Stellar Populations in Spectroscopically Confirmed Galaxies at ~~Redshift ≥ 6~~

$5.6 < z < 7.0$

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Outline

- Background
- Sample and data
- Stellar populations
  - Age
  - Stellar mass
  - Dust
  - SFR, etc.
- LAEs vs. LBGs
- Summary

Background

- High-z galaxies as of 2012
  - Large sample of photometrically-selected LBGs with decent IR data, e.g., in several HST ultra/deep fields
  - Lack of a sizable sample of spectroscopically-confirmed galaxies with deep IR data (HST + Spitzer)
- A simple idea
  - HST and Spitzer imaging of spectroscopically-confirmed galaxies in the Subaru Deep Field (SDF) and Subaru-XMM Deep Field (SXDS)
  - Three HST programs and two Spitzer programs (PIs: Jiang and Egami)

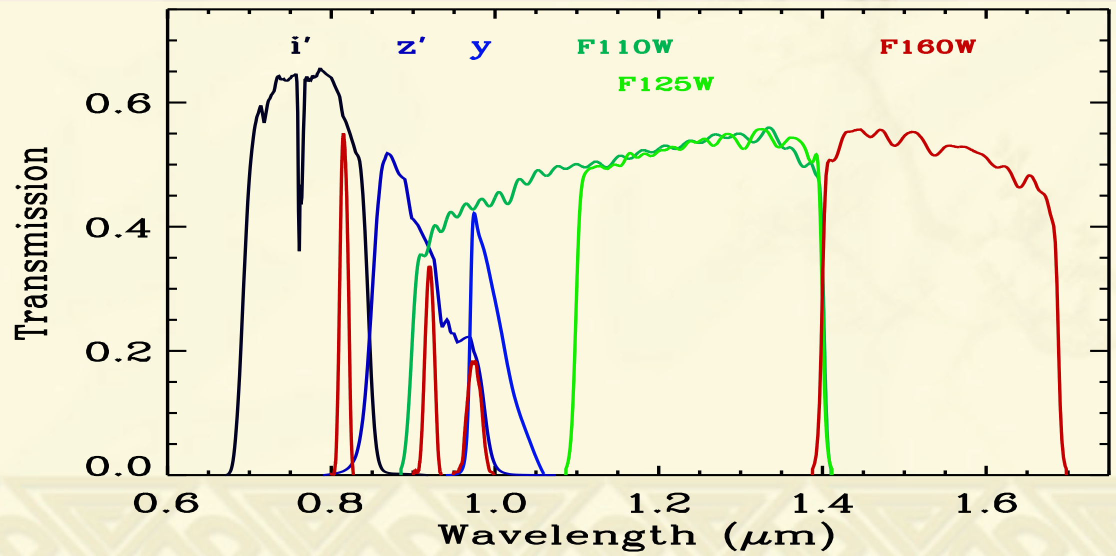
A study of spectroscopically-confirmed galaxies at z ≥ 6

➢ The sample

- 67 galaxies at 5.6< z < 7.0, including 16 LBGs and 51 LAEs
- The brightest sample in this redshift range

