Probing Reionization with Lyman Alpha Emitters

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Dayal et al., MNRAS, 2008, 389, 1683

Dayal et al., MNRAS, 2009, 400, 200

Dayal et al., MNRAS, 2010, 402, 1449

Dayal et al. arXiv:0908.1571

Dayal et al. arXiv:1002.0839

17th February, 2010

Harish-Chandra Research Institute

The focus of the talk

Q1: What are LAEs?

Q2: Why are they important ?

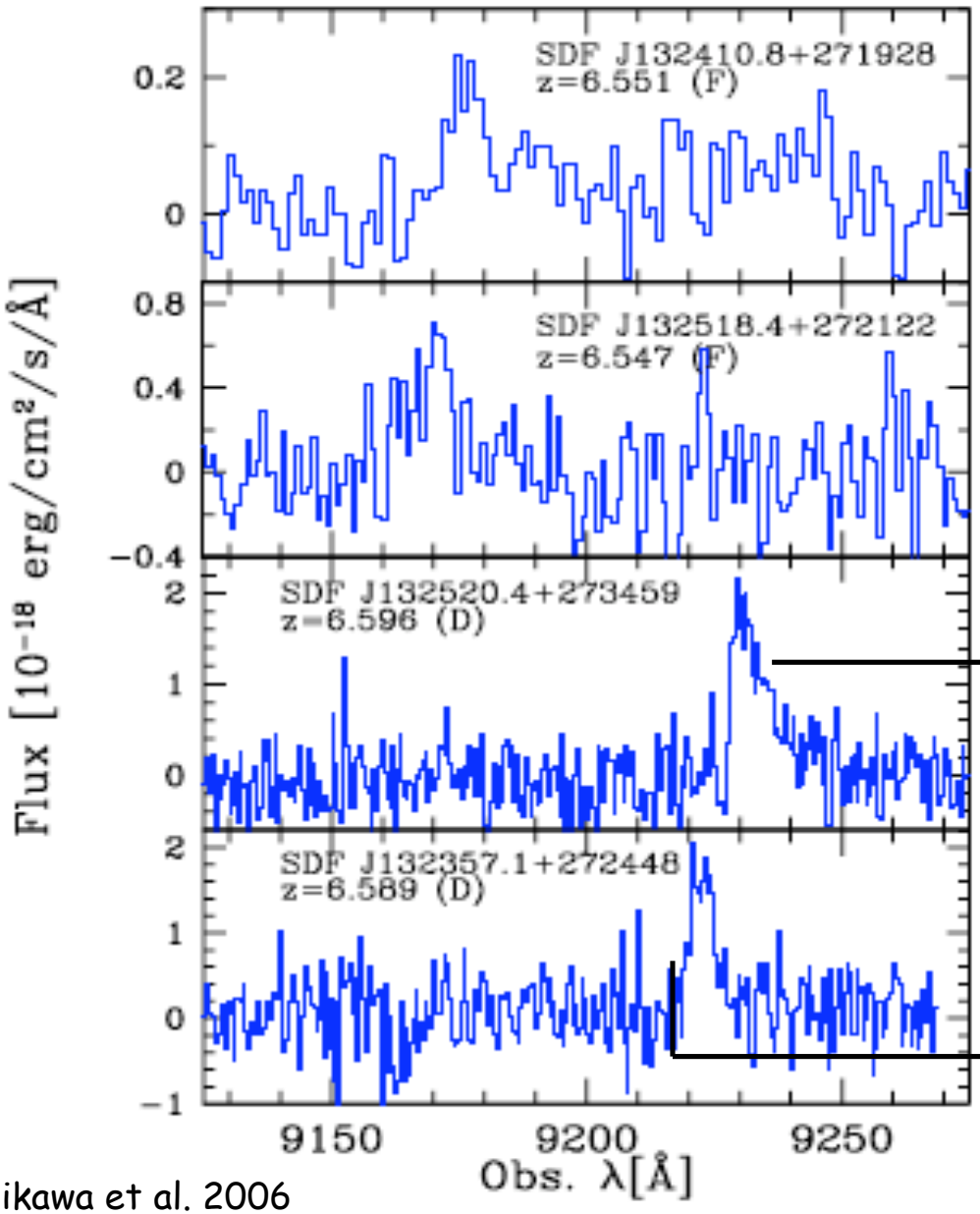
Q3: Can they be used to probe :

a) Reionization ?

b) the dust enrichment of high-z galaxies ?

Q4: What is the nature of LAEs?

What are LAEs ?



