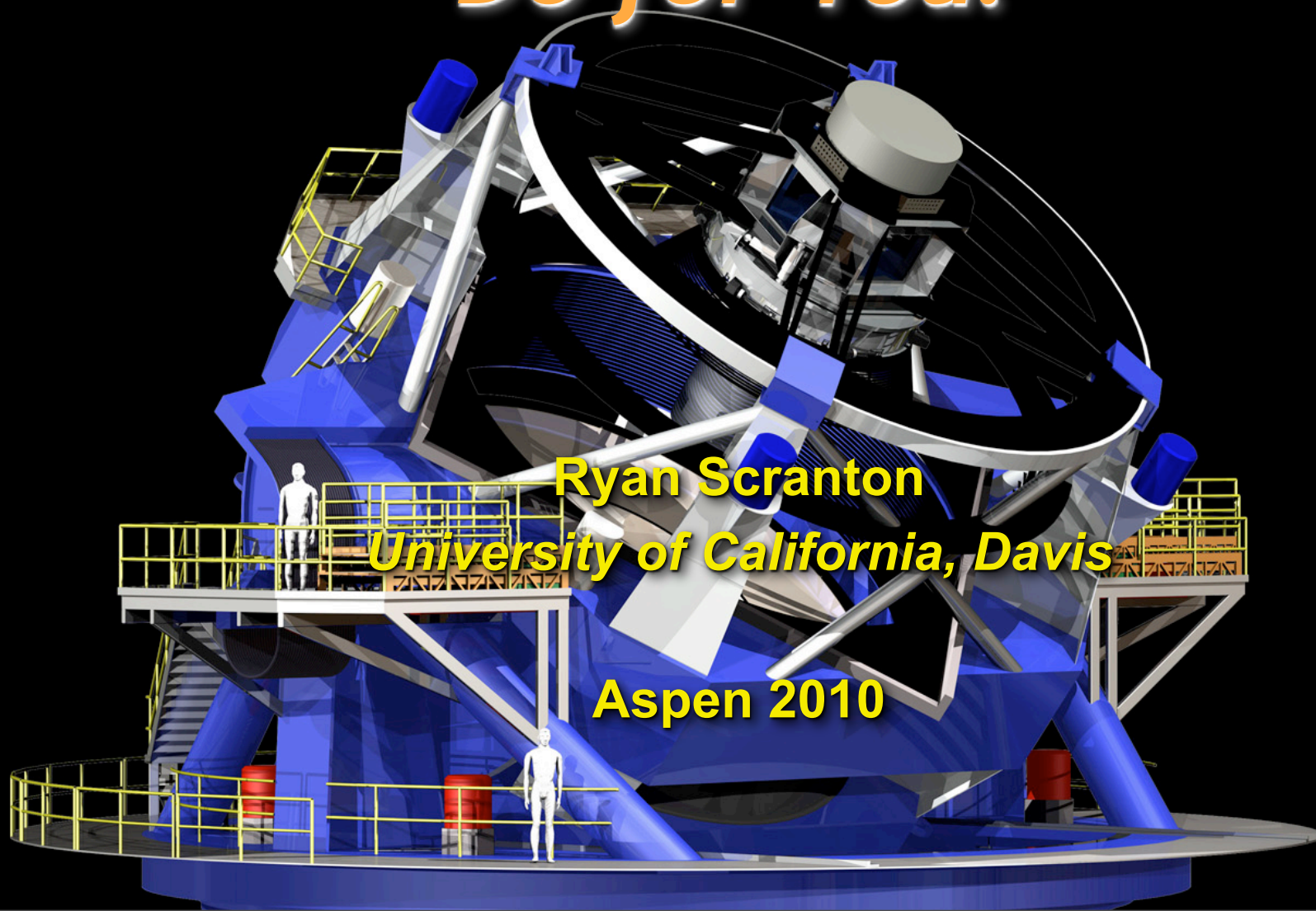


What Can LSST Do for You?



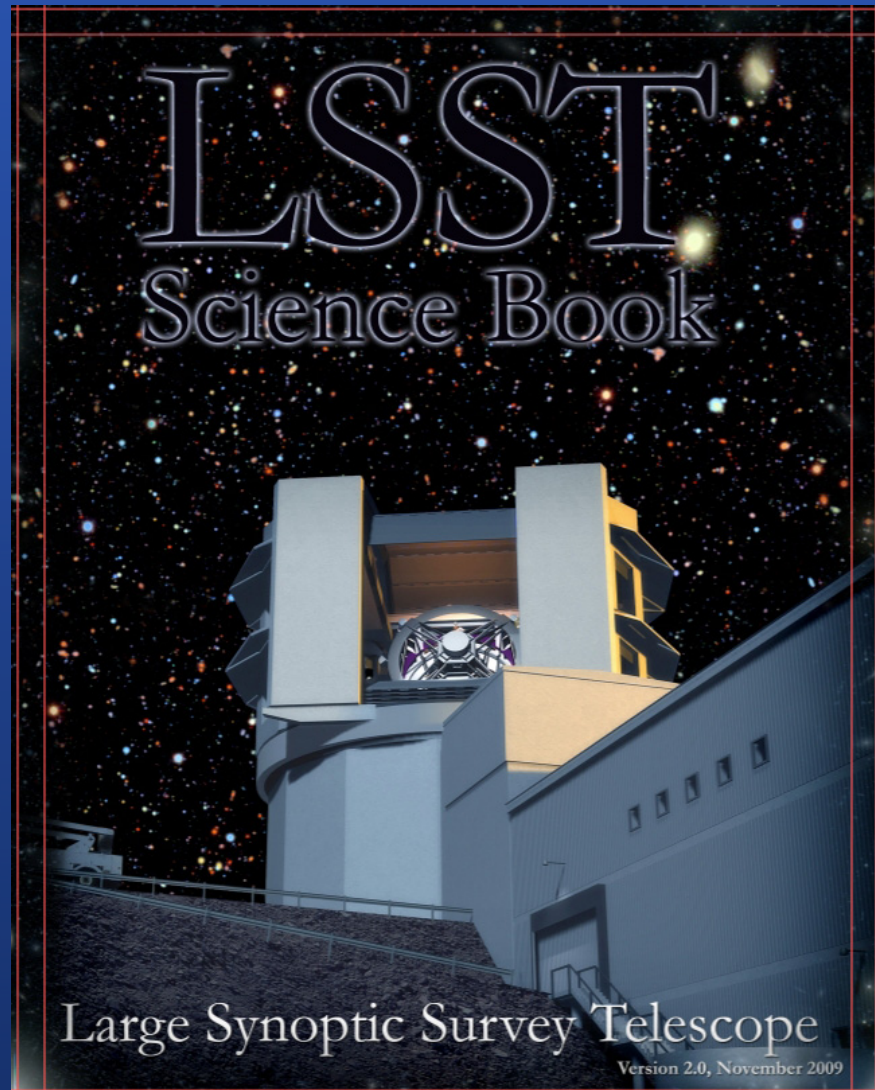
Ryan Scranton
University of California, Davis

Aspen 2010

LSST Science Book v2

- 245 authors
- 598 pages
- Living document
(on lsst.org)

