CHORUS (Cosmic HydrOgen Reionization Unveiled with Subaru): Progress report 2018.08

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ON BEHALF OF CHORUS TEAM

CHORUS FILTER SET

Filter	Developer	Budget source
NB387	K. Shimasaku (U. Tokyo)	JSPS Kakenhi
NB527	I. Iwata (NAOJ)	JSPS Kakenhi
NB718	Y. Taniguchi (Ehime U.)	MEXT
NB921 (SSP)	M. Ouchi (U. Tokyo)	JSPS Kakenhi
IB945	A. Inoue (Osaka S. U.)	JSPS Kakenhi
NB973	M. Ouchi (U. Tokyo)	JSPS Kakenhi

Coordinated by the HSC filter consortium (and there are more)

OBSERVATION SCHEDULE

Dates	Filter	Reports
Jan/26/2017 Jan/28/2017	NB973	~15 h data of COSMOS (+ ~5 h of SXDS UD)
Feb/25/2017	NB718	No meaningful data due to thick clouds
Mar/23/2017 Mar/25/2017	NB718	~6 h data of COSMOS (+ 40min each for 4 points in ELAIS-N1 D)
Dec/16-18/2017	NB527	Almost cloudy, 0.5 h data of COSMOS
Jan/17-19/2018	NB387	~21 h data of COSMOS but seeing ~1.2 arcsec
Mar/15, 16, 18/2018	NB527	~10 h data of COSMOS (seeing ~1 arcsec)
Dec/2018 0.5 nights + 11.5h (S18B Queue)	IB945	
		Total 13+ nights

LIMITING MAGNITUDES

CHORUS team reduction (hscPipe ver.4)

Filter	Request (5σ,2") [AB]	Usable exposure [sec]	ETC (*) (5σ,1.5") [AB]	Achieved (5σ) [AB]	PSF size [arcsec]	Remarks
NB387	26.8					ongoing
NB527	27.5	32,361	27.60	26.7 (Φ1.6")	0.82	
NB718	26.8	27,600	27.13	26.2 (Φ1.5")	0.69	
IB945	26.2	-	-	-	-	
NB973	25.6	52,800 16,800	25.90 25.27	24.9 (Φ1.5") 24.2 (Φ1.5")	0.64 0.78	COSMOS SXDS

- 1 mag shallower than ETC.
  - M1 reflectivity degrade was ~40% ?
  - Sky model in ETC is too optimistic ?

(*) Dark, transparency 0.9, seeing 0.7", point source
(The seeing value does not change the ETC results, why?)

SUMMARY

- **CHORUS observation is 80% complete.**
- **The last filter (IB945) will be scheduled in December.**
  - We have 0.5 nights and additional 11.5 hours in S18B HSC Queue.
- **The achieved limiting magnitudes are 1 mag shallower than those expected by ETC.**
  - M1 reflectivity ? and/or optimistic sky ?

DISCUSSION

- **Retake for NB387 ?**
  - NB387 can be installed in March
  - Need to estimate the limiting magnitude.

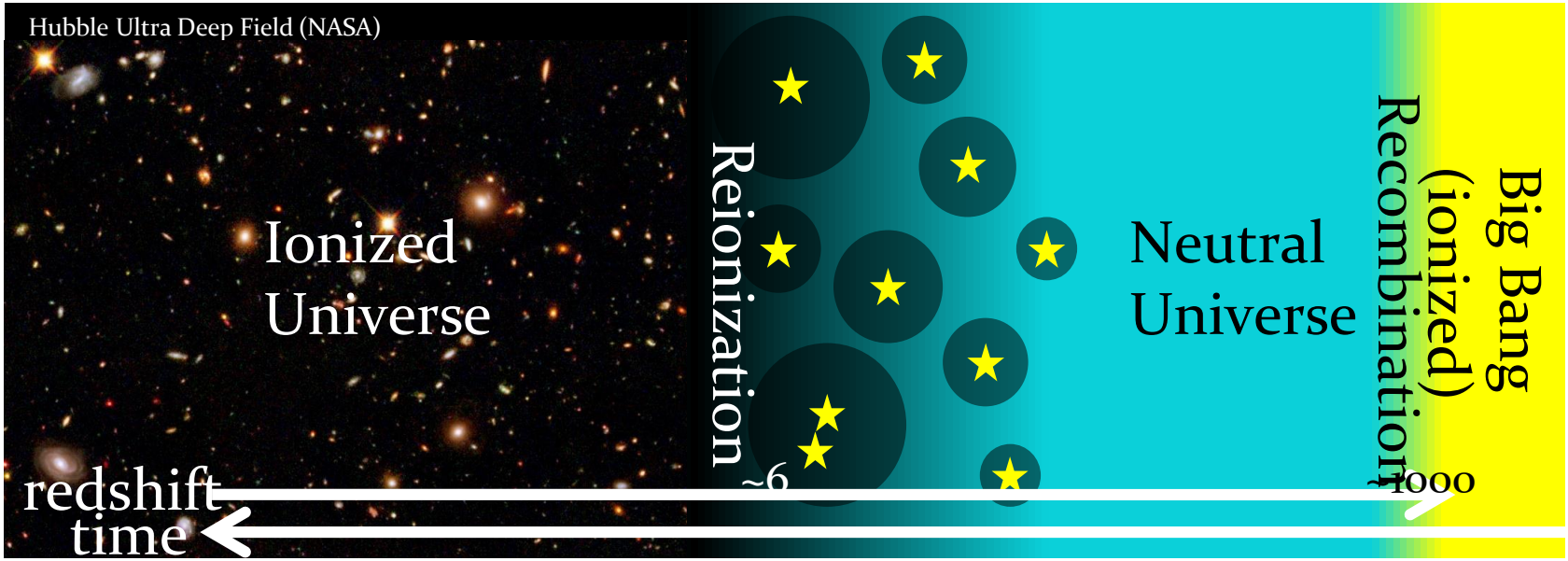
- **Follow-up for interesting objects ?**
  - NB527-NB718 LyC emitter candidates at z=4.9

