LSST E- News

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FROM THE PROJECT OFFICE

V. Krabbendam, S. Jacoby, L. Walkowicz & C. Claver stand ready to tell everyone about LSST. Image credit: LSST

This issue of LSST E-News follows the team from Washington, DC, to Chile, as we move toward the realization of the LSST. Highlights this quarter include:

- LSST submitted an updated Major Research Equipment and Facility Construction (MREFC) proposal to the NSF on Feb 1, 2011.
- The April meeting of the LSST Board took place in La Serena, Chile, and included a visit to El Peñón on Cerro Pachón.
- Mechanical samples of prototype sensors have been delivered from two vendors, demonstrating the technical ability to reach design specifications.
- M1/M3 is now in the final phase of loose abrasive grinding.
- The first production blast to break up rock on the LSST site, funded by private sources, occurred on March 8th, 2011.
- Requirements for user interfaces for both science and public users of LSST have been drafted.
- Webcams from Cerro Pachón have been installed and linked to the LSST online Gallery page so others can follow the site leveling activity.

LSST Board Members stand on the recently leveled Cerro Pachón summit during the April meeting in La Serena, Chile. Image credit: LSST

LSST was sponsored by the American Astronomical Society to participate in the 16th annual Science-Technology-Engineering Working Group's Congressional Visits Day (CVD). Team members were joined by Susan Hutchison (Charles Simonyi Fund for Arts & Sciences) in Washington, DC, April 6 & 7, 2011 for the CVD exhibit as well as visits to NSF program staff in Astronomy and Education.

Rainbow over Cerro Pachón image by C. Claver.

While standing on Cerro Tololo near the Blanco 4m, LSST Board members were surprised and a bit disappointed as rain drops began to fall, meaning we were unlikely to see the dark Chilean night sky after dinner. But disappointment turned to amazement as a rainbow formed and seemed to touch the Cerro Pachón summit near the future location of LSST. It's hard to miss a sign like that – the future is bright for LSST!

In This Issue

KABOOM! LIFE'S A BLAST ON CERRO PACHÓN

Site leveling activities have begun on the El Peñón summit of Cerro Pachón in preparation for the LSST. "First Blast", detonated on El Peñón on the morning of March 8th, broke up ~320 cubic meters of material; 13,000 cubic meters must ultimately be removed to provide the platform for LSST at the summit and another 6,000 cubic meters for calibration hill and road work. Approximately 55 blasts of similar size are necessary to remove all the remaining material.

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A short film about First Blast was compiled by Emily Acosta and premiered at the April Board Meeting in La Serena. It can be viewed on YouTube or downloaded through links at http://www.lsst.org/lsst/gallery. Webcams have been installed in two locations on the summit, one on El Peñón itself and another from the Gemini South telescope building. Both webcams are updated every minute and available from the LSST gallery URL. This site leveling activity is made possible by private funding to the LSST Corporation and will be completed in July, 2011.

First Blast was a spectacular event as documented in these images from F. Delgado, M. Warner/CTIO. The white line in the upper image shows how much material must ultimately be removed to provide the platform for LSST.

LOOSE ABRASIVE GRINDING OF THE M1/M3

The LSST M1/M3 optic is now in the final phase of loose abrasive grinding as optical processing continues at the Steward Observatory Mirror Laboratory (SOML). Damage to the mirror sustained during the fixed abrasive grinding has been repaired, completely restoring the optical and mechanical properties of the mirror.

The wet slurry of 40-micron grit particles is currently in use as the computer controlled lap is actively shaped during the coordinated movement to remove material and converge towards the final mirror surface shape. This phase also provides a "shining" of the surface that enables a thorough inspection of the face sheet internal glass quality that has revealed no unexpected scratches, bubbles, or inclusions which would affect continued processing. Also during this phase, additional measurements are made to ensure the wedge (or tilt), the vertex position, and concentricity of the optical surface are all within specification relative to the substrate and the M3 surface.

