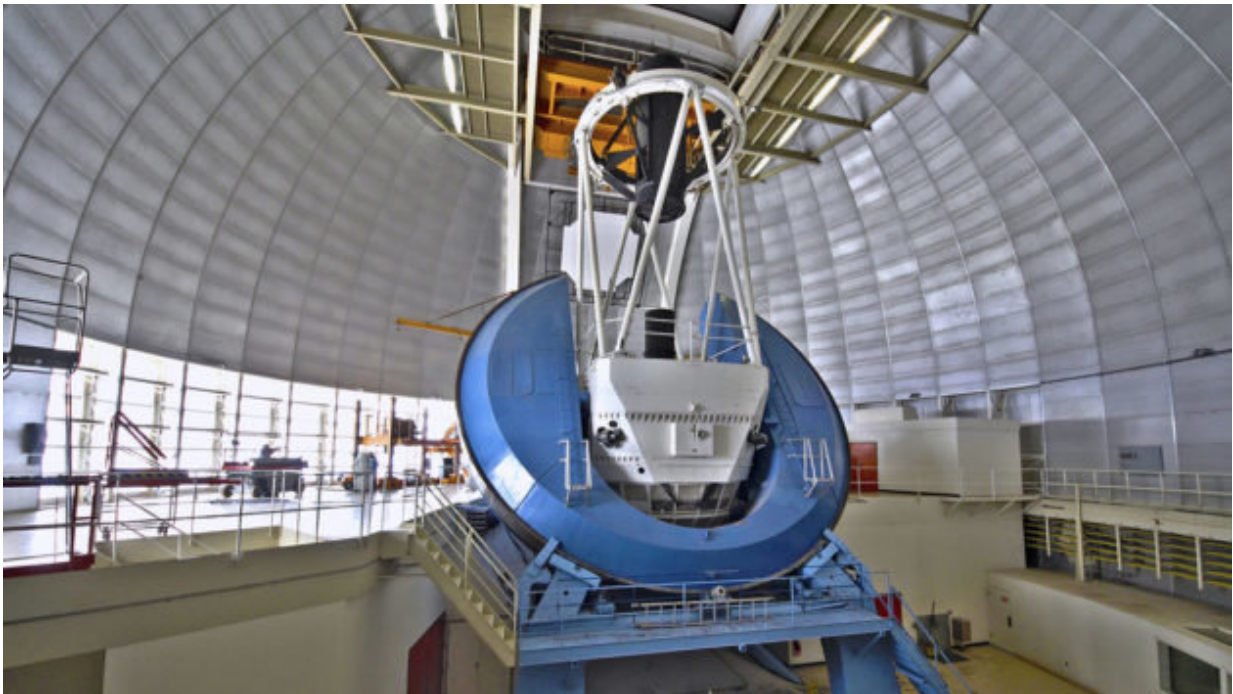


Solving the dark energy mystery: A new assignment for a 45-year-old telescope

February 12 2018, by Glenn Roberts Jr.



A view inside the dome at the Mayall Telescope near Tucson, Arizona. The 2-meter corrector barrel atop the telescope will be removed and replaced with a new corrector barrel for the Dark Energy Spectroscopic Instrument. DESI's installation will begin soon. Credit: P. Marenfeld and NOAO/AURA/NSF

Forty-five years ago this month, a telescope tucked inside a 14-story, 500-ton dome atop a mile-high peak in Arizona took in the night sky for the first time and recorded its observations in glass photographic plates.

Today, the dome closes on the previous science chapters of the 4-meter Nicholas U. Mayall Telescope so that it can prepare for its new role in creating the largest 3-D map of the universe. This map could help to solve the mystery of [dark energy](#), which is driving the accelerating expansion of the universe.

The temporary closure sets in motion the largest overhaul in the telescope's history and sets the stage for the installation of the Dark Energy Spectroscopic Instrument (DESI), which will begin a five-year observing run next year at the National Science Foundation's Kitt Peak National Observatory (KPNO) - part of the National Optical Astronomy Observatory (NOAO).

"This day marks an enormous milestone for us," said DESI Director Michael Levi of the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab), which is leading the project's international collaboration. "Now we remove the old equipment and start the yearlong process of putting the new stuff on." More than 465 researchers from about 71 institutions are participating in the DESI collaboration.

The entire top end of the telescope, which weighs as much as a school bus and houses the telescope's secondary mirror and a large digital camera, will be removed and replaced with DESI instruments. A large crane will lift the telescope's top end through the observing slit in its dome.

