LSST E- News

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In This Issue

The LSST Project has emerged from a busy and exciting summer preparing the technical and administrative aspects of the Project for the final stages of design and construction readiness. In July, the LSST project management transitioned to Victor Krabbendam, who kicks off his contribution to LSST E-News below…

PROJECT MANAGER'S CORNER

More than 260 project, science collaboration, and international affiliate members attended the 2012 LSST All Hands Meeting held August 13-17 at the Ritz-Carlton Dove Mountain in Marana, Arizona. Here, the participants pose for a group photograph on the resort's Brisa Lawn. (Image Credit: Pete Marenfeld)

I have been on the job for three months now, and I am very excited to be working with a great team on a spectacular project. It is a tremendous privilege to be named the LSST Project Manager. It is already well established that the Project is positioned to address many of today's compelling questions in astronomy and physics. It will also provide a new paradigm for data intensive science and engineering and will offer countless opportunities to address STEM education. The privilege for me is the opportunity to work with the team of engineers, scientists, and other professionals to derive, build, and commission this observatory. The team has been led by Don Sweeney since 2003, and it is my pleasure to take over and lead this team in making the LSST a reality.

The agency-led reviews in May (see our June issue of E-news) were milestones in several aspects. These reviews were jointly sponsored by the NSF and DOE to address issues and concerns held by each agency. The Cost review focused on the changes made to program cost and schedule in order to align the NSF and DOE elements of the program. The result of this review is a schedule and cost that we now consider to be the baseline not-to-exceed values. The Joint Interface and Management review addressed the LSST management structure of the dual agency program and took a critical look at the interface definitions of those areas where the scope for the two funding agencies depend on each other. The positive comments from both of these review panels were a testament to the hard work completed by a vast number of individuals throughout the team. The team was rewarded with excellent news in July when the National Science Board authorized the Director of the NSF to advance the LSST into the final design phase, an action that also permits the NSF Director to put LSST into a future MREFC budget.

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The All Hands Meeting in August was an unmitigated success (see Survey article). It brought together 267 participants for a week-long meeting to discuss LSST. There were 22 plenary talks and 59 working group sessions throughout the week, so the science collaborators and engineers alike could work together on common and otherwise just important project development issues. Also at the meeting were 32 participants from 29 potential international affiliates, those organizations world-wide that provided letters of interest in supporting LSST operations. The value of bringing the team together was clear, and I will work with the team to provide similar opportunities in the future. All Hands Meetings may not always be this big, but I will strive to bring the scattered members of the collaboration together for more face-to-face interactions.

2012 LSST All Hands Meeting participants listen to LSST President Sidney Wolff's "Political/Administration Status" presentation during the opening plenary session. The AHM was held August 13-17 at the Ritz-Carlton Dove Mountain in Marana, Arizona.

With the new fiscal year starting in October, the Project is also moving into a new phase to prepare for construction. The NSF has awarded a new cooperative agreement for LSST Design and Development work that starts in fiscal year 2013 and intends to bring the project to the start of construction. There remains uncertainty in the start date for MREFC construction, but the program plan continues a high level of activity focused on preparing for the next Agency reviews and a construction start. The NSF Final Design Review and the DOE CD-3a review are both anticipated late in calendar year 2013, and we will advance the Project to be ready for an MREFC construction start in July 2014.

LSST SCIENCE COLLABORATIONS: A LOOK AHEAD

Eleven LSST science collaborations have been in place and working actively with the Project for the past several years. These collaborations have been very helpful in developing the scientific arguments for constructing the LSST and determining the science requirements, with authoring the LSST Science Book being just one example.

The LSST Corporation (LSSTC) was founded in 2003 to develop and promote the LSST Project, and the many major milestones accomplished this past year testify to the success of the efforts to make the Project ready for construction. But the primary motivation was and continues to be successfully enabling the great science that LSST will make possible. The LSSTC Board is now increasing its focus on promoting and encouraging scientific activities related to LSST. The scientific community must interface to the Project to provide input on survey strategy, gain familiarity with the LSST data products and the tools needed to handle the immense quantity of data that the Project will deliver, and begin developing Level 3 data products and analysis tools that in some cases will be required to pursue specific scientific programs.

Science collaboration team members gather in December 2008 at the University of Washington's Friday Harbor Laboratories to begin writing the LSST Science Book

The diverse scientific goals of the users of LSST survey data will require different levels of preparation and organization.

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The importance of preparations for the effective exploitation of LSST data as soon as operations begin has already been recognized by the Department of Energy, which has encouraged the formation of a twelfth science collaboration focused on dark energy. The Dark Energy Science Collaboration (DESC) is drafting a white paper describing the scientific preparations that need to be carried out while LSST is under construction. Participants will then seek funding to complete this work. The DESC is also developing its own set of rules for governing the collaboration. This is one example of how to address a scientific problem that requires a large collaboration and significant resources. Other scientific projects continue to be best pursued by small groups and individual PIs. In either case, the interfaces between the Project and the community will involve new approaches and support.

