

# 遠方銀河観測レビュー 2018年版

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# 内容

Selection criteria

1. Published or arXived in 2018
2. Galaxies in the epoch of reionization (EoR;  $z > 6$ )
3. Personal interest

ALMA

Subaru HSC

Other interesting ones

# はじめに

天文月報2017年4月号

## 1. 発 端

「あ、松尾さん。この前のプロポーザルは、」  
「・・・オースリーが強いっていうモデルが欲しい」

「え？」

「理論屋だったら、オースリーが強いっていうモデルを作って欲しい。絶対強いと思うんだ。実際カリーナとかサーティドラドスとかでオースリーは強いから・・・」

「・・・はあ・・・考えてみます・・・」

お酒のせいもあったかもしれないが、頬を紅潮させ、真剣な眼差しの松尾宏（国立天文台）の表情は今もよく覚えている。慧眼の士。2012年春の天文学会，懇親会にて。

# 輝線赤方偏移ランキング2018

	Object name	Line redshifts	Lines	References
1	MACS1149-JD1	9.110, 9.094	[OIII]88, LyA	Hashimoto+18a
2	EGS8p7	8.683	LyA, NV1243	Zitrin+15, Mainali+18
3	A2744_YD4	8.382	LyA, [OIII]88	Laporte+17
4	MACS0416_Y1	8.312	[OIII]88	Tamura+18
5	EGS-zs8-1	7.730	LyA, CIII]1909	Stark+17
6	Z7_GSD_3811	7.664	LyA	Song+16
7	QSO J1342+0928	7.541	[CII]158, LyA+	Banados+18
8	Z8_GND_5296	7.508	LyA	Finkelstein+13
9	EGS-zs8-2	7.477	LyA, CIII]1909	Stark+17
10	GS2_1406	7.452	LyA	Larson+18
11	SXDF-NB1006-2	7.215, 7.212	LyA, [OIII]88	Shibuya+12, Inoue+16

2018/11/21

初代星初代銀河2018（茨城大）

# [OIII]88赤方偏移ランキング2018

	Object name	Type	Redshift	Features	References
1	MACS1149-JD1	LBG	9.110	[OIII]88, LyA	Hashimoto+18a
2	A2744_YD4	LBG	8.382	LyA, [OIII]88, dust	Laporte+17
3	MACS0416_Y1	LBG	8.312	[OIII]88, dust	Tamura+18
4	SXDF-NB1006-2	LAE	7.212	LyA, [OIII]88	Inoue+16
5	B14-65666	LBG	7.151	[OIII]88, [CII]158, dust	Hashimoto+18b
6	BDF-3299	LAE	7.097	[OIII]88	Carniani+17
7	SPT0311-58-E/W	SMG	6.900	[OIII]88, [CII]158, dust	Marrone+17
8	SDF_LBG_ID34	LBG	6.311	LyA, [OIII]88, [CII]158	Hashimoto+
9	RXCJ2248-ID3	LAE	6.105	LyA, [OIII]88	Sunaga+
10	J2054-0005	QSO	6.039	[OIII]88, [CII]158, dust,+	Hashimoto+18c
11	J2310+1855	QSO	6.004	[OIII]88, [CII]158, dust,+	Hashimoto+18c

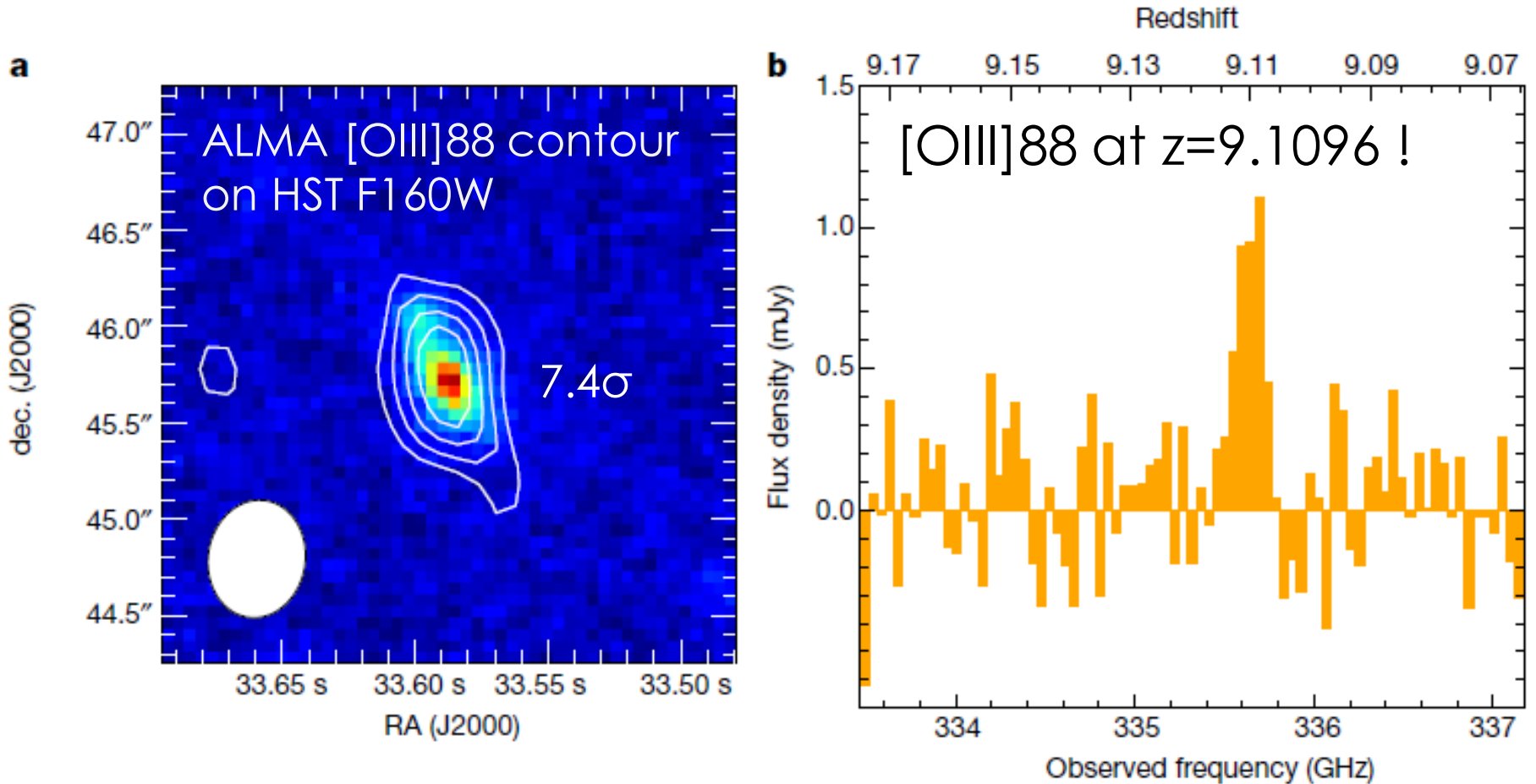
2018/11/21

初代星初代銀河2018（茨城大）

# MACS1149-JD1

Hashimoto+AKI+18, Nature

[OIII] 88  $\mu\text{m}$  line was detected at  $7.4\sigma$   
The new spectroscopic redshift record !



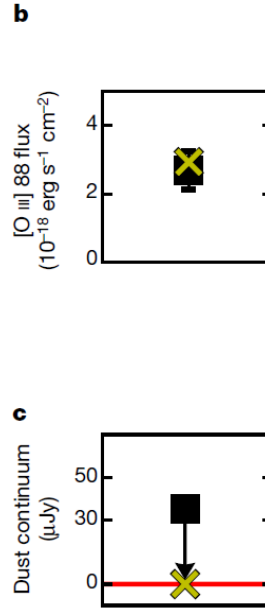
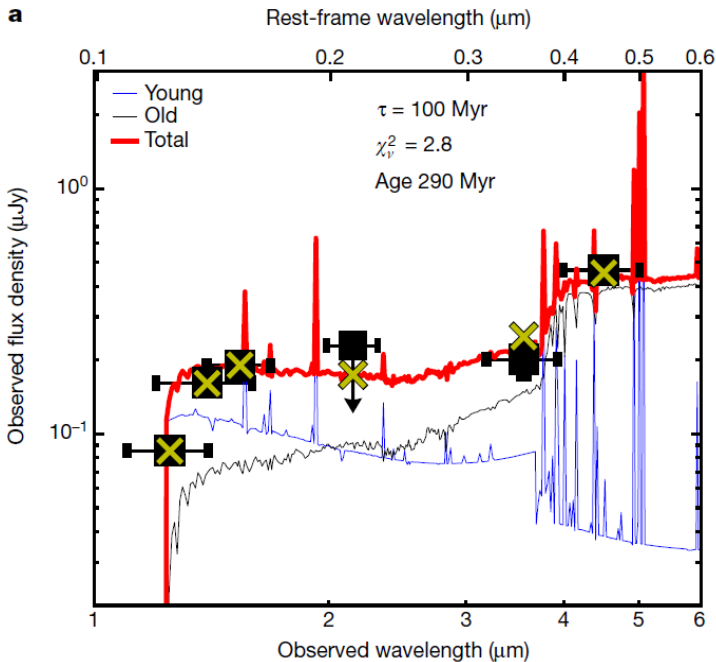
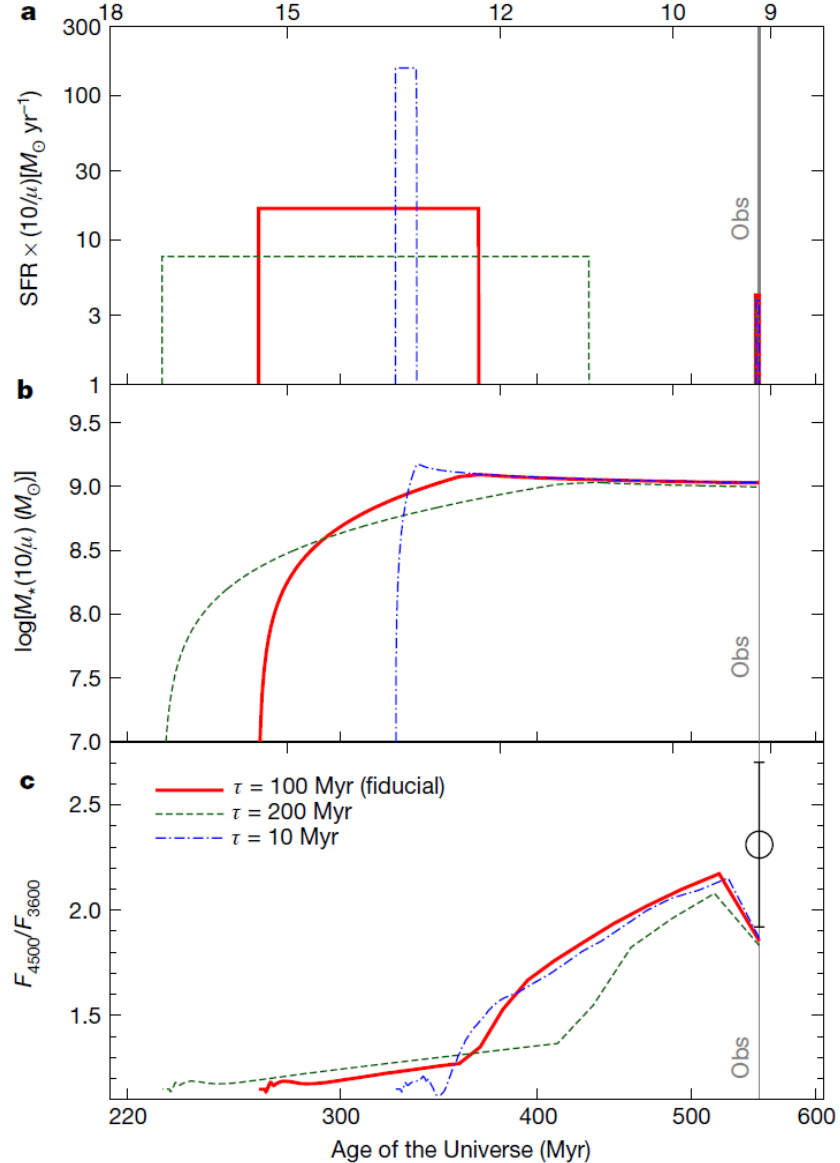
# MACS1149-JD1

