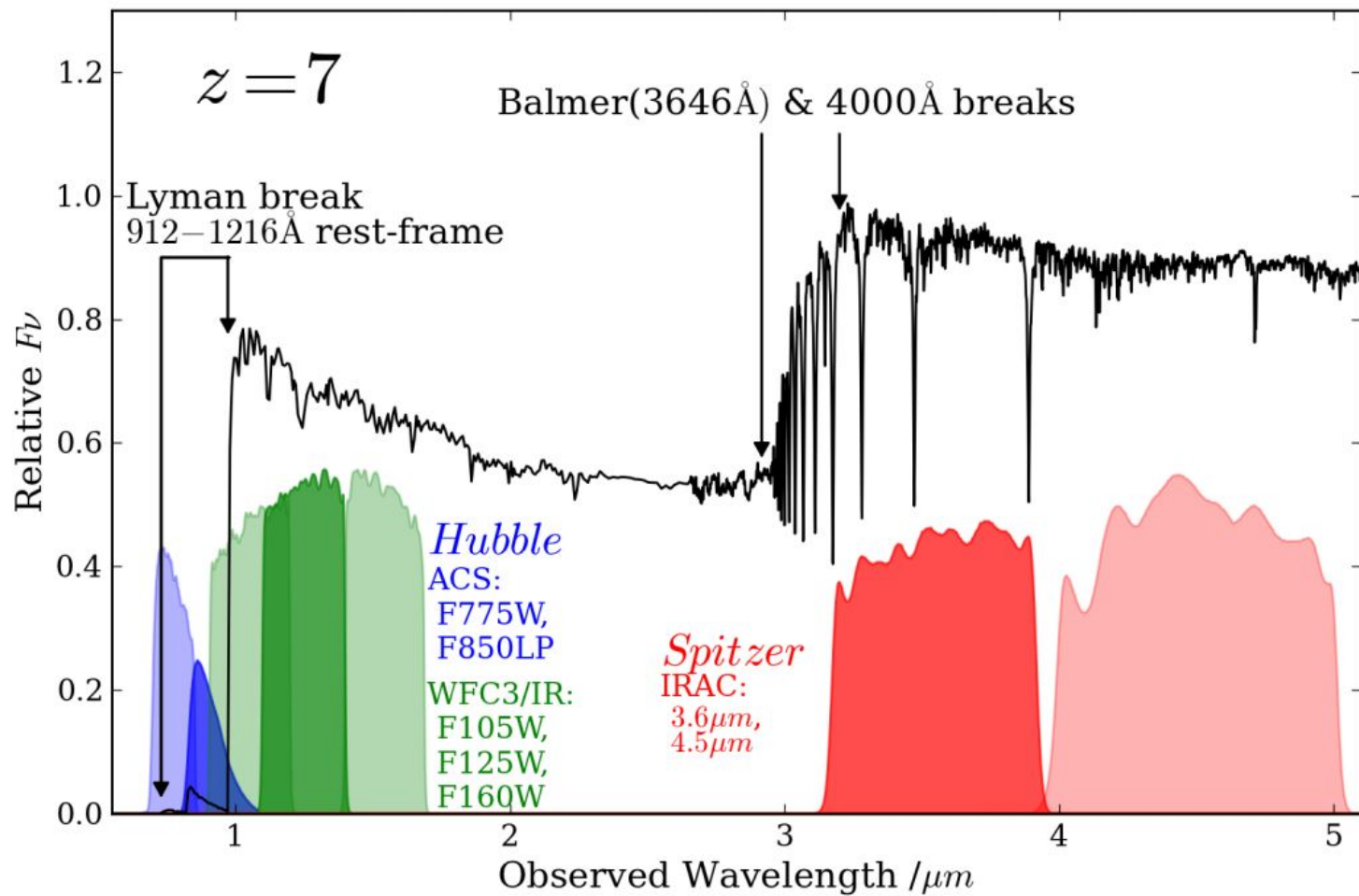


Observing the first galaxies

James S. Dunlop (2012)

Selection techniques

1. Lyman break galaxies (LBGs)
 - HI absorption in IGM and ISM
2. Lyman-alpha Emitters (LAEs)
 - HI emission from ISM
3. Balmer break galaxies
 - Quenched star formation, $>0.5\text{Gyr}$
 - None found!



