Resolving stellar populations in (and around) the nearest giant elliptical galaxy

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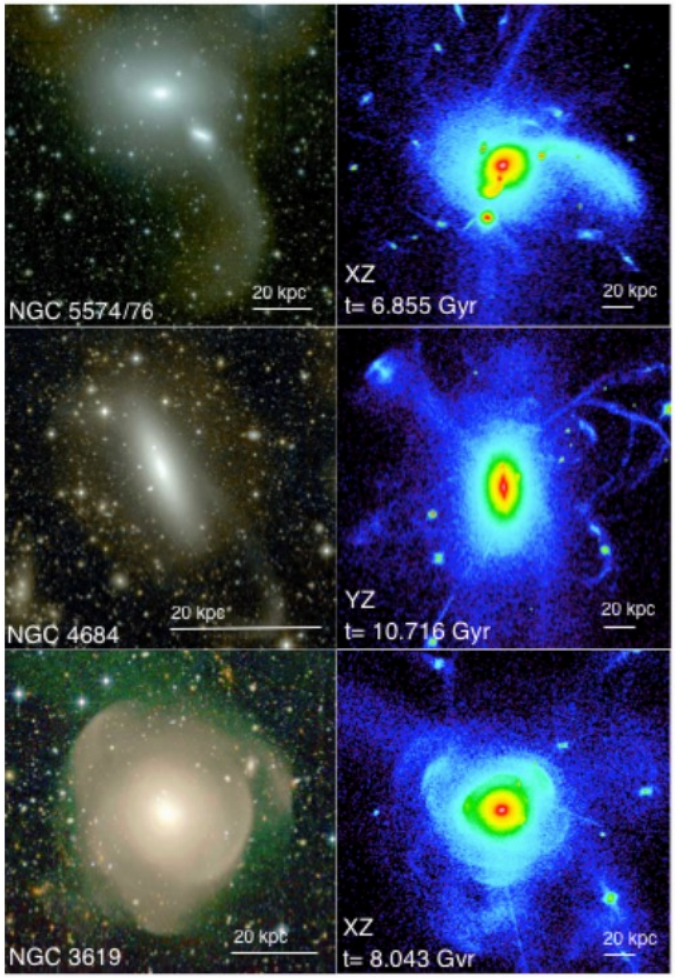
O. Müller, K. Fahrion, M. Pawlowski, M. Hilker, F. Lelli, H. Jerjen

Hierarchical model of galaxies formation & evolution



ETGs from MATLAS survey (Duc+2015)

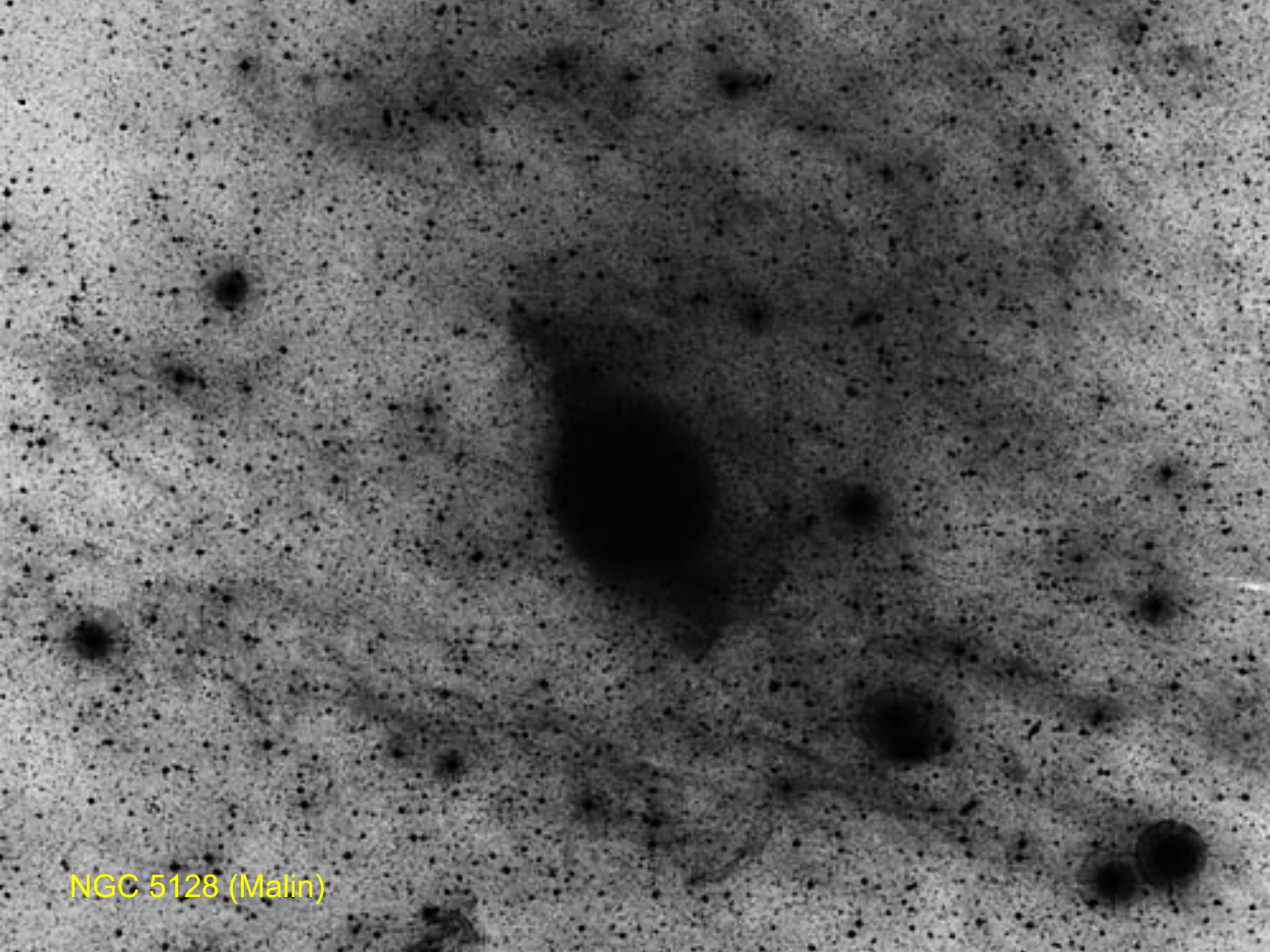
Simulated galaxies (Mancillas et al. 2019)

- Low surface brightness features:
  - Tidal tails
  - Stellar streams
  - Shells

Tracers of interactions and merging events

Most faint substructures at ~29 mag/arcsec^2 trace major and intermediate mass merger events.

Survival of most substructures ~0.7-4 Gyr


NGC 5128 (Malin)

Resolving the stellar halo of Cen A = NGC 5128

Cen A as an example of a large nearby galaxy

(not in the Euclid footprint)

