CGM properties of various galaxy populations in the SSA22 field

Very Preliminary Result!

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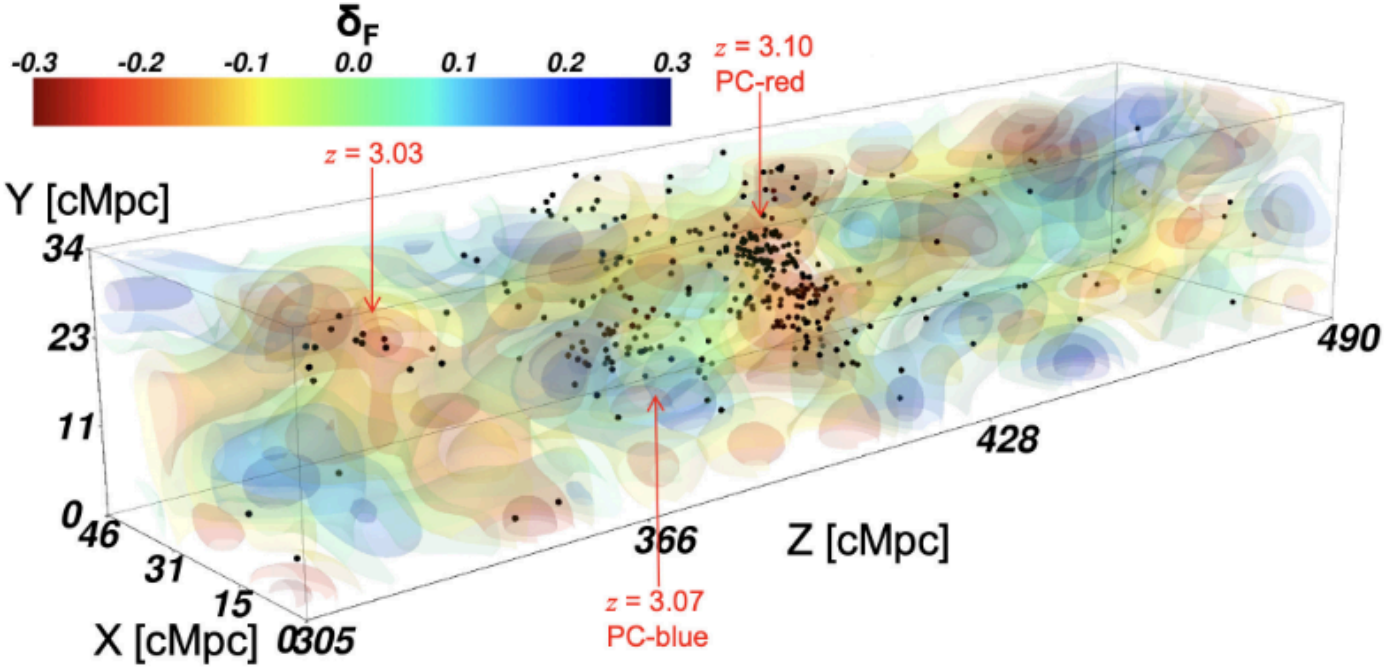
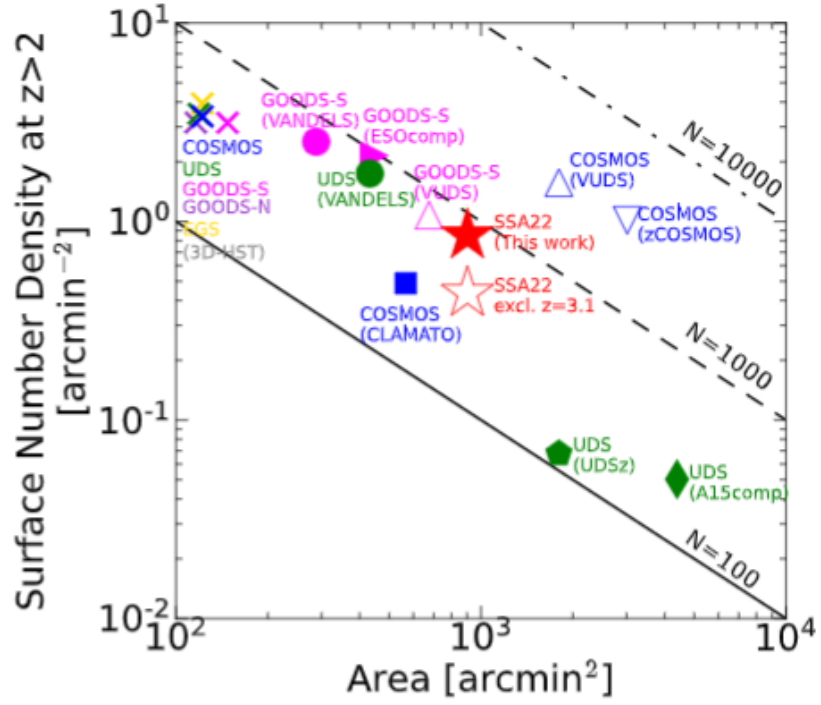
SSA22 HI Tomography (HIT) project progress

1. Construct large compilation of specz catalogs
   (Mawatari et al. under the HSC-SSP internal review)
   - SSA22 is one of the best fields for high-z galaxy research: Rich amount of specz & multi-band imaging.

