A new quasar discovered at redshift 6.6 from Pan-STARRS1

Tang, Goto et al., 2017, MNRAS, 466,4568
Liu, Goto et al. submitted

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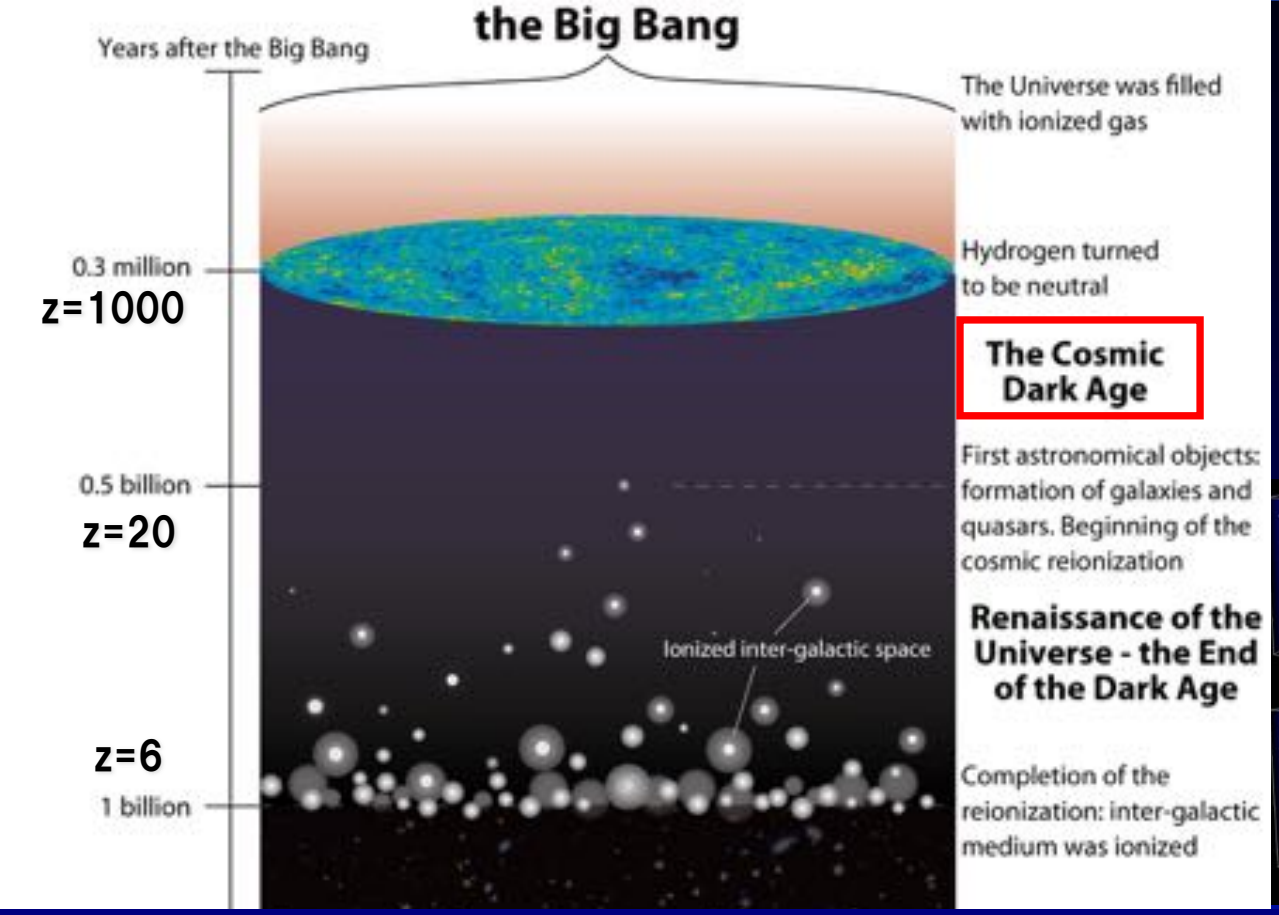
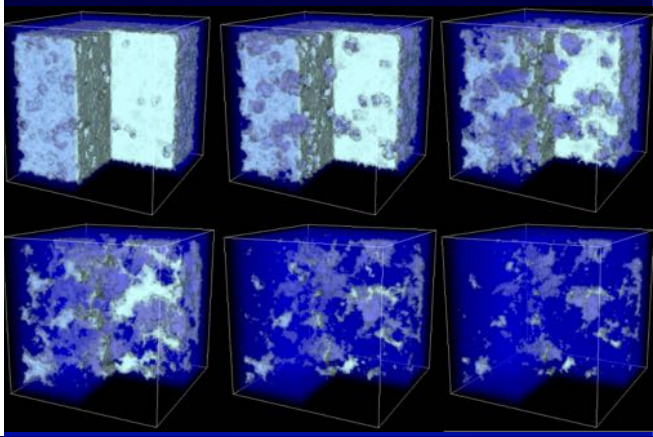
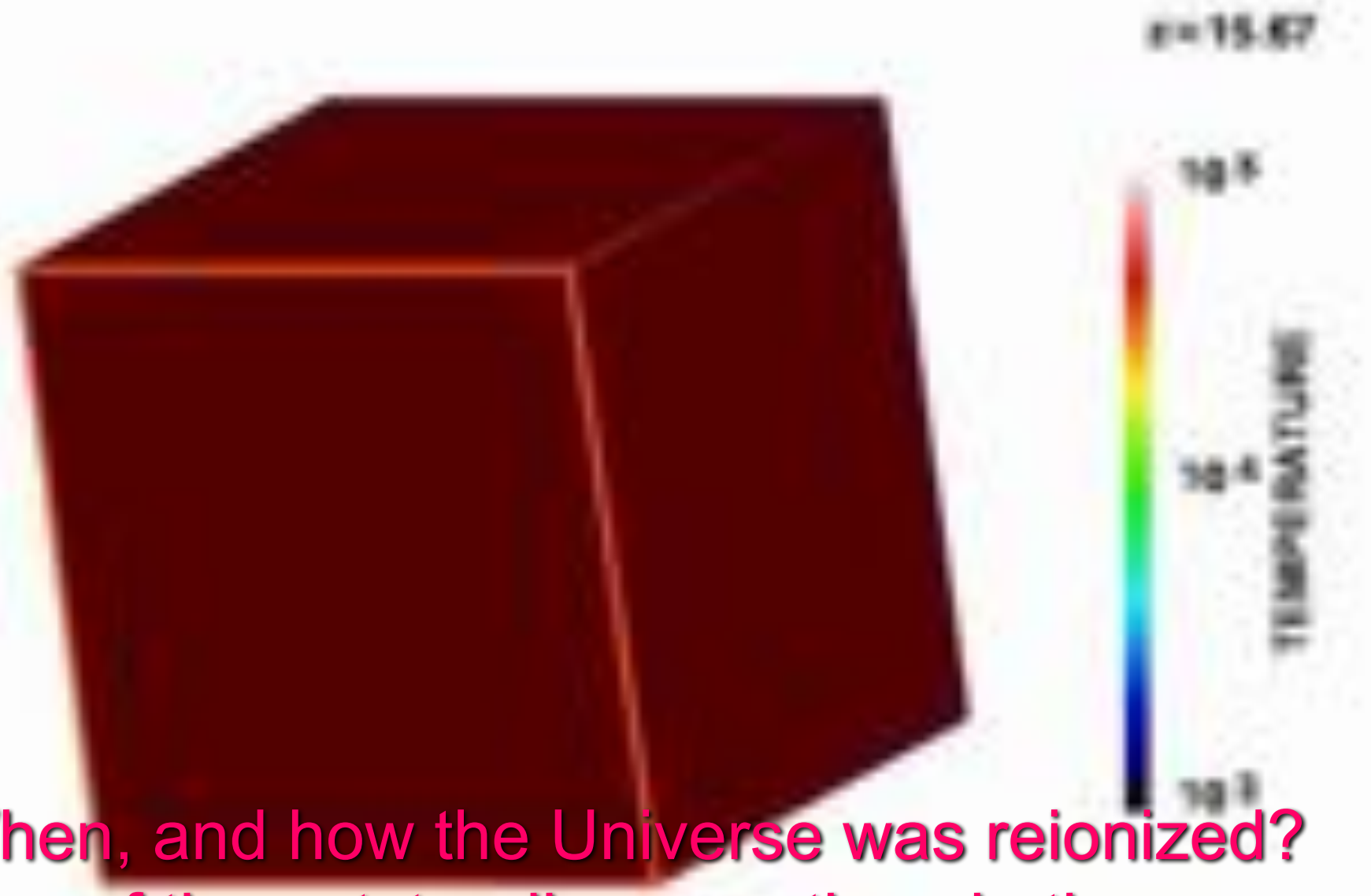
+PS1 team



