simulating the Milky Way and its satellite galaxies

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FIRE collaboration
Feedback In Realistic Environments

model for star formation + feedback

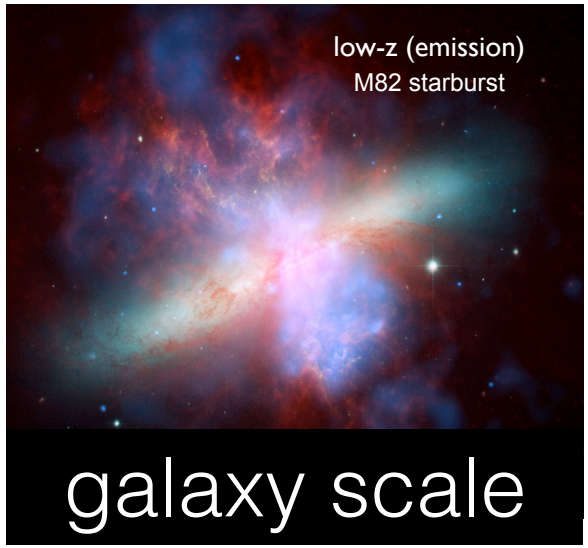
Hopkins, Wetzel et al 2018

goals

- model dense multi-phase ISM in a cosmological setting
- directly model single stellar populations
- explicitly model 3 feedback channels supernovae, stellar radiation, stellar winds

high resolution

- particle mass
  - MW-mass simulations: ~5000 (900) M_{sun}
  - LMC-mass simulations: ~300 M_{sun}
  - dwarf-mass simulations: ~30 M_{sun}
- spatial resolution: ~1pc

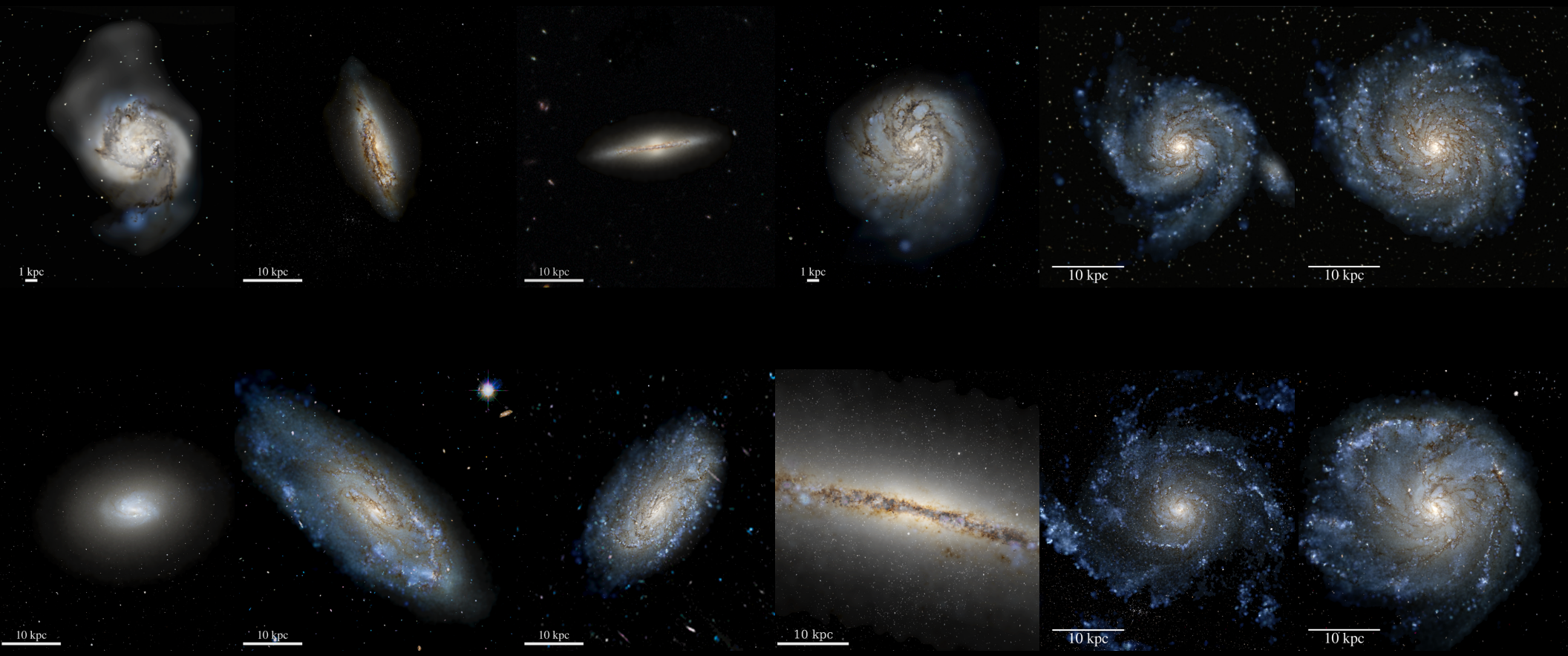


FIRE-2 simulation suite of MW-mass systems

Feedback In Realistic Environments

Latte suite: 8 isolated MW-mass systems

ELVIS suite: 3 LG-like pairs (6 halos)



DWARF GALAXIES

SIGNIFICANT CHALLENGES TO CDM MODEL

‘missing satellites’ problem

CDM (possibly) predicts **too many** dark matter subhalos compared with observed satellite galaxies

