Cosmic Shadow 2018 in Ishigaki

Closing Remarks by Yoshi Taniguchi (The Open University of Japan)

24 - 25, November 2018
Oohama Nobumoto Museum

クエーサー吸収線系研究会の歴史

箱根・強羅 in 2007

北海道・長万部 in 2008

長崎・雲仙 in 2009

信州・松本 in 2011

柏川、三澤、辻本、大越らが立ち上げた

クエーサー吸収線系の研究

大口径望遠鏡と超高分散分光

→ クエーサー吸収線系の研究は

富裕層のみができる

パロマー・ケックを運用して来た

カリフォルニアの研究者らが牽引

(e.g., Wolfe et al. 2005, ARAA, 43, 861)

日本における観測的な
クエーサー吸収線系研究の歴史

すばる望遠鏡が動き出した（2000年）

Subaru Deep Field などの深宇宙探査がひと段落

そしてクエーサー吸収線系の観測が始まった

(e.g., Kashikawa et al. 2014, ApJ, 780, 116)

日本における理論的なクエーサー吸収線系研究の歴史

Mini Halo Model for Lyα Forests

Murakami & Ikeuchi 1990, PASJ, 42, L11
Murakami & Ikeuchi 1993, ApJ, 409, 42
Murakami & Ikeuchi 1994, ApJ, 420, 68
Murakami & Ikeuchi 1994, ApJ, 421, L79

Superwind Model for DLAs

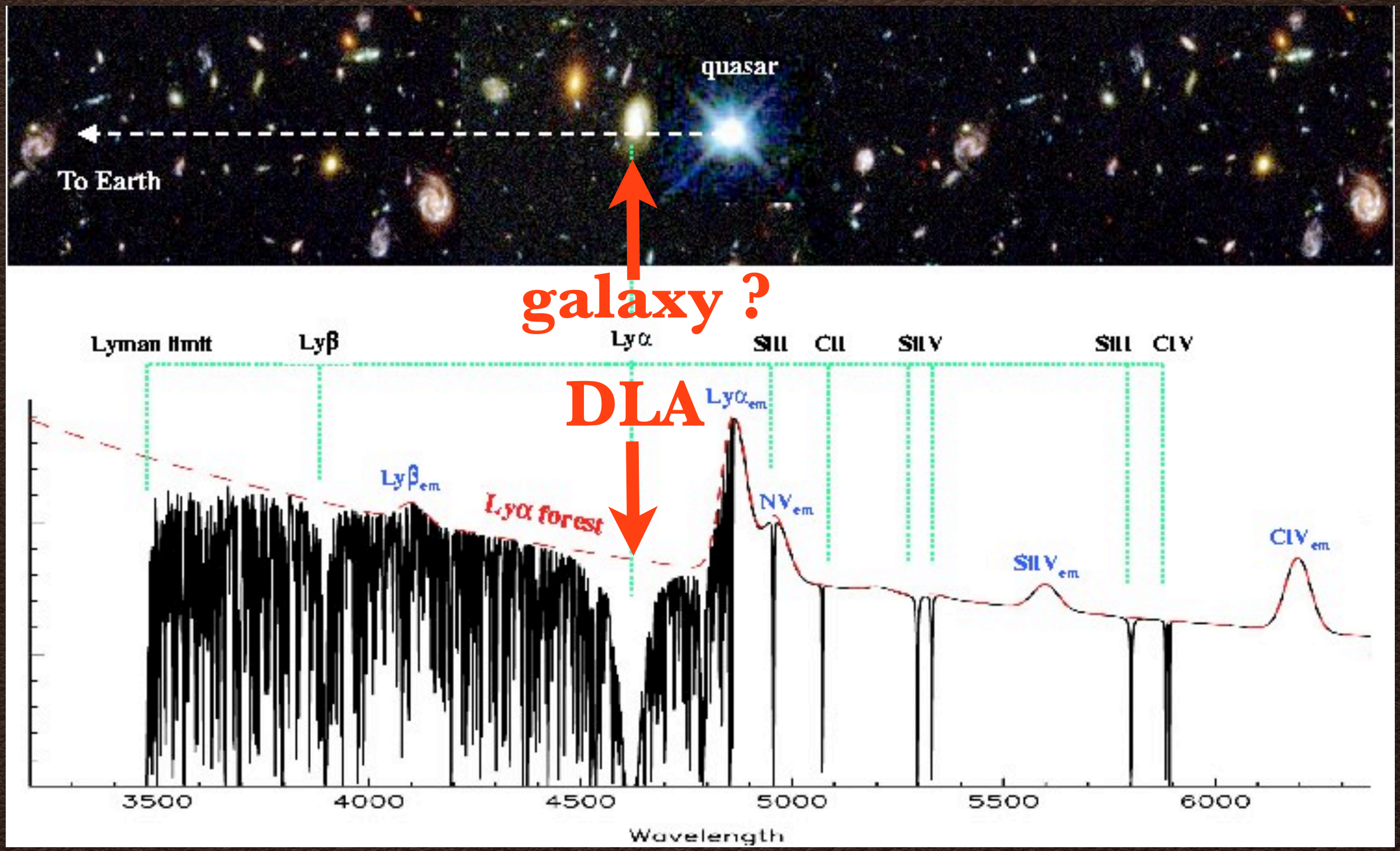
Taniguchi & Shioya 2000, ApJ, 523, L13
Taniguchi & Shioya 2001, ApJ, 547, 146