Cosmic reionization



When, and how the Universe was reionized?
One of the outstanding questions in the observational cosmology.



When, and how the Universe was reionized?
One of the outstanding questions in the observational cosmology.

Gunn-Peterson（1965）test

We need a bright QSO
z～20mag

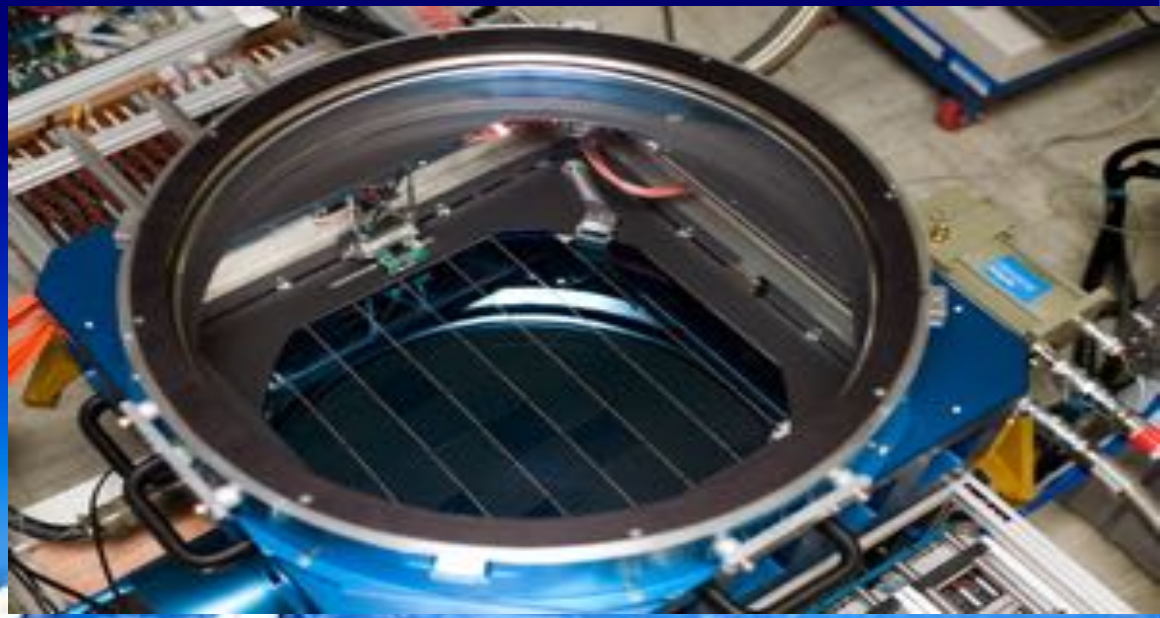
$Flux_{transmitted} = Flux_{original}\ e^{-\tau}$ Galaxy continuum is too faint.