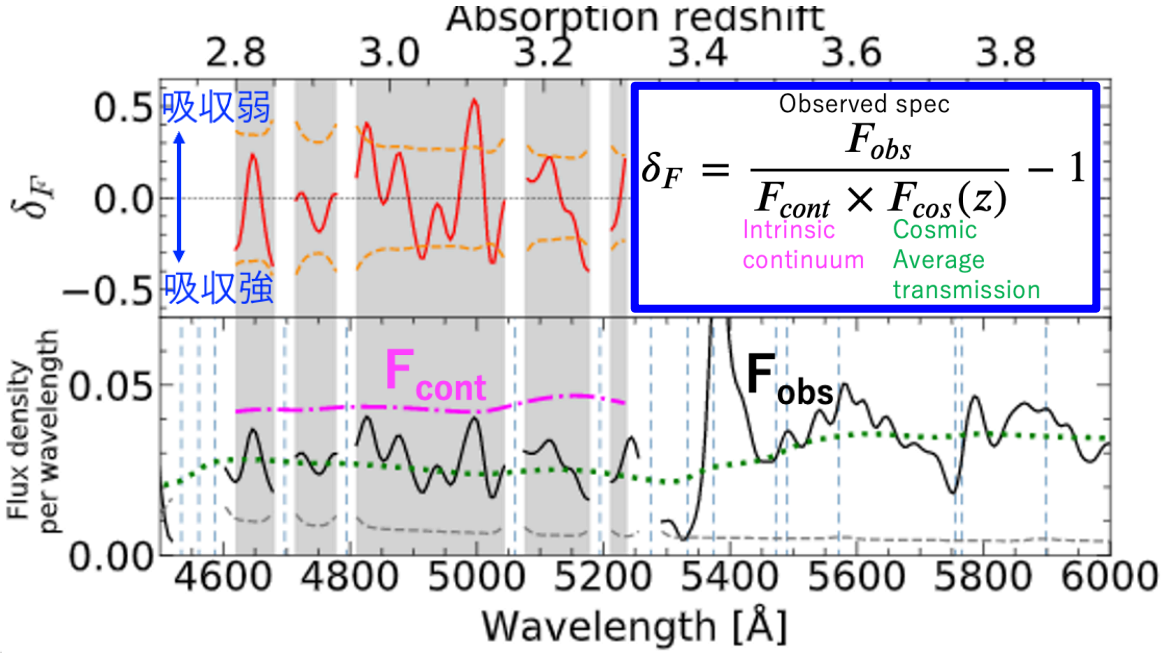
2. Generate HI tomography map (Mawatari et al. in prep)
   - Highest-z HI map at 2.7<z<3.55
   - Moderate mapping resolution = 5 (20) cMpc along transverse (LOS) direction

