Evolutionary Histories of the Satellite Dwarf Galaxies in the Local Group

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UC Santa Barbara KITP

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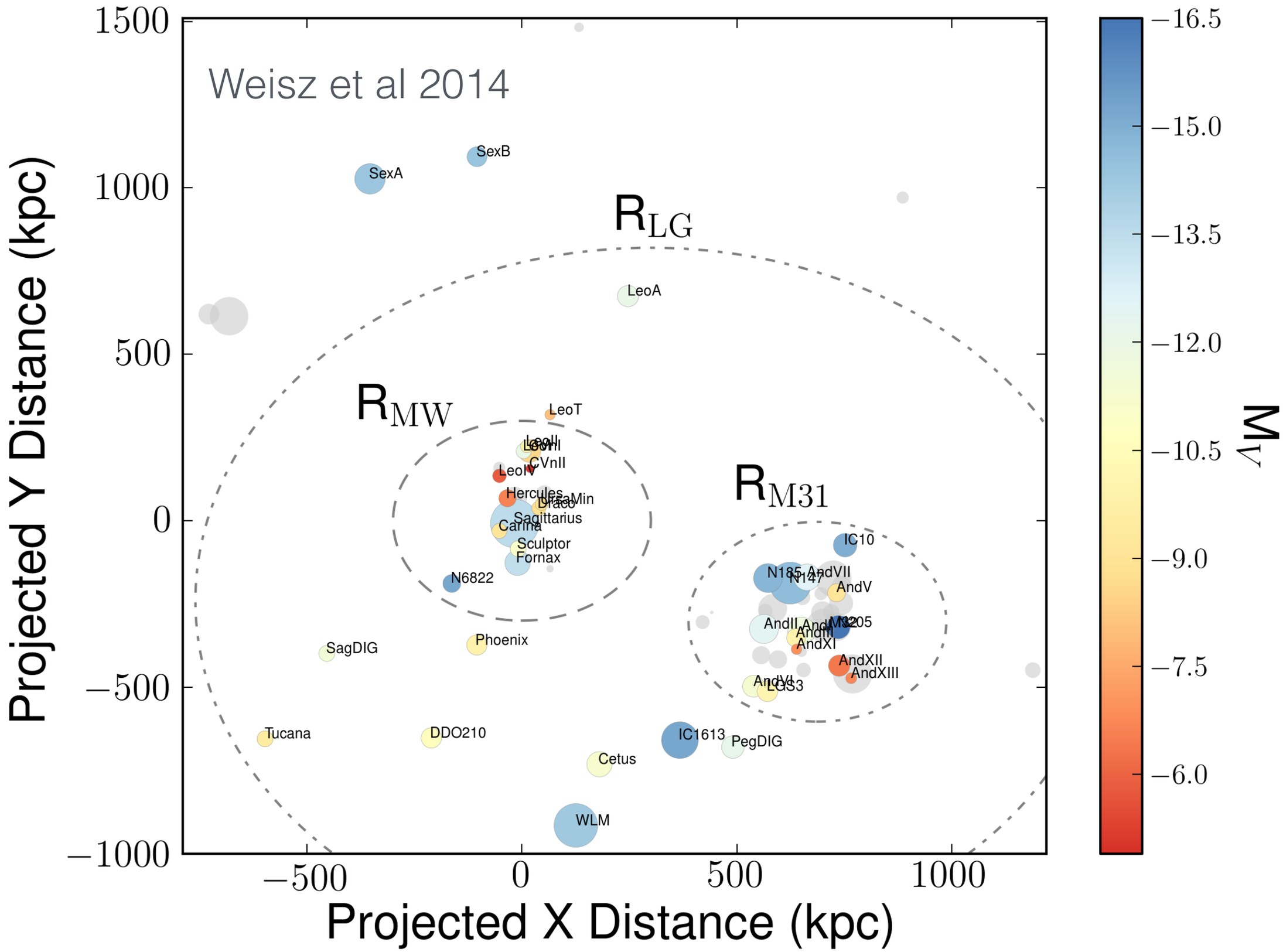
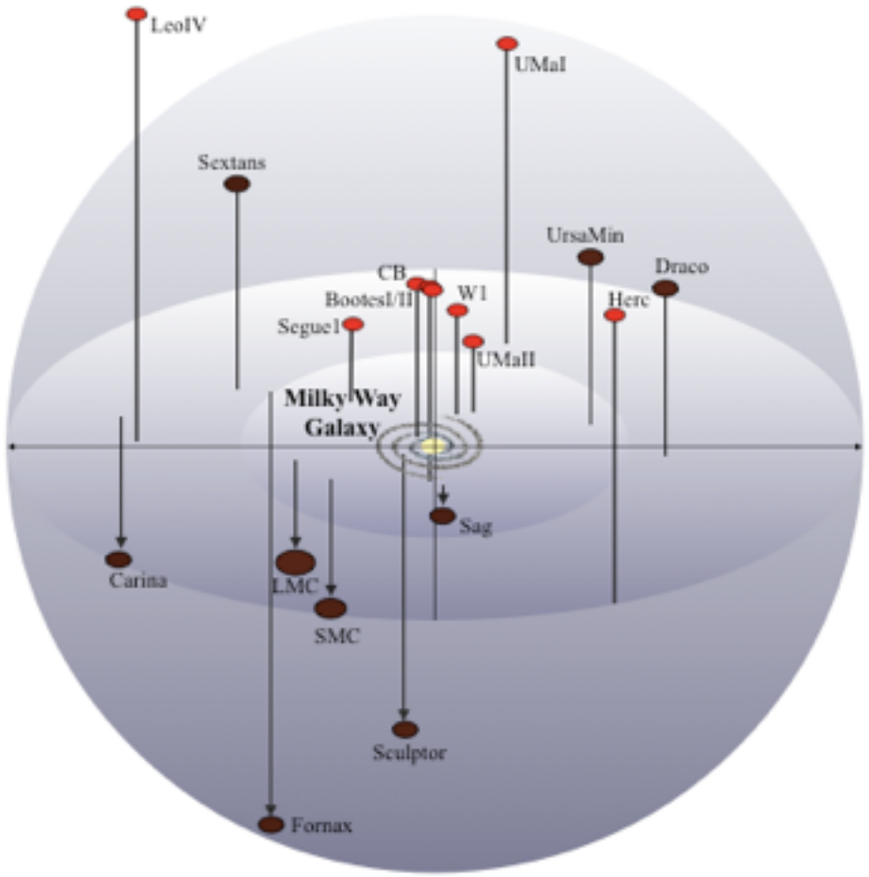
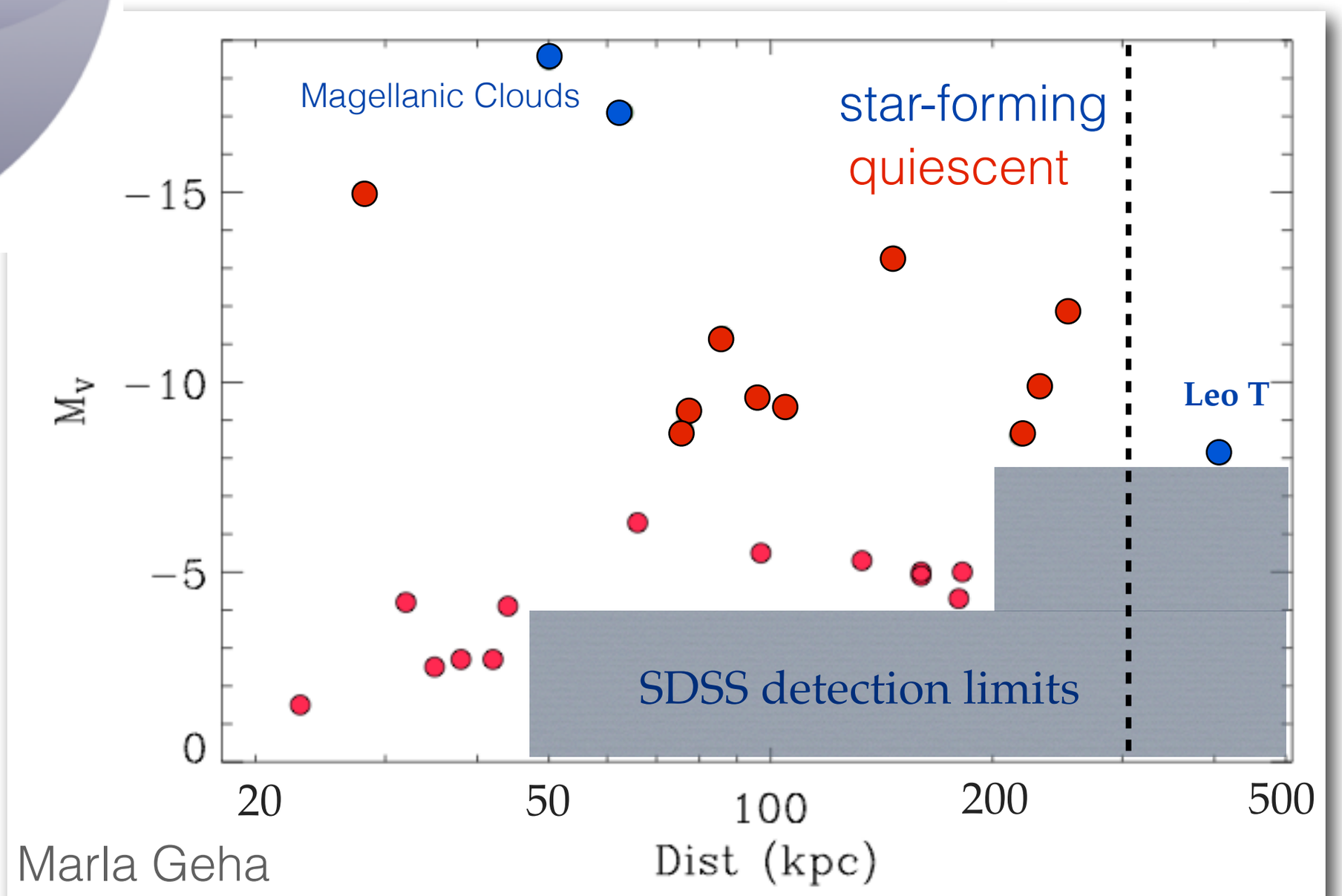
The Local 'Group'



