Search for distant (z > 6) quasars with SWIMS + Subaru/HSC

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Today's talk

1. Motivations and the frontier of high-z quasar survey
2. HSC-SSP z > 6 quasar survey
3. Proposal of SWIMS + HSC survey (a single slide...)

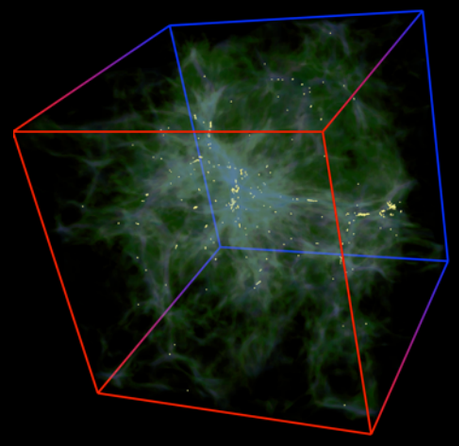
Motivations

Formation of SMBHs

✶ What were the seeds?

✶ When were they born?

✶ How did they grow?



Cosmic Reionization

✶ When and where?

✶ How did it proceed?

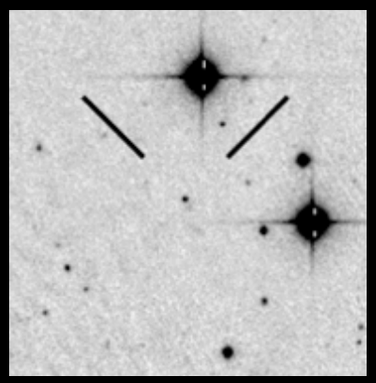
✶ Ionizing sources?

