

# NSF's NOIRLab



Discovering Our  
**Universe**  
Together



## Table of Contents

What is NSF's NOIRLab?	3
Astronomy's Golden Age	4
The International Gemini Observatory	6
Vera C. Rubin Observatory	8
Kitt Peak National Observatory	10
Cerro Tololo Inter-American Observatory	12
The Community Science and Data Center	14
The US Extremely Large Telescope Program	
— Two Telescopes, One System	16
Our Values	18
Community Support — We Are Here for Astronomers	20
Societal Benefits — We Are Here for You	22

# What is NSF's NOIRLab?

**For the first time, all of the state-of-the-art nighttime optical observatories funded by the National Science Foundation have been unified.**

NSF's NOIRLab's mission is to enable incredible new discoveries about the Universe, and empower astronomers to tackle the most pressing questions in astrophysics today.

NOIRLab operates a suite of nighttime observatories and data facilities in the darkest places in the world: the international Gemini Observatory, Vera C. Rubin Observatory (jointly with SLAC), Kitt Peak National Observatory, Cerro Tololo Inter-American Observatory, and the Community Science and Data Center.

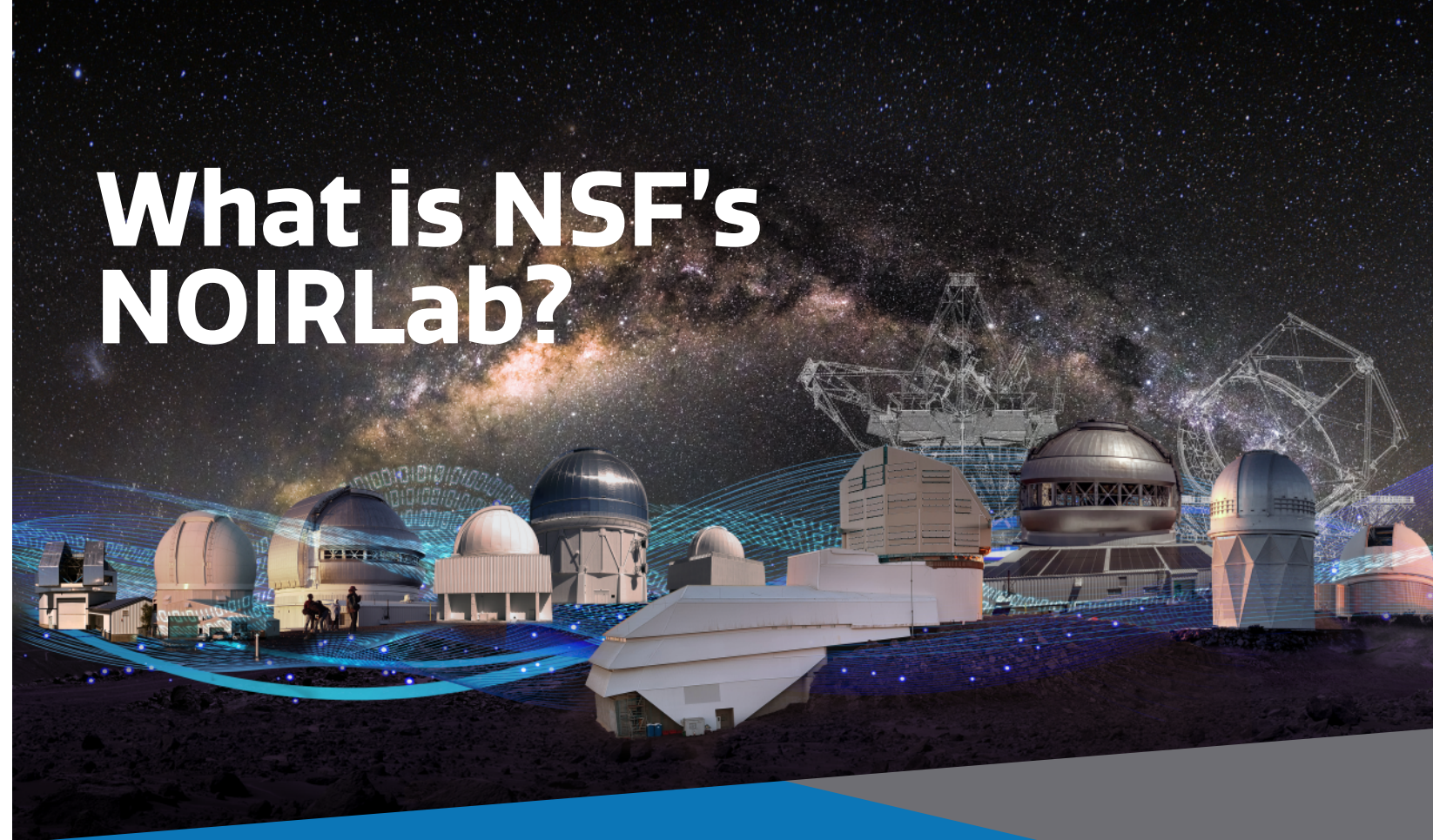
NOIRLab hosts 70 of the most diverse and innovative ground-based telescopes in the world, located at three amazing observing sites in Chile, Hawai'i, and Arizona, and is headquartered in Tucson, Arizona, USA.

The integration of these unique world-class facilities creates a powerful capability for discovery, technology development, education and workforce growth in the disciplines of science, technology, engineering and math.

Scientists from around the world use NOIRLab's telescopes to conduct their research. Scientists also pursue novel research through data mining within NOIRLab's petabyte-scale online data archive.

NOIRLab is managed by the Association of Universities for Research in Astronomy, Inc. (AURA) under a cooperative agreement with the National Science Foundation.

