A detailed study of Lyman alpha emission in z~3 galaxies

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ESO/VLT Large Program

- Deep Lyα imaging plus spectroscopy
  - 8 radio galaxies with $2 < z < 5.2$ (4 at z~3)
  - 23 nights with VLT/FORS2 + 10 hours Keck/LRIS
  - 49 □′ per field (~3x3 Mpc^2)
- Results:
  - >330 candidate Lyα emitters found in 8 fields
  - ~165 of the candidates (>91% success rate) confirmed to be Lyα emitting galaxies at $z > 2$
  - 6 out of 8 radio galaxy fields are overdense

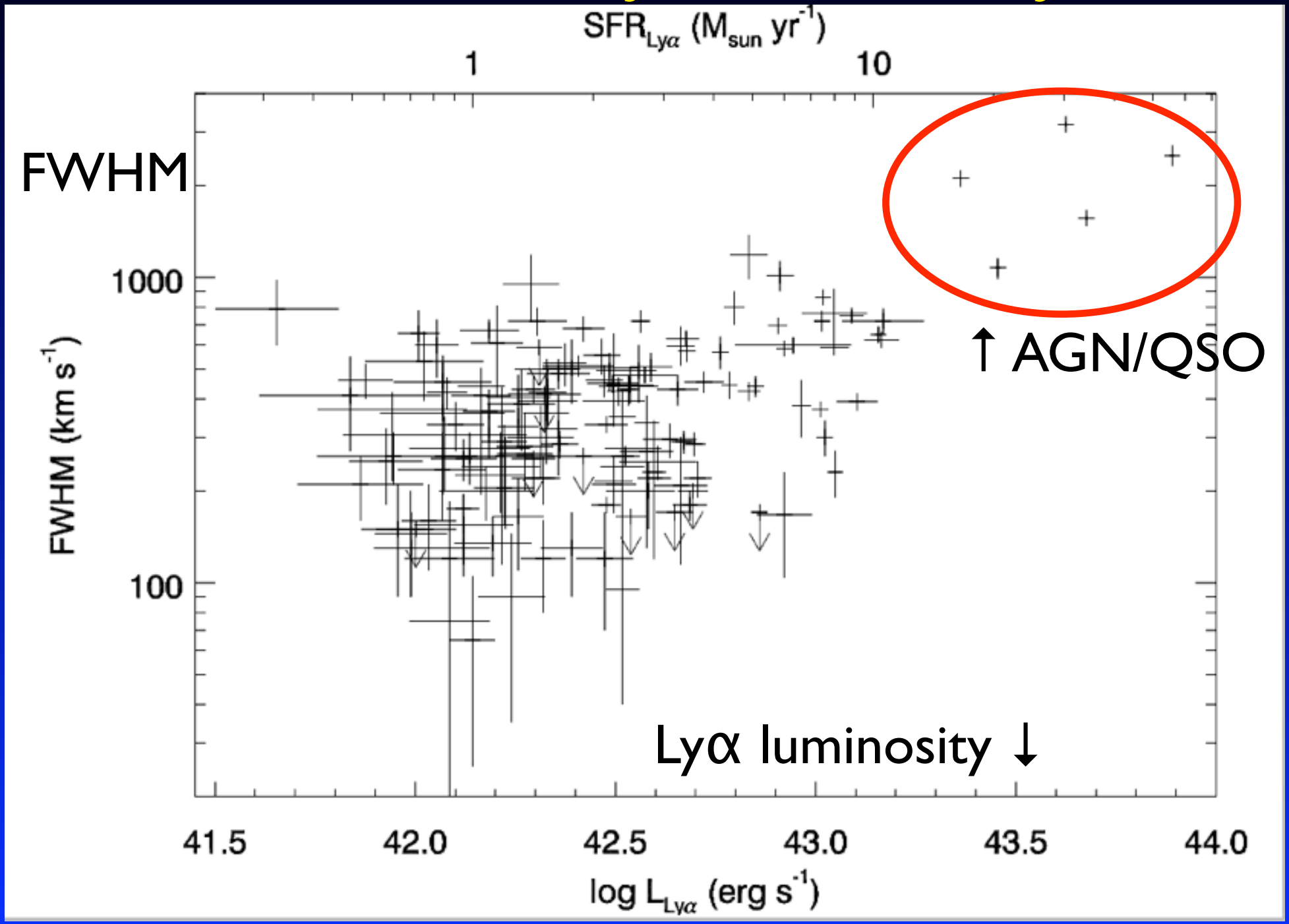
(Venemans et al. 2007)

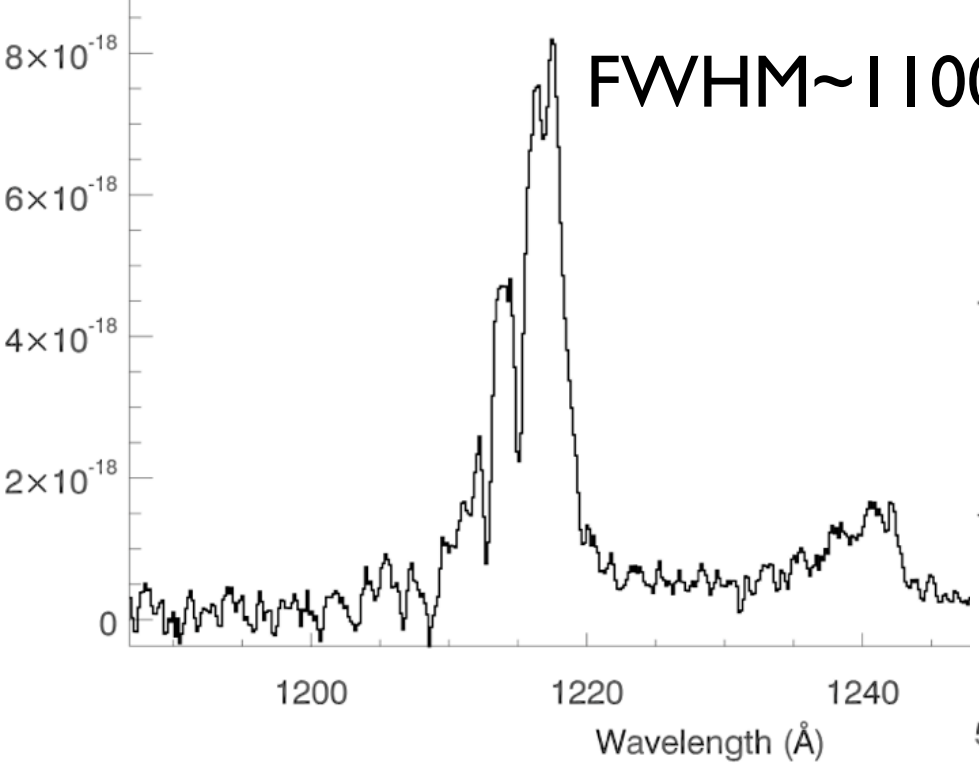
→ more data (being) taken (IR, ACS, Spitzer,…)

