MIRACLES

Mapping of **I**onizing **RA**diation on the **C**osmic web with **L**yα **E**mission and **S**hadow

S21A-114QI

Yuichi Matsuda (NAOJ)

MIRACLES (HSC/98h/S21A-S23A)

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Subaru Telescope
National Astronomical Observatory of Japan

Semester	S21A
Proposal ID	S21A0114QI
Received	09/08/2020

Application Form for Telescope Time (Queue Normal+Intensive Programs)

1. Title of Proposal

Mapping of ionizing radiation on the cosmic web with Lya emission and shadow

2. Principal Investigator

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3. Scientific Category

- ☐ Solar System
- ☐ Extrasolar Planets
- ☐ Star Formation and Young Disk
- ☐ ISM
- ☐ Normal Stars
- ☐ Metal-Poor Stars
- ☐ Compact Objects and SNe
- ☐ Milky Way
- ☐ Local Group
- ☐ Nearby Galaxies
- ☑ IGM and Abs.Line Systems
- ☐ Cosmology
- ☐ Gravitational Lenses
- ☐ Clusters and Proto-Clusters
- ☐ Galaxy Properties and Environment
- ☐ High-z Galaxies(LAEs, LBGs)
- ☐ High-z Galaxies(others)
- ☐ AGN and QSO Activity
- ☐ Miscellaneous

4. Abstract *(approximately 200 words)*

We propose direct Lyα imaging of the cosmic web toward the $z = 3.09$ SSA22 protocluster with HSC. This program will map out the spatial distribution of both ionized HII gas (via Lyα emission) and neutral HI gas (via Lyα absorption) simultaneously in and around the protocluster in a cosmological volume of $180 \times 180 \times 50$ comoving Mpc by using the same, deepest NB497 image. We will unveil (1) the physical properties of the gas filaments, (2) the connection between the cosmic web and galaxies/AGNs, and (3) the role of the cosmic web on cluster formation. To identify HII gas filaments down to Lyα surface brightness of $SB_{Ly\alpha} = 3 \times 10^{-19}$ ergs s^{-1} cm^{-2} arcsec^{-2} with a 3-σ level at a 3-arcsec resolution, we request 63 hours integration for NB497, in addition to 6 hours for g-band, and 9 hours for r-band images for precise continuum correction. To trace HI gas overdesity with a 5 cMpc resolution, we request 3 hours integration for NB527 to select $\sim$400 LBGs at $z = 3.3$ with Lyα emission as background light sources. This special combination of emission and absorption line studies will enable us to constrain the total mass of main gas reservoir and radiative feedback process during the peak epoch of galaxy, super massive black hole, and cluster formation.

5. Co-Investigators

4 more Co-Is

Name	Institute	Name	Institute
Hideki Umehata	RIKEN	Michele Fumagalli	Durham University
Ken Mawatari	Univ. of Tokyo	Ian Smail	Durham University
Hidenobu Yajima	Univ. of Tsukuba	David Alexander	Durham University
Masayuki Umemura	Univ. of Tsukuba	Yoichi Tamura	Nagoya Univ.
Masao Mori	Univ. of Tsukuba	Keiichi Matsuda	Nagoya Univ.
Takuya Hashimoto	Univ. of Tsukuba	Satoshi Kikuta	NAOJ
Scott Chapman	Dalhousie University	Kentaro Nagamine	Osaka Univ.
Tomoki Hayashino	Tohoku Univ.	Masami Ouchi	Univ. of Tokyo
Toru Yamada	JAXA	Yoshiaki Ono	Univ. of Tokyo
Charles Steidel	Caltech	Kotaro Kohno	Univ. of Tokyo

6. Thesis Work

☐ This proposal is linked to the thesis preparation of _____

7. Subaru Open Use Intensive Programs

☑ This is a proposal for Intensive Programs.

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Proposal ID S21A0114QI

Title of Proposal

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12. Observing Run

Instrument	Hours	Moon phase	Moon distance	Seeing	Transparency	OnSrc Hours
HSC	98	dark/gray	120	3	0.7	81

comments:

Total Requested Number of Hours 98 Minimum Acceptable Number of Hours 9

13. Instrument Requirements *Specify the set of filters to use (HSC).*

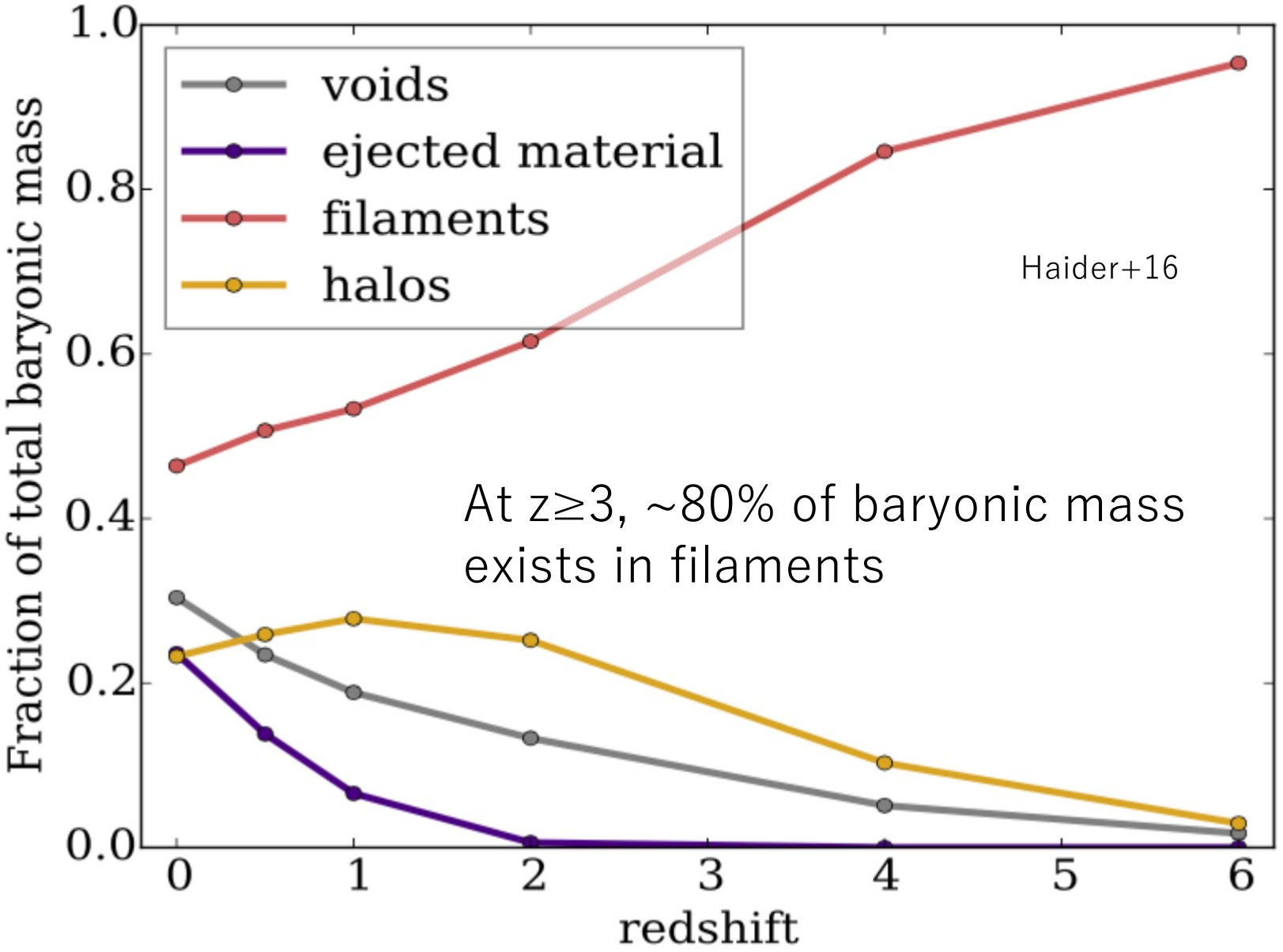
We are going to use g, r, $NB497$ and $NB527$ filters.

