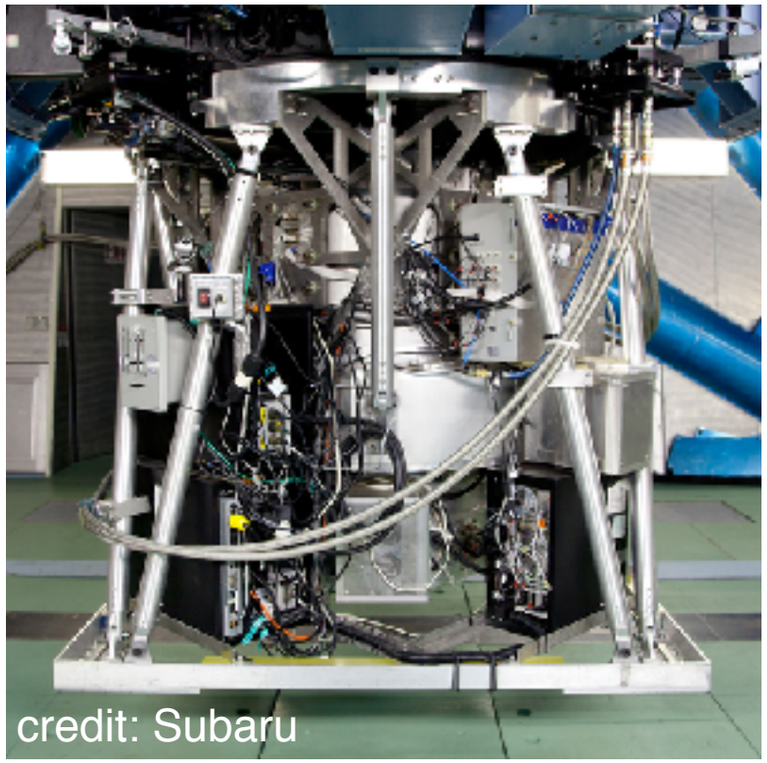
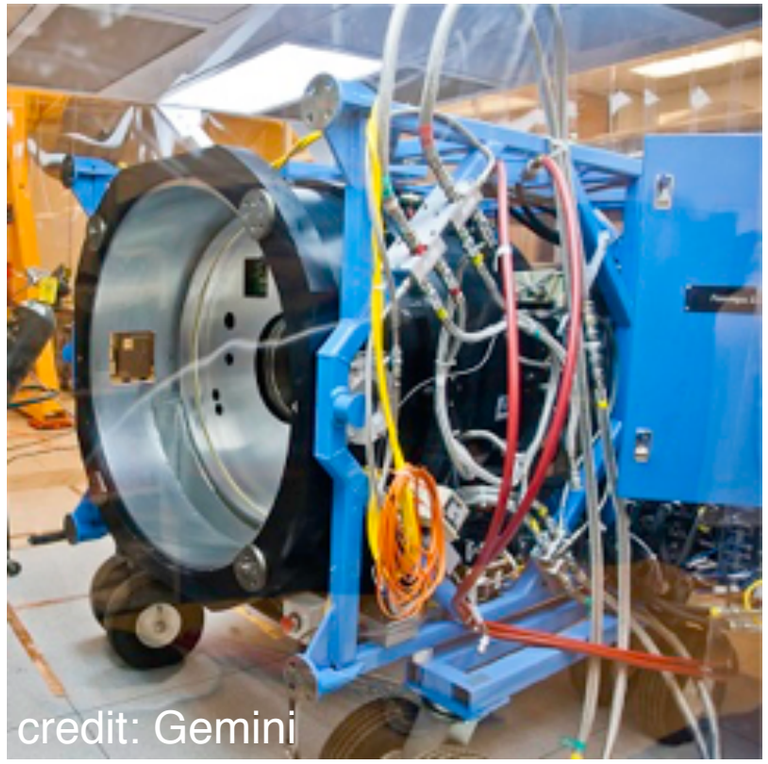
Science Cases for Multi-Object Spectroscopy

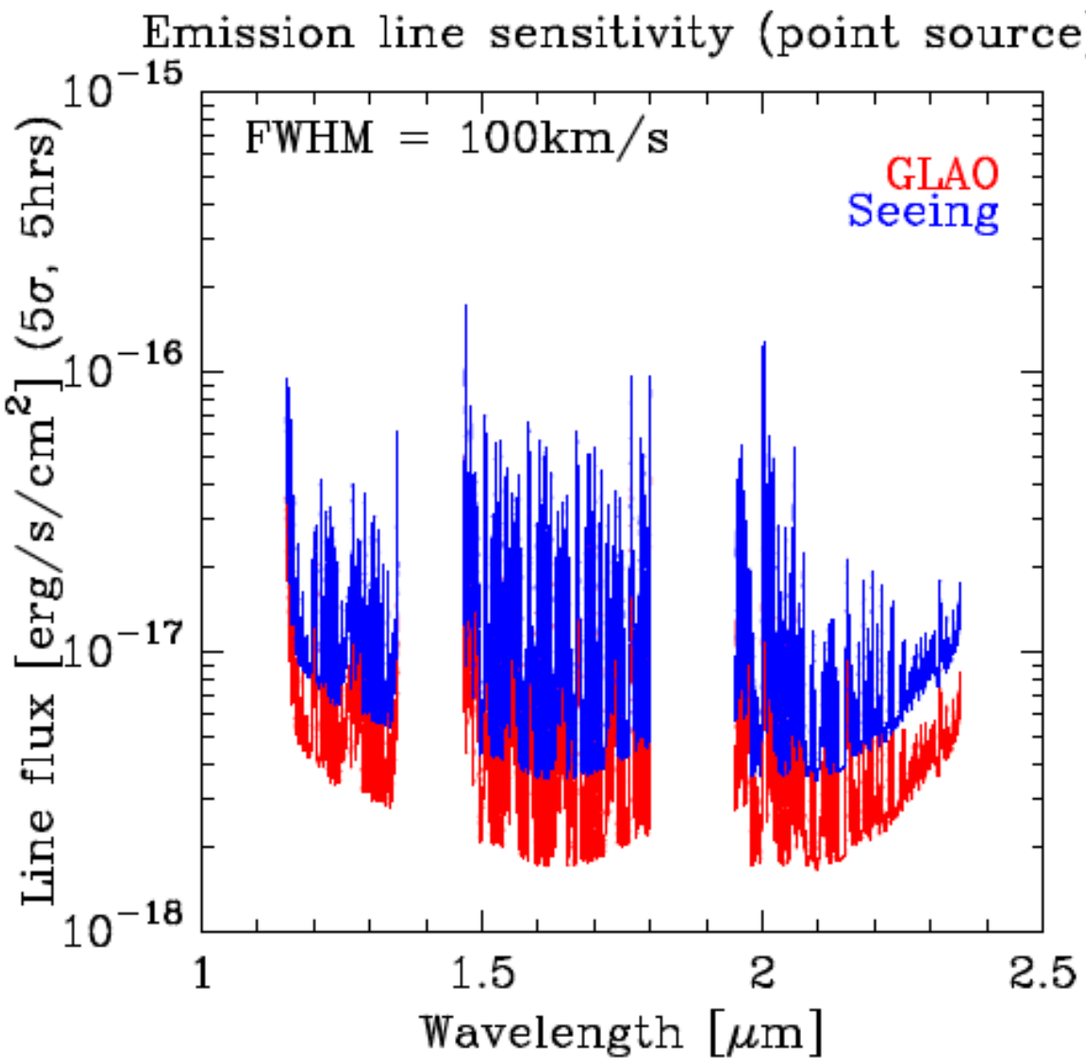
Ken-ichi Tadaki[1], Masayuki Akiyama[2], Masao Hayashi[1], Yoshiki Matsuoka[3], Tohru Nagao[3], Kimihiko Nakajima[4], Masato Onodera[1], Takatoshi Shibuya[5], Yoshiki Toba[6], and Kiyoto Yabe[7]

