Darkness on the edge of town: Exploring simulated ultra-faint dwarf galaxies

Alyson Brooks
Rutgers, the State University of New Jersey

In collaboration with the University of Washington's N-body Shop™
makers of quality galaxies

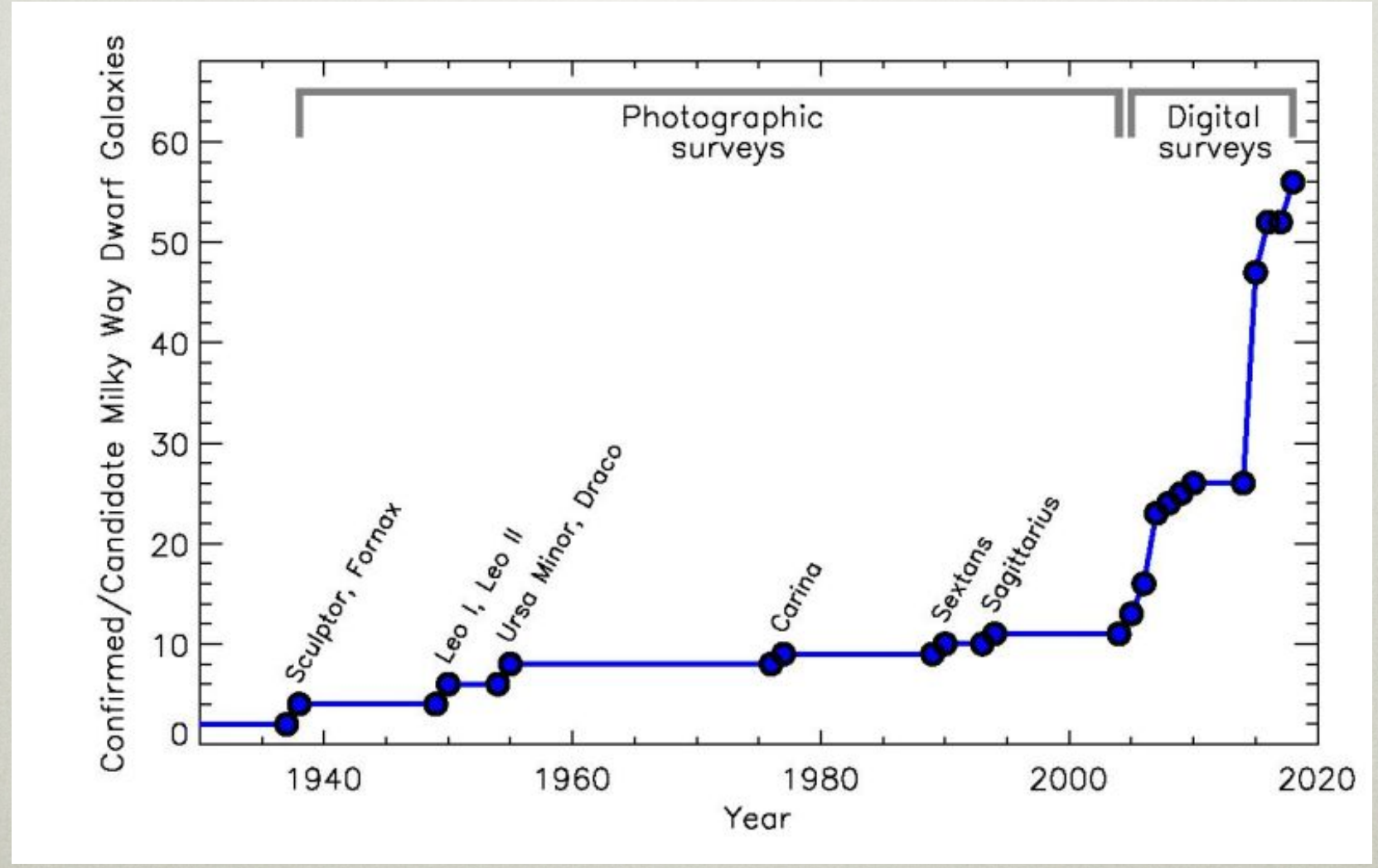
Darkness on the edge of town: Exploring simulated ultra-faint dwarf galaxies

"Dancing in the Dark: Uncertainty in ultra-faint dwarf galaxy predictions from cosmological simulations", Munshi et al. ApJ, 2019, 874, 40, arXiv:1810.12417

,

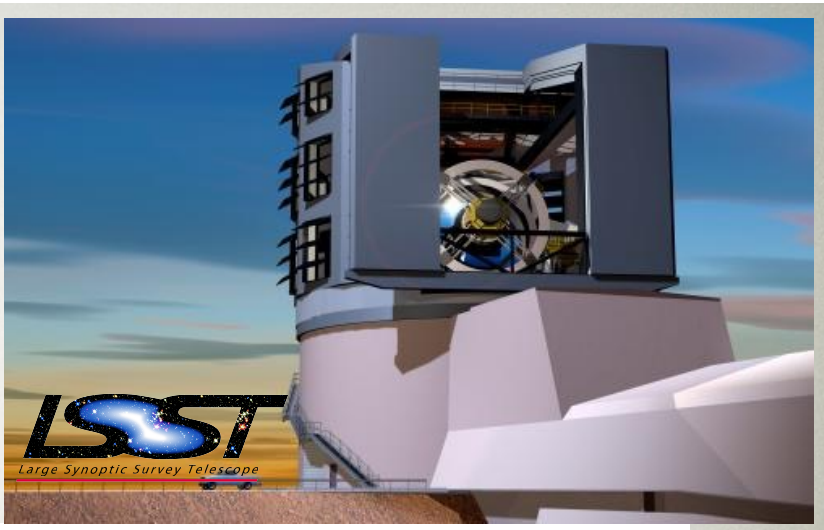
"Darkness on the edge of town: Simulated ultra-faint dwarfs in a MilkyWay context," Applebaum et al., in prep

