The Evolving Lya Properties of LBGs between z=3 and z=8

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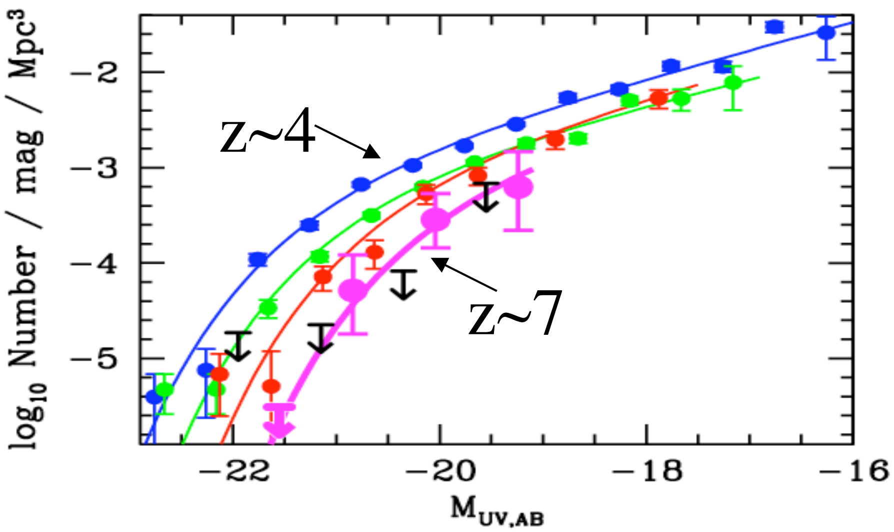
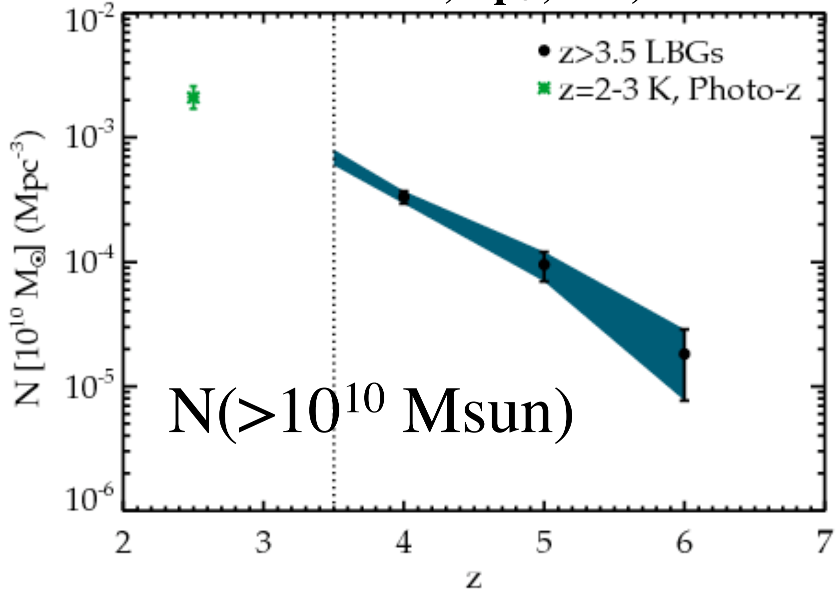
Evolution of LBGs over 3<z<7