Superwind Model for DLAs

Yoshi Taniguchi

The Open University of Japan

HI Absorption-line systems in the Universe



(http://enki.phyast.pitt.edu/qso_abs.html)

HI Absorption-line systems in the Universe

Damped Lyα Absorption System:
DLA — N(HI) > 2 x 10^{20} cm^{-2}

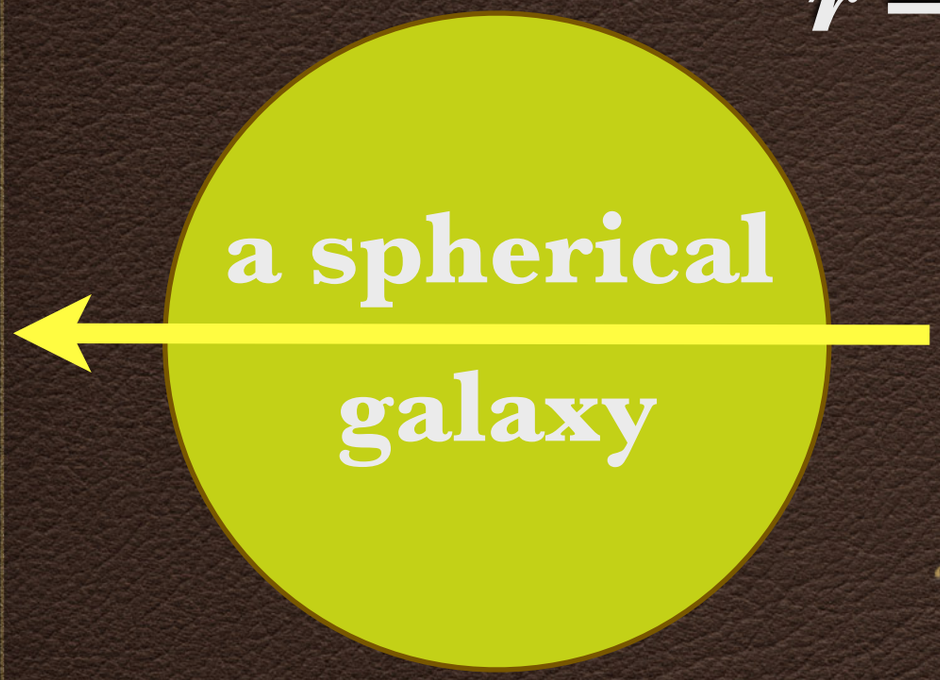
Lyman Limit Absorption System:
LLS — N(HI) ~ 10^{19} cm^{-2}

Lyα Forests: N(HI) < 10^{17} cm^{-2}

(e.g., Wolfe+06, ARAA, 43, 861)

What are DLAs ?

Lesson



r = 5 kpc & M(HI) = 10^9 M_{sun}

$V \sim 2 \times 10^{67}$ cm^3

$\mathfrak{N}$(HI) = M(HI) / m_p
$\sim 1 \times 10^{66}$ atoms

n(HI) = $\mathfrak{N}$ (HI) / V
$\sim$ 0.05 cm^{-3}

N(HI) = n(HI) x 2 r
$\sim 3 \times 10^{21}$ cm^{-2}

Oh, DLAs must be galaxies !

Predictions of galaxy models for DLAs

1. Impact parameters should be less than several kpc

2. We could easily identify a galaxy as a counterpart

However .....

