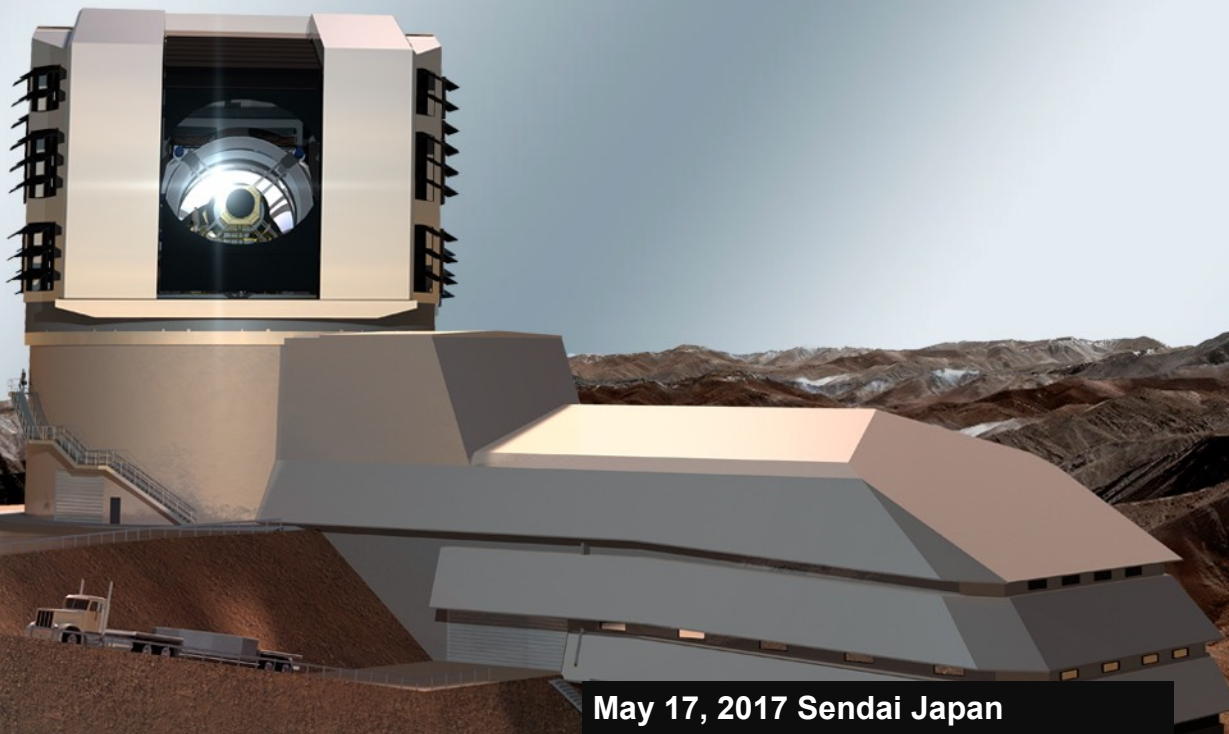




LSST science reach: two examples Transients and Dark Energy

Sam Schmidt
UC Davis



May 17, 2017 Sendai Japan



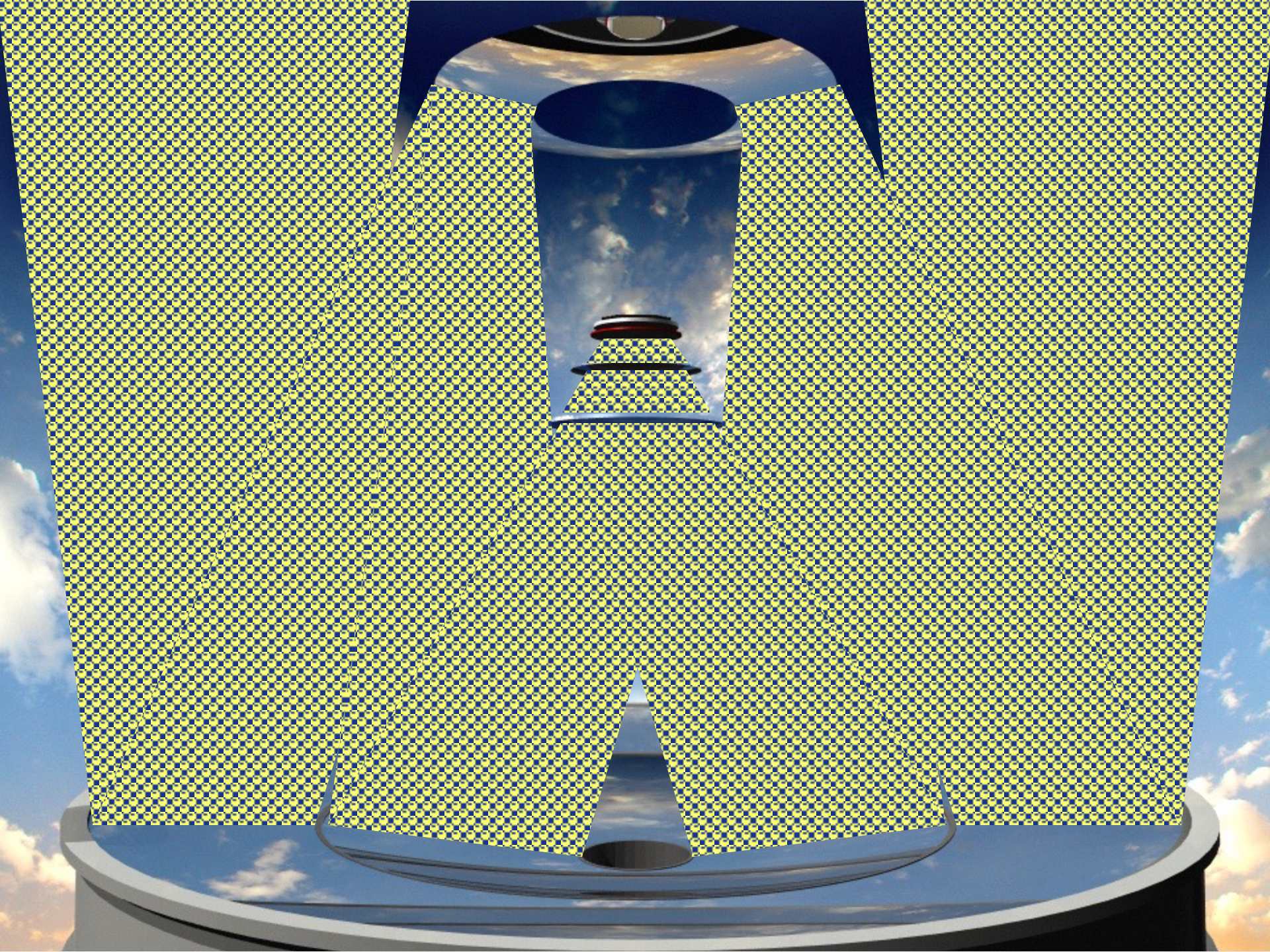
LSST in one sentence:

An optical/near-IR survey of half the sky in ugrizy bands to $r \sim 27.5$ based on 1000 visits over a 10-year period:

A catalog of 17 billion stars and 20 billion galaxies with exquisite photometry, astrometry and image quality!