Balmer break !  
 ~200 Myr old stellar population  
 2 SF episodes

*Formation at  $z \sim 15$*

Hashimoto+AKI+18, Nature

Redshift



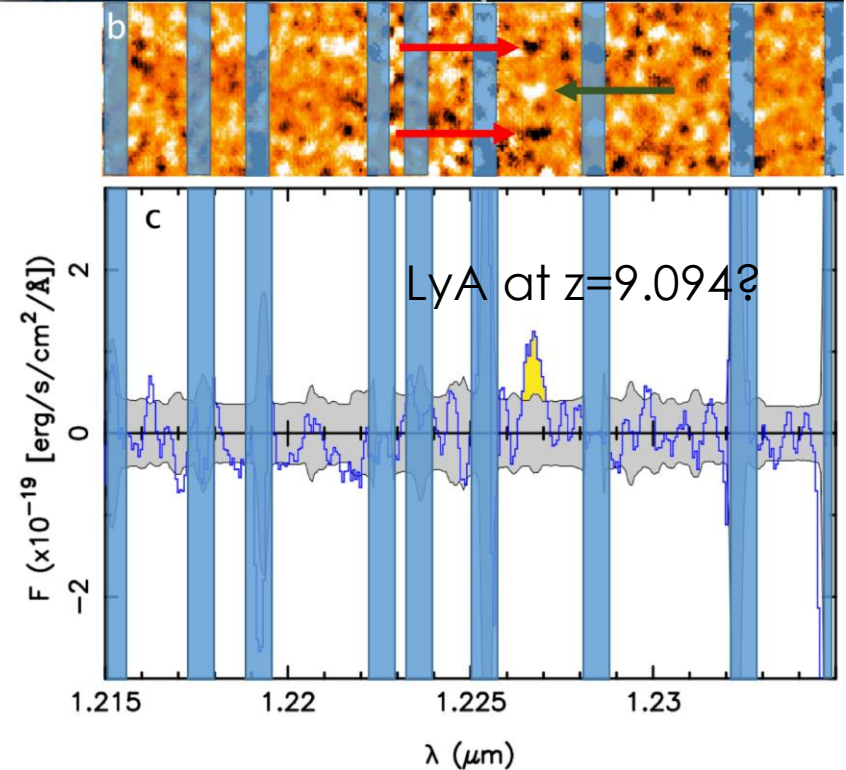
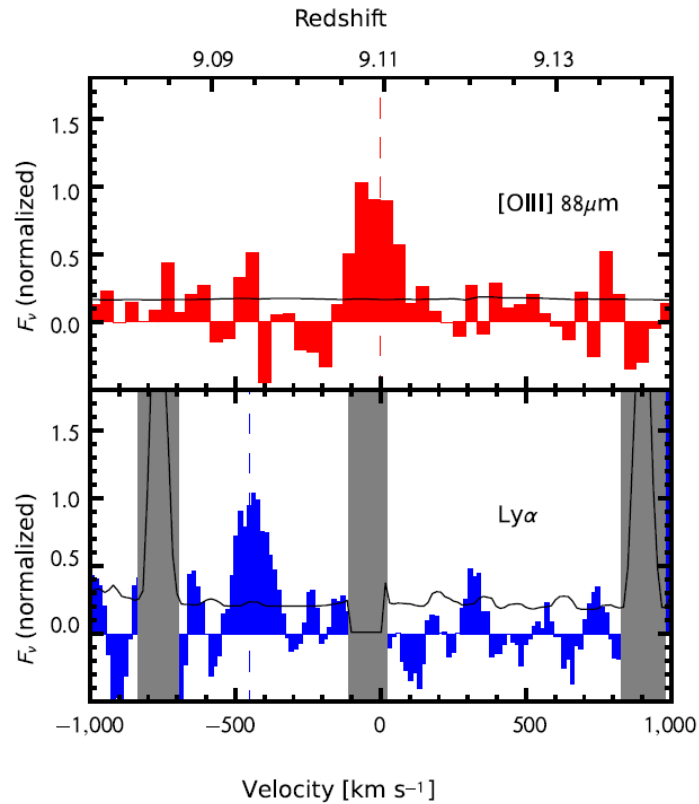
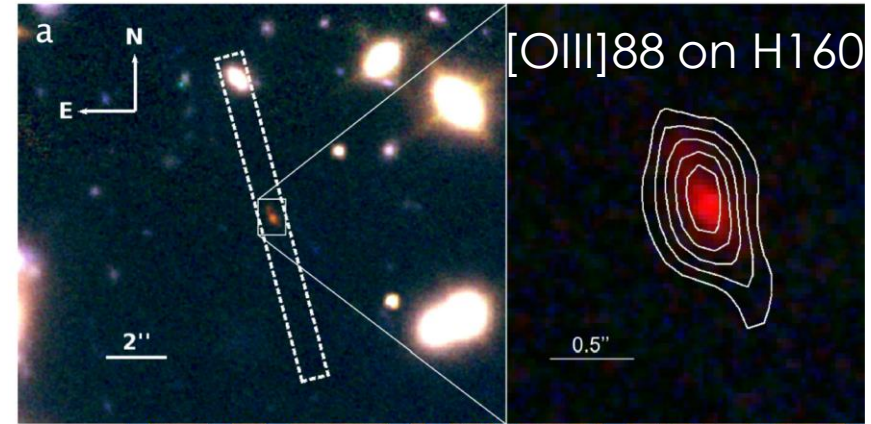
# MACS1149-JD1

Possible ( $4\sigma$ ) detection of LyA

$\Delta v = -450$  km/s  $\rightarrow$  blueshift!

The initial burst may create a large ionized bubble?

Hashimoto+AKI+18, Nature



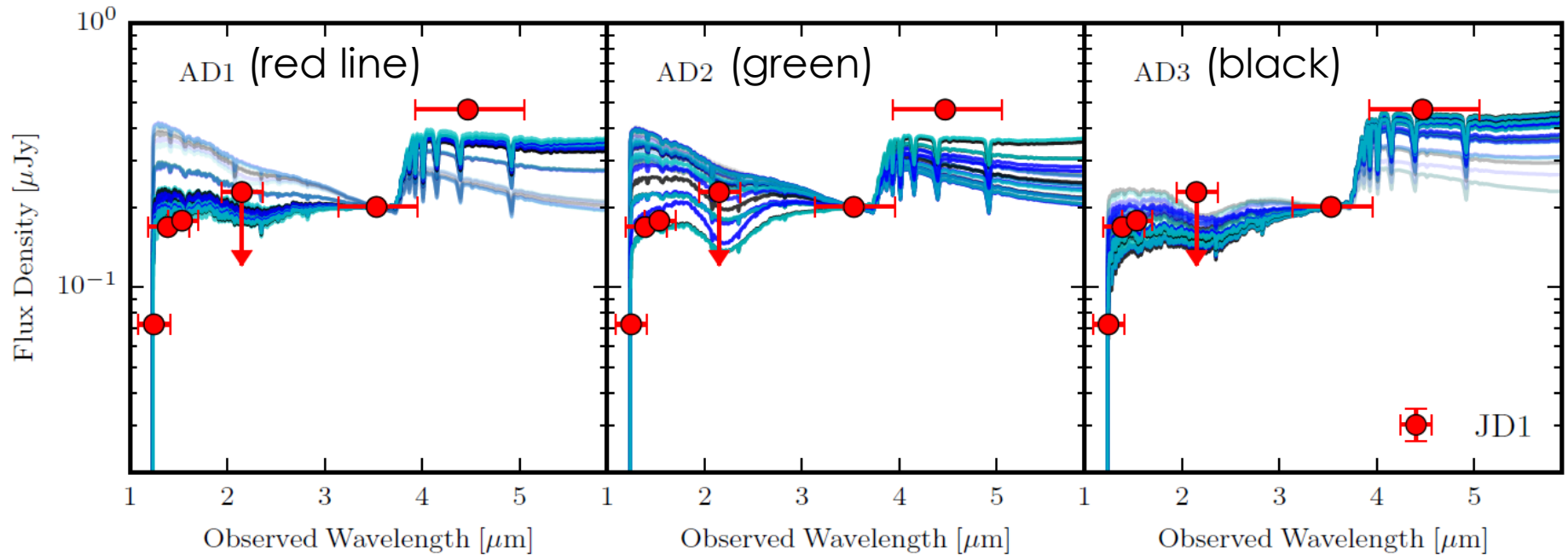
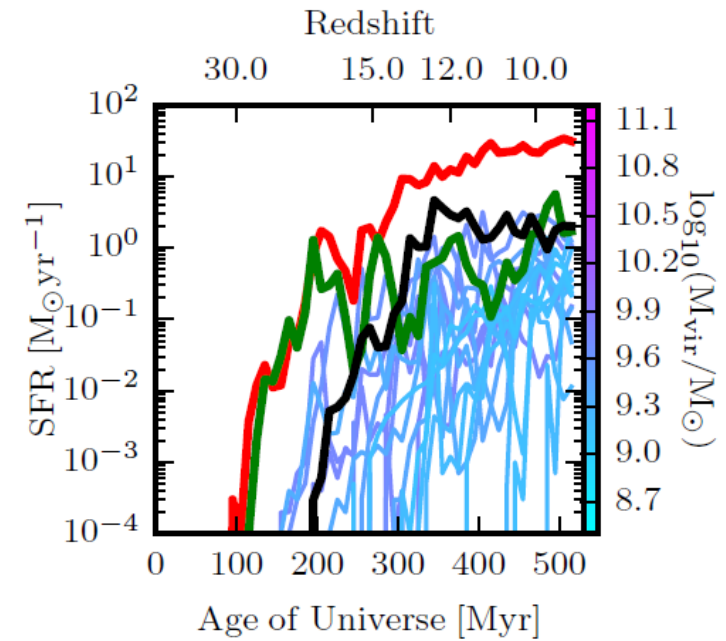


# MACS1149-JD1

Katz+18 simulation

Dust reddening plays a role  
to reproduce the “Balmer break”.