Bouwens et al. 2008, ApJ, 686



Stark et al. 2009, ApJ, 697, 1493

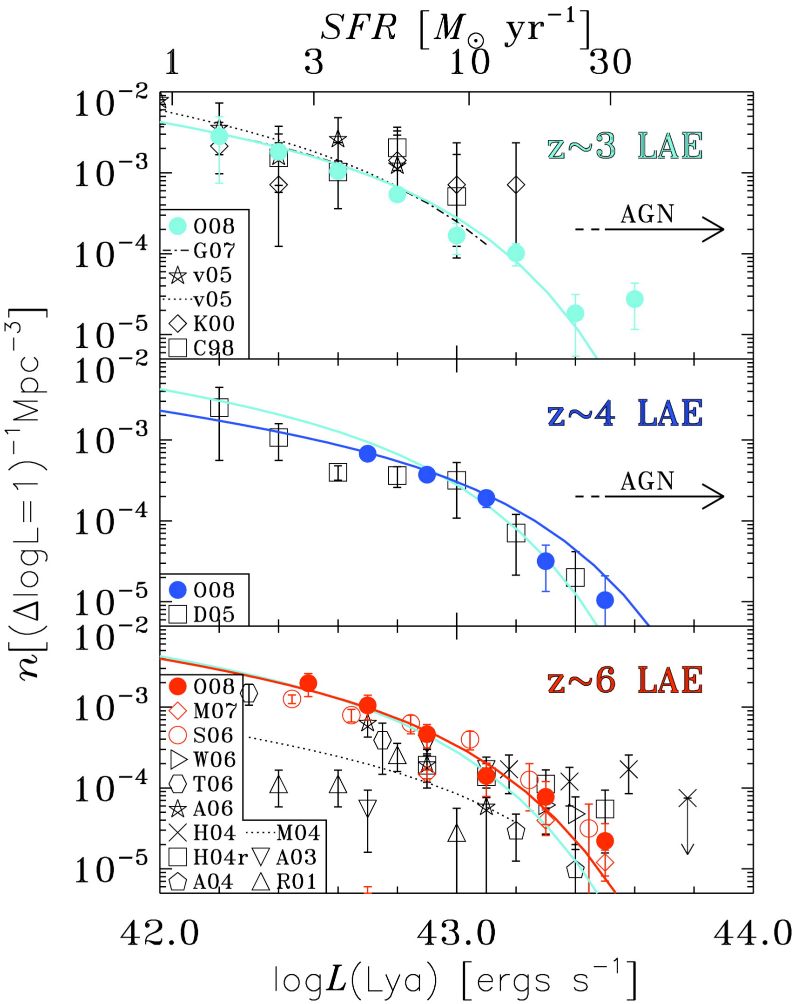


- Evolution of LBGs over 3<z<7 is luminosity/mass dependent.
- Luminous and massive LBGs grow rapidly in abundance while less luminous sources grow less rapidly.
- Evolution consistent with expectations from rapid growth of massive DM halos.

Do the LAEs show similar 'hierarchical growth' over 3<z<7?

Evolution of LAEs between z=3 and 6

Ouchi et al. 2008, ApJS, 176, 301



Lya luminosity function does not evolve strongly between z~3 and z~6 - *in contrast to 'hierarchical growth' exhibited by LBGs.*

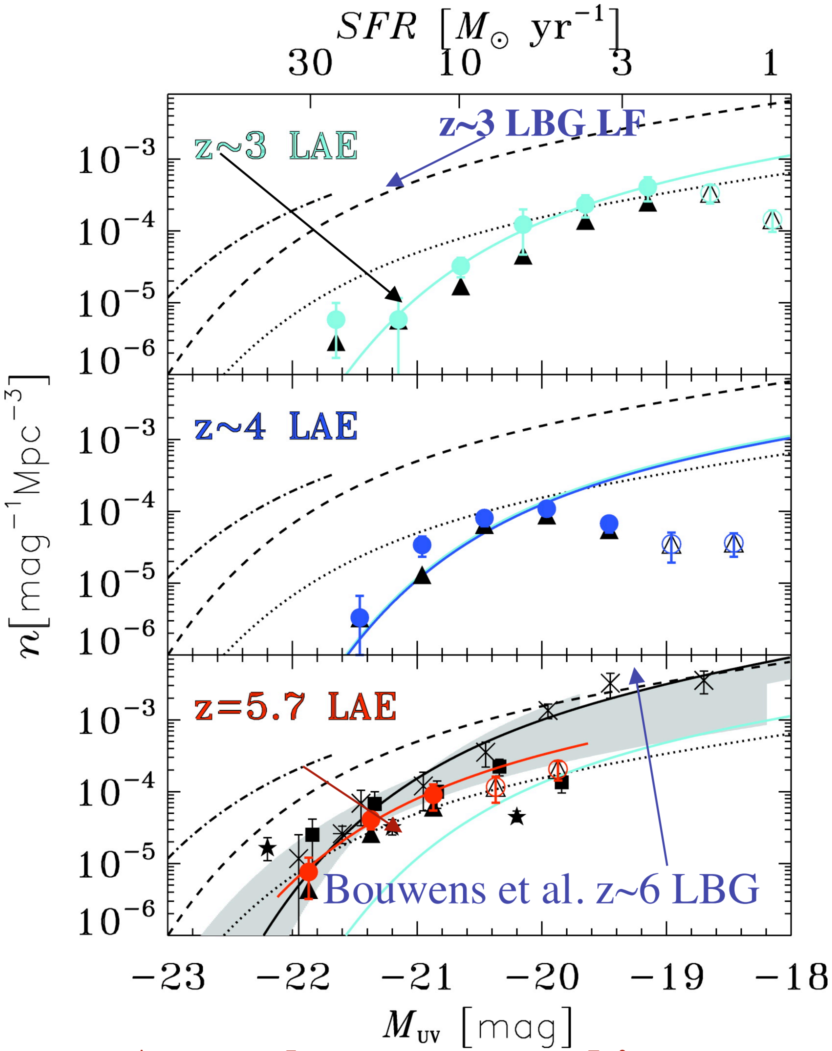
Does Lya emission become much more common in galaxies as reionization is approached?

