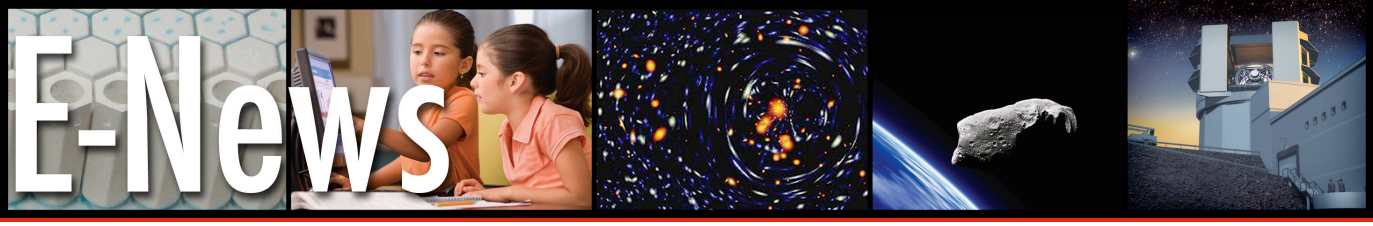
Large Synoptic Survey Telescope
E-News



LSST E- News October 2008 • Issue 3

EDITOR'S NOTES

Suzanne Jacoby, Manager for EPO

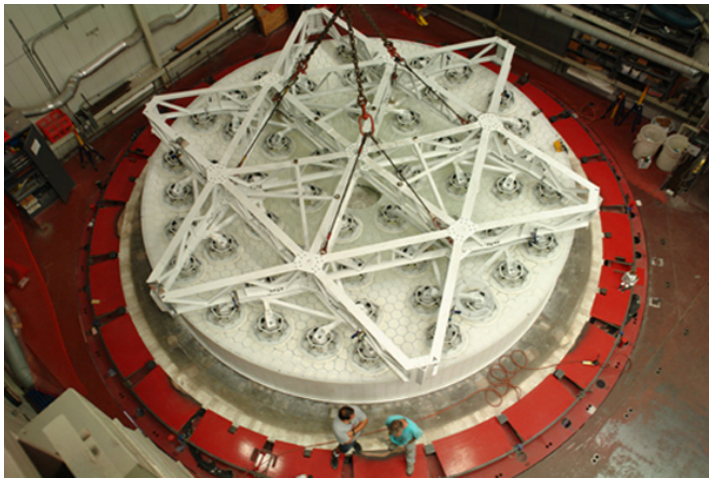
Welcome to the third issue of the LSST E-News. This quarter has seen exciting progress with the mirror construction, the addition of new institutional members, and increasing opportunities for communication and participation with LSST.

Participants in the Web Information Architecture Workshop. Photo courtesy Oskar Holm/LSST.

I've just walked back from the Steward Observatory Mirror Lab (SOML) where lifting pads were fixed to the mirror blank in preparation for moving the monolithic glass from the oven hearth to the handling ring. Although this is the 4th 8-meter class telescope cast at the SOML, LSST's record weight and unique primary/tertiary casting make it far from routine. The perfect casting of the mirror was publicized in an early September photo release featuring more than 60 well-dressed contributors to the LSST effort.

We've begun working with Interface Guru, a Tucson-based company that specializes in designing organized websites with effective user interfaces. To better serve public and technical users of lsst.org, the plan is to reorganize, relabel and revise existing content on lsst.org. This is being done to present a better outward face for LSST and to use lsst.org as a staging area, a placeholder site, for an anticipated implementation of a Content Management System (CMS).

We've approached this as an opportunity for professional development and team building throughout the project as we learn how to organize information and what our users expect from our public website. Expect preliminary changes at www.lsst.org by the end of October; implementation of the CMS and a more streamlined method of updating online information for all our primary audiences will follow.



