Massive galaxies at z>4 from UltraVISTA

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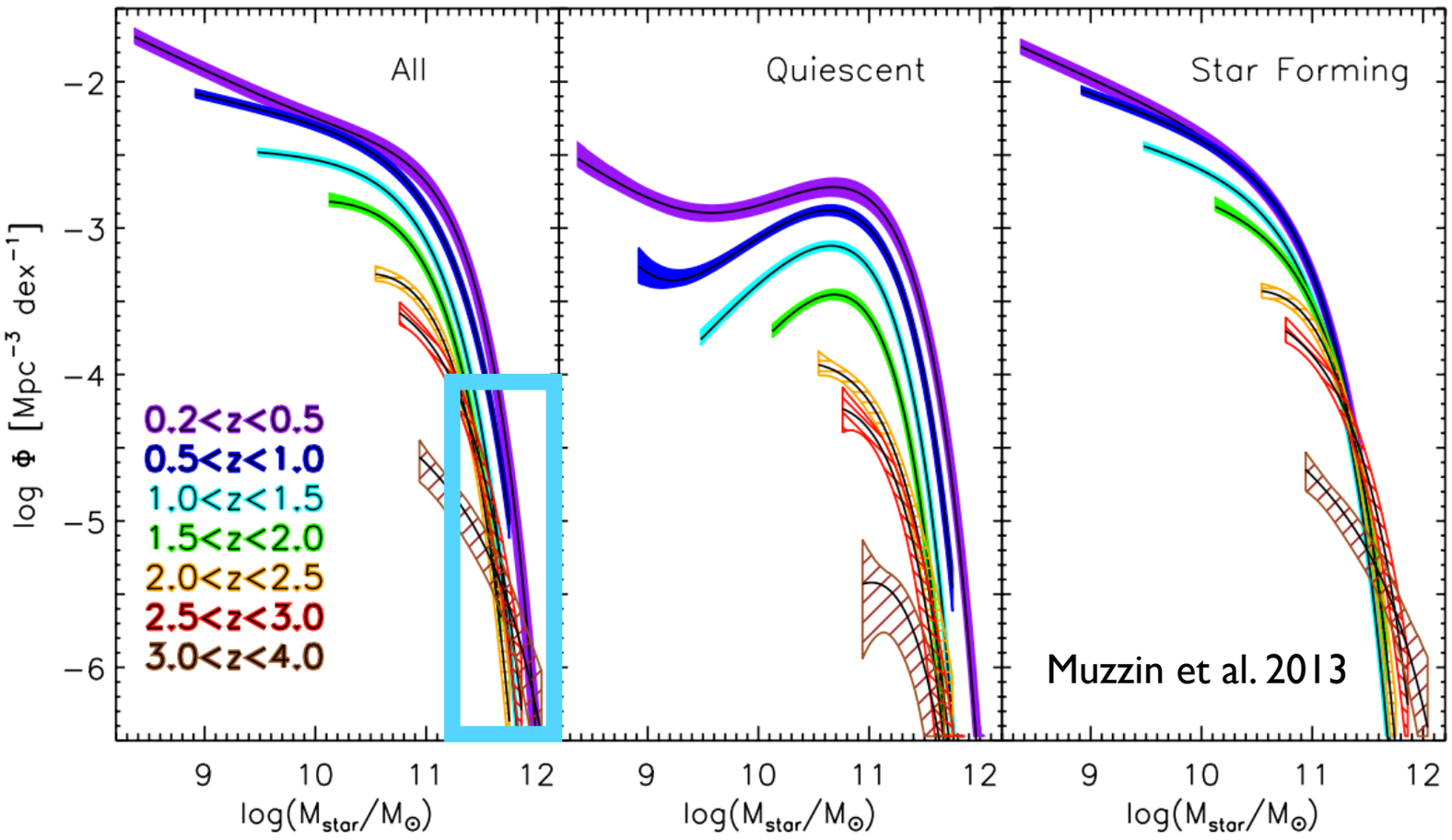
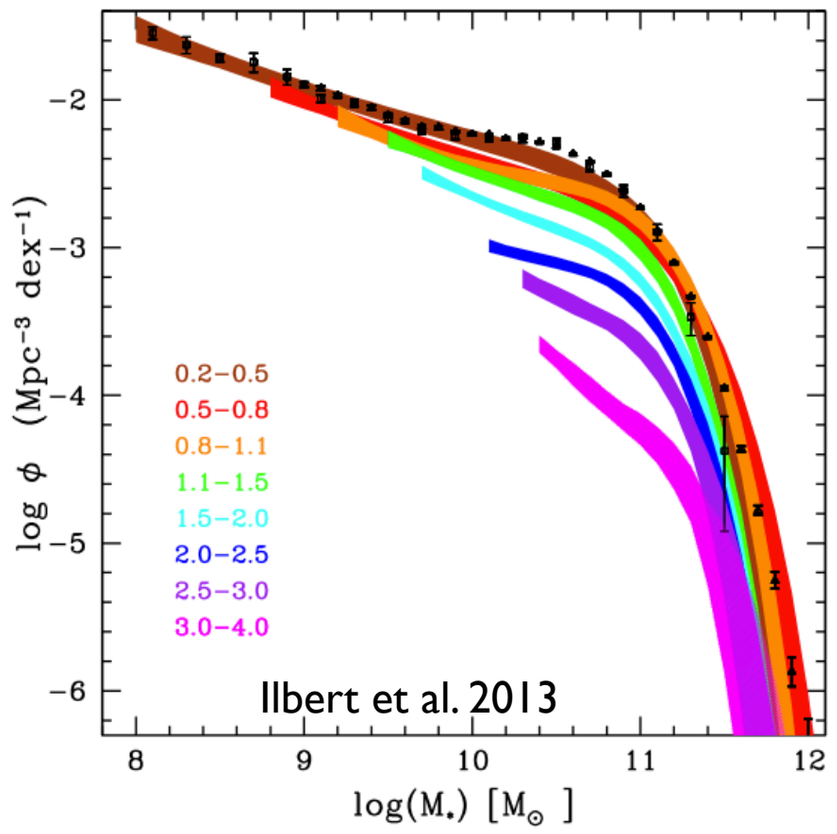
Adam Muzzin (Cambridge)

Universiteit Leiden

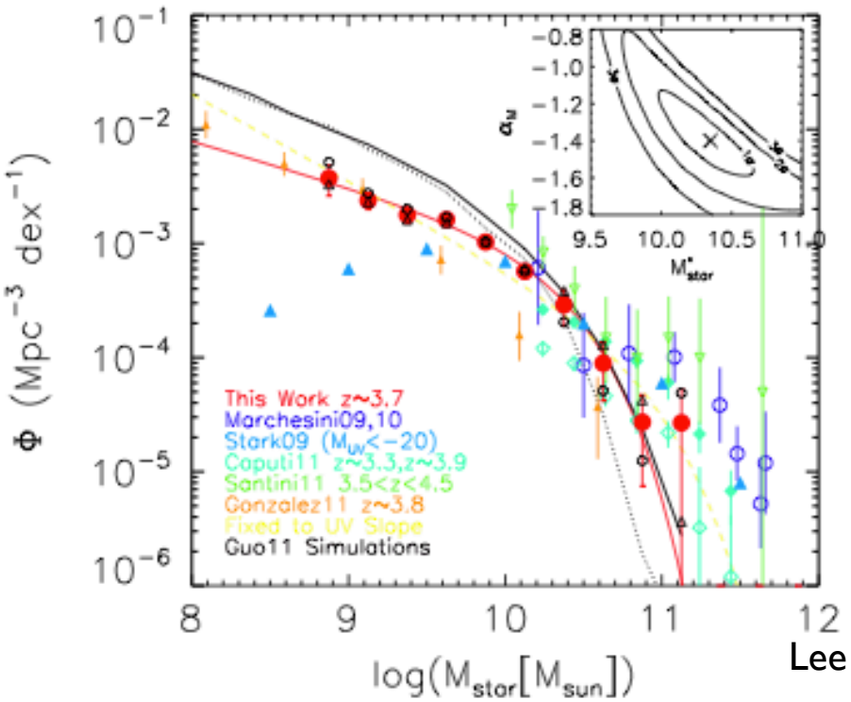
Observational framework



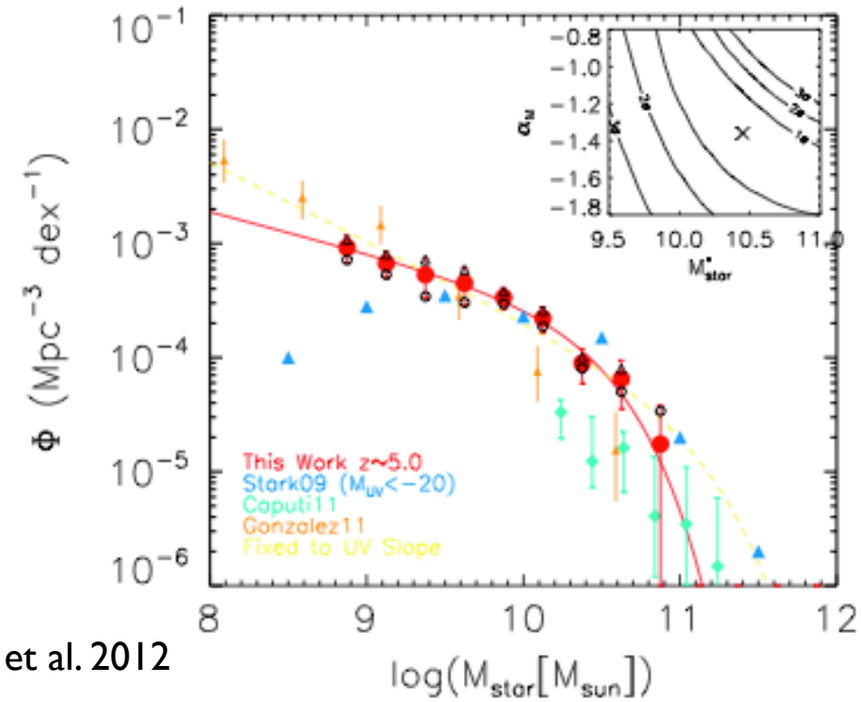


- Most massive galaxies already in place at z~4
- Little evolution down to z~1
- When did massive galaxies form? z~4? z>4?
- How have they evolved?