Gunn-Peterson test には明るいQSOが有利

- 20mag vs 25mag
- 明るさの差が100倍!
- 望遠鏡時間にしたら10000倍
- 1発で吸収線テストができる！

明るいQSO→広いサーベイ、PS1

- One 1.8m telescope
- Built on Haleakala（on Maui, Hawaii）



The PS1 3π Survey

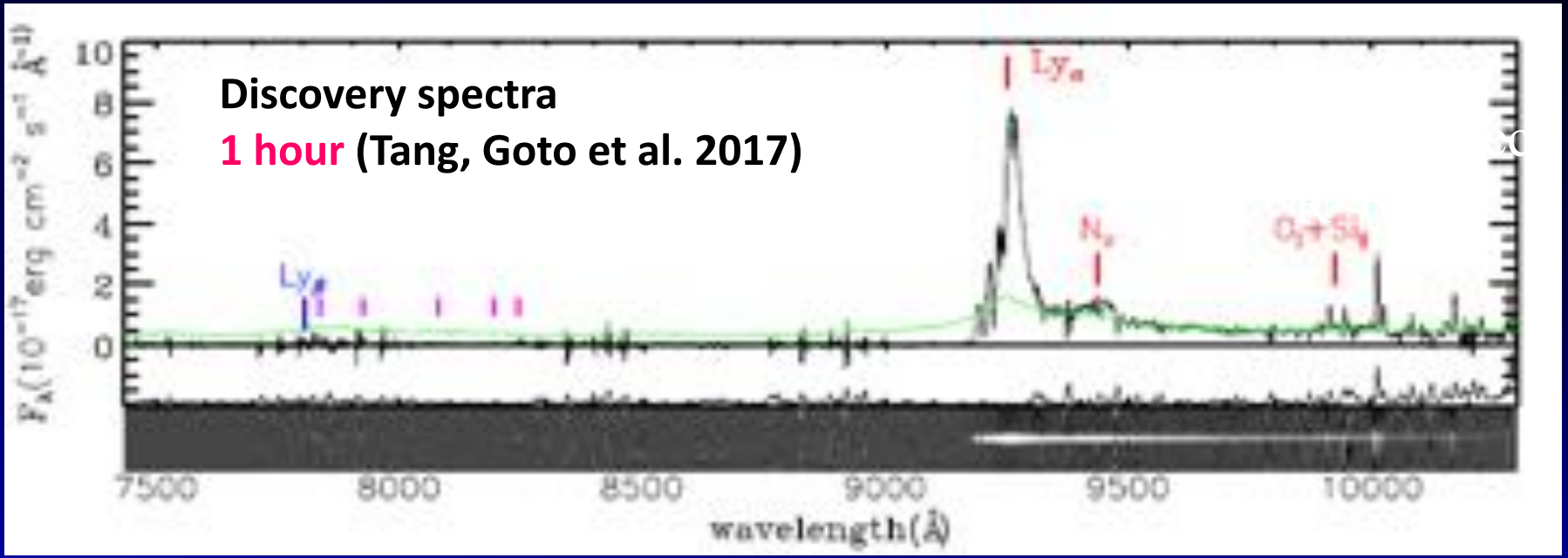
30,000平方度

(c.f. HSC 1400deg^2)

[g r i z y]

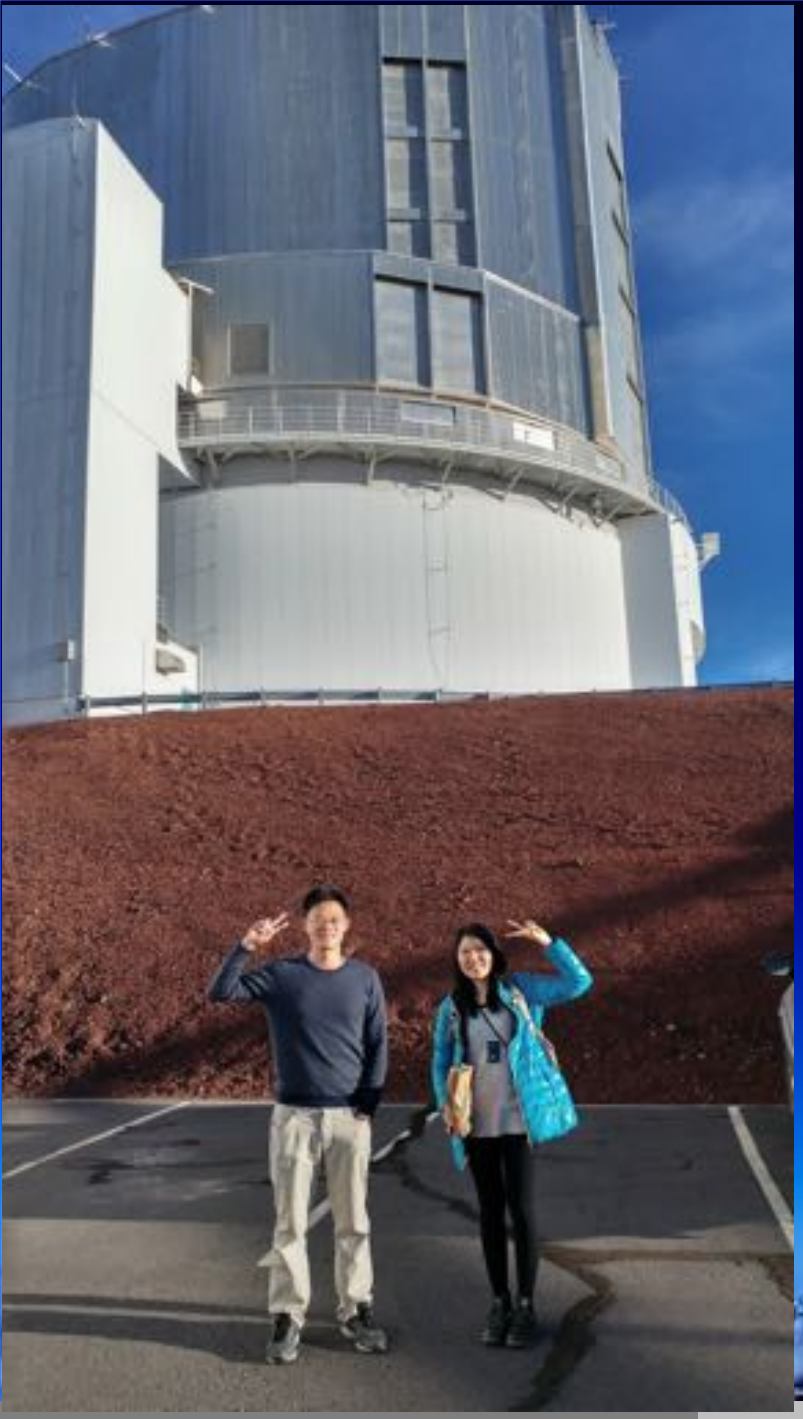
= [23.95, 23.48, 23.42, 22.38, 20.61] 5sigma (AB)

We found a new QSO at z=6.6!



