LSST E- News

April 2010 • Volume 3, Number 1

With this issue of E-News, the LSST Project Office enters our third year of producing a quarterly newsletter. Our goal is to make it informative to a broad audience, whether they are working directly on the project or just interested in following its progress. Back issues are available online (http://www.lsst.org/lsst/news/enews).

The LSST Science Council, Operations and Image Simulations groups, Data Management team and assorted managers gather at UW in Seattle to discuss a range of project issues in early March, 2010.

In This Issue

Activities are accelerating as we prepare for our Preliminary Design Review and get ready for construction. The Science Council convened at the University of Washington in early March to review proposed changes to the Science Requirements Document. An additional day was scheduled to review the Operations Simulator and Image Simulation efforts, as well as a side meeting on User Interfaces for both Science and EPO. We had a successful on-site NSF review in mid-December to evaluate our Final Design Proposal, which has requested funding for the 30-month period prior to construction start. Additional activities are described in the articles that follow.

M1/M3 MIRROR UPDATE

A mid-March visit to the Steward Observatory Mirror Lab shows the exciting work underway on the LSST M1/M3 mirror with the Large Optical Generator (LOG): diamond generating the front surface curvature of the combined mirror surfaces.

Recall the primary (M1) and tertiary (M3) mirrors are built into a single piece of glass, like two concentric rings, with the outer 8.4-m primary mirror enclosing the 5.0-m tertiary mirror. It will be necessary to remove nearly 5 tons of glass to achieve the approximate shape before polishing can begin. In late February, work began on the M1 surface; attention now has shifted inward to the M3 surface, removing 2 cubic centimeters of glass per second while generating the steeply curved shape to within 5mm of its final thickness. Working from the outer edge to the center, it's a bit like

LSST mirror blank on the Large Optical Generator

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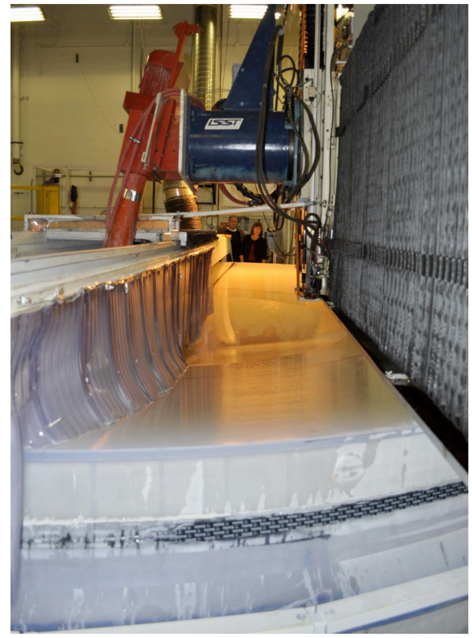
Grinding wheel removing glass from the LSST tertiary mirror.
Photo courtesy D. Ketelsen, SOML

the needle on a record player spiraling inward, removing a ridge of material in a circular pattern as you work your way around. The rough generating work shown here is done with a rotating wheel of 20 diamond "pellets", seen as shiny "teeth" on the underside of the black grinding wheel. A subsequent pass will use a wheel with finer pellets, followed by another pass with resin-bond pellets, each pass smoothing the surface a bit more. Coolant is applied through the blue tubes as the grinding proceeds. The flash image (left) freezes the wheel rotation to show the diamond pellets and coolant droplets. The safety roller to the right provides real-time feedback to the computer of the glass position.

All this grinding takes place behind the plastic baleen curtain shown at right, while the mirror substrate slowly rotates about once per minute. The generating of the M1/M3 figure should be finished by early May; then on to the grinding and polishing!

Suzanne Jacoby, Dean Ketelsen, and Bill Gressler contributed to this article.



Reflections of B. Gressler and S. Jacoby can be seen in the front mirror surface; photo by D. Sweeney.

IT'S TERAGRID TIME

We've just received word that the Data Management (DM) team has been awarded significant resources on the TeraGrid, the National Science Foundation's supercomputing infrastructure consisting of large clusters of computers located at eleven centers in the US. This award will allow the team to perform its most ambitious test to date as it practices processing the massive amounts of data LSST will produce.

As it carries out its 10-year survey, LSST will produce over 15 terabytes of raw astronomical data each night (30 terabytes processed), resulting in a database catalog of 22 petabytes and an image archive of 100 petabytes.

During the LSST design & development phase, the DM group has been developing a software framework and science codes with the scalability and robustness necessary to process this unprecedented data stream.

