Spectroscopic Searches for Lyα Emission

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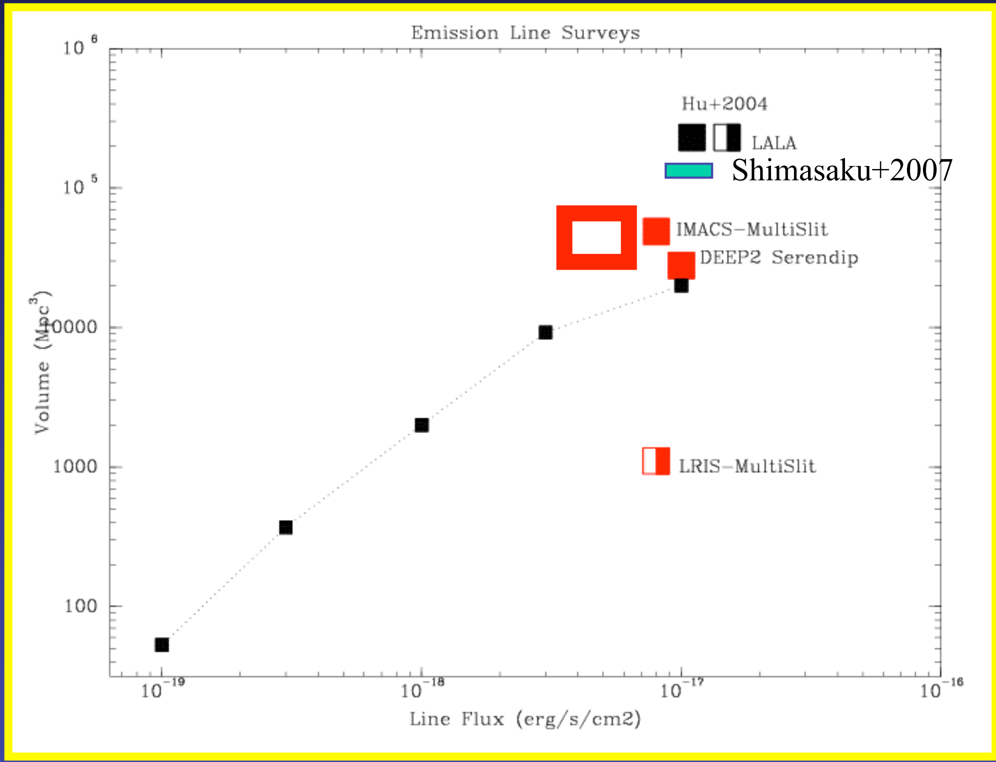
See astro-ph/0802.2393

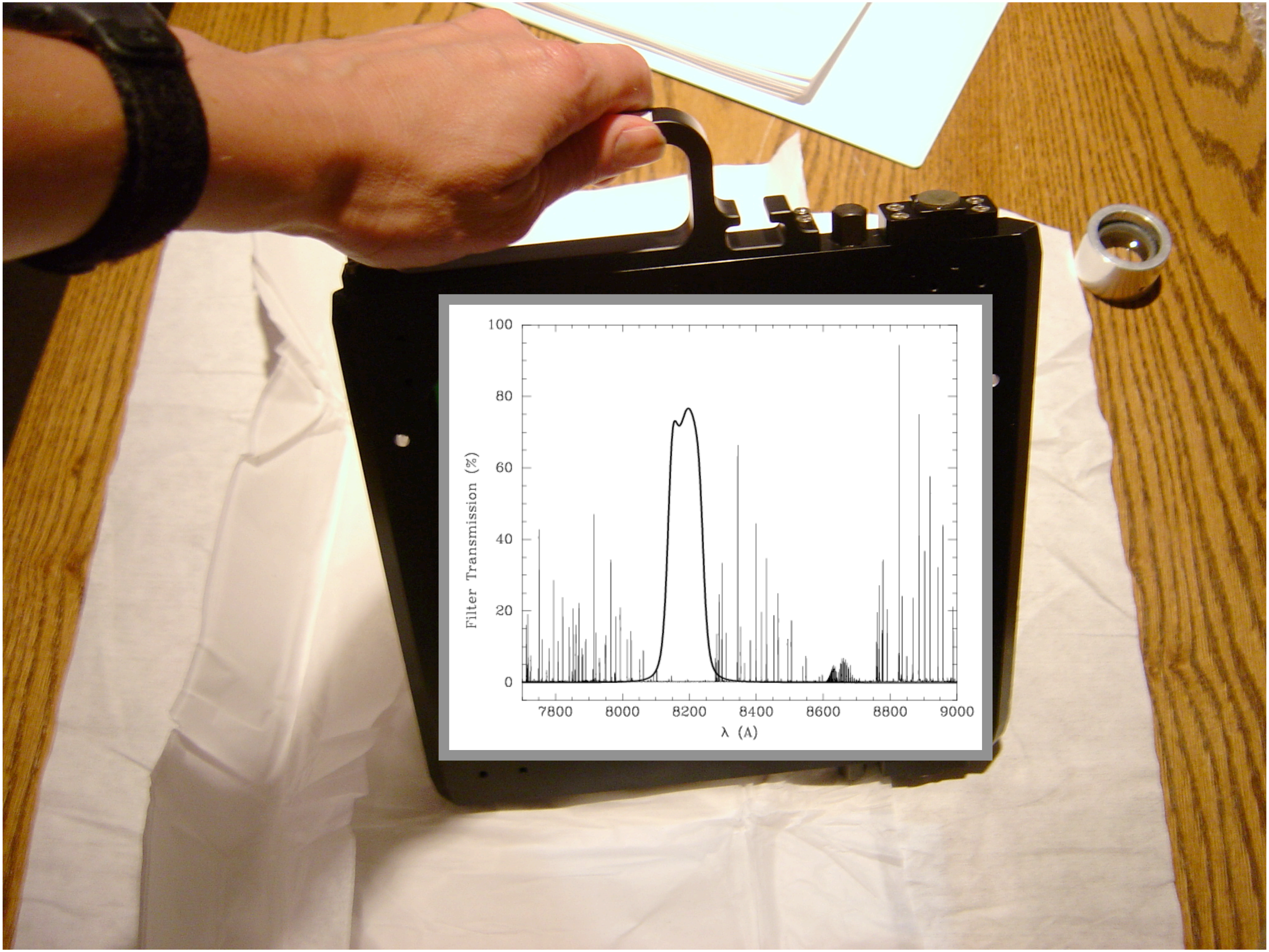
Why Lya Selection?

- Optimizes contrast with night sky (from ground)
- Selects the building blocks of galaxies
- Quantifies stellar feedback
- Probes progression of Cosmic Reionization

