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NEWS FROM THE PROJECT MANAGEMENT OFFICE

The New Year closes out our 3rd year of quarterly E-News and finds us busier than ever, as our high ranking in the NRC's Decadal Survey has given the project greater visibility in higher circles. Top priority is submitting a new construction proposal to the National Science Foundation, due at the end of January. But we're always busy at this time of year preparing for the January meeting of the America Astronomical Society, this year taking place in Seattle, WA, home of UW, one of the four founding members of LSST. We'll have an especially high presence at the meeting with a full-day "splinter meeting" at UW on Sunday 1/9, a special session on "Community Science with LSST" on Monday afternoon 1/10, and 25 posters about LSST up all day on Tuesday the 11th. Check the Meetings tab on lsstcorp.org for more information.

Planning is underway for the April meeting of the LSST Board which will take place in La Serena, Chile, giving everyone a chance to visit the site of LSST on Cerro Pachón, building some excitement - before we build a telescope! The Board will enjoy some wonderful Chilean hospitability and see where the LSST Base and Summit facilities are planned to be integrated into the existing NSF and AURA infrastructure. With all the environmental and building permits and approvals in hand, planning continues for LSSTC's investment in initial site leveling, adding an exciting (explosive?) element to the Board's summit tour.

Once again Business Administrator Daniel Calabrese has taken us through the maze of auditing, guiding the project successfully through its 4th consecutive A-133 federal financial audit, a critically important requirement toward receiving direct federal funding. This NSF certification review is almost complete with an announcement expected sometime in January regarding this decision. We welcome Teresa Bippert-Plymate to the Project Office, providing some much needed administrative support as the project moves forward. Teresa previously worked with the Large Binocular Telescope Interferometer group as a Technical Specialist doing "a little bit of everything". Her familiarity with astronomy is invaluable as she plows headfirst into assisting with the construction proposal.

Deputy Project Manager Victor Krabbendam adds his signature to the LSST holiday cards.

Article written by Suzanne Jacoby and Don Sweeney

SC10: INTERNATIONAL CONFERENCE ON HIGH PERFORMANCE COMPUTING

LSST is one of the premier examples of how high performance computing advances will expand our scientific boundaries. Salman Habib, Jeff Kantor and Stuart Marshall demonstrated these advances at SC10, Super Computing's 23rd meeting in November 2010 where its theme, The Future of Discovery, showcased how high performance computing, networking, storage and analysis lead to advances in scientific discovery, research, education and commerce. IEEE Computer Society and Association for Computing Machinery (ACM) sponsored the meeting and over 11,000 attended. While much focus was on computing in climate studies, LSST collaborators impressed attendees with the plans for data management and the possibilities for discoveries well beyond our planet.

In 2007, the National Science Foundation pointed out that science and engineering research and education are becoming more and more data-intensive due to expanding digital technologies, instrumentation, and data networks. With the enormous growth of available scientific data, new opportunities arise. Sky surveys have already changed our understanding of our Solar System and the earliest Universe. LSST will scan the sky from Chile, capturing 30 trillion bytes of image data each day – a volume equal to two entire Sloan Digital Sky Surveys each day. Massive computing

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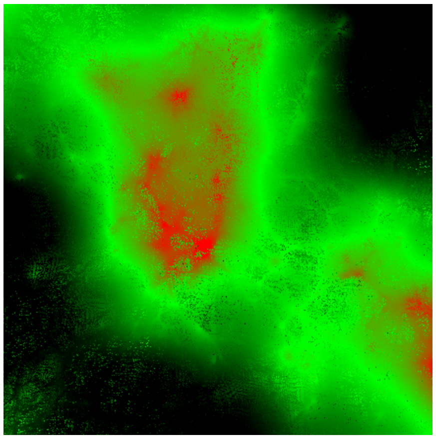
Data Management Project Manager Jeff Kantor explains LSST cyberinfrastructure to New Orleans conference attendee.



