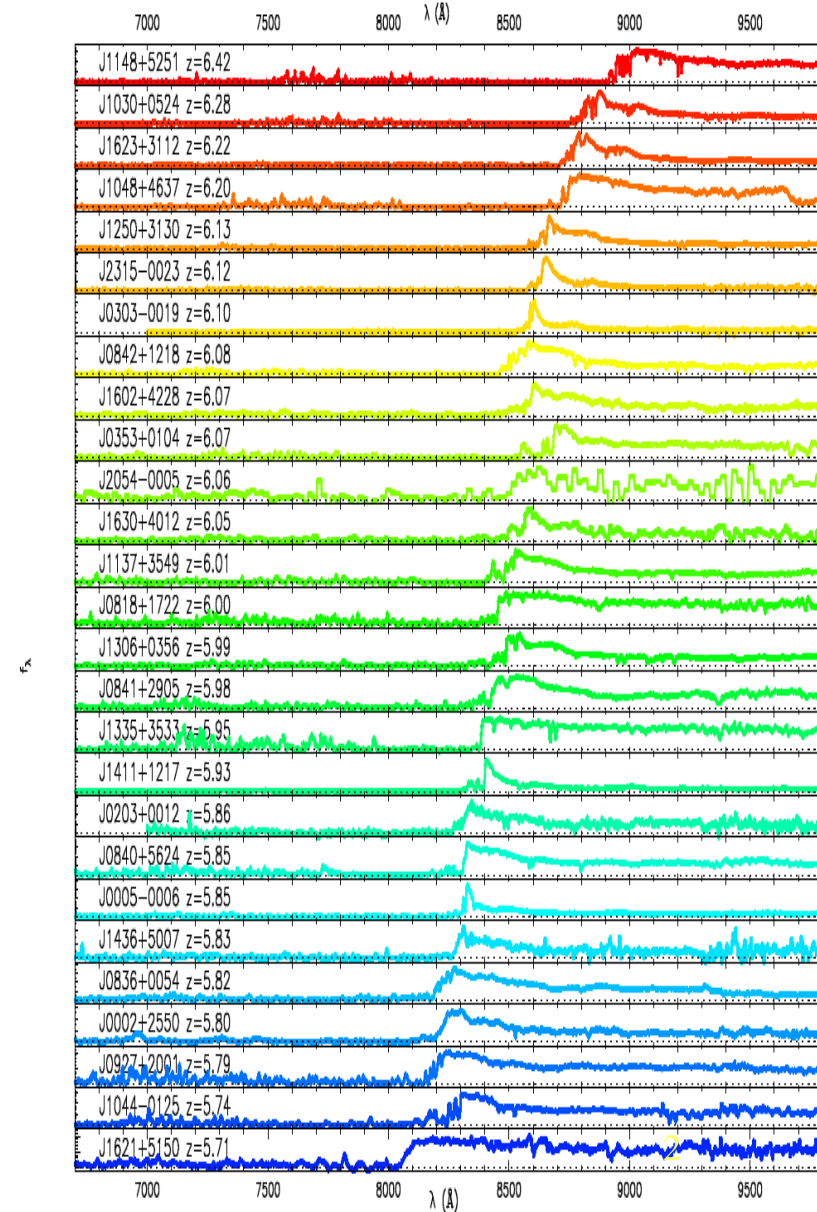
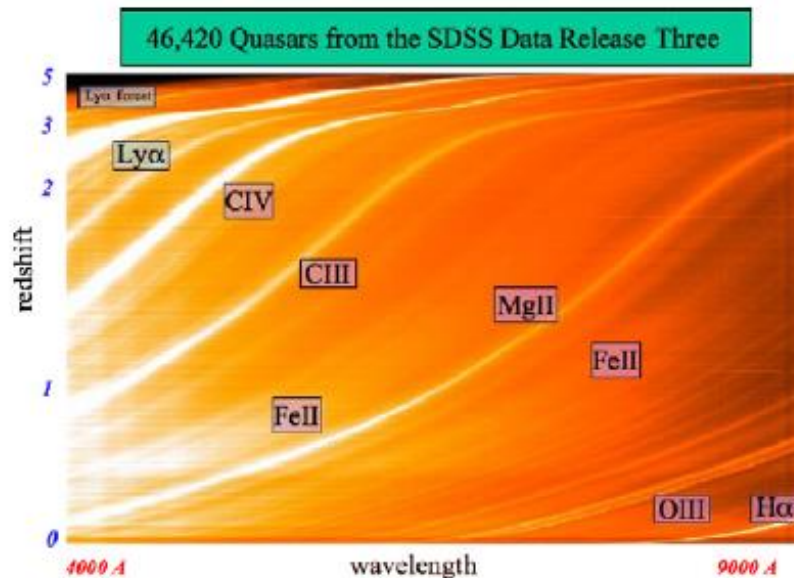


First quasar 検出への展望

柏川伸成（国立天文台）

$z \sim 6$ quasars

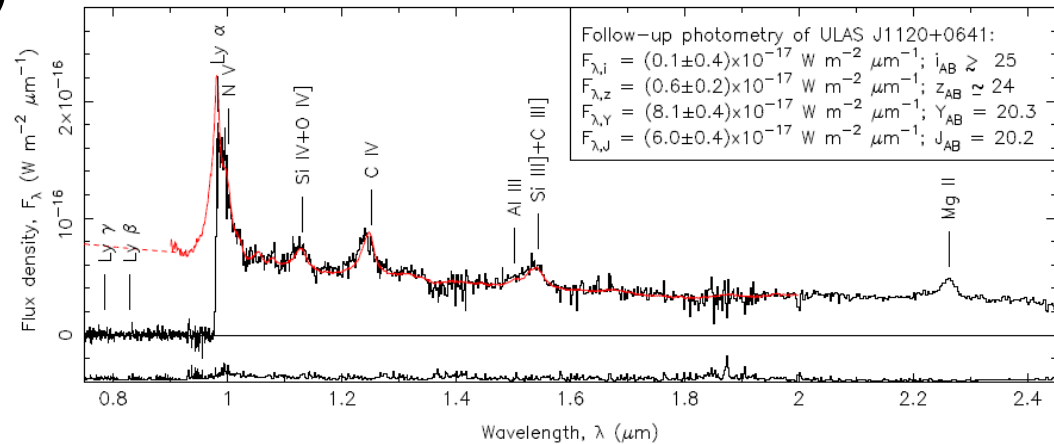
- $z \sim 4$: >1000 known
- $z \sim 6$: >40
- **SDSS**:
 - 6600deg², $z_{AB} < 20$
- SDSS Faint QSO Survey (**SFQS**):
 - 300deg², $z_{AB} < 22.5$
- Canada-France high- z QSO Survey (**CFHQS**):
 - 500deg², $z_{AB} < 22.5$



$z \sim 7$ quasars

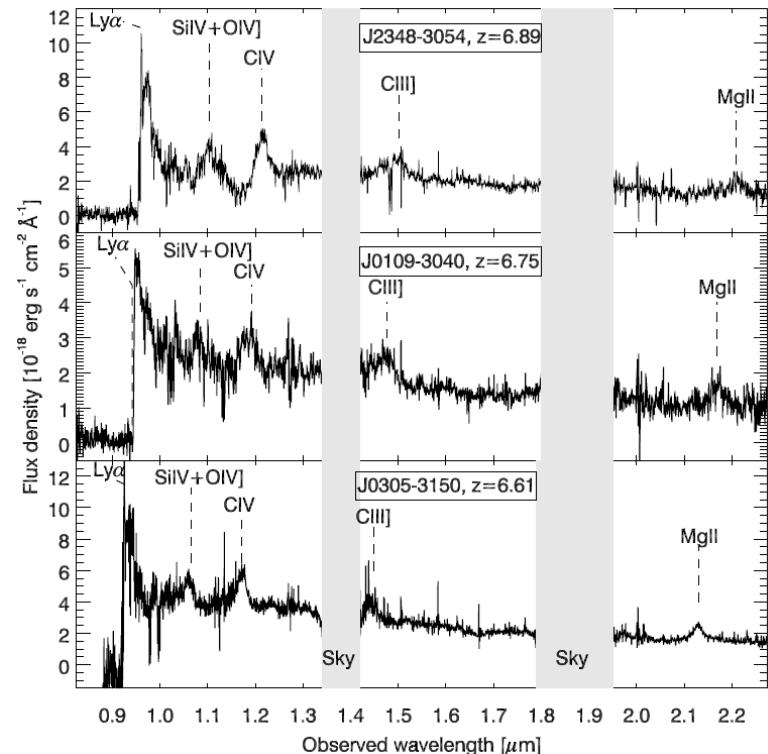
UKIDSS (Mortlock+ 11)

- $z=7.08$
- 2250sqdeg, $J < 20.5$
- need deep (i,Y) followup photometry



VIKING (Venemans+ 13)

- $z=6.61, 6.75, 6.89$
- 332 sqdeg, $J < 21.3$
- need deep (i,z) followup photometry