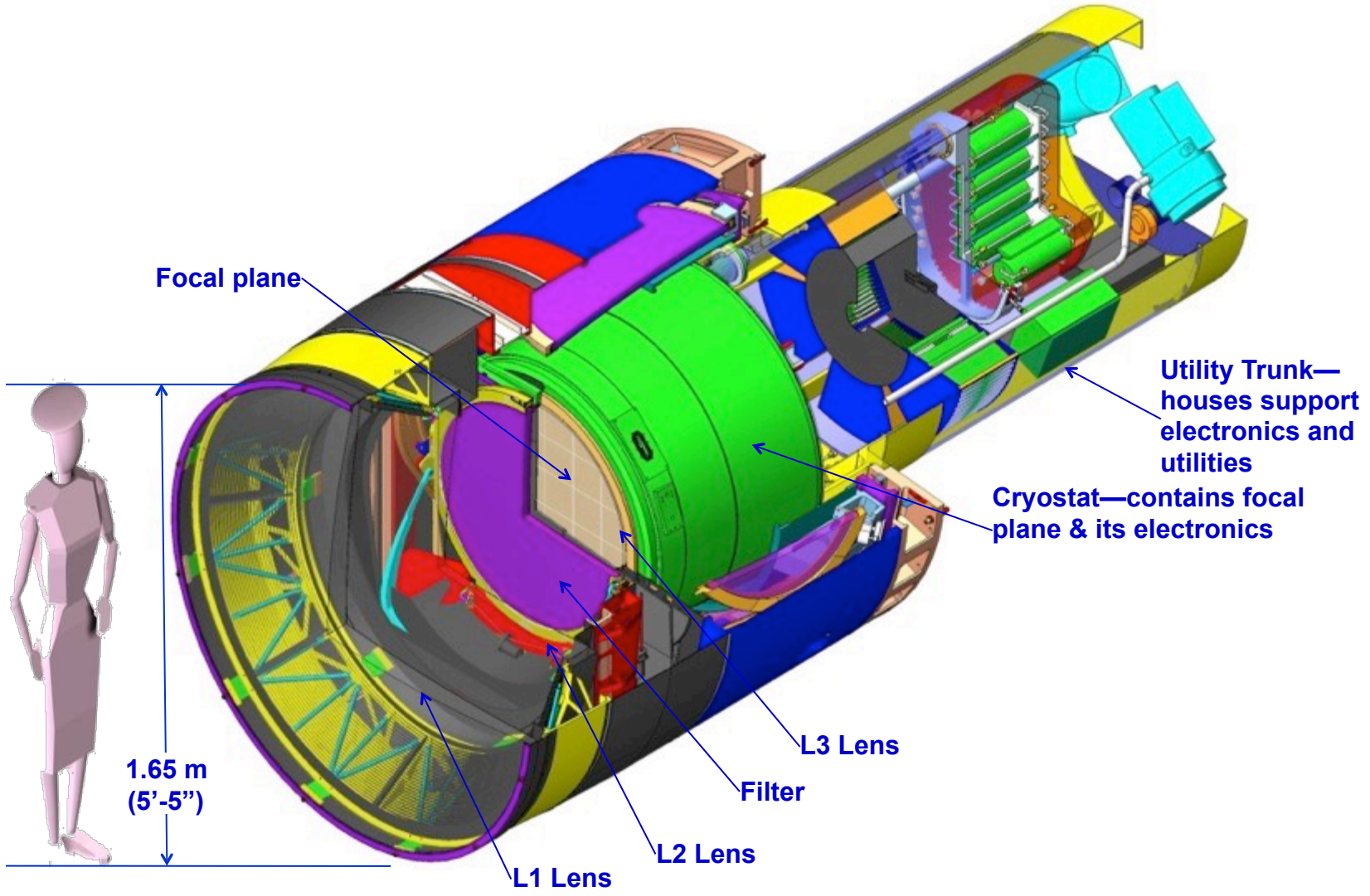
More information
at www.lsst.org
and [arXiv:0805.2366](https://arxiv.org/abs/0805.2366)



