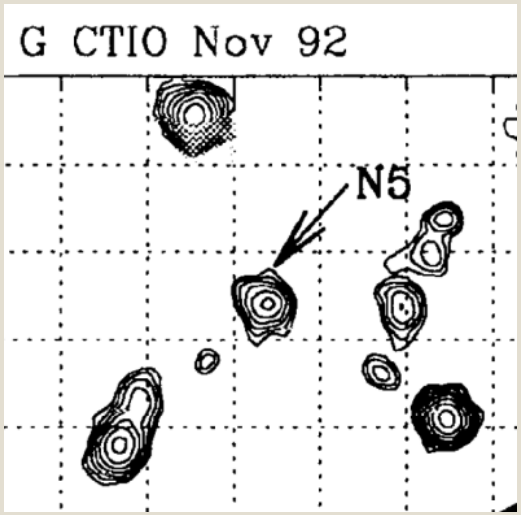
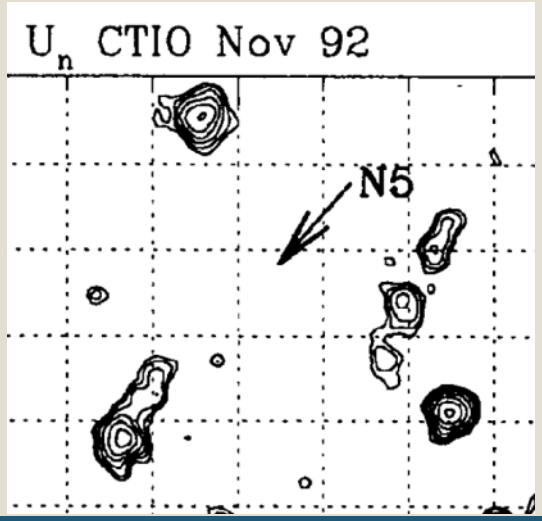
Photometric Drop-Outs

NOW YOU SEE THEM, NOW YOU DON'T

BEN COOK – 02/27/13





High Redshift Galaxies

- What can they teach us?
  - When did massive galaxy formation begin?
  - When did SFR peak?
  - When did the Hubble Sequence develop?
- How do we find them?

Lyman Break Galaxies (LBGs)

- What is the Lyman Break?
- How do we use it to identify high-z galaxies?
- What types of objects are LBGs?

The Lyman Limit

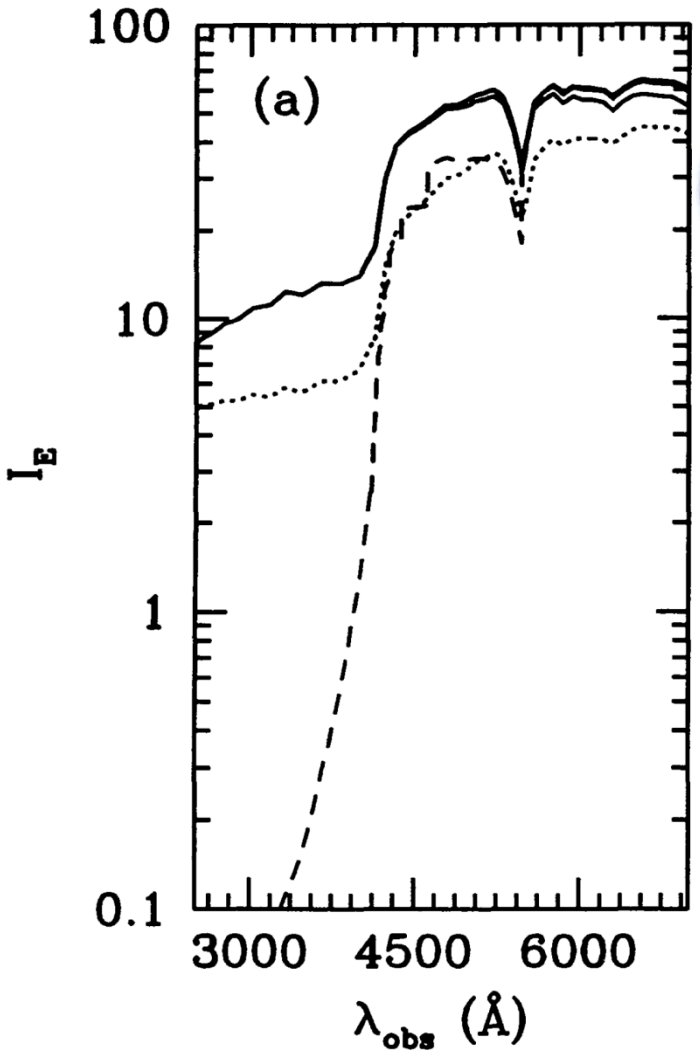
- $h\nu > 13.6$ eV photons can ionize HI
  - $\lambda < 912$ Å - rest frame UV
  - "Lyman Limit" (Not Lyα, $\lambda = 1217$ Å)

