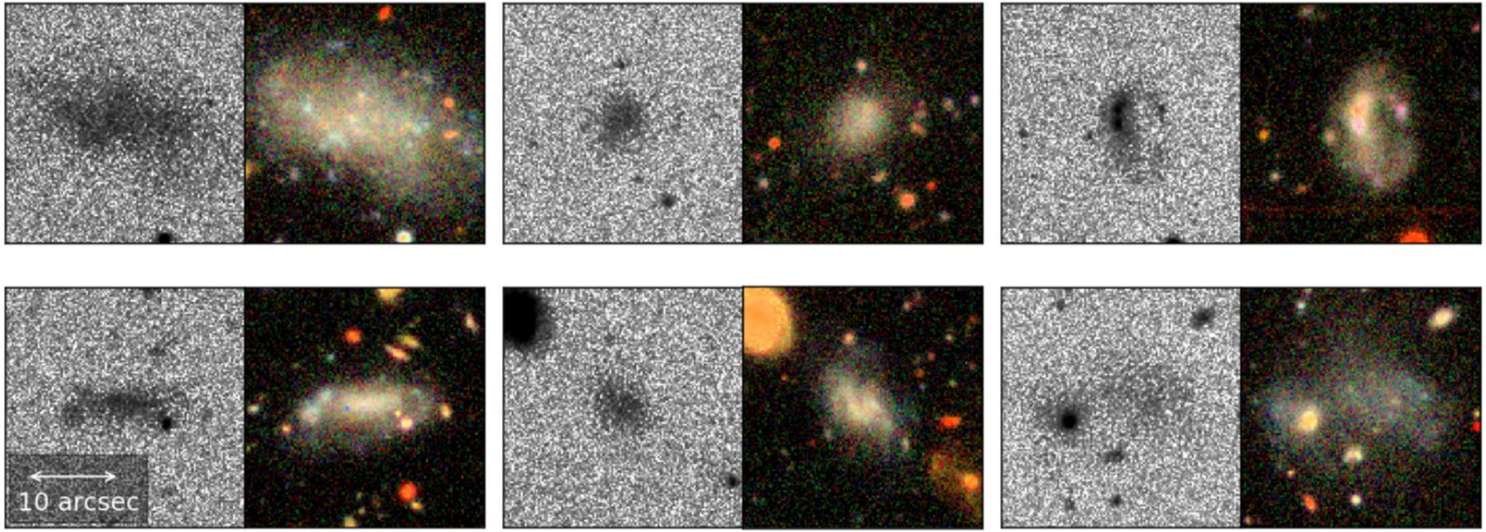
CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

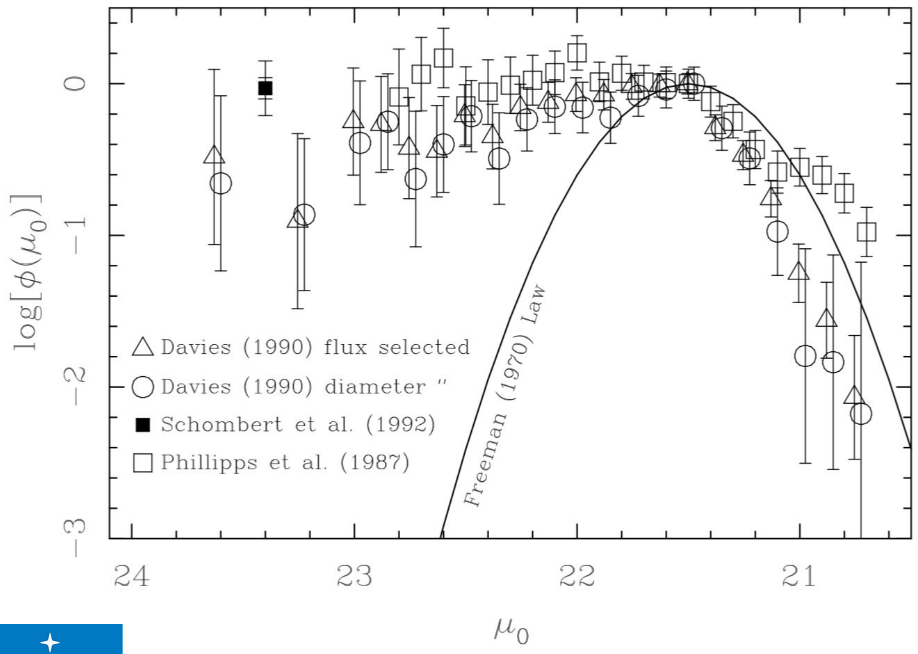
# Characterising Low Surface Brightness Galaxies in the Field using Large Sky Surveys



