Lya Galaxies at the end of Cosmic Reionization with DECam

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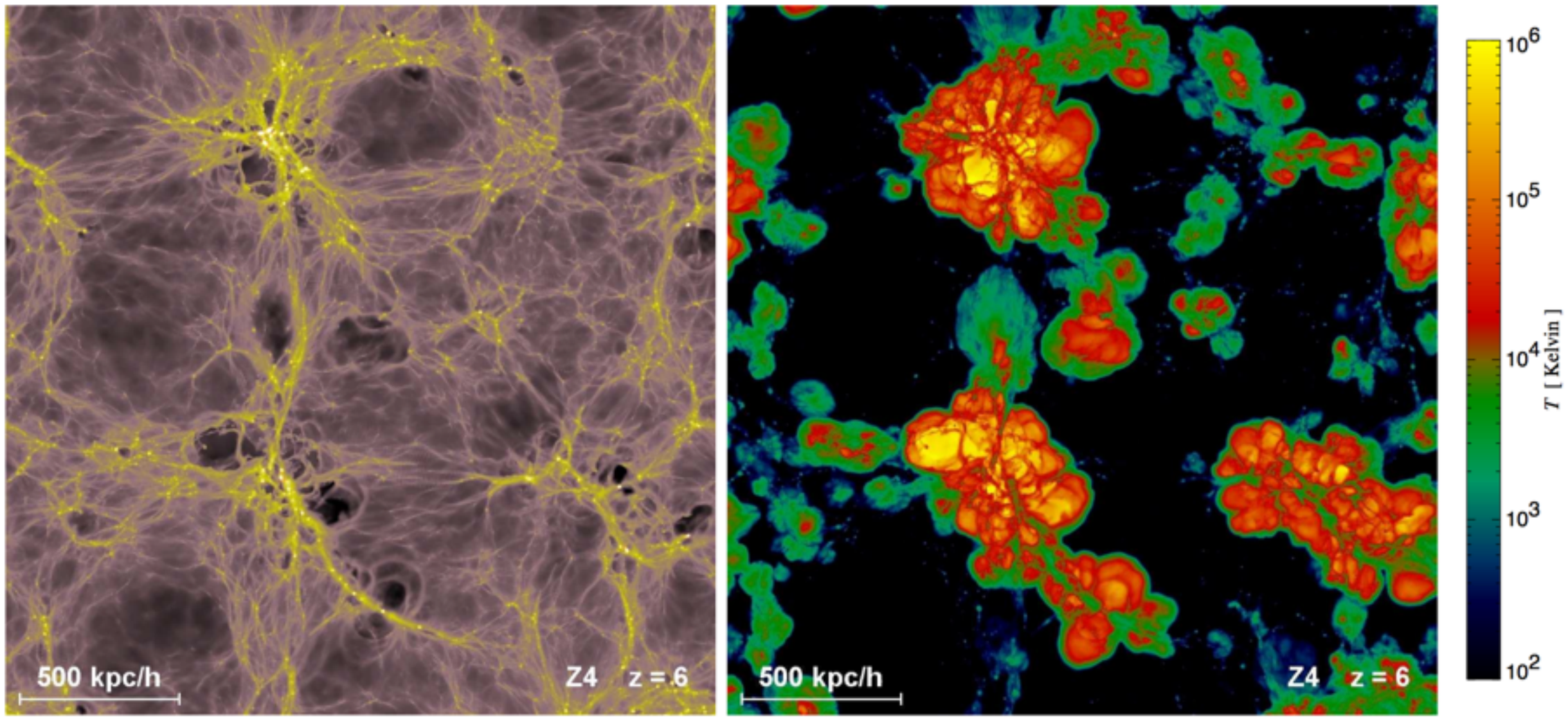
Cosmic Reionization

The history of star formation in a LCDM universe
Springel V., Hernquist L., 2003, MNRAS, 339, 312.

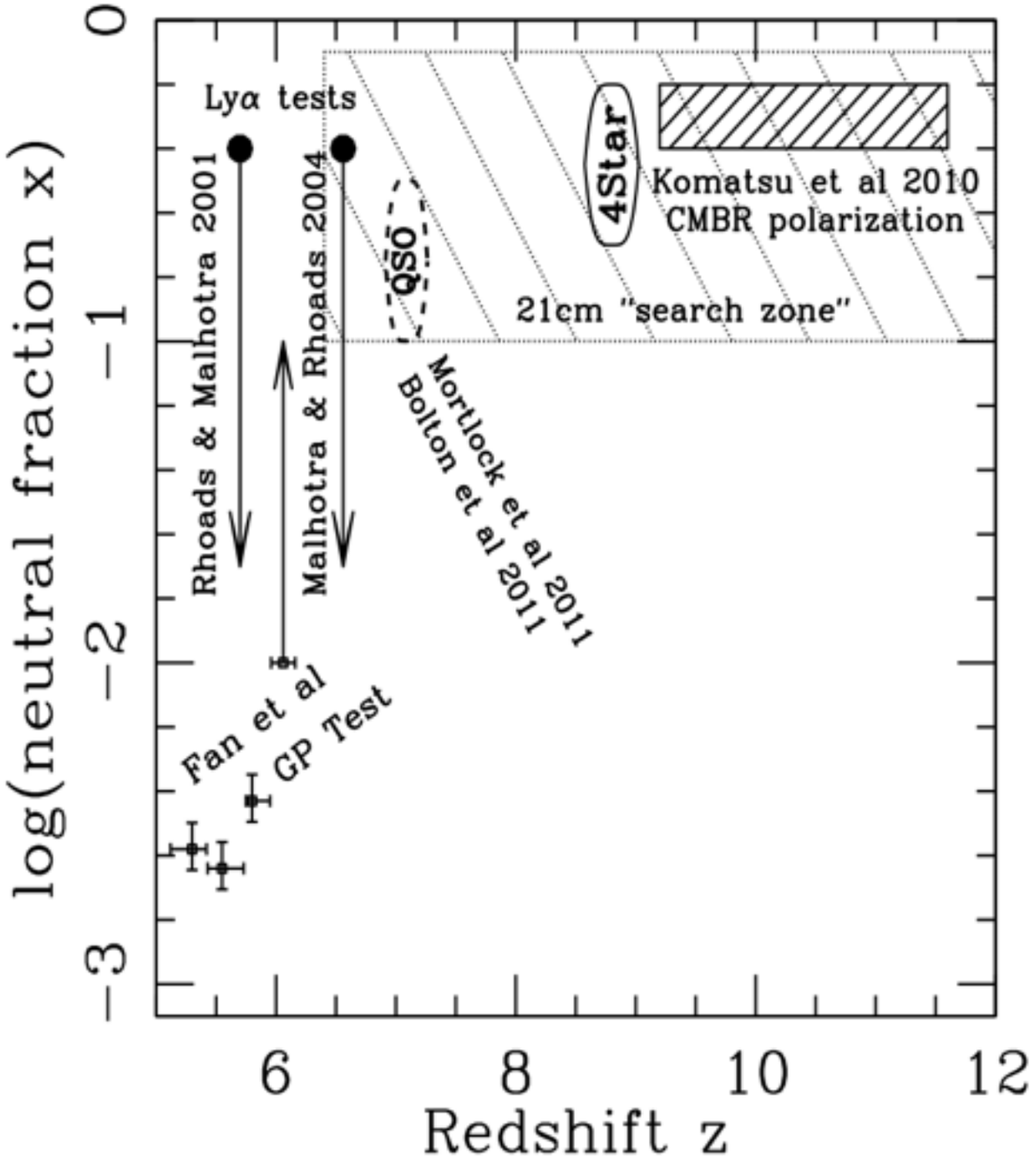


Last phase-change epoch over the whole Universe

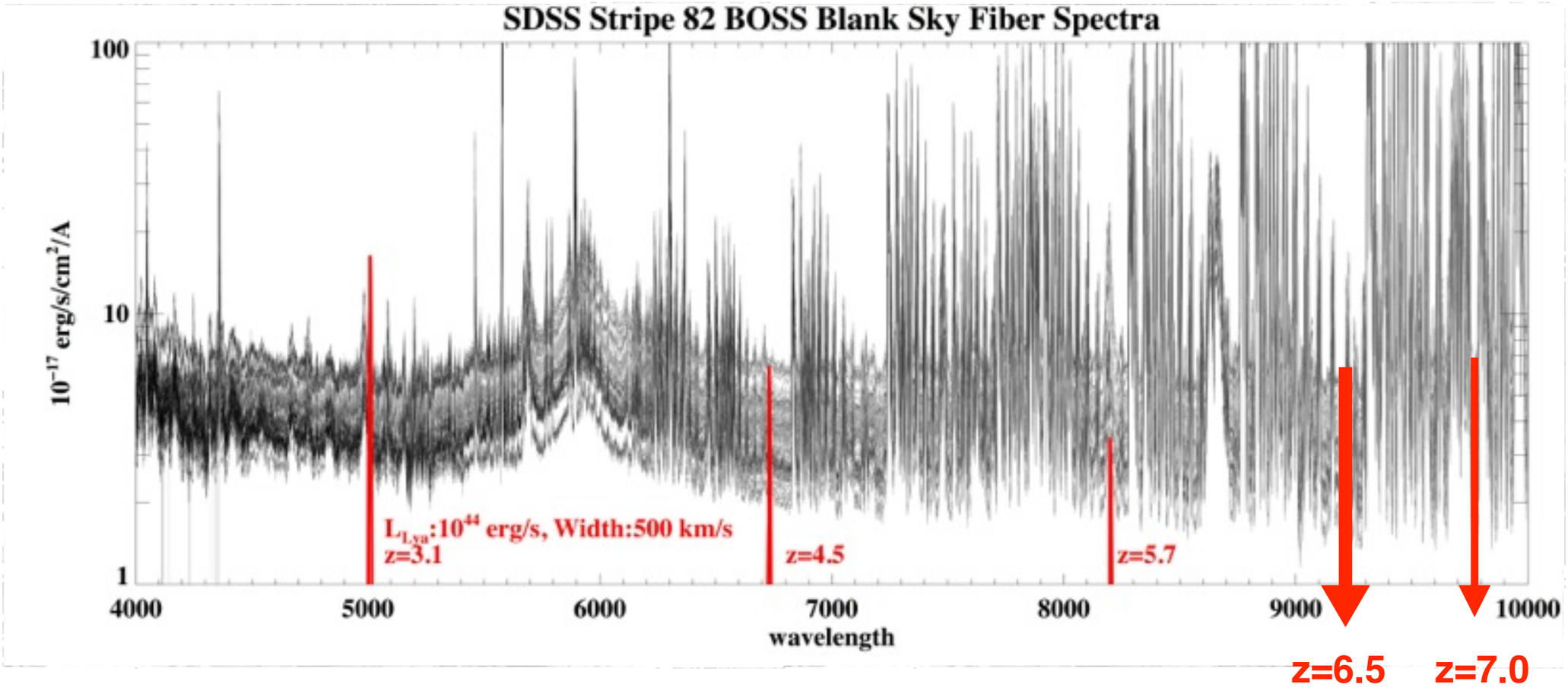
How to observe the first light and cosmic reionization?