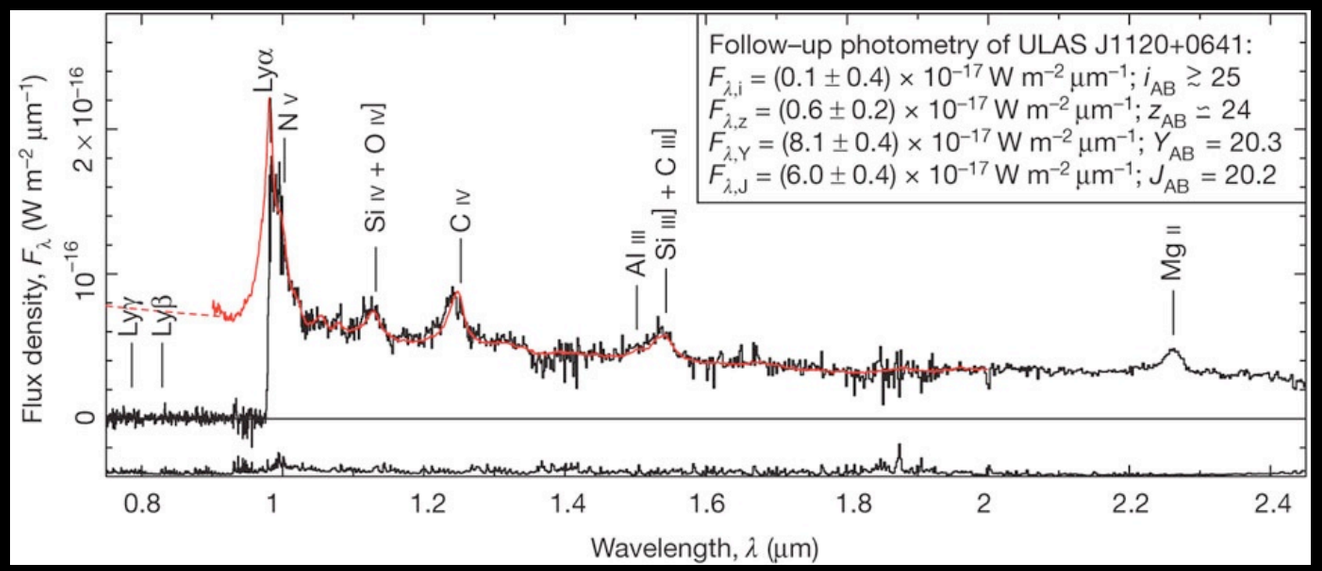
Evolution of the host galaxies

✶ Chemical evolution

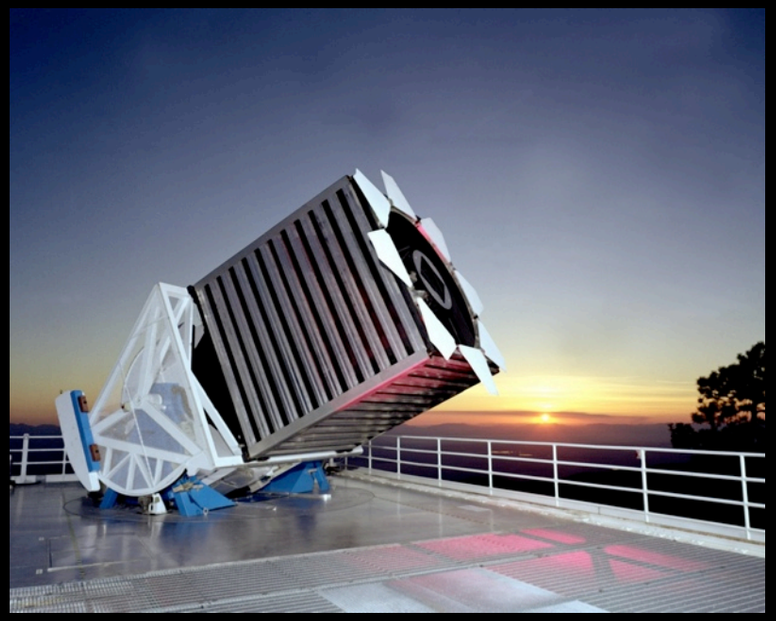
✶ Star formation activity

→ High-z quasars as a unique probe of the distant Universe





Era of systematic surveys



Sloan Digital Sky Survey

- 2.5 m telescope
- optical (u, g, r, i, z) bands
- $z < 20.5$ mag
- 8,000 deg^2

High-z quasars
- 30 objects