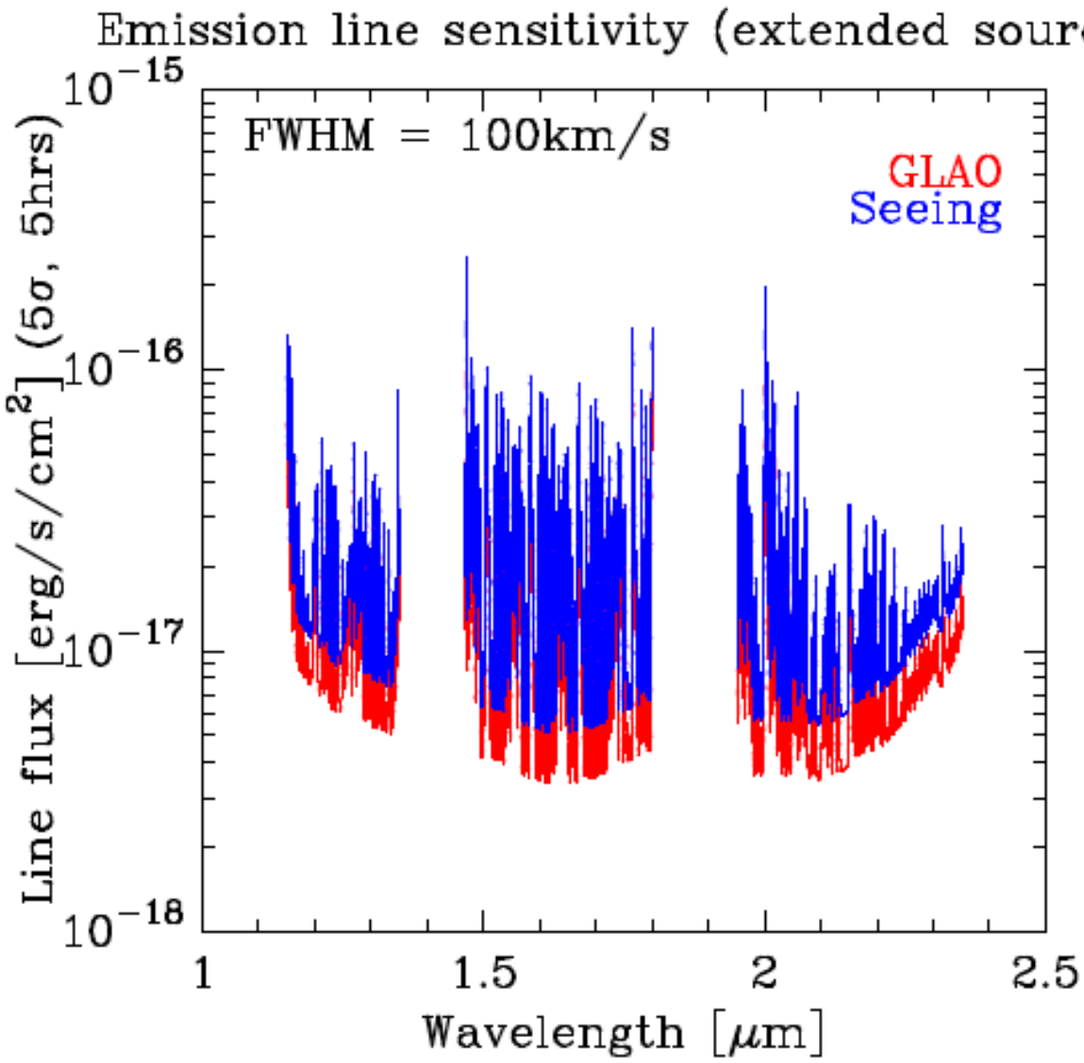
[1] National Astronomical Observatory of Japan
[2] Astronomical institute, Tohoku University
[3] Research Center for Space and Cosmic Evolution, Ehime University
[4] European Southern Observatory
[5] Institute for Cosmic Ray Research, The University of Tokyo
[6] Academia Sinica Institute of Astronomy and Astrophysics (ASIAA)
[7] Kavli IPMU, The University of Tokyo

NIR MOS instruments on 8-10 m telescopes

Keck/MOSFIRE	Subaru/MOIRCS	(Gemini/FLAMINGO-2)
 credit: Keck	 credit: Subaru	 credit: Gemini
3′×6′	4′×7′	2.0′×5.8′
R~3600	R~3000	R~3200

