Lyα view around a z=2.84 hyperluminous QSO at a node of the cosmic web

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Based on Kikuta et al. 2019, PASJ, 71, L2 (arXiv:1904.07747)

19 November 2019, Subaru 20th anniversary

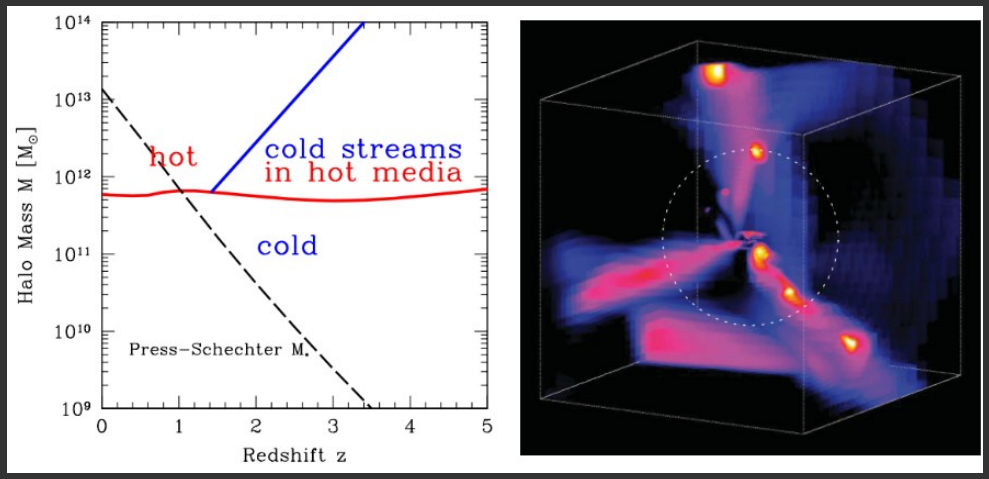
Galaxy Formation in the Cosmic Web

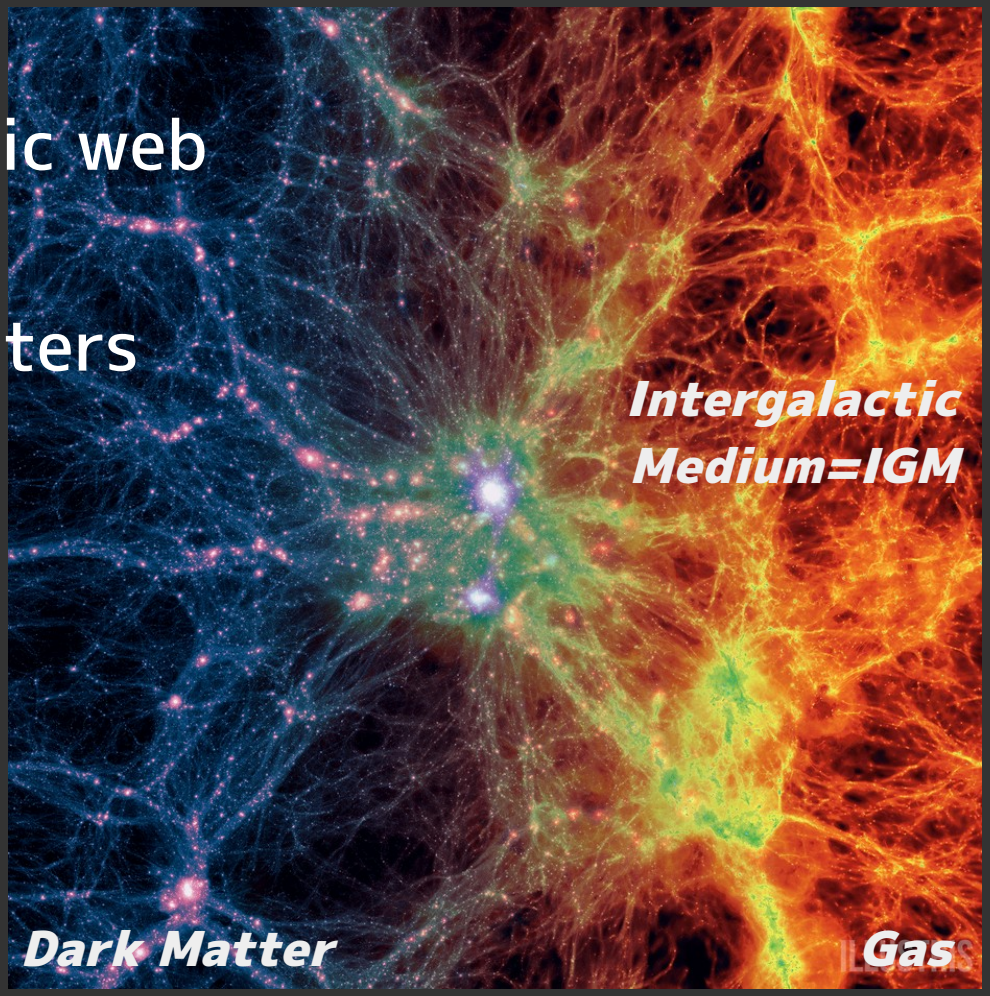
Galaxies are formed within **the cosmic web**, a network of dark matter & baryons

