

ARE THEY ULTRA-SPECIAL?

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# ULTRA-DIFFUSE GALAXIES

# SO...IT IS POPULAR...

At least 201 papers since 2015...

ultra diffuse galaxies [edit](#)

**description** [edit](#)

My ADS library

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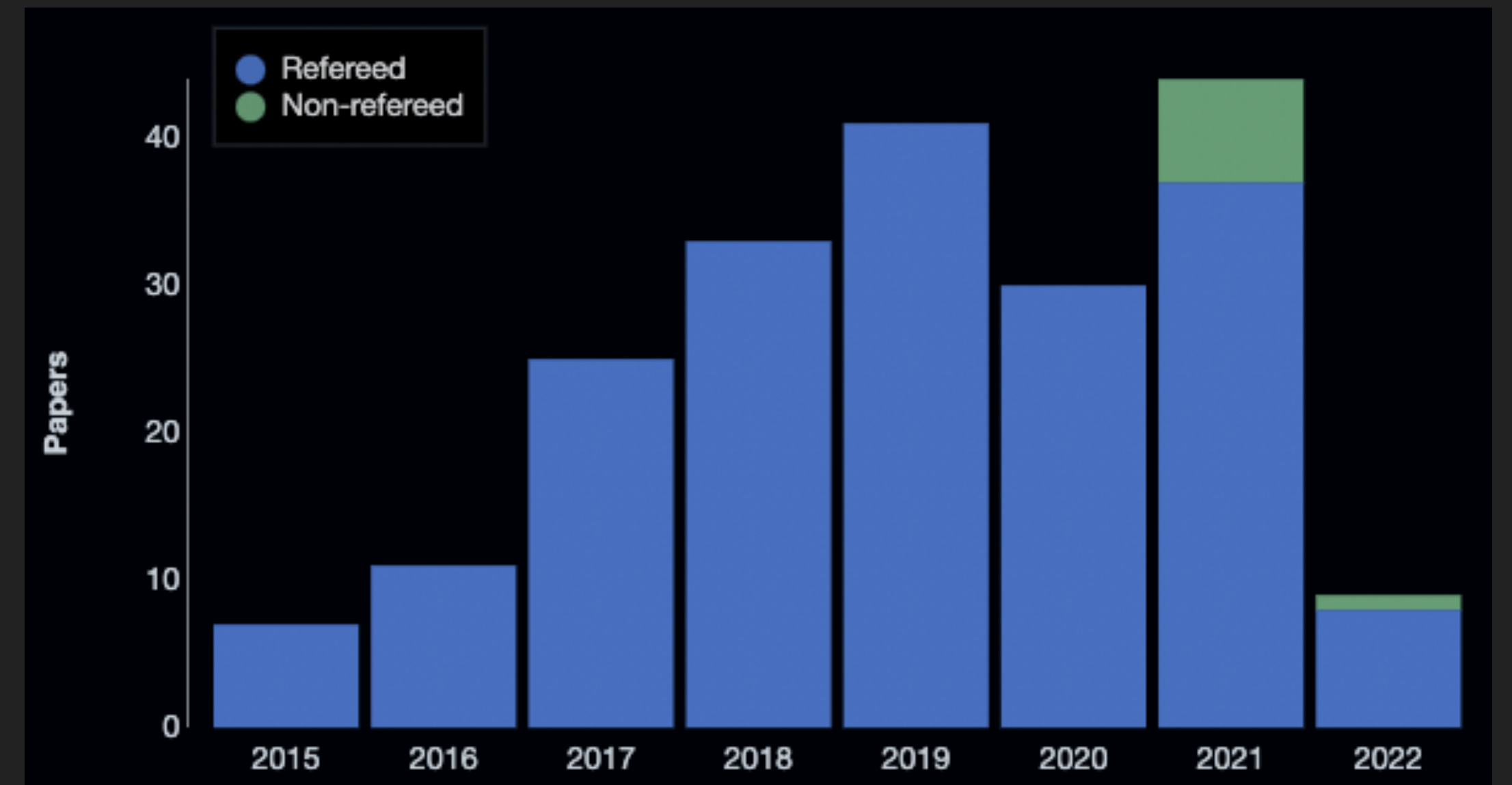
**Number of Papers:** 201

**Date Created:** Mar 3 2022, 10:54pm

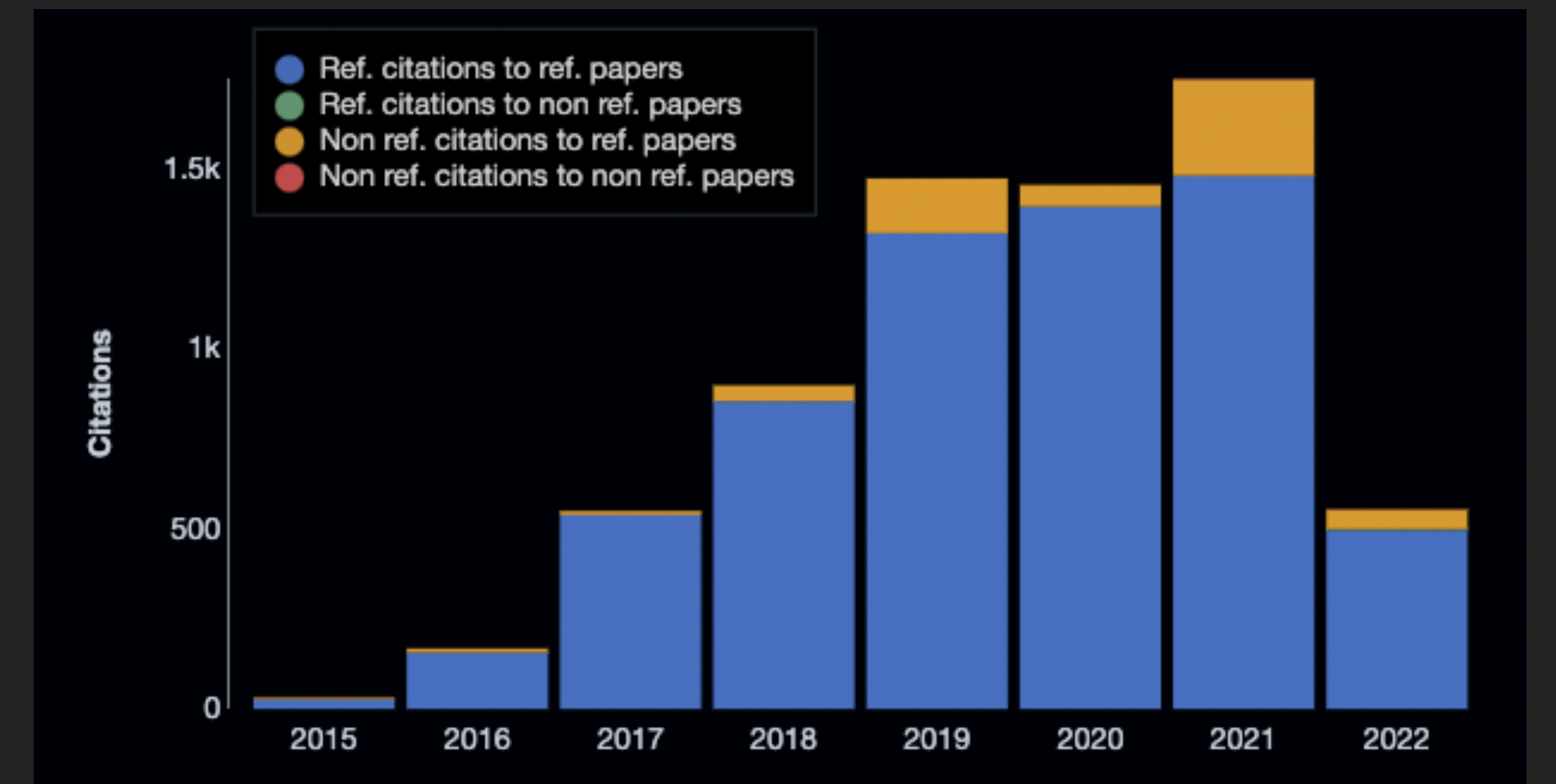


The library is public if you are interested...

## Publication



## Citation



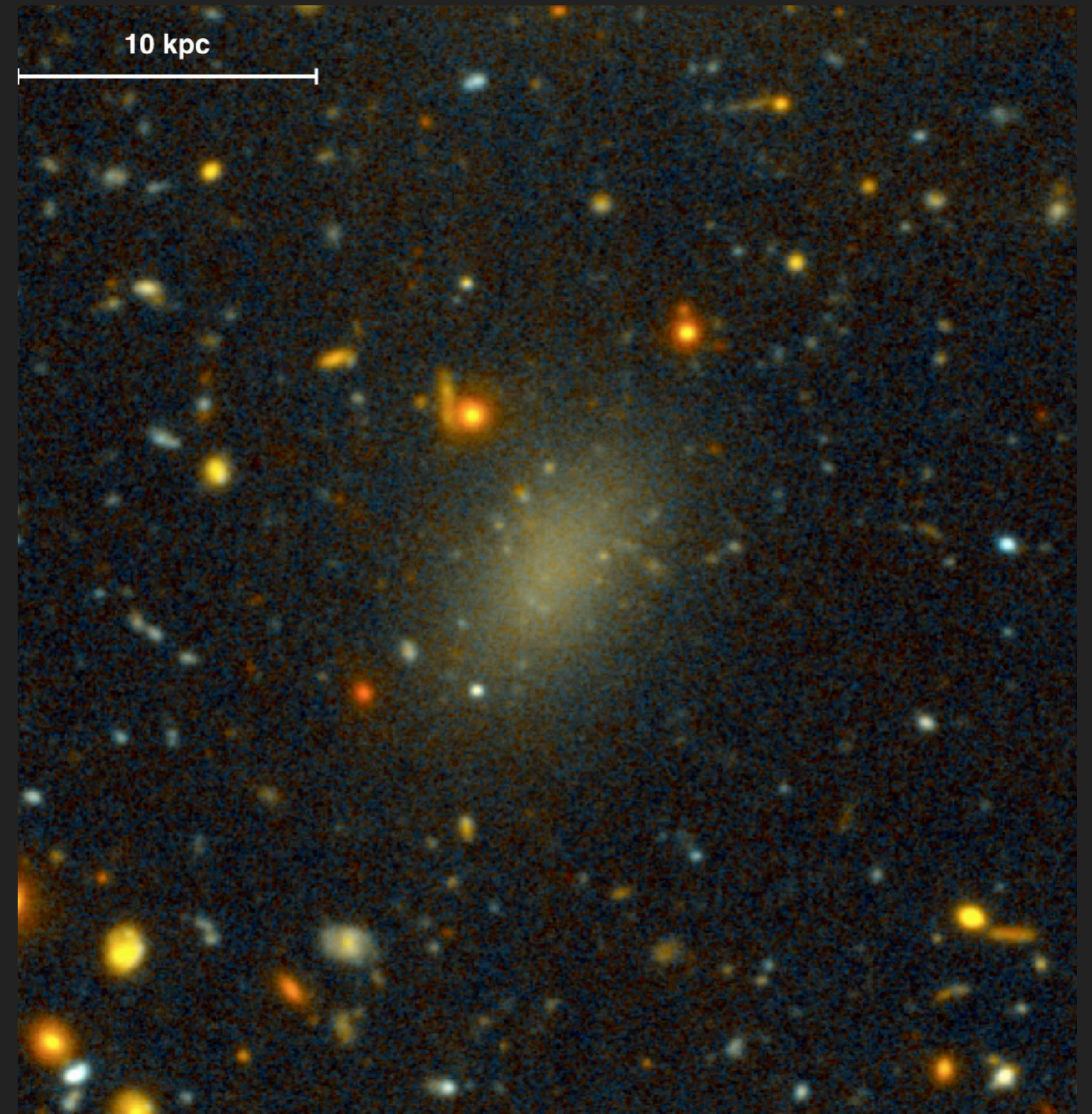


## A PERSONAL VIEW

- ▶ From an observational point-of-view
- ▶ I am very biased
- ▶ It is highly incomplete...

## WHAT I WILL COVER TODAY

- ▶ **7** basic facts (given what we know for now)
- ▶ **2** controversial (and open) questions
- ▶ **2** positive and **2** negative aspects of this topic



