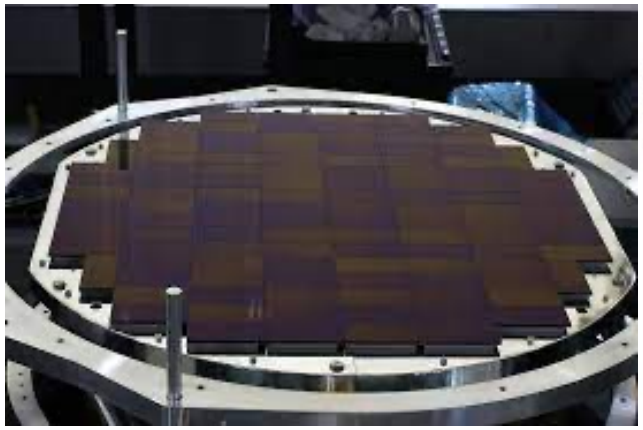
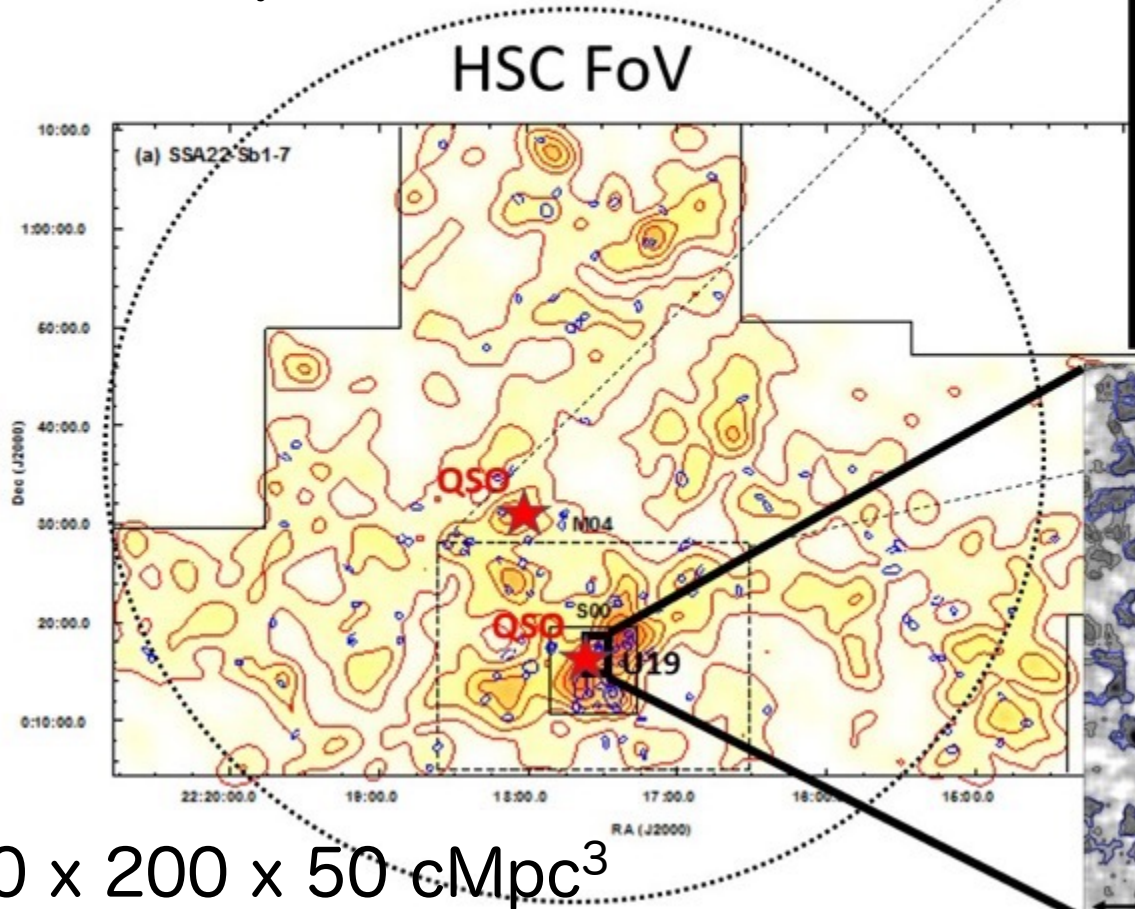
MIRACLES (S21A-114QI)