1. Galaxies with an observable Lyα line.
2. Observed EW > 20 A

Lyα line very strong and narrow

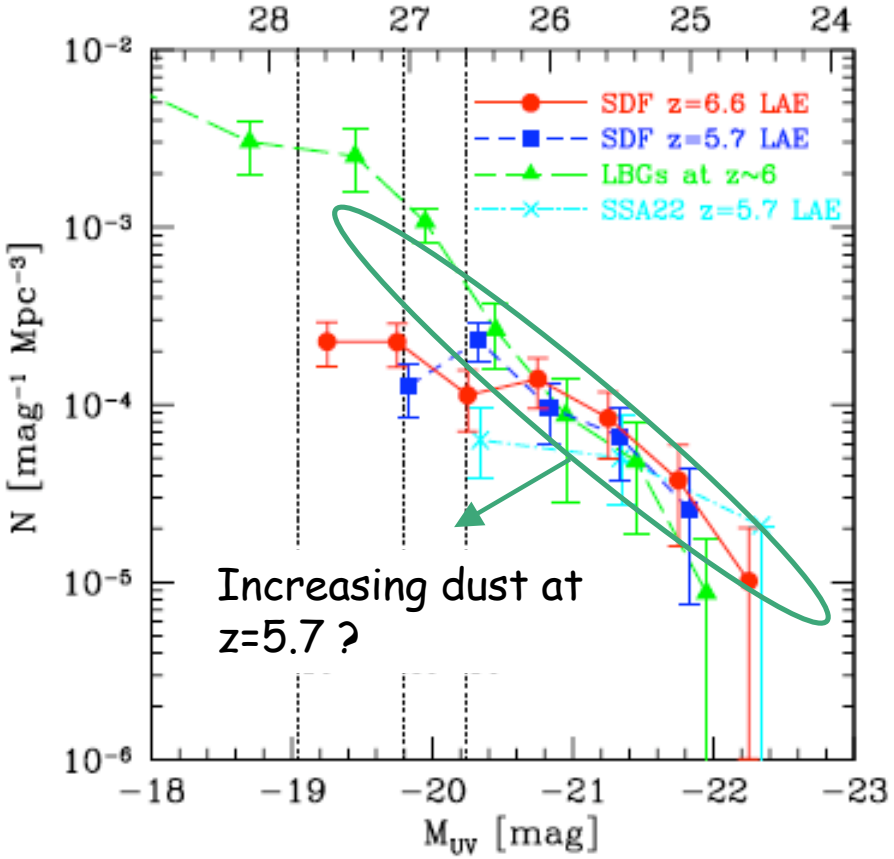
Sharp cut-off blueward of the Lyα line

Kashikawa et al. 2006

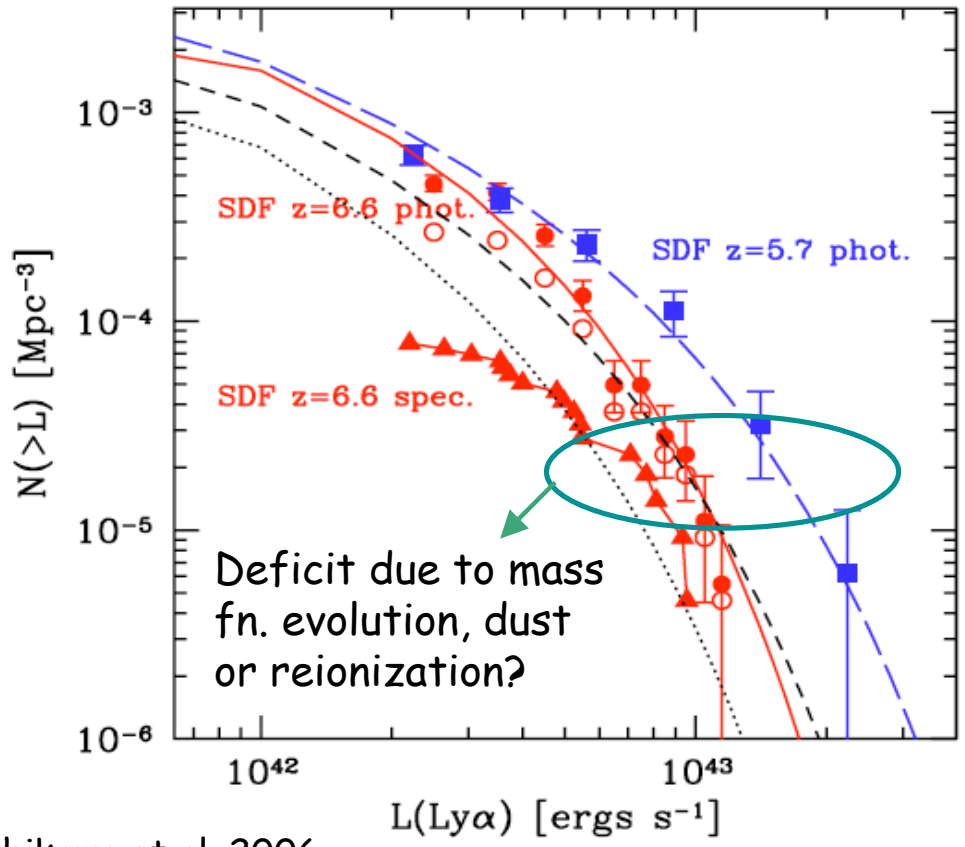
Why are LAEs important ?