Observational framework

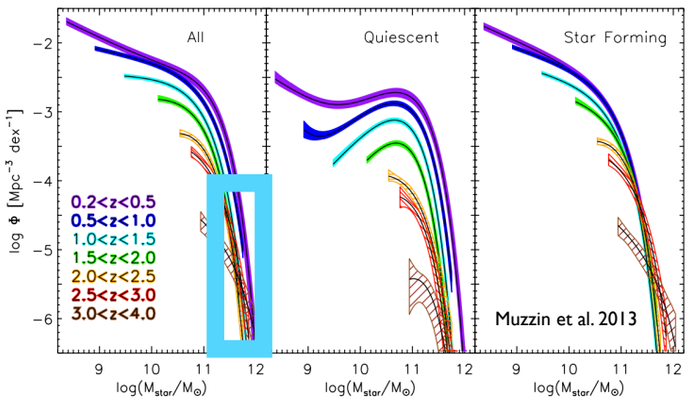


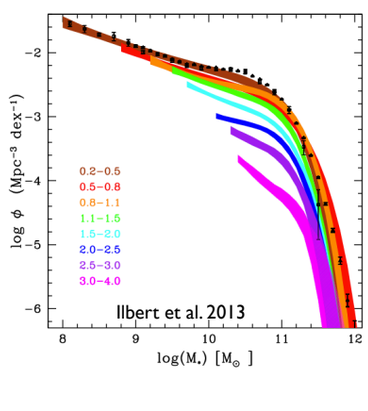
Lee et al. 2012



Dropout selections

- Rest Frame UV-bright
- Narrow fields





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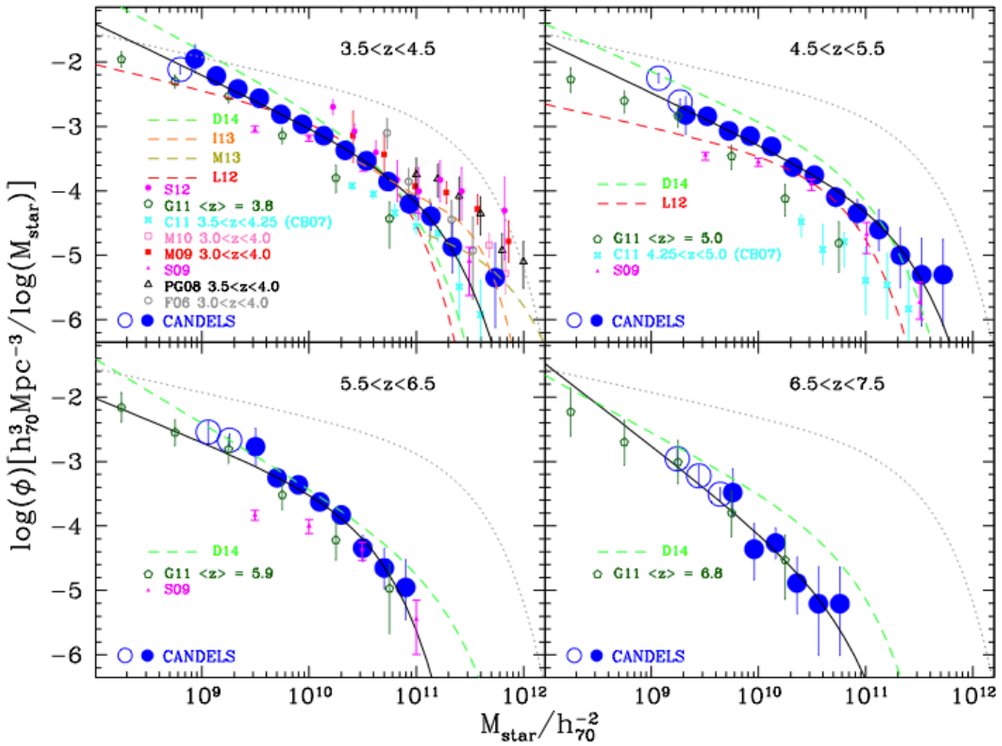
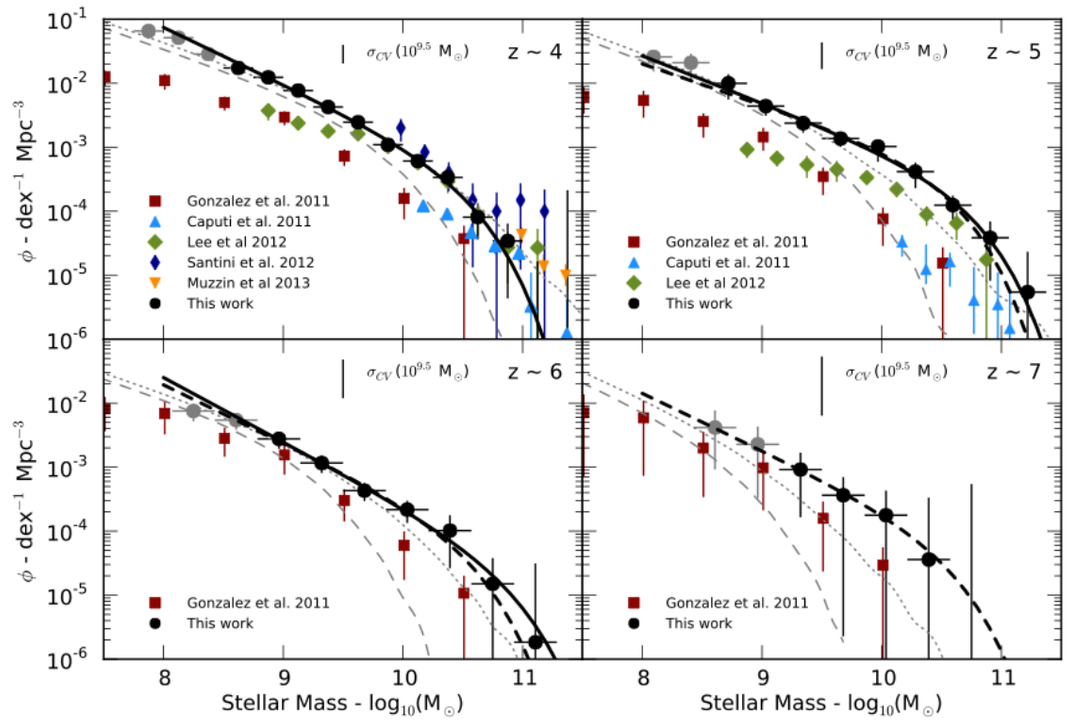


Grazian et al., 2015



Duncan et al. 2014

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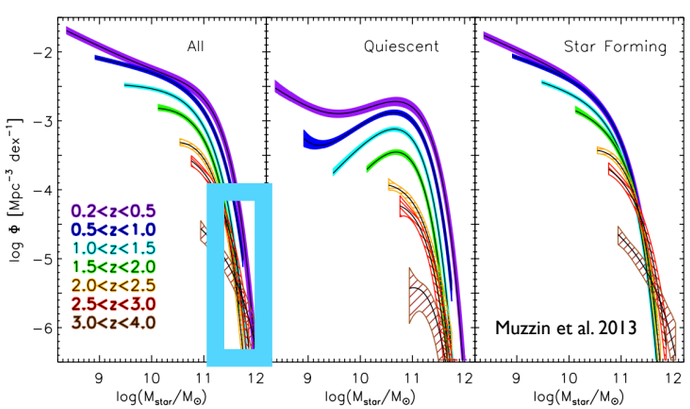

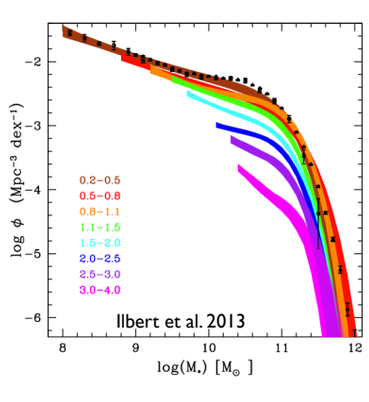

- Most massive galaxies already in place at z~4
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UltraVISTA

- Ultra Deep, near-infrared survey with 4m-VISTA telescope ESO-Paranal, imaging the COSMOS field in 5 bands resulting in three key surveys:
- an ultra-deep broad-band (Y, J, H, Ks) survey (1408hr) covering 0.73 deg^2
- a deep broad-band (Y, J, H, Ks) survey (212hr) covering the full 1.5deg^2 COSMOS field
- a narrow-band (180hr) survey covering the same region as the ultra-deep broad-band survey.
- DR1 -> Muzzin et al. 2013 Ks-band selected catalog (but see also Ilbert et al. 2013)

Table 1. Characteristics of UltraVISTA stacks.

Filename	Filter	Av. Exposure per. pixel	Mean FWHM (" +/- 0.1")	5-sigma 2" ap. (AB MAG; +/- 0.1 mag)	95% completeness
UVISTA_Y_27_04_11_skysub_015_v1.fits	Y	42360	0.82	24.6	24.2
UVISTA_J_03_04_11_skysub_015_v1.fits	J	49720	0.79	24.7	24.2
UVISTA_H_26_04_11_skysub_015_v1.fits	H	42520	0.76	23.9	24.1
UVISTA_Ks_15_12_10_skysub_015_v1.fits	K	39400	0.75	23.7	23.8
UVISTA_NB118_20_08_11_skysub_015_v1a.fits	NB118	23773	0.75	22.9+/-0.2	TBD

Sample construction

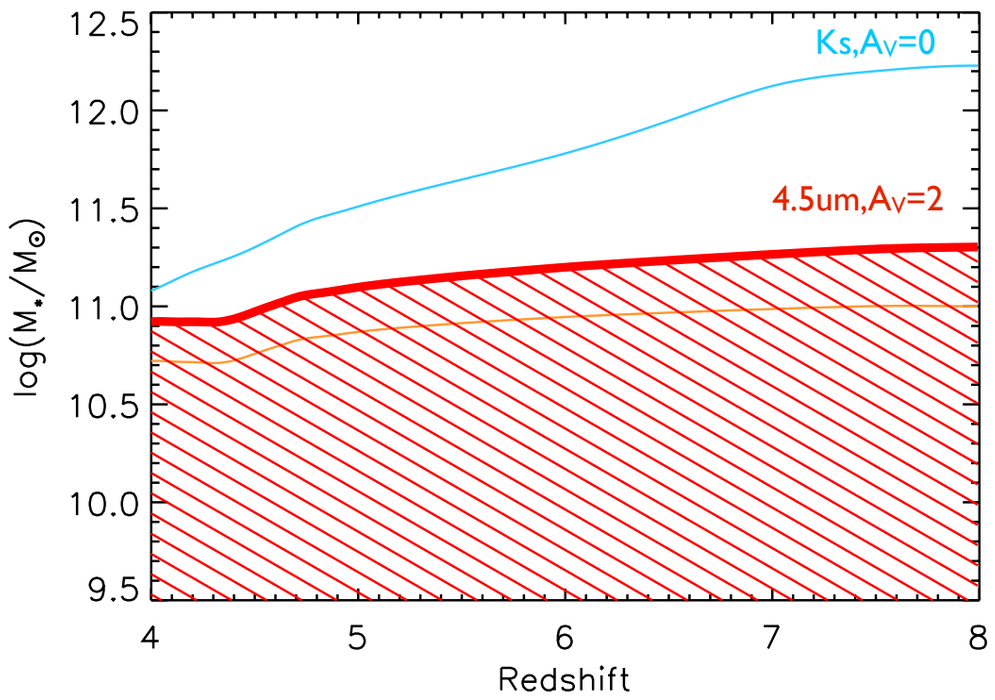
- **Aim: Stellar-mass complete sample at z>4**
  (vs. UV-bright samples selected by dropouts)

  - Balmer/4000A-break enters Ks at z~4

    - **IRAC 4.5um-complete sample**: complement UltraVISTA Ks-selected catalog with detection on IRAC 4.5um residual images. Remove de-blending issues.