BACKUP

REVEALING REIONIZATION

- **History**
- **Sources**
- **Topology**

- SSP LAE LF/ACF measurements



STRATEGY

HSC-SSP UD

5 Broadband filters (g, r, i, z, Y)

1 Narrowband NB921

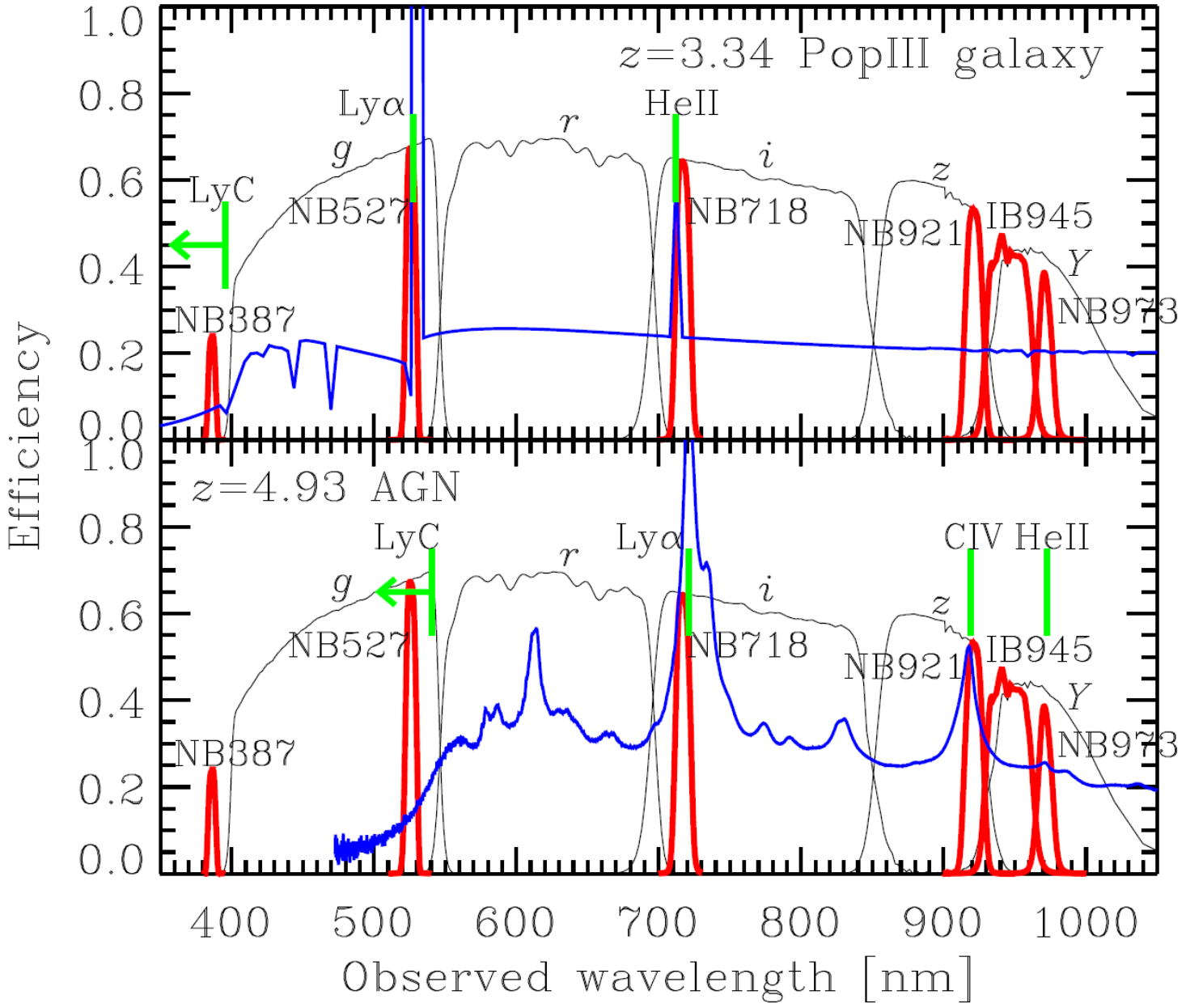
There are two more NBs in SSP: NB816, NB101

5 Narrowband filters

NB387, NB527, NB718, IB945, NB973

→ **CHORUS**

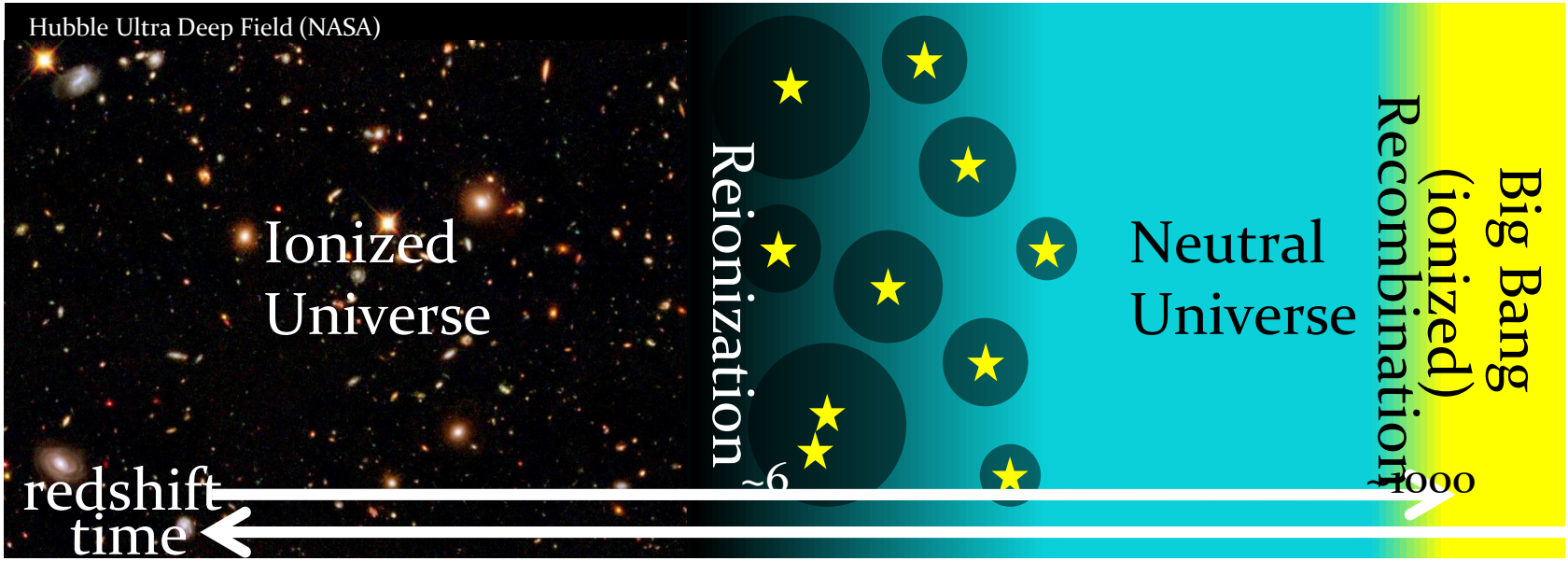
CHORUS FILTER SET



REVEALING REIONIZATION

- **History**
- **Sources**
- **Topology**

- SSP LAE LF/ACF measurements
- LyC measurements of galaxies and AGNs
- Faint-AGN LF measurements
- Pop-III SFRD measurements
- Visualization of spatial distribution of xHI



