The evolution of Lyα emitters and Lyα fraction: a LBT spectroscopic survey

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Reionization in the Red Centre

The LBT/LUCI Survey of z~7 galaxies

Near-IR imager and spectrograph for LBT
Imaging, long-slit, and multi-slit spectroscopic modes
zJHK band spectroscopy with R~1000-4000

- Bright Lyα emitter at z~7.7 (L. Jiang)
- Bright Lyman break galaxies at z~7 in UDS field. (F. Bian/D Stark)
- Bright Lensed galaxies at z~7 in CLASH cluster Abell 2261 (B. Clement)

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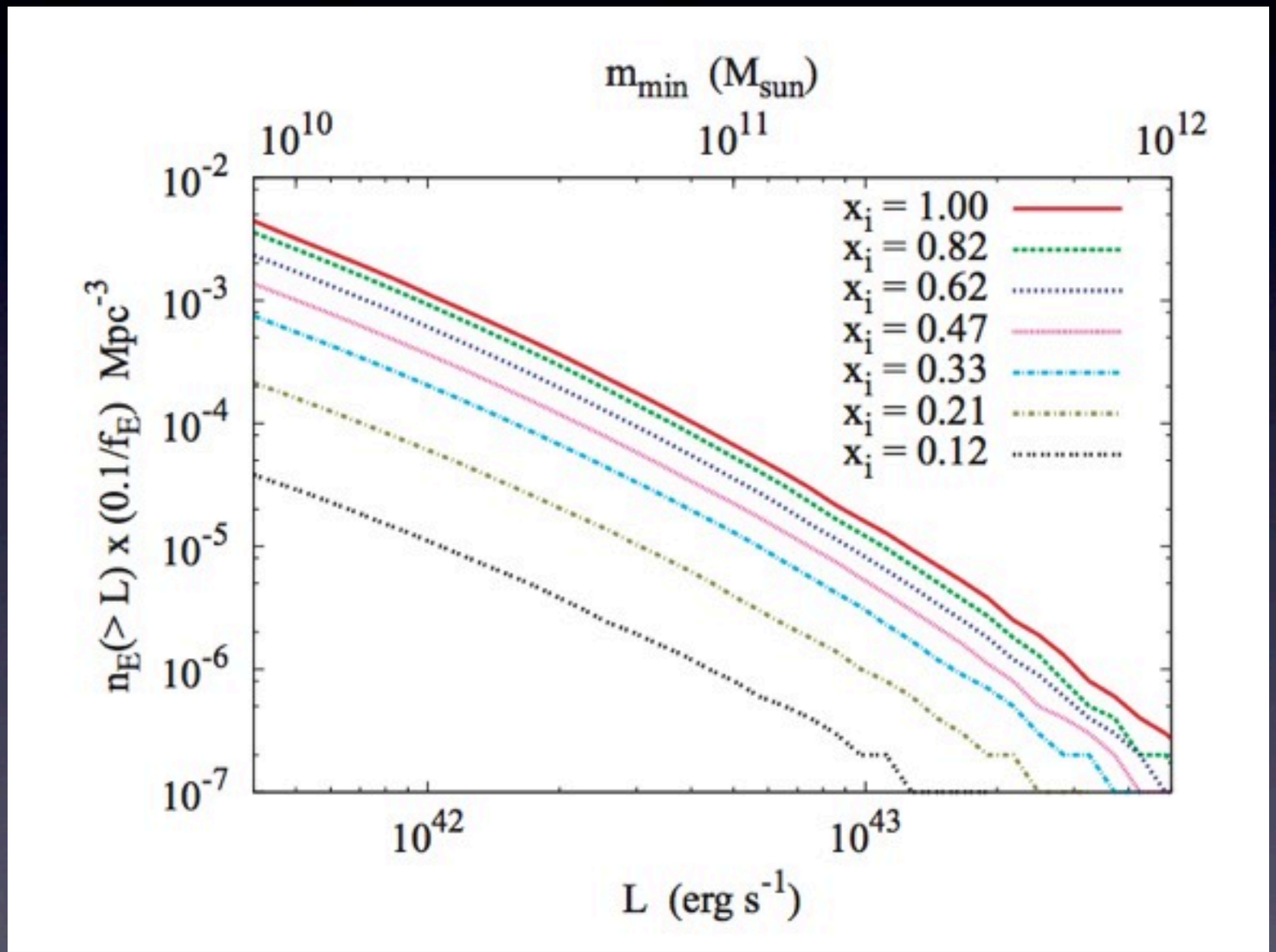
Deep LBT/LUCI Spectroscopy of a Lyα Emitter Candidate at z~7.7

