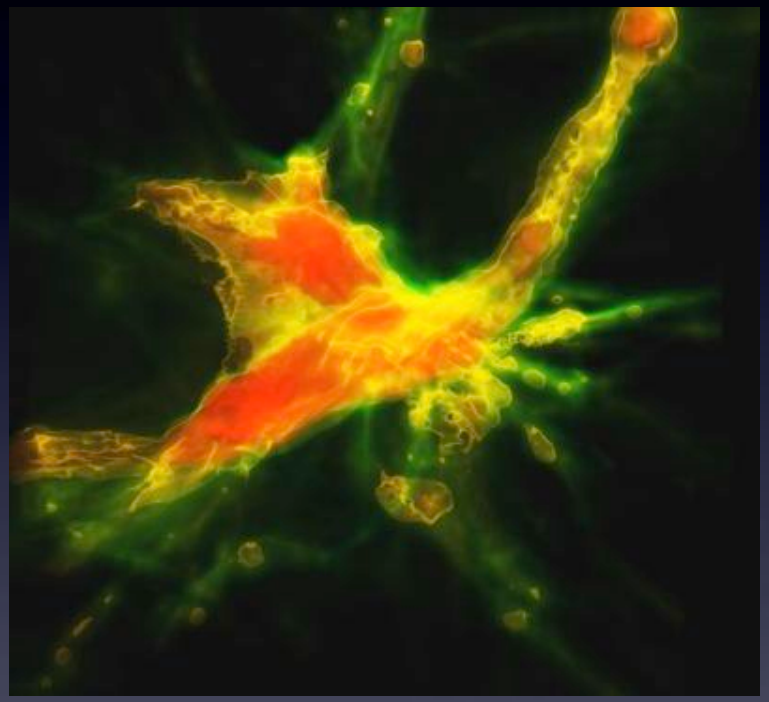
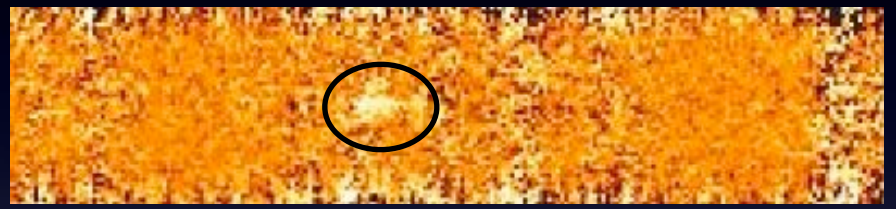
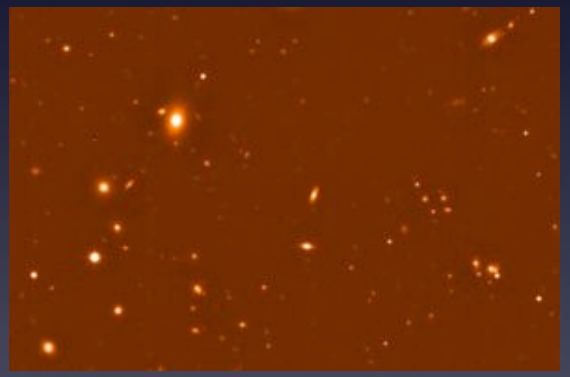
Bright LAEs at z~9:

Constraints on the luminosity function from HizELS

David Sobral







P. Best, **I. Smail**, **J. Geach**, **M. Cirasuolo**, **R. Ivison**, K. Coppin, J. Kurk, M. Casali, G. Dalton

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Sobral et al. 2009a&b

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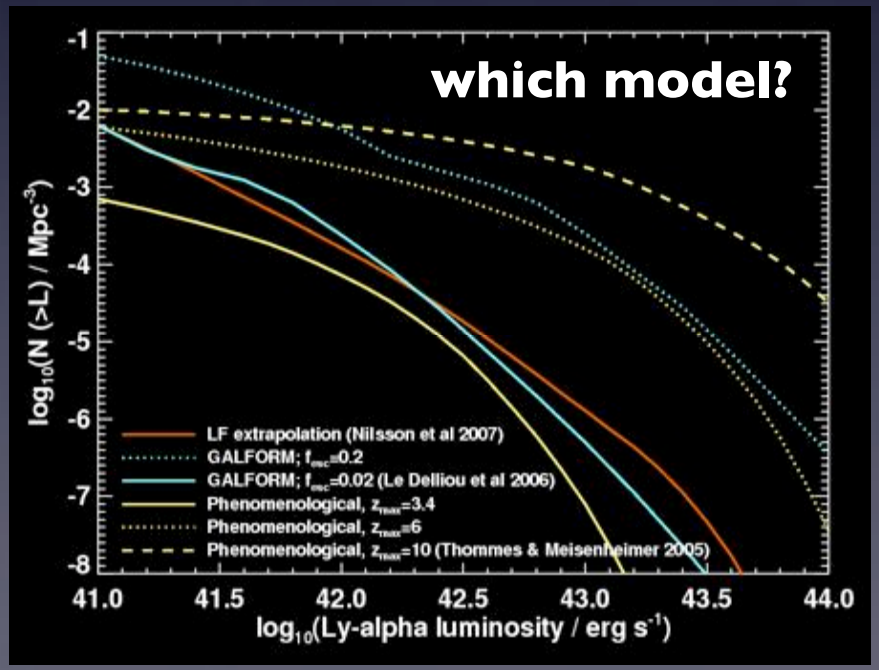
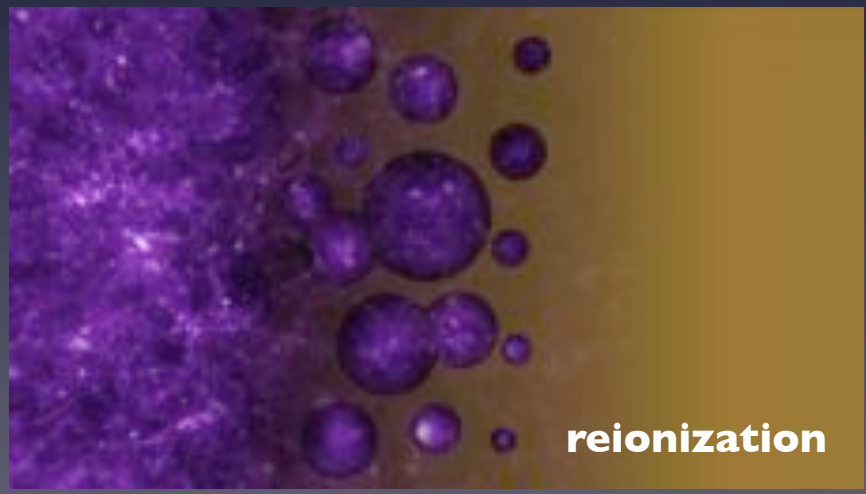
Why high-z?