DWARF GALAXIES

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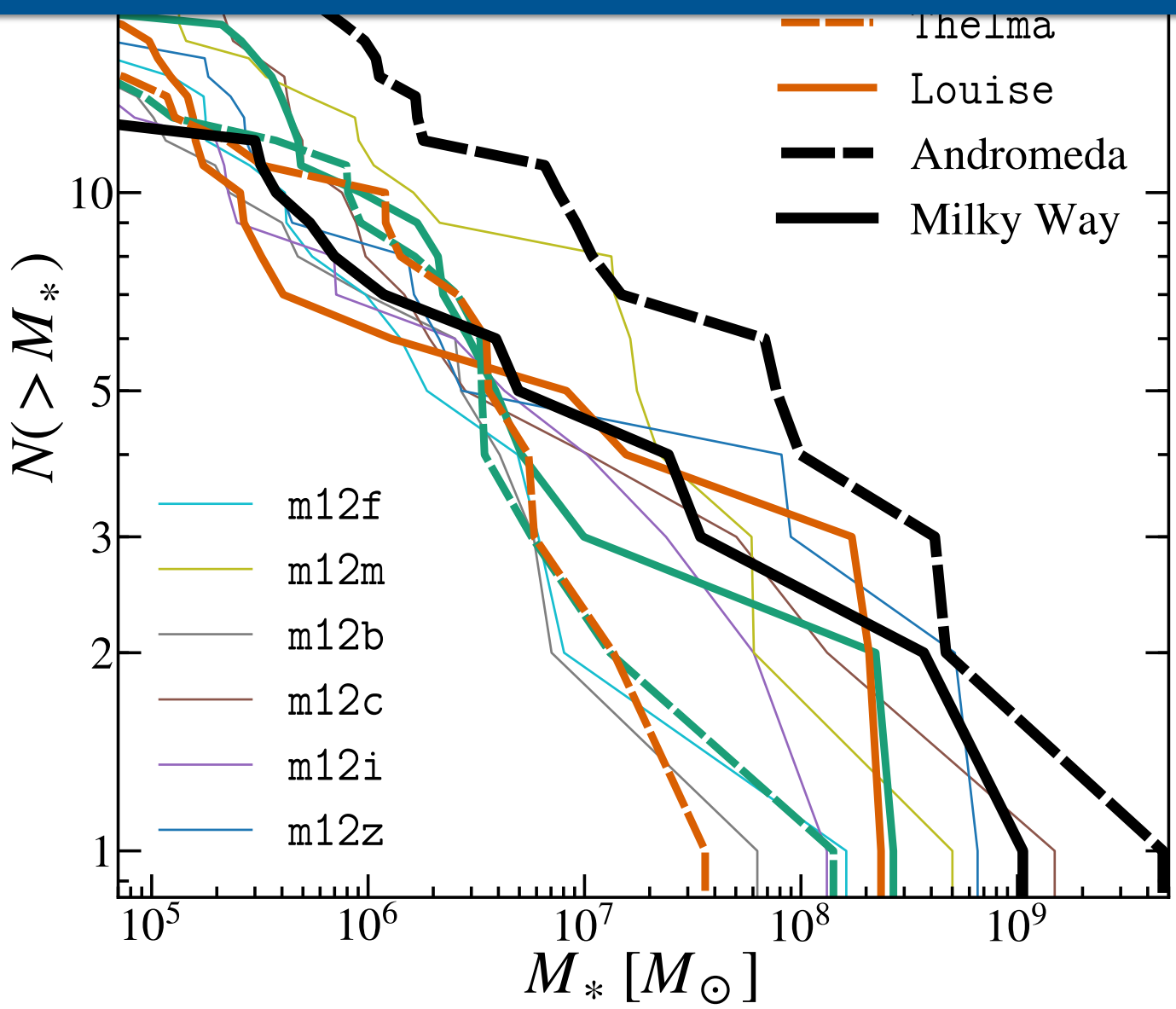
Can a CDM-based model produce satellites with observed distribution of stellar masses?

Garrison-Kimmel, Hopkins, Wetzel et al 2018

no 'missing satellites' problem ($M_{star} > 10^5\ M_{sun}$)



