LSST Status

Kirk Gilmore
Stanford/SLAC/KIPAC
Dark Energy Probes

* Expansion Rate
  – Supernovae: Standard Candles
  – Baryon Acoustic Oscillations: Standard Ruler
    • The decoupling of photons and baryons in the early universe imprints a feature on the large-scale clustering of galaxies at a given scale.
    • Systematics can come from non-linear bias, photo-z errors.

* Growth of Structure
  – Weak lensing
    • focus for the next generation will be on the shear power spectrum, as probed by the shapes of background galaxies.
    • Systematics can come from photo-z errors, PSF, calibration.
  – Galaxy Clusters
    • The number of galaxy clusters is determined both by the geometry (volume) and the growth of structure. Excellent probe of DE.
    • Primary systematic is calibration of the mass-observable relation.
LSST Science Requirements focus on 4 Representative and Divergent Programs

**Dark Energy-Dark Matter**
LSST enables multiple investigations into our understanding of the universe

**Exploring our Solar System**
LSST will find 90% of hazardous NEOs down to 140 m in 10 yrs

**“Movie” of the Universe: time domain**
Discovering the transient and unknown on multiple time scales

**Mapping the Milky Way**
LSST will map the rich and complex structure of our Galaxy.

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SLAC

SLUO
SLAC USERS ORGANIZATION

SLUO 2008 Annual Meeting
The LSST Project is a Complete System: Image, Analysis, Archive, Publish and Outreach

Telescope and Site

Data Management

Camera

Education and Public Outreach

SLUO 2008 Annual Meeting
### Institutional Members LSSTC, September 08

- Brookhaven National Laboratory
- California Institute of Technology
- Carnegie Mellon University
- Chile
- Columbia University
- Google Inc.
- Harvard-Smithsonian Center for Astrophysics
- Johns Hopkins University
- Kavli Institute for Particle Astrophysics and Cosmology at Stanford University
- Las Cumbres Observatory Global Telescope Network, Inc.
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- National Optical Astronomy Observatory
- Princeton University
- Purdue University
- Research Corporation
- Rutgers University
- Stanford Linear Accelerator Center
- The Pennsylvania State University
- The University of Arizona
- University of California, Davis
- University of California, Irvine
- University of Illinois at Urbana-Champaign
- University of Pennsylvania
- University of Pittsburgh
- University of Washington
The LSST Camera Team: 72 People from 16 Institutions

**Brandeis University**
J. Besinger, K. Hashemi

**Brookhaven National Lab**
S. Aronson, C. Buttehorn, J. Frank, J. Haggerty, I. Kotov, P. Kuczewski, M. May, P. O’Connor, S. Plate, V. Radeka, P. Takacs

**Florida State University**
Horst Wahl

**Harvard University**
N. Felt, J. Geary (CfA), J. Oliver, C. Stubbs

**IN2P3 - France**

**Lawrence Livermore National Lab**
S. Asztalos, K. Baker, S. Olivier, D. Phillion, L. Seppala, W. Wistler

**Oak Ridge National Laboratory**
C. Britton, Paul Stankus

**Ohio State University**
K. Honscheid, R. Hughes, B. Winer

**Purdue University**
K. Ardnt, Gino Bolla, J, Peterson, Ian Shipsey

**Rochester Institute of Technology**
D. Figer

**Stanford Linear Accelerator Center -**

**University of California, Berkeley**
J.G. Jernigan

**University of California, Davis**
P. Gee, A. Tyson

**University of California, Santa Cruz**
T. Schalk

**University of Illinois, Urbana-Champaign**
J. Thaler

**University of Pennsylvania**
M. Newcomer, R. Van Berg
Camera Organizational Chart

Camera Lead Scientist
Kahn (SLAC)

Camera Project Scientist
Gilmore (SLAC)
WBS 3.1

Camera Project Manager
Fouts (SLAC)

Project Control
Price (SLAC)
WBS 3.1

Systems Engineering
Gilmore (act.) (SLAC)
WBS 3.2

Performance, Safety and Environmental Assurance
(SLAC)
WBS 3.3 / 3.4

Camera Integration & Test Planning
Nordby (SLAC)
WBS 3.6

Calibration
Burke (SLAC)
WBS 3.5.1

Camera Data Acq. & Control
Schalk (UCSC)
WBS 3.5.6

Corner Raft WFS/Guider
Olivier (LLNL)
WBS 3.5.9

Optics
Olivier (LLNL)
WBS 3.5.5

Camera Body & Mechanisms
Nordby (SLAC)
WBS 3.5.3

Antilogus (IN2P3)
LPNHE LAL APC

Corner Raft WFS/Guider
Olivier (LLNL)
WBS 3.5.9

Electronics
Oliver (Harvard)
WBS 3.5.8

Cryostat Assembly
Schindler (SLAC)
WBS 3.5.7

Sensor/Raft Development
Radeka/O’Connor (BNL)
WBS 3.5.4

Antilogus (IN2P3)
LPNHE LAL APC

Camera Utilities
Nordby (SLAC)
WBS 3.5.2

Observatory Integ., Test & Commission Support
(SLAC)
WBS 3.7

Performance, Safety and Environmental Assurance
(SLAC)
WBS 3.3 / 3.4

Optics
Olivier (LLNL)
WBS 3.5.5

Camera Body & Mechanisms
Nordby (SLAC)
WBS 3.5.3

Calibration
Burke (SLAC)
WBS 3.5.1

Camera Data Acq. & Control
Schalk (UCSC)
WBS 3.5.6

Corner Raft WFS/Guider
Olivier (LLNL)
WBS 3.5.9

Camera Utilities
Nordby (SLAC)
WBS 3.5.2
Unique challenges and implications for the LSST camera design

- Large FOV → 64cm diameter focal plane
  - Large optics and focal plane

* Excellent image quality and control of PSF systematics
  - High precision optic coatings
  - Optical, mechanical, and electronics stability of components

* High quantum efficiency over the range 330 – 1,070 nm
  - Broad-band AR coatings on thick, biased sensors

* Two second readout with less than 5 electrons read noise
  - Segmented sensors
  - Integrated ASIC Electronics

* Electronics in cryostat
  - Contamination qualification for all components

* Camera in beam
  - Vibration and thermal management
The camera consists of the camera body and cryostat.

