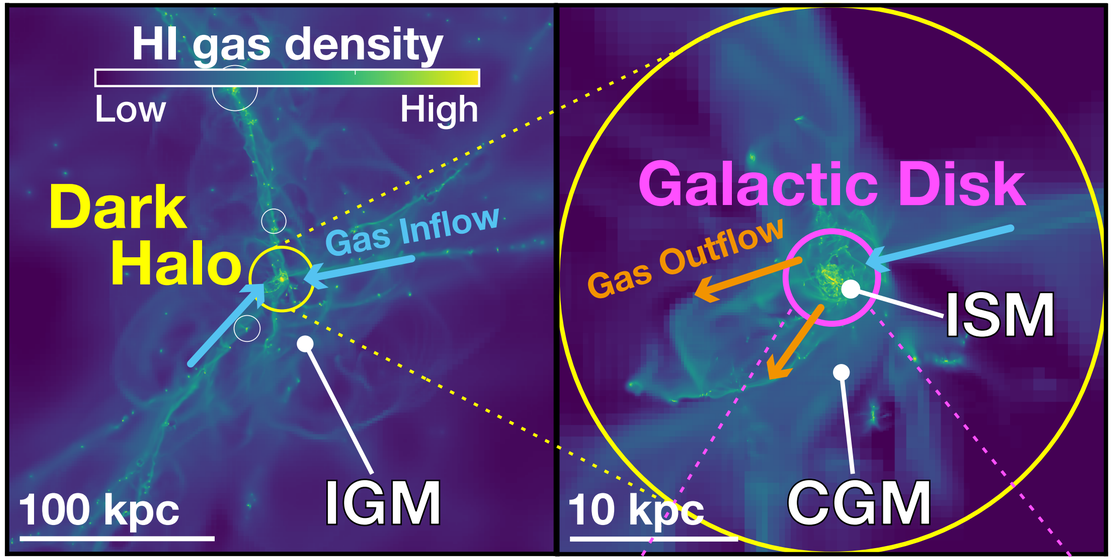
# The Diversity of IGM-galaxy connection at redshift z = 2-3

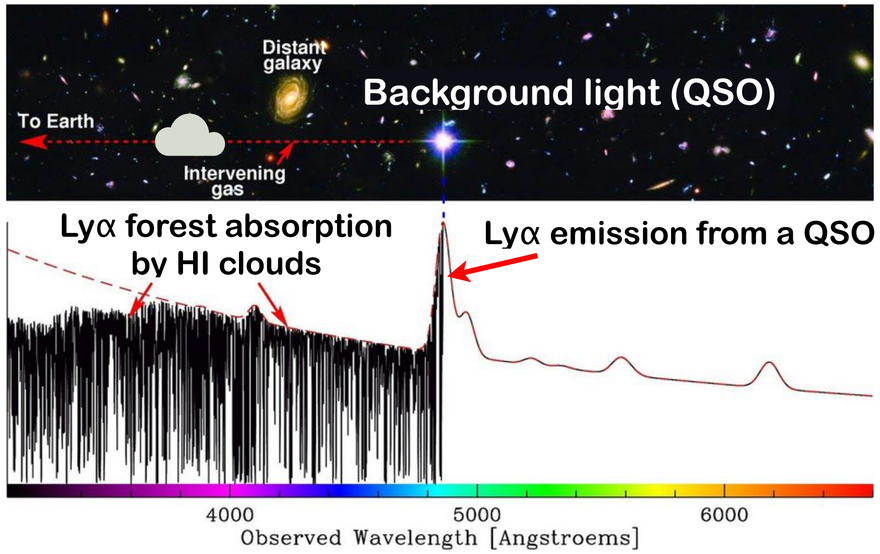
**Rieko MOMOSE (U. Tokyo)**

Based on RM+2021a, c

in collaboration with
K. Shimasaku, N. Kashikawa, K. Nagamine, I. Shimizu,
K. Nakajima, Y. Terao, H. Kusakabe, M. Ando,
K. Motohara, L. Spitler