Explore the Cosmic Reionization

Opt & NIR:
Quasars & Galaxies
at z= 6—8



Sky Background

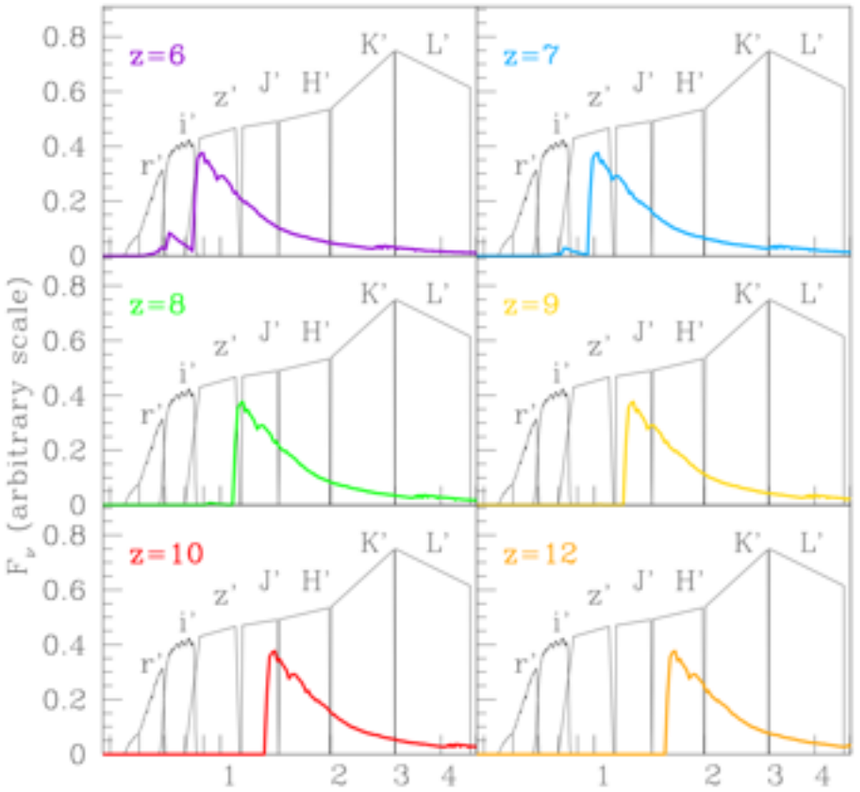


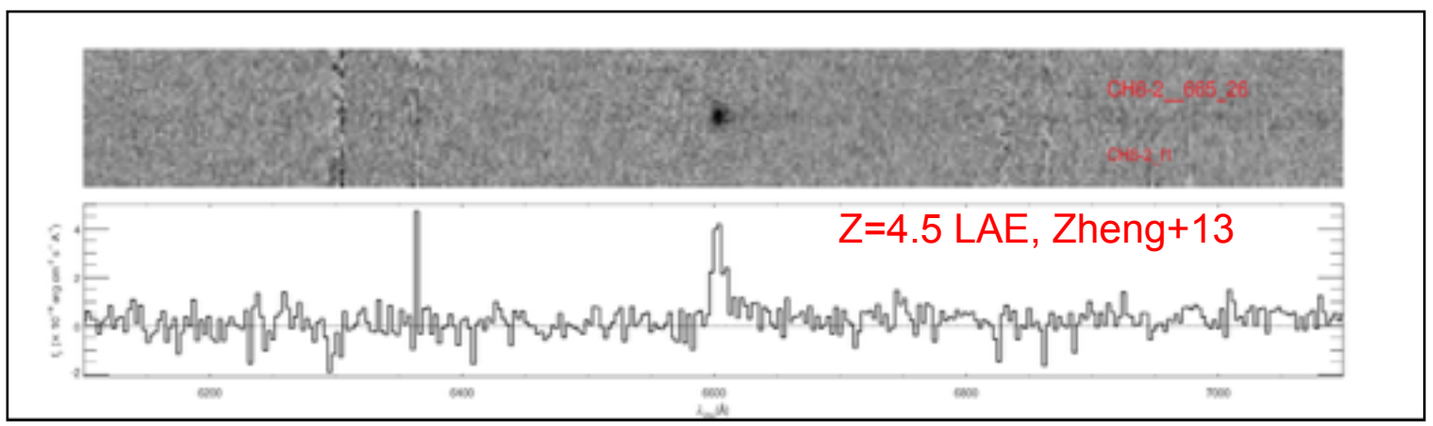
SDSS BOSS BLANK SKY-FIBER SKY-EMISSION, AND A LYA EMITTER WITH L(LYA)=10^44, WIDTH=500KM/S AT Z=3.1, 4.5, AND 5.7.

LAE surveys at z=7.0 (Last CCD window);
LBG z > 7 surveys only in Space (HST/WFC3,JWST)

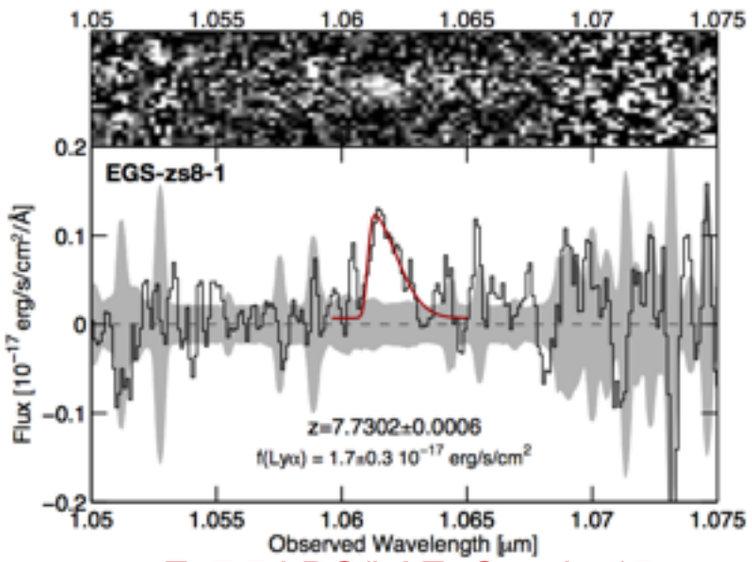
Explore the Phase-changing Epoch

- Lyman Break (Drop-out) Technique
- Lyman Alpha Emission line Search



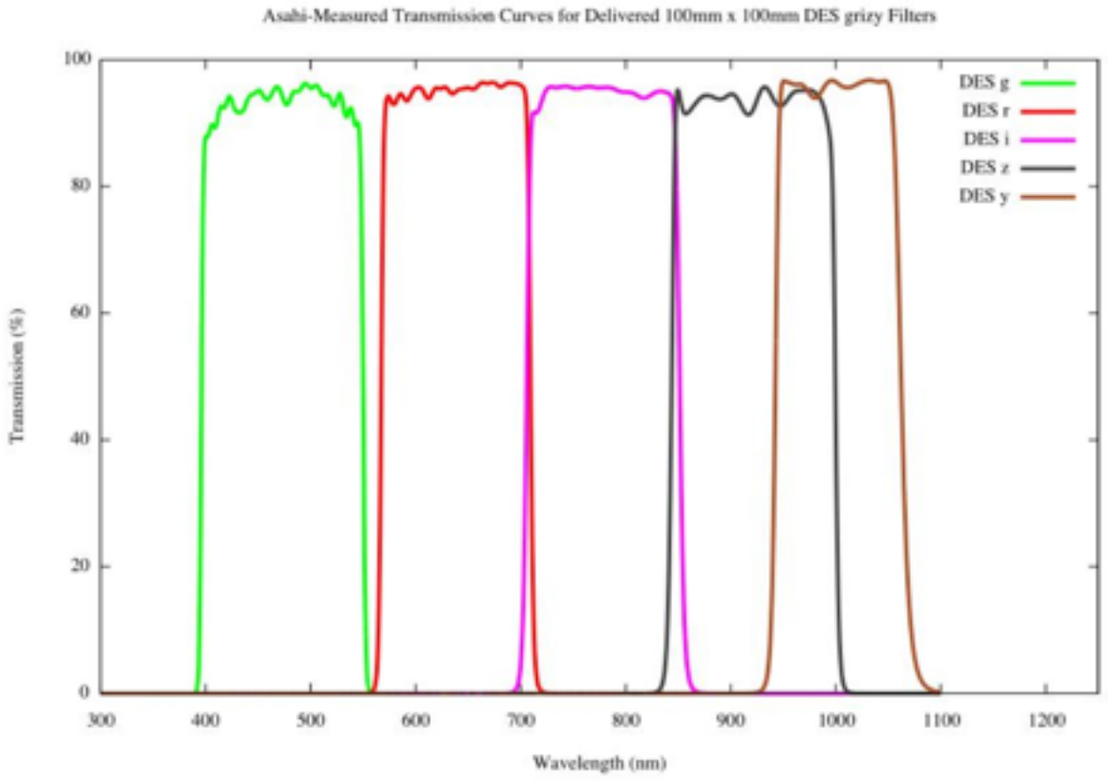


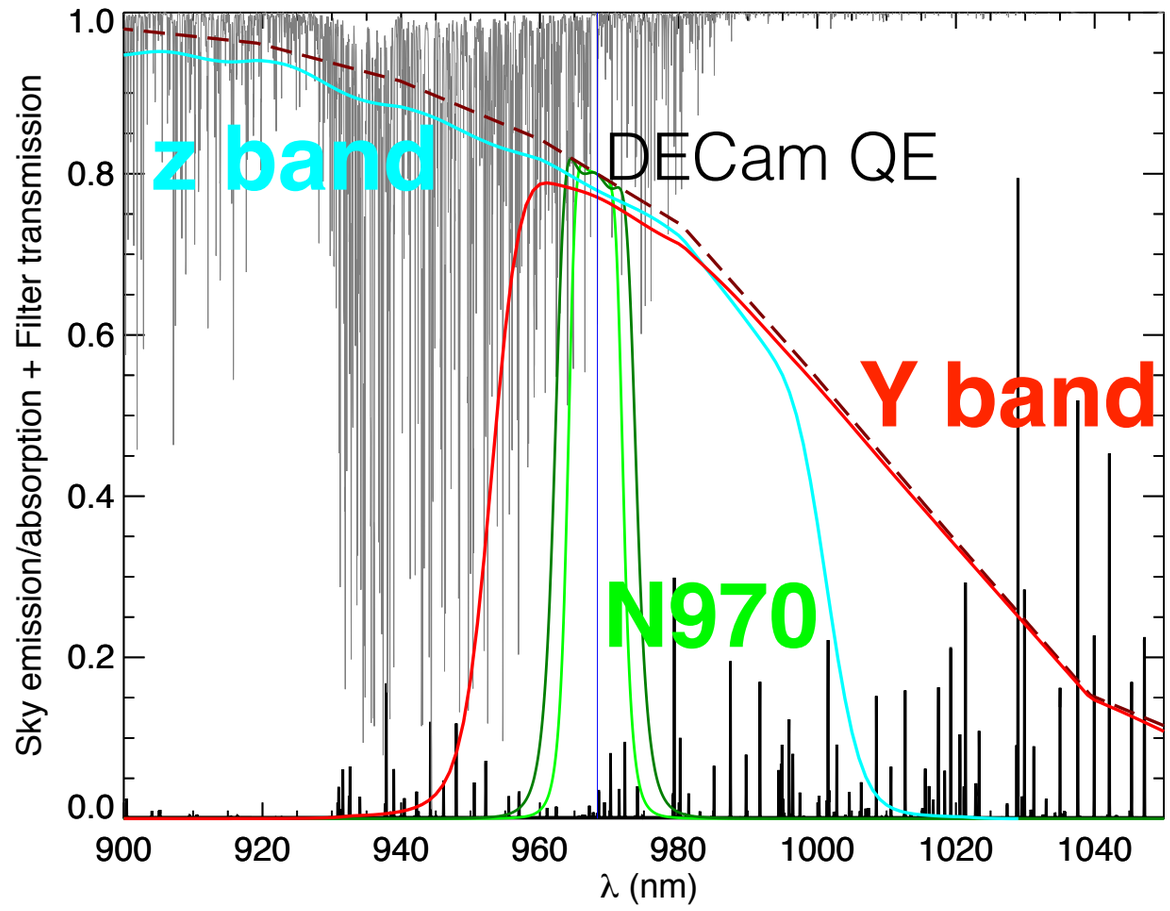
Z=4.5 LAE, Zheng+13



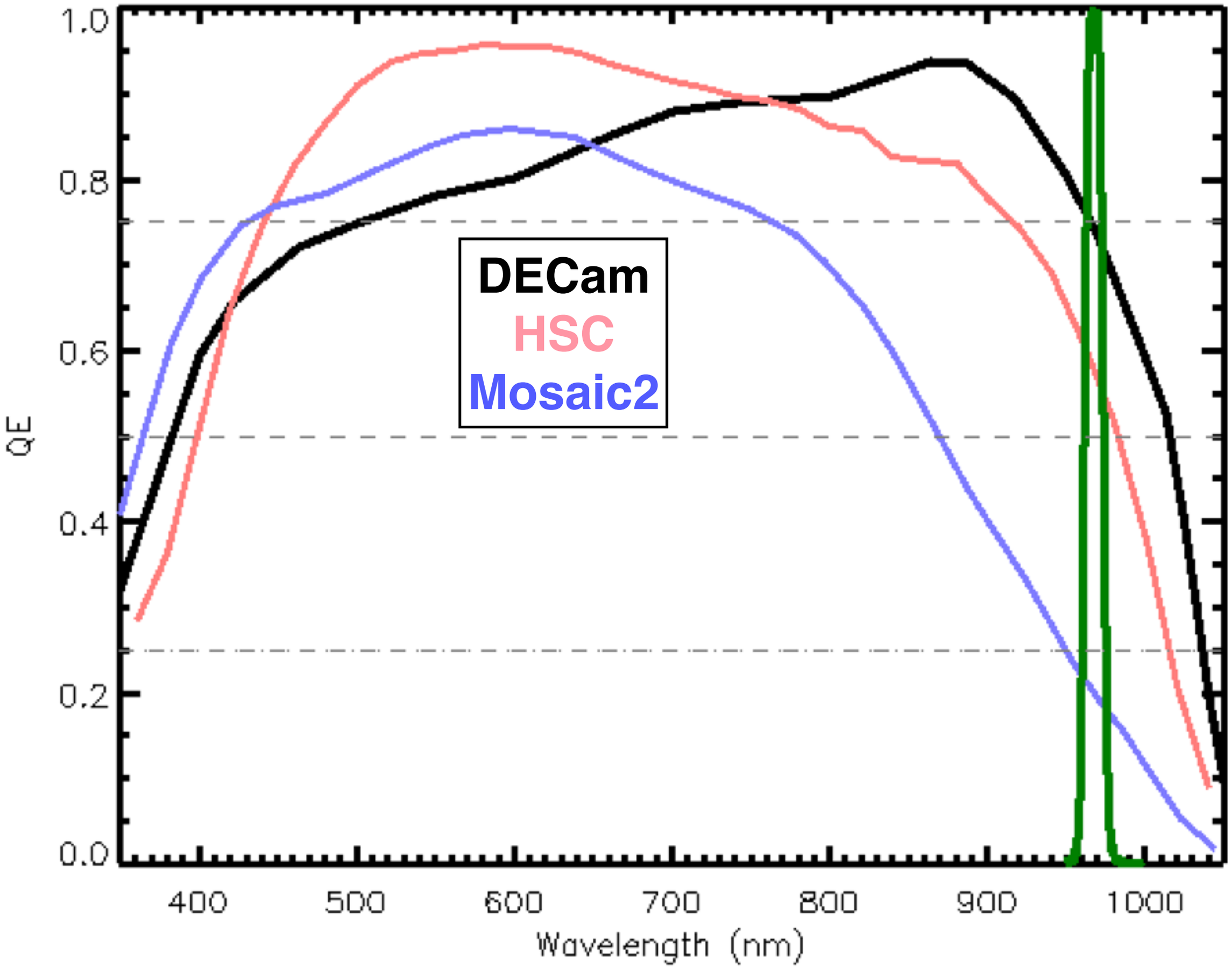
Z=7.7 LBG/LAE, Oesch+15

Narrowband Filter NB970 for DECam





N970: Central Wavelength: 9680A, Band width: 100A


DECam
HSC
Mosaic2
QE
1.0
0.8
0.6
0.4
0.2
0.0
400
500
600
700
800
900
1000
Wavelength (nm)

High-z NB surveys

- **Our DECam (4m, 3 deg^2) NB970 project (2015—)**
  (we are waiting our filter to be coated and delivered.)

