

# Requests for PFS - as an AGN researcher-

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**NAOJ/Subaru Telescope**

**With help from SWANS team**



# AGN science using PFS: Spectroscopy of HSC-detected QSOs

- $z \sim 7$

10 (1000 deg<sup>2</sup>) (candidates = X a few ?)

Use extra several fibers  
in other galaxy surveys

but see my remark later

- $z \sim 6$

300 (1000 deg<sup>2</sup>) (candidates = X a few ?)

Use extra several fibers  
in other galaxy surveys

- $z = 3-5$

10-1000 (1 deg<sup>2</sup>) (candidates = X <a few ?)

PFS very important

# 1. $z \sim 7$ QSO science

Currently, most distant QSO :  $z \sim 6.4$

Most distant, bright QSOs

Constraints on SMBH formation theory

$z=25$  : 100  $M_{\odot}$  BH Eddington growth



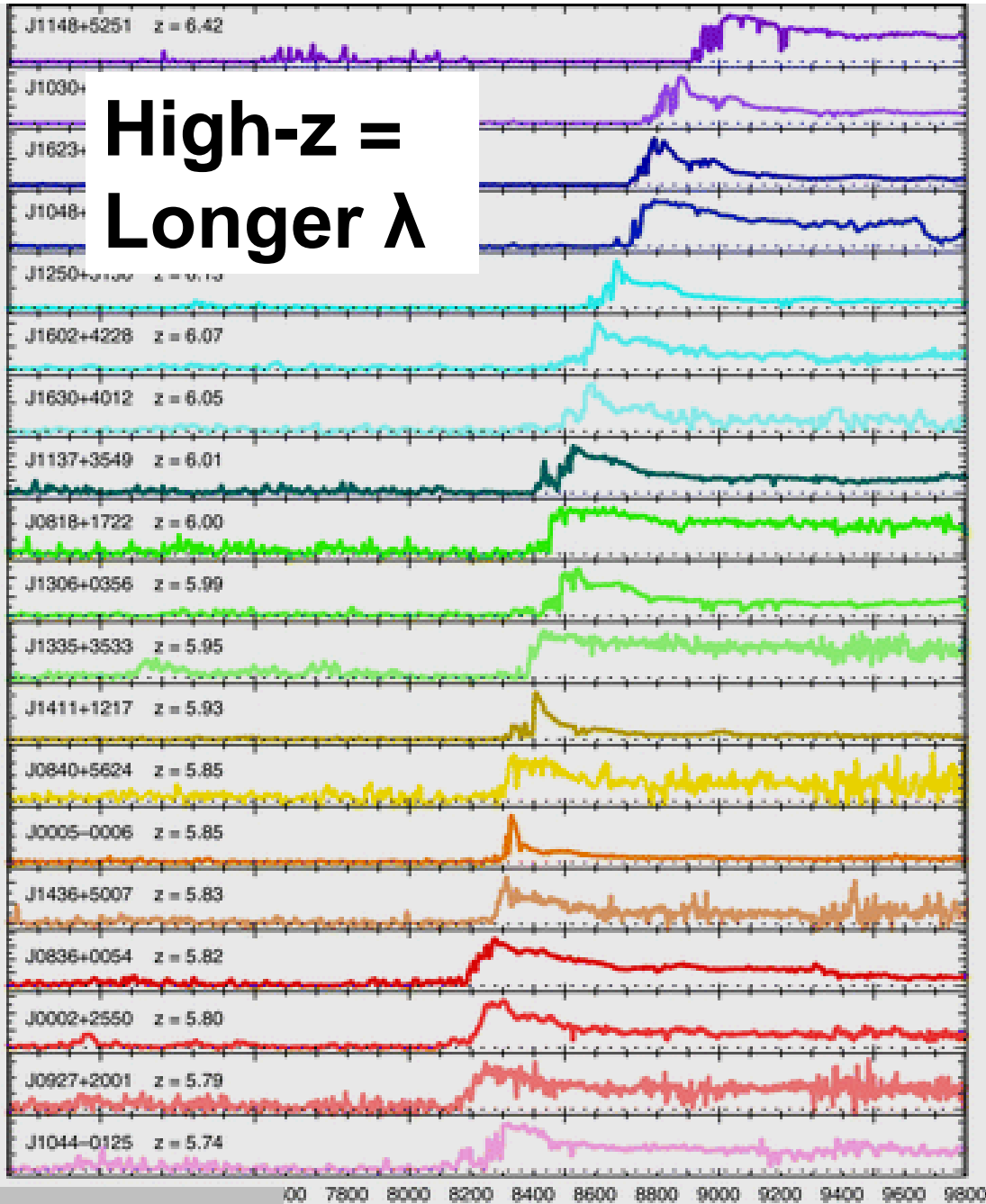
$z=6.5$  :  $10^9 M_{\odot}$

$z=7.5$  :  $10^8 M_{\odot}$

Study the physics (including neutral fraction) of more distant IGM with high S/N

**High-z =  
Longer  $\lambda$**

$f_{\lambda}$

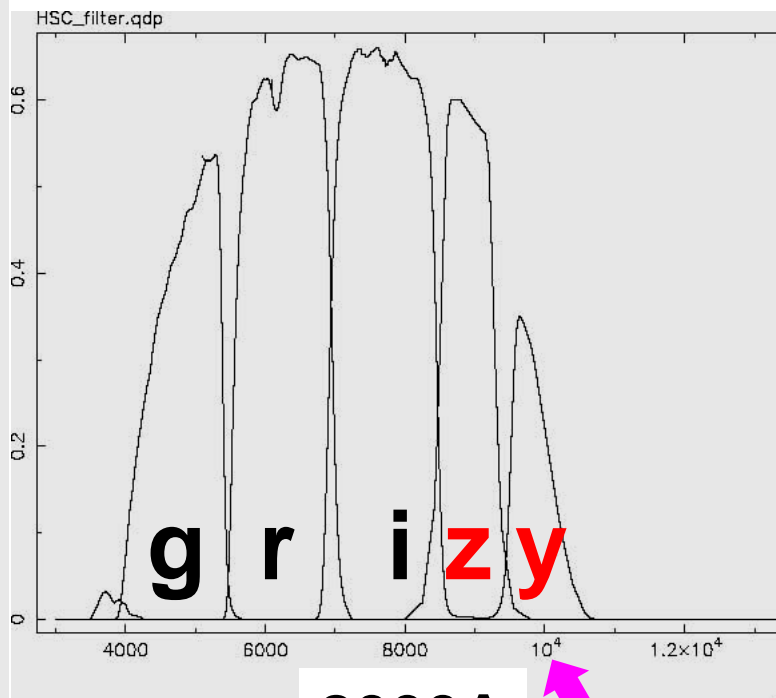


**Fan+06**

**8000A**

**9000A**

**HSC  
z,y filters**



**8000A**

**10000A**

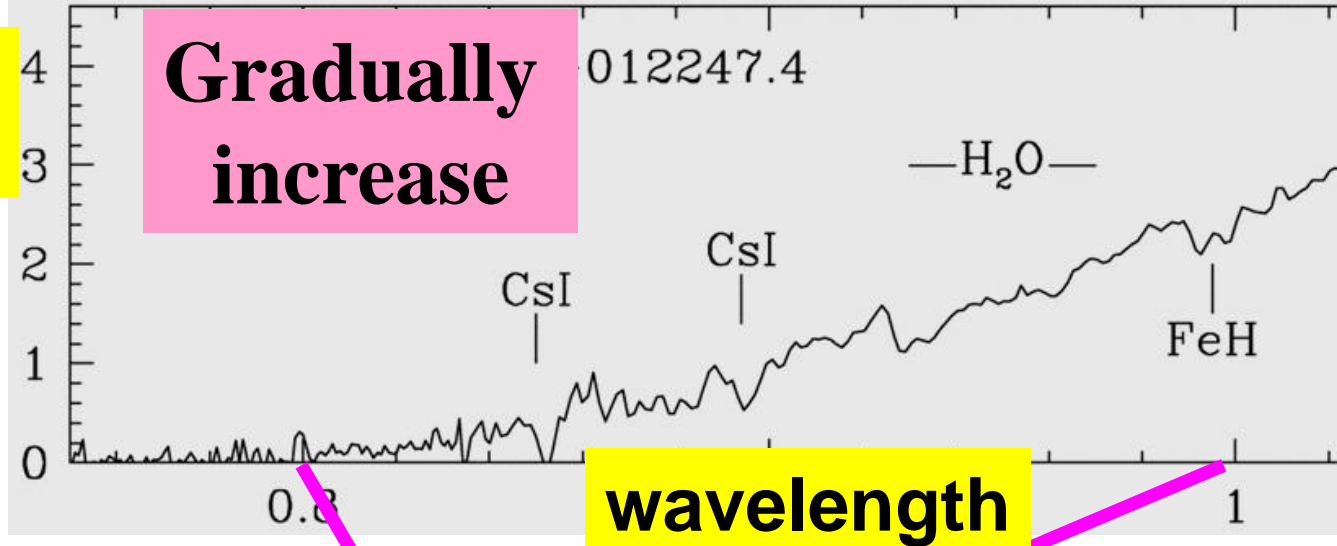
