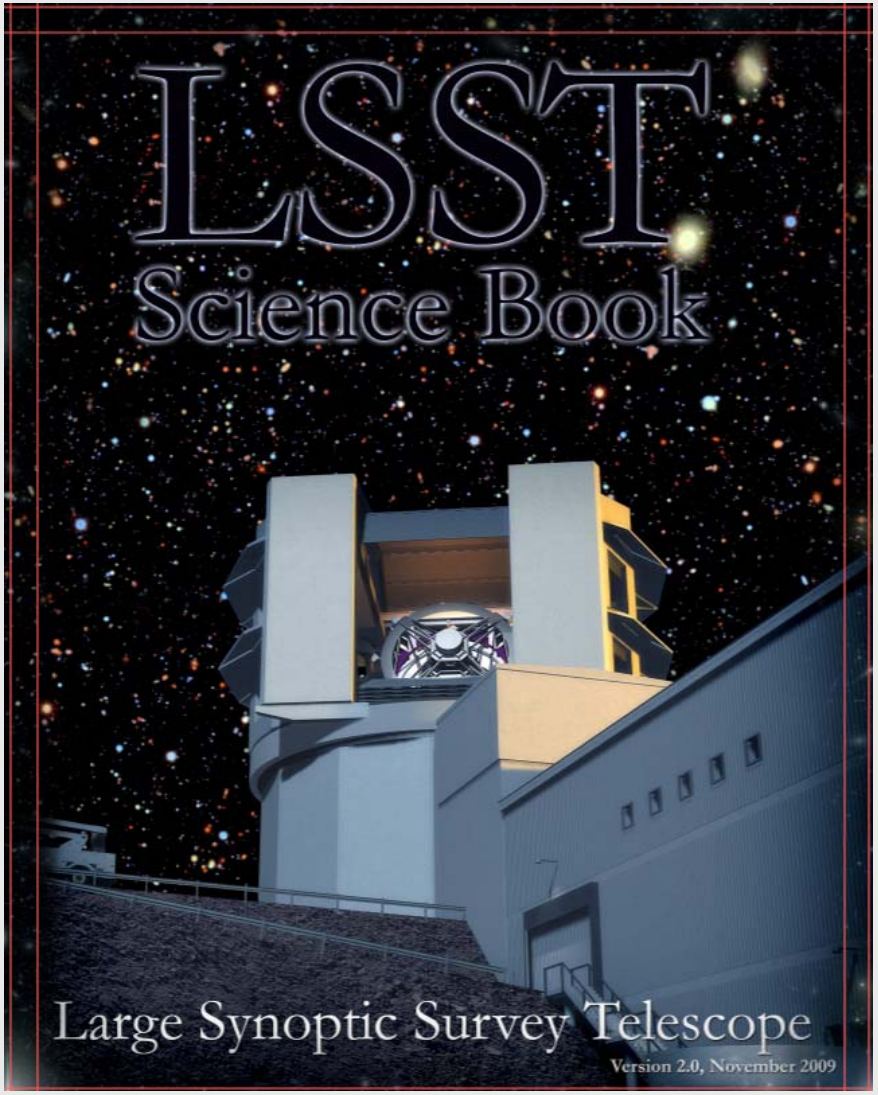
Large Synoptic Survey Telescope

Tony Tyson
LSST Director &
LSST Collaboration

LSST Science Book, v2.0 is available now at www.lsst.org and in print in a few weeks

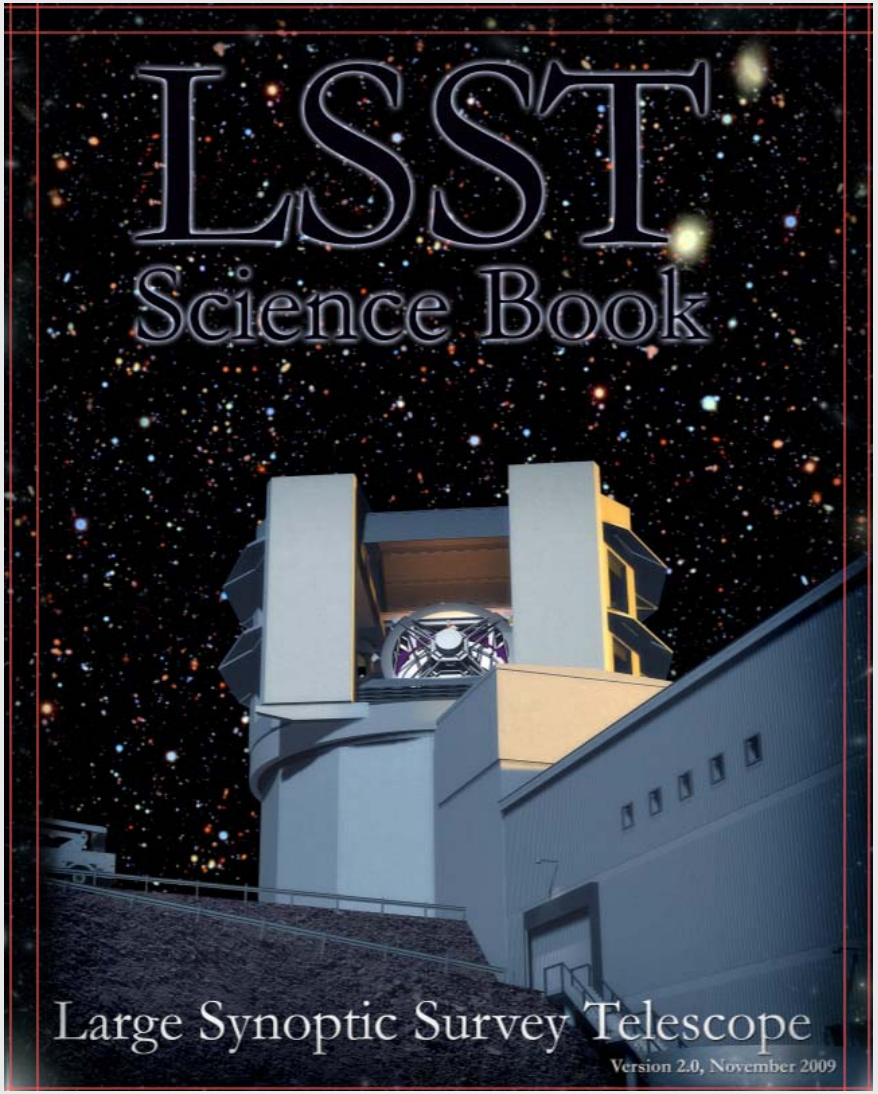
- Strong case
- 243 authors
- 598 pages
- November publication
- Living document
  (on lsst.org)



Chapters in the Science Book

– Introduction
– LSST System Design
– System Performance
– Education and Public Outreach

– The Solar System
– Stellar Populations
– Milky Way and Local Volume Structure
– The Transient and Variable Universe
– Galaxies
– Active Galactic Nuclei
– Supernovae
– Strong Lenses
– Large-Scale Structure
– Weak Lensing
– Cosmological Physics



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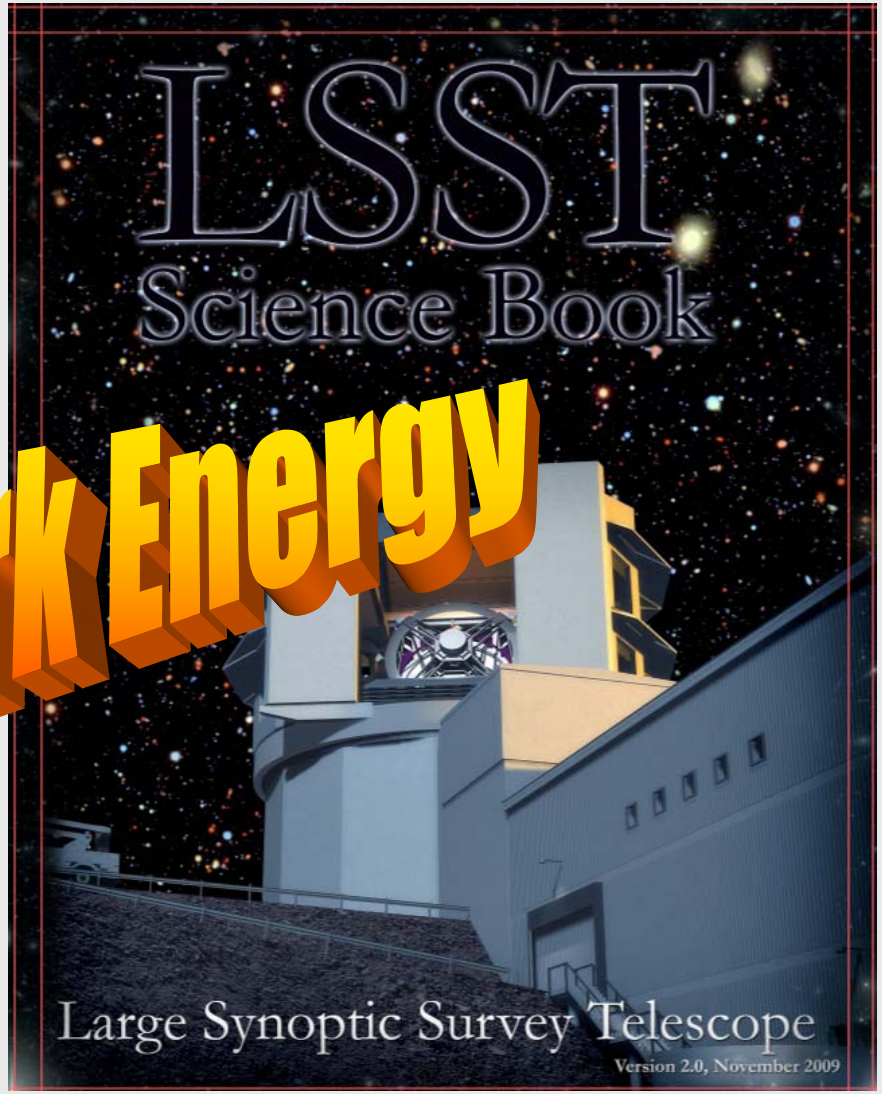