- **Subaru HSC (8m, 1.5 deg^2) NB(921, 816, 515) surveys (2015—)**

- J-PAS (2.5m, 3 deg^2, Benitez+14), 2015—
  8500deg^2, 54 NB filters, 3500-10000A, depth 22.5
  (much shallower)

- Euclid Satellite (1.2m, 0.6deg^2), 2020——
  deg^2, NIR (z > 7.3)

40

Our planned project:
DECam + NB970

- **Mainly search for z ~ 7 LAEs.**
  (NB excess + Dropout selection)

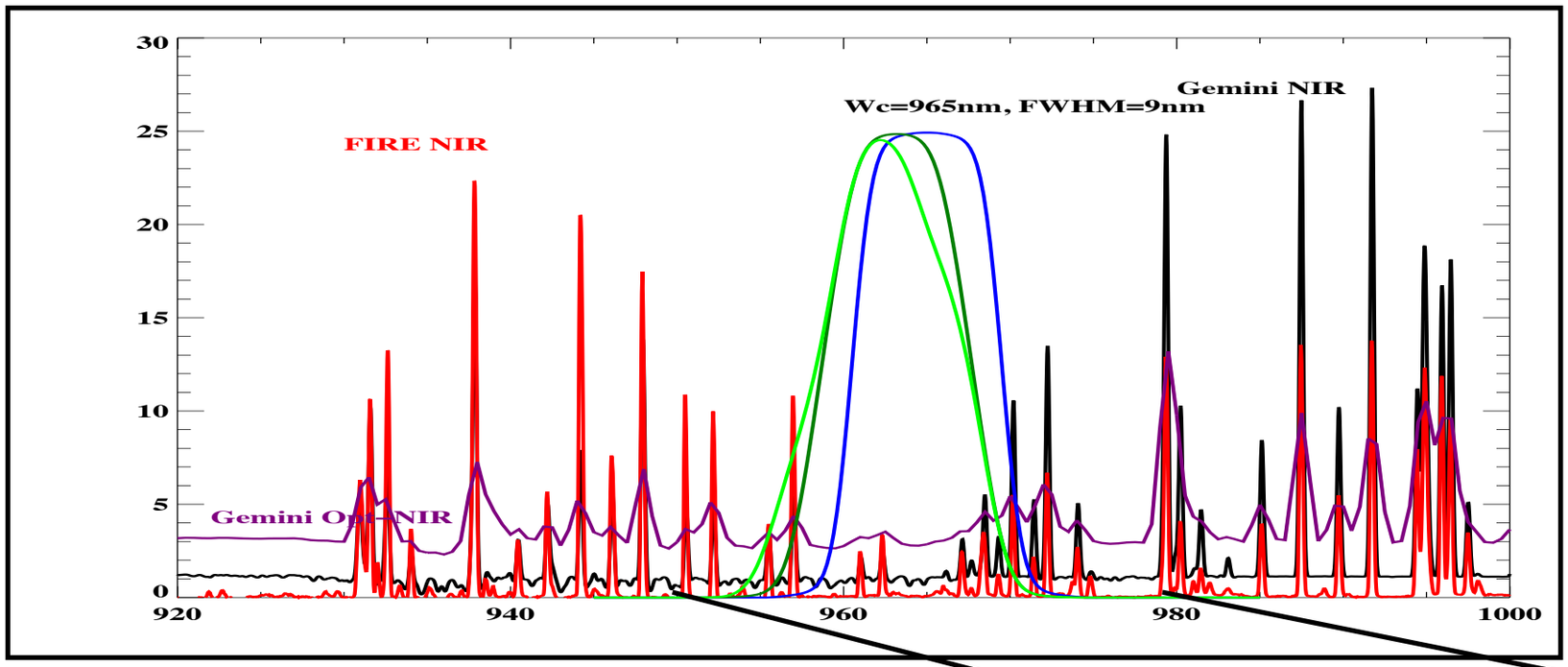
- Help to select Lyman-Break Galaxies at z~6-7 (Dropout selection with NB, Spectral Conf.)

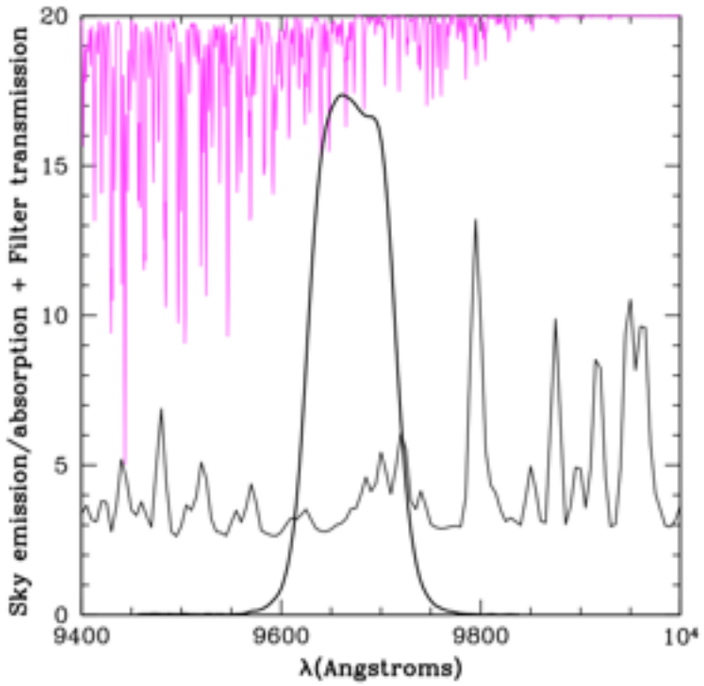
- Other emission line objects, e.g., Ha, OIII, Hb, OII emitters. (NB excess + photo-z)

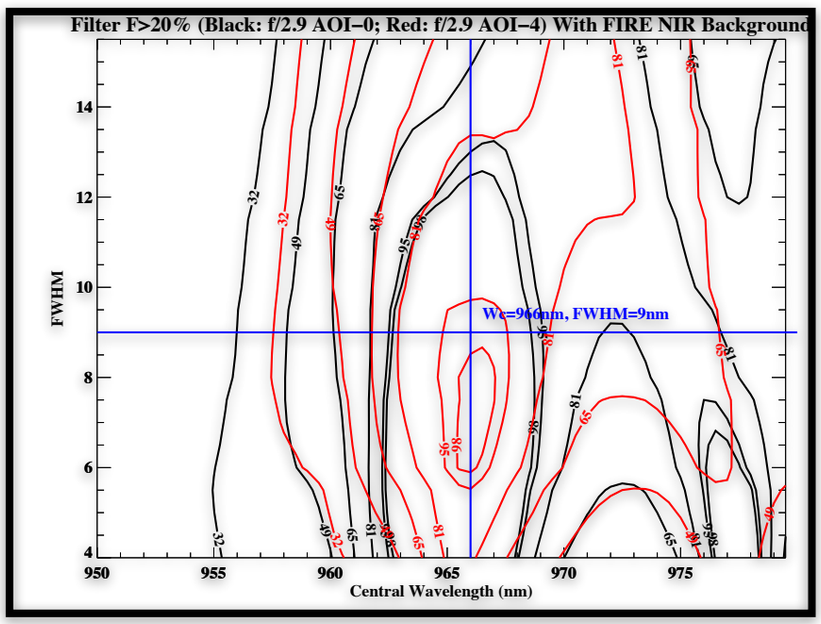
- High-z QSOs, through Lya, Civ, MgII,… (Brightness + Spectral Conf.)

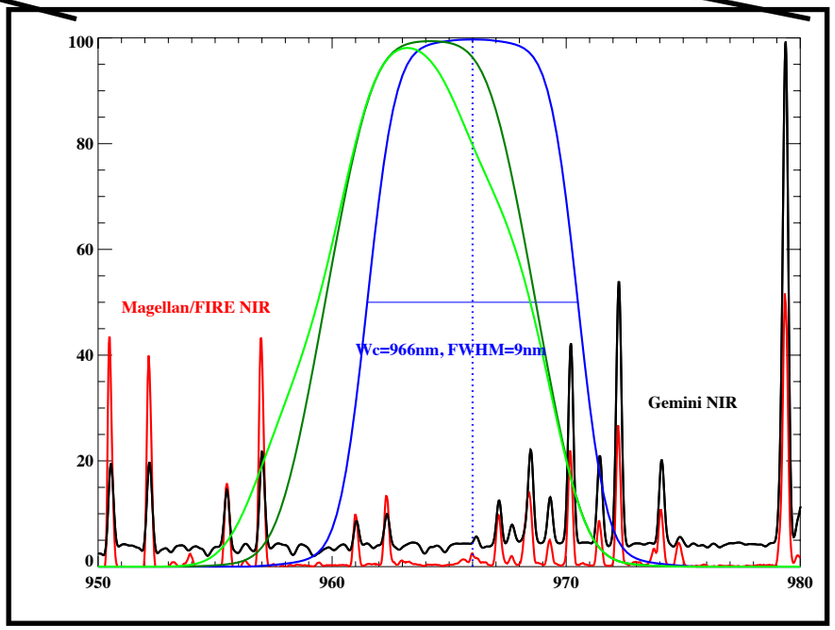
- Lyman Alpha Blobs (morphology)