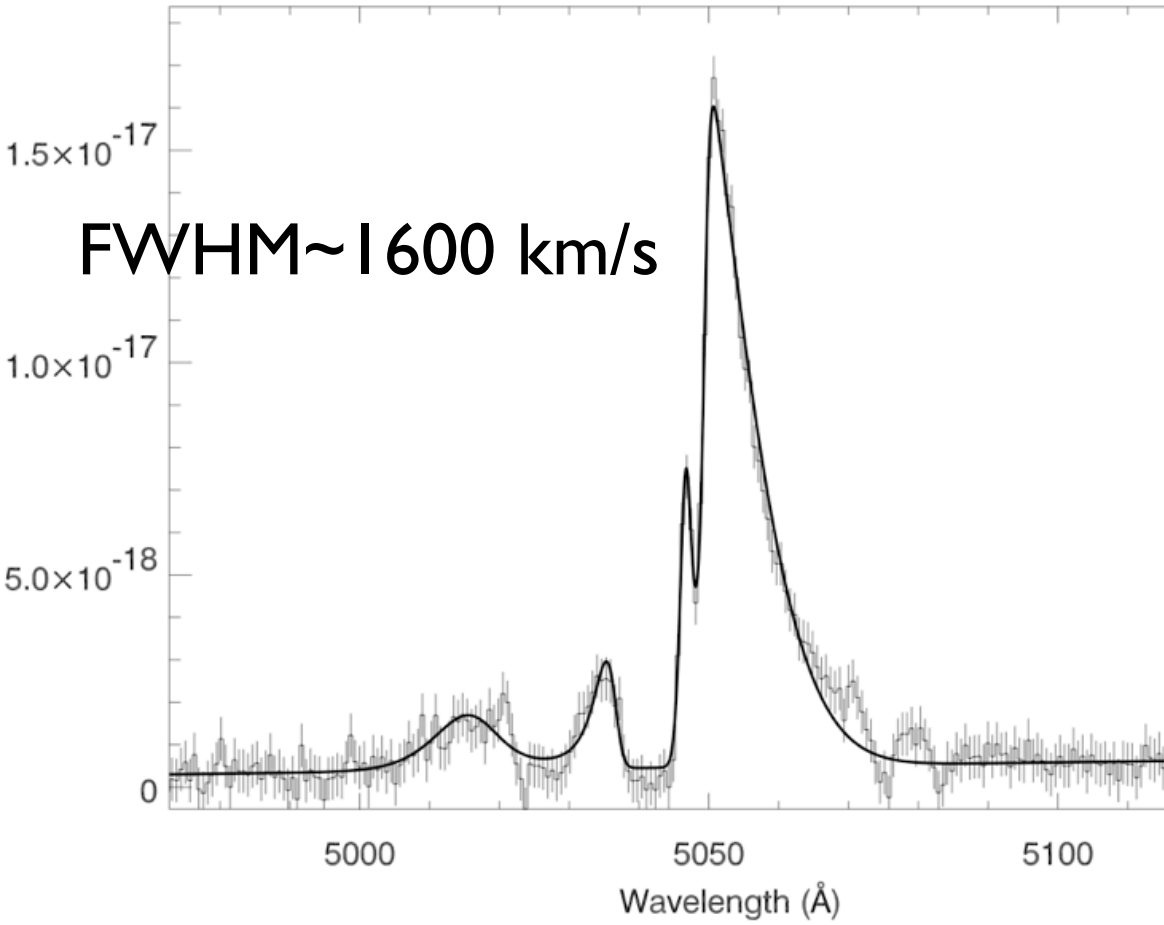
Properties of Lyα emitters

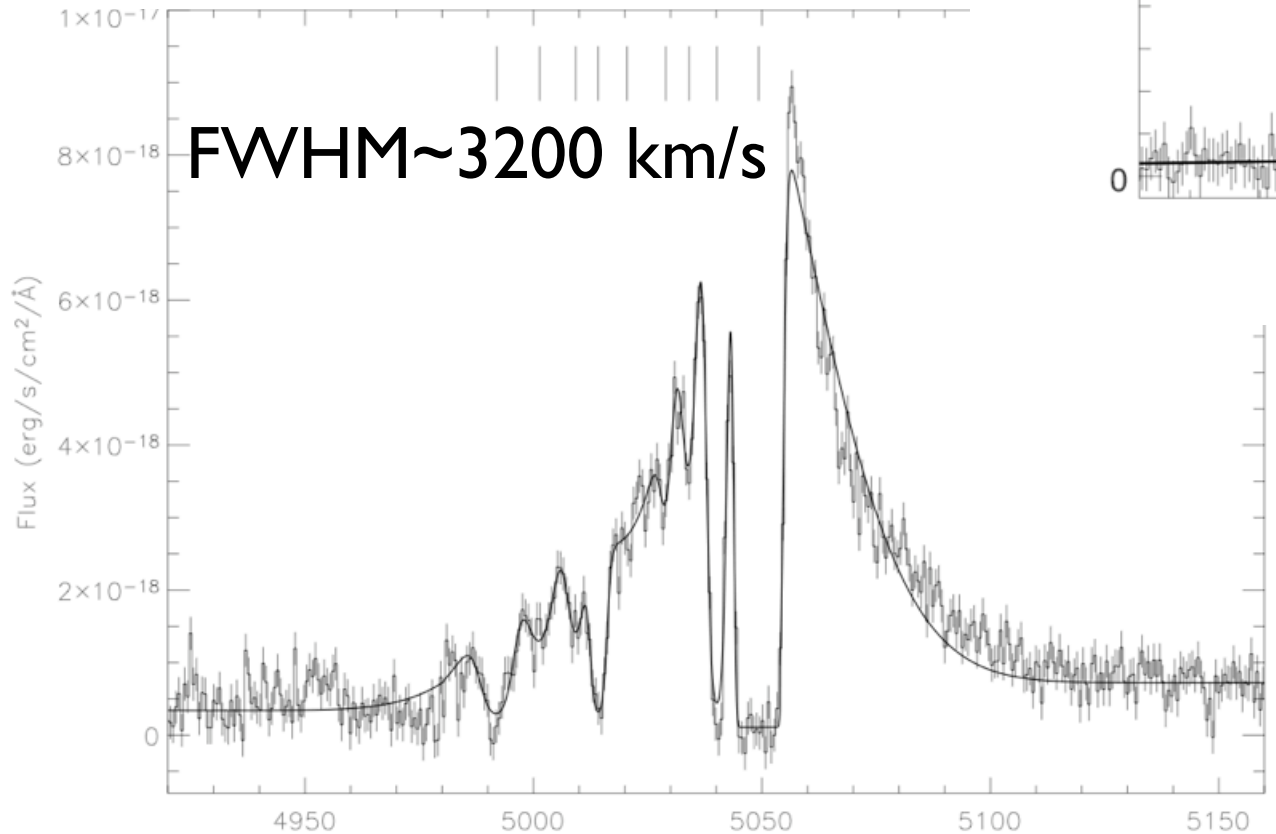
- Active or star forming galaxies?

FWHM vs Lyα luminosity




FWHM~1100 km/s
8×10^-18
6×10^-18
4×10^-18
2×10^-18
0
1200
1220
1240
Wavelength (Å)


FWHM~1600 km/s
1.5×10^-17
1.0×10^-17
5.0×10^-18
0
5000
5050
5100
Wavelength (Å)


FWHM~3200 km/s
8×10^-18
6×10^-18
4×10^-18
2×10^-18
0
Flux (erg/s/cm²/Å)
4950
5000
5050
5100
5150

Properties of Lyα emitters

- Active or star forming galaxies?
  → 8/168 LAEs with FWHM > 1000 km/s (~5%)

  Brightest LAEs, all with L>2x10^{43} erg/s are AGN

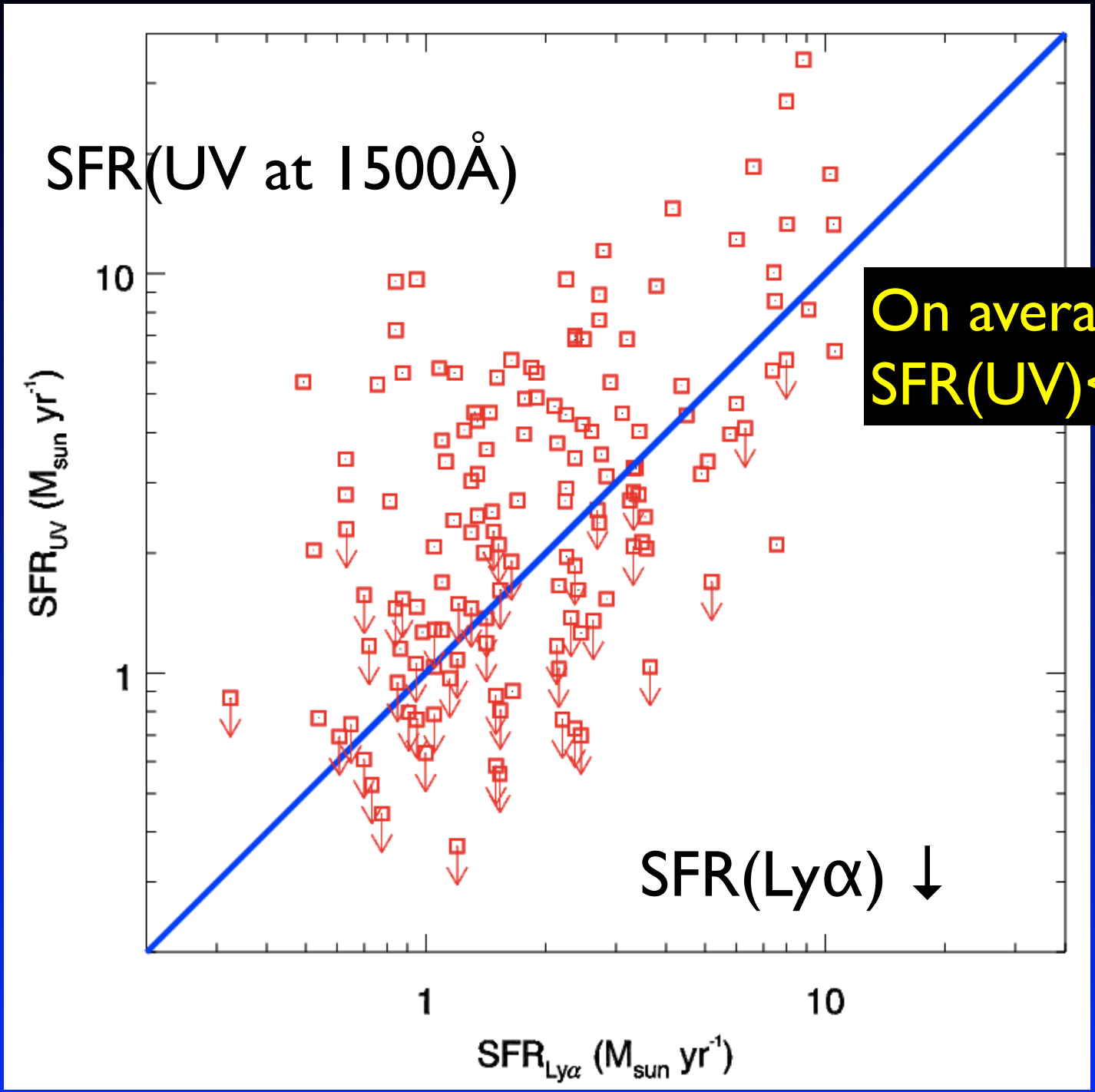
- Likely more (type-II) AGN among LAEs
  - X-ray data (Pentericci et al. 2002; Croft et al. 2005)
  - high ionisation lines like (NV 1240; CIV)

  → Type 1: Type 2 ~ 1:1

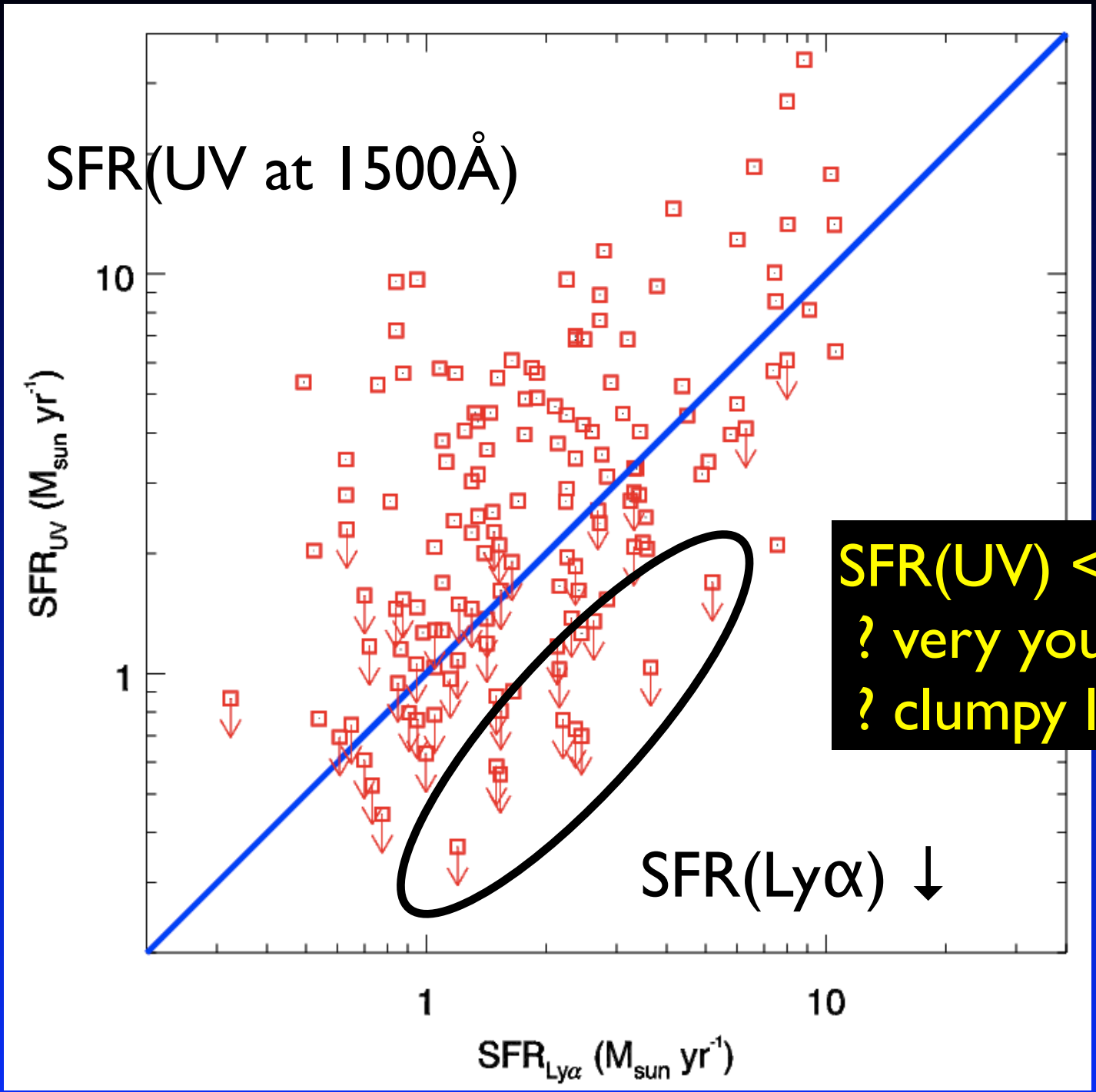
AGN fraction among LAE small
→ LAE mostly SF galaxies