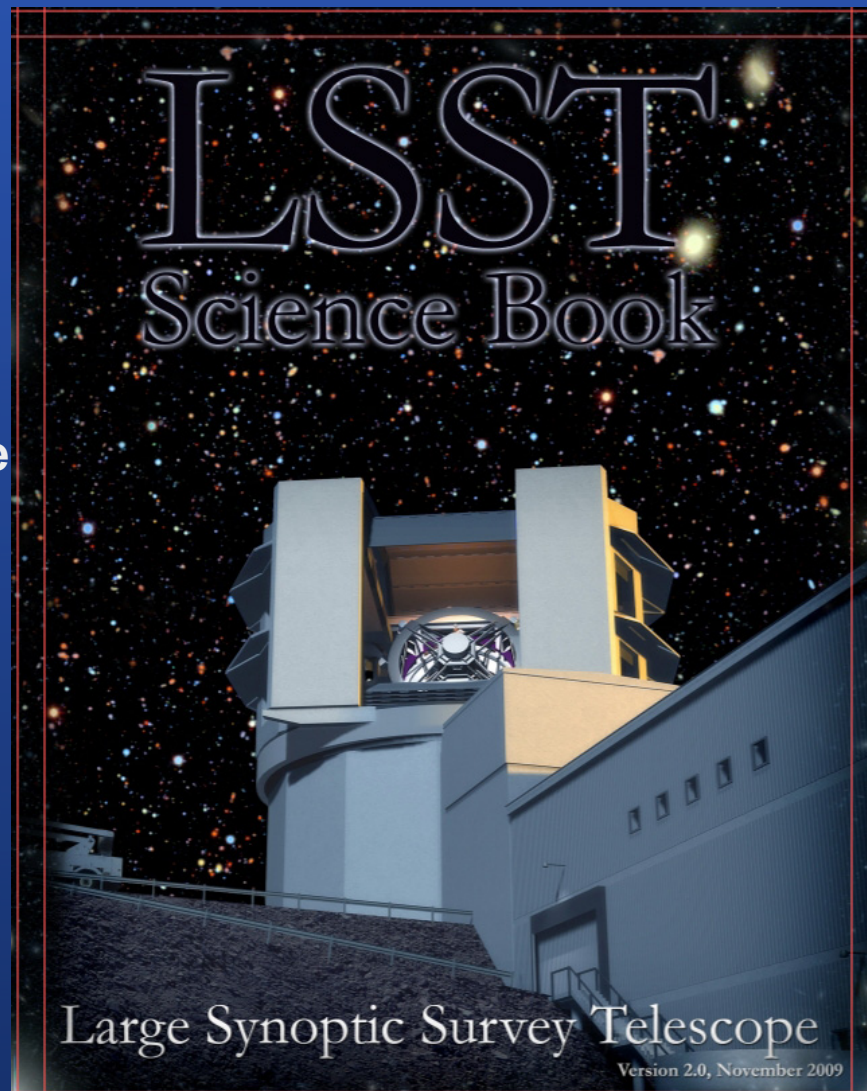
<http://www.lsst.org/lsst/scibook>



Chapters in the Science Book

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

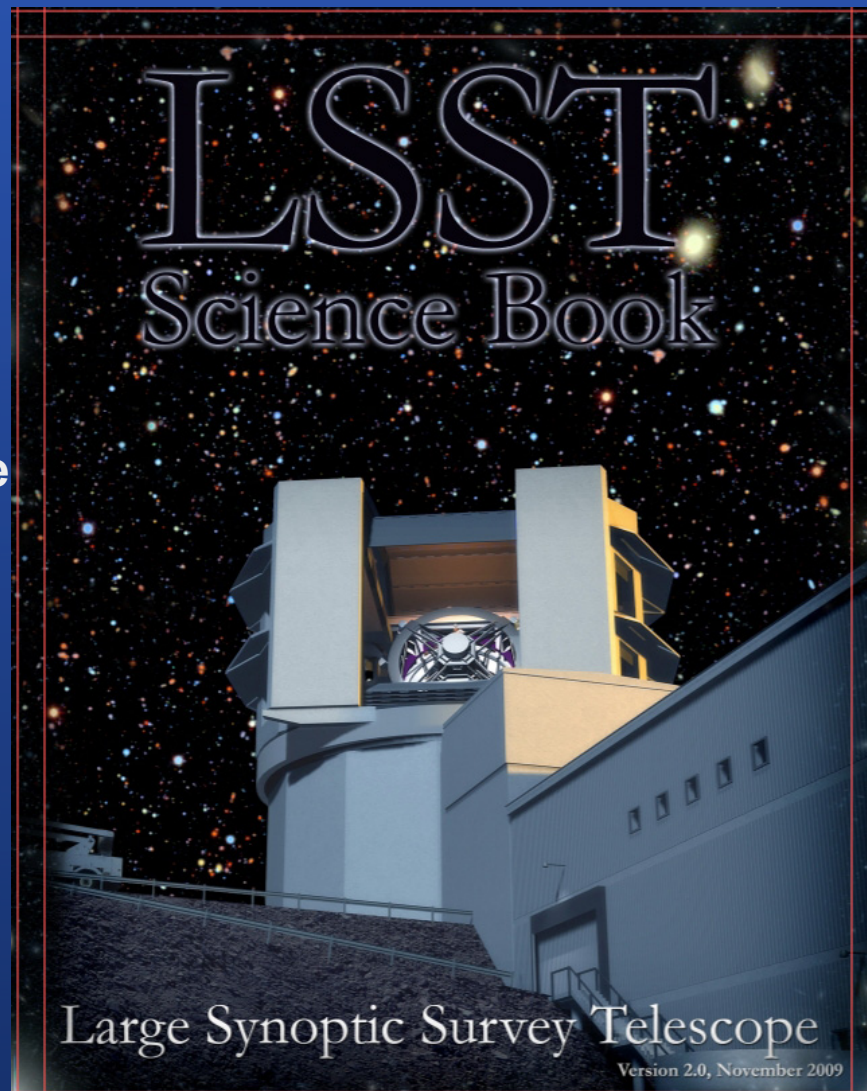
- The Solar System
- Stellar Populations
- Milky Way and Local Volume Structure
- The Transient and Variable Universe
- Galaxies
- Active Galactic Nuclei
- Supernovae
- Strong Lenses
- Large-Scale Structure
- Weak Lensing
- Cosmological Physics



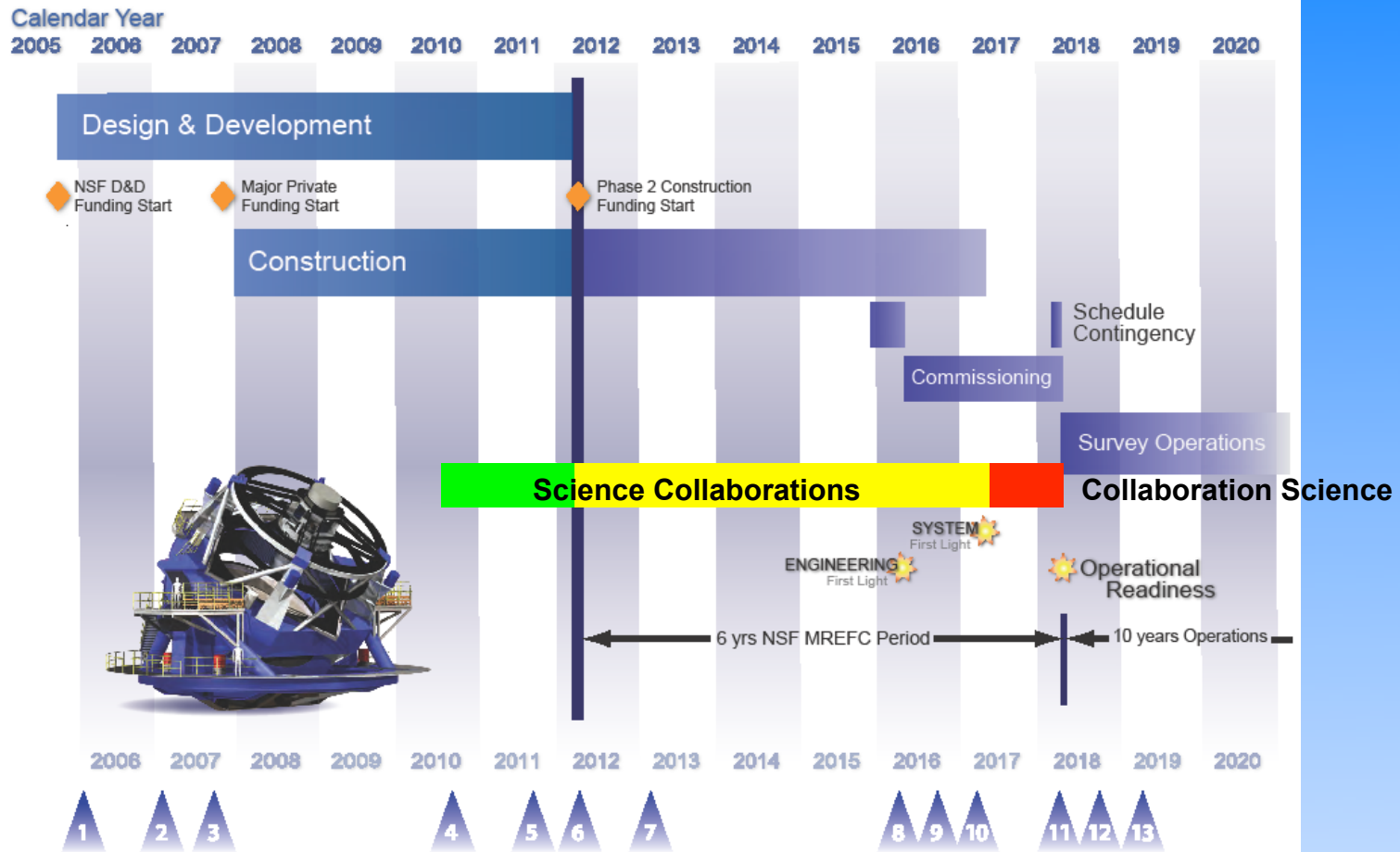
Chapters in the Science Book

- Introduction
- **LSST System Design**
- **System Performance**
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- The Solar System
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- **Galaxies**
- Active Galactic Nuclei
- **Supernovae**
- **Strong Lenses**
- **Large-Scale Structure**
- **Weak Lensing**
- **Cosmological Physics**



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 2010 NSF Preliminary Design Review
5. Oct 2011 NSF Critical Design Review
6. Apr 2012 Construction Funding Start; DOE Acquisition Funding Start
7. Apr 2013 First Camera Raft Complete
8. Apr 2016 First Engineering Light with Eng Camera System Integration and Test Begins
9. Oct 2016 Archive Center Complete
10. Mar 2017 System First Light with 3.2 GP Camera System Science Validation Begins
11. Apr 2018 Full Science Operations Begins
12. Oct 2018 First LSST Data Release
13. Apr 2019 Second LSST Data Release

Private donations allowed us to fabricate all three large mirrors







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

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

200 PB
data

Processing
Cadence

Image Catalog
(files)

Alert Catalog
(database)

Alert Category
(database)

Nightly

Raw science image
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Data Release
(Annual)

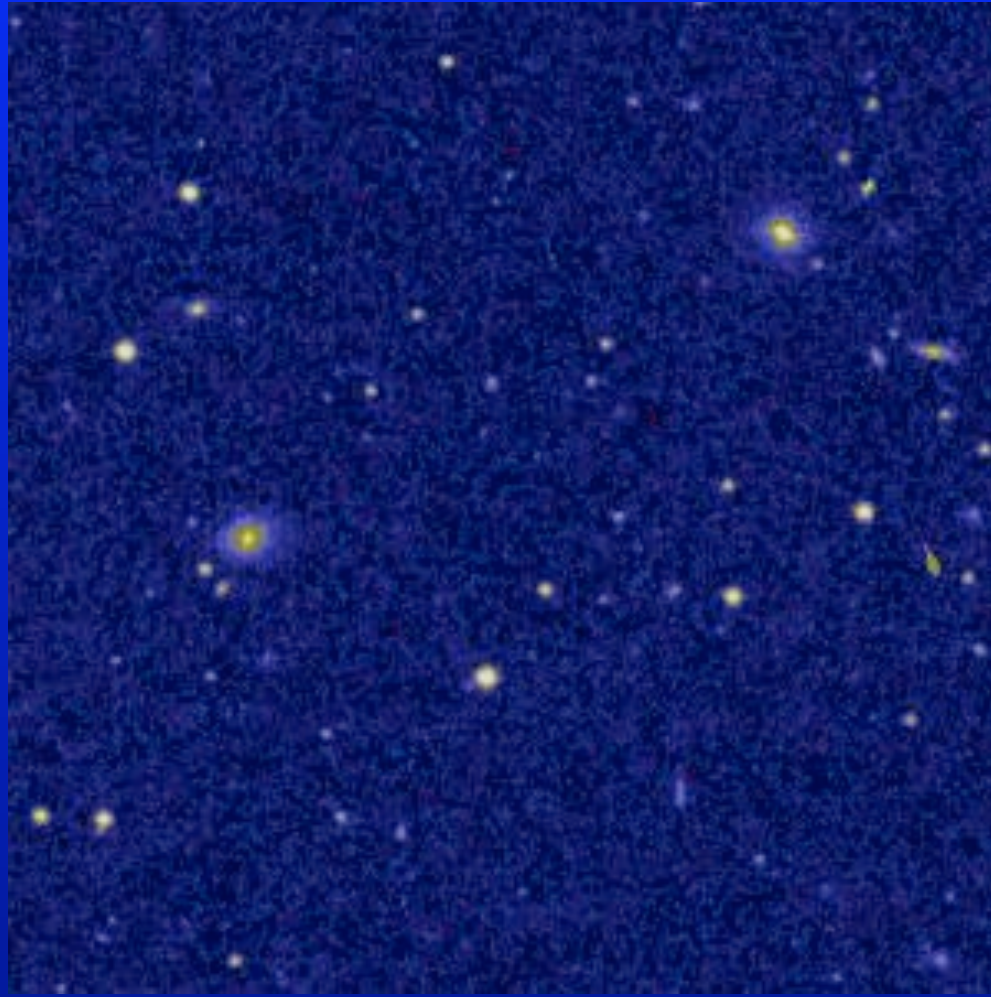
Stacked science image
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Calibration image
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Data quality analysis

