Beyond the Local Group

Session 1

Henry Ferguson (STScI)
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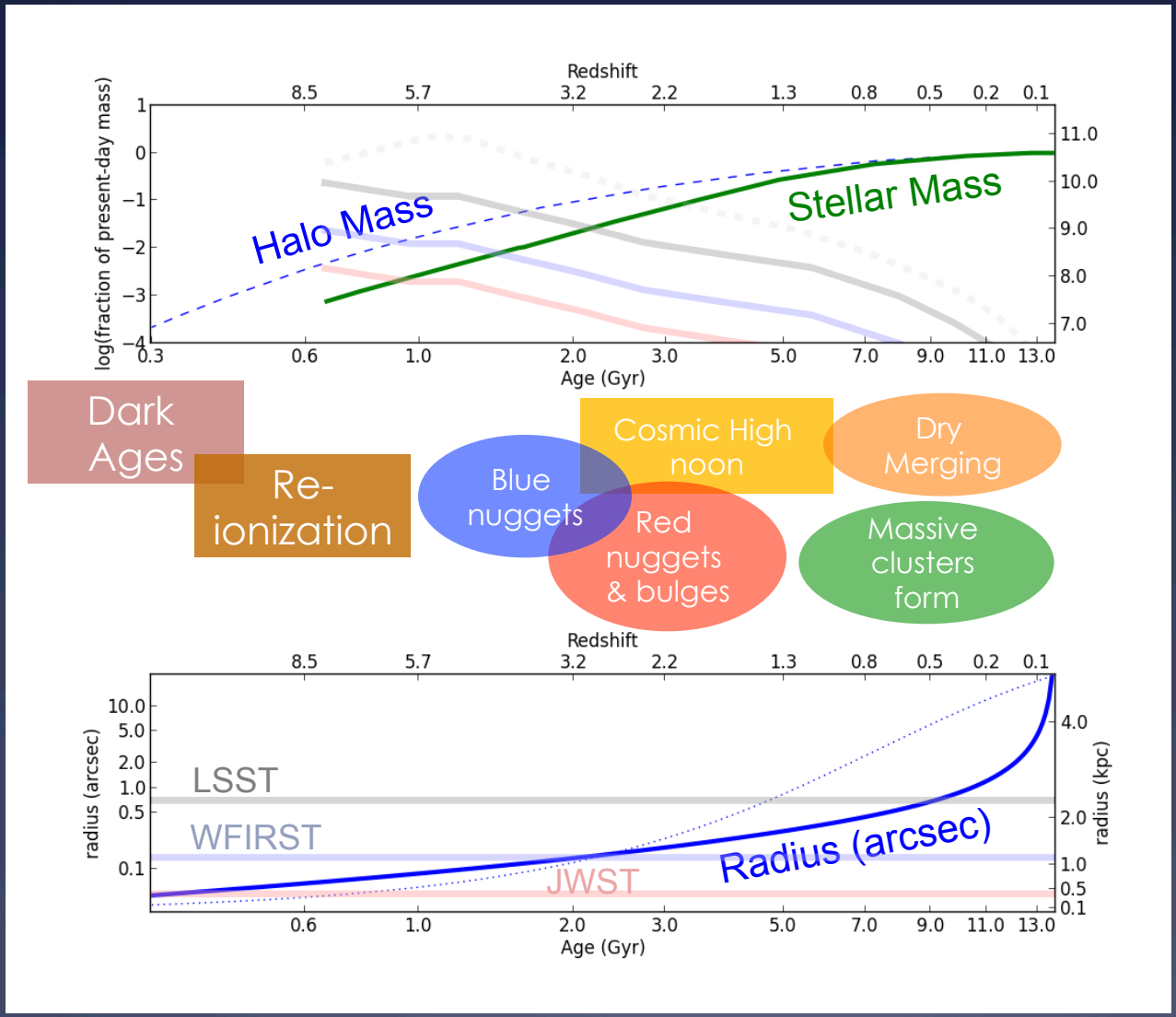
Topics

- Reionization and ultra-high redshift
  - Robertson, Oesch
- Galaxy assembly at later times
  - Somerville, Ferguson
- Clusters and effects of environment
  - Mei, Abramson
- Emission line diagnostics
  - Kewley, Appelton
- Gravitational-wave counterparts
  - Metzger

