associates Inc.

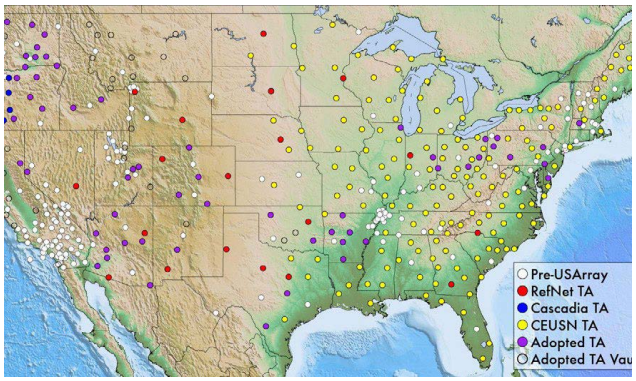
Regional Class Research Vessel

Major Research Equipment and Facilities Construction Account project

The Regional Class Research Vessel, RCRV, project is a major component in the plan for rightsizing and modernizing the U.S. Academic Research Fleet and will provide vessels essential for U.S. coastal ocean research. RCRV is a Major Research Equipment and Facilities Construction Account, MREFC, project.

The RCRV project is funded through a cooperative agreement with Oregon State University to manage the design, construction and commissioning of three RCRVs and the operation of the first RCRV —R/V *Taani*; "taani," pronounced "tawney," is a word in the Siletz tribal language meaning "offshore." The East Coast Oceanographic Consortium, led by the University of Rhode Island, was selected for operation of the second RCRV, R/V Narragansett Dawn. NSF selected the Gulf-Caribbean Oceanographic Consortium — whose members include the University of Southern Mississippi, the Louisiana University Marine Consortium and 15 associate members — as operator for the third RCRV, R/V Gilbert R. Mason.

Oregon State has contracted with Bollinger Houma Shipyards in Houma, Louisiana, for construction of all RCRVs (Bollinger acquired the shipyard from Gulf Island Shipyards). Oversight is provided by the GEO Division of Ocean Sciences.



Credit: Architectural design by Glosten Associates Inc.

Geodetic Facility for the Advancement of Geoscience

The Geodetic Facility for the Advancement of Geoscience, GAGE, is a distributed, multi-user, national facility that supports fundamental research and discovery on continental deformation, plate boundary processes, the earthquake cycle, the geometry and dynamics of magmatic systems, continental groundwater storage and hydrologic loading.

GAGE is managed and operated for NSF through a cooperative agreement with the University NAVSTAR Consortium, or UNAVCO, which was renewed for a five-year term from October 1, 2018, through September 30, 2023, and subsequently authorized by the National Science Board for an additional two years.

UNAVCO is a consortium of 115 U.S. universities and nonprofit institutions with research and teaching programs in geophysics and geodesy, and 108 associate members from foreign institutions. Oversight is provided by the GEO Division of Earth Sciences.

- GEO recently announced that GAGE and the Seismological Facility for the Advancement of Geoscience, or SAGE will be open to competition for management by a single entity beginning in 2025 (start date changed from 2023 to permit input from a decadal survey and interagency discussions).
- UNAVCO and the Incorporated Research Institutes for Seismology — the current manager of SAGE — have merged to form the EarthScope Consortium, effective January 1, 2023.

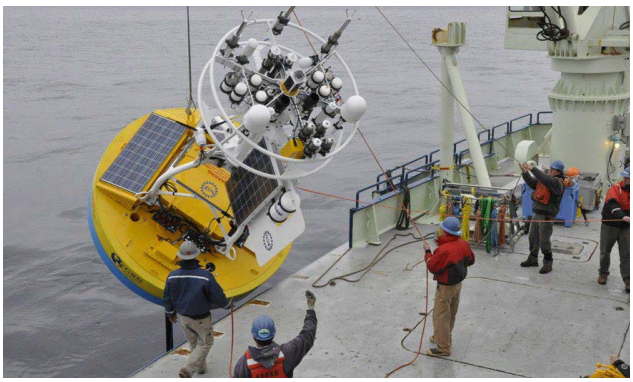
Credit: William Crawford and IODP

International Ocean Discovery Program

The International Ocean Discovery Program, IODP, represents an international partnership of scientists, research institutions and funding organizations from 23 nations to explore the evolution, structure and behavior of Earth as recorded in the ocean basins. Annual operations and maintenance support for operating the JOIDES Resolution, the most-used IODP platform, represents NSF's primary contribution to the program.