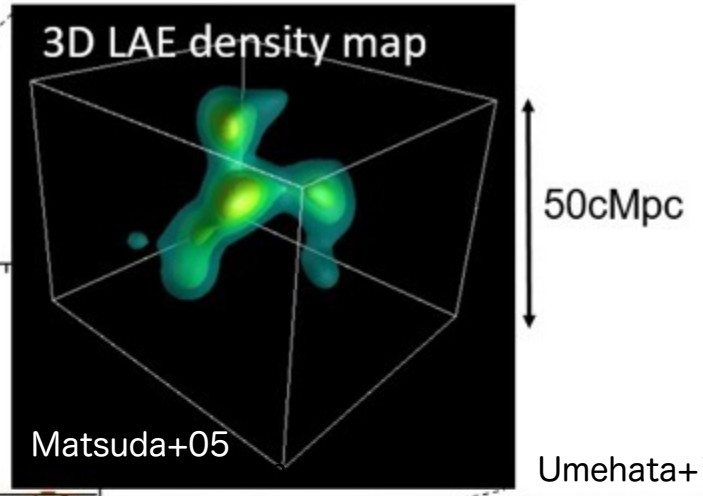
Mapping of Ionizing RAdiation on the Cosmic web with Lyα Emission and Shadow

Yuichi Matsuda (NAOJ) and the MIRACLES team

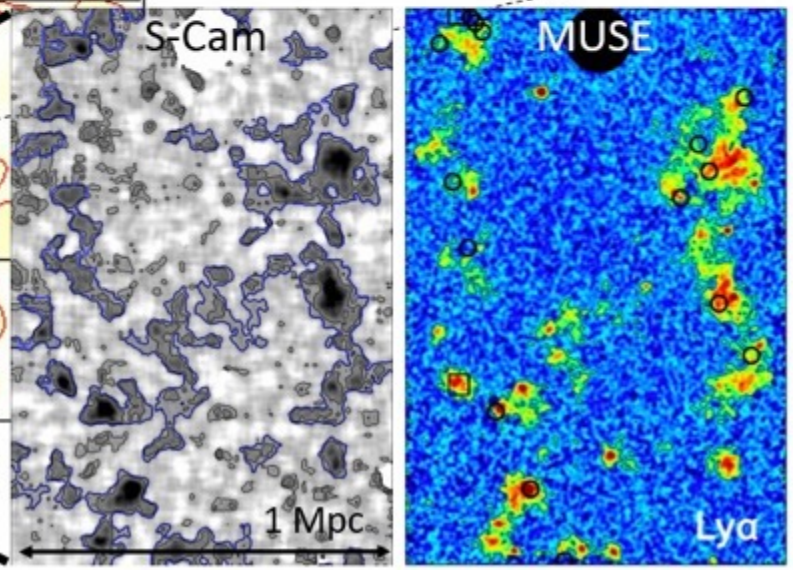


