GLASS

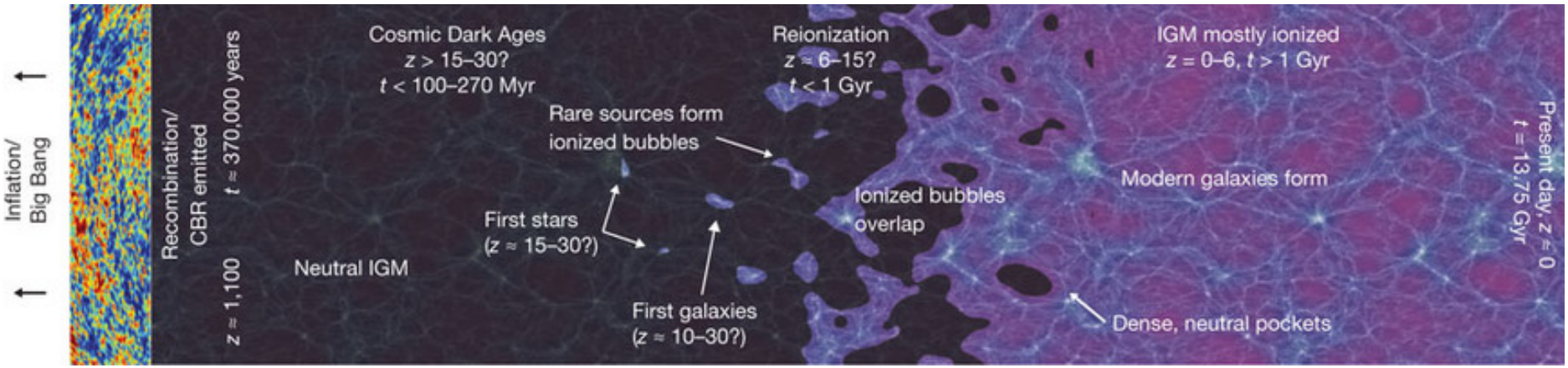
Spectroscopy of galaxies at cosmic dawn through a magnifying GLASS

TOMMASO TREU (UCLA)

Outline

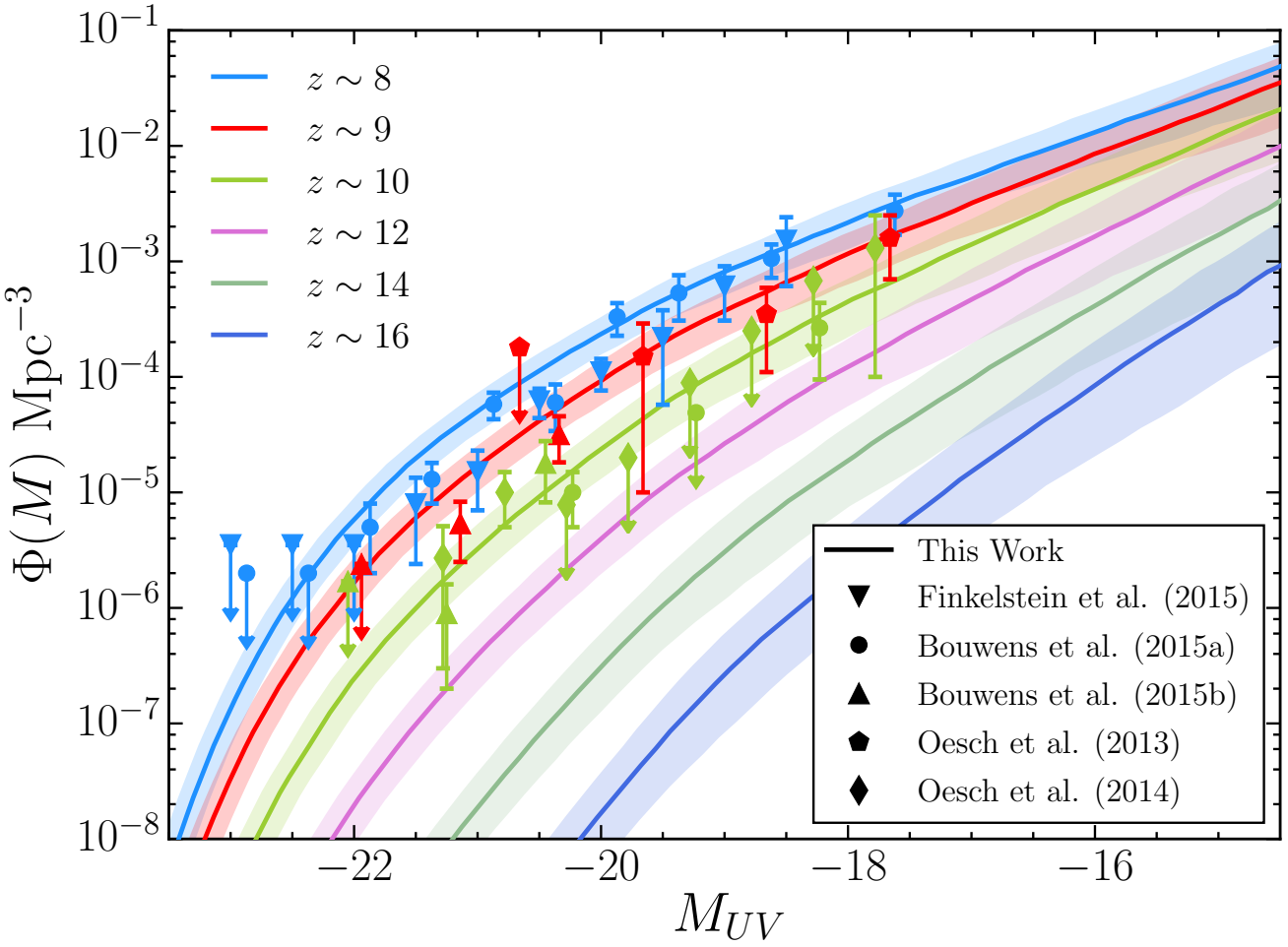
- Introduction.
  - Reionization
  - The power of gravitational telescopes
- The Grism Lens Amplified survey from Space (GLASS)
  - Status Update
  - Lya at the epoch of reionization

Cosmic reionization



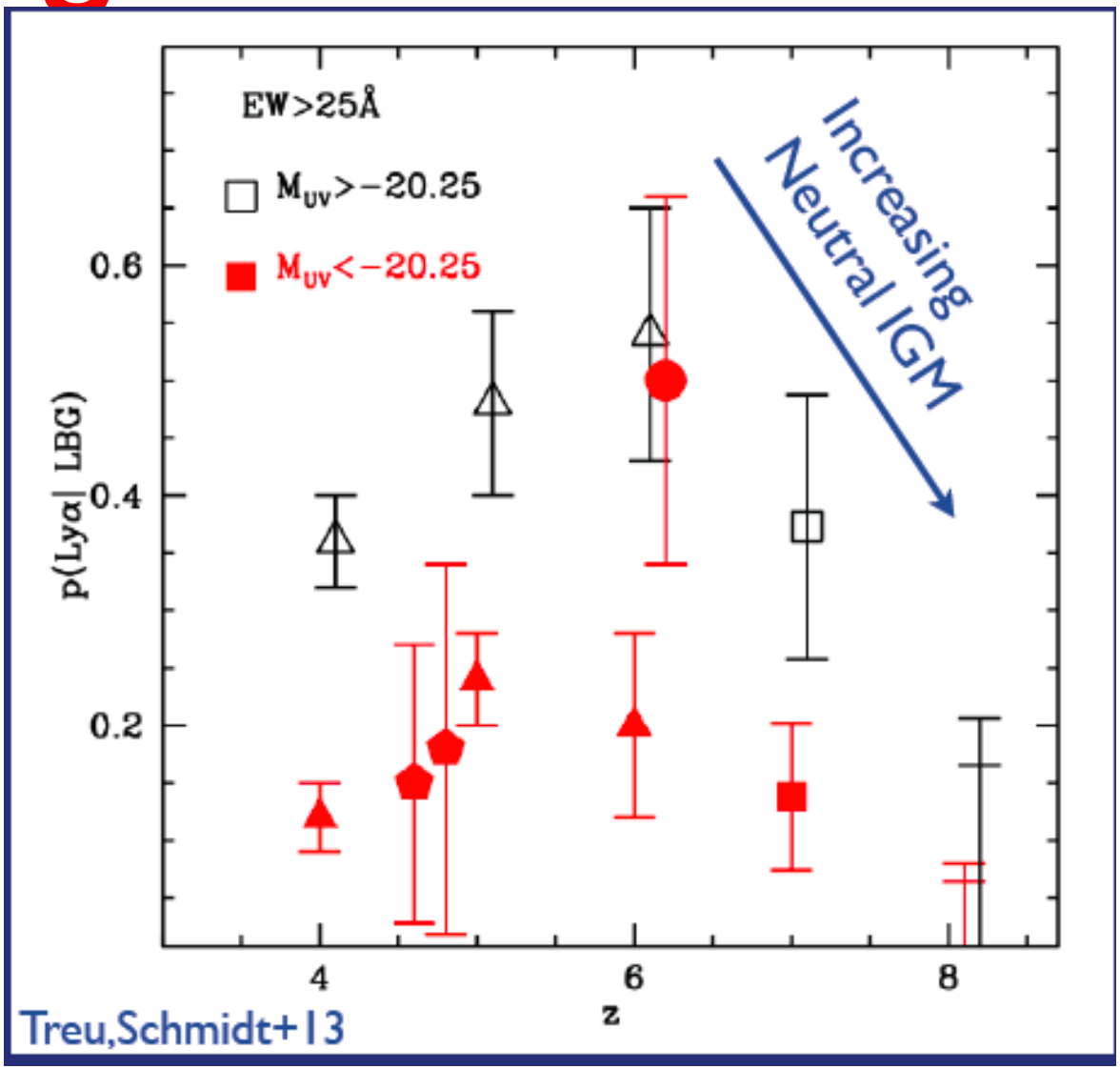
Whodunit?

