

# The Gaseous Environments of DLA-Host Galaxies at $z \sim 2$

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(CfA)

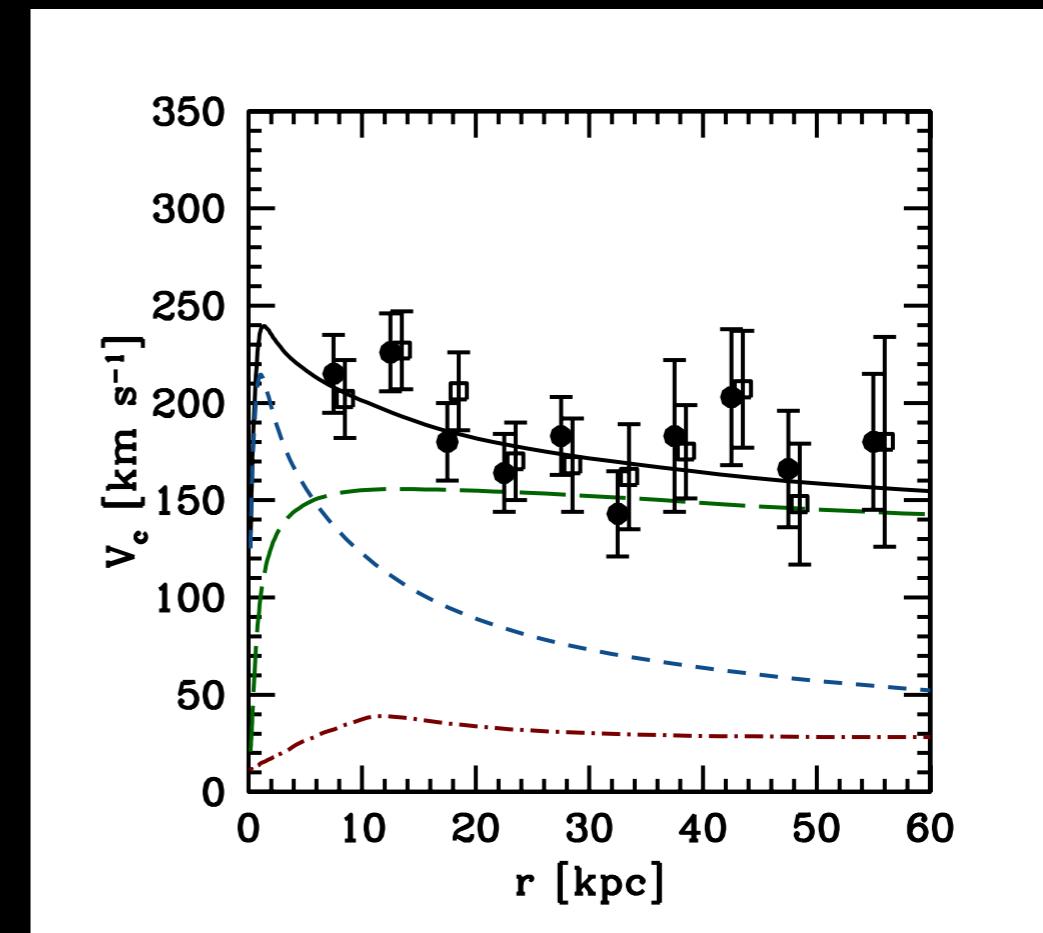
Rob Simcoe (MIT), X. Prochaska (UCSC), Joe Hennawi (MPIA),  
Adam Myers (U Wyoming), Neil Crighton (Swinburne)

February 13, 2014

Cosmological ‘zoom’ simulations can now reproduce the luminous properties of galaxies in exquisite detail...

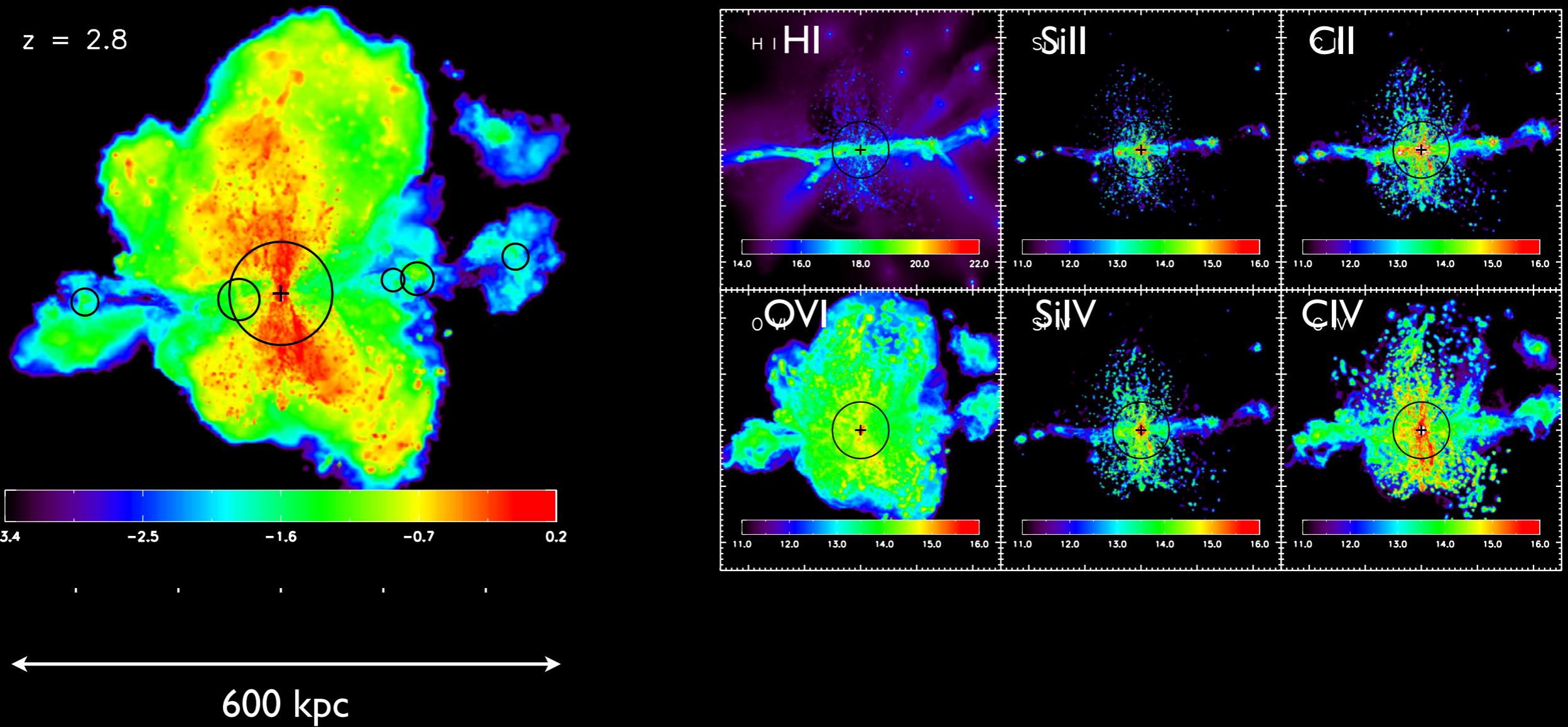


Eris: Milky Way analog



Guedes+11

... while simultaneously predicting the content and kinematics of the surrounding CGM.

