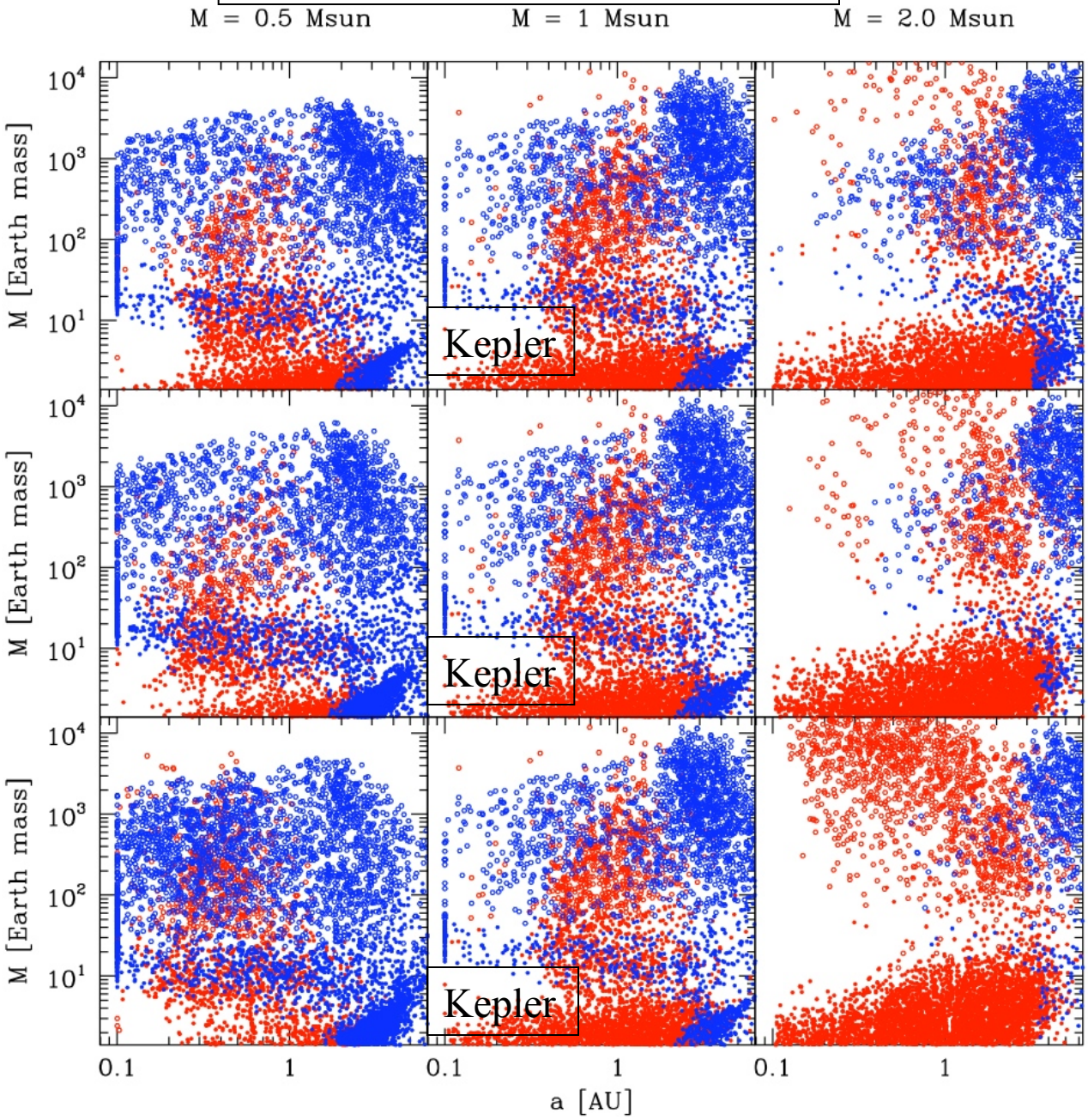
WFIRST/AFTA – the Observatory

Dark Energy – the experiment

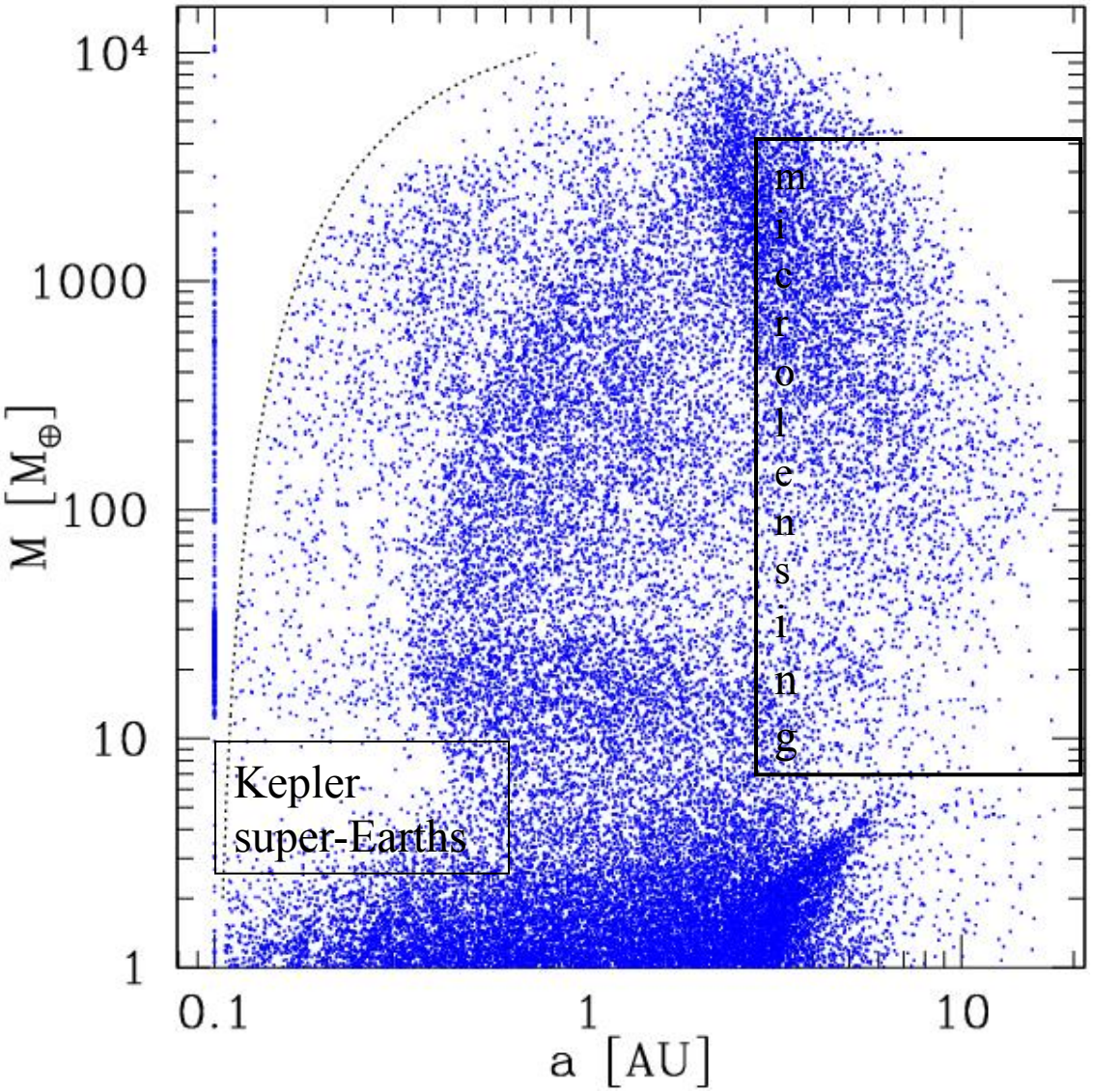
Microlensing Planet Search – the program

Alibert, Mordasini, & Benz (2011)

