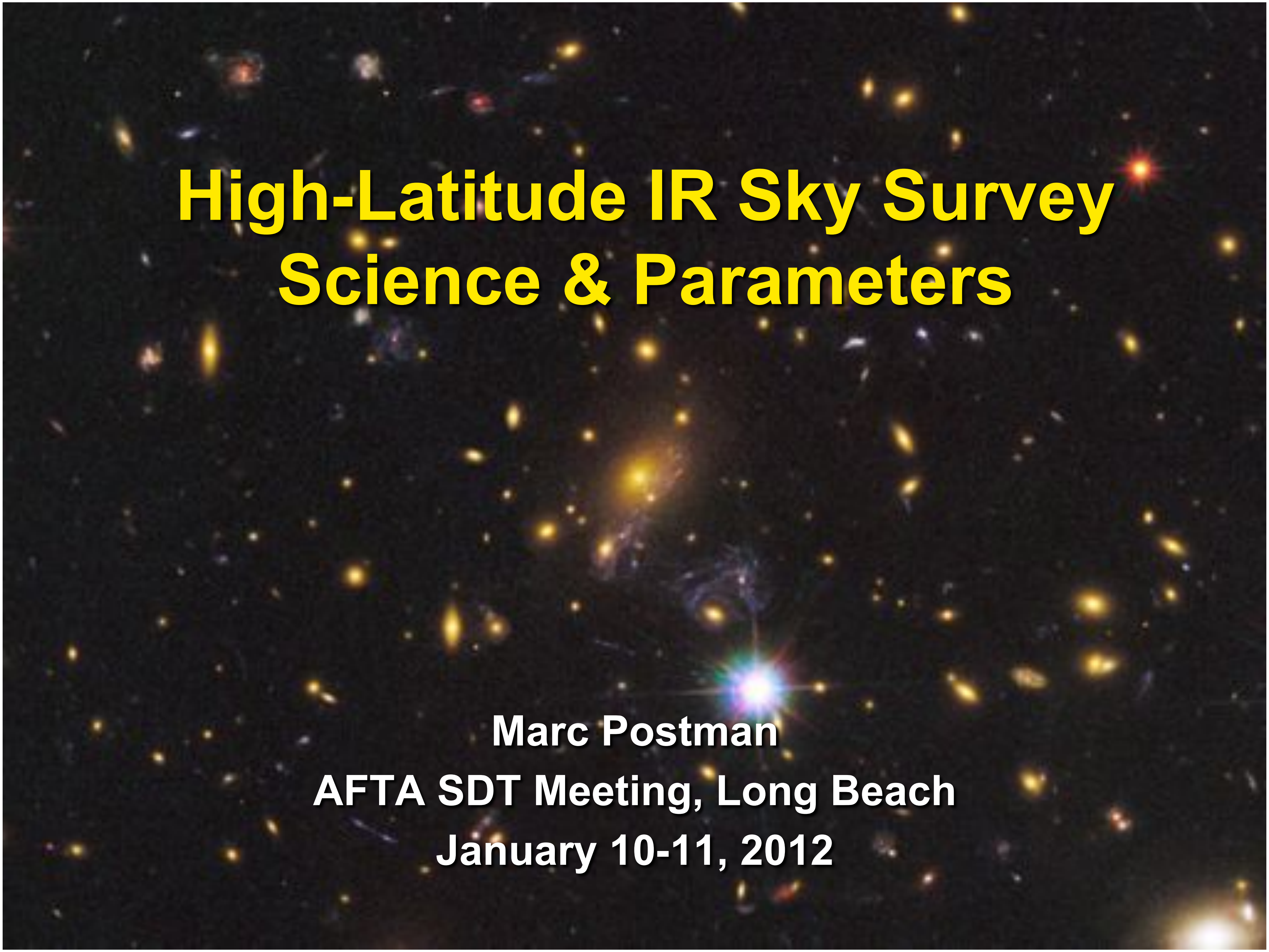


High-Latitude IR Sky Survey Science & Parameters

Marc Postman

AFTA SDT Meeting, Long Beach

January 10-11, 2012

Overview

- HLS presumed to be the primary data resource for the WL constraints on dark energy equation of state. Will also enable cluster counts to be used as D.E. probe.
- Here I will focus on some additional high-profile science that can be done with HLS and, in particular, the significant advantages a 2.4m aperture brings to the table.
- HLS likely to be one of the most widely used data products from WFIRST. Need to make this very clear in the report.
- In progress: STScI science staff developing synergy science cases between AFTA and JWST.

Wide-Field NIR High Latitude Surveys performed from space

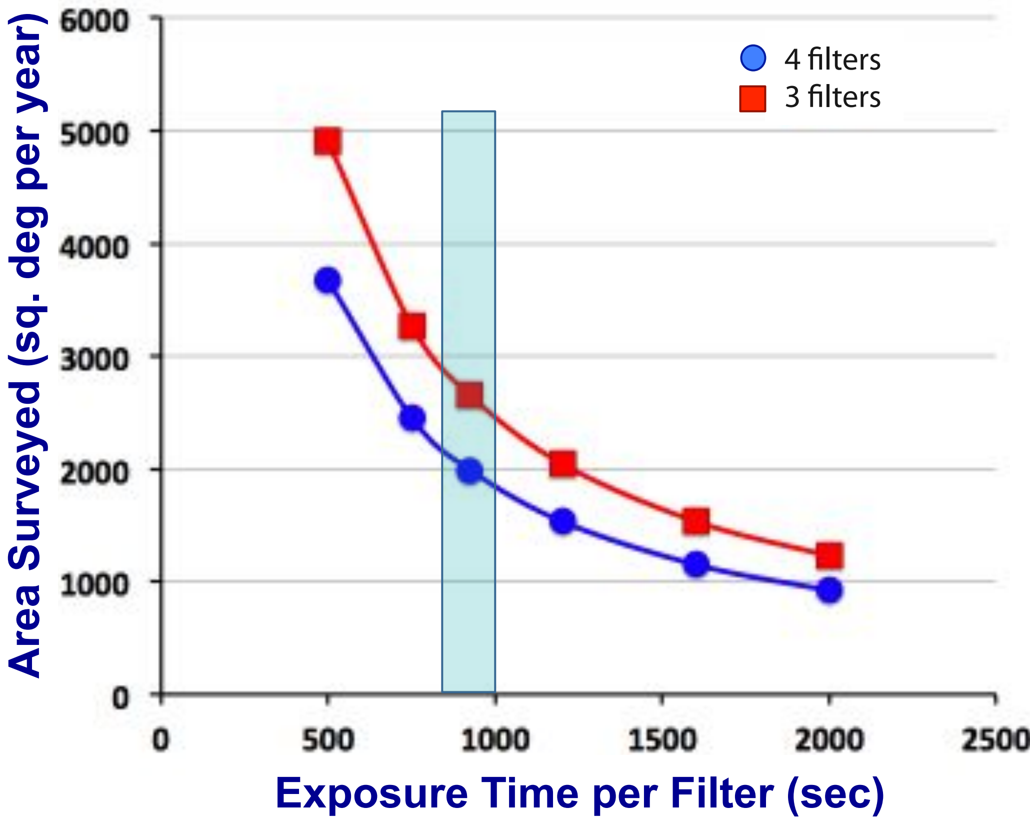
	WFIRST DRM1	WFIRST DRM2	Euclid	WFIRST 2.4m
Imaging Survey [4 filters for all WFIRST DRMs; depths are 5σ for isolated pt src in AB mags]	0.92—2.40 μm 26.0—26.2 mag EE50: 0.15" - 0.21"	0.92—2.40 μm 25.8—26.0 mag EE50: 0.18" - 0.25"	1.05 – 1.6 μm ~24.1 mag (10σ) EE50: ~0.30"	0.92—1.8 μm 26.7—27 mag EE50: 0.11" - 0.14"
High Latitude Survey Area	3,400 deg^2	3,400 deg^2	15,000 deg^2	>3,500 deg^2 ??
Redshift Survey [≥7σ Hα detections]	z = 1.28—2.66 4900 gal/deg^2	z = 1.59—2.66 2900 gal/deg^2	z = 0.70 – 2.0 ~3300 gal/deg^2	z = 1.13 – 2.20 4900 gal/deg^2

