Quenching Quandaries in the MgII Circumgalactic Medium

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Intergalactic Matters

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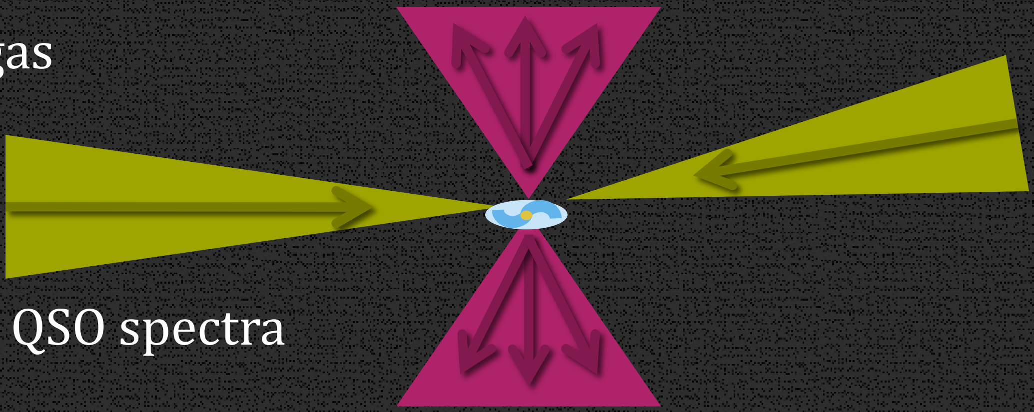
Circumgalactic Medium



- Large reservoir of multiphase gas
- Fuel for star formation
- Massive (e.g., Werk 2013)

- MgII absorption in background QSO spectra

- Accretion along dark matter filaments
  - e.g., Rubin 2012
- Outflows from SN feedback/stellar winds
  - e.g., Bouche 2012
- Merging satellite galaxies

- Infalling and outflowing material preferentially found along major and minor axes (e.g., Bordoloi 2011, Kacprzak 2012, Lan 2014)

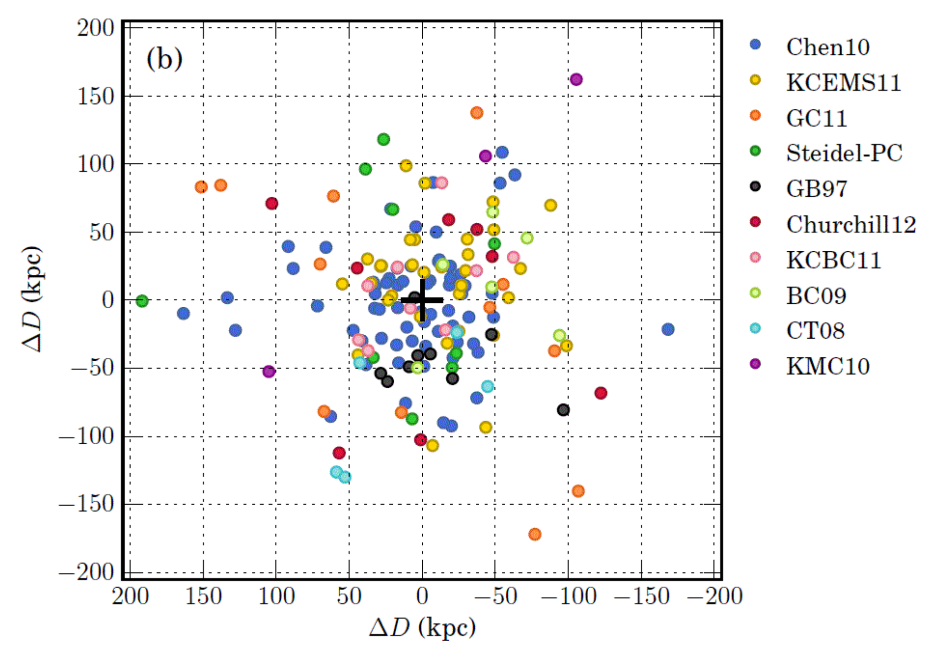
MAGIICAT

- MgII Absorber-Galaxy Catalog
- Isolated galaxies have:
  - Detected MgII absorption or an upper limit on absorption
  - D < 200 kpc
  - Spectroscopic redshifts z < 1
- Halo masses
  - Abundance matching
  - $10.7 < \log (M_h/M_{sun}) < 13.8$
  - Median $\log (M_h/M_{sun}) = 12$

astronomy.nmsu.edu/cwc/Group/magiicat

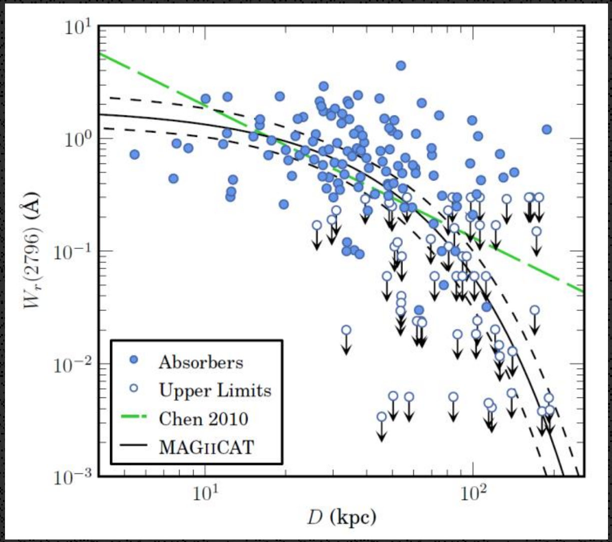
Table 4
MAGIICAT Properties

Property	Min	Max	Median
$W_r(2796)$ (Å)	0.003	4.422	0.400
z_{gal}	0.072	1.120	0.359
D (kpc)	5.4	93.5	48.7
M_B	−16.1	23.1	−20.4
M_K	−17.0	25.3	−22.0
L_B/L_B^*	0.017	5.869	0.611
L_K/L_K^*	0.006	9.712	0.493
$B-K$	0.04	4.09	1.48



