Dark Cosmology Centre

Lyα emission from GRB host galaxies

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Based on Milvang-Jensen et al. (2012)

Galaxies meet GRBs at Cabo de Gata, 26 Sep 2013

Why Lyα?

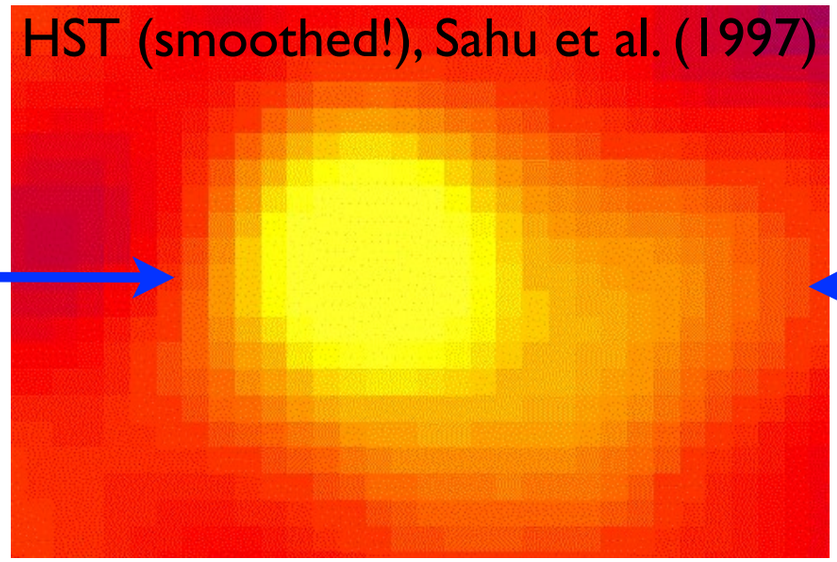
1216 Å: accessible to high redshift

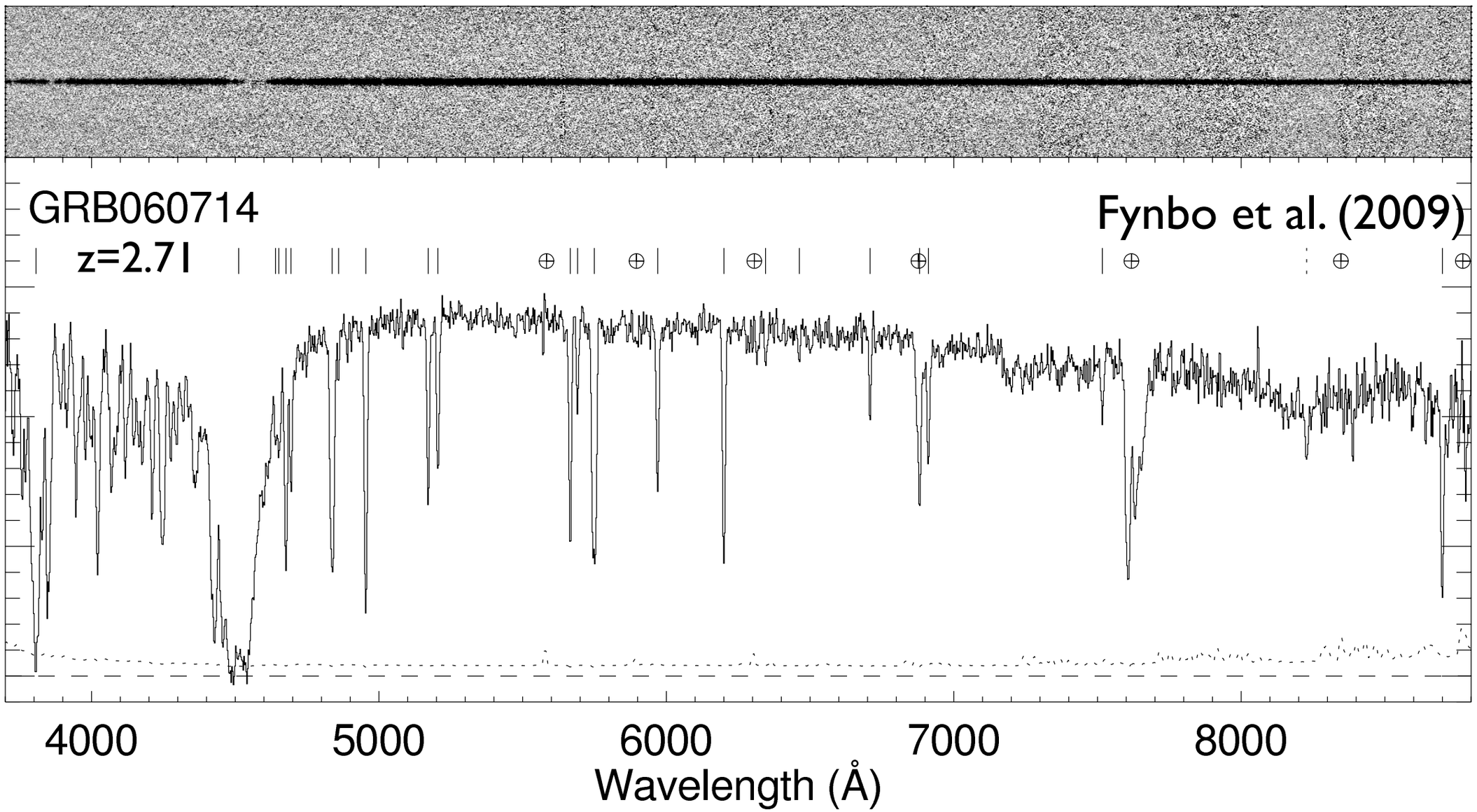
Gamma-ray burst basics (for the sake of good order!)