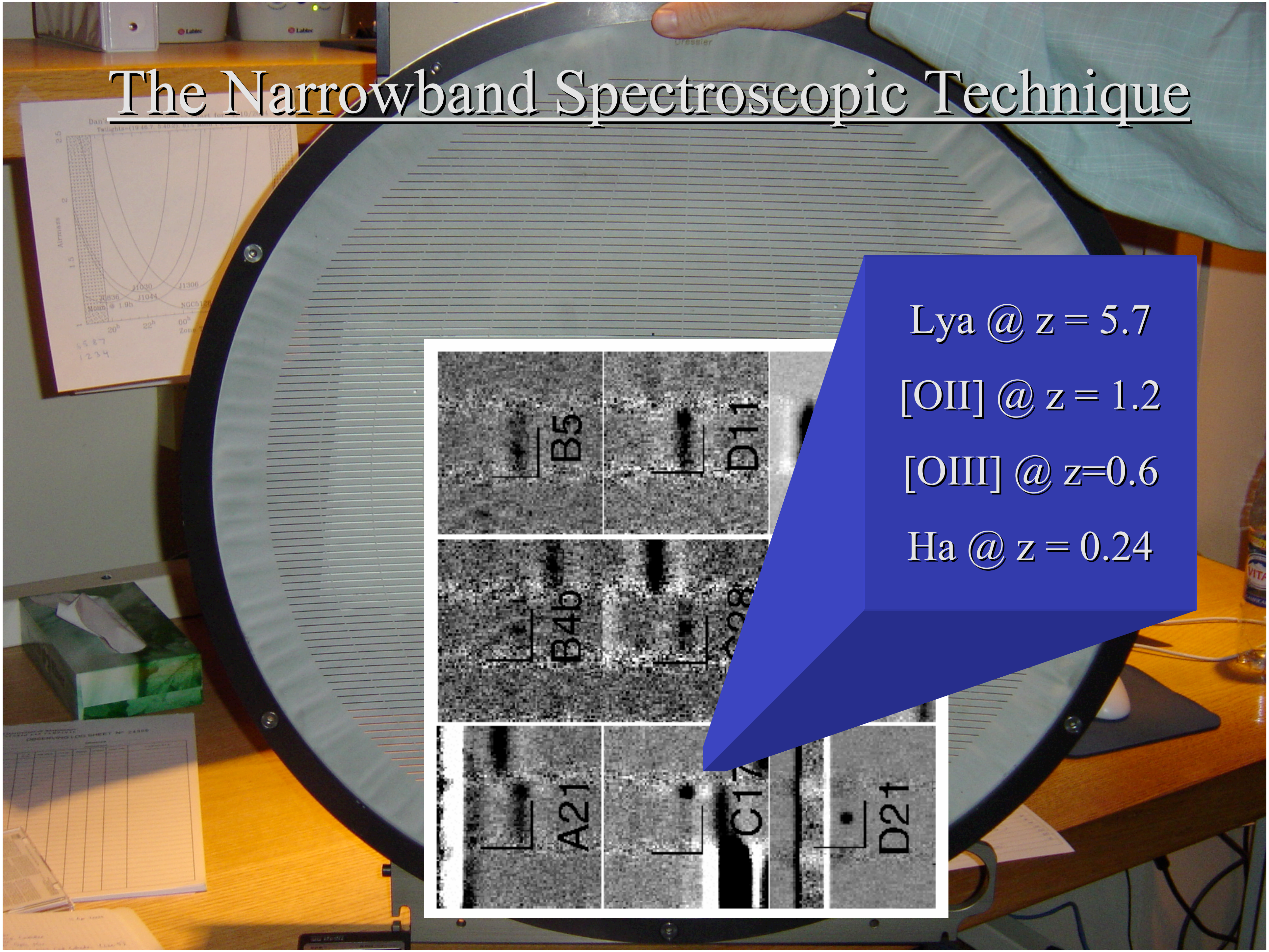
Pilot Programs: Multislit Narrowband Spectroscopy

1. Crampton & Lilly 1999 ASP Conf Series 191, 229
2. Martin & Sawicki 2004, ApJ 603, 41.
3. Tran et al 2004 ApJ 612, 89
4. Martin, Sawicki, Dressler, McCarthy 2008 ApJ May 20




Filter Transmission (%)
0
20
40
60
80
100
7800
8000
8200
8400
8600
8800
9000
λ (Å)

