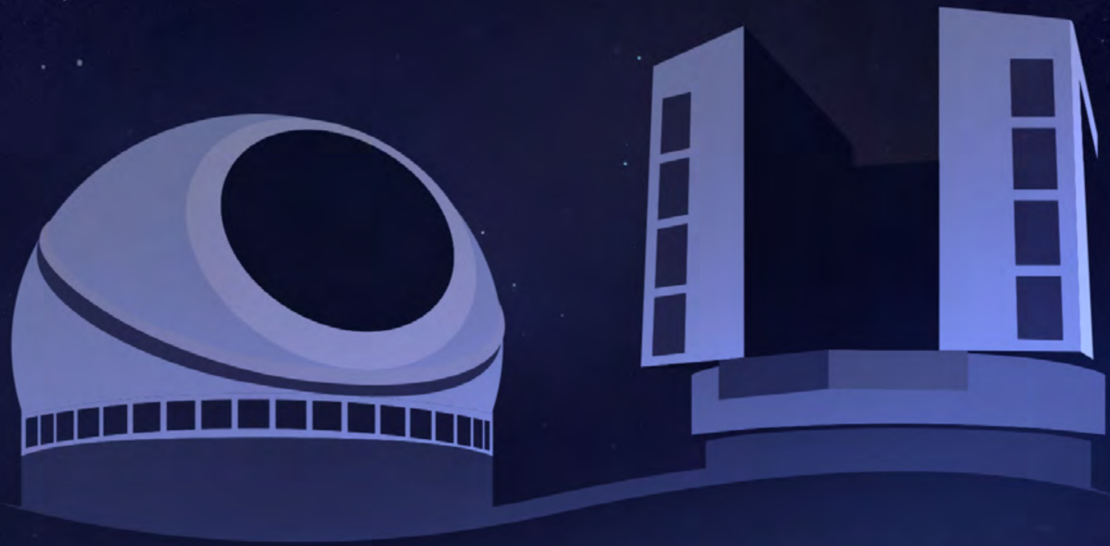
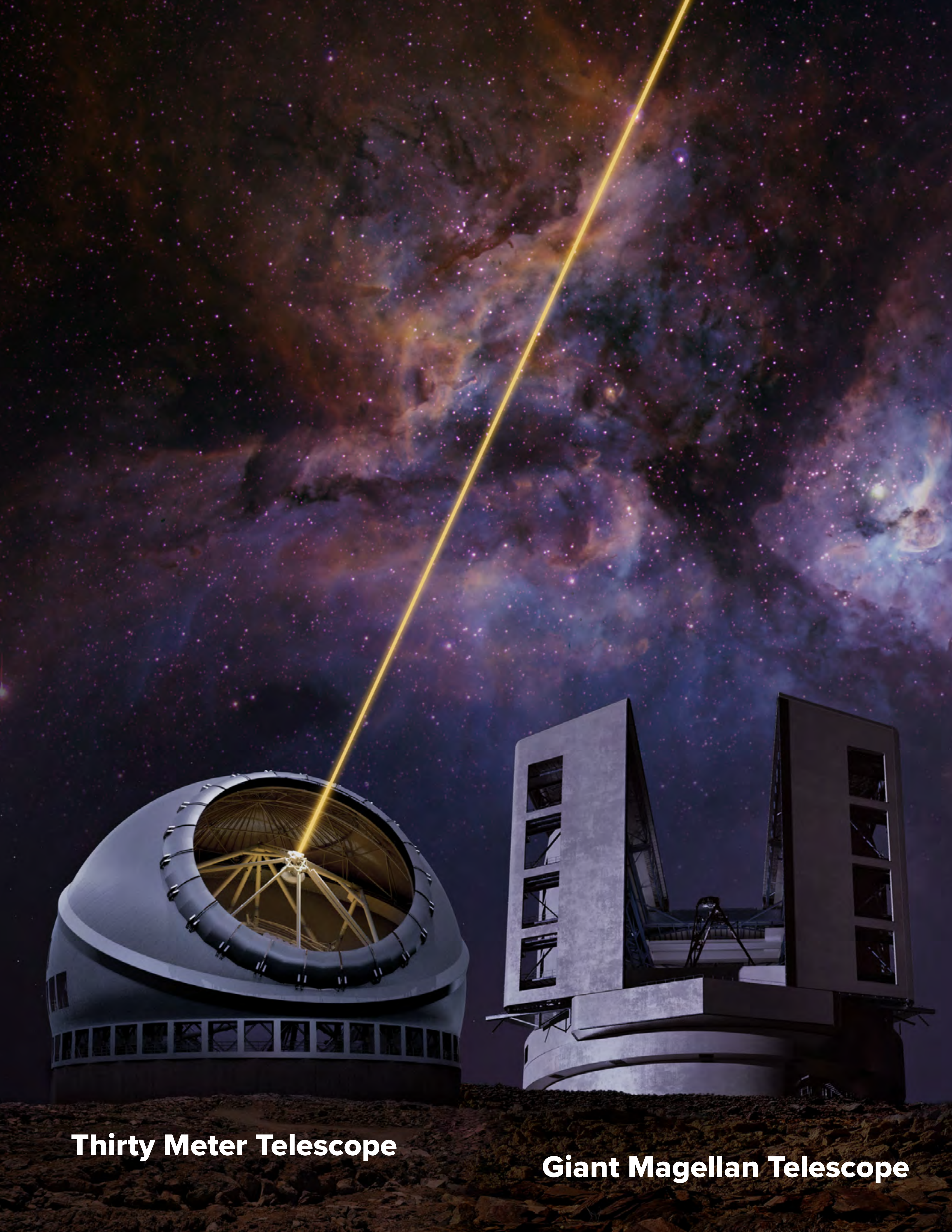