MAGIICAT Papers

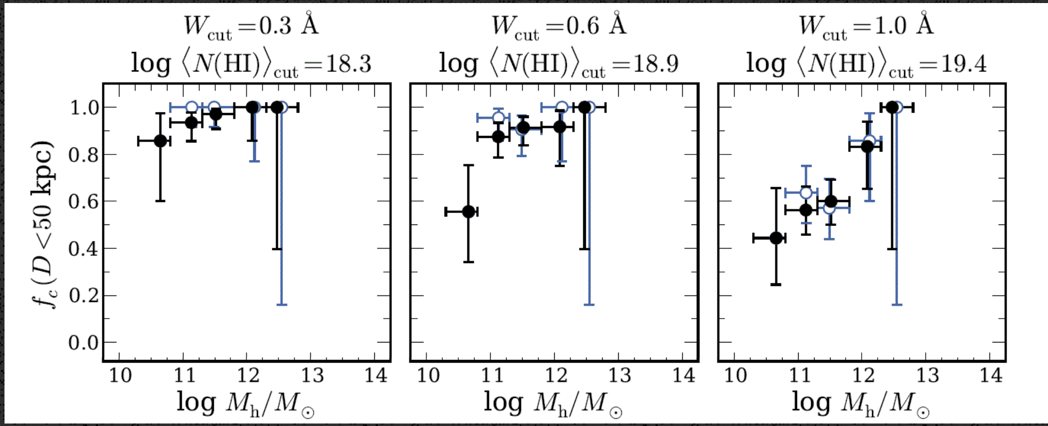
Paper I: Nielsen+ 2013, ApJ, 776, 114
Description of and methods used to create MAGIICAT



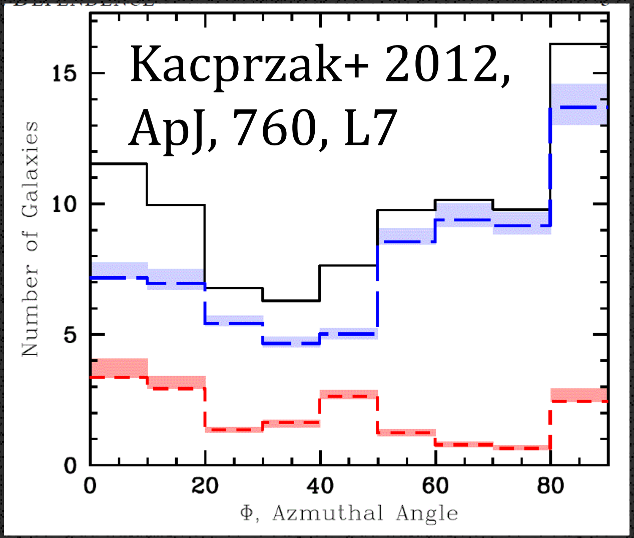
Paper II: Nielsen+ 2013, ApJ, 776, 115
Anti-correlation between W(MgII) and D, covering fractions, luminosity-scaled radii