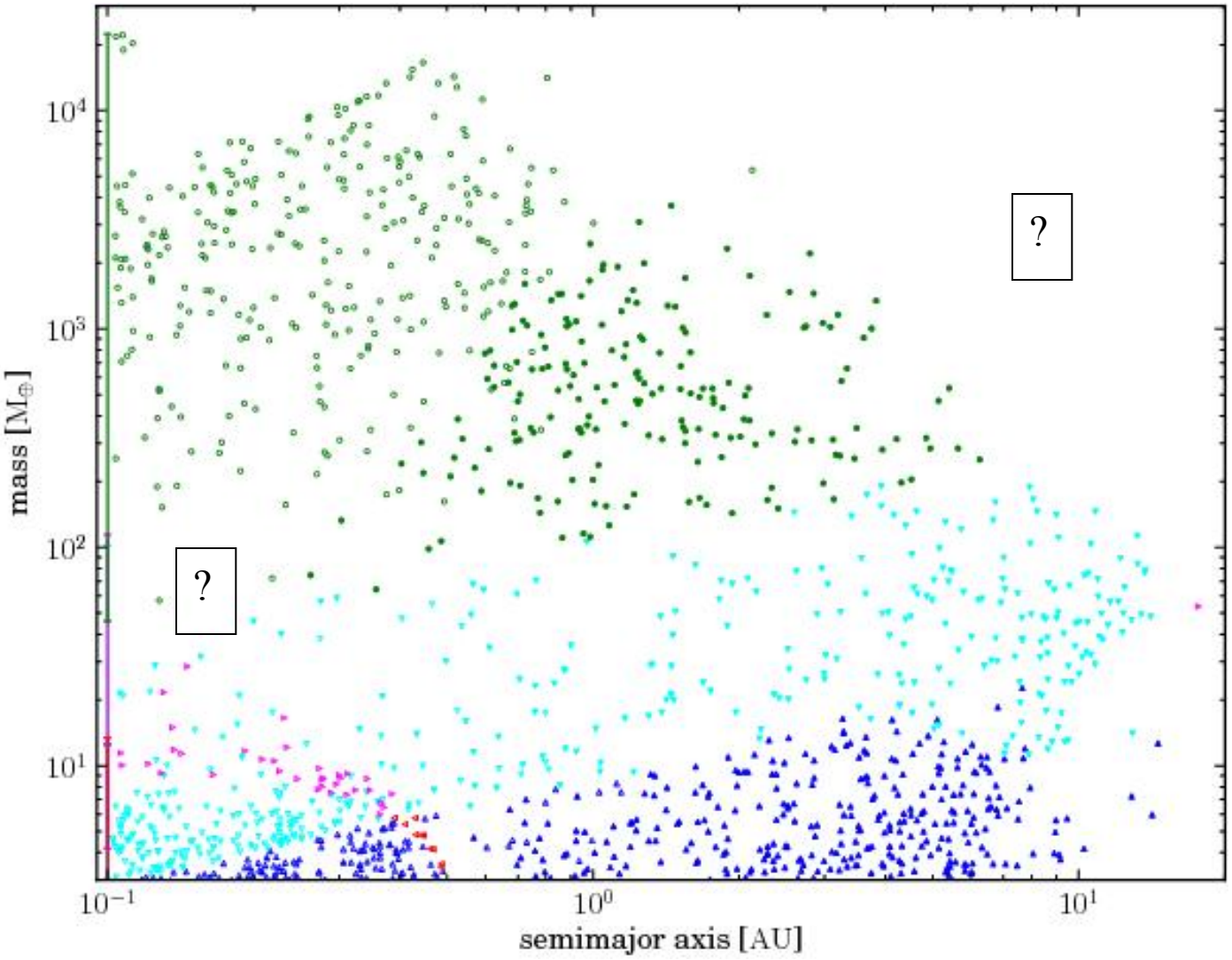


$M_d \sim M_s^{\alpha D}$

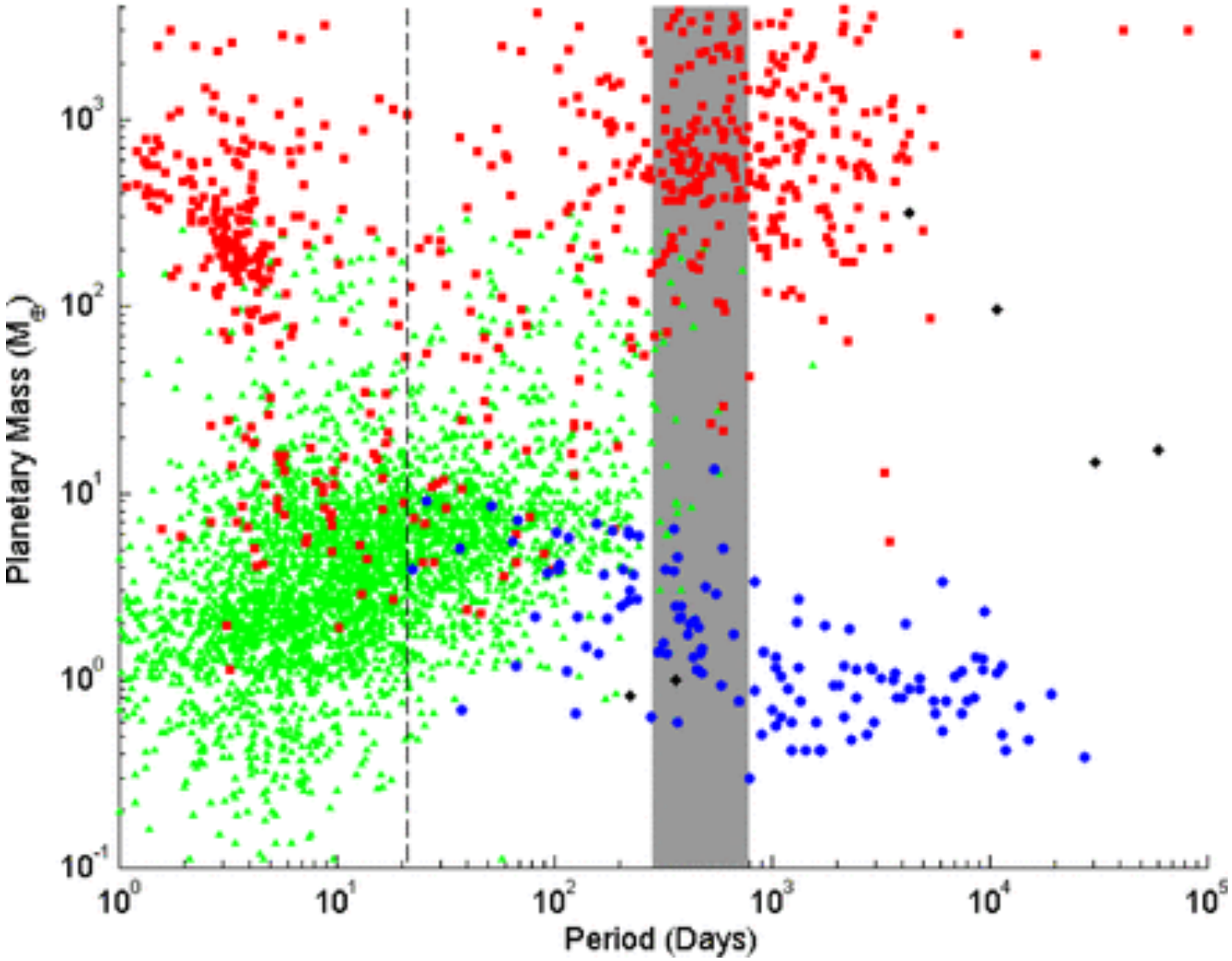
Mordasini et al. (2012): 1 M_{sun} , $f_I = 0.001$



Dittkrist, Mordasini et al. (2014): new migration model & stellar irradiation of disk



Coleman & Nelson (2014): blue dots = detailed oligarchic growth & migration model



PLAN: HIGHLIGHT & SYNTHESIZE THE EXCITING "BEYOND THE LOCAL GROUP" ONE PAGE SCIENCE IDEAS PRESENTED IN THE SCIENCE DEFINITION TEAM'S 2013 AND 2014 REPORTS.

Community Members that Submitted 1-page Descriptions of Potential GO Science Programs in the 2013 SDT Report

RED is good GREEN is good

LSST ELT Euclid JWST Other X HLS?

Red on the left means the facility in the column cannot do it. So if a row is all red then it means it's unique to WFIRST.

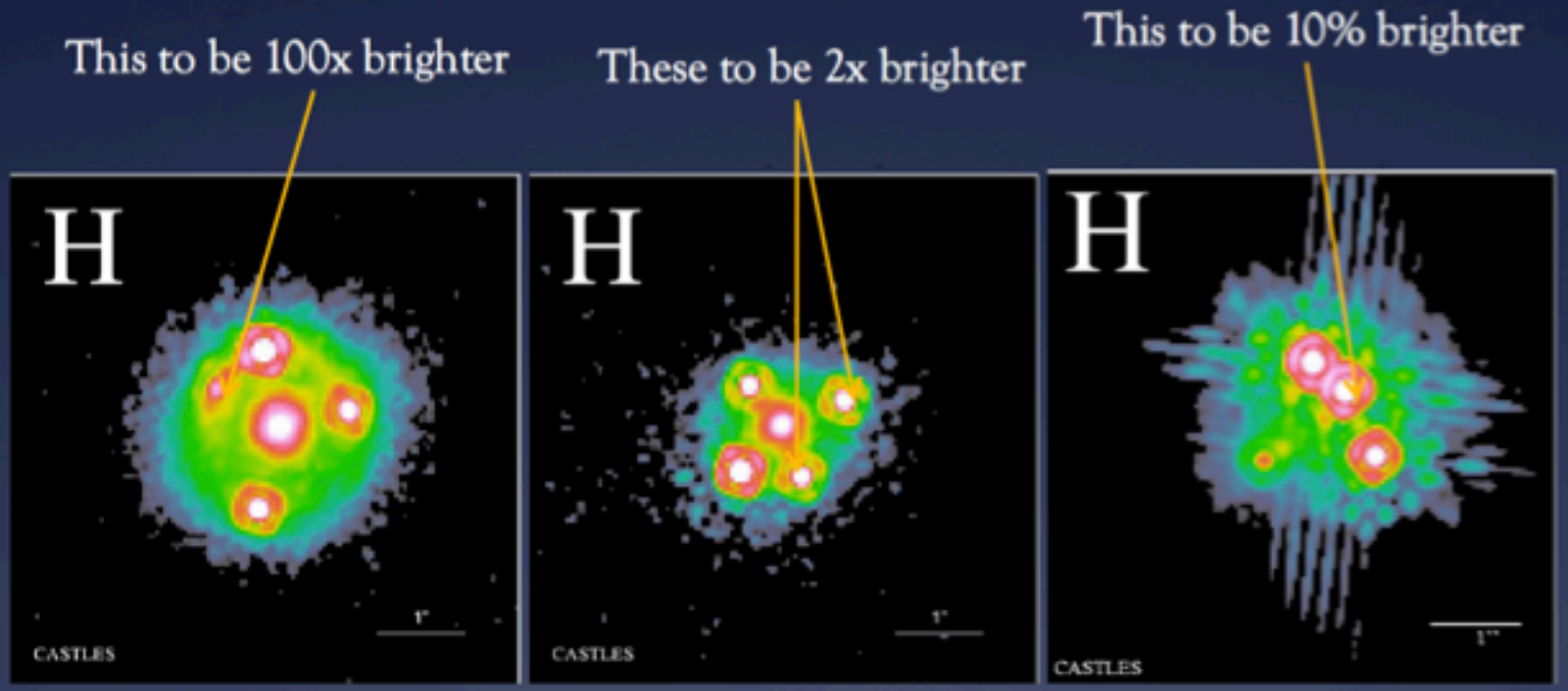
Names are omitted. Text is intentionally illegible... don't even try. Just look at the colours.

Green means it has that 'X-factor'. For me, this was mainly how exciting it felt, and with bonus points for how synergistic it felt.

Green means it can be done as part of the high-latitude survey so guest observer time would be pointless.

Flux Ratio Anomalies

A smooth mass distribution would predict:



What causes this the anomaly?

1. Dark satellites?
2. Astrophysical noise (i.e. microlensing and dust)?

Slide credit: T.

Science topic	Done by HLS	Done by Microlens	Done by SNe	Truly GO	Comments
KBO				X	Feasibility - requires 7000 sq deg
Oort cloud				X	Feasibility - can detectors be read out at 40 Hz?
free floating planets				X	Requires galactic plane survey
Transit planet masses				X	Feasibility - requires high cadence - exp every few minutes
Exoplanet spectra					Not clear WFIRST can do this at all
Additional Exoplanets (transits)		X			requires 500 days of time - so longer than microlensing survey
Additional Exoplanets (astrometry)		X			requires 500 days of time - so longer than microlensing survey
substellar populations	X				if HLS were to include H-band
Brown dwarf survey	X		X		
stellar fossils				X	requires obs of Milky Way disk
IR CM Relation				X	requires obs of Galactic globular clusters
closest young stars			X		If SNe survey uses IR bands
distant SF regions	X		X		If K-band was available
hi-res imaging of low mass stars				X	requires well-sampled images at bluest wavelength. May not be feasible.
nuetron stars & black hole survey		X			
motions of disk and bulge stars				X	Requires ~10,000 epochs
QSO ref frame behing MCs				X	HLS will not observe SMC or LMC
Magellanic stream				X	HLS will not survey a LMC stream in its enitrety
faint MW satellite survey				X	needs cadence not used in HLS
mass of MW Galaxy	X				
CDM vs WDM test				X	requires observing LG dwarf galaxies
Missing Satellite survey				X	requires observing LG Globular cluster streams
Map MW Potential				X	requires observing LG Globular cluster streams
Dissecting Nearby Gals				X	requires obs of nearby galaxies
Halo Age Distributions				X	requires obs of nearby galaxies
50 Mpc substructure				X	requires blue (700 nm) filter
Deep photom of gals and clusters	X		X		
Galaxy Structure / Morph	X				
Strong Lensing	X		X		
Shock dominated systems	X				HLS grism survey should suffice
Cluster matter distrib.	X				
Merging galaxy clusters	X				
Group-scale Lenses	X				
Masses of hi-z clusters	X				although would benefit from more area
Evol of massive red gals					not feasible - needs medium band filters
Ly-alpha emitter survey				X	needs greater depth than HLS grism survey
obscurred QSOs	X				
faint end of QSO LF	X				probably can be gleaned from HLS. Precise depth not specified in 1-pager.
strongly lensed QSOs	X				

Thanks to Marc Postman!

<u>48 proposals</u>

19/48 = 40% genuine GO

22/48 = 46% 'genuine' GO
(but about 6 were from NIRSS

7/48 = done by Microlens or SNe Survey

Science topic	Done by HLS	Done by Microlens	Done by SNe	Truly GO	Comments
hi-z QSOs	X				
Re-ionization sources	X				Didn't specify precise depth required. Might be doable from HLS grism survey. Might also require more data.
cosmic explosions					not feasible - requires filters redwards of 2 microns
z=2 stellar pops	X		X		
LSST & WFIRST synergy	X				
Euclind & WFIRST synergy	X				
Galaxy halo shapes	X				
WFIRST & IRSA synergy	X	X	X		
Binary nuetron star mergers				X	Follow up gravitay wave detections. May not be feasible if GW system not on-line.

CONCLUSION
CONCUSSION

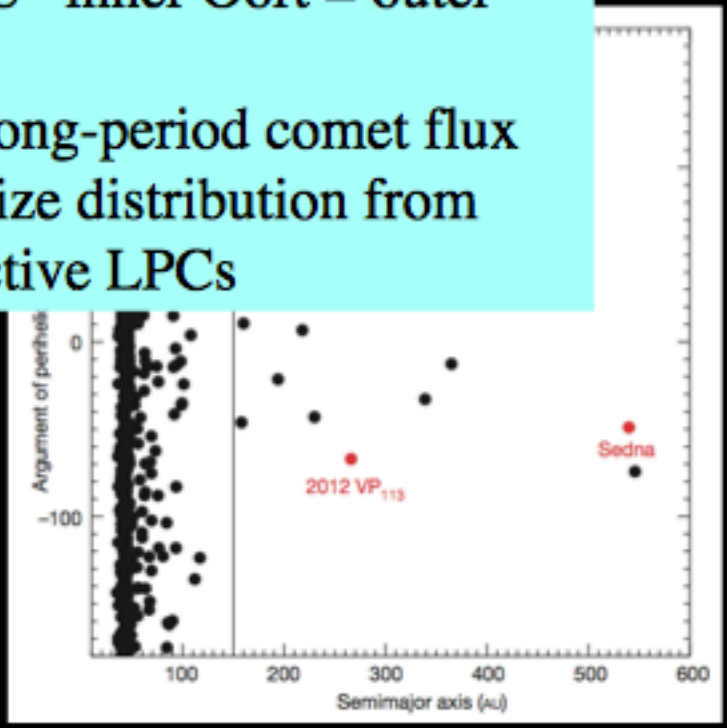
- #WFIRST is Sloan in Space disguised as a dark energy mission.