Milky-Way-like galaxy timeline

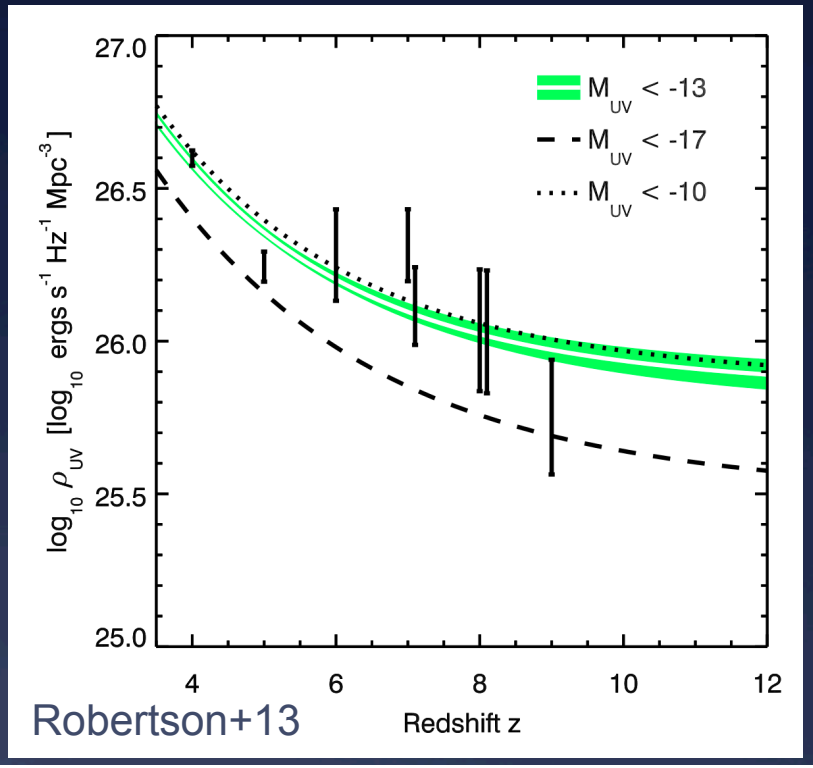


WFIRST M* limits
High-latitude
Deep

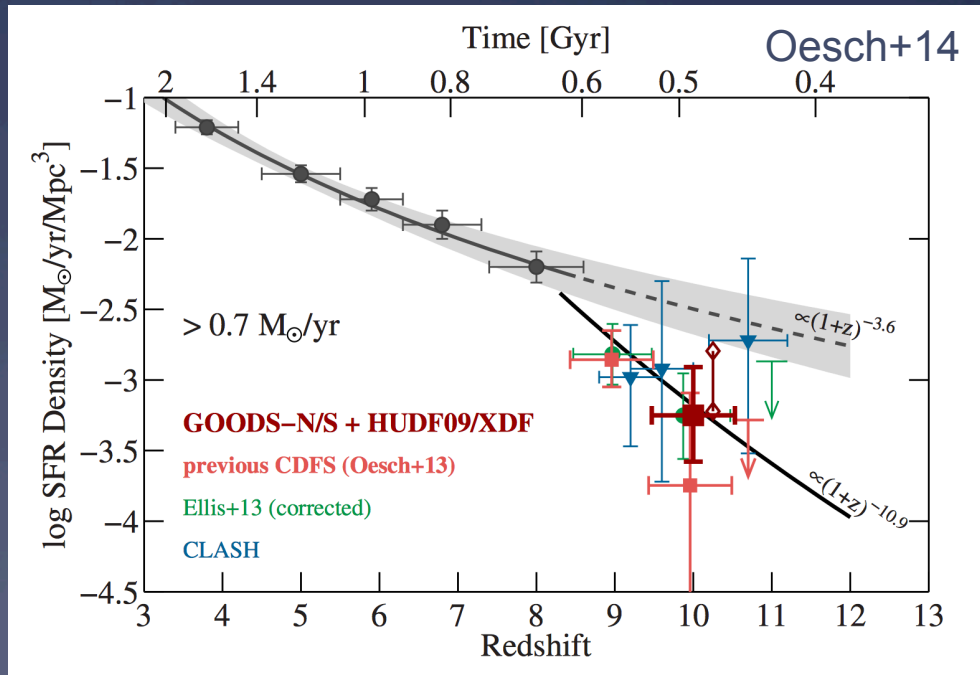
JWST M* limit

What's happening at z>8?