- Camera back flange—interface to telescope
- L3 Lens Assembly
- Access port for Manual Changer
- Filter in on-line position
- Auto Changer
- Utility Trunk
- Cryostat support pedestal
- Filter Carousel
- Filter in stored position
- Camera Housing
- L2 Lens with perimeter light absorber
- Aperture ring to define Beam Entrance
- Lens support ring with light baffles
- L1 Lens
LSST will build on resources available at SLAC for I&T

GLAST - LAT
Built at SLAC

LSST Camera
A camera integration plan is complete

Cryostat

Camera Body

Utility Trunk

L1/L2 assy

Sept. 18, 2008

SLAC

SLUO 2008 Annual Meeting
Other major efforts using SLAC resources

Contamination test chamber at SLAC

Camera Controls

- CCS prototyping now has a functioning set of DAQ hardware sufficient for a test stand

Working is proceeding on plans to deliver a prototype test stand by end of calendar year 2008 - Goal by PDR
LSST Data Management System

Data Access Centers
U.S. (2) and Chile (1)
45 TFLOPS, 87 PB

Data Access, Mining & Visualization
Fault Tolerance

Archive Center
NCSA, Champaign, IL
100 to 250 TFLOPS, 75 PB

Database & Pipeline Parallelization
Fault Tolerance

Mountain Summit/Base Facility
Cerro Pachon, La Serena, Chile
10x10 Gbps fiber optics
25 TFLOPS, 150 TB

Transient Alerts, Pipeline Parallelization
Fault Tolerance

Long-Haul Communications
Chile - U.S. & w/in U.S.
2.5 Gbps avg, 10 Gbps peak
High-speed transfer
Fault Tolerance

1 TFLOPS = 10^12 floating point operations/second
1 PB = 2^50 bytes or ~10^15 bytes
LSST Primary Mirror Blank, September 2008
Dark Matter Simulations at SLAC
Image Simulation Flow

Catalog Generation (Millenium Simulations)

Image Generation (Full Photon Ray Tracing)

Connolly, Jee, Jernigan, Krabbendum, Peterson, Rasmussen, Tyson

SLAC
Full LSST end-to-end photon Simulation

Sky->Atmosphere->Optics->Detector

12 million objects, billions of raytraced photons

Peterson, Meert, Nichols, Grace, Bankert (Purdue)

Jernigan (Berkeley)
Connolly (U Wash)

Rasmussen (SLAC)
Ultra-large Data Management: LSST

* 100+ petabyte system
* Multi-dimensional data set
* Large user base ranging from professional astronomers to general public. Complex analytics
* **SLAC is responsible for delivering the LSST database and data access system**
Ultra-large Data Management: XLDB

* XLDB = eXtremely Large Data Bases
* XLDB workshops and community
  – Idea born at SLAC
  – Yearly workshops organized by SLAC, at SLAC
    • 2\textsuperscript{nd} workshop: September 29/30, 2008
  – Community includes data-intensive industrial users, data intensive sciences, database researchers, all major database vendors. Coordinated by SLAC
    • Huge interest. Google, Yahoo!, eBay, Amazon, Facebook, AT&T, AOL, Microsoft, IBM, Oracle, Sun, LG, CERN, MIT, PNNL, LLNL, LBNL, FermiLab, SDSC, CMU, GMU, UW, ..., many others on board

* SLAC is helping to advance state-of-the-art of database technology and bridges the gaps within the database community
Ultra-large Data Management: SciDB

* SciDB - a new open source data management system for data-intensive scientific analytics
  – Design led by world-class database researchers
    • Mike Stonebraker, David DeWitt
  – Non profit foundation, substantial funds available from eBay and (very likely) Microsoft. Discussions with DoE/ASCR and NSF in progress

* SLAC's involvement
  – Actively helped define SciDB
  – Coordinates input from all sciences
  – Some contributions to the development
  – Provides office space for the startup

* SLAC has a chance to make big positive impact on complex scientific analytics and beyond
The current LSST timeline

- NSF D&D Funding
  - MREFC Proposal Submission
  - NSF CoDR
  - MREFC Readiness
  - NSF PDR
  - NSF CDR

- NSF MREFC Funding
  - Telescope First Light
  - System First Light
  - Commissioning
  - ORR

- NSF + Privately Supported Construction (8.5 years)

- Privately Supported camera R&D
- DOE MIE Funding
  - DOE + Privately Supported Fabrication (5 years)
  - Sensor Procurement Starts

- DOE R&D Funding
  - DOE CD-0
  - DOE CD-1
  - DOE CD-2
  - DOE CD-3
  - DOE CD-4

- DOE Operating Funds
  - Camera Delivered to Chile
  - Camera Ready to Install

- DOE Operating Funds

- NSF + Privately Supported Construction (8.5 years)