  (Fan+00,01,03,04,06; Jiang+08,09)
- $5.7 < z < 6.4$
- $-27.9 < M_{1450} < -24.4$
- (nearly) Completed.

Canada-France High-z Quasar Survey

- CFHT 3.6 m
- optical (u, g, r, i, z) bands
- $z \lesssim 22$ mag
- ~600 deg^2

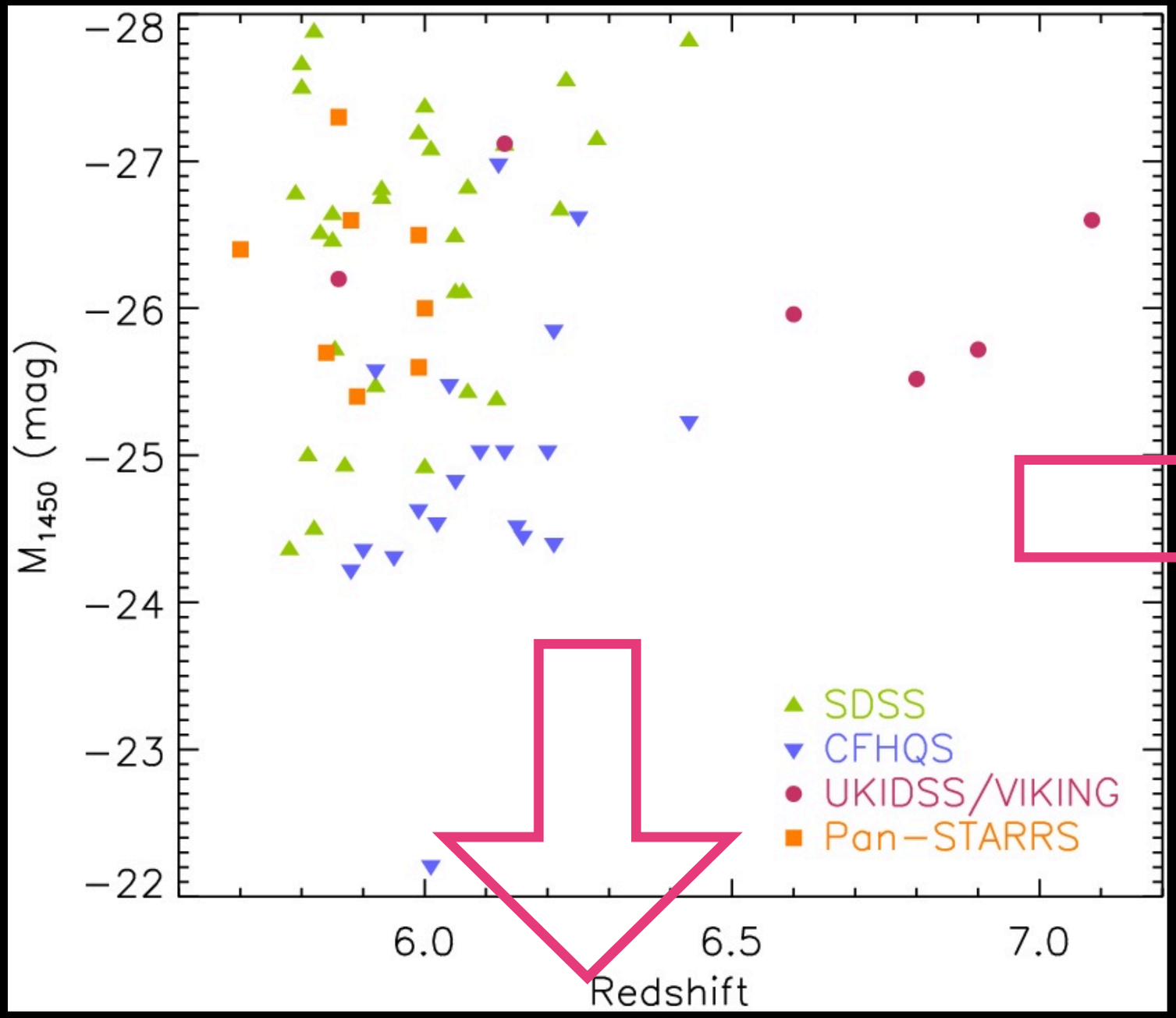
High-z quasars
- 19 objects
  (Willott+07,09,10)
- $5.9 < z < 6.4$
- $-27.0 < M_{1450} < -22.2$
- (nearly) Completed.