Or is narrowband-selected Lya population primarily low luminosity galaxies - which don't evolve as strongly as UV luminous systems?

If we are to use Lya LF to probe IGM at z>7, must understand how galaxy evolution affects LF: important to understand its evolution in the context of UV-selected star forming galaxies.

The UV continuum LF of narrowband-selected LAEs

Ouchi et al. 2008, ApJS, 176, 301



At z~3, number density of LBGs is >10x that of NB-selected LAEs at all UV luminosities.

But at z~5.7, the number density of LAEs is equivalent to that of i-drops.

Seemingly implies that Lya becomes more prevalent in star-forming galaxies in 1 Gyr between z~3 and z~6.

Two caveats:

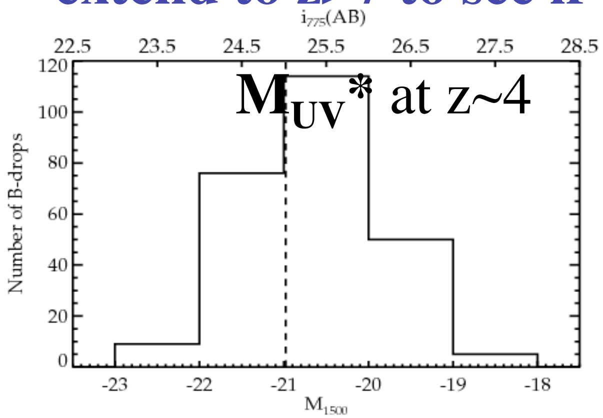
(1) redshift distributions of z=5.7 LAEs and i-drop (z~6) LBG population are different.

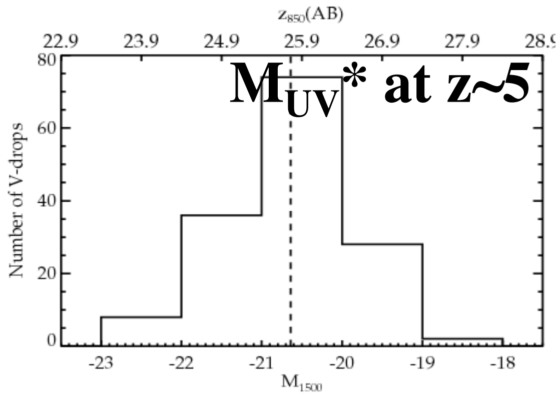
(2) LBG color-selection is affected by Lya emission.

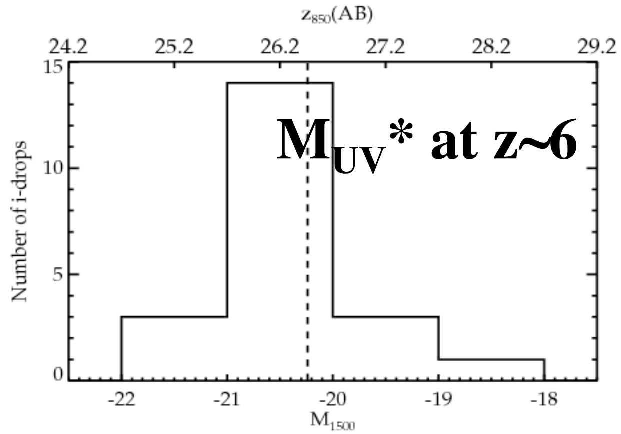
A complementary, and in some sense cleaner, approach is to study prevalence of Lya emitters *within dropout population* as a function of redshift/M_{UV}.

A Keck spectroscopic survey of z>3.5 UV-selected galaxies

- **Use 600 line grating on DEIMOS: 4000A< λ<10,500 A (2.3<z_{Lya}<7.6).**
- **Target B (z~3.5-4.5) and V-drops (z~4.5-5.5) simultaneously. Recover those V-drops scattered into B-drop window due to strong Lya EW.**
- **Goal is to determine fraction of LBGs with strong Lya emission as function UV luminosity/redshift.**
- **Calibrate evolution in Lya fraction after reionisation (3<z<6), then extend to z>7 to see if there is a sudden drop.**