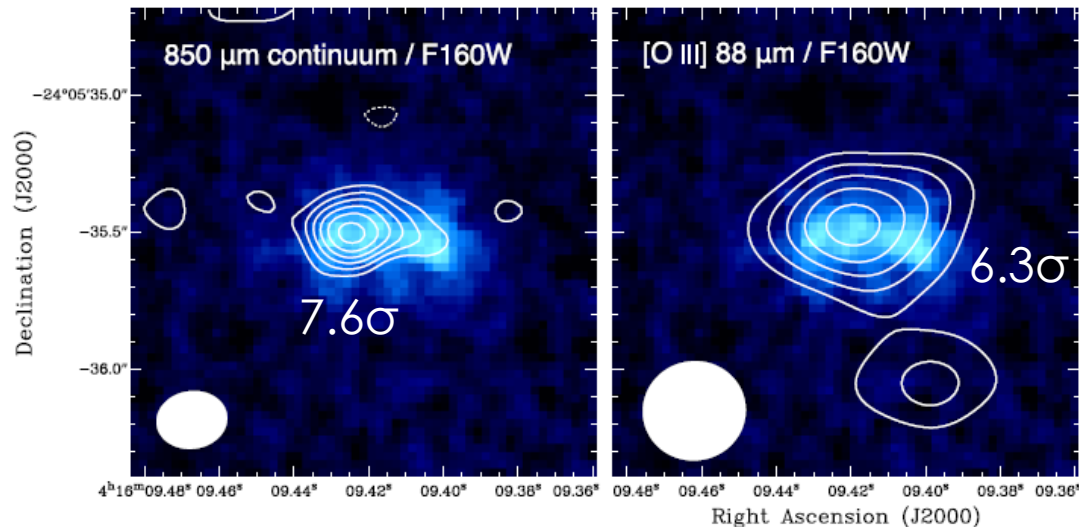
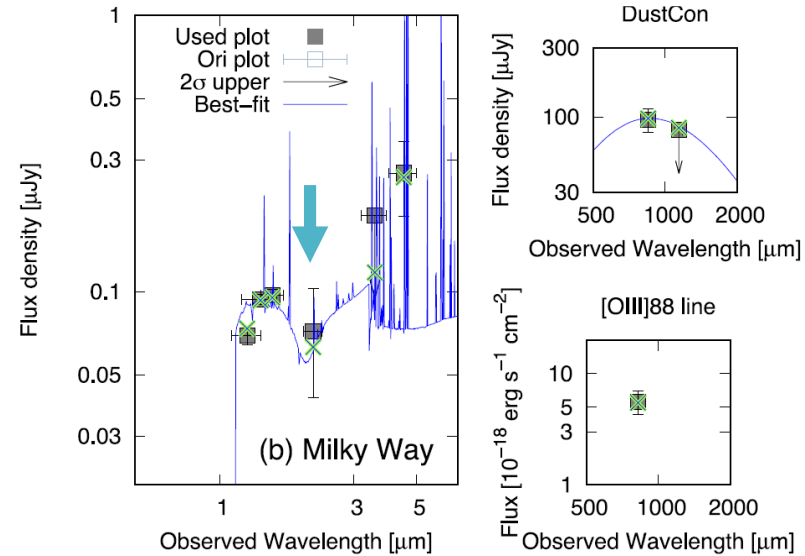
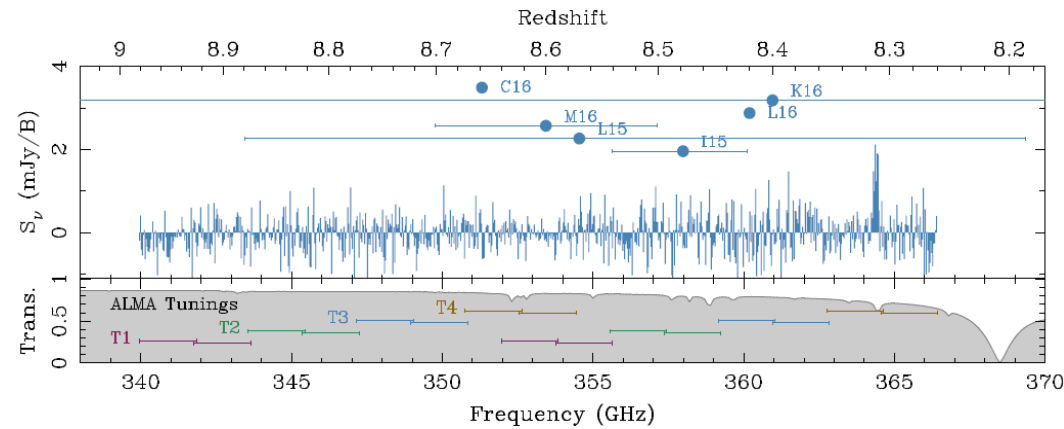
But weak [OIII]88 line  
(they proposed enhanced O ???)



# MACS0416\_Y1

Tamura+AKI+18

## Dust and [OIII] 88 at $z=8.312$



Faint K-band  
→ 2175A dust bump?  
(carbonaceous grains)

# B14-65666

Big-Three-Dragons

Hashimoto+AKI+18b

大三元



The first complete set of [OIII], [CII] & dust!

$M_{UV} = -22.3$

$z[\text{OIII}] = 7.1510$

$z[\text{CII}] = 7.1521$

Dust (Band 6)

$[\text{OIII}]/[\text{CII}] = 2.2$

$z(\text{Ly}\alpha) = 7.1730$

$\Delta v(\text{Ly}\alpha) = +772 \text{ km/s}$

Contour:

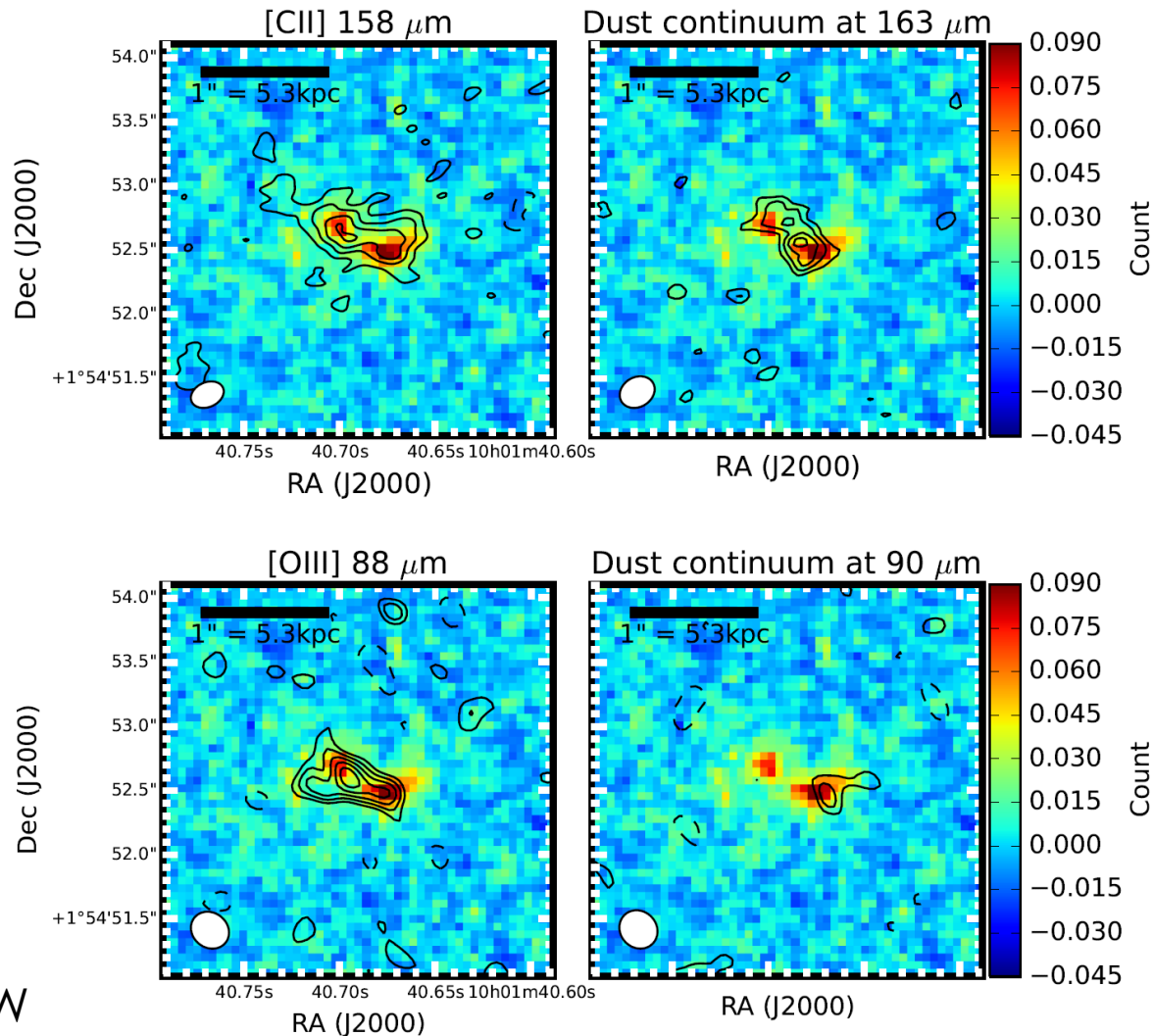
[CII] line  $-2, 2, 4, 6, 8\sigma$

163 mic cont.  $-2, 2, 3, 4, 5\sigma$

[OIII] line  $-2, 2, 3, 4, 5, 6\sigma$

90 mic cont.  $-2, 2, 3\sigma$

Background: HST/WFC3 F140W



# B14-65666

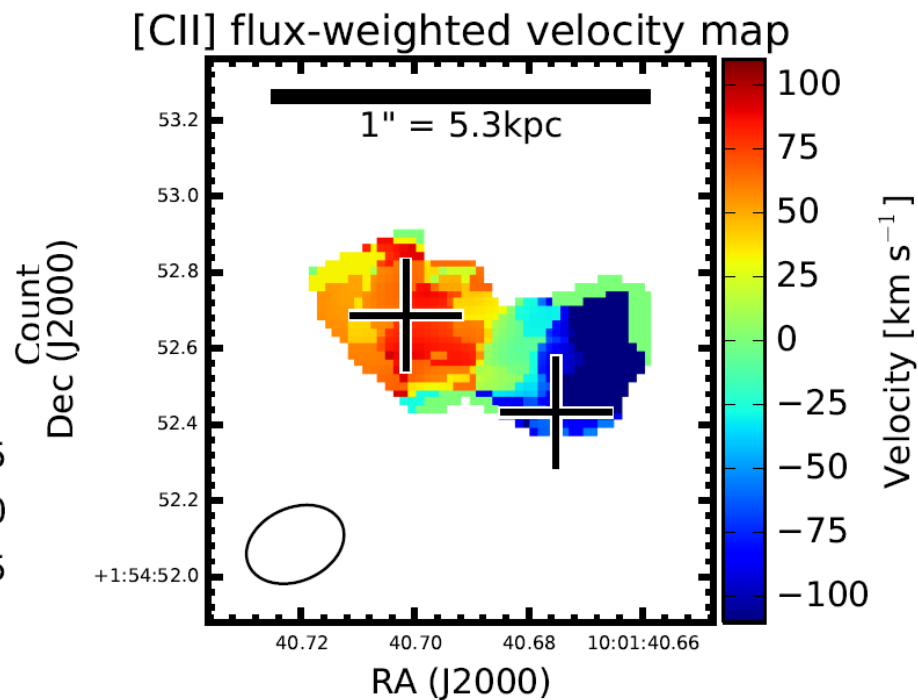
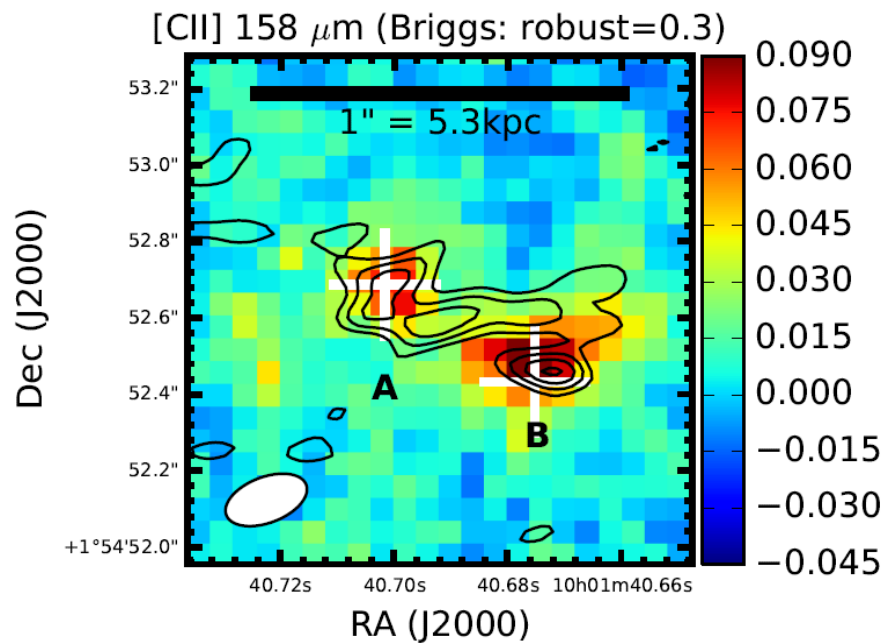
Big-Three-Dragons