Gas accretion along the cosmic web governs galaxy evolution

- "**cold mode accretion**" matters

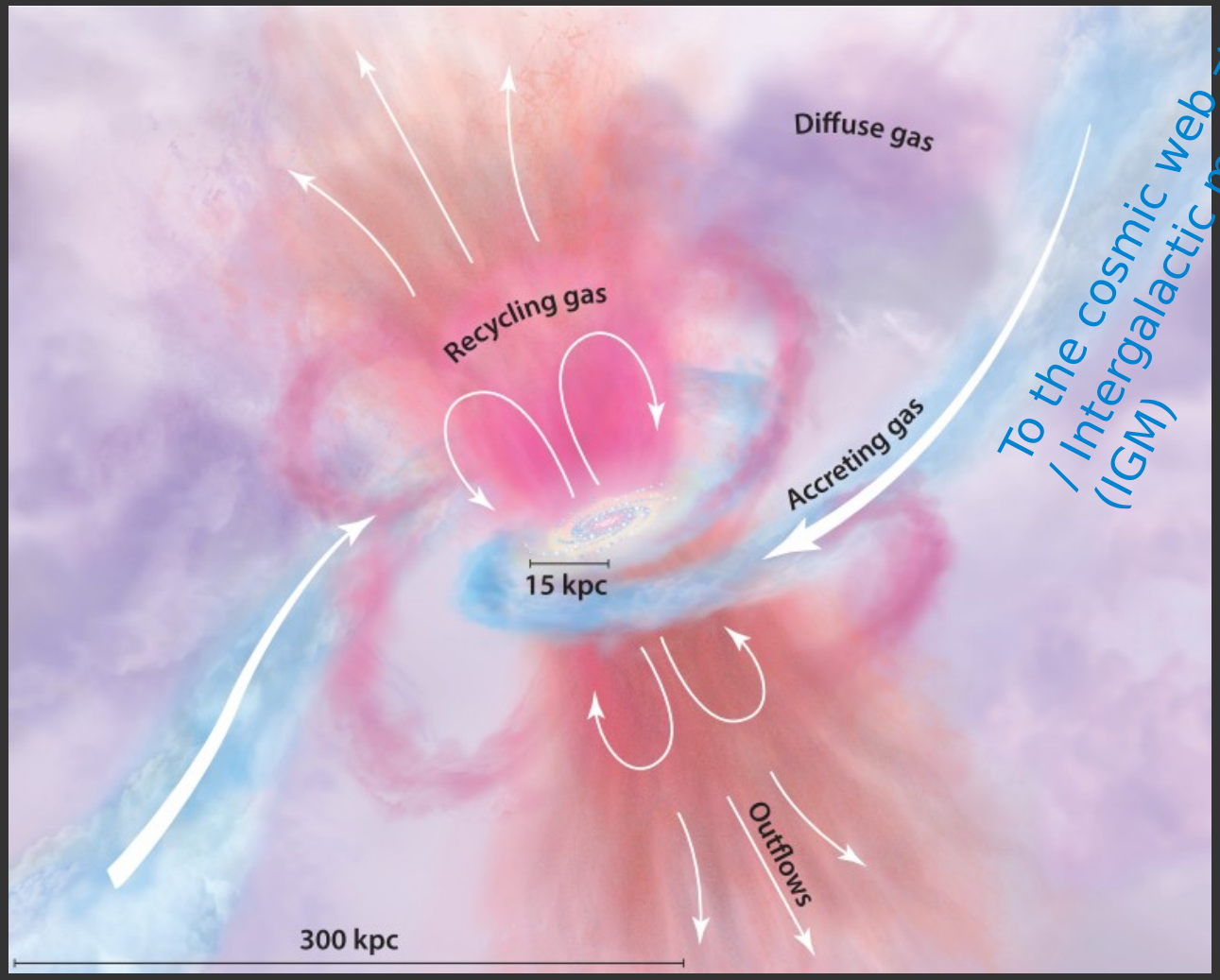
Direct observation needed!