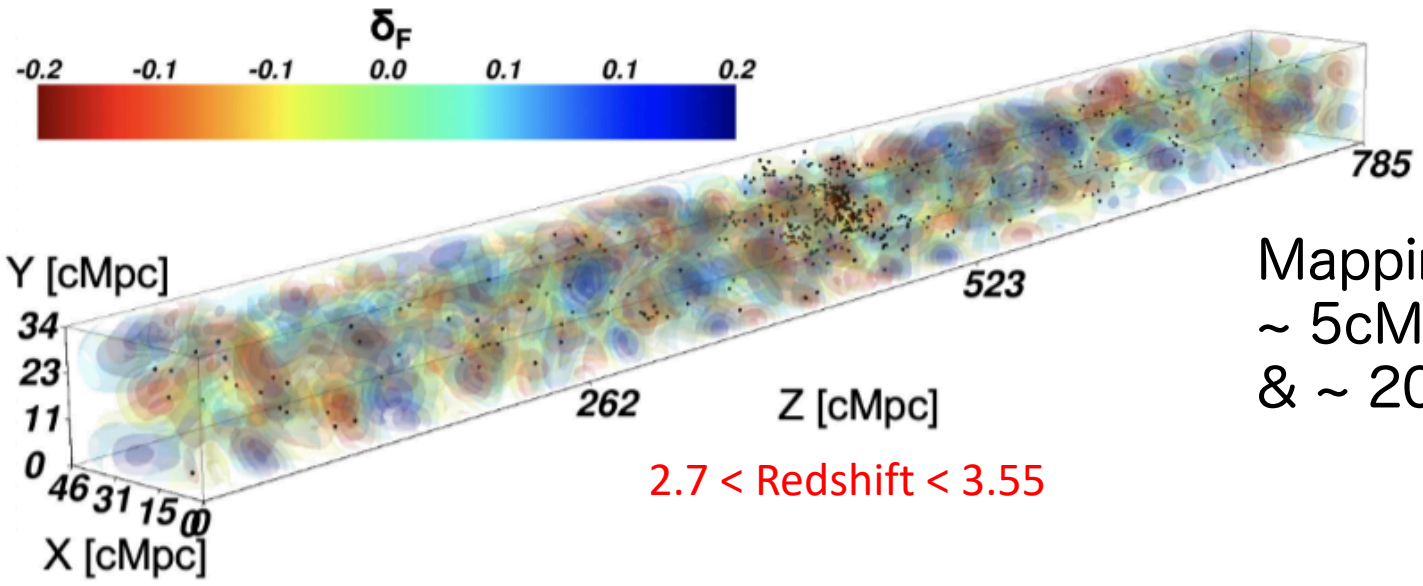




HI map data

- Wiener filtering 3D reconstruction to background galaxies' spectra
- Each galaxy spectrum is normalized by the continuum in the Lya forest range -> δ_F
  - $\delta_F < 0$ (>0) : strong (weak) HI absorption





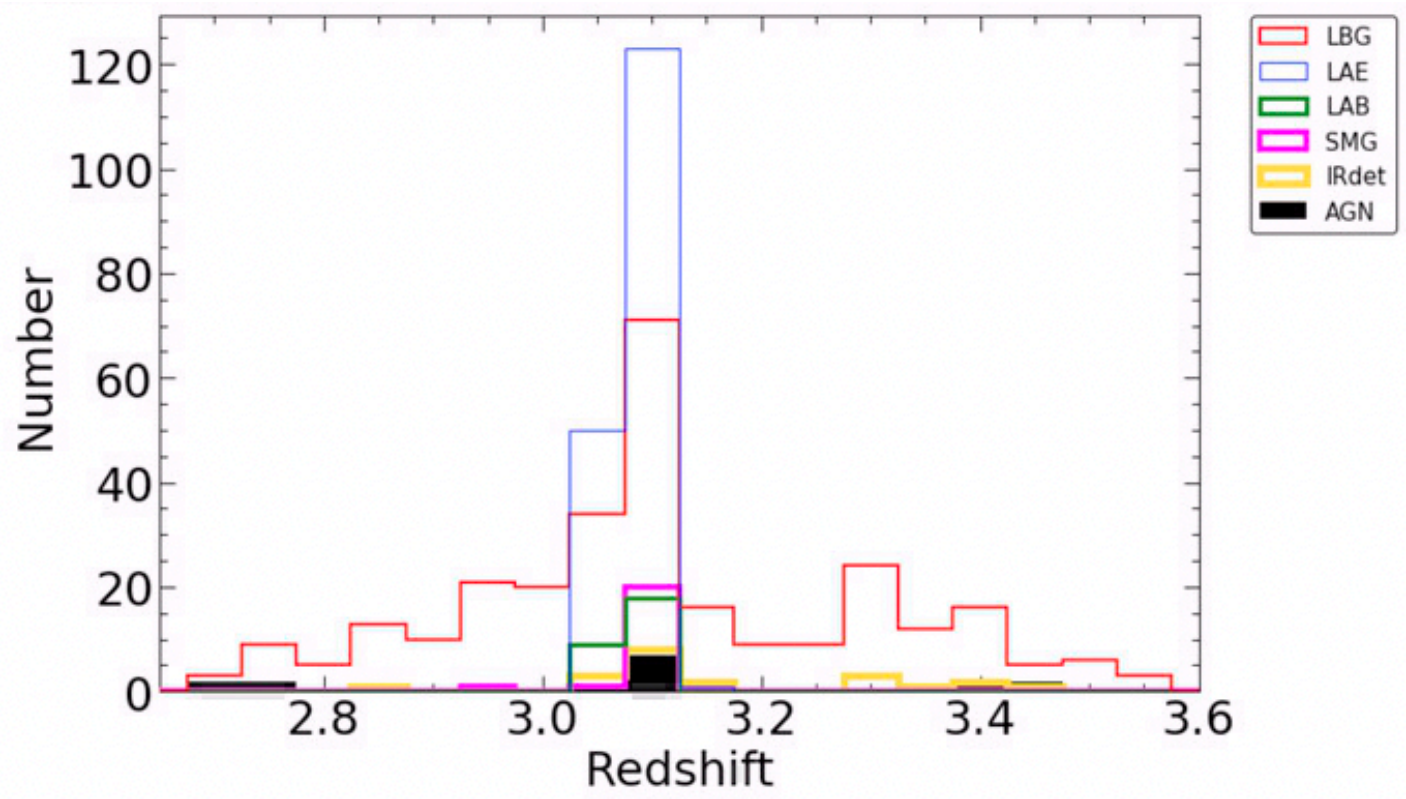
2.7 < Redshift < 3.55

Mapping Resolution
~ 5cMpc (along RA/Dec)
& ~ 20cMpc (redshift)

References: Lee+18, Lee+14, Stark+14, Mukae+20

Galaxy data

- LBGs (N=286), LAEs (174), LABs (27), SMGs (22), IR-detected (21), AGNs (16)
- Overlap is allowed
- Redshift calibration formula (Adelberger+05) is applied: z_Lya or z_UVabs -> z_sys
- All populations but LBG are proto-cluster members at z = 3.1