**Up to  $z \sim 7.3$  QSO**

# High-z QSO and brown dwarf (BD)

Galactic  
BD

flux

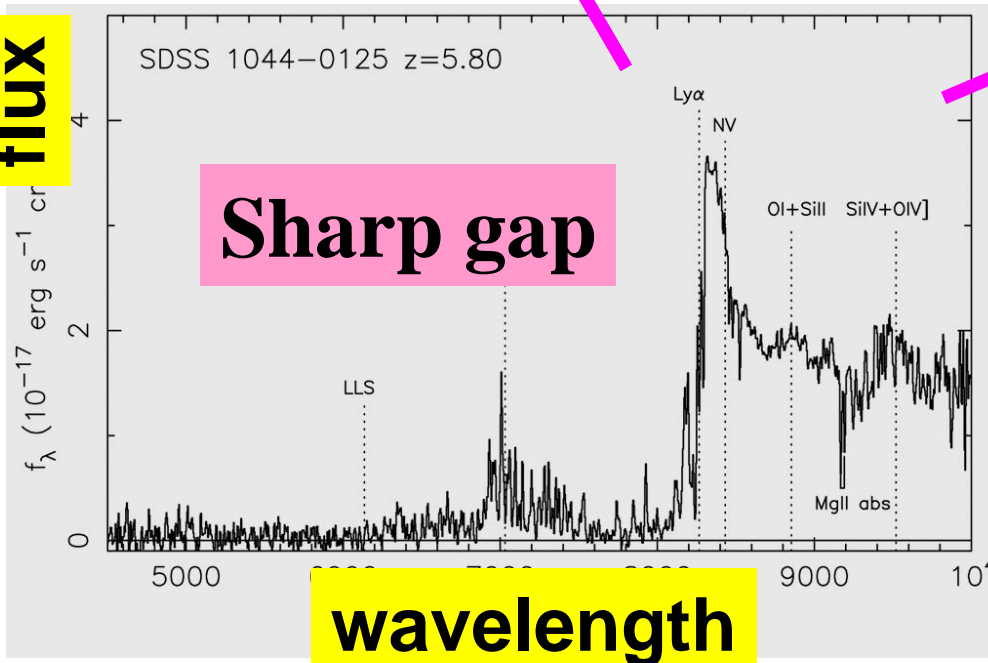
Gradually  
increase



High-z  
QSO

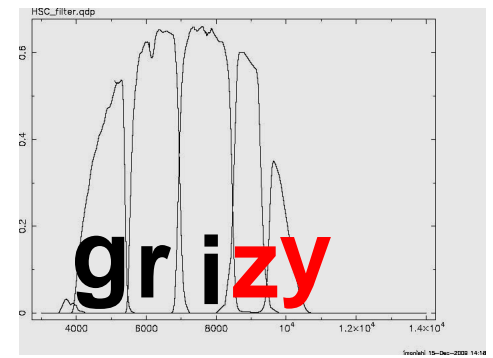
flux

Sharp gap



**z~7 QSO (z-dropout,y-detected)**

**z-y>2-2.3 selection (remove BD)**

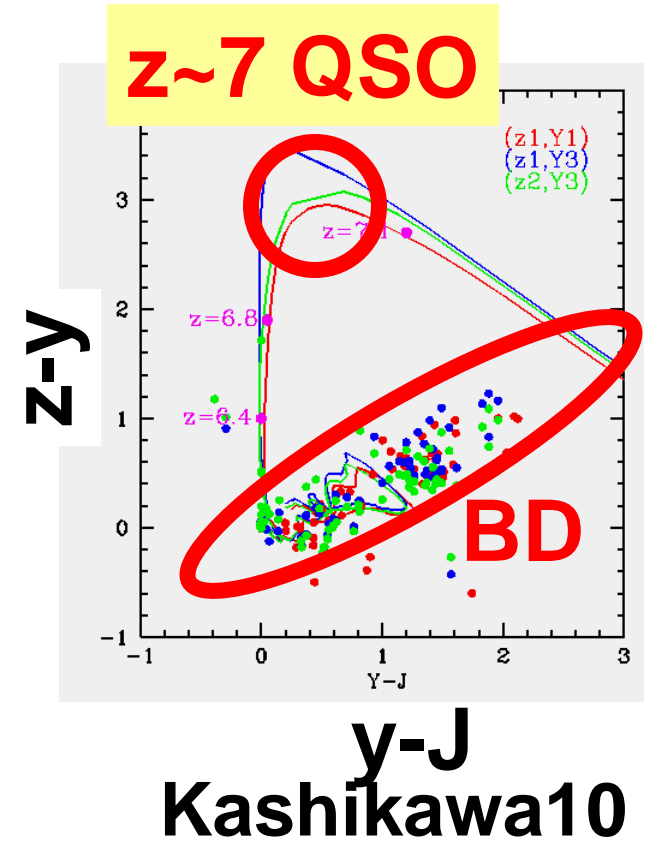


**In VIKING field (J=22.2)AB,  
z-y>1.5-1.7, y-J<1**

**Assumption**

**HSC wide survey**

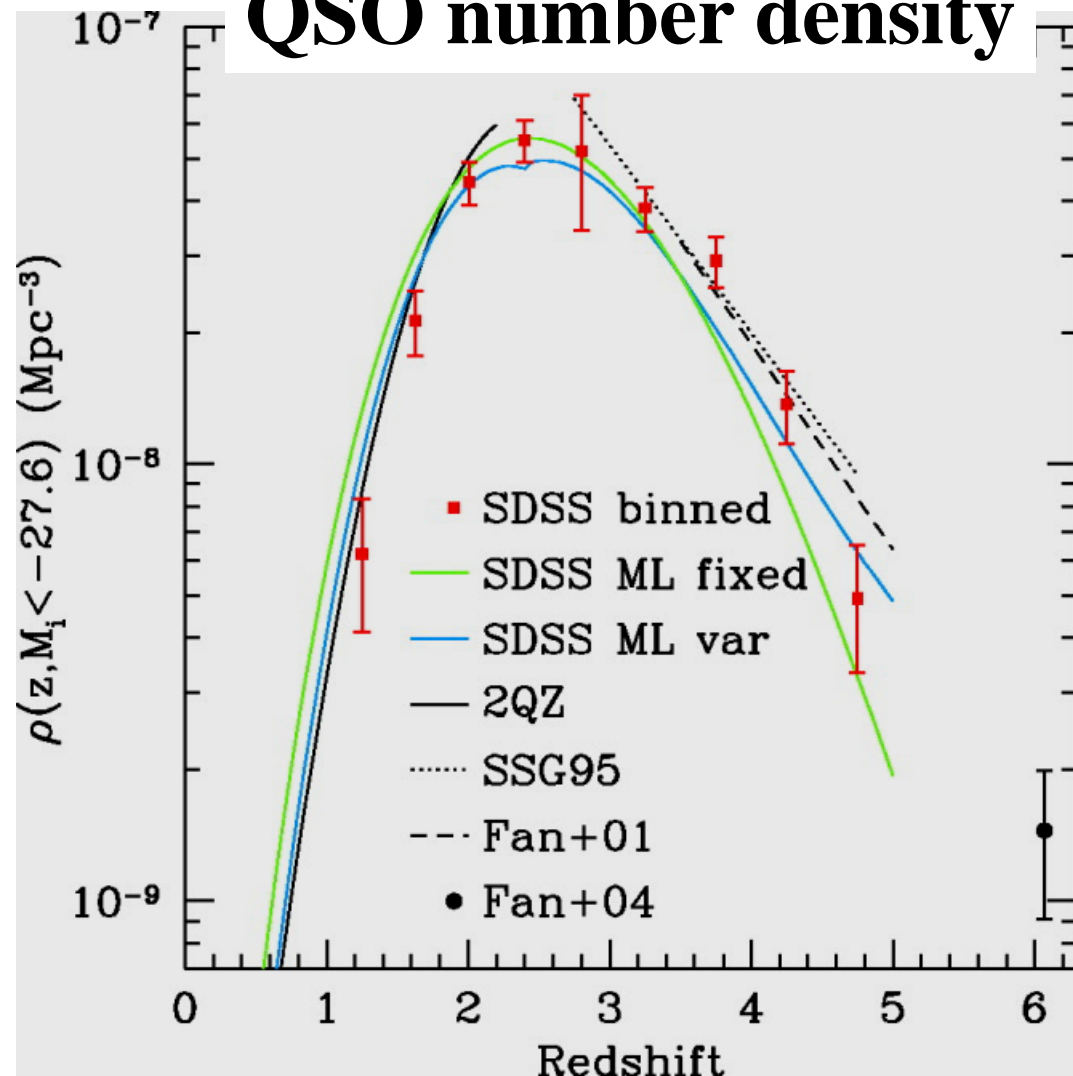
**(i,z,y) = (20m, 20m, 20m)  
= (26.0, 24.9, 23.8) AB**