- Understand galaxy formation and evolution
- Really break degeneracies (and test) Models
- Find the "first galaxies"
- Important insight into the "early years"



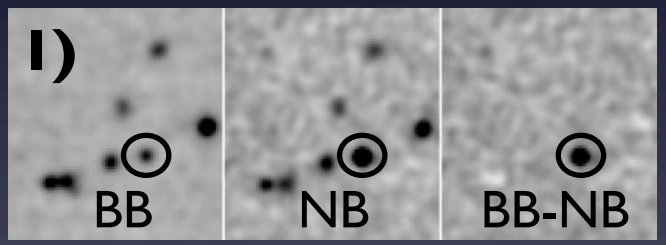


What are we looking for?

- Extremely distant galaxies; probably the first ones to have formed.
- Population III signatures? Different IMF? "Different" Physics? Ages? SFRs? Dust? Fundamental properties?
- What are they like?
- Is there an optimal approach?

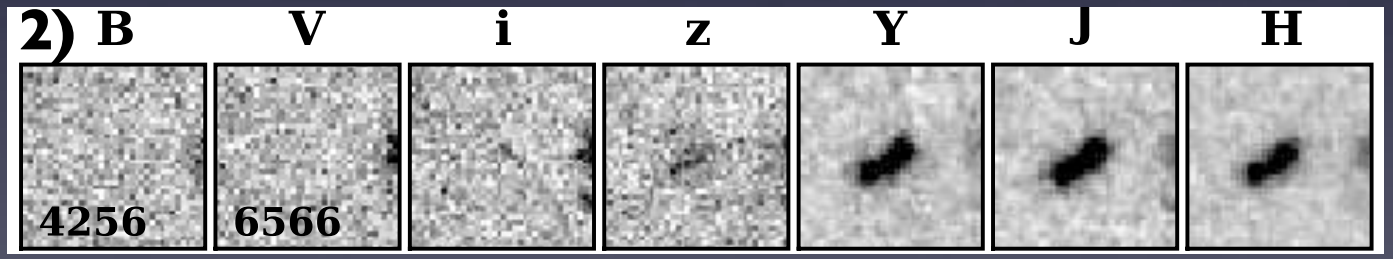
In practice...

- Various techniques **~10-100s of hours**
- 1) Narrow-band imaging - infrared **(Lyα!)**
- 2) Deep broad-band photometry **(Lyman-breaks!)**
- 3) Spectroscopy & Blind spectroscopy **(Lyα emission!)**



All need deep imaging and follow-ups to exclude low-z contaminants

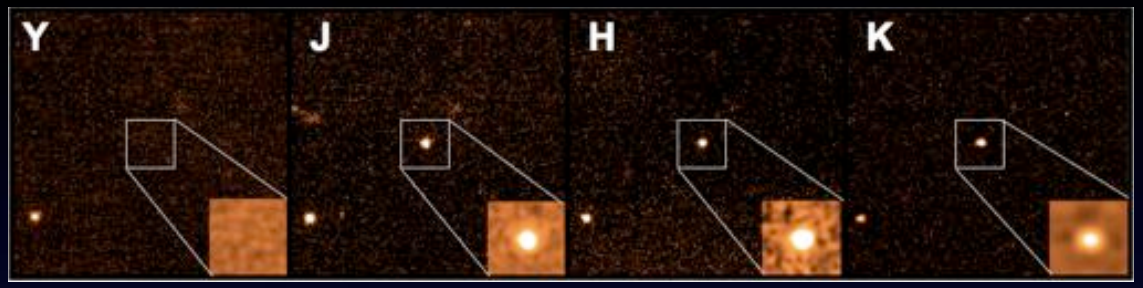
Lyman breaks at z>7:



UV absorption by H - either in the galaxy or along the line of sight

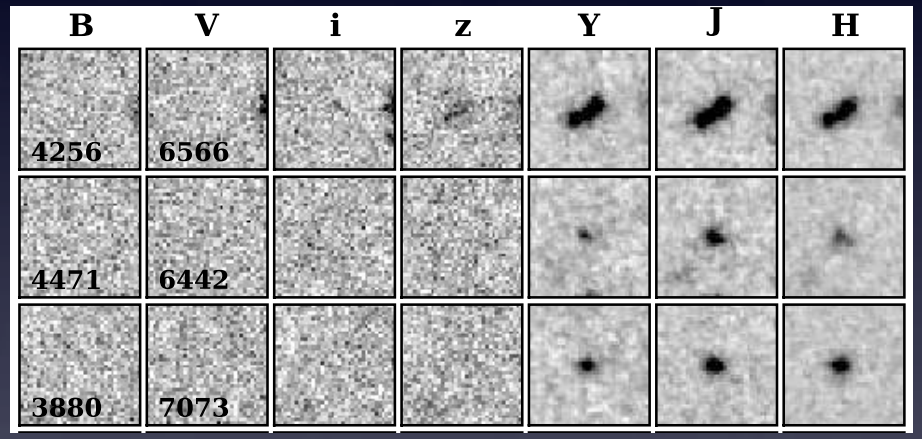
Typical line profile

(Very) Recent Progress



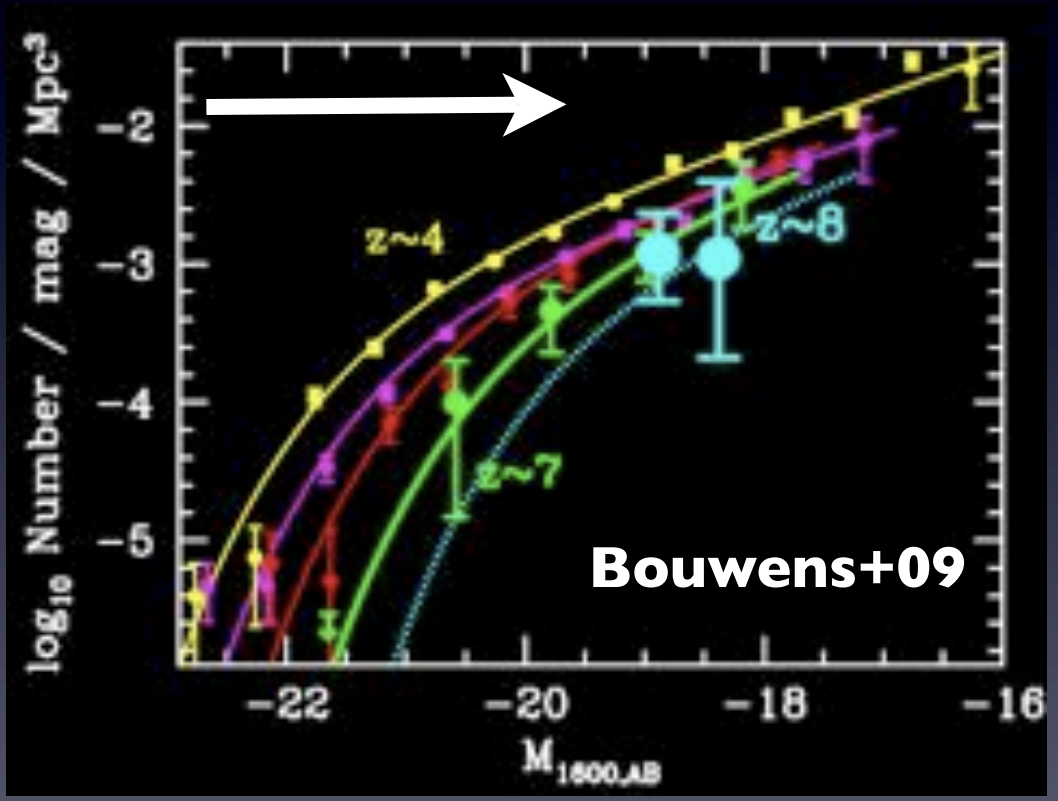
Most distant object, **z**~8.2

- GRBs (Tanvir et al. 2009)
- Lyman-break searches
- **WFC3/HST "revolution"**
- ~20-50 z>6 candidates in a few days
- Bouwens et al. 2009, Oesch et al. 2009
- McLure et al. 2009, Bunker et al. 2009, (many more et al. 2009)