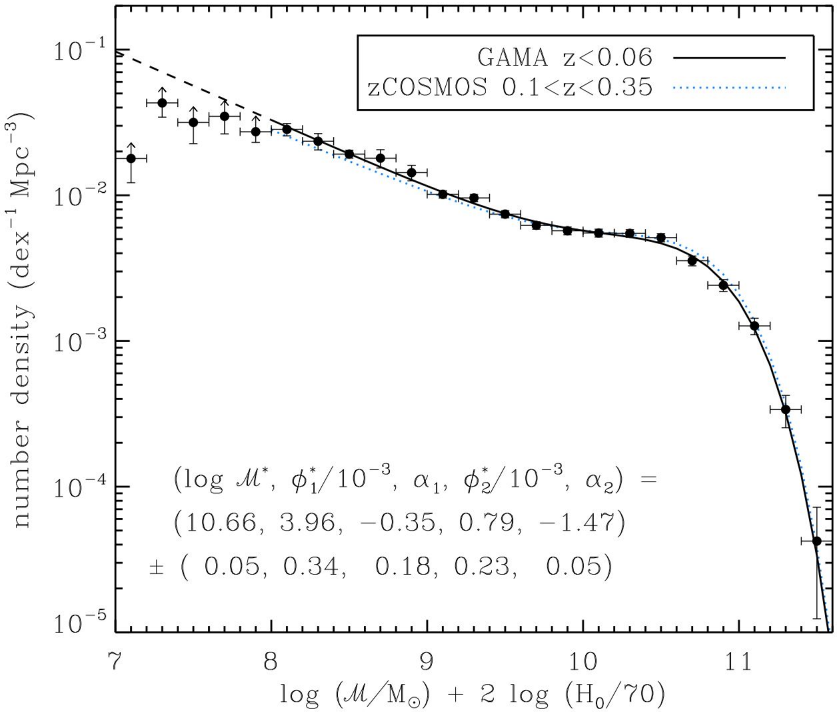

Daniel J. Prole

Supervisors: J. I. Davies (Cardiff), Michael Hilker & Remco van der Burg (ESO)

# Low Surface Brightness (LSB) Galaxies




*McGaugh et al. (1995)*




*Baldry et al. (2012)*

# Telescopes & Surveys

**Optical design:**

- Narrow PSF wings
- Minimal scattered light
- Fast optics

**Survey design:**

- Sufficient integration times
- Careful background subtraction
- Appropriate source extraction software

**The Dragonfly Telephoto Array**
*(Abraham & van Dokkum 2014)*

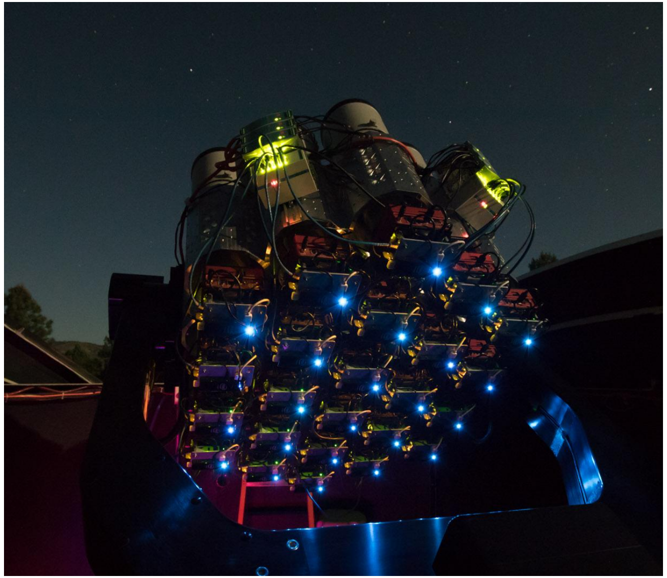


*Photo: Pieter van Dokkum*

# Ultra-Diffuse Galaxies (aka large LSB galaxies)

Milky way sized (effective radii > 1.5 kpc)