The Narrowband Spectroscopic Technique

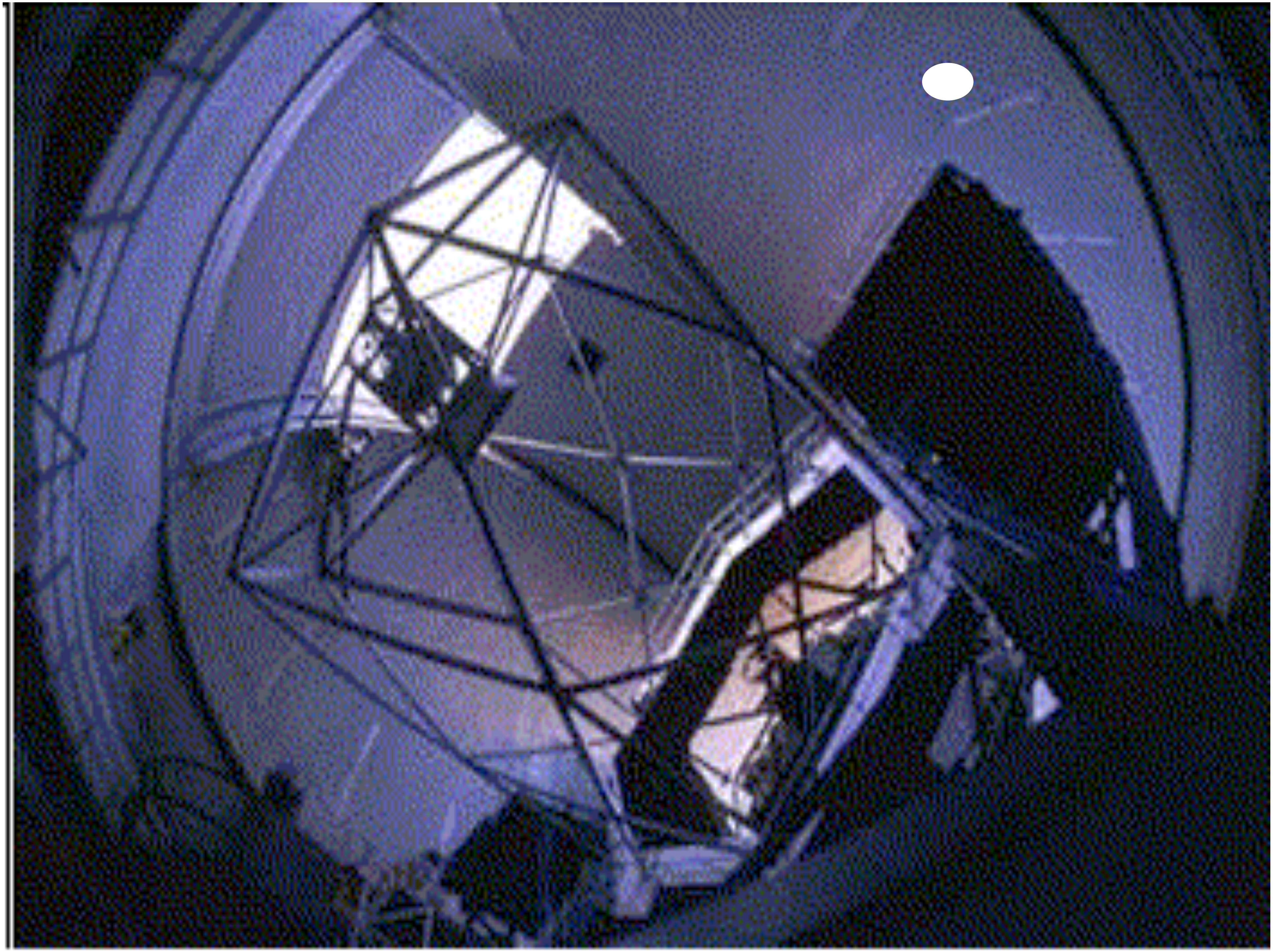


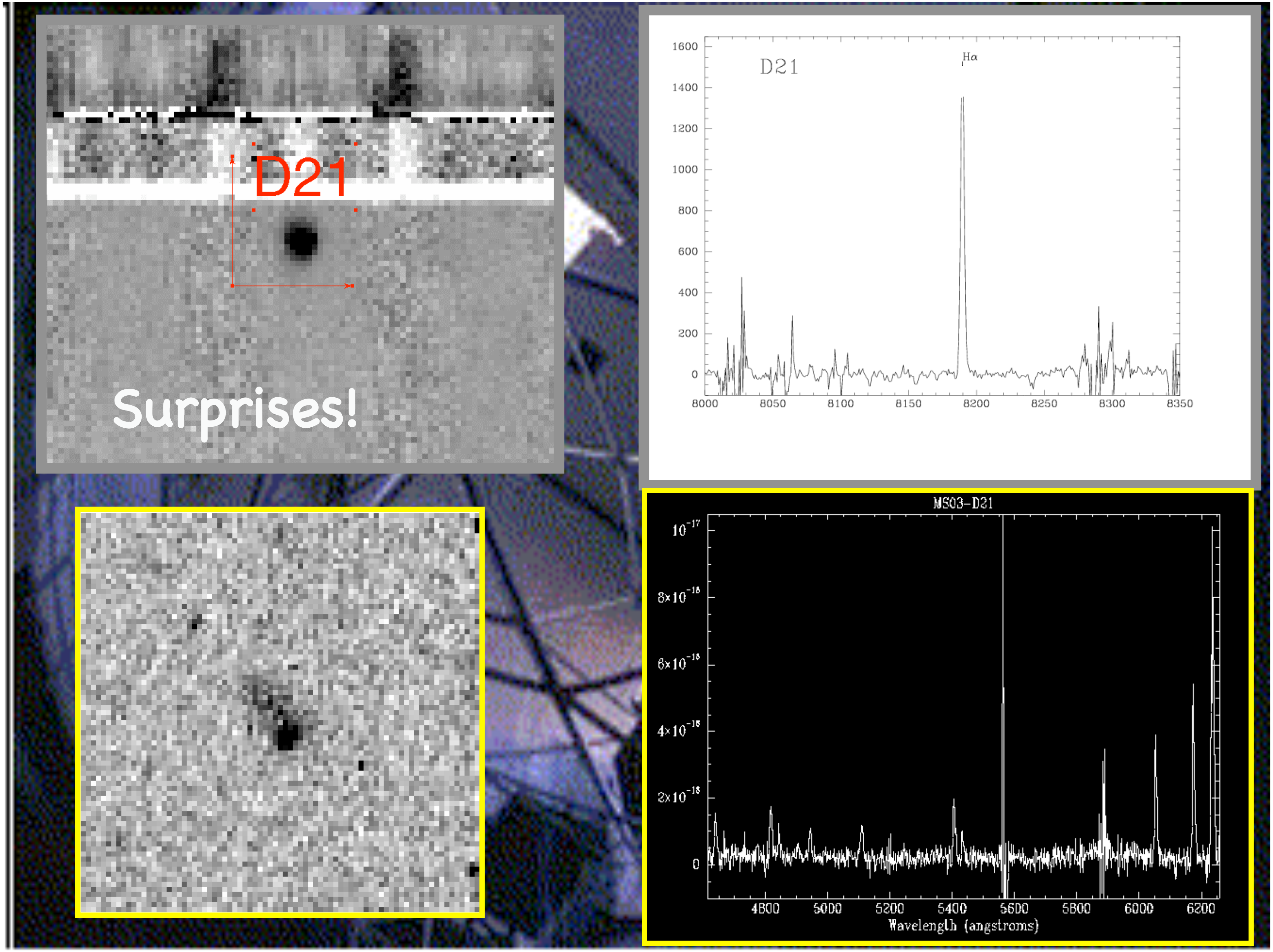
Lya @ z = 5.7

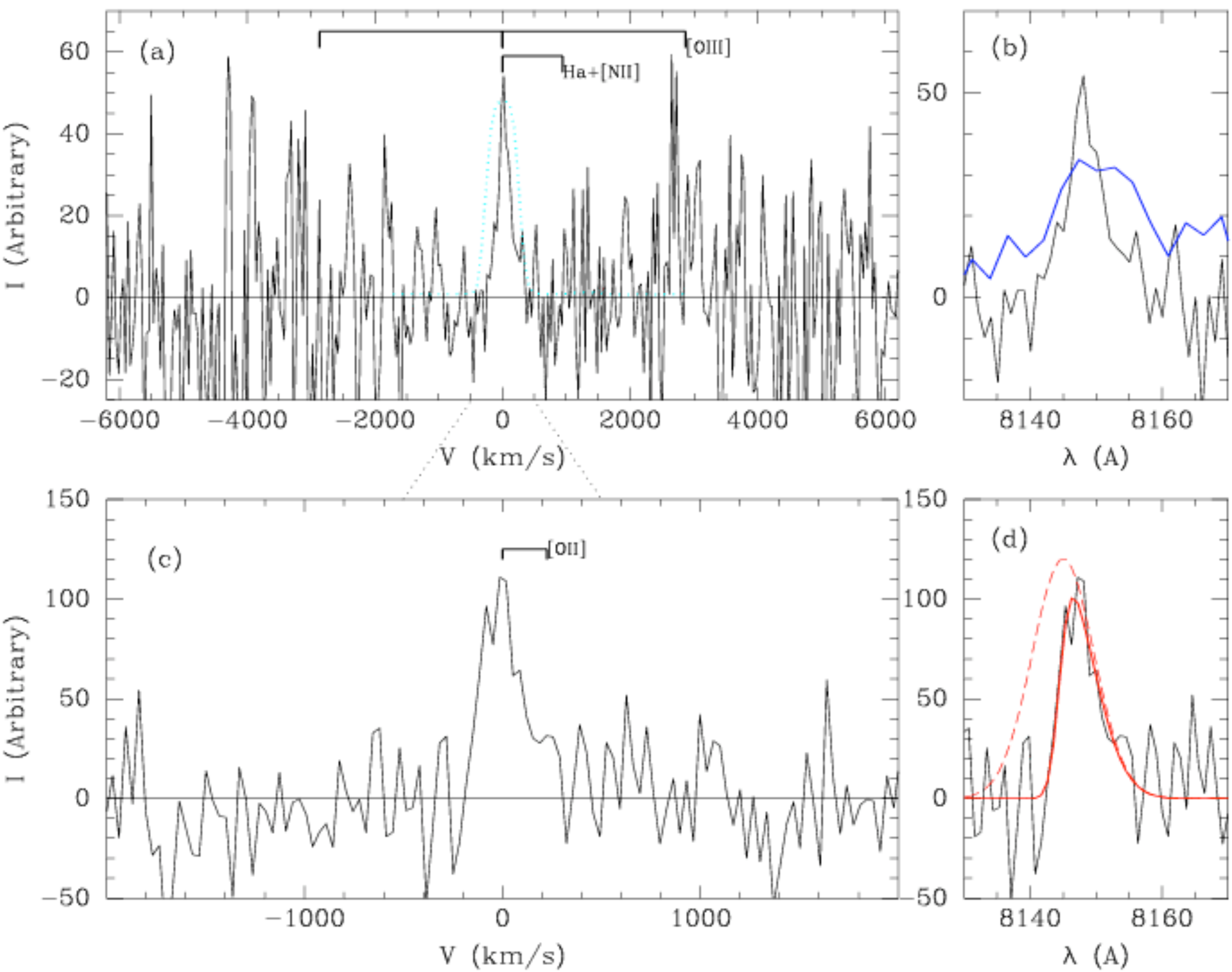
[OII] @ z = 1.2

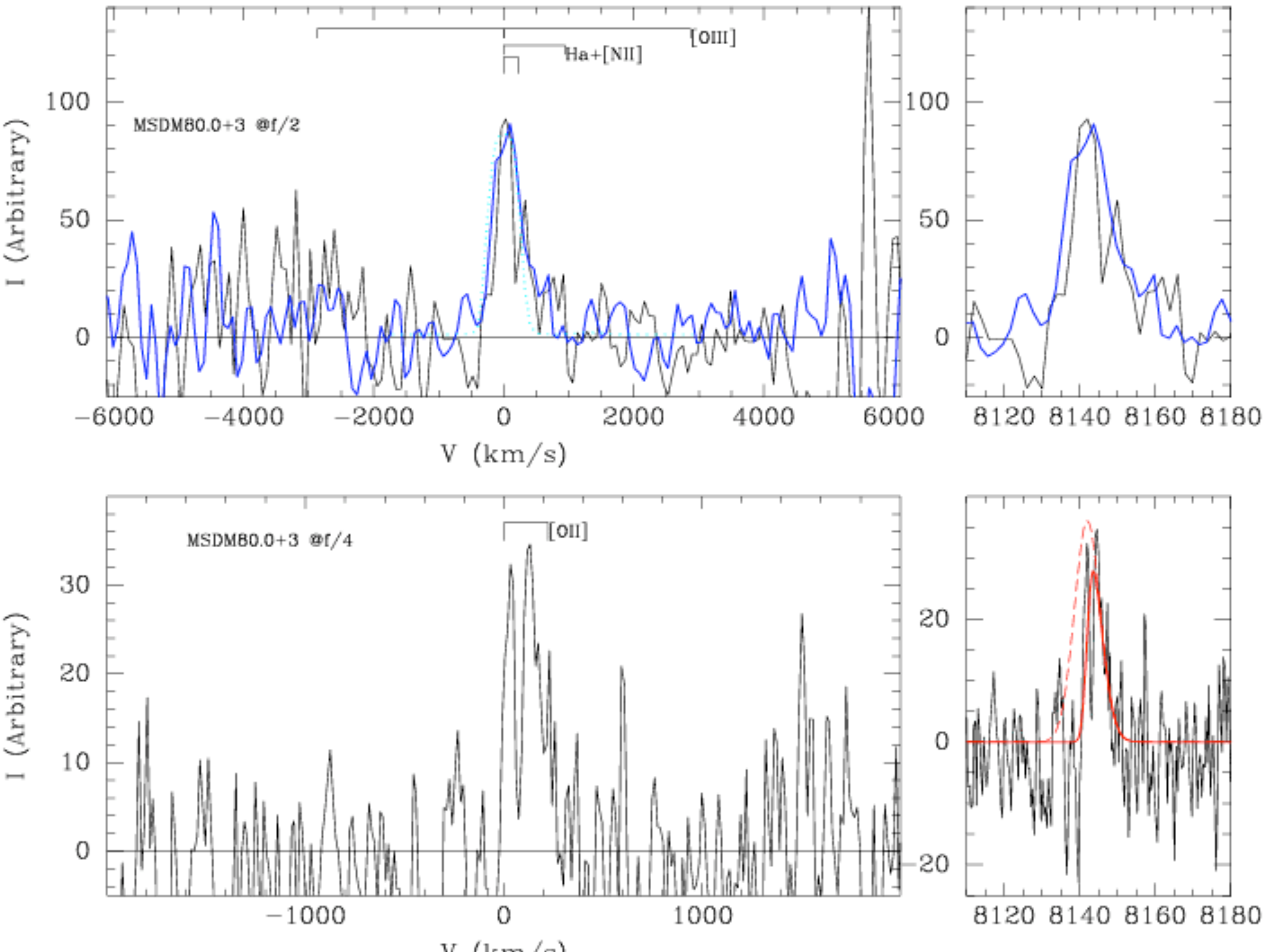
[OIII] @ z=0.6