Benefits from GLAO

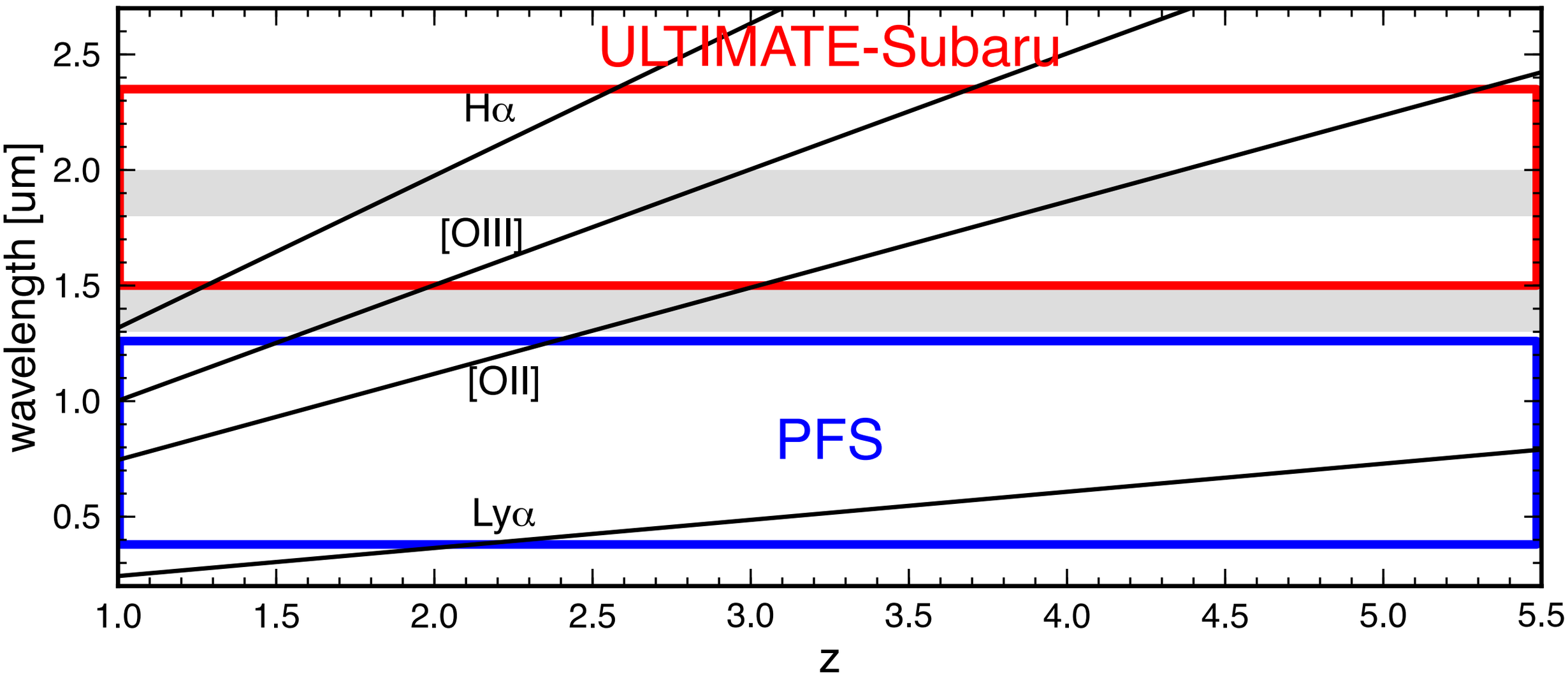




R~3000 instrument with a slit-width=0.4″
- point source: a factor of two improved
- extended source (R_e=2kpc): 60% improved

MOSFIRE has R~3600 with 0.7″ slit

Synergy between ULTIMATE and PFS



sample1: z=2.0-3.7 emission-line galaxies with PFS spectra
sample2: z=2.0-2.6 mass-complete sample with $\log M_{star}>10.5$
(sample2: z=2.0-3.7 emission-line galaxies identified by ULTIMATE-Subaru narrow-band imaging)
In 65 nights, we get H,K-band spectra for 6000 galaxies over 1 deg^2.

Star formation activity

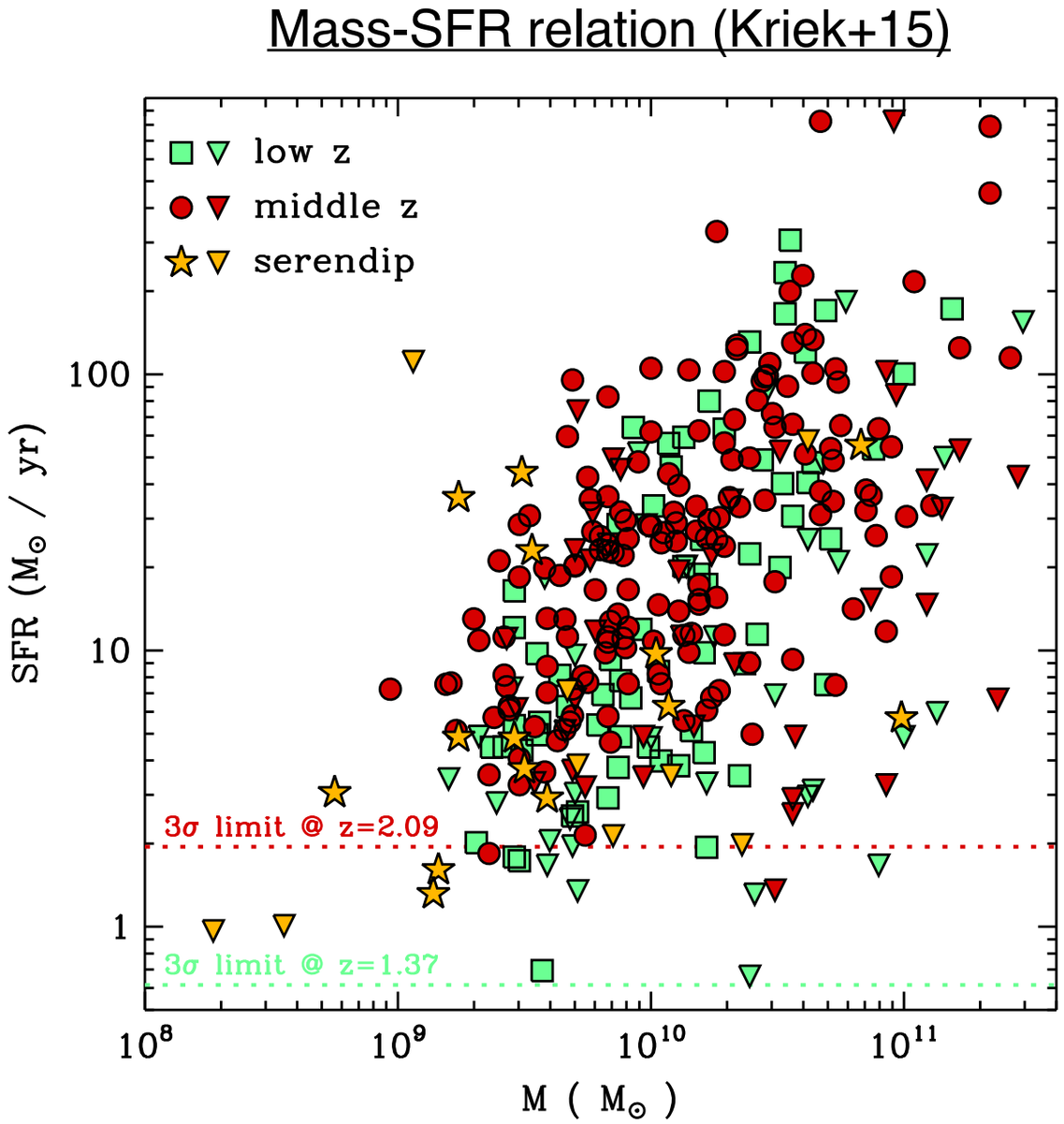
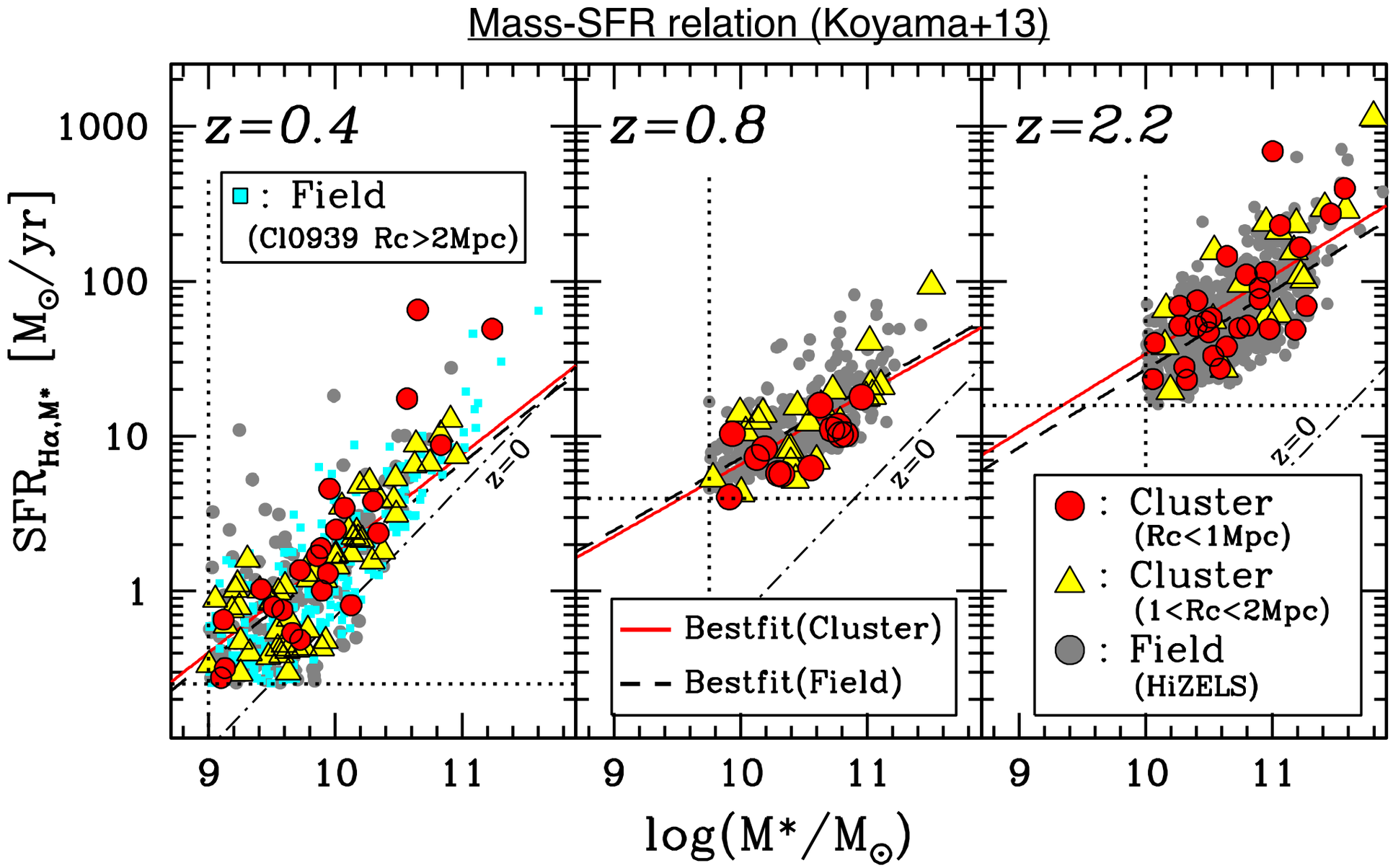