■ $M_{\text{BH}} \sim 10^9 M_\odot$

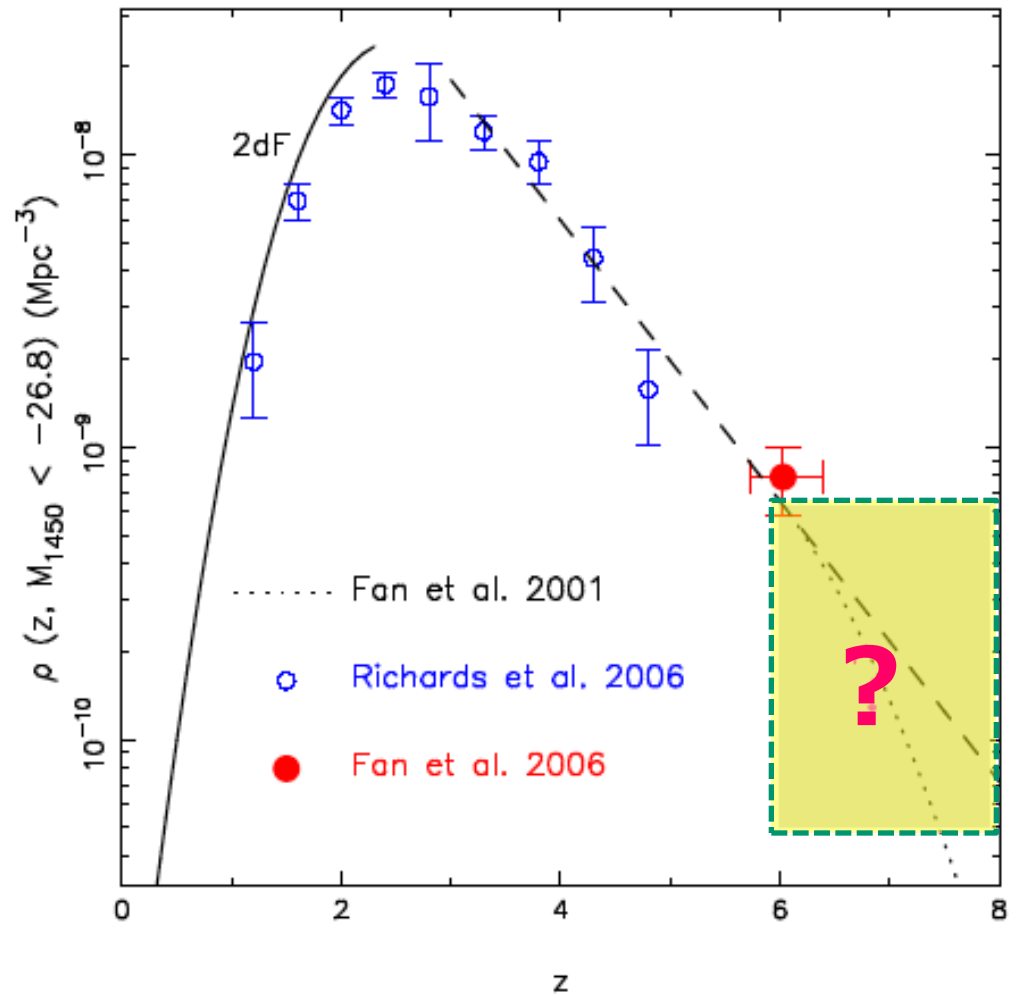
quasars beyond $z=7$

■ Number density of quasars at $z=7$

■ significant decline w/ z :
factor ~ 40 @ $z=2.5 \rightarrow 6$

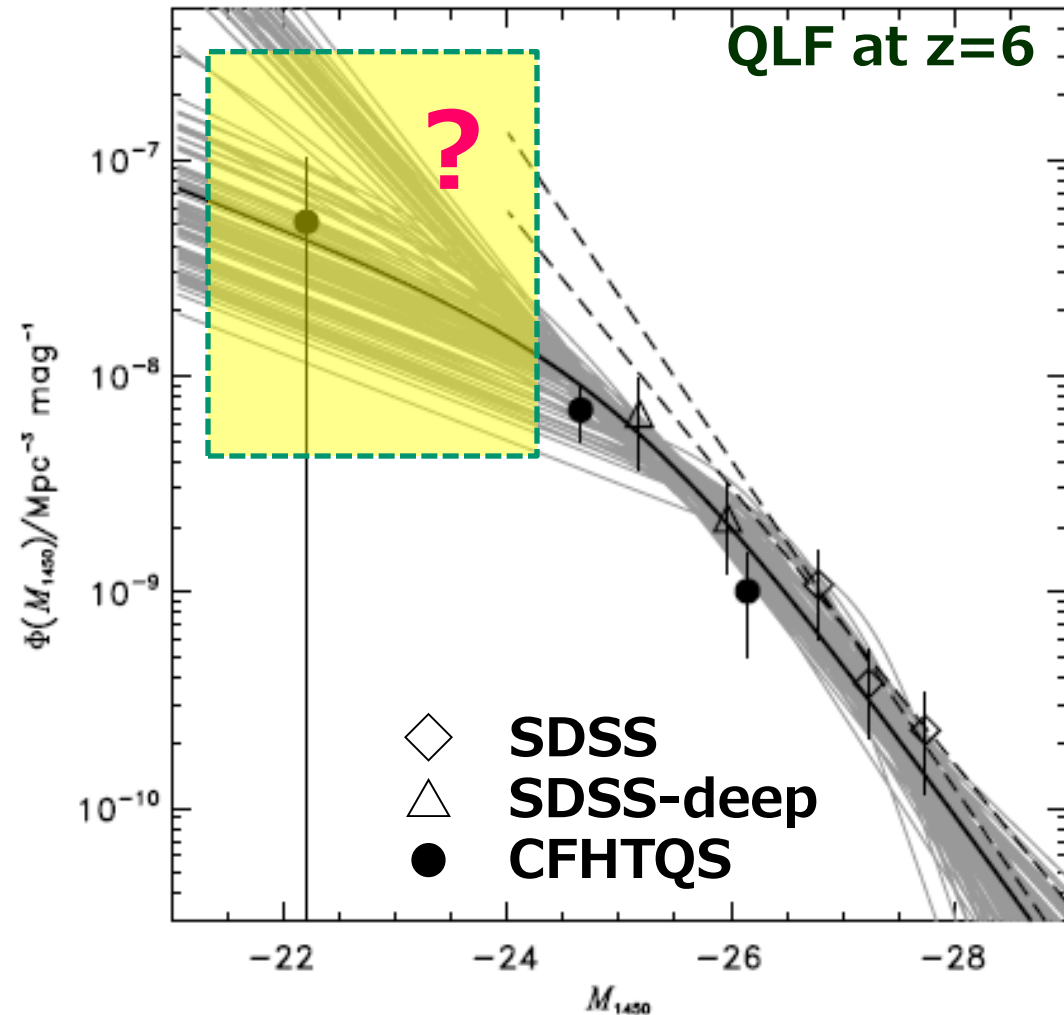
■ SMBH formation

- $M_{\text{SMBH}} \sim 10^9 M_{\text{sun}}$
- $z > 7$: formed within a few Gyr in the early epoch
- constraints on models of the SMBH formation



■ Whole shape of the QLF at $z > 6$

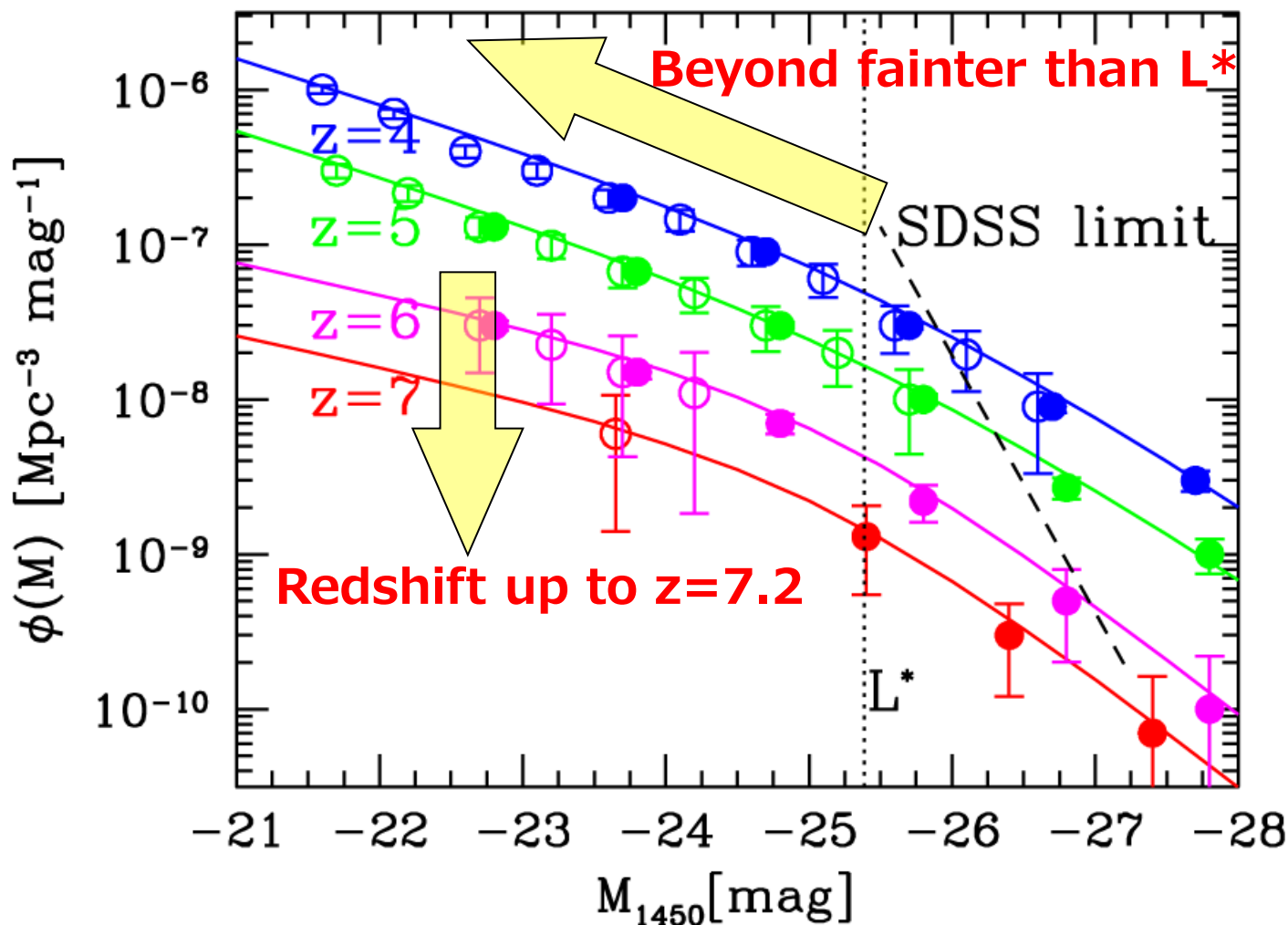
- BH evolution models make qualitatively different predictions on the faint end slope of QLF at high- z
- Evolution of UVB
- Quasar contribution to the photon budget of the cosmic reionization



high-z quasar survey

■ Beyond the limit of SDSS: higher-z & fainter quasars

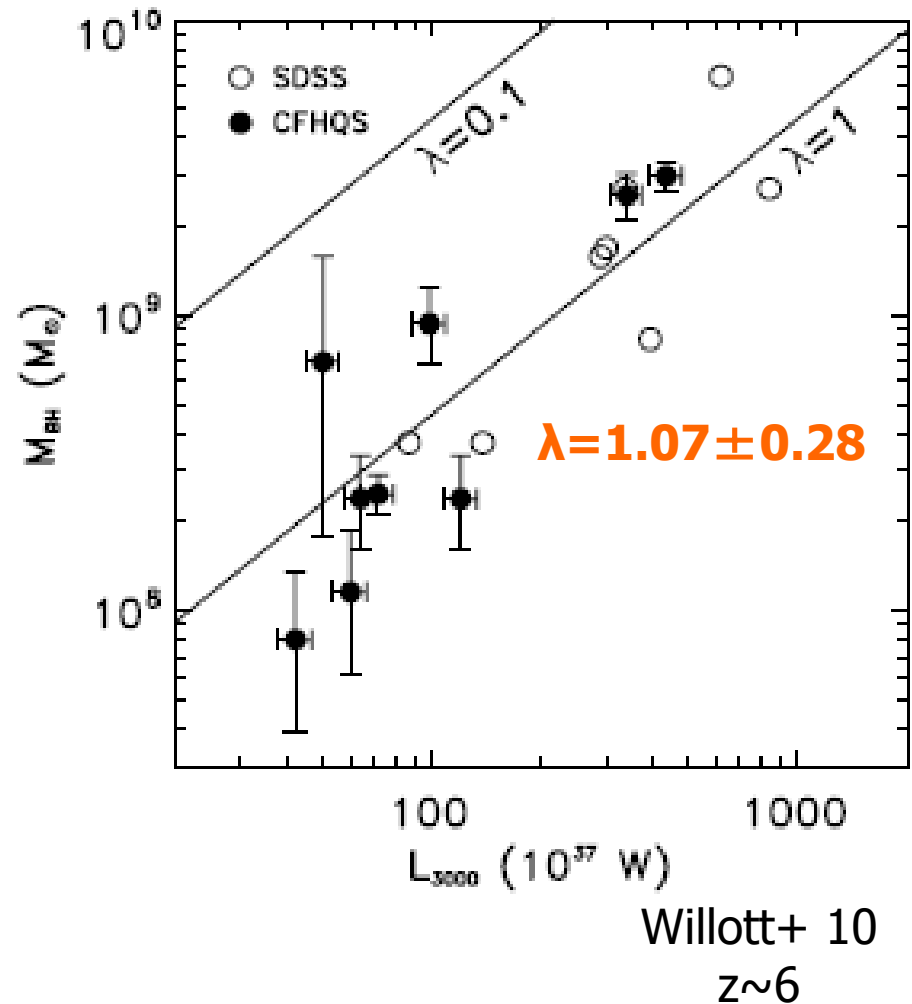
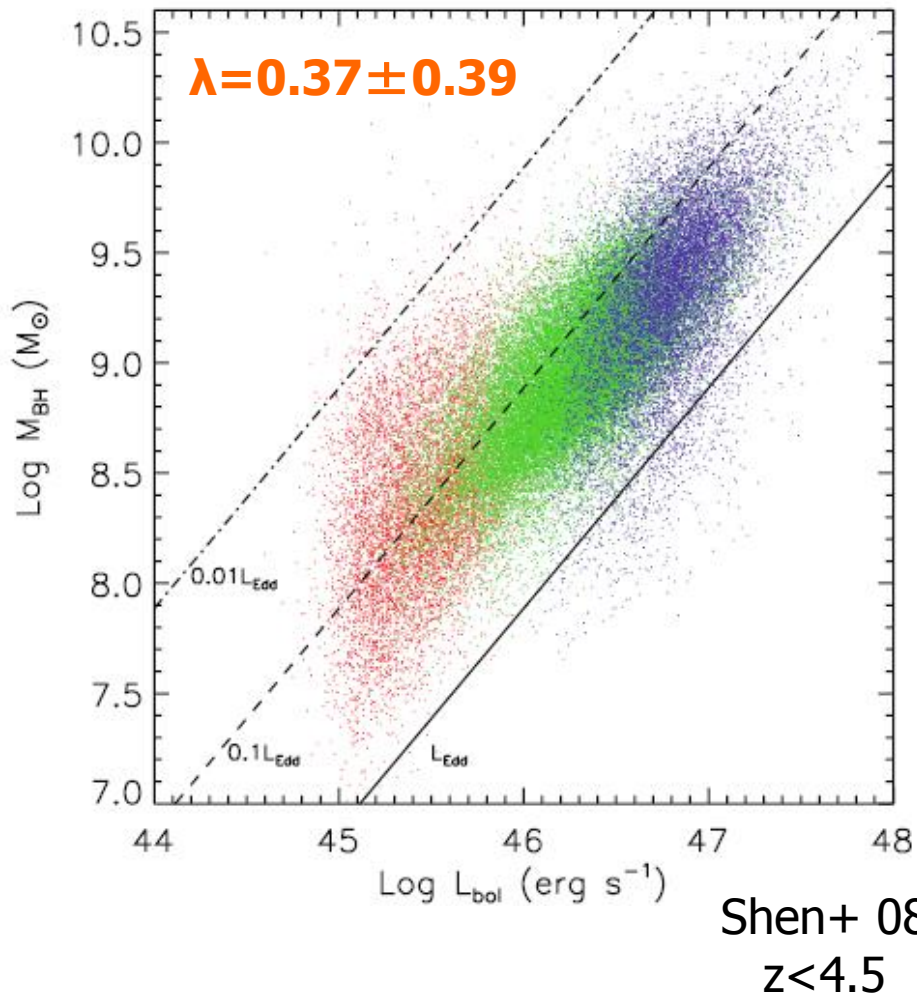
- Large ground-base telescope
- High-sensitivity instrument
- Very wide FOV
- Effective selection technique