たった一時間もたたずに！？
ば、化け物か

Tang, Goto et al., 2017, MNRAS, 466,4568

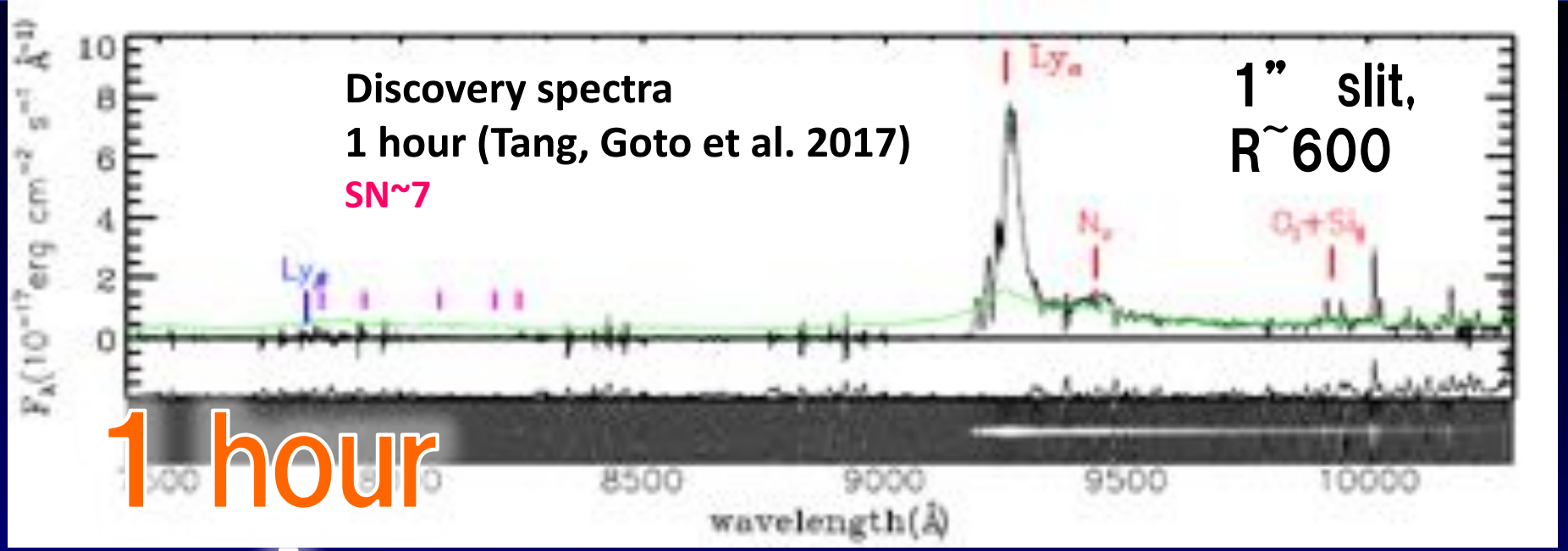


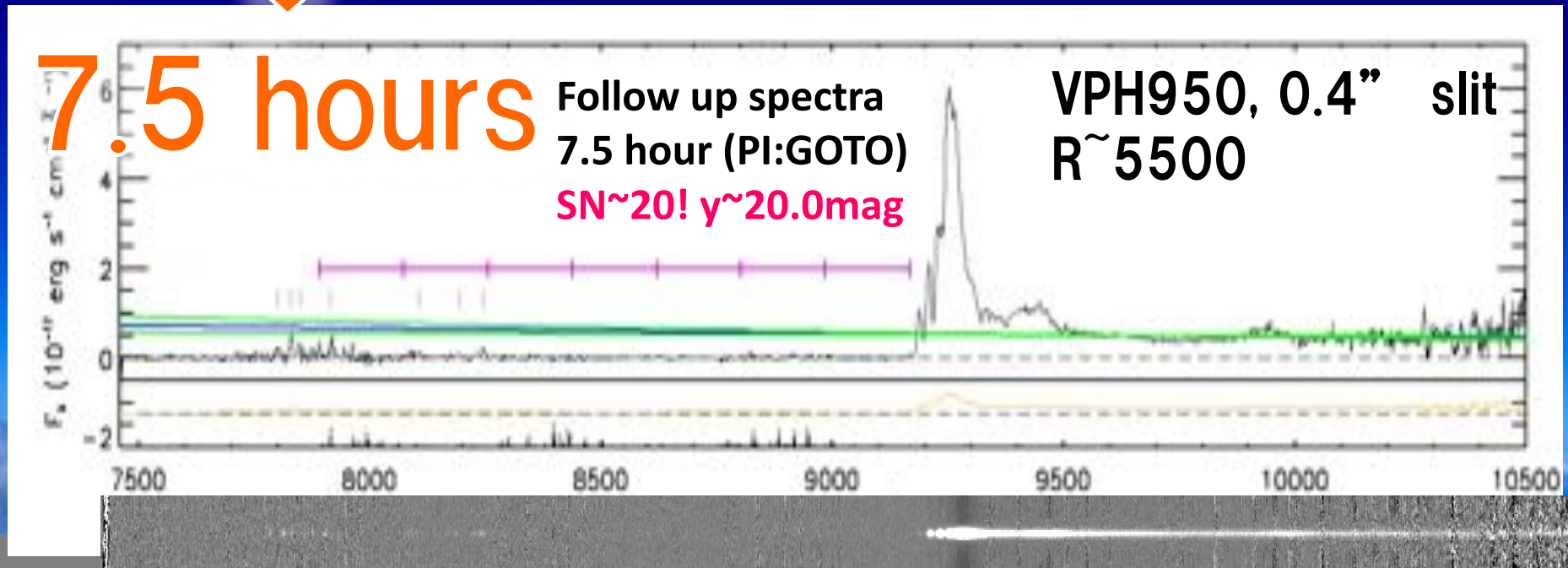
1 hour

↓

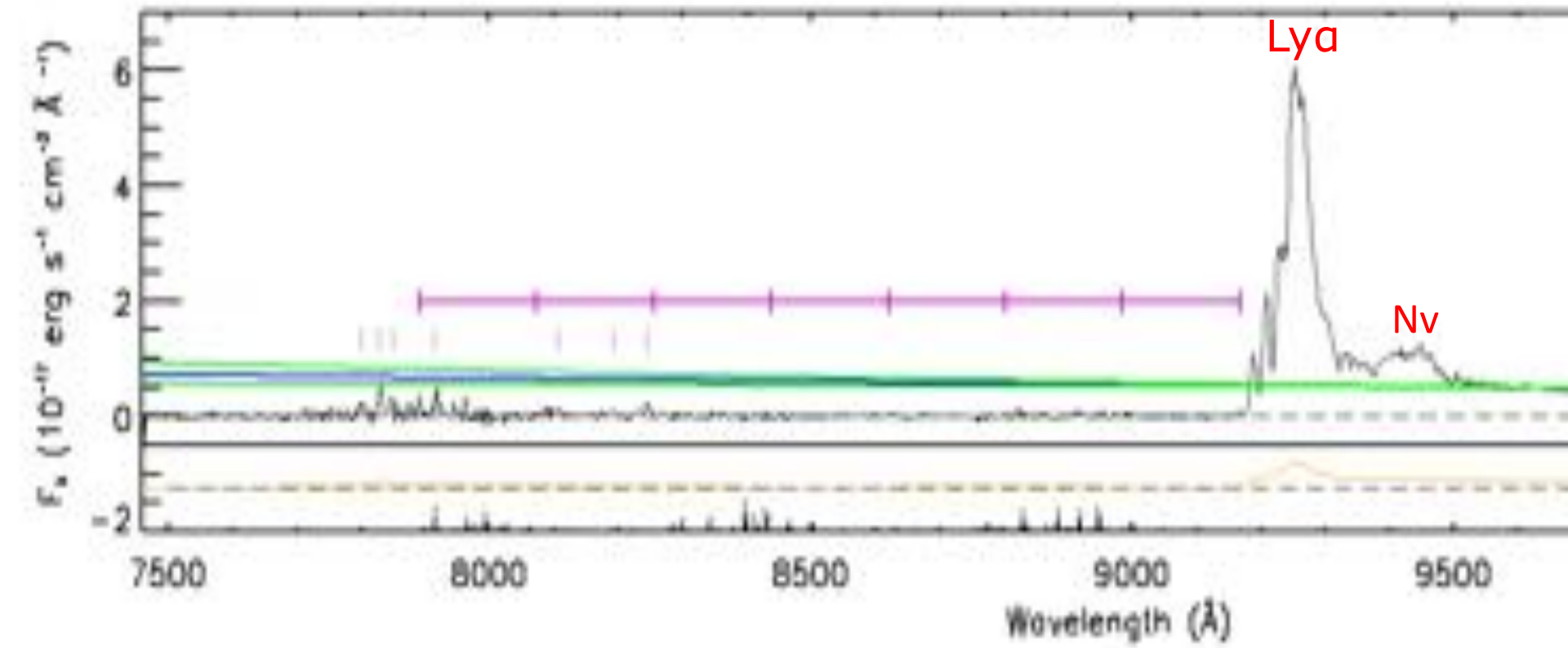
7.5 hours

spectra


Discovery spectra
1 hour (Tang, Goto et al. 2017)
SN~7
1" slit,
R~600
1 hour
wavelength(Å)