Figure 14. SFR vs. stellar mass for galaxies in the low (green) and middle redshift interval (red) for a Chabrier IMF. The 3σ upper limits are indicated by the upside-down triangles. The yellow symbols indicate the galaxies that were serendipitously detected. **The SFRs are derived from the combination of Hα and Hβ.** The 3σ limits on the SFR, calculated using the optimal 3σ line sensitivities in H and K, are shown for $z \sim 1.37$ and $z \sim 2.09$ (i.e., the lower boundaries of the redshift intervals), respectively. In this calculation we assume no dust attenuation.

- study the main sequence of star-forming galaxies and the environmental dependence using the most reliable measurements of SFR

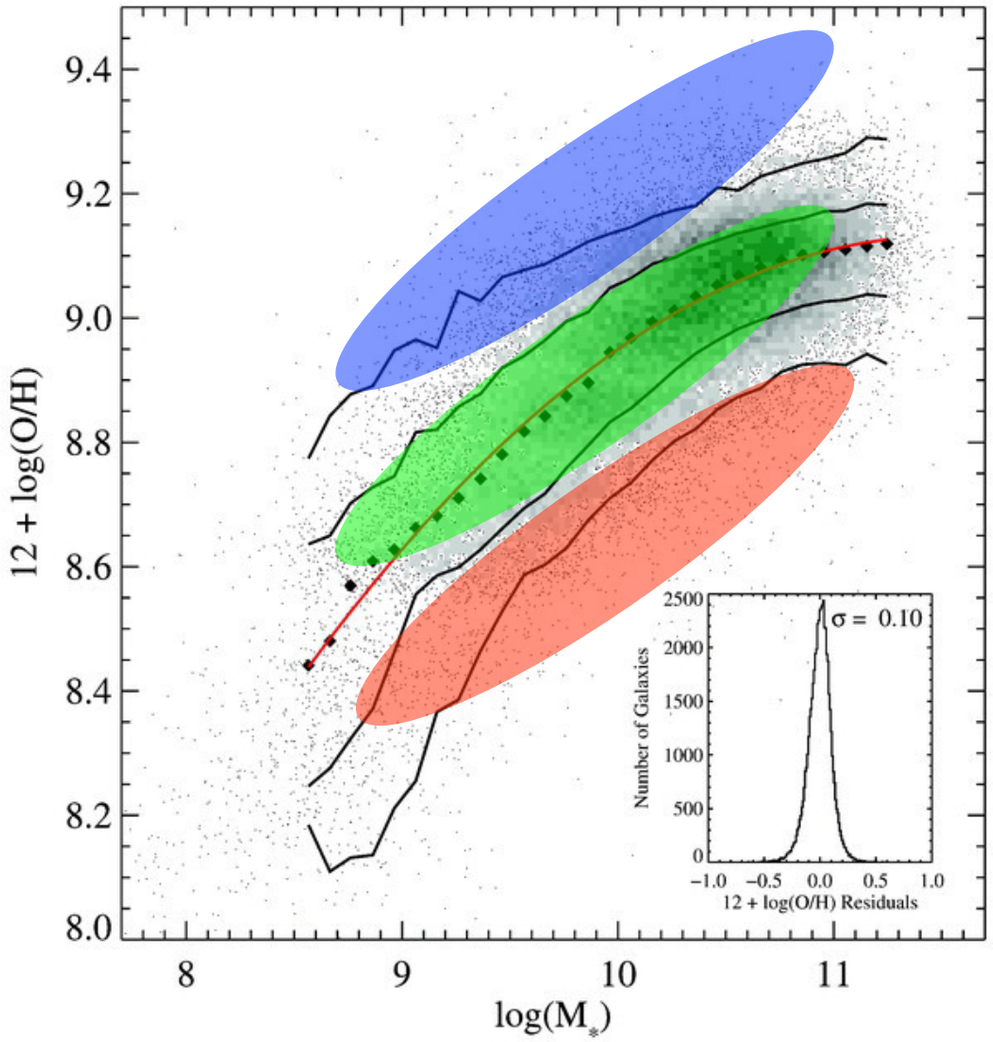
Star formation activity



- study the main sequence of star-forming galaxies and the environmental dependence using the most reliable measurements of SFR

