Large scale structures and galaxy evolution across a z=0.9 supercluster

z=0.9 の超銀河団における大規模構造と銀河進化

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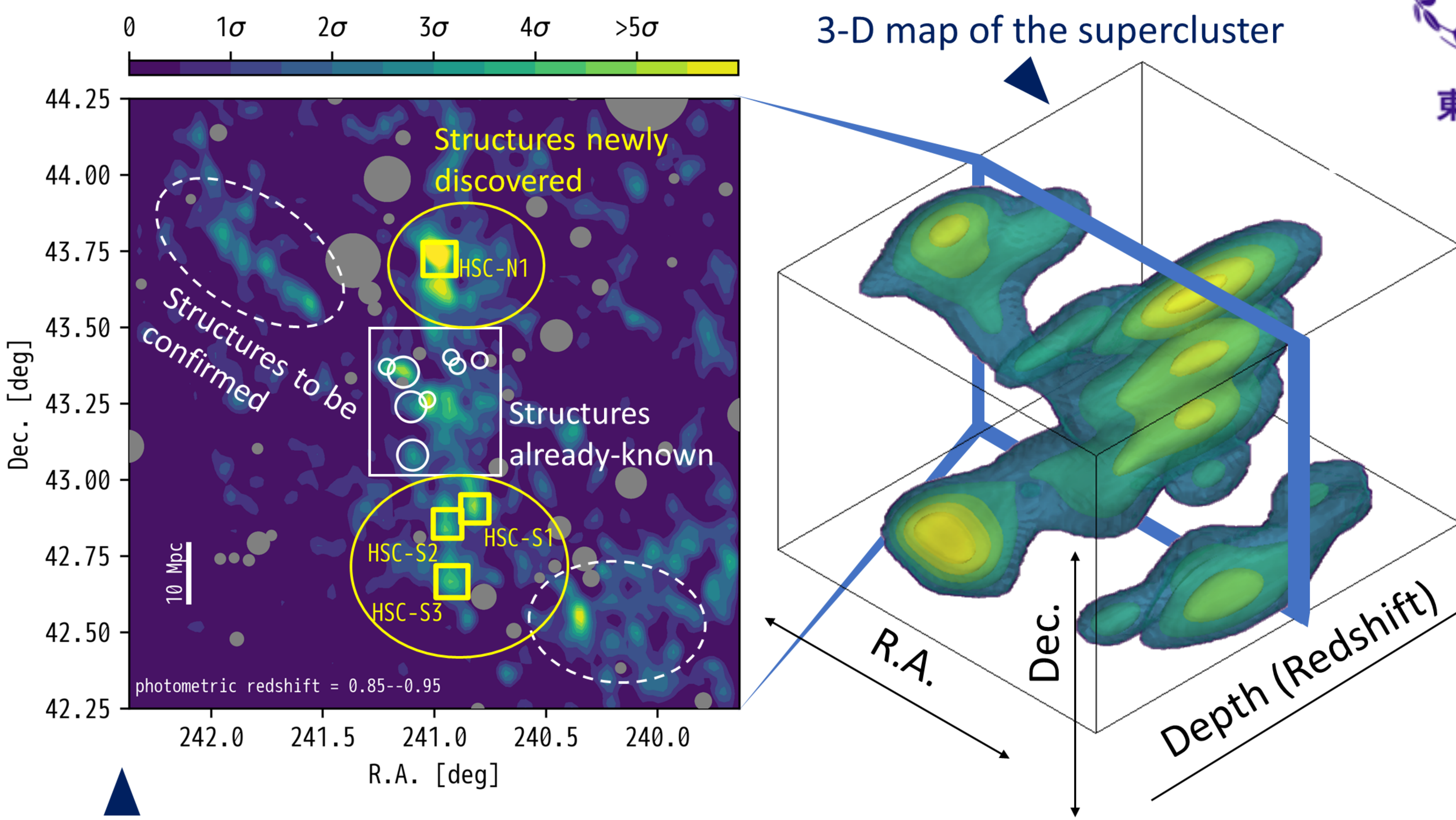


2-D map of the supercluster 7.3 billion light-years away

Credit: NAOJ

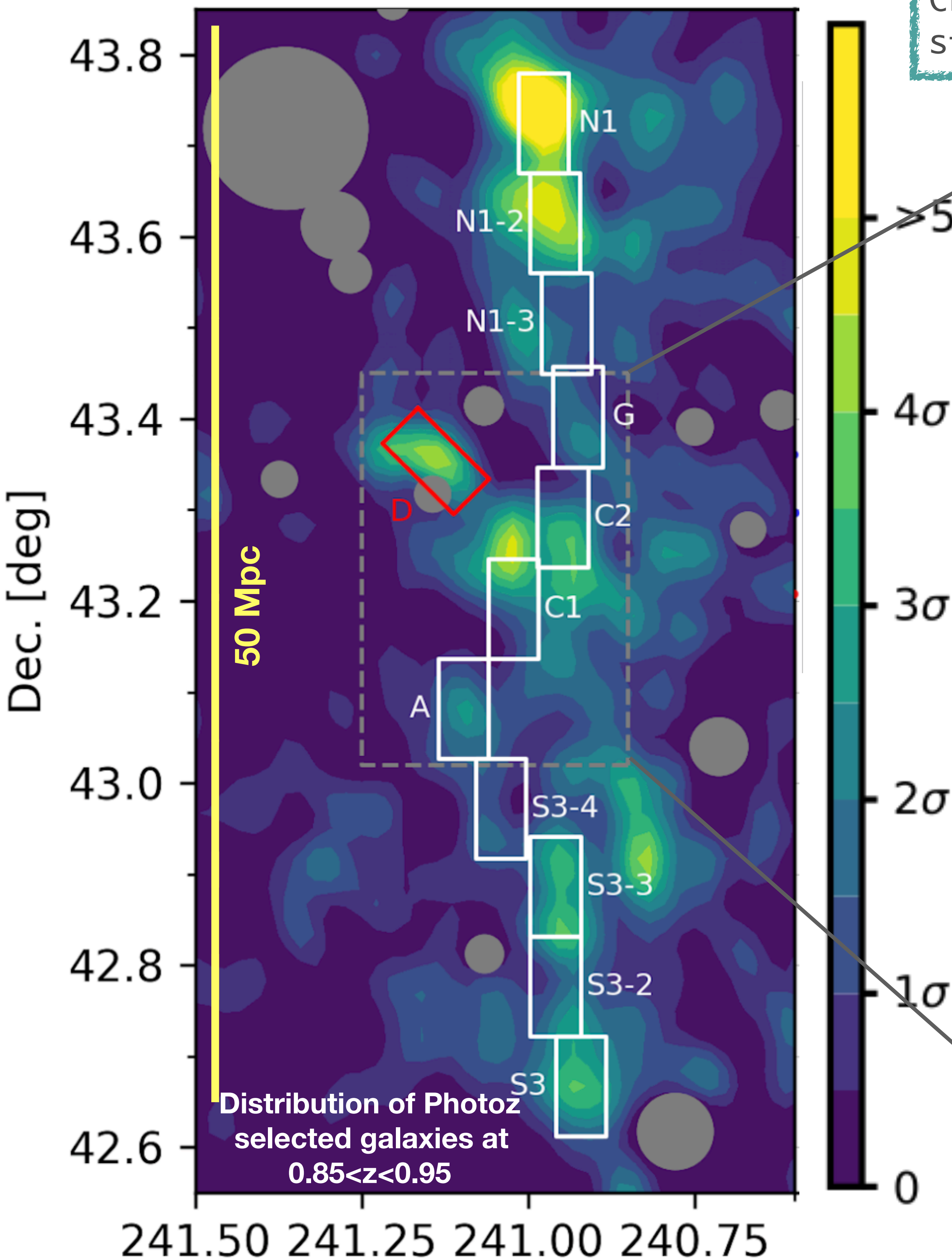
Zhaoran Liu (Tohoku Univ.), Tadayuki Kodama (Tohoku Univ.), Kentaro Motohara (NAOJ), Yusei Koyama(NAOJ), chi Tanaka (NAOJ), Tomoko Suzuki (IPMU), Jose Manuel Perez Martinez (Tohoku Univ.), Masahiro Konishi (Univ. of Tokyo), Hidenori Takahashi (Univ. of Tokyo), Yusei Koyama (NAOJ), Lori Lubin (UC Davis), Brian Lemaux (UC Davis)

