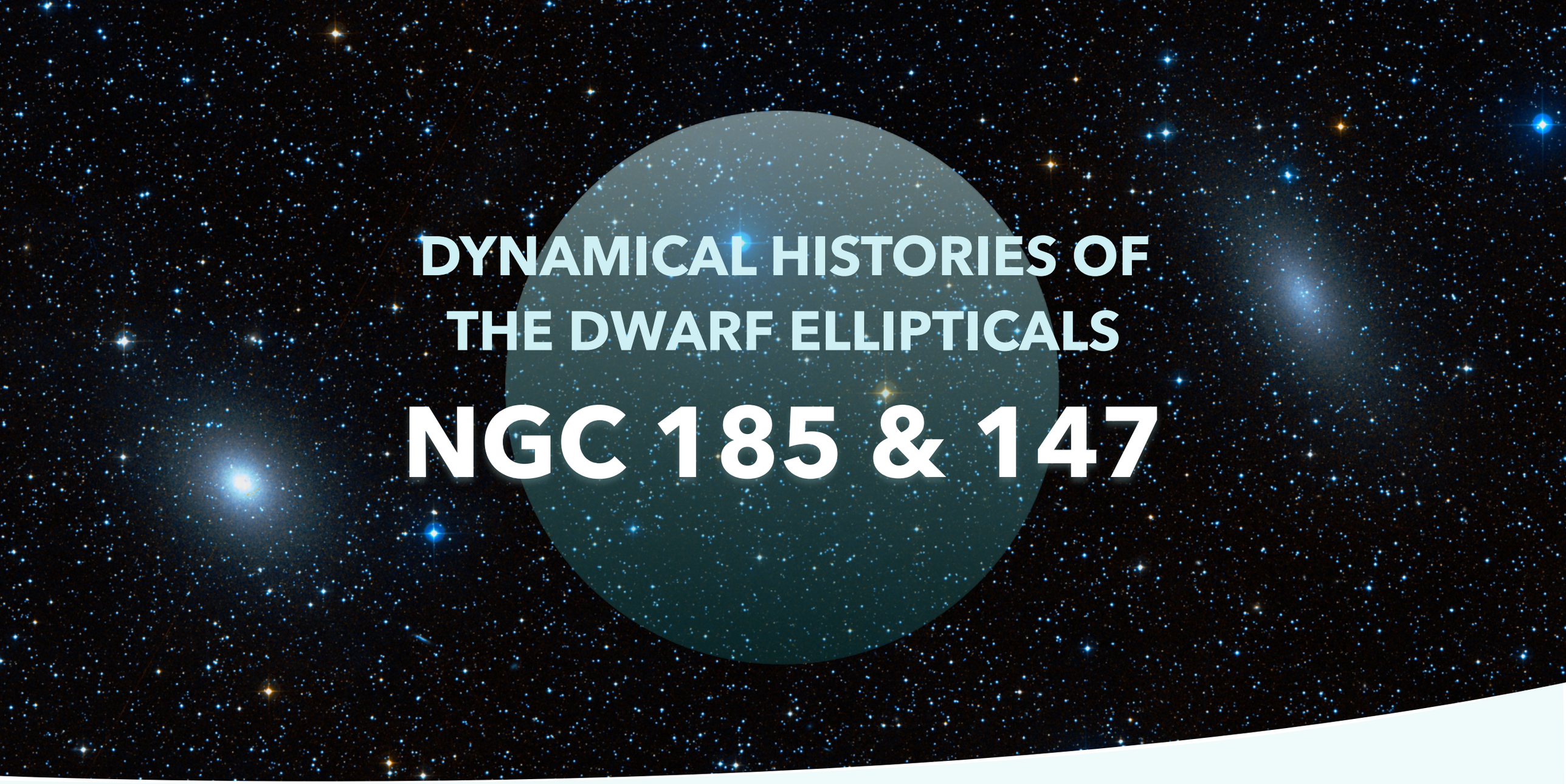


DYNAMICAL HISTORIES OF THE DWARF ELLIPTICALS NGC 185 & 147

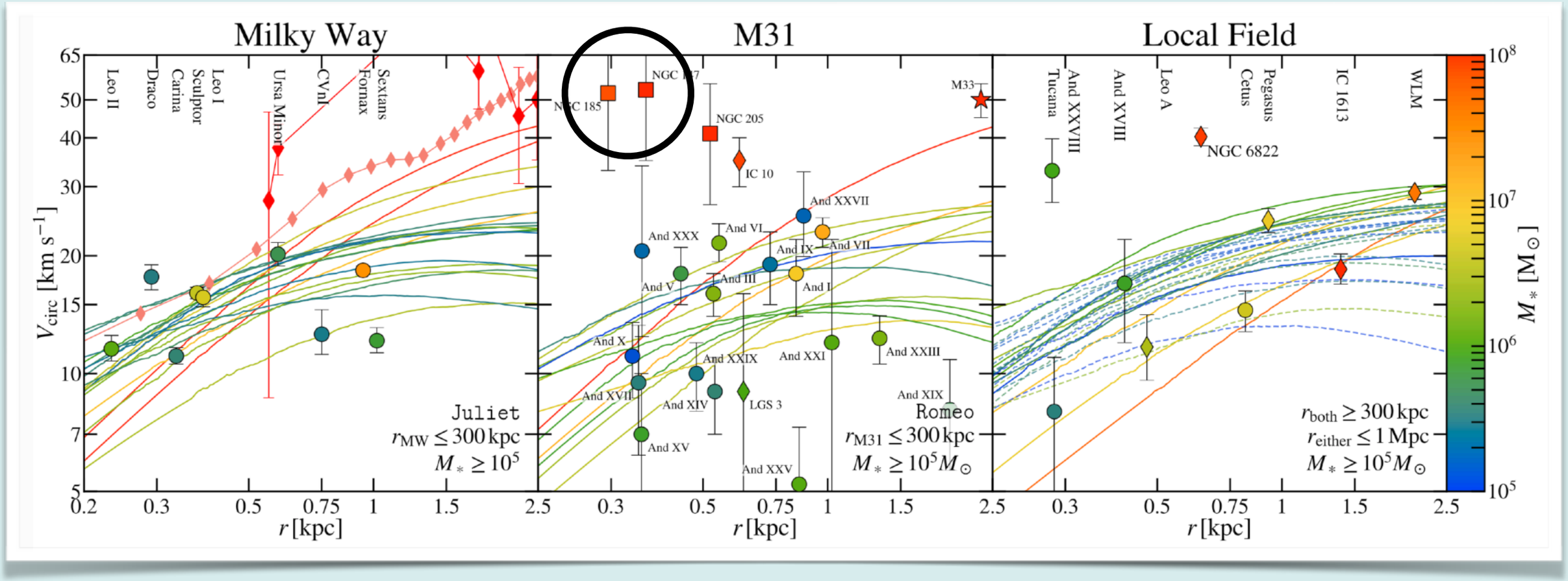
S. Tony Sohn (STScI, HSTPROMO)

Mark Fardal, Ekta Patel, Gurtina Besla, Marla Geha,

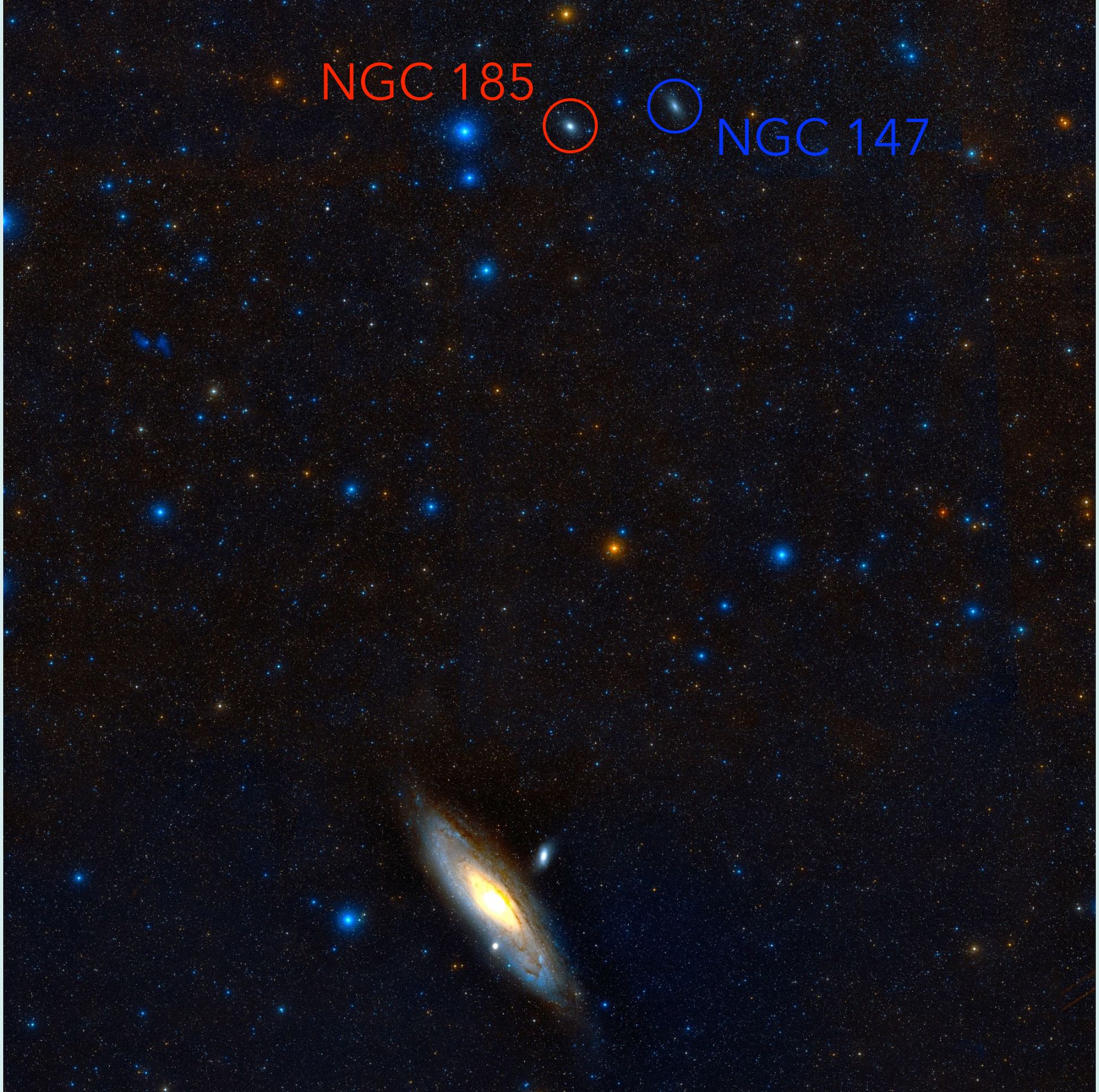
Raja Guhathakurta, & Roeland van der Marel