Zoom-in showing cosmological structure in a 130 Mpc cut-out from a 2 Gpc cube simulation run with 8 billion particles using a new hybrid simulation code. The simulation particles are colored according to the local gravitational potential. Credit: Salman Habib.

power is needed to use these data to extend the investigations of our Solar System, our Galaxy and the Universe.

In the "Big Science, Big Data" session, one of the SC10 Masterwork sessions, Jeff Kantor (LSST) and Salman Habib (Los Alamos National Laboratory (LANL)) shared the progress on data management and computational cosmology.

Computational cosmology – cosmological numerical simulation – plays a critical role in incorporating nonlinear aspects of structure and galaxy formation into a precision theoretical framework. Habib demonstrated the need for high-fidelity simulations of the visible Universe to understand the astrophysics underlying interpretations of the cosmological surveys. "The essential role of cosmological modeling and simulation is to extract scientific insight from large, complex observational datasets - such as the detailed maps of the sky to be revealed by LSST. "Petascale computing and beyond will be essential to this endeavor, which will employ some of the world's largest computers," Habib told participants.

LSST cyberinfrastructure supports "computing at a distance" to overcome the difficulties in processing all data for all users, Kantor told a large group of listeners. "The data management system (DMS) processes incoming images, produces transient alerts, archives over 50 petabytes of exposures, creates and archives astronomical objects, makes LSST data available without a proprietary period and facilitates analysis and production of user-defined data products with supercomputing resources."

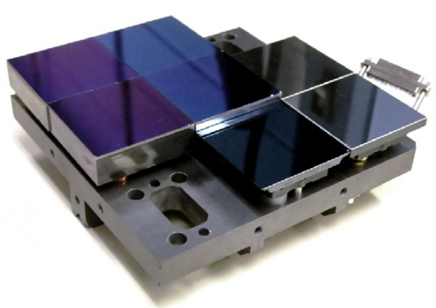
In addition to these two talks about the computing capabilities of LSST, Stuart Marshall, a member of the LSST camera team, was part of the SLAC exhibition at the conference. More information about the SLAC exhibit can be found at

http://today.slac.stanford.edu/feature/2010/sc-2010.asp

For more about Kantor's, Habib's and Marshall's efforts, see the LSST Science Book. Kantor contributed to Chapter 2, LSST System Design, and Habib to section, 15.5, Cosmological Simulations in Chapter 15, Cosmological Physics. Chapter 2 discusses the LSST camera.

Article written by Anna Spitz

LSST'S FOCAL PLANE COMPONENTS TAKE SHAPE



Prototype sensors mounted on a raft baseplate

When the survey begins near the end of the decade, an array of 201 specially-designed CCDs and electronics buried within LSST's massive camera will begin converting the light captured by the telescope into digital data at a rate of about 11 trillion bits per hour. Accomplishing this task requires an entirely new generation of CCD image sensor, and a team of engineers within the Camera collaboration has been working for the past several years with experienced vendors to demonstrate the needed new technologies. To meet the exacting requirements of LSST's science program, the CCDs have to be made from specially-grown silicon crystals and then mounted in precision packages that will form the "paving stones" of the mosaic focal plane.

The key characteristics needed by LSST's sensors are high sensitivity across the ultraviolet-to-near-infrared wavelength range, fast readout, and excellent spatial resolution. The thickness of the silicon layer required to achieve good near infrared response while preserving fine spatial resolution is about five times greater than current CCDs use, and its electrical resistivity must be over 100 times higher. Furthermore, the optical system which gives LSST its wide field of view has a very shallow depth of focus meaning the CCDs' imaging surfaces must be exceedingly flat, no more than 5 microns deviation from a perfect planarity. Finally, the CCD packages must be able to be butted closely together on all four sides to minimize dead area as much as possible. The vendors partnering with LSST have recently demonstrated successful prototypes satisfying these characteristics.

