



The circumgalactic medium of the Milky Way and Andromeda

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Outline

Observations of metals

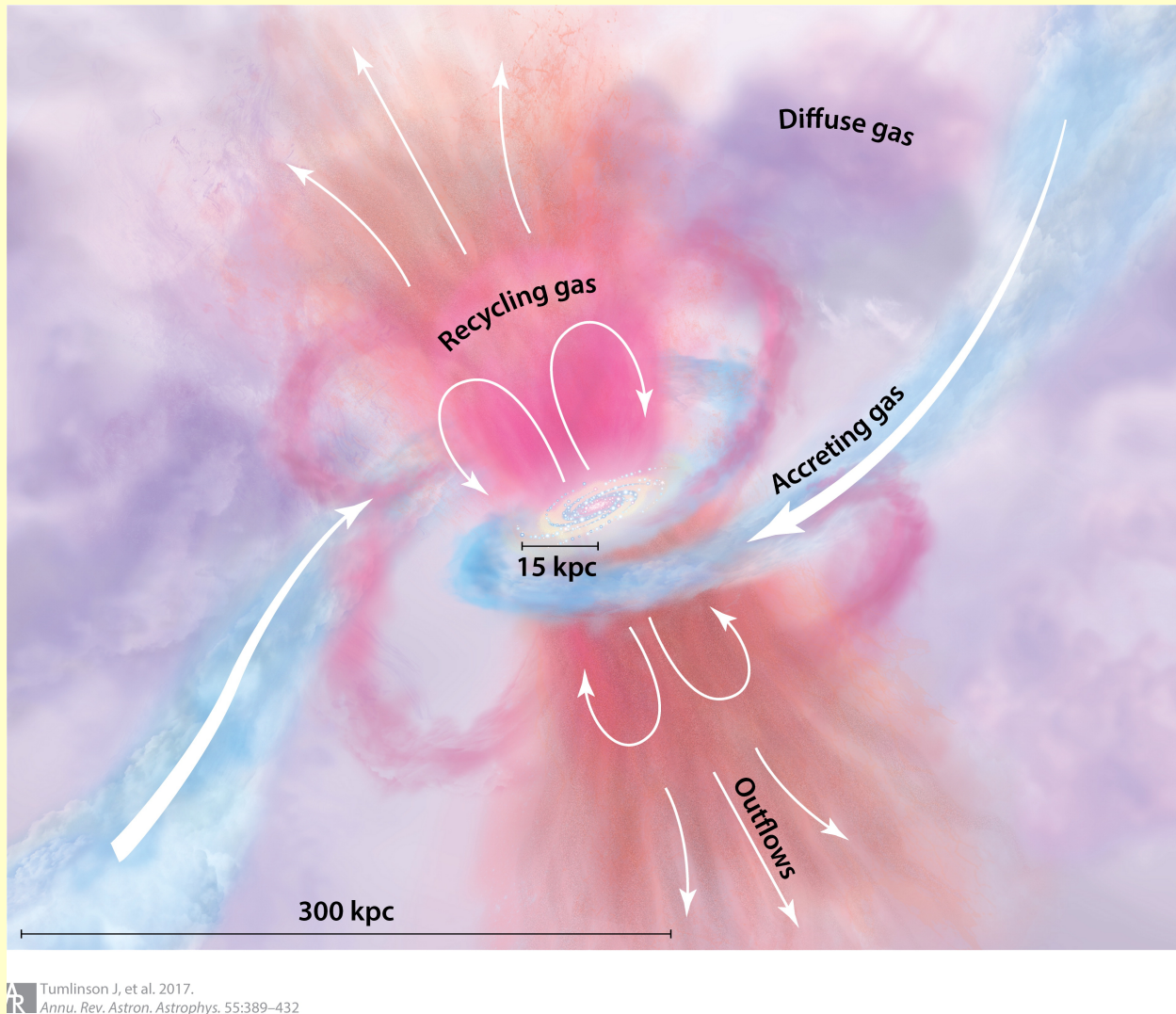
Observations of HI

Cosmological context

Conclusions