NGC 147 & 185

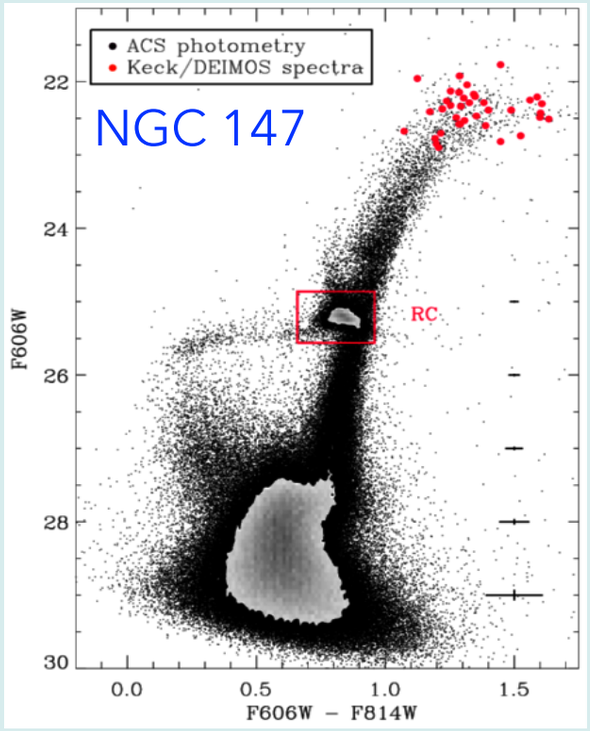
Garrison-Kimmel et al. (2019) - FIRE (hydrodynamic) simulations

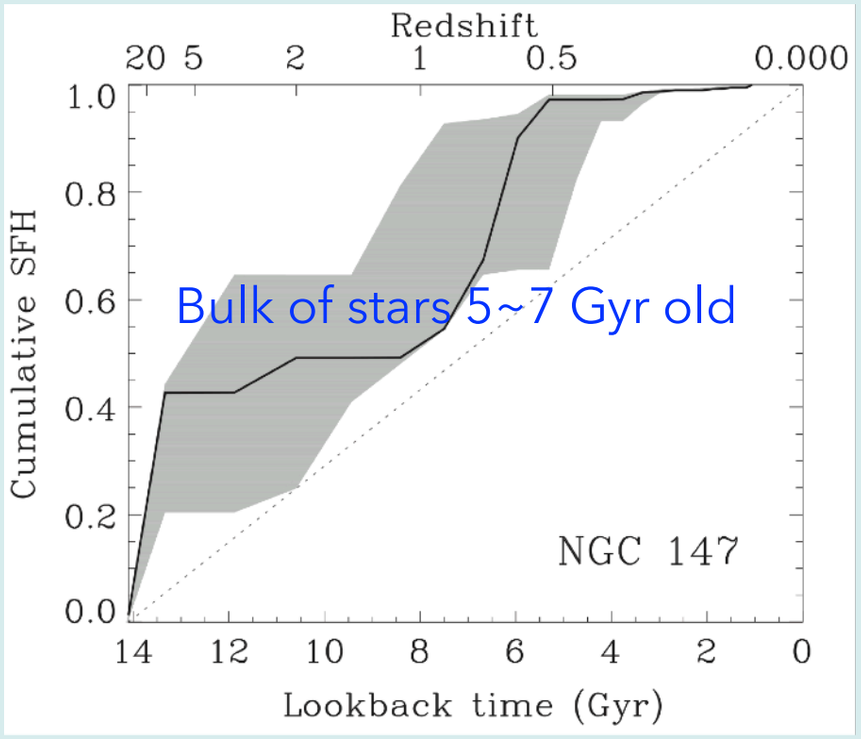


"The simulations here do not produce any galaxies with densities as high as those of the baryon-dominated compact dEs around M31… with $V_{circ} \approx 35$ km/s at $r < 1$ kpc."

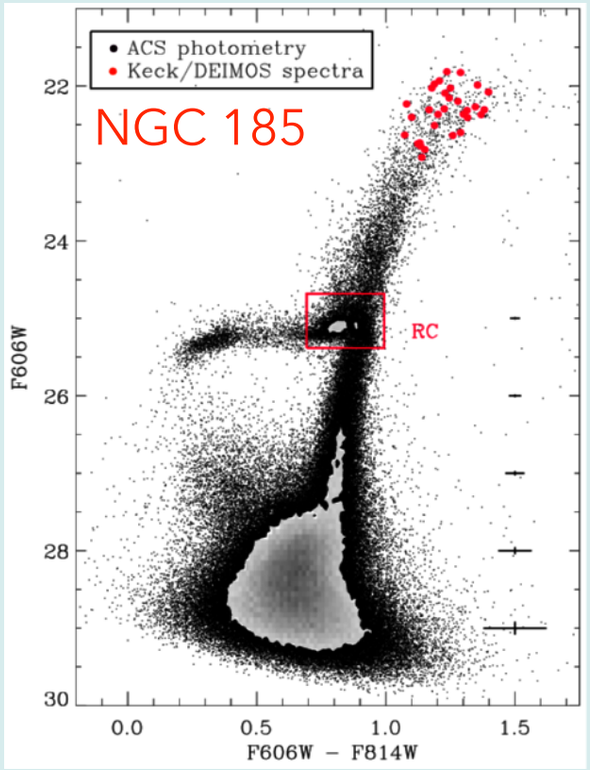

NGC 185
NGC 147

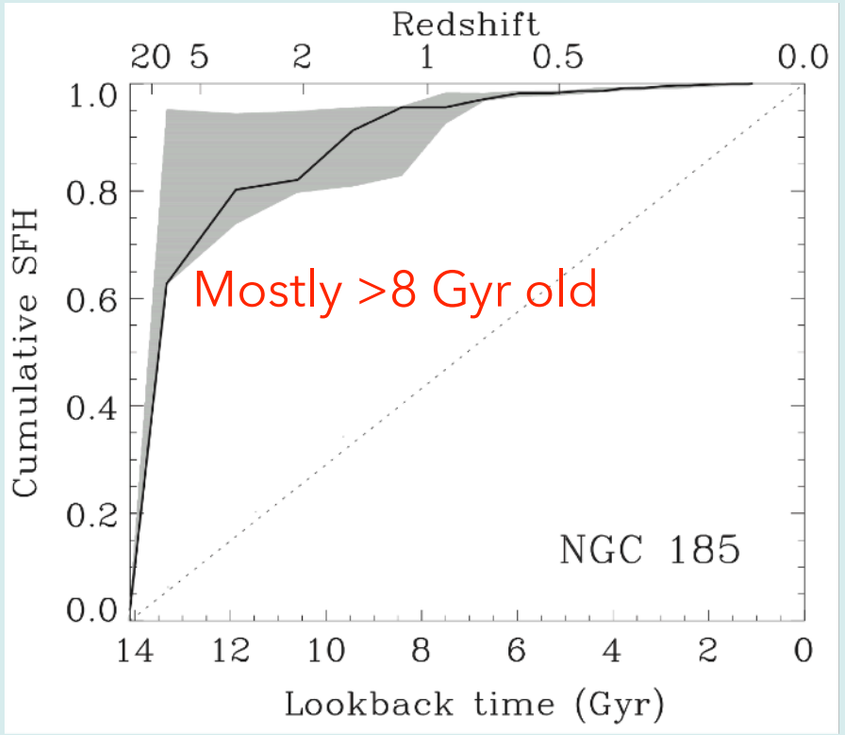
NGC 147 & 185





Geha et al. (2015)