14. List of Targets

Target Name	RA	Dec	Magnitude (Band)
SSA22	221734.00	+001700.0	30.4 ABmag arcsec^{-2} ($NB497$)

Akio Inoue, Ikki Mitsuhashi, Mariko Kubo,
Rieko Momose, Satoshi Yamanaka

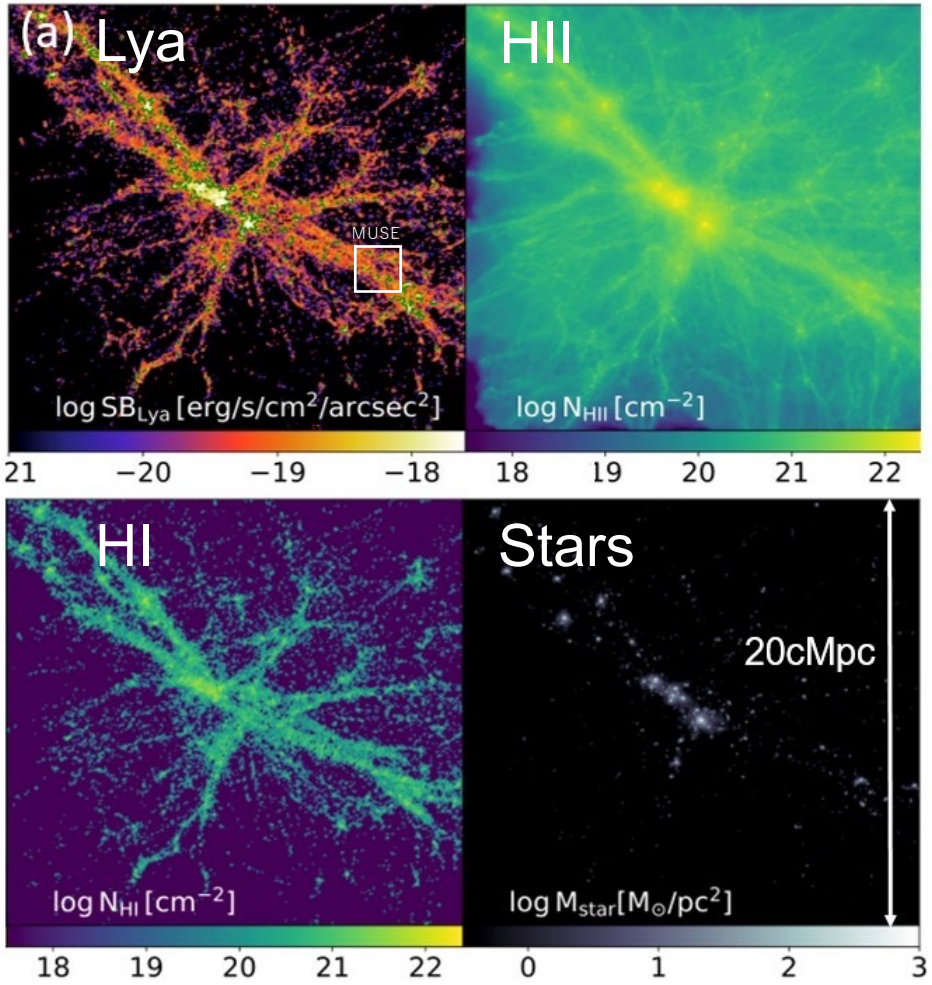
Cosmic Web: Main Gas Supplier for Galaxy Formation