Outlines

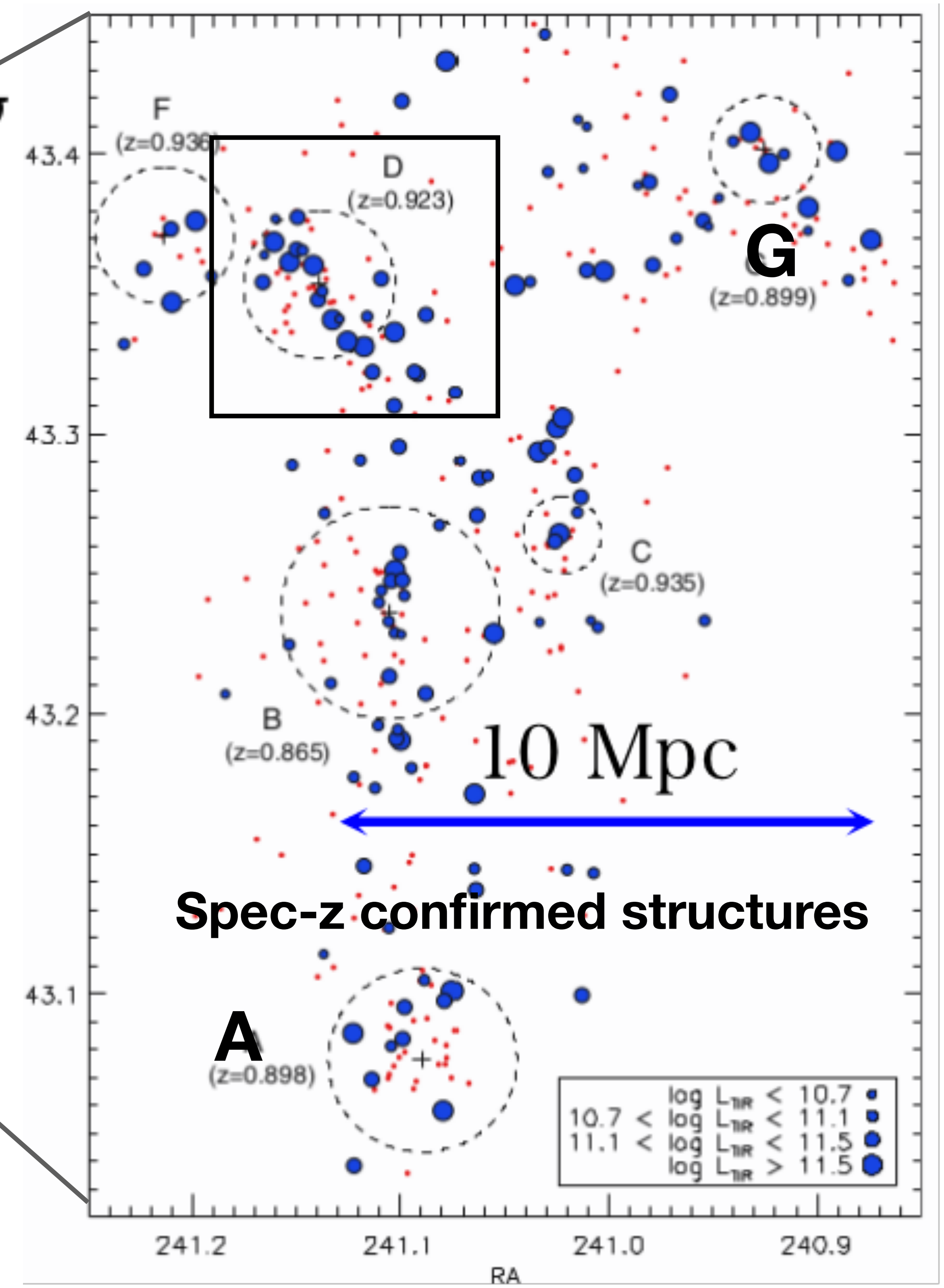
- Target ——CL1604, a supercluster at z = 0.9
- Unsolved issues —— Dust extinction
- Observations and archived data
- Scientific Analysis
- Summary and future prospects

Target

CL1604: an ideal laboratory for investigating star formation at intermediate redshift



Hayashi et al. 2019 HSC-SSP wide survey



Kocevski et al. 2011, ApJ, 736, 38

Gal et al. 2008 ; Lubin et al. 2009; Tomczak et al. 2019

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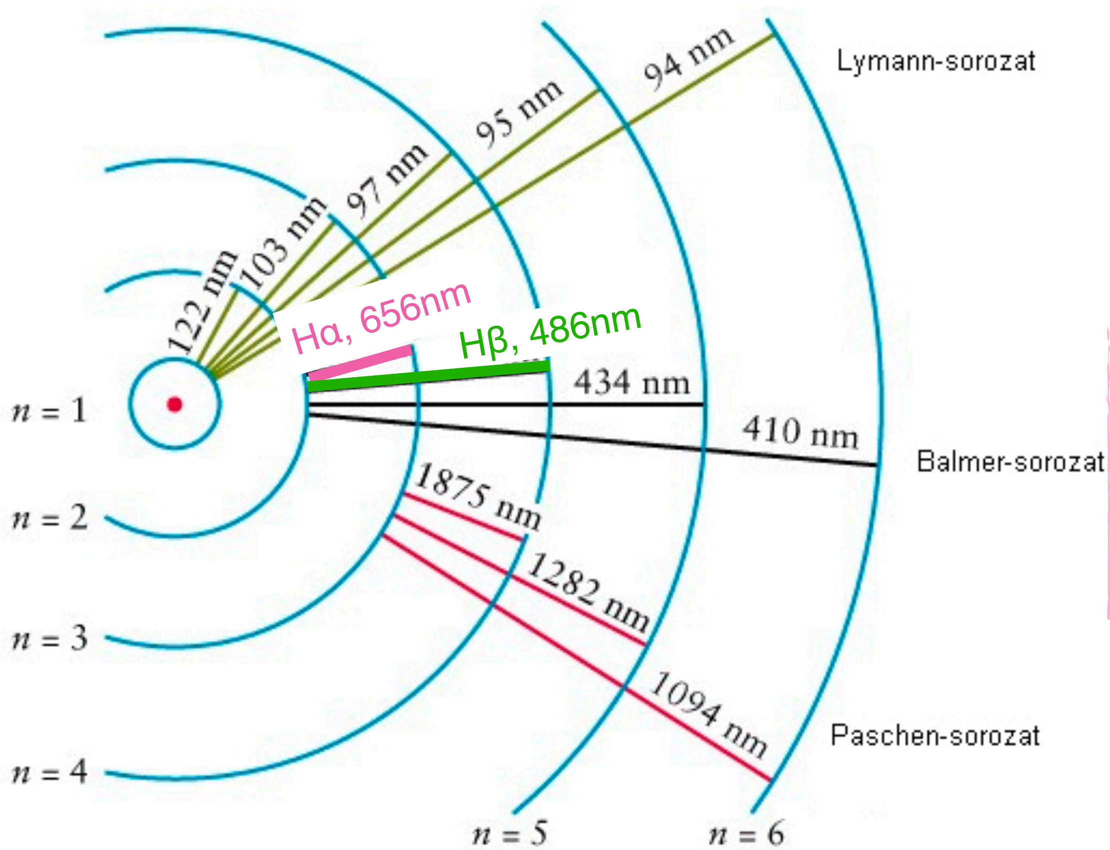
Unsolved issues **Balmer Decrement , the most reliable estimator of dust extinction**



The Balmer Decrement

- Balmer lines are the most well known emission lines. They arise from recombination to the n = 2 level of the hydrogen.

The Phenomenon of Interstellar Reddening

- Interstellar reddening produced by dust particles dims bluer light more than it does redder light, leading to Balmer line ratios that differ from the theoretical predictions.

It has been well calibrated in nearby galaxies!

Science goals

- Unveiling the relationship of structure evolution and galaxy evolution therein.
- Mapping star formation activities and investigating the environmental dependence across the unique supercluster.
- Correcting for the dust extinction accurately and identifying the mode of star formation.

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How to achieve these science goal?