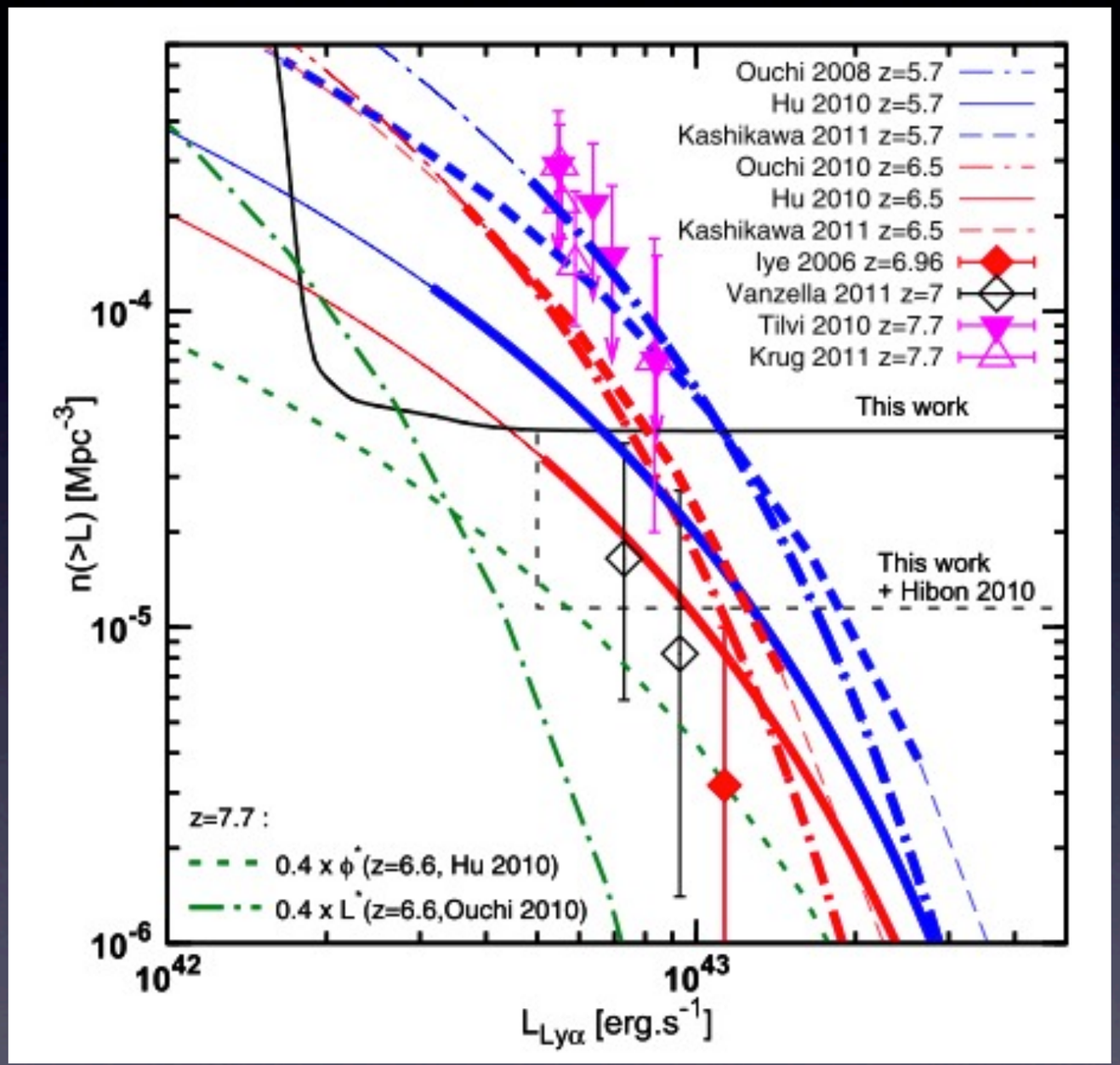
Jiang, Bian, Fan et al. 2013 ApJL

Probing Reionization with Lyα Emitter (LAE) LF



McQuinn et al 2007

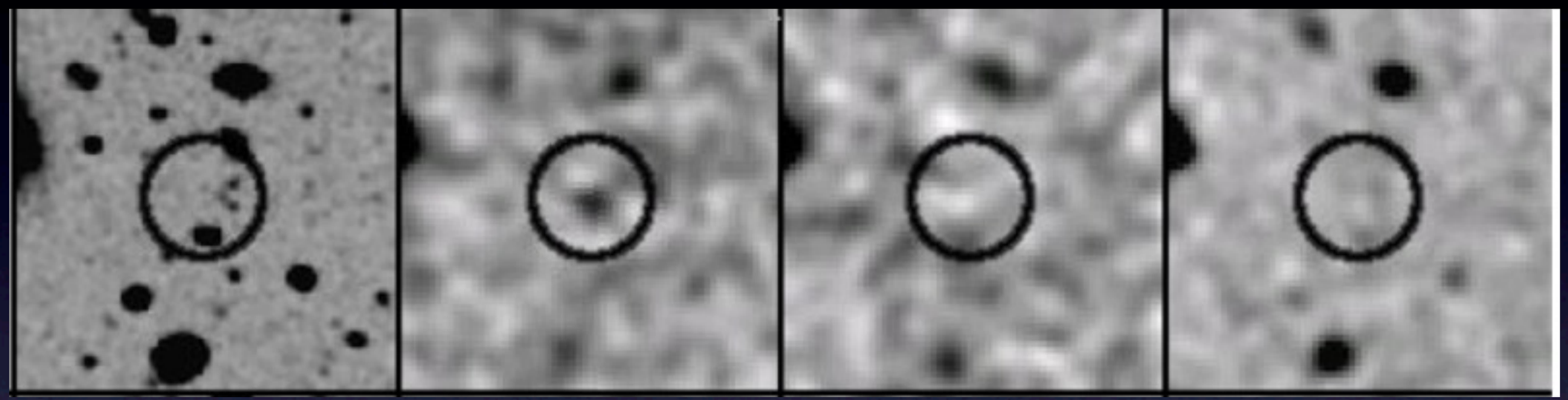
Evolution of LAE LF



Clement et al. 2012

- Rapid evolution of LAE LF from z~6 to z~7
- Discrepancies in different LAE surveys at z~7.7.

The Bright z~7.7 LAE Candidate in the Newfirm COSMOS survey



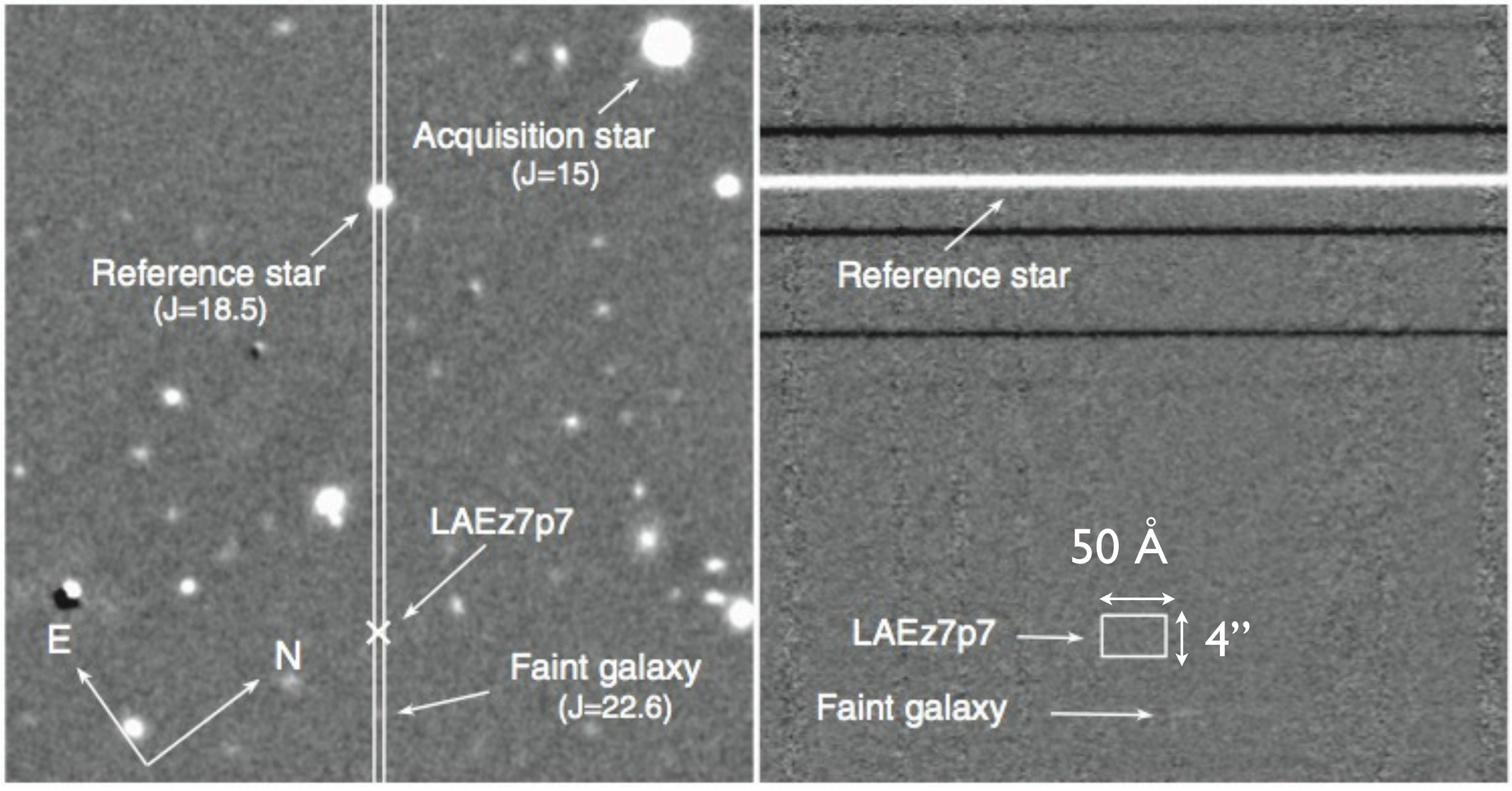
Combined Optical | Newfirm 1.056µm | Newfirm 1.063µm | J UKIRT

R.A.	Decl.	mag_{AB}	Line Flux (erg s^{-1} cm^{-2})	$L_{Ly\alpha}$ (erg s^{-1})	$EW_{Ly\alpha}$ (Å)
10:00:46.94	+02:08:48.84	21.87	1.21×10^{-17}	8.34×10^{42}	7.32