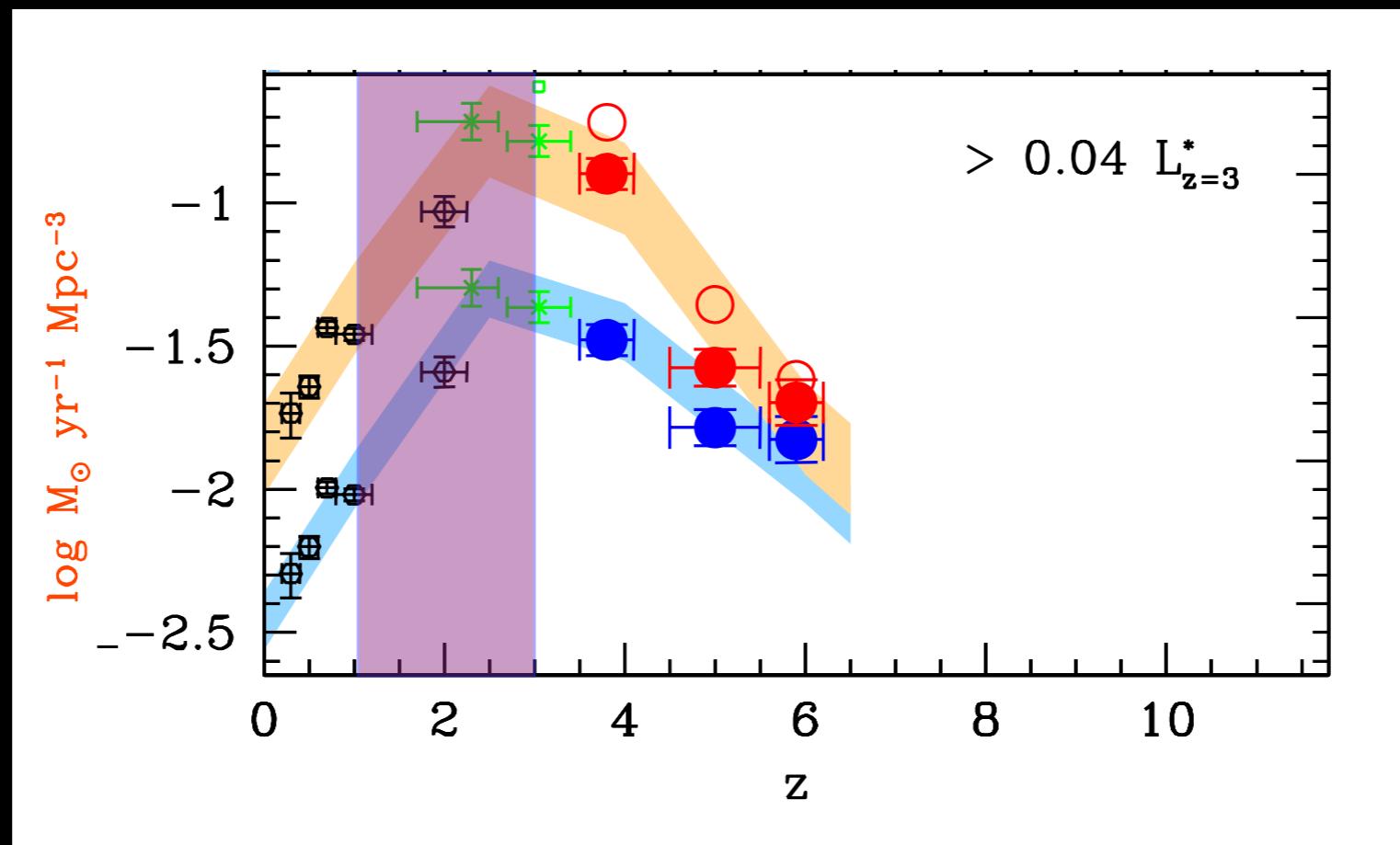


Eris2: gas metallicity map

Shen et al. 2012, 2013

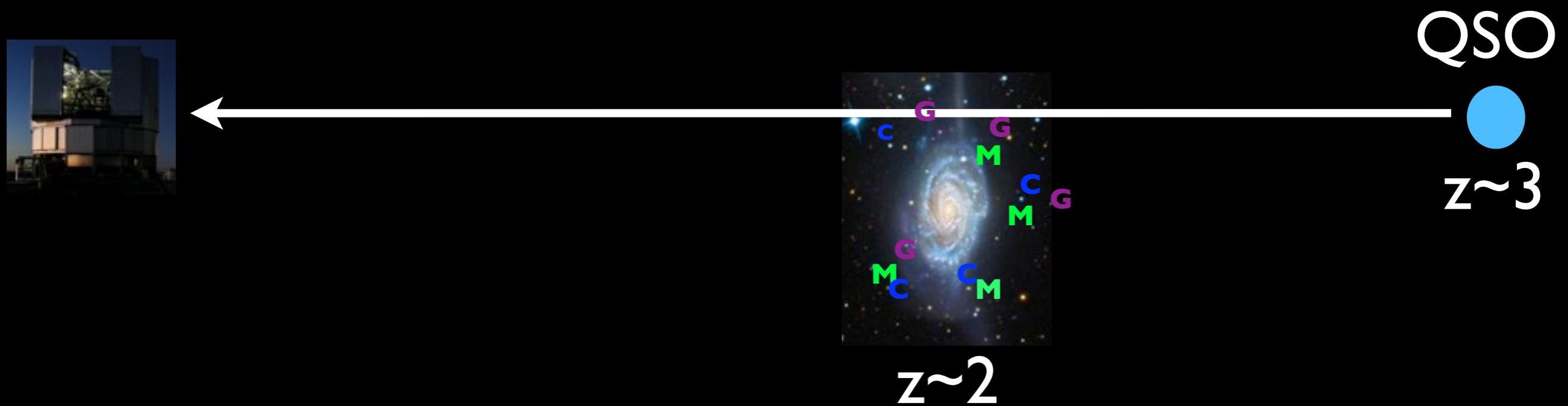
So let's test those predictions!  
And let's do it at  $z \sim 2$  (during the brouhaha)...

Bouwens et al. 2009

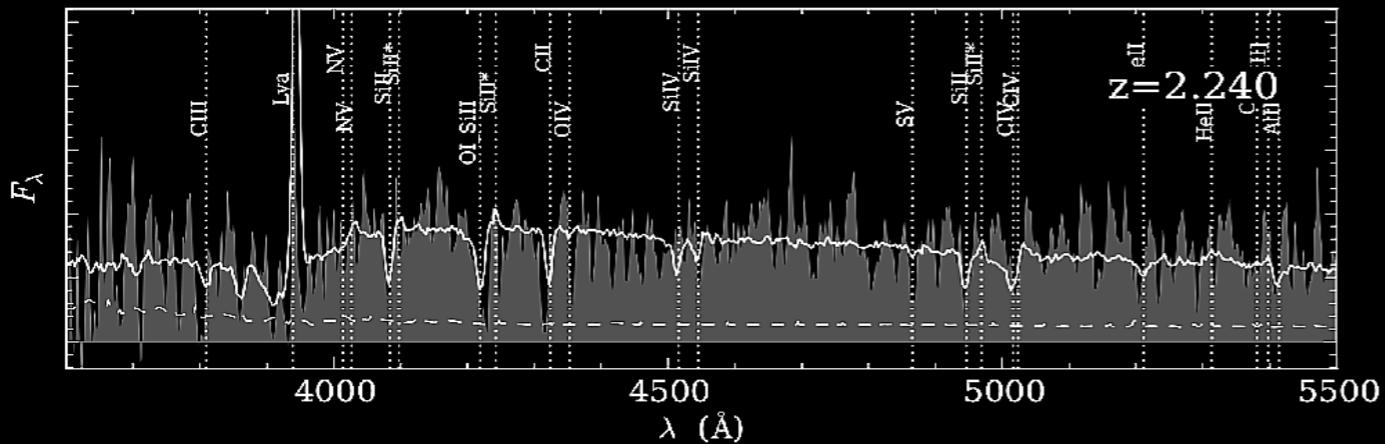


# Plan of attack:

1. Find galaxies at  $z \sim 2$
2. Measure their CGM (in absorption)



We've mostly searched for  $z \sim 2$  galaxies in emission...



