Title: Multiple Probes of Dark Energy

Date: Jun 05, 2008 11:50 AM

URL: http://pirsa.org/07060081

Abstract:

Multiple Probes of Dark Energy

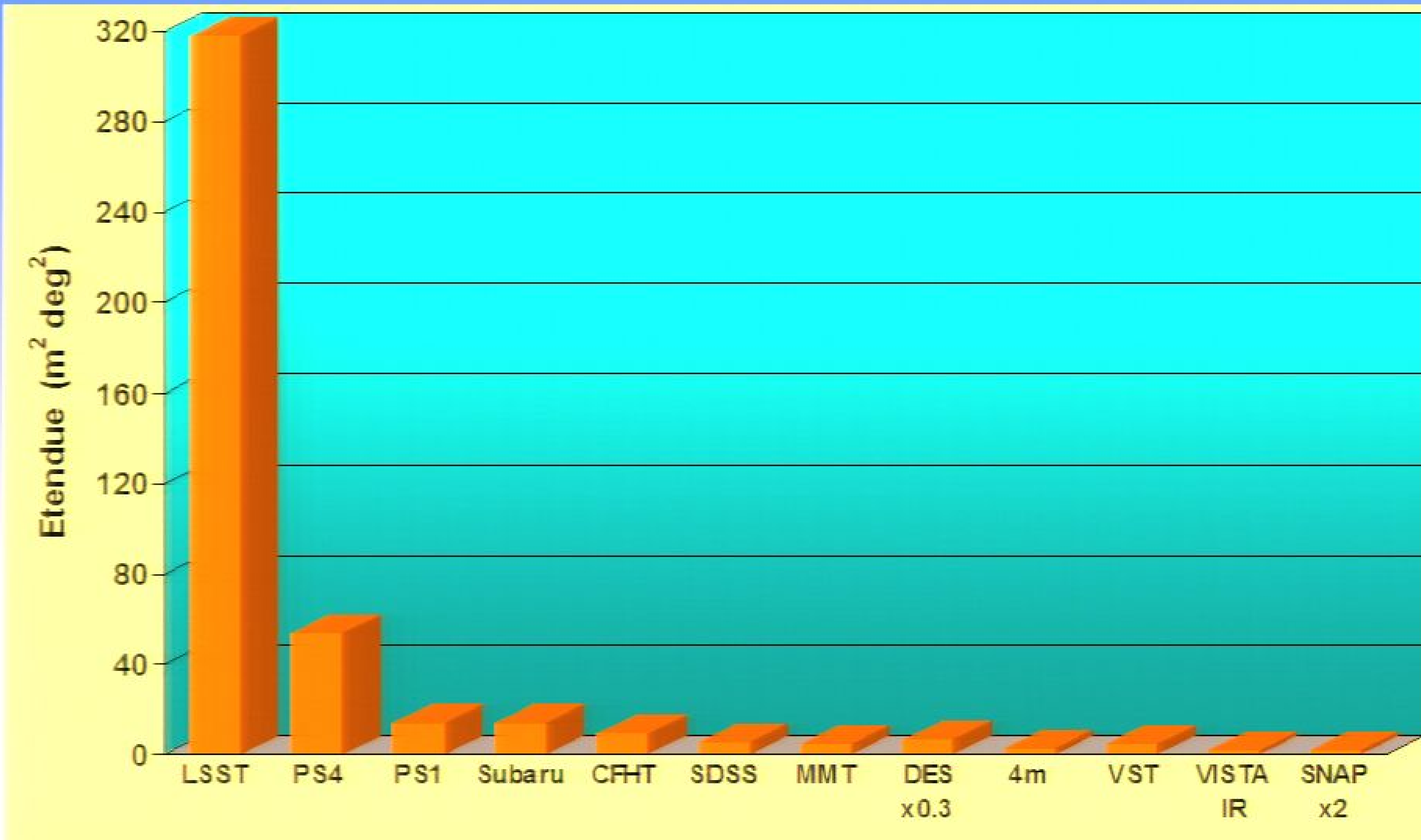
Tony Tyson, UC Davis

Outline:

1. LSST Project
2. Multiple probes of distance and growth
3. Controlling Systematic Errors
4. Testing >2 dimensional DE models

PASCOS '08
June 5, 2008

Relative Survey Power



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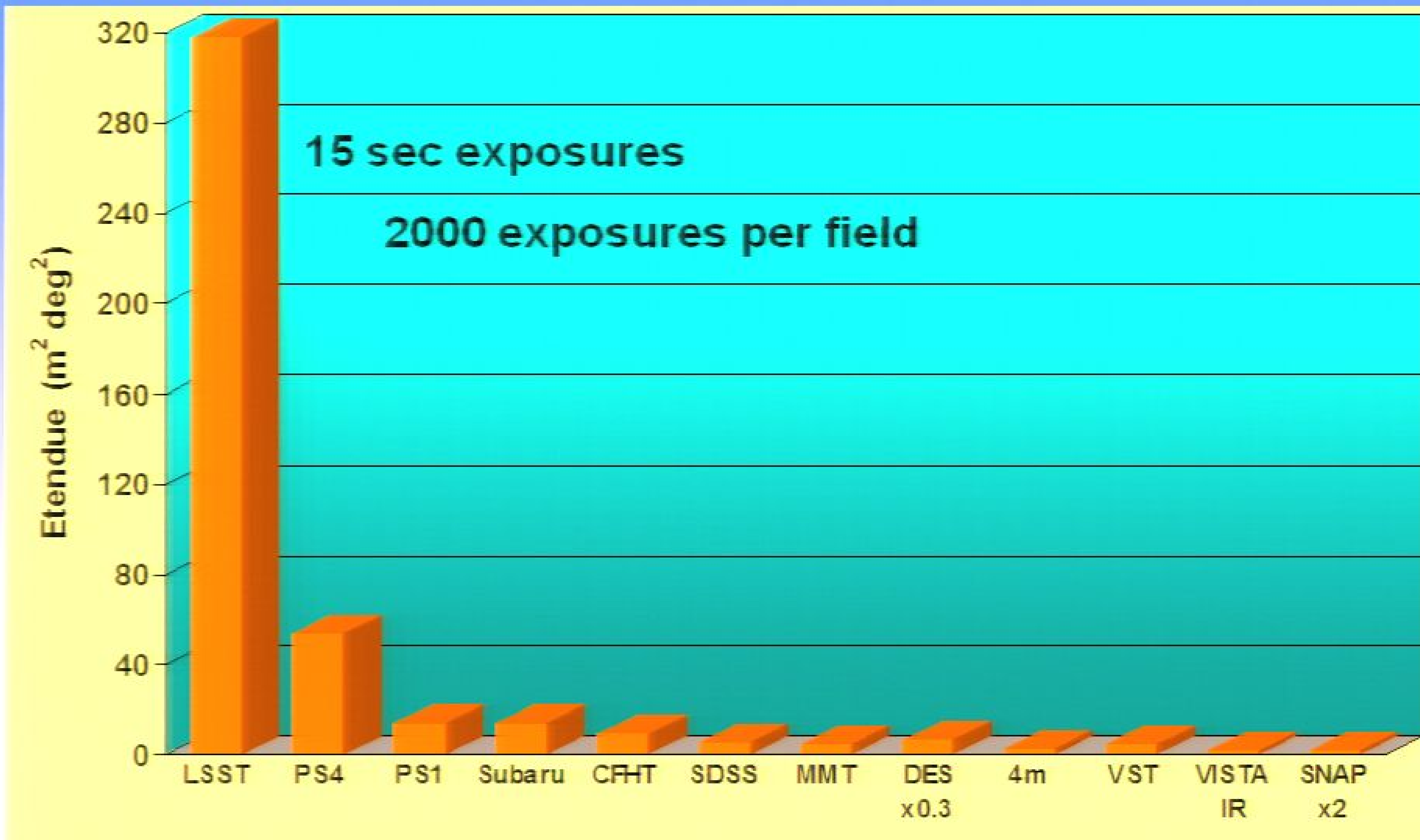
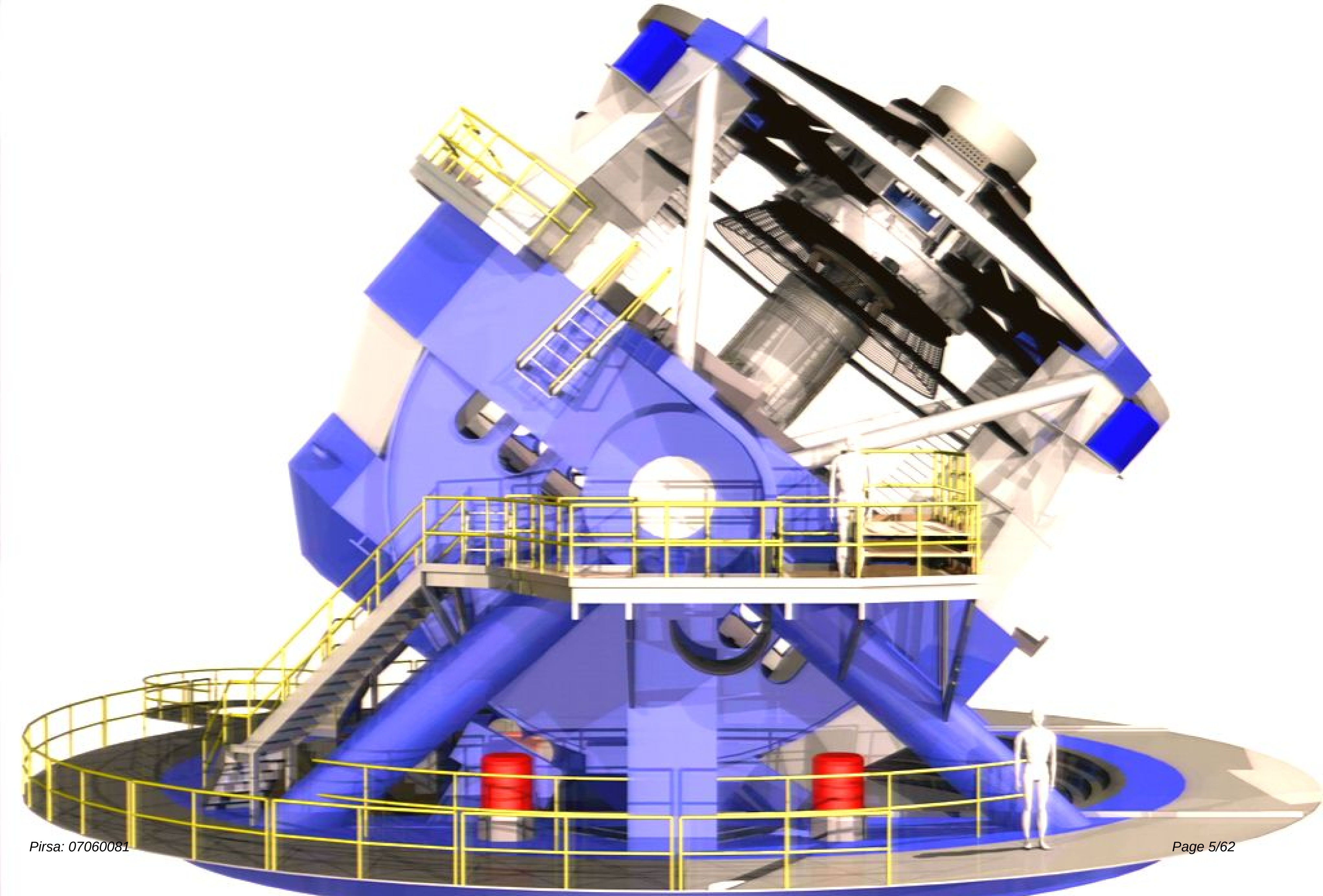
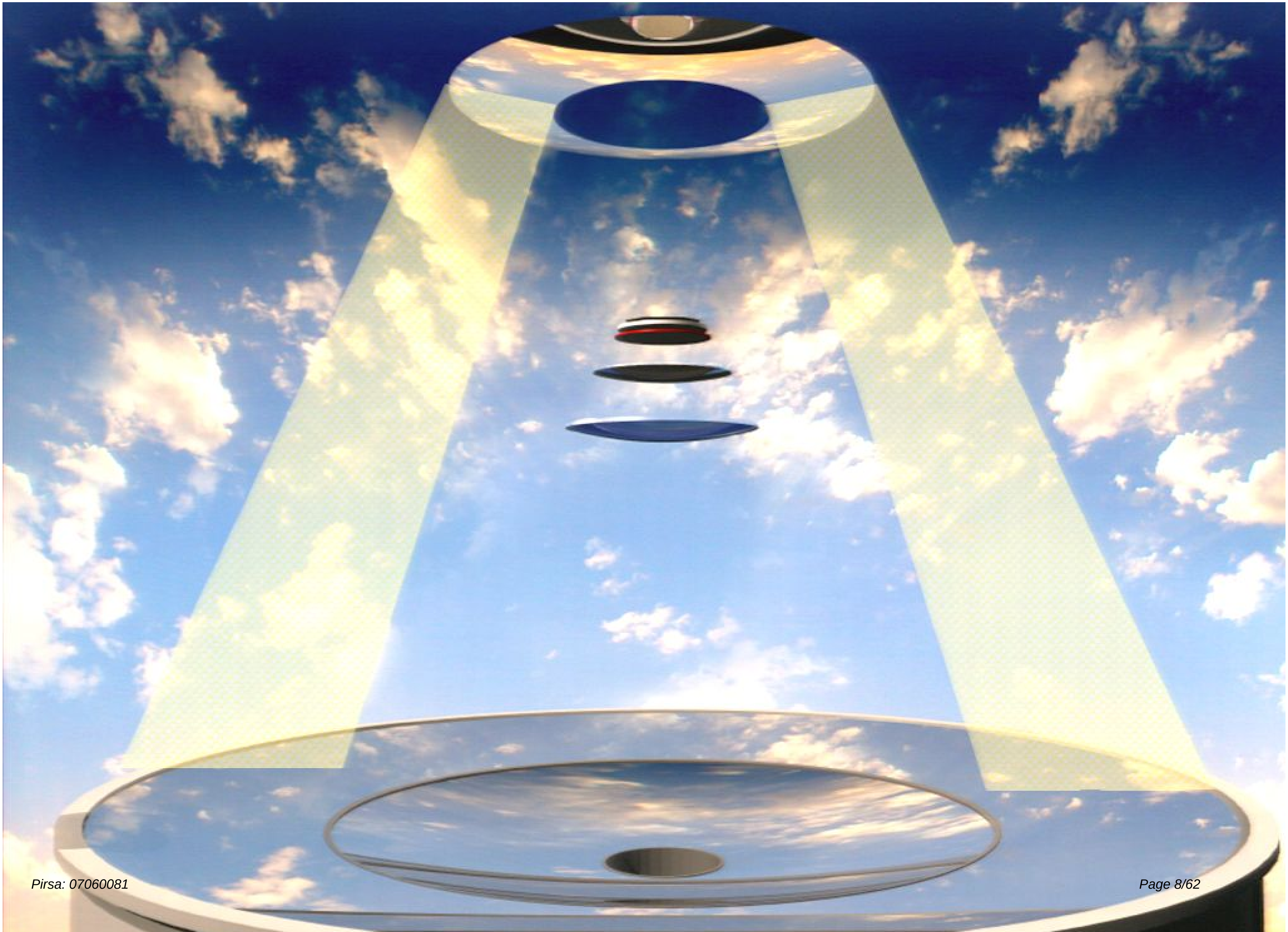




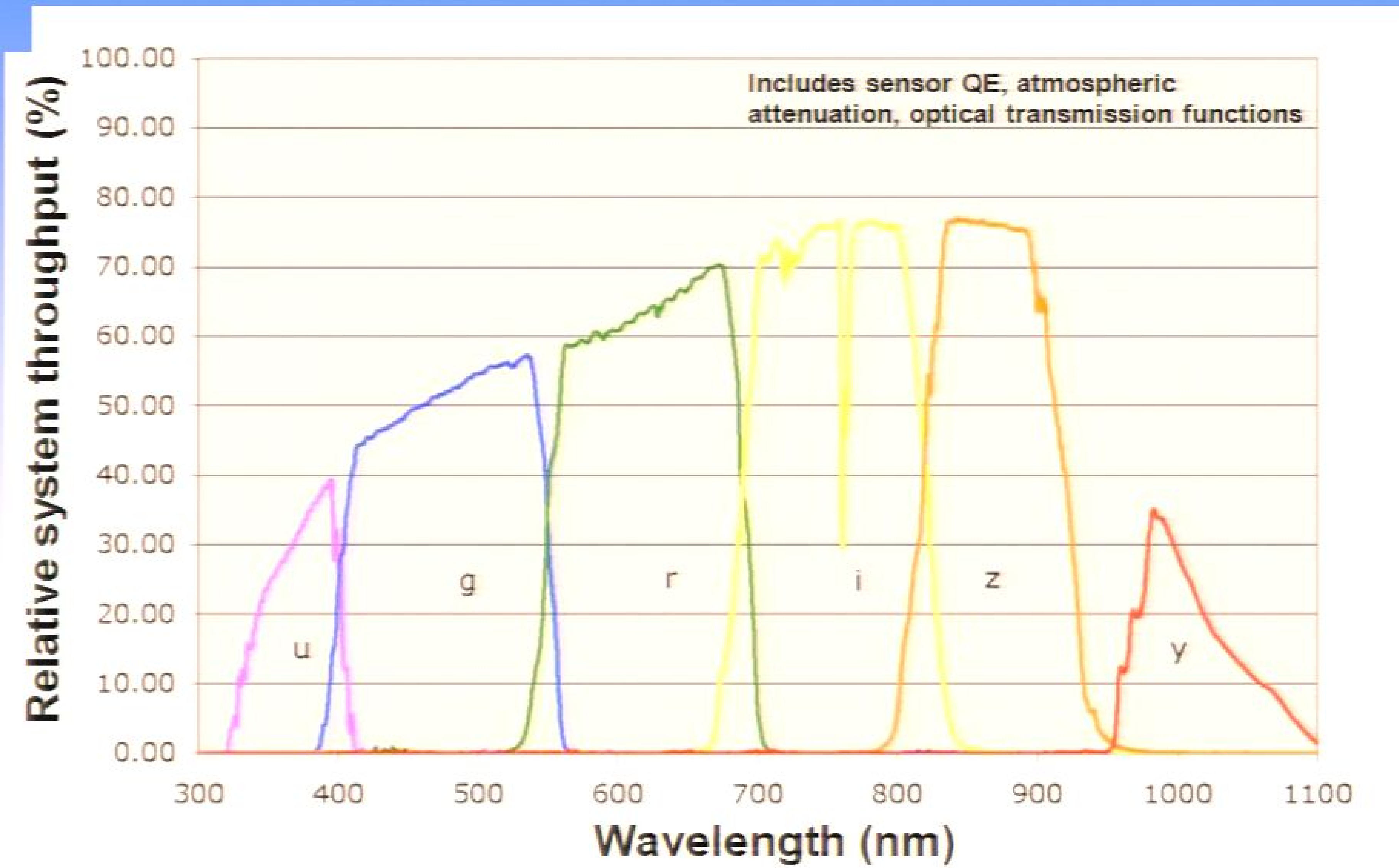

deep wide fast



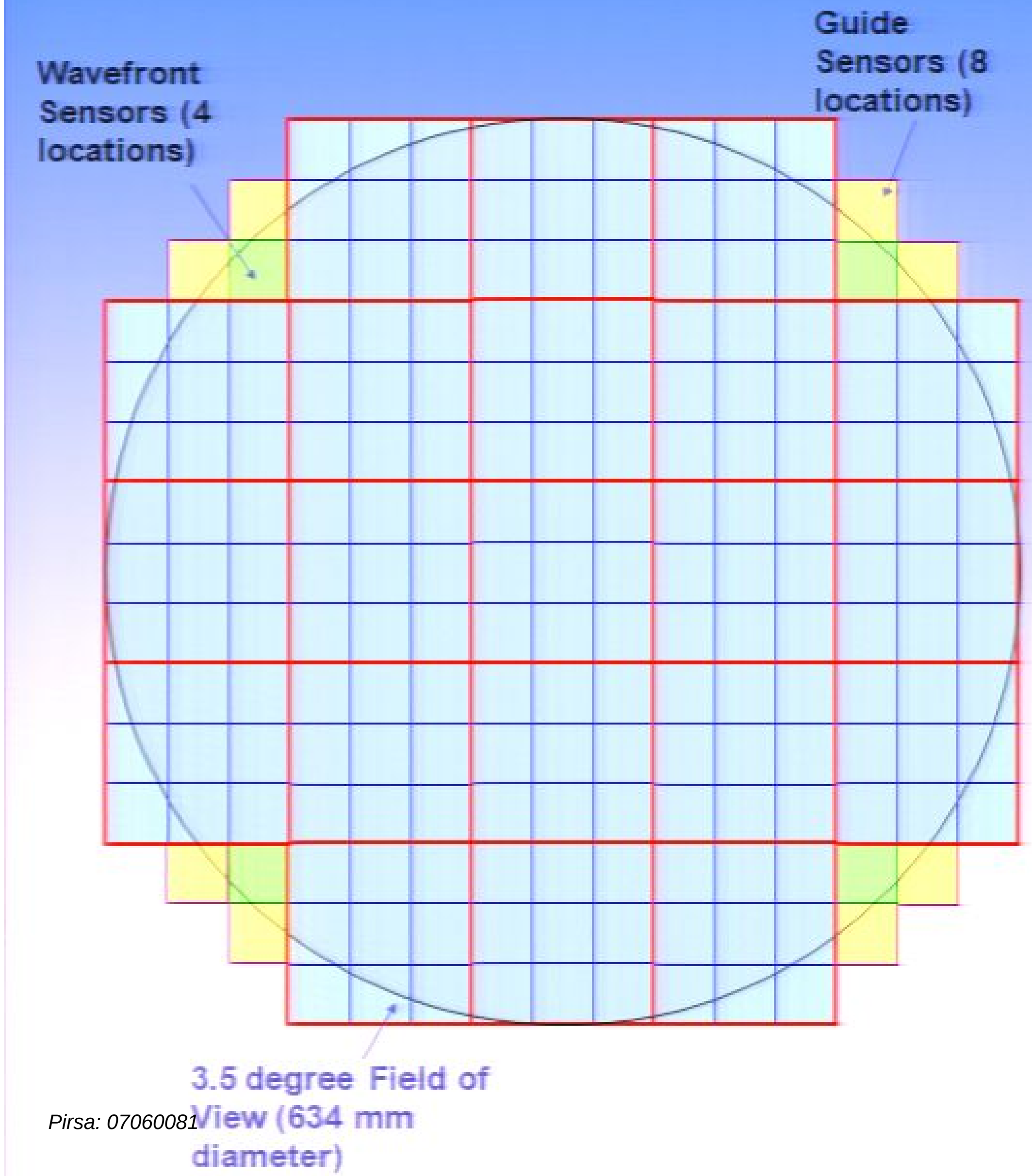
LSST Primary/Tertiairy Mirror Fabrication