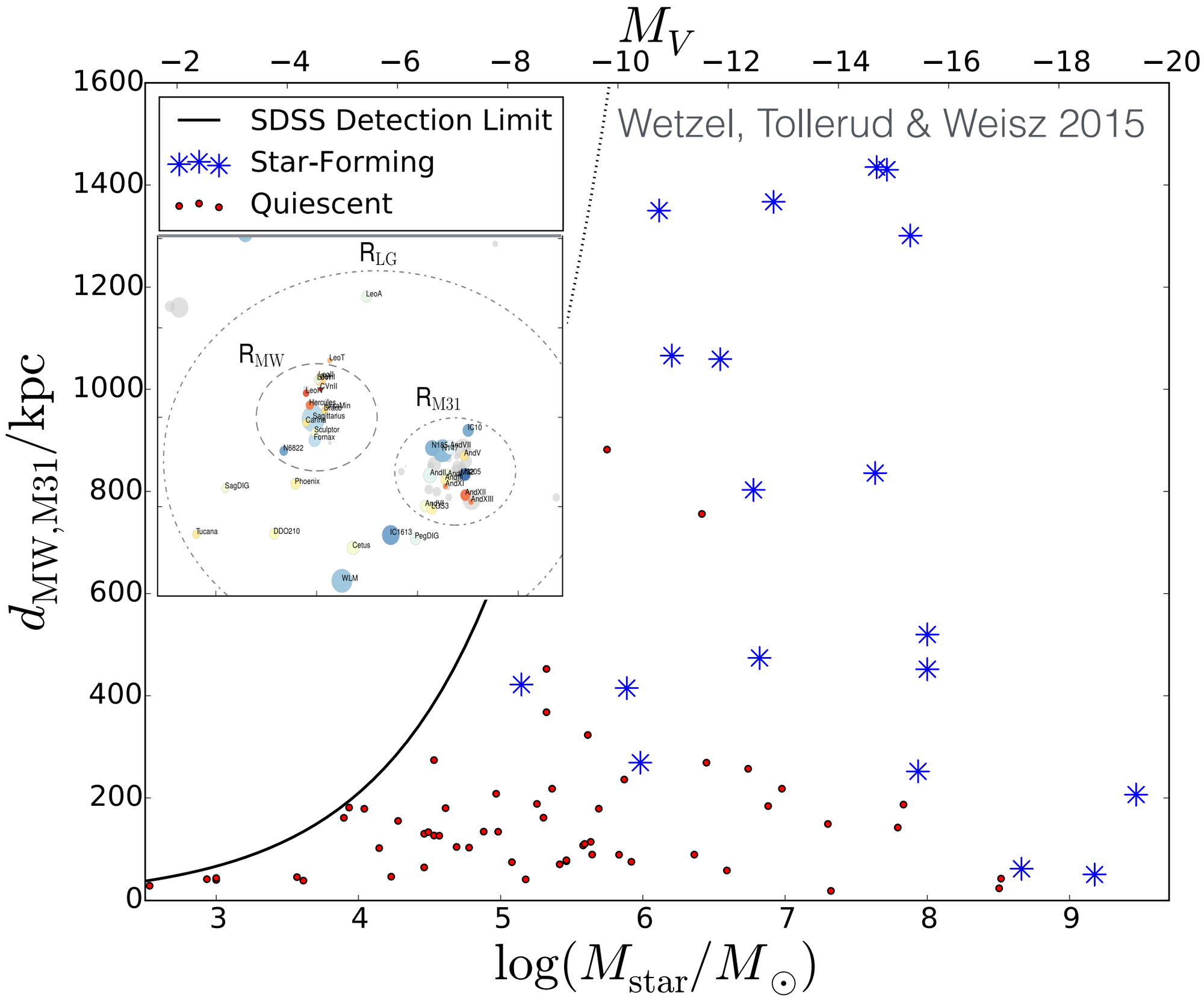


Satellite Dwarf Galaxies in the Milky Way Halo

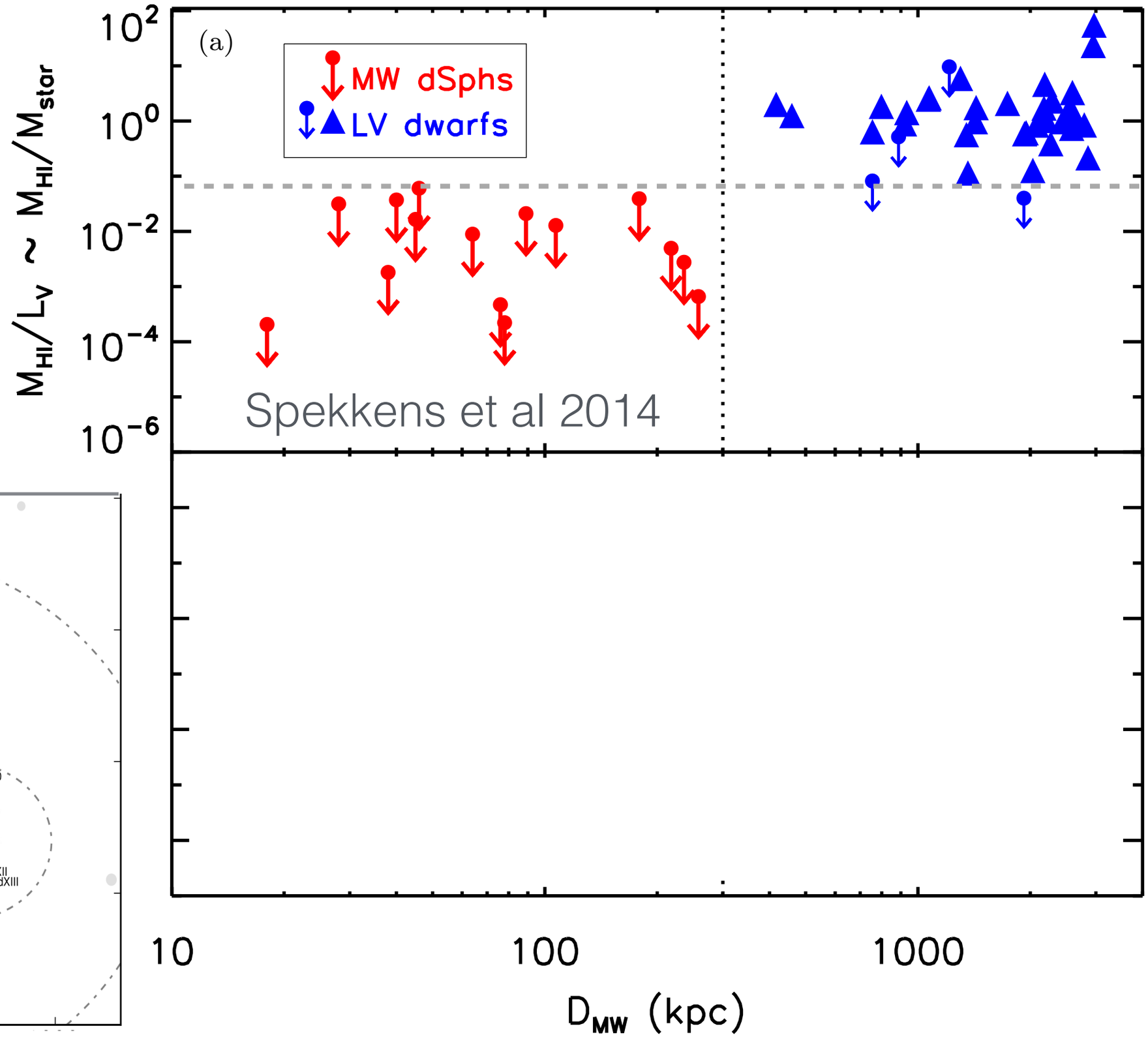


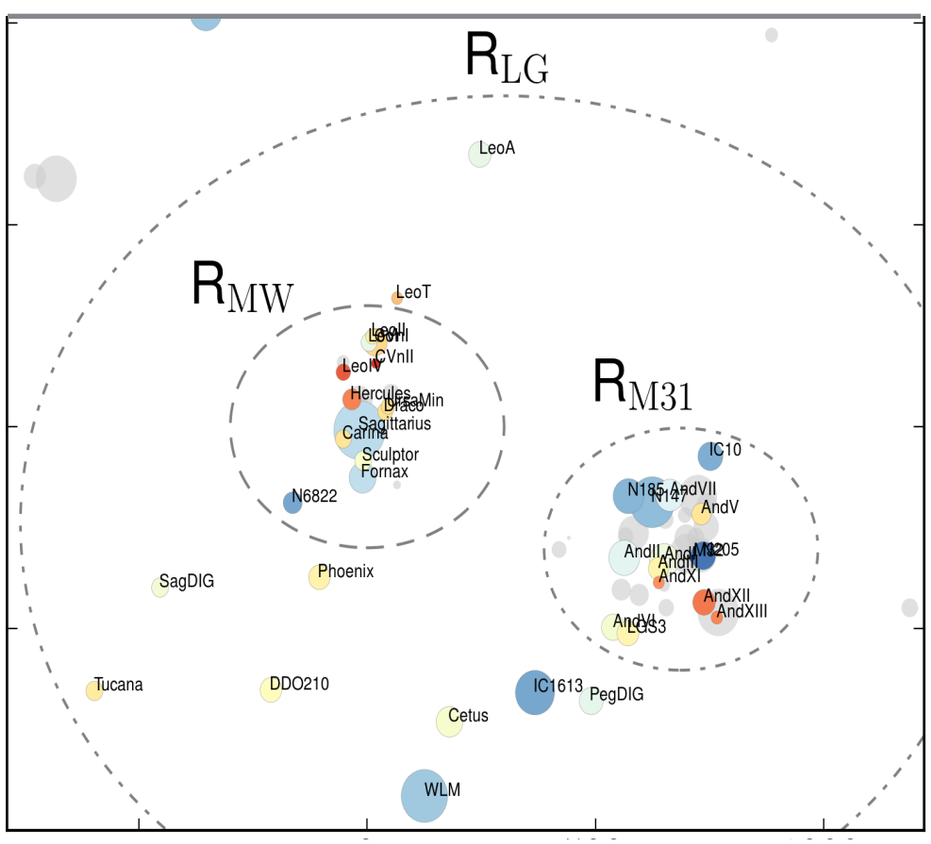
Marla Geha

Star formation in dwarf galaxies in the Local Group



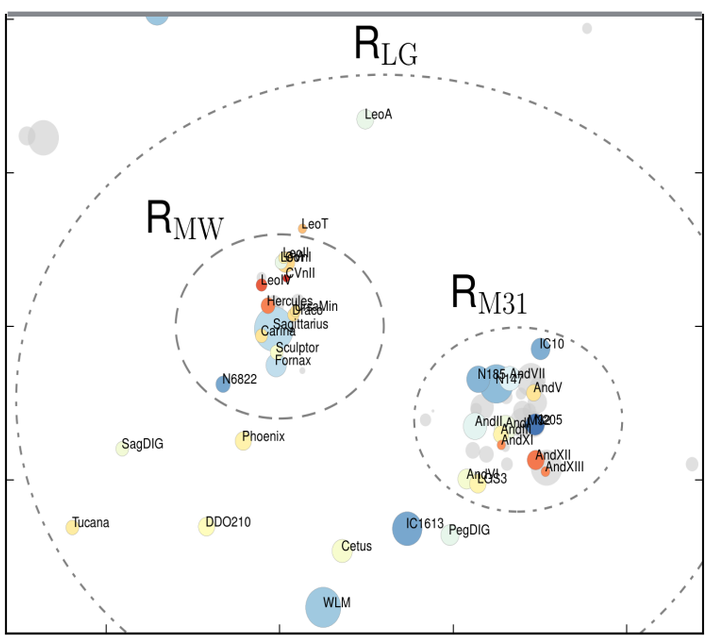
Cold gas in dwarf galaxies in the Local Group

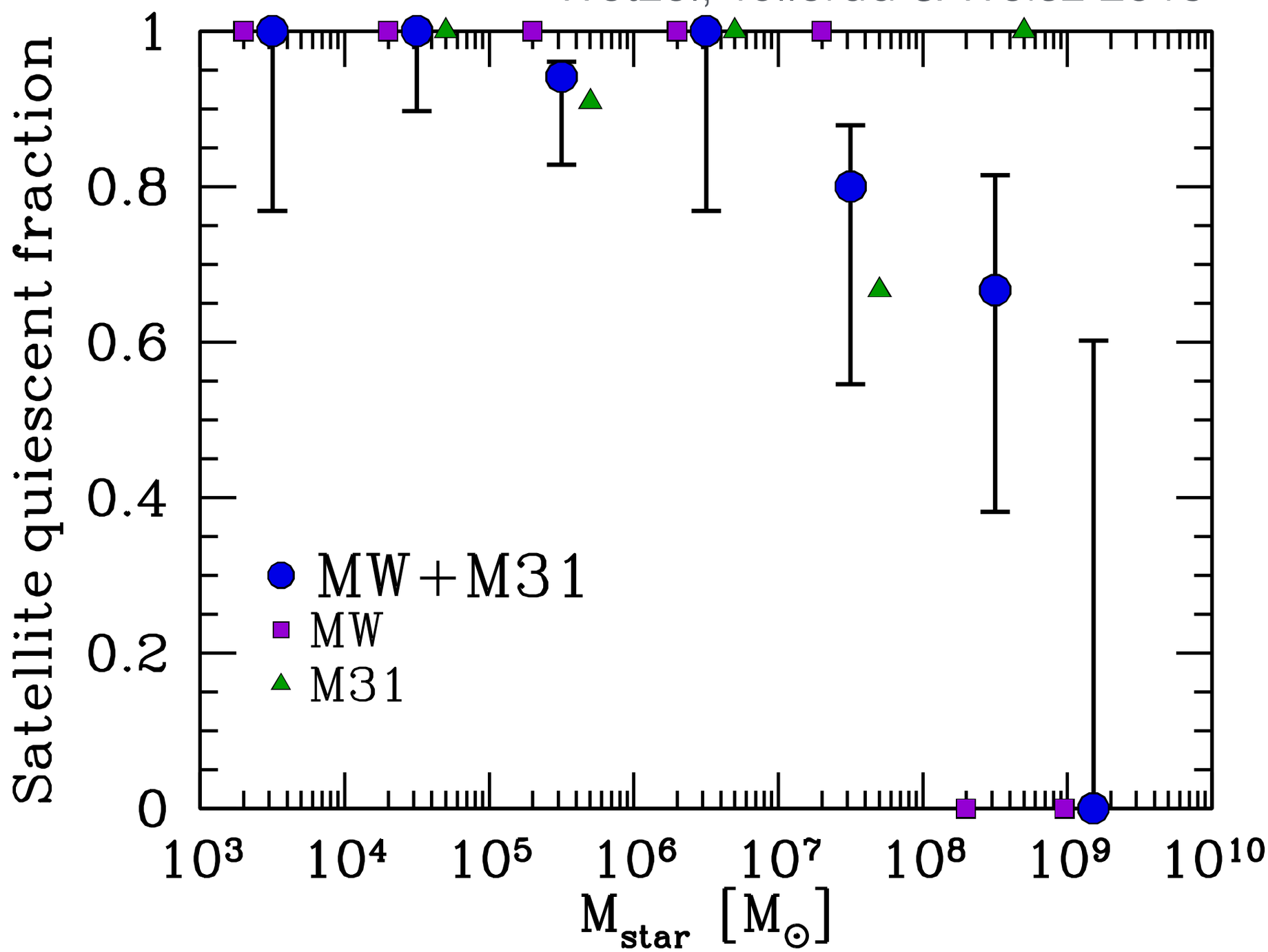




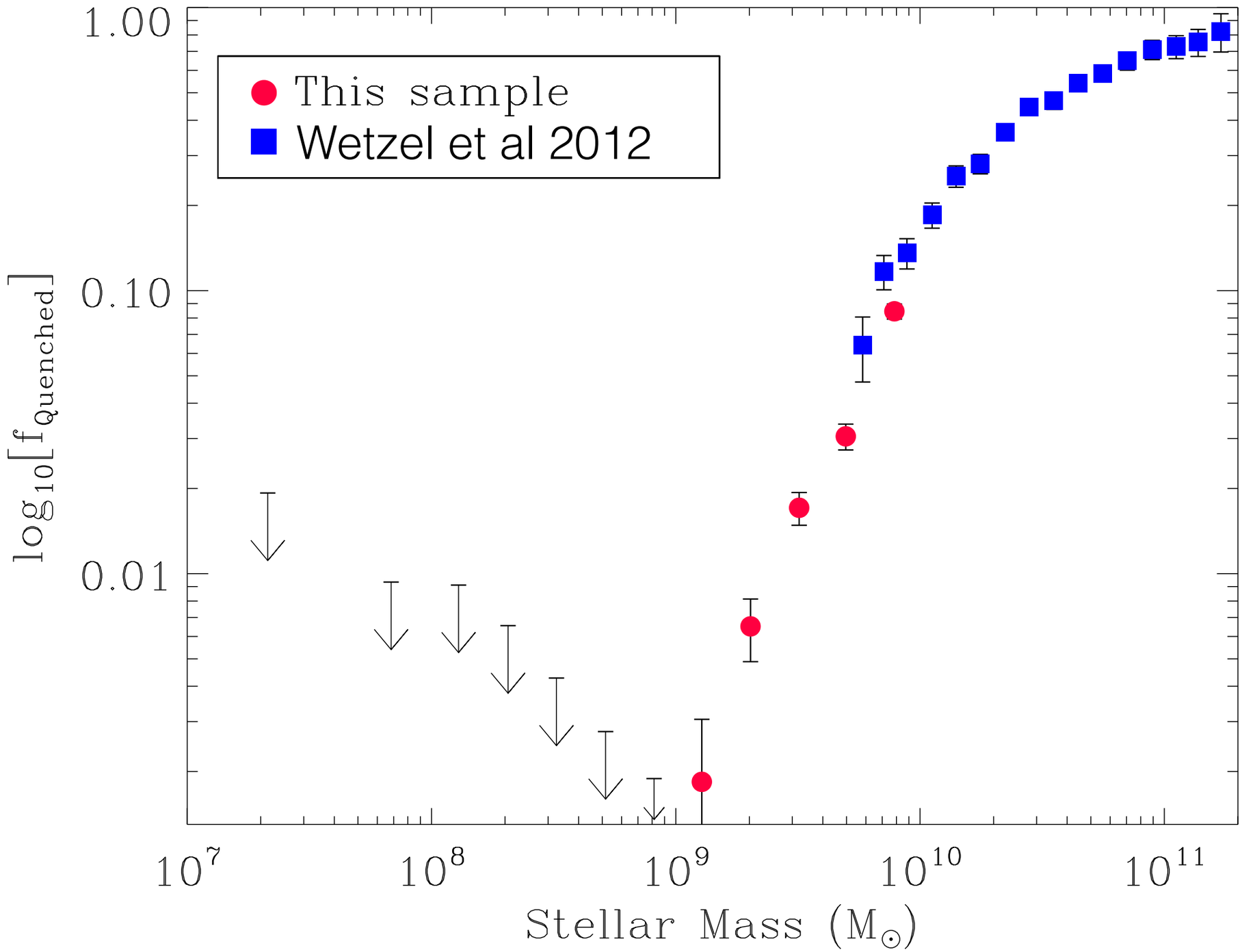
Quenching of star formation in the satellite galaxies of the MW/M31

Wetzel, Tollerud & Weisz 2015





Geha et al 2012



Isolated galaxies $M_{star} < 10^9\ M_\odot$:

Essentially all are star-forming, almost none are quiescent

Outline

1. Infall Times & Orbital Histories of the Satellite Population

2. Gas Loss & Star-formation Quenching of the Satellite Population

3. Satellite-by-satellite analysis using individual star-formation and orbital histories

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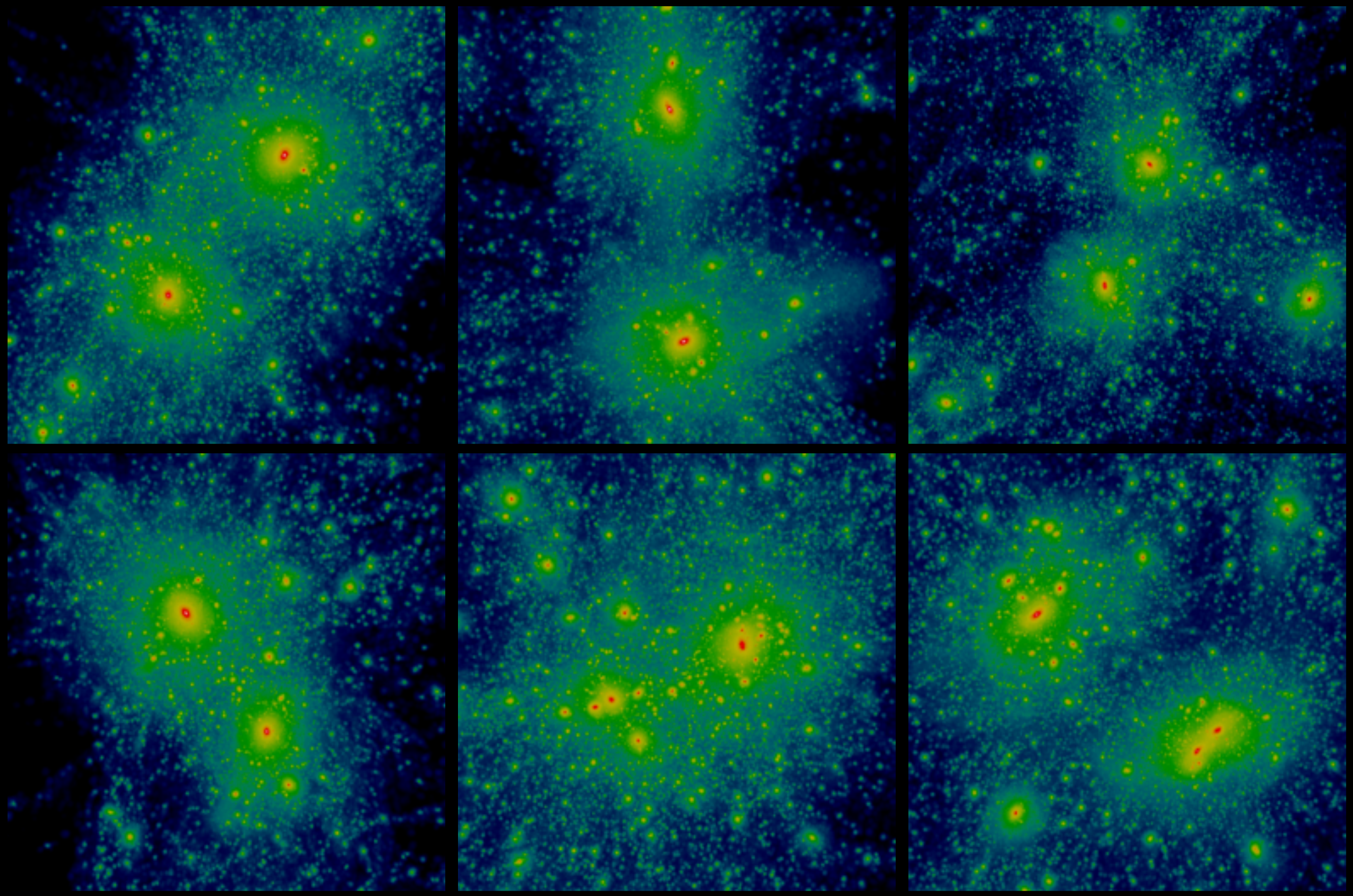
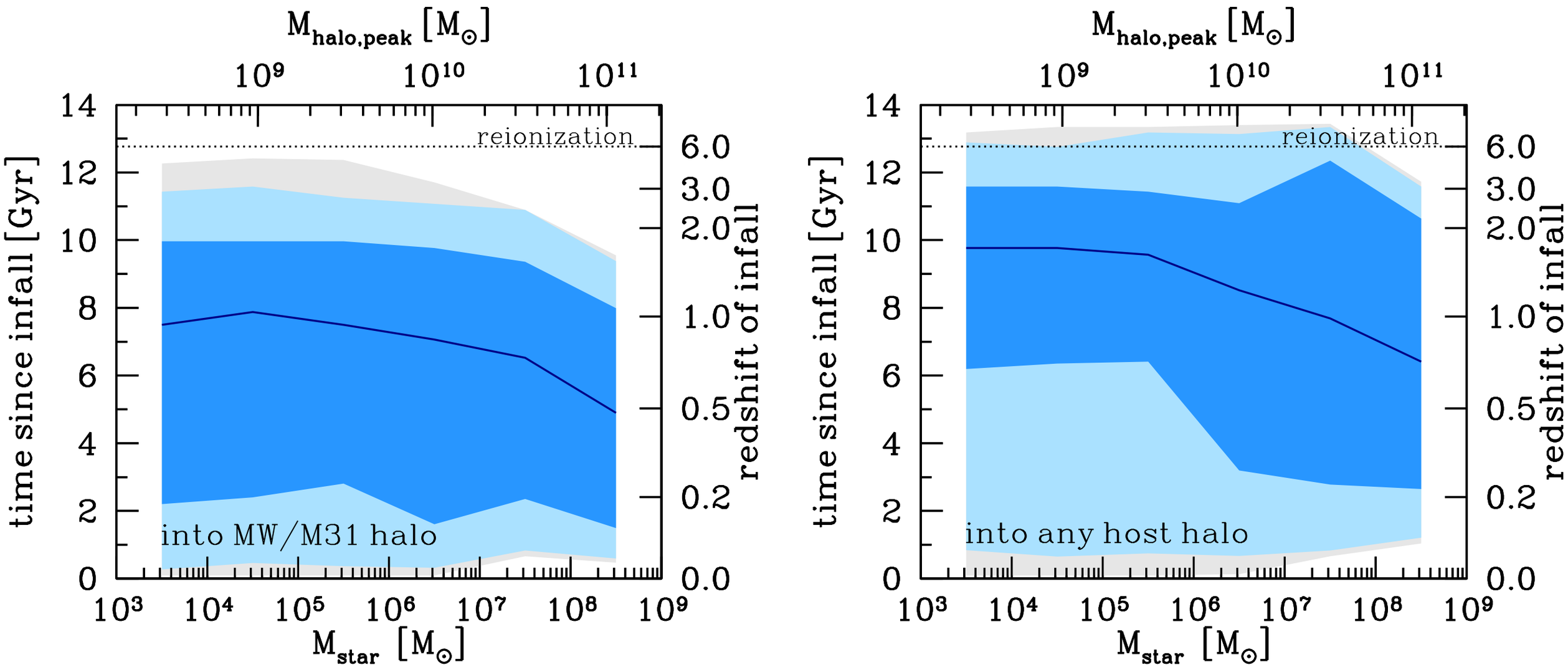
ELVIS Suite

Cosmological zoom-in *N*-body simulations of Local-Group-like halo pairs

Garrison-Kimmel et al 2013



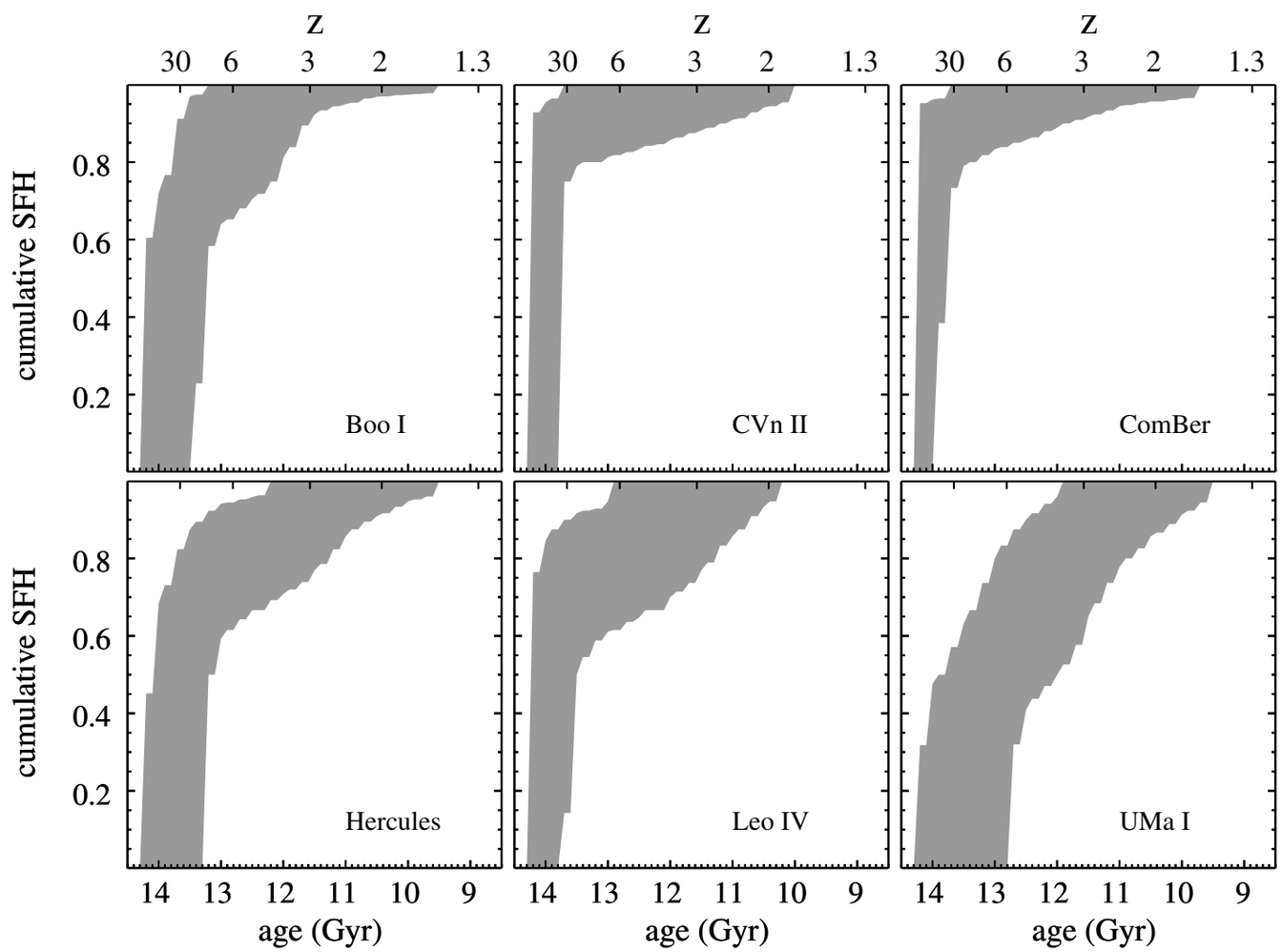
Infall times of satellite dwarf galaxies