First quasarとは何か？

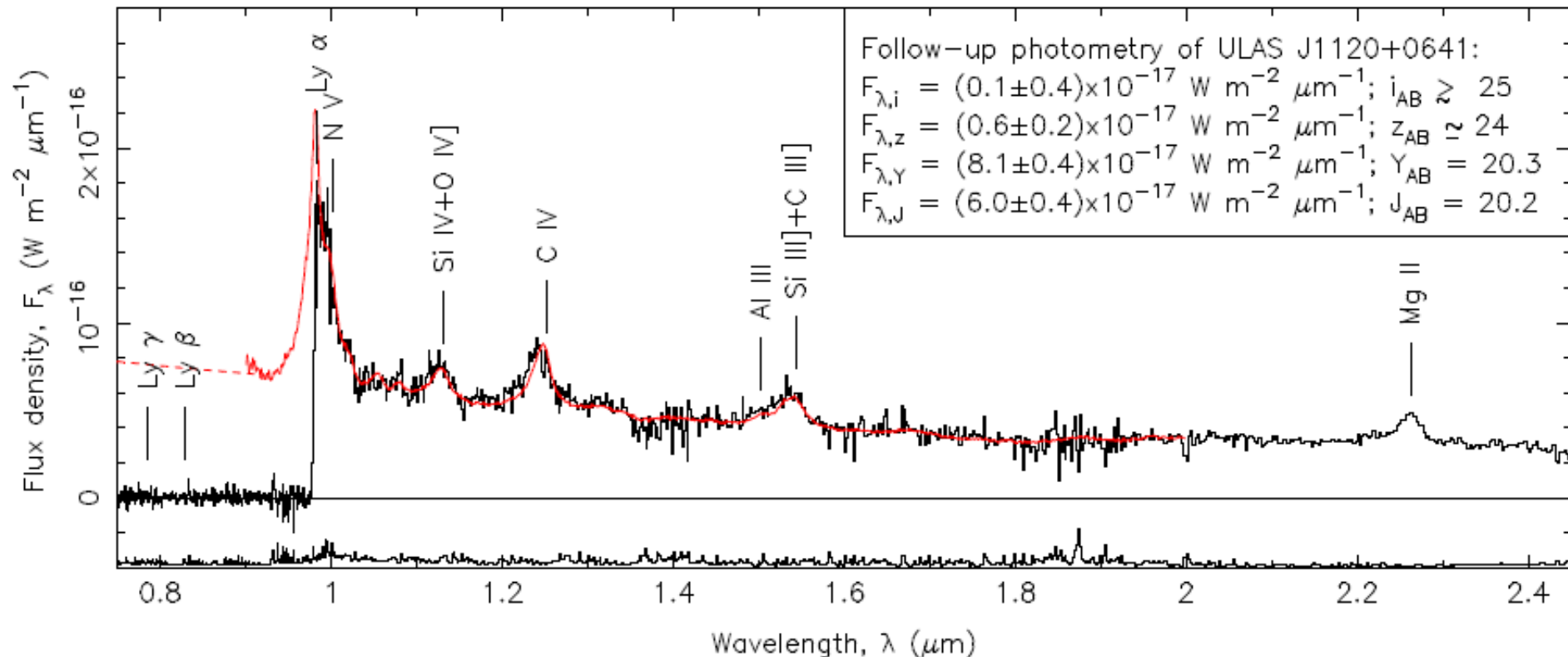
SMBH at $z \sim 6$

- Eddington-limited accretion at $z \sim 6$
- Initial growth phase due to their young host galaxies and a plentiful gas supply



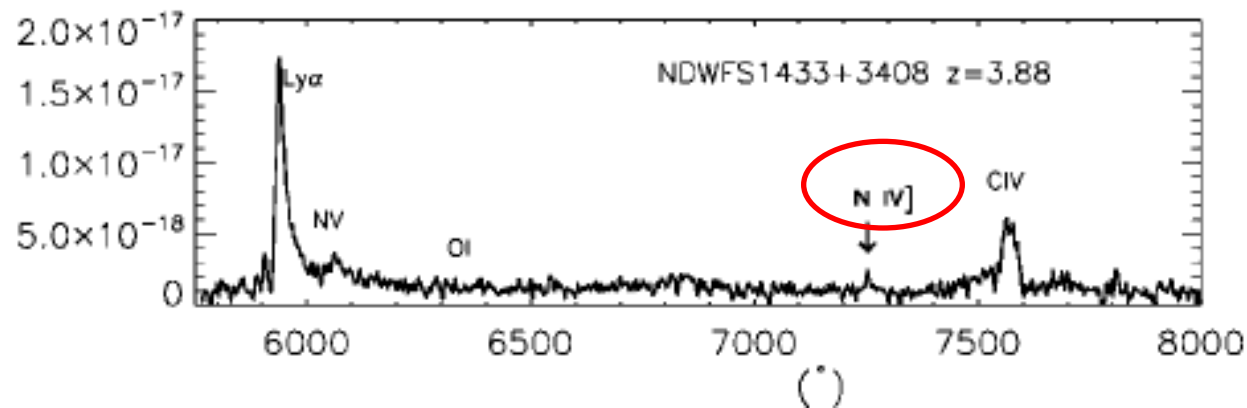
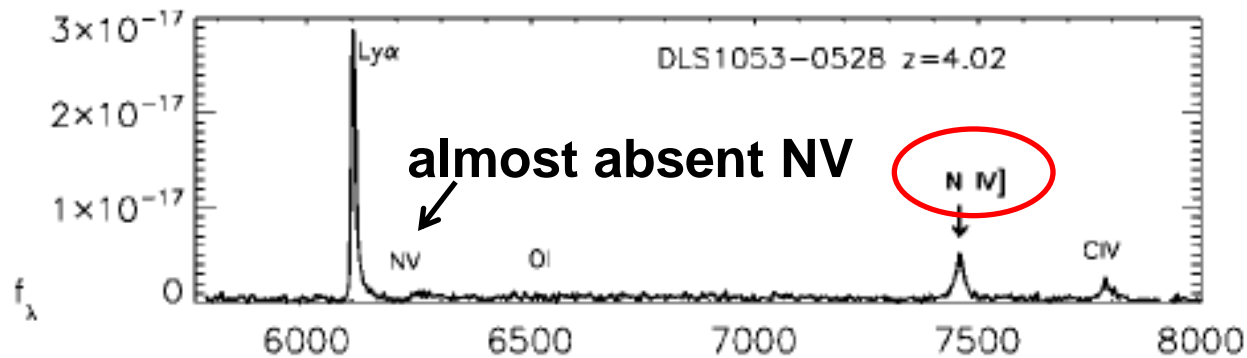
Metallicity of high-z quasars

- The $z \sim 7$ spectrum strikingly good fit to the spectral shape of lower- z . Not yet the 1st QSO.
- $\text{NV/CIV} \sim 0.7 \rightarrow$ Supersolar metallicity at $z=6.28$ ($t \sim 0.8 \text{ Gyr}$)?
- Constraints on the initial star formation history and SMBH evolution



Peculiar low-L quasars

- Prominent N IV] λ 1486 emission (Glikman et al. 2007)@ $z\sim 4$
 - 0.2-0.7% ($M < -24.63$) \rightarrow 8.7% (0.7mag deeper)
 - EW: 3.7Å \rightarrow 24.5Å, 280.2Å
 - Seen on the composite AGN SED@ $z\sim 2$ (Hainline+ 11)
 - Top-heavy IMF, evolution of BLR?



Weak or no line quasars

Weak or no emission line
quasars @ $z \sim 6$

(PAN-STARRS)

No L-dependence

1.3% @ $z < 4.2 \rightarrow$

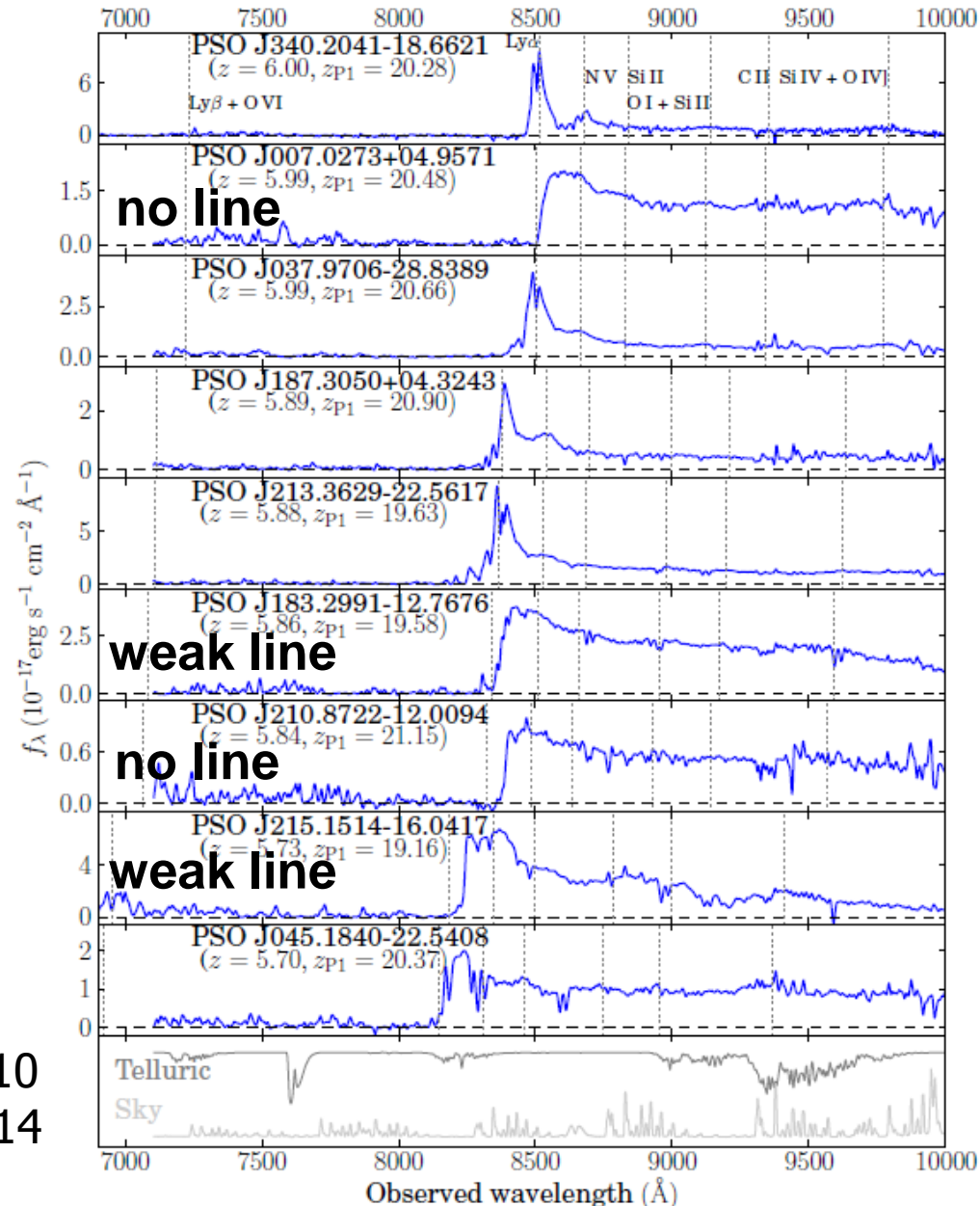
6.2% @ $z > 4.2 \rightarrow$

25% @ $z \sim 6$

Cold accretion disk /
Beginning of quasar
activity / BL Lac /
strongly lensed galaxies?

Shemmer+ 10

Bañados+ 14



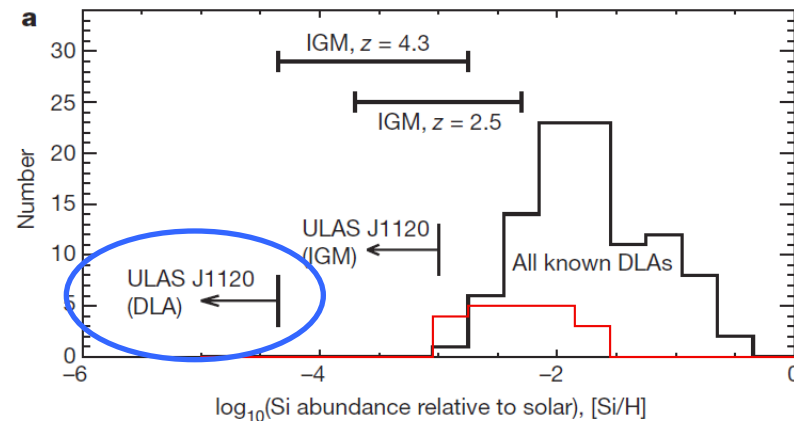
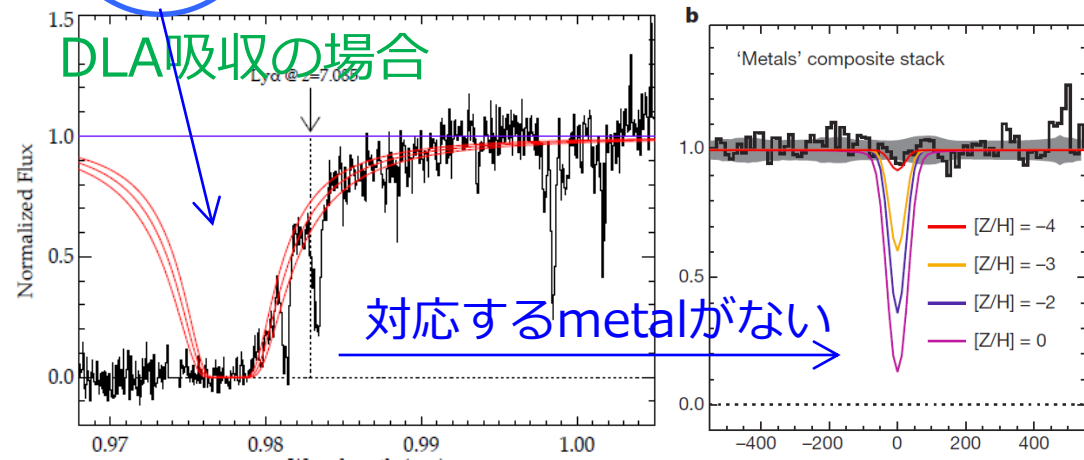
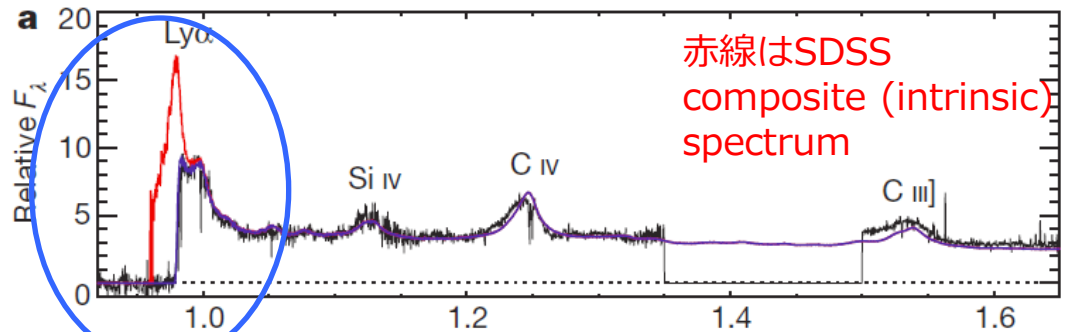
Extremely metal-poor gas at $z=7$