  - 408 new sources (after removal of contaminated sources, AGN, brown dwarf candidates) over ~1.5 sq. deg.

  - Matched aperture photometry on CFHT, UVISTA, IRAC, MIPS



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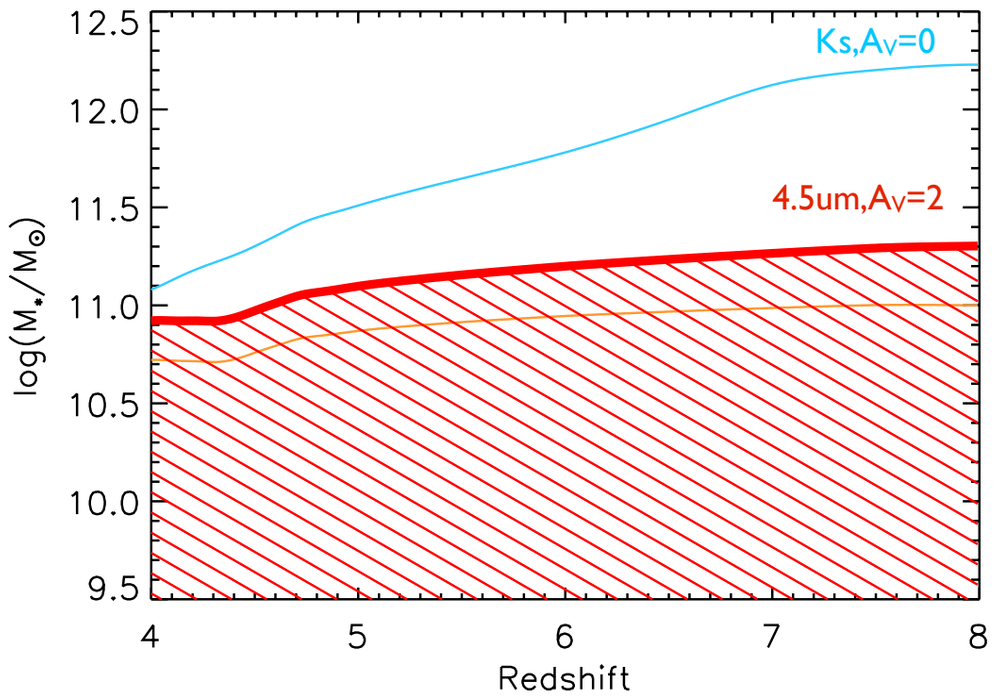

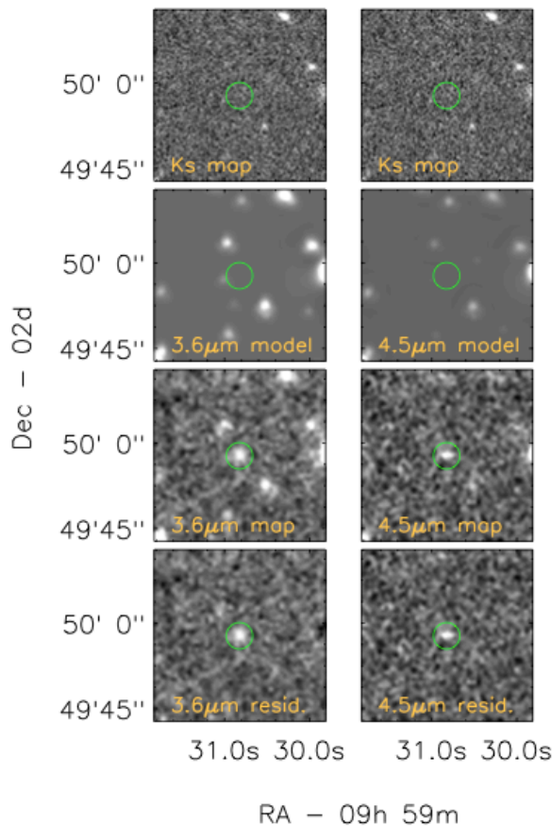

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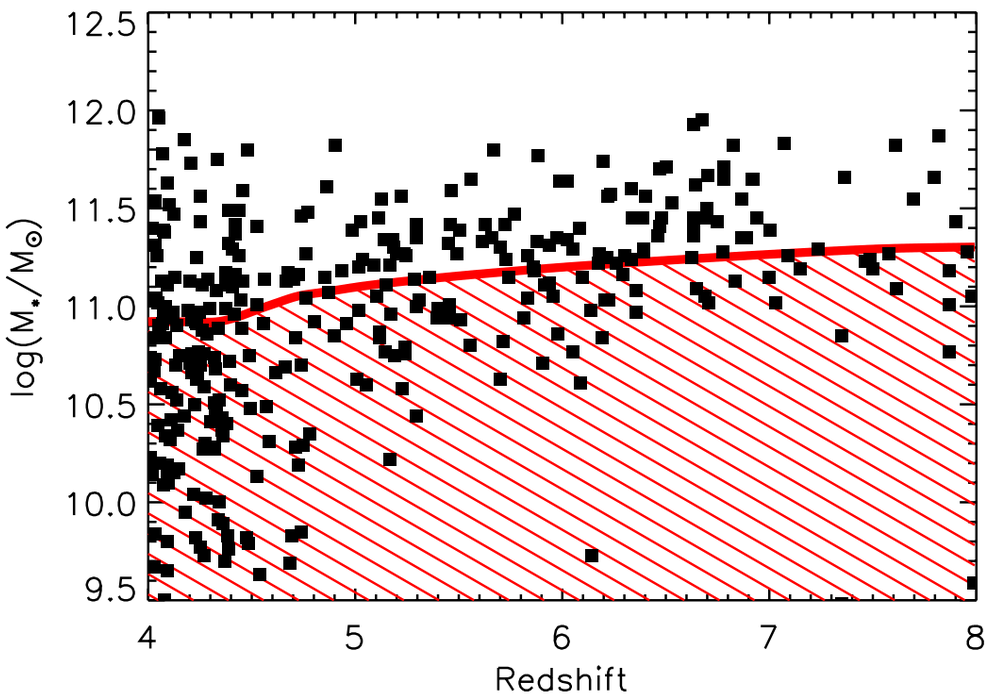

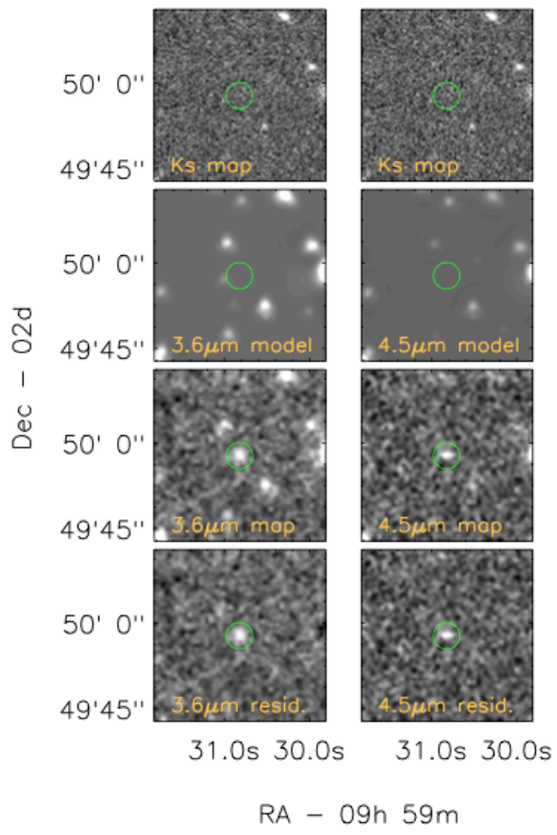

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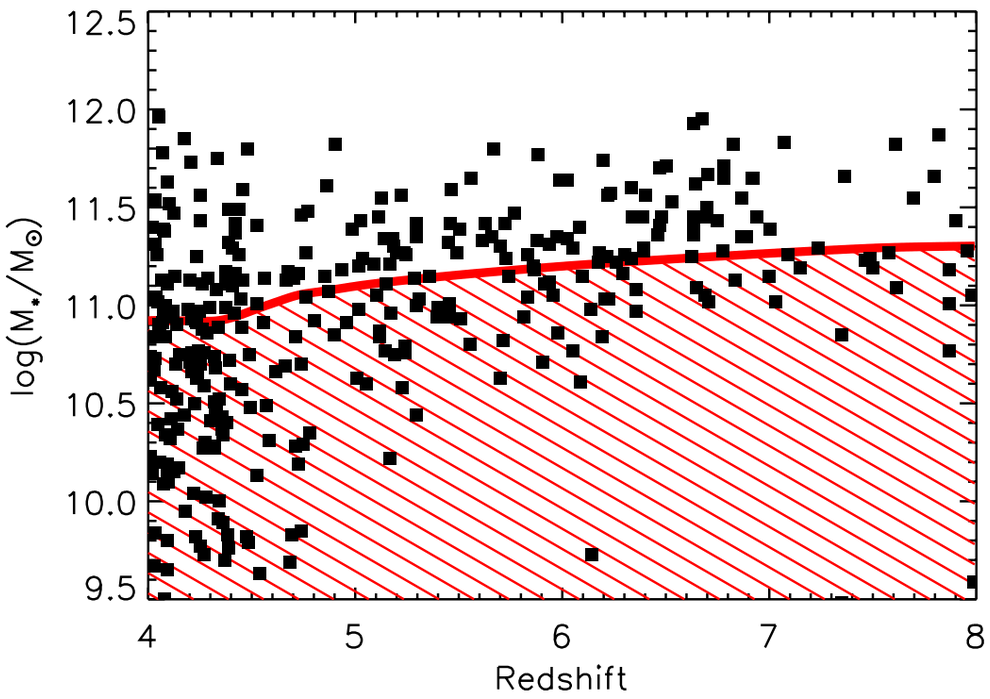
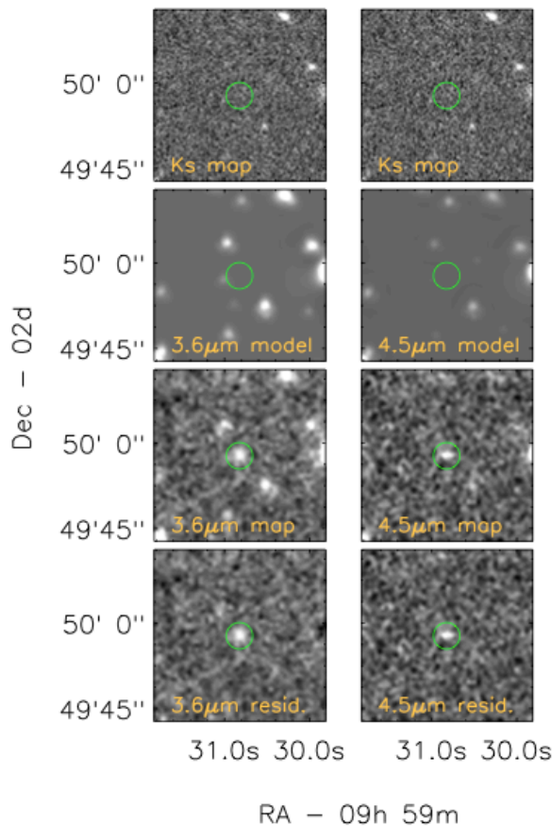
- **POTENTIAL SYSTEMATIC EFFECTS**