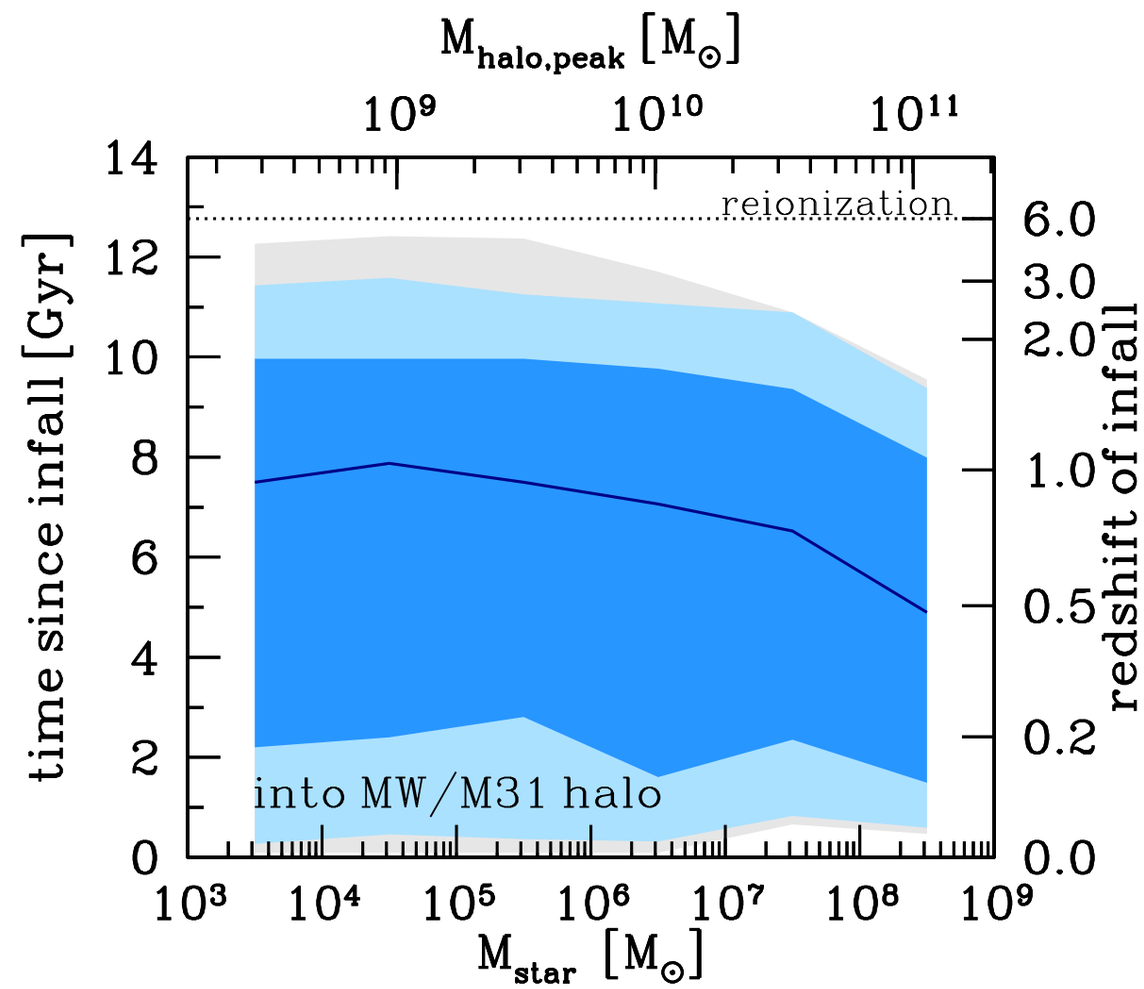
Wetzel, Deason & Garrison-Kimmel 2015

Implications for dwarf galaxies as probes of reionization

Brown et al 2014

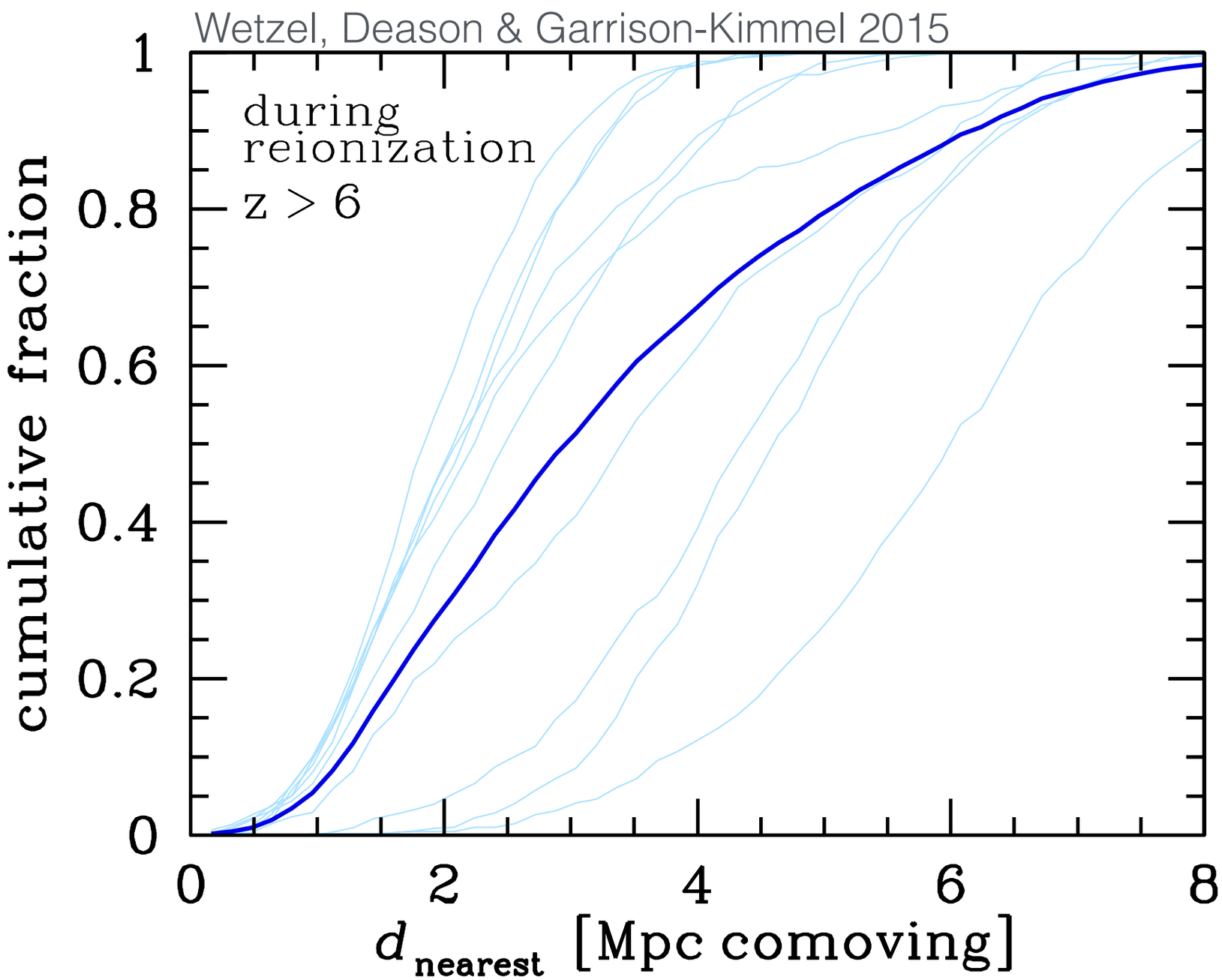


Wetzel, Deason & Garrison-Kimmel 2015



- Effects of reionization versus host-halo environment are separable in time

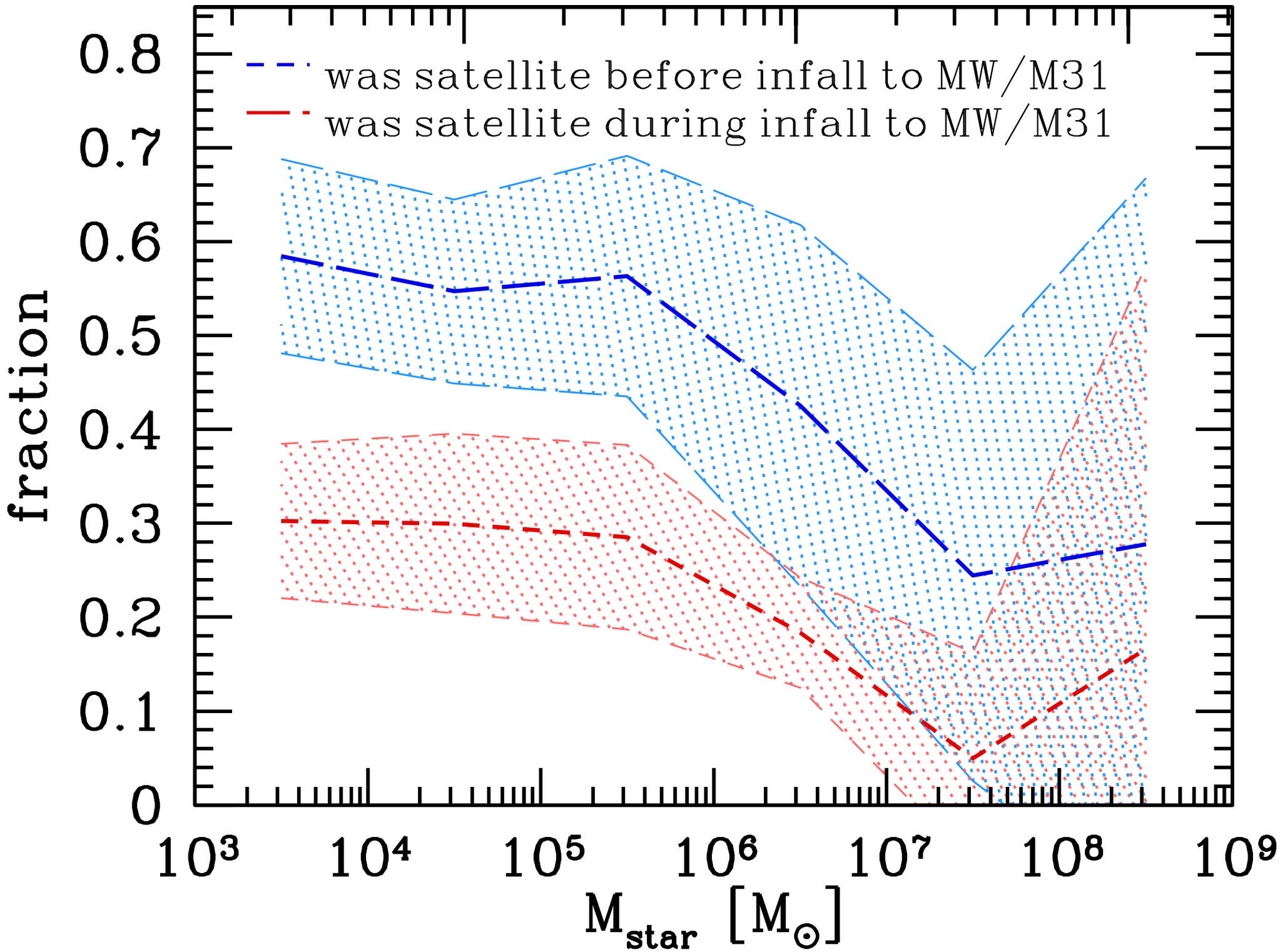
Progenitors of satellite dwarf galaxies: distance from more massive host halo during reionization



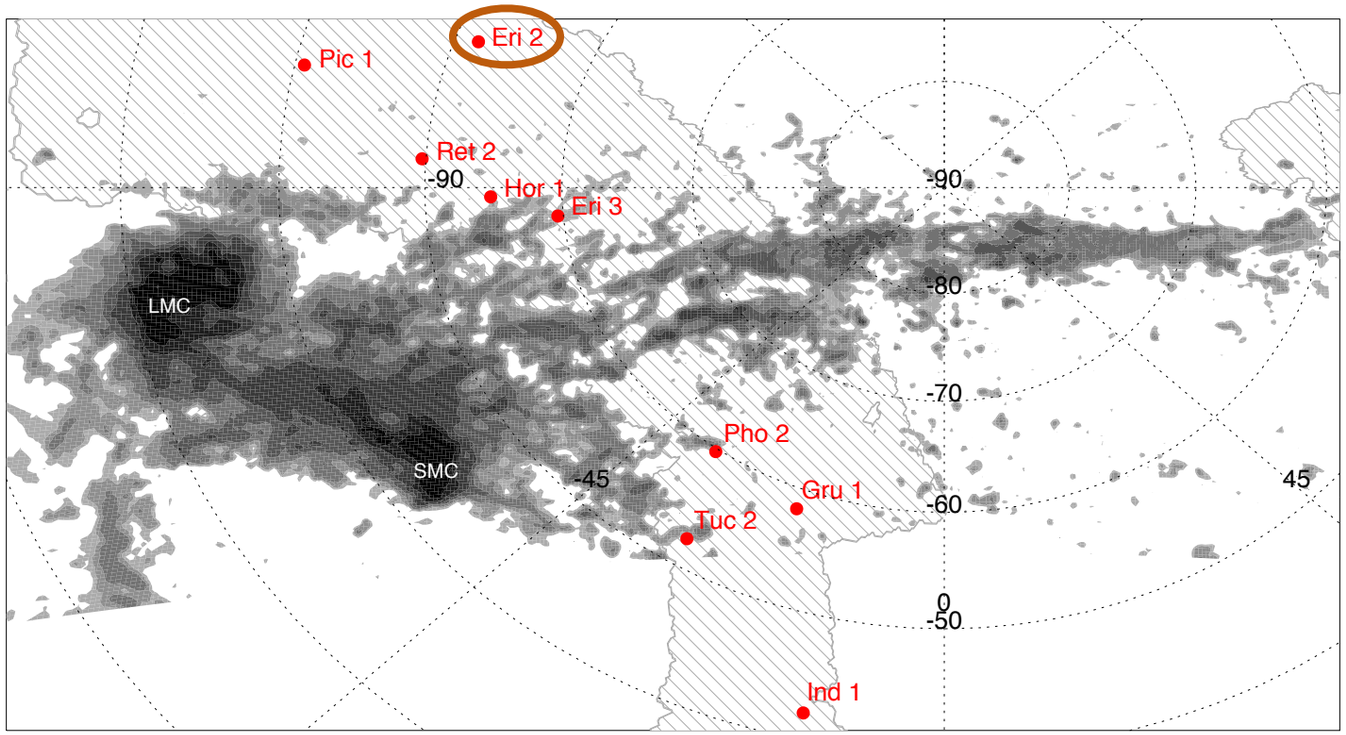
- Effects of reionization versus host-halo environment are separable in time

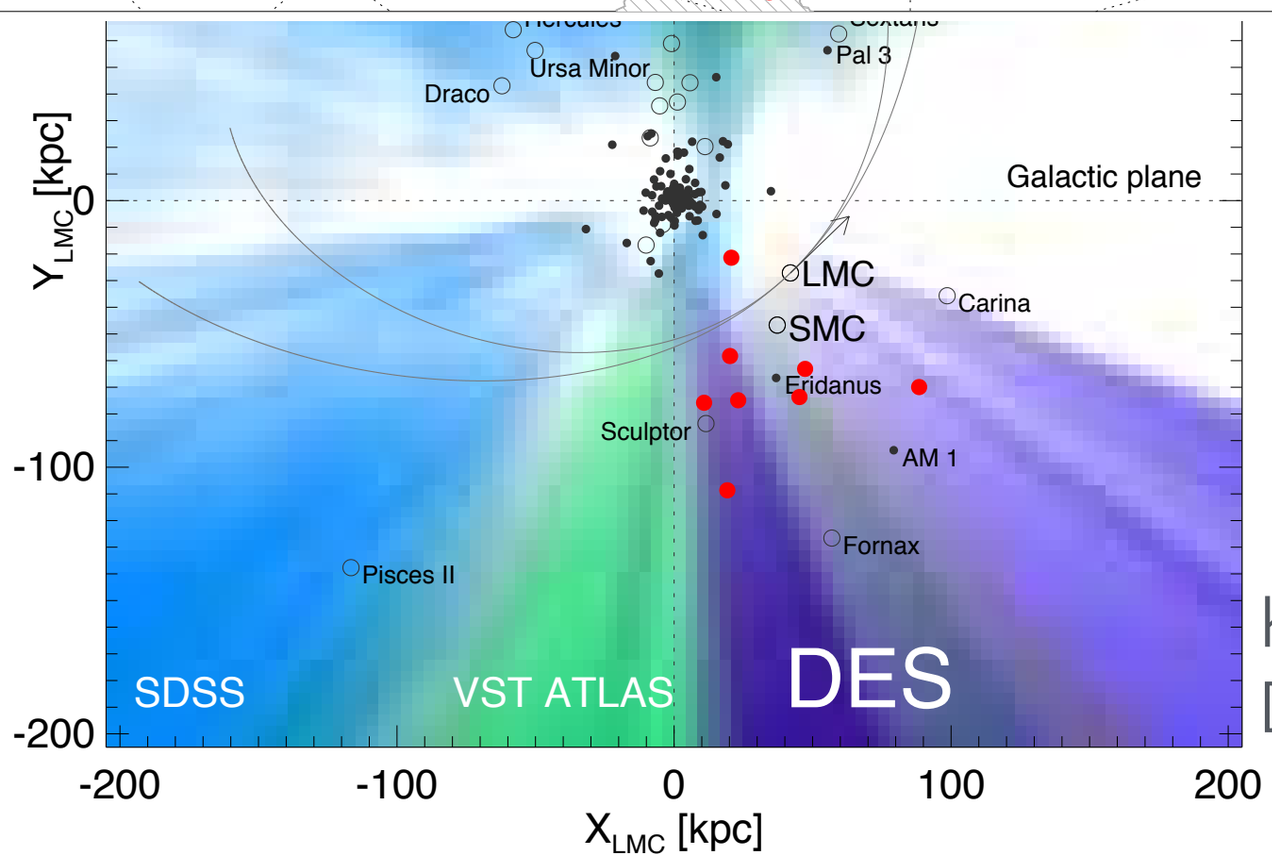
Group infall/preprocessing of satellites