Stellar masses more like dwarfs ($M_* \sim 10^8\ M_\odot$)

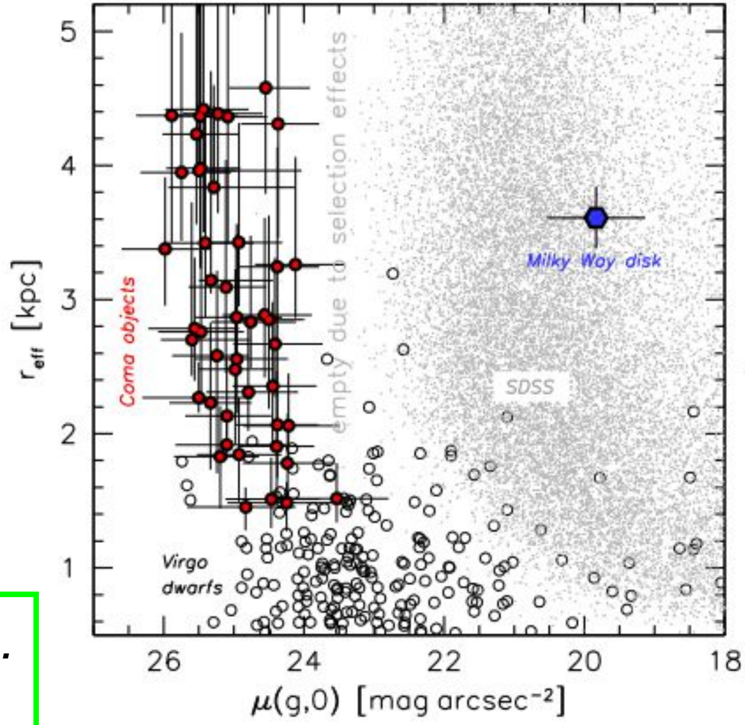
**Properties in groups/clusters:**

Red sequence; Old stellar pops / metal poor

Absence of tidal features (high ML ratios)

Halo masses similar to dwarfs (e.g. Prole +19)

***Relatively little is known about the field population…***
Estimating distances is hard!




*van Dokkum +15*

# Ultra-Diffuse Galaxies: Where do they come from?

| Secular mechanisms | Environmental mechanisms |
|---|---|
| Stellar feedback:<br>Supernovae<br>Massive stars | Tidal heating in group or cluster potentials<br>Interactions with other galaxies |
| High angular momentum<br>(dwarf galaxies with high spin) | Early quenching of massive galaxies? |

Question: What are the relative importances of secular & non-secular evolution?
Compare UDGs in the field vs. in groups & clusters...

# Data: KiDS, HSC-SSP, GAMA

**Detection / Structural parameters**:

KiDS r-band (VST / OmegaCam)

~180 square degrees (GAMA overlap)

Wider & shallower than HSC-SSP DR1

**Colours**:

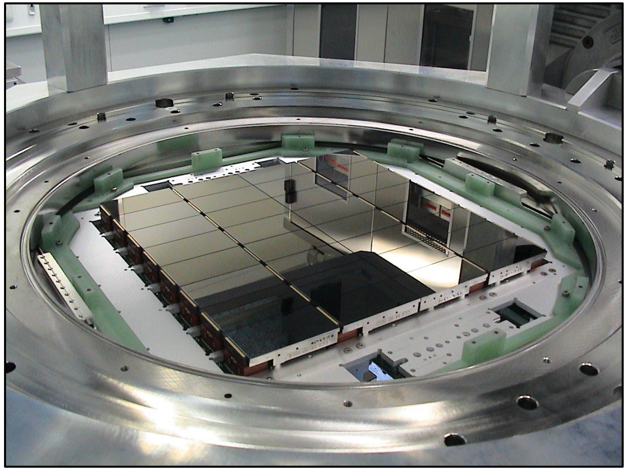
HSC-SSP (g, r)

