The UV Luminosity Function at the Epoch of Reionisation

Lessons from the Hubble Frontier Fields

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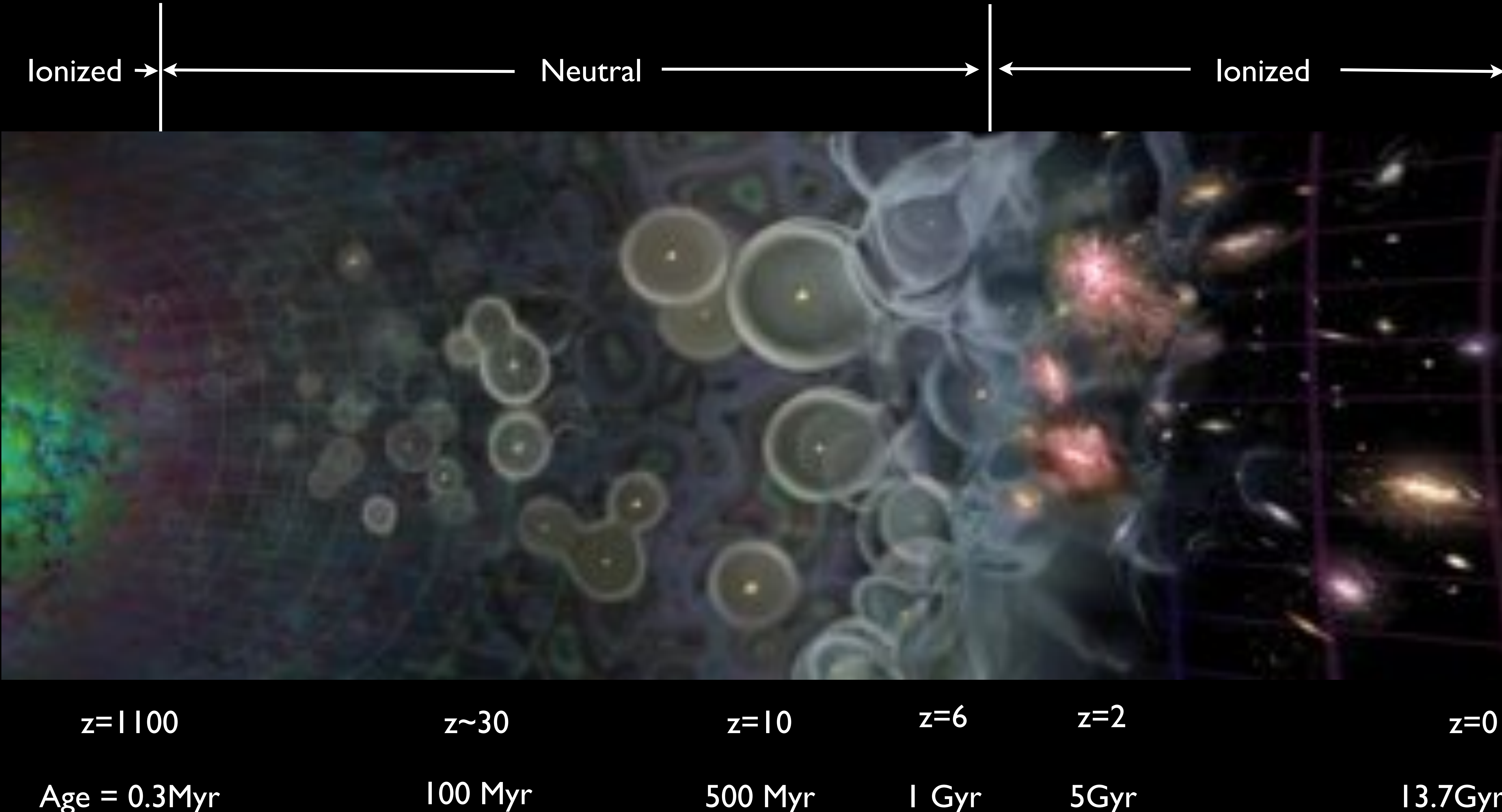
& the CATS team

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

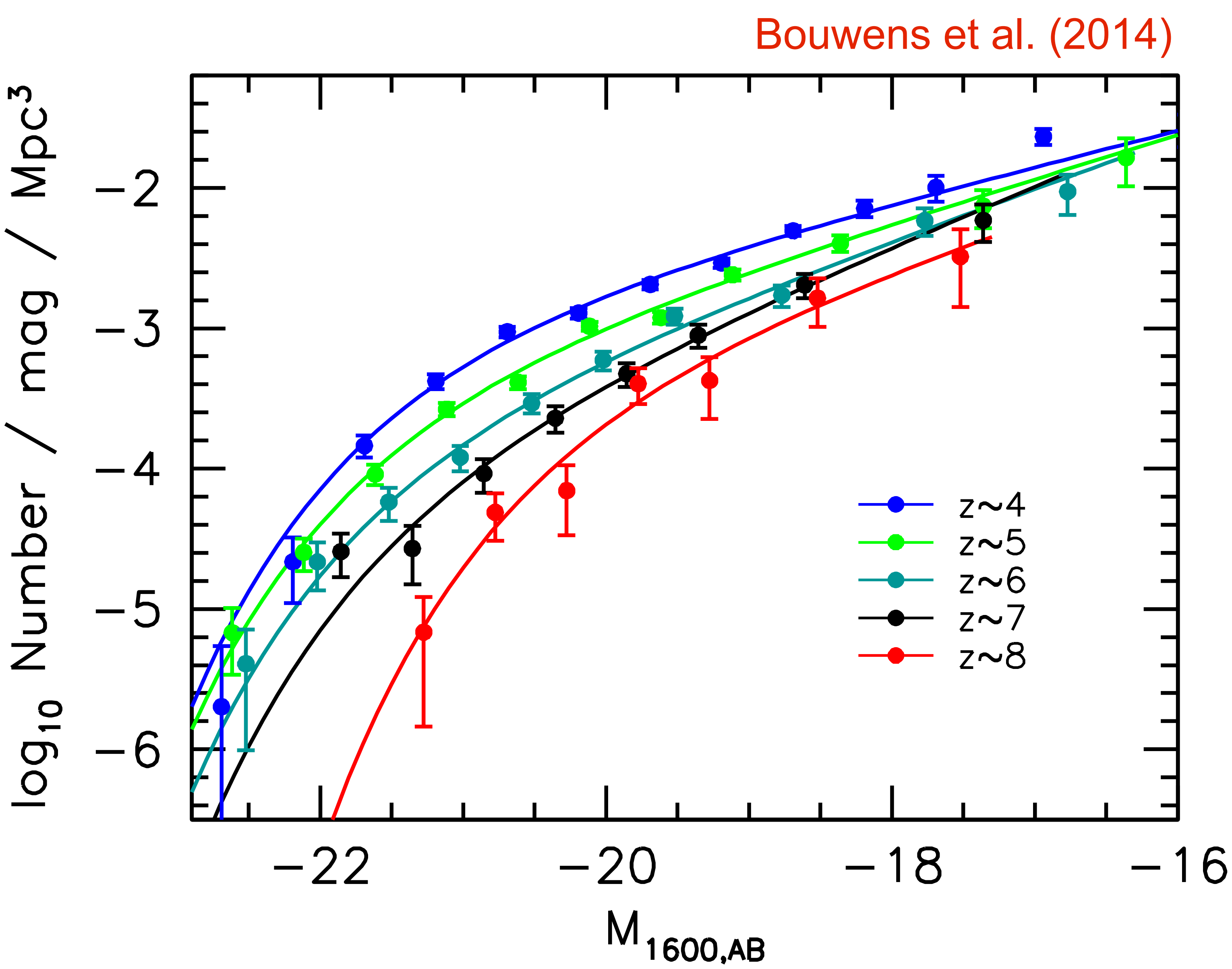


CMB **Dark Ages** **Epoch of Reionization**

Blank Field Surveys

more than 800 galaxies at z >7 from all HST legacy fields

better constraints of the overall shape of the luminosity function.

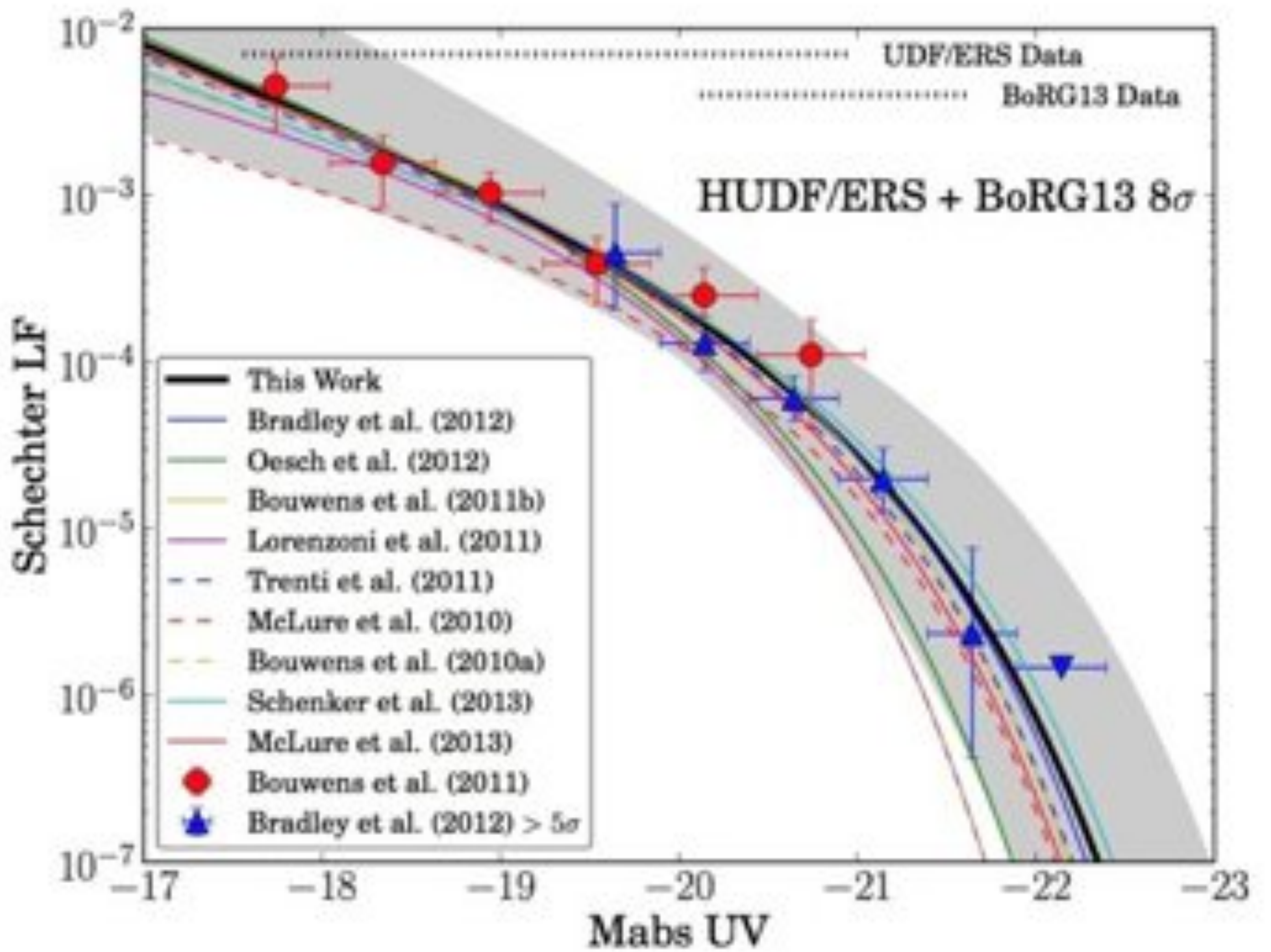


The Bright-end of the UV LF

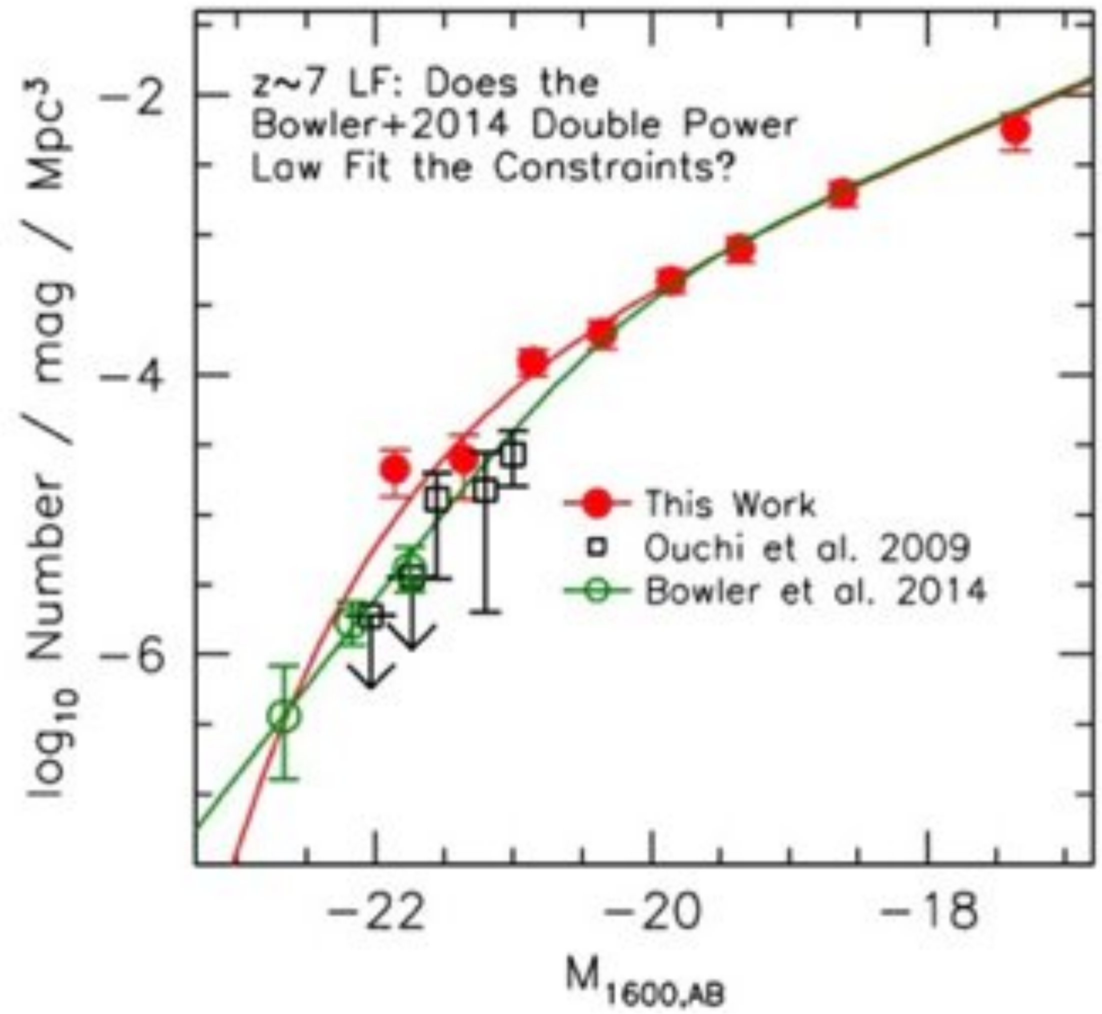
- Wide Field surveys probe the brightest of the luminosity function at z>7
- Large uncertainties still affect the slope (shape ?) of the bright end.