OBSERVATION STATISTICS

Clear fraction

Dates	Allocation [n]	Filter	COSMOS visible [h]	Success [h]	Fraction [%]
Jan/26, 28/2017	2	NB973	15	15	100
Feb/25/2017	1	NB718	8	0	0
Mar/23, 25/2017	2	NB718	12	6	50
Dec/16, 17, 18/2017	1.5	NB527	15	0.5	3
Jan/17, 18, 19/2018	3	NB387	21	21	100
Mar/15, 16, 18/2018	3	NB527	18	10	55
	12.5 /13		89		53

Clear fraction
(nominal ~70%)

OBSERVATION STATISTICS

Achievement fraction

Filter	Request [h]	Achieved [h]	Fraction [%]	Used [n]	Dates
NB387	15	21	140 (~1.2”)	3	Jan/17, 18, 19/2018
NB527	12	10.5	87.5	4.5	Dec/16, 17, 18/2017 Mar/15, 16, 18/2018
NB718	8	6	75	3	Feb/25, Mar/23, 25/2017
IB945	15	-	-	-	
NB973	15	15	100	2	Jan/26, 28/2017
	65	52.5	80.8	12.5 /13	

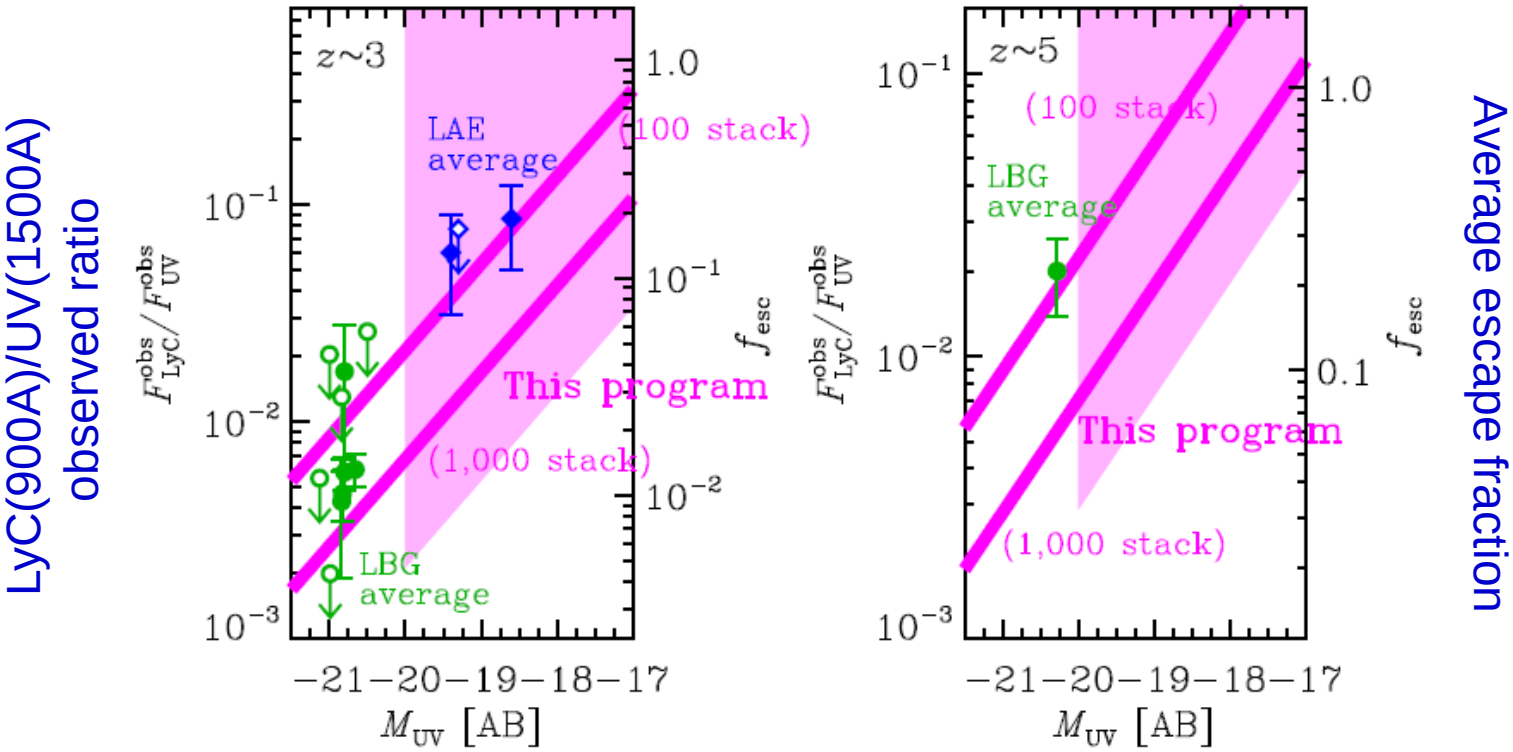
Only 0.5 nights are left for IB945.
We have requested an OPEN USE program in S18B to complete IB945.

