Large Synoptic Survey Telescope

Extragalactic Science with the LSST

Phil Marshall

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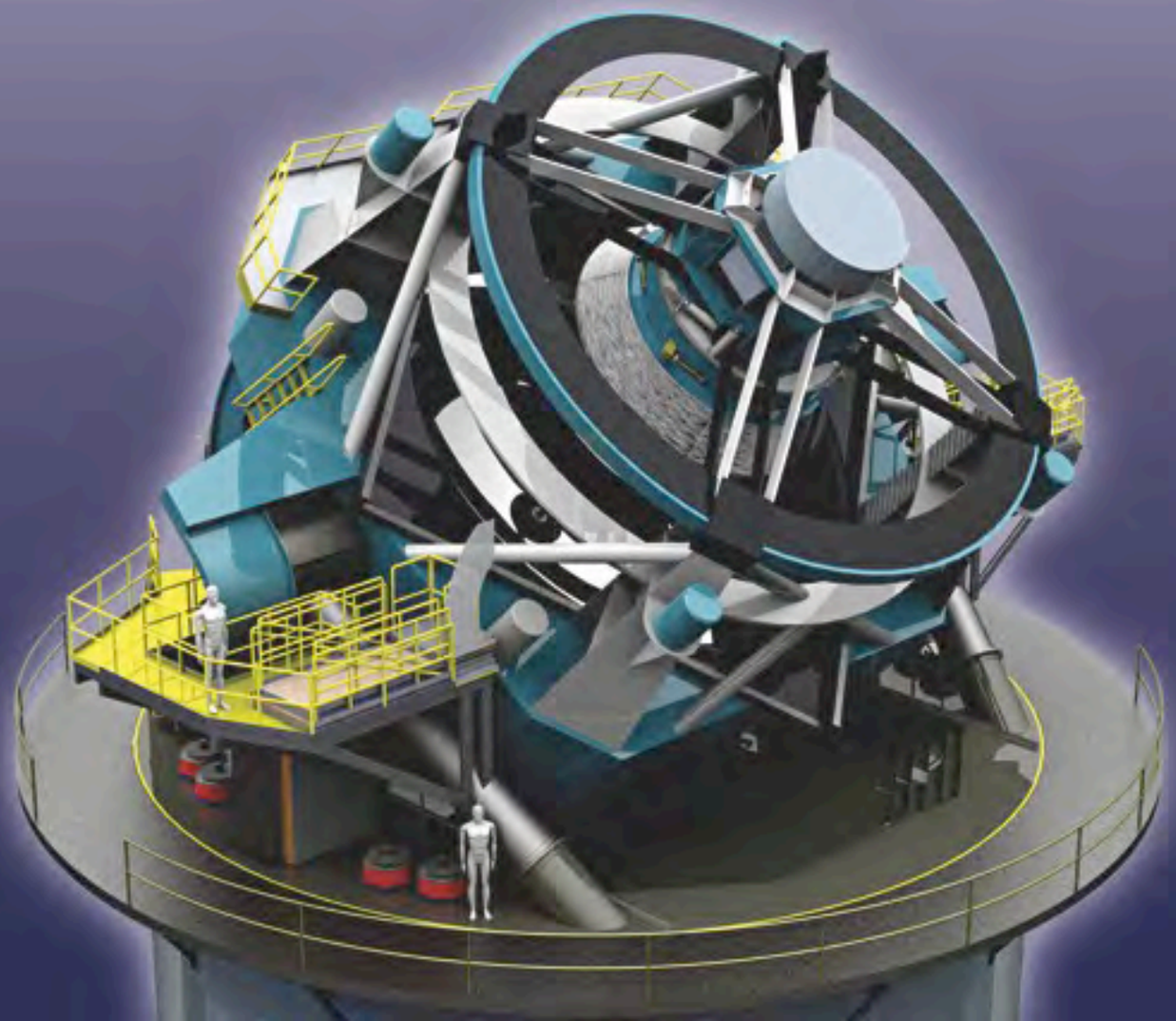


6 collaborations, 200 scientists

Large Synoptic Survey Telescope

Tim Axelrod * Ross Fadely * Masamune Oguri * Ted Baltz * Emilio Falco * Aaron Roodman * Roger Blandford * Chris Fassnacht * Marusa Bradac * Charles Keeton * Tommaso Treu * Greg Dobler * **Phil Marshall** * Ardis Eliasdottir *

Scott Anderson * Xiaohui Fan * Don Schneider * David Ballantyne * Rob Gibson * Anil Seth * Aaron Barth * Alexander Gray * Ohad Shemmer * **Niel Brandt** * Richard Green * Howard Smith * Robert Brunner * Mark Lacy * Michael Strauss * George Chartas * Paulina Lira * Ezequiel Treister * Paolo Coppi * Greg Madejski * Meg Urry * Wim de Vries * Jeffrey Newman * Dan Vanden Berk * Mike Eracleous * Gordon Richards

Mark Allen * John Haggerty * John Peterson * Eric Aubourg * Zoltan Haiman * Leslie Rosenberg * Jogesh Babu * Jean-Christophe Hamilton * Terry Schalk * Deborah Bard * Tin Ho * Rafe Schindler * Jim Bartlett * John Irwin * Rachel Bean * **Bhuvnesh Jain** * Neelima Sehgal * Gary Bernstein * Mike Jarvis * Erin Sheldon * Guillaume Blanc * James Jee * Ian Shipsey * Jim Bosch * Garrett Jernigan * Marina Shmakova * Pat Burchat * Ken Johns * Mike Sokoloff * David Burke * Steve Kahn * Paul Stankus * Chihway Chang * David Kirkby * Masahiro Takada * Elliott Cheu * Ted Lavine * Jon Thaler * Mickey Chiu * Jennifer Lotz * Tony Tyson * Douglas Clowe * Zhaoming Ma * Ludovic Van Waerbeke * Wei Cui * Rachel Mandelbaum * Sheng Wang * Scott Daniel * Vera Margoniner * **David Wittman** * Ian DellAntonio * Morgan May * Bo Xin * Eric Feigelson * Brian Meadows * Andrew Zentner * Yannick Geraud-Heraud * Paul O'Connor * Kirk Gilmore * Martin Perl