Properties of Lyα emitters

- Star formation rate (SFR)



On average:
SFR(UV)<1.6xSFR(Lyα)



SFR(UV) << SFR(Lyα)
? very young star burst
? clumpy IGM

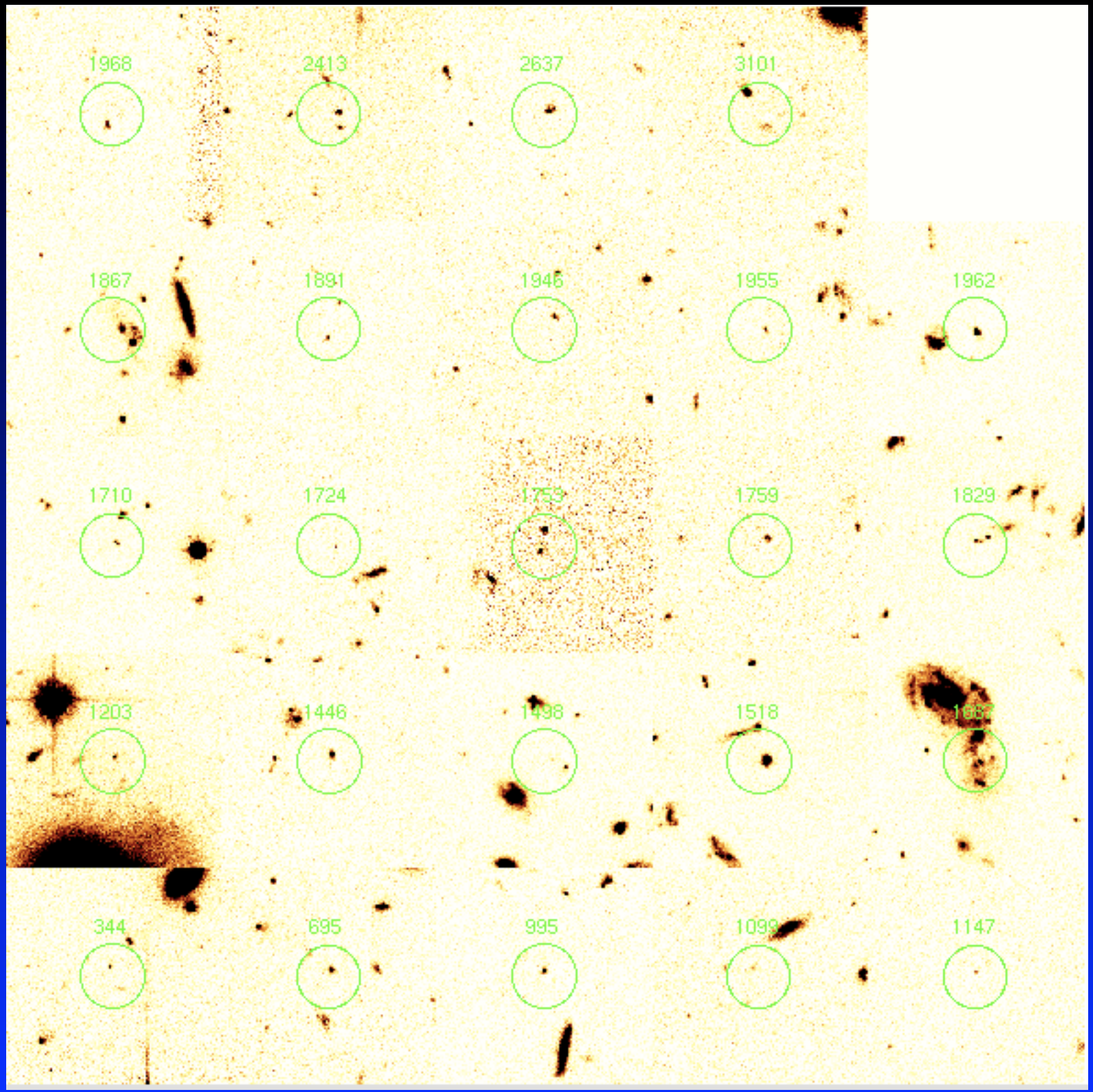
Properties of Lyα emitters

- UV continuum colours

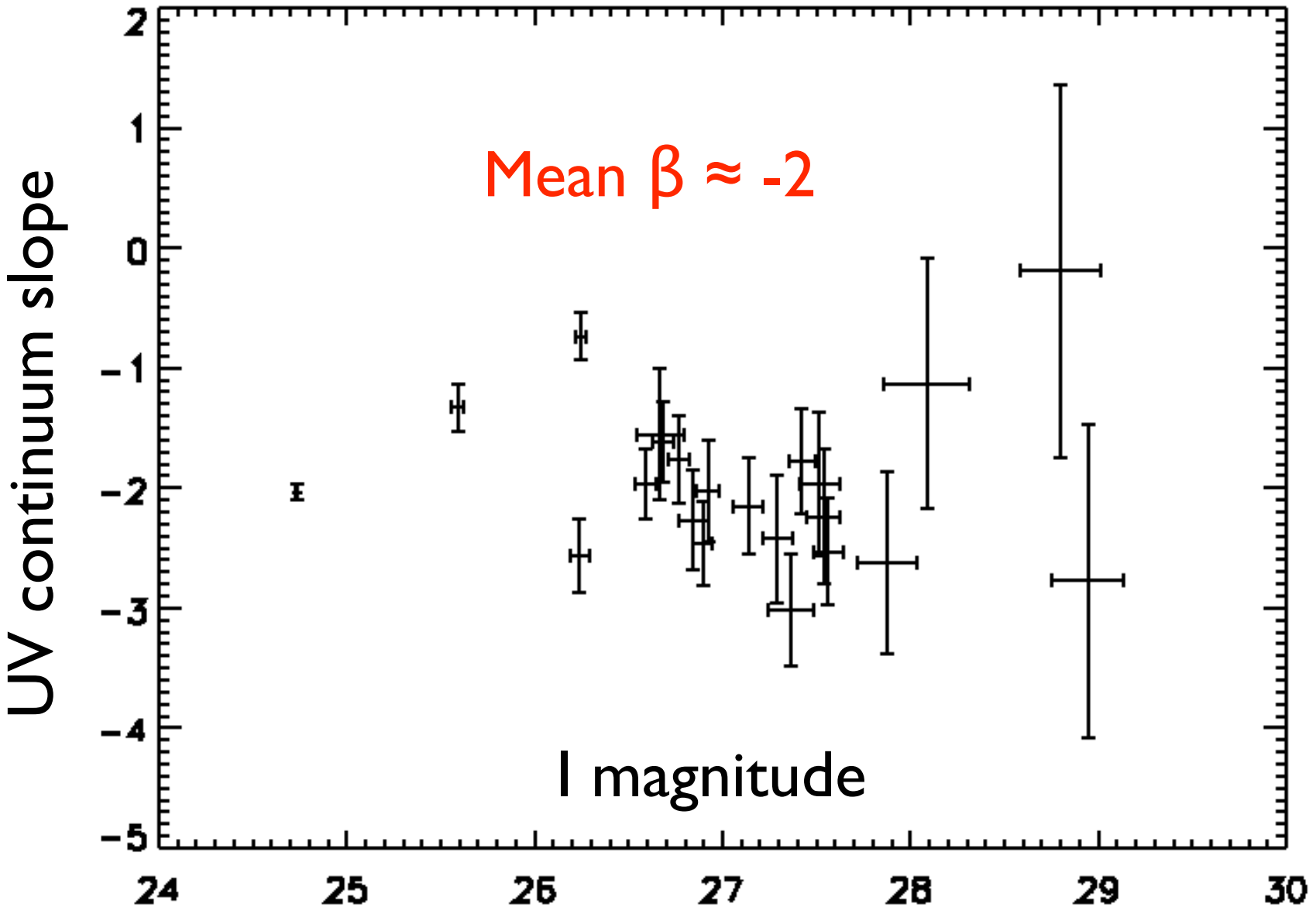
Because of selection method galaxies are faint in the observed optical

Some objects remain undetected in deep, 1.5h VLT I band image

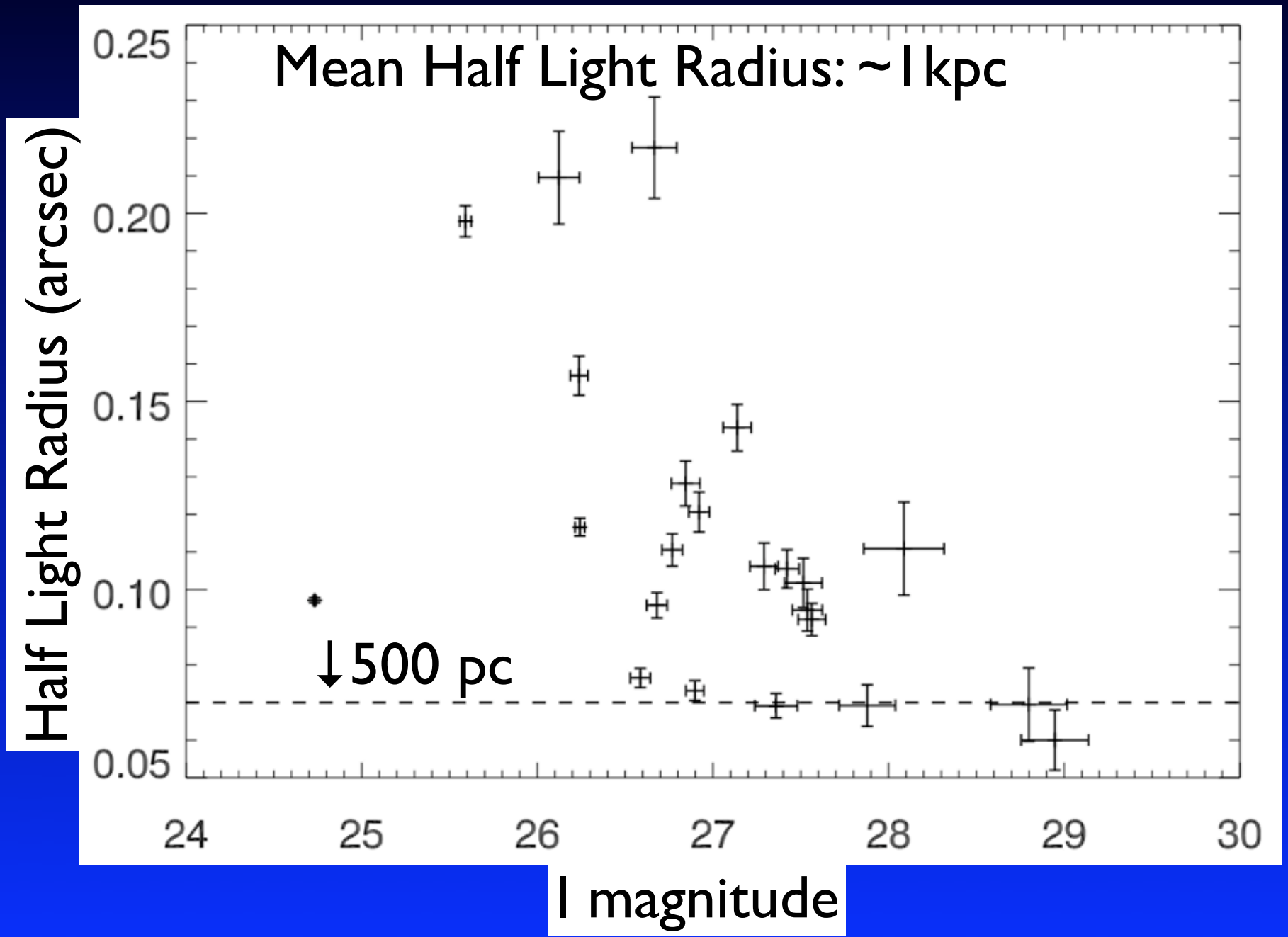
Need HST/ACS imaging


1968
2413
2637
3101
1867
1891
1946
1955
1962
1710
1724
1759
1829
1203
1446
1498
1518
344
695
995
1147