Steidel+00/Hayashino+04/Matsuda+04,05,06,11,12/Yamada+12ab





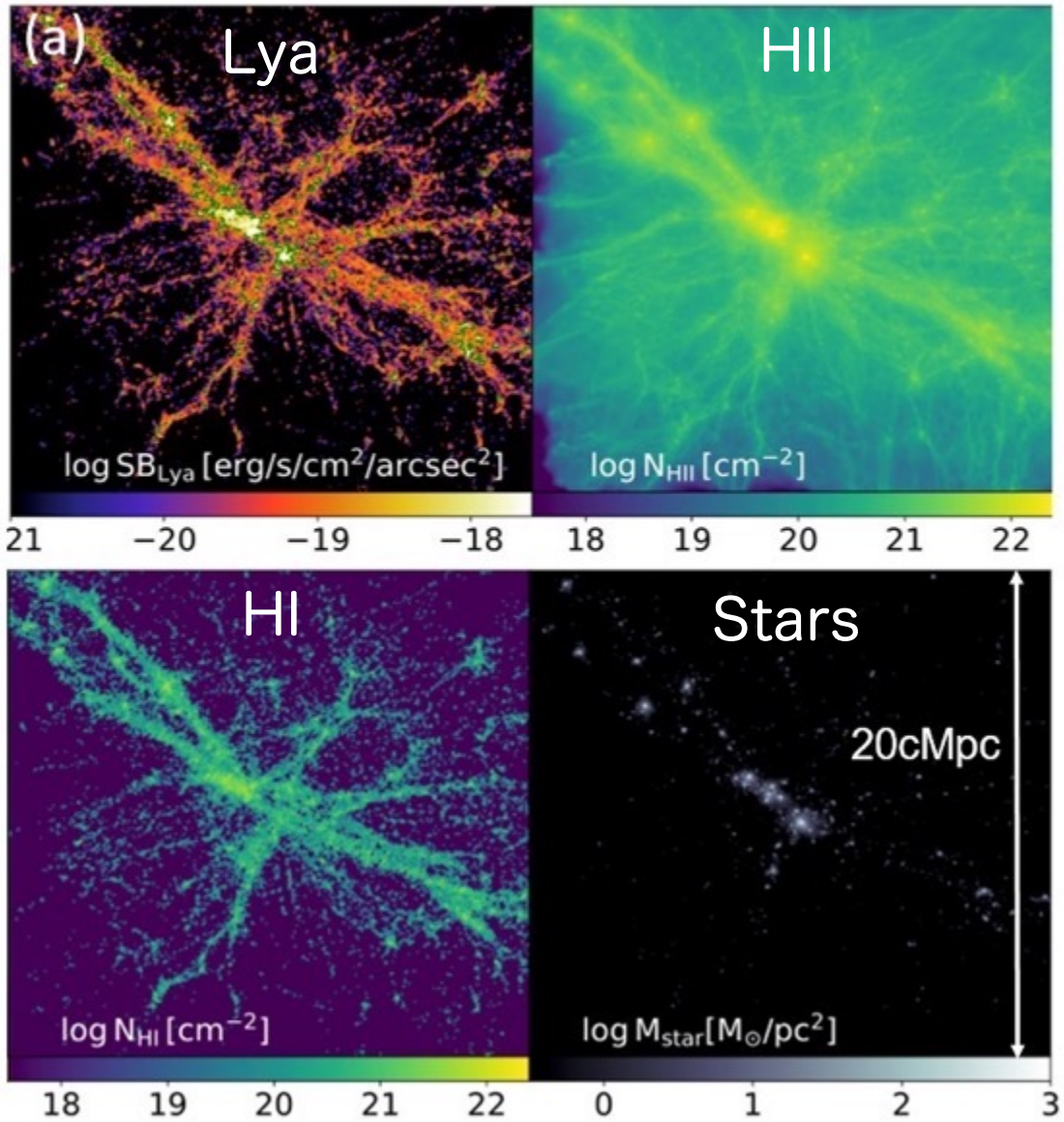
Umehata+19



Survey Volume ~200 x 200 x 50 cMpc^3

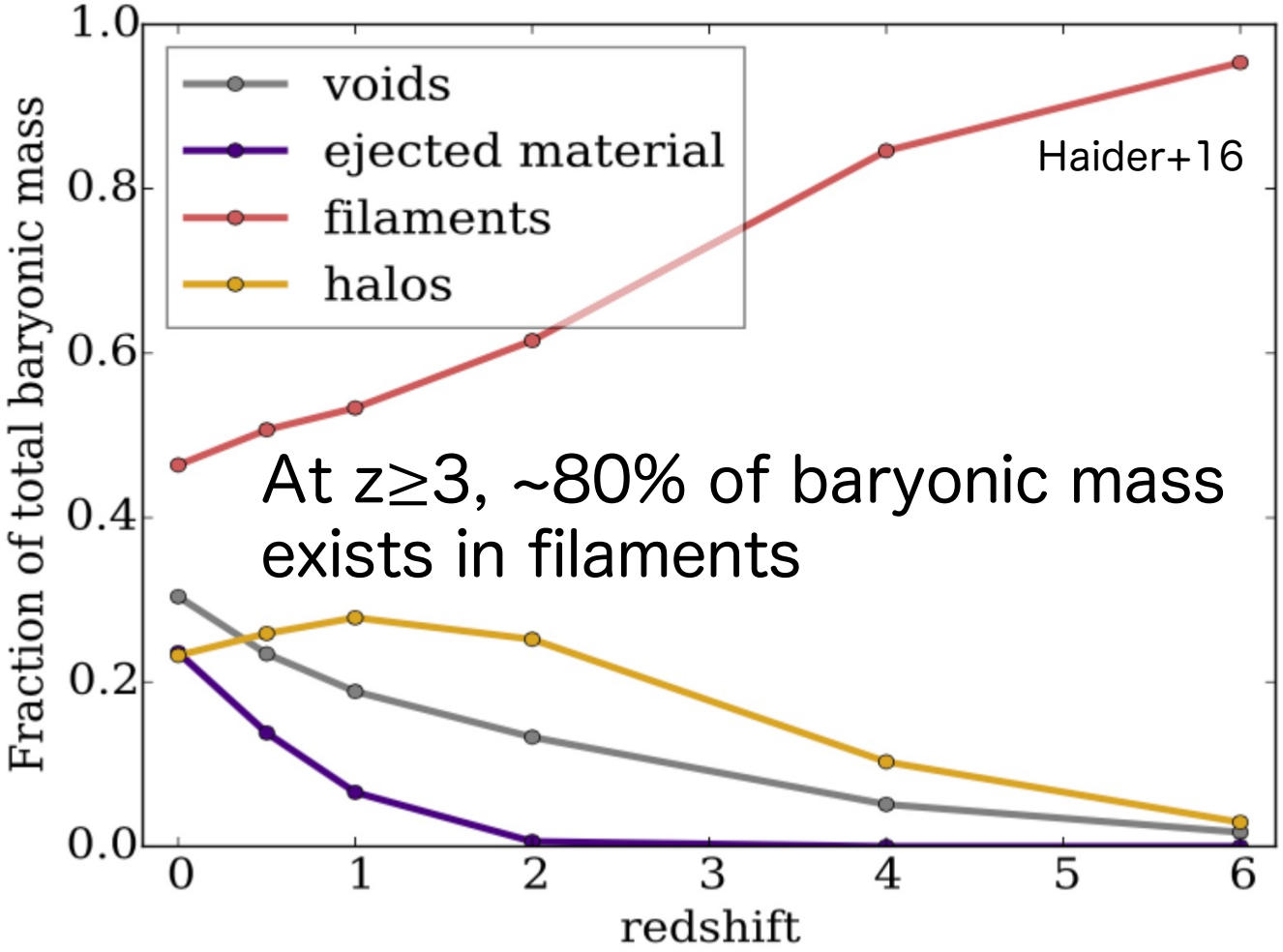
Cosmic Web: Main Gas Supplier for Galaxy Formation