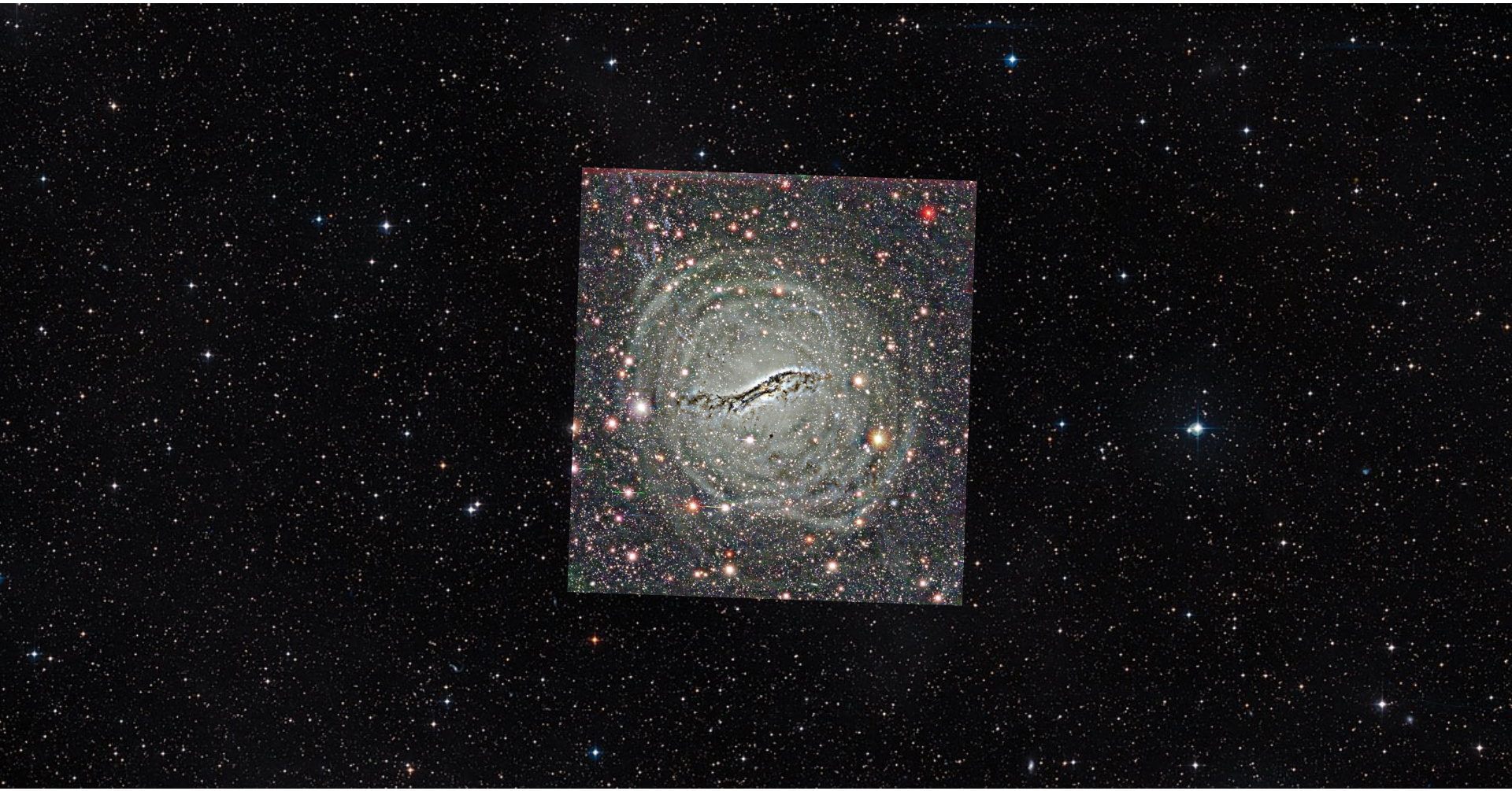
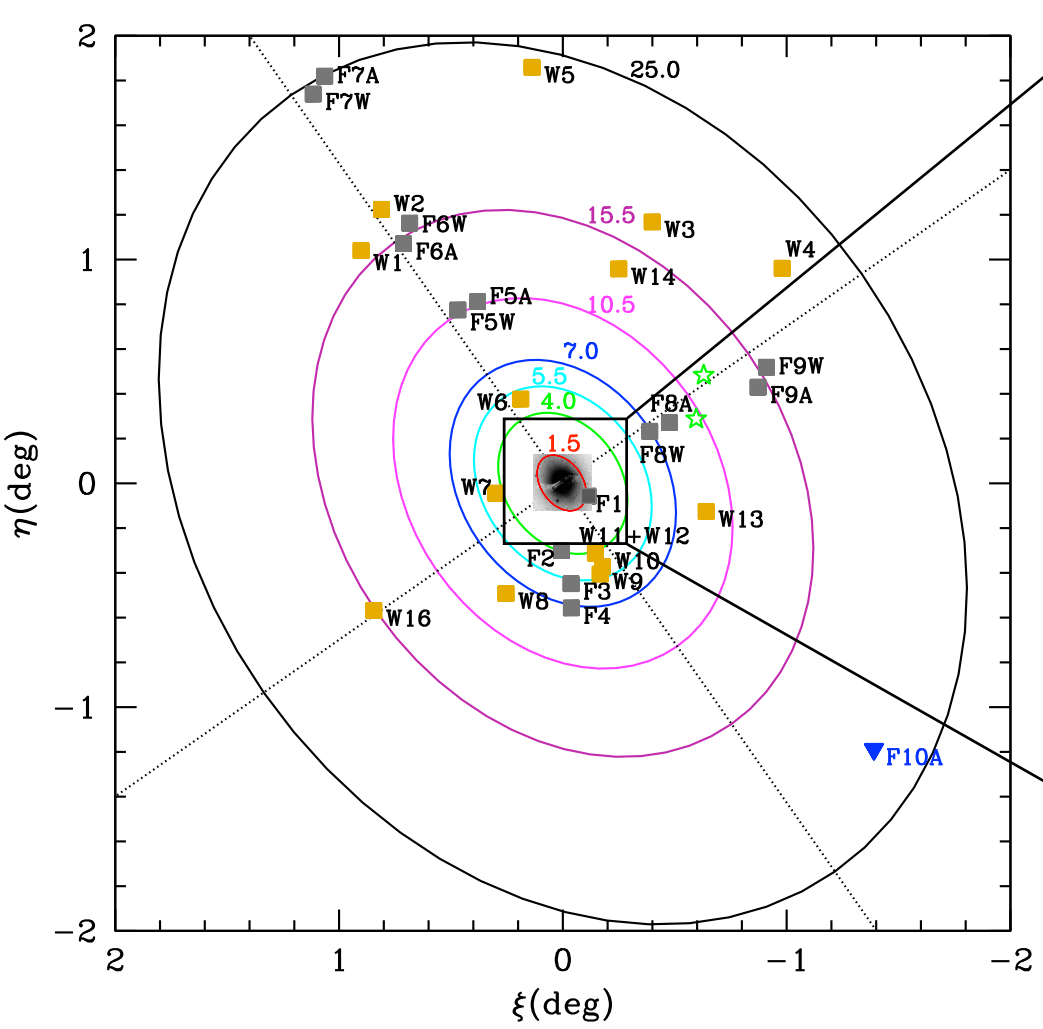


Image credit: NASA, ESA & M. Rejkuba (European Southern Observatory)

26 halo fields observed with the HST ACS and WFC3 cameras

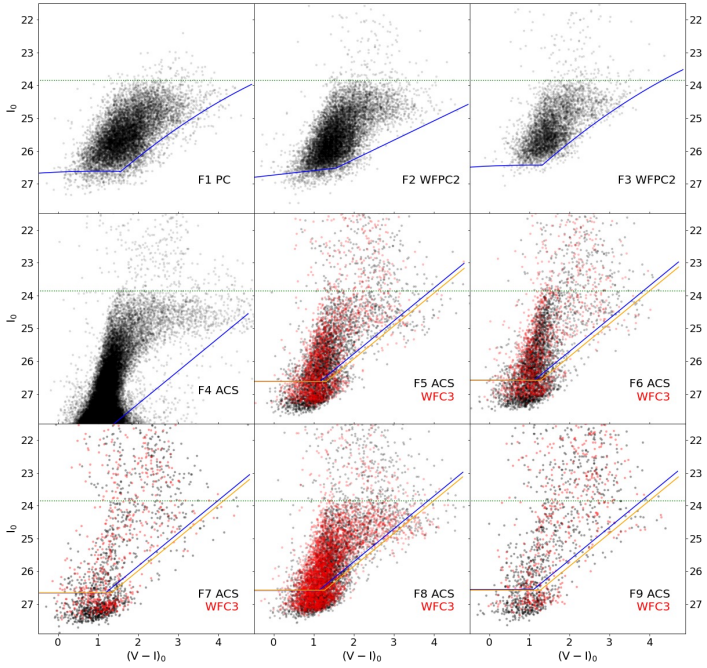


Rejkuba+22

Ellipses: b/a=0.77 (Dufour+1979)
Distances in units a/Re

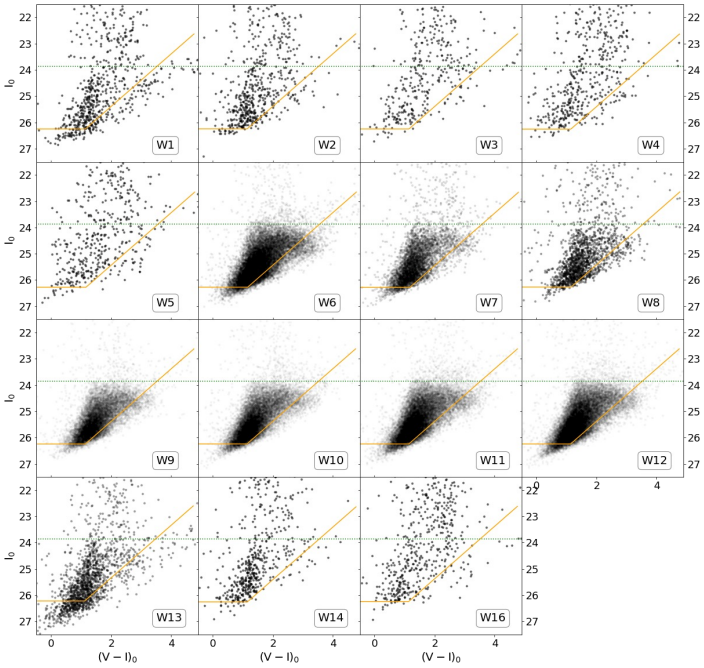
HST cycle 20
5 fields ACS+WFC3 parallel
1 orbit F606W + 1 orbit F814W

3 along major axis: F5, F6, F7
2 along minoor axis: F8, F9



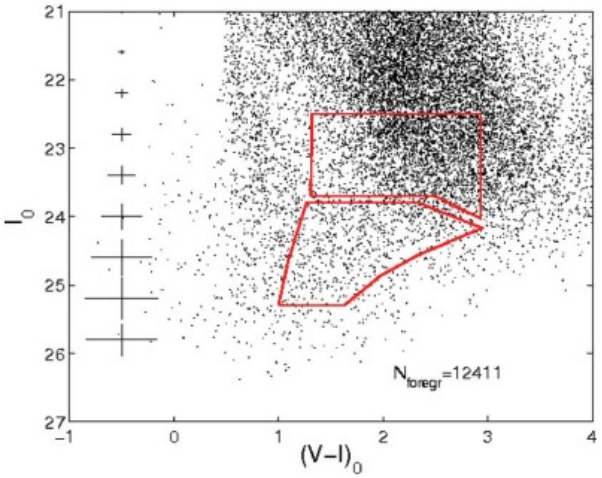
HST cycle 22
15 WFC3 parallel pointings
½ orbit F606W + ½ F814W

