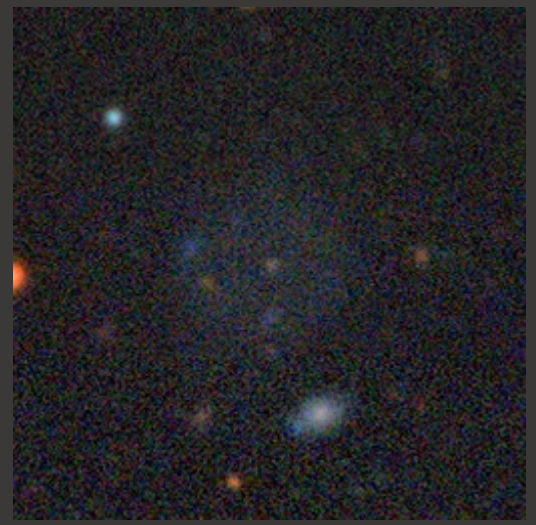
Gas-rich ultra-diffuse galaxies in the field






Mike Jones

Steward Observatory, University of Arizona

DECam at 10 years – Sept. 12th 2022

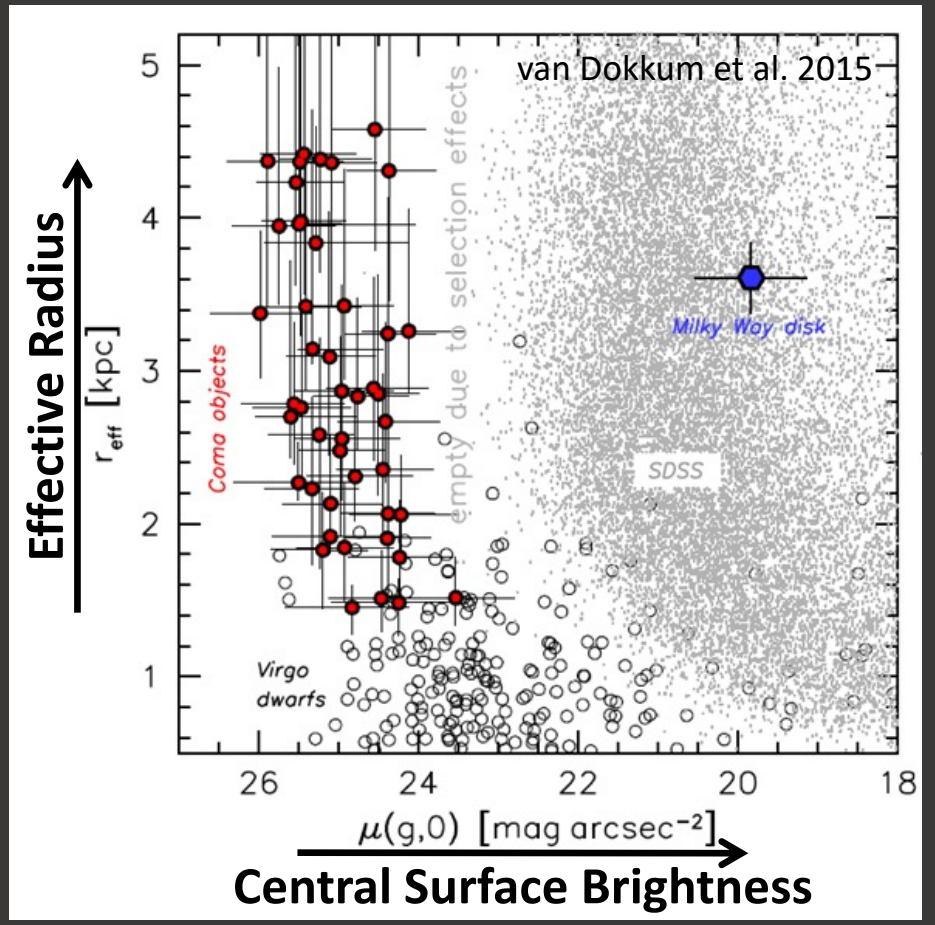
Ultra-diffuse galaxies (UDGs)

- The extreme of low surface brightness dwarf galaxies.
- Only recently (last 5-10 years) appreciated how ubiquitous they are.
- Do not fit comfortably into the standard picture of galaxy formation.
- UDGs are usually defined as:

$$r_{\rm eff} > 1.5\ {\rm kpc}$$

$$\mu_{\rm g,0} > 24\ {\rm mag\,arcsec^{-2}}$$

However, some definitions use average SB.



Ultra-diffuse galaxies

Virgo (16.5 Mpc)

15 kpc

VCC 1287

Coma (100 Mpc)