Chemical evolution

Mass-metallicity relation (Tremonti+04)



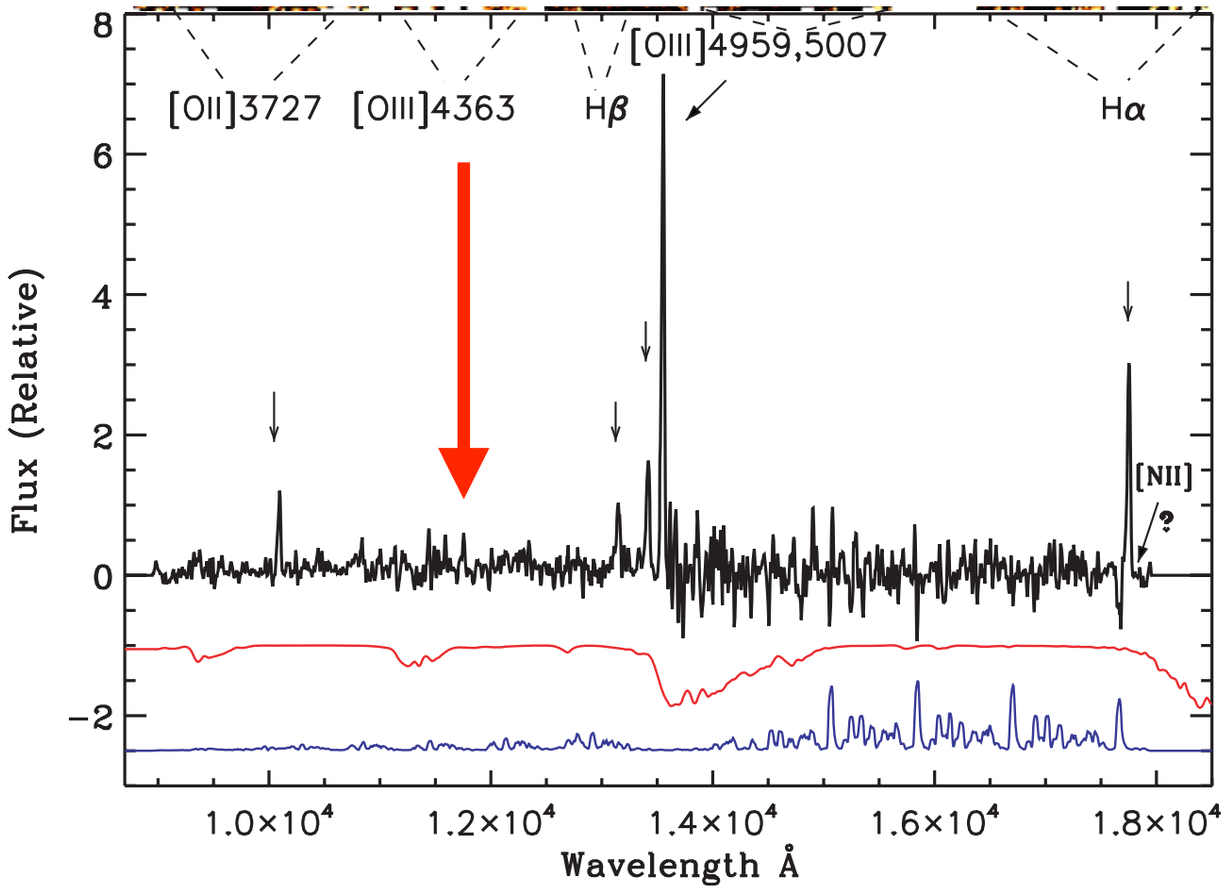
Cluster galaxies are

- **more metal rich** (Shimakawa+15)
- **as metal rich as field ones** (Tran+15)
- **more metal poor** (Valentino+15)

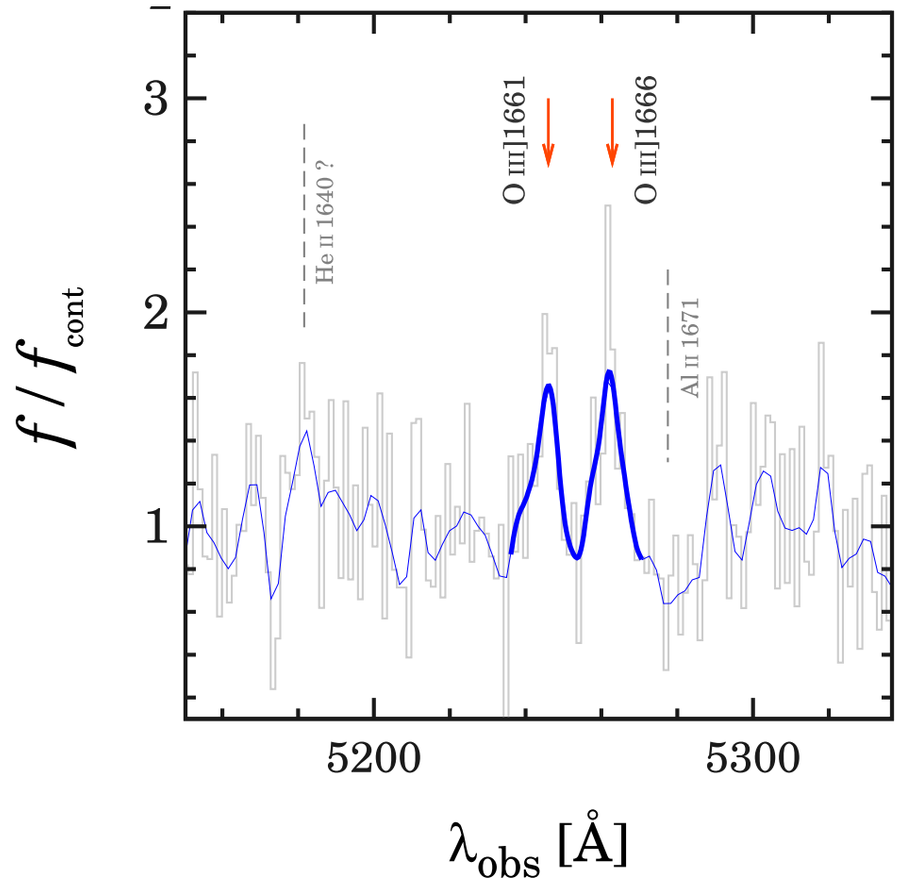
- study the environmental dependence of mass-metallicity (or mass-SFR-metallicity) relation

Metallicity measurements with Te-method

[OIII]4363 at z=1.7 (Yuan+09)



