Ultra-Diffuse Galaxies - dwarfs or giants ?

David Martinez-Delgado, ***Ronald Läsker****, Margarita Sharina, Elisa Toloba, Jürgen Fliri, Rachael Beaton, David Valls-Gabaud, Igor D. Karachentsev, Taylor S. Chonis, Eva K. Grebel, Duncan A. Forbes, Aaron J. Romanowsky, J.Gallego-Laborda, Karel Teuwen, M. A. Gomez-Flechoso, Jie Wang, Puragra Guhathakurta, Serafim Kaisin, Nhung Ho*

Ultra-Diffuse Galaxies - what are they?

- "New" : firstly observed 2015, van Dokkum et al., 47 UDGs

- not a misnomer:

  dwarfs : $M_{\star} \sim 10^7$ - 10^8 M_{sun} → $\mu_{g,c} \sim 26$ mag/arcsec^2

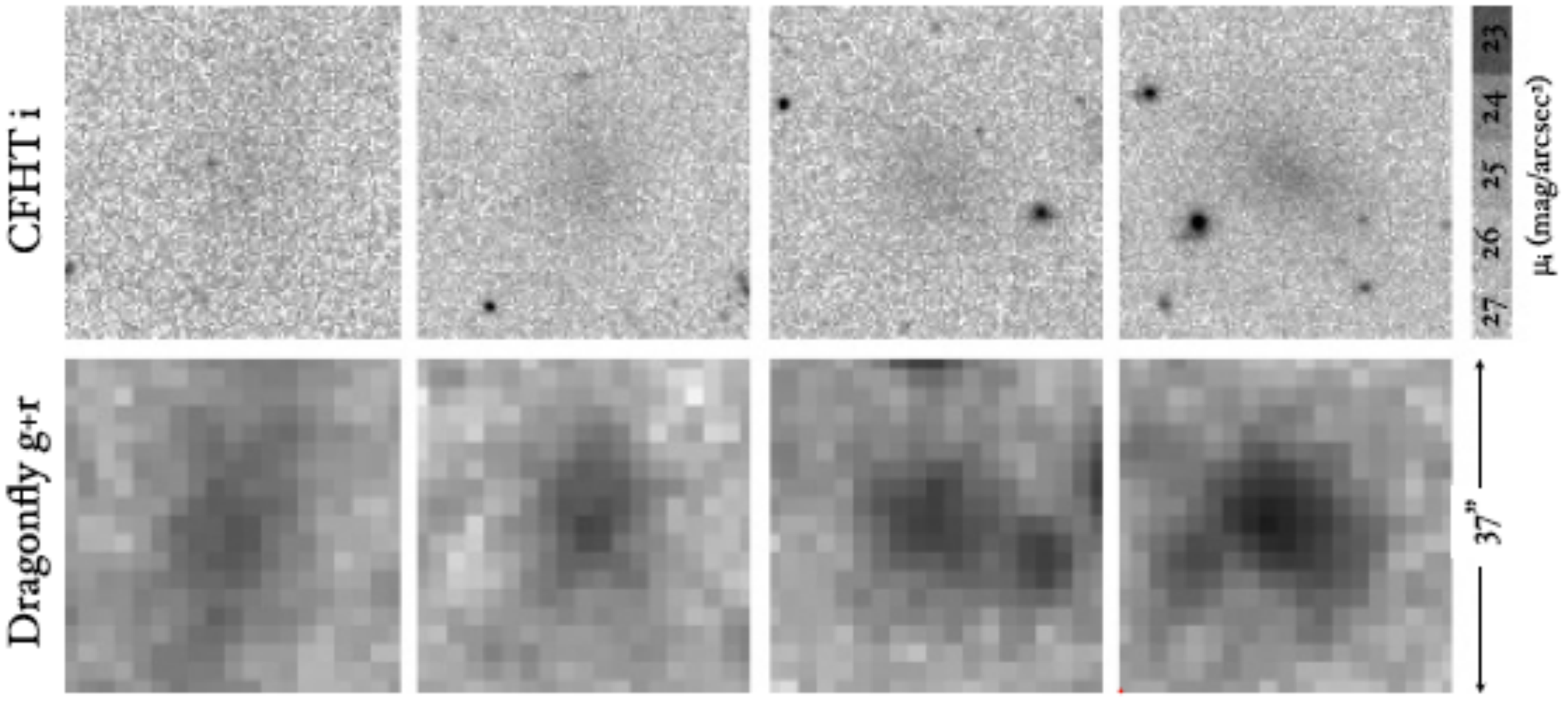
  diffuse : Re ~ 1.5 - 4.5 kpc

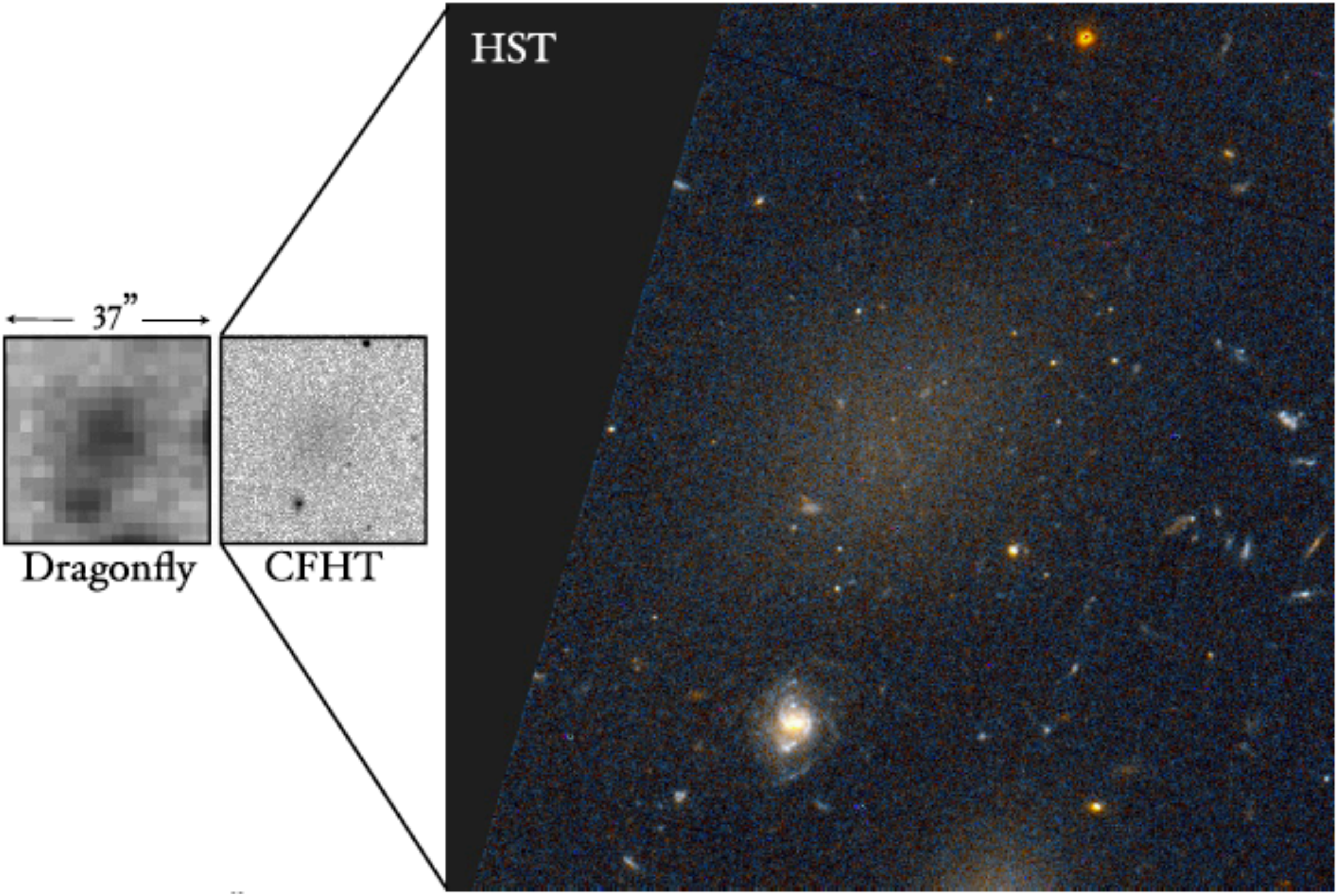
- probably Dark-Matter dominated in order to be long-lived in cluster environments

- Milky-Way sized galaxies with the (stellar) mass of small dwarf-Ellipticals !!

van Dokkum+15:

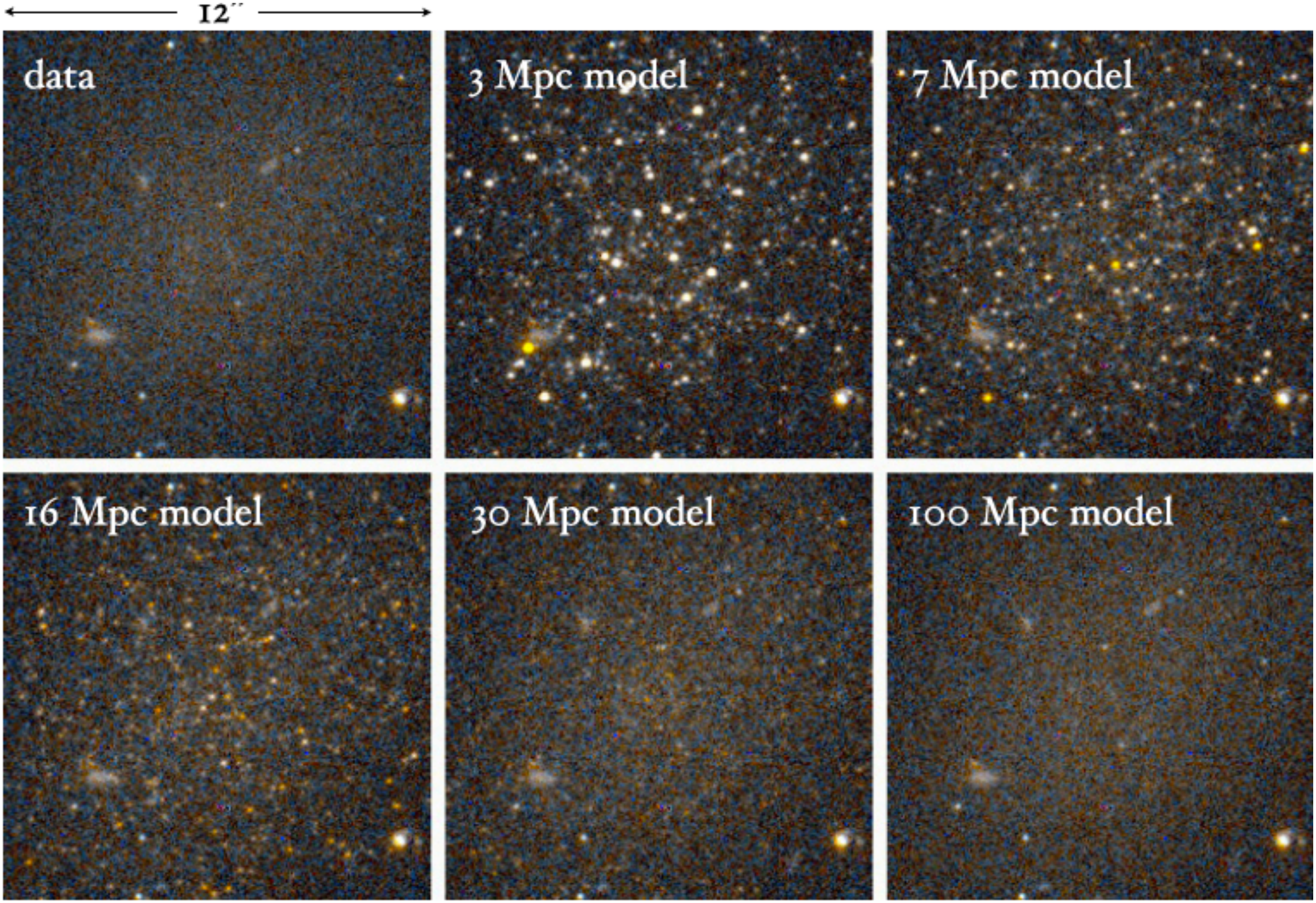
- 47 objects overlapping the Coma cluster
- no redshift distances
- but stars not resolved even with HST/ACS





credit: van Dokkum et al. (2015)

van Dokkum et al. (2015)