7.5 hours
Follow up spectra
7.5 hour (PI:GOTO)
SN~20! y~20.0mag
VPH950, 0.4" slit
R~5500
7500
8000
8500
9000
9500
10000
10500

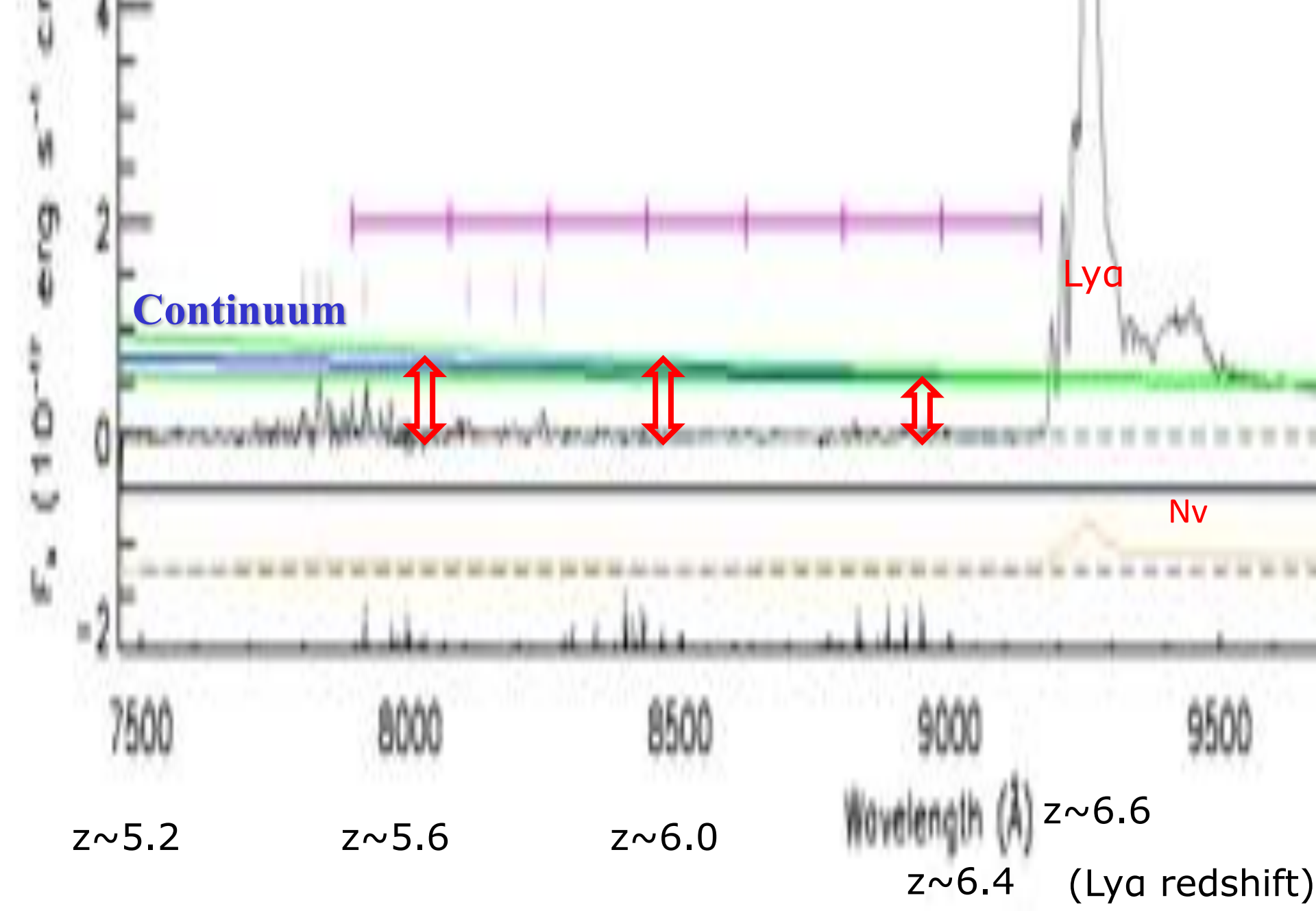
Advantage of y～20mag
SN ～20 Å^{-1} (7.5hrs)



Spectrum: Later we will preform 3 methods to probe the phase evolution with the spectrum