Based, in part, on info provided by Chris Hirata

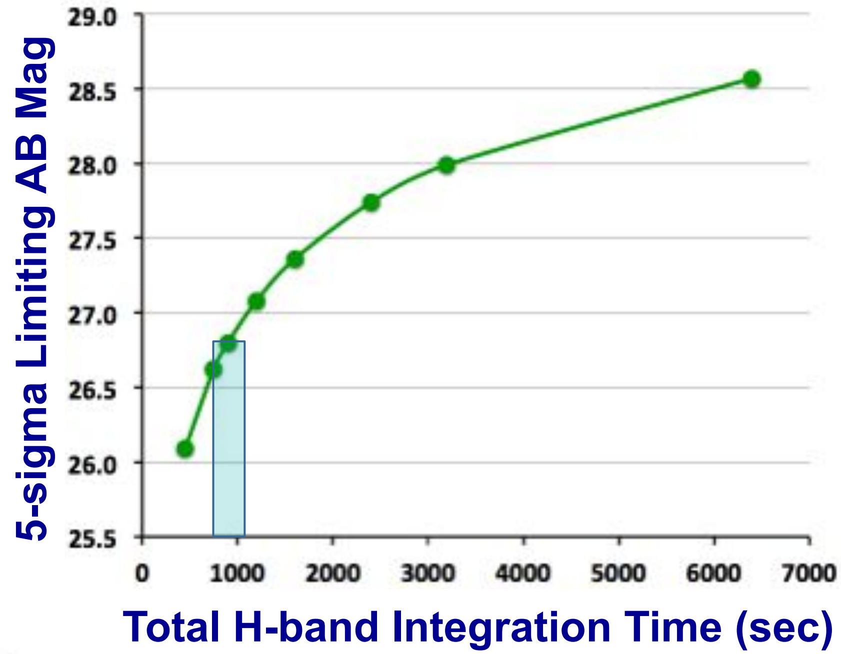
Comparison with Ground-based IR surveys

Survey	Area (deg^2)	Depth (5-sigma, AB)
UKIDSS-LAS	4000	Ks=20.3
VISTA-VHS	20,000	H=20.6
VISTA-VIKING	1500	H=21.5
VISTA-VIDEO	12	H=24.0
WFIRST DRM1	3,400	K = 26.2
WFIRST DRM2	3,400	K = 25.8
WFIRST AFTA 2.4m	>4,000?	H = 26.7

High-Latitude Survey: Area vs. Depth



Assumes an imager with a 0.28 deg^2 FOV and an 80% on-target observing efficiency. Does not include time allocated for slitless spec survey. Chris Hirata's estimates may be higher fidelity.