LSST All Hands Meeting at NCSA

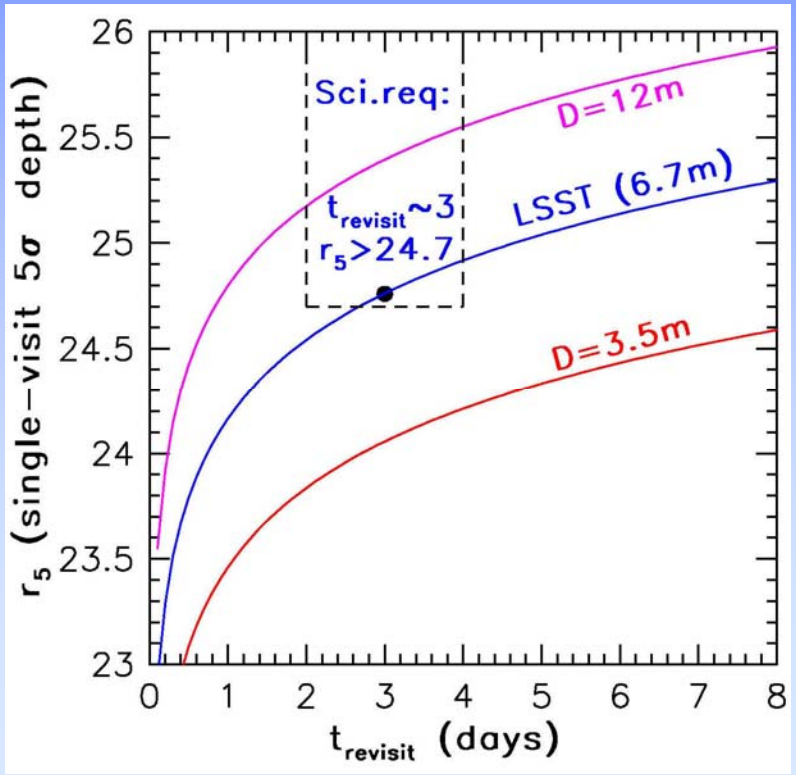
31 Institutional Members of LSST

- Brookhaven National Laboratory
- California Institute of Technology
- Carnegie Mellon University
- Chile
- Columbia University
- Cornell University
- Drexel University
- Google Inc.
- Harvard-Smithsonian Center for Astrophysics
- IN2P3 Labs France
- 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 for Science Advancement
- Rutgers University
- Space Telescope Science Institute
- SLAC National Accelerator Laboratory
- 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
- Vanderbilt University

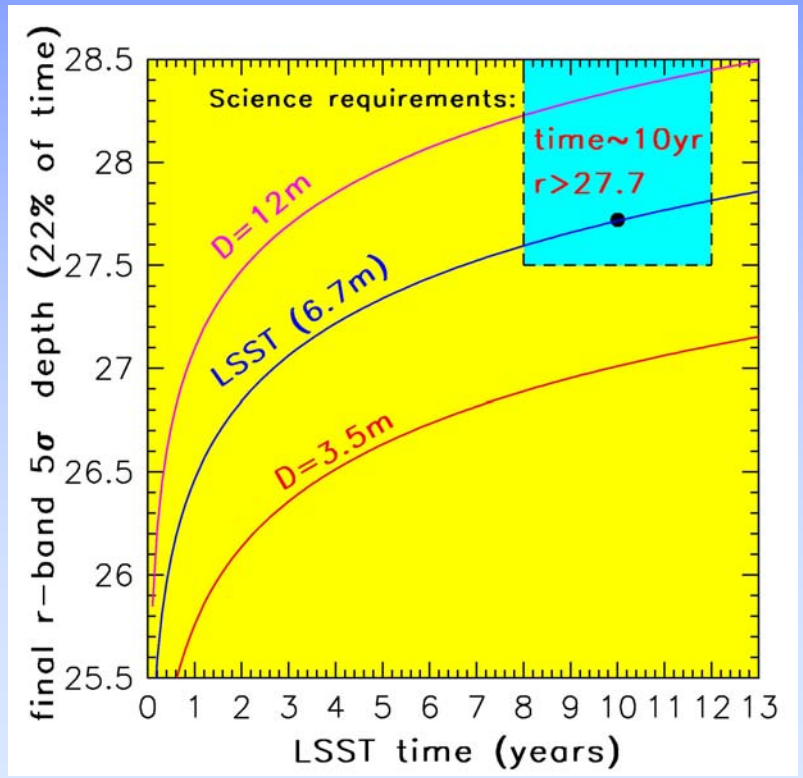
Choice of aperture and exposure time

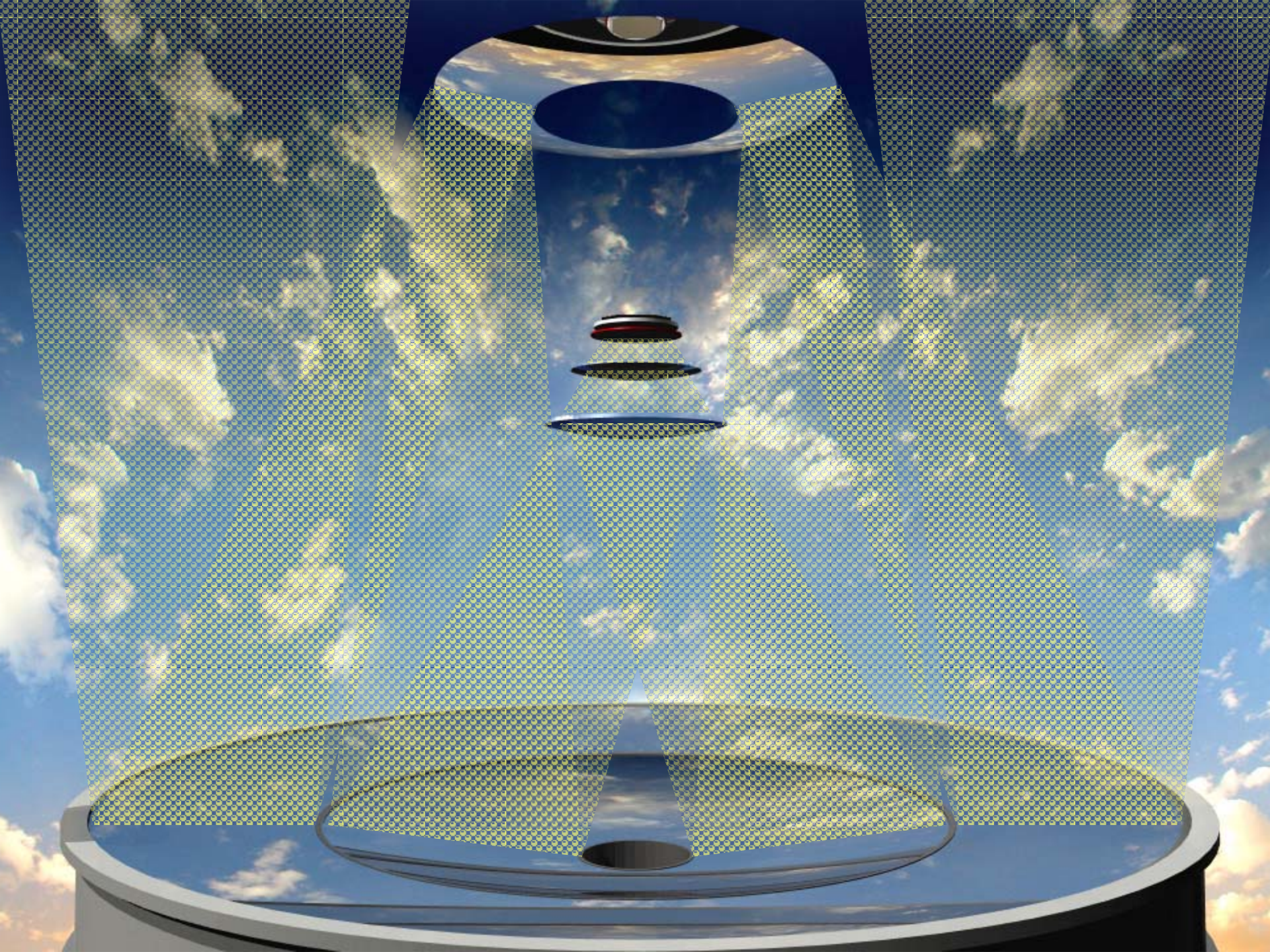
Driven by all four science themes from:
limiting depth, areal coverage, number of exposures and revisit time.