US EXTREMELY LARGE TELESCOPE PROGRAM

GIANT MAGELLAN TELESCOPE

NOIR Lab

TMT
THIRTY METER TELESCOPE


Thirty Meter Telescope
Giant Magellan Telescope

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 Giant Magellan Telescope and the Thirty Meter Telescope. It was ranked as the highest ground-based priority by the community in the Astro2020 Decadal Survey report, Pathways to Discovery in Astronomy and Astrophysics for the 2020s.

Proposed to the National Science Foundation (NSF), the US-ELTP system will provide astronomers in the US with nationally funded access to at least 25% of the observing time on both the Giant Magellan Telescope in the southern hemisphere and the Thirty Meter Telescope in the northern hemisphere.

Scientists anywhere in the US will be able to use the US-ELTP system to observe objects anywhere in the sky and carry out transformational research on topics ranging from the search for life outside the Solar System to the nature of dark matter and dark energy. With their complementary designs and a diverse set of instruments, the two next-generation telescopes will offer great synergy with other facilities in space and on the ground.

The 50% sky overlap between the telescopes will facilitate observations of the most interesting objects in the sky with both observatories.

Being situated in substantially different time zones on the globe will allow the two telescopes to study astronomical phenomena for longer spans of time — which is important for studying rapidly changing objects.

NSF's NOIRLab will be the US community portal to the US-ELTP system and will provide an extensive suite of user services, documentation, and training to support the entire research lifecycle — from submission of proposals, to observations, to data analysis.

NOIRLab will archive all scientific data from both observatories and lead the US-ELTP Research Inclusion Initiative that will support the scientific participation of the broadest US astronomical community by specifically addressing the concerns of researchers at small and under-resourced institutions.

Through the US-ELTP, the US national scientific community will partner with 8 other countries in the observatories' global consortia.

Ground-breaking Science

The US-ELTP will enable scientists to carry out transformational research with the Giant Magellan Telescope and the Thirty Meter Telescope, addressing all three primary science themes identified by the Decadal Survey report *Pathways to Discovery in Astronomy and Astrophysics* for the 2020s.

Worlds and Suns in Context

Studying exoplanetary systems, including their formation and evolution and the interconnections between planets and their host stars.

Is there life outside our Solar System?

Both telescopes will have the capability to image planets in the habitable zones around nearby stars, and measure atmospheric biomarkers that can indicate whether a planet harbors life. Access to both hemispheres will allow US-ELTP to detect extraterrestrial life, wherever it may arise, even if it is rare.

What can other planetary systems teach us about our own?

The unprecedented resolution of these technologically advanced telescopes will reveal the physics and chemistry of forming planetary systems, and their unprecedented sensitivity will permit precision measurements of the architectures of planetary systems around other stars.

