



COSMOS in the 2020s: Helping to Unveil the Nature of Dark Energy

Dan Masters

Jet Propulsion Laboratory / California Institute of Technology

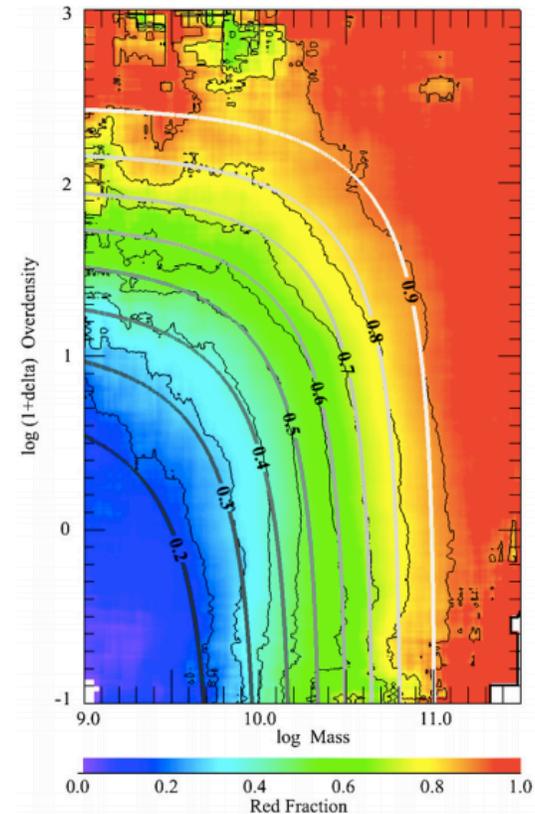
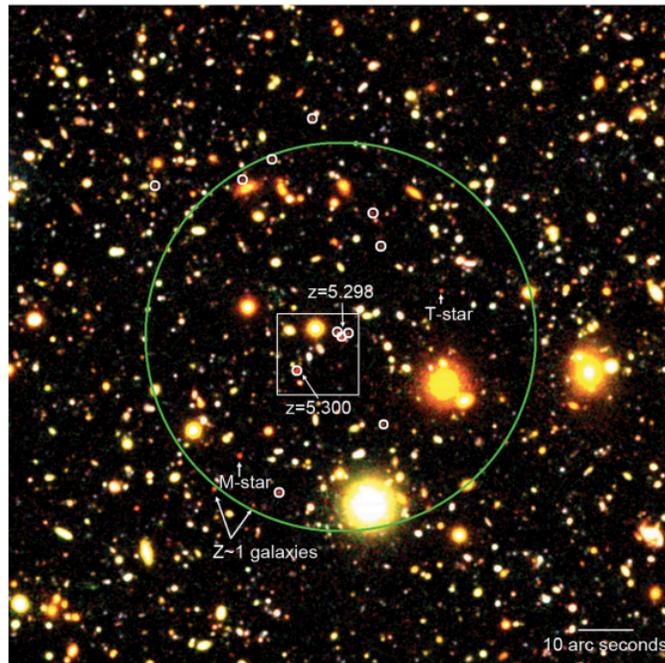
On behalf of the COSMOS & C3R2 teams

COSMOS: A Spectroscopy Goldmine

- Major surveys targeting the field:
 - zCOSMOS, DEIMOS 10k, MOSDEF, LEGA-C, IMACS, CLAMATO...
- >50,000 galaxies with high-quality spectra
- +30 band (low-res spectral) data on everything!
- COSMOS has enabled some of the most detailed studies of galaxy evolution ever

Spectroscopic Legacy

- Wonderful results from the field:
 - Peng, Lilly et al. 2010 – the mass and environment dependence of quenching
 - Discovery and characterization of the earliest proto-cluster (Capak et al. 2011)
 - ALMA follow-up studies (Faisst et al. 2018)

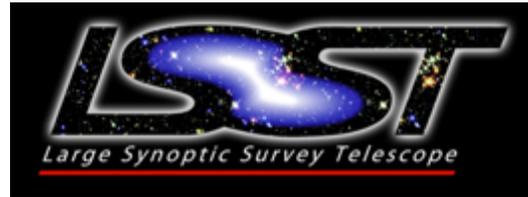


The 2020s: Cosmology & Dark Energy

- This decade will be characterized by deep surveys (Euclid, WFIRST, LSST) over 1000s of square degrees
- The primary goal of these experiments is to shed light on the nature of dark matter and – especially – dark energy