- γ-ray burst, localised to a few arcmin (e.g. *Swift* satellite)
- X-ray afterglow usually seen, localised to a few arcsec
- Optical/NIR afterglow may be seen
- Spectroscopy of the afterglow can provide a redshift from interstellar absorption lines, e.g Si II, C IV, Fe II, Mg II

Example afterglow image and spectrum

GRB 970228
z=0.7





GRB basics cont'd

- A *host galaxy* may be found, typically in deep observations at later times
- Long-duration GRBs are associated with the deaths of massive stars, i.e. GRBs trace star-forming galaxies:
  → *GRB-selected galaxies*
- GRBs can potentially locate faint galaxies up to very high redshifts (the GRB redshift record is z = 8.2)

Do GRB host galaxies have Lyα emission?

In the pre-*Swift* era, Fynbo et al. (2003) noted:
5 detections of Lyα emission from GRB host galaxies out of 5 possible.

This result needed to be verified using a large, well-defined and complete sample of *Swift* bursts

The Optically Unbiased GRB Host (*TOUGH*) sample

- Sample of 69 bursts selected by their X-ray afterglow, hence *optically unbiased* (Hjorth et al. 2012)

Subsample for the Lyα spectroscopy:

- The 20 bursts with z = 1.8–4.5

  Not used for the selection: deep R-band host imaging:
  R_{host} = 24.4–27.5 (14 hosts) and R_{host} > 27 (6 hosts)

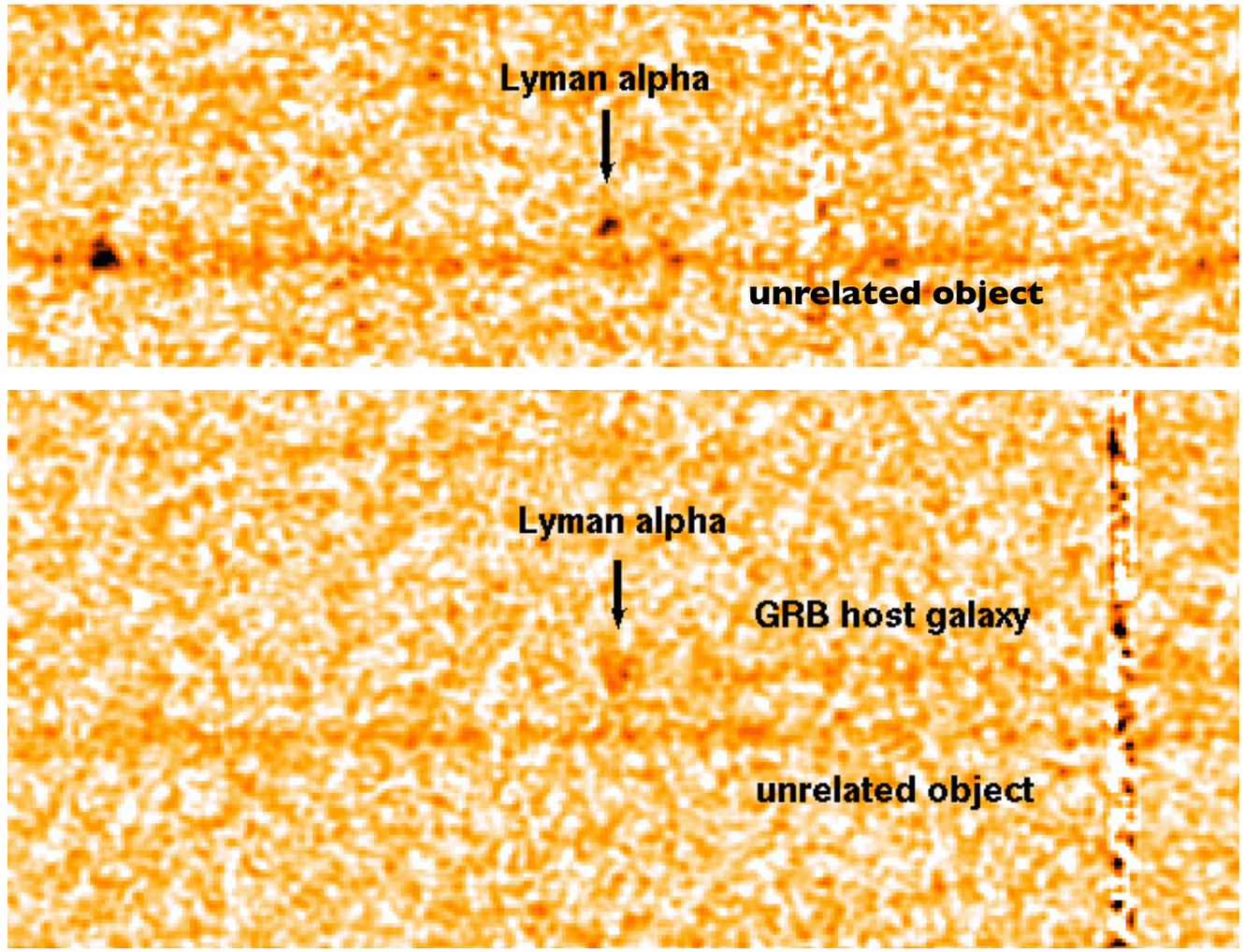
Not selected for Lyα spectroscopy:

- The 21 bursts with z < 1.8 or z > 4.5
- The 27 bursts without a known redshift at the time
  - 7 of these were later found to be at z = 1.8–4.5 (Krühler et al. 2012): not yet incorporated in the analysis

Lyα spectroscopy

VLT FORS1 longslit observations of 20 GRB positions,
1.5–4 hours per target

3 examples:

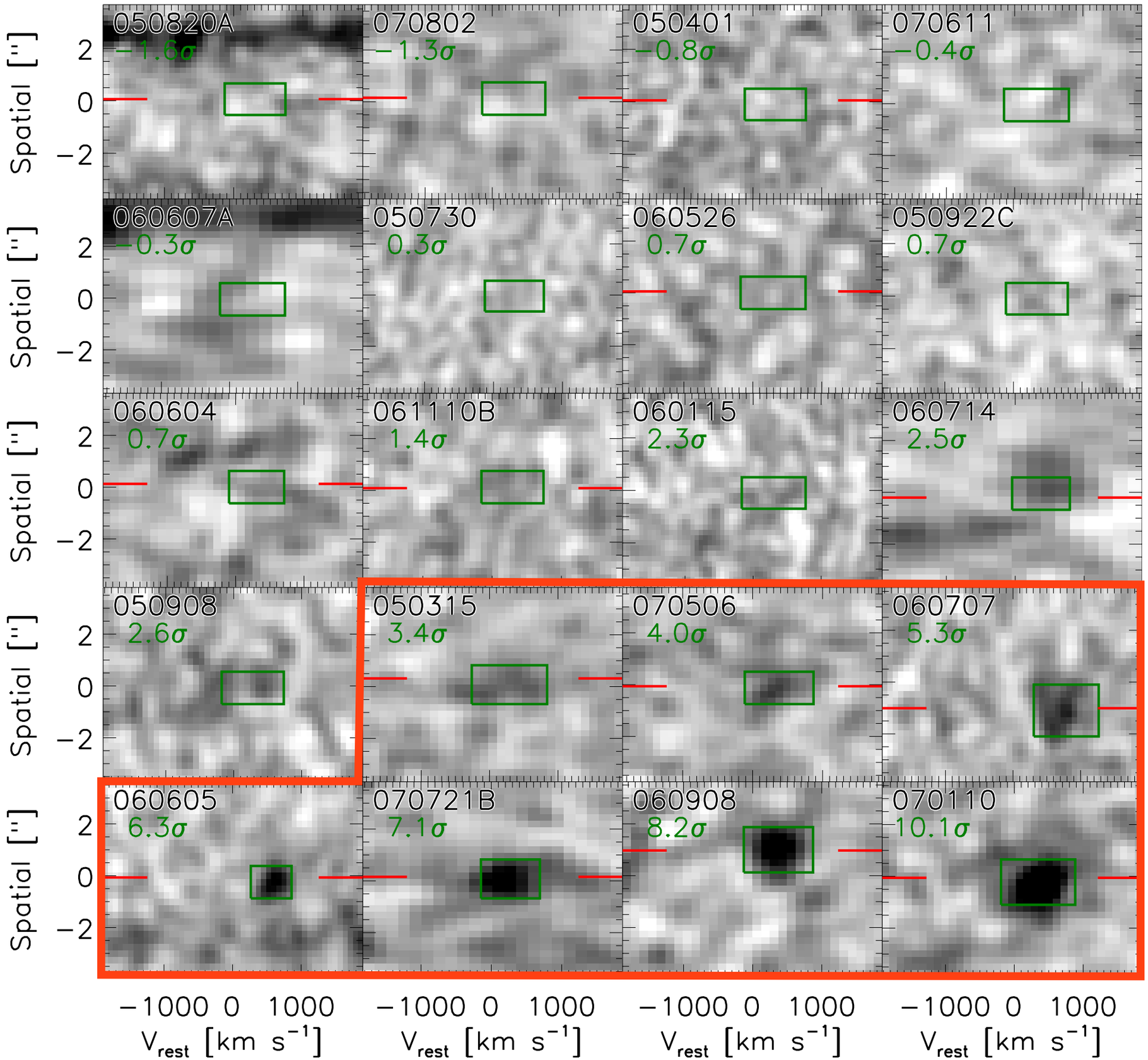


GRB 060605

GRB 060707

GRB 070110

All the 2D spectra: Lyα emission detected in 7 hosts

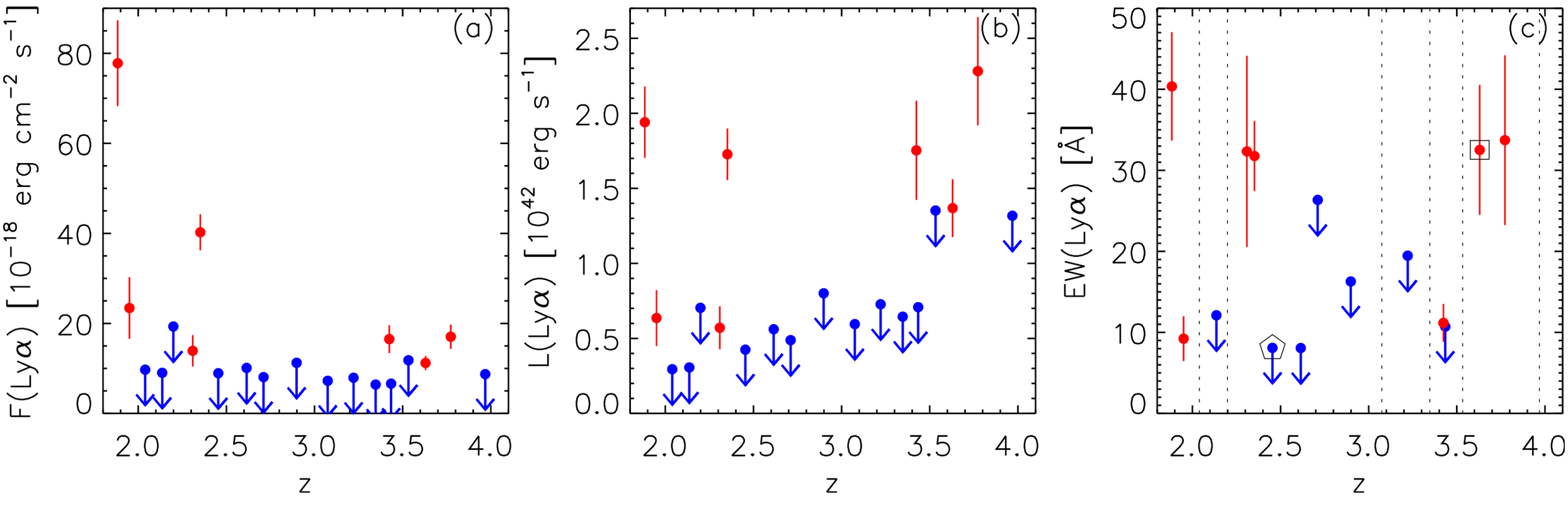


The 7 Lyα detections at ≥3σ