The lifting spider is attached to the mirror blank, September 18, 2008. Ray Bertram/Steward Observatory

In This Issue

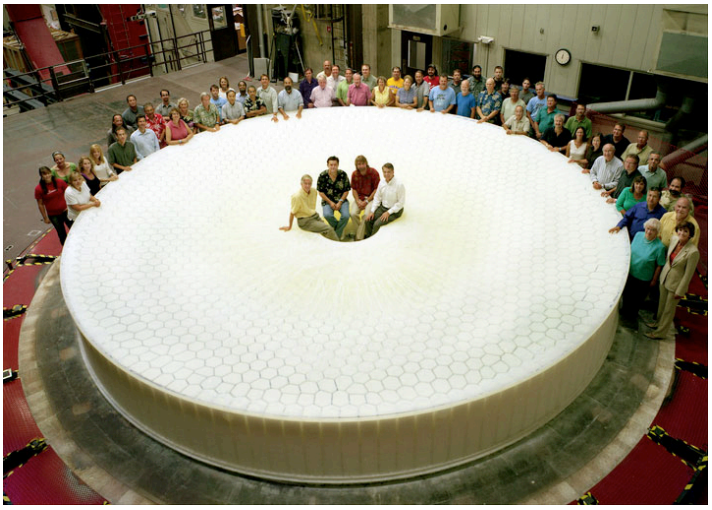
PROJECT MANAGER'S CORNER

Don Sweeney, LSST Project Manager

The LSST 8.4-meter primary/tertiary mirror has emerged from the furnace at the University of Arizona. The Steward Observatory Mirror Lab (SOML) opened the oven on July 23 to reveal a beautifully cast M1M3 mirror. After the furnace was disassembled we all had a rare opportunity to walk around on the mirror surface — providing a number of great picture opportunities. In early September, SOML workers performed a test of the newly assembled lifting fixture and crane to ensure the 30 metric ton mirror and mirror mold can be safely lifted off of the furnace hearth. The lifting fixture utilizes 54 steel disks that are bonded to the front surface of the mirror with silicone adhesive. The mirror will be lifted from the hearth in the next few weeks and placed on its side to allow cleanout and processing of the backside of the mirror blank. These steps will be completed in spring 2009; next steps include backside finishing followed by polishing of the front surface. The completed mirror will be delivered in January 2012.

In September the LSST Corporation welcomed Los Alamos National Laboratory (LANL) as the newest Institutional Member. Physicist Dr. Salman Habib will be the LANL Institutional Representative. LANL brings expertise in the areas of astrophysics, cosmology, large datasets and real-time data extraction and analysis, all of which have strong overlap with LSST science and engineering

In July, AURA, on behalf of LSST, filed the Environmental Impact Declaration with the Chilean national environmental commission (CONAMA.) Representatives of local government agencies that make up CONAMA's assessment commission conducted a site visit in August and later in the month AURA presented the Declaration and environmental mitigation procedures to the regional environmental commission (COREMA.) AURA has received and answered the questions and comments that were formally submitted through the process and final review with approval is anticipated in late October.



Members of the team building the LSST gather to celebrate the successful casting of the telescope's 27.5-foot-diameter mirror blank. Image Credit: Howard Lester/LSST Corporation

LSST staff and collaborators are meeting the challenge of preparing for the Preliminary Design Review (PDR). The project team has scheduled five one or two-day technical reviews of sub-systems in preparation for the LSST PDR next spring. Reviews will focus on telescope and site, camera, data management, project management control system and system engineering and calibration. Our objective is identification of potential weaknesses in the LSST baseline plan. Each reviewer is uniquely qualified to give us an expert opinion.

FOCUS ON...

Simulating the Universe

How do you find out what LSST will see and how it will see it? Simulations. Although astronomers and optical engineers have been simulating images and operations for space telescopes and adaptive optics systems for years, no one has simulated how data will be used — until LSST. On other telescopes, observers do the data reduction. Because the LSST data will be available to all, LSST's data management group will do the data reduction to make sure that data are correct before "observers" have access to them for study. The science studies that can be done are dependent on the design of the sky survey and the attendant operations of LSST — the subject of current simulation activities. "Working in concert with science collaborations, the data management group and design engineers, the simulations will help us design the robotic brain (the scheduler) of LSST," promises Philip Pinto, LSST scientist leading the Simulation and Data effort.

Why Simulate?

The LSST is designed to make very precise measurements of a wide range of astrophysical phenomena — to measure the unknown. To understand how well current designs can perform this daunting task, they must be tested and refined before the final design is actually built. The fact that the LSST is an all-purpose survey just makes this task more difficult — the LSST must achieve the best compromise among the many competing demands of a wide variety of measurements.

