Intergalactic LyA absorption excess in a proto-cluster environment at z=3.1

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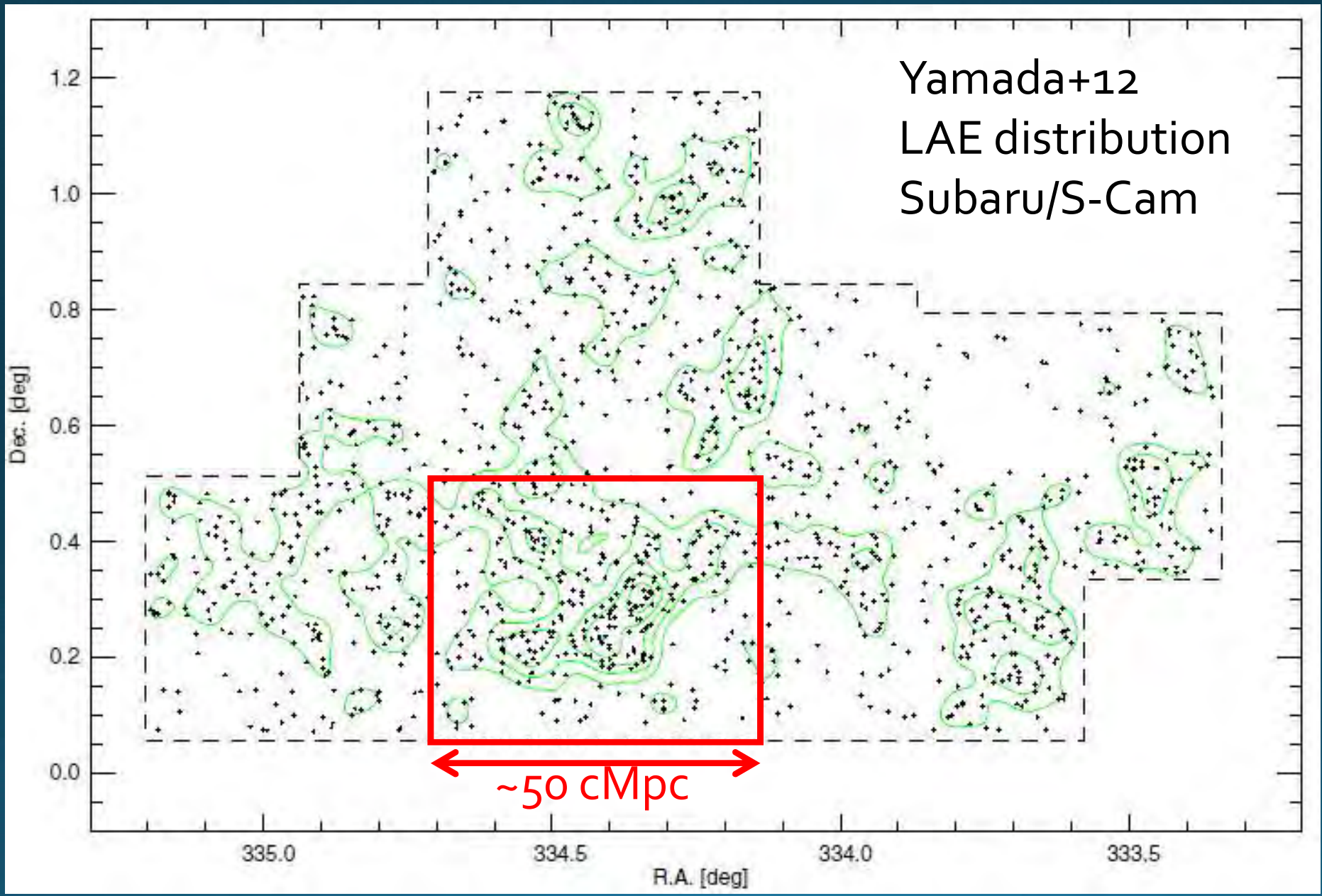
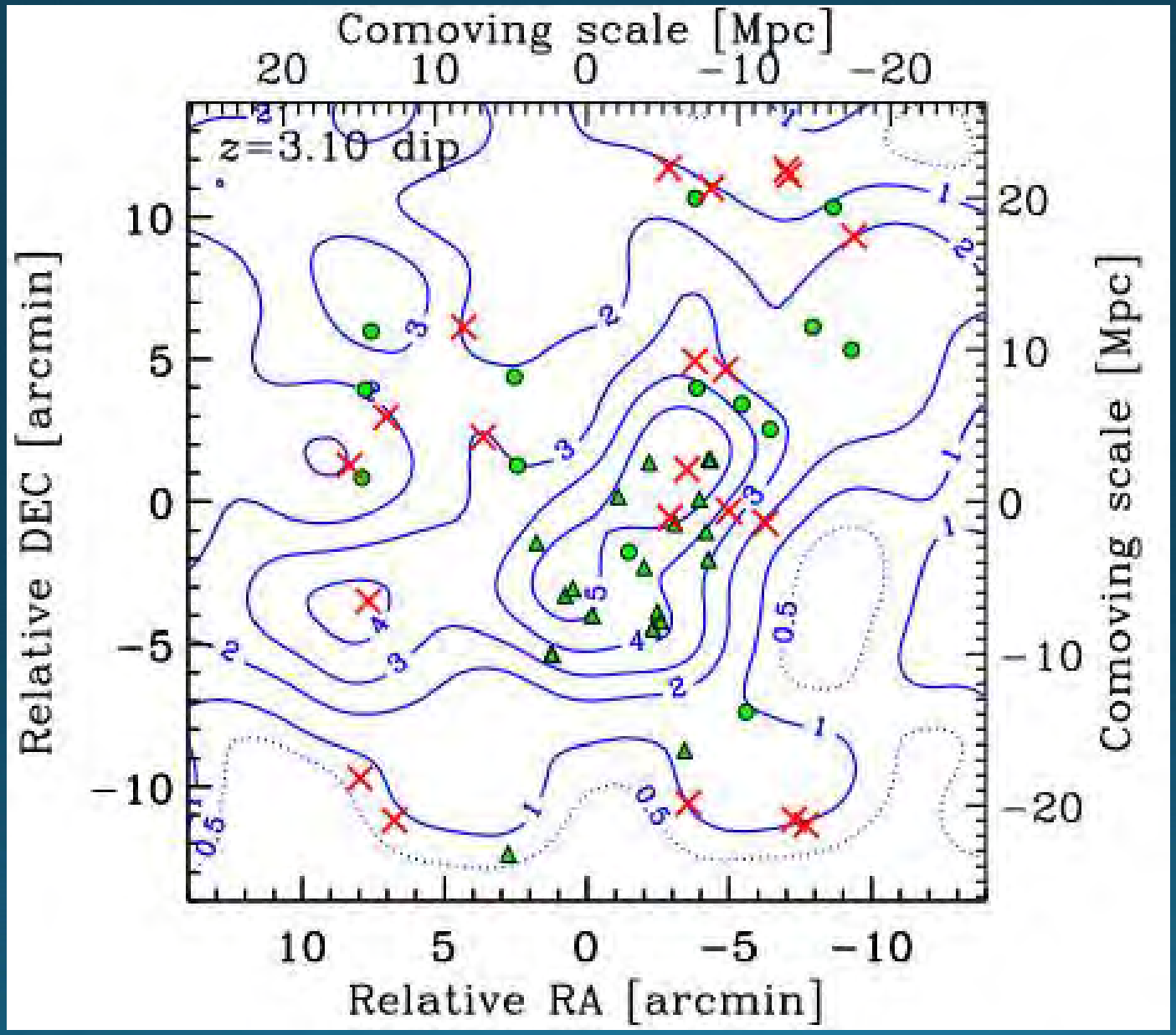
SSA22 proto-cluster at z=3.1