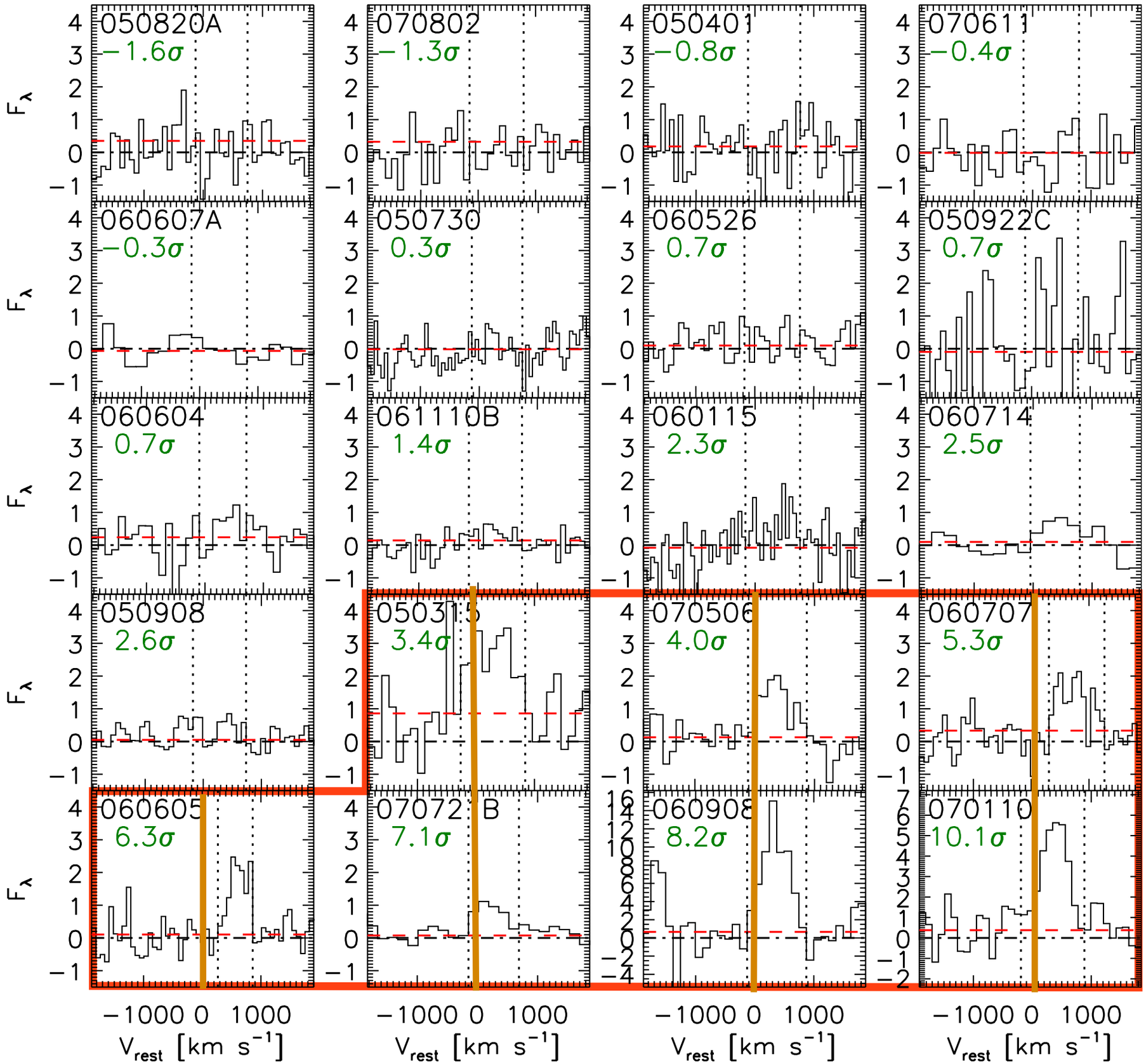
Results

- 7 Lyα detections (all with continuum detected)
- 13 Lyα non-detections:
  - 7 with continuum detected
  - 6 with nothing seen in the spectra

Flux [10^{-18}] Luminosity [10^{42}] EW [Å]