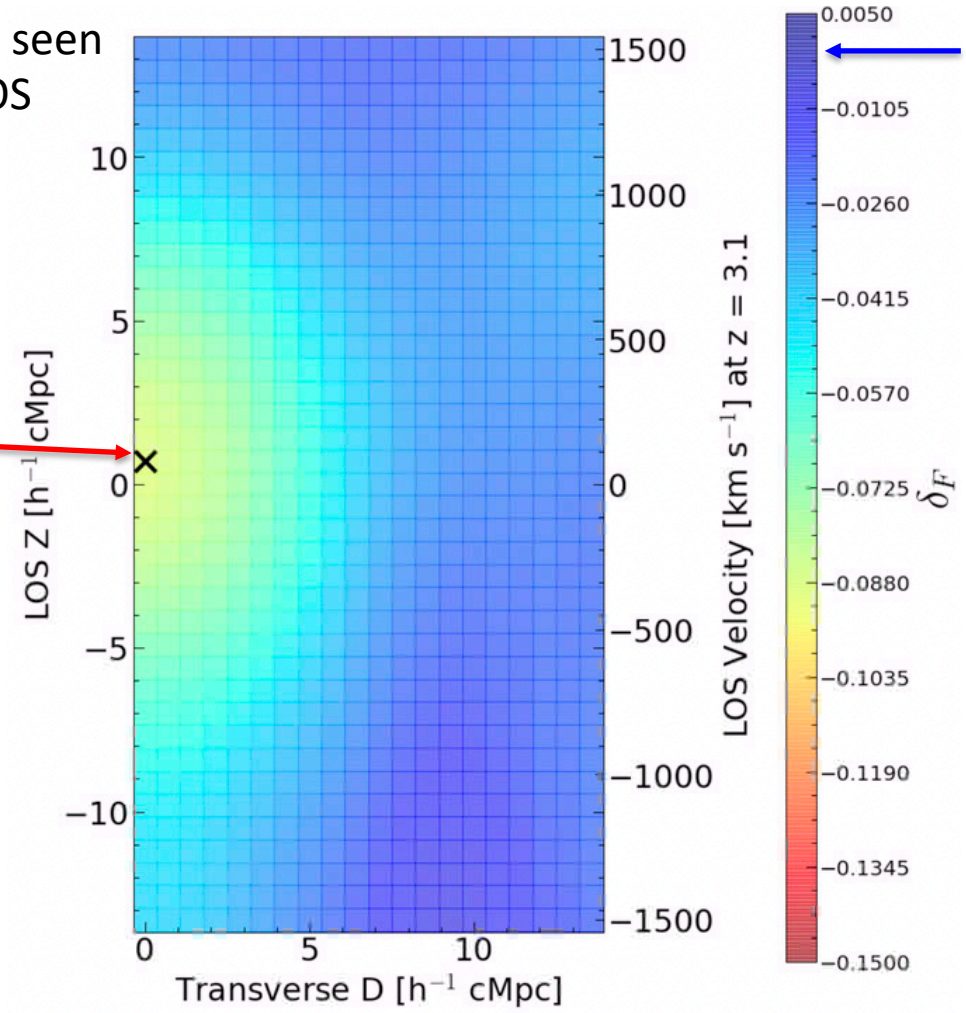


2D stacked HI profile of LBGs

- Stacking of HI map data around LBGs on transverse-D vs LOS Z 2D space

1. Redshift Space Distortion cannot be seen
: due to the coarse resolution along LOS

3. HI δ_F Peak
Redshifted HI from the LBG?



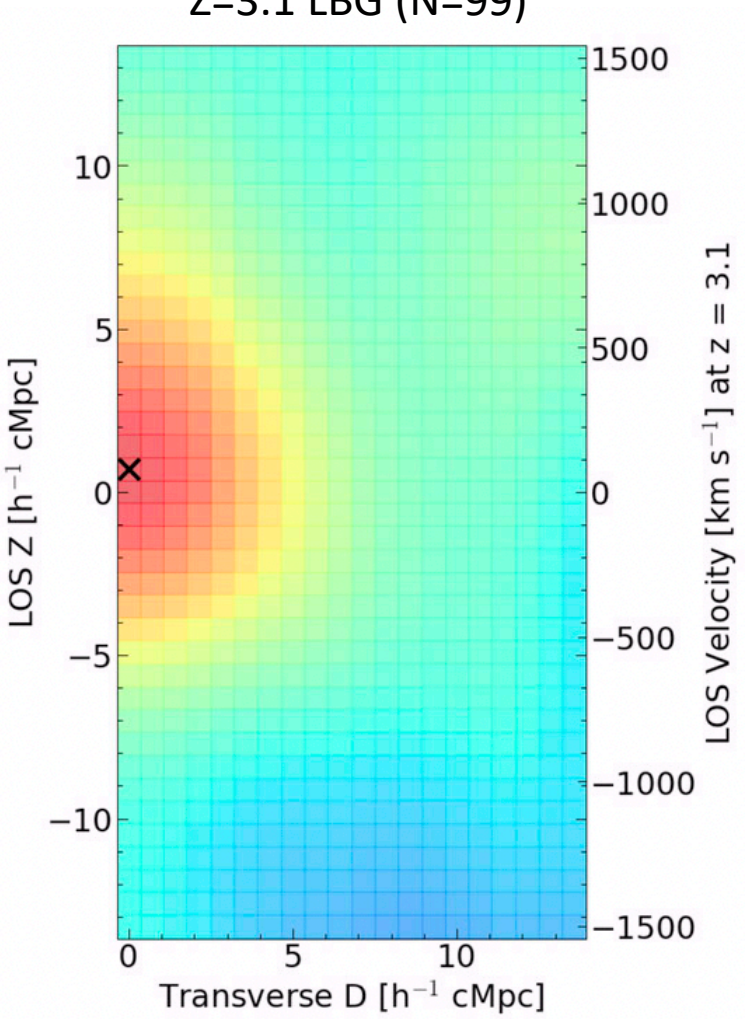
δ_F=0 level