SSA22 proto-cluster at z=3.1



Intergalactic LyA absorption in SSA22

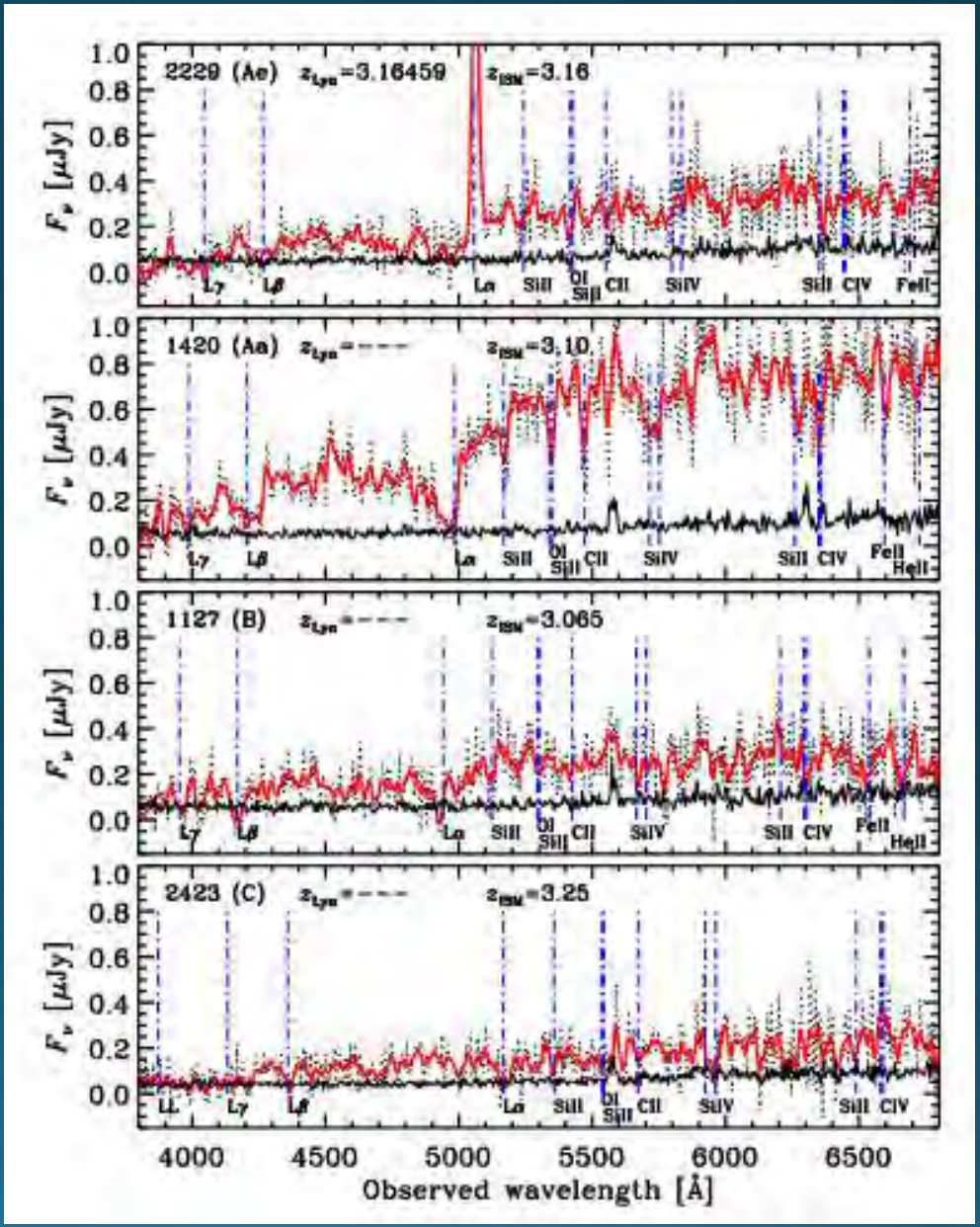
1. Spectroscopic detection of HI absorption excess in the proto-cluster
   - Synchronization of IGM HI fluctuation and LBG distribution along the line-of-sight
   - Hayashino/Kosai et al. to be submitted soon

2. Photometric detection of HI absorption excess in the proto-cluster
   - Mawatari et al. to be submitted

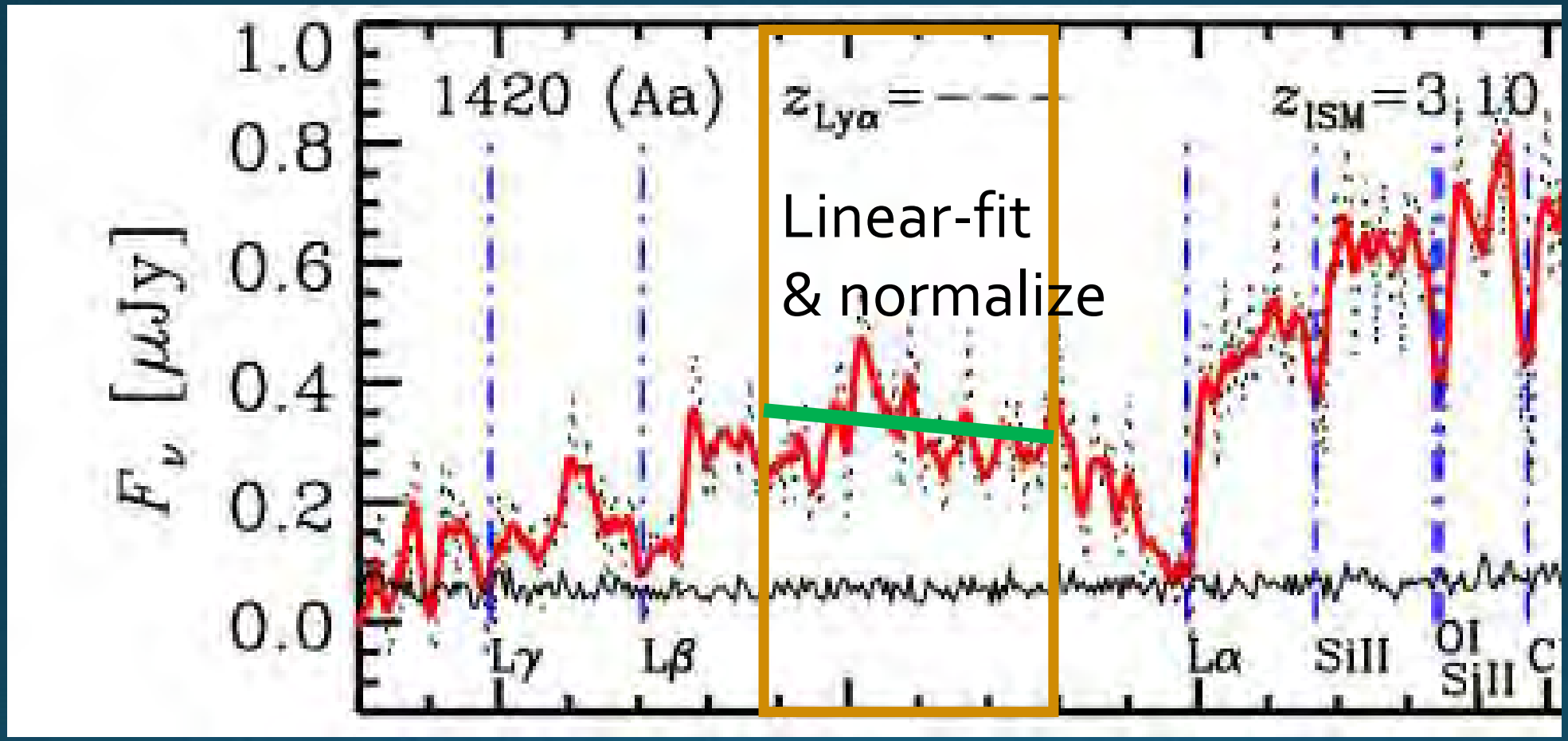
VLT/VIMOS spectroscopy for LBGs

- 2008 July-October
- LR-Blue/OS-Blue
  - R~180
  - 5.3A/pix
- 3.9 hours exposure