We know there are LBGs

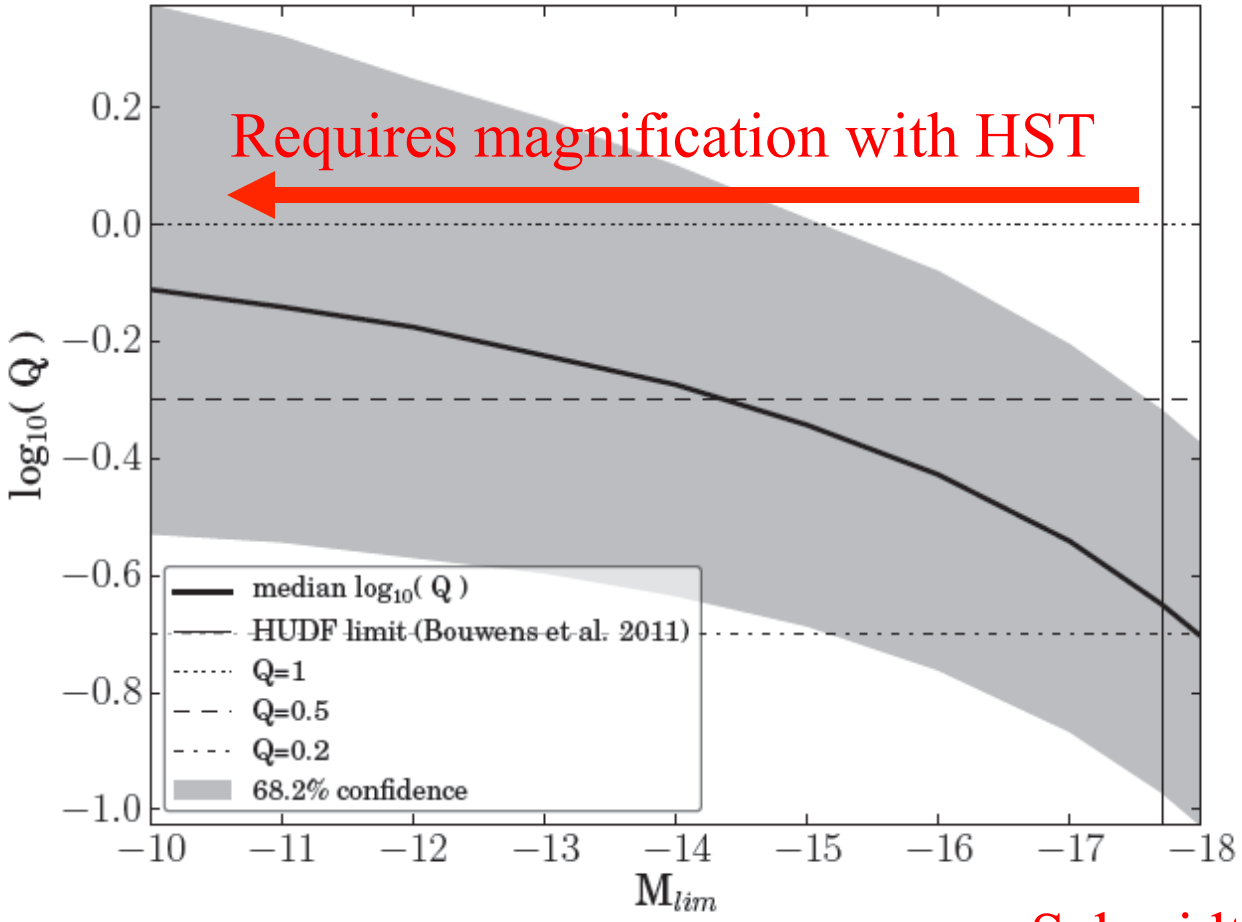


Mason, Trenti & Treu 2015

Is decline in lya a smoking gun of reionization?



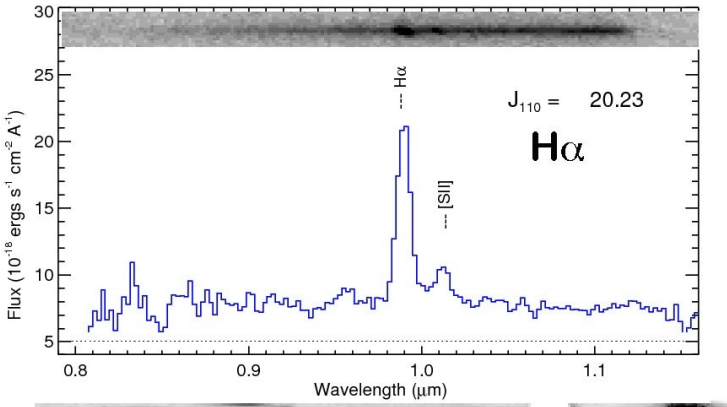
Not clear if they are sufficient for reionization