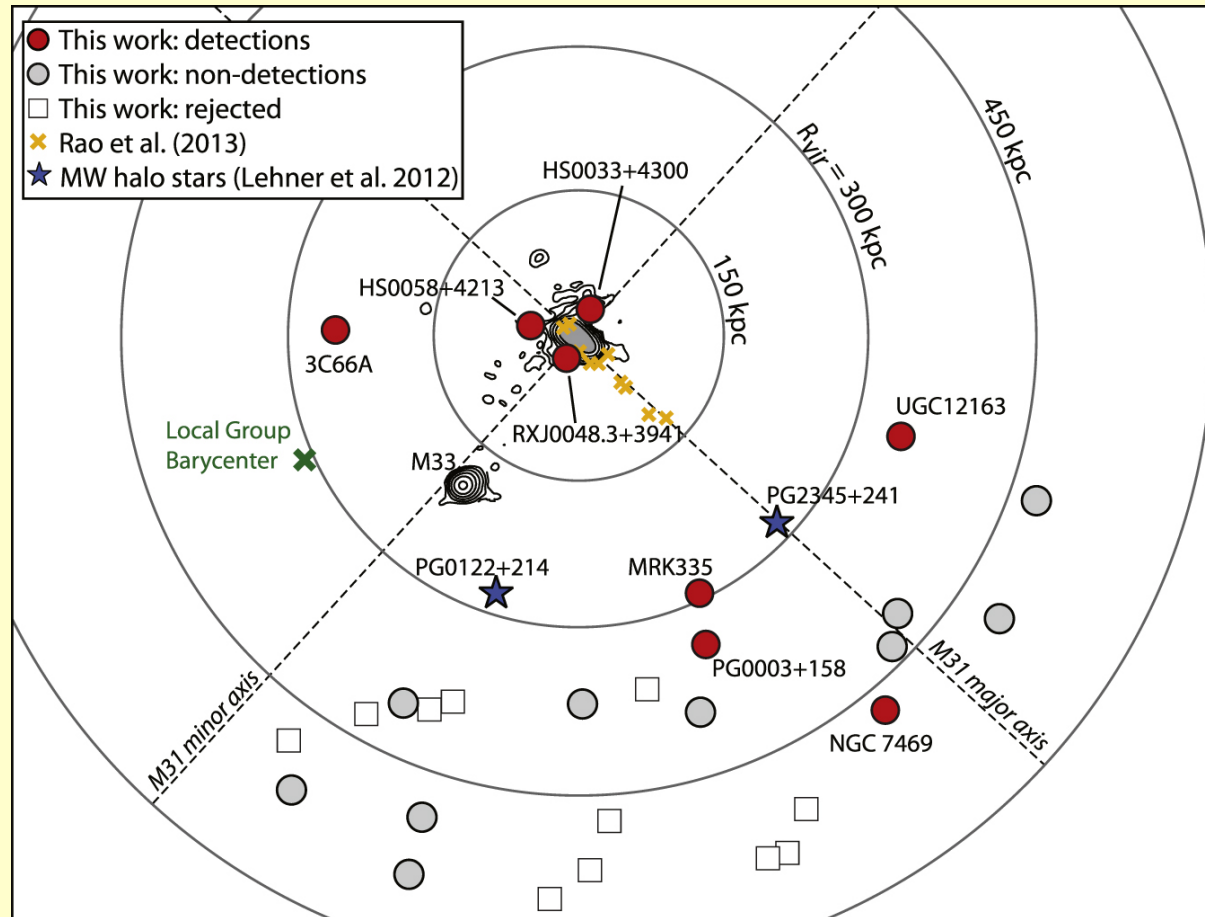


Andromeda



(from Tumlinson et al. 2017)

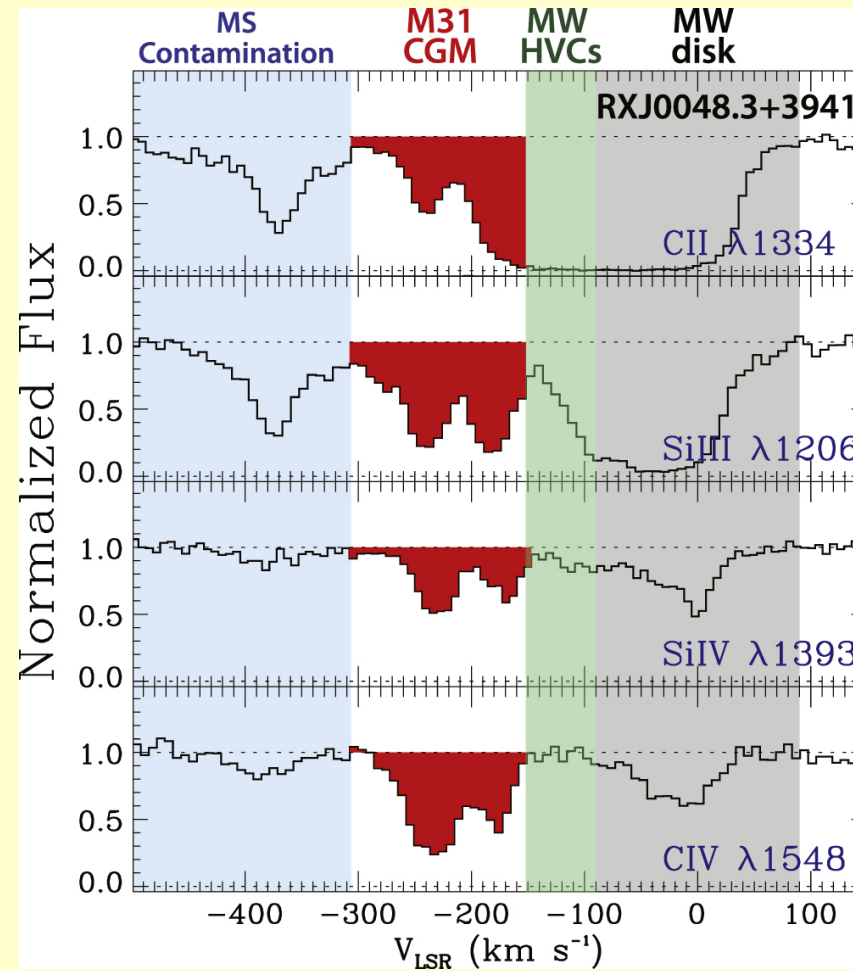
Metal absorption lines: Andromeda



HST/COS lines of sight to background AGN

(Lehner, Houk & Wakker 2015)