■ ULAS J1120+0641
 $z=7.085$

■ LyA吸収→1) DLAによる吸収, 2) 中性水素IGMによるdamping wing吸収。

■ DLA吸収だとすると金属の存在量としては $[Z/H] < -4$

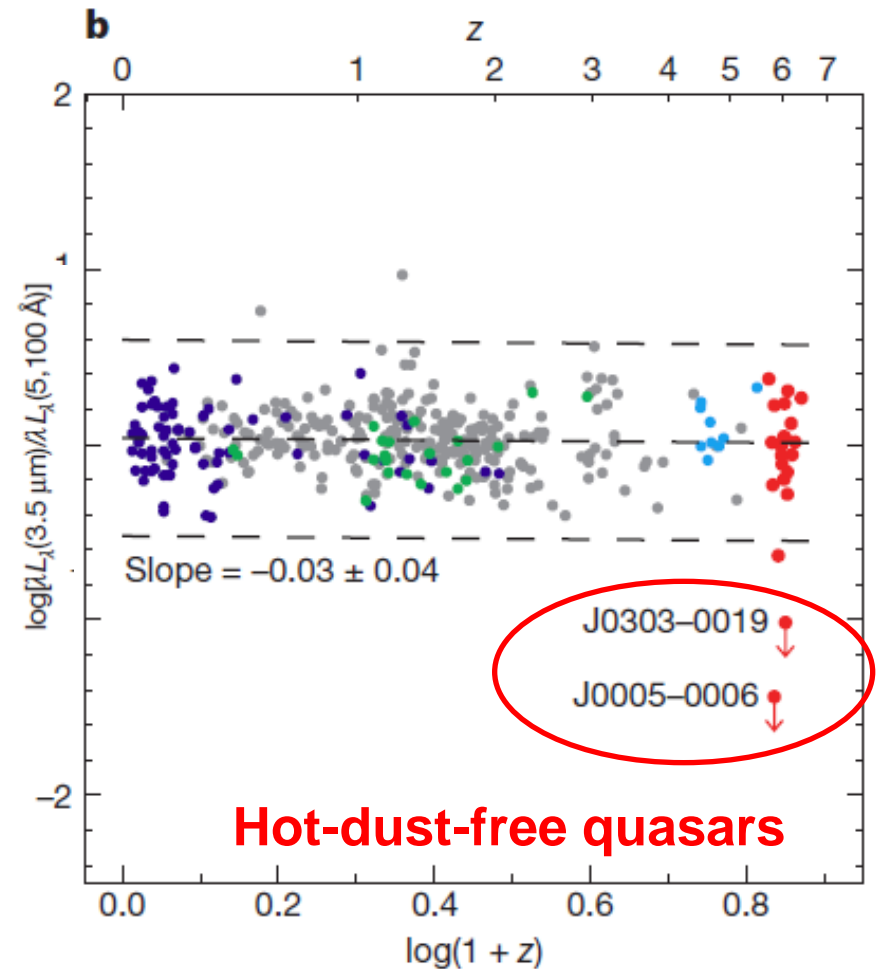
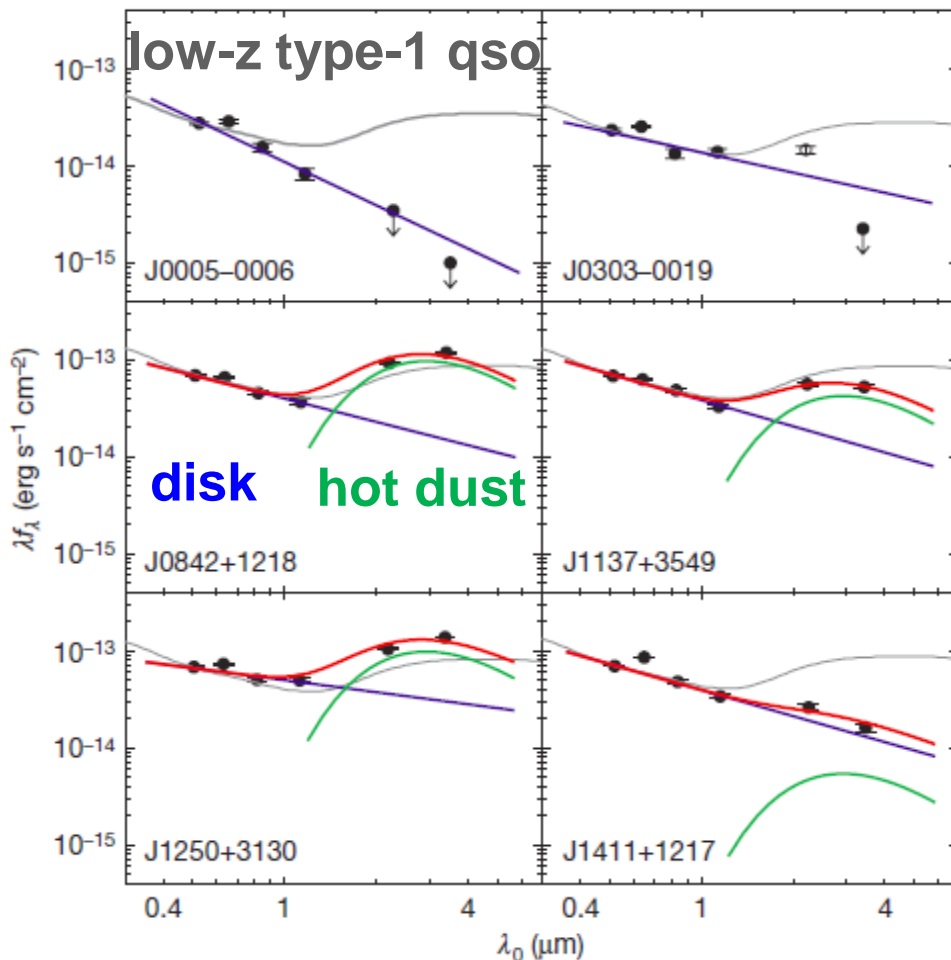
■ まだ金属汚染されていない非常にprimitive ($Z < 10^{-4}$)なHI gasの塊 or $z \sim 7$ の宇宙の中中性度は45%程度で $Z < 10^{-3}$ 程度の低金属量だった。



Dust-free high-z quasars

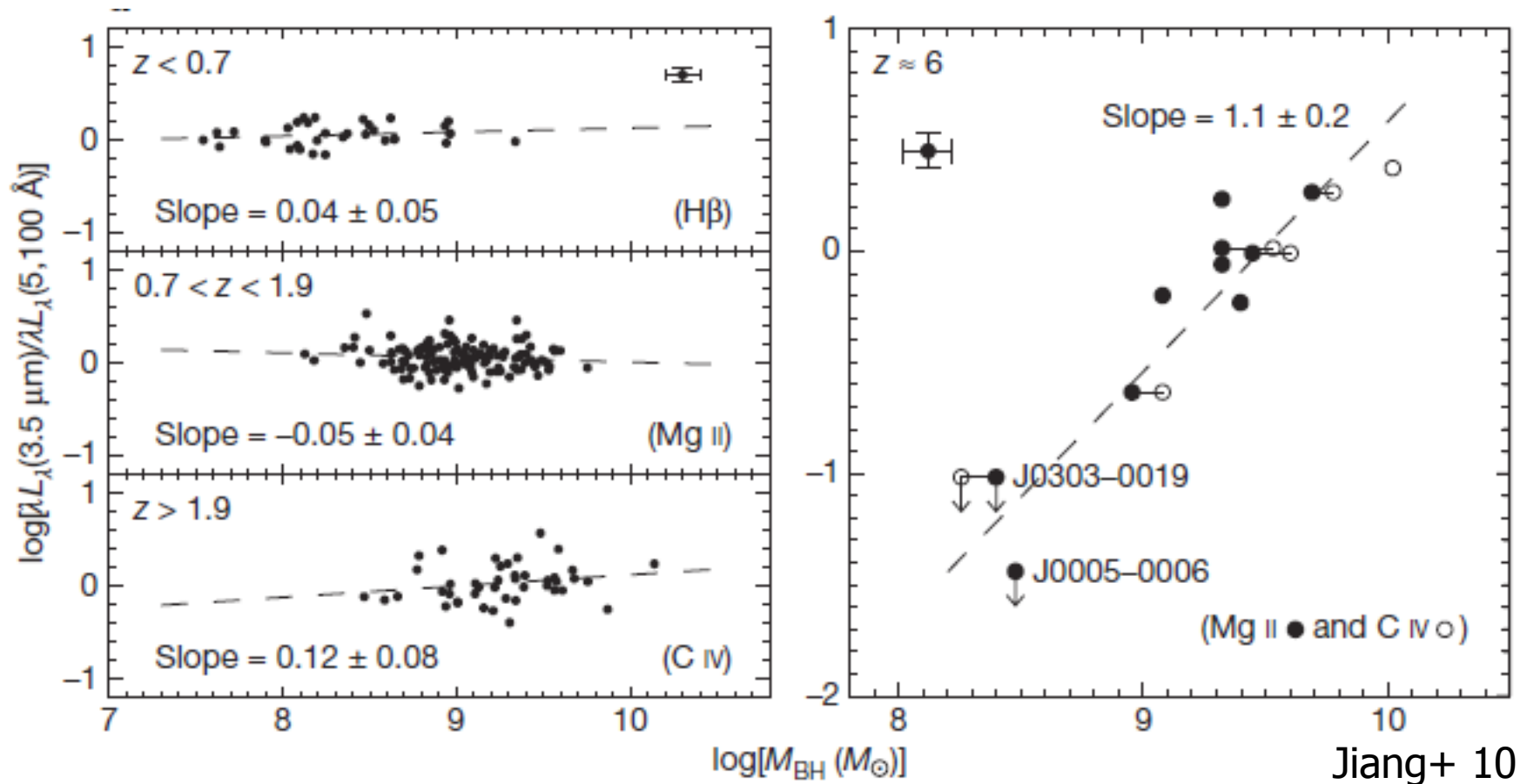
Jiang+ 10

- Hot-dust-free quasars @ $z \sim 6$
- Spitzer 3.5 μm flux = hot-dust component



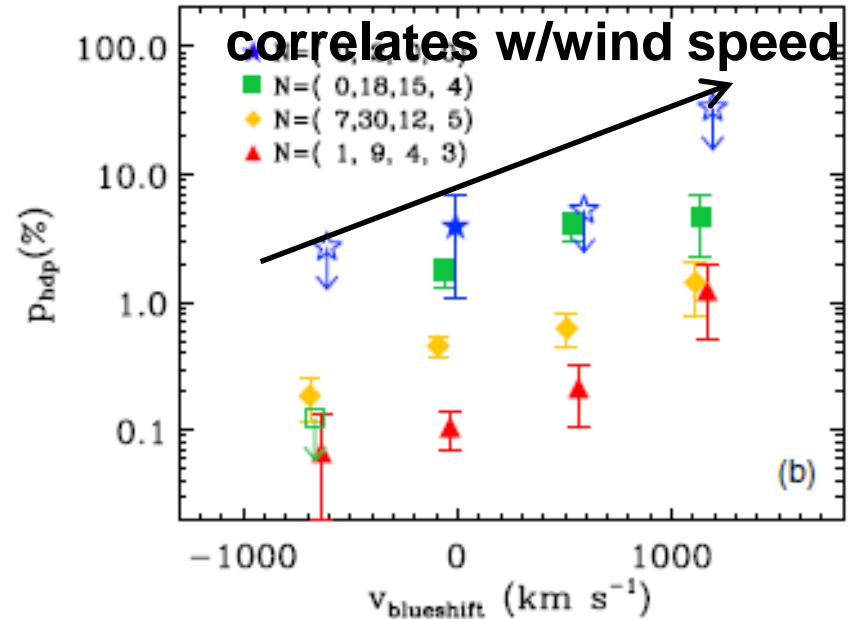
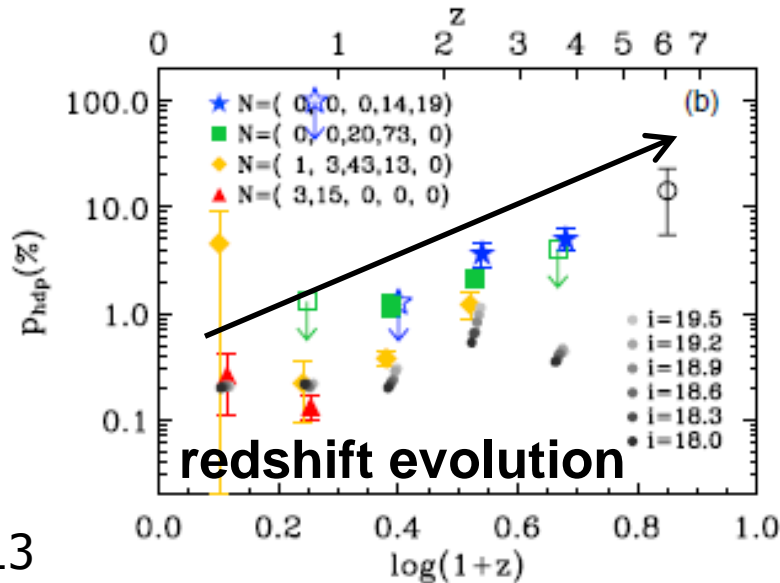
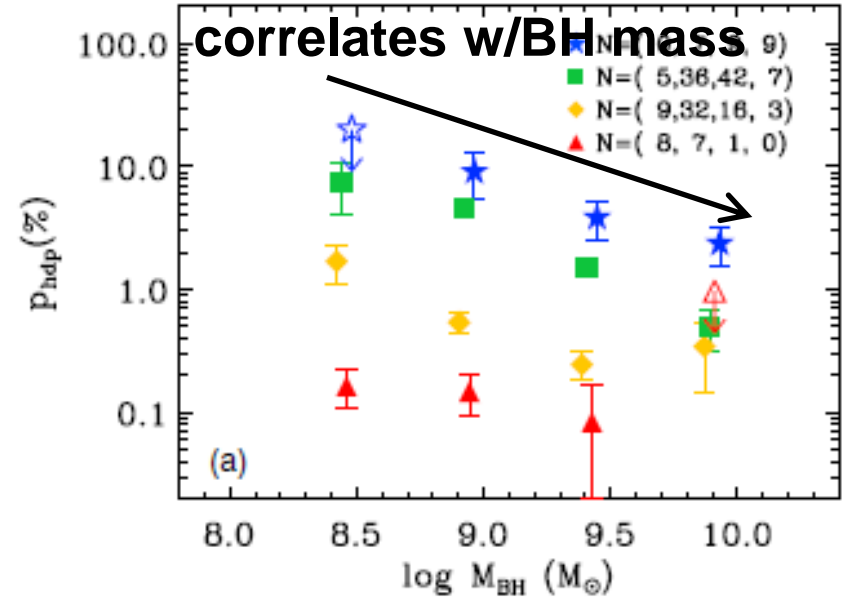
Dust-free high- z quasars