- Highest redshift galaxies with good statistics.
- Since Lyα sensitive to HI, excellent probes of ionization state of the IGM.
- Relative damping of Lyα and UV used to constrain dust amounts/distribution.

UV LF - shaped by dust



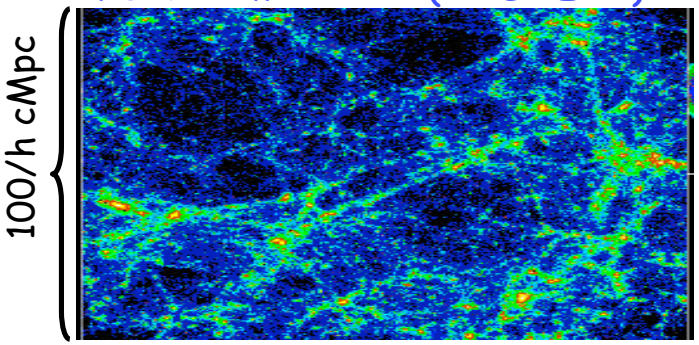
Cumulative Lyα LF - shaped by dust + IGM transmission



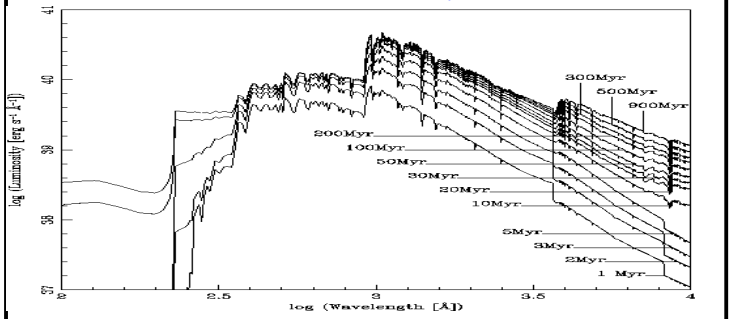
Kashikawa et al. 2006

The LAE model - SPH + RT using CRASH

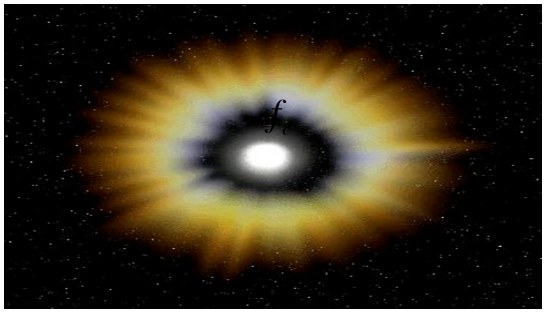
1. SPH simulations (GADGET2)



2. Intrinsic luminosity calculation



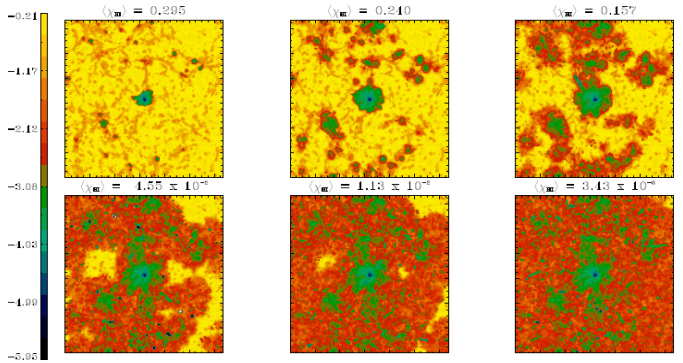
3. SNII dust enrichment



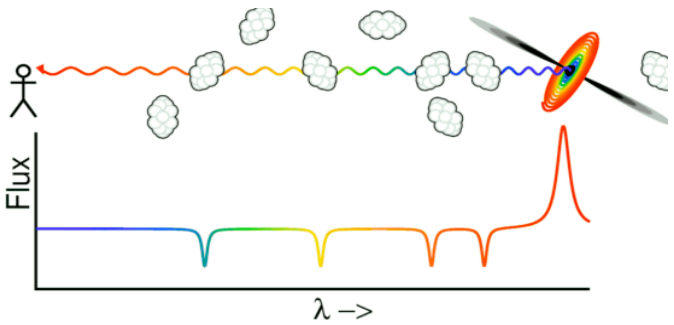
Obtain the escape fraction of UV photons, f_c
This fixes the UV LF