NSF provides the JOIDES Resolution as the light IODP drillship through a five-year cooperative agreement with Texas A&M University, renewed Oct. 1, 2019. NSF funding is leveraged by international partners. Oversight of IODP is provided through the GEO Division of Ocean Sciences.

- JOIDES Resolution was damaged during a dry-dock accident in 2018; all necessary repairs have now been completed at no cost to NSF.
- COVID-19 disrupted the drilling expeditions planned for Fiscal Years 2020 and 2021. Under strict mitigation protocols, several engineering cruises were conducted during this period, setting the stage for future scientific expeditions. The first expedition, including a complement of scientists, was conducted in late FY 2021, following quarantine and COVID-19 testing protocols.



Credit: Elizabeth Caporelli, © Woods Hole Oceanographic Institution

Ocean Observatories Initiative

The Ocean Observatories Initiative, OOI, is a networked, ocean-focused research observatory with arrays of instrumental buoys, profilers, gliders and autonomous vehicles operating in different open-ocean and coastal regions and with a cabled array of instrumented platforms and profilers on or above the seafloor over the Juan de Fuca tectonic plate. This networked system enables researchers to study complex, interlinked physical, chemical, biological and geological processesthat occur on both short-term, episodic and long-term, climate-related timescales.

Based on community input, the relocatable Coastal Pioneer Array, is scheduled to move in 2024 from the New England shelf to the southern Mid-Atlantic Bight. Data from this array identified patterns of water and material exchange between the continental shelf and the open ocean. These processes were episodic and more intense than expected; they seem to be related to larger scale climate change processes in the atmosphere and open ocean.

Oversight is provided by the GEO Division of Ocean Sciences. OOI is managed and operated under a five-year cooperative agreement with Woods Hole Oceanographic Institution, which began Oct. 1, 2018 and ends on Sept. 30, 2023.

Credit: Earthscope

Seismological Facility for the Advancement of Geoscience

The Seismological Facility for the Advancement of Geoscience, SAGE, is a distributed, multi-user, national facility for the development, deployment and operational support of modern digital seismic instrumentation to serve national goals in basic research and education in earth sciences, earthquake research, global real-time earthquake monitoring, and nuclear test ban verification.

SAGE is managed and operated by the Incorporated Research Institutes for Seismology, or IRIS, which is incorporated as a nonprofit consortium representing 125 U.S. universities and nonprofit organizations with research and teaching programs in seismology. See the Geodetic Facility for the Advancement of Geoscience section for information on award status and the next competition. Oversight is provided by the GEO Division of Earth Sciences.

- IRIS and the University NAVSTAR Consortium (the current manager of GAGE) have merged to form the EarthScope Consortium,, effective in January 1, 2023.

Credit: © UCAR byCarlye Calvin (CC BY-NC 4.0)

National Center for Atmospheric Research

Boulder, Colorado

Federally Funded Research and Development Center

The National Center for Atmospheric Research, NCAR, is an NSF- sponsored Federally Funded Research and Development Center serving a broad research community, including atmospheric and geospace scientists and researchers in complementary areas of the environmental sciences and geosciences. NCAR provides world-class research programs, services and facilities that enable the research community to advance understanding of the sun-atmosphere system. These facilities include the NCAR-Wyoming Supercomputing Center, the Mauna Loa Solar Observatory, two research aircraft, a transportable ground-based radar system, an atmospheric sounder and other surface sensing systems.

NCAR is managed under a five-year cooperative agreement through Sept. 30, 2023, with the University Corporation for Atmospheric Research. Oversight is provided by the GEO Division of Atmospheric and Geospace Sciences.

- The NCAR aviation infrastructure in Broomfield, near Boulder, Colorado, has been replaced with a new facility, which opened for operation in September 2021.