- Photons likely to be absorbed by neutral gas clouds

The Lyman Break

Due to combination of:

- Intrinsic Spectral Energy Distribution of galaxy
- HI opacity within a star forming galaxy
- Opacity of HI regions/galaxies in IGM along line-of-sight

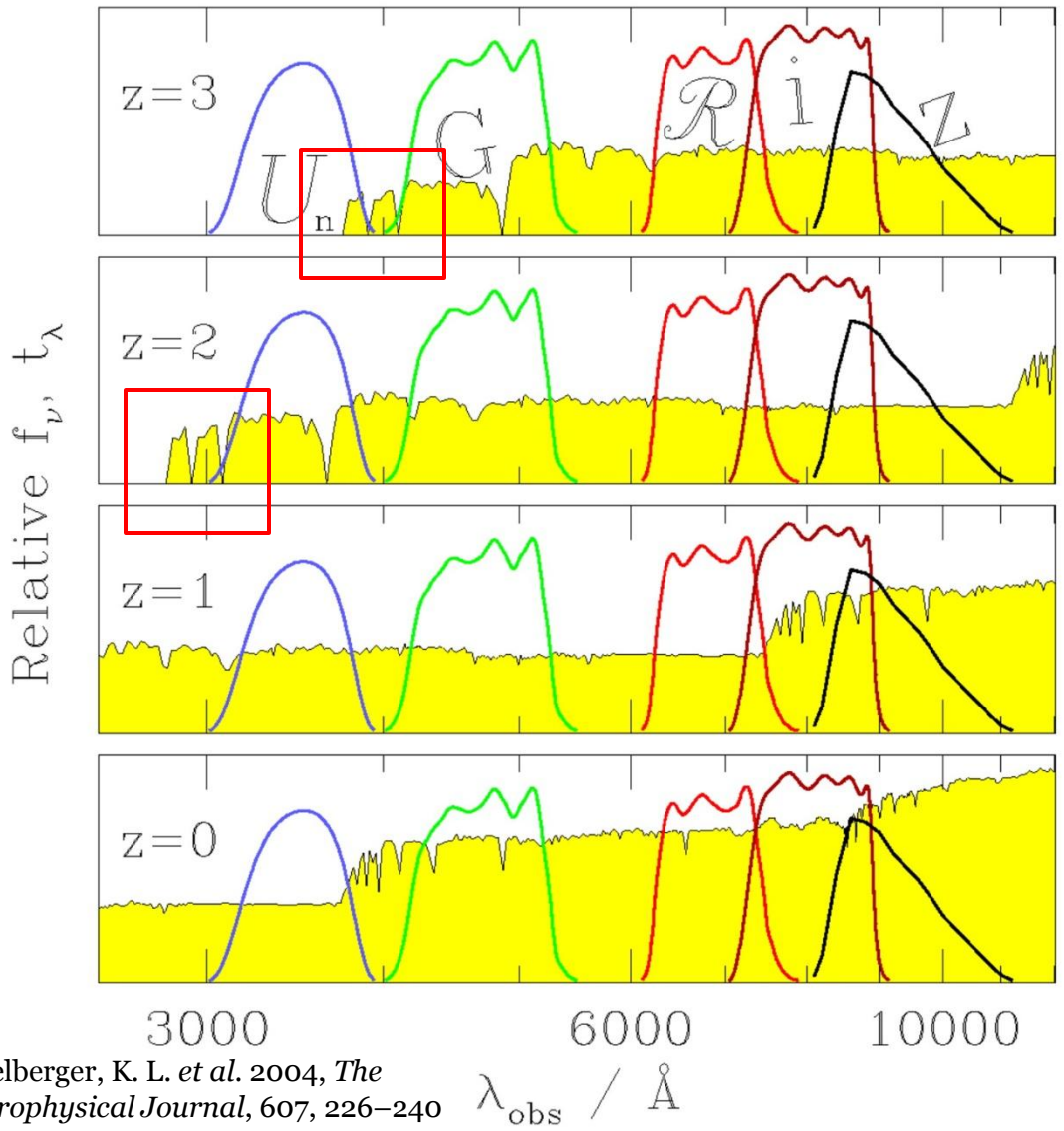


Madau, P. 1995, *The Astrophysical Journal*, 441, 18

Photometry and the Lyman Break