The SOML processing plan calls for approximately 200 hours of grinding with this grit size before transitioning to a 20-micron particle size, and then to a 12-micron size. Throughout these iterative grinding steps, the surface is measured to guide the removal process and maintain a convergence on the final specifications and prepare it for the final polishing phase. Each grinding phase produces a progressively smoother surface with a shape closer to the final expected form. Processing of the M1 surface through these grit sizes is expected to take a little over 3 months. Once the M1 surface is ready for polishing, the lap will be re-tooled to enable a similar sequence of grit size processing on the M3 surface.

Article written by B. Gressler

These photos show the 1.2-m diameter stress lap attached to the Large Optical Generator (top) and (bottom) processing the M1 surface, where the first few hours of loose abrasive grinding removed the fixed grinding tool marks.

Image credit: B. Gressler/NOAO/LSST (top) & J. Kingsley/SOML/UA/LSST (bottom)

LSST/ICRAR AGREEMENT TO TACKLE DATA DELUGE

Artist's impression of the SKA dishes. Credit: SPDO/ Swinburne Astronomy Productions

LSST and the International Centre for Radio Astronomy Research (ICRAR) have signed an agreement to work together on designing common database systems for optical and radio astronomy and research tools that will enable direct comparisons of objects they observe. The agreement funds a post-doctoral appointment to facilitate multi-wavelength astronomical research with very large data collections from LSST and the radio survey telescopes such as the Australian Square Kilometre Array Pathfinder (ASKAP), and Murchison Widefield Array (MWA).

ICRAR Director Prof. Peter Quinn said "this collaboration will give us a great head start in preparing for the enormous data challenges of the SKA and will allow access to both optical and radio data to probe the Universe across all wavelengths"

Jeff Kantor, Project Manager for LSST Data Management, points out "once you have separated the incoming data into sources and objects, it makes little difference to the system if the signal is at optical or radio wavelengths. So it makes sense to join forces with ICRAR to find data processing solutions for the enormous databases that will be generated by both of these amazing telescopes."

Using supercomputers located at the new Pawsey Centre in Perth, ICRAR's Professor Andreas Wicenec is heading up the international team designing data systems for the SKA radio telescope. "We expect to detect more than 100 billion objects, which is at least 10 times more than we've observed in the last 400 years of astronomy. This represents an immense challenge but potentially huge scientific reward", said Professor Wicenec.

ICRAR is a joint venture between Curtin University and The University of Western Australia providing research excellence in the field of radio astronomy.

Article based on a media alert written by Pete Wheeler, ICRAR

SUPERNOVAE: SEEDING THE ELEMENTS AND MEASURING THE UNIVERSE

This E-News article is based on Chapter 11 of the LSST Science Book: Supernovae. The Authors of Chapter 11 are:

W. Michael Wood-Vasey, David Arnett, S.J. Asztalos, Stephen Bailey, Joseph P. Bernstein, Rahul Biswas, David Cinabro, Kem H. Cook, Jeff Cooke, Willem H. de Vries, Benjamin Dilday, Brian D. Fields, Josh Frieman, Peter Garnavich, Mario Hamuy, Saurabh W. Jha, Richard Kessler, Stephen Kuhlman, Amy Lien, Sergei Nikolaev, Masamune Oguri, Scot S. Olivier, Philip A. Pinto, Jeonghee Rho, Evan Scannpieco, Benjamin D. Wandelt, Yun Wang, Patrick Young, Hu Zhan

Supernovae are some of the most spectacular events we can observe in the Universe. These stunning stellar endings seed the cosmos with elements that give rise to stars, solar systems, and even life, while providing one of the best ways to measure distances in the Universe. They serve as standard candles at large distances revealing evidence for the accelerated expansion of the Universe. Observers have recorded about 1,000 supernovae with descriptions of these events found recorded in texts of many civilizations stretching back 1,000 years. Today astronomers study supernova explosions in distant galaxies and remnants in our own and nearby galaxies with sensitive telescopes. LSST's data will dwarf the observations to date as it discovers over 10 million supernovae during its ten-year survey. And "LSST will find ten of each type of rare, once-in-a-million supernova," according to Michael Wood-Vasey. Using this unprecedented compendium of stellar death throes, scientists will expand our understanding of stellar evolution, the large-scale structure of the Universe, and dark energy using observations of these cataclysmic events.