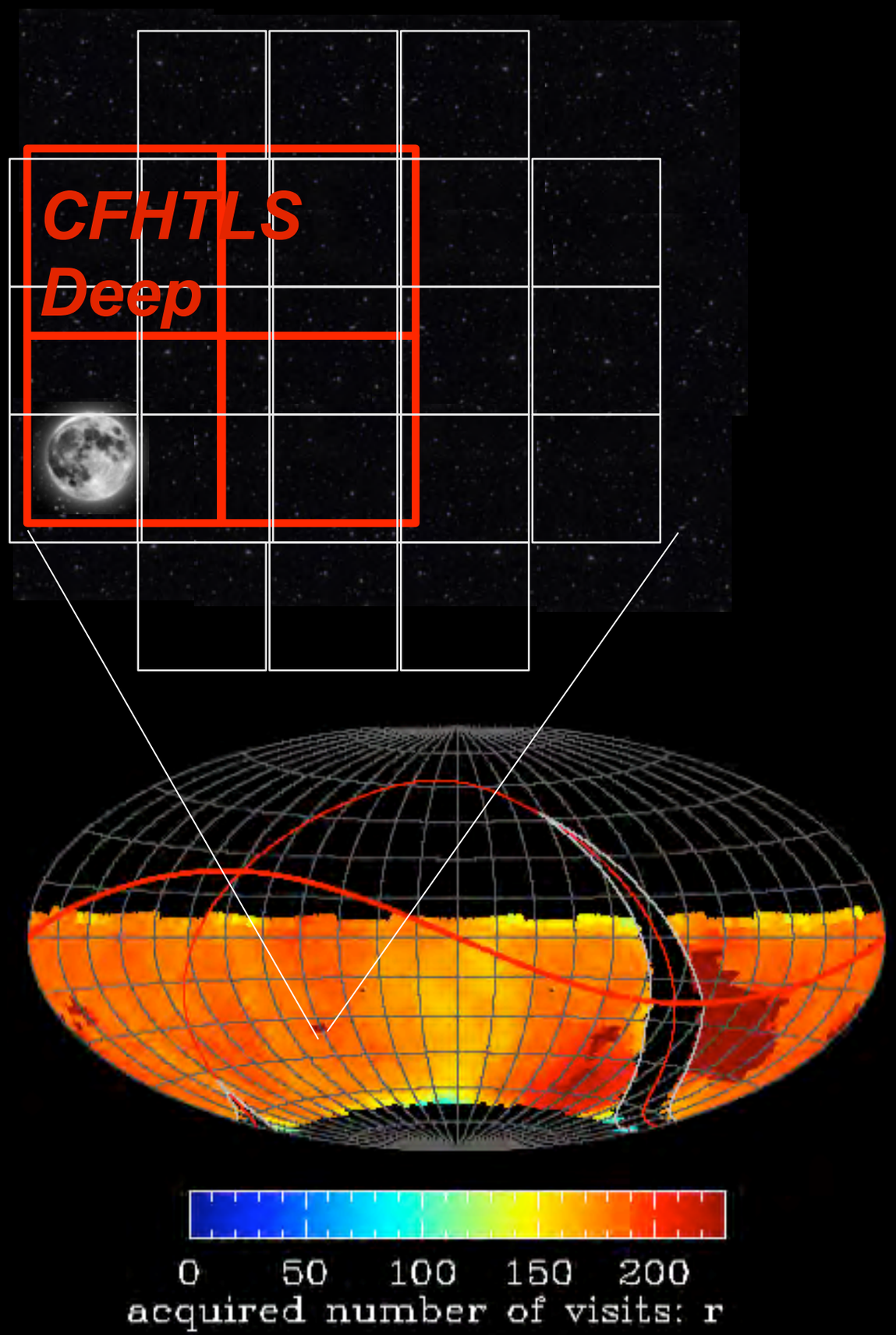
Pierre Antilogus * Julien Guy * Dovi Poznanski * David Arnett * Mario Hamuy * Nicolas Regnault * Pierre Astier * Craig Hogan * Masao Sako * Steve Asztalos * Saurabh Jha * Evan Scannpieco * Stephen Bailey * **Richard Kessler** * Michael Sivertz * Joseph Bernstein * Robert Kirshner * Chris Smith * David Cinabro * Stephen Kuhlmann * Chris Stubbs * Alejandro Clocchiatti * Tod Lauer * Ben Wandelt * Arlin Crotts * Yun Wang * Ben Dilday * Johnny Ng * Lifan Wang * Raffaele Flaminio * Scot Olivier * Josh Frieman * Reynald Pain * Patrick Young * Peter Garnavich * Phil Pinto * **Michael Wood-Vasey**

Lee Armus * Zeljko Ivezic * Andy Rasmussen * Felipe Barrientos * Vishal Kasliwal * Naveen Reddy * Michael Blanton * Jennifer Lotz * Brant Robertson * Kirk Borne * Lori Lubin * Rok Roskar * Carrie Bridge * Kevin Schawinski * Mark Dickinson * Jeffrey Newman * Sam Schmidt * **Harry Ferguson** * Dara Norman * Adam Stanford * Steven Finkelstein * Mirela Obric * Gaspar Galaz * Nelson Padilla * Michael Vogeley * Eric Gawiser * Casey Papovich * Jim Pizagno * Peter Yoachim * Andrew Ptak

Alexandra Abate * Brian Gerke * Tom Quinn * Viviana Acquaviva * Salman Habib * Paul Ricker * Steve Allen * Andrew Hamilton * Eduardo Rozo * Mark Allen * Jean-Christophe Hamilton * Ryan Scranton * Reza Ansari * Alan Heavens * Anze Slosar * Eric Aubourg * Katrin Heitmann * Alex Szalay * Wayne Barkhouse * Jack Hughes * Aurelien Barrau * Leopoldo Infante * James Bartlett * Benjamin Koester * Licia Verde * Andreas Berlind * Lori Lubin * Nick Bond * Felipe Menanteau * Risa Wechsler * Robert Brunner * Chris Miller * Tamas Budavari * Joe Mohr * Idit Zehavi * Luis Campusano * Marc Moniez * **Hu Zhan** * Asantha Cooray * Jeffrey Newman * Zheng Zheng * Laurent Derome * Nelson Padilla * **Eric Gawiser** * Nikhil Padmanabhan

CFHTLS Deep:

- 4 sq deg
- 5 filters, grizy
- 5 year survey
- few day cadence
- depth ~ 27 mag
- resolution ~0.9”



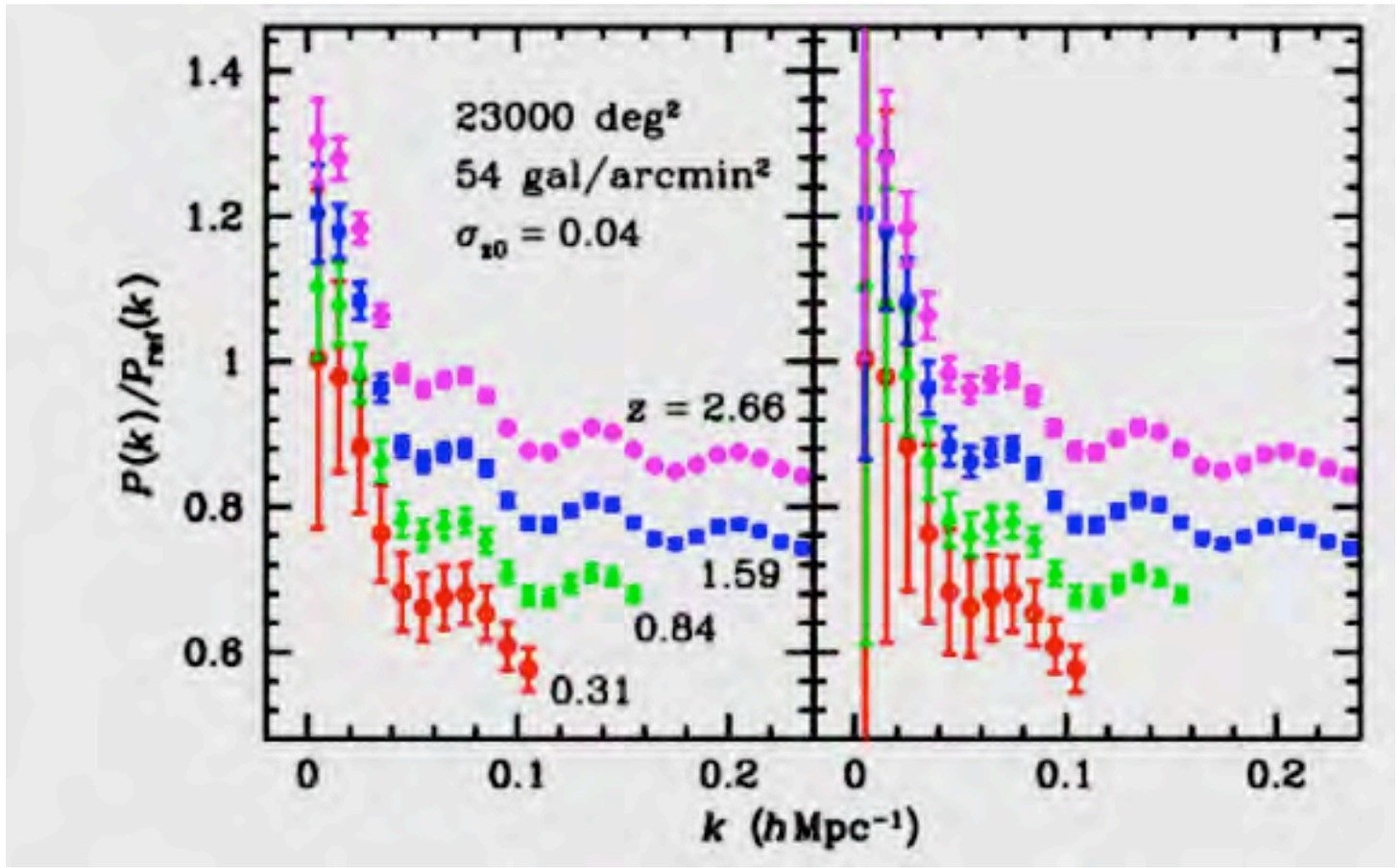
LSST:

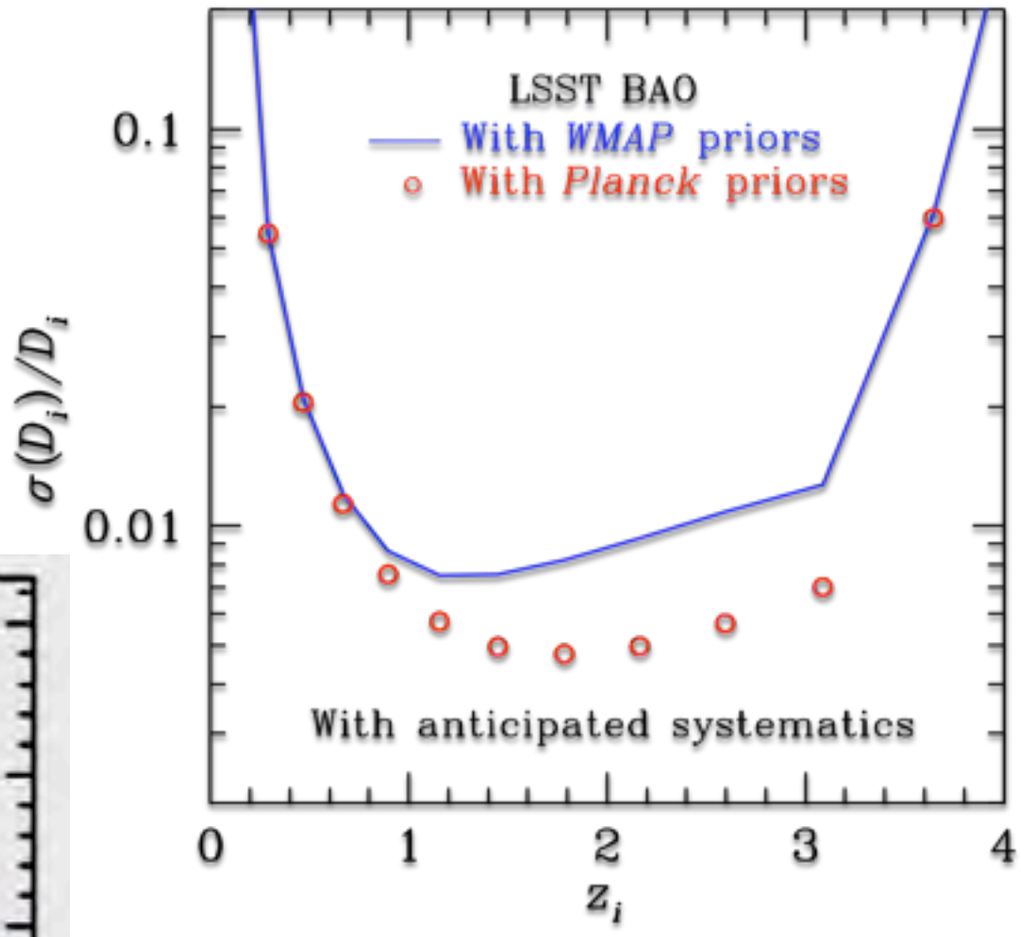
- 4x**5000** sq deg
- 6 filters, ugrizy
- 5x**2** year survey
- few day cadence
- depth ~ 27 mag
- resolution **0.4**-1.0”

x100 in volume, billions of galaxies

A Galaxy Redshift Survey

With photo-z's to 0.05(1+z), LSST will see the BAO feature in the galaxy power spectrum, and measure D(z=1,2) to < 1%