Selection techniques

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4. Redshifted thermal dust

- Sub-mm/mm
- Completeness

5. AGN emission in radio and optical

- Stellar populations in radio galaxies

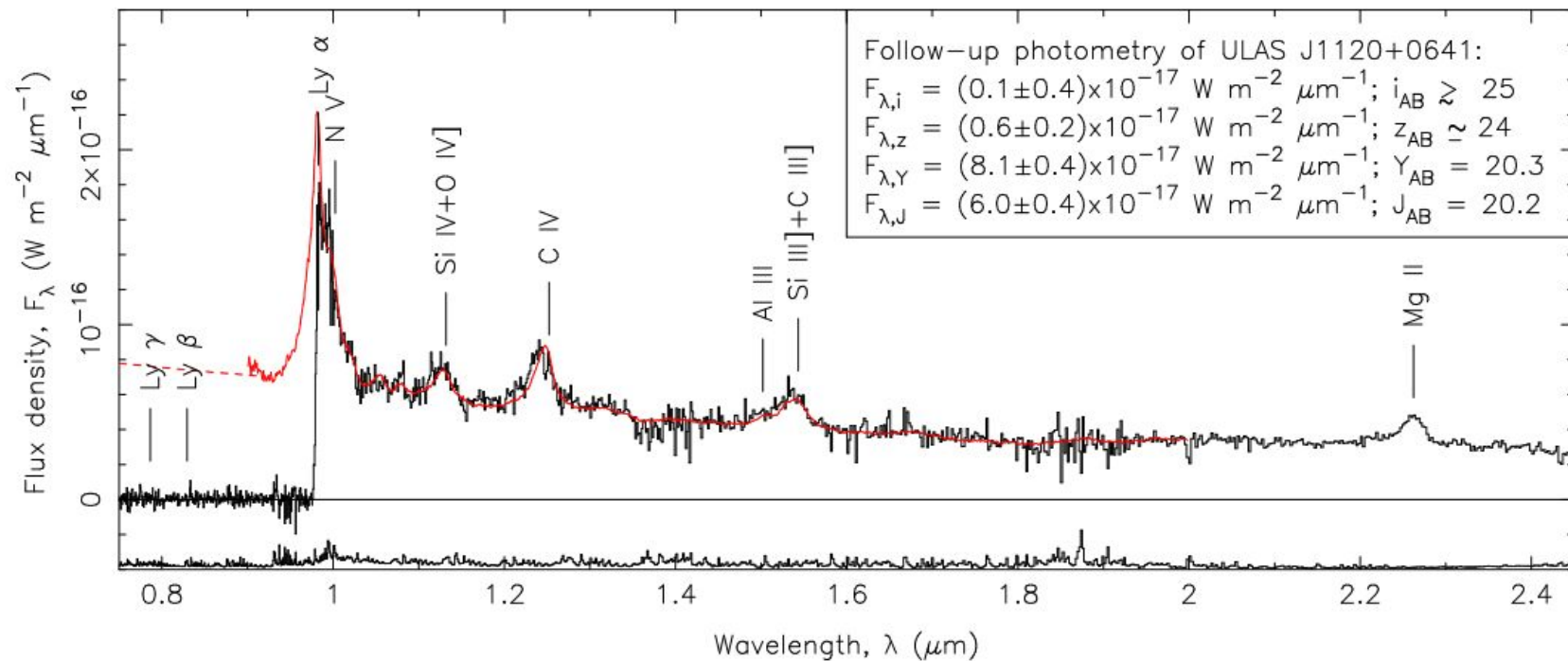