# Galaxy evolution and the intergalactic medium

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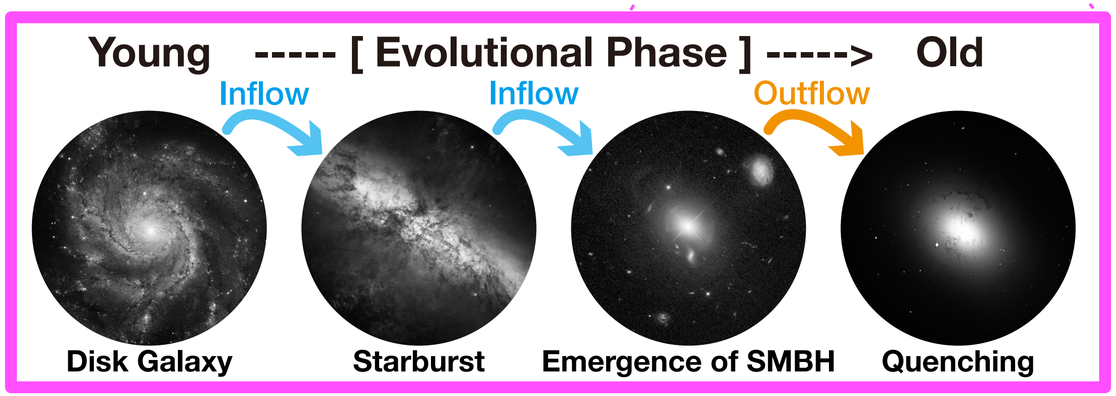
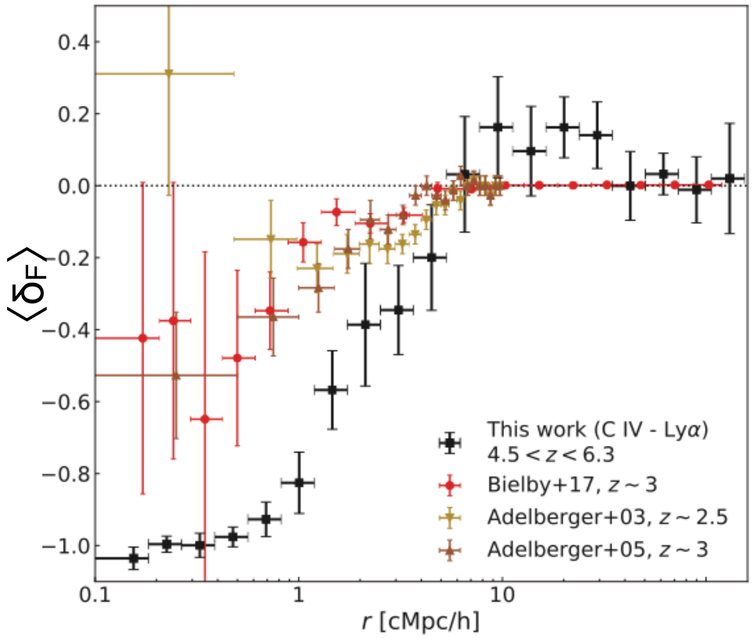



Weak Lyα absorption
Underdense
↑
Mean density
↓
Overdense
Strong Lyα absorption

【 Lyα transmission excess $\delta_F$ 】

$$\delta_F = \frac{F - \langle F_z \rangle}{\langle F_z \rangle} = \frac{F}{\langle F_z \rangle} - 1$$

