New Satellite Dwarf Galaxies of NGC2683 and M104 and the Search for Satellite Planes

IAUS379: Dynamical Masses of Local Group Galaxies

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Satellite Planes Problem: The Ongoing Discussion

Satellite Planes are inconsistent with ΛCDM

Kroupa et al. 2005

Found the satellite plane of the MW

Metz et al. 2009

Found co-rotation in the MW plane

Ibata et al. 2013
Conn et al. 2013

Found the satellite plane of M31

Tully et al. 2015
Müller et al. 2016

Found the satellite plane of Cen A

Pawlowski et al. 2020, 2021

Gaia/HST motion data confirms the MW and M31 planes

Zenter et al. 2005
Kang et al. 2005
…

Anisotropic planes do exist in simulations

Libeskind et al. 2009
Lovell et al. 2011
…

Unique cosmic histories may have produced satellite planes

Bahl & Baumgardt 2014
Gillet et al. 2015
…

Satellite planes are a unstable phenomena

Cautun et al. 2015

The analysis of the MW and M31 planes is biased.

Sawala et al. 2022

Gaia motion data shows the MW is consistent with simulations

Satellite Planes are consistent with ΛCDM

Satellite Planes: Search for more.

- Current hypotheses:
  - Local cosmic structures favoured the formation of satellite planes.
  - Our analysis sample is biased and exposed to issues including the ‘Look-elsewhere’ effect.
  - With limited (only 3) robustly defined satellite planes, the Local universe might be an outlier.

- Next step? Characterise more systems of satellites:
  - Limits bias from the unique characteristics of satellite systems.
  - Allows us to control for the properties of cosmic structures.
  - Builds a sample that is statistically robust.

The Hyper-Suprime Cam Sample

- Wide field images of 8 galaxy environments were captured in January 2019 using the Hyper-Suprime Cam on the 8.2m Subaru telescope, Maunakea, Hawaii.
- These environments reside within the Local Volume, a ~10 Mpc spherical volume
- They were selected to maximise potential satellite dwarf galaxy discoveries.

Host Galaxy	Type	Distance (Mpc)	Stellar Mass [1] $(10^{10} M_{\odot})$
M104	SA(s)a or E	9.55	12.3
M66	SAB(s)b	9.6	6.4
NGC891	SA(s)b	9.12	5.2
M106	SAB(s)bc	7.31	4.7
NGC2903	SAB(rs)bc	9.33	4.6
NGC2683	SA(rs)b	9.36	2.1
NGC3521	SAB(rs)bc	8.03	2.3
UGCA127	Scd	10.60	0.4

Distances and Types extracted from NASA/IPAC Extragalactic Database. Stellar Masses from S4G:

[1]: Querejeta, M., et al., THE SPITZER SURVEY OF STELLAR STRUCTURE IN GALAXIES (S4G): PRECISE STELLAR MASS DISTRIBUTIONS FROM AUTOMATED DUST CORRECTION AT 3.6 μ m. 2015, ApJSS, 219, 1, 5