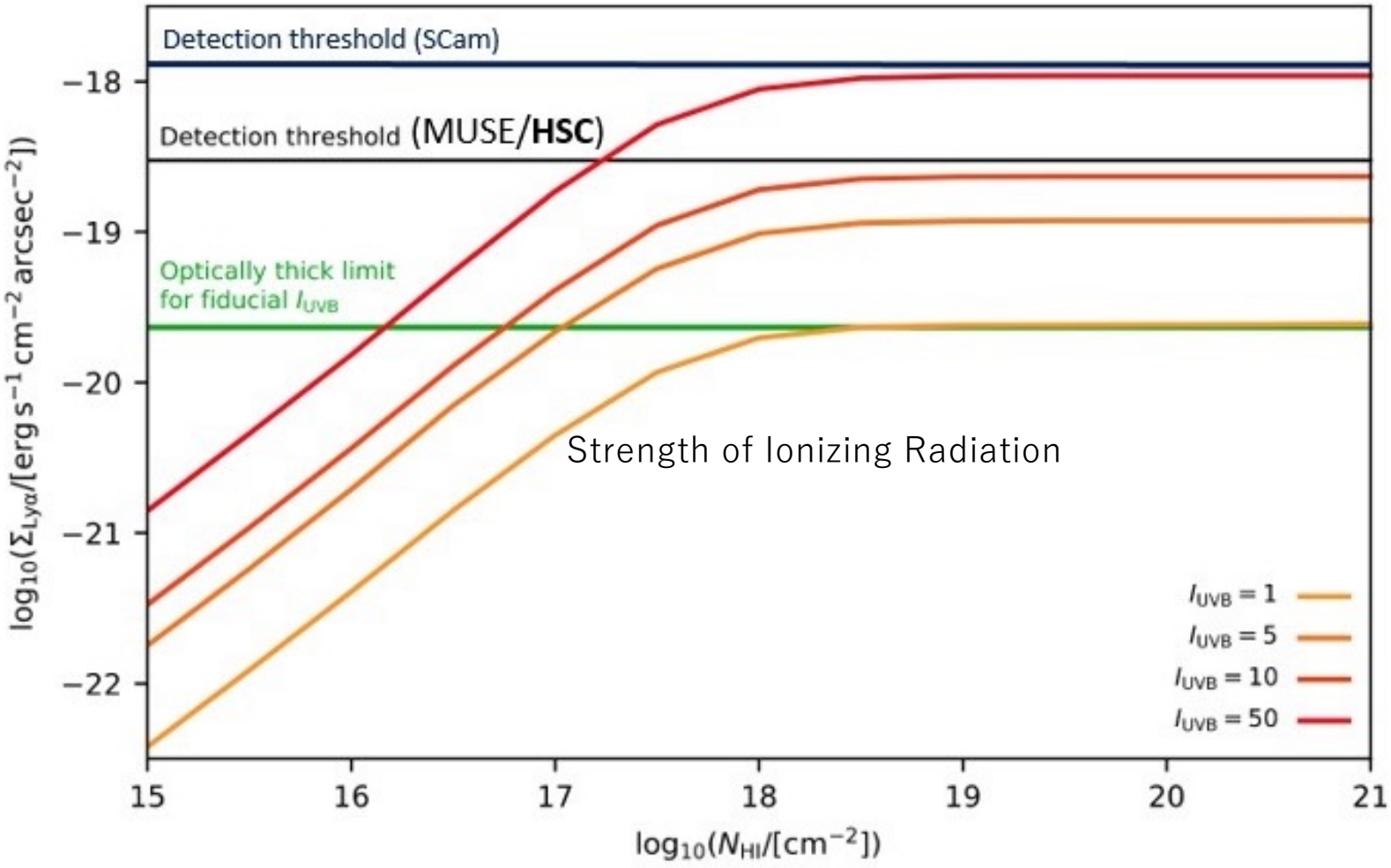
Mapping of Lya emission & absorption lines

Lya surface brightness ⟺ Ionizing radiation field

Predicted Lya emission from z=3 (Yajima+21)