**z~7 QSO**

**QSO number decreases with high-z**

## QSO number density



$$\propto 10^{-0.47(z-6)}$$

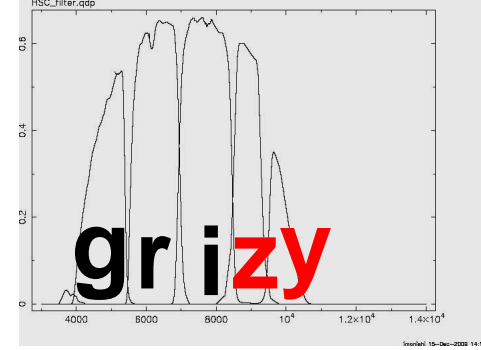
**Willott+10**

**z=6 → 7 : ~1/3**

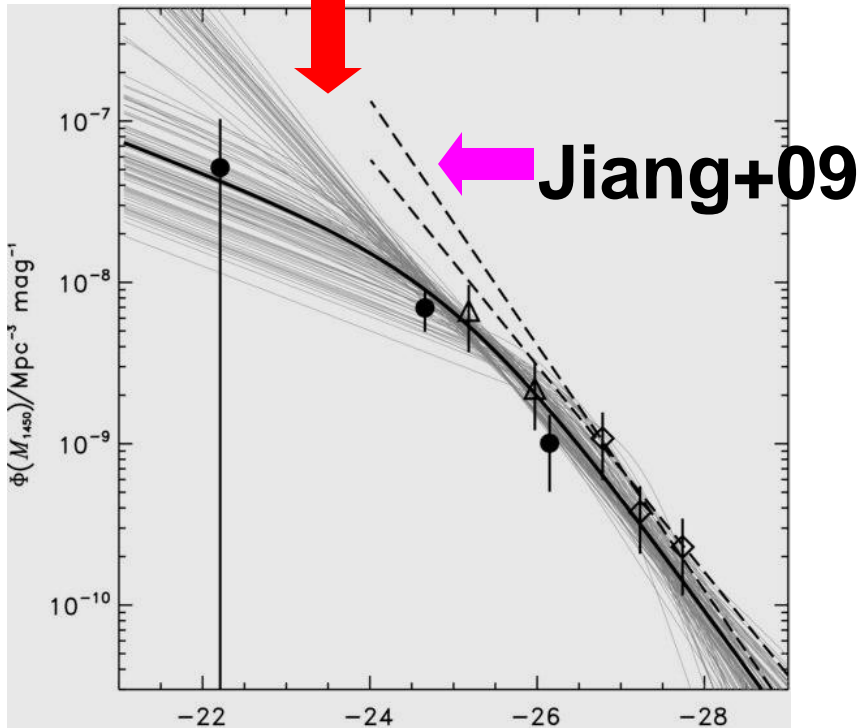
**Richards+06**

# z~7 QSO

Number of faint QSOs :  
Smaller than previously expected



**HSC/wide (z~7)**



faint

$M_{1450A}$

bright

**Selectable z~7 QSO:**

7/1000 deg<sup>2</sup>

12 (VIKING)

**(conservative)**

Lim-mag:

(z,y) = (24.9, 23.8) AB

z~7 QSOs included

in y-band : ~35/1000deg<sup>2</sup>

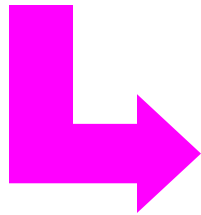
Selection z-y > 1.5



# PFS (z~7 QSO)

Follow-up spectroscopy of HSC z~7 QSO candidates

Several 10s candidates/1000 deg<sup>2</sup>



Use extra several fibers in other galaxy surveys

At least cover Ly $\alpha$  : 9000 - 10500A

High sensitivity required

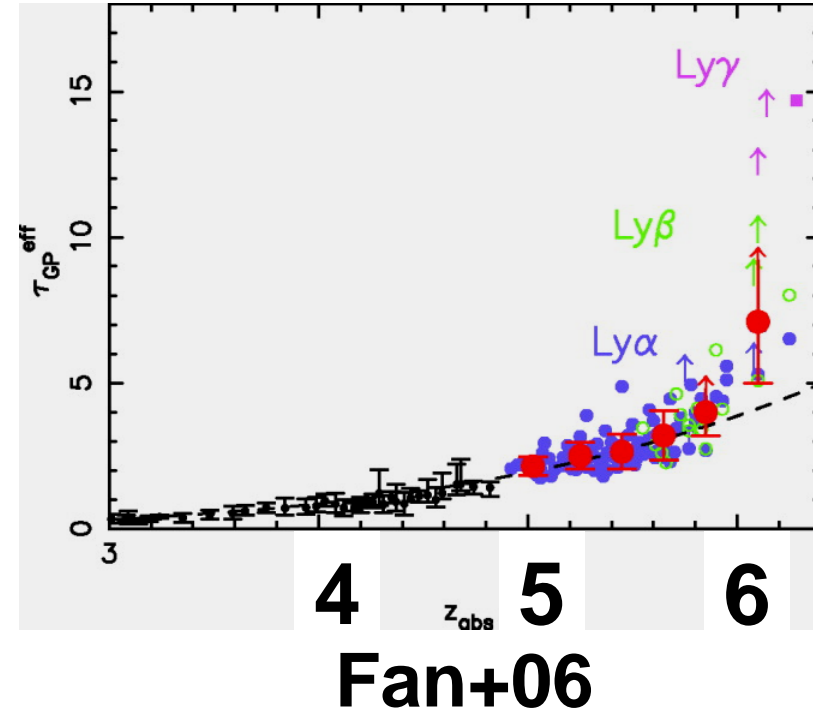
SMBH mass  MOIRCS

IGM physics  TMT

## 2. $z \sim 6$ QSO science

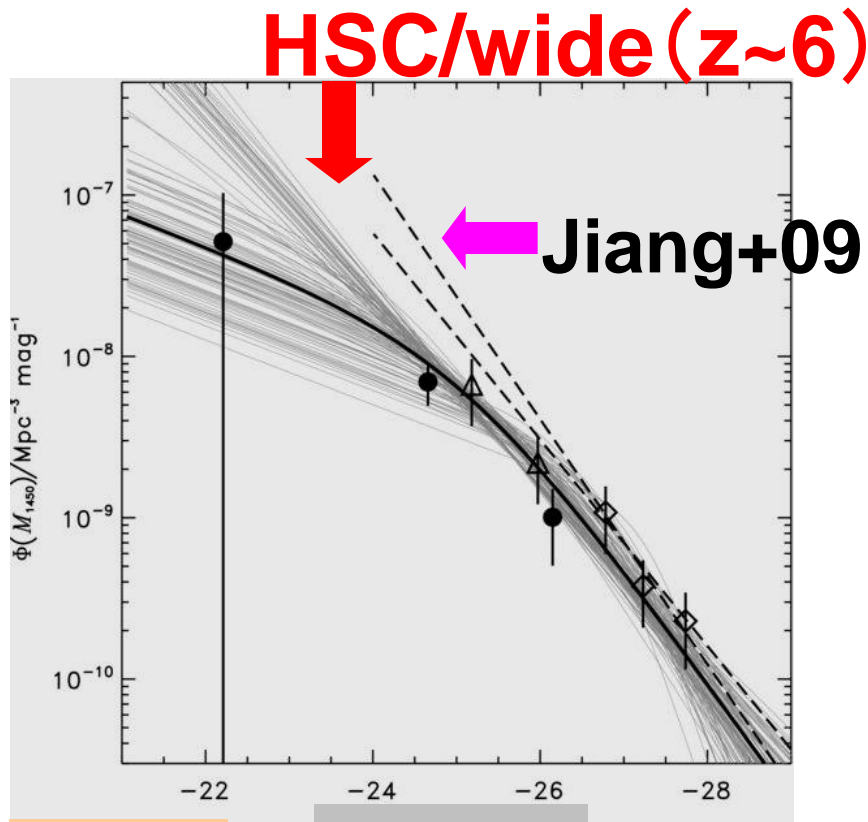
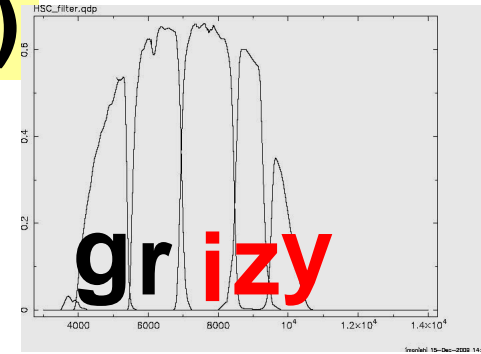
Many faint  $z \sim 6$  QSO

$z \sim 6$  IGM study in many sightlines  
(neutral fraction increases?)