2. $\delta_F < 0$ all over the field
: systematics? Large-scale component?

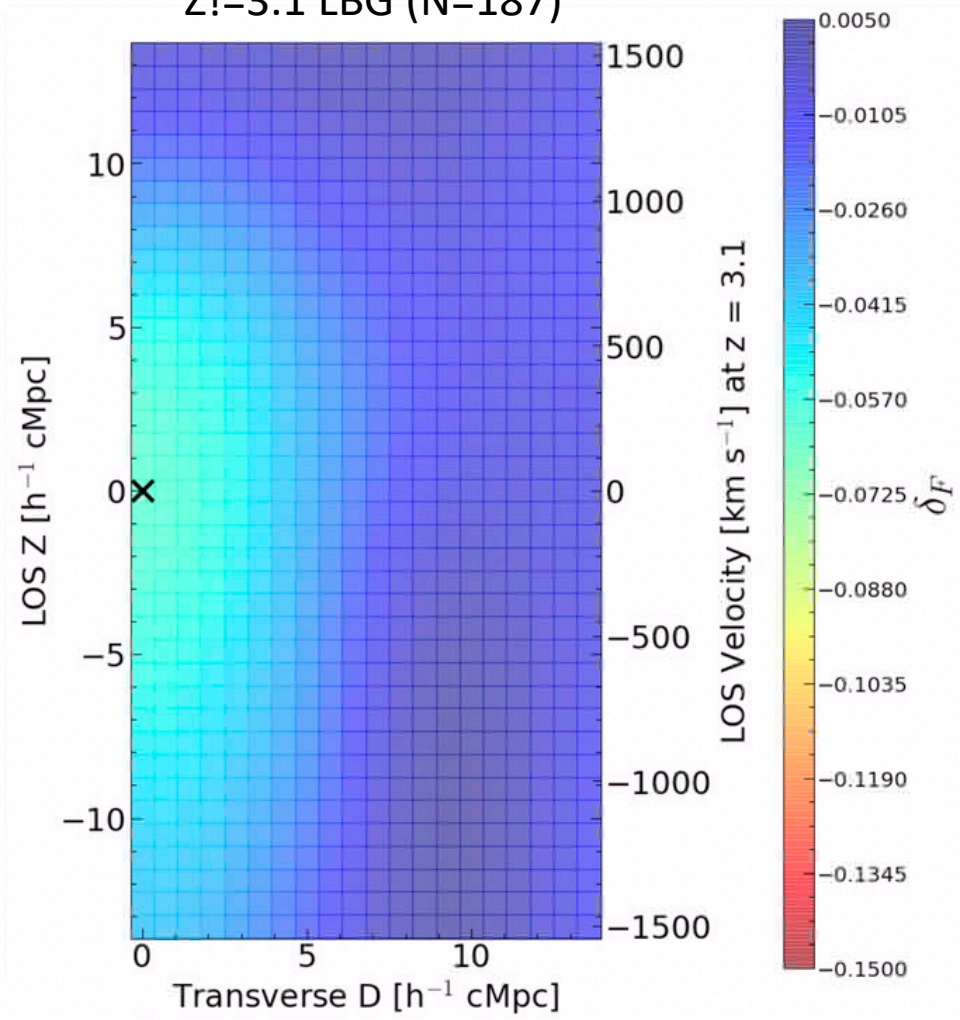
z=3.1 proto-cluster vs z!=3.1 field

- Divide the LBG sample into z=3.1 proto-cluster and z!=3.1 field subsamples

Z=3.1 LBG (N=99)



Z!=3.1 LBG (N=187)



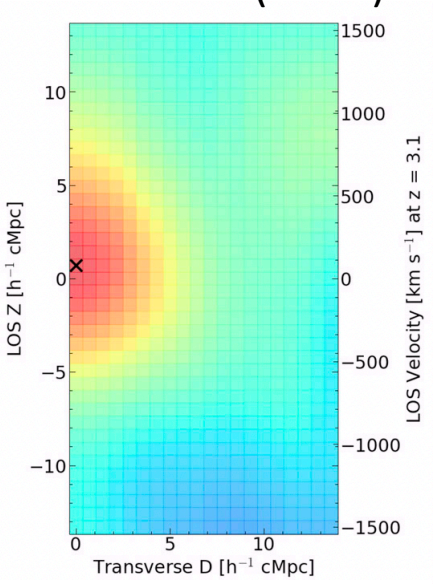
Significantly different!