Only free parameter to match Lyα LF is f_α / f_c

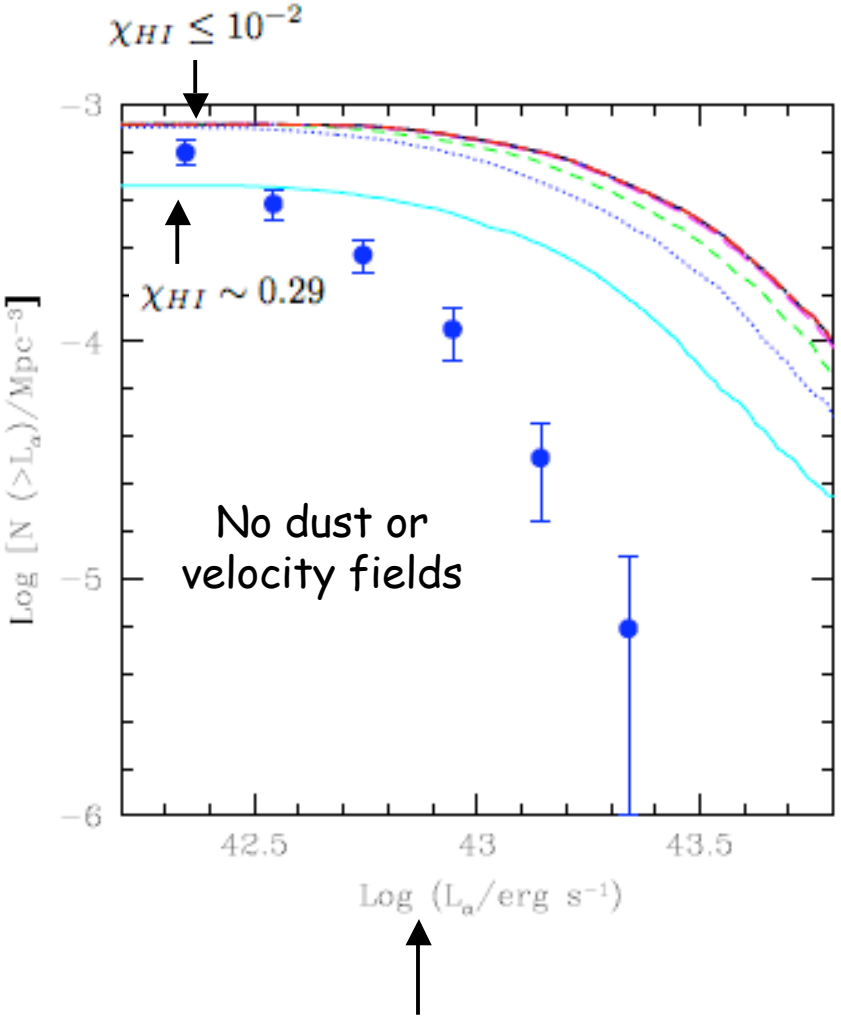
4. RT using CRASH



5. IGM Transmission



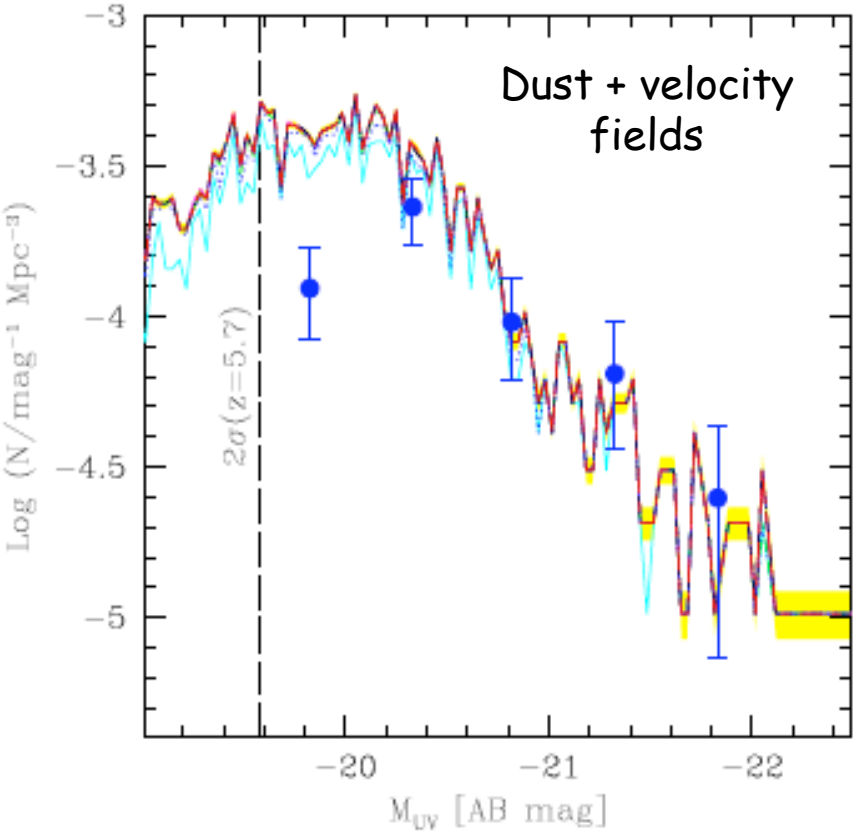
The key parameters governing the Lya and UV LFs