Colours of LAE in 0316 at z=3.1



Size of LAEs in 0316 at z=3.1



Properties of Lyα emitters

- Overzier et al. 2008:
  Properties of 12 z=4.1 LAE in the ACS data

  - UV SFRs 1-14 M_{sun} / yr
  - Flat continuum between i and z ($\beta_{iz} \approx -2$)
  - Half light radii: 0.08″-0.24″: 0.6-1.7 kpc

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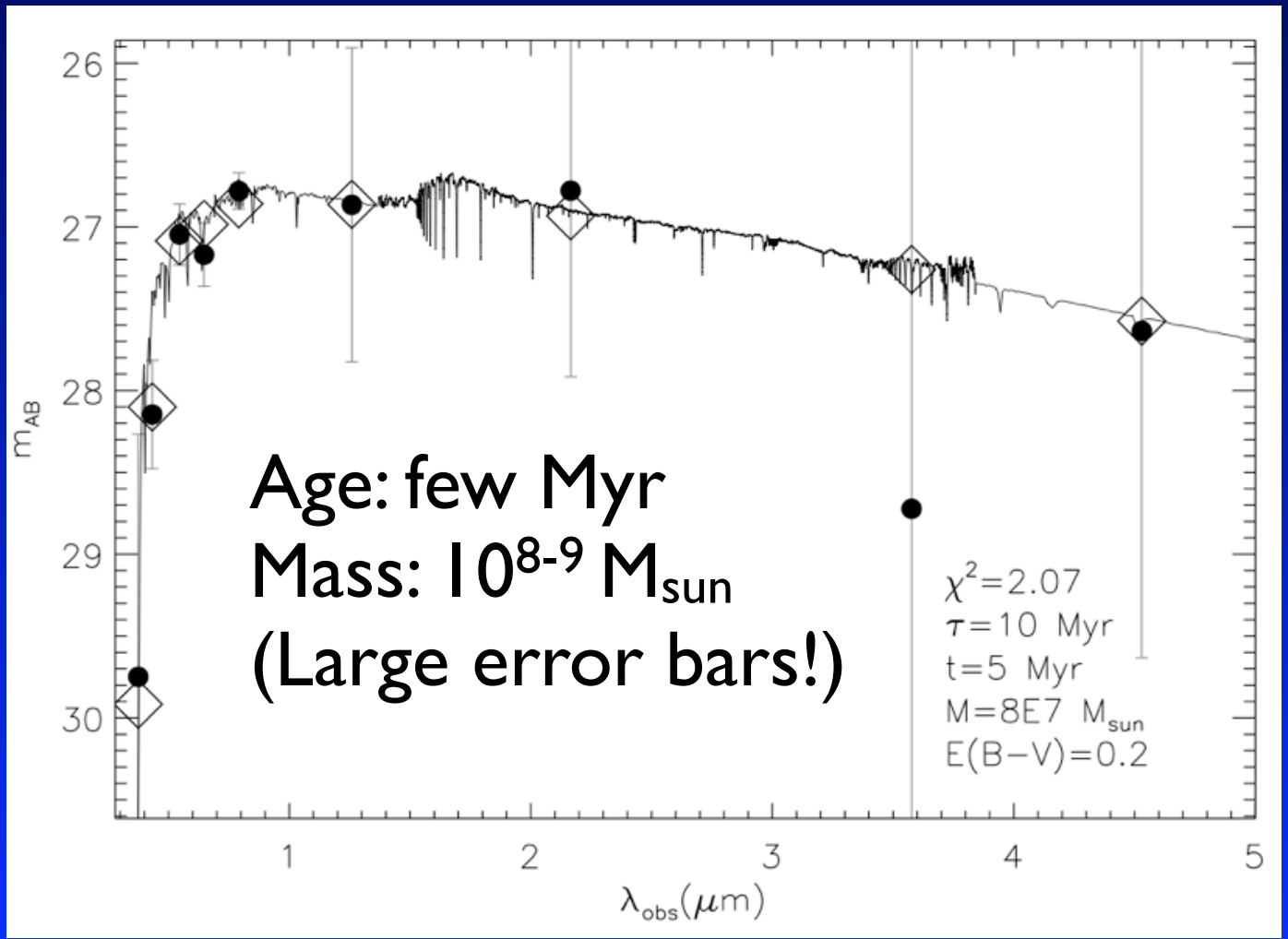
The rest-frame UV properties of LAEs (SFR, size, morphology, UV slope) are similar to those of LBGs when selected at the same UV luminosity.

Properties of Lyα emitters

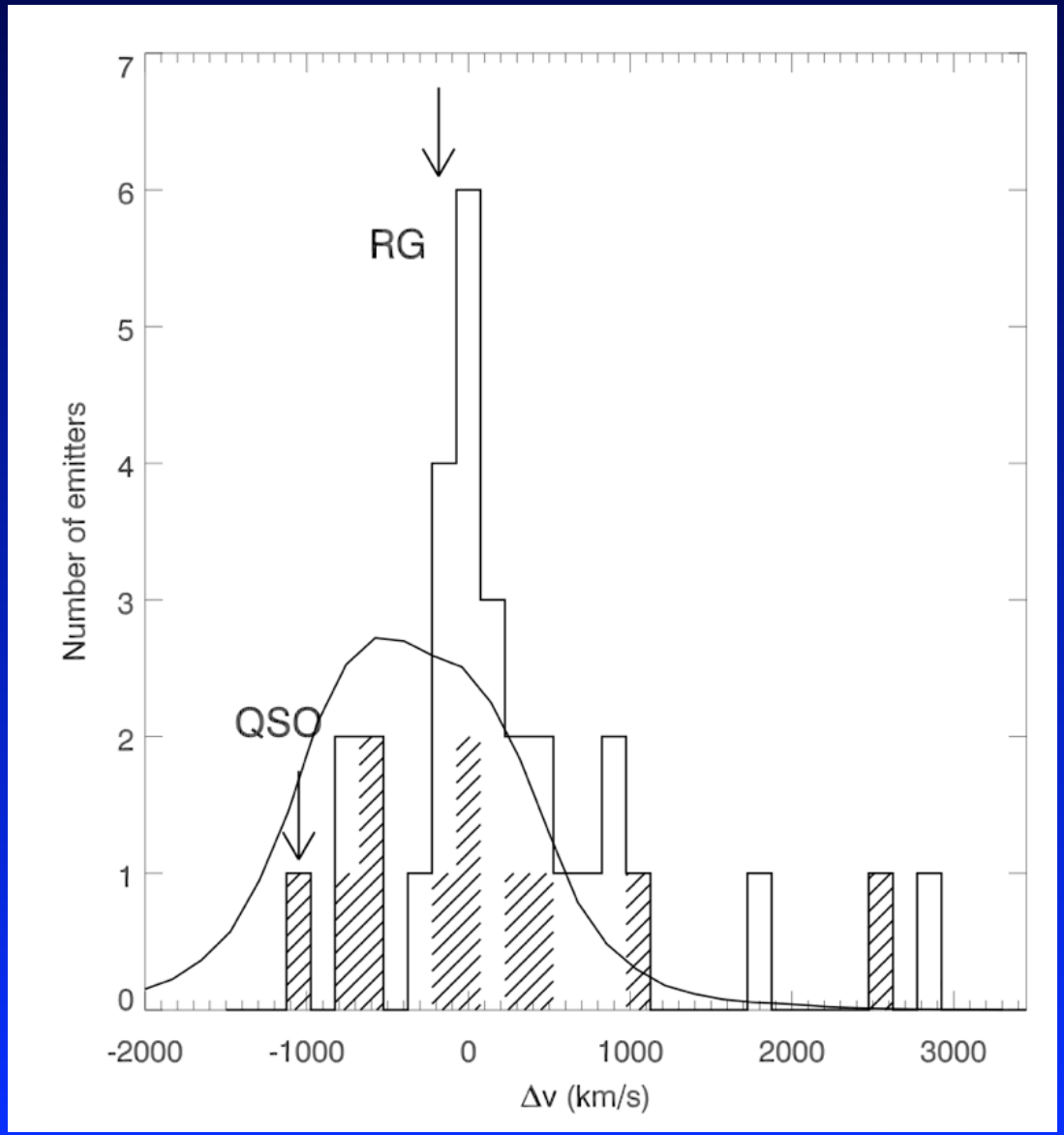
- Age and mass of LAE near 0316:
  Preliminary results (see poster Ernst Kuiper)



