Title: Mapping the z ~ 2 Circumgalactic Medium with KBSS Galaxy Pairs

Speakers: Nikolaus Prusinski

Collection/Series: Cosmic Ecosystems

Subject: Cosmology

Date: July 30, 2025 - 11:00 AM

URL: https://pirsa.org/25070041

Abstract:

Despite a growing body of observational and theoretical work, the connection between galactic-scale feedback processes, the underlying distribution of gas in the circumgalactic medium (CGM), and host galaxy properties remains uncertain. Focusing on the latter two points, we present new results on the spatial structure and kinematics of Lyα and several far-UV metallic ions in the CGM of Keck Baryonic Structure Survey (KBSS) galaxies using rest-frame far-UV spectra of foreground/background galaxy pairs with angular separations ≤ 30 arcsec. Medium resolution ($R\simeq 1500$) Keck/KCWI and Keck/LRIS spectra of 736 background galaxies with $\langle z_{\rm bg}\rangle=2.58 \pm 0.38$ probe sightlines through 1033 foreground galaxies ($\langle z_{\rm fg}\rangle=2.03 \pm 0.36$) at projected distances $8\leq D_{\rm tran}/\mathrm{kpc}\leq250$. For each ion, we measure rest-frame equivalent widths (W_{λ}) as a function of $D_{\rm tran}$; we observe higher ionization species (C IV) decrease less rapidly and extend to larger $D_{\rm tran}$ compared to low ions (O I, C II, Si II). Splitting the pair sample into subsets based on foreground galaxy properties, we find $W_\lambda(\text{C IV})$ exhibits a strong dependence on stellar mass (M_*) and a weaker dependence on star formation rate. Similarly, $W_\lambda(\text{Ly}\alpha)$ increases with M_*, albeit with more scatter. In 2D, we map the excess Lyα and C IV absorption as functions of line-of-sight velocity and $D_{\rm tran}$ and fit the observed Lyα map with a simple two-component model. Combining the 1D and 2D trends, we discuss the improved constraints these results place on CGM gas-phase kinematics in the context of previous studies at $z\sim 2$.

Mapping the z ~ 2 CGM with KBSS Galaxy Pairs

Nikolaus Prusinski (Caltech),
Chuck Steidel (Caltech), Yuguang Chen (CUHK)

Cosmic Ecosystems, Perimeter Institute
7/30/25

Outline

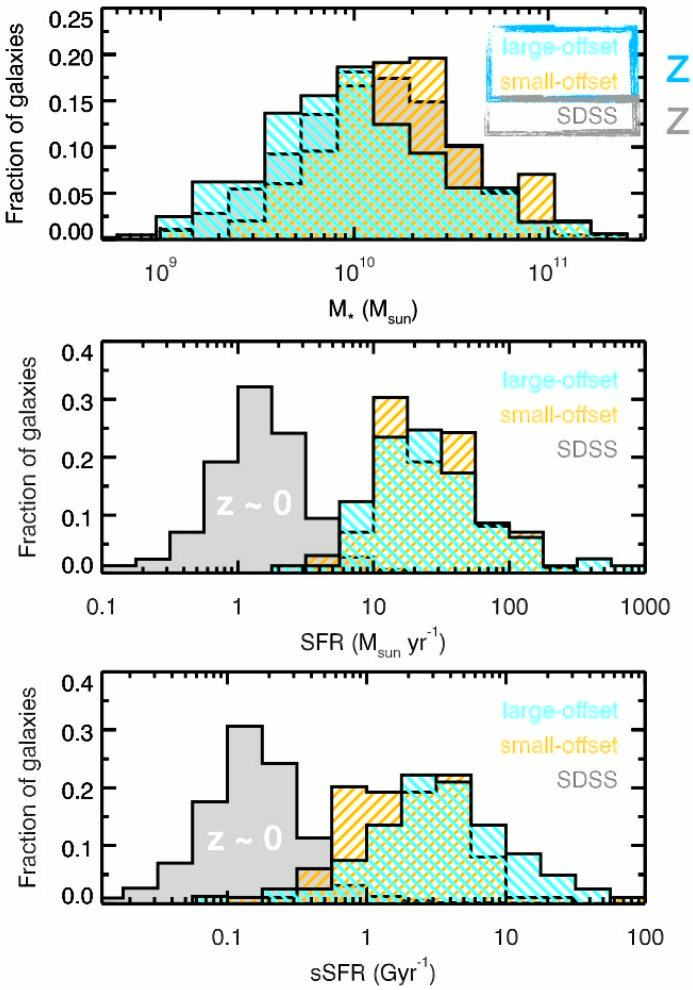
Keck Baryonic Structure Survey (KBSS) Galaxies