Filter design



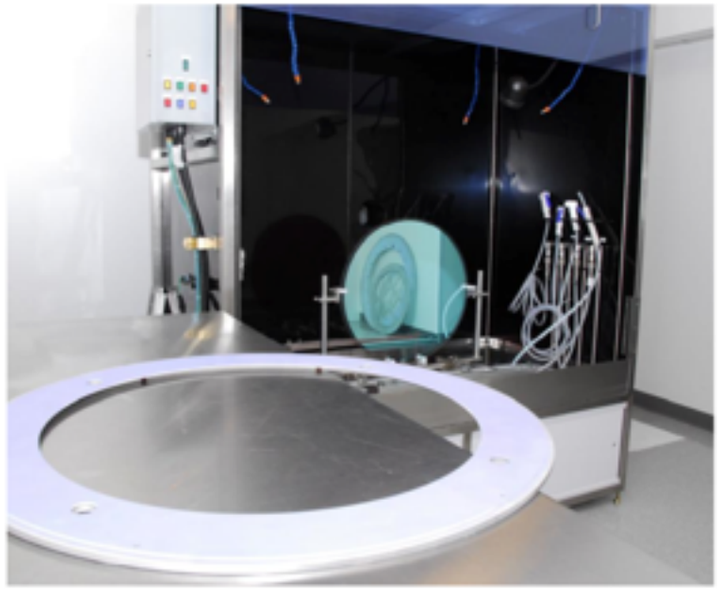






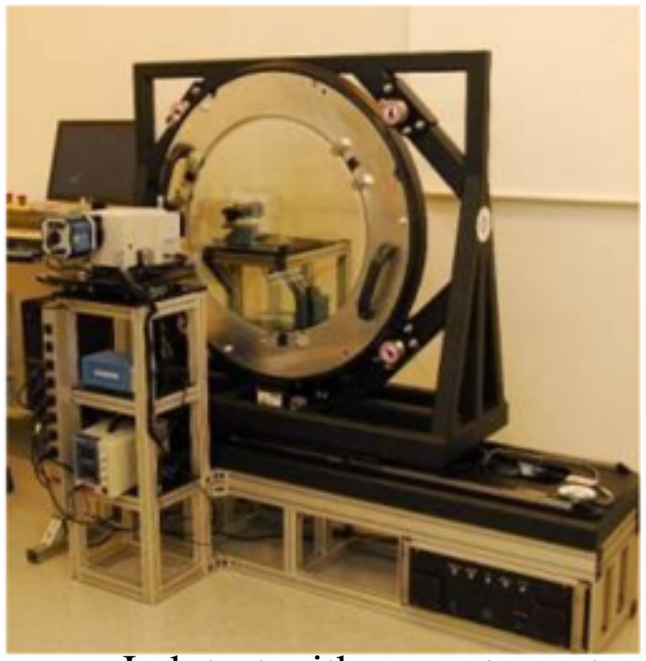
At Materion

Deposition Chamber



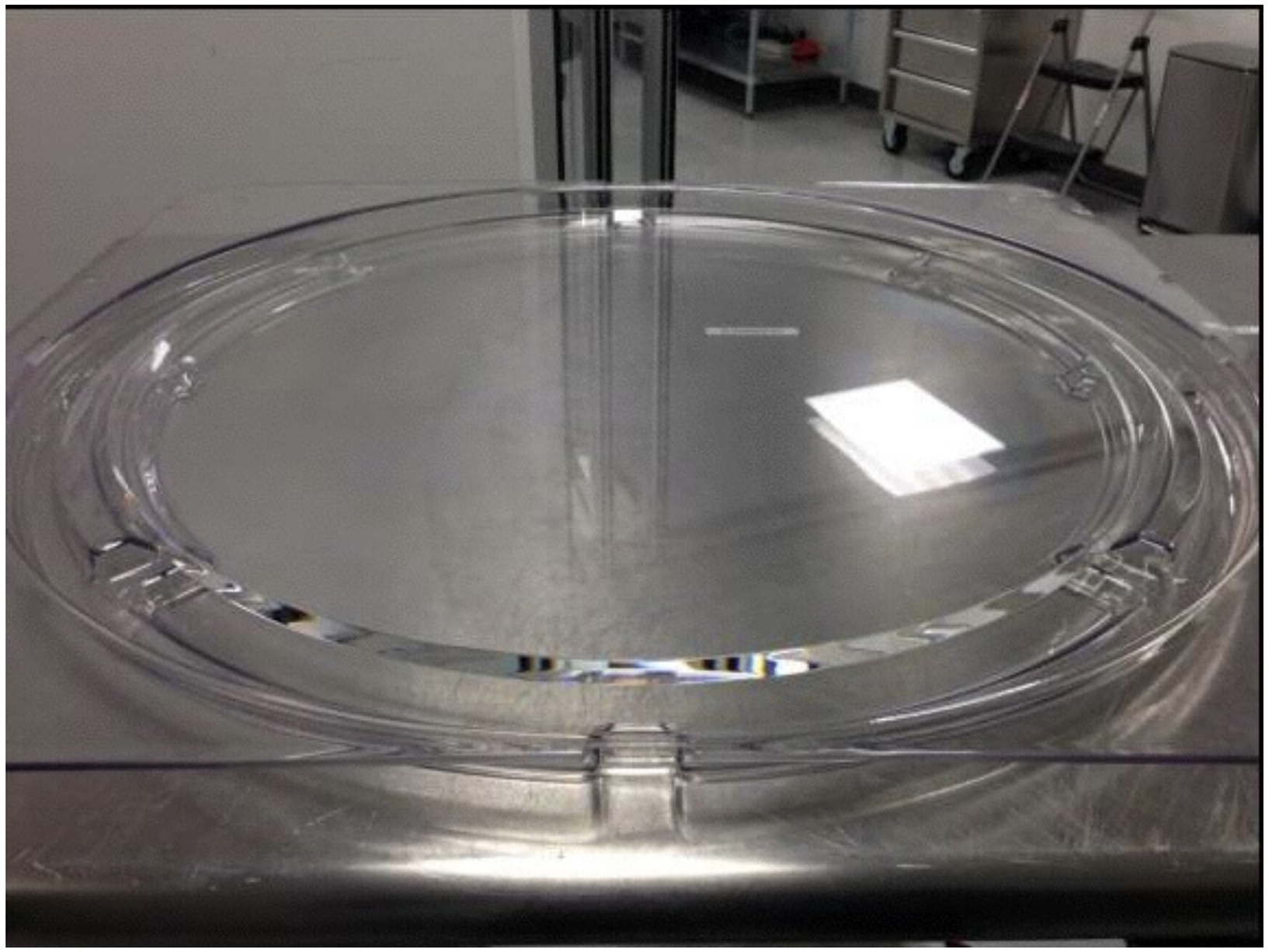
Cleaning Station

A 600 mm filter after coating



Lab test with a spectrometry

Pictures from Mooney et al. 2014



Our filter substrate at Materion, waiting for coating

Observing Plan

- Pilot Survey (1 night, cosmos field)

    1. Determine on-site filter performance.
    2. Check NB survey efficiency.

- Large Survey (25 nights, 5 fields, 2-3 years ?)

    Deep RIz + Deep NB

- Spectroscopic Followup of 6.5-10m telescopes.

Expected Products

- **600 LAEs at z~7 with L(Lya) >= L*(at z=6.5, e.g. Kashikawa+11)**

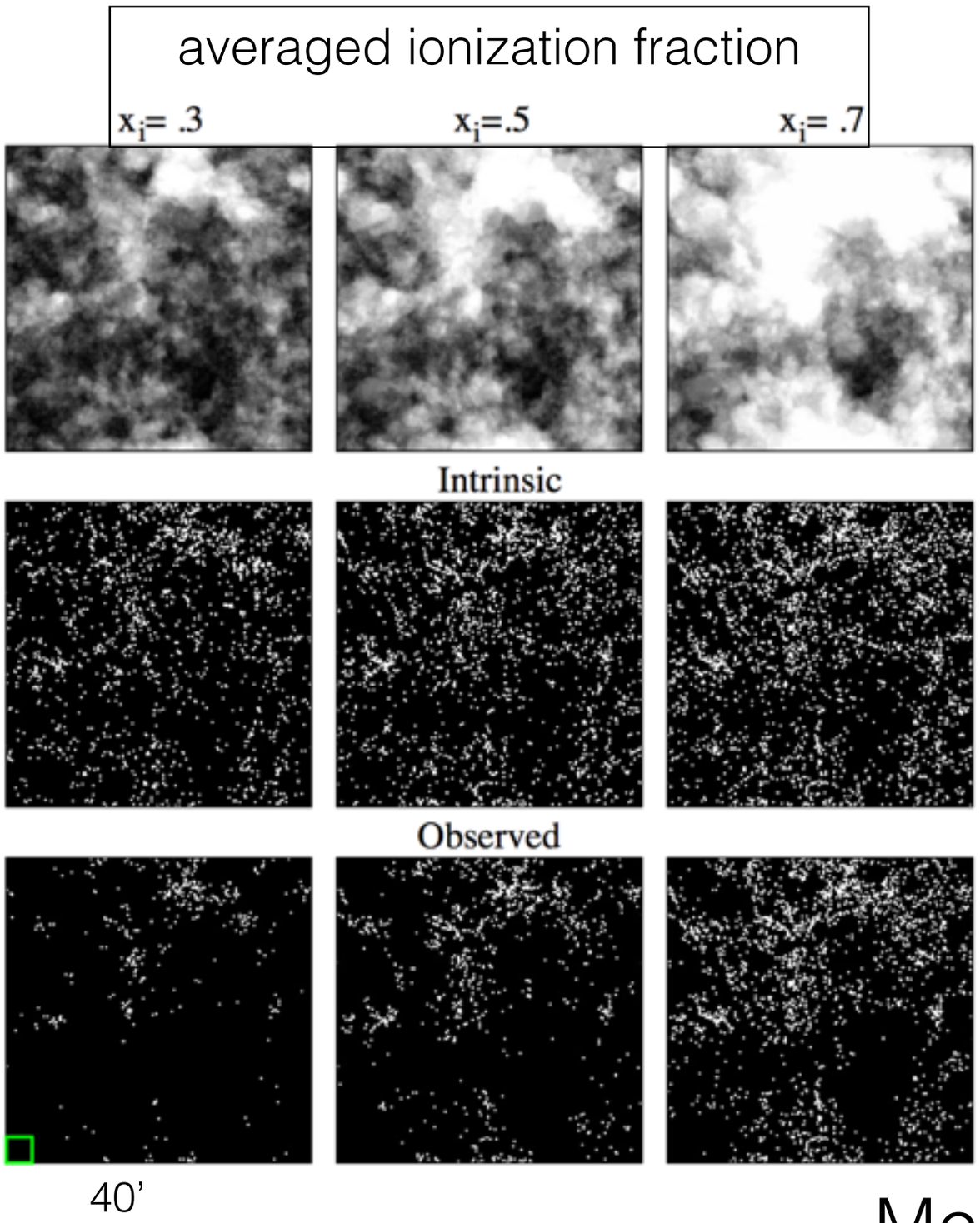
- 300 LBGs

- Thousands Low-z emitters, e.g., Ha, Hb, OIII, OII (Pirzkal+13)

- High-z Quasars, e.g., through Lya (z=7), CIV(z=5.3)

- Others like Lya Blobs, transit objects, etc.

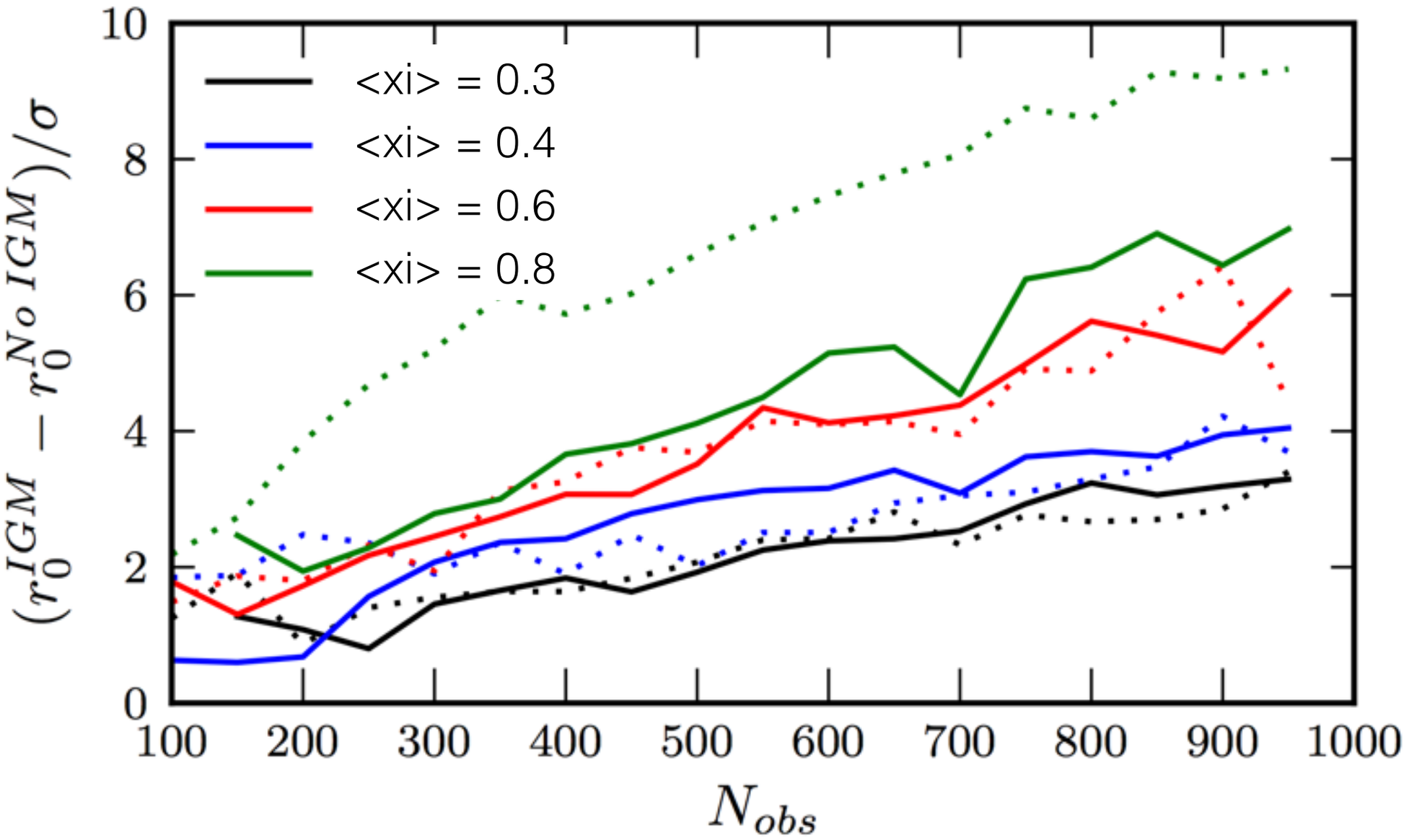
Clustering



- Distribution of ionized gas
- Intrinsic distribution of galaxies
- Apparent distribution of galaxies