Churchill+ 2013, ApJ, 763, L42
Self-similarity of the CGM with mass

Paper III: Churchill+ 2013, ApJ, 779, 87
Masses from halo abundance matching

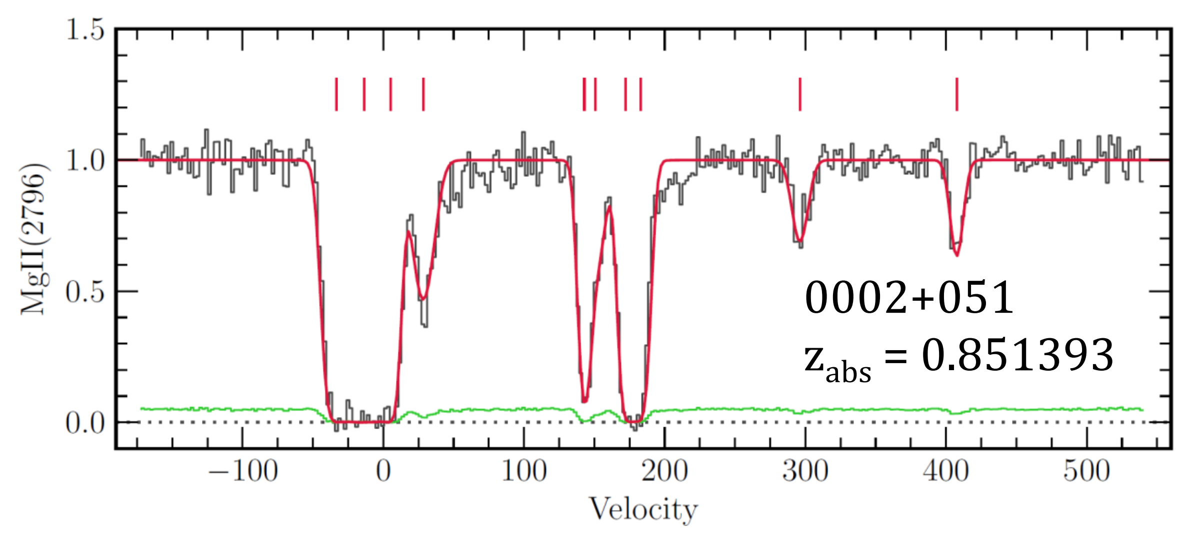


Kacprzak+ 2012, ApJ, 760, L7



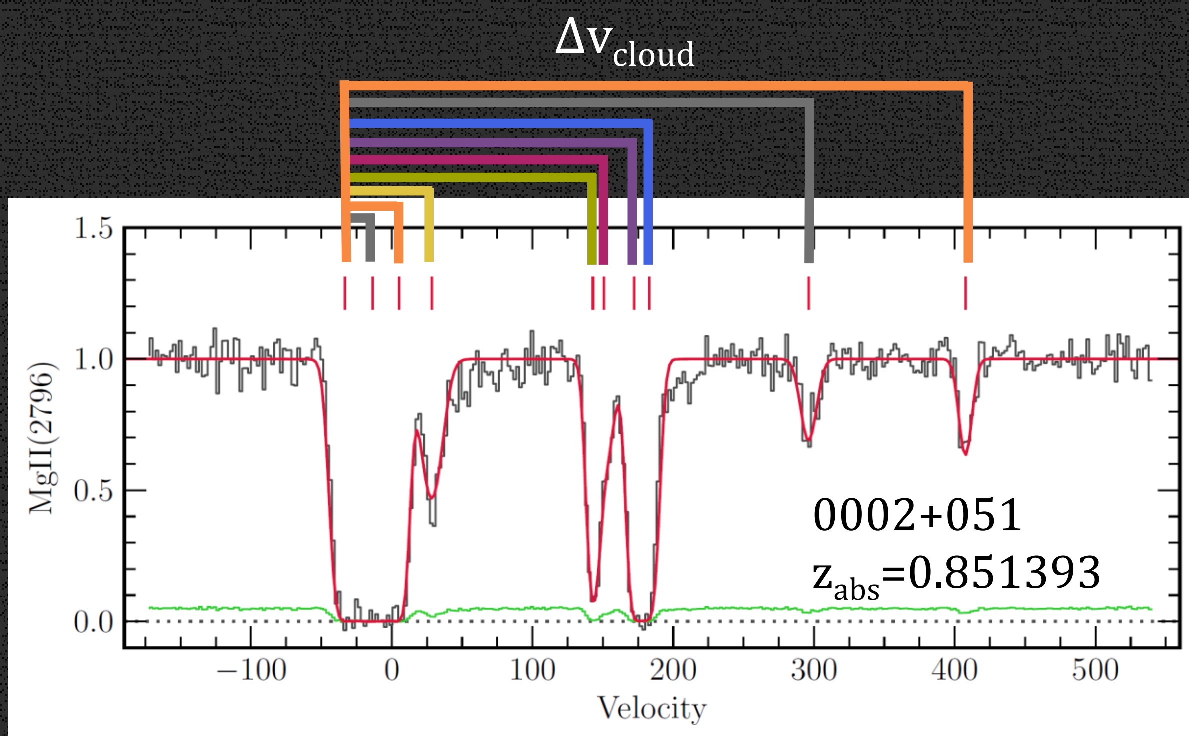
Kinematics Subsample

- 47 MAGIICAT absorber-galaxy pairs with HIRES/UVES spectra
- Voigt profile fitted
- Quantities obtained from fitting:
  - # of clouds and cloud velocity, EW, column density, & Doppler b parameter
- EW sensitivity cut of 0.07 Å

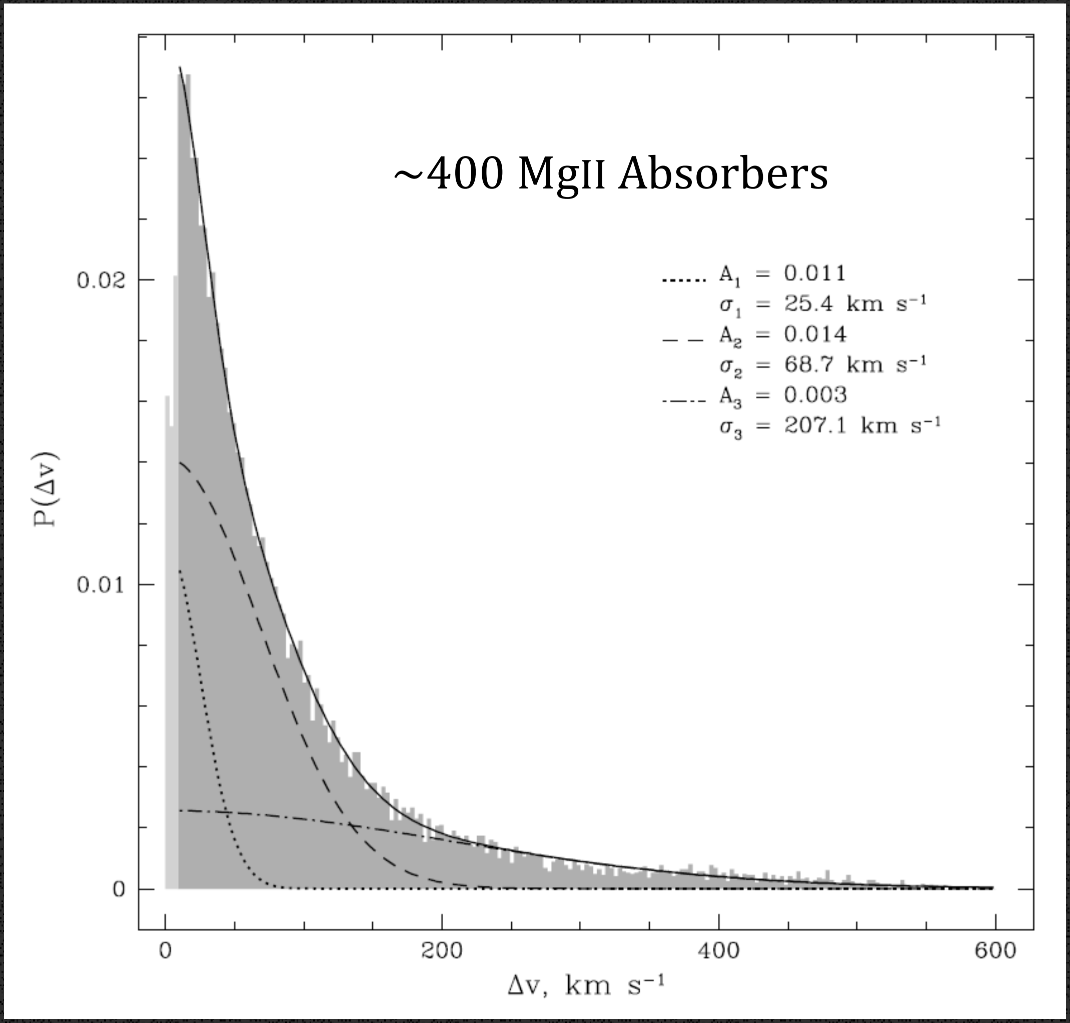


Two-Point Velocity Correlation Function

- Cloud-cloud velocity probability distribution function
- Probability of finding any two clouds separated by Δv



Two-Point Velocity Correlation Function



Other works attribute gaussians to:

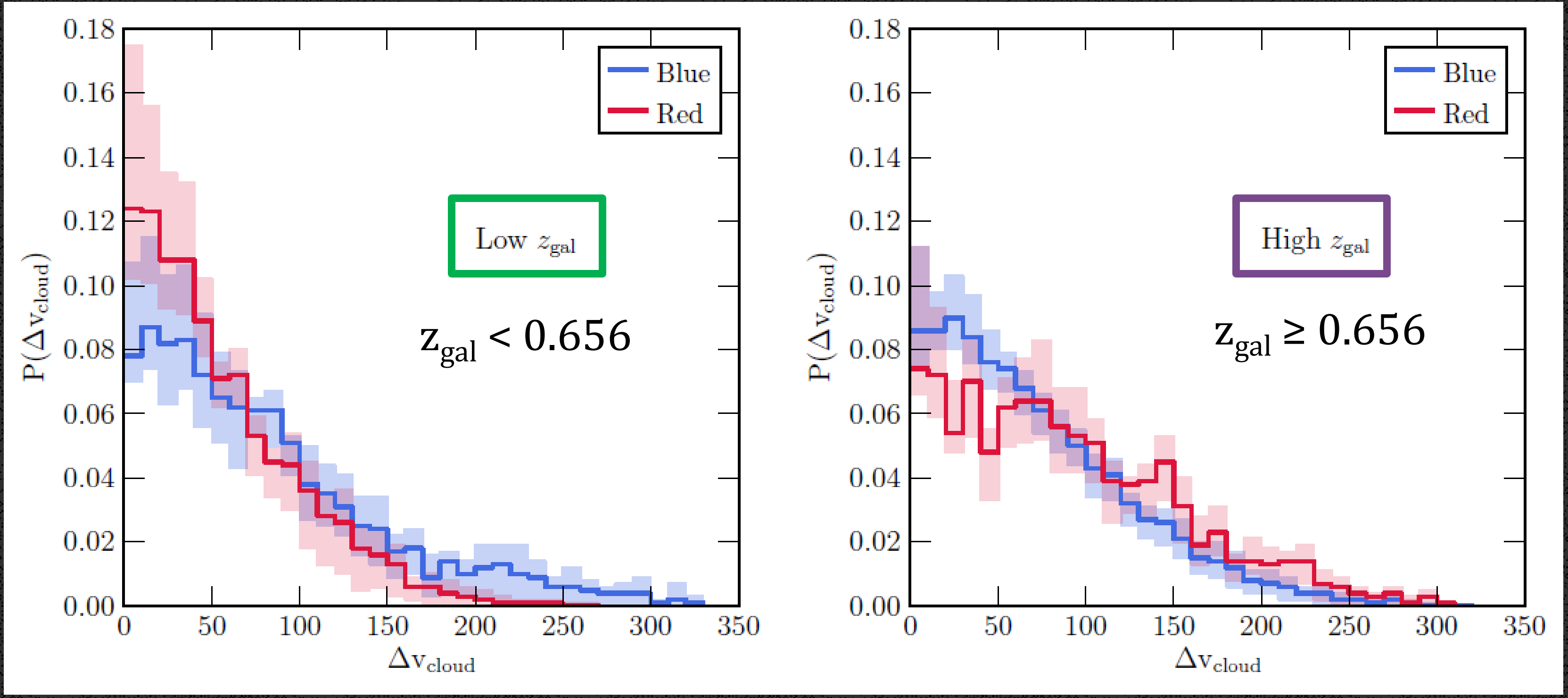
Motions within galaxy and between galaxy pairs (Petitjean & Bergeron 1990)

Vertical dispersion in galaxy disks and rotational motion (Churchill+ 2003)

Absorption TPCF (velocities with respect to z_{abs})

- Low z: absorbers around red galaxies are more relaxed than blue
- High z: similar velocity structure