UKIDSS/VIKING surveys

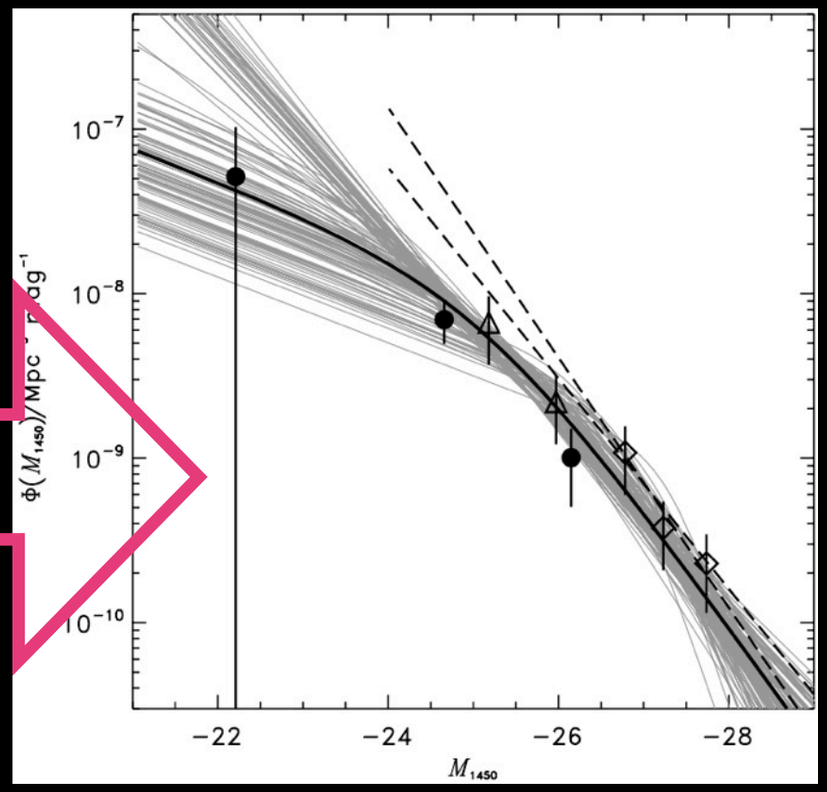
- 4-m telescopes
- NIR (Z, Y, J, H, K) bands
- $Y < 22.3$ mag
- 1,500 deg^2