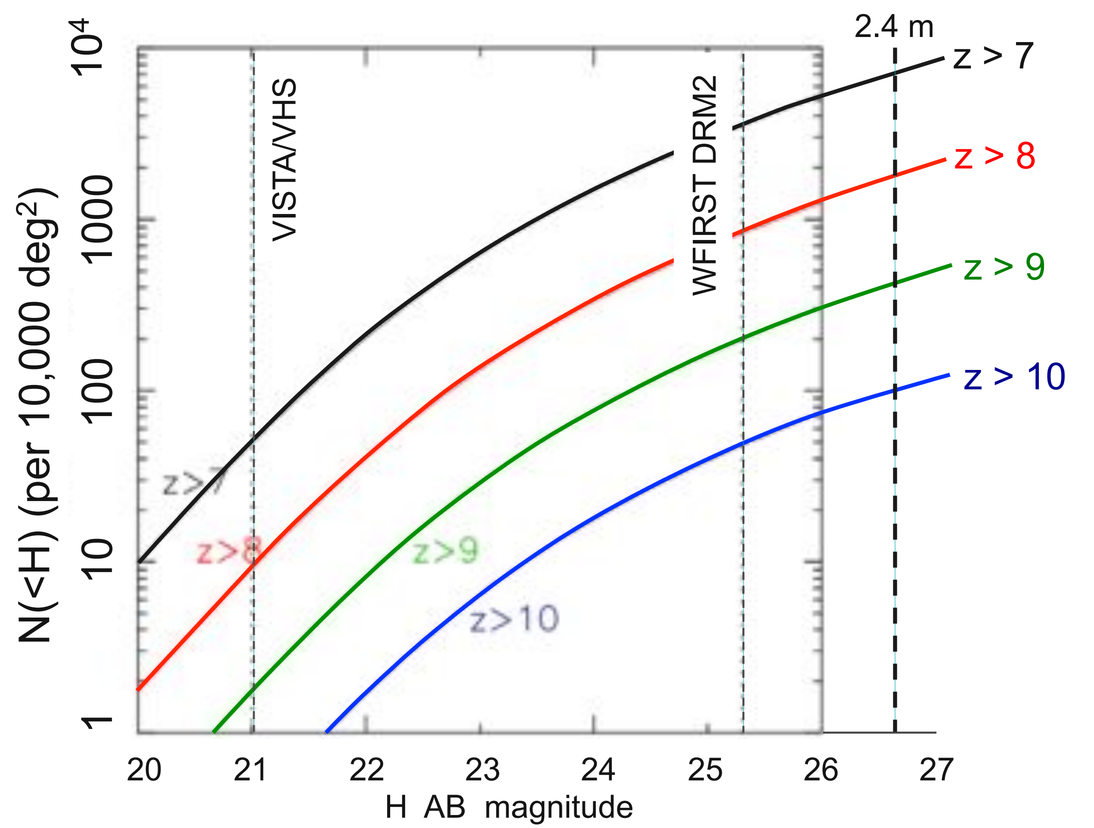


Assumes 2.4m aperture, 0.11"/pixel and 5 independent exposures co-added to achieve final integration time.

HLS Science: High-z Quasars

Identification and characterization of QSO's at z > 6 will directly probe SMBH and the IGM at early cosmic times. The existence of high-z QSOs indicates the presence of 10^9 solar mass BH only a few 100 Myr after the big bang and QSO spectra will further map the reionization history of the universe.

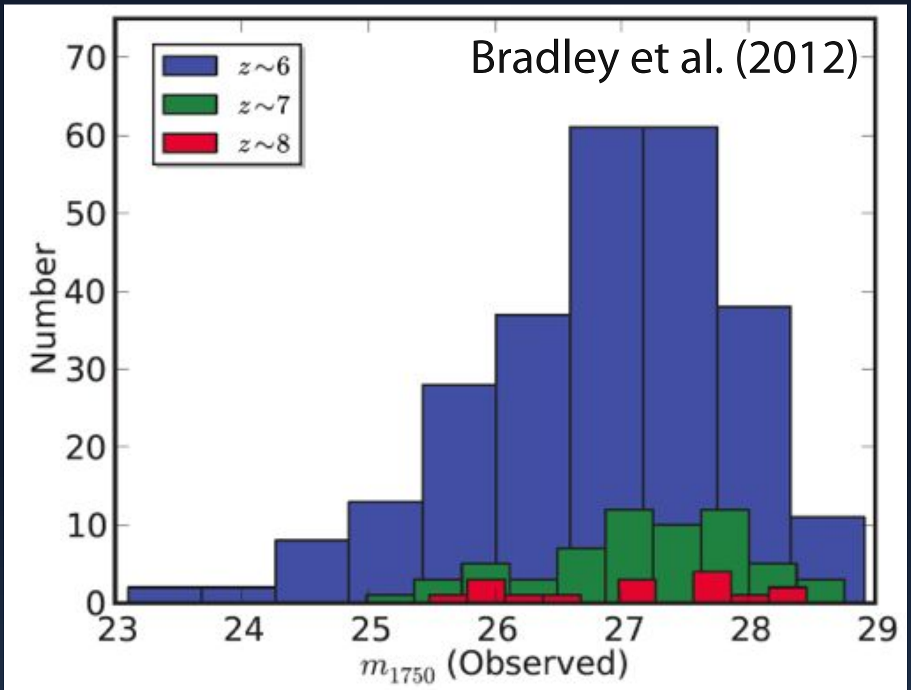
- Expect about one z>7 QSO per square degree in HLS with 2.4m NRO telescope. This is ~2x higher density than DRM2.
- Up to 34 z>10 QSO's in 3,400 deg^2 (if they exist).
- Requires a multi-band NIR survey with slitless spectroscopy to fully optimize science return.
- Synergy with JWST

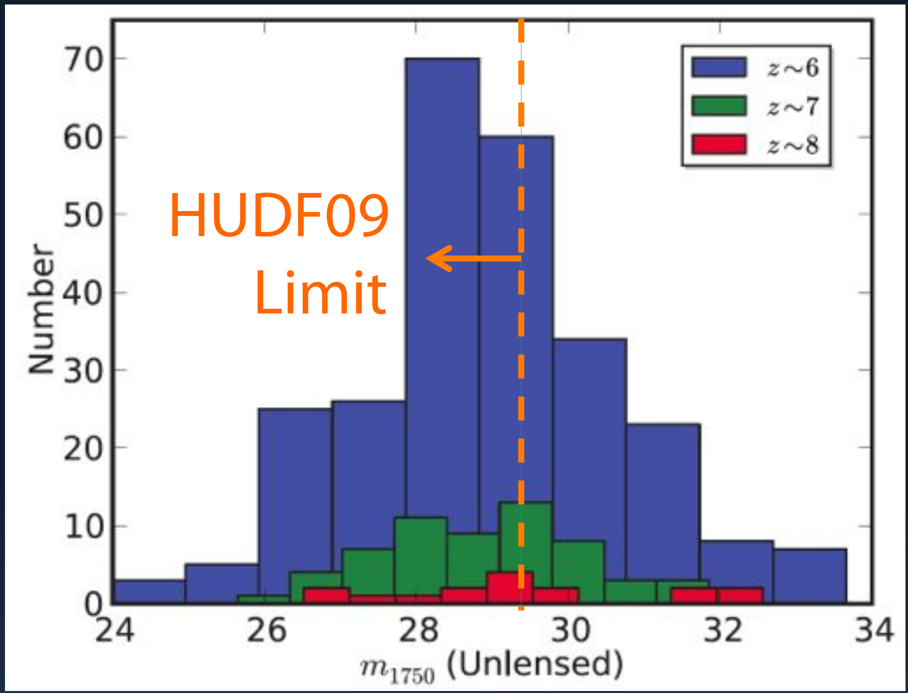


QSO count estimate from Xiaohui Fan

HLS Science: z > 6 Galaxies

AFTA 2.4m can make a major increase in the number of known z > 6 galaxies (both lensed and unlensed) enabling LF, clustering and SFR densities to be analyzed as a function of many different galaxy properties. Estimates suggest as many as 10^6 z~8; 30,000 z~10; and 1,000 z~11 field galaxies will be found with AFTA 2.4m in 3,400 square degrees.