- Strong dependence on BH mass @ $z \sim 6$
- Early stage of with rapid mass accretion and dust formation

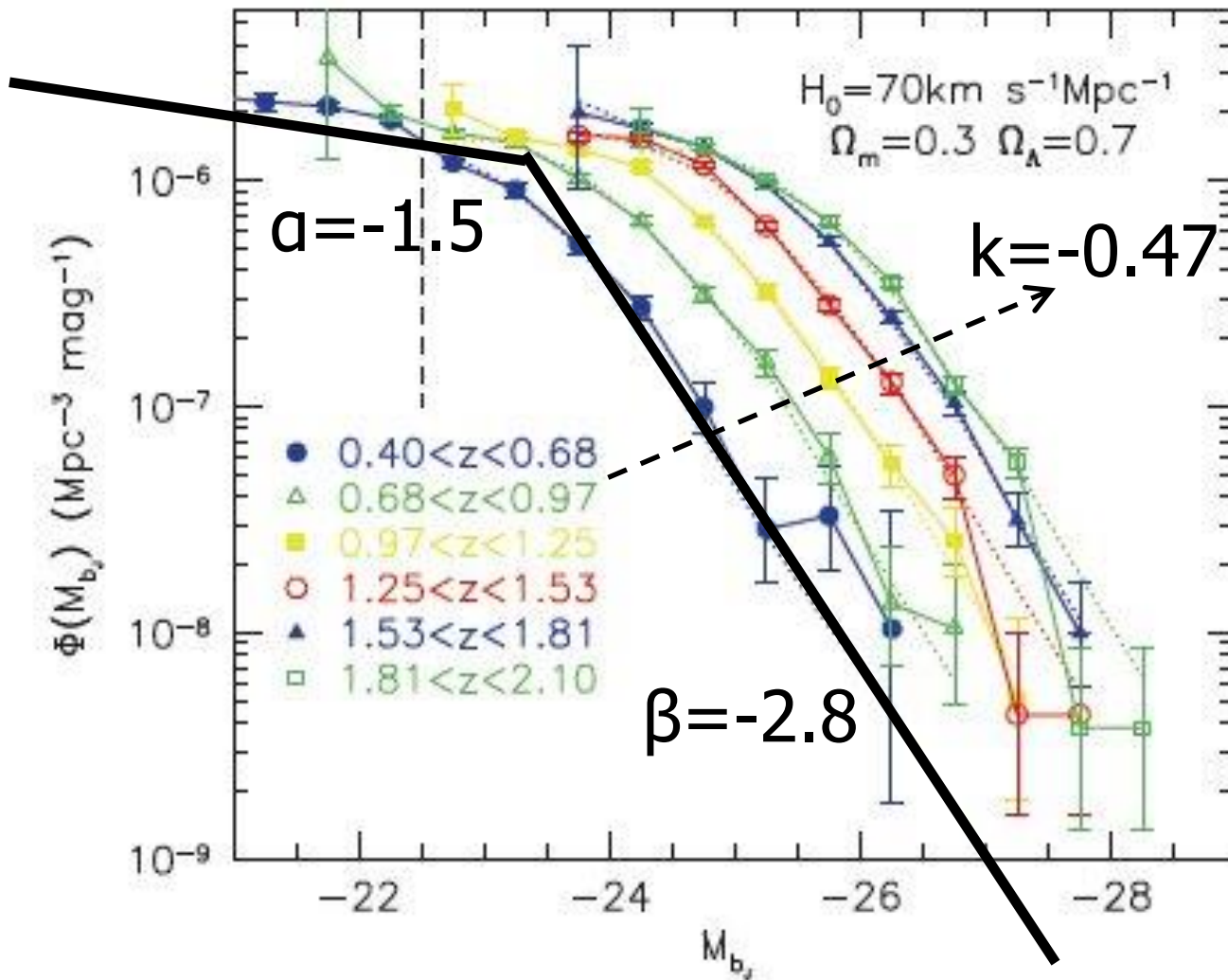


Dust-free high-z quasars

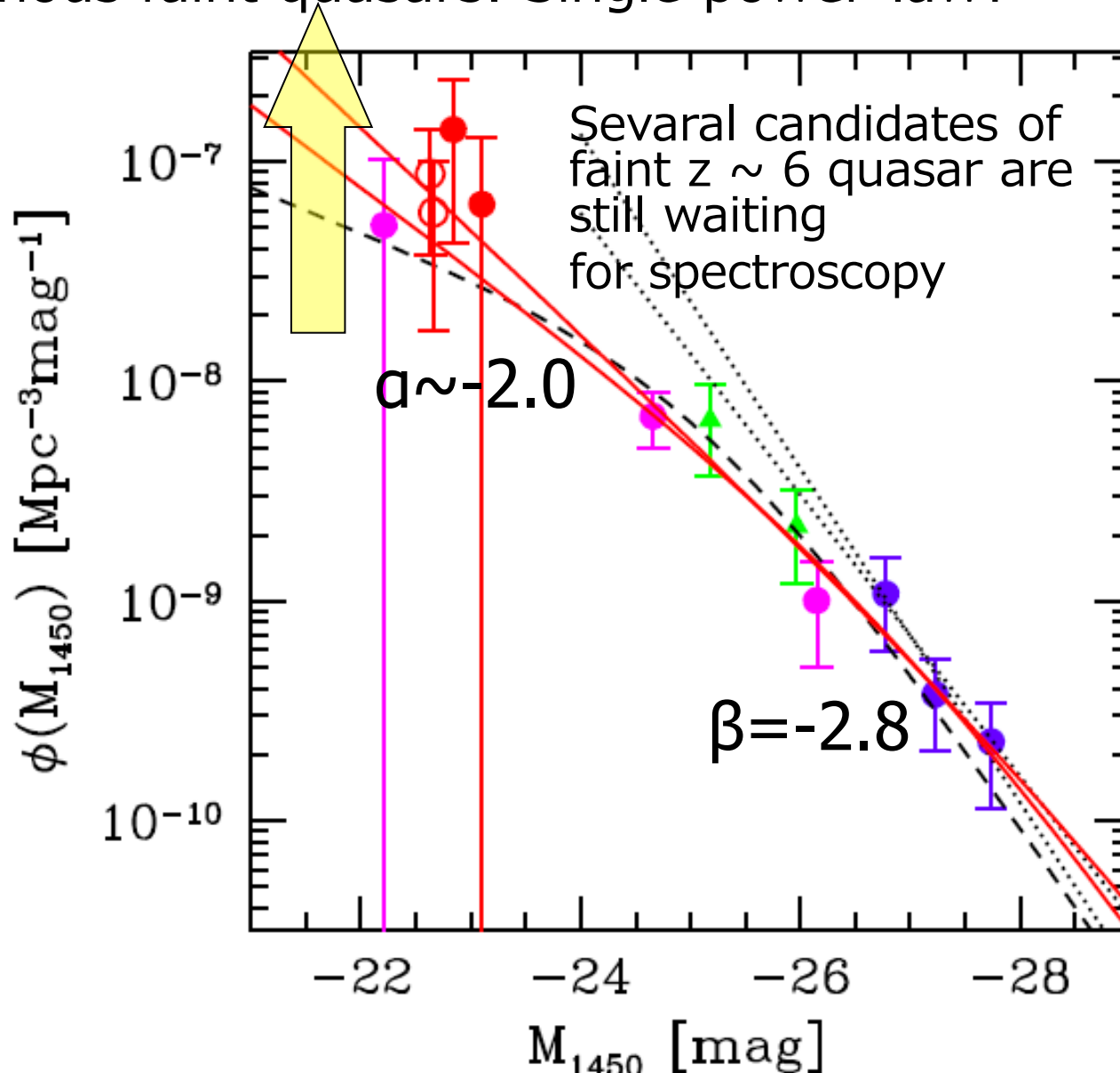
- Systematic study of 41000 quasars @ $0 < z < 5$ (Jun&Im 13)
- Hot-dust-free quasar fraction has BH-mass dependence even @ $z < 5$
- It also correlates w/ wind speed, ...



Double power-law



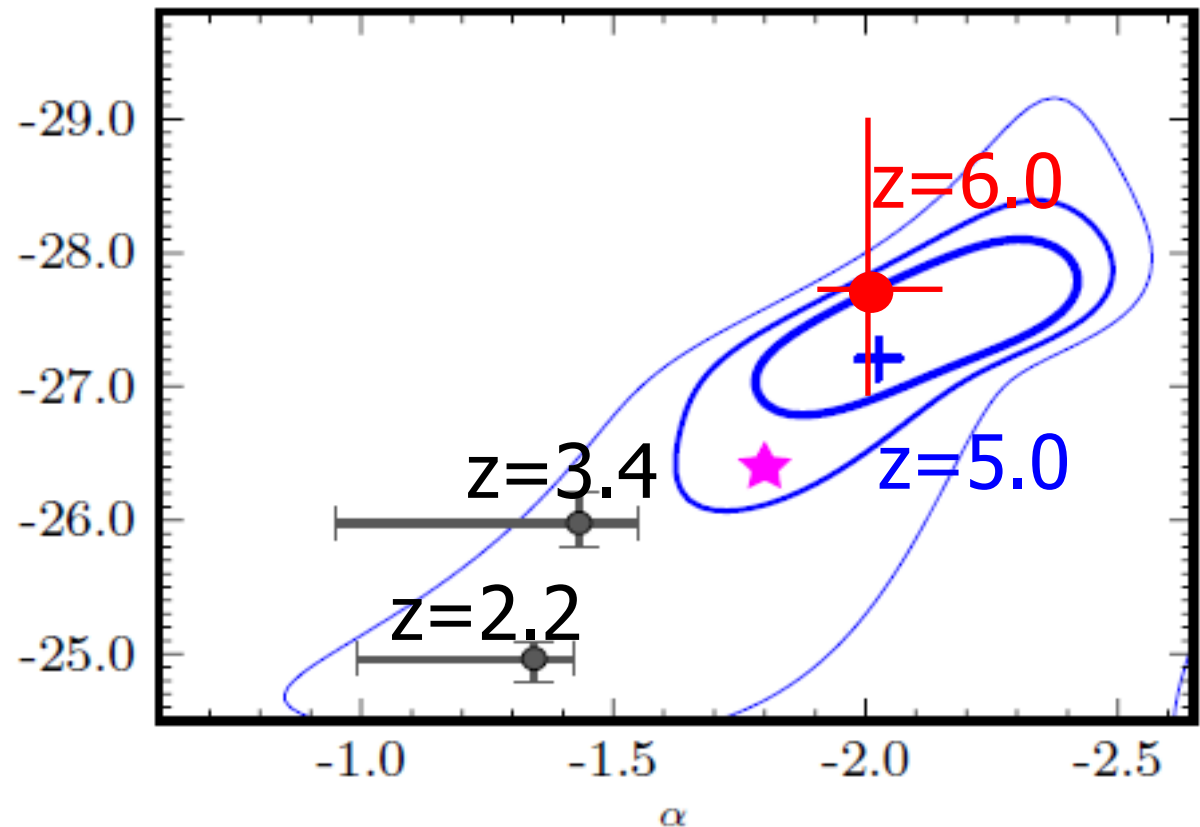
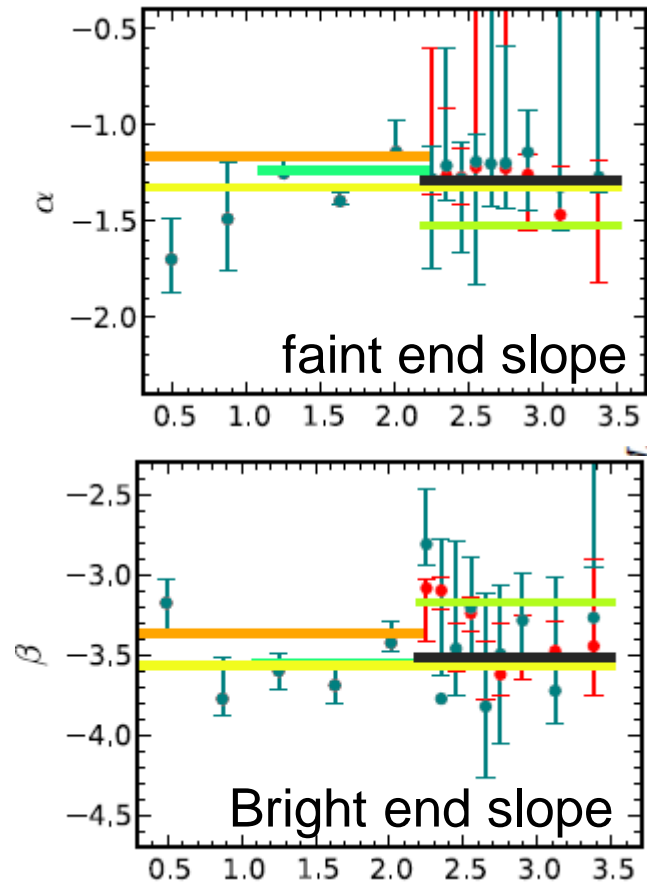
Enormous faint quasars. Single power-law?