## 2. $z \sim 6$ QSO (i-dropout, z-detected)

i-z red ( $>1.8$ ) : by IGM absorption  
z-y blue ( $<0.5$ ) : BD removal



350/1000 deg<sup>2</sup>  
(conservative)

Selection :  
i=26.0, z=24.2, y=23.8  
(AB)

faint

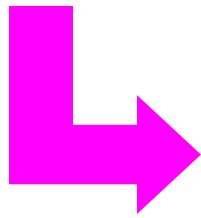
$M_{1450A}$

bright

# PFS (z~6 QSO)

Follow-up spectroscopy of HSC z~6 QSO candidates

1000 candidates/1000 deg<sup>2</sup> (1/deg<sup>2</sup>)



Use extra several fibers in other galaxy survey

At least cover Ly $\alpha$  : 8000 – 9000A

High sensitivity required

z~6 IGM multiple sightlines  TMT

# 3. $z=3-5$ QSO science

Faint, numerous  $z=3-5$  QSOs

LF faint end

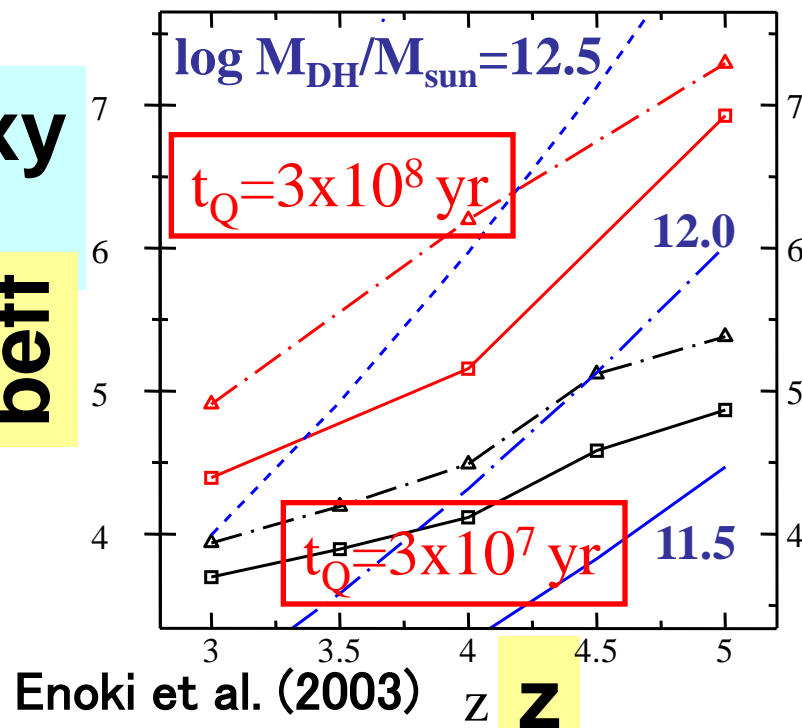
Origin of ionizing UV background

QSO-QSO, QSO-galaxy correlation (bias)