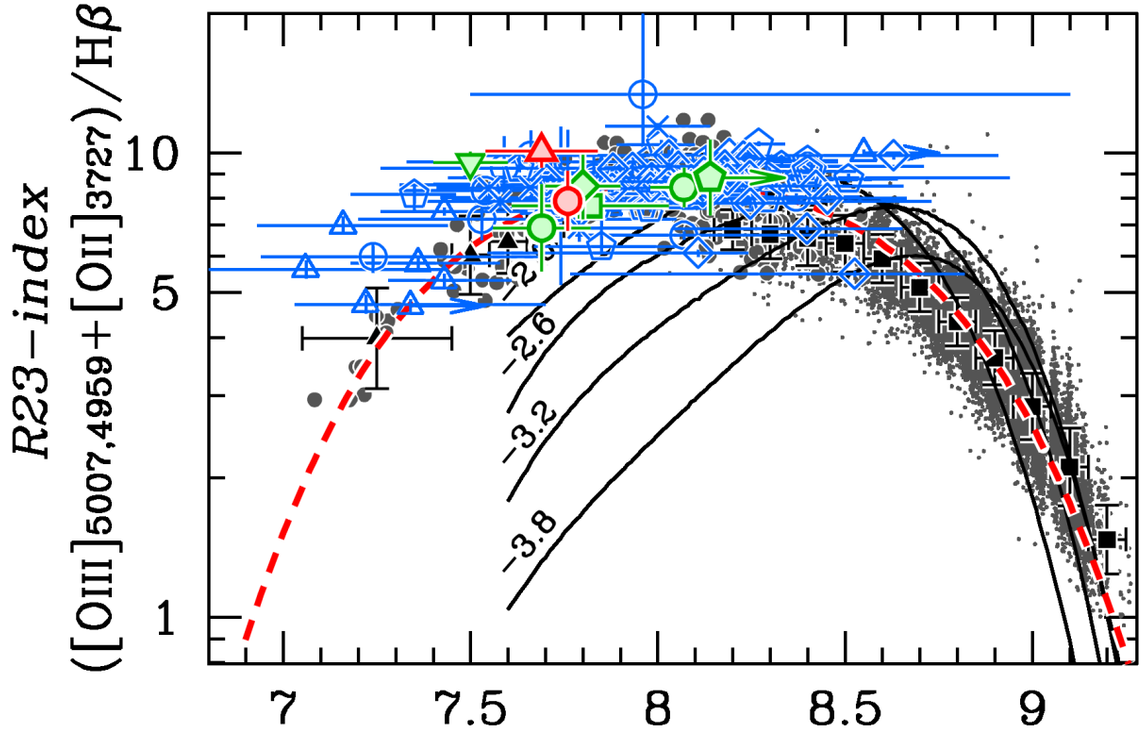
OIII]1661,1666 at z=2.2 (Kojima+17)



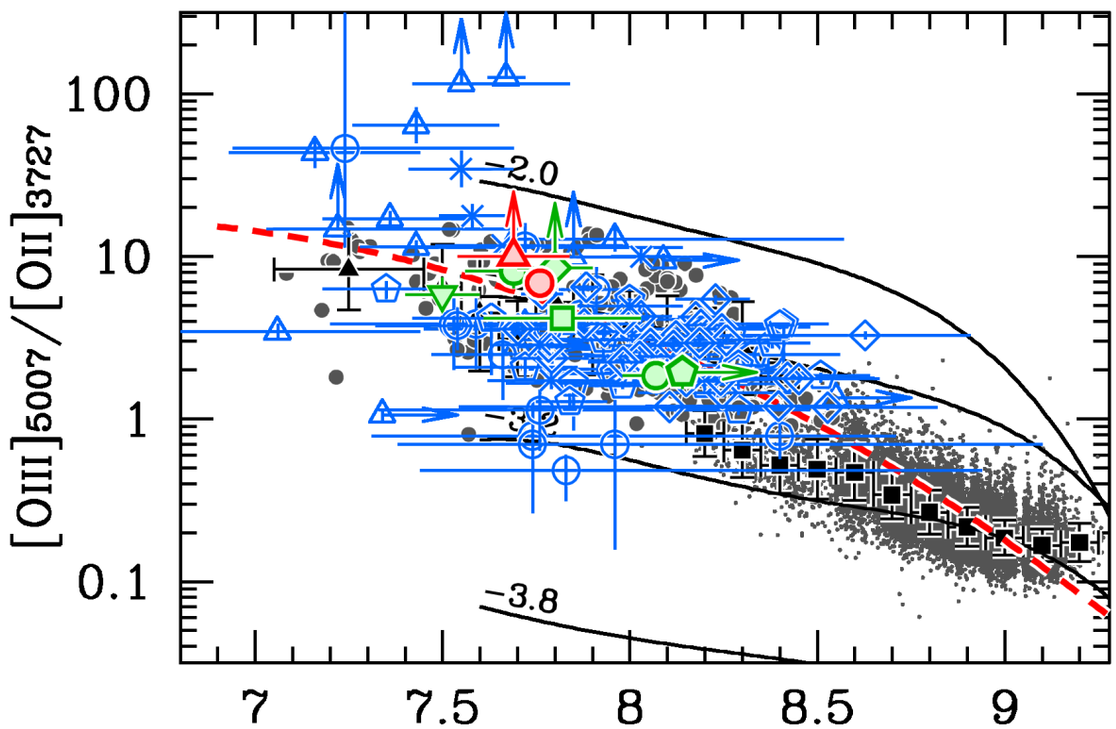
only ~10 galaxies at z~2

- significantly enlarge the sample size of z=2-3 galaxies with accurate metallicity measurements