30 kpc

DF17

30 kpc

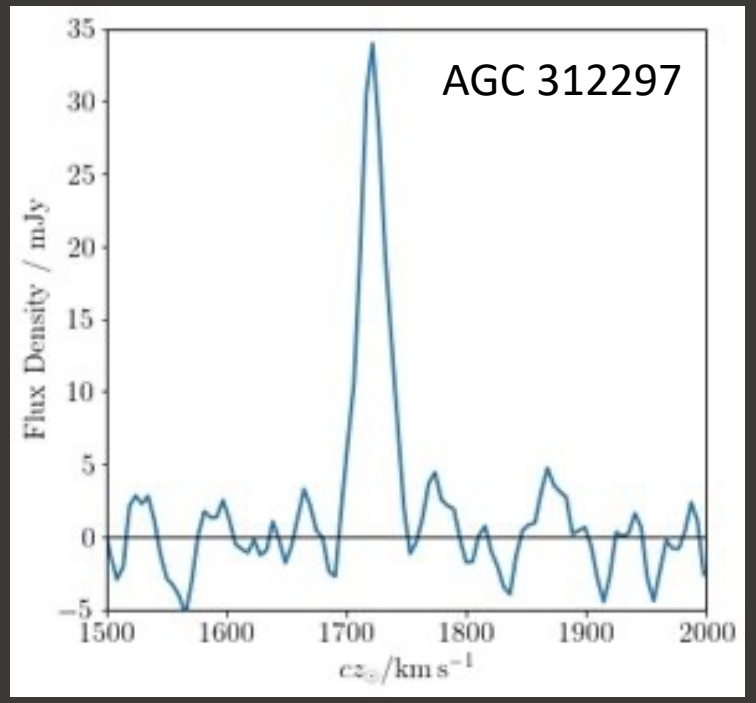
DF30

Large scale searches for UDGs

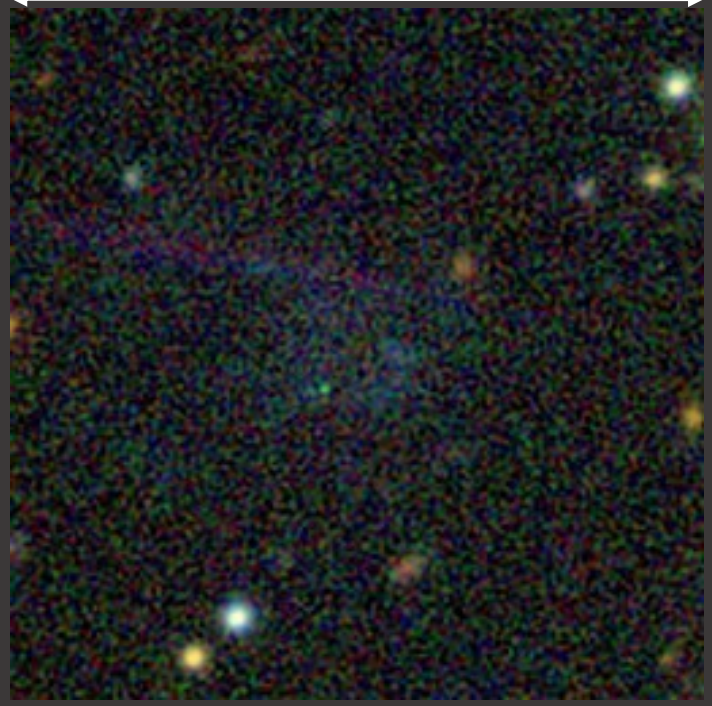
- There are several large-scale optical searches for UDGs e.g.:
  - DECaLS – SMUDGes (Zaritsky et al. 2019, 2021, 2022)
  - HSC-SSP (Greco et al. 2018)
  - KIWICS (Mancera Piña et al. 2018)
- However, optical-only searches struggle with **distance estimates** to most sources. Thus, physical sizes are approximate/unconstrained.
- Extremely LSB objects require deep imaging to robustly identify, but those with neutral gas are **point sources in HI surveys**.
- In the ALFALFA HI survey (Haynes et al. 2011, 2018) there are ~200 high SNR HI sources that meet the UDG criteria (Leisman et al. 2017, Janowiecki et al. 2019).

