See: Mathes et al. 2014 (arXiv:1406.2314; ApJ accepted)

Halo Mass Dependence of HI Absorption: Differential Kinematics

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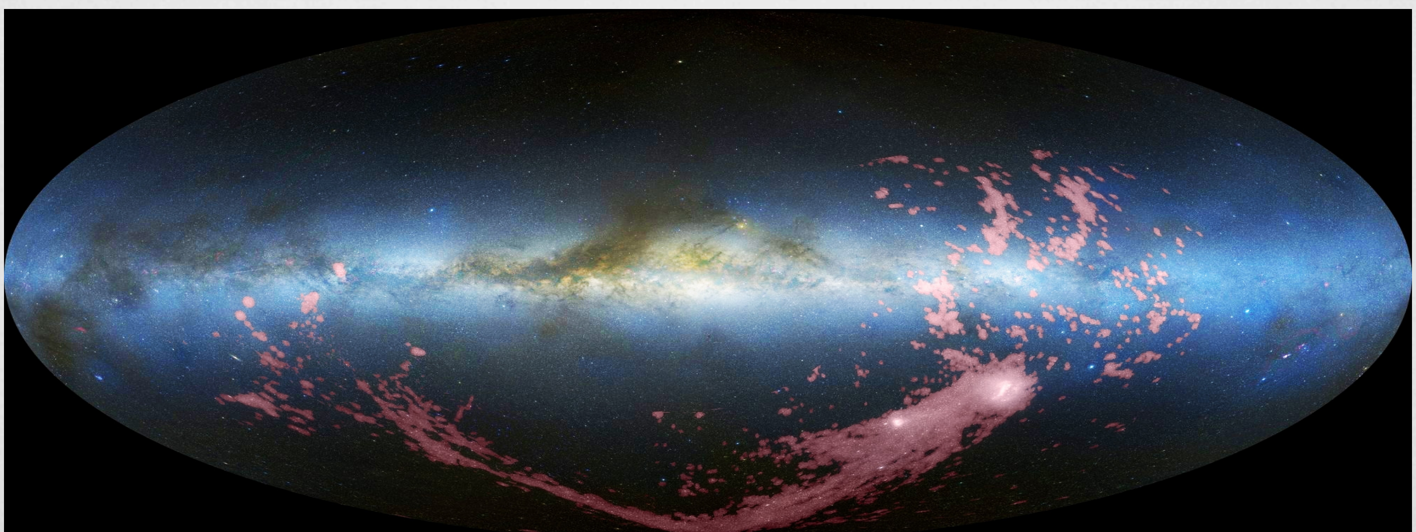
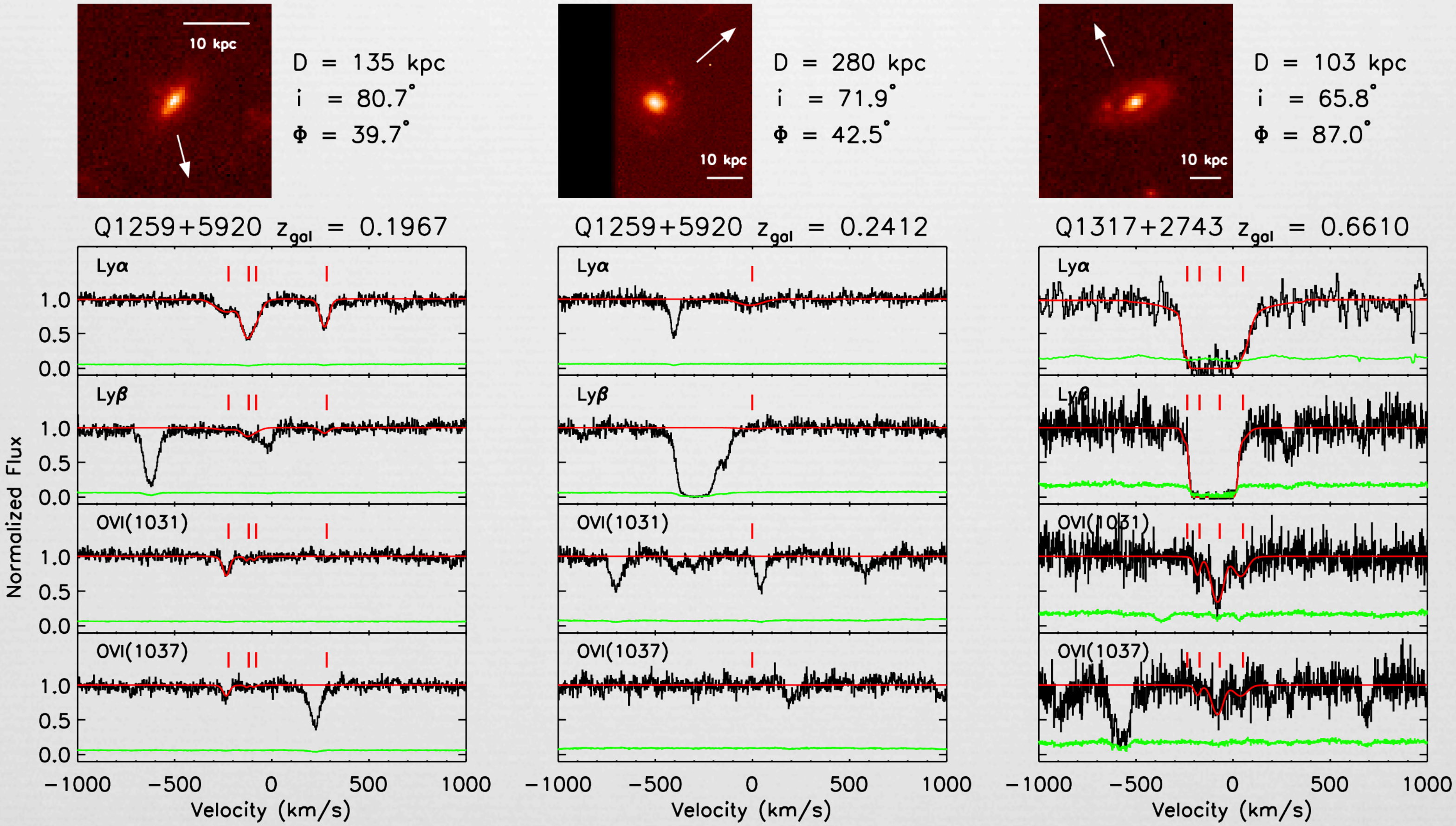
Introduction