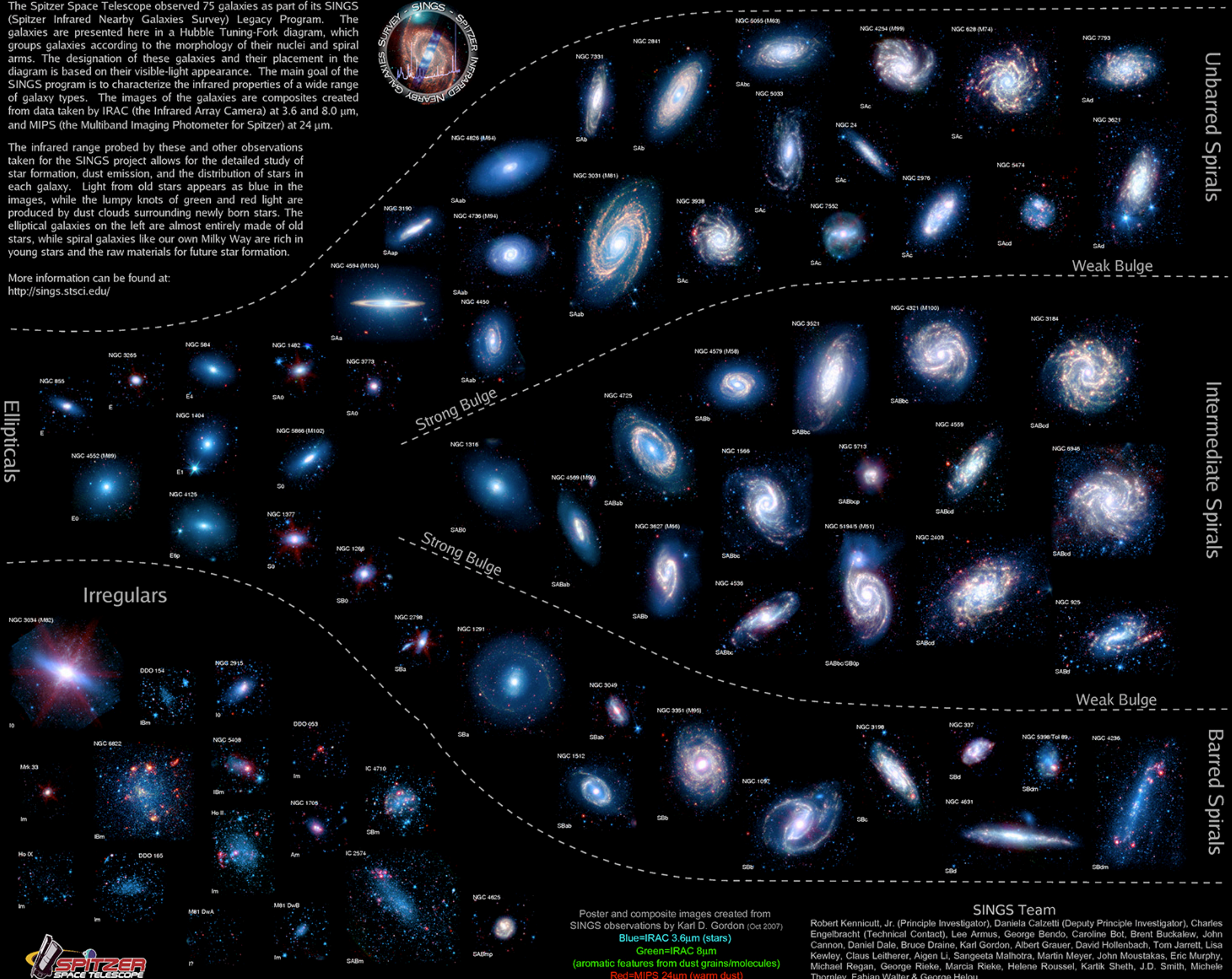


# The Spitzer Infrared Nearby Galaxies Survey (SINGS) Hubble Tuning-Fork

The Spitzer Space Telescope observed 75 galaxies as part of its SINGS (Spitzer Infrared Nearby Galaxies Survey) Legacy Program. The galaxies are presented here in a Hubble Tuning-Fork diagram, which groups galaxies according to the morphology of their nuclei and spiral arms. The designation of these galaxies and their placement in the diagram is based on their visible-light appearance. The main goal of the SINGS program is to characterize the infrared properties of a wide range of galaxy types. The images of the galaxies are composites created from data taken by IRAC (the Infrared Array Camera) at 3.6 and 8.0  $\mu\text{m}$ , and MIPS (the Multiband Imaging Photometer for Spitzer) at 24  $\mu\text{m}$ .

The infrared range probed by these and other observations taken for the SINGS project allows for the detailed study of star formation, dust emission, and the distribution of stars in each galaxy. Light from old stars appears as blue in the images, while the lumpy knots of green and red light are produced by dust clouds surrounding newly born stars. The elliptical galaxies on the left are almost entirely made of old stars, while spiral galaxies like our own Milky Way are rich in young stars and the raw materials for future star formation.

More information can be found at:  
<http://sings.stsci.edu/>



So, why do we think UDGs are special ?

Or...What is a UDG?

Poster and composite images created from SINGS observations by Karl D. Gordon (Oct 2007)  
 Blue=IRAC 3.6 $\mu\text{m}$  (stars)  
 Green=IRAC 8 $\mu\text{m}$  (aromatic features from dust grains/molecules)  
 Red=MIPS 24 $\mu\text{m}$  (warm dust)

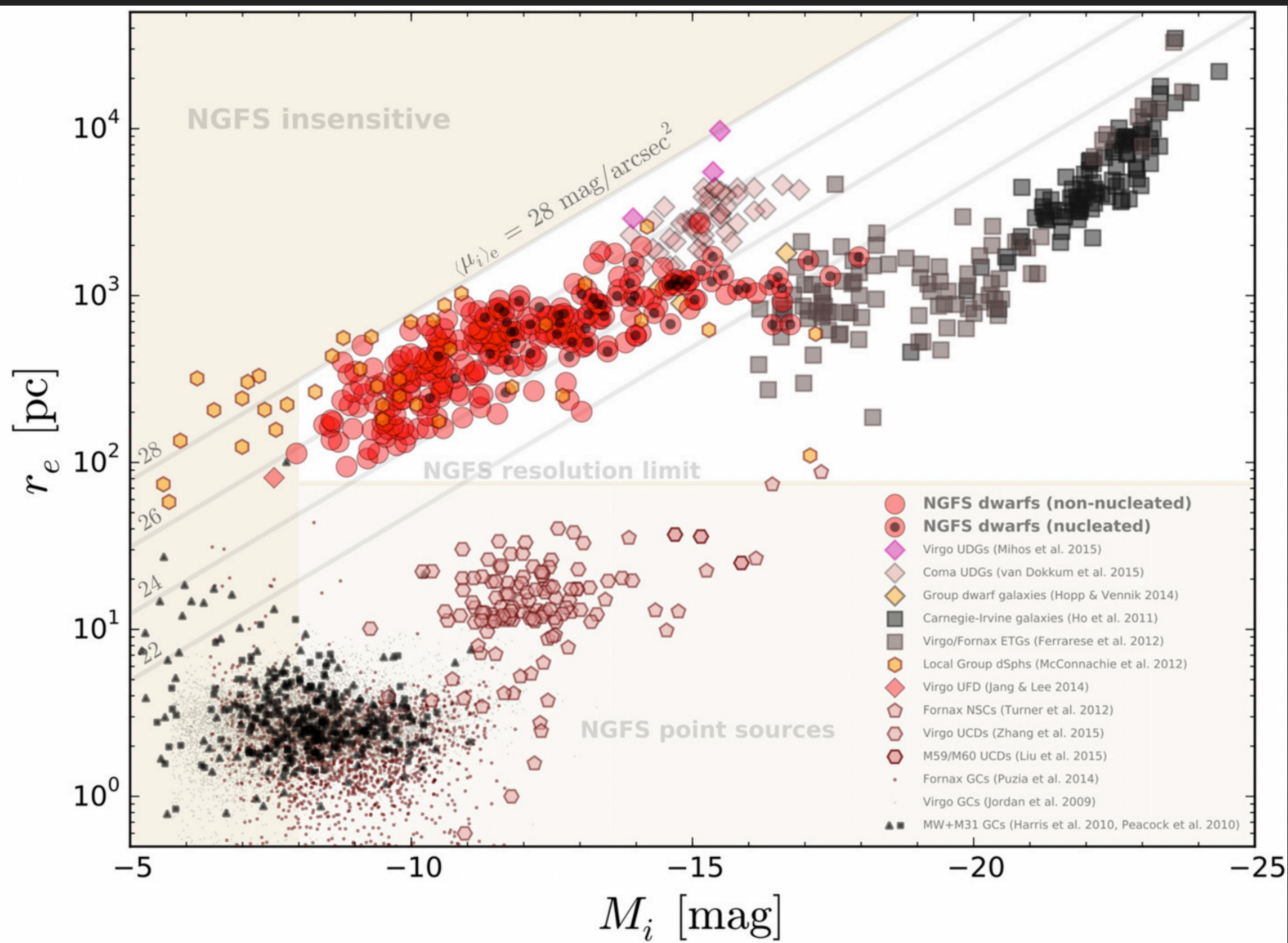
**SINGS Team**  
 Robert Kennicutt, Jr. (Principle Investigator), Daniela Calzetti (Deputy Principle Investigator), Charles Engelbracht (Technical Contact), Lee Armus, George Bendo, Caroline Bot, Brent Buckalew, John Cannon, Daniel Dale, Bruce Draine, Karl Gordon, Albert Grauer, David Hollenbach, Tom Jarrett, Lisa Kewley, Claus Leitherer, Aigen Li, Sangeeta Malhotra, Martin Meyer, John Moustakas, Eric Murphy, Michael Regan, George Rieke, Marcia Rieke, Helene Roussel, Kartik Sheth, J.D. Smith, Michele Thornley, Fabian Walter & George Helou





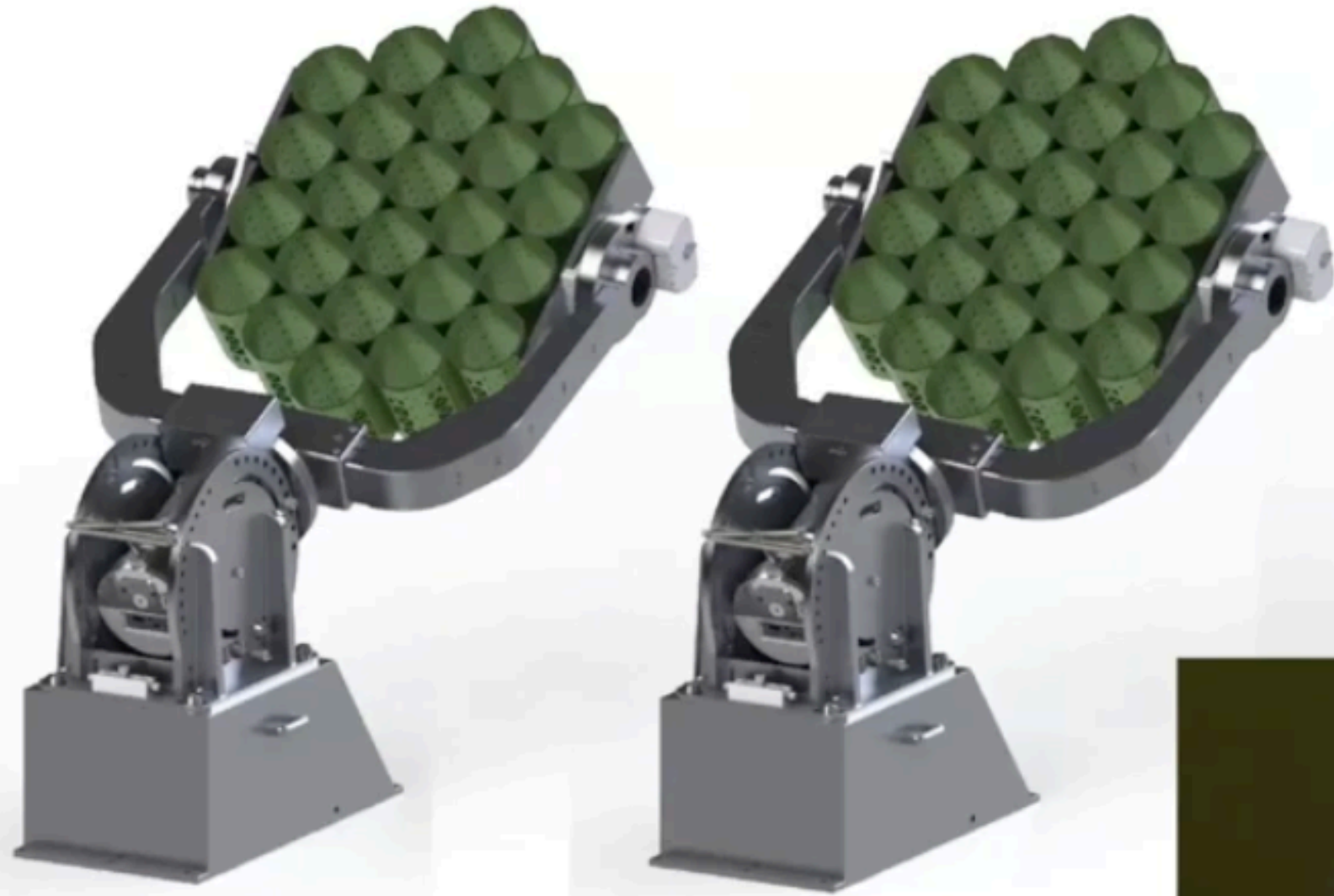
**LET'S GET BACK TO THE DRAWING BOARD**







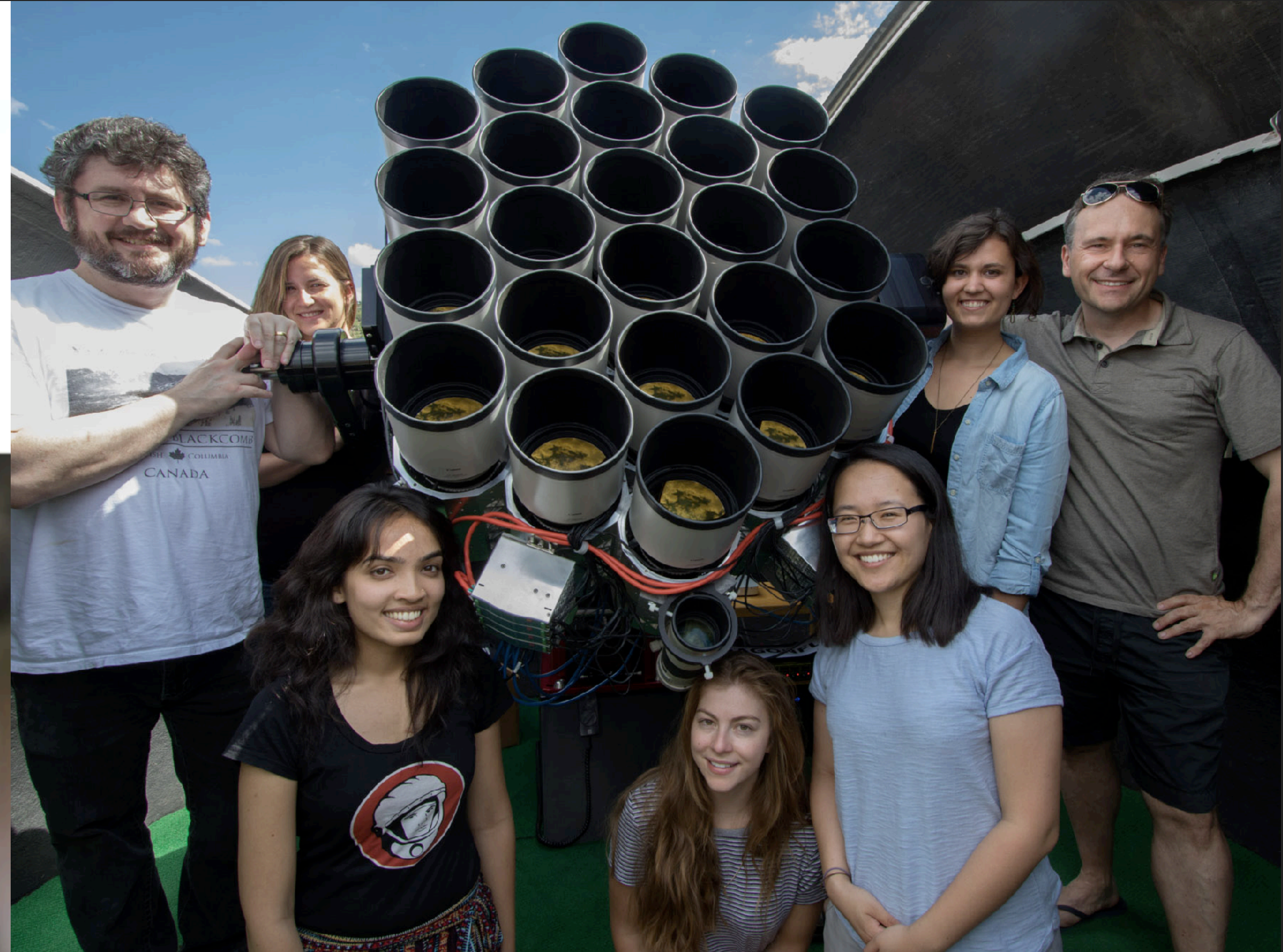
# THE BEGINNING...