Foreground LBG at  $z = 2.2$



QSO at  $z = 2.9$

80 kpc

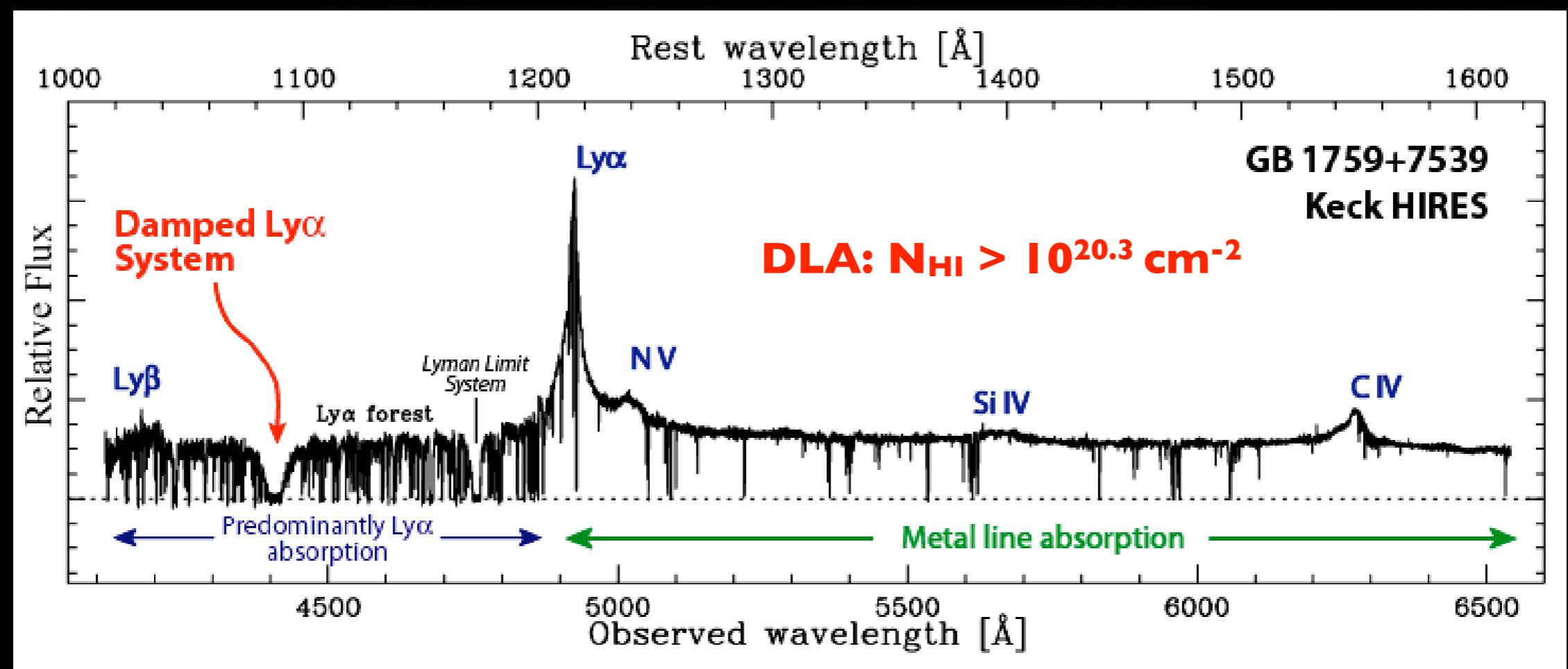
see also:

Adelberger et al. 2005, Steidel et al. 2010, Rudie et al. 2012

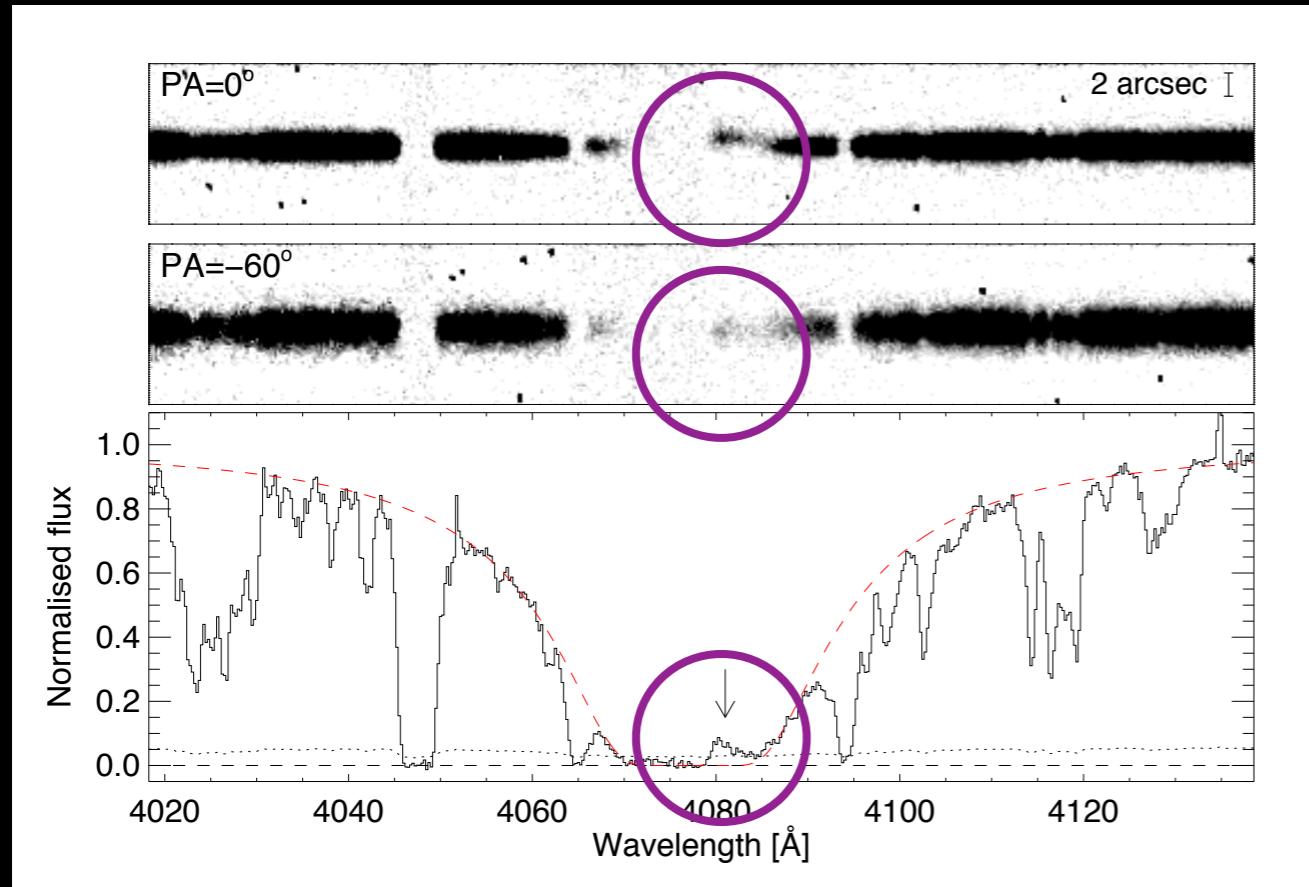
Crighton et al.

LBT/LBC Ugr images

But one may also search in absorption.