Lyman Break is in rest frame far-UV

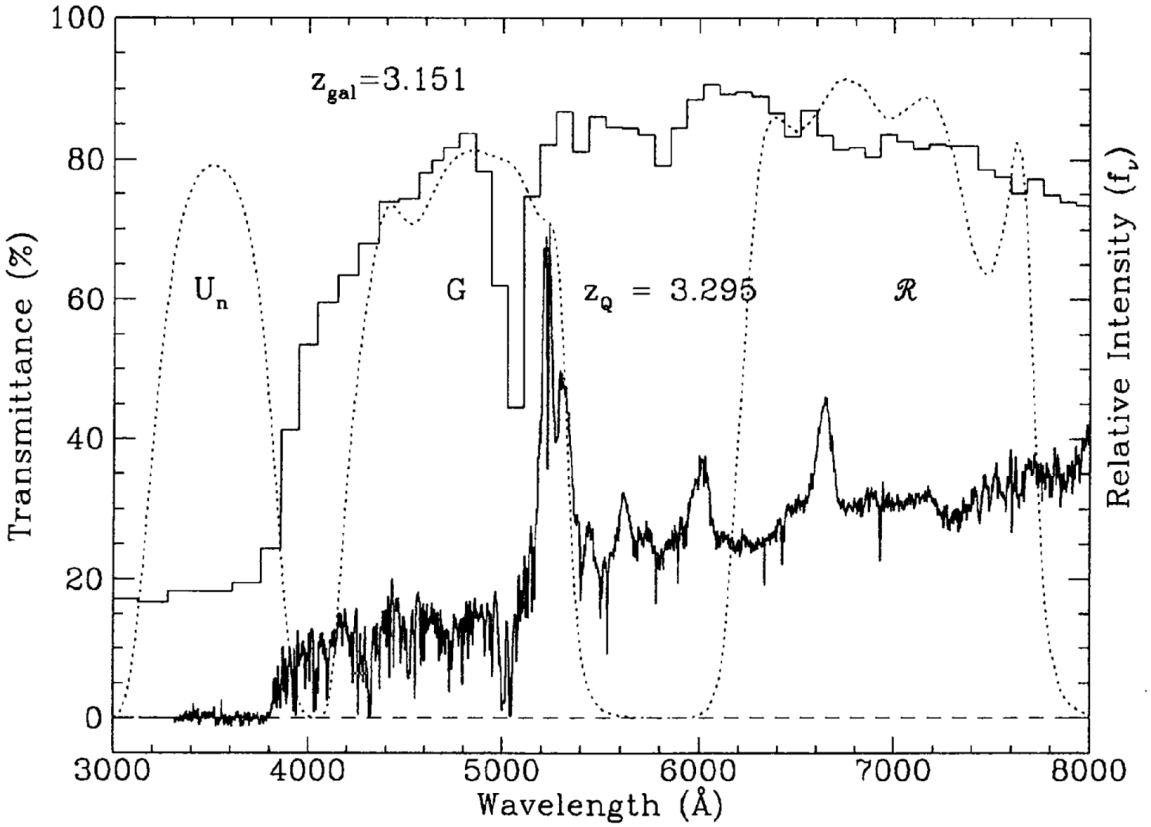
But at z~3, enters optical / near-UV



Adelberger, K. L. *et al.* 2004, *The Astrophysical Journal*, 607, 226–240

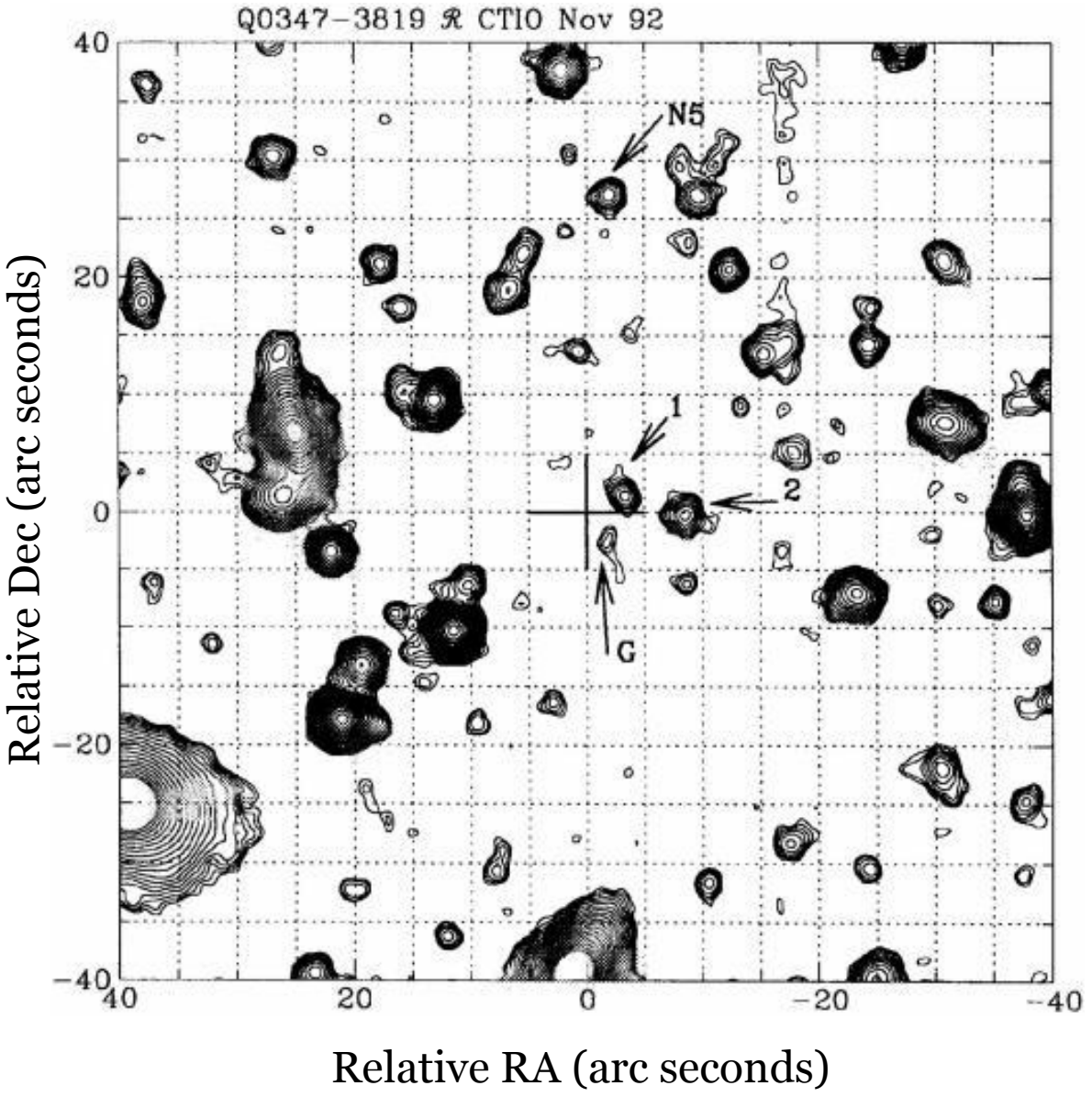
Steidel LBG Survey

Surveyed fields around Quasars with z~3 Lyman Limit absorbers



Steidel, C. C., Pettini, M. & Hamilton, D. 1995, *The Astronomical Journal*, 110, 2519

Steidel Survey



Steidel, C. C., Pettini, M. & Hamilton, D. 1995, *The Astronomical Journal*, 110, 2519

Steidel Survey Results

- 27 robust candidates from color-color selection
  - 16 spectroscopically confirmed galaxies $3.01 \leq z \leq 3.43$
  - 3 faint QSOs with same redshift ranges
  - 8 galaxies consistent with $z > 3$
  - => 70% of robust candidates confirmed with $3.0 \leq z \leq 3.5$