(Continued on p.3)

The light which arrives at the top of Earth's atmosphere carries with it the subtle signals LSST is designed to detect. These signals include the distortions in the images of distant galaxies caused by intervening Dark Matter, the "fingerprint" of the chemical makeup of exploding stars, or the trajectories of potentially hazardous asteroids.

To understand if LSST can detect these signals, the image simulation team makes computer models of how this light is produced and how it is altered by its long passage to Earth. The next phase of simulations traces the passage of light through the Earth's atmosphere and the telescope itself to the camera where it is detected and converted to "raw" digital images. Finally, this simulated image data is passed on to the LSST's automated data-processing system. The end result is a database containing measurements. The important question is then: how close are the measurements to the original signals?

While these simulations test how well the LSST's optics, electronics, and software can detect subtle signals, the operations simulation team is learning how to use this powerful new tool. How does one look often enough and in the right places to track moving objects? How uniform a map of the sky can LSST make in the face of ever-changing weather conditions? How much time should be spent moving the telescope from place to place on the sky and how much should be spent taking images? LSST will take roughly five million images during its ten-year survey. Operations simulation answers the question: which one should we do next? The algorithm for making this choice will become the brain of the robotic observatory.

While these simulations work in concert to test the design of LSST, it's helpful to look at the separate activities and goals of each.

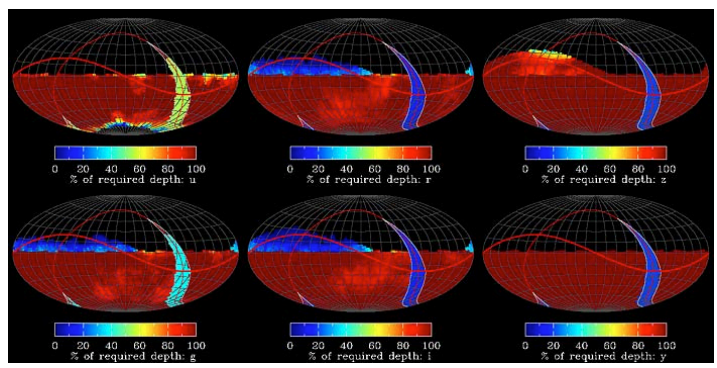
What questions do the simulators seek to answer?

- Which of the 5.5 million exposures over 10 years should LSST do next?
- How should LSST revisit points on the sky?
- How should LSST distribute survey coverage?

Creating an image

The main purpose of image simulations is to provide high fidelity simulations of what the actual signal will be. Using a model of the Universe and assumptions about the light travel through the Universe for given distances, atmospheric turbulence and other imperfections of conversion into electronic signal and bytes, the team creates facsimiles of observations.

The questions facing LSST's image simulators are different from those of other projects. For example, simulations for designing control systems, such as adaptive optics systems, for telescopes usually deal with the response for a single or very few point source(s) as images. LSST must consider objects across a very large field and is focused on second order effects of object ellipticity, not just axi-symmetric PSFs. Most projects are not trying to generate the whole data flow of images to produce a final answer as LSST is. Also, consider the quantity of data to be simulated: the space telescope Gaia (launch date: 2011) will catalogue on the order of 1 billion stars with completeness to about 20th magnitude to make the largest, most precise 3-D map of the Galaxy. LSST will catalogue to four magnitudes fainter than Gaia. Only the proposed Pan-STARRS rivals LSST's data collection goals. Finally LSST is interested in a different "flavor" of data: whereas a project such as the Large Hadron Collider generates far more data than LSST, it looks for rare events, and so a large portion of its data is not interesting to investigators.



Simulations produce a uniform survey over time. Graphic courtesy of Philip Pinto/UA.

"LSST doesn't know what's interesting or what's not; so we need to consider everything interesting," says Pinto.

The image simulation team is gradually ramping up from providing small pieces of the focal plane to producing a larger and larger sample of data. This summer the team provided a simulation of ½ night's data to the data management team. Work is still at the stage of inputing basic physics into the simulation models. The next steps are further model refinement and increased data amounts.