- δF offset ~ -0.05 at large radius in the z=3.1 subsample
  - Stacking of random “mock” objects at z=3.1 also show the same offset.
  - -> large-scale component particular to the proto-cluster environment (IPCM?)

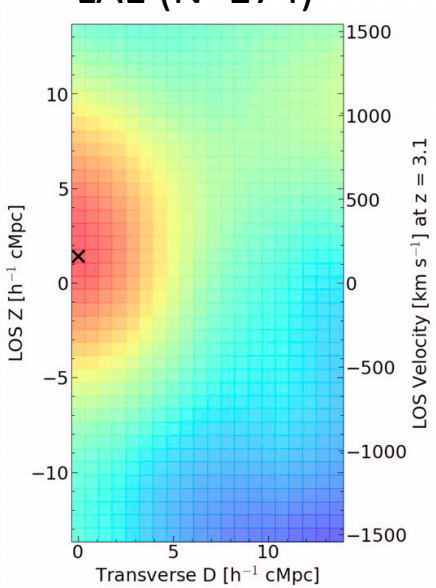
- Stronger HI peak in the z=3.1 LBGs

Different galaxy populations at z=3.1

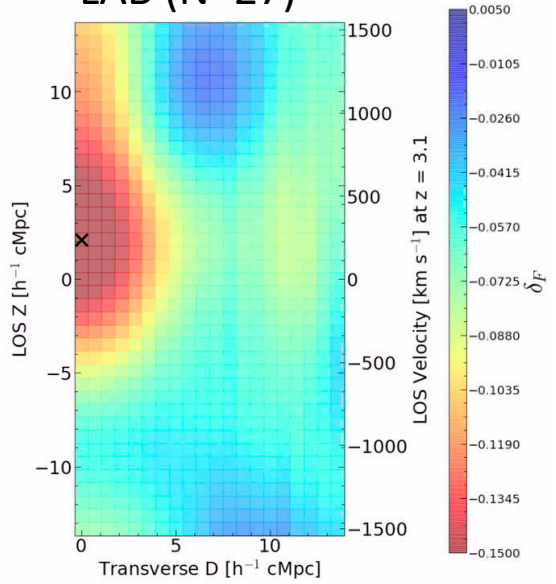
Z=3.1 LBG (N=99)



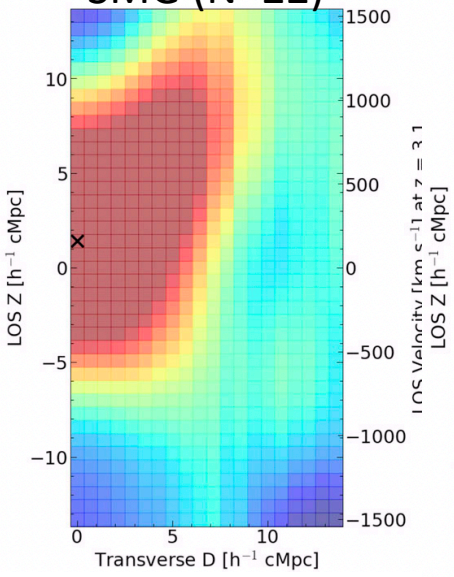
LAE (N=174)



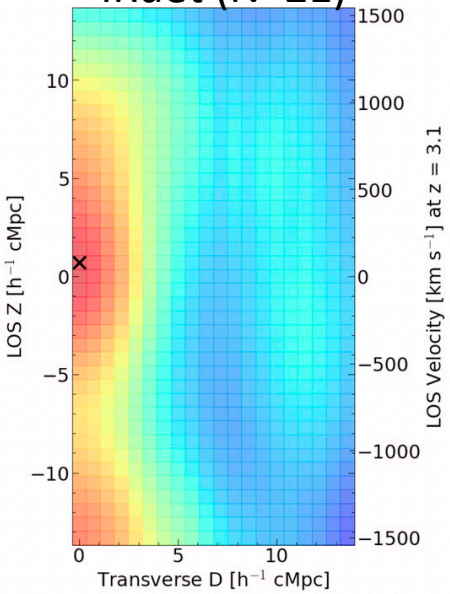
LAB (N=27)



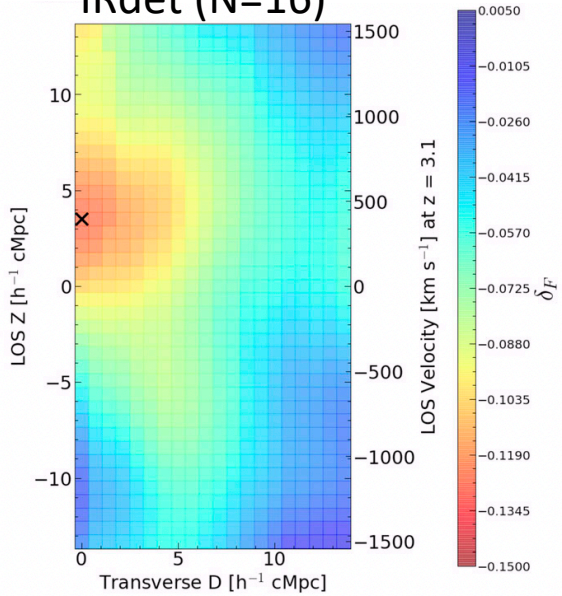
SMG (N=22)