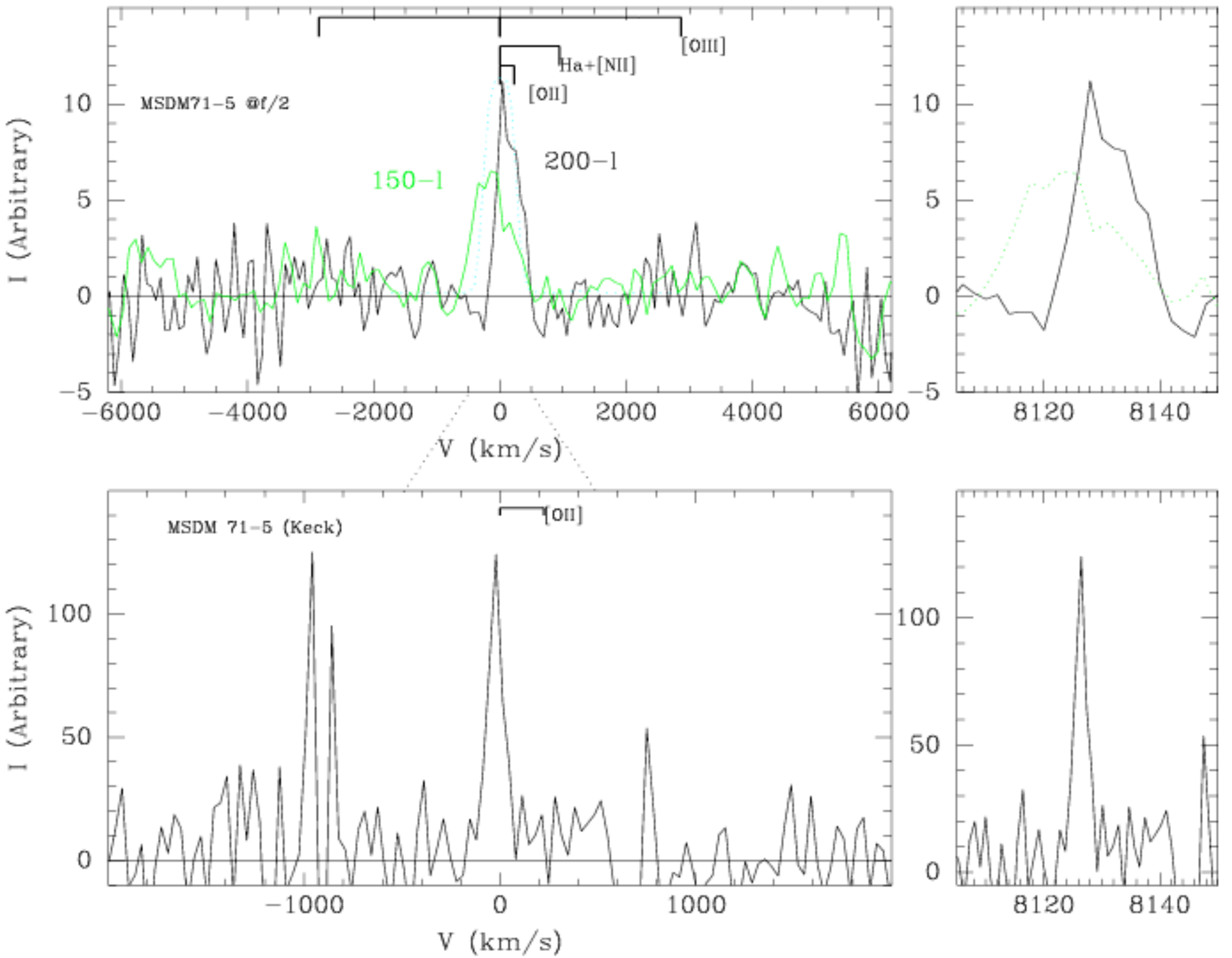
Ha @ z = 0.24




D21
Surprises!
D21
Hα
1600
1400
1200
1000
800
600
400
200
0
8000
8050
8100
8150
8200
8250
8300
8350
MS03-D21
10^{-17}
8×10^{-18}
6×10^{-18}
4×10^{-18}
2×10^{-18}
0
4800
5000
5200
5400
5600
5800
6000
6200
Wavelength (angstroms)

