U.S. National Science Foundation

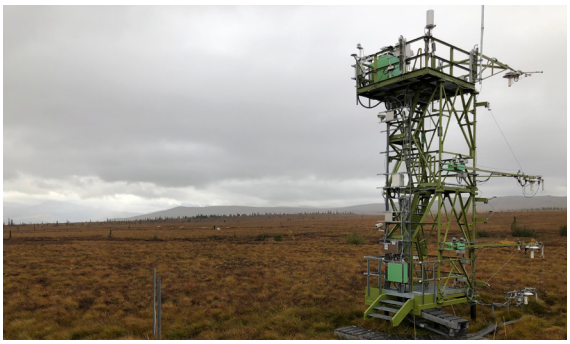
NSF Major Multi-User Facilities

Modern and effective research infrastructure is critical to maintaining U.S. international leadership in science and engineering. The U.S. National Science Foundation (NSF) supports cutting-edge research facilities and infrastructure that span the globe, from mountaintop observatories and ocean vessels to powerful electromagnets and supercomputers. Every day, researchers use these facilities and infrastructure to devise new materials for manufacturing and medicine, improve responses to natural catastrophes, understand weather and climate patterns, and explore extreme environments — from celestial bodies to the Earth's poles and ocean depths.

NSF 75 YEARS OF DISCOVERY & INNOVATION

2025 marks the 75th anniversary of NSF. Throughout the year, the agency will host in-person and virtual activities to commemorate this significant milestone. For more information, visit: new.nsf.gov/75years

NSF Directorate for Biological Sciences (NSF BIO):



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

NSF National Ecological Observatory (NSF NEON)

NSF 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 archives and remote sensing provide the research community with up to 181 data products freely available through a data portal, application programming interface (API), and Google Earth Engine. NEON is the first research platform and the only national facility specifically designed to collect consistent and standardized sensor and observational measurements at a continental scale from 81 sites distributed nationwide.

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

NEON is funded through a cooperative agreement with the managing organization, Battelle Memorial Institute Inc., for which NSF oversight is provided by the Division of Biological Infrastructure in the NSF BIO Directorate. NEON has been in full operation since May 2019 and underwent its first open competition for the management of operations and maintenance between 2020 and 2023, resulting in a new five-year award with a possible five-year extension that started Nov. 1, 2023.

NSF Directorate for Geosciences (NSF GEO):

Credit: Oregon State University

U.S. Academic Research Fleet (ARF)

In 2023, the U.S. Academic Research Fleet (ARF) included 17 vessels which range in size, endurance and capabilities and serve as the main platform for the collection of oceanic data, testing of hypotheses about the structure and dynamics of the ocean, and development and testing of novel oceanographic instrumentation. Vessels in the ARF are owned by NSF, academic institutions or the Office of Naval Research (ONR).

The ARF is financially supported through an interagency partnership, principally with ONR and the National Oceanic and Atmospheric Administration. Oversight is provided to the ARF by the Division of Ocean Sciences in NSF GEO through cooperative agreements with each ship-operating institution and through a separate cooperative agreement with the University-National Oceanographic Laboratory System, which coordinates the scheduling of ship time for research cruises. NSF is the cognizant agency for ship day-rate negotiations for all ARF vessels, regardless of the owner. All cooperative agreements for ship operations were renewed in 2018 and will be again in 2024. Operators for NSF-owned vessels are competed or renewed every 10 years. A proposal from the University of Alaska Fairbanks to operate and maintain the R/V Sikuliaq will be reviewed for a continued award through 2028.

NSF funding for Calendar Year 2023 provided support for 2241 ship operating days, which represents 70% of the total projected operating year of 3198 days.

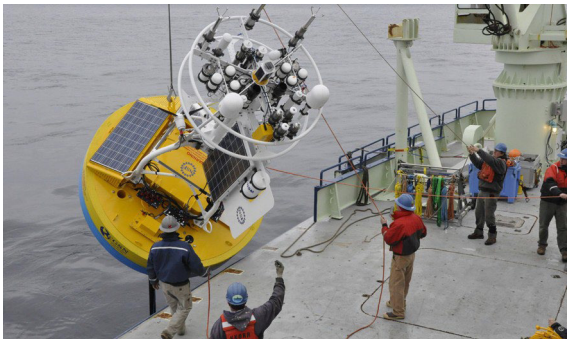
Credit: Architectural design by Glosten Associates Inc.