Object catalog
(from difference images)
Data quality analysis
(optimally measured properties)
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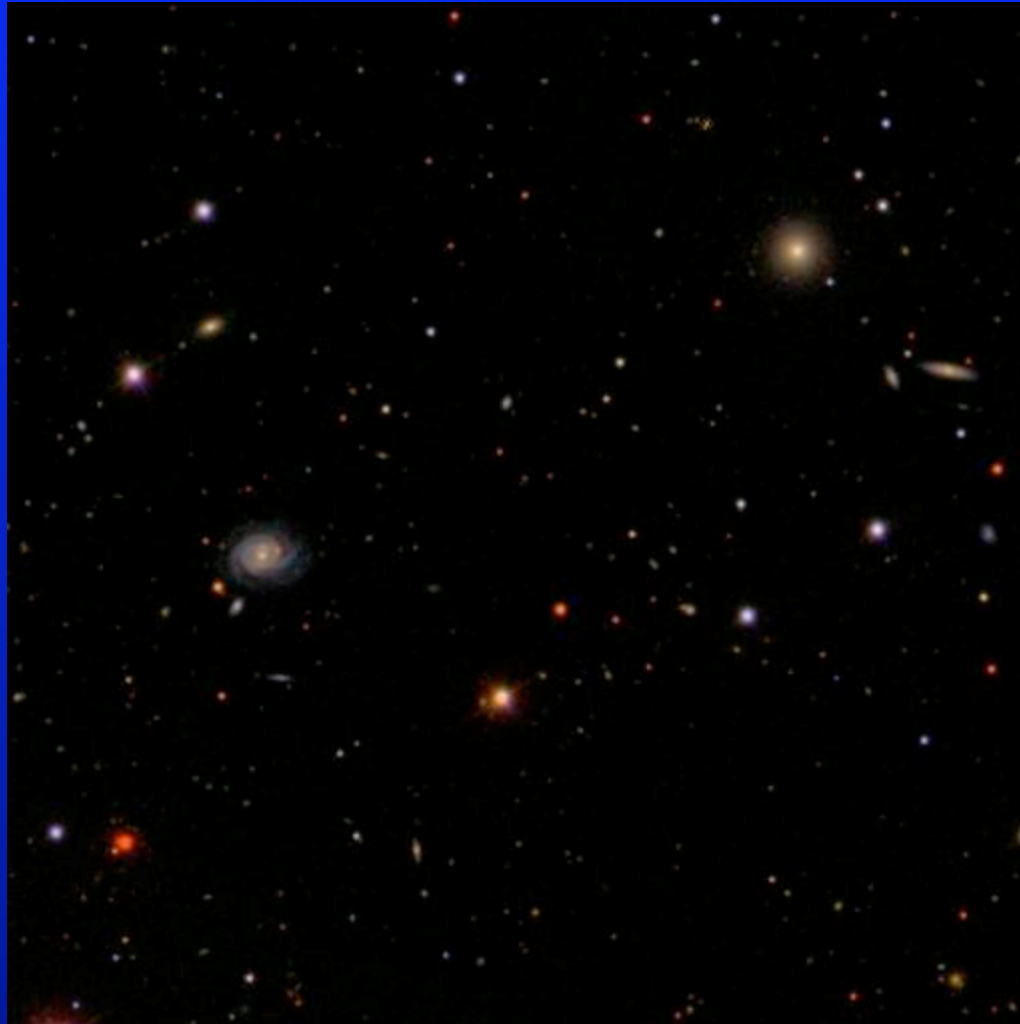
Alert statistics &
summaries
Data quality analysis

DSS: digitized photographic plates

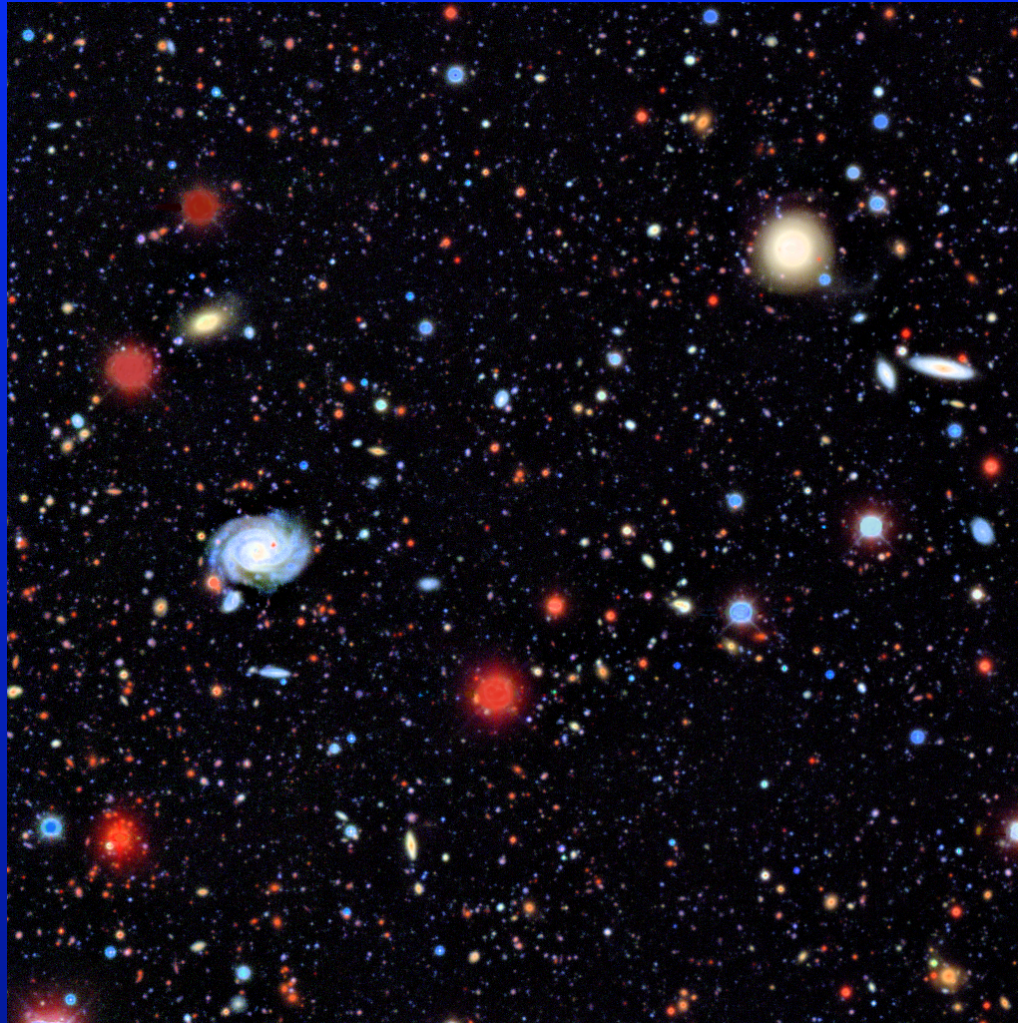
7.5 arcminutes



Sloan Digital Sky Survey



LSST -- almost



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

Key LSST Mission: Dark Energy

Precision measurements of all dark energy signatures in a single data set. Separately measure geometry and growth of dark matter structure vs cosmic time to determine dark energy equation of state (w).

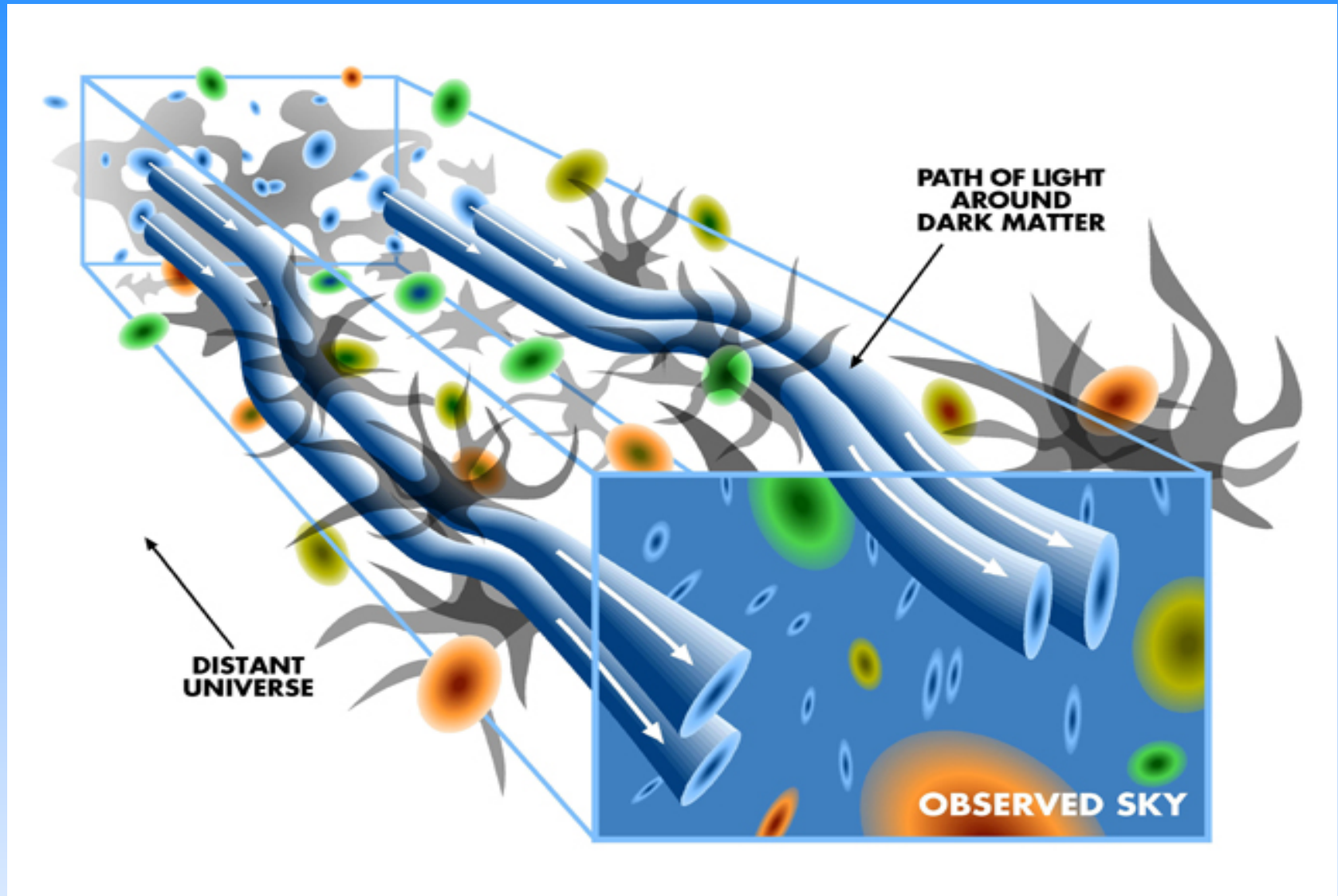
- ☀ Weak gravitational lensing correlations
(multiple lensing probes!)
- ☀ Baryon acoustic oscillations (BAO)
- ☀ Counts of dark matter clusters
- ☀ Supernovae to redshift 0.8
(complementary to EUCLID)
- ☀ Probe anisotropy