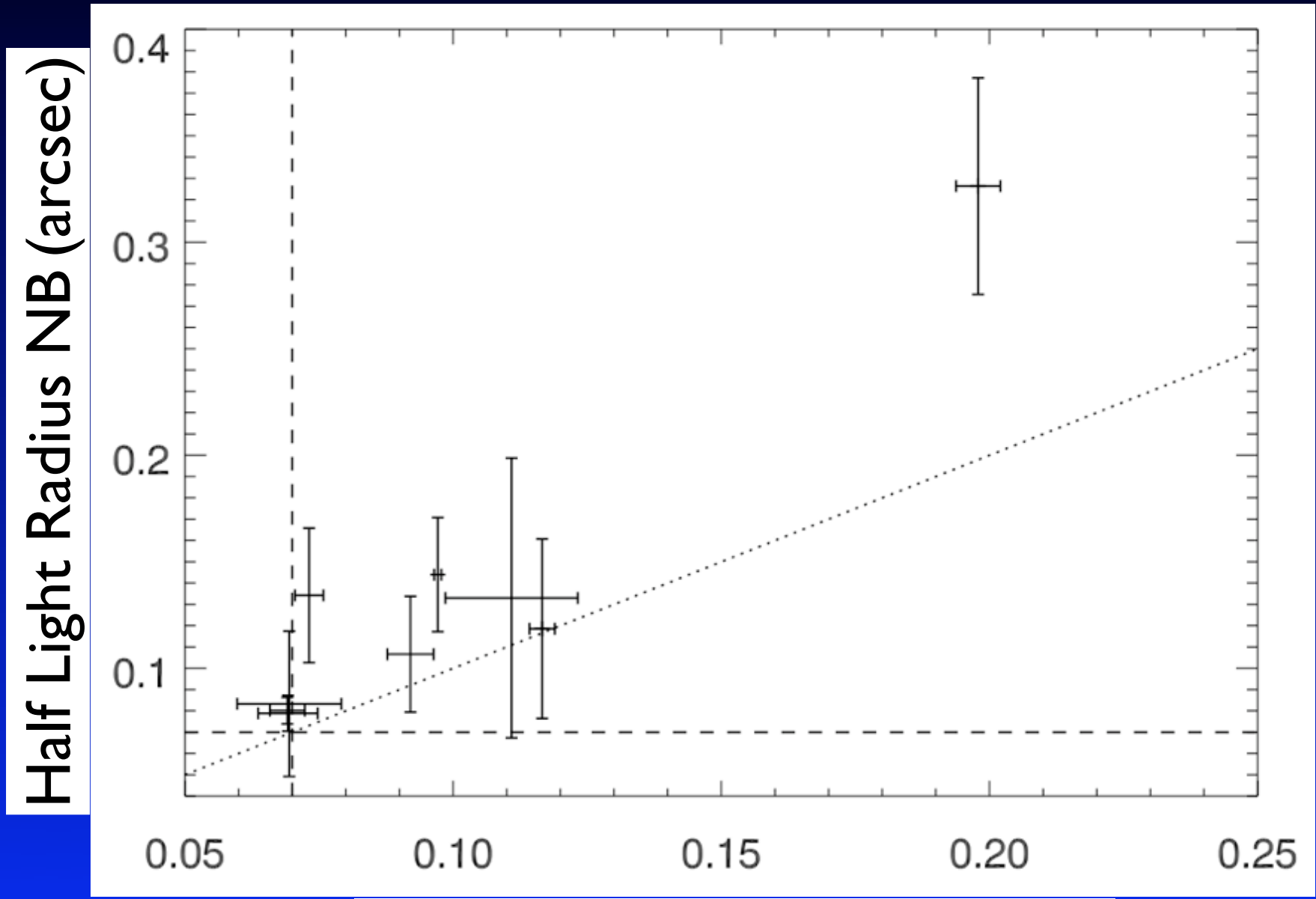
Properties of Lyα emitters

- Morphology of the Lyα emission line

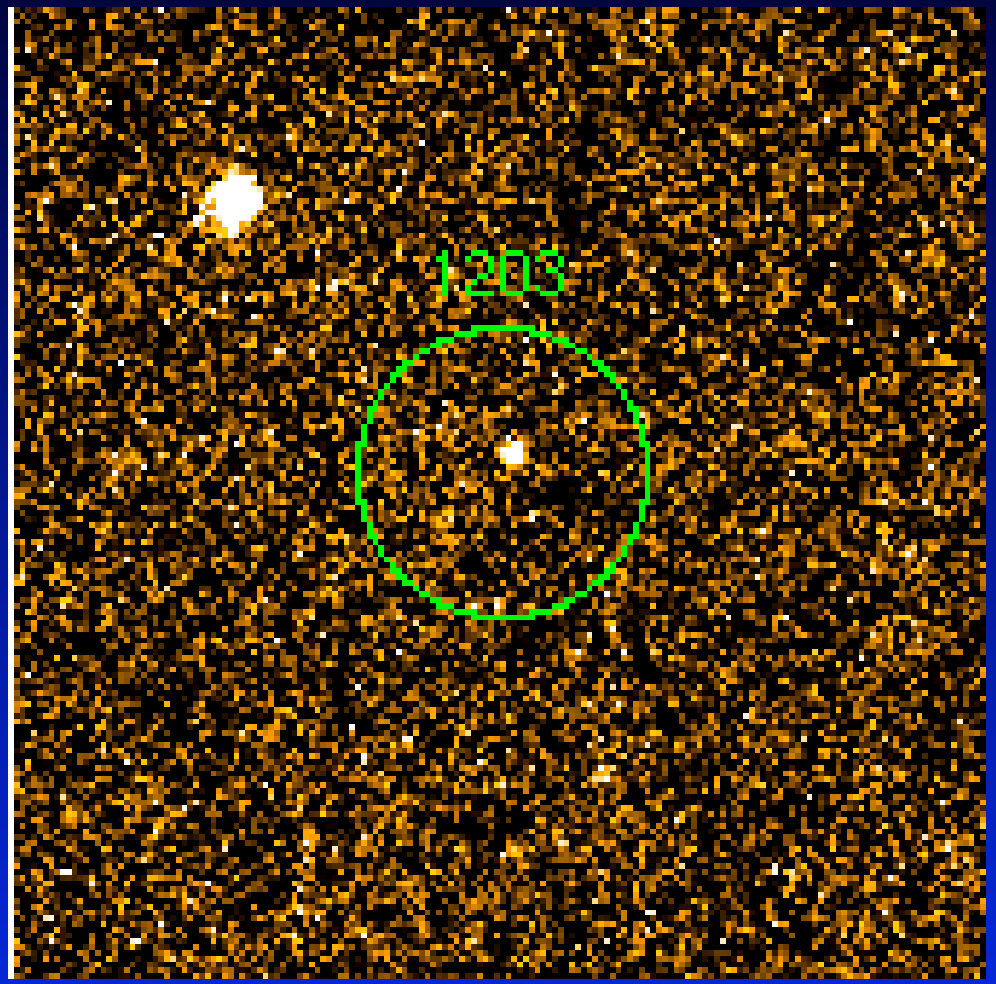
ACS has/had a narrow band filter centred at 5023 Å
→ Lyα at z=3.13