Gas-rich, field UDGs

ALFALFA HI Spectrum



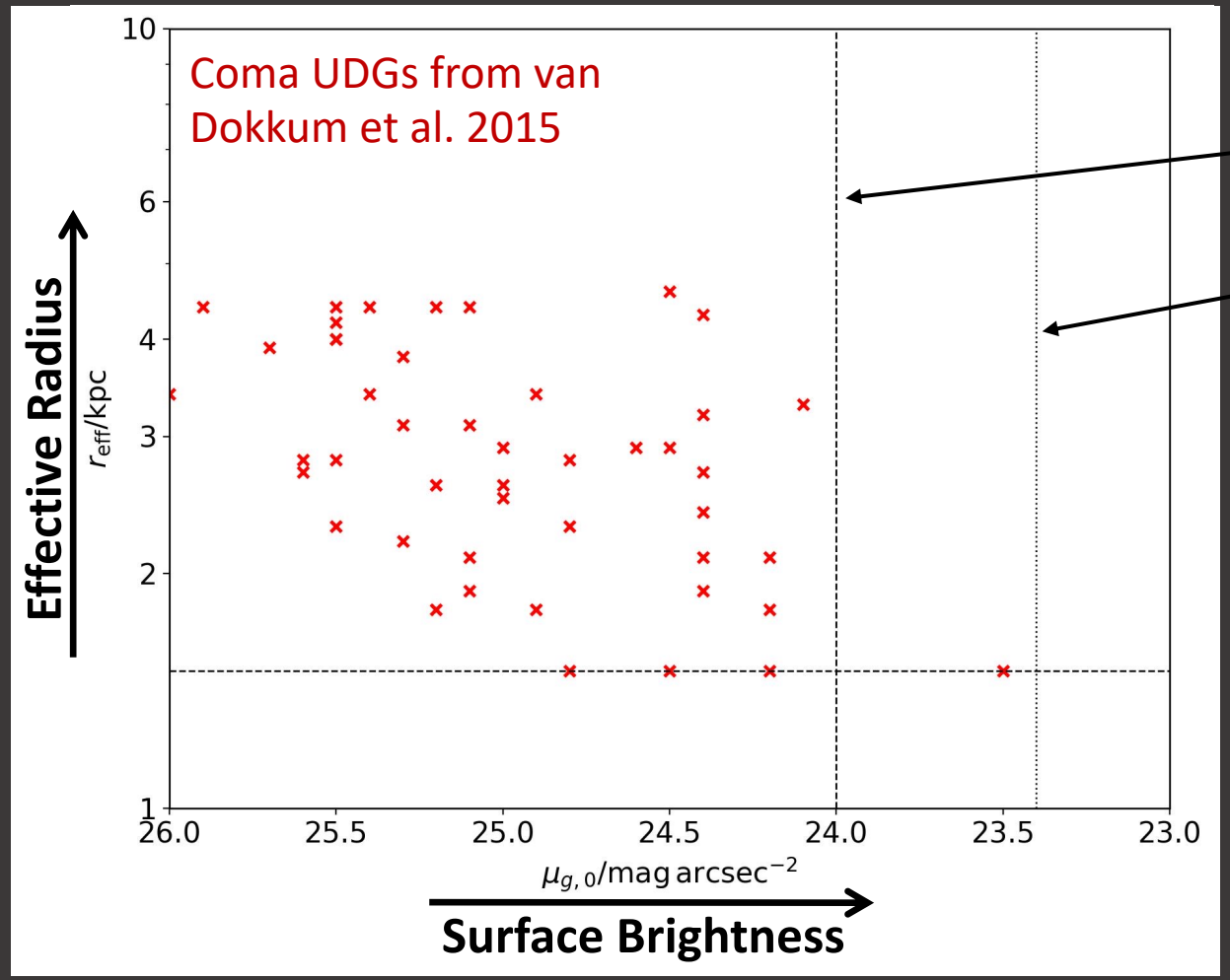
8.5 kpc



SDSS

DECaLS

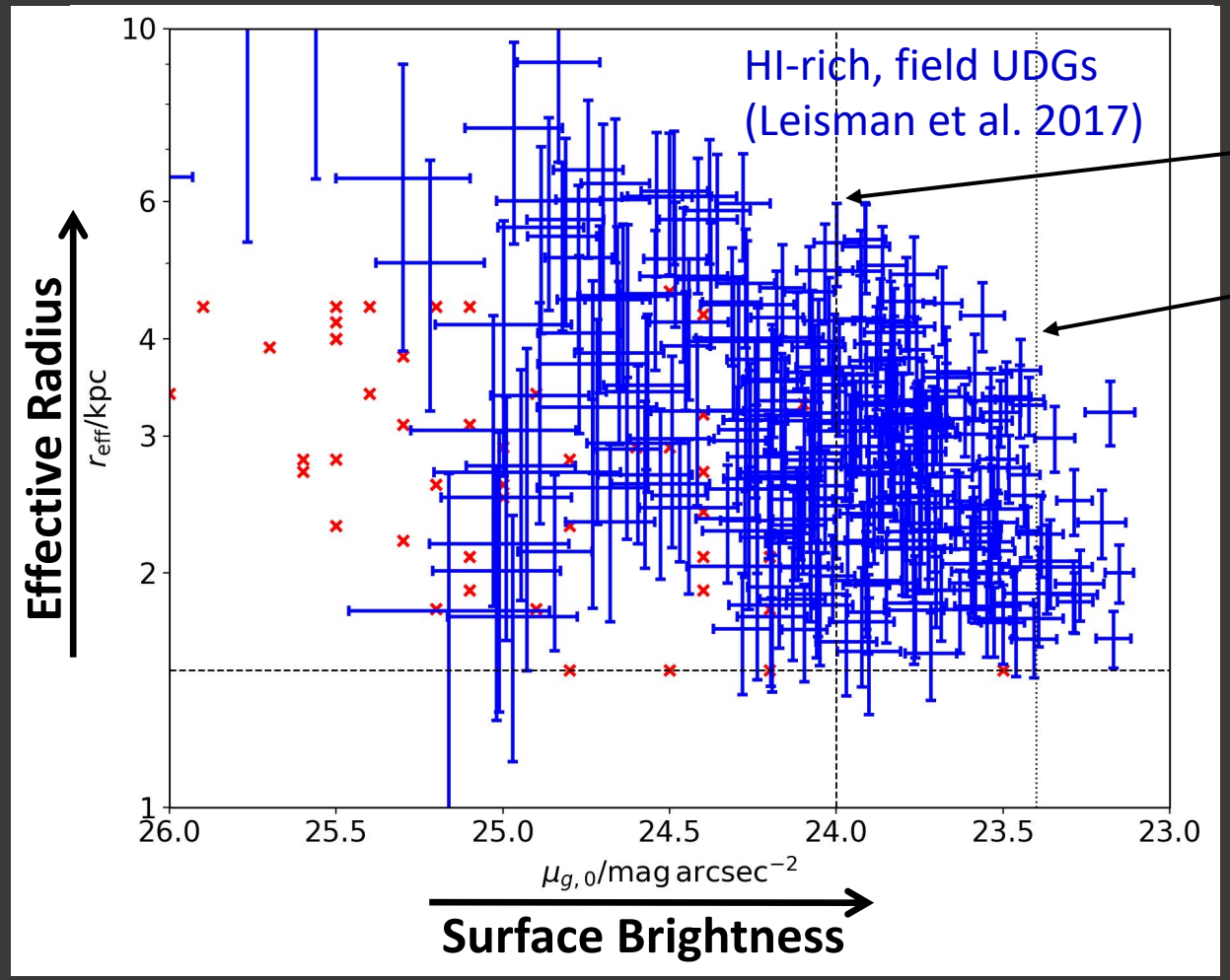
Gas-rich, field UDGs



Strict UDG definition

Alternative definition based on mean surface brightness (e.g. van der Burg et al. 2016)