UV luminosity function

- Strong decrease in M^*
- Steep faint end-slope...
- Implications for reionization?
- Observed not enough...?
  - z~8?



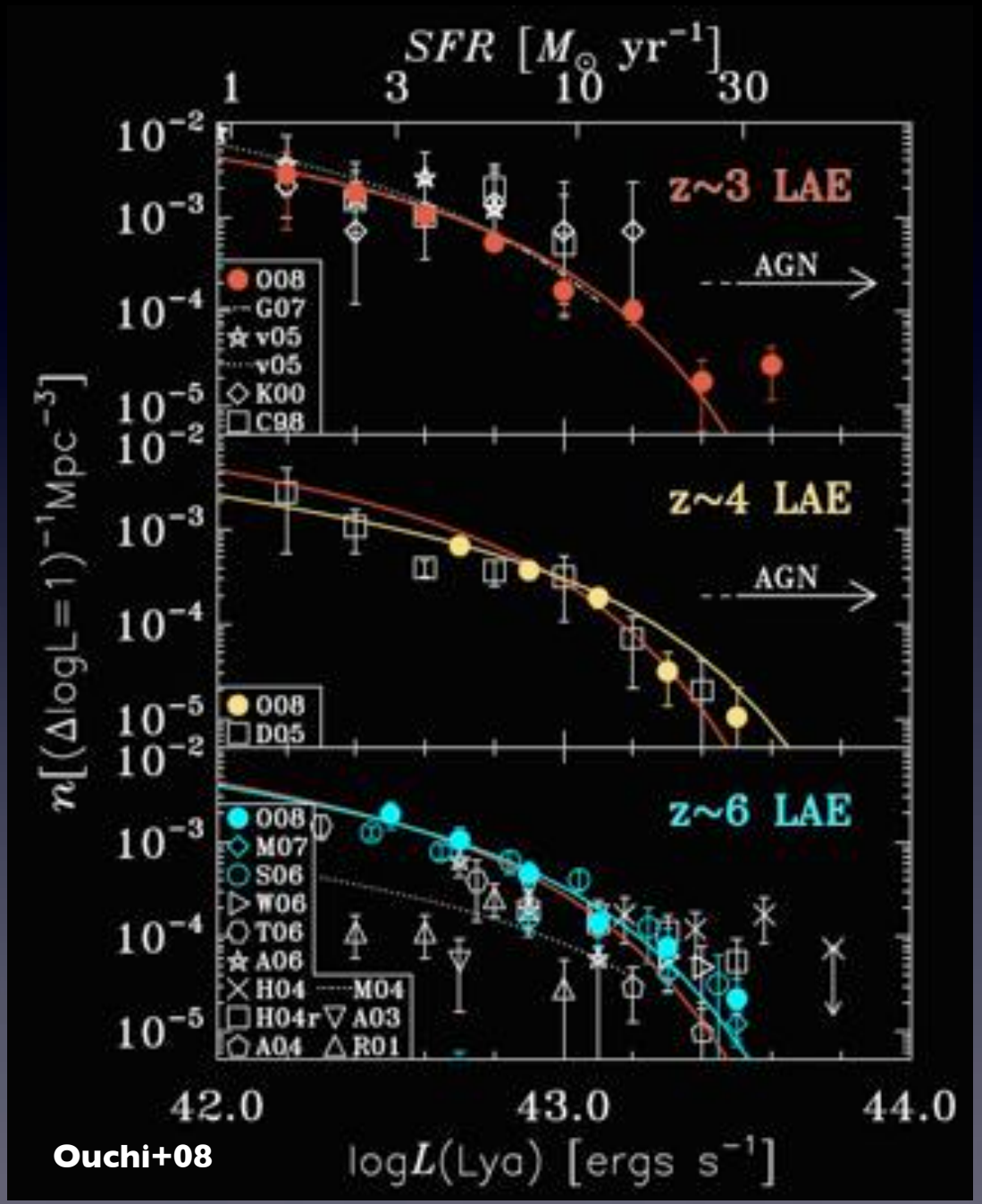
- **What about the NB Ly-α searches?**

The NB Lyα Searches up to z~6

Deep ground-based NB searches

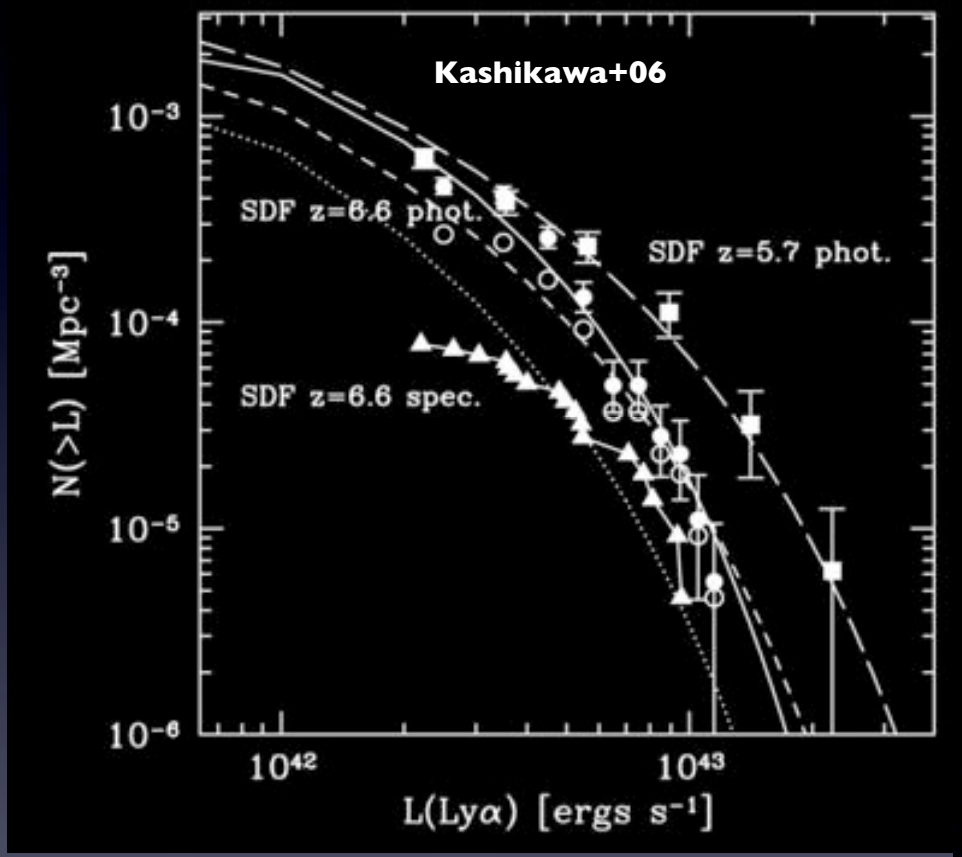
~Little Evolution 3<z<6

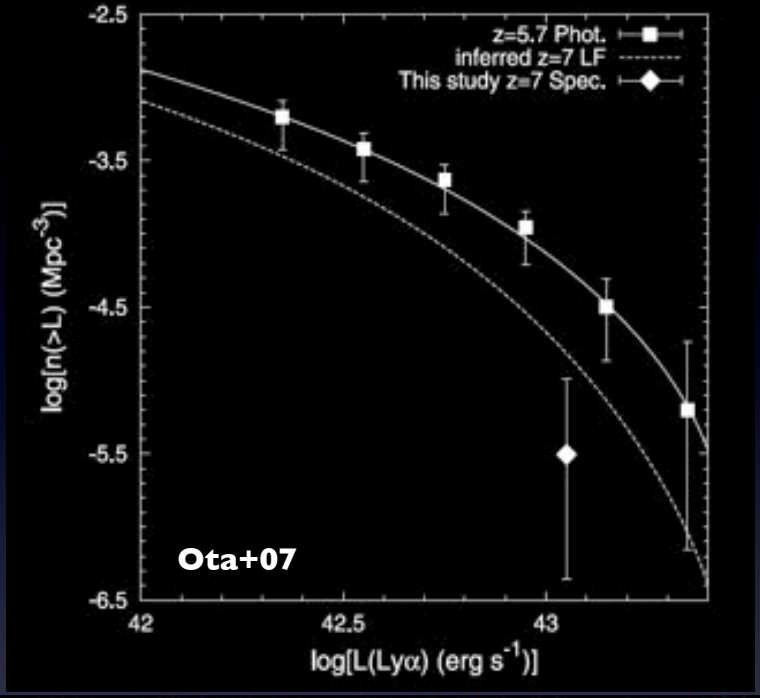
Samples ~small Cosmic variance Contaminants

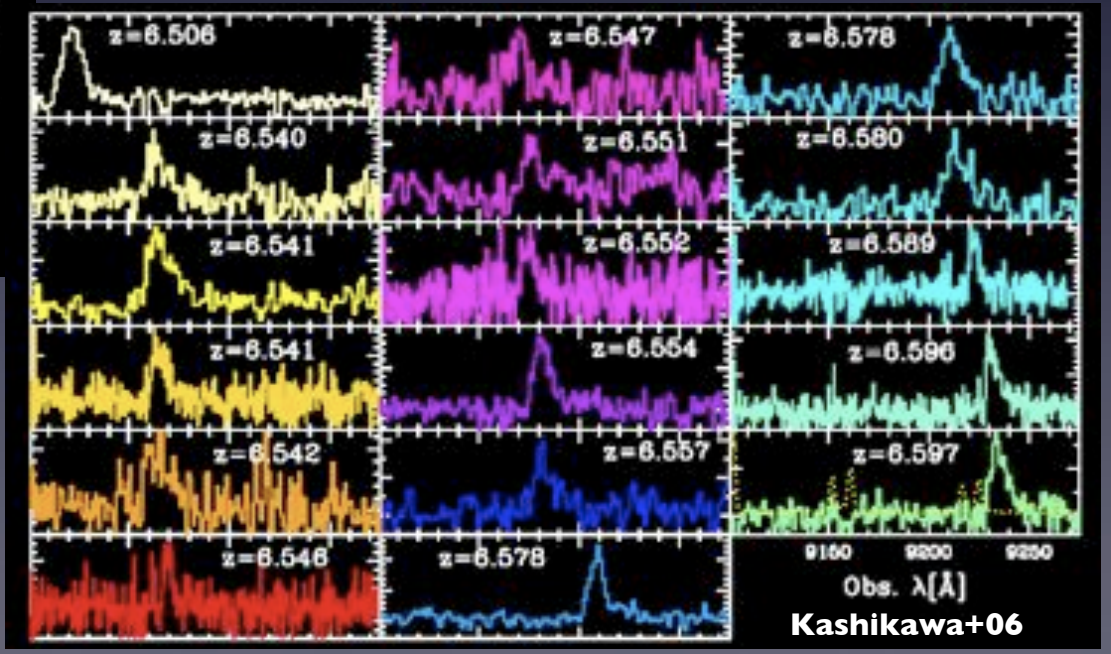


Significant changes at z>6 ?

Lyα emitters





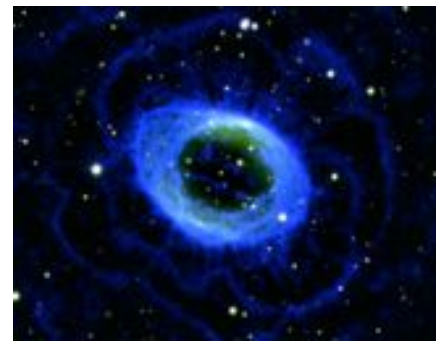