Besides providing new insights about the universe's expansion and large-scale structure, DESI will also help to set limits on theories related to gravity and the formative stages of the universe, and could even provide new mass measurements for a variety of elusive yet abundant subatomic particles called neutrinos.

"One of the primary ways that we learn about the unseen universe is by its subtle effects on the clustering of galaxies," said DESI Collaboration Co-Spokesperson Daniel Eisenstein of Harvard University. "The new maps from DESI will provide an exquisite new level of sensitivity in our study of cosmology."

The Mayall Telescope has played an important role in many astronomical discoveries, including measurements supporting the discovery of dark energy and establishing the role of dark matter in the universe from measurements of galaxy rotation. Its observations have also been used in determining the scale and structure of the universe. Dark matter and dark energy together are believed to make up about 95 percent of all of the universe's mass and energy.

It was one of the world's largest optical telescopes at the time it was built, and because of its sturdy construction it is perfectly suited to carry the new 9-ton instrument.

"We started this project by surveying large telescopes to find one that had a suitable mirror and wouldn't collapse under the weight of such a massive instrument," said Berkeley Lab's David Schlegel, a DESI project scientist.

Arjun Dey, the NOAO project scientist for DESI, explained, "The Mayall was precociously engineered like a battleship and designed with a wide field of view."

The expansion of the telescope's field-of-view will allow DESI to map out about one-third of the sky.

Brenna Flaugher, a DESI project scientist who leads the Astrophysics Department at Fermi National Accelerator Laboratory, said DESI will transform the speed of science at the Mayall Telescope.

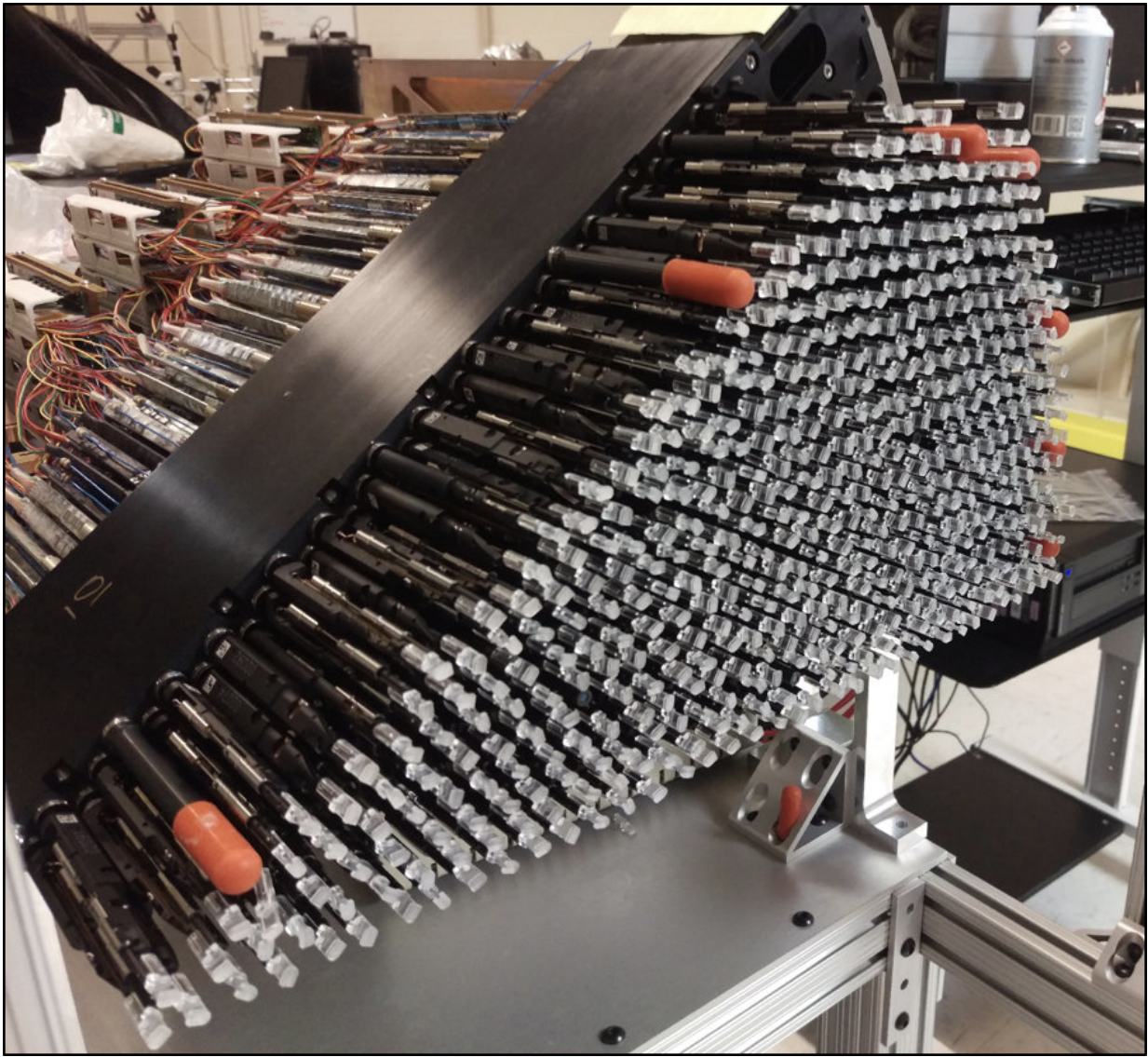
"The telescope was designed to carry a person at the top who aimed and steered it, but with DESI it's all automated," she said. "Instead of one at a time we can measure the velocities of 5,000 galaxies at a time - we will measure more than 30 million of them in our five-year survey."