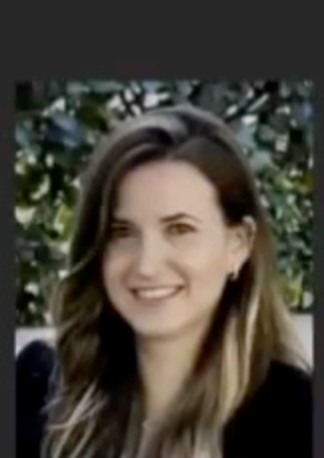
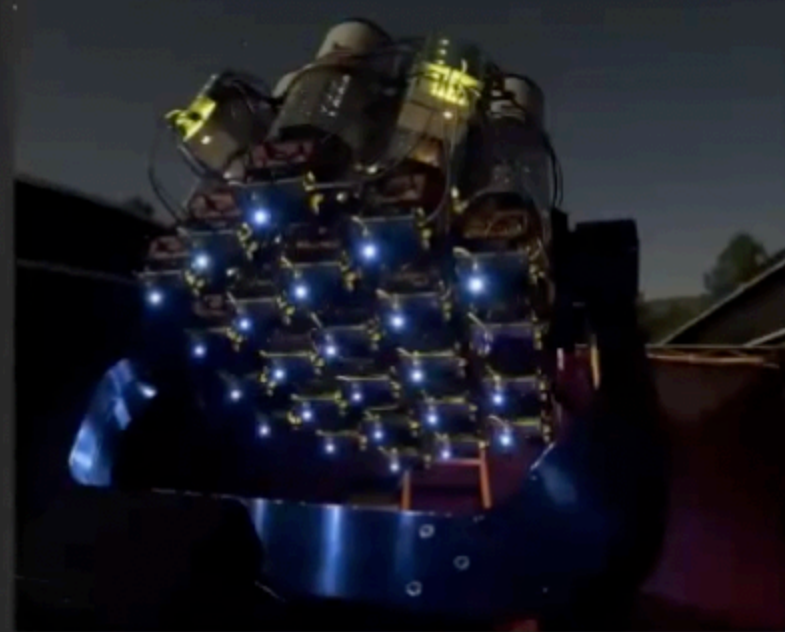
ommateum

## The Dragonfly Telephoto Array

48 high end telephoto lenses  
equivalent to 1m diameter, f/0.4 refractor  
superb optics  
(Abraham & van Dokkum 2014,  
Merritt et al. 2016, Danieli et al. 2020)







Shany Danieli



Zili Shen



Dhruba Dutta Chowdhury



Deborah Lokhorst



Pieter van Dokkum

# Galaxies lacking dark matter

- Pieter van Dokkum
- Shany Danieli
- Zili Shen
- Asher Wasserman
- Dhruba Dutta Chowdhury
- Allison Merritt
- Jielai Zhang
- Deborah Lokhorst
- Colleen Gilhuly
- Roberto Abraham
- Aaron Romanowsky
- Charlie Conroy
- Ava Polzin
- Tim Miller
- Jiaxuan Li
- Diederik Kruijssen
- Michael Keim



.07 / 1:04:00



Pieter van Dokkum: Ultra-diffuse galaxies and their implications for galaxy formation and evolution

213次观看 · 2021年7月15日

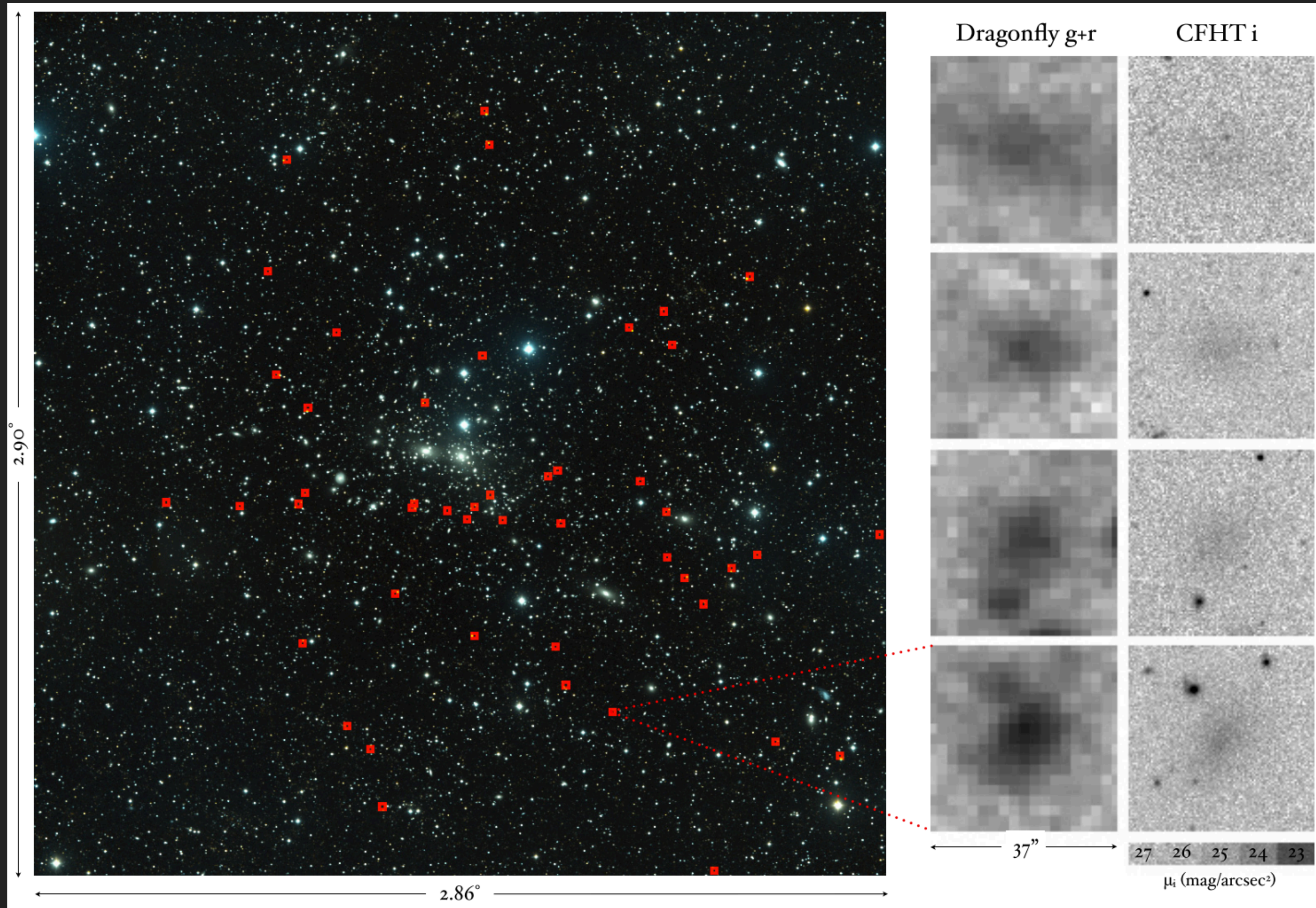
👍 6 🗨️ 踩 🔄 分享 📌 保存 ...



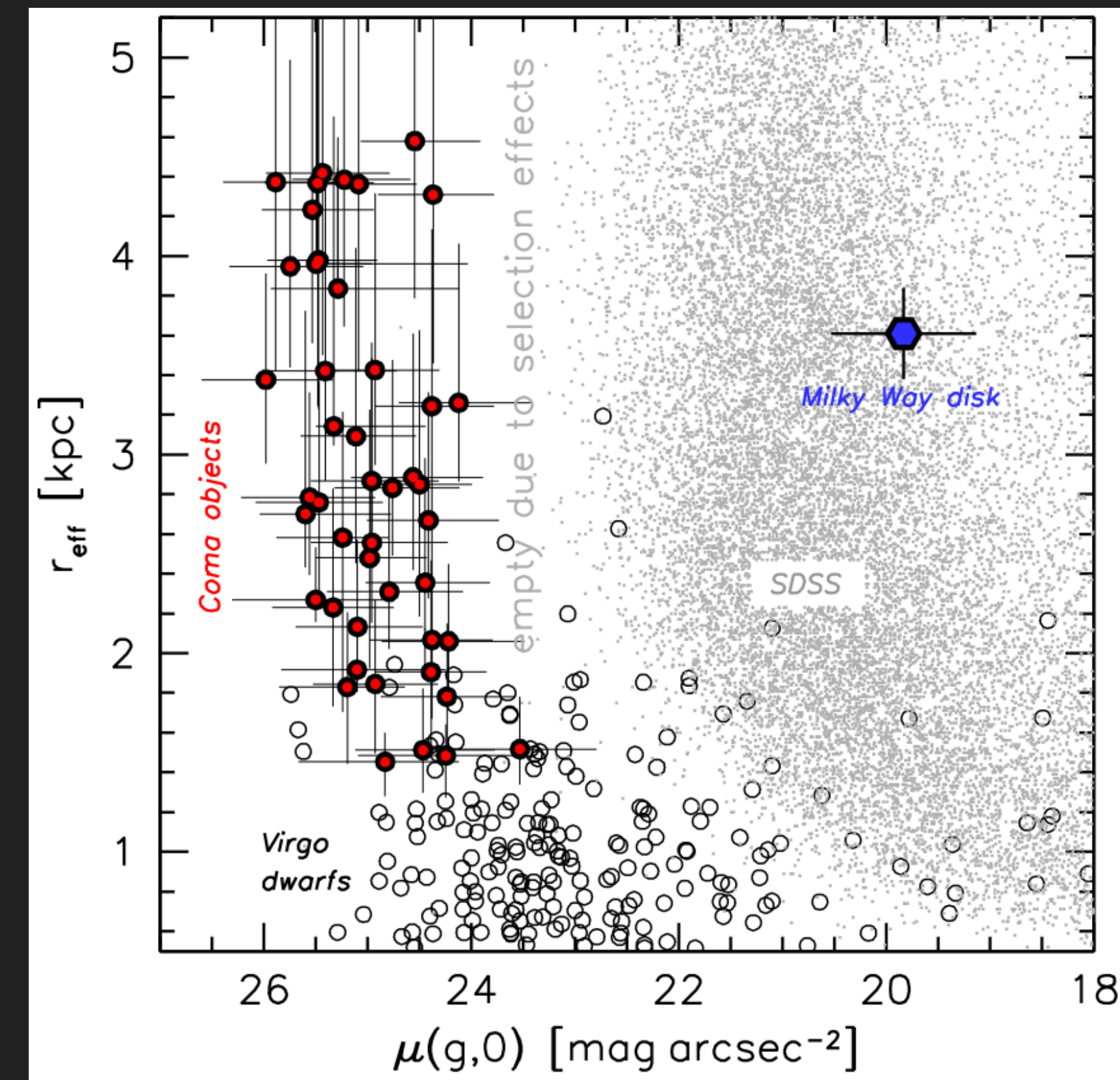
Anna Franckowiak: Multi-messenger Astronomy with...  
AstronomyHeidelberg