Hashimoto+AKI+18b

大三元



Merger-like morphology

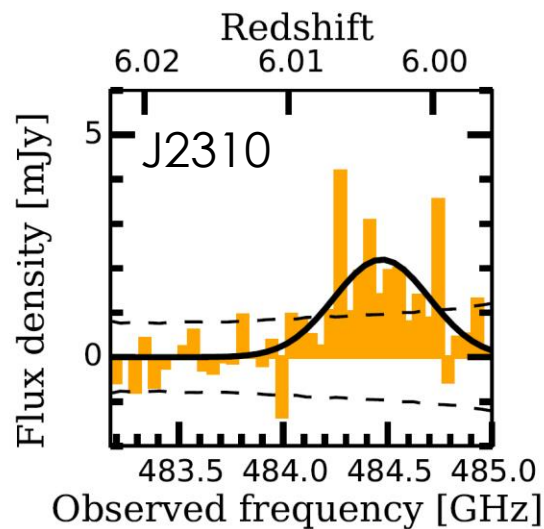
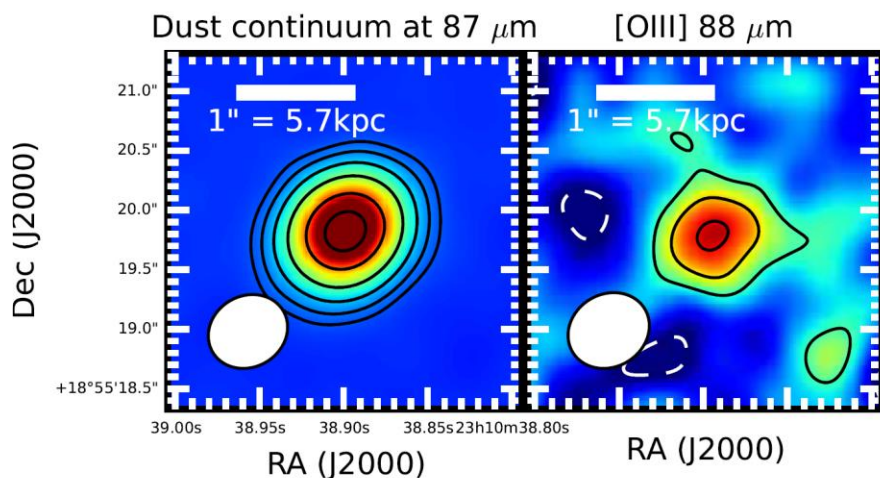
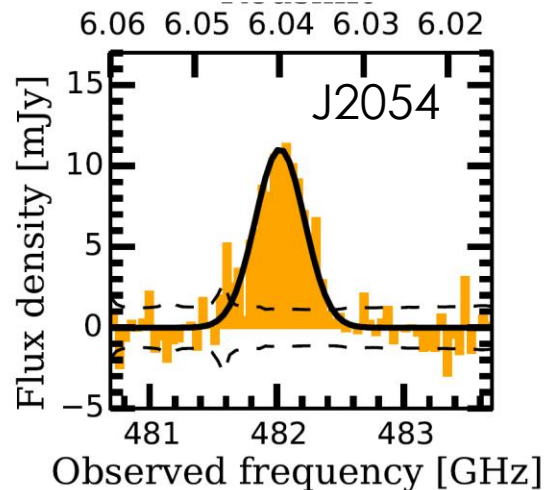
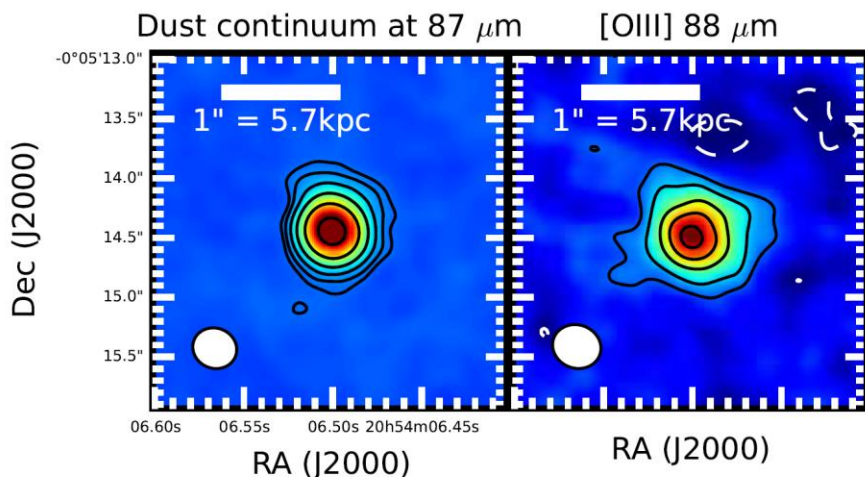