No, it's not. Spectra?

Dave Jewitt
Solar system

2012 VP113

- Assess the q > 50 AU "inner Oort = outer Kuiper" population
- Assess the arriving long-period comet flux
- Determine nucleus size distribution from photometry of pre-active LPCs



Trujillo & Sheppard 2014

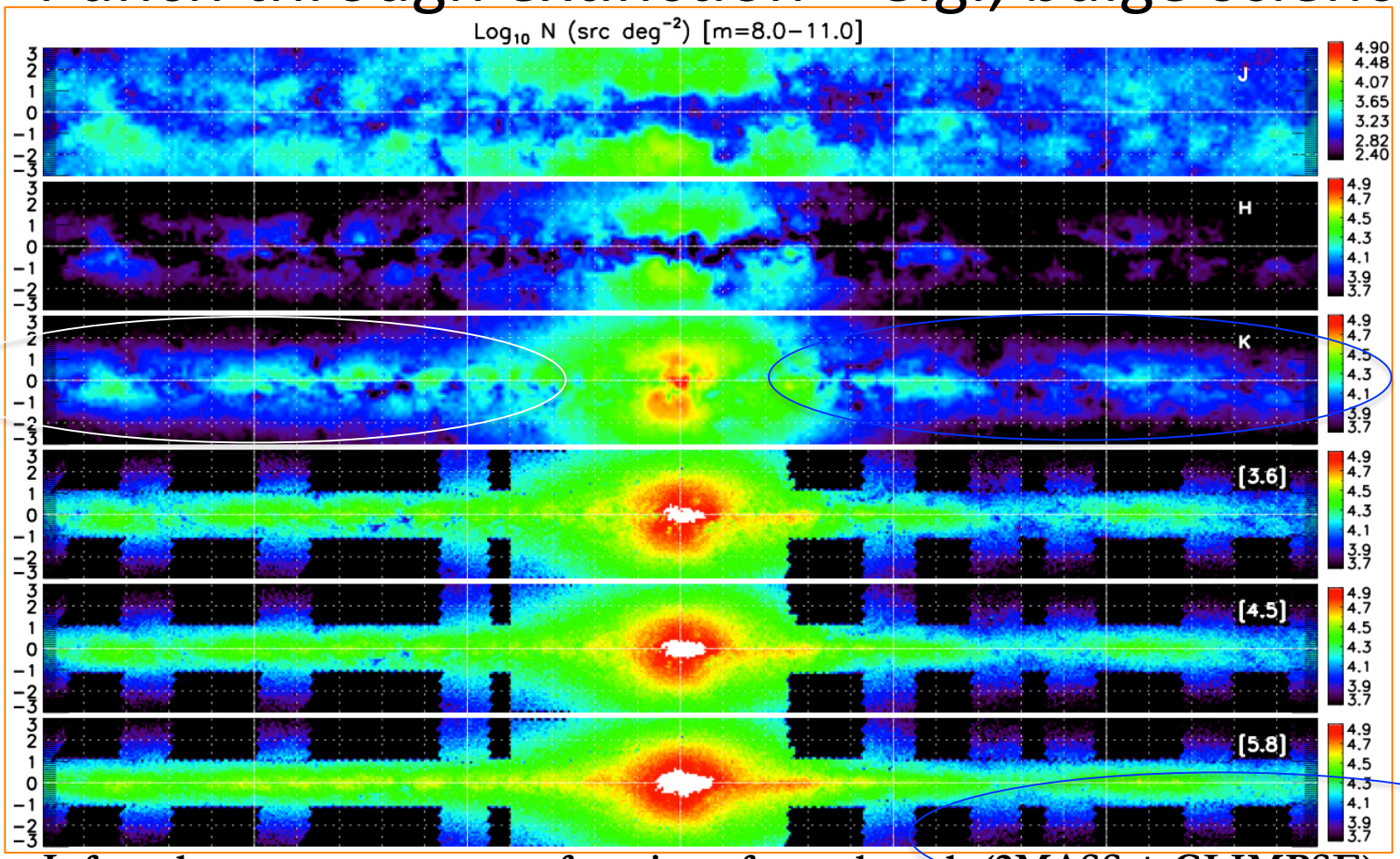
Detection of large perihelion objects

Planet	V(1,1,0)	R (V=27) AU
Earth	-3.9	1230
Jupiter	-9.3	4300
Neptune	-6.9	2500
Pluto	-1.0	630

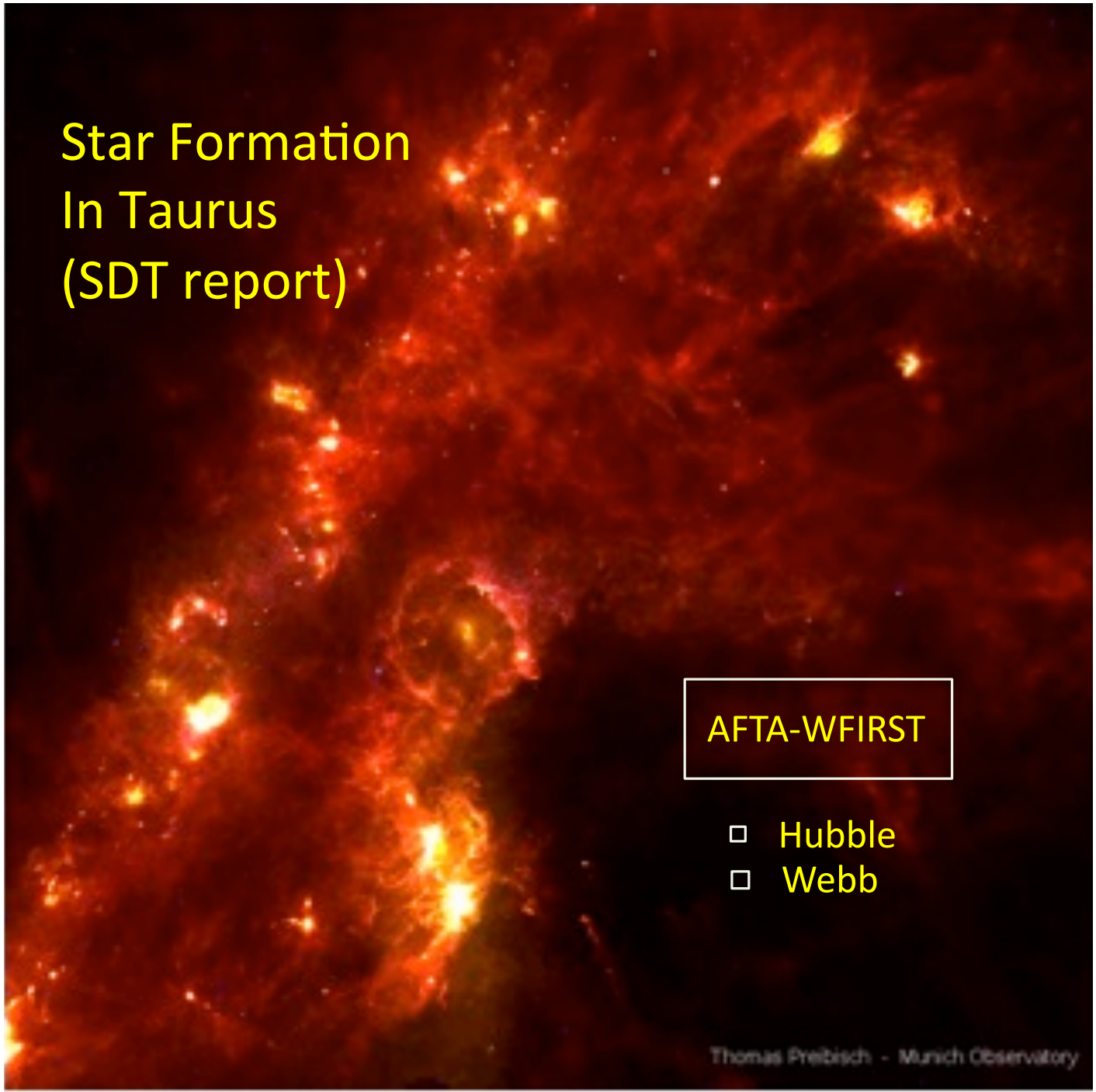
Dave Solderblom
Steve Majewski

Summary Wishlist

1. Longer λ desired (i.e.., K_s), w/no Δλ broadening
   - Punch through extinction – e.g., bulge science

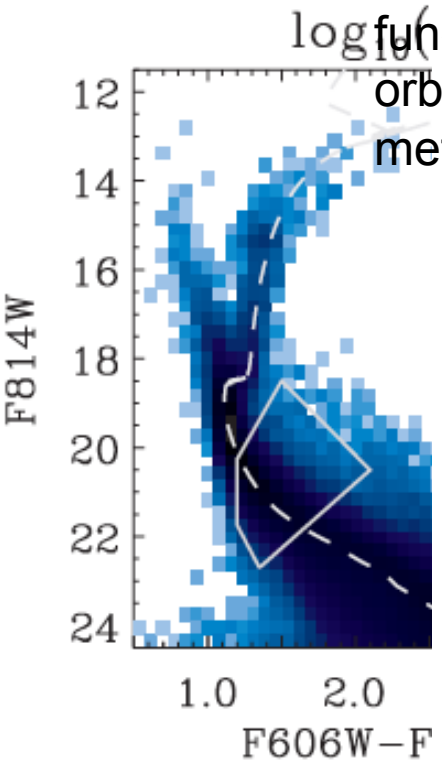


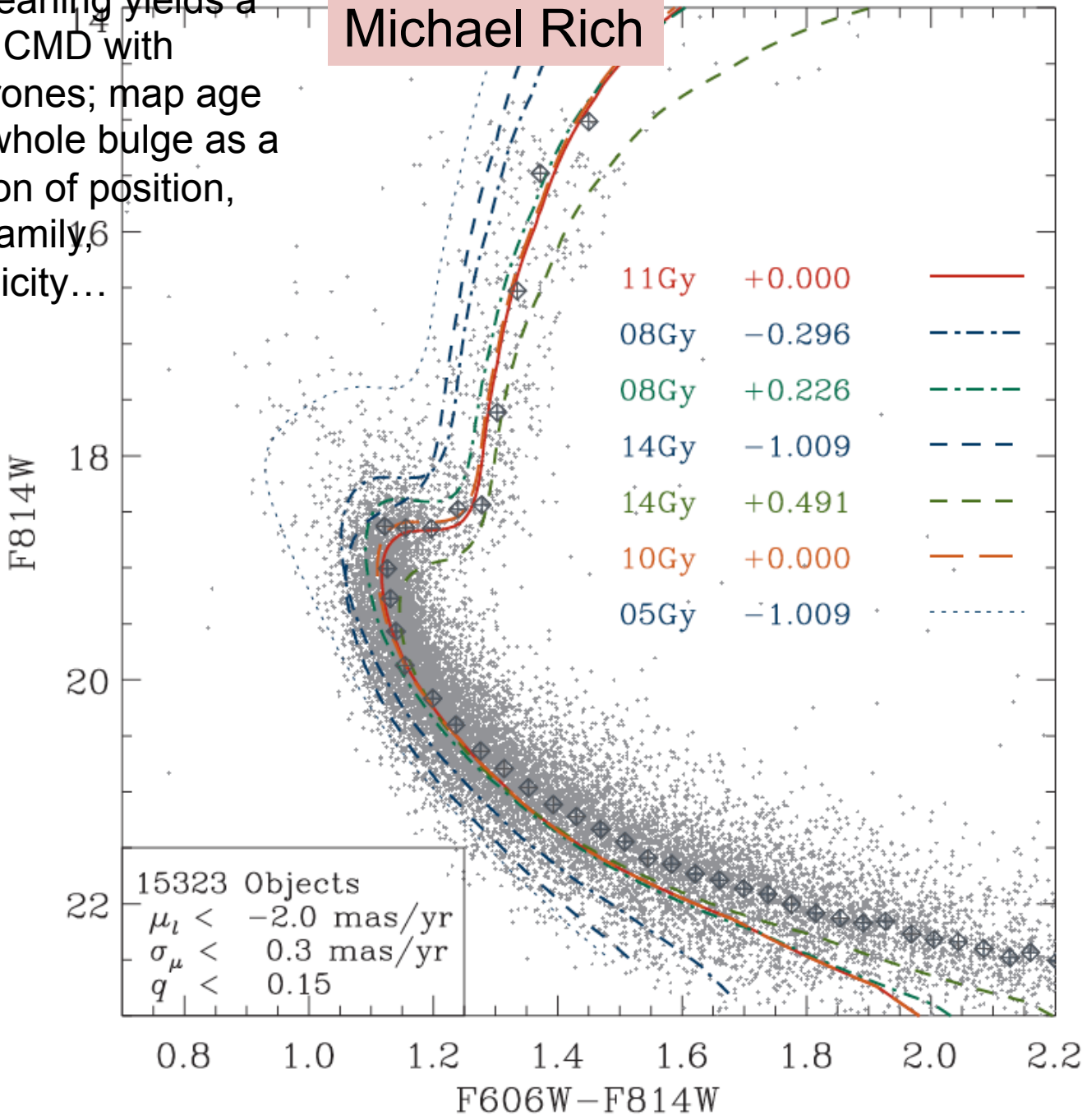
Infrared star-count map as a function of wavelength (2MASS + GLIMPSE)
(Benjamin)