NGC 147 & 185

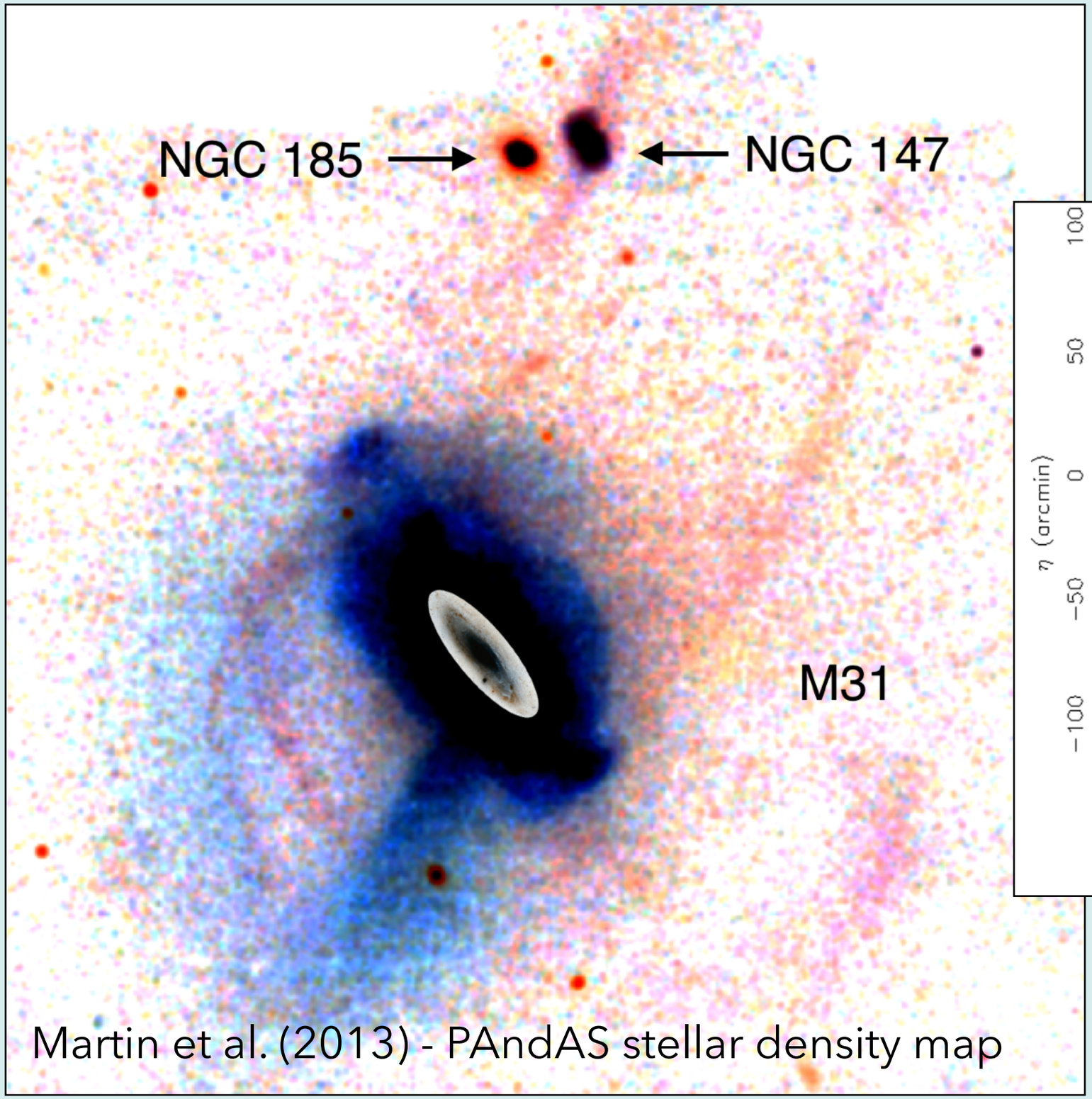
	NGC 147	NGC 185
Separation on Sky	~ 1 deg	
Galaxy Type	Dwarf Ellipticals (dEs)	
Brightness ($M_{V,0}$)	-16.5	-15.5
Stellar Abundance ([Fe/H])	-1.1	-1.3
Stellar Mass (M_{dyn})	6×10^8 $M_\odot$	7×10^8 $M_\odot$
Systemic Velocities (V_{LOS})	-193 km/s	-204 km/s

} Geha et al. (2010)

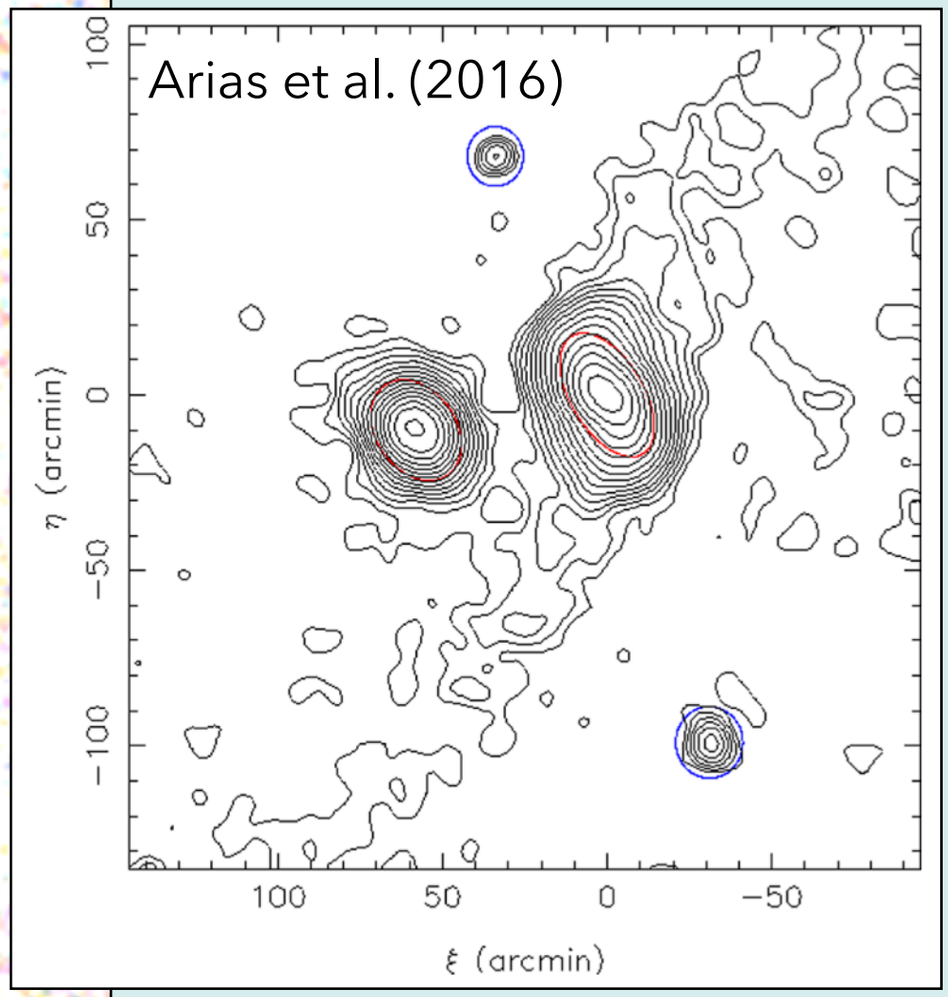
Star Formation Histories	5~7 Gyr	> 8 Gyr
Distances	724 kpc	636 kpc
Tidal Tails?	Yes	No

} Geha et al. (2015)