~0.5mag deeper

Reduces footprint by ⅓

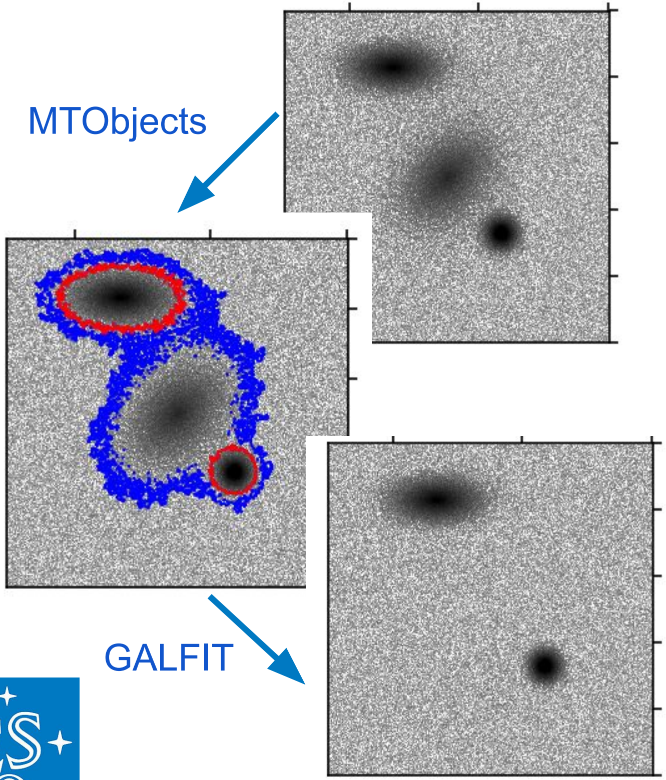
**DR2 in May**

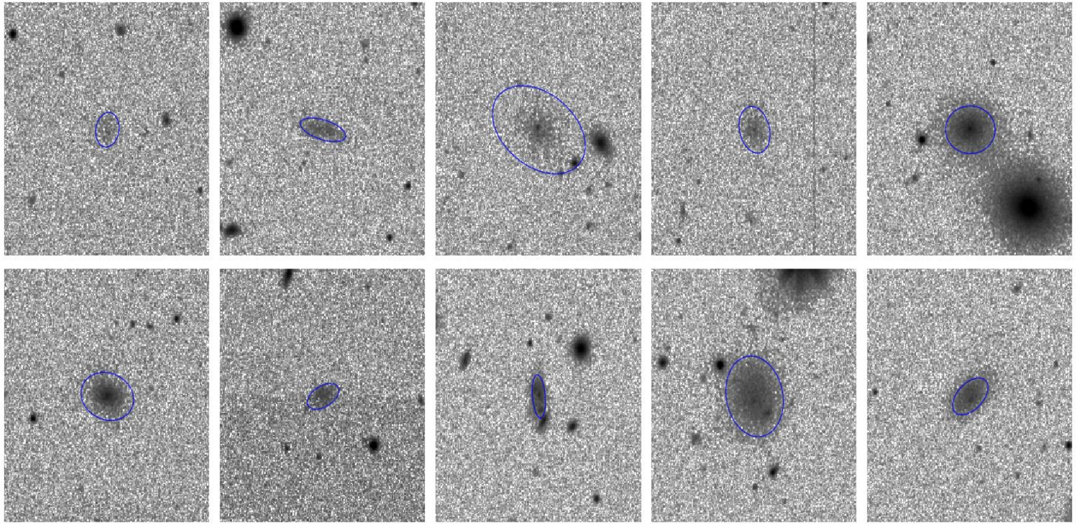
***OmegaCam***



Recovery Efficiency measured using synthetic galaxy injections and running full pipeline...