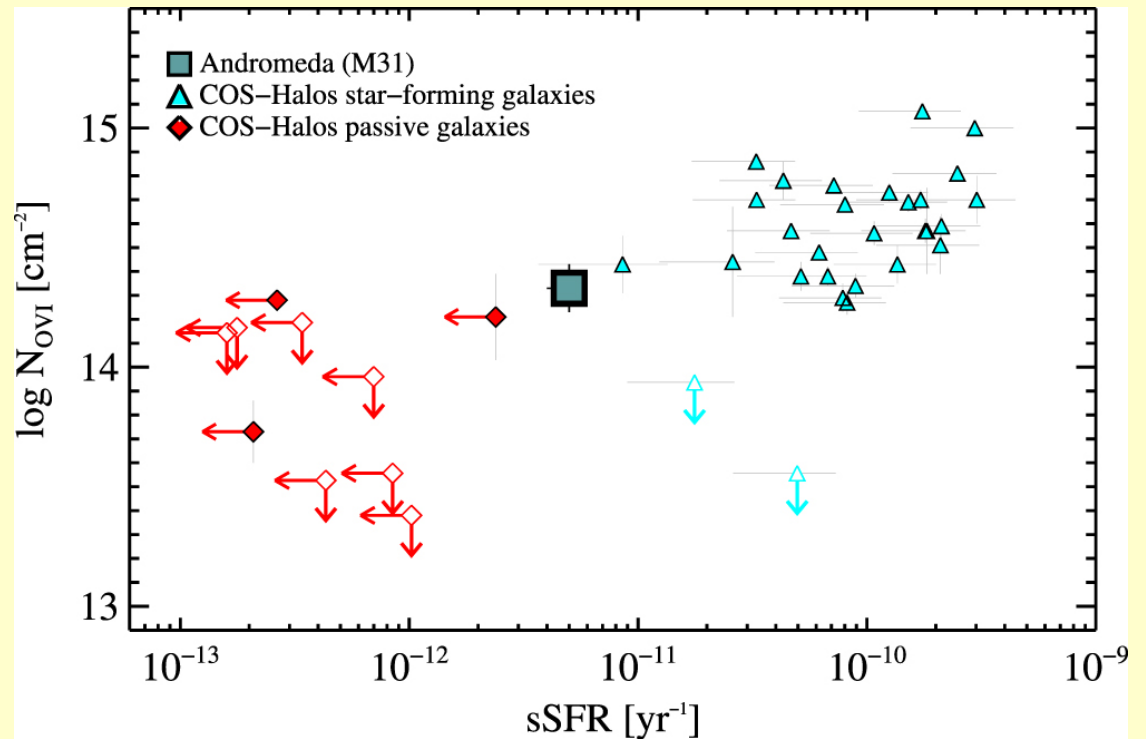
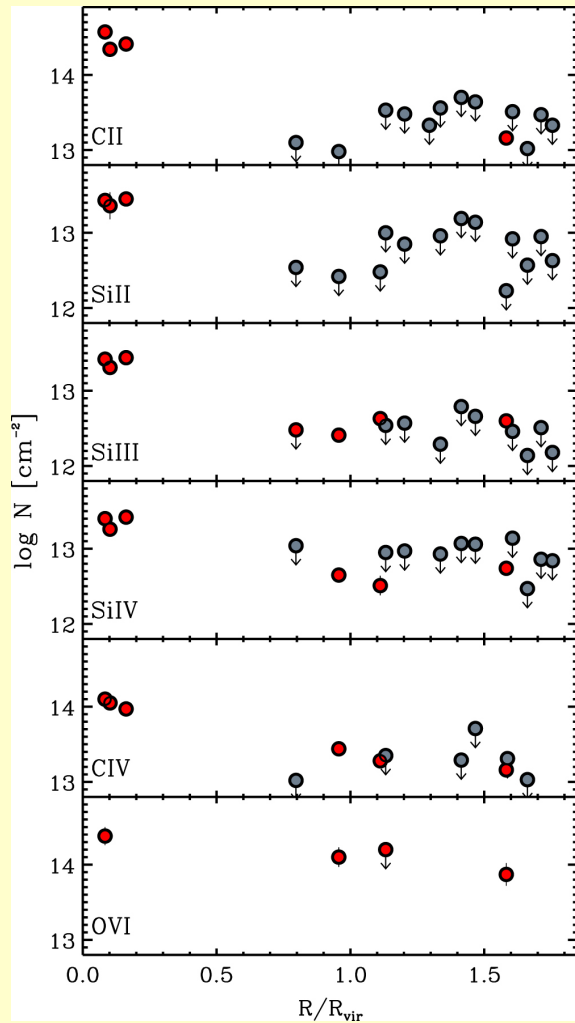
Metal absorption lines: Andromeda



HST/COS spectra to background AGN

(Lehner, Houk & Wakker 2015)

Metal absorption lines: Andromeda



Range in ionization states: evidence for multiphase CGM

(Lehner, Houk & Wakker 2015)

Metal absorption lines: Andromeda

Metal ion covering fractions

High ionization species

- At $r < 0.8R_{\text{vir}}$, f_c for SiIII and CIV is 0.6-1.
- At $r > R_{\text{vir}}$, f_c for SiIII and CIV drops to 0.1-0.2.