NGC 147 & 185

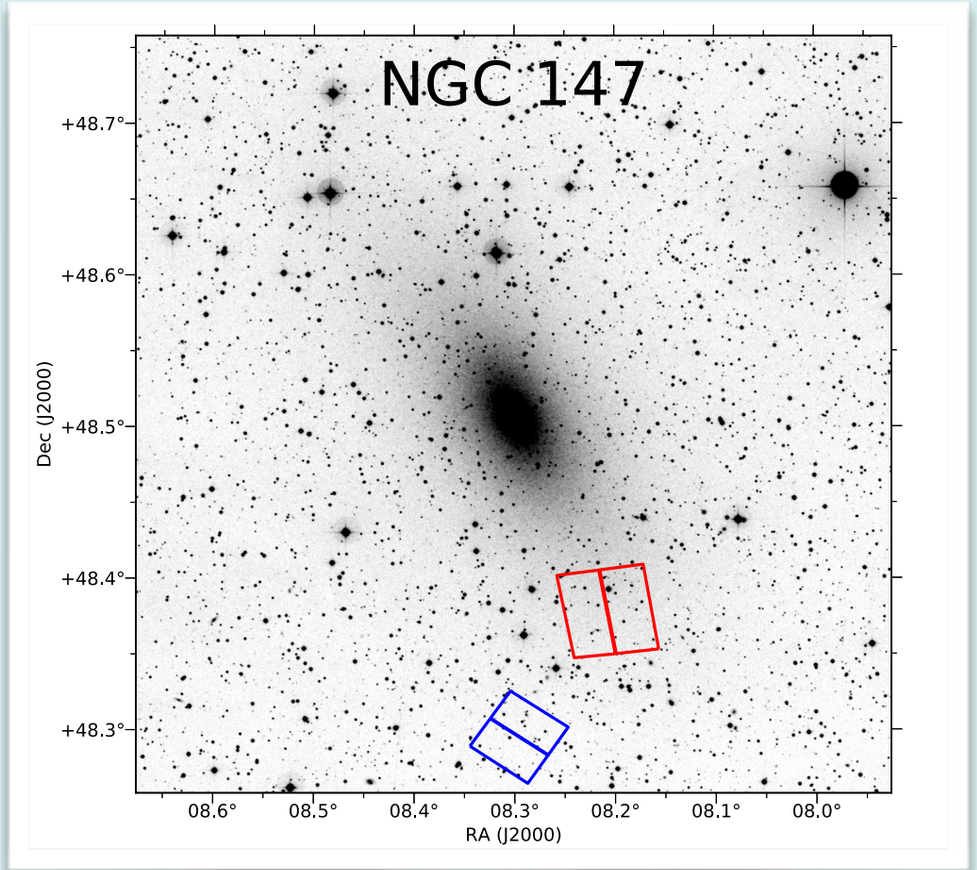


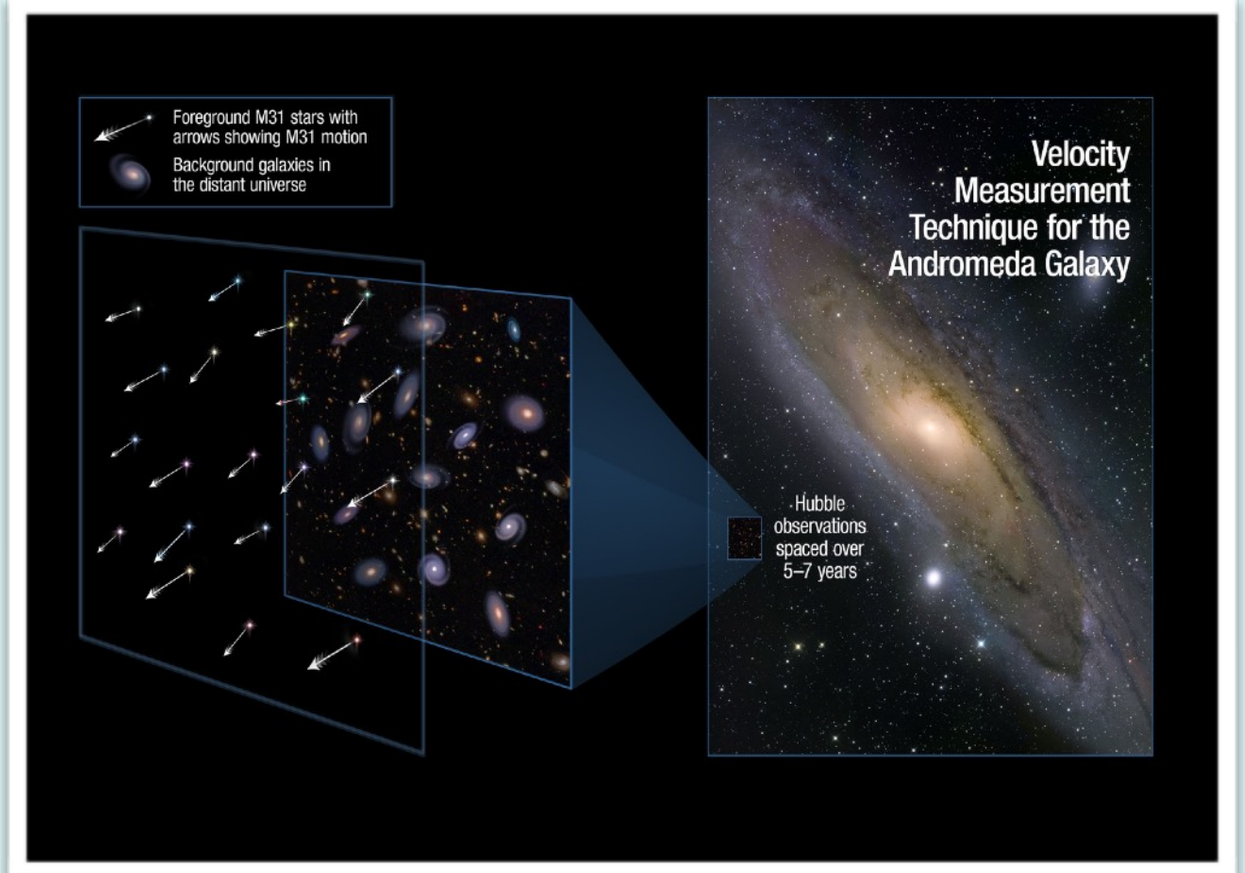
Martin et al. (2013) - PAndAS stellar density map

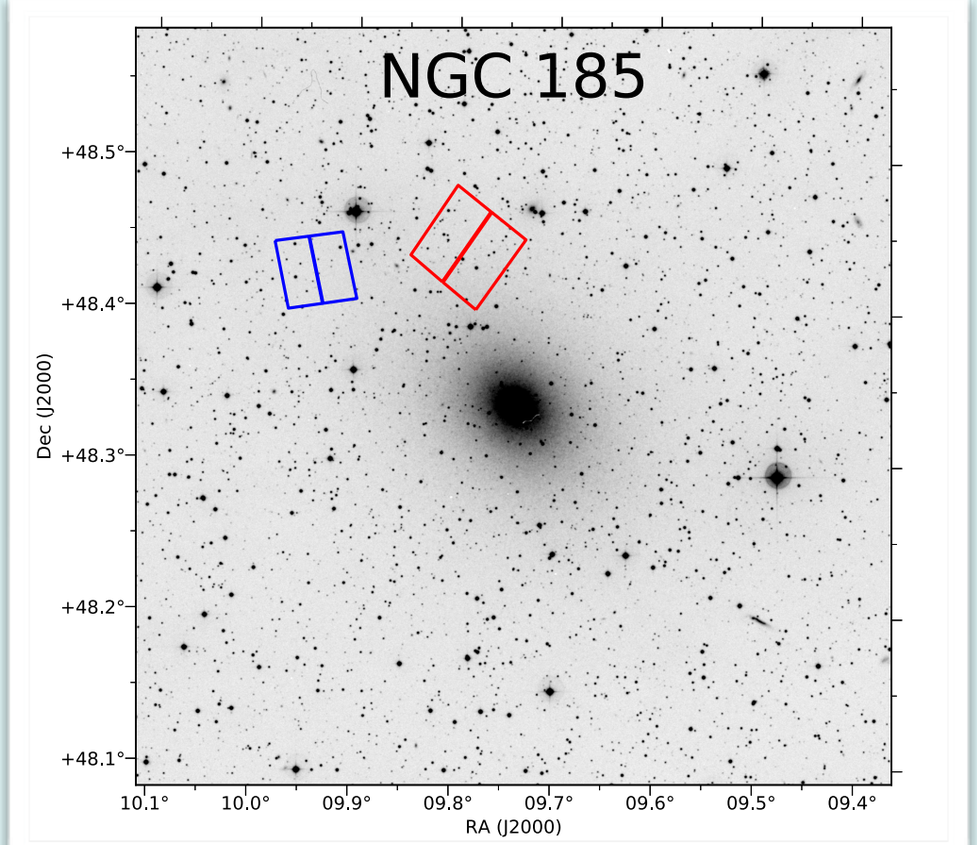


DATA & ANALYSIS

- 1st epoch: previously imaged fields (Geha et al 2015)
- Time baseline ~8 years
- Primary ACS/WFC + Parallel WFC3/UVIS