Wetzel, Deason & Garrison-Kimmel 2015

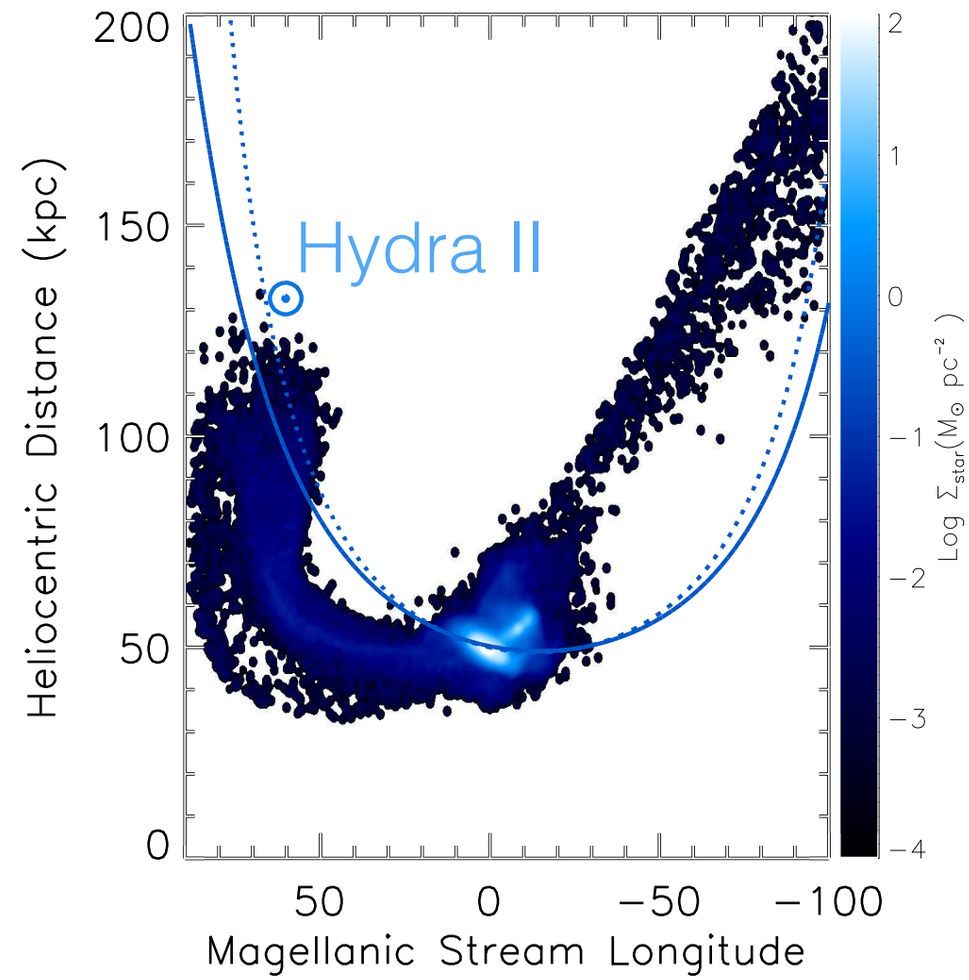


A lot of dwarf galaxies near the Magellanic Clouds





Martin et al 2015



Koposov et al 2015
DES Collaboration 2015

Outline

1. Infall Times & Orbital Histories of the Satellite Population

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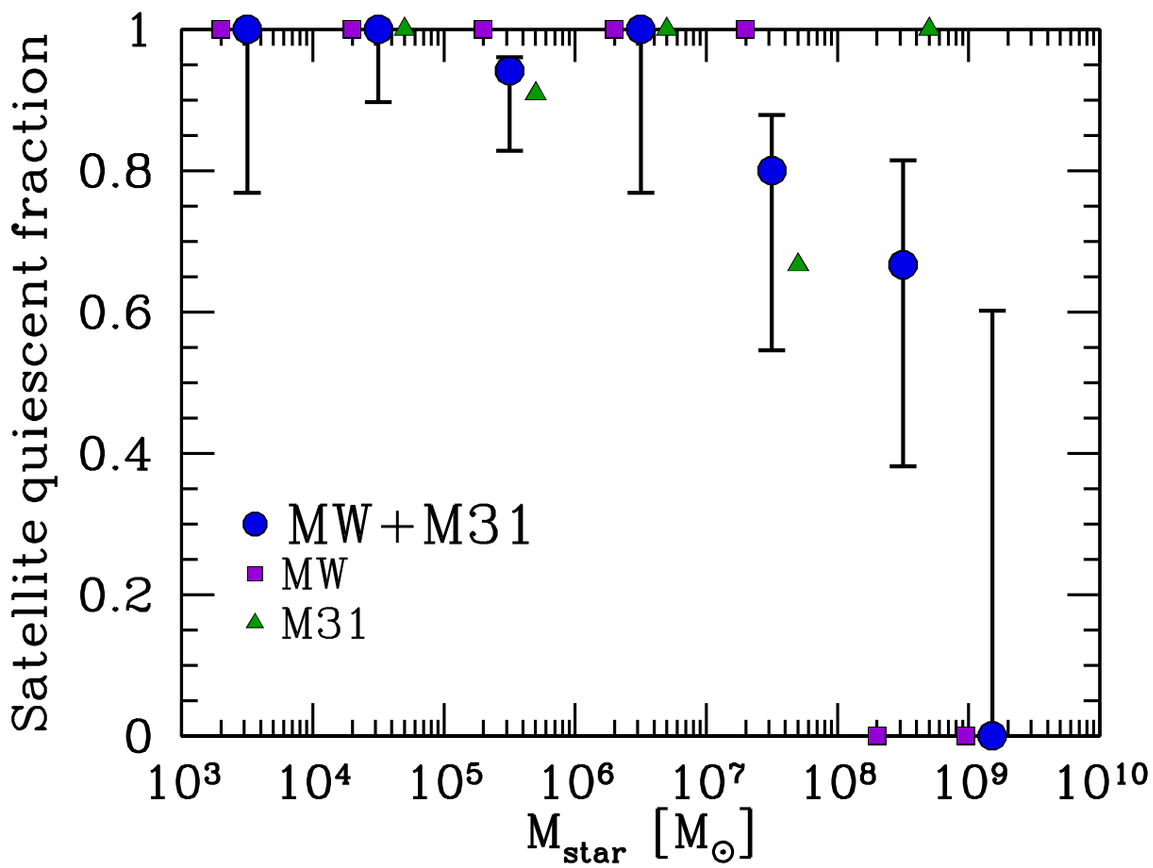
Quenching timescales for satellite dwarf galaxies

Wetzel, Tollerud & Weisz 2015



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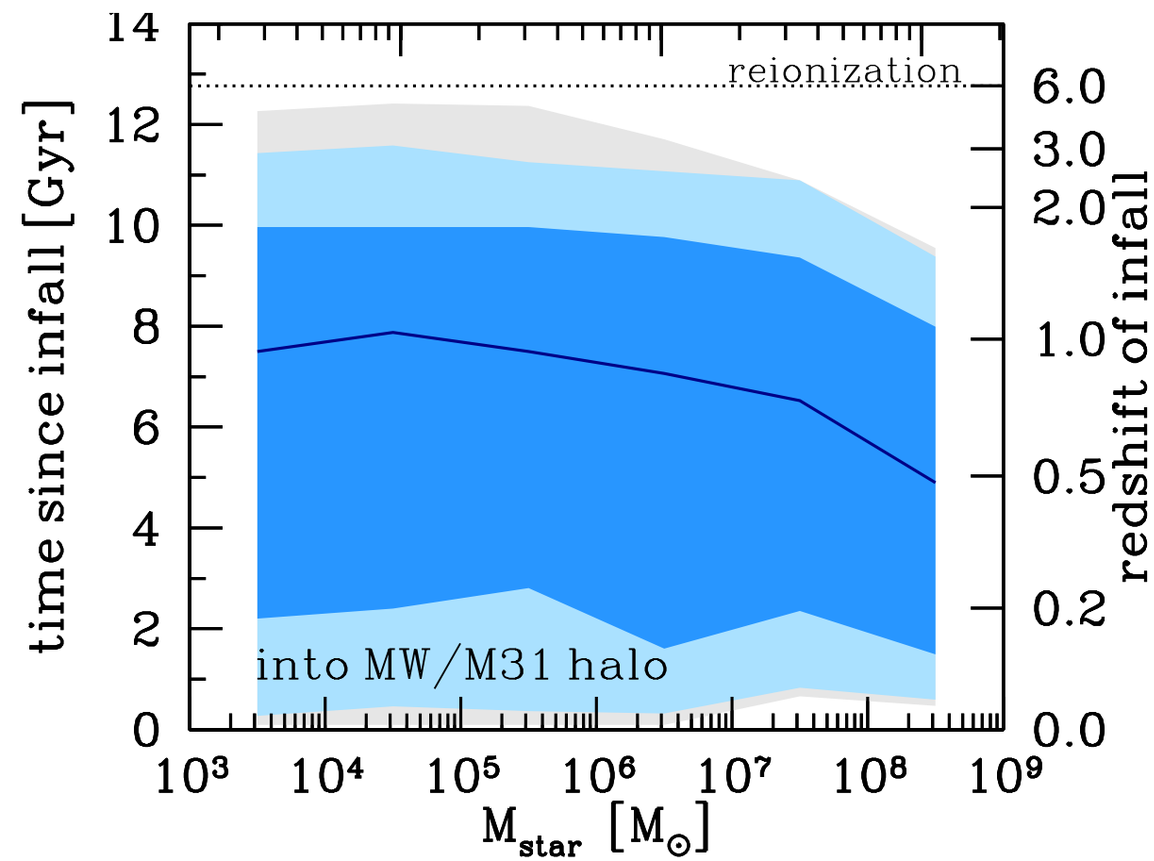
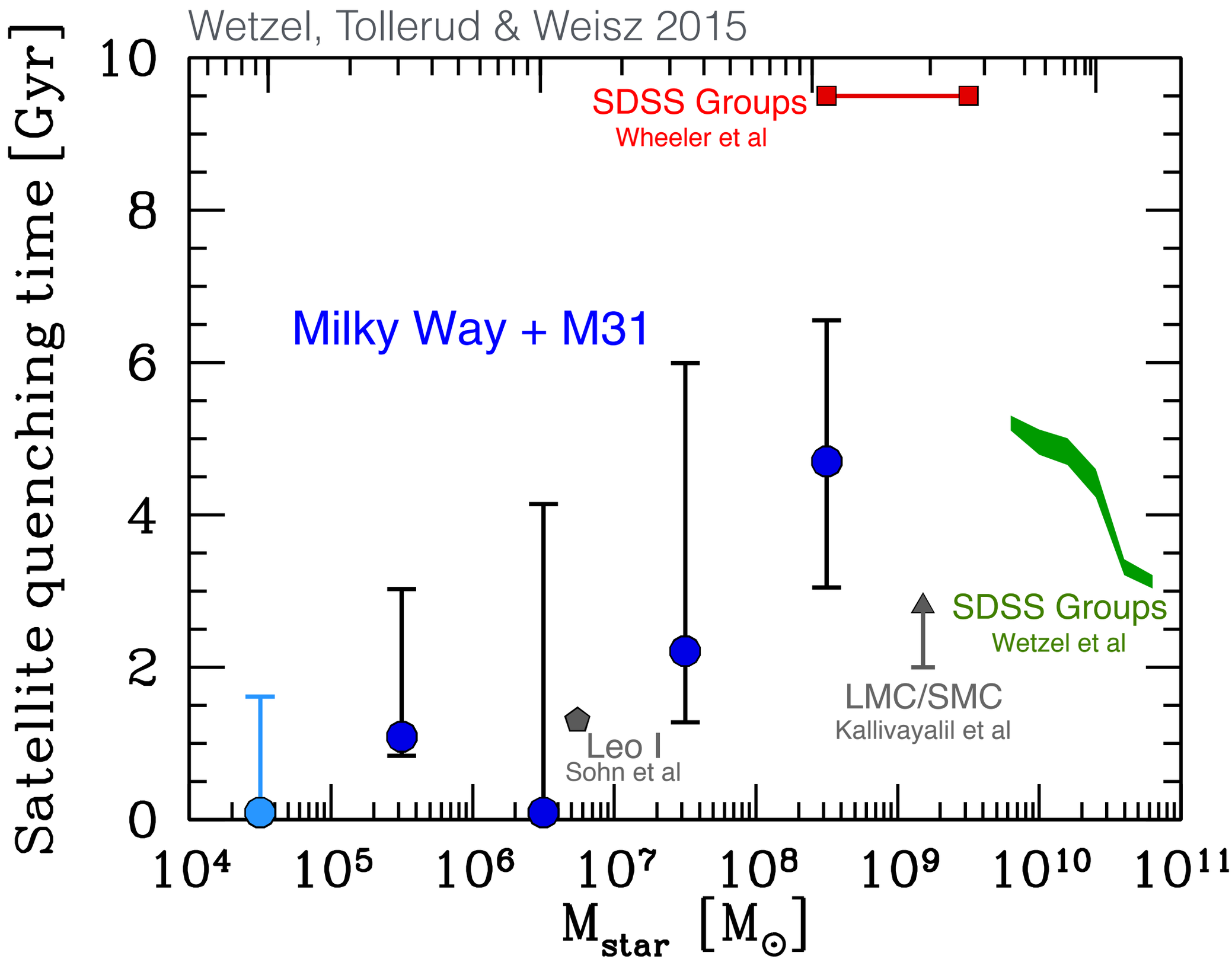
Wetzel, Deason & Garrison-Kimmel 2015