Dekel+09

Cricumgalactic/Intergalactic Medium (CGM/IGM)



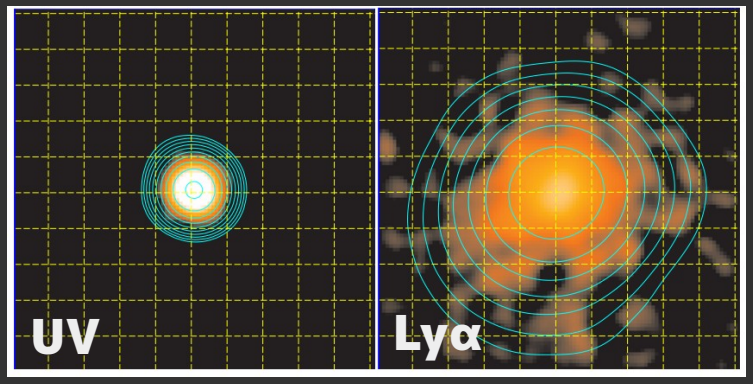
©Tumlinson, Peeples, and Werk,
“The Circumgalactic Medium”, ARAA, 2017

※No clear demarcation between CGM and IGM

Lyα nebulae around high-z galaxies

Diffuse Lyα nebula is ubiquitous around z>2 SF galaxies

e.g., Momose+14, Wisotzki+16, Leclercq+17



Stacked UV(left) and Lyα(right) image of LBG @ z=2.65 (Steidel+11)

Extreme cases:

Lyα blobs (LABs)

Often found in **overdense environments**

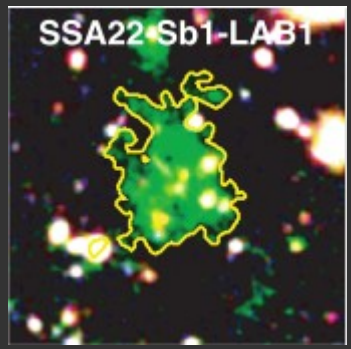
e.g., Matsuda+04, Prescott+08, Badescu+17