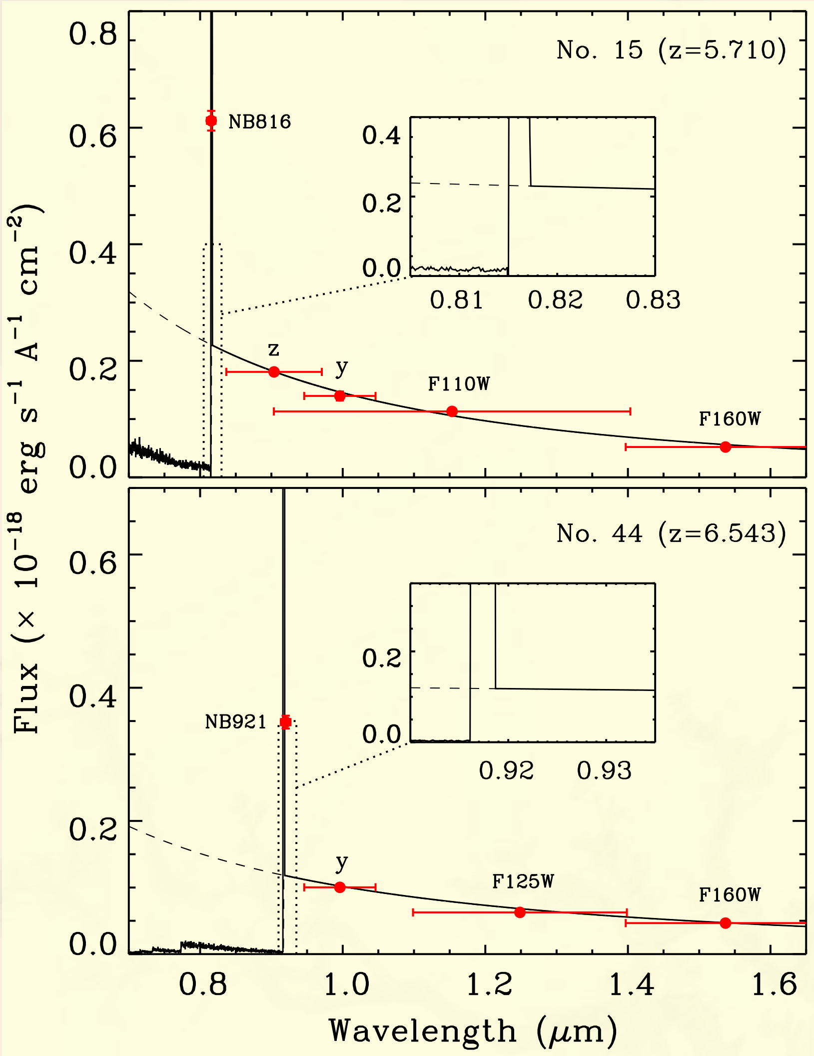
➢ Imaging data

- Optical data from Subaru Suprime-Cam (PSF ≈ 0.6−0.7”)
- Broad-band data (AB mag at 3σ): BVRi ≈ 28.5, z ≈ 27.5, y ≈ 26.5
- Narrow-band data (26 mag): NB816 and NB921, NB973 (25 mag)
- HST near-IR data (~2 orbits per band): F125W (or F110W) and F160W
- Spitzer mid-IR data (6 ~ 7 hrs): IRAC 1 and 2



A study of spectroscopically-confirmed galaxies at z ≥ 6

- Properties
  - UV line and continuum emission (Jiang et al. 2013a)
  - UV continuum and Lyα Morphology (Jiang et al. 2013b)
  - Stellar populations (Jiang et al. 2016)



(Jiang et al. 2013a)

Note:
- LAEs: found by the narrow-band (Lyα) technique
- LBGs: found by the dropout technique

Stellar populations: SED modeling

➢ Data

- Sample: 27 galaxies with HST and IRAC detections
- Data points: 1–3 optical points + 1–2 near-IR points + 1–2 mid-IR points
- Great advantages of this sample:
  a) Secure redshifts → remove one free parameter
  b) Accurate Lyα line emission → nebular emission