Imaging properties are determined by the CCD's silicon technology, but reading out the entire 3 gigapixel array in 2 seconds requires a highly-parallel electronics system to transform the microvolt-level signals generated by the CCDs into digital data. Unlike other astronomical cameras, LSST's focal plane will be constructed from an array of 21 identical modules known as "raft towers", each containing a 3 x 3 mosaic of CCDs with their associated processing electronics in an enclosure roughly the size of a shoebox. Processing the raft's 144 independent video streams in such a small volume is possible only by using custom-designed integrated circuits. Engineers in LSST's collaborating universities have designed and successfully tested

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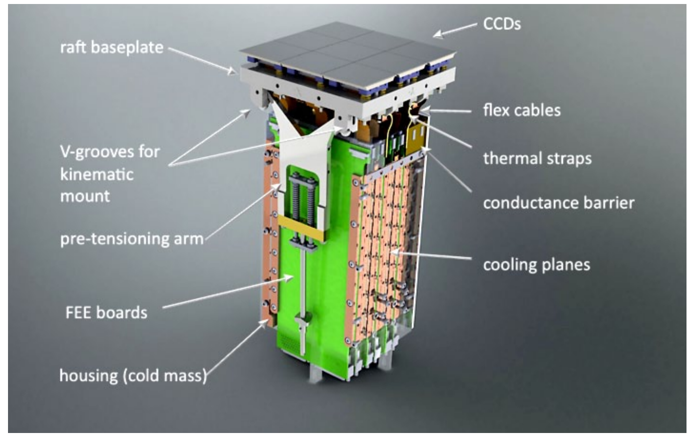
readout ICs that will be used in the raft towers.

Over the next year the team at Brookhaven Lab and collaborating institutions will assemble sensors, electronics, and mechanics together and start building up the test capability to verify the performance of the modules which will become the heart of the LSST camera.

Article written by Paul O'Connor, Brookhaven National Laboratory



Right: LSST's focal plane wil be made up of 21 copies of the "raft tower", an assembly of nine CCDs with their front end electronics and thermal management components. The Raft Tower is an autonomous, fully testable 144 Mpixel camera.

ACTIVE GALACTIC NUCLEI -
REVEALING BLACK HOLE GROWTH IN GALAXIES AND THE STRUCTURE OF THE UNIVERSE

This E-News article is based on Chapter 10 of the LSST Science Book: Active Galactic Nuclei. Authors of Chapter 10 are:

W.N. Brandt, Scott F. Anderson, D.R. Ballantyne, Aaron J. Barth, Robert J. Brunner, George Chartas, Willem H. de Vries, Michael Eracleous, Xiaohui Fan, Robert R. Gibson, Richard F. Green, Mark Lacy, Paulina Lira, Jeffrey A. Newman, Gordon T. Richards, Donald P. Schneider, Ohad Shemmer, Howard A. Smith, Michael A. Strauss, Daniel Vanden Berk

Active galactic nuclei (AGN) are brilliant and enigmatic markers distributed throughout the Universe. AGN host the most powerful energy sources in the Universe and are some of the most distant cosmic objects observed. The central engine of an active galaxy can produce more than 100 times the energy of a large spiral galaxy such as the Milky Way across the spectrum of wavelengths from radio waves to X-rays and sometimes the highest-energy gamma rays. They do have, however, a wide luminosity range of greater than 10^7. Their distribution can trace large-scale structures in the Universe, revealing not only how galaxies come to be but also how the Universe is organized. LSST observations will make significant contributions to the information we have about these remarkable objects.

Ordinary galaxies such as the Milky Way harbor supermassive black holes (SMBH) at their centers; but while the black hole in a normal galaxy is "starved," active galaxies are well fed with gas and stars. Their central core emits much more energy than can be explained by their stellar content, and we observe them as AGN. Some can be optically variable over hours (e.g., blazars) or weeks (e.g., quasars) indicating a small accretion disk (around the size of our Solar System in many cases) with material heated to emit prodigious amounts of energy, which in some cases is ejected in jets that are likely aligned with the spin axis of the central black hole. The Milky Way's central black hole was probably active in the distant past but has now largely settled into hibernation, an example of how galaxies can switch from being active to being normal and vice versa.