ISM properties

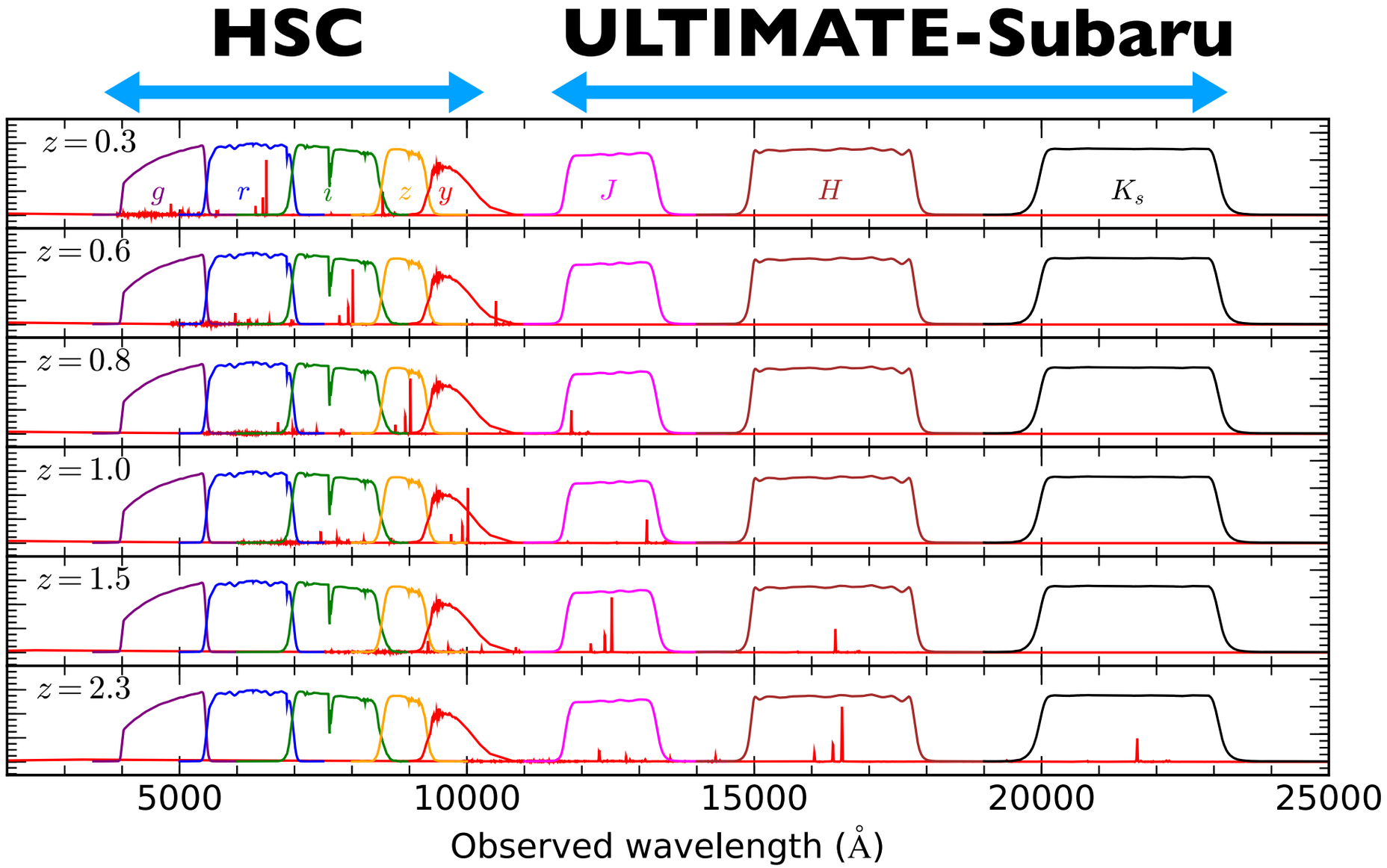


blue: z~1
green: z~2
red: z~3



- **ionization parameter**
- **shape of ionizing spectrum**
- **electron density**
- **abundances of heavy element**