  - photo-z: luminosity prior, maximally red SED template

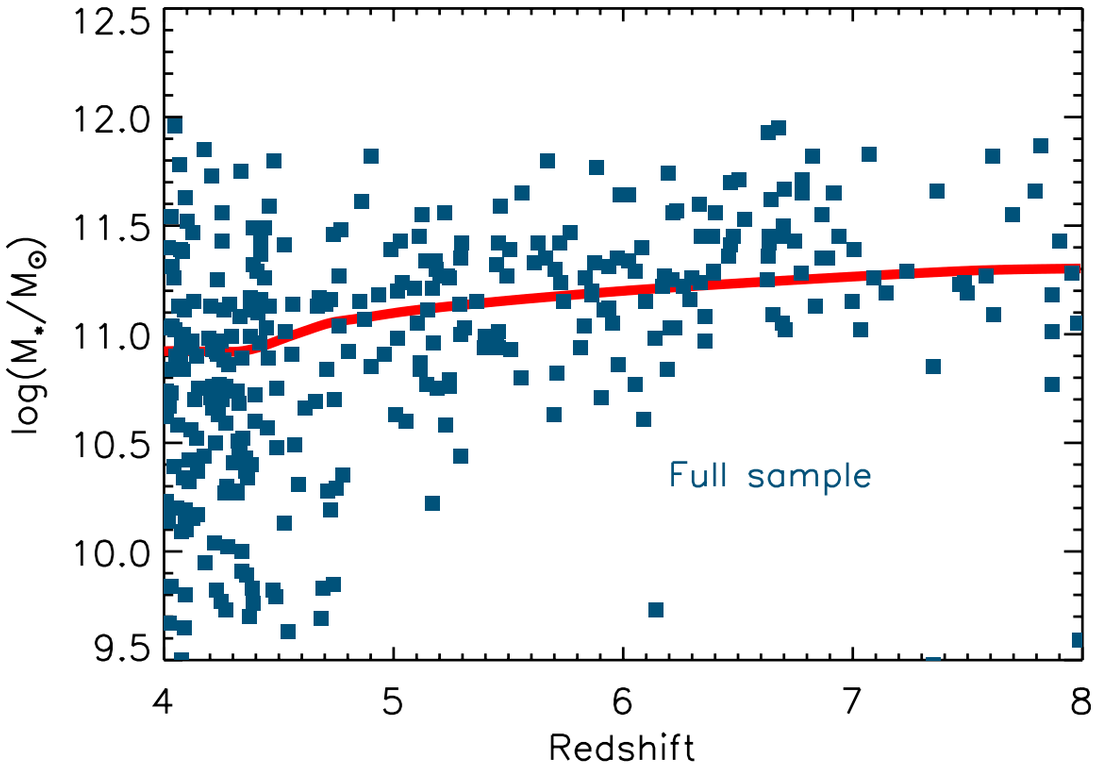
  - stellar pop. params: nebular line emission contamination, SFH





Robust massive galaxies at z>4

- Different configurations for photo-z (prior/ no prior, standard EAzY SED templates/ adding old&dusty) and stellar population parameters (with/without nebular lines, Exp/ Del-exp SFHs)
  - 382 galaxies at 4<z<7 under main configuration (no prior, no old&dusty template)



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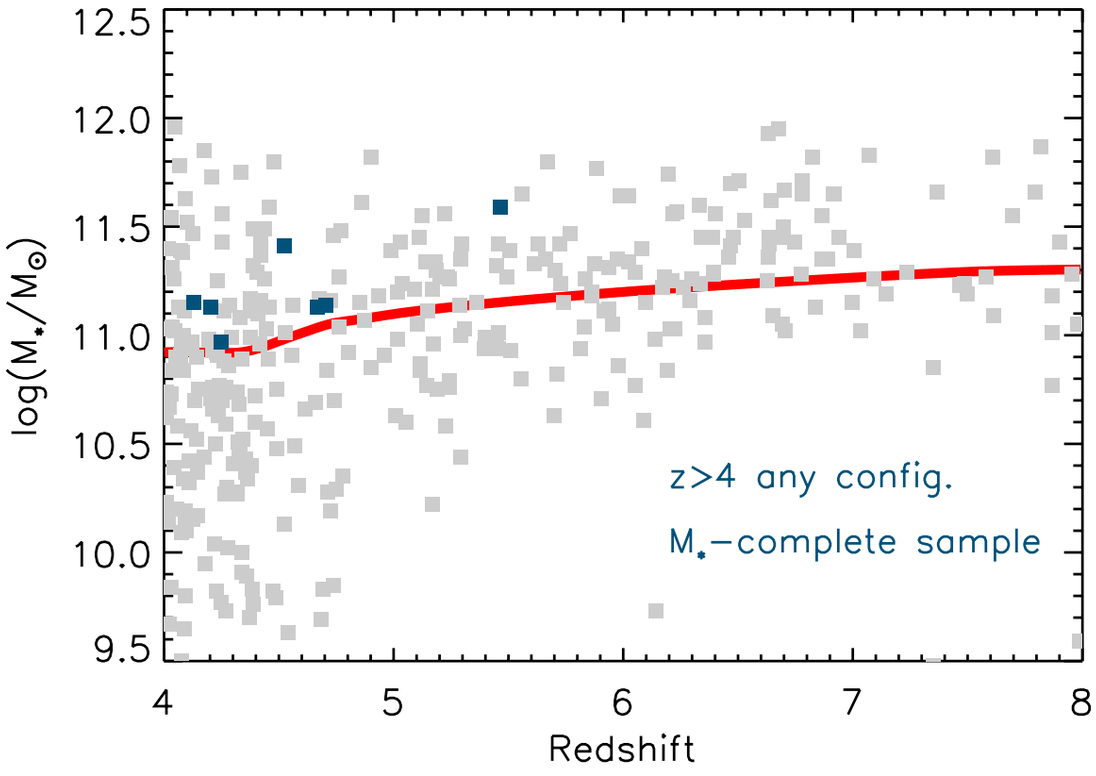

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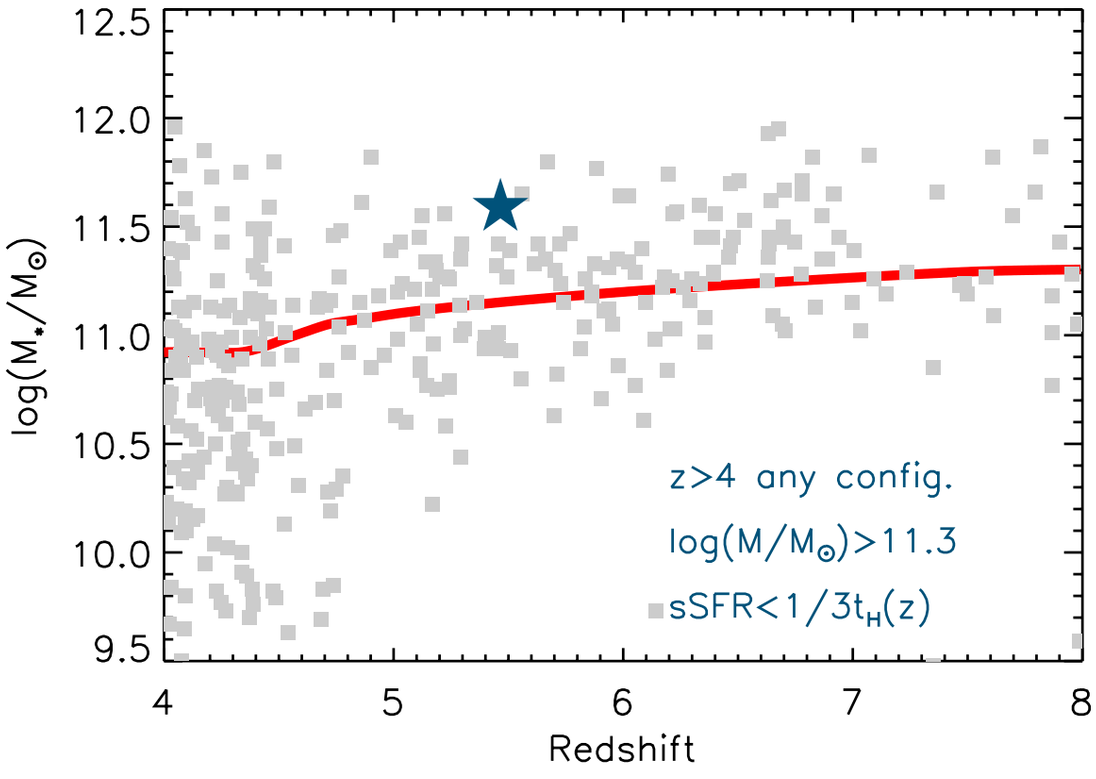
  - 52 galaxies with z>4 irrespective of configuration - 7 of which in the stellar mass complete sample. Strong effect from luminosity prior (SAM models).
  - 1 potential massive and post-starburst galaxy.