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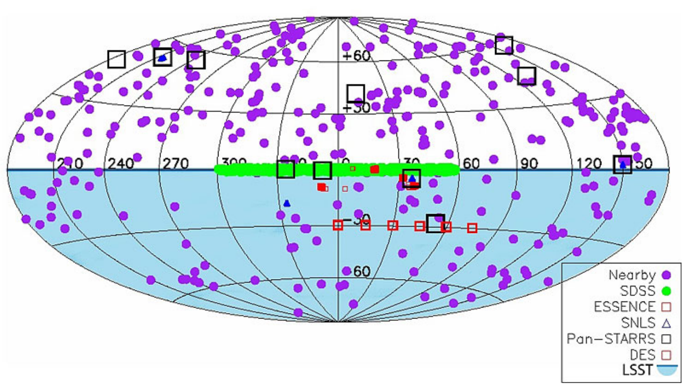
What is a supernova?

A supernova is a spectacular stellar explosion, which for a brief time can outshine its host galaxy. Our understanding of these catastrophic explosions comes from the observations of spectra and light curves. Generally, supernovae come in two varieties: Type I, supernovae with spectra lacking hydrogen lines, and Type II, with spectra displaying hydrogen lines. Differences in the spectra and light curves define subgroups within these categories. Type Ia supernovae are understood as white dwarf stars that accrete mass from a close companion until they reach a critical limit at 1.4 the mass of our Sun and collapse catastrophically. Type Ib, Type Ic and Type II supernovae are thought to result from the core collapse of stars at least eight times as massive as our Sun. LSST data will reveal even more variations in behavior and properties as its survey increases observations by 10,000 times current numbers. These results will enable scientists to explore how and why a star evolves into a supernova.

LSST will discover almost as many Type II supernovae as Type Ia supernovae. It will obtain finely sampled light curves for both types in many colors. The chemistry of these core collapse supernovae will provide understanding of the cosmic chemical evolution of iron-group elements. Supernovae in galaxies can be used to measure the star formation history of the Universe.

Although Type Ia supernovae are currently understood well enough to measure the accelerating expansion of the Universe, the details of variation in peak luminosity need to be understood to enable the exploitation of ever-growing supernova data sets. There is considerable debate about the physics of supernovae. With a large sample size,



Distribution of supernovae on the sky as found from existing and planned surveys. The nearby supernovae are relatively uniformly distributed, but the higher-redshift surveys have targeted only limited areas. The green SDSS stripe and boxes (Supernovae Legacy Survey (SNLS), ESSENCE Supernovae Survey, Pan-STARRS, and Dark Energy Survey (DES)) have a redshift range comparable to LSST but the LSST survey will cover the entire southern half of the sky. Credit: M. Wood-Vasey.

The arrow at the top right points out the supernova, SN 2004dj, in galaxy NGC 2403, 11 million light years away. This image from the Hubble Space Telescope shows the supernova shining with the light equivalent to 200 million Suns in 2004. It was the closest stellar explosion seen in more than a decade. Credit: STSci-2004-23.

researchers will be able to test for the underlying causes of the dispersion of peak luminosity and determine if well-measured properties of the supernova and its host galaxy can be used to reduce this dispersion. Dependence on cosmic time or redshift would indicate evolution of the progenitor population. There is good evidence for a variation in Type Ia supernovae properties as a function of galaxy type – higher luminosity, slowly brightening and slowly declining Type Ia supernovae are associated with star-forming galaxies. LSST will allow correlations of supernovae properties with those of their host galaxies. Wood-Vasey points out: "With millions of supernovae, we can take only the best 1% to form a uniform set of 10,000 Type Ia supernovae that will be free from the most important systematic uncertainties limiting Type Ia supernova cosmology today." The significantly larger sets of data will help in understanding the progenitors and explosion models of supernovae and improve their precision for cosmology.