これから
三つの
テストをします

Gunn-Peterson test

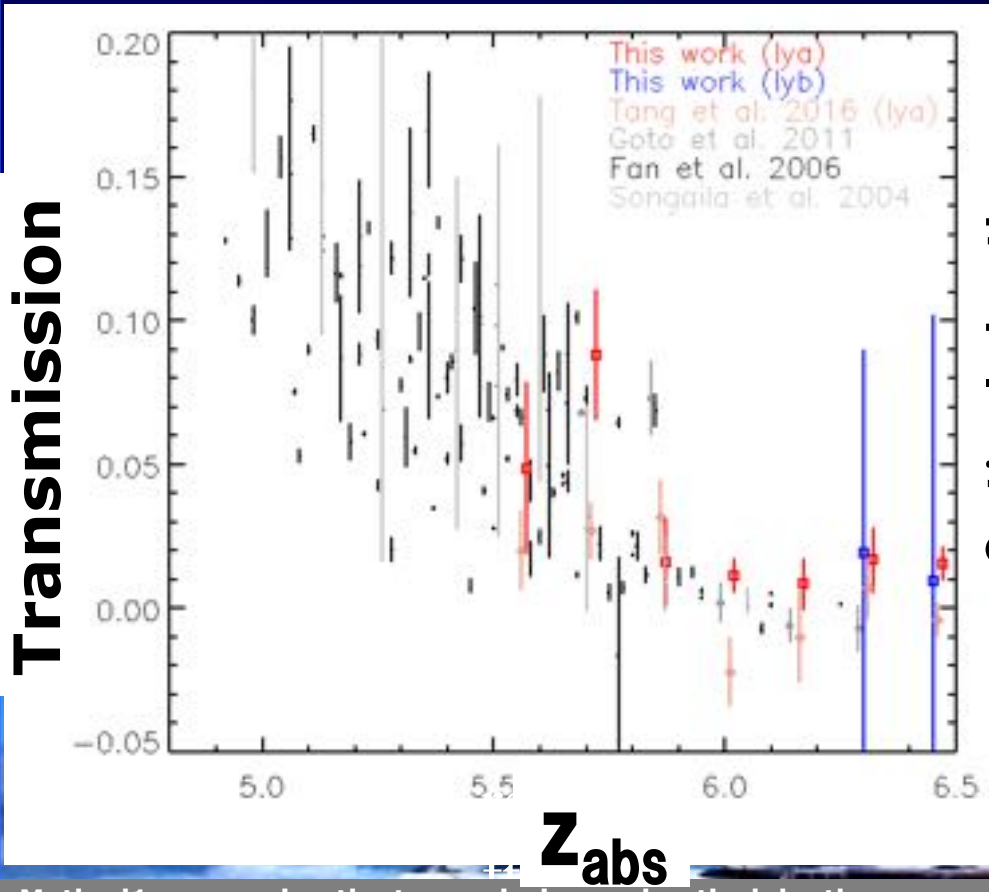


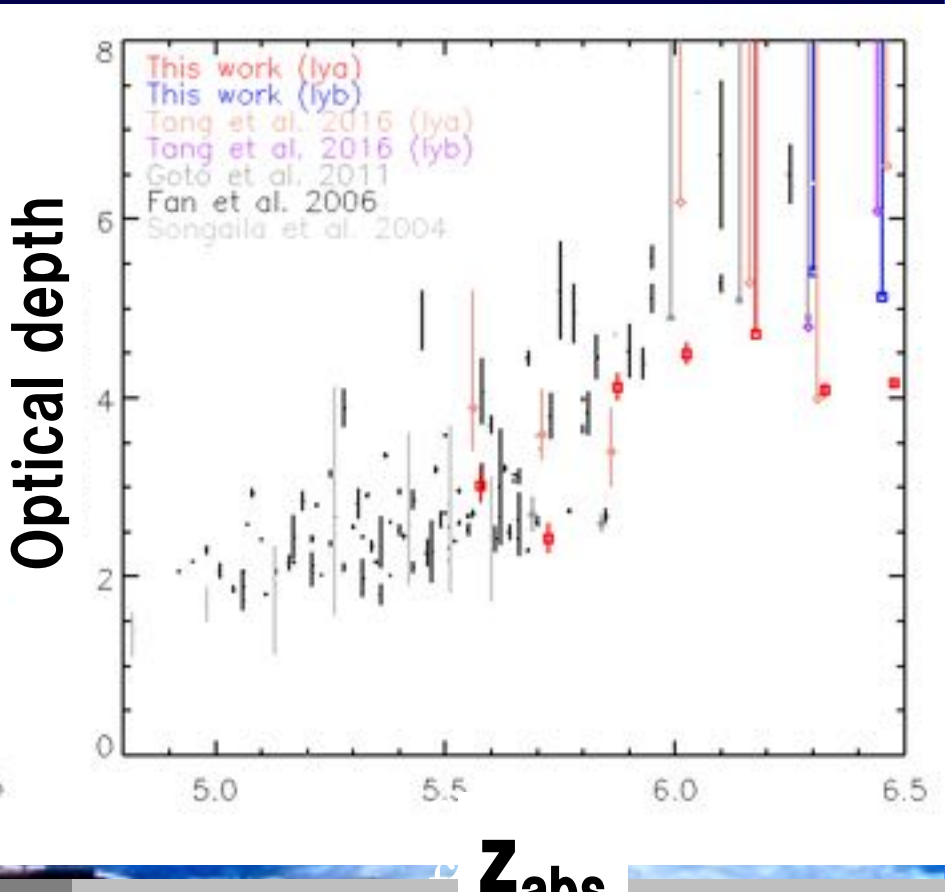
z~5.2 z~5.6 z~6.0 z~6.4 z~6.6 (Lyα redshift)

Spectrum: Later we will preform 3 methods to probe the phase evolution with the spectrum