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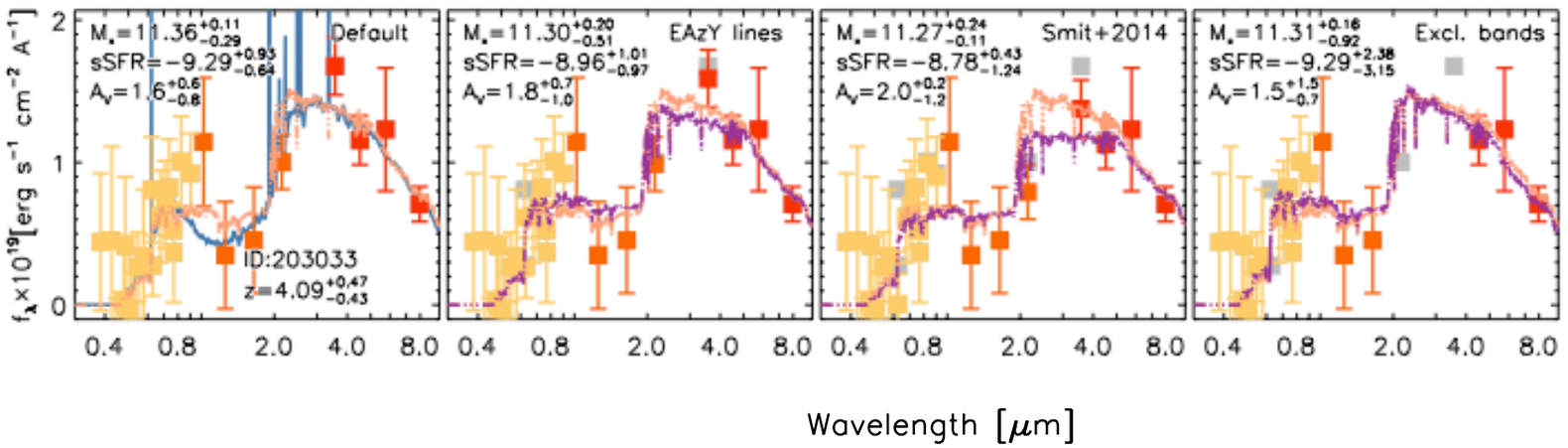
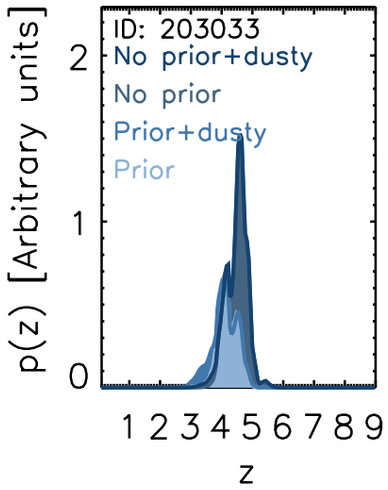
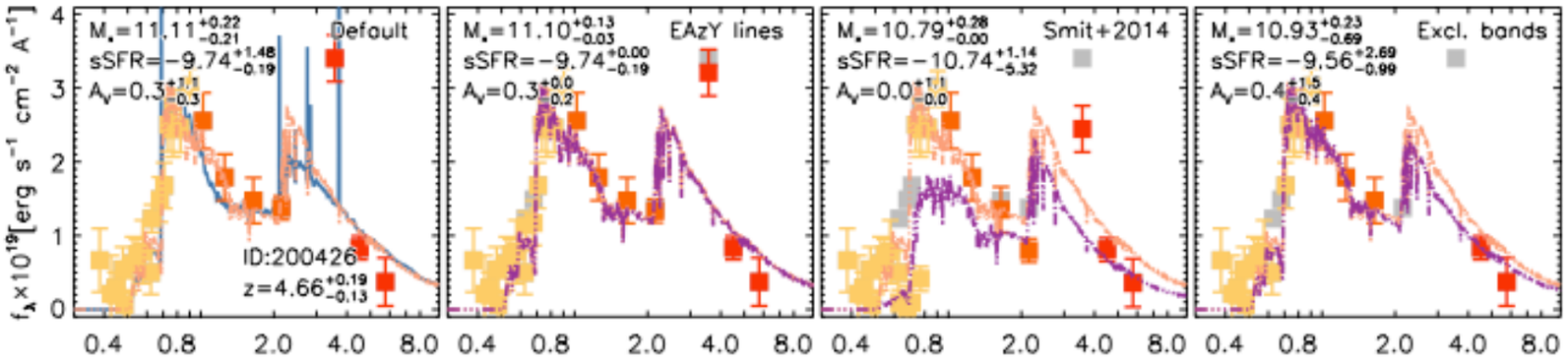
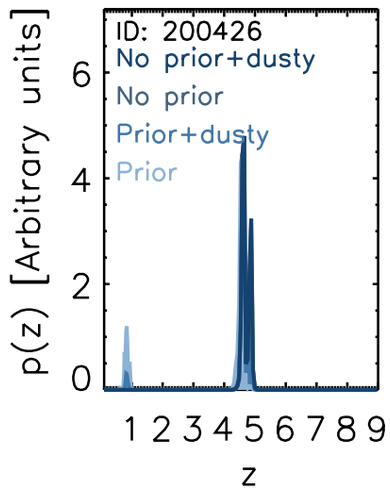
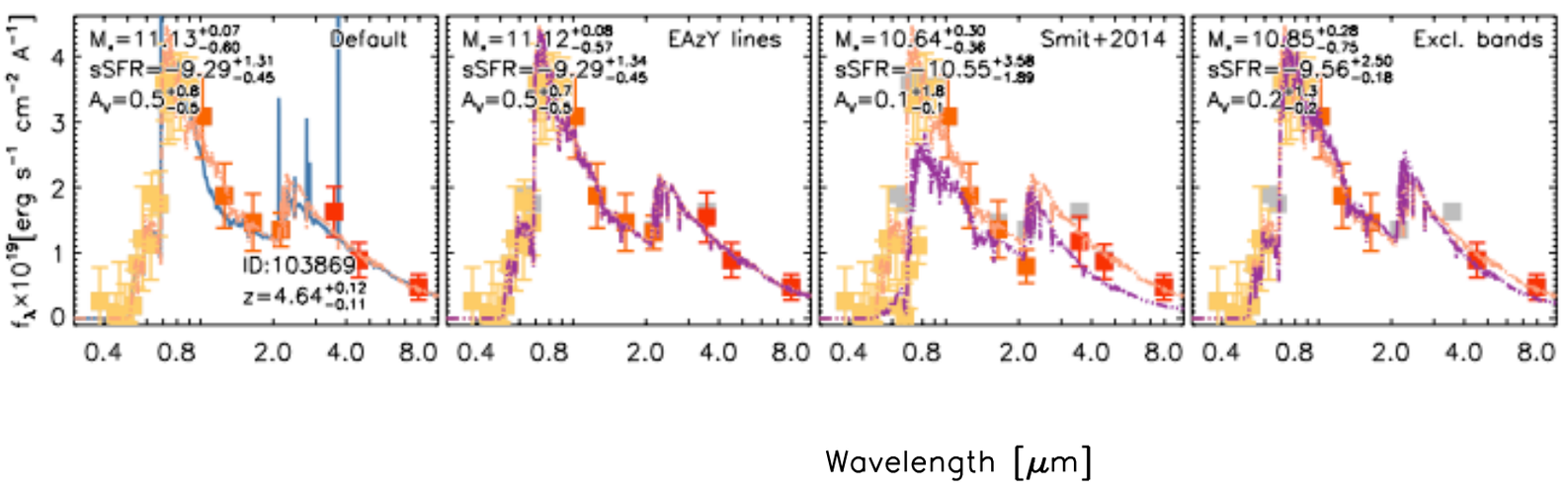


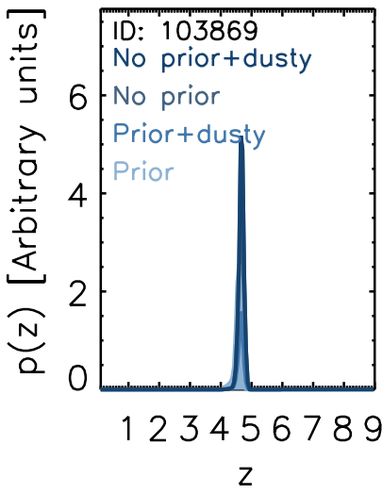




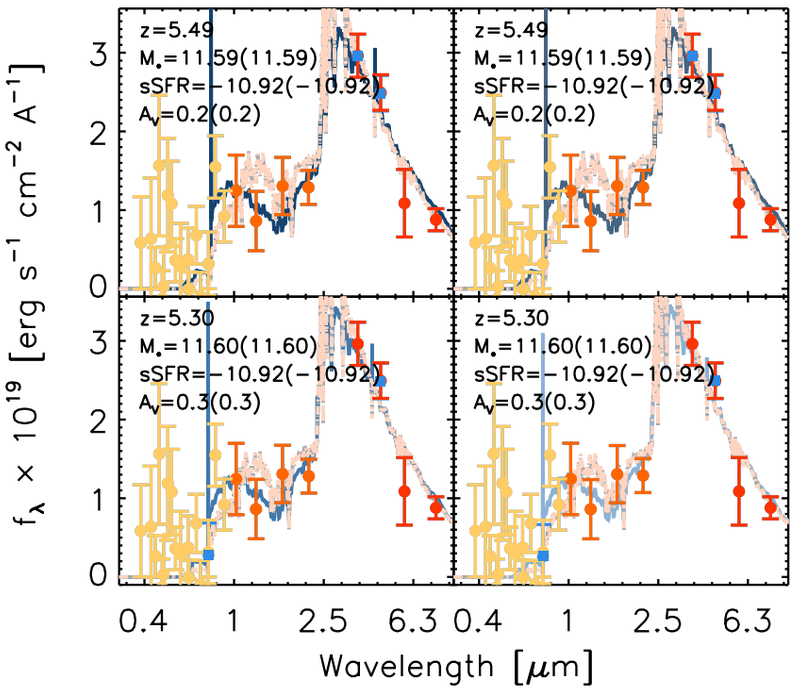


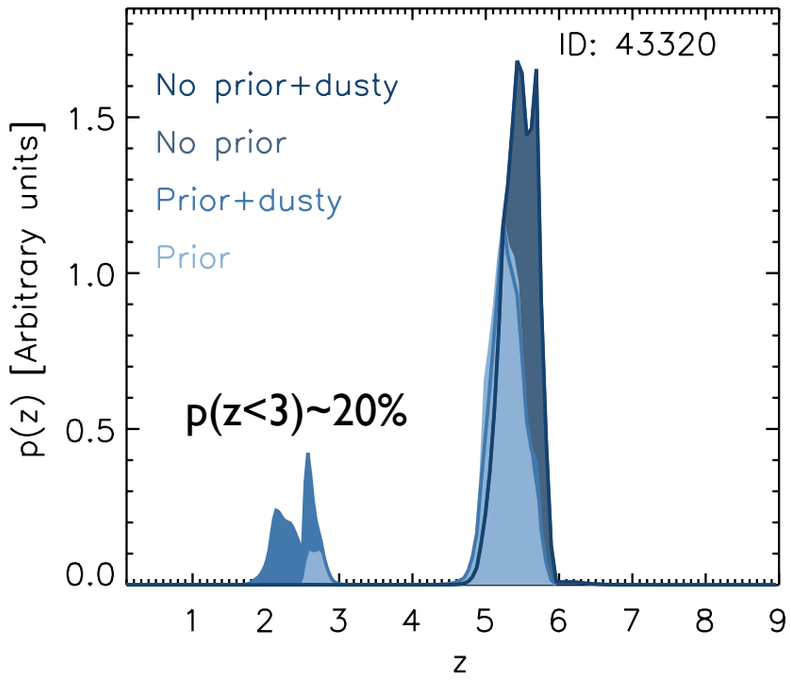
- Peaked p(z)
- SED characteristic of SF galaxies
- Some of the galaxies show extreme nebular emission