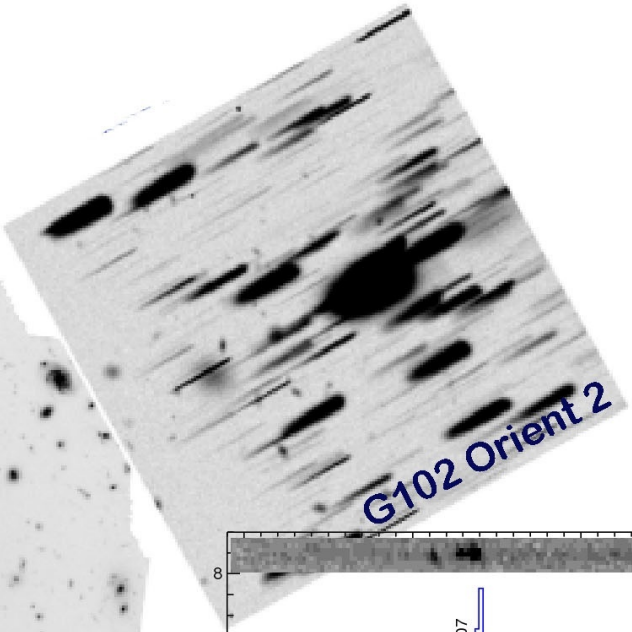
Schmidt et al 2014

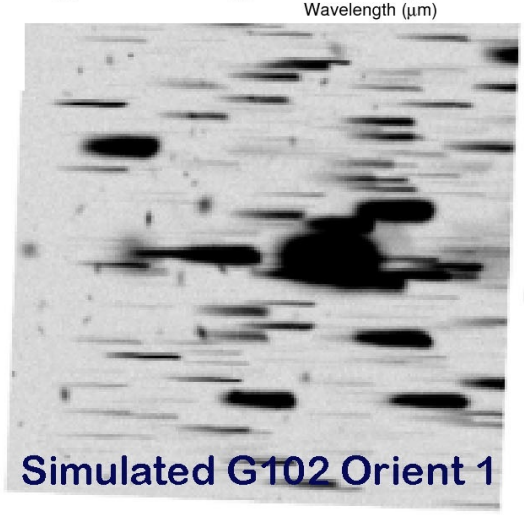
GLASS

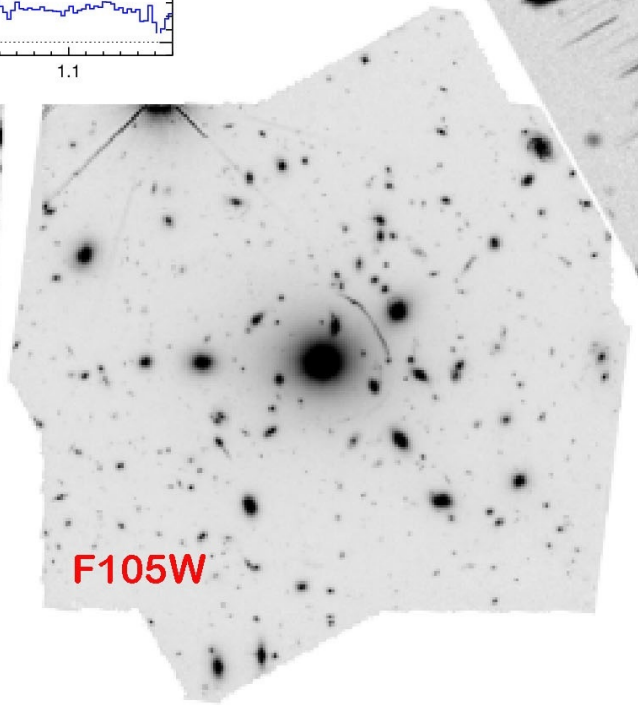
The tool: HST grisms

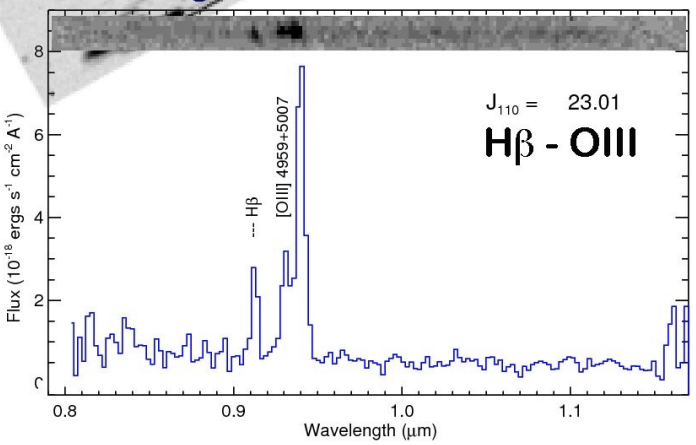


WISP Survey

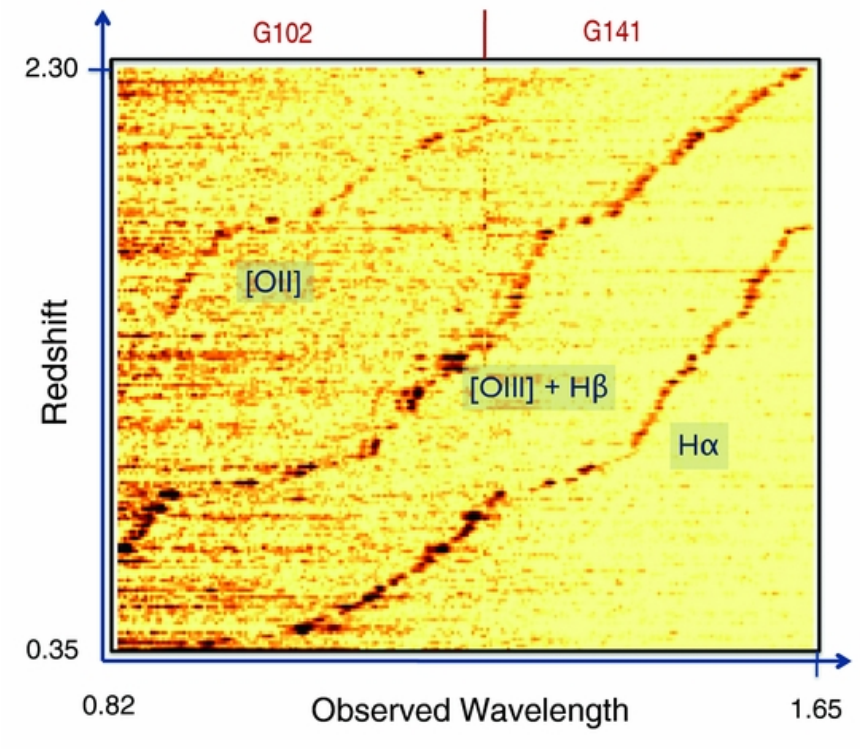


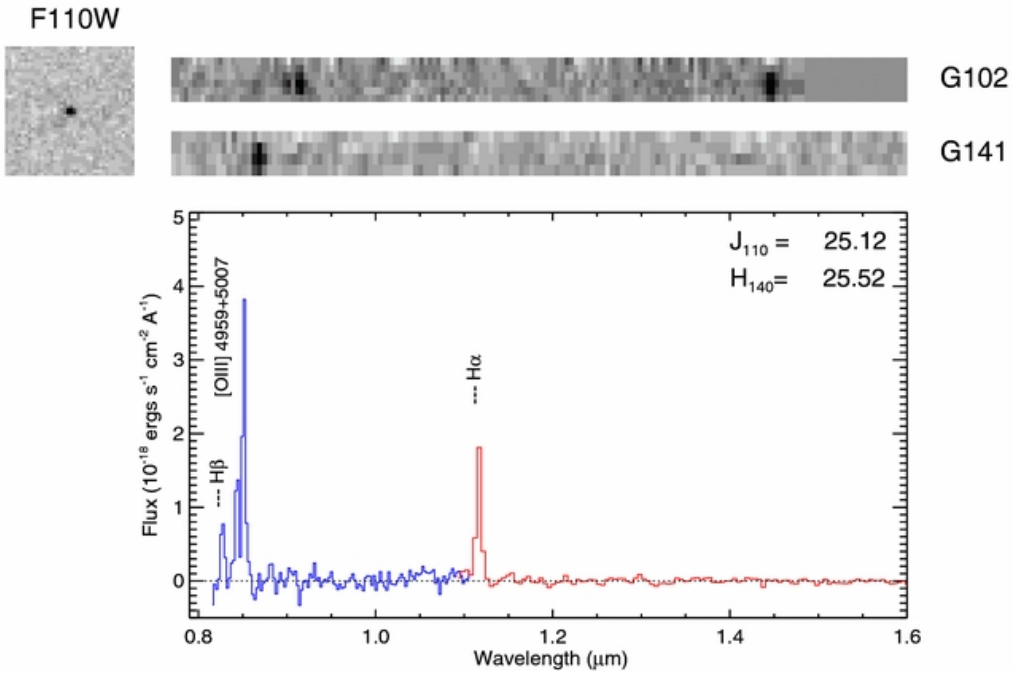






Wavelength coverage and observational strategy





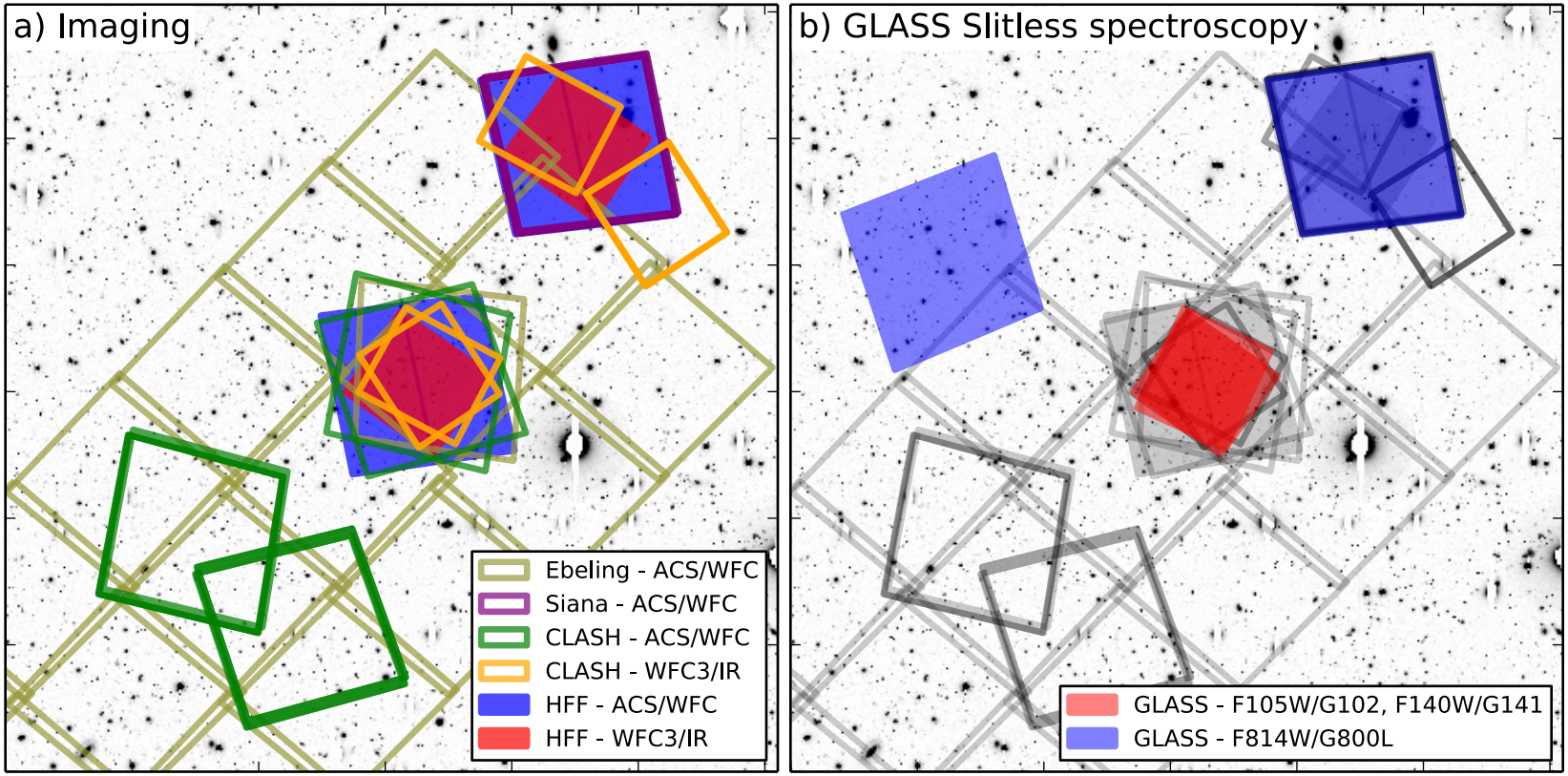
- Spectroscopy of 10 clusters, including HFF and CLASH
- 140 orbits cycle 21 (PI Treu) glass.astro.ucla.edu