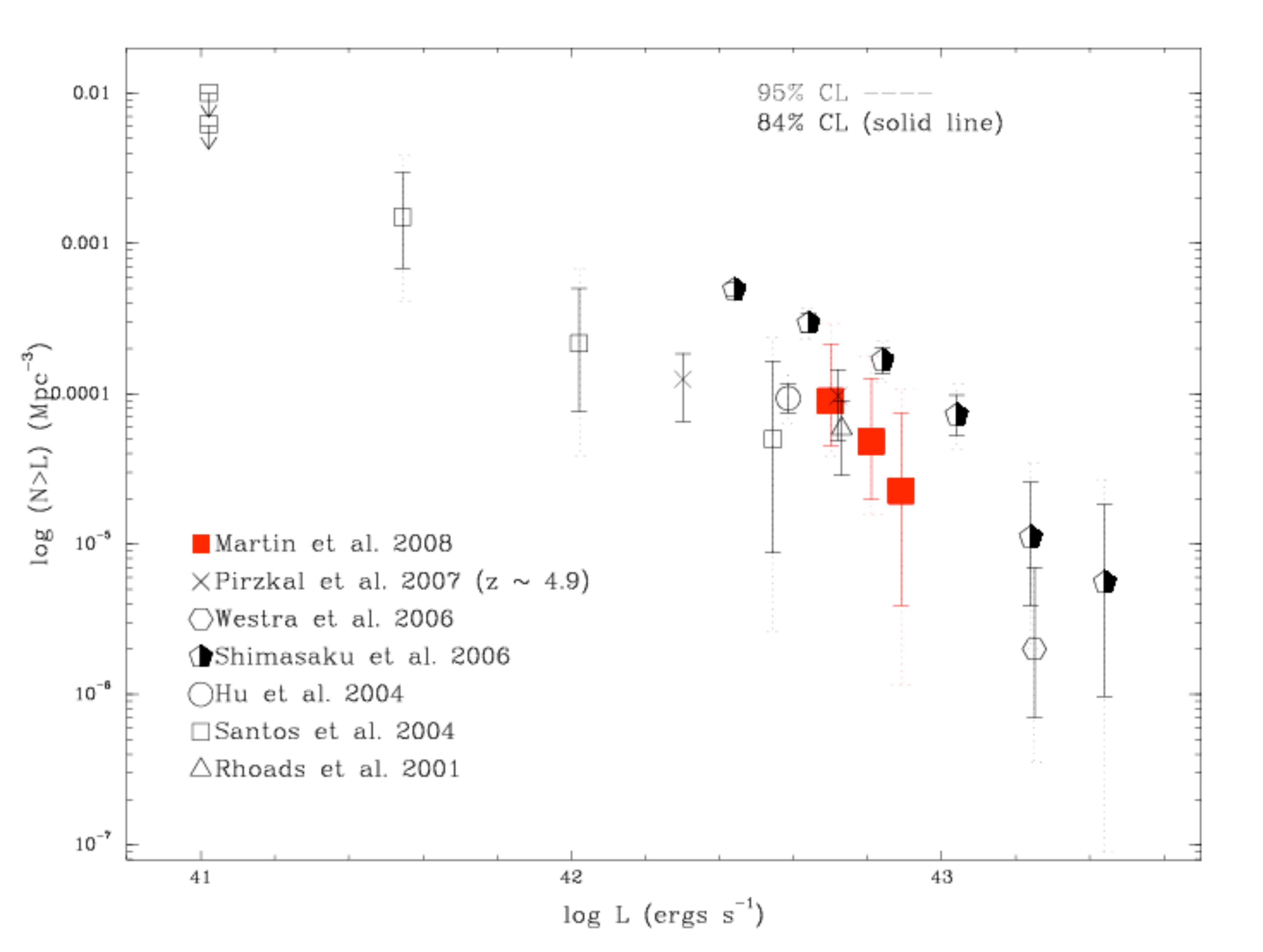

(a)
[OIII]
Ha+[NII]
I (Arbitrary)
V (km/s)
(b)
λ (A)
(c)
[OII]
I (Arbitrary)
V (km/s)
(d)
λ (A)


[OIII]
Ha+[NII]
MSDM80.0+3 @f/2
I (Arbitrary)
V (km/s)
MSDM80.0+3 @f/4
[OII]
I (Arbitrary)
V (km/s)



[OIII]
Ha+[NII]
[OII]
MSDM71-5 @f/2
150-1
200-1
I (Arbitrary)
V (km/s)
MSDM 71-5 (Keck)
[OII]
I (Arbitrary)
V (km/s)

Cumulative LyA Luminosity Function



Constraints on LAE LF

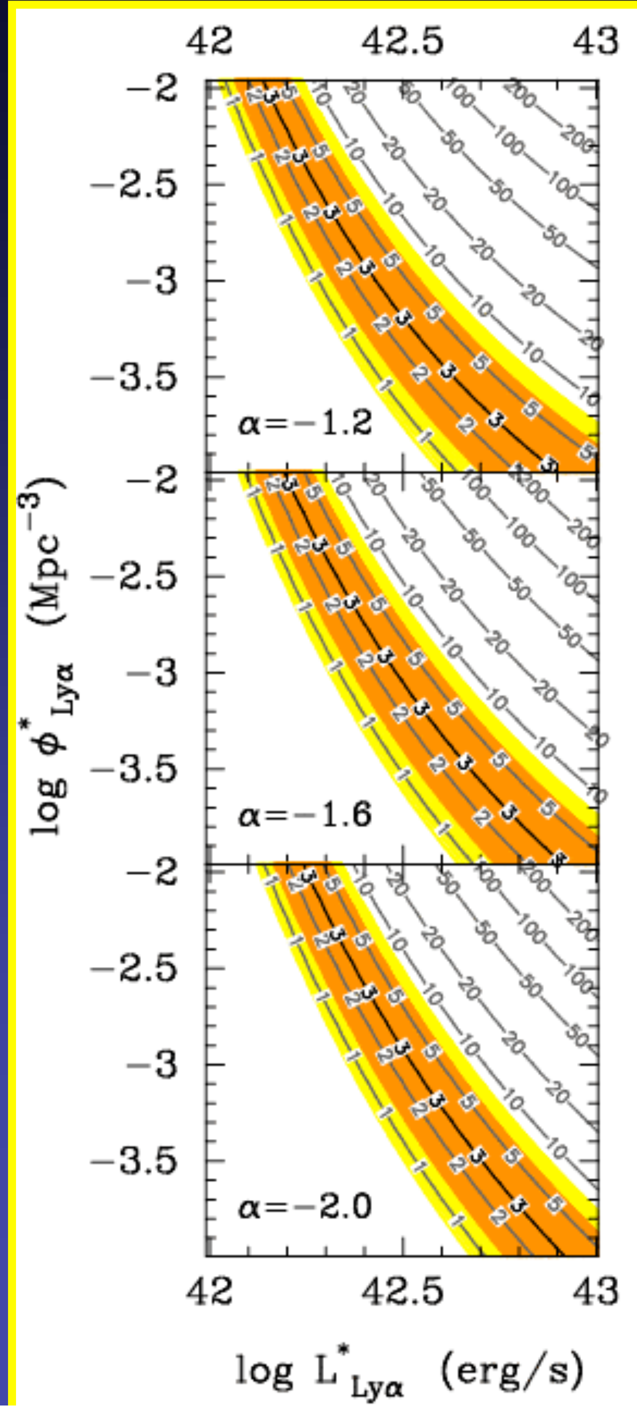
$$d\Phi(L) = \mathbf{\Phi_0}\,(L/\mathbf{L^*})^{-\alpha}\, e^{(-L/\mathbf{L^*})}\, d(L/\mathbf{L^*})$$