Cosmic Web and Galaxies at z=3 (Yajima+21)



Lya mapping of the cosmic web

→ Big observational challenge!!

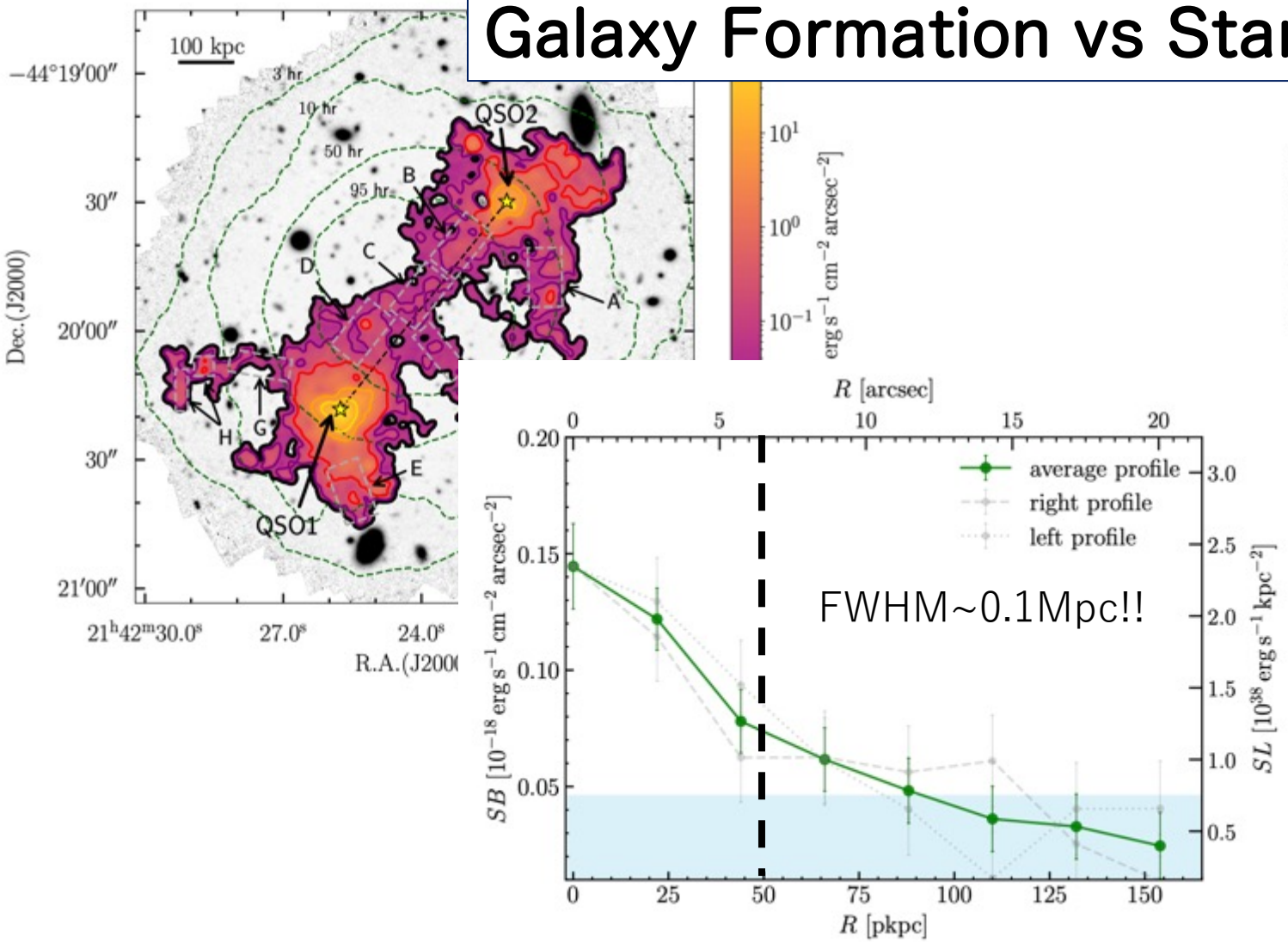


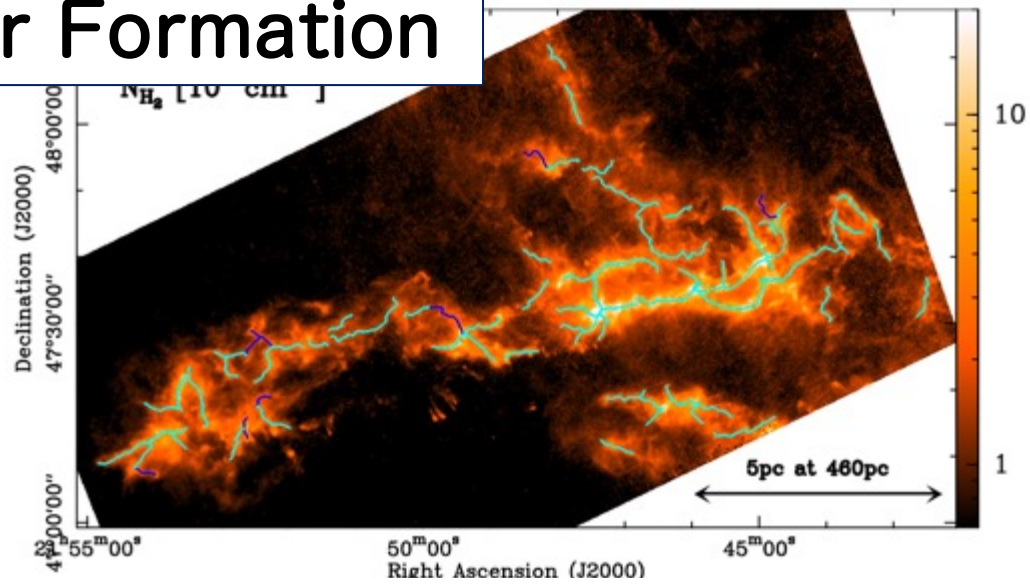
Do the Lya filaments also have a typical width?

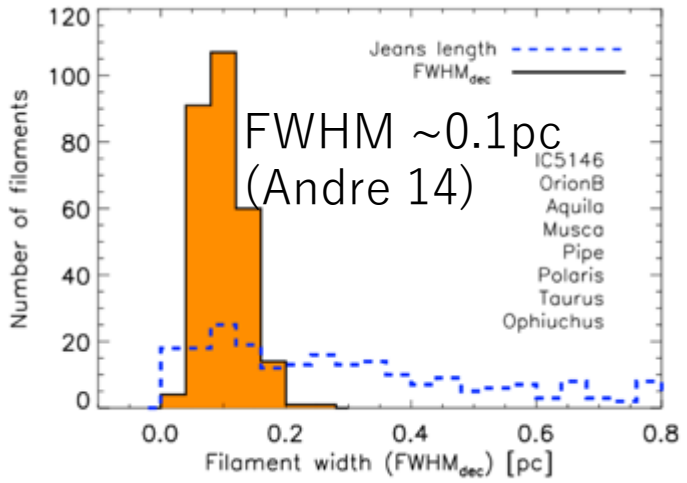
Intergalactic filaments (Tornotti+25)

Interstellar filaments (Arzoumanian+11, 19)