IRdet (N=21)



IRdet (N=16)



- HI absorption is strong in the order of
  SMG > LAB > LBG~LAE~IRdet > AGN

- Anisotropic along LOS direction
  HI peaks are redshifted by 50~400km/s
  - Wrong redshift calibration (zLya-> z_sys)?
  - Wrong spectral reduction (λ calib)?
  - Lya selection/confirmation bias

- LABs may be affected by the small sample effect
  Median stacking gives very different result

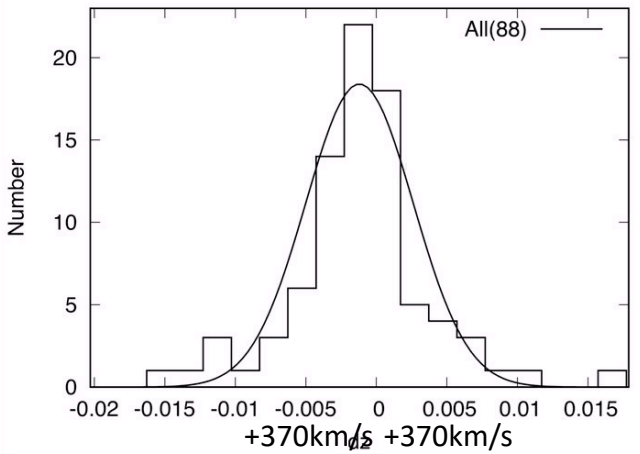
HI Peak redshifted?!

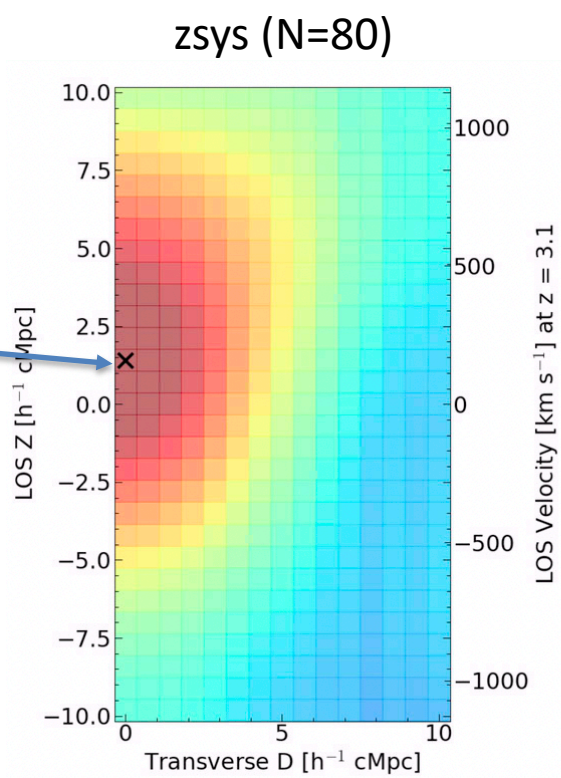
Anisotropic along LOS direction: HI peaks are redshifted by 50~400km/s

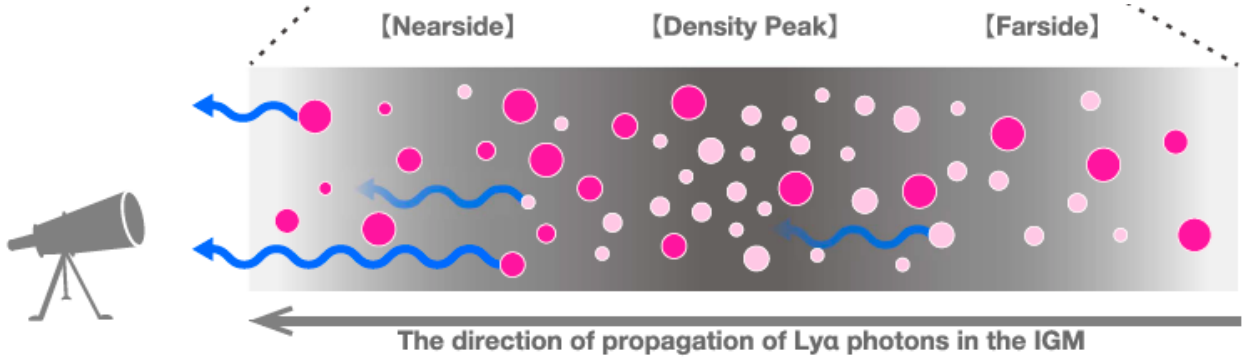
- Wrong redshift calibration (zLya-> z_sys)? -> NO
  - Even if using objects for which z_sys = z_neb are measured, the peak-shift remains.