Credit: Peter Rejcek, National Science Foundation

Antarctic Facilities and Operations

The Office of Polar Programs, OPP, manages Antarctic facilities and operations and provides the infrastructure needed to support U.S. research conducted in Antarctica, including research funded by NSF and by U.S. mission agencies, for year-round work at three U.S. stations, on two research ships and at numerous remote field camps. Through its active and influential presence on the continent, the U.S. Antarctic research program advances science in support of some of the most critical issues of our time, including climate change and its impacts.

OPP has overall responsibility for managing Antarctic facilities under the U.S. Antarctic Program. The Antarctic prime support contract is currently held by Leidos Innovations Corporation, with many separate subcontractors for supplies and technical services. NSF has initiated a competitive procurement process for the follow-on acquisition at the end of the current contract in Fiscal Year 2025.

- COVID-19 and its associated risks and restrictions caused significant delays in science support for the 2020-21 and 2021-22 research seasons. Operational and scientific infrastructure was safely maintained, but a large backlog of science activities resulted from a severe reduction in on-ice deployers. The 2022-2023 research season has been more reflective of pre-pandemic levels of on-ice research and support.

Credit: Jeffey Donenfeld

IceCube Neutrino Observatory

South Pole, Antarctica

The IceCube Neutrino Observatory is the world's first high-energy neutrino observatory. It is located deep within the ice cap under the U.S. NSF Amundsen-Scott South Pole Station in Antarctica. The observatory includes a Deep Core Array with tightly spaced digital optical modules to detect lower energy neutrinos. It provides unique data on the engines that power active galactic nuclei, the origin of high-energy cosmic rays, the nature of gamma ray bursts, the activities surrounding supermassive black holes and other violent and energetic astrophysical processes.

IceCube is managed by the University of Wisconsin-Madison under a five-year cooperative agreement that began on April 1, 2021. Oversight is the joint responsibility of the GEO Office of Polar Programs and the MPS Division of Physics.

- Operations at the South Pole have continued over the southern winter seasons despite the challenges to South Pole access during COVID-19, with remote work by staff in the U.S. sustaining the data flow to the scientific community.
- An upgrade of the IceCube digital optical modules that will allow for detection of lower energy neutrinos and provide better detector calibration is underway.

Credit: Courtesy OZ Architecture

Antarctic Infrastructure Recapitalization

Formerly, Antarctic Infrastructure Modernization for Science project Major Research Equipment and Facilities Construction project

The Antarctic Infrastructure Modernization for Science, AIMS, project was envisioned as the first step to replace major facilities at McMurdo Station, Antarctica, one of three stations that make up the U.S. presence in Antarctica, to meet anticipated science support requirements for the next 35 to 50 years. McMurdo Station's main purpose is to support both near- and deep-field science in Antarctica, including activities at Amundsen- Scott South Pole Station.. Oversight is provided by the GEO Office of Polar Programs.

The extended on-ice work stoppage resulting from the COVID-19 pandemic, as well as disruptions to workforce and supply chains, forced NSF to move in a new direction. Two of the facilities under the original AIMS scope will be completed. The remaining scope and funding will be moved to the Antarctic Infrastructure Recapitalization (AIR) program, which is an ongoing recapitalization effort that picks up where AIMS leaves off. The AIR program comprises investments that improve general-purpose USAP infrastructure including facilities, utilities, equipment, and fleet equipment that are used across the program. This critical infrastructure supports all fields of science. Investments are prioritized across all USAP locations, and acquisition strategies are tailored to individual activities.

- The first project authorized under the AIR program is the replacement of the McMurdo Station ice pier with a permanent pier solution. Supplies needed to sustain life and support science at two of the USAP stations and the deep field camps rely on an ice pier at McMurdo for cargo off- and on-load. The rate of ice pier failure has increased in recent years.

DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES:

Credit: NAIC Arecibo Observatory, a facility of the NSF

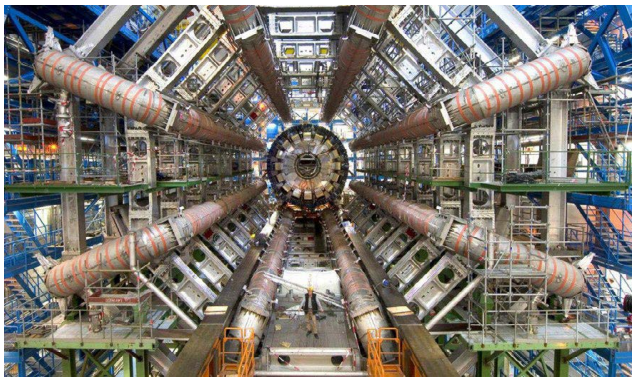
Arecibo Observatory

Arecibo, Puerto Rico *(National Astronomy and Ionosphere Center)*

Built in 1963, Arecibo Observatory was for decades the site of the world's largest operating single-dish radar/radio telescope, with a 305-meter diameter reflector. Three major areas of research were supported at Arecibo: radio astronomy, planetary science using radar, and geospace and atmospheric sciences. Arecibo suffered a direct hit by Hurricane Maria in 2017 and a series of major earthquakes from late 2019 into 2020. Following an initial cable failure in August 2020, the receiver platform of the 305-meter telescope suffered a catastrophic collapse on December 1, 2020. Clean-up of the debris from that collapse, which destroyed the upper parts of the support towers and a significant portion of the reflector dish, is complete.

Arecibo is currently operated by the University of Central Florida; Yang Enterprises, Inc.; and Universidad Ana G. Méndez under a five-year cooperative agreement that expires on March 31, 2023, although NSF is planning to grant an extension to September 30, 2023. NSF is currently planning on shifting responsibilities for site maintenance to a local contractor to provide a flexible foundation for potential future educational and scientific activities on the site.

Arecibo was also supported by NASA under their Near-Earth Object Observation Program, but that support ended in FY 2022 because the NASA radar system is not operable without the 305-meter reflector.



Credit: CERN

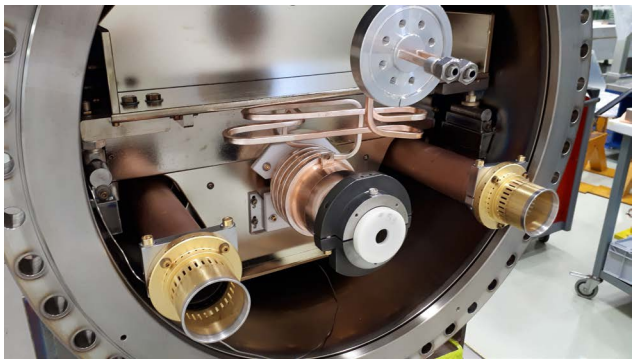
Large Hadron Collider

European Organization for Nuclear Research
Geneva, Switzerland

The Large Hadron Collider, LHC, is an international project at the European Organization for Nuclear Research, CERN, laboratory in Geneva, Switzerland. It is the most powerful particle accelerator ever constructed and has the highest energy particle beams ever created, making it the premier facility in the world for research in elementary particle physics. It consists of a superconducting particle accelerator, about 16.5 miles in circumference, providing two counter-rotating proton beams. Four large particle detectors collect the data delivered by the LHC. Researchers use the data to search for new particles and forces.

CERN is responsible for meeting the overall LHC project goals and coordinating international participation. The U.S., through a partnership between NSF and the U.S. Department of Energy, is a major contributor to the construction and operation of two of the largest particle detectors: A Toroidal LHC ApparatuS, ATLAS; and the Compact Muon Solenoid, CMS. Oversight is provided by the MPS Division of Physics.

- The LHC resumed operations in 2022 following a three-year shutdown. During that time, upgrades to the ATLAS and CMS detectors were installed and CERN upgraded elements of the accelerator. CERN plans to operate the accelerator to collect data through late 2025.
- CERN is currently engaged in preparing for a major upgrade to significantly increase luminosity and event rate by 2029, as described below.