6. Gamma Ray Bursts

- Follow up in optical and IR
- Mostly occur in dwarf galaxies

7. Radio spectroscopy

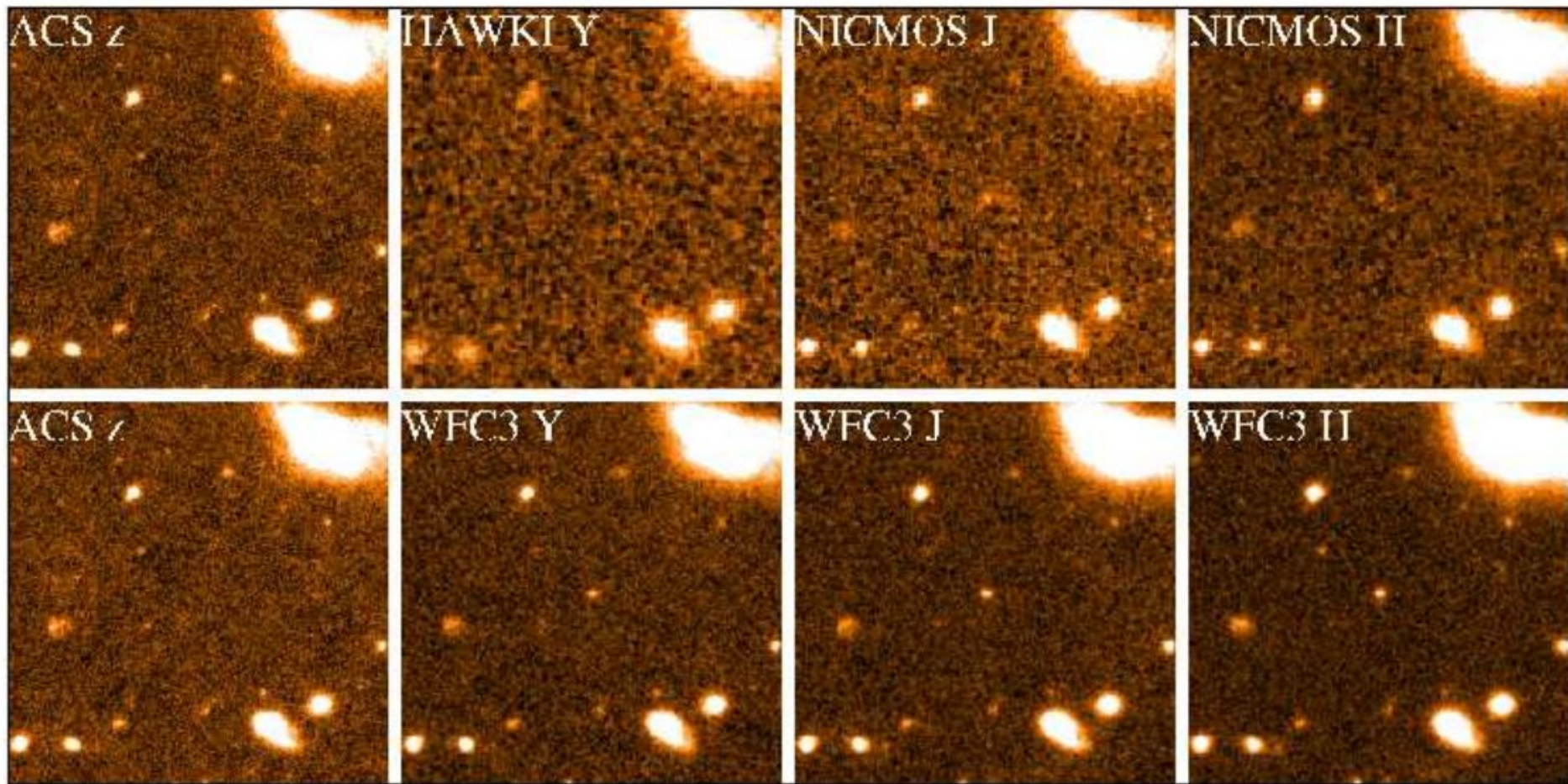
- CO line detection

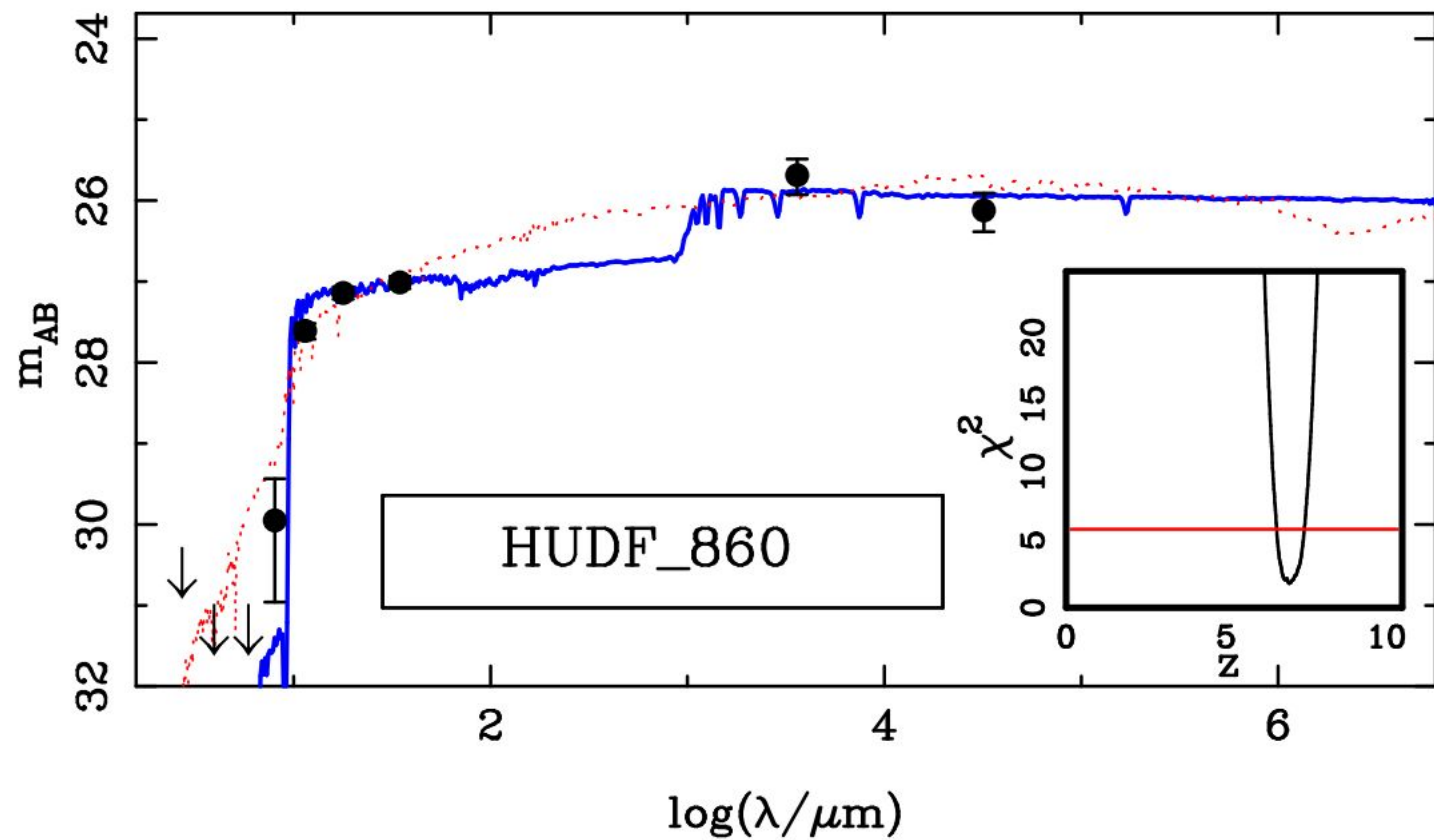
Lyman Break Galaxies