*NOIRLab's current and potential future system  
NOIRLab/NSF/AURA/  
P. Marenfeld*



# Astronomy's Golden Age

*Dark Energy Survey deep field image  
Dark Energy Survey/DOE/FNAL/  
DECam/CTIO/  
NOIRLab/NSF/AURA*

Astronomy is in a golden age of discovery with new and more powerful telescopes and instruments both in space and on the ground. In a remarkably short timespan, our knowledge of the Universe and our understanding of our place in the cosmos have changed radically.

Our inventory of the contents of the Universe has been turned on its head: 96% of the cosmic mass-energy is in forms undetected in terrestrial laboratories – dark matter and dark energy.

The once lonely night sky is now seen to be teeming with thousands of other worlds – many potentially hospitable to

life. New technologies will allow us to not only discover those other worlds, but observe them directly and analyze their atmospheres.

Violent events – exploding stars, merging black holes and colliding neutron stars – create ripples in the very fabric of spacetime that expand across the heavens that will be detected on Earth with Vera C. Rubin Observatory and the LIGO facility.

To solve these mysteries we're putting the greatest minds to work and are operating and building some of the largest and most advanced telescopes in the world.

*Víctor M. Blanco  
4-meter Telescope  
CTIO/NOIRLab/NSF/AURA/  
D. Munizaga*

*NOIRLab is the new US national center for nighttime astronomy and creates a powerful capability for discovery, technology development, STEM workforce growth and education. NOIRLab empowers astronomers to tackle the most pressing questions in astrophysics today and opens up new discovery spaces for the future.*

*NOIRLab is a national resource that will lead the world in data-intensive astronomy, drive exploration of the new frontier in time-domain astrophysics, and provide a foundation for scientists to make full use of the coming US Extremely Large Telescopes and other new tools for discovery in the 2030s and beyond.*

*NOIRLab aims to be the premier big data resource for US optical astronomy and will host a unique science archive of large-area surveys of the deep sky linked to powerful ancillary datasets. Data science schools train the power users of tomorrow and equip the community with powerful analytic tools.*

*Patrick McCarthy  
NOIRLab Director*



*M45 Pleiades  
NOIRLab/NSF/AURA/T.A.  
Rector/R. Cool/WIYN*

# The International Gemini Observatory

The international **Gemini Observatory**, a Program of NSF's NOIRLab, spans two continents, with an 8.1-meter telescope at each of two of the world's best observing sites. Gemini North is located near the summit of Maunakea in Hawai'i, and Gemini South is on Cerro Pachón on the edge of the Chilean Andes.

True to its namesake constellation, Gemini Observatory comprises two telescopes – the most infrared-optimized in ground-based astronomy – and together provide complete coverage of the sky.

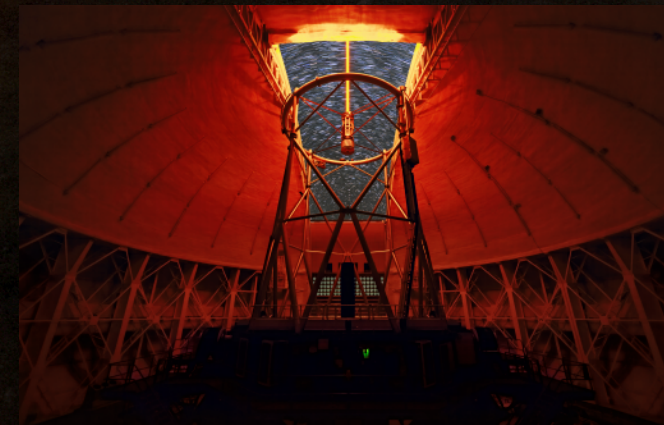
The Gemini international partnership is composed of the United States, Canada,



Chile, Brazil, Argentina, and Korea. The suite of capabilities at Gemini includes a wide-field laser adaptive optics system that complements other current ground- and space-based telescopes. Its exceptionally flexible operational model means it will be readily available to follow up rapid detections from the upcoming Vera C. Rubin Observatory.

Both Gemini North and Gemini South are operated from their base facilities at night and each telescope can also be operated from either hemisphere. Few facilities in the world have this capability and it means that observing time is more accessible to the wider astronomy community.