# 47 "SMUDGES" IN THE COMA CLUSTER



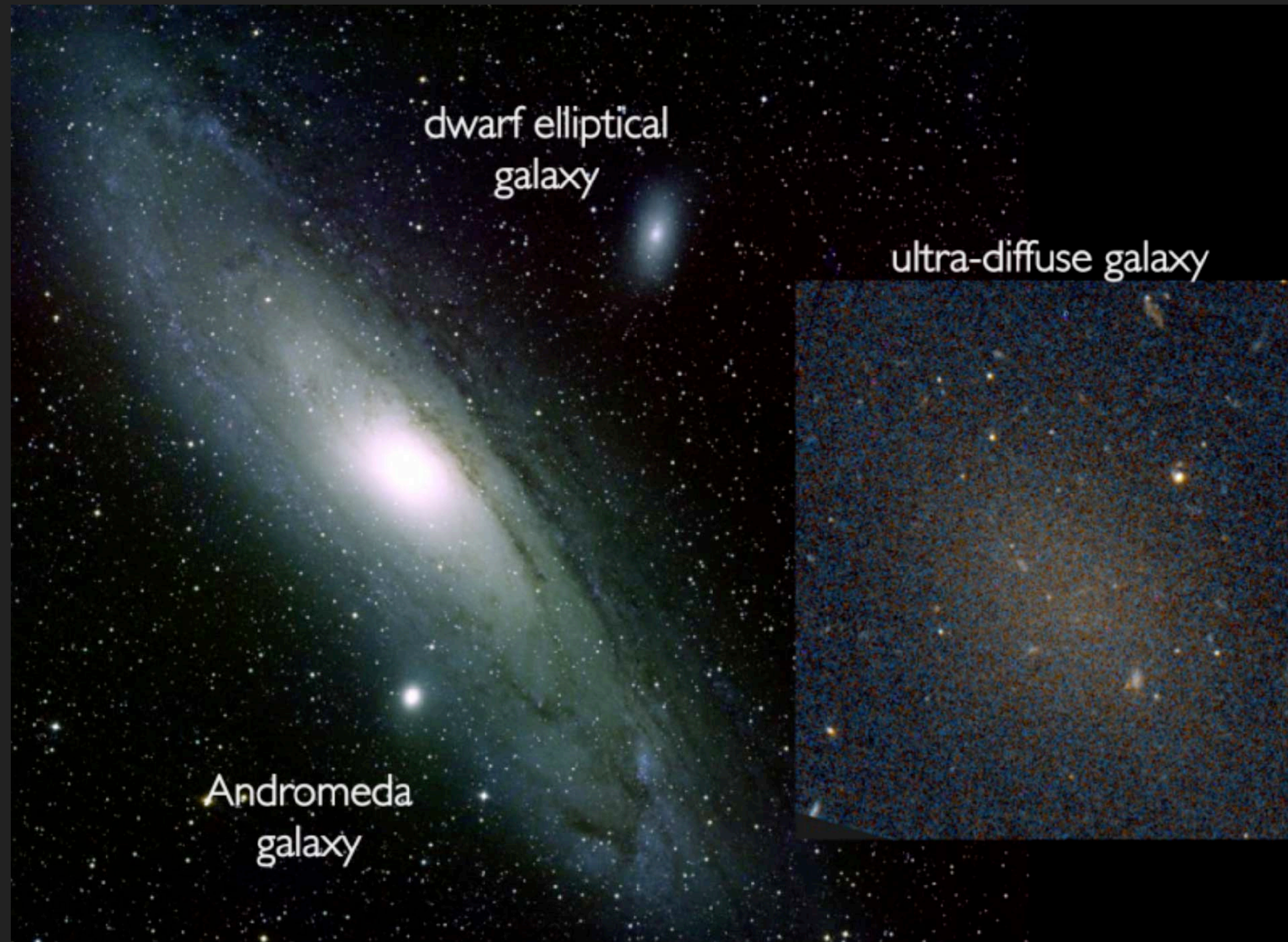
van Dokkum et al. 2015





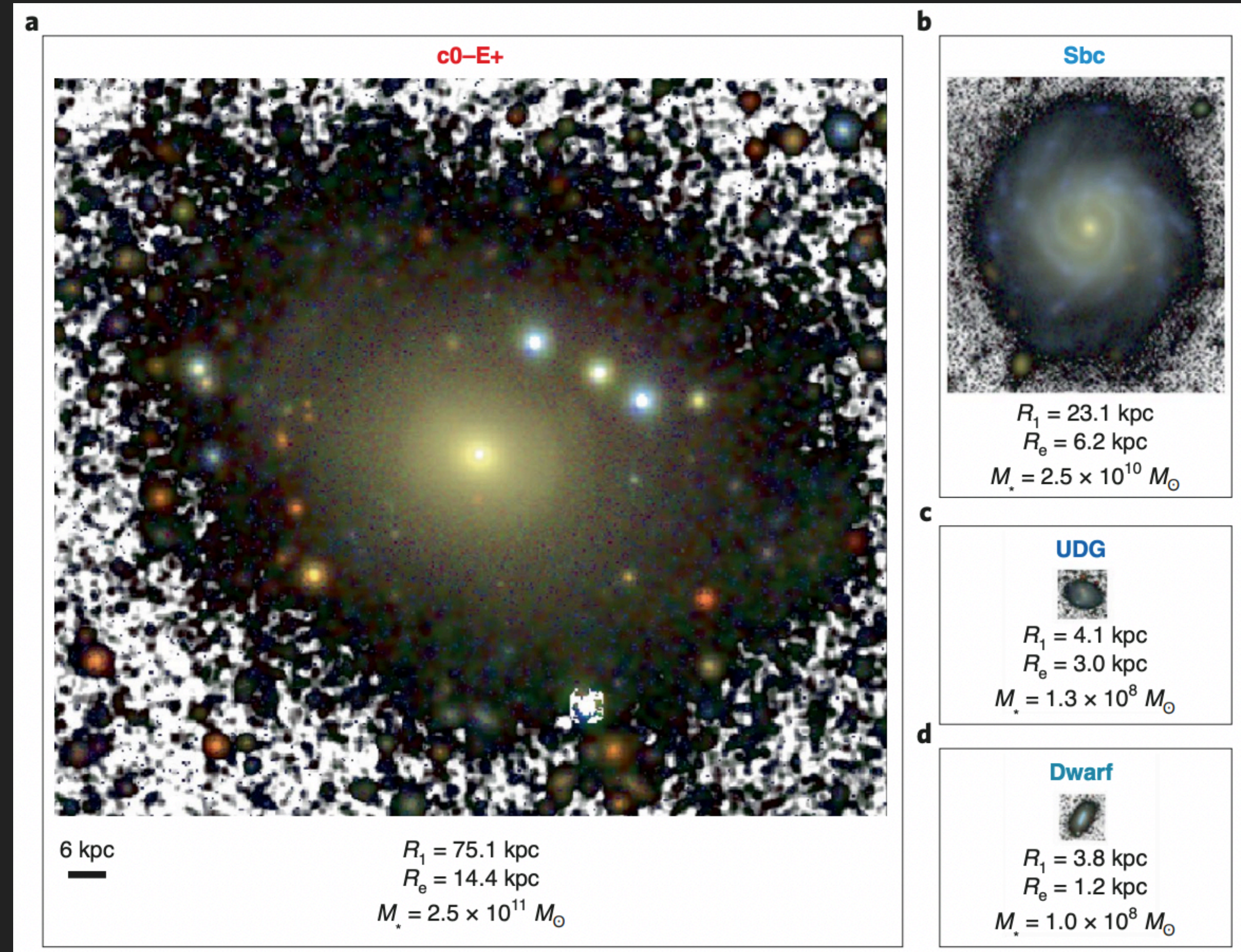
# “MILKY WAY SIZE” GALAXY?

van Dokkum et al. 2015



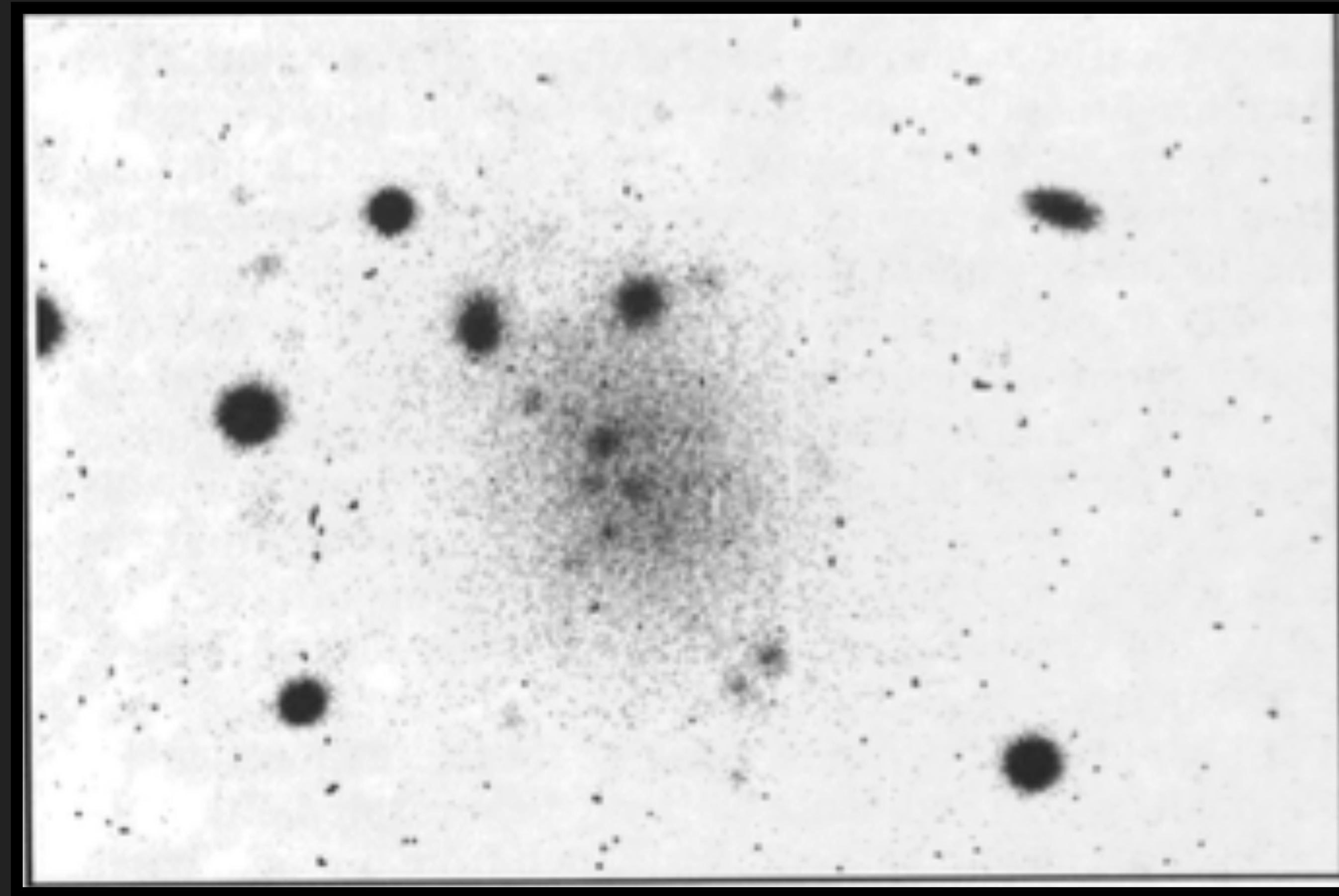
# Who's Right?

Trujillo 2021





# Low-Surface Brightness (LSB) Dwarf Galaxies



Bothun+1991

in Fornax

Also see:

Impey+1988;

Turner+1993

Dalacanton+1997

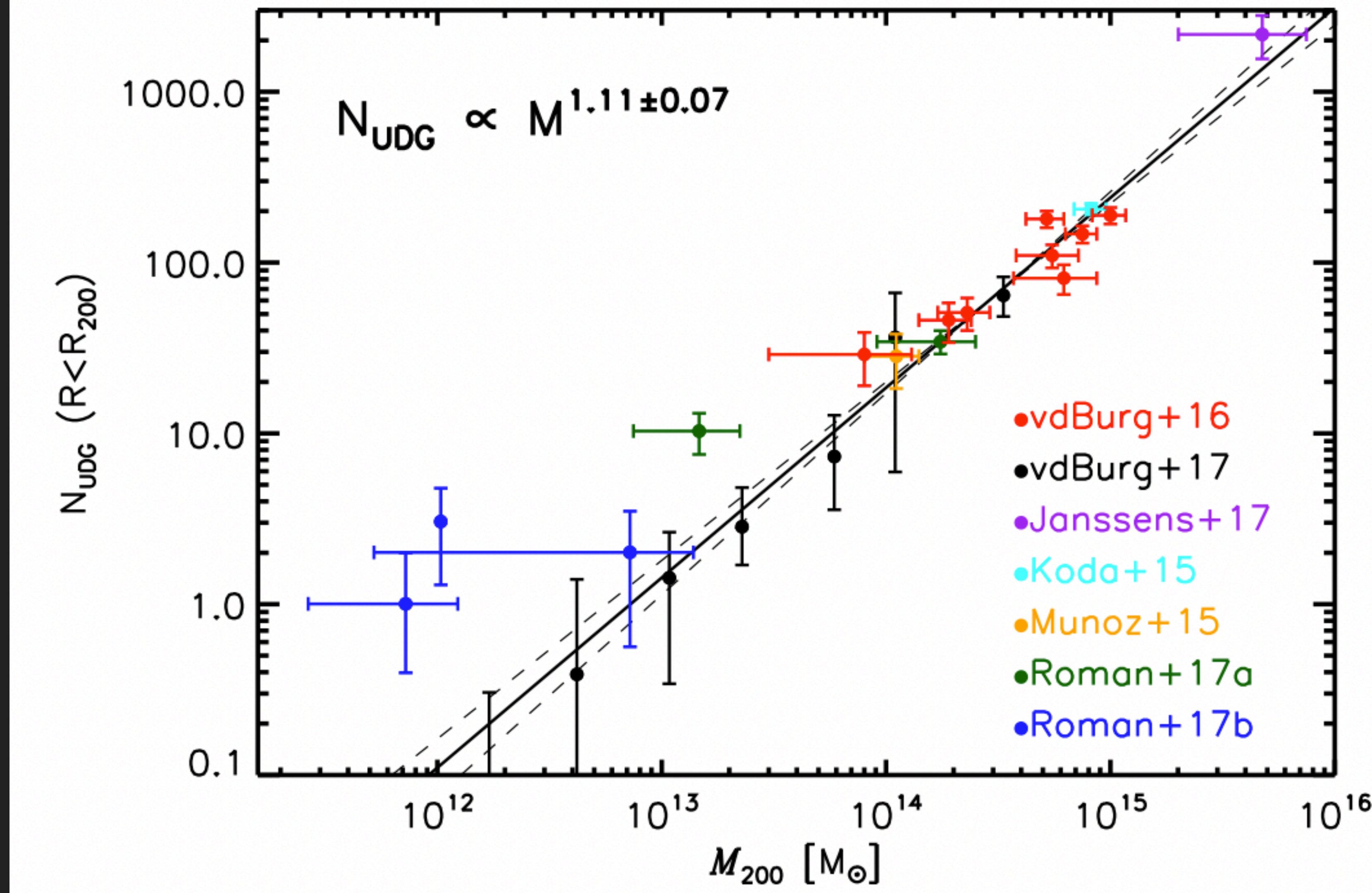
Caldwell 2006

Why haven't people notice they are "special" before?

