Large Synoptic Survey Telescope
E-News

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This issue of LSST E-News completes our first year of publication. Highlights this quarter include progress on the primary and secondary mirrors fabrication, obtaining all environmental and building permits for construction of the LSST in Chile, acquisition of the 1.2-m Calypso telescope currently located at Kitt Peak near Tucson, and a scientific meeting hosted by the University of Washington to write an "LSST Science Book."

Seasons Greetings and Best Wishes for 2009

PROJECT MANAGER'S CORNER

Don Sweeney, LSST Project Manager

In November the LSST Corporation (LSSTC) welcomed Vanderbilt University as the newest Institutional Member. Dr. Keivan Stassan will be the Vanderbilt Institutional Representative. The addition of Vanderbilt brings the total LSST membership to 27 with at least two additional applications pending before the Board.

LSSTC has named Dr. Chuck Claver as the LSST Systems Engineer. Chuck has been acting Systems Engineer for the last two years and the System Scientist for Telescope and Site. Chuck has resigned the latter position to focus full-time on system engineering.

As a sign of our growing project, the LSSTC is pleased to announce that we have a full-time Business Administrator as of December 28th. Mr. Daniel Calabrese, shown in the photograph, (dcalabrese@lsst.org) joins us having spent the last four years at NOAO, Central Administrative Office. At NOAO he was responsible for many of the LSST contracts and agreements. He will now have that responsibility and many others within the Corporation.

LSST staff continues to prepare for the NSF Preliminary Design Review (PDR) and DOE Critical Decision-1 Review (CD-1); both reviews are tentatively scheduled for mid-2009. The project completed a series of internal reviews lasting a total of six days with six external reviewers to access our readiness for the PDR and CD-1 reviews. As always, we learned of areas where we can improve but the overall assessment is we are absolutely ready to move forward with these federal agency reviews. All of us on the project appreciate the generosity of the six external experts who contributed their time for the benefit of the LSST.

Corning Prepares to Fuse the LSST's Secondary Mirror (M2) Substrate

Anna Spitz and William Gressler

Corning Incorporated has successfully manufactured and selected all glass material and machined a test piece for a section of the LSST's secondary mirror (M2) substrate. M2 will be the largest secondary convex mirror ever manufactured and polished. Its extensive size supports the stringent imaging requirements of LSST wide-field science, while permitting occupancy of the camera system within its central hole. Corning technicians are now working through the long, cold, dark, bleak winter in the upper reaches of New York State (Canton) and will continue through next year to produce the M2 annulus shaped substrate (inner hole diameter 1.8 meters and outer diameter 3.5 meters). Corning will complete the substrate in late 2009, and LSST will deliver the Corning substrate to an optical fabricator (not yet selected).

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Corning forms its mirror substrates from a series of fusion-sealed Ultra Low Expansion (ULE®) boules. Historically Corning has cut boules into hexagonal shapes for layout and fusing into mirror substrates. But because the LSST secondary has a large inner diameter, technicians will cut the boules into new "petal" shaped segments and arrange them in an annular pattern.

After manufacturing and inspecting the boules for coefficient of thermal expansion (CTE) homogeneity and quality, workers selected the eight required for use in the mirror substrate. During November, they completed machining of one ULE® test boule to demonstrate the first test petal-shaped piece. After they complete machining of all eight boules, they will load the petals into Corning's 8-meter furnace in a pattern that optimizes CTE homogeneity in the fused monolithic substrate. By late February 2009, the glass will be fusion sealed into a solid piece of glass at a temperature of 1800°C. The plano substrate will be verified for critical zone placement and ground oversize on both surfaces and on the inner and outer circumference. This phase in the process culminates in a 3.5-meter diameter annular plano mirror blank with a thickness of 100 millimeters.

After the mirror substrate is fused workers will again load the plano substrate into the furnace and heat it to 1500°C until it slumps onto, and takes the meniscus shape of, a contoured sag form. Corning will perform the standard ULE® fine anneal at 1000°C after the final heat treatment of the sagging process, which will ensure that it meets minimal residual stresses and final CTE requirements. Technicians will generate the concave back and convex front surface of the substrate as well as the outside and inner diameters on Corning's 4-meter grinding machine. Corning will provide an aspheric contour ground convex surface to reduce material that the optical polisher will need to remove. Finally Corning will acid etch all substrate surfaces, which provides a pristine surface on which mounts are placed, reduces residual stresses, and increases the overall structural integrity of the substrate. The total schedule for the substrate development will be eighteen months.