- We use 79 spectra with reliable redshifts for background sight-lines.
  - S/N_DA~3 (1—8)



"DA" range: 1070—1170 A



Only LyA forest, except for few stellar photospheric and ISM absorption lines which we masked.

Observed-frame composite

- Clip out the DA range in the source rest-frame: $f_\nu^{\rm obs}$
- Make a linear-fit of the clipped-out spectrum and normalize it:

$$\widetilde{f_\nu} = f_\nu^{\rm obs} / f_\nu^{\rm fit}$$

- Make a median (or average) composite of the normalized spectra in the observers' frame.

IGM optical depth:

$$\tau_\nu = \langle \tau_\nu \rangle + \delta\tau_\nu$$

Observed spectrum:

$$f_\nu^{\rm obs} = f_\nu^{\rm int} \exp(-\langle \tau_\nu \rangle - \delta\tau_\nu)$$

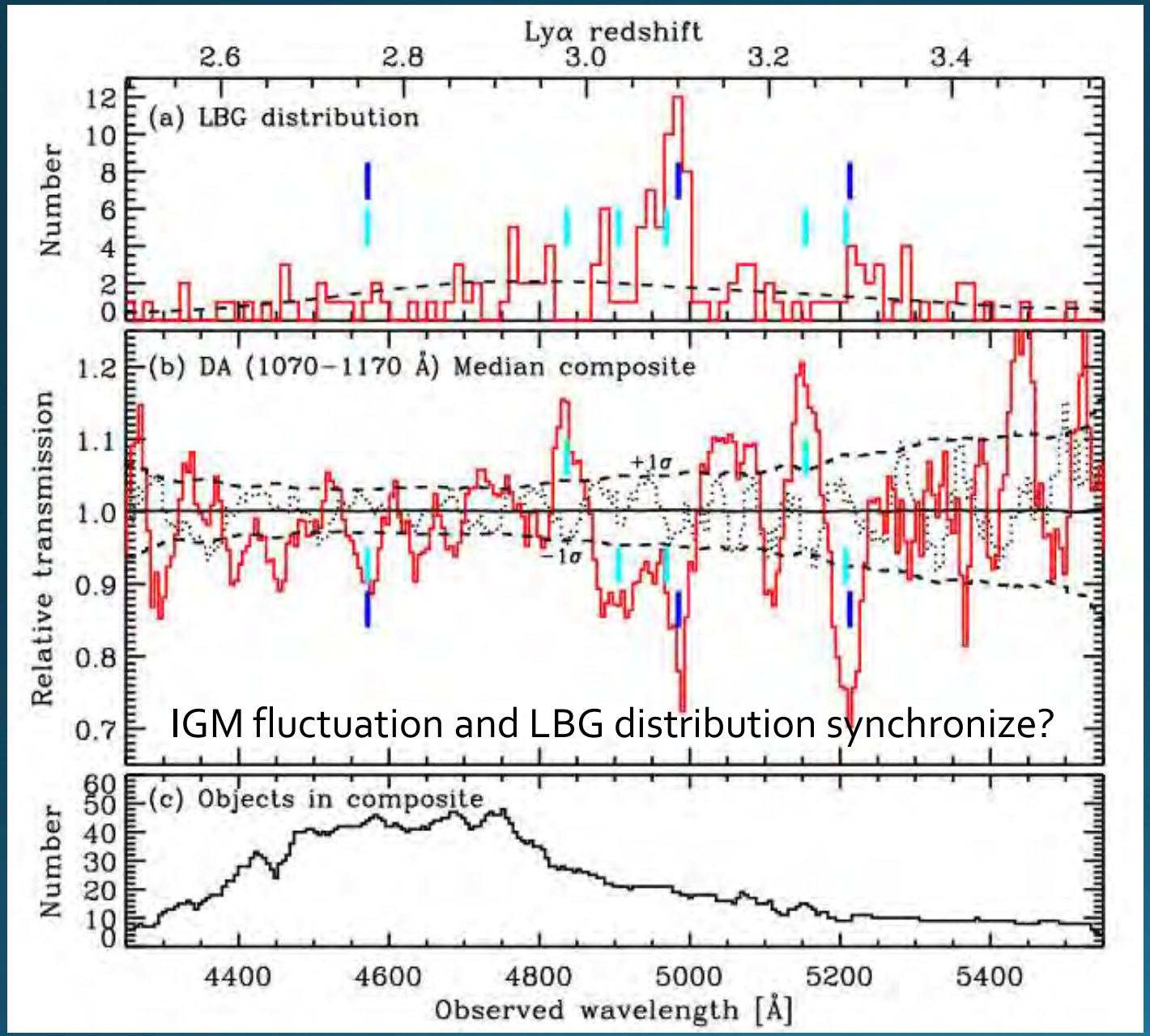
Continuum fit spectrum:

$$f_\nu^{\rm fit} = f_\nu^{\rm int} \exp(-\langle \tau_\nu \rangle)$$

Normalized spectrum:

$$\widetilde{f_\nu} = f_\nu^{\rm obs} / f_\nu^{\rm fit} = \exp(-\delta\tau_\nu)$$