Krug et al 2012

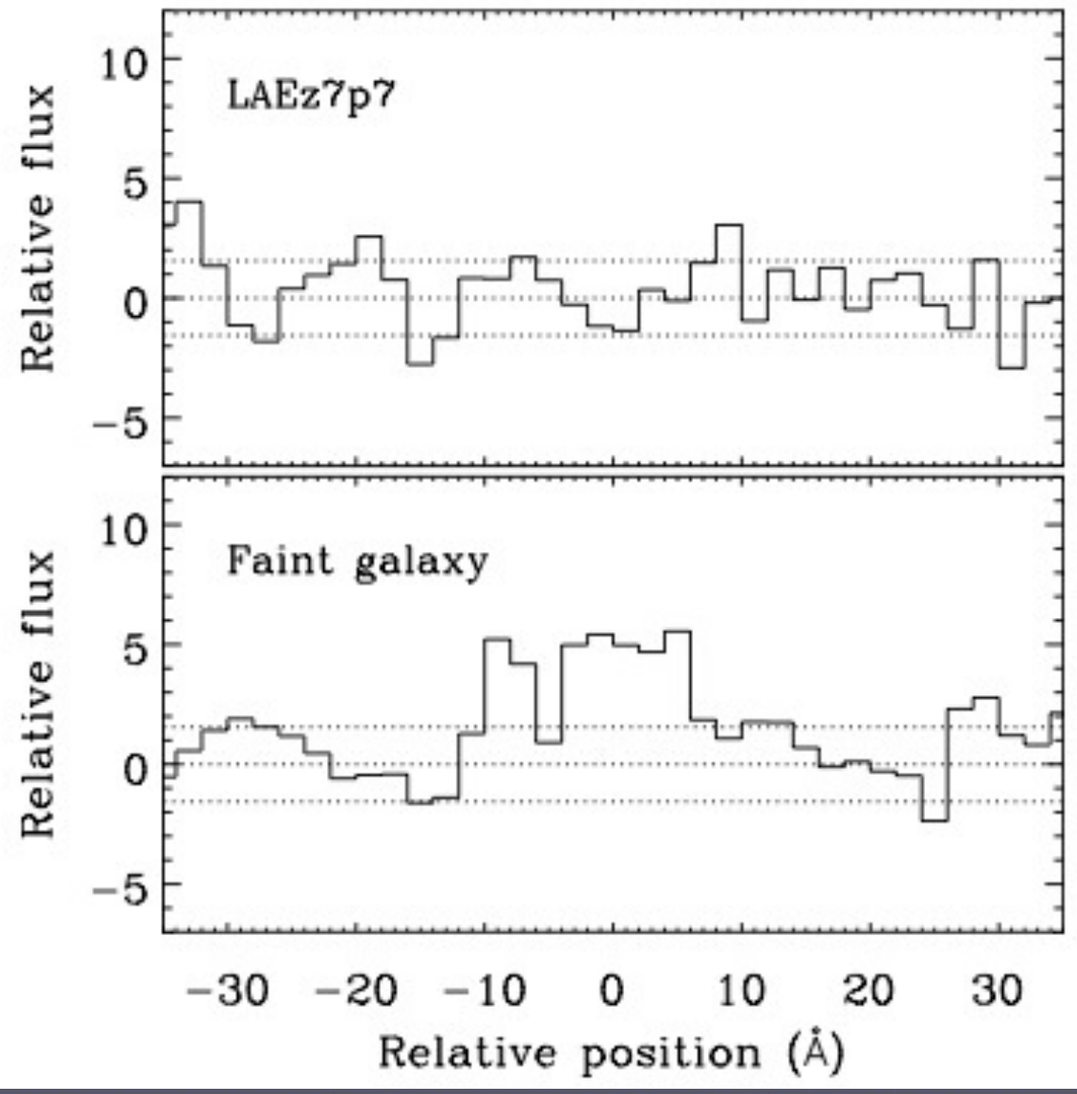
LBT/LUCI Observations

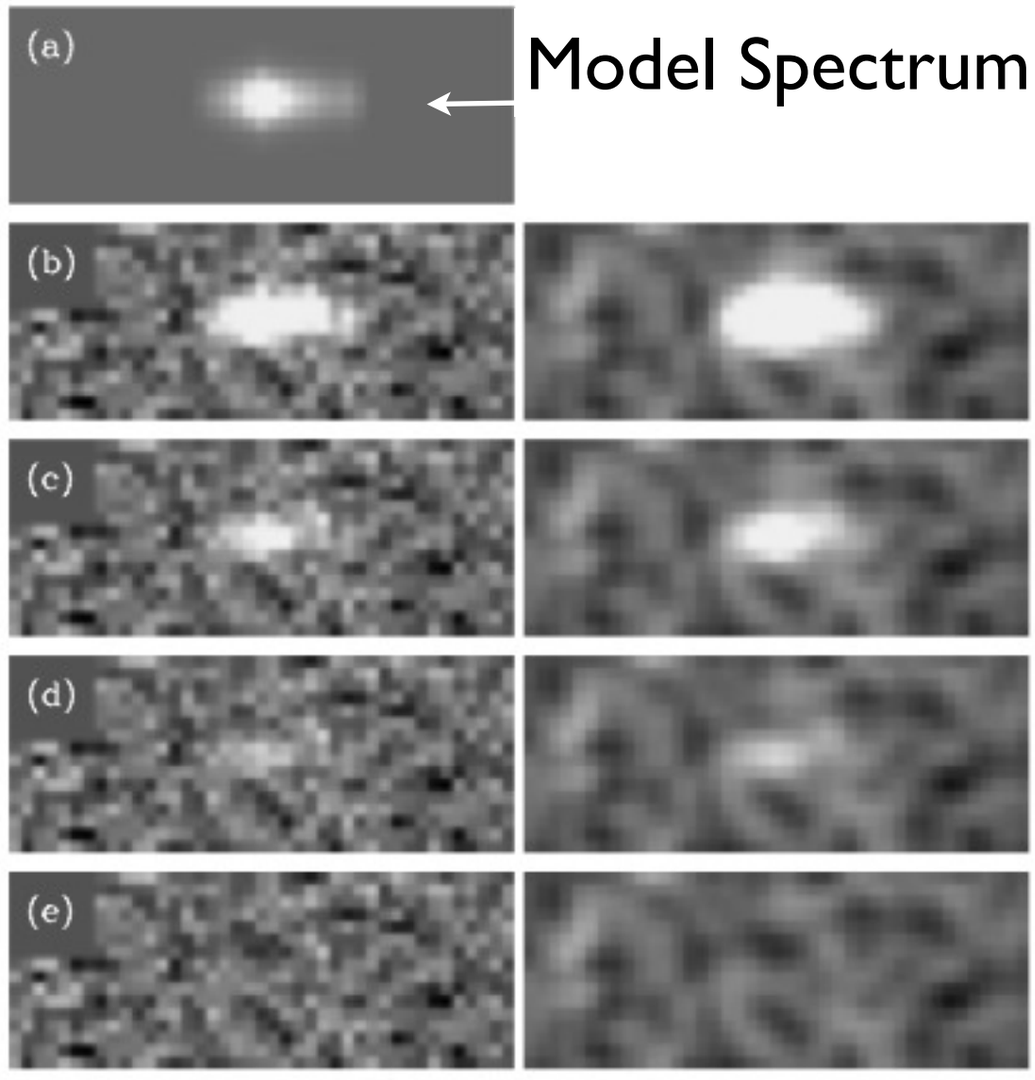
- 7.5 hours (28x900s) exposure using LBT/LUCI in long-slit mode.
- Observation Condition: Clear and image quality of 0.6”-0.9”.
- Reference star with J=18.5, and a bonus faint galaxy in the slit.



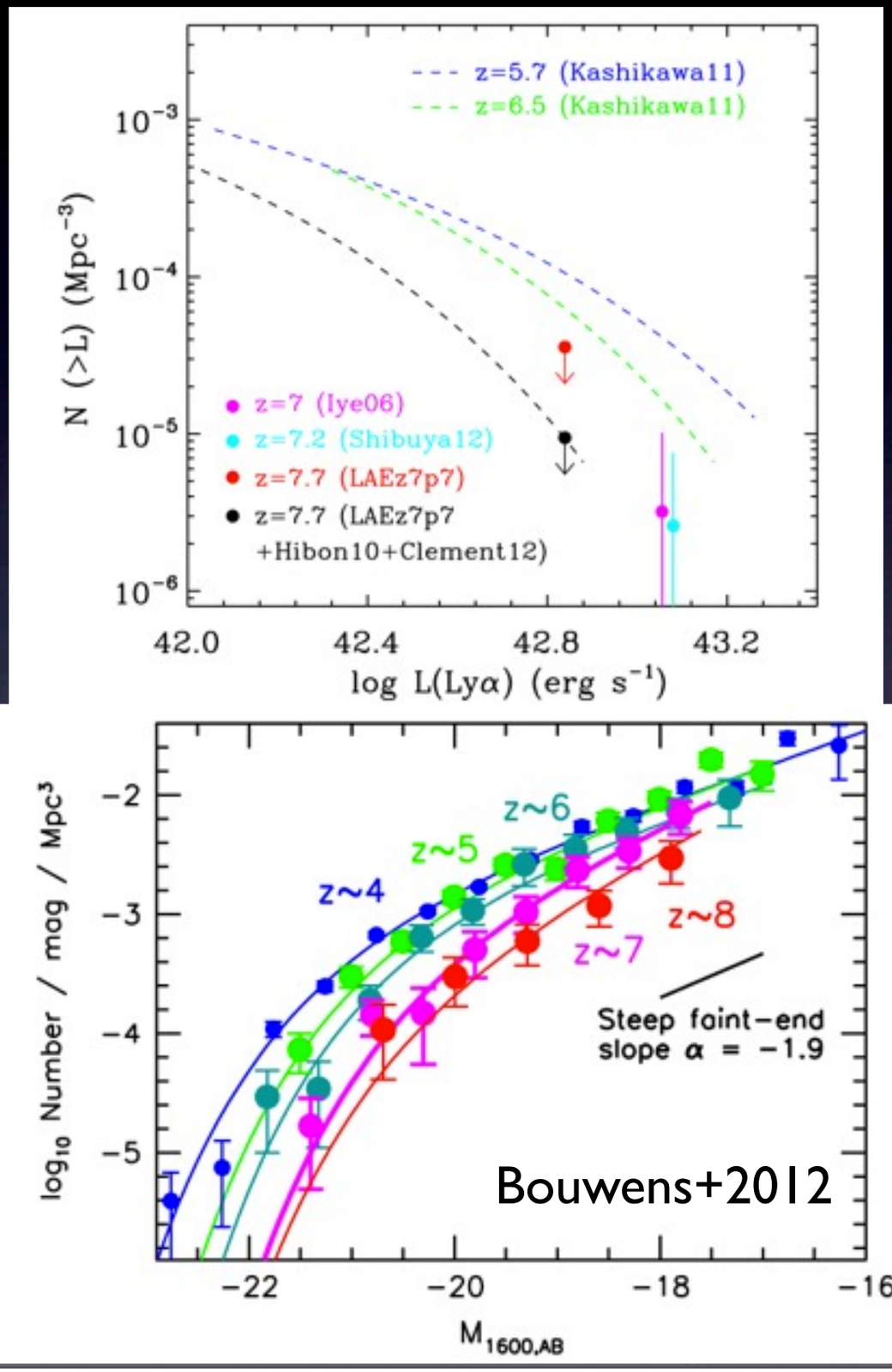
No Lyα Emission found in LAEz7p7

- The Spectrum is deep enough to detect the Lyα emitter at least 3σ level.
- No Lyα emission feature was found in 1D and 2D spectra.





