Protected: DESI's 5000 eyes open as Kitt Peak Telescope prepares to map space and time

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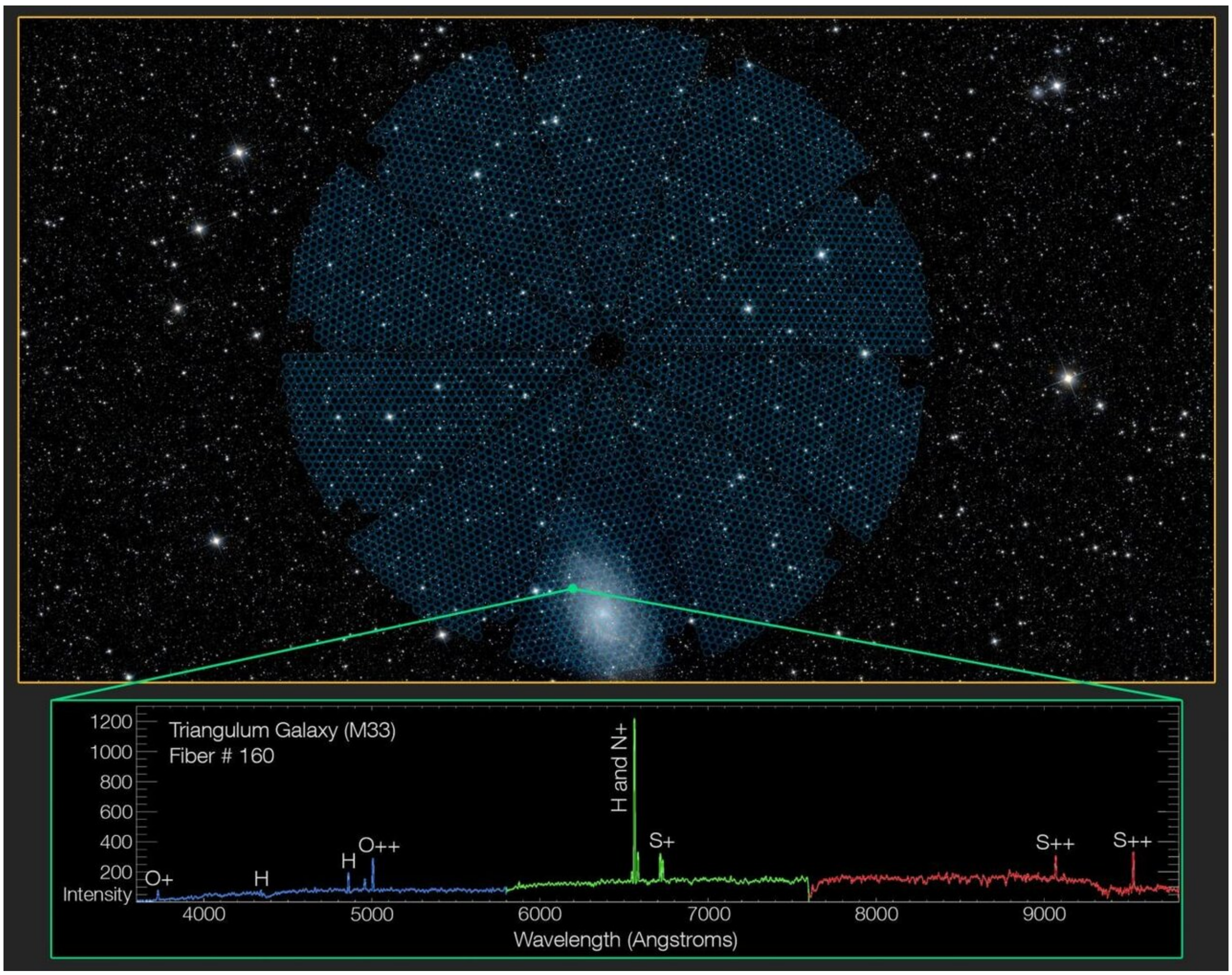


DESI's 5000 spectroscopic 'eyes' can cover an area of sky approximately 38 times larger than the full moon, as seen in this overlay of DESI's focal plane on the night sky (top). Each of the robotically controlled eyes can fix a fiber-optic cable on a single galaxy or star to gather its light. The green dot marks the location of a single fiber positioner. In the test spectrum captured by DESI on October 22, 2019, the light gathered from a small region in the Triangulum galaxy, M33, by a single fiber-optic cable is dispersed into a spectrum (bottom) that reveals emission lines. The lines both encode the elements present in the galaxy and aid in gauging the galaxy's distance. Credit: DESI Collaboration; Legacy Surveys; NASA/JPL-Caltech/UCLA; NSF's National Optical-Infrared Astronomy Research Laboratory

A new instrument on the 4-m Mayall telescope has opened its array of thousands of fiber-optic "eyes" to the cosmos and successfully captured the light from distant galaxies. The milestone marks the beginning of final testing for the Dark Energy Spectroscopic Instrument (DESI), which is poised to begin creating the most detailed map of the Universe ever undertaken. The Mayall telescope is located at Kitt Peak National Observatory (KPNO), which is operated by the National Science Foundation's National Optical-Infrared Astronomy Research Laboratory (NSF's OIR Lab).