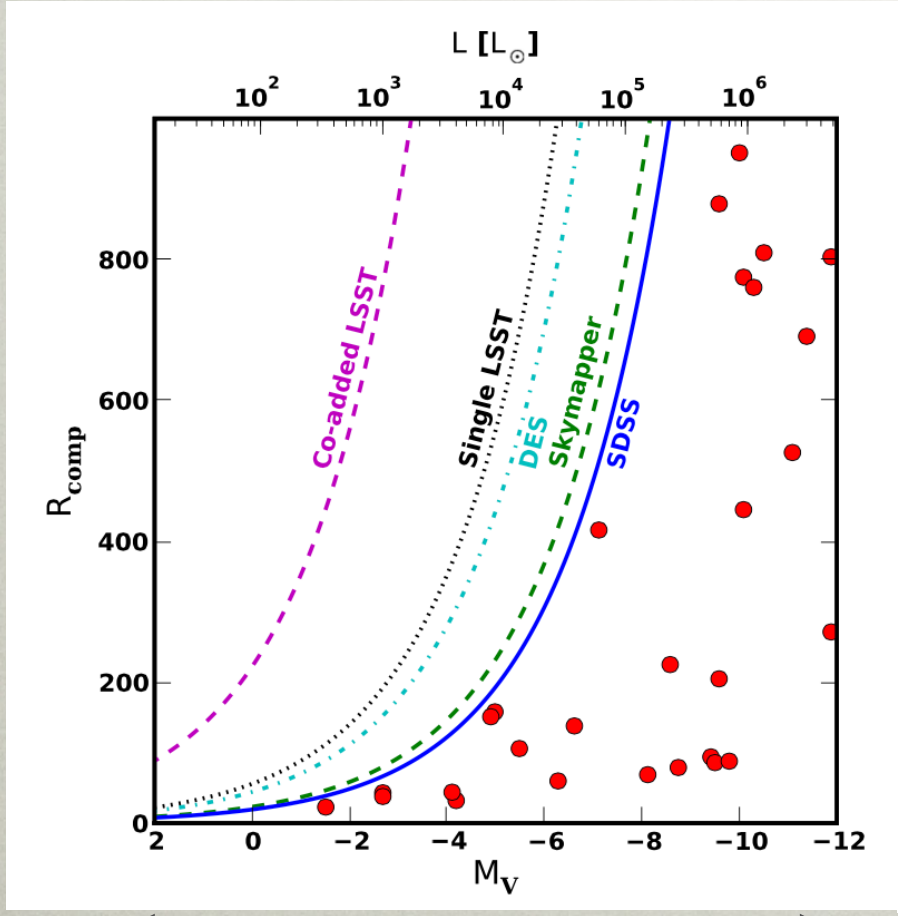
The Faint Galaxy Boom

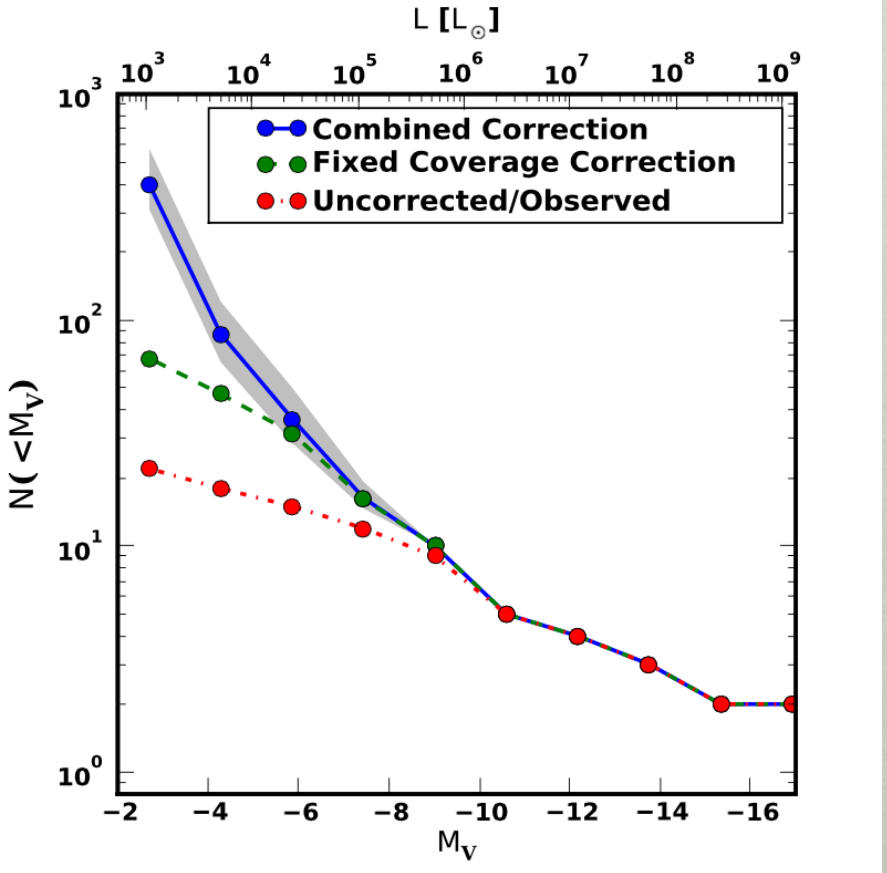


J. Simon, ARA&A (2019)

The Future is Dwarfy







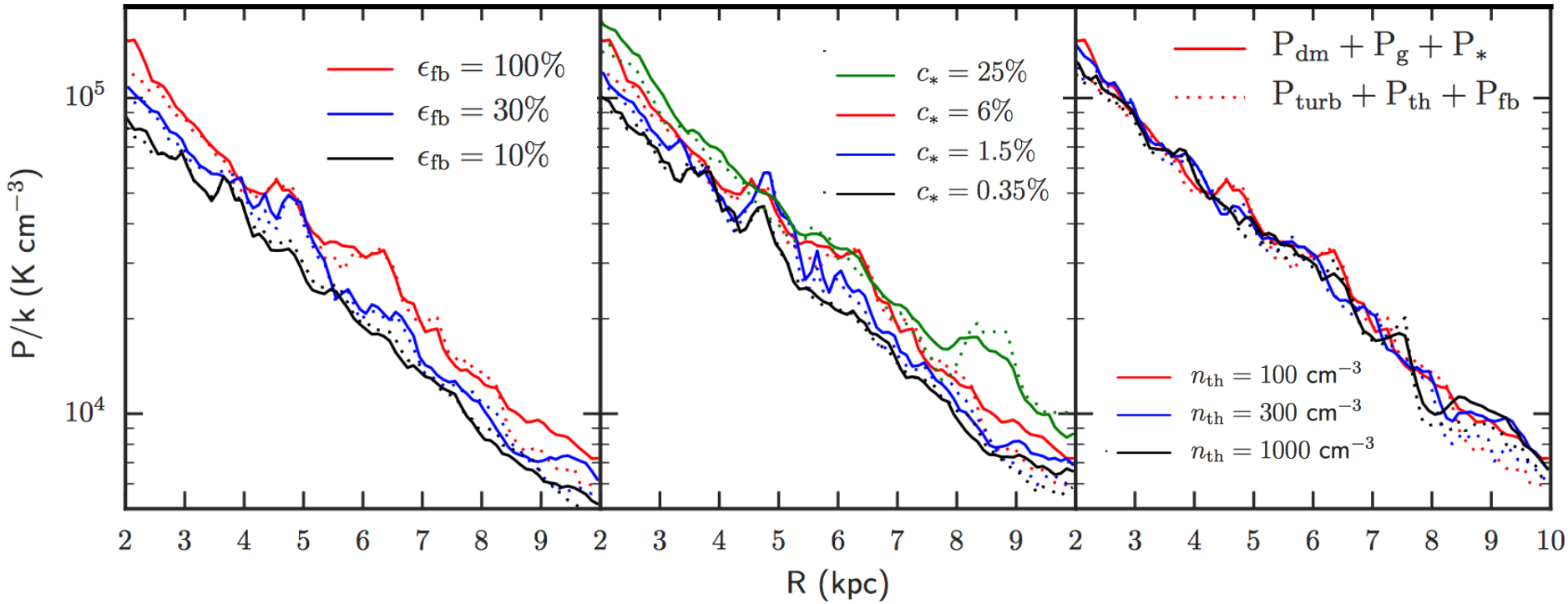
Tollerud et al. (2008)
see also Walsh et al. (2009); Newton et al. (2018)

Will We Understand What We'll Find?

- What is the lowest mass halo that contains a galaxy? (talks next session)
- Stellar Mass to Halo Mass? Scatter?
- Occupation fraction?
- Today's talk: the role of star formation prescription

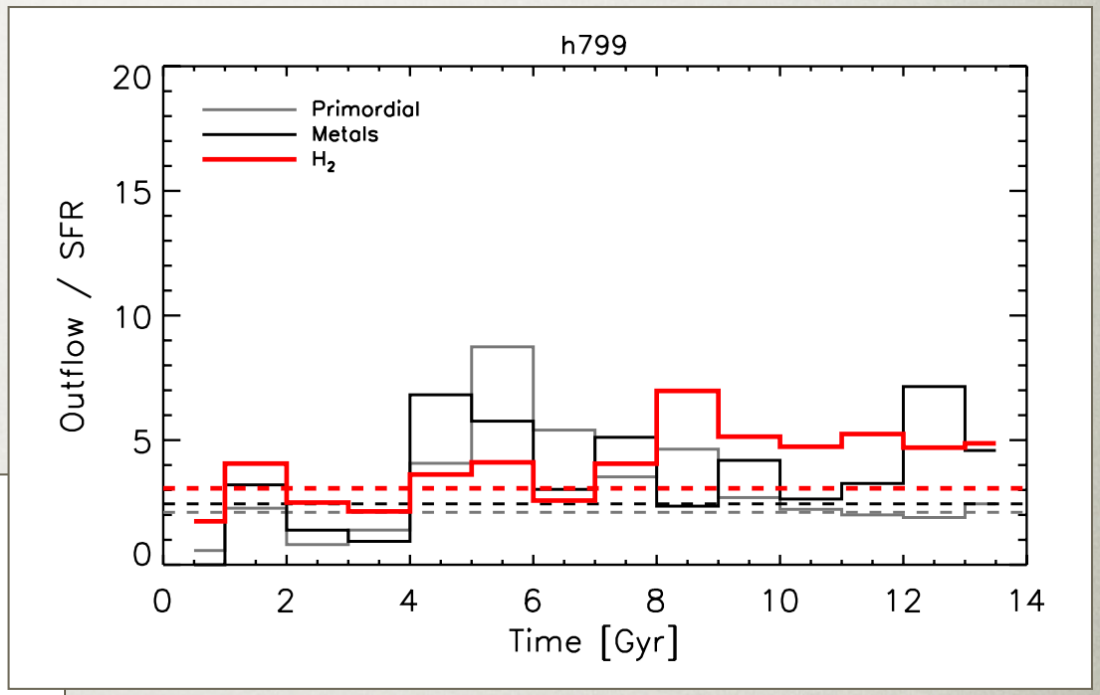
MC (high density/low temp) vs H_2 (follow molecular hydrogen)