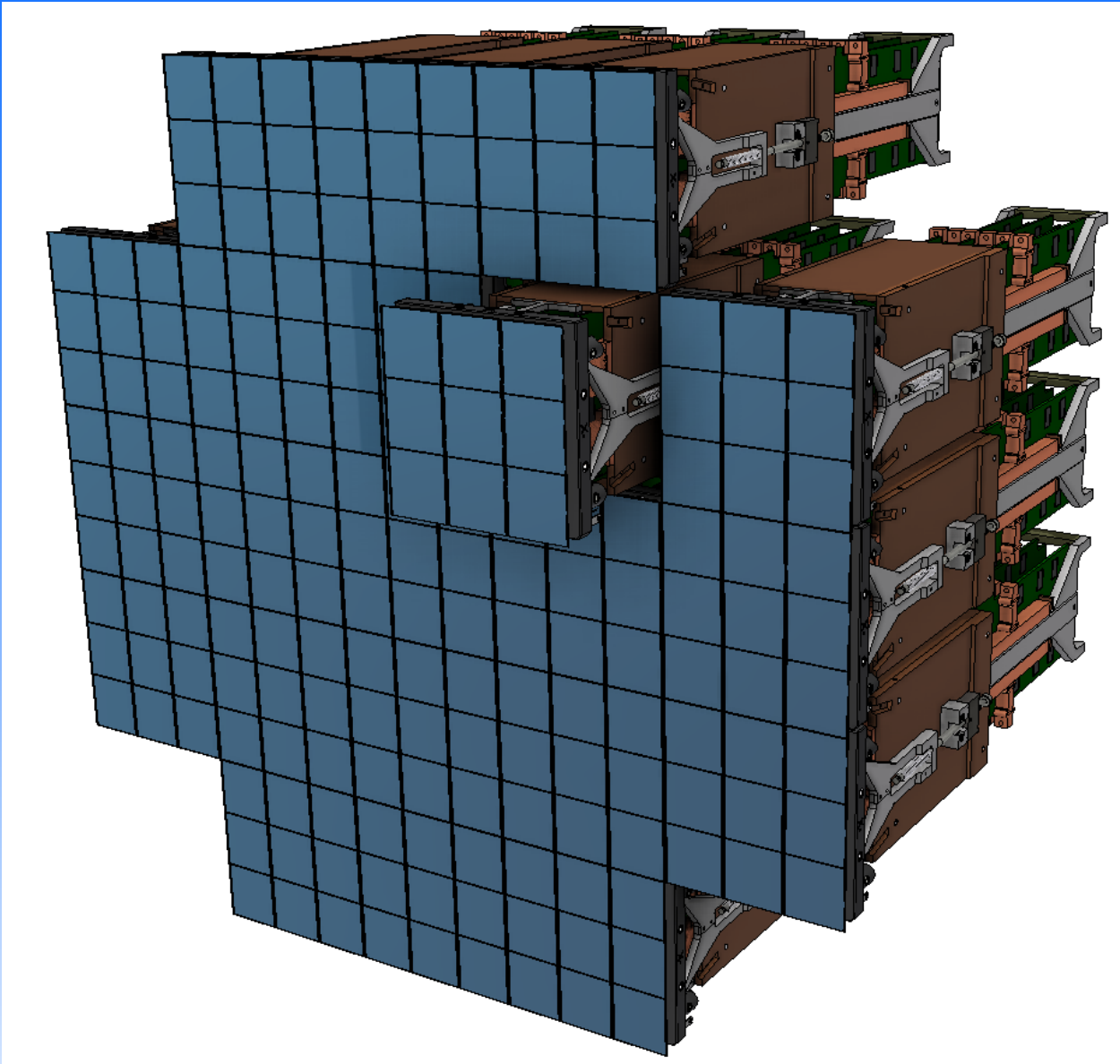




3.2 Billion Pixel Camera, 10 sq.deg Field



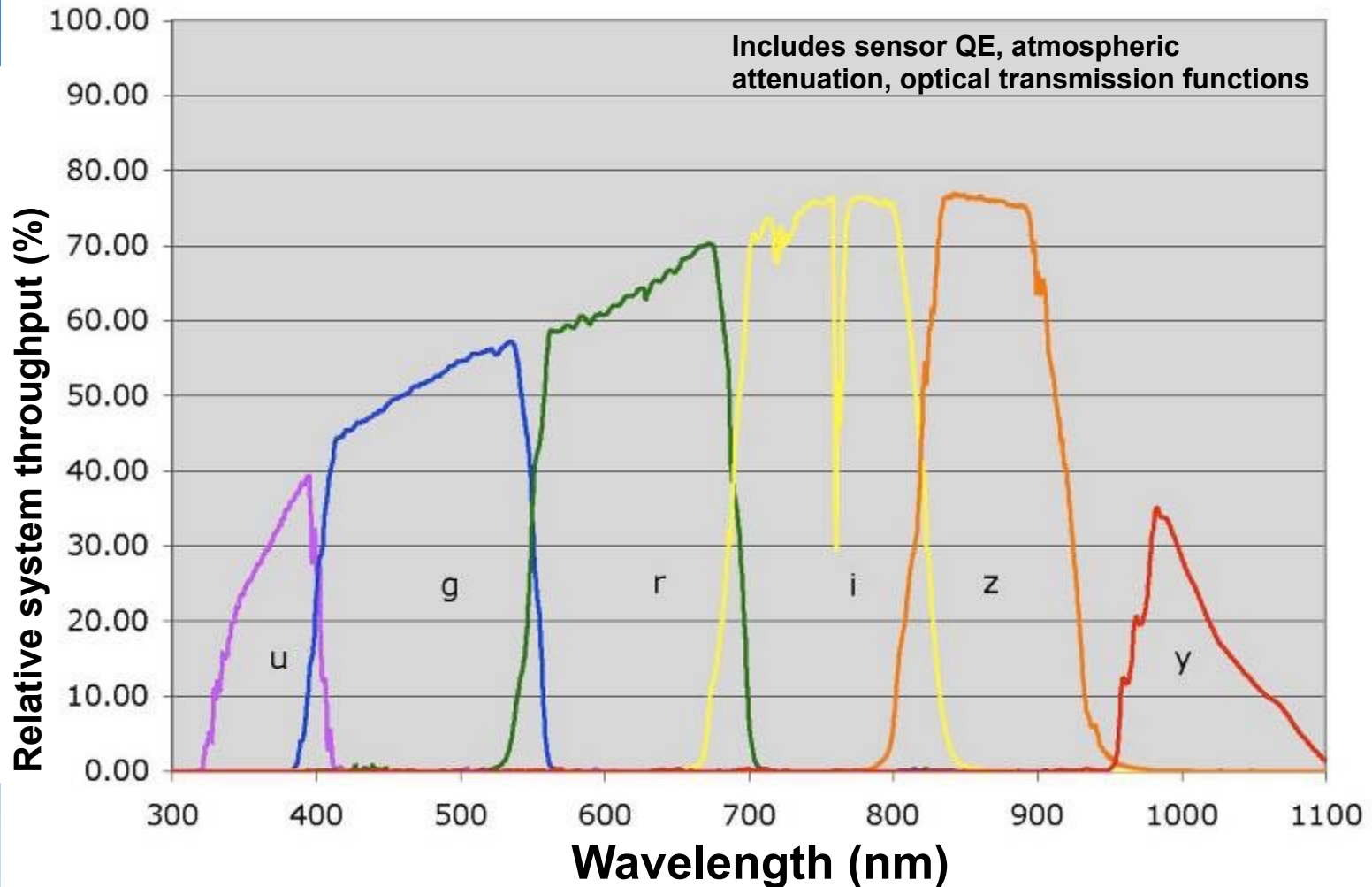
21 science rafts, 189 4K x 4K CCDs



21 “rafts”