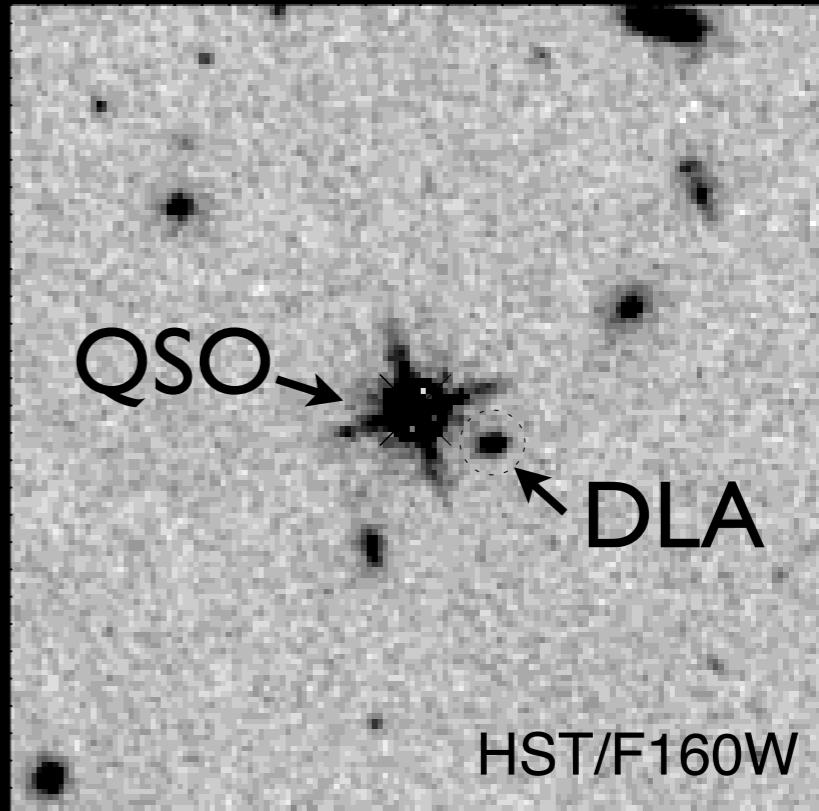


# (What are DLAs, really?)



SFR  $\sim 10 M_{\text{sun}}/\text{yr}$   
L  $\sim 0.1 L^*_{\text{H}\alpha}$

Fynbo et al. 2010



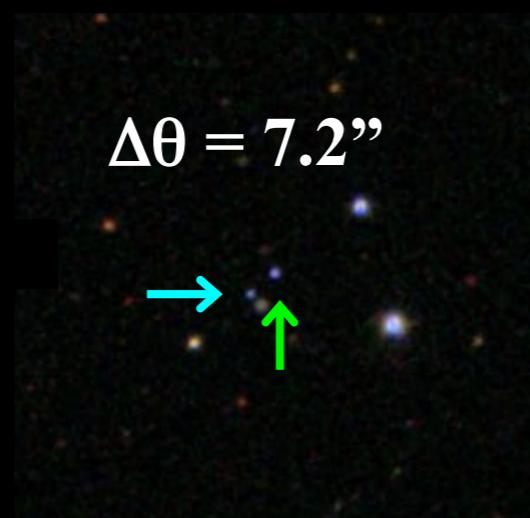
SFR  $\sim 30 M_{\text{sun}}/\text{yr}$   
 $\log M^*/M_{\text{sun}} \sim 10$

DLA bias suggests they arise in halos with masses up to  $10^{12} M_{\text{sun}}$   
(Font-Ribera et al. 2012)

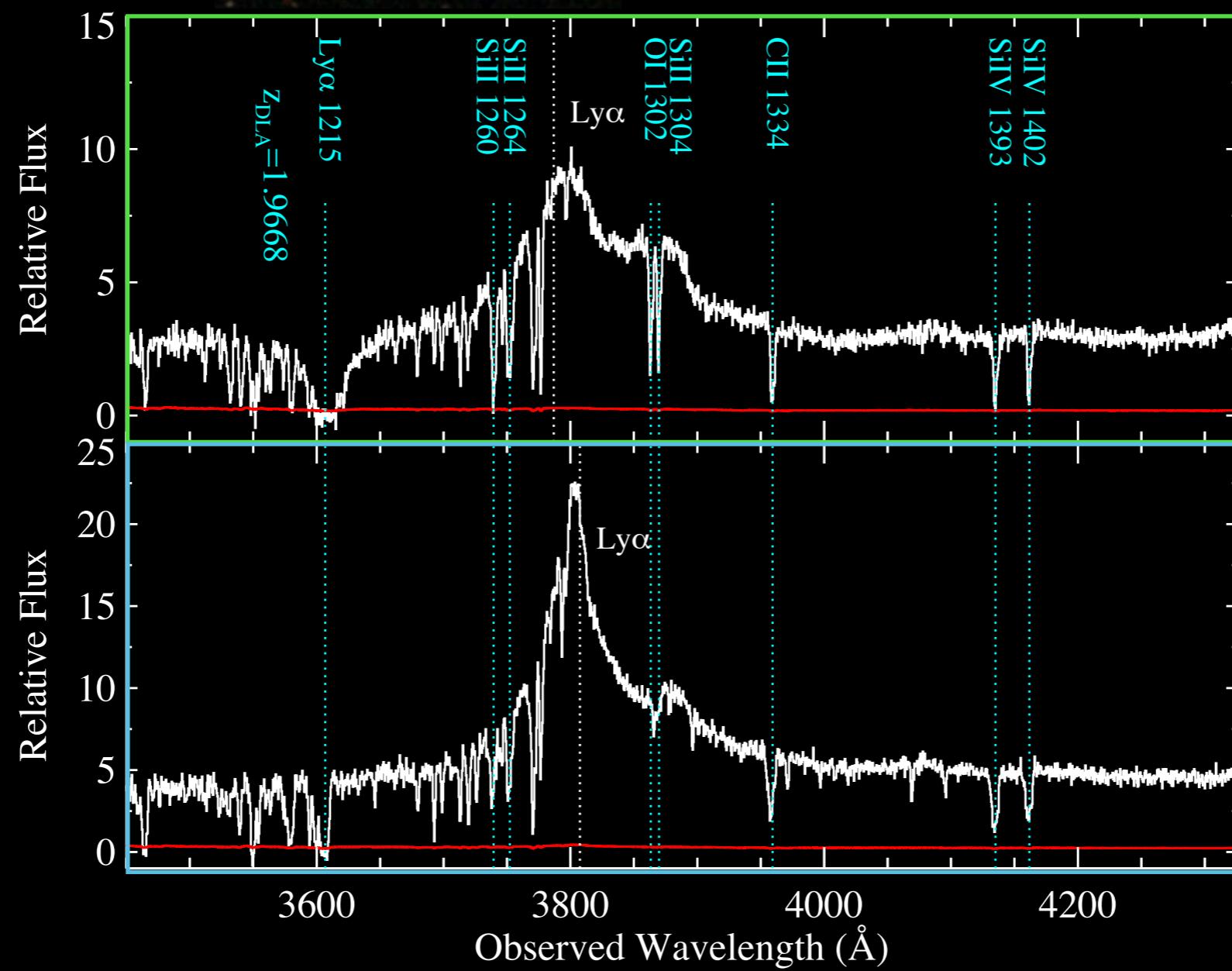
Fynbo et al. 2013

# Finding galaxies in absorption at $z \sim 2$

Search SDSS  
+BOSS for:  
(Hennawi et al. 2006, 10)