Gas-rich, field UDGs

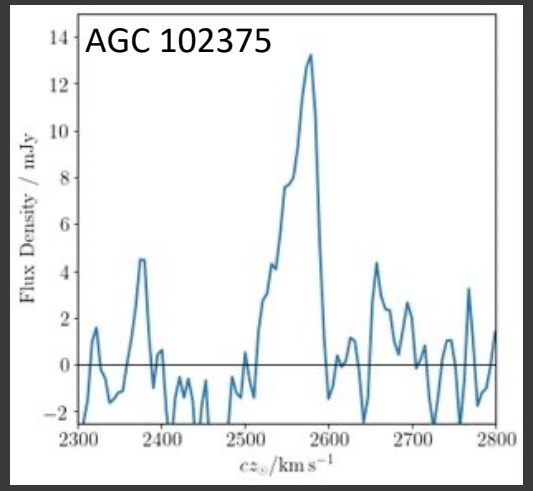


Strict UDG definition

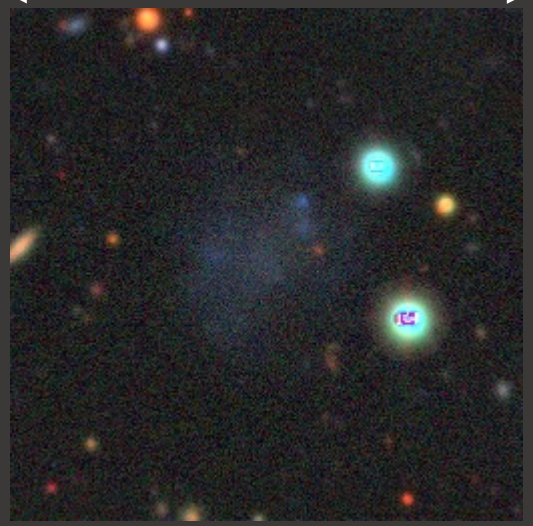
Alternative definition based on mean surface brightness (e.g. van der Burg et al. 2016)