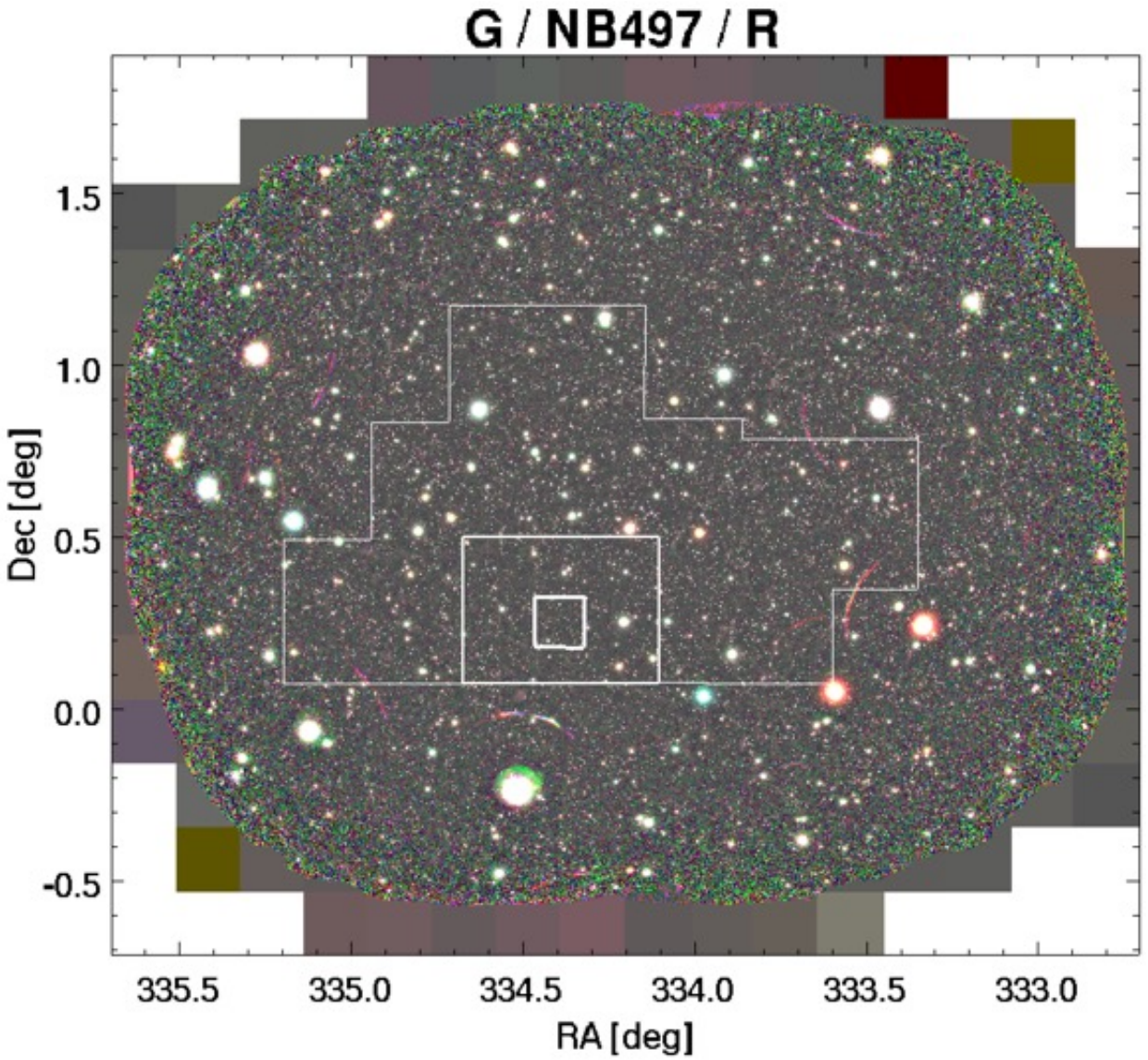
Galaxy Formation vs Star Formation



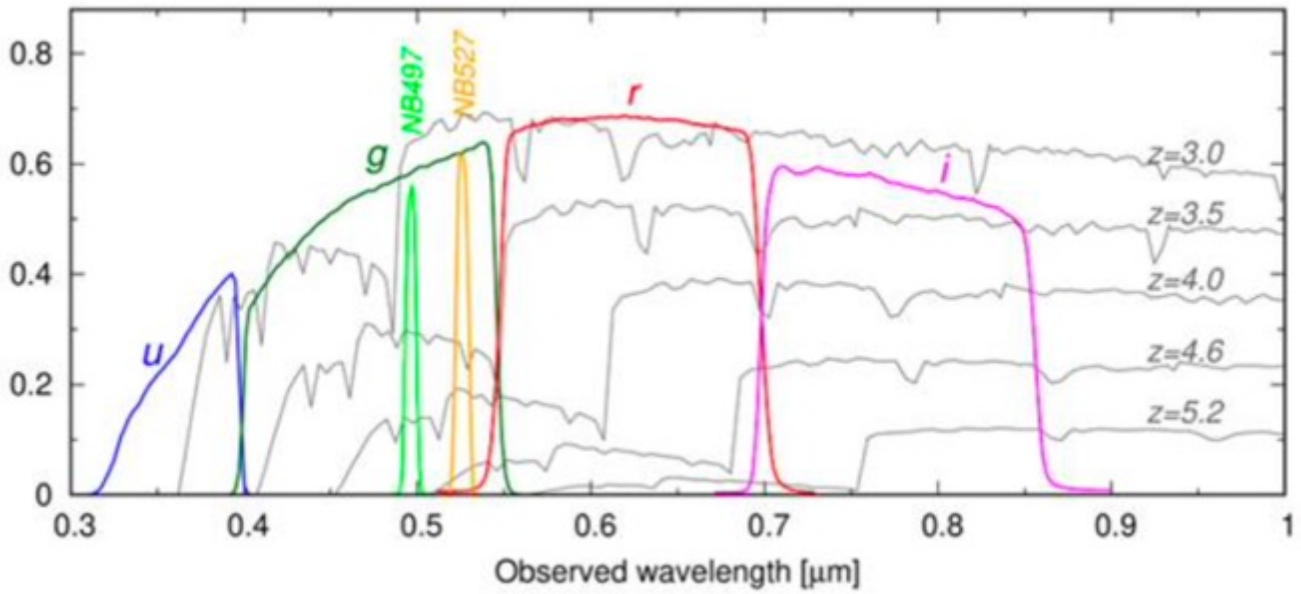




Internal Data Release (Mawatari/Yamanaka+)