New Messengers and New Physics

Connecting the new frontiers of gravitational wave detection, time domain astronomy, and state-of-the-art telescopes to answer fundamental questions in physics and cosmology.

What can gravitational waves teach us about the basic properties of matter?

The Nobel Prize-winning detection of gravitational waves emitted by merging neutron stars and black holes has opened up a new vista of cosmic physics. Follow-up optical observations will decode the role of gravitational wave events in the creation of heavy elements and the physics of ultra-dense matter. Most gravitational wave events will be too faint for today's telescopes, but the US-ELTP system will extend our reach, enabling us to observe these cosmic explosions — wherever they occur in the sky.

Will our observations reveal hidden physics beyond the standard model?

Less than 5% of the mass in the Universe is in the form of normal matter made of atoms. The rest is composed of dark matter and dark energy of an unknown nature. Observations with the cutting-edge technology of the US-ELTP system will provide new insights into the fundamental properties of dark matter and will allow unique measurements of cosmic expansion that will reveal the true nature of dark energy.

Above: Neutron star collision.
Credit: Harvard-Smithsonian Center for Astrophysics

Background image: Exoplanet system. IAU/L. Calçada

Cosmic Ecosystems

Decoding the interconnections of gas, stars, and black holes in galaxies that shape the evolving life cycle of galaxies.

How did galaxies form and grow in the early Universe?

The US-ELTP system will resolve the detailed inner structure of galaxies in the young Universe and measure the cycle of flowing gas that connects galaxies to the cosmic web of intergalactic matter.

What does the fossil record reveal about the formation of galaxies and black holes?

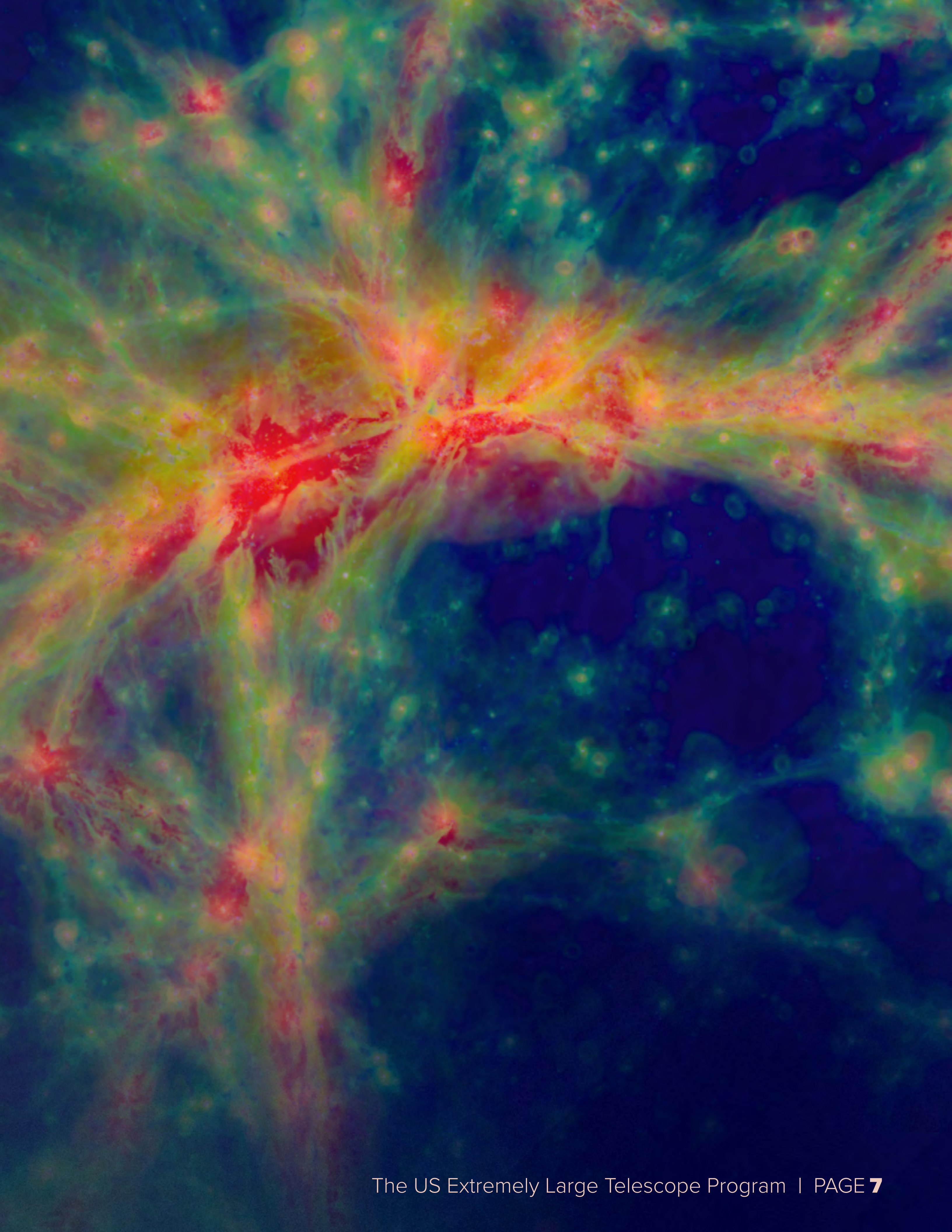
Our Milky Way and nearby galaxies are a rich laboratory in which to study the history of galaxy formation. Observations with the US-ELTP system will diagnose these stellar fossils and search for the missing link between stellar and supermassive black holes.