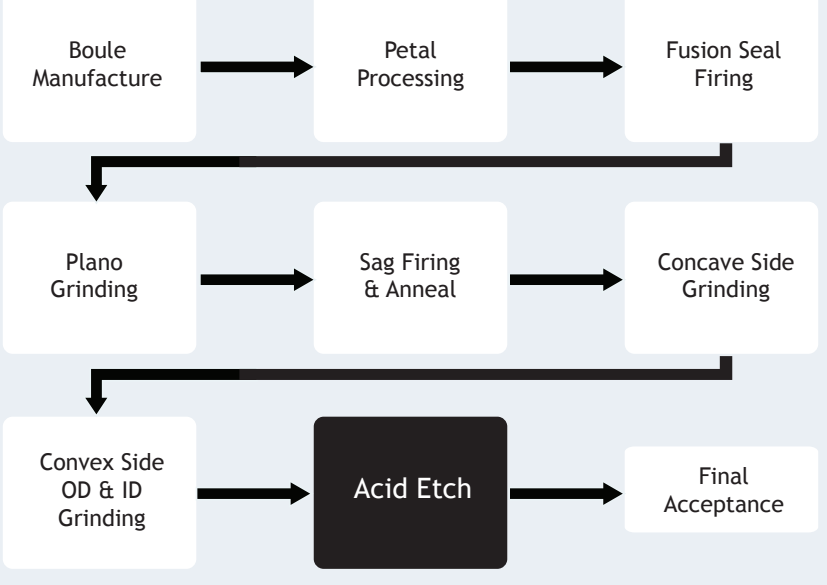
LSST chose this design and process after investigating various telescope optical design options. During the design phase, science constraints and telescope packaging drove design criteria: the wide-field necessitates a large convex secondary, while packaging

M2 petals selected and machined

dictates a generous inner diameter to support the camera system. Aspects such as weight limitations, material availability, and cost further defined specifications. Based on the science requirements, design constraints and examples of successful similar mirrors in telescope projects such as SOAR, Discovery Channel Telescope, and VISTA, LSST optics designers settled on the current M2 design. The desire for low expansion glass to meet design specifications limited the choice of available vendors, and Corning provided the winning competitive bid.

Armory Houghton founded Corning Glass Works in 1851. The company has produced the mirrors for the Hubble, Gemini, and Subaru telescopes. Corning's creation of ULE® glass traces its ancestry to its decision to use the glass blend, Pyrex, to cast the 200-inch mirror for Mt. Palomar in the 1930s.

After Corning finishes its work, the M2 substrate will move on to the optical fabricator for final polishing to achieve better than 20-nanometer surface accuracy. And after the polishing phase, the fragile secondary mirror will move to Chile for integration into the LSST telescope system on-site. M2 has a long journey ahead—full of delicate and demanding activities. Stay tuned for future updates.



M2 Substrate Processing Plan

FOCUS ON....Science Collaboration Teams' Meeting at Friday Harbor

Anna Spitz

Representatives from the ten science collaborations met in Friday Harbor, San Juan Island, Washington from December 10th to December 15th to work on the "LSST Science Book" (working title). Zeljko Ivezic, Chair of Science Council, organized the meeting and kept all attendees on the straight and narrow.

The University of Washington's Friday Harbor Laboratories (FHL) are located on San Juan Island, part of an archipelago that lies between the mainland and Vancouver Island. It is about 70 miles north of Seattle. The attendees reached the appointed site at the appointed time via air and ferry. FHL provided cottages for all forty-two attendees, and the meeting convened in the assembly/dining hall with breakouts in various other rooms on the campus.