1

FACT

They are everywhere



2

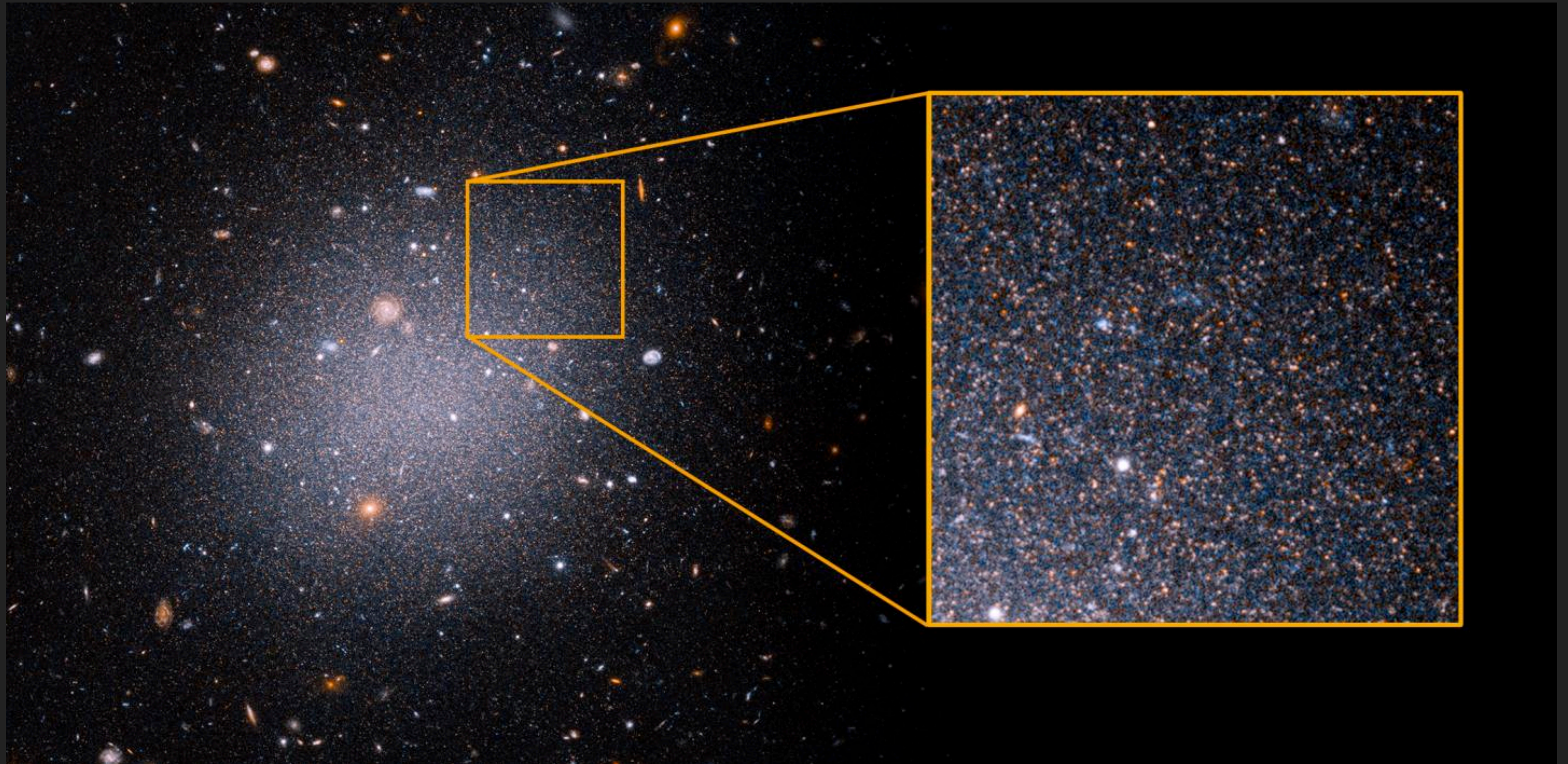
FACT

Ah...Distance...What a  
cursed word in astronomy



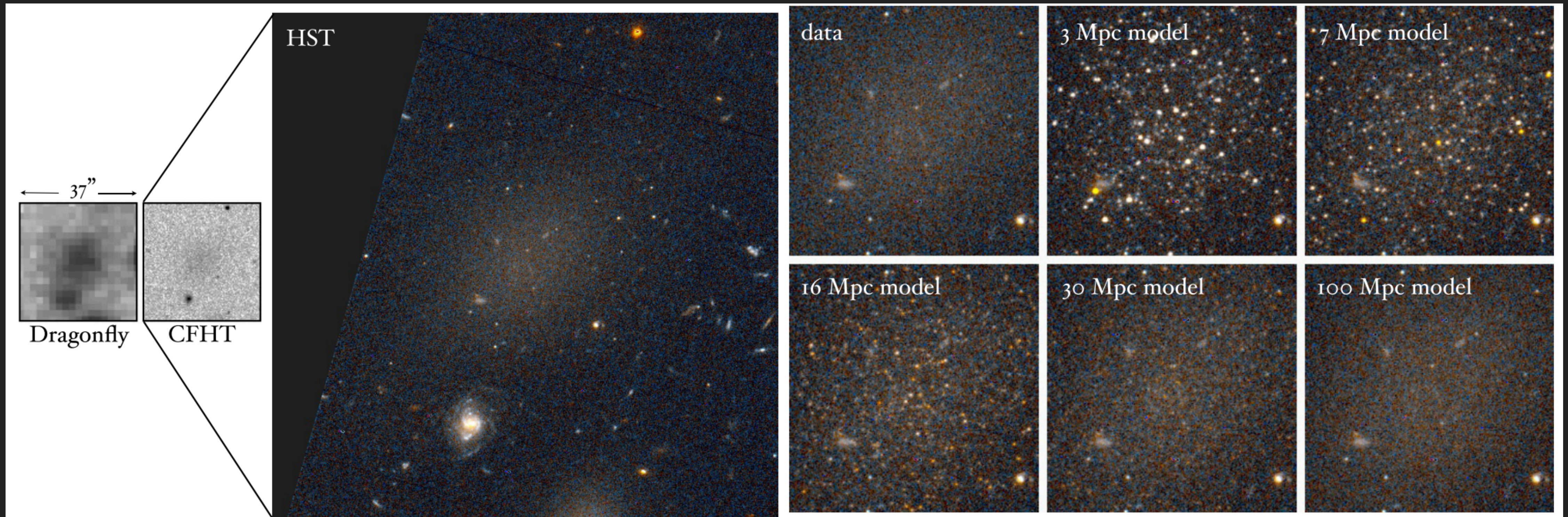
Why redshift or line-of-sight velocity is no longer good?

How do you measure the distance of them?





# Surface Brightness Fluctuation





3

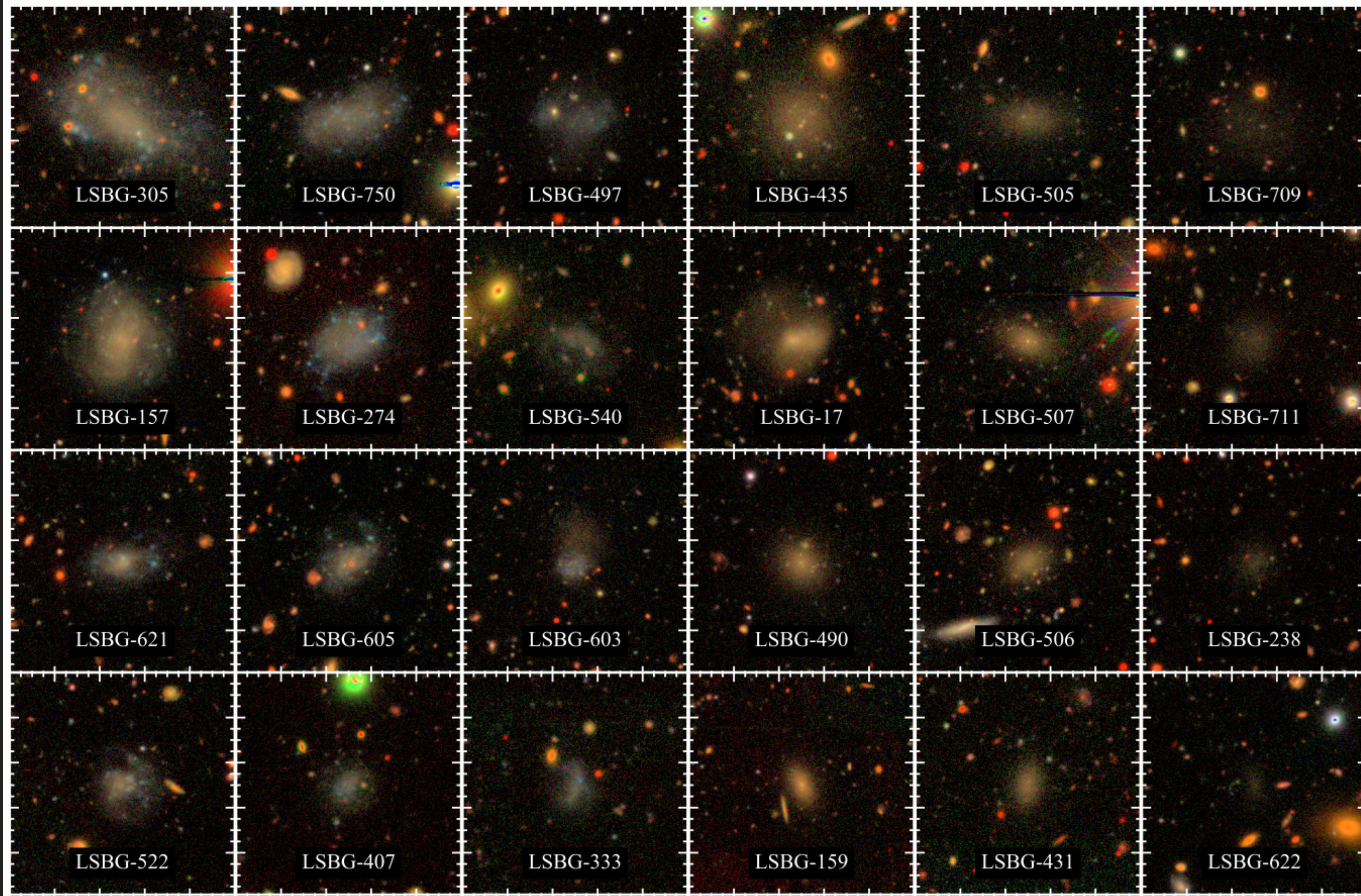
FACT

There is a range of looks...