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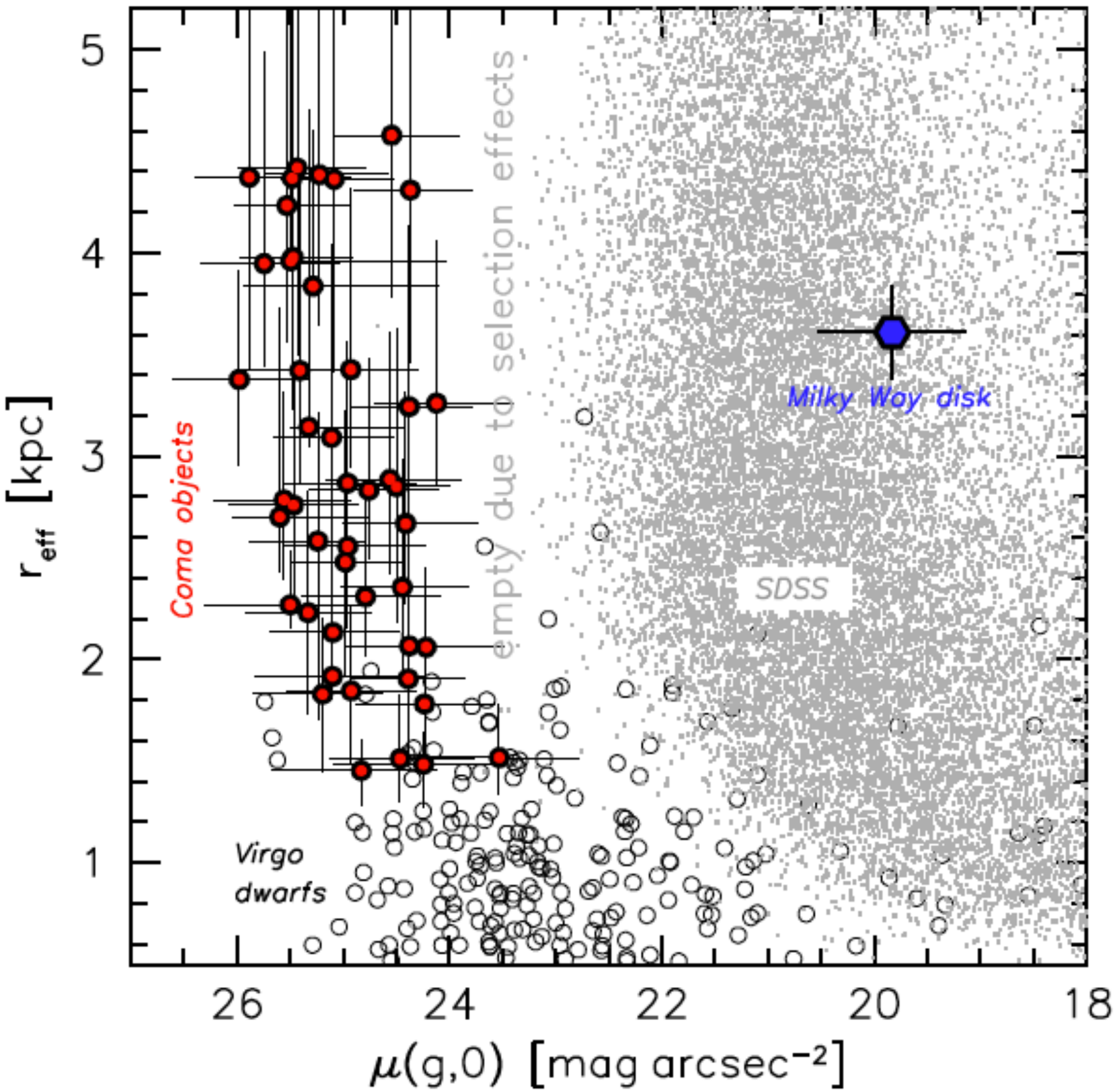
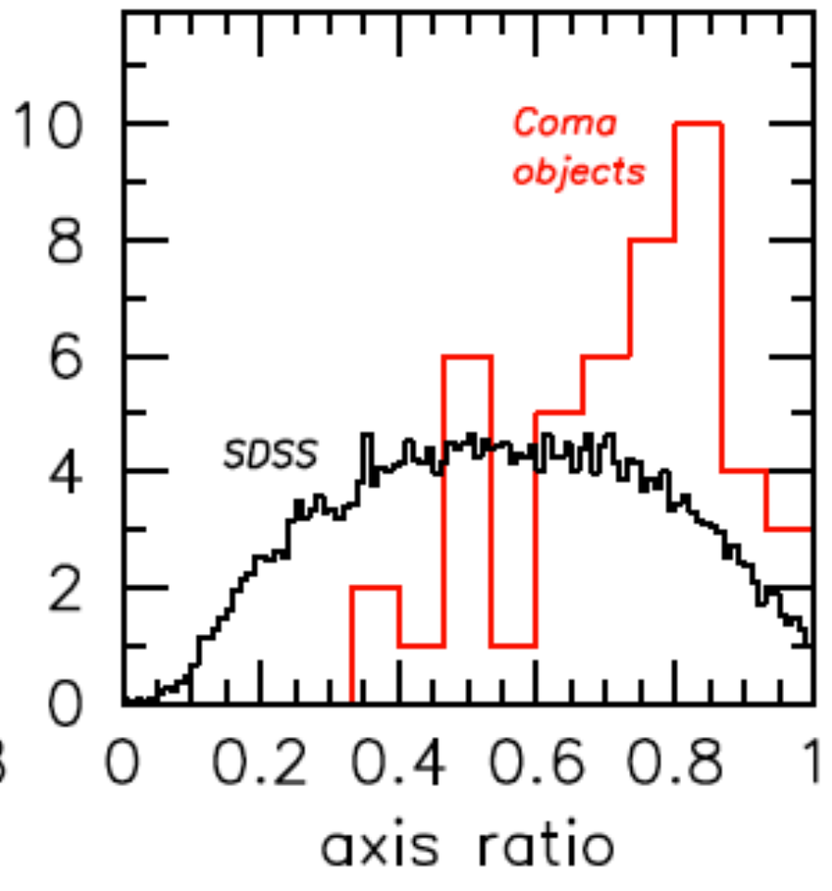
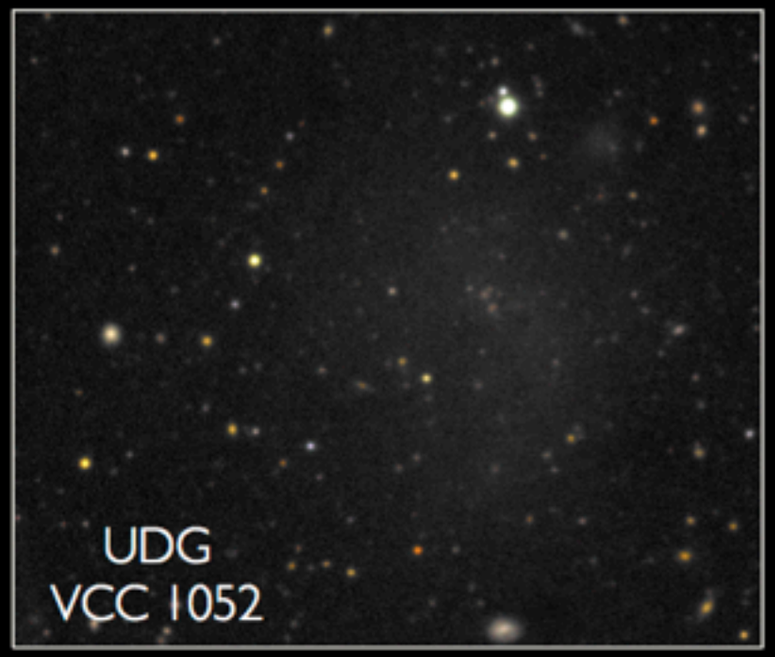
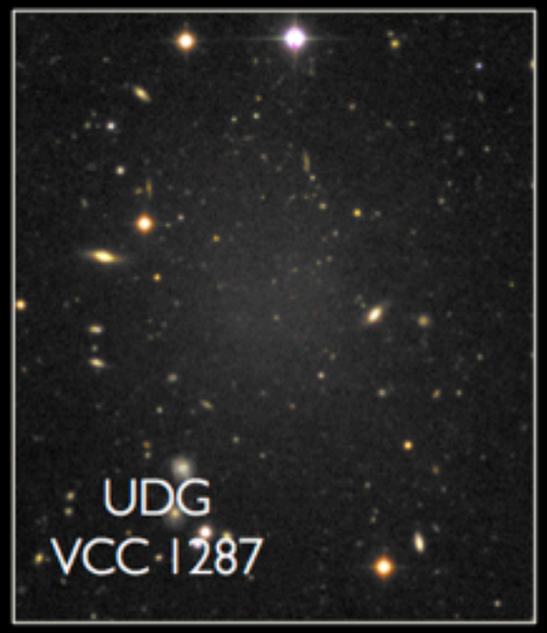
van Dokkum+15

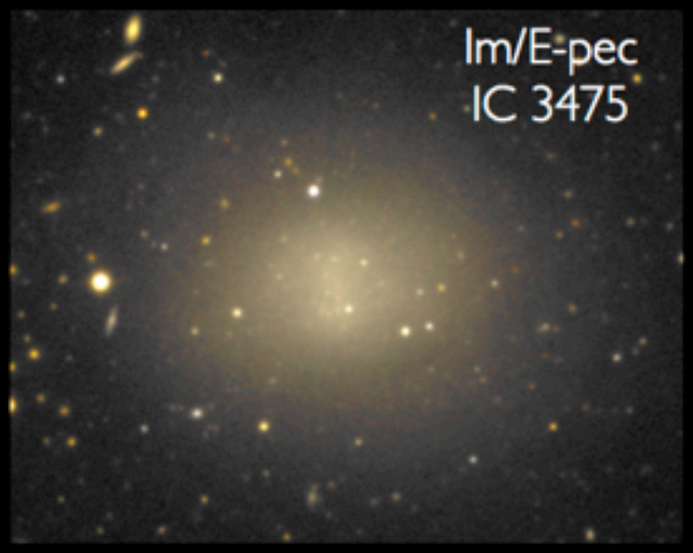


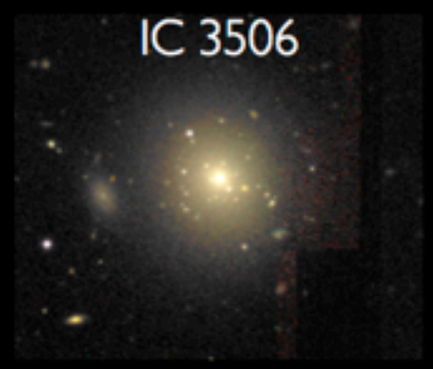


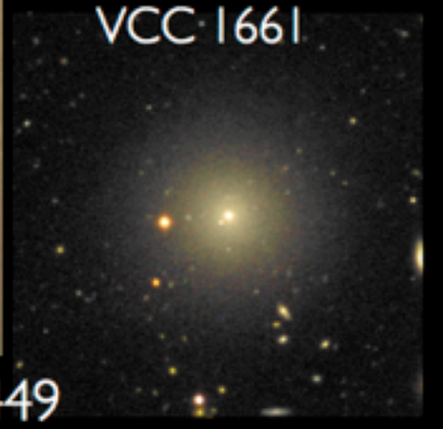
Diffuse galaxies, credit: Aaron Romaowski