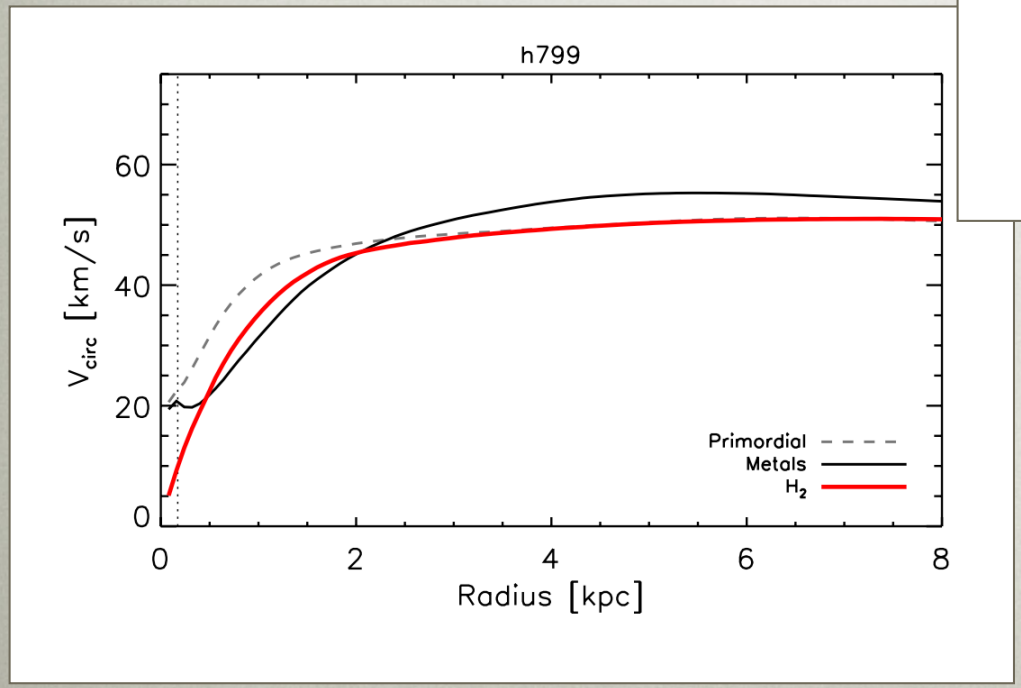
First: Why Simulators Generally Don't Worry About This



Benincasa et al. (2016)

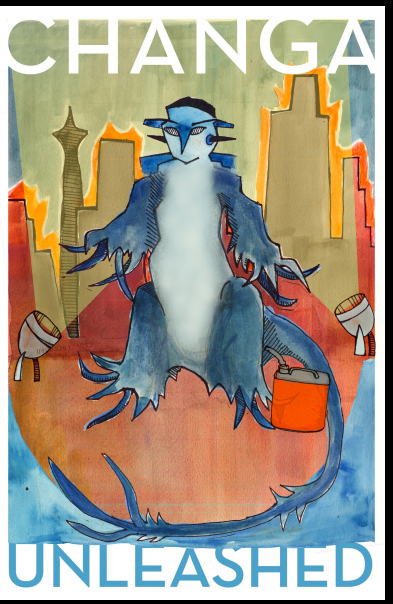
Self-Regulation in Classical Dwarf Galaxies

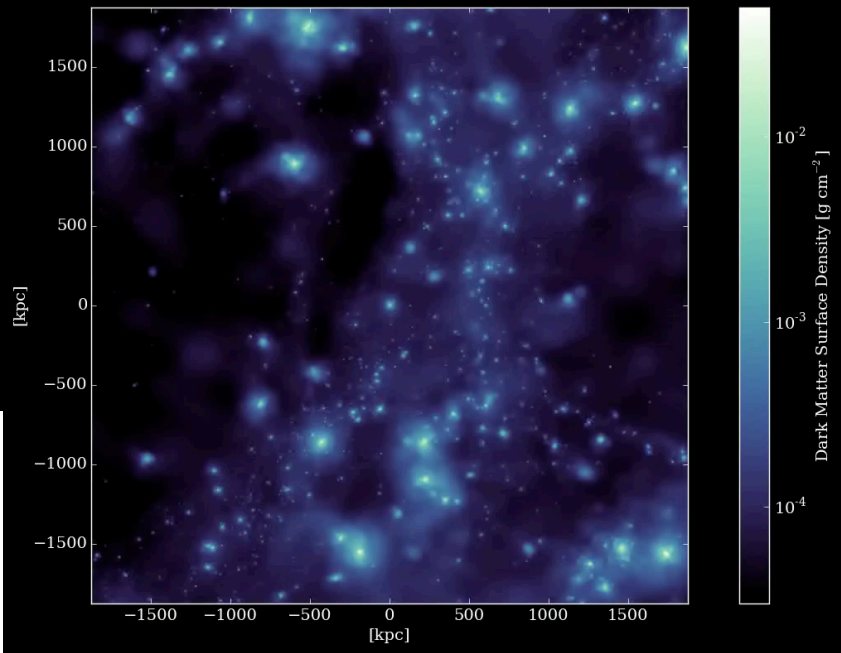




$M_{star} \sim 10^8 M_\odot$

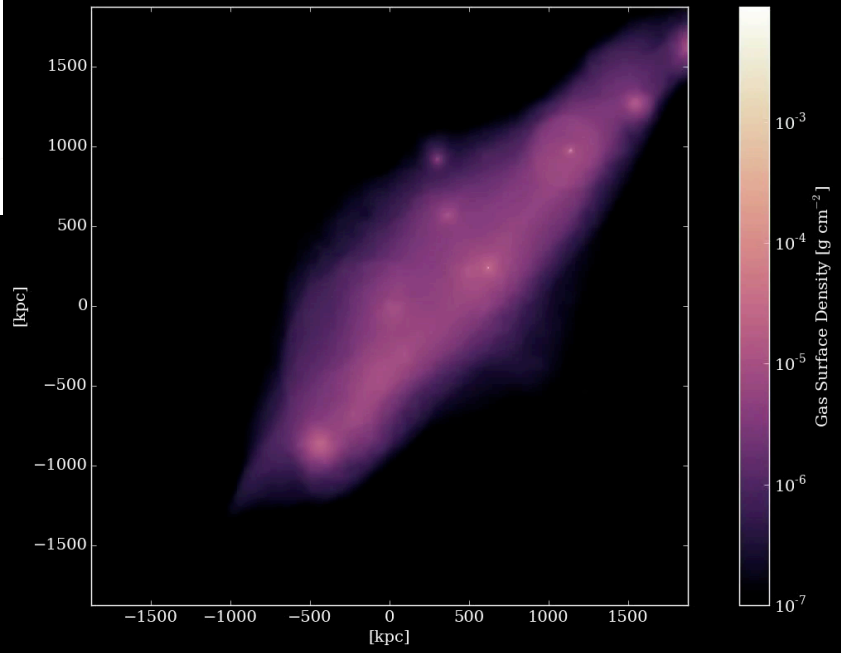
Christensen et al. (2014)