Candidate massive post-starburst galaxy at z~5.5





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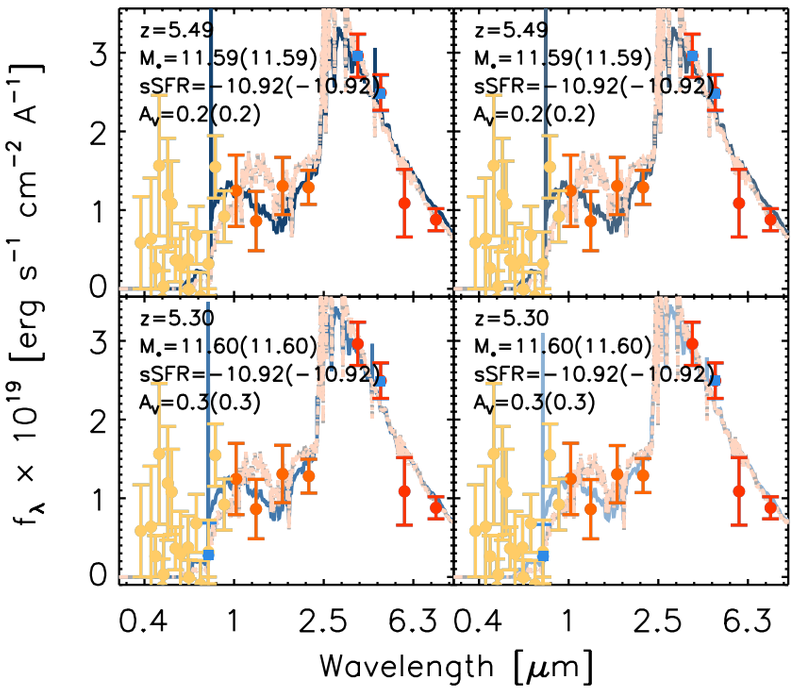