Low ionization species

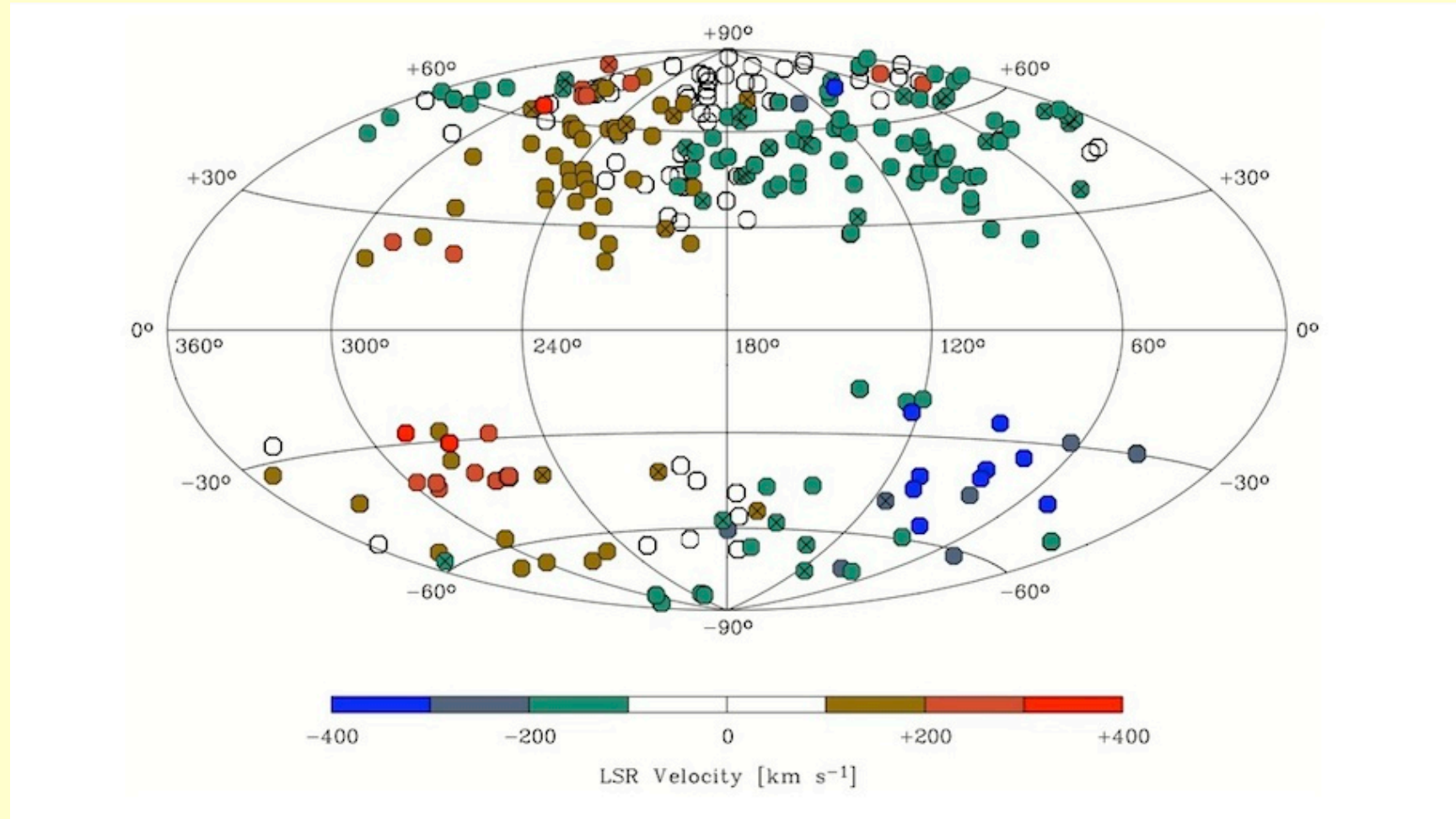
- At $r < 0.8R_{\text{vir}}$, f_c for SiII and CII is ~ 1 .
- At $r > R_{\text{vir}}$, f_c for SiII and CII is $\ll 1$.

Gas mass of cool component (based on SiII, SiIII and SiIV)

$$M_g(r < R_{\text{vir}}) \sim 1.3 \times 10^9 M_{\odot} (Z/Z_{\odot})^{-1}$$

(Lehner, Houk & Wakker 2015, 2017)

Metal absorption lines: Milky Way HVCs

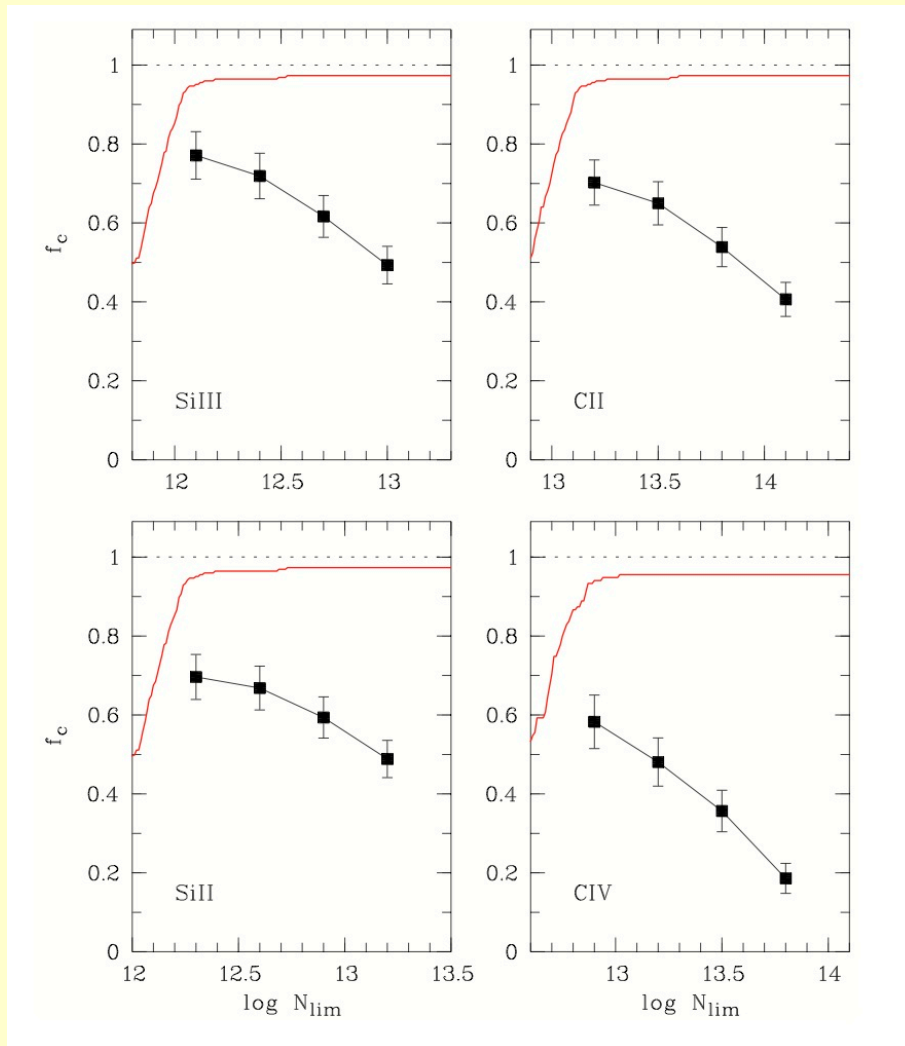


HST/COS lines of sight to background AGN

(Richter et al. 2017)