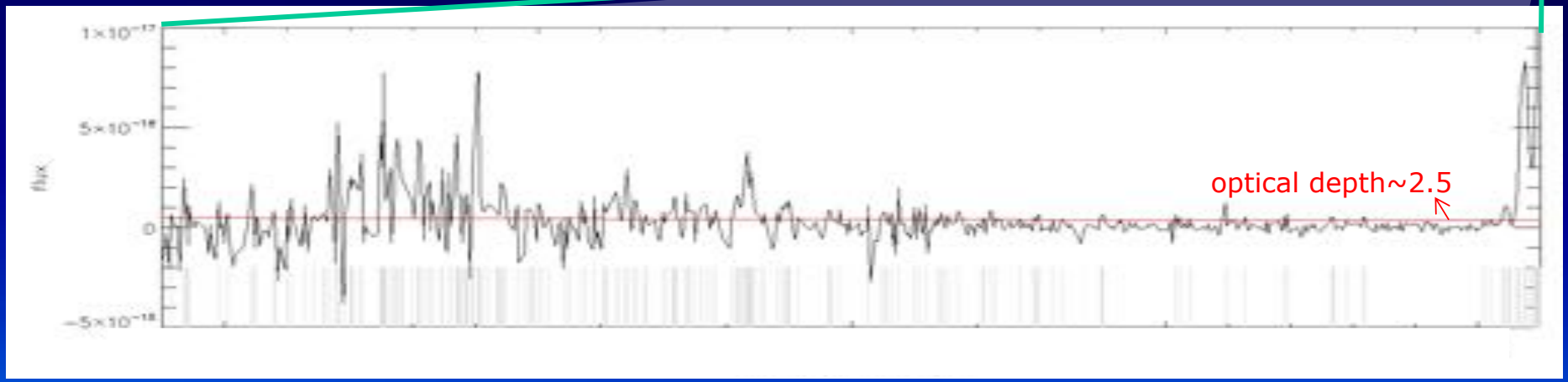
1. Transmission & Optical depth

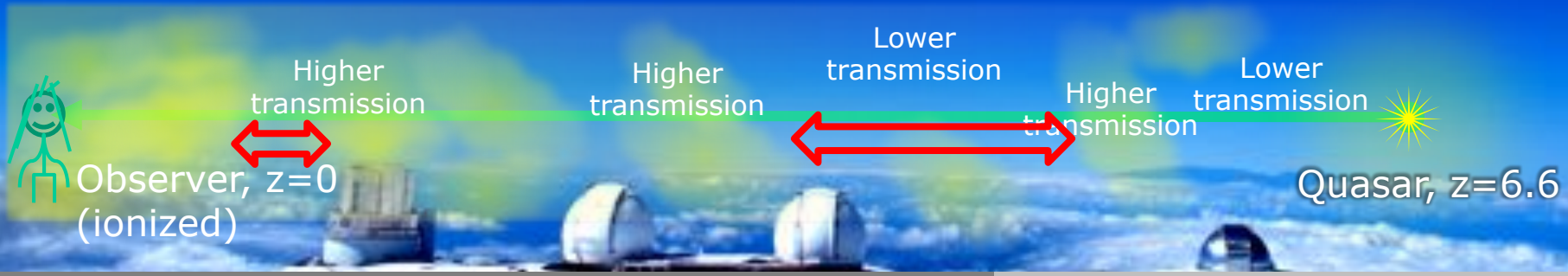
Transmission: $\mathcal{T} = \left\langle \frac{Flux_{obs}}{Flux_{int}} \right\rangle$ **Optical depth:** $\tau = -\ln \mathcal{T}$