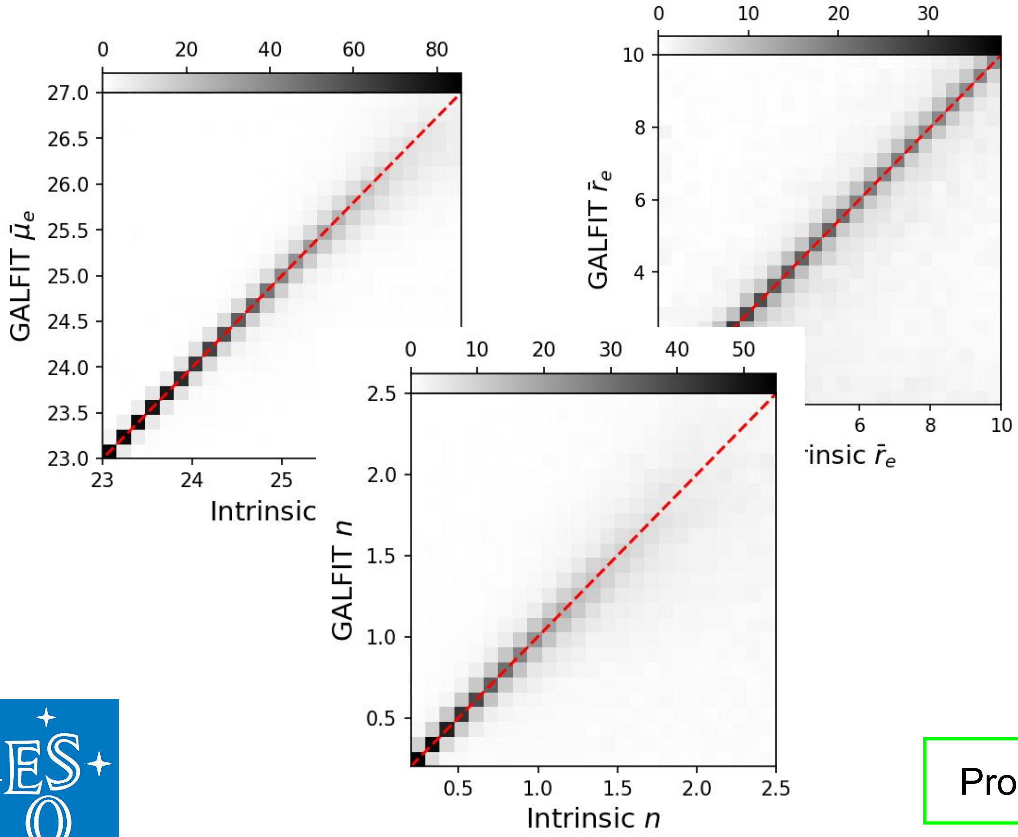
# Detection & Measurement Pipeline

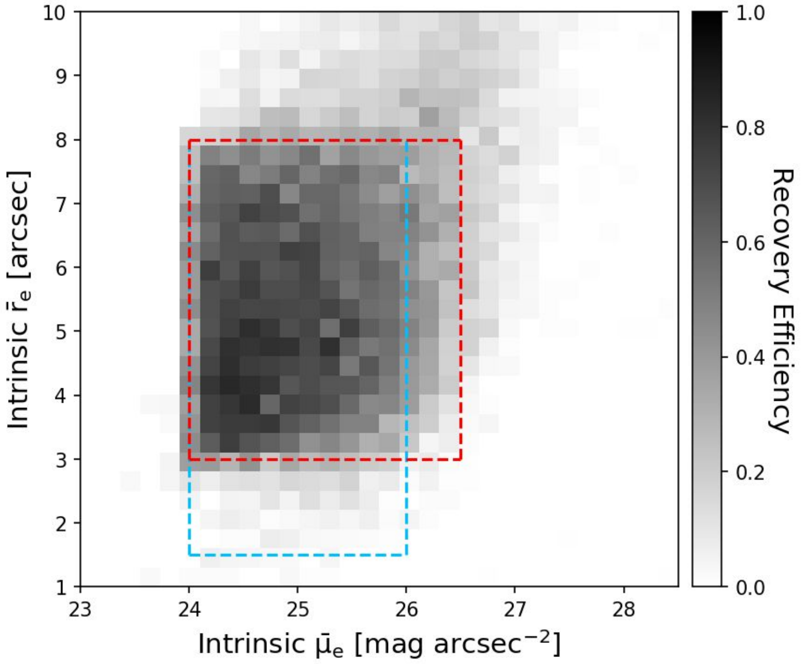


Final selection: 212 UDG candidates
No distances!