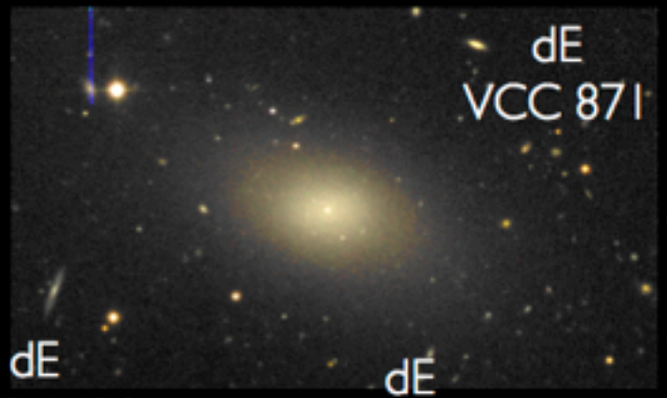




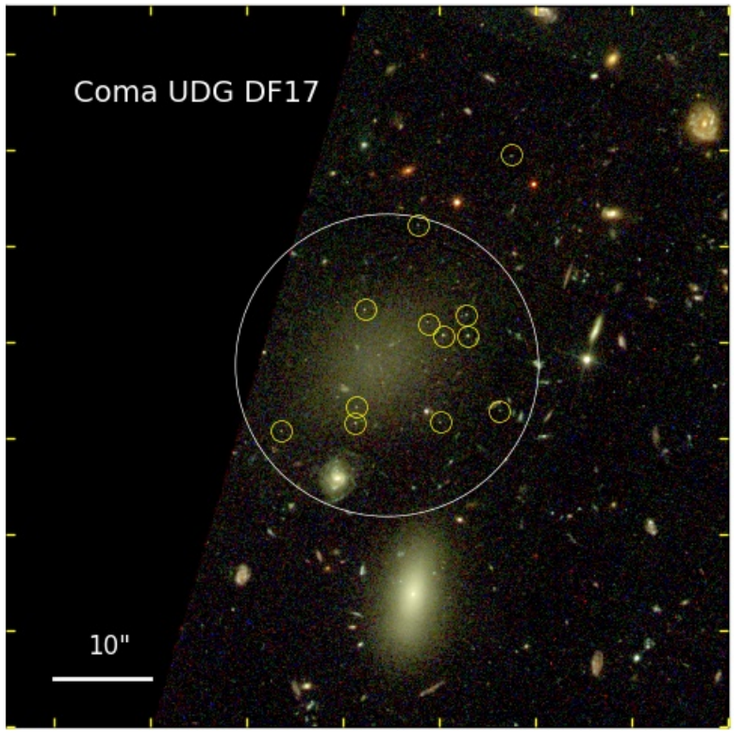


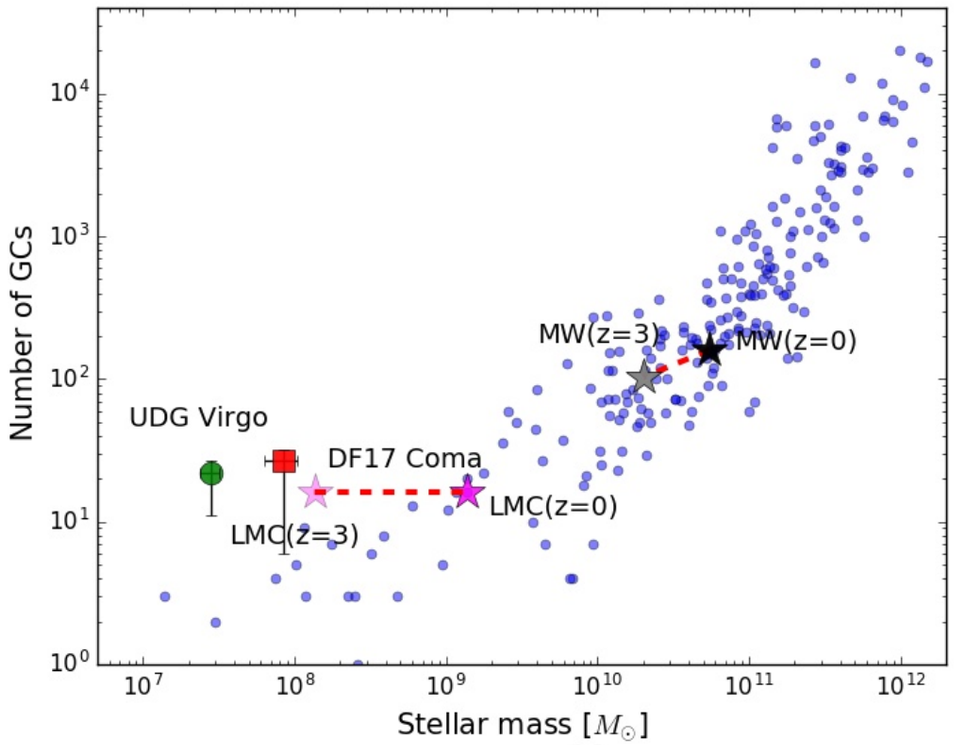






UDG Globular Cluster (GC) population



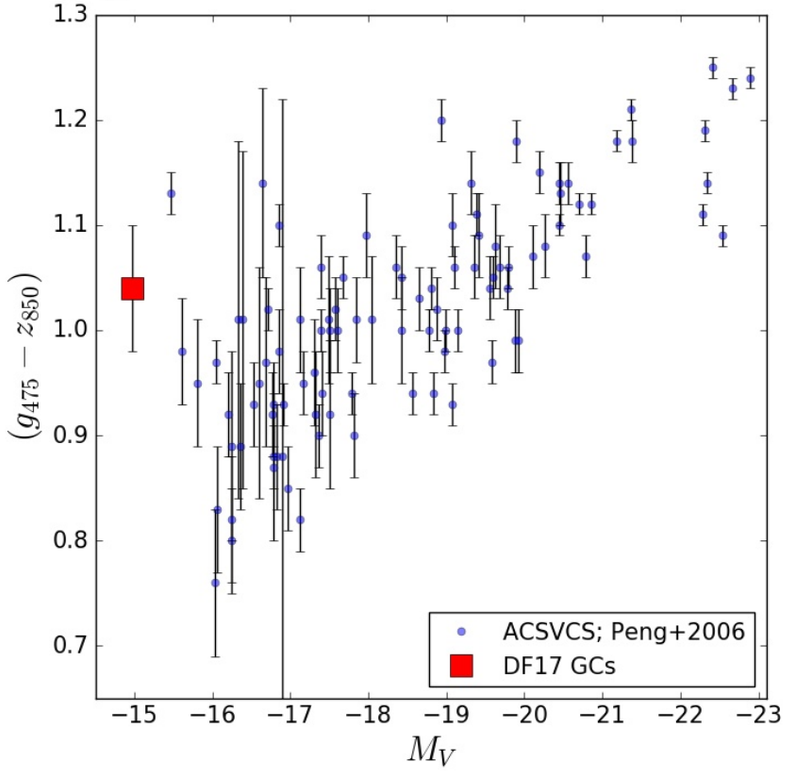


- Beasley & Trujillo (2016): "DF27"

  → N_{GC}=27±5

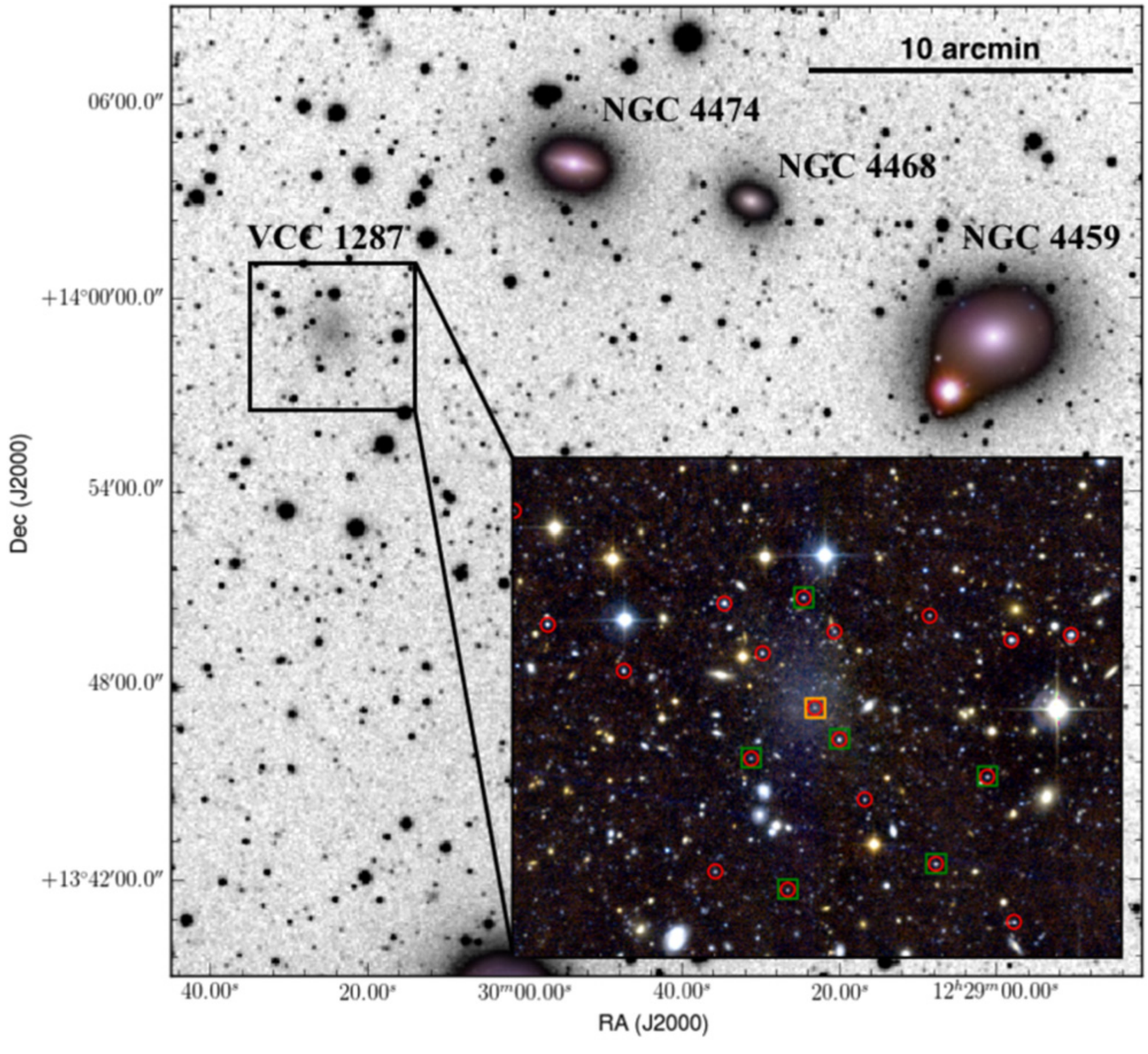
  → high specific GC frequency

  → M_{DM}~$10^{11}M_{sun}$, f_{DM}~1000



UDG Globular Cluster (GC) population

- Beasley+16: VCC128

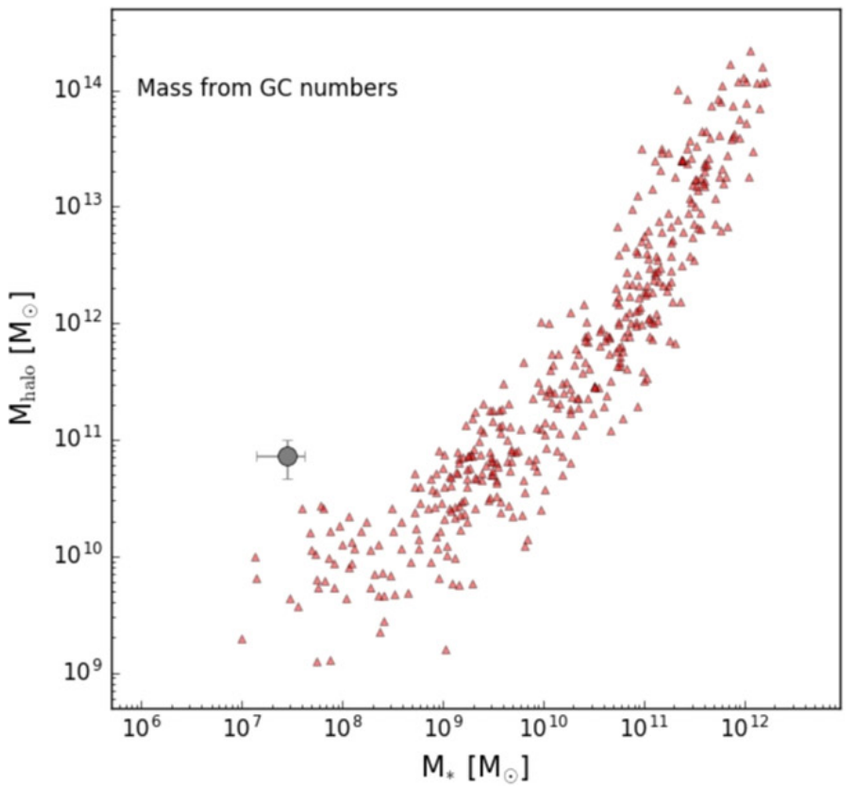


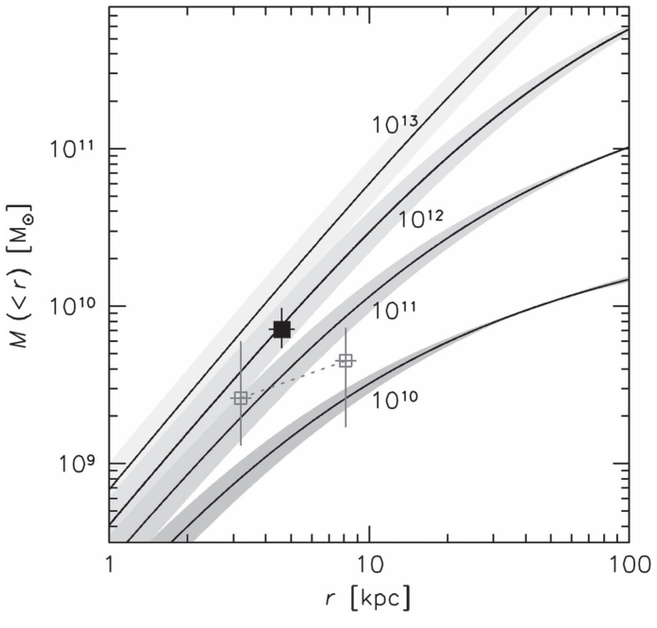
UDG Globular Cluster (GC) population

- Beasley+16: VCC128

- also high specific GC frequency
- $M_{DM} \sim 10^{11} M_{sun}$, $f_{DM} \sim 1000$

- in Re, $f_{DM} \sim 100$ (cf. van Dokkum+16)

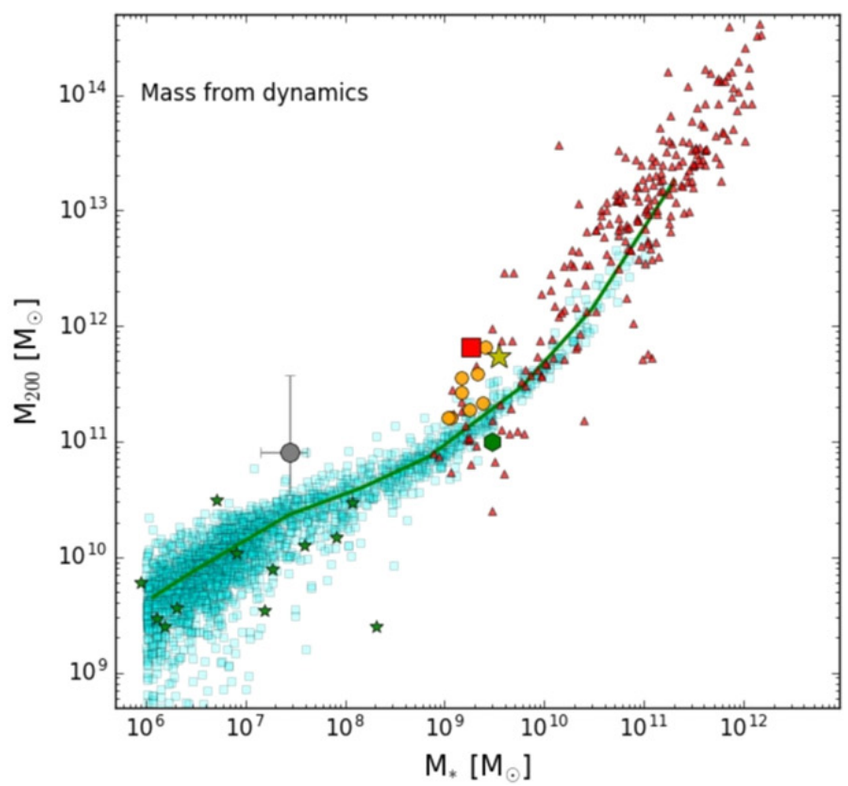




- "DF44": $N_{GC} \sim 100$ (!)