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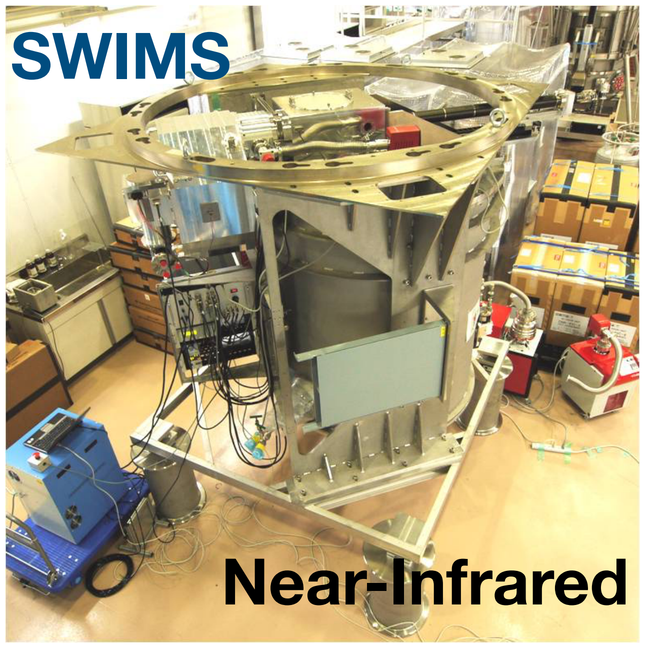
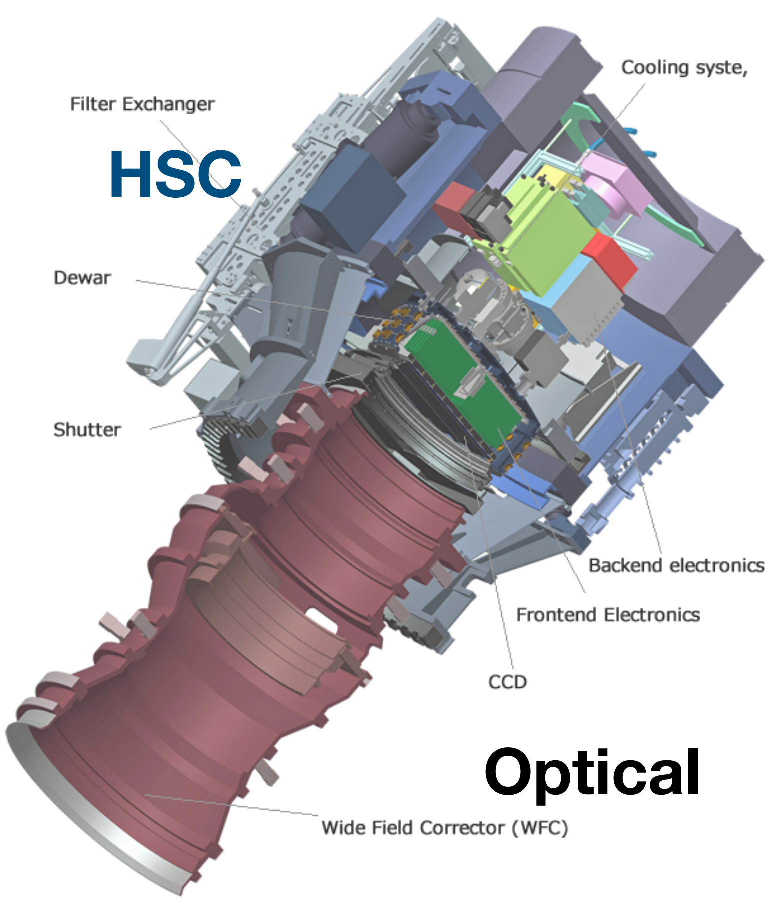
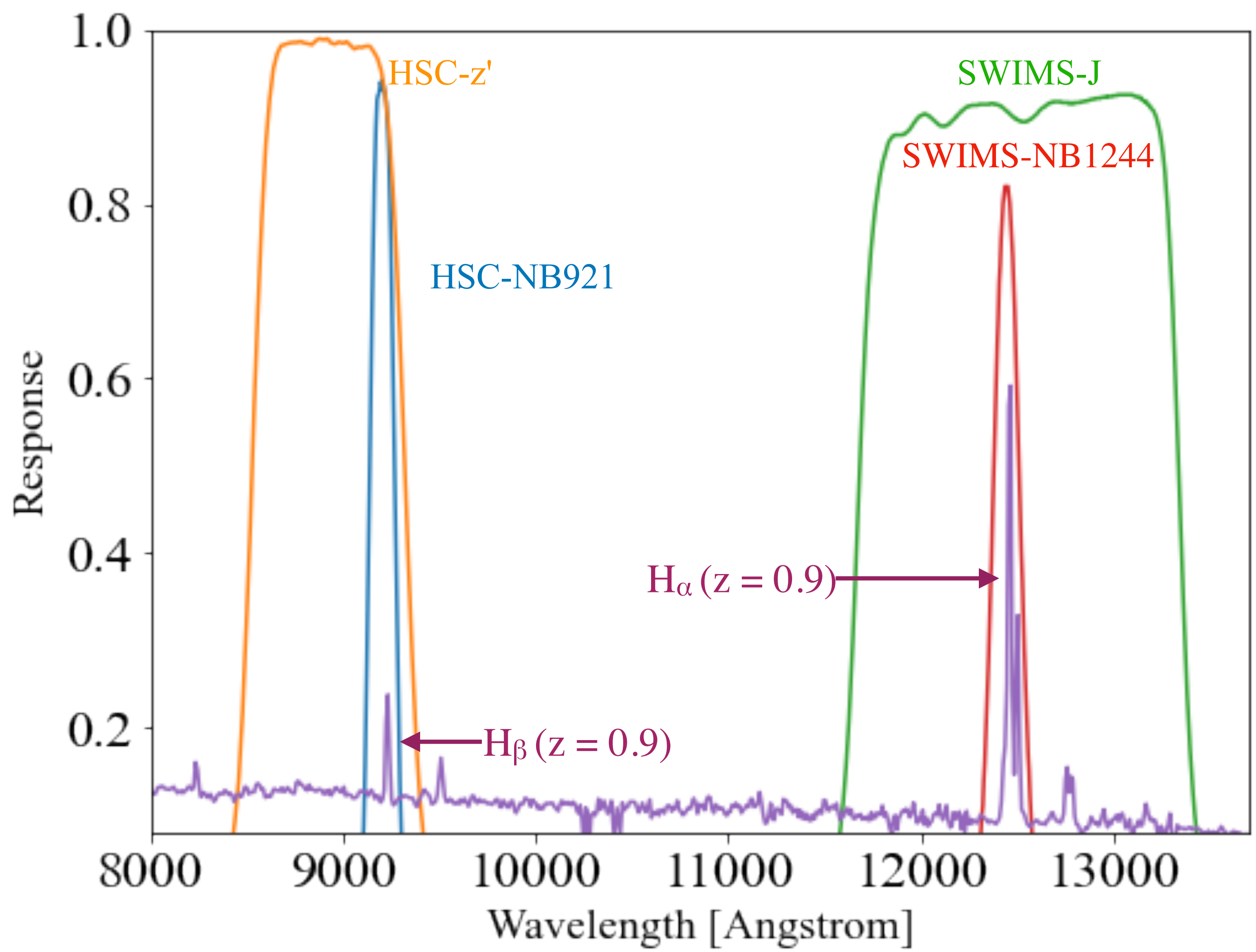
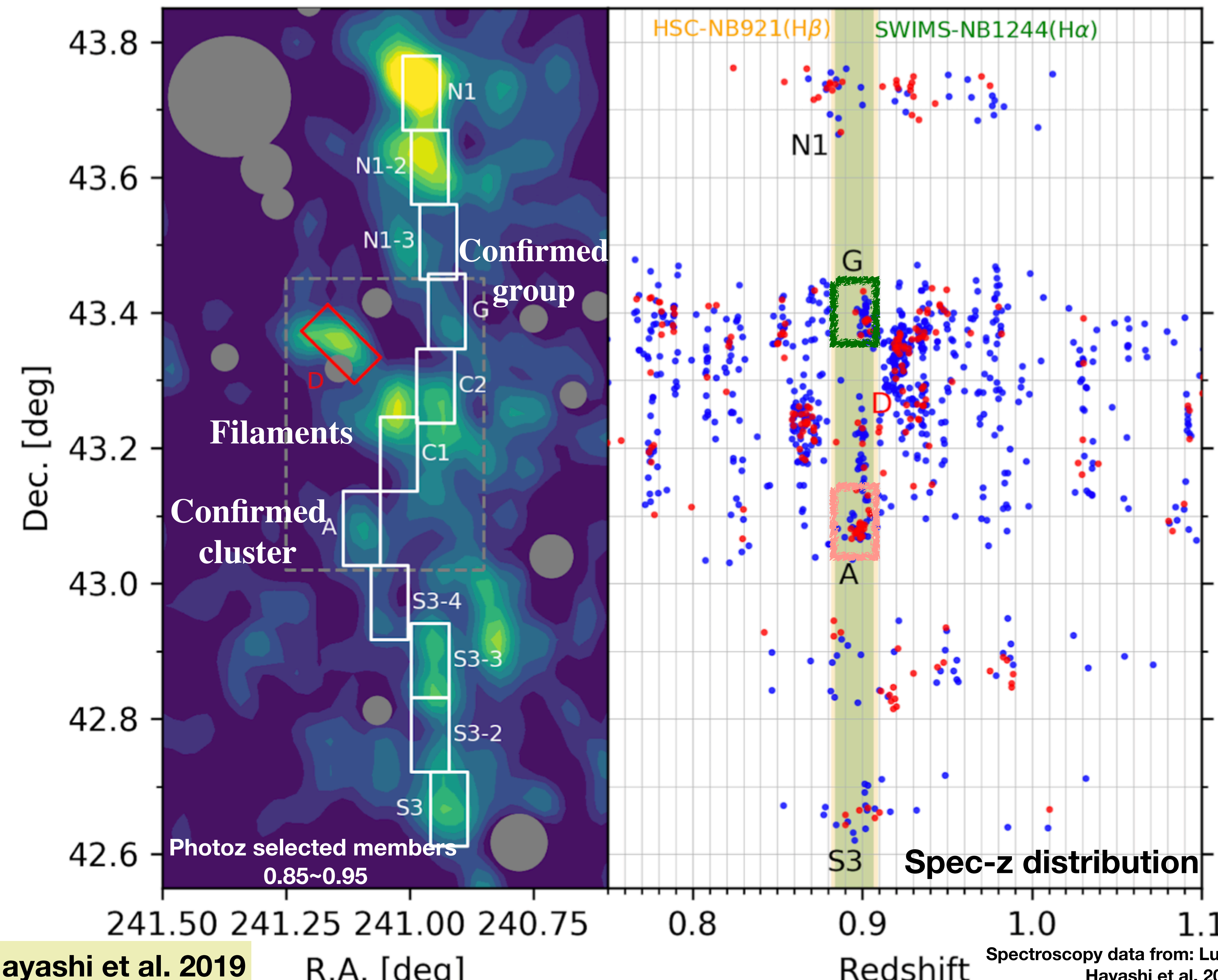
Observations Balmer Decrement only by imaging!