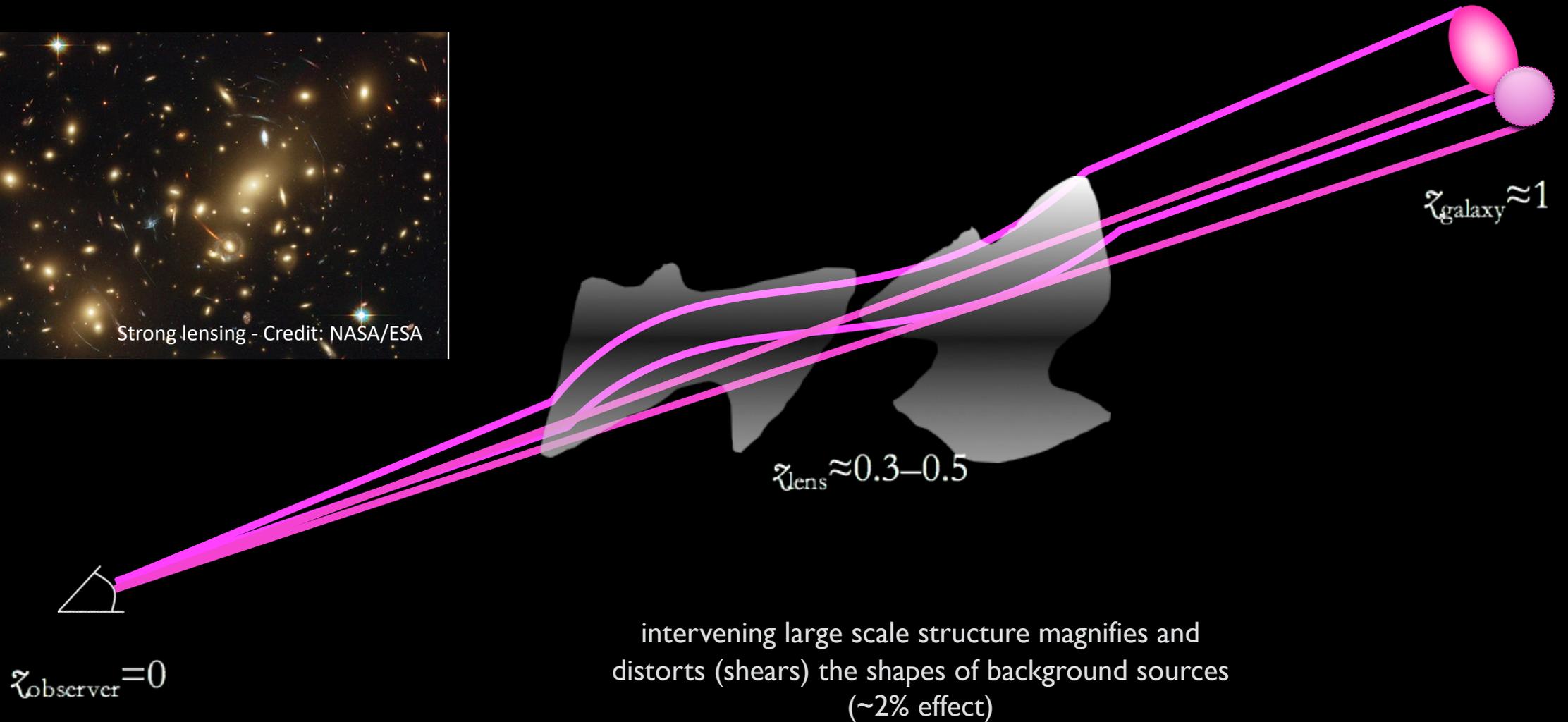
“Dark energy is not only terribly important for astronomy, it's the central problem for physics.”
-Steven Weinberg

Upcoming Dark Energy Missions



Proposed lifetime	2022 - 2032	2022 - 2028	2025 - 2031
Mirror size (m)	6.5 (effective diameter)	1.2	2.4
Survey size (sq deg)	20,000	15,000	2,227
Median z (WL)	0.9	0.9	1.2
Depth (AB mag)	~27.5	~24.5	~27
FoV (sq deg)	9.6	0.5 (Vis) 0.5 (NIR)	0.28

Probes of the Structure Formation: Weak Gravitational Lensing



2020s: Wide surveys, limited information

- Incredible requirements placed on the systematics of large scale surveys
 - Galaxy shapes and redshift distributions must be measured extremely well
- Billions of galaxies in the weak lensing shear samples
 - Redshifts must be inferred from broad-band imaging data
 - Individual redshifts will have large error, but redshift statistics of populations must be known with high accuracy
- Deep fields with extensive ancillary data are key to understanding the wide field data produced by WFIRST/Euclid/LSST

COSMOS: A Wealth of Information

- Photometric data across the EM spectrum
 - Radio through X-ray, with intermediate and narrow-band data in the optical/near-IR
- Spectra to calibrate photometric redshifts
- One of the key calibration fields for the upcoming Stage IV surveys
 - LSST deep drilling field
 - Euclid calibration field