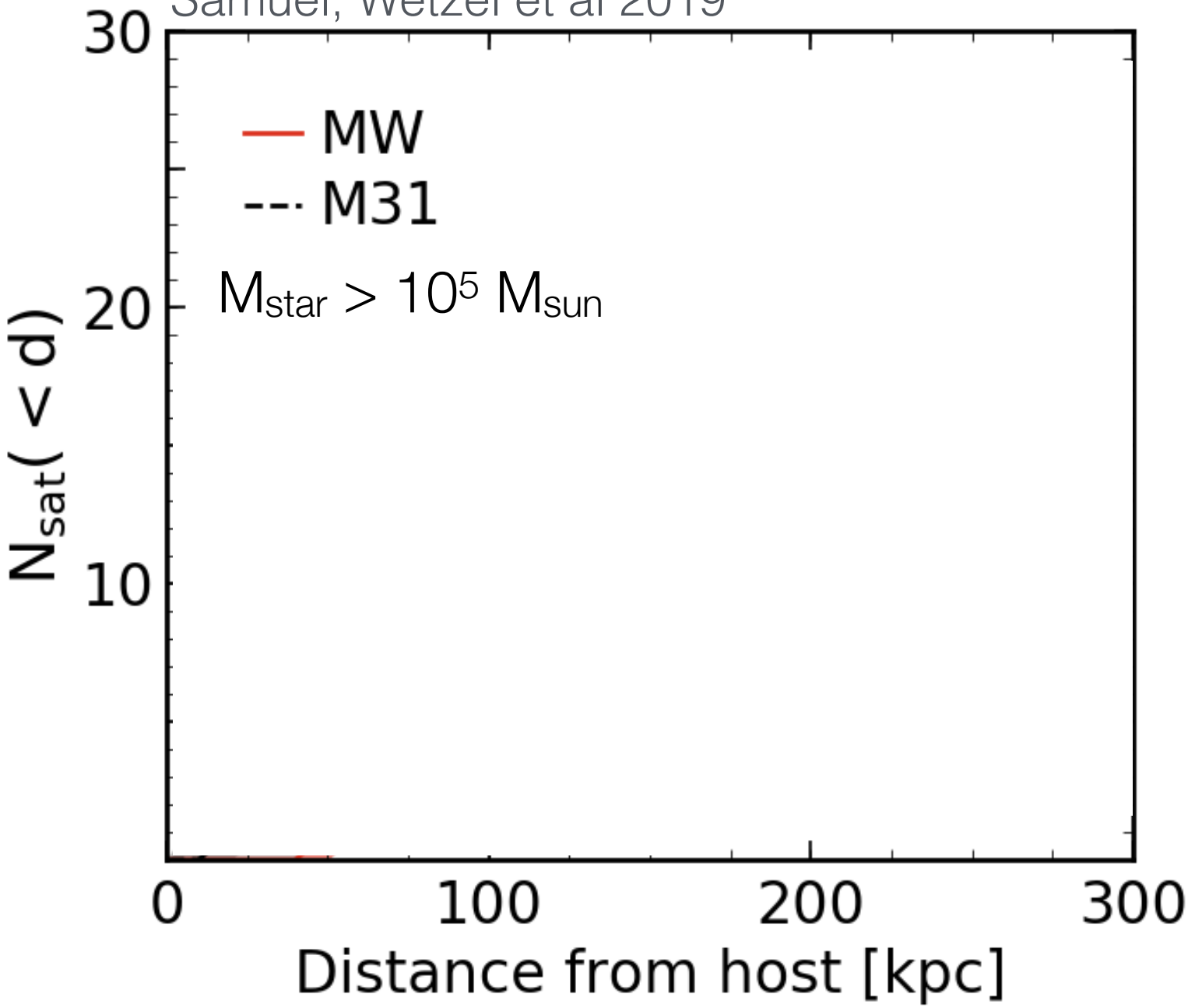
MORE RIGOROUS TEST

WHAT ABOUT SPATIAL DISTRIBUTION OF SATELLITES?

Jenna Samuel
(grad student @ UC Davis)

observed distances of satellite dwarf galaxies

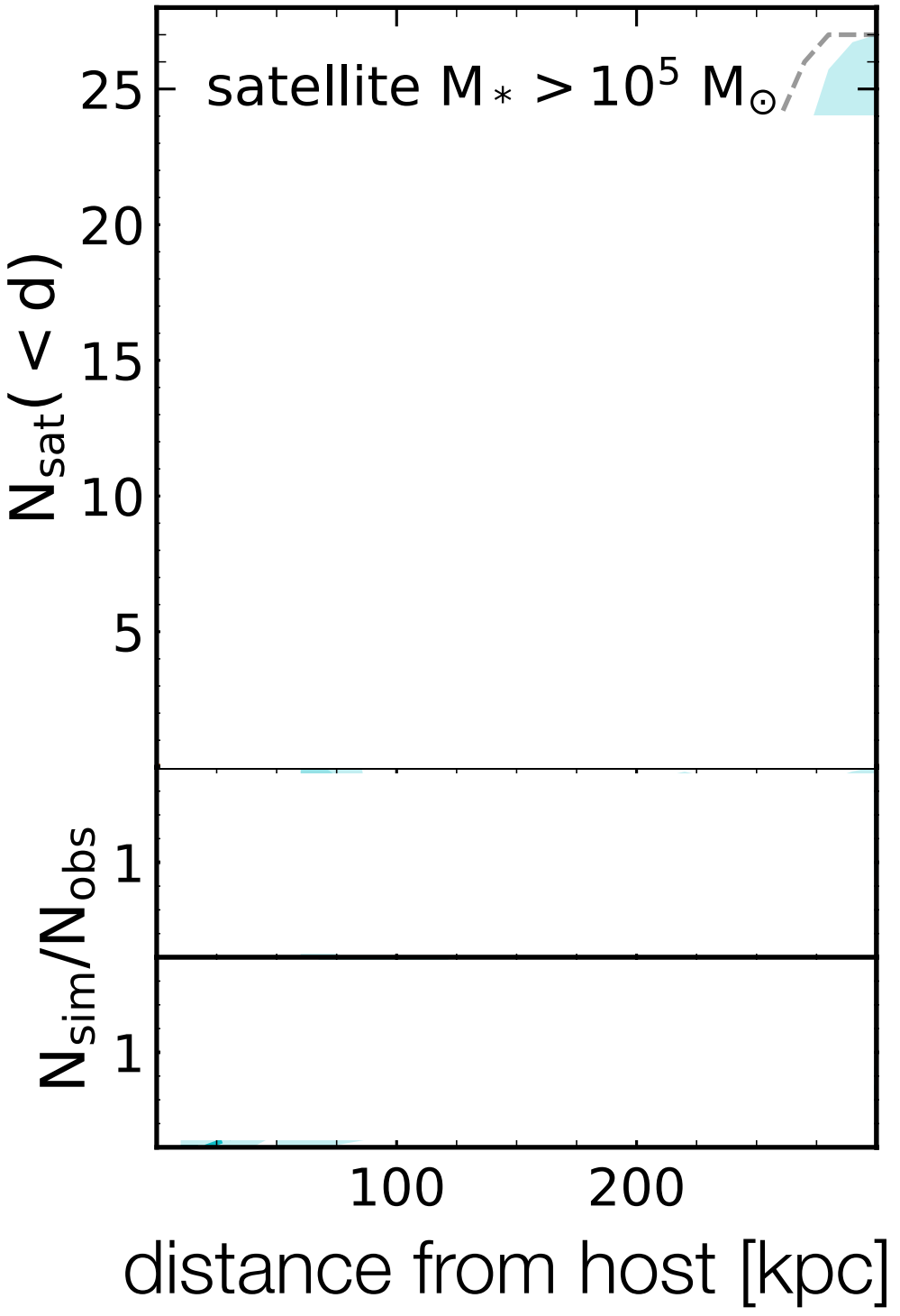
Samuel, Wetzel et al 2019



FIRE simulations broadly agree with MW + M31

numerically well resolved (even at d <~ 50 kpc)