Unexpected discoveries anywhere in the sky

Allowing US astronomers to make surprising discoveries with the US-ELTP system — in both the northern and southern skies. The Universe never fails to astonish!

Above: Deep galaxy field. (Dark Energy Survey/DOE/FNAL/DECam/CTIO/NOIRLab/NSF/AURA)

Background image: Cosmic Web. (Eagle Project)



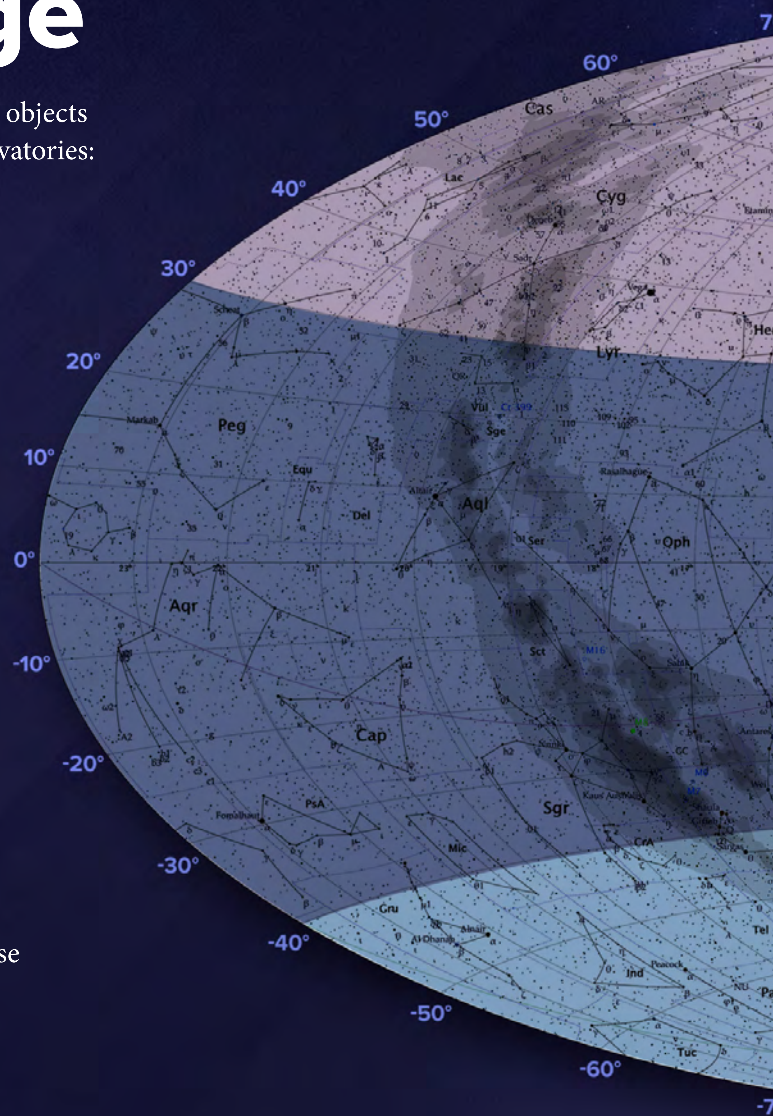
All-sky Coverage

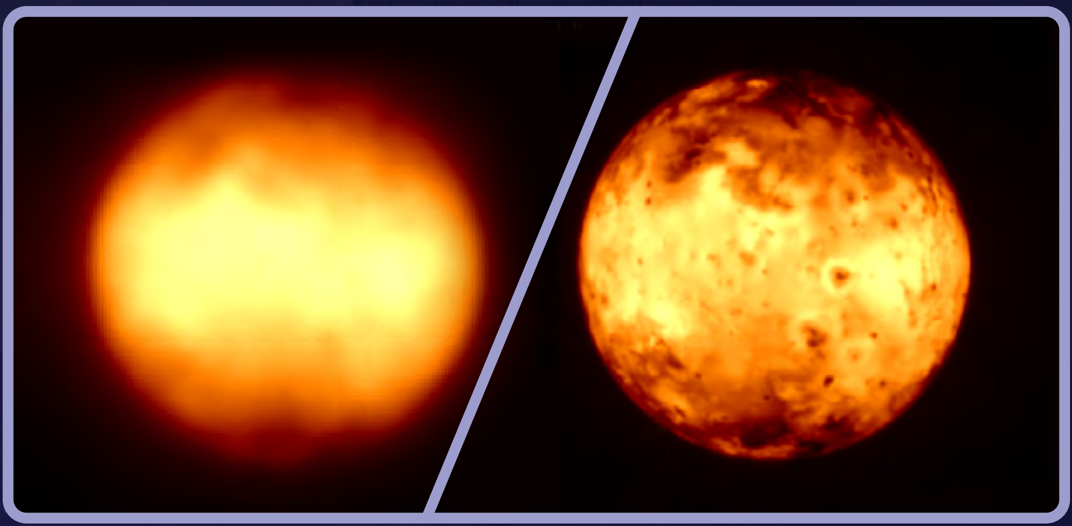
The US ELT Program will empower US astronomers to observe objects anywhere in the sky using two powerful, next-generation observatories: the Giant Magellan Telescope and the Thirty Meter Telescope.

Their extremely large primary mirrors will enable observations from ultraviolet to mid-infrared wavelengths with up to 80 times the sensitivity of today's largest telescopes. State-of-the-art adaptive optics systems will compensate for the blurring effects of Earth's atmosphere, and deliver images at infrared wavelengths that are more than 12 times sharper than those of the famed Hubble Space Telescope, and 4 times sharper than those of the new James Webb Space Telescope.