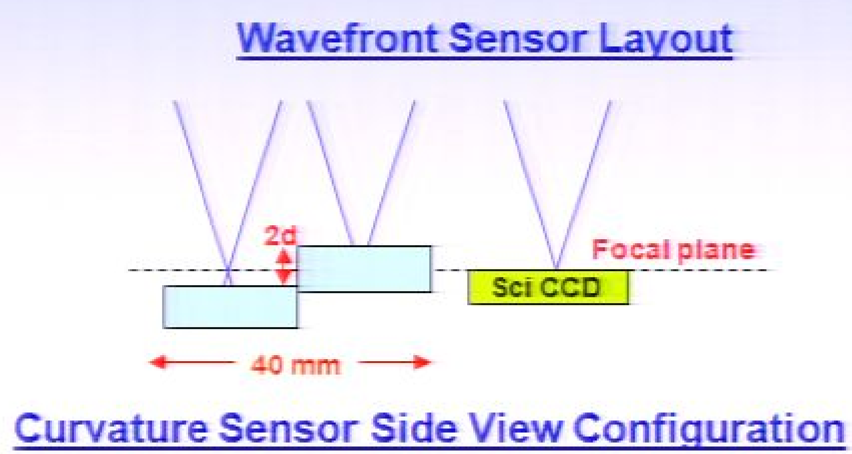
3200 megapixel camera
Camera (Actual Size)

LSST six color system



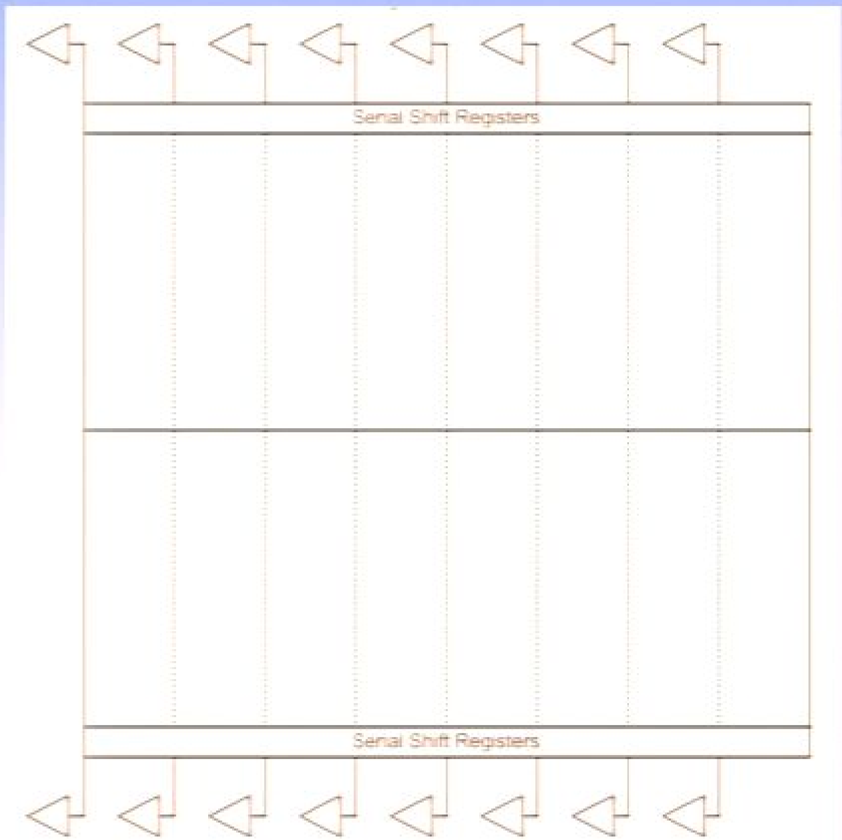
The LSST Focal Plane

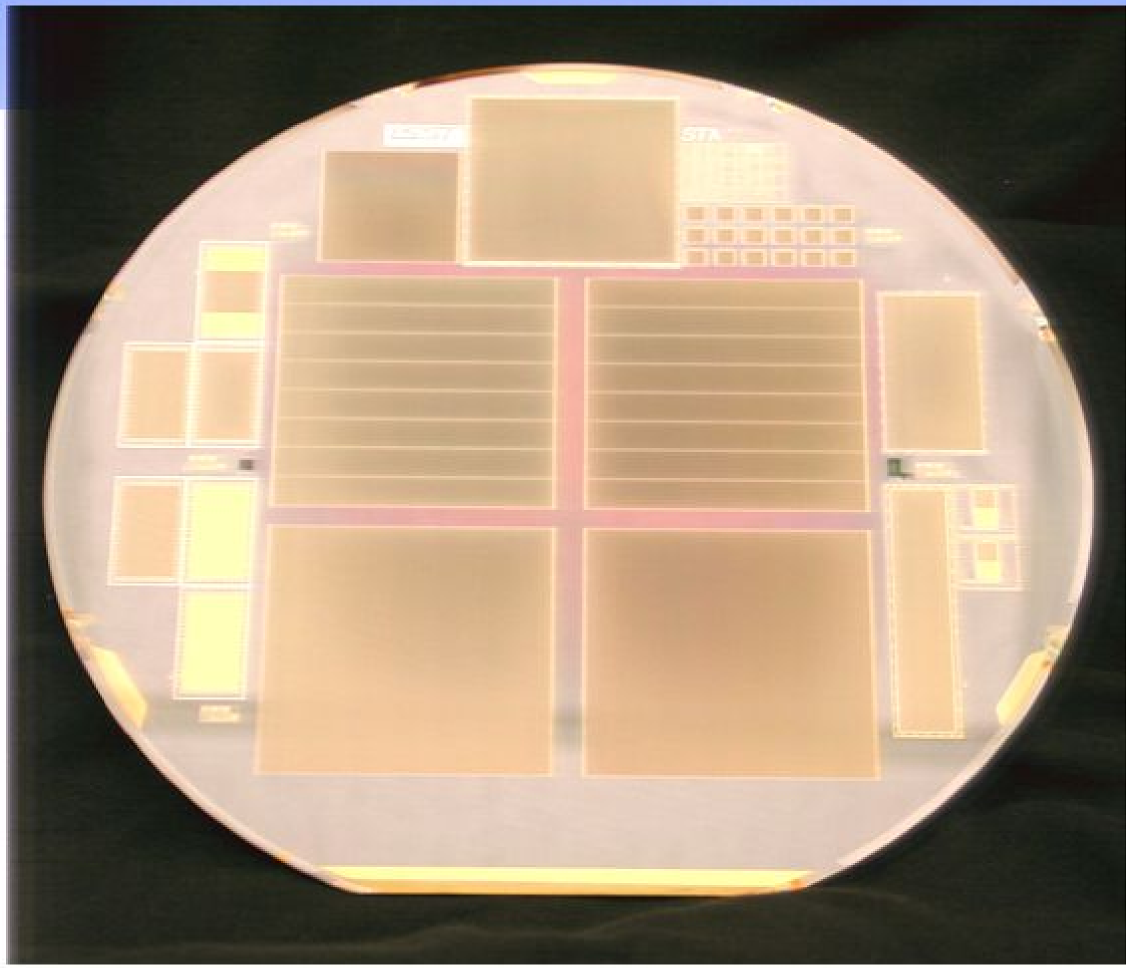




The LSST CCD Sensor

16 segments/CCD
200 CCDs total
3200 Total Outputs





There are 24 LSSTC US Institutional Members

- Brookhaven National Laboratory
- California Institute of Technology
- Carnegie Mellon University
- Columbia University
- Google Inc.
- Harvard-Smithsonian Center for Astrophysics
- Johns Hopkins University
- Las Cumbres Observatory
- Lawrence Livermore National Laboratory
- National Optical Astronomy Observatory
- Princeton University
- Purdue University
- Research Corporation
- Rutgers University
- Stanford Linear Accelerator Center
- Stanford University -KIPAC
- The Pennsylvania State University
- University of Arizona
- University of California, Davis
- University of California, Irvine
- University of Illinois at Champaign-Urbana
- University of Pennsylvania
- University of Pittsburgh
- University of Washington

+ IN2P3 in France

Funding: Public-Private Partnership NSF, DOE, Private

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Open Data

Funding: Public-Private Partnership NSF, DOE, Private

LSST Survey

- 6-band Survey: u*grizy* 320-1100 nm
  Frequent revisits: grizy
- Sky area covered: >20,000 deg^2
  0.2 arcsec / pixel
- Each 10 sq.deg field revisited ~2000 times
- Limiting magnitude: 27.6 AB magnitude @ 5σ
  25 AB mag /visit = 2x15 seconds
- Photometry precision: 0.005 mag requirement,
  0.003 mag goal

The LSST site in Chile

1.5m photometric
calibration telescope

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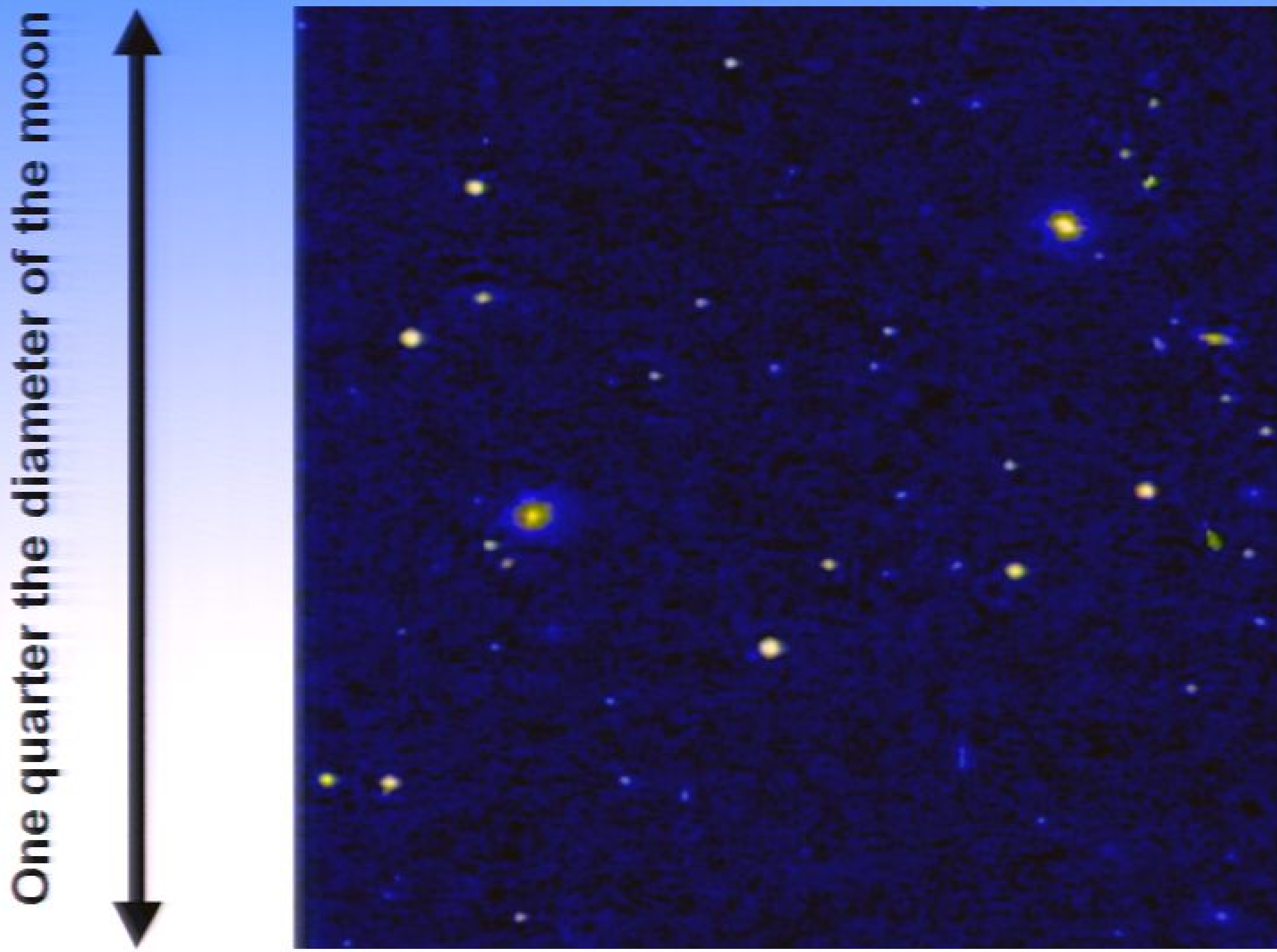
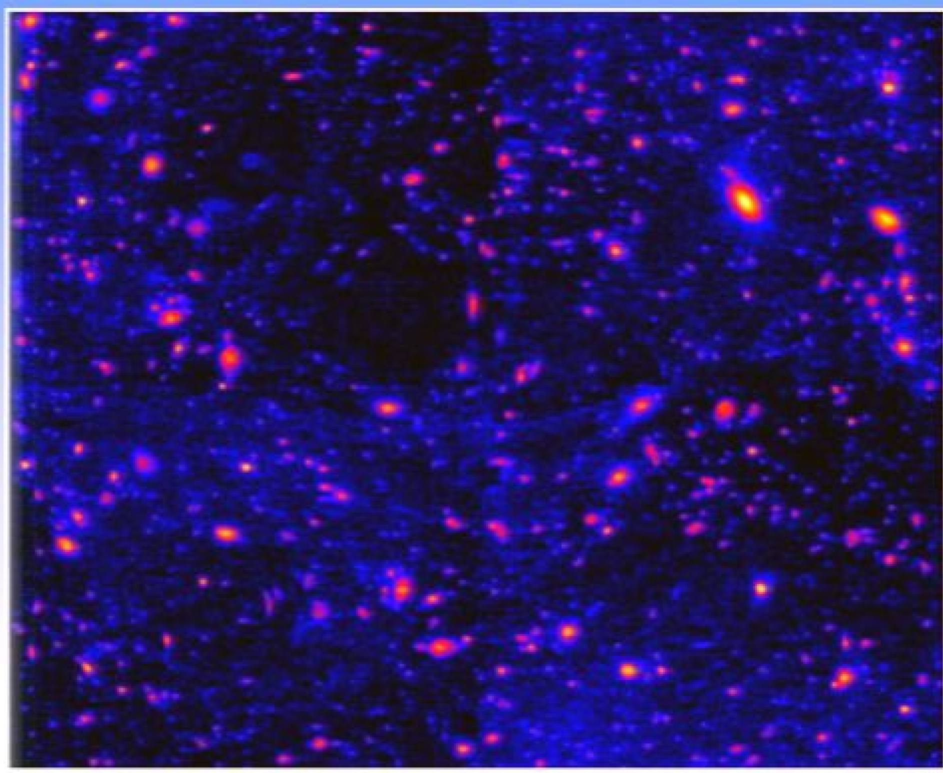
DSS: digitized photographic plates



Sloan Digital Sky Survey

Deep Lens Survey

LSST imaging & operations simulations



Sheared HDF raytraced + perturbation + atmosphere + wind + optics + pixel

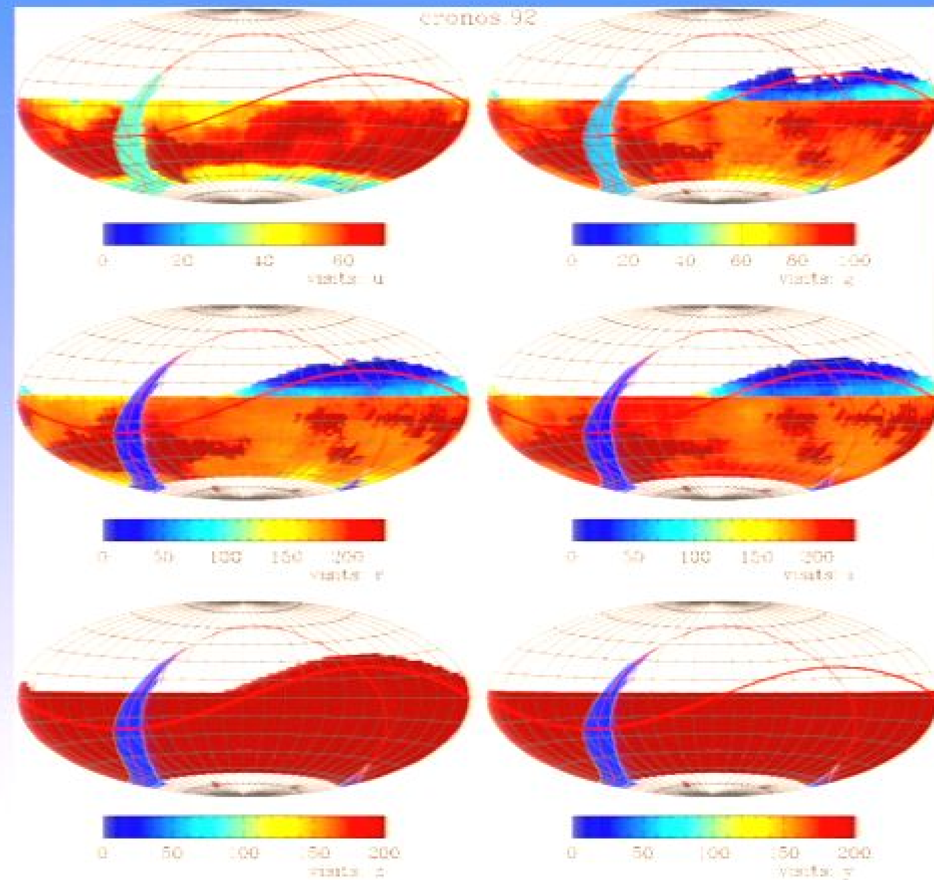
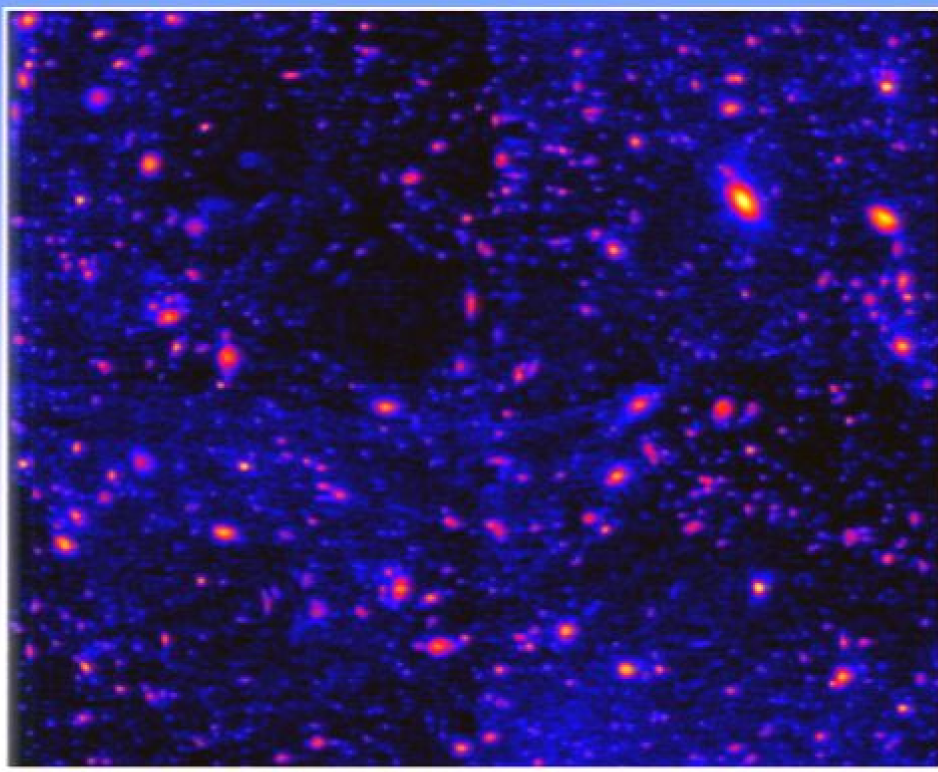