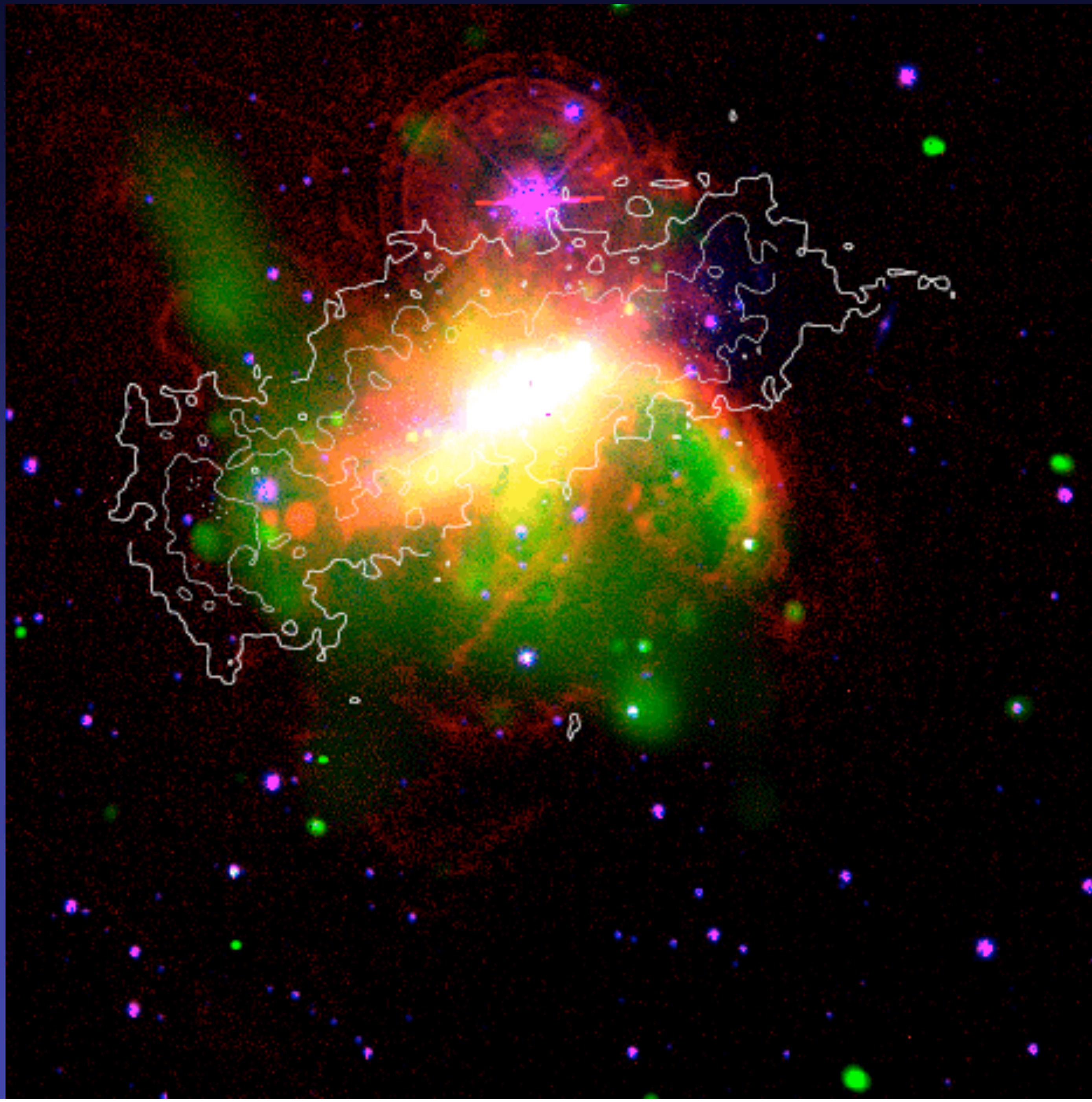
- Faint-end slope
- Exponential cut off
- Normalization

• Fold model through experimental response function to get average number recovered.

• Poisson errors on our 3 confirmed LAEs define the range of acceptable LF parameters.

• Contribution to IGM ionization?





Lyα Luminosity Density

Integrate from Log L_{min}(Lya) = 42.57, 41.0

Photon production rate to ionize intergalactic gas…

$$\dot{N}_H = 10^{50.72}\ \mathrm{s^{-1}\ Mpc^{-3}}\ C_6 \left(\frac{1+z}{6.7}\right)^3 \left(\frac{\Omega_b h_{70}^2}{0.047}\right)^2$$

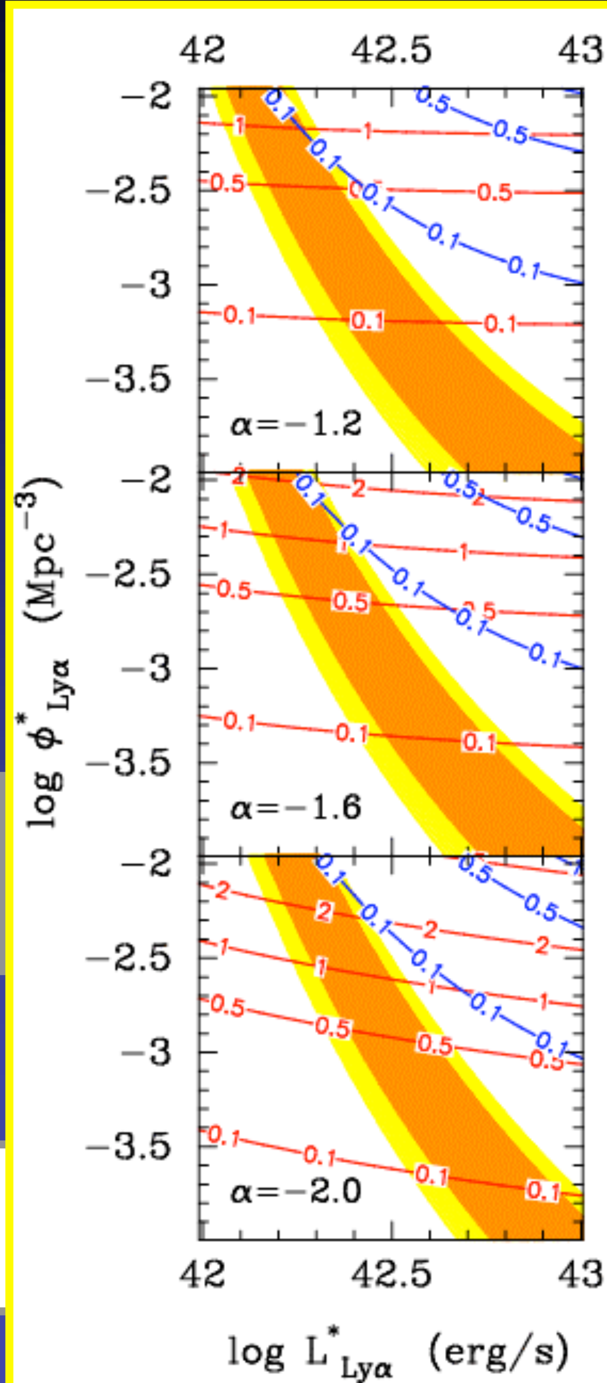
Assume stellar IMF to get SFR…

$$\dot{\rho}_* = 0.02\ \mathrm{M_\odot\ yr^{-1} Mpc^{-3}}\ C_6 f_{LyC,0.1}^{-1} \left(\frac{1+z}{6.7}\right)^3 \left(\frac{\Omega_b h_{70}^2}{0.047}\right)^2$$