Star Formation
In Taurus
(SDT report)
AFTA-WFIRST
Hubble
Webb
Thomas Preibisch - Munich Observatory

PM cleaning yields a bulge CMD with isochrones; map age over whole bulge as a function of position, orbit family, metallicity…

Michael Rich



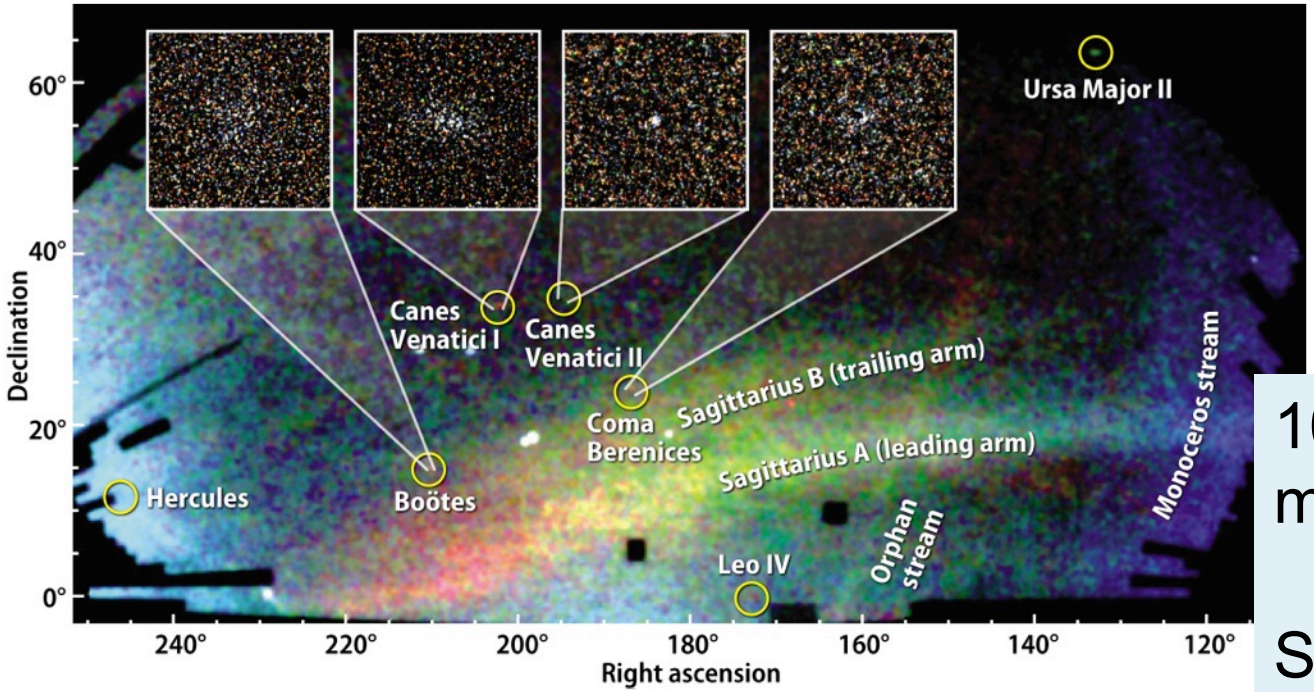


Proper motion Clarkson et al. populations

Galactic Science Example

Dark Matter Properties through Luminous Tracers

AFTA will survey 2000 sq deg of MW Halo at Hubble's power and IR image quality



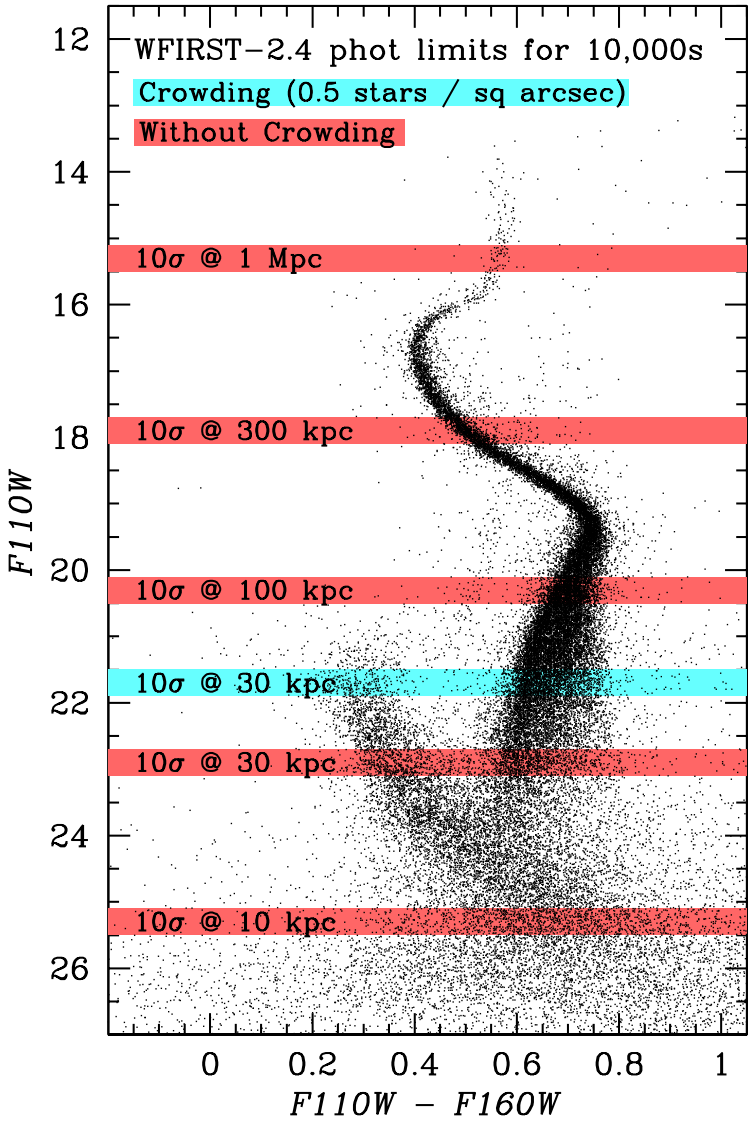
Current census of Milky Way DM-dominated streams and dSphs is heavily incomplete.

WFIRST will be very efficient at finding missing dSphs

10% of the mission? Easily.

Stars and Stellar Populations – much richer data than galaxies!

Galactic Science Example
Stellar Pops and IMF



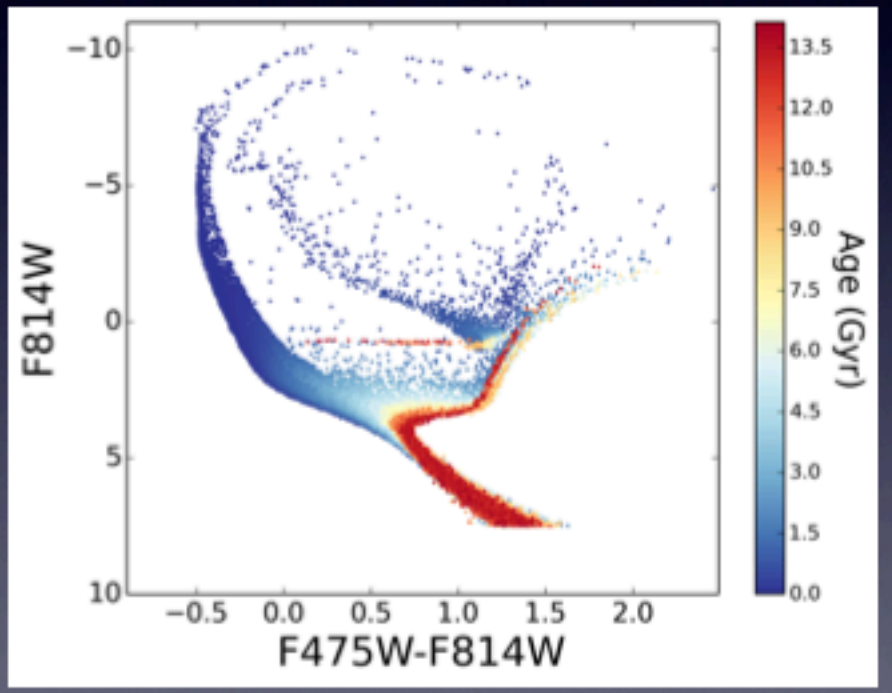
- M dwarfs out to the edge of the Galaxy
- Exquisite star/galaxy separation
  - High-precision photometry
  - Takes advantage of rising stellar luminosity function
    - Discovery of dozens of low SB systems
    - IMFs, SFHs, SB profiles, and structure

A stellar population (47 Tuc + SMC) in the IR (Kalirai et al. 2012)