GLASS Strengths

- Spectrum of everything in the field of view
- High sensitivity and angular resolution owing to lensing magnification
- Excellent photometric redshift owing to HFF/ CLASH photometry
- Uninterrupted wavelength coverage, potentially able to detect weaker and redder nebular lines
- Many l.o.s reduce cosmic variance and lya patchiness effects (c.f. Robertson et al. 2014)

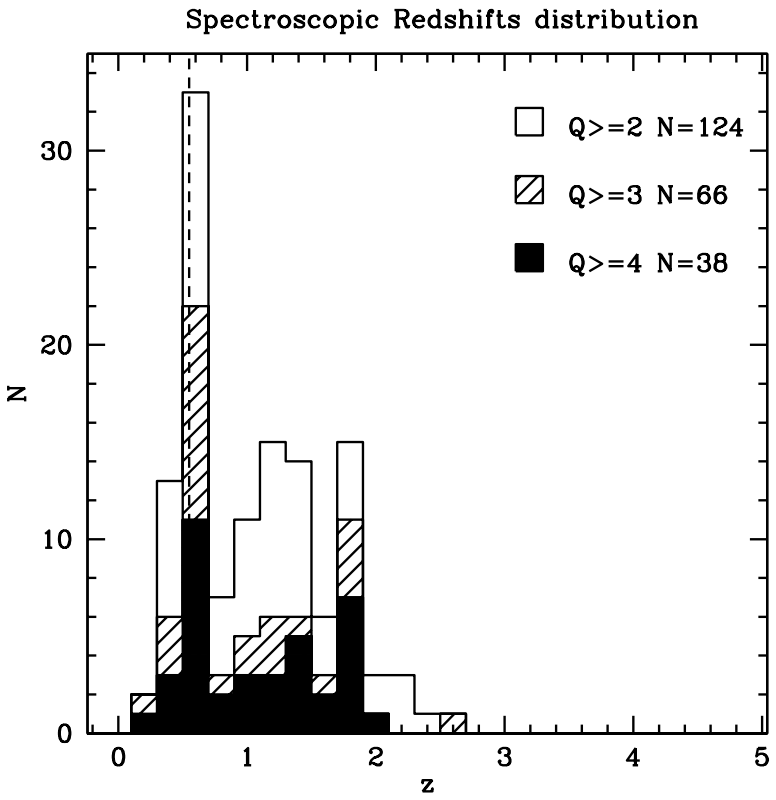
GLASS Status

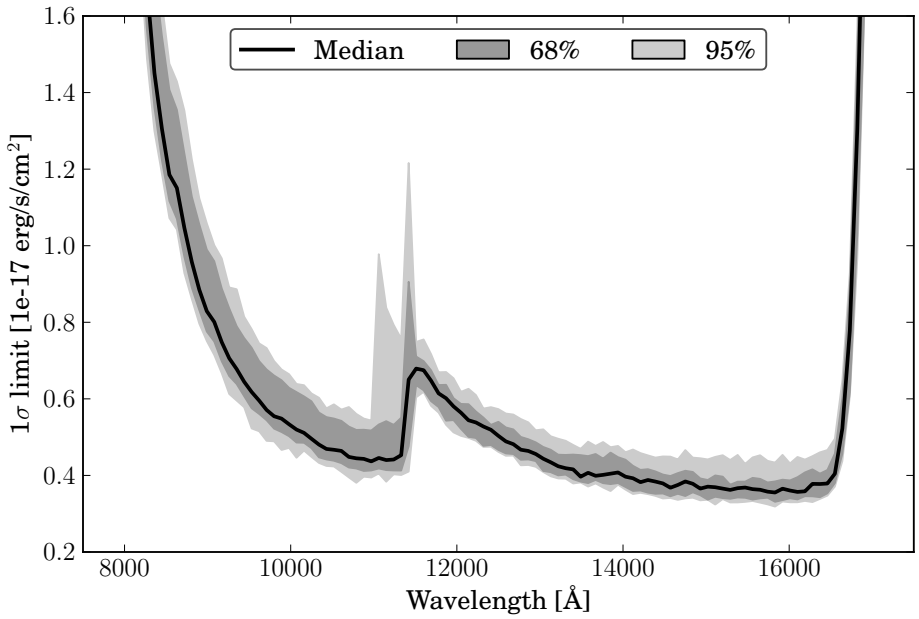
- **Data acquisition completed. First data release available at https://archive.stsci.edu/prepds/glass/ (Treu+2015)**



GLASS Status. II

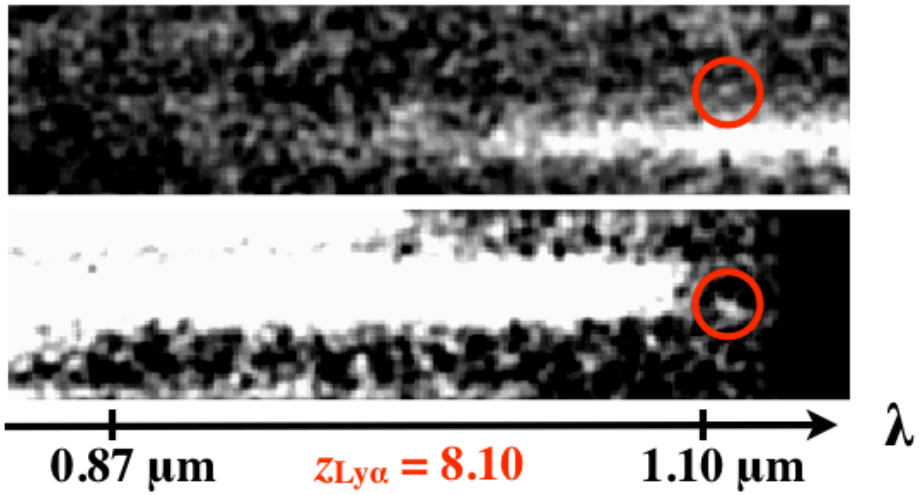
- First release includes all WFC3 spectra as well as redshift catalogs. ACS parallels will be in second release