Mapping to Understand Dark Energy

Beginning early next year, DESI will embark on a five-year mission to map the cosmos. Its goal: to chart the positions and distances of 35 million galaxies spread across 1/3 of the sky and over cosmic time, as far back as 11 billion years ago. DESI will also study 10 million stars in our galaxy, the Milky Way. The undertaking will tackle one of the most puzzling and profound problems in physics: the nature and physics of dark energy, an unknown form of energy that is currently understood to permeate the Universe and accelerate its expansion.

To measure the distances to galaxies, DESI takes the fingerprint of a galaxy by measuring its spectrum: the light from individual galaxies is dispersed into fine bands of color to measure a galaxy's redshift and its distance from Earth. To measure the distances to millions of galaxies, DESI is highly multiplexed and employs state-of-the-art technology. Robotic positioners automatically point DESI's fiber-optic eyes at preselected sets of galaxies, 5000 at a time, and by measuring their spectra, gauge how much the Universe expanded as their light traveled to Earth. In ideal conditions, DESI can study more than 100,000 galaxies a night.

"After a decade in planning and R&D, installation and assembly, we are delighted that DESI can soon begin its quest to unravel the mystery of dark energy," said DESI Director Michael Levi of the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab), the lead institution for DESI's construction and operations."Most of the Universe's matter and energy are dark and unknown, and next-generation experiments like DESI are our best bet for unraveling these mysteries," Levi added. "I am thrilled to see this new experiment come to life."

A Venerable Telescope at the Forefront of Discovery

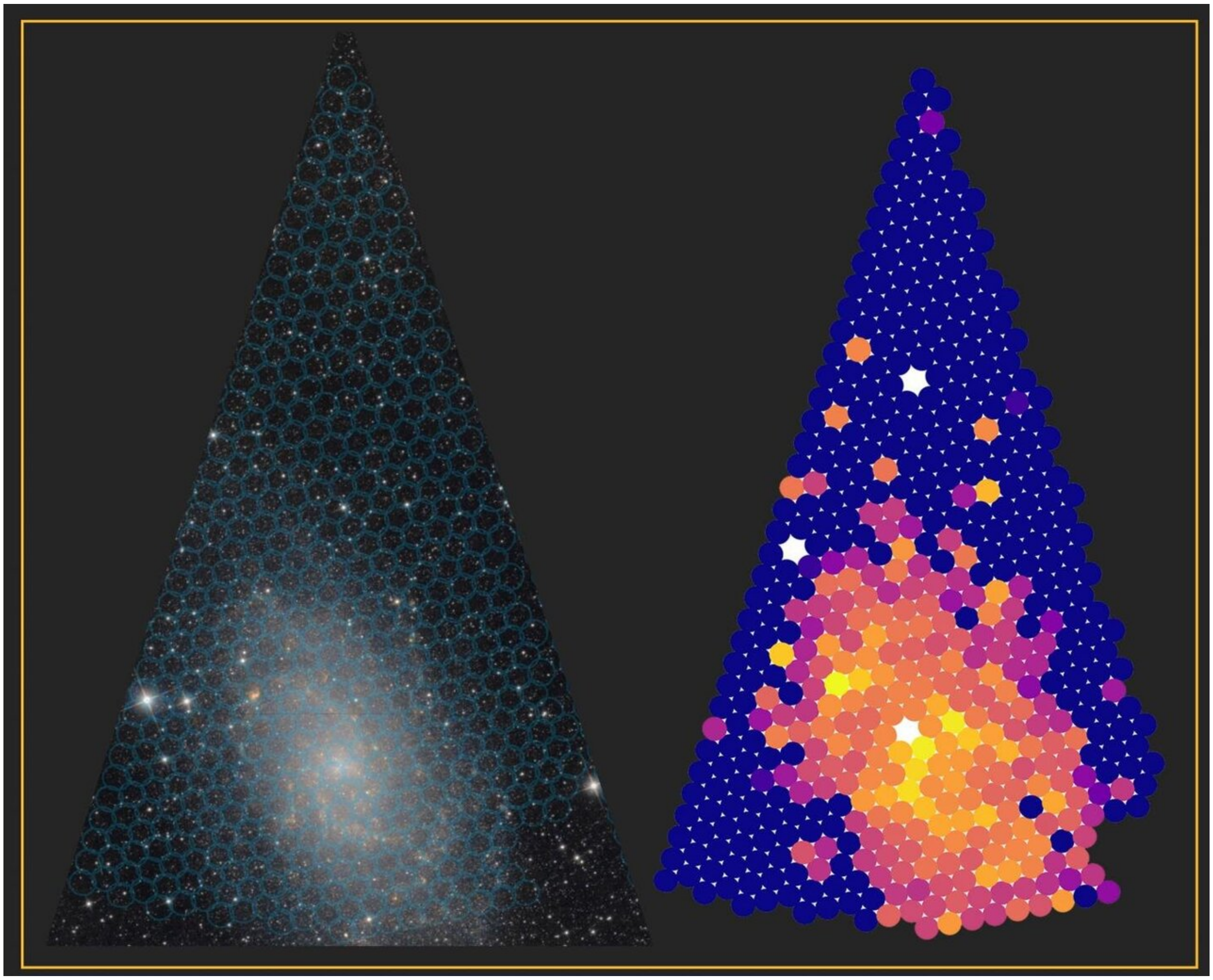
The installation of DESI at the 46-year-old Mayall telescope, begun in February 2018, marks the Mayall's successful transformation from an "all-purpose research tool" to more a specialized facility at the forefront of technology and discovery.