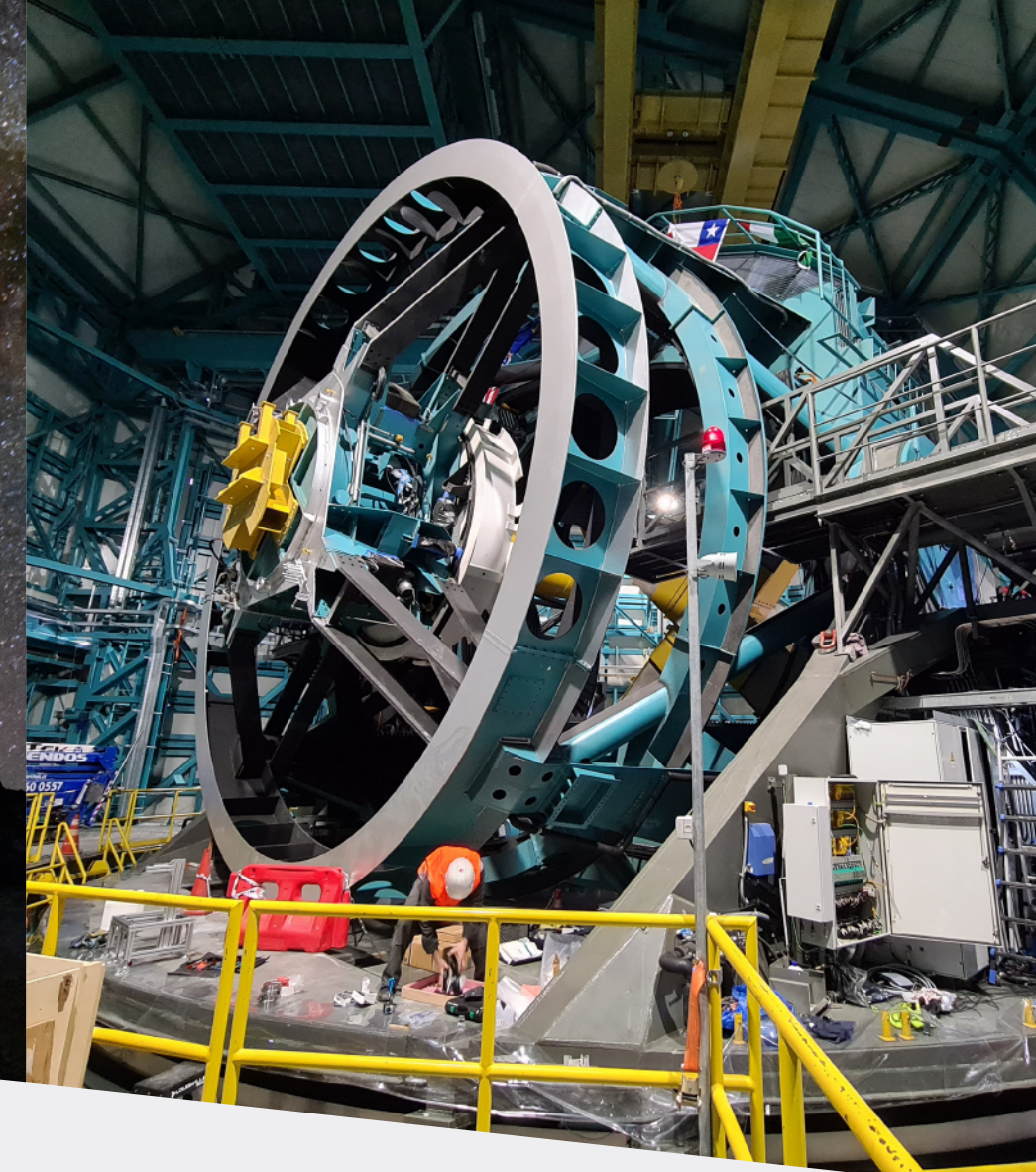
*Gemini North on Maunakea  
International Gemini  
Observatory/NOIRLab/NSF/  
AURA/P. Horálek*



*Gemini North  
International Gemini Observatory/NOIRLab/NSF/AURA/J. Chu*



*Carina Nebula western wall with adaptive optics  
International Gemini Observatory/NOIRLab/NSF/AURA/  
P. Hartigan (Rice University)*



# Vera C. Rubin Observatory

*Vera C. Rubin Observatory  
Rubin Obs/NSF/AURA/B. Quint*

The newest NOIRLab facility is **Vera C. Rubin Observatory**, which will survey the entire visible night sky in unprecedented detail every few nights, and detect 10 million changes in the sky per night. Rubin Observatory will be a leading resource for cutting-edge astronomical science, answering questions such as: *What is the nature of dark matter and dark energy? When and how did the Milky Way and other galaxies form? What processes shaped our Solar System? What risk do some Solar System objects, like asteroids, pose to life on Earth? What can we learn from the changing Universe by studying it in real time?*

Rubin Observatory is an integrated system consisting of an 8.4-meter telescope, a 3200-megapixel camera, an automated data processing system, and an online public engagement platform.

In its first ten years of operations, Rubin Observatory will conduct the Legacy Survey of Space and Time (LSST), capturing about 1000 images of the sky every night. Rubin Observatory will generate approximately 20 terabytes of data per night, and over its ten-year survey will produce a 15 petabyte catalog database – a massive amount of astronomical data.

Rubin Observatory is a partnership supported equally by funding from the US National Science Foundation (NSF) and the US Department of Energy (DOE) and is operated by NSF's NOIRLab and SLAC National Accelerator Laboratory.

Rubin Observatory is a remarkable engineering and technical achievement, the result of many years of work by a diverse team of skilled experts in a variety of fields.

*Inside the observatory, progress continues on the Telescope Mount Assembly  
Rubin Obs/NSF/AURA*

# Kitt Peak National Observatory



High atop a mountain range in Arizona's Sonoran Desert sits **Kitt Peak National Observatory** (KPNO), the very heart of ground-based nighttime astronomy in the continental US since 1958. It is home to one of the largest collections of optical and radio telescopes in the world.

The Dark Energy Spectroscopic Instrument (DESI), at the Nicholas U. Mayall 4-meter Telescope at KPNO, is the most powerful multi-object spectrograph in the world, measuring

the distances to more than 100,000 galaxies every night to understand the impact of dark energy on the expansion of the Universe. DESI is led by the US Department of Energy's Office of Science and Lawrence Berkeley National Laboratory. DESI has already mapped more galaxies than all previous similar surveys combined.

KPNO also operates the 3.5-meter WIYN Telescope — a partnership between Indiana University, the University

of Wisconsin, Pennsylvania State University, the University of California Irvine, Purdue University and NOIRLab, with NSF and NASA partnering on the NEID instrument through the NN Explore program. NEID is designed to measure the motion of nearby stars with extreme precision, with the potential to uncover Earth-mass exoplanets.