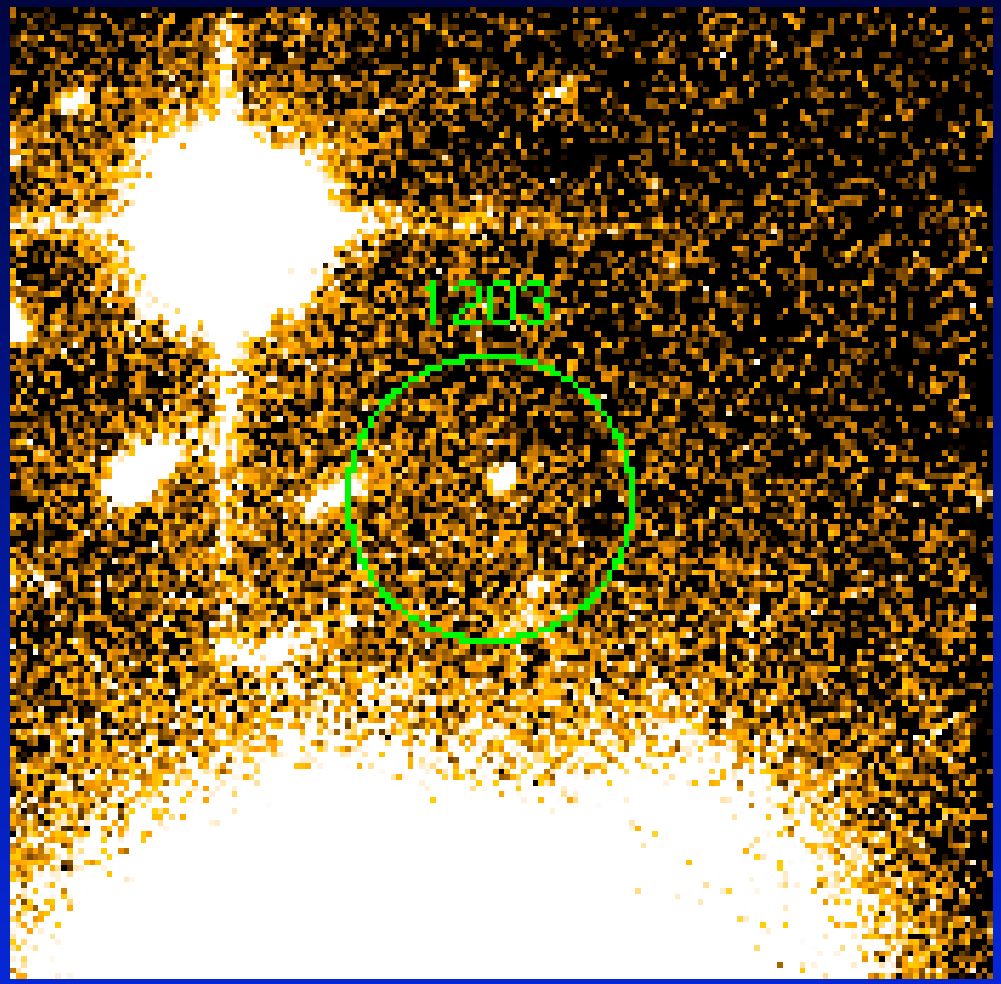


Properties of Lyα emitters



Examples of ACS Lyα imaging

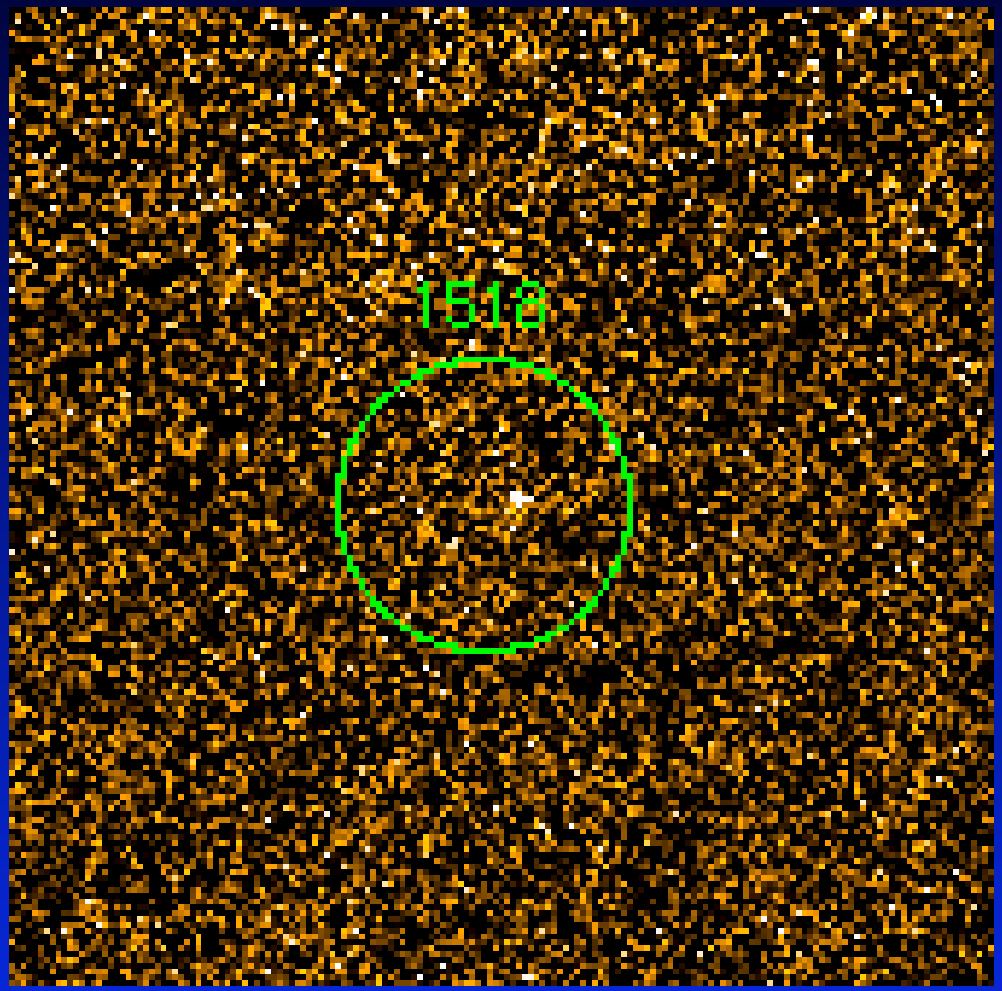


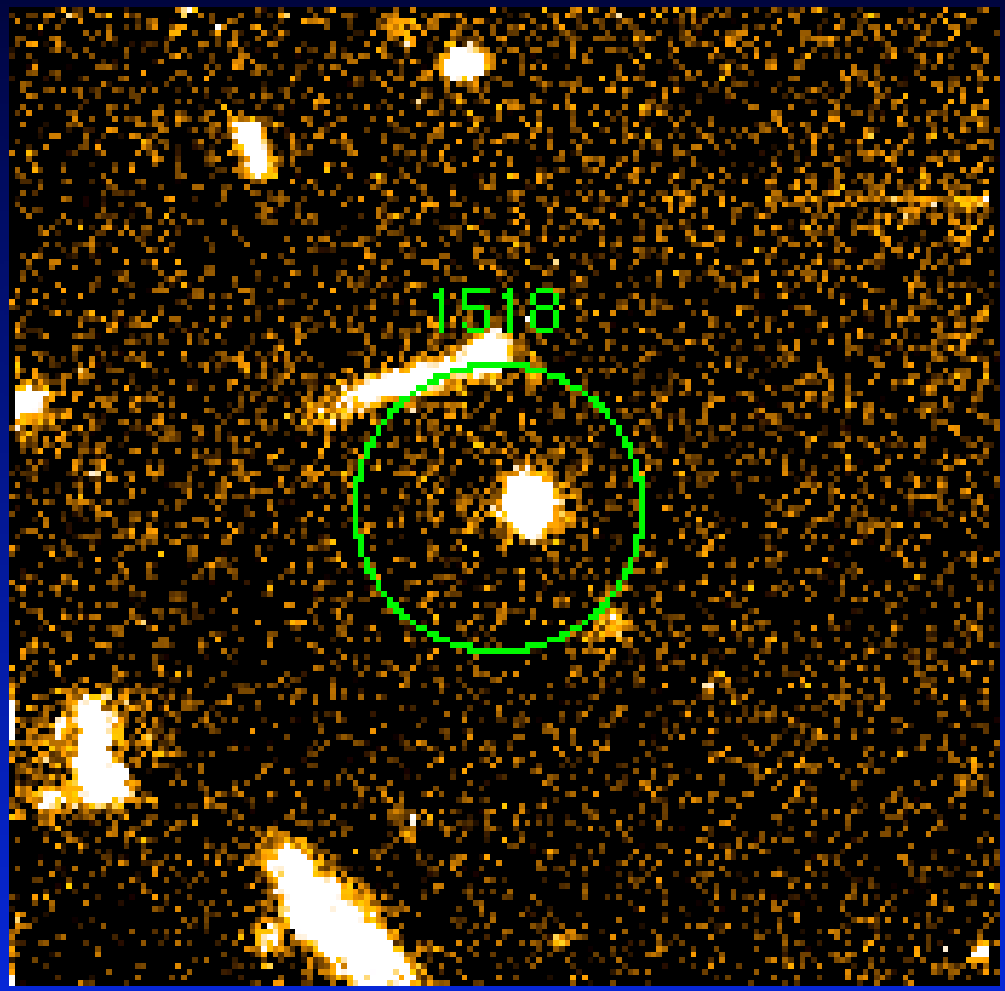


Lyα Continuum

F (FORS2) = 4.6×10^{-17} erg/s/cm^2

Examples of ACS Lyα imaging

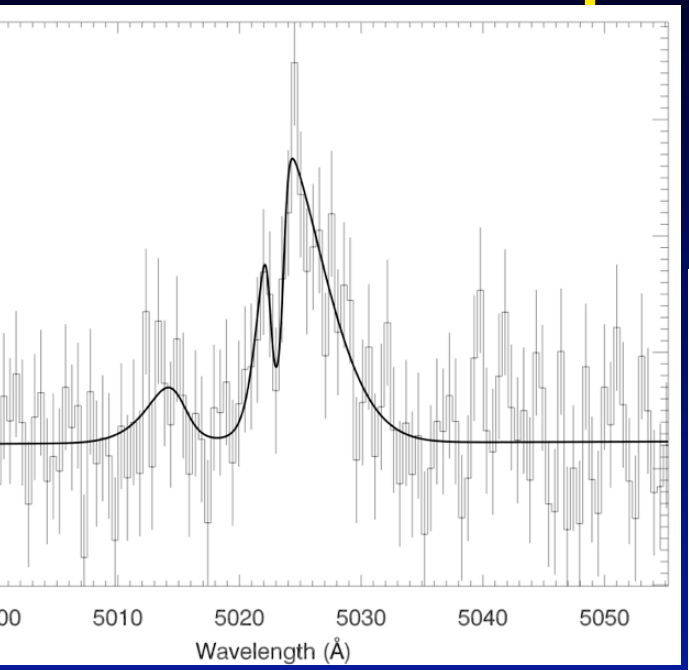




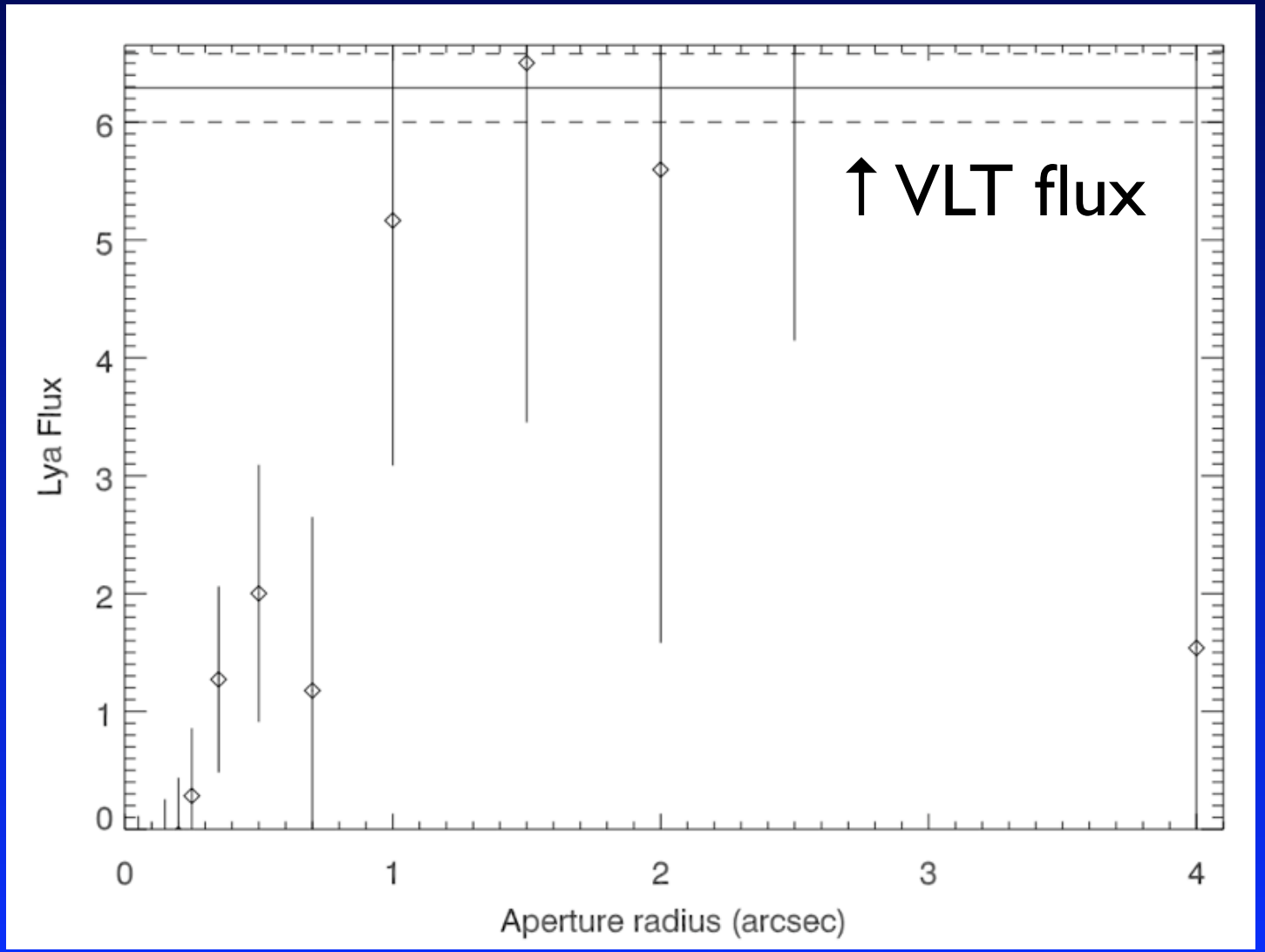
Lyα Continuum

F (FORS2) = 6.7×10^{-17} erg/s/cm^2