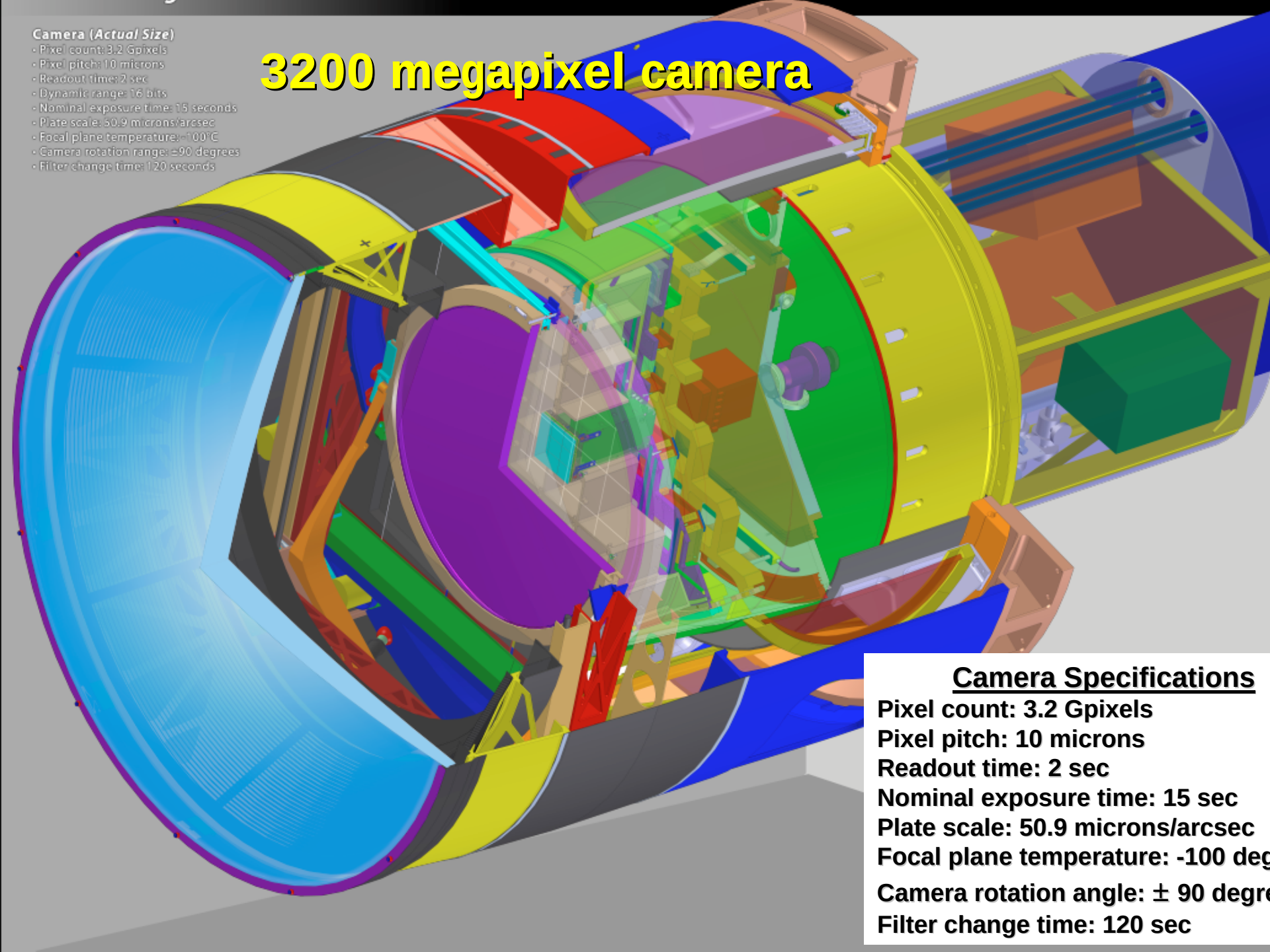
Single image depth



Stacked image depth







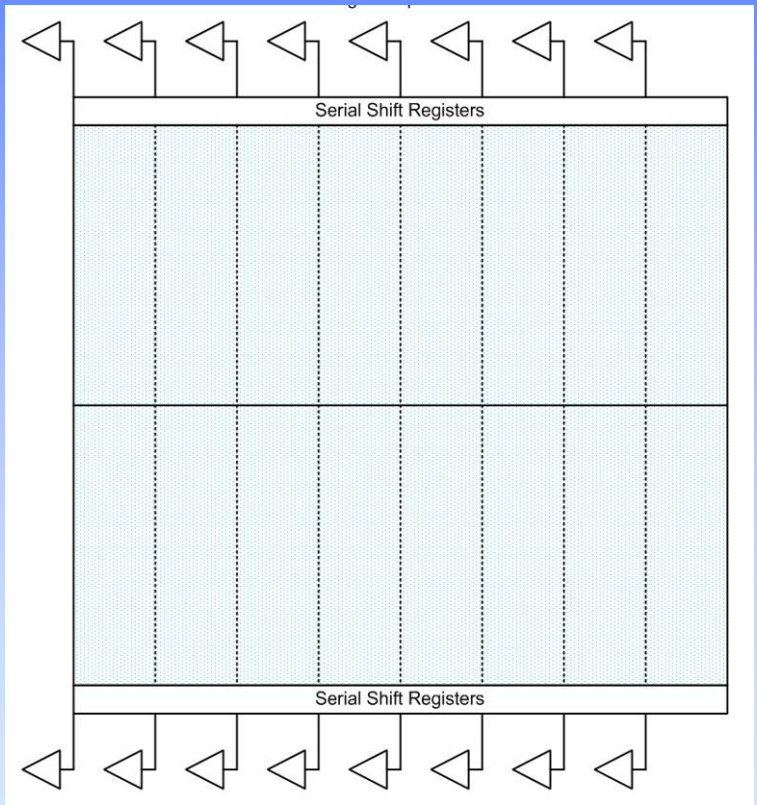
3200 megapixel camera

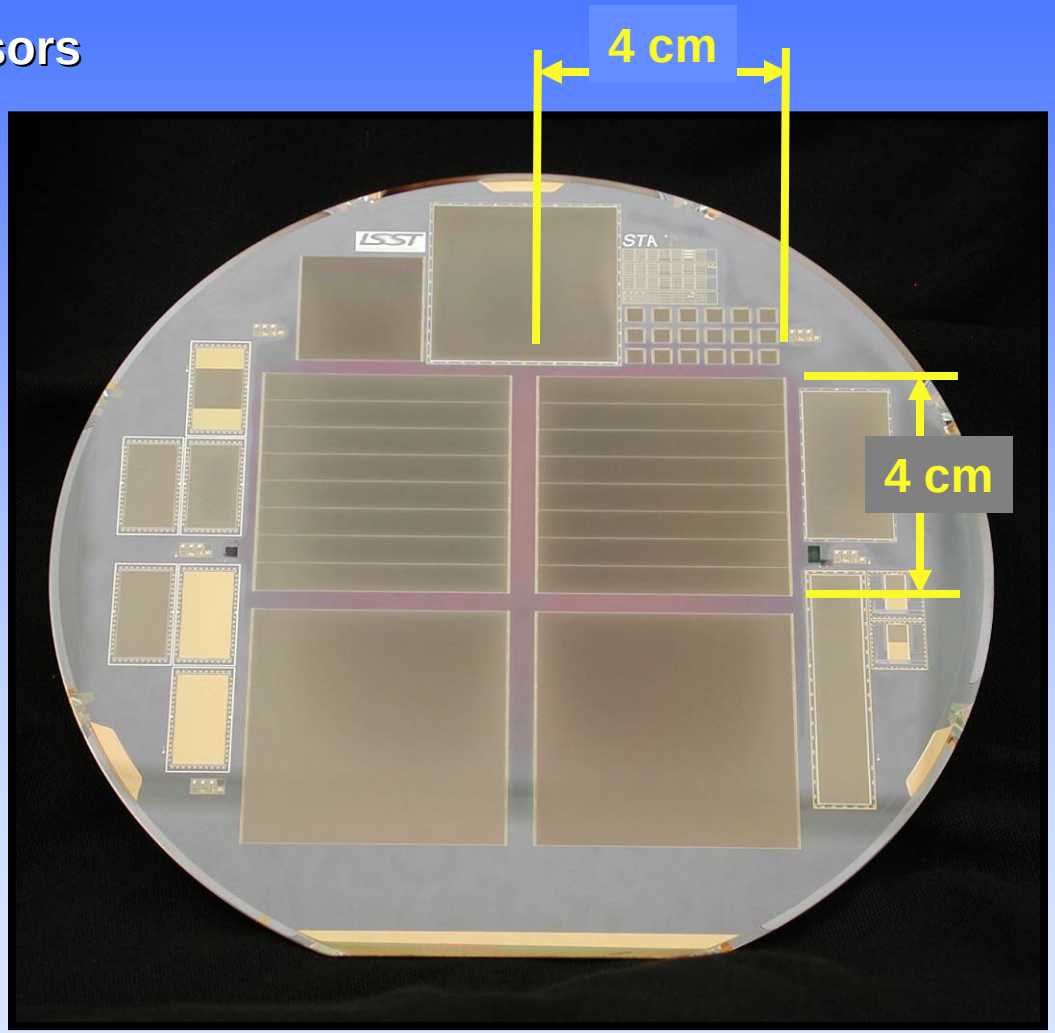
Camera Specifications

Pixel count: 3.2 Gpixels
Pixel pitch: 10 microns
Readout time: 2 sec
Nominal exposure time: 15 sec
Plate scale: 50.9 microns/arcsec
Focal plane temperature: -100 deg
Camera rotation angle: ± 90 degre
Filter change time: 120 sec

The LSST CCD Sensor

16 segments/CCD
189 Science CCDs
8 Guiders, 4 wavefront sensors
3168 Total Camera Outputs



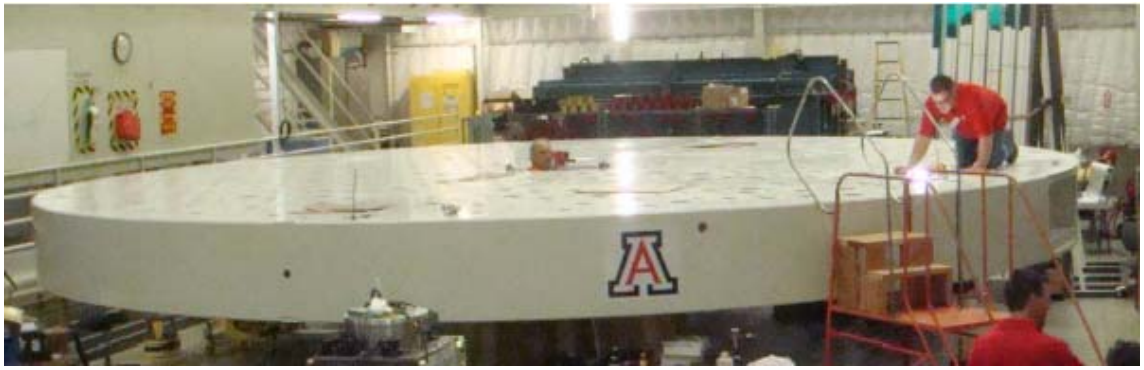



LSST
Large Synoptic Survey Telescope
CONSTRUCTION OF THE
RGE SYNOPTIC SURVEY TELESCOPE
posal submitted to the National Science Foundation
Large Synoptic Survey Telescope Corporation (LSSTC)
February 2007
LSST
Paul O'Connor
BNL