SMBH play critical roles in galaxy evolution: bulge mass and velocity dispersion correlations with SMBH mass suggest a close link between the build-up of mass in galaxies and their central SMBH. Researchers believe feedback exists between the central black hole and star formation in galaxies: as the black hole swallows gas and stars, the process generates tremendous luminosity or photon power, heating gas in the vicinity. Radiation pressure generates winds that blow outward clearing out gas and thus decreasing star formation and SMBH feeding. The emission coming from these AGN is a broadband phenomenon, so observations across many wavelengths probe different aspects of the physics of the central engine and in combination can answer the questions about the SMBH's nature and evolution.

Types of AGN -Variation on a Theme

- **Quasar (quasi-stellar object)** – strong ultraviolet emission, broad emission lines, 90% are radio quiet without relativistic jets.
- **Seyfert galaxy** – spiral galaxy with AGN with strong, broad emission lines, variable on timescale of days to months, moderately massive black hole.
- **Blazar (blazing quasi-stellar object)** – strong radio emission, emission over large range of frequencies, strong and rapid variability, high linear polarization, relativistic jets.
- **Radio galaxies** – strong radio emission aligned with visible jets.

LSST will be instrumental in producing data in the .3 to 1.1 micron range. It will provide a well-defined sample of at least 10 million optically selected AGN – at least an order of magnitude more than we now know. LSST will allow detection of AGN out to redshifts of approximately z=7, observing objects in the first billion years of cosmic time. The exponential growth in the detection of quasars over the last few decades

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will continue as LSST increases the sample size to likely over 10^7 quasars. LSST will observe AGN across many observation epochs, through a range of timescales, with multi-color coverage and high photometric accuracy. Over the 10-year survey many visits will allow examination of the variability of AGNs and discovery of rare events such as transient SMBH fueling. LSST will be able to resolve close companion galaxies to AGN letting scientists study how mergers drive quasar activity. LSST will monitor gravitationally lensed AGN and its cadence is well suited to map out wavelength-dependent microlensing light curves of AGN to probe AGN emission regions.

Combining LSST and other surveys' data to execute multi-wavelength investigations will probe the mysteries in more depth. For example, LSST will enable excellent optical follow-up for AGN in thousands of Chandra and XMM-Newton fields. Scientists will use radio survey data of LSST AGN to quantify in great detail how radio properties depend on luminosity and redshift across a wide part of the luminosity-redshift parameter space. Augmenting LSST photometry with multiwavelength data will make possible unprecedented temporal investigations. For example, AGN that exhibit flares or other unusual temporal behavior in LSST data will trigger alerts for multiwavelength follow-up at other relevant wavelengths.

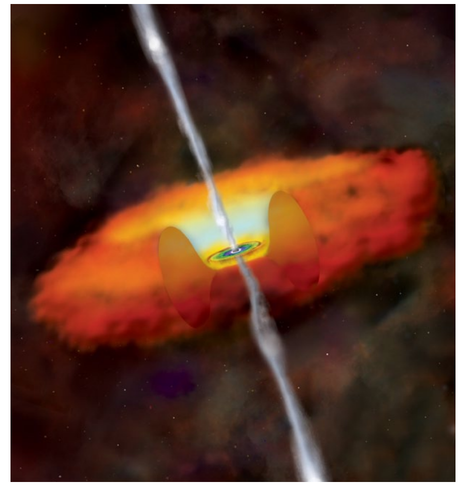
Understanding AGN requires looking further into why their emission is variable on different timescales. Scientists have proposed several reasons for AGN emission variability including accretion disk instabilities, changes in accretion rate, evolution of relativistic jets, and line-of-sight absorption changes. The observed variability depends on luminosity, wavelength, timescale, and the presence of strong radio jets but correlating the observations with proposed physical causes is complex. The data from LSST will help to unravel the different mechanisms that produce variability on different timescales. Because LSST will expand existing databases enormously, it will improve greatly the categorization of the range and kinds of AGN variability and consequently, understanding of the underlying physics. LSST's massive number of observations will allow scientists to track variability and to identify rare but revealing events in numbers sufficient for modeling.