Blue LSBGs

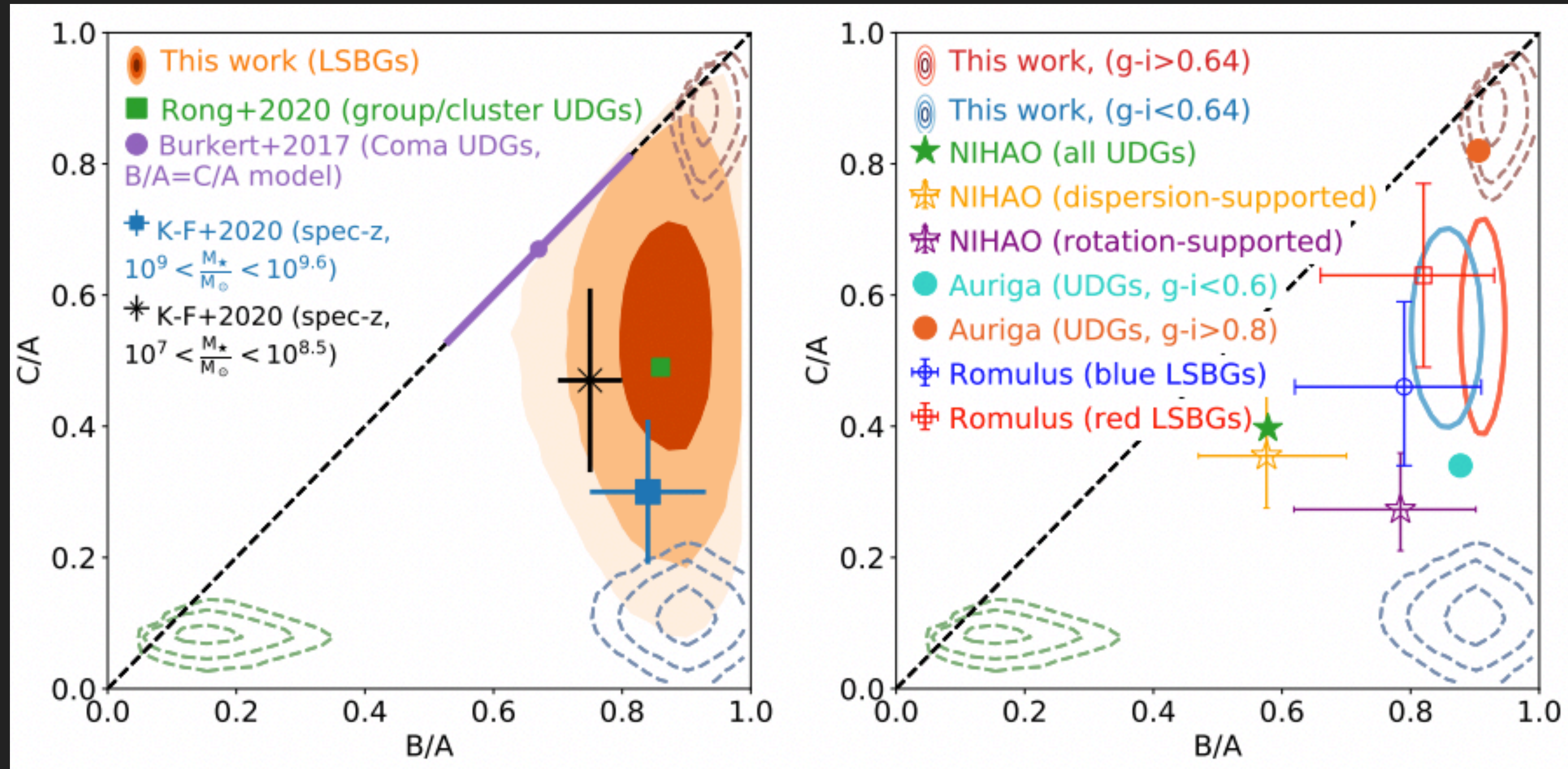
Red LSBGs





# Intrinsic Shape: between a football and a frisby

Kado-Fong et al. 2021



4

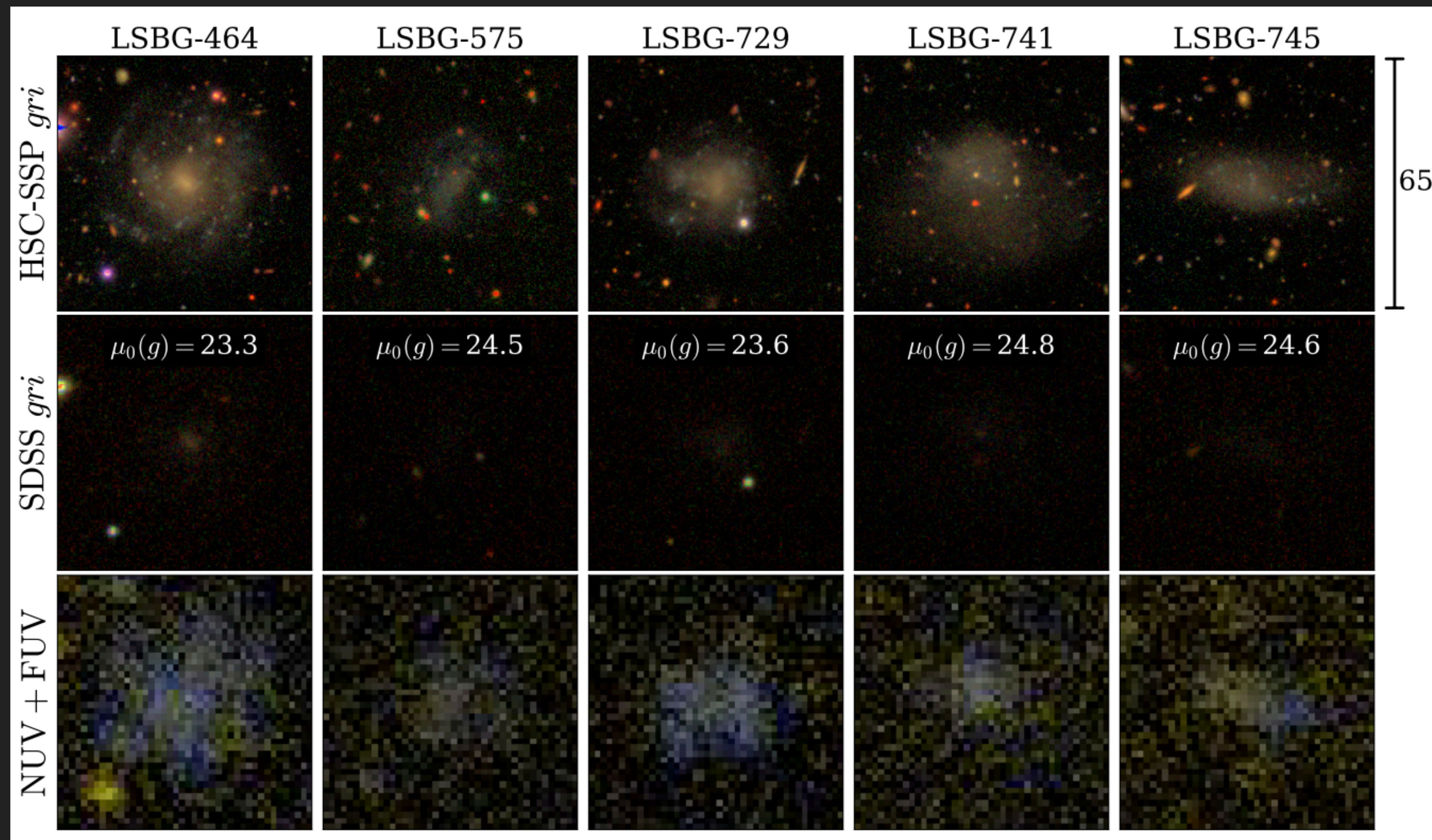
FACT

Yes, they can form stars;  
Yes, they can be gas rich



# Mostly not in cluster environment; Also has emission line detections

Greco et al. 2018



Also see "HI-rich LSB/UDGs"

5

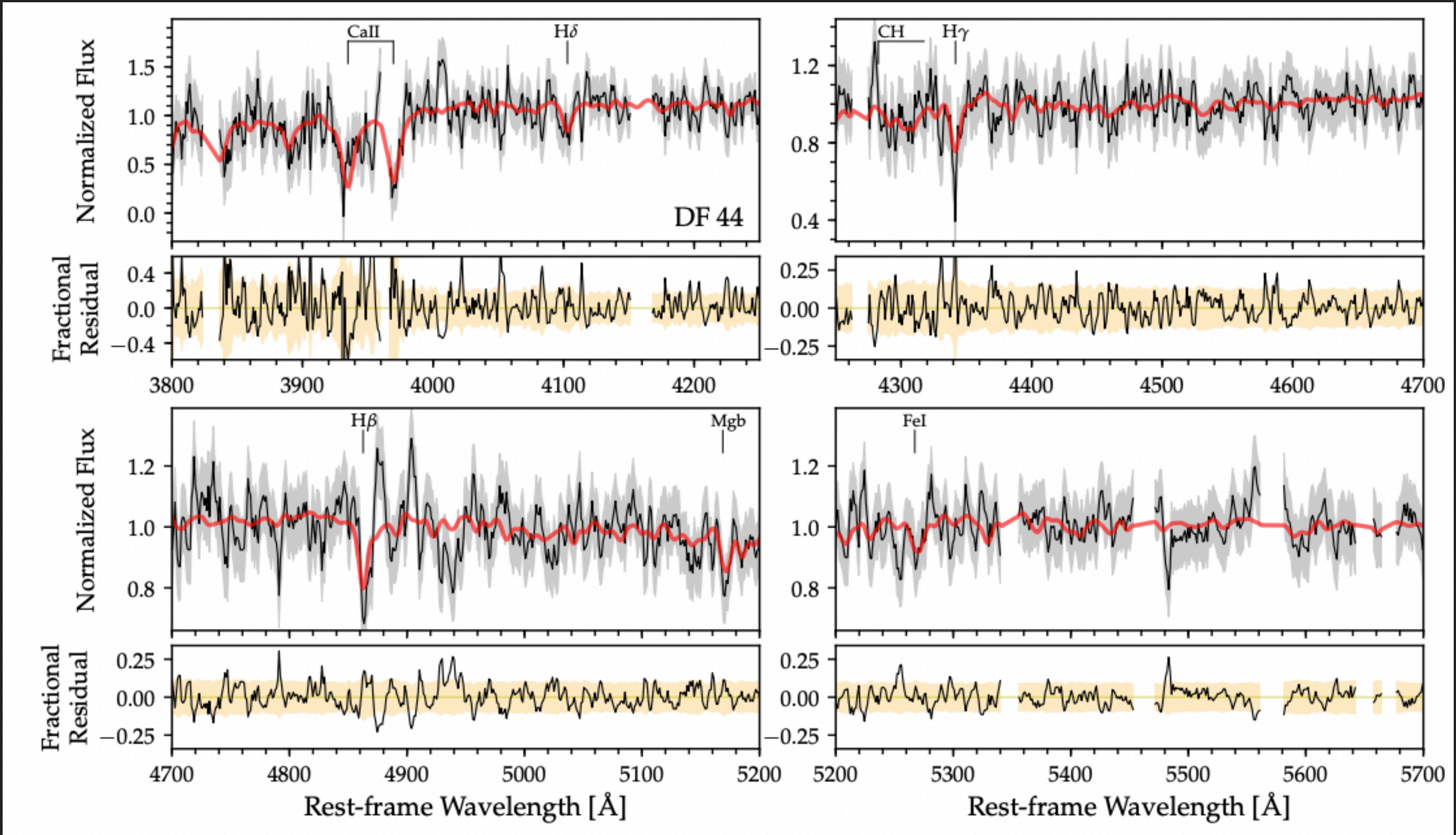
FACT

Stellar population and Star  
Formation history are diverse as well



# Spectroscopic observation is extremely difficult...

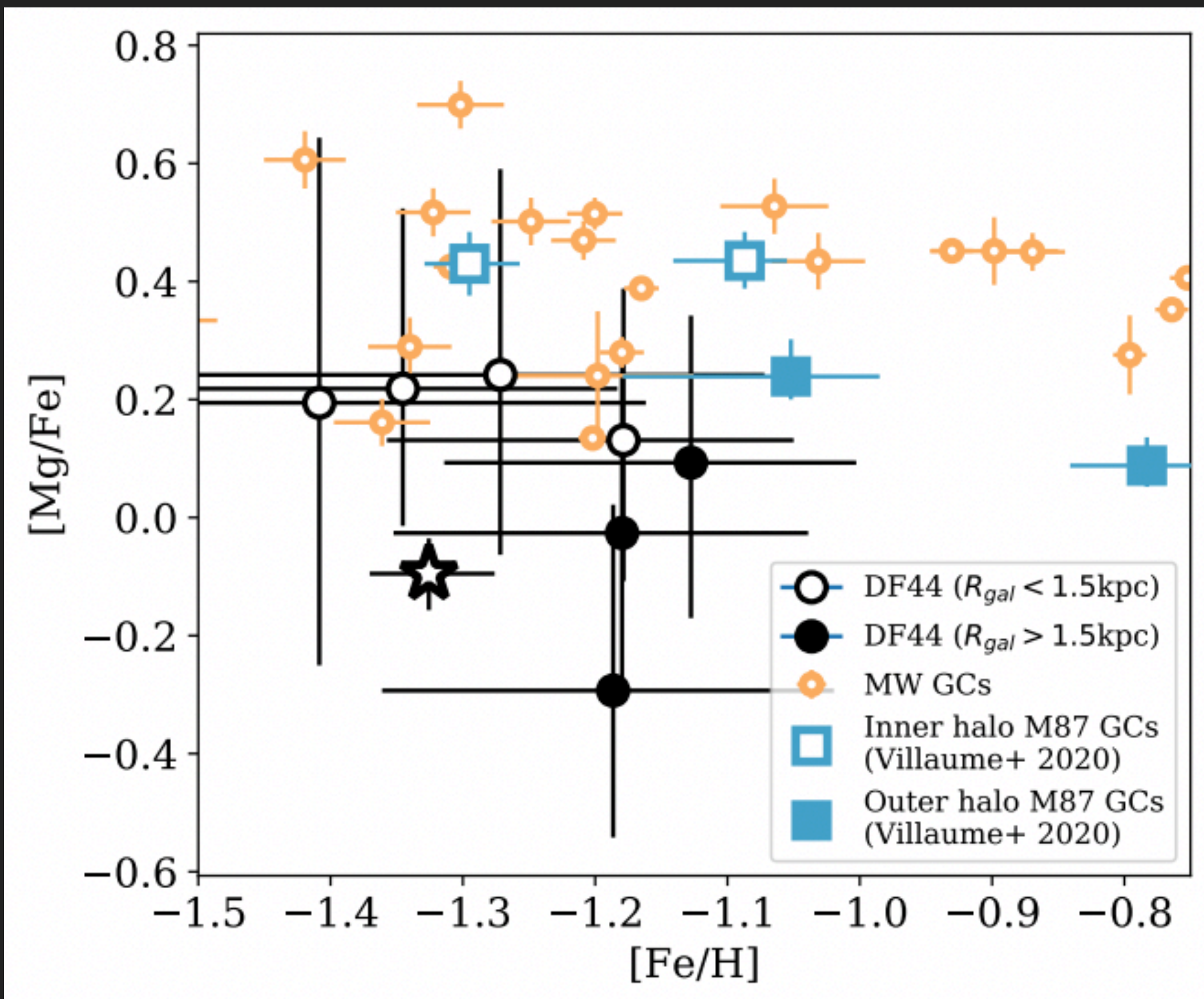
Gu et al. 2017



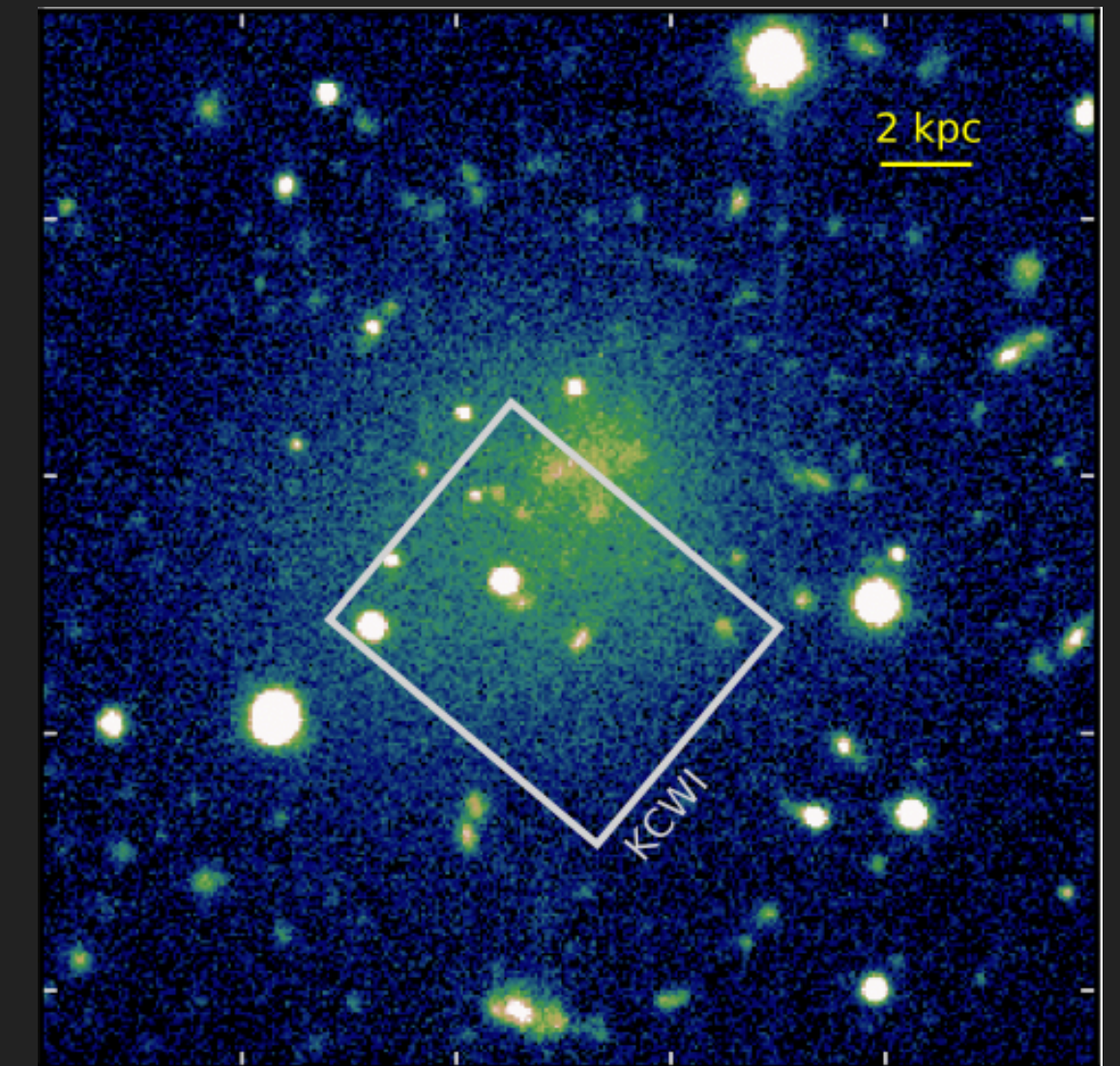
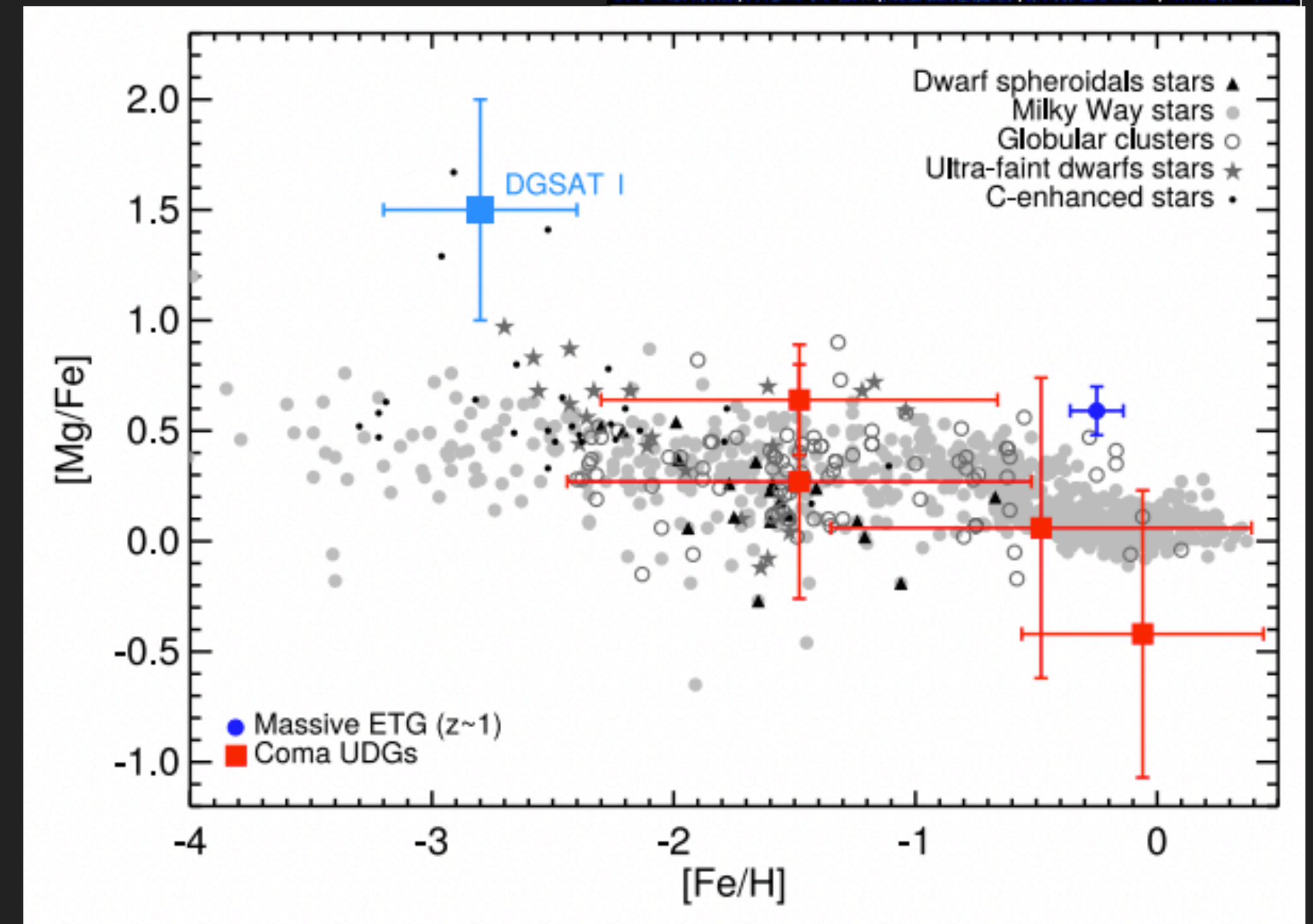