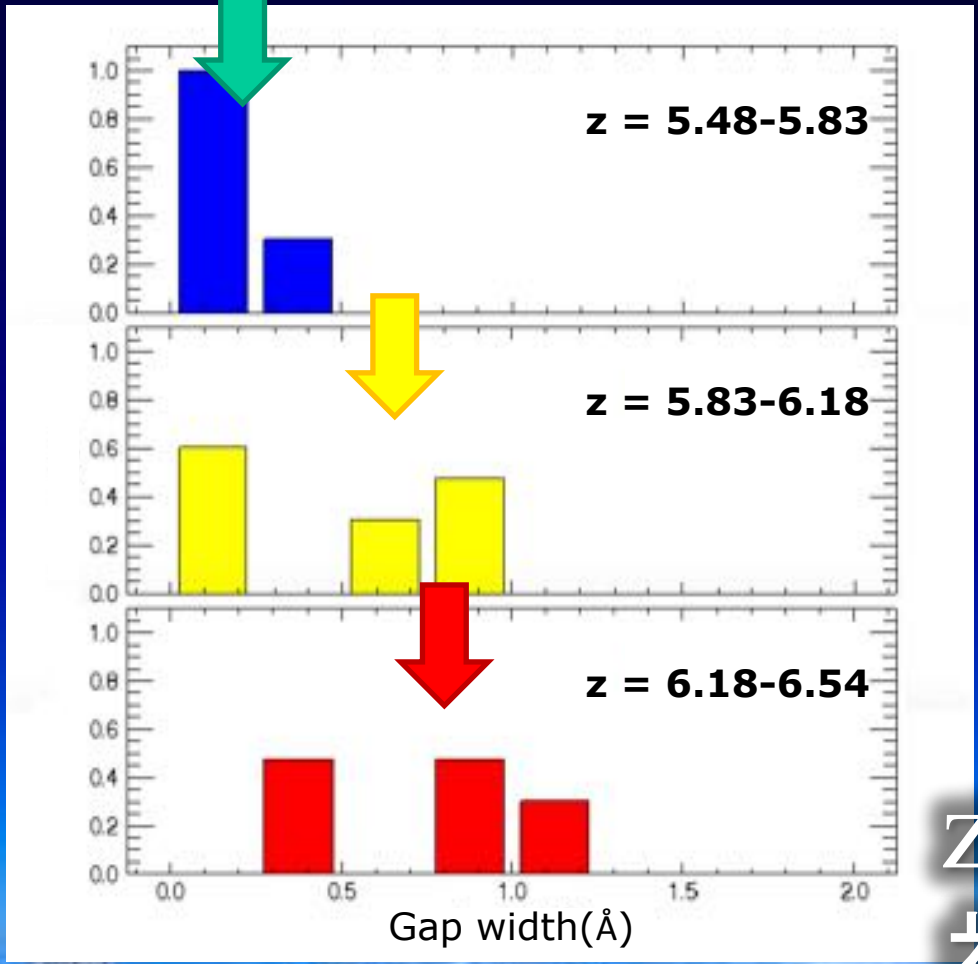
2. Dark gaps statistics





Method2: counting the gap span by two adjacent peaks

2. Dark gaps statistics



median of the gap width

0.20Å

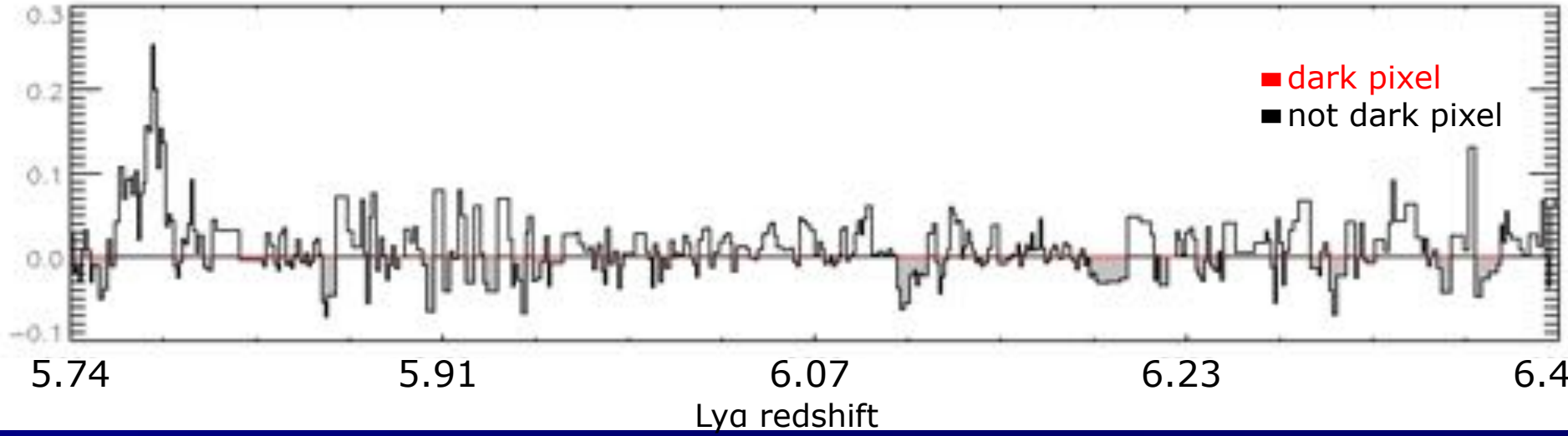
0.66Å

0.80Å

z>6.1 では初めて

Method2: The gaps size(neutral region) is larger at higher redshift

3. The dark pixel fraction

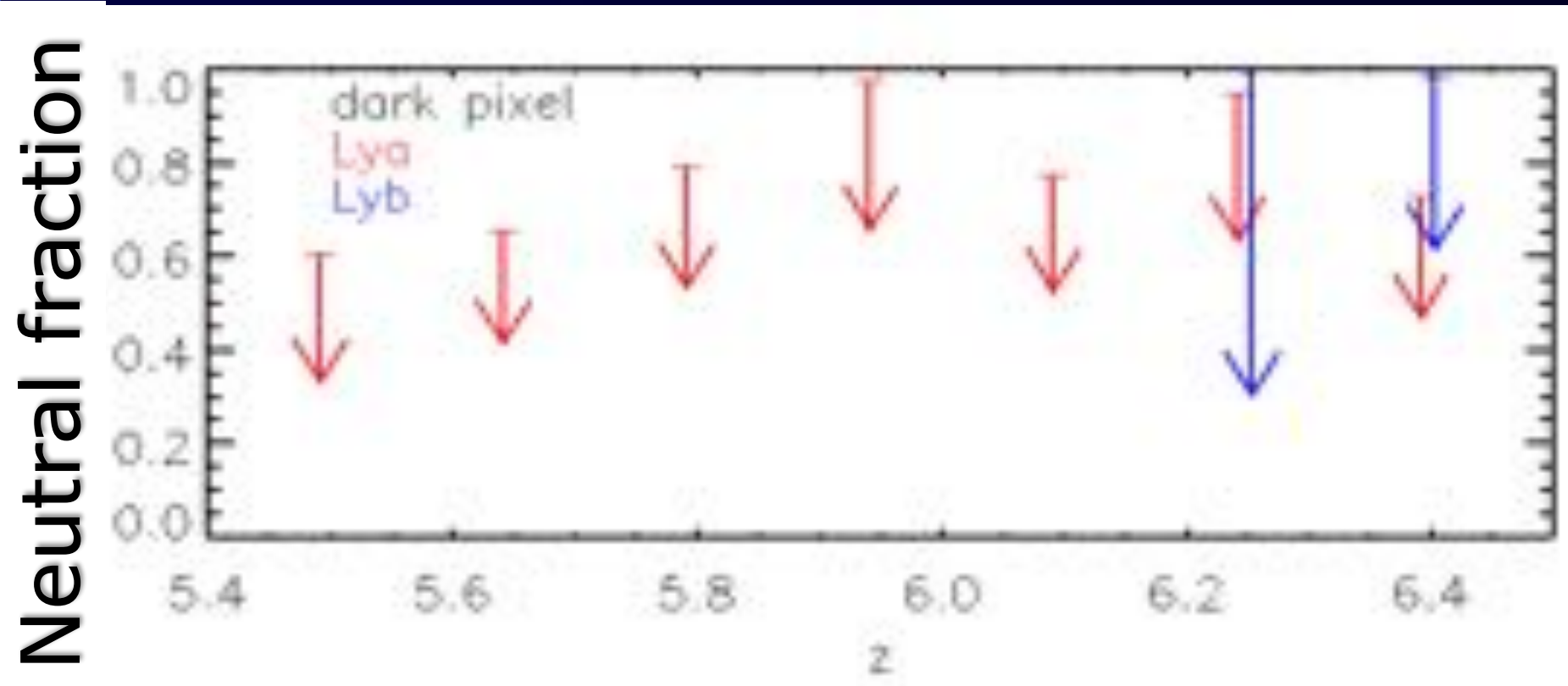


Dark fraction
(neutral)

$$= \frac{\text{number of the pixel without detected flux}}{\text{total pixels in the spectrum}}$$

ポイント：No need to assume the intrinsic flux!

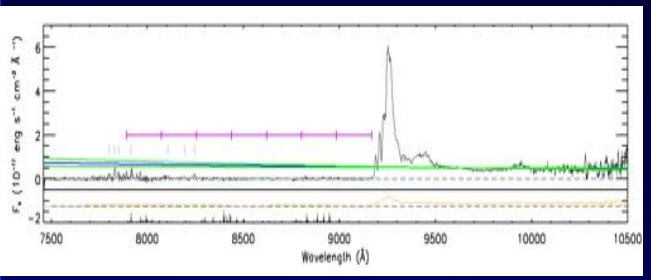
3. The dark pixel fraction



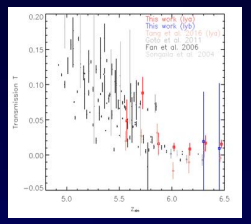
z>6.1 では初めて

Method3: dark fraction = upper limit of the neutral fraction

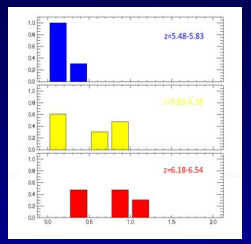
Three abs. tests up to z~6.6



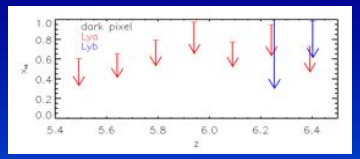
We found a bright QSO at z=6.6



1.Transmission:
flux~0 at z>6 even with our high-quality spectrum.



2. Dark gap distribution:
A jump of gap width at 5.8<z<6.2



3. Dark pixel fraction:

Extended the measurements from z~6.1(literature) to z~6.5(this work).

Many thanks for your attention!