Figure : Visits numbers per field for the 10 year simulated survey

LSST Operations, including real weather data: coverage + depth

LSST imaging & operations simulations



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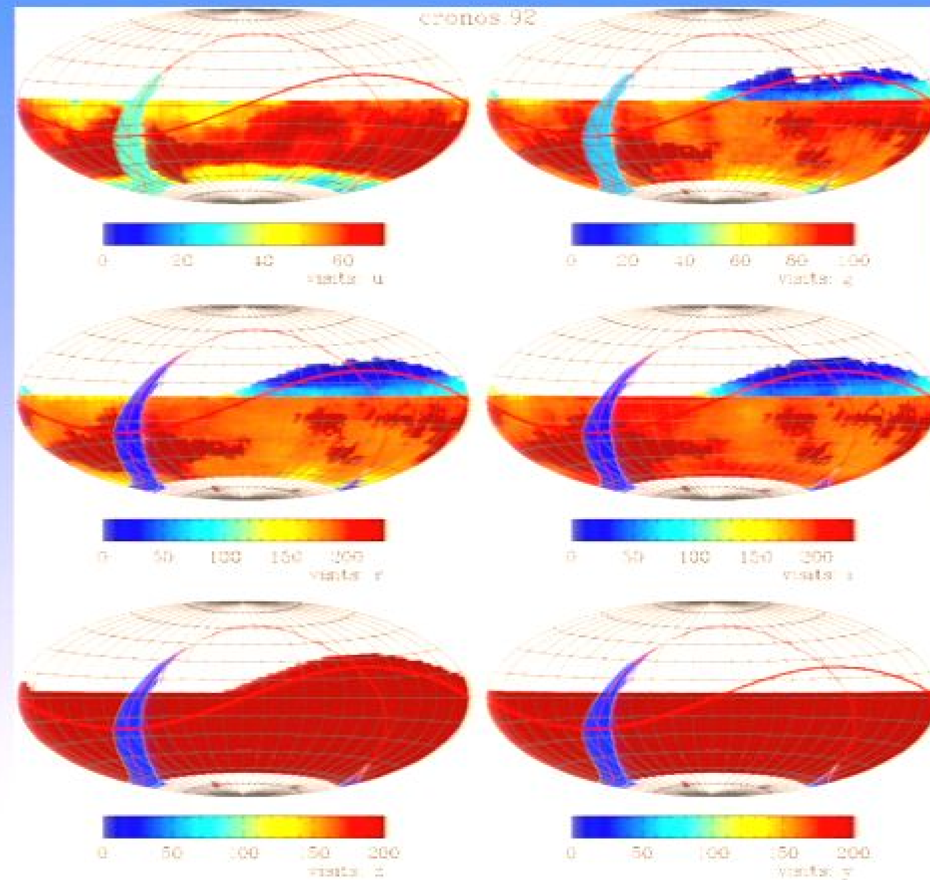

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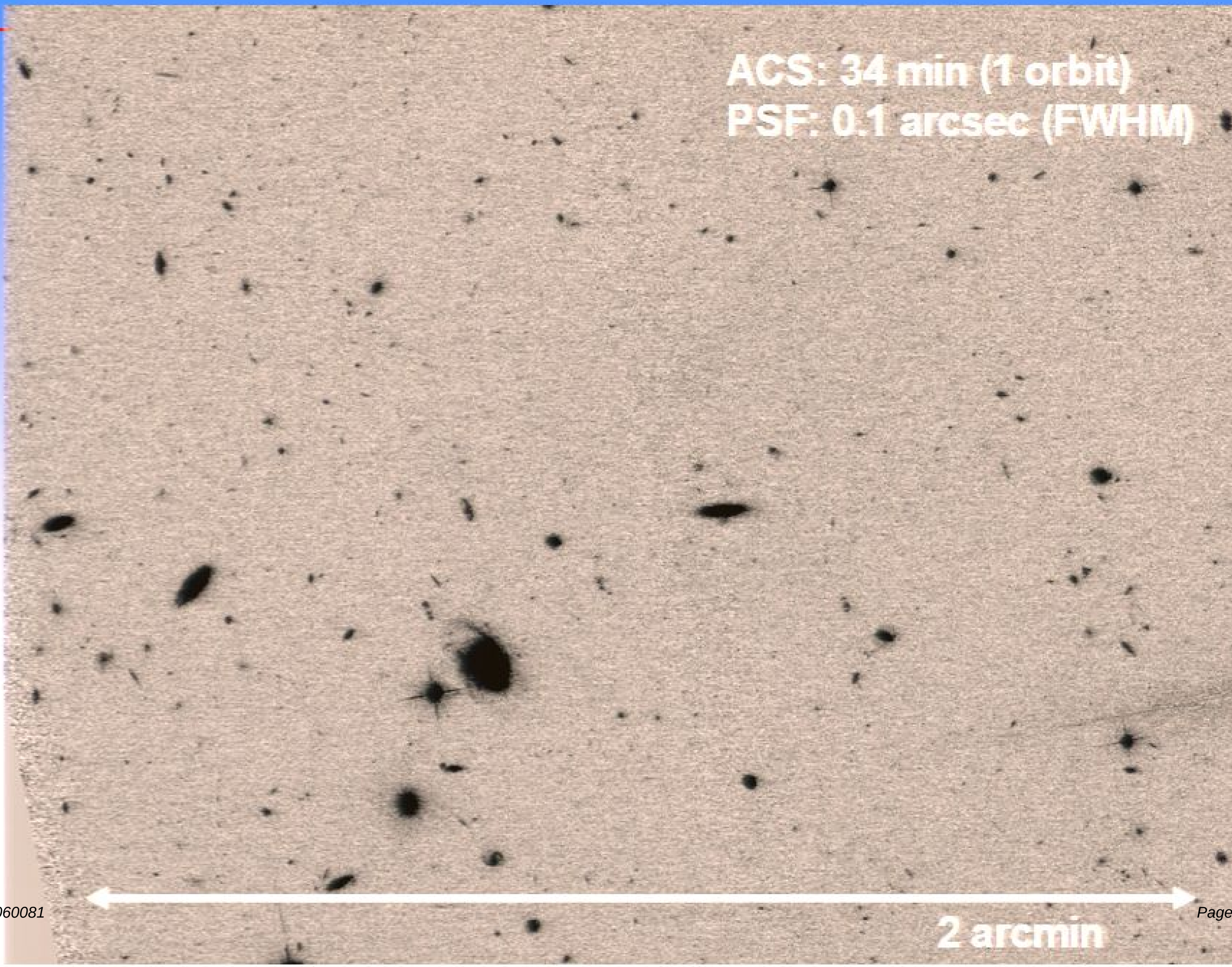
LSST Operations, including real weather data: coverage + depth

Performance verification using Subaru imaging

Comparing HST with Subaru



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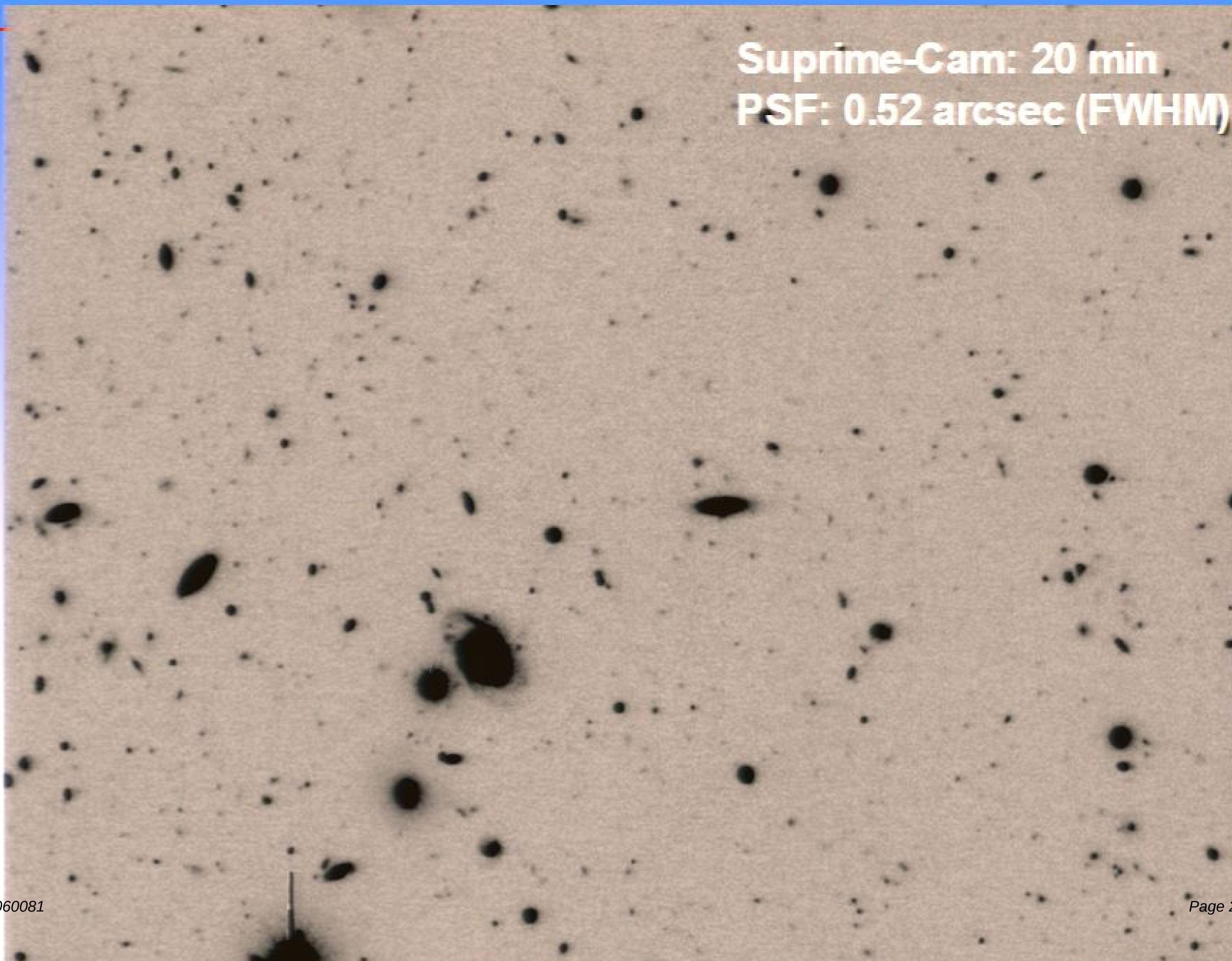

LSST survey of 20,000 sq deg

- 3 billion galaxies with redshifts
- Time domain:
  1 million supernovae
  1 million galaxy lenses
  5 million asteroids
  new phenomena

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.

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

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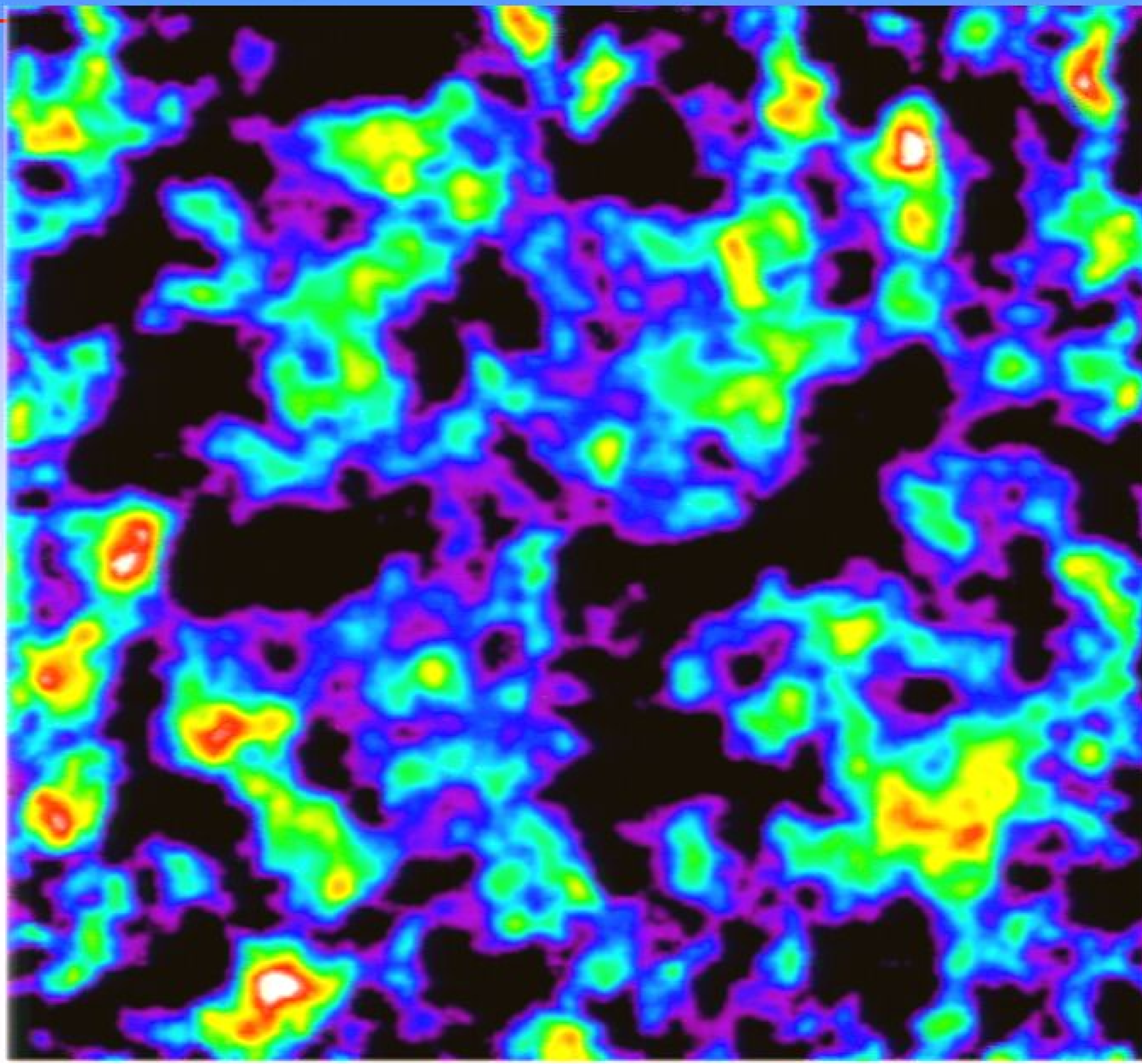
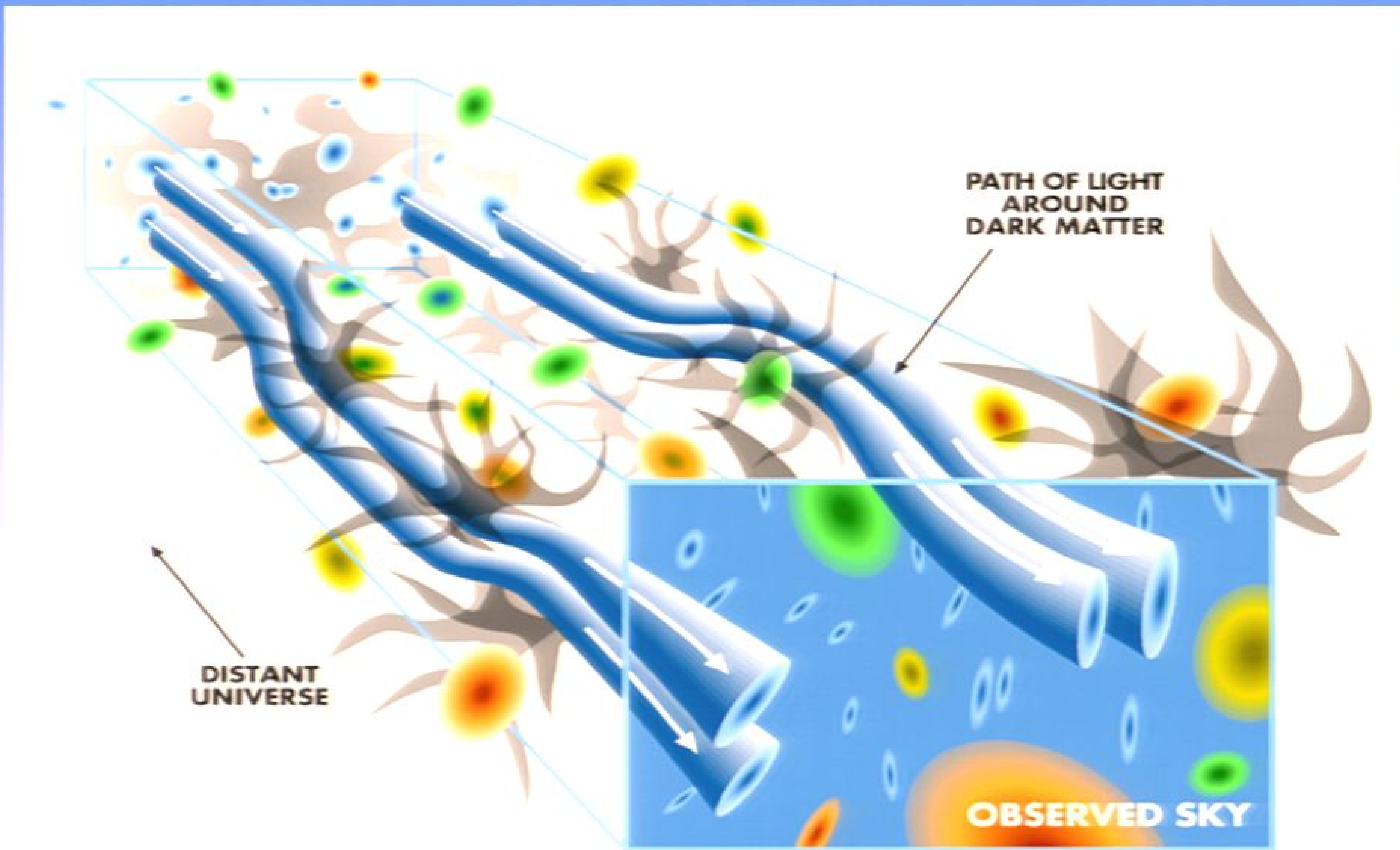
3-D Weak Lens Mass Tomography