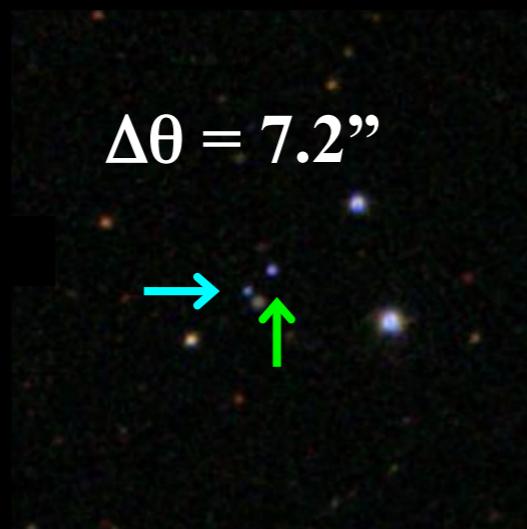


$z = 2.13$   
 $z = 2.12$   
 $R_{\text{perp}} = 62 \text{ kpc}$



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Search SDSS  
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(Hennawi et al. 2006, 10)



$$\Delta\theta = 7.2''$$

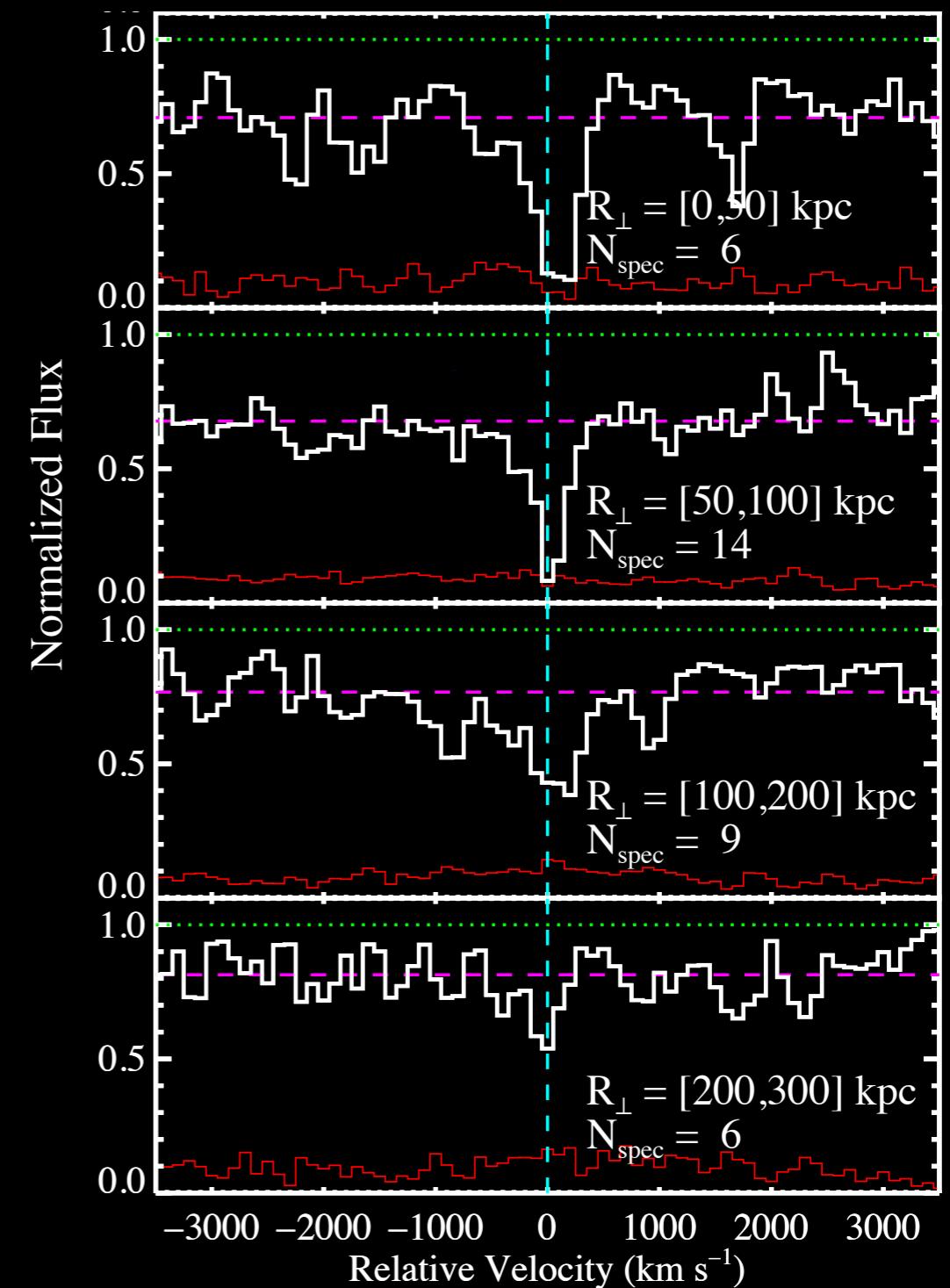
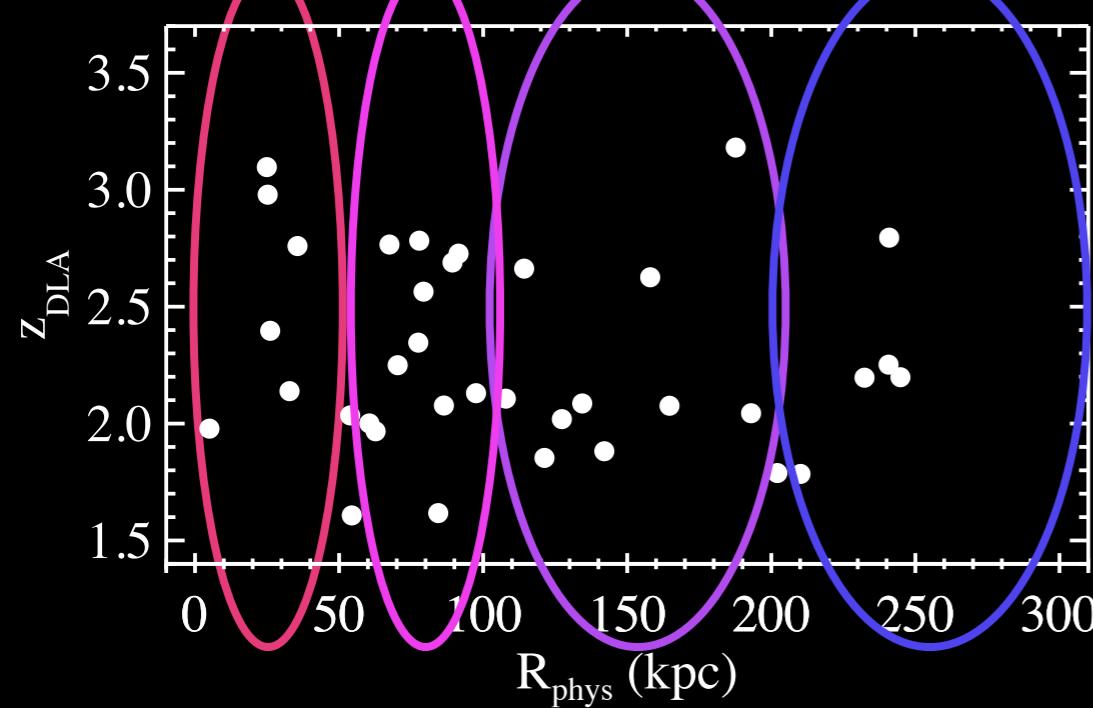
$$z = 2.13$$