Main program: dwarf candidates
parallels: ”smooth halo”

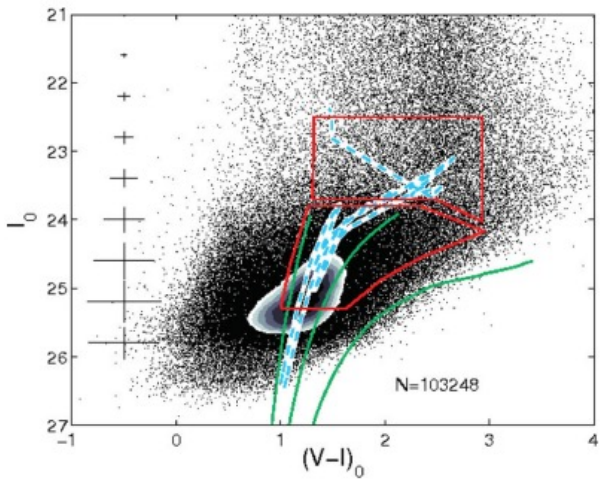


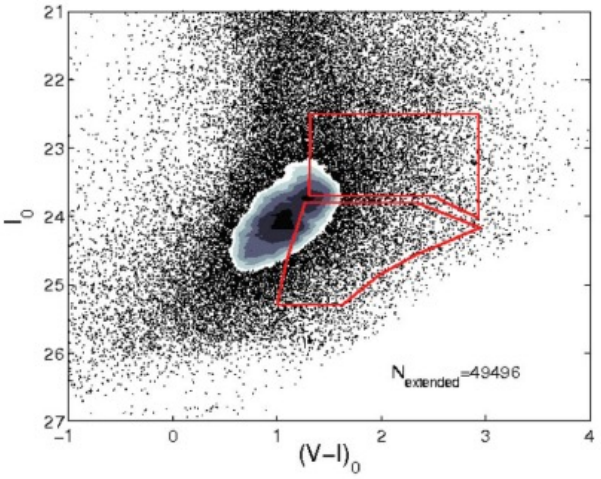
Foreground+background contamination

Besançon simulation of Galactic foreground

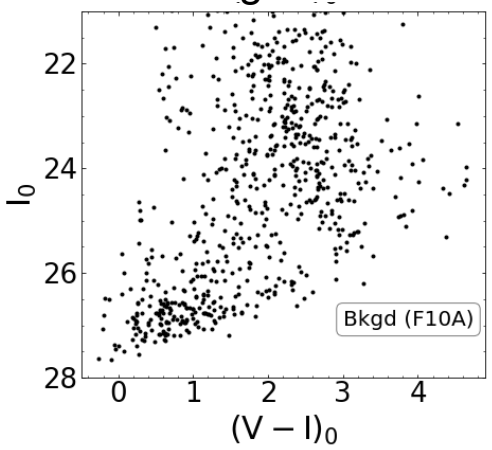


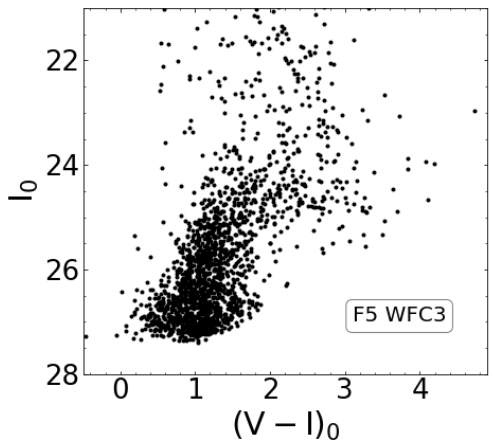
Crnojevic, Ferguson et al. 2013: VIMOS survey of Cen A halo

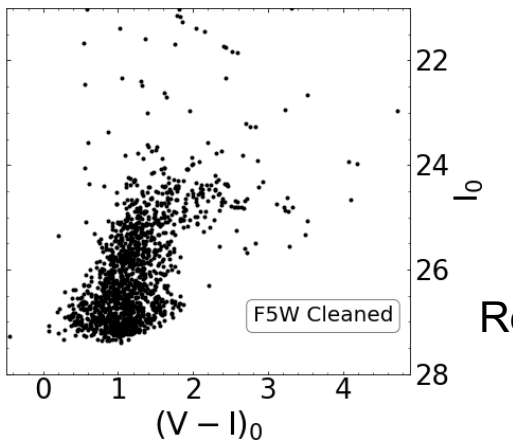




"Fore/background field"