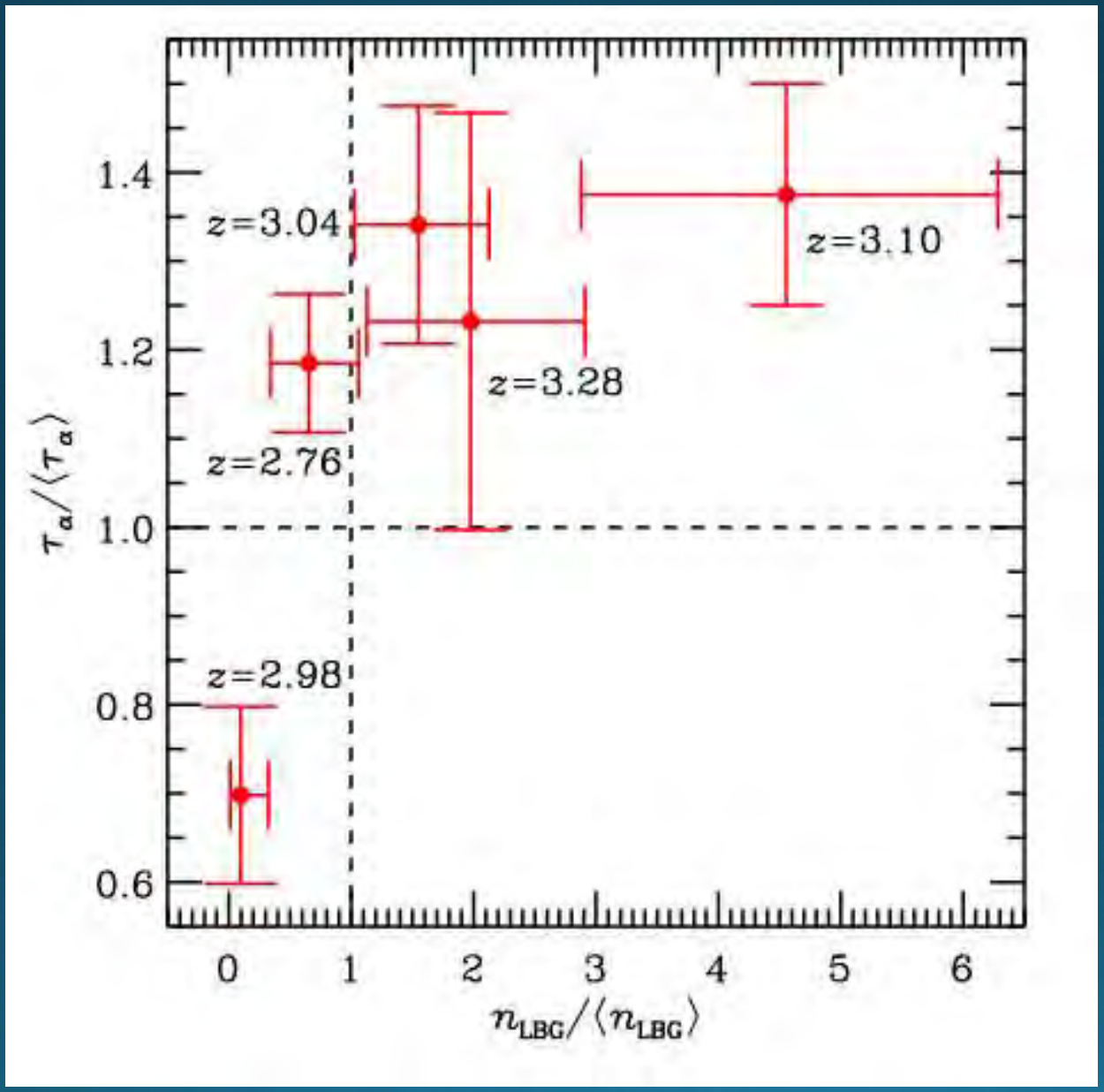
IGM fluctuation toward SSA22



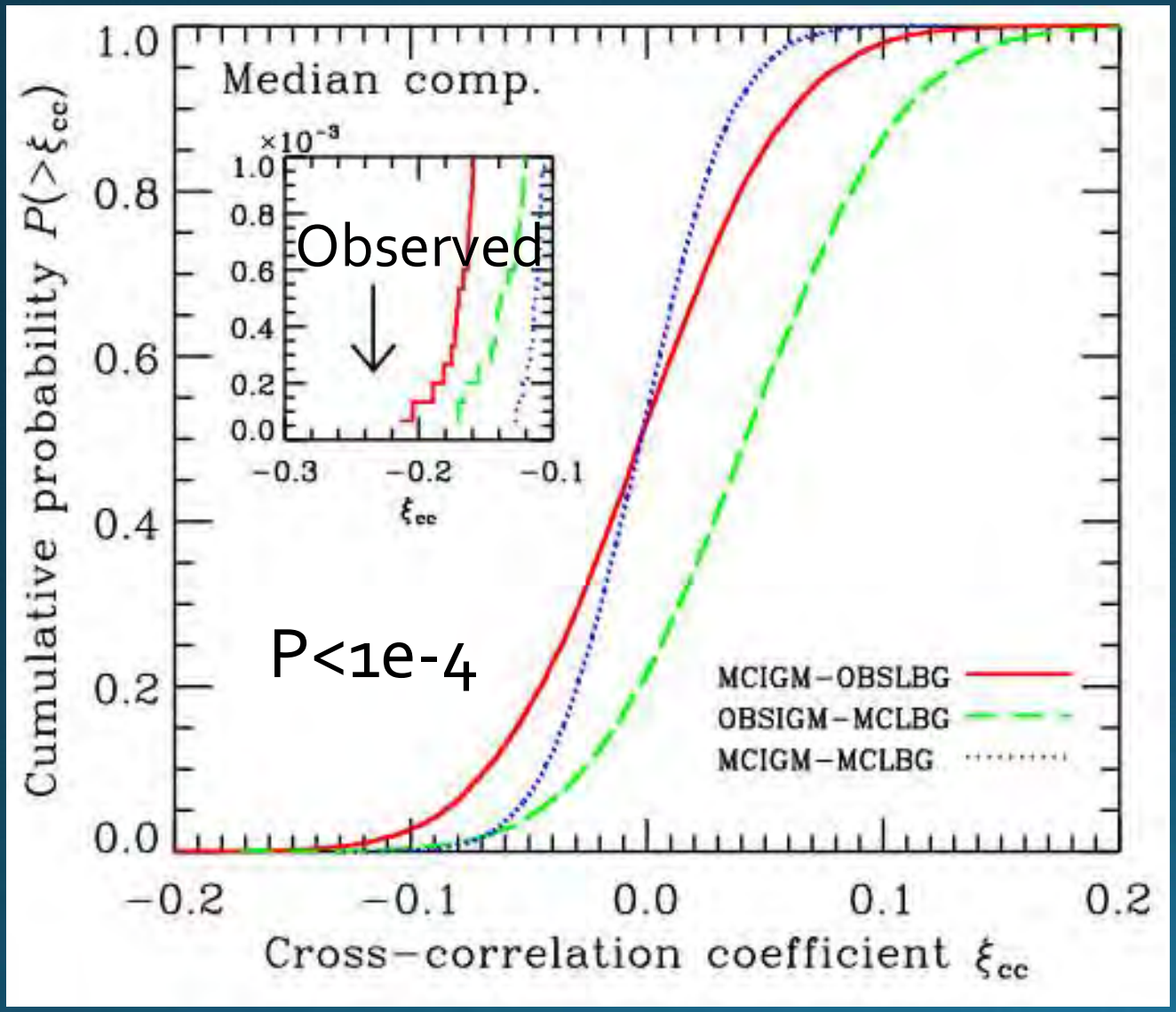
Solid: Object distribution
Dashed: Uniform dist.