- $M_{DM} \sim 10^{12} M_{sun}$ (MW!)

- in Re, $f_{DM} \sim 50$



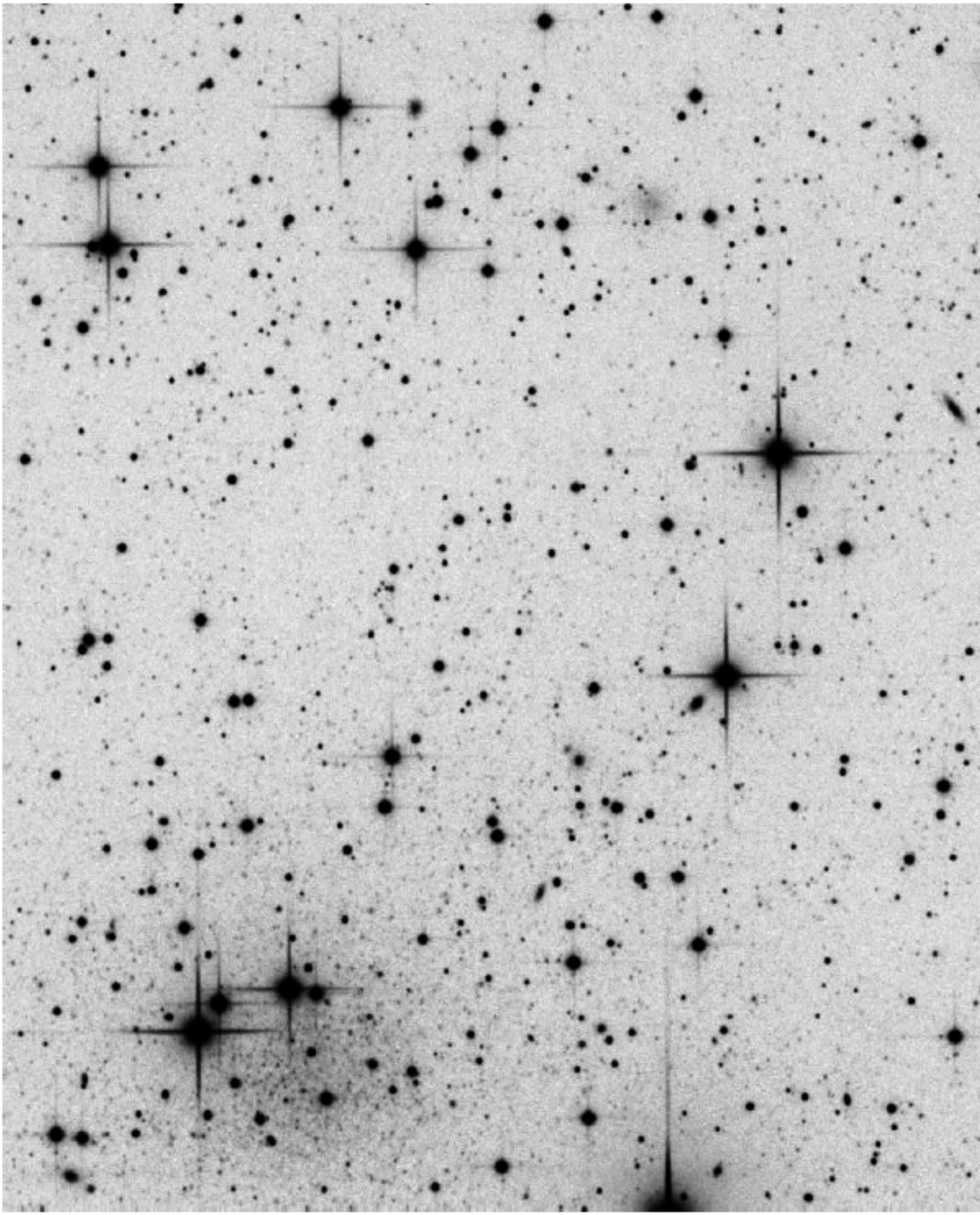
Another UDG: DGSAT-I

- first UDG with confirmed distance (78 Mpc, redshift): hence confirmed size & luminosity

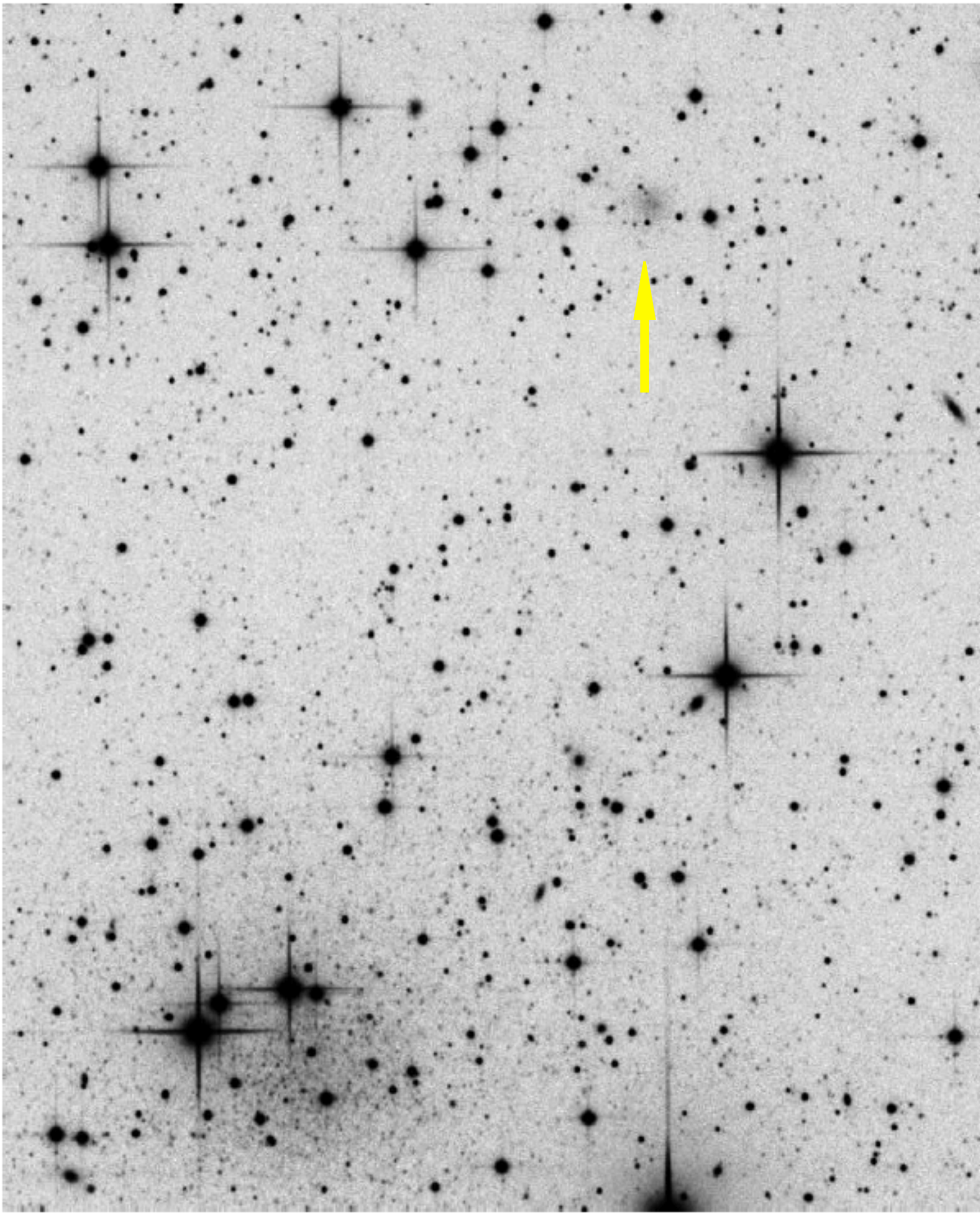
- first data collected with:
  15-cm aperture refractor, 43800s exposure time
  40-cm Newton telescope, 13200s exposure time

- original purpose: search for M31 dSphs

- no stars resolved in follow-up Subaru V,I-band images!



← 11 arcmin →



← 11 arcmin →

Follow-up observations of DGSAT-I

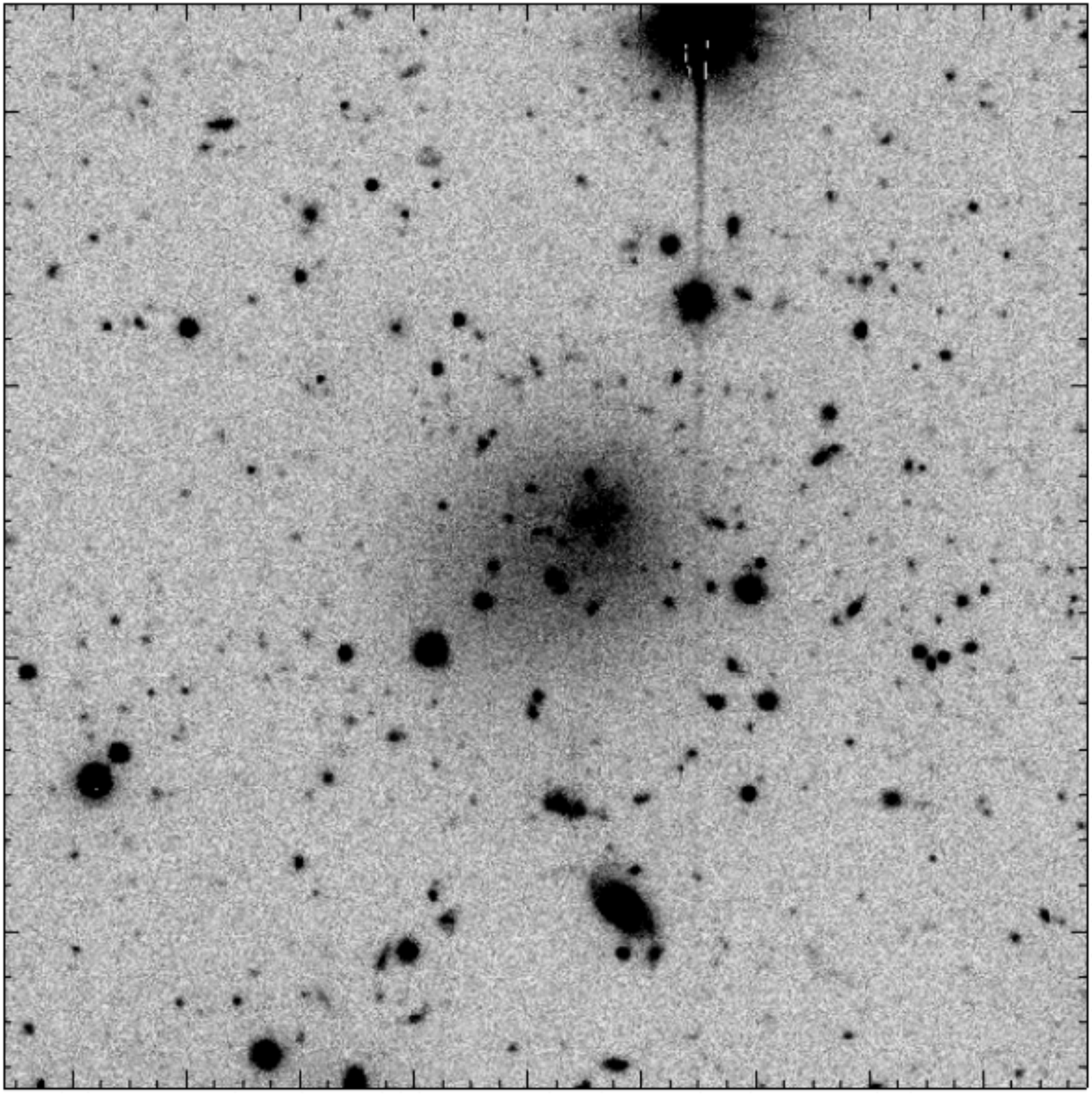
- Subaru SuprimeCam images in V+I band from the SMOKA archive, 7000s total integration time