McQuinn et al. 2007

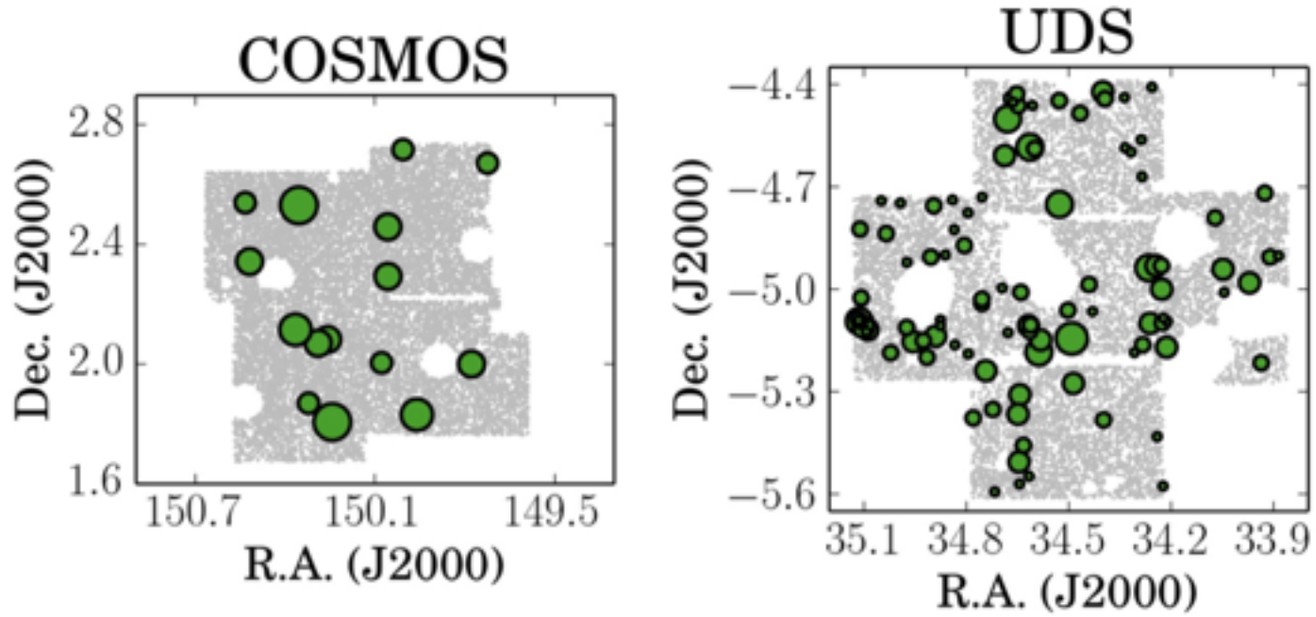
Correlation: IGM vs. noIGM

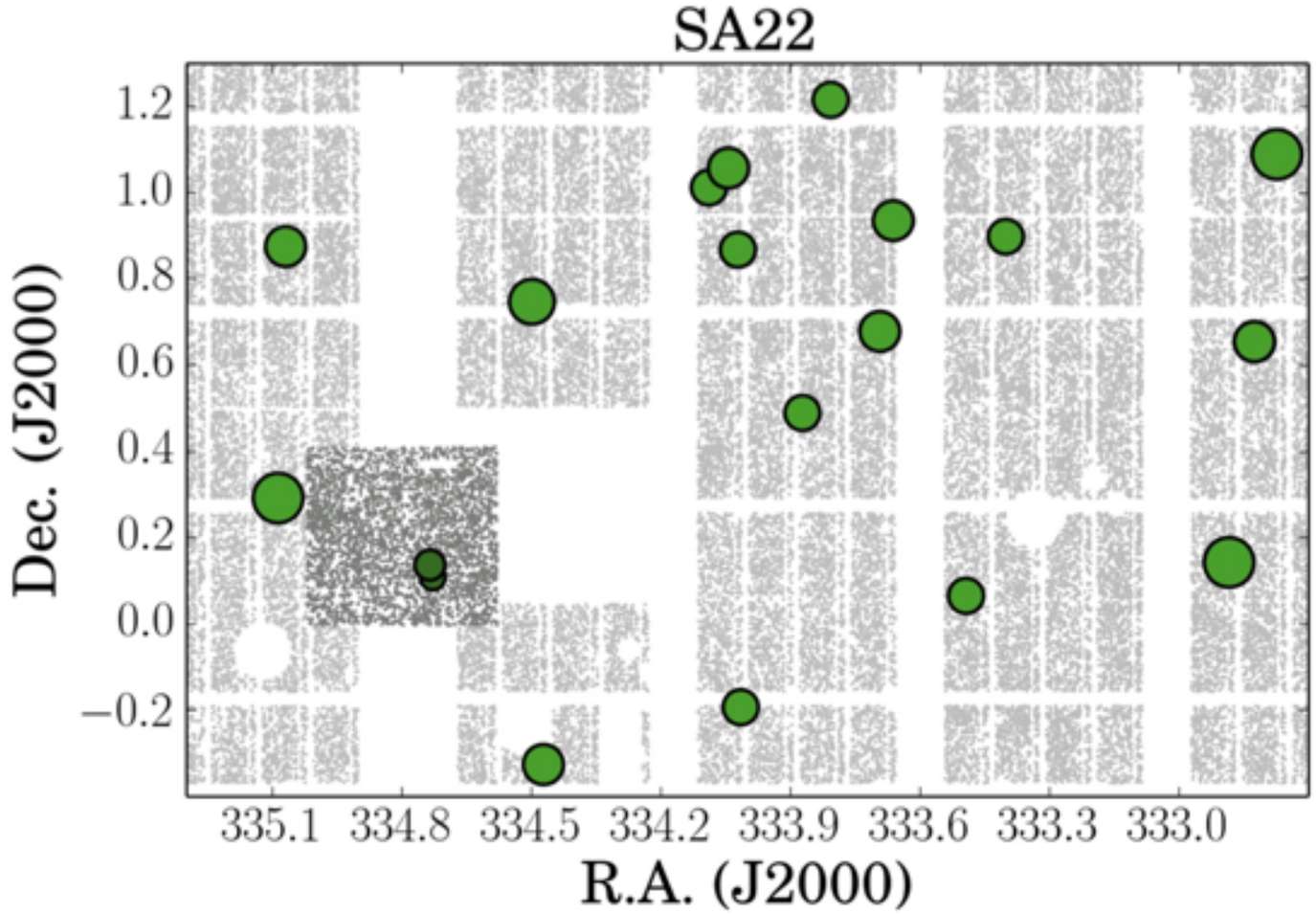


Jensen et al. 2012

Subaru Suprime-Cam
+ NB921

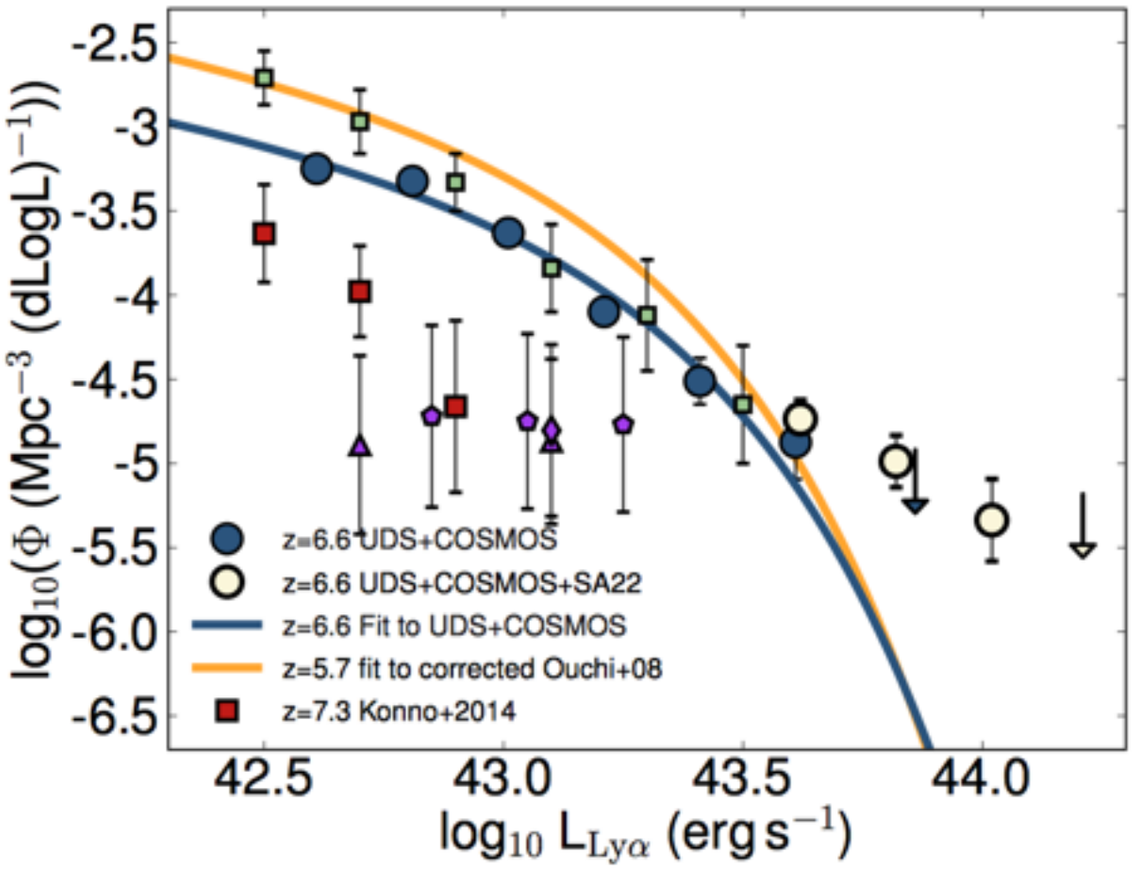
New surveys of LAEs
at z = 6.5;
Same L limits to Subaru
NB surveys at z = 5.7;
5 deg^2 in total;
Candidates: 135 at z=6.5
2 brightest confirmed





Matthee et al. 2015

Luminosity Functions



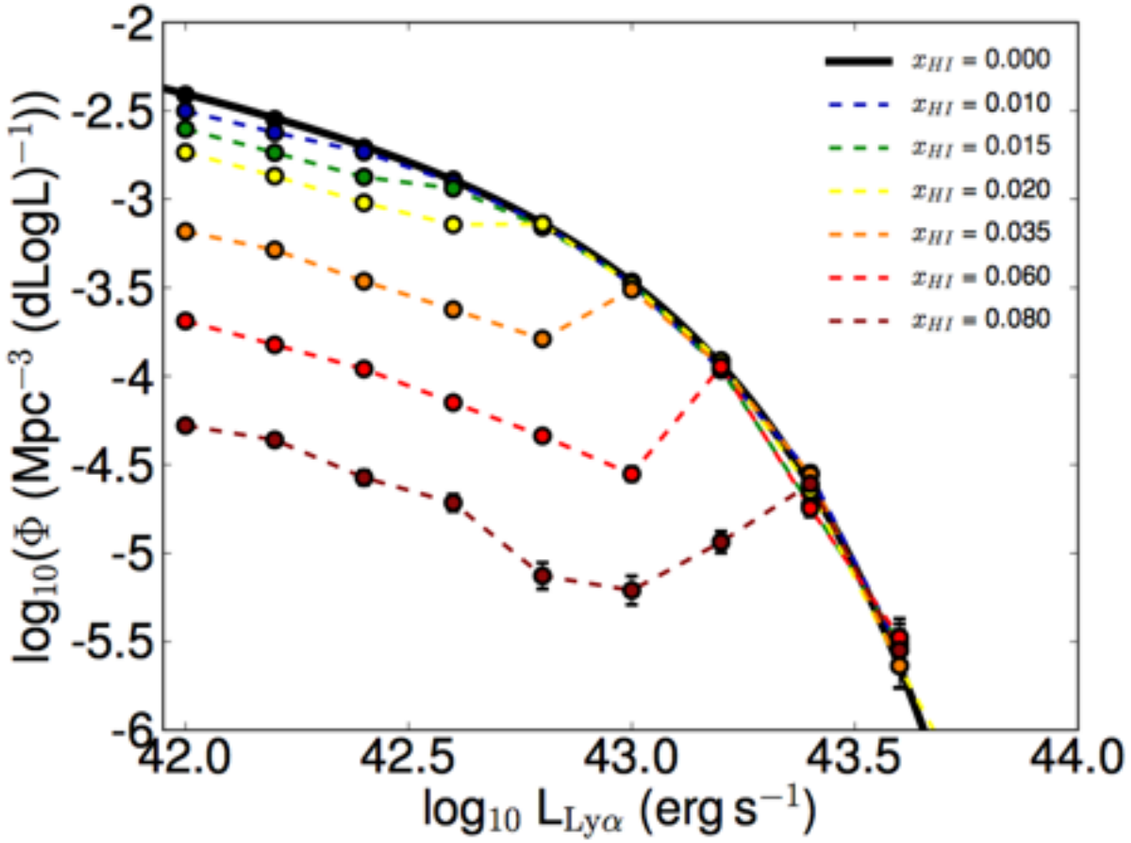


Figure 8. *Left:* Evolution of the luminosity function evolution from $z = 7.3$ to $z = 5.7$. We compare our $z = 6.6$ LF (blue solid line) to published data at $z > 7$ Konno et al. (2014) (red squares) Shibuya et al. (2012); Ota et al. (2010); Iye et al. (2006) (purple triangles, pentagons and diamond, respectively). We also show our LF fit to the corrected $z = 5.7$ data (orange solid line) and the green squares show the number densities at $z = 5.7$ from Ouchi et al.