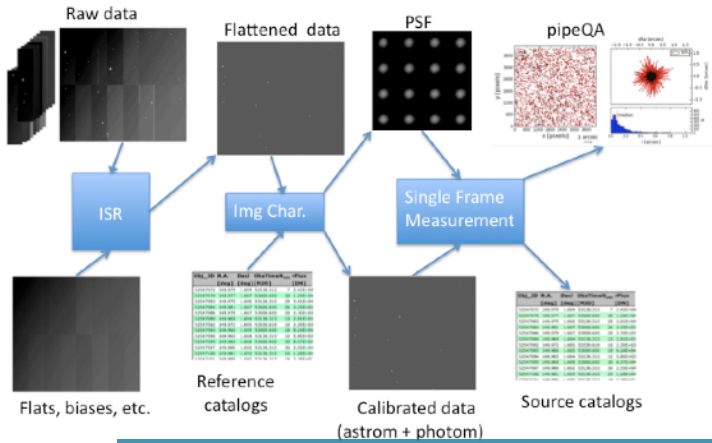
9 CCDs per raft

LSST six color system

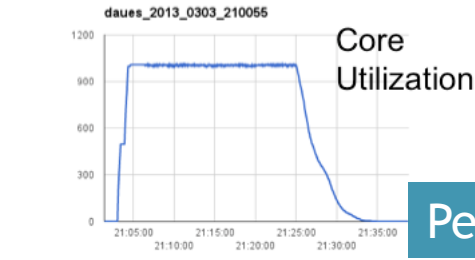
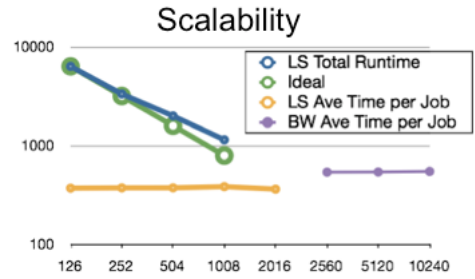




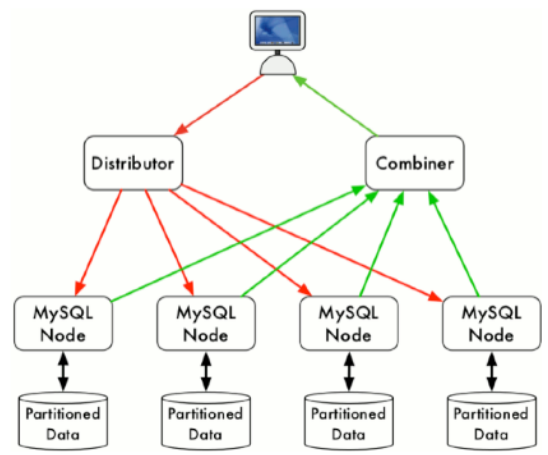
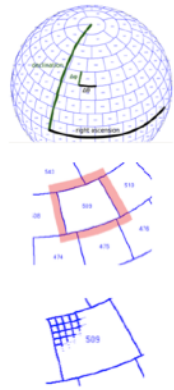
Data Management must transport, process, archive and serve 15 Tb of raw data / night - 500Pb in 10 years



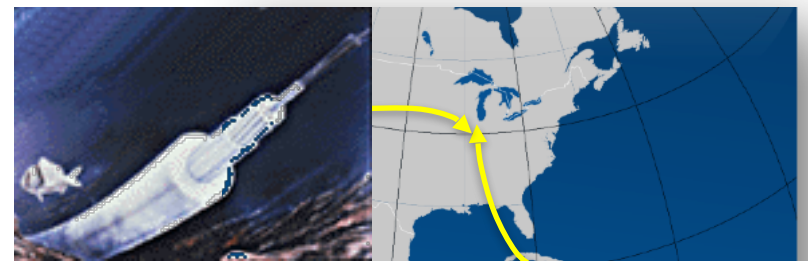
Algorithm Design



Petascale Computing Design



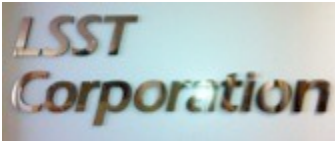
Petascale Database Design



Gigascale Network Design

Data Management Sites and Centers

HQ Site
HQ Facility
Observatory Management
Science Operations
Education and Public Outreach

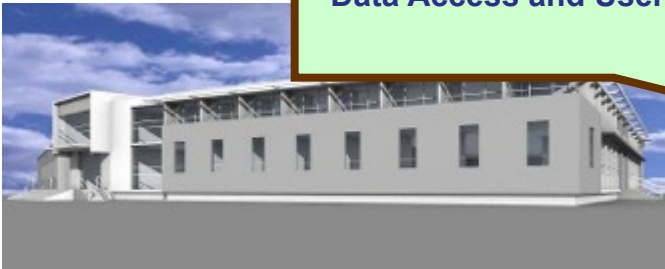


Archive Site
Archive Center
Alert Production
Data Release Production
Calibration Products Production
EPO Infrastructure
Long-term Storage (copy 2)
Data Access Center
Data Access and User Services

French Site
Processing Center
Data Release Production



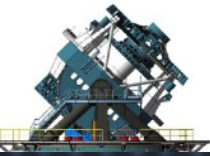
Base Site
Base Facility
Long-term storage (copy 1)
Data Access Center
Data Access and User Services