cf Michele's talk

Schmidt et al. (2014)

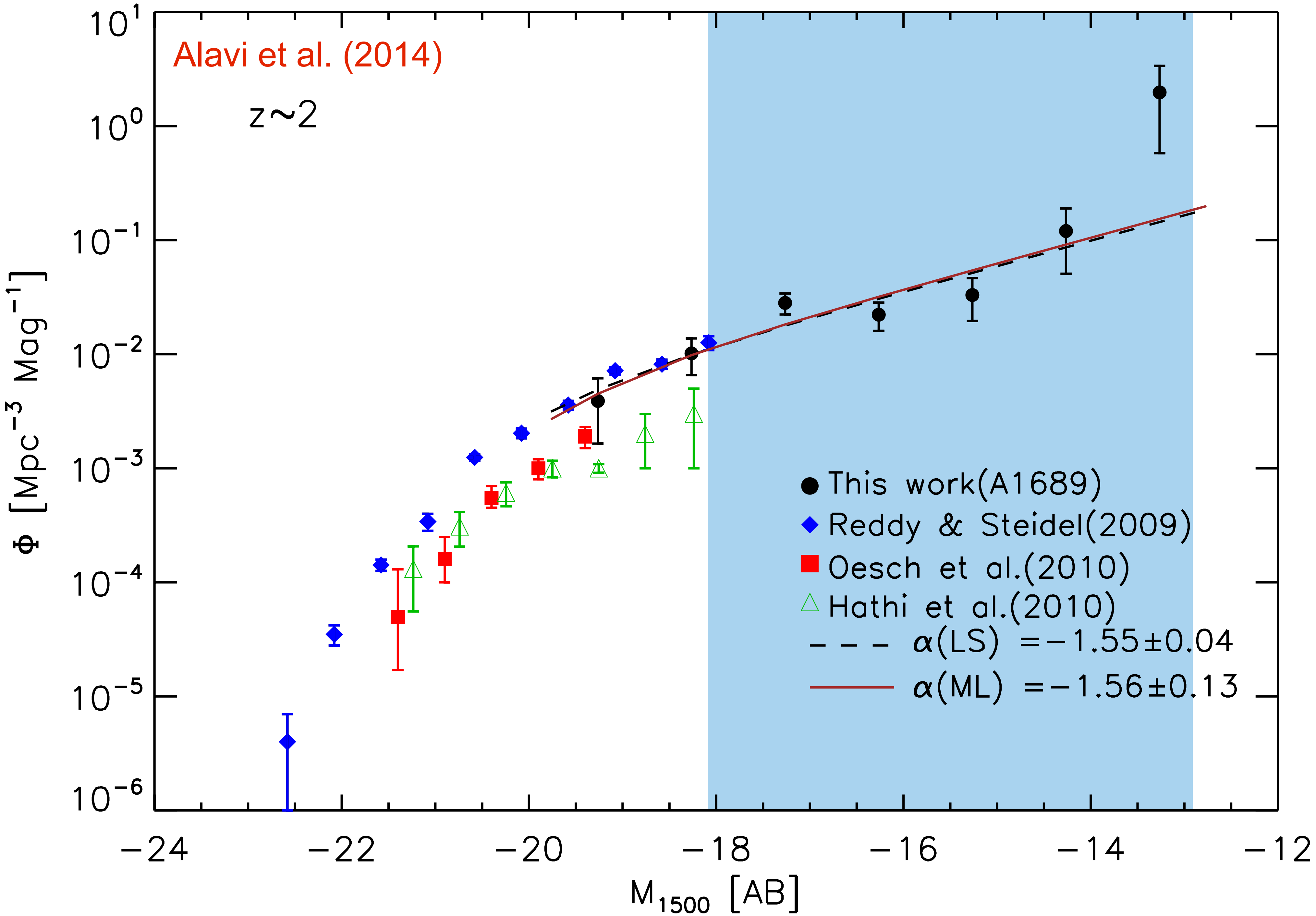


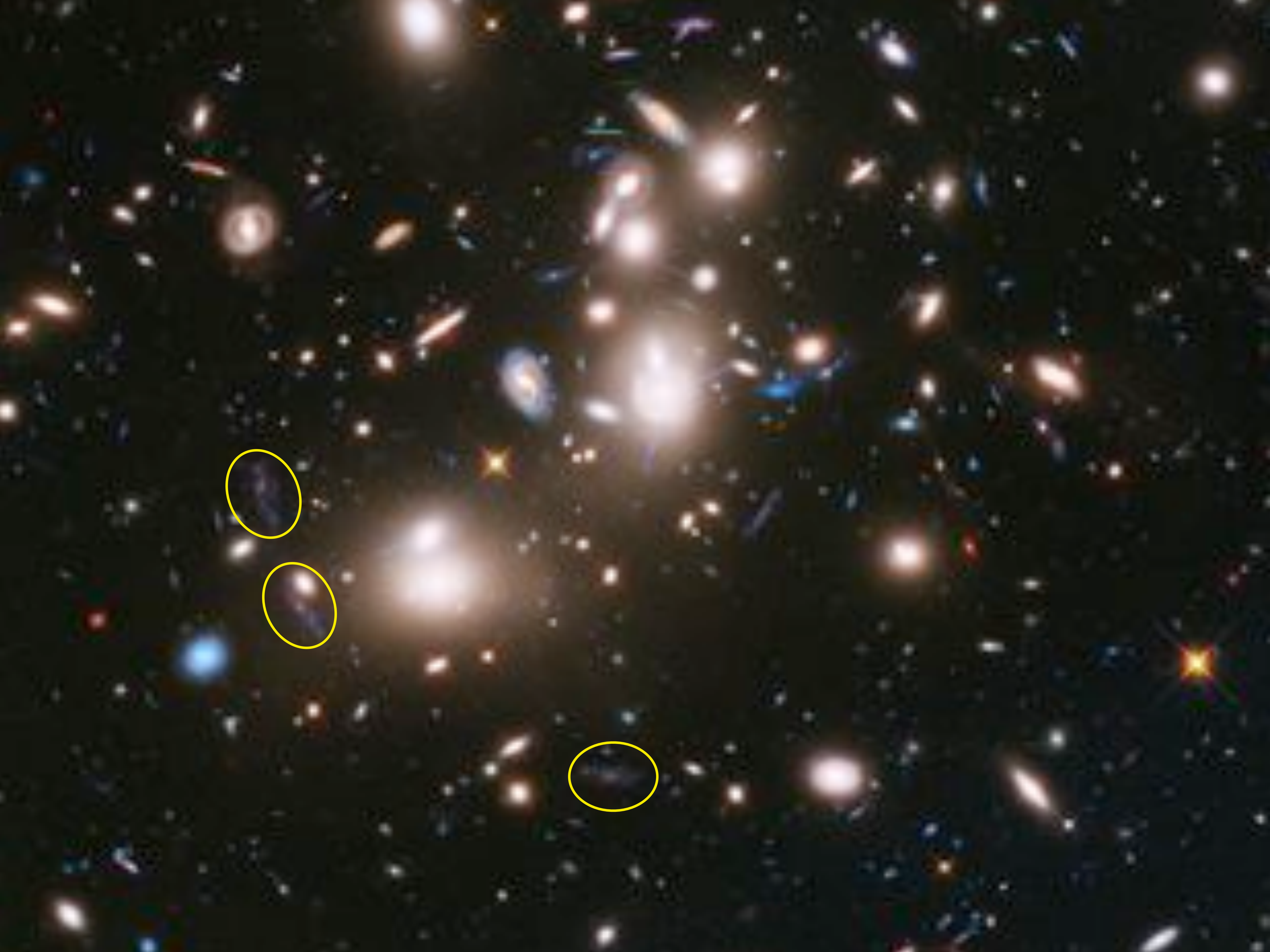
Bouwens al. (2014)



The Faintest Galaxy Population through "Gravitational Telescopes"

UV LF at z~2 down to Muv=-13
No sign of turnover in the UV LF





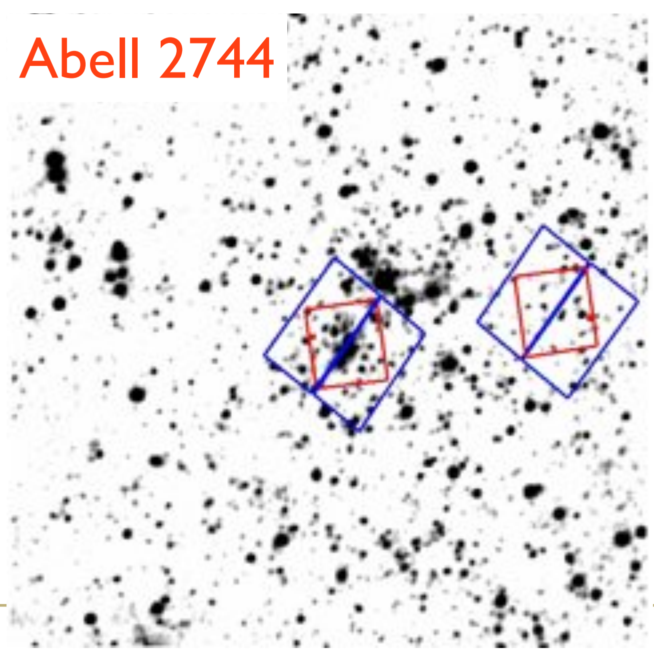
The Hubble Frontier Fields

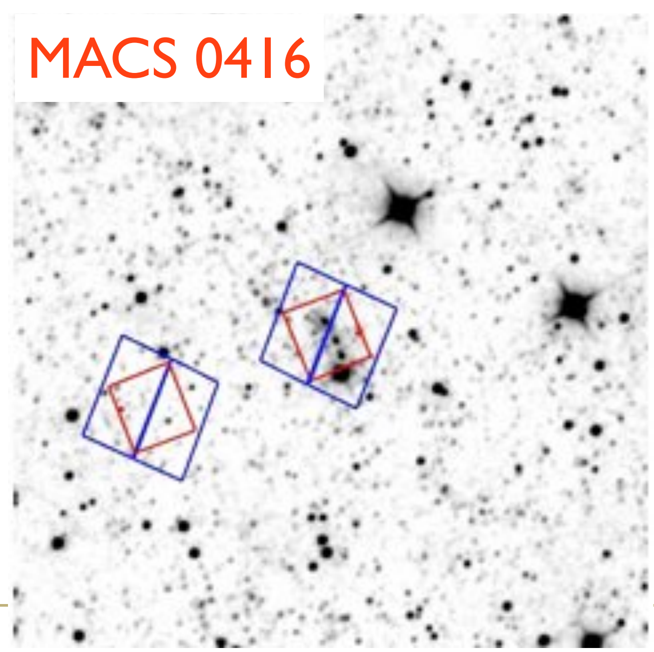
Combining the power of gravitational lensing with the unique HST observing capabilities

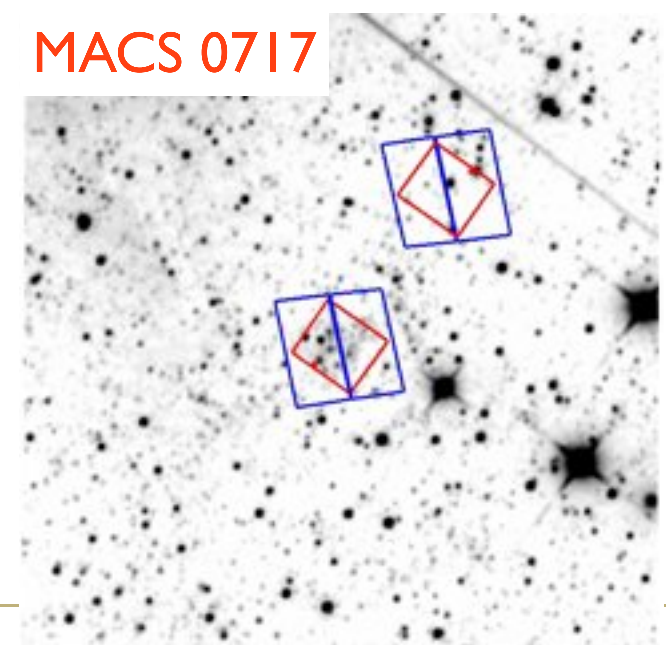
DDT time of 560 orbits to observe four (possibly six) lensing clusters and parallel fields in Cy21/22

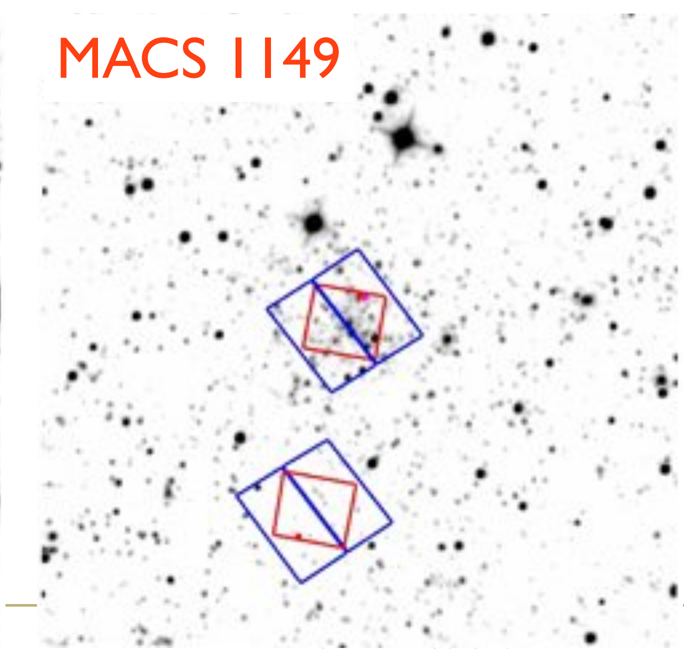
- WFC3/IR and ACS/optical imaging
- Spitzer, ALMA, VLT, Spectroscopy, etc.
- Lensing maps publicly available