Decrease in bright end z>6?

Can we go beyond z~8 and how much would (will) we learn?

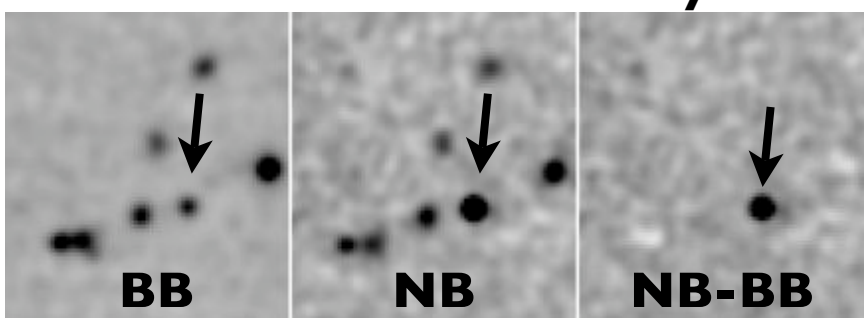
- Highest-z galaxy spectroscopically confirmed z=6.96 (Iye et al. 2006), most distant object z=8.2 (Tanvir et al. 2009)
- Most candidates come from pencil beam ultra-deep surveys and are too faint for detailed follow-up - so until a new generation of instruments/telescopes comes along we can't learn that much from them
- Despite that, can we really get to z~9 and beyond?
- Can larger area surveys pick very rare, brighter sources which we can follow-up in detail? HizELS!