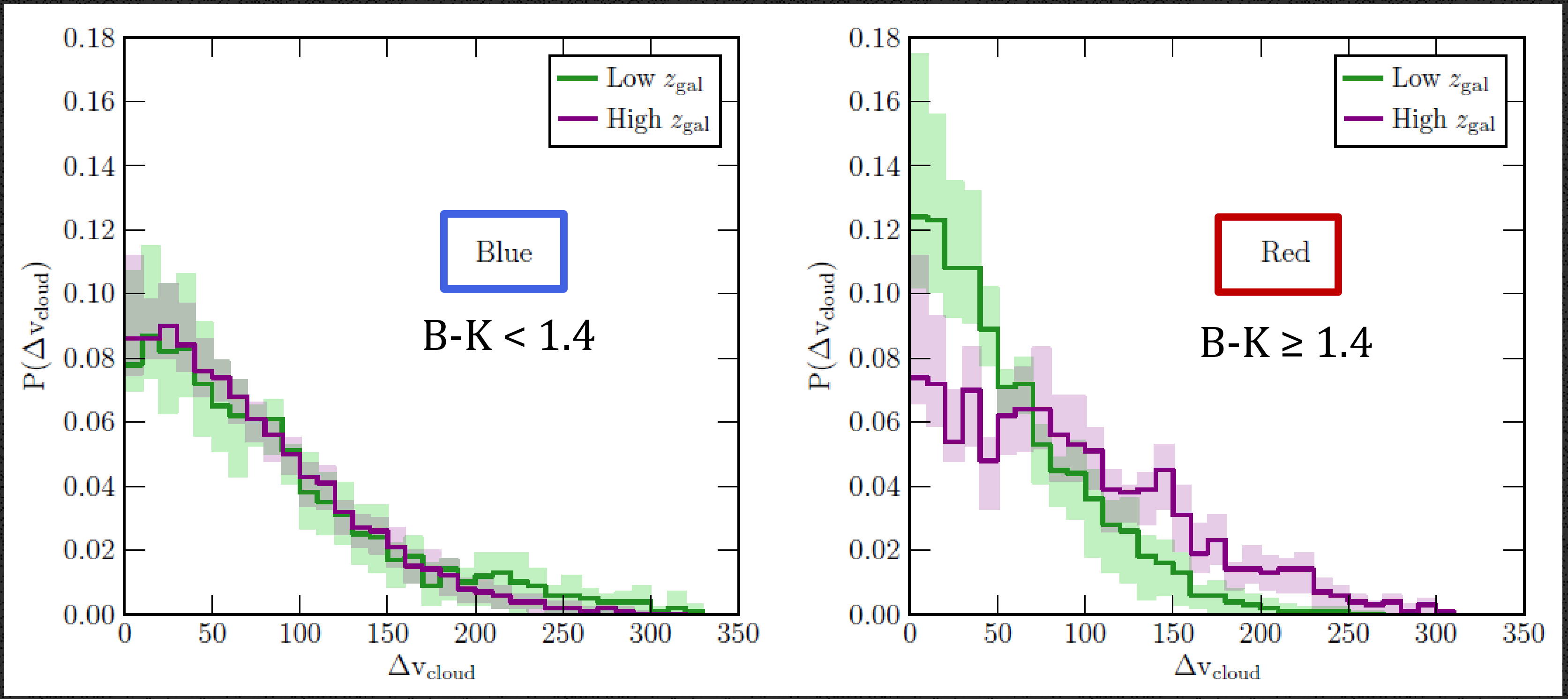
B-K cut = 1.4



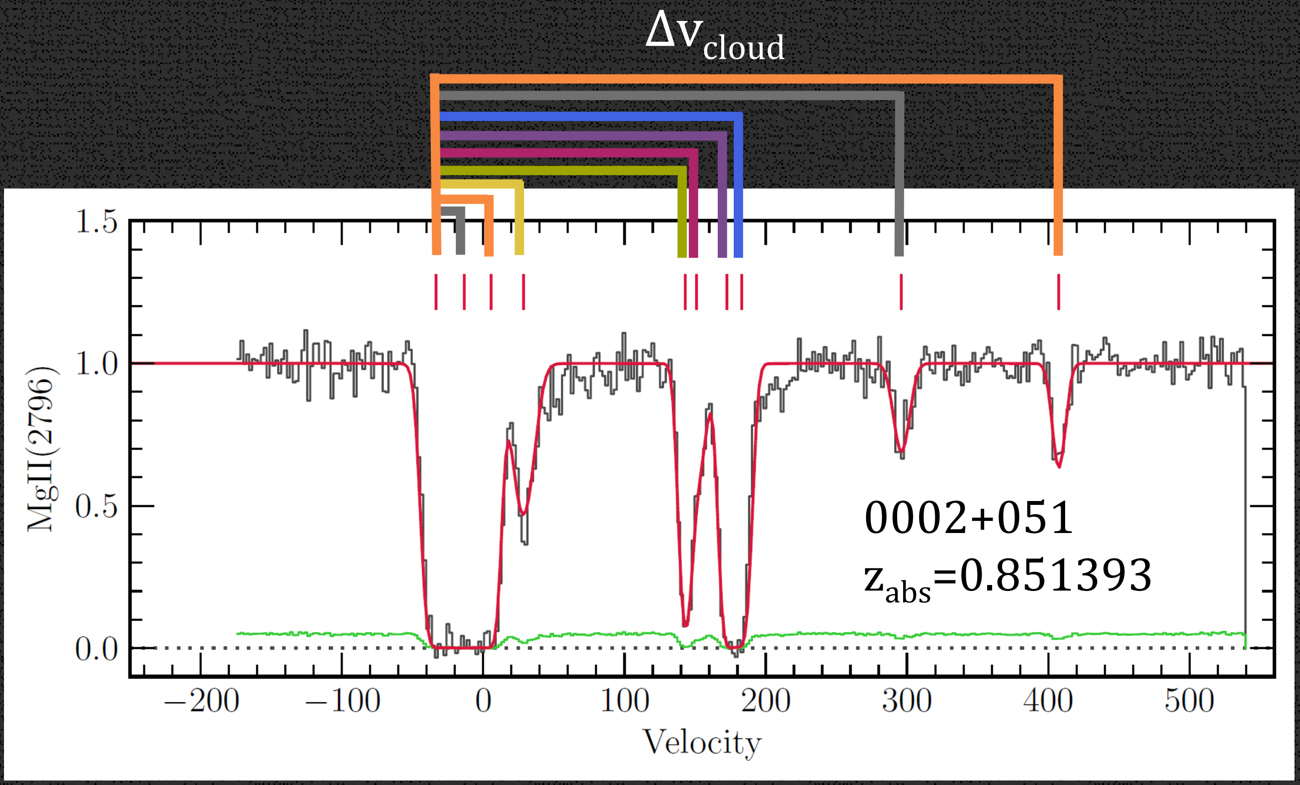
Absorption TPCF (velocities with respect to z_{abs})

- Blue galaxies – velocity structure unchanged over 2 Gyrs; P(KS)=0.0186
- Red galaxies – redshift evolution with gas becoming more relaxed at low z; absorbers less turbulent