10

Primary Mirror Fabrication Continues on Schedule

Back surface inspection after final polish



Special hole polishing completed at hardpoints for increased mirror strength

Steel polishing cell delivered and actuator installation has begun

Secondary Mirror Substrate nearly complete at Corning

- **Secondary mirror blank will be delivered in November 2009.**

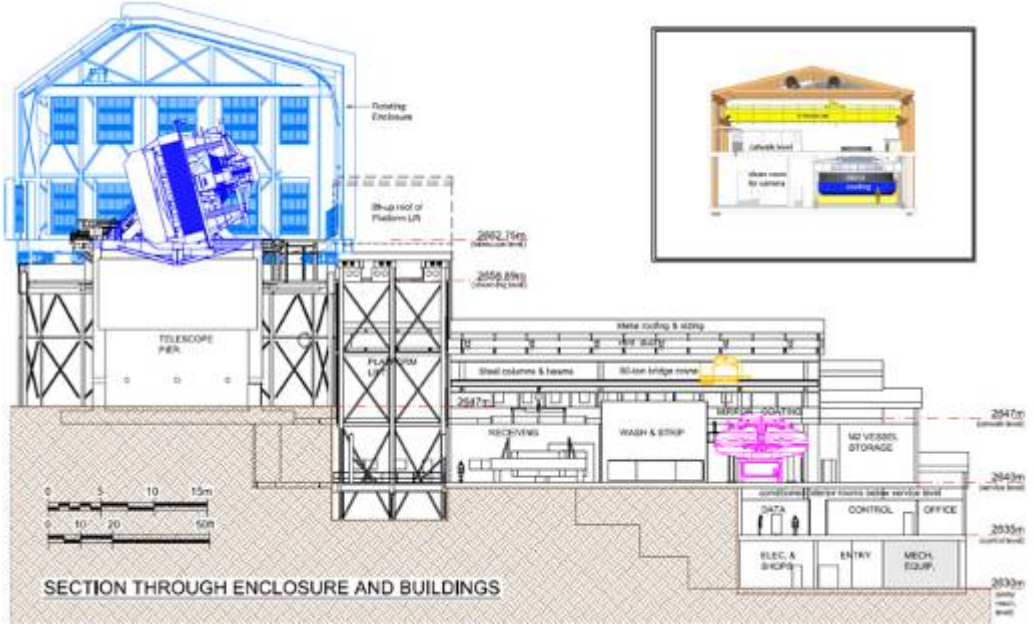
M2 substrate after slumping / annealing

Grinding inside bevel before acid etching

Architectural and Engineering Services Procurement Process underway in Chile

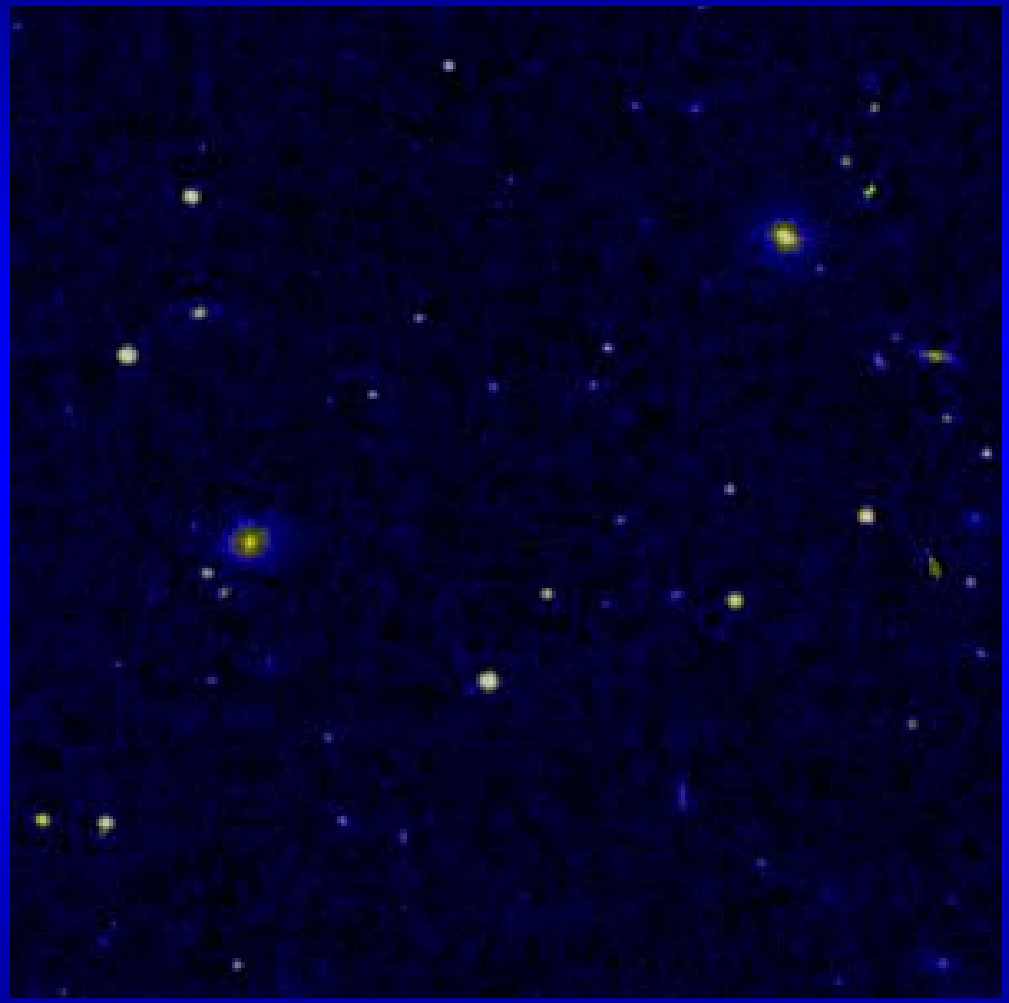
- **Summit building is on critical path for construction**
- **Design process and contractor selection to be completed prior to Final Design Review (FDR)**
- **Plan significant Chilean involvement – NOAO South to contract effort for LSST group**

Proposals due end Oct.



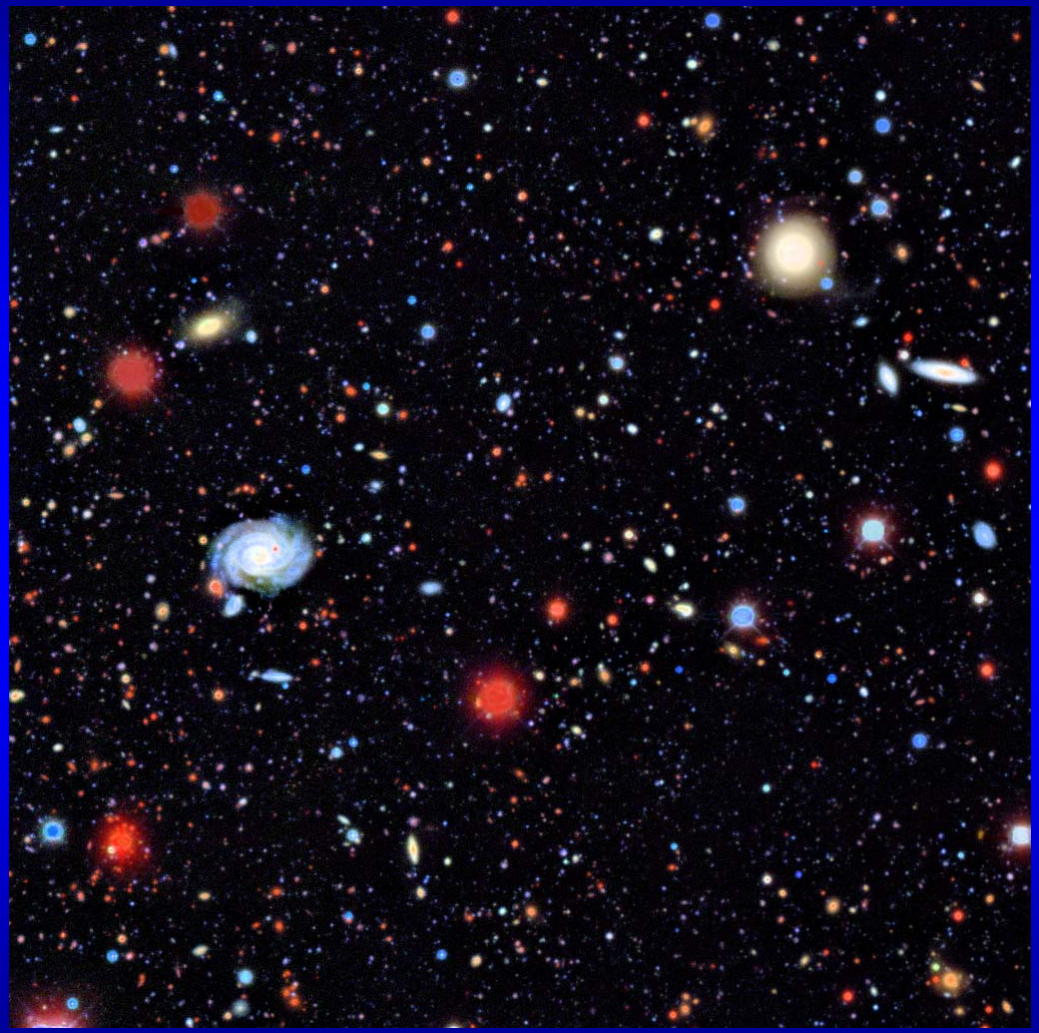
The LSST site

DSS: digitized photographic plates



Sloan Digital Sky Survey

LSST -- almost



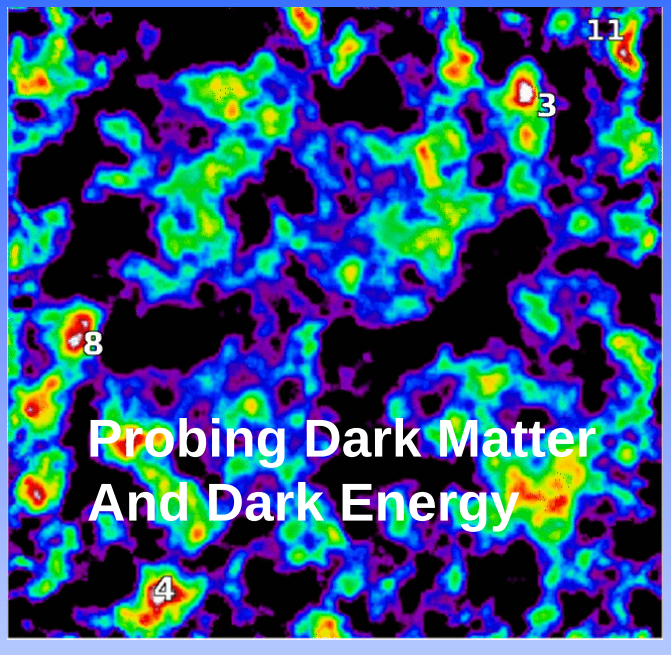
40
Galaxies
per sq.arcmin
i<25 mag
S/N > 20