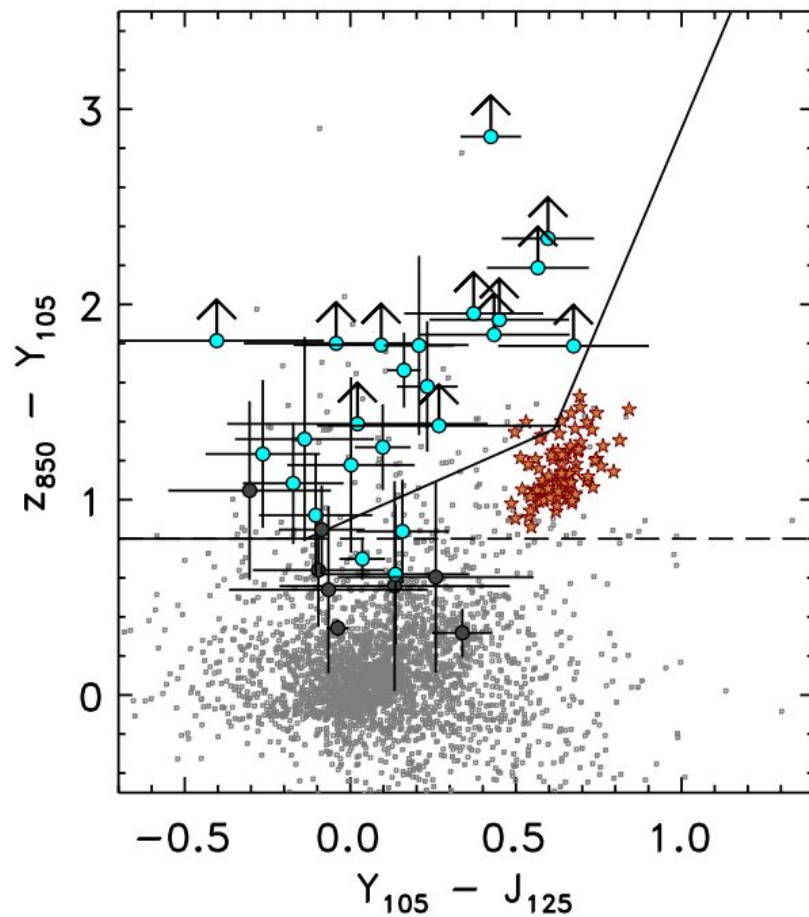
Lyman Break Galaxies

- LyC photons
 - Hydrogen edge in stellar photospheres
 - Neutral H absorption in ISM
- Ly- α forest between 912 Å-1216 Å
- Easier at higher redshifts ($z > 5$)