KPNO's visitor center offers daytime guided tours and a variety of evening

stargazing programs. NOIRLab also hosts a variety of programs with the Tohono O'odham Nation.

NSF's new *Windows on the Universe Center for Astronomical Outreach* at Kitt Peak will provide the public with a new way to experience the cutting-edge research carried out by NSF's astronomy facilities around the globe.

*Kitt Peak National Observatory  
KPNO/NOIRLab/NSF/AURA/  
P. Marenfeld*

# Cerro Tololo Inter-American Observatory



*Cerro Tololo Inter-American Observatory  
CTIO/NOIRLab/NSF/AURA/  
B. Tafreshi*

Since 1965 US astronomers have used **Cerro Tololo Inter-American Observatory** (CTIO) in Chile as the principal platform for their investigations of the southern skies.

The largest telescope at CTIO, the Víctor M. Blanco 4-meter Telescope, features the Dark Energy Camera (DECam). One of the best performing wide-field CCD imagers in the world, the 570-megapixel DECam was funded by the US Department of Energy (DOE), and was built and tested at DOE's Fermilab. Its science archive is curated by NOIRLab's Community Science and Data Center.

CTIO has over 40 telescopes that are used to investigate a wide variety of research topics, including exoplanets, the Sun, Earth's atmosphere, meteors, supernovae, gamma-ray bursts, and dark energy. Some of these telescopes are also used for educational purposes.

CTIO operates the 4.1-meter Southern Astrophysical Research (SOAR) Telescope, designed to produce the best quality images of any observatory in its class. Located on Cerro Pachón, SOAR is a joint project of the Ministério da Ciência, Tecnologia e Inovações do Brasil (MCTIC/LNA), NSF's NOIRLab, the University of North Carolina at Chapel Hill, and Michigan State University.

*SOAR Telescope  
CTIO/NOIRLab/NSF/AURA/M. Paredes*





NOIRLab Headquarters  
computer room  
NOIRLab/NSF/AURA/T. Slovinsky

# The Community Science and Data Center

NOIRLab's **Community Science and Data Center (CSDC)** is a sophisticated science platform providing high-level tools for the discovery, exploration, and analysis of large public survey datasets. CSDC supports and enables a broad range of science activities for the US ground-based optical and infrared astronomical communities.

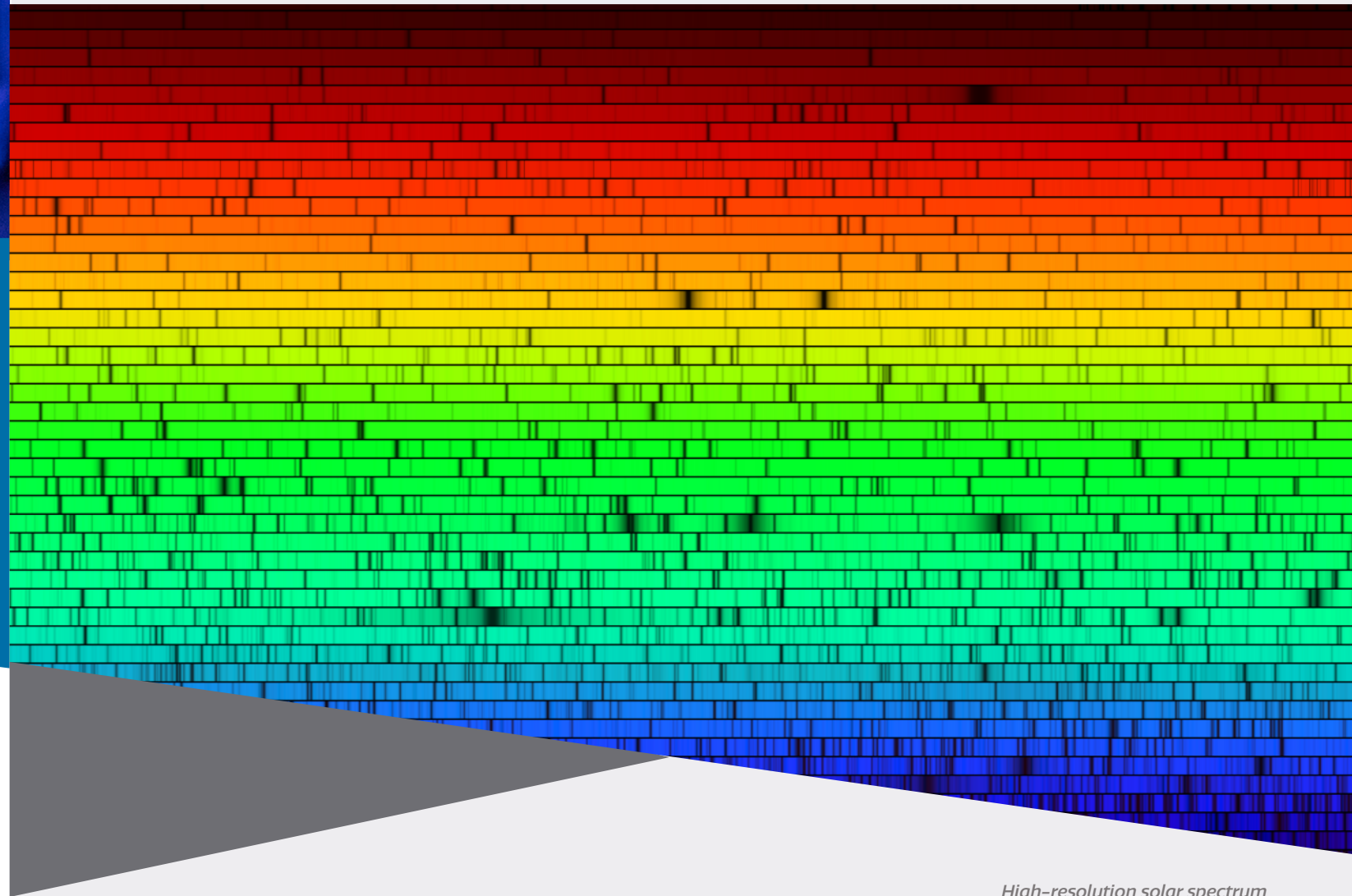
Using archival data to make new discoveries is becoming increasingly important in astronomy. CSDC's Data Management Operations provides core transport, archiving, processing, and online distribution for data obtained at CTIO and KPNO telescopes to facilitate archival data-discovery.