2x2 degree mass map from Deep Lens Survey

Cosmic shear vs redshift



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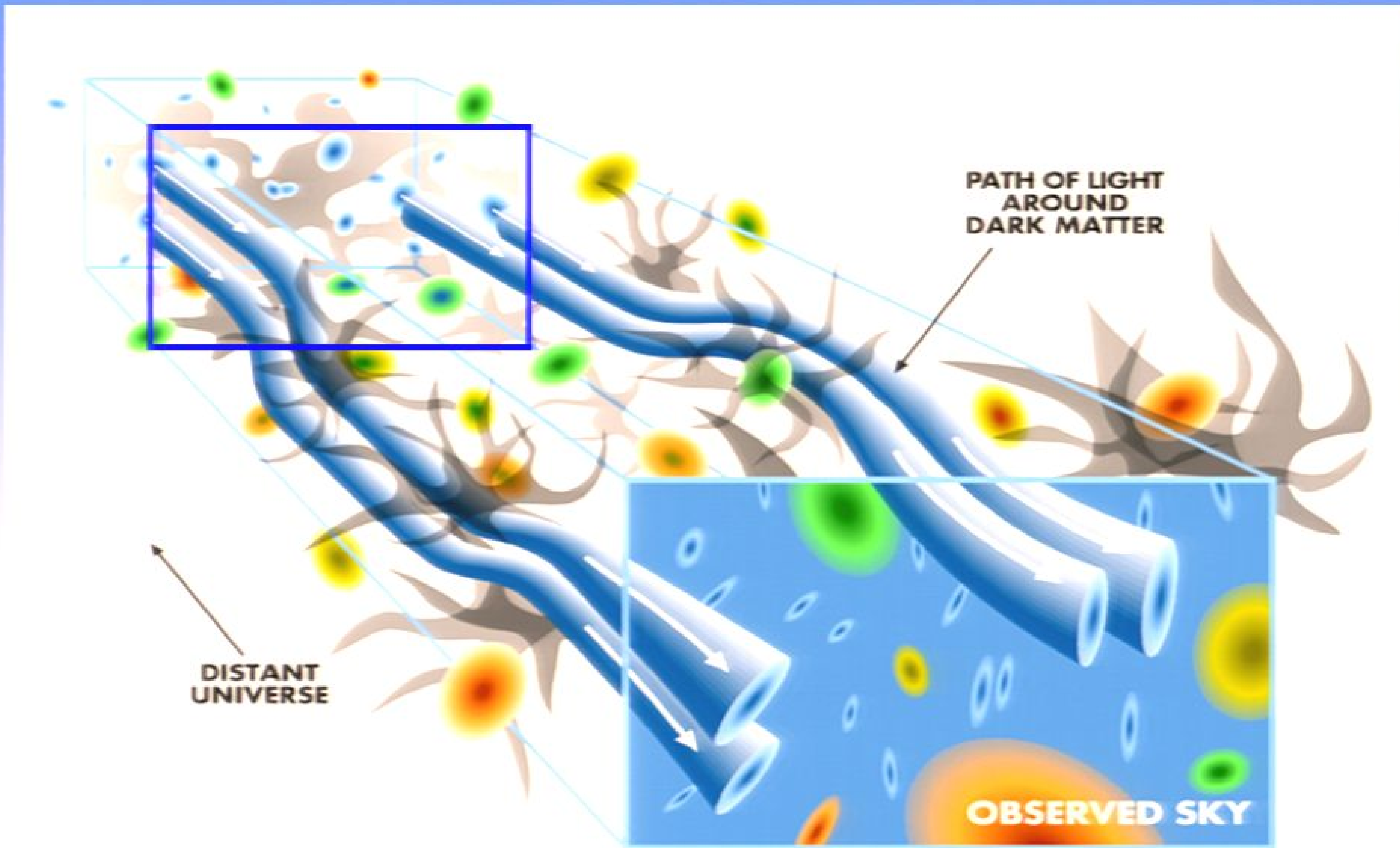

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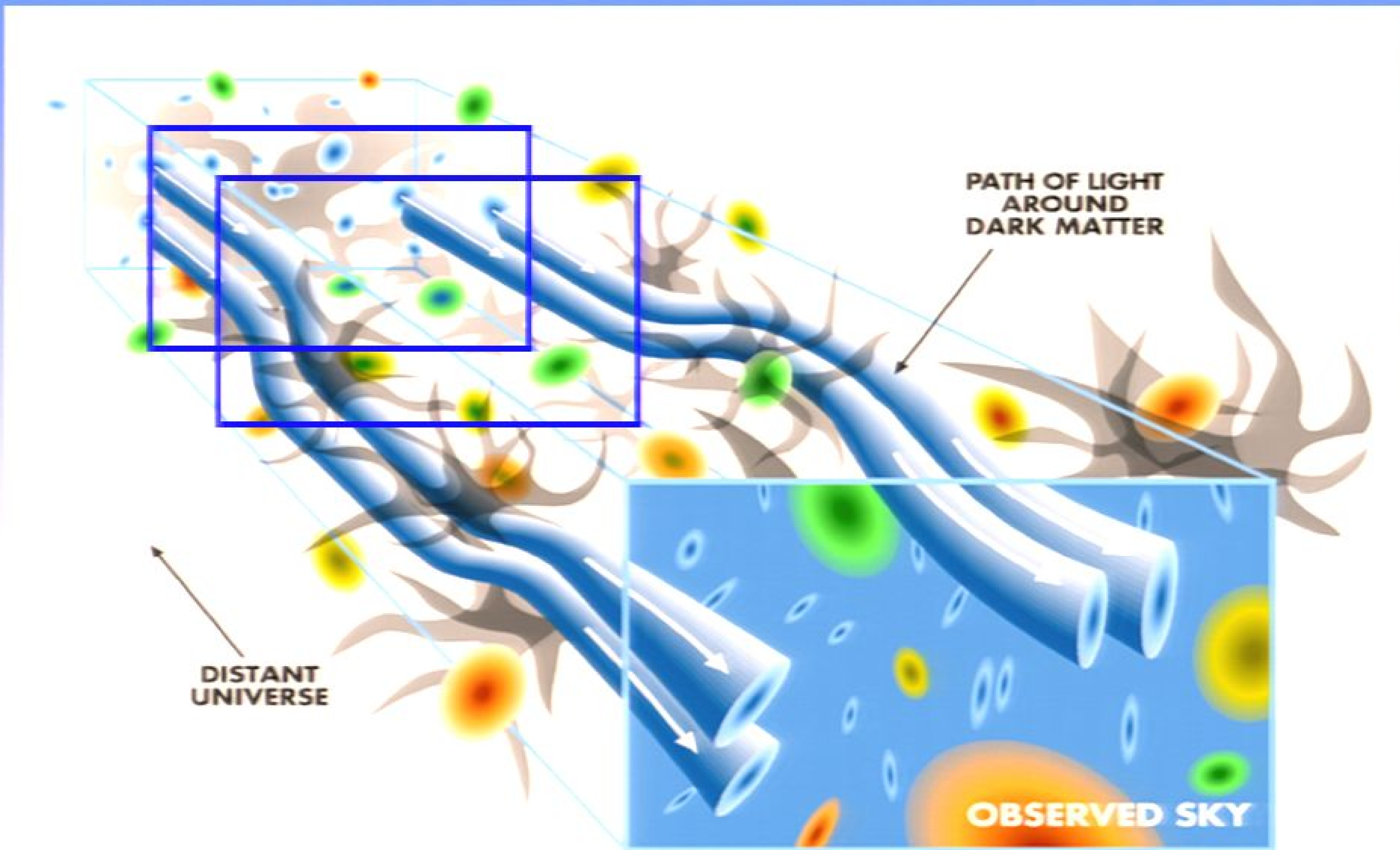

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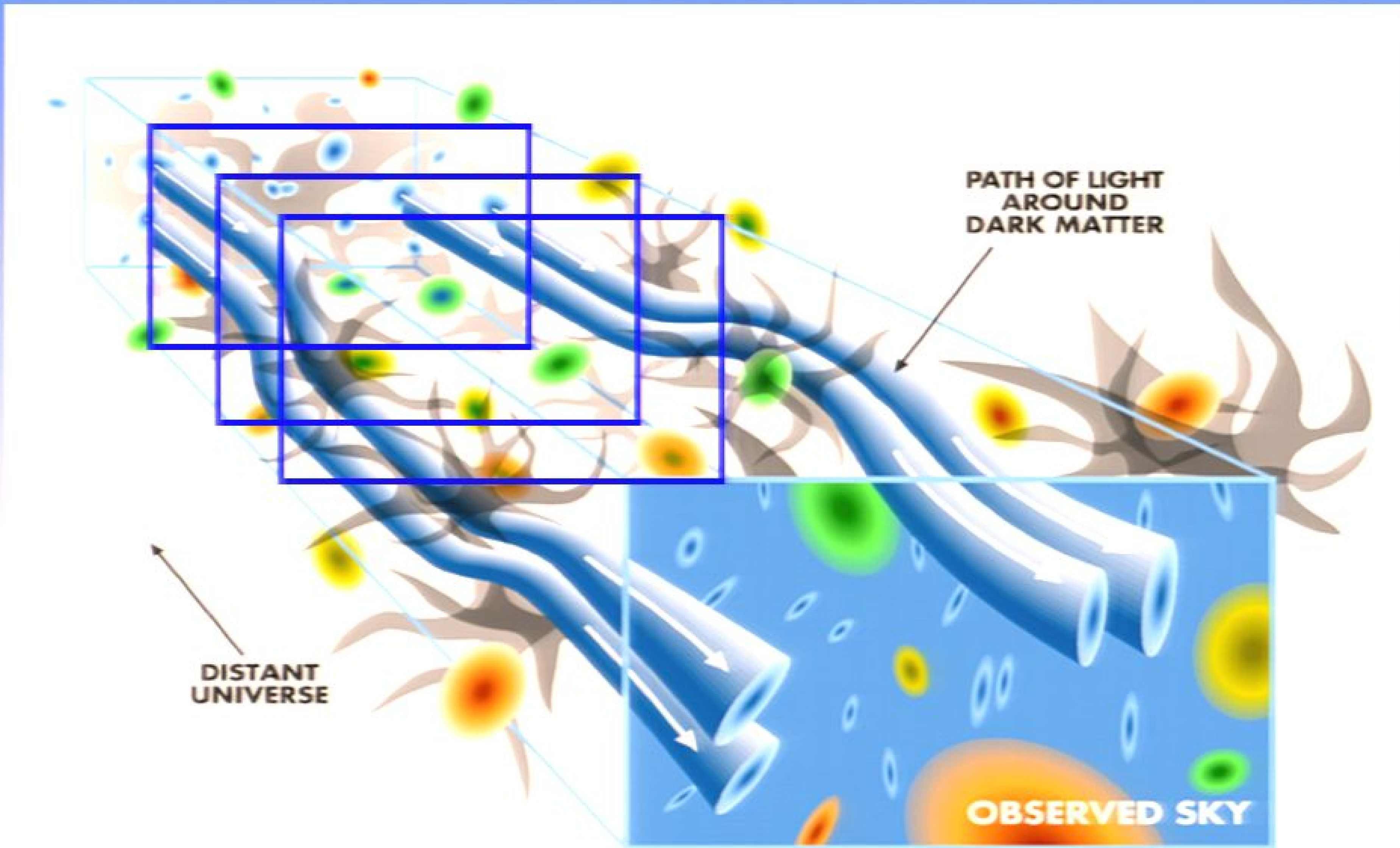
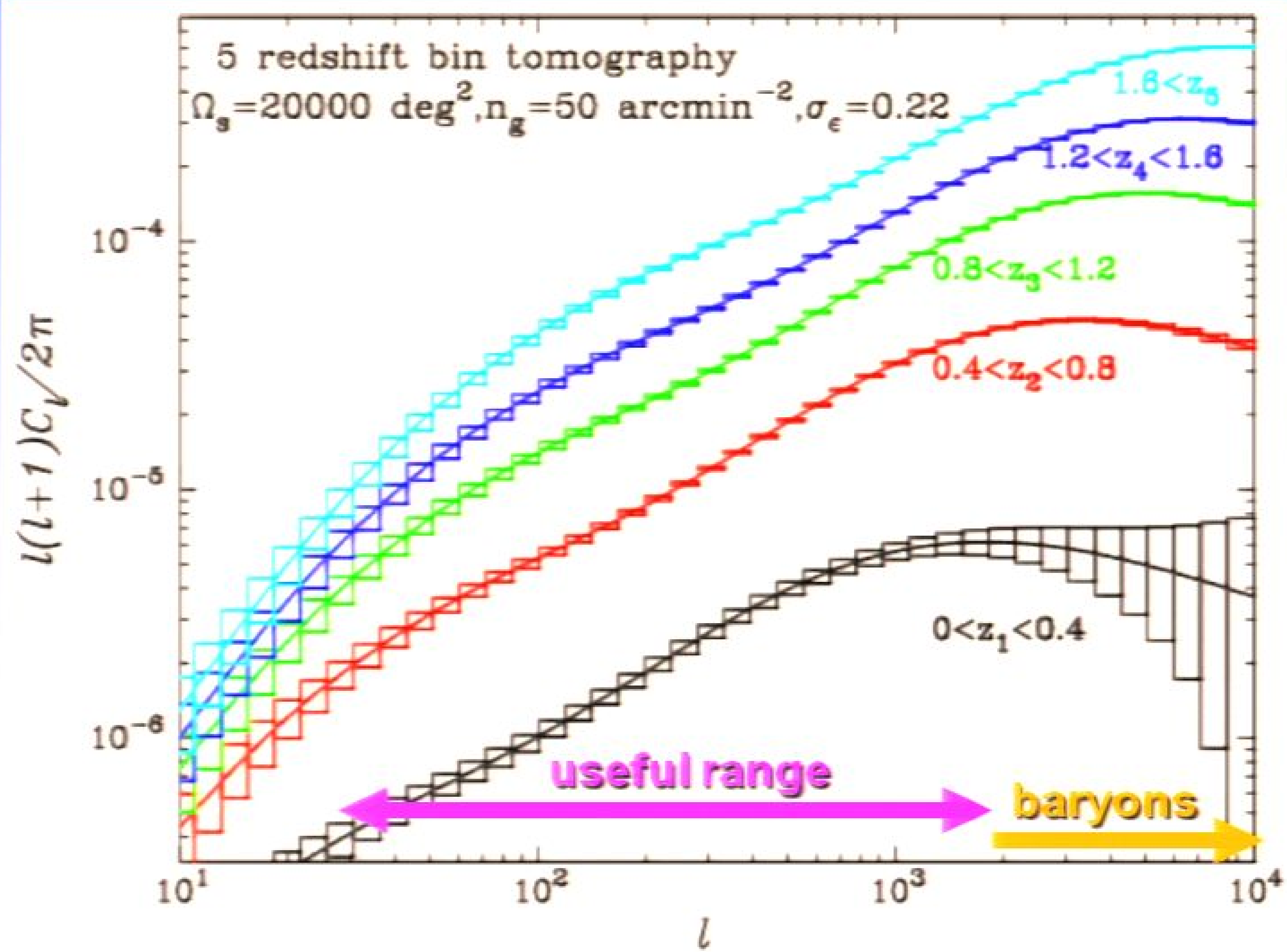
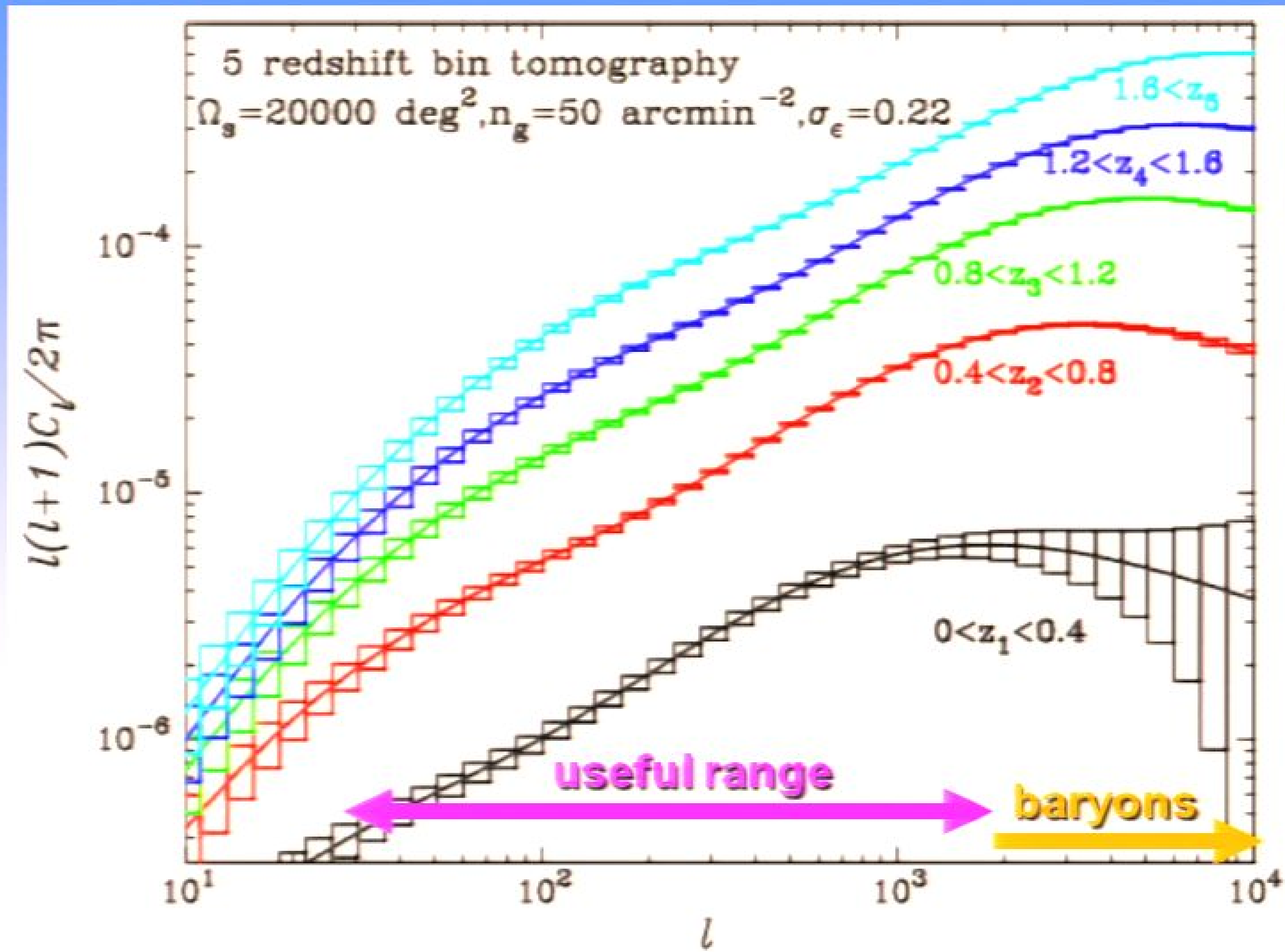