Science collaboration team members gather at FHL to write LSST Science Book

The idea for an LSST Science Book has been germinating for quite a while. The decision to prepare the book at this time was prompted by internal progress on LSST (the level of simulations, the work of the science collaborations) and external events such as Astro2010, Astronomy & Astrophysics Decadal Survey. The editors hope to produce a public product in mid-April for use by Astro2010. The LSST Science Book will be a living document, however, as well as a reference publication, with updates over the years.

This was a working meeting dedicated to organizing and producing material for Science Book chapters. The science collaborators had prepared for the meeting to differing extents: some chairs had assigned topics and required written elements of the chapters, others arrived with little formal preparation and launched into spirited deliberations on the expectations for their science. Representatives from all ten science collaborations discussed the science they want to pursue with LSST, the overlap of investigations with other collaborations and the simulation, cadence and data management needs for their research.

Ivezic and Michael Strauss, Chair of Science Advisory Council, made sure that the meeting included discussions among the scientific teams and the data management and simulation teams as well as the hard work of writing. Andrew Connolly and Philip Pinto discussed the progress of simulations and varieties of cadence. Tim Axelrod presented details about the data management system. Each solicited information from the science teams about what they need from the simulations and infrastructure to do their science. Dave Burke discussed how LSST will achieve a level of calibration previously unheard of in astronomy. Kirk Gilmore provided an update on the status and performance of filters and sensors. Dave Monet provided a curmudgeon's view of astrometry with LSST.

The purpose of the book is to lay out the case for doing science with LSST. Teams will identify representative and interesting science that will be possible with LSST, which provides unique opportunities for comprehensiveness and depth of observations.

The Friday Harbor meeting succeeded in eroding boundaries between science groups and boundaries between science and infrastructure groups. While the legacy of the meeting will be the physical book detailing the amazing science plans for LSST, perhaps a more important outcome is the improved communication and collaboration LSST team members will carry back to their home institutions and other collaboration members.

Regional Authorities Approve LSST's Environmental Declaration

Anna Spitz and Victor Krabbendam

Chile's environmental commission of the Coquimbo IVth Region, Comisión Regional del Medio Ambiente (COREMA), completed its final review and approved the environmental declaration, Declaracion De Impacto Ambiental (DIA), that the Association of Universities for Research in Astronomy (AURA) prepared on behalf of LSST and submitted to the national environmental protection agency, Comisión Nacional del del Medio Ambiente (CONAMA). This approval effectively permits LSST to build and operate on Cerro Pachón.

AURA's 85,000 acre property that includes both Cerro Pachón and Cerro Tololo, in Chile is already designated a scientific preserve. This simplifies the environmental permitting process but CONAMA still requires that each new significant development on the preserve produce an environmental declaration prior to use of the site. This declaration has similar submittal requirements to US EPA environmental impact statements, and is a one-time activity. AURA submitted the 100-page DIA describing LSST's development and operations plans in July to CONAMA. Elements of this

COREMA approves LSST's environmental declaration

report included flora and fauna surveys, evaluation of physical impacts to the site, and how any impacts will be mitigated. In all, seventeen

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(Regional Authorities...)

Chilean agencies reviewed the submittal. As part of the evaluation, the COREMA regional assessment committee made a site visit in August (see LSST E-News October 2008), held public meetings (see the government report of the meeting at http://www.gorecoquimbo.cl/gore_news02.php?sc=2&id=2126#), provided comments, and requested responses to the concerns of the agencies.

"The process was positive, collaborative, and thorough" says Enrique Figueroa, Manager of AURA Observatory Support Services and the lead of the LSST DIA effort. After a series of comments, questions, and responses, AURA's final presentation to COREMA representatives occurred in December. See the regional government's notice of the meeting at http://www.gorecoquimbo.cl/gore_news01.php?sc=2&id=2280. Final approval was immediate. This approval authorizes site construction activities for LSST to begin immediately.

This is a significant milestone for the LSST project. "Environmental permitting, even for low impact astronomical observatories, can often cause projects difficulty. Completing the DIA enables us to proceed with initial site leveling and further geotechnical testing of the site," reports Jeff Barr, the Project Architect on the LSST Telescope and Site Team responsible for summit facility and site development. Many thanks go to Enrique Figueroa and his staff for their help in completing the DIA process for LSST.