C3R2 = Complete Calibration of the Color-Redshift Relation

→ A large Keck Program to prepare for Stage IV Dark Energy Experiments

Judith Cohen (Caltech) - PI of Caltech Keck C3R2 allocation

16 nights (DEIMOS + LRIS + MOSFIRE)

Daniel Stern (JPL) - PI of NASA Keck C3R2 allocation

10 nights (all DEIMOS; “Key Strategic Mission Support”)

Daniel Masters (JPL) – PI of NASA Keck C3R2 allocation 2018A/B, 2019B, 2020A

16 nights (8 each LRIS/MOSFIRE; “Key Strategic Mission Support”)

Dave Sanders (IfA) - PI of Univ. of Hawaii Keck C3R2 allocation

6 nights (all DEIMOS) + H20

Bahram Mobasher (UC-Riverside) - PI of UC Keck C3R2 allocation

2.5 nights (all DEIMOS)

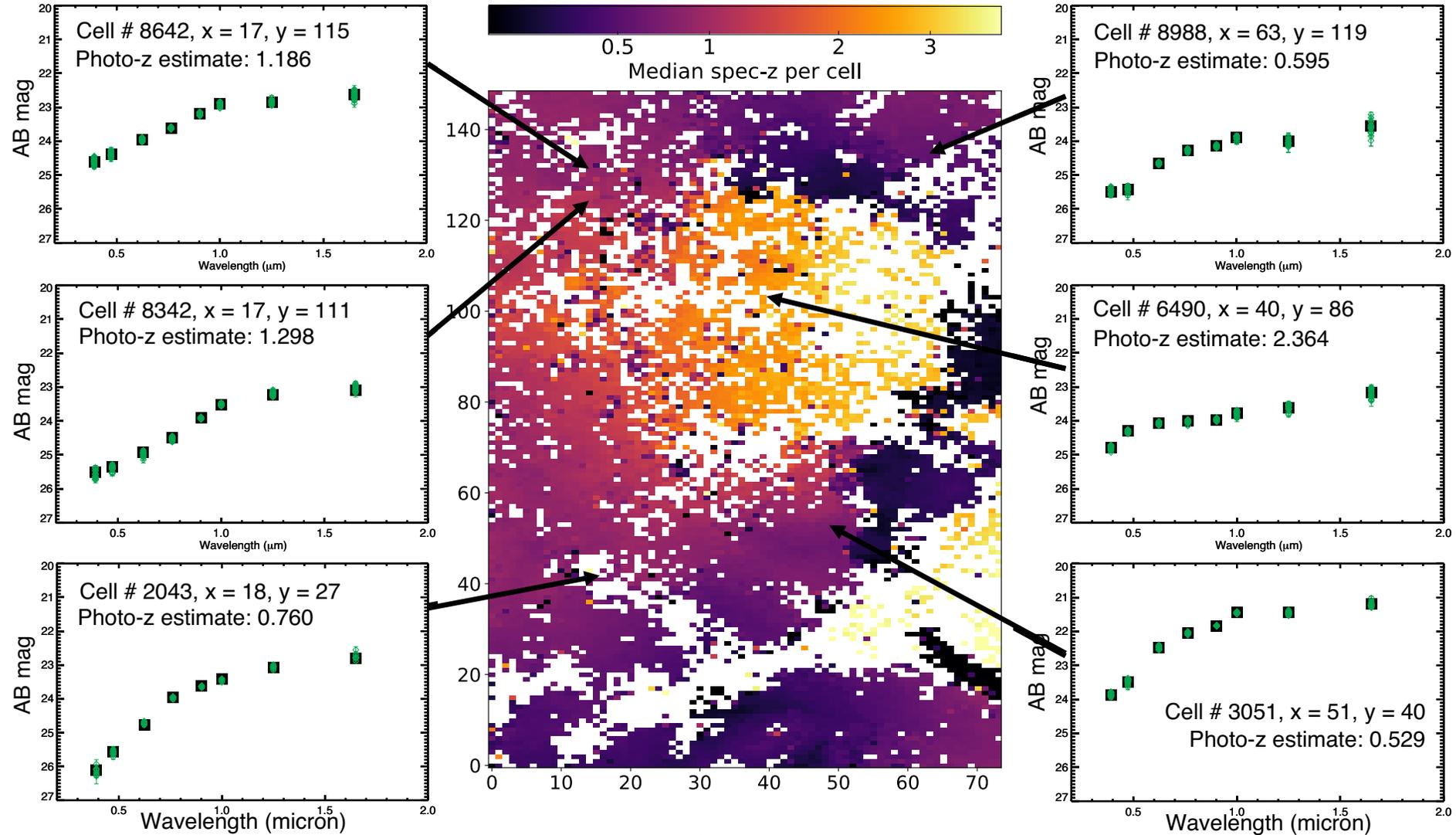
+ time allocations on VLT (PI F. Castander), MMT (PI D. Eisenstein), and GTC (PI C. Guitierrez)