LSST and Cosmic Shear



LSST and Cosmic Shear

Ten redshift bins yield 55 auto and cross spectra



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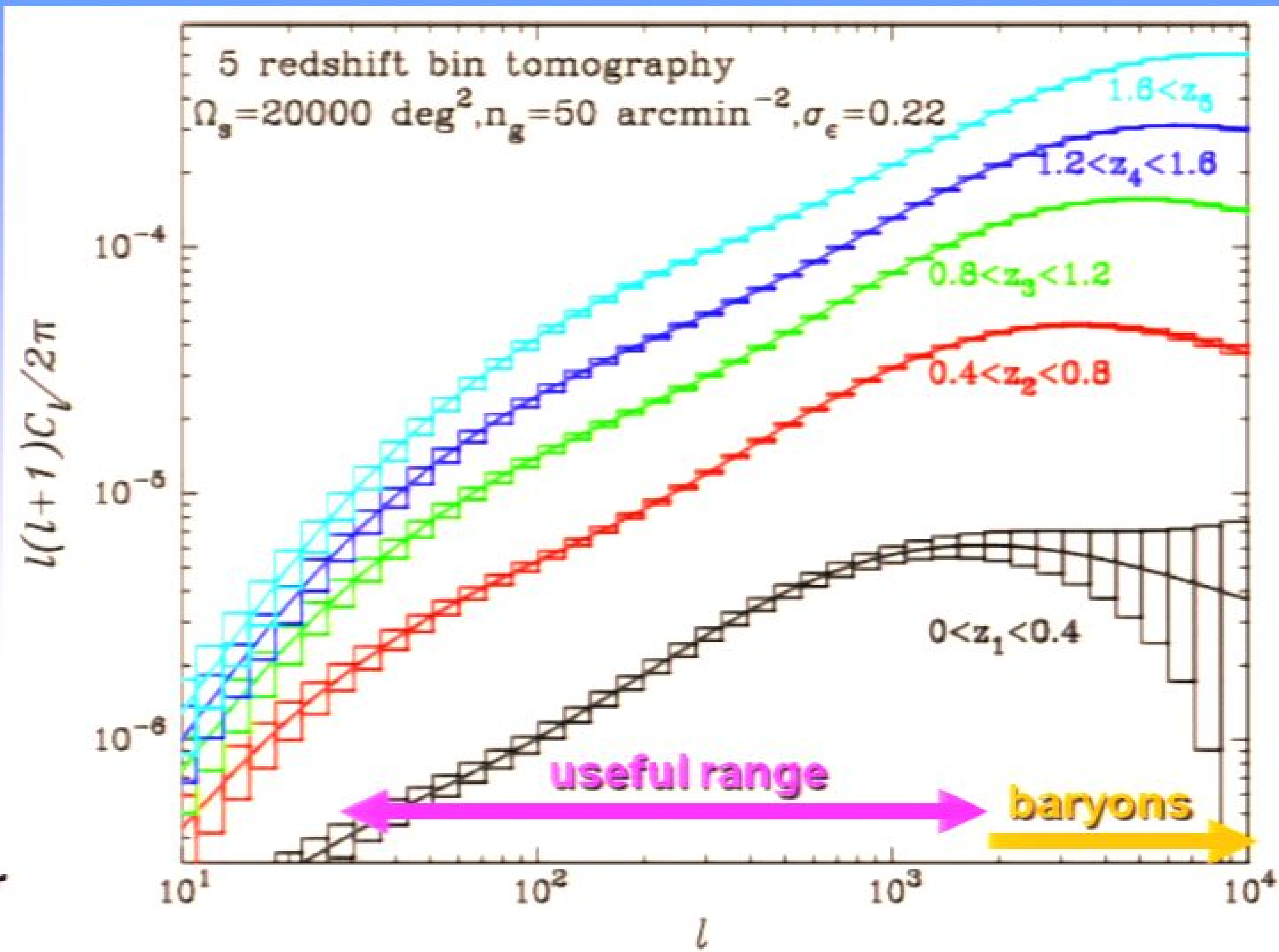
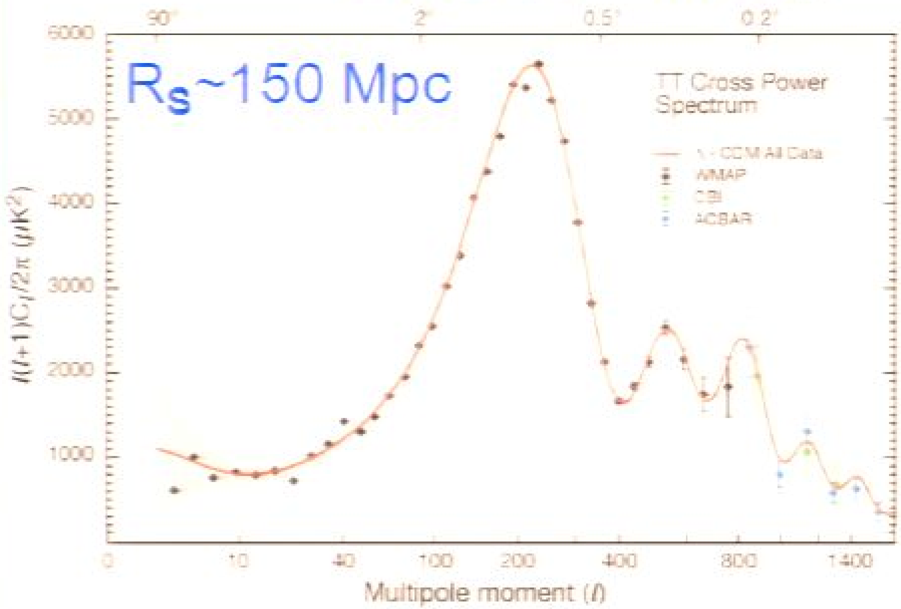
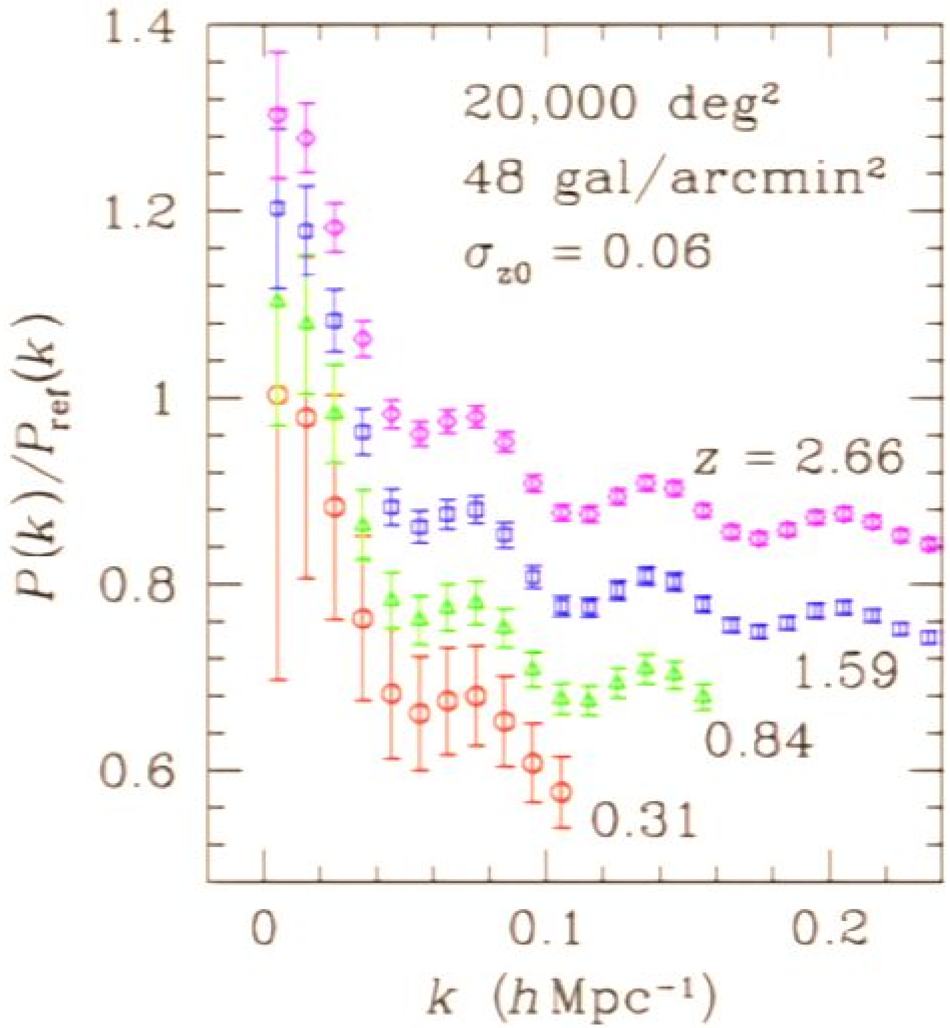


+ higher order

2-D Baryon Acoustic Oscillations

CMB (z = 1100) ⇒ BAO





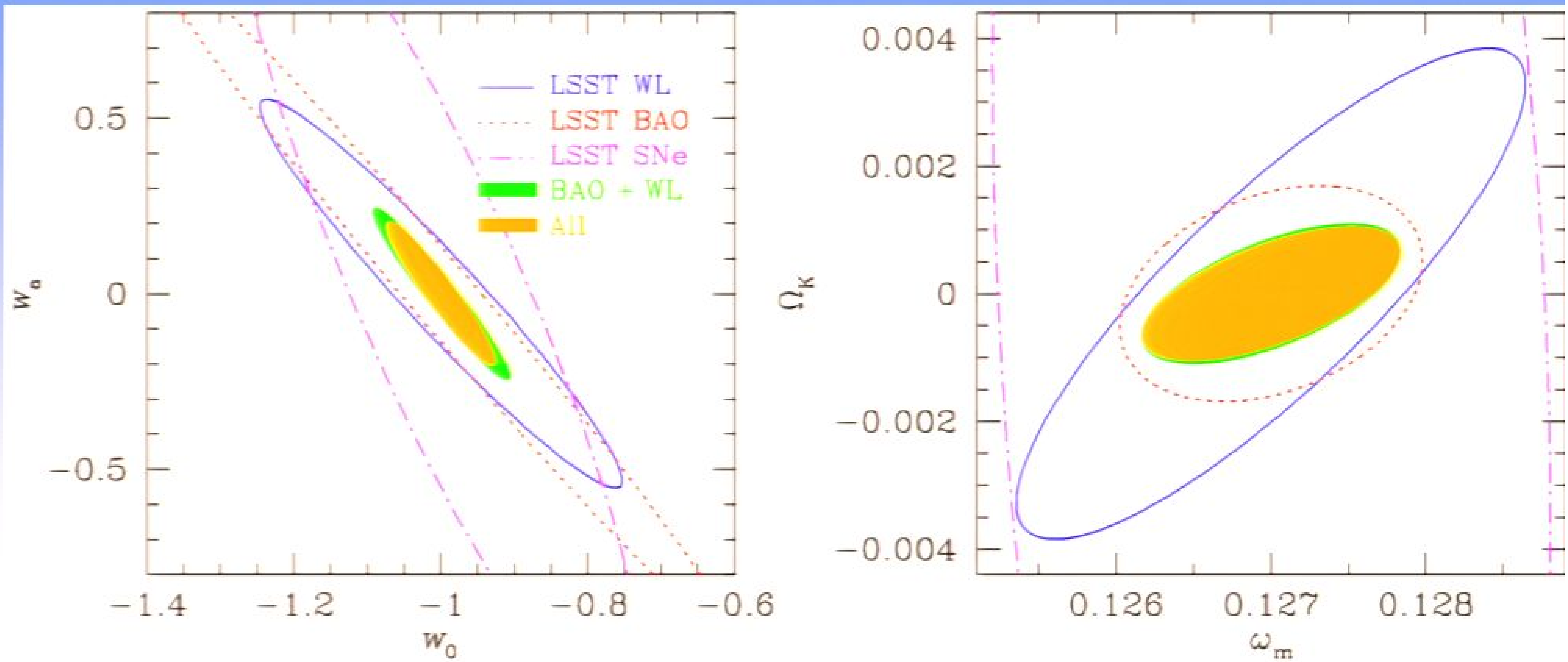
Standard Ruler

Two Dimensions on the Sky

Angular Diameter Distances

LSST Precision on Dark Energy [in DETF language]

Zhan 2006



Combining techniques breaks degeneracies.

Requires wide sky area deep survey.

Critical Issues

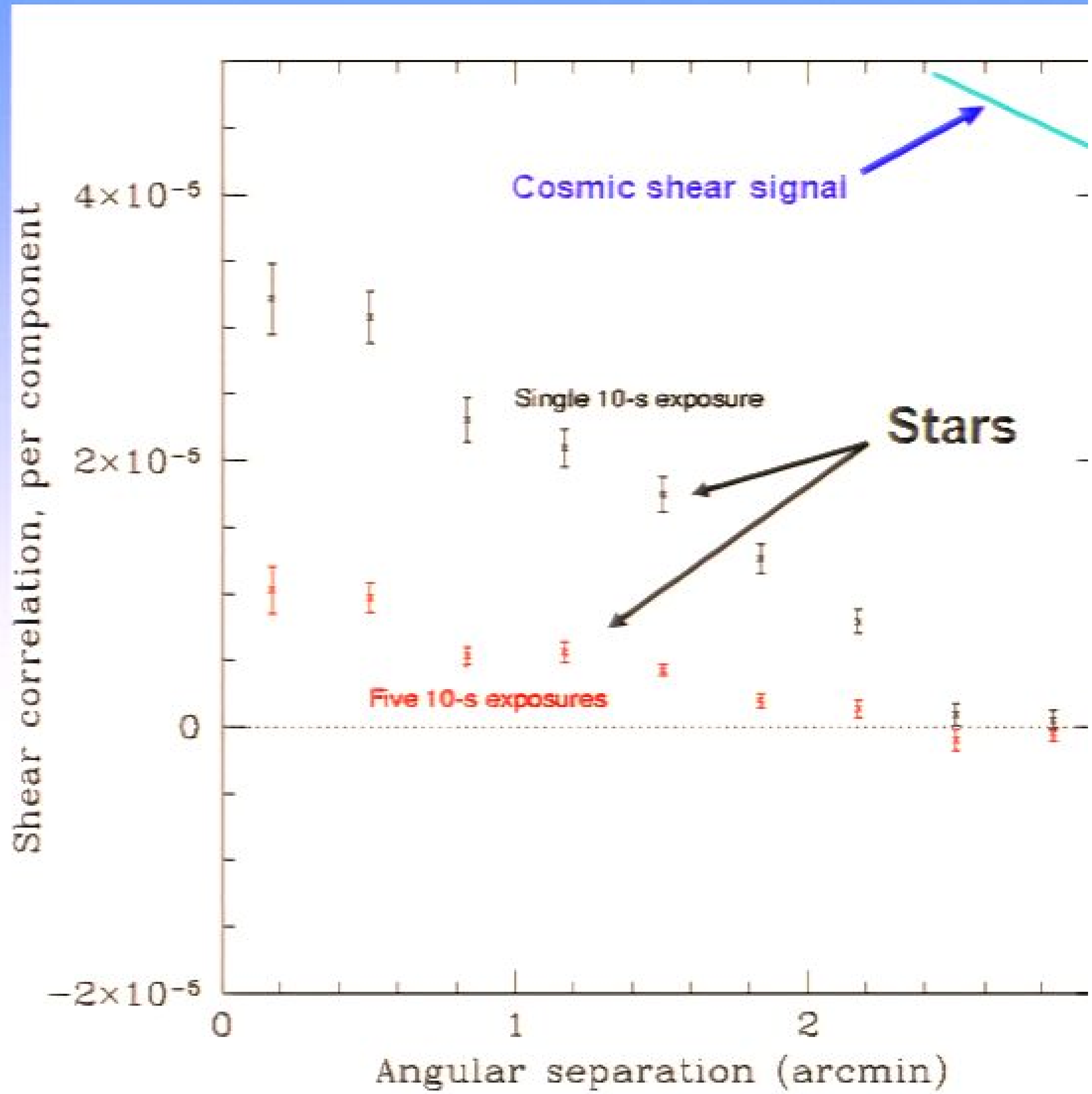
- WL shear reconstruction errors
  - Show control to better than required precision using existing new facilities ✓
- Photometric redshift errors
  - Develop robust photo-z calibration plan ✓
  - Undertake world campaign for spectroscopy (✓)
- Photometry errors
  - Develop and test precision flux calibration technique ✓

Residual shear correlation

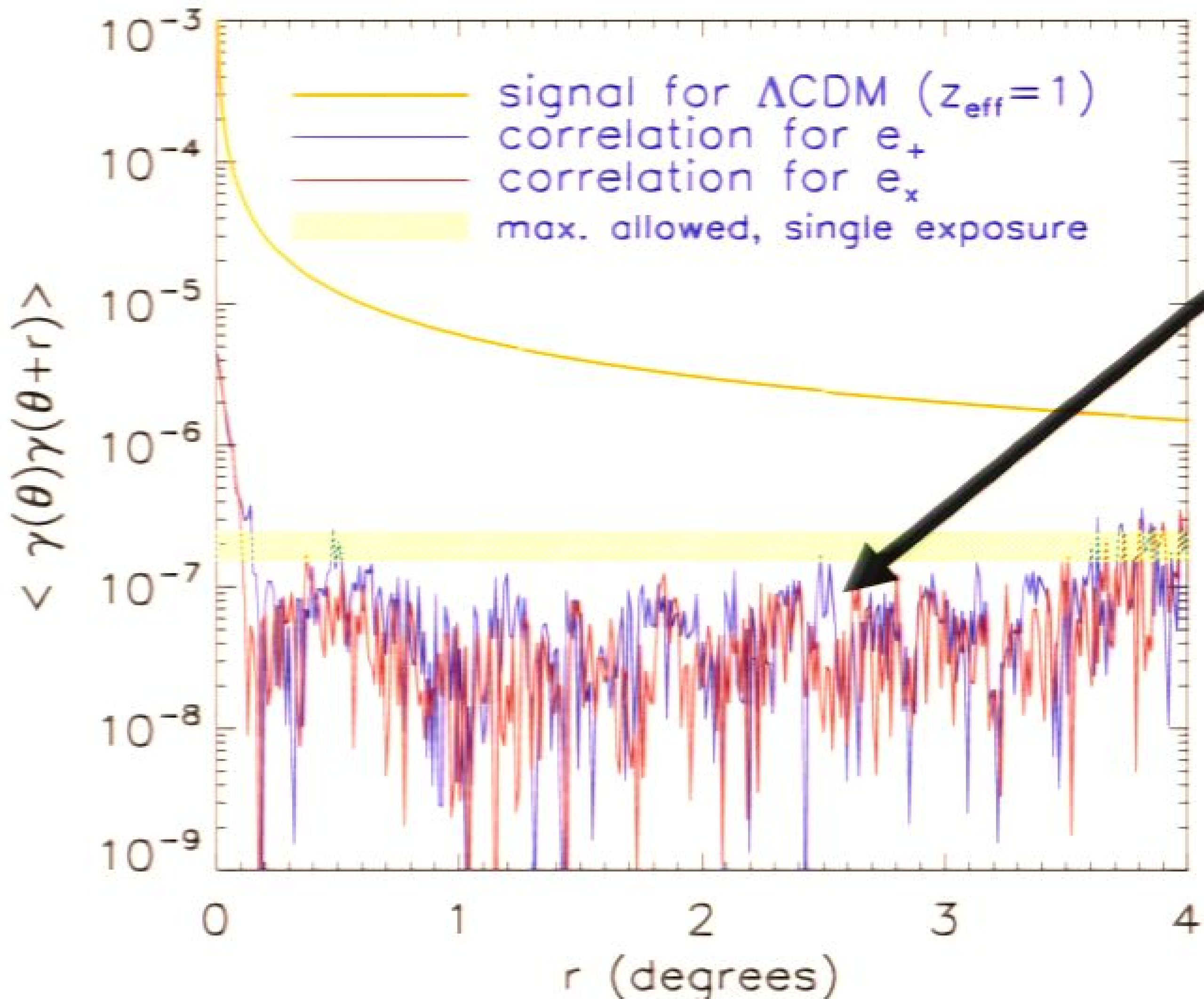
Test of shear systematics: Use faint stars as proxies for galaxies, and calculate the shear-shear correlation after correcting for PSF ellipticity via a different set of stars.

Compare with expected cosmic shear signal.

Conclusion: 200 exposures per sky patch will yield negligible PSF induced shear systematics. Wittman (2005)



ellipticity correlation of the residual PSF: single exposure

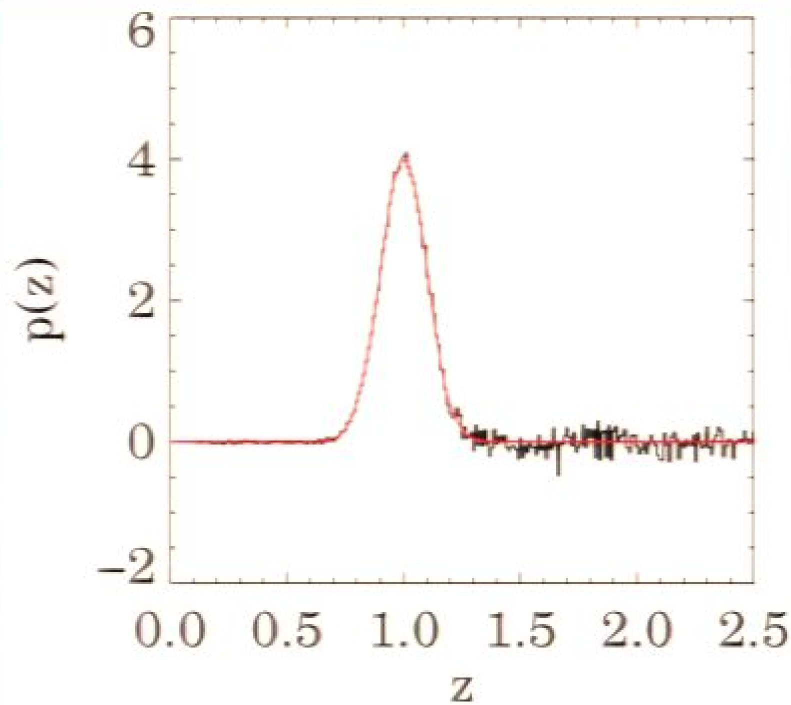


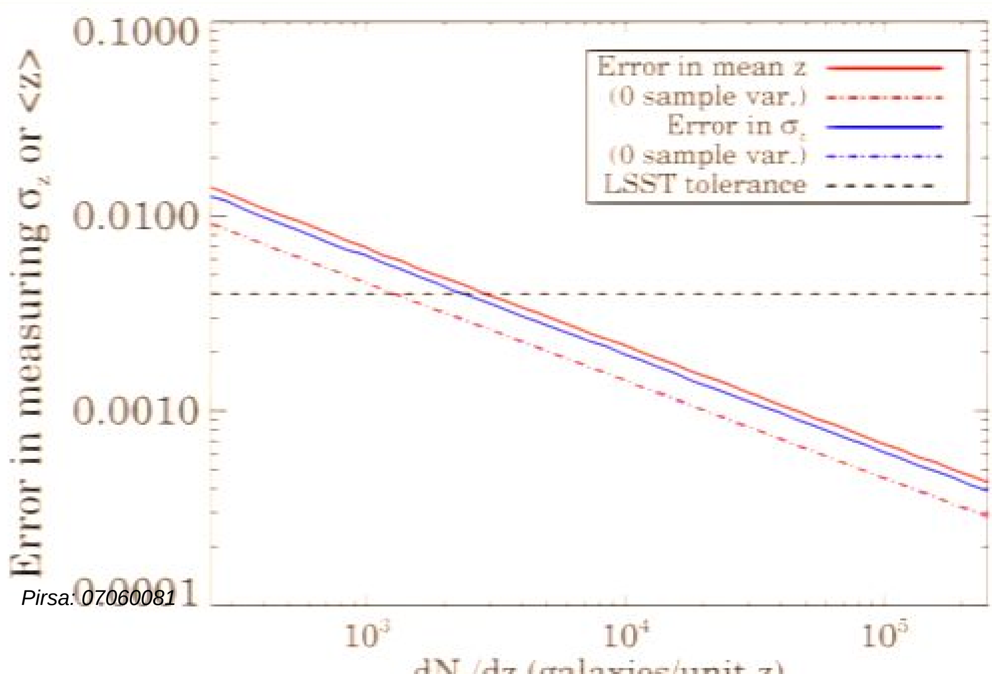
Averages down like 1 / number of exposures

Simulation of 0.6" seeing. J. Jee 2007

Calibrating photometric redshifts

Cross-correlation LSS-based techniques can reconstruct the true z distribution of a photo-z bin, even with spectroscopy of only the brightest galaxies at each z.