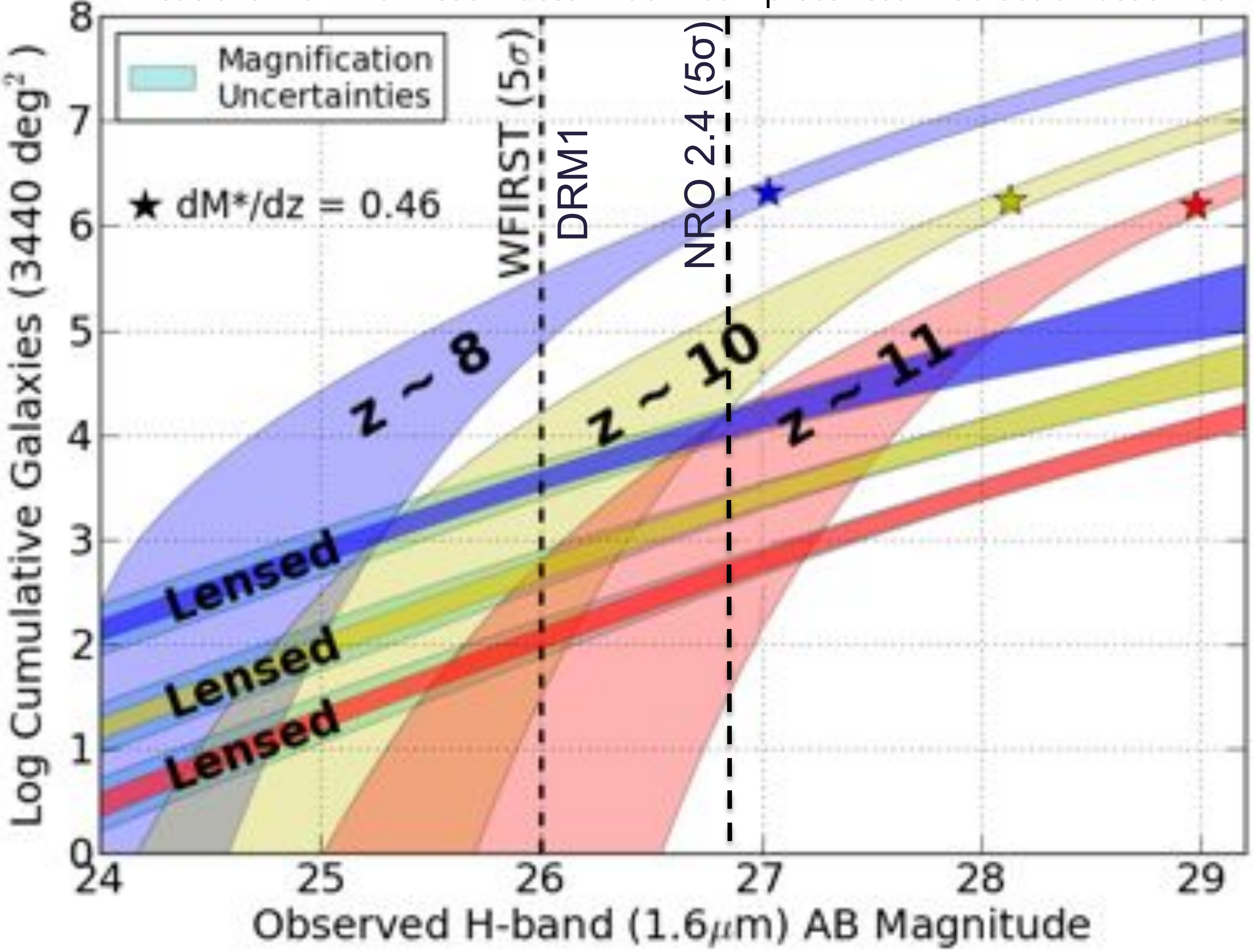


Most z > 6 galaxies (even those that are gravitationally lensed) are fainter than AB 26 mag. *NRO 2.4m survey will contain orders of magnitude more field galaxies at these high redshifts (and 3 – 4 x as many lensed z > 7 galaxies) than DRM1, DRM2, or Euclid.*

Expectations for High-z Galaxy Discoveries

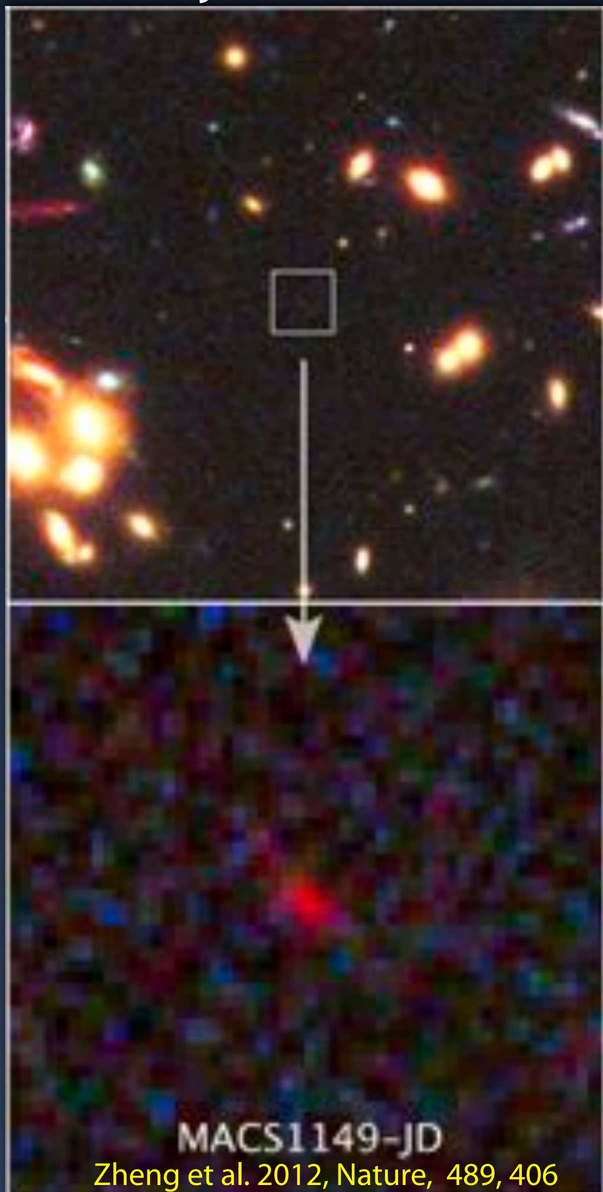
Unlensed z=8 LF constrained by BoRG data for 26 – 29 mag. Extrap. to z=9,10 assume dM*/dz=0.46.
Lensed Galaxy counts assume ~1 strongly lensing cluster per sq degree with typical CLASH mass model.