Key LSST Mission: Dark Energy

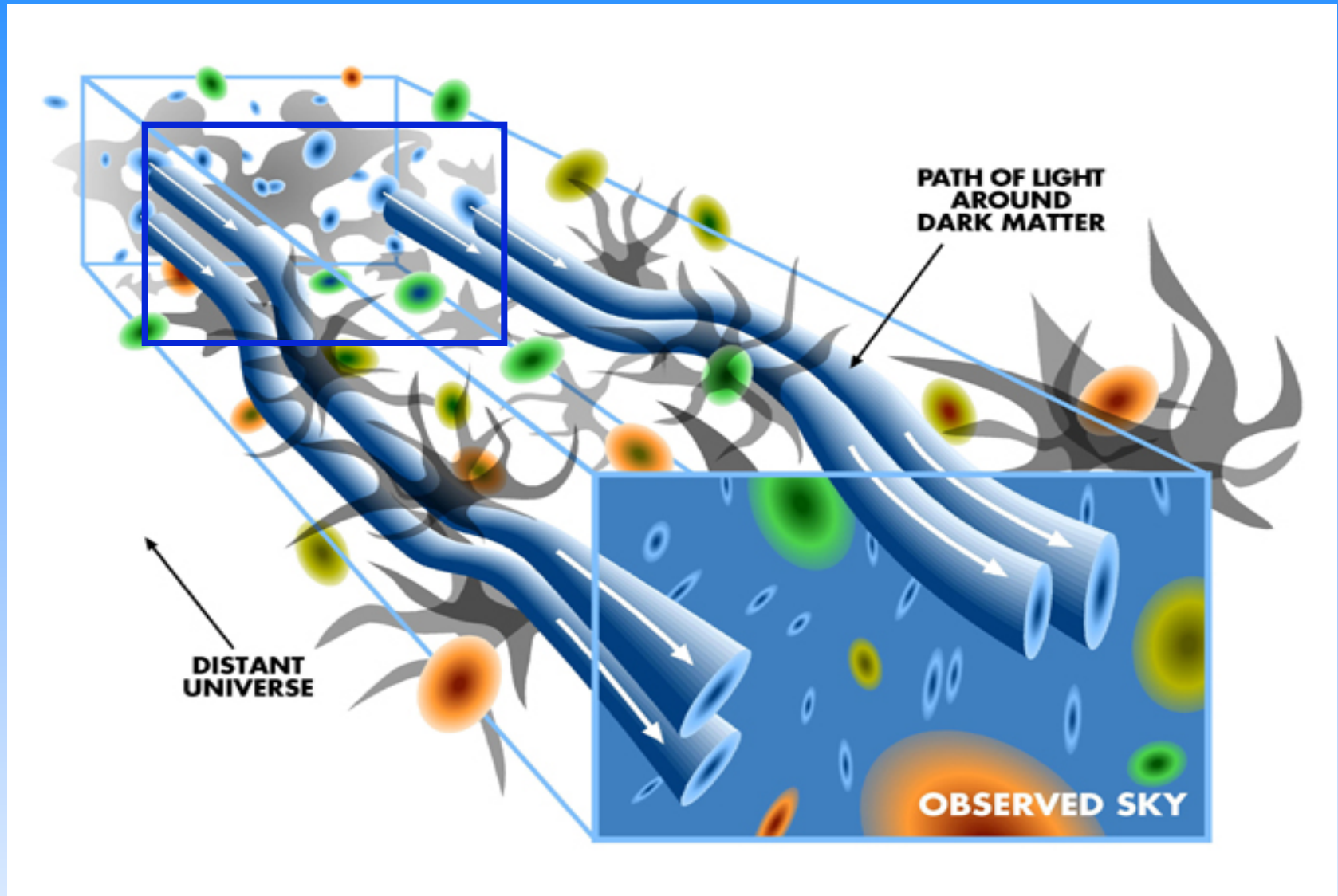
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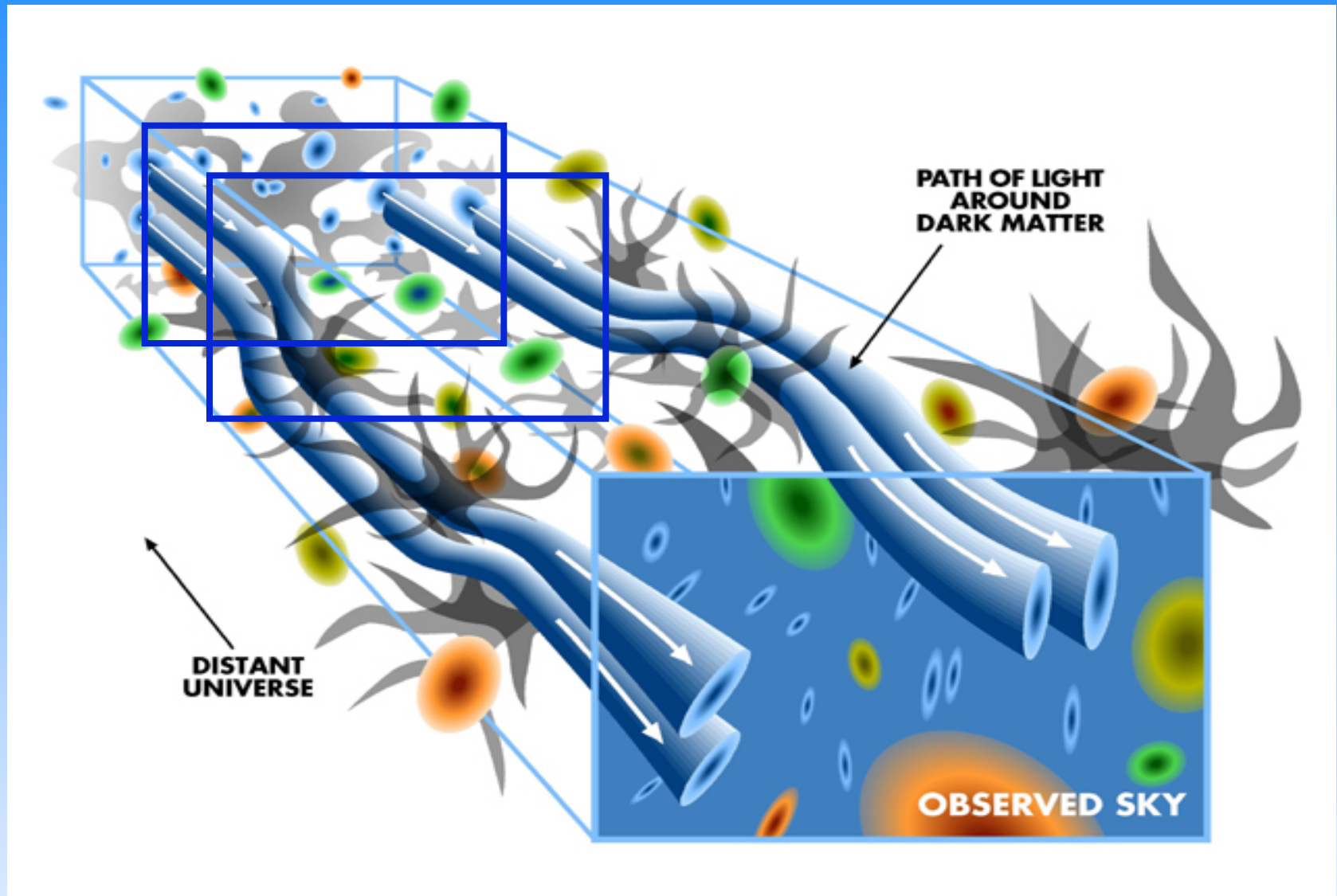
Cosmic shear vs redshift