ACS: (70 orbits per position)			WFC3/IR: (70 orbits per position)		
Filter	Orbits	AB_mag	Filter	Orbits	AB_mag
F435W	18	28.8	F105W	24	28.9
F606W	10	28.8	F125W	12	28.6
F814W	42	29.1	F140W	10	28.6
			F160W	24	28.7







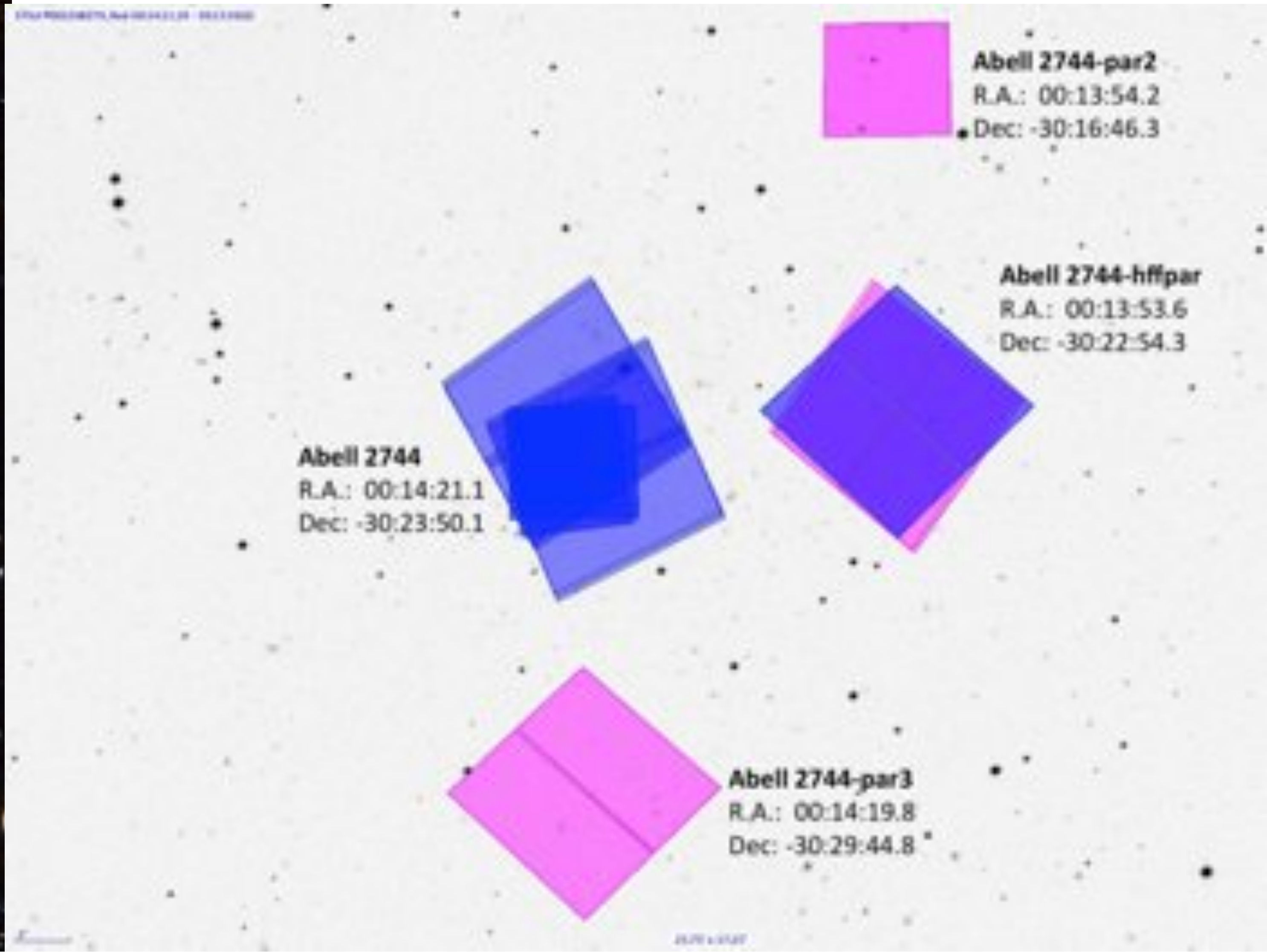


First Results from Abell 2744

Observations

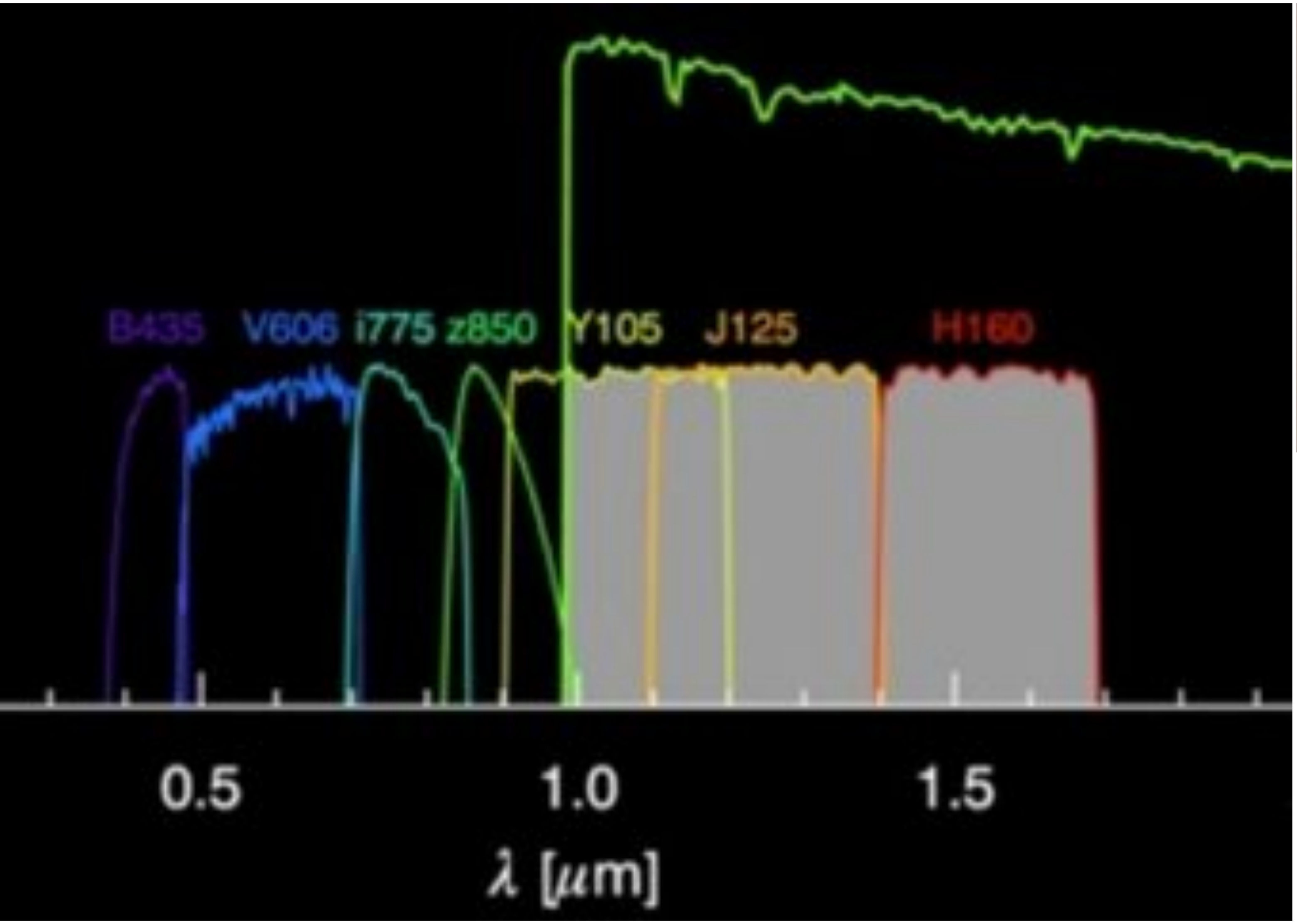
– HFF ACS & WFC3:
- A total of 140 orbits down to 29 mag: deepest observations of a lensing cluster

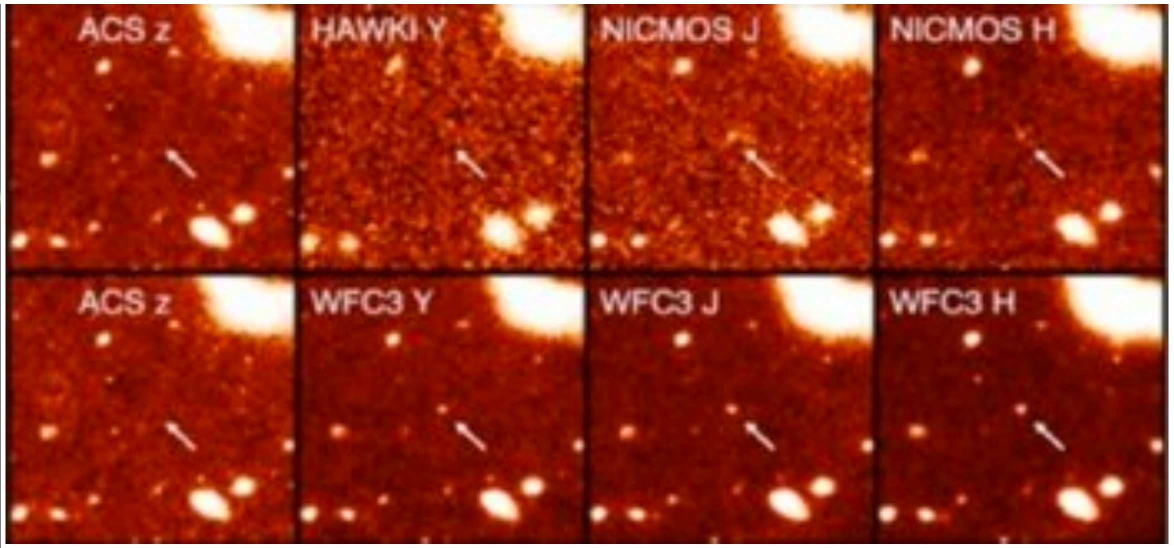
– Spitzer/IRAC observations: 3.6 and 4.5 microns
- 2-sigma sensitivity of 0.1 and 0.15 micro Jy in Ch1 and Ch2.