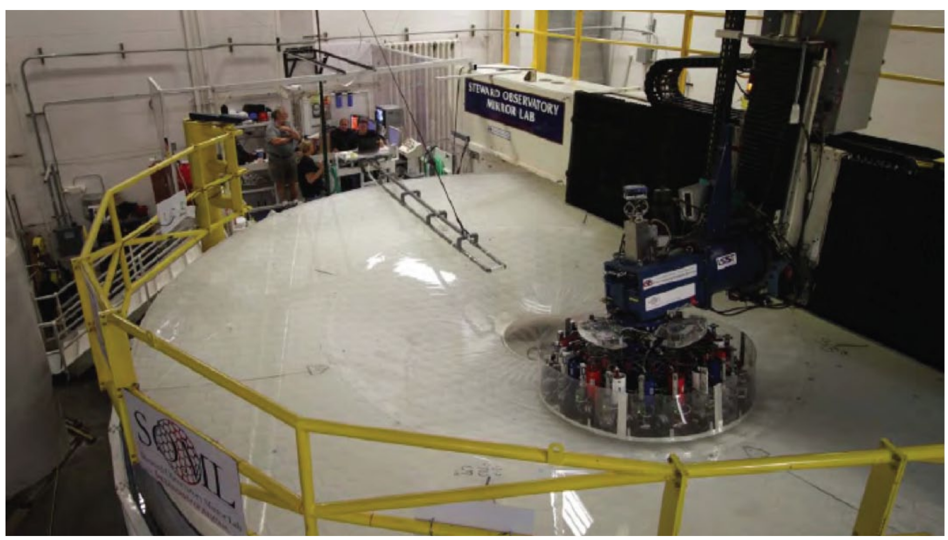
The LSSTC Board is now exploring how it might facilitate the organization, funding, and effectiveness of science collaborations that intend to conduct research with LSST data. As a first step, the LSSTC Board decided at its October meeting to establish an ad hoc committee, led by Michael Strauss, to explore how best to enable activities of the original 11 science collaborations. It is likely that this committee will recommend a combination of increased self-governance for these collaborations so that they can address their scientific goals in the most appropriate manner while also providing some of the infrastructure needed to facilitate interactions both within each collaboration and with the Project construction team.

The report from the LSSTC Board will be available in January and will guide new applicants about how the science collaborations are expected to evolve during the next few years and what the expectations are for the roles and responsibilities of new members of the collaborations. In previous years, there has been an open call, administered by NOAO, each fall for applications to join the science collaborations. This year, the call for new science collaboration members will be announced in January, both online and at the LSST booth at the AAS Meeting in Long Beach.

Article written by Sidney Wolff, LSSTC President

LSST MIRROR PROGRESS

Exciting progress has been made on both the LSST primary/tertiary (M1/M3) and M2 mirror systems. Steward Observatory Mirror Laboratory (SOML) has commenced optical polishing of M1/M3, and a formal request for proposal (RFP) bid package was released for the M2 optical fabrication effort.



A 1.2-meter stress lap performs a polishing run of the LSST tertiary mirror (M3) at Steward Observatory Mirror Laboratory. The M3 is positioned inside the primary mirror annulus ring as part of a single monolith. (Image Credit: Steward Observatory Mirror Laboratory)

M1M3 Moves into Final Optical Polishing

The M1 and M3 surfaces, which share a single monolithic blank with the M3 positioned inside the M1 annulus ring, are beginning to shine (literally) as they move into final optical polishing. Both surfaces have been generated to rough dimension and located in position via a coarse diamond wheel, removing nearly 5 tons of excess material to allow the steep M3 surface to emerge from within the M1 substrate. Next, they underwent loose abrasive grinding with finer and finer particle sizes to achieve the initial optical shapes (analogous to sanding a piece of wood with finer grit sandpaper). Now, polishing indicates we have finally reached the last optical processing step. However, this milestone also begins the most challenging aspect of optical fabrication as minute levels of material are removed and then measured to confirm convergence towards the final optical surface quality.

The polishing process is guided by optical test measurements of the mirror surface taken under the SOML test tower. The first photo on page 3 left shows preparation for M3 testing (fiducial patches on the mirror relate the test data to the location on the surface). The photo on the right side is a view looking

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upward to show the bridge structure which supports all the optical test equipment for M3. A similar bridge sits at the very top of the tower supporting the M1 test hardware.

The first optical test data of the M3 surface is shown in the next graphic. This interferogram represents a contour map of the surface, showing the deviation (in height) from the desired final mirror surface. The measurement data is used to determine the next polishing run. The information guides the location and dwell time of the polishing tool to remove small amounts of material, essentially polishing away the high contour areas to make the final smooth optical surface.

Notice the scale of the data is currently in microns of deviation which certainly is small, but this will eventually become nanometers of deviation as the polishing process is completed. Polishing of M3 and M1 will continue at SOML with final acceptance testing scheduled for late 2013.

M2 RFP Bid Package Released

The Telescope and Site team recently completed a successful M2 Final Design Review in early August to support the release of the RFP for the M2 optical fabrication effort. The baseline scope of work includes polishing the 3.4-meter convex surface and attachment of 78 mirror support pads. Optional scope for the polishing vendor includes the final design and fabrication of the complete M2 Cell Assembly system, consisting of the mirror cell structure, the mirror support system, electronics and sensors, thermal control, and the mirror control system.