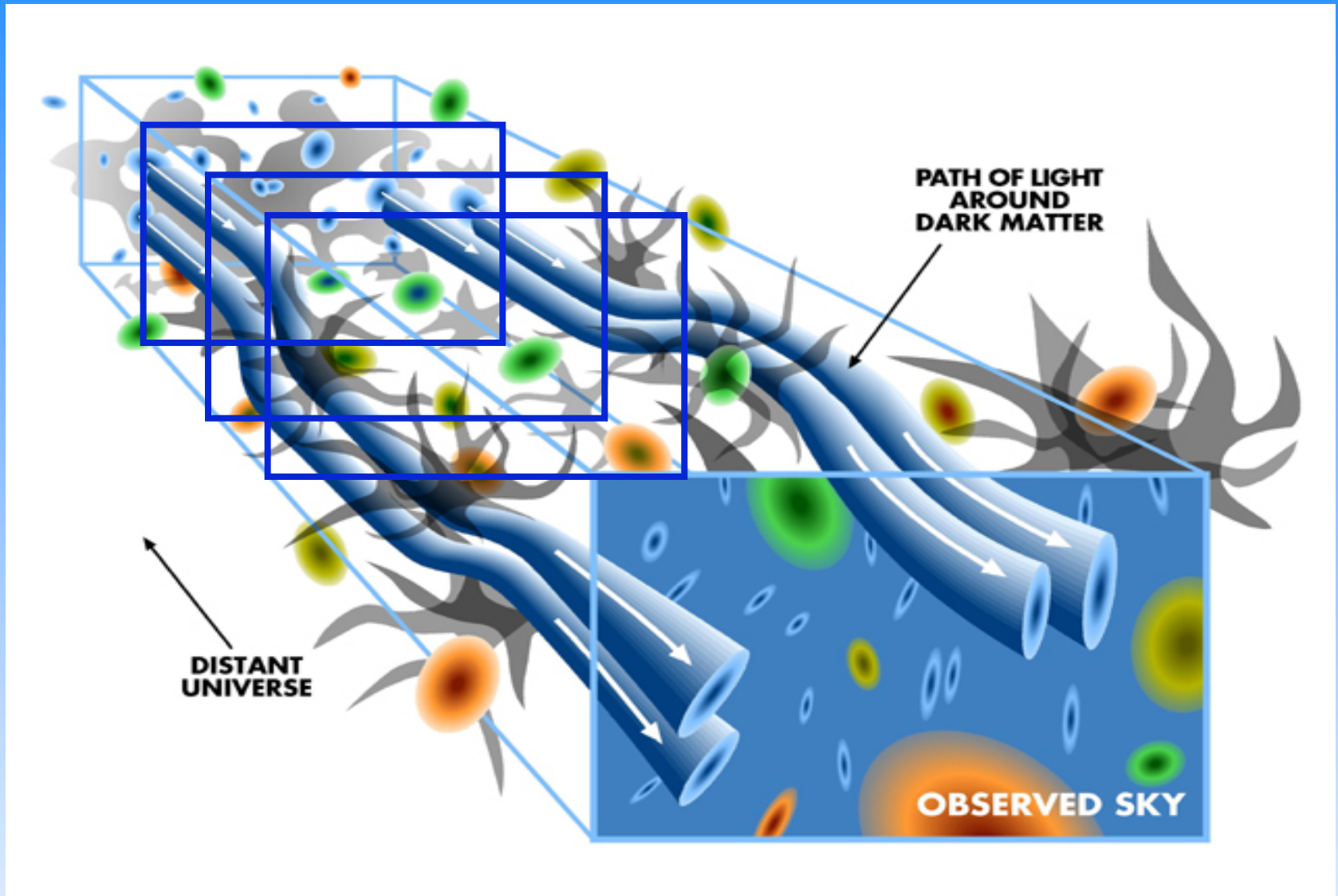
Cosmic shear vs redshift



Cosmic shear vs redshift



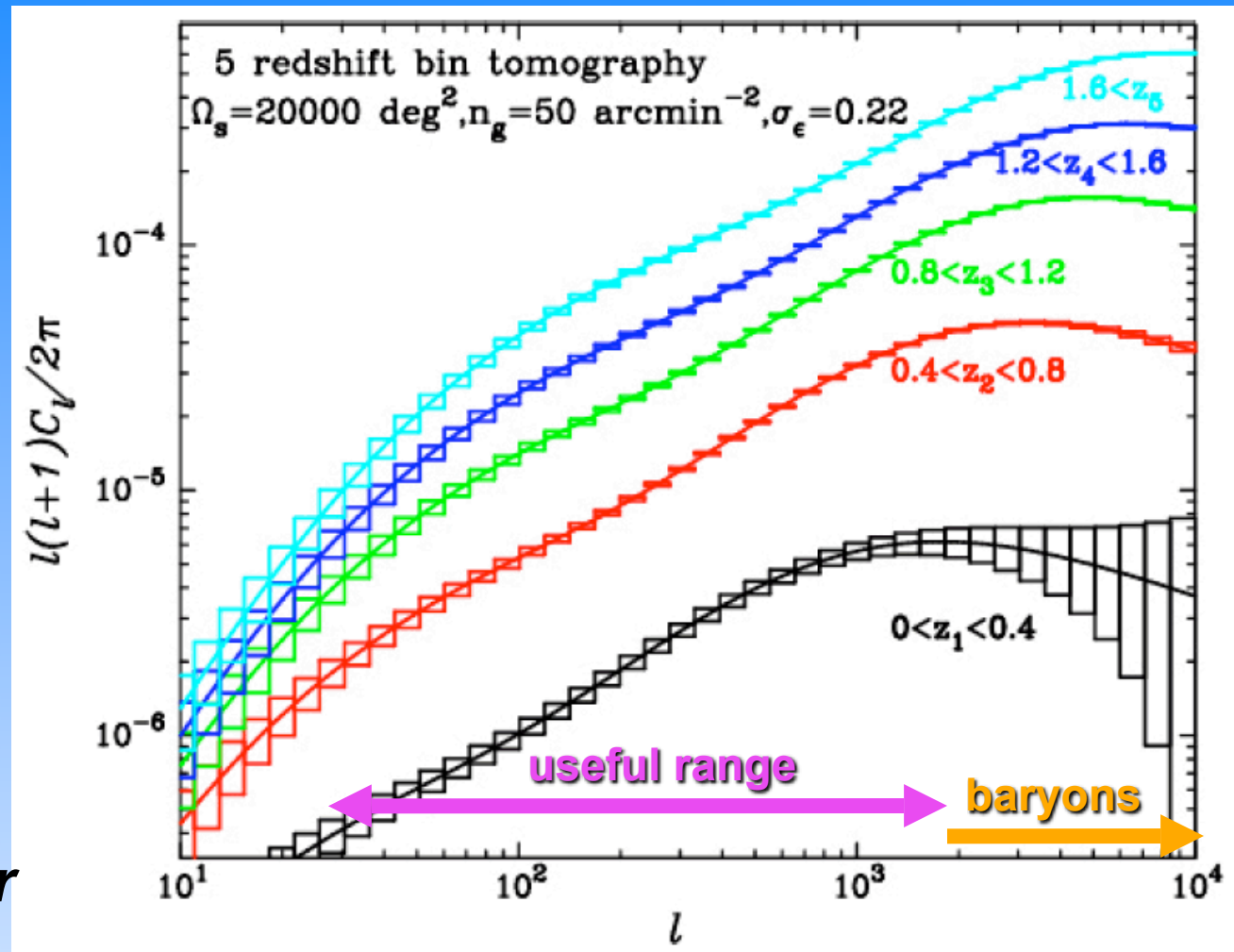
Cosmic shear vs redshift



LSST and Cosmic Shear

Ten redshift bins yield 45 auto and cross spectra

+ higher order

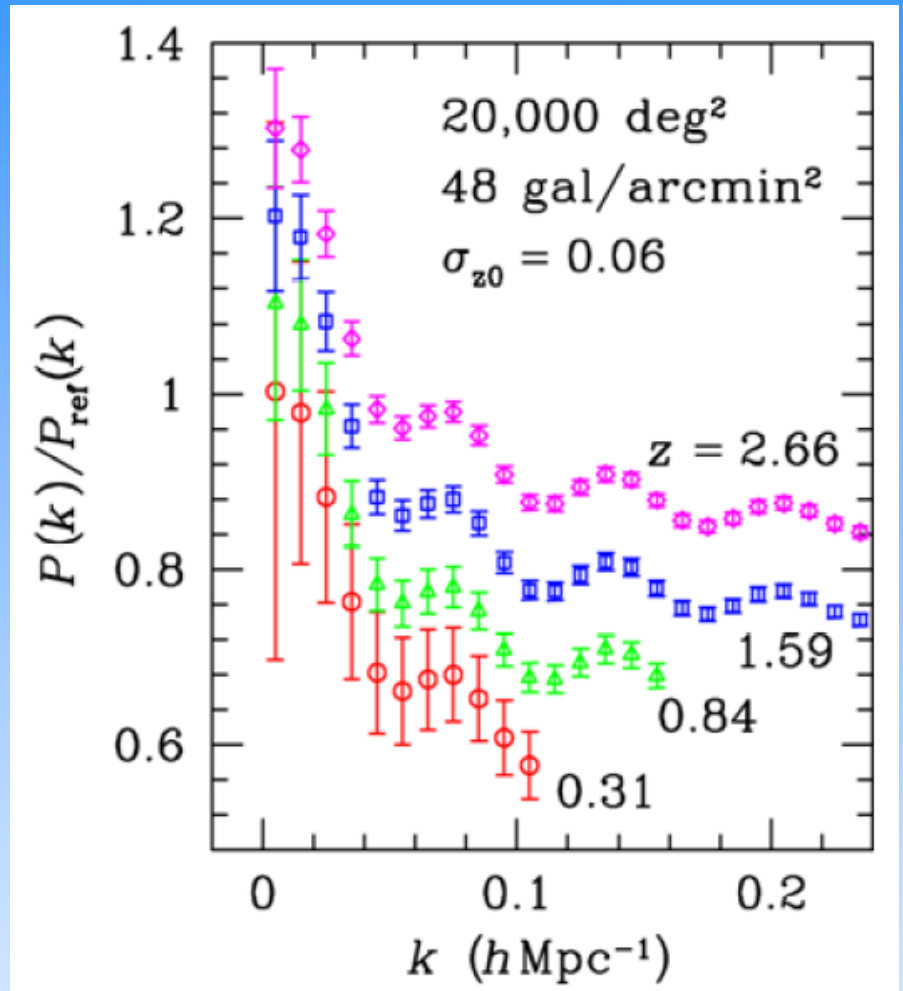
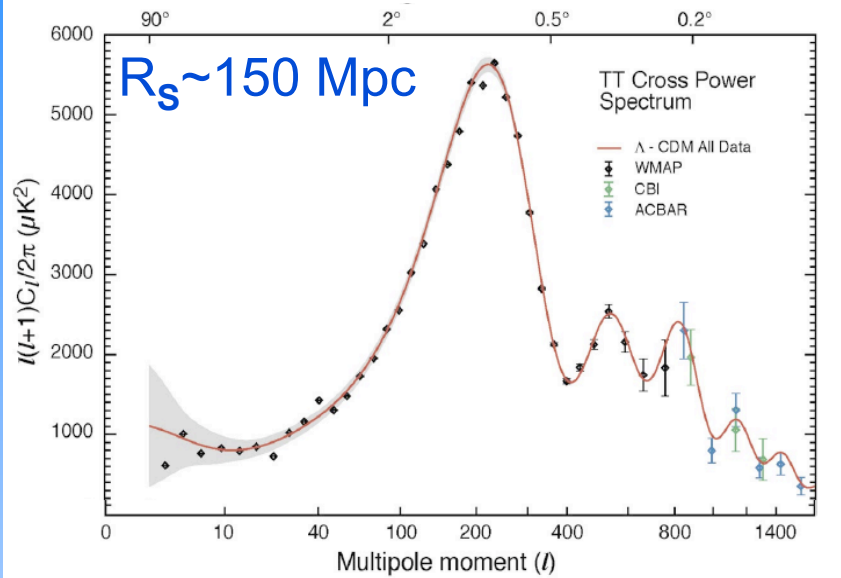


2-D Baryon Acoustic Oscillations

CMB ($z = 1100$)