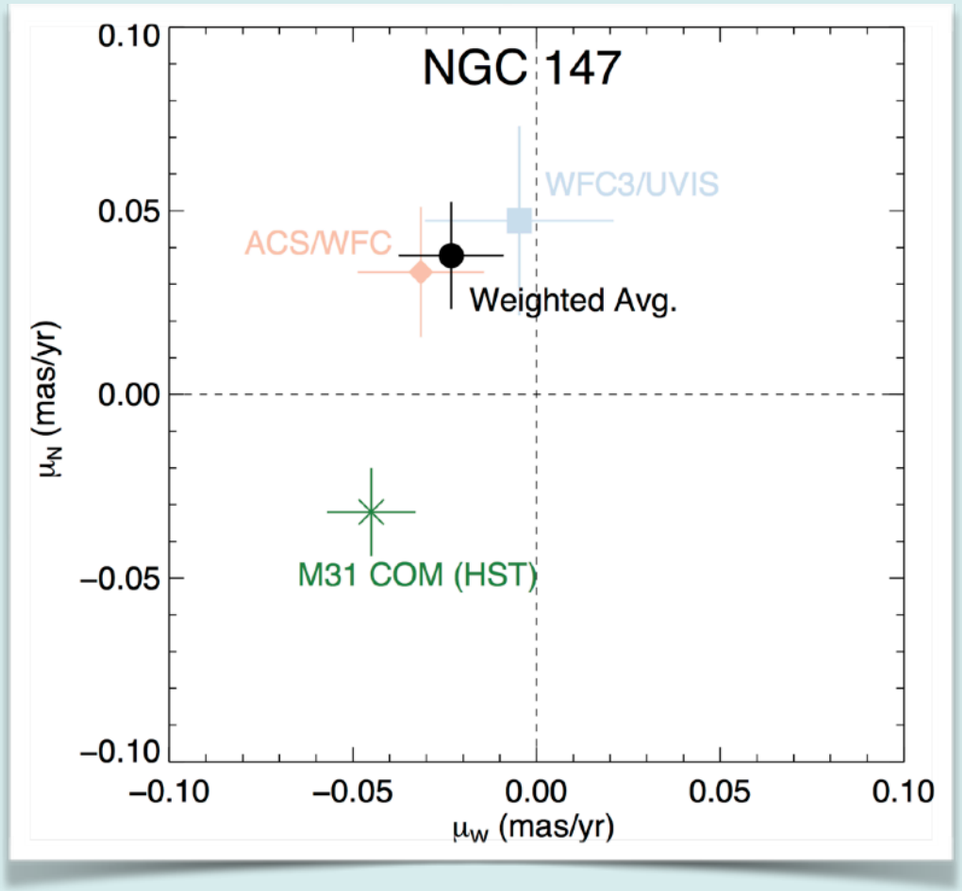


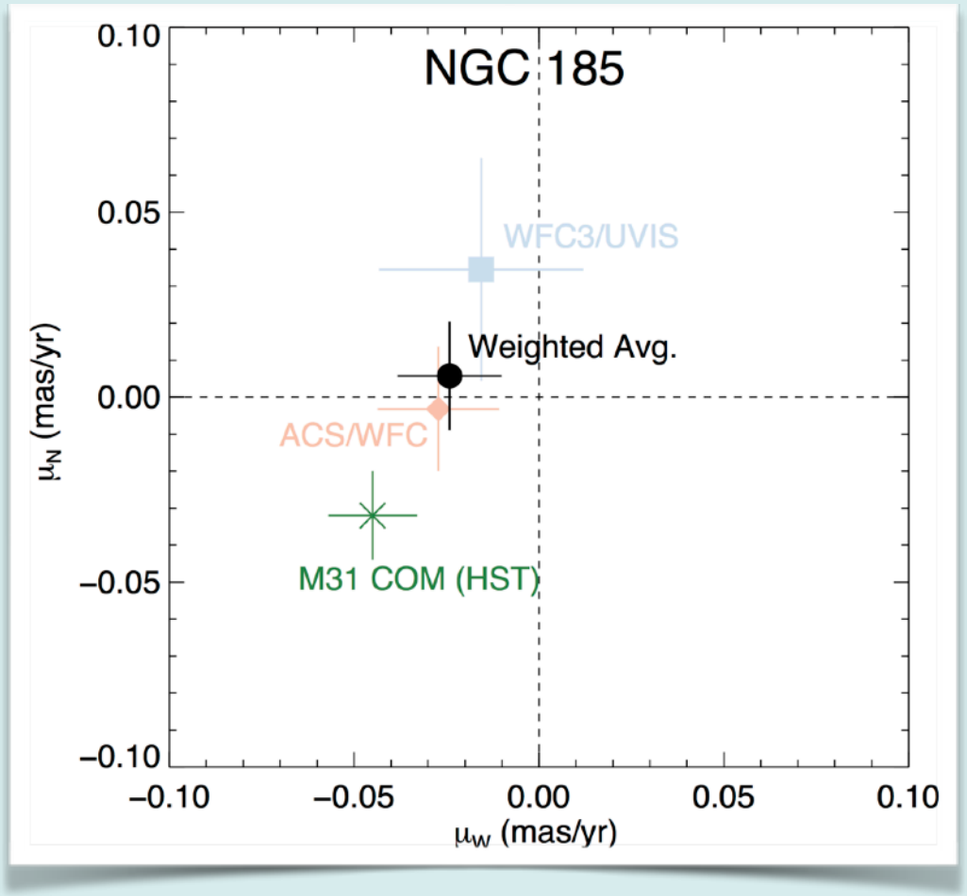
PM RESULTS

- ACS/WFC and WFC3/UVIS measurements for each galaxy consistent within 1σ

- Black points
  = weighted avg. of ACS/WFC + WFC3/UVIS

- Final PM uncertainty: $\sigma_{1\text{-}D}$ = 14.5 μas/yr
  → σ_{Vtan} = 40~50 km/s @ galaxy distances





Key Questions

1. Orbital histories vs. galaxy properties?

2. Are NGC 147 & 185 a galaxy pair?

3. What can we learn about mass of M31 using NGC 147 & 185?

4. Were the galaxies quenched upon infall into M31 or earlier?

5. Do past orbits show possible interactions with other satellites?

6. Why are there no N147/185 counterparts in the MW halo?

7. Why do both N147/185 have such high central density?

8. How do I fill this list with more questions?

9. What is today's lunch menu?

10. Why are you still reading this?

Orbital Integrations

- M31 Potential =
  Hernquist Bulge +
  Miyamoto-Nagai Disk +
  NFW Halo

- M31 Mass
  - High: $M_{vir,M31} = 2\times10^{12}\ M_\odot$
  - Low: $M_{vir,M31} = 1.5\times10^{12}\ M_\odot$

- M31 V_{tan} → velocity zero-point
  - HST (Sohn+2012; van der Marel+2012)
  - <HST + Gaia DR2> (vd Marel+2019)

- Observational errors propagated
  through 1,000 Monte Carlo sampling
  for each (M_{M31}, $V_{tan,M31}$, NGC 147/185)

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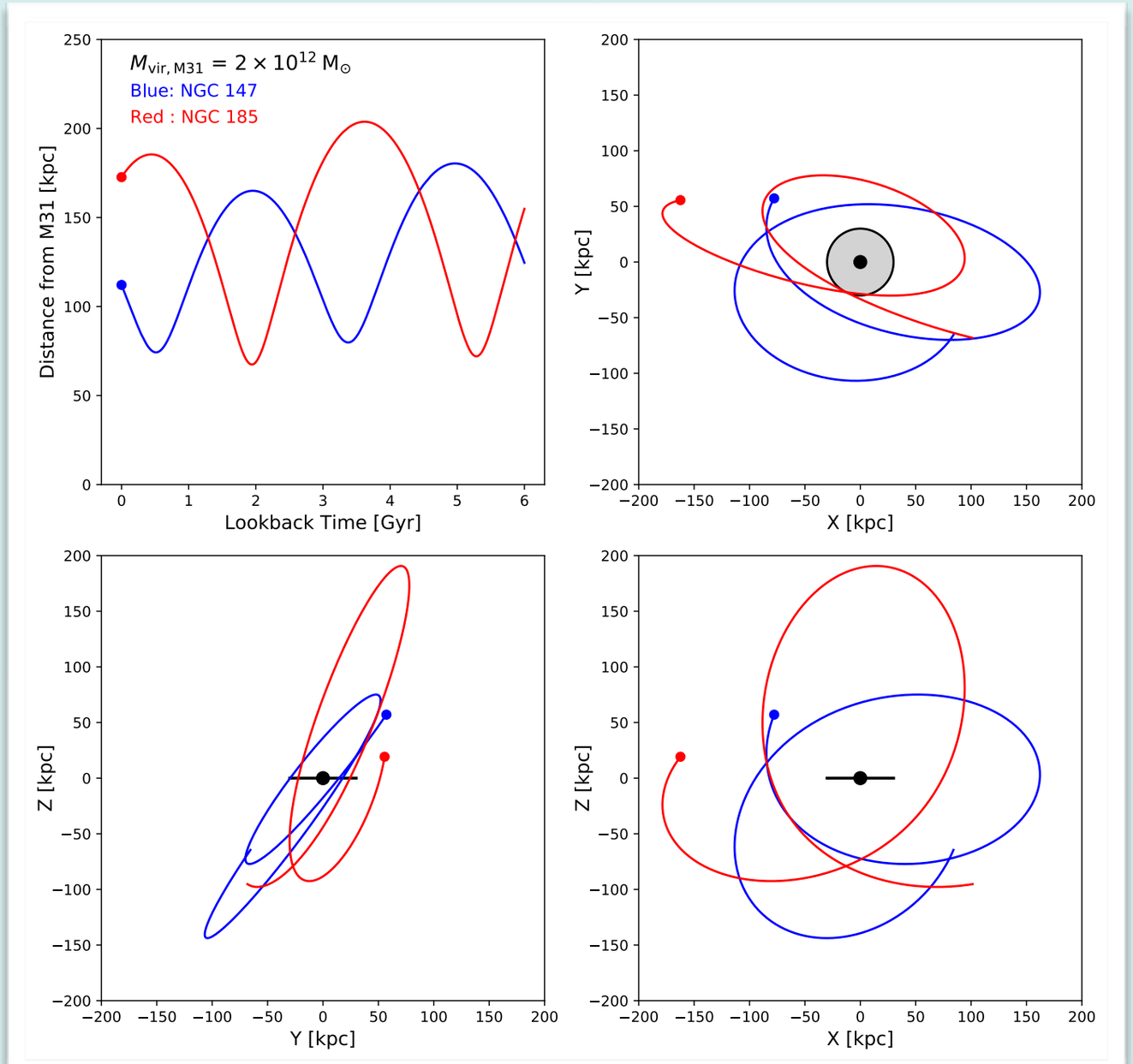
High-mass + HST M31 V_{tan}