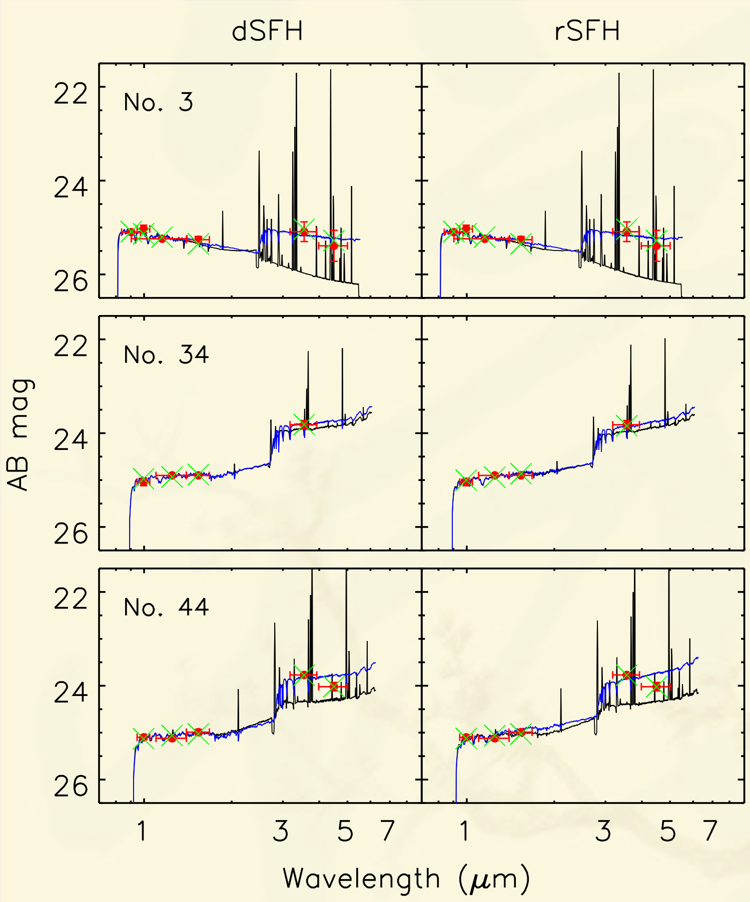
➢ SED modeling

- Model: GALEV (Kotulla 2009) with nebular emission included
- Parameters:
  a) IMF: Salpeter 0.1–100 $M_{\odot}$
  b) Metallicity: 0.2 $Z_{\odot}$
  c) SFH: an exponentially declining (dSFH) and a smoothly rising (rSFH)
  d) Measure: Age, stellar mass, dust extinction

➢ Model degeneracy

a) Young galaxies with prominent nebular emission
b) Older galaxies with strong Balmer breaks
c) Our method: Lyα → nebular emission

- dSFH: declining SFH
- rSFH: rising SFH
- Red: observed data
- Blue: model + NoEM
- Black: model + EM
- Green: model mag