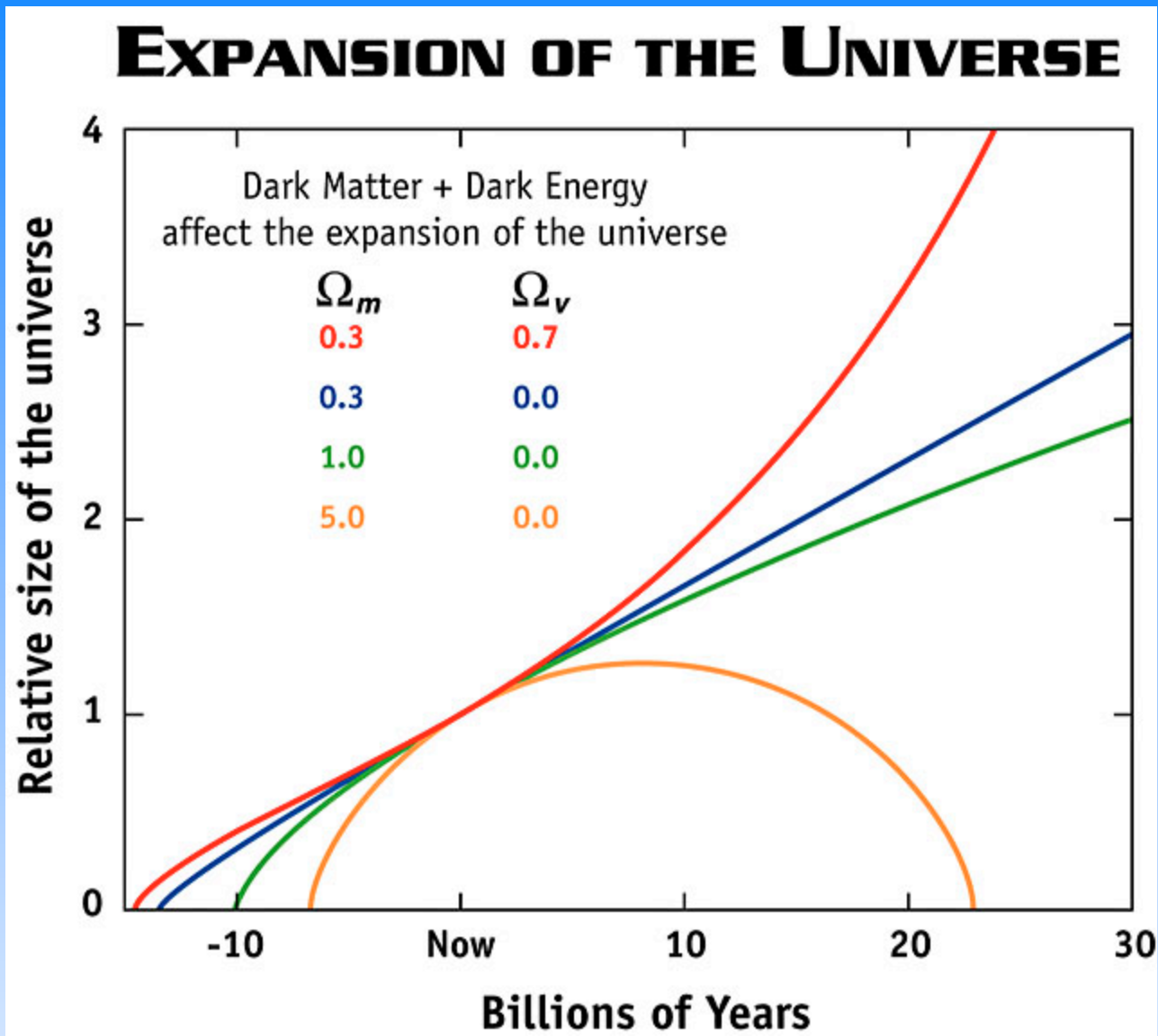
BAO



Standard Ruler

Two Dimensions on the Sky
Angular Diameter Distances

Standard Ruler Tracing Expansion



Combining WL+BAO

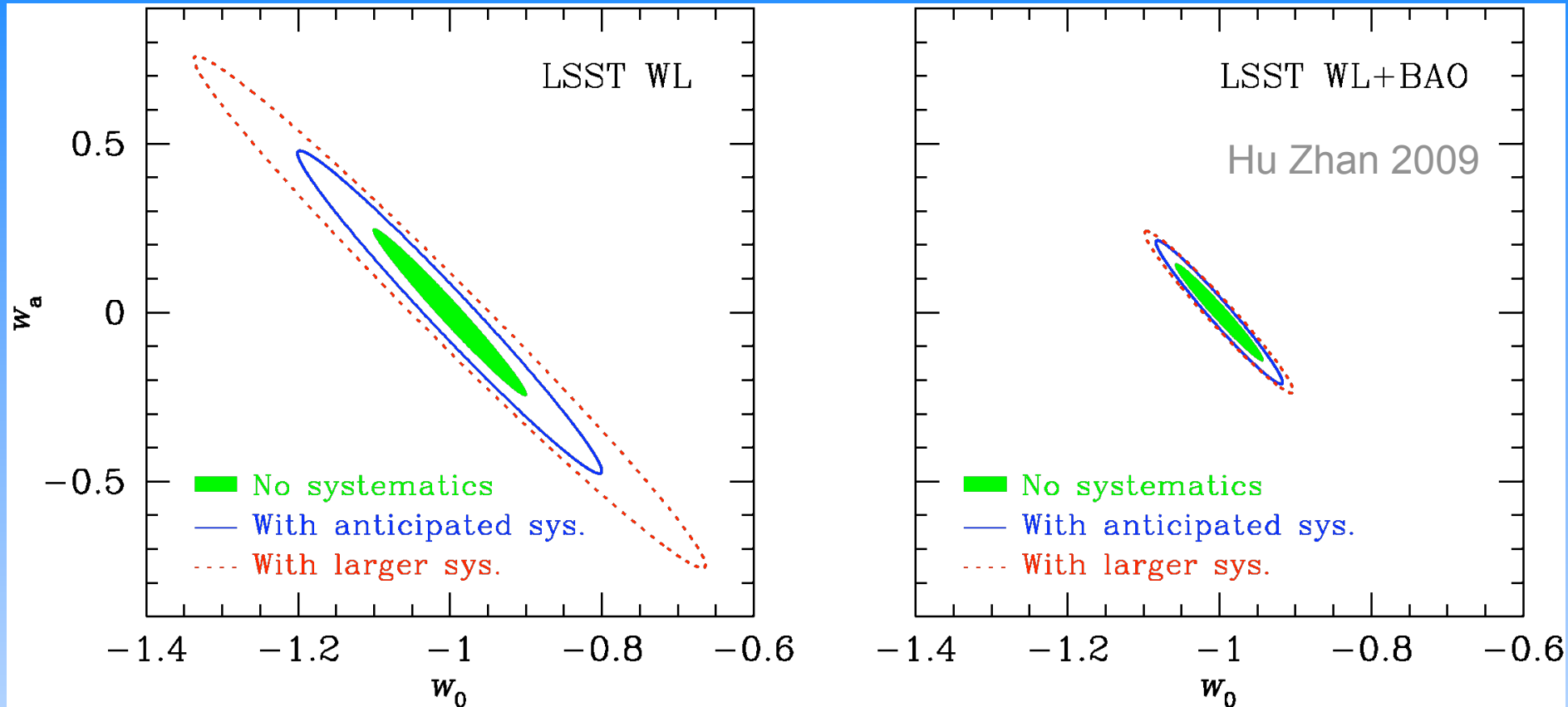
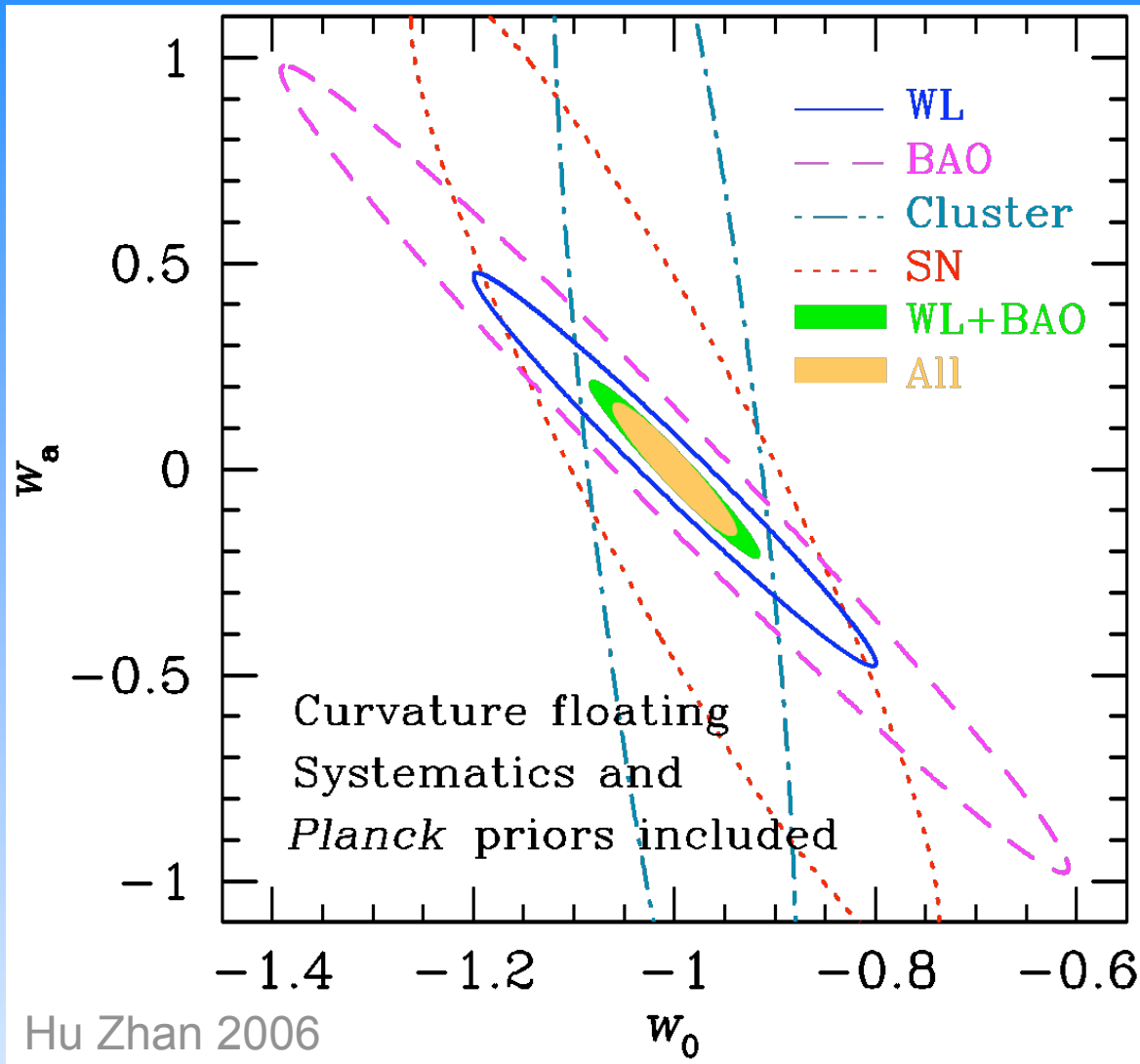


photo-z cross correlations calibrate $\delta\langle z \rangle$ to 0.01 at $z=1$.