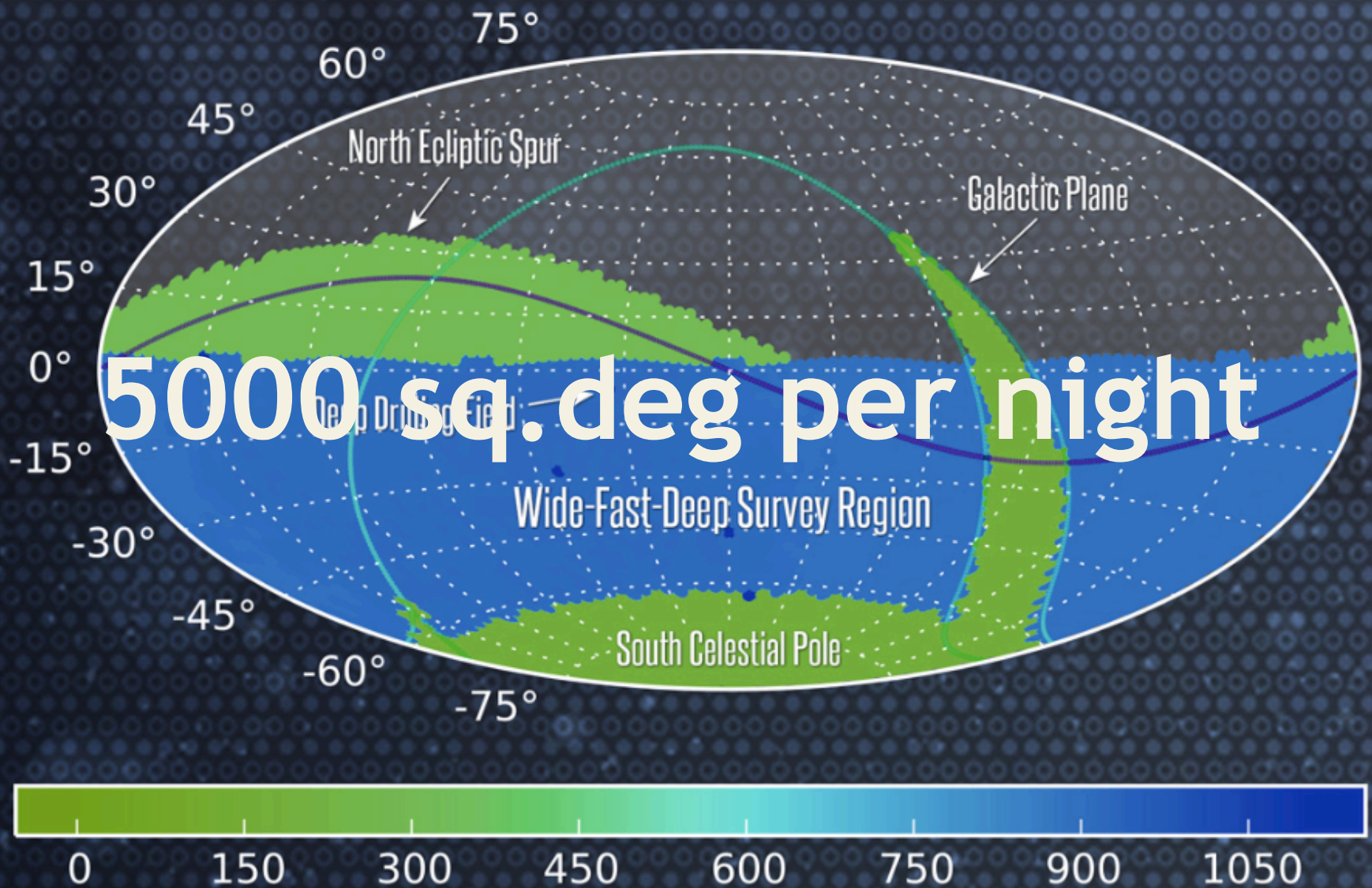
Summit Site
Summit Facility
Telescope and Camera
Data Acquisition
Crosstalk Correction







Main Survey Sky Coverage: number of visits



LSST surveys entire sky south of $+5^{\circ}$ dec
with rapid 10 sq.deg exposures

TWO PLANNED SURVEYS:

MAIN SURVEY

Deep Wide Survey: 18,000 square degrees to a uniform depth of
 $u: 26.1$ $g: 27.4$ $r: 27.5$ $i: 26.8$ $z: 26.1$ $y: 24.9$

DEEP DRILLING SURVEY

10% of time: ~20 selected fields. 300 square degrees
Continuous 15 sec exposures. 1hour/night

*Most of sky covered over 800 times with 30s visits. Alerts on
transient objects released worldwide within 60s.*

LSST Wide-Fast-Deep survey

**A survey of 37 billion objects
in space and time**

***Each sky patch will be visited over 800 times:
30 trillion measurements***



LSST From the User's Perspective



- A stream of ~1-10 million time-domain events per night, detected and transmitted to event distribution networks within 60 seconds of observation.
 - A catalog of orbits for ~6 million bodies in the Solar System.
-
- A catalog of ~37 billion objects (20B galaxies, 17B stars), ~7 trillion observations (“sources”), and ~30 trillion measurements (“forced sources”), produced annually, accessible through online databases.
 - Deep co-added images.
-
- Services and computing resources at the Data Access Centers to enable user-specified custom processing and analysis.
 - Software and APIs enabling development of analysis codes.