Calypso telescope with enclosure rolled to observing position

LSST Acquires 1.2-meter Calypso Telescope

Anna Spitz and Victor Krabbendam

The LSST project acquired the 1.2-meter Calypso Telescope from Edgar Smith in November. LSST will use the telescope in its current location on Kitt Peak to conduct unique scientific investigations in support of calibration plans and to prototype hardware and software components. In the future, LSST plans to move the telescope to Chile to use it for atmospheric monitoring.

Edgar O. Smith, a businessman and astrophysicist, led the Calypso development in the late 1990s. The team developed the state-of-the-art telescope for high-resolution imaging of globular clusters among other studies. The primary, secondary, and tertiary mirrors are all made of Corning ULE® and coated with aluminum. The telescope's primary mirror is a thin meniscus design. The telescope has two cameras: a high resolution camera and a wide field camera with a 4096 x 4096 15 micron pixel, thinned and backside-illuminated CCD that covers a 9.8' square field of view. Finished in 2001, Calypso has operated as the only stand-alone private facility on Kitt Peak since that year. Dr. Smith offered very generous terms for LSST to take over the facility, and the project is pleased to be able to put the facility to good use now and in the future.

The scientific plans for Calypso focus on several long baseline time domain observing programs for the next few years. The goal is to develop a strategy for photometric calibration that will achieve better than 1% photometry by observing over long baselines and varying conditions. LSST will migrate or improve coordination of observing programs prototyped at Cerro Tololo Inter-American Observatory, Kitt Peak, and Mt. Bigelow to Calypso to achieve a more comprehensive calibration investigation.

The team will use Calypso to measure stars with known spectral energy distribution over the entire visible sky, every 5-10 minutes, and several nights per lunar cycle over multiple observing seasons. From these data, LSST scientists will generate temporally and spatially dependent extinction maps of the atmospheric color terms. They will combine these spectral measurements with simultaneous photometric measurements of stars surrounding the spectral reference star. These measurements, in conjunction with the gray extinction measurements on scales from a few arc minutes to several degrees, will allow LSST to establish a new grid of photometric reference stars across the whole sky. These measurements are needed to know precisely the magnitude of these variations over the expected range of observing conditions that LSST will likely experience. While 1.6 magnitudes of extinction is clearly recognized as poor observing conditions, subtle cloud structure is not so easy to spot, but does materially affect the programs aiming for sub 1% photometry such as LSST.

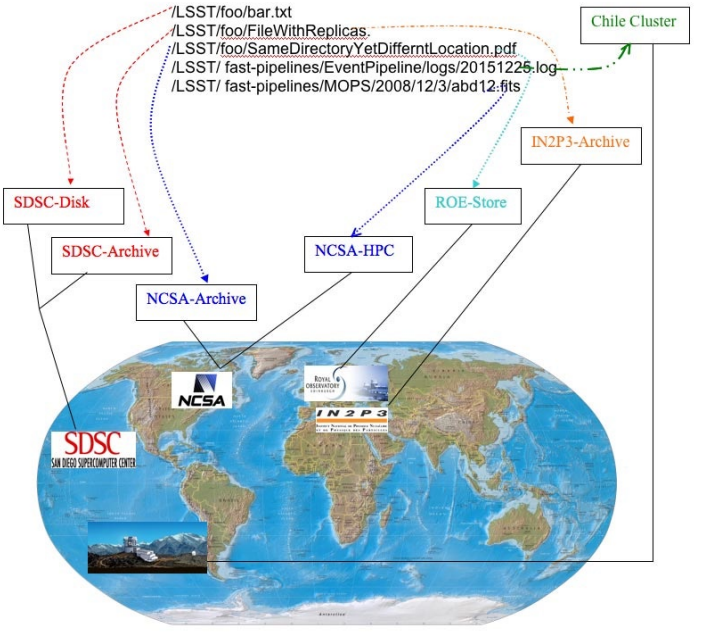
In order to carry out this program, Calypso will need spectroscopic capability. LSST engineers will replace the high-resolution camera with a new small imaging, moderate resolution instrument and will also place LSST filters on the wide field imager. LSST has established professional services agreements with principals of the observatory to ensure the smooth handover of design and operational knowledge and encourage participation in development of new instrument plans.