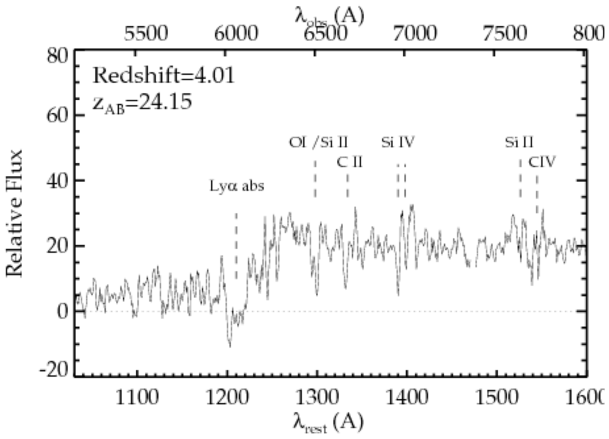




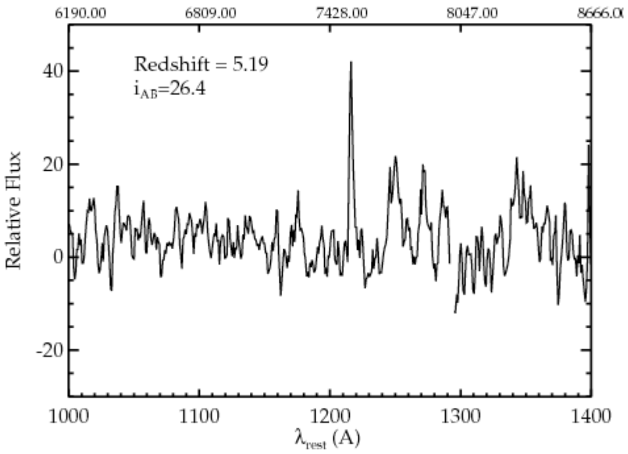
- **Combine with publicly available FORS/VIMOS datasets in CDF-S to increase sample size and extend redshift baseline to z~3.**
- **DEIMOS program targets Lya properties UV faint sources that will be most prevalent probes of IGM evolution at z~7-10.**
- **spectroscopic redshifts for 254 B-drops, 148 V-drops, and 21 i-drops.**