 - Thicker Ly α forest- Gunn Peterson trough
 - Higher Ly α emission
- Broad band optical imaging!
 - SED fitting gives better z (sometimes alternative z)



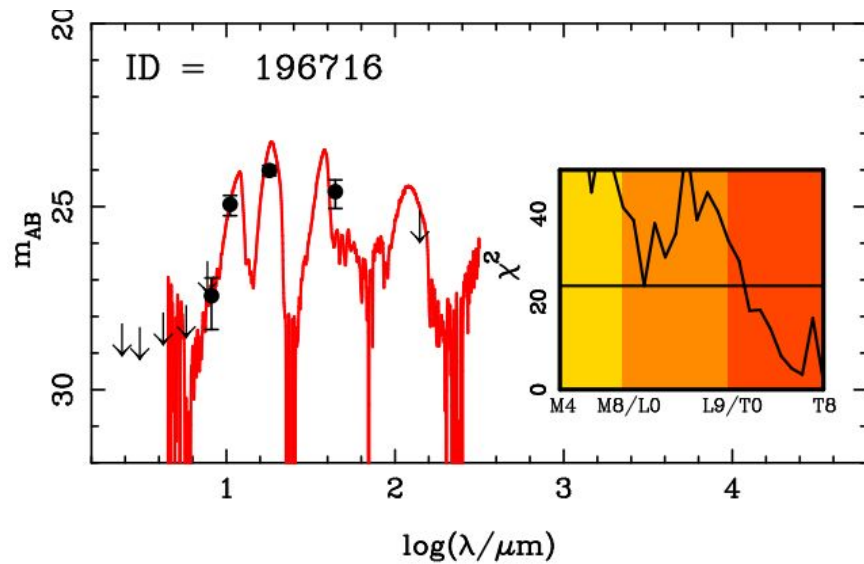
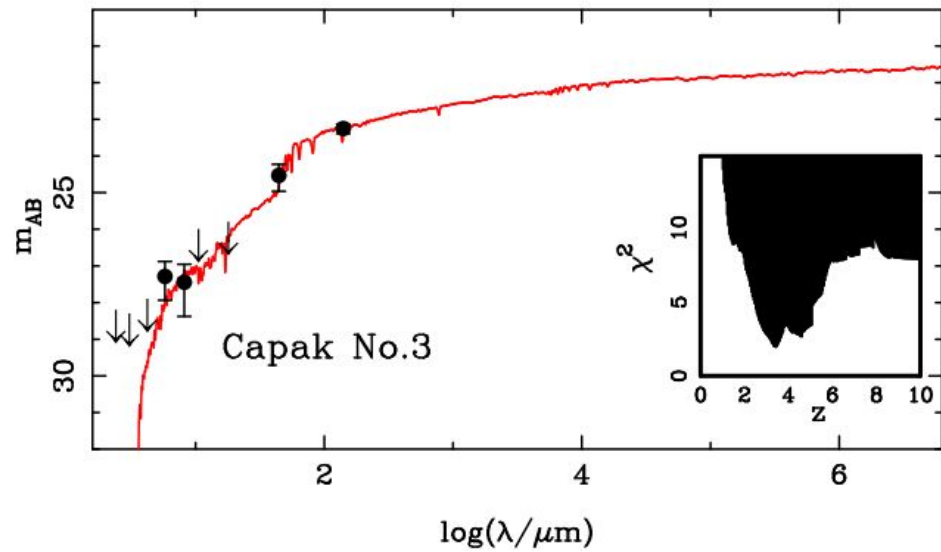