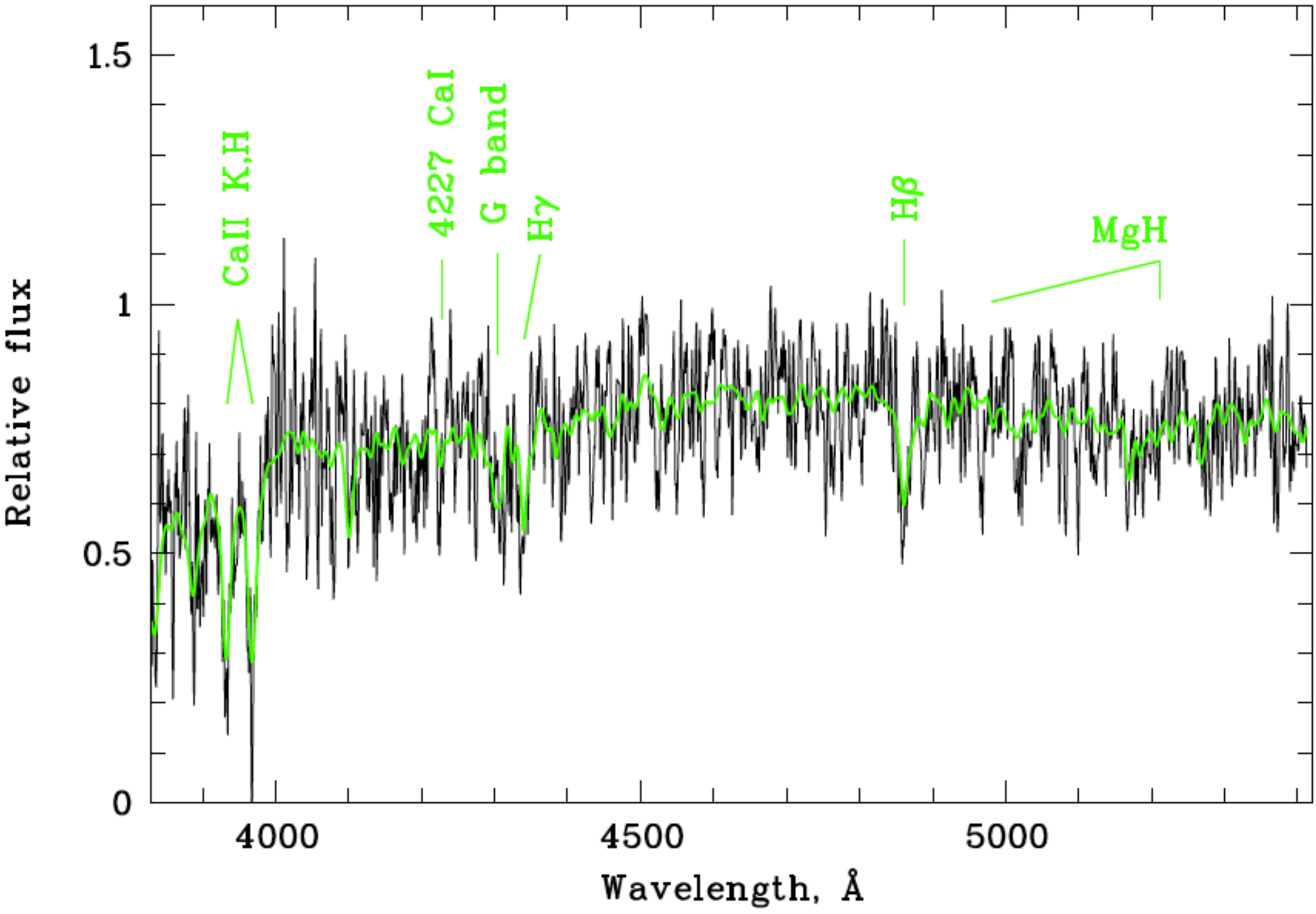
  → no stars resolved at 0.6” resolution!

- slit spectroscopy: SCORPIO spectrograph on the 6-m BTA telescope of the SAO RAS

  total 25200s, coverage 3700-5500Å, resolution 5Å

- Hα narrow-band imaging




CaII K,H
4227 CaI
G band
Hγ
Hβ
MgH
Relative flux
1.5
1
0.5
0
4000
4500
5000
Wavelength, Å

Results

- V_h = 5450±40 km/s → V_{LG} = 5718 ± 40 km/s

→ Hubble distance 78 Mpc

→ association with an outer filament of the Pisces-Perseus supercluster

→ but isolation is also possible

Photometric analysis

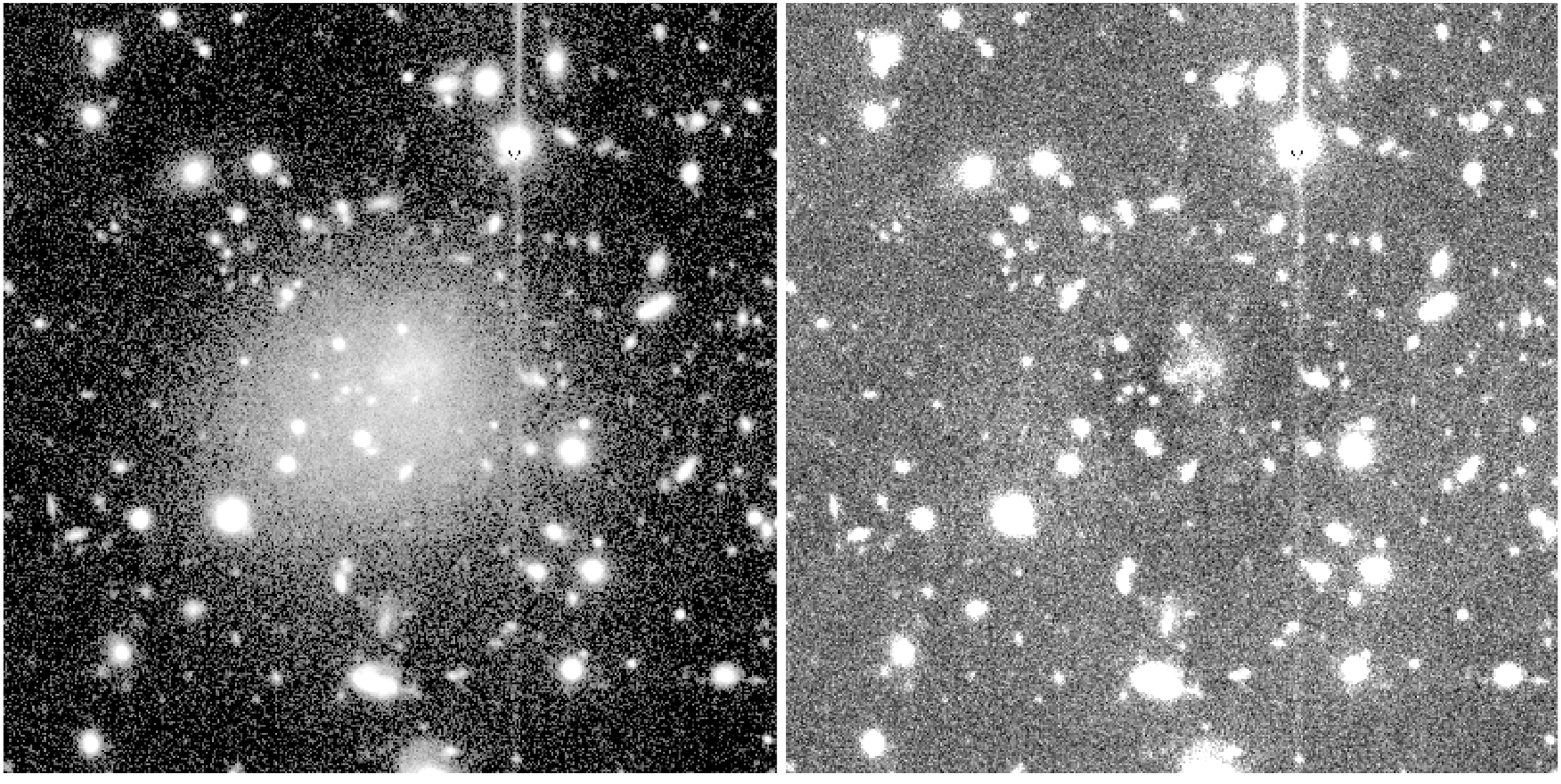
- important and difficult:
  complete masking and precise background subtraction

  → multi-step masking and object detection

- use GALFIT to fit a Sersic profile
- no background component to reduce degeneracy

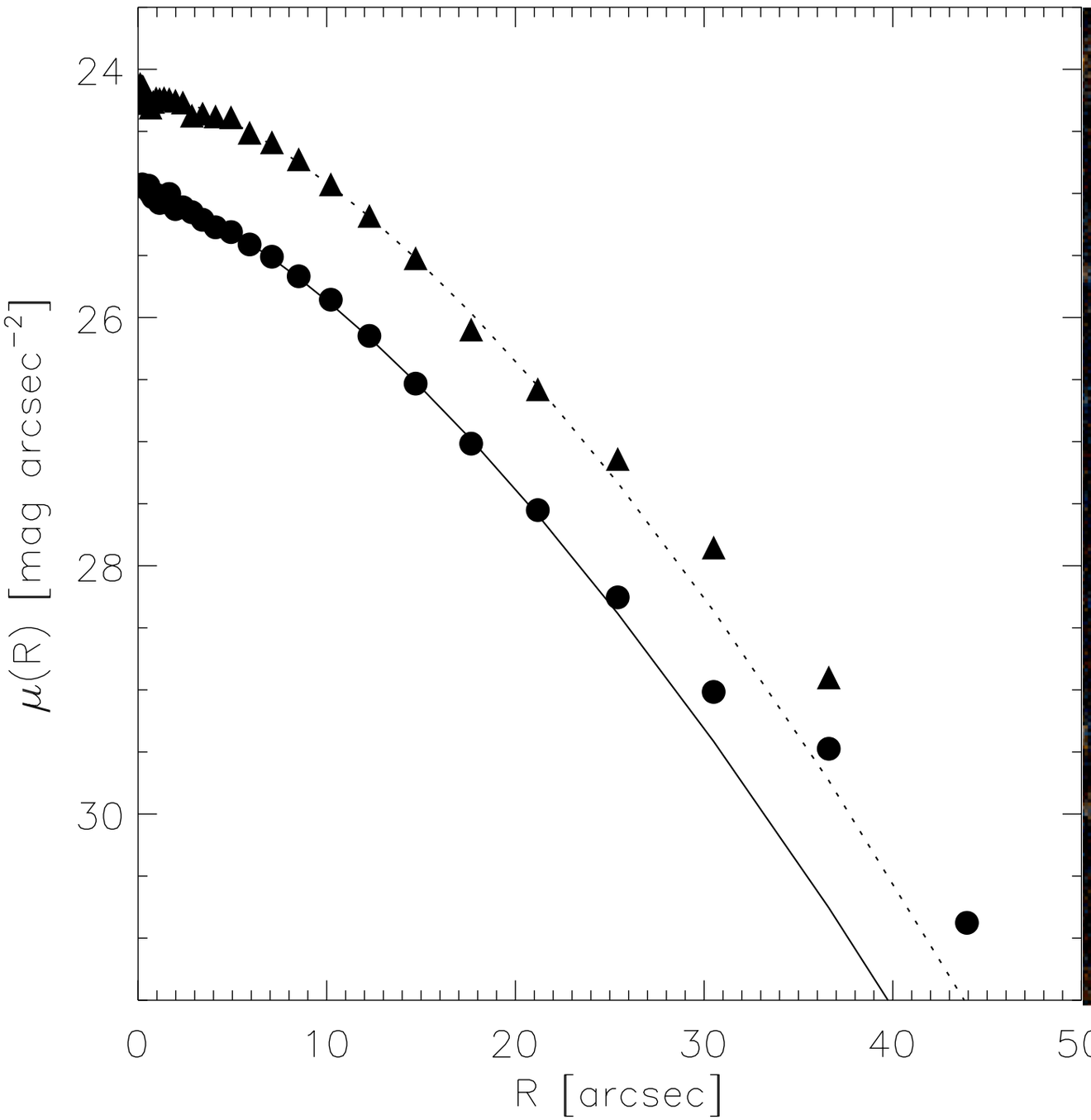
- optionally fit central-offset overdensity (bar?) with separate component, or mask it (?)