A Keck spectroscopic survey of z>3.5 UV-selected galaxies

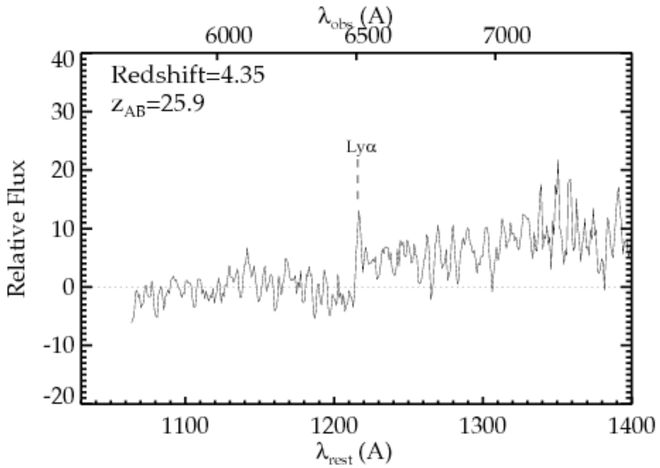
zmag=24.15



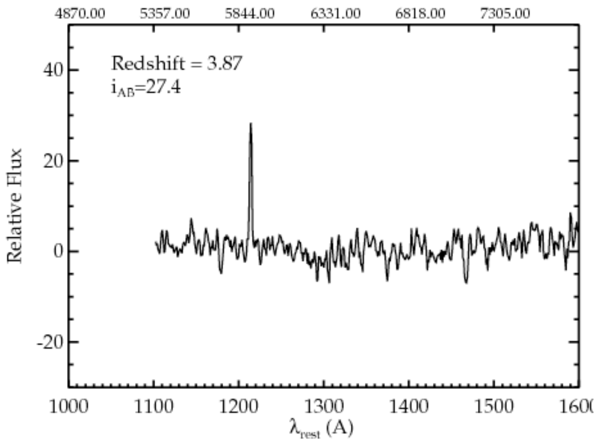
zspec=5.19



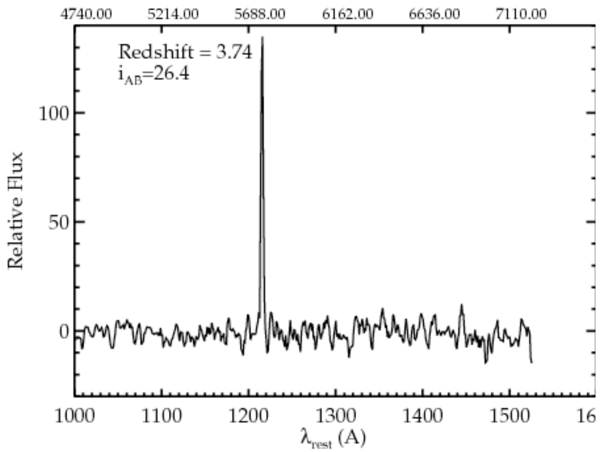
zmag=25.9



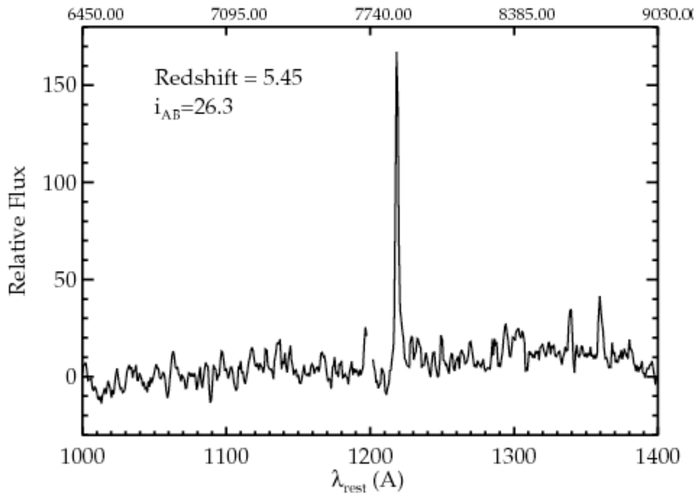
zmag =27.4



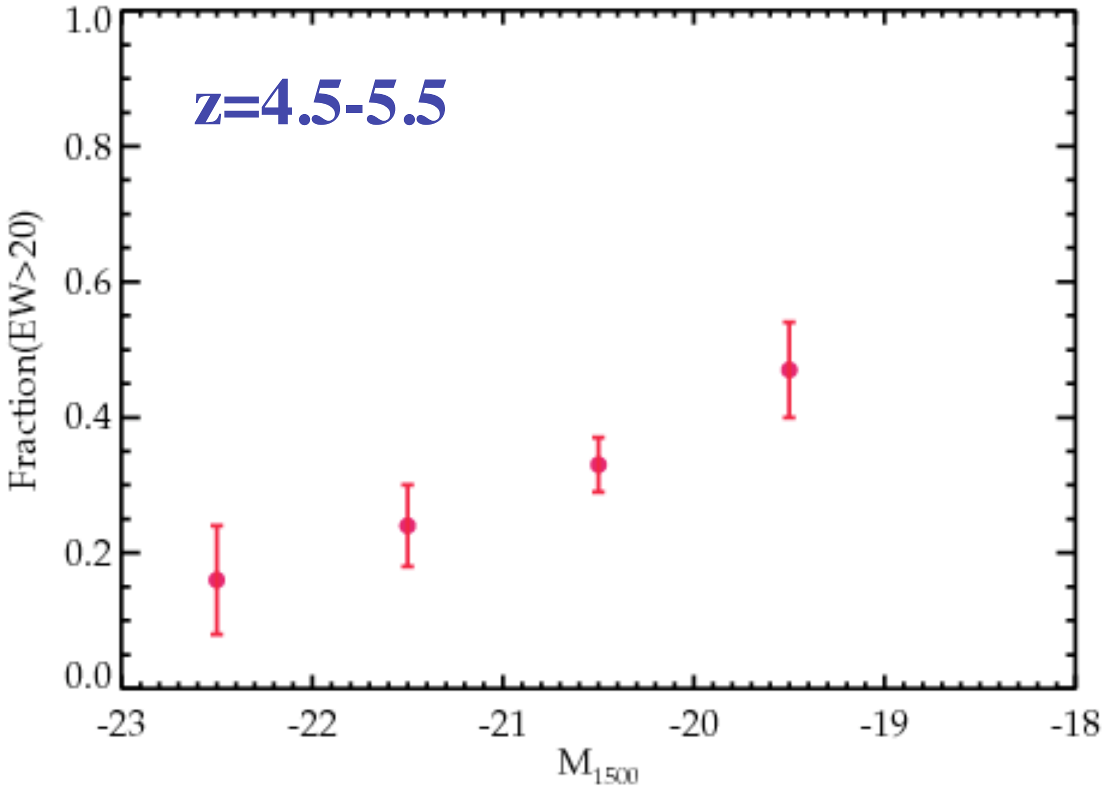
EW(rest)>300 A



zspec=5.45

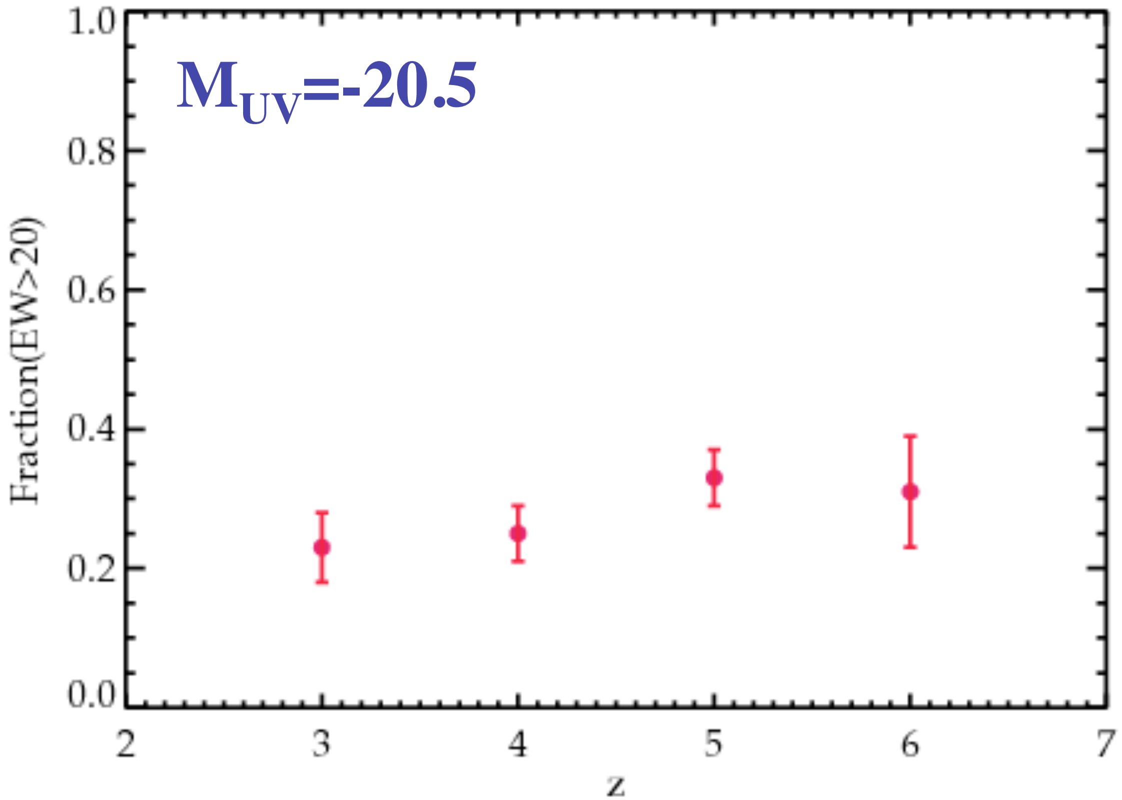


Variation in Lya fraction with UV luminosity



- Carefully corrected for magnitude bias and redshift bias in determination of Lya fraction.