The team invested considerable engineering effort to develop a comprehensive baseline system solution to enable a design/build procurement approach. The image to the right shows a cross section of the M2 Cell Assembly with the integrated M2 (pointing downward). Three rings of actuators comprise the 72 axial

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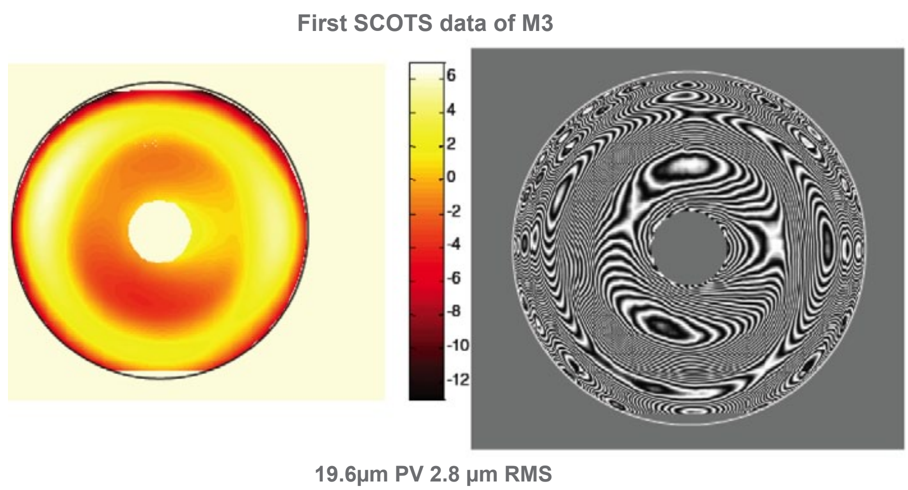
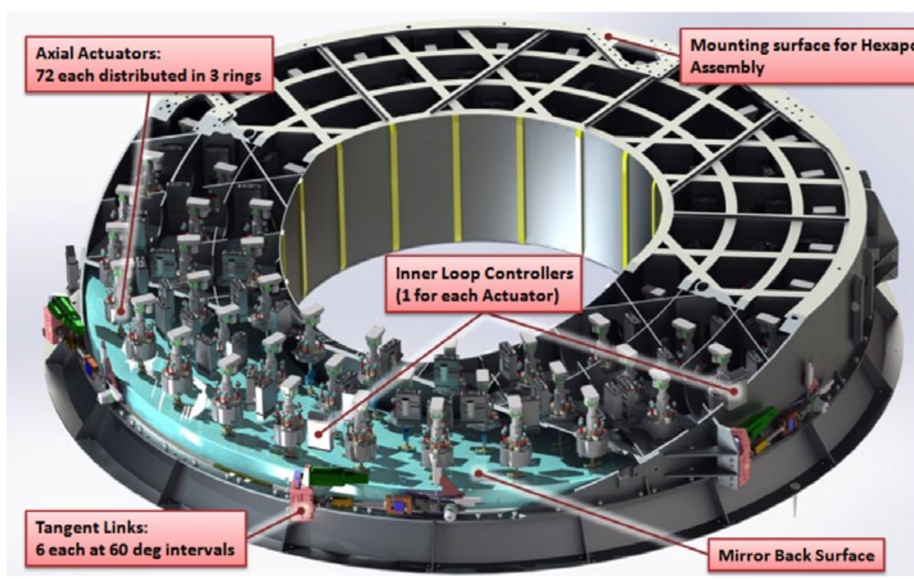
On the left, SOML team members prepare the LSST M3 for optical testing in the test tower. On the right, a view from below shows the SOML test tower bridge structure that supports the optical test equipment for M3. (Image Credit: Steward Observatory Mirror Laboratory)



An interferogram contour map of the M3 surface shows the deviation (in height) from the desired final mirror surface. The measurement data is used to determine the next polishing run. (Image Credit: LSST Corporation)



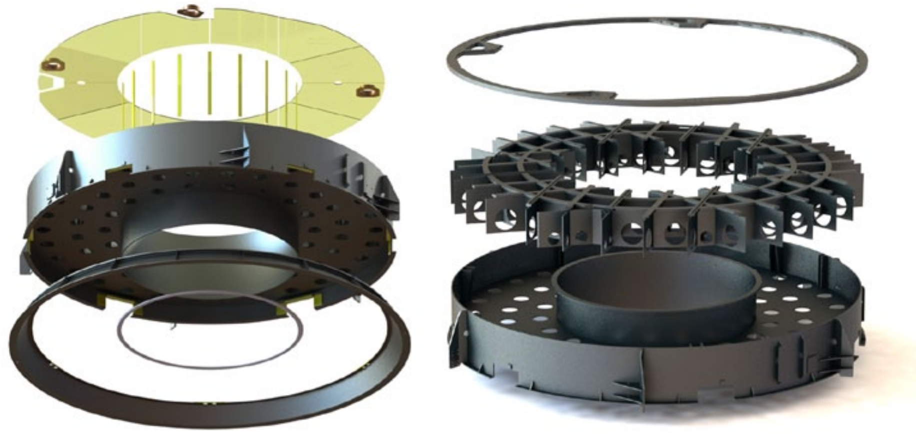
A cross section of the M2 Cell Assembly shows the integrated M2 (pointing downward) and three rings of actuators. The actuators push and pull on the mirror to control the convex mirror shape. (Image Credit: LSST Corporation) supports which attach to the small pads bonded on the concave backside of M2. These actuators push and pull on the mirror to control the convex mirror shape. Six tangent links around the outer diameter support the transverse loads as a function of zenith angle to minimize stress and deformation in the mirror substrate.

As shown to the right, the top of the Cell Assembly includes removable panels to enclose the system for thermal control and provides for attachment to the M2 hexapod which aligns the M2 on the telescope mount. The bottom of the Cell Assembly includes aperture rings to define the clear aperture of the M2 and safety stops to prevent any catastrophic damage due to a seismic event. The actuator circular ring geometry enables an efficient steel structure design for the mirror cell. The mirror cell exploded view highlights the design features which enable a high natural frequency (to minimize vibration on the telescope), access for maintenance, and clearance holes for cable routing and air flow.

In addition to engineering design and analysis activities, the team performed hardware testing of a prototype actuator. The image to the right shows the baseline actuator design and the prototype axial actuator in a test fixture. Laboratory testing confirmed performance of the component.