Note: 135 candidates at z = 6.5 (5 deg^2, Matthee+15)
but 7 candidates at z = 7.3 (0.4 deg^2, Konno+14)

Matthee et al. 2015

Summary:

For our proposal of z=7 LAEs with DECam

DECam + NB970 VS. HSC + N921 & N820

1. **600 LAEs at z~7 with L(Lya) >= L*(at z=6.5, e.g. Kashikawa+11)**
2. 300 LBGs
3. Thousands Low-z emitters, e.g., Ha, Hb, OIII, OII (Pirzkal+13)
4. High-z Quasars, e.g., through Lya (z=7) or CIV(z=5.3) and Lya Blobs.

- **Clustering** → Cosmic ionized Fraction at z=7
- **Lya LF**
- **Galaxy properties, e.g., mass, metallicity, age, dust, morphology** → First generation galaxies?
- **Lya Escape fraction (compare to UV, IR)**
- **Lya line profile, width, EW distribution**
- **other sciences related with LBGs, low-z emitters, Quasars and Lya Blobs.**

THANKS!

Technical Challenges

- Filter profile varies over DECam FOV.

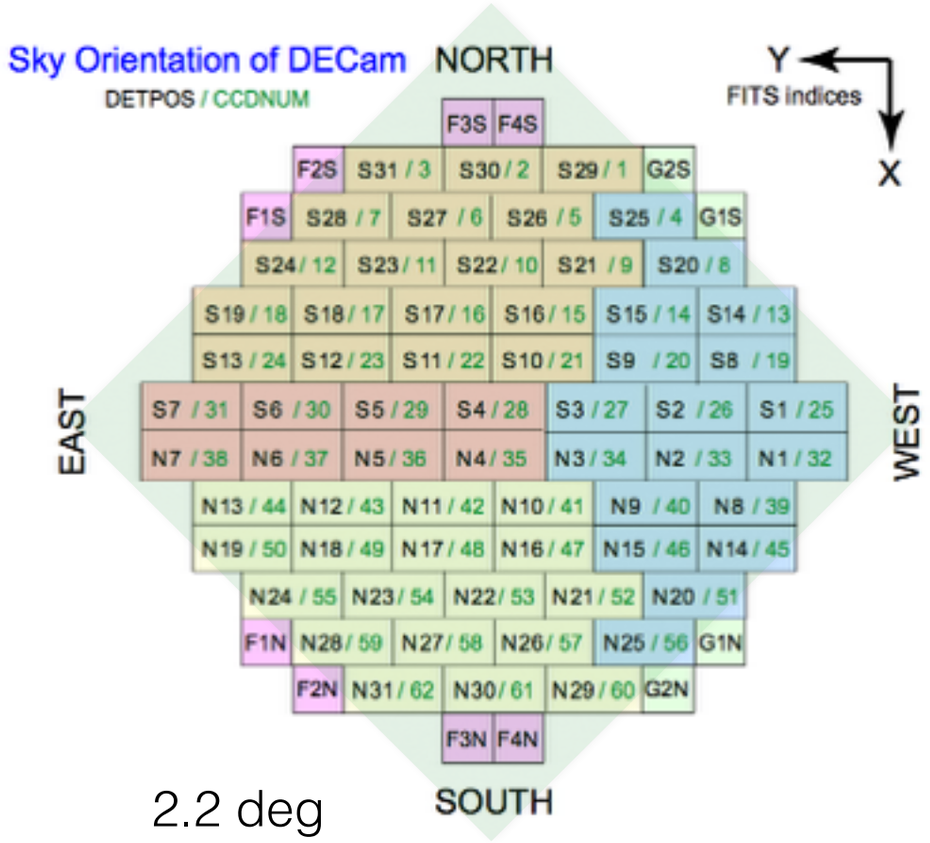
  Use zcosmos catalog, or see (Ting Li's poster)

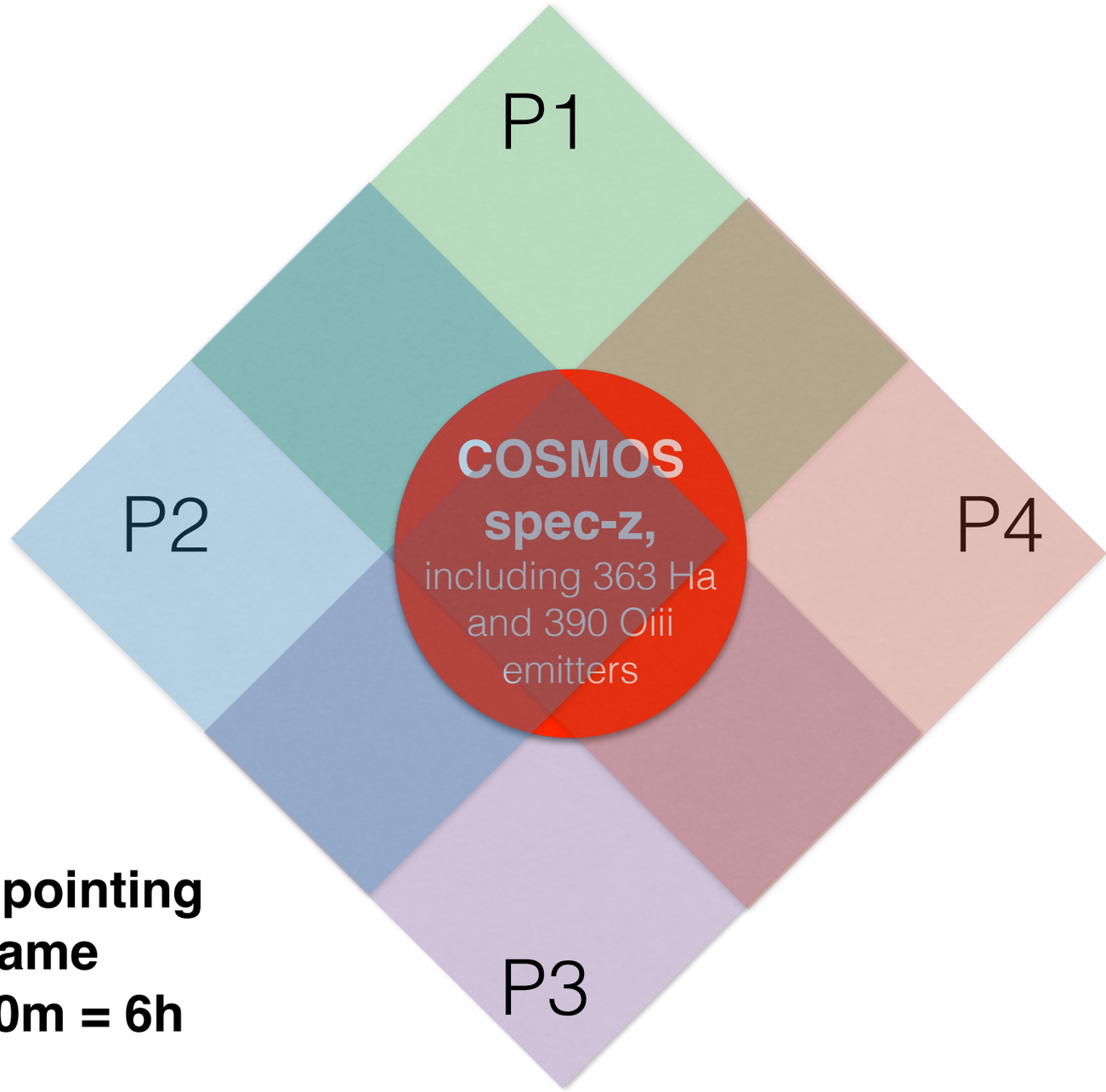
- Nonlinearity at low-ADU. (Gary Bernstein's talk)

- Data reduction, optimized for narrowband data

Pilot Survey on NB968 with DECam

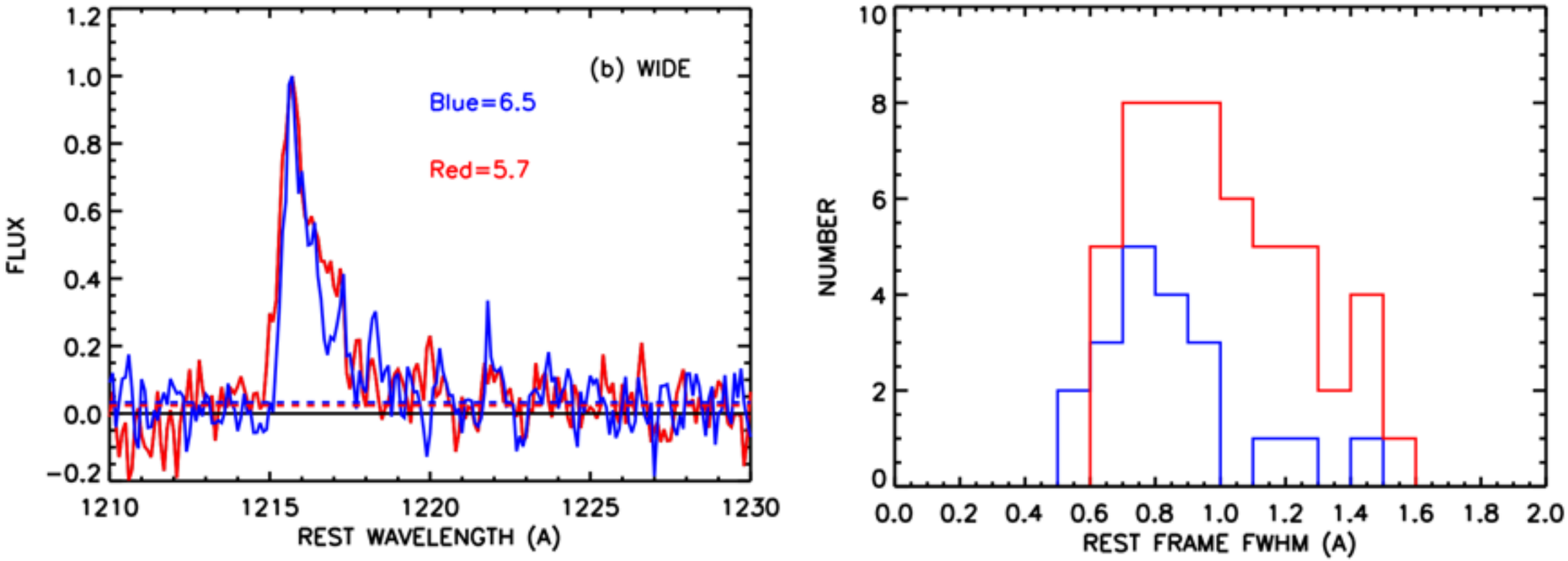
—proposed for 2015A/B Chilean time





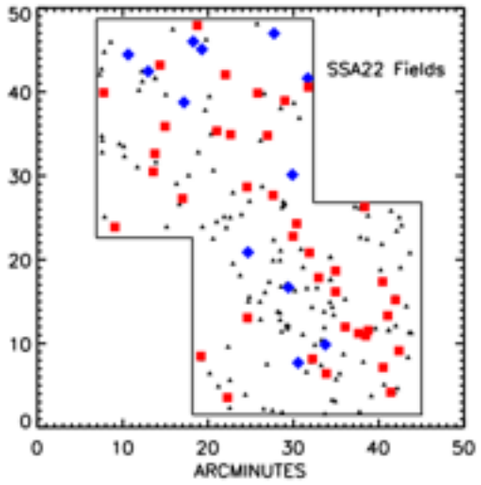
4 pointings, with 9 frames per pointing
10min NB exposure each frame
total NB exposure: 4x9x10=360m = 6h

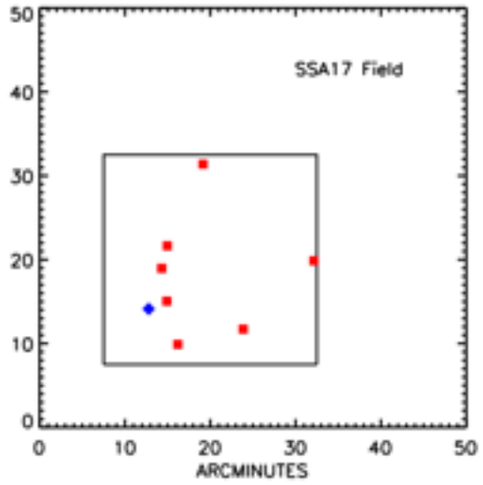
Line Profile & Width (need spectroscopic obs.)