- Strong Lya emission more common in UV faint sources (consistent with Shapley et al. 2003, Ando et al. 2006, Ouchi et al. 2008).
- Possibly reflects fact that UV faint sources are less dusty than more UV luminous galaxies (e.g. Reddy et al. 2009)?
- Suggests z>7 sources (which are primarily UV faint) should be readily detectable with spectroscopy --- in absence of evolution in Lya escape fraction.

Evolution of Lya fraction over 3<z<6



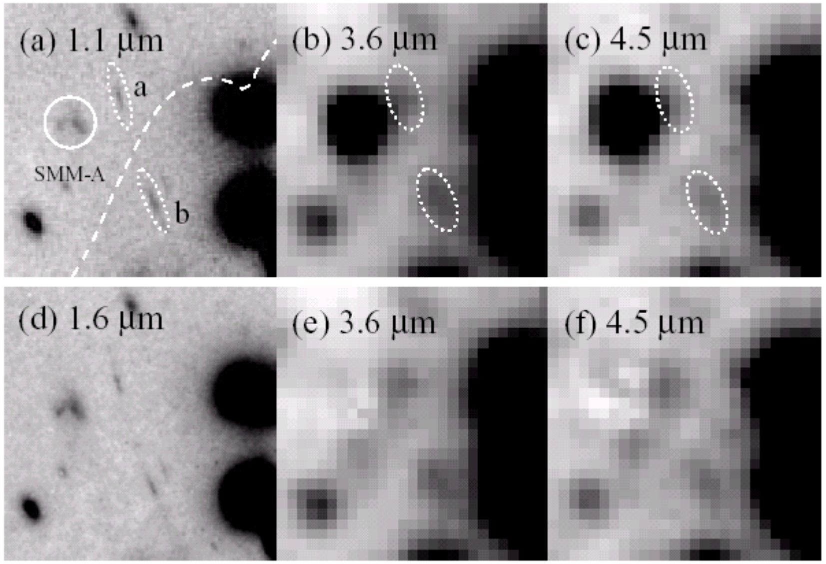
• The prevalence of Lya emission within dropout population does not evolve strongly between z=3 and z=6, perhaps increasing by <1.5x (errors still considerable).