Evolution of the Lyα Luminosity Function from 6 to 7.7



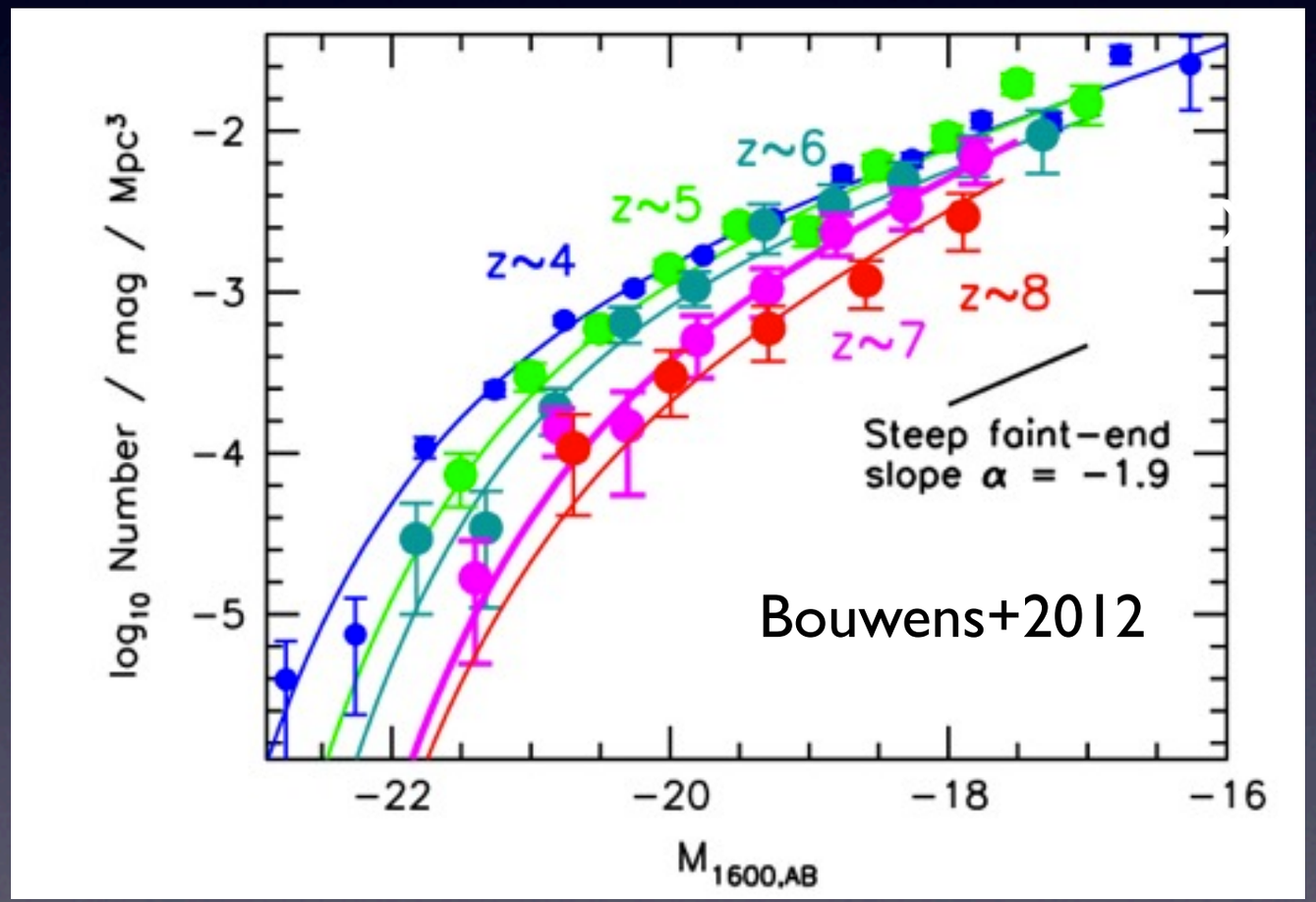
- A rapid evolution of LAE LF between z~6 and z~7.7: the LF upper limit at z~7.7 is a factor of six lower than the LF at z~6.5.
- This evolution of LAE LF beyond z~6 is much more rapid than that of UV LF and LAE LF at z<6.
- The Lyα emission is likely to be suppressed by the neutral hydrogen at z~7.

The Evolution of Lyα Fraction in Lyman Break Galaxies (LBGs) Beyond z~6: Implication of Reionization

Bian, Stark, Fan, Jiang et al. in preparation

Probing Reionization with Lyα Fraction in LBGs

high-z LBG sample



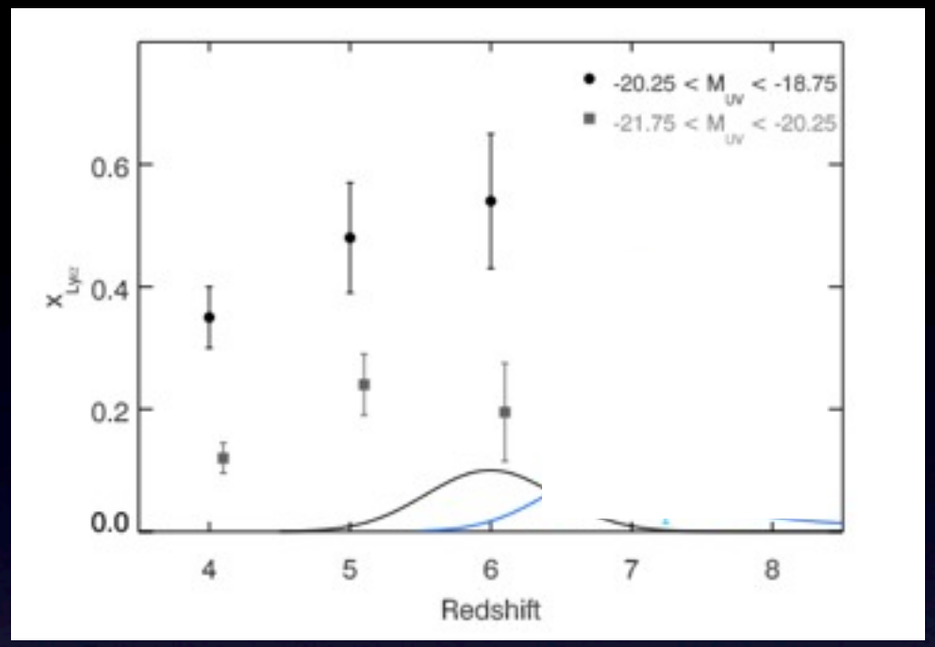
Method

- Deep spectroscopy of LBGs candidate at 6<z<10.
- Fraction of LBGs with Lyα emission above a fixed EW threshold:

$$X_{Ly\alpha}(z) = N_{Ly\alpha} / N_{tot}$$

- Evolution of the Lyα emission fraction

Evolution of Lyα Fraction in LBGs



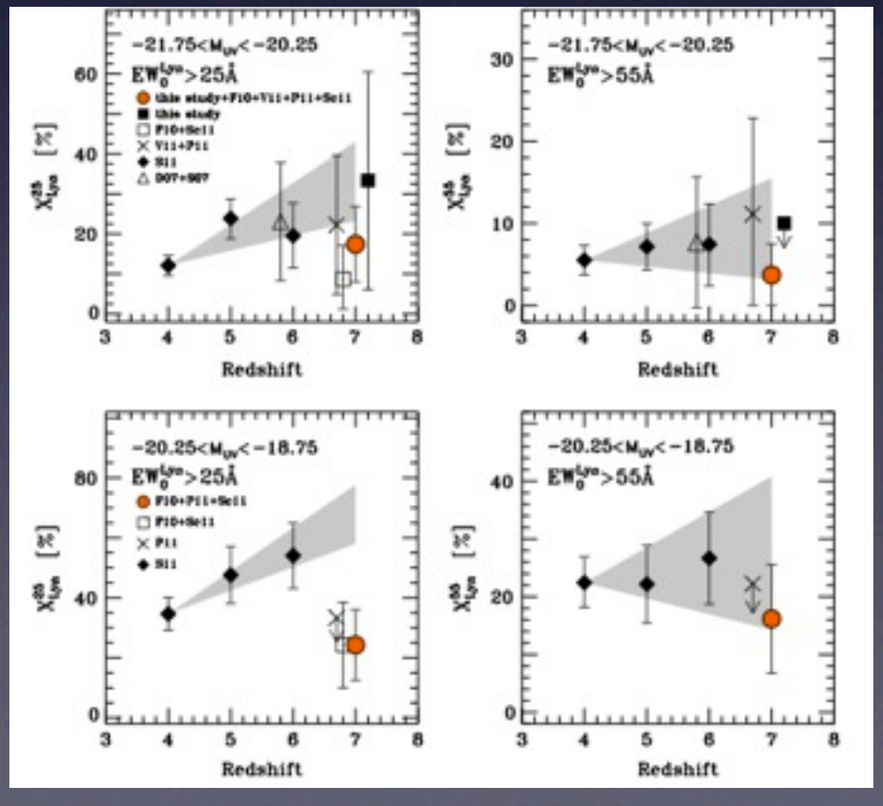
Schenker et al. 2012

- The Lyα emission fraction increases with increasing redshifts from z=4 to z=6 (Stark et al. 2011).
- The Lyα emission fraction rate declines from z=6 to z=7.
- For galaxies with low EW Lyα, the decline rate in bright galaxies is lower than that in faint galaxies, perhaps suggesting that the reionization proceeds from high density region to low density region
- Needs to improve the statistics in the luminous galaxies with strong Lyα emission lines.