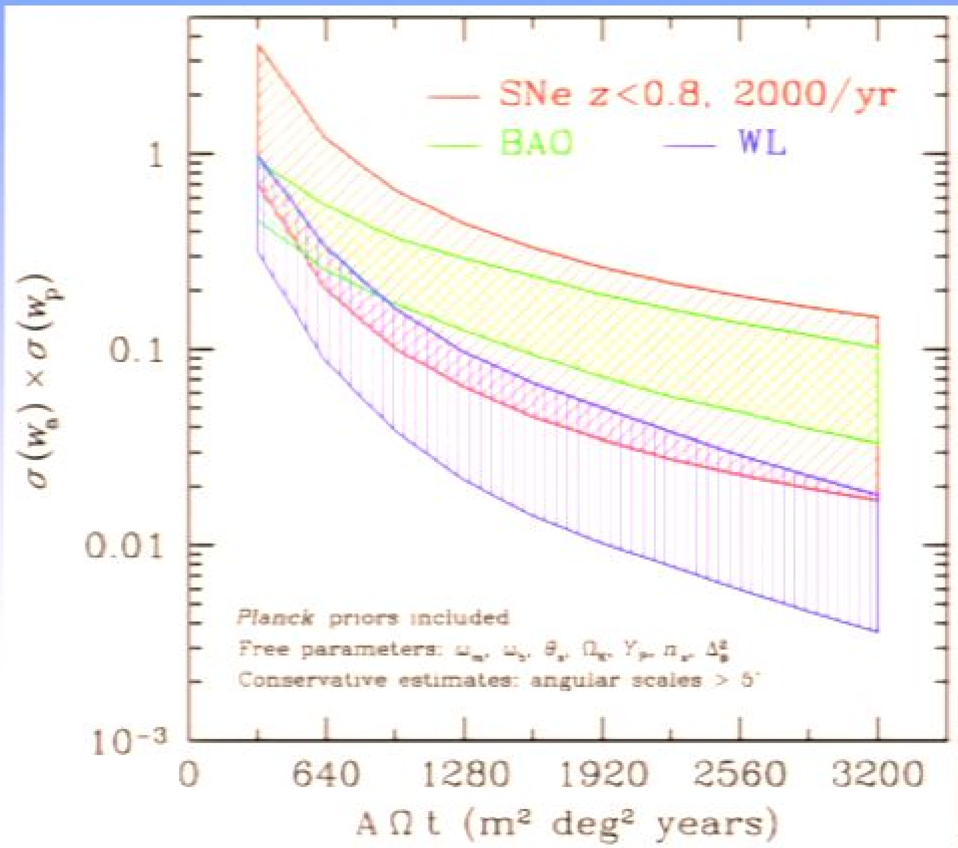


These techniques meet LSST requirements with easily attainable spectroscopic samples, ~10^4 galaxies per unit z.

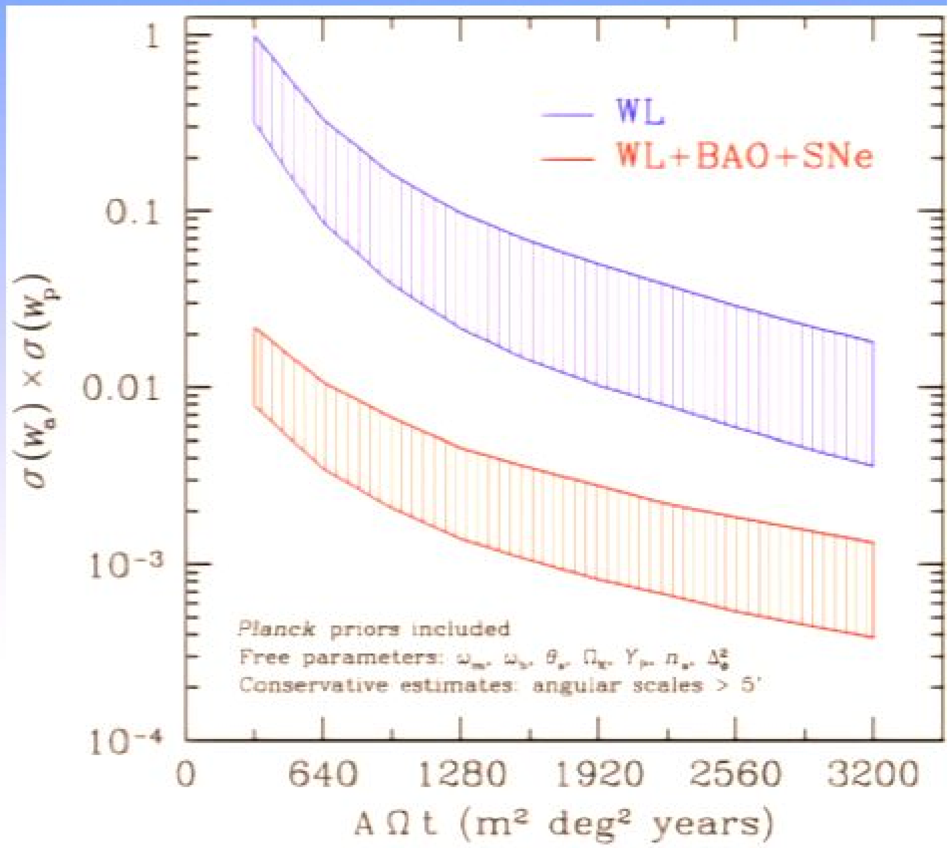
Newman 2008

DETF FoM vs Etendue-Time

Separate DE Probes

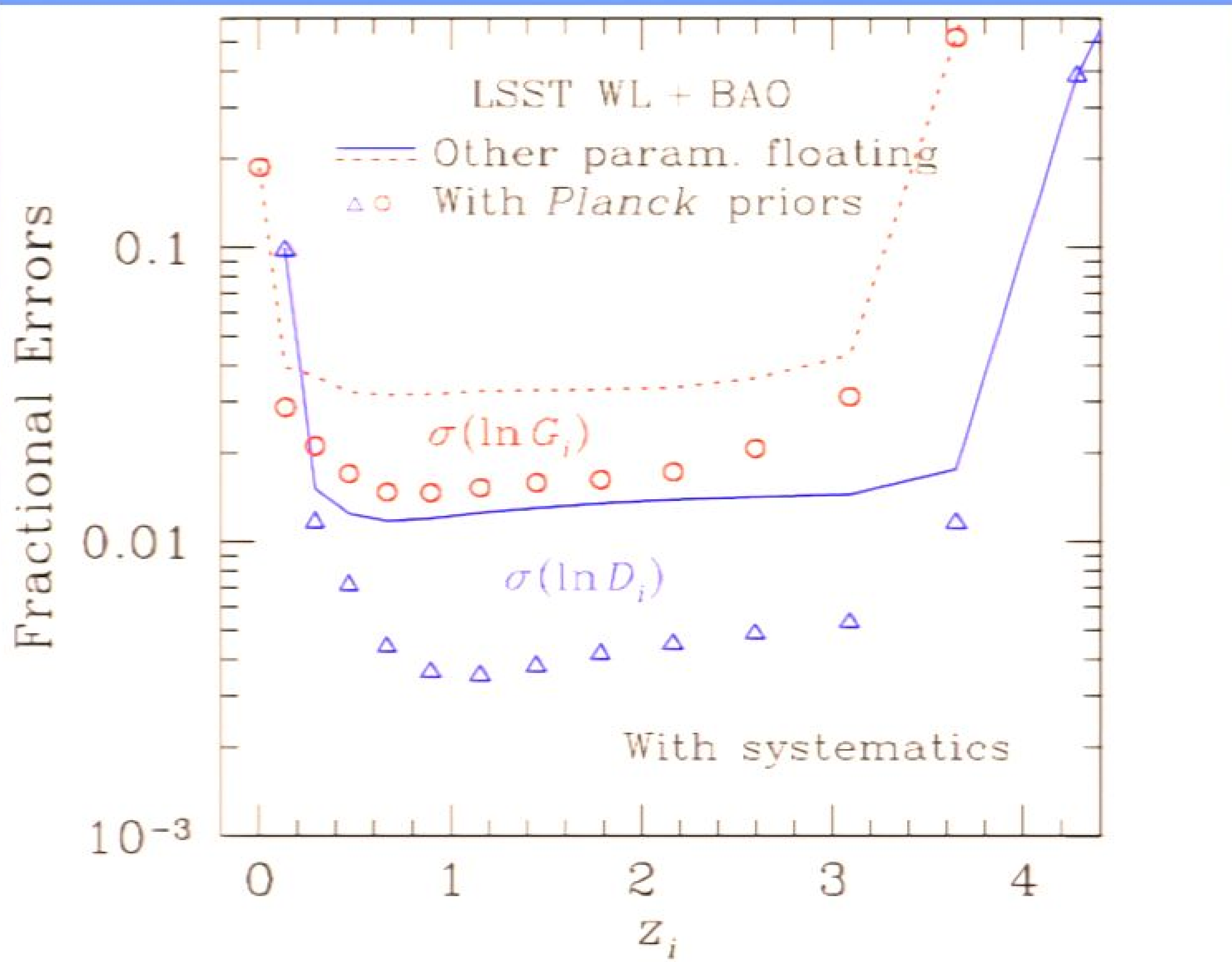


Combined

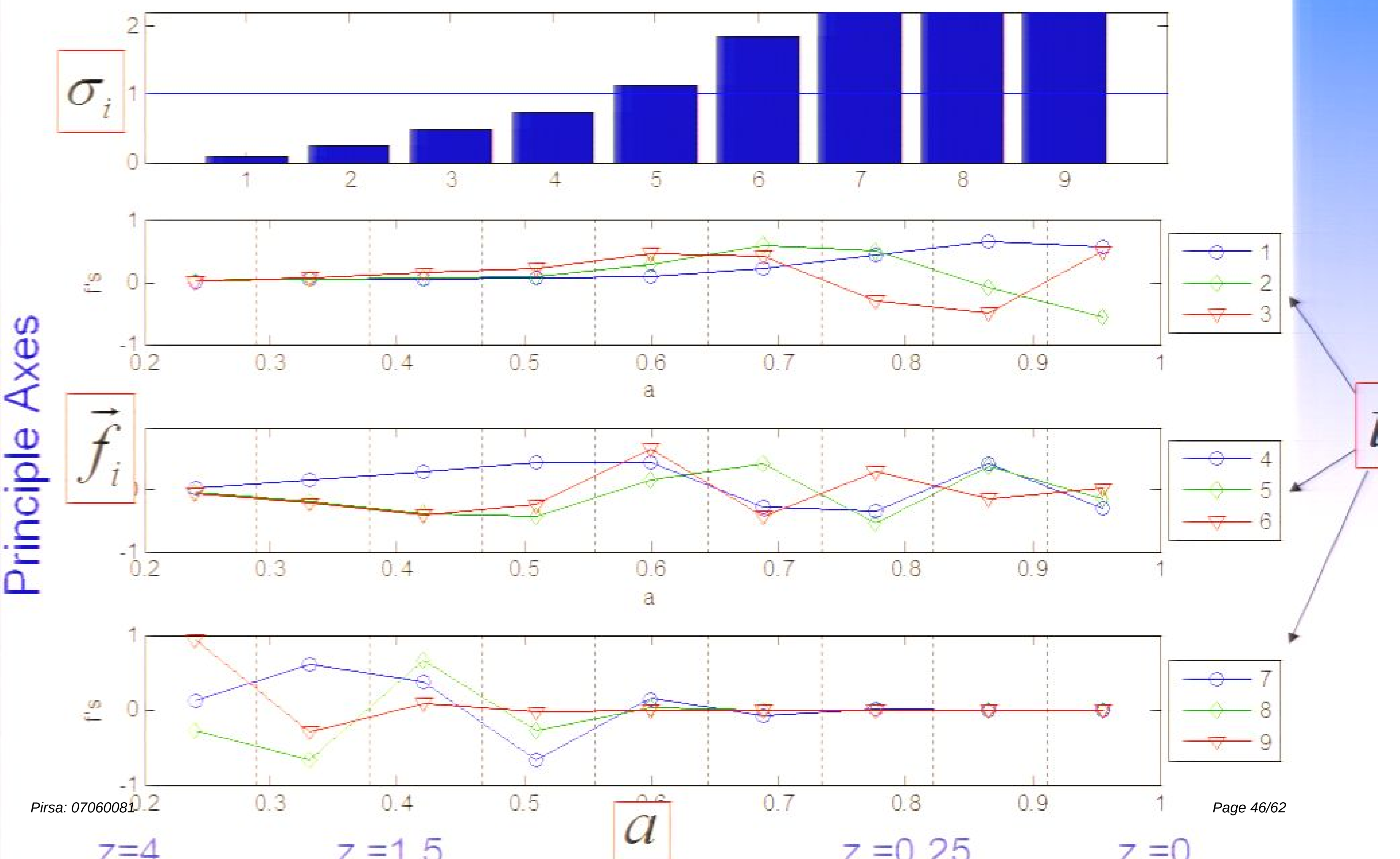


First light 2014 Survey commissioning & operations 2015-2025

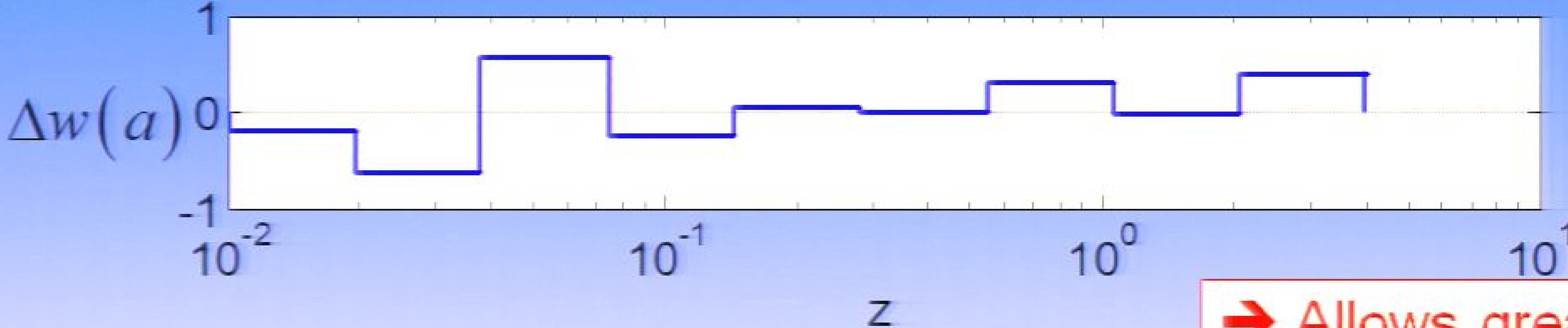
Testing more general DE models



DETF Stage 2 (now)



Try 9D stepwise constant w(a)



$$w(a) = -1 + \Delta w(a) = -1 + \sum_{i=1}^{9} \Delta w_i T(a_i, a_{i+1})$$

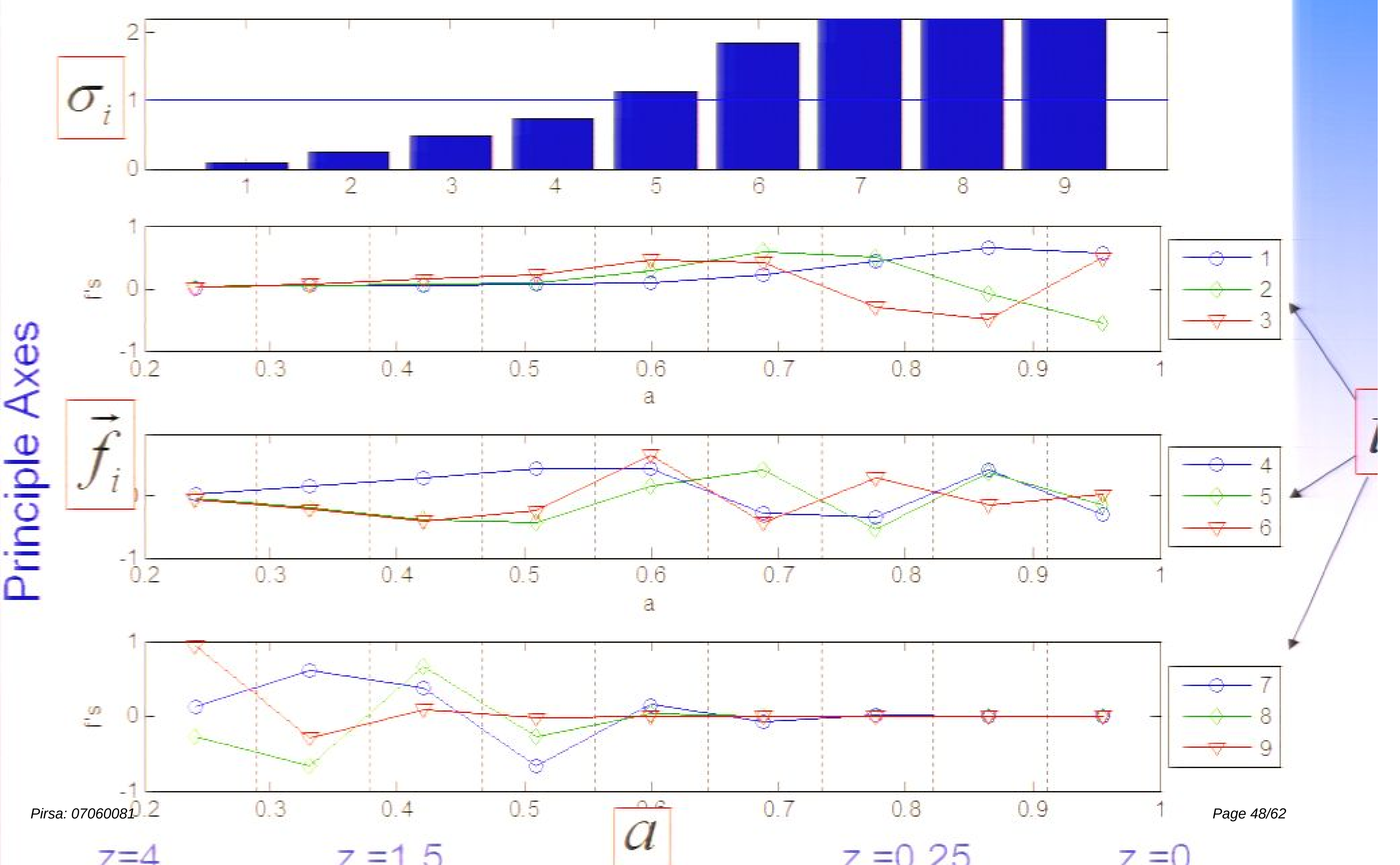
9 parameters are coefficients of the "top hat functions" $T(a_i, a_{i+1})$