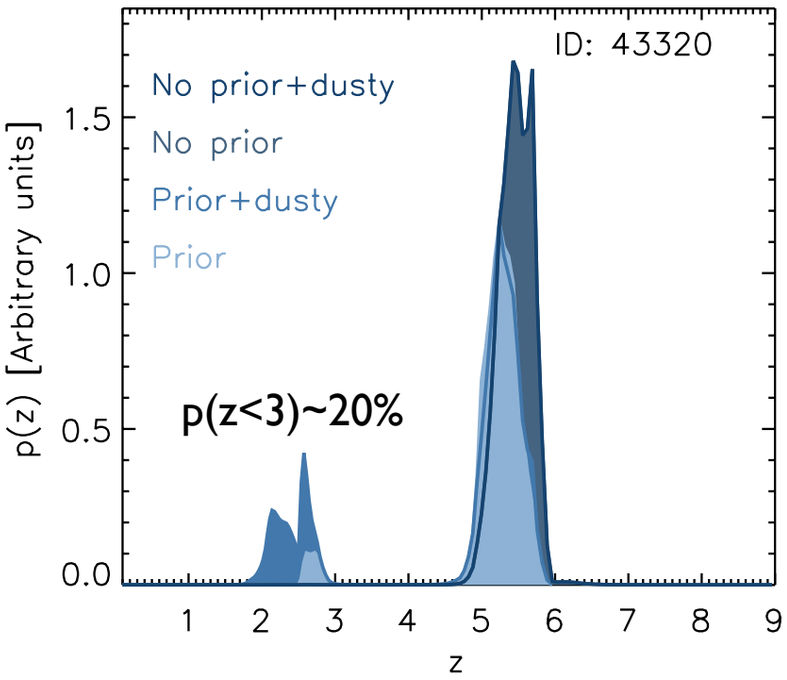

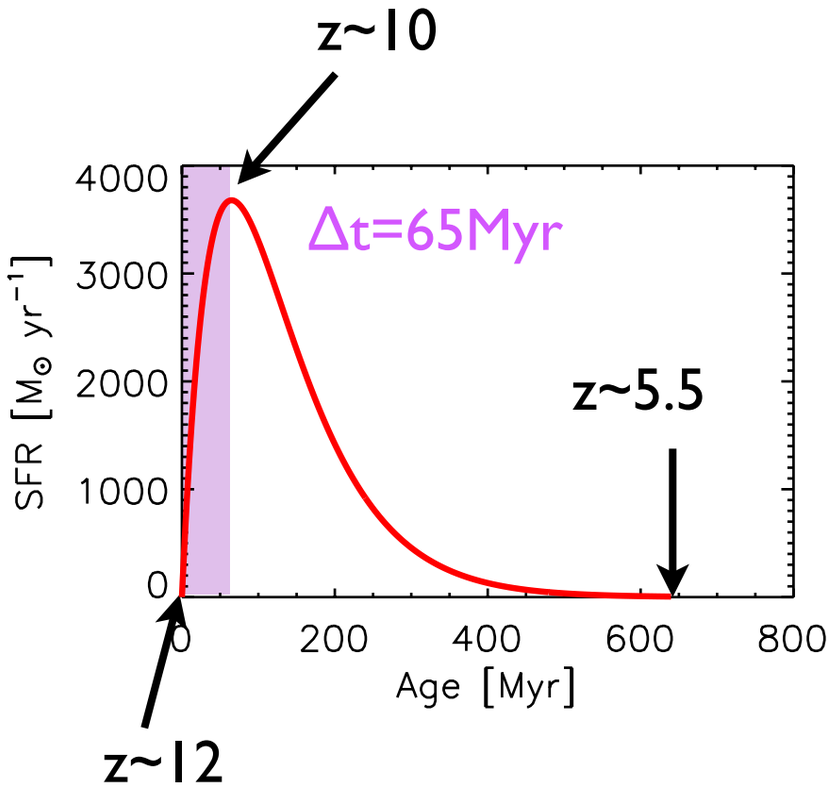

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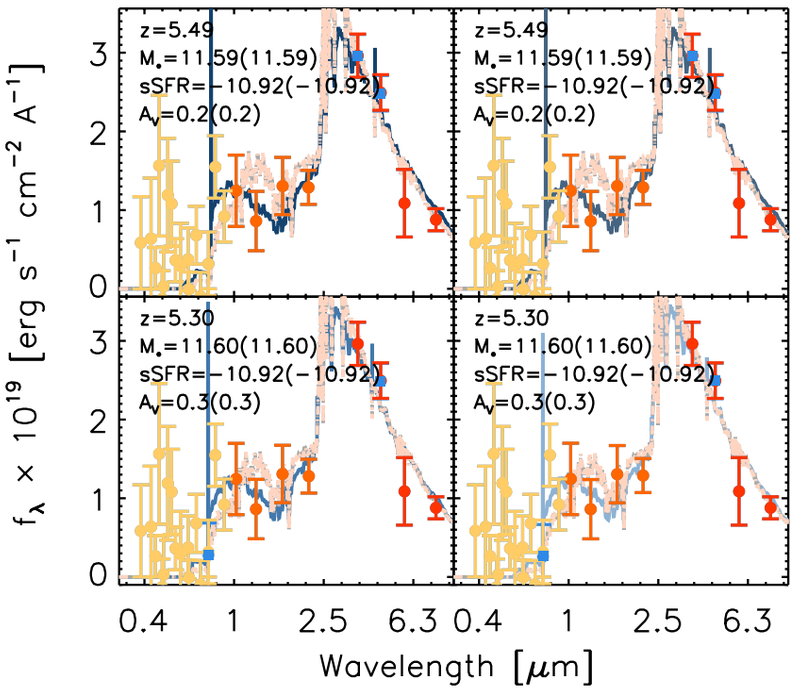
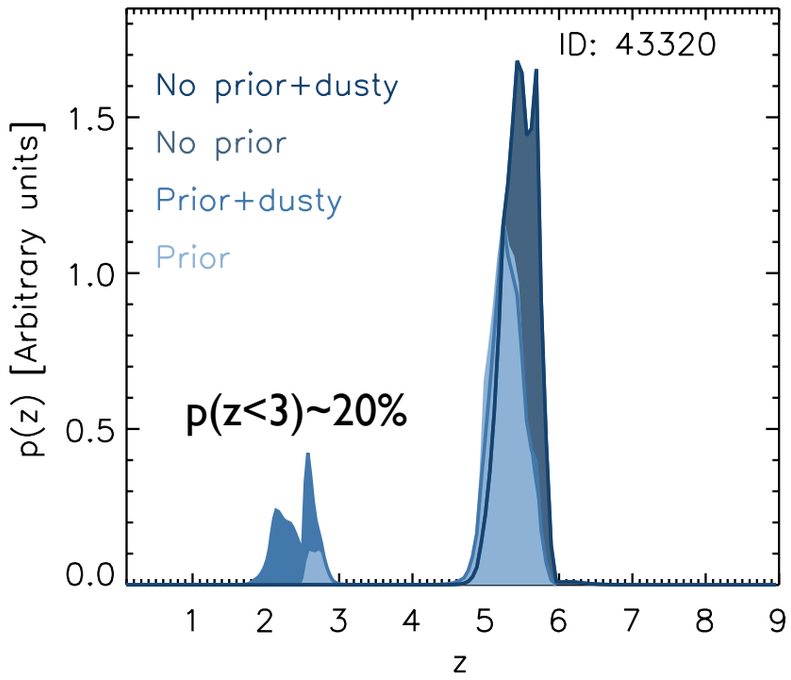
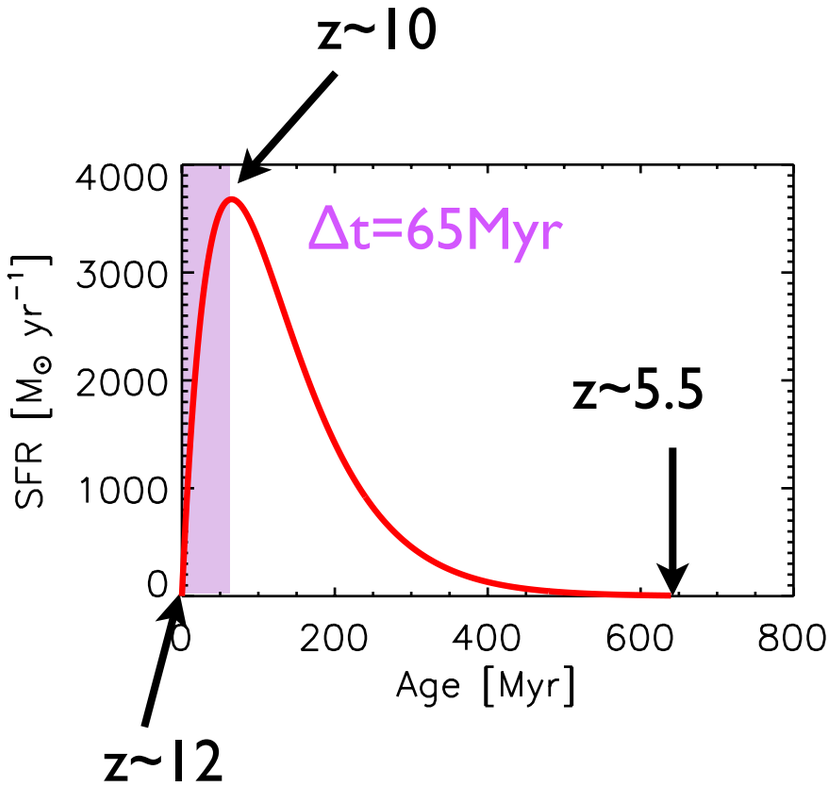
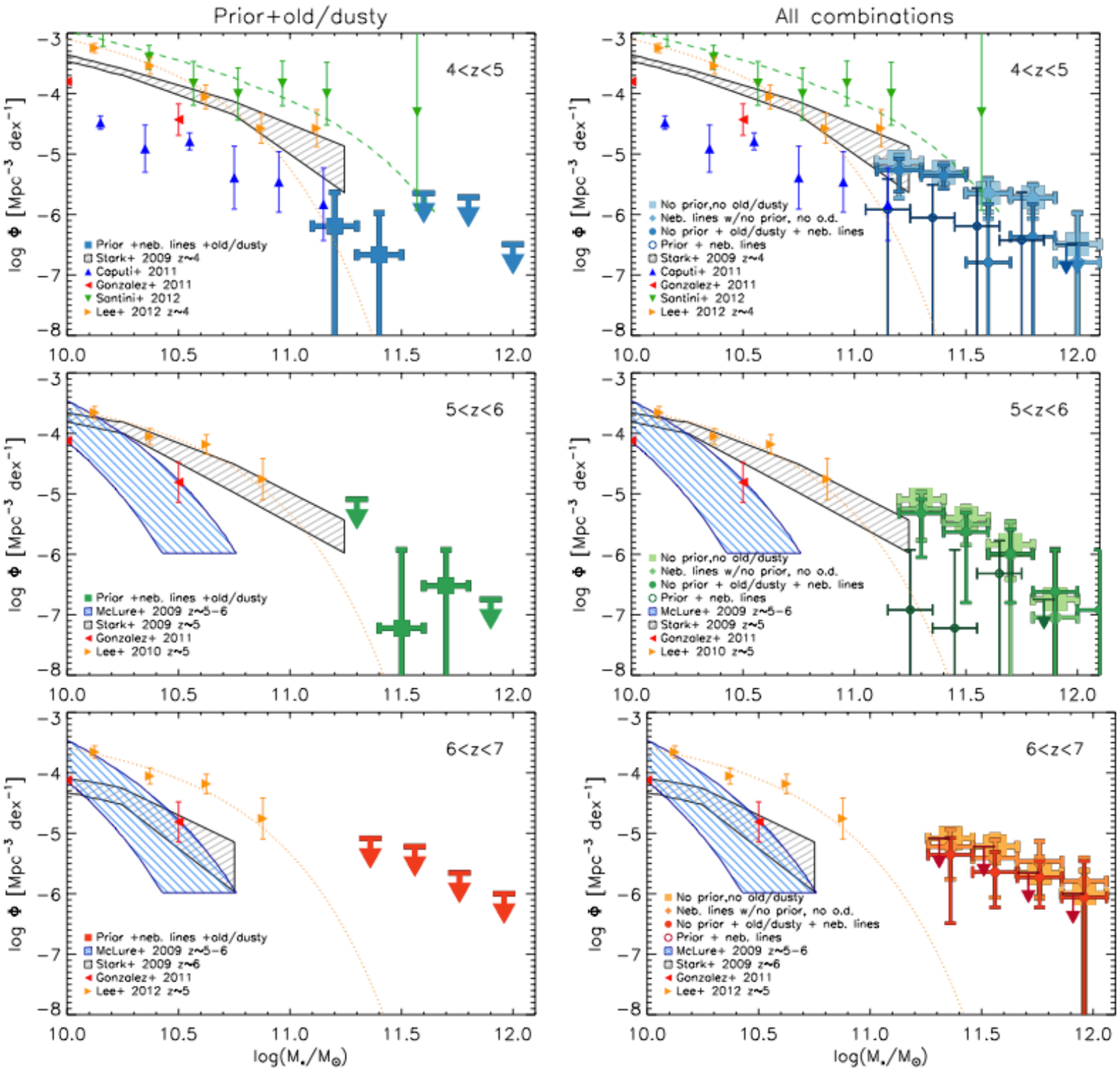






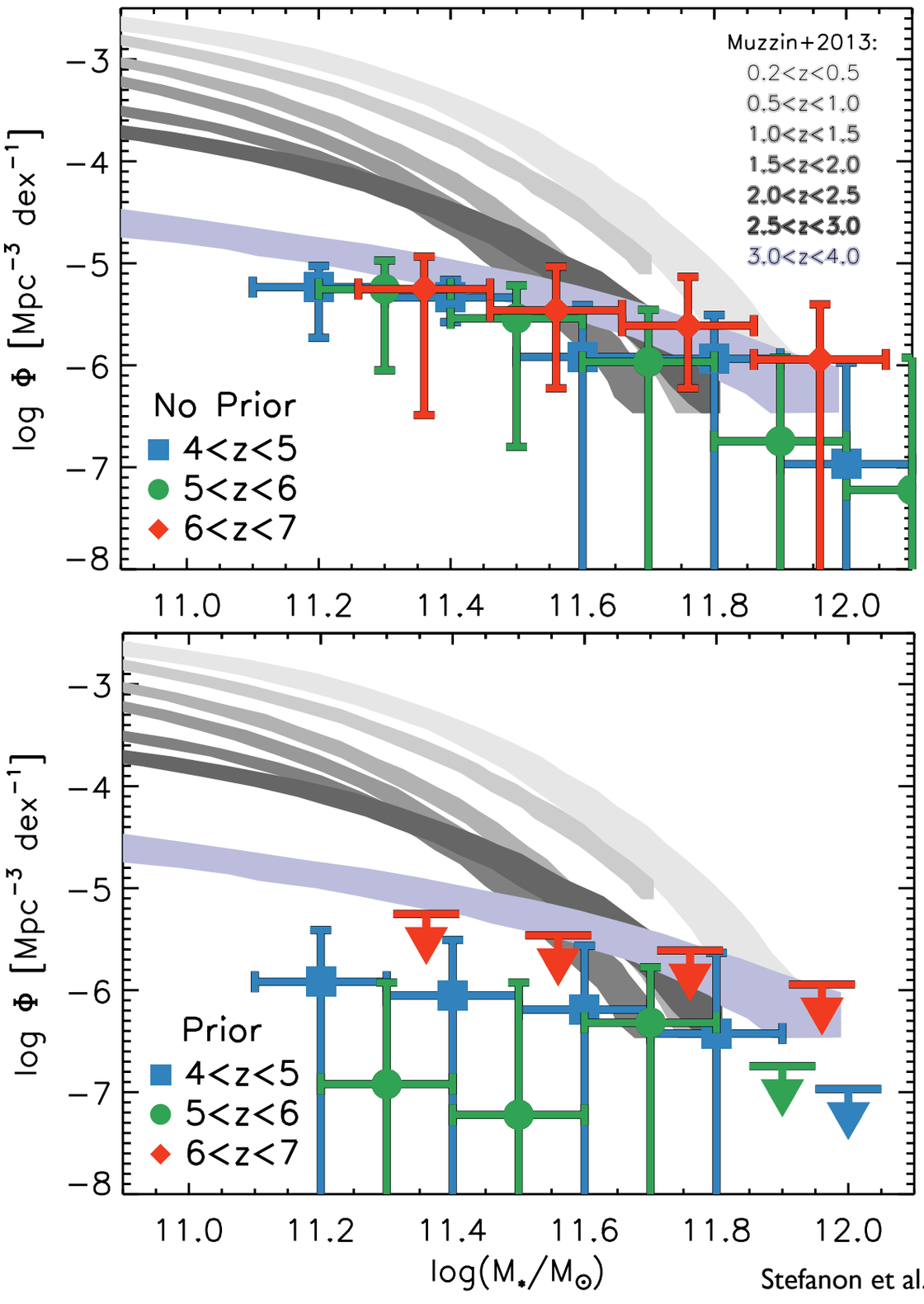
- ..but clear MIPS 24um detection:
  - if z~2 then HyLIRG
  - if z~5.5 then AGN contamination (quenching?)

4<z<7 SMF



Stefanon et al. 2015 ApJ accepted

Evolution of SMF ?



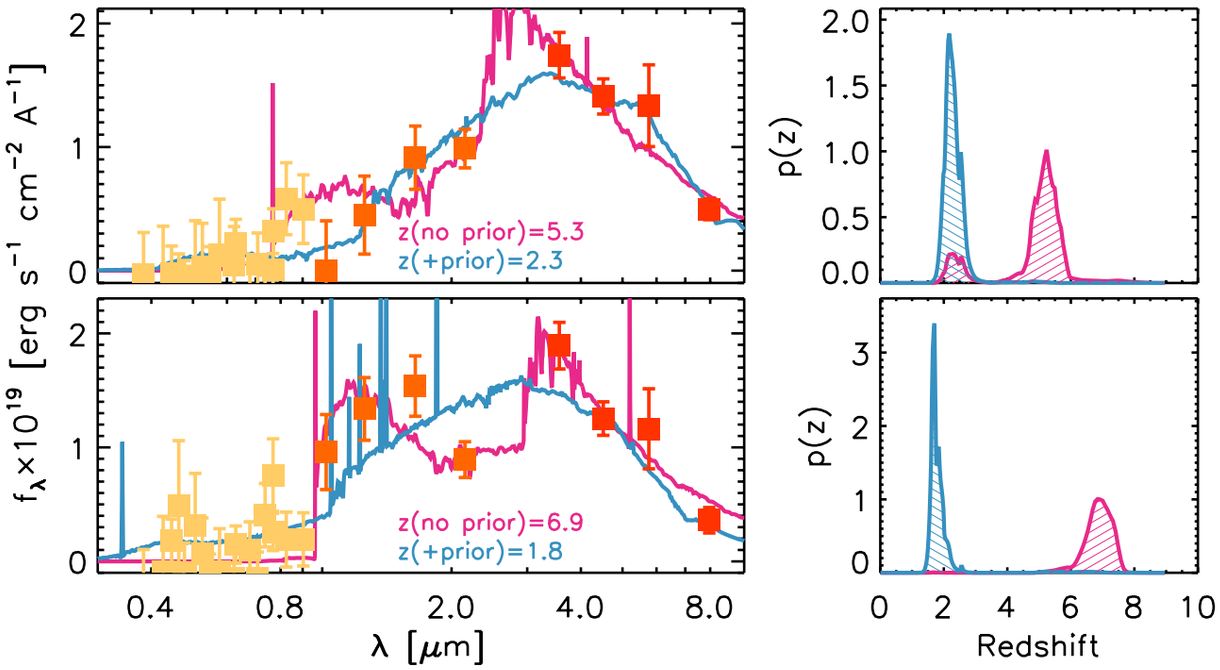
- No prior: consistent with no evolution for 3<z<7. All massive galaxies observed at z~4 already in place at z~6.5!
- Prior: mostly upper limits suggesting strong evolution with z!