NGC2683

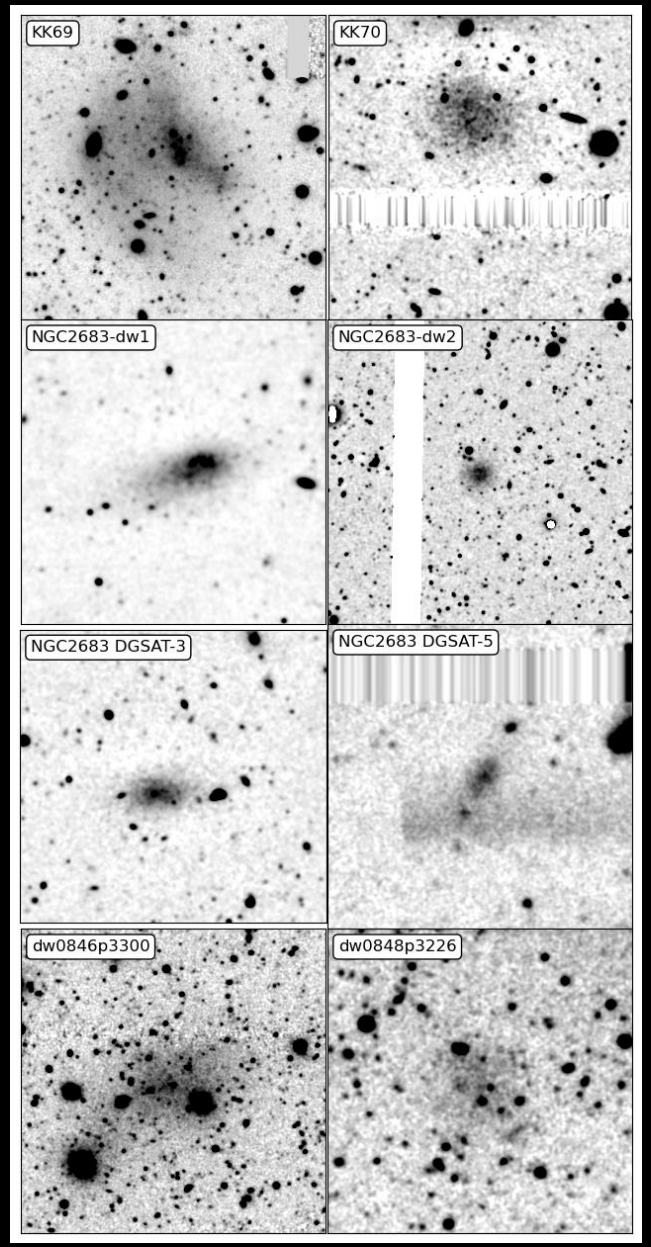
- NGC2683 (the UFO galaxy) is spiral galaxy, about half the diameter of the Milky Way.
- 9.36 Mpc [1] away in the Leo Spur, a spare filamentary structure.

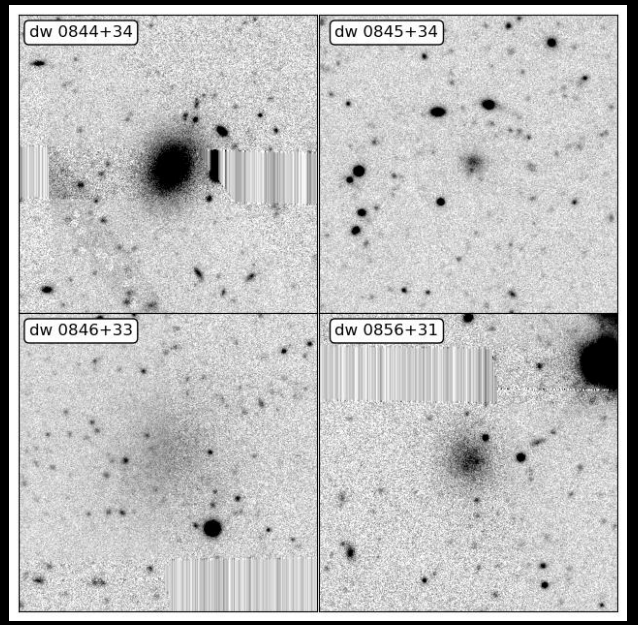
Image Credit: Subaru Telescope (NAOJ), Hubble Space Telescope; Image Assembly **Processing, & Copyright:** Robert Gendler

[1]: Karachentsev I. D., Tully R. B., Makarova L. N., Makarov D. I., Rizzi L., 2015, ApJ, 805, 144

NGC2683 System

- Each environment is captured with 7 pointings, extending the field of view to ~3-5 degrees, which exceeds the virial radius.
- 8 satellites known, 4 new discoveries.
- Images are complete to
  $M_g < -10\ (m_g < 20)$
  $\log(L_\odot) > 5.9$
  at $r_e > 2''$