These are maximum estimates –100% completeness in selection assumed



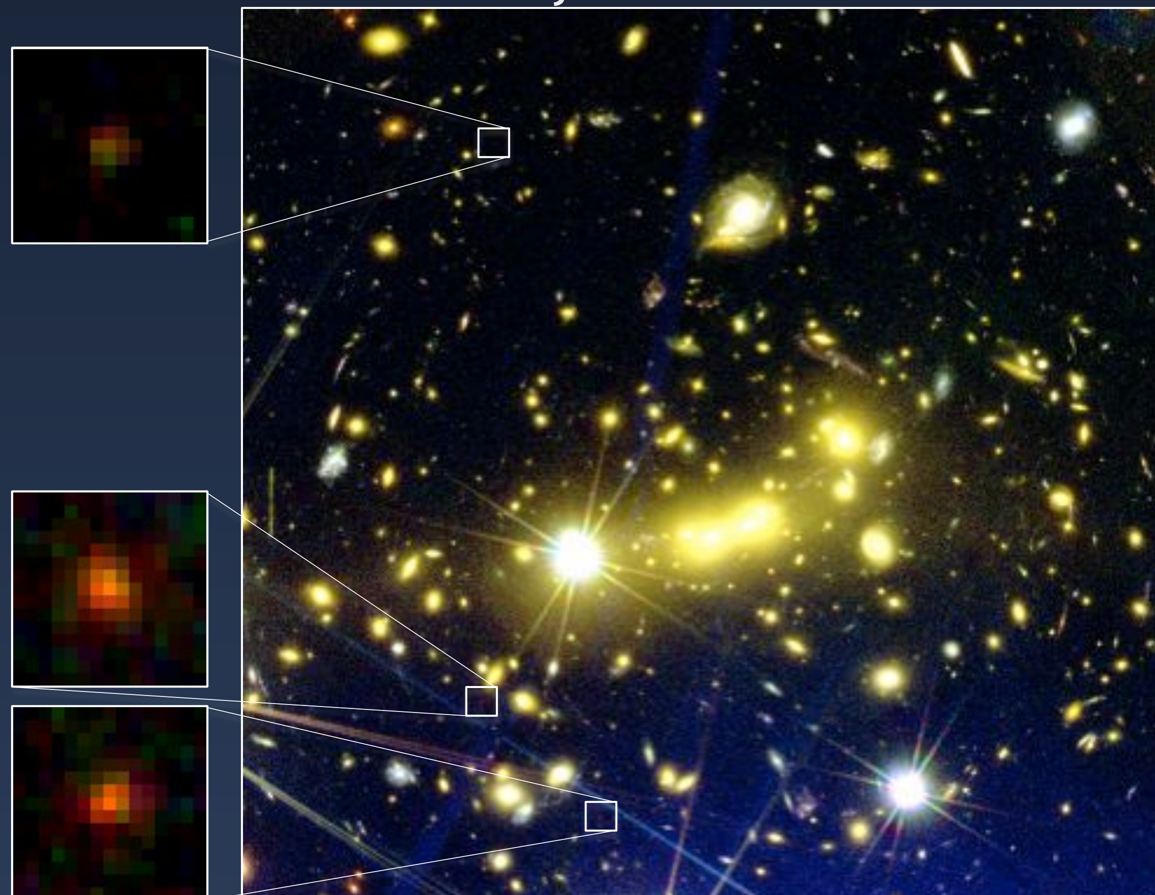
z > 9 Lensed Galaxies

z = 9.6 object in MACSJ1149+2223



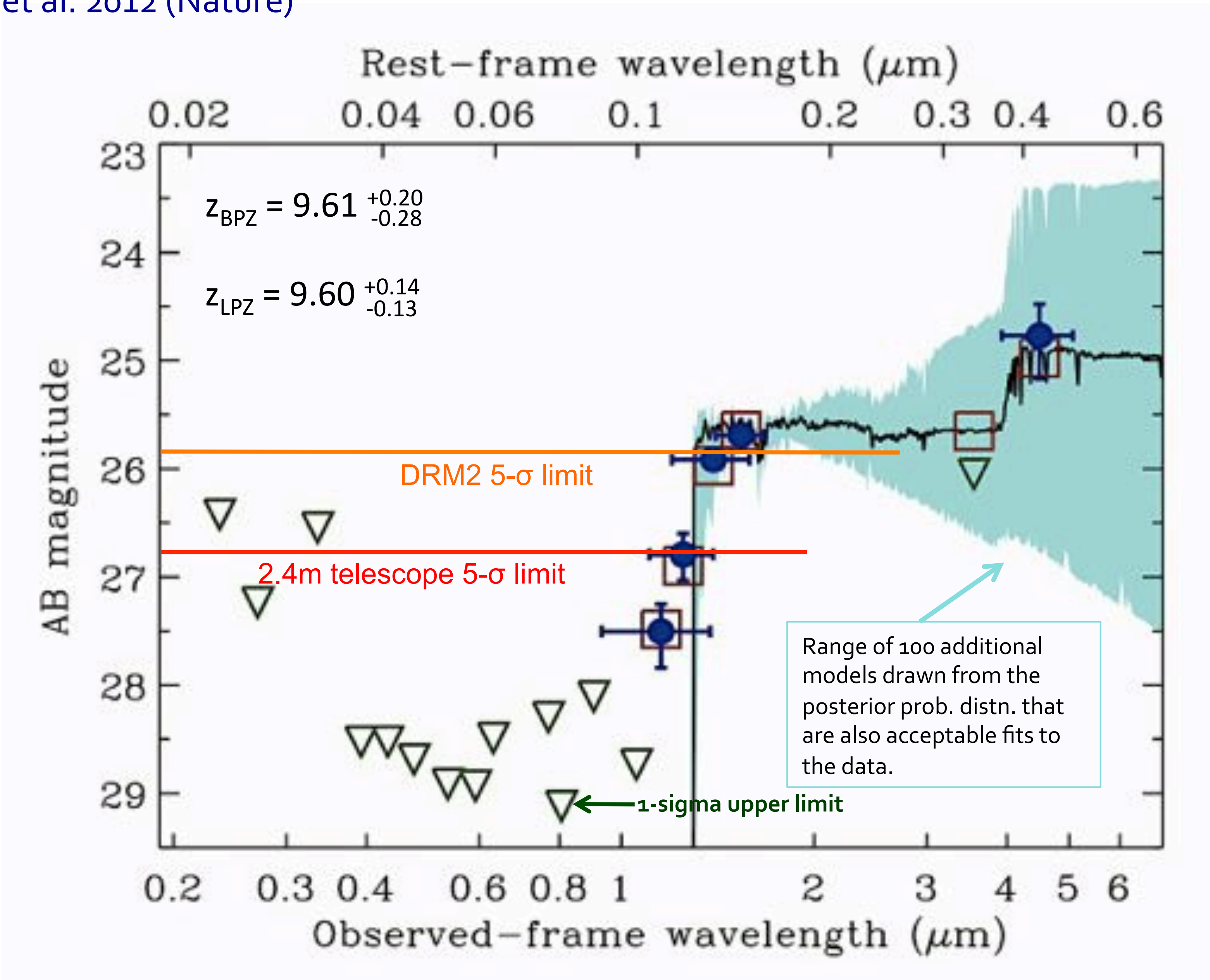