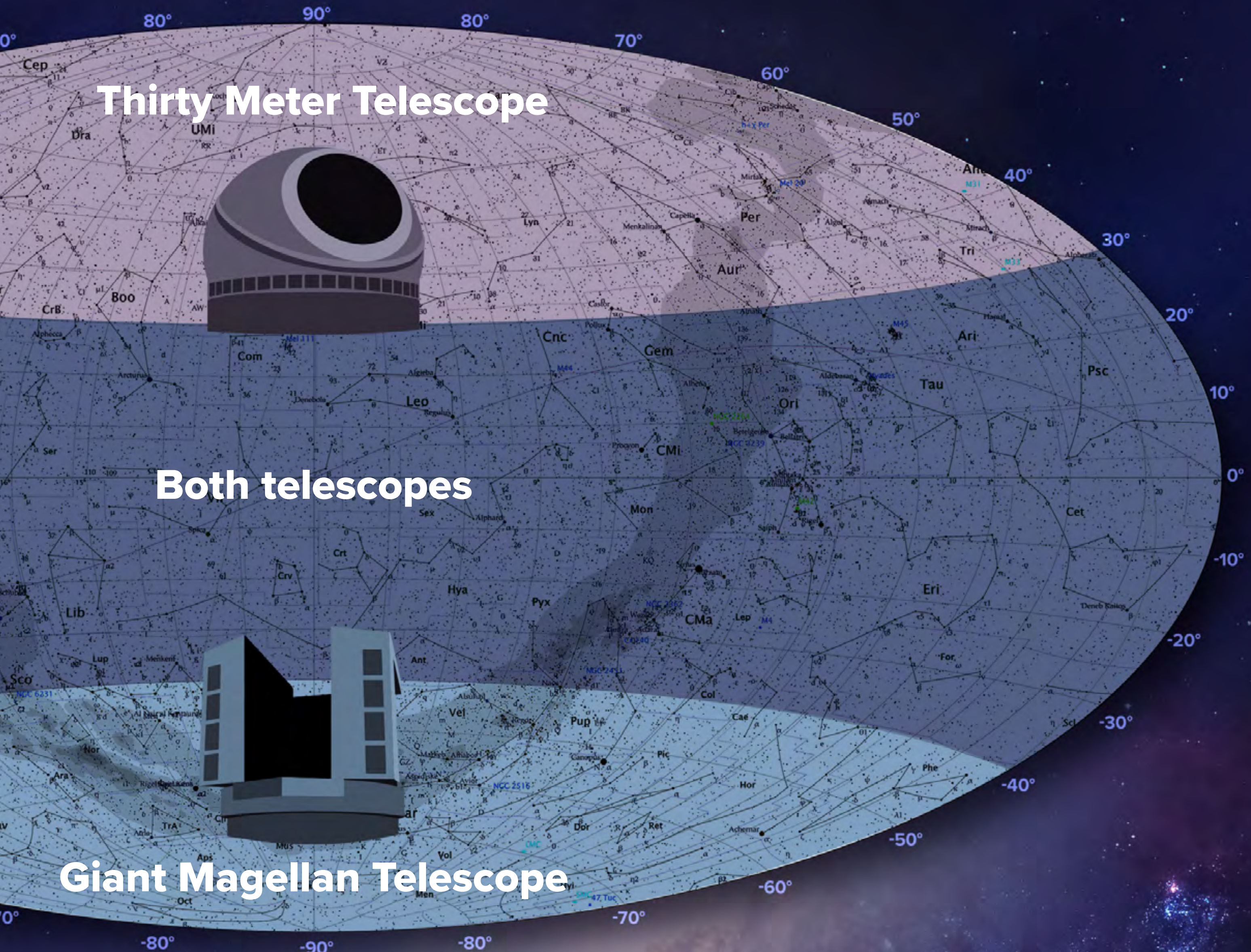
This combination of sensitivity and image quality will allow these telescopes to peer deeper into the Universe and reveal details of cosmic objects that are invisible with today's observatories. Both observatories incorporate innovations in precision control that make it possible to acquire a new science target anywhere on the sky within a few minutes — a critical capability