Credit: CERN

High Luminosity — Large Hadron Collider Upgrade

Geneva, Switzerland

Major Research Equipment and Facilities Construction project

A major international effort is underway to upgrade the luminosity of the particle beam at the Large Hadron Collider, or LHC (see above), to increase the intensity of the high-energy particle collisions and unleash a torrent of data for research in elementary particle physics. NSF is one of more than 45 funding agencies contributing to this effort. NSF's contributions to the upgrades will enhance the ATLAS and Compact Muon Solenoid detectors at the LHC to enable them to exploit the scientific opportunities that will result from high luminosity operation of the LHC. NSF funding is concentrated in a few key areas such as high granularity sensor and electronic signal readout, where the work it supports can proceed relatively independently from that supported by other agencies; however, the upgrade effort, like LHC operations, is being closely coordinated with the U.S. Department of Energy. Oversight is provided by the MPS Division of Physics.

- FY 2020 was the first year of requested and appropriated construction funds for a five-year project.
- The pandemic, supply chain problems, and the very tight technical labor market have significantly delayed efforts supported by NSF and other funding partners to upgrade the detectors. CERN has stretched out the high luminosity upgrade schedule to accommodate these impacts. NSF plans to rebaseline its parts of the ATLAS and CMS upgrade projects in spring 2023.

Credit: Caltech/MIT/LIGO Lab

Laser Interferometer Gravitational-wave Observatory

Livingston, Louisiana, and Hanford, Washington

The Laser Interferometer Gravitational-wave Observatory, LIGO, is the most sensitive gravitational-wave detector ever built, with two main facilities: at Livingston, Louisiana, and Hanford, Washington. Each facility has an L-shaped vacuum chamber with two 4-km long arms joined at right angles and each houses an optical interferometer. A passing gravitational wave causes one arm to lengthen and the other to shrink. Einstein's theory of relativity predicts that cataclysmic processes involving extremely dense objects in the universe — for example, the collision of black holes — will produce gravitational radiation. LIGO directly observed gravitational radiation from a black hole merger for the first time in September 2015, following the Advanced LIGO upgrade. Through a program of observations and commissioning activities, LIGO is now tenfold more sensitive than before the Advanced LIGO upgrade.

LIGO is operated by the California Institute of Technology through a five-year cooperative agreement that began October 1, 2018. NSF is currently considering a renewal proposal for continued operation of LIGO by CalTech. Oversight is provided by the MPS Division of Physics.

- NSF has funded the "A+" upgrade to LIGO, involving improved mirror coatings and quantum light squeezing, toapproximately double the sensitivity. LIGO plans to complete the installation and commissioning of the A+ enhancement by 2025-6.
- LIGO's fourth scientific observing session (O4), is expected to commence as early as March 2023 at a sensitivity 15-20% greater than obtained during O3.

Credit: National MagLab

National High Magnetic Field Laboratory

Tallahassee, Florida

The National High Magnetic Field Laboratory, NHMFL, develops and operates high magnetic field facilities that scientists and engineers use for research in condensed matter and material physics, materials science and engineering, chemistry, biology, biochemistry, neuroscience, energy and the environment. It is the world's premier high magnetic field laboratory. It is an internationally recognized leader in magnet design, development and construction, including the development of new superconducting materials.

NHMFL is operated by a consortium of Florida State University, the University of Florida and Los Alamos National Laboratory under a cooperative agreement covering a five-year period from Jan. 1, 2023, to Dec. 31, 2027Oversight is provided by the MPS Division of Materials Research, with some oversight by the Division of Chemistry.

- The NHMFL celebrated 25 years in operation in October 2019.
- NSF is currently supporting the design of a new 40-Tesla all-superconducting magnet at the NHMFL through the Mid-scale Research Infrastructure-1 program.

Credit: NSF/GBO/Jee Seymour

Green Bank Observatory

Green Bank, West Virginia

Federally Funded Research and Development Center

Green Bank Observatory, GBO, is a major NSF research facility and a Federally Funded Research and Development Center located in Green Bank, West Virginia. Its radio telescopes, including the Robert C. Byrd Green Bank Telescope, or GBT, provide key ground-based radio-wavelength research facilities. The GBT is the world's largest fully steerable single-dish radio telescope and is GBO's flagship research instrument. In conjunction with observations from other types of telescopes, data from GBT address topics from fundamental physics to the discovery and characterization of interstellar organic molecules that provide insight into the organic chemistry of life on Earth and the search for life beyond. GBO is located in the 13,000-square-mile National Radio Quiet Zone.