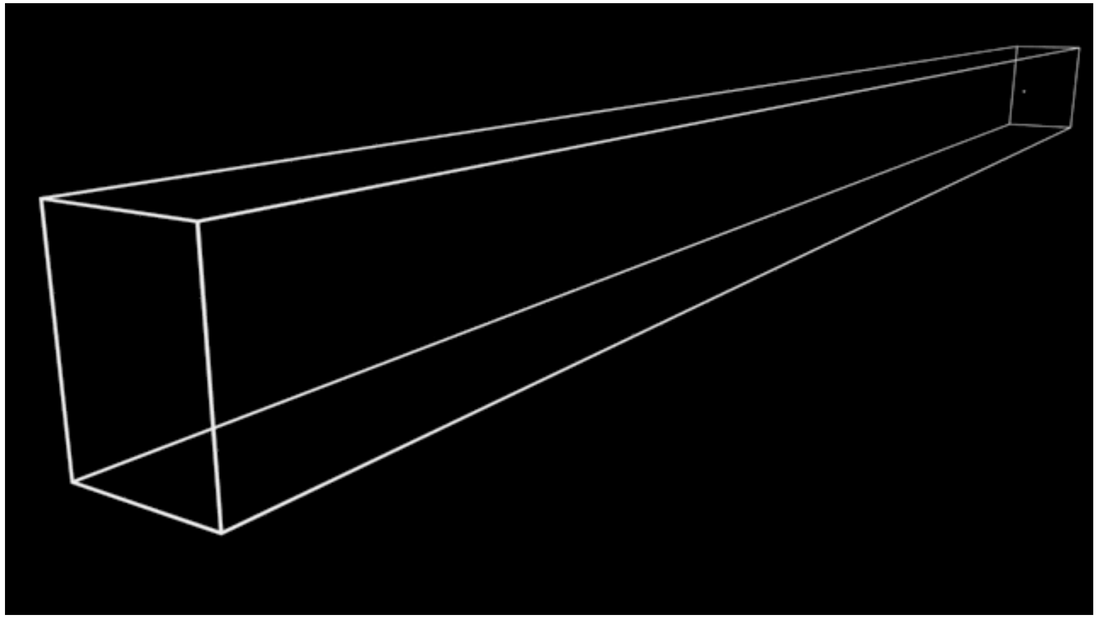
$F$ : Lyα transmission flux

$\langle F_z \rangle$ : The cosmic mean of $F$

Meyer+18a; RM+21b, see also Nagamine+21

# The Cosmic Web traced by Neutral Hydrogen

## The cross-correlation between galaxies and Lyα 3D tomography data



×

- Lyα emitters (LAE)
- Hα emitters (HAE)
- [OIII] emitters (O3E)
- Active Galactic Nuclei (AGN)
- Submillimeter galaxies (SMG)
- (Stellar) Continuum-selected galaxies

**CLAMATO (Lee+16, 18)**

- Footprint: 0.157 $\mathrm{deg}^2$ in the COSMOS field
- Volume : $3.15 \times 10^5\ h^{-3}\ \mathrm{Mpc}^3$
- Redshift : $2.05 < z < 2.55$

**Archival catalogs**

**(LAE: Nakajima+12; Hashimoto+13; Nakajima+13; Shibuya+14; Konno+16) (HAE: Sobral+13b) (O3E: Terao in prep.) (AGN: Straatman+16; Cowley+16) (SMG: Smolčić+12; Brisbin+17; Michalowski+17) (Cont.-selected: RM+21a and reference therein)**