Observational properties of DLAs are far from the predictions

1. Impact parameters are large up to several 100 kpc

2. Detection rate of counterparts is only 10 %

(e.g., Wolfe+06, ARAA, 43, 861)

Something wrong !

Another option

Intergalactic Shock Waves

(Chernomordik & Ozernoi 1983, Nature, 303, 153)

Motivated by OCI models for the formation of large scale structures

(Ostriker & Cowie 81, ApJ, 243, L127; Ikeuchi 81, PASJ, 33, 211)

~10^{60} ergs explosions in early Universe made the observed LSSs

But, now we accept ΛCDM origin of LSSs

One more option

Superwind Model for DLAs

(Taniguchi & Shioya, 00, ApJ, 532, L13 [TS00]; 01, ApJ, 547, 146 [TS01])

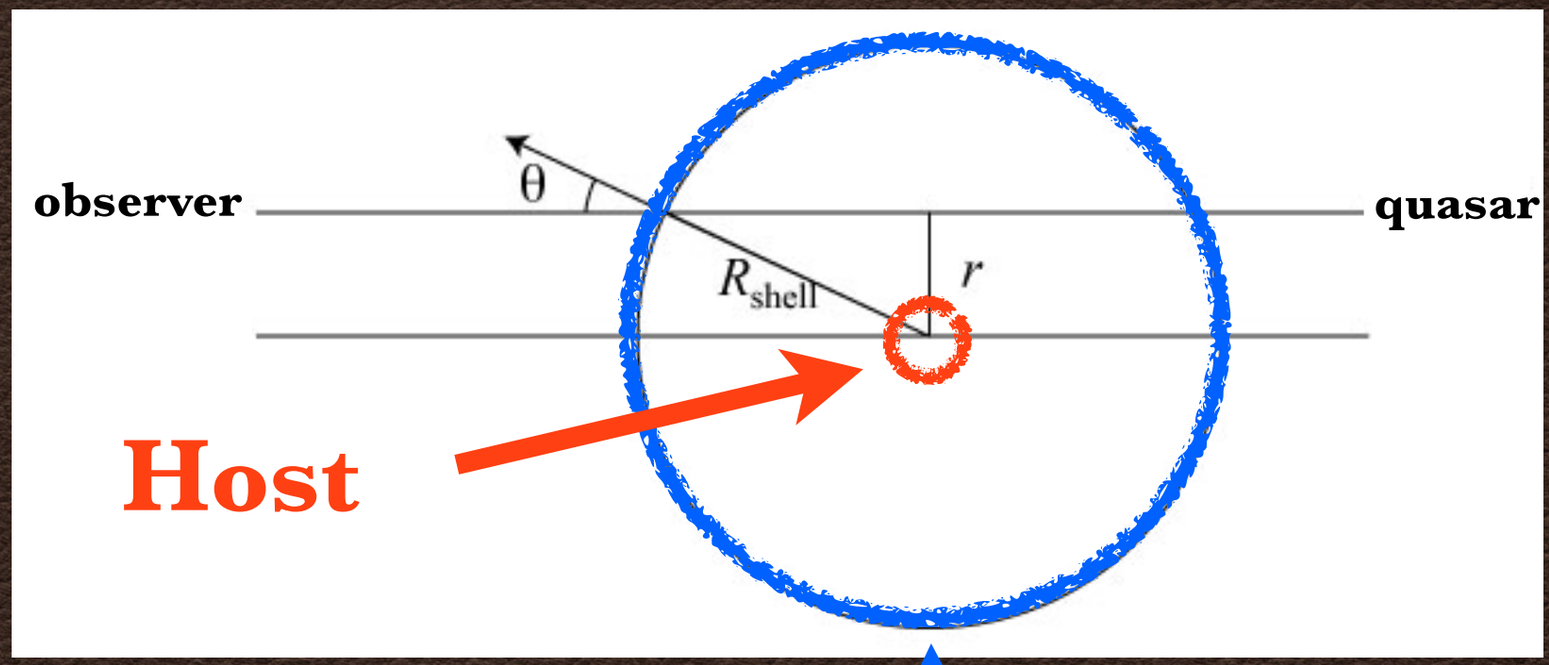
Originally, proposed to explain

1. Origin of **Lyα blobs** (TS00)
2. Origin of **chain galaxies** (TS01)

But, also explains origin of DLAs

Superwind Model for DLAs

(Taniguchi & Shioya, 00, ApJ, 532, L13 [TS00]; 01, ApJ, 547, 146 [TS01])



shocked cool shell
formed by a superwind

Properties of shocked cool shell - 1

(Taniguchi & Shioya, 00, ApJ, 532, L13 [TS00]; 01, ApJ, 547, 146 [TS01])