LYC EMISSIVITY OF GALAXIES

JWST target

Redshift	LyC	Lyα	# of obj.
3.3	NB387	NB527	~10k
4.9	NB527	NB718	~6k

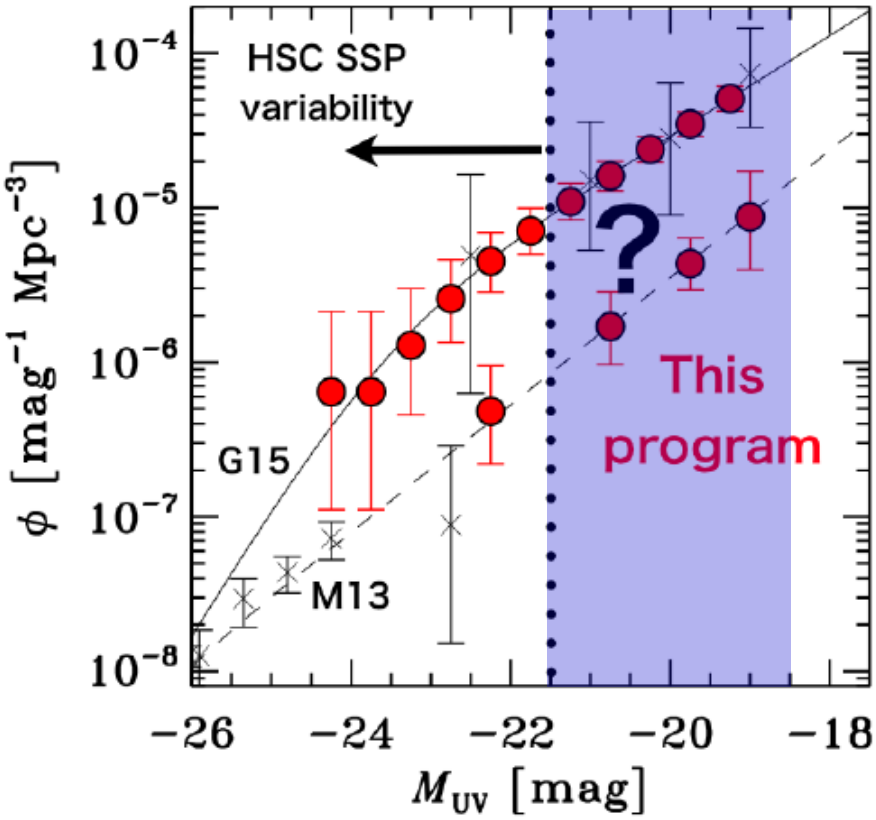
Individual detections (~40@z~3, ~10@z~5) → Characterize of LyC emitters
Average LyC emissivity of LAEs → Galaxies' role in reionization



FAINT-AGN LF

Faint-AGN＝Lyα-CIV dual emitters

Redshift	LyC	Lyα	CIV	Offband	HeII
4.9	NB527	NB718	NB921	IB945	NB973



If Giallongo+15 LF is correct, only AGN can complete reionization.

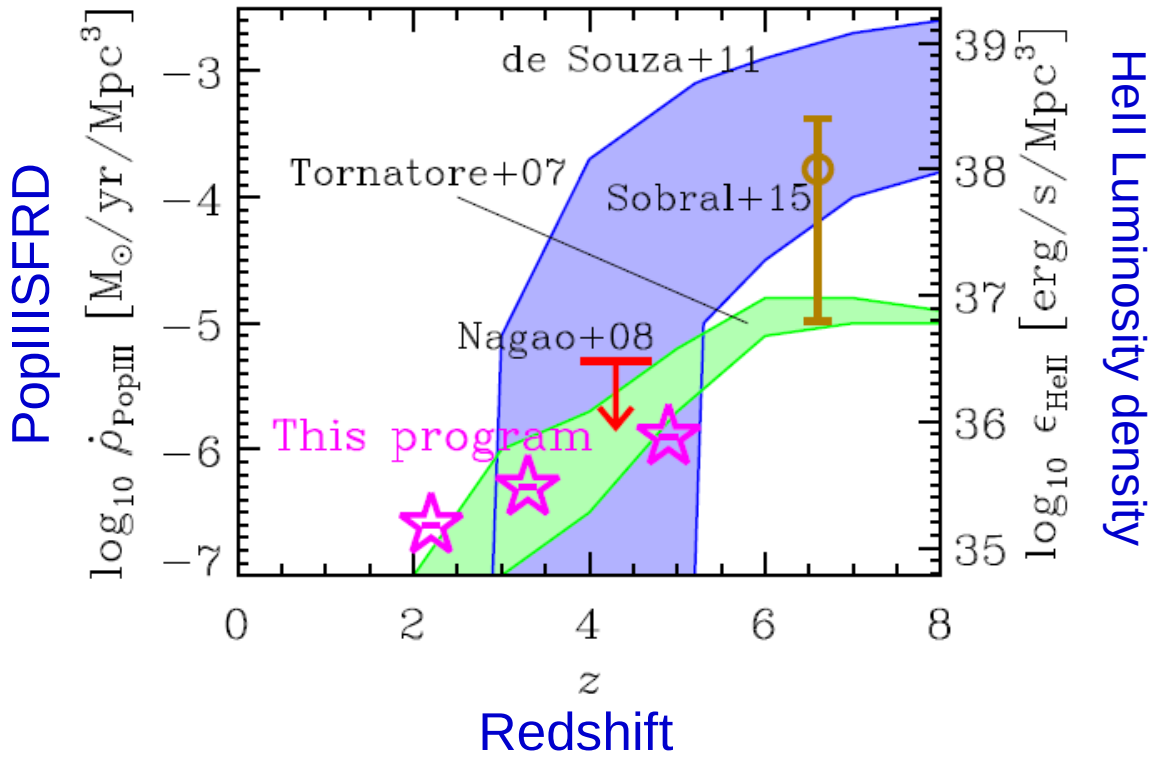
- 2.5 mag fainter AGNs than the SSP's variability survey can be detected.
- Direct measure of LyC from AGNs

⇒ Revealing the role of faint-AGNs in reionization.

POP-III ABUNDANCE

Pop-III galaxy candidates ＝Lyα-HeII dual emitters

Redshift	Lyα	Offband	HeII	SFR lim.[Mo/yr]
2.2	NB387		NB527	0.15
3.3	NB527		NB718	0.48
4.9	NB718	IB945	NB973	1.7