Zheng et al. 2012, Nature, 489, 406

z = 10.8 object in MACSJ0647+7015



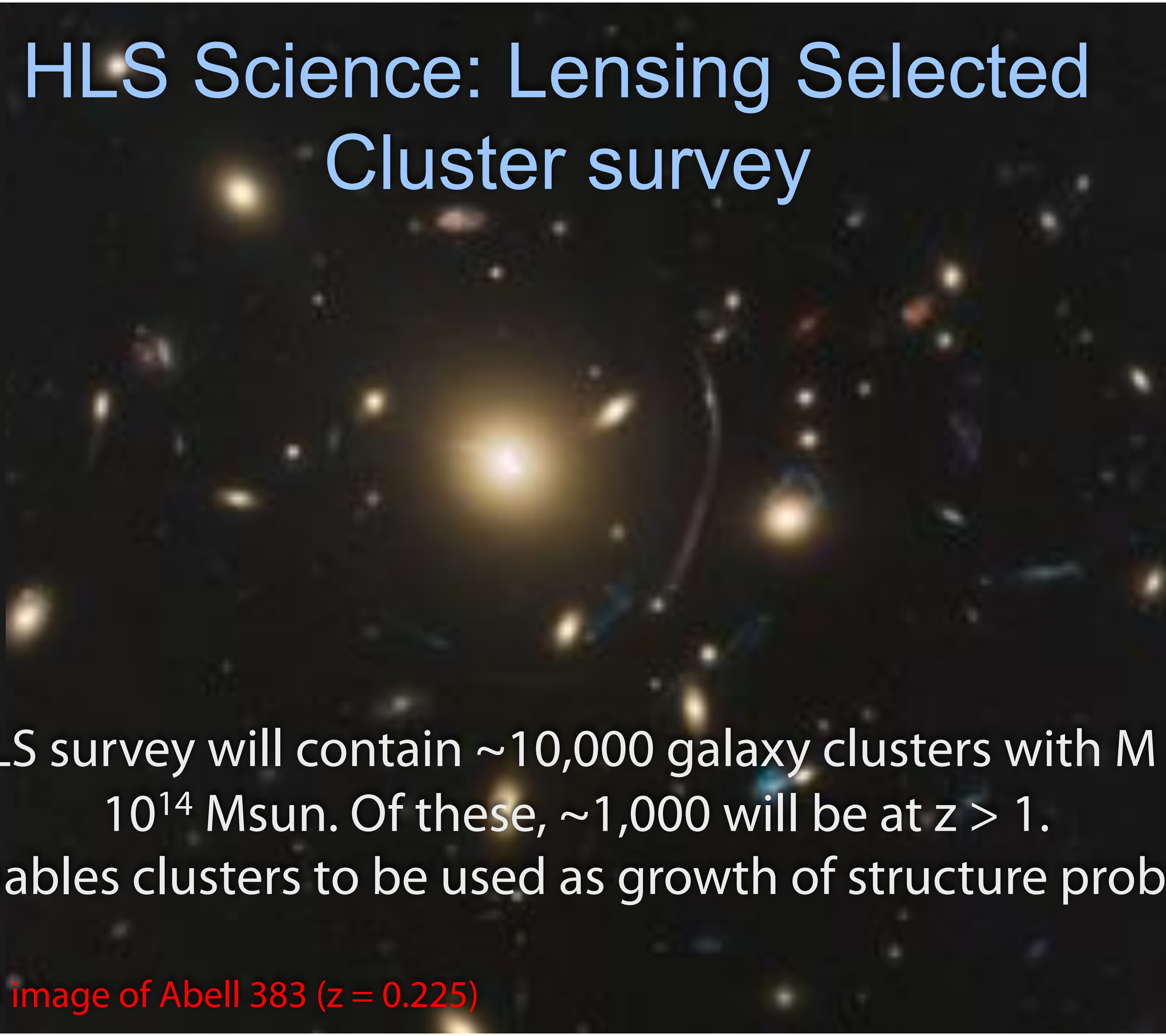
Coe et al. 2012, ApJ, accepted

Zheng et al. 2012 (Nature)