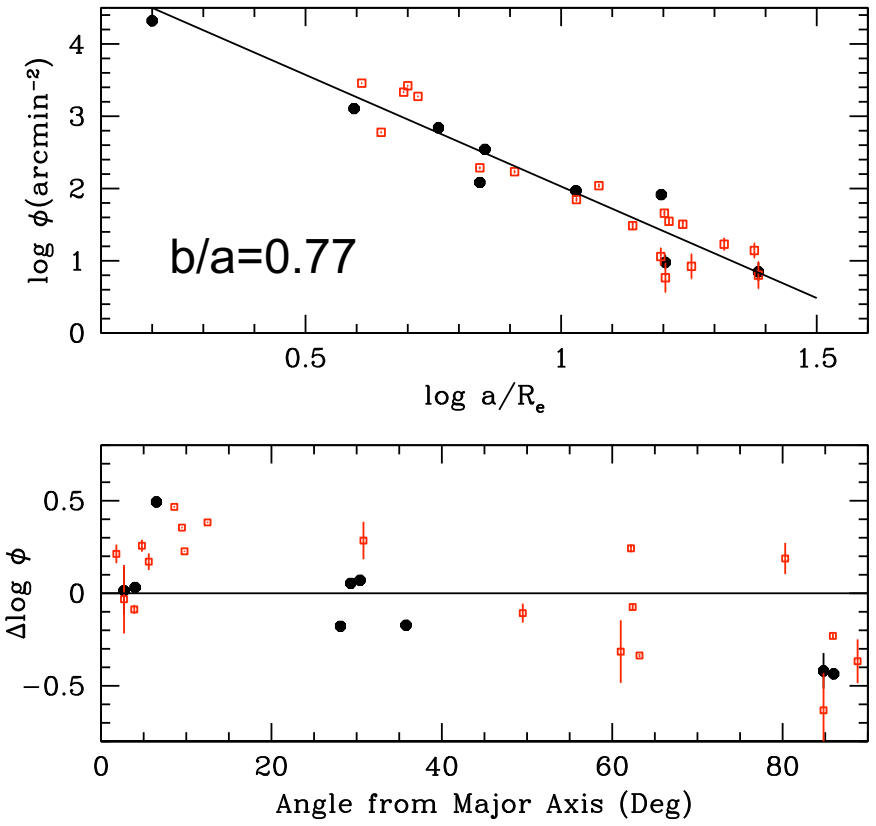


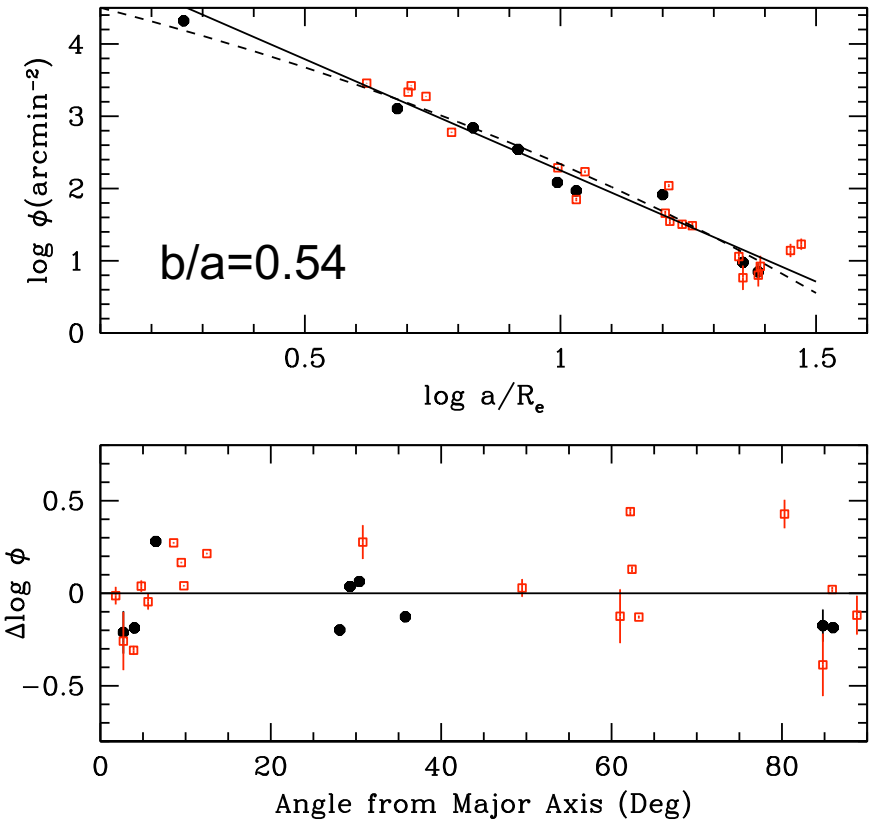


Rejkuba+22

Stellar density profile

Number of stars within 2 mag from TRGB per unit area





b/a = 0.77 best fit power law
Line: $log\Phi_{RGB} = 5.328 - 3.077log(a/R_e)$

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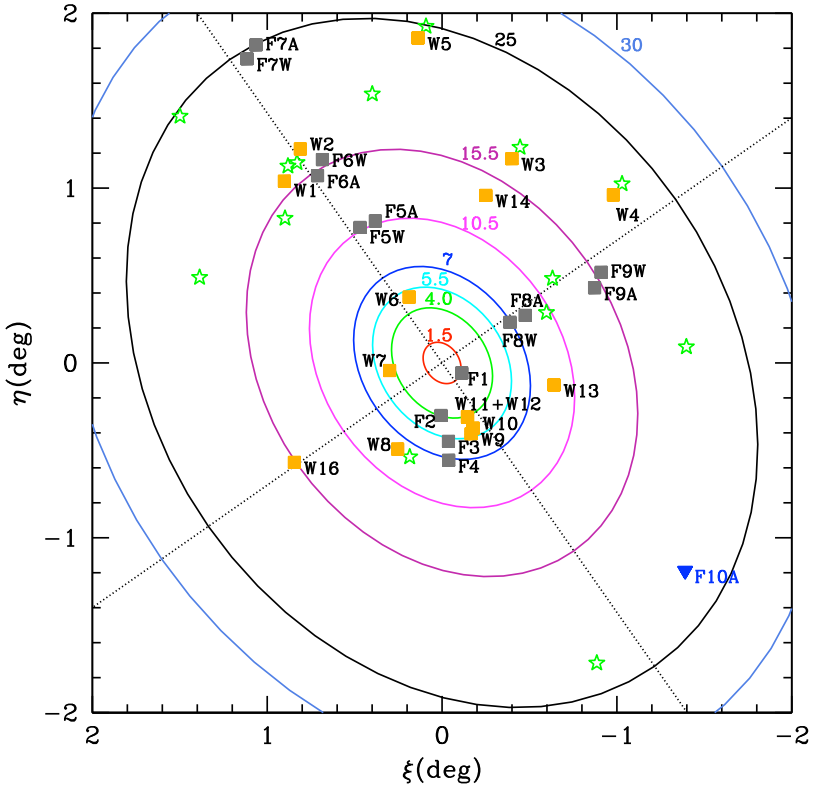
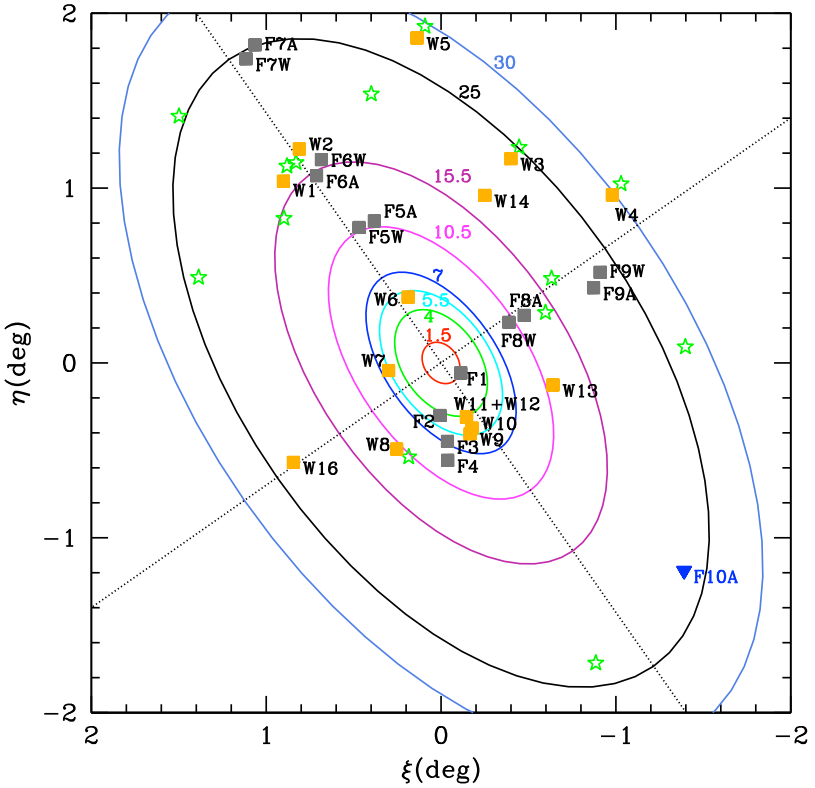
Dash: $log\Phi_{RGB} = 7.685 - 3.008(a/R_e)^{1/4}$