- We need to discover the origin and life cycle of halo gas in order to learn how galaxies evolve
- Building a worthy sample involves imaging and identifying galaxies in the fields of background quasars



Nidever et al. 2010

Observing the Gas



Analyzing the Data

Model galaxy in WFPC2 images

- Halo Mass
- On-sky orientation
- Inclination

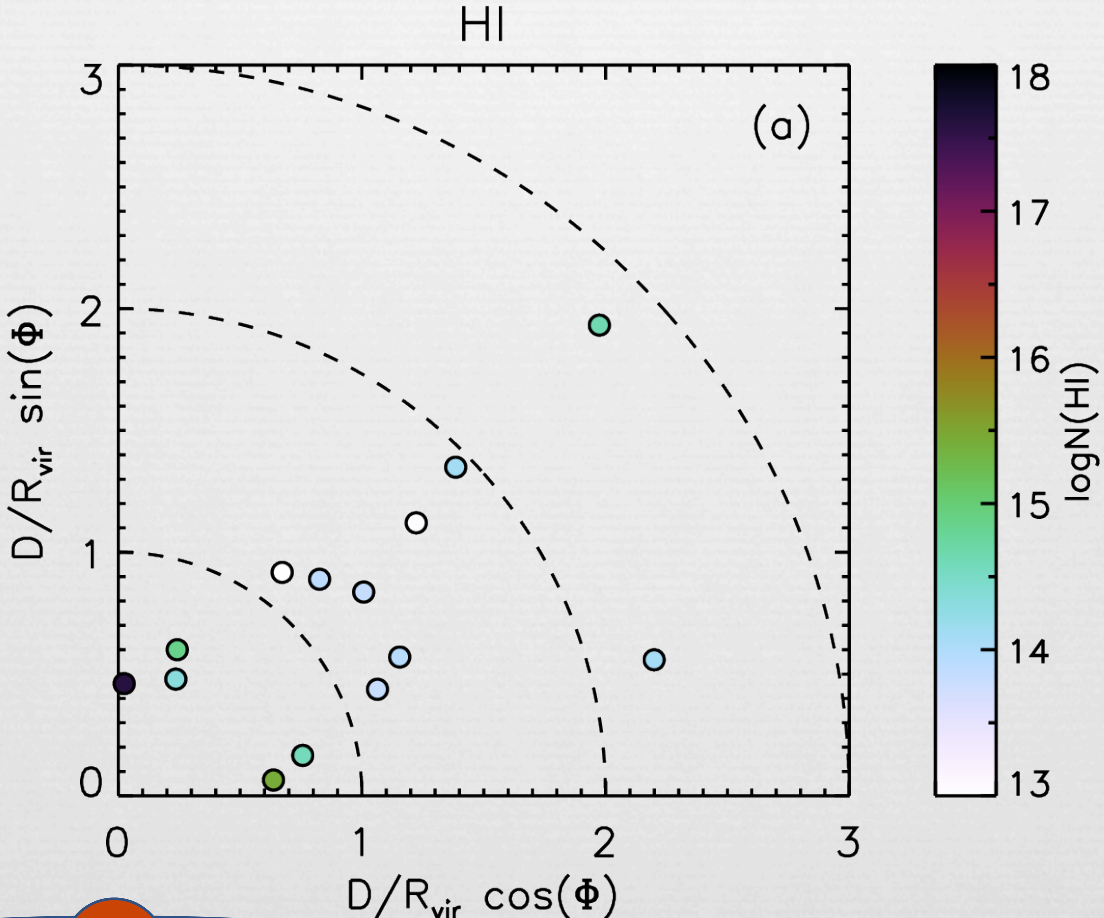
Voigt Profile analysis of COS spectra

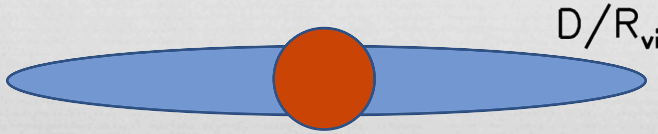
- Column density
- b parameter
- Component velocity