Metal absorption lines: Milky Way HVCs

Metal ion covering fractions



(Richter et al. 2017)

Combining HVC distances and metallicities with C and Si covering fractions and column densities gives cool gas mass

$$M_g(r < R_{\text{vir}}) \sim 4.3 \times 10^7 M_{\odot}$$

~1% of Magellanic Stream

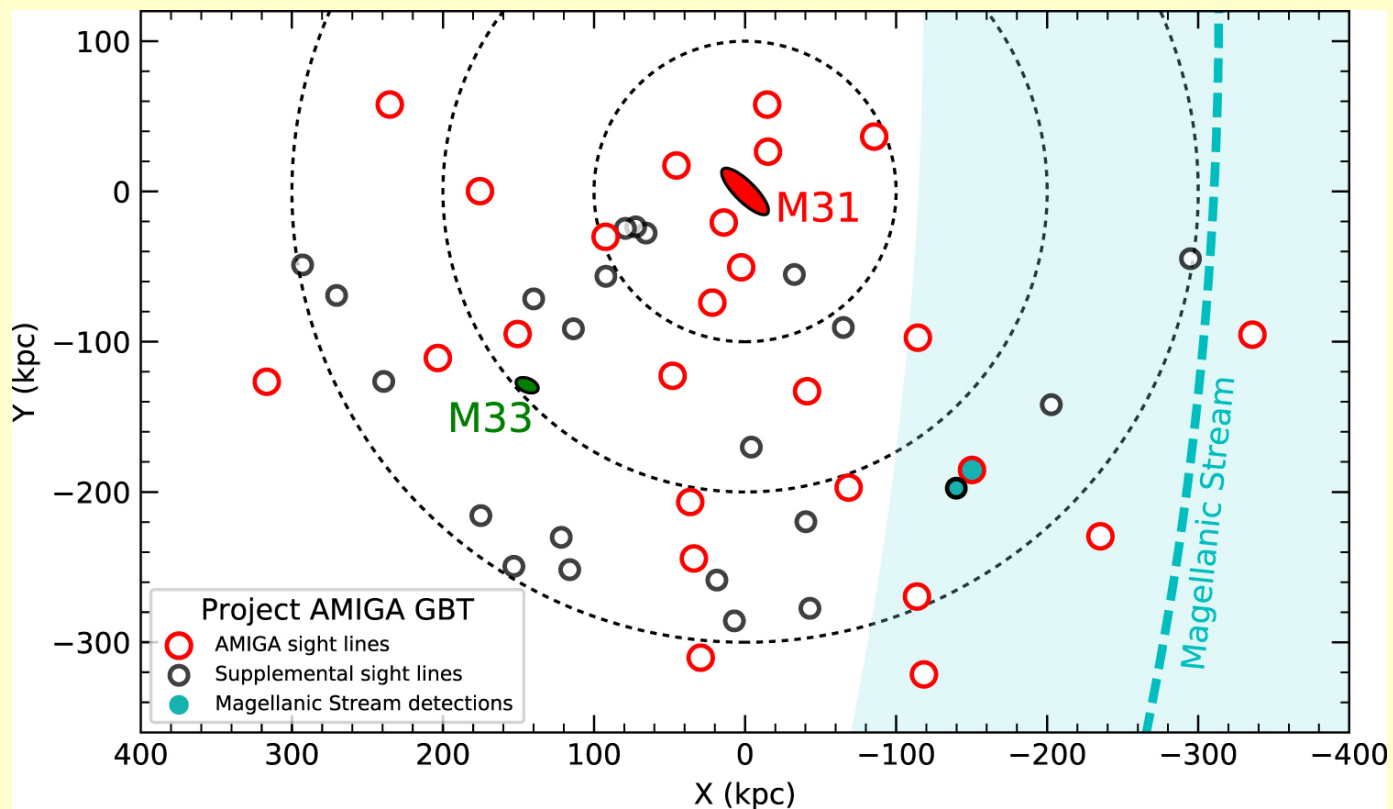
An infall velocity of $v_{\text{infall}} \sim 100 \text{ km s}^{-1}$ gives an accretion rate (for 100% infall)