# UDGs can show very broad range of star formation efficiency

Villaume et al. 2021



Martin-Navarro et al. 2019





6

FACT

They are mysterious little  
jewelry boxes...

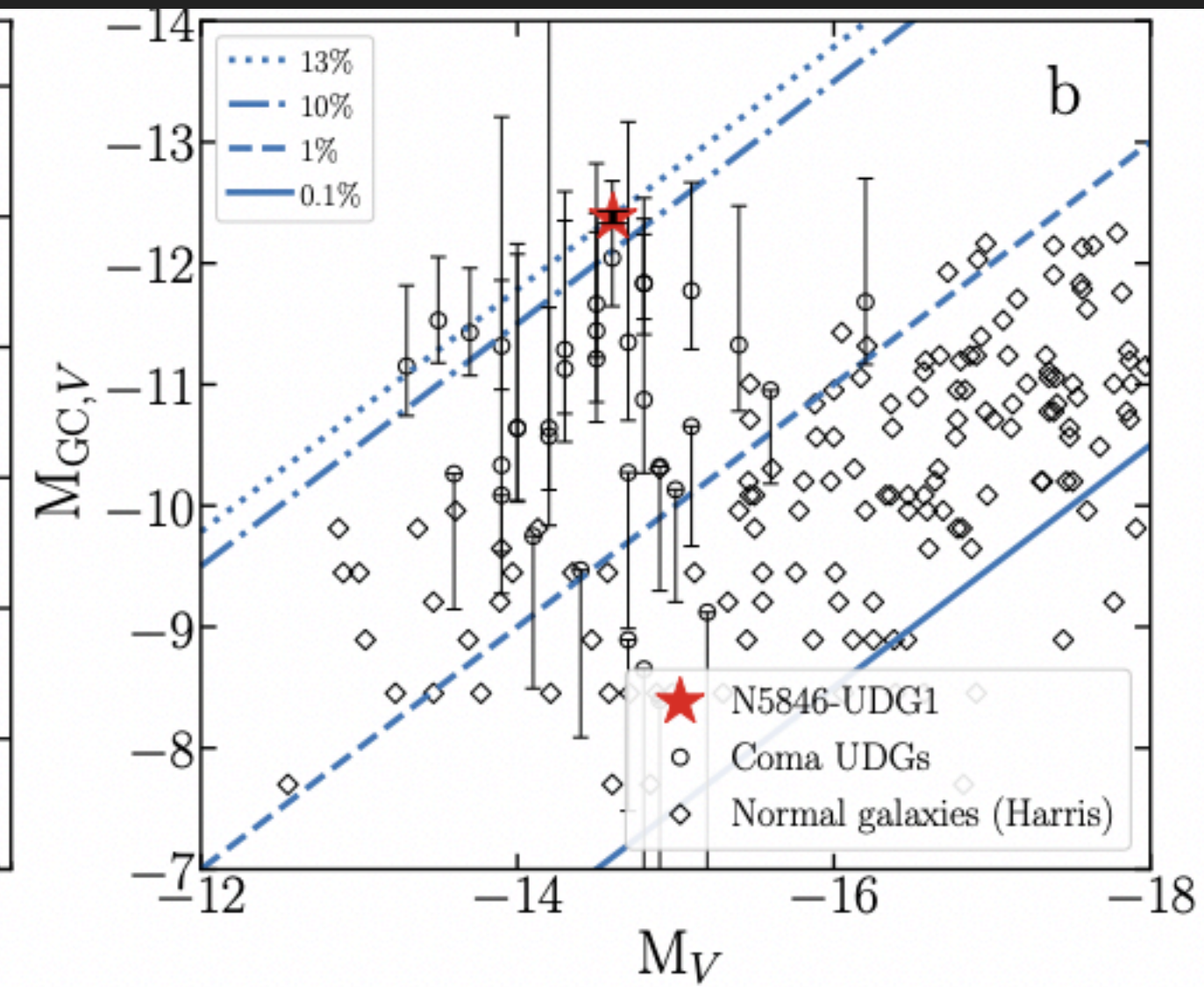
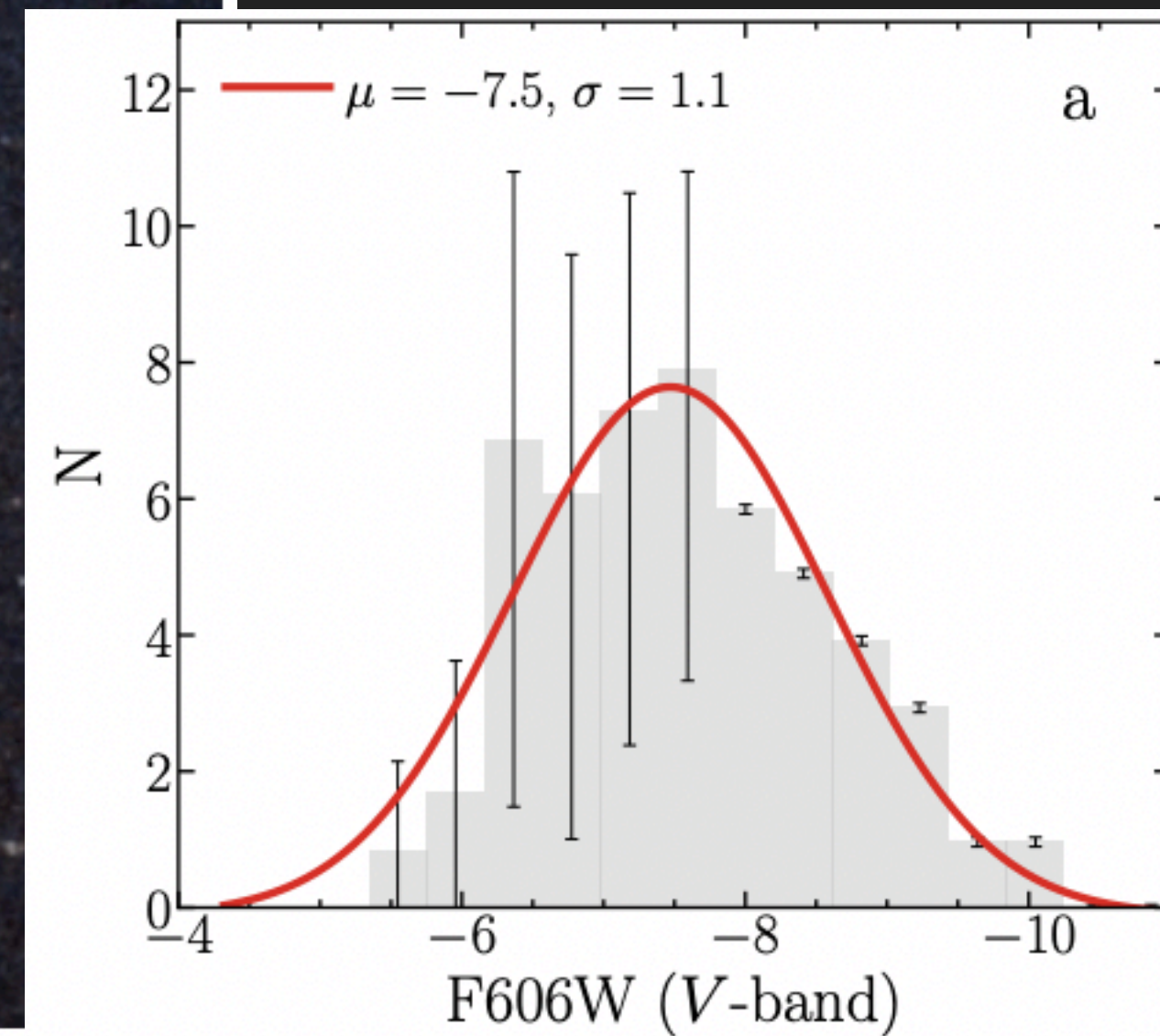
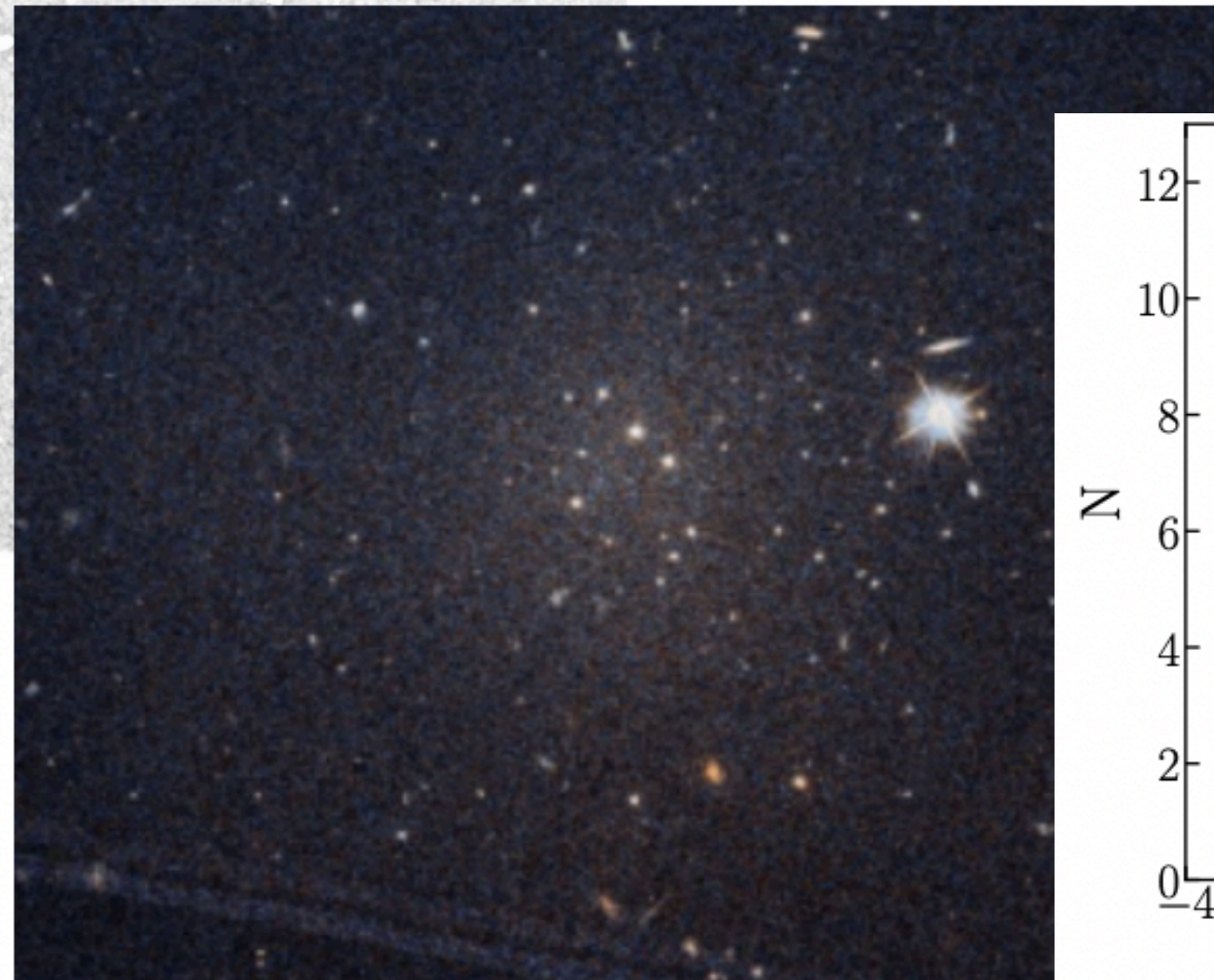