Instrument	Filter	λc (μm)	z(Hα) 6563Å	z(Hβ) 4861Å	Field of view	Pixel scale (arcsec.)
SWIMS	NB1244	1.244	0.896	1.559	6.6 × 3.3 arcmin^2	0.095
HSC	NB921	0.921	0.403	0.895	90 arcmin diameter	0.17









Hayashi et al. 2019

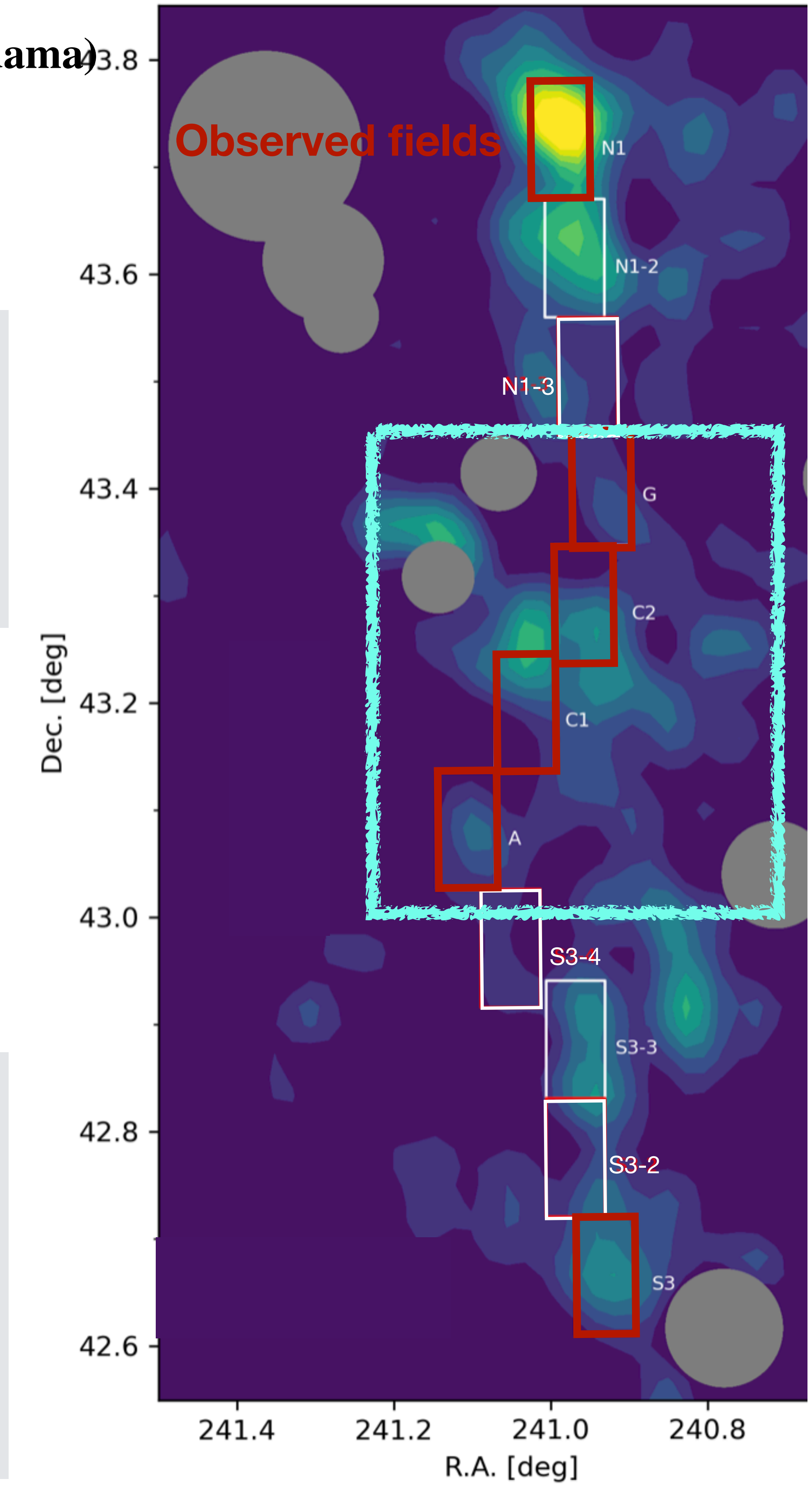
Spectroscopy data from: Lubin et al. 2009, Hayashi et al. 2019

Observations

SWIMS only allocation for S22A-006 (PI: T. Kodama)
50% lost due to bad weather(1 night)

Exposure time: 1 hour for NB1244 and 30 mins for J

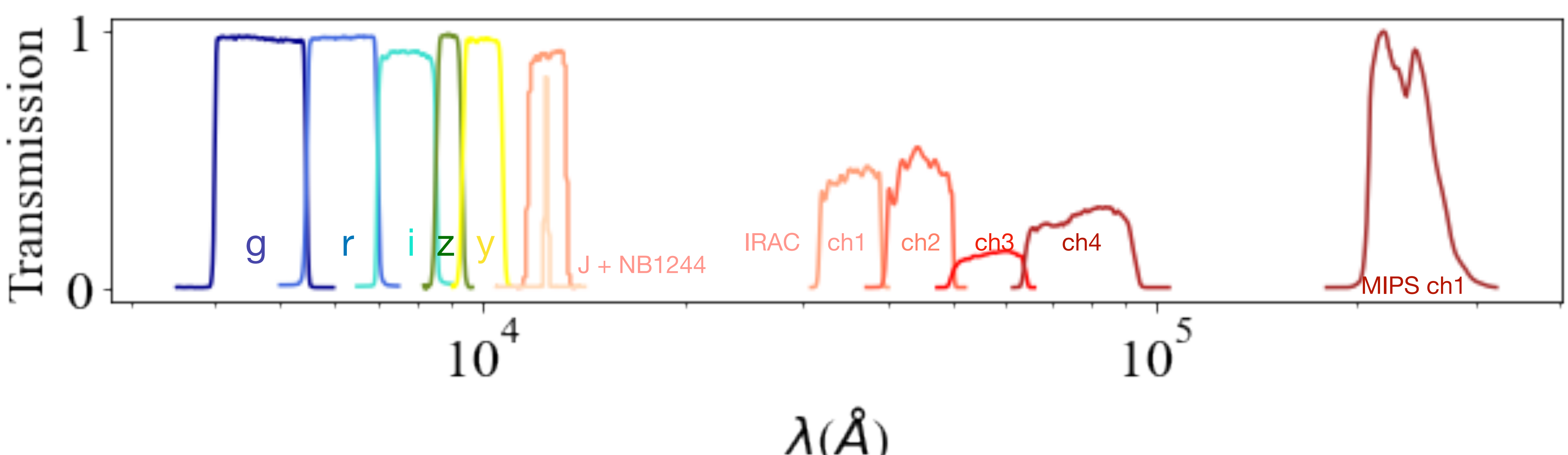
Field	SWIMS(NB1244)	SWIMS(J)	Existing data UKIRT(J)
N1	√		
N1-2			
N1-3			
G	√		√
C2	√		√
C1	√	√	√
A	√	Partly	√
S3-4			
S3-3			
S3-2			
S3	√		



S22A is the last chance we could observe CL1604 with NB1244 filter as SWIMS will be shipped to Chile in 2023.

Additional data in archives

Instrument	Band	Depth (5σ; AB)
Subaru(HSC-SSP wide) Aihara et al. 2018a	g, r, i, z, y	~26mag
Spitzer Rieke et al. 2004	IRAC: [3.6], [4.5], [5.8], and [8.0] MIPS: 24 μm	IRAC: ~24.7mag MIPS: ~ 19.9 mag
Keck(ORELSE) Lubin et al. 2009	Optical Spectroscopy	i′= 24.5 mag
UKIRT(ORELSE) Tomczak. 2017	J	22.1 mag