Willott+ 10
NK+ 14

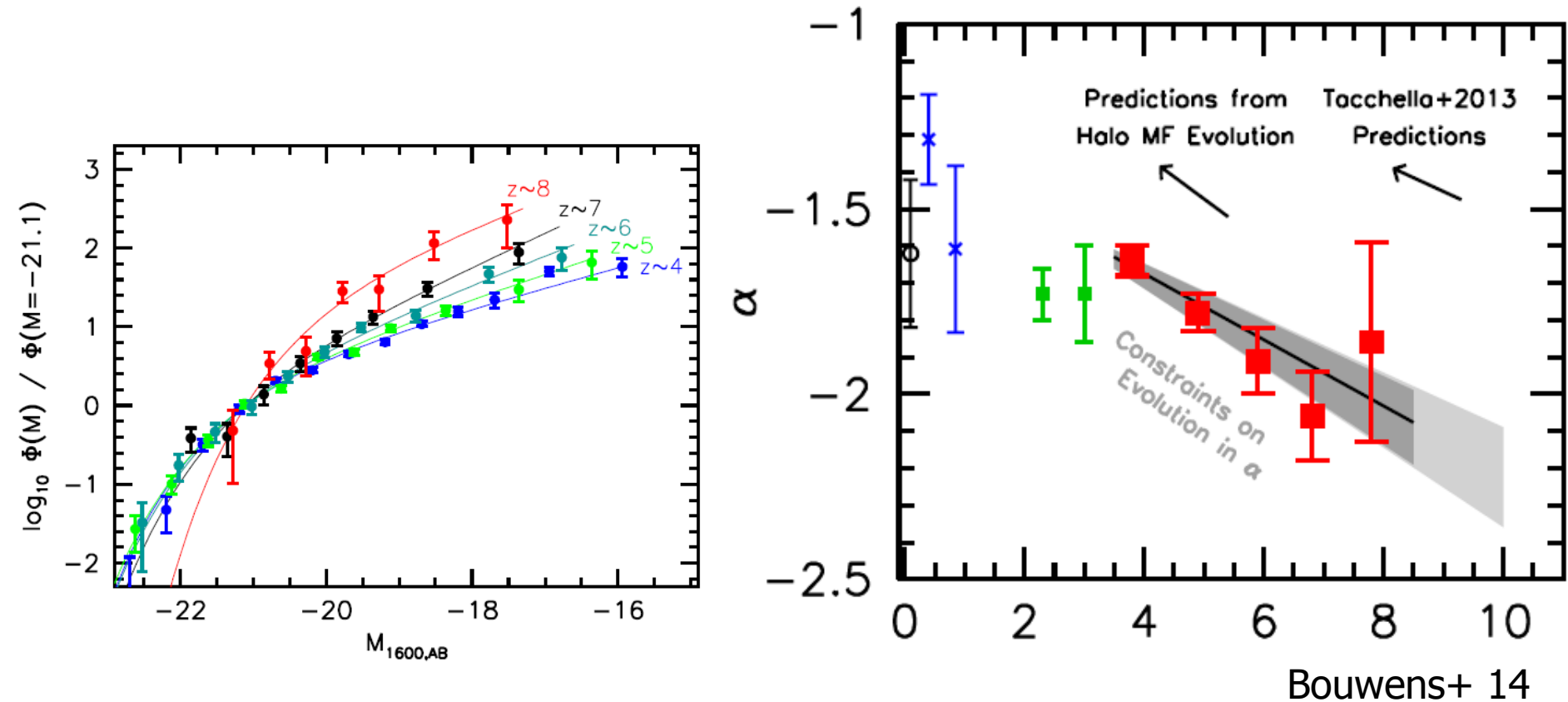
QLF steepening?

- No evolution in both bright and faint-end slope @ $z < 3.5$
- LF steepening at higher- z ?



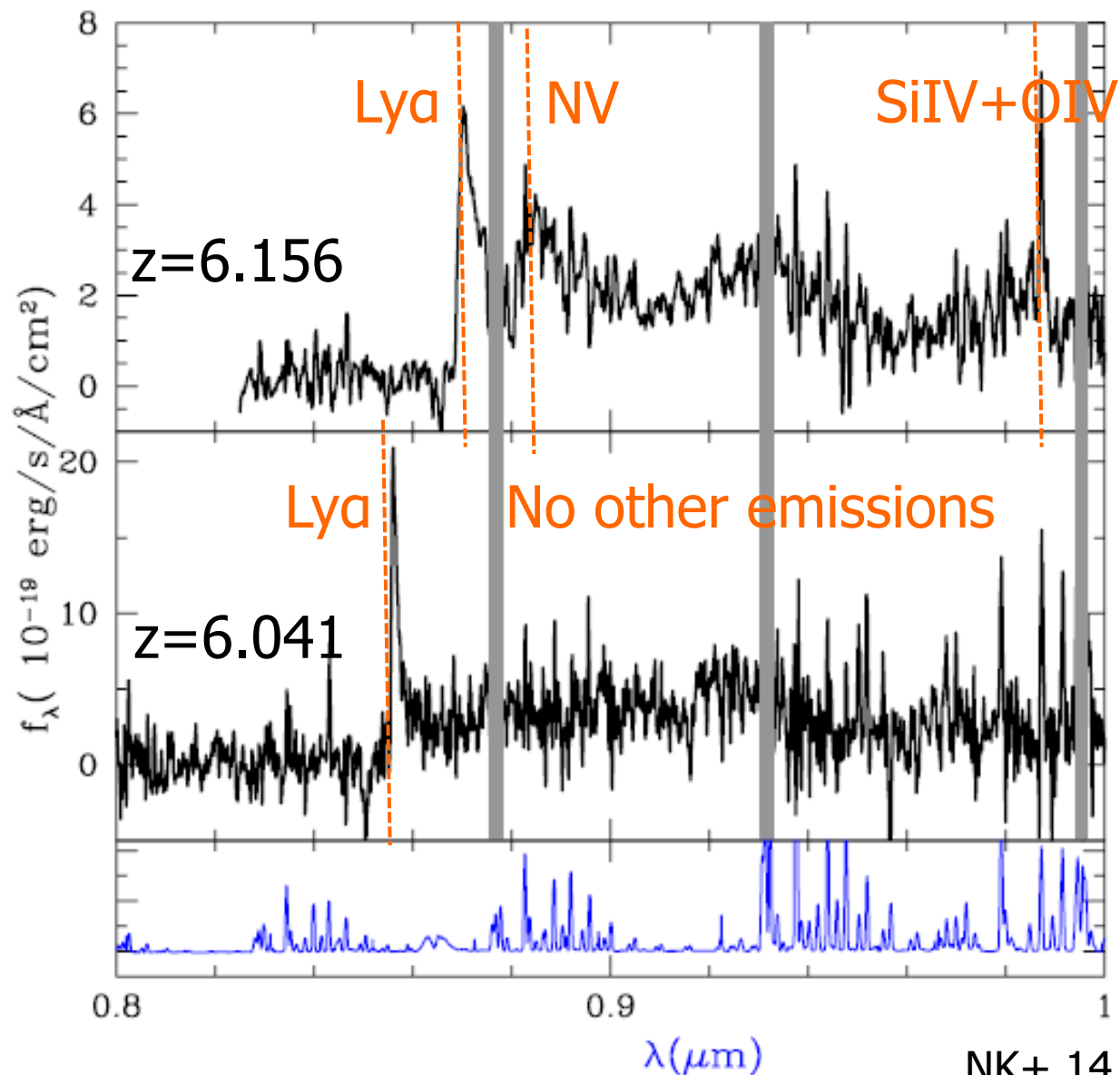
LF steepening of galaxies

- GLF steepening at higher- z
- Consistent with halo mass function evolution

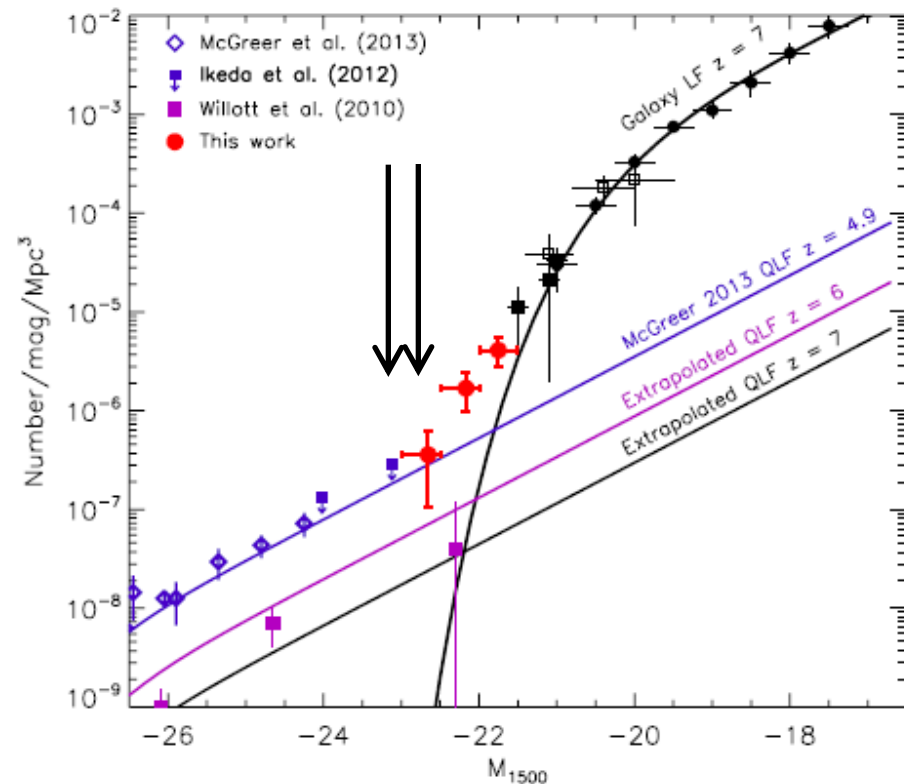
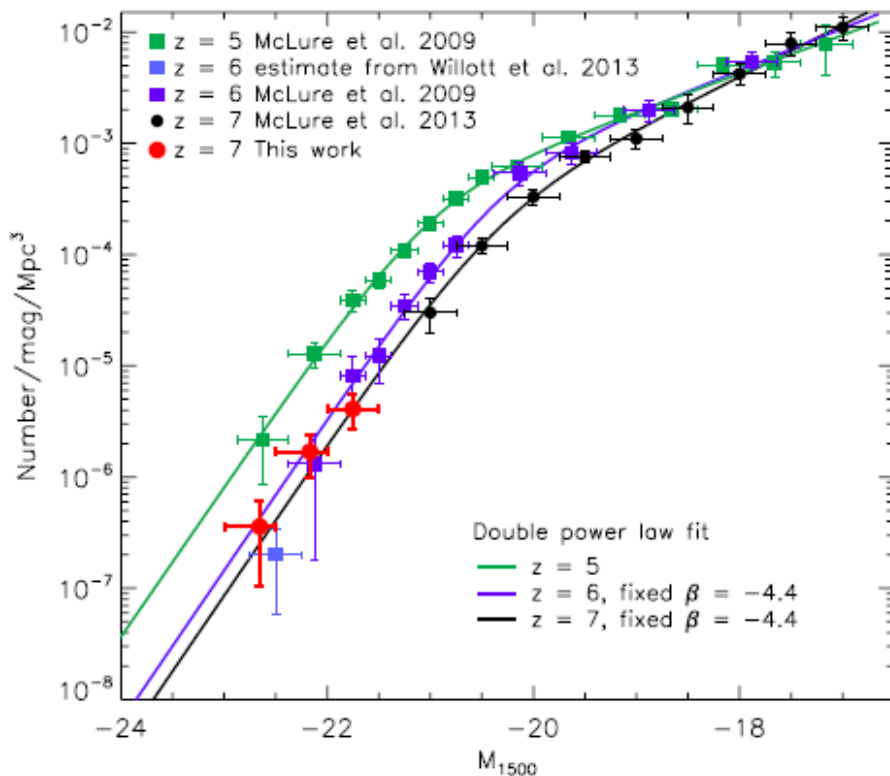


quasar or galaxy ?