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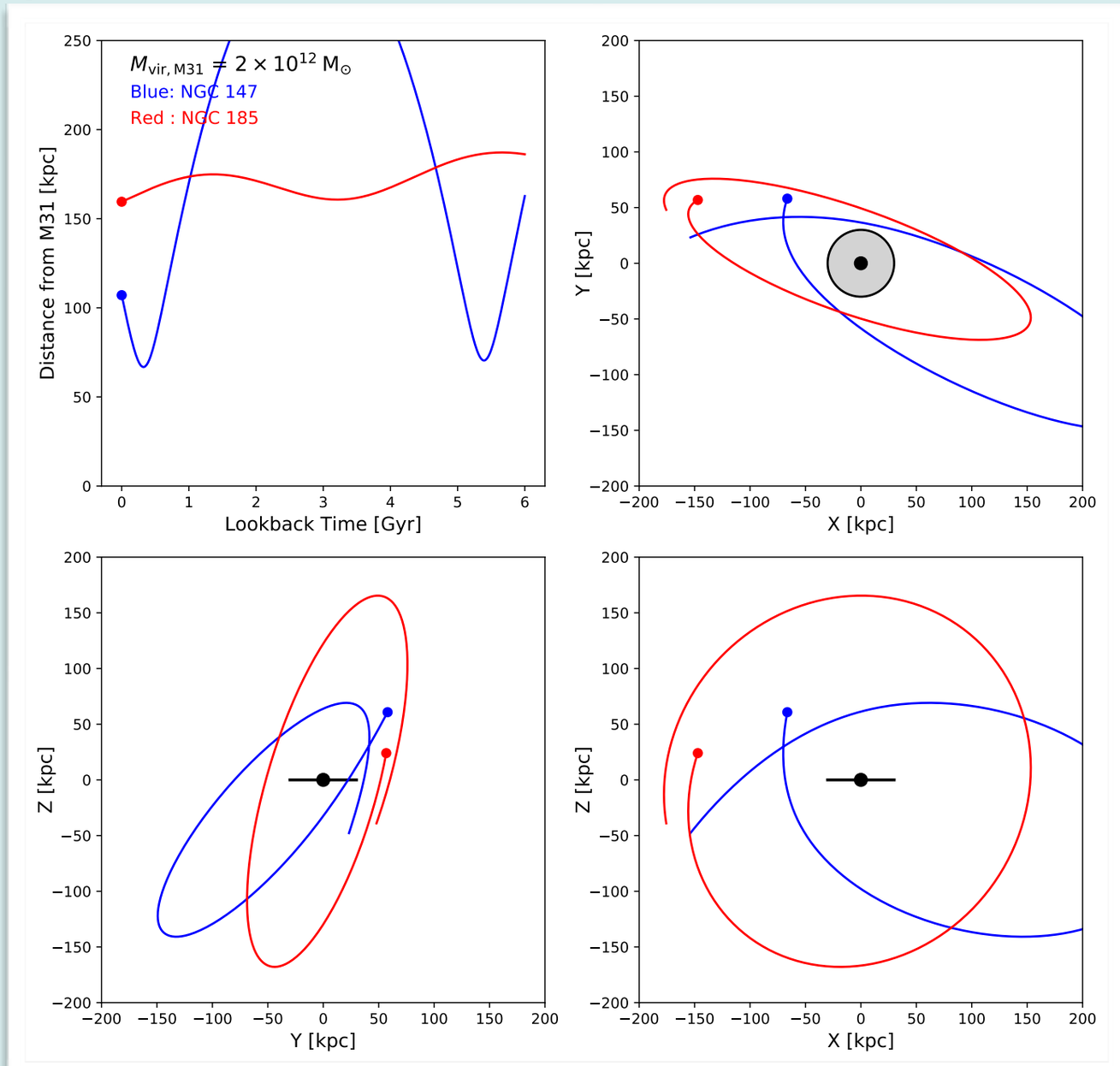
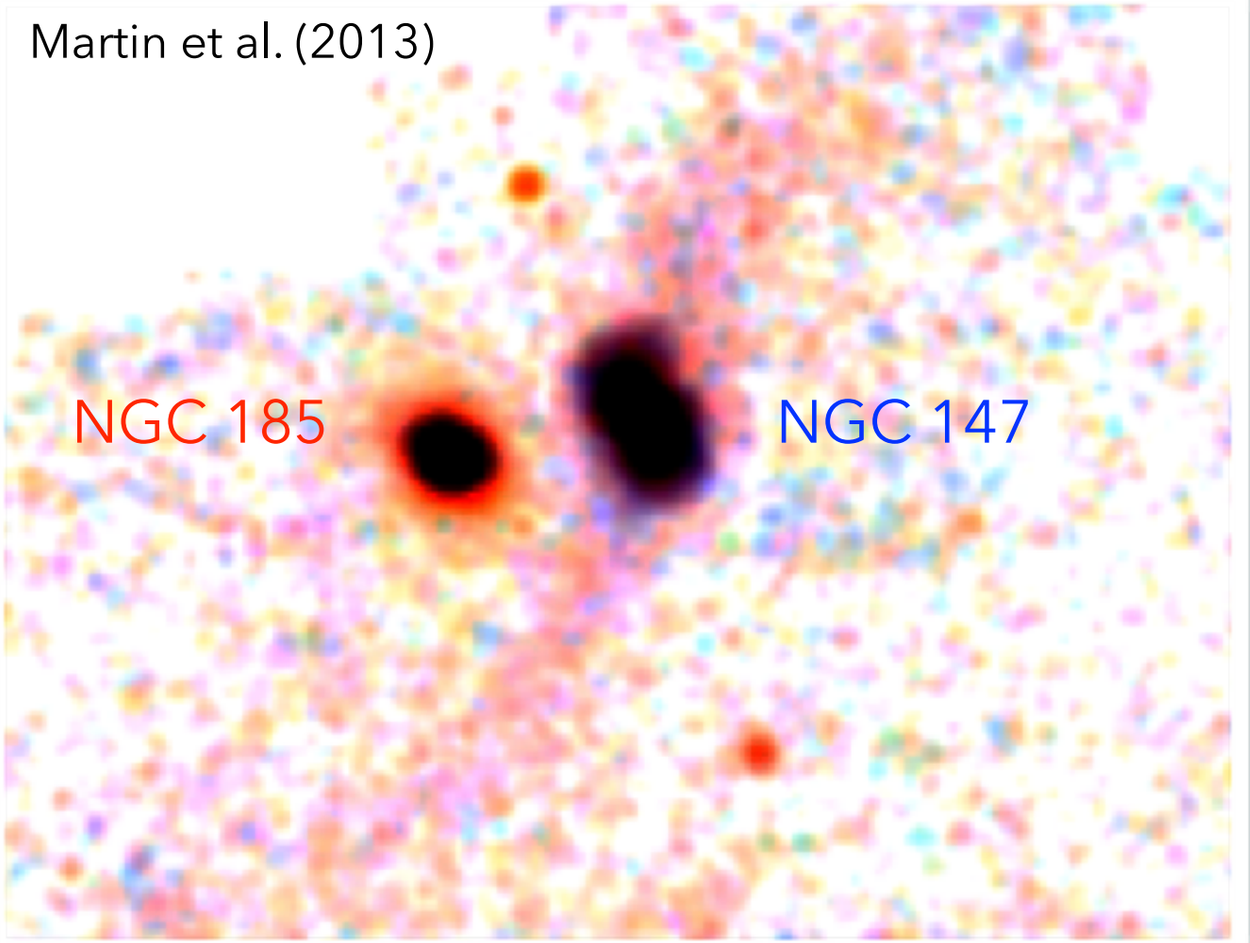