Stefanon et al. 2015 ApJ accepted

Conclusions

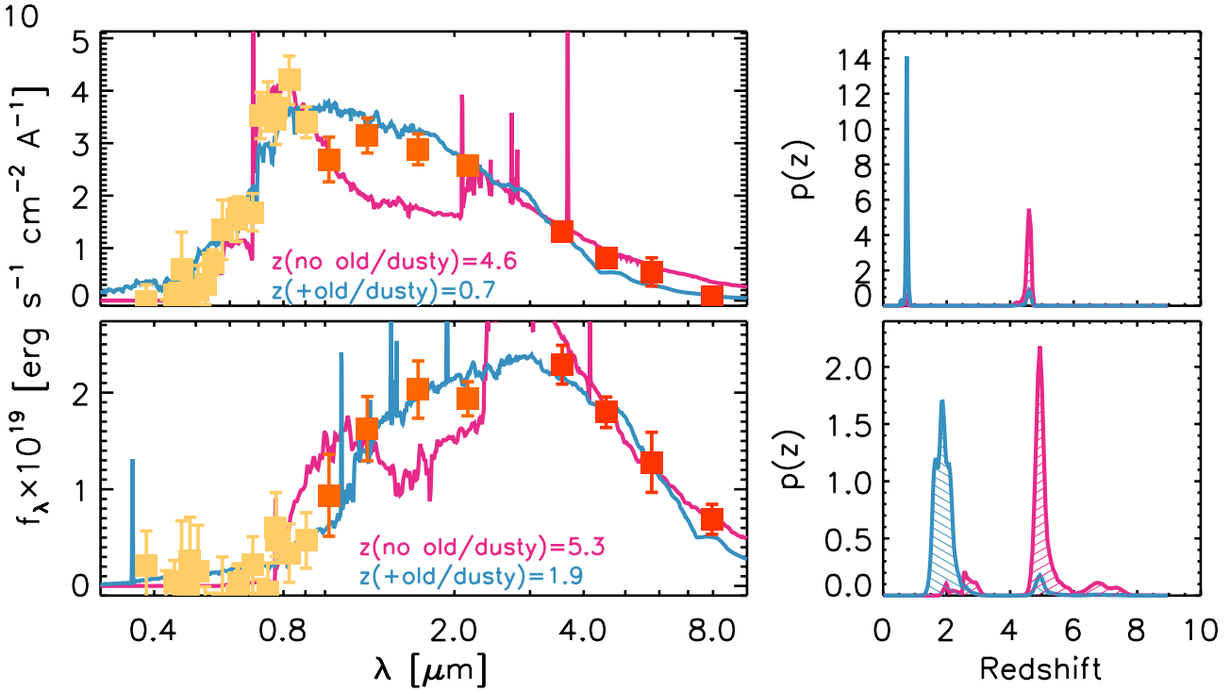
- We implemented a stellar-mass complete sample of galaxies at z>4 complementing a Ks-selected catalog with detection in IRAC 4.5um
- We detected a sample of seven robust very massive galaxies with z>4 and SEDs typical of star-forming or post-starburst galaxies.
- We detected one candidate for a massive ($M* \sim 10^{11.6} M_{\odot}$), quiescent (sSFR~ $10^{-10.3} yr^{-1}$) galaxy at $z \sim 5.4$.
- SMF measurements mostly affected by the systematic effects in the measurement of photometric redshifts from the introduction of the old-and-dusty template and from the adoption of the luminosity prior on the observed flux. These prevent us from constraining the evolution of the high-mass end of the SMF of galaxies over the redshift range $4 < z < 7$ and from detecting any possible evolution in the range of redshift between $z \sim 6.5$ and $z \sim 4.5$

Systematics: luminosity prior and max red SED

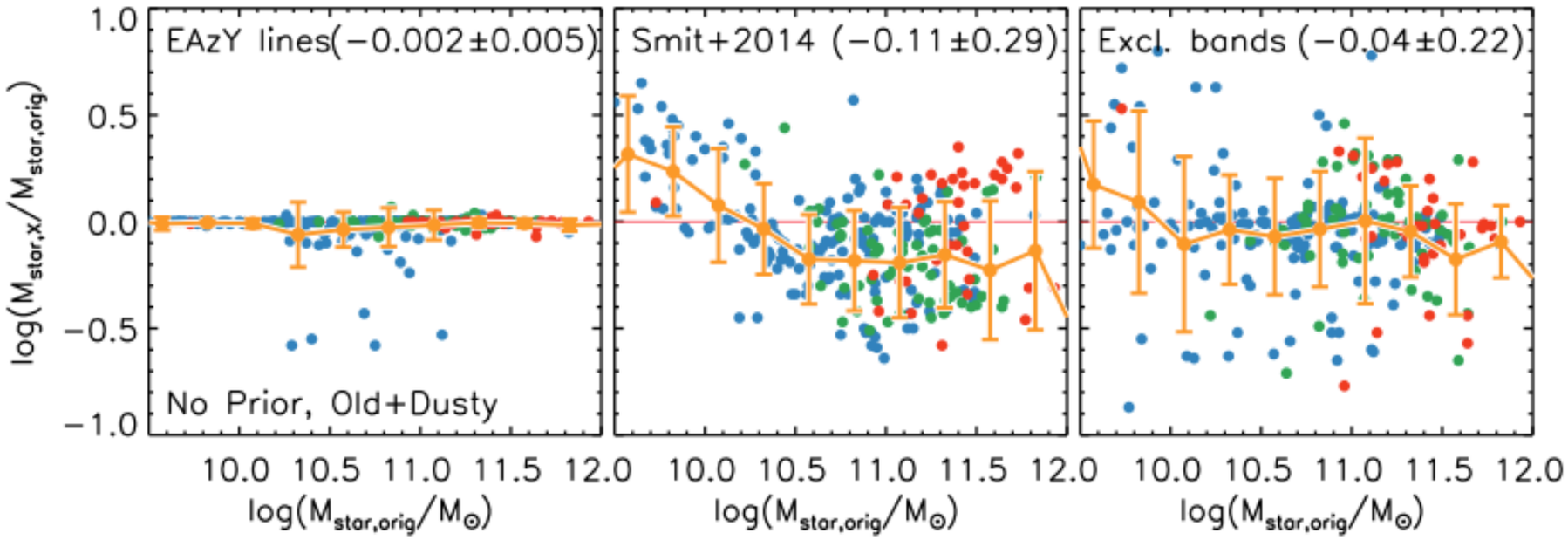


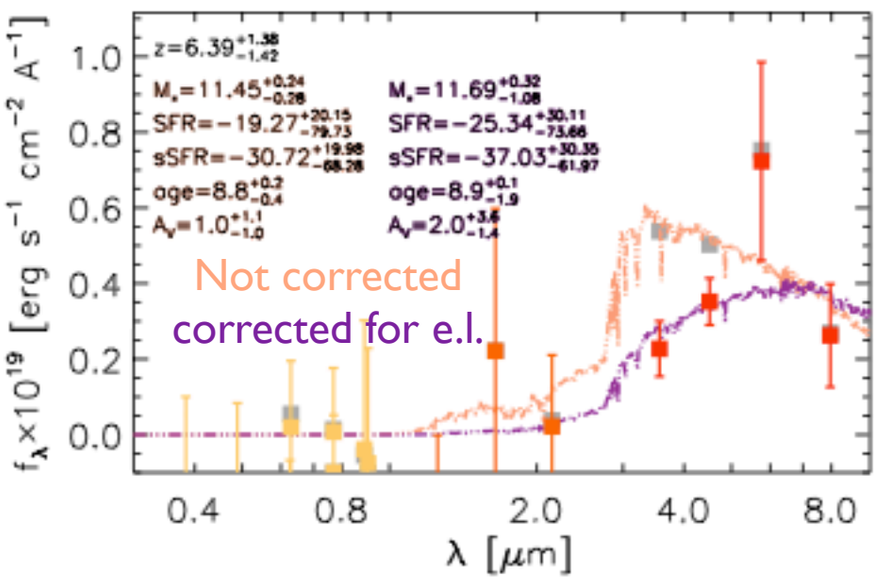
Sometimes hard to judge which configuration provides best solution

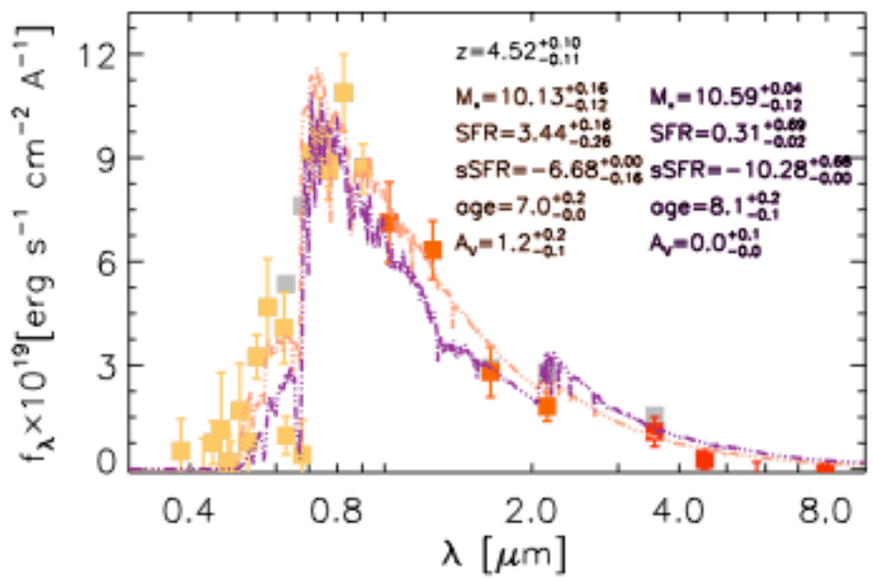
Adopted SED template set is critical to get "good" photo-z



Systematics: nebular emission contamination







Systematics: SFHs