Simple parametrized model of UV luminosity-density evolution constrained by z<8 LF and WMAP optical depth.



Possible downturn detected via luminosity function measurements at z>8



Power of WFIRST Surveys (Fisher Forecasts)

Survey	Area [deg^2]	Depth [5-σ AB]	N Galaxies	Uncertainty on M*	Uncertainty on Φ* (x10^{-4})	Uncertainty on α
Current (Bouwens et al. 2014)	0.0013-0.21	H=26.3-29.5	481 (z~7) 217 (z~8) 6 (z~10)	0.26 (z~7) 0.36 (z~8)	0.2 (z~7) 0.2 (z~8)	0.13 (z~7) 0.23 (z~8)
Supernova Wide	27.44	J=27.5	1.6x10^5 (z~7)* 7.1x10^4 (z~8)	0.027 (z~7)* 0.039 (z~8)	0.145 (z~7)* 0.149 (z~8)	0.015 (z~7)* 0.026 (z~8)
Supernova Medium	8.96	H=28.1	1.1x10^5 (z~7)* 5.0x10^4 (z~8)	0.037 (z~7)* 0.050 (z~8)	0.185 (z~7)* 0.194 (z~8)	0.014 (z~7)* 0.023 (z~8)
Supernova Deep	5.04	H=29.4	1.5x10^5 (z~7)* 7.1x10^4 (z~8)	0.040 (z~7)* 0.051 (z~8)	0.168 (z~7)* 0.170 (z~8)	0.009 (z~7)* 0.015 (z~8)
Single WFIRST Field of View (z~7)	0.281	H=29.5	8.6x10^3 (z~7) 3.97x10^3 (z~8) 3.48x10^2 (z~10)	0.16 (z~7) 0.21 (z~8) 0.97 (z~10)	0.775 (z~7) 0.588 (z~8) 0.362 (z~10)	0.039 (z~7) 0.061 (z~8) 0.22 (z~10)

*if color selection is possible

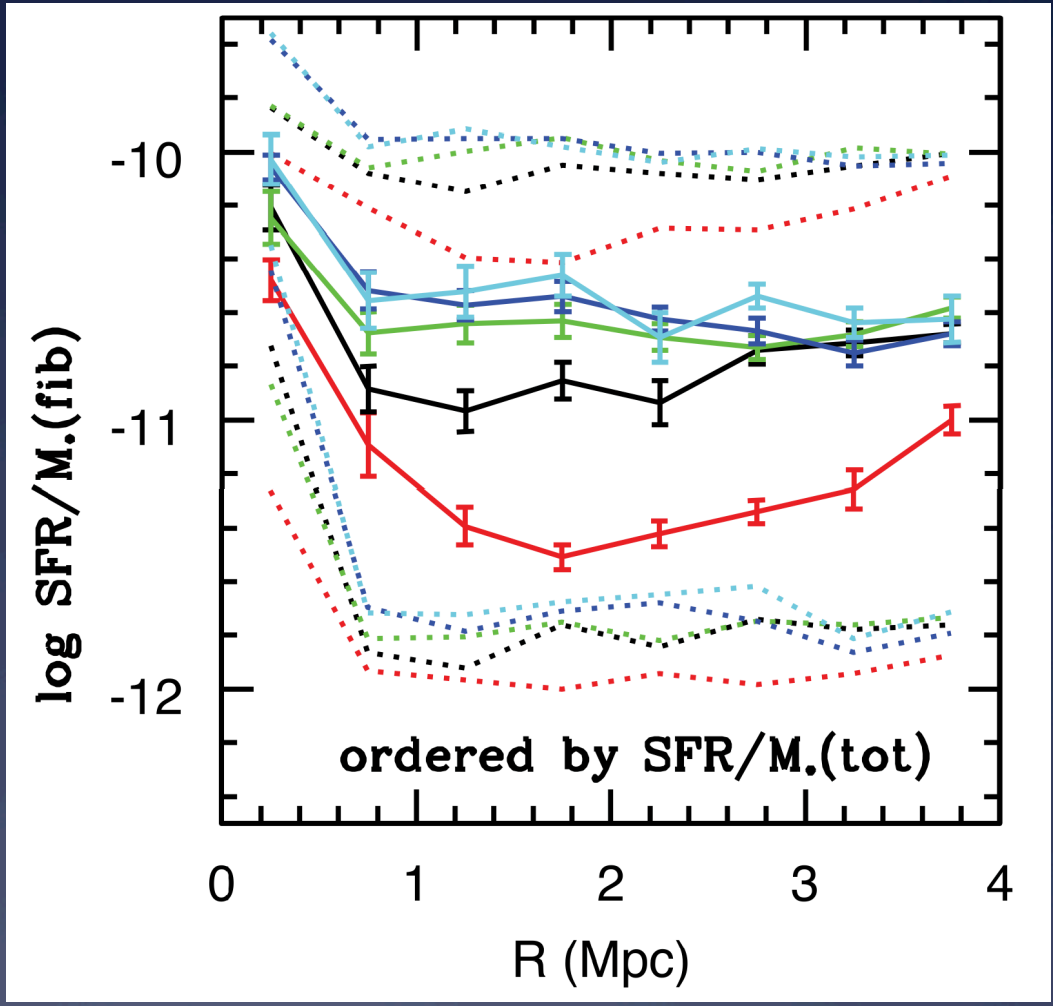
see formalism in BER, ApJ, 713, 1266 (2010)