for rapid follow-up of gravitational wave sources and other cosmic explosions.

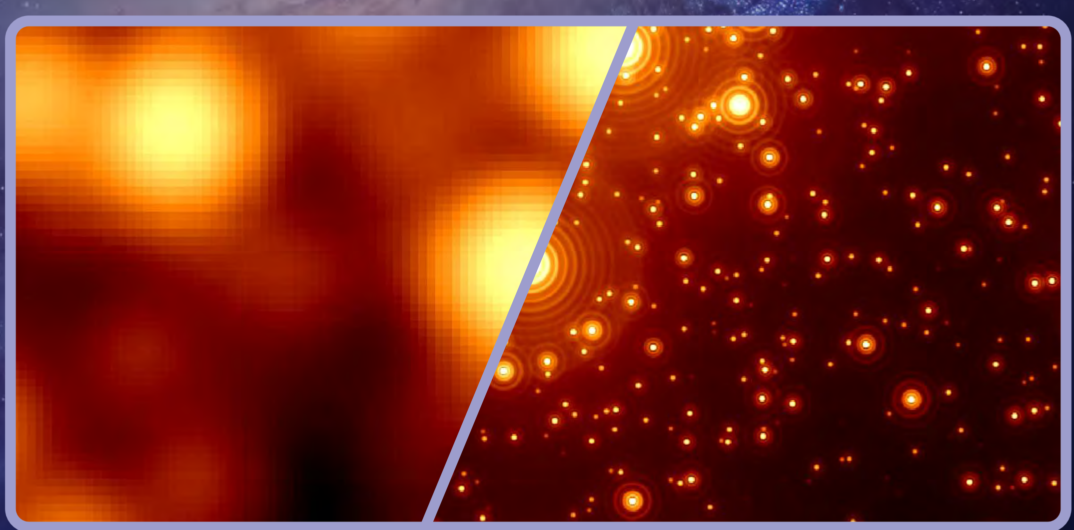
The two telescopes have complementary designs, each offering unique scientific advantages. The US-ELTP will support a diverse suite of powerful instruments that will enable US researchers to conduct forefront scientific investigations and transform our understanding of the Universe.