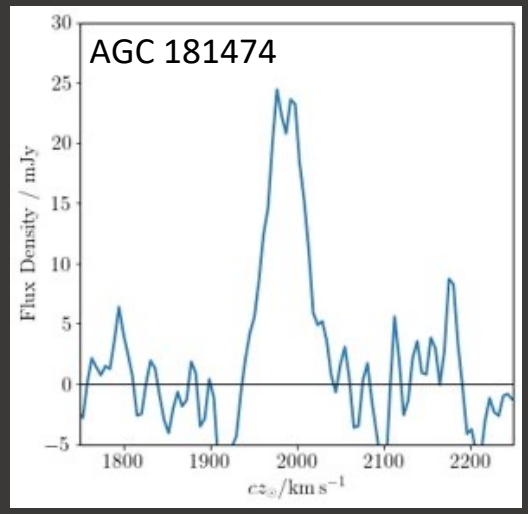
Gas-rich, field UDGs

11 kpc

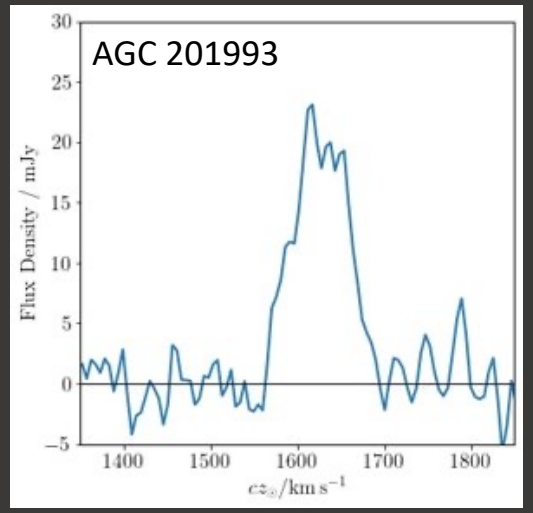


13 kpc





16 kpc



The origin of UDGs – An open question

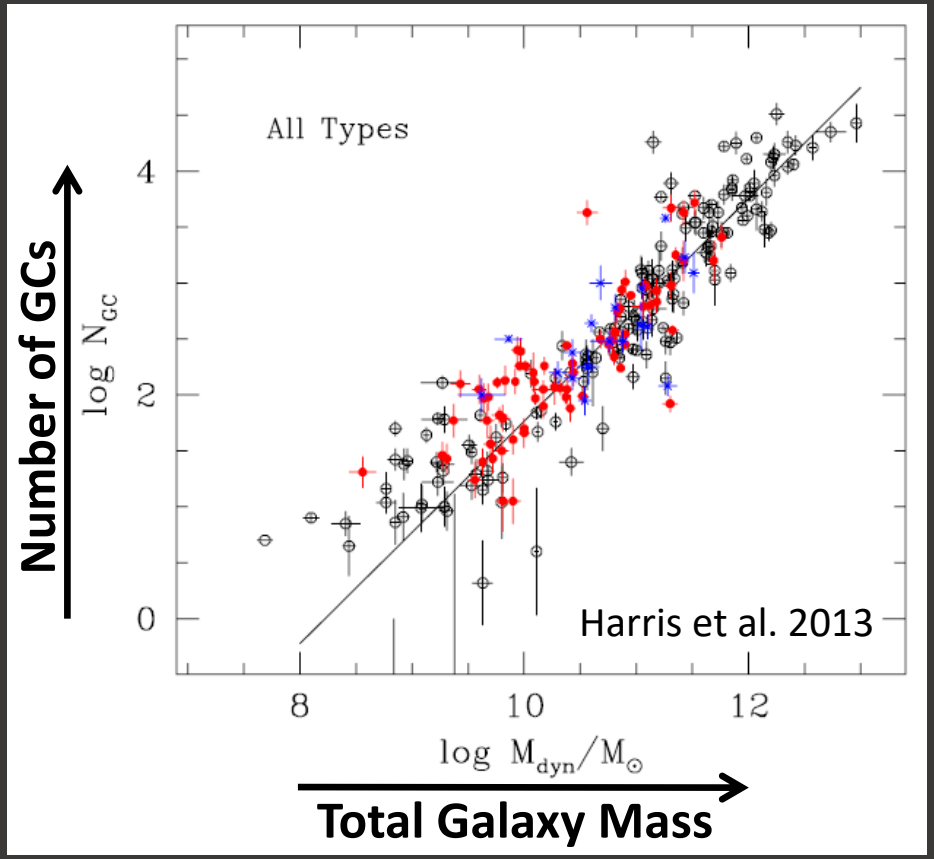
- Proposed formation mechanisms fall broadly into two categories:
  - Internal – Star formation feedback, halo spin parameter, or early or peculiar star formation.
  - External – Tidal heating, mergers, or early environmental quenching.

- Bennet et al. 2018 and Jones et al. 2021 found evidence for UDGs in groups forming via tidal heating of normal dwarfs. But is this the only mechanism?

- Are field and cluster UDG connected or distinct populations? **Could field UDGs be progenitors of some in denser environments?**