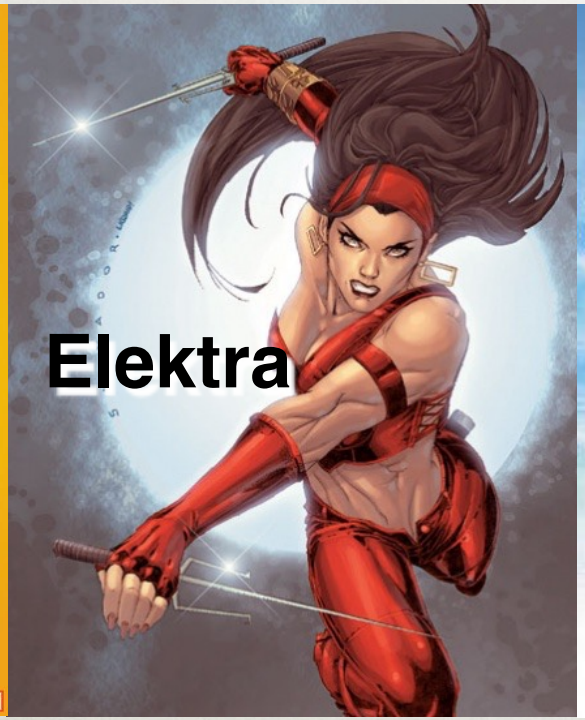
z=0 DM density

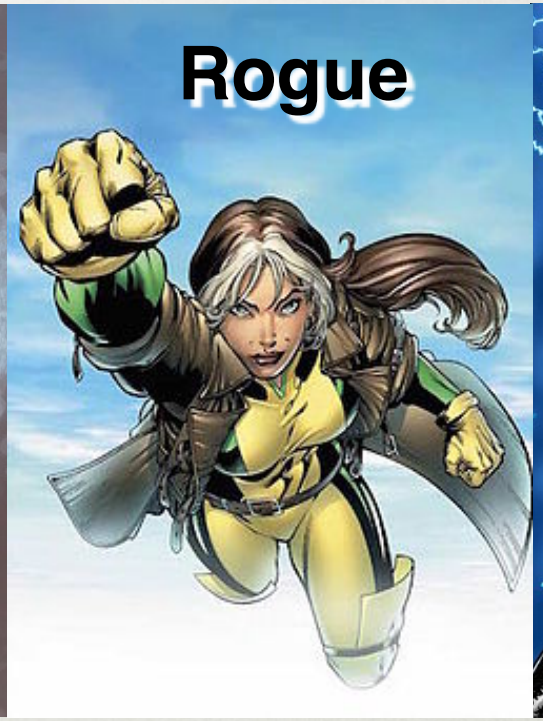
The Goal:
Hundreds of Simulated Dwarf Galaxies to Interpret Local Volume Studies



z=0 Gas density

The Marvel-ous Volumes

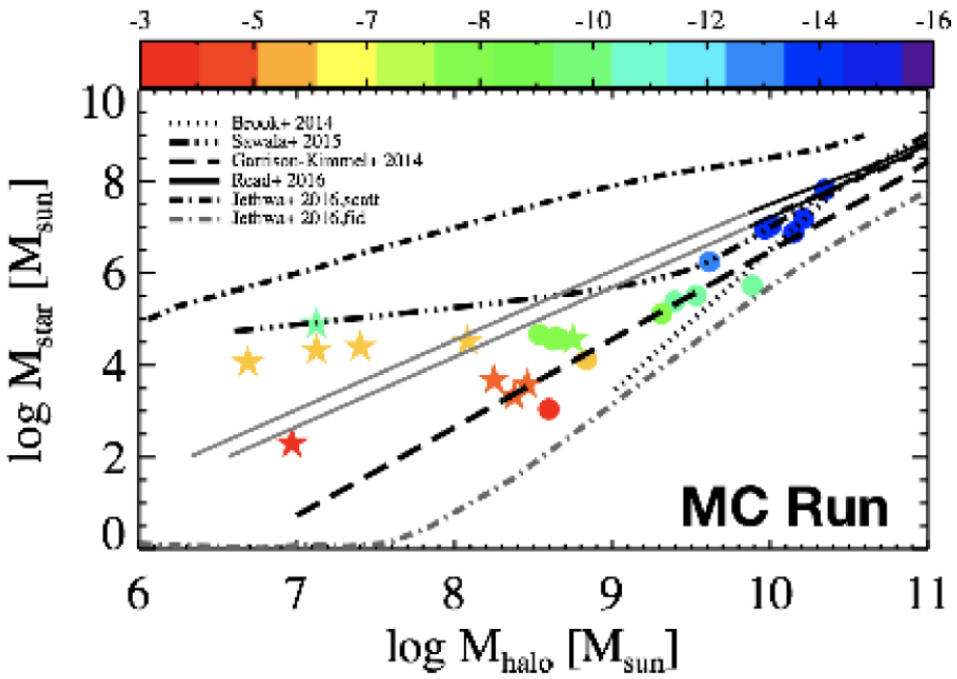


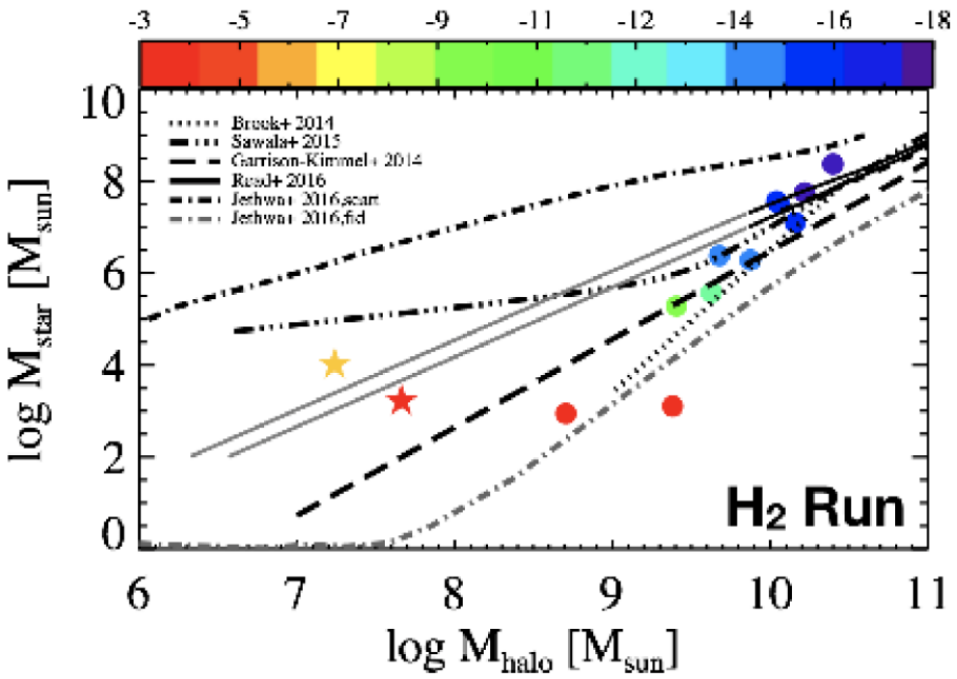


Force resolution: 60pc
SPH resolution: 6pc
M_{star}: 400 Msun
M_{dm}: 6000 Msun
z~129 to 0

Many flavors:
- DM only
- With H2 + Black Holes
- Metal cooling + self shielding
- SIDM