Background: HST/F140W

# First detections of [OIII]88 in QSOs

Hashimoto+AKI+18c

Two QSOs at  $z=6.0$

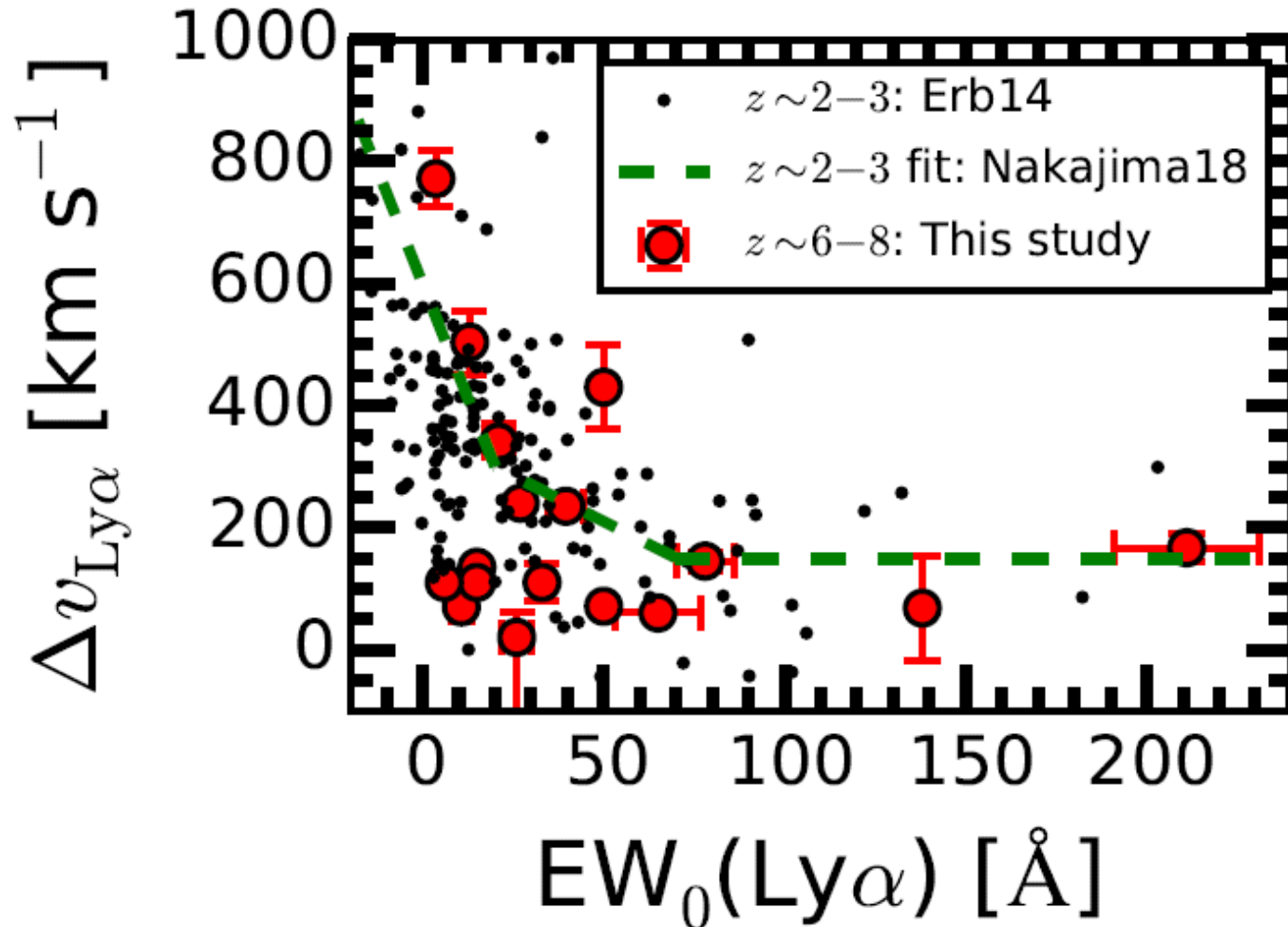


# EW(Ly $\alpha$ )- $\Delta v$ (Ly $\alpha$ ) anti-correlation

Hashimoto+AKI+18b

A large Ly $\alpha$  velocity offset  $\rightarrow$  a high N<sub>HI</sub>

LAEs have a smaller  $\Delta v$ (Ly $\alpha$ )  $\rightarrow$  less HI



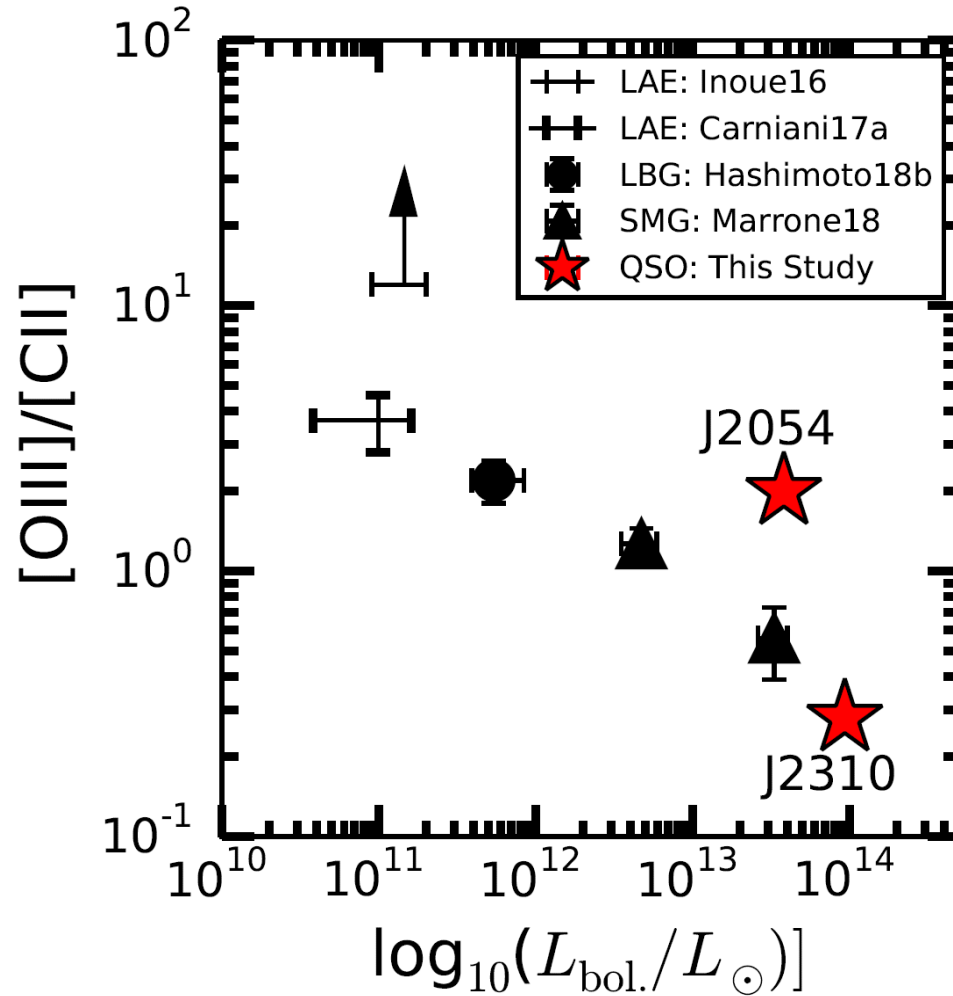


# [OIII]/[CII] ratio

Hashimoto+AKI+18b,c

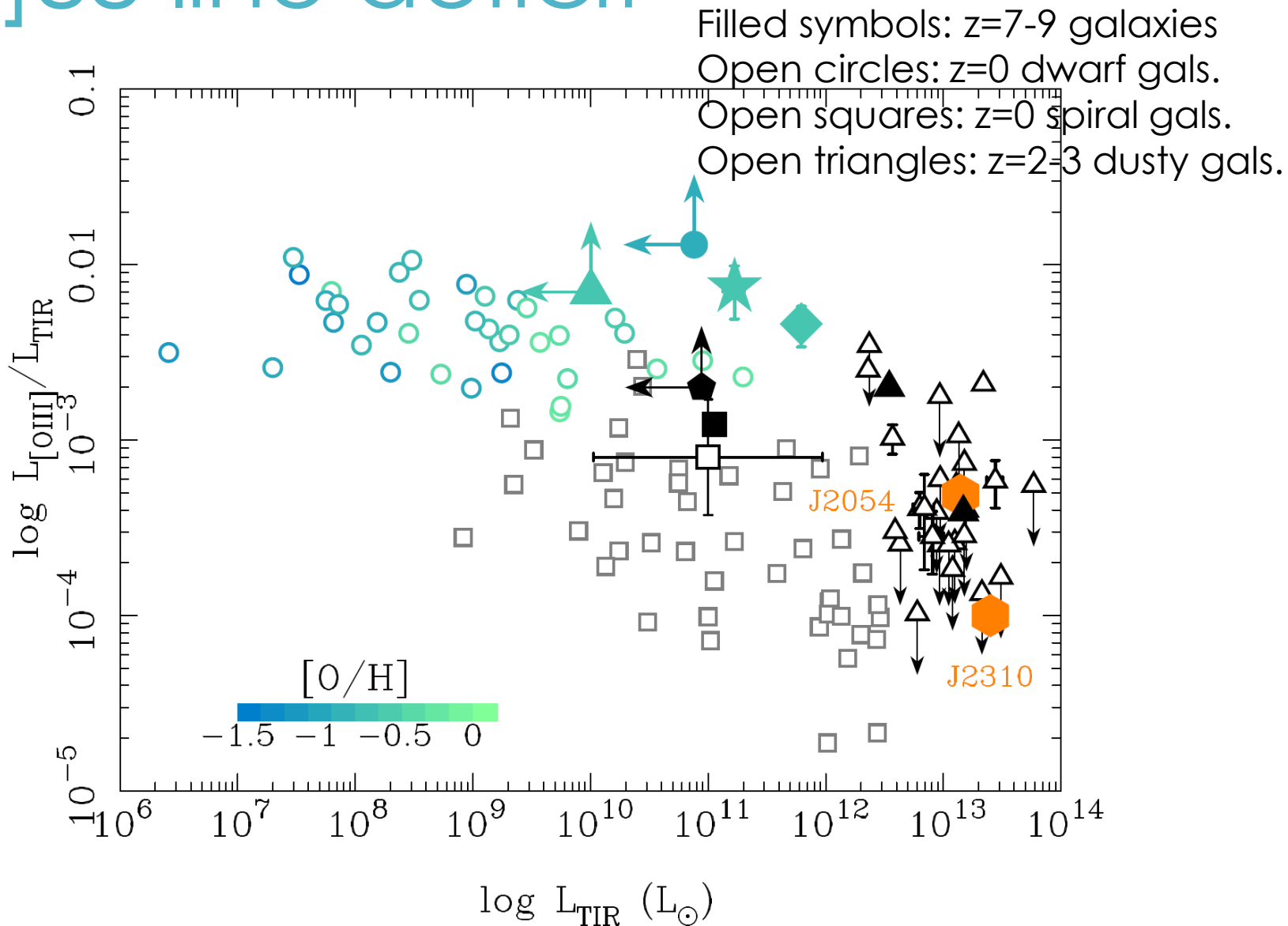
LAEs show a higher [OIII]/[CII].

Fainter, less dusty (i.e. less massive?) galaxies are higher in [OIII]/[CII].



# [OIII]88 line deficit

Hashimoto+AKI+18c





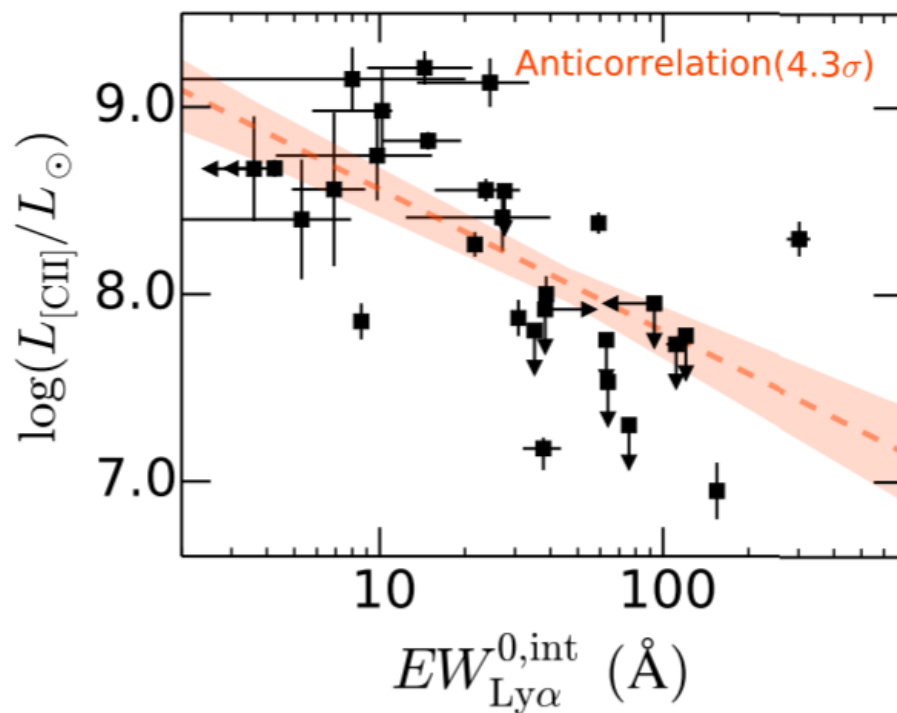
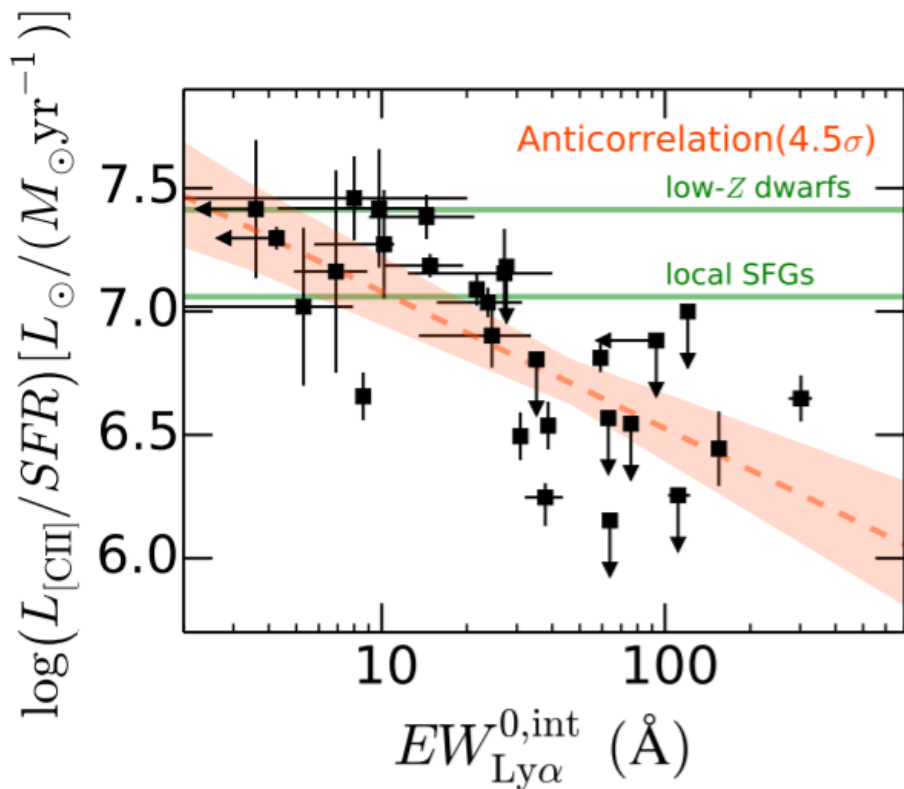
# [CII]-Ly $\alpha$ anti-correlation

Harikane+AKI+18

LAEs are weak in [CII]  $\rightarrow$  less HI (PDR)