Relate galaxy and absorption properties

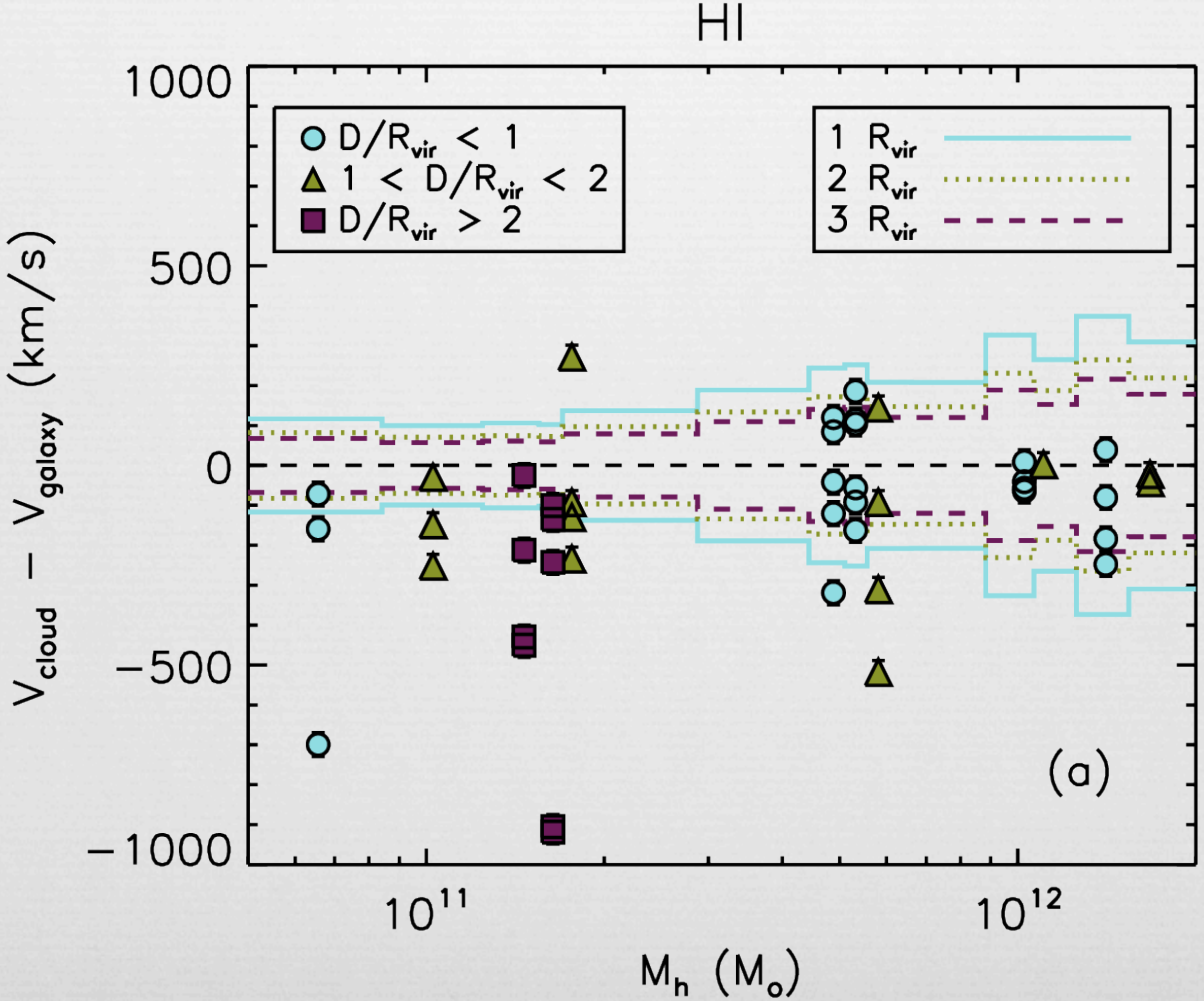
- Full 2-D picture of absorbing gas around galaxies

