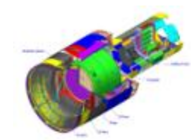
World’s largest digital camera gets green light

By Mike Ross

Tuesday, November 8, 2011

A U.S. Department of Energy review panel last week gave a glowing endorsement for the Stanford Linear Accelerator Center (SLAC)-led project to create the world’s largest digital camera, which will enable a new telescope being built on a Chilean mountaintop to investigate key astronomical questions ranging from dark matter and dark energy to near-Earth asteroids.



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Once constructed, the Large Synoptic Survey Telescope's 3.2-billion-pixel camera will be the largest digital camera in the world. Roughly the size of a small car, the camera will take 800 panoramic images each night, surveying the entire southern sky twice a week. These images will enable researchers to create a 3-D map of the universe with unprecedented depth and detail, and could shed light on the fundamental properties of dark energy and dark matter.

After two and a half days of presentations and meetings at SLAC, the panel of 19 experts recommended that the 3.2 gigapixel (billion pixel) camera for the Large Synoptic Survey Telescope receive Critical Decision-1 status, the DOE’s project-management milestone that defines a large project’s approach and funding for achieving a specific scientific mission.

The camera, which will be built at SLAC, is expected to cost about one third of the nearly $500 million price tag for the new telescope, which is being borne by the DOE and the National Science Foundation, as well as several public and private organizations in the United States and abroad.

"The LSST Camera Project team is experienced and has demonstrated a good working relationship," said Kurt Fisher, DOE/SC Review Chairperson from DOE's Office of Project Assessment. "The initial, plenary presentations were impressive, and the team was well-prepared for the review."

Actual CD-1 status will not be officially conferred until higher DOE management reviews the panel’s report, but the experts’ positive comments had LSST managers very optimistic. “Congratulations! You’ve reached a very important milestone on the road to becoming real,” said Fred Borcherding, DOE’s LSST program manager, after the review panel had presented their findings and recommendations at the review’s final session.

“This was an incredibly professional review,” said Steven Kahn, lead scientist on SLAC’s camera project and deputy director of the overall LSST effort. “We learned a lot and will take the panel’s recommendations very seriously as we move forward.” More than 100 people (about 30 full-time equivalents) from four DOE laboratories, nine universities and one foreign organization are working on the camera project.

The LSST design is driven by four main science themes: probing dark energy and dark matter, taking an inventory of the solar system, exploring the transient optical sky and mapping the Milky Way.

Sporting an 8.4-m diameter primary mirror, the LSST will be a large, wide-field ground-based telescope designed to provide time-lapse 3-D maps of the universe with unprecedented depth and detail. Of particular interest for cosmology and fundamental physics, these maps can be used to locate the mysterious dark matter, which many scientists think constitutes more than 80% of all matter in the universe, and to characterize the properties of the even more mysterious dark energy, which is driving the accelerating expansion of the universe.

The LSST will also create a detailed map of the Milky Way and a comprehensive census of our solar system and open a movie-like window on objects that change or move rapidly: exploding supernovae, potentially hazardous near-Earth asteroids and distant Kuiper Belt Objects. A new telescope is needed because no existing space- or ground-based instrument has, or can be economically modified to provide, the capabilities that LSST’s science mission requires.

“The speed at which a telescope can survey the sky is proportional to both the size of its mirror and the field of view of its camera,” said Nadine Kurita, SLAC Camera Project manager. “While a telescope in space can take pictures at a finer level of detail because it's not looking through a turbulent atmosphere, it would necessarily be much smaller than LSST, and thus could not possibly provide such an extensive survey.”

Each night, the LSST will take more than 800 wide-field 15-second exposures, each covering 49 times more sky area than the moon. It will photograph the entire visible sky twice a week. Although it will weigh 650 tons (including 60 tons of optical components), the LSST will be nimble enough to move between its image-aiming points in just five seconds.

Since 2001, the LSST has been ranked highly by a dozen national advisory committees, most recently last year’s National Academy of Sciences/National Research Council’s “New Worlds, New Horizons” decadal review, which said it was the highest-priority large ground-based telescope for the coming decade.

In 2003, the non-profit LSST Corporation was set up in Tucson, Ariz., to raise private and agency funding and to manage the collaboration, which now includes 35 institutions, universities and national labs from around the world.

DOE approved the camera’s mission need (CD-0) in June. Future milestones include CD-2 (baseline design approved), CD-3 (construction start), and CD-4 (construction finished; full operation begins).

While SLAC is the lead organization for the LSST camera, the National Optical Astronomy Observatory will provide the telescope and site team, the National Center for Supercomputing Applications will construct and test the archive and data access center, and the Association of Universities for Research in Astronomy is responsible for overseeing the LSST construction. Work on the telescope and its site atop Cerro Pachón in northern Chile is already under way.

At the heart of the 3.2-gigapixel LSST camera—and its most critical components—are its 189 sensors, light-sensitive semiconductor chips far more sophisticated than those used in commercial digital cameras.

“We’re going to be looking at light that’s 100 million times fainter than the human eye can see,” said Paul O’Connor, the Brookhaven National Laboratory scientist in charge of the camera’s sensor subsystem. “The LSST telescope has enough resolving power to distinguish the images of two stars separated by the equivalent of a pair of car headlights seen at a distance of 400 miles. We designed our charge-coupled device (CCD) chips to record these images with unparalleled clarity while using the minimum silicon area, cost and power.”

The LSST sensors are designed to respond to a range of light—ultraviolet, visible and infrared—that is much broader than commercial CCDs, and must also be extremely flat so the entire image will be in perfect focus. Moreover, to move all the image data off the chip in just two seconds—rather than the several minutes typical of astronomical images—every sensor is divided into 16 data sectors, each with its own output channel. Each night the LSST will produce more than 15 TB of raw astronomical data. Over its 10-year operating lifetime, the LSST will produce the world’s largest public data set: a 22-petabyte database catalog and a 100-PB image archive.

LSST has been designed as a public facility from the beginning, with deep color imaging and multi-dimensional data products made available quickly over the Internet. Supercomputers will continuously transform LSST imaging data into a revolutionary four-dimensional space-time landscape of color and motion, offering exciting possibilities for exploration and discovery by curious minds of all ages. Anyone with a computer will be able to fly through the universe, zooming past objects a hundred million times fainter than can be observed with the unaided eye.

LSST’s results may well be much more significant than just learning about the cosmos, O’Connor said:“I think finding the source of dark energy may have long term impacts with the potential to transform society—just like the fundamental discoveries in electromagnetism and atomic physics have done in producing the technologies we take for granted today.”

LSST Corporation

Large Synoptic Survey Telescope site

National Optical Astronomy Observatory

National Center for Supercomputing Applications

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