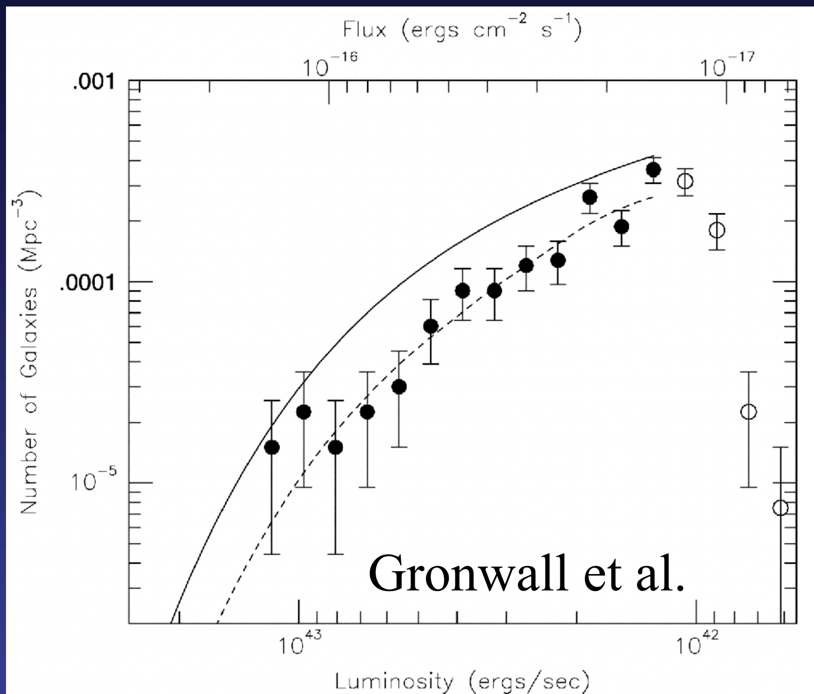
CASE B Recombination Lya emission…

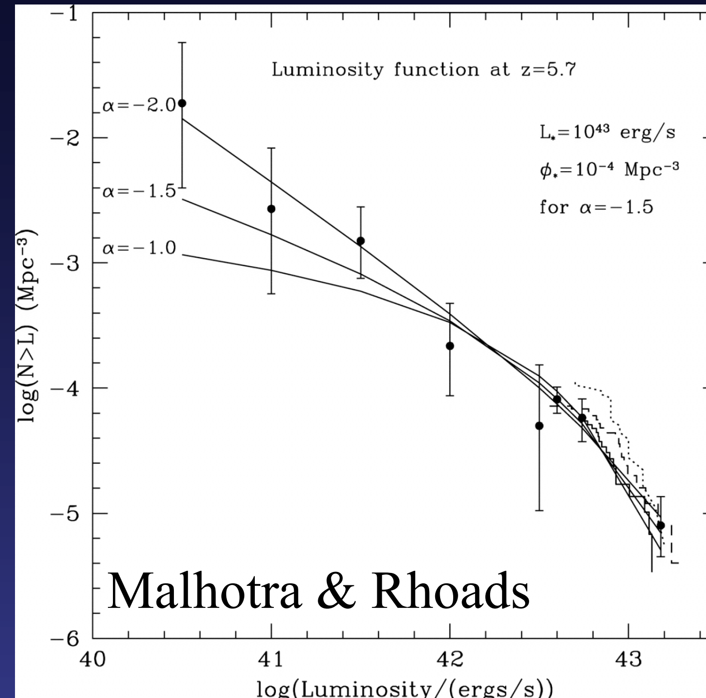
$$L_{Ly\alpha} = 3.0\times 10^{40}\ \mathrm{erg\ s^{-1} Mpc^{-3}}\ C_6 (1-f_{LyC,0.1}) \left(\frac{f_{Ly\alpha,0.5}}{f_{LyC,0.1}}\right) \left(\frac{1+z}{6.7}\right)^3 \left(\frac{\Omega_b h_{70}^2}{0.047}\right)^2$$

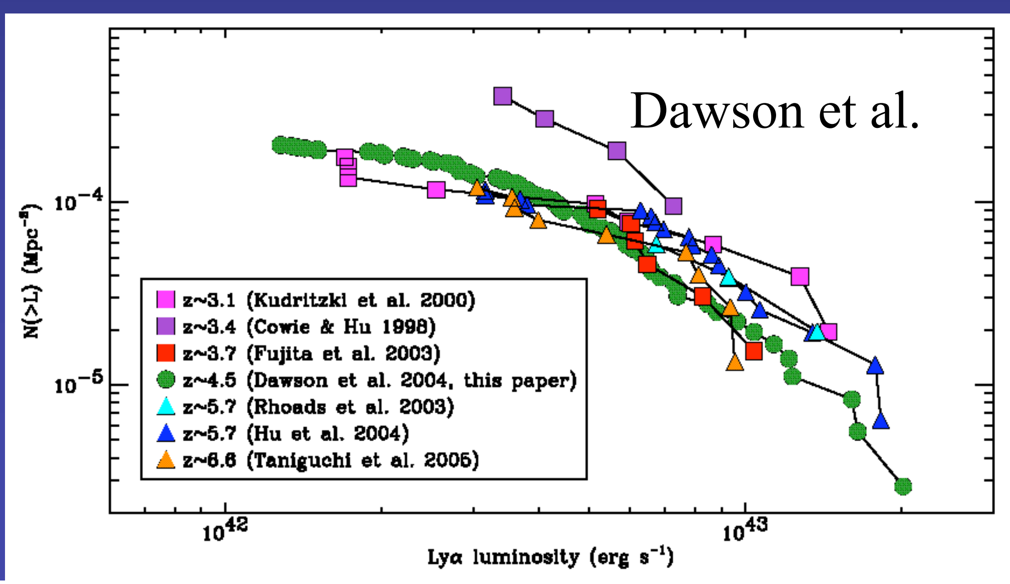
= 0.1, 0.5, 1, 2

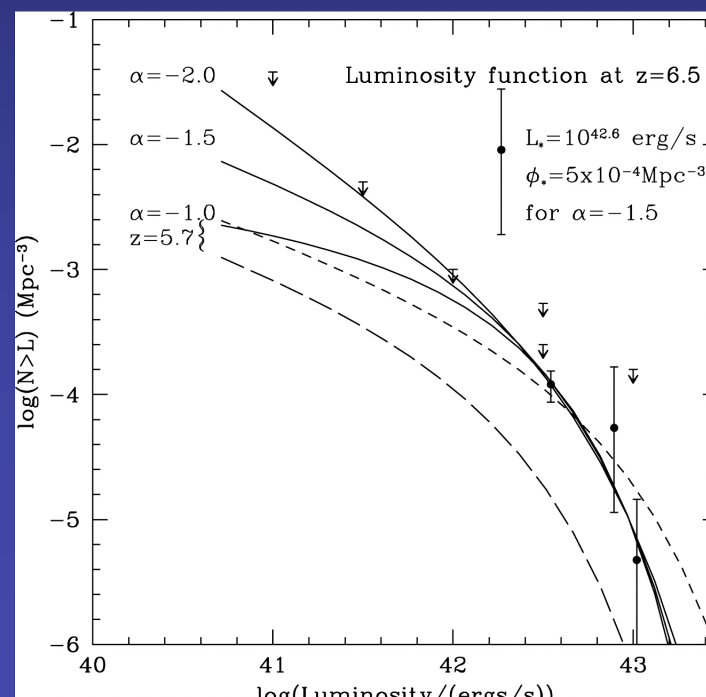


Is L*(Lya) Constrained?