Formerly part of the National Radio Astronomy Observatory, NRAO, GBO was separated in Fiscal Year 2017 from NRAO but continues to be managed by Associated Universities, Inc., or AUI. In FY 2020, NSF awarded a new five-year cooperative agreement to AUI for operations and maintenance of GBO. Oversight of GBO is provided through the MPS Division of Astronomical Sciences.

- GBO receives support from external partners and other sources, including Breakthrough Listen, the Gordon and Betty Moore Foundation, the NSF-funded NANOGrav Physics Frontier Center, and numerous small contracts, in exchange for observing time on the GBT.

Credit: Andrew Clegg, NSF

National Radio Astronomy Observatory

Headquartered in Charlottesville, Virginia

Federally Funded Research and Development Center

The National Radio Astronomy Observatory, NRAO, conceives, designs, builds, operates and maintains state-of-the-art radio telescopes used by scientists from around the world. Operating synergistically with optical, infrared, x-ray, particle, and gravitational wave telescopes, NRAO facilities enable discovery over a remarkably broad range of key problems in modern astrophysics that reach from within our solar system to the most distant parts of the universe. NRAO supports facilities in Chile and the U.S. including: the Atacama Large Millimeter/submillimeter Array, ALMA, in Chile; the Very Large Array, VLA, near Socorro, NM (pictured left); and the Very Long Baseline Array, VLBA.

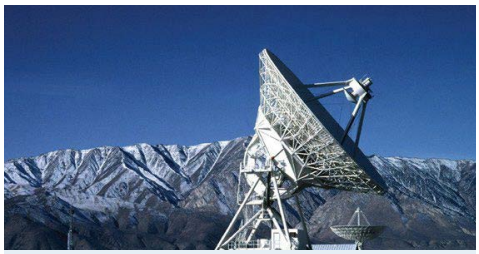
The managing organization for NRAO is Associated Universities, Inc., which is funded by a cooperative agreement with NSF. Oversight is provided by the MPS Division of Astronomical Sciences.

Credit: Karen Pearce, NSF

ALMA is an international partnership among a number of organizations, in cooperation with the Republic of Chile: NSF; the European Southern Observatory; the National Institutes of Natural Sciences of Japan; the National Research Council of Canada; the National Science Council and the Institute of Astronomy and Astrophysics, Academia Sinica, in Taiwan; and the Korea Astronomy and Space Science Institute in the Republic of Korea. ALMA — the largest astronomical project in existence — is a single telescope of revolutionary design, composed of 66 high-precision antennas located on the Chajnantor plateau, at 5,100 meters altitude in northern Chile.

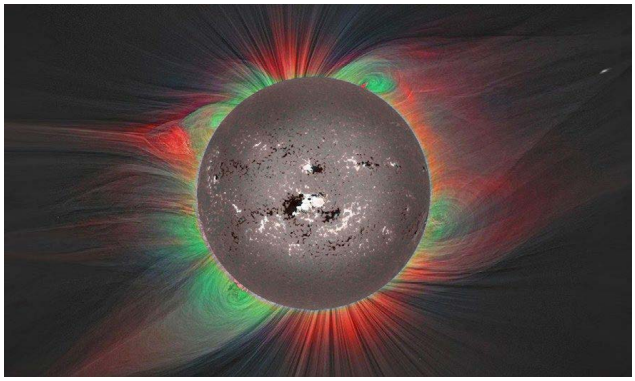
Credit: Alex Savello, NRAO

The Very Large Array is one of the world's premier astronomical radio observatories, consisting of 27 radio antennas in a Y-shaped configuration on the Plains of San Agustin, 50 miles west of Socorro, New Mexico. Each antenna is 25 meters (82 feet) in diameter.