The outer halo is more elongated

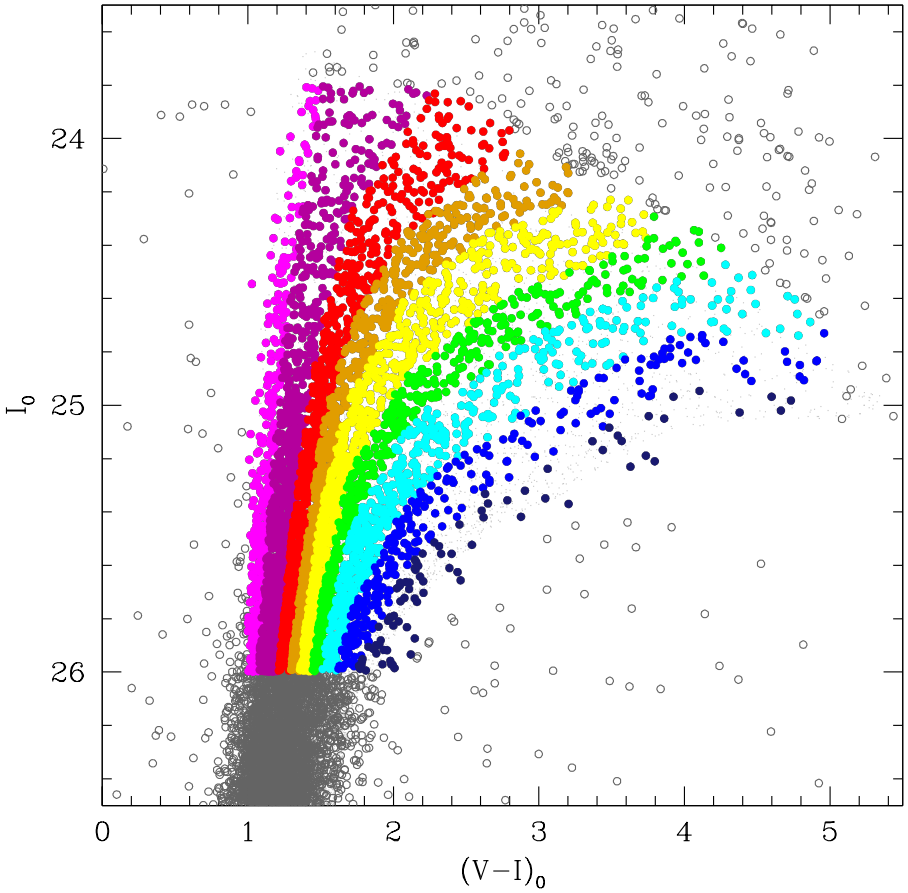


b/a = 0.77

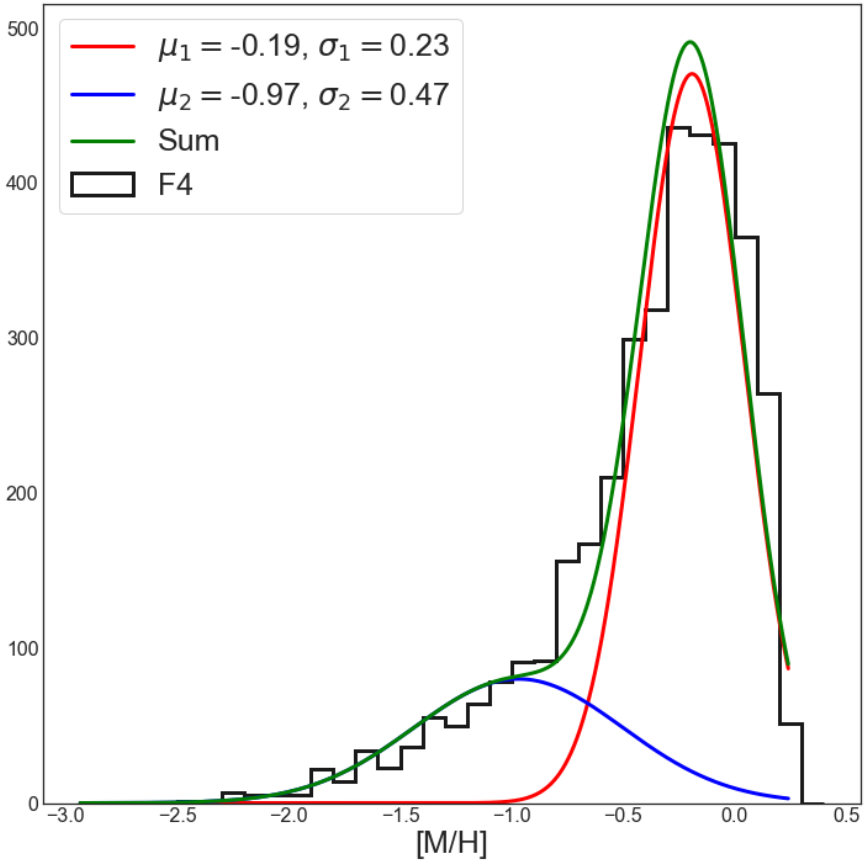


b/a = 0.54

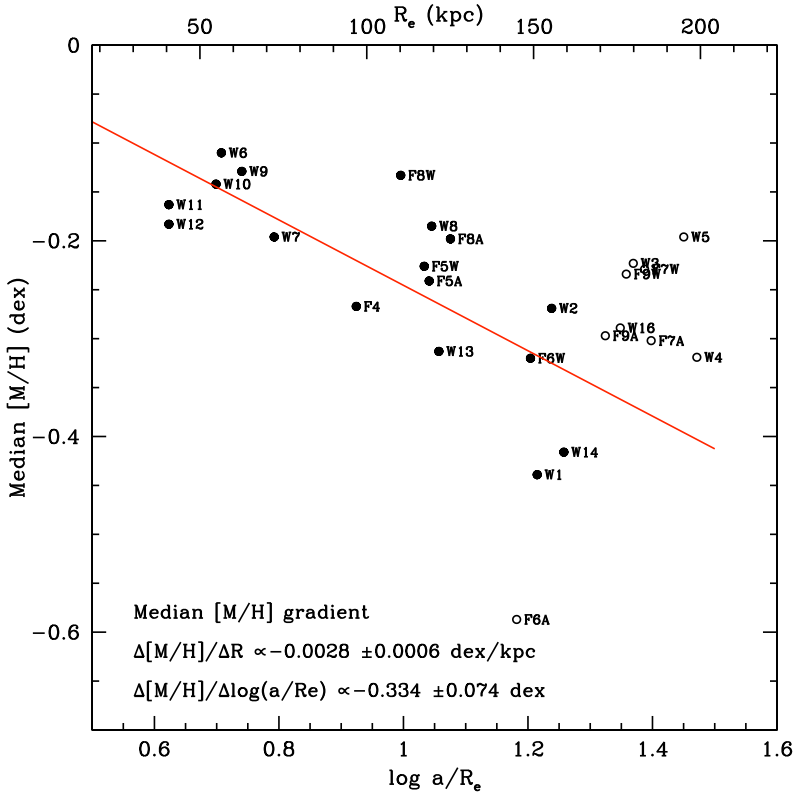
Metallicity Distribution Function

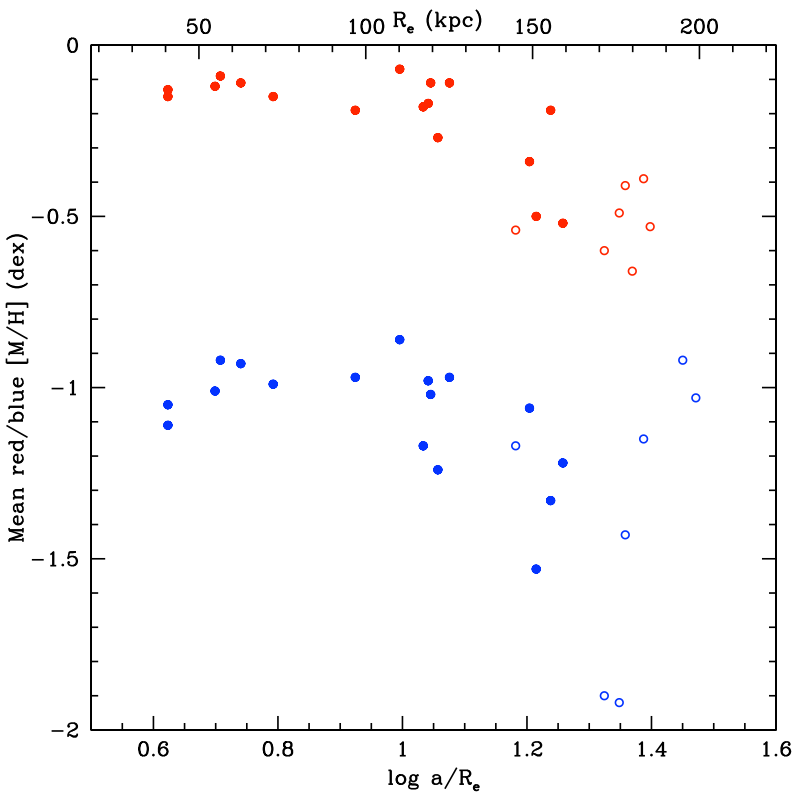


GMM: 2 Gaussian components

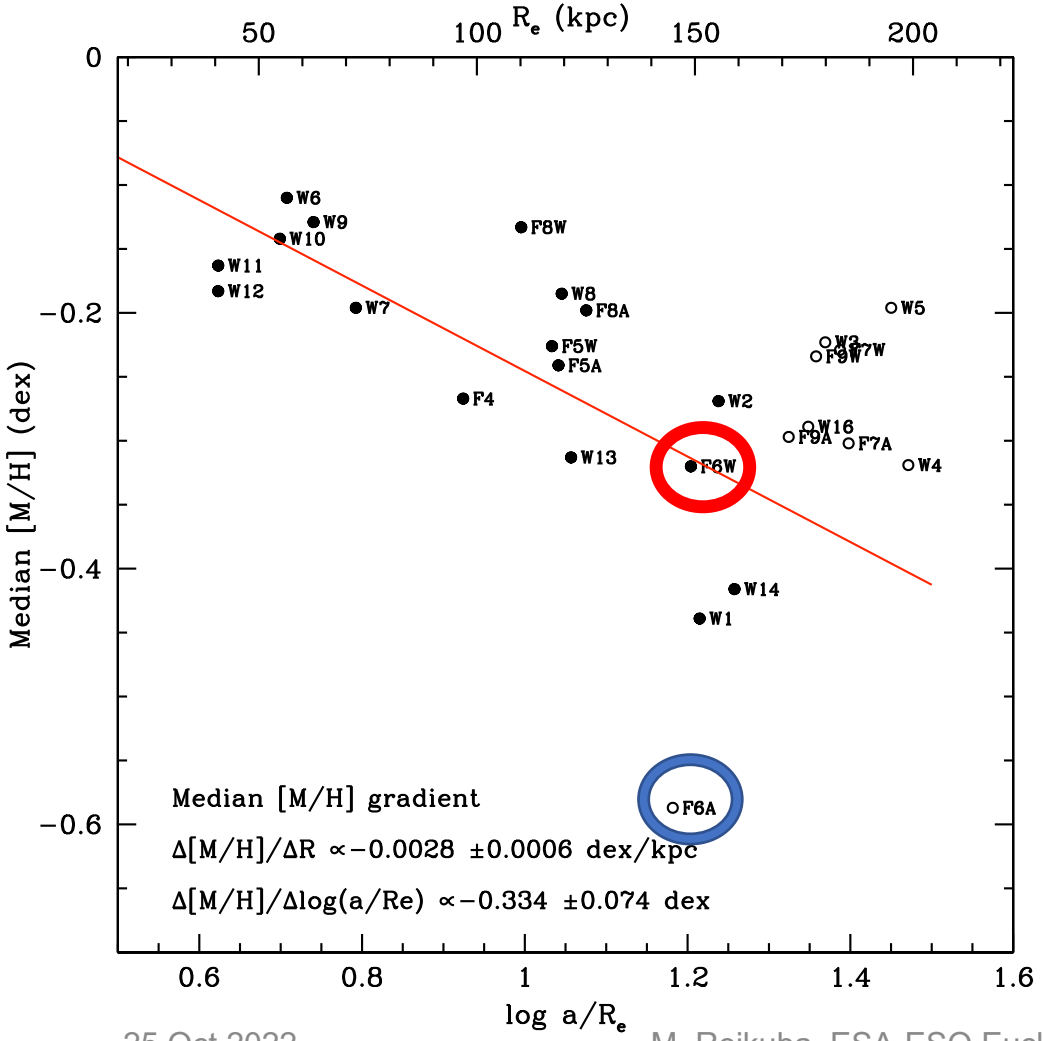


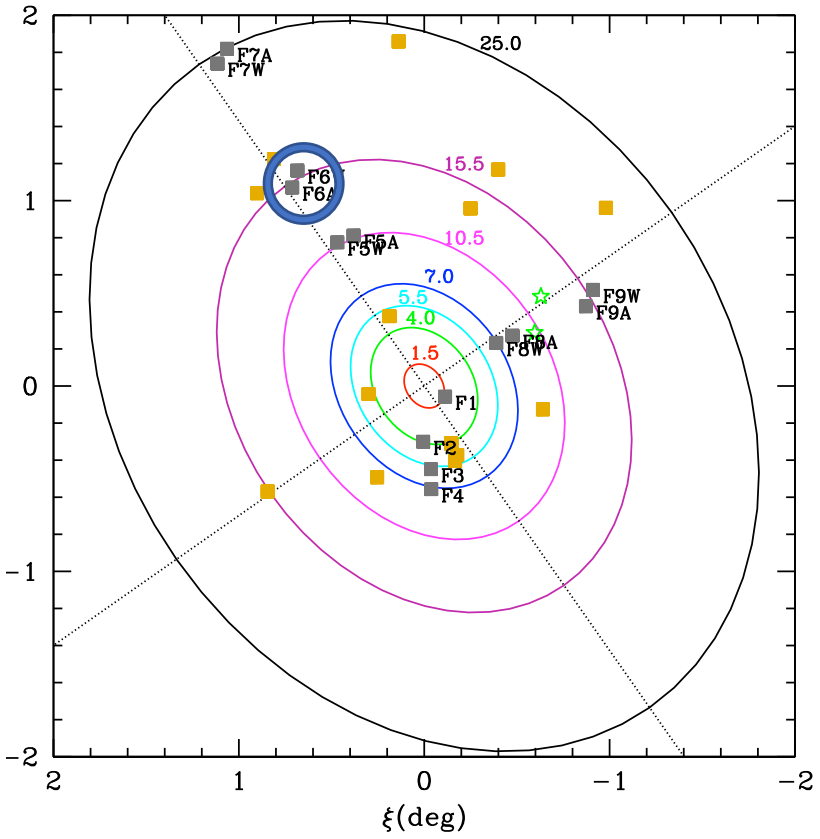
Metallicity gradients





Field-to-field variations

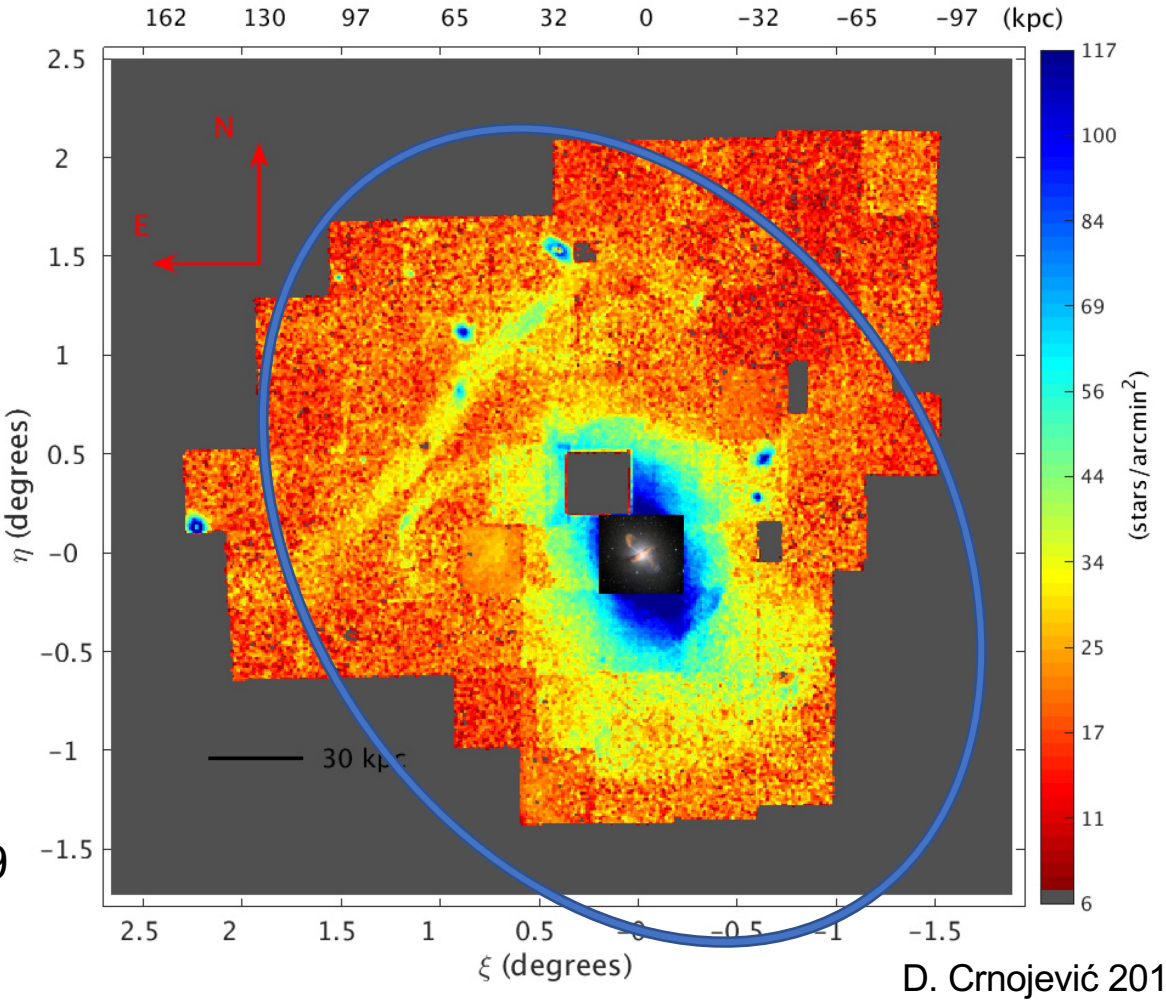