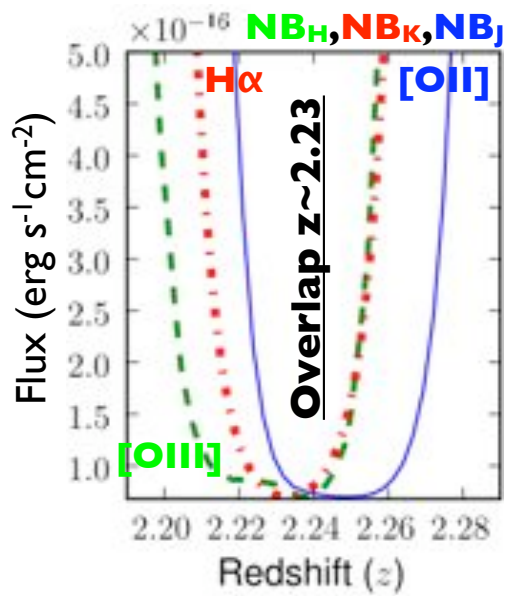
HizELS: the High-z Emission Line Survey

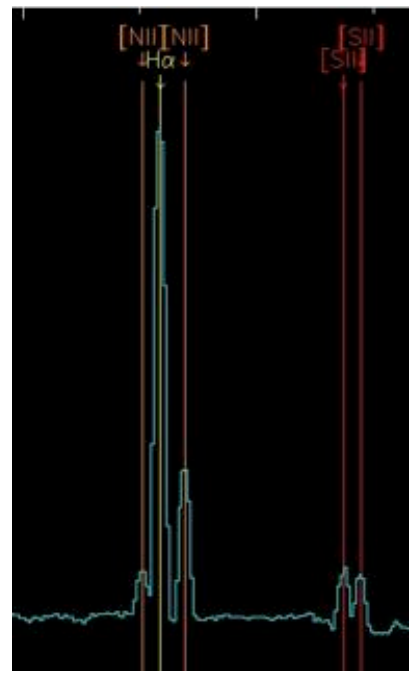


- **H**igh-Redshift(**z**) **E**mission **L**ine **S**urvey
- Selecting Star-forming galaxies at $z < 9$
- **Hα** at z= ***0.84***, 1.48, 2.23 (Geach et al. 08, Sobral et al. 09a)
- **NB$_J$**: [OIII] at z=1.44, [OII] at z=2.23, **Lyα at z=8.9** (**Sobral et al. 09b**)
- ~10 sq.deg, >1000 SF galaxies in each band (+AGN)
- Campaign Program at the UKIRT

Narrow band survey







HizELS search at z~9

Deepest+wider NB survey in near infrared: UKIRT/WFCAM

NB_J survey : $F_{lim} > 7.8x10^{-17}$ erg $s^{-1}cm^{-2}$ over ~1.5 sq.deg in 2 fields

At z=8.96±0.06: $V_{Ly\alpha} \sim 10^6$ Mpc^3

$L_{Ly\alpha} > 10^{43.8}$ erg/s

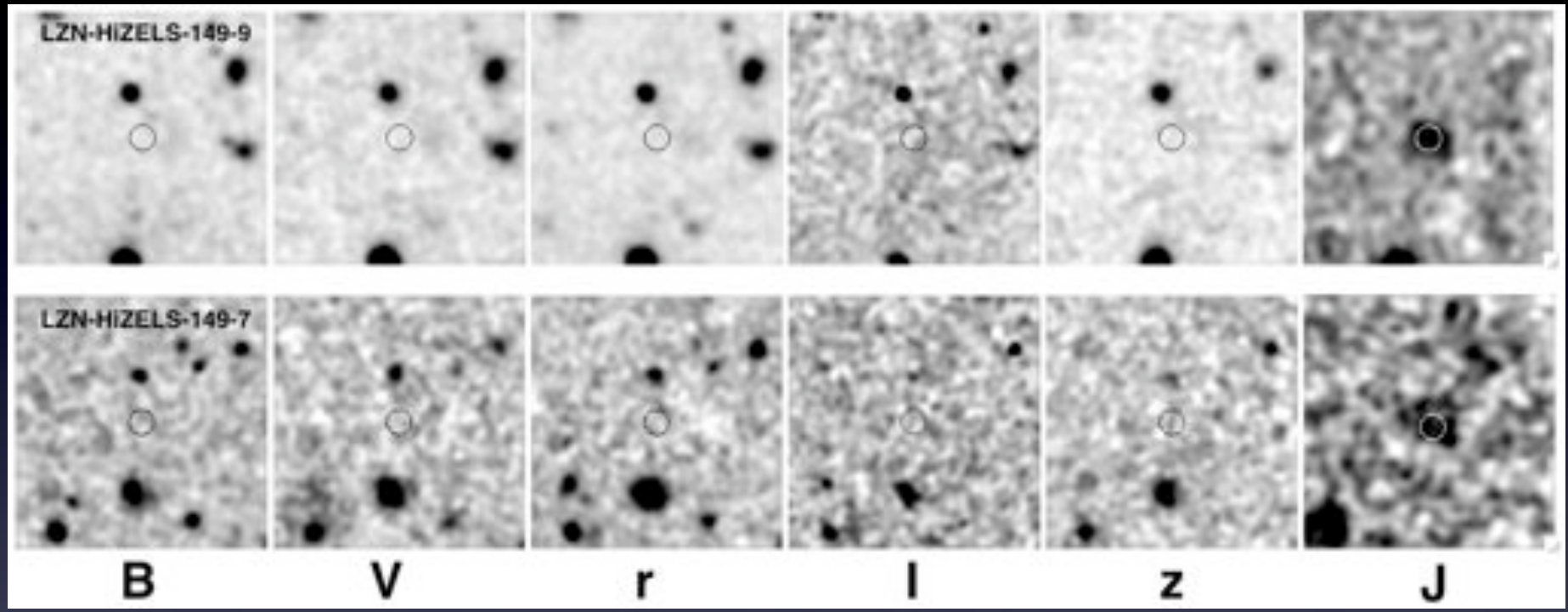
COSMOS and UKIDSS UDS

Sobral et al. 2009a, MNRAS, 398, 75
Sobral et al. 2009b MNRAS, 398 L68

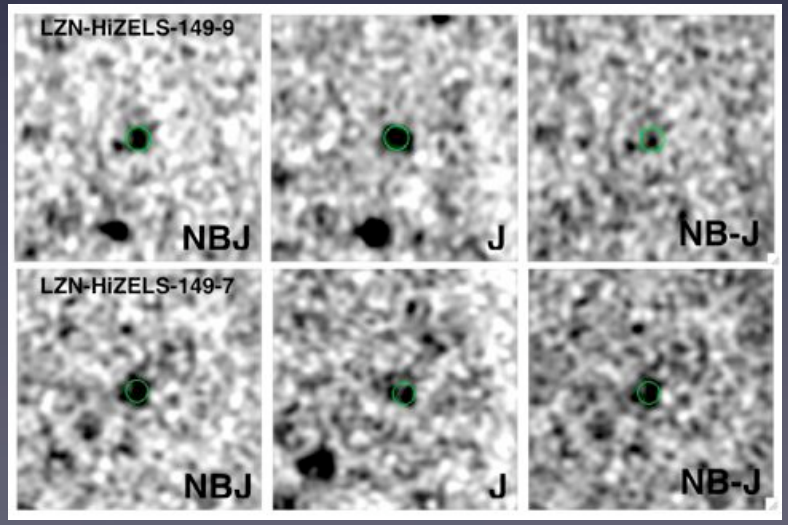
Dedicated detailed search:

- 1) Selected Emitters: ~1600
- 2) Avoid clear noisy areas - detailed visual inspections: ~1500
- 2) Robust detection (>5sigma) at least in NBJ: ~1400 emitters
- 4) No detection in any deep visible imaging data (ZJ drop): 2 candidates

HiZELS candidates z~9



- z-J>4 + emission line
- Detection on night-by-night
- No proper motion t~1 month

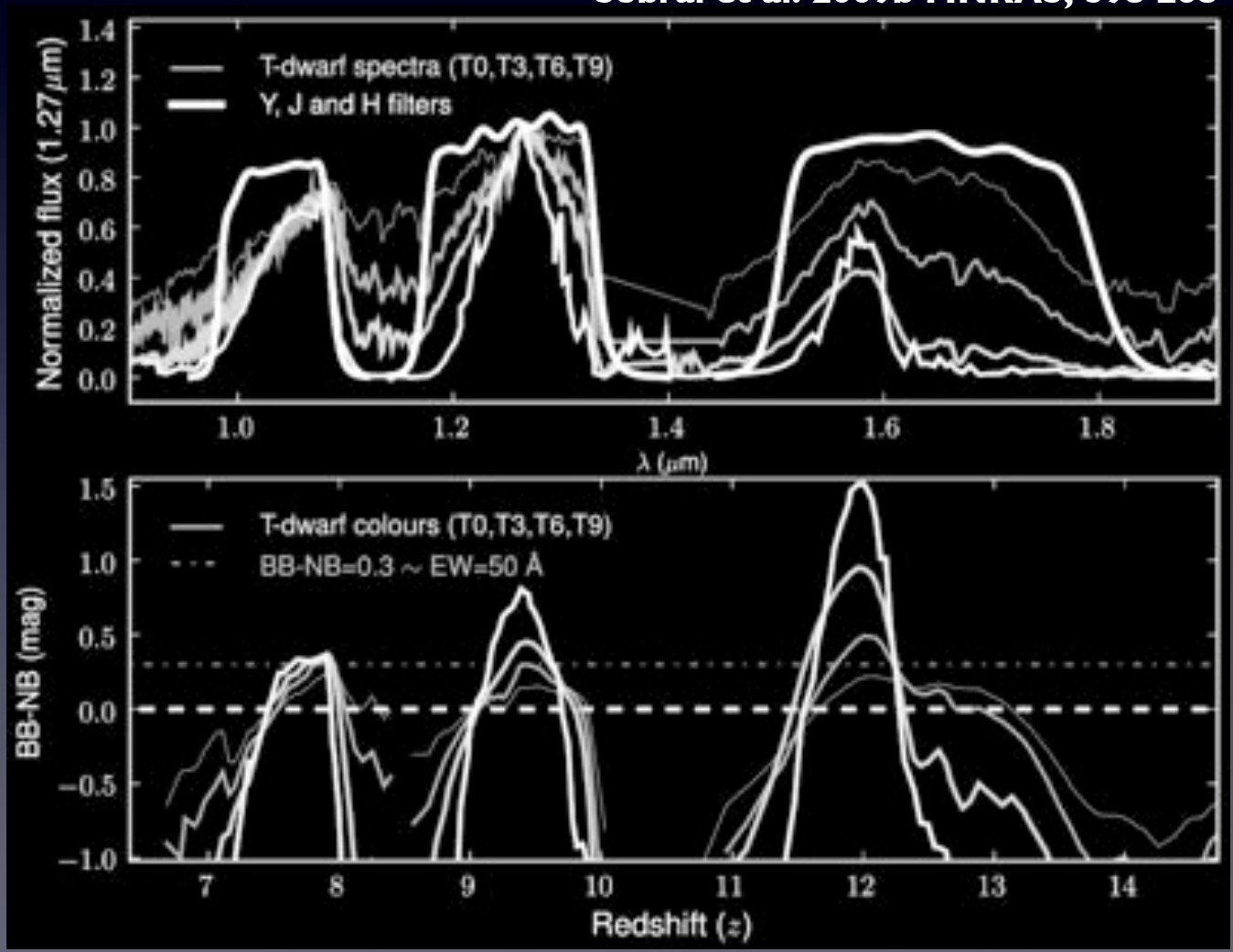


Contamination by cool stars?

- NB excess and z-J drops ~4 with ~flat NIR imaging?
  - Yes! But at 7.5<z<8.0, 9.1<z<9.5 and 11.5 < z < 12.2

- VISTA an JWST are "safe" and the data can potentially be used to identify the coolest brown dwarfs as they should present negative BB-NB colours