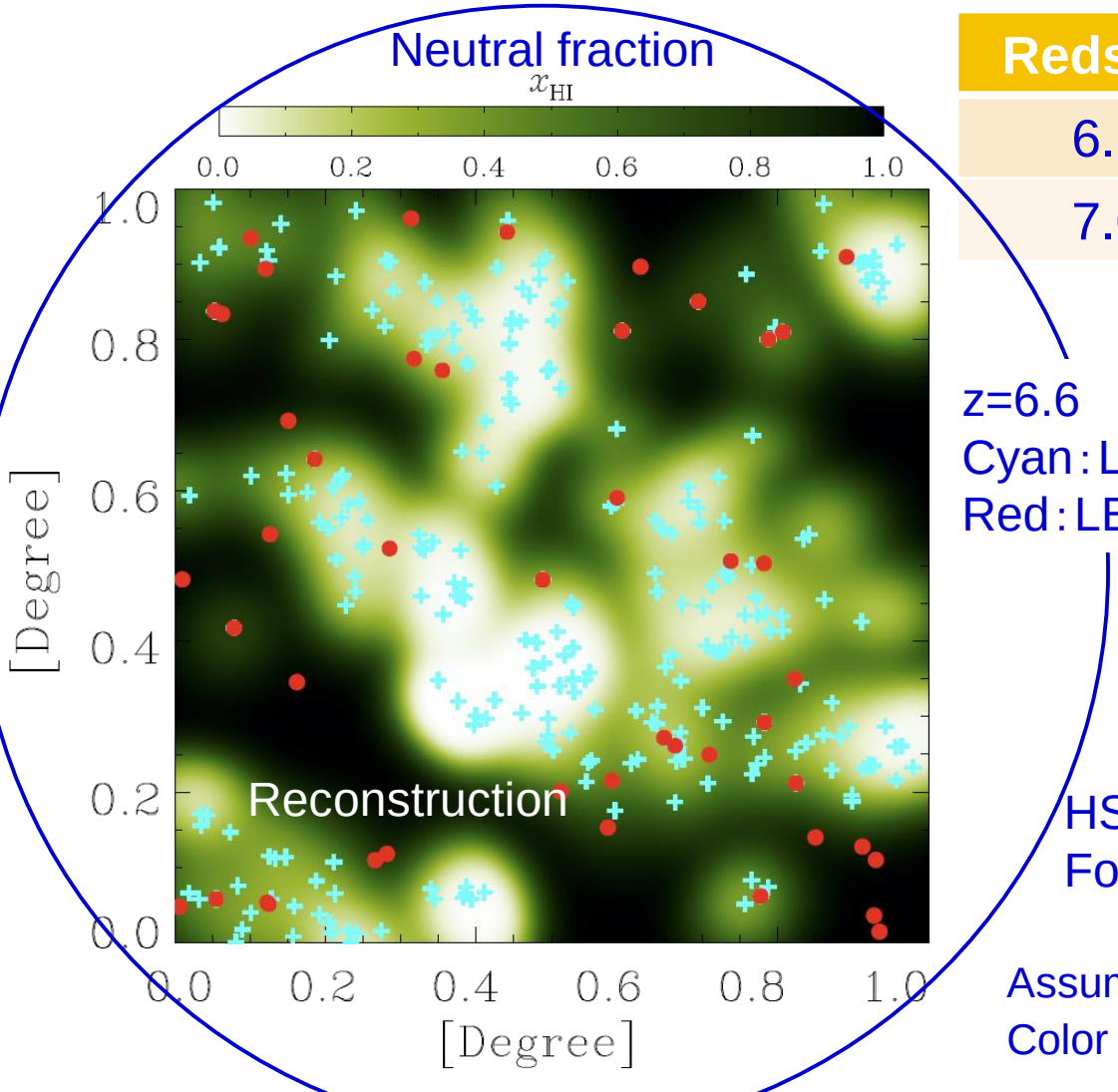


JWST spectroscopy for candidate objects → Pop-III IMF

There are contamination of AGN and WR stars in the detected Lyα-HeII dual emitters.

VISUALIZATION OF HI DIST.

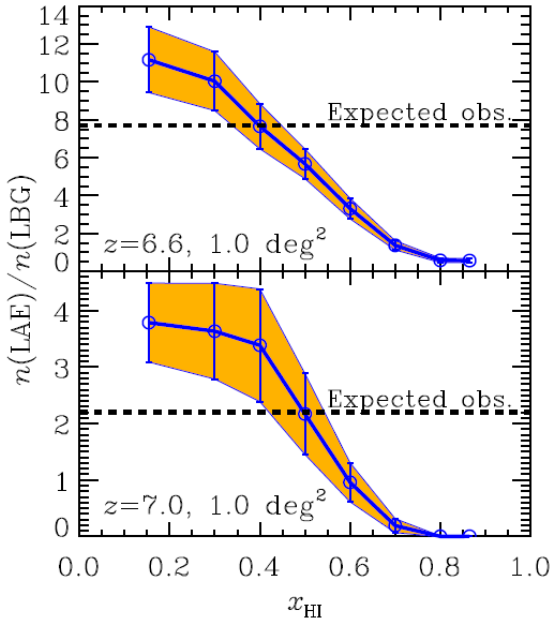
- **LAE/LBG number ratio well correlates with the neutral hydrogen fraction.**
- **By using IB945, LBG selection tailored to LAE redshift can be realized.**



z=6.6
Cyan : LAE
Red : LBG

HSC
FoV

Redshift	LAE selec.	LBG selec.
6.6	NB921	IB945, z, Y
7.0	NB973	IB945, z, Y



Assuming $x_{HI} - T_{Ly\alpha}^{IGM}$ (Jensen+13)
Color selection with photometric errors

DATA PRODUCT

- **Final product of CHORUS will be images and catalogs made by the SSP team using the latest version of the pipeline.**
- **CHORUS team has made "β-version" using hscPipe ver.4 (S16A) to start scientific analyses before the SSP team's reduction.**
- **SSP team reduced the NB images using the hscPipe ver.5 (S17A) but the catalogs have a problem (see next page).**
- **CHORUS team continues to use the "β-version" (S16A) currently and recommends it to all HSC SSP members.**
- **Both (S17A [ver.5] and S16A [ver.4]) of NB718 and NB973 photometric catalogs are already available in the HSC database.**
  - Using the NB photometry, just email to us.
  - If you like to access the NB images, please become a member of CHORUS. How? Just email to us.