Ultra high-z issues

- Lack of "veto" bands shortwards of Y
  - Seriously limits high-z candidate ID
- Bright end of the LF may be seriously affected by lensing magnification bias
- Matched deep observations at $\lambda > 2\,\mu$ are important
  - Veto & stellar masses

Galaxy Conformity (Somerville)

- Star-formation activity in centrals and satellites is correlated
  - Out to surprisingly large separations
  - Not reproduced by models
- WFIRST observations will allow much finer diagnosis
  - Vs. galaxy properties, environment, redshift



Kauffmann+13

Also, evolution of the galaxy size—mass relation is very sensitive to feedback.

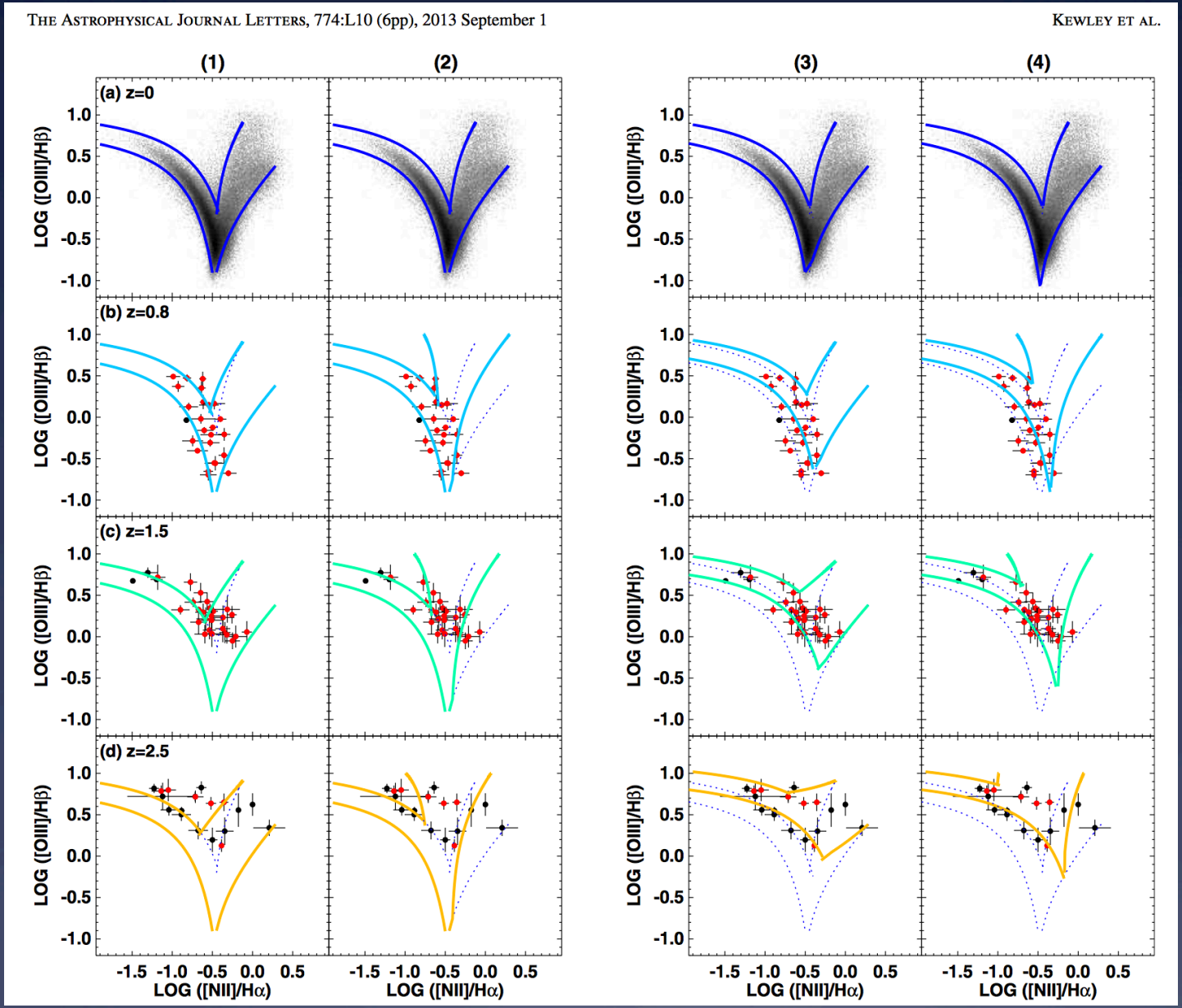
Cluster & Group Environments

- Quenching vs. accelerated evolution (Abramson)
- Finding clusters at z>1.8 (Mei)
- HLS Grism survey is well suited
  - Possibly better than the red sequence at high z
  - Not many galaxies per cluster; need to stack many to study environmental effects

Emission-line diagnostics

- Appleton: Finding shock-dominated galaxies
- Kewley: Evolution of EUV hardness, ISM pressure, electron density, & metallicity (global & gradient)