First Results from Abell 2744

Lyman Break Selection



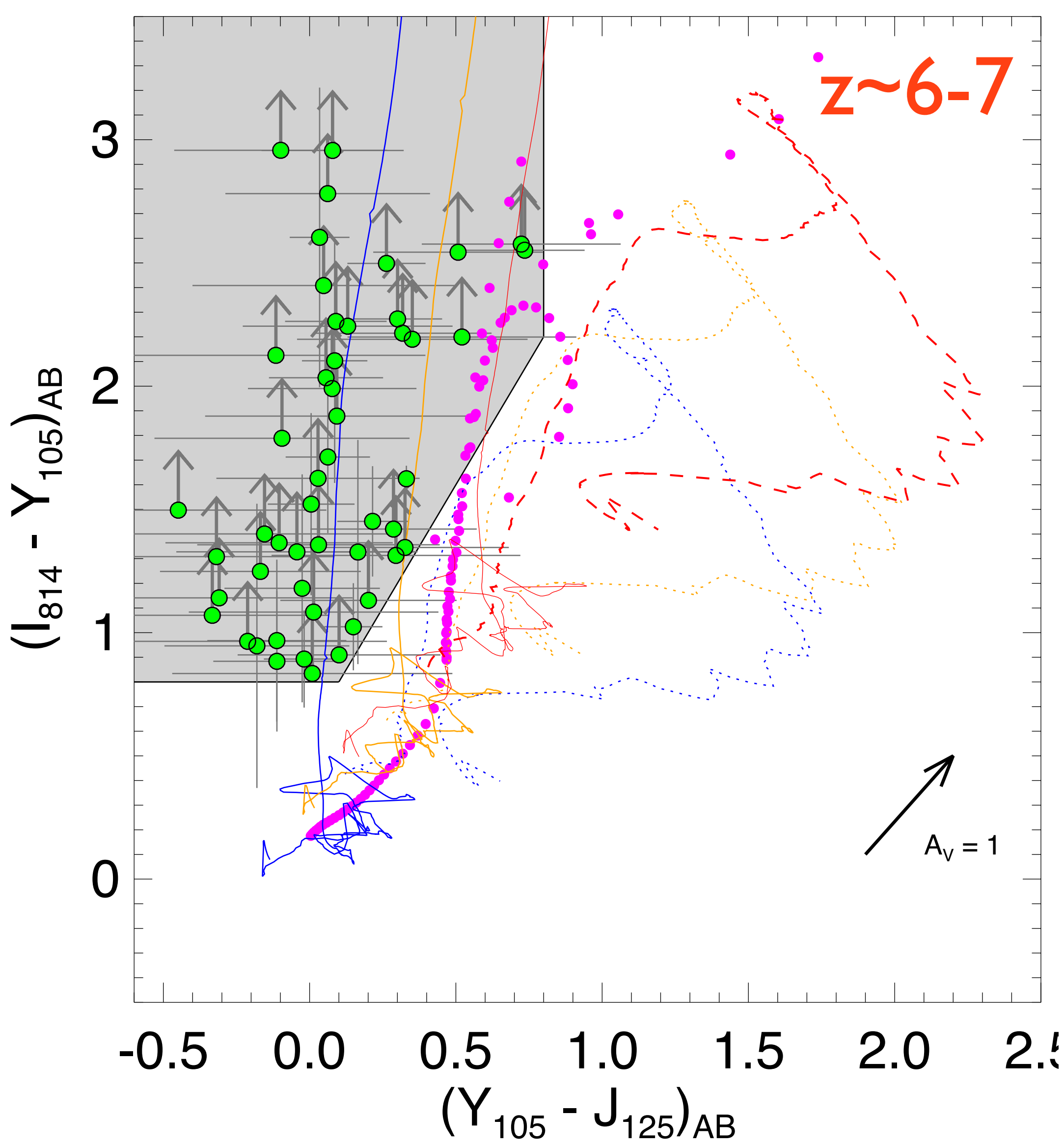


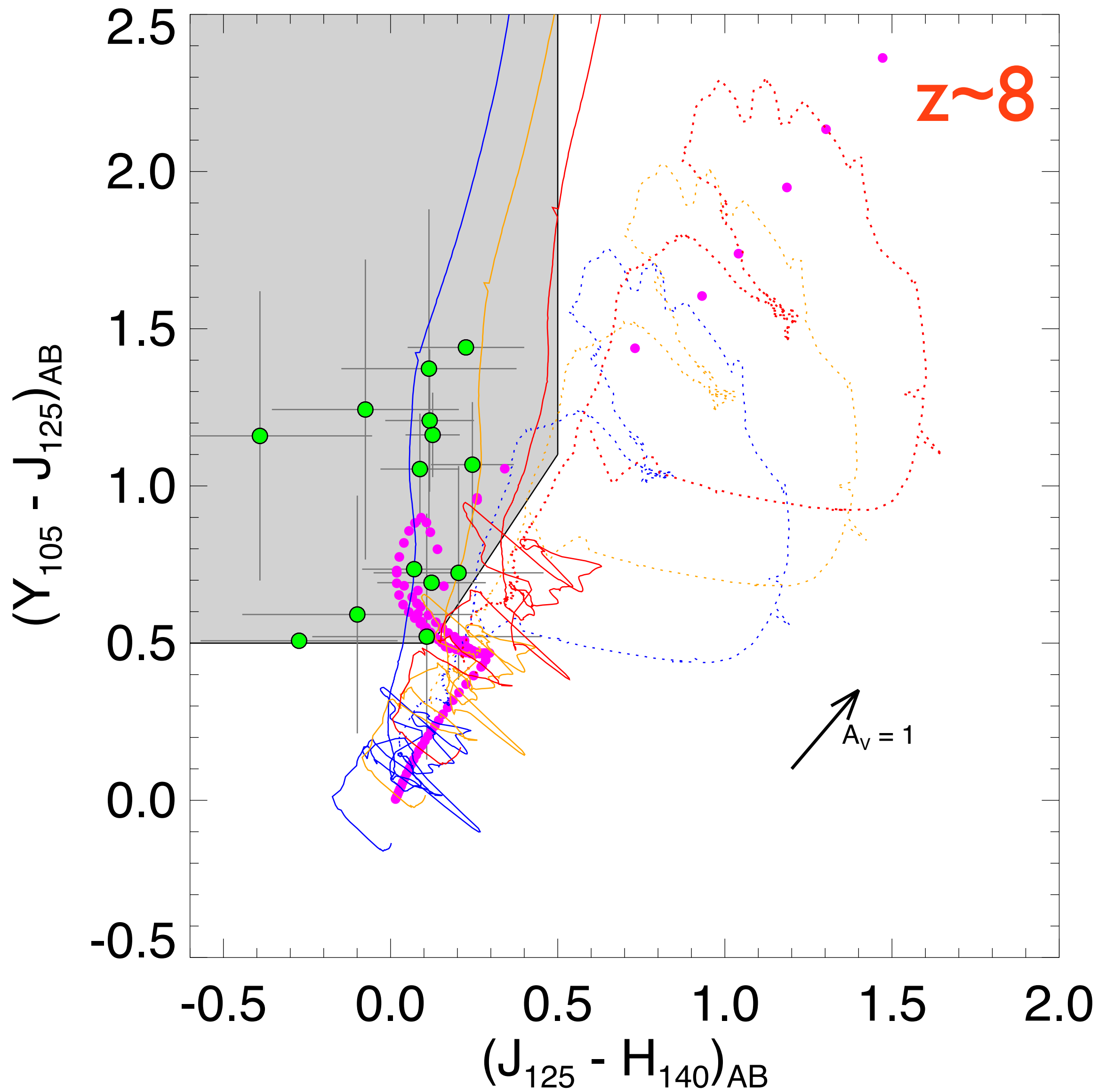
WFC3 data of blank fields from multiple surveys: HUDF, CANDELS, BoRG ...

Selecting z>6 Galaxies

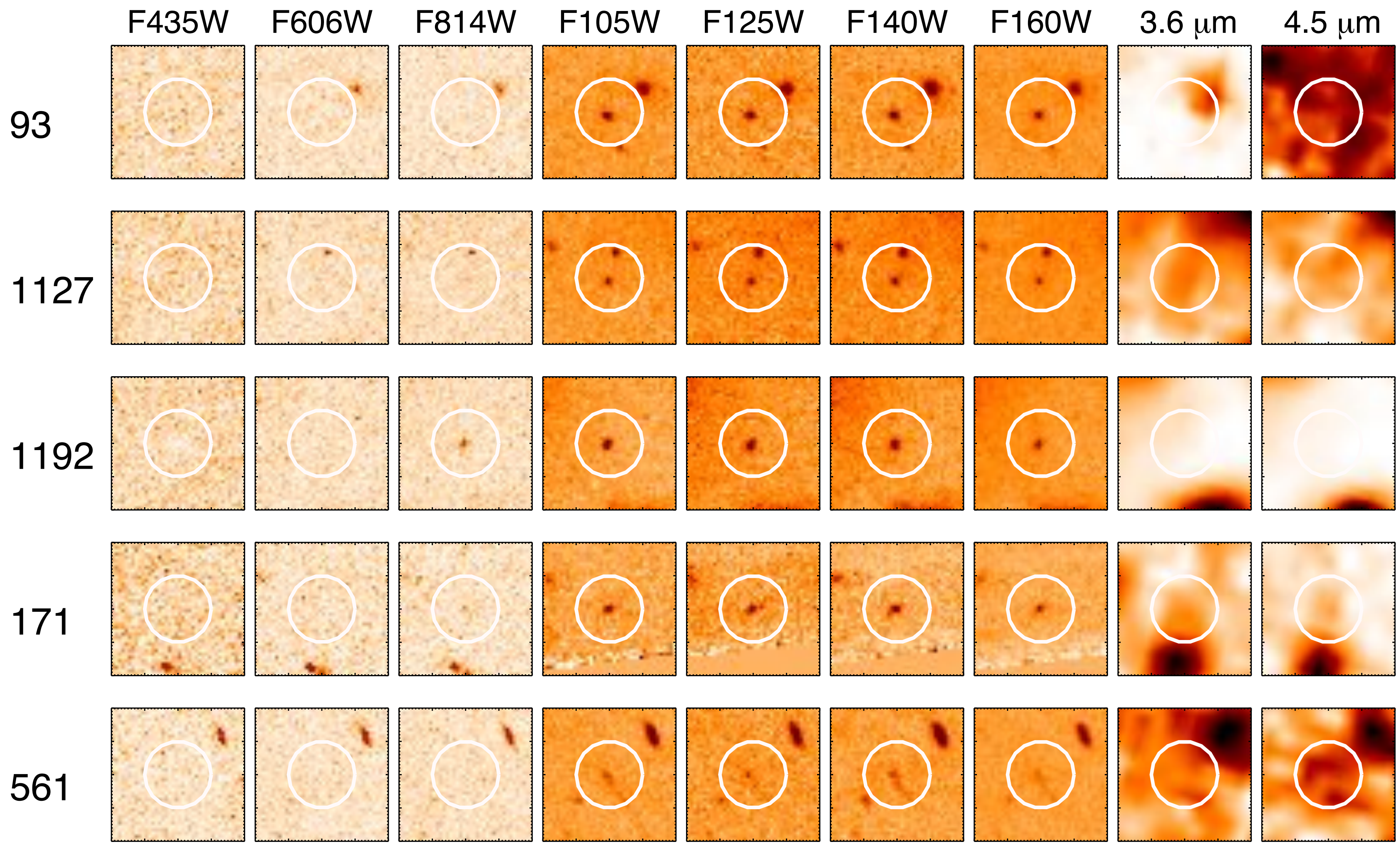
color-color selection

Atek et al. (2014d)