Initial starburst in L^* galaxy at z=5
➔ Superwind causes shocked shell

T_{shell} =2.1 Gyr (z_{shell} = 1.6) ⟵ cooling time
R_{shell} = 160 kpc (large impact parameter)

$N(HI)_{shell} = 1.5 \times 10^{20}$ cm^{-2} (good for DLAs)

$Z_{shell} = 4 \times 10^{-4}$ (note that $Z_{IGM} = 2 \times 10^{-4}$)

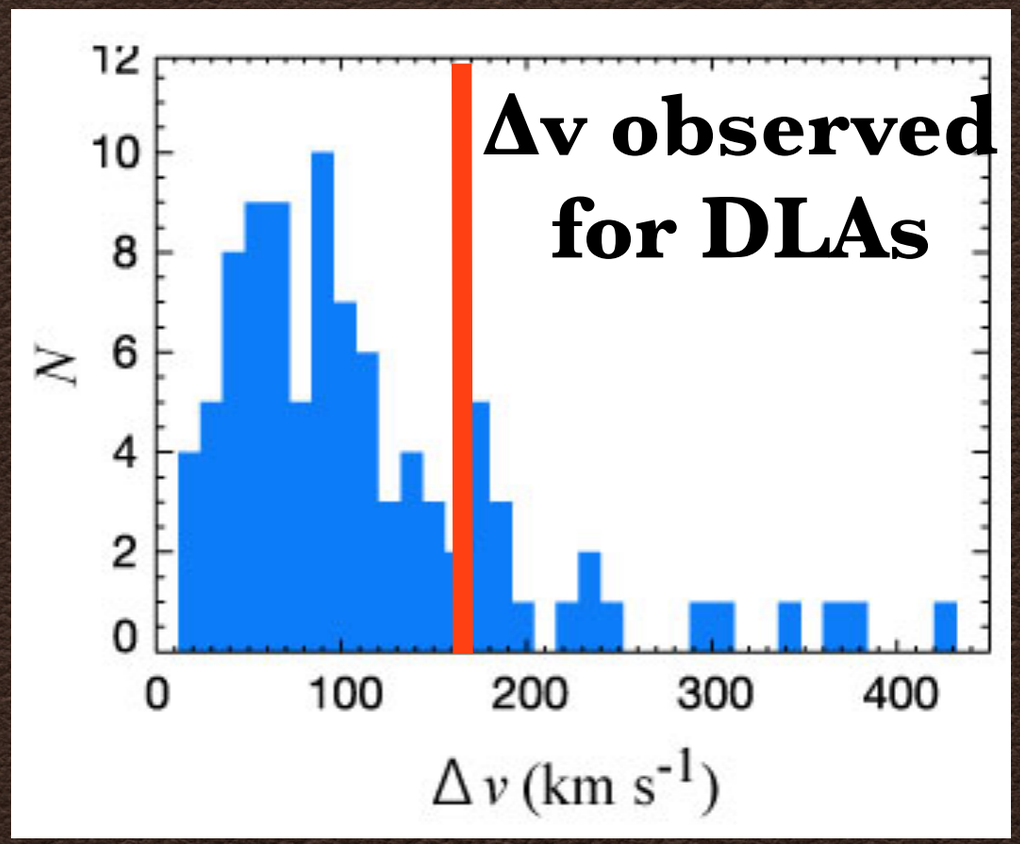
Chemical abundance pattern:
Type II SNe driven
~ consistent with that in DLAs

(a flat universe with Ω_m=0.3, Ω_Λ=0.7, & h = 0.7)

Properties of shocked cool shell - 2

(Taniguchi & Shioya, 00, ApJ, 532, L13 [TS00]; 01, ApJ, 547, 146 [TS01])

Shell width: $\Delta R_{shell} \sim 24$ kpc
Velocity dispersion: $\Delta v_{shell} \sim 160$ km s^{-1}



(Wolfe+06, ARAA, 43, 861)

Predictions of Superwind Model for DLAs

(Taniguchi & Shioya, 00, ApJ, 532, L13 [TS00]; 01, ApJ, 547, 146 [TS01])

1. *N*(HI) is okay
2. Large impact parameters
   Also, explains small values
3. Metallicty is consistent
4. Abundance pattern is consistent
5. Velocity dispersion is consistent

&

Since host galaxies evolved passively, they are too faint to be detected. *R*~28

Everything is fine !!!