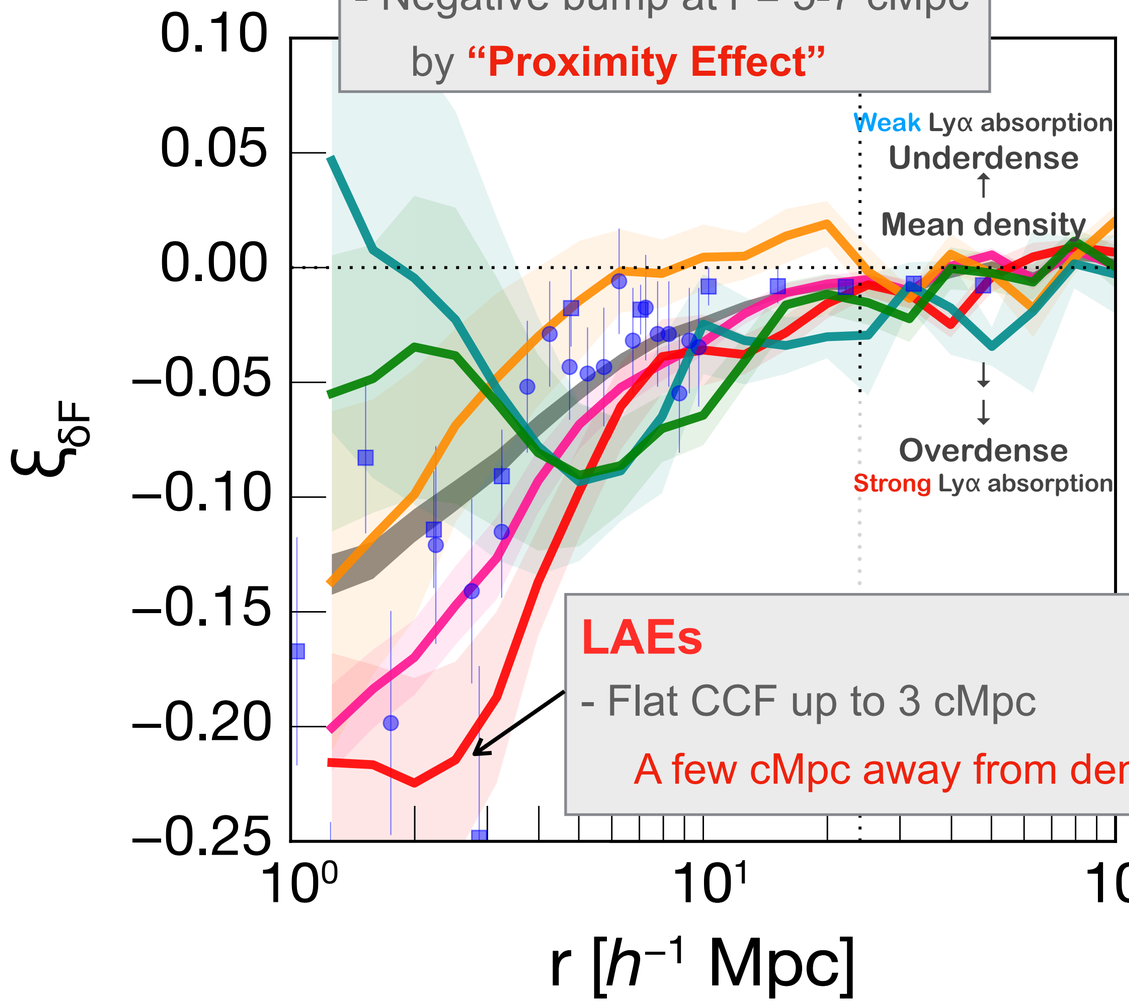


Lee+18

# Diversity of IGM-galaxy connection among the population

**AGNs** & **SMGs**

- Weak signal at the center
- Negative bump at r = 5-7 cMpc
  by **"Proximity Effect"**




**LAEs**

- Flat CCF up to 3 cMpc
  A few cMpc away from density peaks

- Lyα emitters (LAE)
- Hα emitters (HAE)
- [OIII] emitters (O3E)
- Active Galactic Nuclei (AGN)
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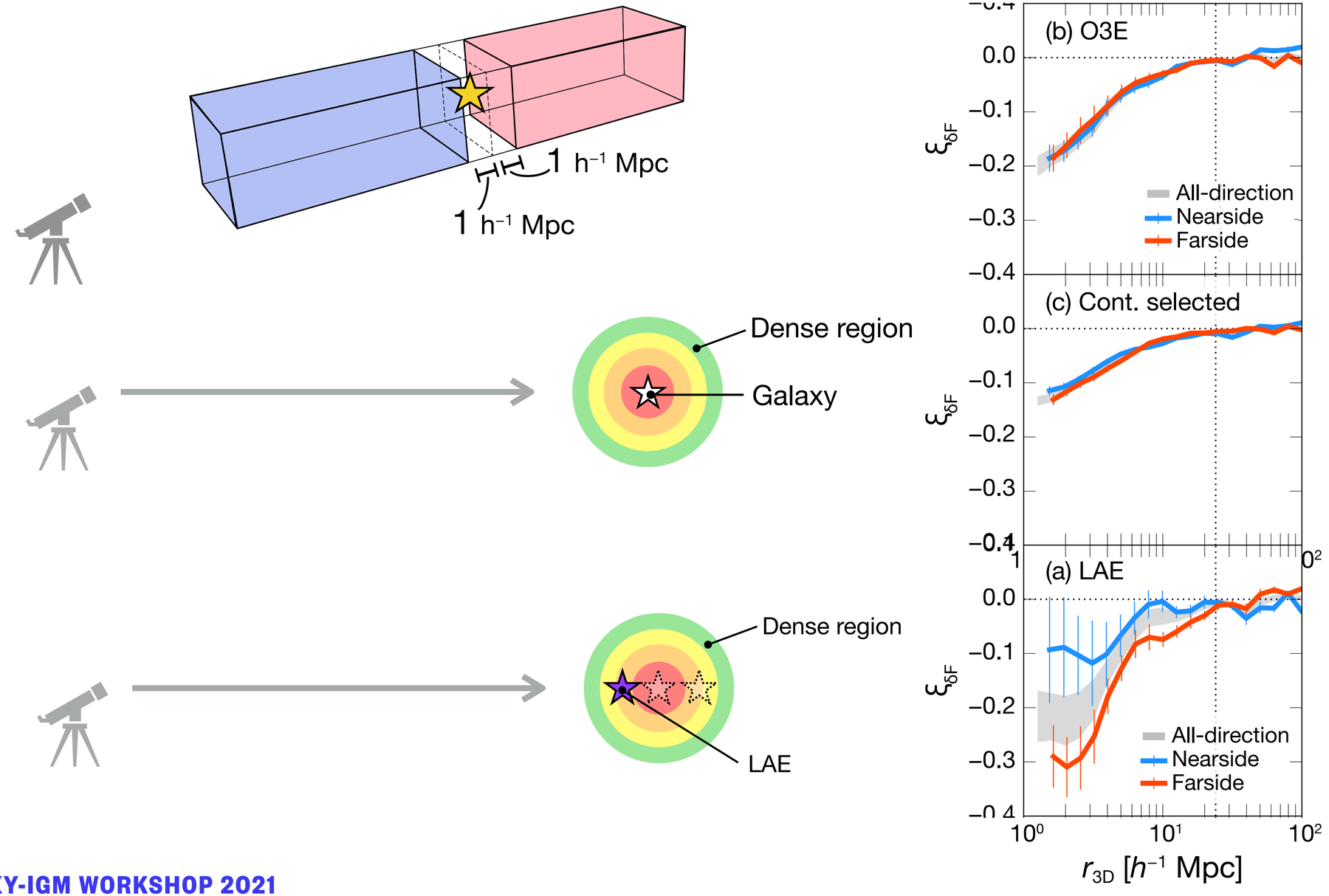
RM+21a