CSDC offers Time Domain Services, developing infrastructure for time-domain astronomy, including the ANTARES event broker, a software tool built at NOIRLab to process information about changing objects in the night sky.

Astro Data Lab relieves the technical burden of downloading billion-object astronomical catalogs and opens the discovery space to the astronomy community from a variety of institutions.

CSDC operates the peer-review proposal process through which scientists can implement their observational research programs. CSDC staff also provide support to astronomers to analyze the data they obtain from NOIRLab telescopes.

On behalf of NOIRLab, CSDC provides institutional support for the US Extremely Large Telescope Program, the La Serena School of Data Science, and other capacity-building initiatives in optical and infrared astronomy.

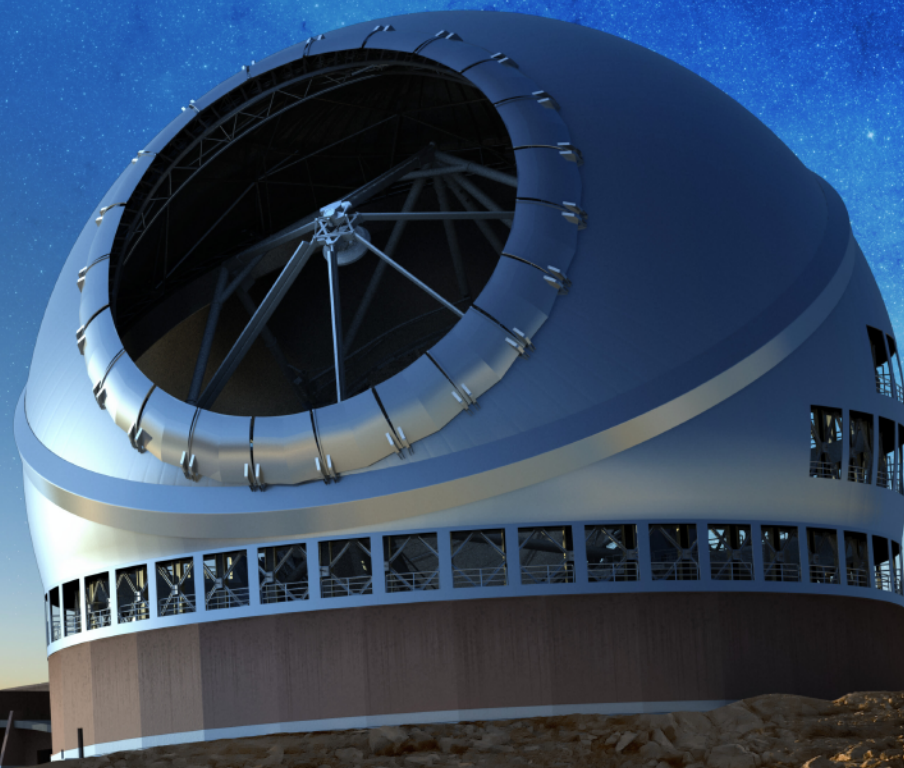


High-resolution solar spectrum  
NOAO/NSO/KPNO/NSF/AURA/  
N.A. Sharp



# The US Extremely Large Telescope Program – Two Telescopes, One System

The **US Extremely Large Telescope Program (US-ELTP)** is a joint endeavor of NSF's NOIRLab and the organizations building the Thirty Meter Telescope and the Giant Magellan Telescope. It was ranked as the highest ground-based priority by the community in the National Academies of Sciences, Engineering, and Medicine's Astro2020 Decadal Survey report *Pathways to Discovery in Astronomy and Astrophysics for the 2020s*.



*Thirty Meter Telescope  
illustration  
TMT International Observatory*



*Giant Magellan Telescope  
illustration  
GMTO Corporation*

The US-ELTP is a joint initiative that will provide astronomers in the US with nationally-funded access to at least 25% of the observing time on the Giant Magellan Telescope in the southern hemisphere and the Thirty Meter Telescope in the northern hemisphere.