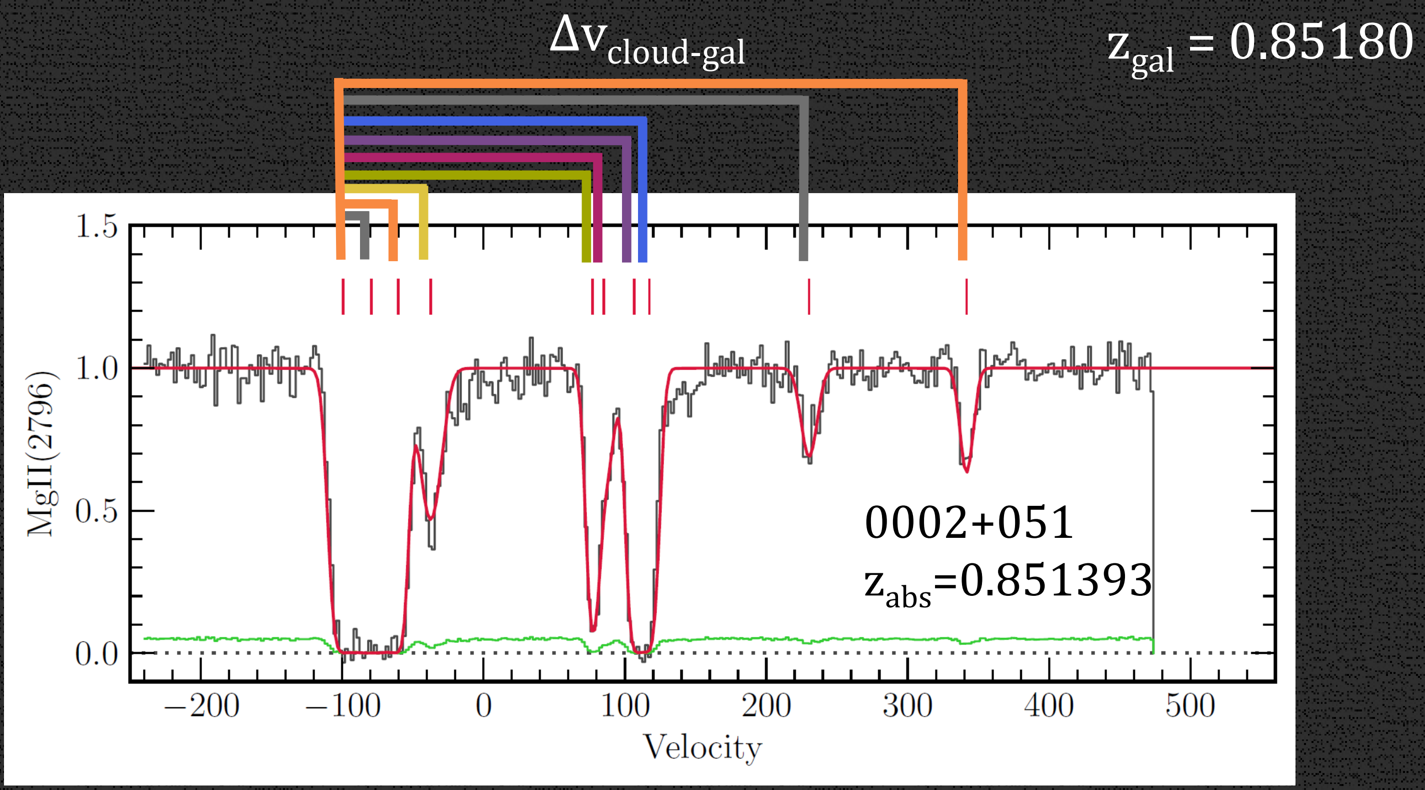
z_{gal} cut = 0.656



TPCF with respect to the galaxy



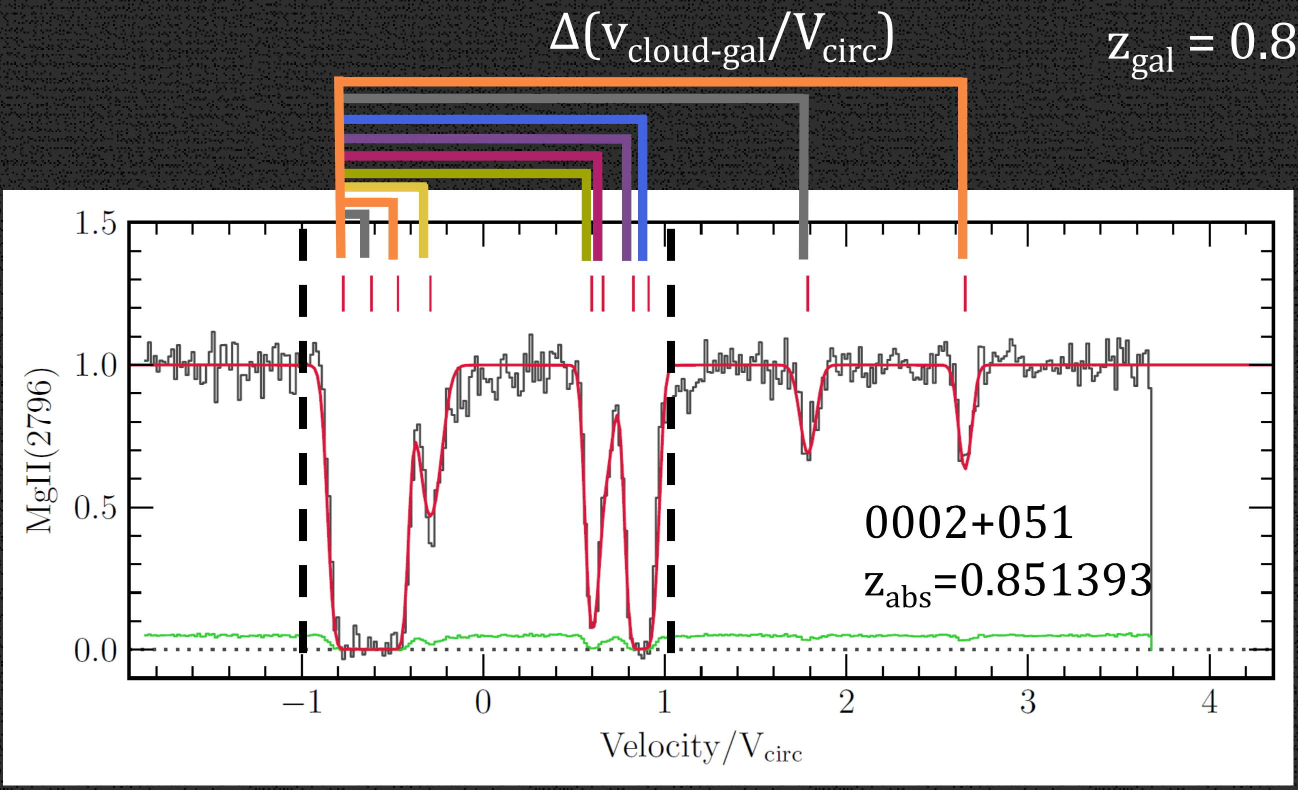
TPCF with respect to the galaxy



TPCF normalized with respect to the galaxy

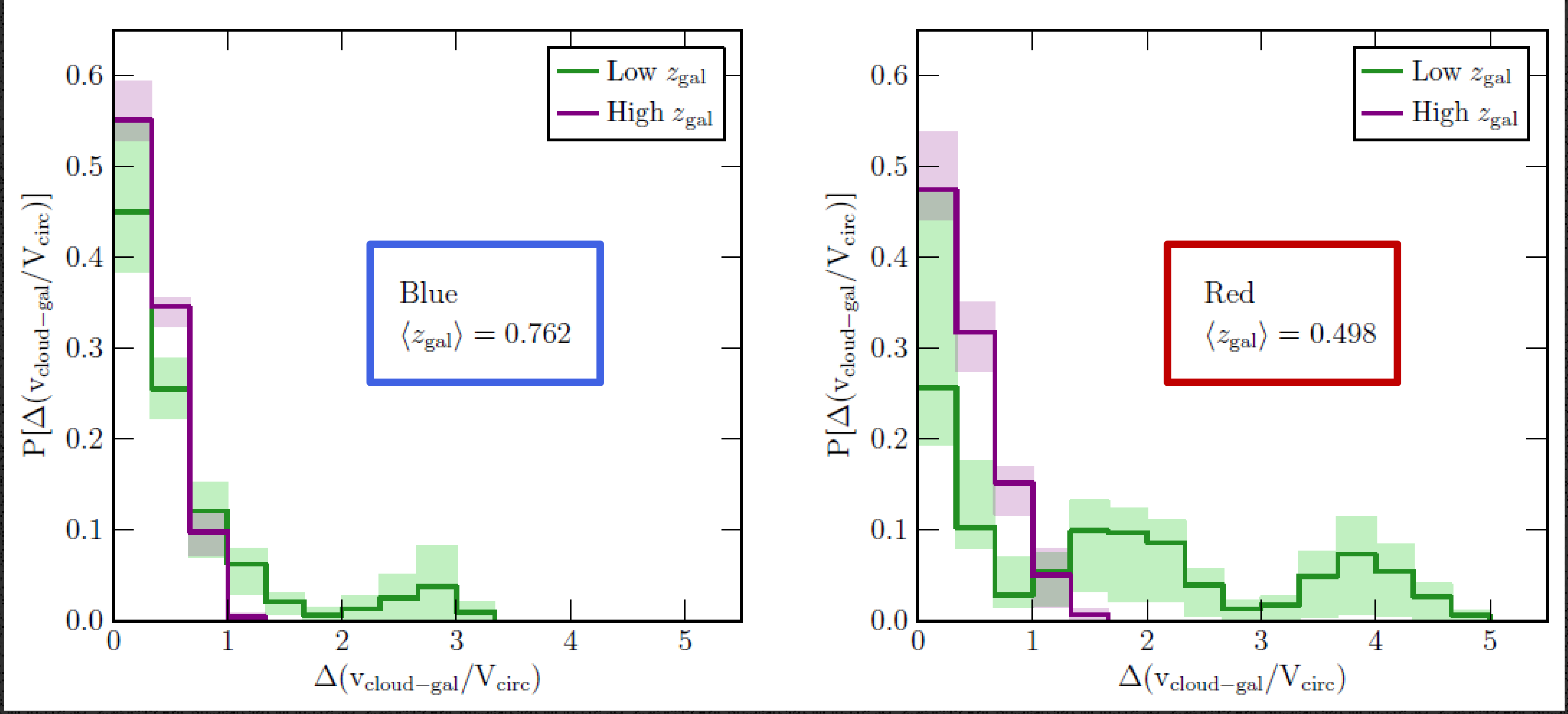
V_{circ} =220 km/s

z_{gal} = 0.85180



TPCF normalized with respect to the galaxy

- Blue galaxies – narrow velocity range, possible winds at low z
- Red galaxies – narrow velocity range at high z, high velocities at low z, more extended in velocity than blue gals



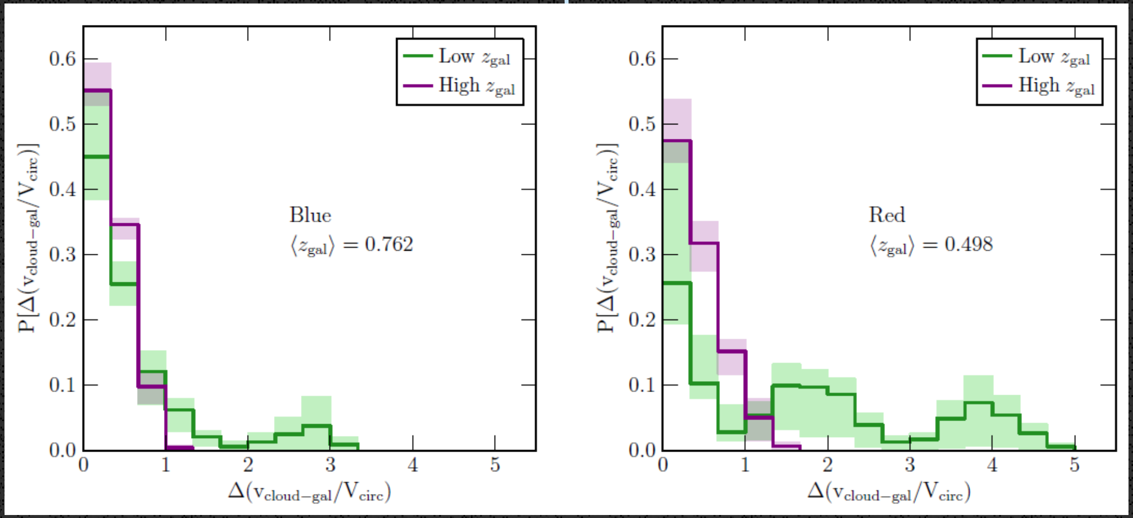
Quandaries…

Questions