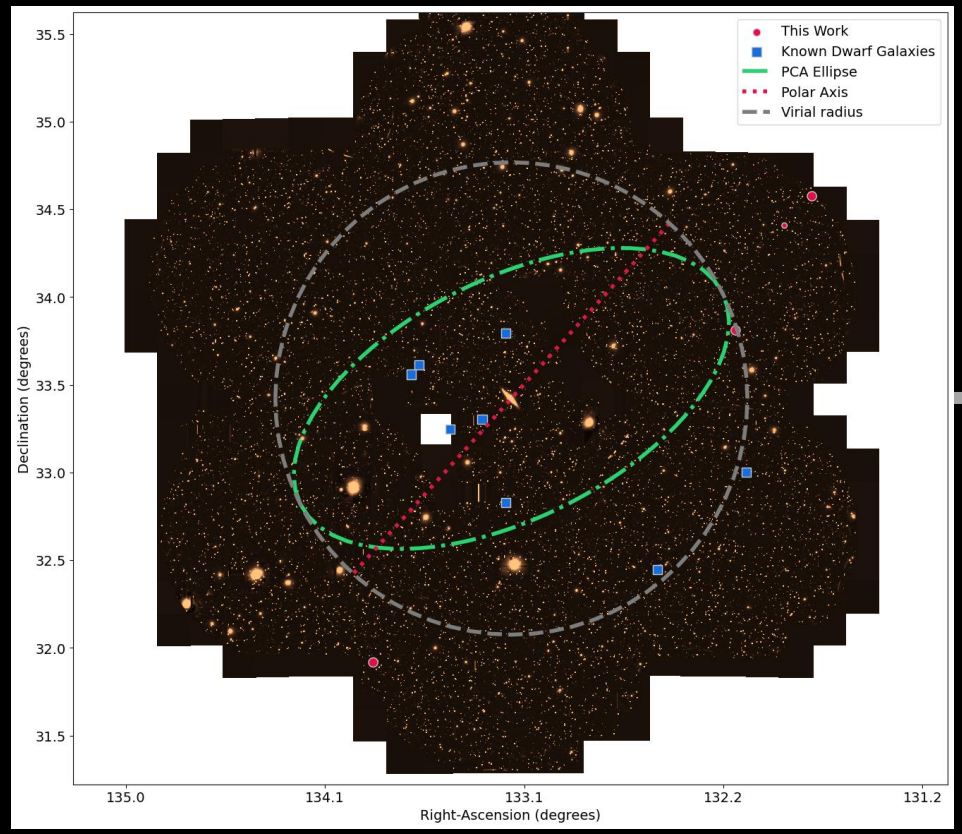




Known Satellite candidates from:

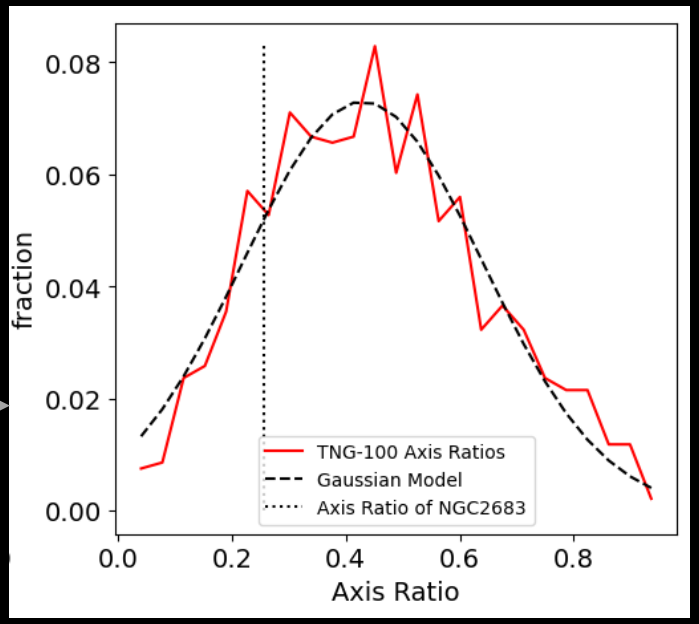
- Carlsten S. G., Greene J. E., Beaton R. L., Danieli S., Greco J. P., 2022, ApJ, 933, 47
- Javanmardi B., et al., 2016, A&A, 588, 89
- Karachentsev I. D., Tully R. B., Makarova L. N., Makarov D. I., Rizzi L., 2015, ApJ, 805, 144