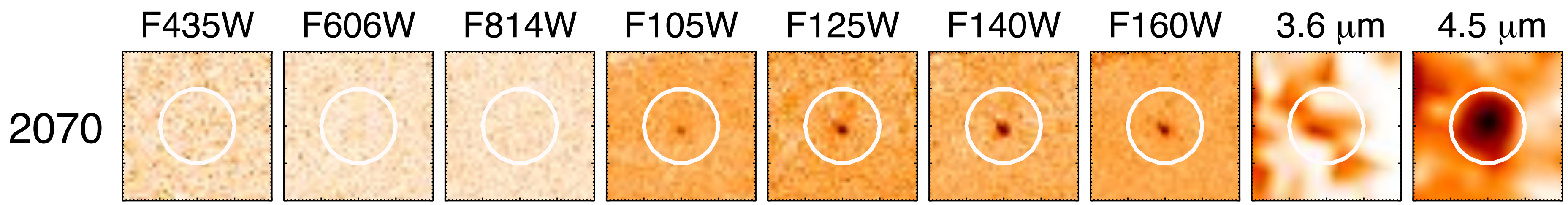




Selecting z>6 Galaxies



z~6-7 Galaxies
I-814 dropouts



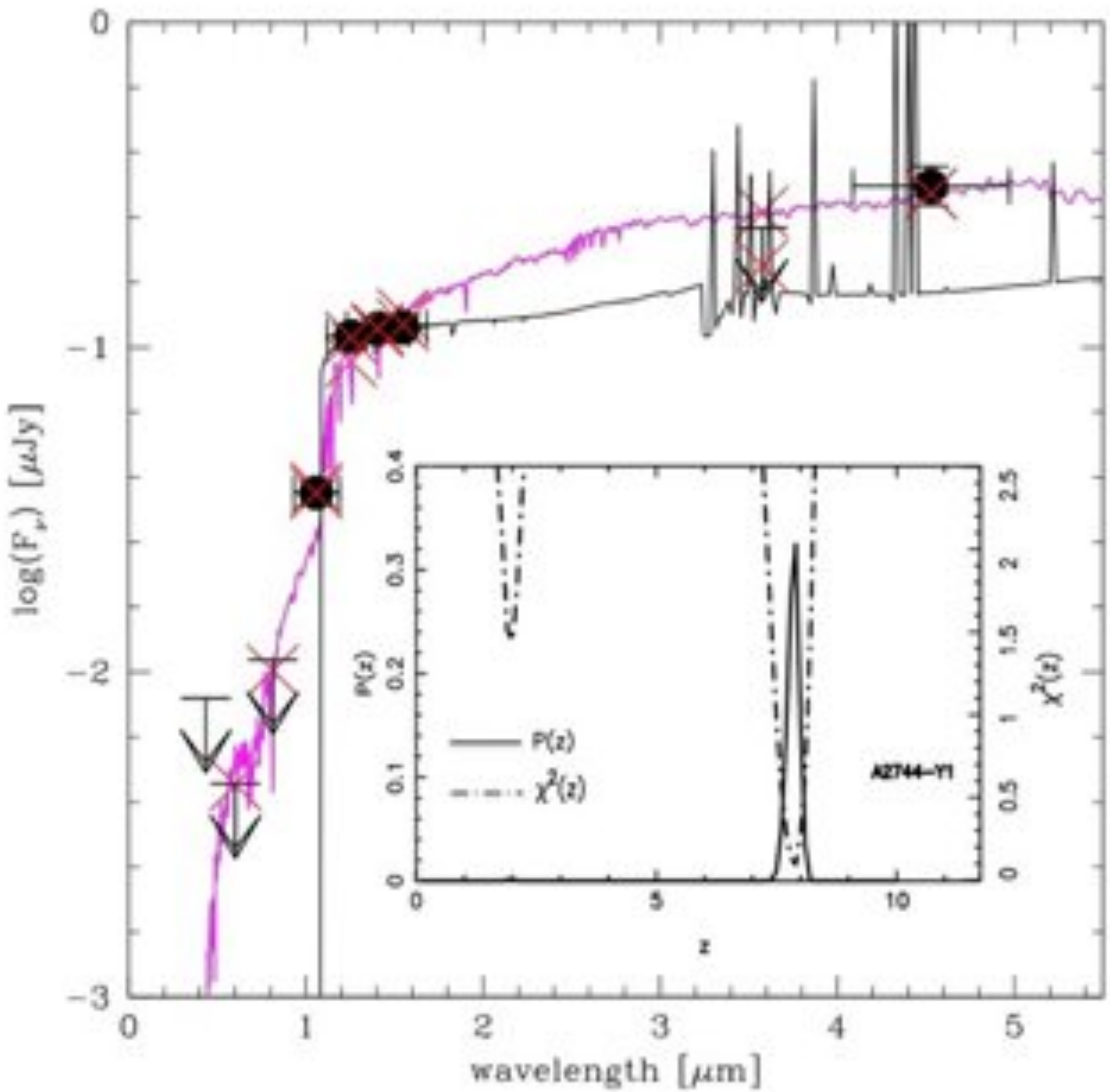
z~8 Galaxy
J-105 dropouts

z~8 Galaxy Candidate

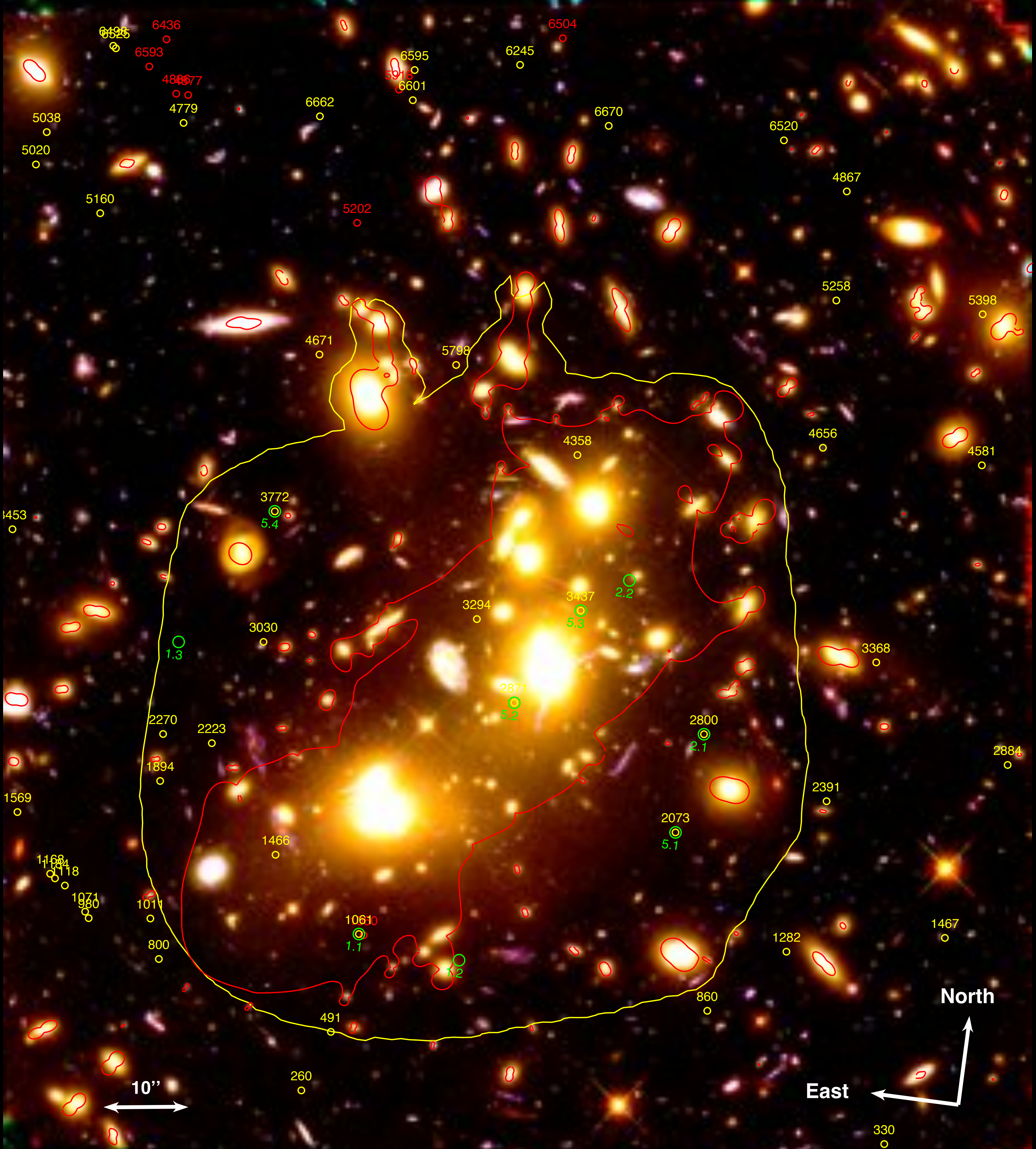
Flux excess in the 4.5 micron channel possibly due to [OIII] +Hbeta emission lines at z~8

H_{160} = 26.2 AB (u ~ 1.5)

- SFR = 10-60 M_{sol} yr^{-1}
- Mass = 2.5-10 x 10^{10} M_{sol}



Laporte et al. (2014)



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10''
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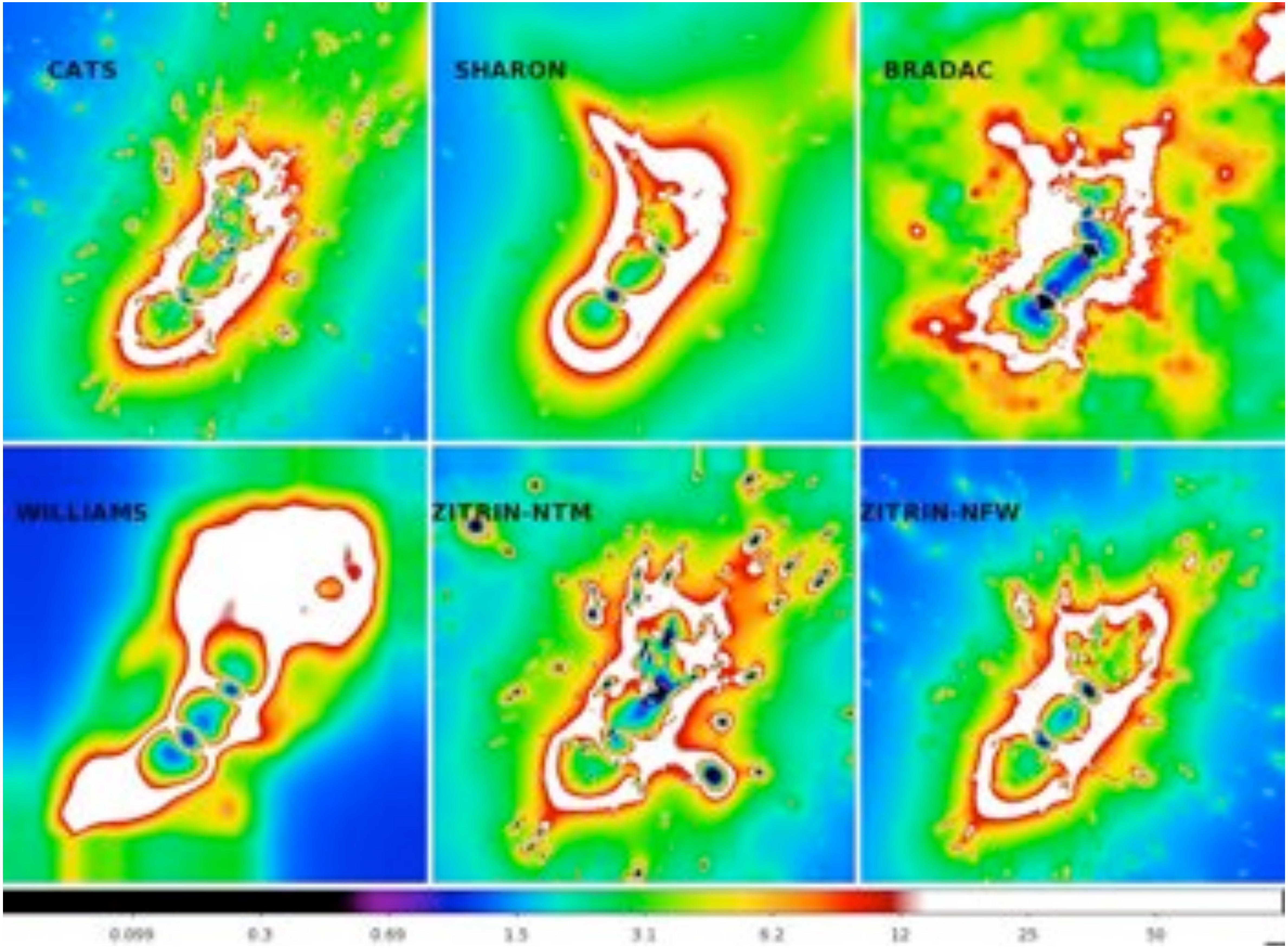
330

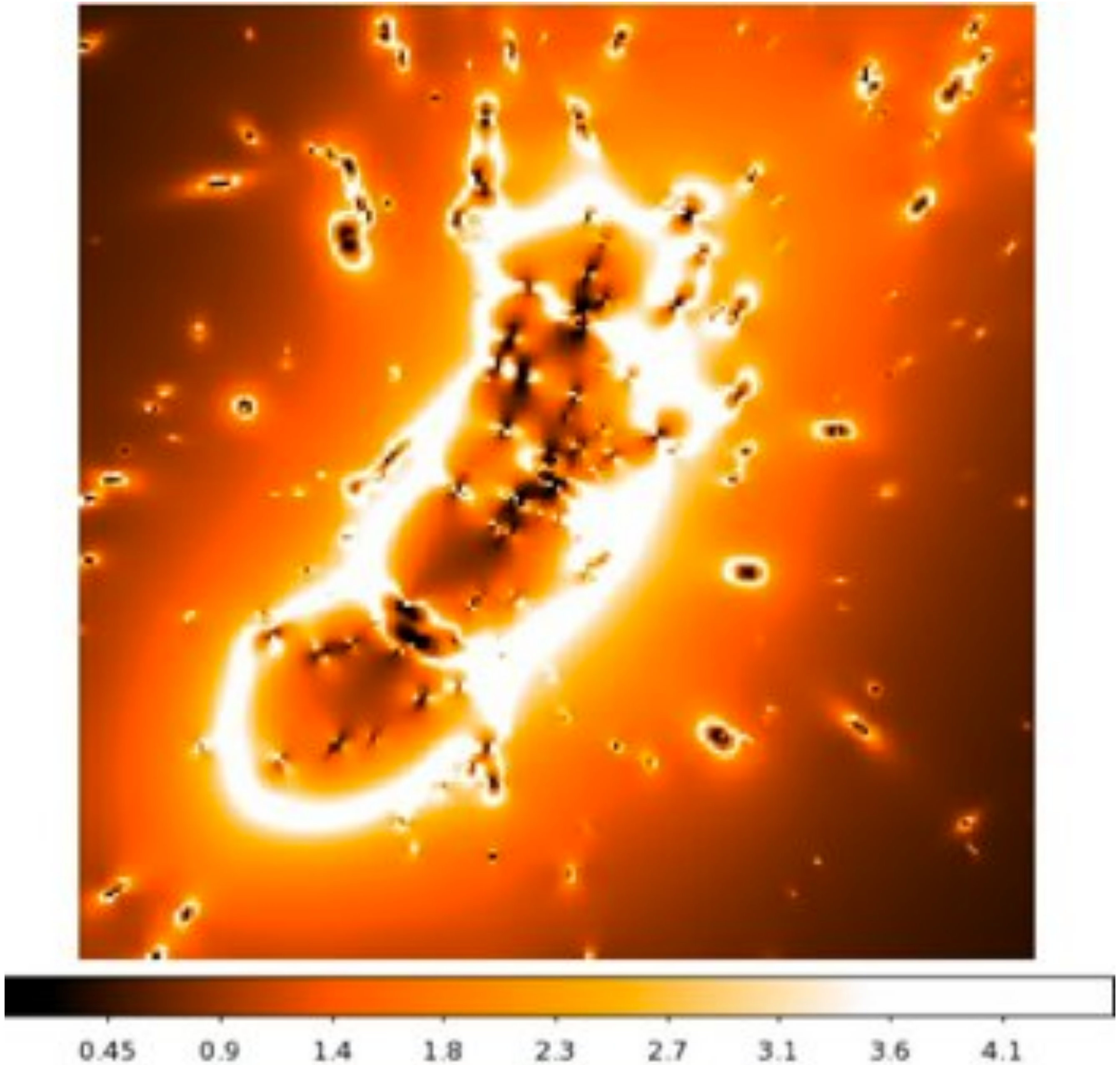
Lensing Model

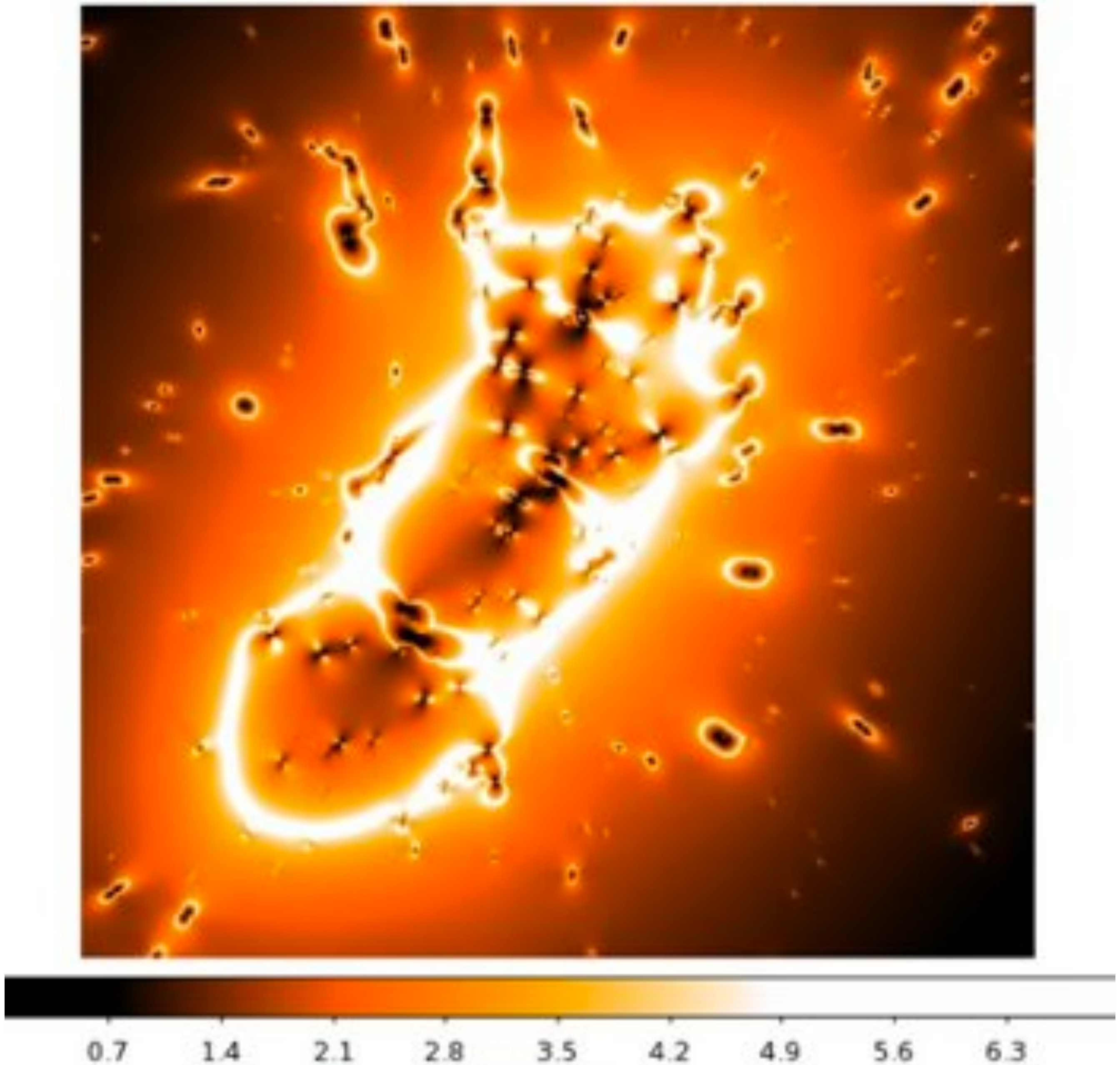


HFF-based Lensing Model

Magnification Map

Richard et al. (2014), Jauzac et al. (in prep)