Level 1

Level 2

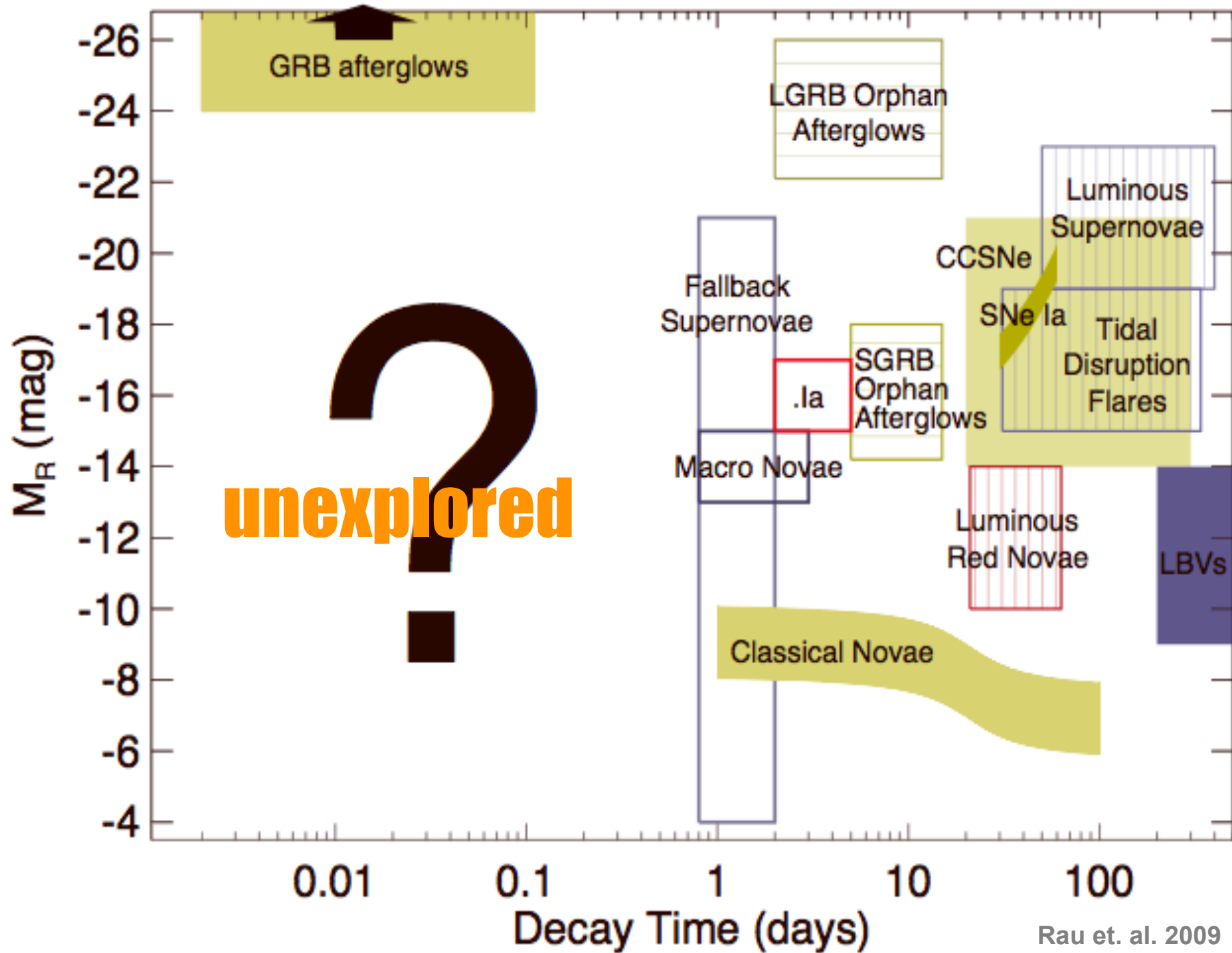
Level 3

Alert Rate

In ten minutes time the LSST transient pipeline is likely to issue ~80,000 alerts at 5σ .

While most of these will be moving objects, perhaps several thousand will be flaring objects or bursts. Possibly new kinds of objects!

Clearly any followup requires high purity samples. What is needed then is highly trusted event classification. FAST





- **Forced Photometry (“Precovery”) Service**
 - Automatically perform and make available forced photometry at the position of all newly detected sources, on imaging acquired over the preceding 30 days
 - On request, for a limited number of positions perform and make available forced photometry on *all* imaging overlapping that position
 - Turnaround on a ~day timescale.
- **Alert generation service**
 - Package and transmit all alerts to community-supported alert distribution networks
- **Limited end-user alert stream subscription and filtering service**
 - Individuals will be able to subscribe to receive a small (~20) number of alerts per visit, filtered based on user-specified criteria
 - Limited functionality: no classification, not planning to cross-match to external catalogs, etc.
 - We expect the community will provide sophisticated event brokers with classification engines, cross-match capabilities to other catalogs, etc.

LSST unique contribution: $t < t_0$ information

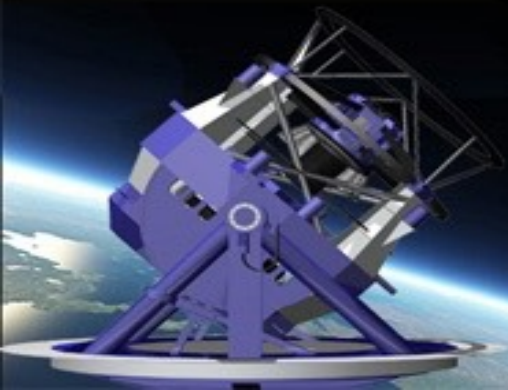
LSST will have the time history of 37 billion objects in the database. Transient phenomena may exhibit precursor activity:

1. Use as Bayesian prior in classification post-alert
2. Treat as part of the “light curve.” 27th -> 24th mag.
3. Catch interesting objects on their way up. Issue pre-alerts.

