COSMOS as a Pathfinder for WFIRST and Euclid

Jason Rhodes (Jet Propulsion Laboratory, California Institute of Technology)

AAS Honolulu

January 7, 2019

COSMOS

Hubble Space Telescope

Cycle 12 GO Proposal

The COSMOS 2-Degree ACS Survey

Principal Investigator: Dr. Nicholas Scoville

Institution: California Institute of Technology, USA/CA

Electronic Mail: nzs@astro.caltech.edu

Scientific Category: COSMOLOGY

Scientific Keywords: COSMOLOGICAL PARAMETERS AND DISTANCE SCALE, CLUSTERS OF GALAXIES, GALAXY FORMATION AND EVOLUTION, LARGE SCALE STRUCTURE AND PECULIAR VELOCITIES, GRAVITATIONAL LENSING

Instruments: ACS

Proprietary Period: 0

Treasury: Yes

Cycle 12 primary orbits: 450 Cycle 13 primary orbits: 450

Cycle 14 primary orbits: 380 Total primary orbits: 1280

Abstract

We propose a 2 square degree imaging survey (Cosmic Evolution Survey -- COSMOS) with ACS in the I (F814W) and g (F475W) bands of the VIMOS-GTO equatorial field. This wide field survey is essential to understand the interplay between Large Scale Structure (LSS) evolution and the formation of galaxies, dark matter and AGNs and is the one region of parameter space completely unexplored at present by HST. The equatorial field was selected for its accessibility to all ground-based telescopes and low IR background and because it will eventually contain ~100,000 galaxy spectra from the VLT-VIMOS instrument. The imaging will detect over 2 million objects with I > 27 mag (AB,10 sigma), over 35,000 Lyman Break Galaxies(LBGs) and extremely red galaxies out to z ~ 5 and ~100 SNIa at z ~ 1. COSMOS is the only HST project specifically designed to probe the formation and evolution of structures ranging from galaxies up to Coma-size clusters in the epoch of peak galaxy, AGN, star and cluster formation (z ~0.5 to 3). The size of the largest structures necessitate the 2 degree field. Our team is committed to the assembly of several public ancillary datasets including the optical spectra, deep XMM and VLA imaging, ground-based optical/IR imaging, UV imaging from GALEX and IR data from SIRTF. Combining the full-spectrum multiwavelength imaging and spectroscopic coverage with ACS sub-kpc resolution, COSMOS will be Hubble's ultimate legacy for understanding the evolution of both the visible and dark universe.

• the assembly of galaxies, clusters and dark matter on scales up to $\geq 2 \times 10^{14}\ M_{\odot}$, well sampled as a function of redshift;

• the evolution of galaxy morphology, galactic merging and star formation as a function of LSS environment and redshift;

• full reconstruction of the dark matter distributions and characteristics out to z ~1 using gravitational lensing shear maps;

• evolution of AGN and the relationship between black hole growth and galaxy evolution.

- Understand the interplay between dark matter and galaxies
- Use weak lensing to map dark matter
  - Weak lensing was a new field
  - Weak lensing studies had been purely statistical
  - Prove the benefits of space-based weak lensing
- Galaxy evolution was the goal with weak lensing as a primary tool