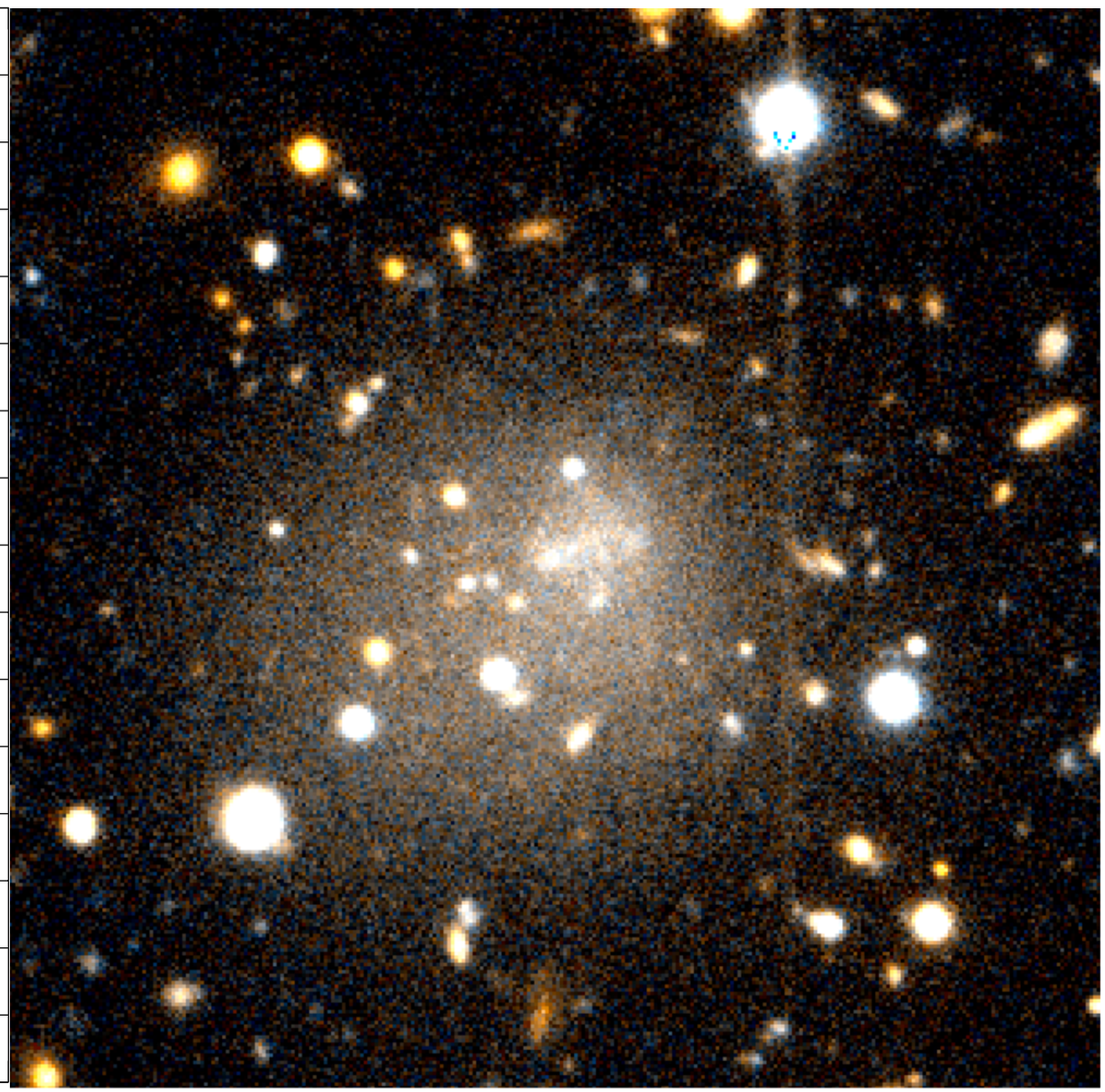
Photometric analysis: GALFIT



Photometric analysis: GALFIT

19 kpc

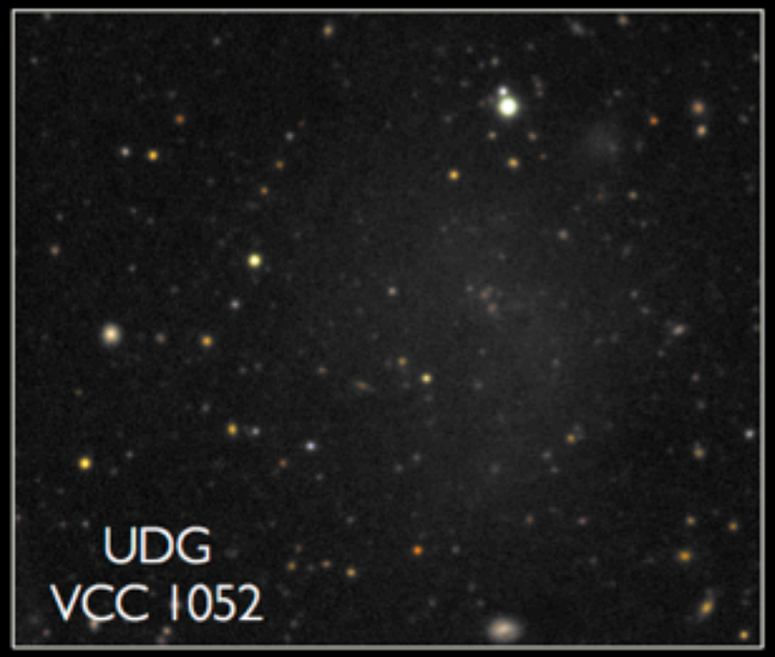


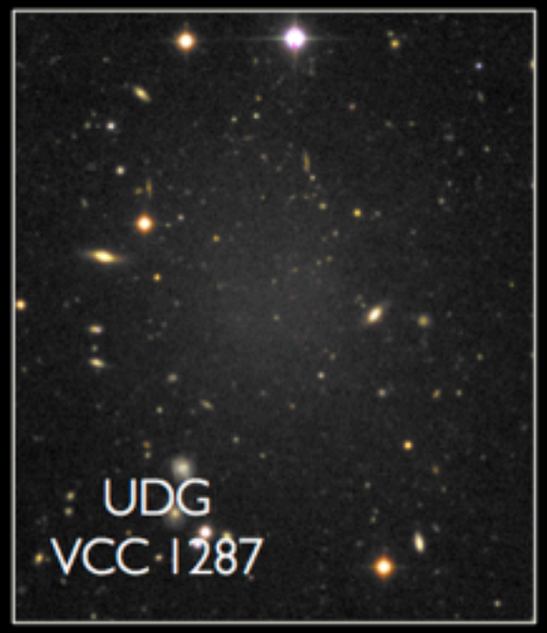


30 kpc

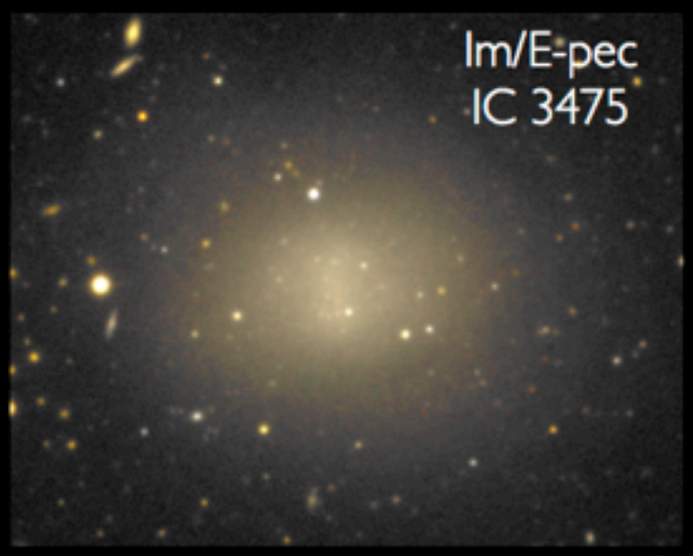
quantity	value
Right Ascension	01h 17m 35.59s
Declination	$+33°\,31'\,42''.37$
radial velocity	$5450 \pm 40\,\mathrm{km\,s^{-1}}$
apparent magnitude	18.5 (SDSS g-band)
	17.7 (SDSS i-band)
central surface brightness	$25.0\,\mathrm{mag\,arcsec^{-2}}$ (g-band)
	$24.4\,\mathrm{mag\,arcsec^{-2}}$ (i-band)
luminosity	$3.6 \times 10^8 L_{\odot,g}$
	$3.5 \times 10^8 L_{\odot,i}$
$g-i$ color	0.9
central $g-i$ color	0.6
effective radius (R_e)	$4.7 \pm 0.5\,\mathrm{kpc}$
axis ratio (b/a)	0.9
Sérsic index (n)	0.6
mass-to-light ratio (i-band)	$0.8\,M_\odot/L_{\odot,i}$
stellar mass	$2.9 \times 10^8\,M_\odot$
gas mass (HI)	$< 5.8 \times 10^8\,M_\odot$
SFR	$< 0.003\,M_\odot\,\mathrm{yr^{-1}}$
sSFR	$< 6 \times 10^{-11}\mathrm{yr^{-1}}$