NGC2683: 2D Projected Flattening is Consistent with the TNG100 Simulation



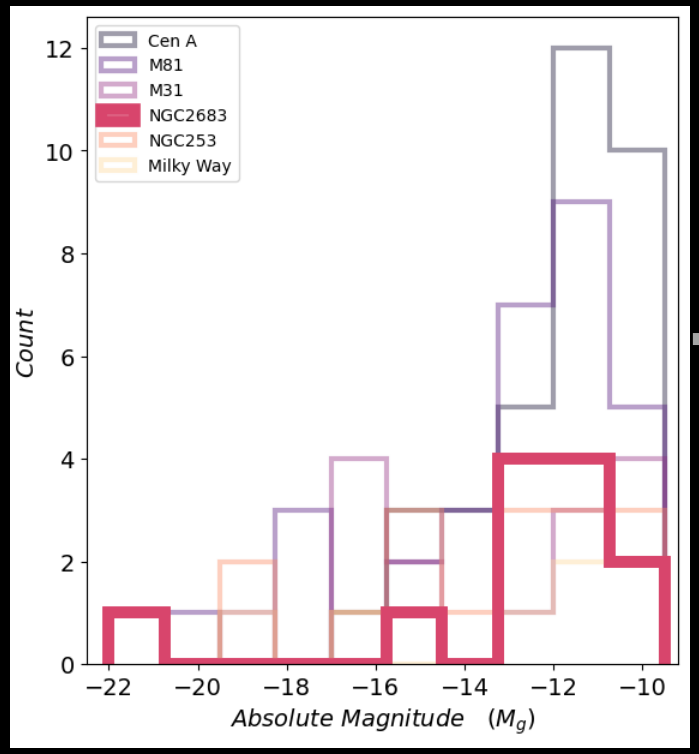
Use PCA in RA, DEC parameter space to generate an ellipse from eigenvectors.

Compare to similar environments from Illustris TNG100-1



NGC2683 has an anisotropically aligned system of satellites in the 2D projection, that is consistent with similar hosts in the TNG-100 simulation.

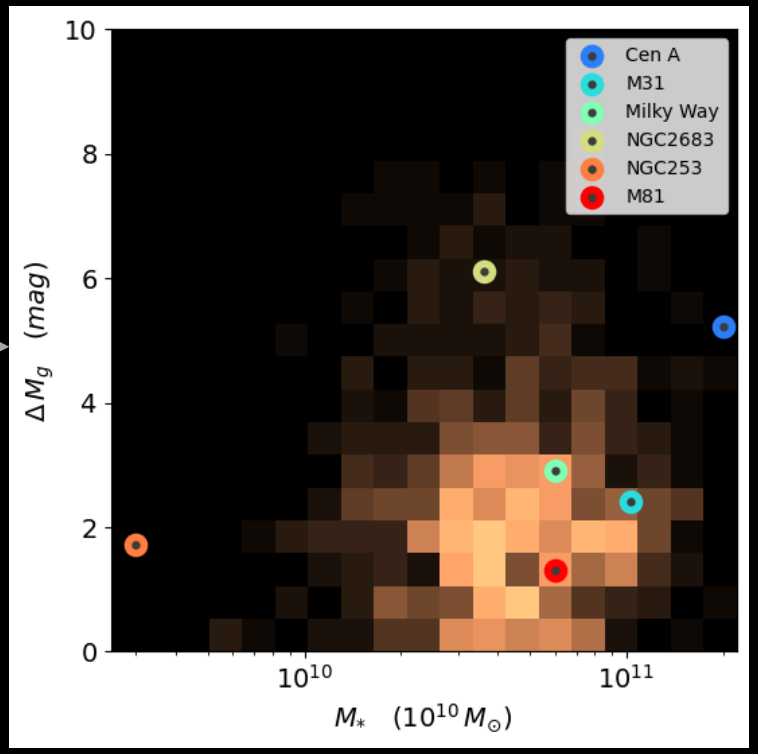
NGC2683: The Unusual Absence of High Luminosity Satellites



An uncharacteristic magnitude gap of 6 magnitudes.