Panoramic Imaging Survey of Cen A

Megacam@Magellan
- r_0 ~ 26 – 27 mag
- Survey to ~15 kpc

Crnojević et al. 2016, 2019



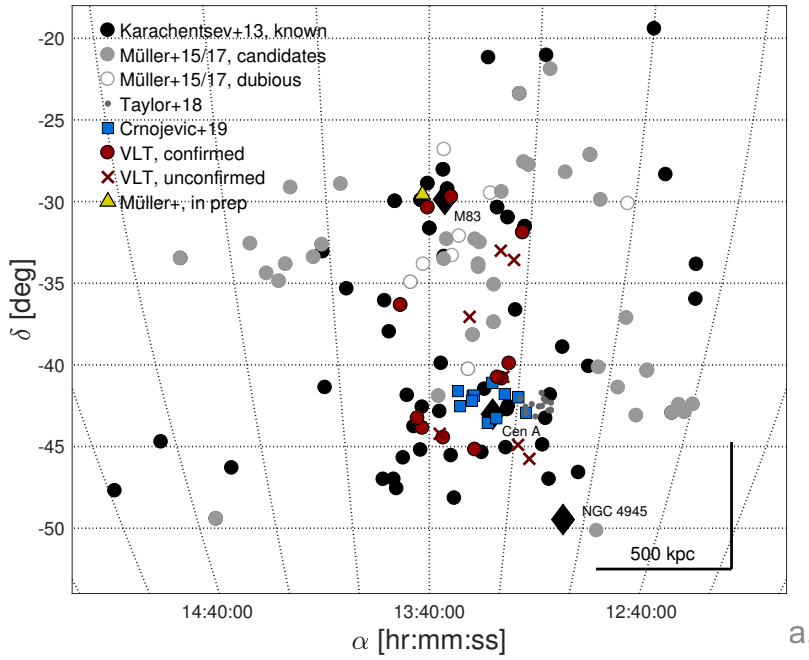
D. Crnojević 2017

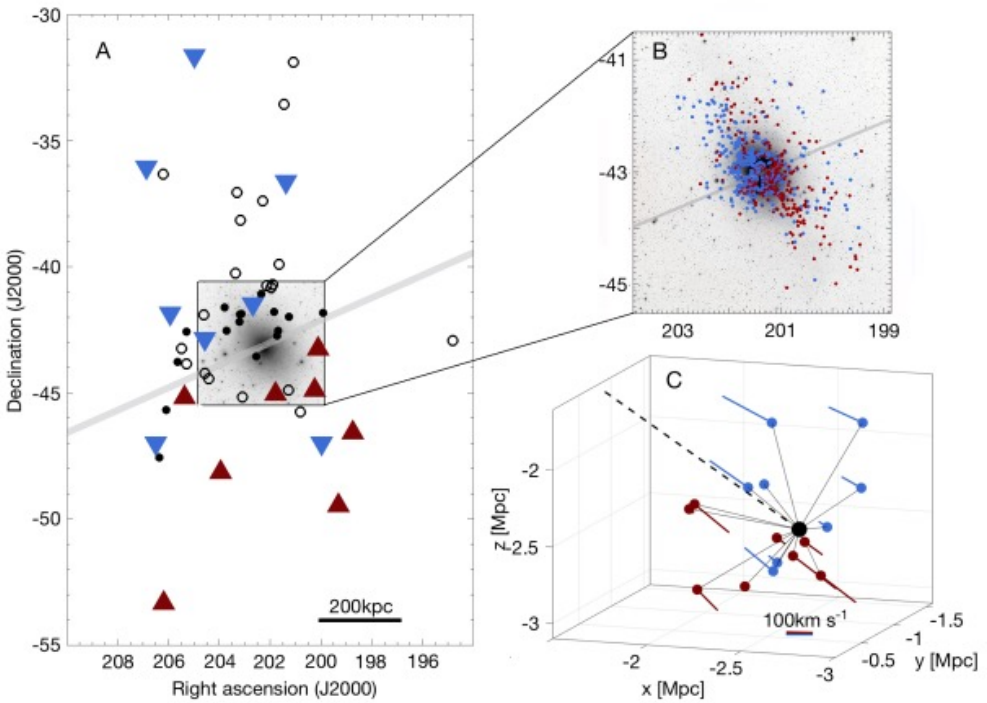
Centaurus A group

Centaurus A group

- Two sub-groups: Cen A & M83
- 57 new dwarf candidates within ≈ 550 sq.deg DECam survey (Müller+2015, 2017)
  - Faintest: $\mu_r \approx 29$ mag/arcsec^2
  - Completeness at $M_V \approx -10$, $M_r \approx -9.5$ mag