What will LSST supernovae data reveal about the earliest times of stellar evolution?

Pair-production supernovae are incredibly massive stars, 140-260 solar masses, which astronomers expect only in primordial environments. In today's Universe the prevalence of elements heavier than hydrogen and helium prevent such massive stars from forming by absorbing radiation from proto-stellar cores and pushing away additional infalling material. The centers of the progenitors

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of pair-production supernovae are so hot that they can produce gamma rays with sufficient energy to create electron-positron pairs as outer layers of the star collapse inward during the last phases of the star's lifetime. LSST will be able to discover these distant rare events through its unique deep, wide and rapid coverage. The light-curves of these explosions will be identified by their extended rise and fall in brightness over hundreds of days that will be very well sampled by the LSST main survey cadence. Pair-production supernovae will provide unique probes into extreme events in stellar evolution in the earliest times of the Universe.

How will supernovae reveal the large-scale structure of the Universe?

Type Ia supernovae can be used as standard candles (a class of objects with same/similar brightness) to determine their distance using the inverse square law. Type II supernovae can serve as distance indicators and validate Type Ia distances measured in the same surveys. Furthermore, since Type Ia supernovae explode in galaxies, they can be used to trace the large-scale structure of the Universe.

What will supernovae tell us about dark energy cosmology?

"The underlying nature of dark energy is unknown, and it is the only fundamental interaction that cannot be studied in a terrestrial laboratory. Astronomical observations are the only tools available to study dark energy, and supernovae observations are among the most precise methods," points out Rick Kessler.

Because type Ia supernovae are the best standard candles at large distances, they provided the first observational constraint for the dark-energy model of cosmology. The challenge for researchers in the next decade will be tounderstand the physics of supernovae, their relationship with their environments, and the nature of the redshift-luminosity relation for Type Ia supernovae. LSST will provide the massive numbers of samples at all redshifts needed to achieve this understanding. Systematic effects can be well studied by dividing the LSST sample into many large independent data sets, each reflecting different properties of the supernova and its host galaxy, and checking for consistency among these samples.

New Supernovae Collaboration Team Members

- Robert P. Kirshner
- Peter Garnavich
- Maryam Modjaz
- Ben Dilday

One of the most powerful properties of Type Ia supernovae as cosmological probes is that each single event provides useful constraints. Comparing the LSST Type Ia sample to other cosmological probes will reveal and minimize systematic errors. Kessler declares, "once this is done, researchers will be able to assess the spatial and temporal uniformity of the dark energy with vastly improved precision."

Supernovae are spectacular events, which inspire awe for the energy they release, for the beauty of the remnants they leave behind and for the knowledge about stars, structure and cosmology that they can produce. "Each supernova is a probe of its place in the Universe and the cosmos in between it and us," states Wood-Vasey. LSST's discoveries will provide data to illuminate the nature and expand the scientific uses of supernovae for generations.

Article written by Anna H. Spitz and Michael Wood-Vasey

SCIENTIST, EDUCATOR AND ENTREPRENEUR – ERIC HILTON

Eric Hilton is poised to complete his graduate studies at the University of Washington in 2011, but he's already launched other aspects of a multifaceted career. While enthralled with his science, as co-founder of *Technically Learning*, an educational non-profit started with several friends, he takes rigorous, research-based science lessons to teachers and teens. His love of science and dedication to research find expression in getting the coolest activities developed by working scientists and engineers to inner city, low-income teachers and kids.