Samuel, Wetzel et al 2019



WHAT CAUSES THE LACK OF (MASSIVE) SATELLITE DWARF GALAXIES?

presence of central galaxy

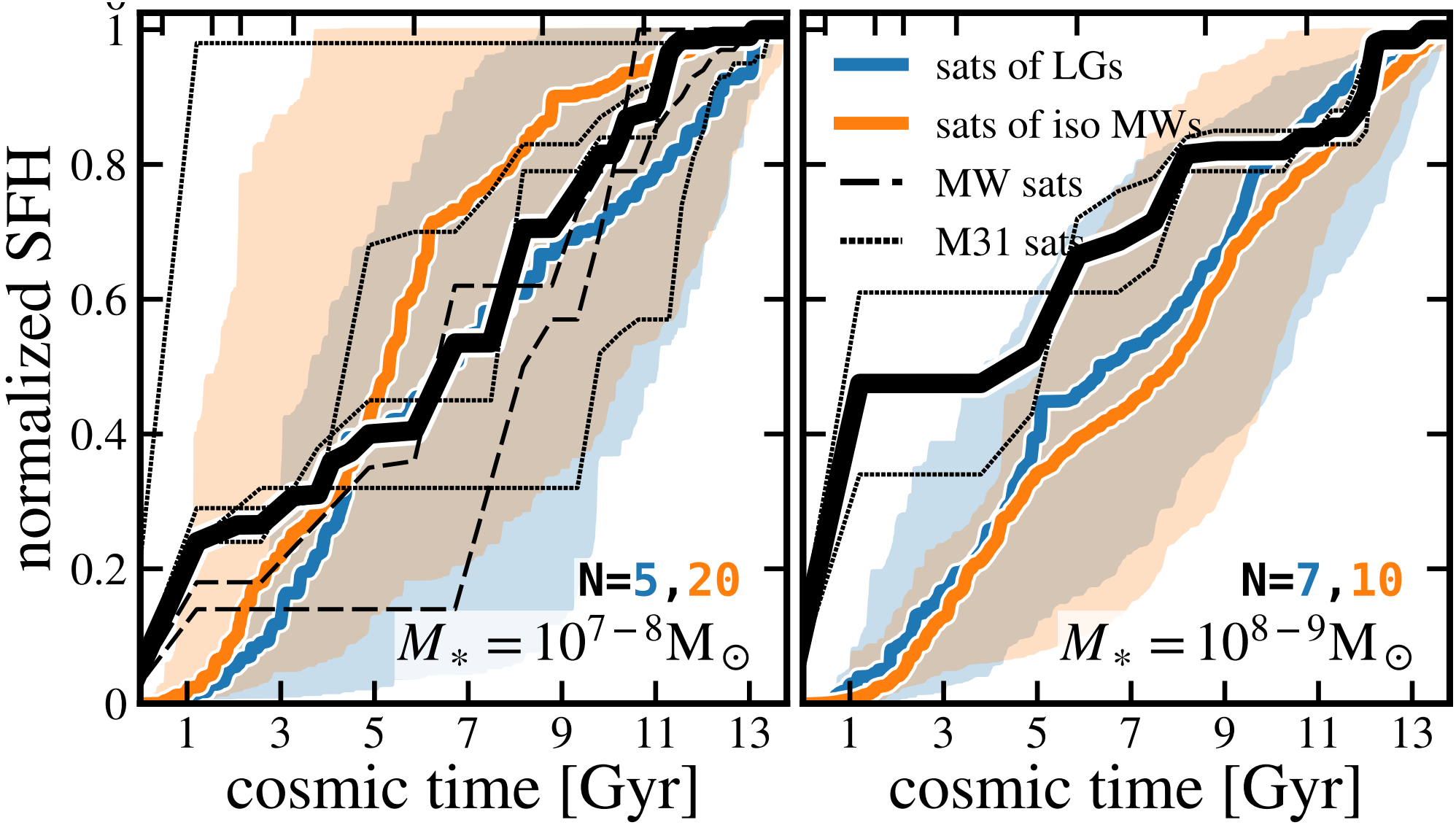
destroys satellites via gravitational tidal forces

meta-galactic UV background + internal feedback

regulates gas cooling + star formation
(at all redshifts, not just during cosmic reionization)