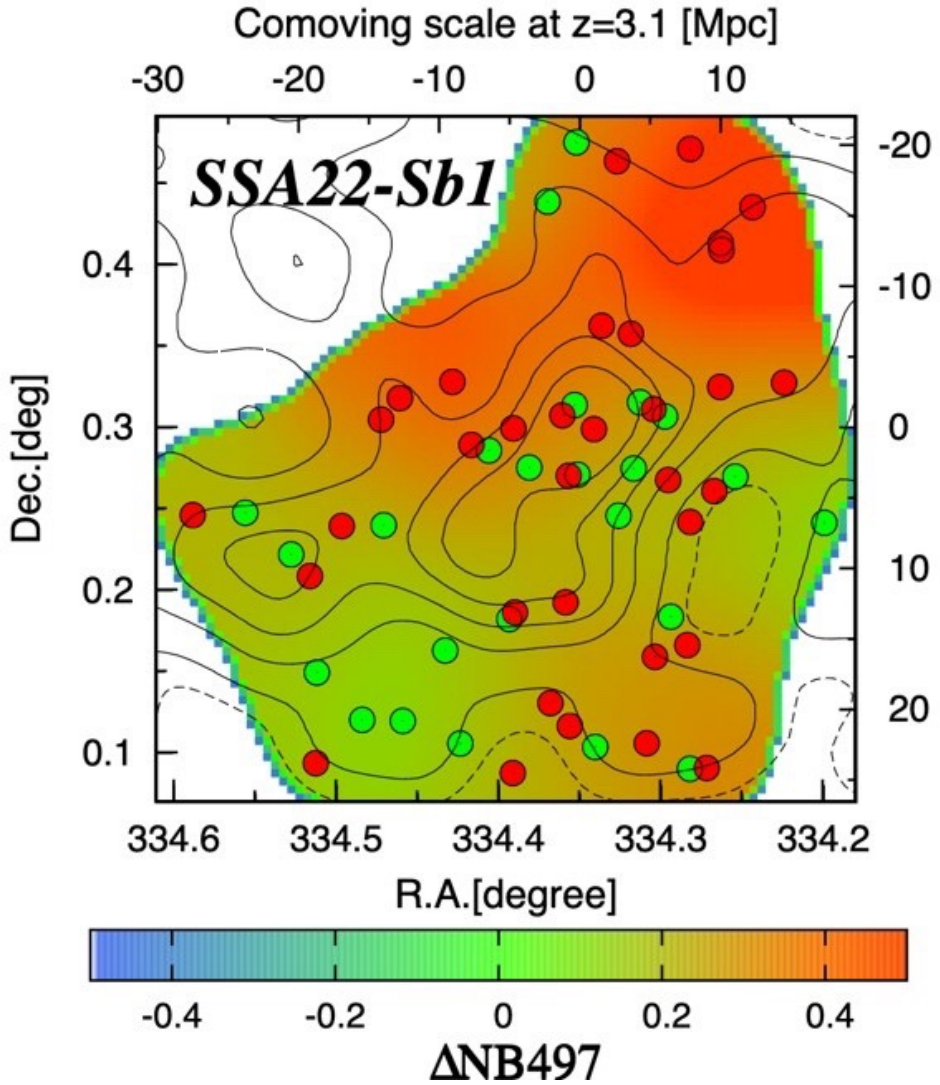


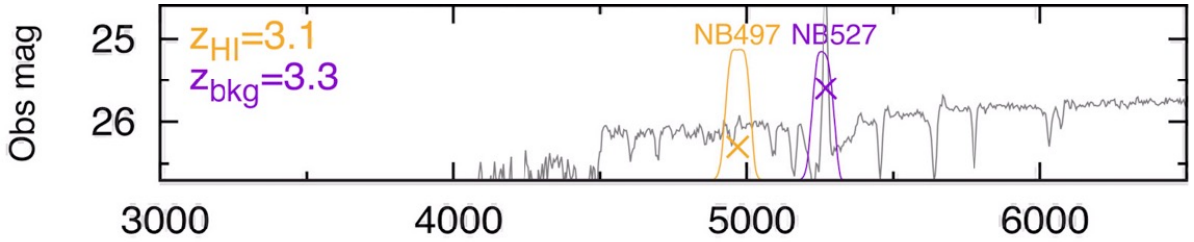
Umehata+19

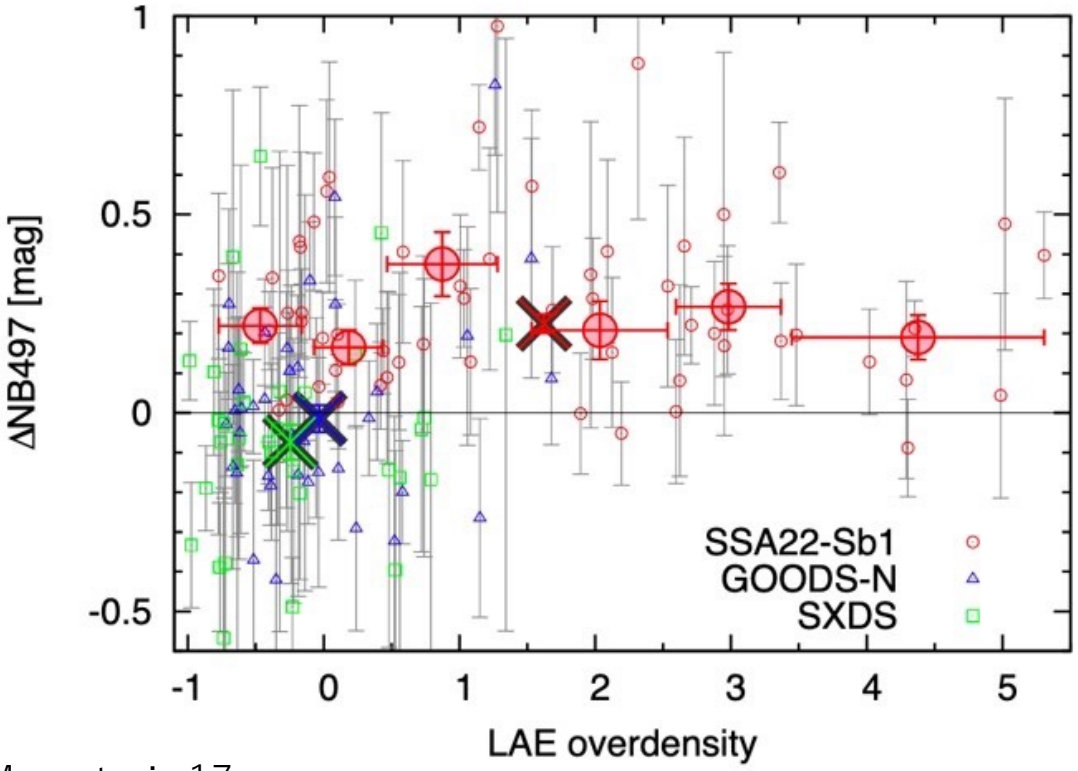


Mapping of Lya emission & absorption lines

2D HI map with a 5cMpc resolution





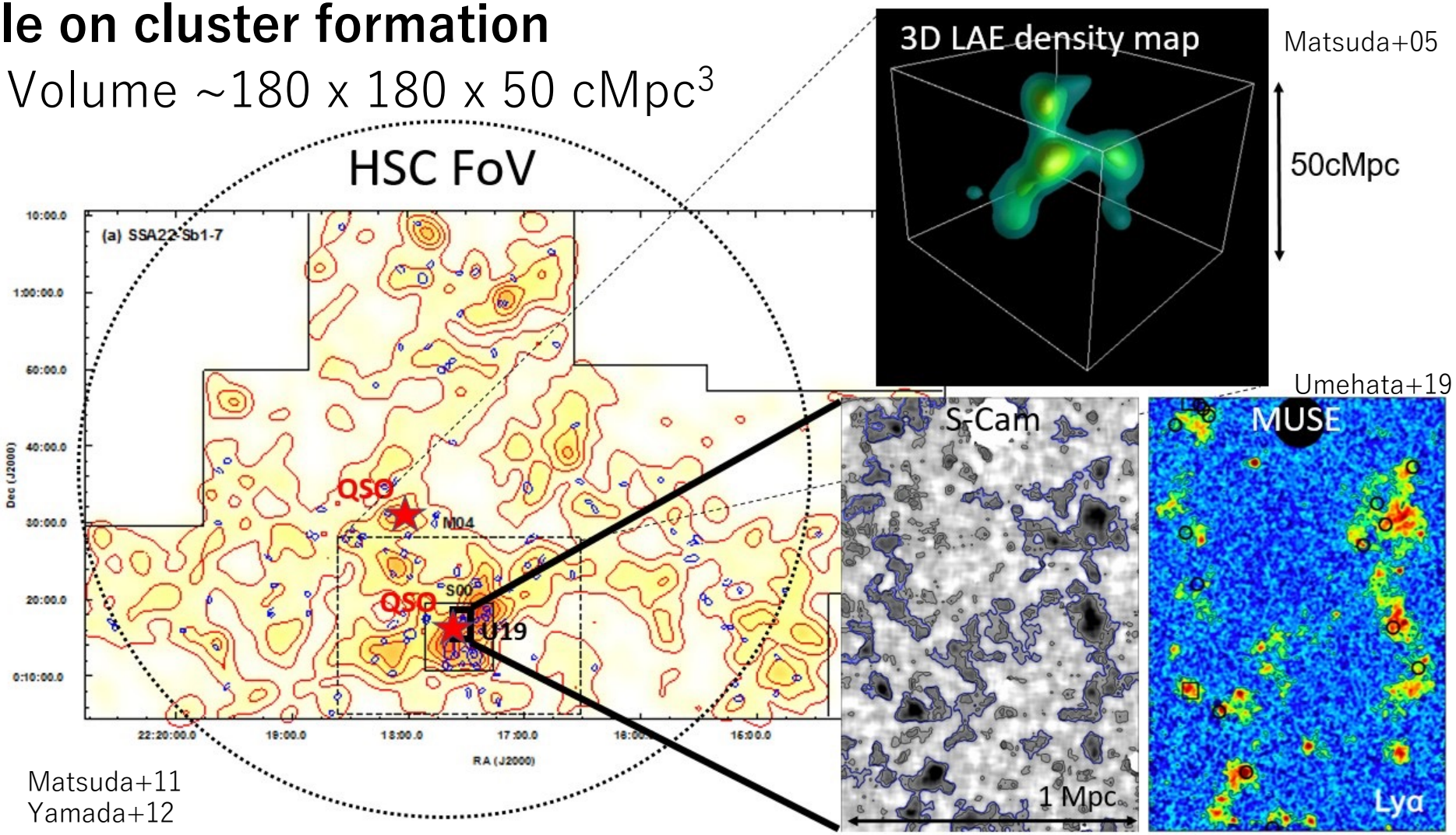