$$z = 2.12$$

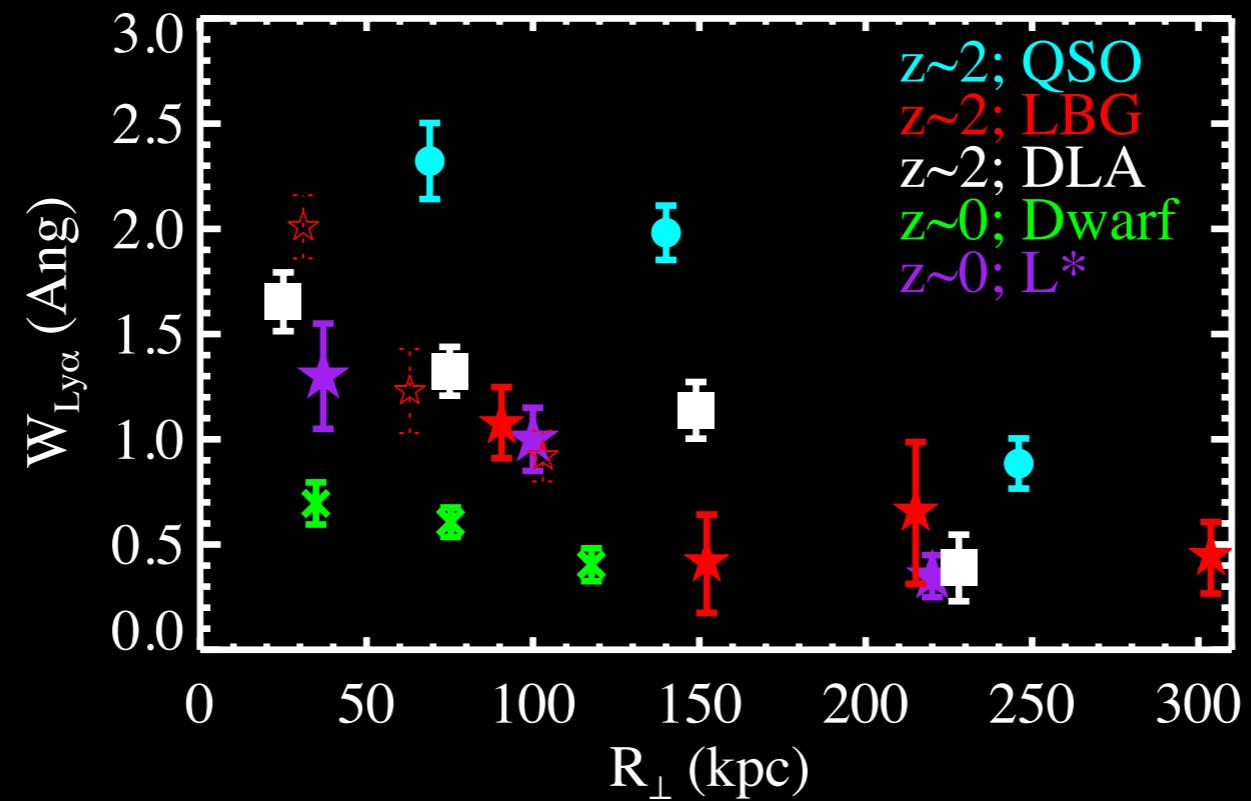
$$R_{\text{perp}} = 62 \text{ kpc}$$

To date: Gemini/GMOS, Keck/LRIS, Magellan/MagE, LBT/MODS, or BOSS spectroscopy of  $\sim 35$  QSO pairs with intervening DLAs

# The CGM of DLA-galaxies in neutral hydrogen:



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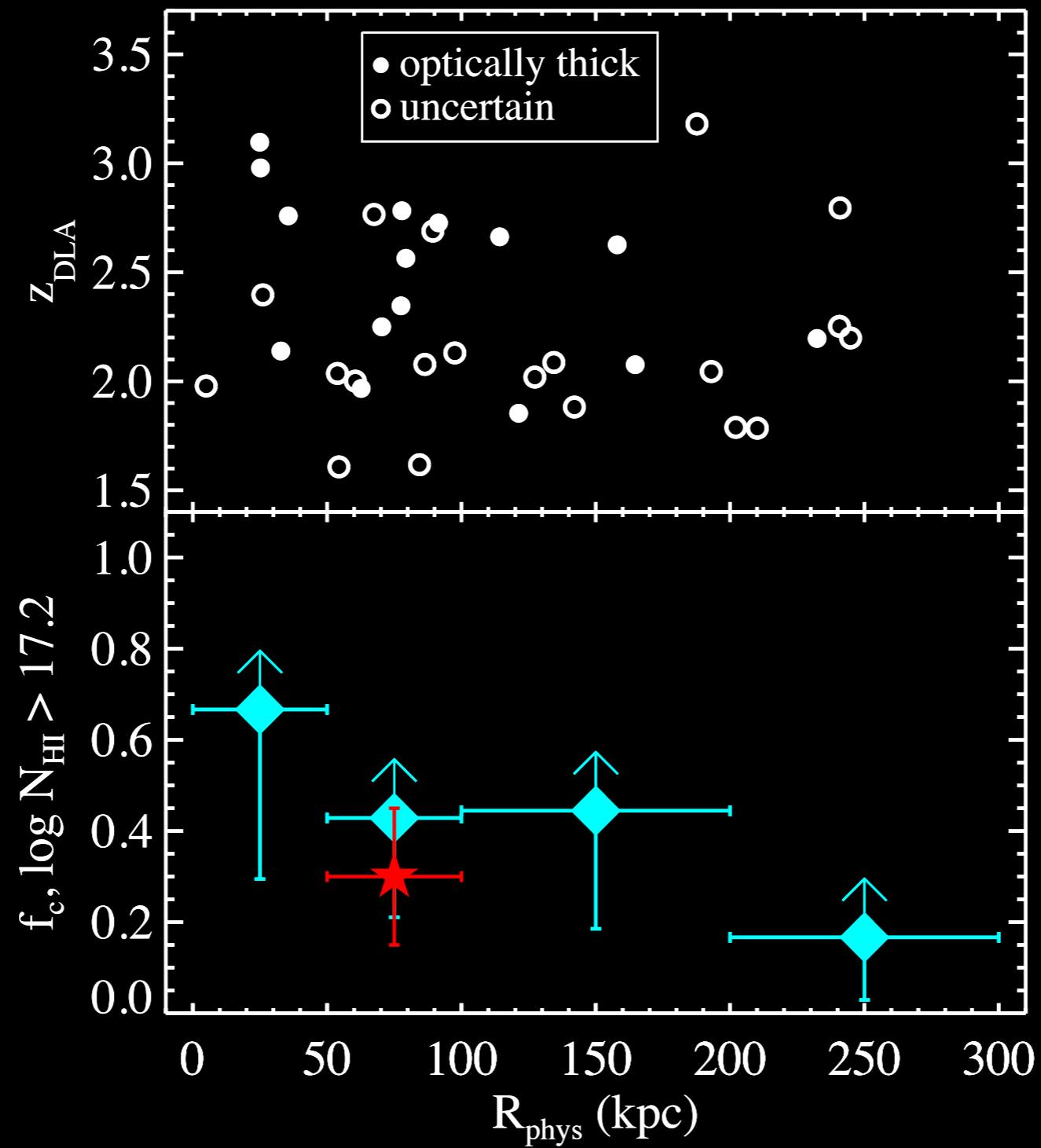
Prochaska+13