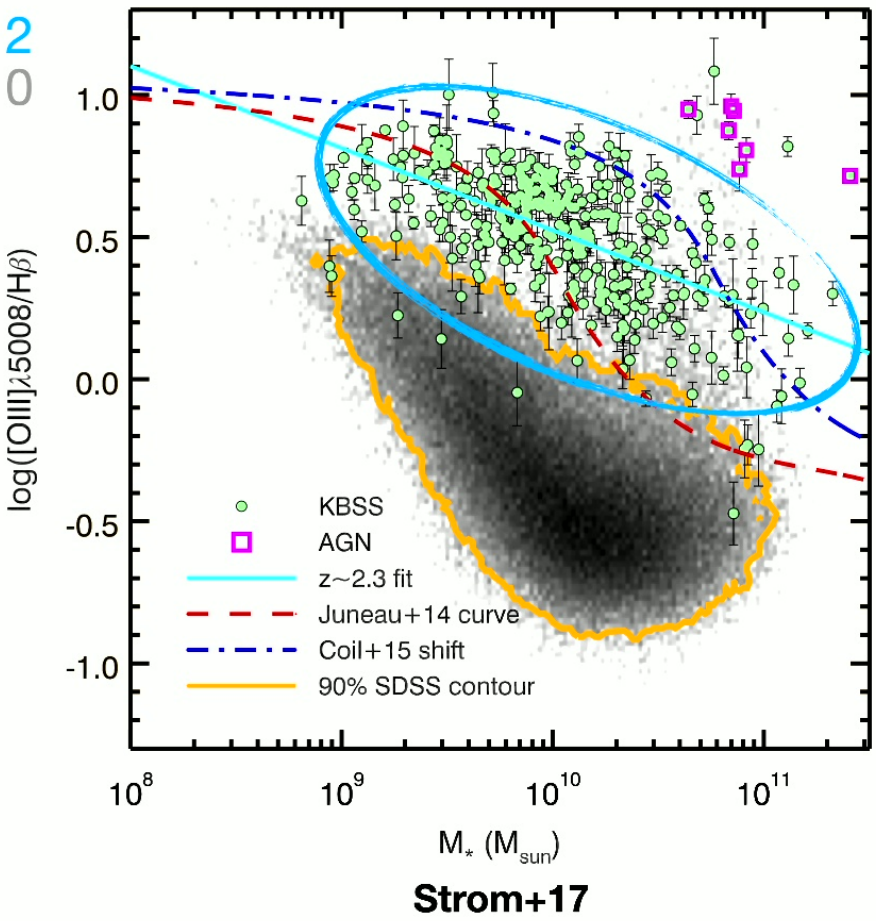
Galaxy-galaxy pairs

Adding KCWI spectra to the KBSS Galaxy Pair Sample

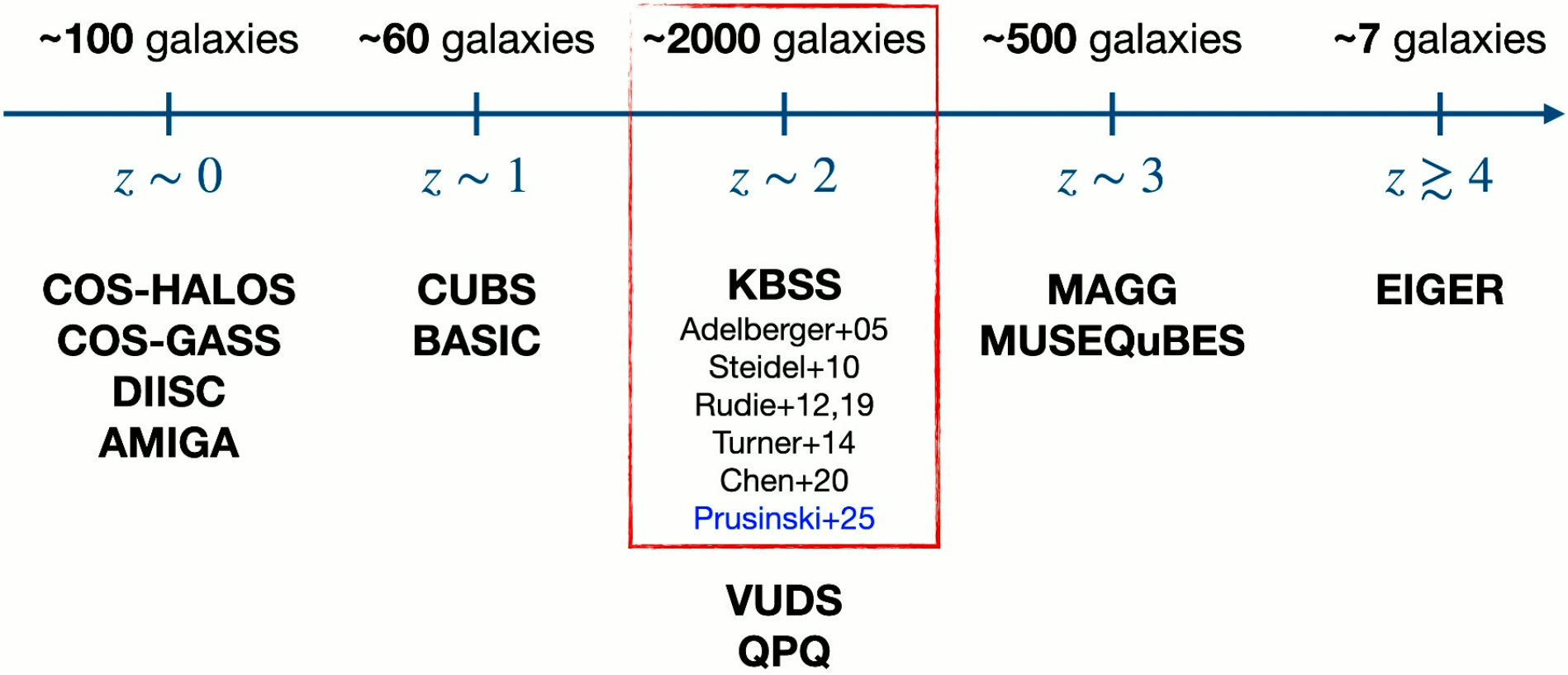
Takeaways

z ~ 2 vs. z ~ 0


Fraction of galaxies
large-offset
small-offset
SDSS
z ~ 2
z ~ 0
M* (Msun)
SFR (Msun yr-1)
sSFR (Gyr-1)

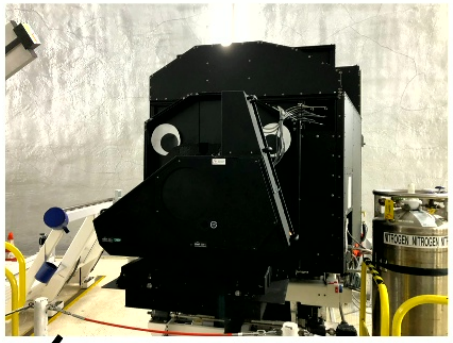

log([OIII]λ5008/Hβ)
KBSS
AGN
z~2.3 fit
Juneau+14 curve
Coil+15 shift
90% SDSS contour
M* (Msun)
Strom+17