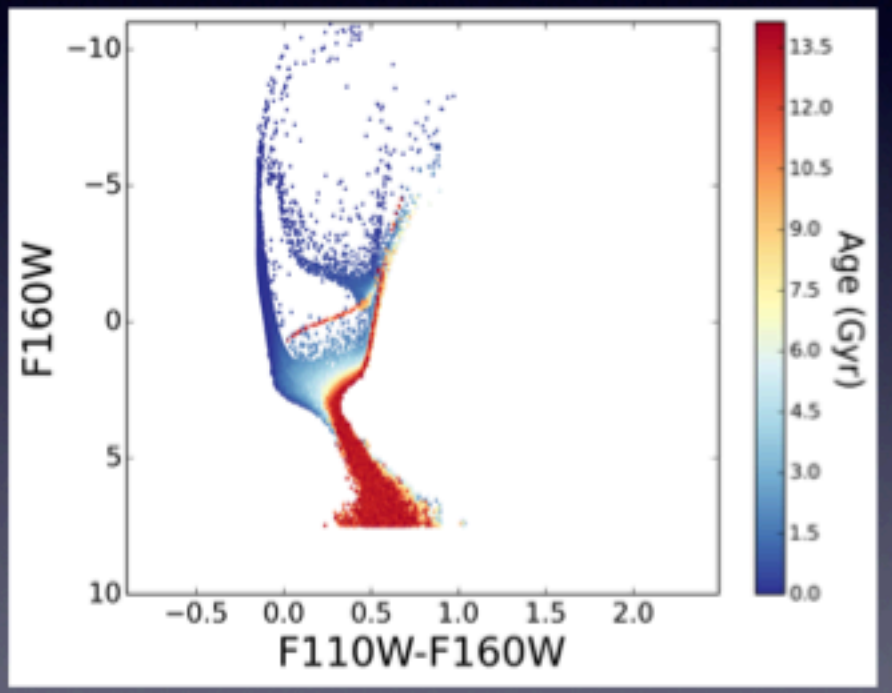
Weisz & Dalcanton

Brief Intro to

Optical CMD



Near-IR CMD



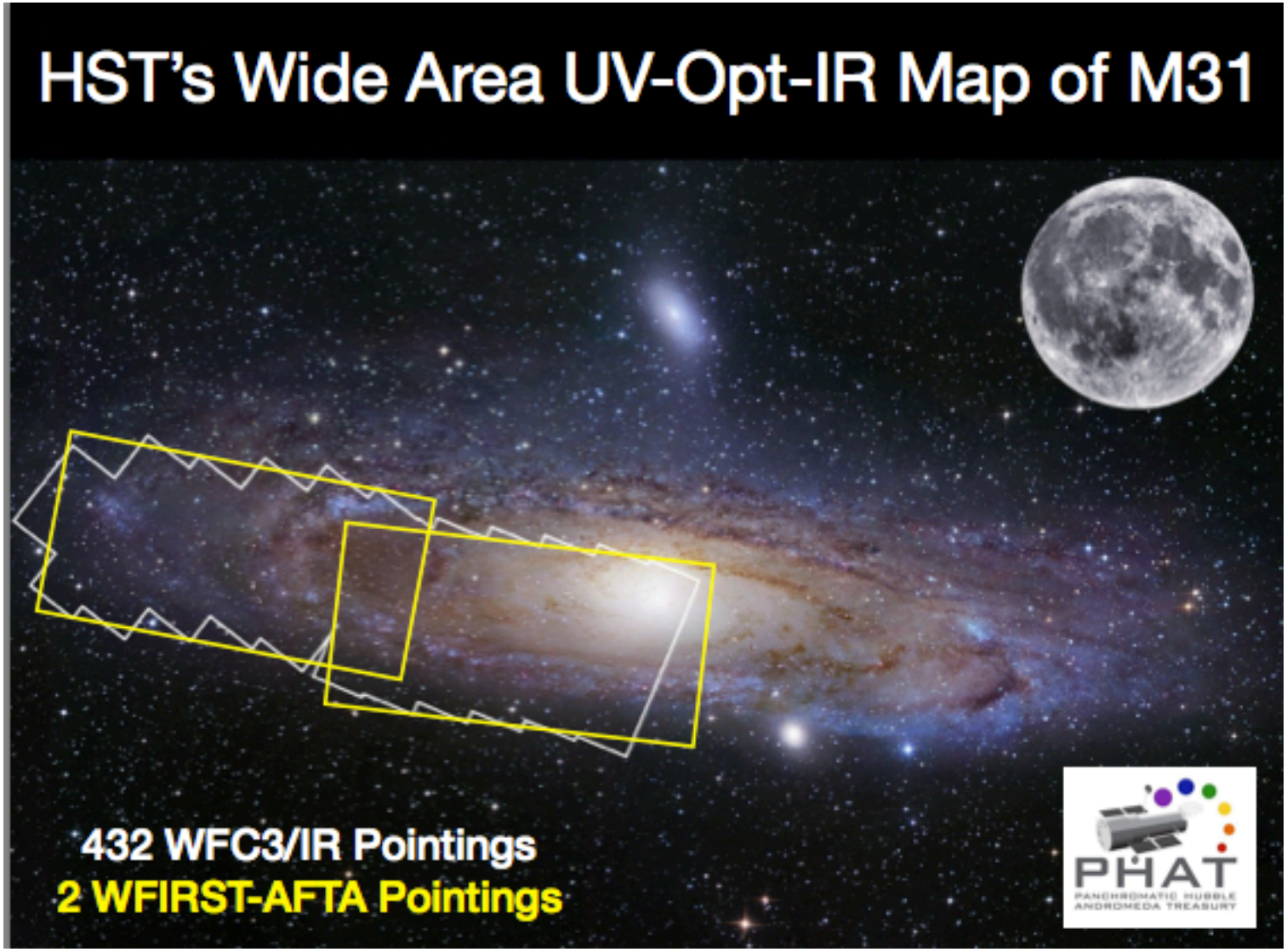
Broad Color Range

Narrow Color Range

and Redundant

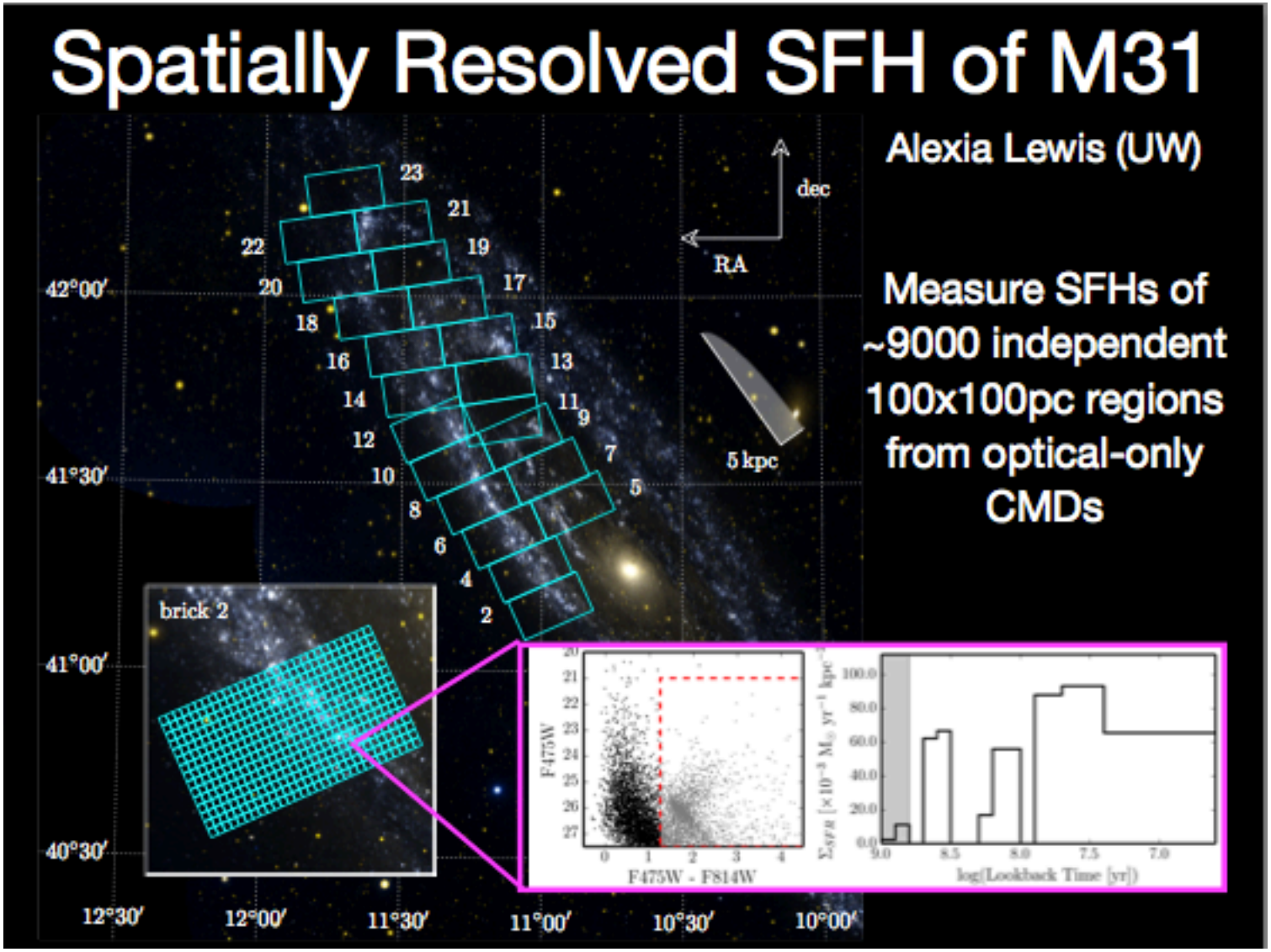
← Hotter

HST's Wide Area UV-Opt-IR Map of M31



Spatially Resolved SFH of M31

Alexia Lewis (UW)

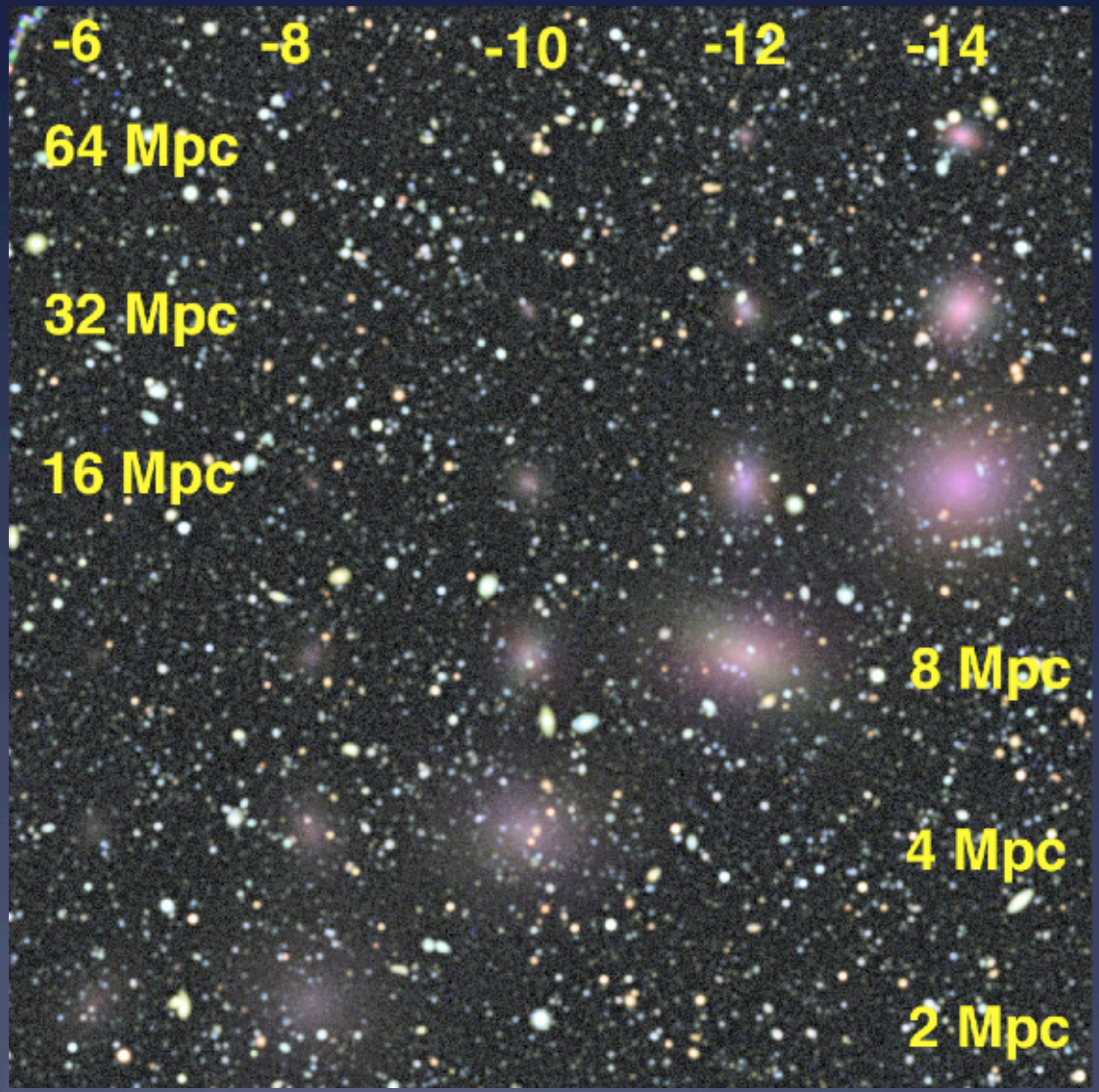


Measure SFHs of ~9000 independent 100x100pc regions from optical-only CMDs

Census of dwarfs in the field

Archival science:

- Expect >1500 dwarfs to Mv = -10 within 32 Mpc in 2000 sq. deg
- Predictions are uncertain by at least an order of magnitude at this luminosity
- TRGB detectable:
  - instant distance estimates



Map diffuse streams, halos, and thick disks with RGB stars for hundreds of nearby galaxies.

Martinez-Delgado+ 08

Galactic Science Examples

Luminous and Dark Matter

Astrometry!