LSST will discover SMBH tidal disruption events (when the SMBH rips apart a star), inspiraling of binary supermassive black holes, and perhaps mergers of binary supermassive black holes. LSST should detect about 100-200 tidal disruption events per year enabling scientists to measure event rates as a function of redshift, host galaxy type, and level of nuclear activity and thereby determine what effects these tidal disruptions have on the luminosity function of moderate luminosity active nuclei. Researchers believe that SMBH mergers are components of SMBH growth and galaxy evolution. It is difficult to find SMBH mergers but if the proposed LISA gravitational wave observatory data are combined with LSST data, identification of emission from these events could provide critical information to study the physics of accretion during SMBH mergers and for measurement of redshifts and cosmological parameters.

LSST Science Collaborations keep growing so in addition to those listed as authors of the Active Galactic Nuclei Science Book chapter, the following are members of the Active Galactic Nuclei Science Collaboration:
Paolo Coppi
Alex Gray
Greg Madejski
Anil Seth
Ezequiel Treister
Meg Urry

LSST will observe approximately 4,000 luminous AGN that are gravitationally lensed into multiple images, more than a 10-fold increase over current observations. These will allow scientists to study the wavelength dependent variability of microlensing events. The large number of expected microlensing events at z=1-4 will allow scientists to search for evolution of AGN structure across redshift range, luminosity, and Eddington ratio (intrinsic luminosity over Eddington luminosity, a measure of observed versus maximum potential brightness).

On an even larger scale, studying AGN clustering can provide information about the galaxies that host AGN. Looking at the relationship between AGN clustering and that of ordinary galaxies can indicate how they are related. Examining this clustering will provide information about underlying dark matter clustering in the Universe. The enormous number of AGN found with LSST will cover a very large range of luminosity in each redshift interval. With these data, researchers will be able to determine the clustering and, therefore, bias and host galaxy halo mass over a large range of cosmic time and black hole accretion rate. These studies will reveal more about quasar activity – how merger activity can drive it – and their surrounding halos.



Artist's rendition of an active galactic nucleus. The super massive black hole (SMBH) with surrounding obscuring material (orange colored torus) with cutaway section shows the accretion disk (dark color at center) and jets emanating from the central disk around the SMBH. Credit: NASA.

AGN provide spectacular examples of powerful galactic processes in the Universe. They are windows into the physics of supermassive black holes, galaxy evolution and the structure of the Universe. LSST's contribution to observations, especially when coupled with those of other observatories and surveys, promises to reveal underlying mysteries at galaxy centers and throughout the Universe over time.

Article written by Anna H. Spitz and Niel Brandt

LUCIANNE WALKOWICZ

How free is the life of an astronomer? For Lucianne Walkowicz, being an astronomer provides freedom that most people don't have or recognize exists in a scientific career: "By and large I get to pursue questions that I find intellectually interesting to whatever manner I can think of. Being an astronomer is a very creative job, which I don't think the general public realizes." Lucianne pursues her interests in a variety of research efforts at the University of California (UC) Berkeley Astronomy Department these days. Her main challenge is to not overcommit herself given the myriad of interesting projects that excite her intellectual curiosity.