Some Recent Surveys



Slide Design: Evan Núñez-Cravin

Foreground/Background Pair

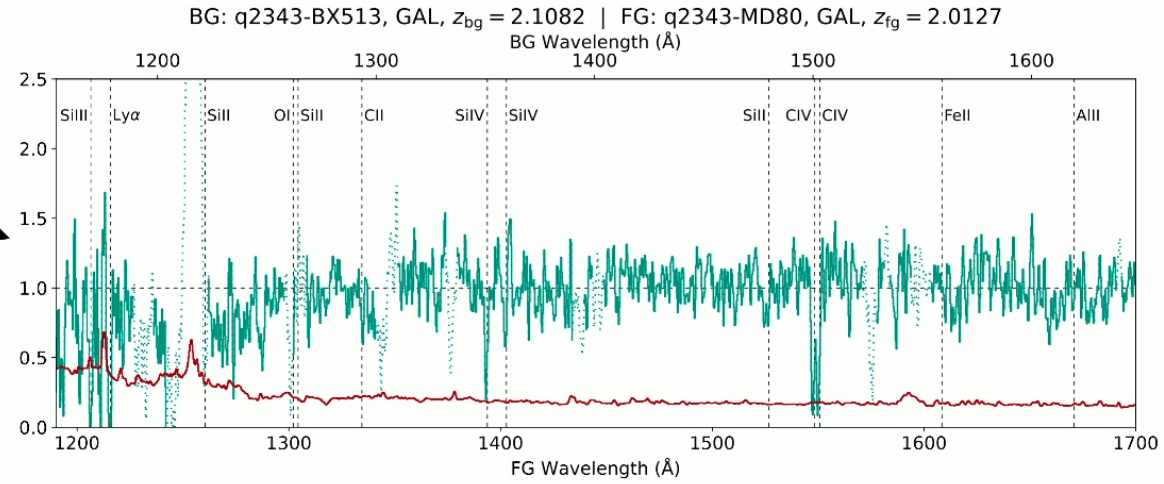


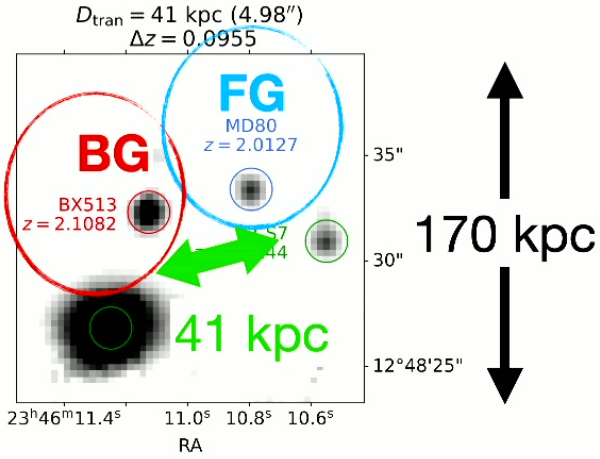
KCWI

"Medium BL" → R ~ 1800

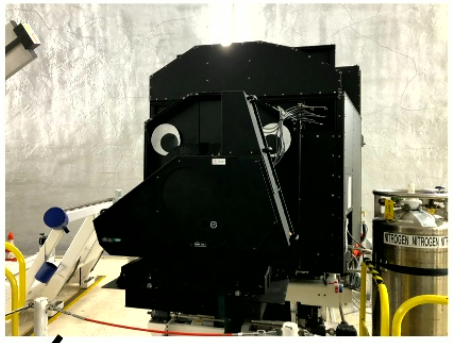
$t_{\rm int} \simeq 5$ hr

$\lambda_{\rm obs} = 3500 - 5500$ Å





Foreground/Background Pair

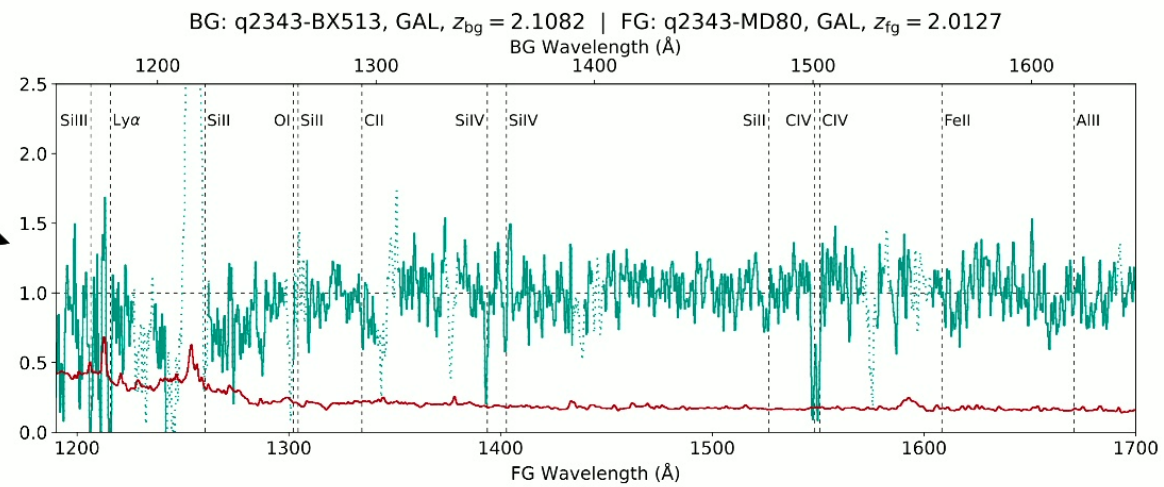


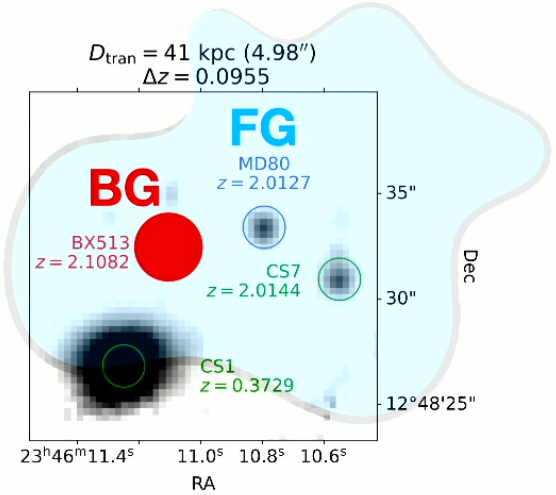
KCWI

"Medium BL" → R ~ 1800

$t_{\rm int} \simeq 5$ hr