Bright QSOs at z~3

Almost always have large Lyα nebulae

Strong ionizing radiation may boost Lyα emissivity

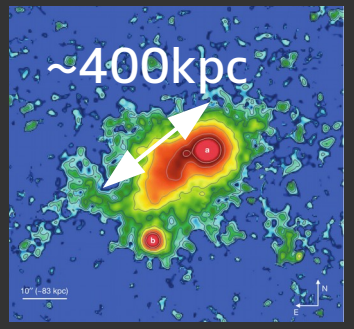
Borisova+16, Arrigoni-Battaia+19



Matsuda+11

Some have sizes > a few 100 pkpc

QSOs in dense environments may be the key objects to probe the cosmic web

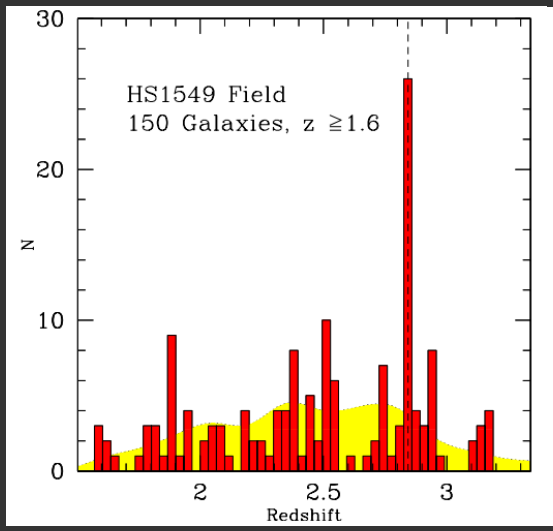


Cantalupo+14

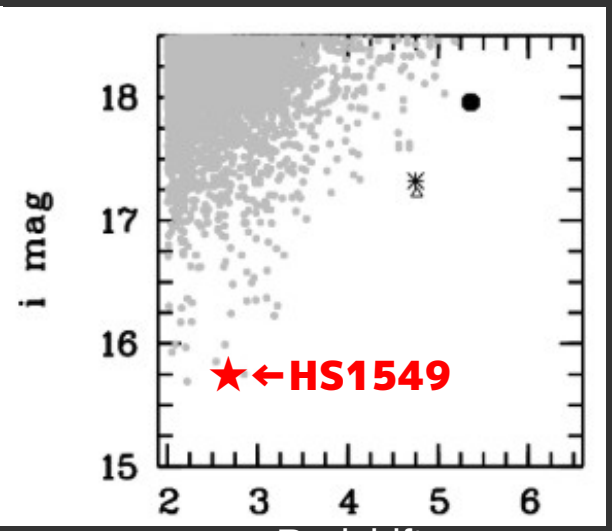
Our Observation

Hyperlumious QSO at z=2.84: **HS1549+1919**

- $L_{1450A}(\nu L\nu \text{ @ } \lambda=1450A)=1.5\times10^{14}\ L_\odot$, $M_{BH}=4.6\times10^{9}\ M_\odot$
  ※$L_\odot=3.8\times10^{33}$ erg/s (Trainor & Steidel 2012)
- reside in **massive overdensity (confirmed protocluster)**
- Deep imaging & spectroscopic data available at the center
- Observed with Subaru **Hyper Suprime-Cam (HSC)**



Mostardi+13



May+18

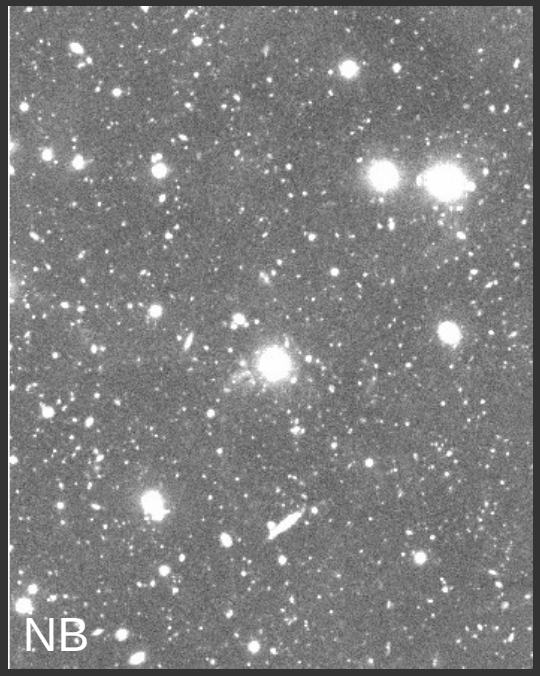
Observation: HS1549+1919

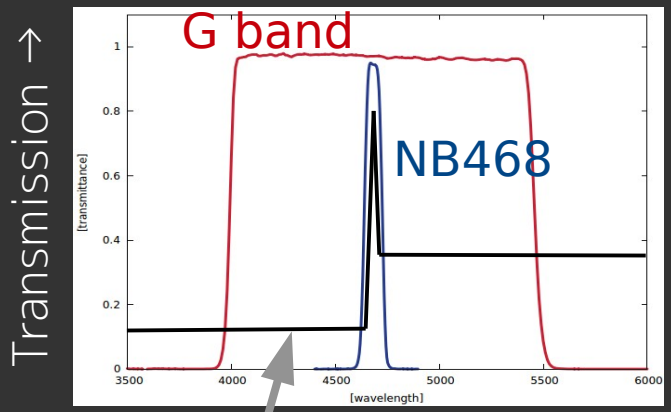
Hyper Suprime-Cam(**HSC**) Observation (S16A-110, PI: Yuichi Matsuda)

FoV= ***1.5 deg diameter*** = **42 pMpc/165 cMpc @ z=2.84**

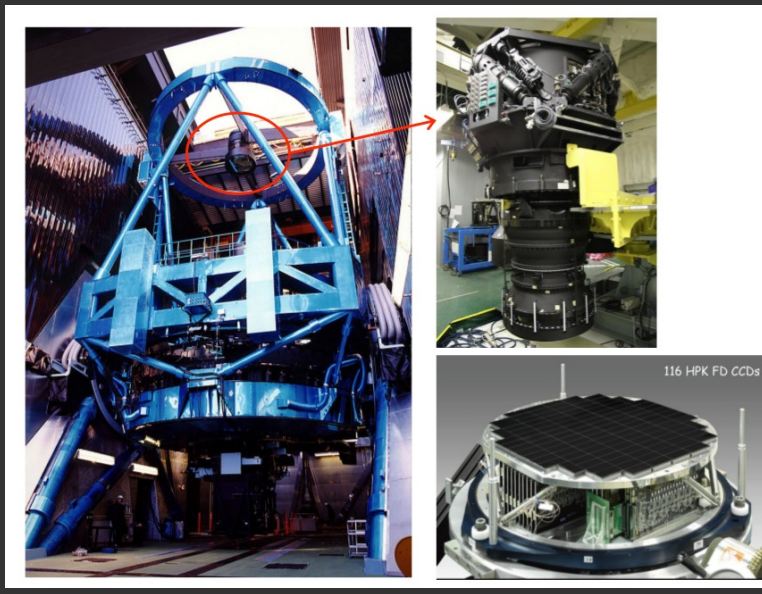
Data reduced using HSC pipeline (hscpipe 4.0.5) **with global sky sub.**