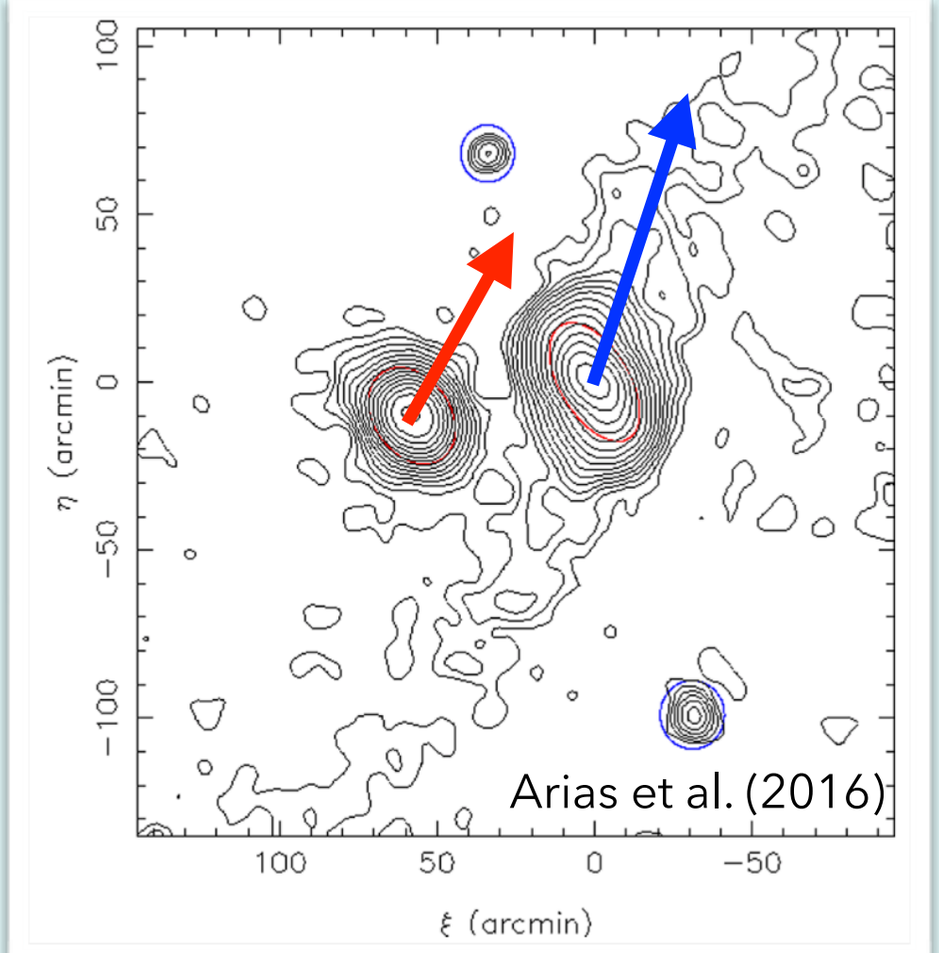
Orbital Integrations

	<HST + Gaia DR2> M31 V_{tan}				HST M31 V_{tan}			
	High-mass M31		Low-mass M31		High-mass M31		Low-mass M31	
	NGC 147	NGC 185	NGC 147	NGC 185	NGC 147	NGC 185	NGC 147	NGC 185
t_{peri} (Gyr)	0.32 ± 0.01	3.30 ± 1.25	0.31 ± 0.01	4.91 ± 0.90	0.46 ± 0.06	1.72 ± 0.36	0.45 ± 0.05	2.12 ± 0.32
r_{peri} (kpc)	67 ± 13	158 ± 23	70 ± 13	164 ± 11	63 ± 13	64 ± 14	68 ± 14	75 ± 17
t_{apo} (Gyr)	2.84 ± 0.80	1.64 ± 1.47	4.07 ± 0.89	2.68 ± 0.86	1.89 ± 0.82	0.37 ± 0.80	2.31 ± 0.75	0.51 ± 0.13
r_{apo} (kpc)	309 ± 78	176 ± 32	403 ± 80	226 ± 55	169 ± 31	170 ± 16	195 ± 46	175 ± 18
P_{orb} (Gyr)	4.5 ± 0.7	3.4 ± 0.3	5.2 ± 0.5	3.6 ± 0.8	2.8 ± 0.6	3.0 ± 0.3	3.6 ± 0.7	3.5 ± 0.3

- In general, orbital parameters strongly depend on which V_{tan} zero point is used.
- NGC 147's last closest passage → 0.3~0.5 Gyr ago @ r_{M31} = 60~70 kpc
- NGC 185's last closest passage → > 1.7 Gyr ago

Orbital Integrations





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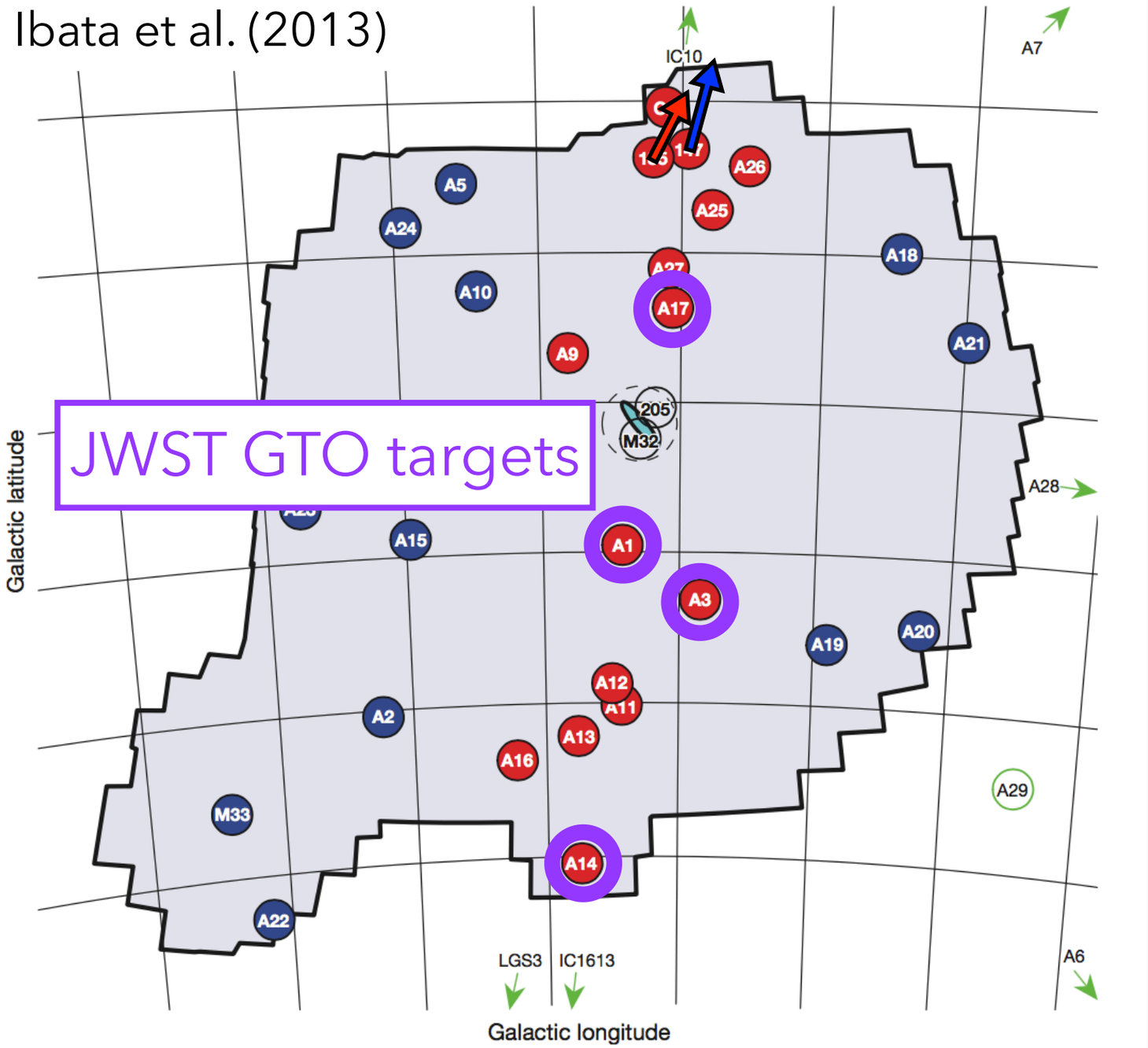
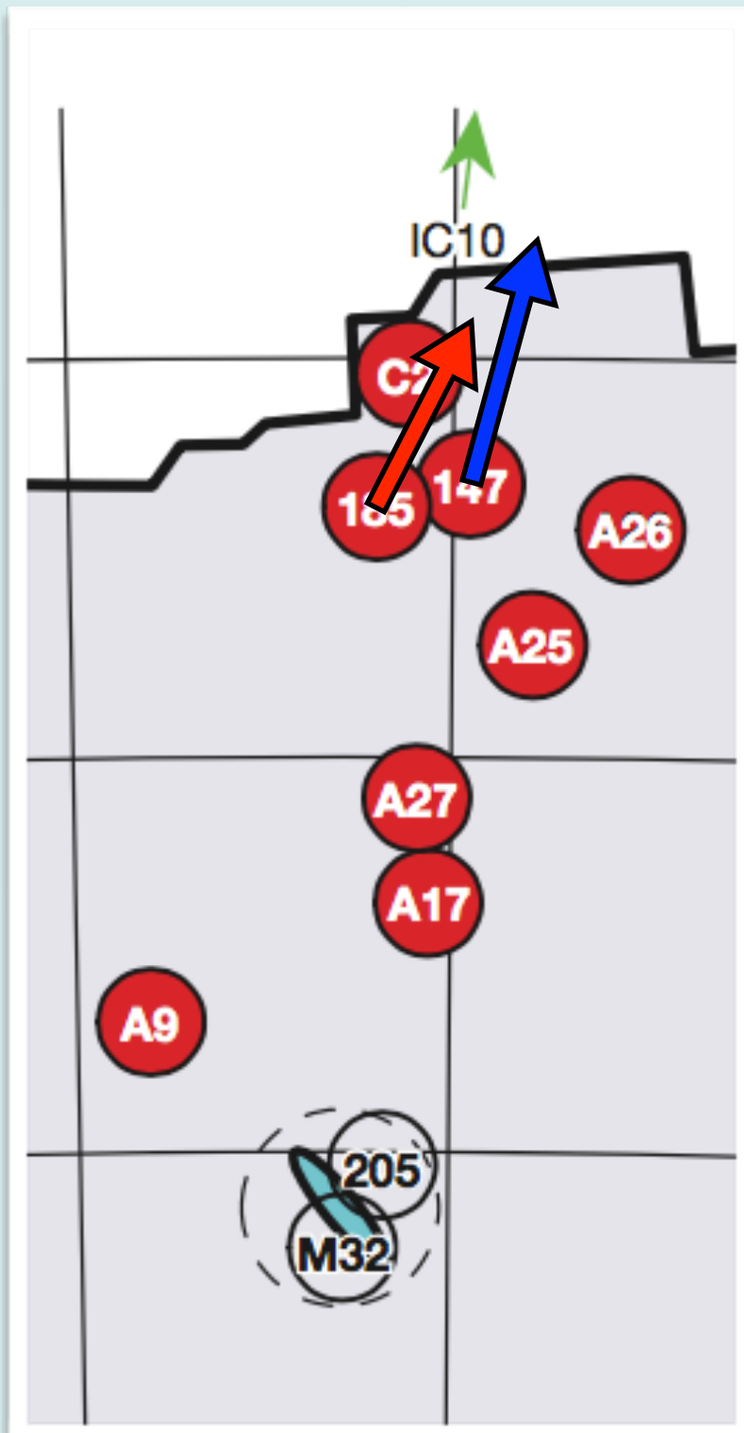
The Great Plane of Andromeda