The 1D spectra

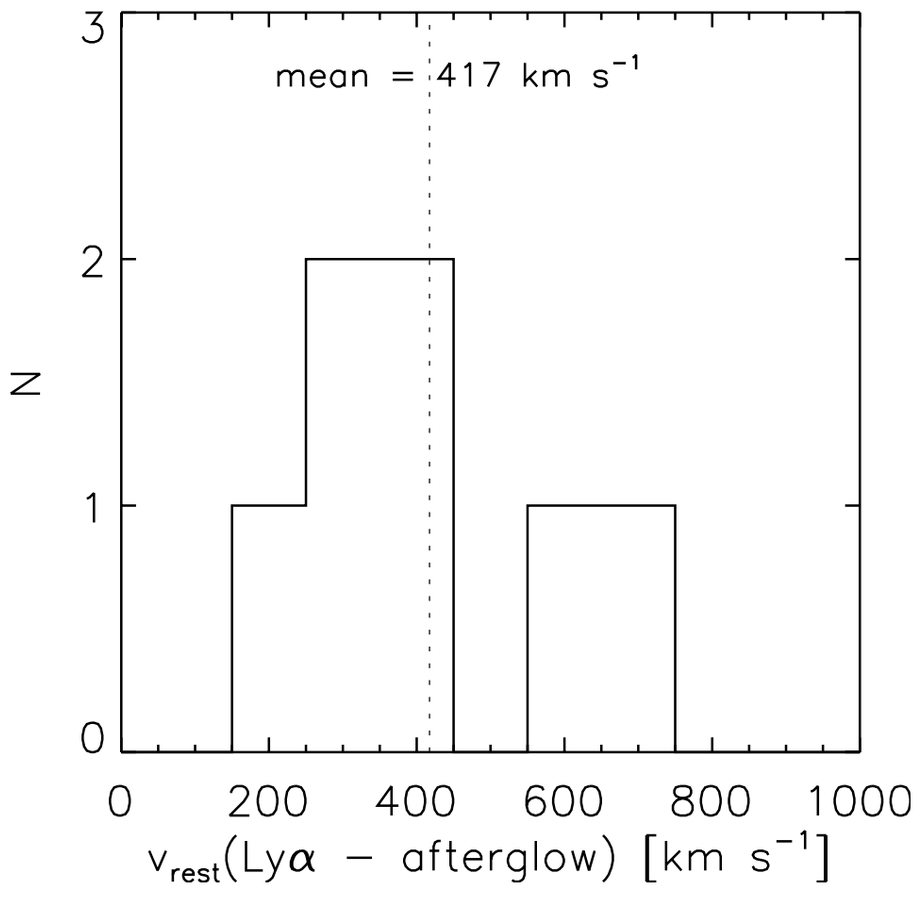


Zero velocity defined by the afterglow redshift, from interstellar absorption lines

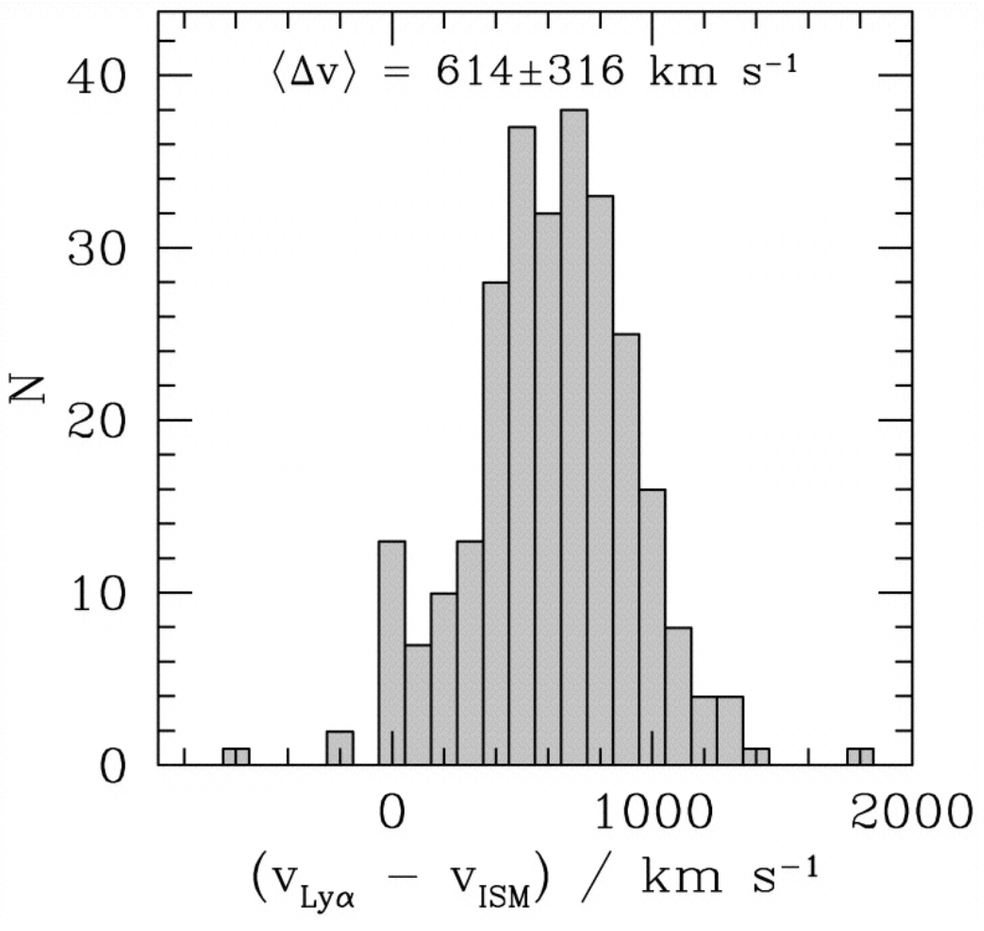
The 7 Lyα detections at ≥3σ

Velocity offset of Lyα wrt. interstellar absorption lines

GRB host galaxies (this work)