Solid: Object composite
Dotted: Background comp.
Dashed: MC simulation

Synchronization of LBG and IGM HI



Synchronization of LBG and IGM HI



Cross-correlation:

$$\xi_{CC} = \frac{1}{n}\sum_{i=1}^{n} \epsilon_i \delta_i$$

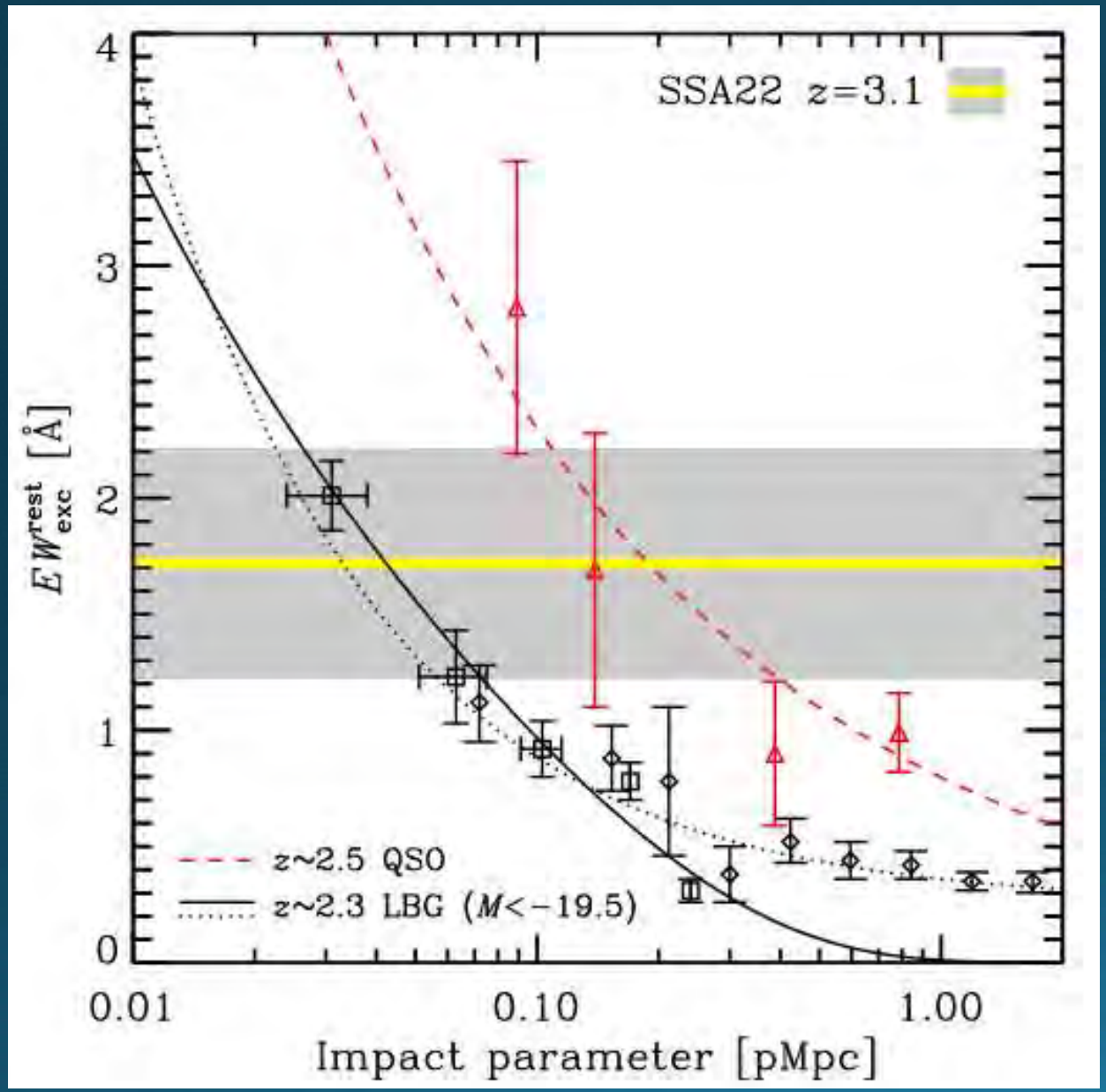
IGM fluctuation:

$$\epsilon_i = \frac{\widetilde{f_{\lambda_i}} - 1}{\sigma_{\mathrm{IGM},\lambda_i}}$$

LBG distribution:

$$\delta_i = \frac{n_{z_i}^{\mathrm{obs}} - n_{z_i}^{\mathrm{exp}}}{\sigma_{\mathrm{LBG},z_i}}$$

Comparison with CGM measurements

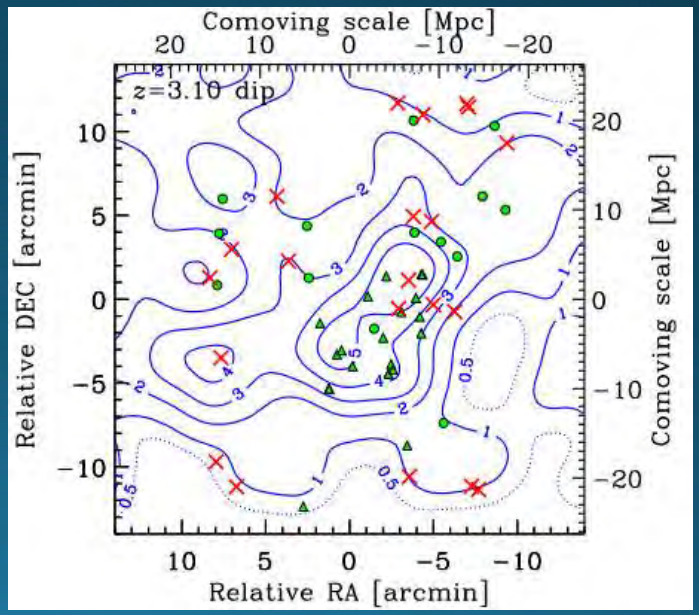


Average impact parameter of our sight-lines to z=3.1 LBG (M<-19.5) is

0.22 pMpc

when an overdensity of LBGs to be 4.6.

→ A higher EW than z~2 LBGs?



NB photometric search of HI excess

- The HI absorption excess at z=3.1 may be found in the deep NB497 photometry of background galaxies.

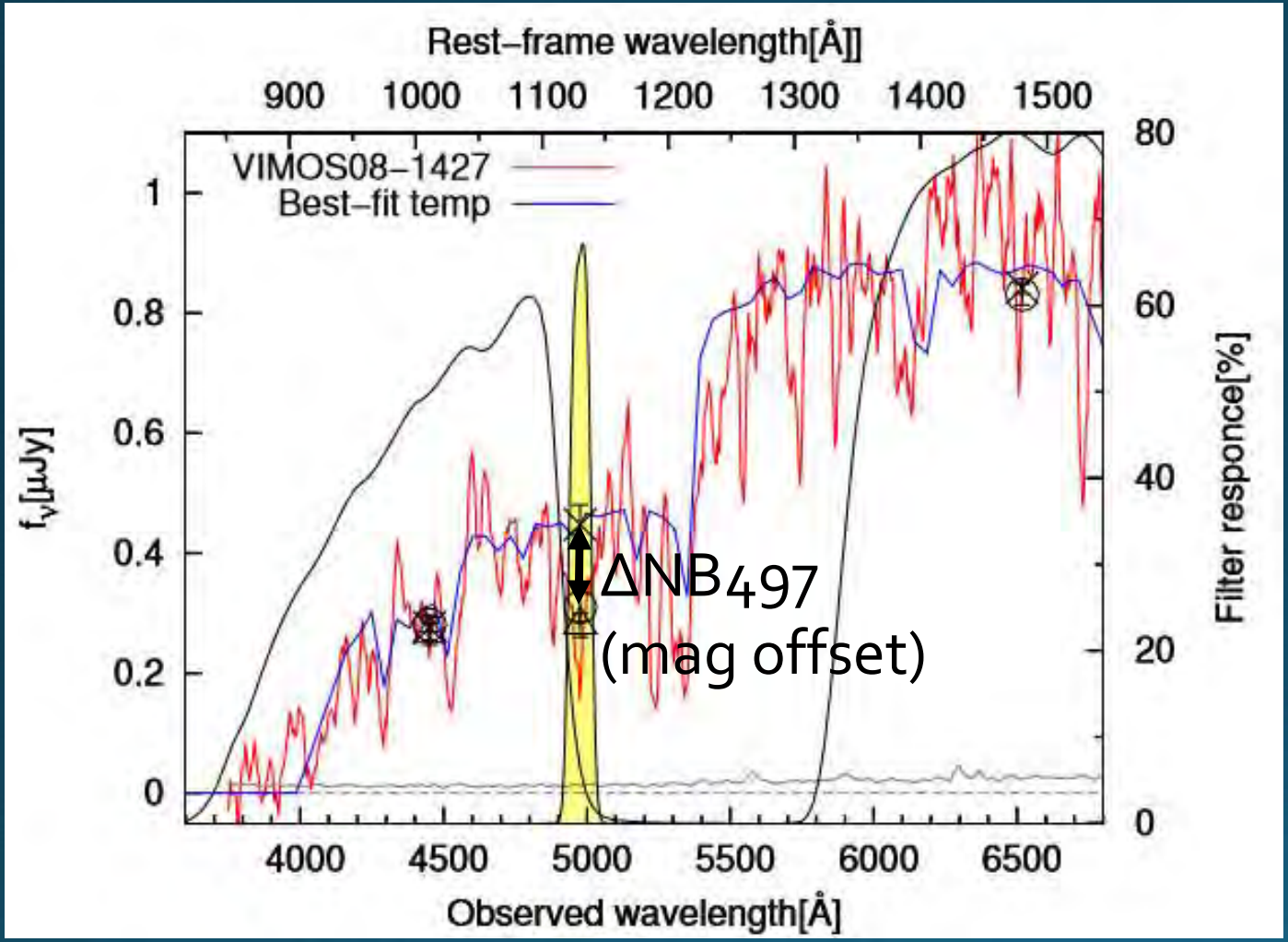
  →Much fainter objects than spectroscopy become useful as background sources.