Adelberger+05, Simcoe+06, Steidel+10, Rakic+11, Rudie+12, Crighton+13

Chen+01, Prochaska+11, Werk+12, Tumlinson+13

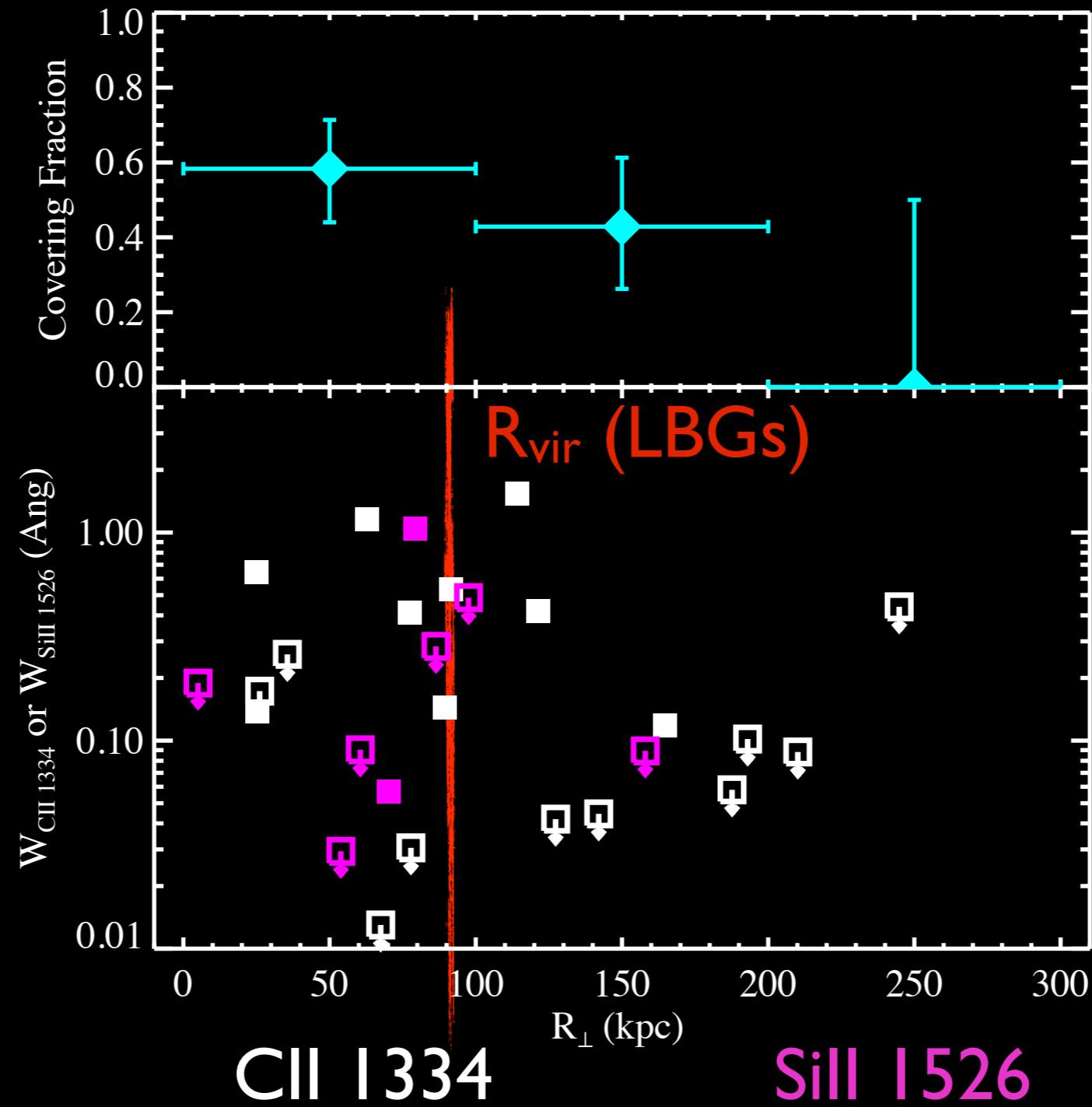
Bordoloi+ (COS-Dwarfs)