- What is the kinematic nature of higher velocity material around galaxies at lower z?
- Why is it present and so dramatic in red galaxies?

Expectations

- Blue galaxies currently forming stars, red galaxies are not
  - Outflows and infall expected in blue galaxies but not in red
- Red galaxies tend to be in more overdense environments
  - Material seen at high Δv might be gas in satellites



Quandaries...

Questions

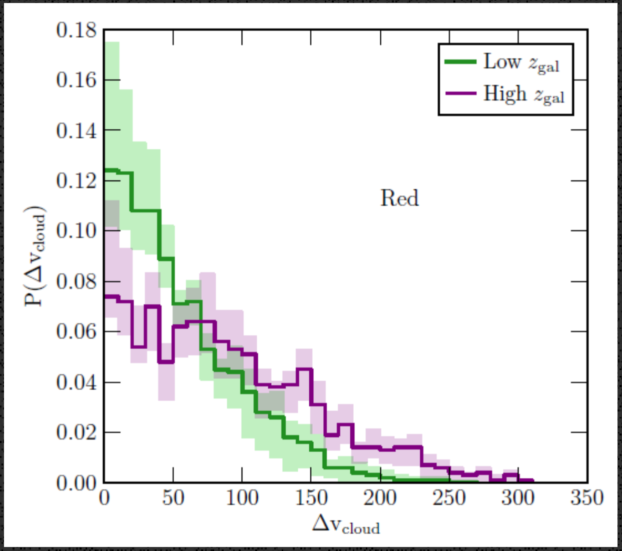
- Why does gas in absorbers become more quiescent over time in red galaxies but more stirred up with respect to the galaxy at lower redshift?