Can not reproduce slope or magnitude of Lya LF in absence of dust and peculiar velocity fields

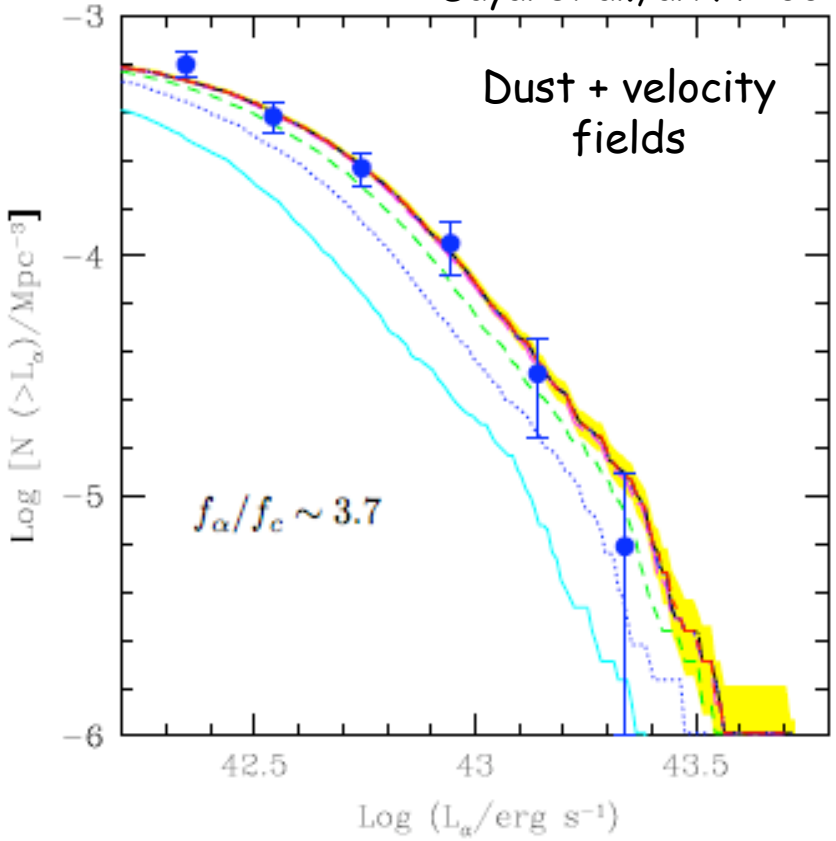
Dayal et al., arXiv:1002.0839

The key parameters governing the Lya and UV LFs



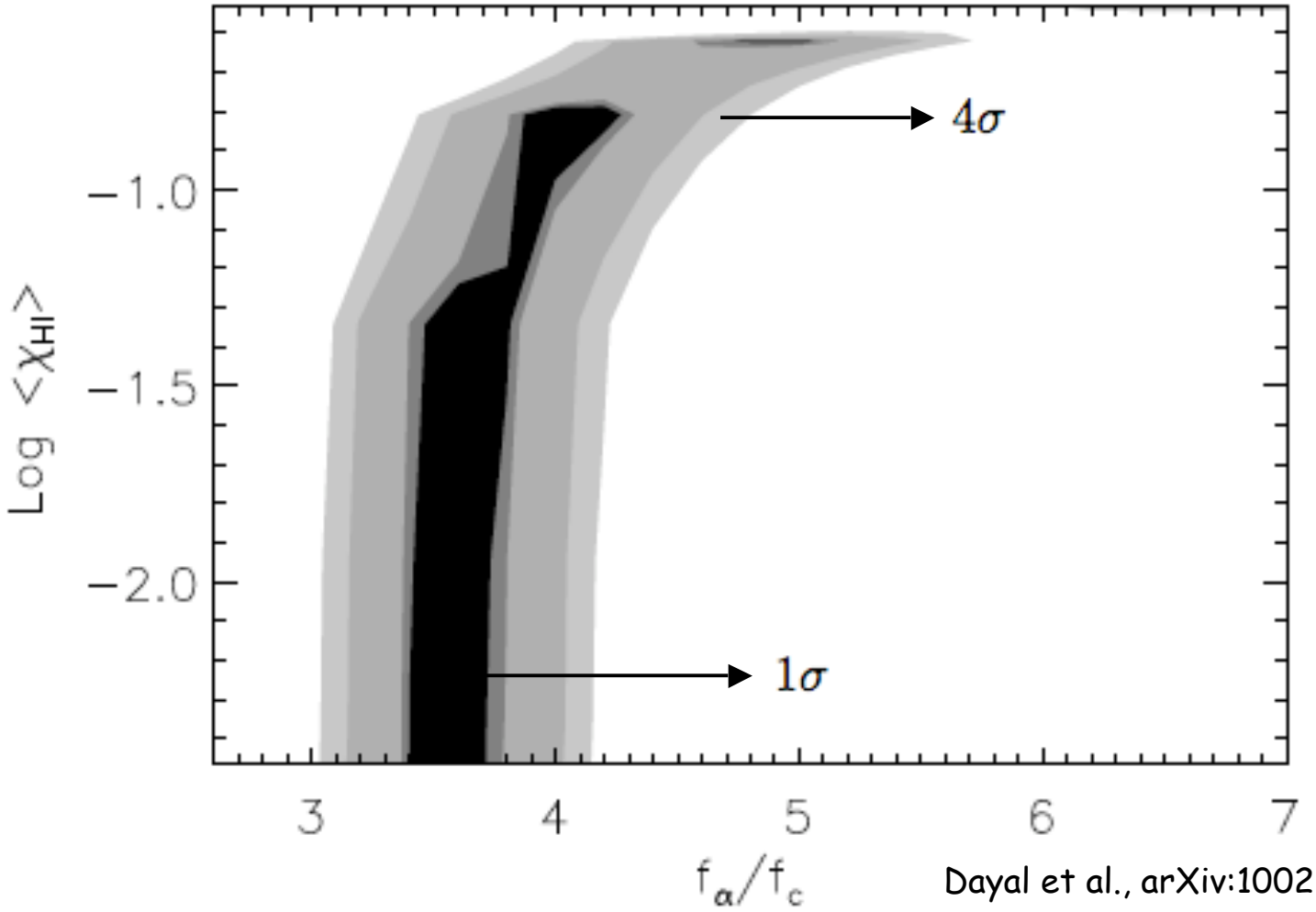
UV LF well reproduced by SNII dust, for all IGM ionization states.