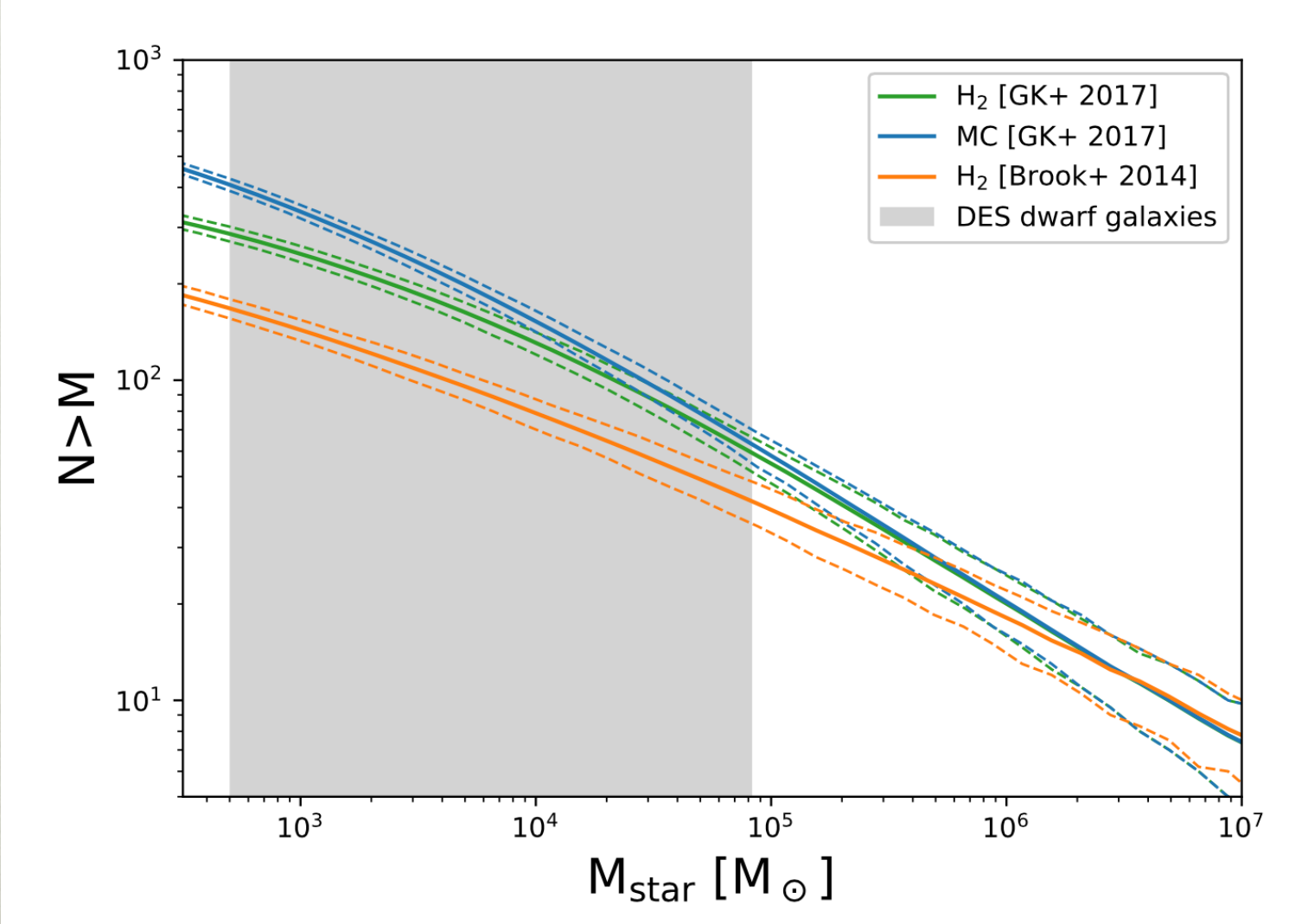
The Role of Star Formation Prescription





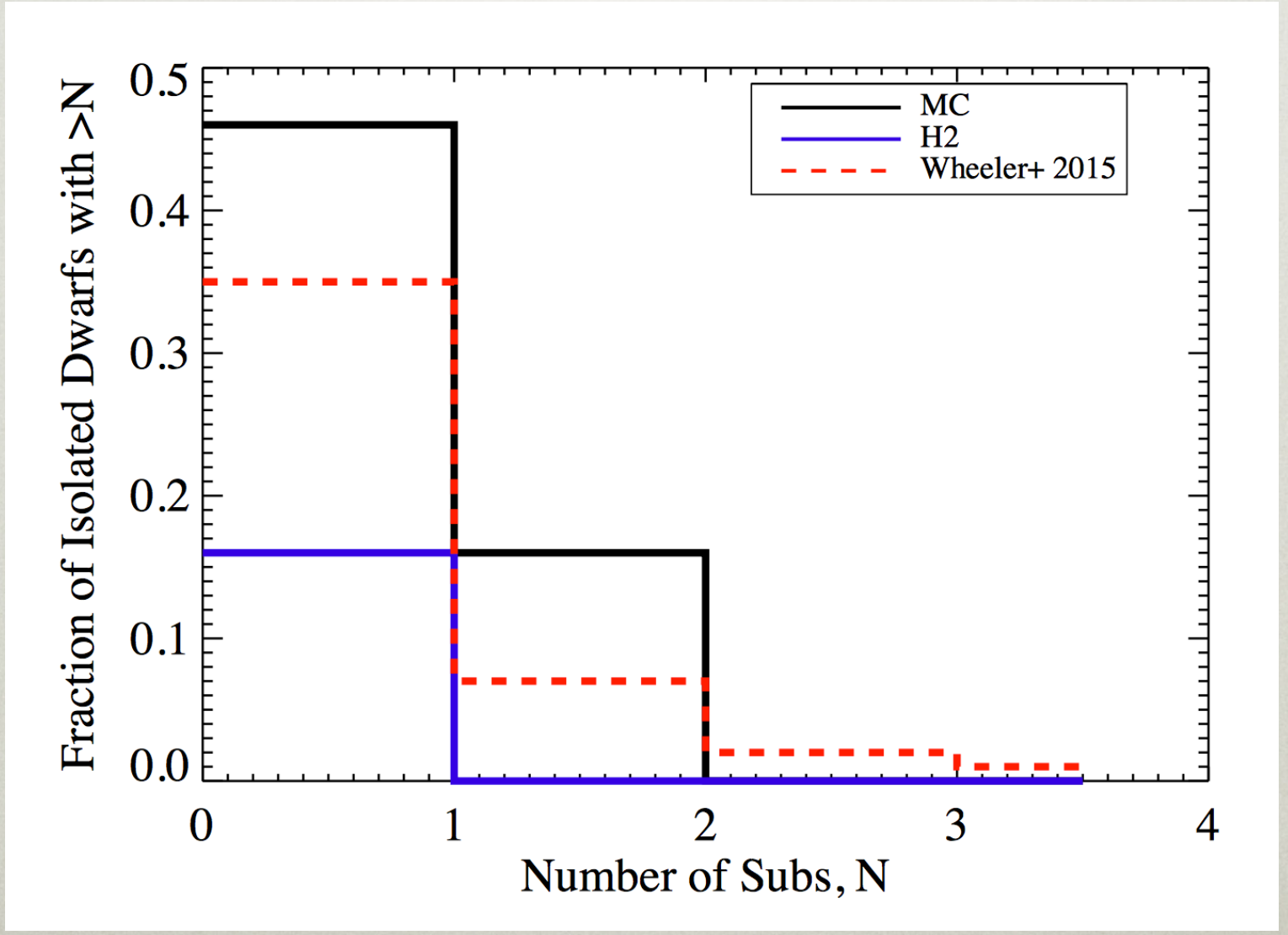
Munshi, Brooks, et al., 2019, ApJ, 874, 40

The Role of Star Formation Prescription



Munshi, Brooks, et al., 2019, ApJ, 874, 40

The Role of Star Formation Prescription



Munshi, Brooks, et al., 2019, ApJ, 874, 40

Take Away (Part I)

- UFD properties are strongly dependent on chosen prescriptions of simulators, unlike in classical dwarf range
- This is because UFDs are strongly affected by external factors (reionization) and can no longer self-regulate.