- We will have deep NB images with HSC through SSP and CHORUS.

  NB387, NB527, NB718, NB816, NB921, NB973, NB101

- Ouchi-san's new HSC NBs around z~2 LyA.

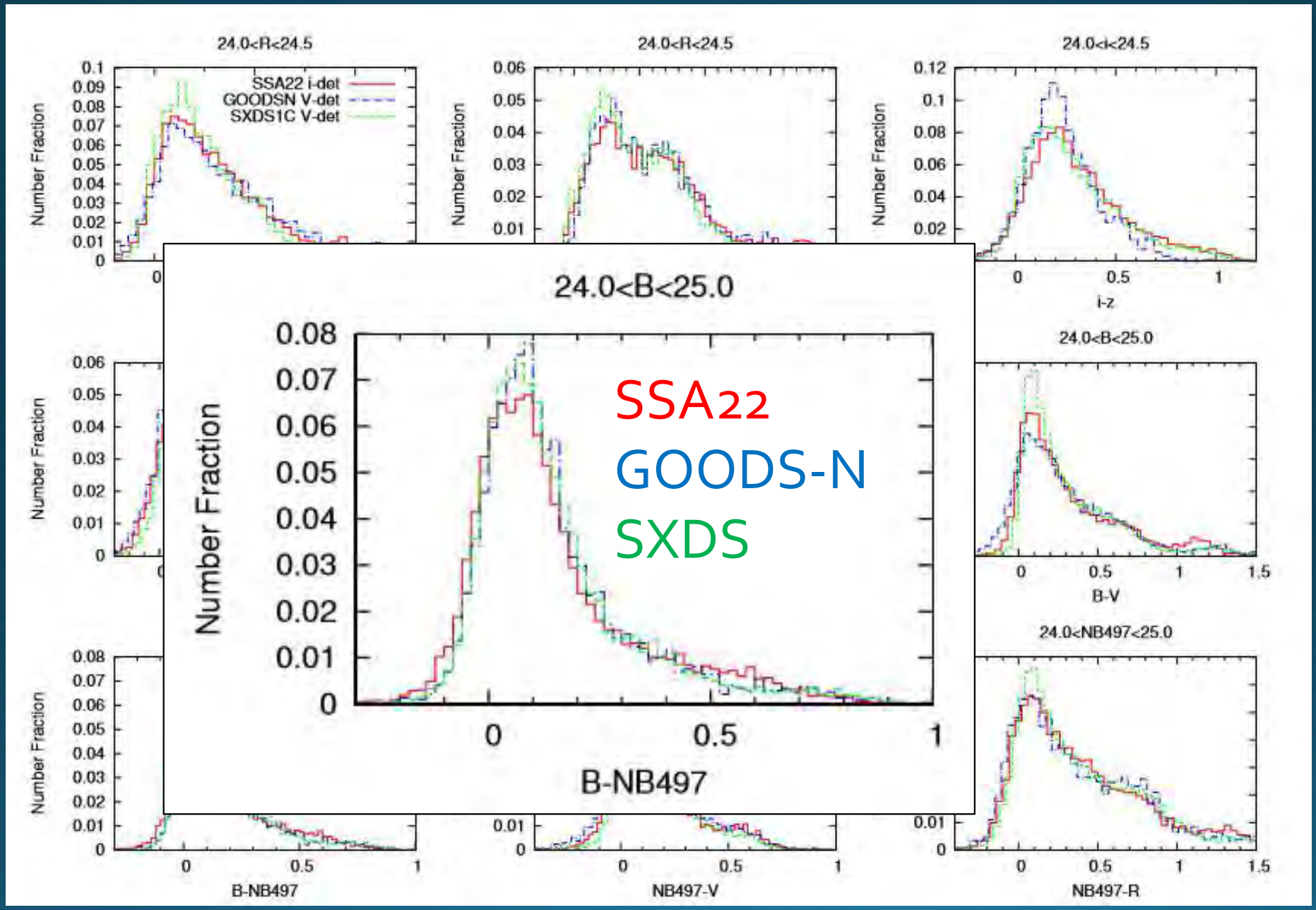
Concept of the ΔNB method



1) SED fit for observed *Briz* photometry※1
→ Best-fit template spec
2) ΔNB_{497} = $NB497_{obs}$ – $NB497_{temp}$