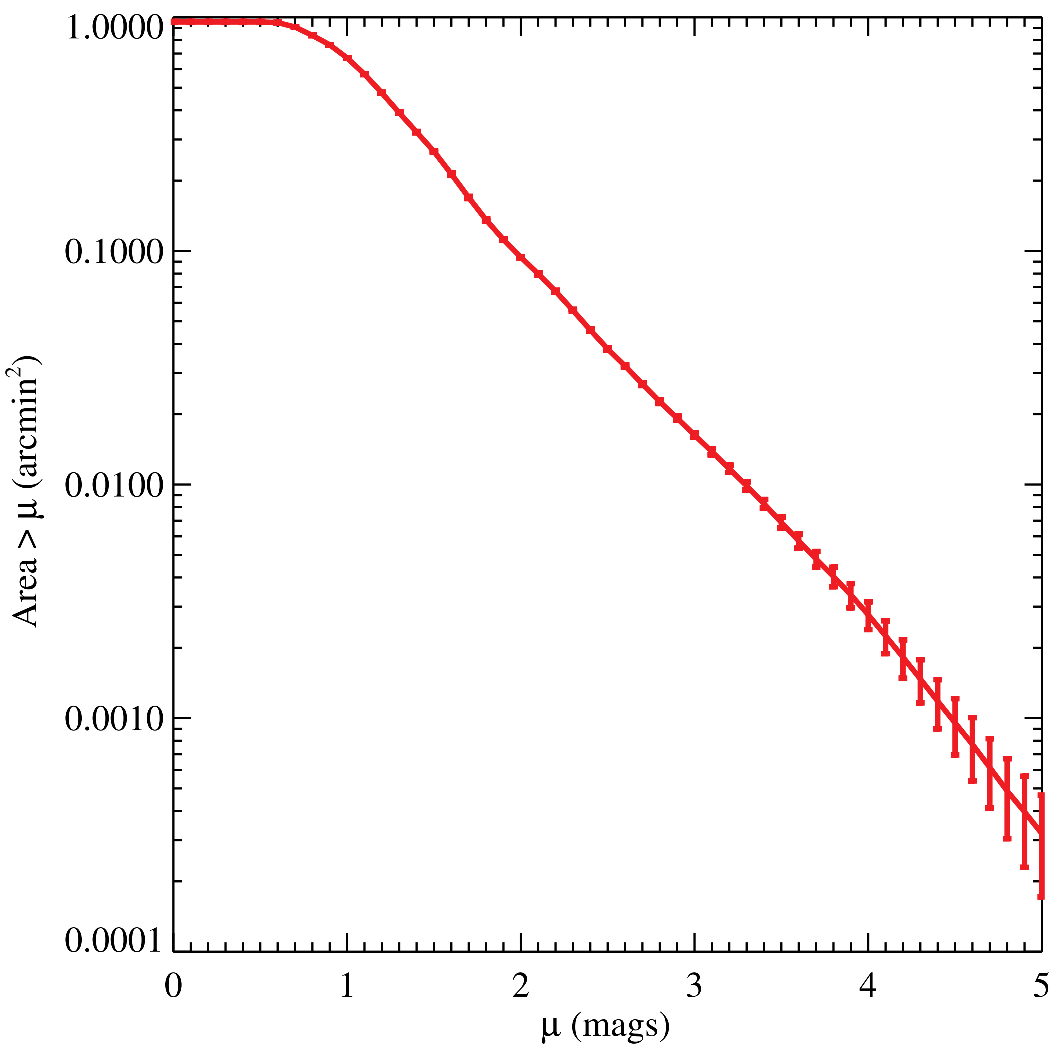


The UV Luminosity Function at z>6

Luminosity distribution of the sources: $\phi(M)dM = \frac{N_i}{V_{eff}(M_i)}$

- Need to estimate the area in the source plane

- Completeness will be a function of magnification (e.g. distortions, source area reduction, sky position ...)



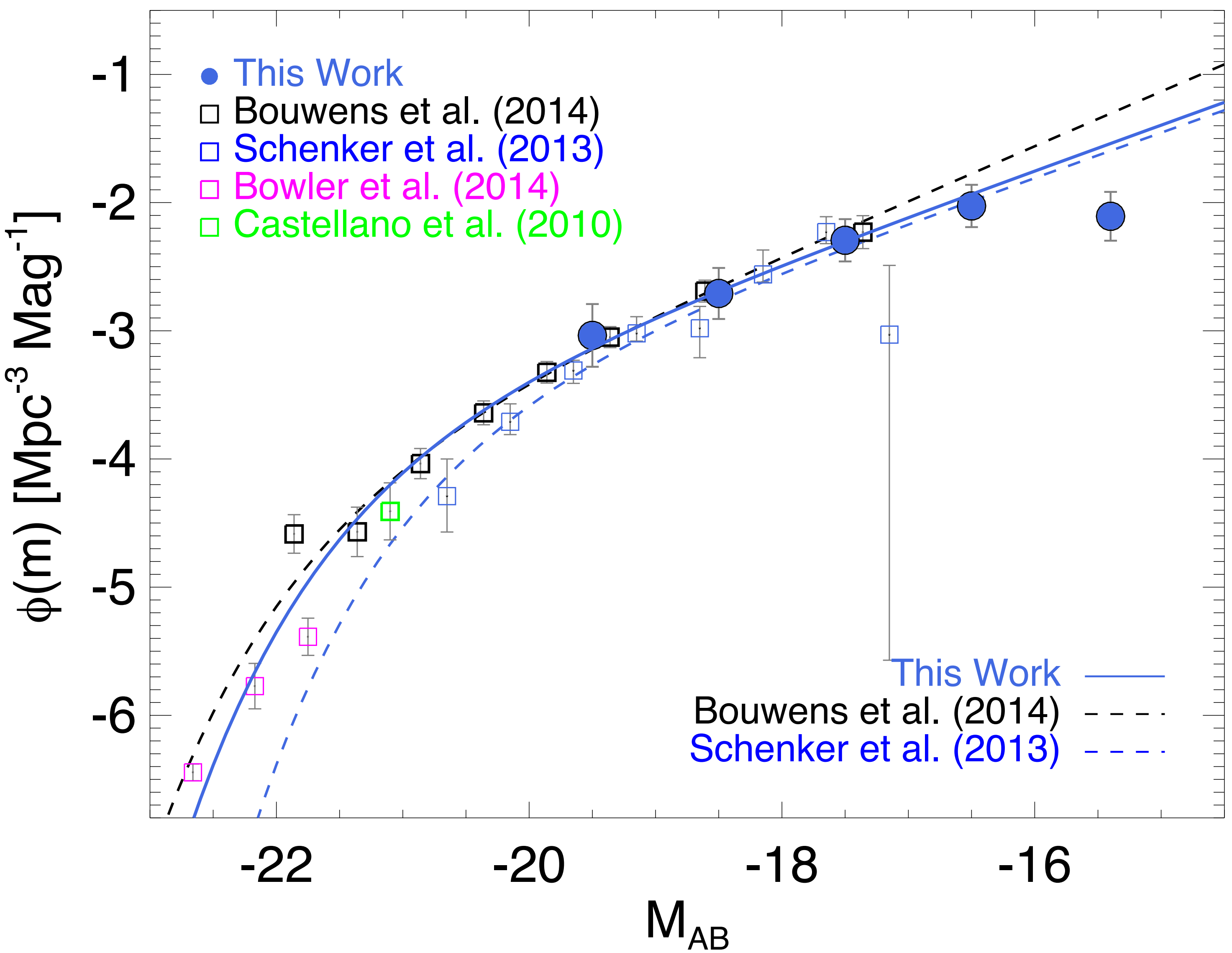
Effective survey volume

$$V_{eff} = \int_0^{\infty} \int_{\Omega > \Omega_{min}} \frac{dV_{com}}{dz} \; f(z, m, \mu) \; d\Omega(\mu, z) \; dz$$

The Faint-end of the UV LF at z>6

- Results in general agreement with blank fields
- Reaching down to Muv,abs ~ -16.5 this is 0.1L* at z=7
- Faint-end slope of alpha=-1.88. The steep faint-end slope holds to very faint magnitudes
- No sign of turnover in the reliable part of the LF

Atek et al. (2014d)



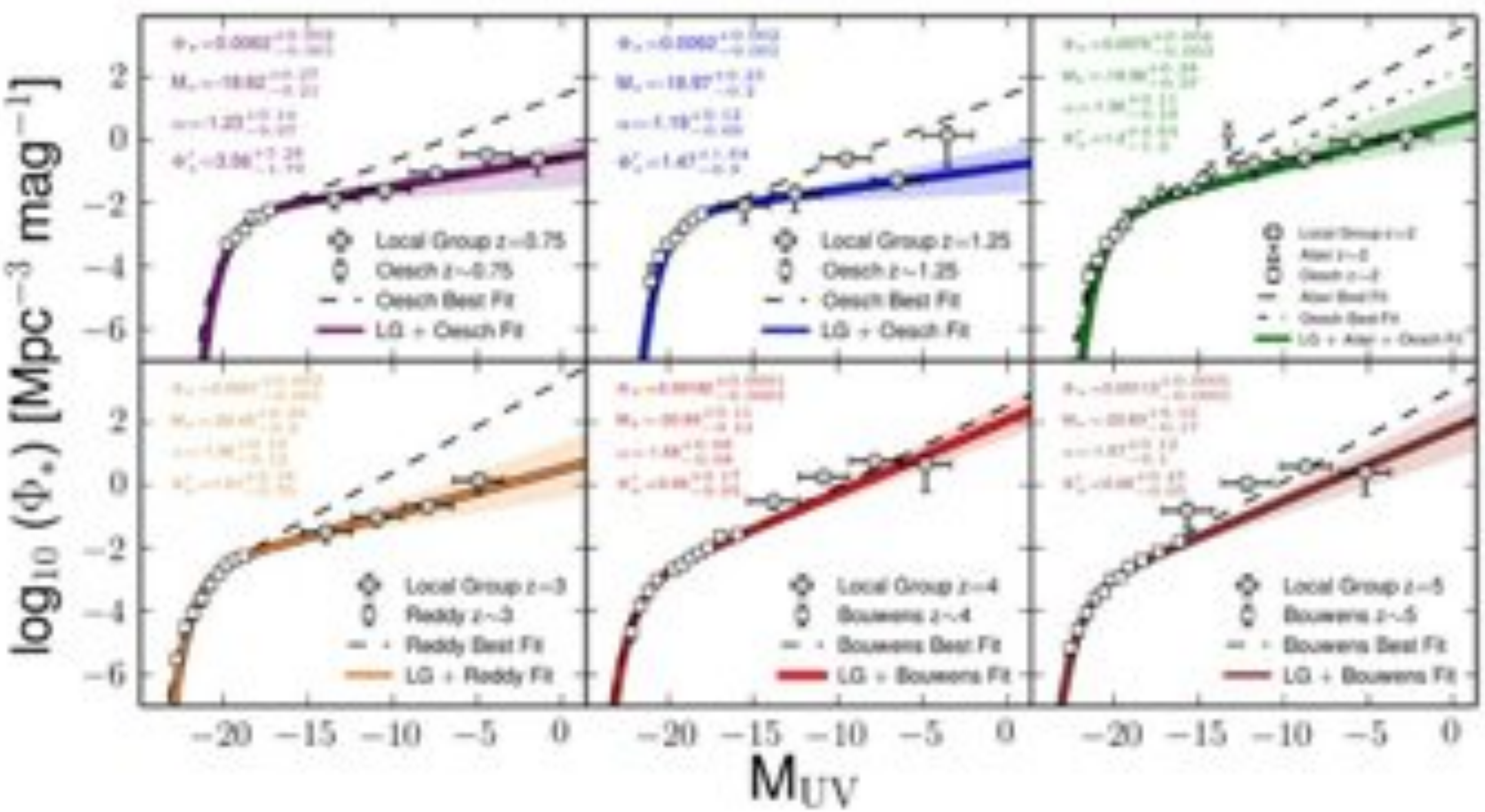
	This work	Bouwens et al. (2014)	Schenker et al. (2013)	Ishigaki et al. (2014)
α	-1.88 ±0.12	-2.0 ±0.14	-1.87 ±0.18	-2.10 (-0.15,+0.3)

Talk by Masami

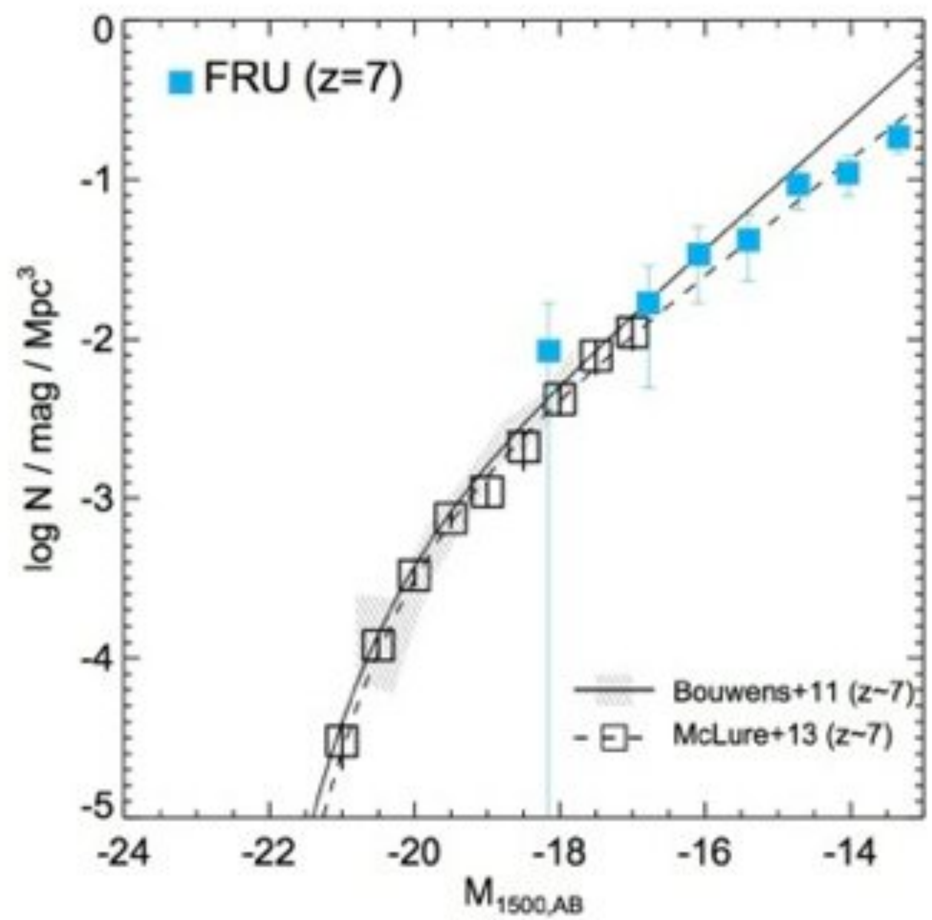
The Faint-end of the UV LF at z>6

The faint-end slope supposedly holds to even fainter magnitudes:
- from cosmological simulations
- reconstruction based on local group LF