Let's go to DLAs with ALMA

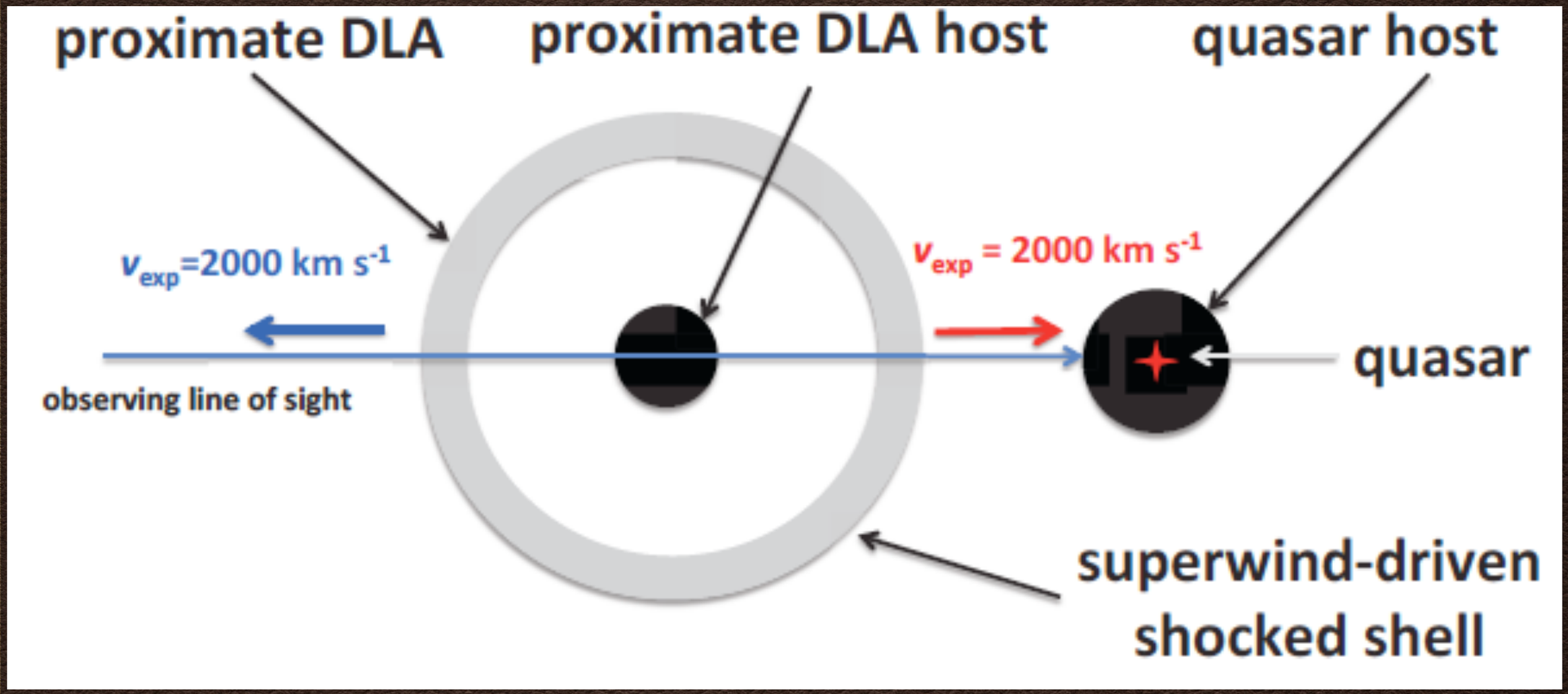
Ideal case for SHOCKED SHELL

[CII] mapping of proximate DLA of SDSS J124020.91+145535.6 @ $z = 3.1$

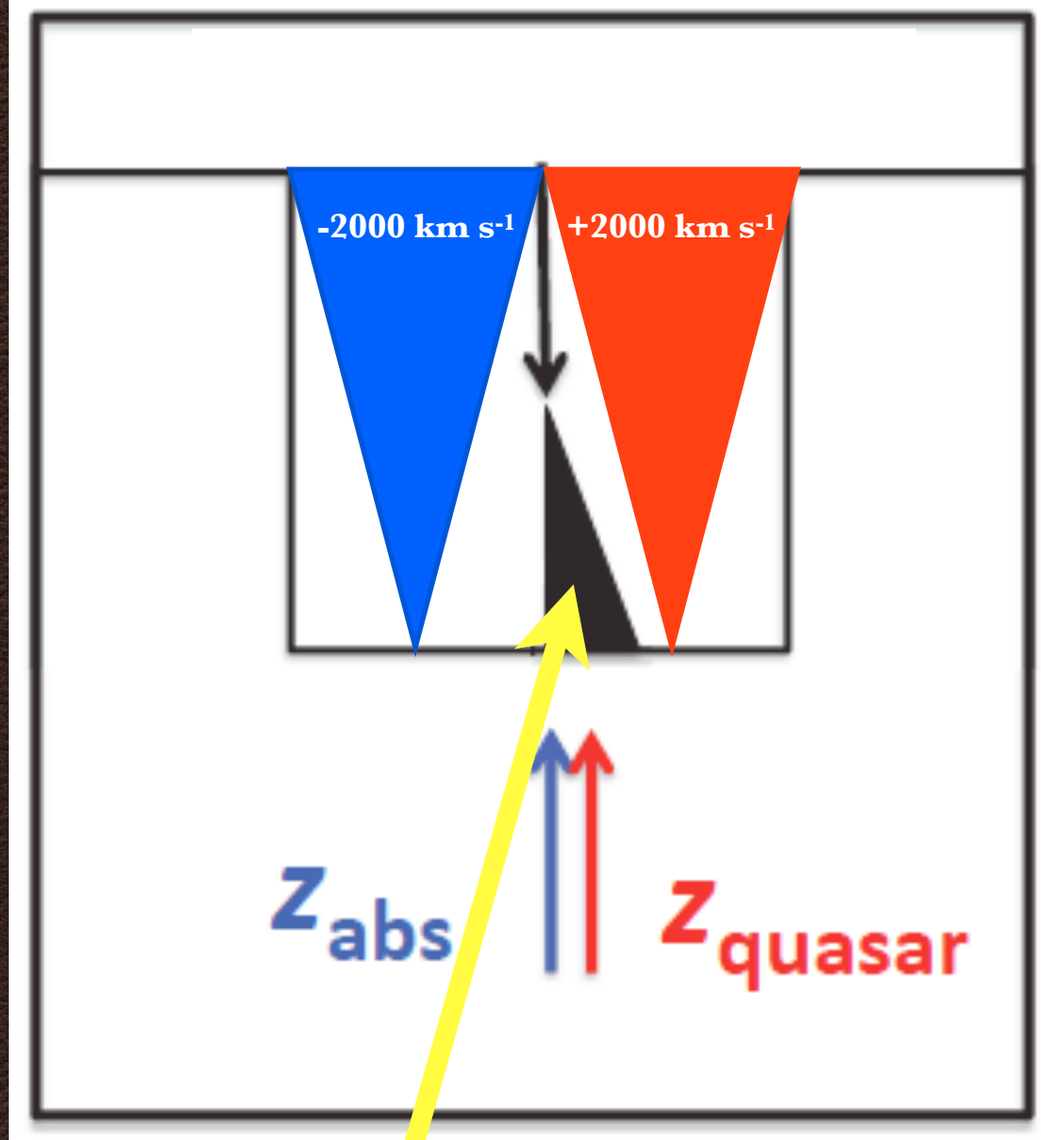
YOSHIAKI TANIGUCHI 2013.1.00227.S

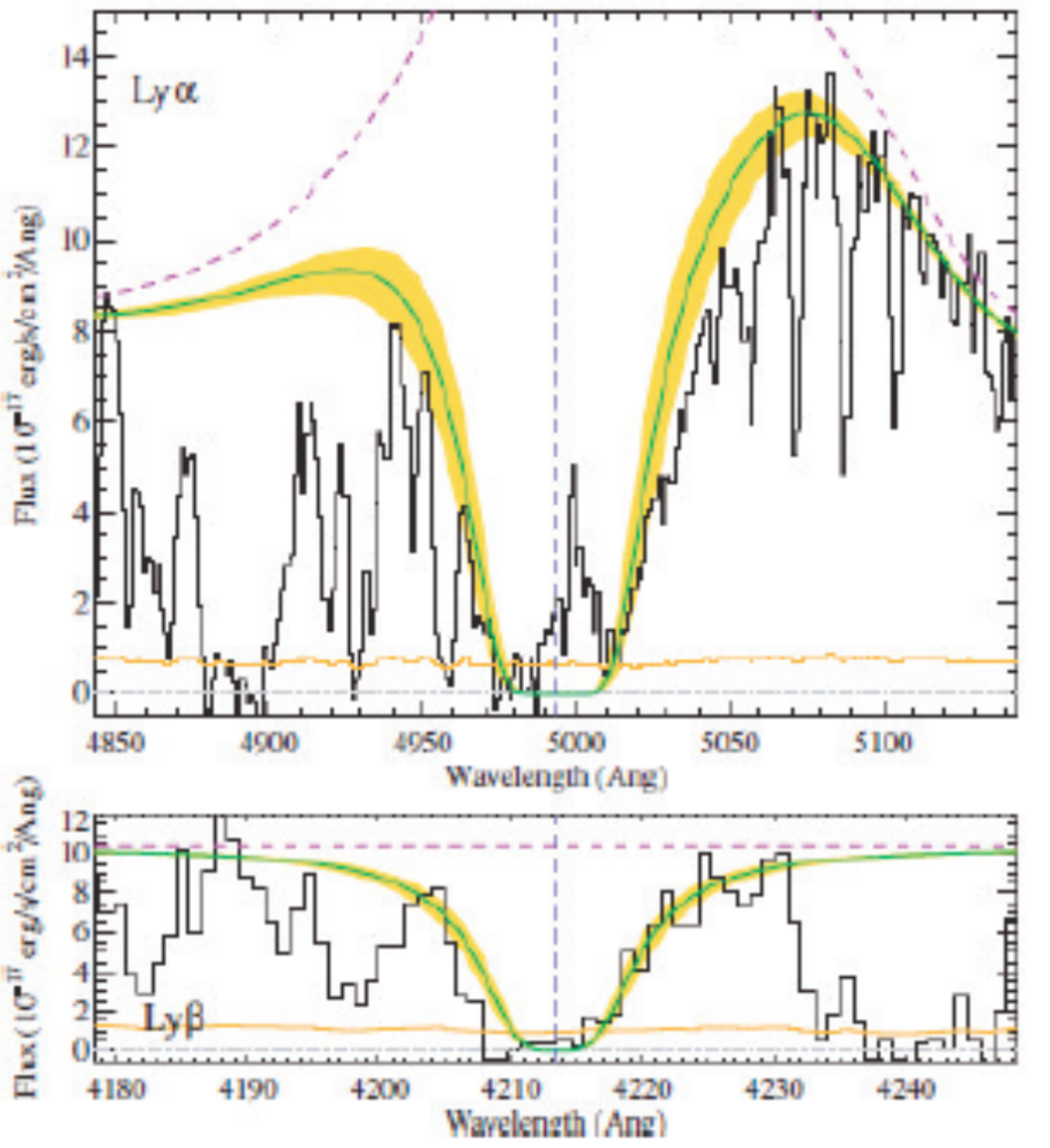
PROJECT TITLE:	ALMA Detection of a Superwind-Driven Shocked Shell Associated with the Proximate DLA of SDSS J124020.91+145535.6 at z=3.1				
PRINCIPAL INVESTIGATOR NAME:	Yoshiaki Taniguchi	PROJECT CODE:	2013.1.00227.S		
SCIENCE CATEGORY:	Cosmology and the High Redshift Universe	ESTIMATED 12M TIME:	1.4 h	ESTIMATED ACA TIME:	5.6 h
CO-PI NAME(S): (Large Proposals only)					
CO-INVESTIGATOR NAME(S):	Yuichi Matsuda; Nobunari Kashikawa; Tohru Nagao; Masaru Kajisawa; Masakazu Kobayashi; Yasuhiro Shioya; Katsuhiro Murata; Kartik Sheth				
EXECUTIVE SHARES[%]:	NA : EU : EA : CL : OTHER :	0 0 100 0 0	STUDENT PROJECT? (Yes/No)	No	
			RESUBMISSION? (Yes/No)	No	