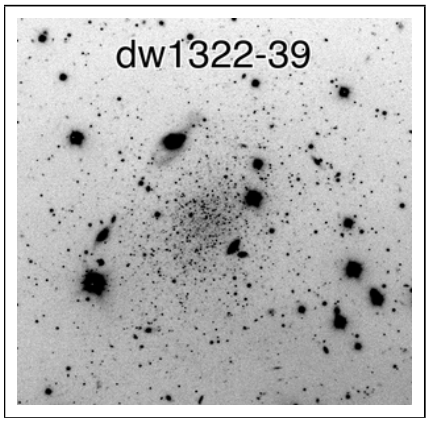
"A whirling plane of satellite galaxies around Centaurus A challenges cold dark matter cosmology"
O. Müller, M.S. Pawlowski, H. Jerjen & F. Lelli, 2018, Science





VLT Follow-up: FORS2 & MUSE

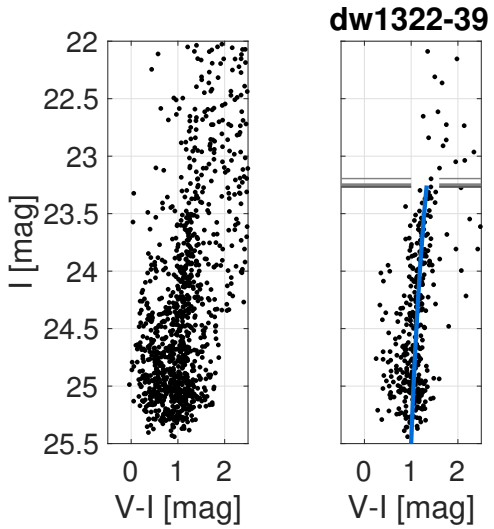
Müller+2019



FORS2 imaging

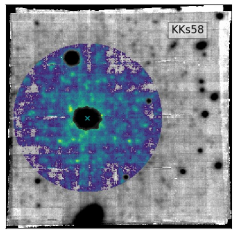
Foreground/background: statistical decontamination using the same images

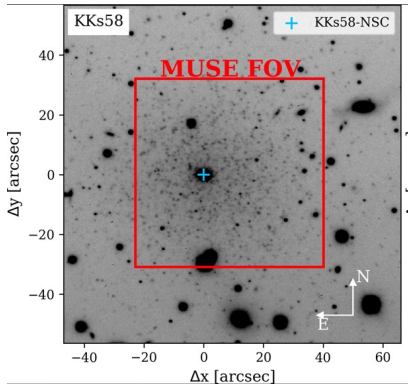
Tip of the RGB (TRGB) distances: membership confirmation for 12/18 candidates

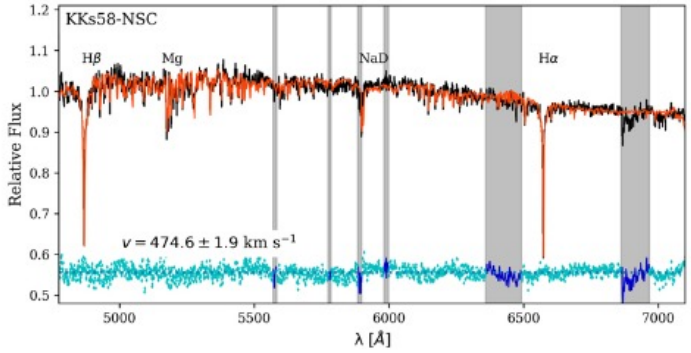


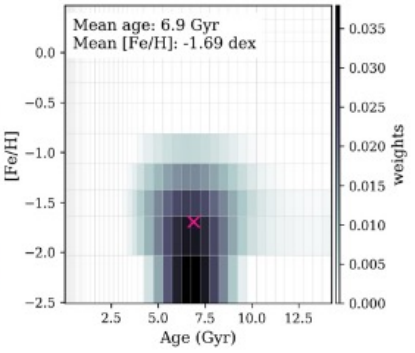
MUSE

Radial velocities (membership)
Mean age & [Fe/H]
Nuclear star cluster & Globular Cls.