- Grism diagnostics
  - Would be very powerful to have [SII] simultaneous with other diagnostics for ISM pressure & ionization parameter constraints

Normal vs. extreme AGN Narrow-line region metallicity
Normal vs. extreme ISM conditions



WFIRST Deep Fields

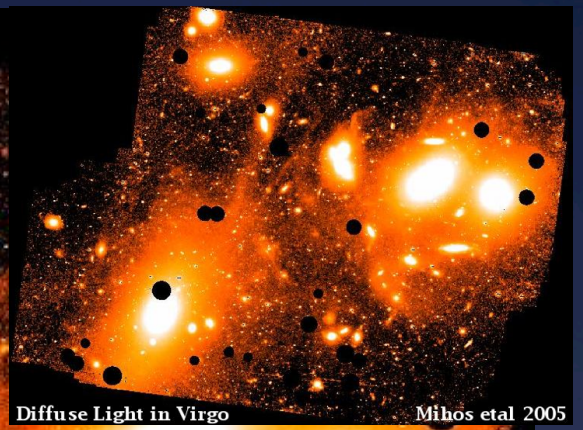
- SNe – 5 sq. degrees to AB~29
  - J, H for SNe
  - Need to supplement with similar depths in the other 3 bands; Need deep optical data
  - Complements JWST – bright reionization sources; clustering
  - JWST:
    - single band at 3.6 microns would take ~200 days to AB~29 (assuming 50% efficiency)
  - Placement of fields where there is deep long-wavelength data is important

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



Conclusions

- WFIRST will be a phenomenal mission for galaxy-evolution science
  - Some optimization desirable (imaging & grism)
- A huge amount can piggy-back on the dark-energy surveys
- Pointed observations of nearby targets will be extremely interesting
- Need to ensure that deep fields have maximal wavelength coverage