Sobral et al. 2009b MNRAS, 398 L68

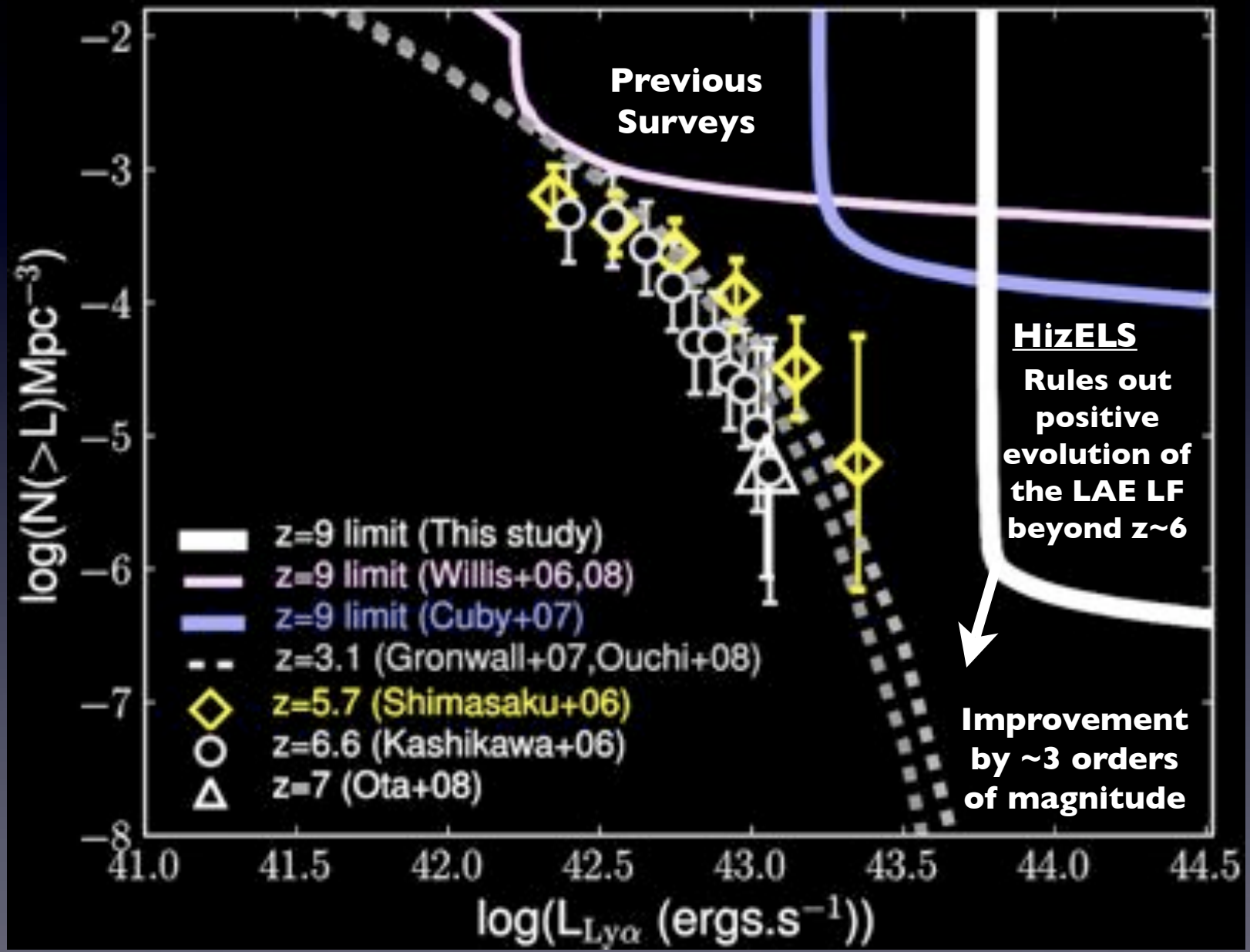


HizELS candidates z=8.96

- CGS4 spectroscopy: no line down to ~4×10^{16} erg/s/cm^2
- No detection with follow-up UKIRT J observations
- Both candidates rejected (explained as complicated artifacts caused by jittering+slightly hot pixels)
- So... 0 detections out of ~1500 emitters
- Allows the best constraint on the LF

Constraints on the LAE LF

Sobral et al. 2009b



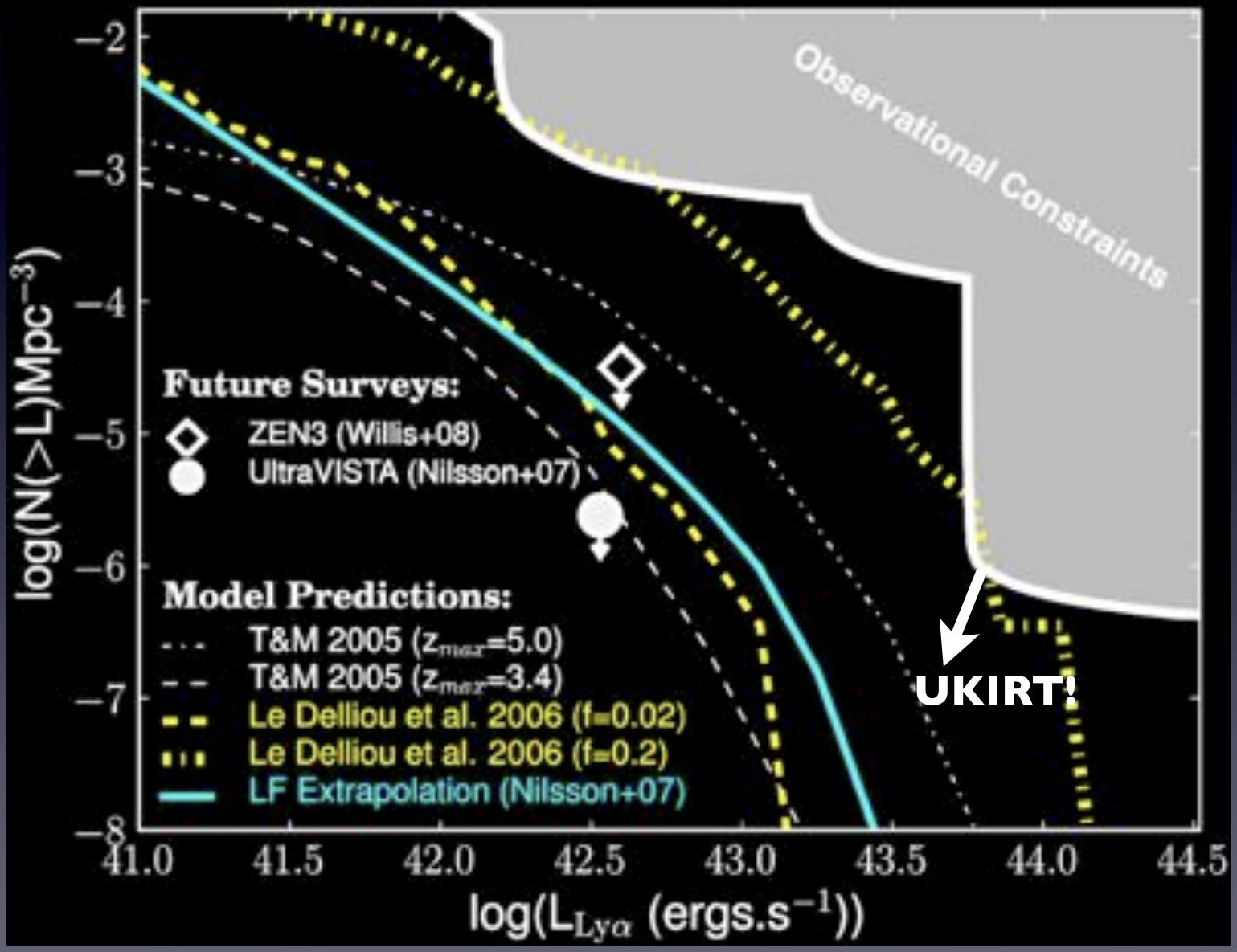
Model Comparison

Extreme models such as T&M 2005 with z_{max}=10 clear rejected

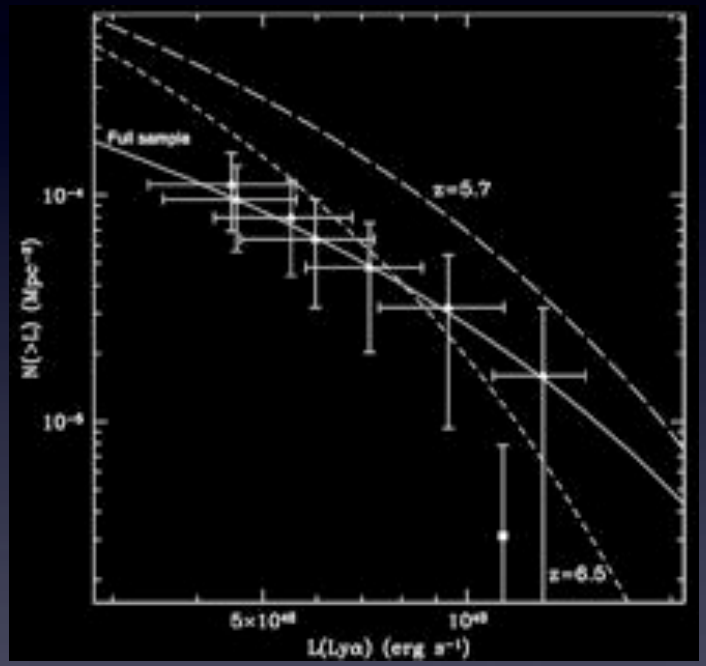
GALFORM with escape fractions of ~0.2 marginally rejected

We need to go deeper (+wider area - more HizELS!)