Low EW High EW

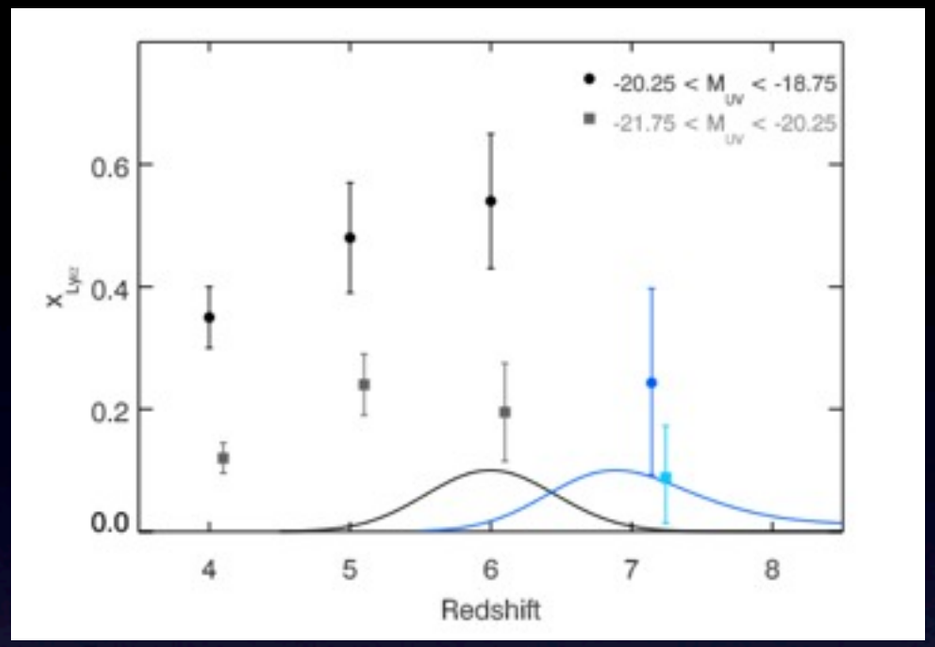
bright

faint



Ono et al. 2012

Evolution of Lyα Fraction in LBGs



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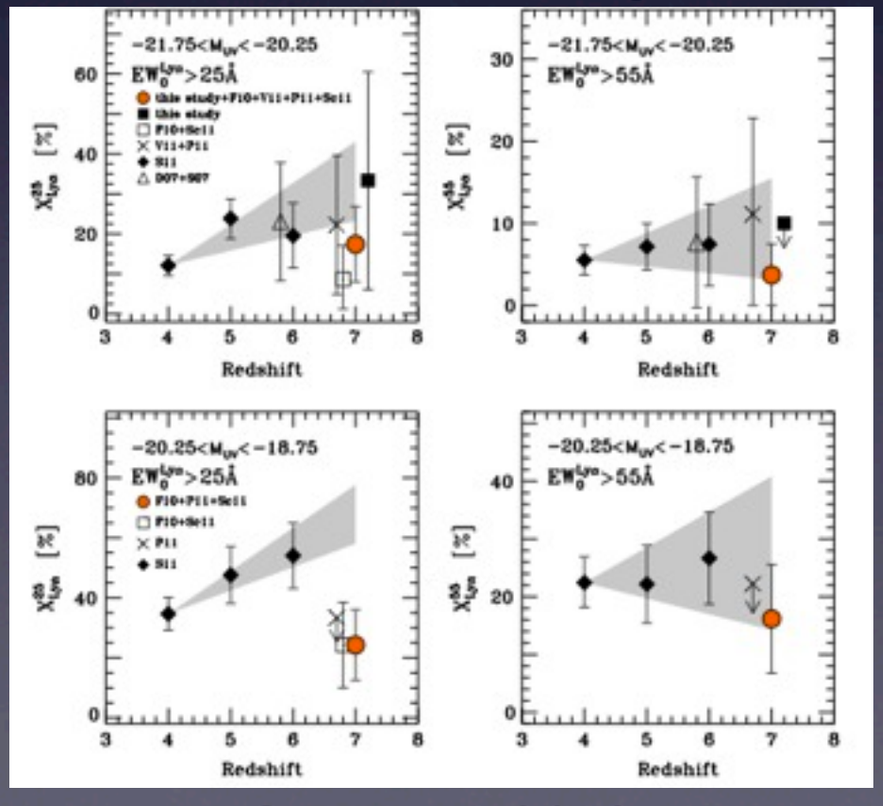

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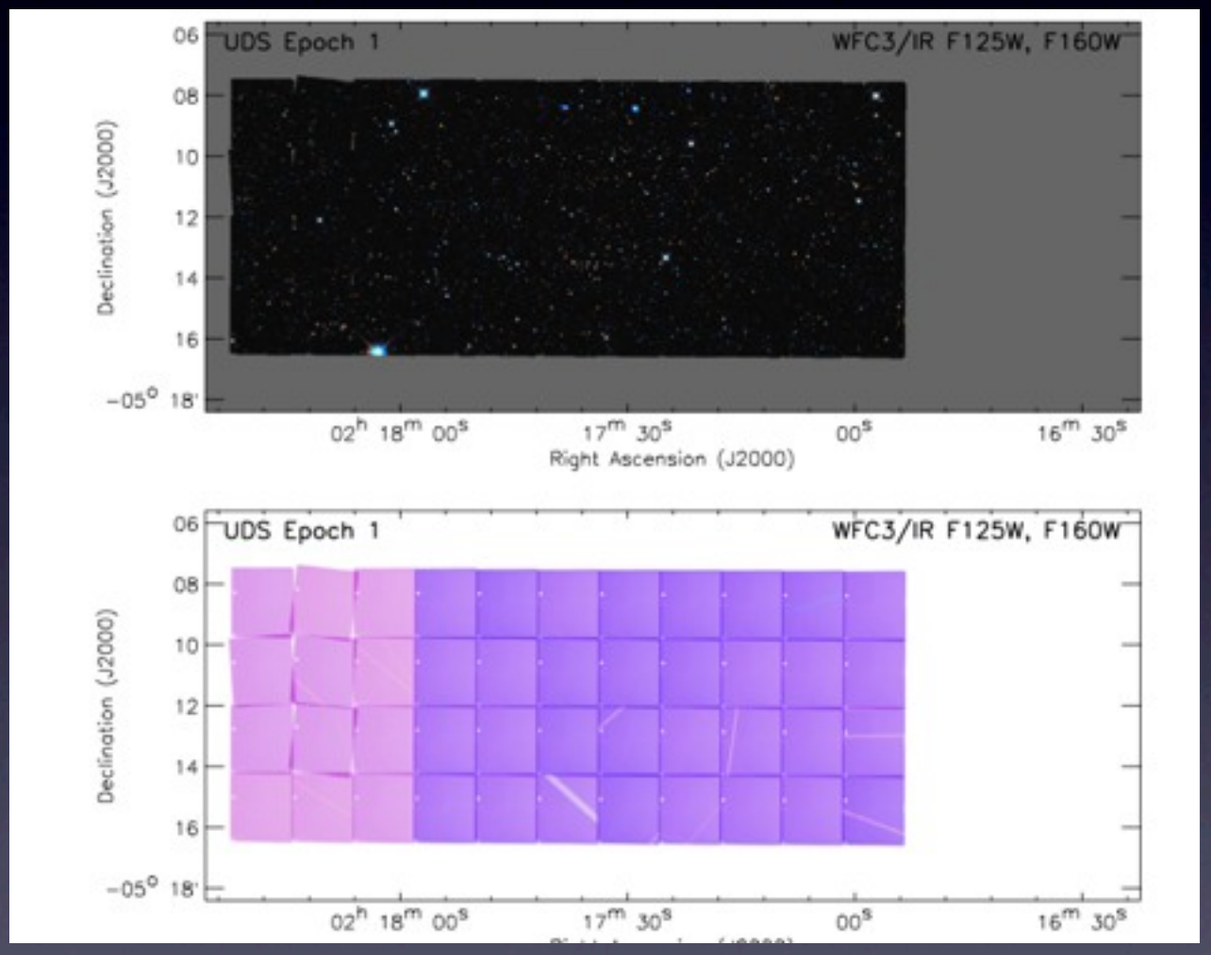
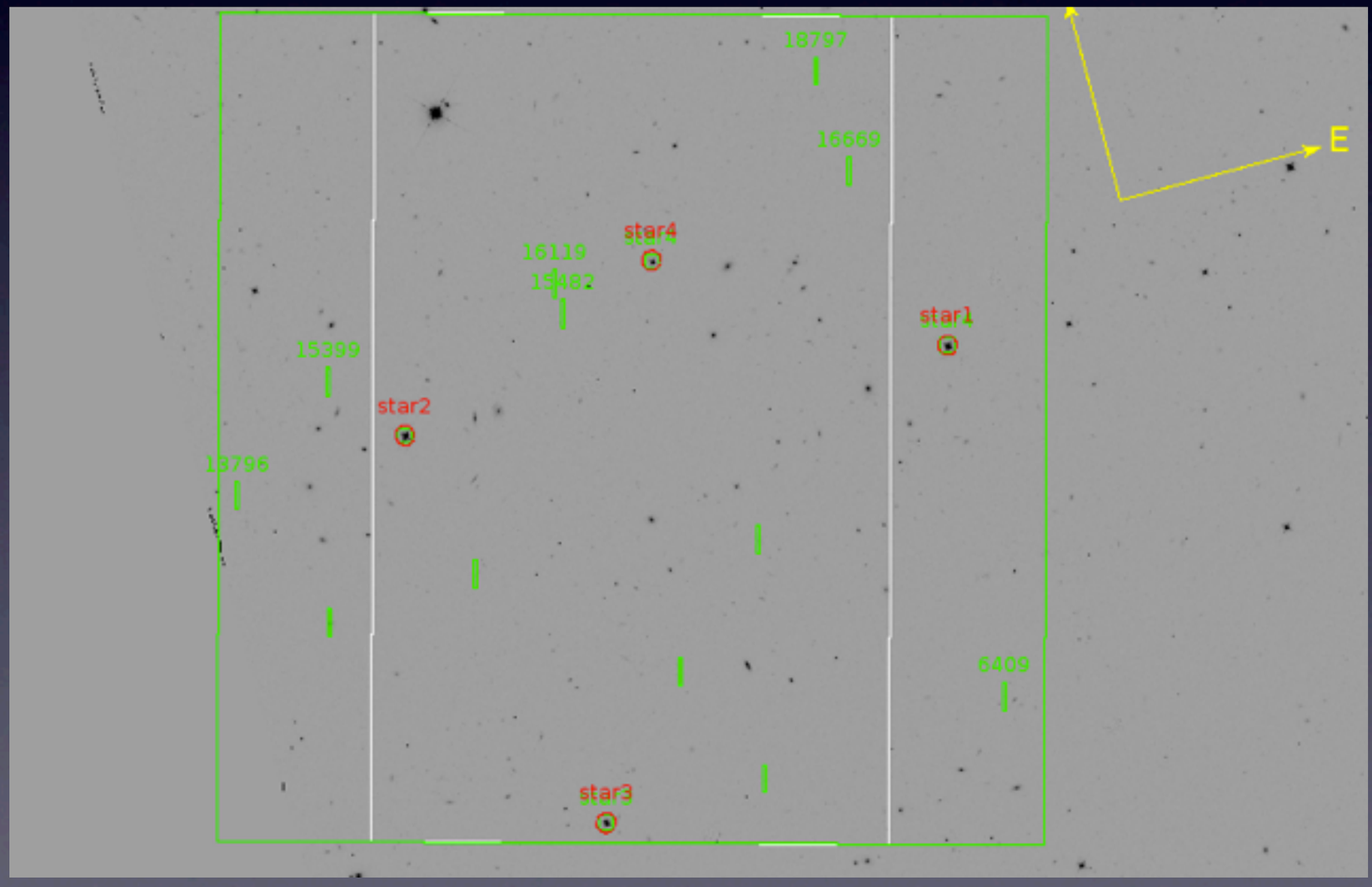
Lyα fraction beyond z=6