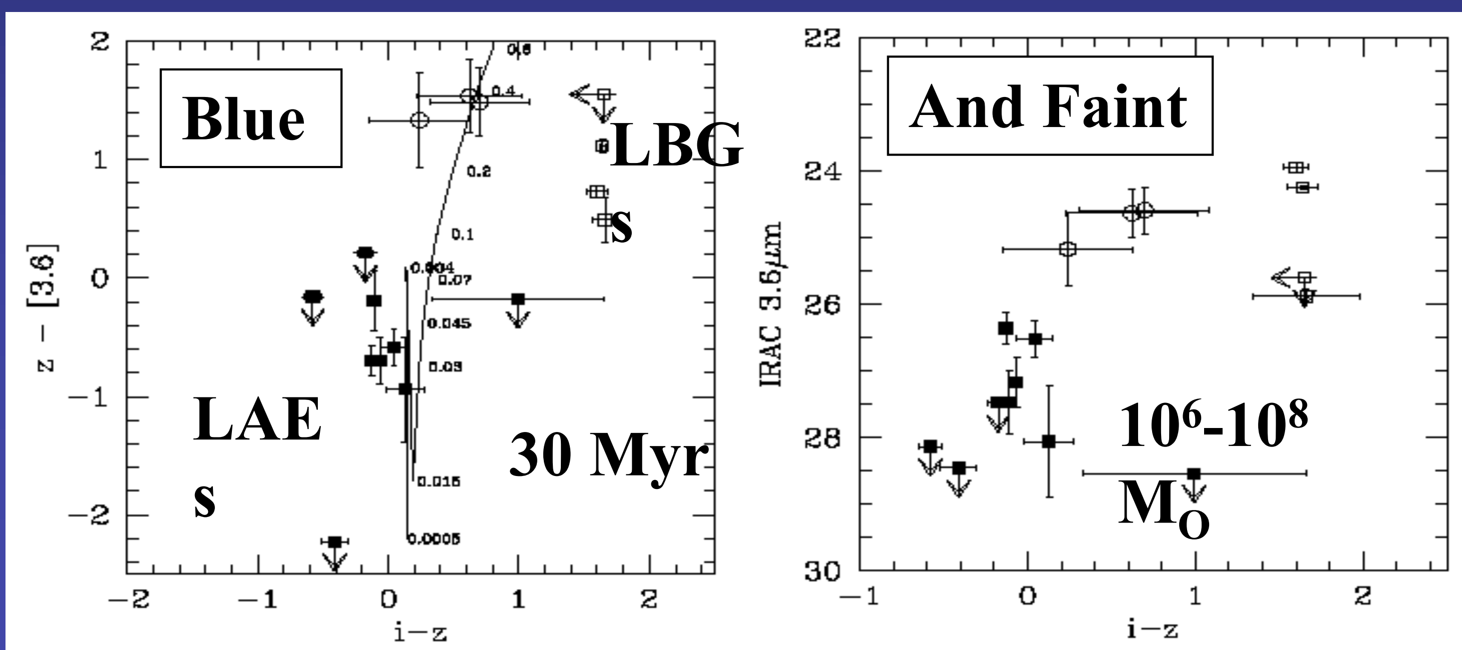


Properties of LAEs:

- Lya Luminosity ==> SFR > 5-7 Msun/yr
- UV Observations of LAEs give SFRs ~ 3-4x higher
- Line widths ~200-250 km/s (corrected to 400 km/s)
- Picks out low metallicity and low mass objects? Awaiting HST observations….

HUDF I-dropouts

.(Pirzkal et al. 2007)



Relation of LAEs and i-dropout Population??

- **Duty Cycle?**

  Know ~25% of LBGs at z~3 are LAEs

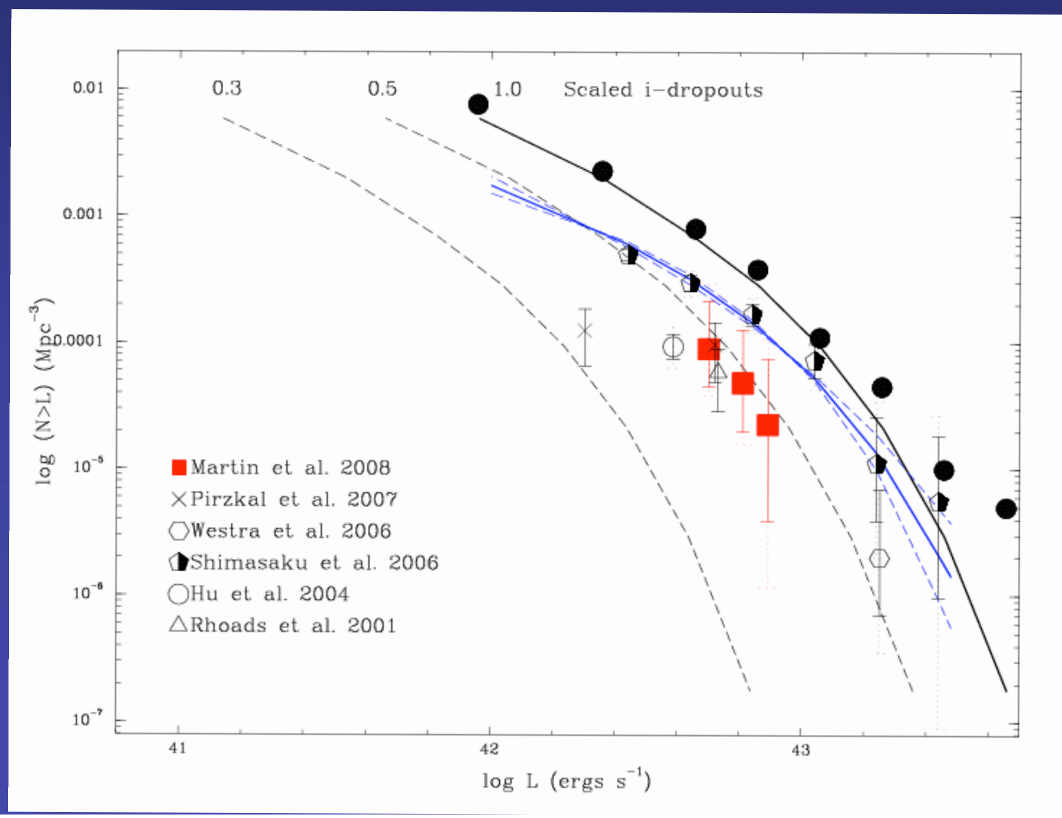
  Kashikawa+2006 say fraction is much higher at z~6.5

  HUDF i-dropouts

  Dow-Hygelund + 2007 (47% of i-dropouts show LyA)

- **Attenuation?** (Effective Luminosity Evolution)

  Must be present at factor of 2 level at least.



4-8x

Conclusions from z=5.7 MNS

- **M**ultislit **N**arrowband **S**pectroscopy is a viable emission-line survey technique with large format detectors on ground-based telescopes
- Find 3 LAEs with SFRs of at least 5-7 Msun/yr
- If the LAE population is drawn from the i-dropout population, then the average LyA attenuation is not more than a factor ~2 and the LyA duty cycle is at least 25%
- (log L*, log phi*) in LAEs is (42.20, -2.0), (42.50,-3.0), or (42.9,-4.0) for faint-end slope -1.6
- Ionization of the z=5.7 IGM by the detected LAEs requires a high normalization and a low value of the break luminosity. Is this ruled out?
- Deeper surveys are presently possible at z=5.7 and higher.
- Main challenge is culling foreground emission-line galaxies.

Line Detection at z > 6 in the Next Decade