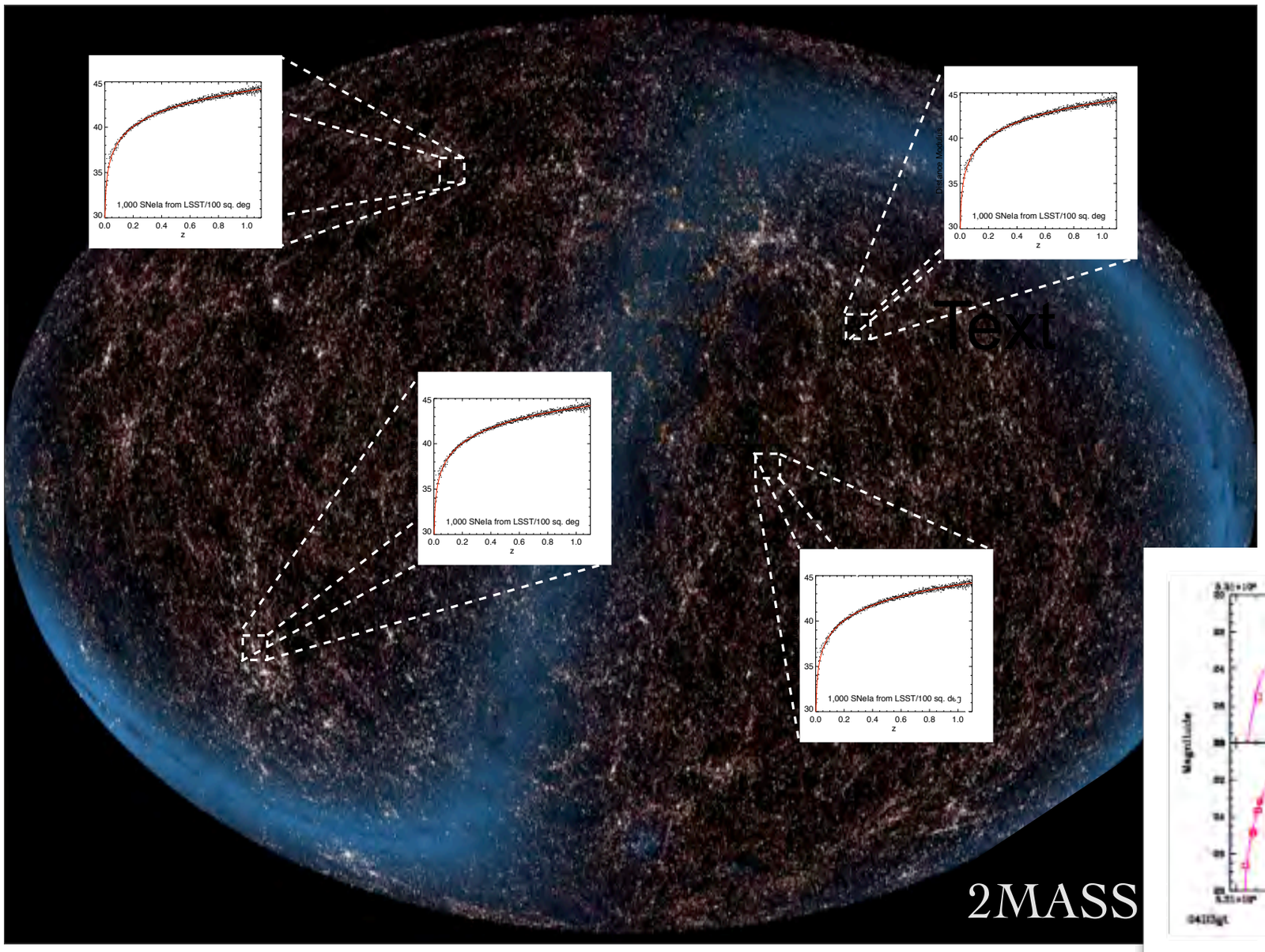




Active research: calibrating galaxy photo-z with large spectroscopic surveys

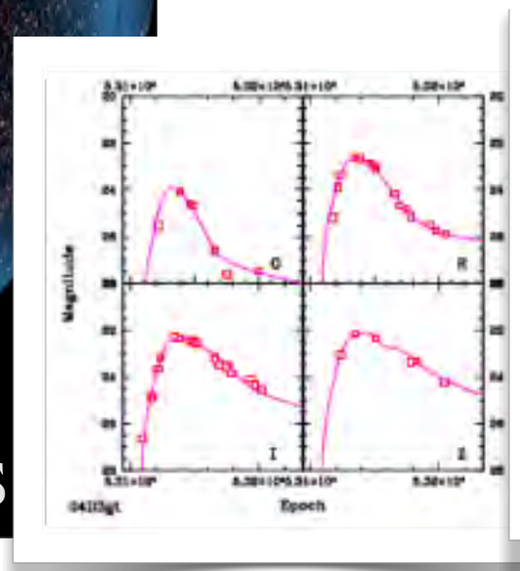
All-Sky Science

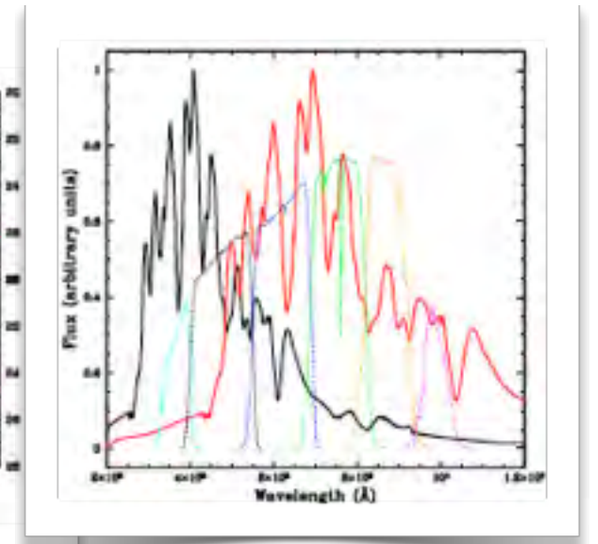
500,000 well-observed Type Ia SNe:
= 1000 each in 500 40 sq deg pixels



Look for anisotropy and inhomogeneity in the expansion of the Universe - new physics!

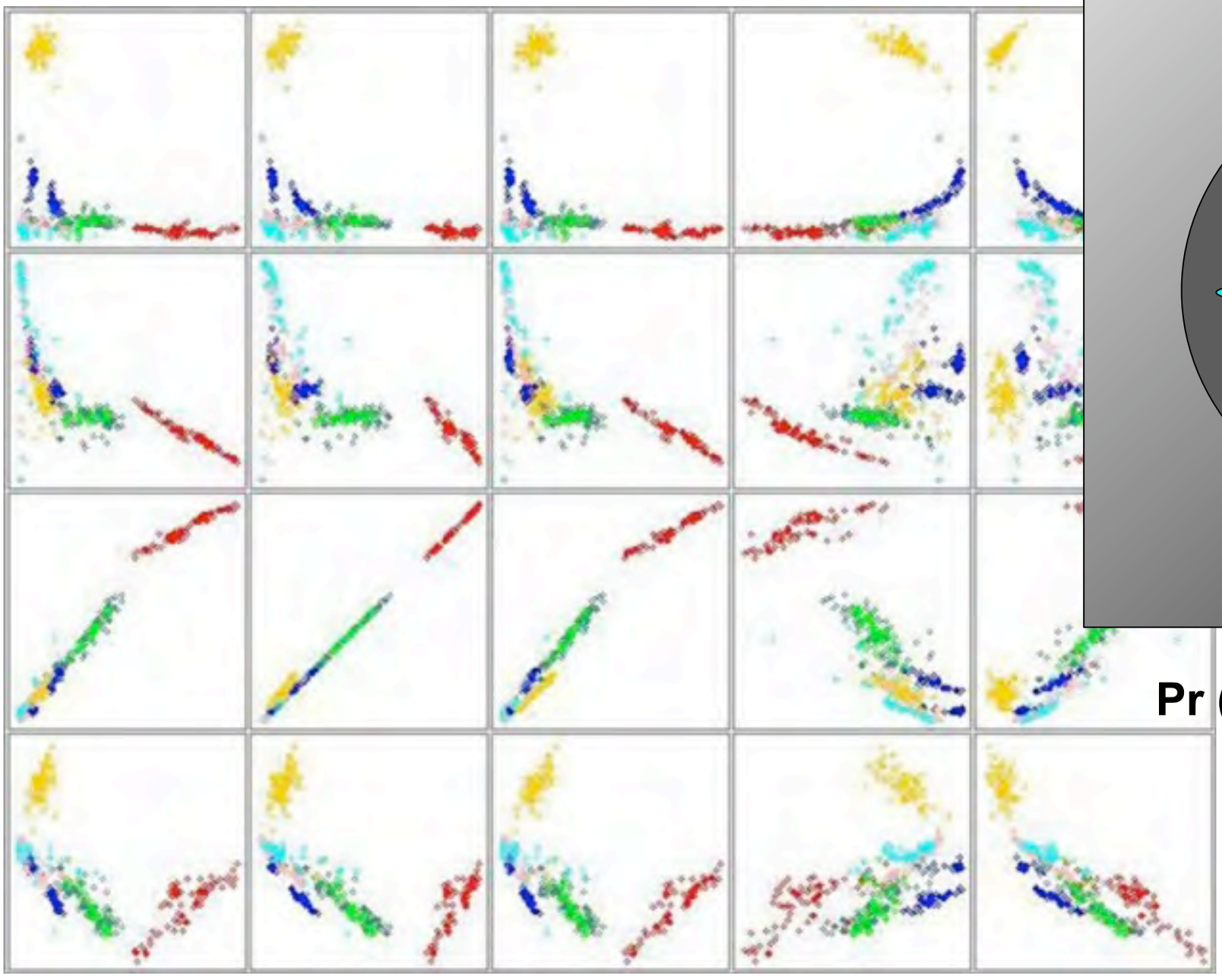
Active research: photo-z and type, deep field calibration