Mawatari+17

Science Goals

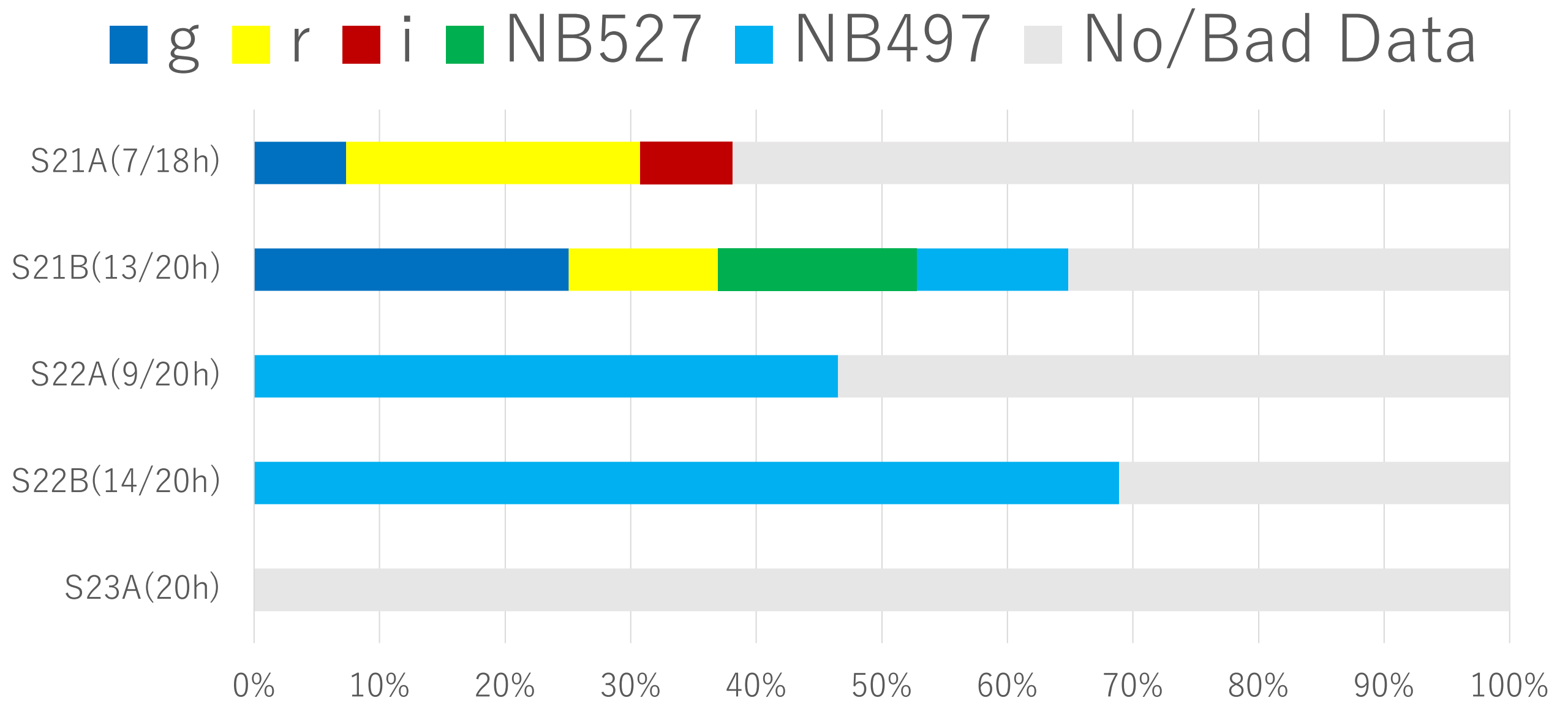
(1) The physical properties (width, length, mass, & ionizing radiation field)
(2) The connection with galaxy / black hole growths
(3) The role on cluster formation