Low-mass strong emission line galaxies

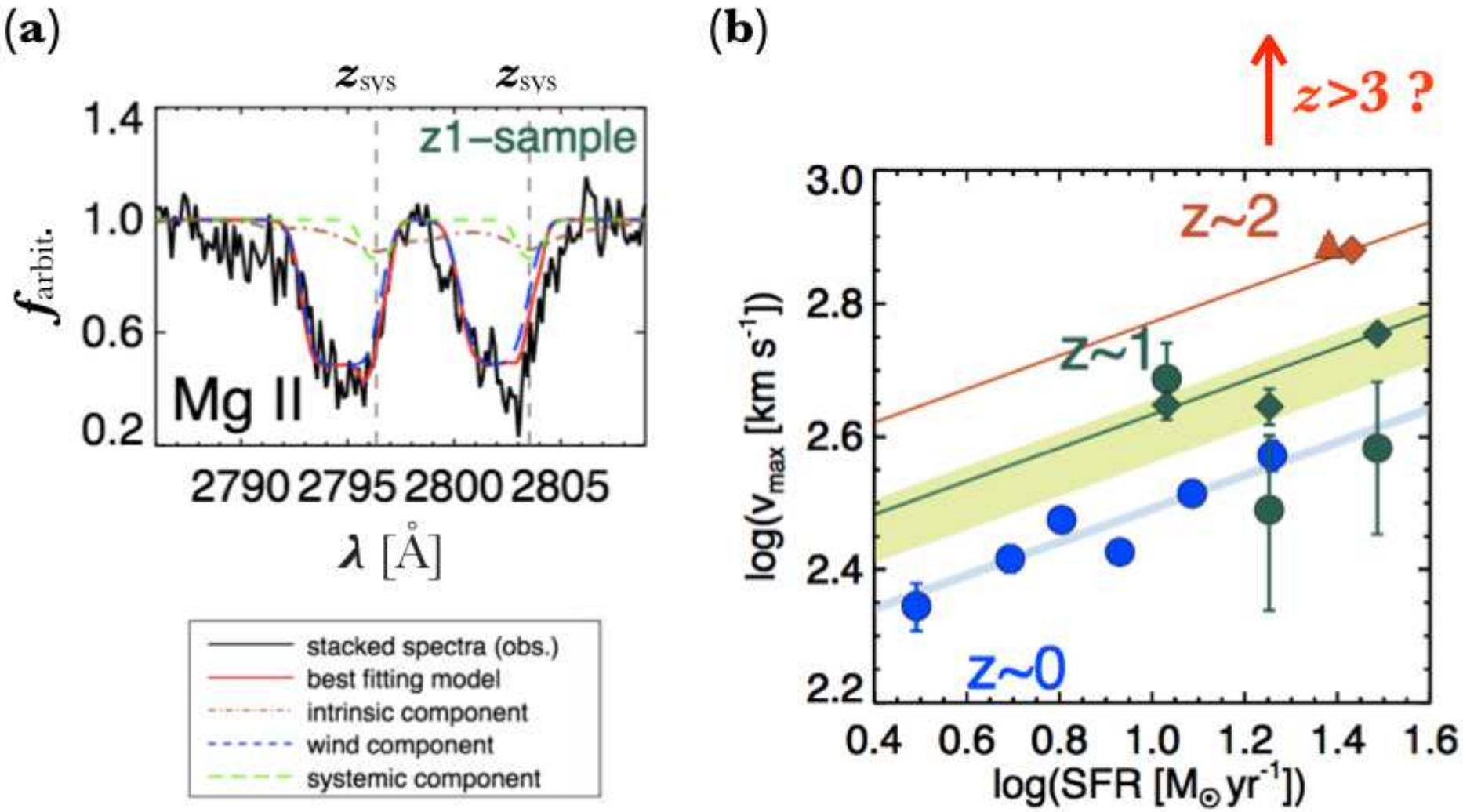


- galaxies with excesses in broad-band photometries

→ **Low-z analogues of star-forming galaxies in very early Universe**

Galactic outflows in galaxies at z=3-5

Sugawara+17

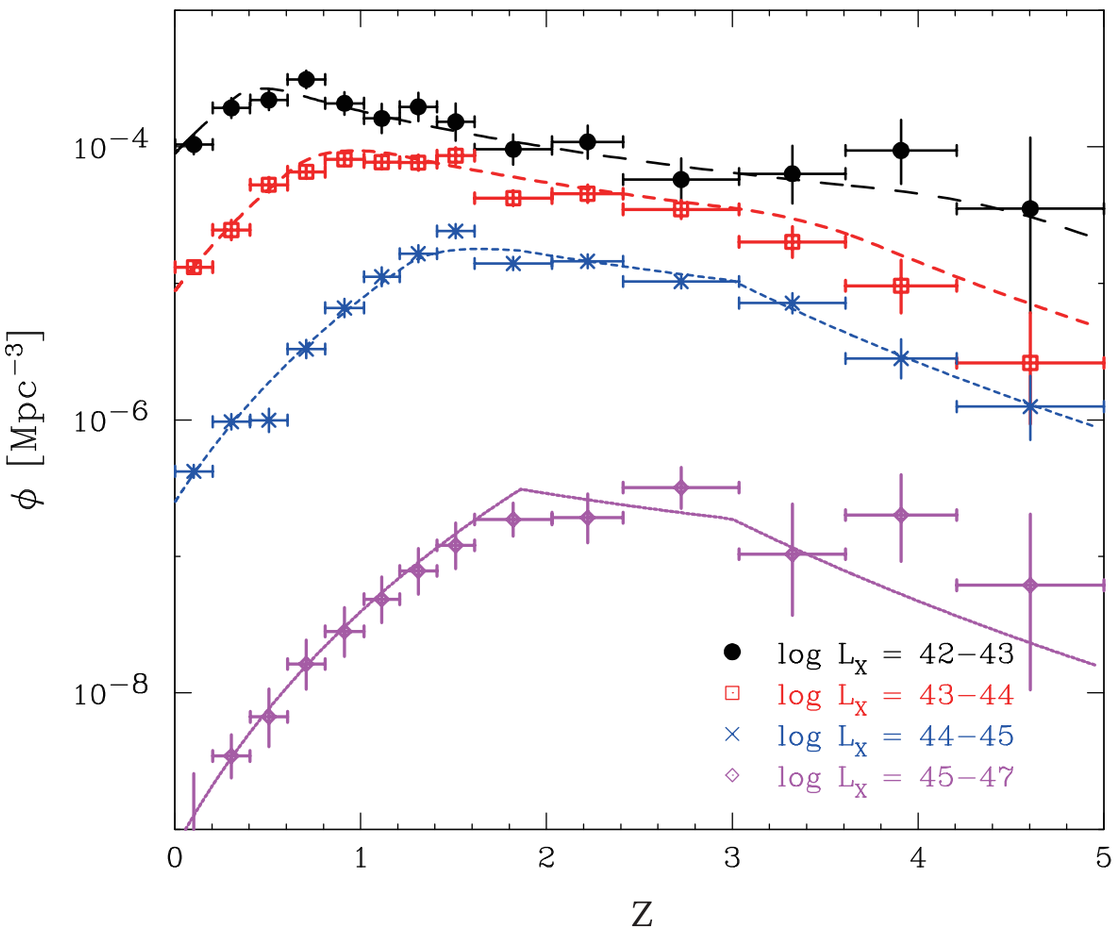


ULTIMATE: systematic velocity using nebular emission lines (e.g., [OII])
PFS: velocity shift using ISM absorption lines (e.g., MgII)

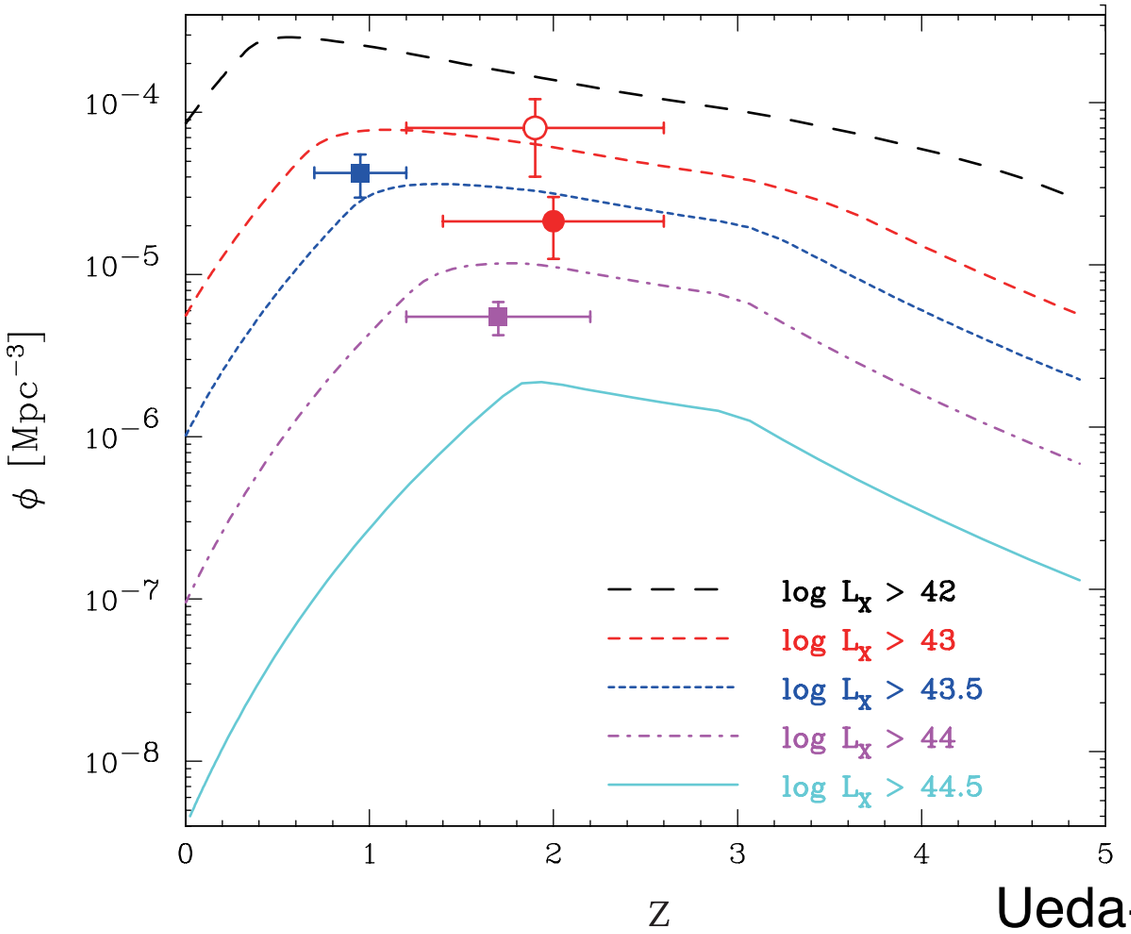
- investigating the outflow velocity in galaxies at z>3

Cosmological Evolution of AGN number density

Compton-thin AGNs



Compton-thick AGNs



Ueda+14

X-ray surveys

Near-infrared surveys

- investigating the cosmological evolution of number density of AGNs

Summary

A role of ULTIMATE-Subaru/MOS survey

	Low-mass galaxies	High-mass galaxies
Imaging (target selection)	HSC	Ultimate-Subaru
Optical spectroscopy	PFS	
Near-infrared spectroscopy	Ultimate-Subaru	