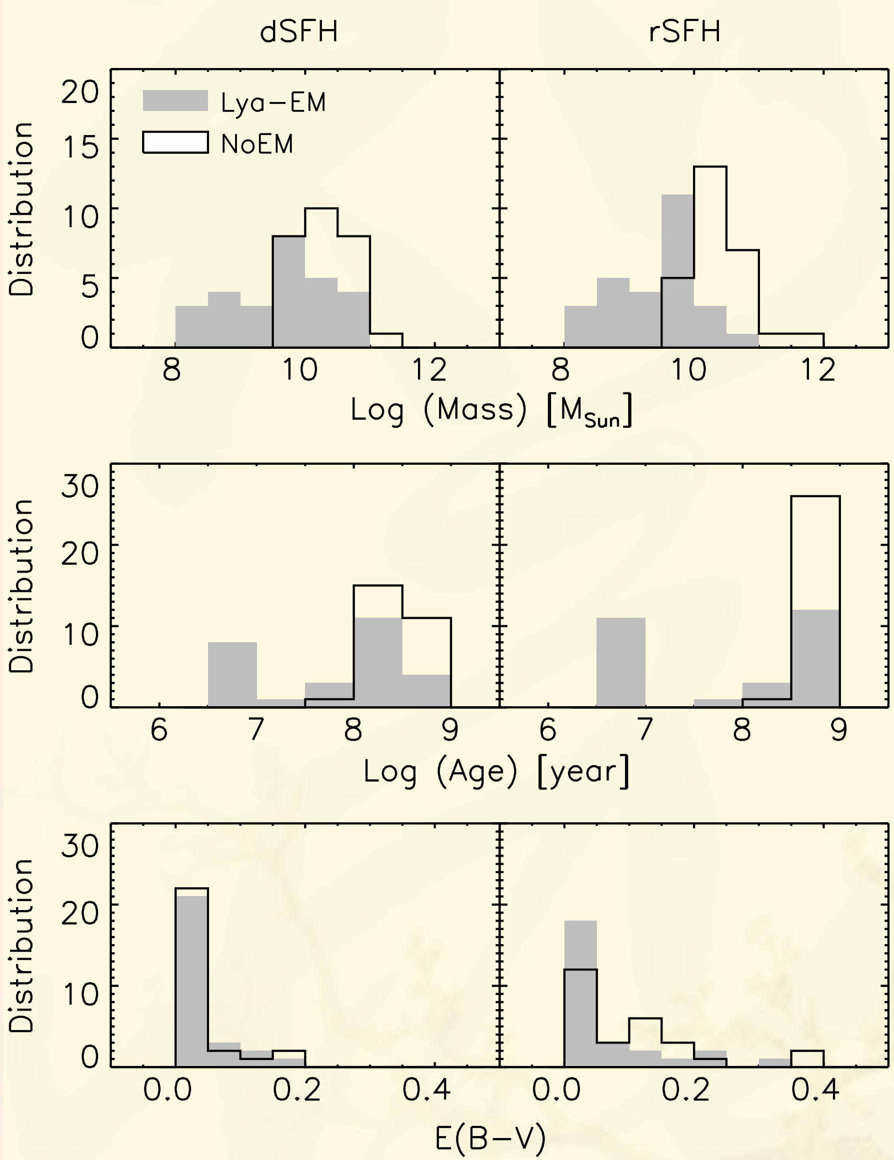


➢ Dust extinction

- E(B-V) ~ 0
- Little or no dust
- Consistent with blue UV slopes (median β ≈ –2.3)