A 2-D View of Galaxy Halos

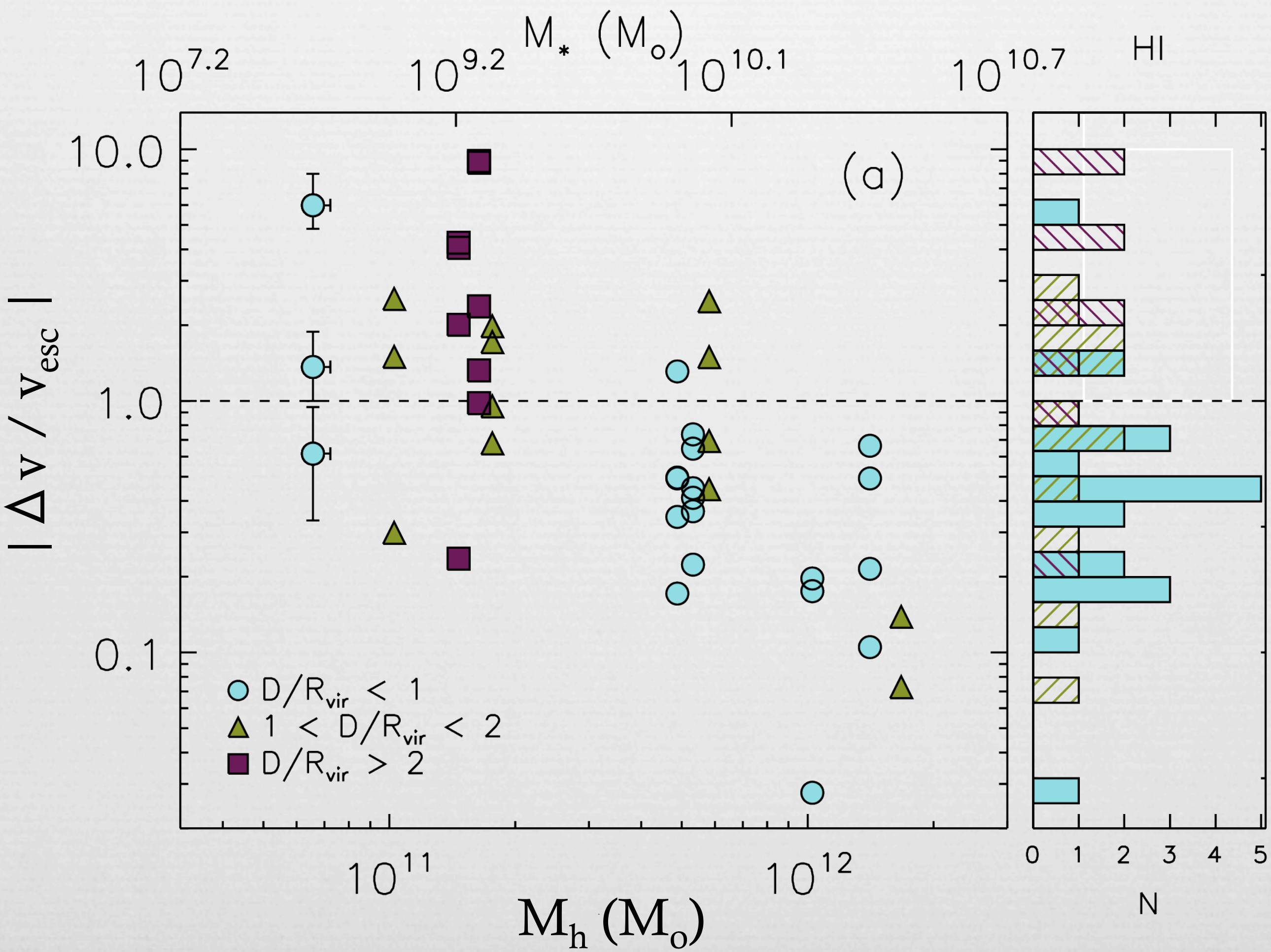




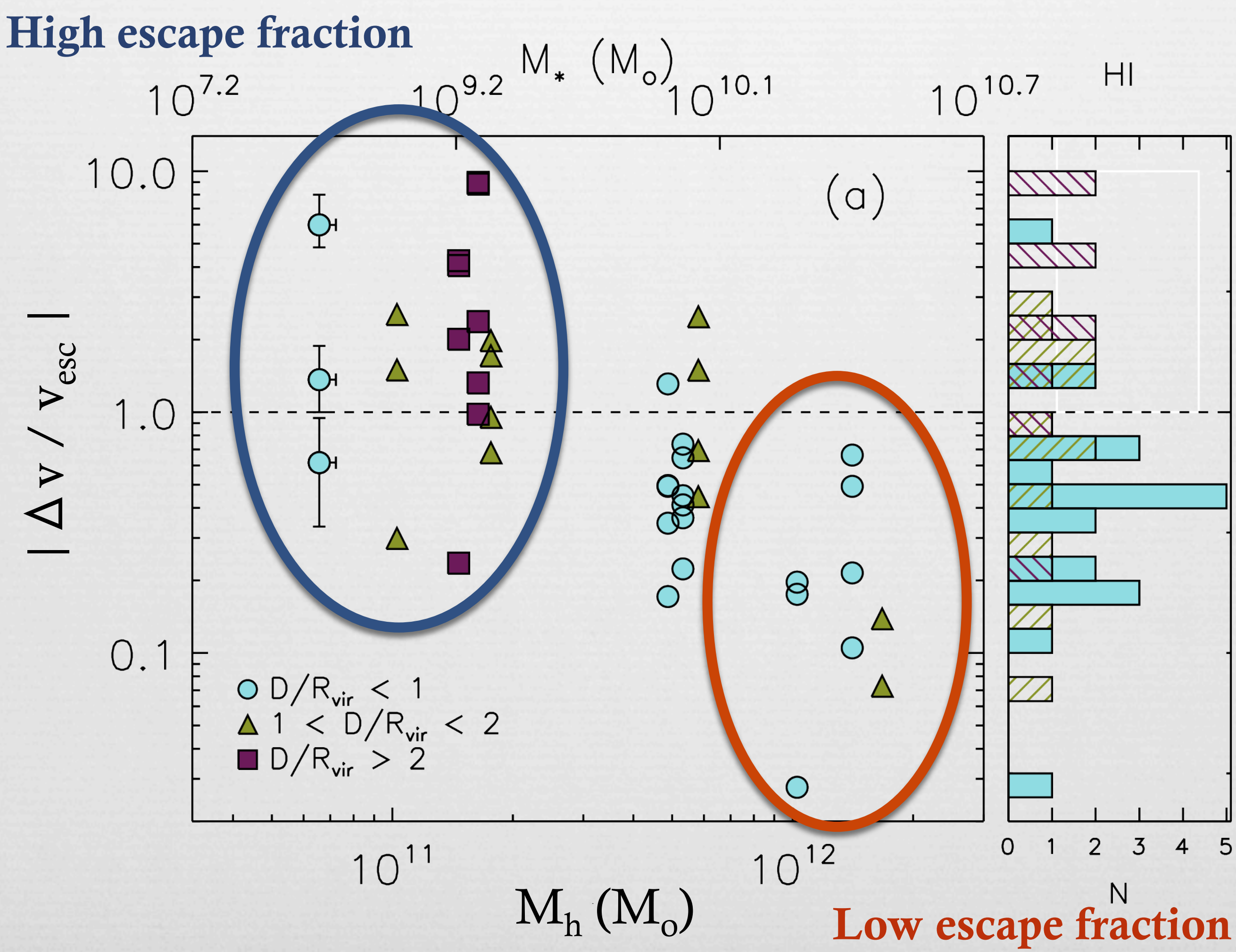
Gas Kinematics



Differential Kinematics



Differential Kinematics