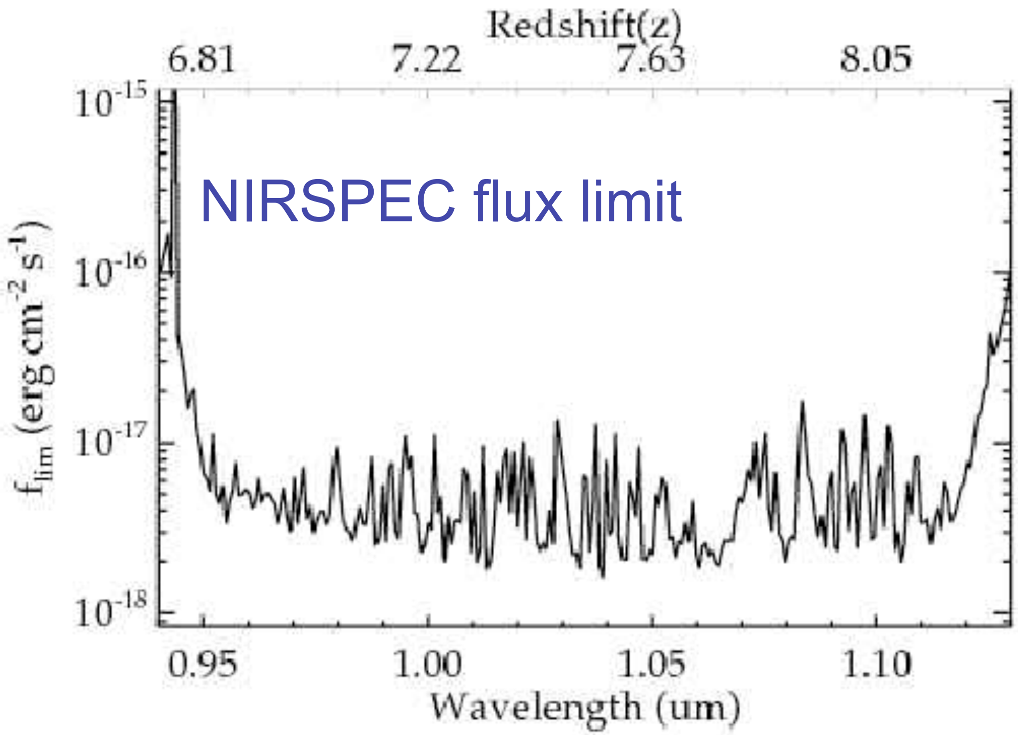
• Tentative small increase may result from redshift evolution in dust content (e.g. Stanway et al. 2005, Bouwens et al. 2006)?

Extension of method to z~7-8

Keck/NIRSPEC follow-up of lensed z~7 galaxies

z~7 galaxy in A2218 - Egami et al. 2005

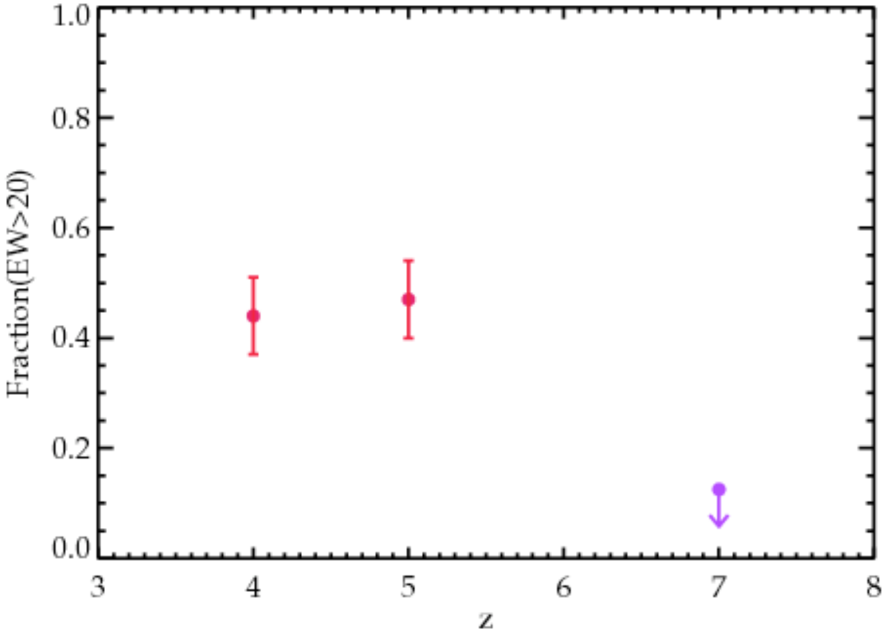




- ❑ Spectroscopic follow-up in the z-band (6.8<z<8.3) for z-drops (Kneib et al. 2004, Richard et al. 2008).
- ❑ 3 to 4 hours with NIRSPEC on 8 LBG candidates at z~7-8.
- ❑ No Lyα emission detected.