-Coordinating closely with these collaborators for these observations

-Sample drawn from 6 fields totaling $\sim 6 \text{ deg}^2$

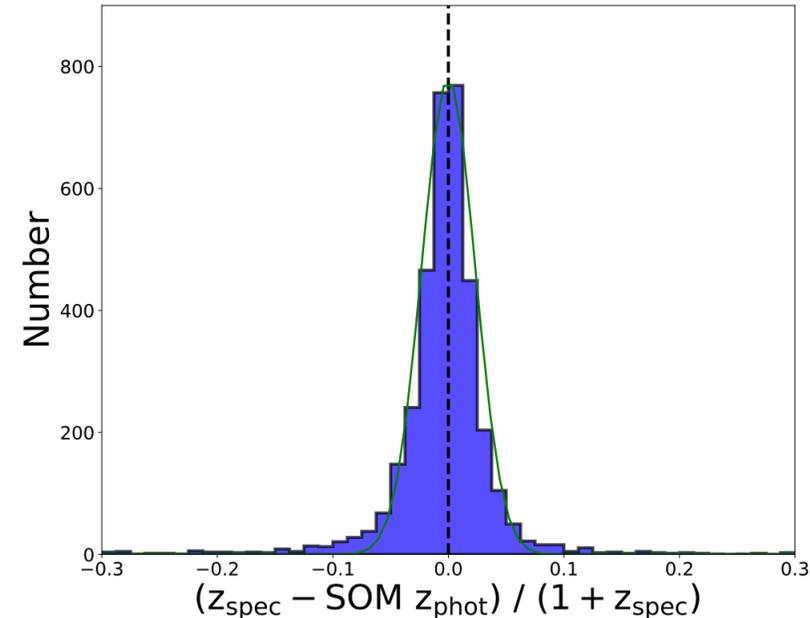
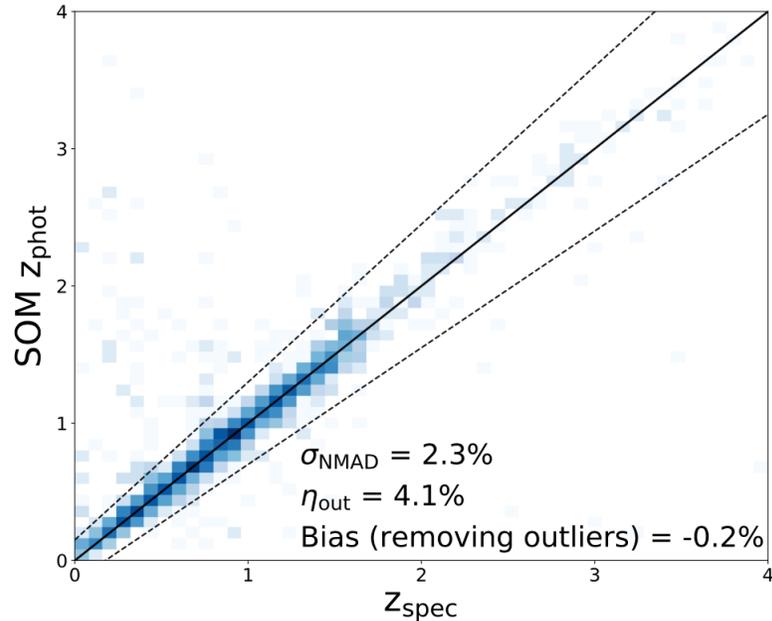
Additional Collaborators: Peter Capak, S. Adam Stanford, Nina Hernitschek, Francisco Castander, Sotiria Fotopoulou, Audrey Galametz, Iary Davidzon, Stephane Paltani, Jason Rhodes, Alessandro Rettura, Istvan Szapudi, and the Euclid Organization Unit – Photometric Redshifts (OU-PHZ) team

The 8-color SOM to Euclid depth



SOM-based redshift performance

- Simple test: Use position on SOM to predict photo-z
 - Incorporate nothing in defining $P(z | C)$ relation other than the median deep survey photo-z in cells of the Euclid/WFIRST color space



- Outlier fraction 4.7%, bias (after removing outliers) of 0.18%

Masters et al. 2019 ApJ 877, 81

Summary

- COSMOS will remain a premier field through the 2020s for characterization and calibration of deep field data
- The wealth of spectroscopic and photometric information in COSMOS is a Rosetta Stone needed to interpret the data from wide area surveys of the 2020s aimed at uncovering the nature of dark energy
- C3R2 survey is complementing the already extensive spectroscopic coverage in the field to map the galaxy color-redshift relation
- Expect great things to come!