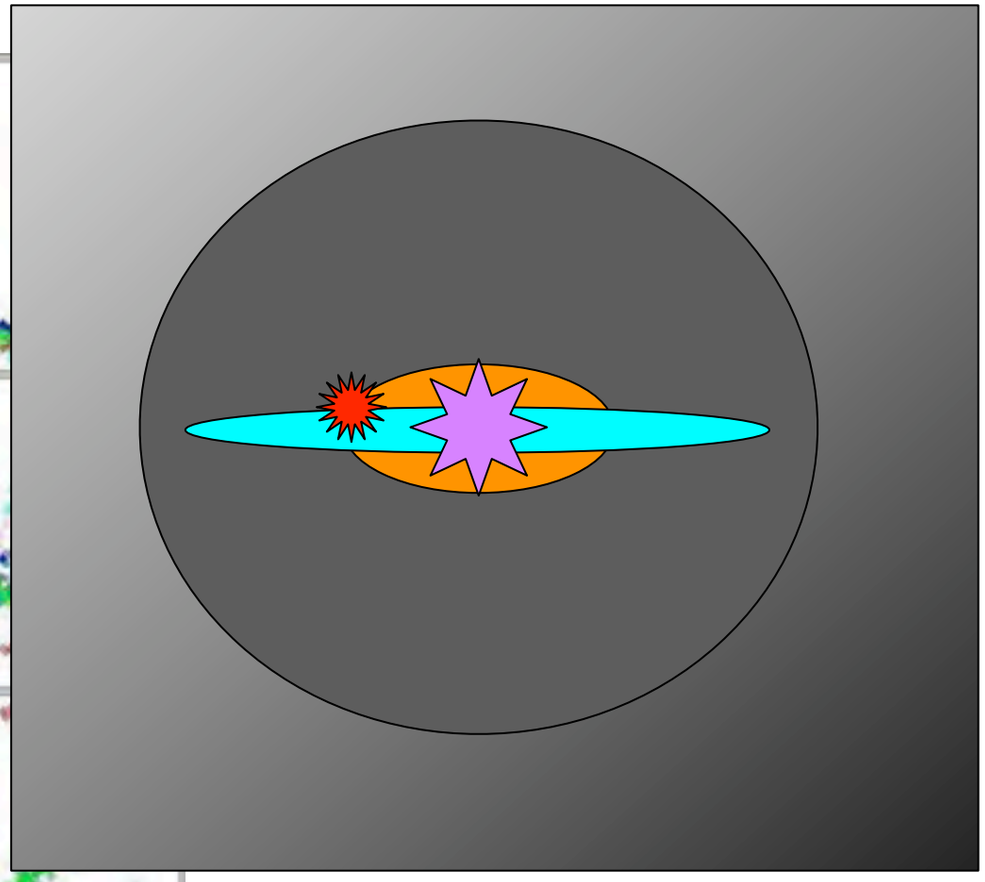




High-dimension galaxy PDFs

x100 more volume, billions of galaxies:

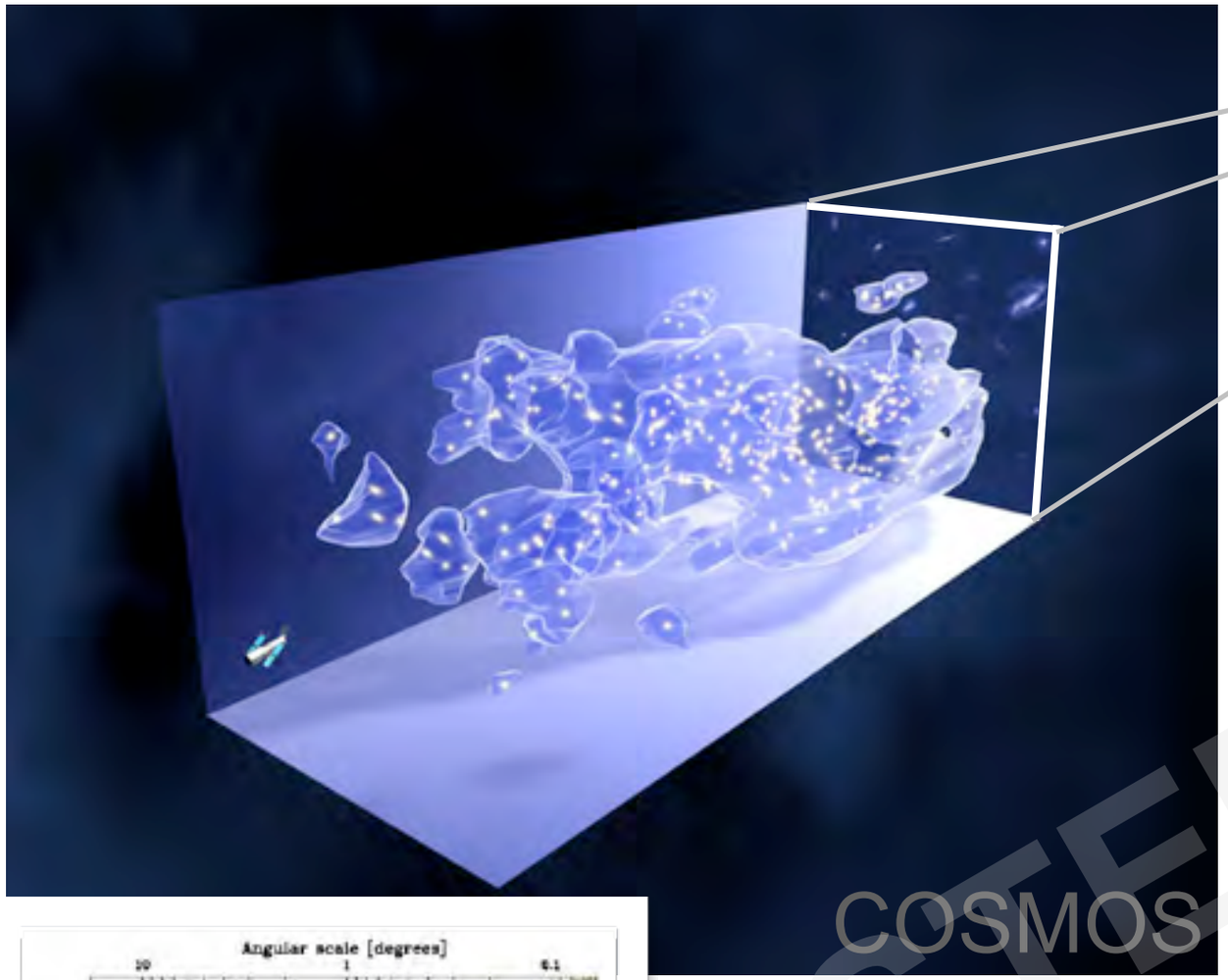


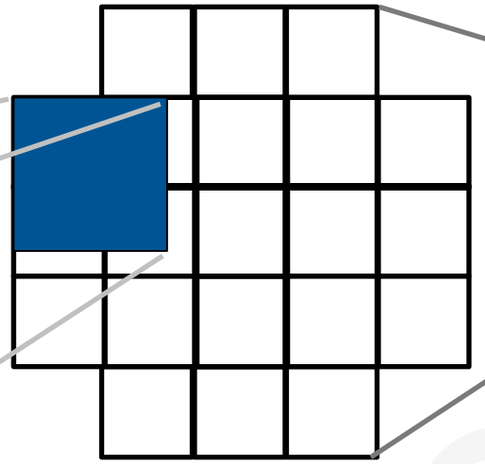


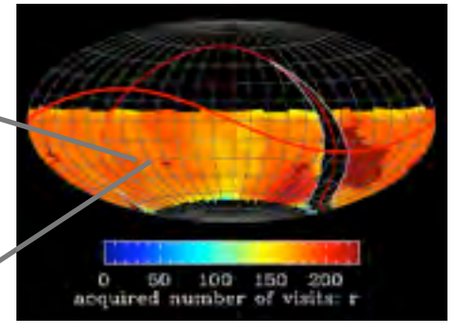
Pr (CDM,galaxyevolution | data)

where data are: SEDs, masses, structure, **SNe**, **AGN**, dust, **environment**, etc etc

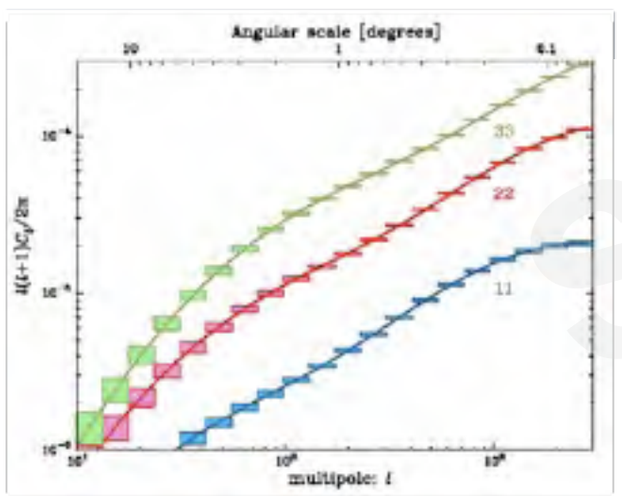
Dark Matter Everywhere



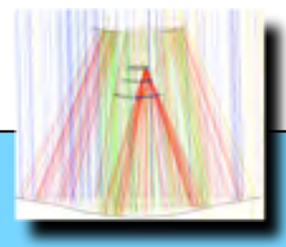




Weak lensing by large scale structure: tomographic mapping, “galaxy environment” = 3-D DM density



High precision power spectra, enhanced by higher order statistics

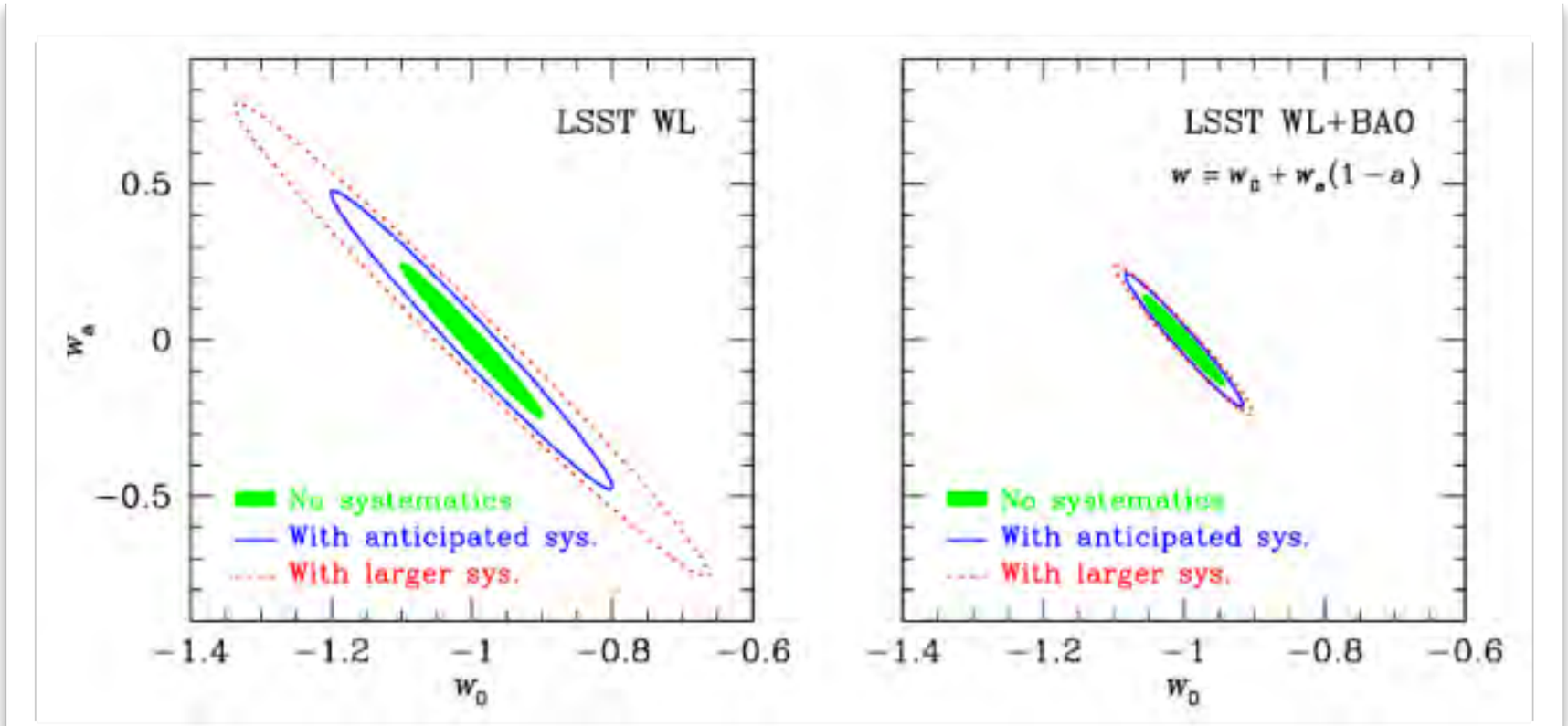


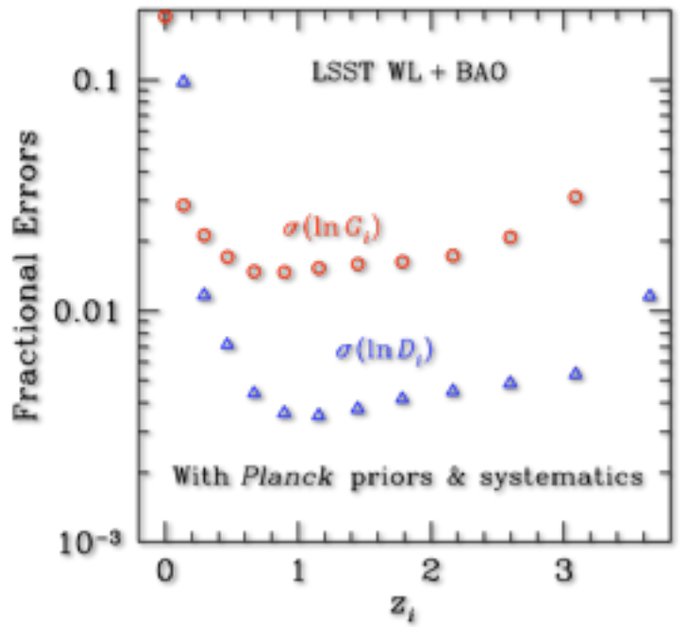
Active research: measuring galaxy shapes, in presence of varying PSF, calibrating photo-z’s with clustering and spectroscopy