$$\sim 0.6 M_{\odot} \text{ yr}^{-1}$$

1/10th of Magellanic Stream

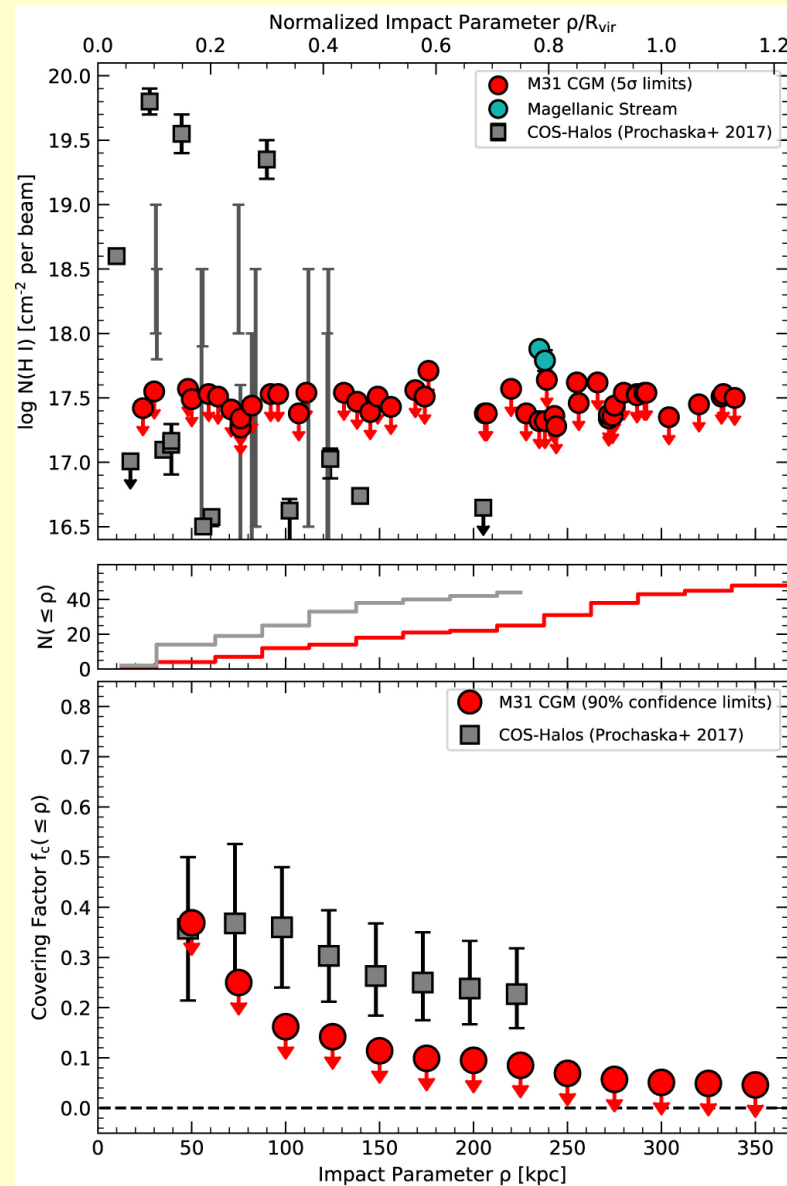
Search for HI in emission: Andromeda

21-cm searches using 100-m Byrd Green Bank Telescope



(Houk et al. 2017)

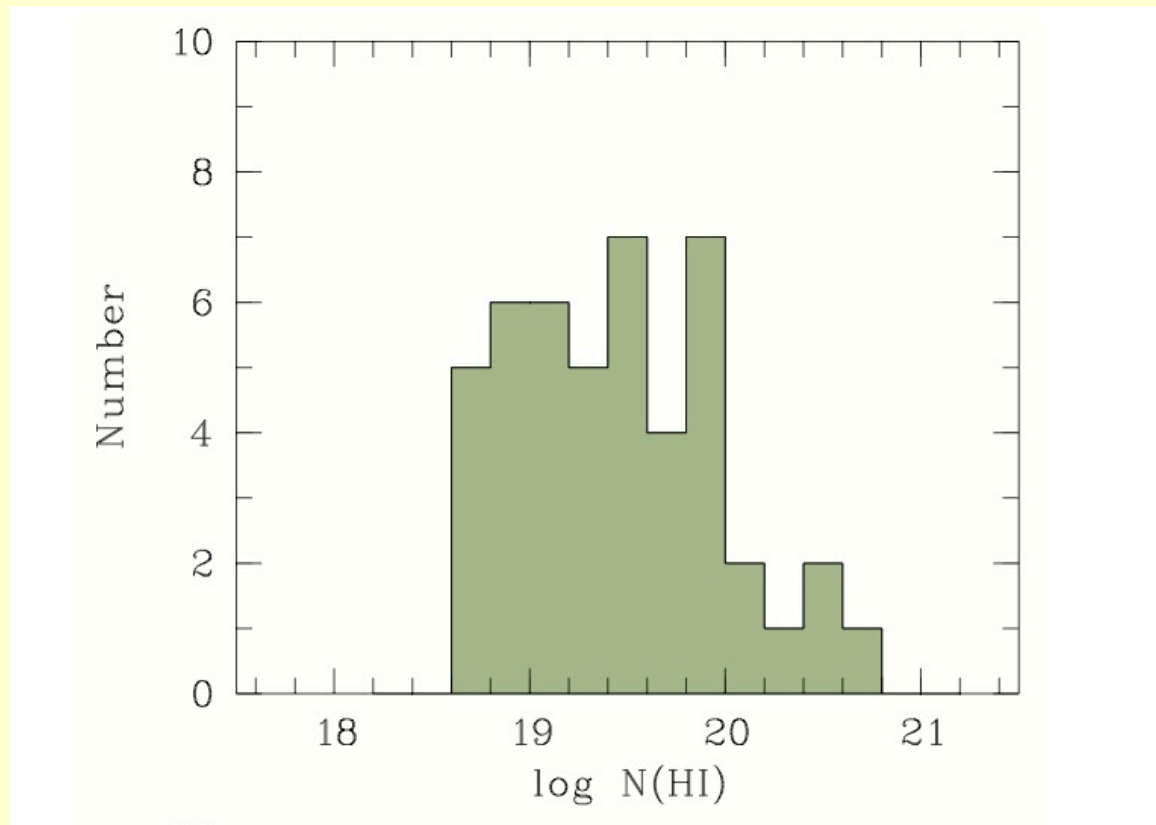
Search for HI in emission: Andromeda



Obtain very low HI
covering fractions
for impact
parameters > 50 kpc

(Houk et al. 2017)