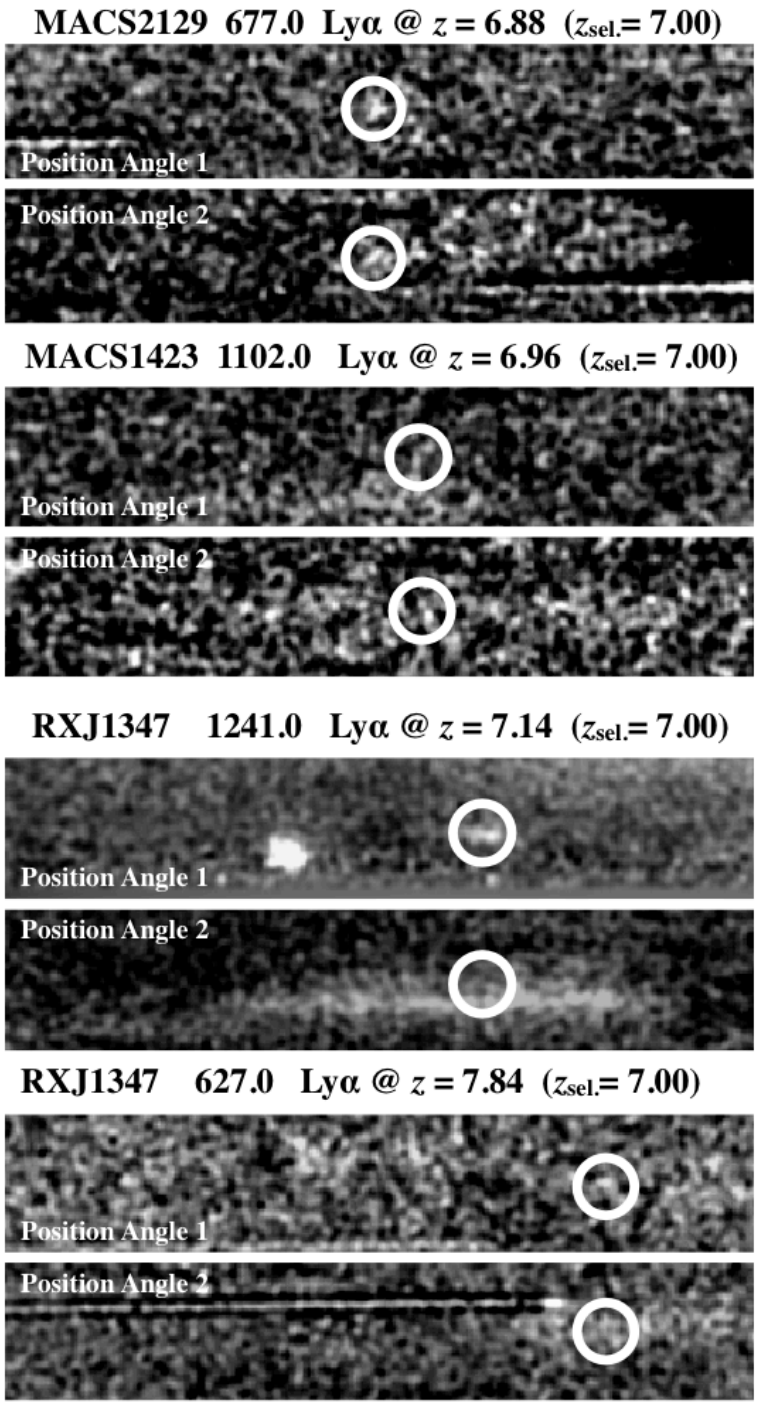
Treu et al. 2015

Lya at z~7 and above

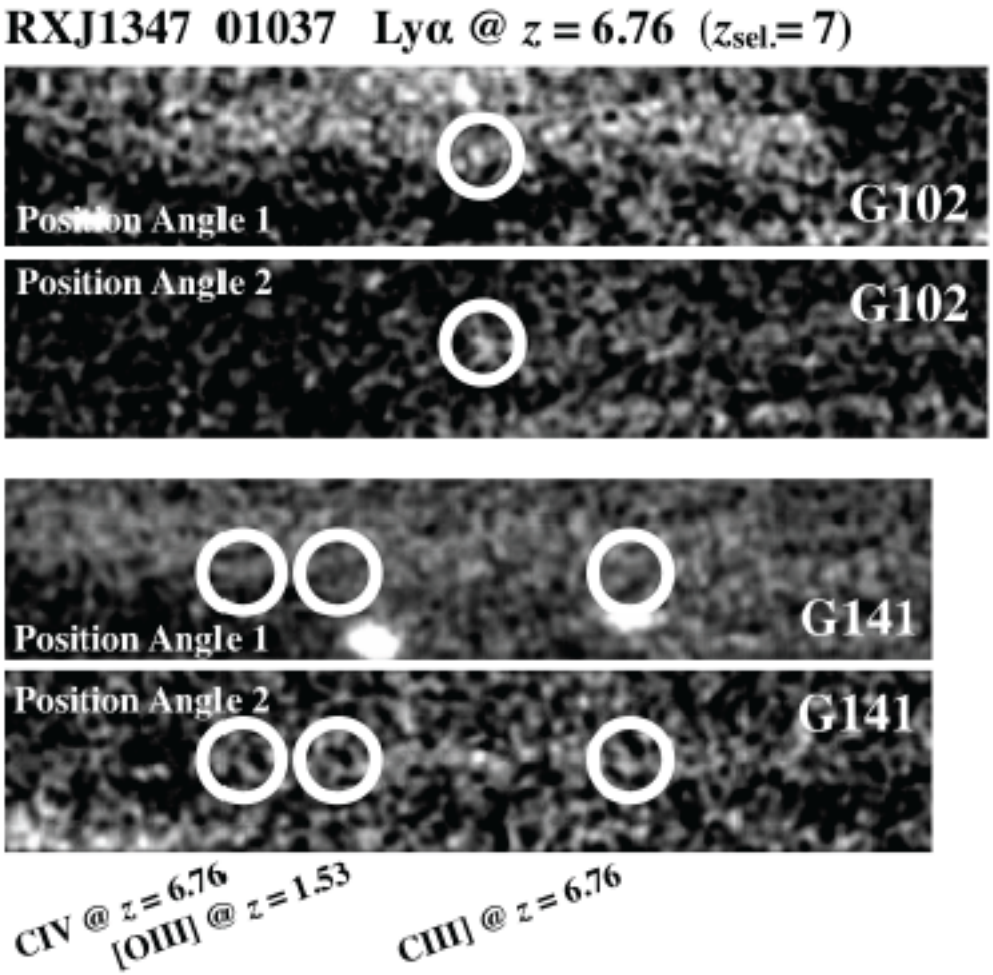


Schmidt et al. 2016

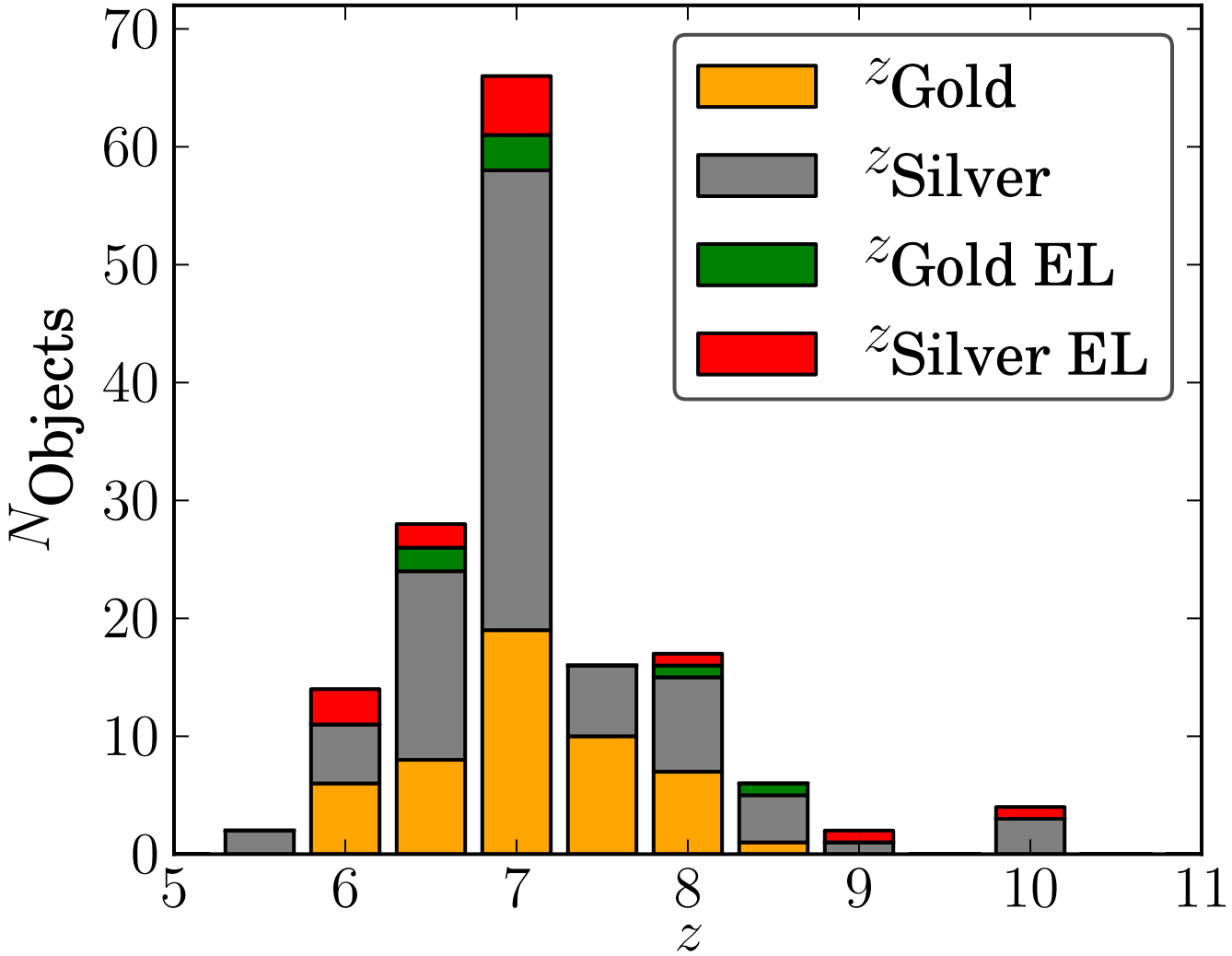
Also, confirmed lya in multiply imaged sources at z=6.1 and 6.4 (Boone+13, Balestra+13, Vanzella+14)