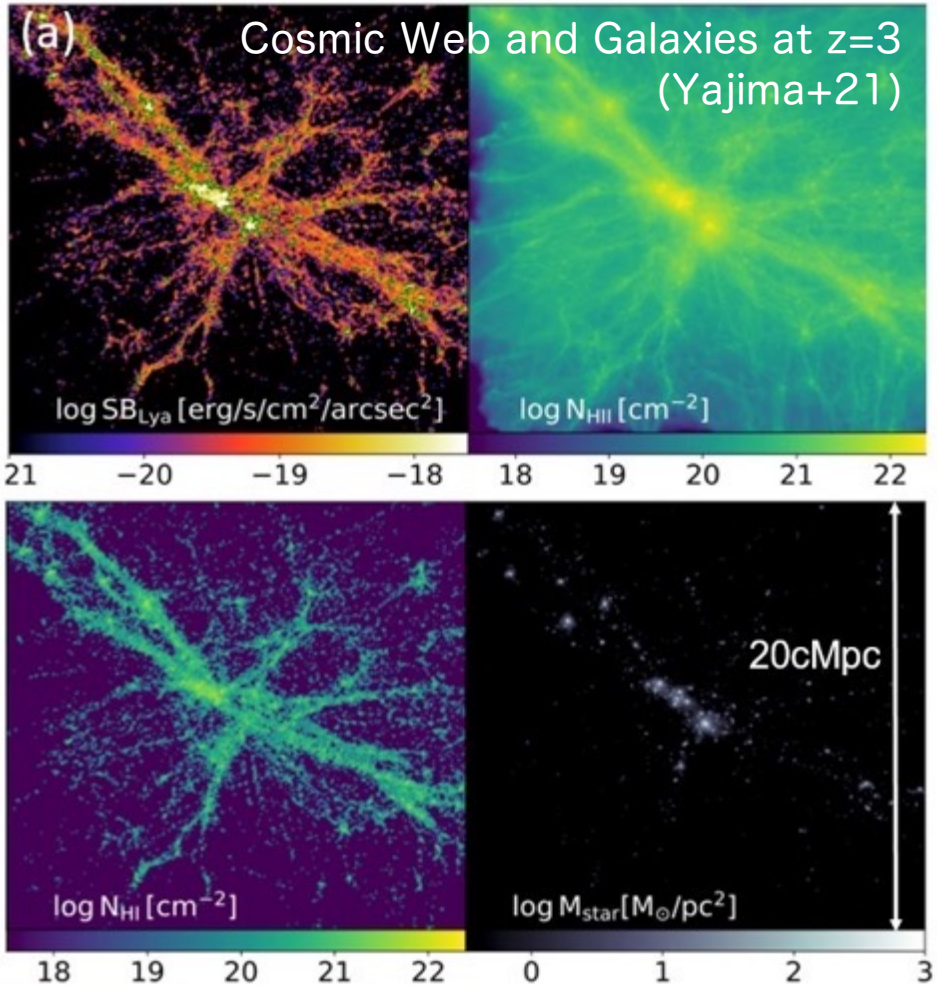


Data Set	u	g	r	i	NB497	NB527
5 σ (2" ap)	27.0AB mag	28.3AB mag	28.1AB mag	26.7A Bmag	27.3A Bmag	26.1A Bmag
On-Source time	14.0h	10.2h	12.2h	2.5h	43.3h	4.2h
Seeing	0.93"	0.76"	0.68"	0.56"	0.78"	0.74"



Science goals

(1) The physical properties (width, length, mass, & ionizing radiation field)
(2) The connection with galaxy / black hole growths
(3) The role on cluster formation



MIRACLES. Subaru HSC Ultra Deep Narrow-band Survey Data for Direct Detection of the Cosmic Web

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1. Background

Perspective from Galaxy formation

- Interplay of dark matter / gas cosmic web and galaxies
- Galaxy morphology/spin and filaments

Perspective from Cosmology

- Formation of large-scale structure
- Spatial/Velocity distributions of gas

Purpose: Detection of cosmic web via Lya emission

200cMpc

2. Observations & Data

Telescope	Filter	Area (deg^2)	Exp. time * (hours)	PSF FWHM† (arcsec)		Limiting magnitude†† (Original)	(PSF-matched)
Subaru / HSC	g	5.81	10.2 / 12.6	0.71	0.67 – 0.81	26.83	26.15 – 27.37	27.24	26.51 – 27.74
	r2	5.91	12.2 / 13.4	0.62	0.61 – 0.67	26.59	25.87 – 27.09	27.02	26.33 – 27.45
	i2	5.80	2.5 / 4.6	0.52	0.50 – 0.57	25.56	24.90 – 25.90	26.07	25.43 – 26.44
	NB497	5.88	43.3 / 53.2	0.71	0.66 – 0.74	26.08	25.41 – 26.58	26.51	25.81 – 26.99
	NB527	2.92	4.2 / 5.6	0.69	0.65 – 0.72	25.45	24.91 – 25.67	25.86	25.25 – 26.08
CFHT	u	1.11	0.96§	26.96§		–	–	–	–