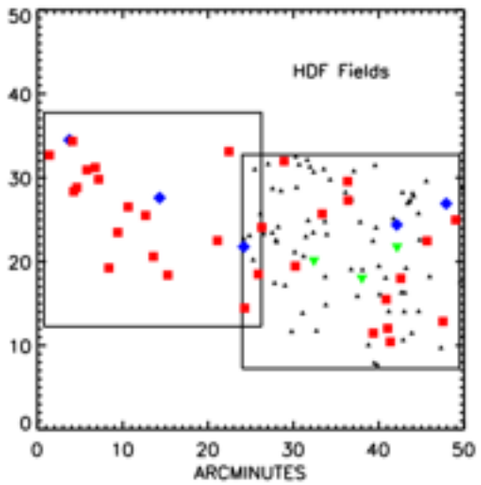


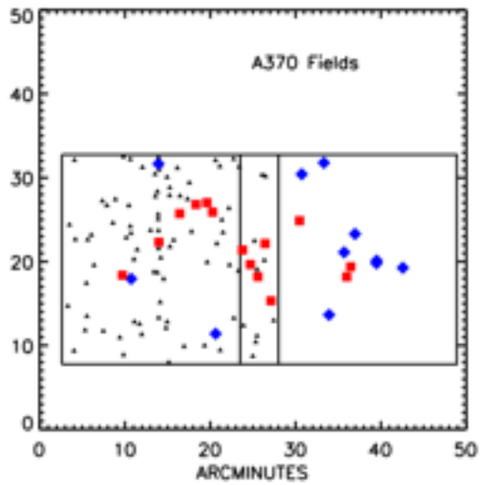
Hu et al. 2010

LAE surveys at z = 5.7 & 6.5 results before 2014







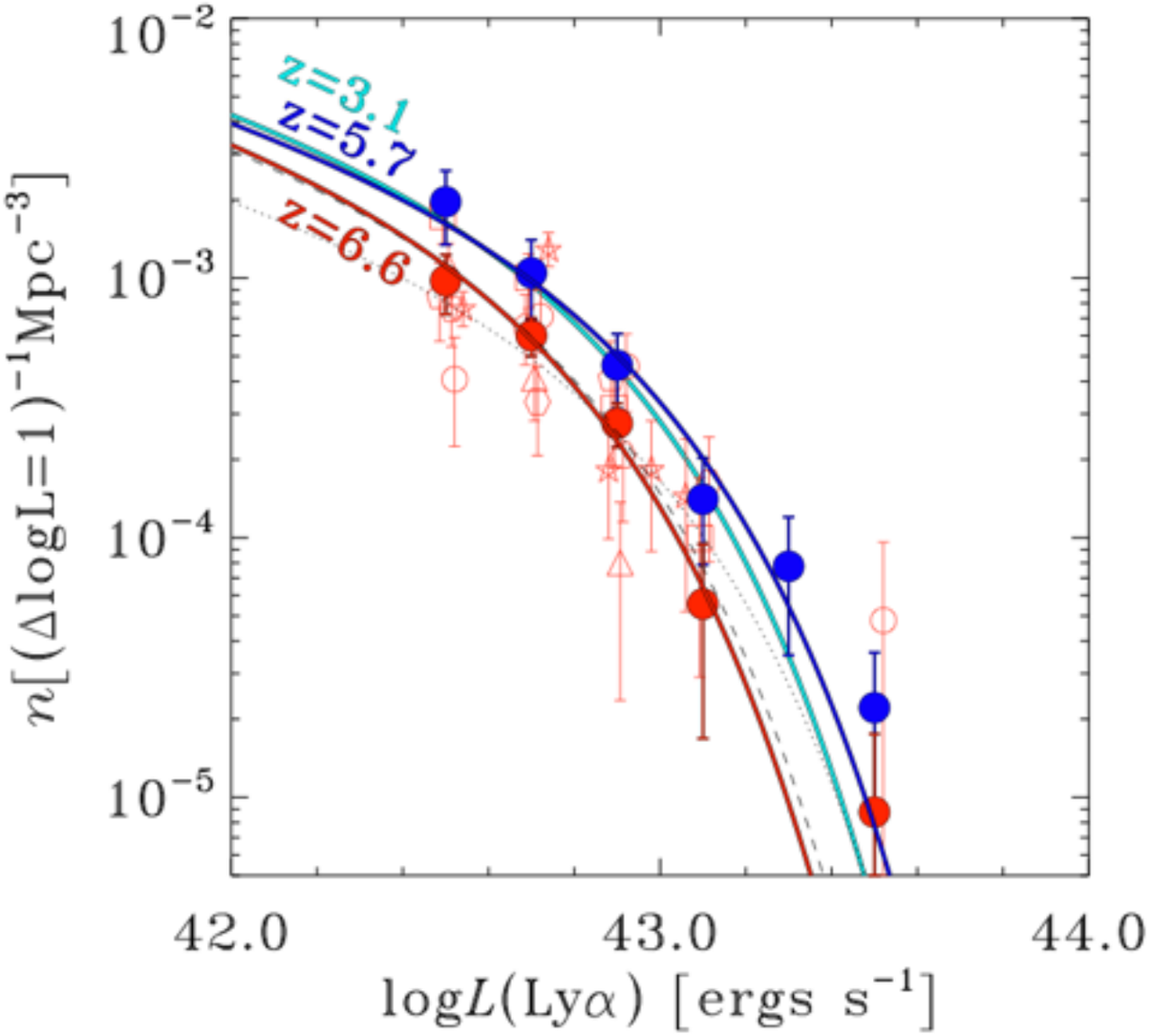


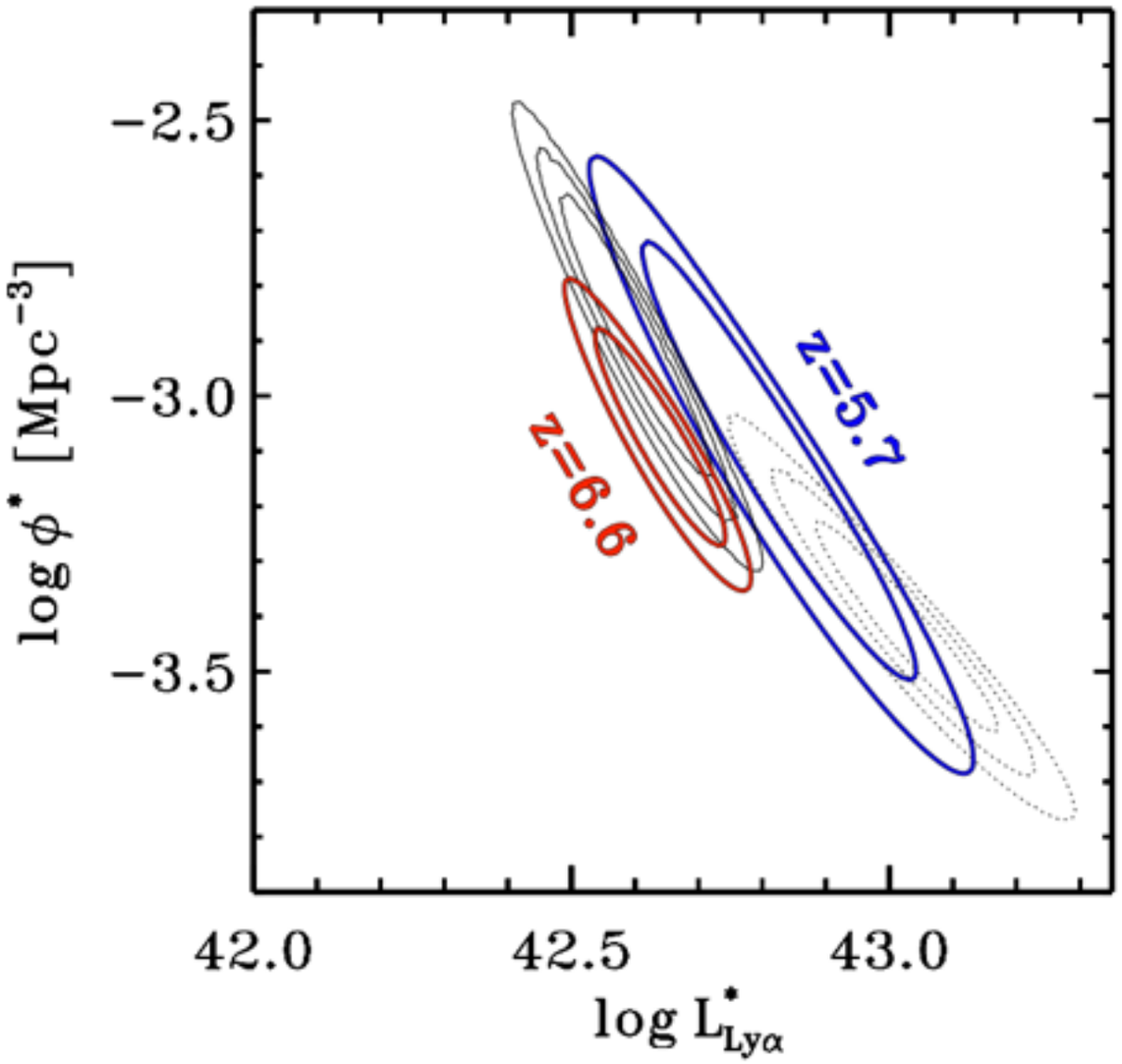
Hu et al. 2010

In Subaru X-ray Deep Field

Ouchi et al. 2010
Kashikawa et al. 2011

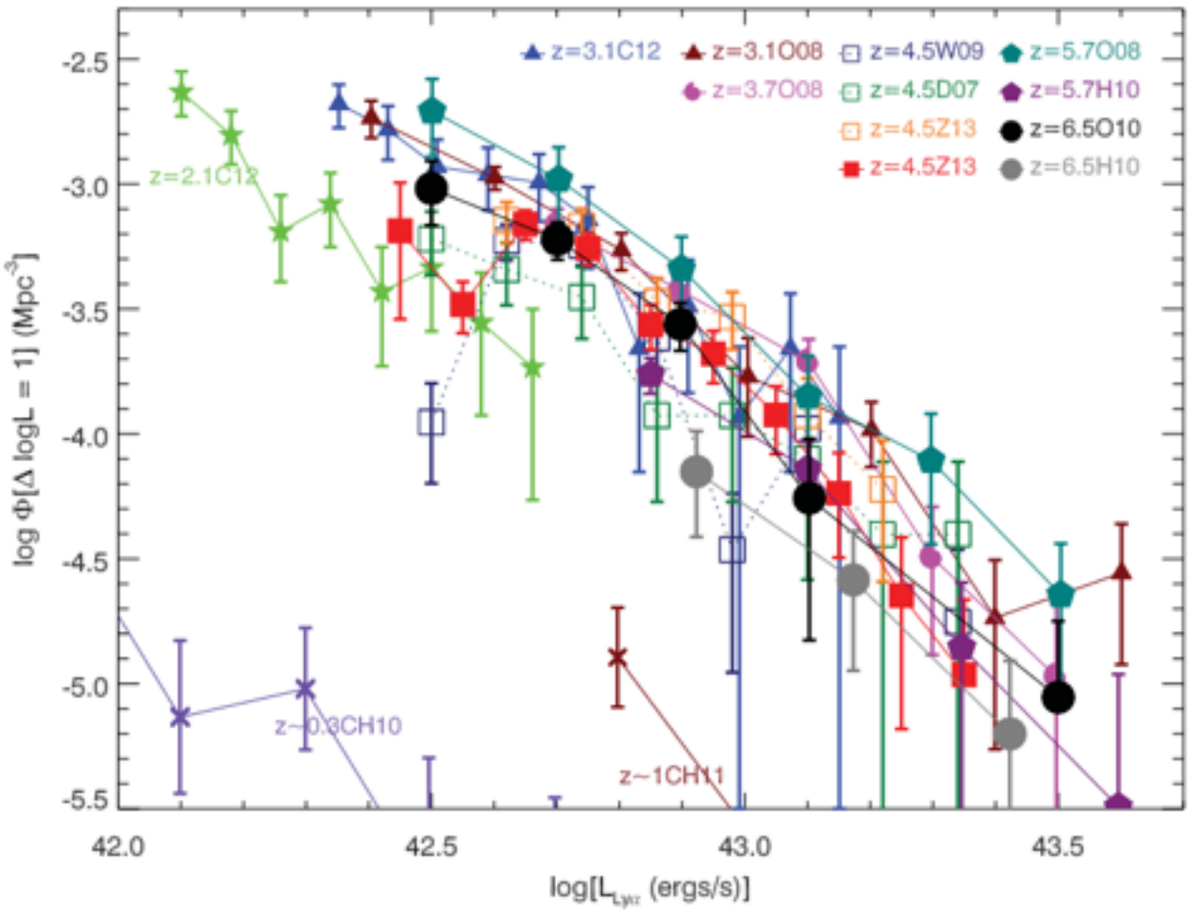
Evolution?