Dayal et al., arXiv:1002.0839



- SNII dust model reproduces Lya LF.
- Effect of velocity fields is an attenuation of Lya photons, and a flattening of the Lya LF.

A startling result - degeneracy between dust and reionization



Dayal et al., arXiv:1002.0839

There is a degeneracy between the ionization state of the IGM and the fraction of Lya photons emerging out of the galaxy.

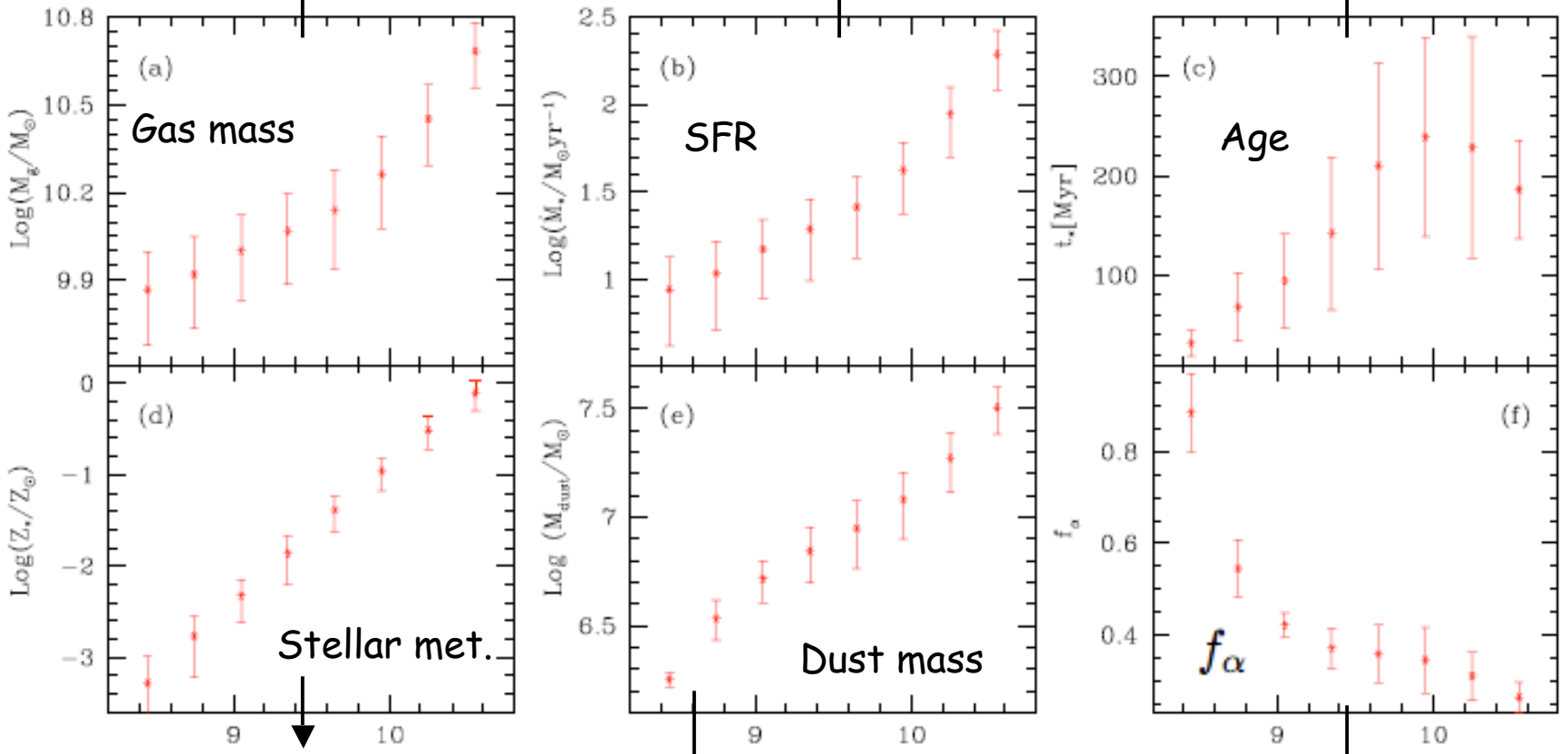
The Nature of LAEs

Dayal et al., arXiv:1002.0839

Largest galaxies most efficient in turning gas into stars

SFR between 3-200 $M_{\odot}\mathrm{yr}^{-1}$

Intermediate ages (20-350 Myr)

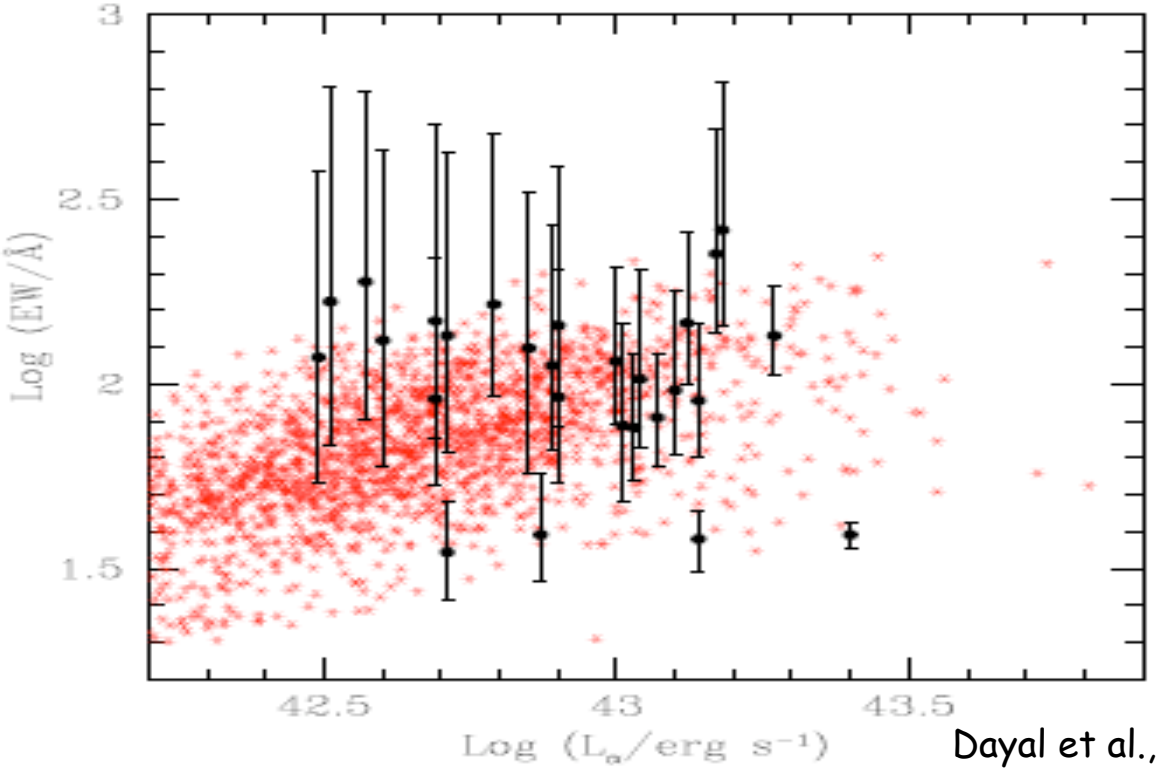


Metallicity increases with SFR.

Larger galaxies more dust enriched

90% (25%) of Lya photons escape from galaxies from low to high mass end.