✖ ✔

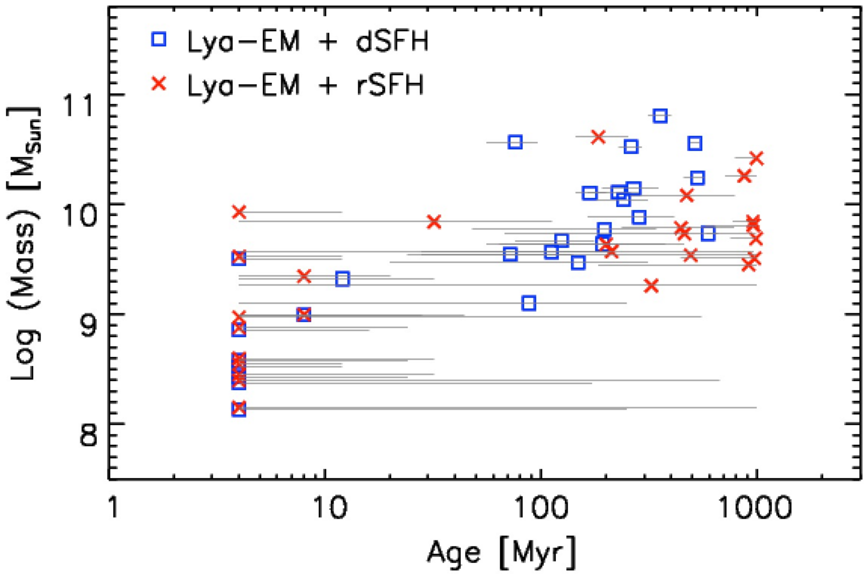
PM2.5 = 300 PM2.5 = 10

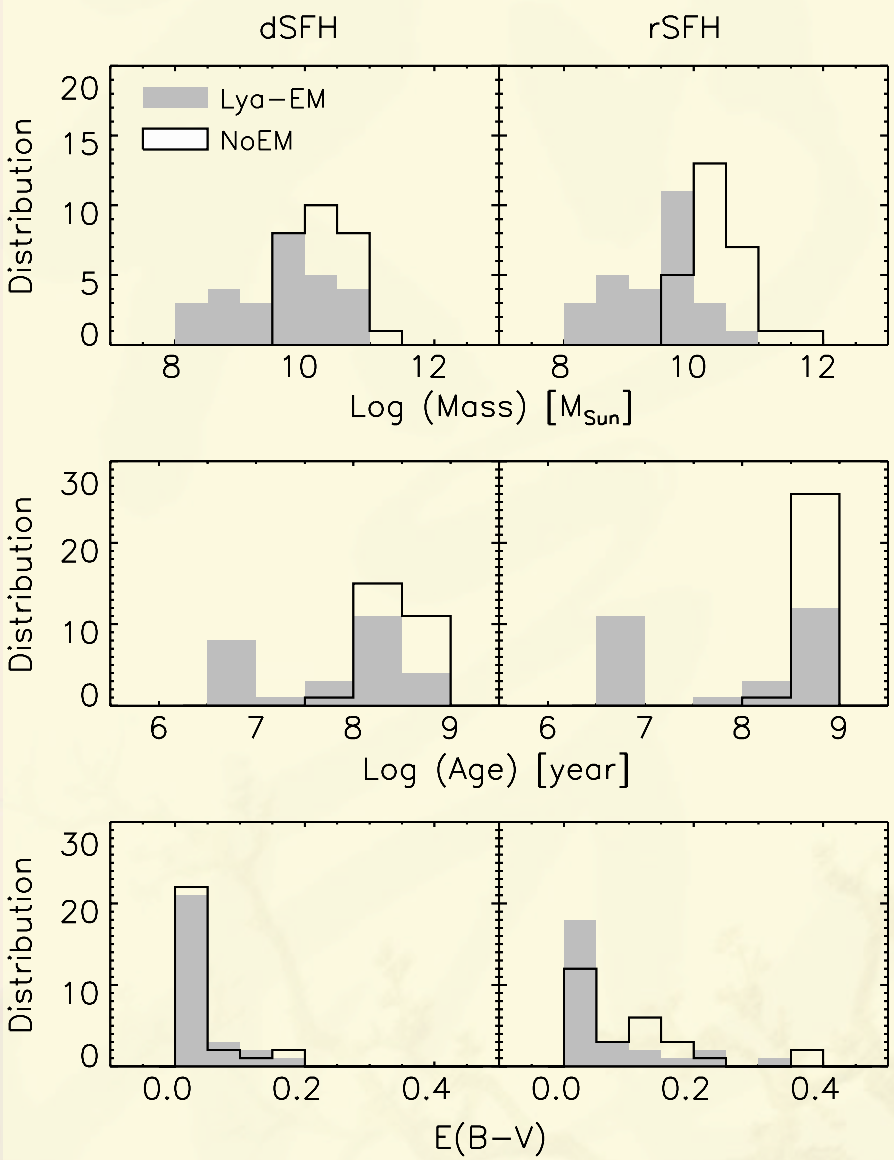


(Jiang et al. 2016)

Age

- Associated with large uncertainties
- Bimodality: selection effects and modeling limitations
- Two subsamples: galaxies with age < 30 Myr and age > 30 Myr
- Extremely young galaxies