Once moved to Cerro Pachón, Calypso's atmospheric monitoring will provide additional contributions to LSST calibration. Observations with Calypso promise to bring important information for LSST's calibration and as well as nice scientific results useful to the general community.

LSST Data Management Team a Finalist at SC08

Anna Spitz and Arun Jagatheesan

The LSST Data Management (DM) team arrived as one of three finalists for the High Performance Computing (HPC) Storage Challenge (SC) at the 20th SC08 conference in Austin, Texas in November, and came home first runner-up out of a field of strong competitors! The SC Conference is the foremost international conference for high performance computing, networking, storage and analysis attended this year by more than 11,000 scientists, engineers, programmers, researchers, system administrators, managers and educators. The conference features the latest scientific and technical innovations from around the world and showcases demonstrations of how these innovations will enhance people's abilities to understand information. In its first attempt at this prestigious competition, LSST placed second, winning a certificate of participation and an invitation to come back next year. LSST earned this distinction by demonstrating how the proposed data management infrastructure will manage anticipated data volumes along distributed pathways between the telescope, base facility, archival center and three data centers over the decade long survey lifetime.



SC08 Team

- Arun Jagatheesan—San Diego Supercomputer Center (SDSC) and iRODS.org
- Michael Wan, Wayne Schroder—iRODS.org
- Chris Cribbs, Ray Plante—National Center for Supercomputing Applications (NCSA)
- Jeff Kantor, Tim Axelrod—LSST
- Chris Smith, Petri Garagorri, Ron Lambert, David Walker—National Optical Astronomy Observatory (NOAO)
- Mark Holliman, Elena Breitmoser, Robert Mann, Arthur Trew—University of Edinburgh
- Jean-Yves Nief—Centre de Calcul-IN2P3
- David Gehrig—University of Illinois at Urbana-Champaign
- Reagan Moore, Arcot Rajasekar—University of North Carolina at Chapel Hill and Renaissance Computing Institute.
- In addition to the above the following people contributed to this challenge: Francesco Pierfederici (LSST), Antoine de Torcy (SDSC), Stephen Pietrowicz (NCSA), Greg Daues (NCSA), Kian-Tat Lim (SLAC) and Sean McGeever (EPCC).

LSST's data management requirements provide opportunities for new data management paradigms to be used for effective solutions in data management. Arun Jagatheesan led the international team on the Challenge, *Data-lifecycle Management Over a Loosely Coupled Distributed Infrastructure*. The LSST data management team and collaborators prepared the various aspects of this Challenge for a year prior to the Austin meeting.

For the SC08 Challenge, LSST's data management team focused on just one of the LSST requirements: data-lifecycle management. LSST data has to be managed over its lifecycle on heterogeneous media at multiple sites. LSST's storage infrastructure resides in geographically distributed data centers. It is a challenge to provide an efficient long-term infrastructure that allows the union of storage from multiple organizations and from multiple storage systems.

The LSST challenge simulated data management with various data centers taking on different roles within the LSST project: CC-IN2P3 in France played the role of the LSST telescope, the Royal Observatory at the University of Edinburgh played the role of a data center at the base of the telescope in Chile, and the National Center for Supercomputing Applications (NCSA) played the role of the data archival center. Three data centers including San Diego Supercomputer Center (SDSC), Cerro Tololo Inter-American Observatory (CTIO) and Renaissance Computing Institute (Renci), acted as data access centers with different capabilities. The team then ran experiments to demonstrate how LSST will handle data.

The team performed multiple experiments to demonstrate the scalability, performance, and innovation of LSST solutions. These experiments (or simulations) showed that the proposed LSST infrastructure can manage more than nine quintillion files (a billion-billion) with hierarchical rules (or policies) at different sites that participate in the LSST—many more than will be required. The SC08 Selection Committee issued the Finalist Certificate with a statement of recognition for LSST's achievement and an invitation to compete next year. Lessons learned by participating in these challenges improve not only LSST's future solutions but also steer the future of data management technologies in the worldwide community.

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