- Masses of the Faintest Milky Way Satellites
  - 80 micro-arcsec/year gives individual star internal velocities
    - provides estimates of dark matter mass and density
    - <2 km/s for 50 stars @ 100 kpc, in 3 years
- The Mass of the Milky Way
  - Tangential velocities of distant tracers in the Milky Way halo
    - <40 km/s error in v_{TAN} at 100 kpc, less than the expected velocity dispersion
    - Breaks the mass-anisotropy degeneracy in the distant halo
- Cold vs Warm Dark Matter
  - Distinguish central density profiles
  - Extrapolate dark matter mass profiles
  - Current v_{RAD} lead to degeneracy b/w the central slope of DM profile and velocity anisotropy.

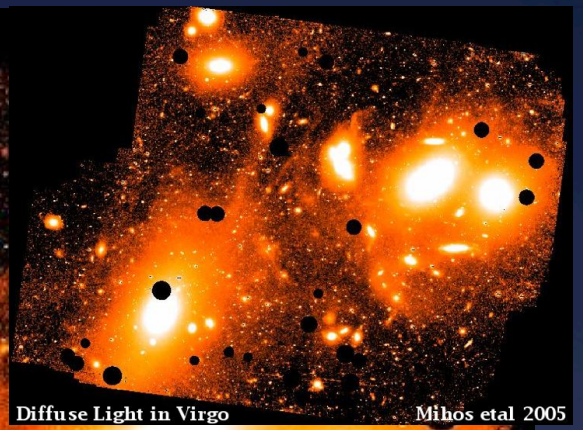
Full science case descriptions are in SDT Report

WFIRST Pointed Observations

- Nearby Clusters

WFIRST Pointed Observations

- Imagine AB=29 deep field on the Virgo Cluster
  - ~4 magnitudes fainter than the TRGB
  - Deep enough to measure the RGB bump
    - Metallicities & age estimates for the entire diffuse population
    - Galaxy streams, wakes
    - Remnants of ram-pressure stripping

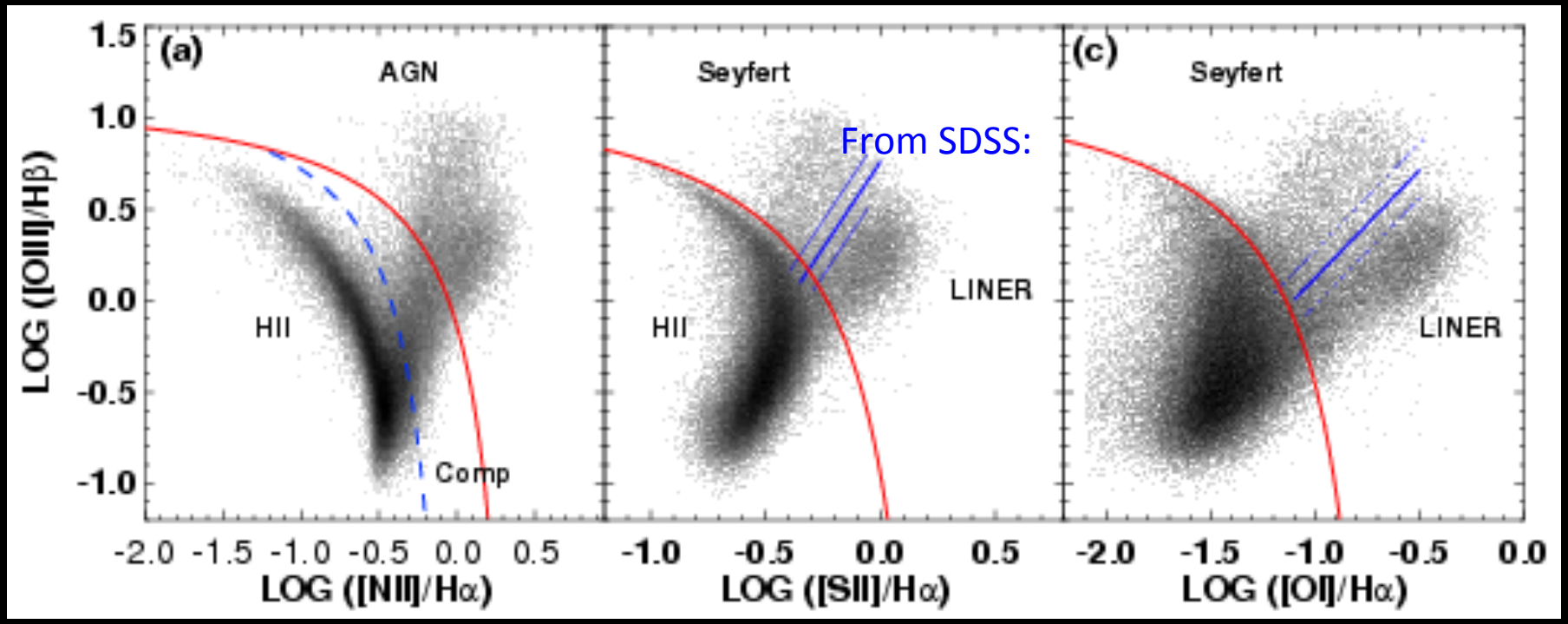


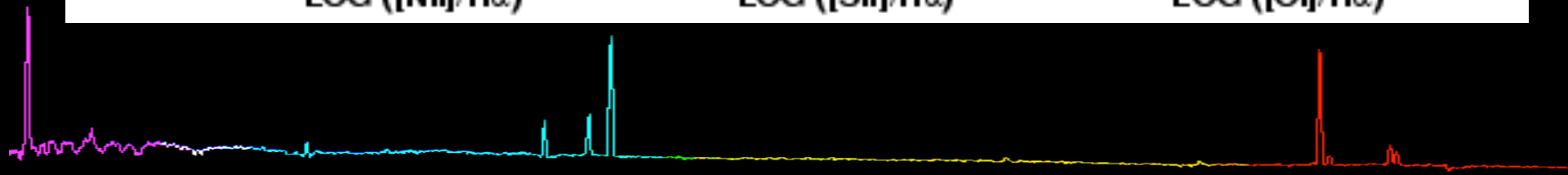
Lisa Kewley

Deep Guest Observer Surveys

Key spectroscopic window: 1.8<z<2

- allows [OIII]/Hβ and [NII]/Hα





The BPT Diagram with redshift

Where do the data lie?

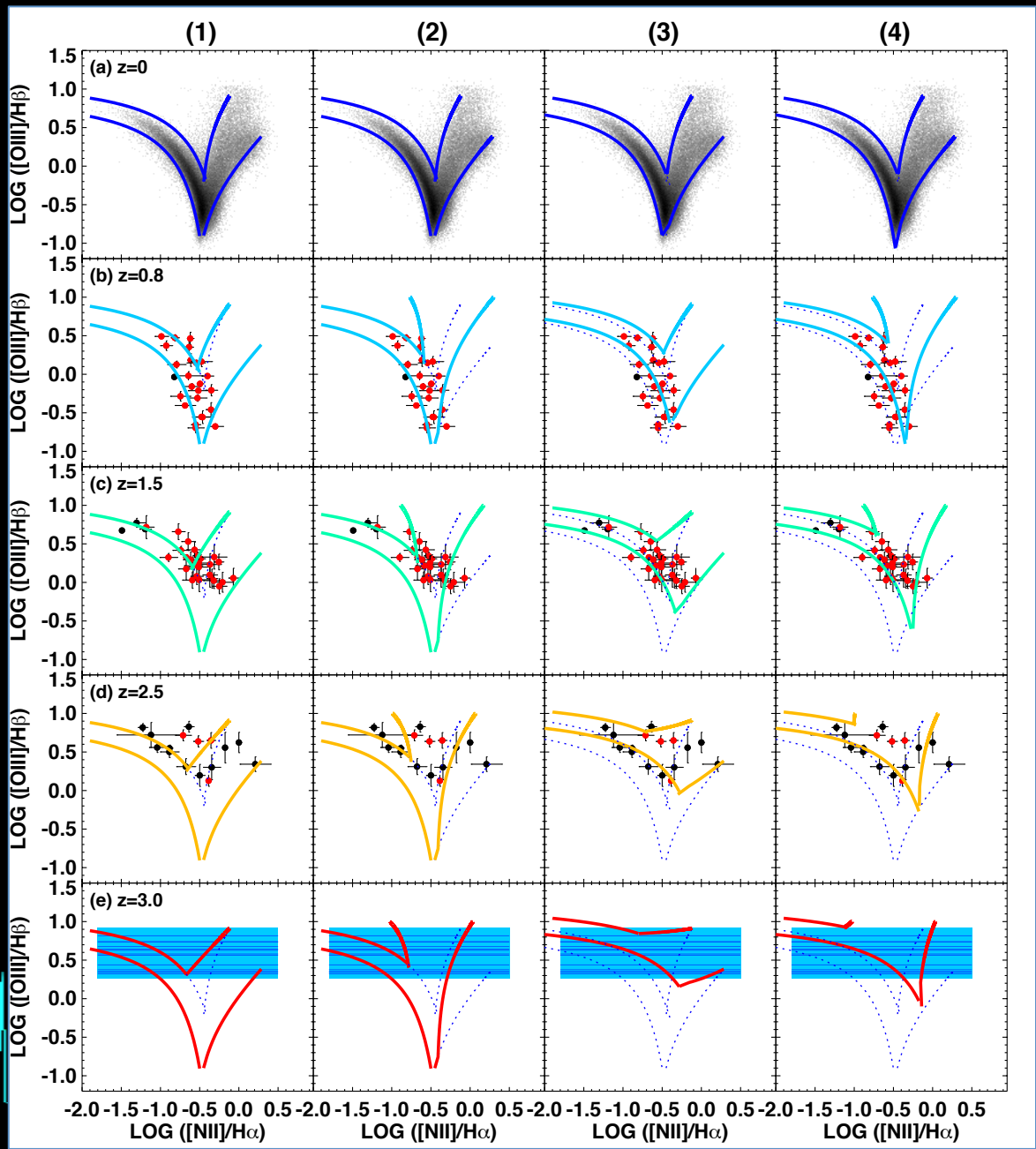
(Kewley+13b, ApJL, 774, 10)

z~0.8: zCOSMOS
(NIR data: Maier+13)

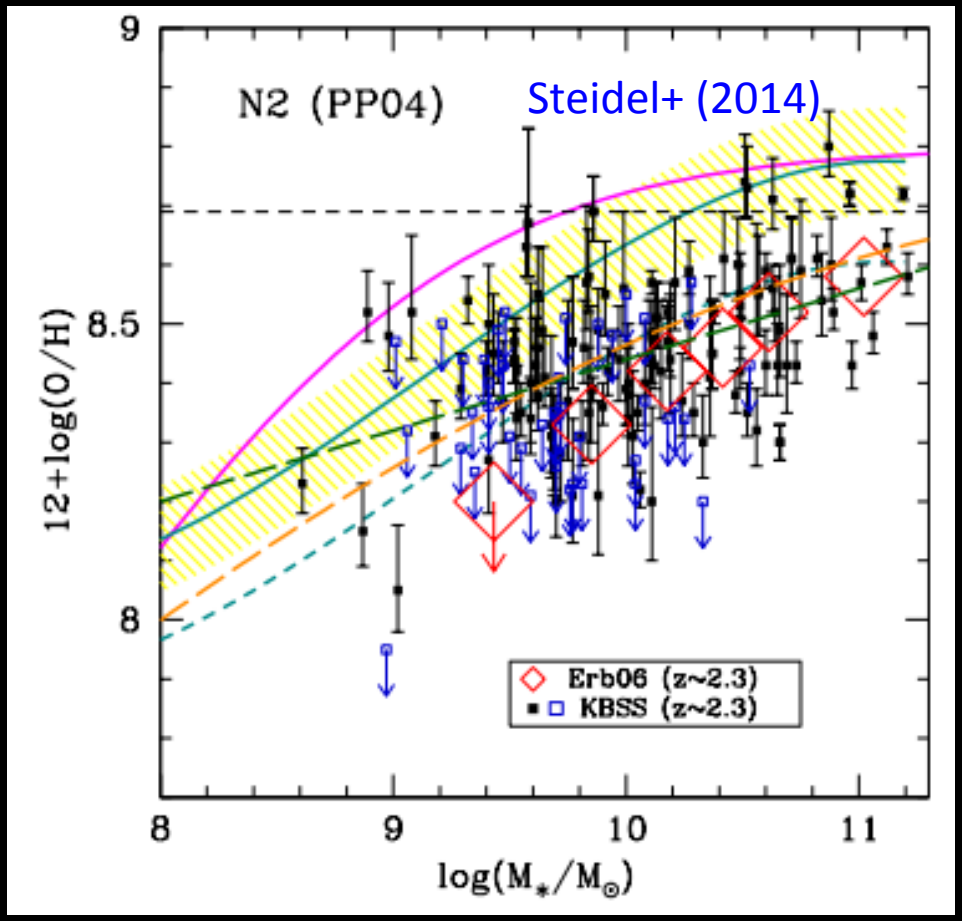
z~1.5: Subaru-XMM Deep Survey and the UKIDSS Ultra Deep Survey
(NIR data: Yabe+12,13)