Comparison of simulated reflected-light observations of Jupiter's moon Io with Keck adaptive optics (left) and the Thirty Meter Telescope (right). The unprecedented resolving power of the US-ELTP system will allow a detailed monitoring of Io's volcanic activity down to 20 kilometers in resolution. T. Do/UCLA/IRIS/TMT.





The simulated image on the right shows the performance of the Giant Magellan Telescope's adaptive optics system, delivering 0.01 arc second resolution, compared to the typical ground-based resolution of 0.65 arcsecond (left). Credit: Giant Magellan Telescope – GMTO Corporation

Thirty Meter Telescope

The Thirty Meter Telescope will be the largest optical telescope in the northern hemisphere. It will be sited either on Maunakea in Hawai‘i, or on Roque de los Muchachos in La Palma, Spain, its alternative site. The telescope will be equipped with a state of the art laser guide star adaptive optics system that will provide unparalleled imaging and spectroscopic capabilities to scientists worldwide. The Thirty Meter Telescope will use a segmented primary mirror, as successfully pioneered on the W.M. Keck Observatory twin telescopes.

The Thirty Meter Telescope project is a non-profit collaboration between the University of California, the California Institute of Technology, the National Astronomical Observatories of the Chinese Academy of Sciences, the National Institutes of Natural Sciences of Japan, the National Research Council of Canada and the Department of Science and Technology of India. Significant funding has been provided by the Gordon and Betty Moore Foundation.

Learn more about the Thirty Meter Telescope at tmt.org.

FAST FACTS

The 50-meter tall telescope weighs 2,650 tons and is enclosed within a very compact 56-meter tall dome.

The 30-meter primary mirror array is composed of 492 hexagonal segments, each 1.44-meters across. It will be three times as wide, with nine times more collecting area, than the largest currently existing optical telescopes in the world.

Its unique adaptive optics system will deliver the sharpest and most stable image quality over a wide patch of sky.

The two Nasmyth instrument platforms can accommodate up to ten versatile scientific instruments and two adaptive optics facilities.

Giant Magellan Telescope

The Giant Magellan Telescope is the most optically efficient of the extremely large telescopes, providing the highest possible resolution over the widest field of view of the Universe with seven of the world's largest mirrors. The telescope is under construction on Las Campanas Observatory at the southern edge of Chile's Atacama Desert, one of the best locations on Earth from which to explore the heavens.

The Giant Magellan Telescope is the work of an international consortium of thirteen universities and research institutions from the United States, South Korea, Israel, Brazil, and Australia. Founders include Arizona State University, Astronomy Australia Ltd., Australian National University, Carnegie Institution for Science, Fundação de Amparo à Pesquisa do Estado de São Paulo — FAPESP, Harvard University, Korea Astronomy and Space Science Institute, Smithsonian Institution, Texas A&M University, The University of Texas at Austin, University of Arizona, University of Chicago, and the Weizmann Institute of Science. The telescope is being designed, built, and operated by the GMTO Corporation, a nonprofit organization headquartered in Pasadena, California.

Learn more at GiantMagellan.org.

FAST FACTS

The 39-meter-tall telescope weighs 2,100 tons and is housed in a 65-meter enclosure that can complete a full rotation in nearly 3 minutes.

The 25.4-meter primary mirror array consists of seven 8.4-meter segments. They are world's largest mirrors, and each take four years to cast and polish.

The built in advanced adaptive optics system offers multiple viewing modes, enabling the highest resolution over the widest field of view of the Universe.

The Gregorian design can accommodate up to ten scientific instruments, from wide field imagers and spectrographs that reach hundreds of objects at one time, to high-resolution imagers and spectrographs that can study exoplanets and even find biosignatures.

GIANT MAGELLAN TELESCOPE

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