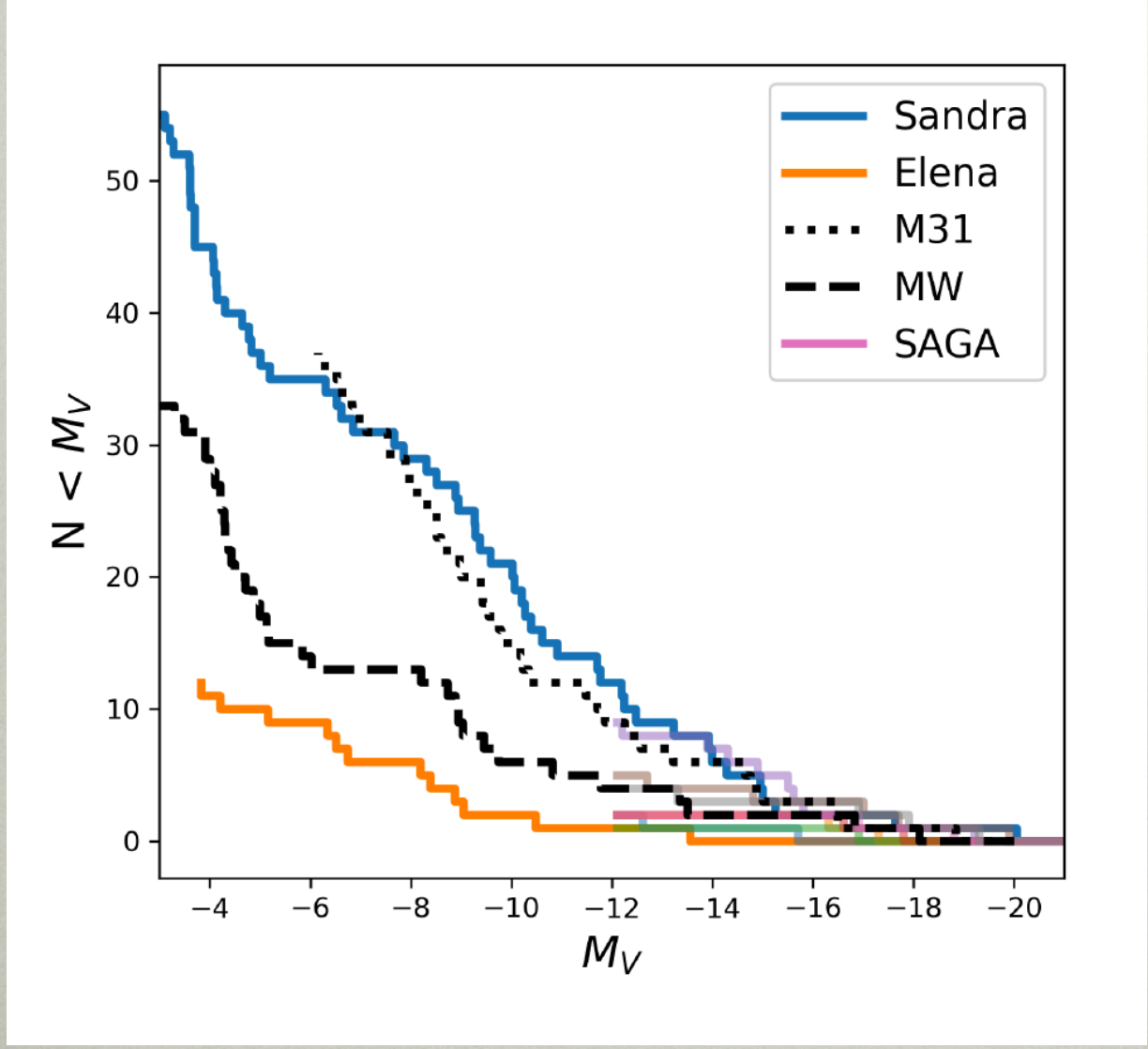
The DC Justice League

4 volumes centered on MW-mass halos

Force resolution: 170 & 85pc
SPH resolution: 17 & 9pc

M_{star}: 8000/1000 Msun
M_{dm}: $1.3 \times 10^5 / 1.6 \times 10^4$ Msun
z~to 0

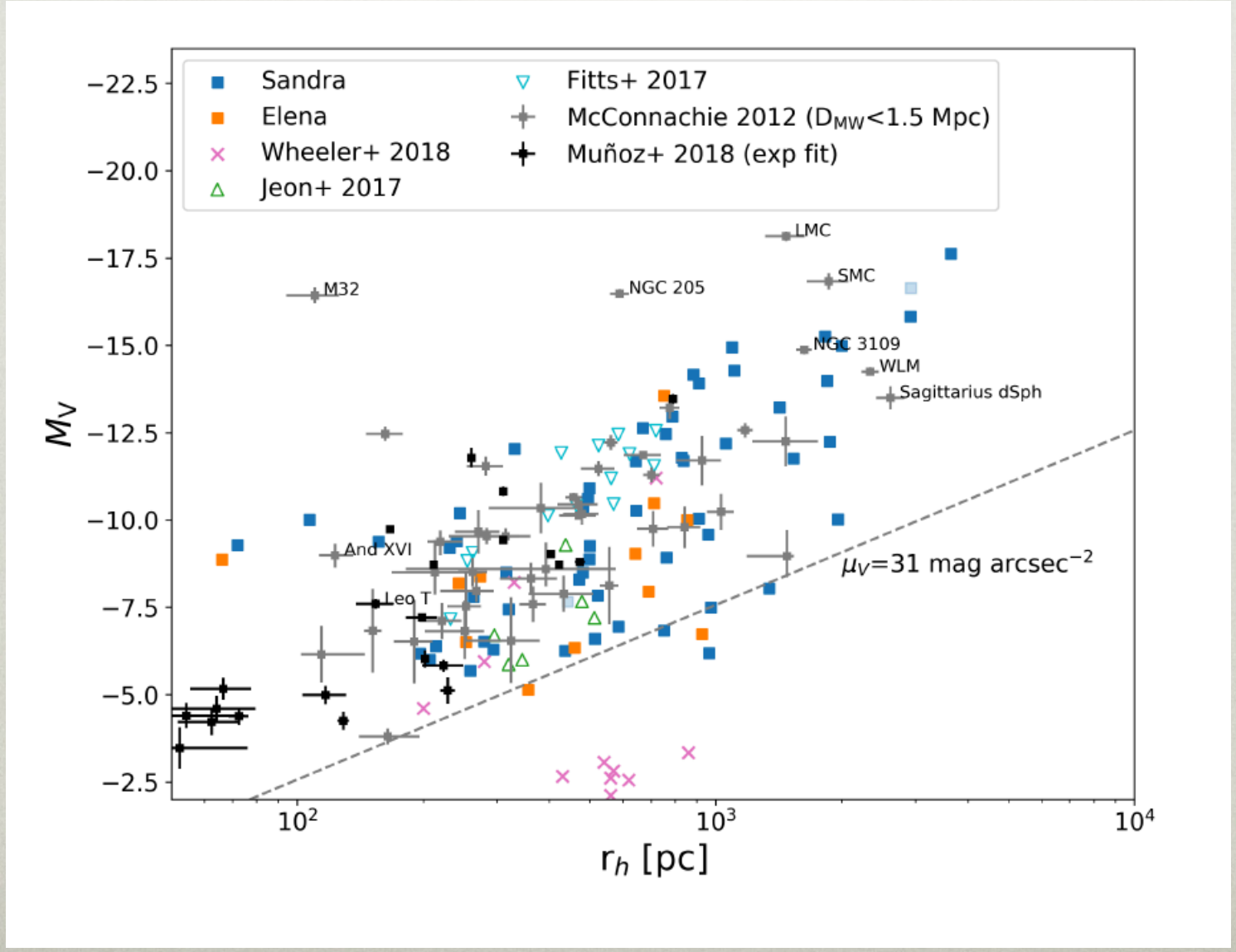
Satellite Luminosity Functions



Elena: 0.75 x 10^{11} M_{sun}
Sandra: 2 x 10^{12} M_{sun}