Black spectrum = best fit from stellar population synthesis modeling

HLS Science: Lensing Selected Cluster survey

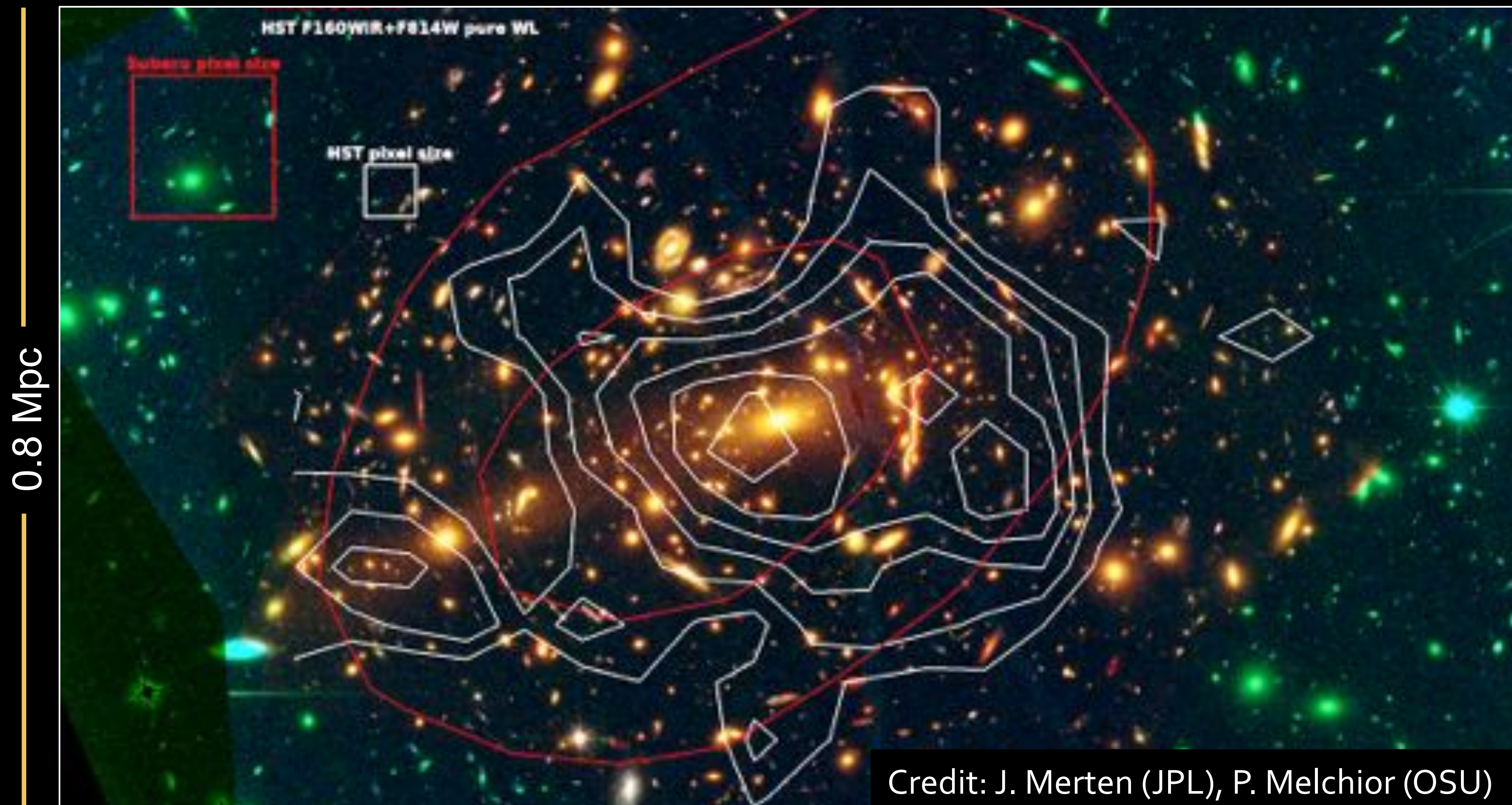


HLS survey will contain ~10,000 galaxy clusters with M > 10^{14} Msun. Of these, ~1,000 will be at z > 1.
Enables clusters to be used as growth of structure probe.

CLASH image of Abell 383 (z = 0.225)

NIR Survey in Space: Depth and Resolution Advantage on Cluster-scales for Weak Lensing

MACSJ1206-08 at z=0.44



Subaru: Usable source density: 8 galaxies / arcmin^2 → 25'' WL map resolution (142 kpc)

HST in H-band (WFC3): ~75 galaxies / arcmin^2 → 7.5'' WL map resolution (43 kpc)

SNR Gain over Subaru or LSST for WL Shear near massive clusters

The SNR of the weak lensing shear signal in the environs of a cluster is:

$$\text{W.L. S/N} \sim b(m,R)\ w(z|m)\ (n_g(m,R))^{0.5}\ (\sigma_g)^{-1}$$

where b is the shear calibration bias, w is the typical distance ratio (D_{LS}/D_S), n_g is the surface density of background (lensable) sources, and σ_g is the intrinsic rms in galaxy ellipticities.

m is the galaxy magnitude and R is the ratio of the typical galaxy size to the PSF of the telescope.

SNR Gain over Subaru or LSST for WL Shear near massive clusters

Using some typical values derived from existing Suprime and HSC Subaru data:

$$\frac{\text{SNR (WFIRST)}}{\text{SNR (Subaru)}} \sim 2.7 \times \sqrt{\frac{n_{gal}\,\text{(WFIRST)}}{60\ \text{gal arcmin}^{-2}}} \left(\frac{\sigma_g}{0.3}\right)^{-1}$$

Expect easily a factor of 3 improvement (and perhaps as high as 4.5) in the SNR of the WL signal around clusters over any large ground-based WL survey with the NRO 2.4m HLS data.