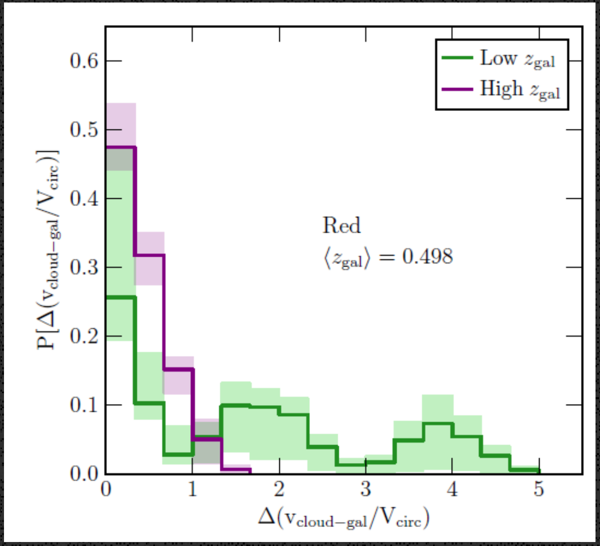
- Simulations would help!

Expectations

- Expect the galaxies to become more quiescent over time rather than more active
  - Ancient outflows in red galaxies stirred up material while absorbers themselves have since settled

Internal absorber dispersion



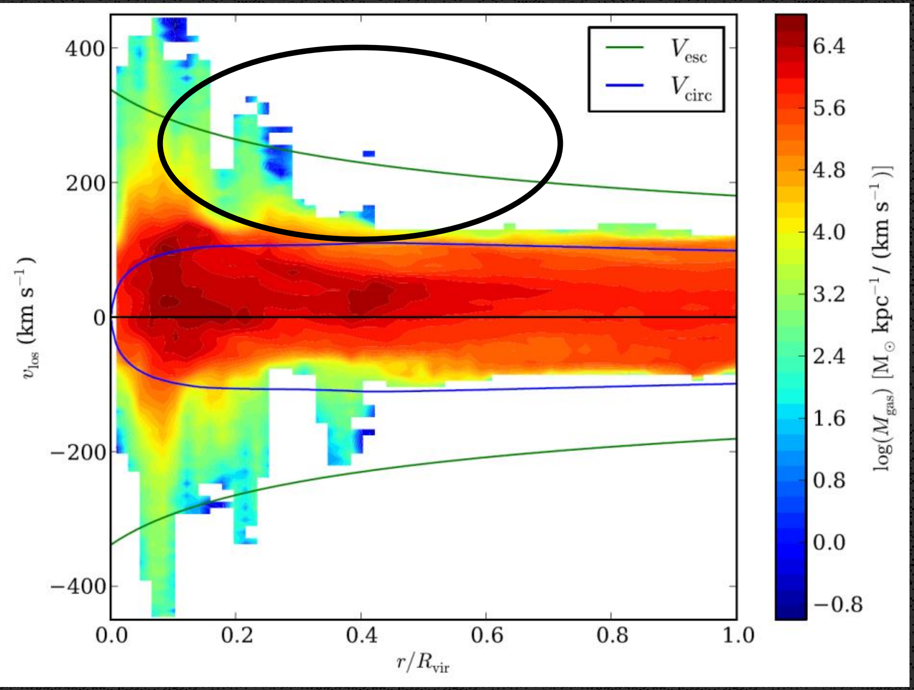


Dispersion of absorbers around galaxy

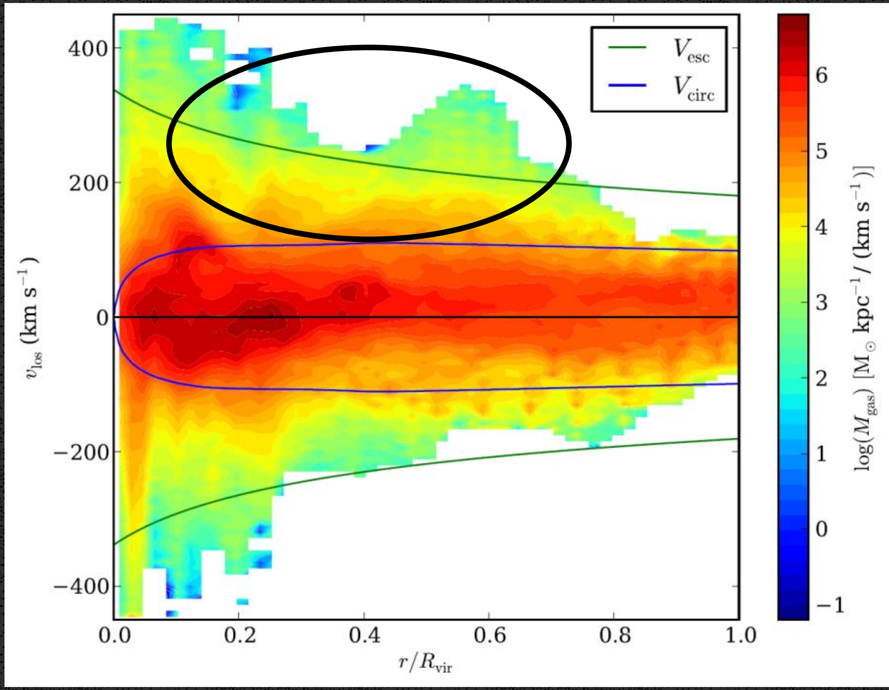
Preliminary Simulation Results

- Adaptive mesh refinement N-body+hydrodynamics code *hydroART*
- Spiral galaxy model: spALL_40;
- log M_h/M_{sun} = 11

Infalling material



Outflowing material



Conclusions

- Absorbers in red galaxies become more quiescent over time while blue galaxy absorber structures do not change over 2 Gyr
  - Absorption in blue galaxies may reflect ongoing evolution, while the settling of absorption in red galaxies may indicate passive evolution – no more stirring of the gas

- Absorption around galaxies at lower redshift has larger velocity dispersions than at higher redshift. Possible outflows at lower redshift?
  - This may indicate some dynamical mixing that could make it more difficult to accrete on the galaxy, especially for absorbers around red galaxies

- Preliminary simulations may indicate that material found with velocities exceeding V_{circ} are more likely to be outflowing