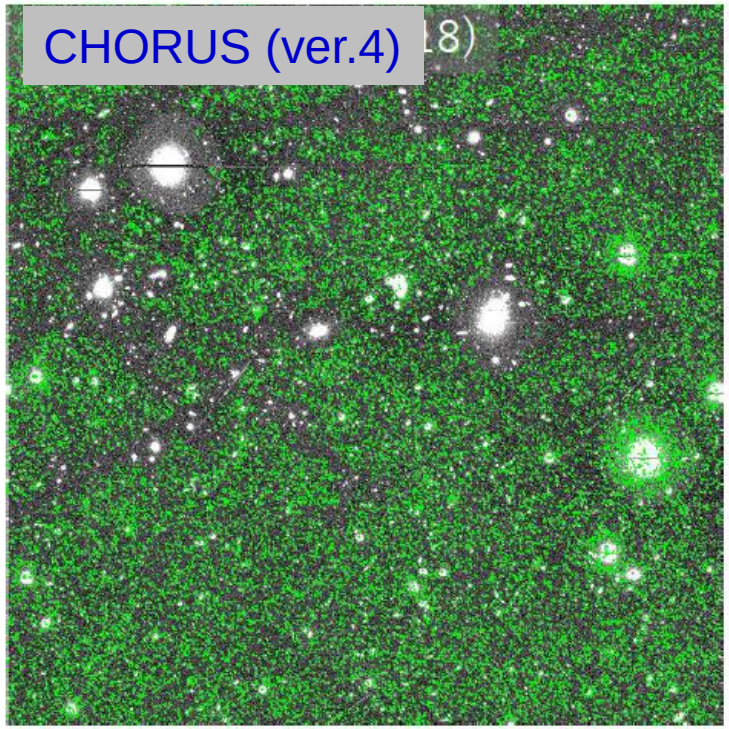
ISSUE IN HSC PIPELINE V.5

- **The S17A (ver.5.4) pipeline has a problem in source detections.**
  - The problem is caused by artifact rejections ?

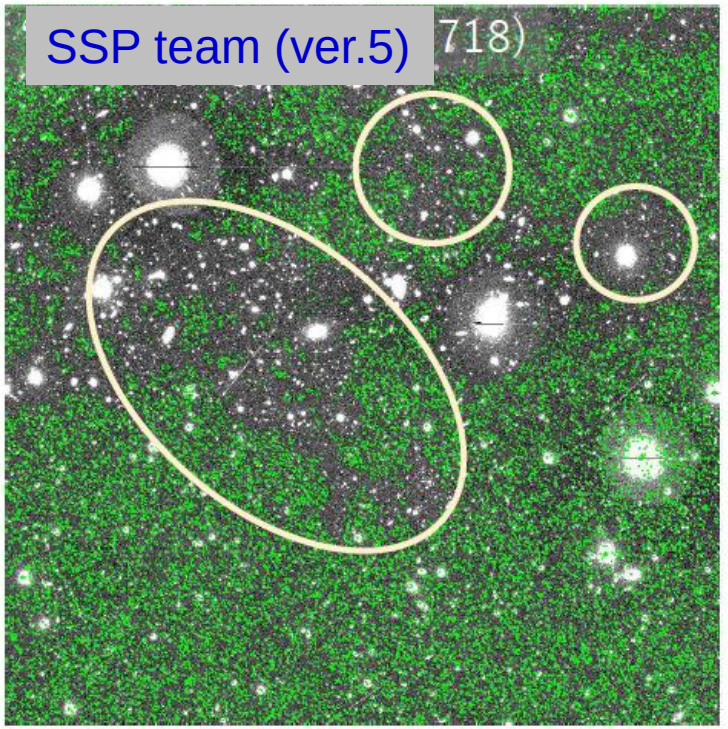
Source detection problem in hscPipe 5.4

- hscPipe 5.4 source detections are strange in some areas!

CHORUS (ver.4)



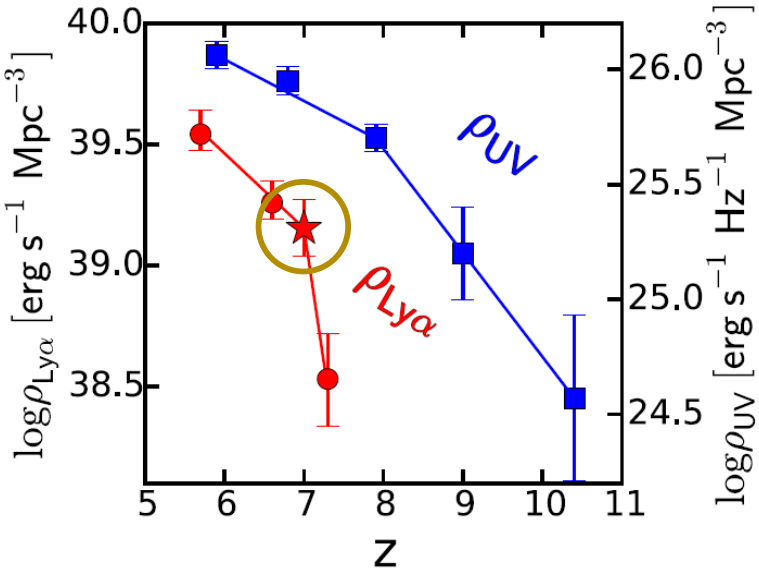
SSP team (ver.5)