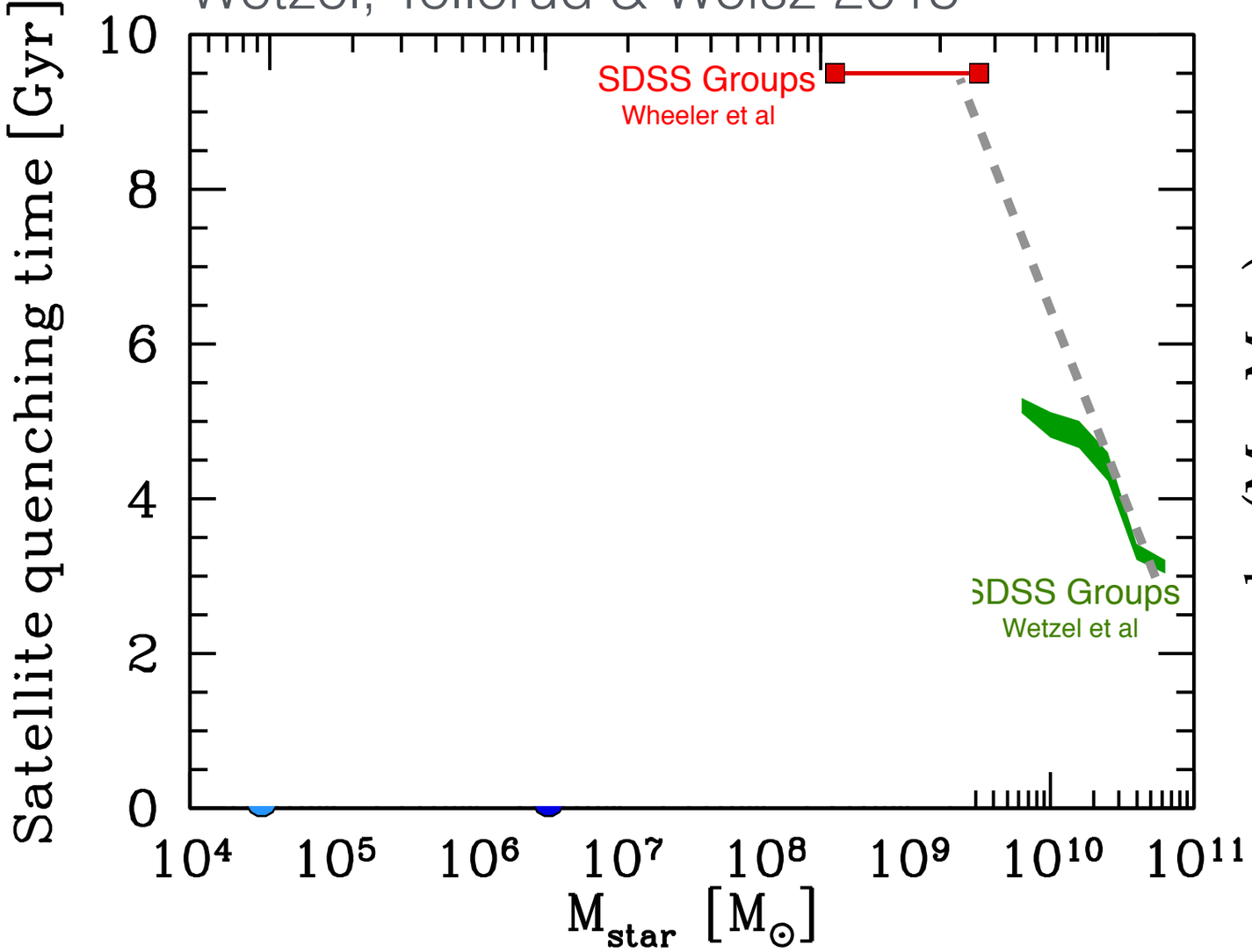
- Ansatz: satellite quenching correlates with time since infall into MW/M31

Quenching timescales for satellite dwarf galaxies

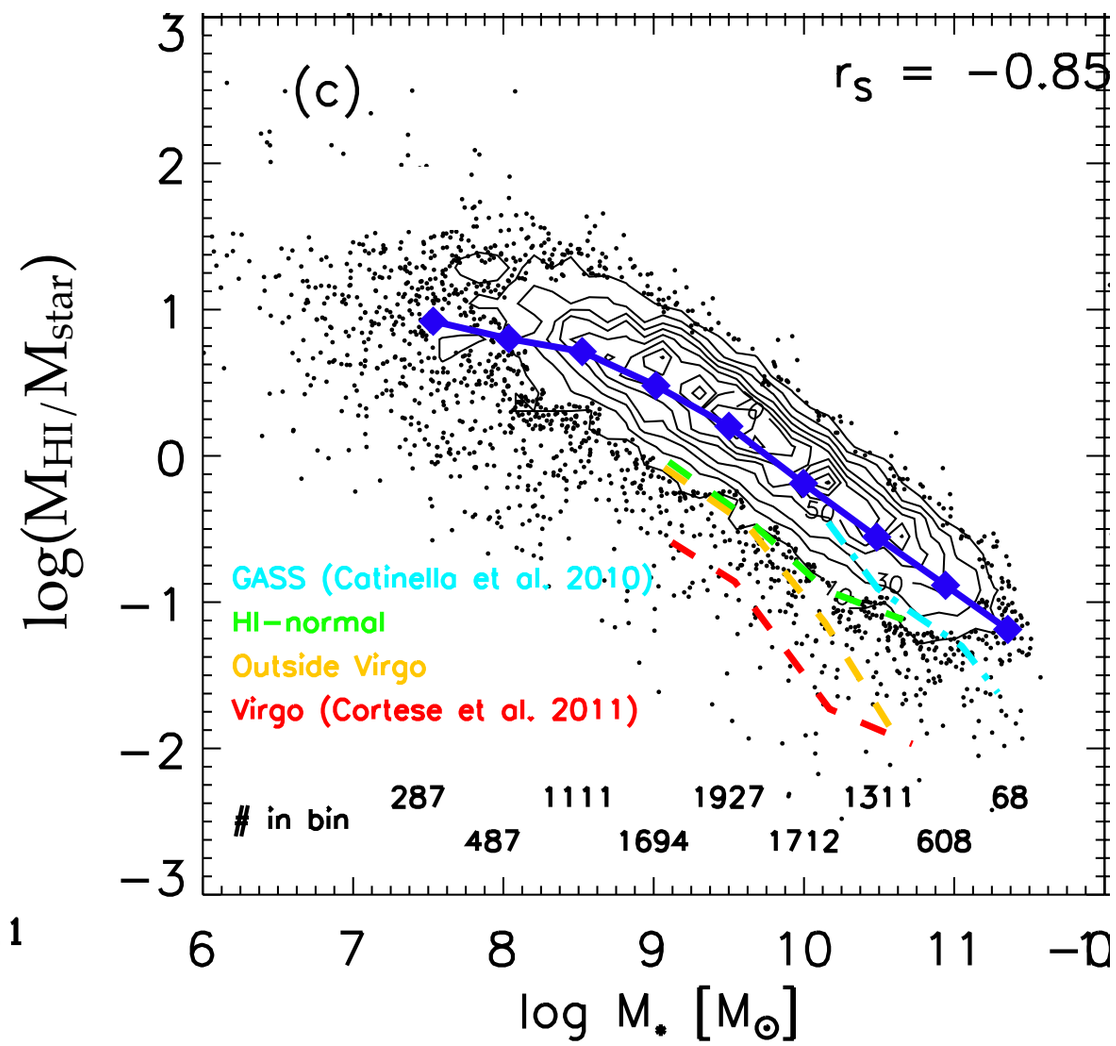


Insight into the quenching of satellites: high mass

Wetzel, Tollerud & Weisz 2015

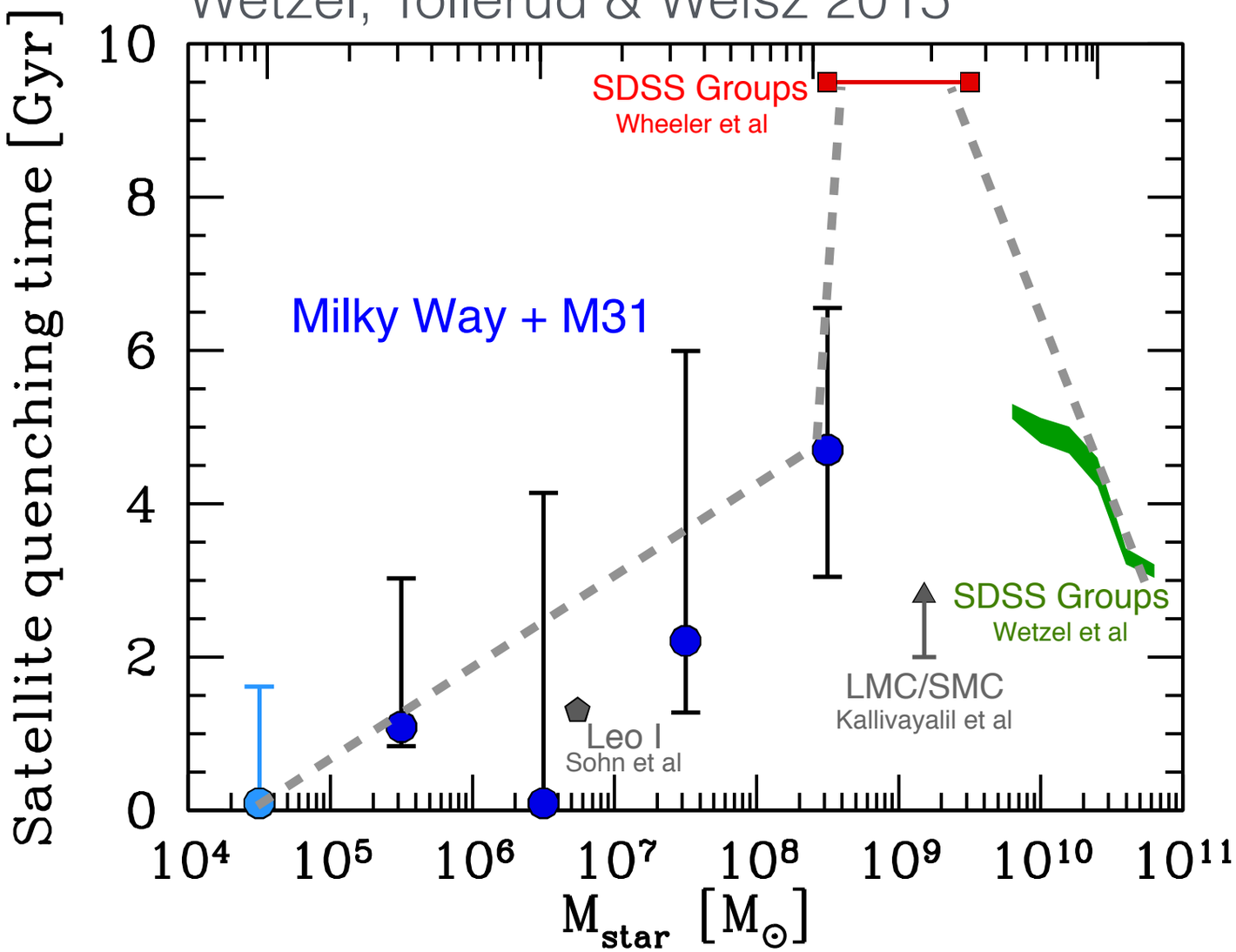


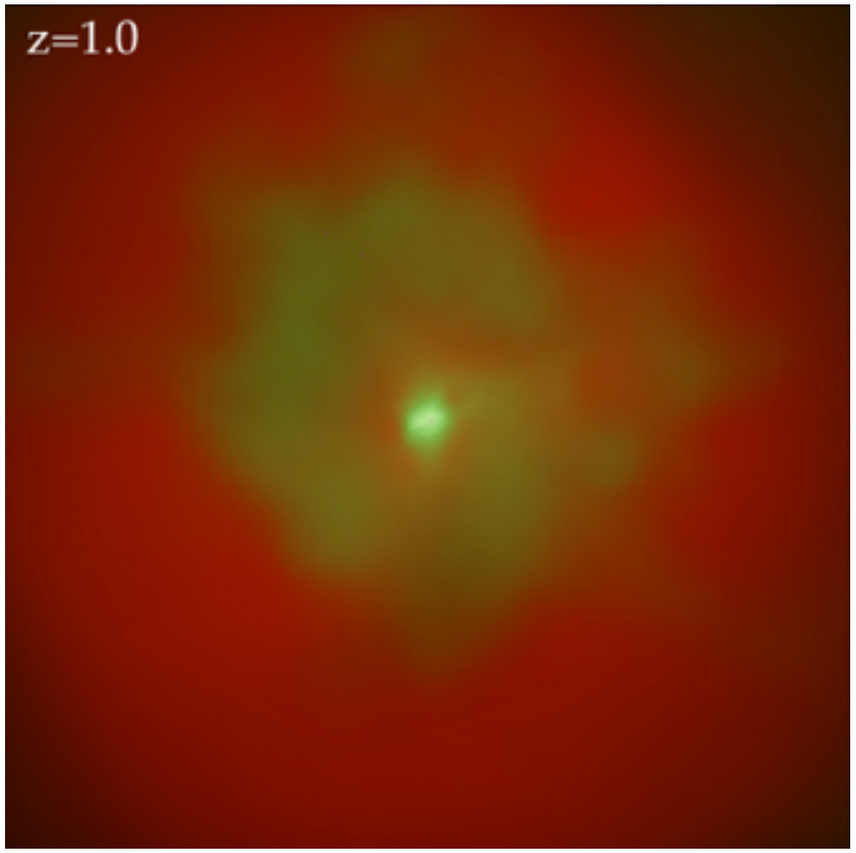
Huang et al 2010 (ALFALFA survey)



Insight into the quenching of satellites: low mass

Wetzel, Tollerud & Weisz 2015





FIRE simulation suite: cosmological zoom-in hydrodynamic simulation of isolated dwarf galaxy (Hopkins et al 2014)

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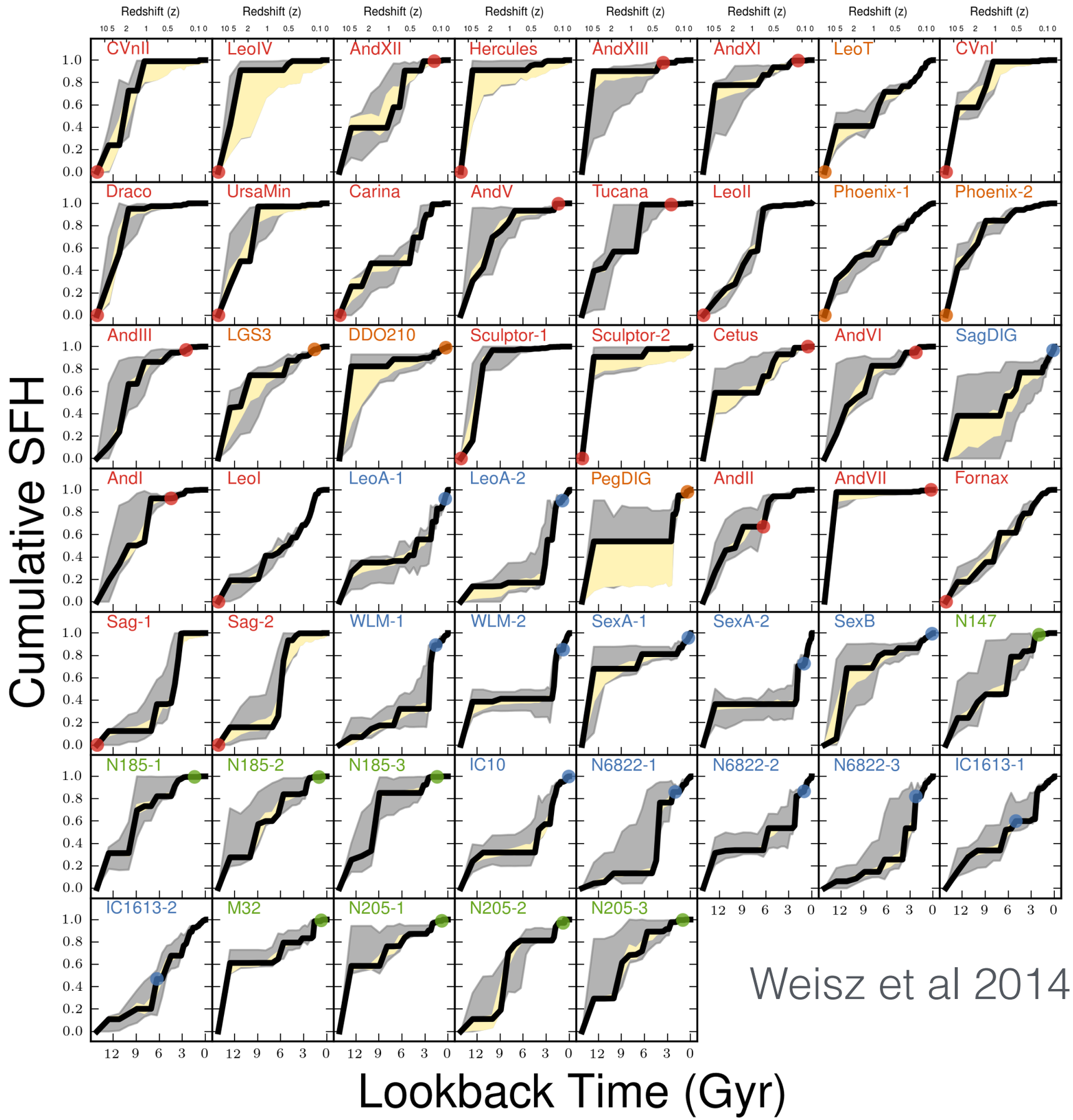
Observed Star-formation Histories