As an undergraduate at Johns Hopkins University, Lucianne worked for the Advanced Camera for Surveys analyzing flight candidate CCDs during the school year. As a graduate student at the University of Washington she worked on M dwarf activity with Suzanne Hawley and became involved in LSST. "If I had a piece of advice to give, I'd say never to be afraid to approach people and ask to work with them when you're just starting out. Every job I had I got by cold-calling astronomy departments or knocking on people's doors and asking if they would let me work on something. Experience helps, of course, but anything you don't know how to do you can learn, you just need to find someone who is wiling to teach you. You can learn a lot and explore a lot of different subtopics that way, long before you get to grad school." This next generation will benefit from mentors but also have much to teach about how to view the modern face of astronomy.

In addition to pursuing her personal research interests with LSST, Lucianne was one of the lead authors of Transients and Variable Stars chapter and with Josh Bloom chairs the Transients and Variable Stars collaboration. Lucianne points out that this is probably the most diverse science collaboration: all things transient - from near by to very, very far away – covers all kinds of objects. "We are the time domain; and transients will make useful observations for lots of different collaborations." It's a thrill watching an event unfold in its entirety: "It's not often that astronomer get to observe phenomena evolve in real time. But for us, the objects of interest are things which change on human timescales."

Lucianne is now a post-doc with Kepler, the NASA Discovery Program to search for habitable planets, at UC Berkeley. As the Kepler Fellow for the Study of Planet-Bearing Stars, she uses Kepler data to study stellar magnetic activity and rotation. Lucianne has a long-standing interest in stellar activity both in what it tells us about the star and in how it affects any orbiting planets. Her work on Kepler satisfies both her interest in stars and in planets: she is also a member of the follow-up group, which takes additional data on Kepler's planet candidates to validate or reject them as true planets. LSST research will expand her Kepler efforts in a variety of ways: building light curves of variable stars, capturing transient events on variable stars and quantifying what is observed to determine if the event is extragalactic or requires immediate follow-up are examples. LSST will also be able to find transiting planets by observing gravitational microlensing and transits.

In five or ten years Lucianne will no doubt be well-established leading a working group of graduate and undergraduate students wherever she is. "In five years I hope to have found a permanent job ideally at a research university where I will be able to have a strong research program as well as the ability to teach."

And her teaching employs intriguing methods. She brings a unique way of communicating – with lots of visualization and significant artistry. Lucianne is an accomplished artist and graphic comic book creator. She not only took art courses in high school and college but last year had her first gallery show. Her plan is to combine her interests in astronomy, art, visualization, teaching, writing and graphic books into educational and instructional materials for students and the general public. Sales of graphic novels and comic books are growing in the US and may one day reach the level they enjoy in Japan. Some of the future volumes may be Lucianne's; and hers may help people who think they are not capable in math and science realize they are perfectly capable when concepts are presented with a different learning style.

"I think that LSST is a going to be a fundamental change in how astronomy is done – the time domain aspect and immediate data availability go beyond even the large surveys. It will be a very exciting time for those of us involved in the field for a while to learn to think about our research processes differently, while new students coming into the field will take this "new" landscape at face value." Lucianne will be working on both the new ways astronomy is done and the ways it is communicated.

Article written by Anna H. Spitz

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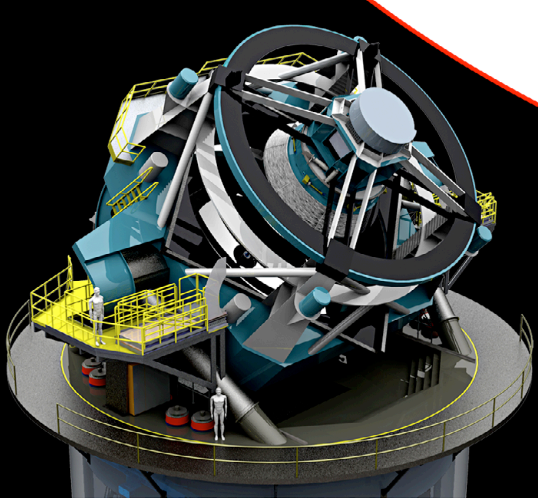

Large Synoptic Survey Telescope