Regional Class Research Vessel (RCRV)

The RCRV project is a major component in the plan for rightsizing and modernizing the ARF 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, the R/V Taani. "Taani," which is 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, the 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, the R/V Gilbert R. Mason.

Oregon State University has contracted with Bollinger Houma Shipyards in Houma, Louisiana, for construction of all RCRVs. Oversight is provided by the Division of Ocean Sciences in the GEO Directorate.



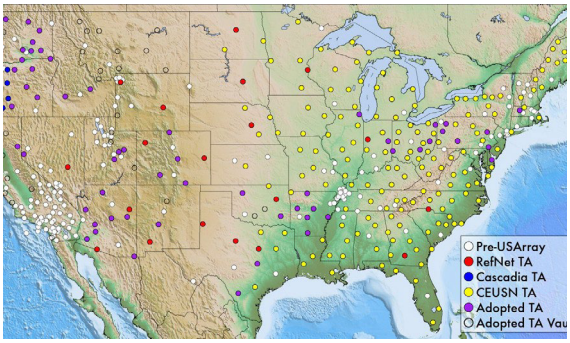
Credit: Elizabeth Caporelli, © Woods Hole Oceanographic Institution

NSF Ocean Observatories Initiative (NSF OOI)

NSF OOI is a networked, ocean-focused research observatory with arrays of instrumented buoys, profilers, gliders and autonomous vehicles operating in different open-ocean and coastal regions. This networked system enables researchers to study complex, interlinked physical, chemical, biological and geological processes that occur on both short-term, episodic and long-term, climate-related timescales.

The OOI facility consists of three types of arrays: two Global, located in the North Atlantic (Irminger Sea) and the North Pacific (Station Papa); two Coastal, located in the North Atlantic (Pioneer) and North Pacific (Endurance); and one Regional Cabled (RCA) in the North Pacific. The relocatable Pioneer Array was initially deployed in the New England shelf, but following community recommendation in the fall of 2024, will be redeployed in the southern Mid-Atlantic Bight. OOI's diverse instrumentation and data are linked by a shared cyberinfrastructure that supports its science goals and facilitates free data dissemination to scientists, students, educators and the public.

Oversight is provided by the Division of Ocean Sciences in the GEO Directorate. OOI is managed and operated under a five-year cooperative agreement with the Woods Hole Oceanographic Institution, which was renewed on Oct. 1, 2023, and extends to Sept. 30, 2028.



Credit: Architectural design by Glosten Associates Inc.

NSF Geodetic Facility for the Advancement of Geoscience (NSF GAGE)

NSF 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 EarthScope Consortium. The cooperative agreement was renewed for a five-year term that ran from Oct. 1, 2018, to Sept. 30, 2023, and subsequently was extended for an additional two years. EarthScope is a consortium of more than 170 member institutions and nearly 250 affiliate institutions with research and teaching programs in geophysics, geodesy and seismology. Oversight is provided by the Division of Earth Sciences in the GEO Directorate.

The EarthScope Consortium formed in 2023 as a result of a merger between the University NAVSTAR Consortium (UNAVCO), the original operator of GAGE, and the Incorporated Research Institutes for Seismology, the original operator of the Seismological Facility for the Advancement of Geoscience (SAGE). In 2023, GEO released a solicitation requesting proposals for managing the operation and maintenance of the National Geophysical Facility, which will be a single consolidated facility to succeed the current GAGE and SAGE and will have a single operator.

Credit: EarthScope

NSF Seismological Facility for the Advancement of Geoscience (NSF SAGE)

NSF 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 for NSF through a cooperative agreement with EarthScope Consortium (see GAGE, above). The cooperative agreement was renewed for a five-year term that ran from Oct. 1, 2018, to Sept. 30, 2023, and subsequently was extended for an additional two years. EarthScope is a consortium of more than 170 member institutions and nearly 250 affiliate institutions with research and teaching programs in geophysics, geodesy and seismology. Oversight is provided by the Division of Earth Sciences in the GEO Directorate.

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

NSF National Center for Atmospheric Research (NSF NCAR)

NSF 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 the 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 as well as state-of-the-art atmospheric and Earth System models.