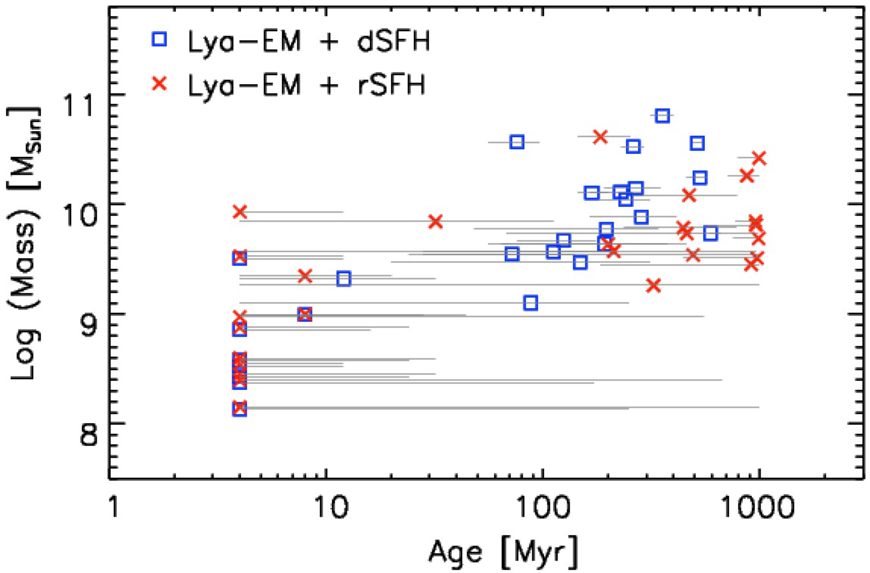


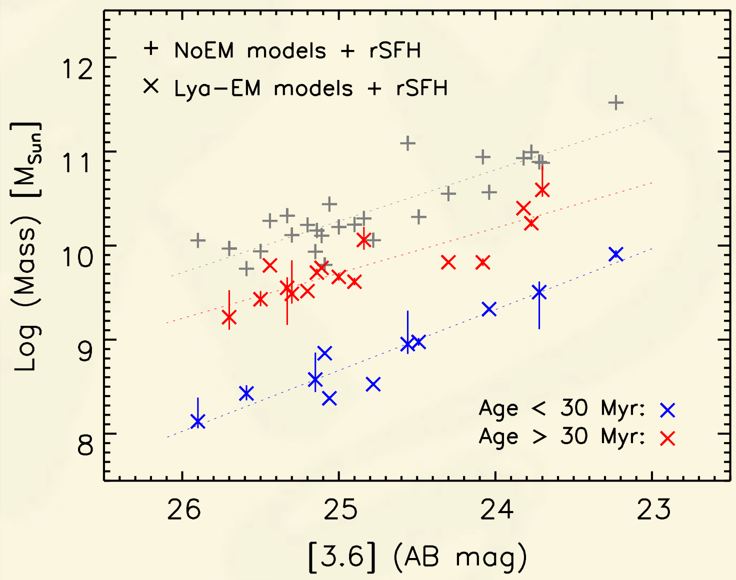


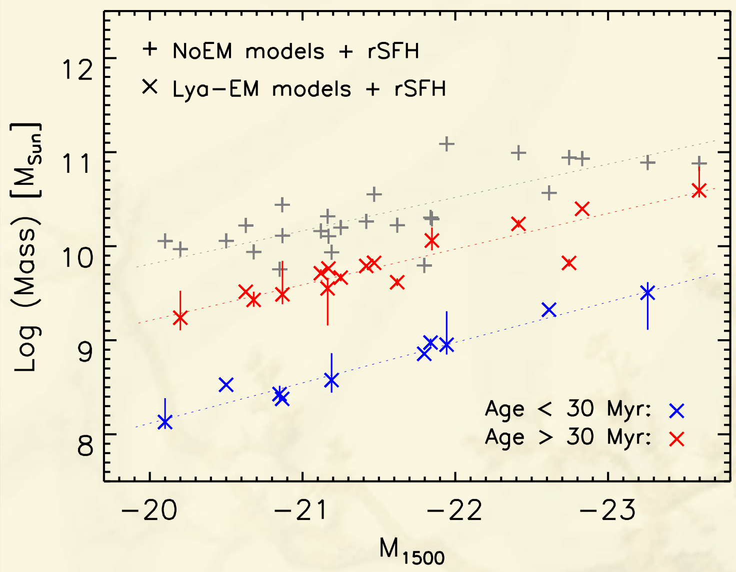
(Jiang et al. 2016)

➢ Stellar mass

- Thought to be least sensitive to model
- Old subsample: massive;
  young subsample: less massive
- Tight mass – optical flux relation
- Tight mass – UV flux relation:
  main sequence of SF galaxies?