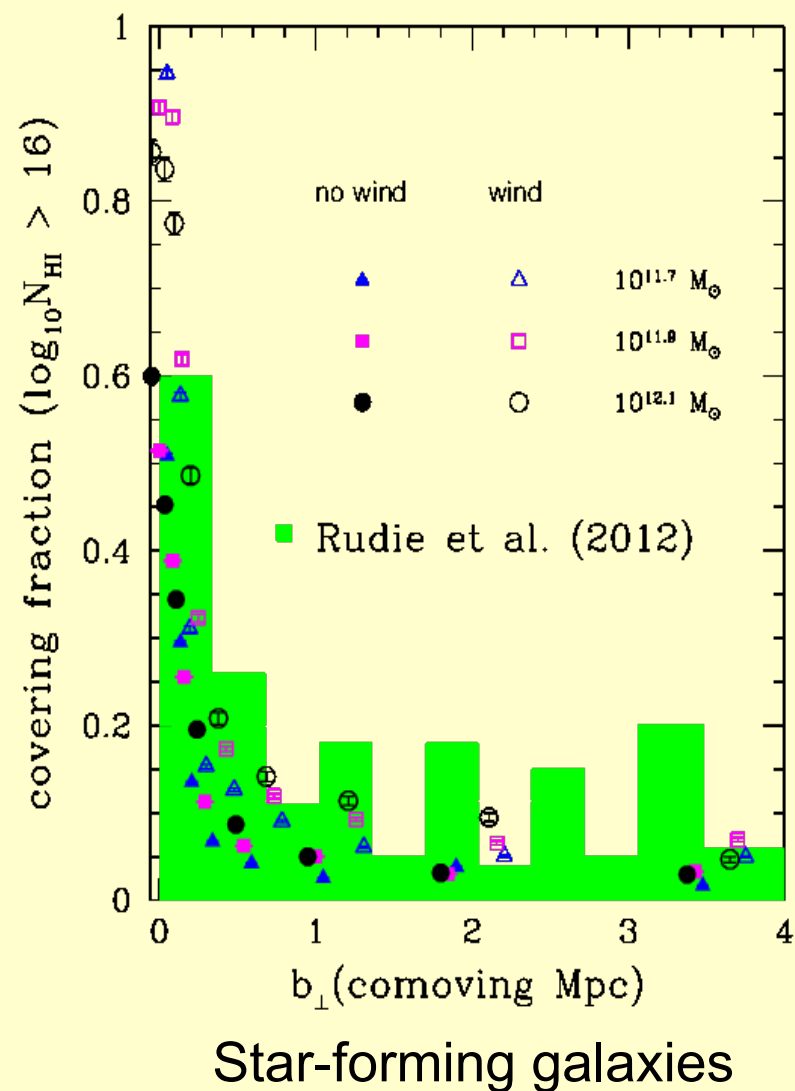
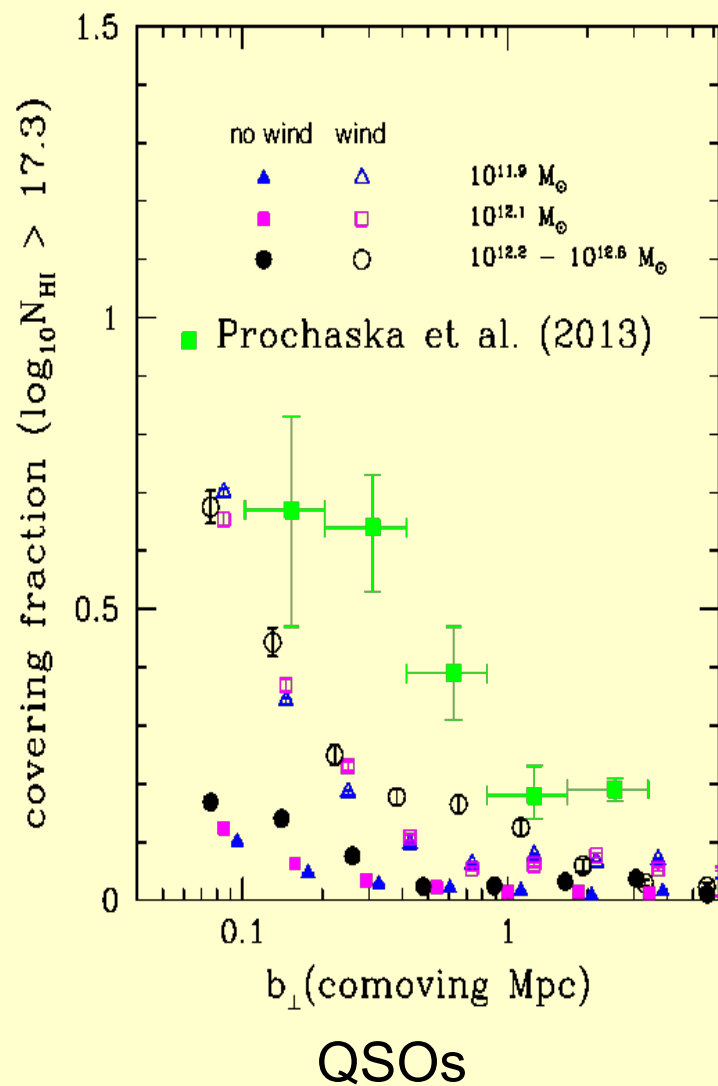
HI in absorption: Milky Way HVCs