$\lambda_{\rm obs} = 3500 - 5500$ Å



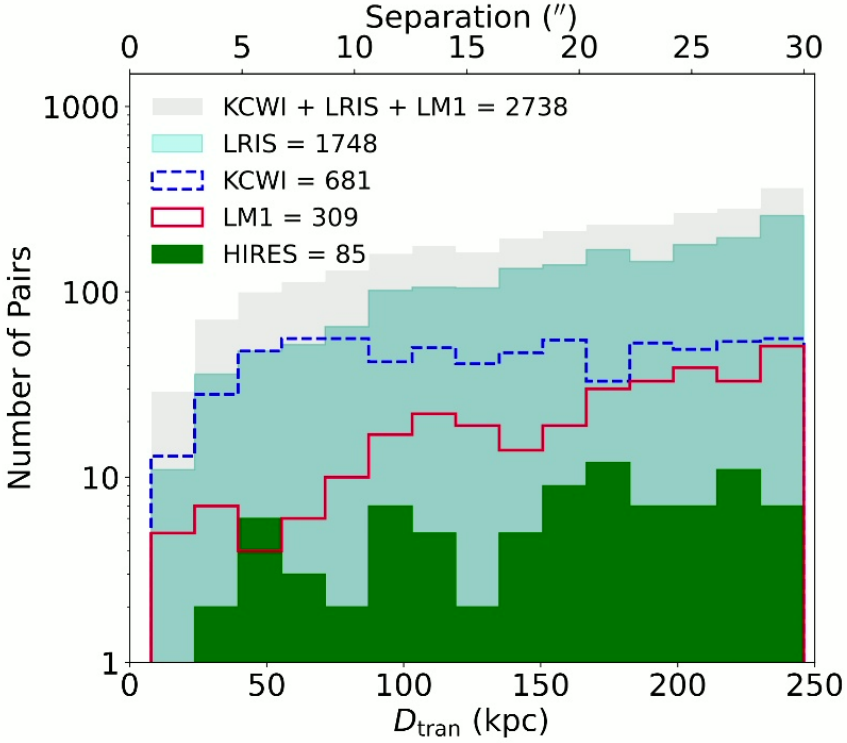


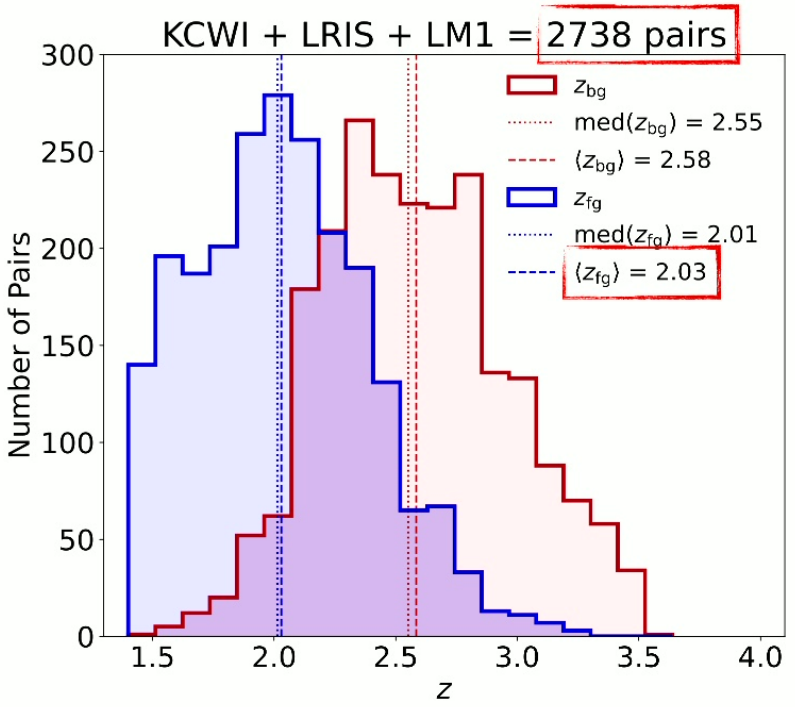
Galaxy Pair Sample

193 KCWI galaxies
(R ~ 1800)

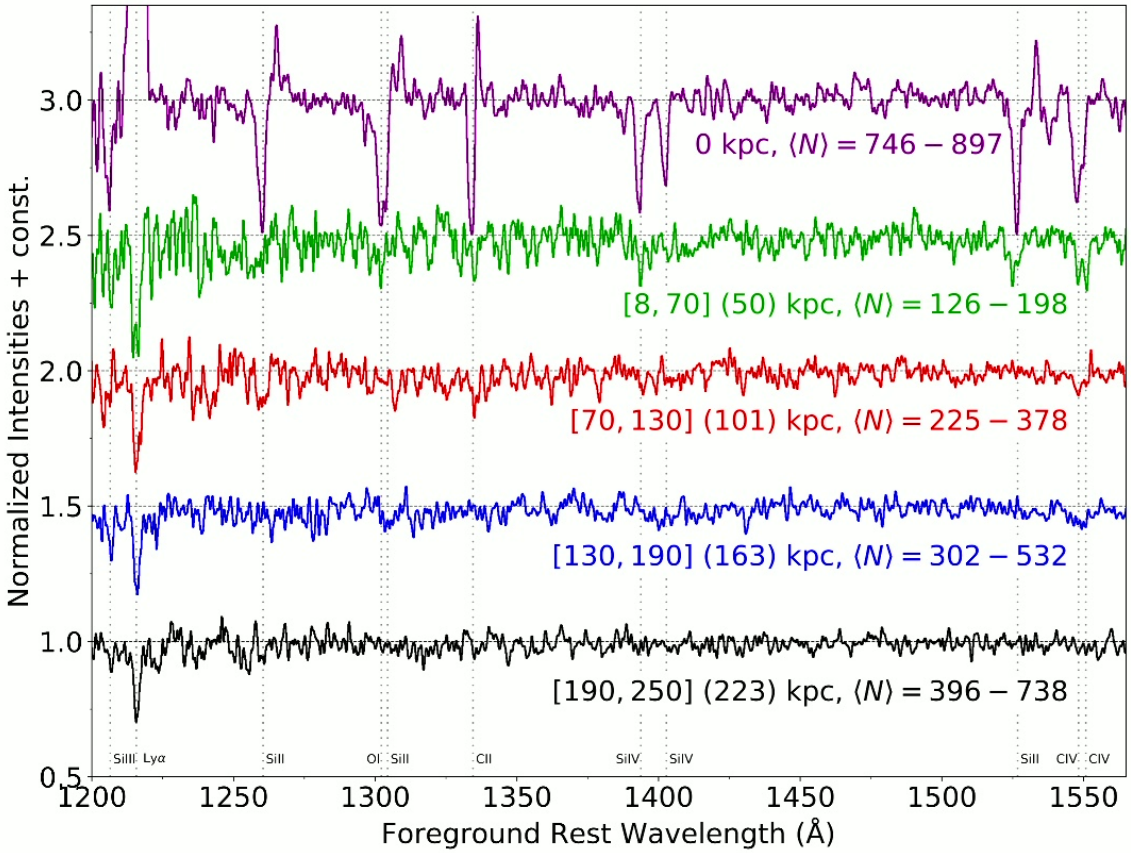
893 LRIS-B galaxies
(R ~ 1300)

Total: **1086 galaxies**



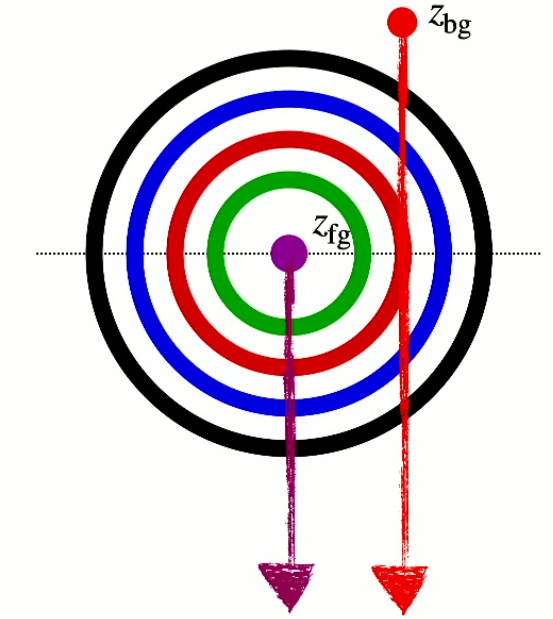


Stacking in bins of $D_{\rm tran}$



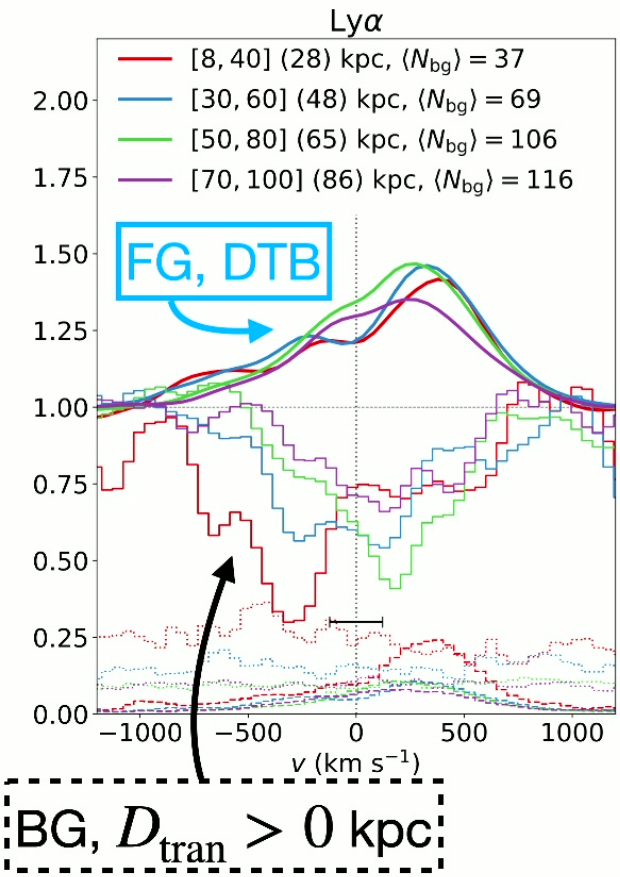
$[D_{\rm tran,\,lo}, D_{\rm tran,\,hi}]$ (Median $D_{\rm tran}$)