Variation in Lya emission with redshift

Fraction of LBGs (M_{1500}>-20) with EW>20A



- Fraction of LAEs w/in LBG sample does not evolve strongly between z=4 and 6.
- Given Lya EW dist' at z~5-6, would have expected ~3-4 Lya emitters if all 8 sources at z~7.
- Correcting for loss of features in OH sky lines and low-z contamination, would have expected to detect 1-2 sources.

• Lack of Lya emitters in z>7 LBG population - surprising?

• Too early to say - current z-drop samples are too small and unreliable for rigorous conclusions. Some controversy over nature of candidates (e.g. Bouwens et al. 2008).

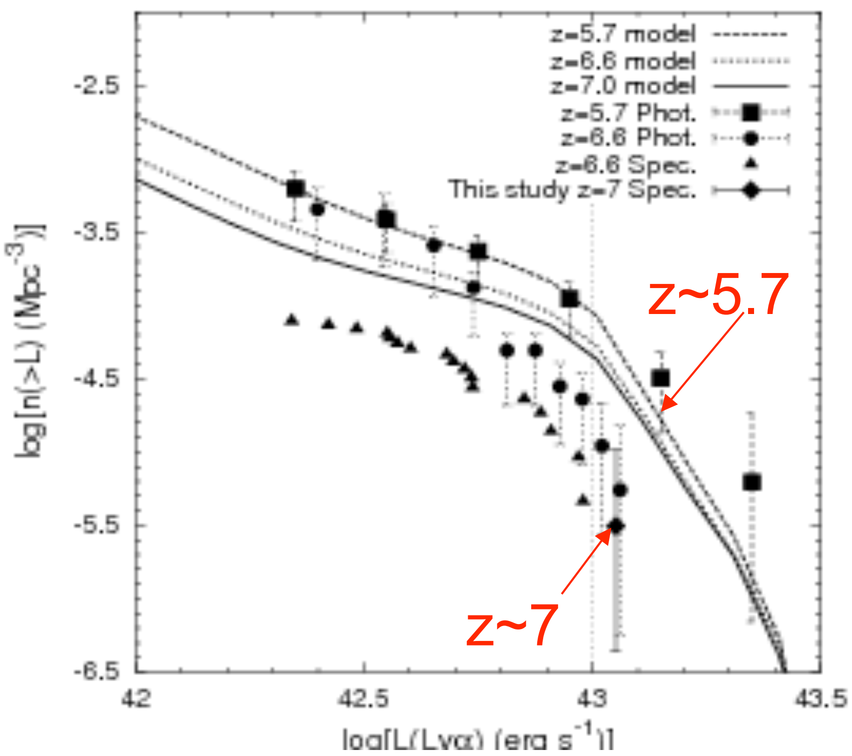
• Larger and more robust samples of z-drops soon on the way with WFC3!

Summary

- Narrowband selected LAEs and LBGs exhibit different evolutionary behavior between z=3 and z=6.
- Important to understand this evolution if we are to use LAEs as a probe of IGM evolution at z > 6.
- Complementary approach recently initiated at Keck to constrain redshift evolution of Lya emitters within LBG population.
- Results confirm previous findings of strong UV luminosity dependence of Lya emission, with faintest sources showing strong Lya more than 40% of the time.
- Marginal increase in Lya fraction within LBG population between z=3 and 5-6, but much less than implied by NB-selected samples.
- Possible decline in Lya fraction at z>7. Key uncertainty is the level of contamination within the z-drops studied thus far.
- Lack of LAEs at z>7 starting to become intriguing. Larger samples of z~7-8 dropouts will soon allow these results to be put on firmer ground.

Evolution of LAEs at 6<z<7

Ota et al. 2008, ApJ, 677, 12



Decline in number density of LAEs over 6.5<z<6.96.

Is decline due to evolution in the ionization state of the IGM? Or due to other factors (e.g. IGM density evolution, galaxy evolution)?

To determine effect of galaxy evolution on Lya LF, must understand how LAEs relate to star-forming galaxy population.

If we are to use LAEs as a probe of reionization, we must be able to understand evolution of LAE LF after reionization.