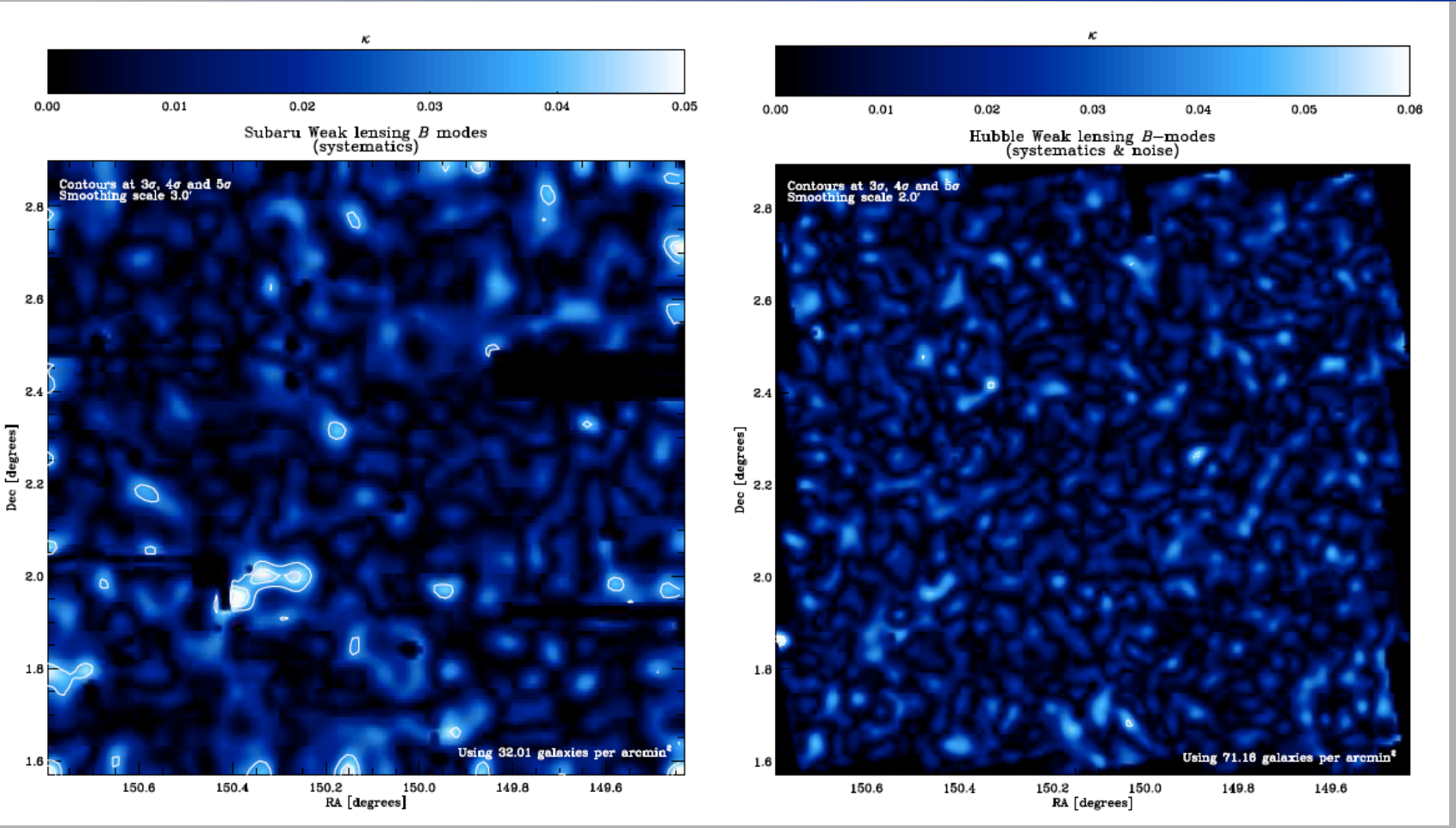
Weak Gravitational Lensing

Jason Rhodes (JPL)

- COMSOS- largest ever HST survey
- Weak gravitational lensing traces the dark matter distribution
- 3-D lensing shows proof of concept of weak lensing to measure dark energy
- Comparison with ground-based images shows power of space based imaging