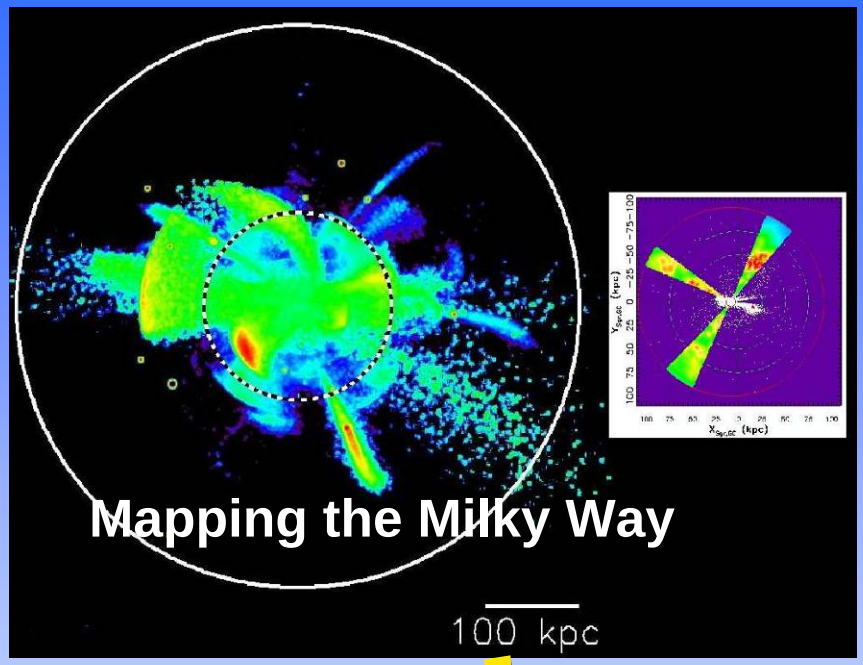
LSST survey

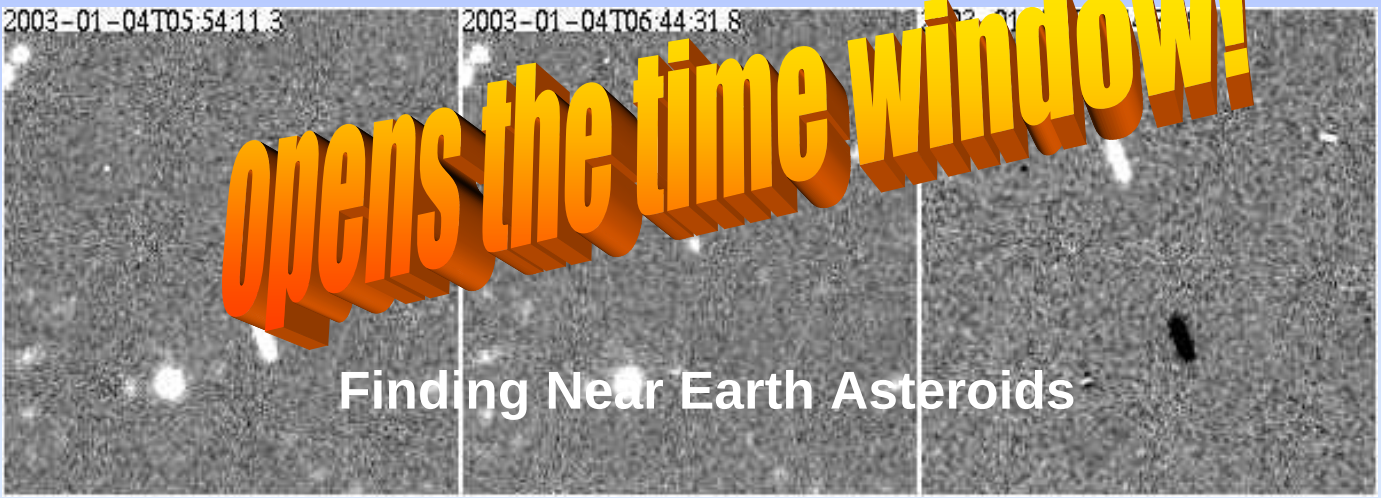
- 4 billion galaxies with redshifts

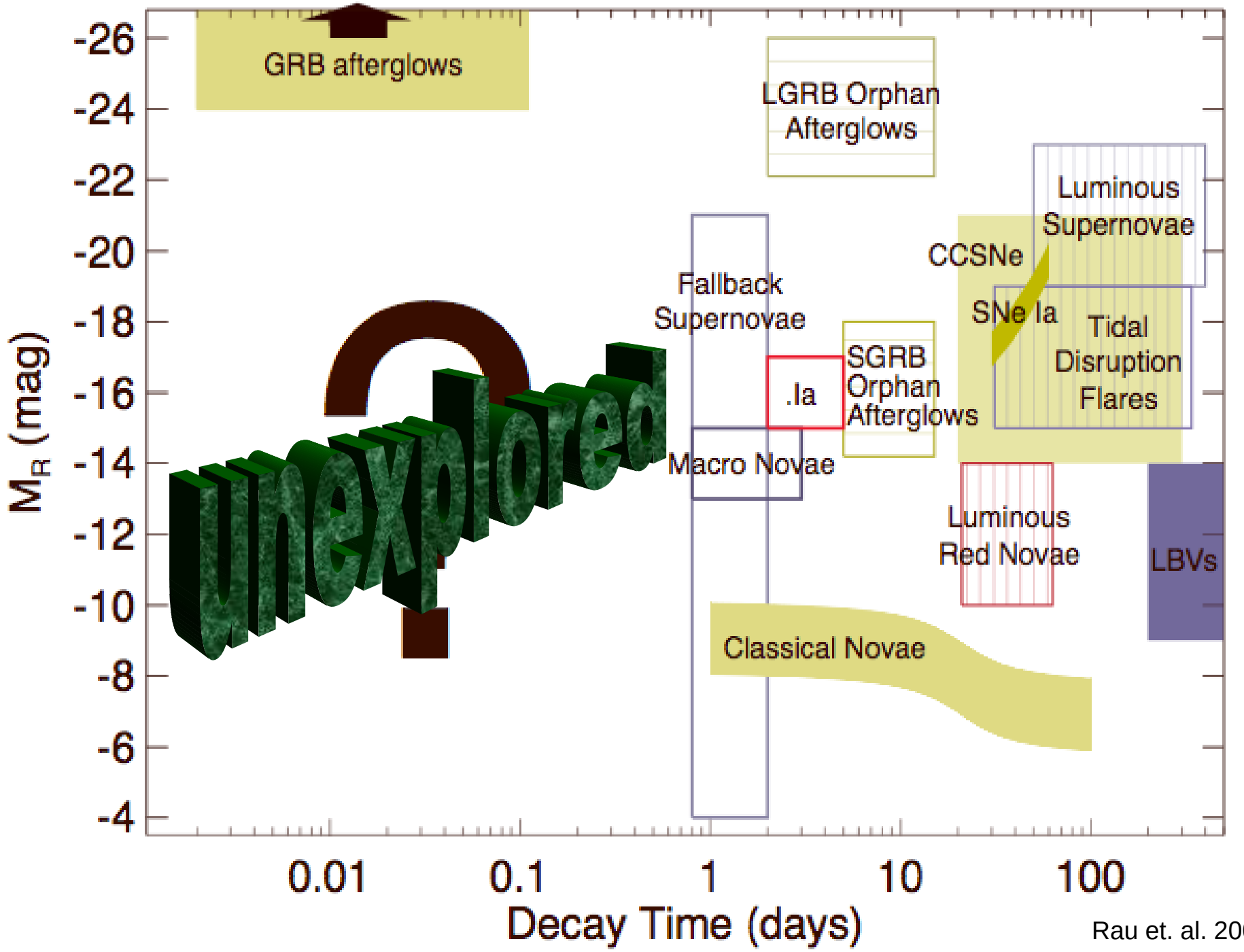
- Time domain:
  1 million supernovae
  1 million galaxy lenses
  new phenomena