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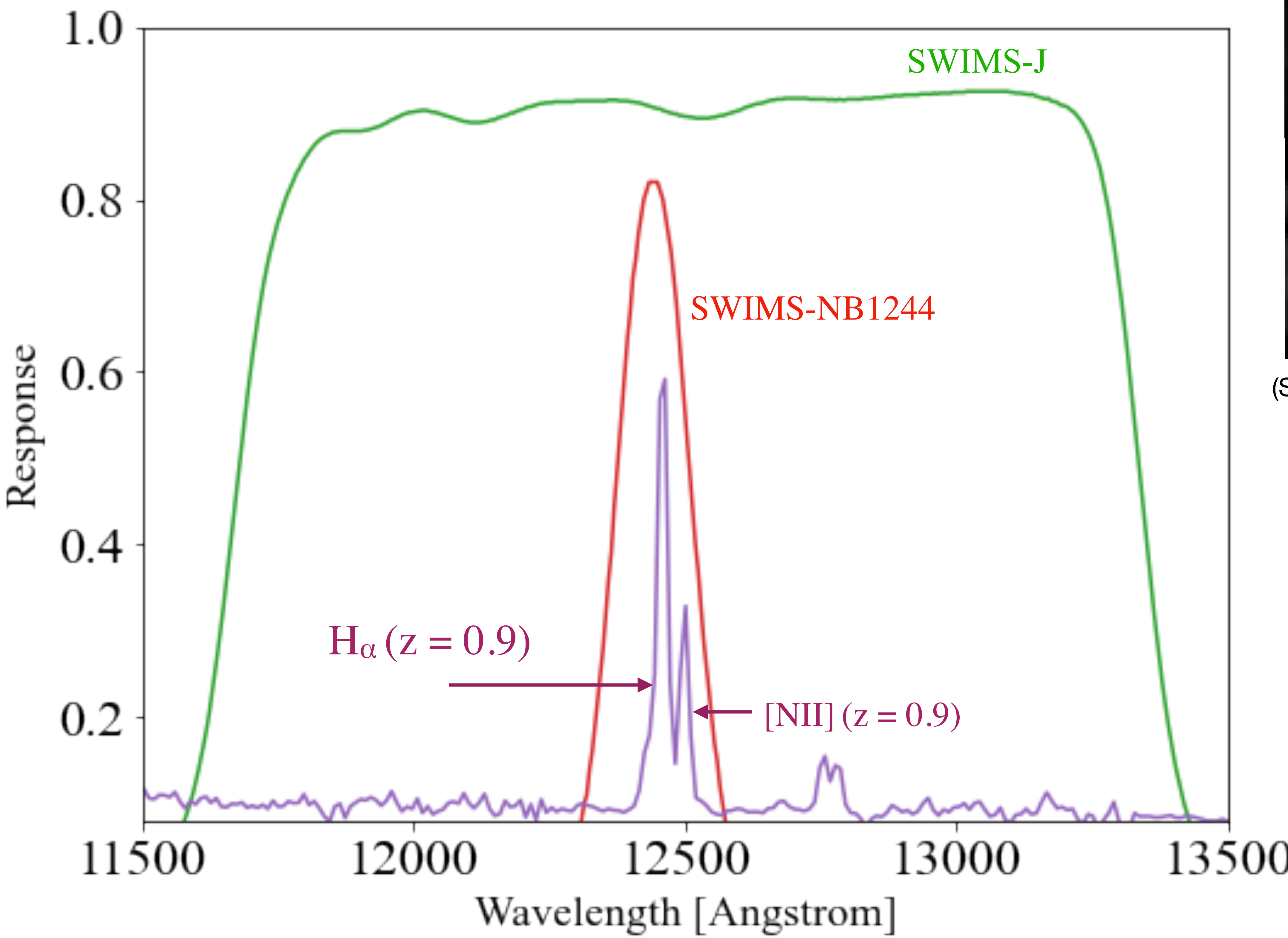
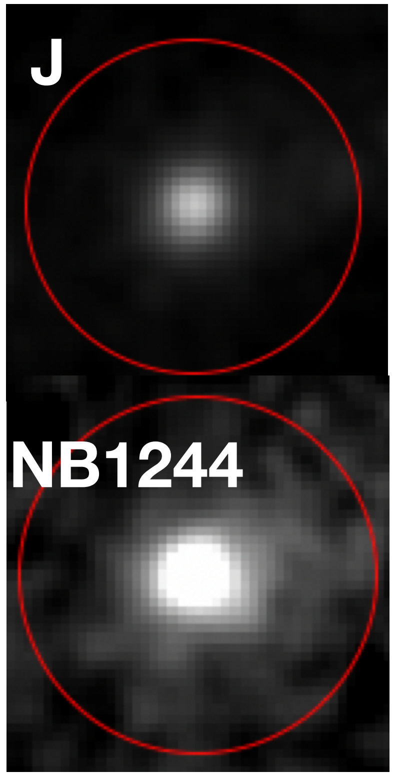
Analysis -- Selection of Hα emitters

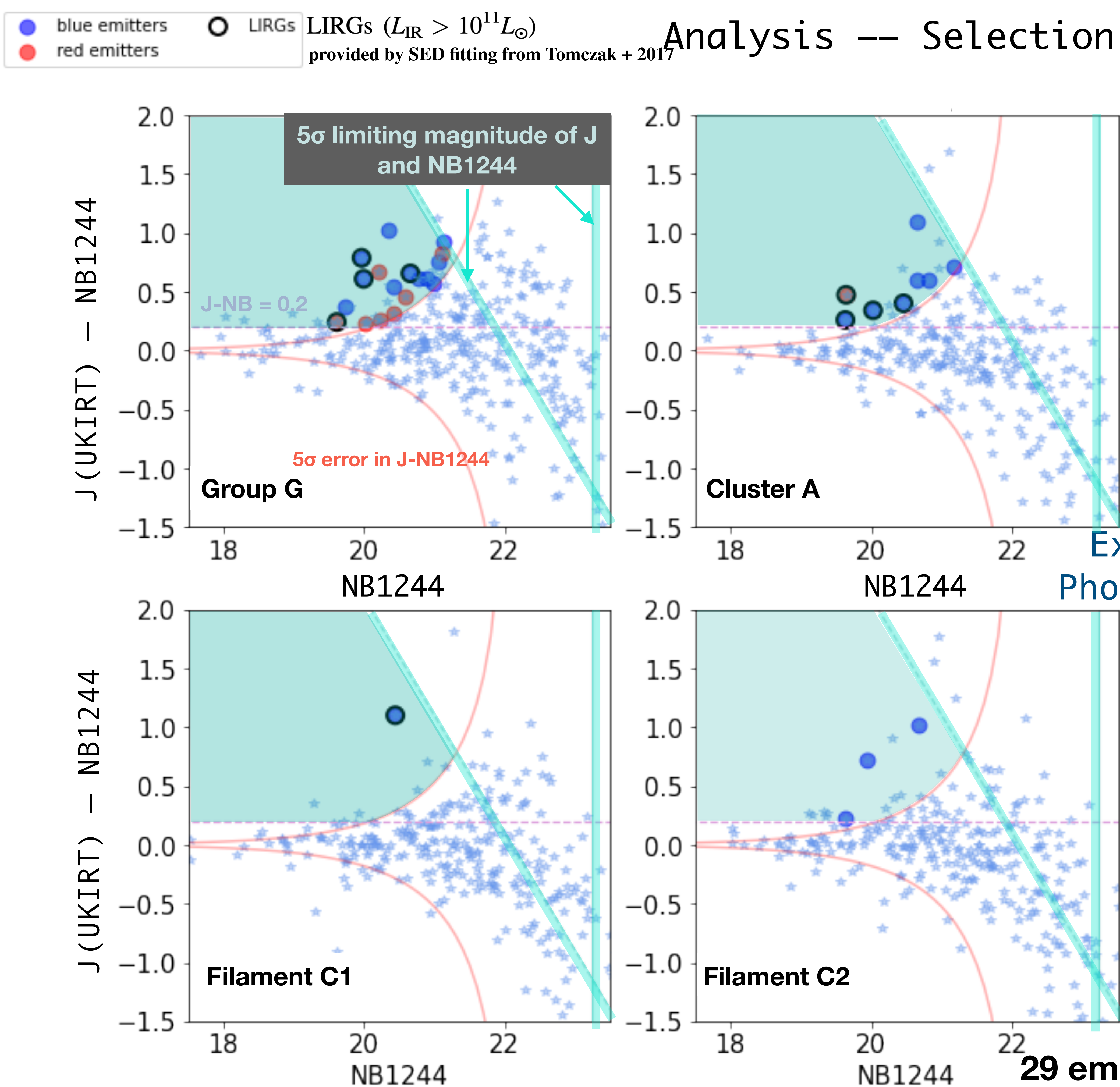


An emitter example



(Scaled for illustration)