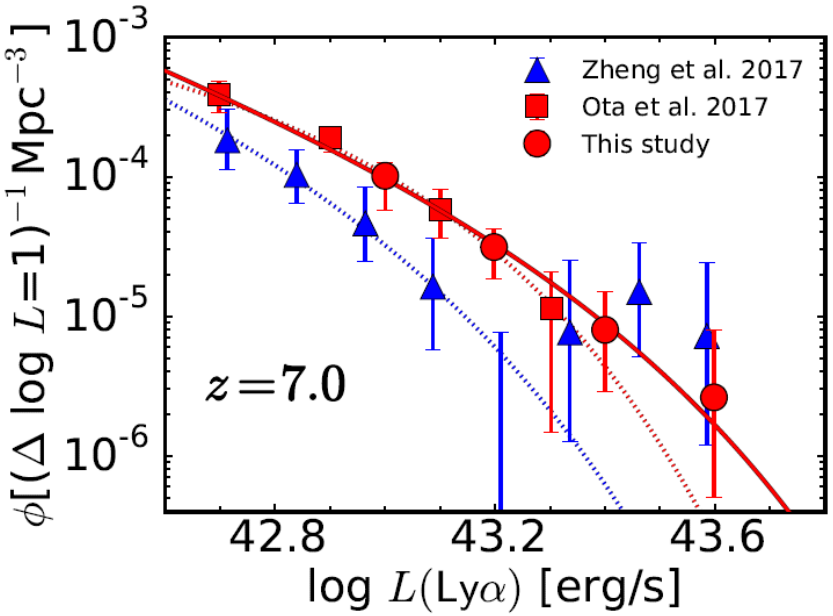


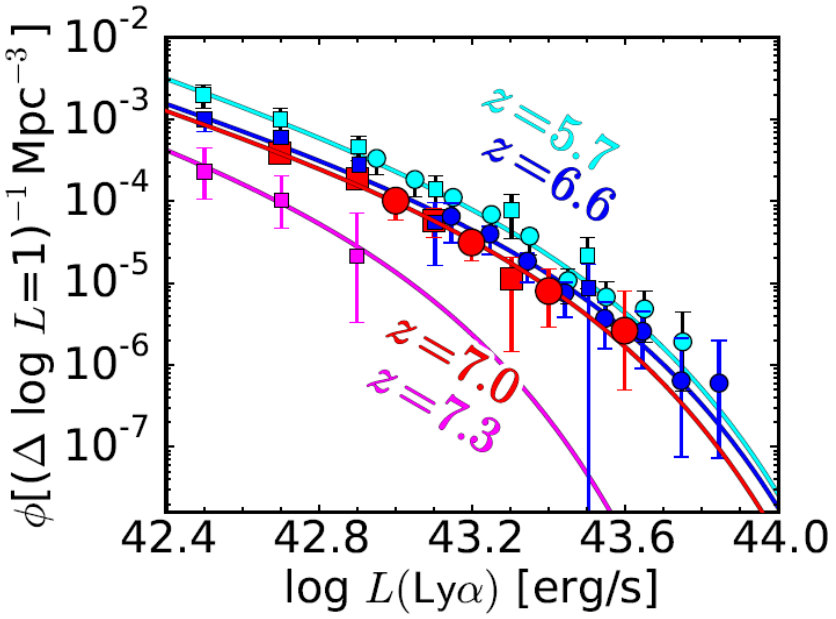
SCIENCE RESULTS #1

R. Itoh (U. Tokyo) et al. submitted (arXiv:1805.05944)

- LAE luminosity function at z=7.0
- A rapid decline of the LAE LF and LyA luminosity density between z=7.0 and z=7.3.



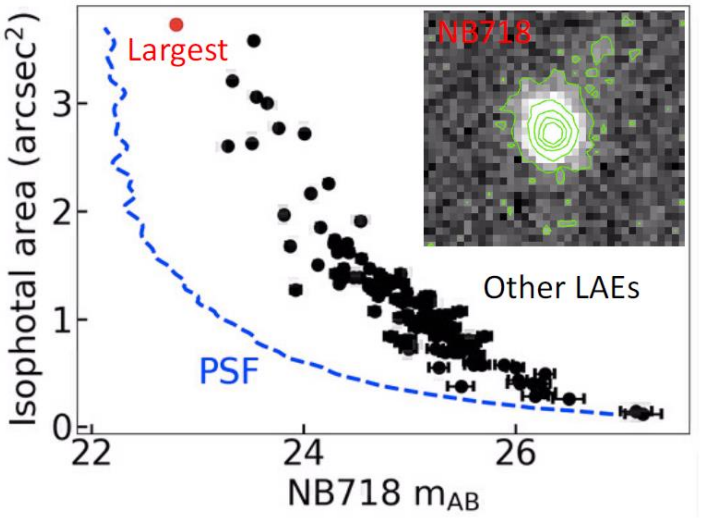


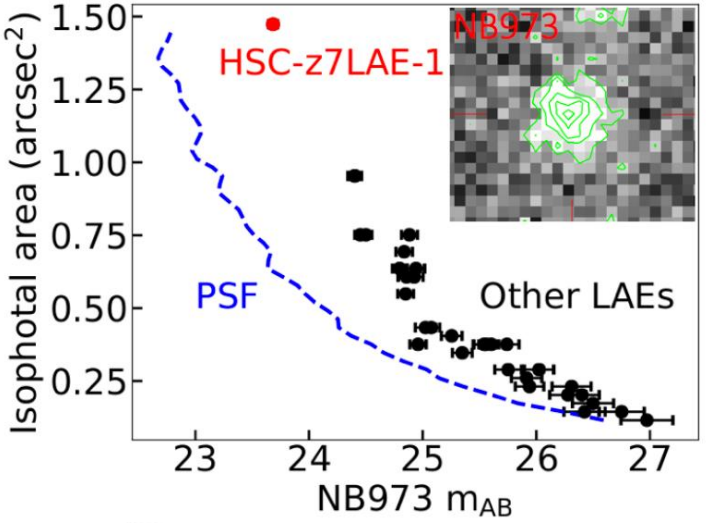


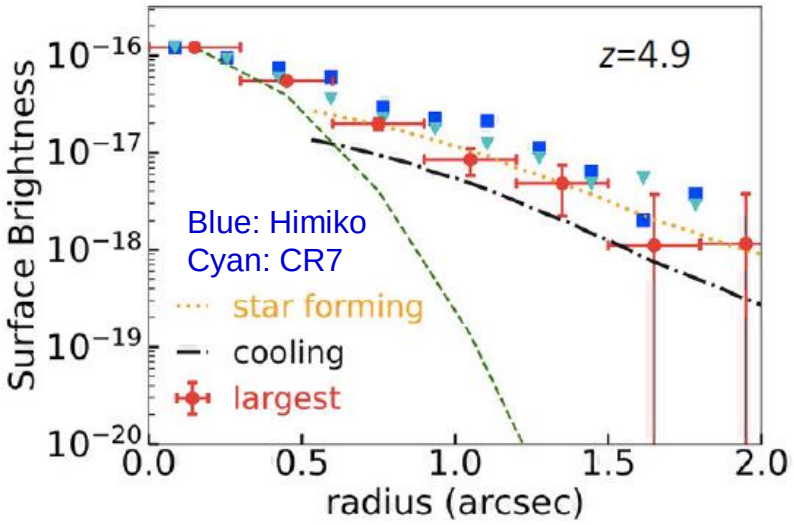
SCIENCE RESULTS #2

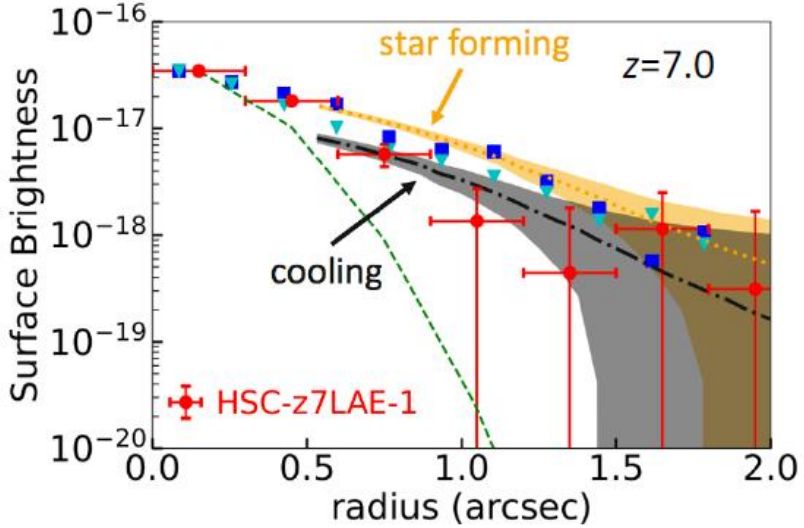
H. Zhang (U. Tokyo) et al. in prep.