- The object has no other emissions except prominent Ly α
- FWHM_Ly α =860 km/s
- M_1450=-22.58
- Not resolved
- Hard to take CIV/CIII/MgII lines at NIR



- Double power-law GLF
- AGN have yet to grow to the masses required to eject gas available for star formation
- How to distinguish between faint quasars and bright galaxies ?



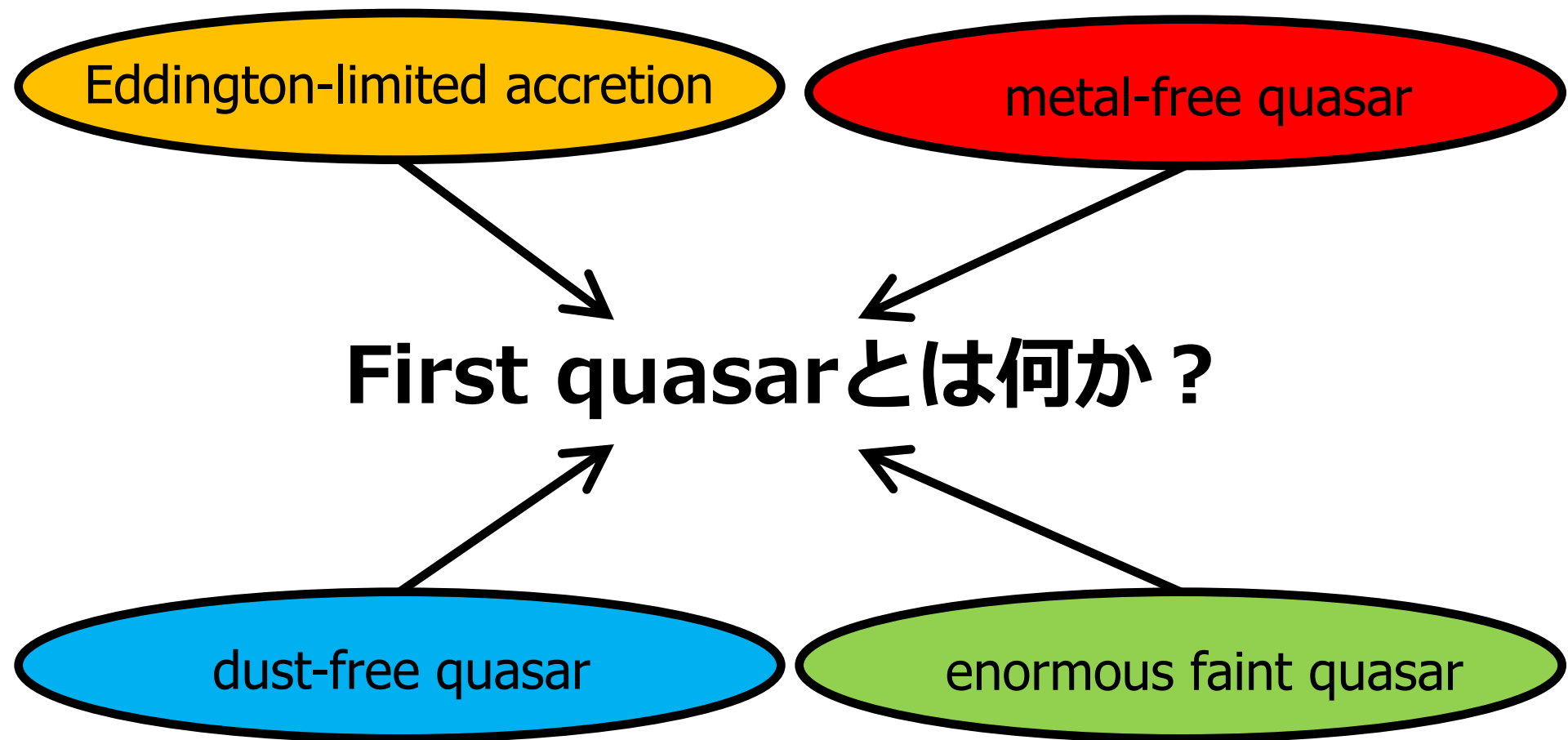
Eddington-limited accretion

metal-free quasar

First quasarとは何か？

dust-free quasar

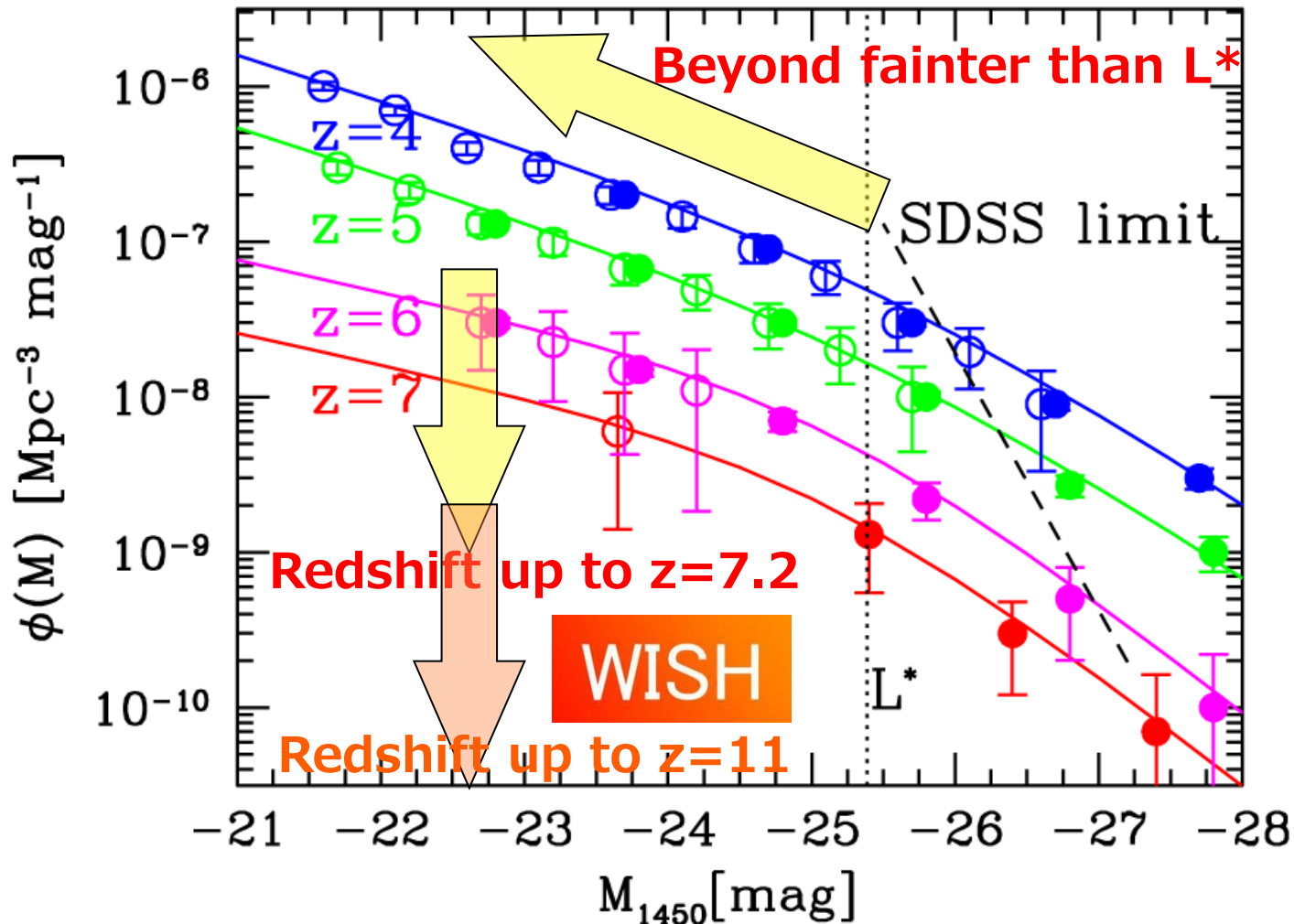
enormous faint quasar

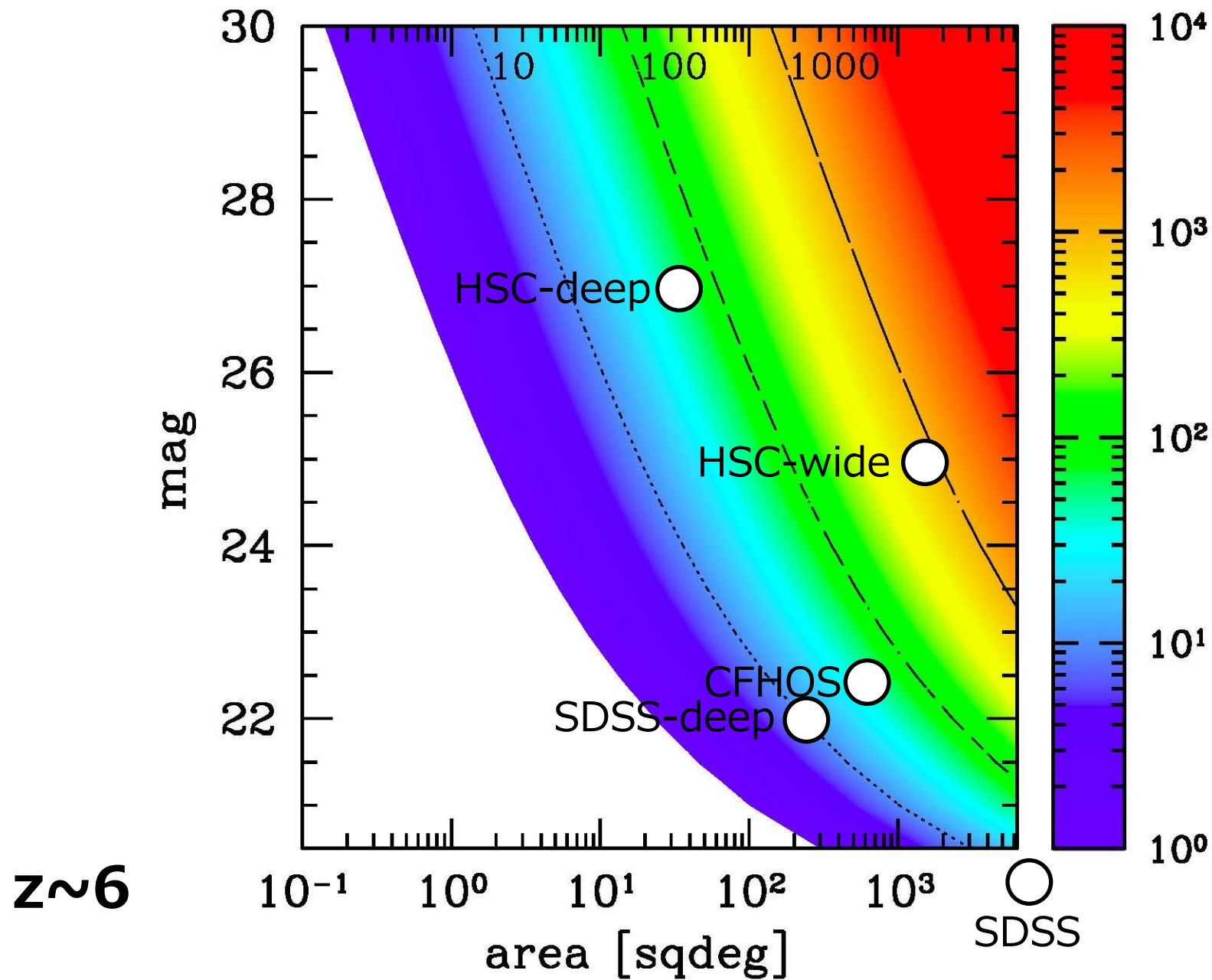


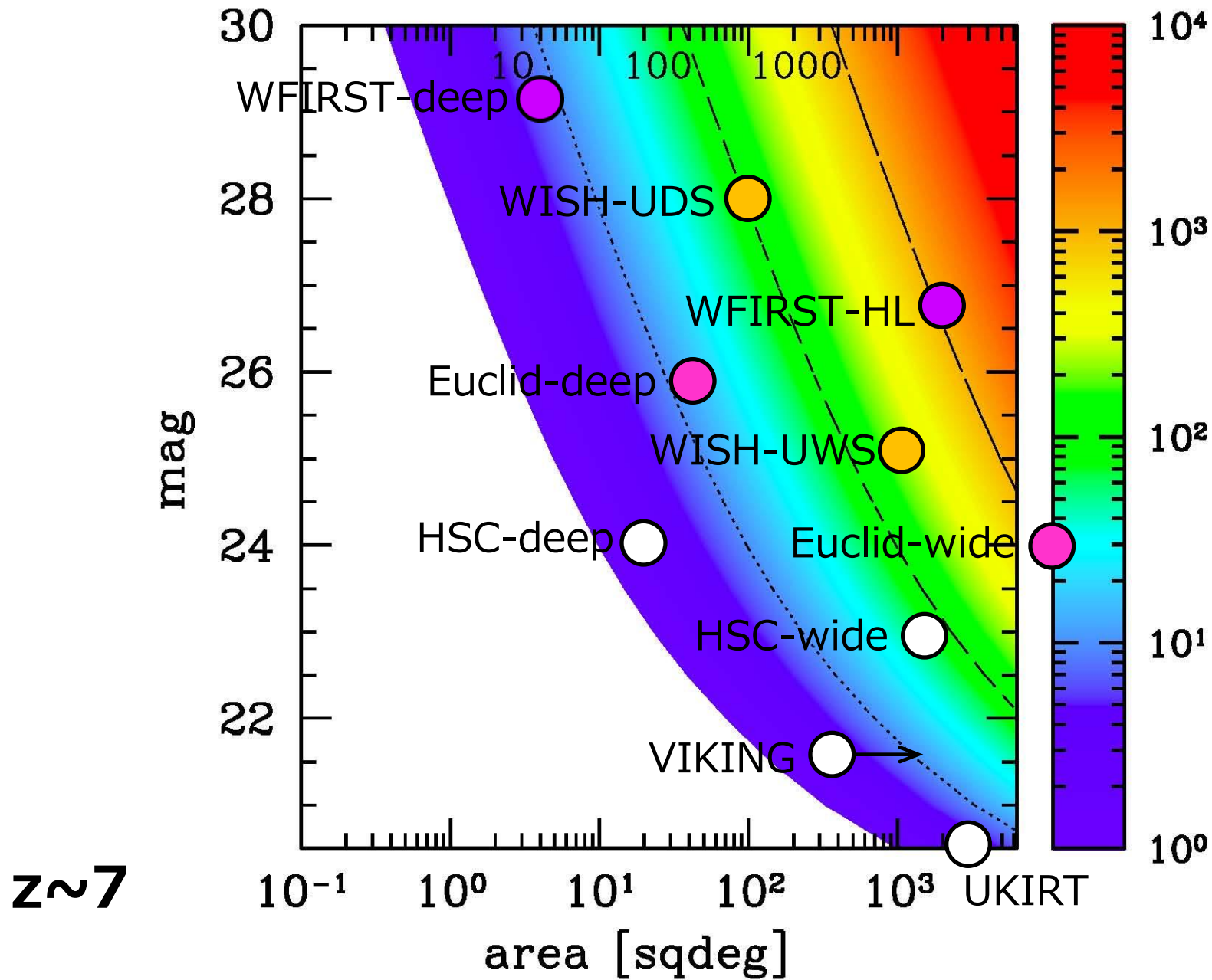