# Measurements & Recovery Efficiency



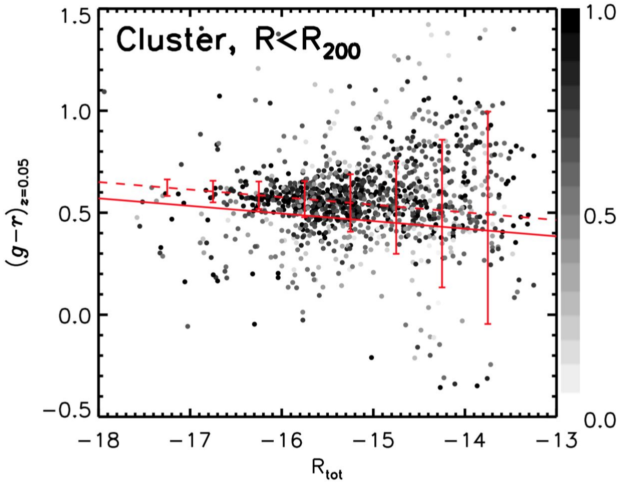




Prole et al. 2019; Submitted to MNRAS

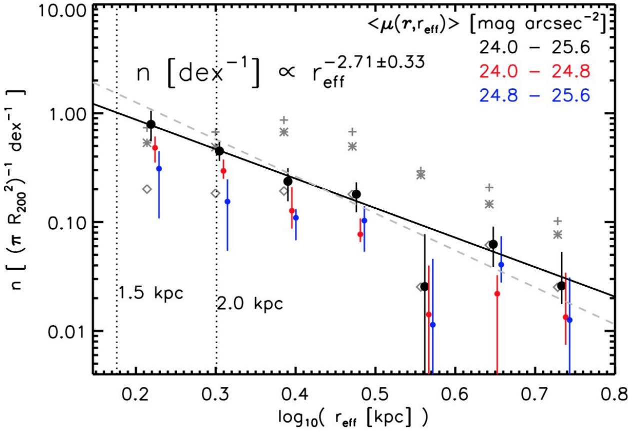
# Empirical UDG model

We know what we observe…
Can we explain it using what we know of UDGs?

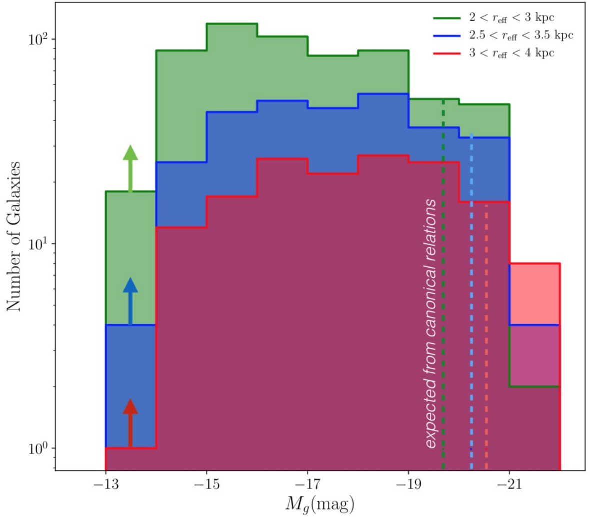
van der Burg+16




van der Burg+17




Danielli+18




Model = Size distribution + Luminosity distribution + Stellar population model + Cosmology

# Empirical model for Interlopers

**Assumptions:**

Interlopers are dominated by bright/massive background galaxies

Massive galaxies with Sersic n <2.5 are typically late types (e.g. Vulcani+14, Danielli+18)

The dominant interlopers are therefore massive late types

**Model ingredients:**

Stellar mass function (Baldry +12, Muzzin +13)

Stellar mass-size relation (van der Wel +14)