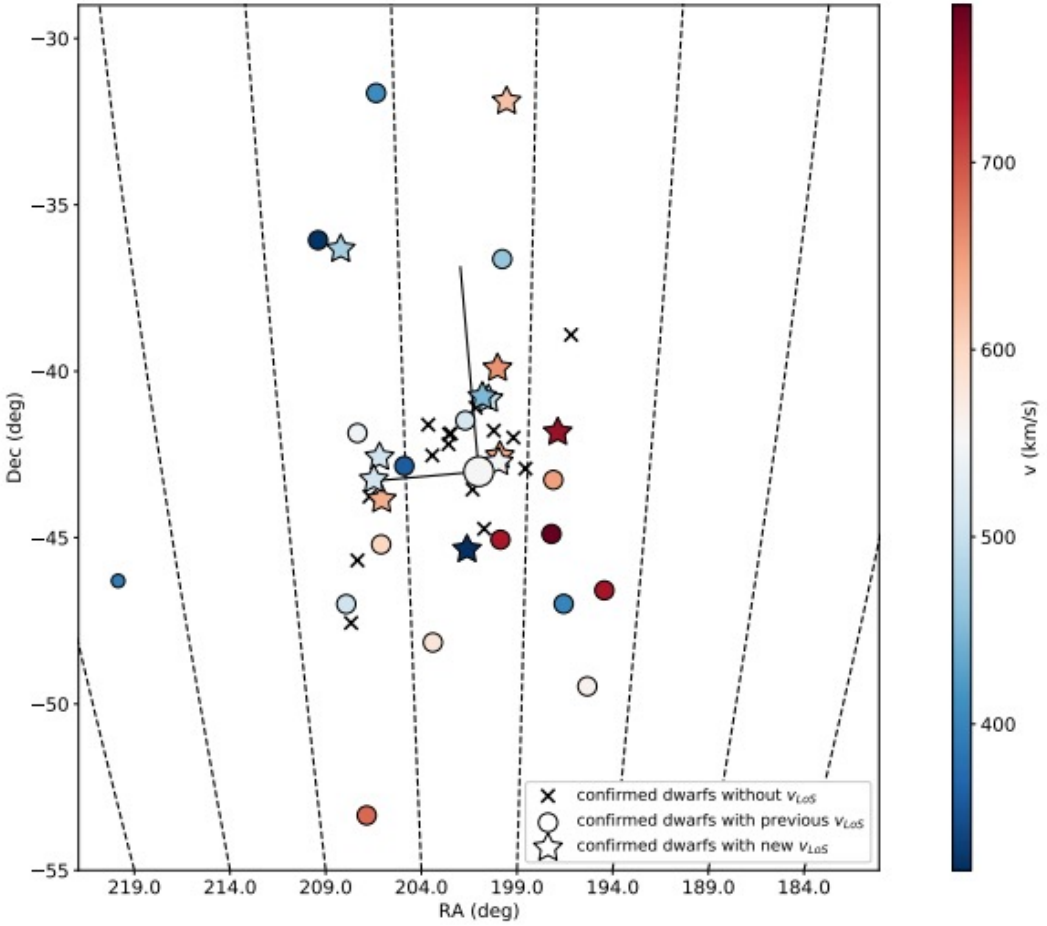




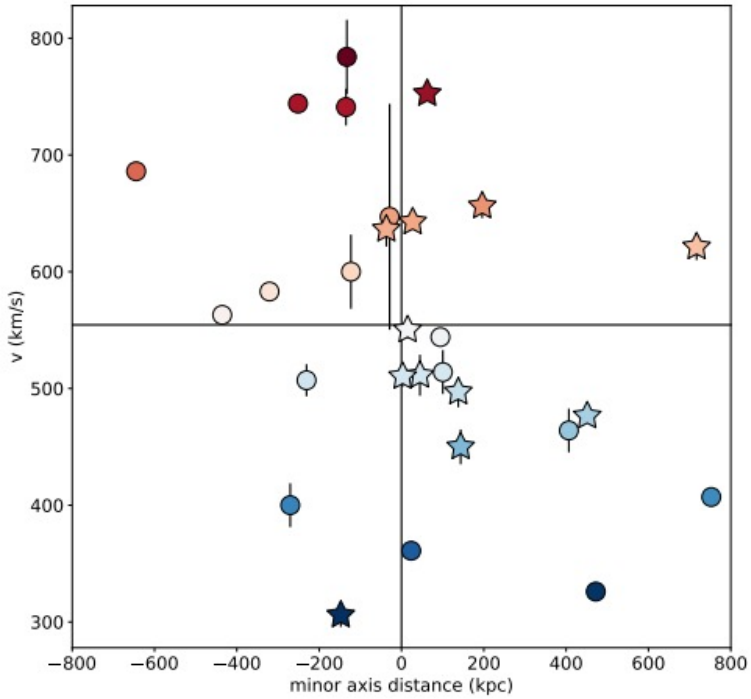
M. Re

Corotating plane of satellites around Cen A

Dwarf galaxies on sky
21/28 show coherent motion



Position velocity diagram for the
28 dwarf satellites of Cen A

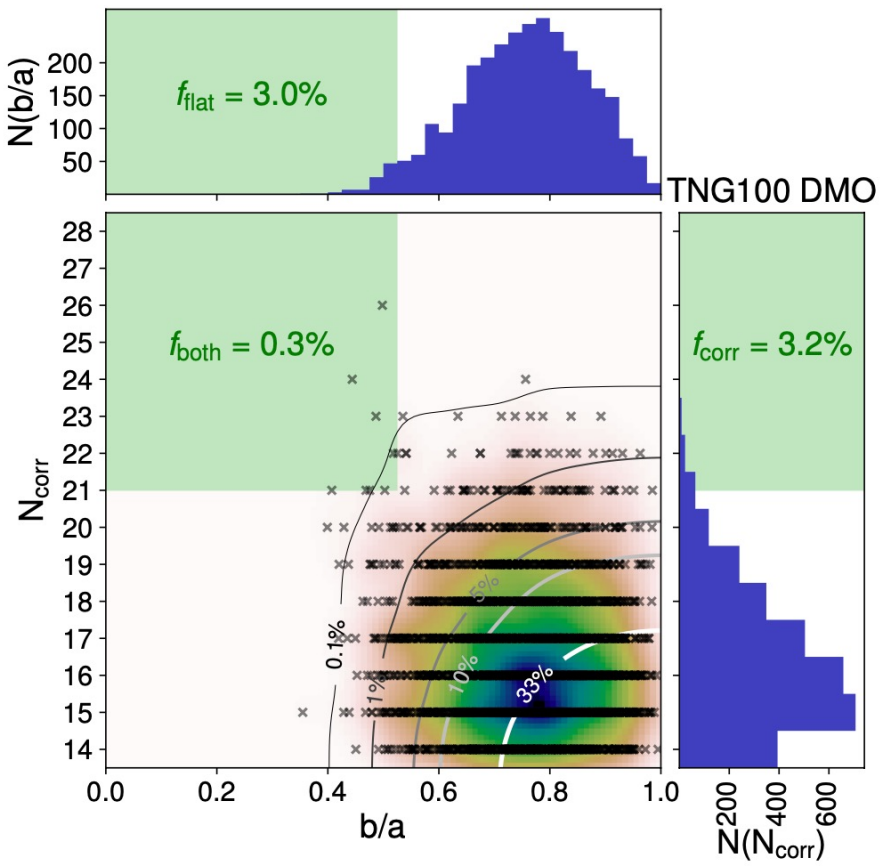


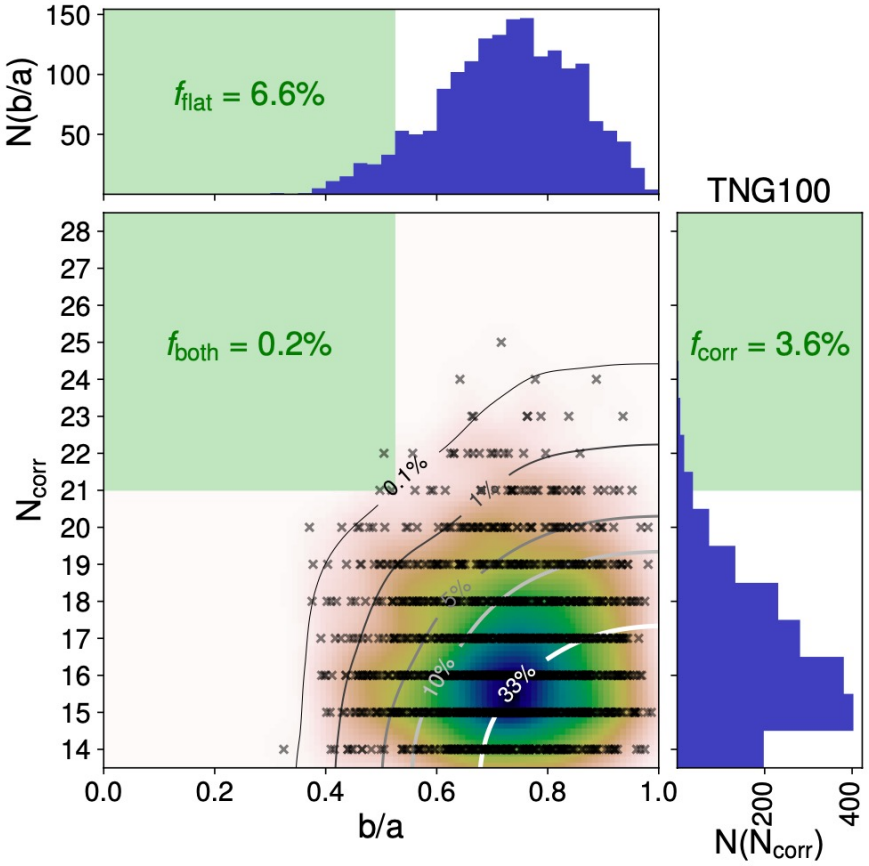
28 satellites with accurate distances (TRGB) and radial velocities
21 satellites are in opposing quadrants:
P(X=21|28) = 0.88%

Müller et al. 2021

Kinematically coherent satellite systems around Cen A analogues in Illustris TNG100

Müller et al. 2021





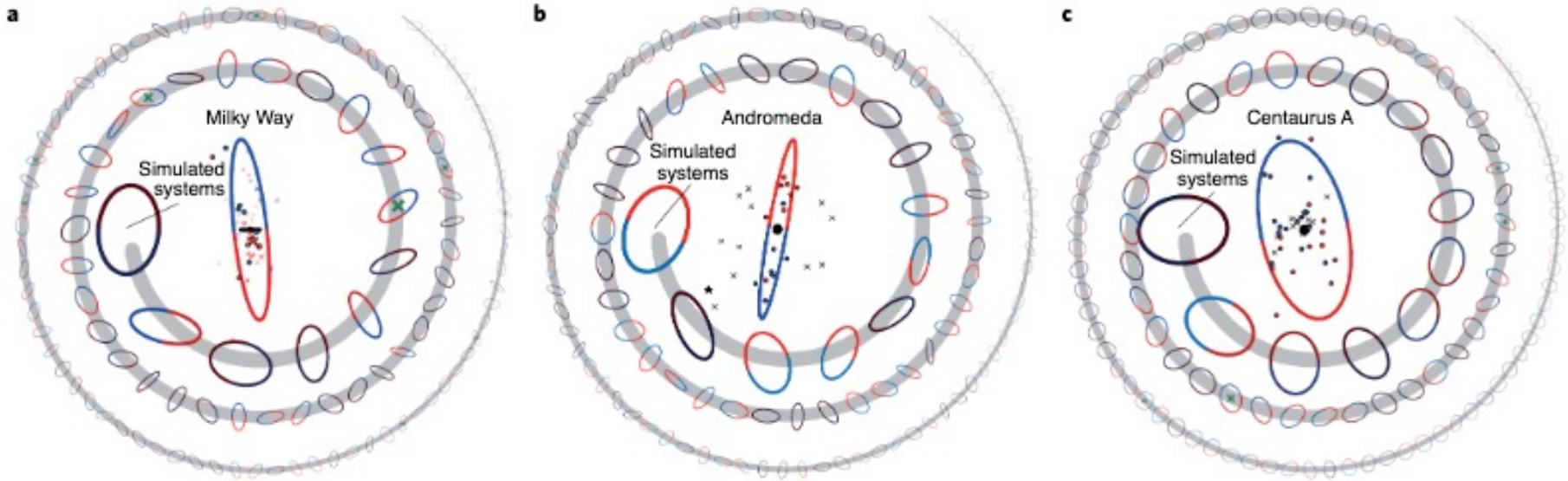
As extreme or more than Cen A system:

- 8 out of 3070 (0.3%) DMO mock systems
- 3 out of 1763 (0.2%) hydrodynamic mock systems

Hosts: M_{200} between 4-12 x 10^{12}

Flattened satellite systems with correlated kinematics

M. Pawlowski, Nature Astronomy, 2021



(a) Edge on view of MW satellate galaxies plane: full orbital alignment from PMs; <20kpc height
(b) On-sky distribution of satellites around Andromeda: about ½ of satellites; rotational signature
(c) On-sky distribution of satellites around Cen A: spatial flattening and rotation signal reminiscent of rotation

Colour-coding: receeding velocity vs approaching the observer

Small ellipses around observed systems: simulated systems from the IllustrisTNG: (+) reproduce flattening & (x) reproduce kinematic correlation; no system with (+ and x) simultaneously.

Resolved stellar populations studies
Euclid + ground-based follow-up

- Nearby galaxies: $\lesssim$5−10 Mpc
  - Vast areas & contiguous coverage
- Background galaxies & foreground stars statistical decontamination
- Unambiguous detections:
  - Distances & membership
  - Surface density gradients
  - Metallicity *distributions* and gradients
  - Census of accretion events & substructures to ~34 mag/arcsec^2
- Star formation histories and assembly histories
- Satellites census & properties