➔ Allows greater variety of w(a) behavior

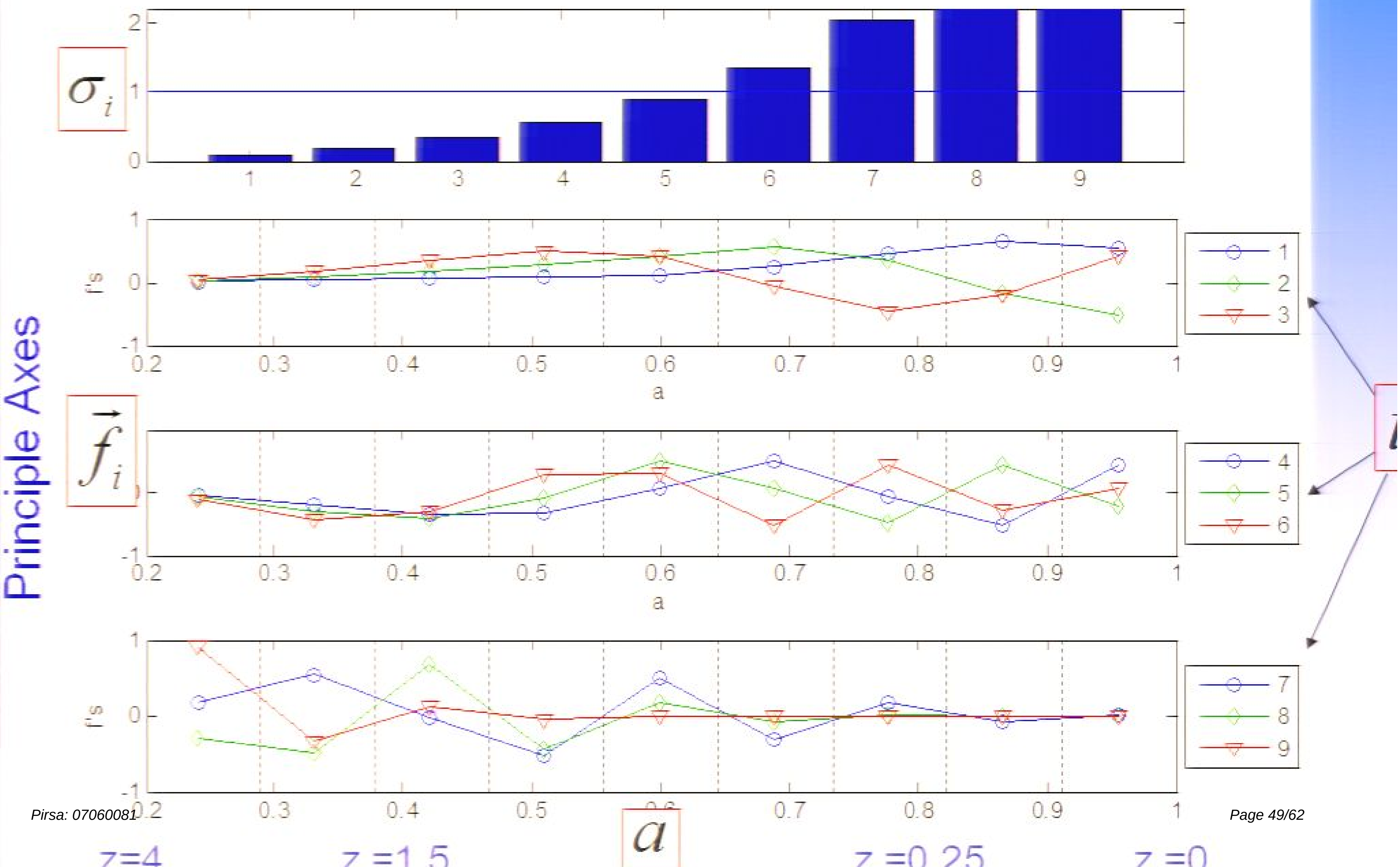
➔ Any signal rejects Λ

Albrecht & Bernstein 2006 astro-ph/0608269

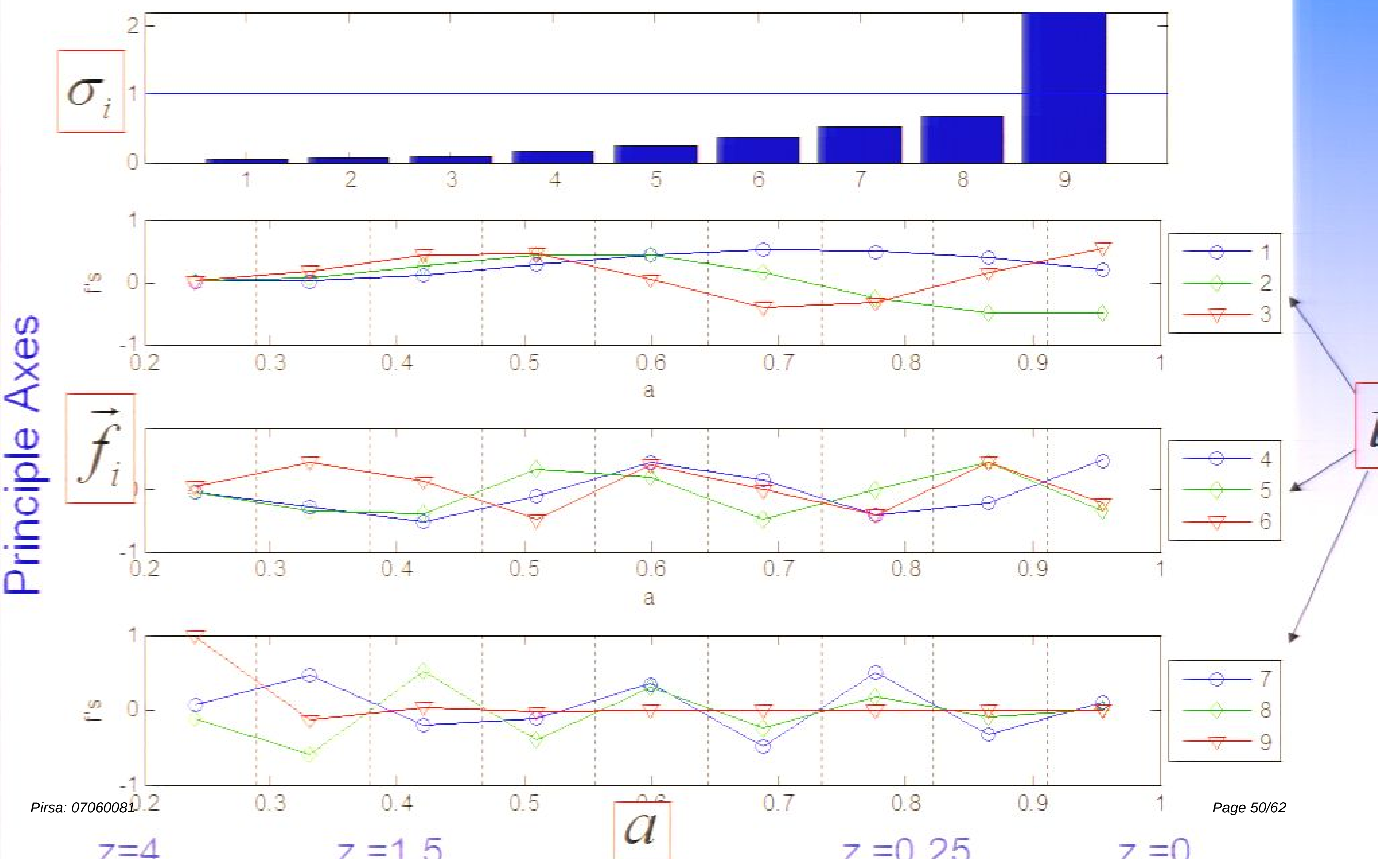
DETF Stage 2 (now)



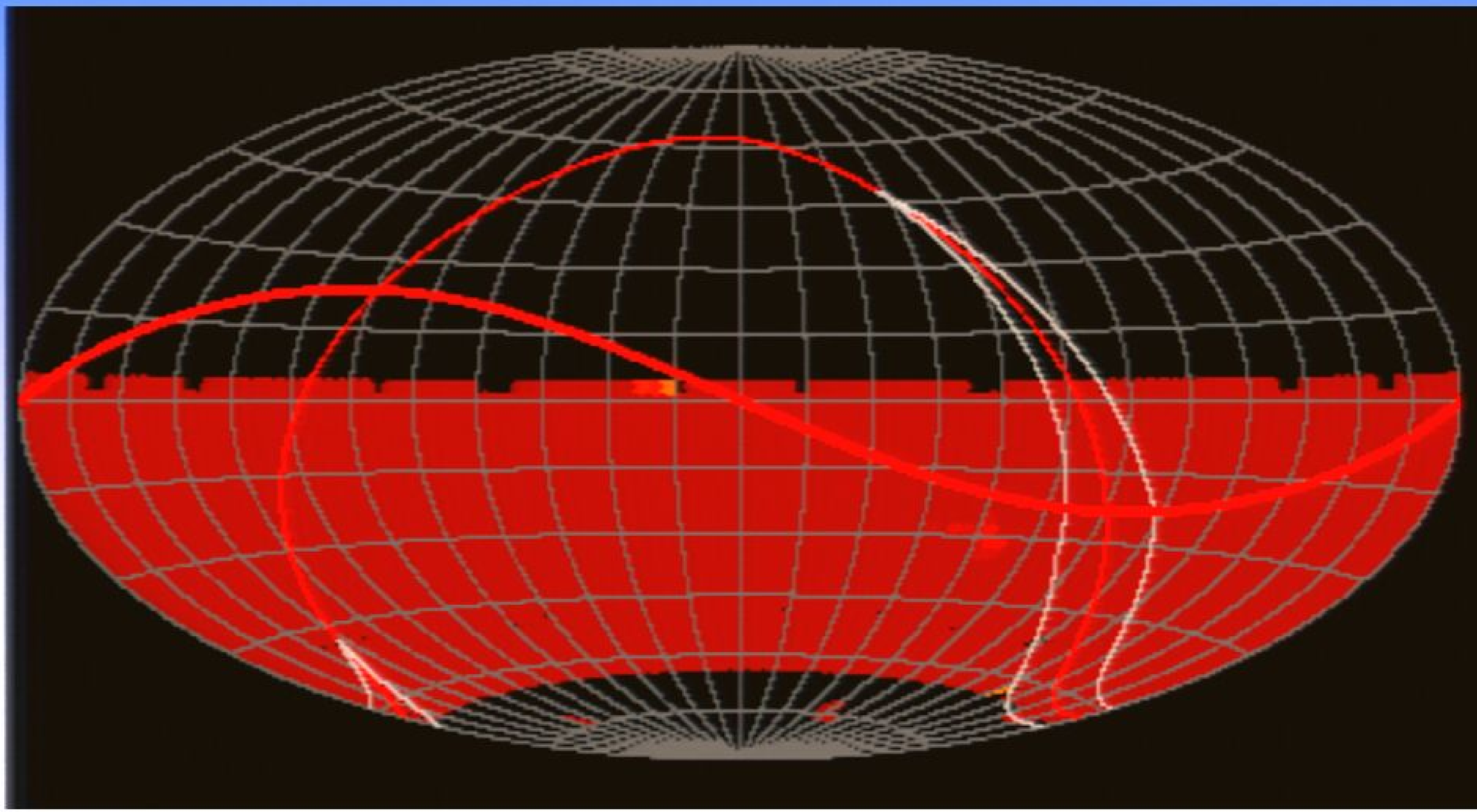
DETF Stage 3 (DES)



DETF Stage 4 (LSST)



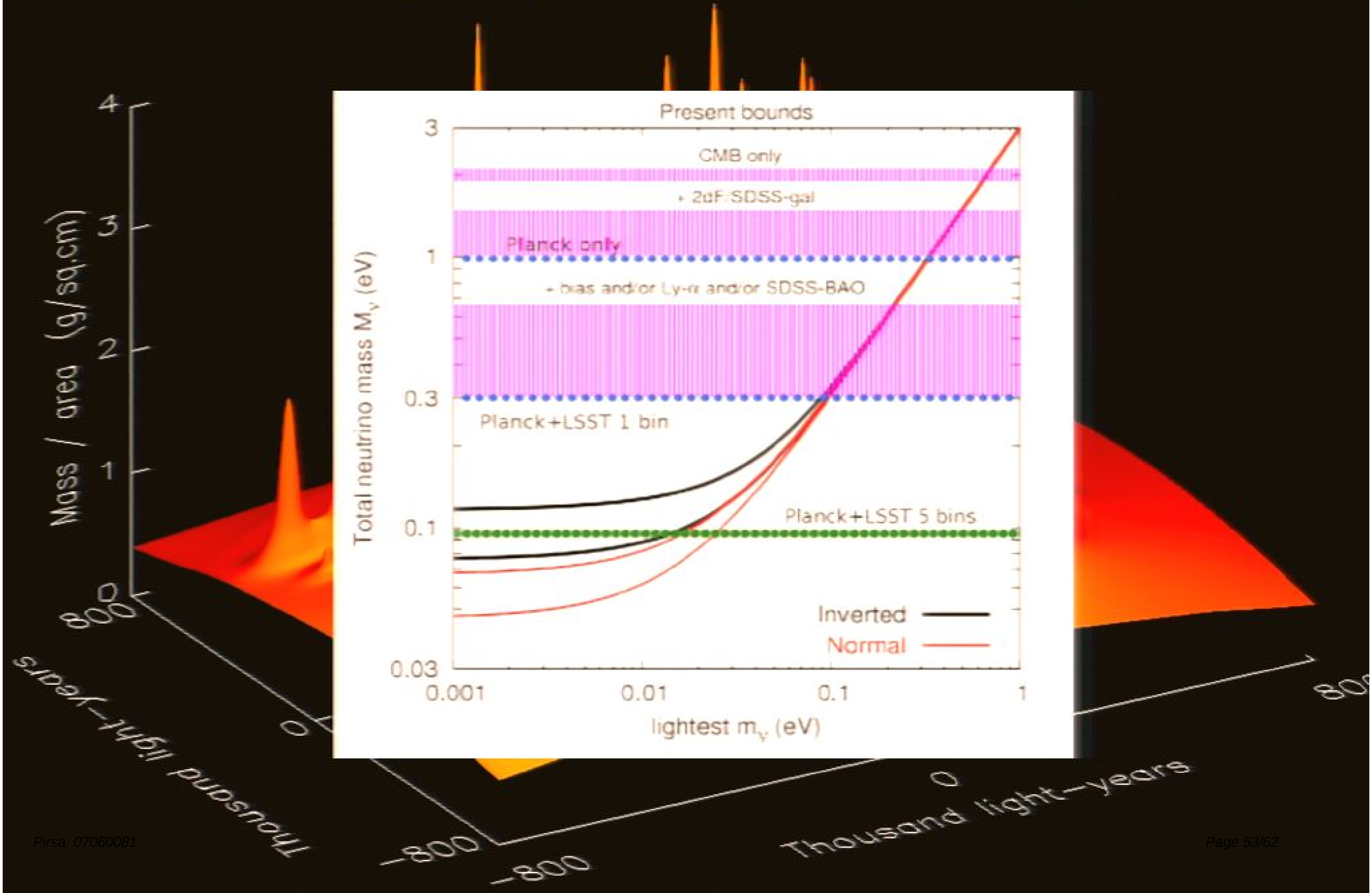
Probe anisotropy



multiple probes of dark energy

- WL shear-shear tomography
- WL bi-spectrum tomography
- Distribution of 250,000 shear peaks
- Baryon acoustic oscillations
- 1 million SNe Ia, z<1 per year
- Low l, 2π sky coverage: anisotropy?
  $3x10^9$ galaxies, 10^6 SNe
- probe growth(z) and d(z) separately
- multiply lensed AGNs and SNe

LSST will measure total neutrino mass



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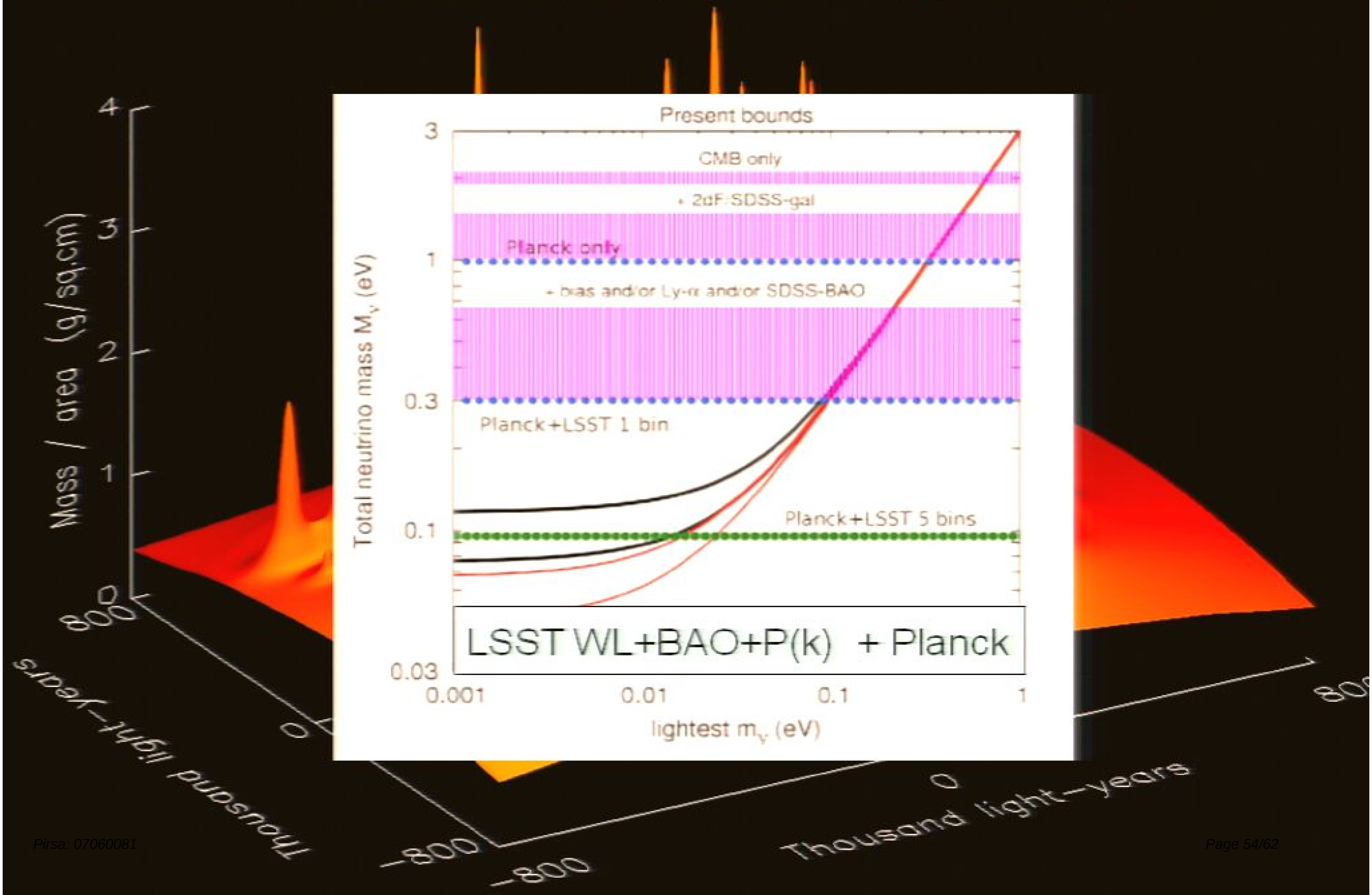
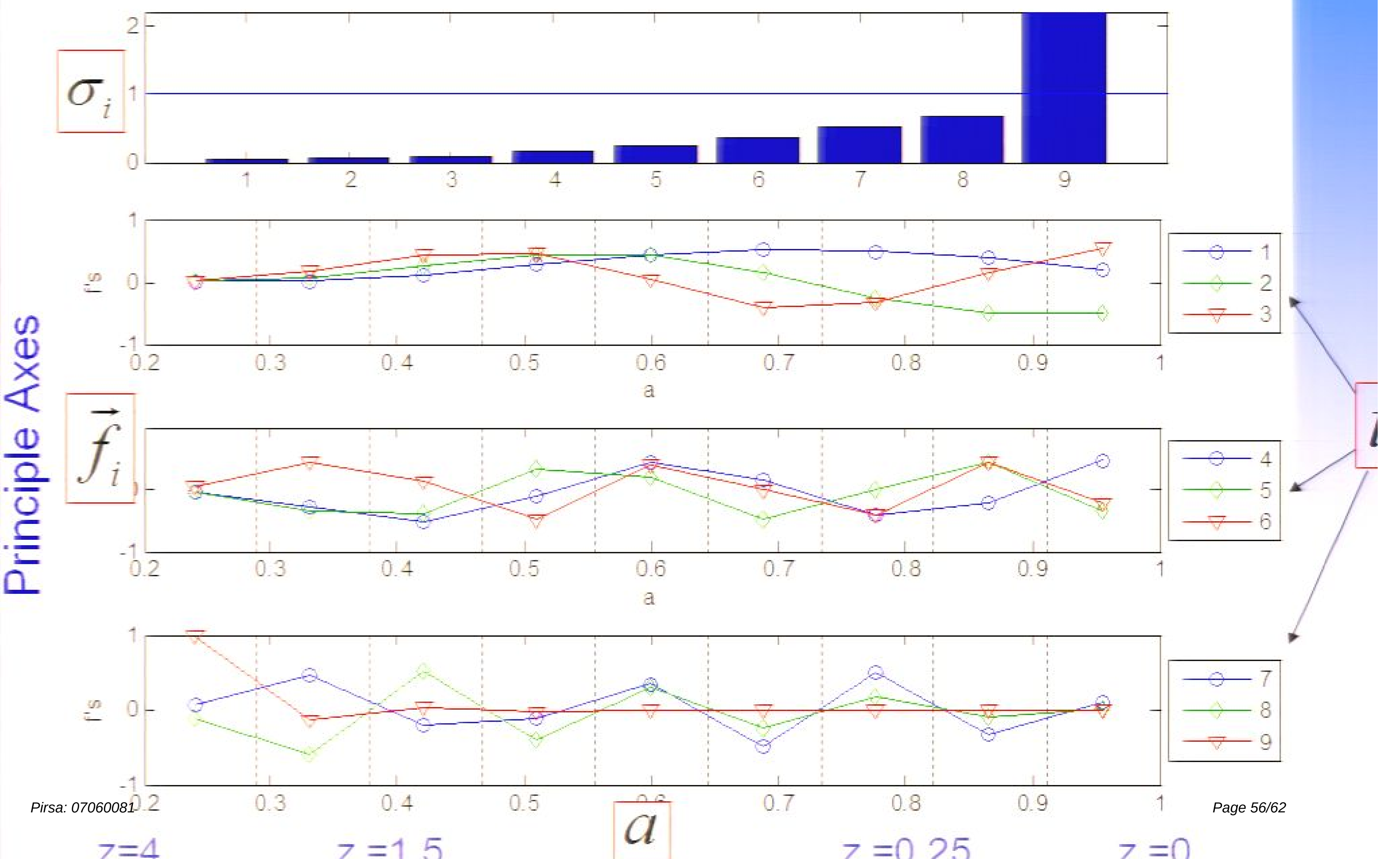



lsst.org

DETF Stage 4 (LSST)