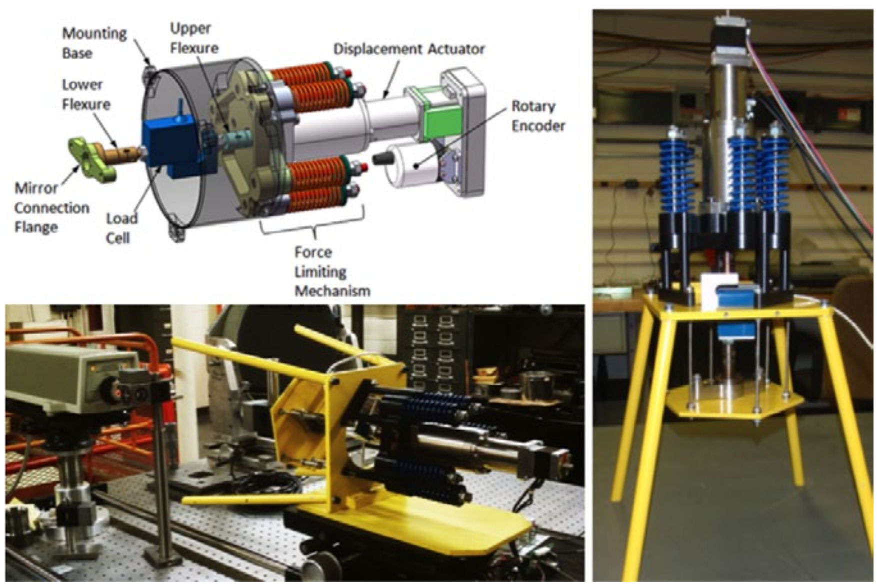
Vendor bids are due in early October, with the plan to award the contract to our polishing vendor in early 2013.

Article written by Bill Gressler, LSST Telescope and Site Subsystem Manager



Left: An exploded view of the LSST M2 Cell Assembly shows removable thermal control panels at the top and aperture rings and safety stops at the bottom. The safety stops prevent any catastrophic damage due to a seismic event. (Image Credit: LSST Corporation)

Right: An exploded view of the mirror cell highlights design features that enable a high natural frequency to minimize vibration on the telescope. Clearance holes enable cable routing and air flow. (Image Credit: LSST Corporation)



Laboratory testing of a prototype axial actuator confirmed the performance of the component's baseline design. (Image Credit: LSST Corporation)

THE LSST DATA AVALANCHE: ASTROINFORMATICS RISES TO THE CHALLENGE

Unlike previous articles in this series, this E-News article is not based on a chapter from the LSST Science Book. LSST formed the Informatics and Statistics Science Collaboration in 2009. Kirk D. Borne is the Chair of the collaboration. The members of the Collaboration are listed at the end of the article.

Every night for 10 years LSST will obtain approximately 2,000 images of the sky with its 3-billion pixel camera. This corresponds to about 15 terabytes of data daily for 10 years. As the survey progresses, researchers will have hundreds of petabytes of data to access, analyze, and interpret. Adjectives such as "flood," "avalanche," "fire hose," and "big data" are used to describe this onslaught of data. One of the major questions facing the LSST scientists and engineers is how to handle the large and complex data collection that LSST will generate. The Informatics and Statistics Science Collaboration is researching the science and engineering of this challenge. To keep up with the flood of data, researchers will need to

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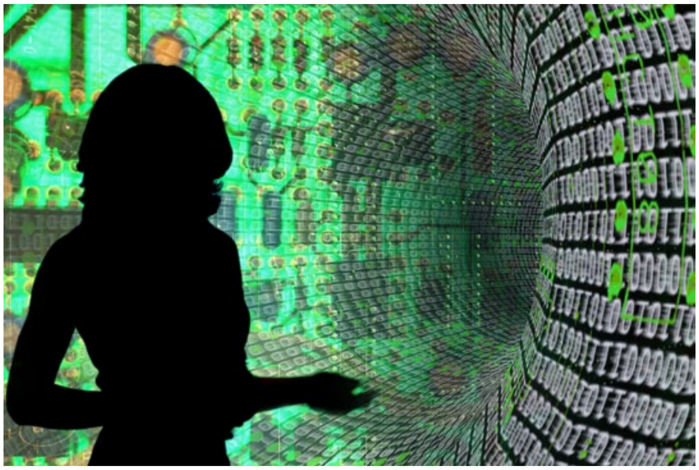

LSST opens the world of data-intensive astronomy, requiring skills in the area of computational and data sciences in order to maximize the opportunities for knowledge. (Graphic: Emily Acosta, LSST)

develop more powerful algorithms, methodologies, and approaches. Rising to the challenge will enable scientists to undertake new modes of discovery, where data-driven, data-rich science goes beyond traditional science.

This new "big data" isn't limited to large astronomy surveys. The growth of data volumes in nearly all scientific disciplines, business sectors, and government is swamping our ability to gain useful insights and understanding from the data in an efficient or effective way. How are we going to access, retrieve, interpret, analyze, mine, integrate, and visualize massive quantities of data? The answer is the informatics approach: the use of digital data, information, and related services for research and knowledge generation [D.N. Baker, EOS 89 (2008)]. Researchers will use the discipline of informatics, or more specifically, astroinformatics, to organize, explore, visualize, and mine the LSST data for new astronomical discoveries. A data-driven revolution in science is underway.