Survey Volume ~180 x 180 x 50 cMpc^3

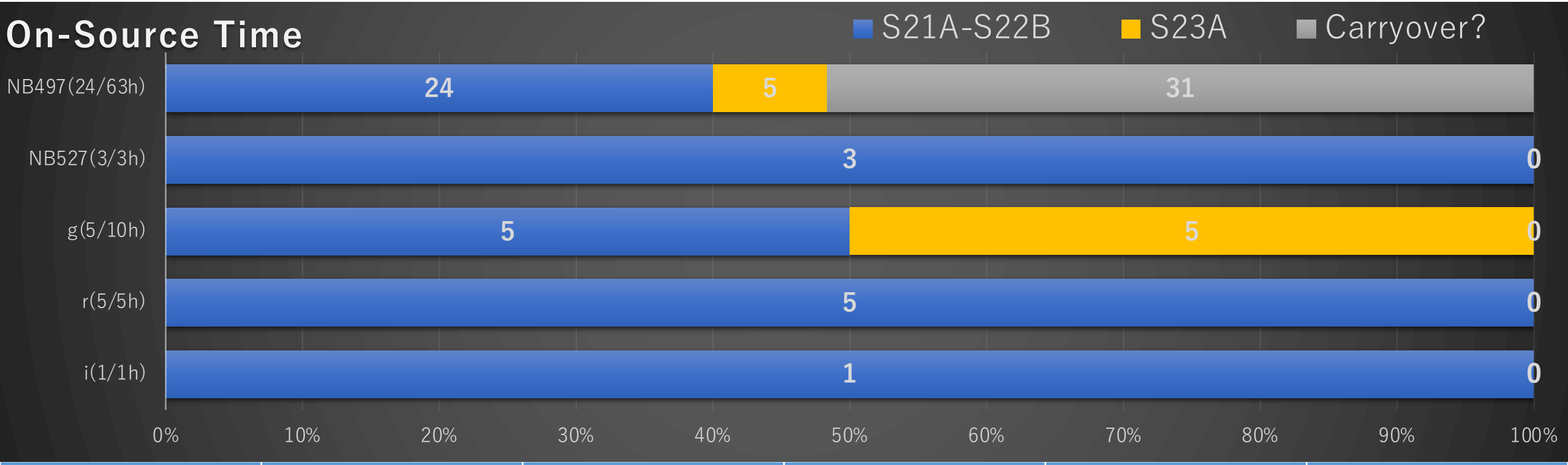


Matsuda+11
Yamada+12

Completion Rate (55%)

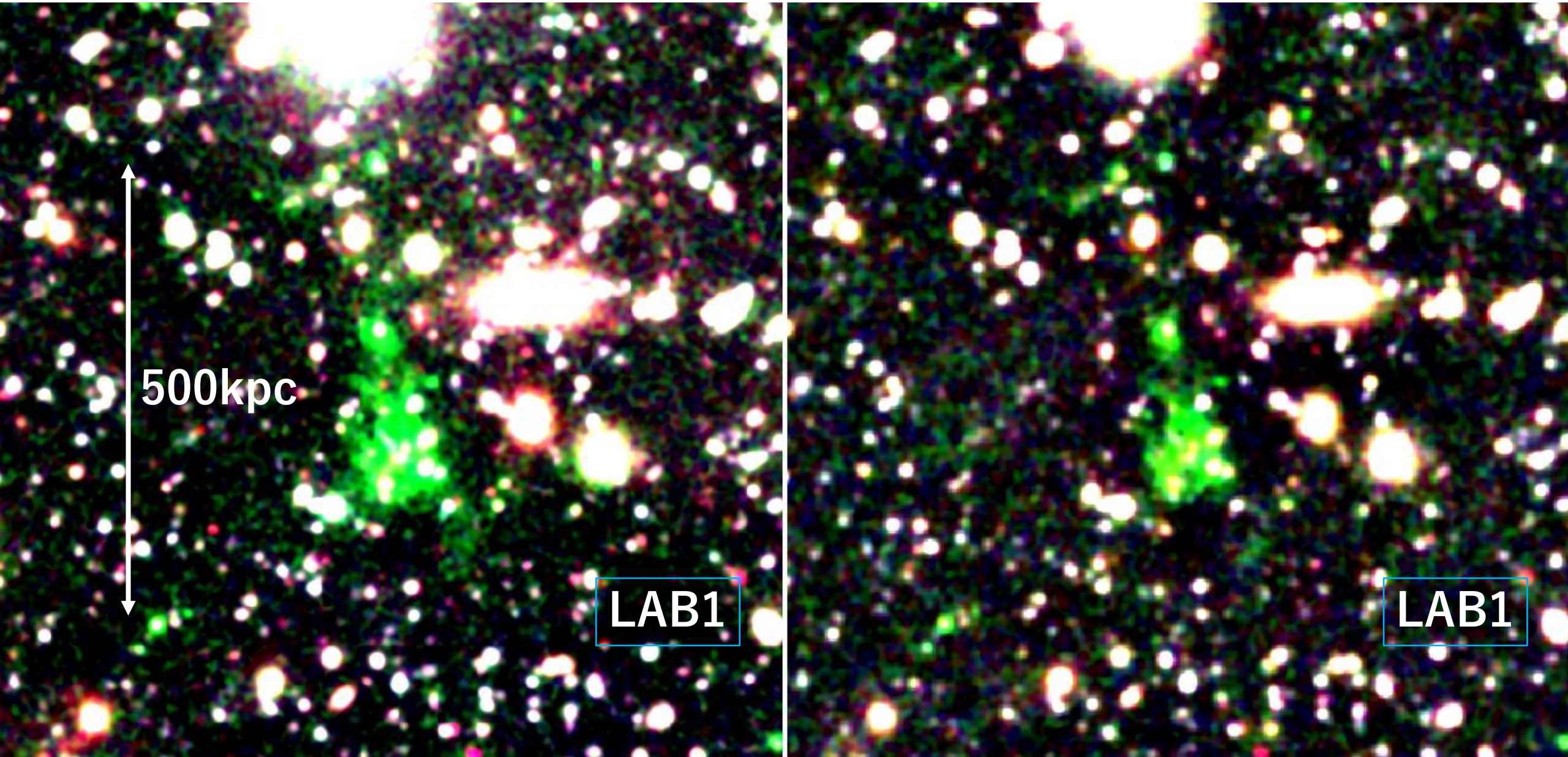


Data Quality (S21A-S22B)