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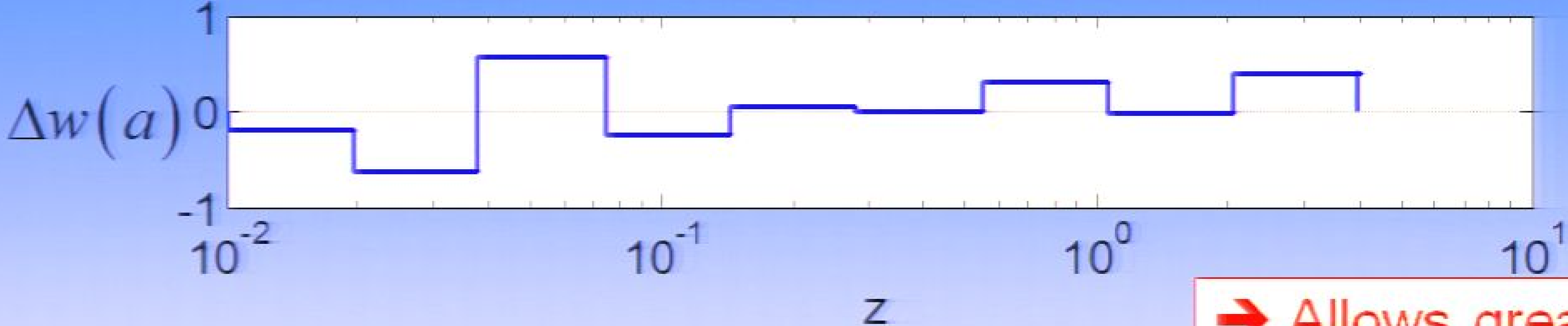

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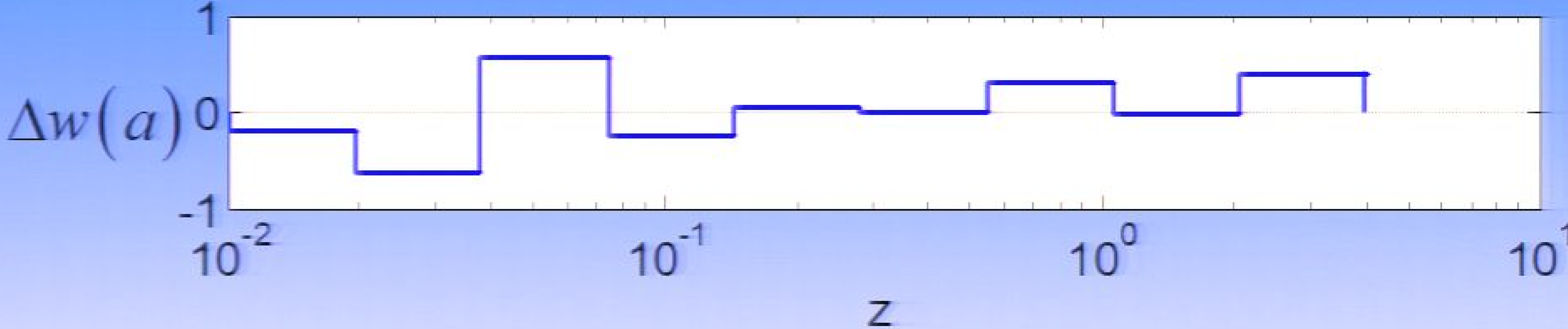

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Used by

Huterer & Turner;
Huterer & Starkman;
Knox et al;
Crittenden & Pogosia
Linder; Reiss et al;
Krauss et al
de Putter & Linder;
Sullivan et al

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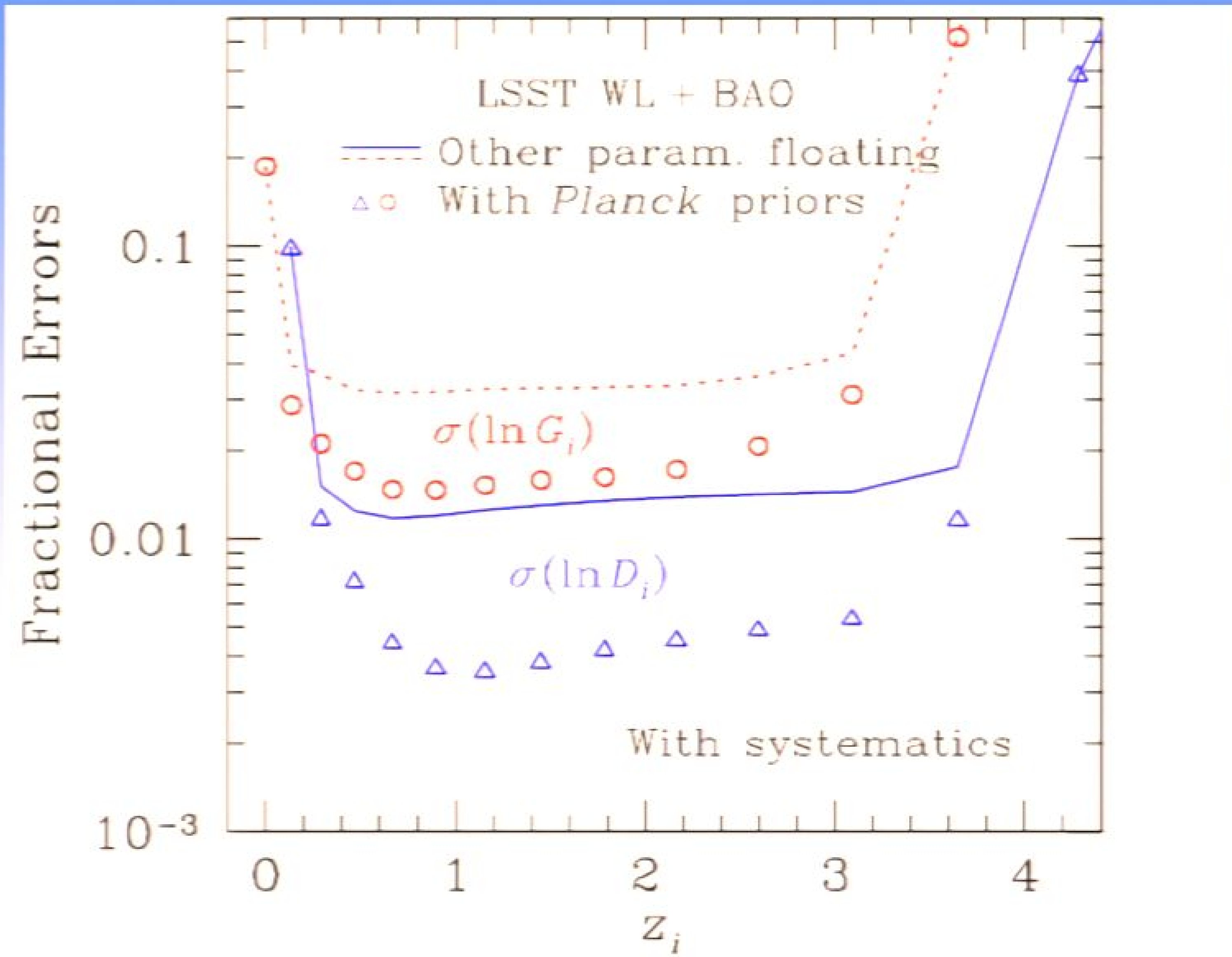

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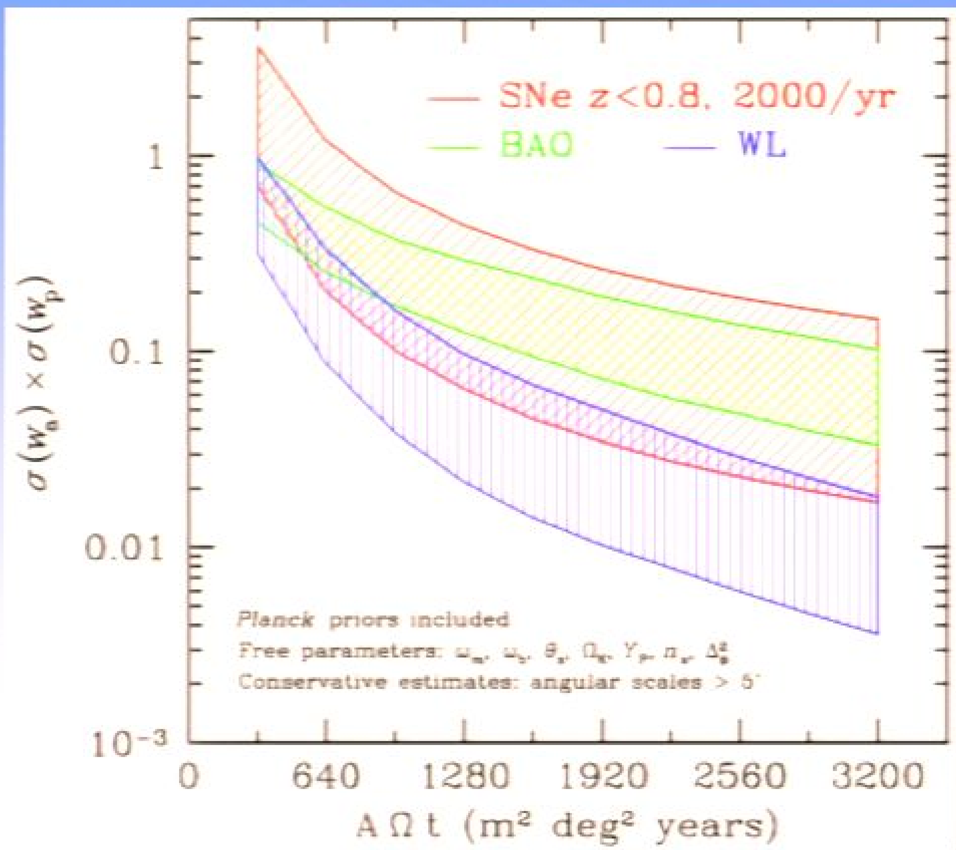

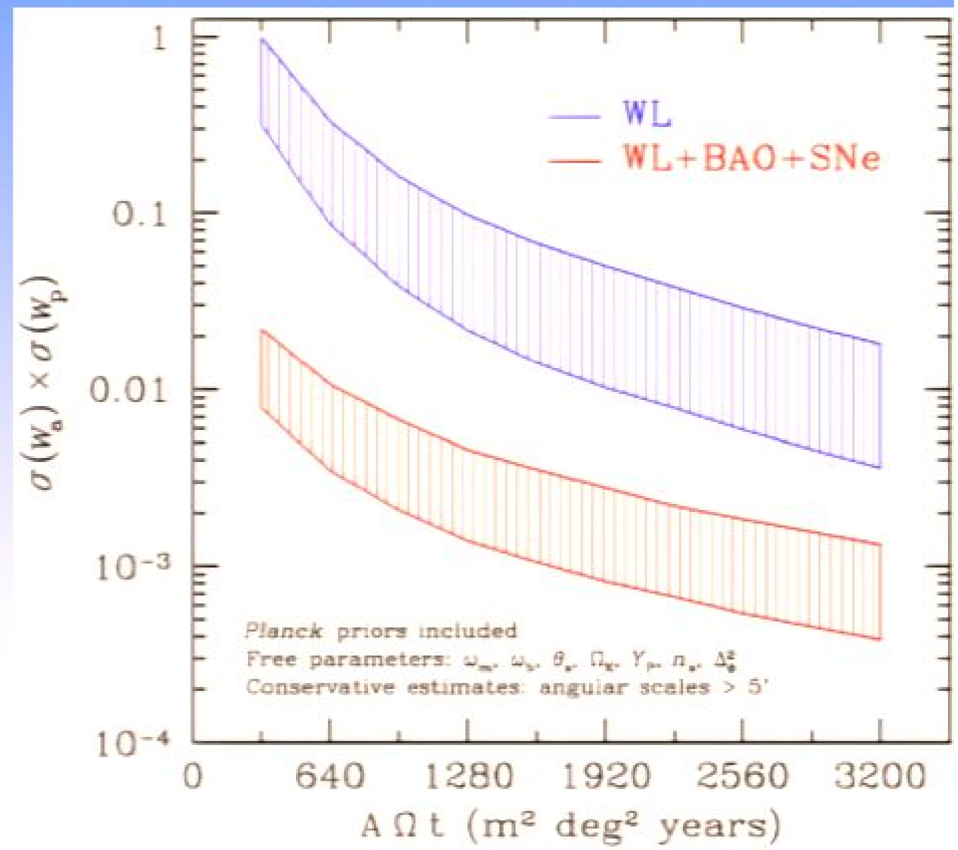

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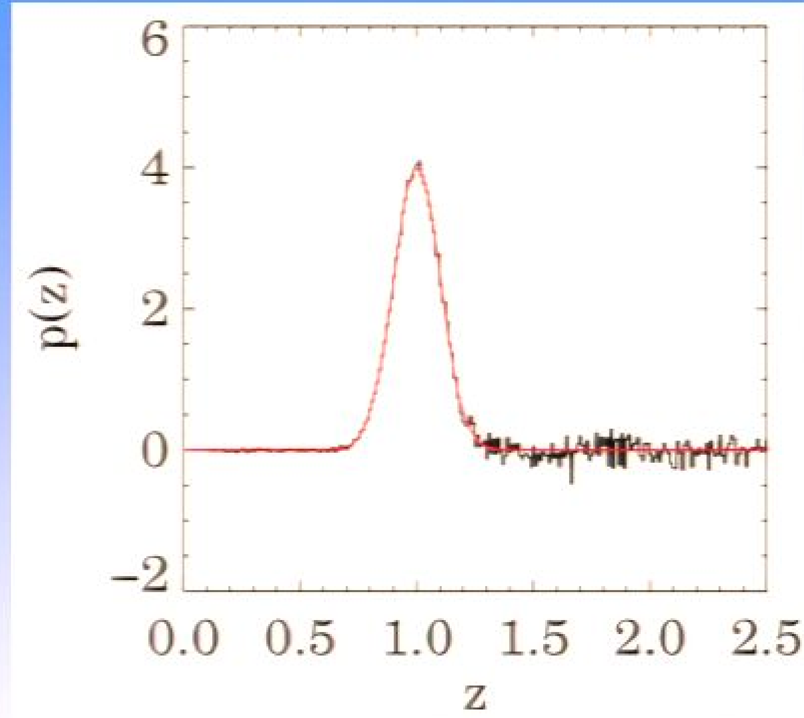

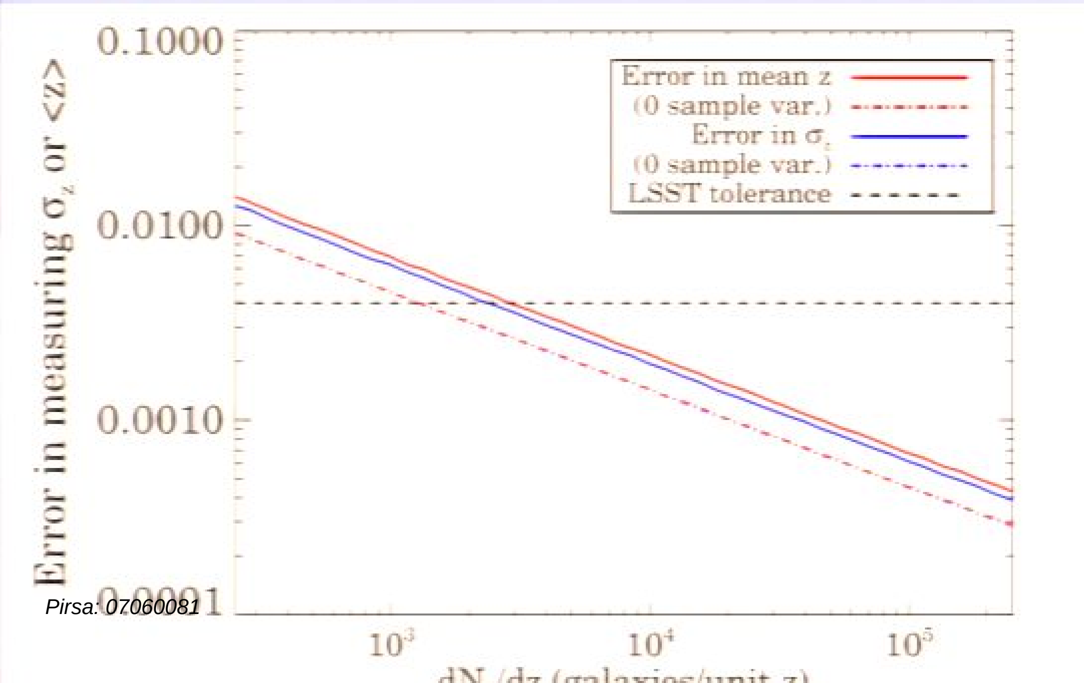

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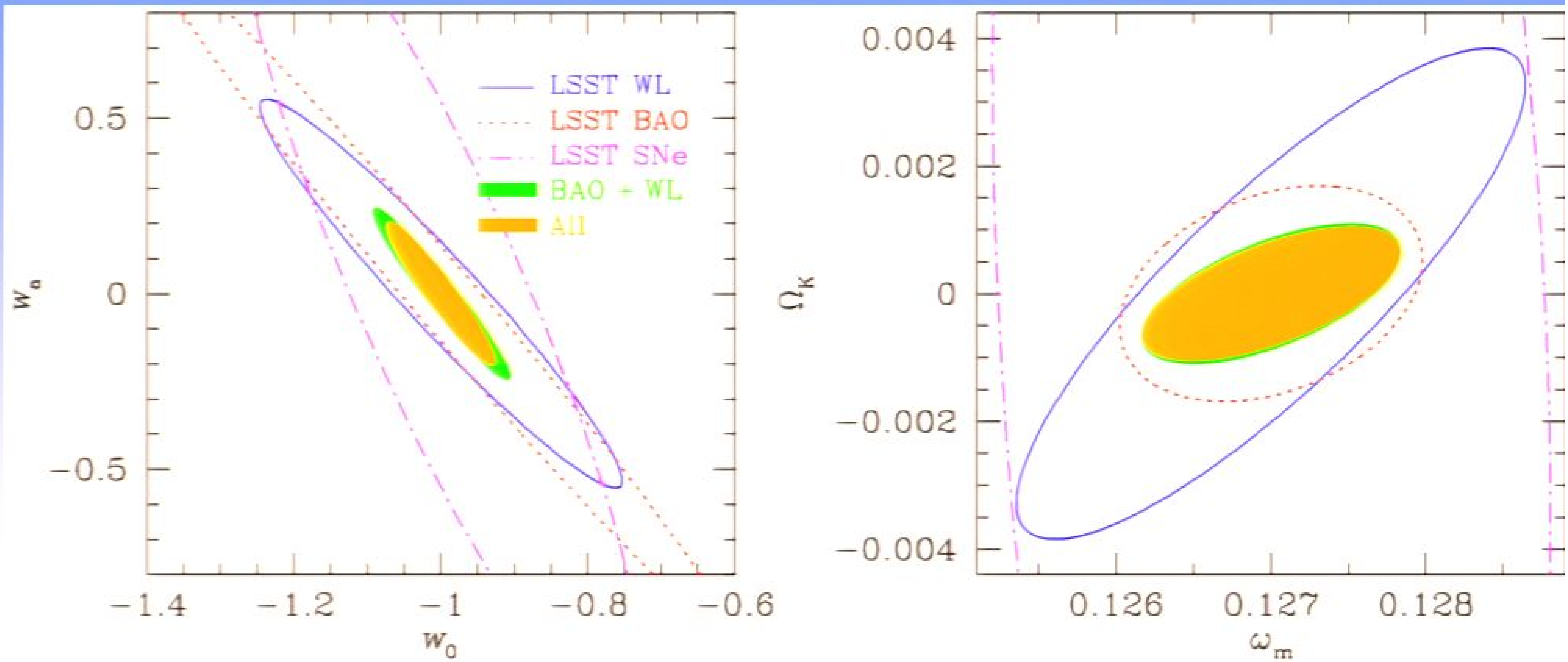

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