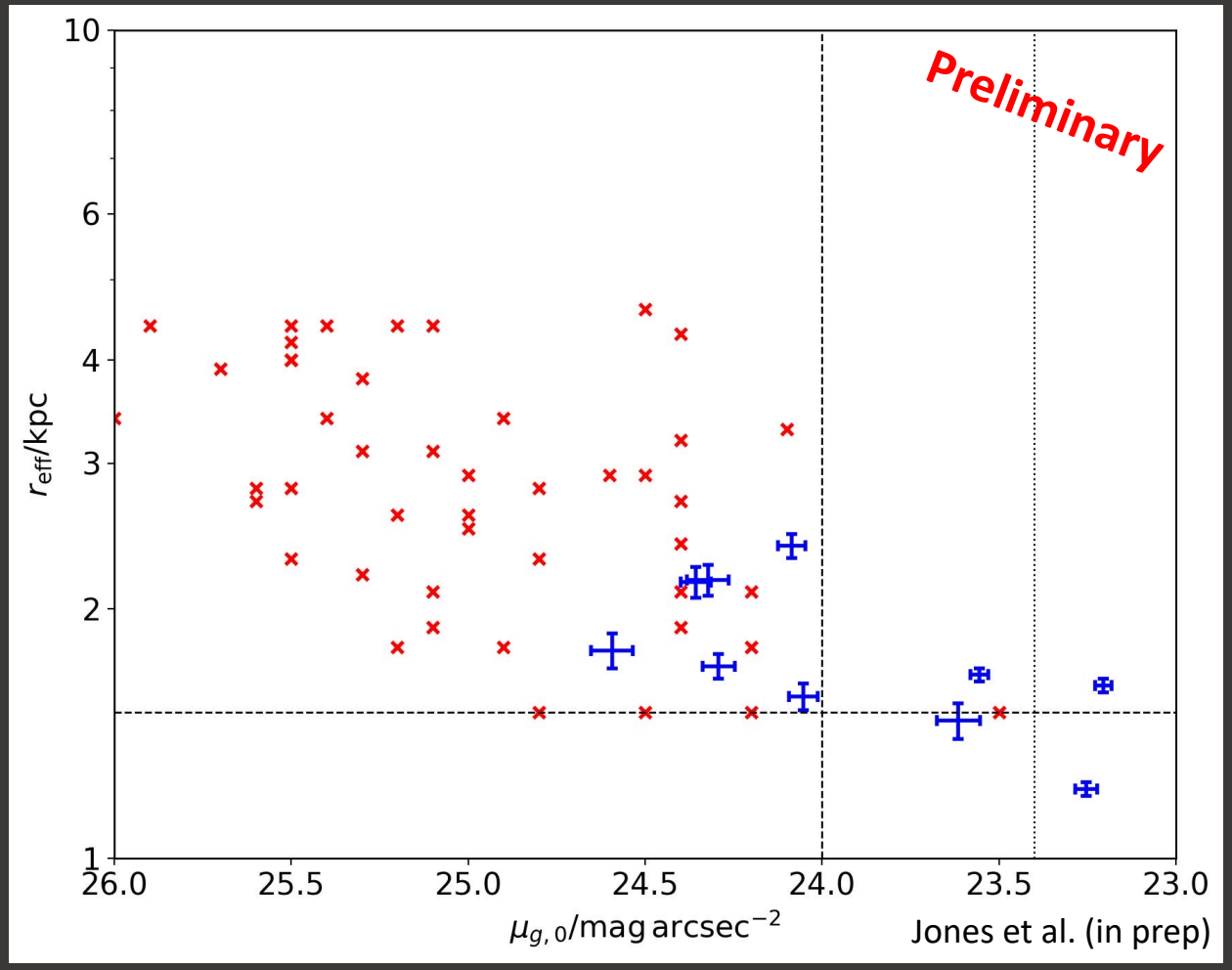
Globular clusters and galaxy formation

- GCs are thought to be tied to the earliest episodes of star formation in galaxies.
- The richness of a galaxy's GC system is strongly correlated with its dynamical mass (or stellar mass or luminosity).
- Thus, GC systems are a means to compare different types of UDGs that doesn't depend on their morphology and colour.
- We targeted gas-rich, field UDGs with an HST SNAP project to measure their GC systems.