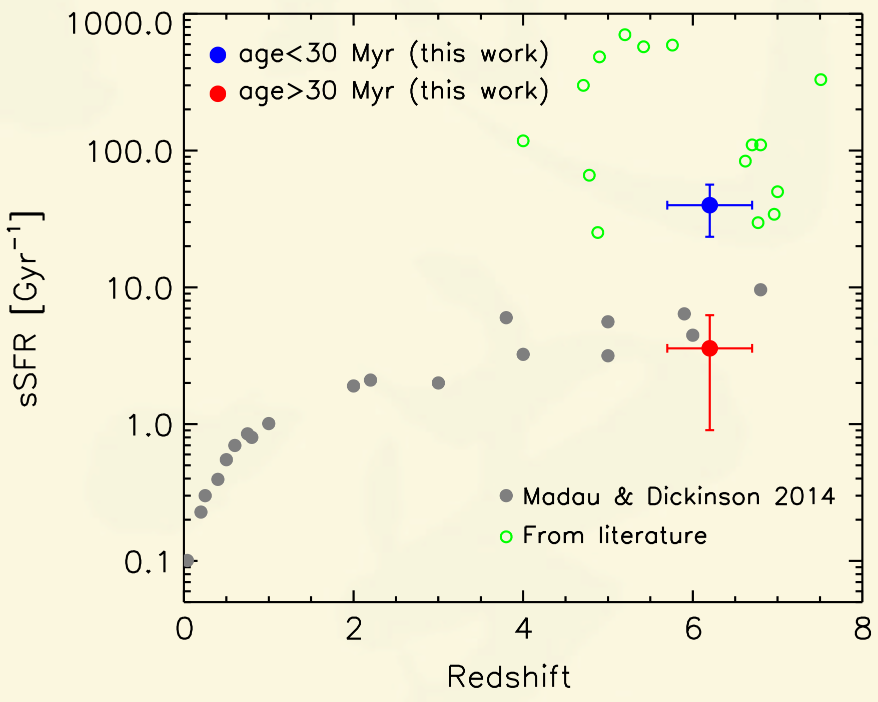


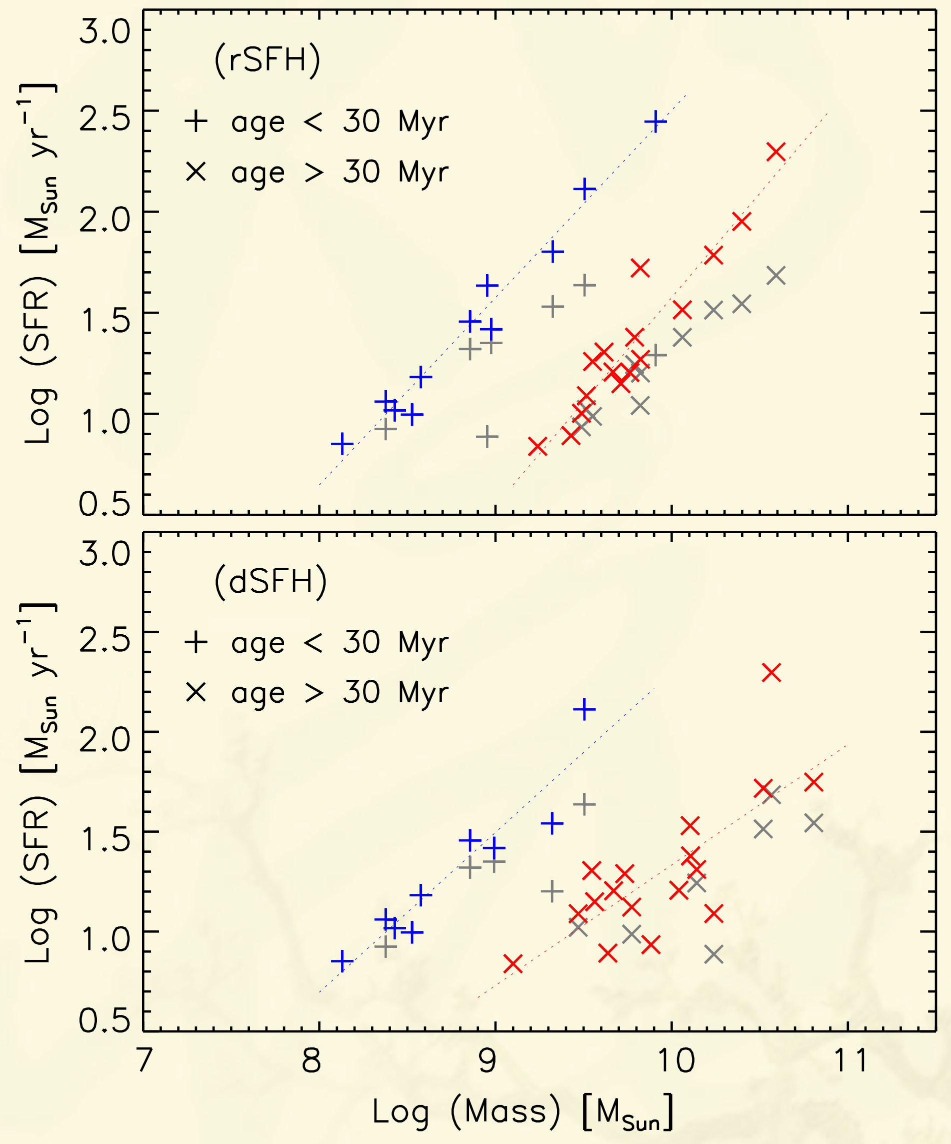


(Jiang et al. 2016)

➢ Mass-SFR relation

- Tight mass—SFR relation (slope~1)
- 'old' subsample: normal 'main sequence' SF galaxies?
- 'young' subsample: starbursts? Not rare at high redshift!