Operating LSST

"Operating the LSST is simply a 'giant traveling salesmen problem' with deadlines," declares Pinto. Just as the traveling salesman has to determine how to get to as many cities as possible in a certain amount of time using the shortest route possible without arriving too early or too late, LSST has to complete observations in a way that optimizes the sometimes competing science goals. Striking the balance of all users' types of science is an exercise in conflict resolution. Avoiding open warfare and preparing a roadmap for operations and observations is the goal of simulations.

The OpSim Team's role is to develop tools to determine how the observing strategy and telescope design affect the science outcomes of LSST Survey. "What if?" simulations help different groups study their own scheduling problems to find solutions that provide science that is just as good but within a schedule that accommodates other science goals. For example, scientists studying near-Earth objects (NEOs) would like to observe ½ hour apart every night because this is the traditional cadence of such observations. But other science collaborations require observing time under differing conditions. Tension occurs among conflicting needs: the time available to sample, to achieve areal coverage and to reach a depth in sky. Add to mix the choice of filter and non-observing time and it becomes a challenge to satisfy (or simulate) all observing desires. The computational effort needed to work out conflicting inputs and desired outcomes quickly becomes too large unless limits are imposed — so the simulations cannot consider every possible alternative but they can provide a very good basis for reviewing operating options.

Operations simulation is based on a detailed design model of LSST: the telescope points to object "A", accelerates to move to object "B", decelerates, stops moving, opens shutter. Information available to the model includes the distance and angle between A and B as well as the time it takes to move between the two. As many such simulations are done, the work provides data management simulations, which predict how LSST will populate the database.

Simulations also help refine the telescope site design. Originally the design called for the dome slit to move in front of the telescope and have it stop at each observation. Running the simulation of this operation showed its inefficiency. Redesigning the dome to move continuously as the telescope moved to observations decreased the power consumption.

Who are the members of the Operations and Image Simulation Groups?

- Justin Bankert (Purdue)
- Srinivasan Chandrasekharan (NOAO)
- Andrew Connolly (UW)
- Kem Cook (Livermore)
- Perry Gee (UC Davis)
- Emily Grace (Purdue)
- Garrett Jernigan (UCB)
- Lynne Jones (UW)
- Victor Krabbendam (NOAO)
- Alan Meert (Purdue)
- Michelle Miller (NOAO)
- Suzanne Nichols (Purdue)
- John Peterson (Purdue)
- Catherine Petry (UA)
- Philip Pinto (UA)
- Andy Rasmussen (SLAC)

Putting it all together for the science

Simulating images and operations of the LSST is a tremendous task with computational, scientific, engineering and even political aspects. The image and operational simulations create a reference survey. This survey is not the LSST survey but a tool for use by the science collaboration teams and engineering teams to determine how best to optimize the work that will be done with LSST. Management and scientists will resolve the issues highlighted in the simulations and prioritize observations.

As simulations continue, they will provide the data management (DM) team with information to populate a database. Using information about individual observations of objects, how often LSST observes a portion of the sky, site information such as seeing and cloud cover and other variables, the image simulations will eventually become the simulated data in the database. The DM team will be able to further test the data pipelines and the database access and manipulation with these data.

The LSST simulations are more extensive and of a different kind than any previous telescope project. Scientists and data managers are learning more from these efforts than even they expected at the start of the project. With each refinement and expansion of the simulations the LSST brain is closer to completion.

AURA and UCH Reach Innovative Agreement for LSST

The LSST will be built on Cerro Pachón, a mountain located on property owned by the Association of Universities for Research in Astronomy, Inc. (AURA). AURA is permitted to operate telescopes in Chile because of an agreement reached with the Universidad de Chile (UCH) at the time Cerro Tololo Inter-American Observatory was established. AURA and UCH, in close consultation with LSST Corp. (LSSTC), have now extended that agreement to cover operations of the LSST. "The goal of all the parties engaged in the negotiation was to ensure that the principles for operation of the LSST would enable full participation of Chilean astronomers in all aspects of the LSST project from planning to analysis of the data," says Sidney Wolff, LSSTC President.

LSST Site on Cerro Pachón. Image courtesy of Victor Krabbendam.