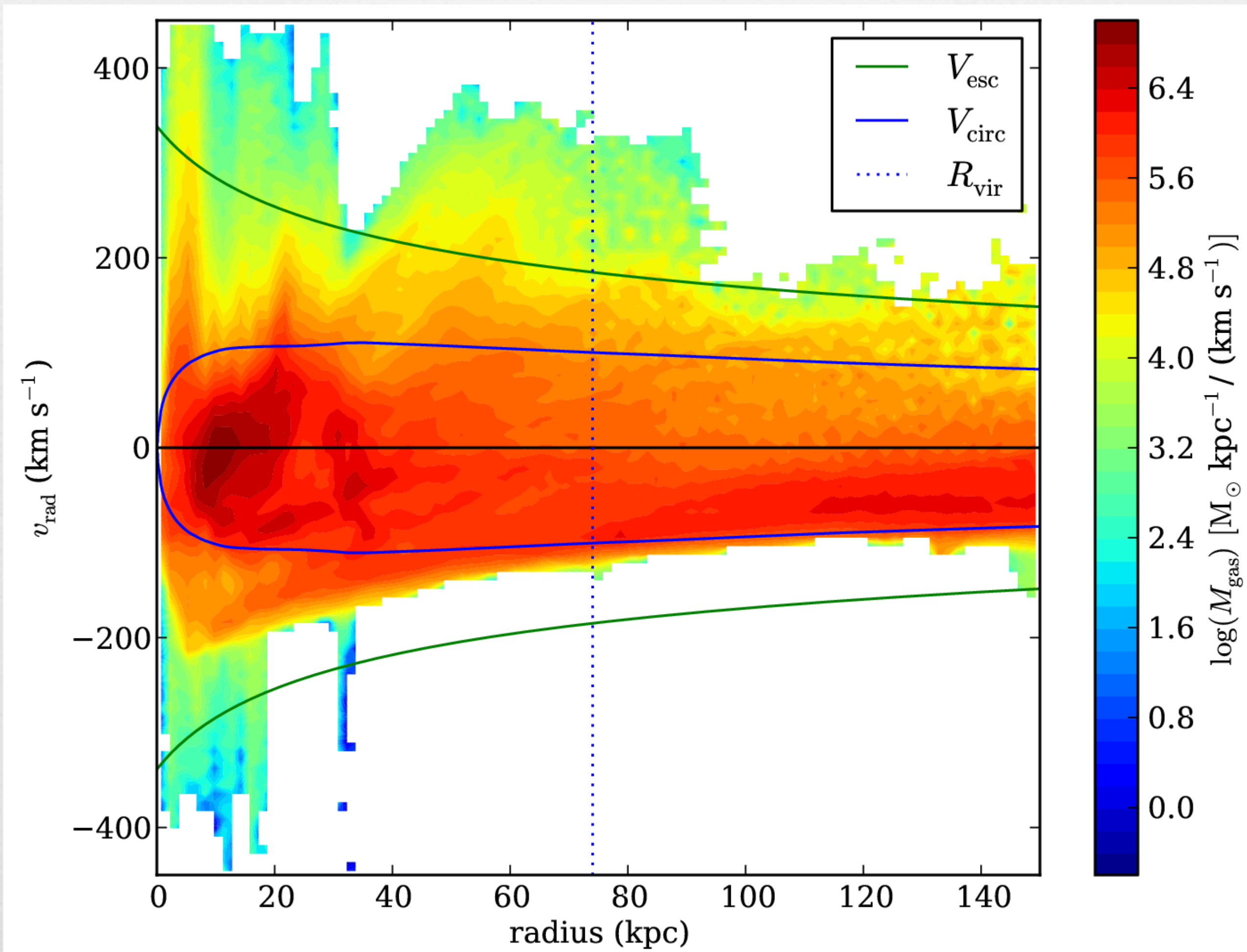
Differential Kinematics

The fraction of bound HI absorbing clouds decreases as D/R_{vir} increases AND as halo mass decreases