The EW distribution

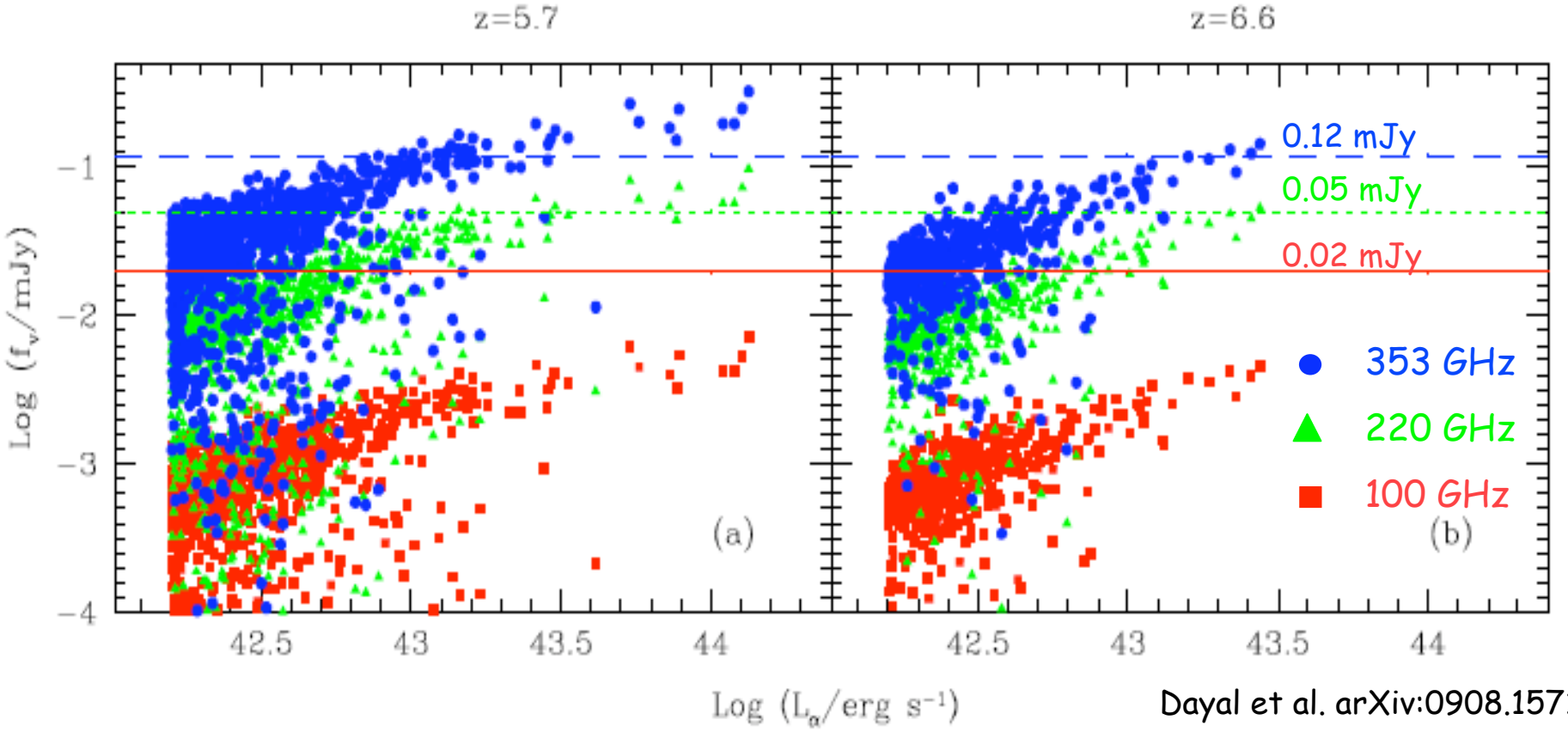


Dayal et al., arXiv:1002.0839

- By using a self-consistent LAE model that
  - (a) uses SPH simulations to obtain the intrinsic galaxy properties
  - (b) includes calculation of Lyα and continuum luminosity based on intrinsic properties
  - (c) includes a calculation of dust enrichment based on galaxy properties
  - (d) uses RT to calculate the IGM transmission,

We can reproduce the range and distribution of LAEs at z~5.7.

Detectability of LAEs in the Sub-millimeter



Dayal et al. arXiv:0908.1571

- UV photons (910-4000 A) absorbed are re-emitted in the Far Infra red (FIR) in the rest frame of the galaxy (submm in observer frame).
- About 3% of LAEs visible with a 5σ 1 hour integration limit in 353 GHz band.
- If observations do not match, exotic scenarios need to be considered: top heavy IMF, popIII stars, ages <10 Myr ?

SUMMARY

- Coupling SPH + CRASH + a previous LAE model, we find a degeneracy between the Lya photons that escape from the galaxy and those transmitted through the IGM.

- Ratio of escape fractions of Lyα to continuum photons is always greater than 1, i.e., the dust is inhomogeneous / clumped.

- We find LAEs have stellar masses between 10^{8.6-10.6} solar masses, SFR between 3-200 solar masses/yr, ages between 20-350 Myr, dust masses between 10^{6.2-7.5} solar masses and EW between 20-250 A.

However, LAEs can not be used as good probes of reionization till the escape fractions of Lya photons is better understood