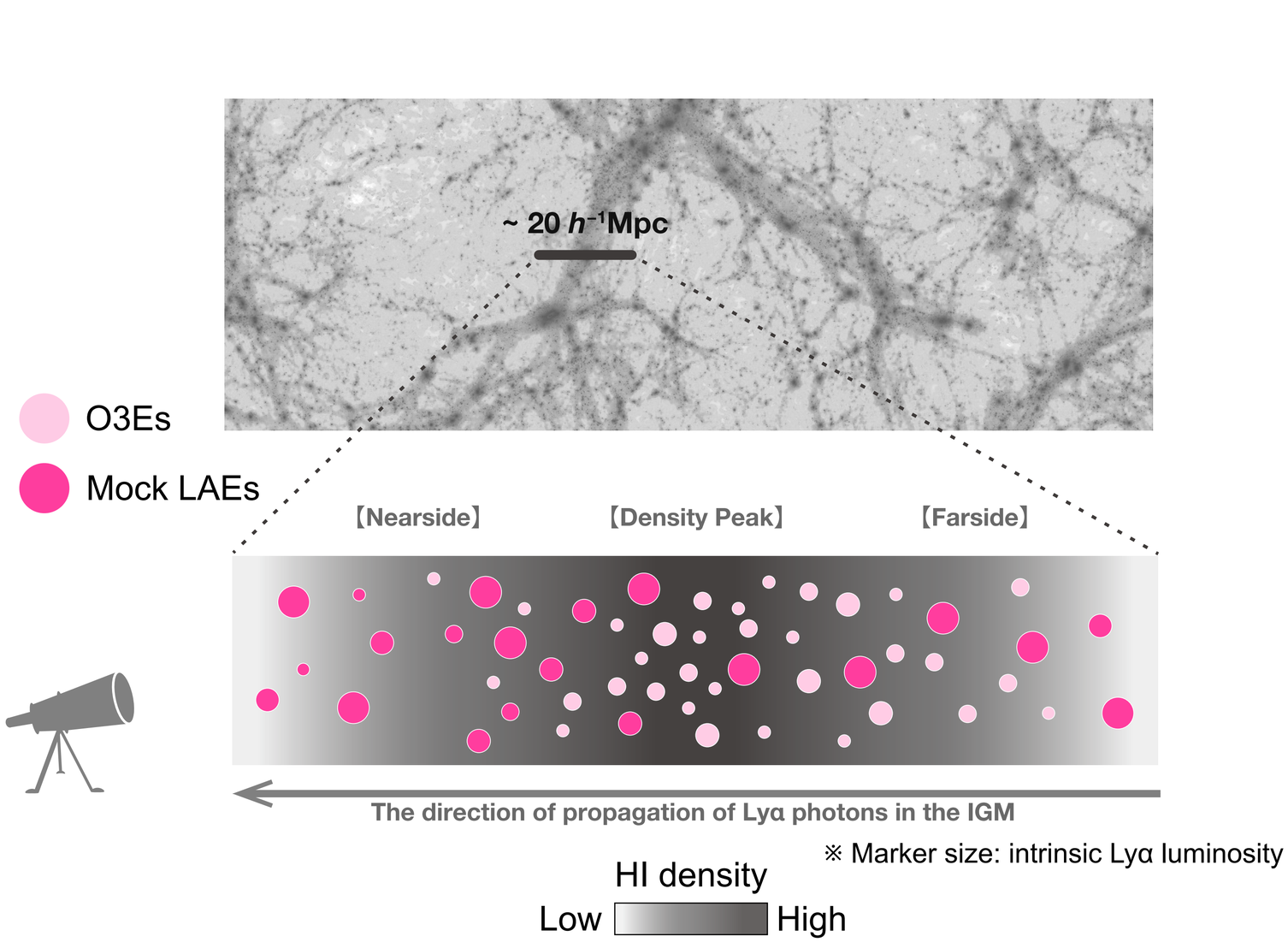
# HI density distribution along the line-of-sight 1