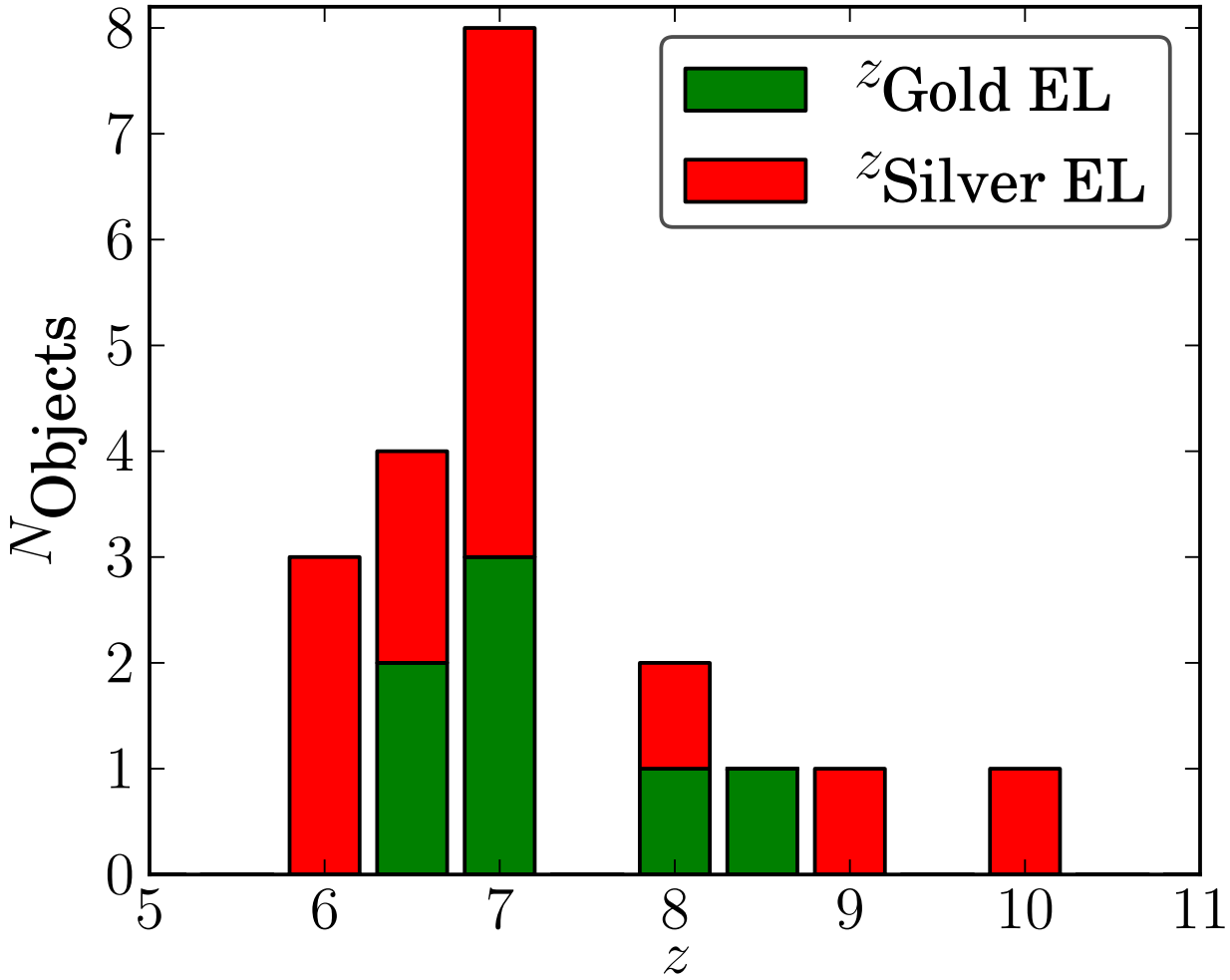
Keck/GLASS confirmed z~7



Huang et al. 2016a; Schmidt et al. 2016

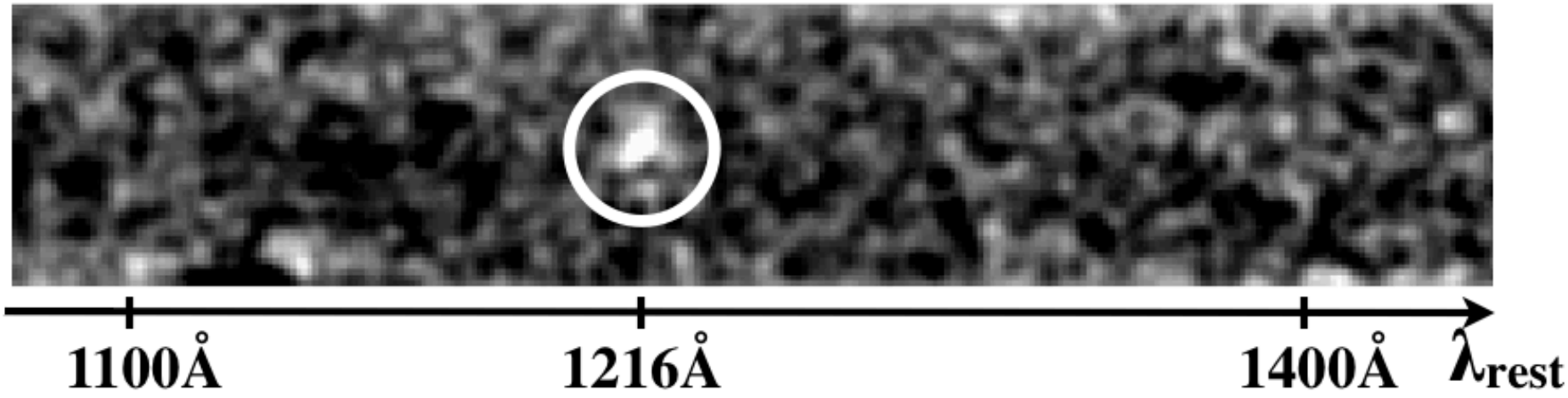


Schmidt et al. (2016); six clusters



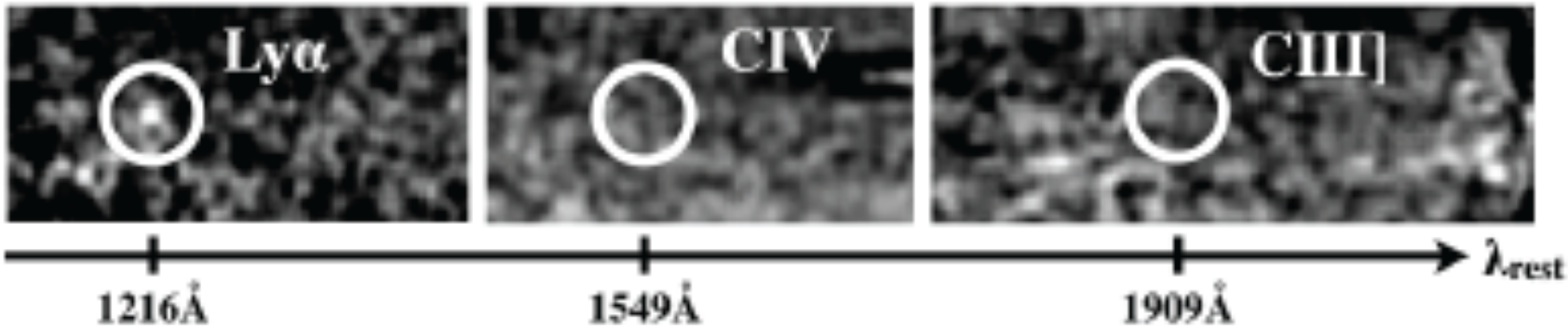
Schmidt et al. (2016); six clusters; currently redoing search with better photometry available from HFF