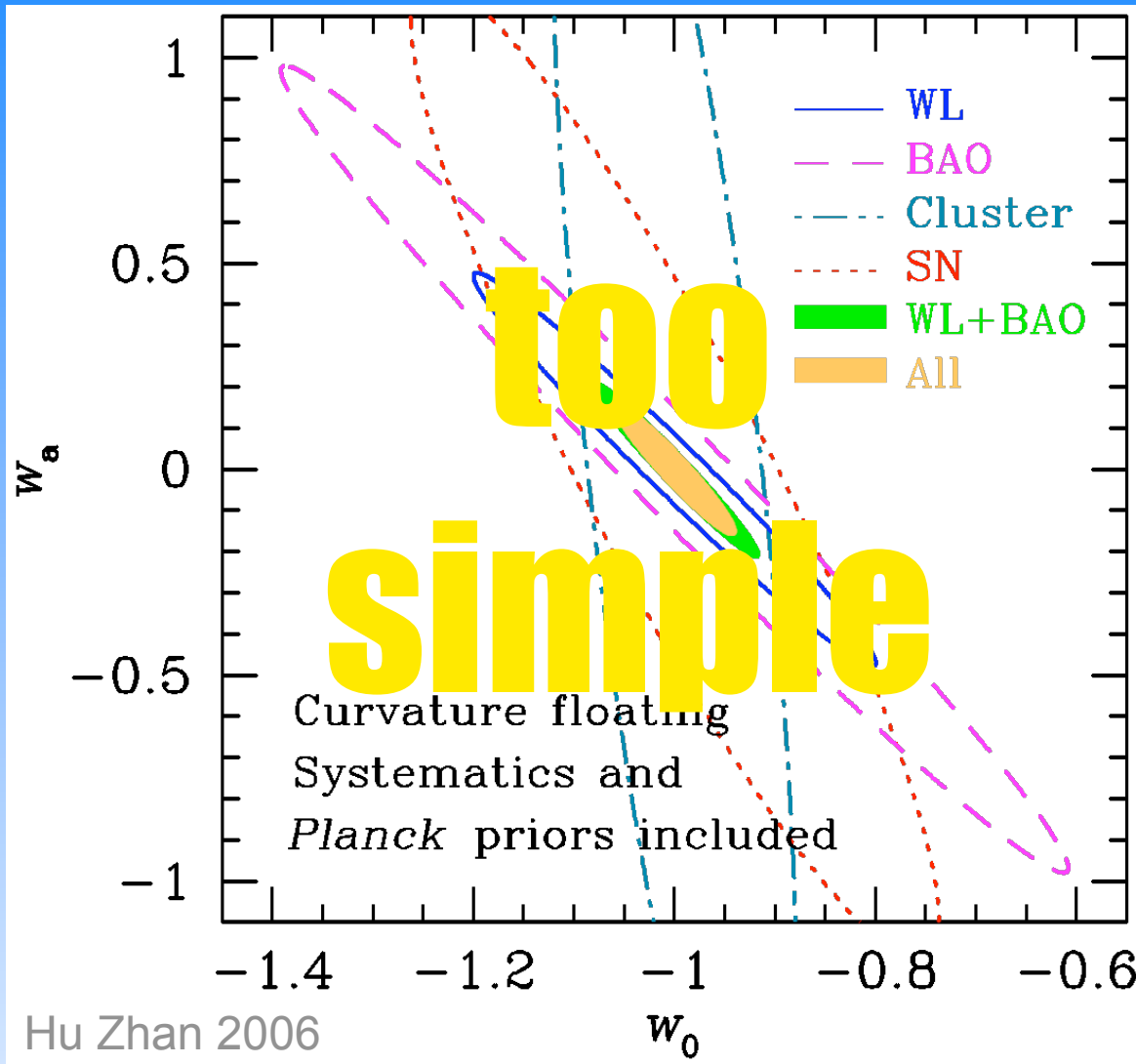
Combining WL + BAO breaks degeneracies in $w = w_0 + (1-a)w_a$.