Proximate DLA of SDSS J124020.91+145535.6 @ $z = 3.1$



Superwind model for Proximate DLA of SDSS J124020.91+145535.6 @ $z = 3.1$

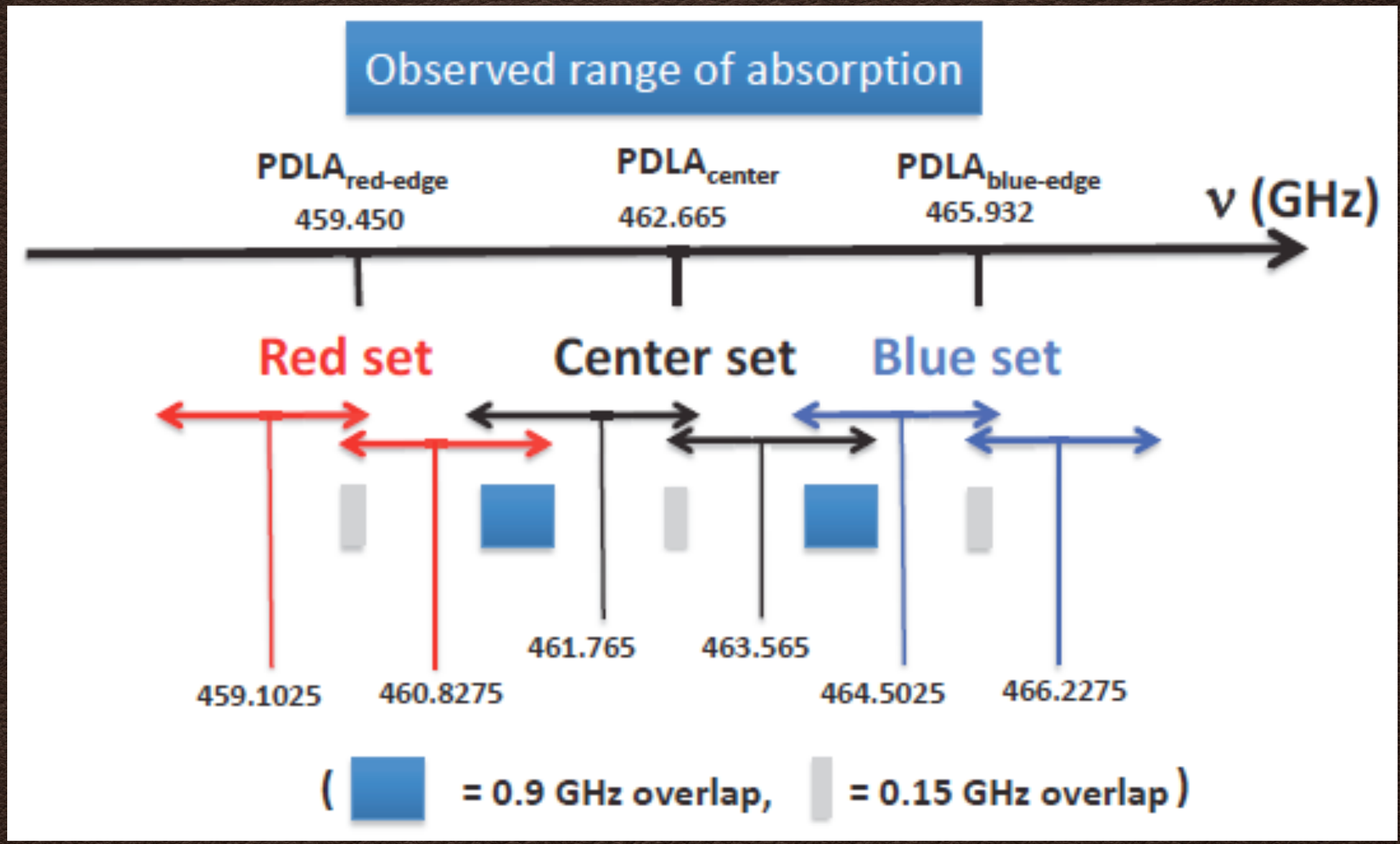




Not Lyα emission
but undamped part of continuum

(Hennami+ 09, ApJ, 693, L49)

Observational Strategy



We will see
a fantastic firework
at high redshift

But, this program was not completed
because of poor observing conditions @ Band 8.
So, next time !

クエーサー吸収線系研究会の歴史

箱根・強羅 in 2007

北海道・長万部 in 2008

長崎・雲仙 in 2009

信州・松本 in 2011

吸収線系に特化した研究会だった

しかし、・・・

Cosmic Shadow 2018 in Ishigaki

1. Galaxy Evolution, environment, & QALs
2. GRB, Cosmic Reionization, & QALs
3. H I & QAL Observations with SKA
4. Quasar/AGN, Outflow, & QALs
5. Galactic Objects, ISM, & QALs

大きな拡がりを見せた！

今後の発展に期待しましょう！