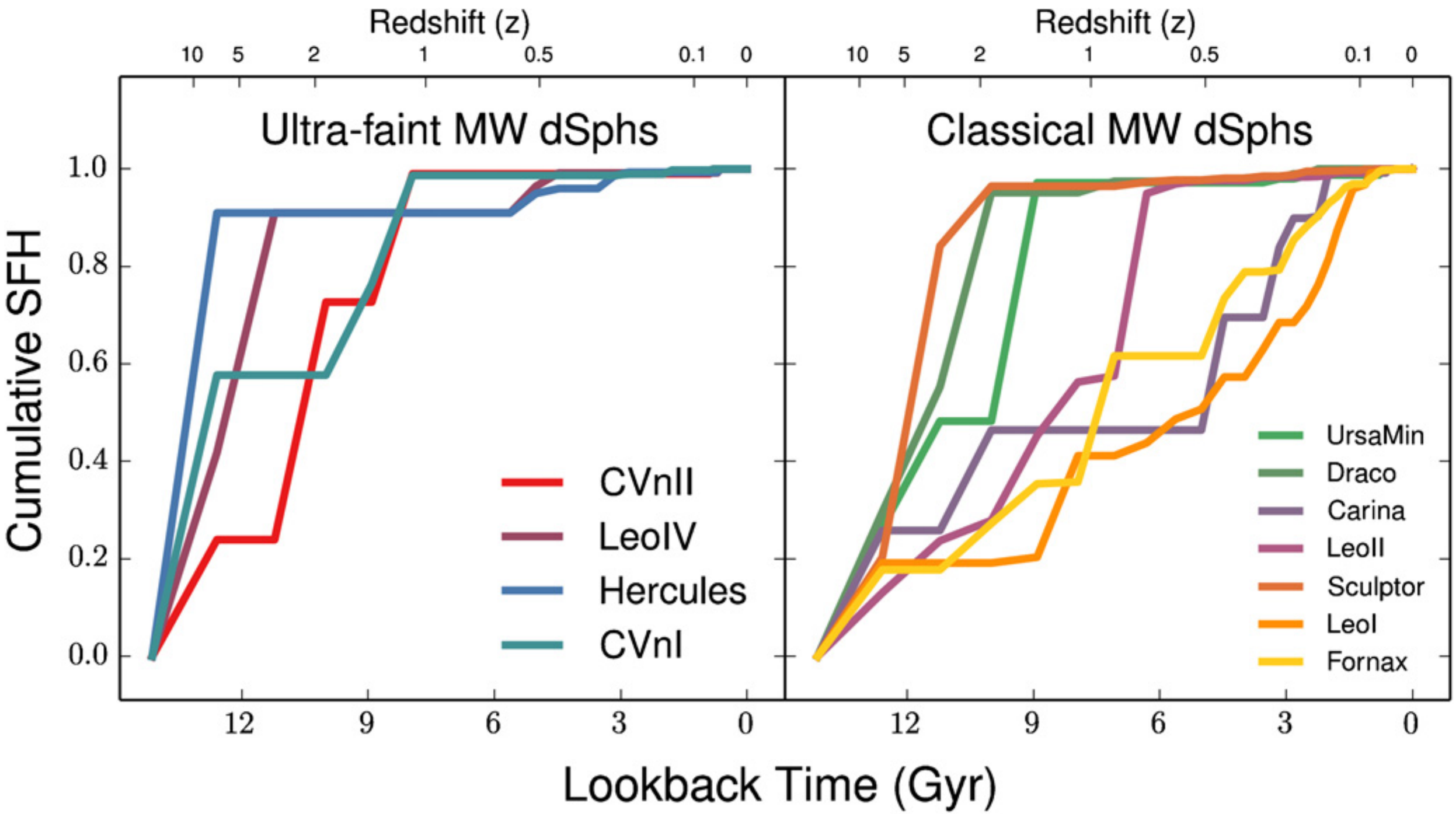
Star-formation histories of dwarf galaxies in the Local Group



Weisz et al 2014

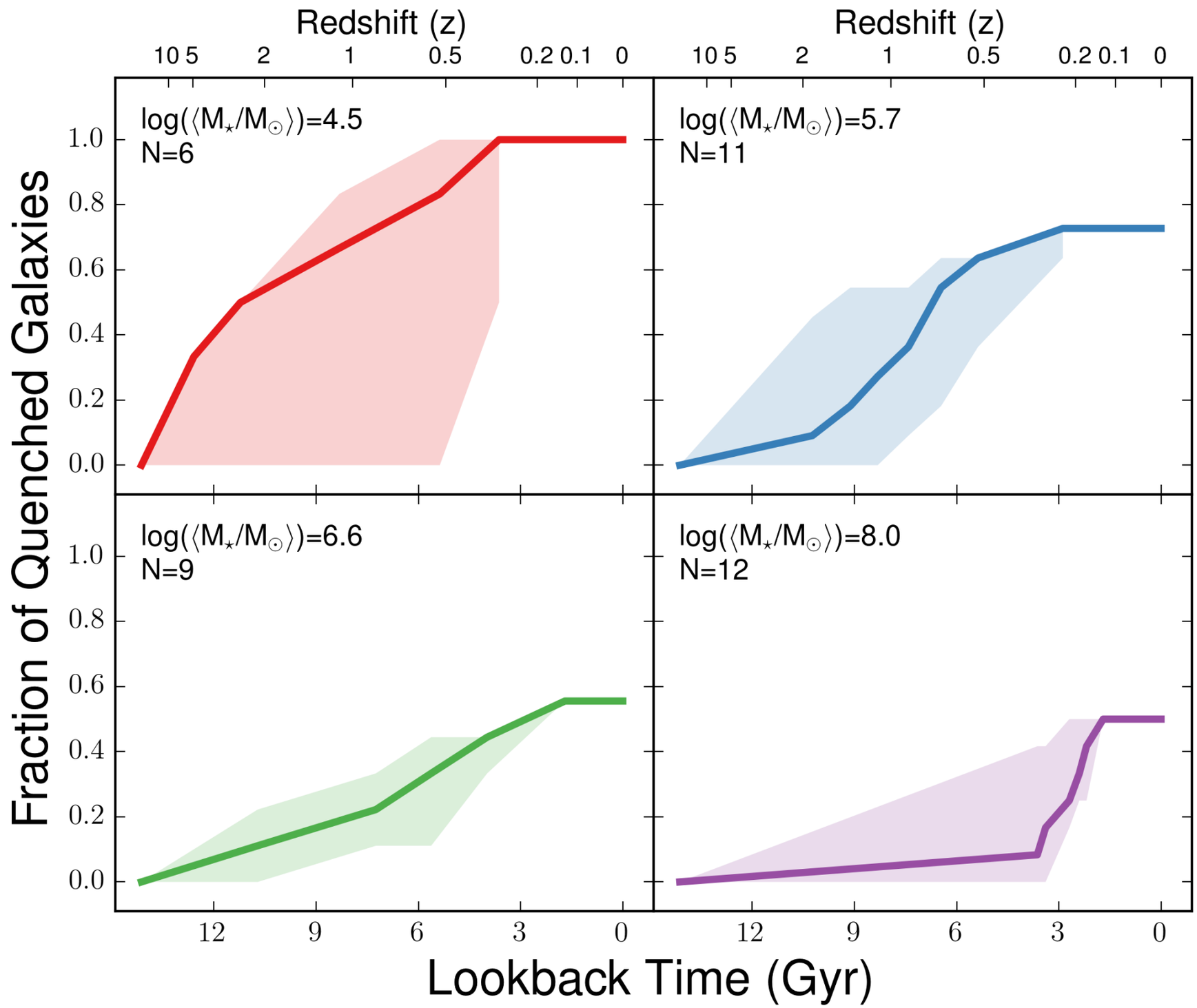
Star-formation histories at different masses

Weisz et al 2014



Evolution of quenching at different masses

Weisz et al 2015



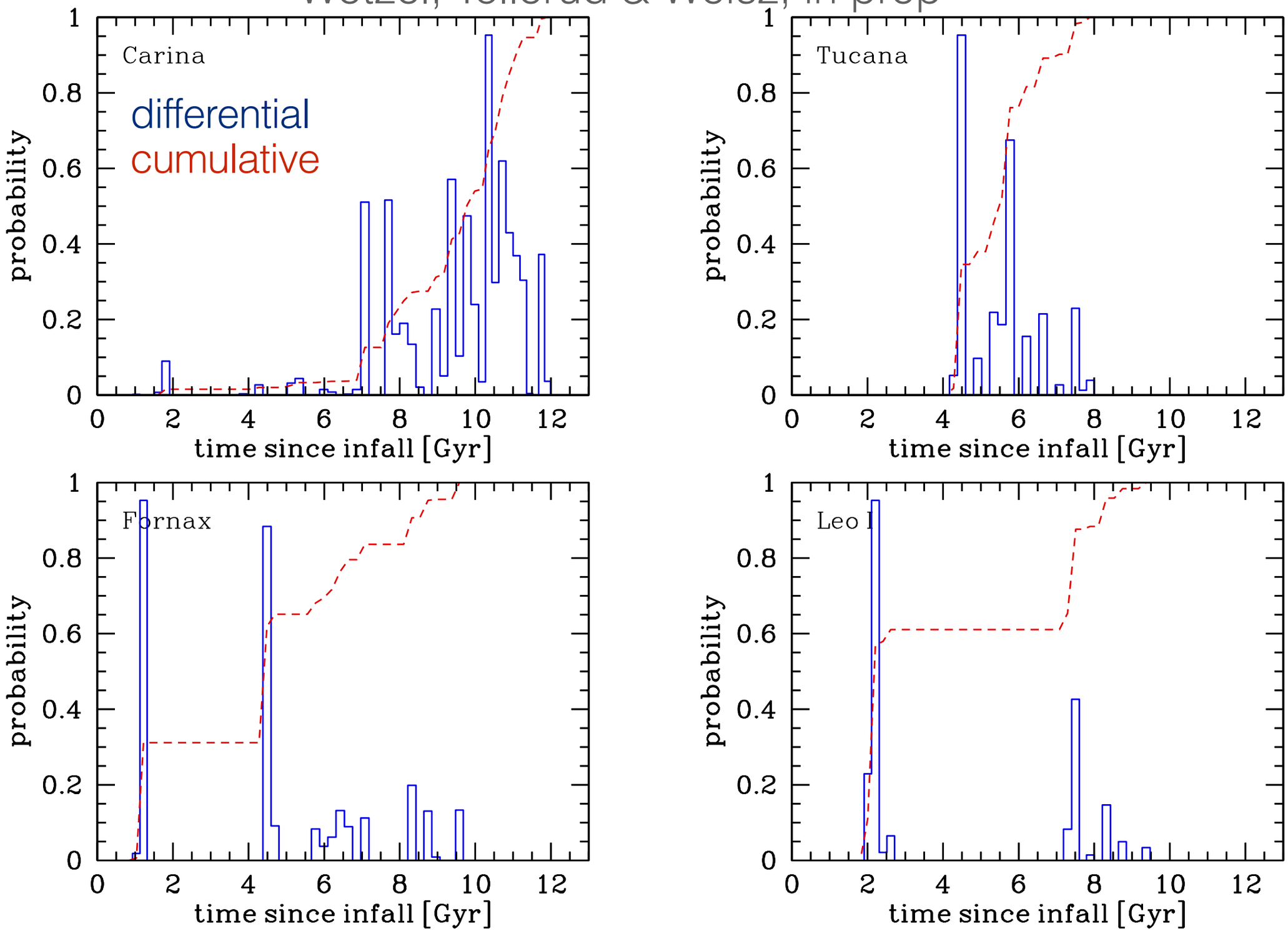
Modeling Orbital Histories

Well-measured 4(6)-dimensional phase-space coordinates for satellites of the Milky Way