- New samples LBGs from CANDELS: wide field, large sample of bright LBGs to study the Lyα emission fraction at z~7.
- With the multi-object capability of LUCI@LBT (and Keck/MOSFIRE, VLT/KMOS, Gemini/FLAMINGO2), enable to improve statistics of Lyα emission fraction in luminous LBGs.

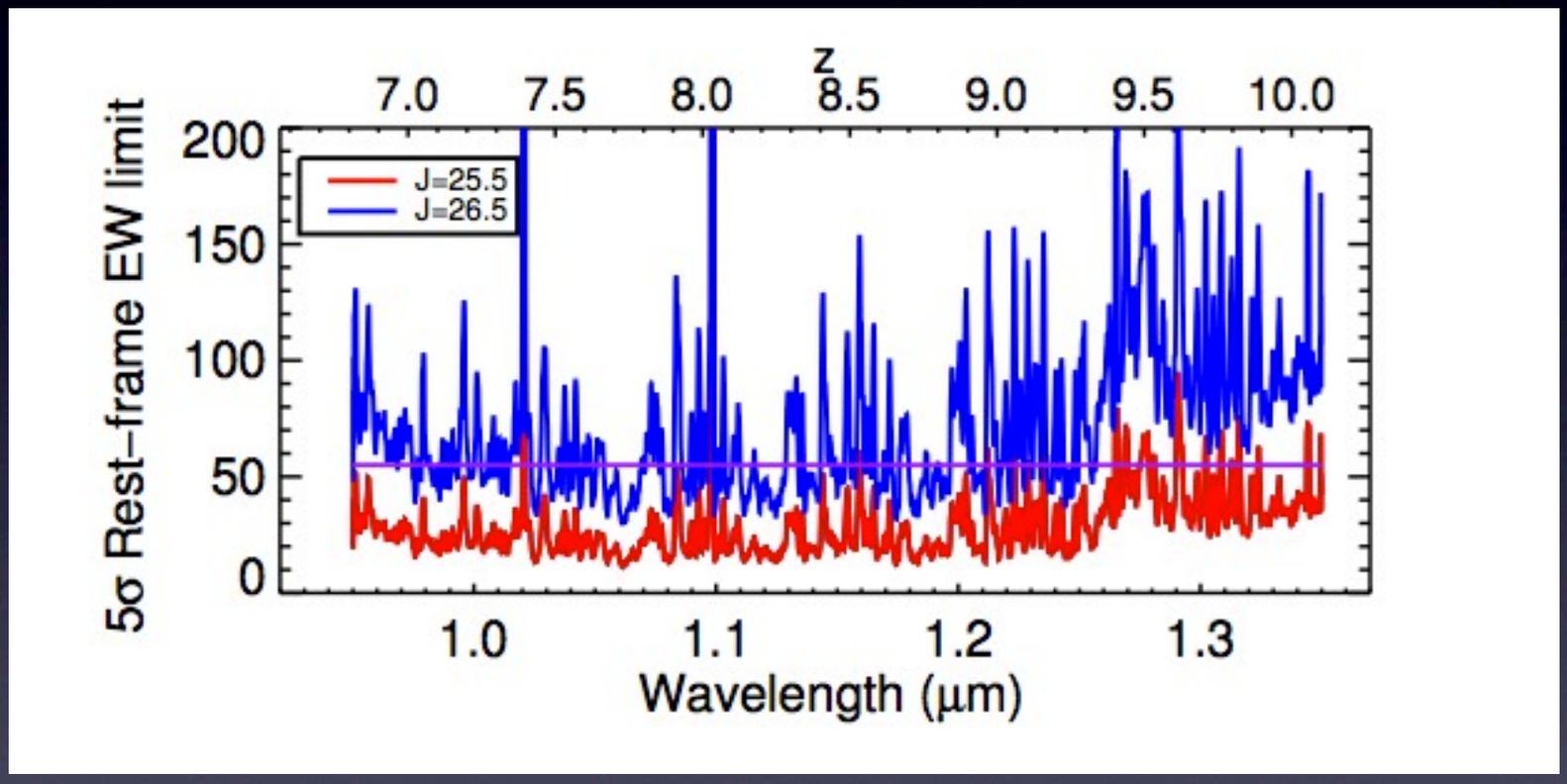
LBT/LUCI Observations of z~7 LBG Candidates in UDS

- Two masks are designed to cover 13 luminous z~7 LBGs (M_{UV}~-21, m_J~25.5-26.5) in CANDELS/WIDE survey, UDS field.
- 4.5-5.25 hours exposures were taken on each mask.



Detection Limits of the LBT/LUCI Spectra

- The median 5σ flux limit is 1.0×10^{-17} erg s^{-1} cm^{-2}.
- A MC simulation was carried out to quantify the detection rate of Lyα with EW_0 >55Å.



Mock Emission features on a 2D spectrum

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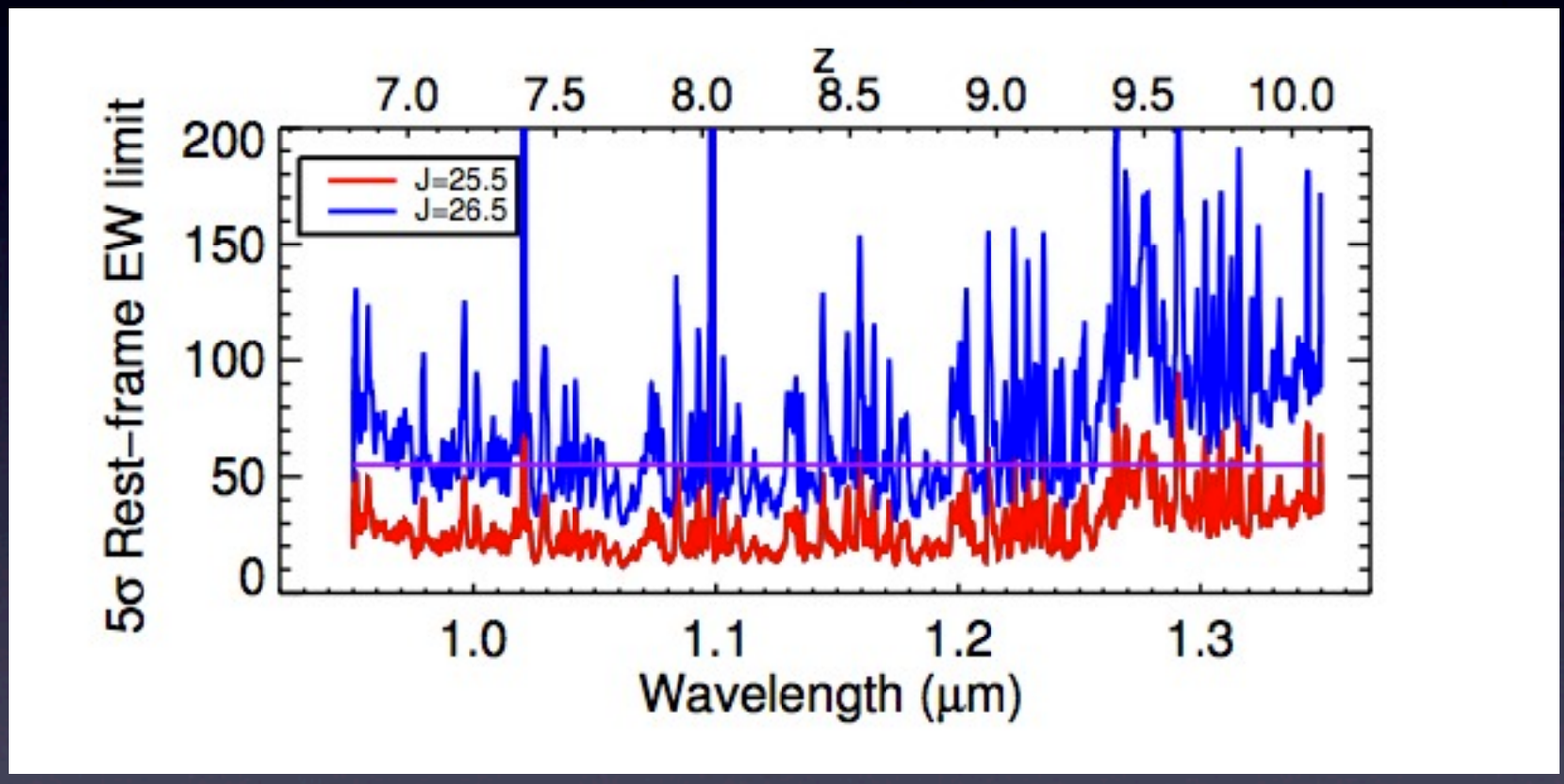