- Wrong spectral reduction (λ calib)? -> Maybe NO? (TBC)
  - If our HIT spectra (Keck DEIMOS) are failed to be reduced in λ, redshifts from the HIT spectra should systematically shift.

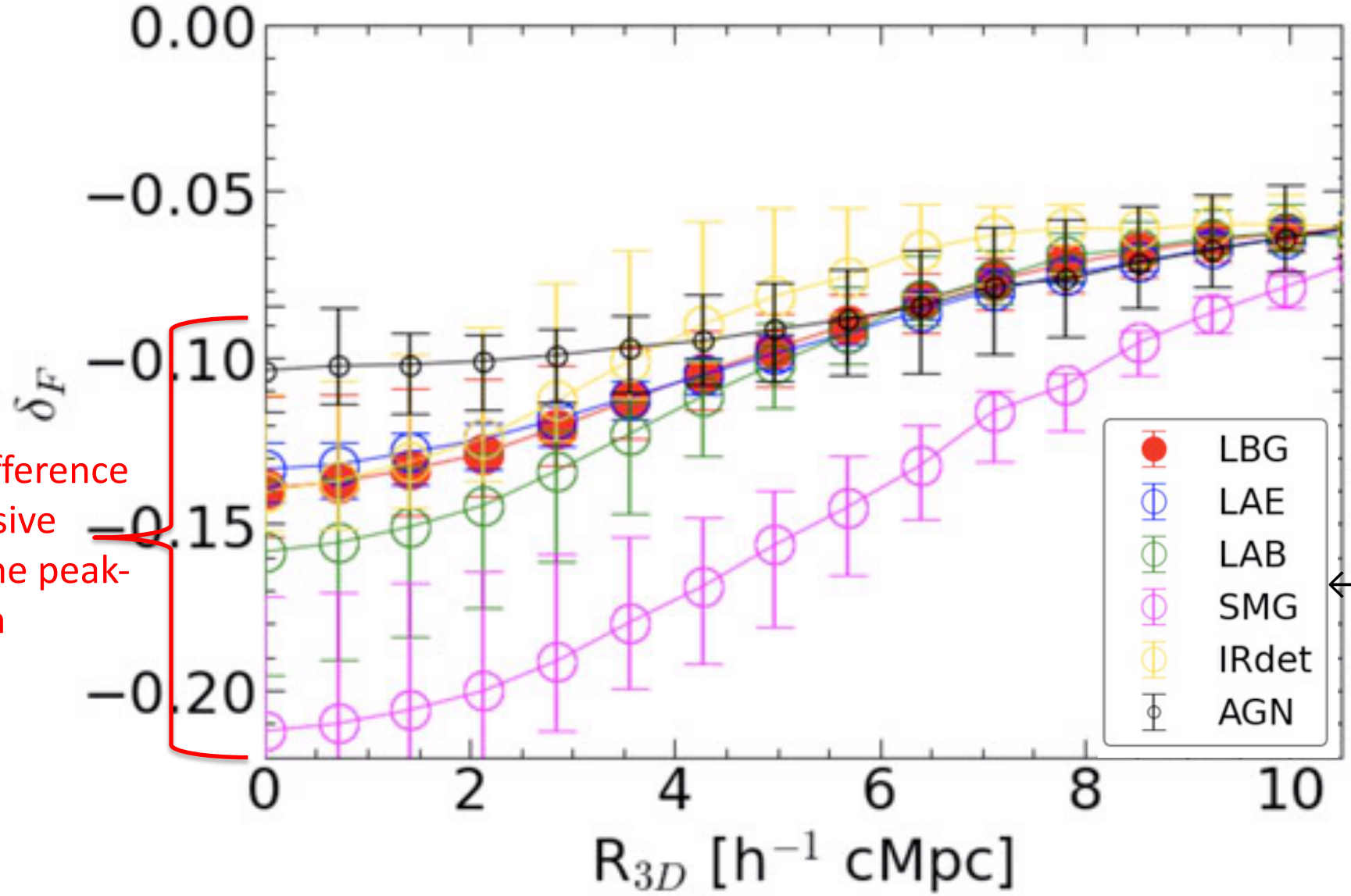
- Lya selection/confirmation bias
  - Majority of our galaxies are selected or confirmed via Lya emission line.
  - ”Galaxies play hide-and-seek behind / in front of HI” (Momose+21)







1D HI profile comparison



← Intra Proto-cluster Medium (IPCM)

← All at z = 3.1

Inner part difference is not conclusive because of the peak-shift problem

Summary

- We detect HI absorption extending several cMpc around LBGs, LAEs, LABs, SMGs, IRdet, AGNs.
- Significant environmental difference (z=3.1 proto-cluster or not) is confirmed.
- At z=3.1, HI absorption is strong in the order of
  SMG > LAB > LBG ~ LAE ~ IRdet > AGN
- HI 2D profiles show anisotropy along LOS: redshifted peak
  Careful check of the calibration/reduction is needed, but it may be by “hide-and-seek” effect.