star-formation histories of dwarf galaxies

Garrison-Kimmel, Wetzel et al 2019



SYNTHETIC STELLAR SURVEYS OF THE MILKY WAY

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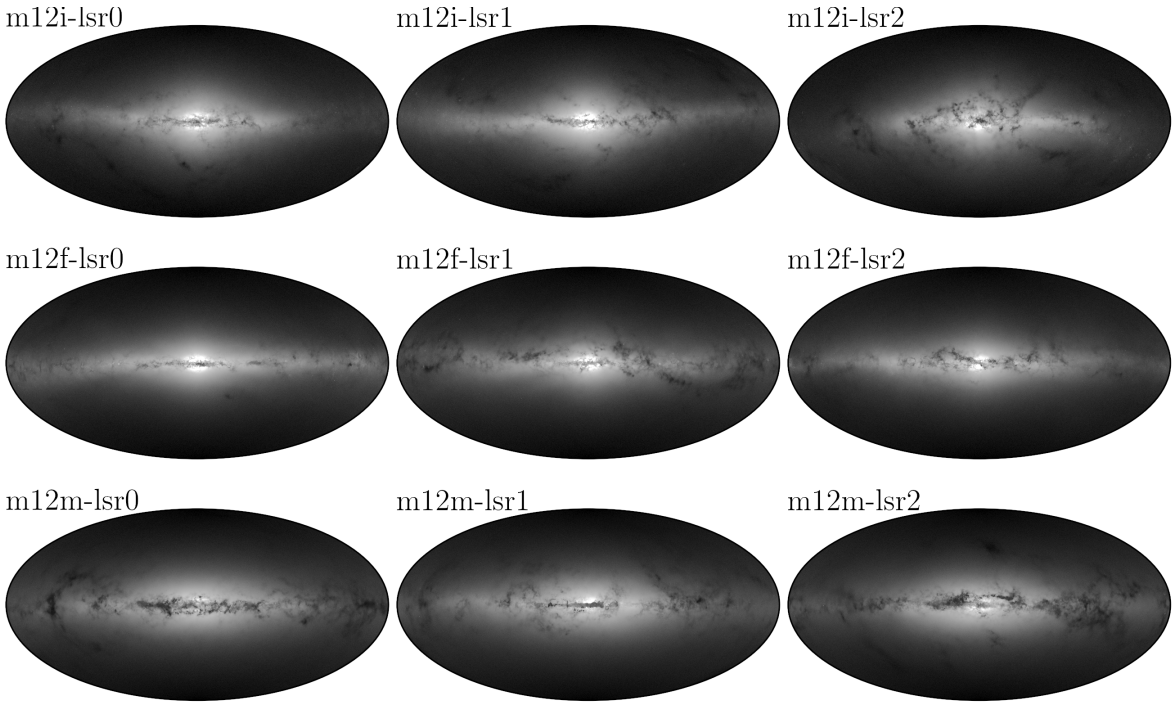
Synthetic Gaia surveys from the FIRE cosmological simulations of Milky-Way-mass galaxies

ROBYN E. SANDERSON,[1,*] ANDREW WETZEL,[2] SARAH LOEBMAN,[2,†] SANJIB SHARMA,[3] PHILIP F. HOPKINS,[1]
SHEA GARRISON-KIMMEL,[1] CLAUDE-ANDRÉ FAUCHER-GIGUÈRE,[4] DUŠAN KEREŠ,[5] AND ELIOT QUATAERT[6]

arXiv:1806.10564

9 synthetic Gaia DR2-like surveys

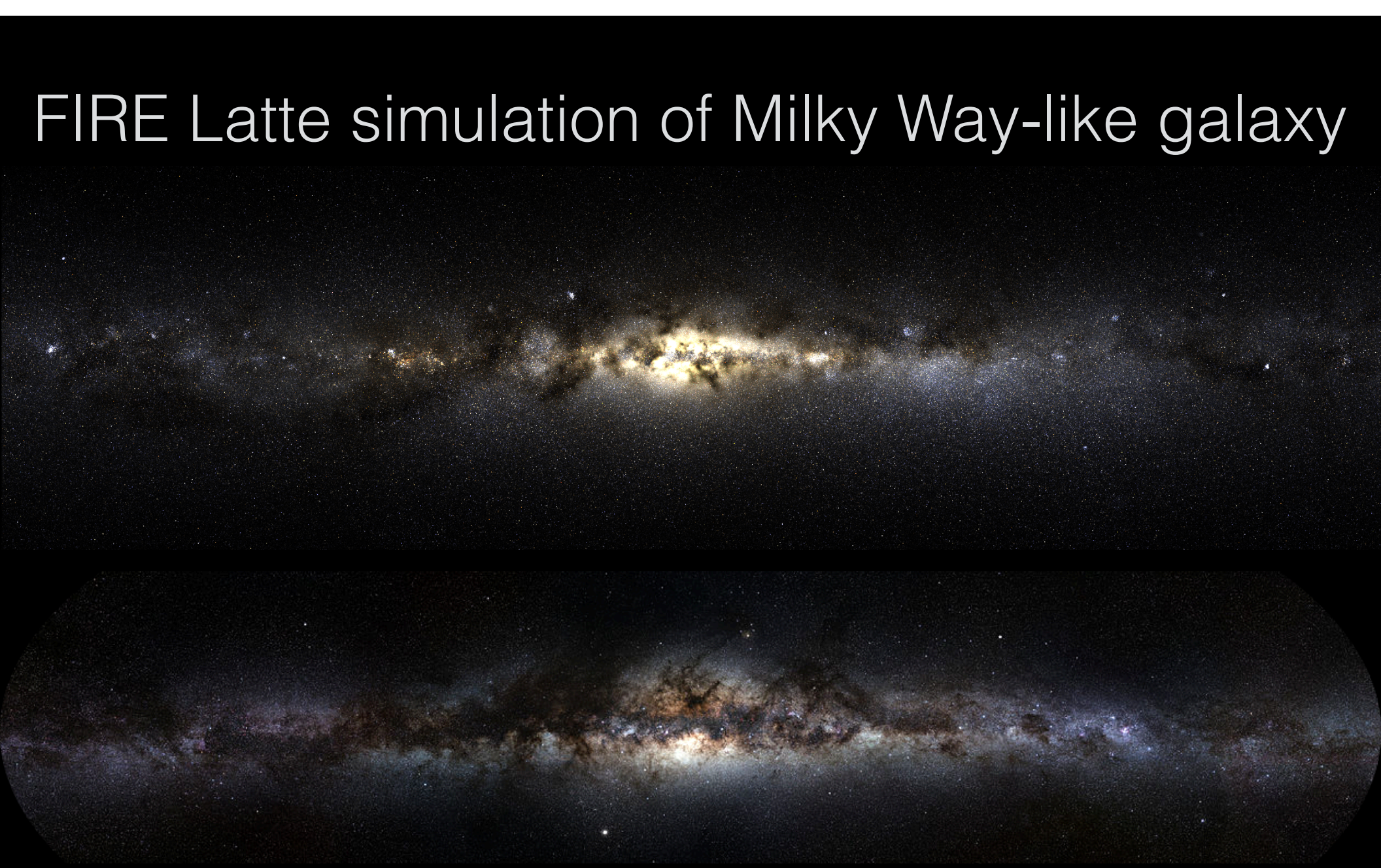
full snapshots (z = 0) from 3 Latte simulations