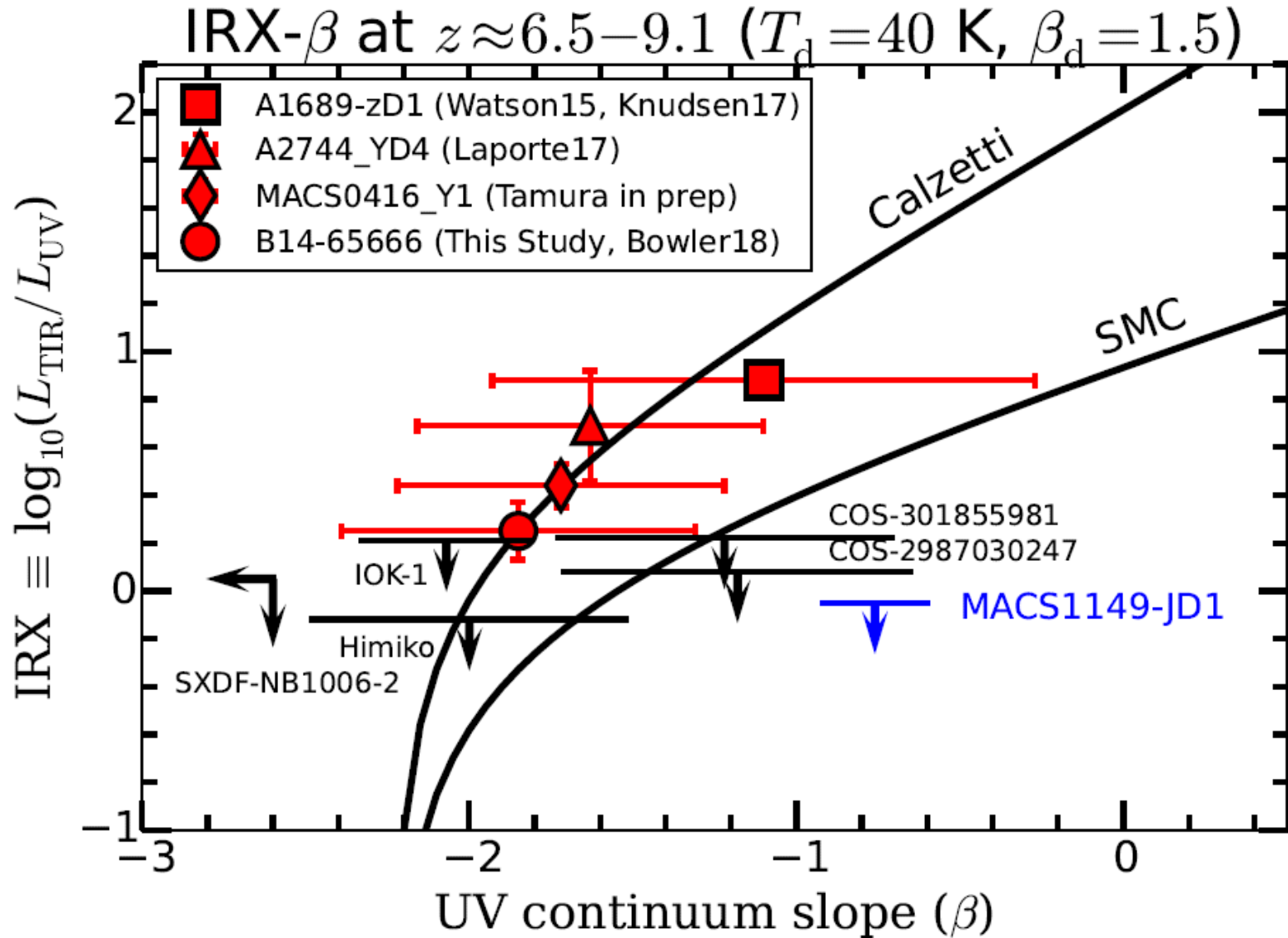
Higher ionization parameter?

High [OIII]/[CII] ratio  $\rightarrow$  Because of weak [CII]



# IRX- $\beta$ diagram

Hashimoto+AKI+18b



# [CII] 158 $z \sim 7$ rotational disks

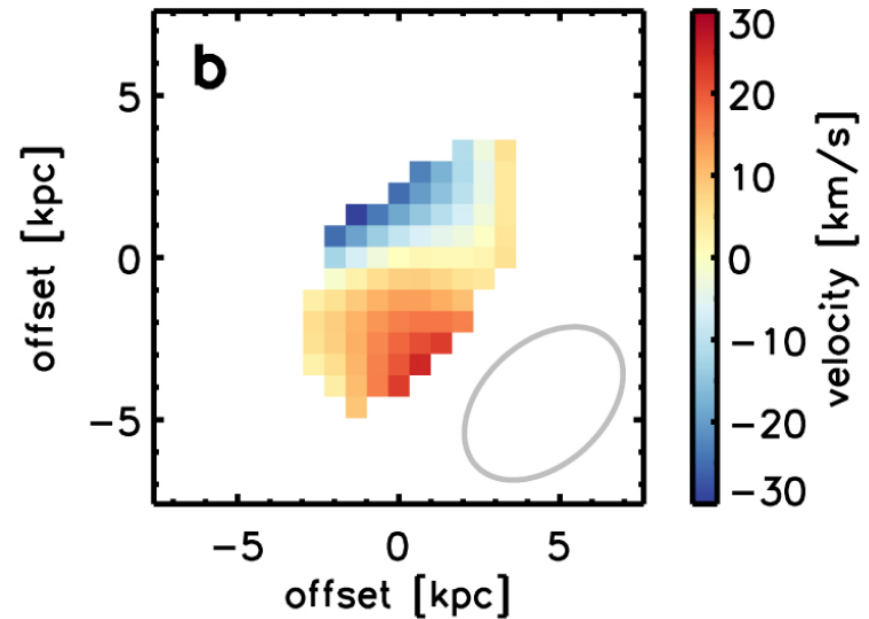
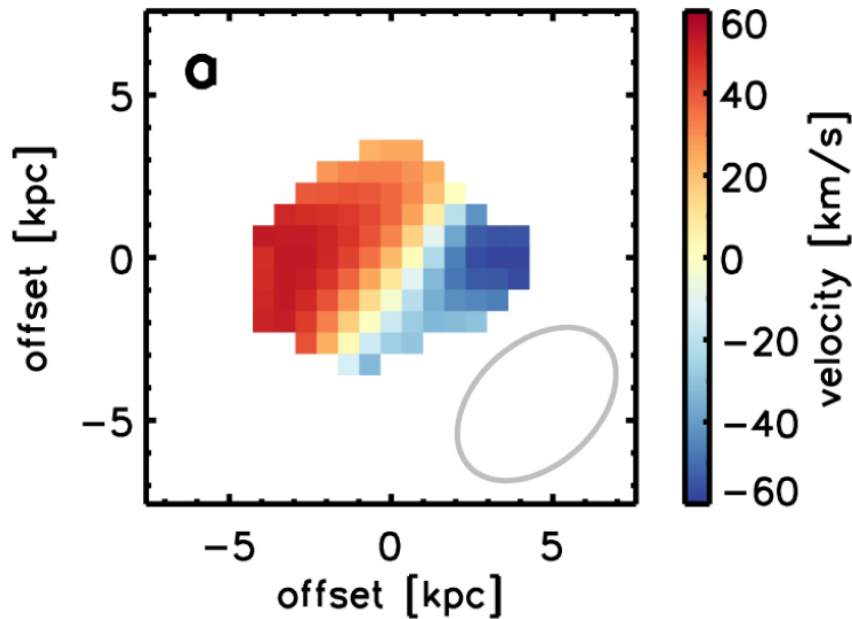
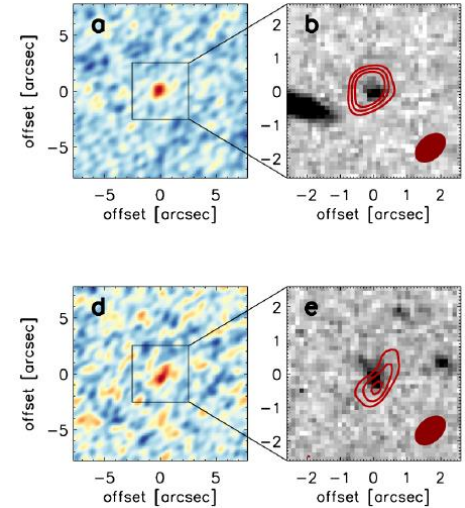
Smit+18, Nature, 553, 178

[CII] detections from 2 galaxies at  $z=6.8$

Spitzer 3.6- $\mu\text{m}$  excess objects

$\rightarrow$   $\text{H}\beta + [\text{OIII}]$  line emitters

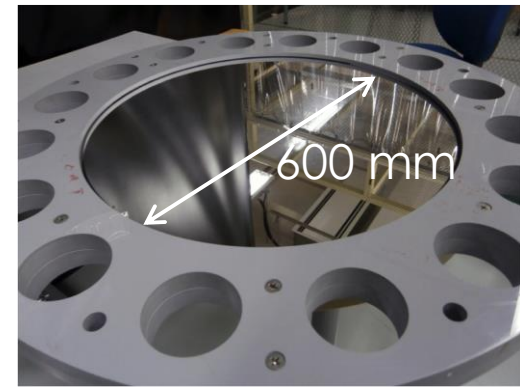
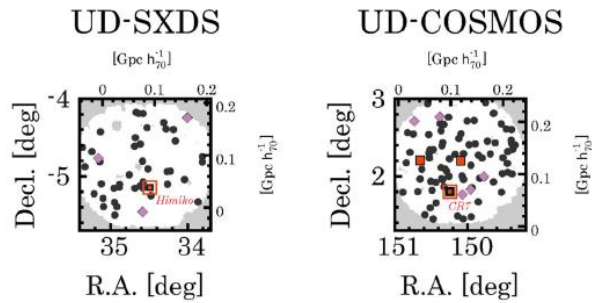
No dust was detected.



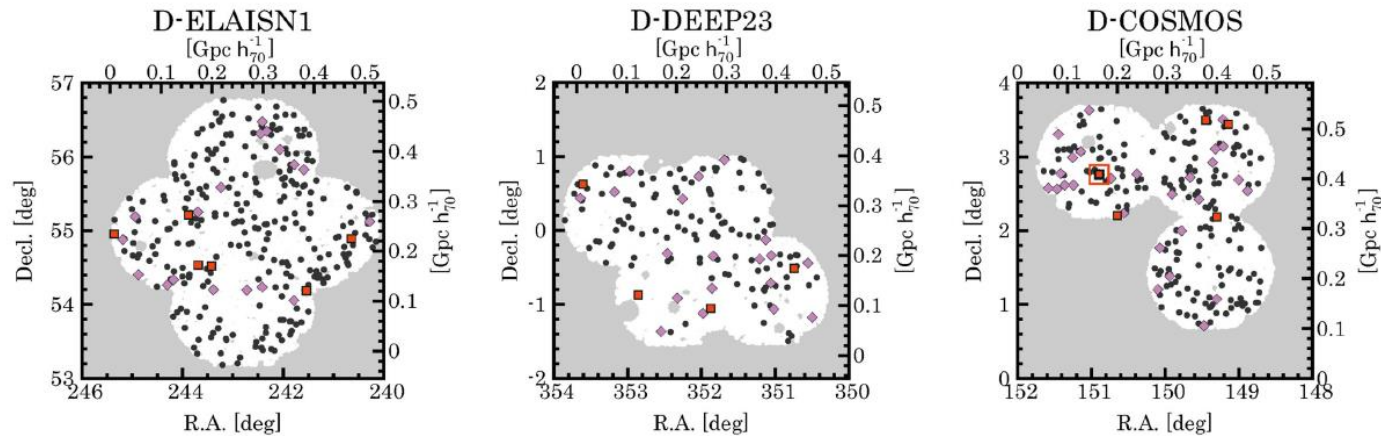
# HSC/SILVERRUSH

Systematic Identification of LAEs for Visible Exploration and Reionization Research Using Subaru HSC