LSST Science Charts New Territory



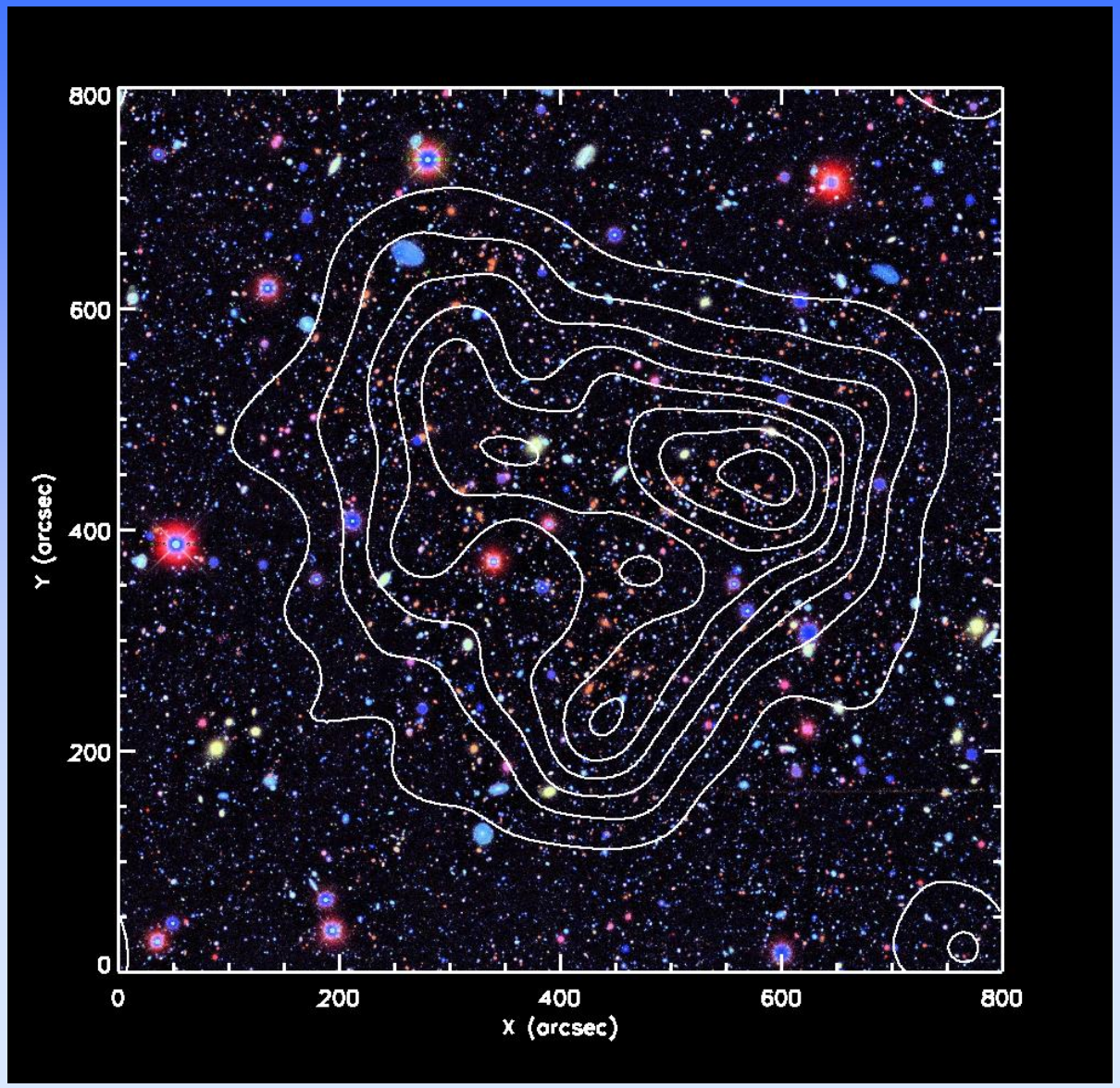






Rau et. al. 2009

Tests to LSST depth on Subaru



Science requirement:
40 galaxies/arcmin^2

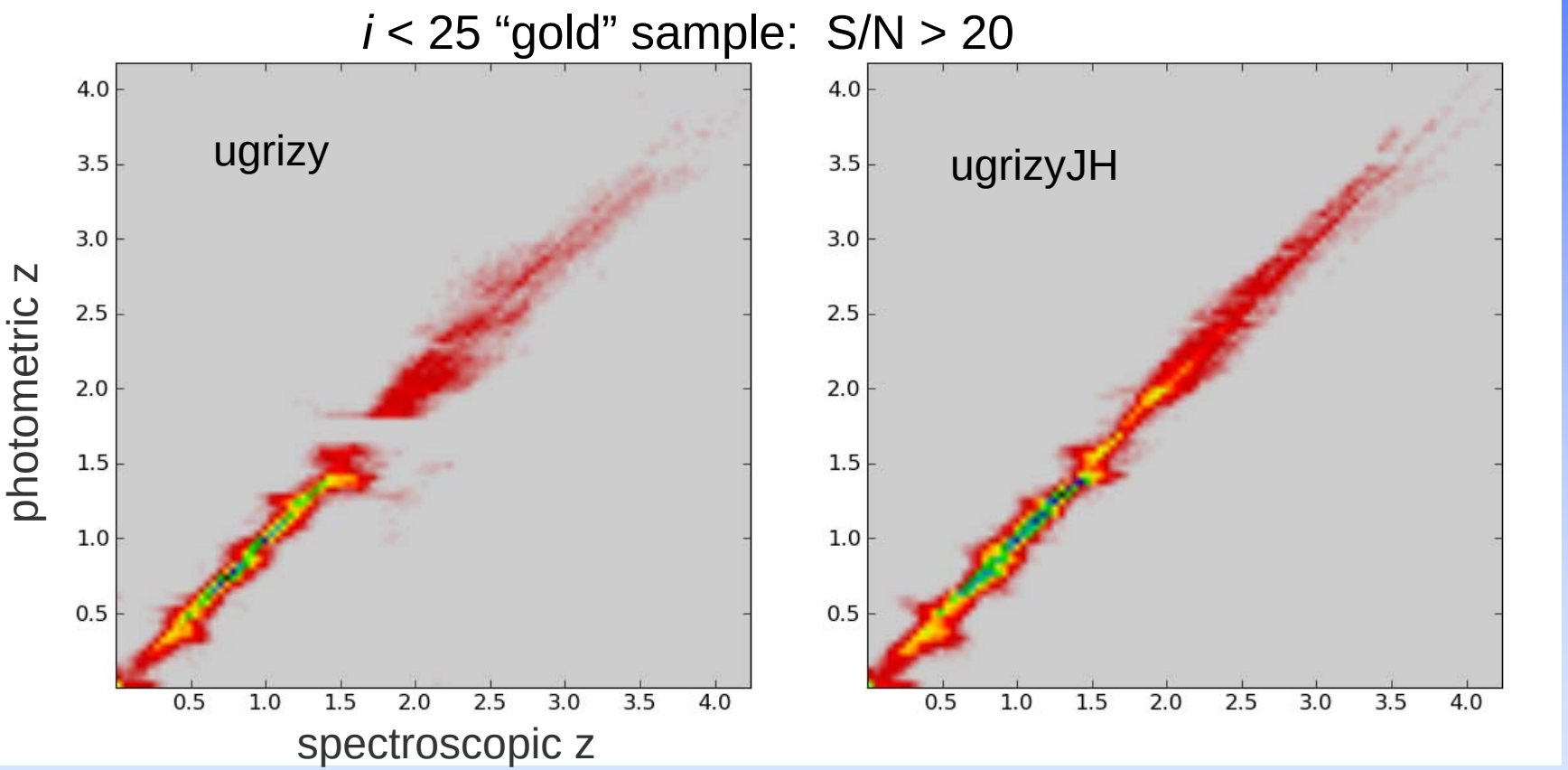
Shown:
Weak Lens mass reconstruction using 40 galaxies/arcmin^2

$i < 25$ mag
Seeing 0.65''

10^{14} solar mass cluster at $z = 0.53$

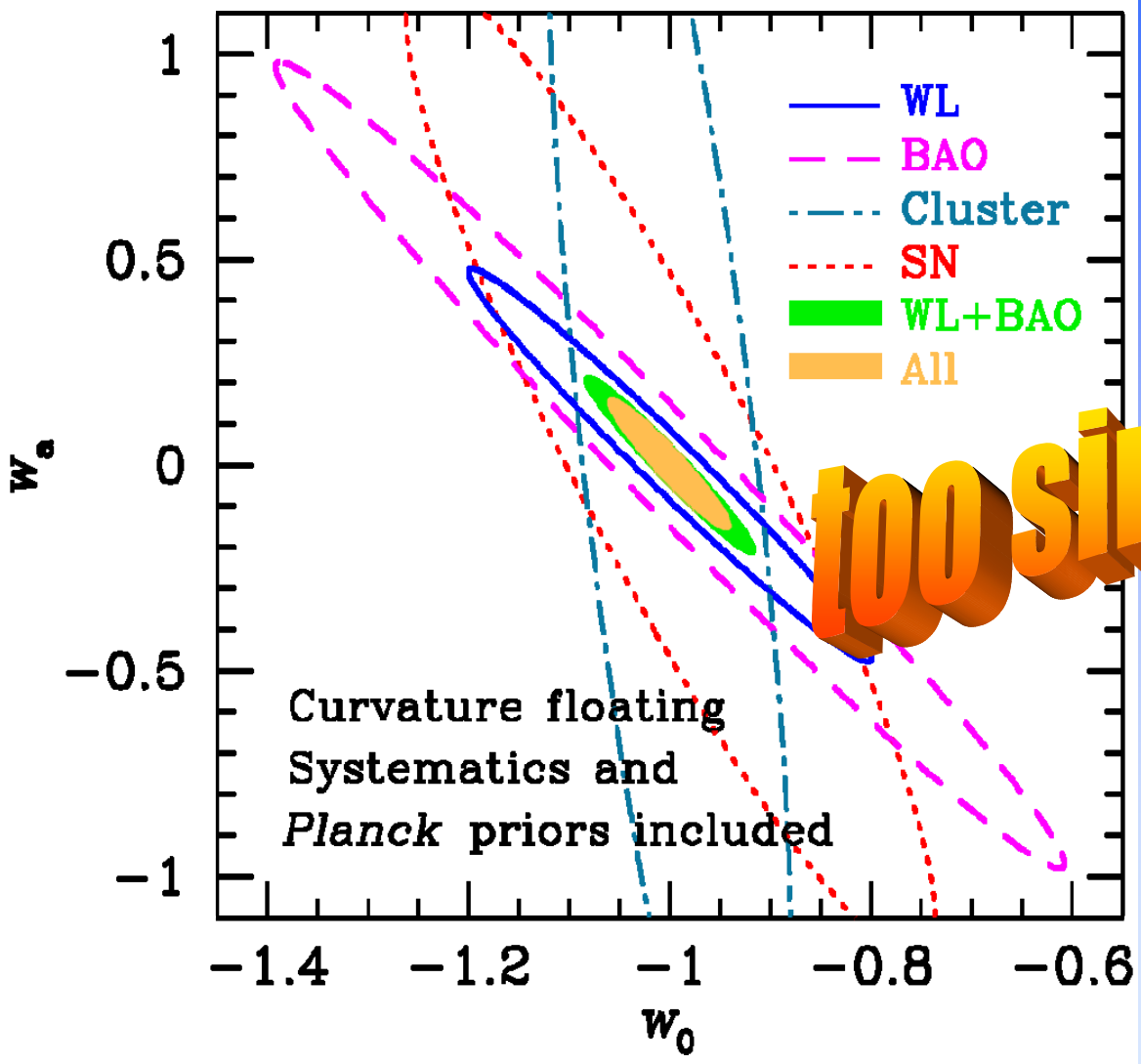
Priors and cuts using restricted templates

Effect of priors using restricted set of empirical spectral templates. Spectroscopic training set, and calibrate via angular-z correlation.



We expect to reduce outliers and bias using surface brightness priors and treating the photo-z as pdfs and not just a number