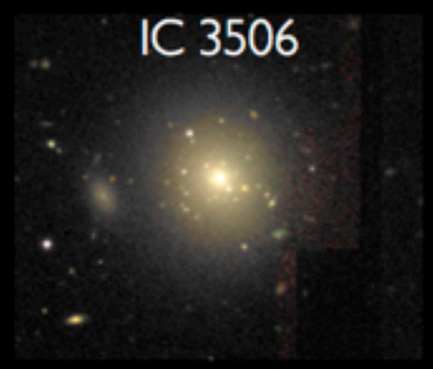
Diffuse galaxies

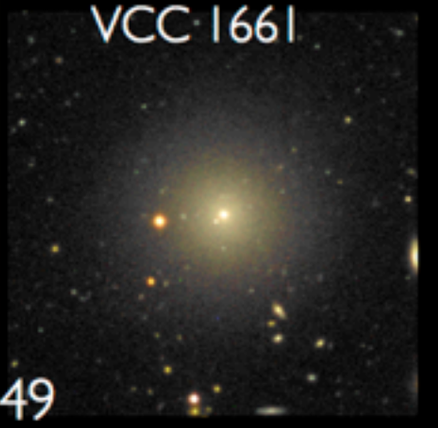




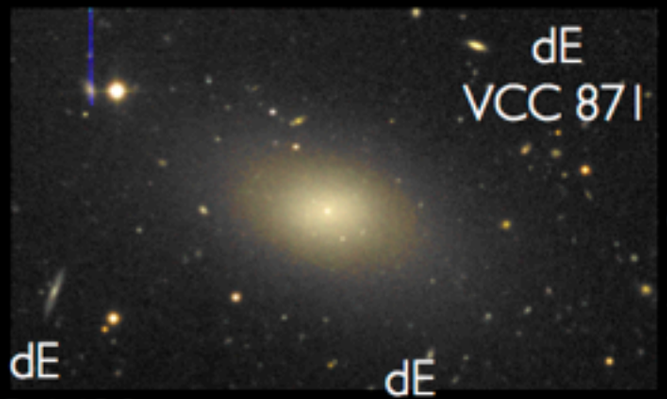
5 kpc



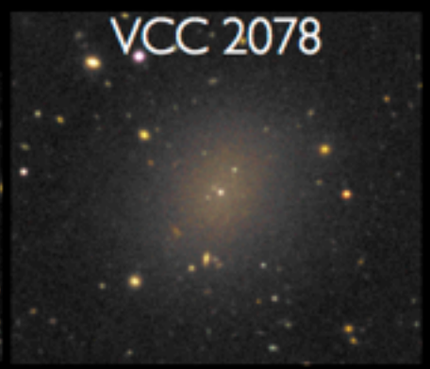




NGC 4449
stream

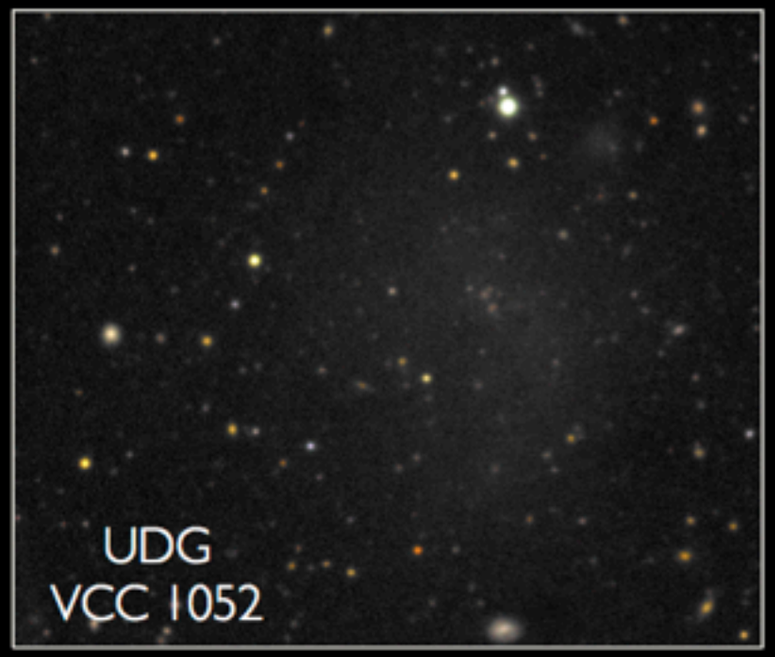


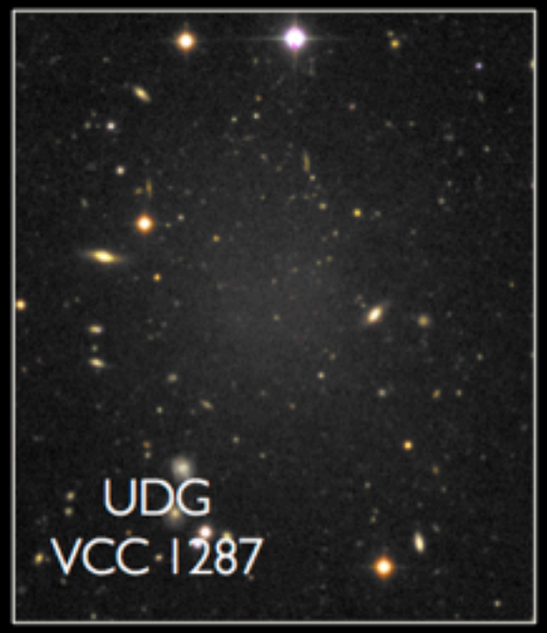
dEs
VCC 972,VCC 968



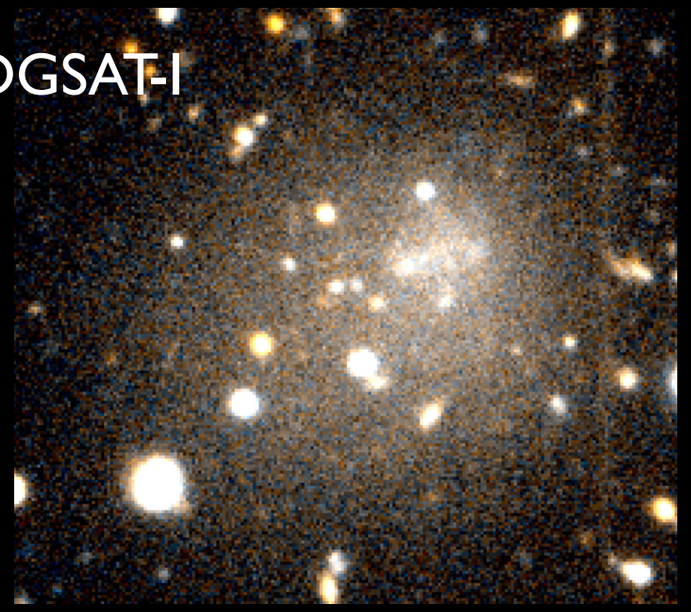
N dsph

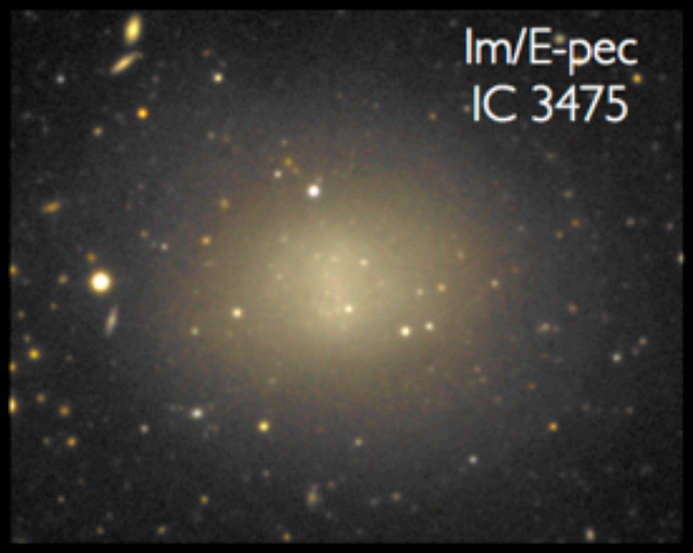
Diffuse galaxies

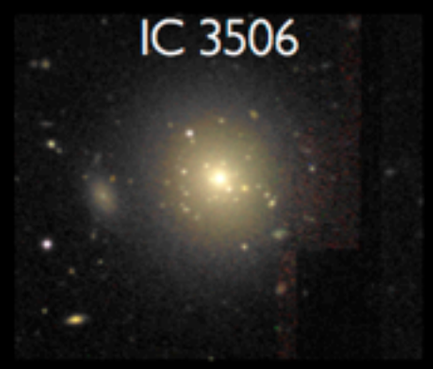




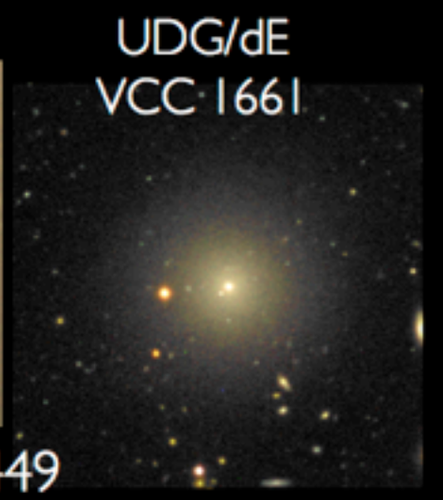
5 kpc

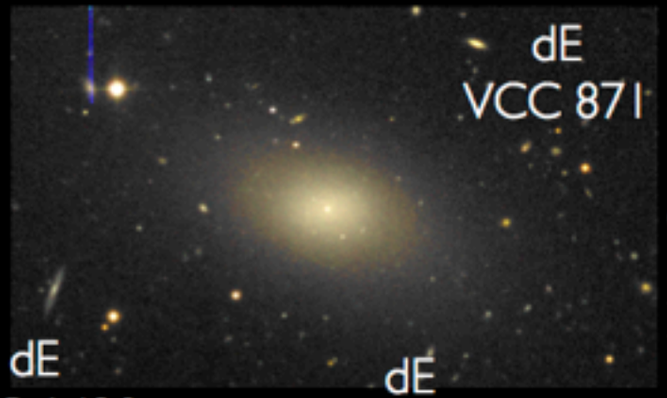






NGC 4449





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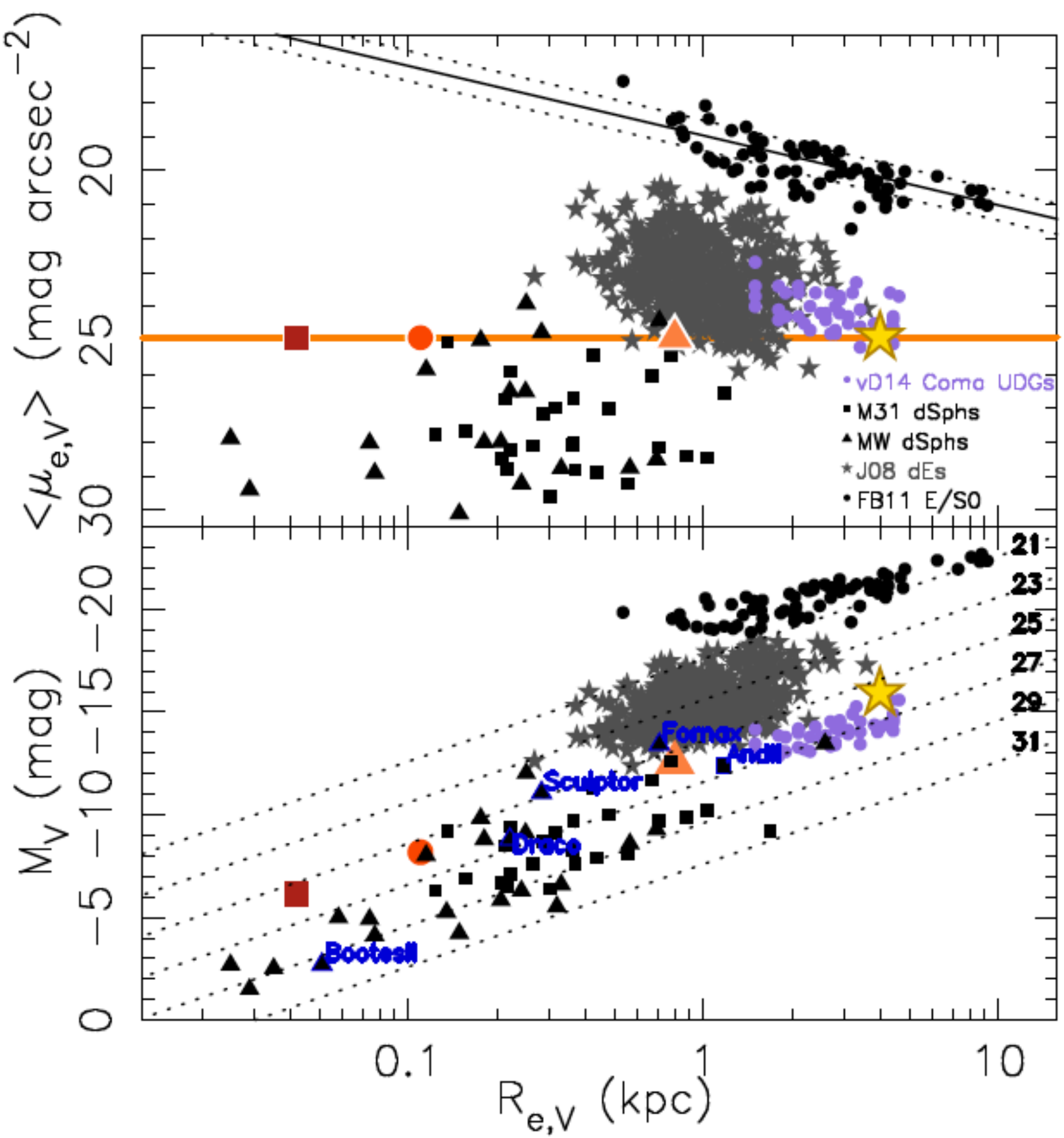
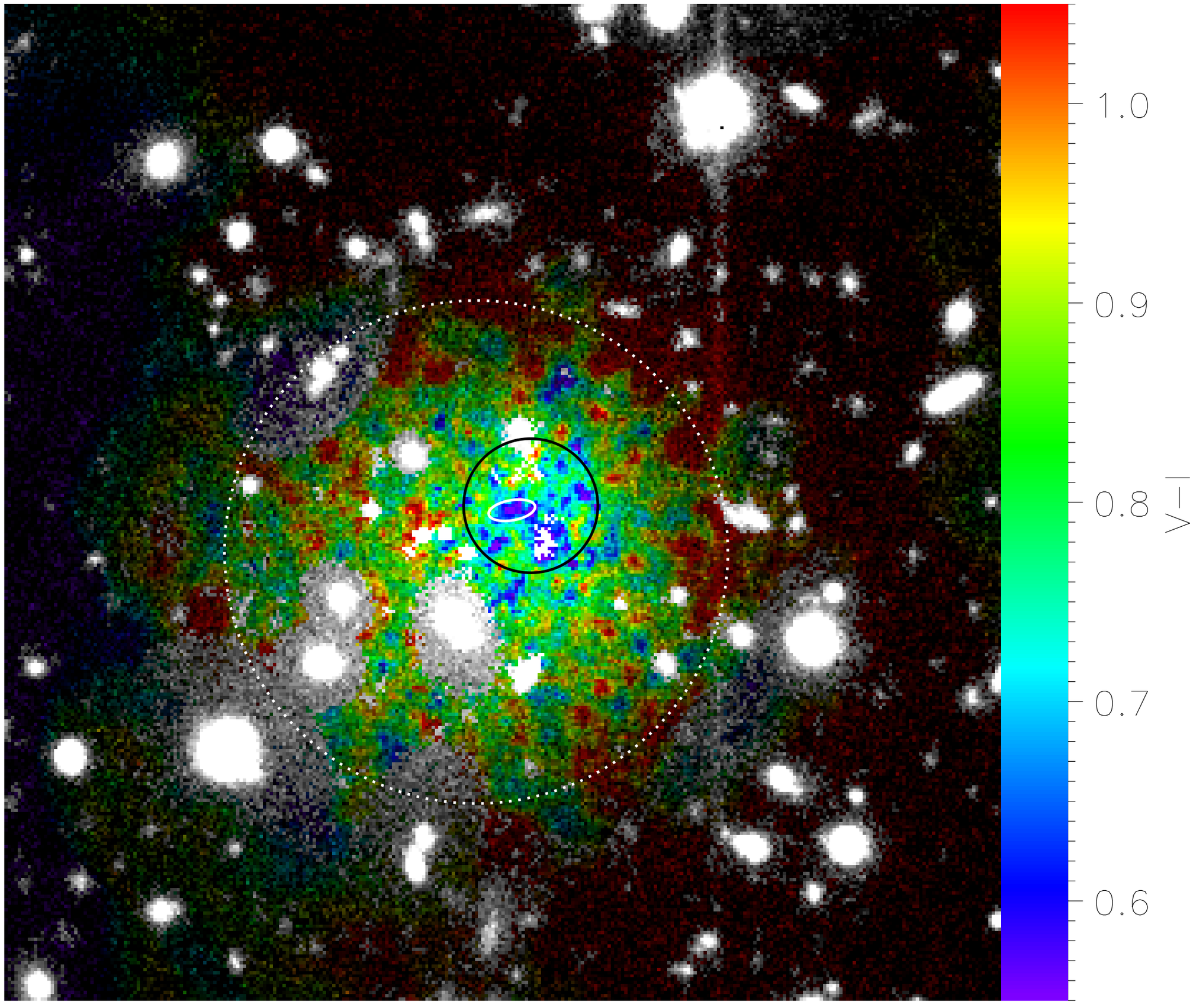
N dsph


$\langle\mu_{e,V}\rangle$ (mag arcsec^{-2})
20
25
30
vD14 Coma UDGs
M31 dSphs
MW dSphs
J08 dEs
FB11 E/S0
21
23
25
27
29
31
Fornax
Antli
Sculptor
Draco
Bootes II
M_V (mag)
0
−5
−10
−15
−20
0.1
1
10
$R_{e,V}$ (kpc)

Color (V-I) : central offset overdensity is ~0.4mag bluer !