G	2.2 hr (389 shots) →	$FWHM_{PSF}$~0.77”, 27.4 mag (5σ, 1.5” aperture)
NB468	6.3 hr (113 shots) →	$FWHM_{PSF}$~0.65”, 26.6 mag (5σ, 1.5” aperture)





Spectrum of Lyman α emitter = **LAE**



LAE detection

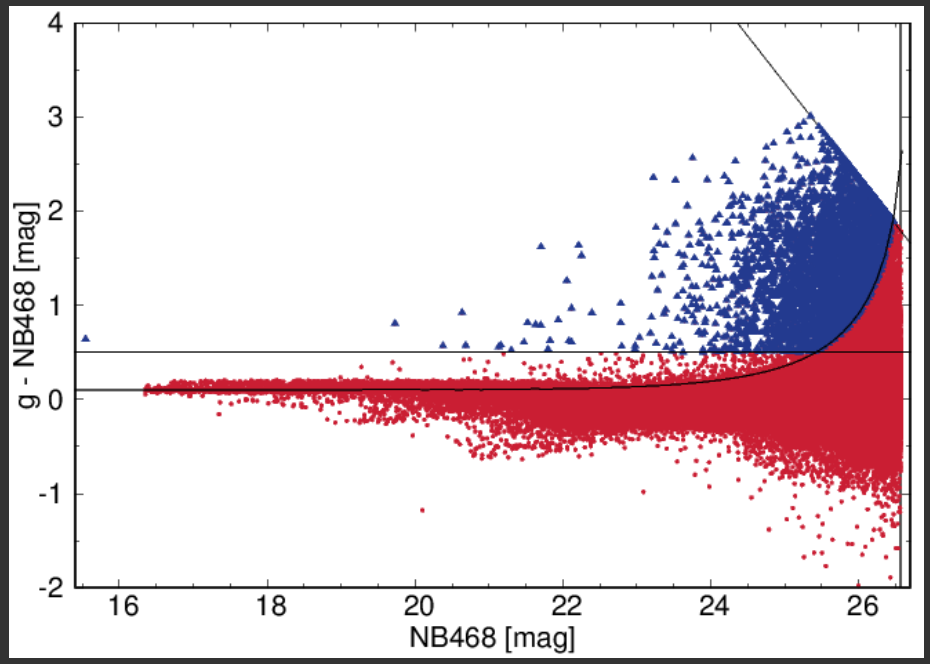
Source detection & photometry with SExtractor (Bertin & Arnouts 96)

LAE selection criteria:

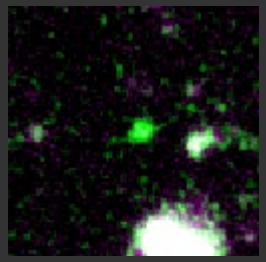
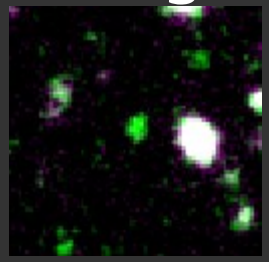
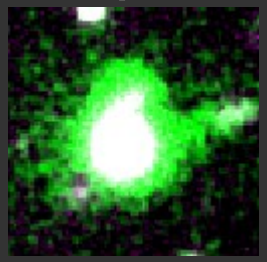
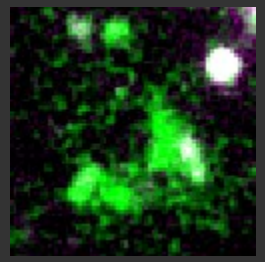
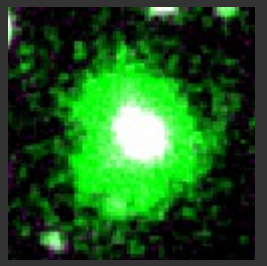
NB < 26.57(5σ)