Credit: NRAO/AUI/NSF

The Very Long Baseline Array is the world's premier long-baseline radio interferometer, using 10 identical 25-meter radio telescopes located across the U.S., from Hawaii to St. Croix, Virgin Islands. The VLBA provides key insight into the structure and evolution of the Milky Way and helps to determine the fundamental distance scale of the universe. VLBA is also used for fundamental support of the International Celestial Reference Frame, under an agreement with the U.S. Naval Observatory.



Credit: NSO

National Solar Observatory

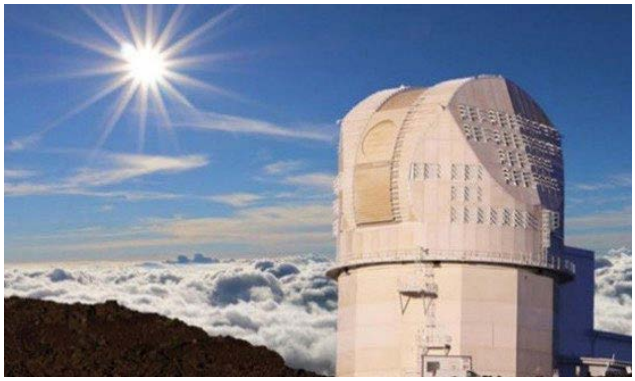
Boulder, Colorado

Federally Funded Research and Development Center

The National Solar Observatory, NSO, is headquartered on the campus of the University of Colorado Boulder and provides leadership to the solar community through management of the NSO Integrated Synoptic Program, or NISP, and the Daniel K. Inouye Solar Telescope, DKIST. NISP, through the Global Oscillation Network Group, provides unique 24/7, full-disk data for both scientific research and operational space weather forecasting.

NSO is operated under a 10-year cooperative agreement, running through September 2024, with the Association of Universities for Research in Astronomy, Inc., or AURA.Oversight is provided by the MPS Division of Astronomical Sciences.

- Scientific operation of the former NSO facility in Sunspot, New Mexico has been transitioned to a university-based consortium led by New Mexico State University (partially funded by NSF), as NSO moves its focus to supporting DKIST and continued operation of NISP.



Credit: NSO/AURA/NSF

Daniel K. Inouye Solar Telescope

Haleakala, Maui, Hawaii

With completion of construction in November 2021, the Daniel K. Inouye Solar Telescope, DKIST, is now operational. It is the world's most powerful solar observatory. DKIST will investigate the structure and evolution of magnetic structures on the sun on spatial scales of tens of kilometers, the scales of the processes that drive space weather.

DKIST is now the flagship facility for the National Solar Observatory (above). Funding for operations is provided by NSF through the NSO cooperative agreement with the Association of Universities for Research in Astronomy, Inc.

Oversight of DKIST is provided by the MPS Division of Astronomical Sciences.

Credit: Munizaga, CTIO/NSF's NOIRLab/AURA/D

NSF's National Optical-Infrared Astronomy Research Laboratory

Federally Funded Research and Development Center

NSF's National Optical- Infrared Astronomy Research Laboratory, NOIRLab, a Federally Funded Research and Development Center, is the foundational hub of U.S. ground-based, optical-infrared astronomy. Through operations in both northern and southern hemispheres using a broad range of 4-meter and 8-meter class telescopes, NOIRLab enables education, training, and cutting-edge science in all areas of modern astronomy and astrophysics, but particularly in time-domain and multi-messenger astronomy follow-up, searches for and characterization of exoplanets, large area surveys, and dark energy science.

NOIRLab facilities include the Gemini North and South telescopes in Hawaii and Chile; the Kitt Peak National Observatory, in Arizona; the Cerro Tololo Inter-American Observatory, in Chile; the Community Science and Data Center, in Arizona; and operations of the Vera C. Rubin Observatory in Chile.

NOIRLab is managed for NSF by the Association of Universities for Research in Astronomy, Inc. , which comprises 47 U.S. institutions and three international affiliates. Oversight is provided by the MPS Division of Astronomical Sciences.