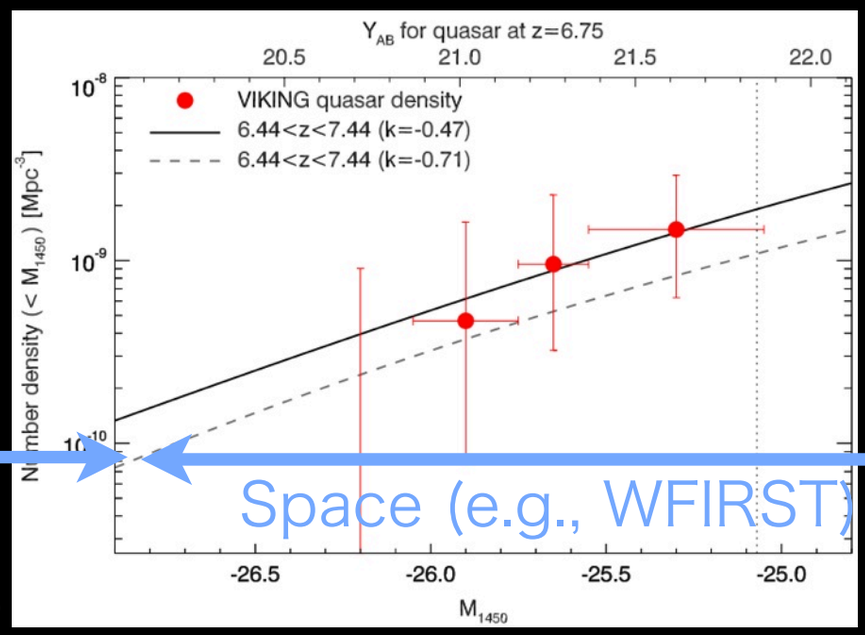
High-z quasars
- 6 objects
  (Venemans+07,13; Mortlock+09,11)
- $5.9 < z < 7.1$
- $-27.1 < M_{1450} < -25.5$
- 10-20 more objects expected at $z \sim 7$.

Era of systematic surveys



Willott+10





Ground (e.g., Subaru/HSC)

Space (e.g., WFIRST)