- **LyA blobs at z=4.9 and z=7.0.**





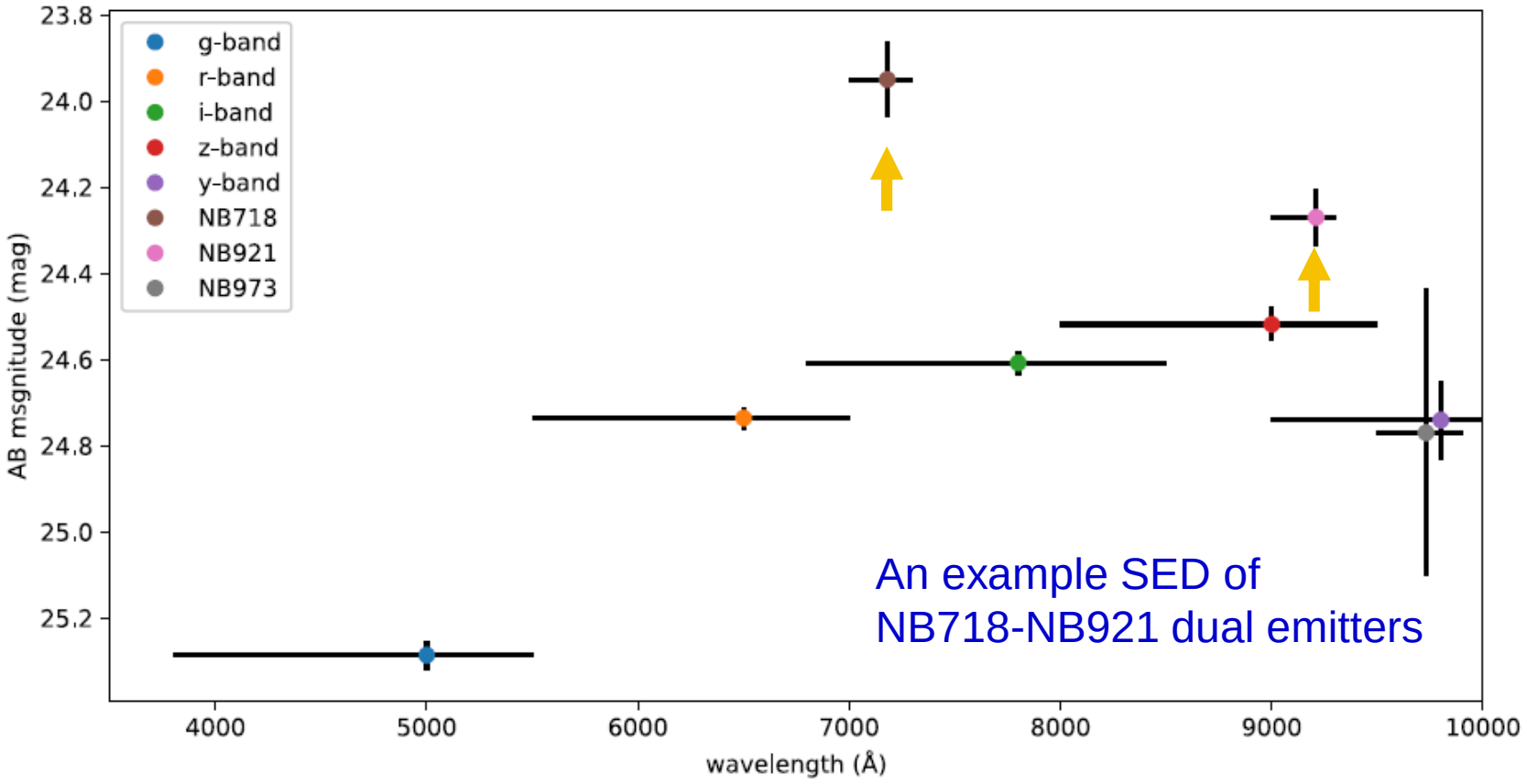




SCIENCE RESULTS #3

K. Iwashita (Ehime U.) et al. in prep.

- **Dual emitter search**
  - 4 NB718-NB921 dual emitters (preliminary)
  - z=4.9 LyA-CIV AGN candidates



SPECIFIC PROJECTS

As of May 17 2018

#147 Cosmic HydrOgen Reionization Unveiled with Subaru (CHORUS) A. K. Inoue

#185 CHORUS: Visualization of the neutral hydrogen fraction at z~7 A. K. Inoue

#189 CHORUS: Identifying and Characterizing High-z Galaxies with Population III Stars M. Ouchi

#190 CHORUS: Evolution of the Extended Line Emission Nebulae Associated with Galaxies at a Redshift Up to z~7 M. Ouchi

#191 CHORUS: Probing the Faint End of the AGN UV Luminosity Function Y. Ono

#192 CHORUS: Multi-wavelength properties of narrowband-selected AGNs T. Nagao

#194 CHORUS: Direct measurement of Lyman continuum emissivity I. Iwata

#197 CHORUS: Probing Cosmic Reionization by Lya Intensity Mapping with HSC Narrow-band Images Y. Harikane

#207 CHORUS: QSO environments at high redshifts probed by NB-selected Lyman alpha emitters S. Kikuta

#240 CHORUS: Data Analysis and Cataloging of Lya Emitters for Luminosity Functions and Correlation Functions with the CHORUS and SSP Images H. Zhang/R. Itoh

#254 CHORUS: SHMRs and BCEs of LAEs at z~2 H. Kusakabe

#260 CHORUS: Mapping Out the HI and HII Gas Distribution in the Large Scale Structures Including Galaxies, Proto-Clusters, AGN, and Metal Absorbers at z~2-3 M. Ouchi

#266 CHORUS: Probing emission-line galaxies at z<1.7 with additional four NB filters M. Hayashi

#267 CHORUS: Searching for metal poor galaxies from line ratios of [OIII] to Halpha M. Hayashi

14 projects by 55 members