Colour-colour selection



Contaminants

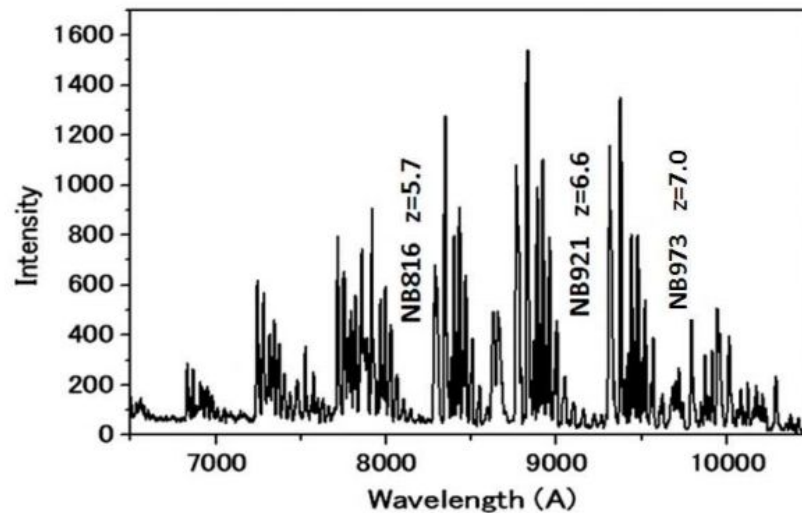
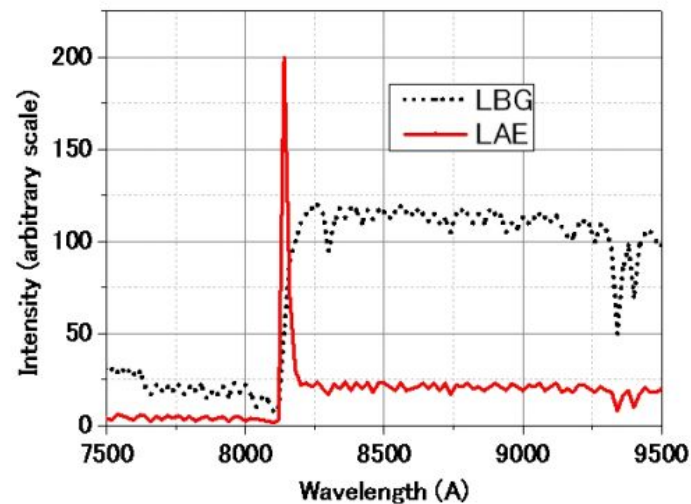
- Low-z dusty galaxies
 - Stricter Ly-break criteria
 - Multiband imaging
 - Confine to young, blue galaxies



Contaminants

- Low-z dusty galaxies
 - Stricter Ly-break criteria
 - Multiband imaging
 - Confine to young, blue galaxies
- Cool galactic stars
 - Deep HST imaging
 - Multiband infrared photometry
 - Still affects $z > 7$
- Low-z Balmer break galaxies
 - Higher SNR
 - Deeper imaging shortward of Lyman-break