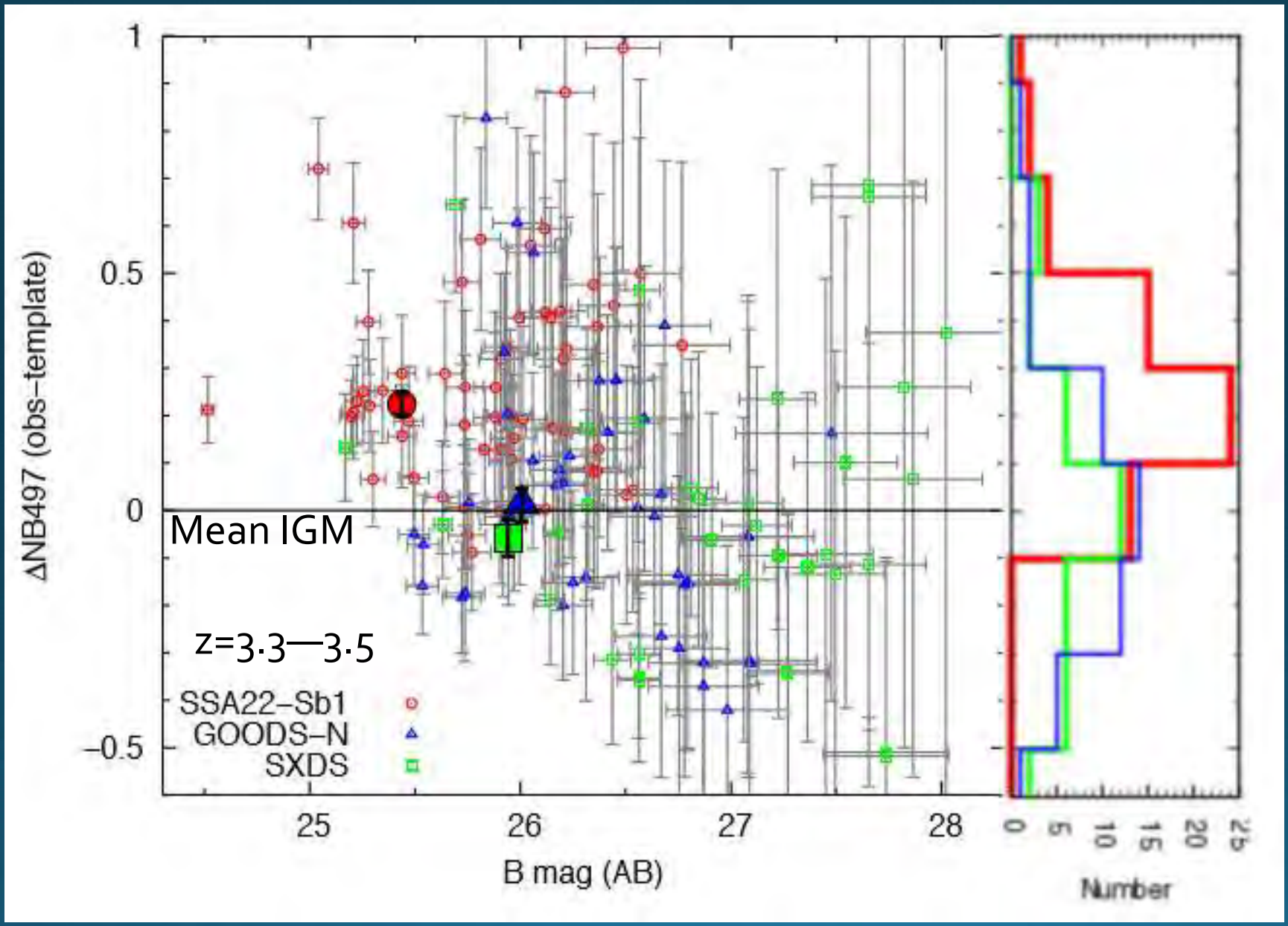
※1 Setting for the SED fit
Bruzual&Charlot (2003) template (Exp declining SFR with τ=1Gyr, 0.2 solar metallicity), 0 < Av < 3, fixed redshift (z = z_{spec}), and Mean IGM absorption (Madau+95)