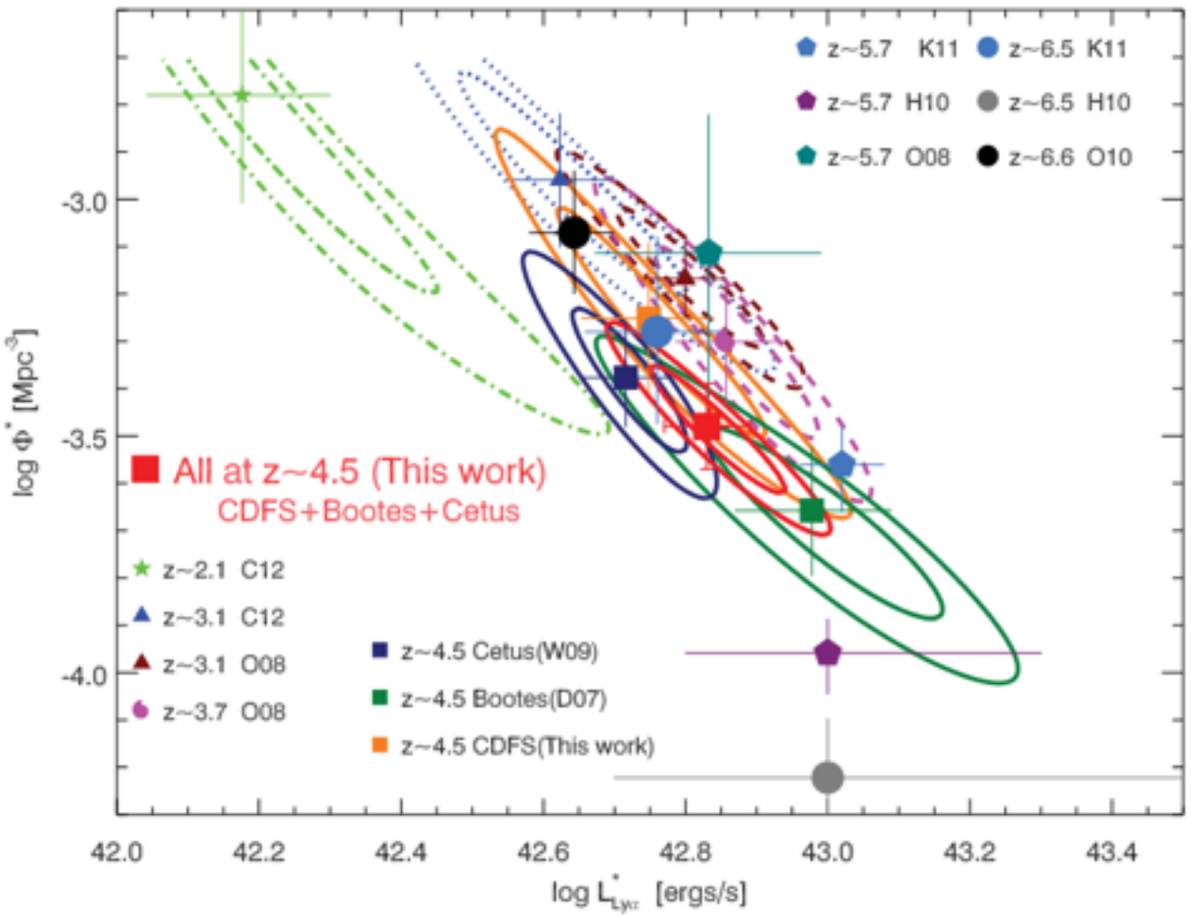




Ouchi et al. 2010

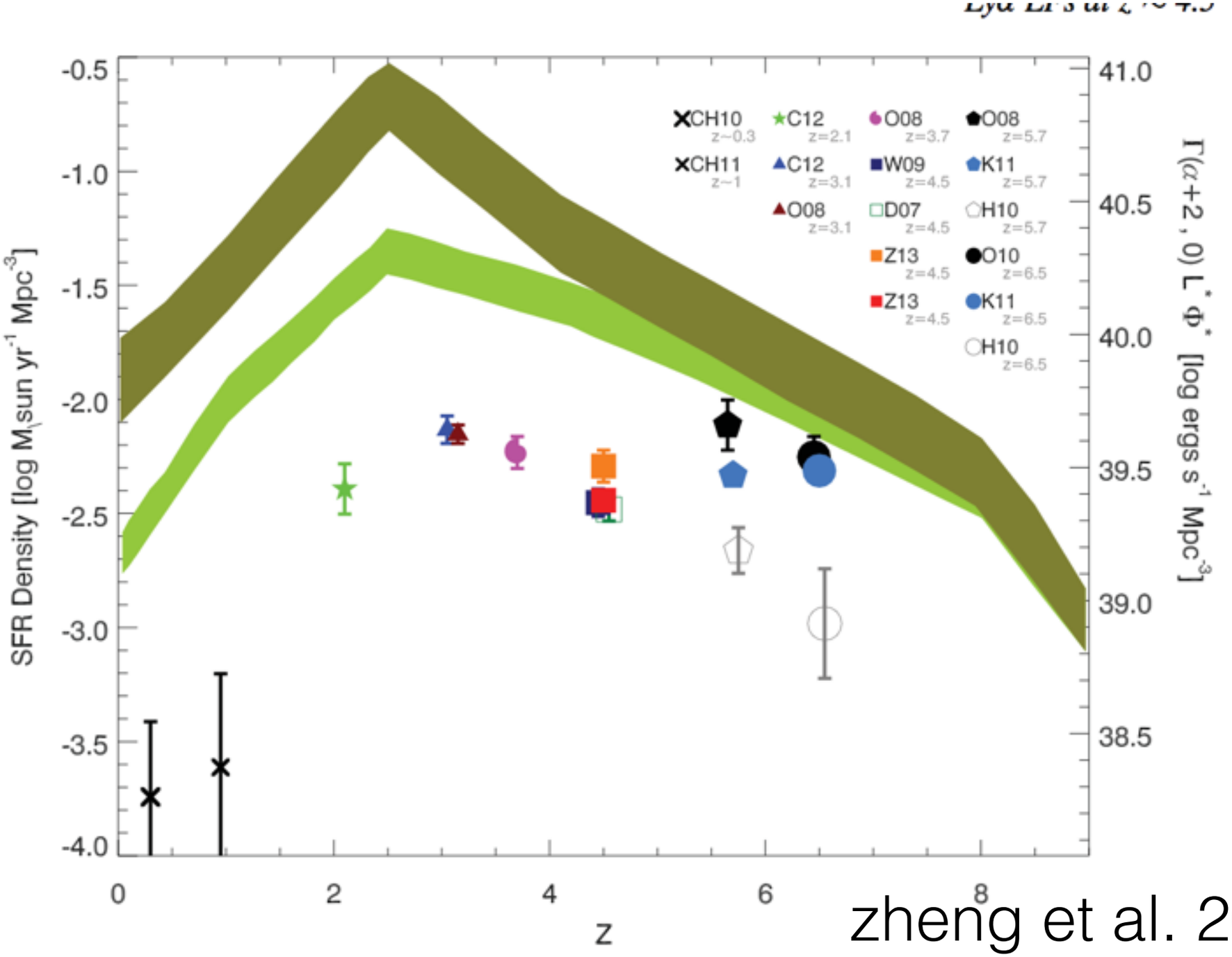
Lya LF from 0.3 to 6.5





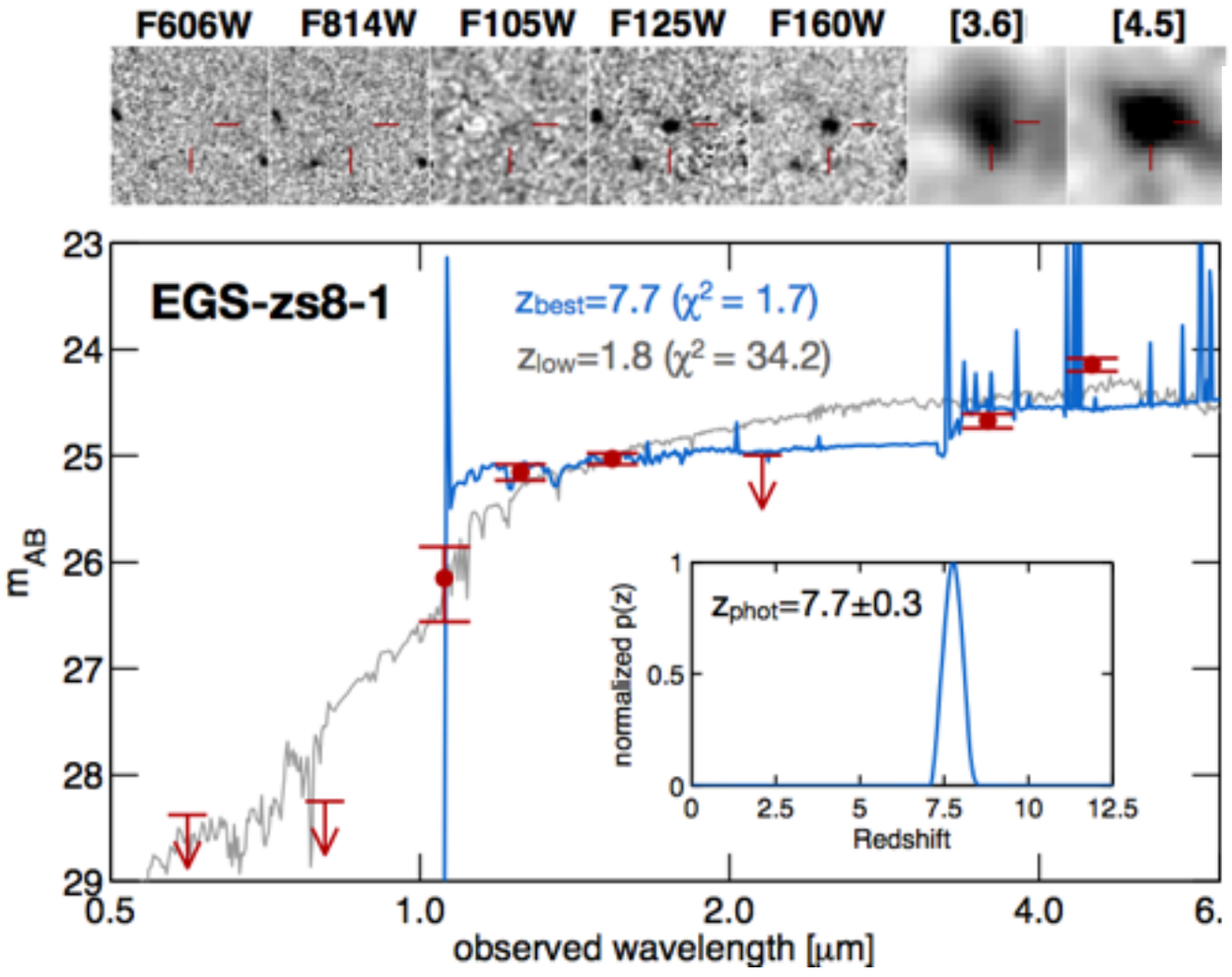
zheng et al. 2013

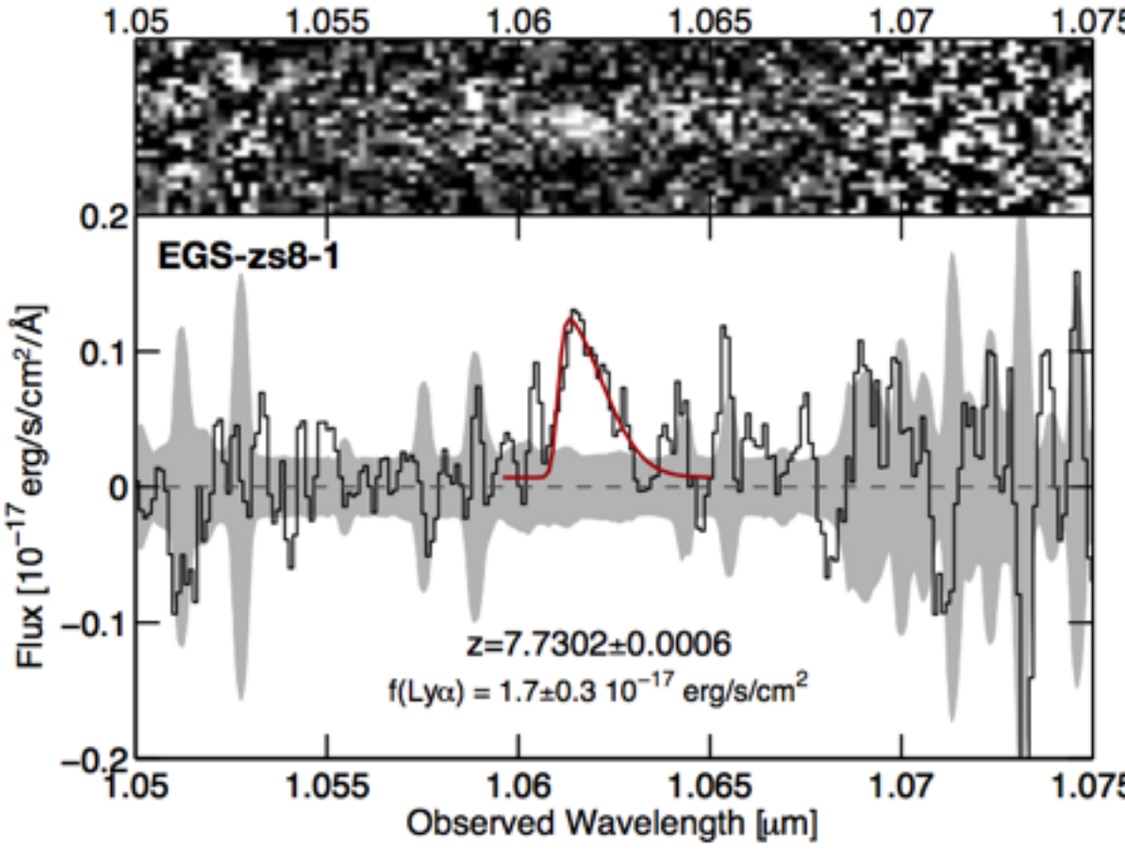
Cosmic SFR Density, Lya Escape



zheng et al. 2013

z=7.73 LBG





Oesch et al. 2015, astro-ph/1502.05399