NCAR is managed under a five-year cooperative agreement with the University Corporation for Atmospheric Research, which was renewed for the period Oct. 1, 2023, to Sept. 30, 2028. Oversight is provided by the Division of Atmospheric and Geospace Sciences in the GEO Directorate.

The NCAR-Wyoming Supercomputing Center launched operation of its new supercomputer “Derecho” in July 2023, The supercomputer provides scientists with a major new tool to help understand the atmosphere and other Earth system processes. It operates with about 3.5 times the computing speed of the previous NCAR supercomputer, “Cheyenne.”

Credit: Peter Rejcek, U.S. National Science Foundation

Antarctic Facilities and Operations

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

The primary support contract for logistical support to USAP is currently held by Leidos Innovations Corporation, with many 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, which ends in Fiscal Year 2025.

Credit: Jeffey Donenfeld

NSF IceCube Neutrino Observatory

The NSF IceCube Neutrino Observatory (NSF IceCube) is the world's first high-energy neutrino observatory. It is located deep within the ice cap under the NSF Amundsen-Scott South Pole Station in Antarctica. The observatory includes the DeepCore array, which contains 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, and the activities surrounding supermassive black holes and other violent and energetic astrophysical processes. An upgrade for the IceCube digital optical modules is underway that will allow for detection of lower energy neutrinos and provide better detector calibration.

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 Office of Polar Programs in the GEO Directorate and the Division of Physics in the NSF Mathematical and Physical Sciences (NSF MPS) Directorate.

Credit: Courtesy OZ Architecture

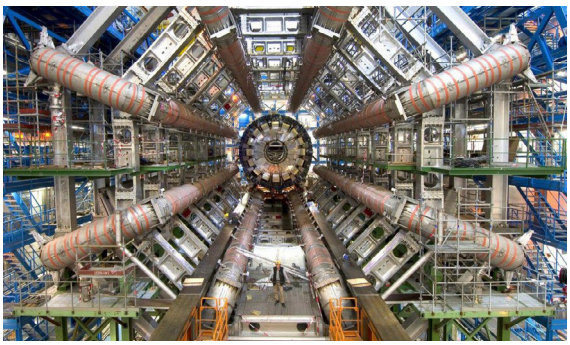
NSF Antarctic Infrastructure Recapitalization (NSF AIR) Program

The NSF AIR program is an ongoing recapitalization effort that comprises investments that improve general-purpose U.S. Antarctic Program (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. Oversight is provided by the Office of Polar Programs in the GEO Directorate.

The NSF Antarctic Infrastructure Modernization, or NSF AIMS, project was envisioned as the first step to replace major facilities at McMurdo Station, one of three year-round stations that make up the U.S. presence in Antarctica, to meet anticipated science support requirements for the next 35 to 50 years. 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 from AIMS to AIR. One of the facilities under the original AIMS scope will be completed as originally planned and the remaining scope and funding will be considered under AIR.

Many projects are now underway in the AIR program, including the replacement of the NSF McMurdo Station ice pier with a permanent pier solution. The rate of ice pier failure has increased in recent years. 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 NSF McMurdo for cargo off- and on-load, so it is a critical piece of infrastructure.

NSF DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES (NSF MPS):



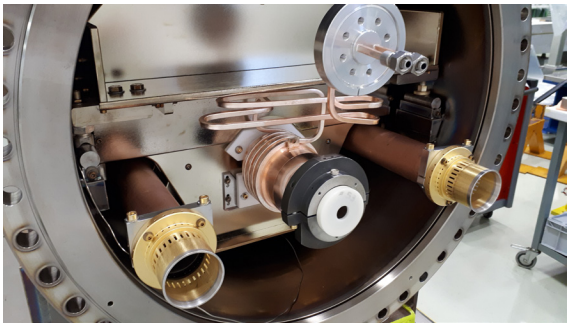
Credit: CERN

Large Hadron Collider (LHC) — European Organization for Nuclear Research — Geneva, Switzerland

The 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 (DOE), 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 Division of Physics in the NSF MPS Directorate.

The LHC is preparing to resume operations in 2024 following a three-year shutdown. It will collect data for approximately two years, at which time installation of the High Luminosity Upgrade described below will begin.