In order to test the scalability of the software, the LSST Data Management team has performed a series of Data Challenges-targeted demonstrations of the processing software, with each challenge encompassing tasks of incrementally larger scope and complexity building toward the final production code that will be used during operations. Data challenges to date were performed on a fairly modest TeraGrid allocation and on High Performance Computing (HPC) clusters hosted at National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign, an LSST Institutional Member.

How much data?

- A megabyte is 10^6 or 1,000,000 bytes
- A gigabyte = 10^9 bytes
- A terabyte = 10^{12} bytes
- A petabyte = 10^{15} bytes.

The DM team is now at the point with the current data challenge, DC3b, where it will process 10 TB of data from an existing astronomical survey and 47 TB of a simulated LSST data set. DC3b will be done in a series of three incrementally more demanding performance tests, resulting in the production of science data products from an archive's worth of data, at a scale of 15% of the operational DM System. The goals of these tests are to verify the code for correctness and robustness, understand the code's performance, and to create a large dataset that can be used by astronomers to plan science projects for the LSST.

"Although we use images from previous surveys, our heavy reliance on simulated images drives the need for 1.5 million core hours on the TeraGrid for the next stage to be conducted over the next few months," comments Tim Axelrod, the LSST DM System Scientist.

In January, 2010, the LSST Data Management project turned in the proposal to the TeraGrid program requesting infrastructure for DM design and development. Several lead scientists and engineers on the DM team developed the proposal under the leadership of NCSA, who have a long history of involvement in the TeraGrid. The period of the allocation is from April, 2010 through March, 2011. The TeraGrid infrastructure allocated will be provided by systems from NCSA, TACC, LONI, and Purdue.

Mike Freeman, Infrastructure Lead for DM and Project Manager at NCSA, says the

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Map of TeraGrid supercomputer clusters. Credit: Courtesy of Indiana University, based on illustration by Nicolle Rager Fuller, National Science Foundation.

team's proposal was awarded their full request of TeraGrid resources both CPU hours and data storage: 1.51M Service Units (CPU-hours), 400TB of dual-copy mass storage, and 20TB spinning disk storage.

NCSA has led the effort to provide infrastructure for DC3b, which in addition to the TeraGrid allocation includes contributions from SLAC, SDSC, IN2P3, CalTech, Purdue, and the REDDnet project/Vanderbilt University. This architecture includes data production and archiving capabilities, database scaling test resources, and for the first time, resources to replicate and serve the input and output data to scientific users in the LSST Science Collaborations for validation and experimentation.

And if the TeraGrid proposal had not been successful what were the options? Tim tells us DC3b could be run on a fast PC, but it would take 1.5 million hours – about 200 years!

Suzanne Jacoby, Jeff Kantor, Tim Axelrod and Anna Spitz contributed to this article.

NEWS FROM CHILE

Vista Sidney Wolff

LSST President Sidney Wolff was honored by the AURA Board in February by the naming of scenic viewpoint Vista Sidney Wolff on the road to the Cerro Pachón in Chile. The construction of the vista point is a tribute to Dr. Wolff's leadership in enabling the construction of world-class facilities on Cerro Pachón high in the Andes Mountains. Dr. Wolff served as President of the SOAR Board and first Director of the Gemini Observatory. Above, Sidney, the AURA Board and other dignitaries gather with the full ridge of Cerro Pachón in the background. Both the Gemini South and the SOAR telescopes can be seen on the ridge; El Penon, the rightmost peak on Cerro Pachón, has been selected as the site for LSST.

(NOAO Press Release)

LSST President Sidney Wolff, the AURA Board and other dignitaries gather at scenic viewpoint Vista Sidney Wolff on the road to the Cerro Pachón in Chile. Image Credit: NOAO/AURA/NSF

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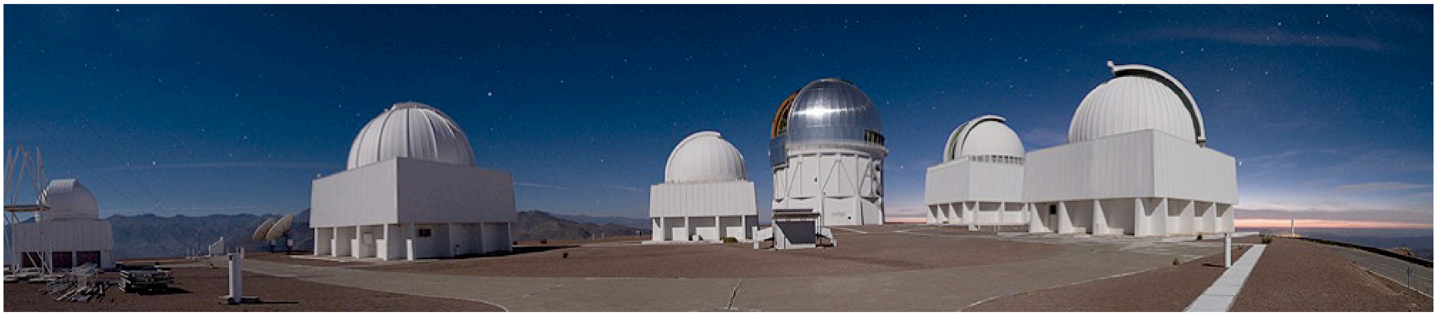