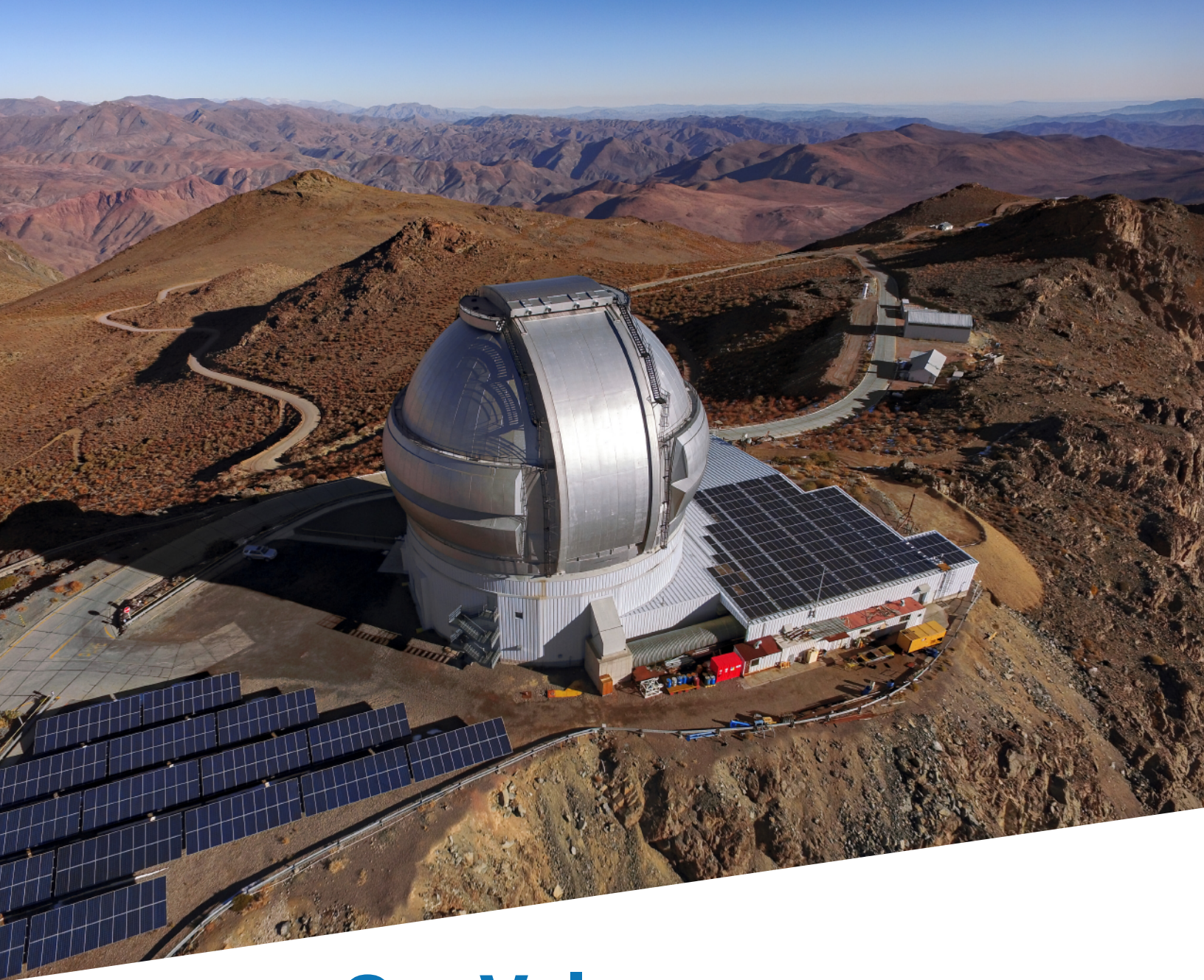
Facilitated by NOIRLab, scientists anywhere in the US will be able to propose to use either or both telescopes to observe objects anywhere in the sky and carry out transformational research on topics ranging from the exploration of exoplanets and their atmospheres to the nature of dark matter and dark energy.

The 50% sky overlap between the Giant Magellan Telescope and the Thirty Meter

Telescope enables complementary, sequential, or simultaneous observations with both observatories.

The capabilities of the two telescope designs are different, offering between them a large and diverse range of instruments and synergy with other space- and ground-based facilities.

NOIRLab will archive all data from both observatories and provide integrated user support services, including data reduction and analysis tools. NOIRLab's US-ELTP Research Inclusion Initiative will support the scientific participation of the broadest US astronomy community.



*Gemini South telescope with its solar panels  
International Gemini Observatory/NOIRLab/NSF/AURA/PK. Chen*

## Our Values

NOIRLab's staff have identified their highest-priority values for the organization which include safety, transparency, respect, accountability and integrity. Diversity and inclusion is a high priority value for the organization. NOIRLab is working to support more diversity in our workforce and scientific user community, and is investing in truly democratizing astronomy.

Being a good steward of Earth and the sky is one of NOIRLab's core principles. This commitment begins in our local host communities in Hawai'i, Arizona, and Chile. We are committed to reducing our carbon footprint from all sources through the use of renewable energy and improved efficiency.



Over the past few decades the relationships between Indigenous peoples and endeavors such as astronomy have been profoundly transformed.