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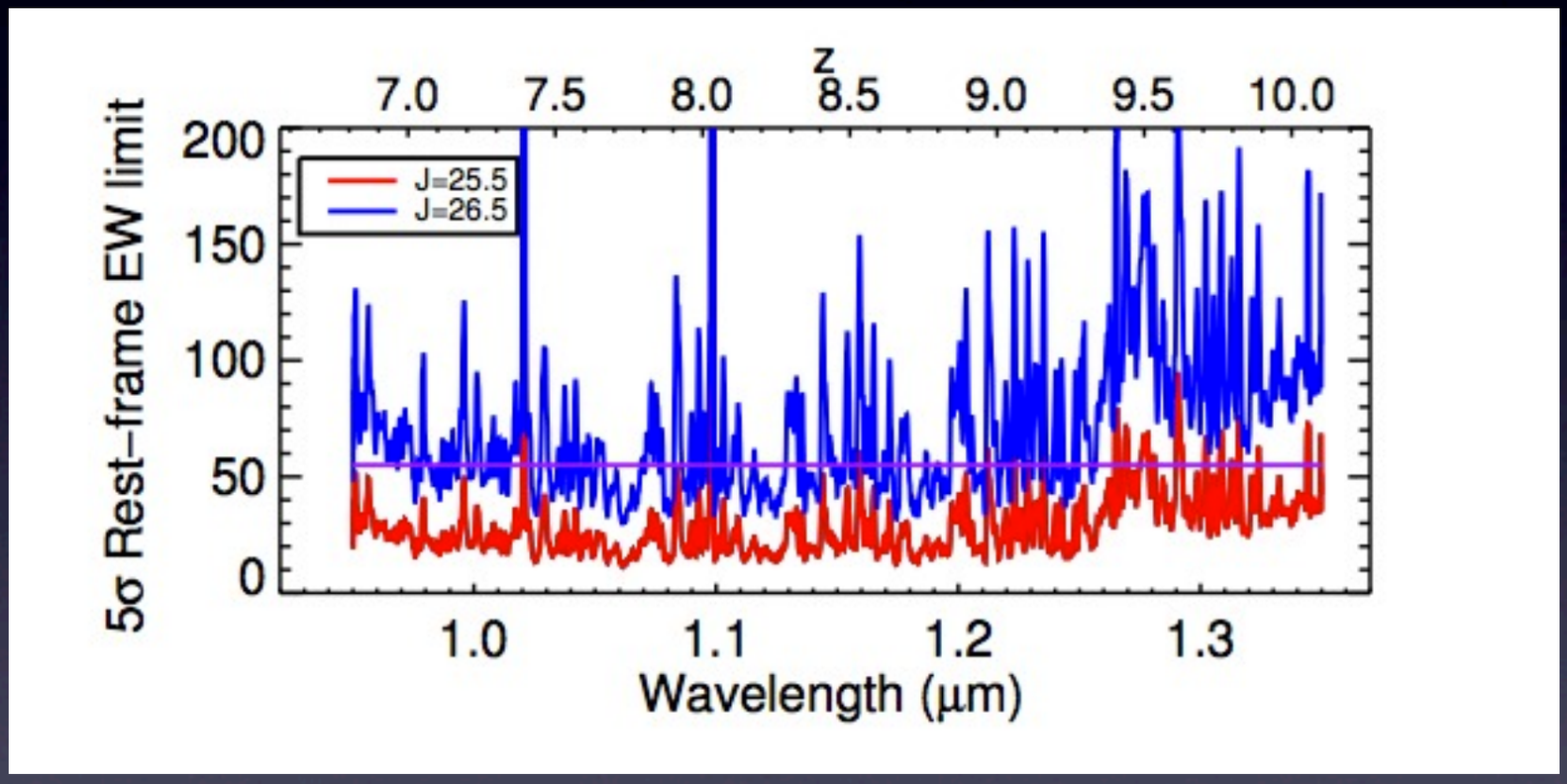
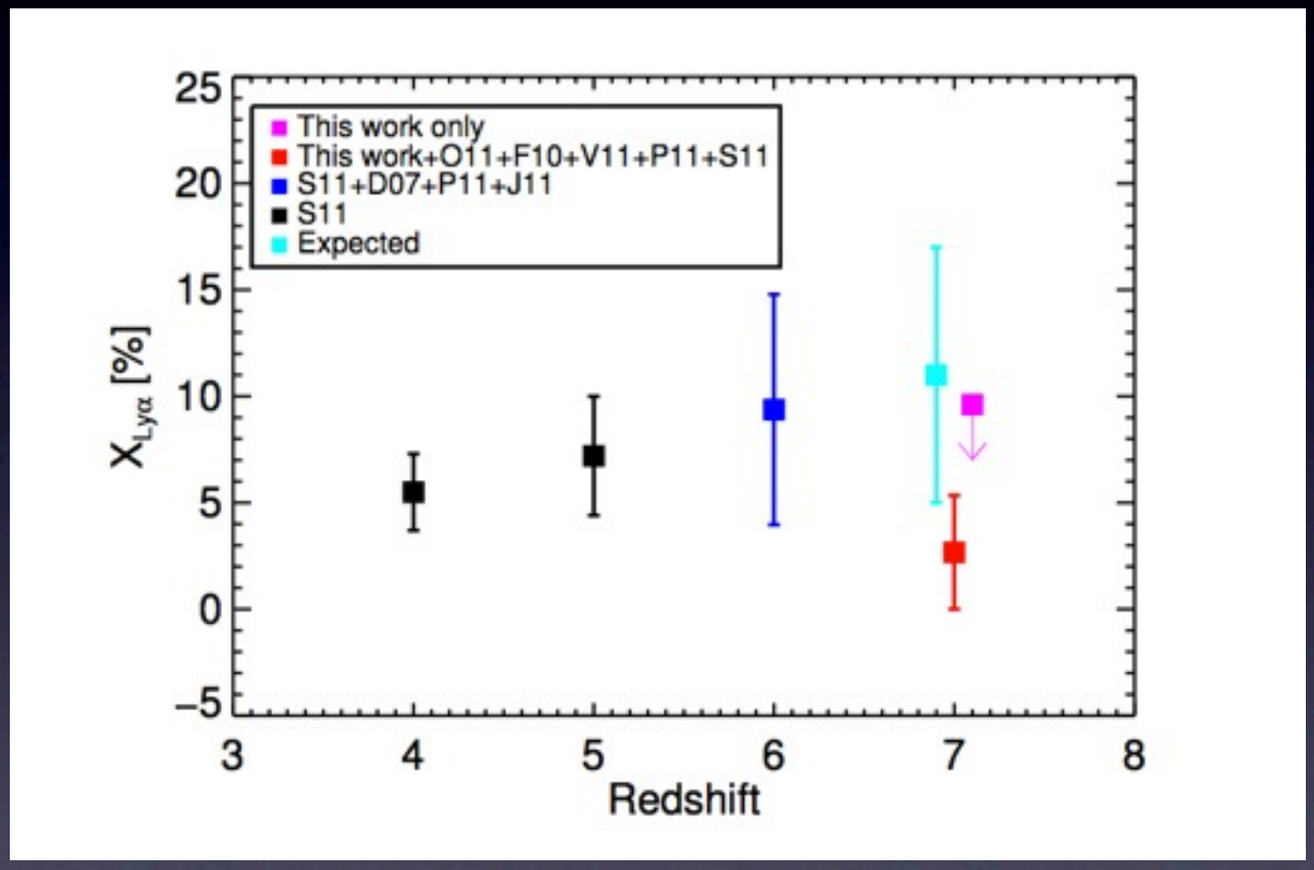