G – NB > max{0.5, 4σ(G-NB)}
(rest EW>~12Å)

+ **LABs** → LAE with $A_{iso,2\sigma}$ > 16 arcsec^2



→ **3490** LAEs / **76** LABs found within **36 arcmin** from HS1549 (1.2 deg diameter)

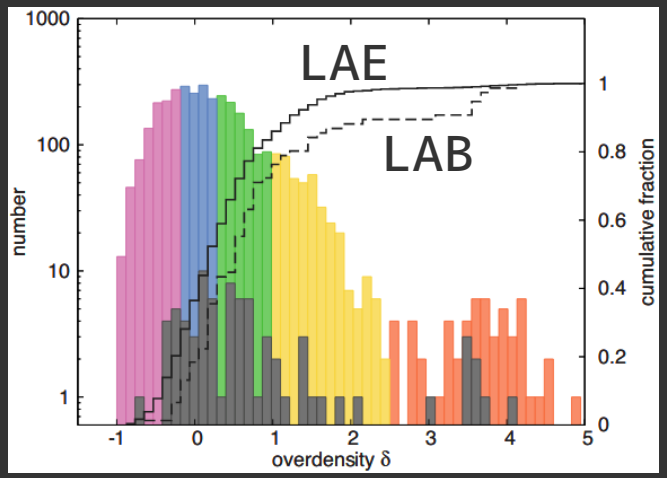



LAB

LAB

LAB

False-color image
R: G
G: NB
B: G

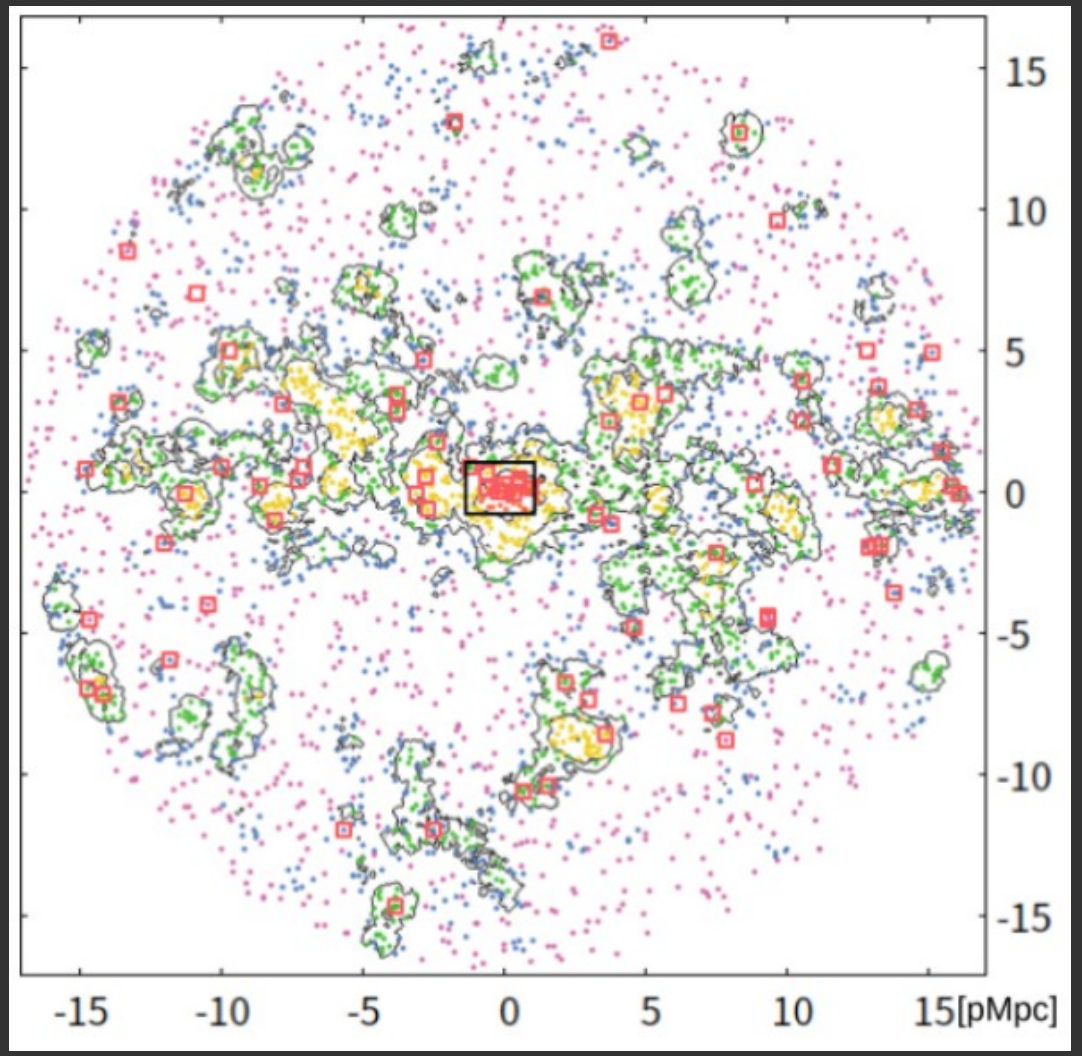
LAE distribution

Filamentary structure

LABs□ are distributed along the structure & clearly prefer denser environments

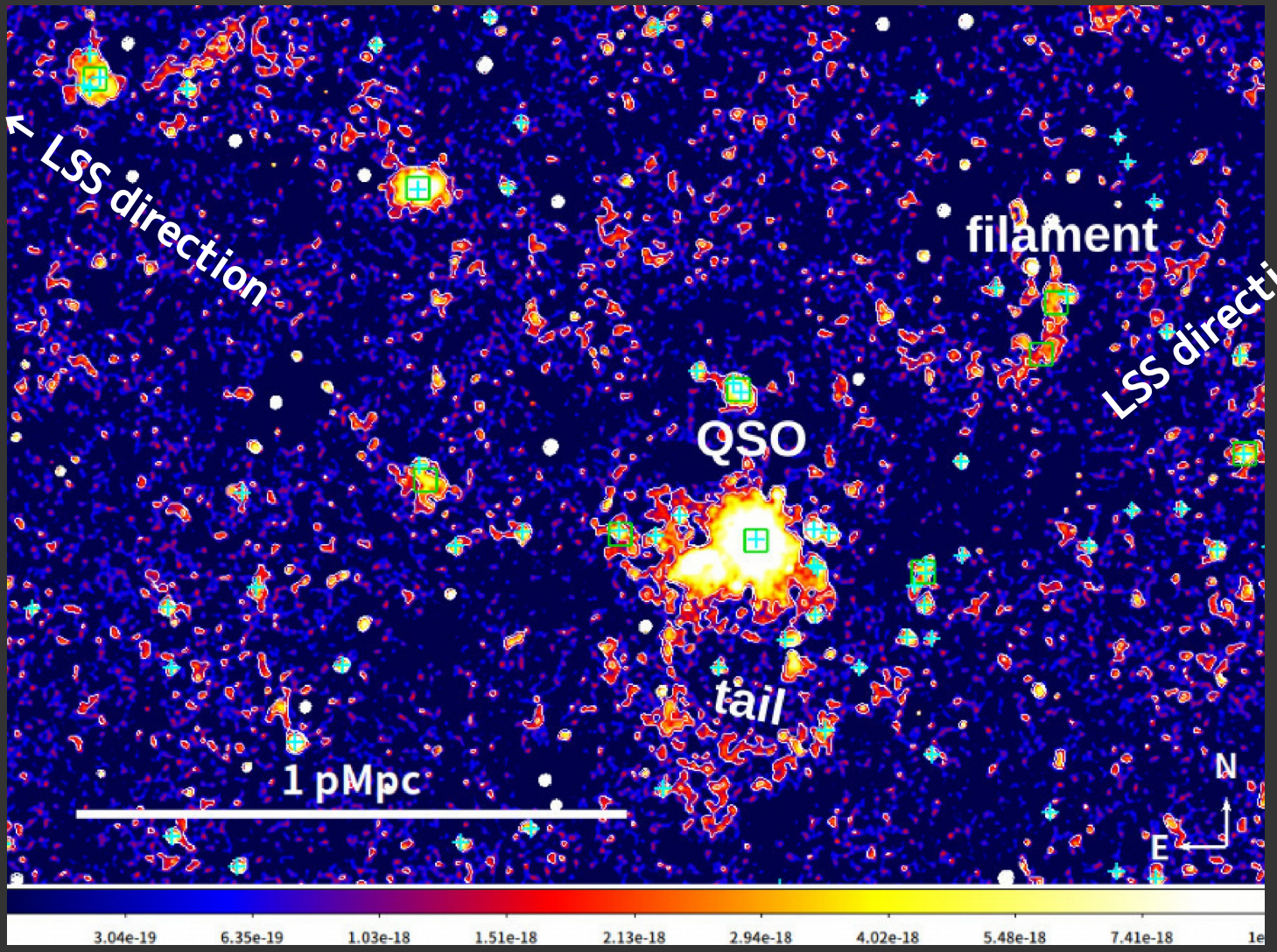