Venemans+13

HSC-SSP High-z Quasar Survey

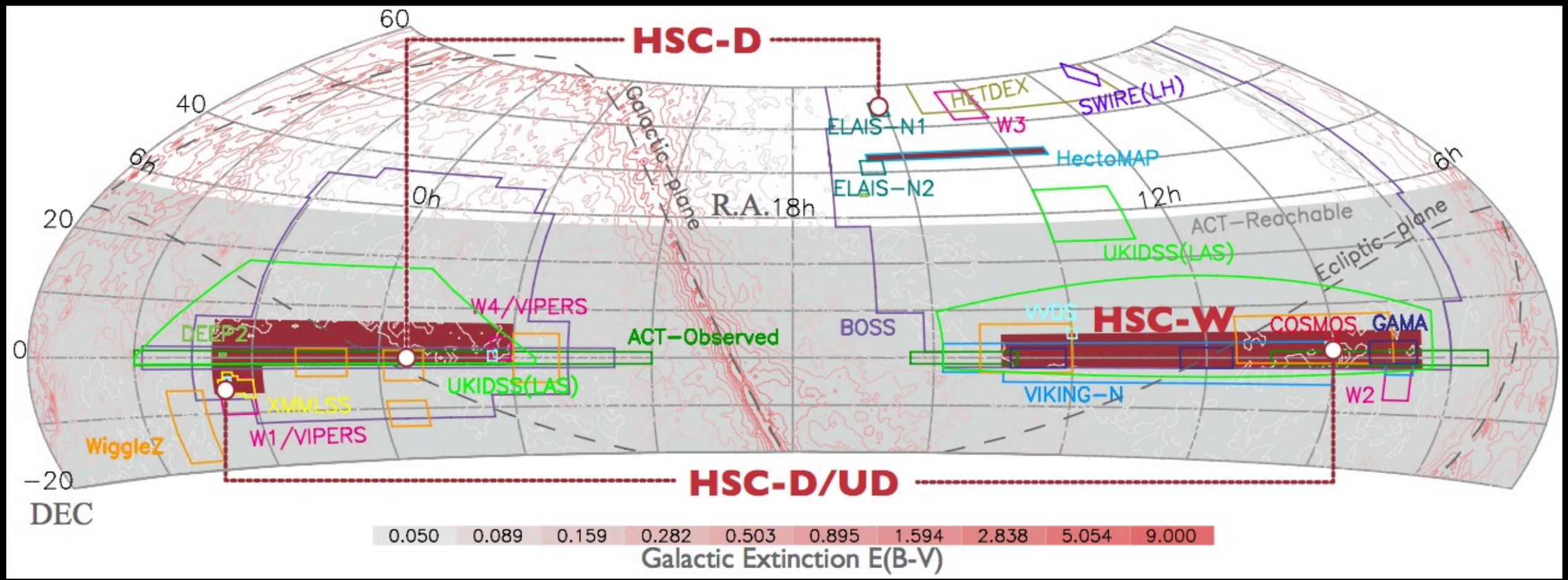


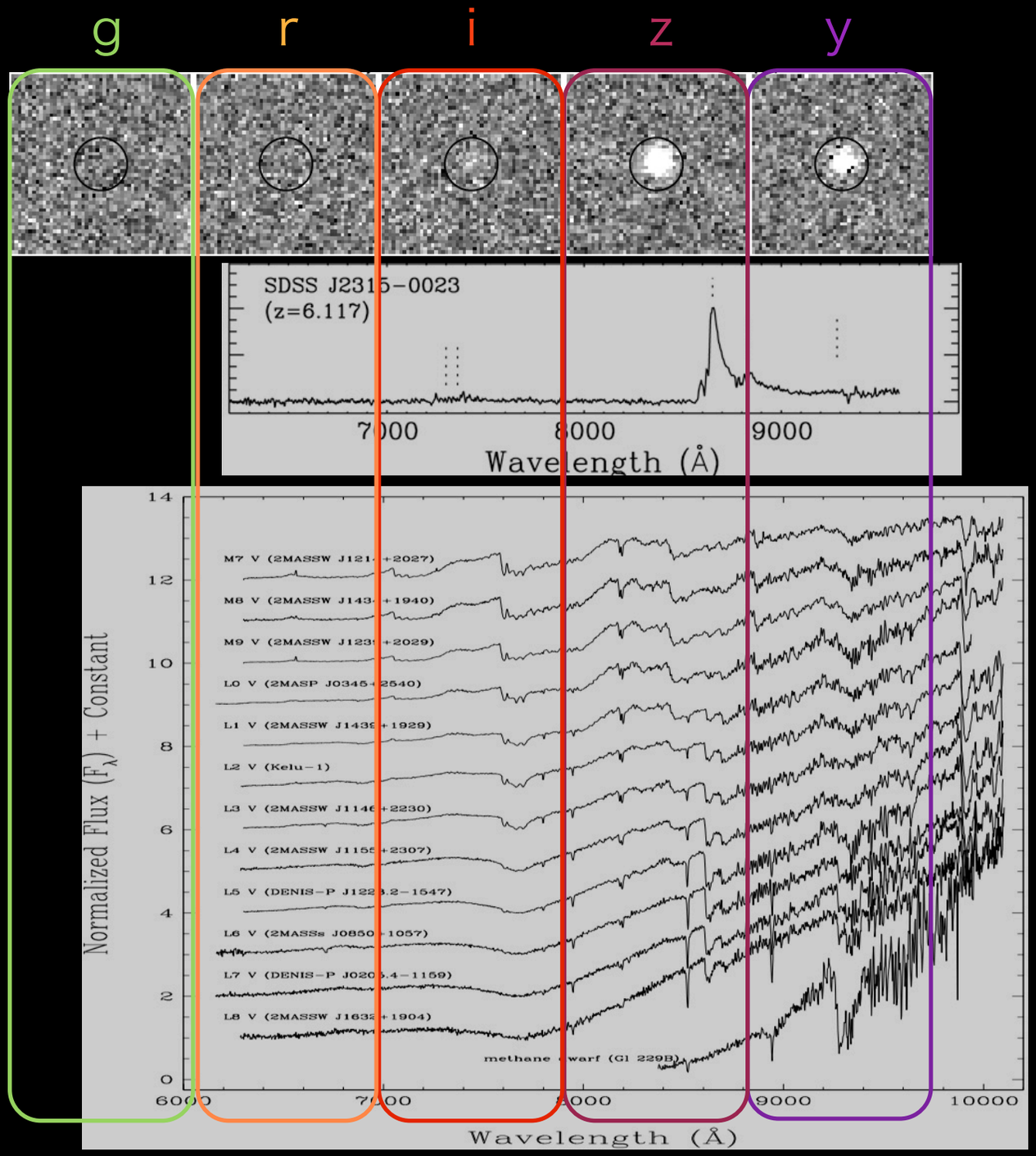
Table 7: Quasar Samples

	Wide (1400 deg^2)				Deep (27 deg^2)			
redshift	3.7–4.6	4.6–5.7	5.9–6.4	6.6–7.2	< 1	3.7–4.6	4.6–5.7	6.6–7.2
mag. range	$r < 23.0$	$i < 24.0$	$z < 24.0$	$y < 23.4$	$i < 25.0$	$i < 25.0$	$i < 25.0$	$y < 25.3$
number	6000	3500	280	50	2000	200	50	3

We will probe the most distant ($5.9 < z < 7.4$) quasars over 1,400 deg^2, down to ~2 mag lower luminosity ($M_{1450} \leq -22$ mag) than any previous wide-field survey.