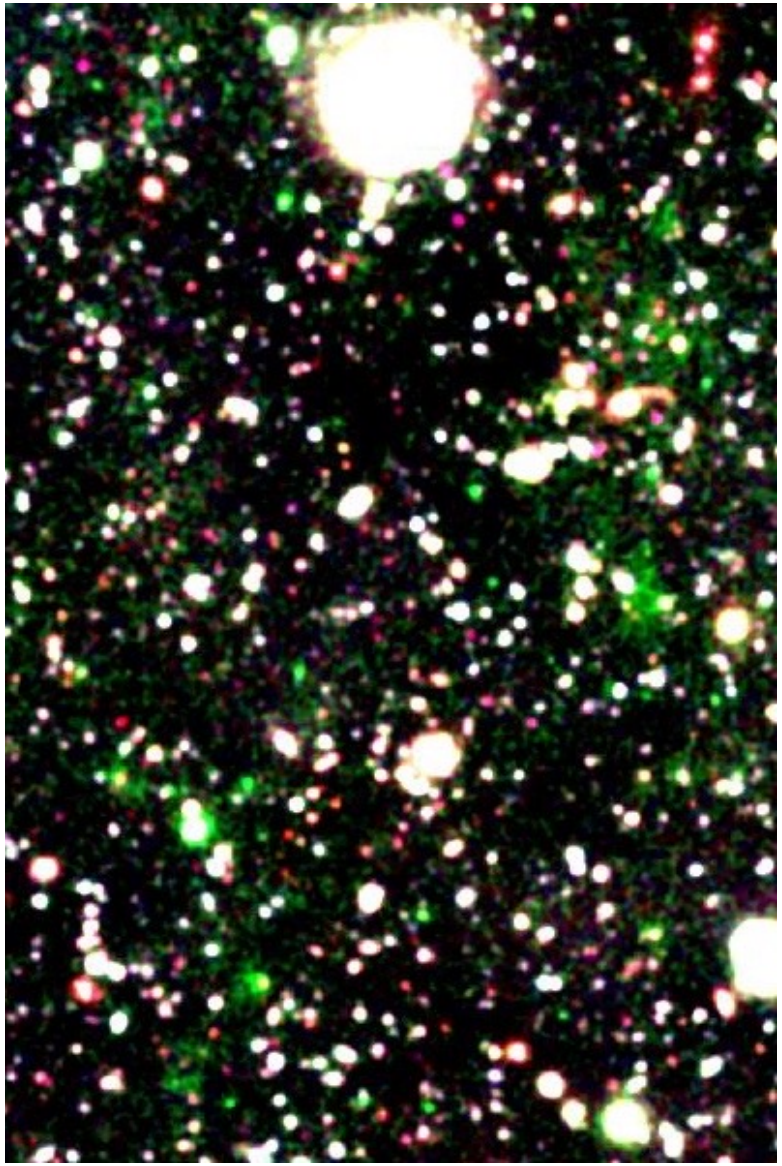


S21A-S22B data	NB497	NB527	g	r	i
5 σ depth (2” ap) [target depth]	27.0ABmag [28.0ABmag]	26.2ABmag [26.7ABmag]	27.8ABmag [28.6ABmag]	27.6ABmag [28.2ABmag]	26.2ABmag [26.8ABmag]
Seeing	0.84”	0.75”	0.82”	0.66”	1.64”