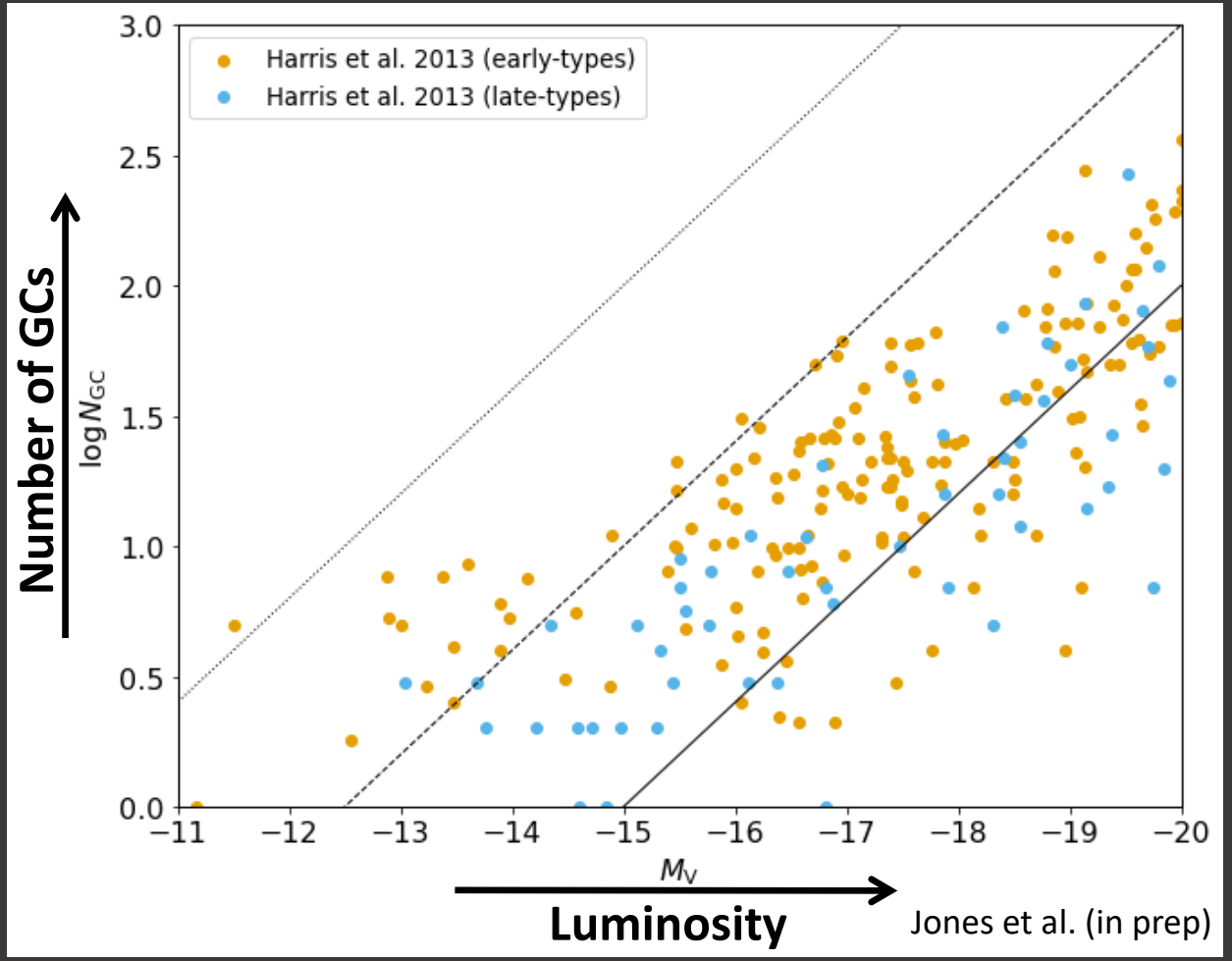


Revised photometry with DECaLS

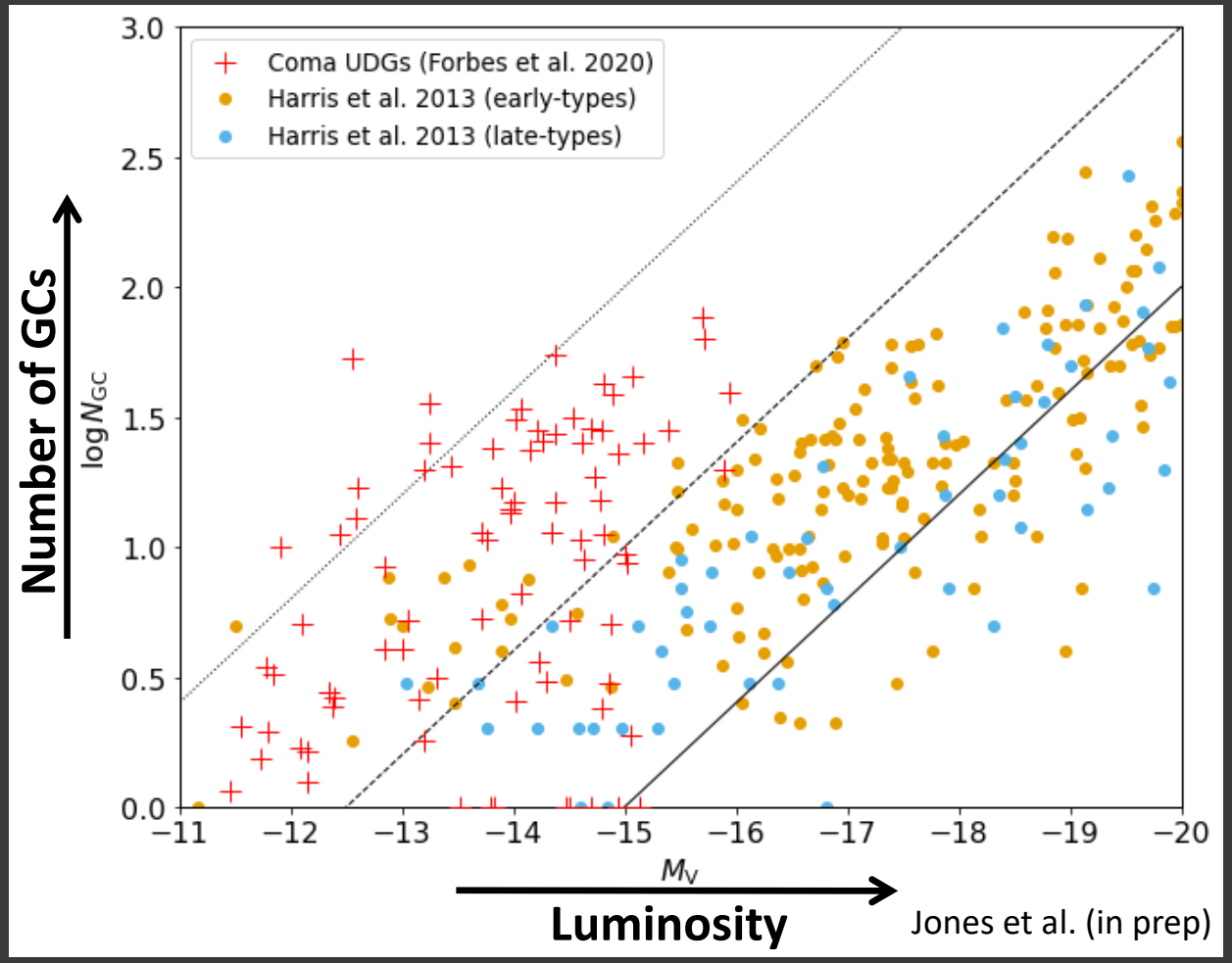
- So far 12 field UDGs have been images in the HST program.
- Revised photometry of these generally shift them to slightly higher SB (Karunakaran et al. in prep.).
- Suggests a continuous population with bona fide UDGs at the extreme.