Analysis -- Selection of Hα emitters



red: R - J >= 2.5

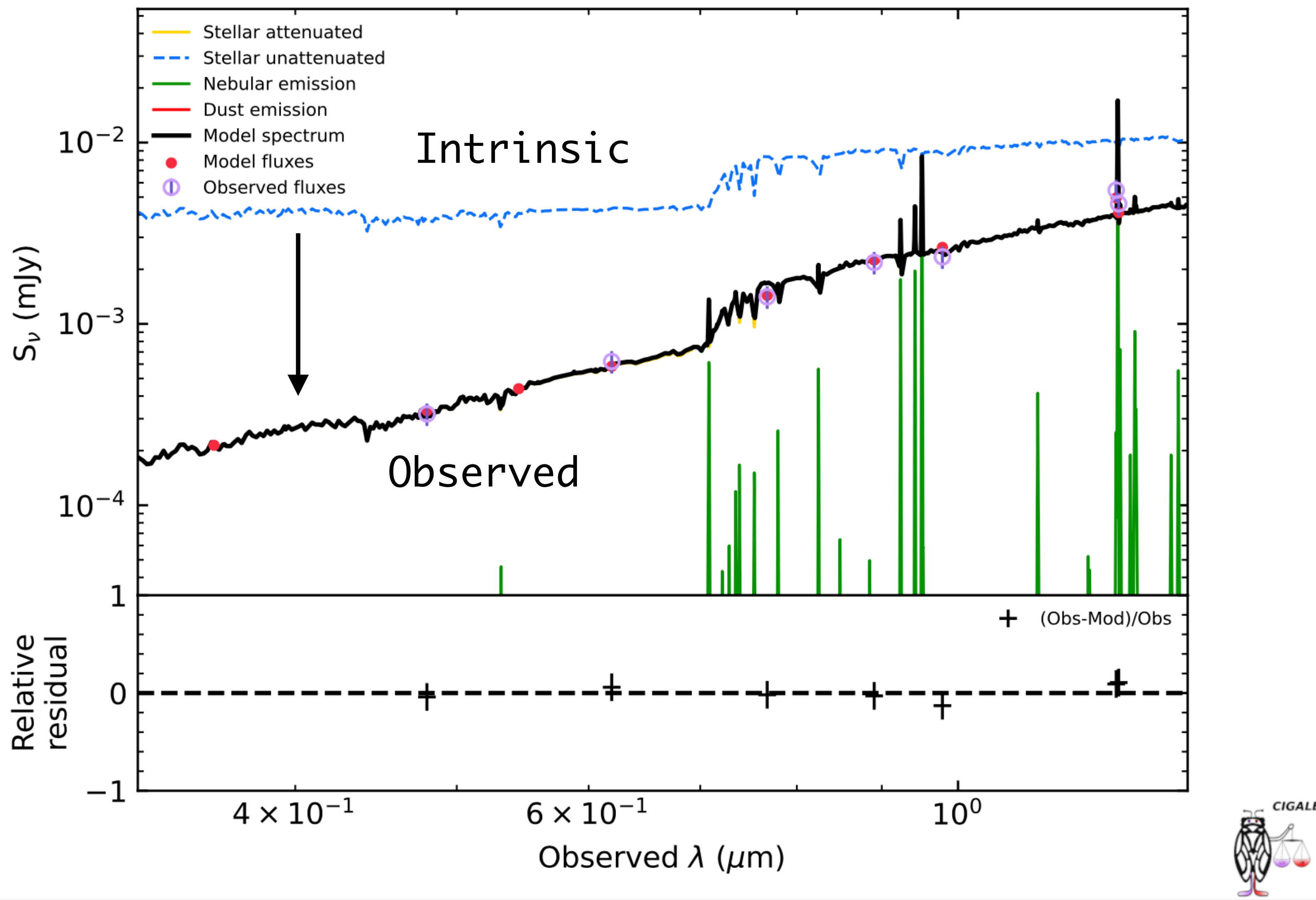
blue: R - J < 2.5

Extra constraint:
Photometric redshift
0.8 <z <1.0

29 emitters picked in total

Analysis -- SED fitting

Best model for 5284
(z=0.9, reduced χ²=1.1)



HSC-SSP g, r, i, z, y band, SWIMS J, NB1244 band

Balmer decrement is ideal but not available yet

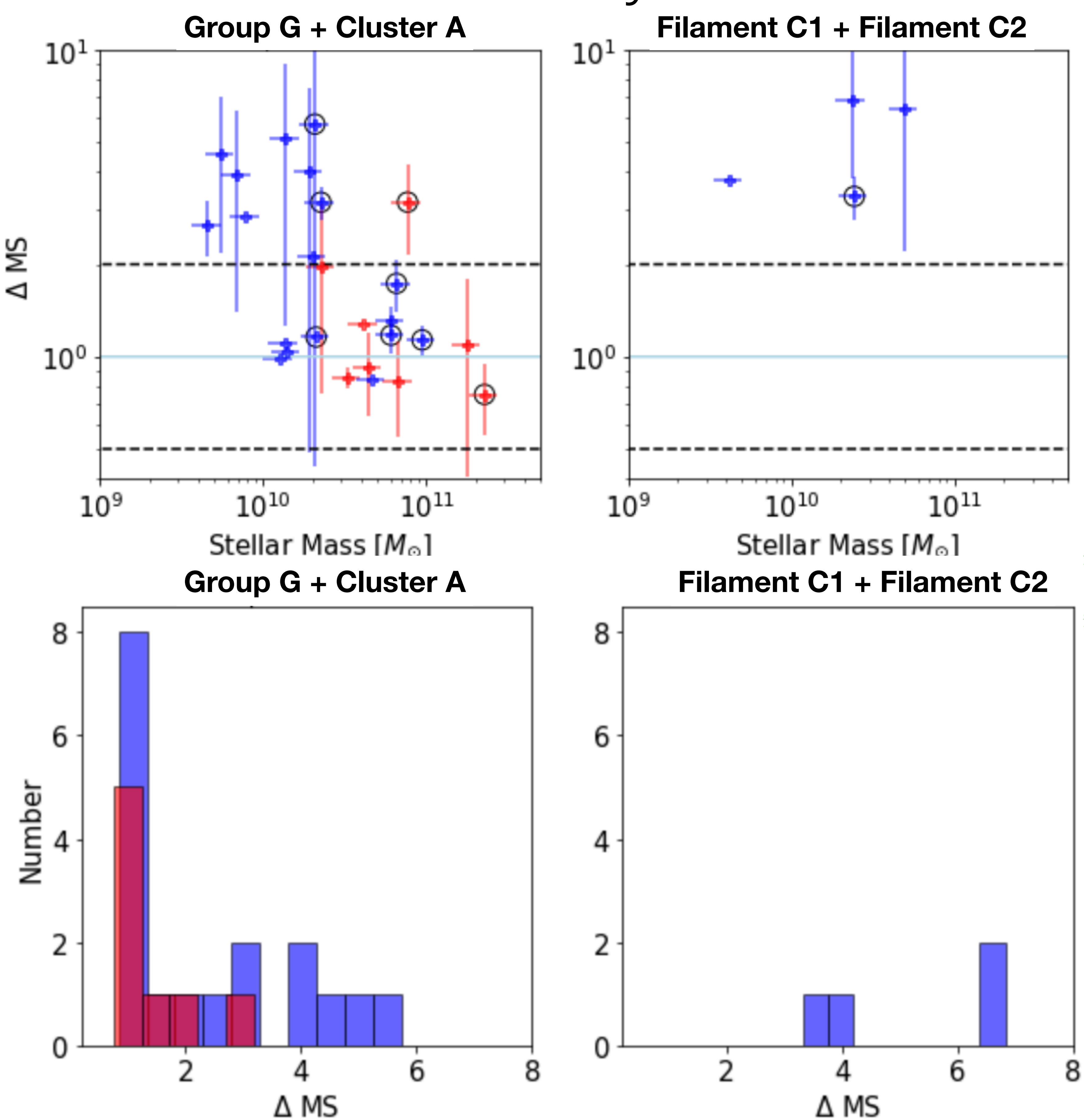
We use SED fitting to estimate dust extinction and stellar mass.

Tools:Code Investigating GALaxy Emission(CIGALE), Boquien et al. (2019)

- CIGALE is a powerful multi-wavelength SED fitting code for extragalactic studies.
- It could also provide the information of dust extinction, but the degeneracy with age and metallicity makes the estimation uncertain.

Analysis -- Delta MS in combined environments

$\Delta\mathrm{MS} = \mathrm{SFR(H\alpha)/SFR(MS)}$



Kolmogorov–Smirnov (K-S) test result

The p-value for ΔMS of emitters in A and G vs. emitters in C1 and C2 is **0.92%.**

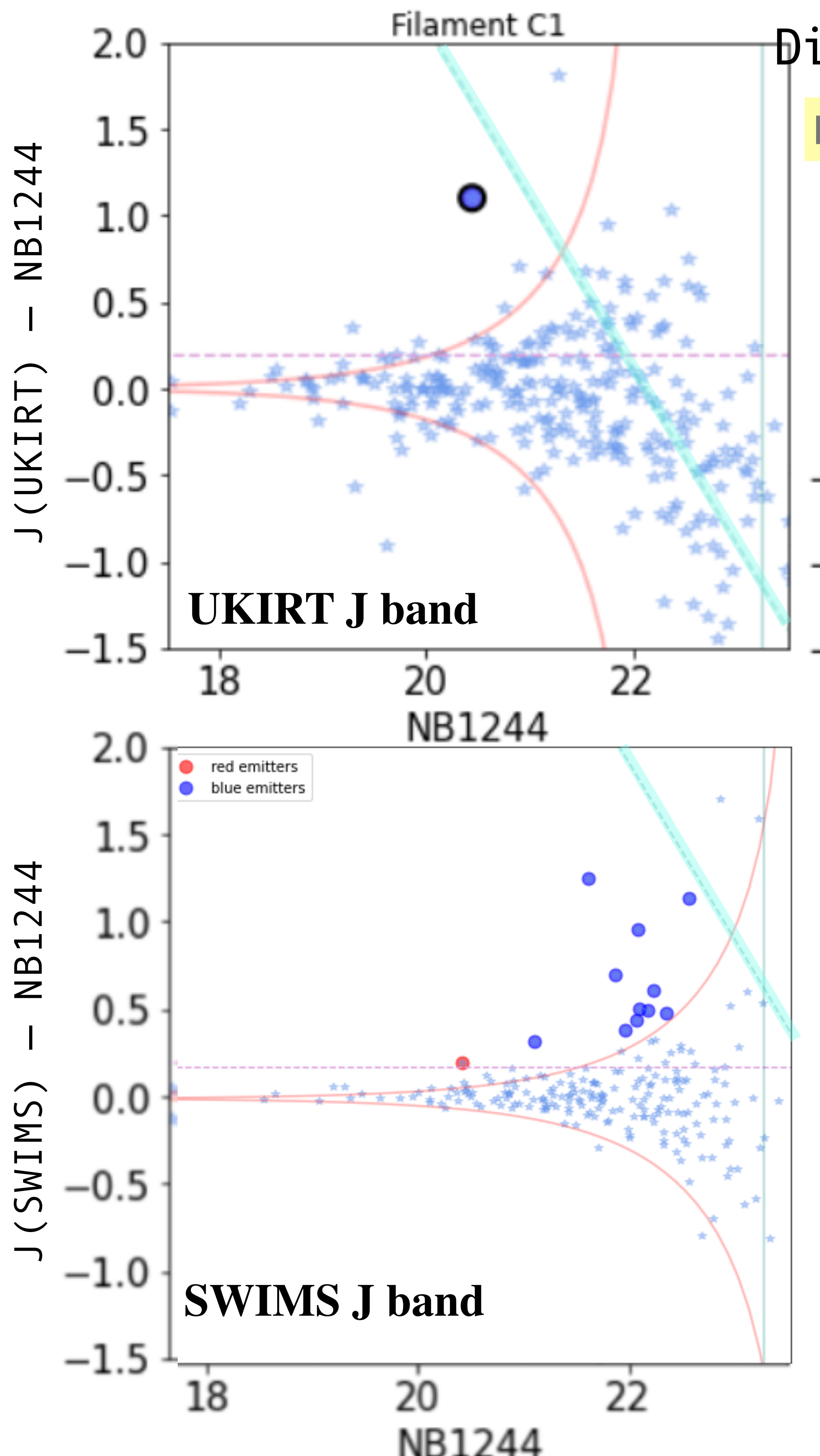
The p-value for ΔMS of blue galaxies and red galaxies is **8.4%.**