Our very basic strategy

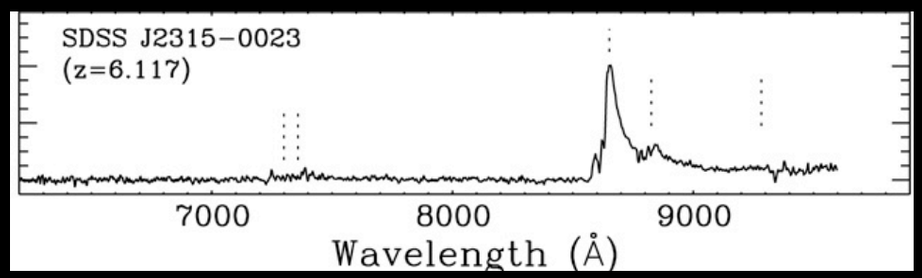
1. Look for red point sources in the HSC catalog
(+ UKIDSS/VIKING catalog)



(2. Follow-up photometry)

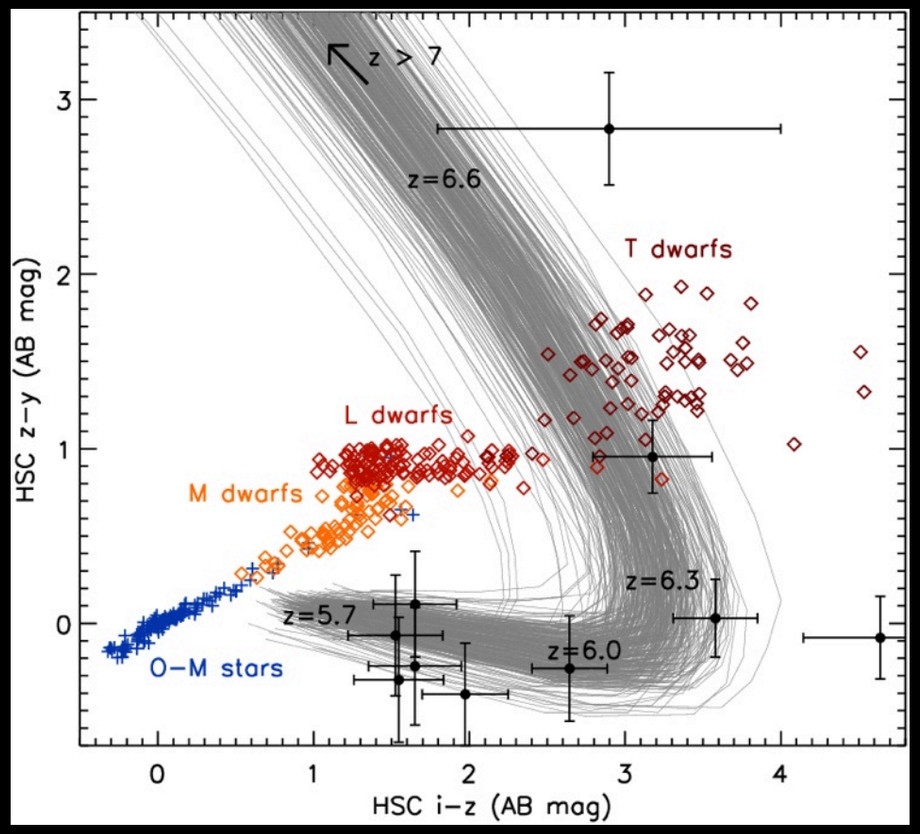
3. Follow-up spectroscopy

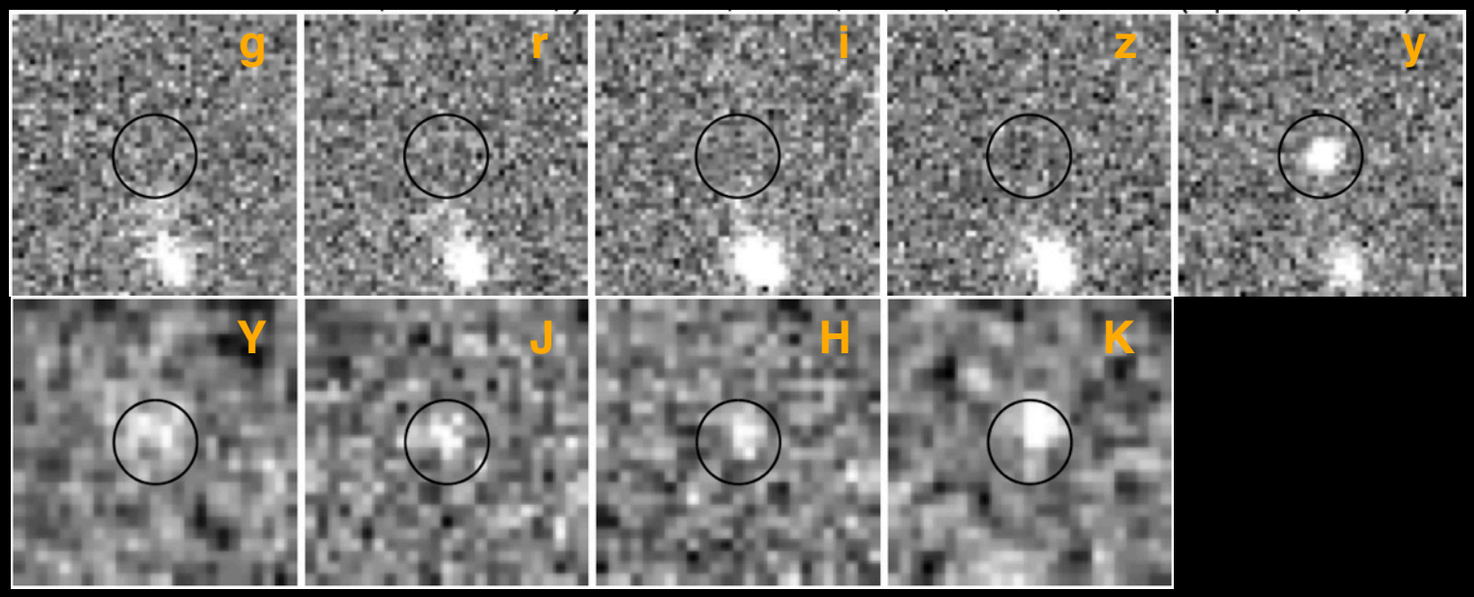
4. Discovery



Where do we stand with the HSC-SSP survey?

- ✶ As of 2015 Sep, ~150 deg^2 (TBC) has been imaged and the data released to the collaboration.
- ✶ Our candidate selection algorithms found a few tens of promising candidates.
- ✶ Follow-up spectroscopy approved with
  - Subaru/FOCAS (2014 Spring) → bad weather
  - GTC/OSIRIS (2015 Fall) → queue obs. in progress
  - Subaru/FOCAS (2015 Fall) → early Nov. and Dec.
- ✶ Follow-up spectroscopy proposed to
  - Subaru/FOCAS (2016 Spring)
  - GTC/OSIRIS (2016 Spring; TBC)
  - Gemini/GMOS (2016 Spring; TBC)





We expect to find the first HSC z > 6 quasars this Fall!

Proposal: SWIMS + Subaru/HSC quasar survey
~ breaking through into z > 7.2 ~

Draft plans

[Plan A] SWIMS 36,000 shots (1,000 deg^2) with t_{JH} = 2 min over the HSC SSP-Wide fields

✶ y_{HSC} < 24.4 mag, J < 23.0 mag, H < 22.5 mag
✶ Expected discovery: 0 ~ 20 quasars at z > 7.2.
✶ SWIMS observing time: 1200 hours (120 nights).

[Plan B] SWIMS 360 shots (10 deg^2) with t_{JH} = 15 min over the HSC SSP-Deep y-band coverage

✶ y_{HSC} < 25.3 mag, J < 24.0 mag, H < 23.5 mag
✶ Expected discovery: 0 ~ 0.6 quasar at z > 7.2.
✶ SWIMS observing time: 90 hours (9 nights).

[Plan C] SWIMS 3,600 shots (100 deg^2) with t_{JH} = 15 min + HSC imaging (60 shots × t_y = 2.1 hrs for SSP Deep depth)