In comparison to other local host galaxies.

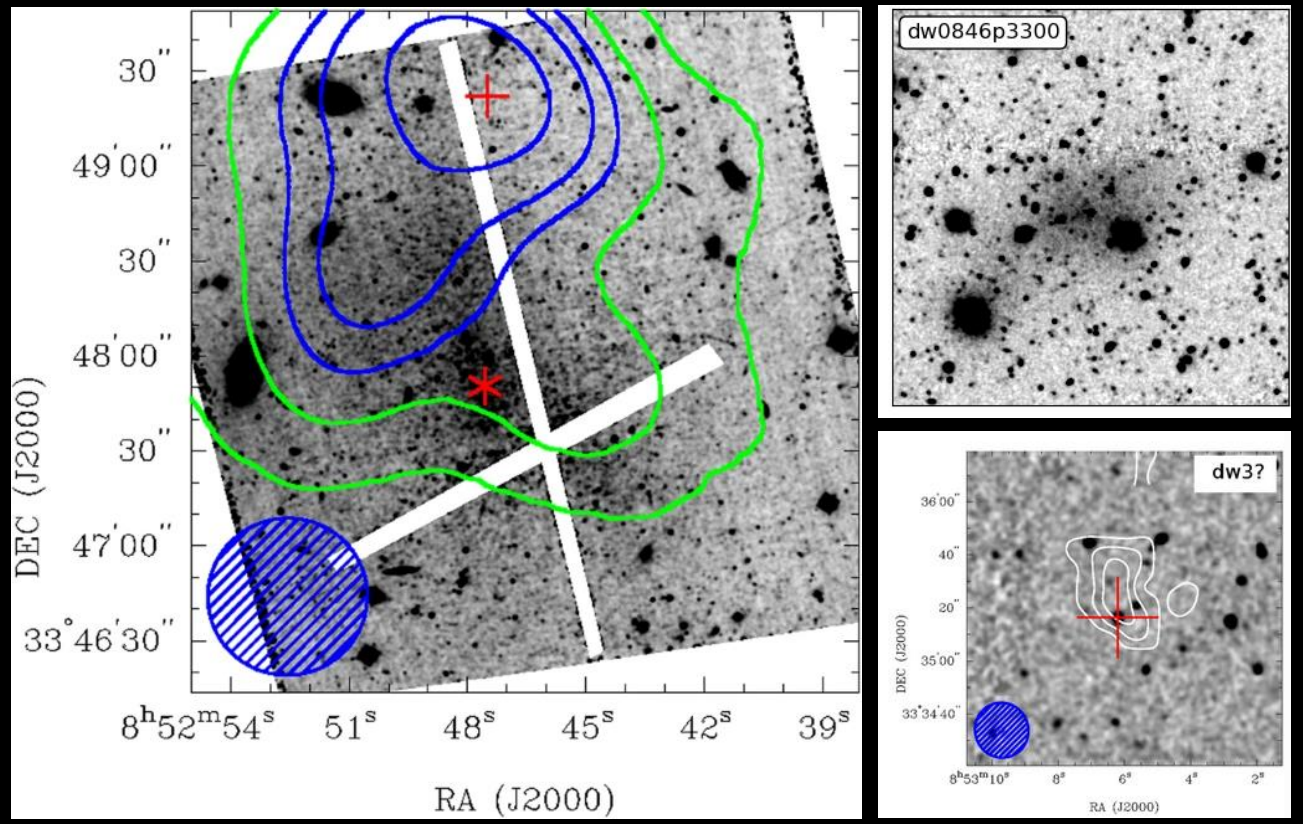
Compare to similar environments from Illustris TNG100-1



NGC2683 is unusual, with 5% of TNG-100 environments having a larger magnitude gap.

Oddities of the NGC2683 System

- The brightest Satellite (KK69) can be described as an ultra-diffuse, dwarf irregular or dwarf transitional galaxy.
- A very low surface brightness and disrupted dwarf.
- An isolated HI cloud.
- Are these galaxies tidal fragments?