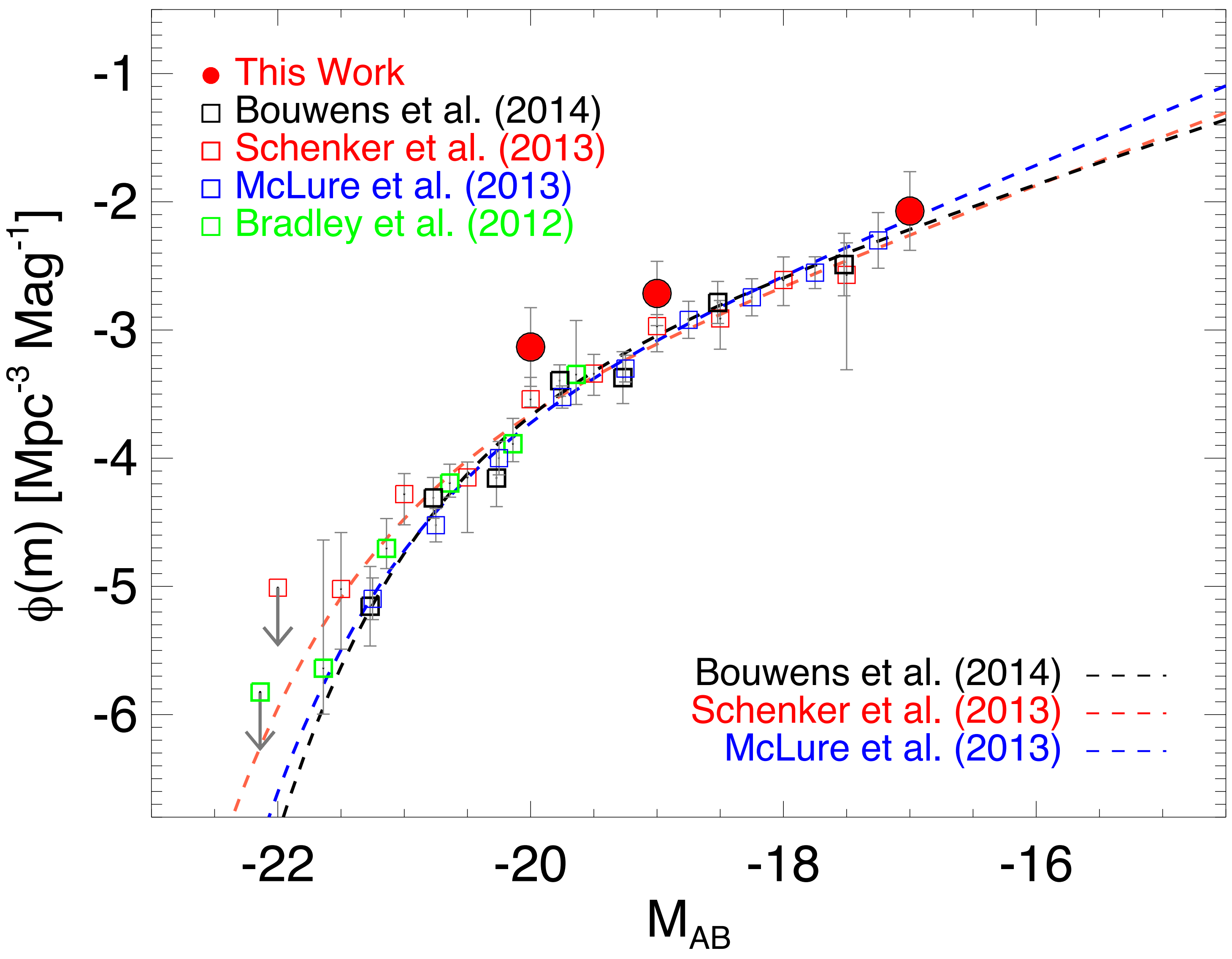
Weisz et al. (2014)



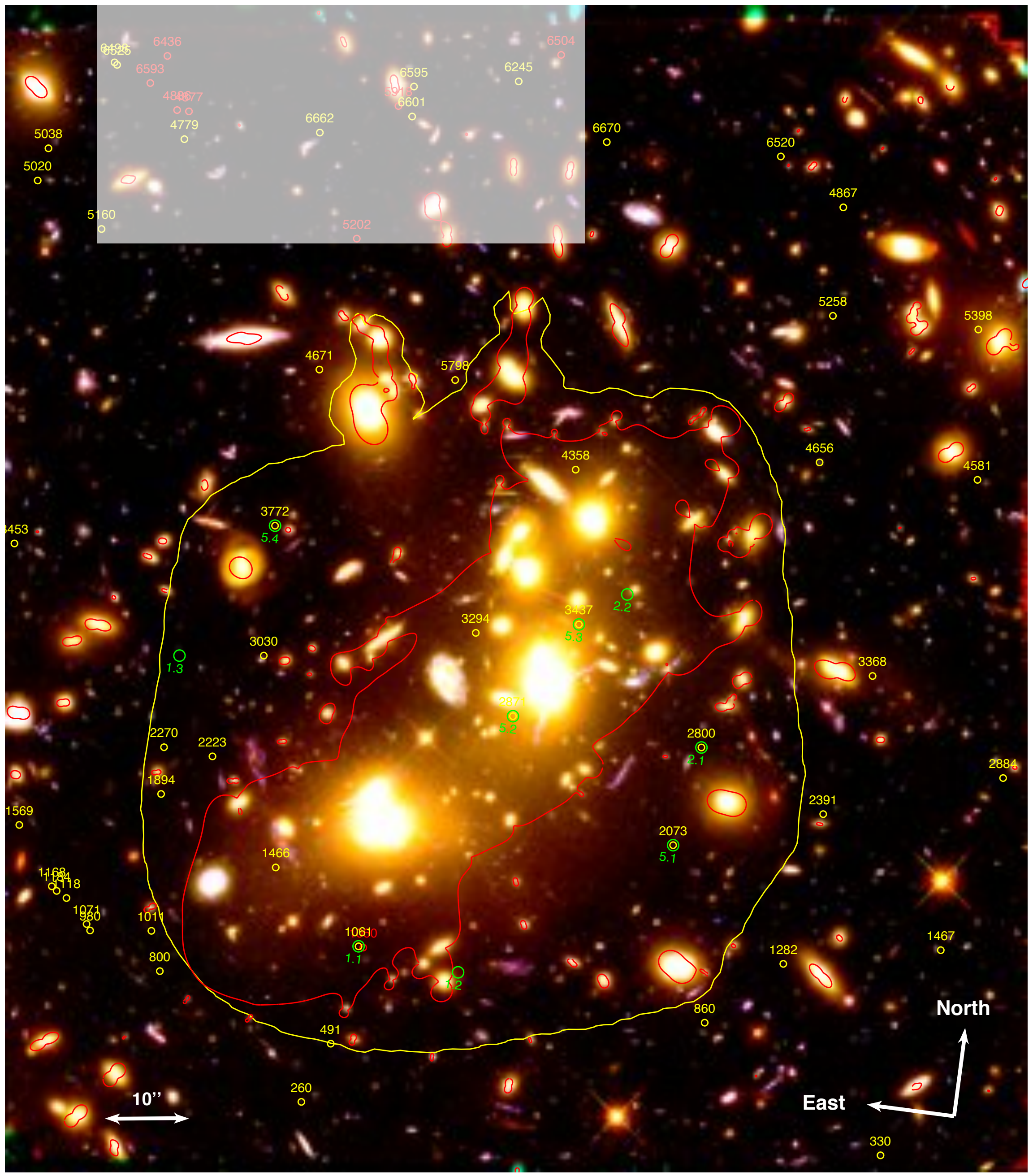
Kimm & Cen (2014)