Mock Emission features on a 2D spectrum

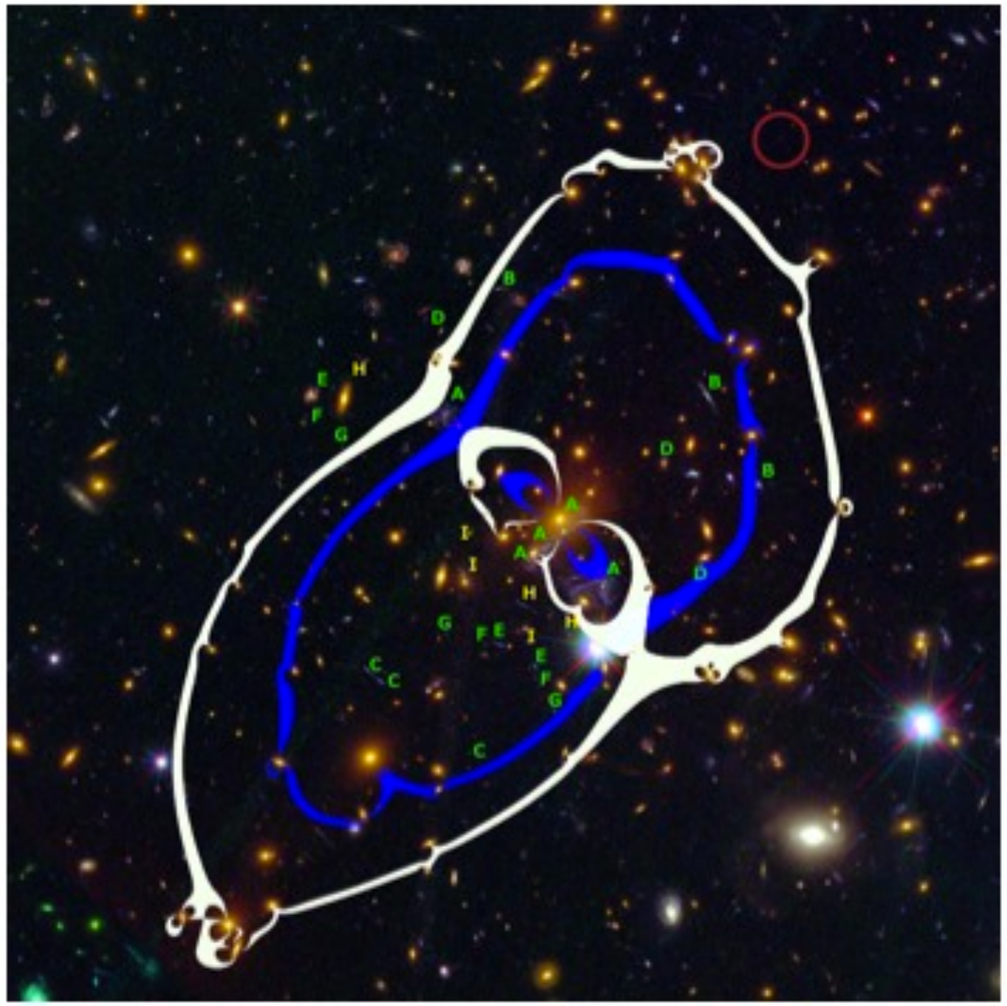
Evolution of Lyα Emission Fraction in Bright Galaxies



- Among 13 bright LBGs in the LBT/LUCI Survey, no Lyα emission line with EW_0 >55Å is found.
- Among a total of 40 bright LBGs with spectroscopic observations, only one galaxy, with Lyα EW_0 >55Å is found. (Fontana+ 10; Pentericci+ 11; Vanzella+ 11; Schenker+ 12; Ono+ 12).
- The Lyα fraction in bright LBGs at z=7 is lower than expected Lyα fraction at 90% significant level.
- Comparison to reionization models implies x_{HI}>0.1 at z~7 (Dijkstra +2011, Bolton&Haehnelt 2013)

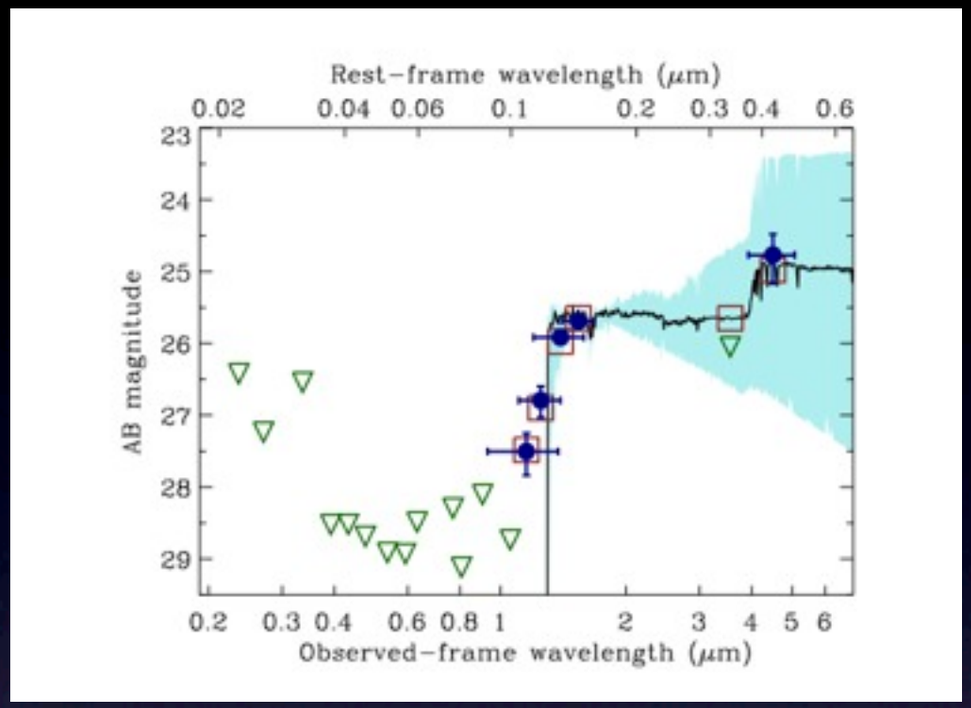
Lyα emission fraction beyond z~7

- CLASH survey: bright lensed LBGs, possibility to push the spectroscopy to higher redshift galaxies z>7.0.



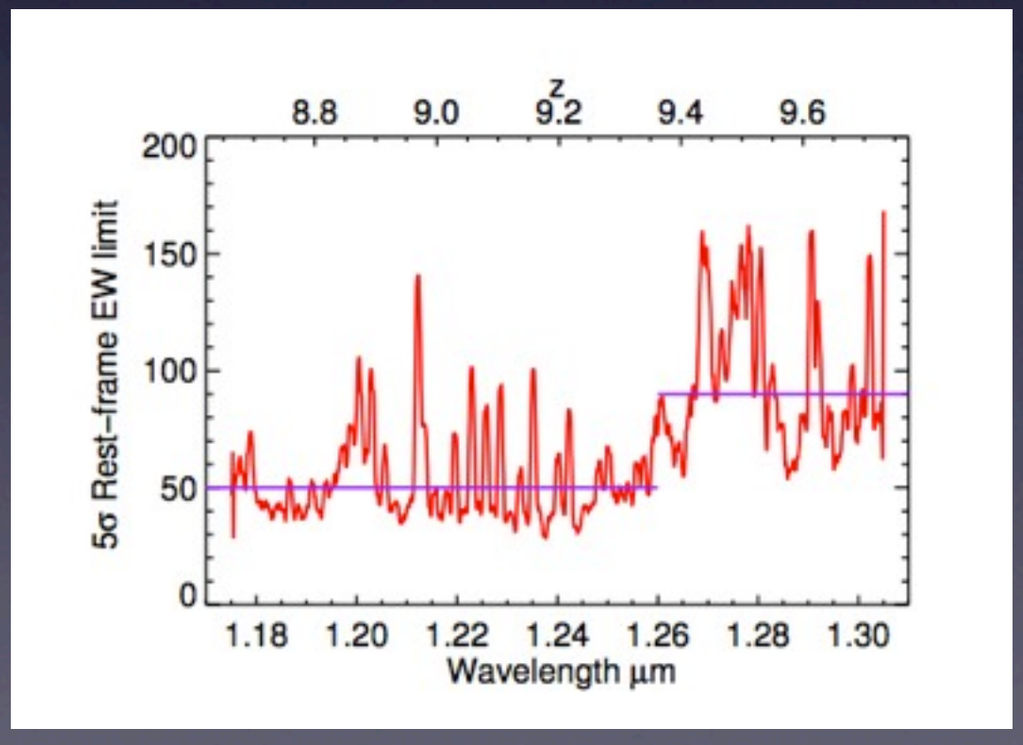
MACS1149

MACS1149-JD1



- MACS1149-JD1 is a z~9.6 Lensed LBG in the galaxy cluster MACS1149 in the CLASH field (Zheng et al 2012).

- With H=25.8, MACS1149-JD1 is one of the brightest LBGs beyond z~9.



- No strong Lyα emission was found in MACS1149-JD1 in 4-hour LBT/ LUCIFER exposure.

Perspectives

- Emergence of near-IR MOS LBT/LUCI, Keck/MOSFIRE, VLT/KMOS, Gemini/Flamingo2, improved sensitivity and higher resolution make more efficient at z>7 spectroscopy, which improves the statistics of z~7 galaxies.
- Lensed bright galaxies in CLASH field and future Frontier field will allow us to push the spectroscopy of galaxies beyond z=7 to study the Lyα emission fraction

Summary

- The LBT/LUCI survey, together with other surveys, shows that rapid evolution of both Lyα emitter LF and Lyα emission fraction in LBGs between z=6 and z=7

- This indicates the neutral hydrogen that suppresses the Lyα emission from galaxies.

- Further multi-slit spectroscopic surveys on both bright and faint LBGs at z>7 will improve the statistics on the evolution of the Lyα emission fraction beyond z=7.