Sobral et al. 2009b

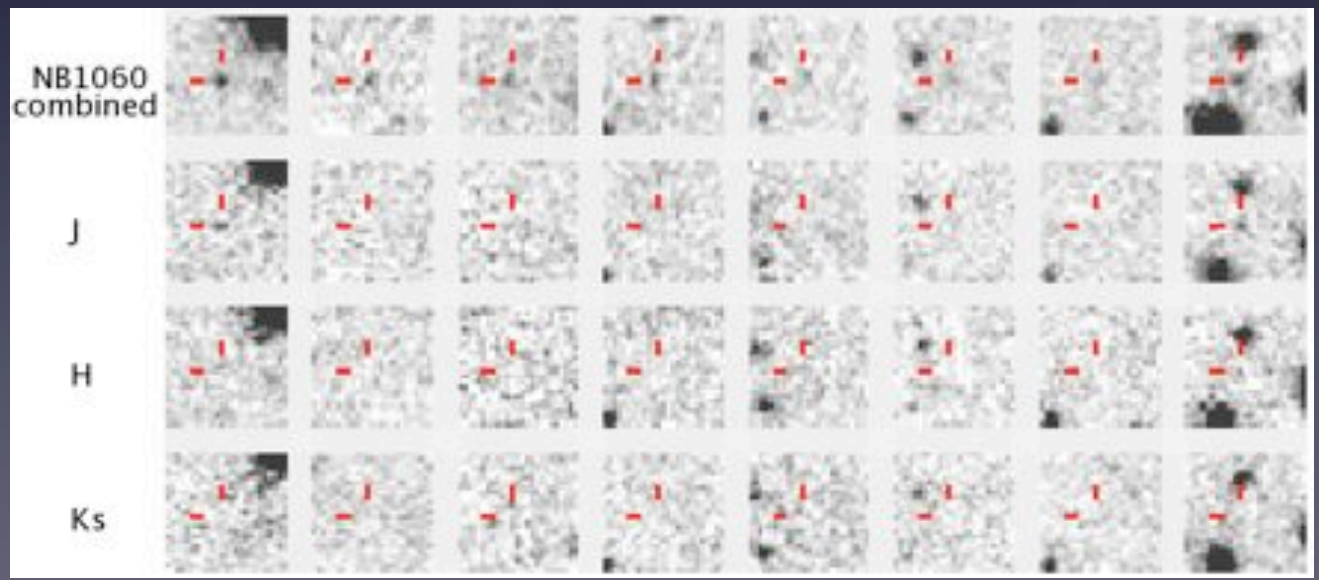


Updates - ZEN3 (ZES)



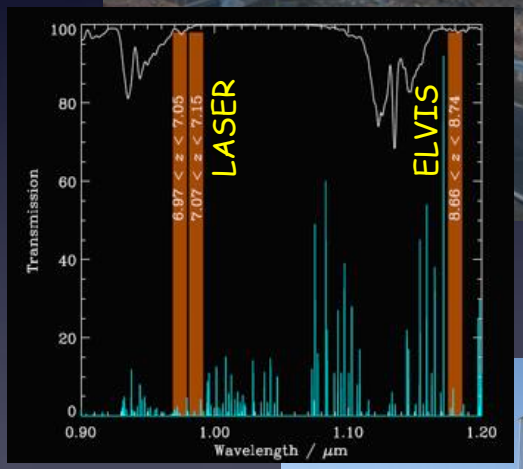
- Seven new z=7.7 LAE candidates?
  - Other candidates?
    - Not very convincing...

Hibon et al. 2009



Ultra-VISTA: ELVIS

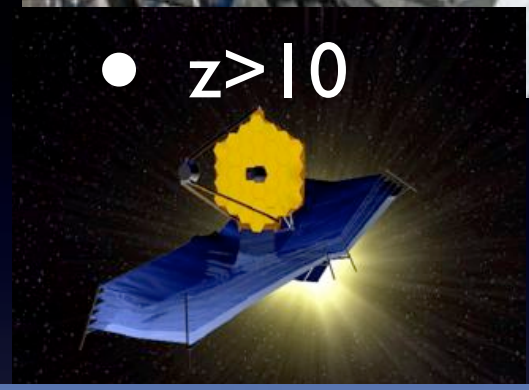
- COSMOS - deep YJHK (1410 hours) + deep NBJ (180 hours) + shallow YJHK (212 hours)
- Window for the Universe at 6.5<z<10
- **~10-30 Lyα emitters at z=8.8** expected to be found
- **HizELS**: LASER, 5 guaranteed nights: Lyα z=7.2 (T-dwarf free!) + [OII] at z=1.6

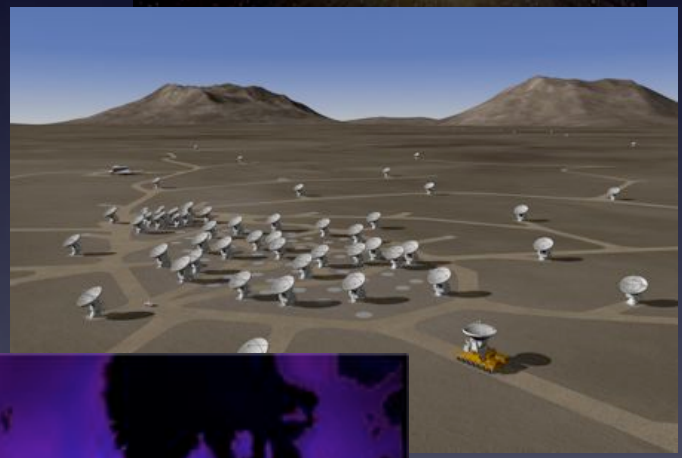


Future looks bright

(although galaxies look faint!)

- The next ~7 years
- ~100s of galaxies at z>7?
- Detailed space & ground follow-ups
- Re-ionization
- AGN vs SF activity at z>7?
- z>10? What is the "limit"?
- UKIRT/HizELS to find the brightest Lyα (AGN?) emitters at z=8.9?





Thank you