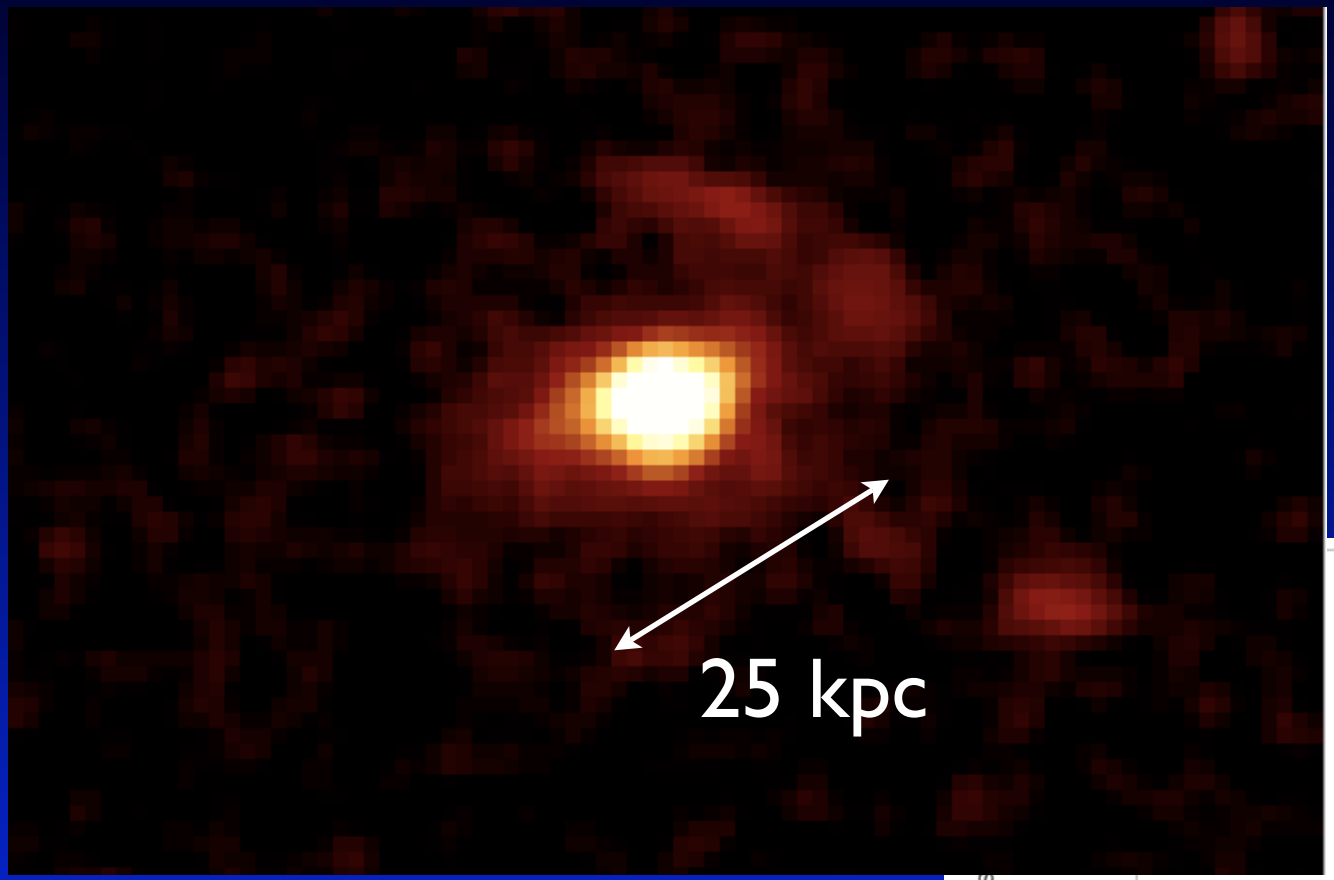
Examples of ACS Lyα imaging



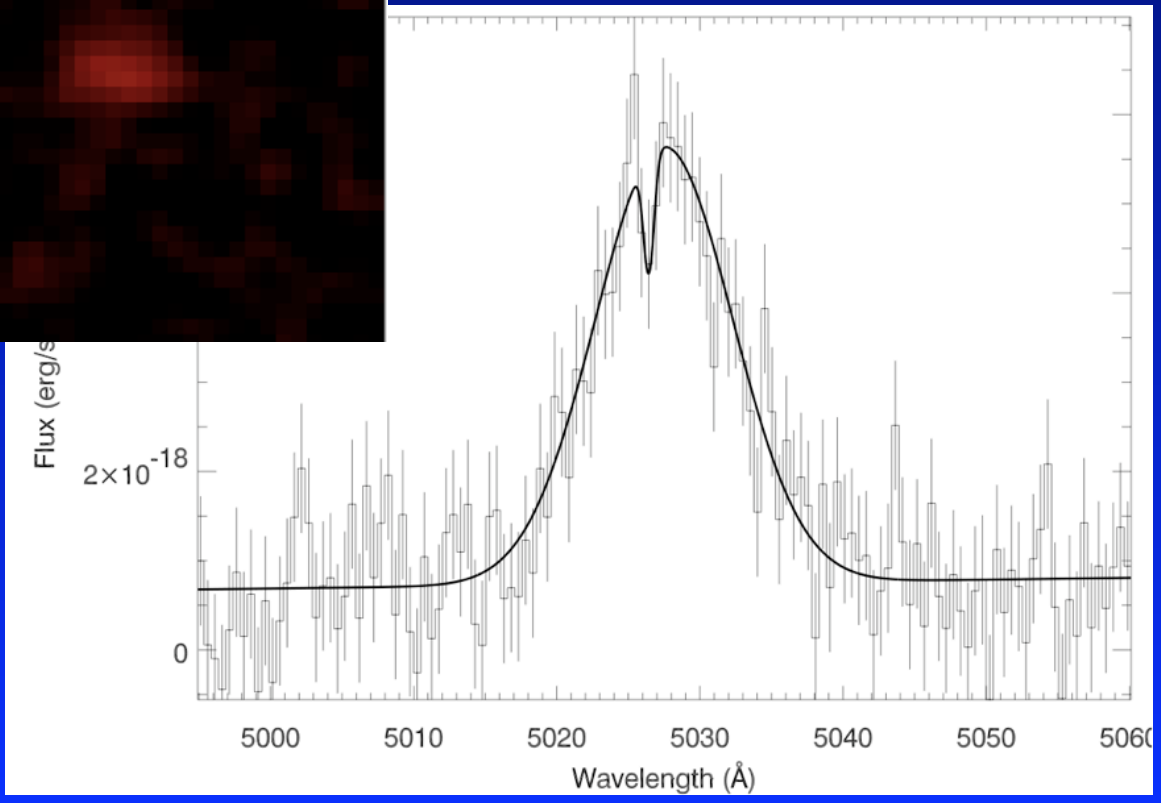
Lyα flux appears to be resolved out



A bright LAE at z=3.1



- Extended Lyα halo
- L=1.7x10^{43} erg/s
- Line roughly symmetric



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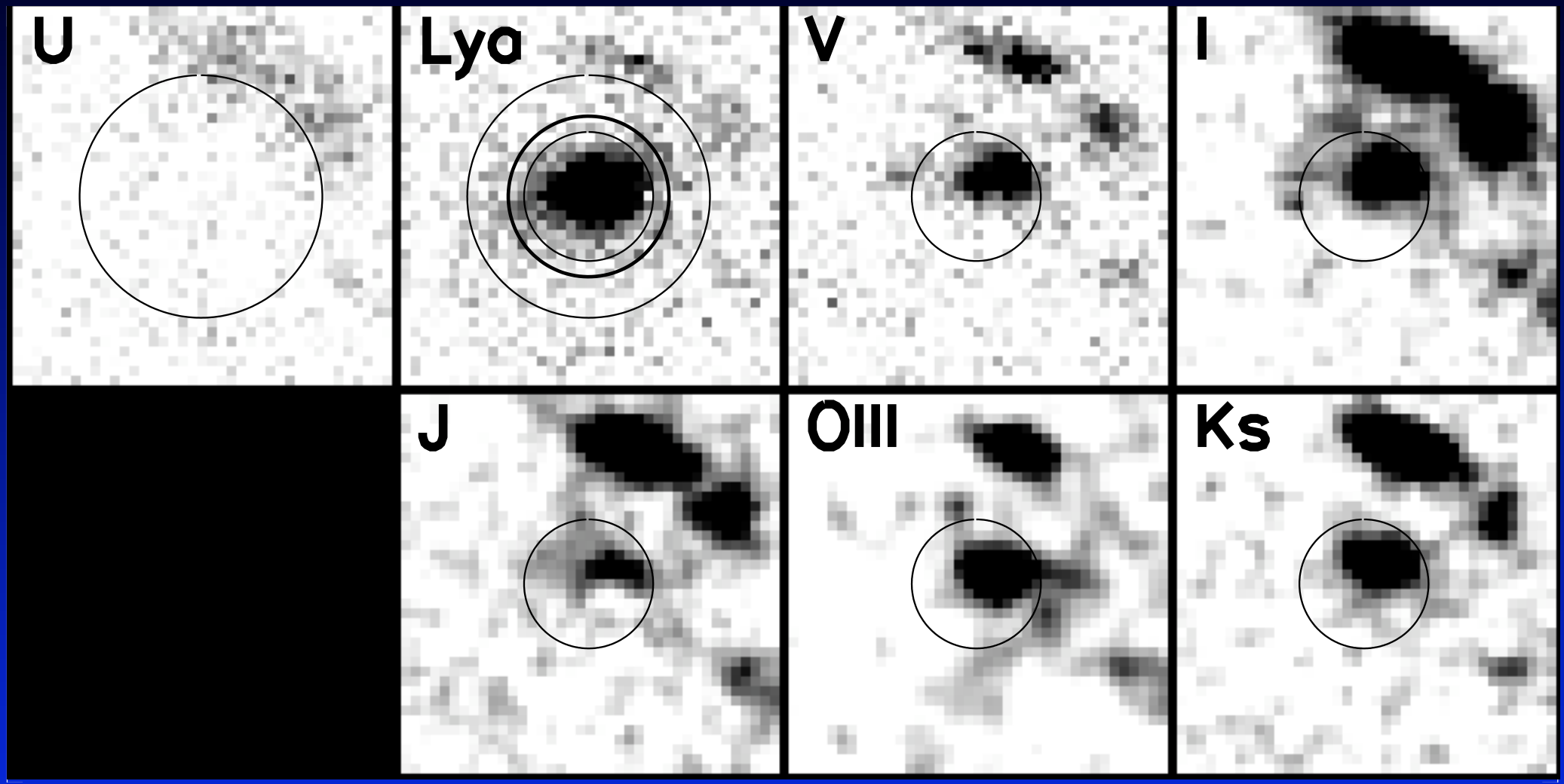
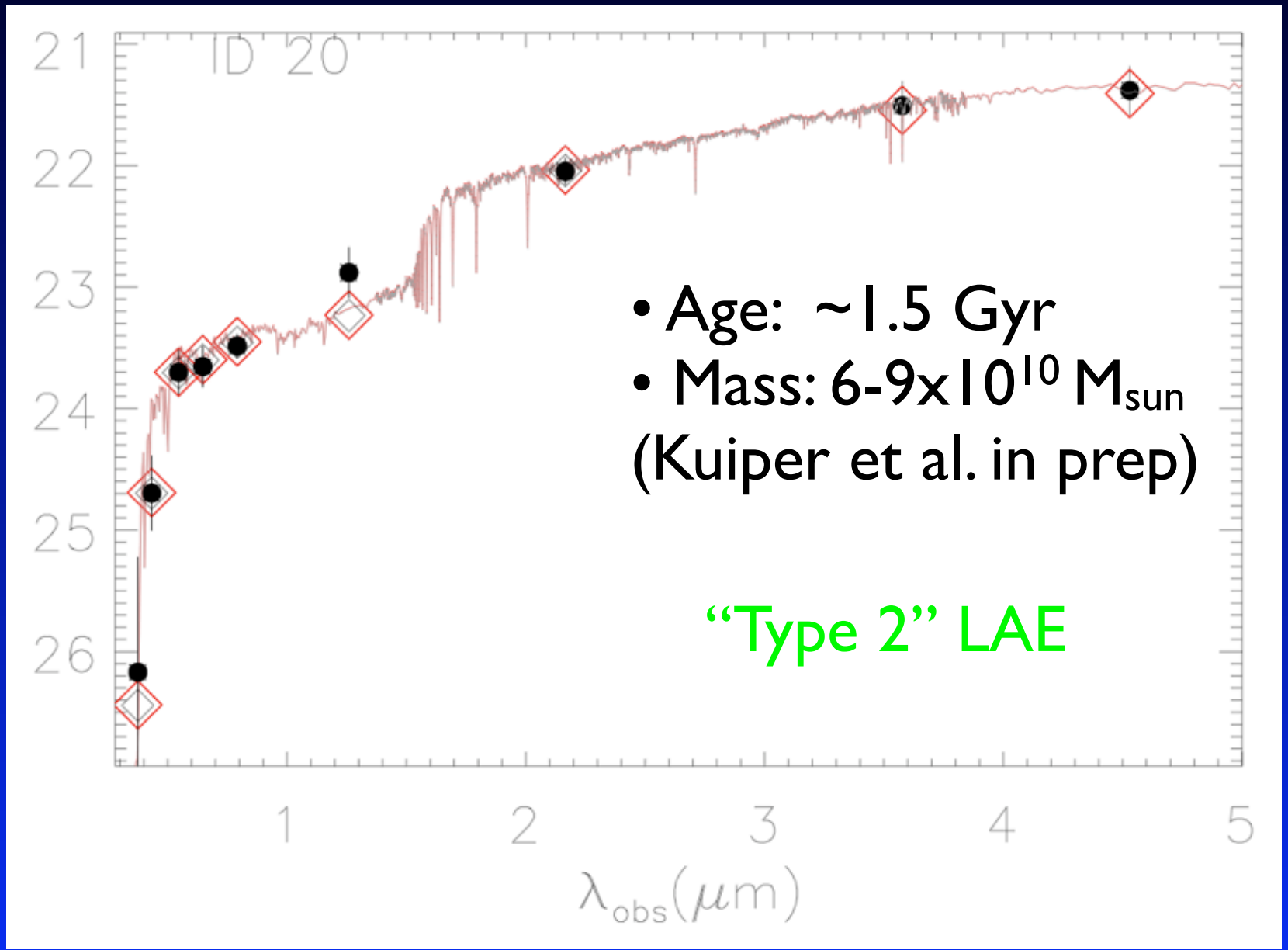
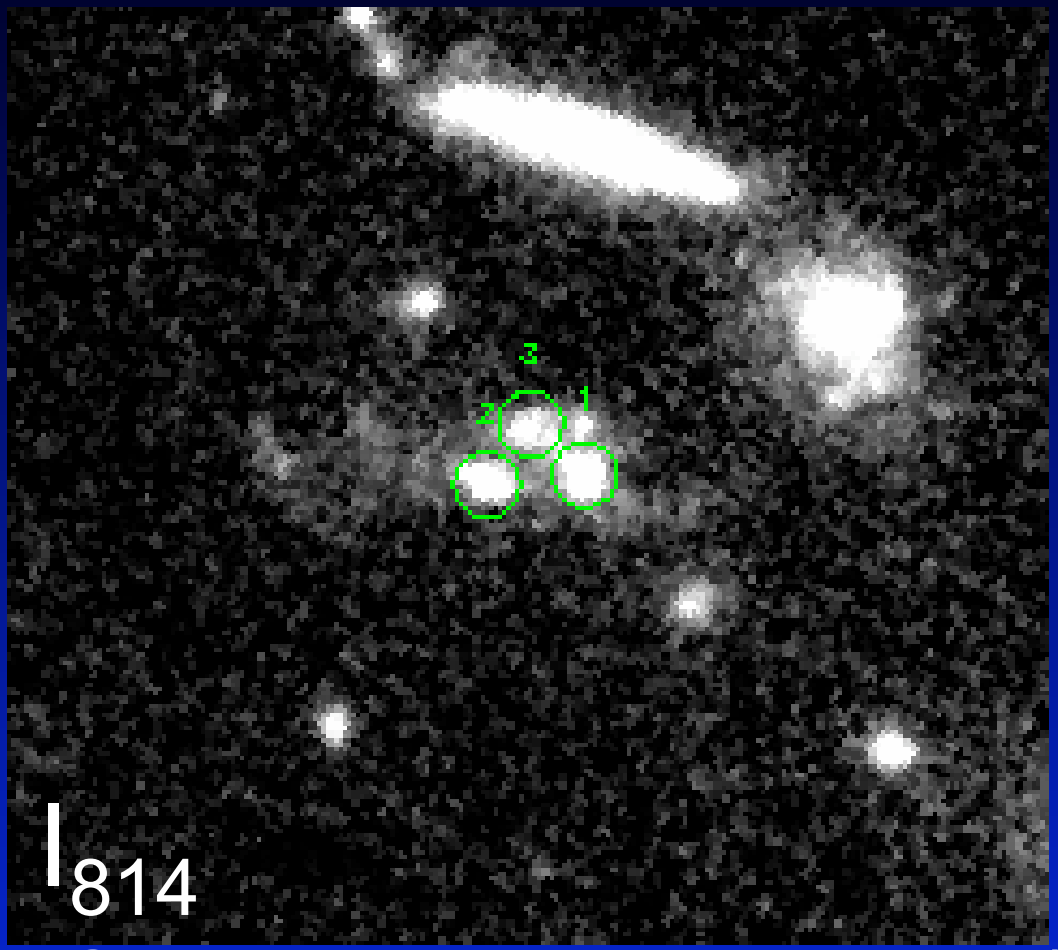