Credit: CERN

High Luminosity — Large Hadron Collider (LHC) 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 "Large Hadron Collider" in previous section) to increase the intensity of 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 contributions to the upgrades, supported as a Major Research Equipment and Facilities Construction project, will enhance the ATLAS and CMS detectors at the LHC, enabling 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 DOE. Oversight is provided by the Division of Physics in the MPS Directorate.

Fiscal Year 2020 was the first year of requested and appropriated construction funds for a five-year project. The pandemic delayed efforts supported by NSF and other funding partners to upgrade the detectors, mostly due to access restrictions. This resulted in a slightly higher total cost and stretched the finish date to 2027 to align with CERN's new overall schedule.

Credit: Caltech/MIT/LIGO Lab

NSF Laser Interferometer Gravitational-wave Observatory (NSF LIGO) — Livingston, Louisiana, and Hanford, Washington

NSF LIGO is the most sensitive gravitational-wave detector ever built, with two main facilities, one in Livingston, Louisiana, and one in Hanford, Washington. Each facility has an L-shaped vacuum chamber with two 4-kilometer-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. Albert Einstein's theory of relativity predicts that cataclysmic processes

involving extremely dense objects in the universe — for example, the collision of black holes and neutron stars — will produce gravitational radiation. LIGO directly observed gravitational radiation from a black hole merger for the first time in September 2015 and from a neutron star merger in August 2017.

LIGO is operated by the California Institute of Technology through a five-year cooperative agreement that began Jan. 1, 2024. Oversight is provided by the Division of Physics in the MPS Directorate.

NSF has funded the "A+" upgrade to LIGO, involving improved mirror coatings and quantum light squeezing, to increase the detector's sensitivity by about 70% over current LIGO capabilities. This upgrade is going on in parallel with the staged effort to reach the full sensitivity of the previous LIGO upgrade; both have been slowed somewhat by the impacts of COVID-19. The current scientific observing session of LIGO, O4, started in May 2023 and will end in the spring of 2025.

Credit: National MagLab

NSF National High Magnetic Field Laboratory (NSF NHMFL) — Tallahassee, Florida

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

NHMFL is operated by a consortium comprising 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, 2027. Oversight is provided by the Division of Materials Research in the MPS Directorate in collaboration with the MPS Division of Chemistry.

NHMFL celebrates 30 years of operation in 2024. NSF is currently supporting the design of a new 40-Tesla, all-superconducting magnet at NHMFL through the Mid-scale Research Infrastructure-1 program.

Credit: NSF/GBO/Jee Seymour

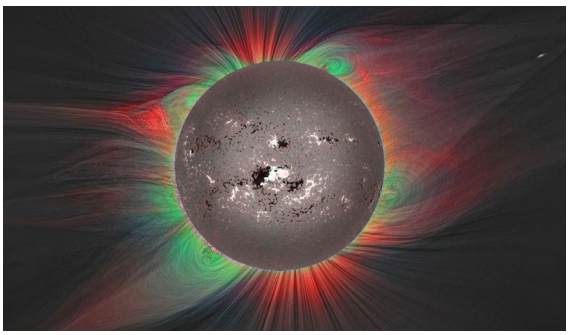
NSF Green Bank Observatory (NSF GBO) — Green Bank, West Virginia

Federally Funded Research and Development Center

NSF 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 (GBT), provide key ground-based radio wavelength research facilities. 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 ranging 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 NSF National Radio Astronomy Observatory (NSF NRAO), GBO was separated in Fiscal Year 2017 from NRAO but continues to be managed by Associated Universities Inc. (AUI). In FY 2020, NSF awarded a new five-year cooperative agreement to AUI for operations and maintenance of GBO. NSF plans to reintegrate GBO into NRAO at the beginning of FY 2025. Oversight of GBO is provided through the Division of Astronomical Sciences in the MPS Directorate.

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



Credit: NSO

NSF National Solar Observatory (NSF NSO) — Boulder, Colorado

Federally Funded Research and Development Center

NSF NSO, is a Federally Funded Research and Development Center 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 (NISP) and the Daniel K. Inouye Solar Telescope. NISP, through the Global Oscillation Network Group, provides a unique 24/7, full-disk dataset for both scientific research and operations, including monitoring of solar active regions that can generate extreme space weather events.