HSC high-z quasar survey

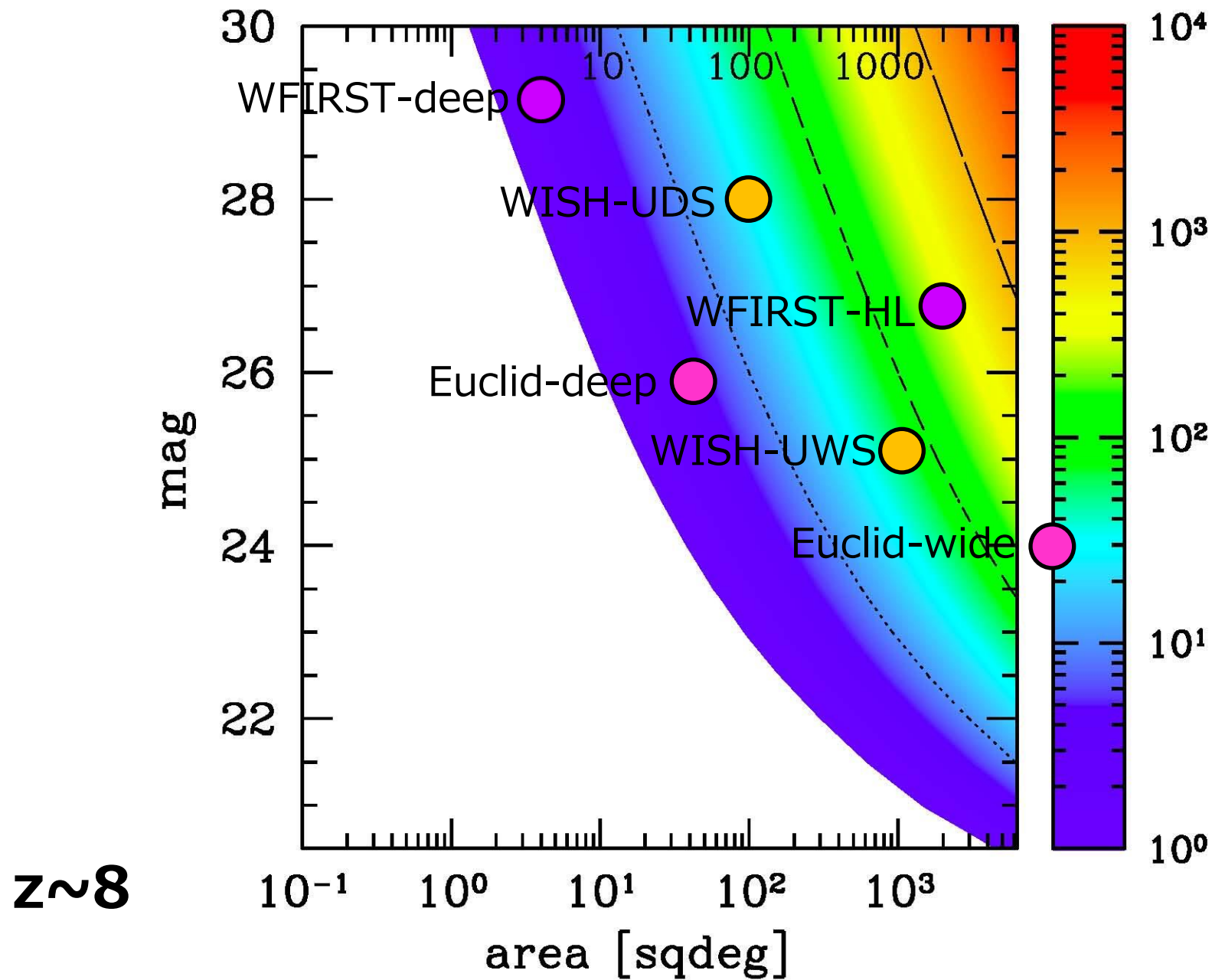
■ Beyond the limit of SDSS: higher-z & fainter quasars

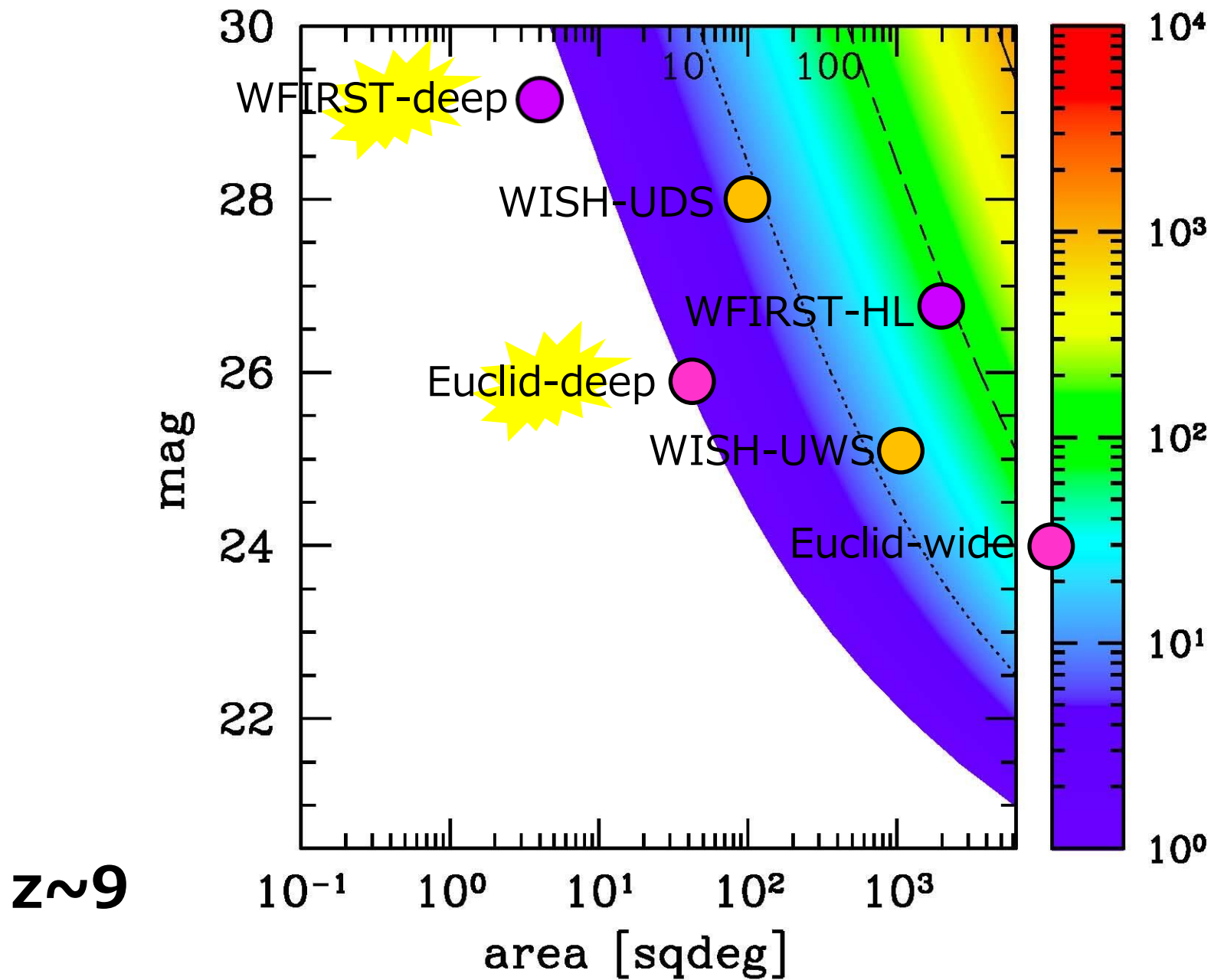
- Large ground-base telescope
- High-sensitivity instrument
- Very wide FOV
- Effective selection technique

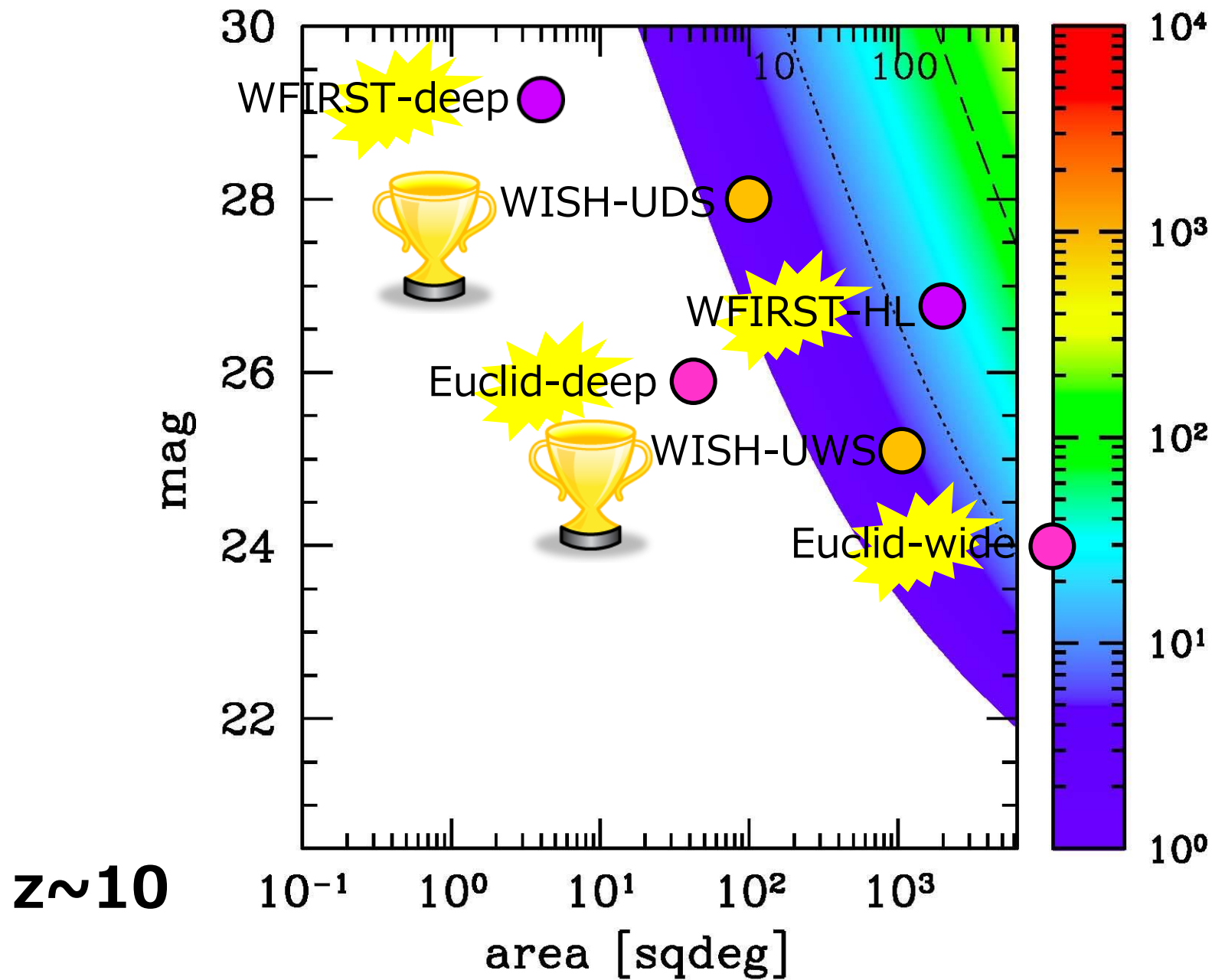












■ First quasarを探すには？

- Eddington-limited accretion: BH-massが小さくて+
- Metal-free quasar: metallicityが小さくて+
- Dust-free quasar: dustが少なくて+
- Faint quasar: 暗いクエーサー = first quasar ???

■ First quasarを見つけるのは？

- HSC
- WISH
- WFIRST
- Euclid
- いづれにせよ分光 + 多波長観測が必須