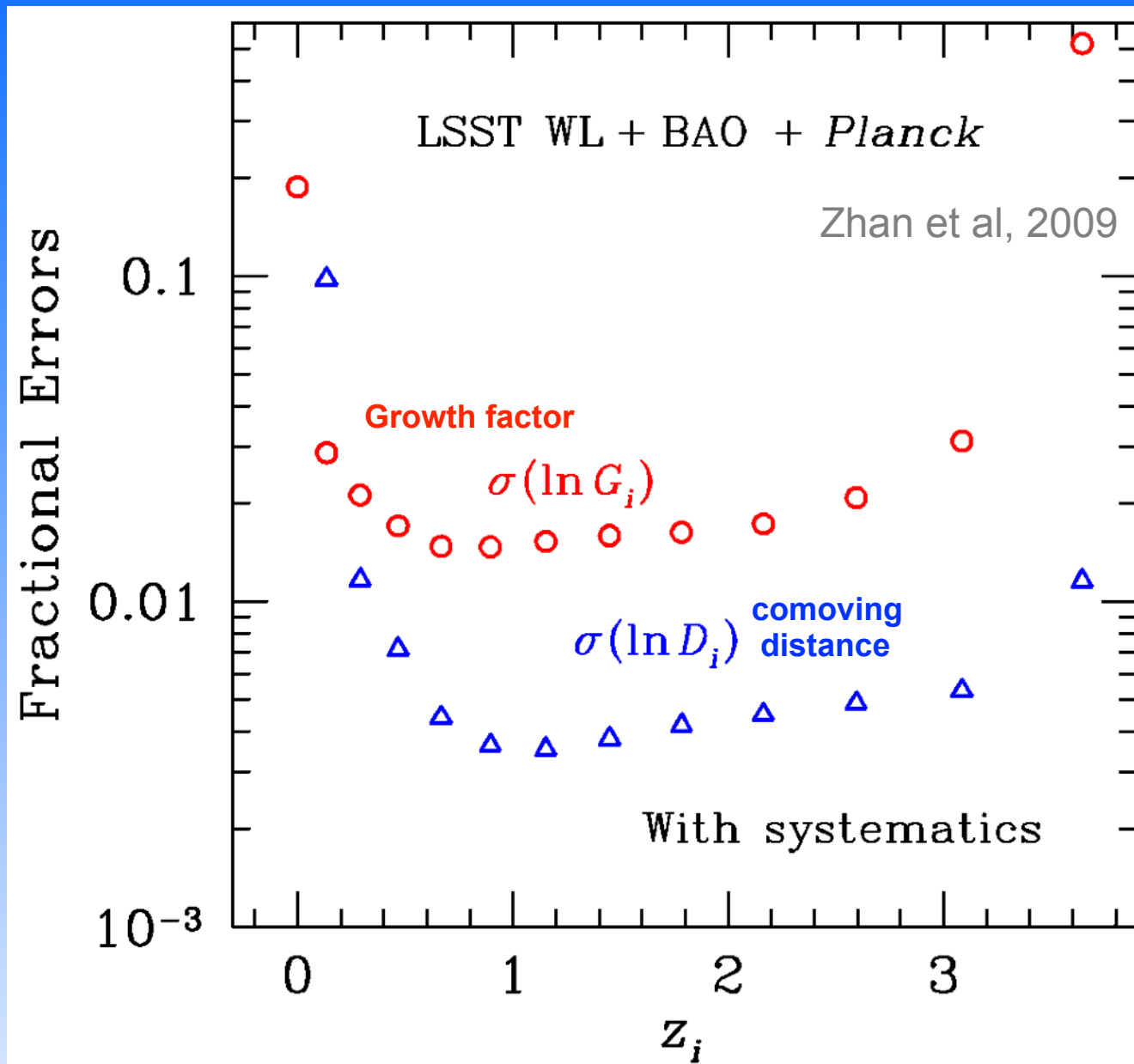
DARK ENERGY

COSMIC TIME

Measure position and shape of 4 billion galaxies



Testing general models of dark energy



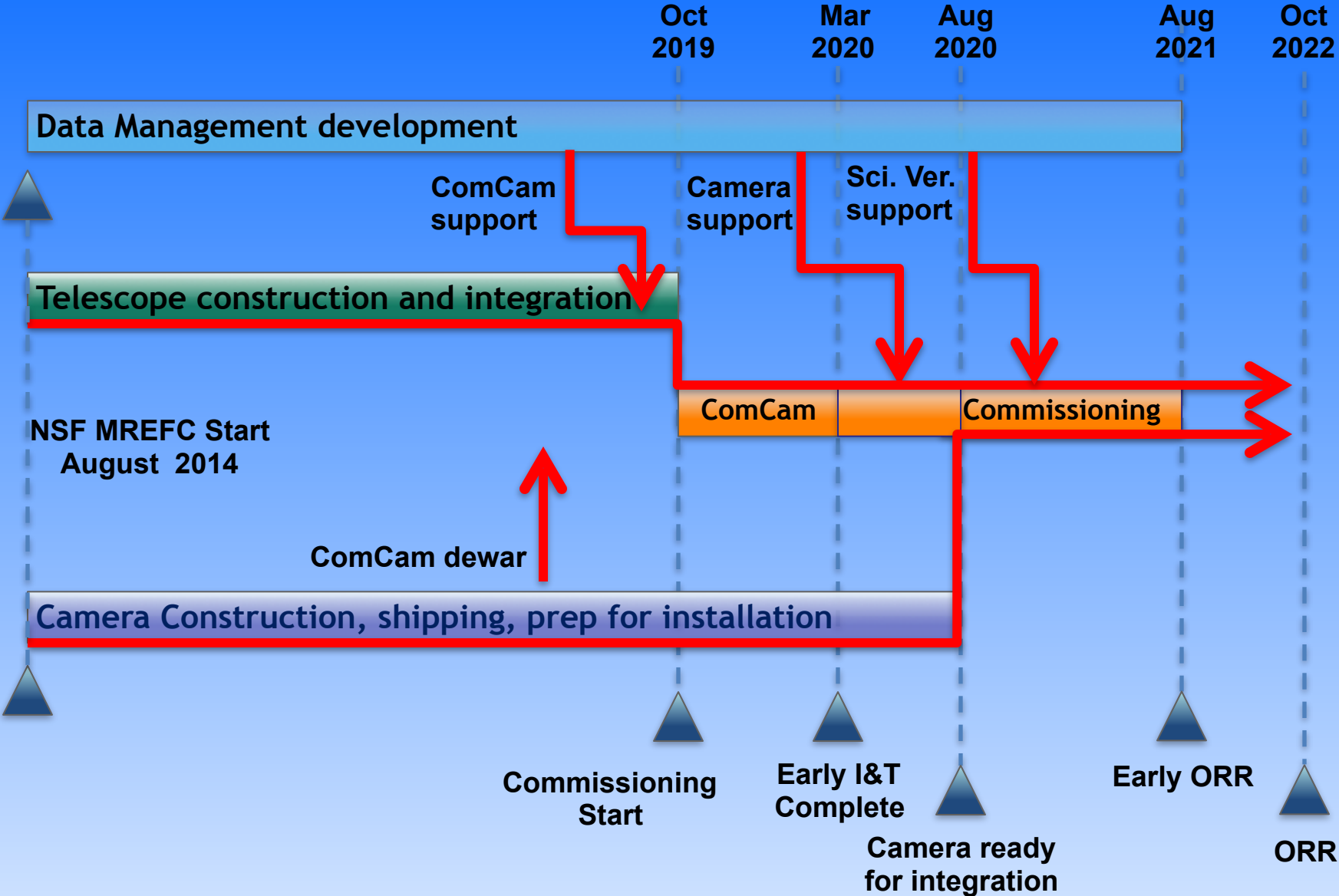
Multiple LSST probes of dark energy

- Use the same LSST survey data products
- Analyzed for different signals
- Multiple cross checks
- Combination is far more powerful than root sum of squares

Primary LSST probes	
Weak Lens shear cross correlation tomography	
Weak Lens magnification tomography	✓
2-D Baryon Acoustic Oscillations	✓
Supernovae	✓
Shear peak statistics	✓
Galaxy cluster counts	✓
Secondary LSST probes	
Time domain tomography of QSOs and AGNs	✓
Anisotropy of WL+BAO and SN signals	✓
New Energy or New Gravity?	✓

Maximally sensitive
to new physics

Integrated Schedule



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 Community

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Topic

Welcome to community.lsst.org

community.lsst.org is a place for the astronomy community to discuss the Large Synoptic Survey Telescope's ongoing development and get help with using LSST's software today. What's here Community members can read, pos... [read more](#)

Science-Driven Optimization of the LSST Observing Strategy

Prepared by the LSST Science Collaborations,
with support from the LSST Project.