A statistical difference between emitters in two different environments.

Galaxies at high density region have started becoming passive while galaxies in filaments are still actively forming stars.

Discussion (1) -- Deeper J band is needed

MOIRCS observations (J, H, K) accepted (S23A-011, PI: Liu)



Discussion (2) -- Hβ imaging by HSC is needed

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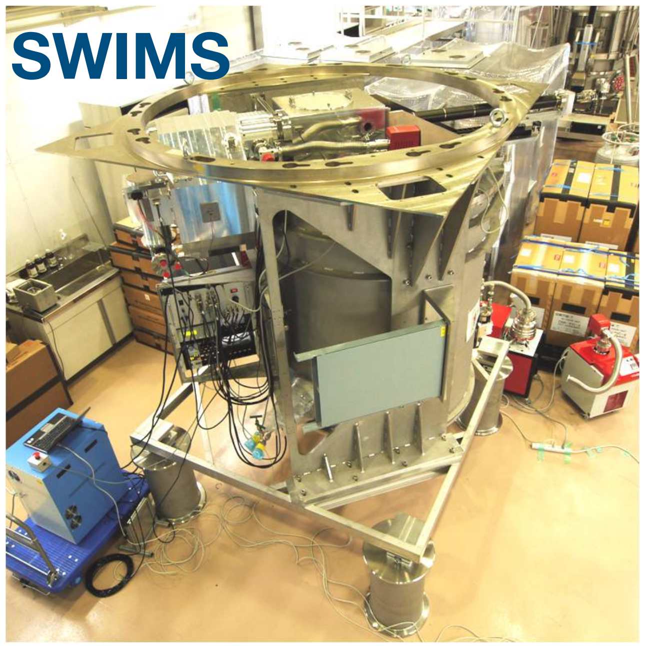
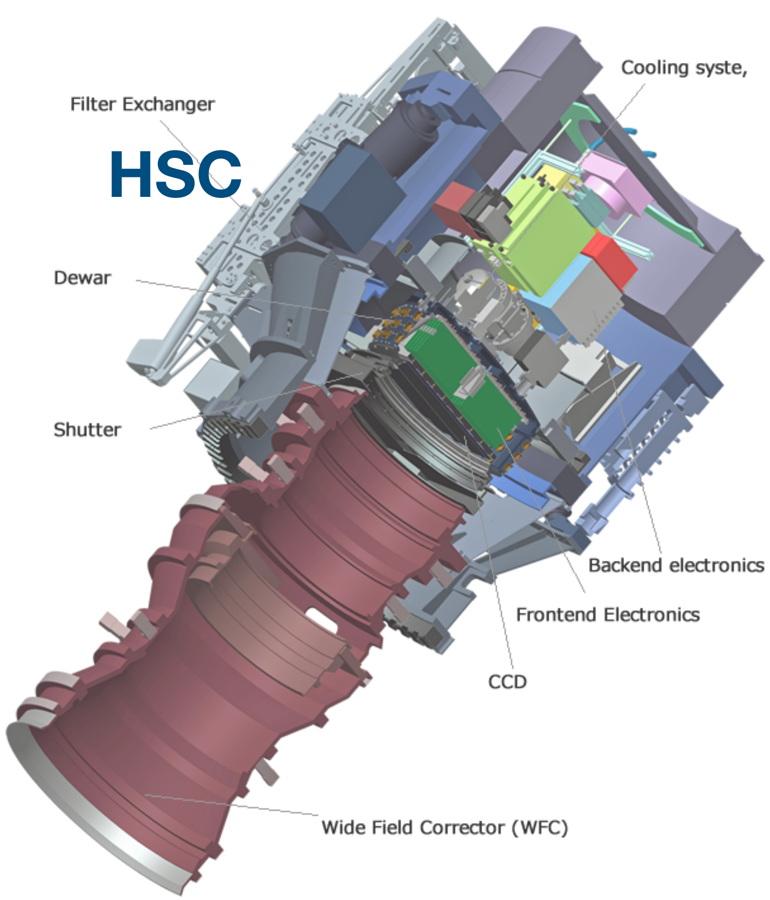
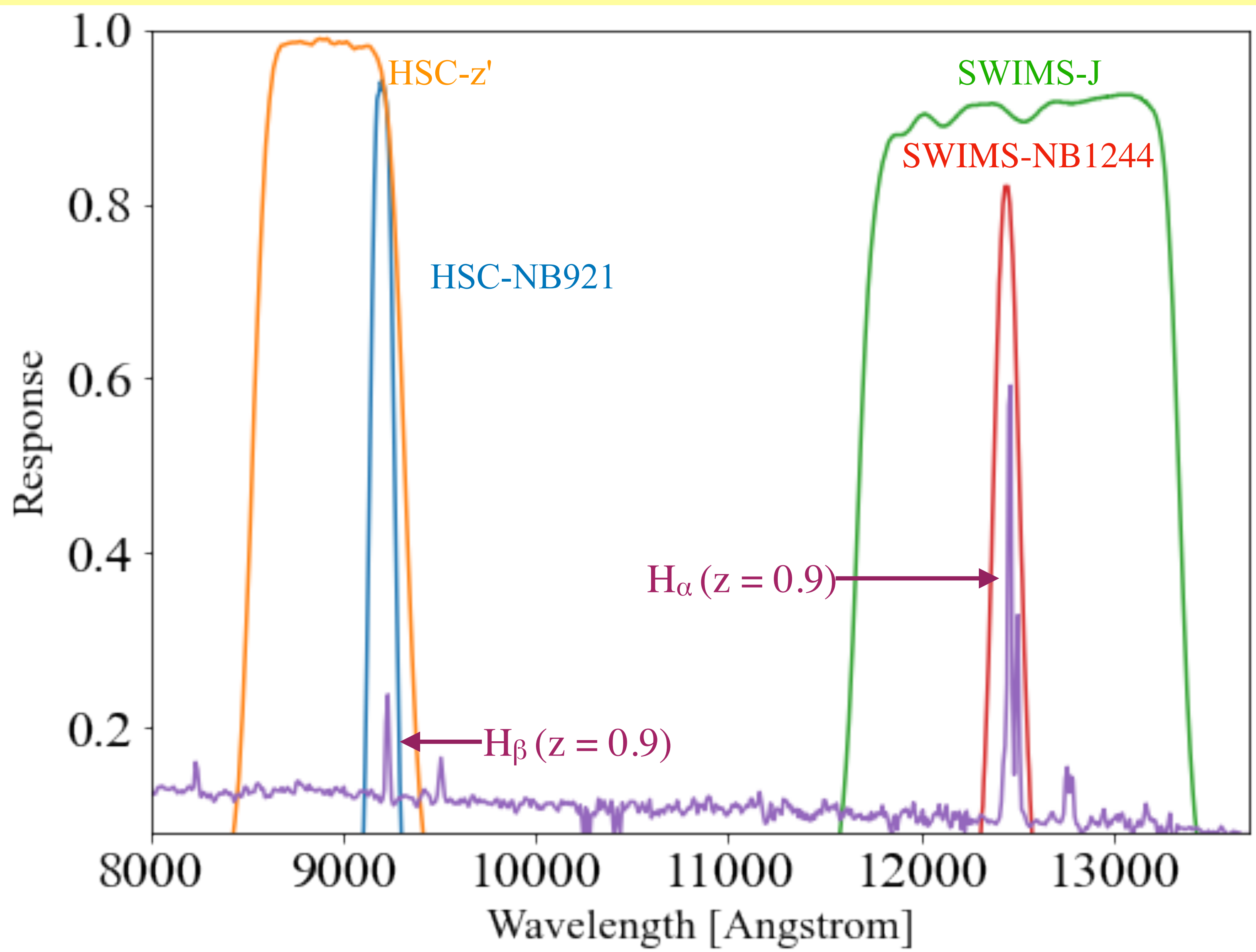