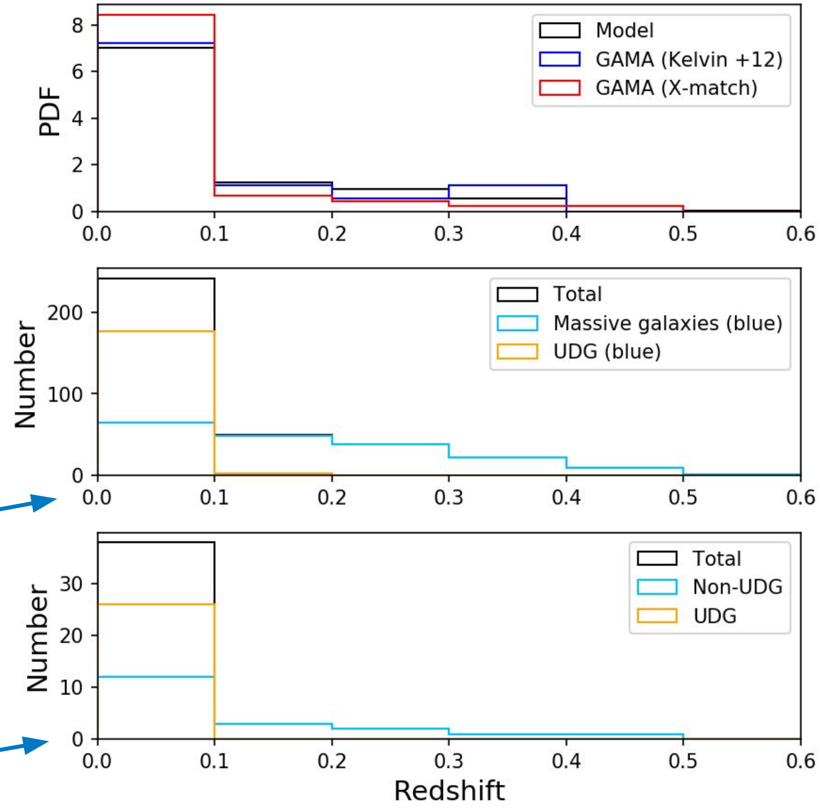
Redshift dependant colour model (Taylor +12)

# Comparison with GAMA redshifts

- Crossmatch KiDS sources with GAMA catalogue (~30 sources)
- Estimate physical sizes from spec. redshifts
- Compare redshift distributions of intrinsic UDGs vs. interlopers

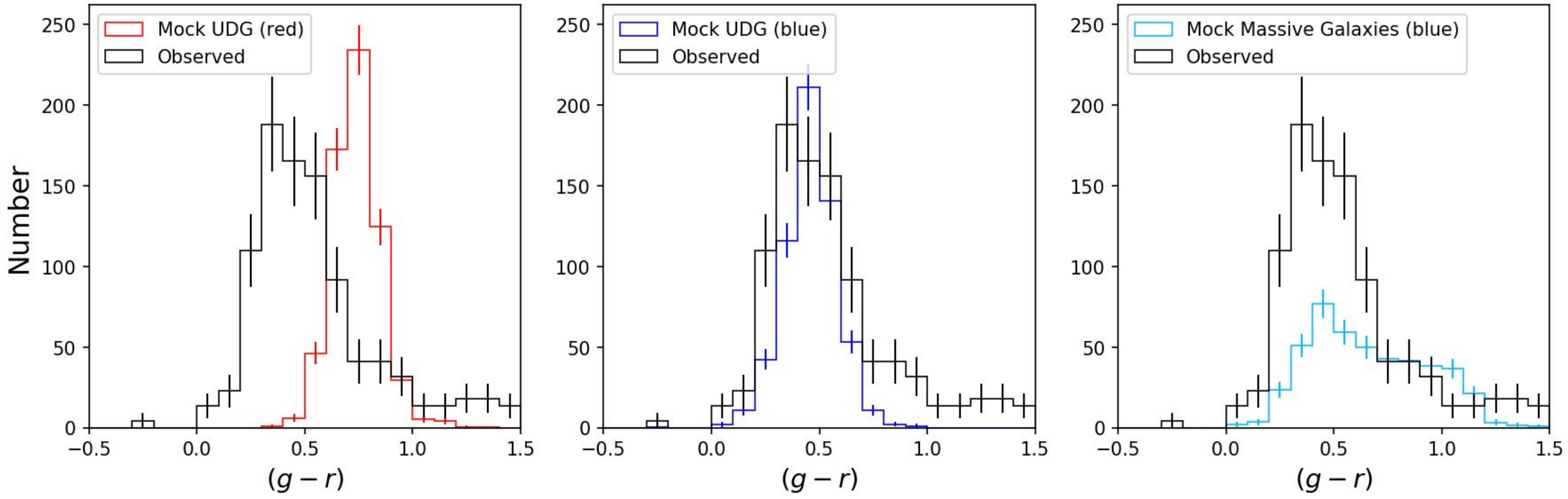
Model

Observed



# Results: Colour distributions

Prole et al. 2019; Submitted to MNRAS




UDGs in the field seem much bluer than those in clusters!