Massey, Rhodes, et al 2007

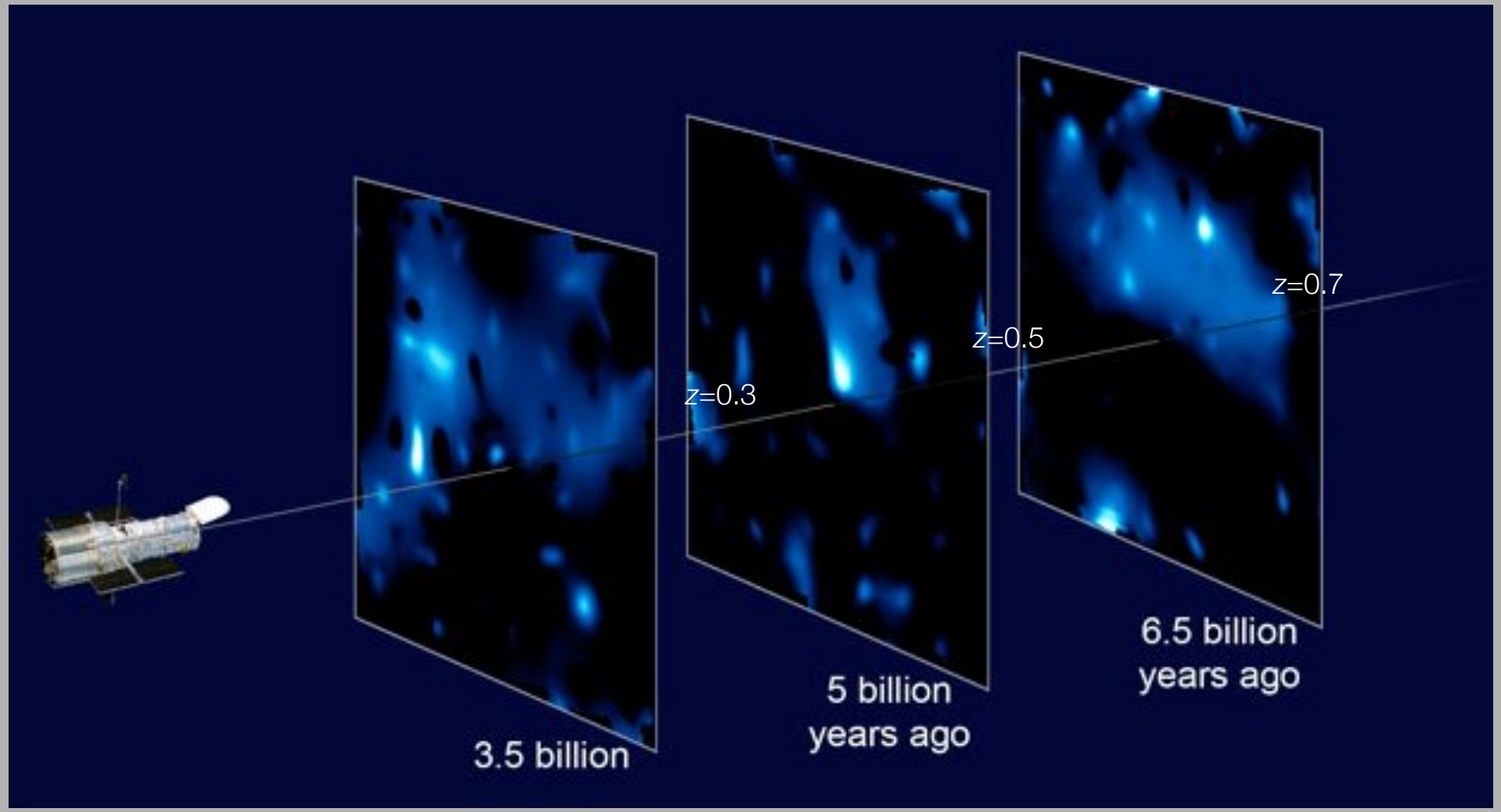
Noise From the Ground and Space



Noise in mass maps of the COSMOS field from the ground (left; Subaru) and space (right; HST). The ground-based map is noisier and produces 'false positives.' Precision lensing measurements must be done from space!