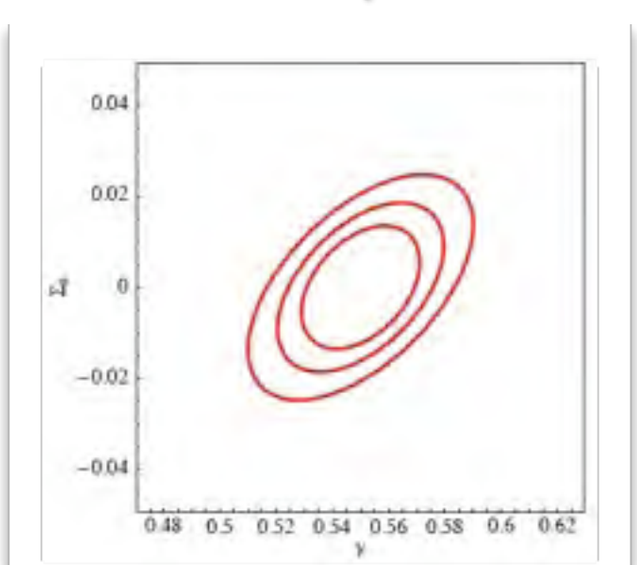
A Synoptic BAO + WL Survey

Joint analysis has additional power:

- BAO data calibrates photo-z's
- WL data constrains bias

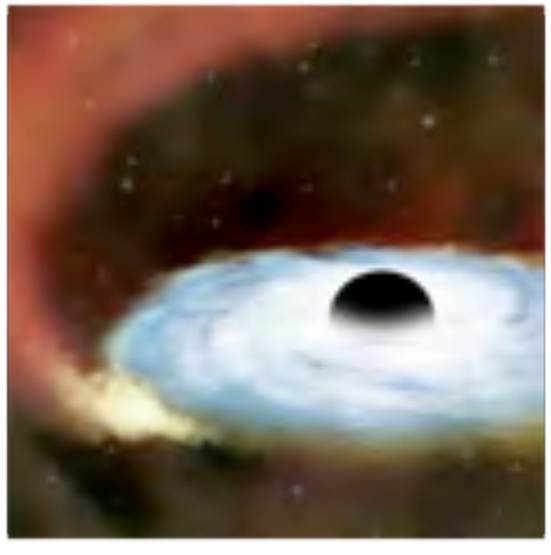






Precision Dark Energy studies; testing GR (geometry vs growth); world model anisotropy; neutrino masses to +/-0.05eV

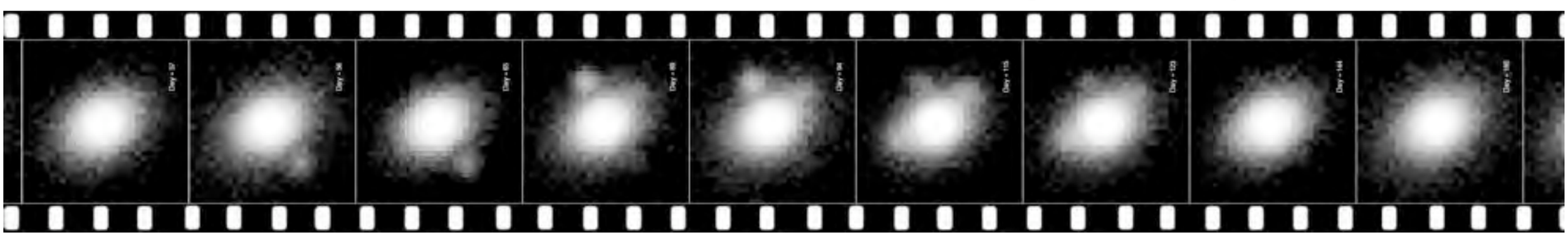
Rare Objects Will Become Common



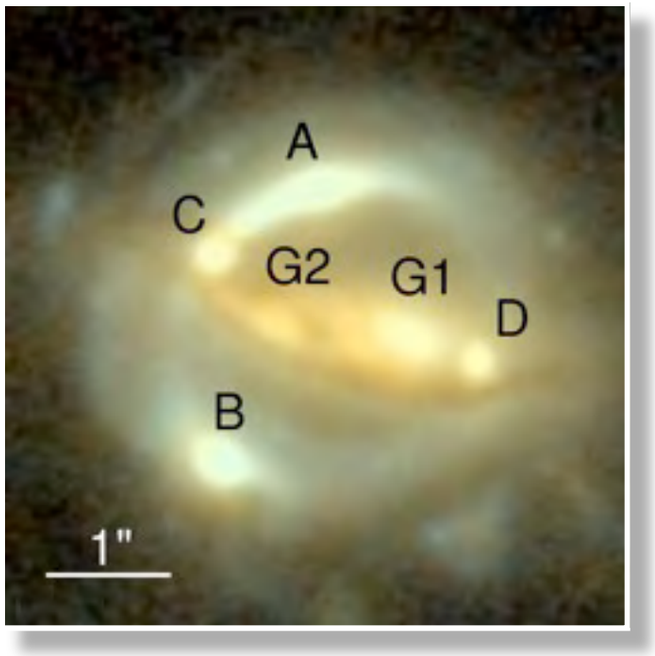
- ~10 million AGN (detected and classified by color and variability)
- Quiescent supermassive black holes visible too: Tidal disruptions, 6000 per year
- SMBH merger events?

Exotic supernovae: pair-production, long duration, ultra-luminous, GRBs, ...