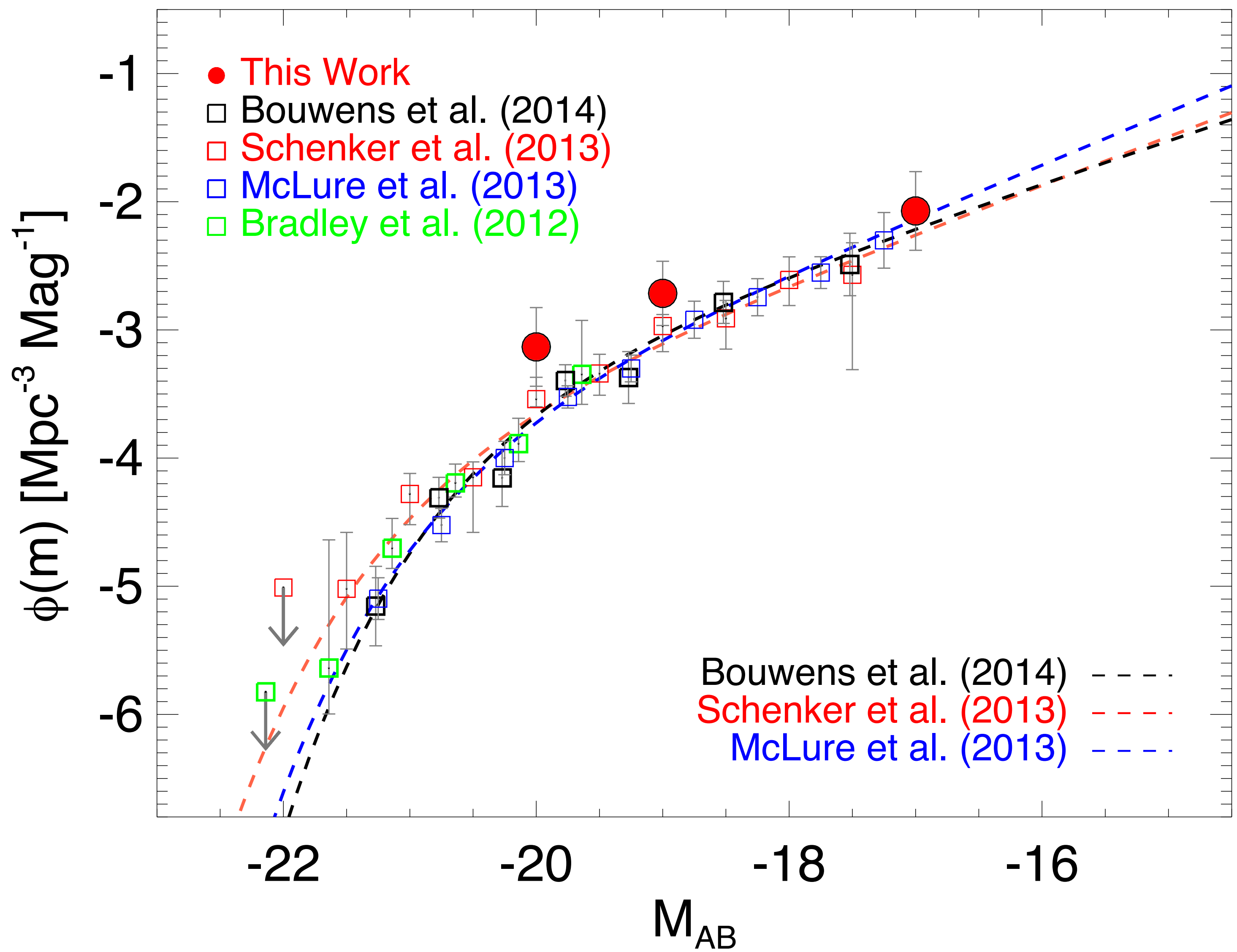


The Faint-end of the UV LF at z=8

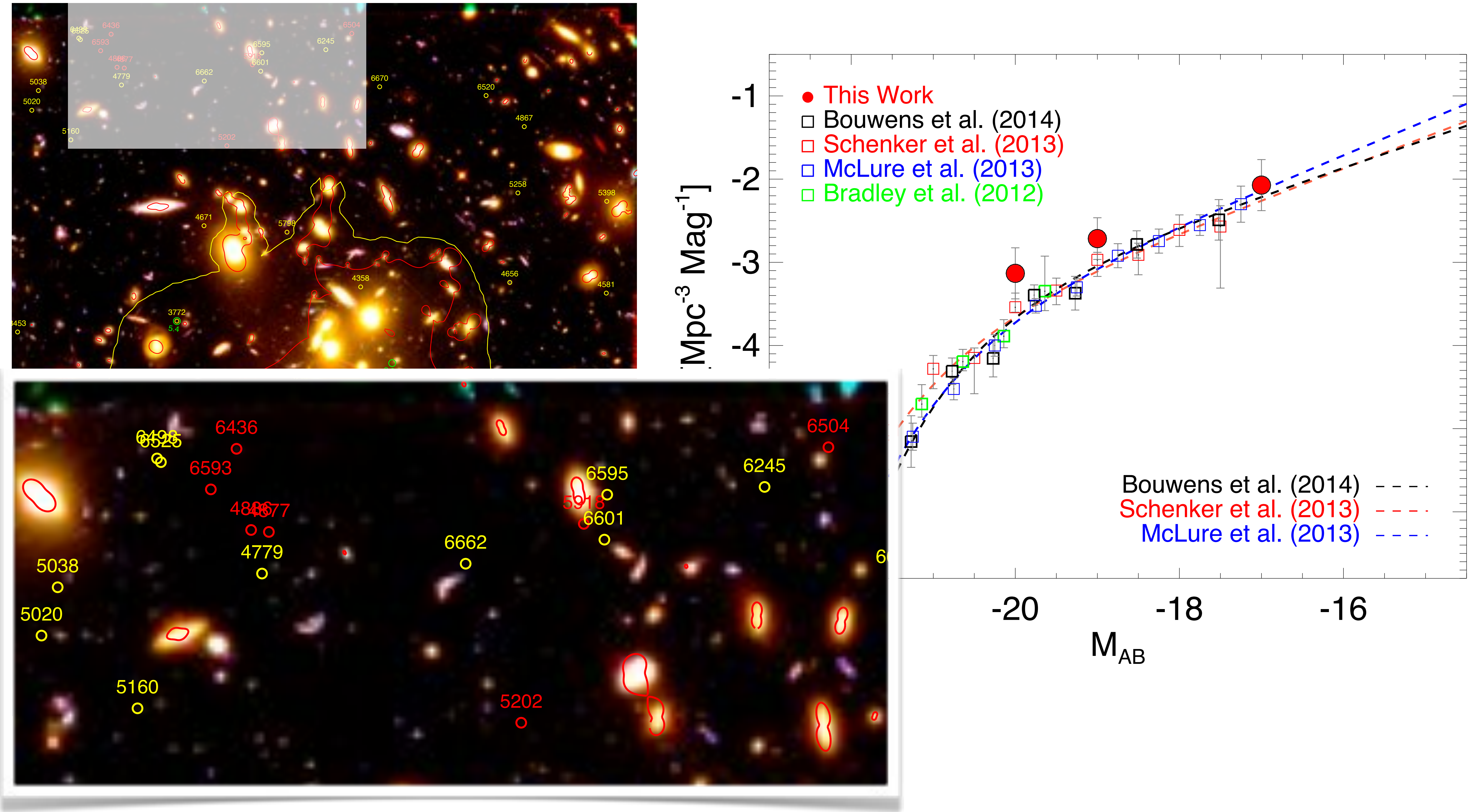


The Faint-end of the UV LF at z=8





The Faint-end of the UV LF at z=8

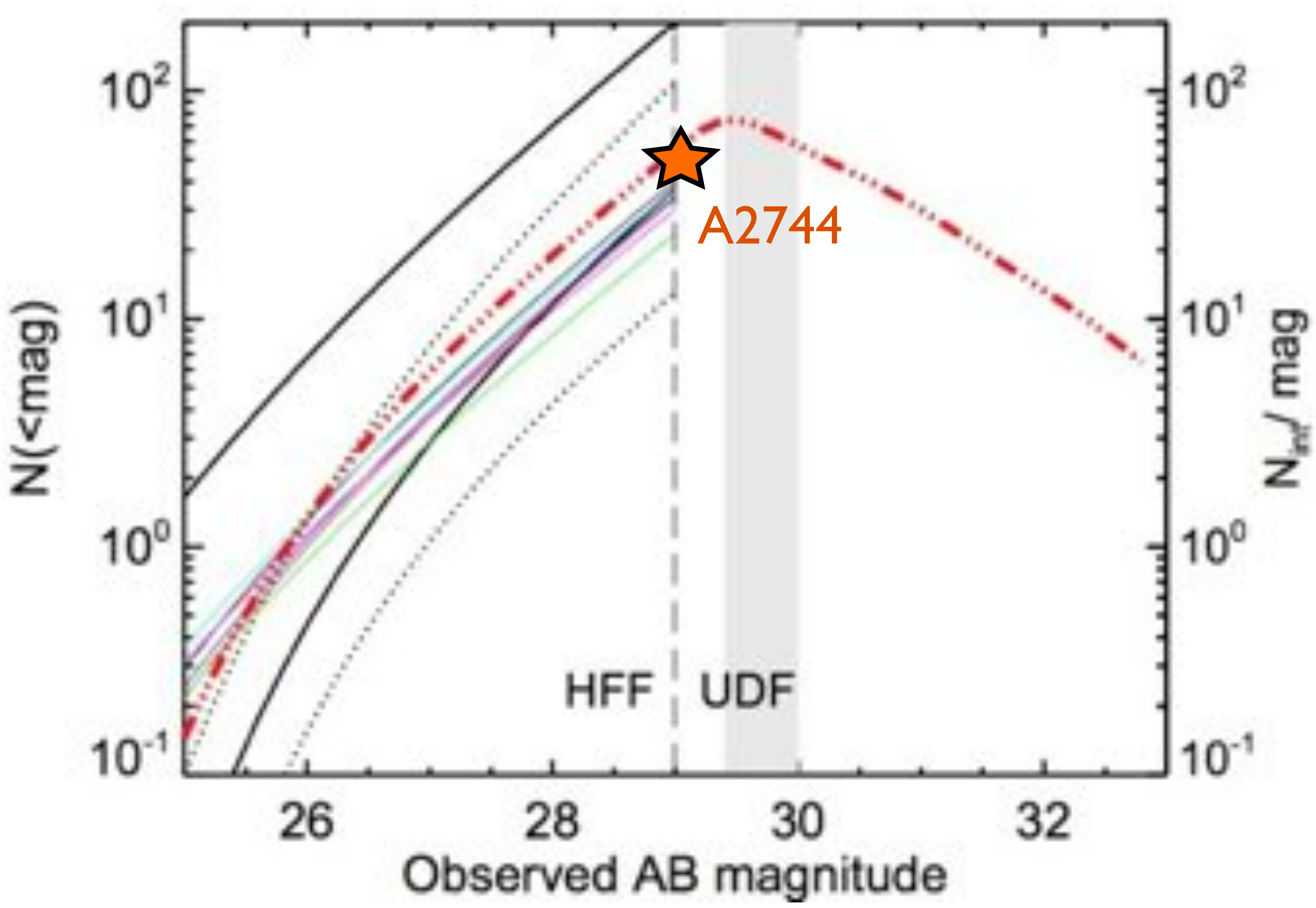


Predictions for High-z Detections

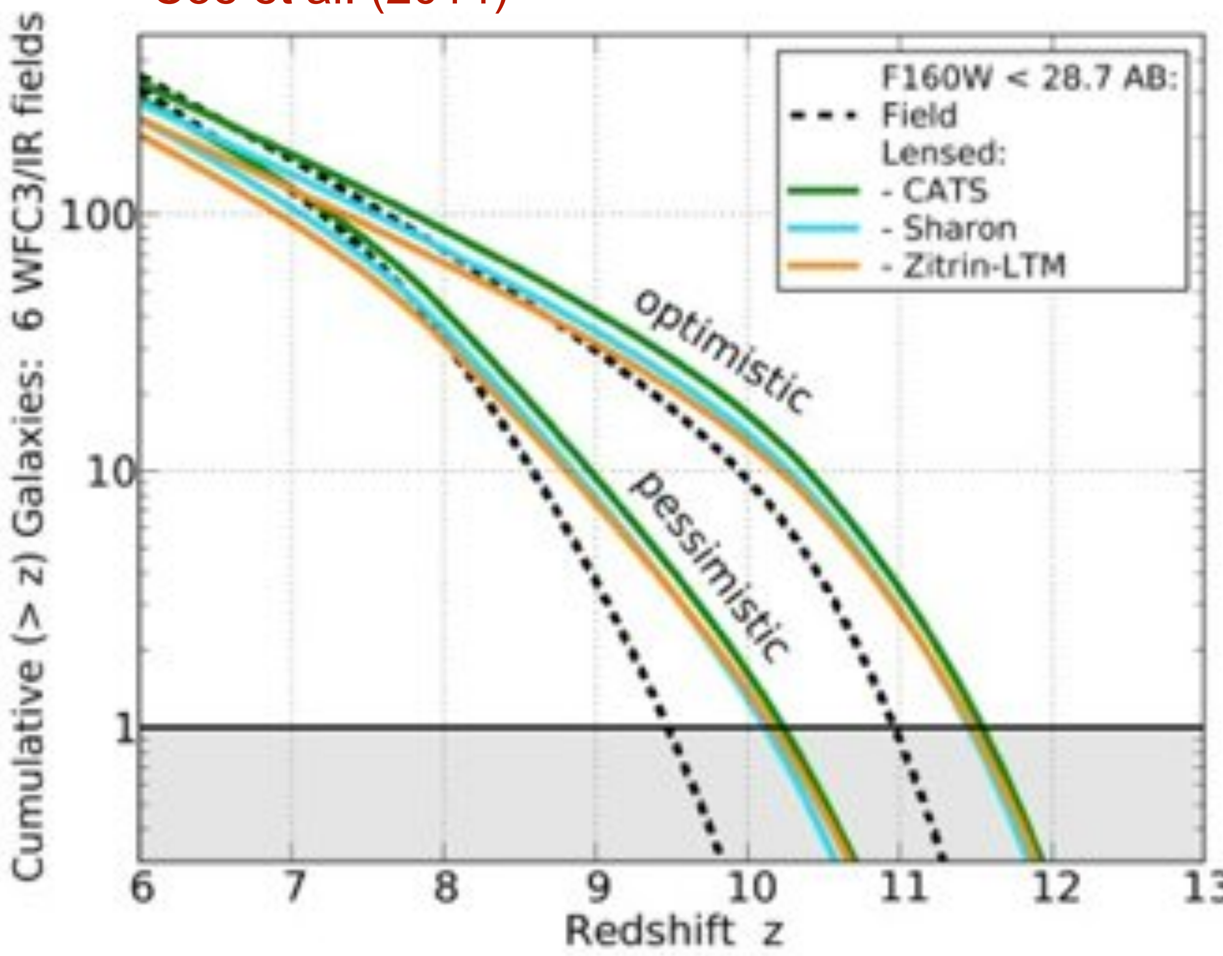
- Number of sources in the six FF compared to blank fields
- probing fainter intrinsic magnitudes

(see also Yue et al. 2014, Johnson et al. 2014)

Richard et al. (2014)



Coe et al. (2014)



Prospects with Current and Future Instrumentation

Gravitational Telescopes:

The Hubble Frontier Fields (PI: Lotz)
access the faint population of dwarf galaxies at high redshift (Richard et al. 2011, Coe et al. 2013, Balestra et al. 2013, Monna et al. 2014, Alavi et al. 2014)

Detailed studies of physical properties: metallicity, ionization, extinction … (Vanzella et al. 2013, Christensen et al. 2012, Jones et al. 2013, Schmidt et al. 2014, Amorin et al. 2014)

VLT/KMOS: efficient spectroscopic follow-up of high-z candidates

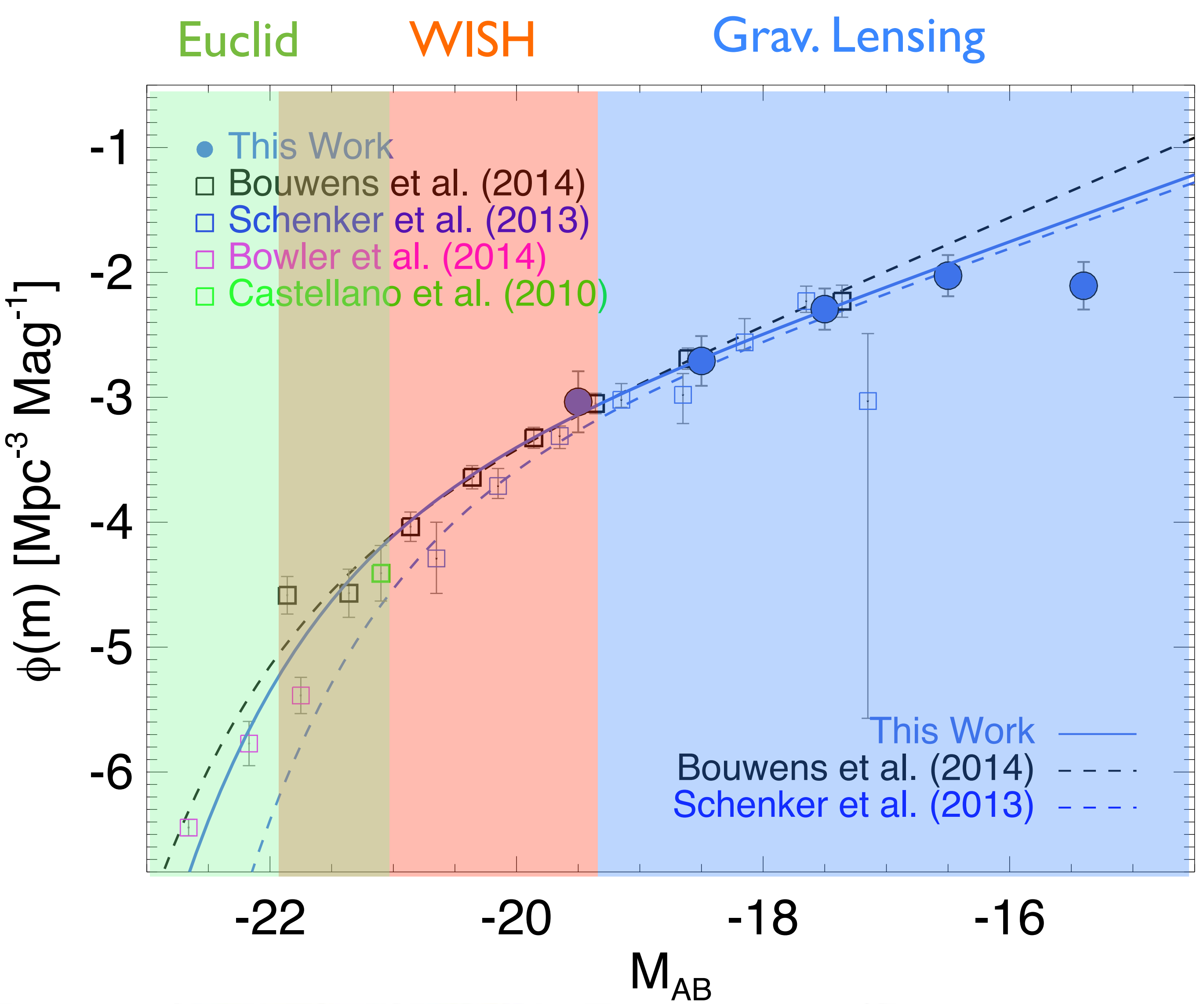
VLT/MUSE: Map lensing clusters for high-redshift ($z > 3$) studies and lens models

WISH & the High-redshift Universe

Wide field IR missions (Euclid) will probe the brightest of the LF

WISH will put strong constraints on the slope and the shape of the bright end.

Gravitational telescopes combined with current and future instrumentation (JWST) put better constraints on the very faint-end of the LF



	Depth (3 σ) (AB mag)	Area	Example of the Filters (a plan, to be determined)
Ultra Deep Survey	**28**	**100 deg^2**	**1.4,1.8, 2.3, 3.0 micron**
Multi-Band Survey	**28**	**10 deg^2**	**1.0,4.0**
Ultra Wide Survey	24-25	1000 deg^2	1.4, 1.8, 2.3
Extreme Survey	29-30	0.25 deg^2	1.0, 1.4, 1.8

Summary

- Gravitational lensing helps reach the faint galaxies likely responsible for cosmic reionization
- The HFF combines HST and strong lensing to probe the distant Universe
- The UV LF goes below 0.05L* at z=7. This is more than 1 mag deeper than the deepest observations in blank fields
- WISH will robustly constrain the bright-end slope and shape of the UV LF at z>8