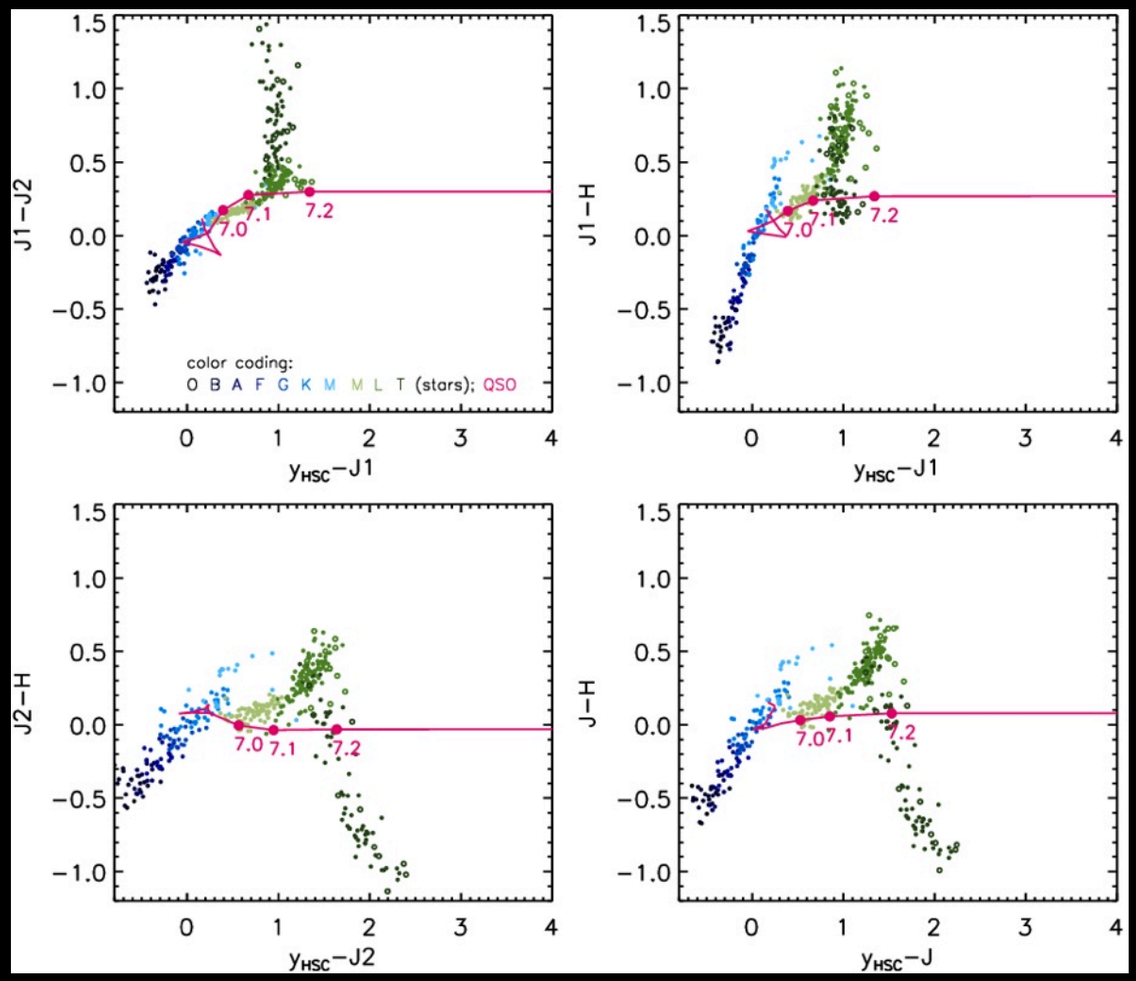
✶ y_{HSC} < 25.3 mag, J < 24.0 mag, H < 23.5 mag
✶ Expected discovery: 0 ~ 6 quasars at z > 7.2.
✶ SWIMS observing time: 900 hours (90 nights).
✶ HSC observing time: 130 hours (13 nights).

	7.2 < z < 7.7	7.7 < z < 8.2	8.2 < z < 8.7	8.7 < z < 10
Plan A	0.0 ~ 0.7 ~ 9	0.0 ~ 0.1 ~ 4	0.0 ~ 0.0 ~ 3	0.0 ~ 0.0 ~ 2
Plan B	0.0 ~ 0.1 ~ 0.3	0.0 ~ 0.0 ~ 0.1	0.0 ~ 0.0 ~ 0.1	0.0 ~ 0.0 ~ 0.1
Plan C	0.0 ~ 0.5 ~ 3	0.0 ~ 0.1 ~ 1	0.0 ~ 0.1 ~ 1	0.0 ~ 0.0 ~ 0.6

Expected number of quasar discovery for three SMBH evolution models (R_{Edd} = 1 model ~ R_{Edd} = 0.5 model ~ $10^{-0.5z}$ model)

[Plan D] SWIMS a few 100 shots with t_Y = 20 min, t_{JH} = 30 min to refine a list of HSC z ~ 7 quasar candidates

✶ Y < 24.4 mag, J < 24.4 mag, H < 23.9 mag
✶ Expected discovery: ~50 quasar at z ~ 7.
✶ SWIMS observing time: a few 100 hours (a few 10 nights).



Expected impacts, to name a few:

- first discovery of z > 7.2 quasars
- SMBH growth via mass estimates
- evolution of the host galaxies
- cosmic reionization