Globular clusters in cluster UDGs

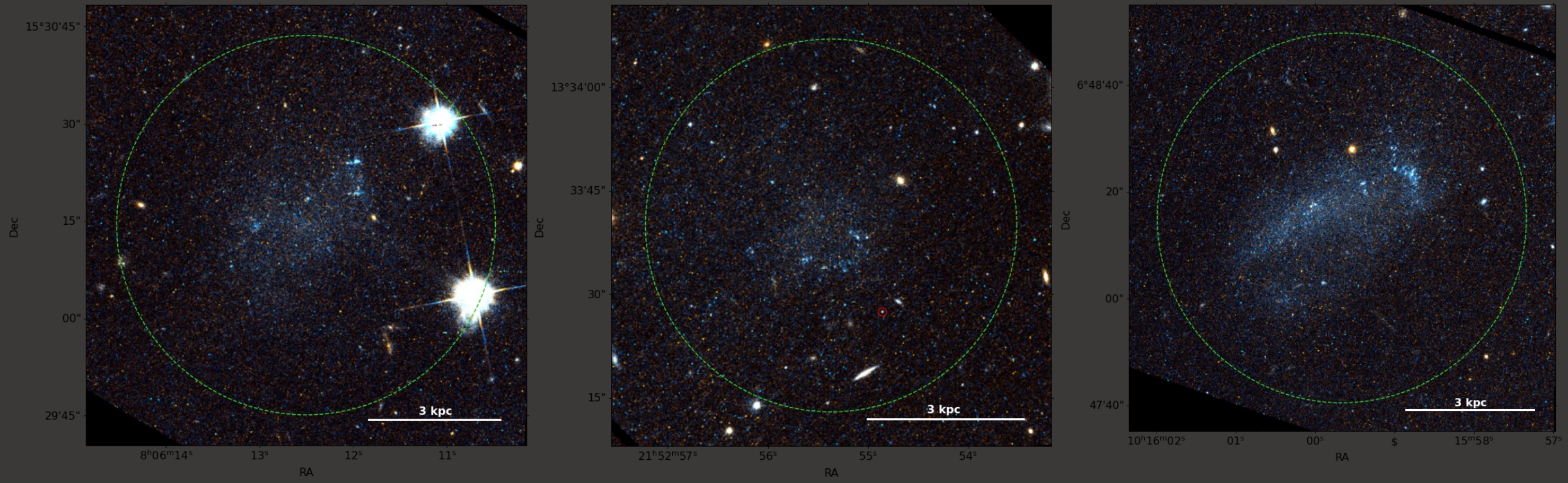


Globular clusters in cluster UDGs



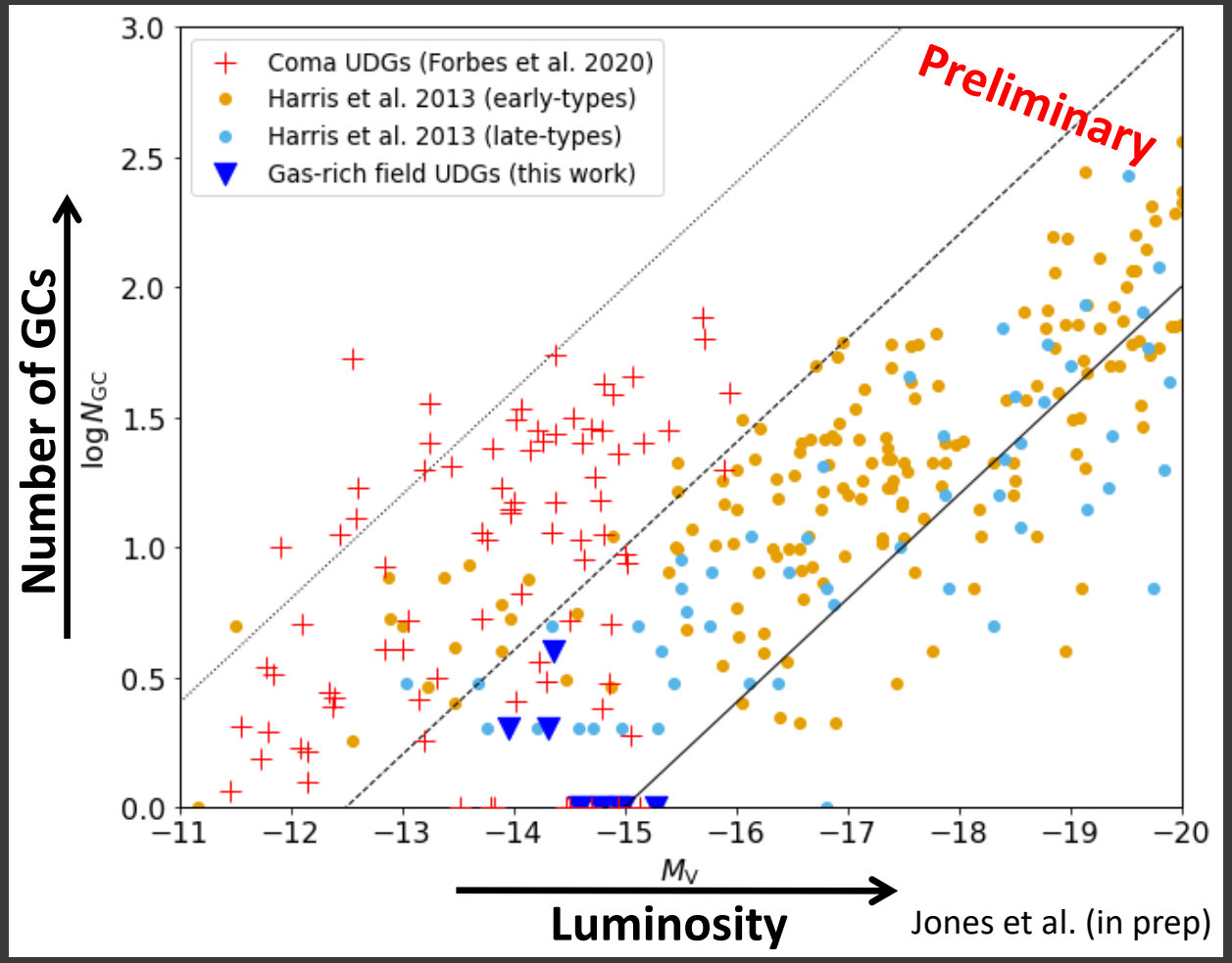
Jones et al. (in prep)

Globular clusters in field UDGs



- GC candidates are selected based on luminosity. We target the upper half of the GCLF.
- In addition, a colour cut and concentration index is used to distinguish them from stars, young stellar clusters, and background galaxies.

Globular clusters in field UDGs



Summary

- Gas-rich UDGs in the field offer a unique window into the properties of a subset of the UDG population.

- They appear to be the LSB extremum of a **continuous distribution** of field dwarf galaxies properties (but we have few data points).

- Initial HST observations suggest that these field UDGs **host very few globular clusters**.

- This makes them physically distinct from GC-rich cluster UDGs and means there **must be multiple UDG formation pathways**.