$\langle N \rangle$ = Number of Pairs in the bin

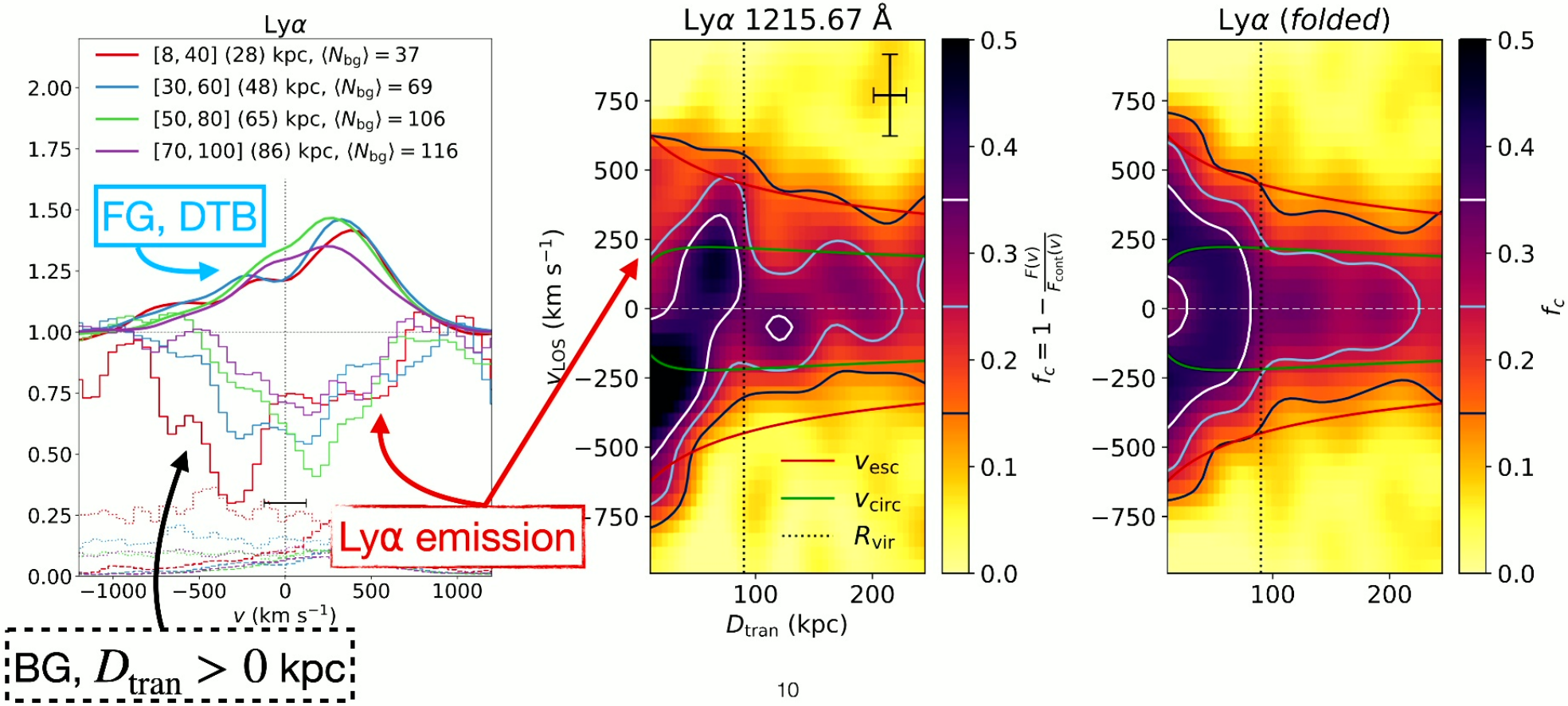


$D_{\rm tran} = 0$ kpc $D_{\rm tran} > 0$ kpc

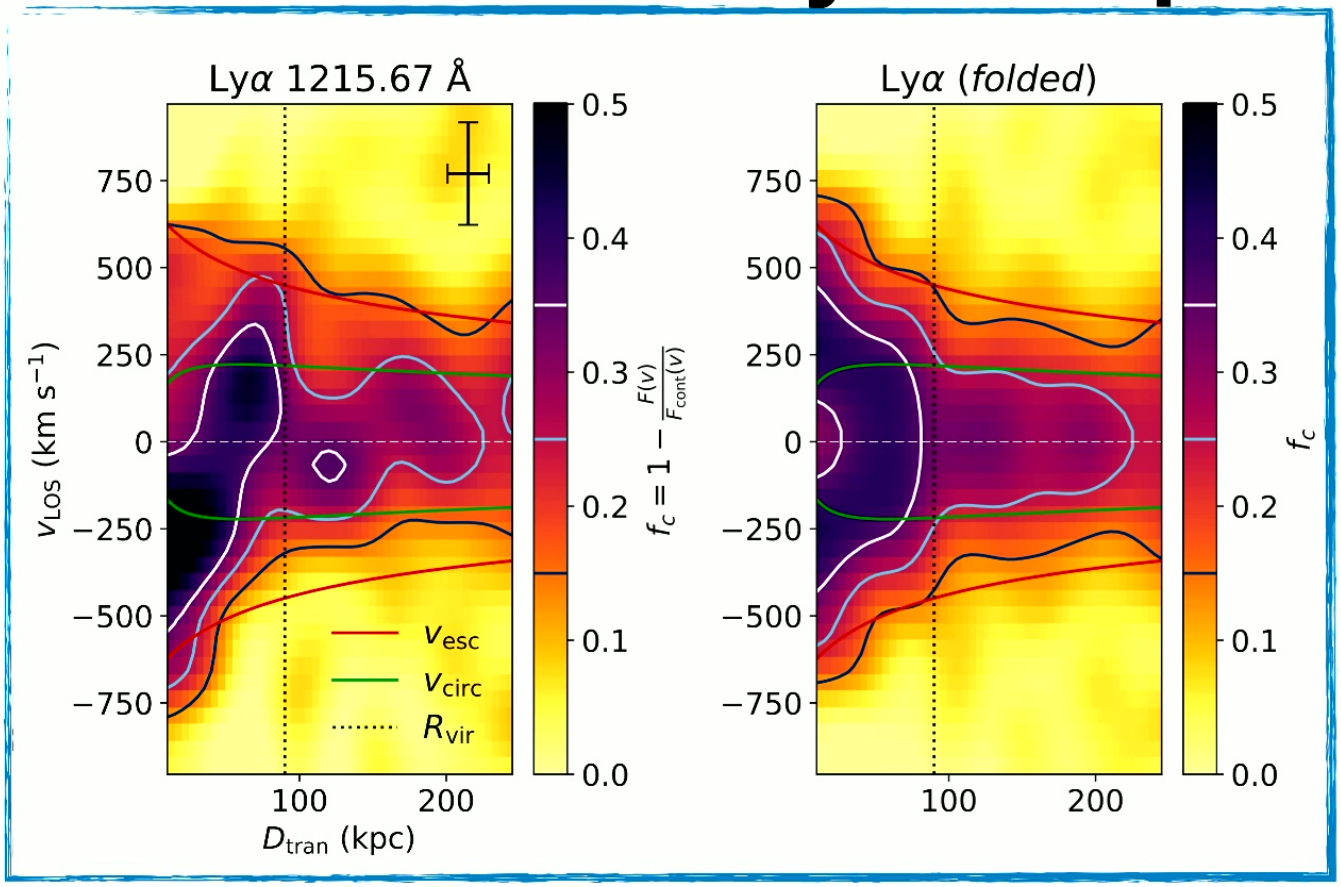
Lyα Maps

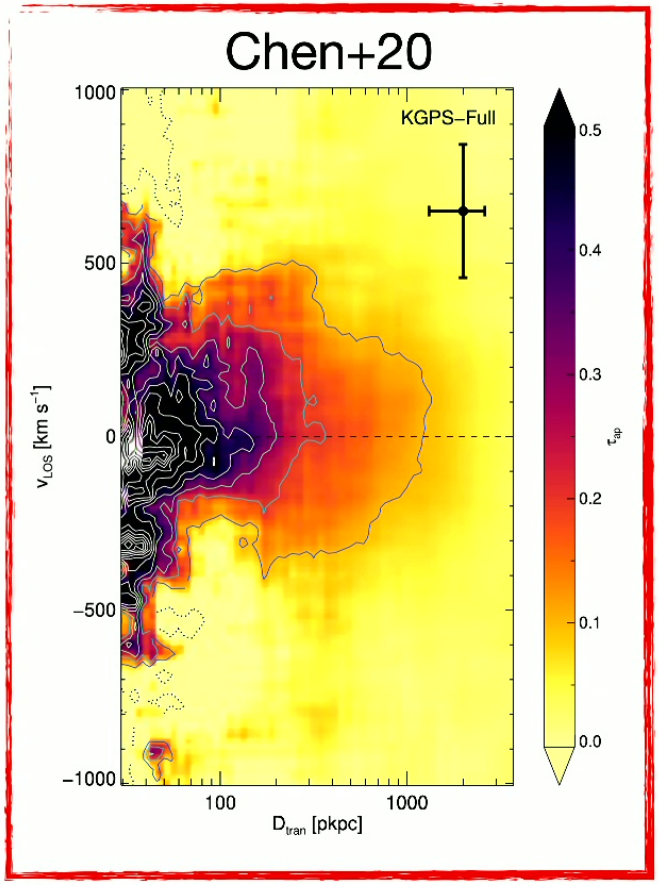


Lyα Maps

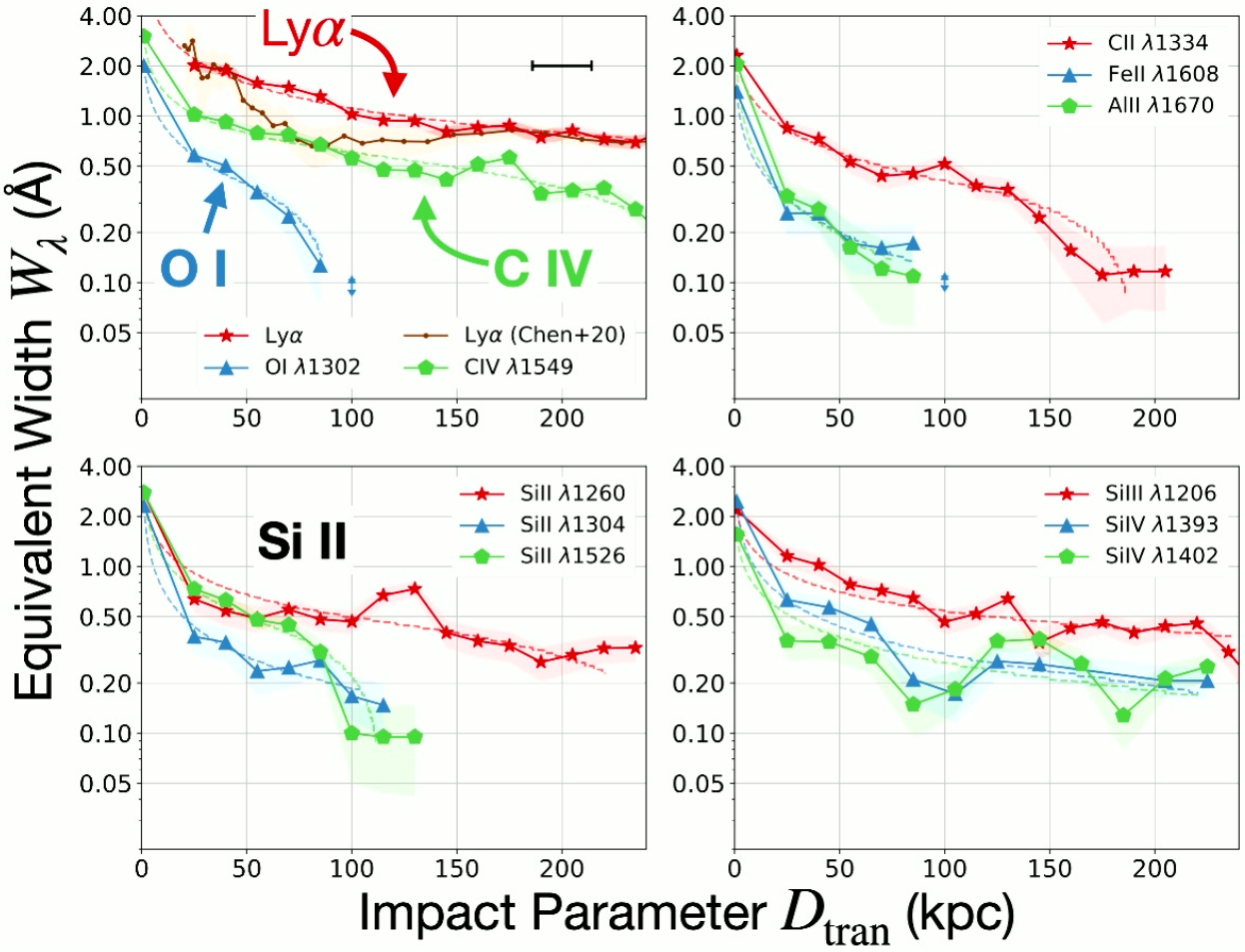


Lyα Maps