* The total exposure time used for our analysis (left) and the total observation time (right) are listed.
† The median, 16-, and 84-percentile values are listed. The format is "median 16-percentile – 84-percentile". For the calculation of these statistical values, we only use the patches where the PSF FWHM is successfully measured.
†† for limiting magnitude measured with 2″.0 apertures.
§ The values of the CFHT/u-band are the measurements for a large image (not the patch-by-patch measurements).

- SSA22 proto-cluster field at z = 3.1
- Subaru HSC **NB497 ~50 hrs exposure**
- Custom dithering pattern (reducing ghost)
- Data reduction with hscPipe8.4
- Careful sky subtraction for detection of filaments with >4 cMpc width
- Patch-by-patch measurements of PSF and limiting magnitude

3. Lya map

Lya emission is extracted from NB497 and g-band by following equations.
(cf. Mawatari et al. 2012,ApJ, 759,133)

$$f_{\lambda,n497} = f_{\lambda,cont} + \frac{F_{Ly\alpha}}{\Delta\lambda_{n497}}$$

$$f_{\lambda,g} = f_{\lambda,cont} + \frac{F_{Ly\alpha}}{\Delta\lambda_{g}}$$

$$F_{Ly\alpha} = \frac{\Delta\lambda_g \Delta\lambda_{n497}}{\Delta\lambda_g - \Delta\lambda_{n497}}(f_{\lambda,n497} - f_{\lambda,g})$$

Gaussian smoothing with ~100 ckpc

Top figure

Dynamic range of Lya surface brightness : -2.2 ~ +4.4 x 10^{-19} erg/s/cm^2/arcsec^2
(i.e., -2 ~ +4 x σ of deepest region)
White masked area: g-detected sources or short exposure (<10hrs) region in NB497

-1.9 -1.2 -0.56 0.099 0.76 1.4 2.1 2.7 3.4

Lya emitters