Phil Marshall,¹ Scott Anderson,² Timo Anguita,³ Ruth Angus,⁴ Jair Arcavi,⁵ Humna Awan,⁶ Federica B. Bianco,⁷ Rahul Bhowmik,⁸ Keaton J. Bell,⁹ Eric C. Bellm,¹⁰ David Bennett,¹¹ Niel Brandt,¹² Chris Britt,¹³ Derek Buzasi,¹⁴ Dana I. Casetti-Dinescu,¹⁵ Laura Chornik,¹⁶ Will Clarkson,¹⁷ Chuck Claver,¹⁸ Andy Connolly,¹⁹ Ken Cook,²⁰ James Davenport,²¹ Victor Debattista,²² Seth Digel,²³ Zohbeyr Doctor,²⁴ Wen-fai Fong,²⁵ Eric Gawiser,²⁶ Mark Giampapa,²⁷ John E. Gizis,²⁸ Melissa L. Graham,²⁹ Carl Grillmair,³⁰ Zoltan Haiman,³¹ Patrick Hartigan,³² Suzanne Hawley,³³ Željko Ivezić,³⁴ C. Johns-Krull,³⁵ Lynne Jones,³⁶ Shashi Kanbur,³⁷ Vassiliki Kalceras,³⁸ Vinay Kashwan,³⁹ Vishal Kashiwal,⁴⁰ Peter Kuzczewski,⁴¹ Michael C. Liu,⁴² Michelle Lochner,⁴³ Michael B. Lund,⁴⁴ Ashish Mahabal,⁴⁵ Raffaella Margutti,⁴⁶ Tom Matheson,⁴⁷ Peregrine McGehee,⁴⁸ Seren Meibom,⁴⁹ Josh Meyers,⁵⁰ Dave Monet,⁵¹ David Nidever,⁵² Knut Olsen,⁵³ Eric Neilsen,⁵⁴ Matthew T. Penny,⁵⁵ Christina Peters,⁵⁶ Radosław Poleski,⁵⁷ Gordon Richards,⁵⁸ Stephen Ridgway,⁵⁹ Jeonghee Rho,⁶⁰ Jason Rhodes,⁶¹ David Rubin,⁶² Samuel Schmidt,⁶³ Ohad Shemer,⁶⁴ Avi Shporer,⁶⁵ Colin Slater,⁶⁶ Nathan Smith,⁶⁷ Marcelles Soares-Santos,⁶⁸ Keivan Stassun,⁶⁹ Jay Strader,⁷⁰ Michael Strauss,⁷¹ Rachel Street,⁷² Christopher Stubbs,⁷³ Paula Szkody,⁷⁴ David Trilling,⁷⁵ Virginia Trimble,⁷⁶ Tony Tyson,⁷⁷ Miguel de Val-Borro,⁷⁸ Stefano Valentini,⁷⁹ Kathy Vivas,⁸⁰ Robert Wagoner,⁸¹ Lucianne Walkowicz,⁸² Beth Willman,⁸³ Peter Yochim,⁸⁴ Bevin Ashley Zauderer,⁸⁵

Meetings

- working group monthly videocons
- collaboration meetings, hackathons

Community Forums

- public discussions for project & community

Observing Strategy White Paper

- science collaborations using OpSim & MAF

Science Roadmaps

Data Challenges

Assessment of Follow-up Capabilities

LSSTC Data Science Fellowship Program

- preparing students (hosting opportunities exist)



Dark Energy Science Collaboration

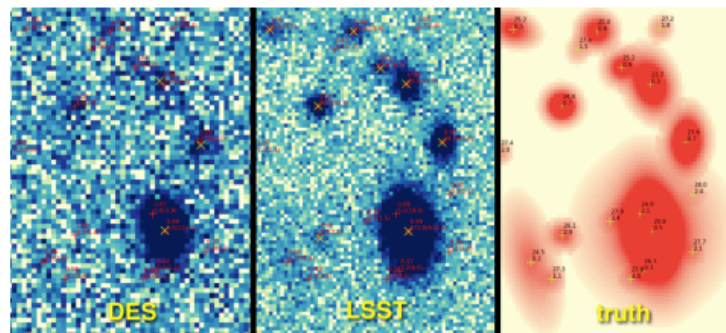
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- DE School

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 - Weak Lensing: Deblending Sims and Analysis
 - Cosmological Simulations: Large-scale simulations for synthetic sky maps
 - Cosmological Simulations: Approximate Mass Function Emulator
 - Weak Lensing: Chromaticity
 - SuperNovae: Cadence Generator
 - Clusters: Shear Measurement Challenge
 - Strong Lensing - Time Delay Challenge
 - Photometric Redshifts: Calibration
 - Cosmological Simulations: Power Spectrum Emulator
 - Cosmological Simulations: Power spectra via perturbation theory

Weak Lensing Featured Project: Fast Simulations and Analysis

Submitted by djbard-admin on Fri, 01/30/2015 - 19:48



Caption: Simulated image showing overlapping sources as seen by DES and LSST.

(Author: David Kirkby)

The [Weak Lensing Deblending Package](#) provides a framework to produce fast simulations and analysis for weak gravitational lensing.

This software was primarily developed to study the effects of overlapping sources on shear estimation, photometric redshift algorithms, and deblending algorithms. Users can run their own simulations (of LSST and other surveys) or, else download the [galaxy catalog](#) and [simulation outputs](#) to use with their own code or analyze with the tools provided here.

The code is hosted on [github](#). Please use the [github issue tracker](#) to let us know about any issues you

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Topic

Welco
community,
discuss the
developme
What's here

Sci
of th

Phil Marshall,¹ See
Federica B. Bianco
Niel Brandt,¹² Chu
Will Clarkson,¹⁷ C
Debatista,²² Seth I
John E. Geis,²⁶ M
Suzanne Hawley,³³
Kaleera,³⁸ Vinay I
Lochner,⁴³ Michae
Peregrine McGehee,
Olson,⁵³ Eric Neils
Richards,⁵⁸ Steph
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Science Roadmaps

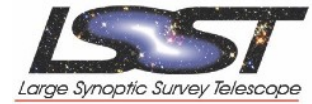
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Useful links for information and participation.



LSST Project Website project.lsst.org

LSST Community Forums community.lsst.org

Science Collaborations www.lsstcorporation.org/science-collaborations

Observing Strategy White Paper github.com/LSSTScienceCollaborations/ObservingStrategy

The 2016 LSST Project and Community Workshop project.lsst.org/meetings/lsst2016 (slides available)

Deep Drilling Fields Whitepapers <https://project.lsst.org/content/whitepapers32012>

Science Drivers to Reference Design (Ivezic et al. 2008; arXiv:0805.2366; Version 4 updated in 2014)

LSST Science Requirements (LPM-17) <https://docushare.lsstcorp.org/docushare/dsweb/Get/LPM-17>

LSST Data Products Definitions (LSE-163) <https://docushare.lsstcorp.org/docushare/dsweb/Get/LSE-163>

LSST DM Applications Design (LDM-151) <https://docushare.lsstcorp.org/docushare/dsweb/Get/LDM-151>

LSST Github Repositories github.com/lsst

LSST Software User Guide (The Stack) confluence.lsstcorp.org/display/LSWUG/LSST+Software+User+Guide

LSST Data Science Fellowship Program for Students

ciera.northwestern.edu/Education/LSSTC_DSFPOverview.php

Maximizing Science in the Era of LSST: A Community-based Study of Needed US OIR Capabilities

noao.edu/meetings/lsst-oir-study