Lyman- α Emitters



LAE contaminants

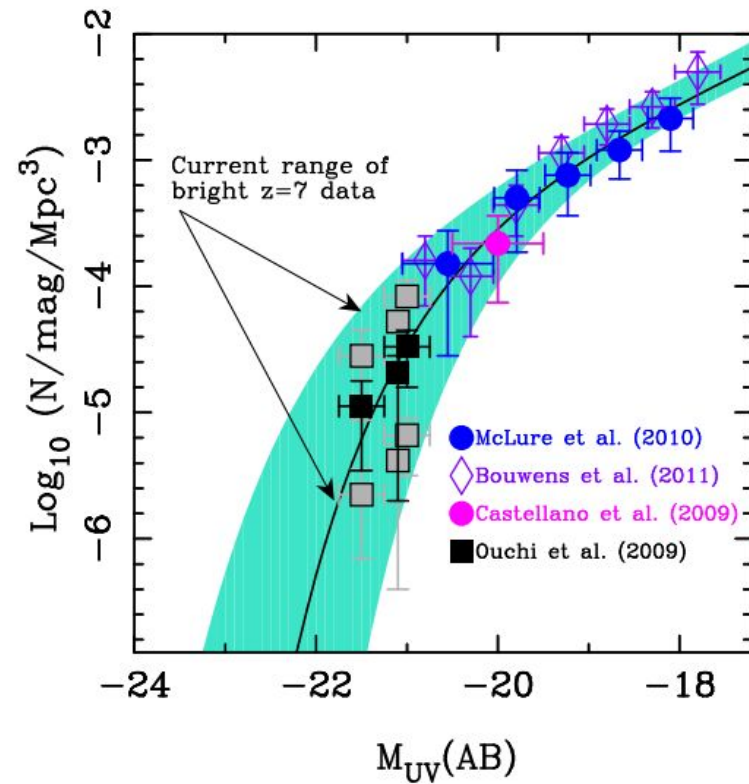
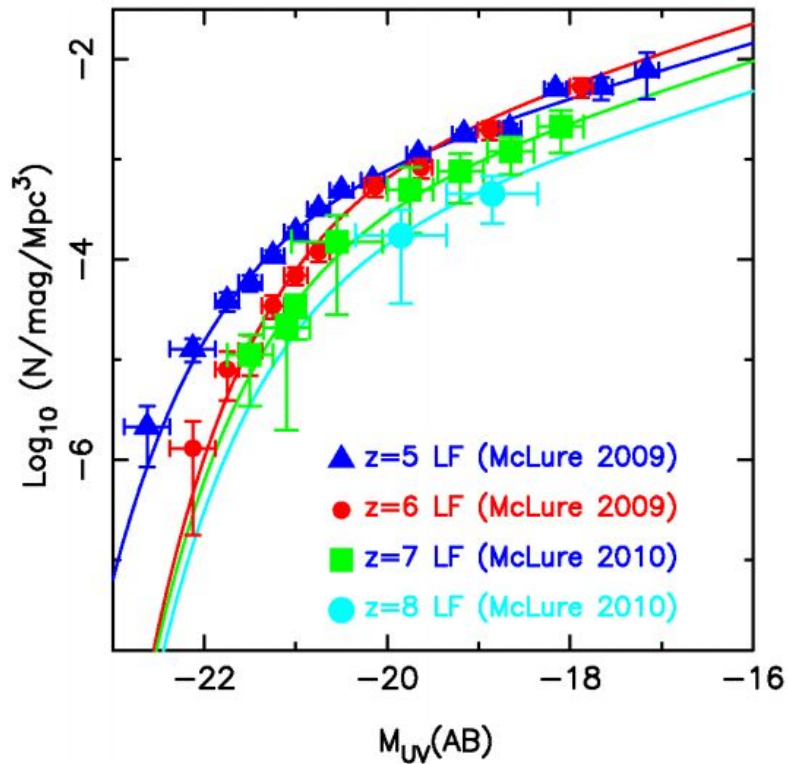
- Other emission line galaxies
 - Spectroscopic follow-up
 - Image a different band- another emission line
- Transients
 - Narrow and broad-band images at the same time
 - Deeper imaging at short wavelengths