Saponara J., et al., New H i observations of KK 69. Is KK 69 a dwarf galaxy in transition?, 2020, Ap&SS, 365, 111

M104

- M104 (the sombrero galaxy) is a massive elliptical galaxy (total mass $M_{\odot} \sim 4 * 10^{12}$)
- Resides 9.55 Mpc [1] in the sparse southern extension of the Virgo cluster.

Image Credit: NASA and the Hubble Heritage Team (STScI/AURA)

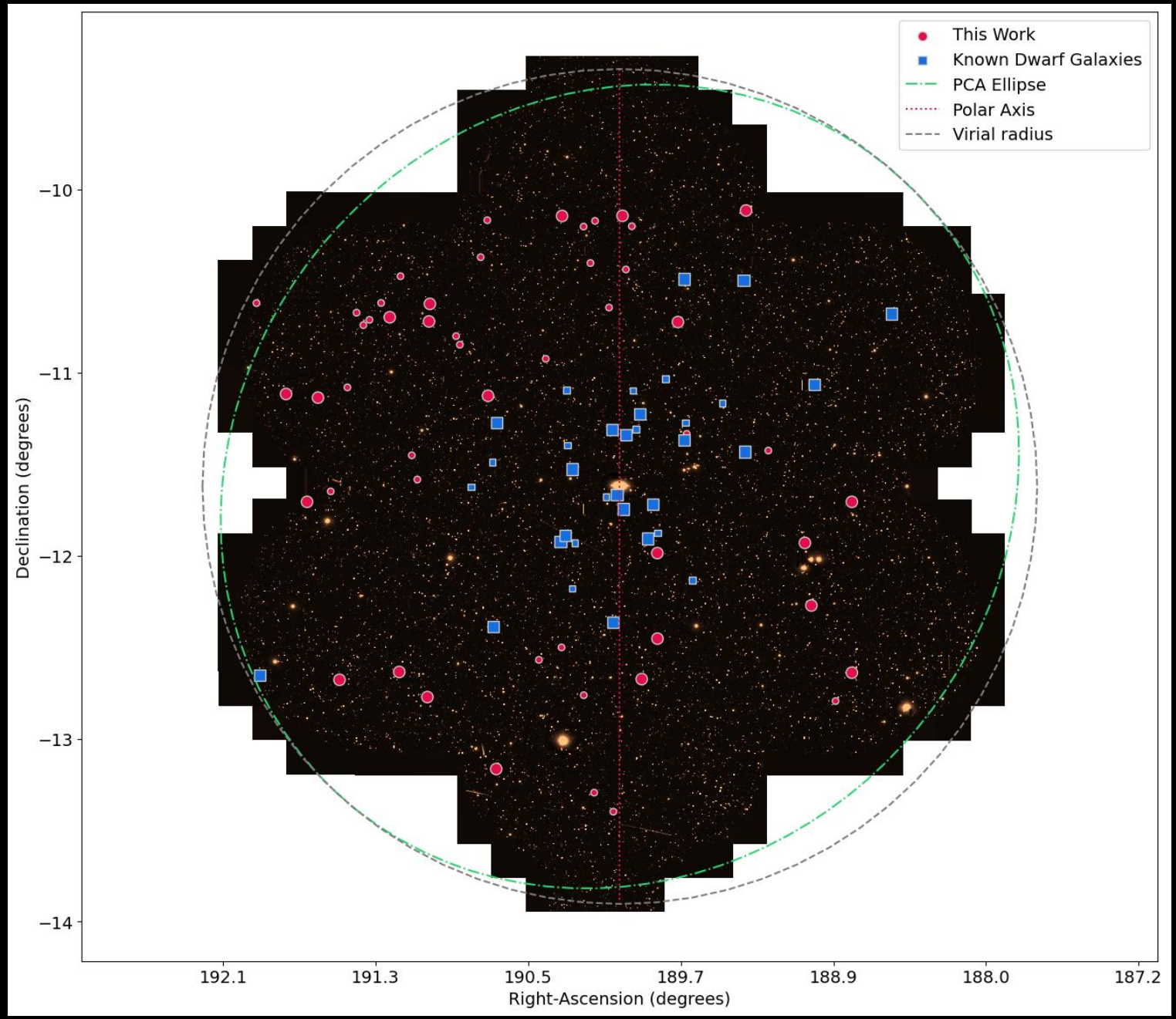
[1]: McQuinn, Kristen. B. W., Skillman, E. D., Dolphin, A. E., Berg, D., & Kennicutt, R., THE DISTANCE TO M104. AJ, 2016, 152, 5, 144