A long-exposure evening panorama of Cerro Tololo Inter-American Observatory in Chile. Image Credit: T. Abbott and NOAO/AURA/NSF

Earthquake in Chile

As has been widely reported, a magnitude 8.8 earthquake struck central/southern Chile on Saturday, 27 February 2010, 210 miles SW of Santiago. The earthquake, one of the most powerful on record world-wide, caused significant casualties and damage throughout central and southern Chile but no significant damage to observing facilities in the area. In the area of La Serena in northern Chile, near the existing CTIO facilities and planned LSST site, the effects were strong, but no significant damage was registered. The CTIO telescopes and observatory infrastructure are intact with no detected damage. Indeed, observations on the telescopes continued immediately after the earthquake. Minor rock slides on the access road were cleared the morning after. Electricity, external telephone, and internet connectivity were lost initially, but internal communications remained stable, allowing operations to continue.

Another earthquake, magnitude 6.8, occurred on March 11, 90 miles SW of Santiago, also with no significant damage to observing facilities.

THE CHANGING UNIVERSE: CATCHING TRUTHS IN FLEETING EVENTS

This issue's article is based on Chapter 8 of the LSST Science Book: *The Transient and Variable Universe*.
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In the supposedly unchanging eternal sky, ancient Chinese observers were drawn to unusual appearances: "guest stars" were portents of earthly events to court astrologers. Today, cosmic explosions and variability announce ever-stranger physical phenomena to modern astronomers, while improved observational tools illuminate intriguing new aspects of known systems. Supernovae, variable stars, gamma-ray bursts, and gravitational lenses are just some of the creatures of the transient Universe that LSST will reveal.

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LSST will make fundamental contributions to characterizing populations and mapping Galactic structure as it identifies large quantities of known variable types. Astronomers will be able to study huge numbers of multiple star systems to reveal what types of stars frequent these systems. LSST will also see the dimming of stellar light due to the transit of orbiting planets to greater distances and lesser brightness than any existing instrument. LSST's all-sky coverage, consistent long-term monitoring, and flexible criteria for event identification will allow researchers to extend observations from other programs and probe a large unexplored region of parameter space to discover new types of transients.

What is a variable and what is a transient?

Transients are objects we can't detect when they are faint and for which individual events are worthy of study. The event – usually a collision or an explosion – changes the object, making it visible to us, something new in the sky. ***Variables*** are objects which are always detectable but change in brightness on various timescales and whose nature isn't altered significantly by the event. Some objects appear variable due to geometry such as systems with multiple objects or whose light is amplified by a gravitational lens that lies between it and the Earth.

What goes boom in the Universe?

LSST will capture explosions in our Local Universe and those at cosmological distances – different types of objects dominate observable explosions in these two areas of space. Our Local Universe is defined as the area of space less than or equal to 200 megaparsecs (a megaparsec is also known as 1021, a sextillion kilometers) and objects sought in the magnitude "gap" between brightest novae and subluminous supernovae are best found locally. These observations will tell us about events such as the collapse of massive stars and the coalescence of neutron stars. LSST will also complement the search for gravitational waves, ultra high energy cosmic rays, TeV photons, and astrophysical neutrinos in the Local Universe. Identifying and characterizing the many transients of the Local Universe will rely on distinguishing those interesting events from known kinds of variable objects in both the foreground and background sky.

Double Supernova Remnants DEM L316. Copyright: Gemini Observatory, GMOS-South, NSF.

Great rewards will come from LSST for transients in the distant Universe as well, especially for events with decay times of less than one day. Gamma-ray bursts (GRBs) are the most relativistic explosions in the known Universe. They signal the birth of rapidly spinning stellar black holes resulting from the death of massive stars and can release more energy in 10 seconds than what the Sun will emit in its entire 10 billion year lifetime. Long GRBs typically last 2-100 seconds and short GRBs last less than 2 seconds but the more complicated picture that LSST will explore includes hydrid GRBs. GRB energy is released in jets so scientists estimate that for every 1 GRB observed here on Earth, there are about 500 GRBs that we don't see. LSST will advance the detection of orphan GRB afterglows from unseen GRBs to understand the stellar deaths that produce them. Of course, even stranger objects such as peculiar transients, very fast transients, and exotic "unknown unknowns" will challenge and excite researchers.