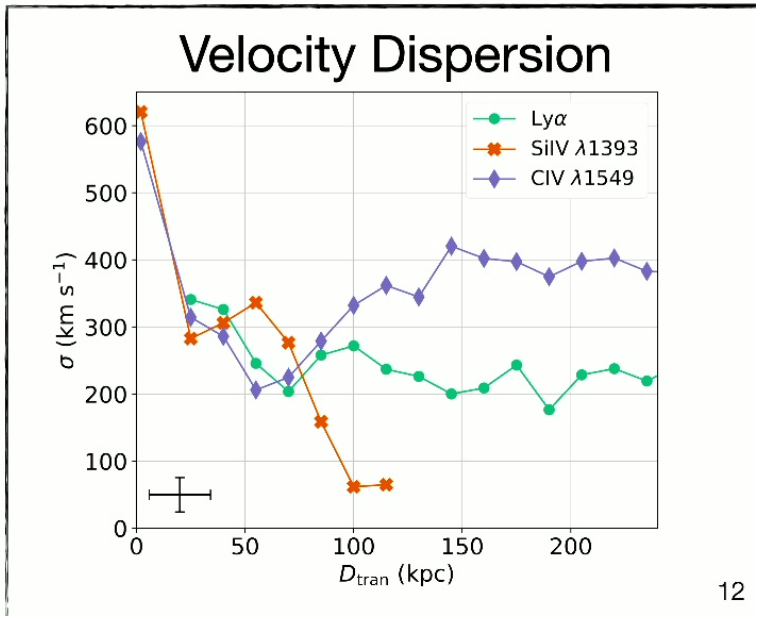




W_λ, σ vs. $D_{\rm tran}$, z ~ 2 LBGs

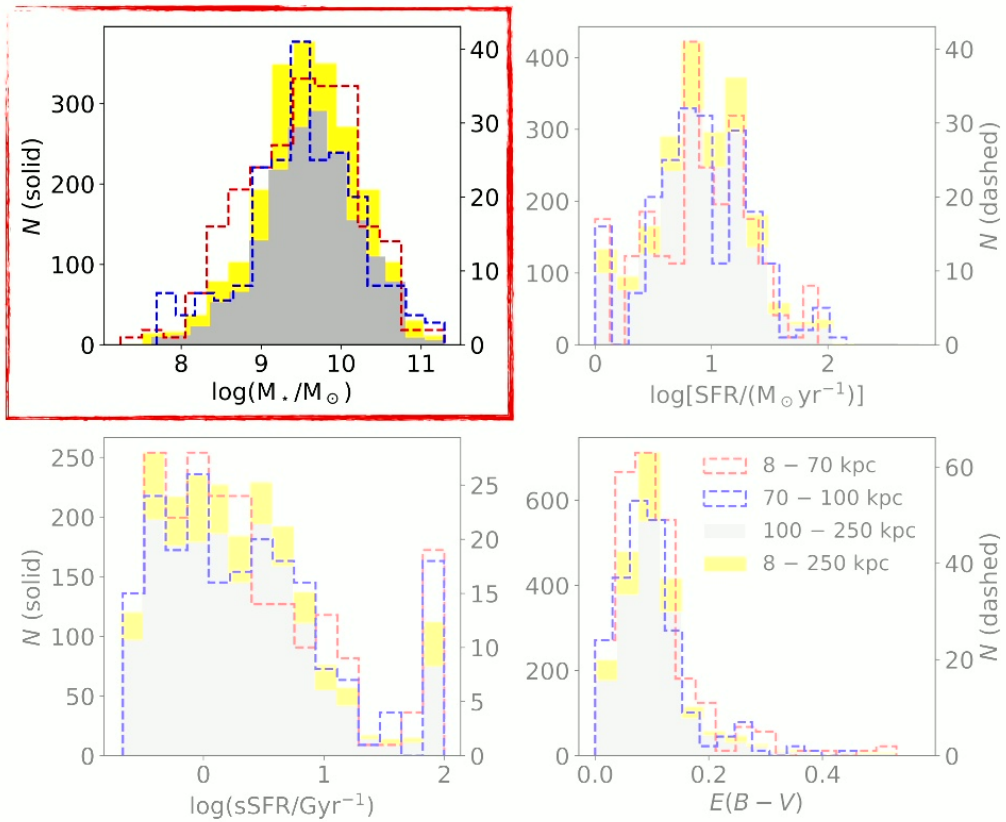


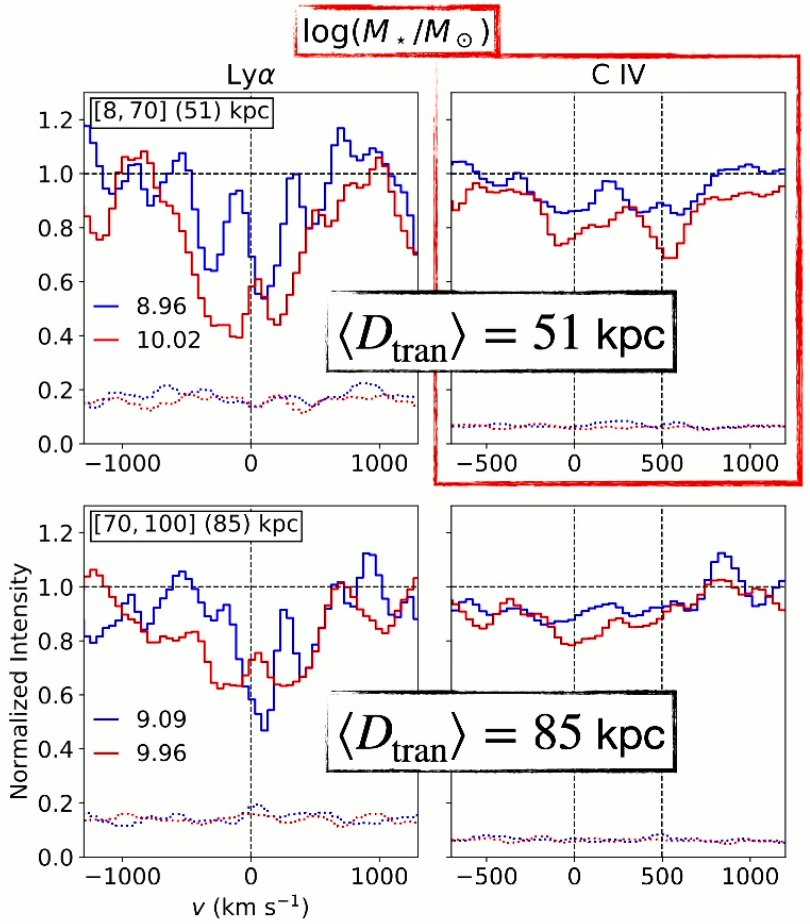
$$f_c(r) = f_{c,\max} r^{-\gamma}$$
$$\gamma \approx 0.2 - 0.5$$



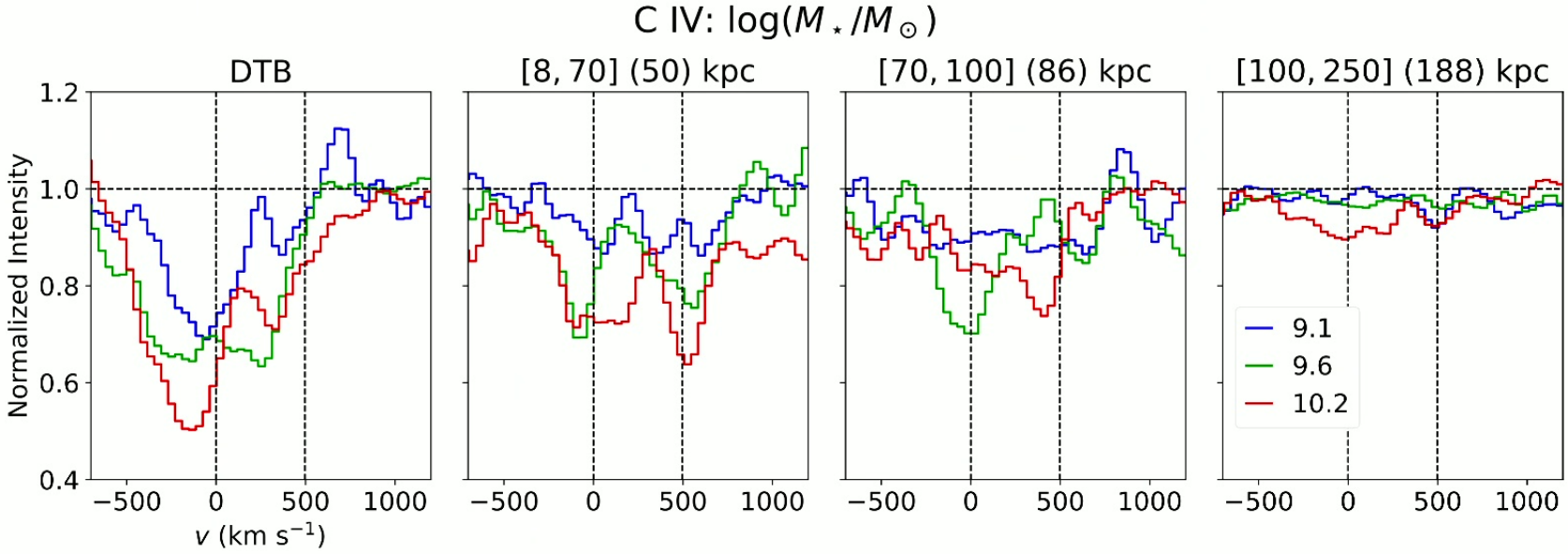
12