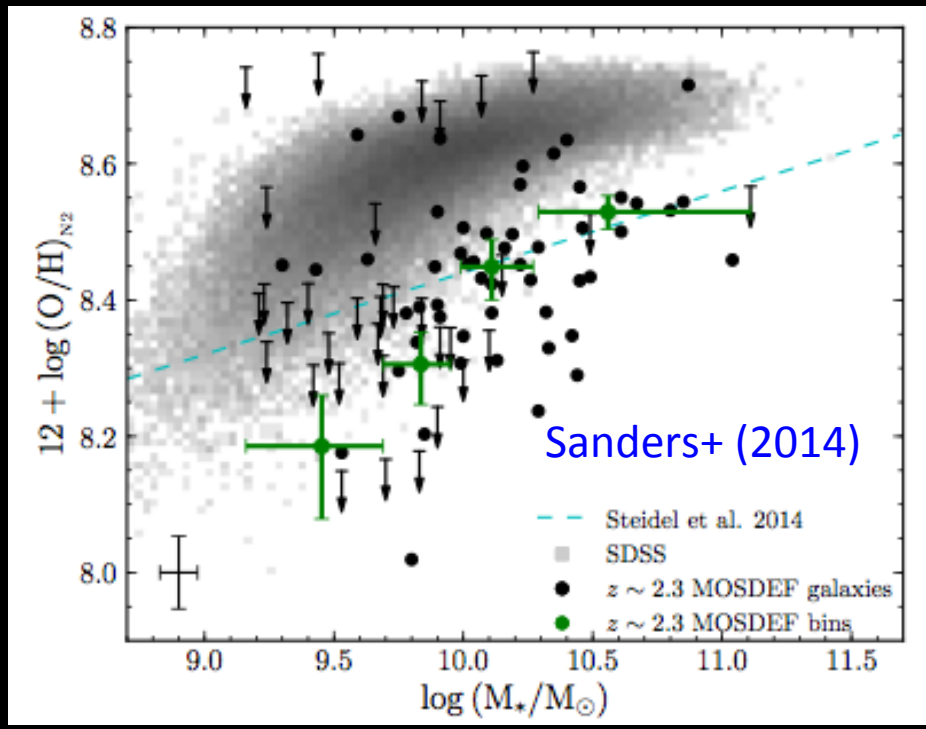
z~2.5: Lensed galaxies + BzKs
(Richard+11, Jones+13, Yuan+13)

z=3 galaxies: LBGs & Lensed Galaxies (Pettini+01, Maiolino+08, Richard+11)



Contribution to metal budget?