After graduating from Carnegie-Mellon University with a B.S. in Physics in 2003, and seeing a poster for the Peace Corps, Eric deferred his start on a Ph.D. at the University of Washington (UW) and traveled to Guyana to spend two years as a secondary school teacher. This experience increased Eric's interest in communicating the wonder and process of science to youth and ignited a passion parallel to his dedication to scientific research. On his return to the States and UW's graduate program, he began to add efforts in science education and outreach to his research activities. His non-profit hired an Executive Director

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Eric Hilton. Image credit: L. Klein

this summer to grow the business based on the partnership of rigorous research and education. His stint in the Peace Corps also initiated travels to over twenty countries to date.

"I think it's incredibly important that the average person has some understanding of science because science has a lot to say about some of the world's most important problems such as climate change, energy policy, health and medicine – the list goes on and on." In addition to co-founding Technically Learning, Eric started *Engage: The Science Speaker Series* with graduate student scientists at UW for the general public and taught a seminar in Fall 2010 to train scientists how to communicate their science effectively.

Working with Suzanne Hawley and Paula Szkody at UW since 2005, Eric focuses his research on flares on low-mass stars. "Although there are billions of them in the Galaxy, they are faint, especially in blue bandpasses. So not much is known about their bulk properties far from the Galactic plane, nor about their variability in the blue. Learning about things no one else knows is one of the most satisfying things about my work. I really enjoy the excitement that comes along with working on a project that will provide so much new science. LSST will see thousands upon thousands of transients every night. Many of them will be understood (known variable stars, etc). But some objects appear as true optical transients - present in one or more images, but then go away, not to be seen again. M dwarf flares have the potential to contribute to this group. The problem is that M dwarf flares might contribute so much that they make finding other kinds of interesting or unknown transients difficult. They could be the haystack hiding the needles, so to speak. Part of my thesis is on estimating this rate of M dwarf flares appearing as blue transients, so that other science can account for it. This is an important part of transient science, and a good reason why my thesis is very relevant to LSST. I am building a model of the Galactic M dwarf flare rate, and I will 'observe' my model with the LSST cadence and depth to estimate this."

Given that Eric has a wealth of experiences and interests, LSST and especially the Transients and Variable Stars science collaboration, provides a great match. "I like the way the project is being run, especially the way that the science collaborations contribute. Collaborating with large groups of people who are not paid to do this work can be challenging. We try to find ways to make the work we're doing to prepare for LSST work for us and be useful for others."

Science, collaboration, communication – all part of this young scientist/educator's plan to move forward into new and unknown research areas and career opportunities. "It's very likely that LSST will observe all kinds of interesting phenomena that we currently don't know anything about. It's the surprises that are especially interesting. We'll just have to wait and see what's in store. I hope to be working on LSST as this happens for the next 5, 10, 15 years."

Article written by Anna H. Spitz

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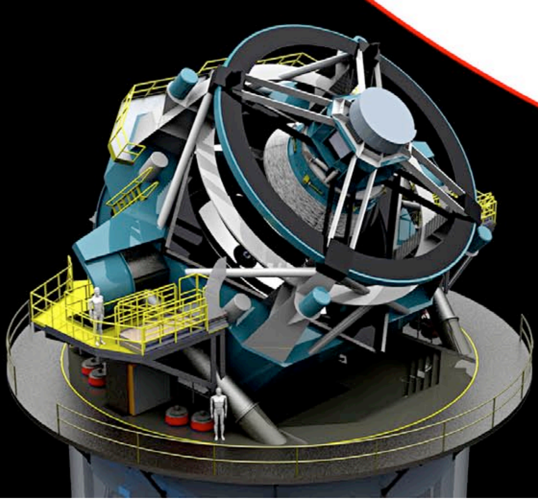

Large Synoptic Survey Telescope