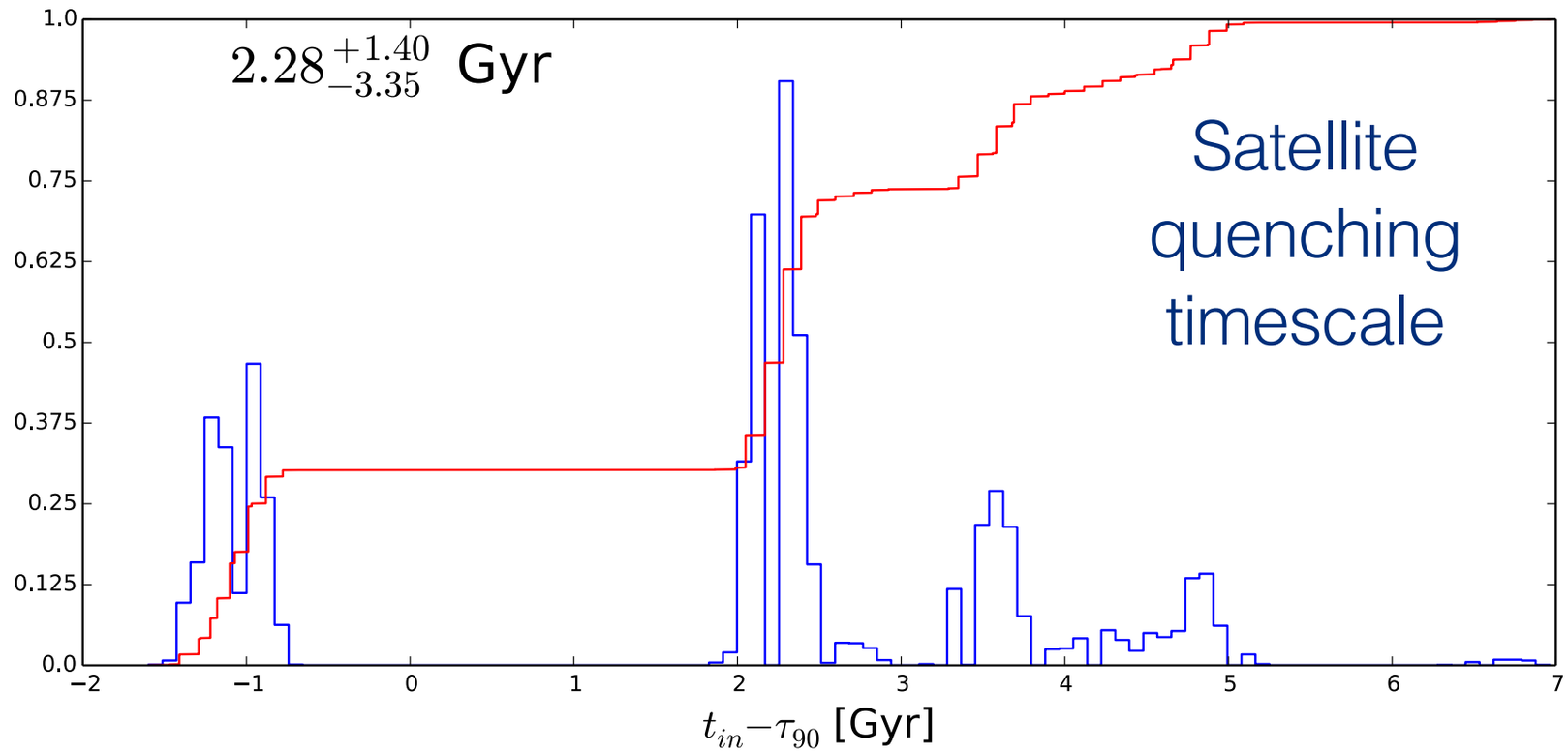
Name	log Stellar Mass [M_sun]	Distance to MW [kpc]	Uncertainty	Velocity Radial [km/s]	Uncertainty	Velocity Tangential [km/s]	Uncertainty
Segue I	2.53	28	2.1	113	5		
Ursa Major II	3.61	38.1	4.4	-33	5		
Canes Venatici II	3.9	161	4.4	-95	5		
Leo IV	4.28	155	6.4	13	5		
Hercules	4.57	126	12.1	145	5		
Leo T	5.15	422	19.2	-58	5		
Canes Venatici I	5.36	218	10	78	5		
Draco	5.46	76	5.9	-96	5		
Ursa Minor	5.46	78	3.5	-75	44	144	50
Carina	5.58	107	6.3	20	24	85	39
Tucana	5.75	882	49	99	5		
Leo II	5.87	236	14	22	4	265	129
Phoenix	5.89	415	19.1	-103	5		
Sculptor	6.36	89	5.5	79	6	198	50
Leo I	6.74	257	14	167.9	3	101	35
Fornax	7.3	149	12.2	-31.8	1.7	196	29
Sagittarius dSph	7.32	18	1.8	169	5		
SMC	8.66	61.2	3.5	-11	5	217	26
LMC	9.18	50	2.1	64	7	314	24

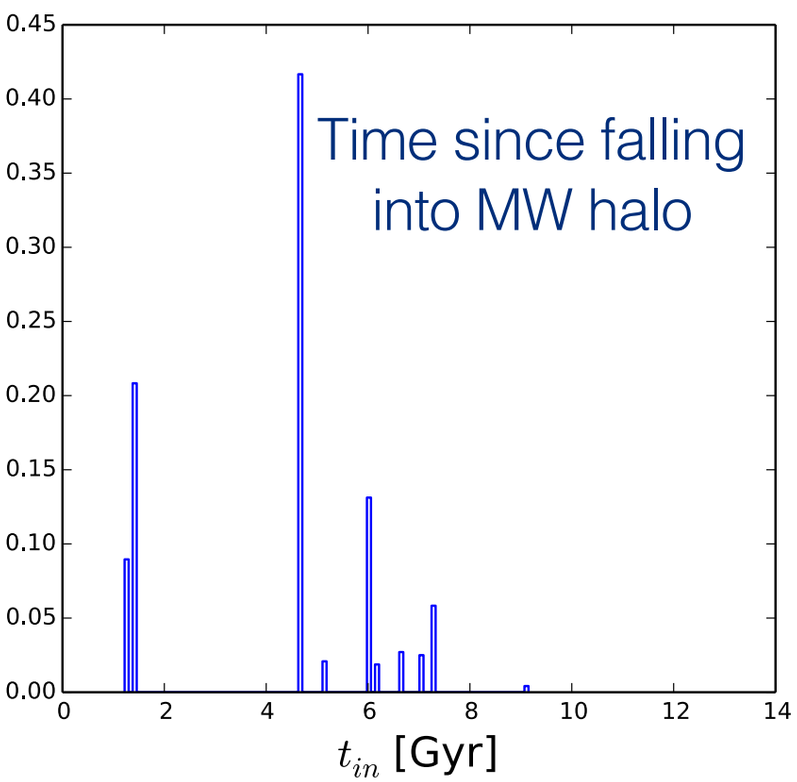
Examples of orbital-history likelihoods for individual satellites of the Milky Way

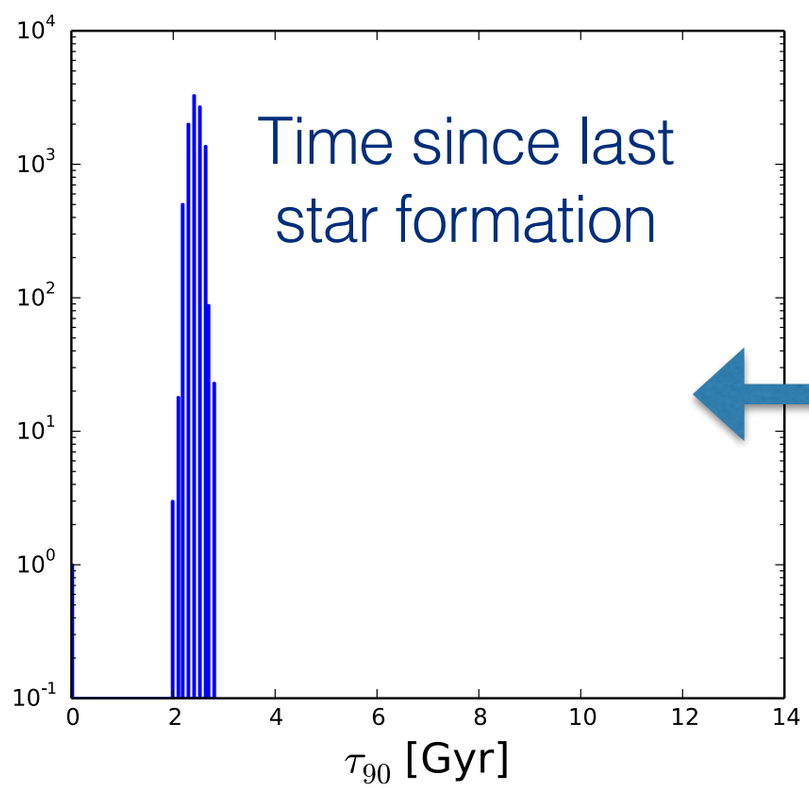
Wetzel, Tollerud & Weisz, in prep

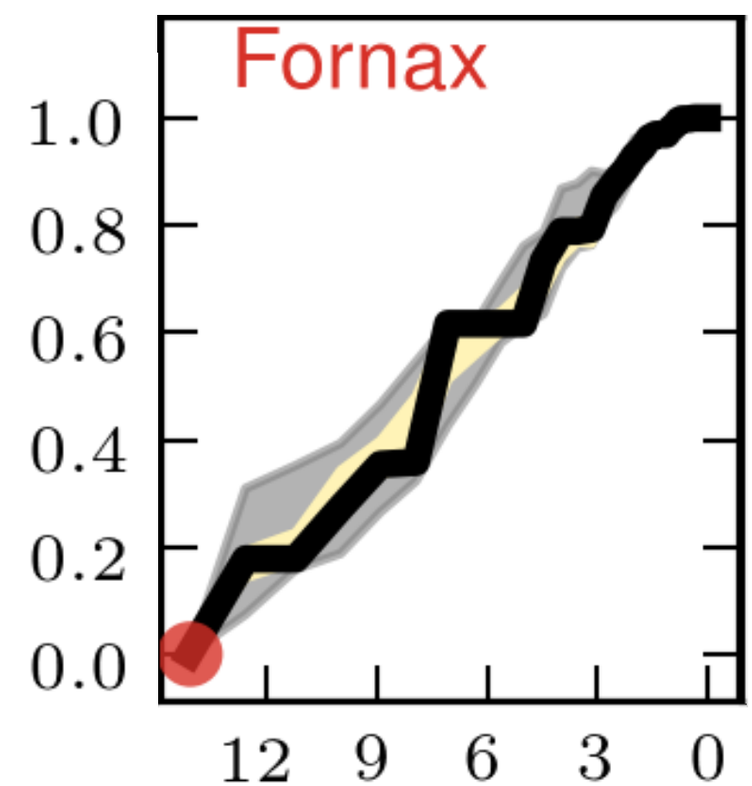


Example: Fornax

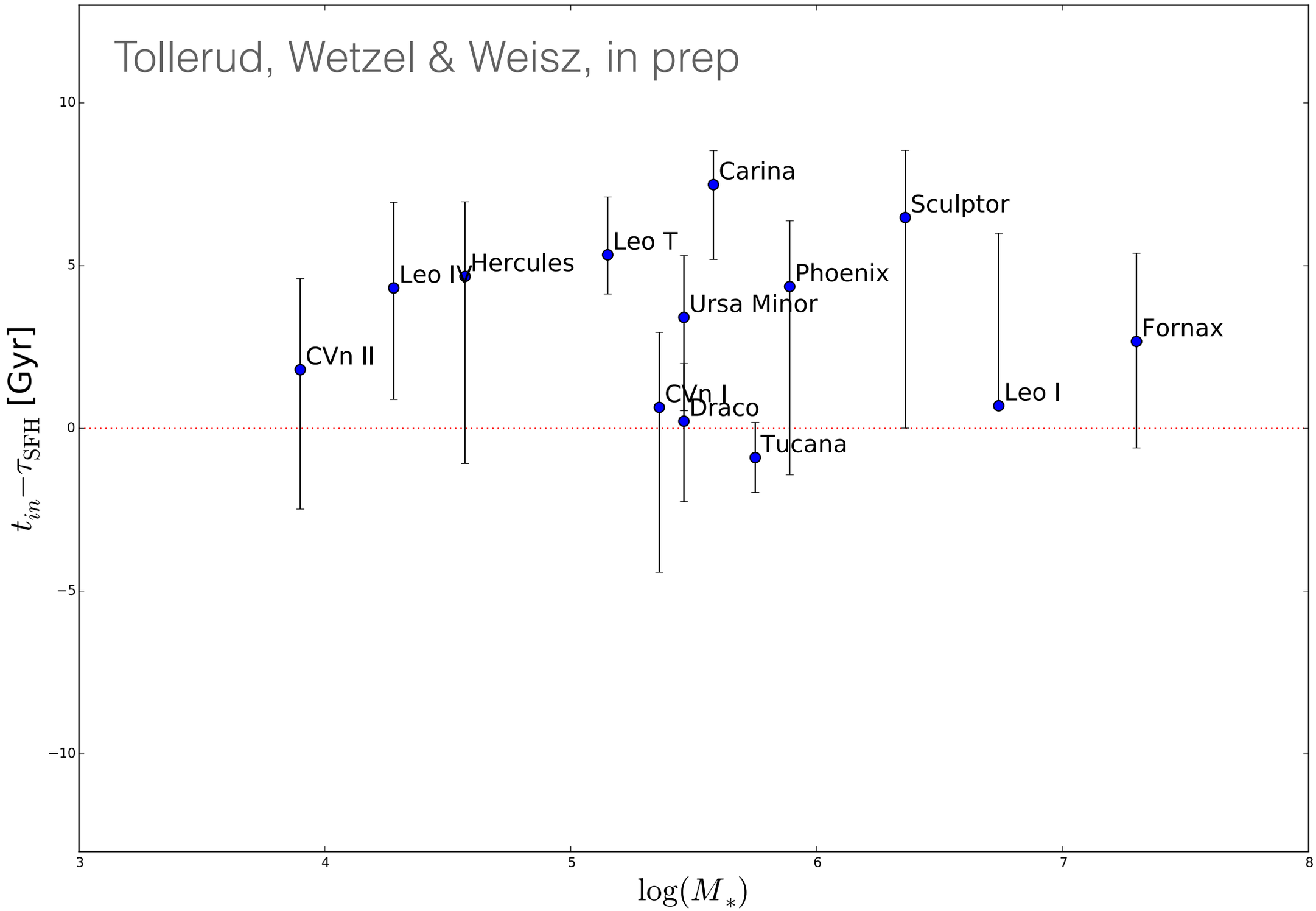








Satellite quenching timescales for individual dwarf galaxies



A Hubble Astrometry Initiative: Laying the Foundation for the Next-Generation Proper-Motion Survey of the Local Group

White Paper for Hubble's 2020 Vision

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Alis J. Deason (UC Santa Cruz)
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March 4, 2015

Abstract

High-precision astrometry throughout the Local Group is a unique capability of the Hubble Space Telescope (HST), with potential for transformative science, including constraining the nature of dark matter, probing the epoch of reionization, and understanding key physics of galaxy evolution. While Gaia will provide unparalleled astrometric precision for bright stars in the inner halo of the Milky Way, HST is the only current mission capable of measuring accurate proper motions for systems at greater distances ($\gtrsim$ 80 kpc), which represents the vast majority of galaxies in the Local Group. The next generation of proper-motion measurements will require long time baselines, spanning many years to decades and possibly multiple telescopes, combining HST with the James Webb Space Telescope (JWST) or the Wide-Field Infrared Survey Telescope (WFIRST). However, the current HST allocation process is not conducive to such multi-cycle/multi-mission science, which will bear fruit primarily over many years. We propose an HST astrometry initiative to enable long-time-baseline, multi-mission science, which we suggest could be used to provide comprehensive kinematic measurements of all dwarf galaxies and high surface-density stellar streams in the Local Group with HST's Advanced Camera for Surveys (ACS) or Wide Field Camera 3 (WFC3). Such an initiative not only would produce forefront scientific results within the next 5 years of HST's life, but also would serve as a critical anchor point for future missions to obtain unprecedented astrometric accuracy, ensuring that HST leaves a unique and lasting legacy for decades to come.

Only 10 of 70 (+11) dwarf galaxies have measured proper motions

18 (+11) dwarf galaxies do not even have good first-epoch observations

Science that proper motions enable:

(1) Cosmic reionization

(2) Environmental quenching

(3) Associations of satellites

(4) MW/M31 mass profiles

(5) Internal kinematics for measuring cores/cusps