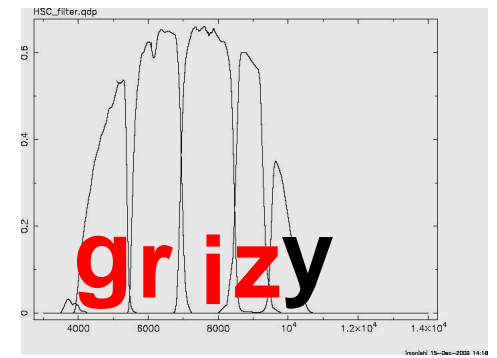
QSO lifetime

Halo mass

beff

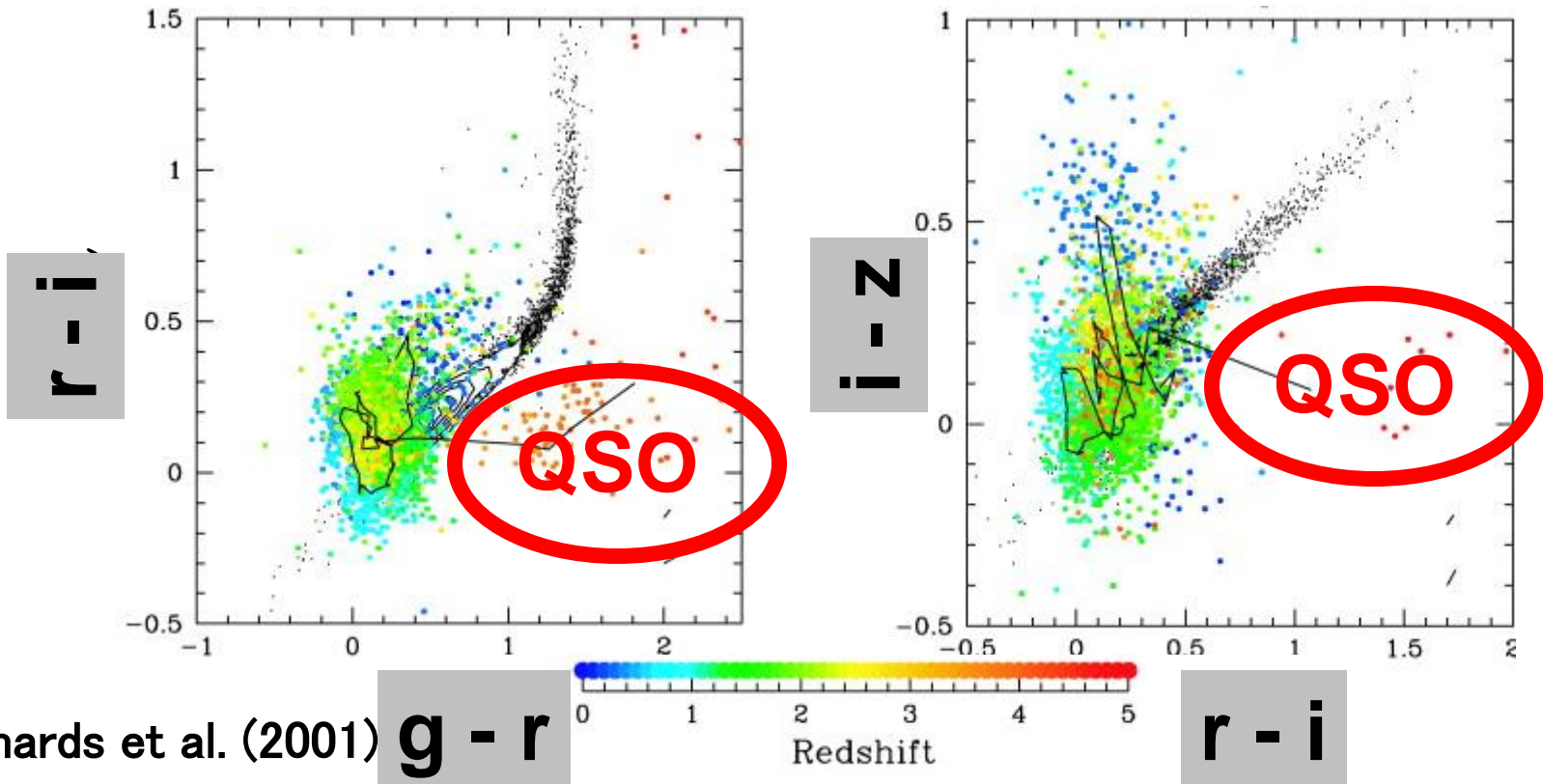


# 3. $z \sim 3-5$ QSO (g,r,i-selection)



**gri :  $z=3.6-4.4$**

**riz :  $z=4.6-5.1$**

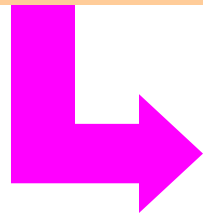


Richards et al. (2001)