A careful calibration of colors

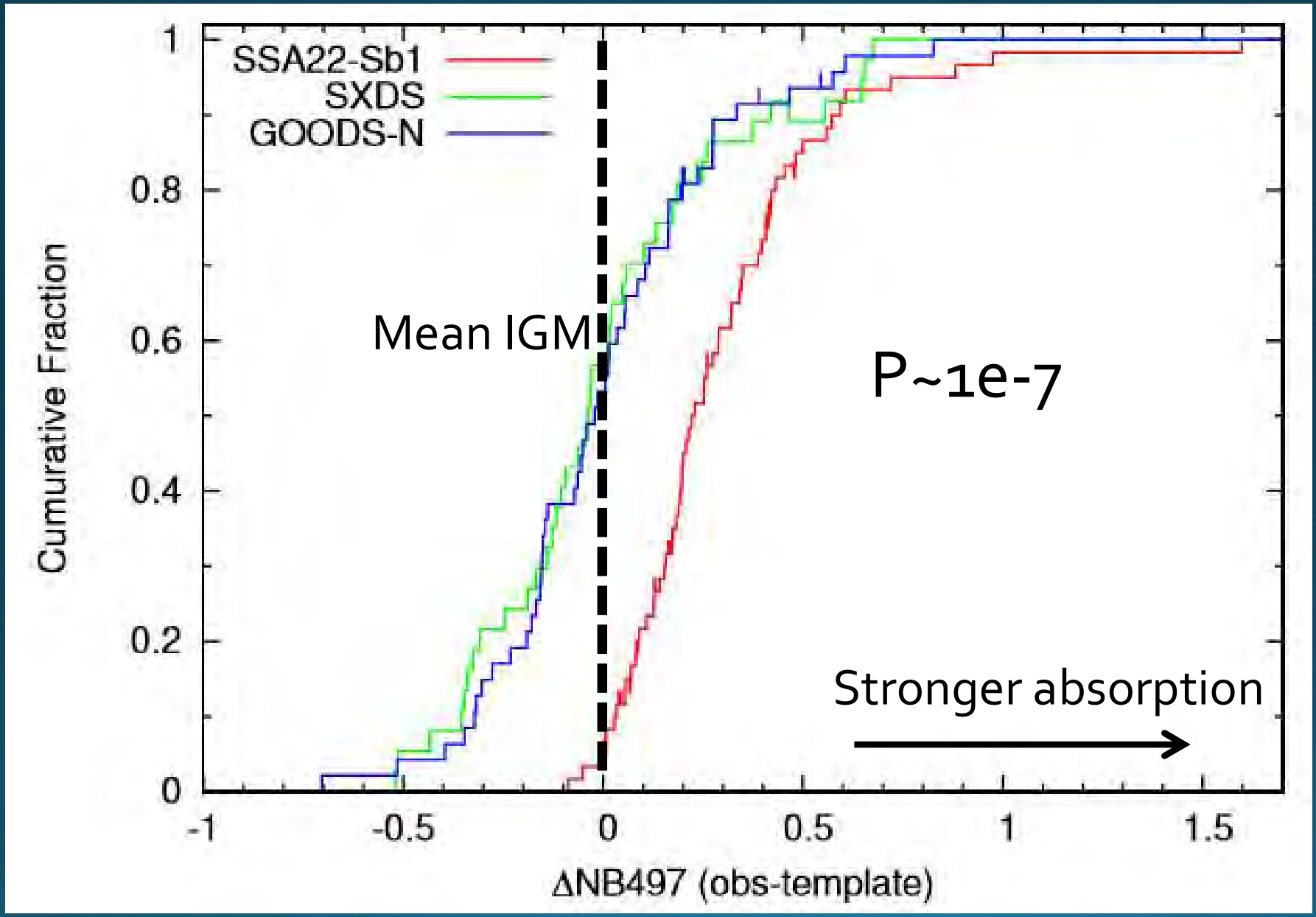


Photometric detection of HI excess

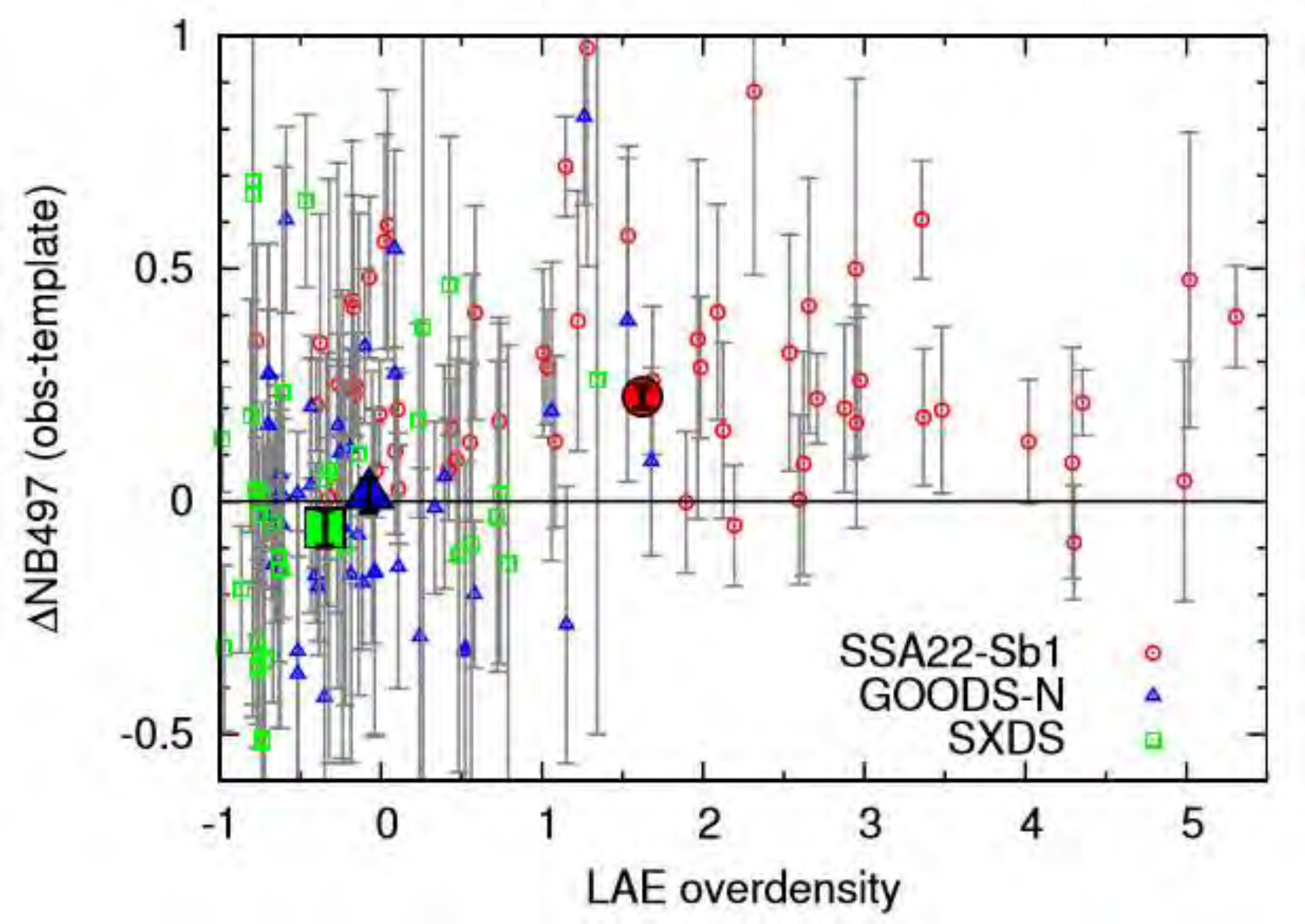
Stronger absorption



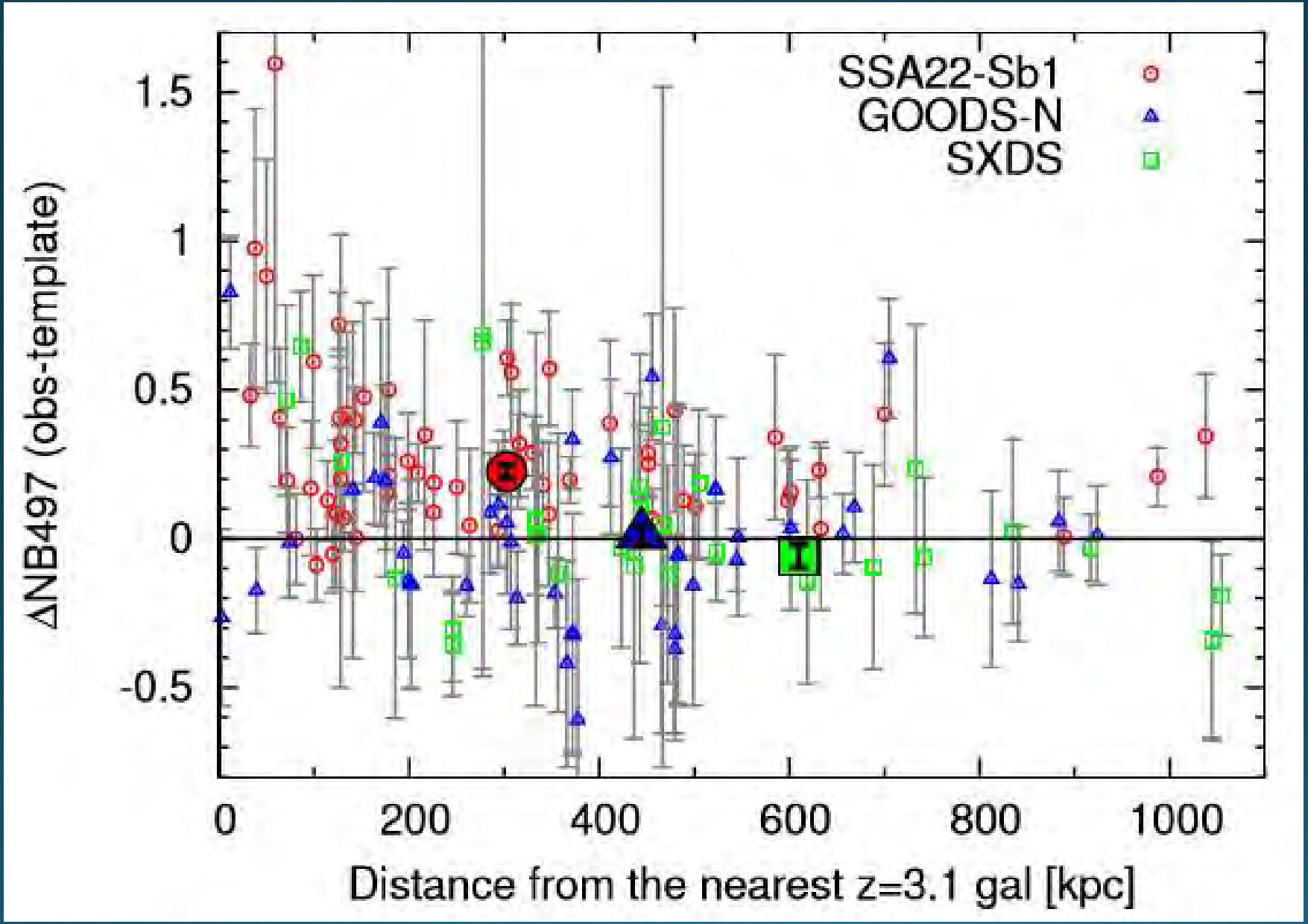
Photometric detection of HI excess



HI excess vs. LAE overdensity



HI excess vs. galaxy distance



Summary

- The SSA22 proto-cluster at z=3.1 shows an excess of the IGM HI LyA absorption.
  - Marginal correlation between the excess and the galaxy density or distance.
  - CGM or "intra-proto-cluster medium"?
- A large-scale correlation between the IGM HI LyA absorption and the LBG density is observed along the line-of-sight for the SSA22.

SSA22HIT (HI Tomography)

- ~400 DEIMOS spectra of z~3 LBGs