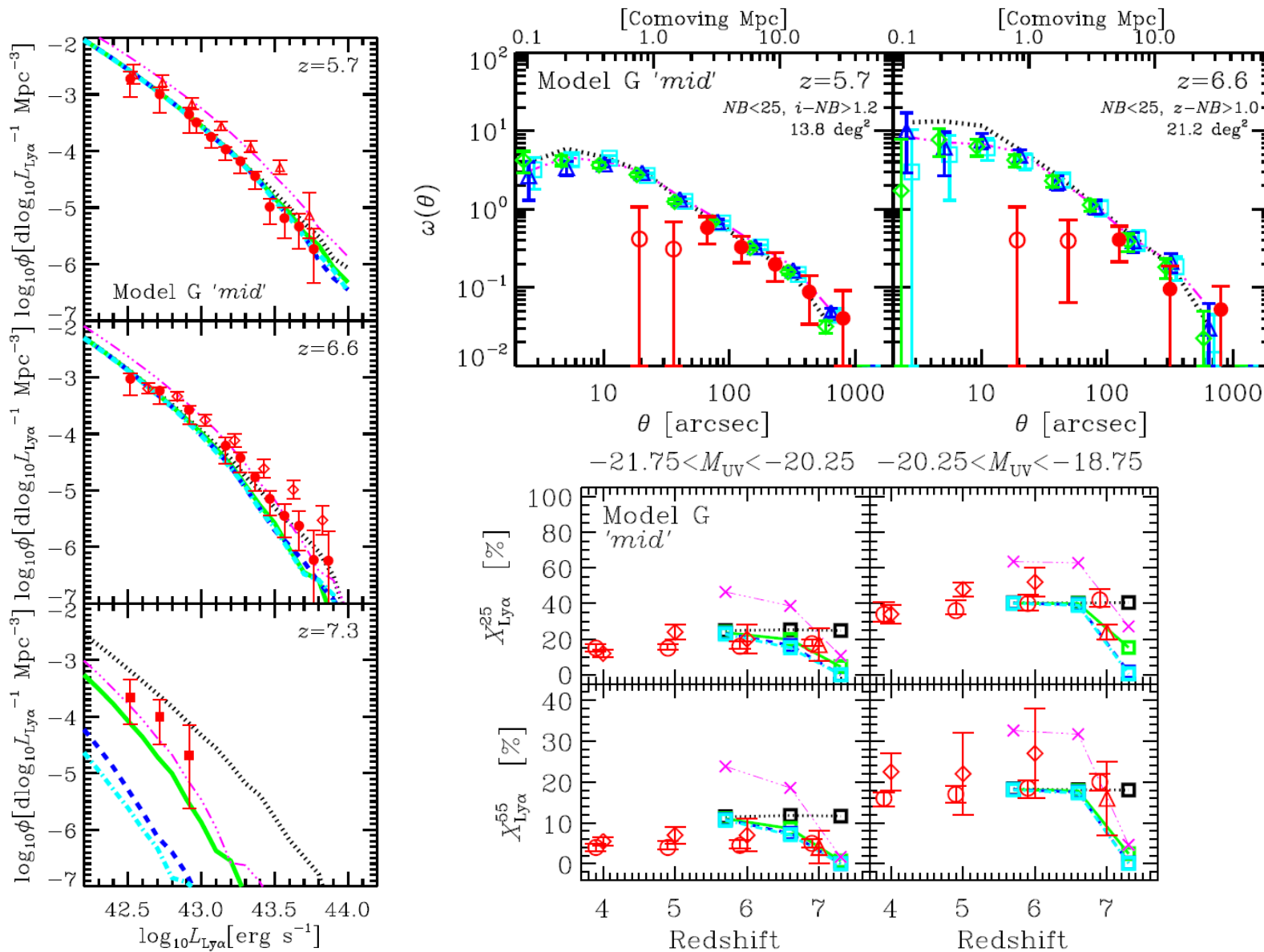
Ouchi+18, Shibuya+18a,b, Konno+18, Harikane+18, Inoue+18, Higuchi+18, ...



NB921  
 $z=6.6$   
21 deg<sup>2</sup>



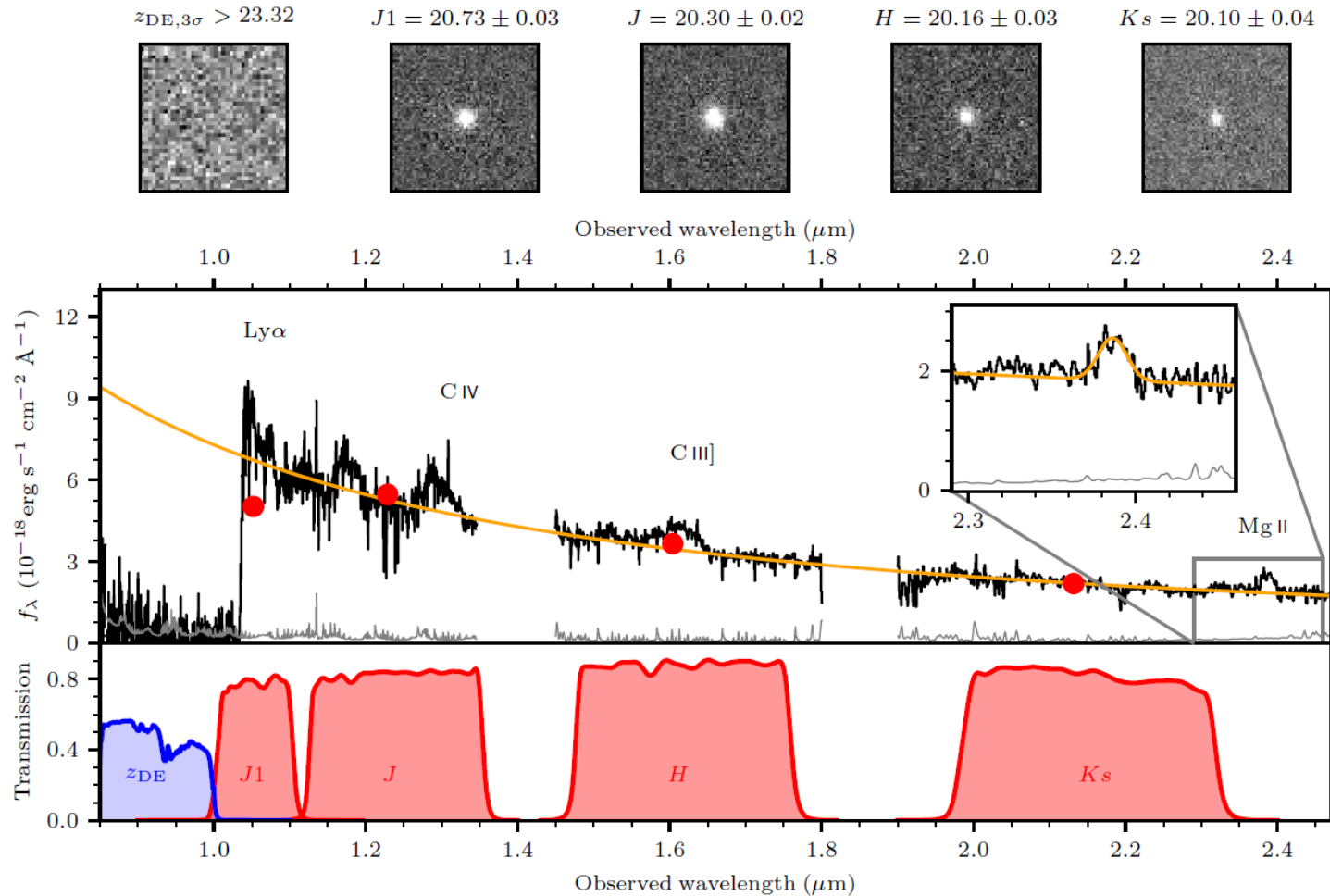
Ouchi+18



# Highest-z QSO at $z=7.5$

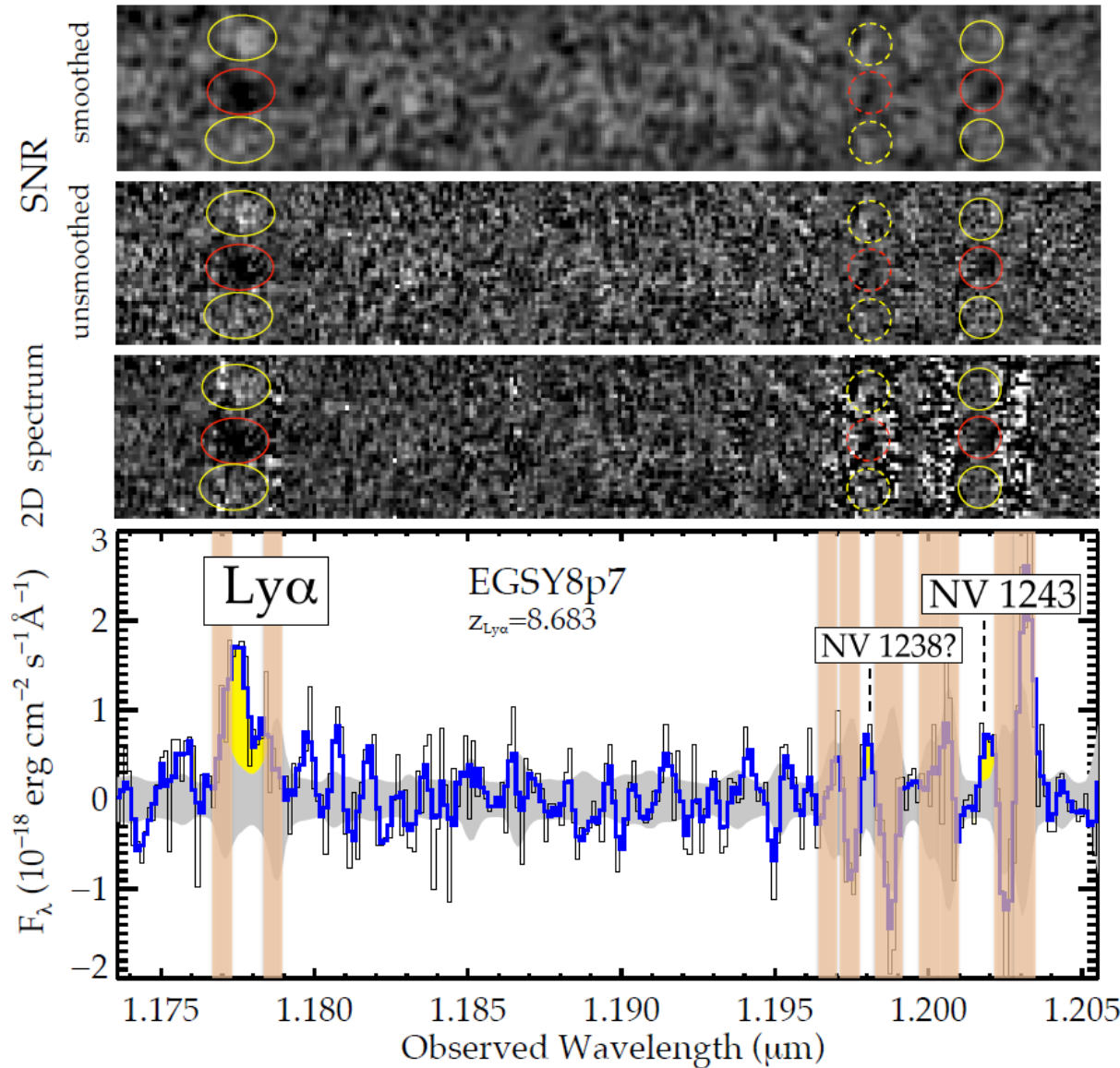
Bañados+18, Nature, 553, 473

Important prob for cosmic reionization and SMBH formation





# NV detection at z=8.7



Mainali+18  
(see also Zitrin+15)

Keck/MOSFIRE  
detects the NV line.