Joint analysis of WL & BAO is less affected by the systematics

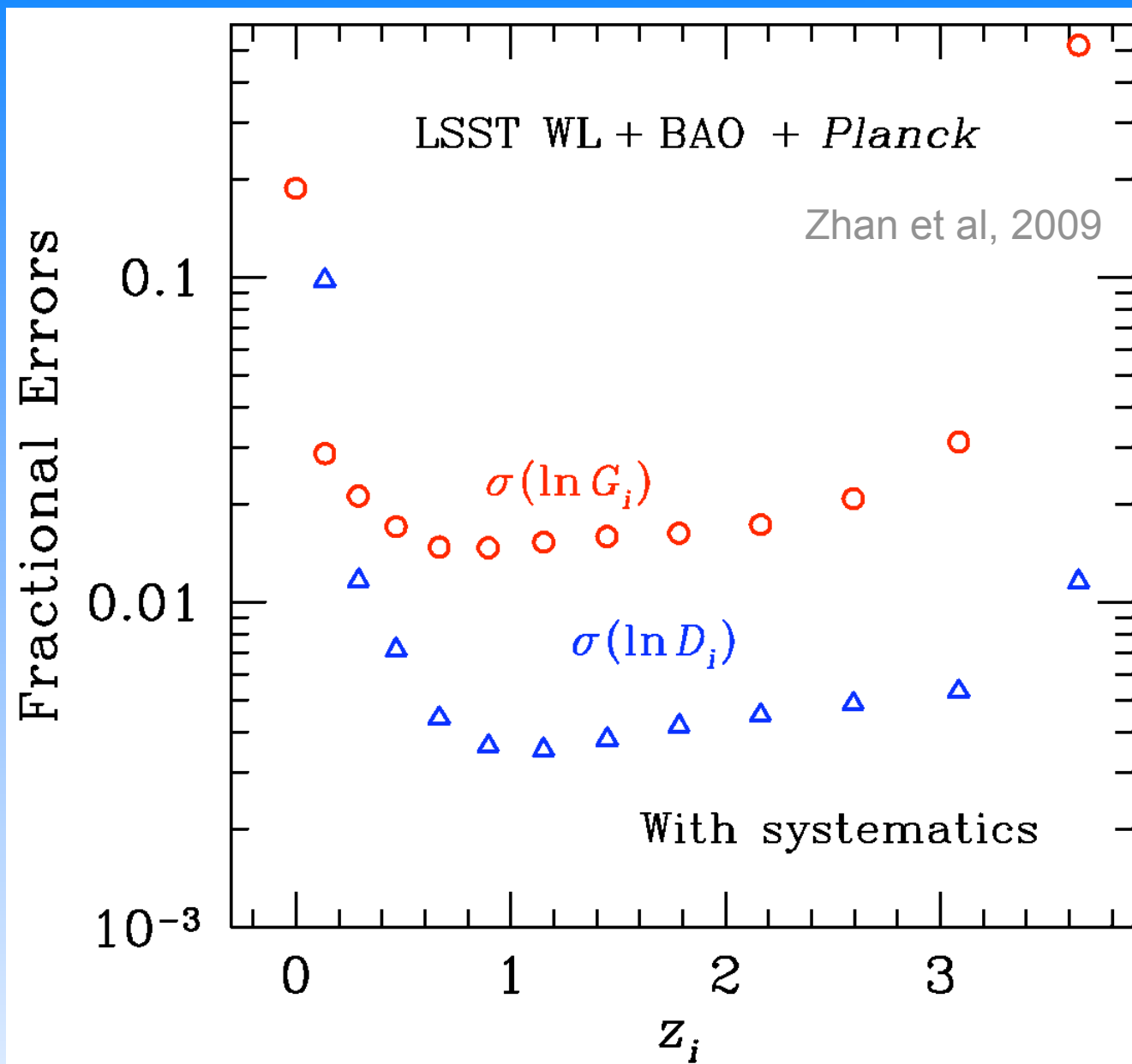
Combining 4 LSST Probes



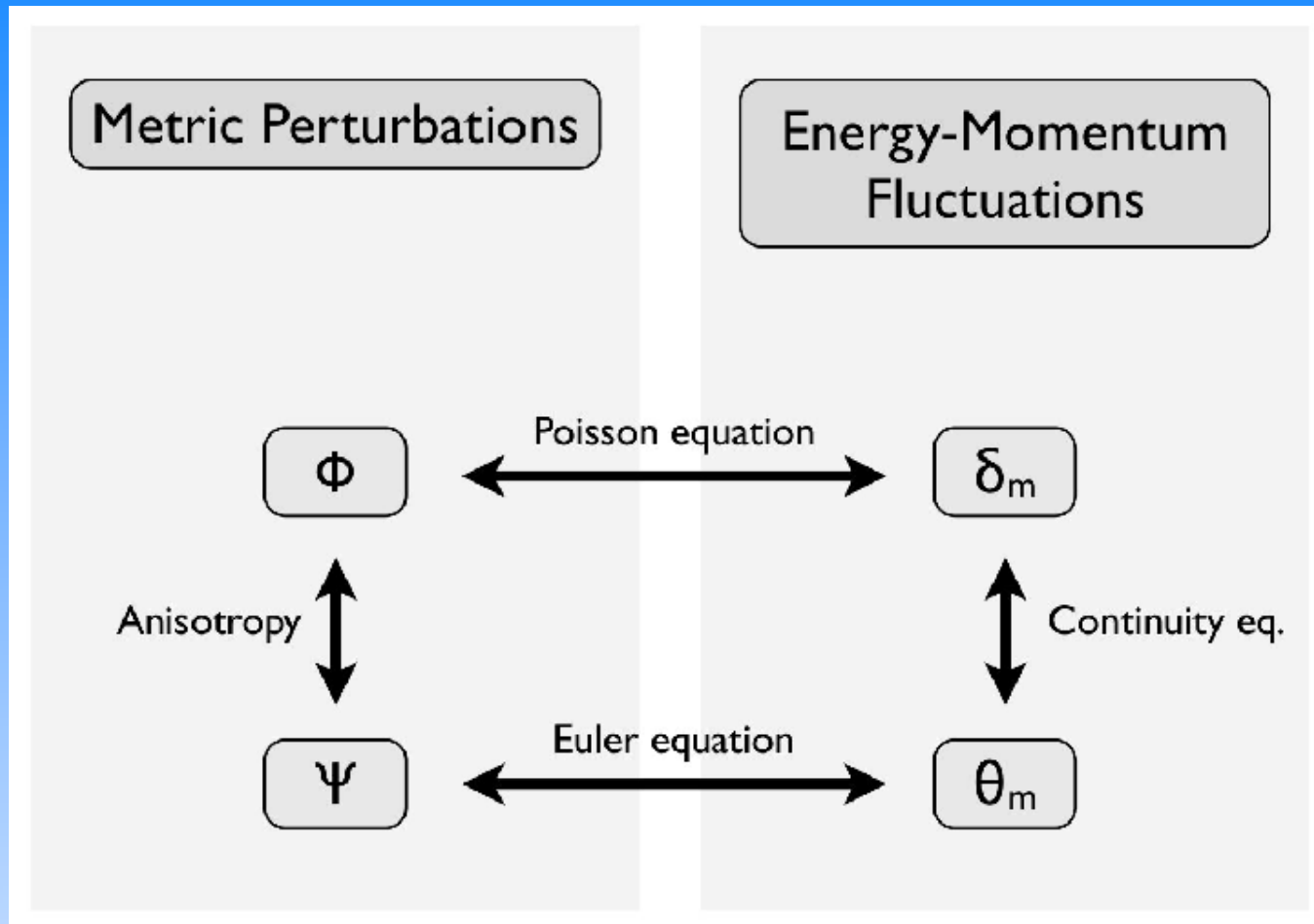
Combining 4 LSST Probes



Testing general models of dark energy

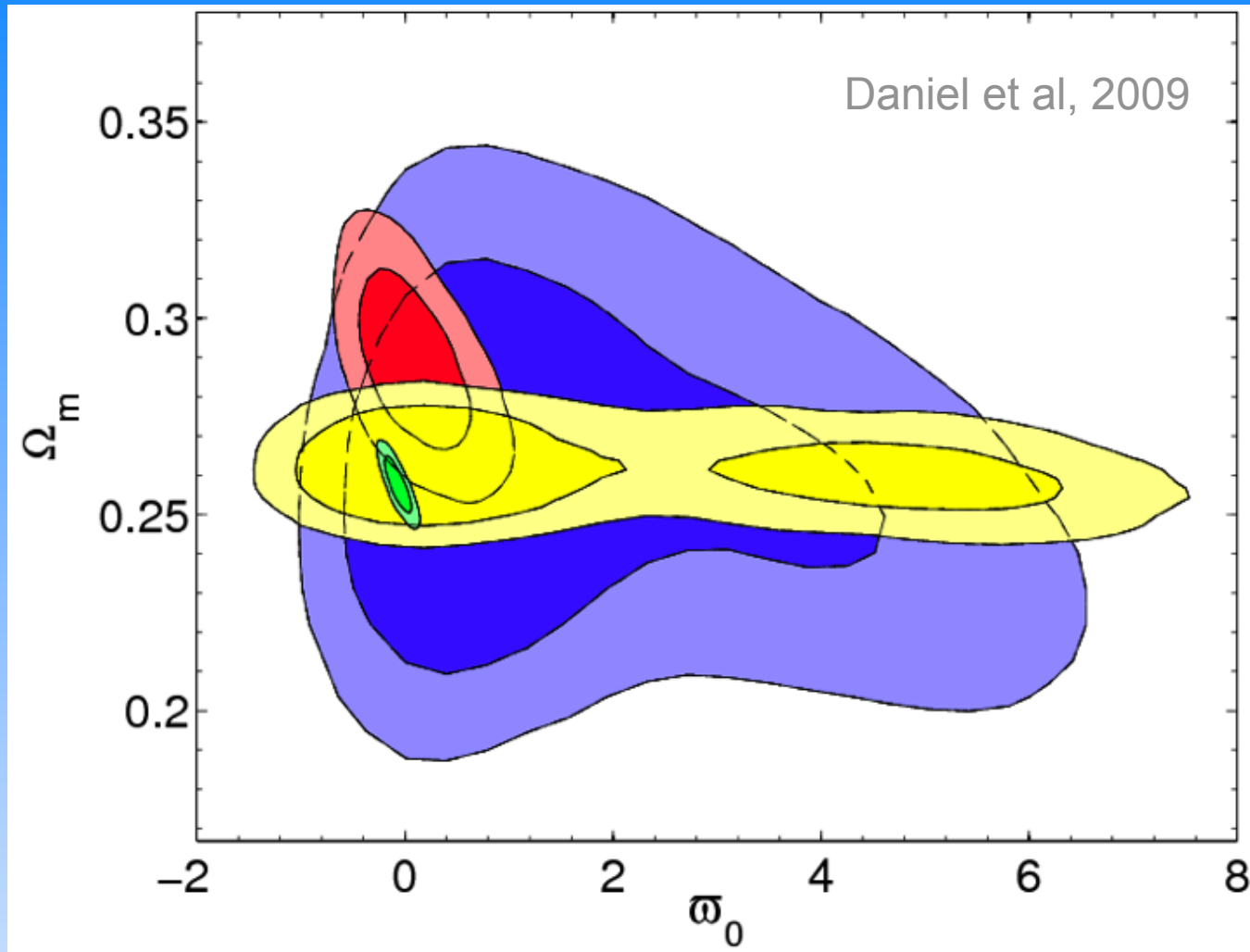


Dark Energy vs. Modified Gravity



Testing consistency between the growth of structure and the expansion of the universe differentiates between DE and MG

Testing specific models of modified gravity

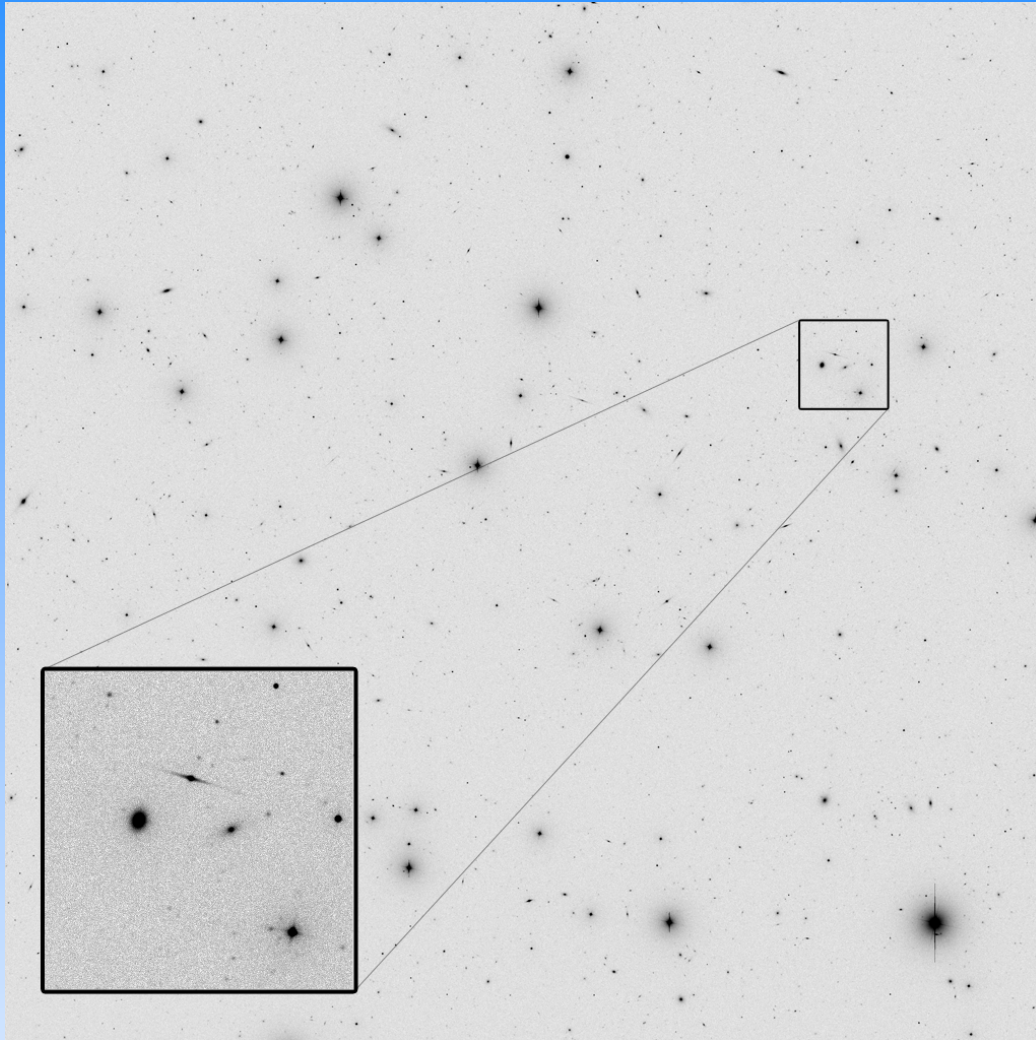


$$\psi = [1 + \varpi(z)]\phi, \quad \varpi(z) = \varpi_0(1 + z)^{-3}$$

LSST Survey

- Begin operations in 2016, with 3-Gigapixel camera
- One 6-Gigabyte image every 17 seconds
- 30 Terabytes every night for 10 years
- 100-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: validate system performance



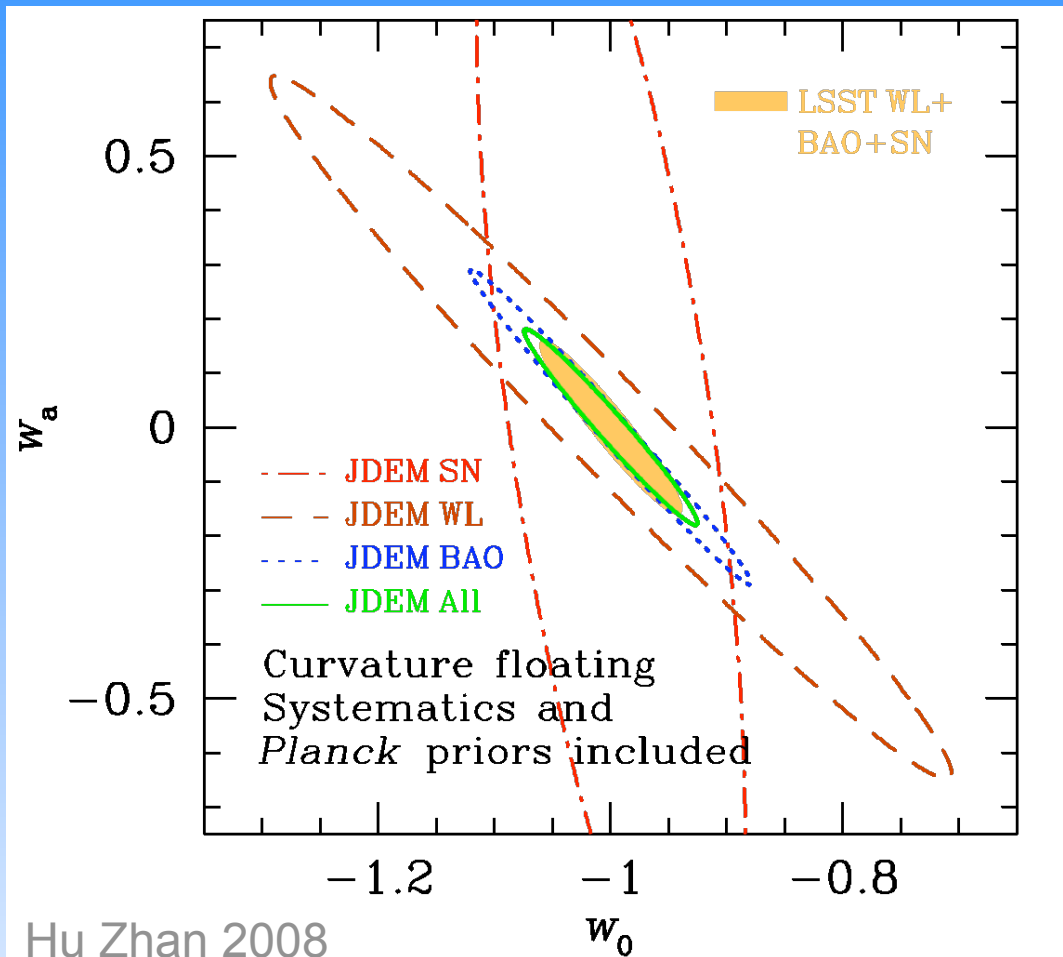
LSST is simulating image performance from end-to-end, including:

- **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

Comparison of Stage-IV facilities for DE

LSST comparable and complementary to JDEM



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

Neutrino mass with LSST