"With DESI we are combining a modern instrument with a venerable old telescope to make a state-of-the-art survey machine," said Lori Allen, Director of KPNO at NSF's OIR Lab. The Lab, created recently from the unification of National Optical Astronomy Observatory (NOAO), Gemini Observatory, and LSST operations, is the preeminent US center for ground-based optical-infrared astronomy.

Today's surveys of many millions of objects require large fields of view—the ability to study large areas of sky in a single pointing—and large, heavy equipment.

"Despite its age, the well-maintained Mayall telescope is the perfect platform for DESI," said David Sprayberry, KPNO Site Director for DESI. "Because it was originally designed for a wide field, the Mayall's optical design was easily adapted to the very wide field-of-view needed for DESI. The telescope is also sturdy enough to carry DESI's massive weight."

The DESI instrument weighs about 11 tons. It also has a field-of-view of 8 square degrees, or approximately 40 times the area of the full moon.



DESI's robotic fiber positioners, which gather the light from individual galaxies and stars, are arranged in 10 wedge-shaped modules called "petals". Left: a portion of the night sky, studied by one petal, that includes the galaxy M33. Blue circles demarcate the region of sky that can be studied by each of the 500 fibers in the petal; each fiber can point to a star or galaxy within its circle. Right: The hydrogen line emission detected by DESI from M33, shown as a color map, with brighter colors indicating brighter emission. Credit: DESI Collaboration; NSF's National Optical-Infrared Astronomy Research Laboratory

Teamwork and Technology

The DESI project and the installation of the DESI instrument is as much about teamwork as it is about technology. The DESI collaboration includes nearly 500 researchers at 75 institutions in 13 countries.

"The DESI instrument is complex and one-of-a-kind. It would never have been possible without a large and capable collaboration, with components coming from throughout the US and Europe. It is very exciting to see this instrument come together almost flawlessly, thanks to the close cooperation of the many remote teams involved," said Parker Fagrelius, KPNO's Observing Operations Supervisor for DESI.

Over the past 18 months, a multitude of DESI components were shipped to Kitt Peak from institutions around the globe and installed on the telescope.

These components include a set of six large lenses packaged in a steel barrel, which has been installed above the telescope's primary mirror, giving the instrument its expansive field of view. The lenses, each about a meter across, were successfully tested in April.

Another major component is DESI's focal plane, which sits at the top of the telescope and carries the 5000 robotic positioners that swivel in a choreographed "dance" to select individual galaxies and stars for study.

Most recently arrived are DESI's spectrographs, eight of which have been installed, with the final two arriving before year's end. Approximately 240 km (150 miles) of fiber-optic cabling connects the focal plane at the top of the telescope with DESI's spectrographs located beneath the telescope.

A Powerhouse Engine of Discovery

Although it was designed to study dark energy, DESI will also make unexpected discoveries, because the spectral "fingerprints" of stars and galaxies that DESI will collect encode much more information than is needed to carry out the DESI project.

"DESI is perfectly designed for the exploration of the unknown. Among the millions of galaxies and stars DESI will study, there are rare, perhaps one-of-a-kind, astronomical sources, some completely unanticipated, that await discovery," said Arjun Dey (KPNO), Head of Observing Operations for DESI. By exploring the cosmos on this scale, DESI may also uncover new phenomena and perhaps even new physics, similar to how dark energy itself was discovered.

"Discovering the unexpected—that's the most exciting part of the whole thing for me," Dey said.

Provided by Association of Universities for Research in Astronomy (AURA)

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