The managing organization for NSO is the Association of Universities for Research in Astronomy Inc. (AURA), which is funded under a 10-year cooperative agreement with NSF. The National Science Board authorized a renewed cooperative agreement with AURA for management and operation of NSO in August 2014. The award started in June 2015 and will run through September 2024, with a currently planned extension through September 2026 to allow for completion of the Inouye Telescope commissioning. Oversight is provided by the Division of Astronomical Sciences in the MPS Directorate.

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 concentration to the Inouye Telescope and continued operation of NISP.

Credit: NSO/AURA/NSF

NSF Daniel K. Inouye Solar Telescope — Haleakala, Maui, Hawaii

With the formal completion of construction in Fiscal Year 2023, the NSF Daniel K. Inouye Solar Telescope is now operational. It is the world's most powerful solar observatory and will be used to 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.

NSO operates and maintains the Inouye Telescope. Funding is provided by NSF through a cooperative agreement with the Association of Universities for Research in Astronomy Inc. NSO and the Inouye Telescope operations are managed through the Division of Astronomical Sciences in the MPS Directorate.

Credit: Andrew Clegg, NSF

NSF National Radio Astronomy Observatory (NRAO) — Headquartered in Charlottesville, Virginia

Federally Funded Research and Development Center

NSF 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 is operated under a cooperative agreement with Associated Universities Inc. (AUI). Oversight is provided by the Division of Astronomical Sciences in the MPS Directorate.

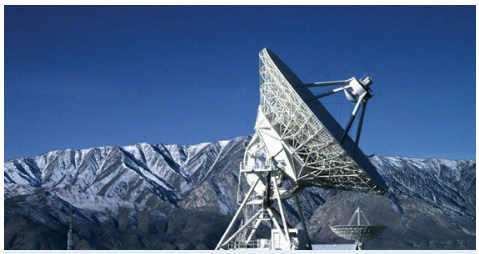
NRAO supports facilities in Chile and the U.S., including the Atacama Large Millimeter/submillimeter Array (ALMA), the NSF Karl G. Jansky Very Large Array (NSF VLA) and the Very Long Baseline Array (VLBA) described below.

Credit: Karen Pearce, NSF

ALMA is an international partnership involving 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 & Astrophysics, Academia Sinica in Taiwan; the Korea Astronomy and Space Science Institute, Republic of Korea; and the host country, the Republic of Chile. 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

NSF VLA 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. The data from the antennas are combined electronically to give the resolution of an antenna 36 kilometers (22 miles) across, with the equivalent sensitivity of a dish 130 meters (422 feet) in diameter. With VLA, scientists can map large-scale structures of gas and molecular clouds and pinpoint ejections of plasma from supermassive black holes.



Credit: NRAO/AUI/NSF

VLBA is the world's premier 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: Munizaga, CTIO/NSF NOIRLab/AURA/D

NSF National Optical-Infrared Astronomy Research Laboratory (NSF NOIRLab)

Federally Funded Research and Development Center NSF 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.

At the start of Fiscal Year 2020, NSF launched NOIRLab, a Federally Funded Research and Development Center that is the foundational hub of U.S. ground-based optical-infrared astronomy in the era of the NSF-DOE Vera C. Rubin Observatory, multi-messenger astrophysics and data intensive science. NOIRLab integrates the programs and activities previously associated with the National Optical Astronomy Observatory, the Gemini Observatory and Rubin Observatory operations into a single center (Note: NOIRLab does not encompass the Rubin Observatory construction project).

NOIRLab enables the U.S. research community to pursue a broad range of modern astrophysical challenges, from studying rapidly moving small bodies within the solar system to characterizing the most distant galaxies in the early universe and indirectly observing dark matter and dark energy.

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 Division of Astronomical Sciences in the MPS Directorate.

Credit: Rubin Observatory/NSF/AURA/B.