Astroinformatics encompasses a set of naturally related specialties including data organization, data descriptions, astronomical classification taxonomies, astronomical concept ontologies, data mining, visualization, and statistics. The accompanying cyberinfrastructure includes databases, virtual observatories (distributed data), high-performance computing (clusters and petascale machines), distributed computing (the Grid, the Cloud, and peer-to-peer networks), intelligent search and discovery tools, and innovative visualization environments.

Astroinformatics will allow data integration, data mining, and knowledge discovery across heterogeneous massive data collections. It will allow re-use and re-purposing of archival data for new projects, integration of data within different contexts, literature linkages, classification of objects, quantitative scoring of classifications, discovery of "interesting" objects and new classes of object, development of an astronomical "genome," and employment of data in educational settings among other uses. According to Borne, "We are not just using more data; qualitatively different methods for doing science with big data are required. It's a revolutionary new way to do science."

Borne sees a wide variety of data mining and statistics use cases for the LSST data collection. These include:

- Provide rapid probabilistic classifications for millions of events each night;
- Find new multivariate correlations and associations in high-dimension (dimensions around 1,000) astronomical attribute parameter space;
- Discover voids in these high dimensional parameter spaces, for example, period gaps;
- Discover new and exotic classes and subclasses of objects and astrophysical processes, along with new properties of known classes;
- Discover new and improved rules for classifying known classes of objects;
- Identify novel, unexpected behavior in the time domain from time series data;
- Hypothesis testing – verify existing (or generate new) astronomical hypotheses with strong statistical confidence, using millions of training samples;
- Serendipity – discover the rare one-in-a-billion type of objects through outlier detection, which Borne calls "Surprise Discovery" algorithms;
- Quality Assurance – identify data pipeline processing errors through deviation detection.

The landscape of astronomical research is changing rapidly. With powerful statistical and informatics methods and the advent of large surveys and massive data collections, astronomers will be able to meet the massive data-to-knowledge challenges of LSST and to discover the unknown unknowns at an unprecedented rate.

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Informatics and Statistics Science Collaboration

Ethan Anderes	George Djorgovski	Kevin Knuth	Chad Schafer
Jogesh Babu	Eric Feigelson	Simon Krughoff	Sam Schmidt
Jacek Becla	Peter Freeman	Tom Loredo	Lior Shamir
Kirk Borne	Christopher Genovese	Ashish Mahabal	Aneta Siemiginowska
Robert Brunner	Matthew Graham	Bruce McCollum	Keivan Stassun
Tamas Budavari	Alexander Gray	Chris Miller	John Wallin
Douglas Burke	Carlo Graziani	Misha Pesenson	Martin Weinberg
Nathaniel Butler	Jon Hakkila	Andrew Ptak	Roy Williams
David Chernoff	Zeljko Ivezic	Joseph Richards	Robert Wolpert
Jim Cordes	Vinay L. Kashyap	Jeffrey Scargle	Michael Woodroofe

For More Information:

K.D. Borne (2006) Data-Driven Discovery through e-Science Technologies. *2nd IEEE International Conference on Space Mission Challenges for Information Technology (SMC-IT'06).*

K.D. Borne and T. Eastman (2006) Collaborative Knowledge Sharing for E-Science. *AAAI Workshop on the Semantic Web for Collaborative Knowledge Acquisition,* 104-105.

K.D. Borne (2010) Astroinformatics: Data-Oriented Astronomy Research and Education. *Journal of Earth Science Informatics,* 3, 5-17.

R. McKercher and S. Jacoby (2011). LSST Key Player in Sea Change of Data Availability *E-News 4* (2).

Article written by Anna H. Spitz and Kirk D. Borne

THE BORNE IDENTITY: THERE'S NO RUNNING FROM BIG DATA

Kirk Borne is used to operating on large scales. Once an avid 40-miles-per week runner, the LSST Informatics and Statistics Science Collaboration chair has finished several marathons, run in exotic locales around the world, and captained the Space Science Telescope Institute (STScI) running team to victory in several corporate challenge running events. Injuries forced Kirk to give up running in 1996, which is appropriate since there's no running from the rising tide of Big Data in astrophysics.

Eight years of managing the staff in NASA's Astronomical Data Center and Astrophysics Data Facility convinced Kirk of the value of Big Data in astronomy and of the enormous scientific discovery potential from datasets. Since 2003, Kirk has been on the faculty of George Mason University's School of Physics, Astronomy, and Computational Sciences, where he researches data-oriented astronomy and teaches courses on Scientific Databases, Scientific Data, Scientific Data Mining, Statistics, Astroinformatics, and Computational Data Sciences. As chair of the LSST Informatics and Statistics Science Collaboration, Kirk is helping to address the data-to-knowledge challenge of LSST's future dataset, which will reach multi-petabyte scale during the first month of the 10-year survey's operations. The Informatics and Statistics collaboration is working on the development and application of sophisticated algorithms for data mining and statistics that will efficiently extract knowledge from the potentially overwhelming mass of LSST data. (See "The LSST Data Avalanche: Astroinformatics Rises to the Challenge" LSST E-News volume 5 number 2).

As an example of informatics in action, Kirk recalled a data mining project he worked on with the National Weather Service, in which they developed a neural network for detecting wildfires in remote sensing satellite data.