Ibata et al. (2013)



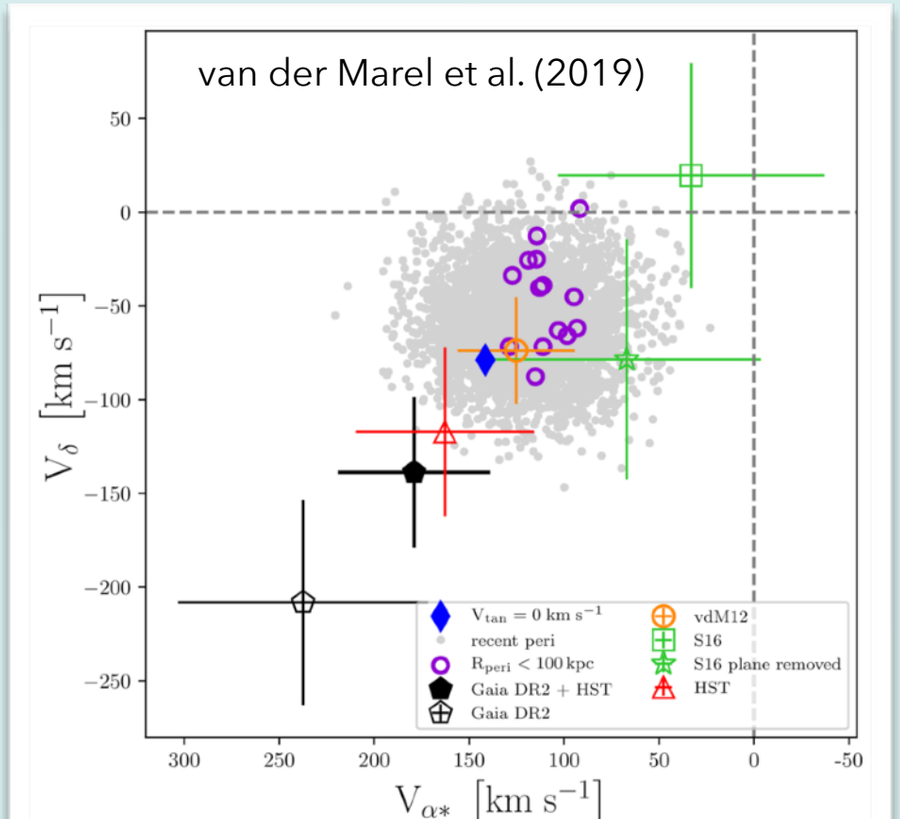
JWST GTO targets

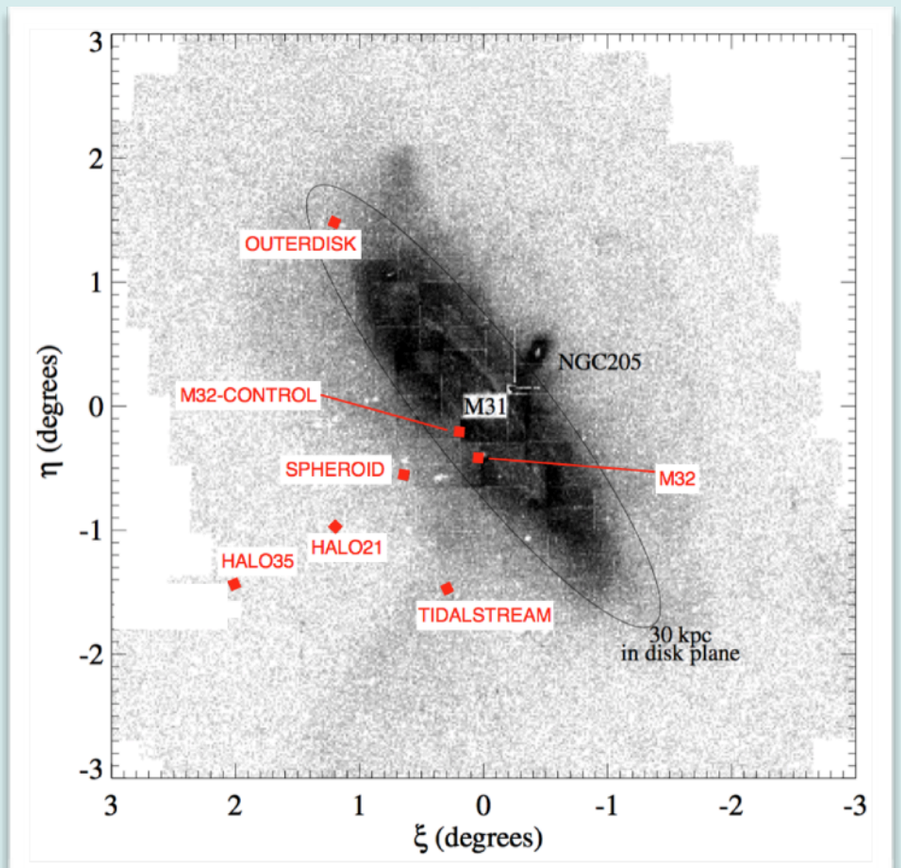


FUTURE WORKS

- M31 Proper Motions (HST Cycle 26)
  - Data will be obtained Aug 2019 - Jan 2020
  - ΔT = 6 yrs (Sohn+2012) → 15 yrs
  - N_{fields} = 3 (Sohn+2012) → 7
  - M31 V_{tan} uncertainty: ≲ 5 μas/yr (18 km/s)
  - Resolved PMs: disk rotation, tidal stream, σ_{tan} profile,...
  - The first PM of M32! - role in shaping M31's halo

- M31 Satellite Proper Motions
  - Gaia will not measure PMs for most
  - HST Cycle 27 GO-15902 (PI: D. Weisz): 1st ep.
  - JWST GTO: obtain 2nd ep. for And 1, 3, 14, 17 (GPoA)
  - HST+JWST, HST+WFIRST





THE LOCAL GROUP

A Laboratory for Near-field Cosmology

STScI

STScI Spring Symposium: 20-24 April, 2020

TOPICS

- How did the Milky Way system assemble and form?
- How similar/different are the MW and M31?
- What mechanisms are involved in the formation and evolution of the LG and its galaxies?
- What are the differences between the LG and other groups in the local universe?

SOC

Annalisa Calamida (chair)
Elena Sacchi (chair)
Tony Sohn (chair)
Tom Brown
Carol Christian
Andres del Pino
Karoline Gilbert
Claus Leitherer
Mattia Libralato
Nora Luetzgendorf
Peter Zeidler
Erik Tollerud
Rosemary Wyse