Table 4
Bound Fractions of H I Clouds

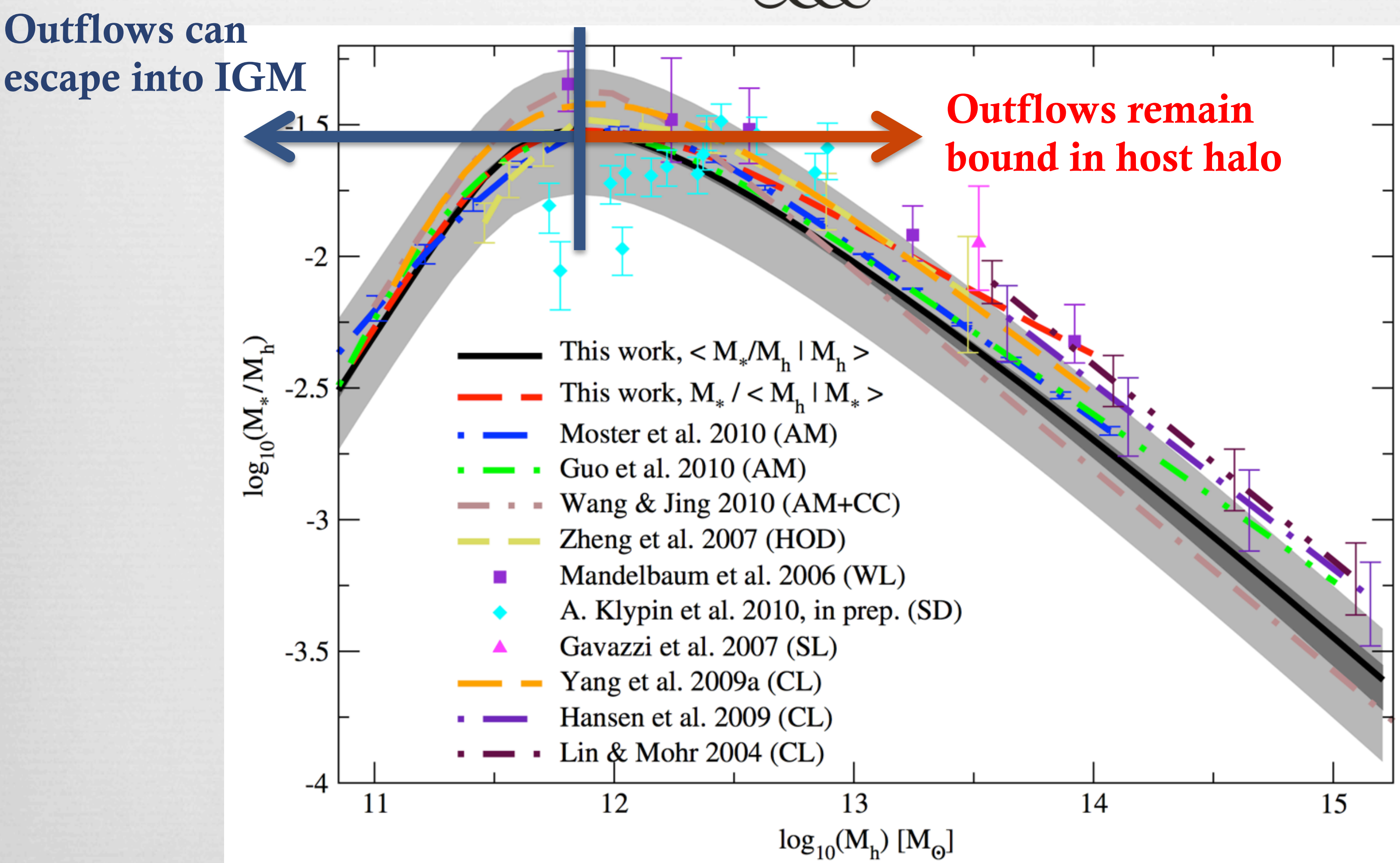
(1) D/R_{vir} range	(2) all M_h $[M_\odot]$	(3) $M_h > 10^{11.5}$ $[M_\odot]$	(4) $M_h < 10^{11.5}$ $[M_\odot]$
$0 < D/R_{vir} \leq 1$	$0.85^{+0.08}_{-0.13}$	$0.94^{+0.05}_{-0.12}$	$0.33^{+0.41}_{-0.28}$
$1 < D/R_{vir} \leq 2$	$0.54^{+0.17}_{-0.17}$	$0.67^{+0.21}_{-0.28}$	$0.43^{+0.25}_{-0.22}$
$2 < D/R_{vir} \leq 3$	$0.11^{+0.21}_{-0.09}$	...	$0.11^{+0.21}_{-0.09}$
$0 < D/R_{vir} \leq 3$	$0.59^{+0.09}_{-0.09}$	$0.87^{+0.07}_{-0.11}$	$0.26^{+0.14}_{-0.11}$