FIRE
Feedback In Realistic Environments

public release: ananke.hub.yt

FIRE Latte simulation of Milky Way-like galaxy



observed Milky Way

PROPER MOTIONS OF DWARF GALAXIES OVER THE NEXT DECADE

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MW-6D: dynamical mapping the MW system

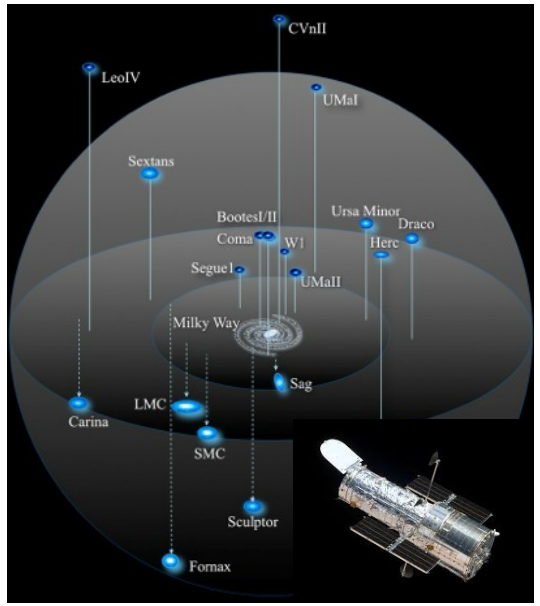
HST Cycle 24 Treasury Program (164 orbits)

first-epoch proper motions + star-formation histories for **all** (+31) dwarf galaxies within 500 kpc of MW

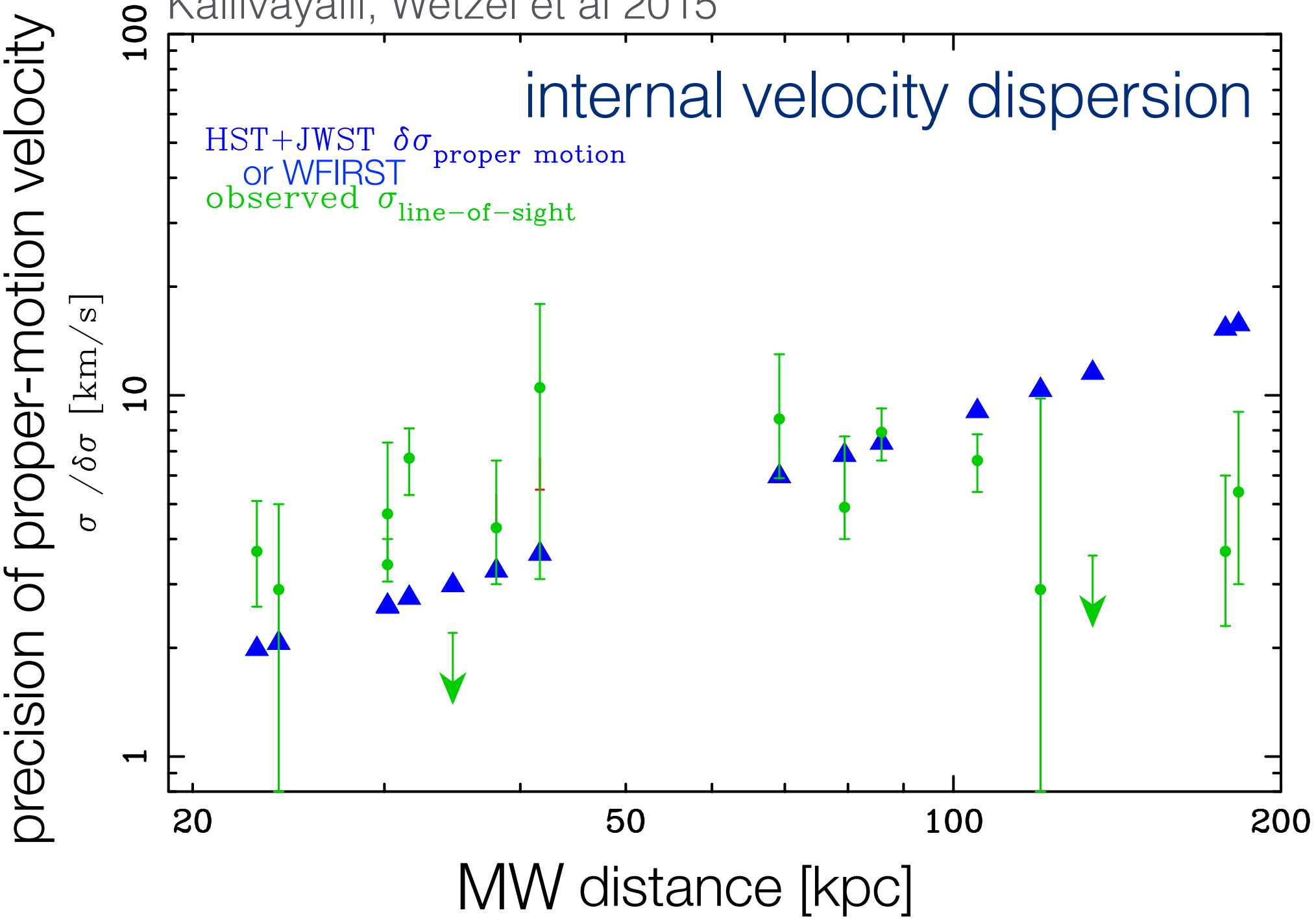
PI: Nitya Kallivayalil co-PI: Andrew Wetzel