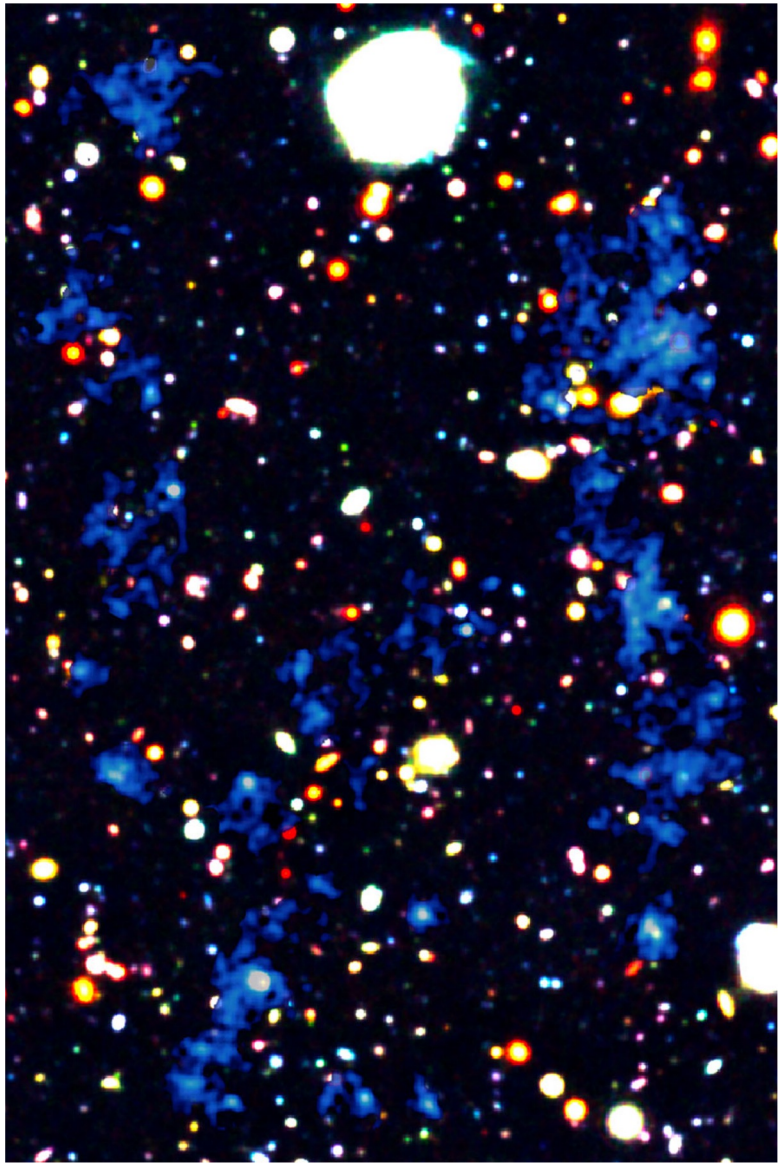
HSC vs SCam

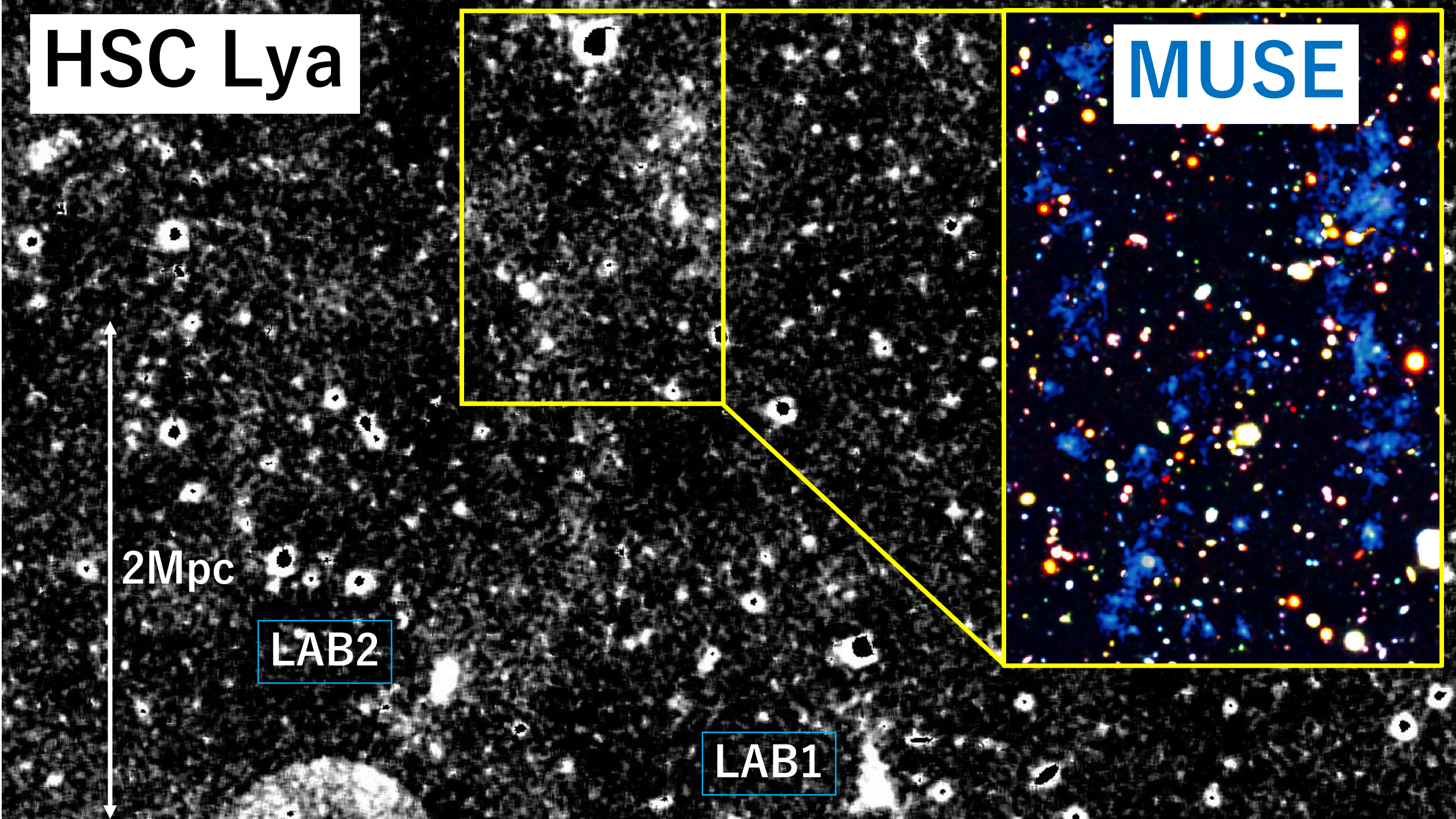


HSC vs MUSE



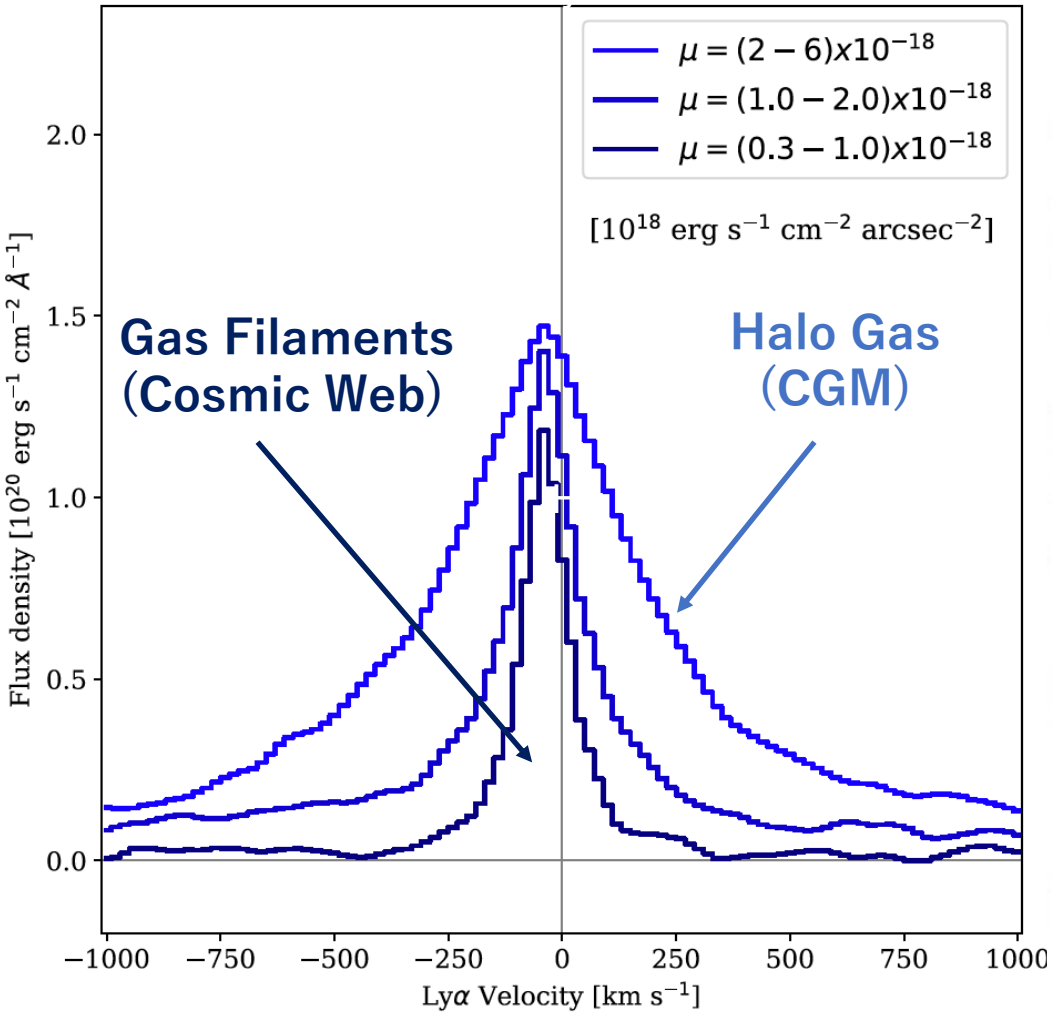
1.5Mpc




HSC Lya
MUSE
2Mpc
LAB2
LAB1

HSC just started detecting the Cosmic Web with log SB_{Lya}<-18 erg/s/cm^2/arcsec^2

Umehata+19



Survey Area ~ >1000 x larger than MUSE