Splitting the pair sample by galaxy properties



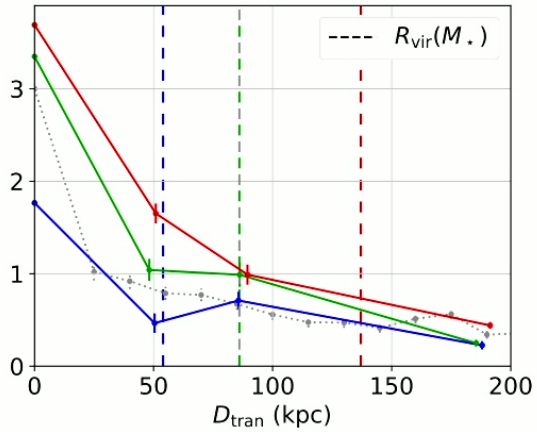


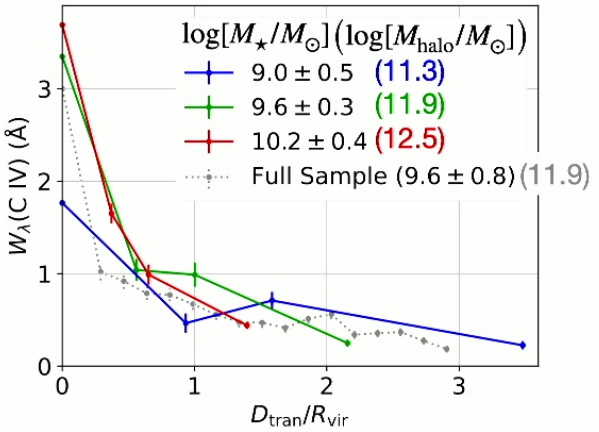
C IV vs. Mass


C IV: log($M_\star/M_\odot$)
DTB
[8, 70] (50) kpc
[70, 100] (86) kpc
[100, 250] (188) kpc
Normalized Intensity
1.2
1.0
0.8
0.6
0.4
−500
0
500
1000
v (km s^{-1})
9.1
9.6
10.2