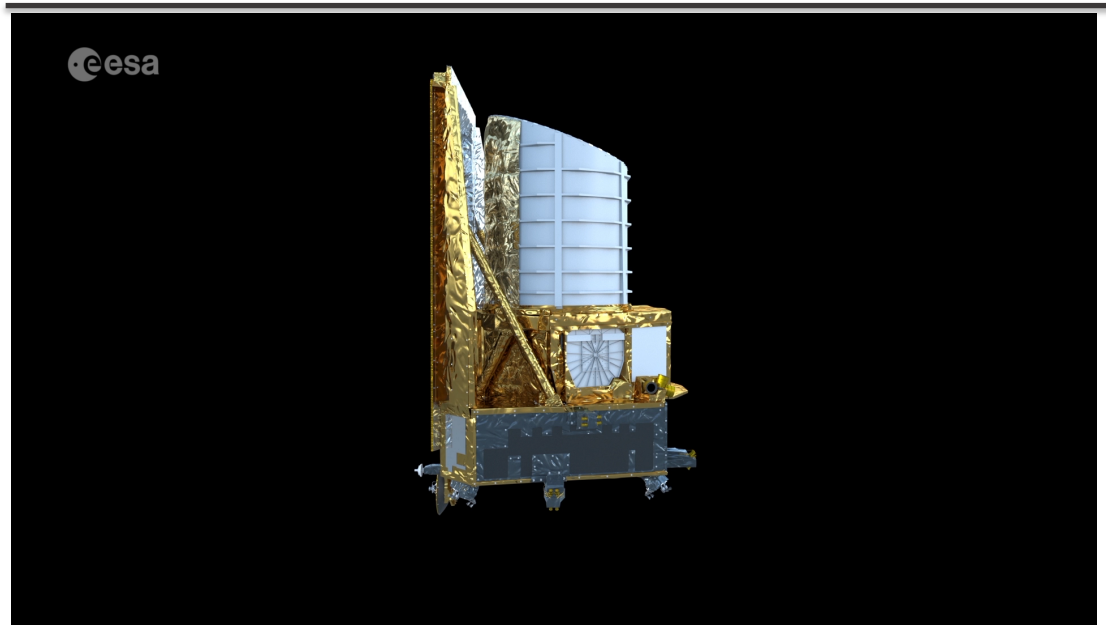
From Kasliwal, Massey, Ellis, Miyazaki, and Rhodes, 2007