Co-I: Jay Anderson, Gurtina Besla, Tom Brown, Alis Deason, Tobias Fritz, Marla Geha, Raja Guhathakurta, Evan Kirby, Steve Majewski, Josh Simon, Tony Sohn, Erik Tollerud, Roeland van der Marel

- dynamically measure the MW halo's mass profile
- derive orbital histories for all MW satellite galaxies
- measure internal kinematics to constrain core/cusp

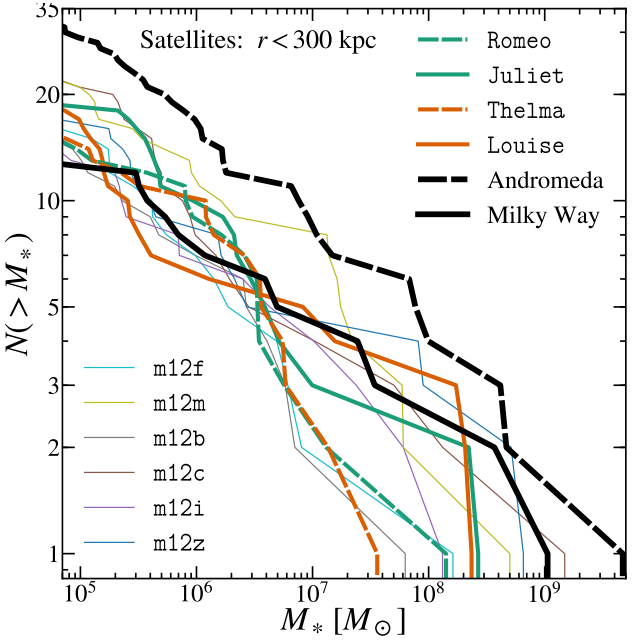


Kallivayalil, Wetzel et al 2015

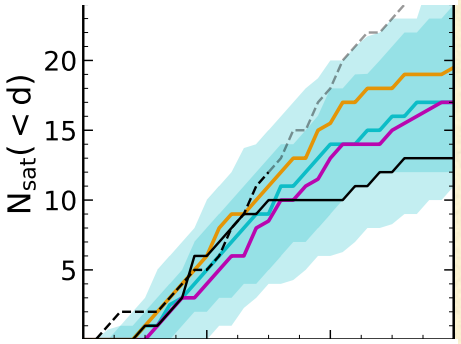


THE MILKY WAY ON

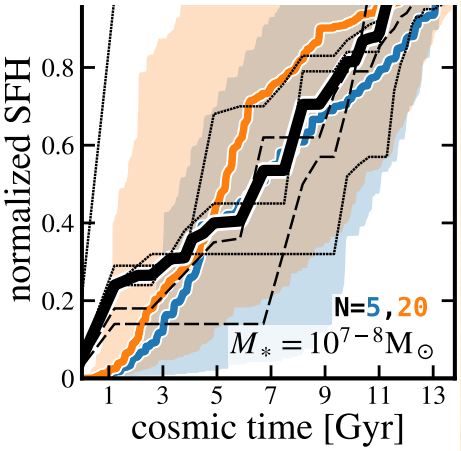
no 'missing satellites'