$\delta_{gal}=n/n_{ave}-1$



Kikuta+19

Lyα view around the HLQSO



See also H. Umehata's talk

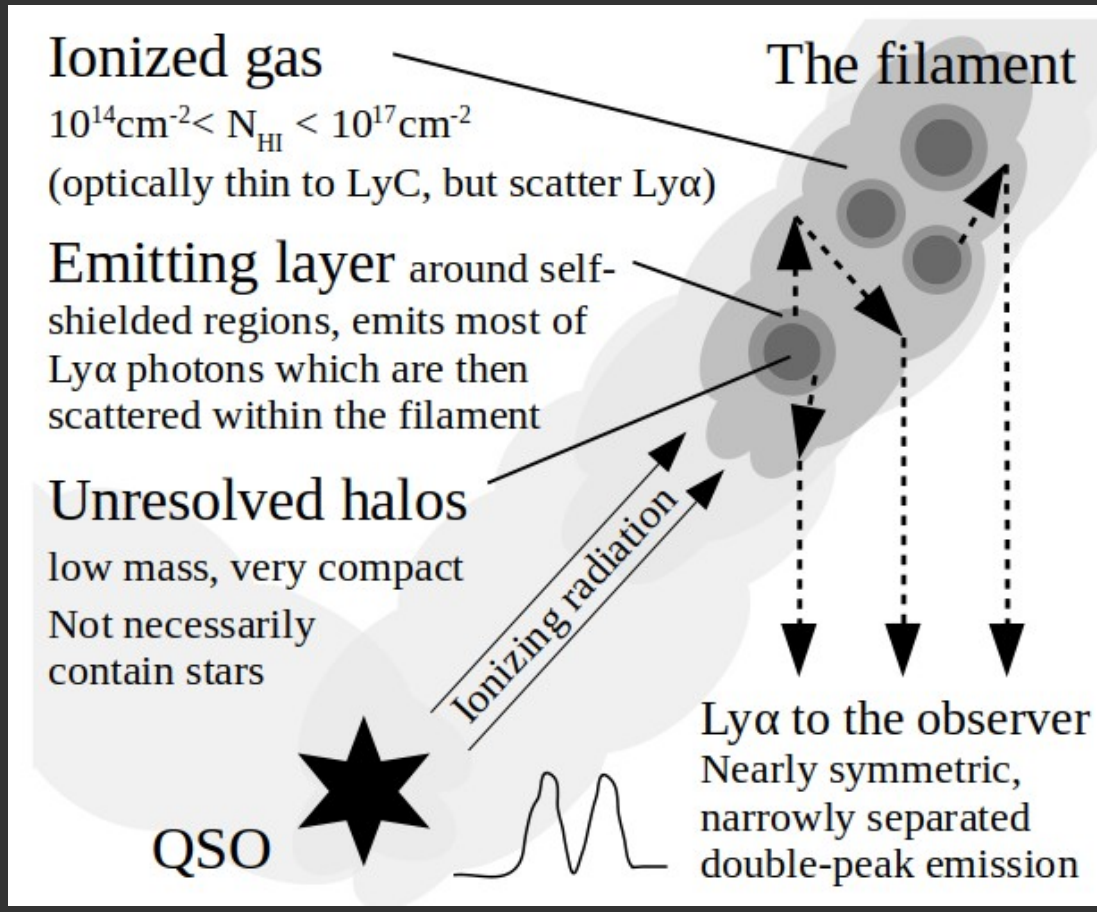
Origin of the Filament

No UV/sub-mm luminous counterpart within it

We proposed scenario for the filament (→) and designed observations to test it with KCWI

Proposal submitted (S20A-119, PI: S. Kikuta)

ALMA band 6 mosaicing observation is ongoing (accepted in Cy7, 2019.1.00403.S, PI: S. Kikuta)



Summary

- The CGM and IGM are key components of galaxy evolution but are still not fully understood.
- Lyα nebulae around QSOs, LABs, and LAEs can be used to constrain physics of the CGM/IGM.
- Our target protocluster is found to be at the intersection of a filamentary structure and in a very active phase of formation
- We detect huge Lyα emitting structure around the core of HS1549 protocluster, correlating with the large scale structure.
- “The filament” may represent dense part of the cosmic web. Follow-up with Keck/KCWI will reveal its origin.