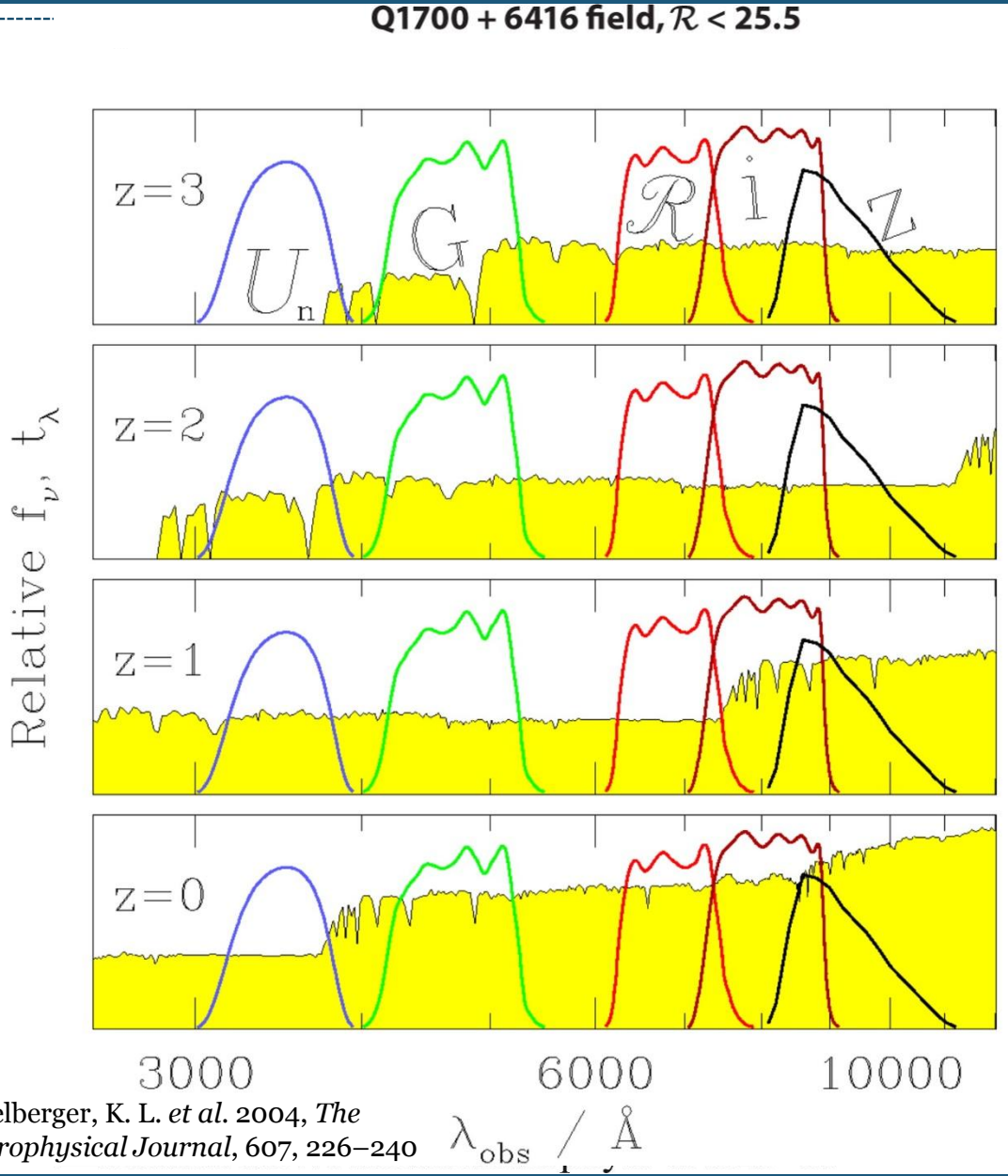
- Surface Density: 0.4 ± 0.07 z~3 gals arcmin^{-2} to $\mathcal{R} = 25$

Steidel, C. C., Giavalisco, M., Pettini, M., Dickinson, M. & Adelberger, K. L. 1996, *The Astrophysical Journal*, 462, L17–L21

Expanding to Other Redshifts

Given a particular set of filters, only a small redshift window is well characterized