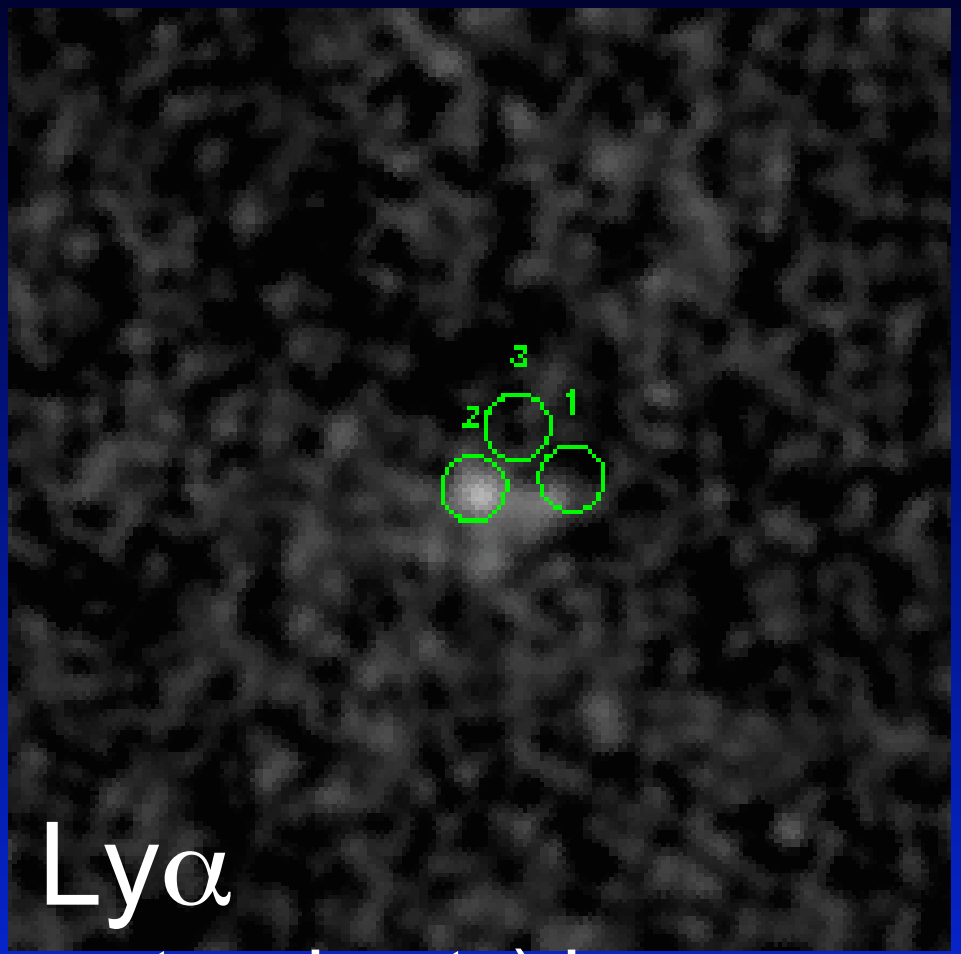
LAE, LBG, DRG, [OIII] emitter!

A bright LAE at z=3.1



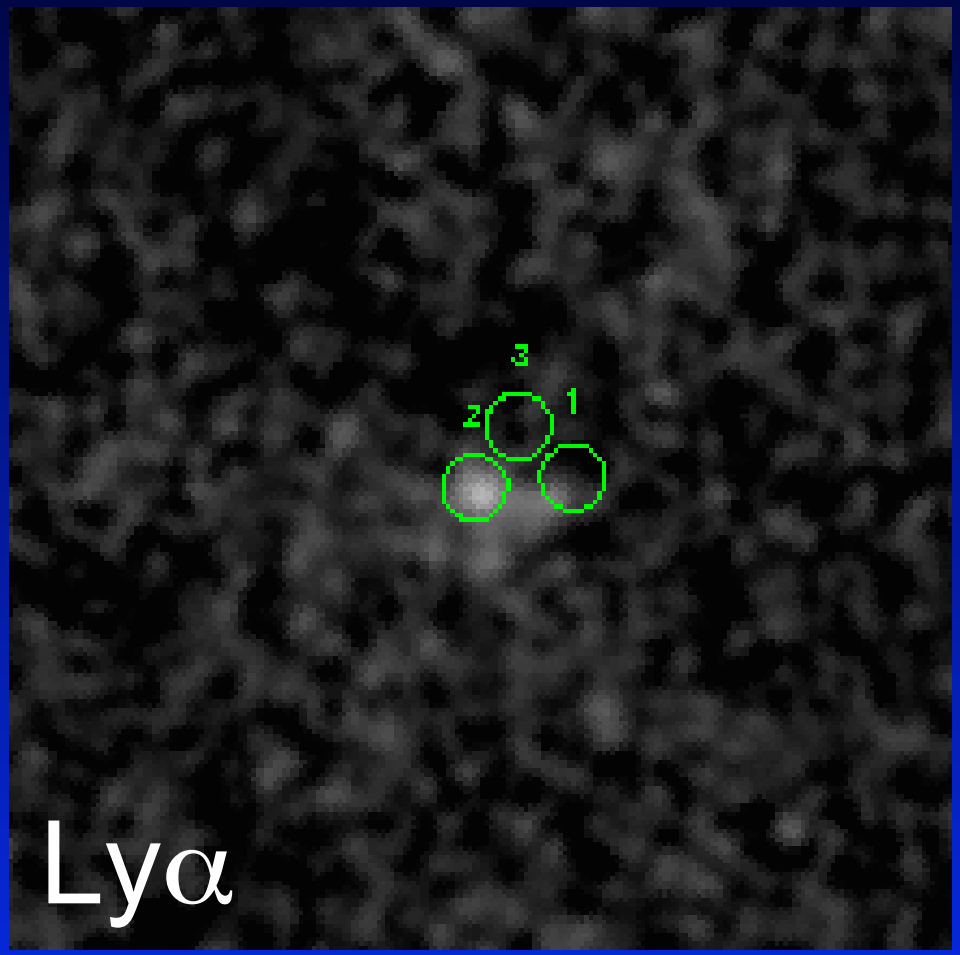
ACS observations





Continuum knots 1 and 2 (lower two knots) have SFRs of 6 and 3 M_{sun}/yr, and both have a *similar UV slope* (r_{625}-I_{814}=0.1), yet the narrow band Lyα seems to come primarily from the *fainter* knot (2)

A bright LAE at z=3.1



- Assuming similar geometry and quantity of the dust for the two knots, the escape of Lyα may be related to kinematics rather than dust
- Lyα flux in ACS narrow band image is factor 50-100 lower than ground based image
  → diffuse gas dominating

Conclusions

- Most luminous LAE at z=3-4 are AGN
- Fraction (~1/4) of LAE: very young or clumpy IGM
- LAE similar in UV properties as LBGs (at same L)
- Mass of LAE: ~$10^{8\text{-}9}$ M_{sun}
- Line emitting gas: range of morphologies
- Evidence for diffuse emission in some cases
- Detailed study of bright LAE: gas kinematics might be important for Lyα escape fraction