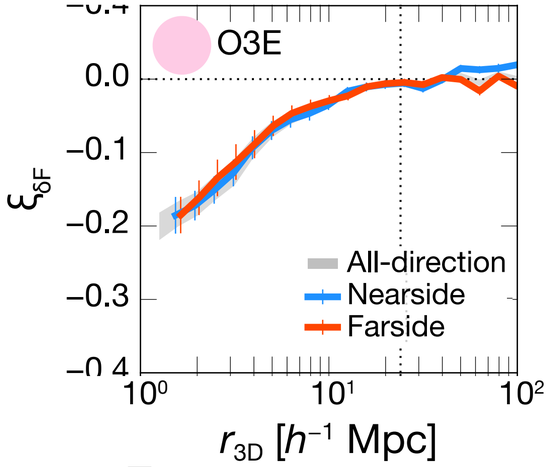





RM+21c

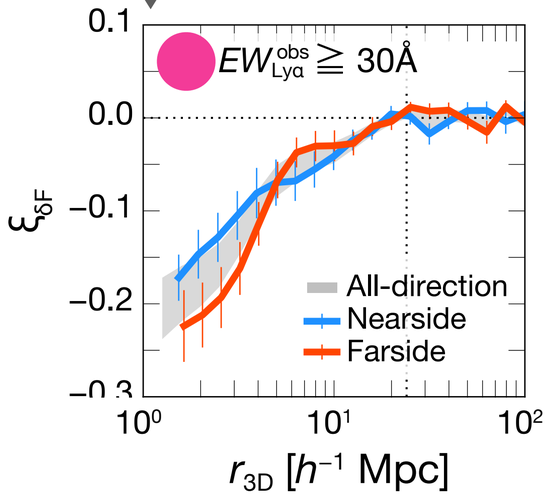
# HI density distribution along the line-of-sight 2




Select galaxies with $EW_{Ly\alpha} \geqq 30$ Å from O3Es
Take them as mock LAEs

Calculate cross-correlation in the near and far sides separately




RM+21c

# Summary

**The cross-correlation analyses between Lyα forest absorption and galaxies have shown**

- **Diversity** of cross-correlation functions among galaxy populations
  - The shape and amplitude of cross-correlation functions give us insight into galaxies' activities and evolutional stage
  - AGNs and SMGs show the highest signal at $r$ > 5-6 Mpc, but lower signal within $r$ < 5 Mpc due to the proximity effect
  - LAEs have the highest signal at small scale, though its reason has not been resolved
- **Anisotropy** of HI density distribution only around LAEs

Thank you!