By using redder filter sets, can expand to z~4,5,6 and beyond



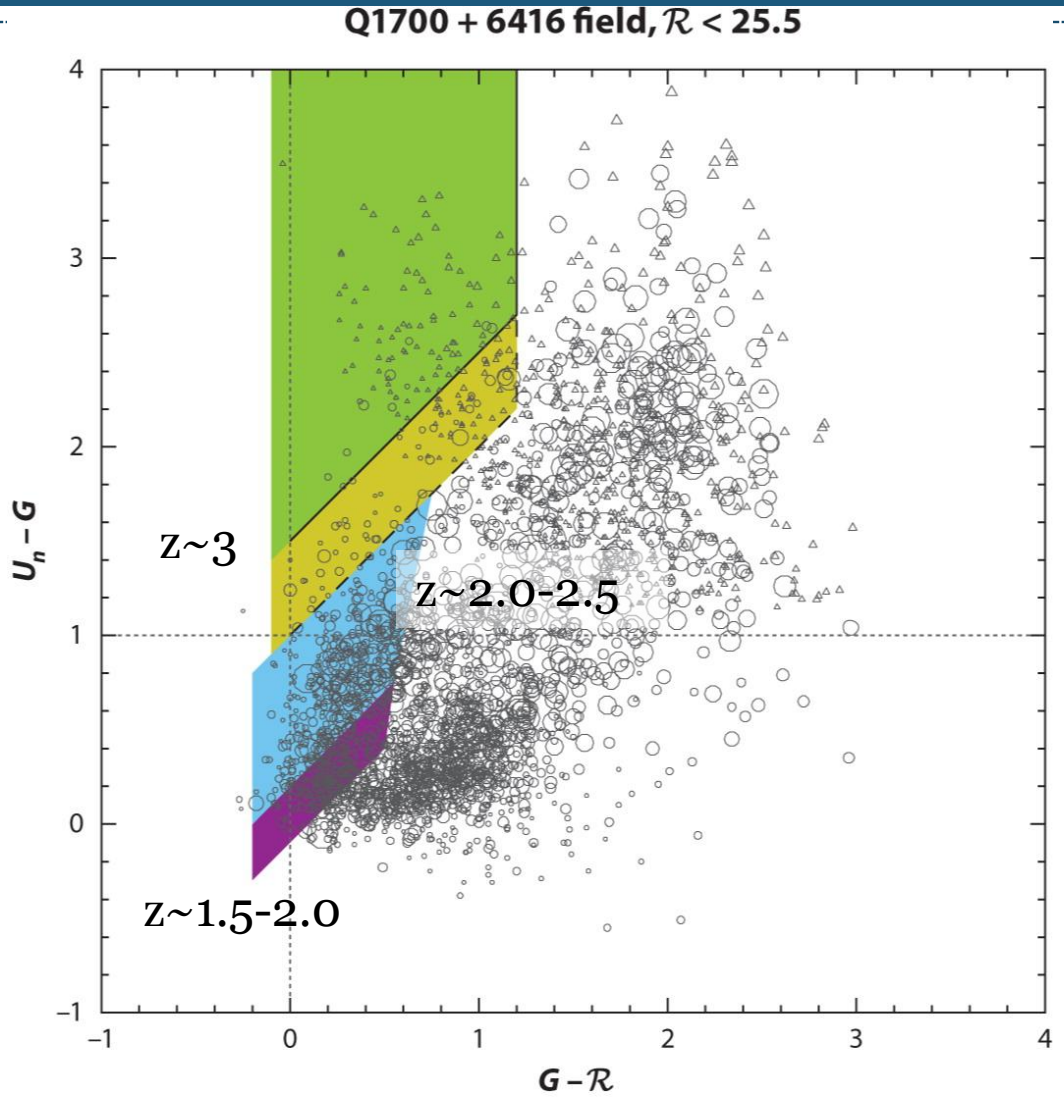
Adelberger, K. L. *et al.* 2004, *The Astrophysical Journal*, 607, 226–240

Expanding to Other Redshifts

Given a particular set of filters, only a small redshift window is well characterized

By using redder filter sets, can expand to z~4,5,6 and beyond

Thousands of LBGS identified



Shapley AE. 2011.
Annu. Rev. Astron. Astrophys. 49:525–80

What are LBGs?