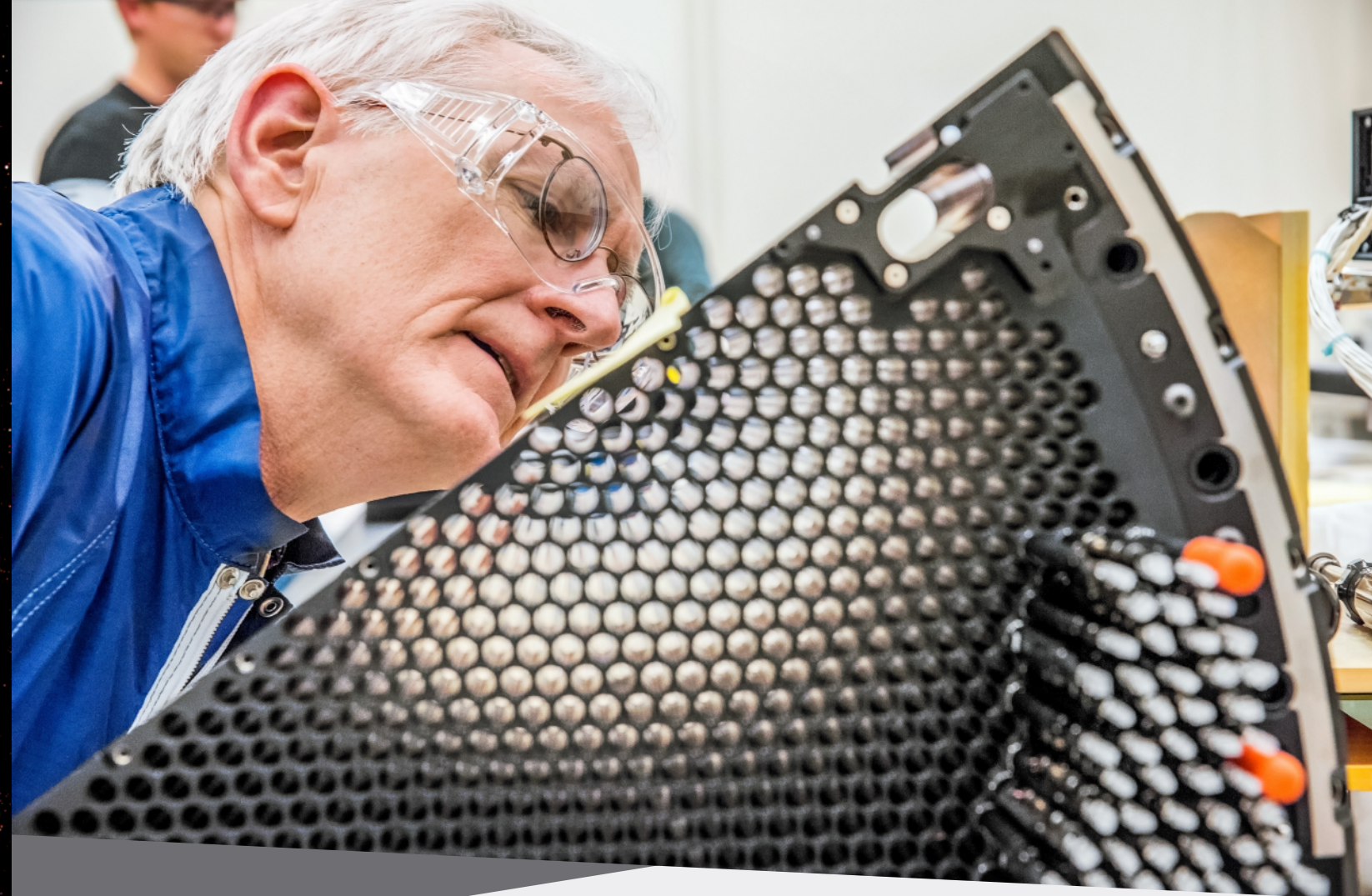
NOIRLab is committed to engaging the local communities where our facilities are located. NOIRLab provides paths to leadership and career opportunities for local workforces and contributes significantly to the local economies of Arizona, Chile, and Hawai'i. We will continue to support local communities by encouraging them to participate in our education and engagement activities, to visit our facilities and to encourage the pursuit of career paths in STEM, management, and support functions.

*NOIRLab's Colors of Nature Summer Academy  
KPNO/NOIRLab/NSF/AURA/  
R. Sparks*

# Community Support — We Are Here for Astronomers

NOIRLab serves as a focal point for community development of innovative scientific programs. NOIRLab is a place where ideas can grow into proposals, proposals into data, data into science, and science into publications. **NOIRLab's infrastructure enables the astronomy community to explore significant areas of astrophysics, including dark energy and dark matter, galaxies and quasars, the Milky Way, exoplanets, and small bodies in our own Solar System.**

*Comet C/2001 Q4 (NEAT)  
WIYN/NOIRLab/NSF/AURA/T.A.  
Rector (University of Alaska  
Anchorage), Z. Levay and L.  
Frattare (Space Telescope  
Science Institute)*