HSC observations (NB921) accepted (S23A-011, PI: Liu)





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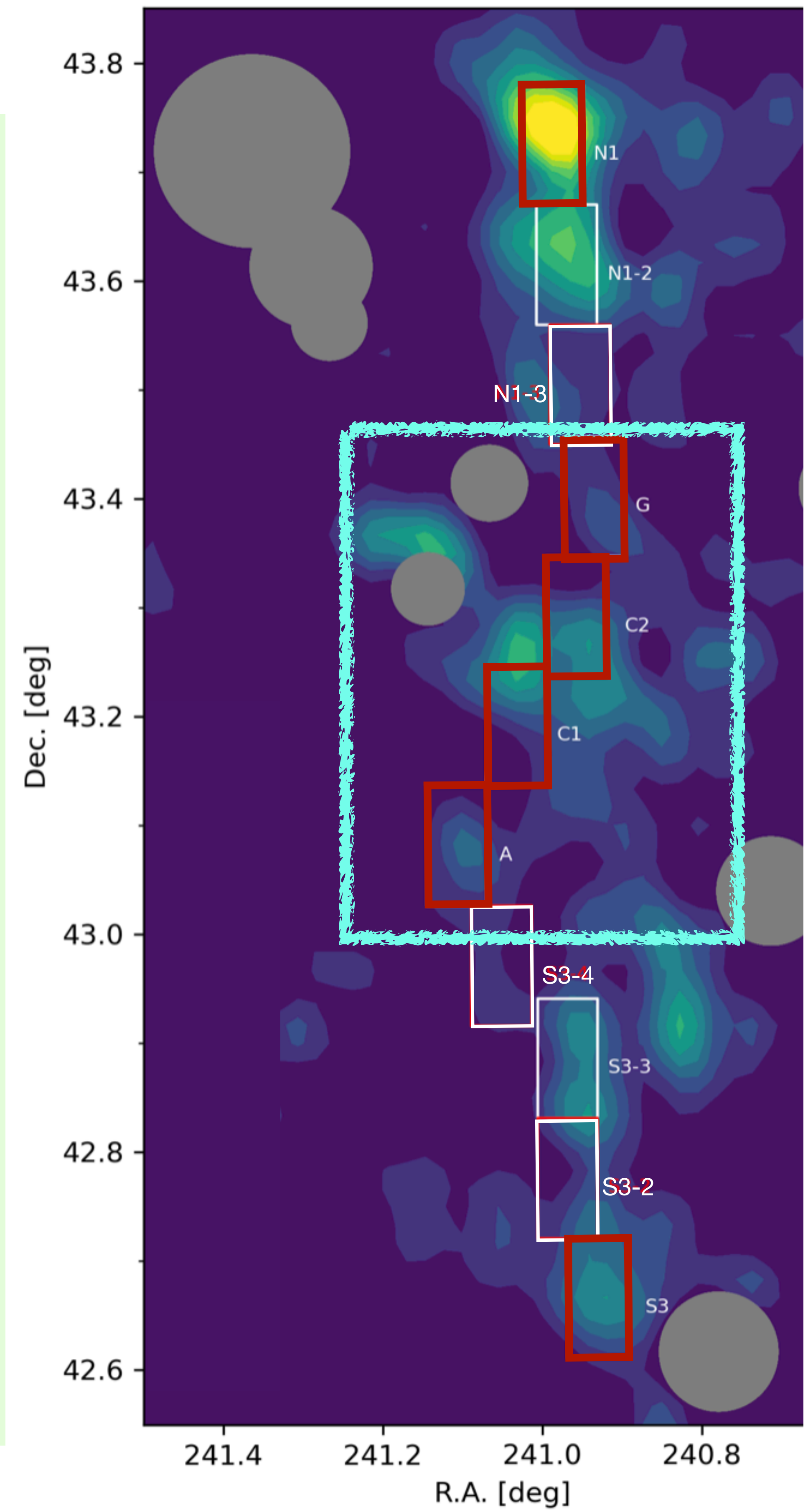
Summary -- Current analysis and results

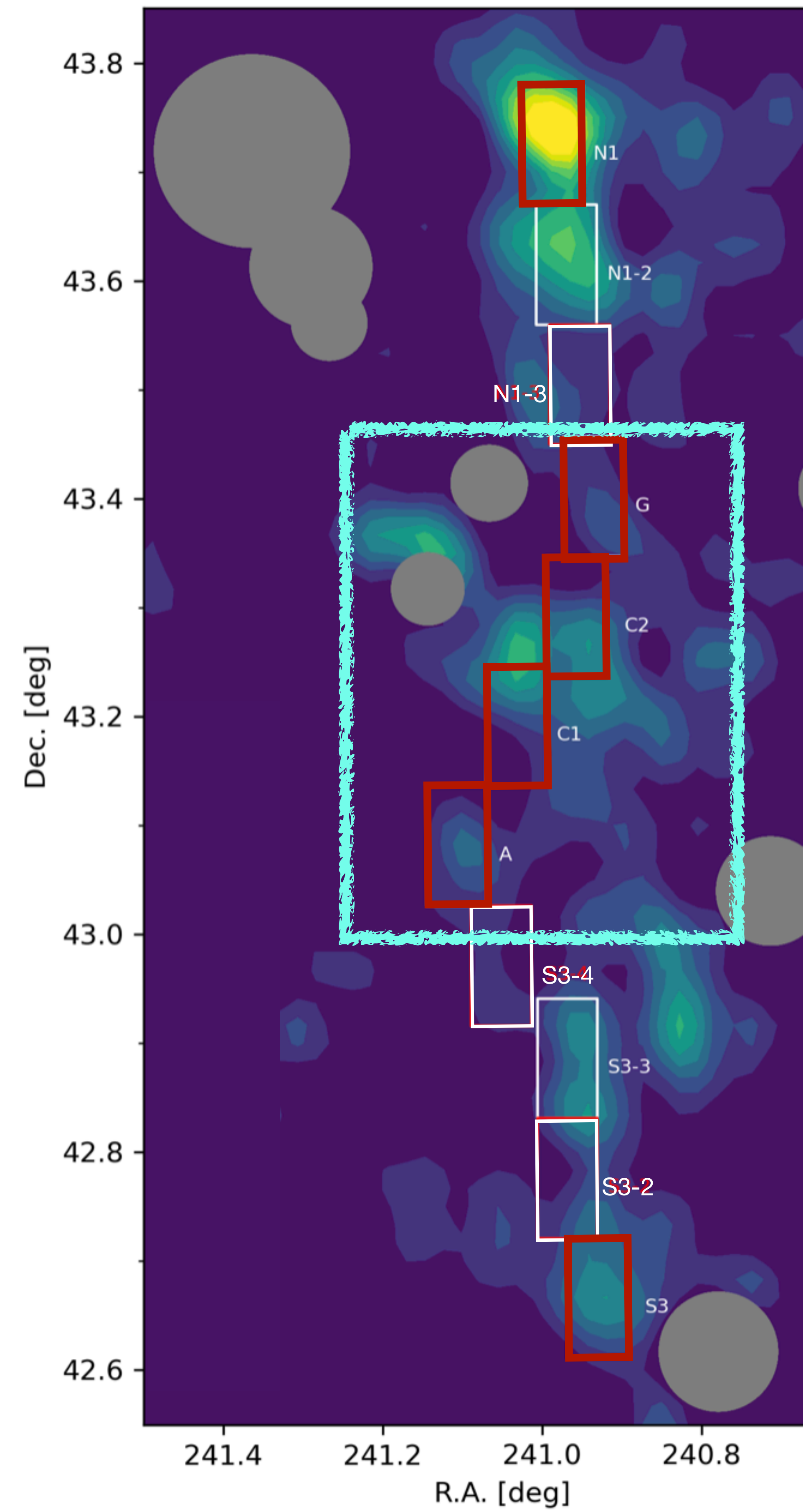
- We selected Hα emitters with original observations (SWIMS) and archived observations (UKIRT), 29 emitters are selected in 4 fields.
- The stellar mass and dust extinction of emitters are based on SED fitting. SFRs are based on Hα flux.
- All of the emitters are star-forming galaxies. Red emitters are more passive than blue emitters.
- Group G and cluster A hold more red emitters compared to filaments. Lower SFRs of red emitters might indicate they are on the way to be quenching their activities.



Future Prospects

- This study is biased towards bright emitters, there is also a large uncertainty on dust extinction estimation. Therefore, the deeper J band imaging and Hβ imaging is needed.

- The J band imaging for rest 5 fields and HSC NB921 imaging are also needed. The proposals has been accepted and the observations will be taken soon in S23A!



Thank you for your attention!