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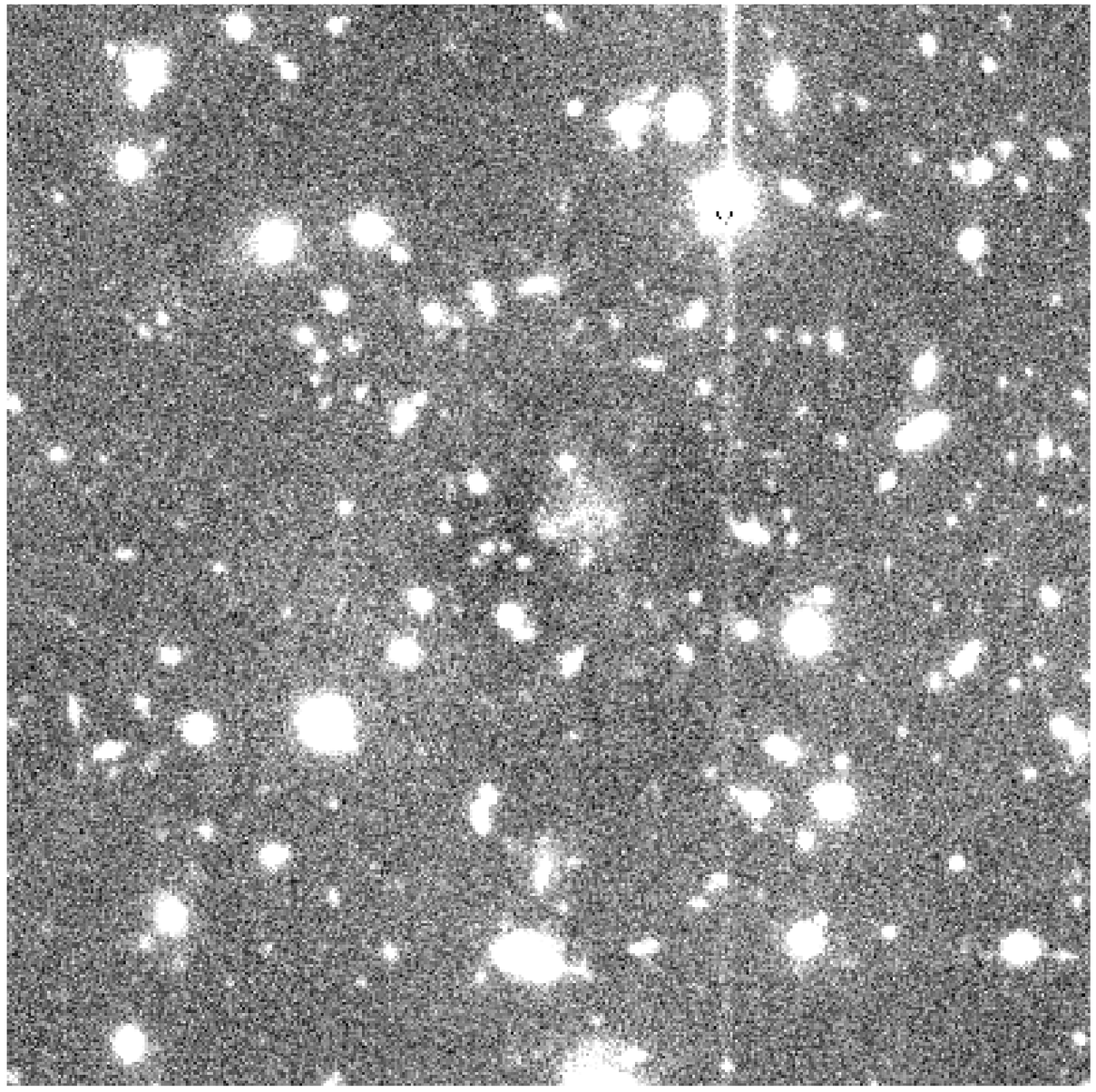
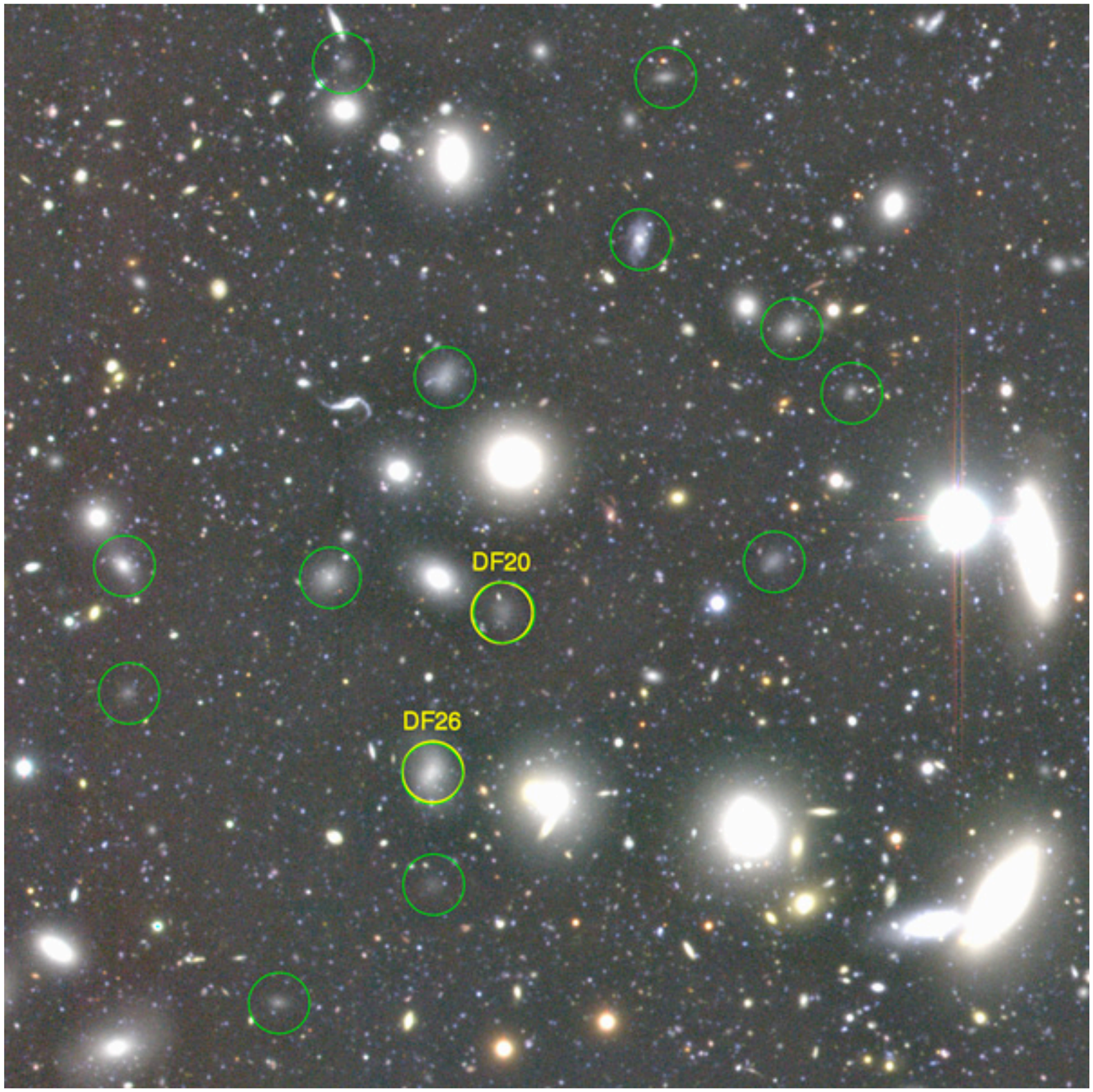


Koda+15 (arXiv:1506.01712): 800 (!) UDGs in Coma



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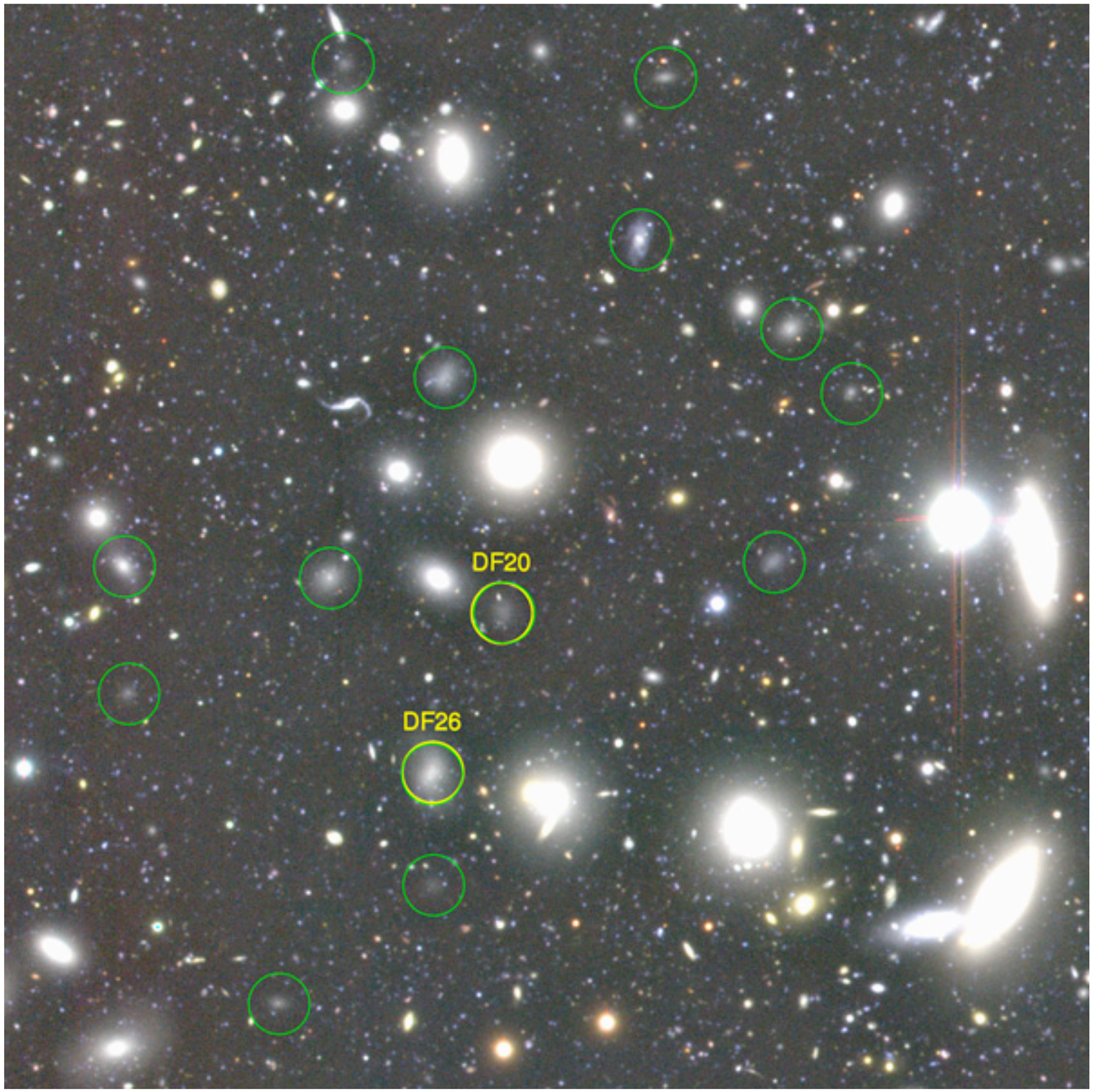
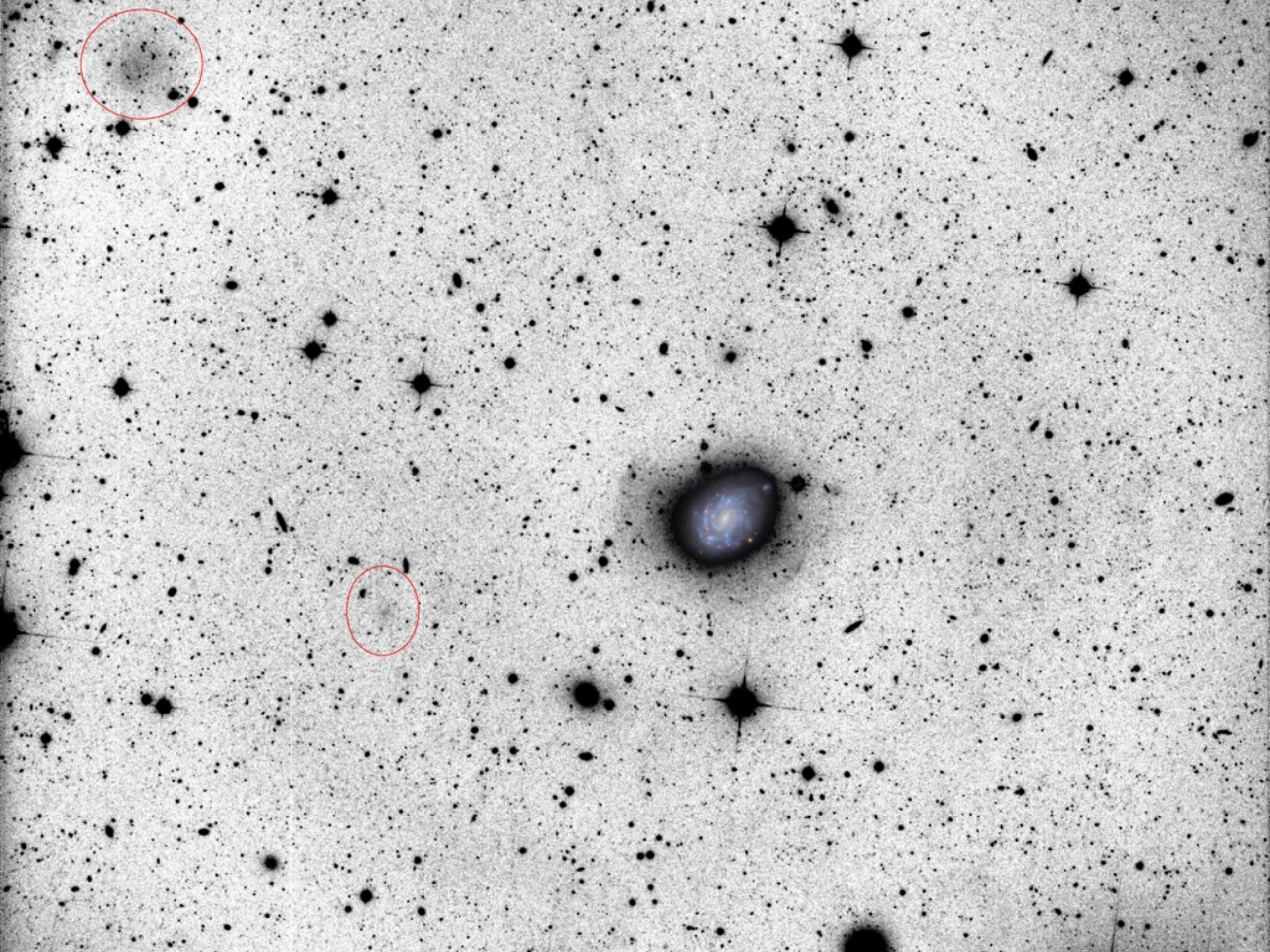


Martinez-Delgado et al. (in prep.)



Ongoing / Future Work

- spatially resolved spectroscopy (e.g., MUSE proposal) to get:
  - kinematic structure, especially ROTATION
  - (inner) mass profile, esp. DM profile
  - stellar population (incl. gradient)

- Globular Cluster kinematics for DM halo mass/profile

- GC counts and metallicities (formation, accretion/ mergers?)

- improve Numbers of analyzed UGDs

Summary

- UDGs may be very ubiquitous and contribute significantly to the faint galaxy population
- Dark Matter content unclear at the moment but likely high
- still need to find a consensus formation model
- more to come soon, including resolved spectroscopy (but hard!)