First measurement of spatial extension of (stacked) lya at z>7



Schmidt et al. (2016); six clusters

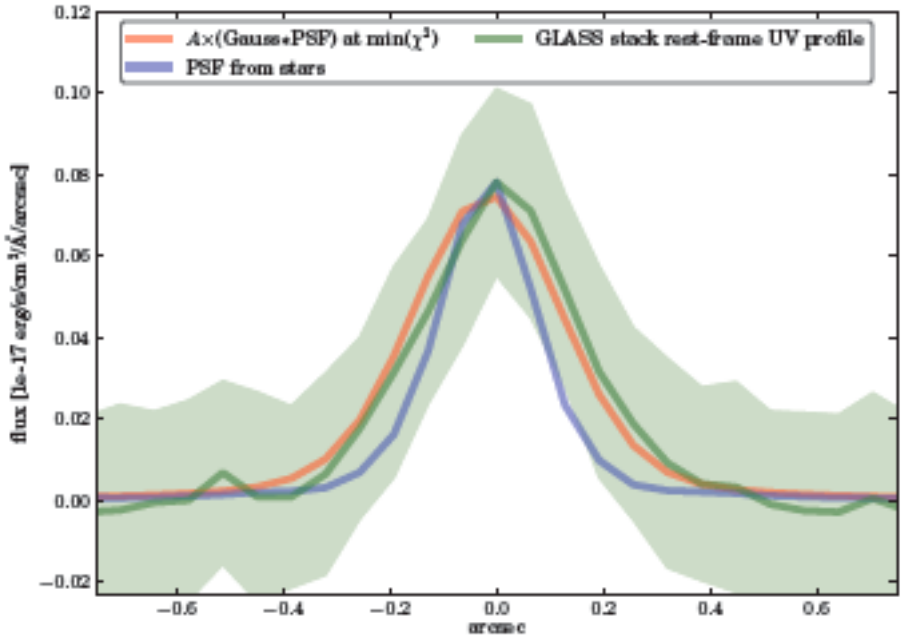
Limits on Lya to C lines

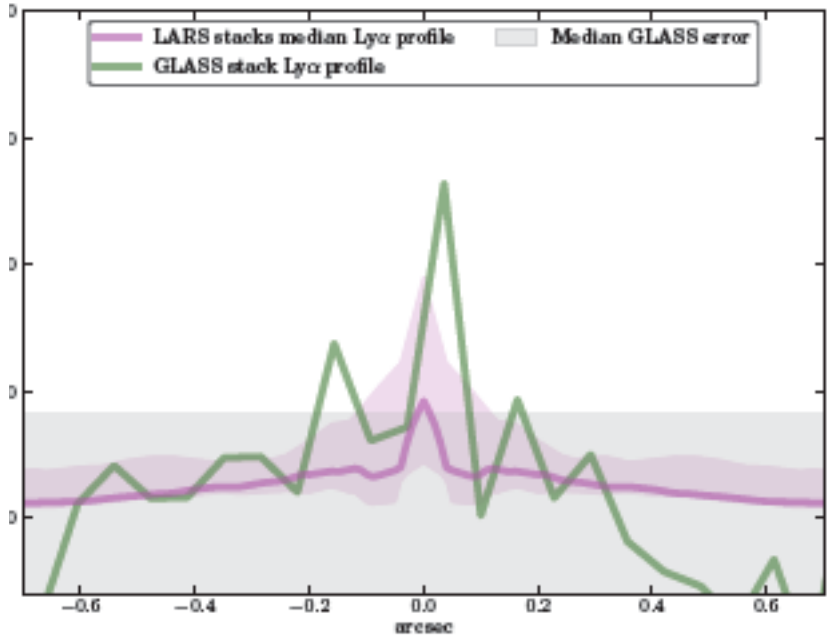


CIII(CIV)/Lya<0.2 95% CL

Schmidt et al. (2016); six clusters

Spatial extension of (stacked) lya at z>7



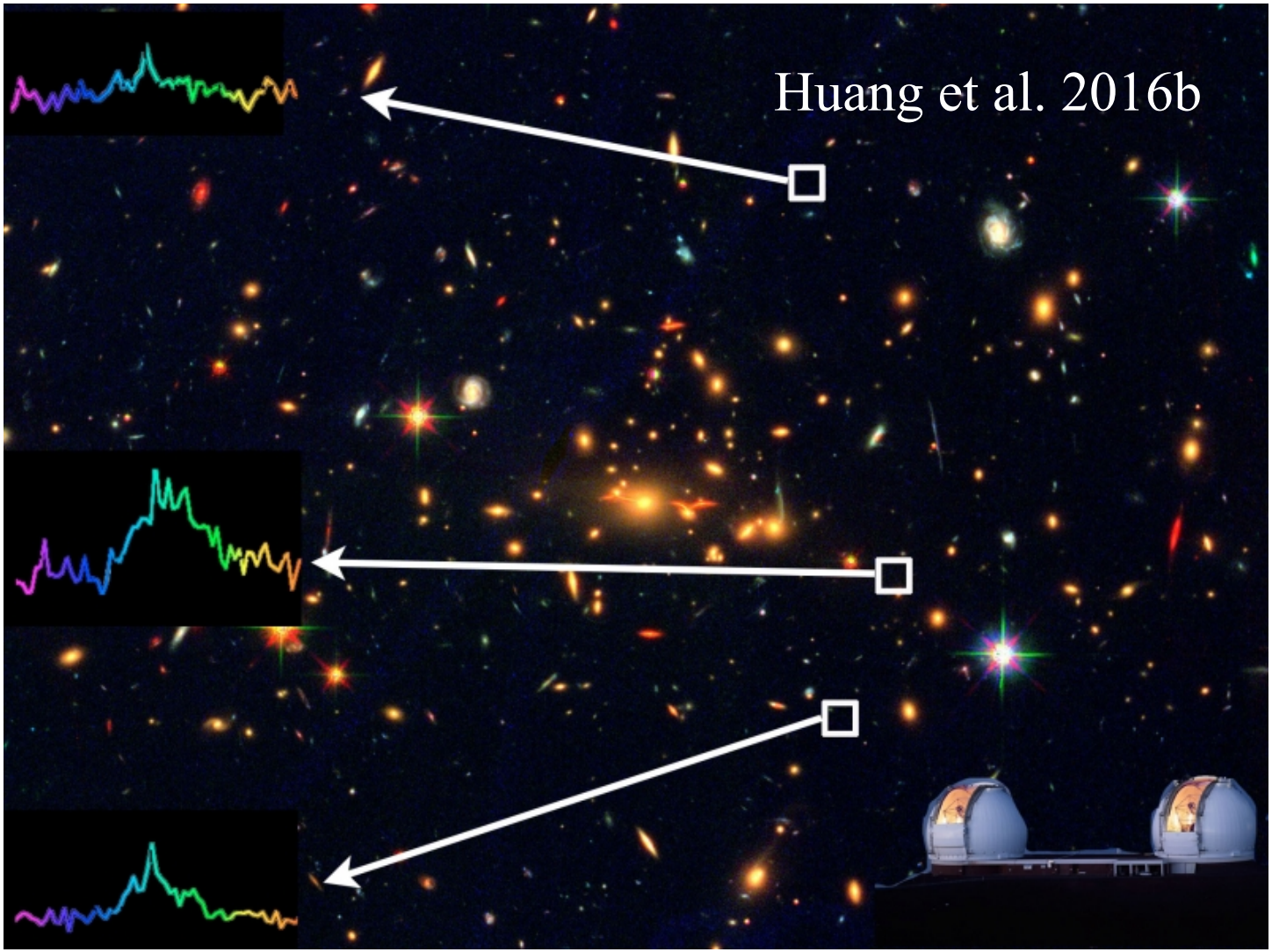


Schmidt et al. (2016); six clusters

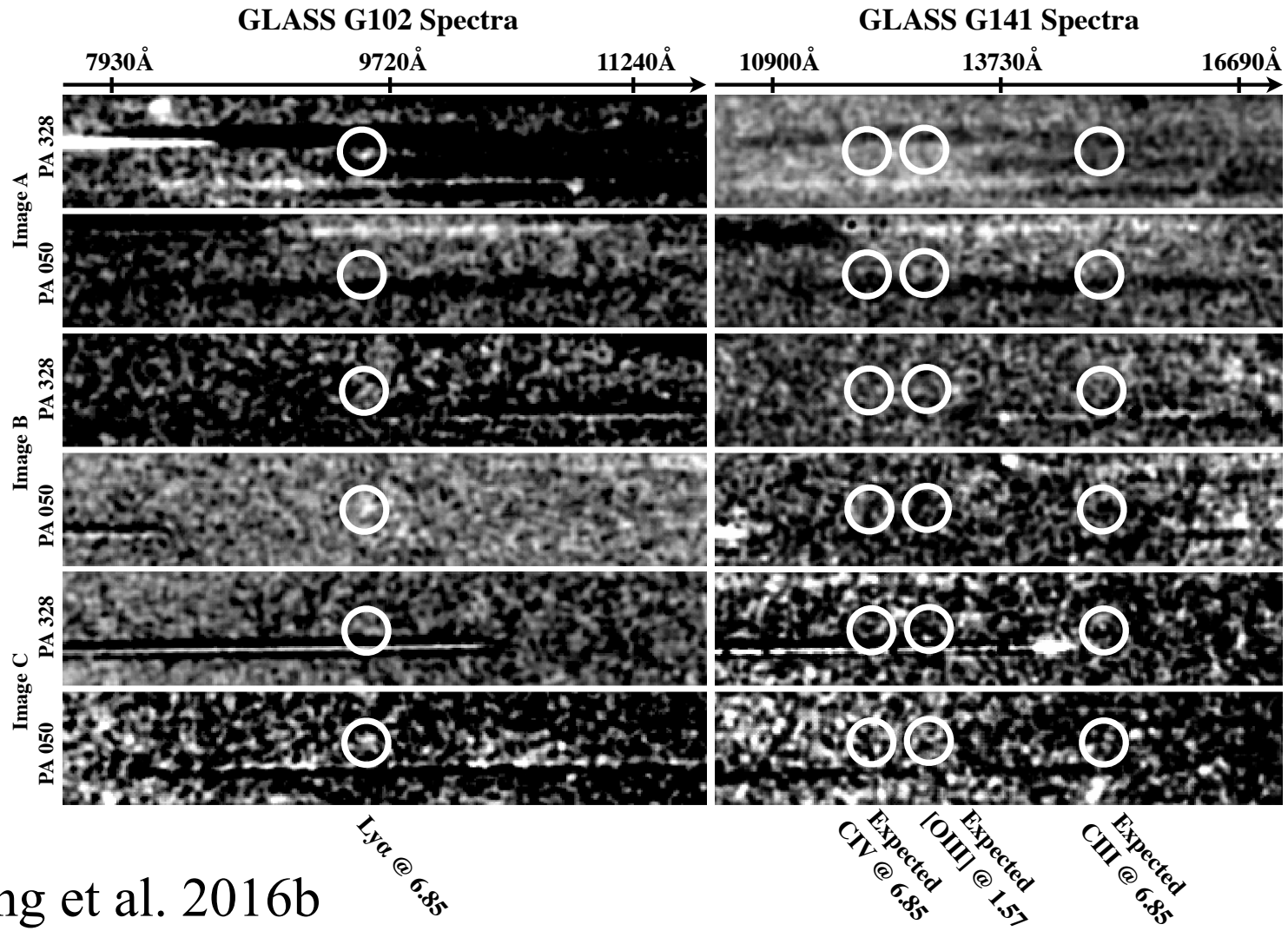
Ground Based Follow-up

GLASS

A faint multiply-imaged lya emitter at z~7

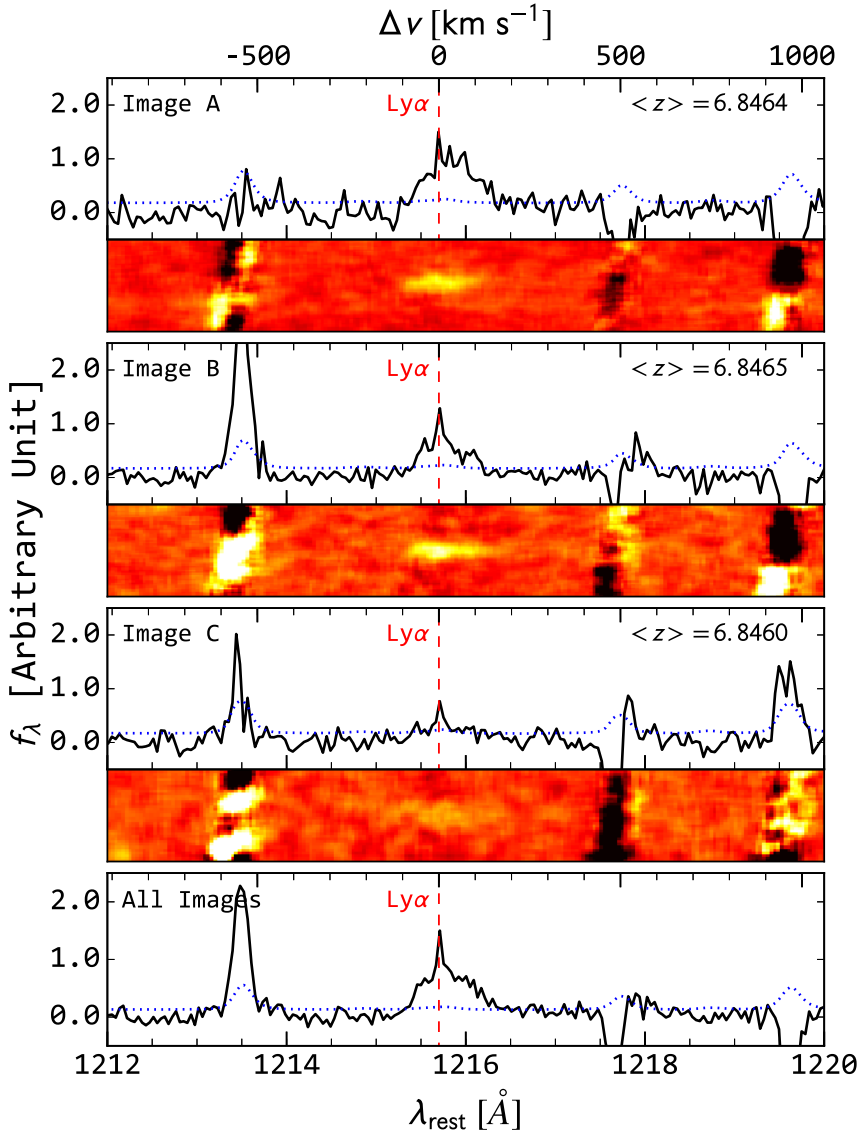


A faint multiply-imaged lya emitter at z~7



Huang et al. 2016b

A faint multiply-imaged lya emitter at z~7



- Magnification=3-11
- M_{UV}=-18.6
- M*~10^7 Msun

Huang et al. 2016b

Ongoing Follow-up

- Keck/MOSFIRE+DEIMOS (PI: Bradac & Trenti)
  - 9 clusters visible from Keck, up to 8-10 hrs **integration** per target
  - Several detections at $z<8$
- VLT/KMOS (PI: Fontana)
  - 7 Clusters visible from VLT, up to 15 hrs **integration** per target
  - Only short exposures so far, no convincing detection ($z>7.3$), work in progress (Mason et al. in prep)
- LBT/LUCIFER (PI: Debarros)
  - MACS1423, 15 hrs **integration**
  - No convincing detection

Summary