"We applied a neural network data mining algorithm on a huge number of

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Kirk Borne, right, discusses Big Data with LSST Informatics and Statistics Science Collaboration colleague G. Jogesh Babu (Pennsylvania State University) during a break at the 2012 LSST All Hands Meeting in August 2012. (Image Credit: Emily Acosta)

large satellite images, in multiple wavebands (optical and infrared) to detect wildfires across the United States. This required a lot of training data (i.e., locations that were confirmed by humans to be locations where fires were truly taking place). The goals were: (a) to emulate with an algorithm what humans were doing slowly and painfully; (b) to automate the process; (c) to remove the human errors and subjectivity of the fire detection assessments (i.e., reduce the classification error on these types of transient events) by training an algorithm to do the discovery and classification; and (d) to extend the discovery and classification of these events to worldwide coverage, not only for the USA anymore. Regarding the last item, we would now call this 'scaling to Big Data'."

With LSST, Kirk said he is especially interested in the application of data mining and knowledge discovery algorithms for finding new properties of galaxies as a function of cosmic time and cosmic environment, particularly pertaining to the mass assembly history of the Universe: the birth rate, current state, and ultimate fate of colliding and merging galaxies.

Although Kirk officially started working on LSST in 2005, he first learned of the project during "delightful discussions" with LSST Director Tony Tyson at an Aspen Workshop in 2001.

"I was attracted to the education opportunities and the scientific discovery potential from the Big Data that LSST will generate, and LSST has now given me an outlet to exercise all of my interests and skills in this area," he said. "The sheer scale of the data management system and scientific data products is far beyond anything ever seen in astronomy. I am confident that LSST will reveal numerous unknown unknowns about the Universe. This is exciting from both the scientific perspective and the outreach perspective."

Kirk also serves on the Outreach Advisory Board for LSST Education and Public Outreach (EPO), including design and development activities at the EPO to Data Management (DM) interface. Kirk wants to help LSST's EPO program to inspire future generations of students and scientists in the same way that a childhood gift from an uncle inspired him.

"When I was 9 years old, I received, as a gift from an uncle, a colorful big coffee table book on astronomy; I was enthralled by everything in it, and I just had to study this stuff for a career," Kirk said. "I was hooked! There was no other career path that could ever satisfy my curiosity except astronomy, physics, and math – i.e., astrophysics!"

He describes the LSST EPO team as extraordinarily creative and forward-thinking, with many plans for both formal and informal education with the LSST data products.

"I believe that the work we are doing in Big Data science, in transforming scientific research (developing the new data-oriented 4th paradigm of science), and in STEM education/public outreach is truly transformative and at the leading-edge of astronomy research and education."

Just as running took Kirk to exotic places around the world for "literally breath-taking experiences," he advises students that STEM education and a multi-disciplinary skill set will take them places they never could have imagined.

"After I learned about data mining and how it is an amazingly useful skill set," Kirk explained, "I found myself invited to speak before audiences in several federal agencies and in several different scientific disciplines, covering a wide range of domains, while consulting on numerous projects from science to healthcare to national security. Astronomy and physics training gives you the most fundamentally important skills that employers seek: critical thinking and problem solving. Never forget how valuable you are for having this training."

Article written by Robert McKercher and Kirk Borne

Tough, and colorful, competitors at the LSST AHM 2012 soccer tournament. (Image Credit: Sidney Wolff)

When the highly paid soccer players of the LSST project and science collaborations landed in Tucson on the Sunday before the 2012 LSST All Hand Meeting (AHM) tournament began, they realized they would be earning their paychecks that week: with the temperature at 107° Fahrenheit at 6pm, they knew this would be a severe test of their stamina, hydration capacity and ability not to stay up late in the hotel bar every night.

First to fall foul of the conditions were the tournament newcomers, the University of Washington Purple Menace, who succumbed to a crushing 12-2 defeat on day one at the hands of reigning champions the NorCal Earthquakes. Arizona in August was always going to be difficult for the Northwesterners – but they would be back. The second match of the first day saw a revamped red team, this year playing under the enigmatic name "TBD." While Tucson Thunder tried to figure out this three letter acronym, Francisco Delgado's team busied themselves knocking in the goals and announcing themselves as serious competitors for the title with a 5-3 victory.

In a highly anticipated matchup with NorCal on day two – one that proved to be decisive in the final standings – TBD maintained their momentum by building a 3-0 halftime lead. A halfway line shot by NorCal broke the scoring drought, and a furious comeback ended in a 4-4 tie. Referee Andy Connolly had to be escorted from the field under heavy security after blowing the final whistle just after Jim Bosch unleashed a guaranteed shot toward an empty net. After much debate about how preferable it would have been to have a basketball-style rule that would have allowed shots already in the air, the goal was ultimately disallowed. Purple Menace then

Tucson Thunder players Jeff Kantor and Chuck Claver (in red) smoothly encourage the puncture-proof ball toward the goal. (Image Credit: Sidney Wolff)

proved that their first day's result was an anomaly caused by full enjoyment of the banquet free drink tickets, with a 5-3 victory over the Tucson Thunder.

The monsoon side of Tucson summer weather made its presence known the night before day three, leaving the pitch uncharacteristically soft and wet. Play went on as scheduled, however, and there were no reports of any teams using this as an excuse for poor performance. In the first game, after a strong start including 2 early goals by Michael Wood-Vasey, the Purple Menace failed to frighten TBD and fell by a 7-3 score. In the final match of the tournament, NorCal might have been overconfident, needing a win by any margin to repeat as champions. But they had never beaten the Thunder, and repeated tie scores in the opening frame threatened to

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The NorCal Earthquakes (in blue) played without fault on their way to being named champions of the 2012 tournament. (Image Credit: Sidney Wolff)

derail their title defense. Cloudy conditions helped minimize Tucson's home-climate advantage, allowing NorCal to speed away in the second half for a final score of 9-6.