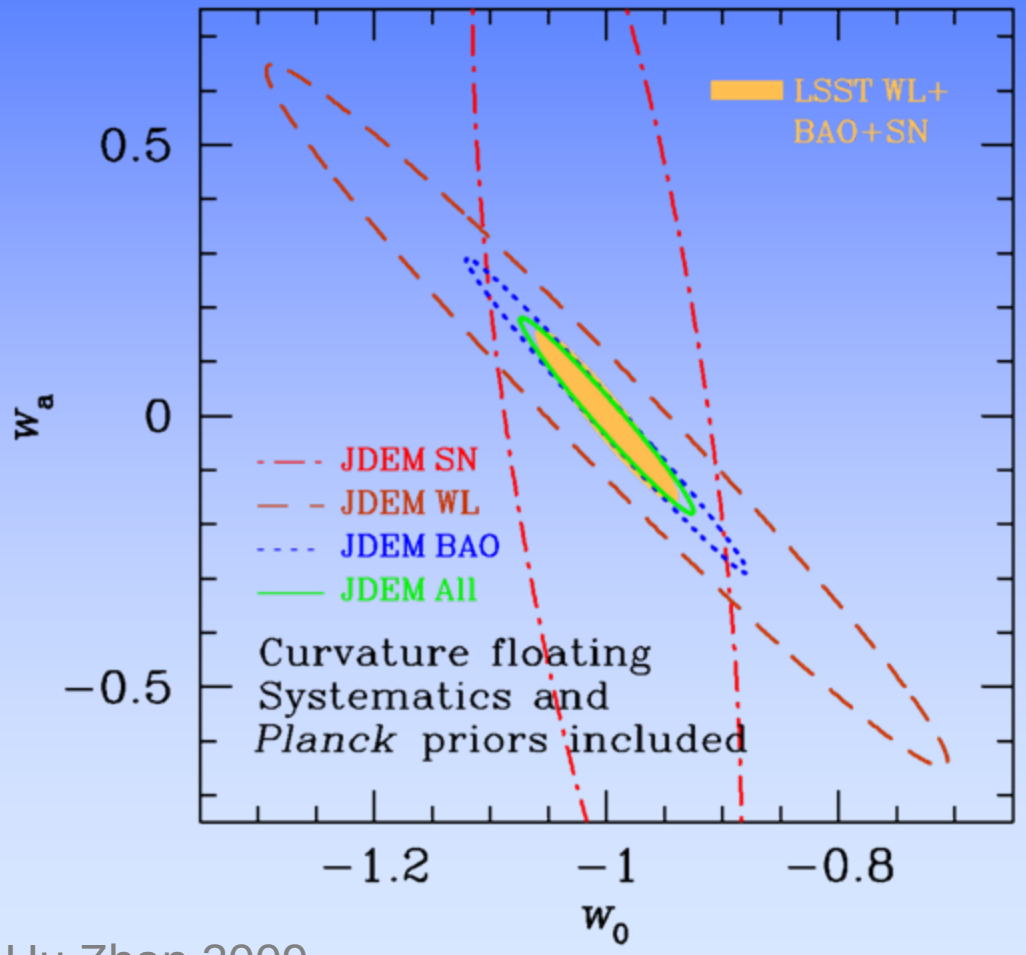
Combining four LSST probes



too simple

Comparison of Stage-IV facilities for DE

LSST comparable and complementary to JDEM

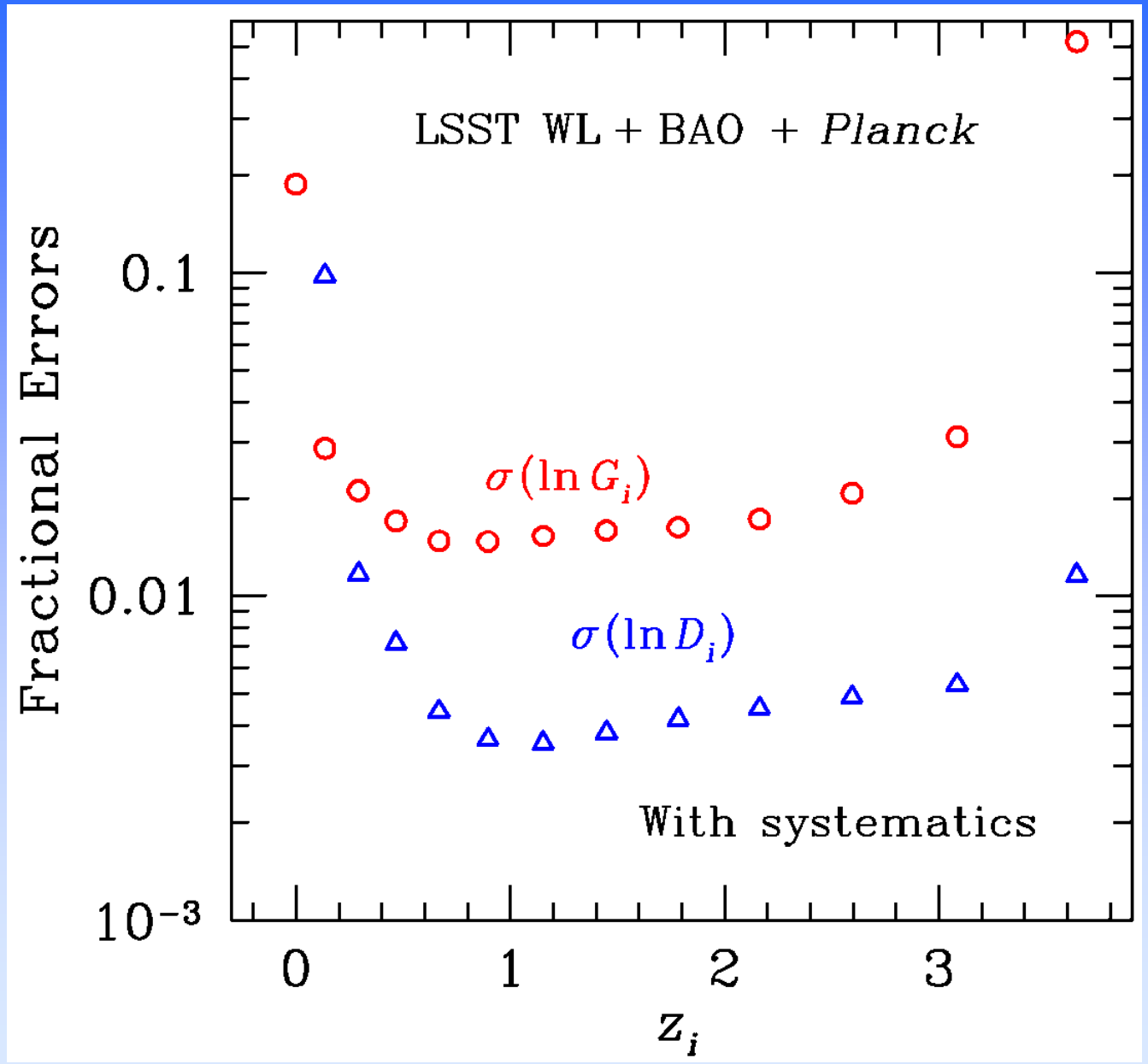


Hu Zhan 2009

Space: x2 resolution & IR

Ground: far more exposures translates directly into control of systematics.
Going to lower surface brightness enables shape measurement of more galaxies

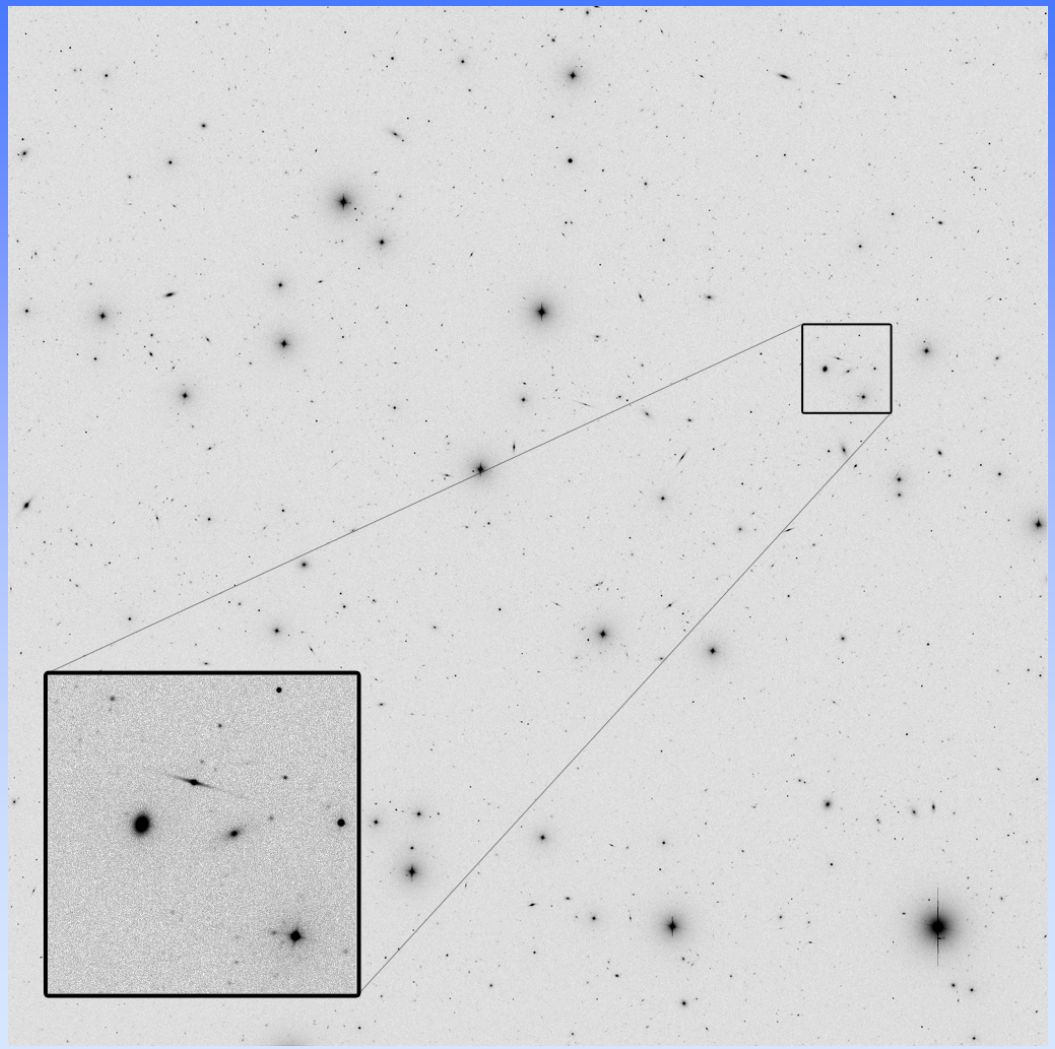
Testing general models of dark energy



LSST Survey

- First light in 2016, with 3-Gigapixel camera
- One 6-Gigabyte image every 17 seconds
- 30 Terabytes every night for 10 years
- 200-Petabyte final image data archive anticipated
- 20-Petabyte final database catalog anticipated
- Real-Time Event Mining: ~100,000 events per night, every night, for 10 yrs
- Repeat images of the entire night sky every 3 nights

Image simulation lets us validate the system performance

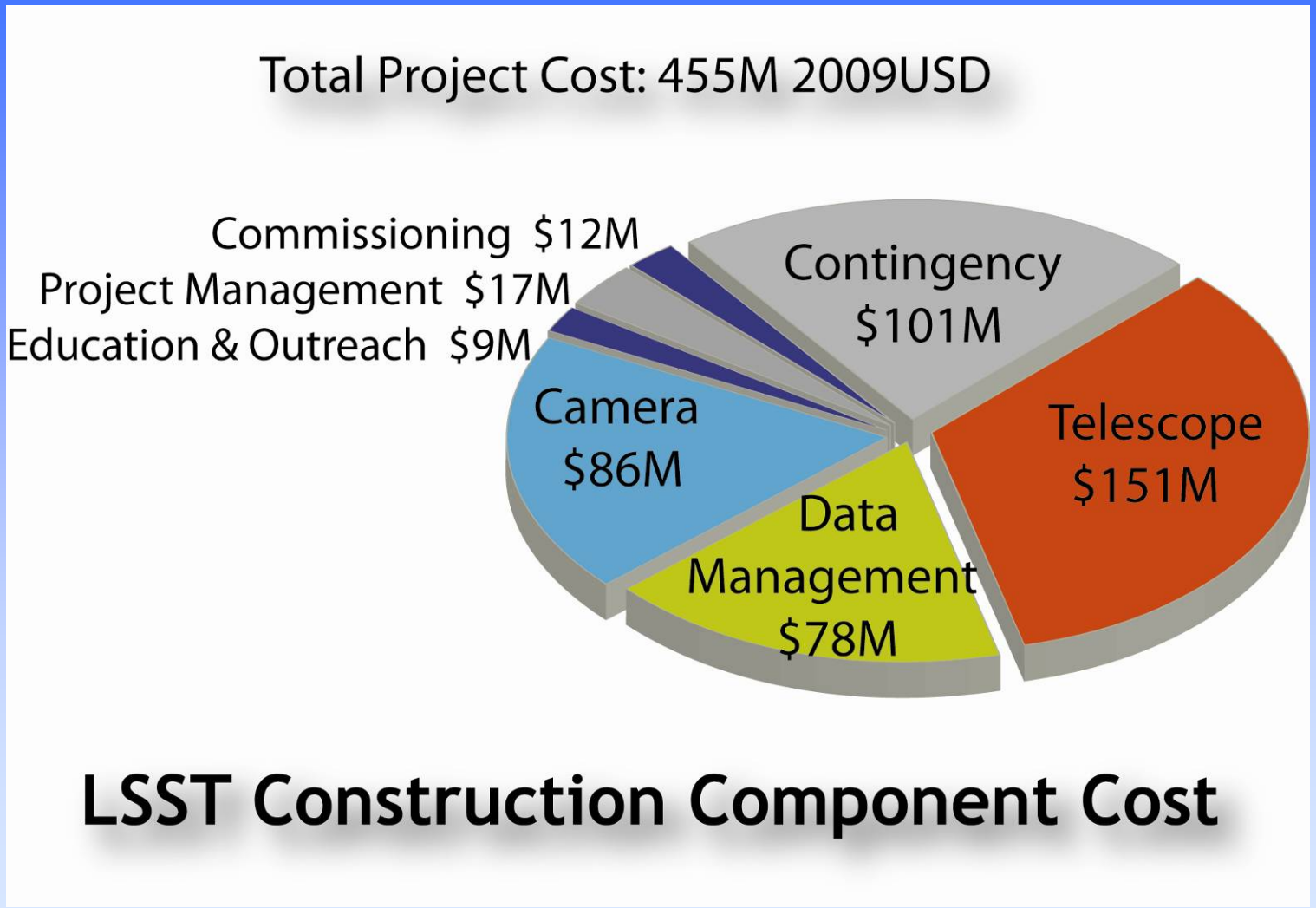


LSST is simulating image performance from end-to-end, including:

- **Cosmology + Milky Way + Solar System**
- **Atmosphere: Turbulence, Refraction, Motion**
- **Optics: Telescope + Camera**
- **Focal Plane: Detectors + Electronics**

Image simulations are used during all phases of the project

LSST construction costs

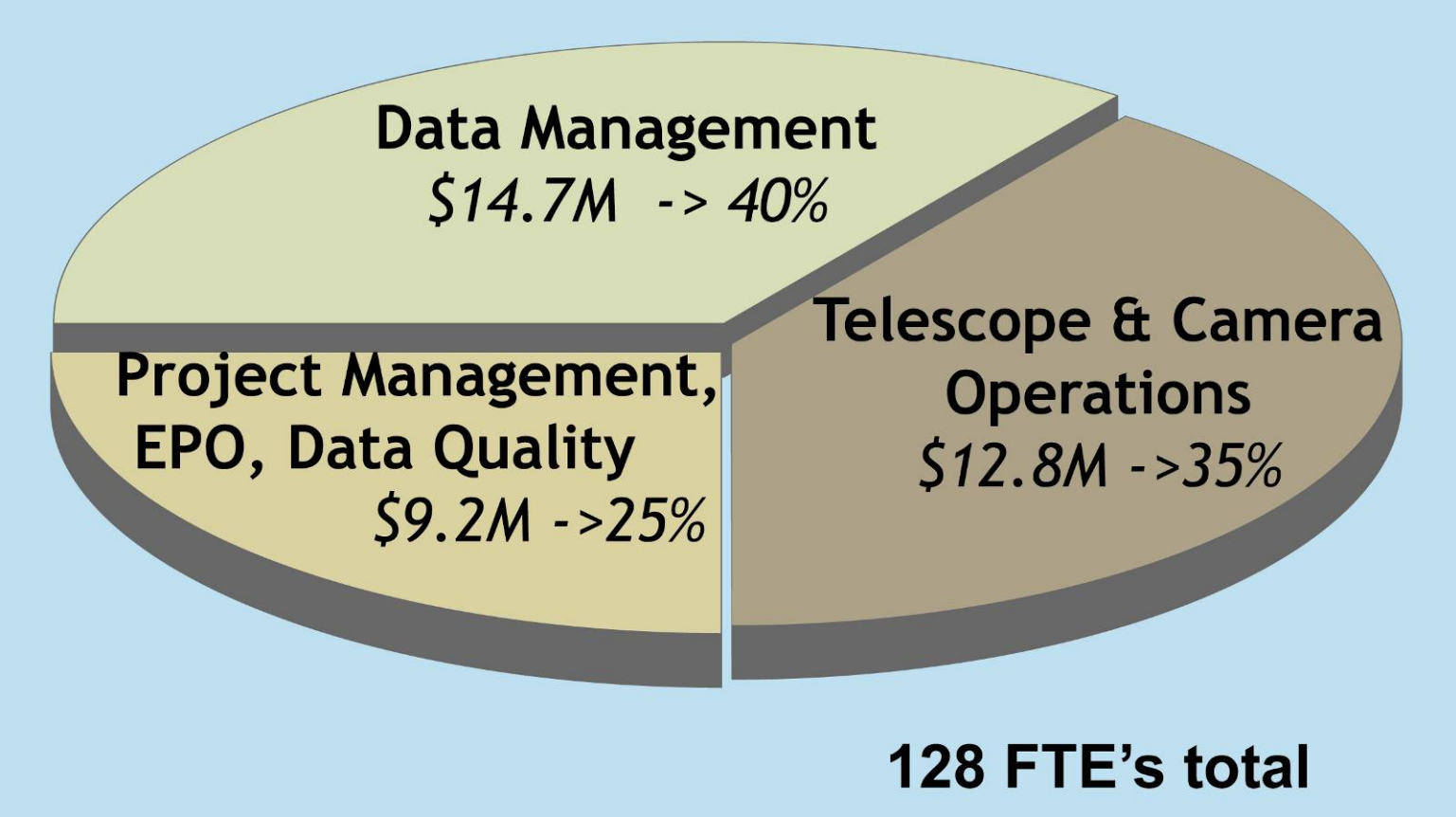


40% of the LSST Annual Operations cost is associated with the data products

Processing Cadence	Image Category (files)	Catalog Category (database)	Alert Category (database)
Nightly	Raw science image Calibrated science image Subtracted science image Noise image Sky image Data quality analysis	Source catalog (from difference images) Object catalog (from difference images) Orbit catalog Data quality analysis	Transient alert Moving object alert Data quality analysis
Data Release (Annual)	Stacked science image Template image Calibration image RGB JPEG Images Data quality analysis	Source catalog (from calibrated science images) Object catalog (optimally measured properties) Data quality analysis	Alert statistics & summaries Data quality analysis

Operations and data budget

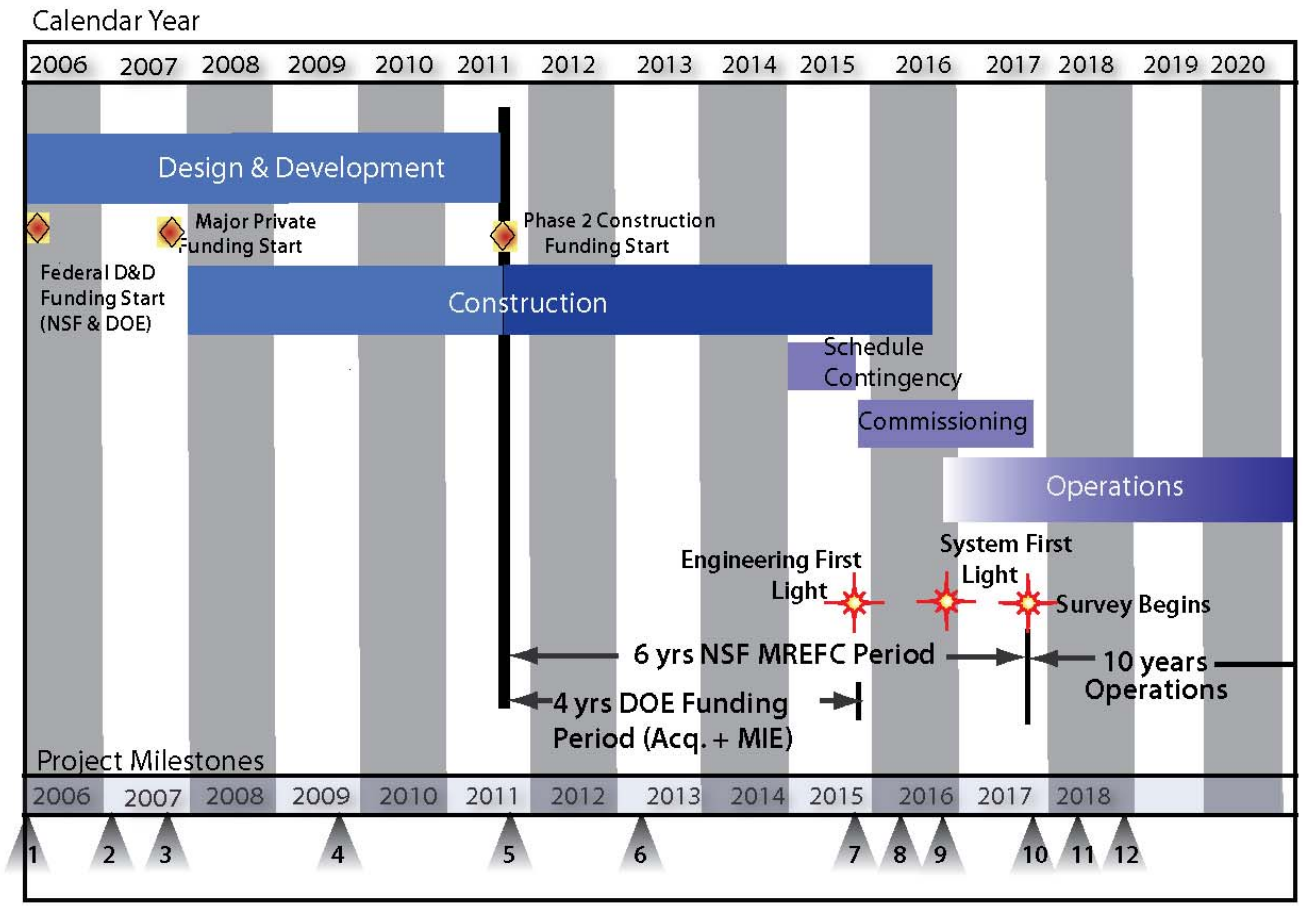
The total LSST annual operating budget is $36.7M ($FY'09)
Approximately 40% is Data Management



What makes LSST and its data products uniquely valuable?

- Unprecedented survey (2000 x SDSS plus time domain)
- 20 billion objects
- Will constrain the properties of dark energy with unprecedented precision
- High precision, high uniformity
- Open source, open data
- Bridge to CS, Math, Stat
- Promotes and enables research
- Leverages existing facilities
- Needed now
- Movie of the universe opens new windows
- Broader impact

Proposed LSST timeline



Major Project Milestones:

1. Sep 2005 NSF D&D Funding Start
2. Feb 2007 NSF MREFC Proposal Submitted
3. Sep 2007 NSF Conceptual Design Review
4. Oct 2009 NSF Preliminary Design Review
5. Oct 2011 NSF Critical Design Review; Construction Funding Start DOE Critical Decision 2a Review; DOE Acquisition Funding Start
6. Apr 2013 First Camera Raft Complete
7. Aug 2017 First Engineering Light with Eng Camera System Integration and Test Begins
8. Mar 2016 Archive Center Complete
9. Sep 2016 System First Light with 3.2 GP Camera System Science Validation Begins
10. Oct 2017 Full Science Operations Begins
11. Apr 2018 First LSST Data Release
12. Oct 2018 Second LSST Data Release