Multiply-imaged supernovae: expect to find several hundred, including ~100 Type IA



Preparing to Detect & Measure

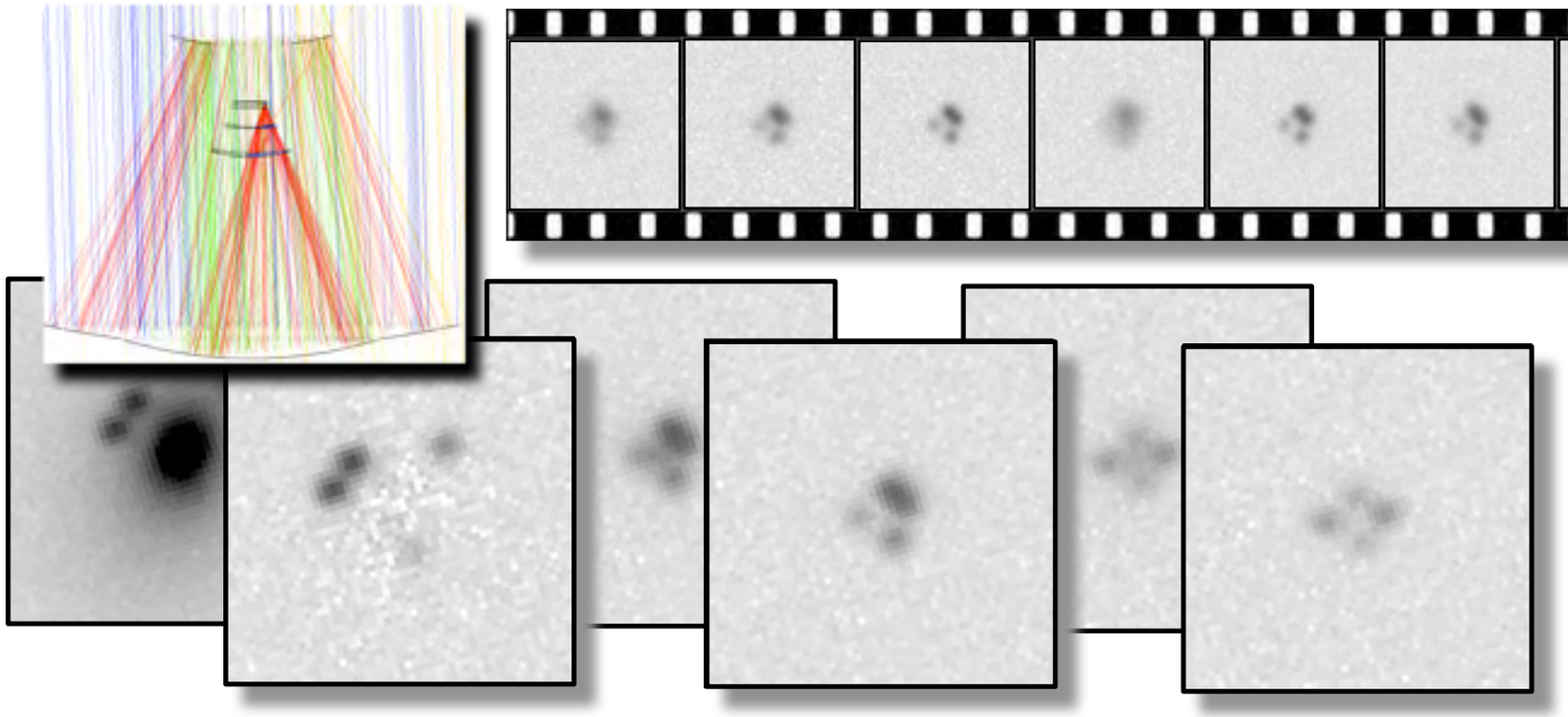


Several thousand strongly-lensed quasars and supernovae:

- time delay distances for sub-percent H0
- sub-galactic CDM structure from statistics of image flux perturbations

Need to learn how to detect a pure sample, and measure them accurately

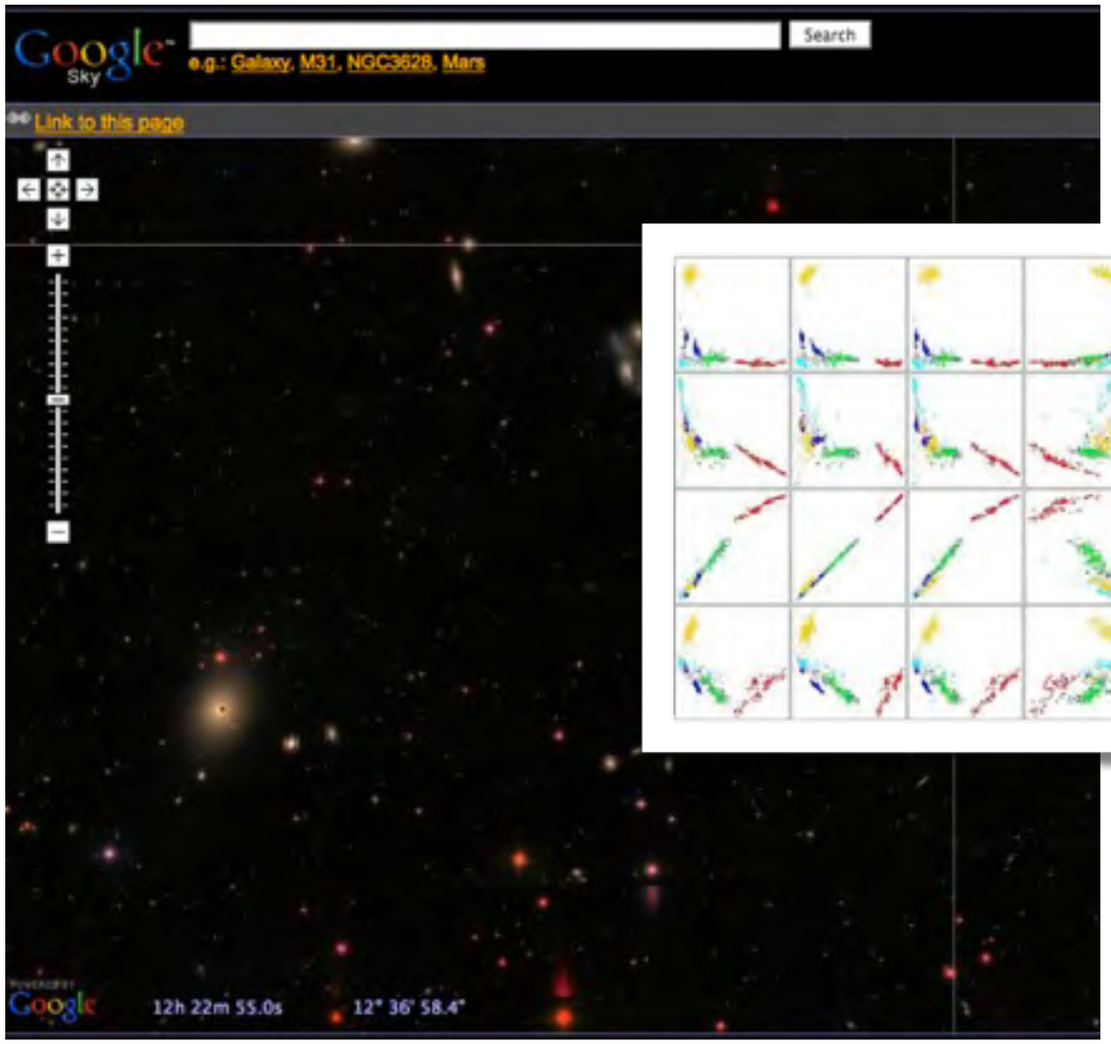
ImSim images of mock lens sample, process with LSST pipelines, develop and test algorithms



Astronomy by Search & Rank

Large Synoptic Survey Telescope

Survey astronomers
query databases:
a transition from star-gazing
to data-mining



Active research:
getting the right quantities
into the database, building
tools to analyse the data

Astronomy by Rank & File

GALAXY ZOO

Some astronomy still best done by eye - why not have millions of citizens analyse the LSST data? LSST is for *everyone*