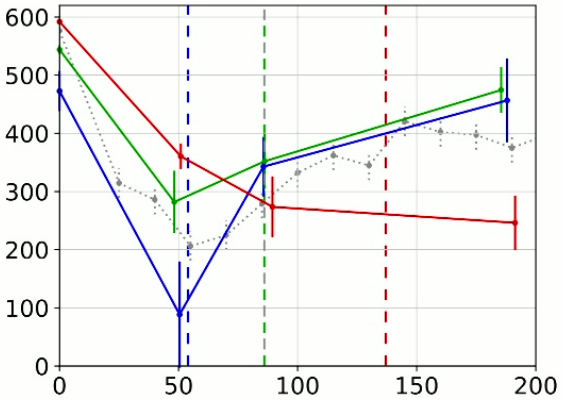
C IV vs. $M_\star$

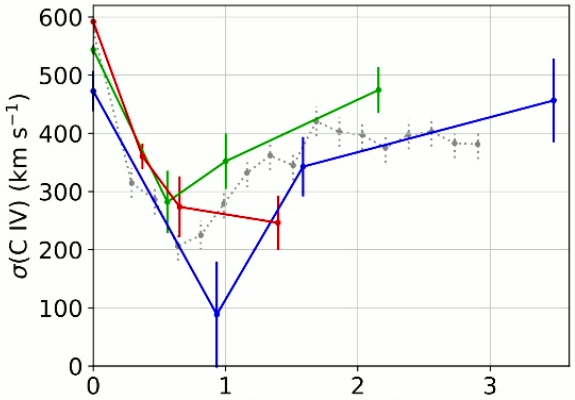
Equivalent Width
W_λ (Å)





Velocity Dispersion
σ (km s^{-1})





Impact Parameter D_{tran} (kpc)

D_{tran}/R_{vir}

Contributions

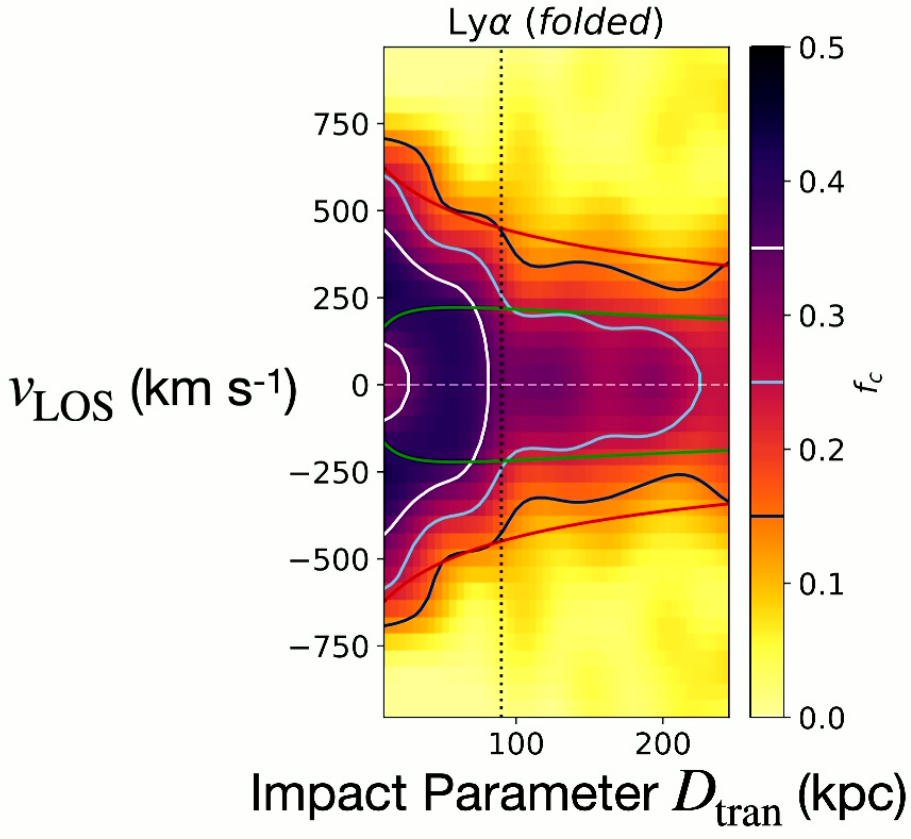
Argued galaxy-galaxy pairs offer a complementary means of probing the CGM to background QSOs

Developed statistically robust maps of the average z ~ 2 CGM

Connected inferred galaxy properties to their CGM structure

W_λ(C IV) and σ(C IV) vs. $M_\star$

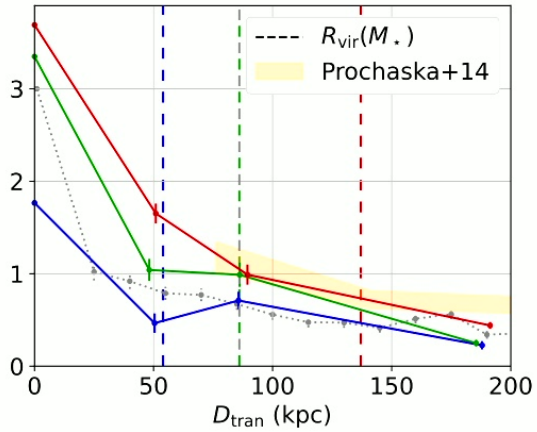
Stay tuned for nonresonant emission results!

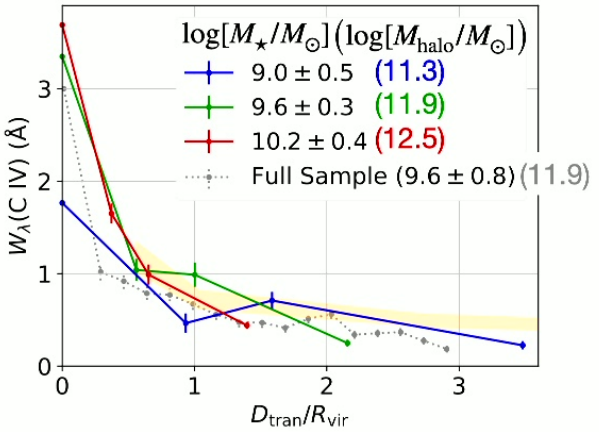


Nikolaus Prusinski | nik@astro.caltech.edu

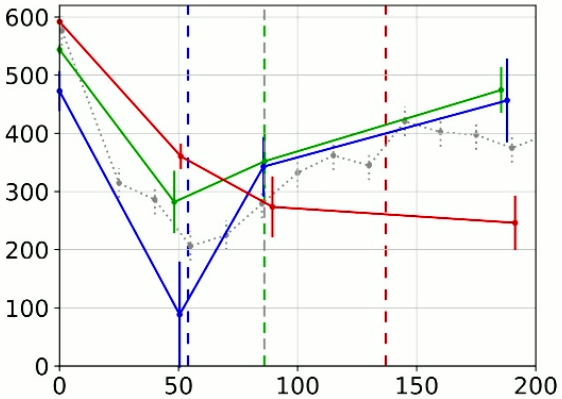
C IV vs. $M_\star$

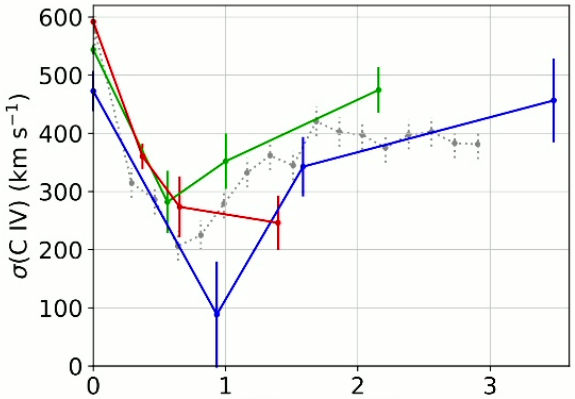
Equivalent Width
W_λ (Å)





Velocity Dispersion
σ (km s^{-1})





Impact Parameter D_{tran} (kpc)

D_{tran}/R_{vir}