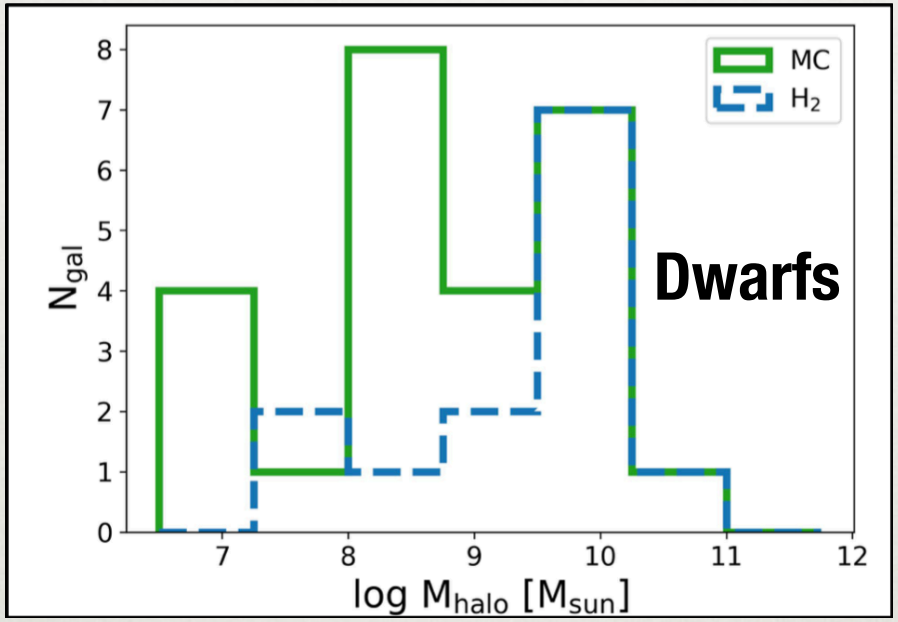
Applebaum, Brooks, et al., in prep

Size-Mass Relations

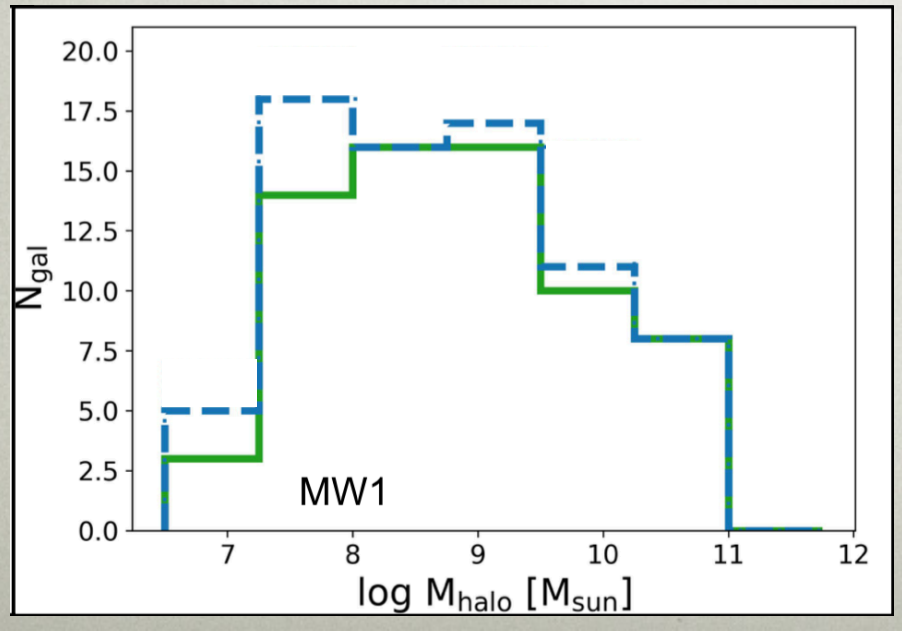


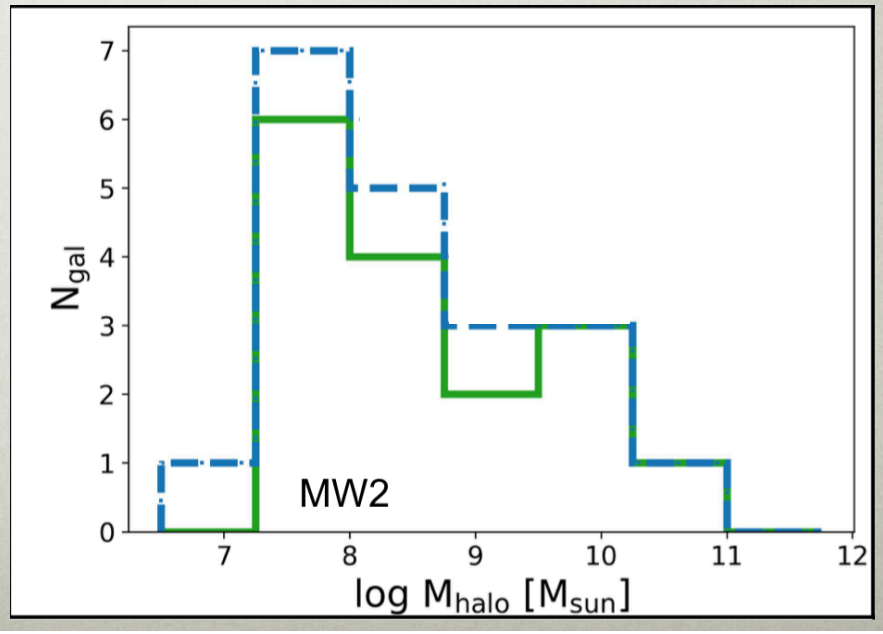
Applebaum, Brooks, et al., in prep

Unlike Dwarf Environment, no dependence on Star Formation



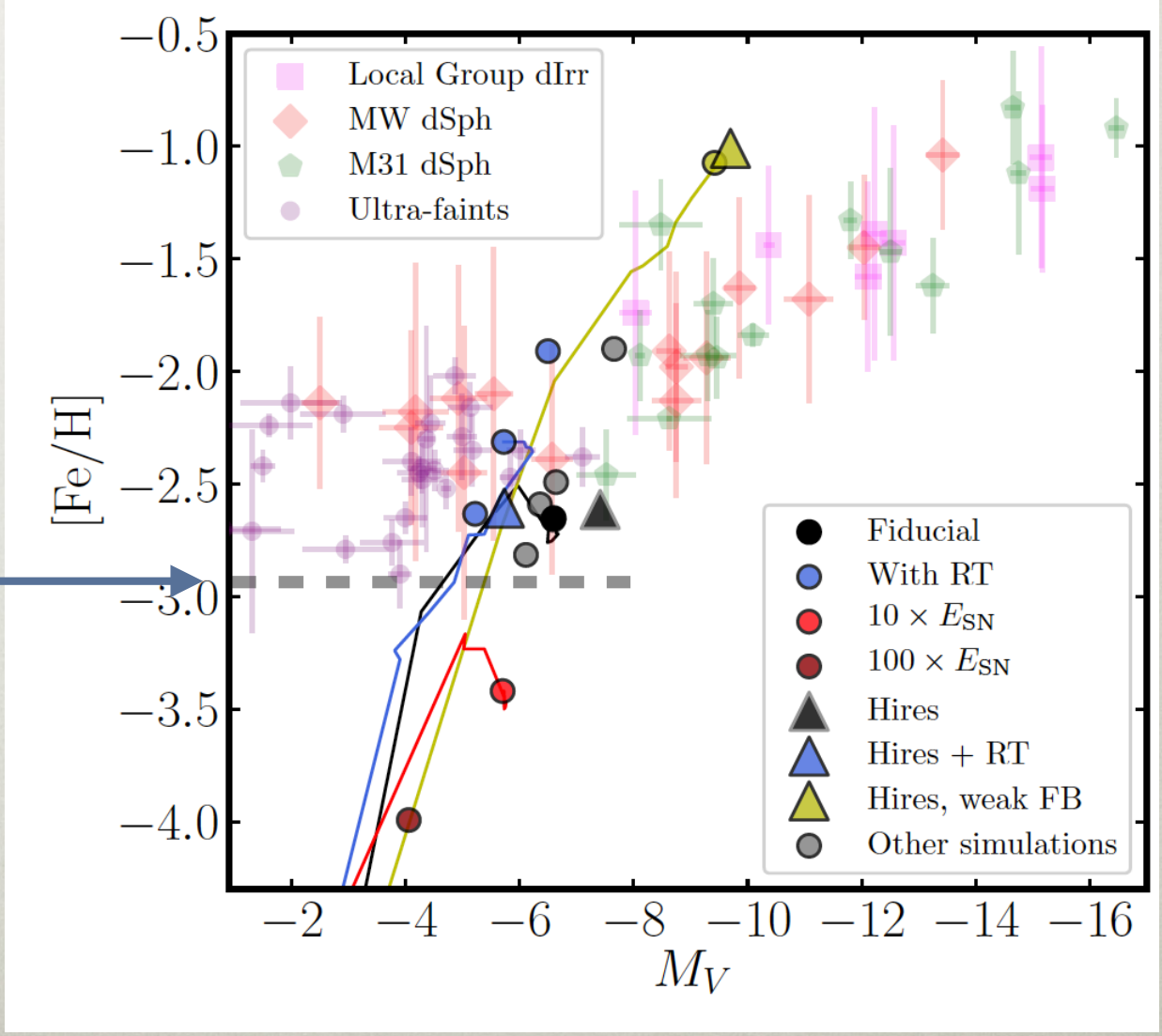
i.e., need Milky Way sims to avoid these issues!