- Something very interesting is happening at z>8:
  - The IGM is becoming neutral (see Planck's optical depth)
  - Or galaxies are changing rapidly
- Lensing magnification allows us to probe the low luminosity regime
- Preliminary results from GLASS show several confirmed ly emitters at z~7 but a dearth of strong emitters at z~8.
  - This is in contrast with recent results for very bright objects
- Follow-up is ongoing to confirm candidates and determine purity and completeness and quantify statistics
- If decline of lya emission is confirmed by follow-up this could mean that the faint galaxies have not had time to carve out transparent bubbles around them by z~8

Credits

- K.Schmidt (AIP)
- L.Abramson (UCLA)
- *S.Bernard* (Melbourne)
- M.Bradac (UCD)
- G.Brammer (STScI)
- M.Dijkstra (UoO)
- A.Dressler (OCIW)
- A.Fontana (Roma)
- R.Gavazzi (IAP)
- L.Guaita (Roma)
- A.Henry (NASA)
- *A.Hoag (UCD)*
- K.Huang (UCD)
- T.Jones (IfA)
- P.Kelly (UCB)
- M.Malkan (UCLA)
- *T.Morishita (UCLA)*
- *C.Mason (UCLA)*
- L.Pentericci (Roma)
- B.Poggianti (Padova)
- M.Stiavelli (STScI)
- M.Trenti (Melbourne)
- A.vdLinden (Stanford/Dark)
- B.Vulcani (Melbourne)
- *X.Wang (UCLA)*

TEAM: glass.astro.ucla.edu;
DATA: https://archive.stsci.edu/prepds/glass/

The end