A range of HI
column densities
(for subsample with
 $\log_{10} N_{\text{HI}} > 18.7$)

(Richter et al. 2017)

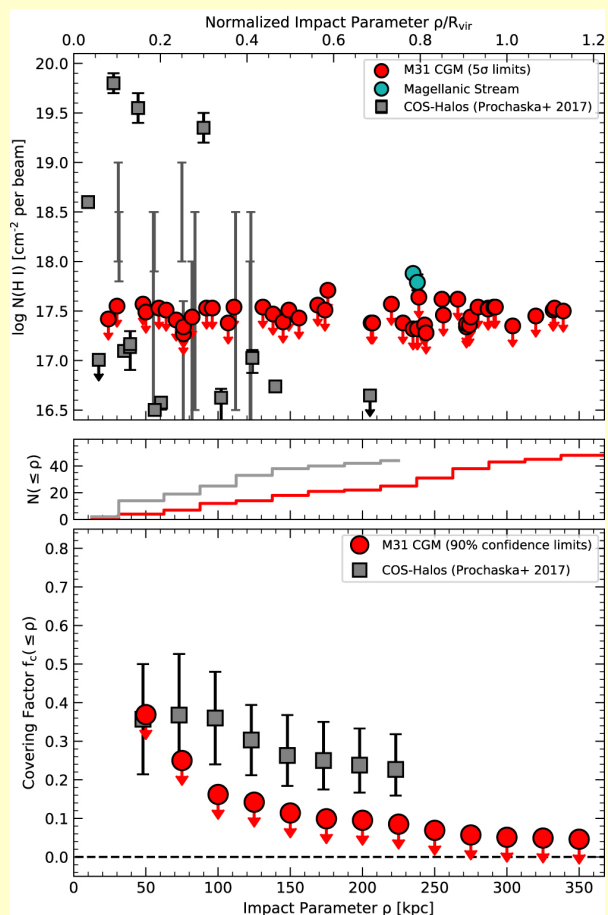
Hydrogen covering fraction at $z > 2$



(AM, Bolton & Puchwein 2017)

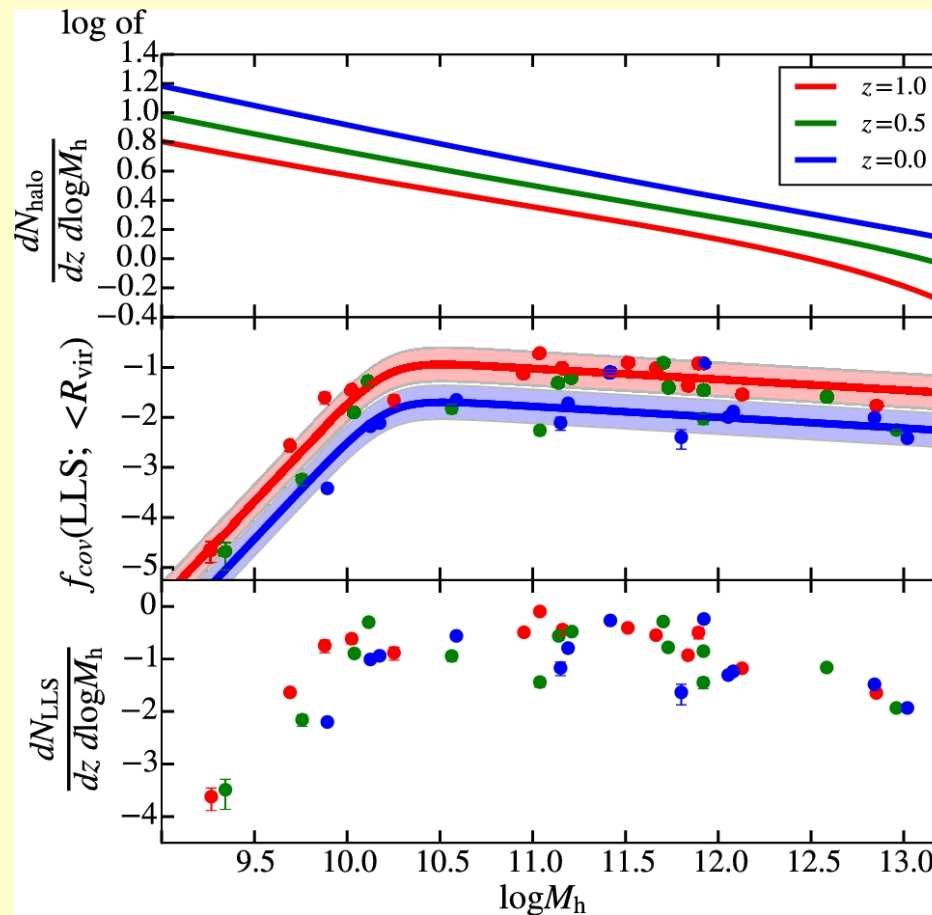
Hydrogen covering fraction at $z < 1$

COS Halos-survey at $z \sim 0.2$



(Prochaska et al. 2017)

FIRE simulations



(Hafen et al. 2017)

Conclusions

- The Milky Way and Andromeda galaxies are surrounded by a metal-enriched multiphase gaseous medium extending out at least as far as their virial radii: the Circumgalactic Medium (CGM).
- Inflow and outflow of gas between the galaxies and their CGM may be occurring at rates comparable to the galactic star formation rates, so that the CGM may play an essential role in the structure and evolution of the ISM of galaxies and star formation within the disks.
- Galactic feedback mechanisms that enrich the CGM and govern the amount of hydrogen gas and metals and their ionization states are still uncertain, but measurements of the properties of the CGM will play a key role in constraining models.