What about geometric variables?

LSST will not only monitor stars and explosions, but will also see variations due to the geometry of certain systems, such as planetary transits and microlensing events. LSST will dramatically increase the number of known hot Jupiter systems and expand the range of observation to greater distances, potentially observing ~20,000 transiting hot Jupiters. The LSST data will lead to gains in understanding planetary migration theories and the effects of intense stellar irradiation of planet atmospheres.

Gravitational lensing is simply a foreground object deflecting and enhancing light from a distant object. Other LSST Science Book chapters deal with weak and strong lensing, but microlensing also exists due to the relative motion of the observer, lens, and source. These events will teach us about dark matter, planets, distant stellar populations and our solar neighborhood.

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What can we count on?

LSST has three major objectives for research on variable stars: produce very large samples of already known types, discover theoretically predicted types, and discover new variable types. LSST will identify variables across all types of stars. Pulsating variable stars make up the majority of periodic variables and LSST data will illuminate the birth of systems, the death rattles of stars, and their tumultuous lives in between.

What types of variables will LSST see?

- RR Lyrae stars
- Asymptotic Giant Branch (AGB) phase stars
- Pulsating white dwarfs
- Interacting binaries
- Cataclysmic variables
- Symbiotic stars
- Magnetic activity – flares and stellar cycles
- Non-degenerate eruptive variables

How to handle all these data?

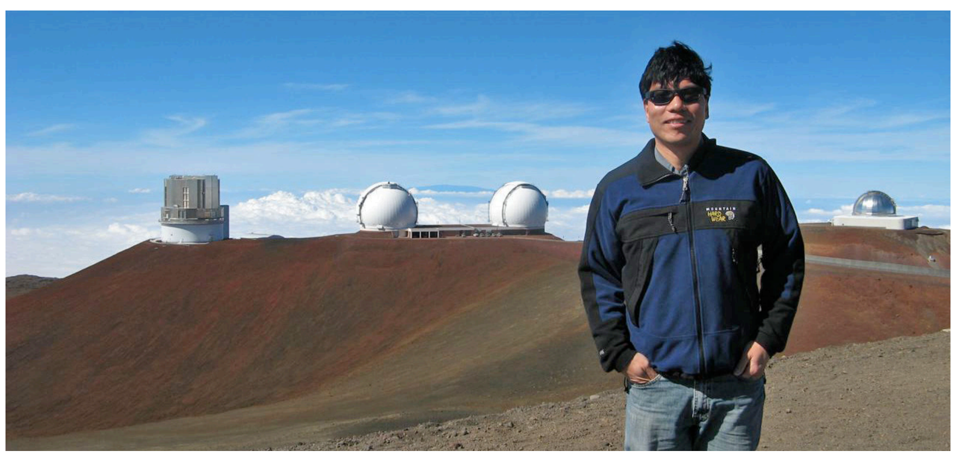
LSST will produce 100 times more data than the current generation transient searches, delivering observations on tens of thousands of transients every night. Filtering time-critical information from the torrent of data - 30 terabytes each night - will be challenging. Recognizing interesting phenomenon for follow-up studies will require sophisticated data management and clever follow-up.

Because a transient is an object that hasn't been seen before, the LSST team has to figure out just how to classify and handle the data. The team is laying out the following steps: 1) a quick initial classification, 2) short listing the nominees – deciding which possible follow-up resources or observations will result in a classification, 3) obtaining the follow-up and reclassification with LSST or other facilities and 4) adding new data and repeating the classification steps as needed. With the details of this system in place, LSST will lead the way to unexpected advances in our knowledge of transients and variables, finding out what mechanisms produce the changeable objects in the Universe.

Article written by Anna H. Spitz and Lucianne M. Walkowicz

KIAN-TAT LIM — HANDLING TRILLIONS OF WEB PAGE VISITS OR TRILLIONS OF OBSERVATIONS

Handling extremely large data sets exhilarates Kian-Tat Lim. Whether it's Yahoo! dealing with billions of users visiting thousands of web pages for trillions of page views or LSST viewing billions of objects thousands of times for trillions of observations, Kian-Tat enjoys the challenge of managing these data.



K.-T. visited Hawai'i in in December 2008. After giving a talk about LSST's data management system at Keck Headquarters in Waimea, he took a tour of Mauna Kea summit and control room.