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# Results: Colour distributions

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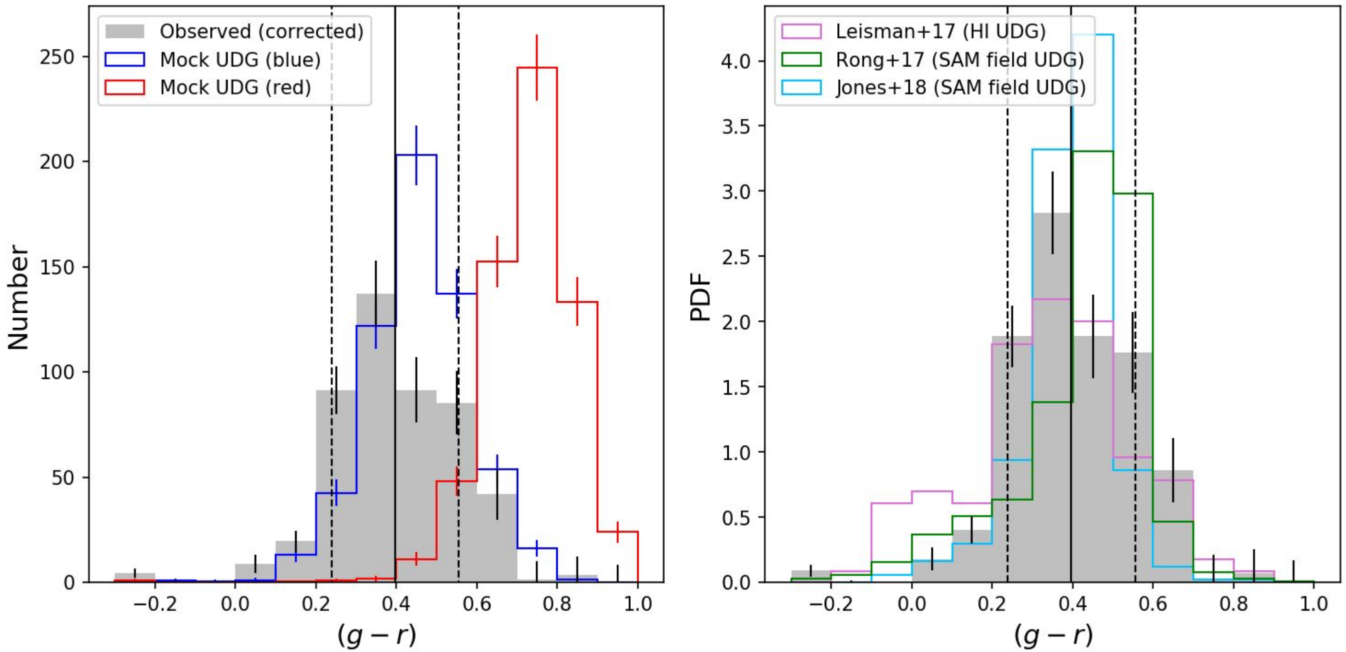


**UDG field density: <8±3 x10-3 cMpc-3 (0.5 times SAM prediction)**

**<5 times HI-UDG field density**

# Conclusions

UDGs appear bluer in the field than in clusters, some showing signs of localised SF

Field UDGs are produced with similar mass efficiencies as cluster UDGs

SAMs overproduce the numbers of UDGs, including HI-rich UDGs

HI-rich UDGs comprise at least one-fifth of the overall field population

# Improvements with LSST

>2 mags deeper than KiDS (r ~ 27.5 vs ~25 for 5σ point source)!

Photometric redshifts will allow distance estimates, redshift distributions etc.

Footprint over an order of magnitude larger than KiDS!

**Things to worry about:**

- Background subtraction
- Wings of PSF?
- Source crowding
- Recovery efficiency estimates?

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