- Lyman Break technique only sensitive to star forming galaxies (UV emitters)
- Features found to be similar to local starbursting regions

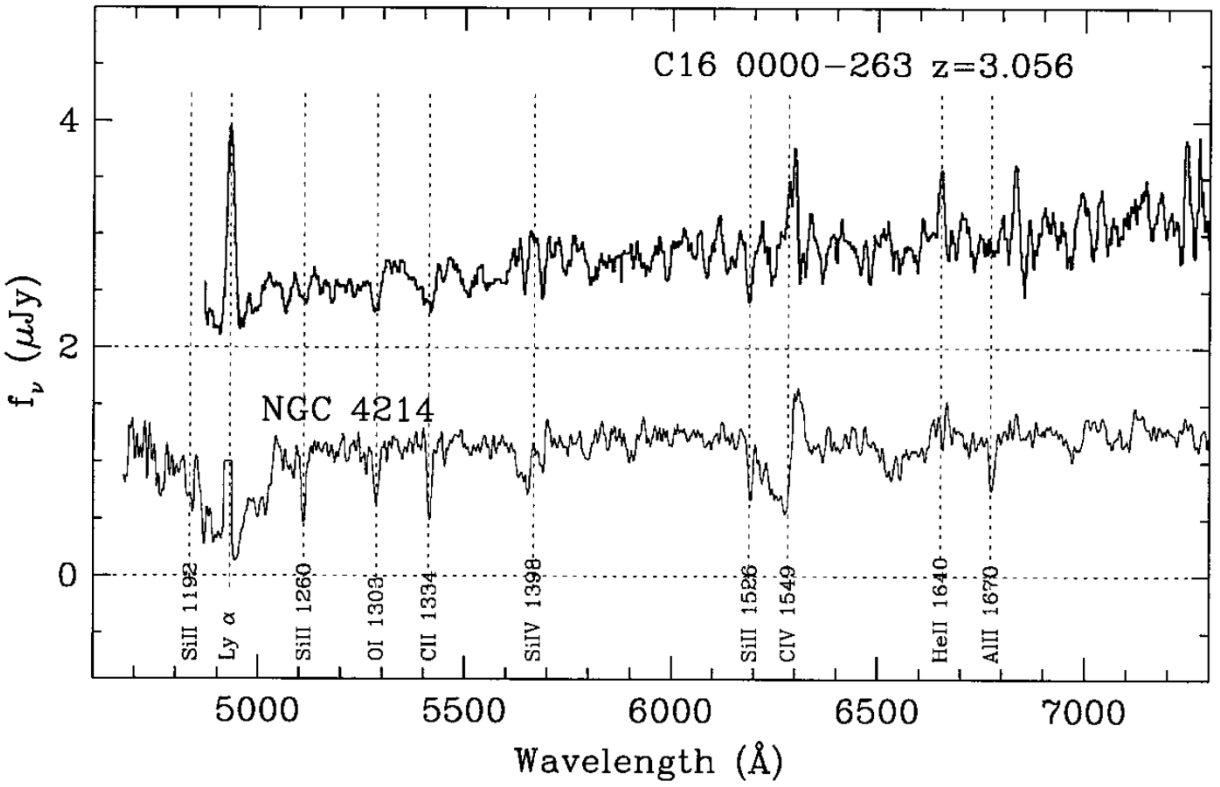
LBGs and Local Starbursts

Flat Rest-frame UV continuum

Weak or absent Lyα emission

High-ionization stellar lines

Low ionization interstellar lines



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What are LBGs?

- Lyman Break technique only sensitive to star forming galaxies (UV emitters)
- Features found to be similar to local starbursting regions
- Compact Morphologies
  - Progenitors of spheroidal component?

Steidel, C. C., Giavalisco, M., Pettini, M., Dickinson, M. & Adelberger, K. L. 1996, *The Astrophysical Journal*, 462, L17–L21

LBG Physical Characteristics

- SFR ~ 10-100 $M_\odot$ yr^{-1}
- $M_* \sim 1\text{-}5 \times 10^{10} M_\odot$
- Moderate dust extinction in rest-frame UV (~5)

- Between Lyα emitters and DRGs/SMGs

Shapley, A. E. 2011, *Annual Review of Astronomy and Astrophysics*, 49, 525–580

Lyman Break Galaxies (LBGs)

- What is the Lyman Break?
  - Spectral discontinuity due to Lyman Limit attenuation
- How do we use it to identify high-z galaxies?
  - Filters straddling the break will result in a dropout from the band blue-ward of the break
  - Only sensitive to star forming galaxies, for limited range of z
- What types of objects are LBGs?
  - Star forming, high-z progenitors of luminous galaxies

Sources

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