LSST, AURA, and UCH recognized that because LSST will be used to conduct a large-scale survey with public access to the data, one of the most important resources needed to take advantage of this new facility is access to a major computing center. Accordingly, the most significant part of the agreement calls for the construction of an LSST Chilean Data Access Center (DAC) in La Serena. Chilean astronomers will have preferred access to the resources of this DAC, which will store the most recent LSST released catalogue, the previously released catalogue, the current source catalogue, and at least half of all the raw data. This center will be fully integrated into the Chilean Grid for astronomical computing with links to institutional Chilean astronomy centers. The Chilean LSST DAC will support theoretical calculations related to LSST science as well as archiving and analysis of LSST data and will provide office space for Chilean astronomers who may wish to visit the DAC. If additional computing power is required by Chilean astronomers, the resources of the LSST Chilean DAC can be supplemented with LSST-supported resources in the US.

Google Earth view of Chile showing LSST site. Image courtesy of Victor Krabbendam and Google Earth.

"This new UCH-AURA agreement affords an opportunity for all Chilean astronomers to participate at the highest level in the planning, development, and execution of this unique experiment, which offers the promise to revolutionize our understanding of the Universe", says Mario Hamuy, Chairman of the Astronomy Department of UCH.

With the signing of the agreement, Chile became an institutional member of the LSSTC and a voting member of the LSSTC Board. Astronomers affiliated with Chilean institutions can join the LSST Science Collaborations, and Chile will have permanent full membership on the LSST Science Advisory Council (SAC) and LSST Science Council (SC). UCH is forming a scientific coordination committee (CNSCC) to coordinate Chilean activities and advise Chilean representatives to the SAC, SC, and LSST Board. Chileans will access LSST computational resources through a resource allocation committee (CNRAC), which will work with LSSTC to optimize the use of the Data Access Center resources for the support of Chilean astronomy. AURA, UCH, and LSST will jointly establish an implementation team to manage and oversee implementation of the agreement.

"This innovative agreement will strengthen the existing ties between Chilean and US astronomers, and we are looking forward to working even more closely with our Chilean colleagues," says Michael Strauss, who heads the science collaborations and the SAC.

Student Labor on LSST:

Summer 2008 REU and FaST Programs

Even years before first-light, LSST is able to provide opportunities to undergraduate students looking for scientific and engineering research experience. This summer LSST researchers mentored several students in the National Science Foundation's (NSF) Research Experience for Undergraduates (REU) program and through NSF supplemental funding to the LSST Design & Development award to support Faculty and Student Teams (FaST) at 3 LSST-affiliated institutions.

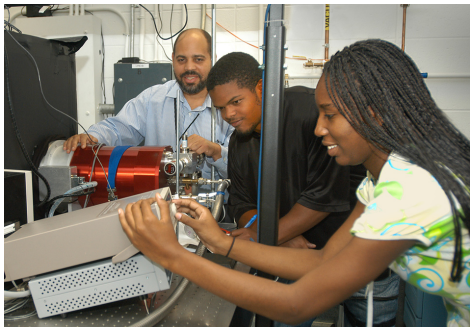
The FaST Program, a cooperative effort of the Department of Energy's (DOE) Office of Science and NSF, supports teams of one faculty member and two to three undergraduate students from institutions with limited research facilities and those serving underrepresented populations in science, engineering and technology (women and minorities). FaST teams typically experience hands-on research opportunities in DOE national laboratories during the summer working with scientists and engineers. This year education leads and researchers at Brookhaven National Laboratory (BNL), Stanford Linear Accelerator Center (SLAC), and the University of Washington (UW) submitted a collaborative proposal to the NSF through LSSTC. These funds allowed the expansion of FaST at BNL and SLAC and the extension of the existing UW PREMap program through the summer. Our eventual goal is to increase the diversity of participants in LSST and to expand the FaST model to all other interested LSST-affiliated institutions in coming years.

At UW, Florida Institute of Technology faculty mentor Hakeem Oluseyi and students Muhammad Furquan and Chris Culliton worked with astronomer Andrew Becker to simulate the sensitivity of LSST to astrophysical variability using a light curve simulation tool.

Chris Culliton, Dr. Andrew Becker, Dr. Hakeem Oluseyi, Muhammad Furqan at the University of Washington program summer 2008.

The team plans to continue working together on this analysis, extending it to other types of variability once the software is in place. Culliton expressed interest in applying to UW for graduate school. Dr. Oluseyi asked Dr. Becker to serve as an external member of student Furquan's graduate work.