Kian-Tat is an Information Systems Specialist at the SLAC National Accelerator Laboratory. He originally joined LSST as a volunteer in January 2007 but was so taken by the project that he started as an employee in June 2007. He builds the database, including the petabyte-scale Database Management System that will support it, and image access systems. He assists with the architecture of the data management systems with a focus on the middleware layer for which he is the Middleware Lead and member of the Data Access Working Group. Kian-Tat finds the most challenging aspect of his work to be designing a system where there is substantial uncertainty with respect to hardware capabilities and end-user needs.

Kian-Tat has experience in both science and computing. After graduating from Haverford in 1987 with a BA in chemistry, he completed his PhD in computational chemistry at CalTech in 1995. Kian-Tat was the Chief Architect for Strategic Data Solutions at Yahoo!, Inc. where he spent more than seven years building extremely large data management system and data mining applications. His time working on extremely large commercial data sets often with a time series analysis

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component is proving very helpful now on LSST. “Working in a commercial environment has also increased my appreciation for documentation and software development processes.” Kian-Tat has three patents and two unpublished patents and has built five proprietary large-scale software systems.

In addition to LSST Lim is consulting for the data management systems for the Linac Coherent Light Source (LCLS) at SLAC. LCLS is an extremely bright, extremely short pulse laser with X-rays that can be used to take movies of chemical reaction, its pulses powerful enough to take images of individual molecules. He is also helping Jacek Becla with the Extremely Large Database workshop series that will bring leaders from science, industry, academia, and database vendors together to discuss the unique challenges of managing massive data sets.

As to where he might be in five or ten years, Kian-Tat looks forward to “something interesting and challenging where I can apply my skills and experience to build something elegant that will help the world.”

Article written by Anna Spitz

LSST SHOWS ITS STUFF IN WASHINGTON

Continuing our annual tradition, LSST again had a strong showing at the January meeting of the American Astronomical Society (AAS), held this year in Washington, DC. In addition to the usual posters and exhibit, approximately 100 scientists gathered for a Splinter Meeting organized by Michael Strauss, chair of the LSST Science Advisory Committee. This meeting was an opportunity for those interested and involved in the LSST Science Collaborations to understand the current state of the project and learn how to contribute during our Final Design Phase.

Our lineup of 25 LSST posters was viewed by most of the 3500 attendees on opening day of the meeting. The posters, which represent all aspects of the project from engineering, education, and simulations to science, are available for online viewing or download at: http://www.lsst.org/lsst/news/aas_215.

Our exhibit announced the availability of the LSST Science Book, and nearly 1000 DVDs of the book were distributed to interested attendees. The book is also available online at http://www.lsst.org/lsst/scibook. The exhibit booth was an active place in part because of our giveaway – the LSST pedometer. Those who recorded 20,000 steps (about 10 miles) on the pedometer could enter a drawing to win a piece of etched LSST glass from the M1/M3 mirror casting. We had 73 entrants and 12 winners:

Charles Steinhardt, Amanda Moffett, Chris Culliton, Jay Strader, Todd Hillwig, Mark Hammergren, Lucas Miller, Mauricio Flores, Adam Smith, Justice Brursema, Daniel Veillette, and Mark Sands.

Congratulations to our winners and we’ll see you all again in Seattle for the January 2011 AAS meeting!

Article written by Suzanne Jacoby

20,000 steps on a LSST pedometer. (photo by M. Kounkel)

Project Manager Don Sweeney congratulates Mark Sands, one of 12 winners. (photo by R. Dreiser)

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LSST is a public-private partnership. Funding for design and development activity comes from the National Science Foundation, private gifts, grants to universities, and in-kind support at Department of Energy laboratories and other LSSTC Institutional Members: Brookhaven National Laboratory; California Institute of Technology; Carnegie Mellon University; Chile; Cornell University; Drexel University; Google Inc.; Harvard-Smithsonian Center for Astrophysics; Institut de Physique Nucléaire et de Physique des Particules (IN2P3); Johns Hopkins University; Kavli Institute for Particle Astrophysics and Cosmology at Stanford University; Las Cumbres Observatory Global Telescope Network, Inc.; Lawrence Livermore National Laboratory; Los Alamos National Laboratory; National Optical Astronomy Observatory; Princeton University; Purdue University; Research Corporation for Science Advancement; Rutgers University; SLAC National Accelerator Laboratory; Space Telescope Science Institute; The Pennsylvania State University; The University of Arizona; University of California, Davis; University of California, Irvine; University of Illinois at Urbana-Champaign; University of Michigan; University of Pennsylvania; University of Pittsburgh; University of Washington; Vanderbilt University

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