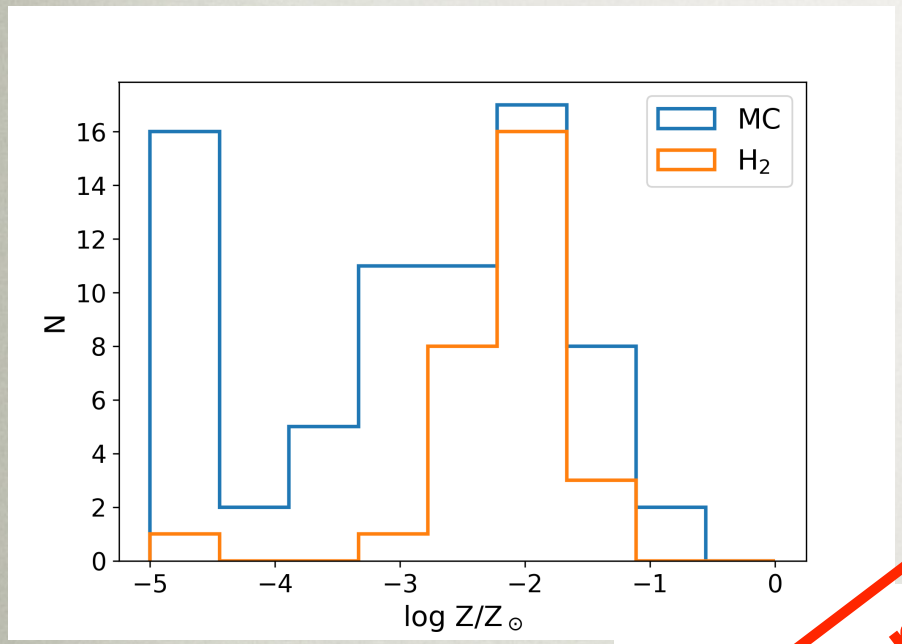
Metallicity as a Test

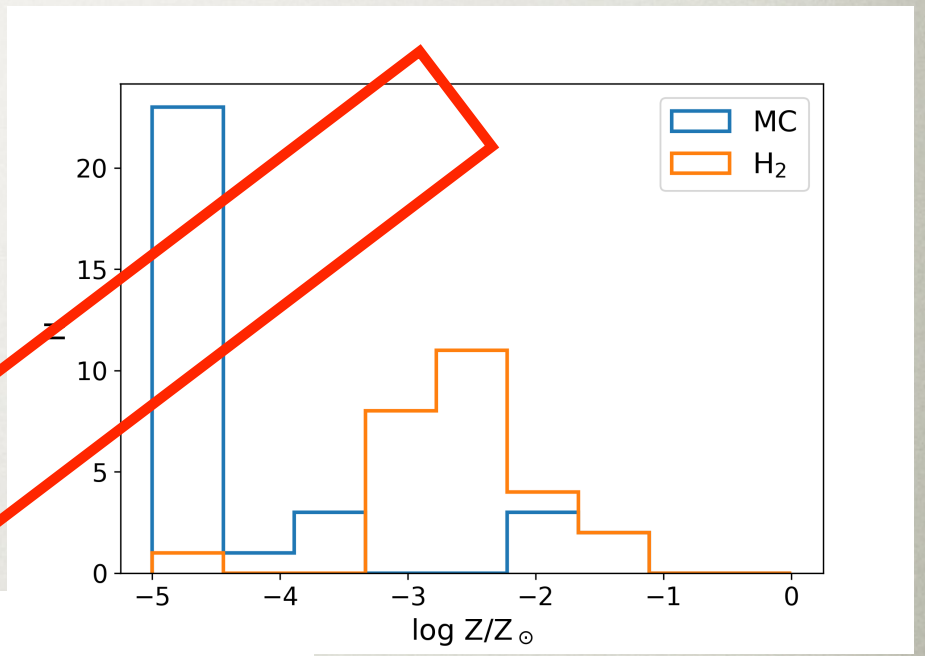
Observational metallicity floor

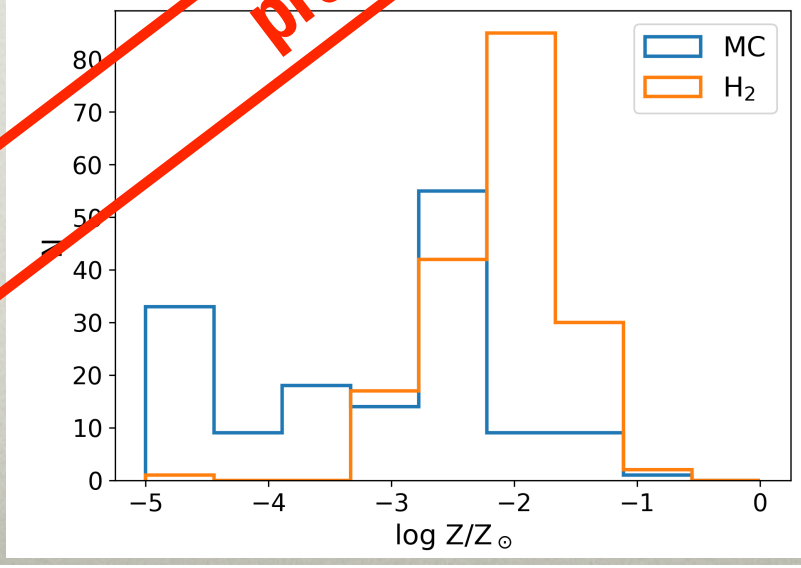


Agertz et al. (2019)

Metallicity as a Test







preliminary

Applebaum, Brooks, et al., in prep

Conclusions

9 out 10 simulators agree: we can now form realistic *classical* dwarf galaxies (thanks to self-regulation)

Self-regulation breaks down in ultra-faints (strongly affected by feedback/reionization)

Caveat emptor: simulation prescriptions lead to differing results based on the *environment* the ultra-faint resides in. To understand UFDs around the Milky Way, need Milky Way-mass simulations (challenging!)

Metallicity distributions of ultra-faints may point us to the conditions of star formation in the early Universe