Lyman break galaxies (Adelberger et al. 2003)

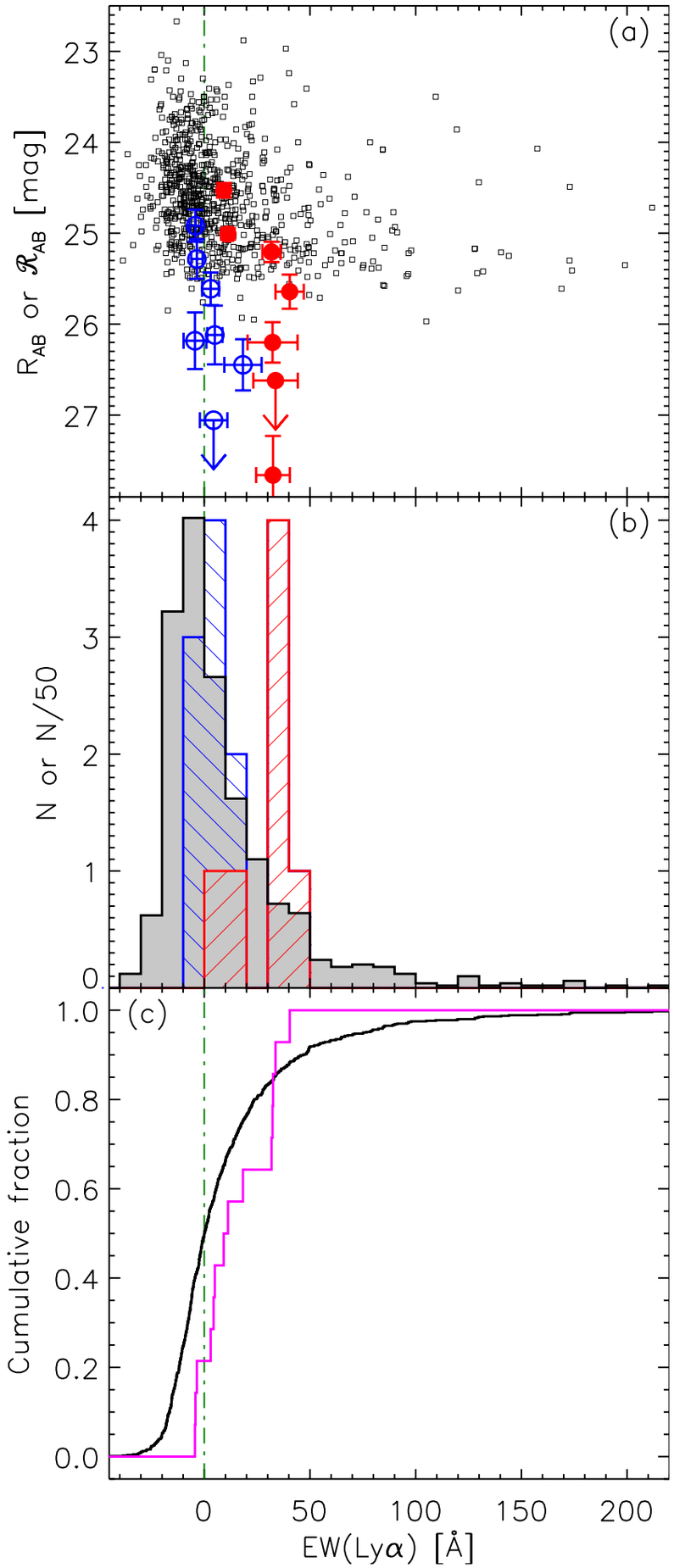


EW(Lyα): GRB host galaxies vs Lyman-break galaxies, at z ≈ 3

Grey: Lyman-break galaxies from Shapley et al. (2003)

Red/blue: GRB host galaxies with/without Lyα emission at 3σ

Marginal evidence for a larger average EW for the GRB host sample, but the sample is incomplete