M104 System

- 44 new dwarf galaxy candidates with:

$$M_g < -9.5$$
$$\log(L_\odot) > 5.7$$

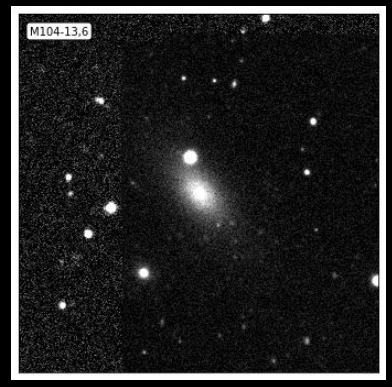
- No flattening in the satellite distribution is found.
- The distribution is lopsided. This appears to be consistent with simulations.
- A large magnitude gap of about 5 magnitudes.

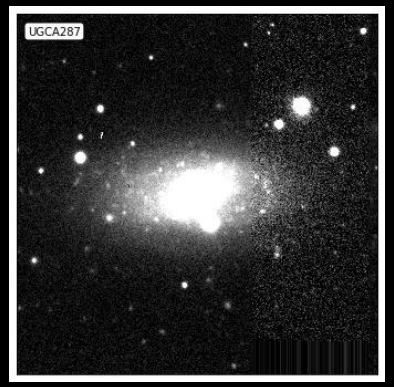


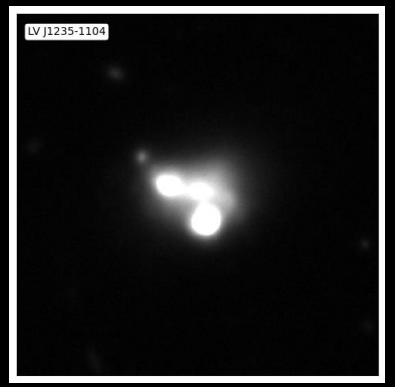
M104 Spectroscopy

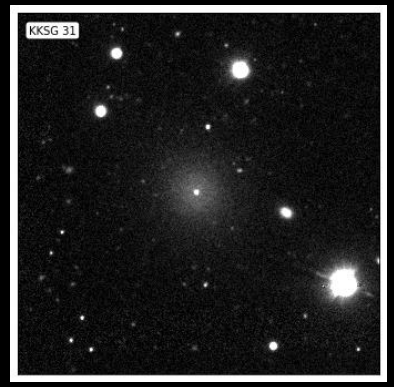
- Integral Field Unit – Magellan (IFU-M) is an IFU spectrograph for the Magellan telescopes at the Las Campanas Observatory (LCO).
- We have observed 4 satellites galaxies.
- Spectroscopy can determine co-rotation and constrain the shape of a satellite plane, if present.

Parameter	Value
Spaxel Dimensions	18 x 20
Spaxel pitch (arcsec)	1.9''
Field Dimension (arcsec)	32.7'' x 31.4''
Spectral Resolution (LoRes)	1000, 4000
Telescope diameter	6.5m









[1]: Karachentsev, I. D., Makarova, L. N., Brent Tully, R., Anand, G. S., Rizzi, L., & Shaya, E. J. , Distance and mass of the M 104 (Sombrero) group, 2020, A&A, 643, A124

Conclusion

- The discussions on the reported satellite planes of the Milky Way, Andromeda and Centaurus A are ongoing.

- This motivates a search for satellite planes beyond the Local Group.

- New satellite dwarf galaxy discoveries in the NGC2683 and M104 environments make promising targets for future attempts to quantify the presence of satellite planes.