Two students from Southern University at Baton Rouge, Zephra Bell and Mark Bryant, and faculty member, Ray H. O'Neal, Jr., from Florida Agricultural and Mechanical University worked with mentor Paul O'Connor at BNL to analyze the optical characteristics of the charge-coupled device for the LSST camera.



Ray O'Neal, Mark Bryant and Zephra Bell at BNL. Photo courtesy of Brookhaven National Laboratory.

A FaST team has been selected to work at SLAC next summer; the timing of the award made it impossible to get things going this year.

Taylor Chonis, a senior in the Physics and Astronomy Department at the University of Nebraska-Lincoln worked with LSST System Engineer Chuck Claver and Jacques Sebag in the Kitt Peak National Observatory (KPNO)/National Optical Astronomy Observatory (NOAO) REU Program to investigate characteristics of El Peñón, future site of the LSST.

The project included a trip to Cerro Tololo for observations on the 0.9-meter telescope to calibrate for LSST.

Taylor's interest in the engineering side of astronomy and physics fit well with the work of his mentors. "I always say that if I were to choose another major instead

(Continued on p.7)

(Student Labor on LSST)

Taylor Chonis taking a break from his work on LSST to visit the Grand Canyon and enjoy the southwest. "Tucson v. Nebraska… well, there's not as much corn in Tucson!"

of physics, it would be engineering. This project was a good mix of the two fields and has reassured me that the two fields are often one in the same, especially for someone who works in instrumentation." After graduating in December, Taylor will start working at University of Texas-Austin on the Hobby Eberly Telescope Dark Energy Experiment (HEDEX) and plans to apply to graduate school in astrophysics or engineering for fall 2009.

For more information about education opportunities with LSST, please contact Suzanne Jacoby, LSST Manager for Education and Public Outreach.

Students will present their workat the January 2009 meeting of the American Astronomical Society.

- Taylor Chonis, Chuck Claver, Jacques Sebag, University of Nebraska — Lincoln, LSST/NOAO: *Site Characterization of El Peñón: Site of the Large Synoptic Survey Telescope*.
- Hakeem Oluseyi, Chris Culliton, Muhammad Furquan, Andrew Becker, Florida Institute of Technology, University of Washington: *LSST Lightcurve Simulation to Quantify Variability Sensitivity.*

Summer Workshop on Wide-Fast-Deep Surveys:

New Astrophysics Frontiers

Scientists are sponsoring a summer workshop at the Aspen Center for Physics June 15-July 3, 2009. The Aspen Center for Physics, which has been a venue for creative informal workshops for the past 46 years, accepted the LSST proposal for Wide-Fast-Deep Surveys: New Astrophysics Frontiers this summer. The Aspen Center for Physics is a non-profit corporation funded by grants and contributions from NSF, DOE, NASA, foundations, corporations, government research laboratories, and individuals.

The three-week workshop will host approximately seventy astrophysics theorists, observers, experimentalists and computational scientists to discuss the exceptional opportunities and challenges driven by the new technologies of large aperture and wide field survey telescopes and powerful data processing systems, as well as the transformative science they enable. Temporal evolution of astrophysical systems is of both fundamental importance to astrophysics and a principle observational challenge. The new technologies surpass the traditional observational paradigm and promise discoveries of anticipated and unanticipated phenomena. The outcomes of the workshop will be refinement of the goals and priorities for the wide-fast-deep survey community, providing input to the National Academy of Sciences' Astro2010 Astronomy and Astrophysics Decadal Survey.

Workshop Agenda

- Weeks I and II: Review and discussion of known and speculative science and how these new survey's contribute to them
- Weeks II and III: Discussion of how to optimize the system for time-domain discovery, in terms of survey strategy and analysis methodology.

Tony Tyson (LSST Director, University of California, Davis) is leading the organizing effort. Other workshop organizers are Zeljko Ivezic (LSST System Scientist, University of Washington), Michael Strauss (Chair of LSST Science Advisory Council, Princeton University), Bob Nichol (University of Portsmouth) and Josh Frieman (Fermilab).

Applications to attend the workshop are now open on http://www.aspenphys.org. The deadline for applications is January 29, 2009.

For more information, visit http://aspenphys.org/documents/program/summer09.html

Aspen Center for Physics. Image Copyright 2007 Rene Rivera

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Large Synoptic Survey Telescope