Δ v > v_{esc} Gas Traces Outflows



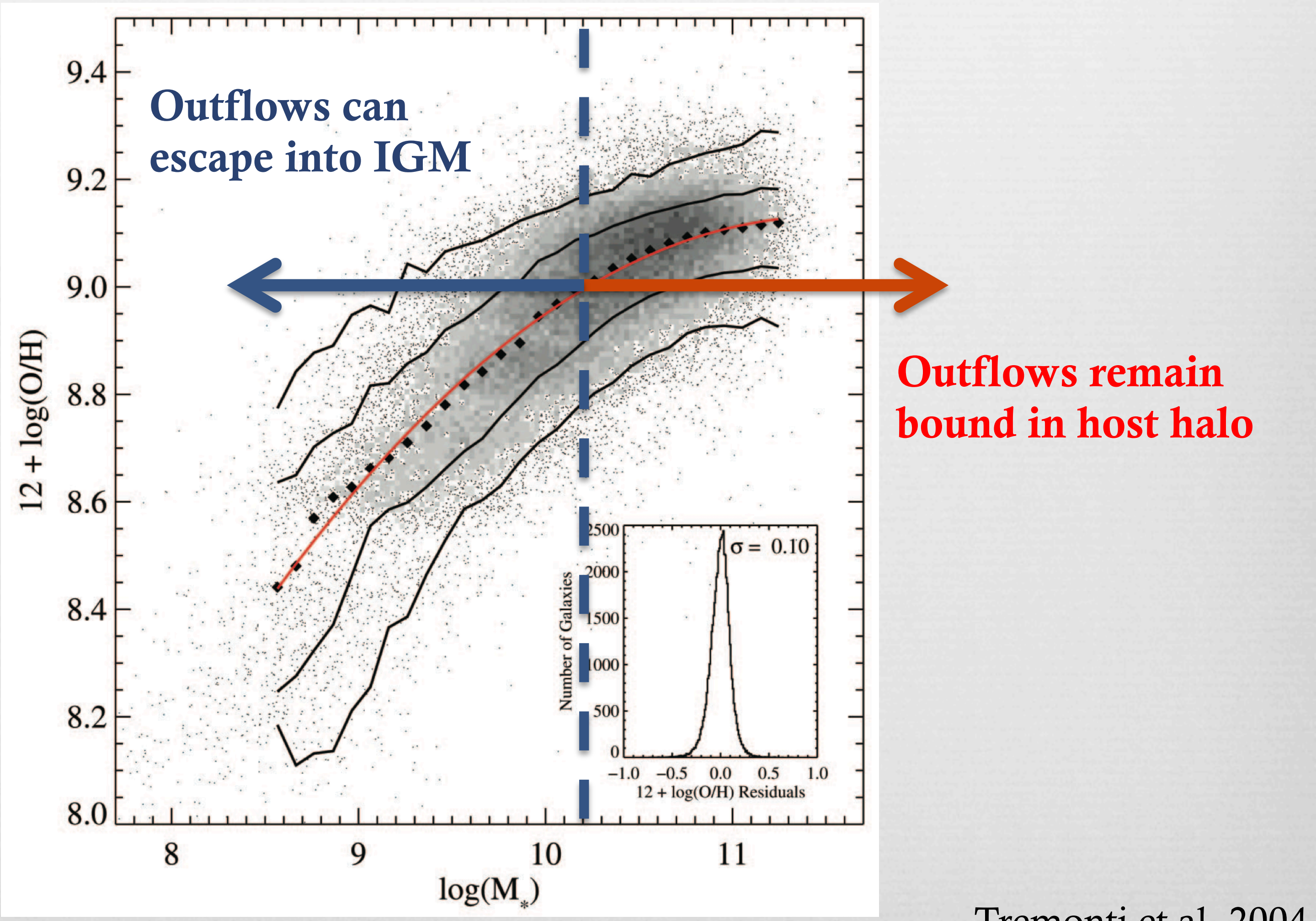
Trujillo-Gomez et al. 2014 (in prep)

Theoretical Implications: Stellar/Halo Mass Relation



Behroozi et al. 2010

Theoretical Implications: Mass-Metallicity Relationship



Tremonti et al. 2004

See: Mathes et al. 2014 (arXiv:1406.2314; ApJ accepted)

Conclusions

- The fraction of HI clouds which could escape their host halo increases with increasing D/R_{vir}.
- Low mass galaxies have a higher fraction of escaping clouds at all D/R_{vir}.
- Lower mass galaxies expelling more of their gas has implications in:
  - The stellar mass – halo mass relationship
  - The mass – ISM metallicity relationship