resolved profiles



star-formation histories



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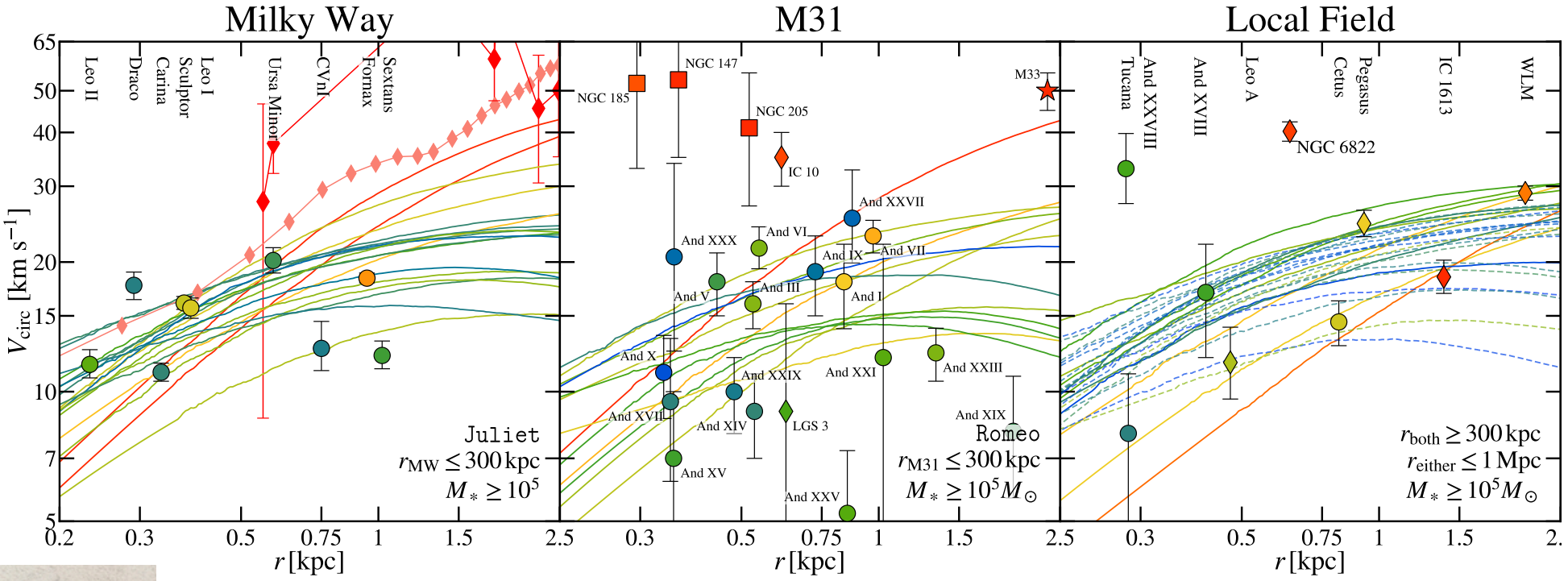
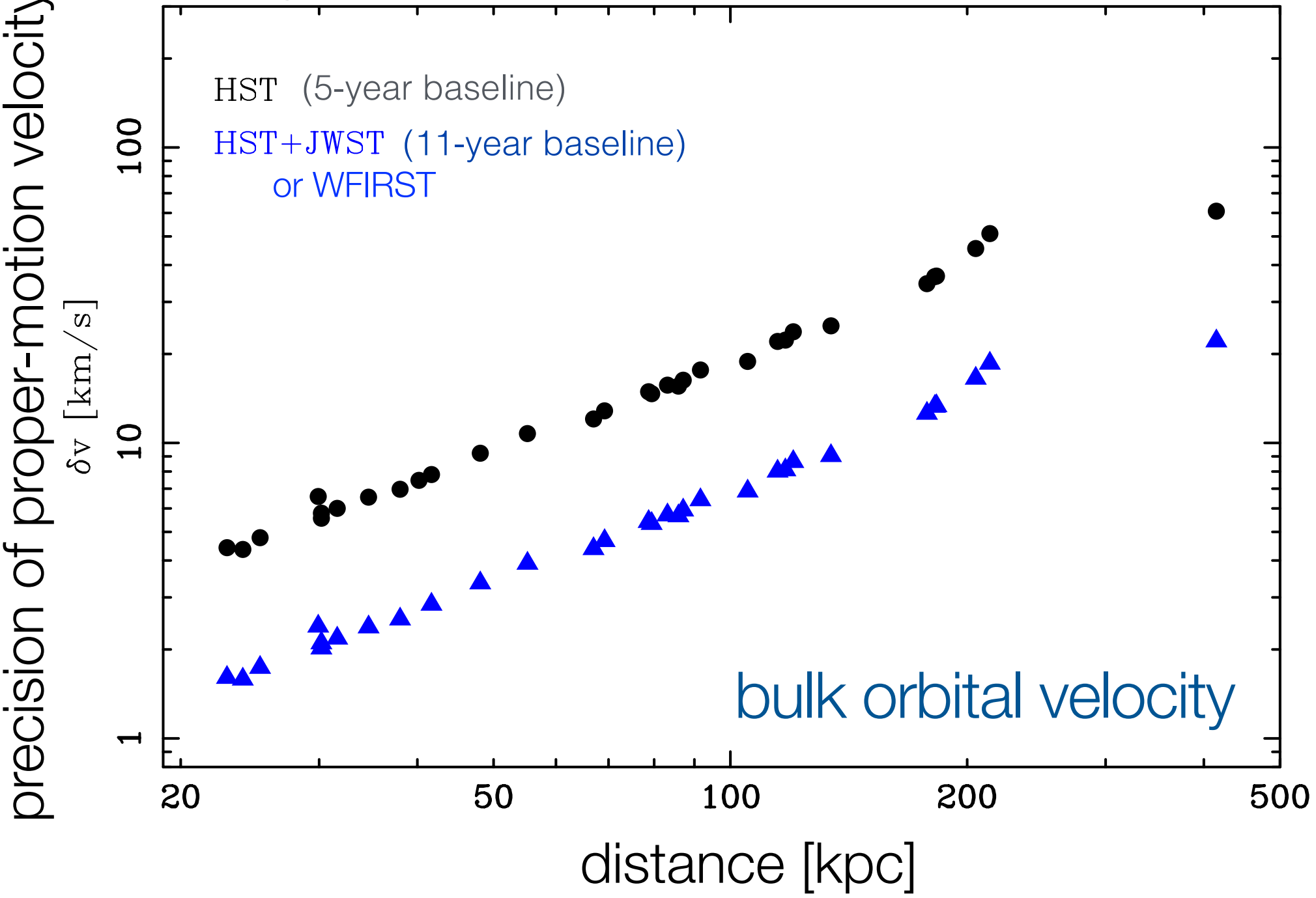
internal velocity (density) profile of dwarf galaxies - agrees with Local Group



Garrison-Kimmel, Hopkins, Wetzel et al 2018

but simulations now form too few dense dwarf galaxies

Kallivayalil, Wetzel et al 2015



similar science doable in M31

M31-6D survey (?)

PIs: Dan Weisz, Nitya Kallivayalil, Andrew Wetzel