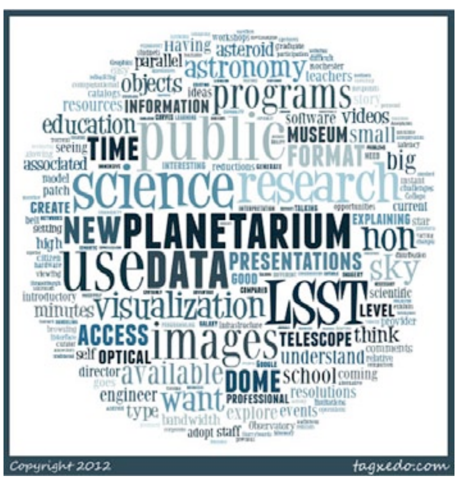
Celebrated sports photographer Sidney Wolff caught some of the day three action on film, with a number of shots that captured the incredible competitiveness and intensity of the event, and also generally made virtually all the players appear significantly more graceful than they actually were.

After much deliberation, NorCal were declared tournament champions, ahead of TBD, on the fourth tiebreaker (overall goal difference). They were aided by retaining the core of their 2010 side, along with the addition of transfers Klaus Honscheid, Andy Rasmussen, and Josh Bloom, the latter two being the only NorCal players to actually work in California. (The postdocs from UC Berkeley chose to play for TBD instead and nearly tipped the scales).

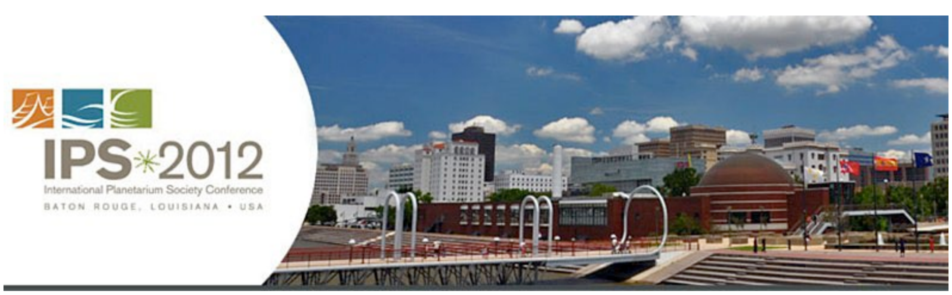
Big thanks to Jeff Kantor for organizing and providing steady leadership of the league. He even solved the problem of last year's multiple punctured soccer balls, by bringing in indestructible blue plastic ones from the One World Futbol Project. That the new balls really were puncture proof turned out to be absolutely necessary, given the number of shots that ended up being saved by cacti.

Article written by Phil Marshall and Eric Gawiser

LSST AT IPS: BRIDGE TO NEW BEGINNINGS



Informal learning centers, including planetaria and science museums, reach a large audience: tens of millions of annual visitors in the US and more than 100 million worldwide. LSST will work with content providers at these institutions to share discoveries and high resolution images with their audiences, an effort that begins with an understanding of their needs. To that end, Suzanne Jacoby, Tim Axelrod (LSST), Mark Subbarao (Adler), and Martin Ratcliffe (Sky-Skan), presented a panel discussion about LSST at the International Planetarium Society Conference in Baton Rouge, LA, July 22 -26, 2012. There were ~750 individuals attending the week-long conference of which ~45% were from foreign countries.



Approximately 30 people came to the LSST session; they represented planetariums large and small as well as companies that provide hardware and software to the planetarium community. After a general description of LSST, we had a mutually informative discussion about the use of data in digital planetaria and a questionnaire to capture ideas from the audience. Our survey asked participants to identify what they considered the most interesting aspects of LSST as well as potential challenges. Recurring answers are summarized in the bullets below. Next steps include maintaining contact with interested participants and documenting these ideas and data needs in the Education and Outreach Plan for LSST during construction and operations.

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Interesting aspects:

- Accessibility of data enables Citizen Science programming which could be integrated into kiosks or dome programming.
- Technical aspects of LSST are interesting: optical design, database design
- Ability to browse and search data
- The Adopt-a-Patch interface, monitoring and personalizing a piece of the LSST sky
- Could use introductory videos now with content that could be integrated into existing programming
- "Hot off the press" information is exciting, opening of the time domain

Challenges:

- Requirements for data access: bandwidth, disk space, format, etc.
- Desire for direct access to LSST scientists
- Need to combine bright object sky with the LSST sky
- Need interpretation of data, or background information for presenting to public
- Adopting for smaller planetariums with limited resources
- Correlation of LSST data with other surveys would add value
- Need ready to use presentation materials for big news items

Article written by Suzanne Jacoby

THE LSST ALL HANDS MEETING 2012 SURVEY RESULTS

The majority of 2012 LSST All Hands Meeting (AHM) attendees enjoyed a productive week, according to a survey conducted after the conference's conclusion. However, many survey respondents felt the experience could have been improved with more downtime for impromptu discussion.

The LSST project held its fifth AHM August 13-17, 2012 at the Ritz-Carlton, Dove Mountain in Marana, Arizona, approximately 30 miles north of Tucson. AHMs are week-long conferences designed to bring together members of the Science Collaborations, advisory boards, and engineers and scientists building the telescope to share ideas and maximize the impact of LSST. More than 260 people, including 32 representatives of potential international affiliates in nine different countries, participated in the five day event.

After the meeting, the project conducted a 10 question survey to assess the success of various elements of the conference. 144 AHM attendees took the survey.