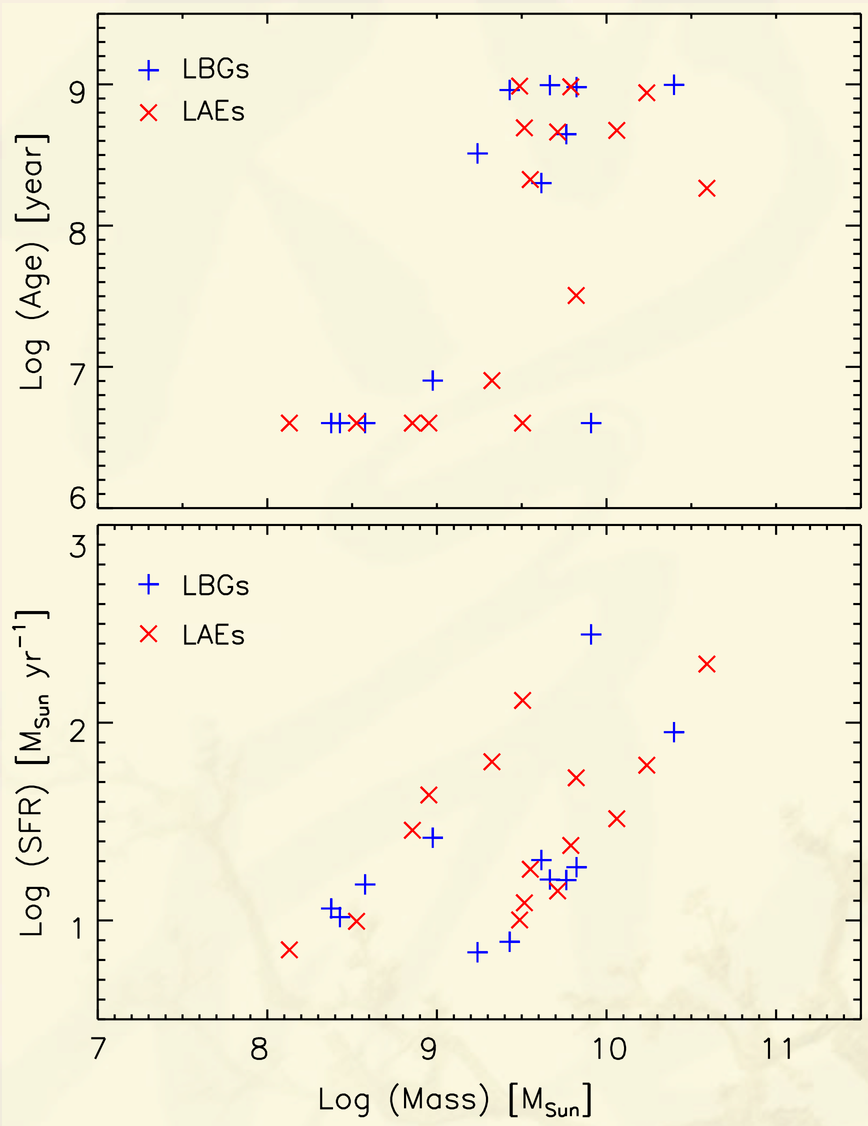




(Jiang et al. 2016)

➢ LAEs and LBGs

- LAEs: narrow-band technique; LBGs: dropout technique
- LBGs in our sample: all have strong Lyα emission lines
- LAEs and LBGs in our sample share many common properties: UV continuum; size and morphology; age; stellar mass, SFR, etc.
- LAEs represent a subset of LBGs with strong Lyα emission



(Jiang et al. 2016)

Summary

- A systematic study of spectroscopically-confirmed galaxies at $z \geq 6$
- Stellar populations from SED modeling with secure z and Lyα emission
- Variety of populations: a wide range of age and stellar mass
- Little dust extinction in most galaxies
- LAEs represent a subset of LBGs with strong Lyα emission