# PFS (z=3-5 QSO)

Follow-up spectroscopy of  
HSC z=3-5 QSO candidates

10-1000/deg<sup>2</sup>

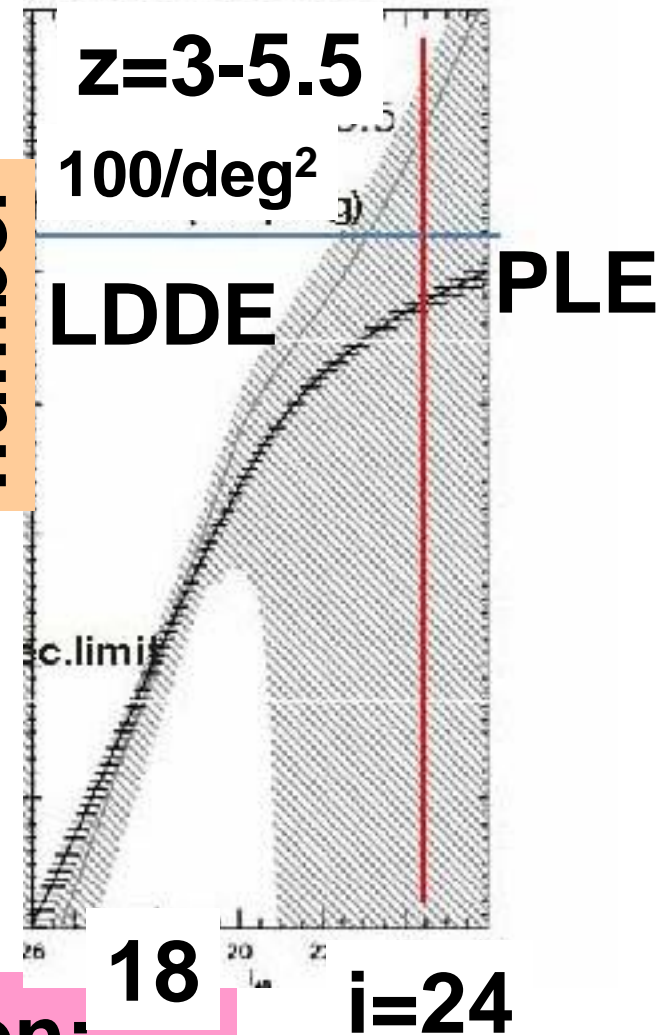


PFS very important

Cover Ly $\alpha$ , CIV(1549A)  
6000 - 9500A

LF, two-point spatial correlation:  
Completely solved with HSC+PFS !

Casey+08



# Summary

- z~7

10 (1000 deg<sup>2</sup>) (a few times candidates?)

9000-10500A

High-sensitivity

Use extra several fibers  
in other galaxy surveys

but see my remark later

- z~6

300 (1000 deg<sup>2</sup>) (a few times candidates?)

8000-9000A

High-sensitivity

Use extra several fibers  
in other galaxy surveys

- z=3-5

10-1000 (1 deg<sup>2</sup>) (<a few times candidates?)

4500-9500A

PFS very important



# PFS operation (personal opinion)

- Red-optimized ( $>6000\text{\AA}$ ) PFS is powerful to  $z=3-5$  QSOs
- $z>6$  QSOs : number density too small

High sensitivity spectrograph at 9000-10500 $\text{\AA}$  better (FOCAS, MOIRCS)

Can be done with PFS, if high sensitivity at 9000-10500 $\text{\AA}$  ?

# Request for PFS operation

(case 1) PFS : soon after HSC survey

If Subaru open use is dominated by PFS SSP,  $z > 6$  QSO spectroscopy will not proceed, and interesting results may be robbed by other telescopes.

SSP must be  $< 25\%$  of Subaru open use

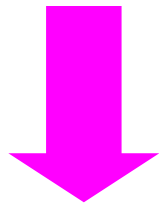
# Request for PFS operation

(case 2) PFS : >3 yr after HSC survey

HSC-selectable  $z \sim 7$  QSO :  $\sim 10 / 1000 \text{deg}^2$

$z \sim 7$  QSOs included in HSC-y-band :

$\sim 35 / 1000 \text{deg}^2$

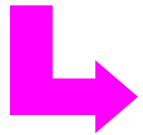


PFS survey (several  $100 \text{deg}^2$ ) of  
y-detected, z-undetected (but  $z-y < 1.5$ ) sources  
may increase the number of  $z \sim 7$  QSO

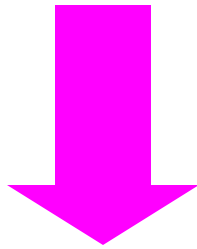
SSP can be  $>25\%$  of Subaru open use

# Request for PFS specification

High sensitivity at  $>9000\text{\AA}$  is an advantage of Subaru (because of Hamamatsu CCD)



Powerful to spectroscopy of  $z>6$  QSO



In any case, PFS should have high sensitivity at  $9000\text{-}10500\text{\AA}$

**End**