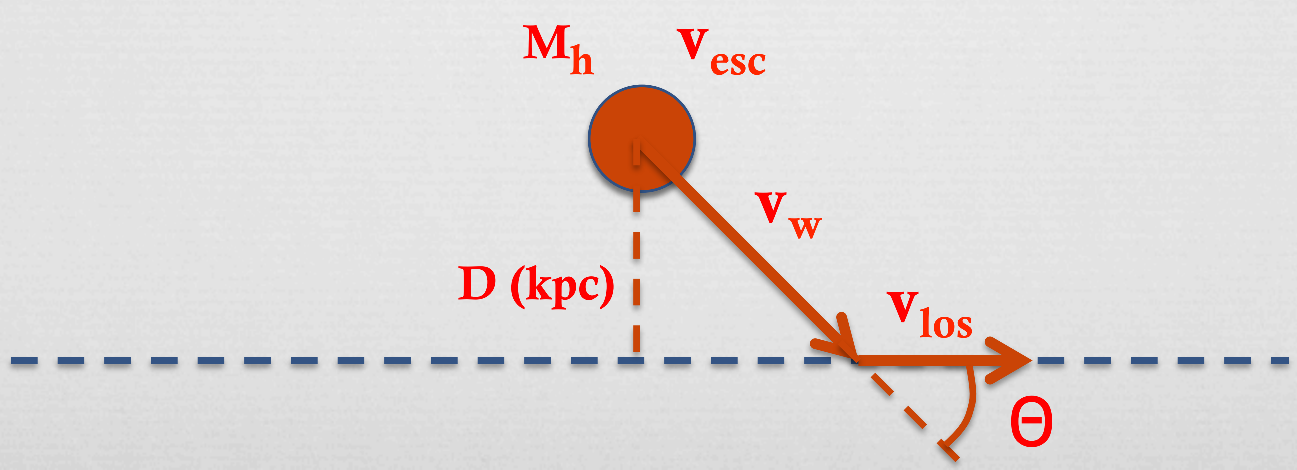
Comparing to Models

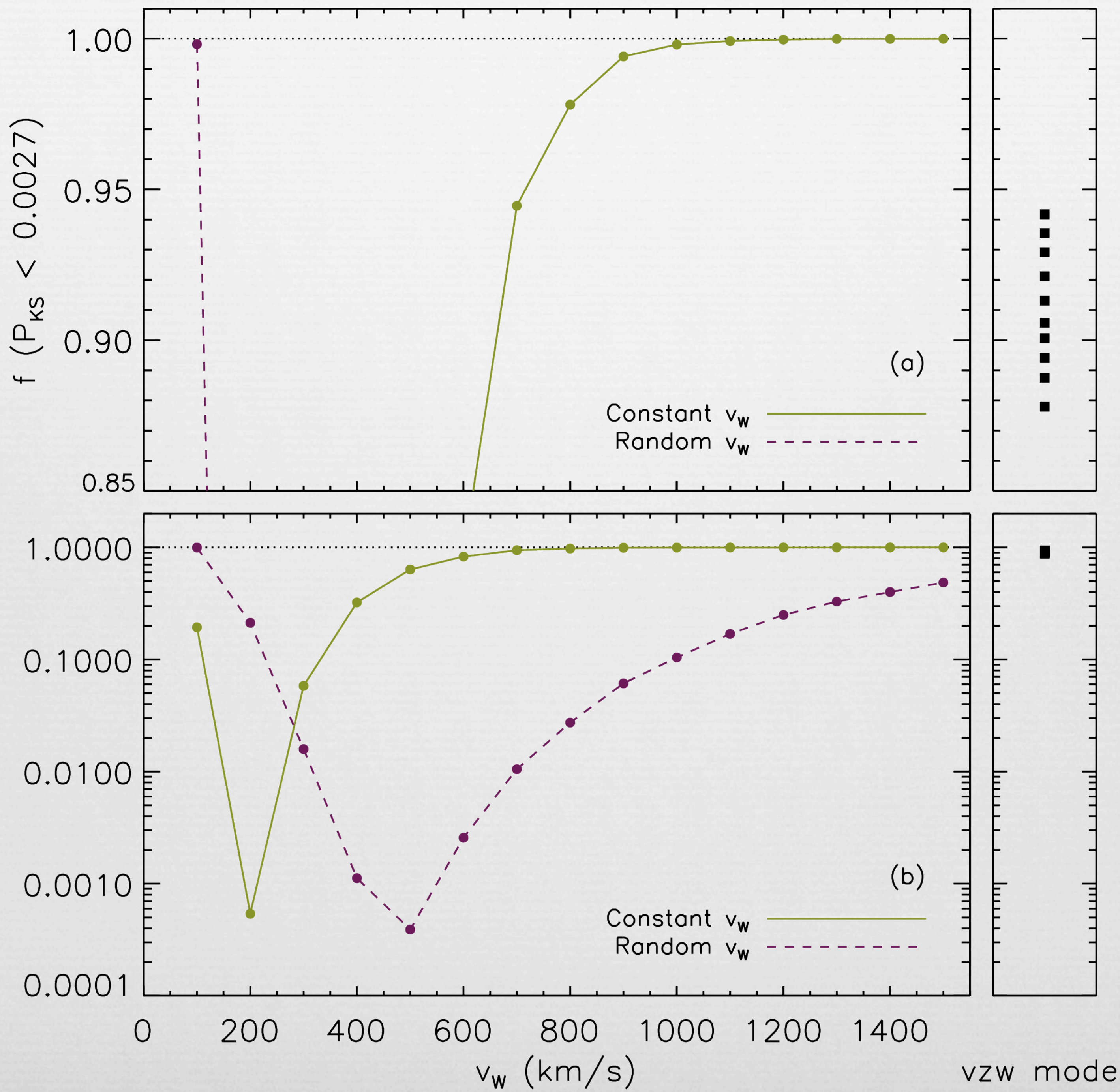
One dimensional plane-parallel outflow models

1.) Constant outflow velocity v_w

2.) Random wind velocity $0 < v_w < v_{max}$

3.) *vzw* wind model of Oppenheimer et al. 2010





f (P_{KS} < 0.0027)
1.00
0.95
0.90
0.85
(a)
Constant v_w
Random v_w
1.0000
0.1000
0.0100
0.0010
0.0001
(b)
Constant v_w
Random v_w
0
200
400
600
800
1000
1200
1400
v_w (km/s)
vzw model

Modeling Conclusions

- The constant wind and *vzw* models have a difficult time reproducing the data
- The most consistent models have random wind velocities peaking between $300 < v_w < 800$ km/s
- The galaxy potential appears to govern the life cycle of halo gas