On the whole, survey participants reported a good experience. More than 85% described the meeting as "extremely" or "quite a bit" productive and enjoyable; 93% are "extremely" or "quite a bit" likely to attend the next AHM. Attendees continue to prefer holding the AHM in the summer months (with August the front-runner) because they present the fewest conflicts with the academic calendar. While most of the respondents gave favorable marks to the venue, and half voted to return for the next AHM, a number of respondents expressed the desire to rotate among LSST's partner institutions such as University of Washington, SLAC, or Princeton. Also, a significant minority expressed concerns about the Ritz-Carlton's cost and isolation. In general, respondents were satisfied with the meeting's agenda.

The most significant area for improvement identified in the survey was the fullness of the agenda. Many survey participants described their informal, impromptu interactions as the most productive of the meeting, but 28% of respondents

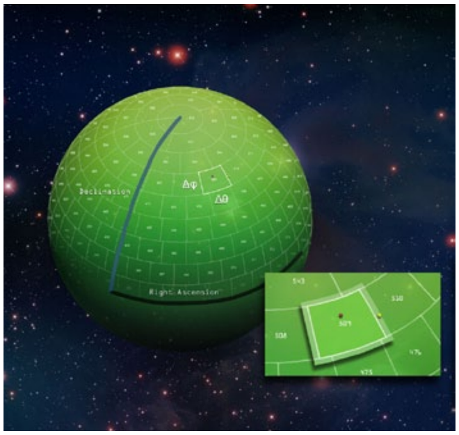
LSST Science Working Groups Chair Michael Strauss (Princeton University) takes advantage of a quiet outdoor moment during the 2012 LSST All Hands Meeting. Michael is wearing the t-shirt designed for the meeting by LSST graphic designer Emily Acosta. (Image Credit: Emily Acosta)

considered downtime for discussion to be "inadequate." The related comments expressed the desire for a less crowded schedule with fewer concurrent breakouts and more opportunities for informal interaction. Suggestions for accomplishing this included

- Scheduling more downtime into the agenda,
- Focusing on cross-domain sessions,
- Limiting prepared talks at breakouts in favor of discussion,
- Having longer breaks in between sessions,
- Setting aside blocks of unscheduled time for ad hoc meetings, and
- Holding more frequent, targeted workshops in addition to AHM.

For a full report on the survey results or more information about the 2012 AHM and to view the meeting's plenary and breakout presentations, visit www.lsstcorp.org/ahm2012.

Article written by Robert McKercher



The overlapping partitioning concept developed by the LSST database team enables efficient searching of enormous databases by allowing neighboring objects to be found without the time-consuming process of searching multiple partitions. (Graphic: Emily Acosta, LSST)

The Large Synoptic Survey Telescope (LSST) database team has developed an innovative "overlapping partitioning" method for storing enormous amounts of information for rapid access. By overlapping equally sized packets of information in the partitioned sphere, searching for nearest neighbor sources becomes quick and efficient. Further, the technique has been shown to work just as efficiently with increasingly complex systems. The improved algorithms resulting from this innovative architecture will be available as open source software that can be used by a broad spectrum of fields to transform access to large databases.

The graphic above illustrates that the LSST database will be partitioned into equal-area chunks, each storing roughly equal quantities of astronomical sources. This concept of "spherical partitioning" is crucial for making the massive LSST data search practical. However, the typical method of partitioning data into chunks requires neighbors to be in the same partition if they are to be located quickly. This creates the problem that finding objects near another object will sometimes require the time-consuming process of searching other partitions for objects near the edge.

The new approach developed by LSST researchers partitions the data with overlaps. The graphic's inset shows the overlapping characteristic, where extracted partition 509 contains all sources within 509 (including the red sphere) plus those that also appear on the edges of neighboring chunks (yellow sphere). This overlapping characteristic of the LSST database structure means we can still use partitioning while searching for nearest neighbors because it allows objects to be found without contacting other partitions, up to a certain distance. Implementing a partitioning scheme along with overlapping edges of partitions means the enormous LSST database can be searched efficiently.

Additionally, the researchers have demonstrated that the architecture proposed for the LSST database is linearly scalable in that more nodes can be added without system performance degradation. The test database had a 55-billion-row data set on a 150-node parallel database cluster; the experiment was similar in scale to searching hypothetical satellite-imagery databases for red, convertible sports cars traveling near white, full-size pick-up trucks on any road on Earth!

LSST is also creating a general-purpose data and algorithm-parallel framework that, like these database innovations, will be available as open source software. The project's open source example will be reusable on any high-performance, parallel scientific application, and as a result, can be leveraged by future projects in many fields of science and engineering, especially those that store spatial information, like maps, and information that changes with time. Domains that will benefit most from LSST's improved spatial search and storage algorithms include the geosciences (e.g. climate, oceanography, and seismology), medical imaging, and oil and gas exploration. And since applications using data that changes with time, or temporal data, are found in virtually every domain, LSST's innovations possess the potential to transform large database access in many fields, including the financial sector, the internet (modeling user behavior, fraud detection), climate modeling, drug discovery, healthcare, and many retail applications.

Article written by Suzanne Jacoby and Robert McKercher

LSST's innovative datbase innovation was featured as an NSF highlight on Research.gov

LSST E-News Team:

- Suzanne Jacoby (Editor-in-Chief)
- Anna Spitz (Writer at Large)
- Robert McKercher (Staff Writer)
- Mark Newhouse (Design & Production: Web)
- Emily Acosta (Design & Production: PDF/Print)
- Sidney Wolff (Editorial Consultant)
- Additional contributors as noted

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Large Synoptic Survey Telescope