HLS Science: Grism Spectroscopy

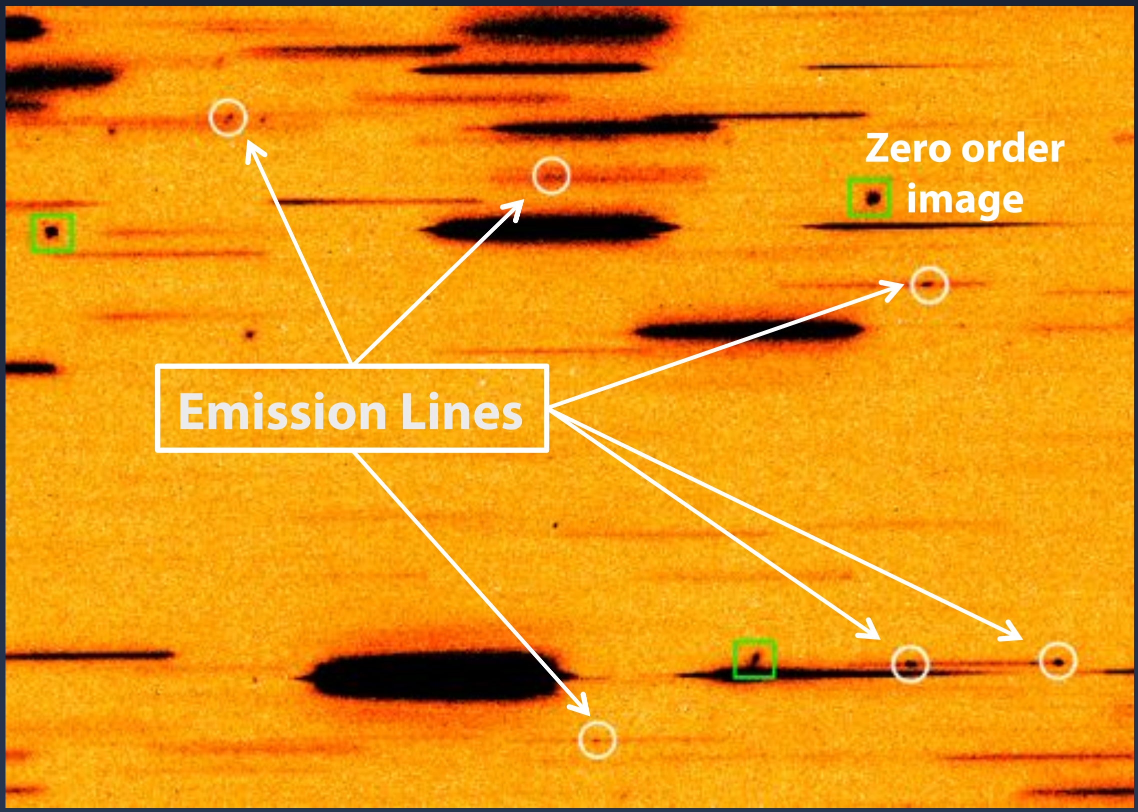
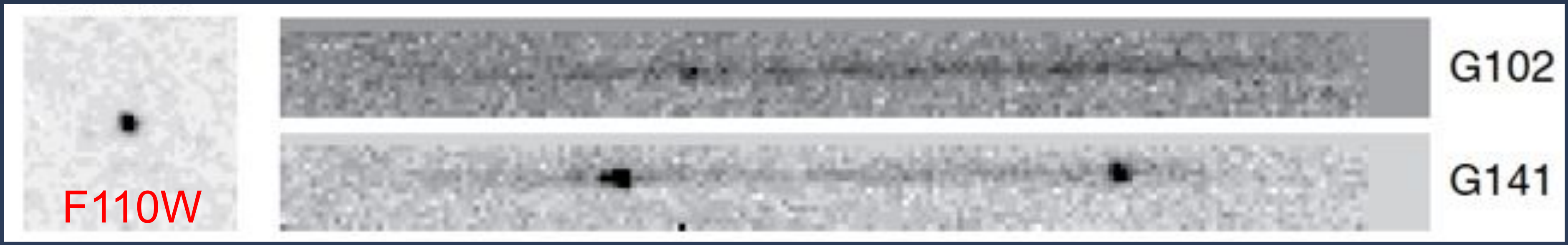
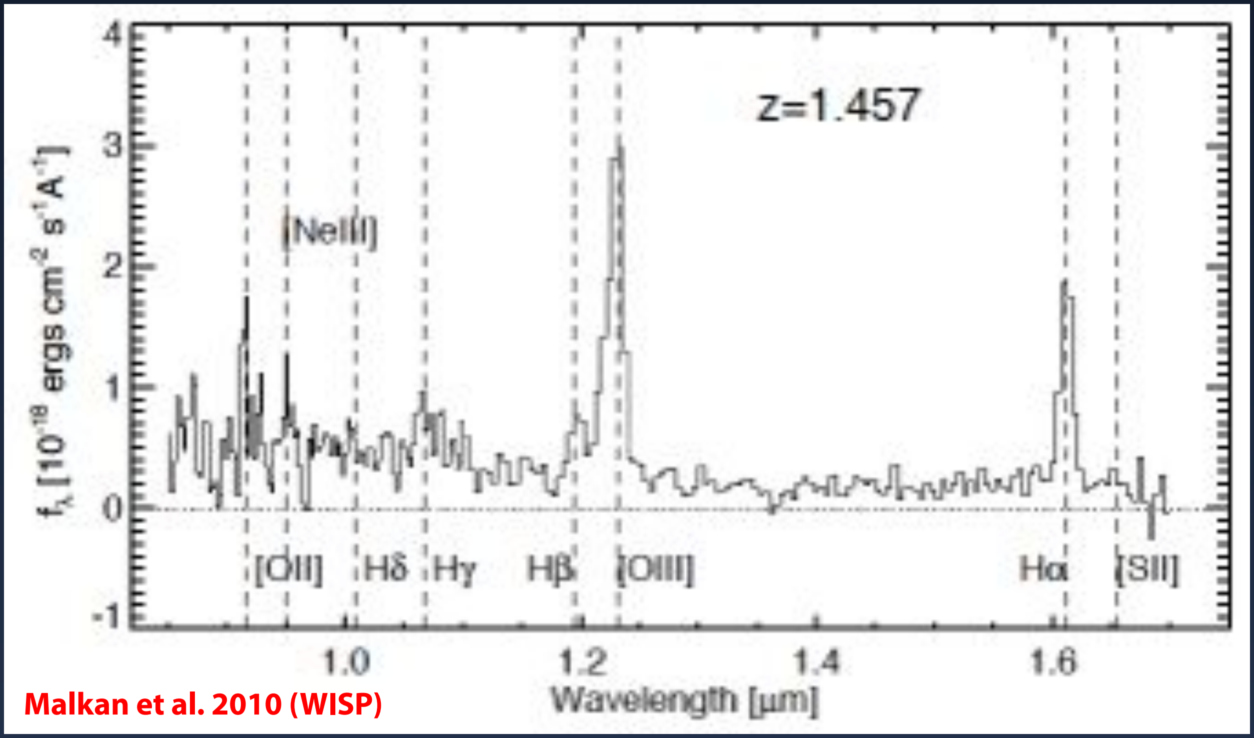


Image from WISP (WFC3 IR Spectroscopic Parallels), Matt Malkan (P.I.)

Just ¼ the FOV shown from single WFC3 IR image:
~15 emitters/arcmin^2

Should be comparable to what we would see with AFTA 2.4m grism survey.





- AFTA 2.4m Grism/prism survey:
  - ~15 – 20 million galaxies with H-alpha emission over all redshifts: sensitivity down to SFR ~3 M_solar yr $^{-1}$
  - Thousands of Lyman-alpha emitters at z > 7 (need to verify this estimate)
  - ~700 z>7 QSO spectra
  - ~300 z>1 brightest cluster galaxy spectra
  - Spectral properties of galaxies much fainter than L* at the peak of the galaxy assembly epoch.

To discuss

- Number of filters in HLS (4 as default)
  - Y (1 micron), J, H, and HK (1.8 micron) or Ks?
  - Overlapping filters (at least in 2 reddest bands) may provide better photo-z constraints on very high-z objects.
- Fraction of time allocated to HLS
  - >40%: min. of 2 years of a 5-year mission ?
- Depth vs Areal Coverage
  - 2.4m HLS is ~0.7 mag deeper than DRM1
  - Minimum survey area of ~3,500 deg^2 should be easy to reach in a 2 year HLS time allocation.
  - 8,000 deg^2 would require ~4 years.