DESI will use an array of 5,000 swiveling robots, each carefully choreographed to point a fiber-optic cable at a preprogrammed sequence of deep-space objects, including millions of galaxies and quasars, which are galaxies that harbor massive, actively feeding black holes.

The fiber-optic cables will carry the light from these objects to 10 spectrographs, which are tools that will measure the properties of this light and help to pinpoint the objects' distance and the rate at which they are moving away from us. DESI's observations will provide a deep look into the early universe, up to about 11 billion years ago.

The cylindrical, fiber-toting robots, which will be embedded in a rounded metal unit called a focal plane, will reposition to capture a new exposure of the sky roughly every 20 minutes. The focal plane, which is now being assembled at Berkeley Lab, is expected to be completed and delivered to Kitt Peak this year.

DESI will scan one-third of the sky and will capture about 10 times more data than a predecessor survey, the Baryon Oscillation Spectroscopic Survey (BOSS). That project relied on a manually rotated sequence of metal plates - with fibers plugged by hand into pre-drilled holes - to target objects.



The first of 10 wedge-shaped petals for the DESI project is fully stocked with 500 slender robotic positioners. These positioners will each swivel independently to gather light from a preprogrammed sequence of space objects, including galaxies and quasars. The petals will fit snugly together to form DESI's focal plane, which will be composed of about 600,000 individual parts. Credit: DESI Collaboration

All of DESI's six lenses, each about a meter in diameter, are complete.

They will be carefully stacked and aligned in a steel support structure and will ultimately ride with the focal plane atop the telescope.

Each of these lenses took shape from large blocks of glass. They have criss-crossed the globe to receive various treatments, including grinding, polishing, and coatings. It took about 3.5 years to produce each of the lenses, which now reside at University College London in the U.K. and will be shipped to the DESI site this spring.

The Mayall Telescope has most recently been enlisted in a DESI-supporting sky survey known as the Mayall z-Band Legacy Survey (MzLS), which is one of four sky surveys that DESI will use to preselect its targeted sky objects. That survey wrapped up just days before the Mayall's temporary closure, while the others are ongoing.

Data from these surveys are analyzed at Berkeley Lab's National Energy Research Scientific Computing Center (NERSC), a DOE Office of Science User Facility. Data from these surveys have been released to the public at legacysurvey.org.

"We can see about a billion galaxies in the survey images, which is quite a bit of fun to explore," Schlegel said. "The DESI instrument will precisely measure millions of those galaxies to see the effects of dark energy."

Levi noted that there is already a lot of computing work underway at NERSC to prepare for the stream of data that will pour out of DESI once it starts up.

"This project is all about generating huge quantities of data," Levi said. "The data will go directly from the telescope to NERSC for processing. We will create hundreds of universes in these computers and see which universe best fits our data."

Installation of DESI's components is expected to begin soon and to wrap up in April 2019, with first science observations planned in September 2019.

"Installing DESI on the Mayall will put the telescope at the heart of the next decade of discoveries in cosmology," said Risa Wechsler, DESI Collaboration Co-Spokesperson and associate professor of physics and astrophysics at SLAC National Accelerator Laboratory and Stanford University. "The amazing 3-D map it will measure may solve some of the biggest outstanding questions in cosmology, or surprise us and bring up new ones."

Provided by Lawrence Berkeley National Laboratory

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