NSF-DOE Vera C. Rubin Observatory — Cerro Pachón, Chile

Major Research Equipment and Facilities Construction project

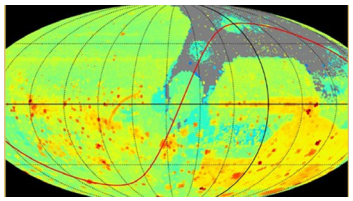
The NSF-DOE Rubin Observatory, formerly known as LSST, will, once commissioned, be NSF flagship optical survey instrument. The observatory will conduct an unprecedented, decade-long survey of the optical sky called the Legacy Survey of Space and Time. The Rubin Observatory is a joint undertaking of NSF 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 the NSF National Optical-Infrared Astronomy Research Laboratory (NOIRLab), but the construction project is independent of NOIRLab. Rubin Observatory's construction is being carried out by the Association of Universities for Research in Astronomy Inc. through a cooperative agreement. Oversight is provided by the Division of Astronomical Sciences in the MPS Directorate.

Credit: Gemini Observatory

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

Credit: NOAO/NSF/AURA



Credit: NOIRLab

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. Though Gemini is used for all areas of astronomy, topics of particular interest are high-resolution adaptive optics-assisted imaging and follow-up of time-domain and multi-messenger alerts. Other fundamental questions being investigated are the age and rate of expansion of the universe, the origins of dark energy, the nature of nonluminous "dark matter", and the birth of stars and their planetary systems. Gemini is supported by an international partnership among the U.S., Canada, Brazil, Argentina, the Republic of Korea and Chile.

Kitt Peak National Observatory (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 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 and international partnerships. The Windows on the Universe Center for Astronomy Outreach is under construction and expected to open in 2024. Kitt Peak is located 56 miles southwest of Tucson, Arizona.

Cerro Tololo Inter-American Observatory (CTIO)

operates the Blanco 4-meter telescope on Cerro Tololo in Chile and the 4.2-meter 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 the Laser Interferometer Gravitational-wave Observatory (LIGO) and the 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.

Community Science and Data Center (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.

NSF MID-SCALE RESEARCH INFRASTRUCTURE TRACK 2:

The NSF Mid-scale Research Infrastructure program, or NSF Mid-scale RI for short, is an NSF-wide effort to meet the research community's needs for modern research infrastructure to support priority science and engineering research. Mid-scale RI-2 covers projects with individual implementation costs between $20 million and $100 million with funding from the Major Research Equipment and Facilities Construction (MREFC) account.

In the 2018 appropriation for NSF, report language from the House of Representatives directed the National Science Board — in collaboration with the National Academies of Sciences, Engineering, and Medicine — to consider steps to bridge the gap between the NSF Major Research Instrumentation (MRI) program and the agency's MREFC account and to develop appropriate processes to address this matter through the MREFC account within a restricted funding environment.

NSF responded to these recommendations and the "American Innovation and Competitiveness Act" mandate to develop a strategy with the detailed Mid-scale RI program that is described in the NSF-wide investments chapter of the budget request. As part of that strategy, funding for mid-scale projects with implementation costs above $20 million was requested in the MREFC account, as Track 2 of an NSF-wide mid-scale program, and funding was first appropriated in that account in Fiscal Year 2020. NSF issued its first solicitation for Mid-scale RI-2 (NSF 19-542) in December 2018, requesting proposals with total implementation costs ranging between $20 million and $70 million. Five Mid-scale RI-2 awards were made from the first solicitation:

- "**High Magnetic Field Beamline**," Cornell University.
- "**Global Ocean Biogeochemistry Array**," Monterey Bay Aquarium Research Institute.
- "**Grid-Connected Testing Infrastructure for Networked Control of Distributed Energy Resources**," University of California, San Diego.
- "**Network for Advanced NMR [Nuclear Magnetic Resonance]**," University of Connecticut.
- "**The Research Data Ecosystem, a National Resource for Reproducible, Robust, and Transparent Social Science Research in the 21st Century**," University of Michigan.

Four more Mid-scale RI-2 awards were made from the subsequent solicitation (NSF 21-537), which was issued in December 2020:

- "**Airborne Phase Array Radar**," NCAR.
- "**Advanced Millimeter Survey Instrumentation in Chile**," University of Pennsylvania.
- "**SafeInsights: A National Research Infrastructure for Large-Scale Learning Science and Engineering**," William Marsh Rice University.
- "**Compact X-ray Free-Electron Laser Project**," Arizona State University.

Descriptions of all Mid-scale RI-2 awards can be found on the program webpage.