Credit: Gemini Observatory

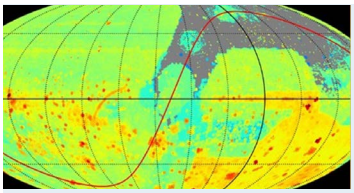
International Gemini Observatory consists of twin optical/ infrared 8-meter telescopes, one each in the northern and southern hemispheres, thereby providing complete coverage of the sky. Gemini provides open, competitive, community-wide access to the skies in all areas of astronomy, with topics of particular interest in high-resolution adaptive optics-assisted observations and rapid follow-up of time-domain and multi-messenger events. Other fundamental questions being investigated are the age and rate of expansion of the universe, the origin of dark energy, the nature of nonluminous "dark matter", the birth of stars and their planetary systems, the characterization of exoplanets and their atmospheres, and the structure and evolution of the solar system. Gemini is supported by an international partnership among the U.S., Canada, Brazil, Argentina, the Republic of Korea, and Chile.

Credit: P. Marenfeld; NOAO/AURA/NSF NOAO

The Kitt Peak National Observatory, or KPNO, supports the most diverse collection of astronomical observatories on Earth for nighttime optical and infrared astronomy. KPNO operates the Mayall 4-meter Telescope (specializing in dark energy science) and the Wisconsin- Indiana-Yale-NOIRLab, or WIYN, 3.5-meter Telescope (specializing in exoplanet characterization). KPNO also supports operations of 22 other small and mid- sized optical telescopes and two radio telescopes for university groups and various national/ international partnerships. The Windows on the Universe Center for Astronomy Outreach is under construction and expected to open in 2023. Kitt Peak is located 56 miles southwest of Tucson, AZ.

Credit: NOAO/NSF/AURA

The Cerro Tololo Inter-American Observatory, or CTIO, operates the Blanco 4-meter Telescope on Cerro Tololo and the 4.2-m Southern Astrophysical Research Telescope, SOAR, on neighboring Cerro Pachón. Blanco excels in survey astronomy and dark energy science, complementing the higher- resolution capabilities of SOAR and Gemini. SOAR, Blanco and Gemini are also being used together as part of NOIRLab's Astronomical Event Observatory Network, responding to multi-messenger alerts from NSF facilities such as LIGO and IceCube Neutrino Observatory. Like KPNO, CTIO also supports operations of over two dozen small and medium-sized telescopes on Cerro Tololo for university consortia and foreign partners.



Credit: NOIRLab

The Community Science and Data Center, or CSDC, provides user support services, software tools and data management services for NOIRLab telescopes and for the entire U.S. community. CSDC maintains a science platform providing high- level tools for discovery, exploration and analysis of large public survey datasets, and is developing infrastructure for time- domain astronomy.

Credit: Rubin Observatory/NSF/AURA/B.

Vera C. Rubin Observatory

Cerro Pachón, Chile

Major Research Equipment and Facilities Construction project

The Vera C. Rubin Observatory, formerly known as the Large Synoptic Survey Telescope, will, once commissioned, be NSF's flagship optical survey instrument. Rubin Observatory will conduct an unprecedented, decade-long survey of the optical sky called the Legacy Survey of Space and Time. Rubin Observatory is a joint undertaking of NSF and the U.S. Department of Energy consisting of an 8-meter class wide-field ground-based telescope, a 3.2-gigapixel camera, an automated data processing system, and a public engagement platform. Rubin Observatory seeks to enable science in four main areas: understanding the nature of dark matter and dark energy, cataloging the Solar System, exploring the changing sky, and probing the Milky Way's structure and formation.

Operations will be part of NSF's National Optical - Infrared Astronomy Research Laboratory (NOIRLab), but the construction project is independent of NOIRLab. Rubin Observatory construction is carried out by the Association of Universities for Research in Astronomy, Inc. through a cooperative agreement. Oversight is provided by the MPS Division of Astronomical Sciences.

- Rubin Observatory was approximately 84% complete as of September 2022. Primary remaining activities included integration of the telescope's optical system, delivery and installation of the DOE camera, completion of the data management system, and overall system integration and commissioning. COVID-19 severely limited work on the mountain beginning in March 2020, resulting in schedule delays amounting to 27 months and associated increases to project costs. Most construction activities returned to normal by the end of fiscal year 2022.