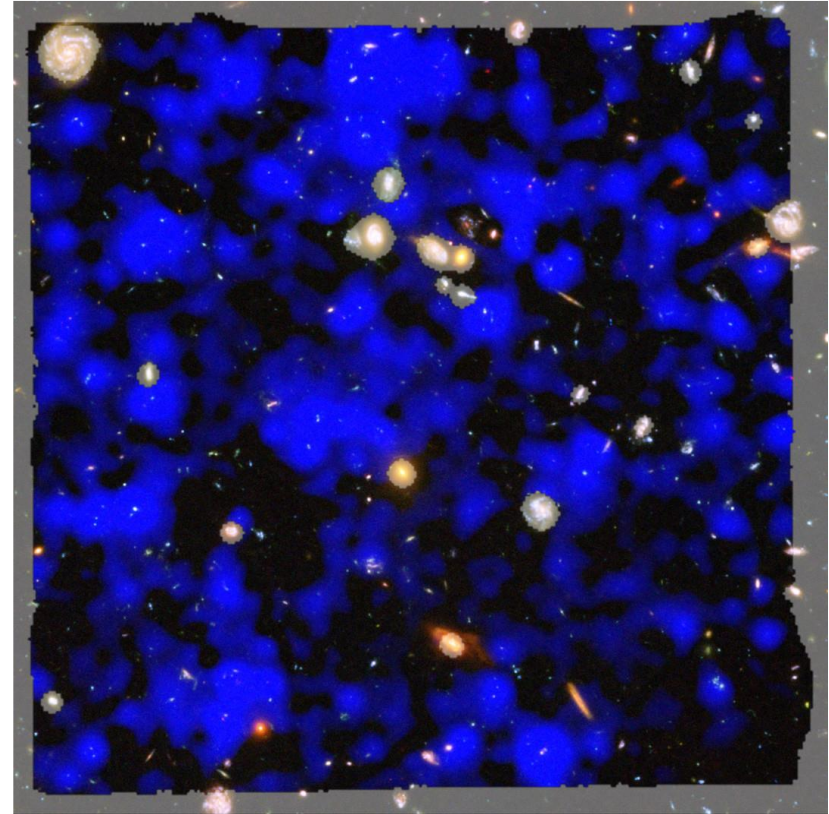
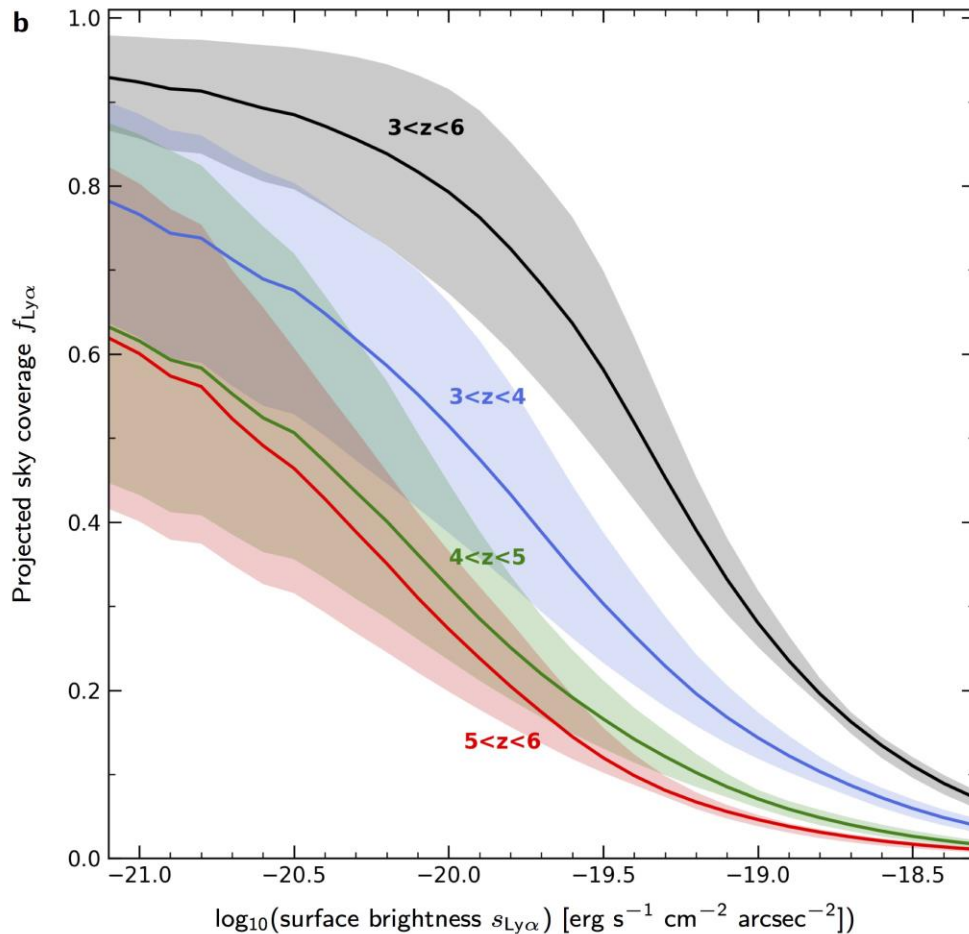
77 eV

AGN or fast  
radiative shock

# VLT/MUSE: Deepest LyA obs.

Wisotzki+18, Nature, 562, 229

“Nearly all sky coverage of LyA”



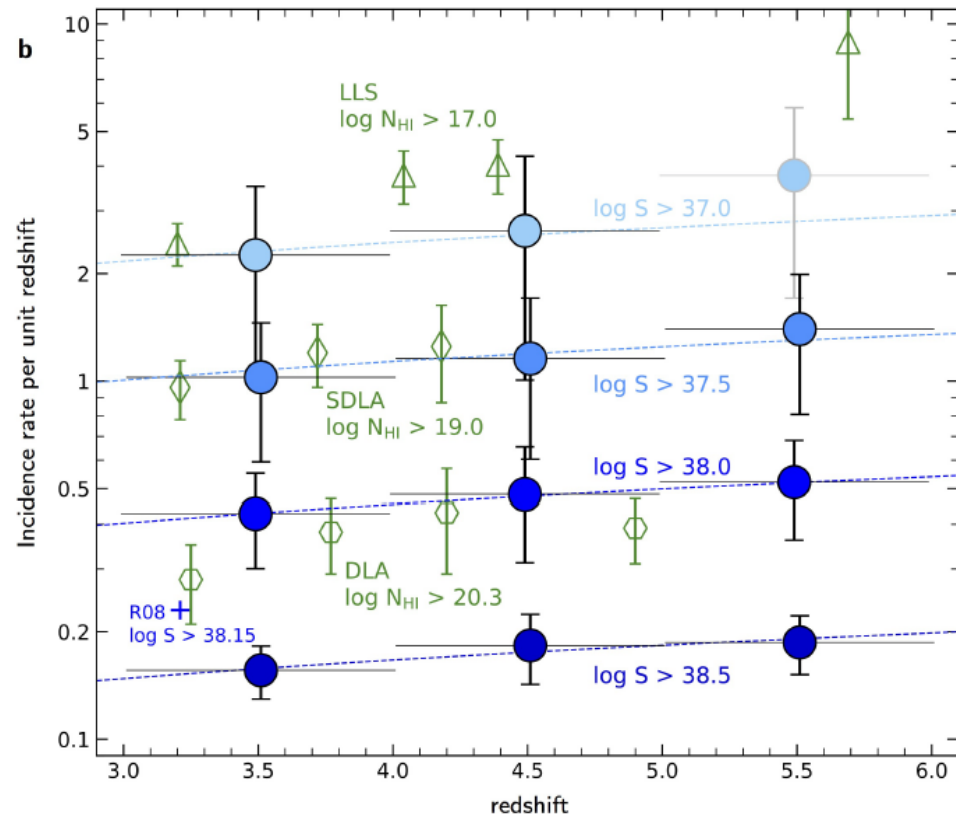
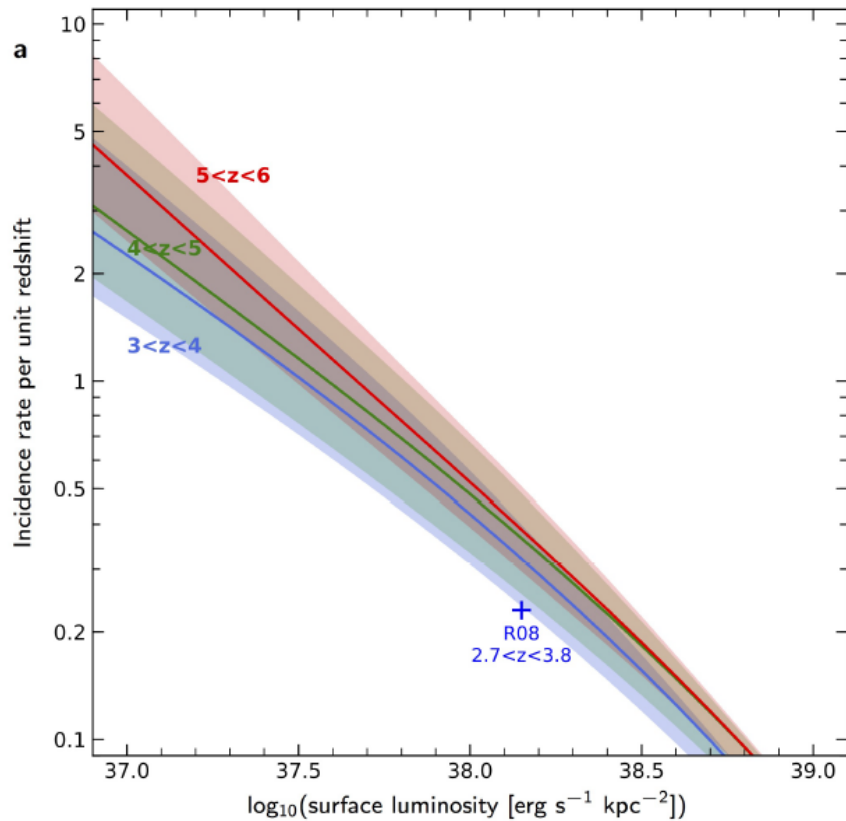
1 arcmin x 1 arcmin in HUDF  
LyA SB >  $1 \text{e-}19 \text{ erg/s/cm}^2/\text{arcsec}^2$   
for  $3 < z < 6$



# VLT/MUSE: Deepest LyA obs.

Wisotzki+18, Nature, 562, 229

“Nearly all sky coverage of LyA”



# まとめ

A biased review of papers of distant galaxies in 2018

- ALMA [OIII] 88 line survey current status
  - Some correlations of [OIII] line and other quantities
  - [CII] line
- Subaru/HSC SILVERRUSH
  - EoR LAE survey and model
- Some other interesting results
  - Most distant QSO, possible AGN signature, LyA halos