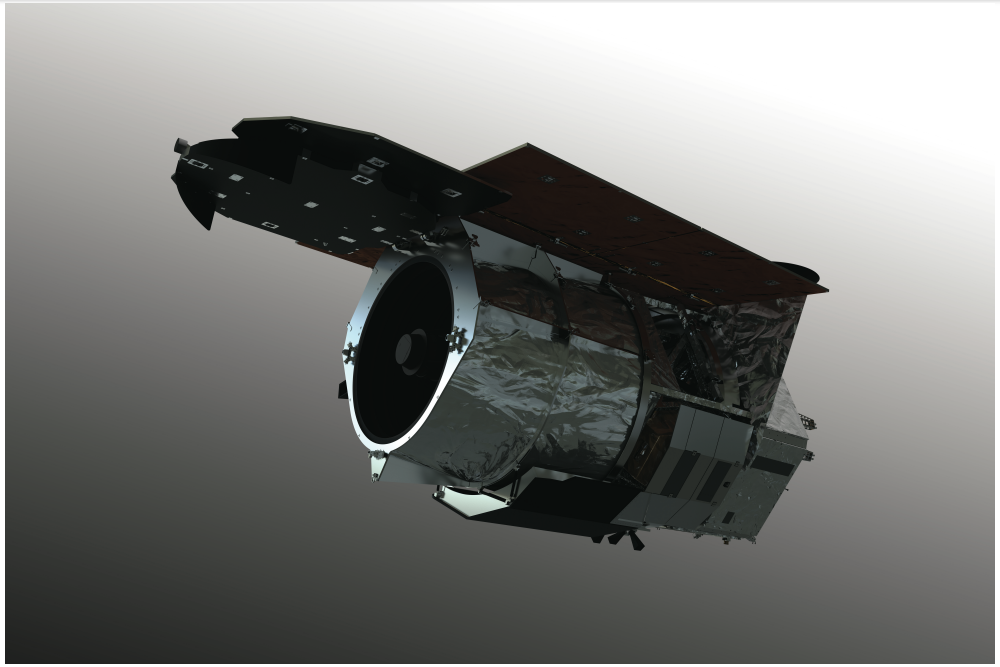
3-D dark matter distribution



Evolution of dark matter structures is a primary probe of dark energy

Euclid and WFIRST





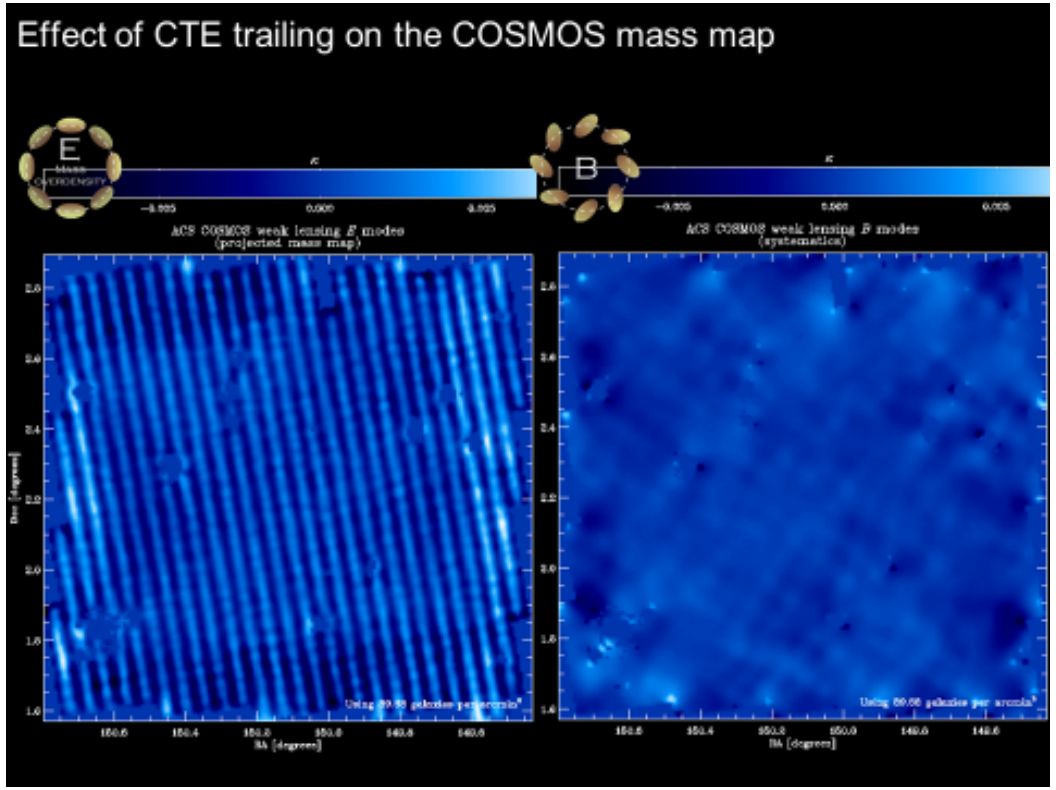
- 1.2m mirror
- 2022 launch for 6 year mission
- 15,000 sq degree weak lensing survey using CCDs
- NIR imaging and grism spectroscopy over same area
- Galaxy evolution a secondary science goal
- Dark matter and dark energy are primary science goals

- 2.4m mirror
- 2025 launch for 5 year primary mission
- ~2000 sq degree weak lensing survey in NIR
- Grism spectroscopy over same area
- Galaxy evolution a secondary science goal
- Dark matter and dark energy are primary design drivers

COSMOS was instrumental in making weak lensing a primary design driver and measurement goal

Lessons Learned

- Charge transfer efficiency degradation mitigation
- NIR detector systematics mitigation (persistence, IPC) from later HST data
- Importance of dark matter mapping in addition to weak lensing statistics
- COSMOS galaxies are basis set for GalSim (used by all current and future weak lensing surveys)
- Photo-z improvements (see talk by Dan Masters)
- Photo-z calibration (see talk by Dan Masters)
- All future surveys (Euclid, LSST, WFIRST) will use COSMOS as a calibration field



Slide from Richard Massey circa 2008