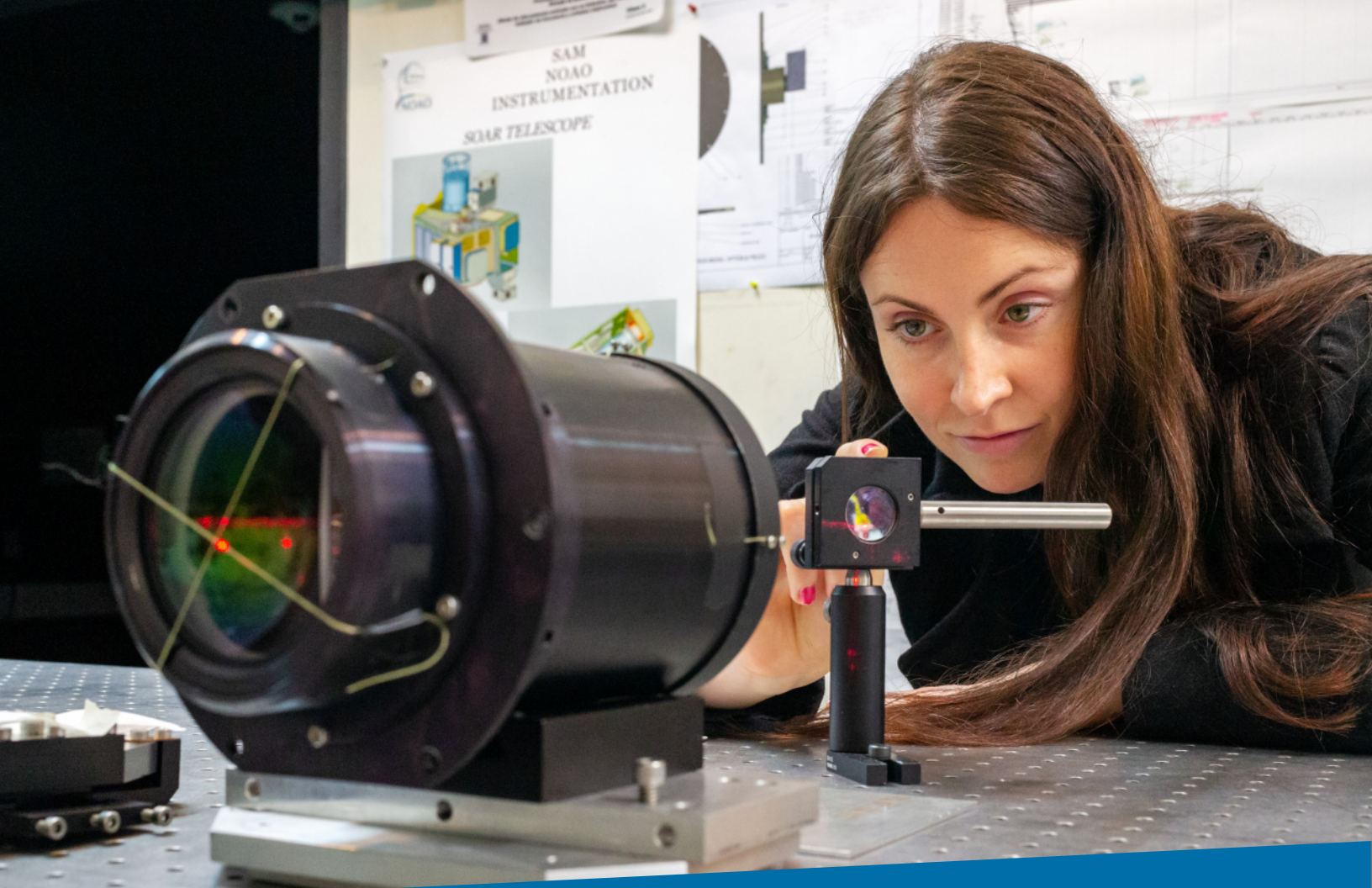
Technical expertise at NOIRLab provides complete support for, and upgrades to, telescope operations, from mechanical, electrical and optical systems to software controls, adaptive optics, and detectors.

NOIRLab serves and empowers our diverse community of users. NOIRLab prioritizes inclusive observing access by implementing best practices to mitigate bias in the allocation of telescope resources. NOIRLab also prioritizes inclusive engagement in data-intensive astronomy research through well-curated data archives and corresponding low-barrier-to-entry portals, workshops, and training.

NOIRLab trains the scientific and technical leaders of tomorrow through internships, student programs, and post-doctoral research fellowships. We work to ensure that astronomy, and scientific careers in general, are accessible to a diverse and inclusive community.

NOIRLab takes a leadership role in community-based discussions for the future. In collaboration with the astronomy community, partner organizations, other US optical and infrared system operators, and NSF, NOIRLab develops and advances a strategic vision for future NSF-funded optical and infrared facilities.

*Assembling the focal plane for  
the Dark Energy Spectroscopic  
Instrument (DESI)  
M. Chung/Lawrence Berkeley  
National Lab/KPNO/NOIRLab/  
NSF/AURA*



# Societal Benefits — We Are Here for You

*Nicole David working on optics  
NOIRLab/NSF/AURA/M. Paredes*

Astronomy as a field of research is extremely fast-moving, delivering new results on a daily basis. Astronomy touches the largest philosophical questions of the human race: *Where do we come from? Where will we end? How did life arise? Is there life elsewhere in the Universe?* Astronomy can lead the way for other natural sciences and be a frontrunner in science communication and education.

NOIRLab's discoveries, facilities, technology, and people are featured in our communication and education activities in order to strengthen the public's appreciation of science and the science community's awareness of NOIRLab's work.

To increase the diversity of the science, technology, engineering, and mathematics (STEM) workforce, both inside and outside NOIRLab, we


take a multifaceted approach that combines attention to NOIRLab's internal workplace culture, best practices in recruitment, and new professional development programs such as mentorships, internships, fellowships, and visitors.

NOIRLab has a vital role to play in the development of the STEM workforce, in sharing our passion for discovery, and in keeping the world informed of the

exciting work done at our observatories. We will leverage our power to grow the STEM workforce that is vital to sustaining US leadership in science and technology.

NOIRLab works in schools in our local communities to bring the excitement of astronomy to the classroom. Educational programs increase the science-literacy of K-12 and college audiences, especially through data-driven materials.

*Gemini Director Jen Lotz participating in Journey Through the Universe International Gemini Observatory/NOIRLab/NSF/AURA/J. Pollard*



*Helix Nebula*  
NASA/ESA/NOIRLab/NSF/  
AURA/M. Meixner/T.A. Rector



[noirlab.edu](https://noirlab.edu)



[info@noirlab.edu](mailto:info@noirlab.edu)



+1 520 318 8000



@NOIRLabAstro  
@NOIRLabAstroES



NOIRLab HQ  
950 N Cherry Ave,  
Tucson, AZ 85719  
USA

Visit our sites in Arizona, Hawai'i,  
and Chile for free!

<https://noirlab.edu/public/visits/>

The astronomical community is honored to have the opportunity to conduct astronomical research on I'oligam Du'ag (Kitt Peak) in Arizona, on Maunakea in Hawai'i, and on Cerro Tololo and Cerro Pachón in Chile.

We recognize and acknowledge the very significant cultural role and reverence that these sites have to the Tohono O'odham Nation, to the Native Hawaiian community, and to the local communities in Chile, respectively.