# Tracing optically-thick HI in the CGM of DLA-galaxies

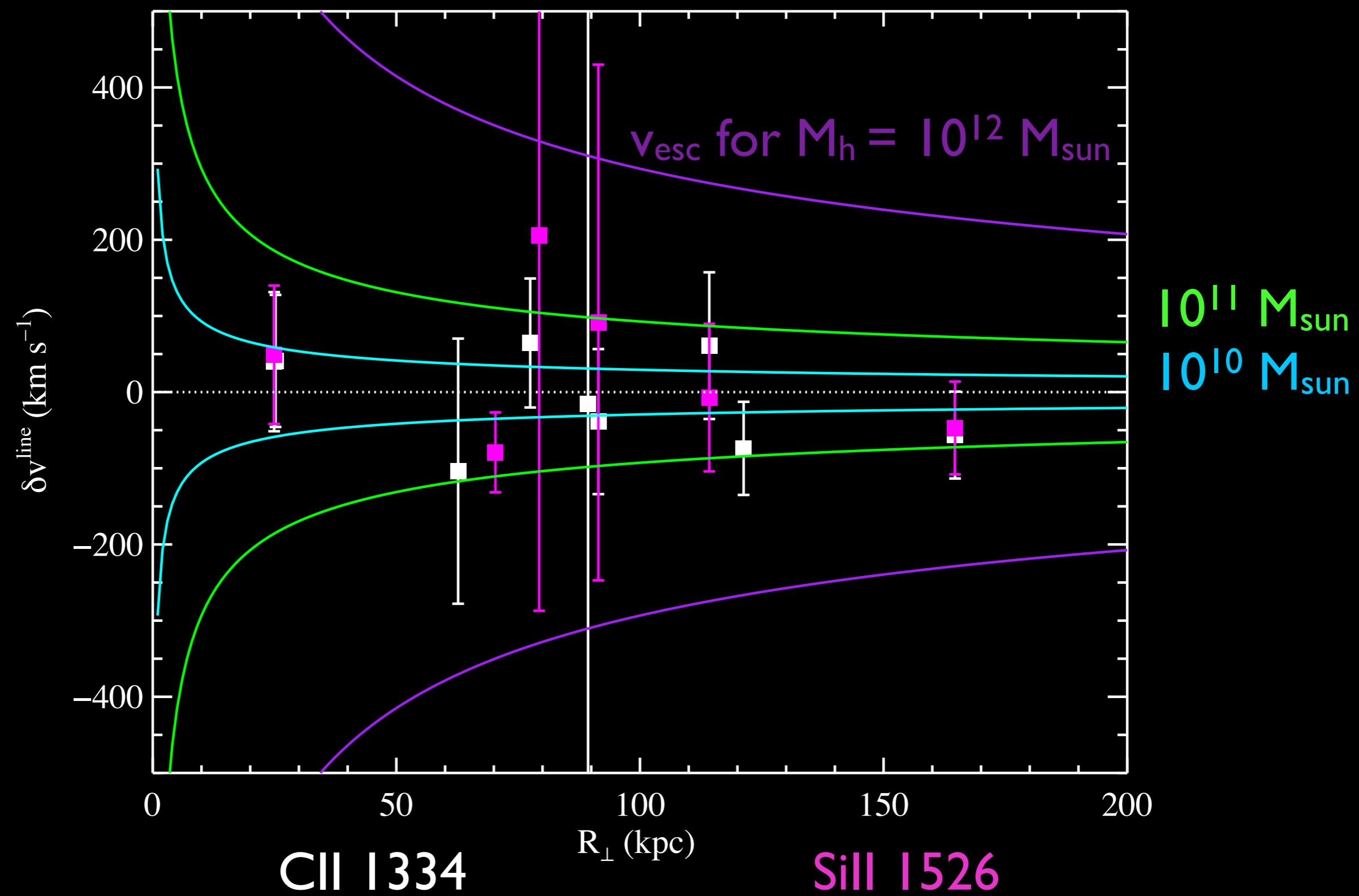


**LBGs**  
Rudie et al. 2012

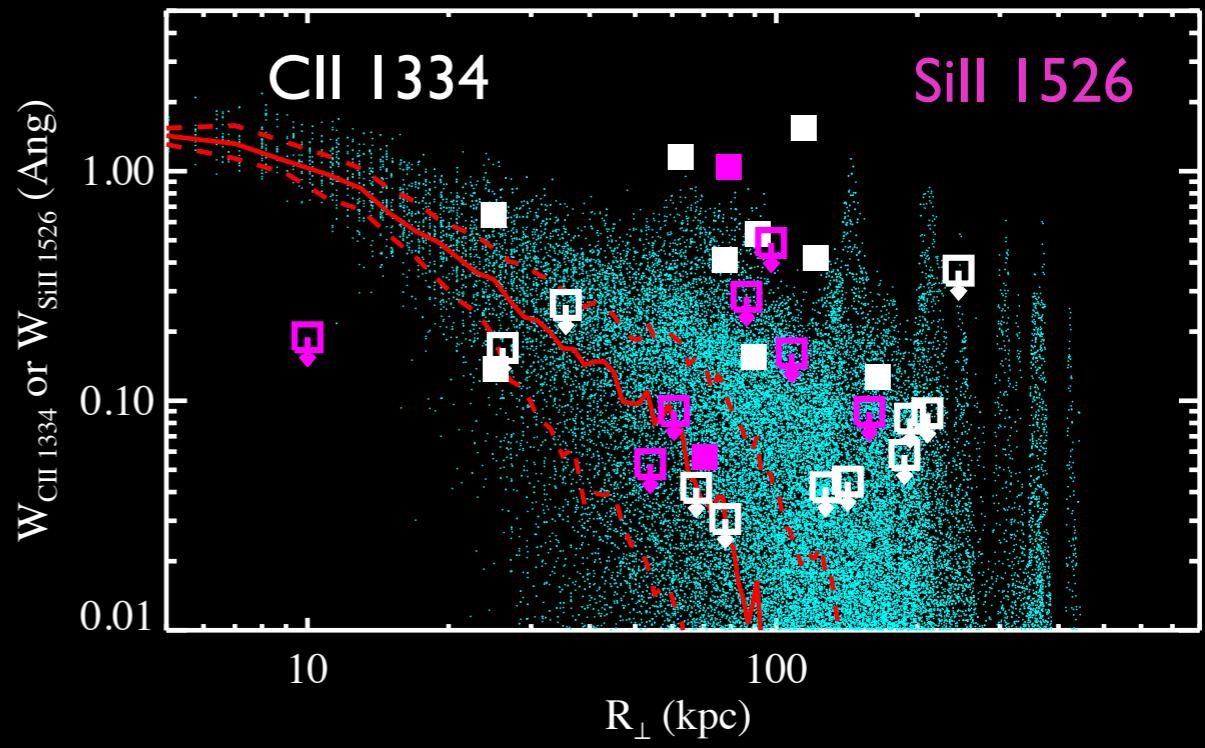
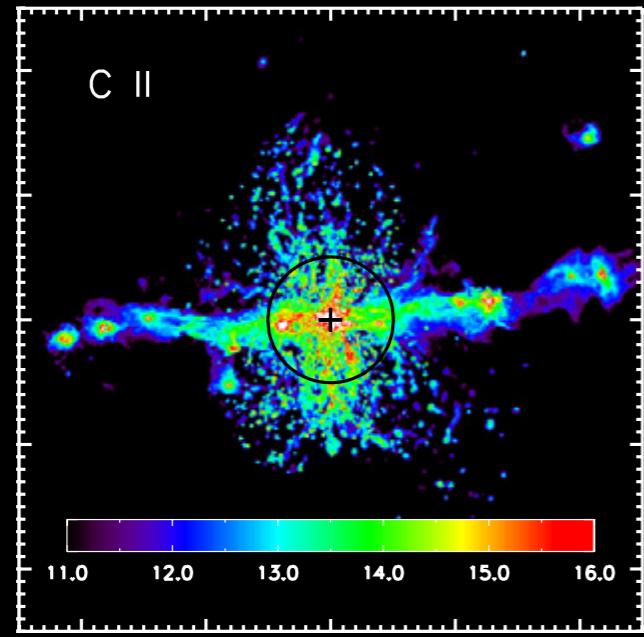
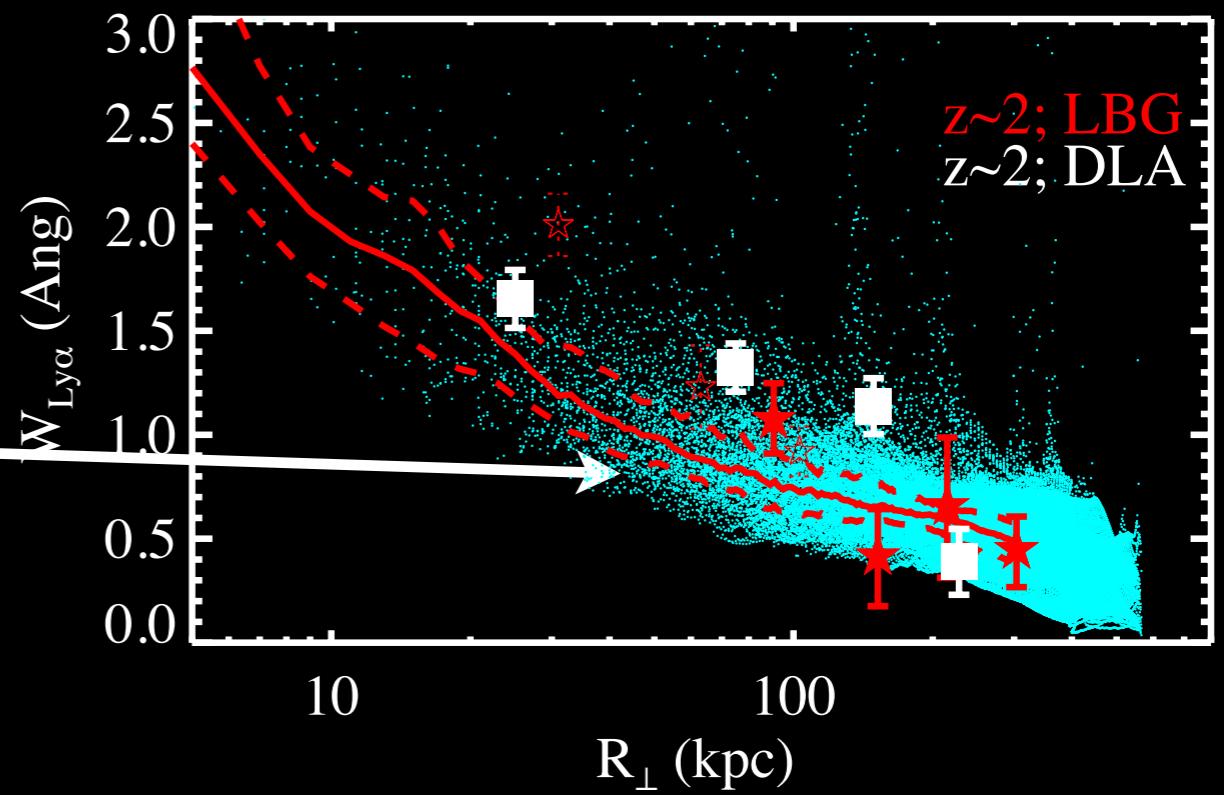
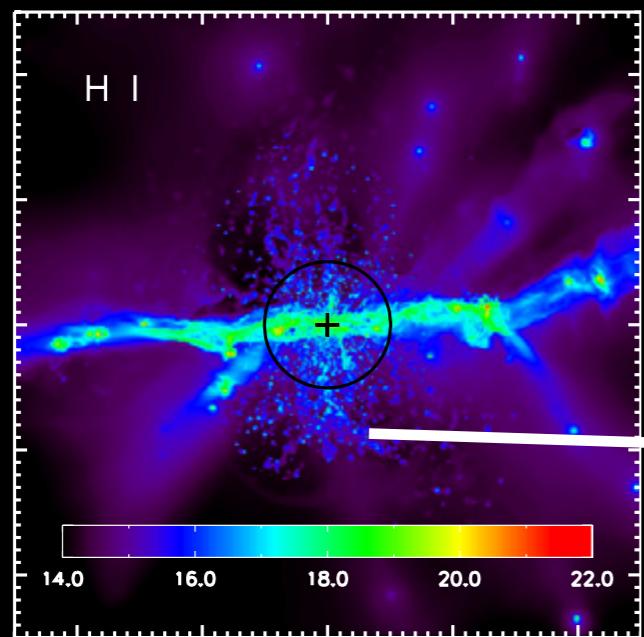
# Low-ionization Metals in the CGM of DLA-galaxies



Much of this material is bound.



# And how did Eris do?



Shen et al. 2013

## Conclusions:

There is an optically thick, metal-enriched CGM around DLA-galaxies extending to at least 100 kpc, and having a covering fraction  $\sim$ 50%

The large observed HI and low-ion EWs are inconsistent with those predicted by Eris...