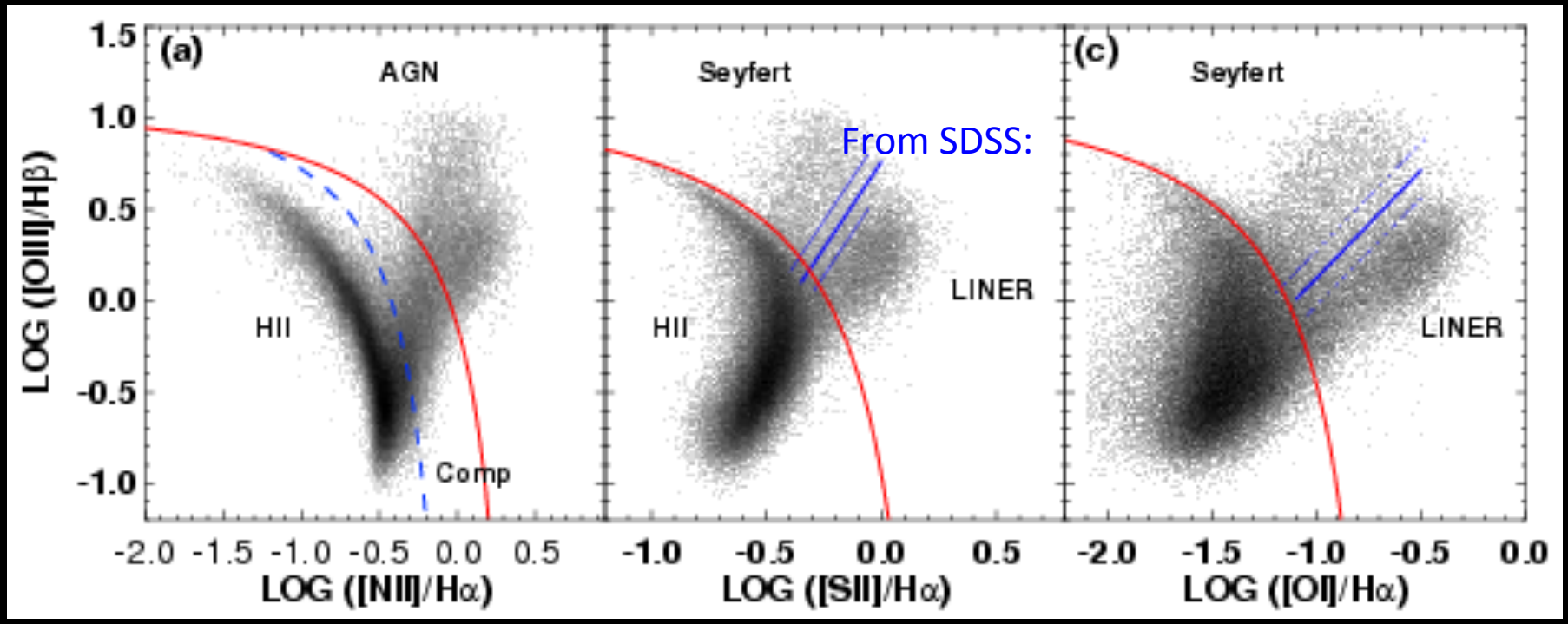




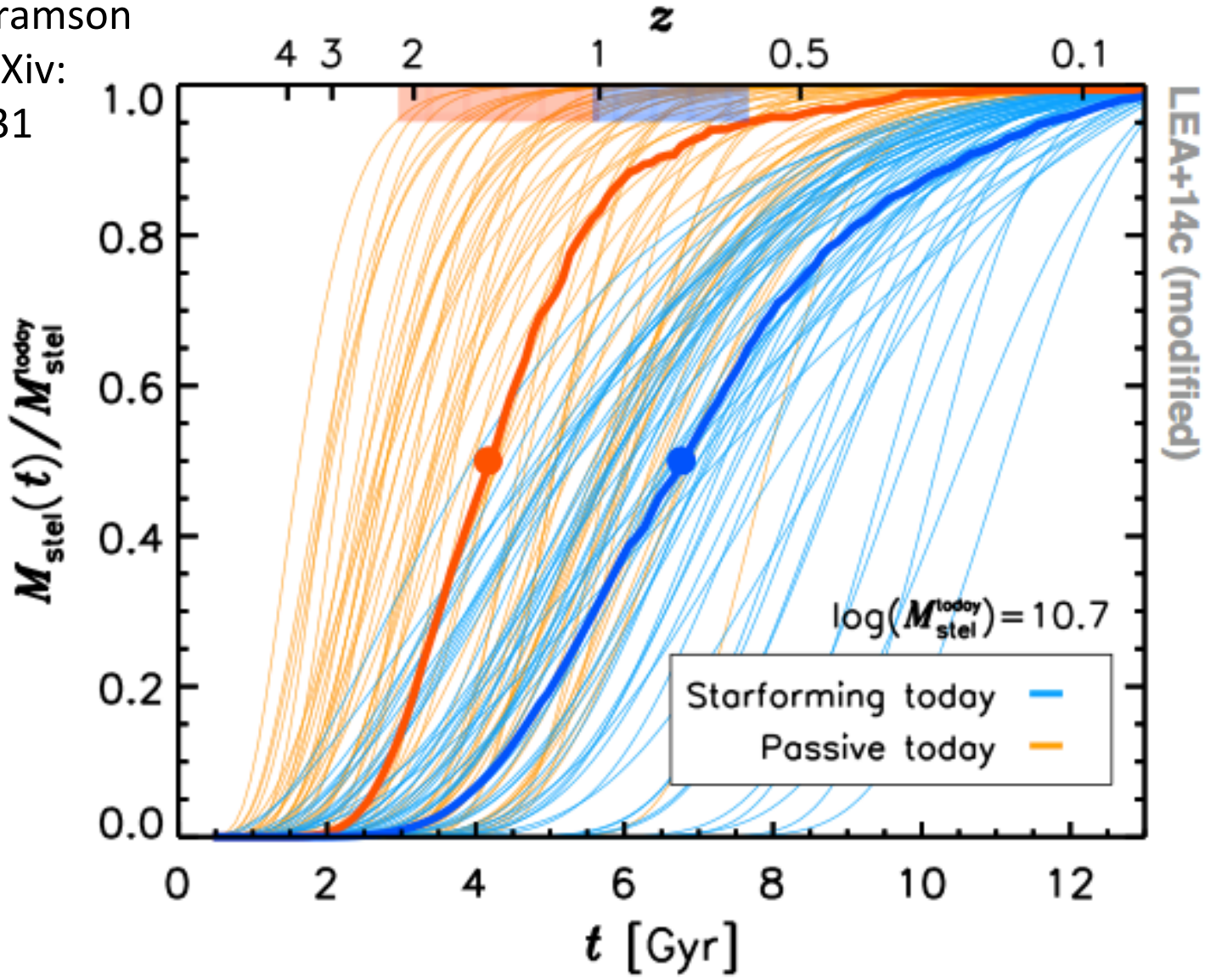
Deep Guest Observer Surveys

Key spectroscopic window: 1.8<z<2

- allows [OIII]/Hβ and [NII]/Hα

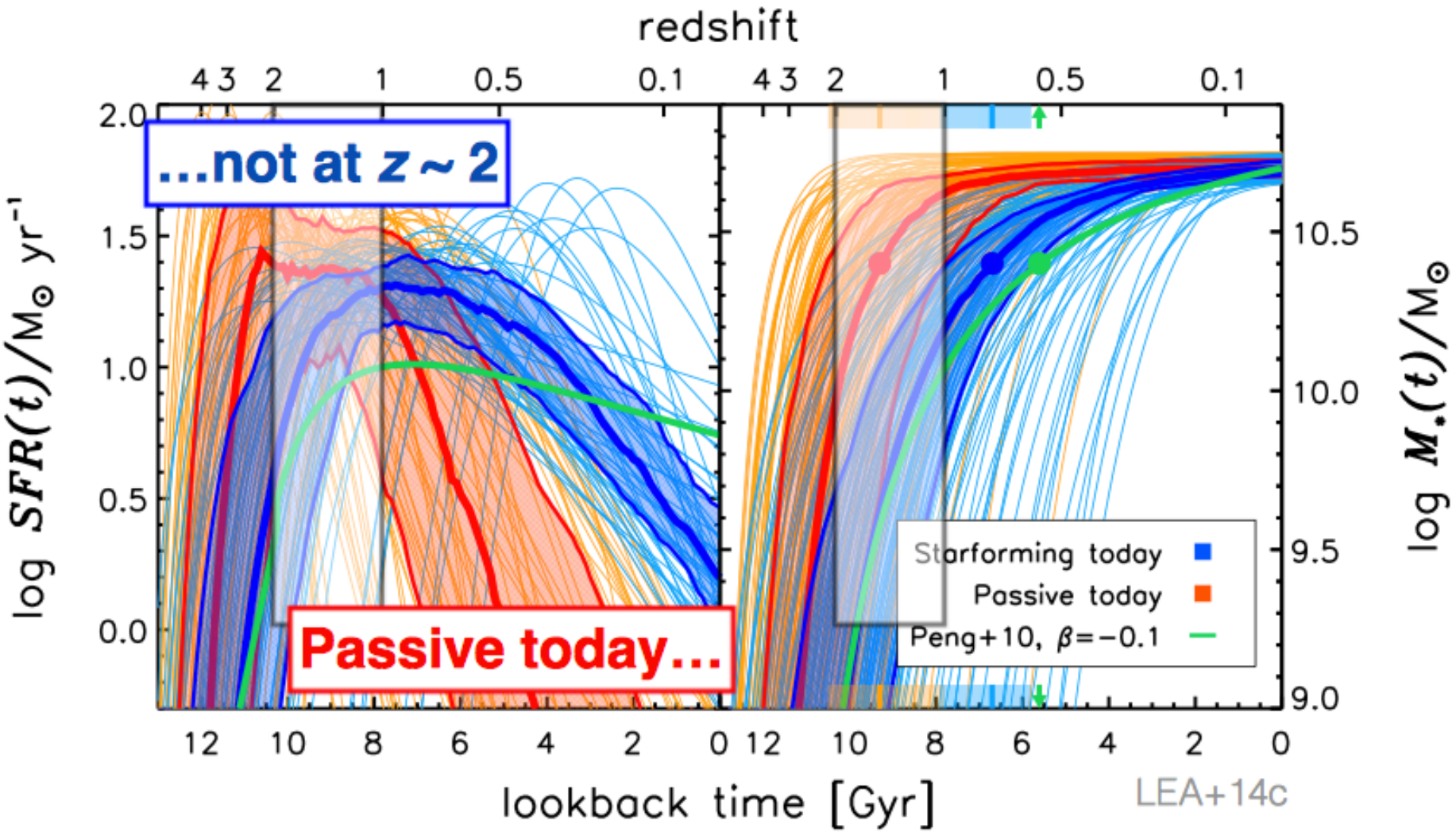


Louis Abramson +2014 arXiv: 1411.1431



Not quenching — ***diversification***

Epoch of galaxy activity



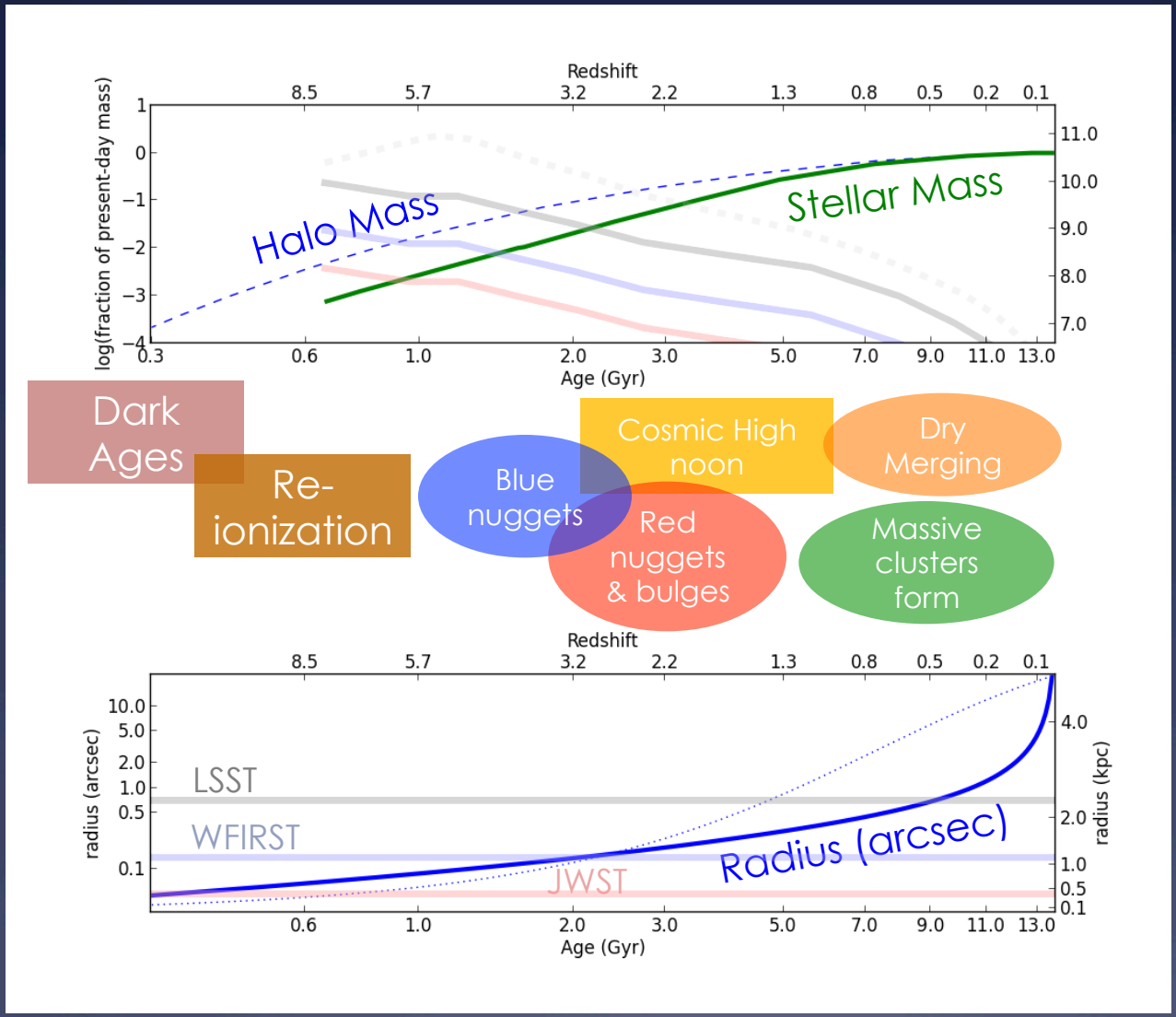
A perfect mission…

- Probe a wide **variety** of (over)densities at an epoch where galaxies in them are still actively starforming.
  - $1 < z < 2$

Too shallow!

- Uniform **spectroscopic** coverage over large areas. (the data, not Louis)
  - Clean selection function — pure redshift association, no color/dynamical state bias.
  - Reduce cosmic variance issues.
- Dig deep in the mass function and SFR—M* relation (MW progenitors).

Milky-Way-like galaxy timeline



WFIRST M* limits
High-latitude
Deep

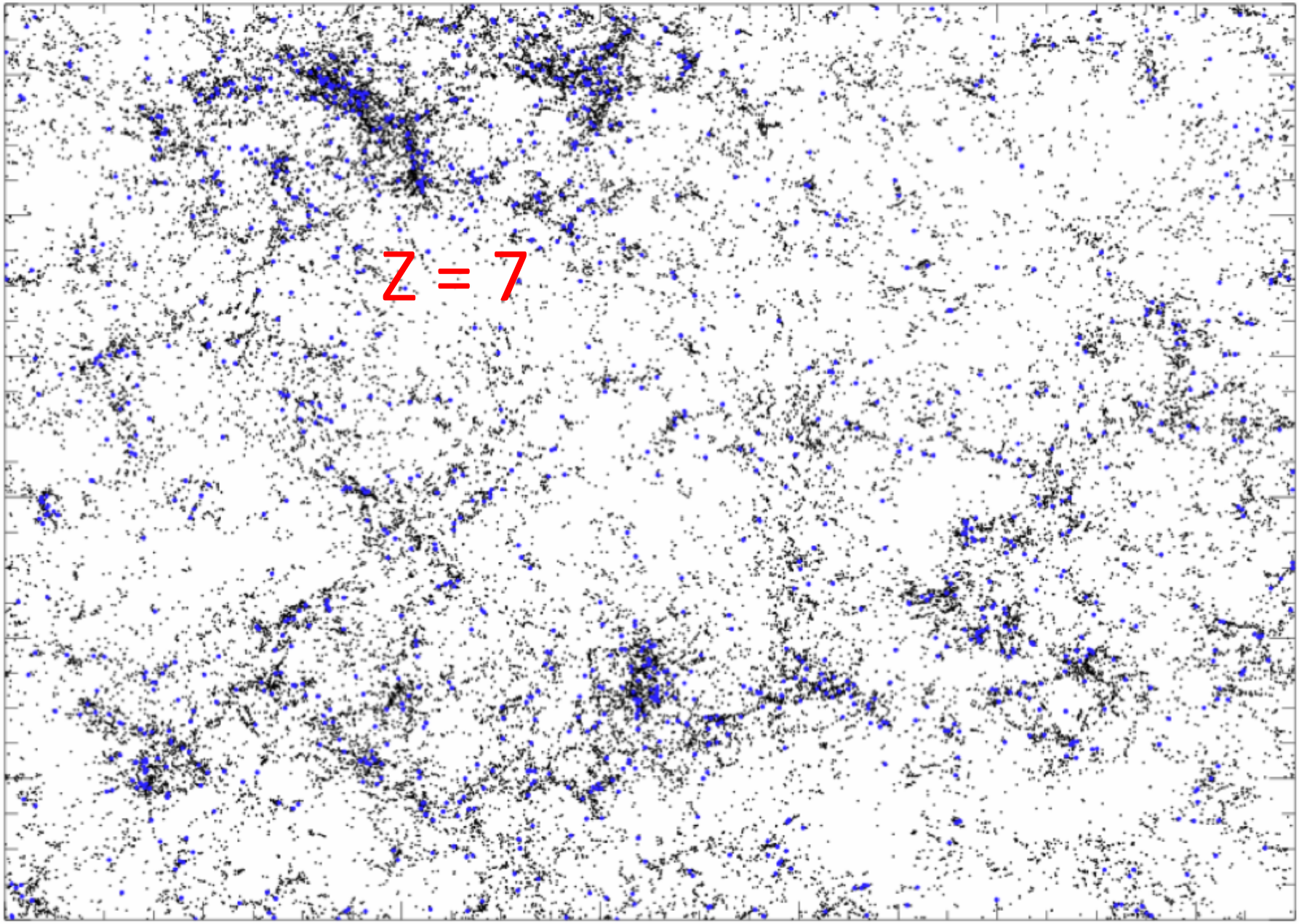
JWST M* limit

WFIRST Deep Fields

WFIRST/AFTA Deep Survey (SNe) could be the answer to such programs, but presently not configured to do so – need all bands and grism

- ar depths in
- o optical
- Complements JWST – bright reionization sources; clustering
- JWST:
  - single band at 3.6 microns would take ~200 days to AB~29 (assuming 50% efficiency)
- Placement of fields where there is deep long-wavelength data is important

Clustering in the Reionization Epoch – Malhotra & Rhoads



CONCLUSION

When do early-type galaxies form?

Roberto G. Abraham[1], Patrick J. McCarthy[2], Erin Mentuch[1], Karl Glazebrook[3], Preethi Nair[1], Jean-René Gauthier[1], Sandra Savaglio[4], David Crampton[5], Stephanie Juneau[5,6], Richard Murowinski[5], Damien Le Borgne[1], R. G. Carlberg[1], Inger Jørgensen[7], Kathy Roth[7], Hsiao-Wen Chen[8], and Ronald O. Marzke[9]

Abstract. We have used the Hubble Space Telescope's Advanced Camera for Surveys to measure the mass density function of morphologically-selected early-type galaxies in the Gemini Deep Deep Survey fields, over the redshift range $0.9 < z < 1.6$. Our imaging data set covers

[7]Gemini Observatory
[8]Dept. of Astronomy & Astrophysics, University of Chicago
[9]Dept. of Physics and Astronomy, San Francisco State University

Abstract. We have used the Hubble Space Telescope's Advanced Camera for Surveys to measure the mass density function of morphologically-selected early-type galaxies in the Gemini Deep Deep Survey fields, over the redshift range $0.9 < z < 1.6$. Our imaging data set covers four well-separated sight-lines, and is roughly intermediate (in terms of both depth and area) between the GOODS/GEMS imaging data, and the images obtained in the Hubble Deep Field campaigns. Our images contain 144 galaxies with ultra-deep spectroscopy, and they have been analyzed using a new purpose-written morphological analysis code which improves the reliability

WFIRST/AFTA – the Observatory

anybody heard of the Hubble Space Telescope?

25% for 'Legacy' and small 'surveys' not enough!

Leave it up to the TAC!

Exoplanet-characterizing Coronagraph

– the technology program

The WFIRST/AFTA SDT thanks you for coming and contributing to our work In developing the mission. It has been gratifying to have such a large turnout, such strong interest (!), and lots of input and ‘food for thought’ for the SDT.

Safe travels!