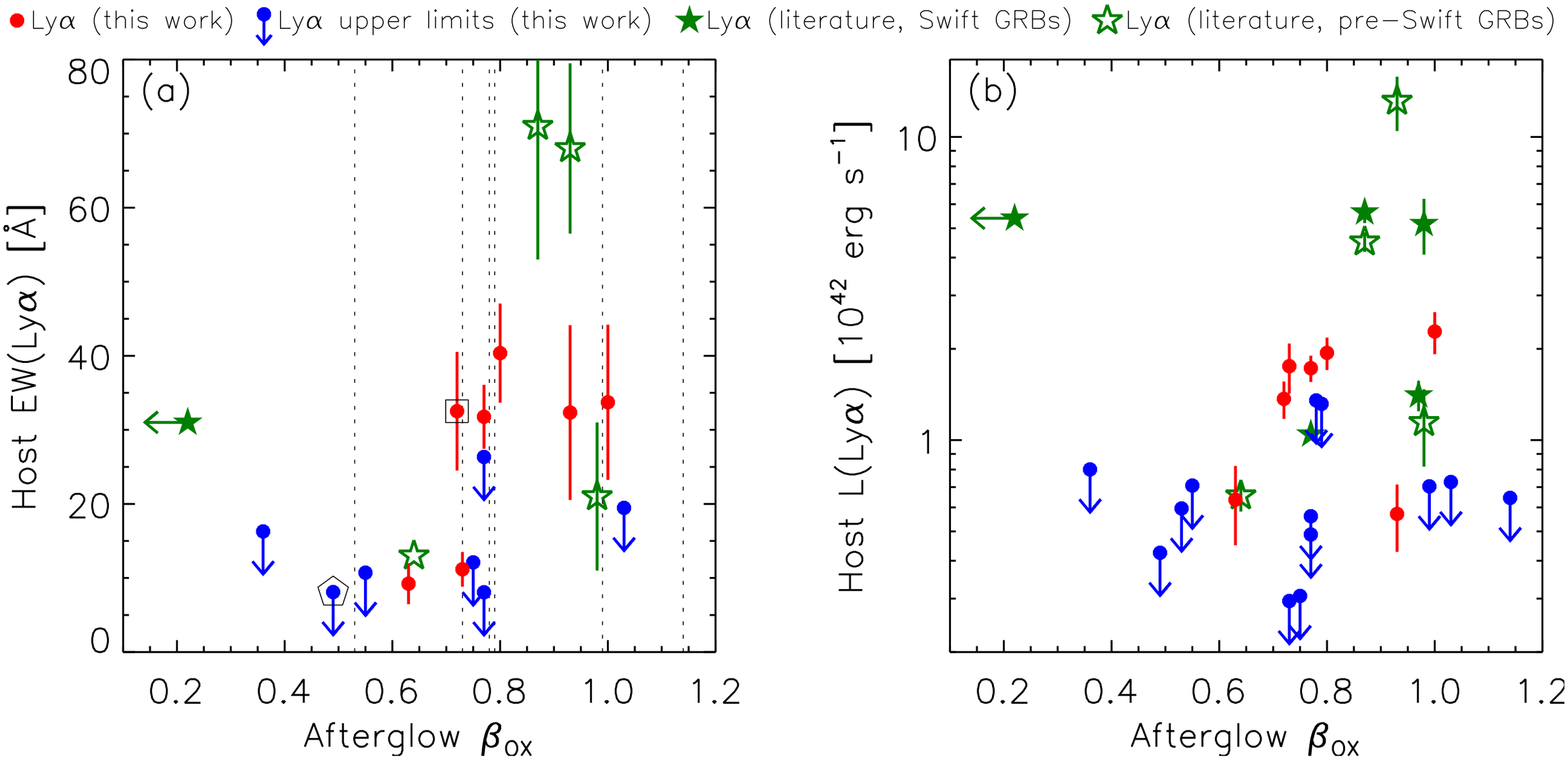


Adding GRB host Lyα emitters from the literature

GRB 971214	Kulkarni et al. (1998)
GRB 000926	Fynbo et al. (2002)
GRB 011211	Fynbo et al. (2003)
GRB 021004	Moller et al. (2002)
GRB 030323	Vreeswijk et al. (2004)
GRB 050315	This work
GRB 060605	This work
GRB 060707	This work
GRB 060714	Jakobsson et al. (2006)
GRB 060908	This work
GRB 060926	Fynbo et al. (2009)
GRB 061222A	Perley et al. (2009)
GRB 070110	This work
GRB 070506	This work
GRB 070721B	This work
GRB 071031	Fynbo et al. (2009)
GRB 090205	D'Avanzo et al. (2010)

Lyα and dust

β_{OX}: Afterglow Optical-to-X-ray spectral index (think $F_\nu \propto \nu^{-\beta_{OX}}$)



GRBs in high-EW Lyα host galaxies have a blue afterglow spectrum (high β_{OX}): Dust effect?

Summary

- 20 z = 1.8–4.5 GRBs searched for Lyα emission: detected in 7 cases, ≈ 35%
- If only considering the hosts detected in the R-band: Lyα emission detected in 7/14 = 50%
- 6 hosts have 3σ upper limits EW < 20 A, and GRB hosts are *not* all strong Lyα emitters
- Velocity offset v(Lyα em.)−v(interstellar abs.) ≈ 400 km/s
- GRBs in high-EW Lyα host galaxies have a blue afterglow spectrum (high β_{OX}): dust effect?

Thank you