Fitting Luminosity functions

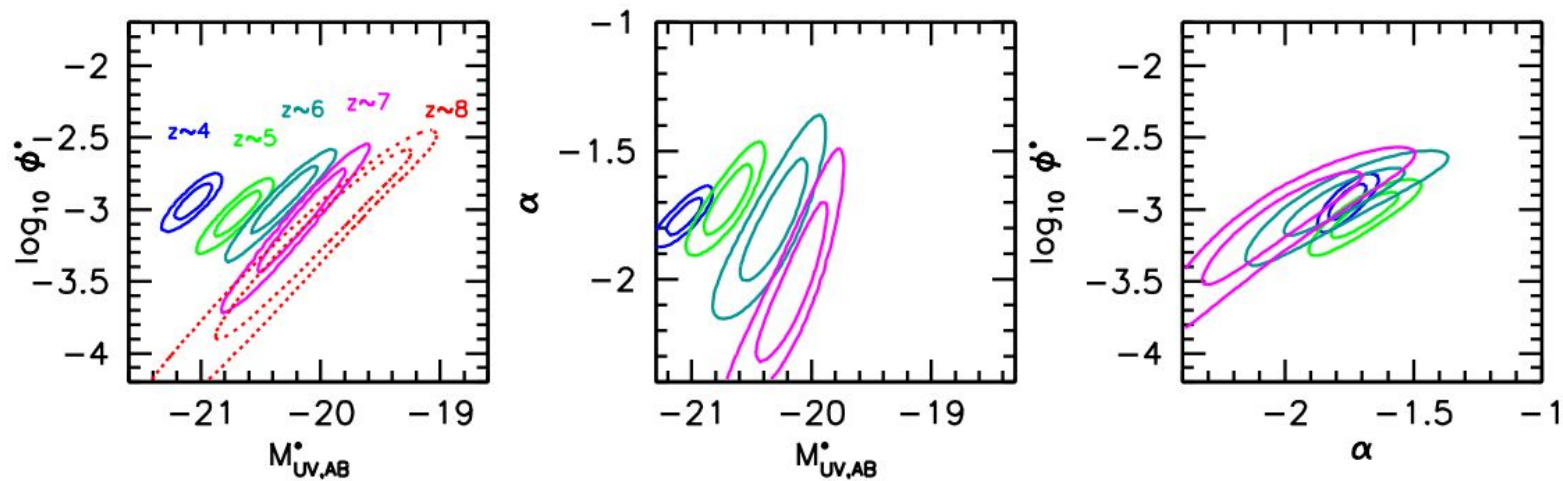
$$\frac{dn}{dL} = \phi(L) = \left(\frac{\phi^*}{L^*}\right) \left(\frac{L}{L^*}\right)^\alpha e^{-(L/L^*)}$$

- LBG - continuum luminosity
- LAE - equivalent width
- Use simulations to correct for
 - Filter dependence of z
 - Incompleteness
- Faint-end:
 - Slope of the function
 - Luminosity cut-off
- Bright end:
 - Small number statistics
 - Contamination
 - Eddington bias
- Cosmic Variance
 - Size of your survey

LBG Luminosity function

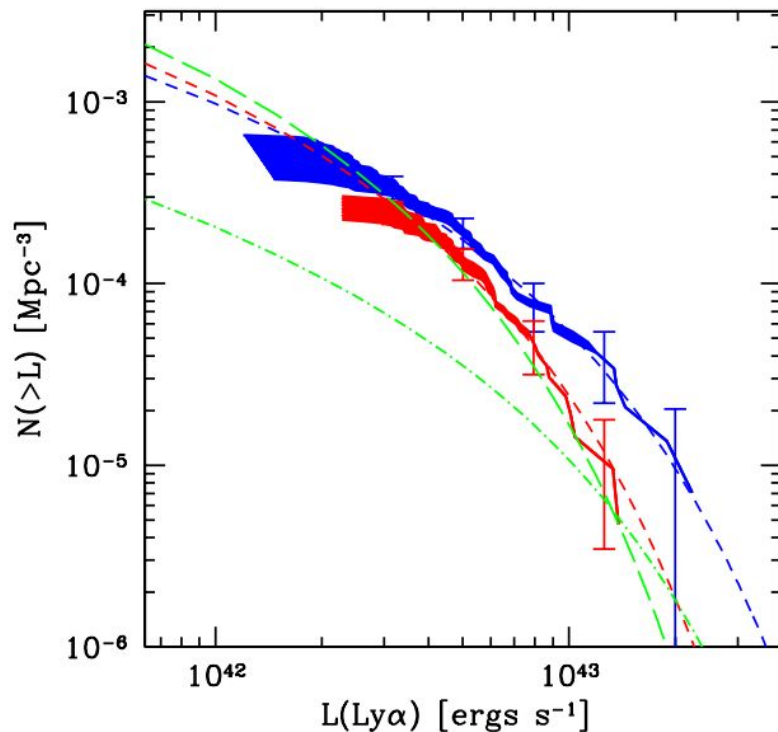


LBG-- Luminosity function parameters



Most of the evolution is in M^* with very small or no evolution in α or ϕ^*

LAE luminosity function



- Solid line- cumulative LF
 - Upper edge- include all samples (even potential contaminants)
 - Lower edge- only confirmed sources
- Red $z \sim 6.5$
- Blue $z \sim 5.7$
- Dashed lines- Best fit
- Green dashed- SXDS survey (larger area)
- Green dot-dashed- Hu et al