HST WFC3/UVIS F606W (1 orbit)

1 kpc

Danieli et al. 2021

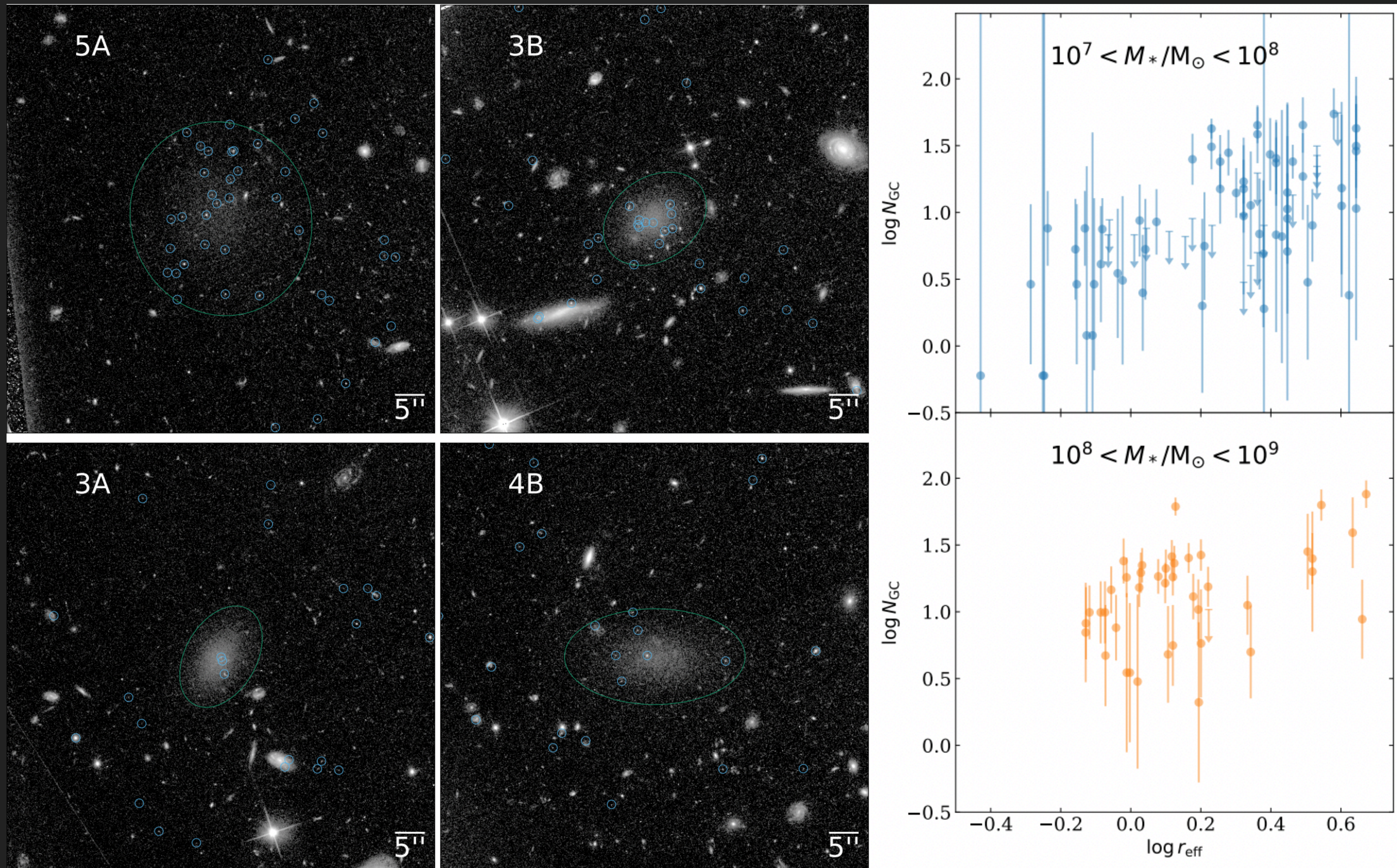
Why do we care about GCs in these systems?





# There is a wide range of GC abundance

Somalwar et al. 2020





7

FACT

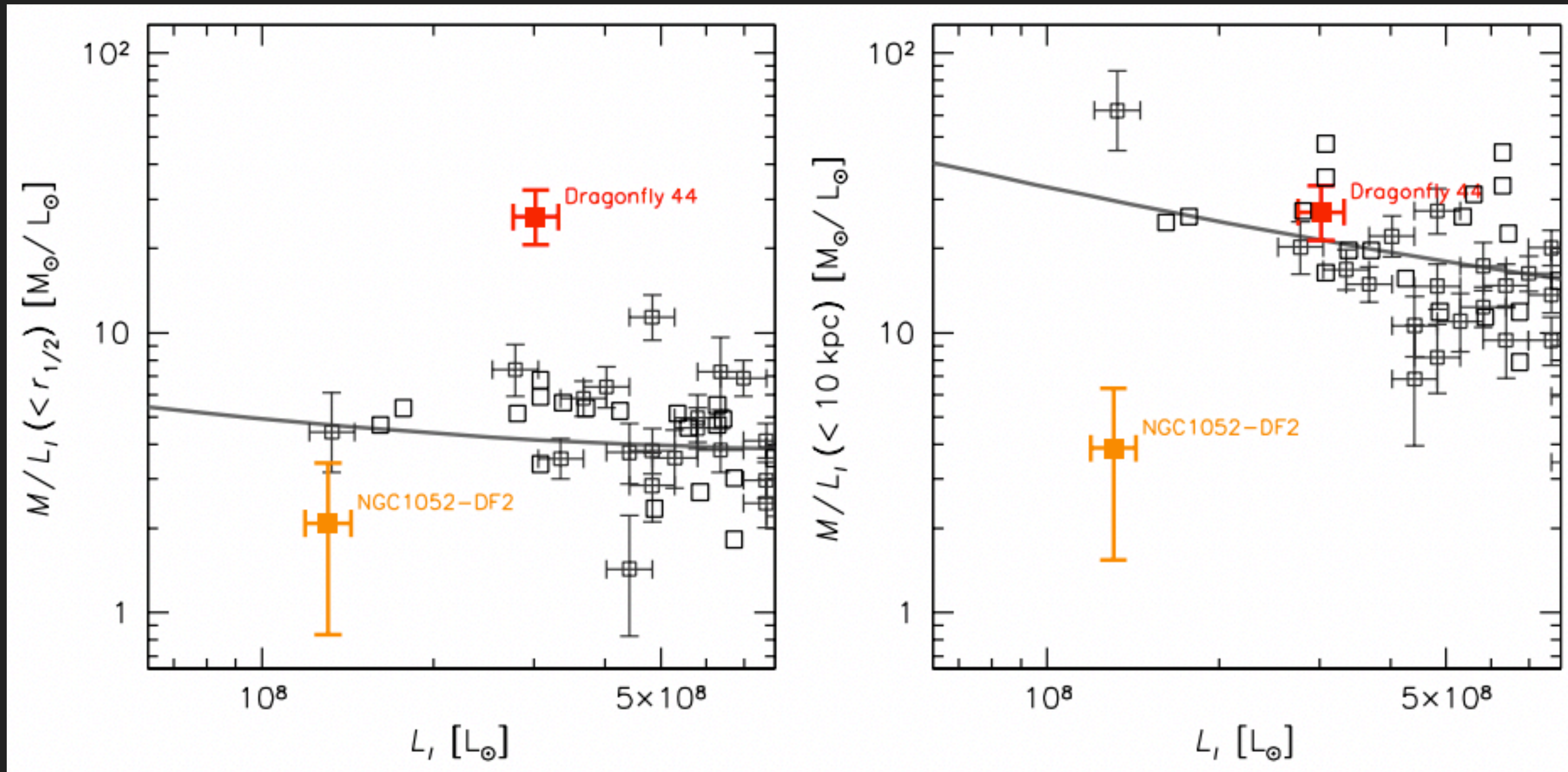
Some have crazy dynamic  
mass to light ratio



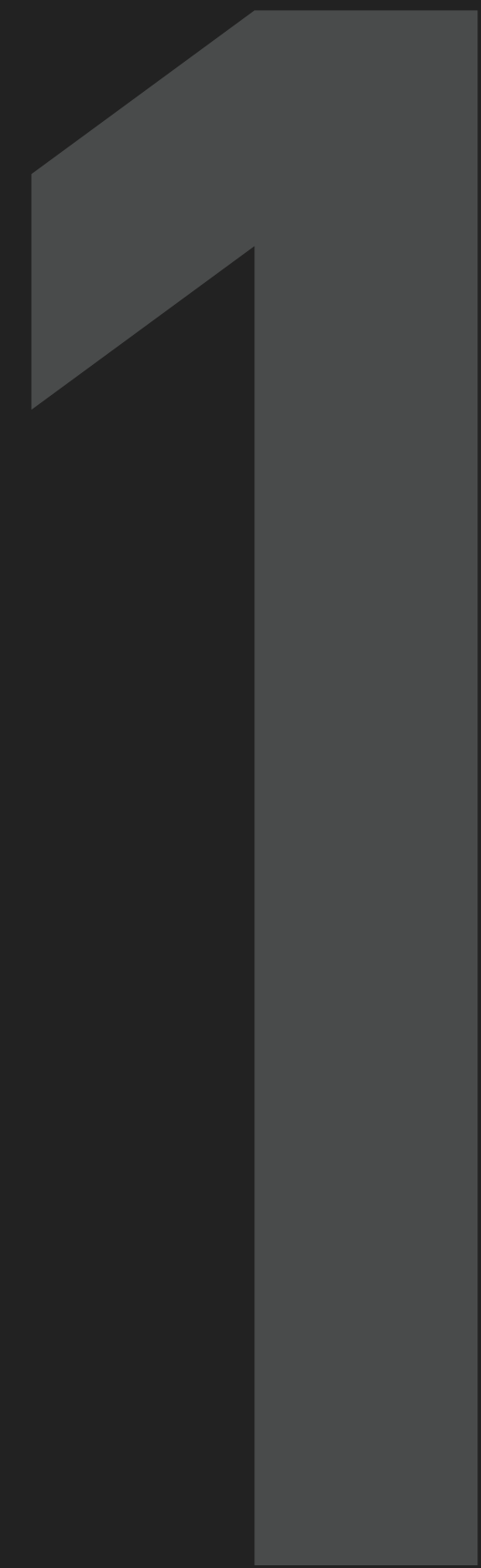
# Turned out that some are very dark matter dominated while others are "dark matter free"?

Using the kinematics of both resolved stellar population and the globular cluster systems

van Dokkum et al. 2019







# QUESTION

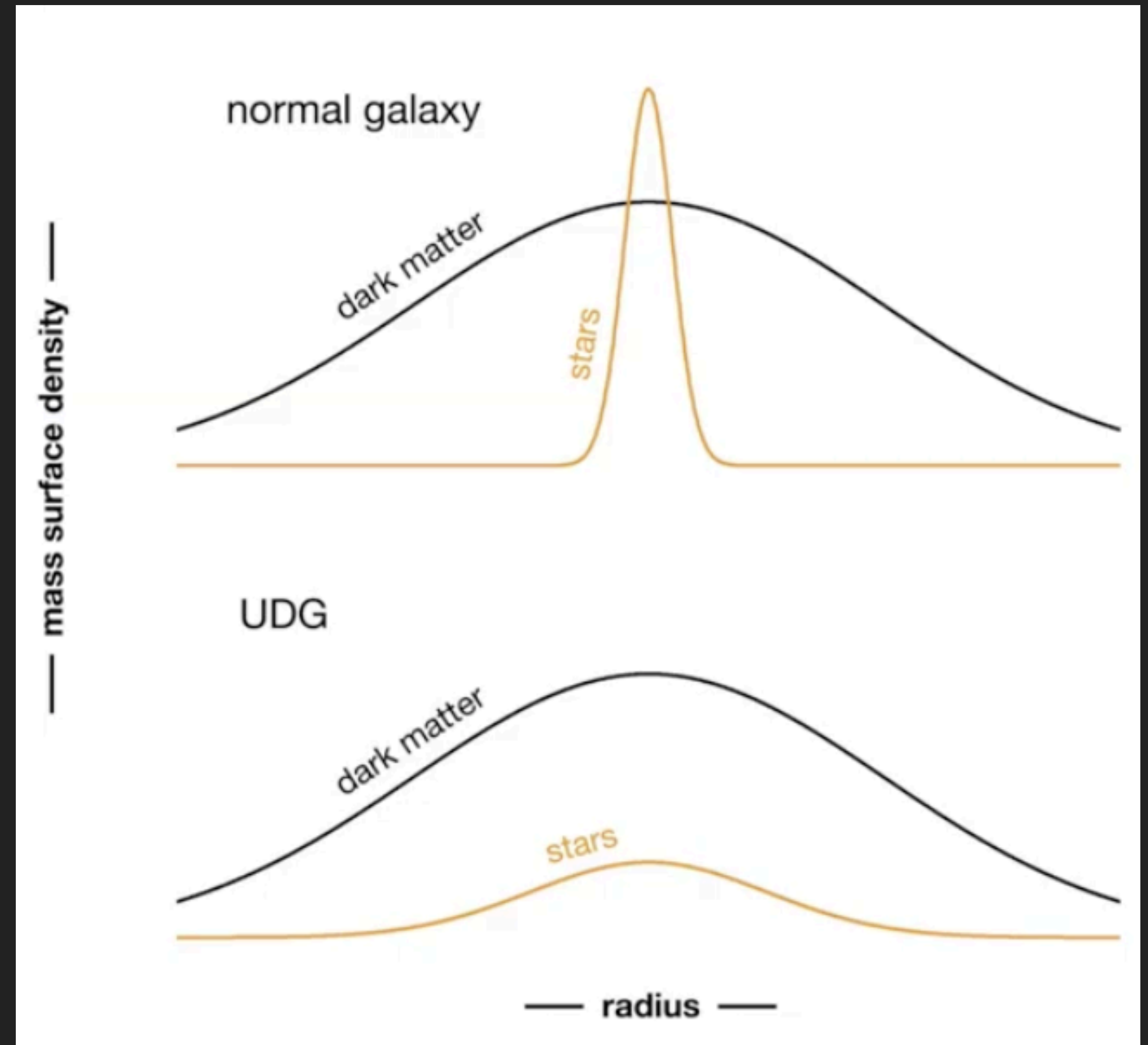
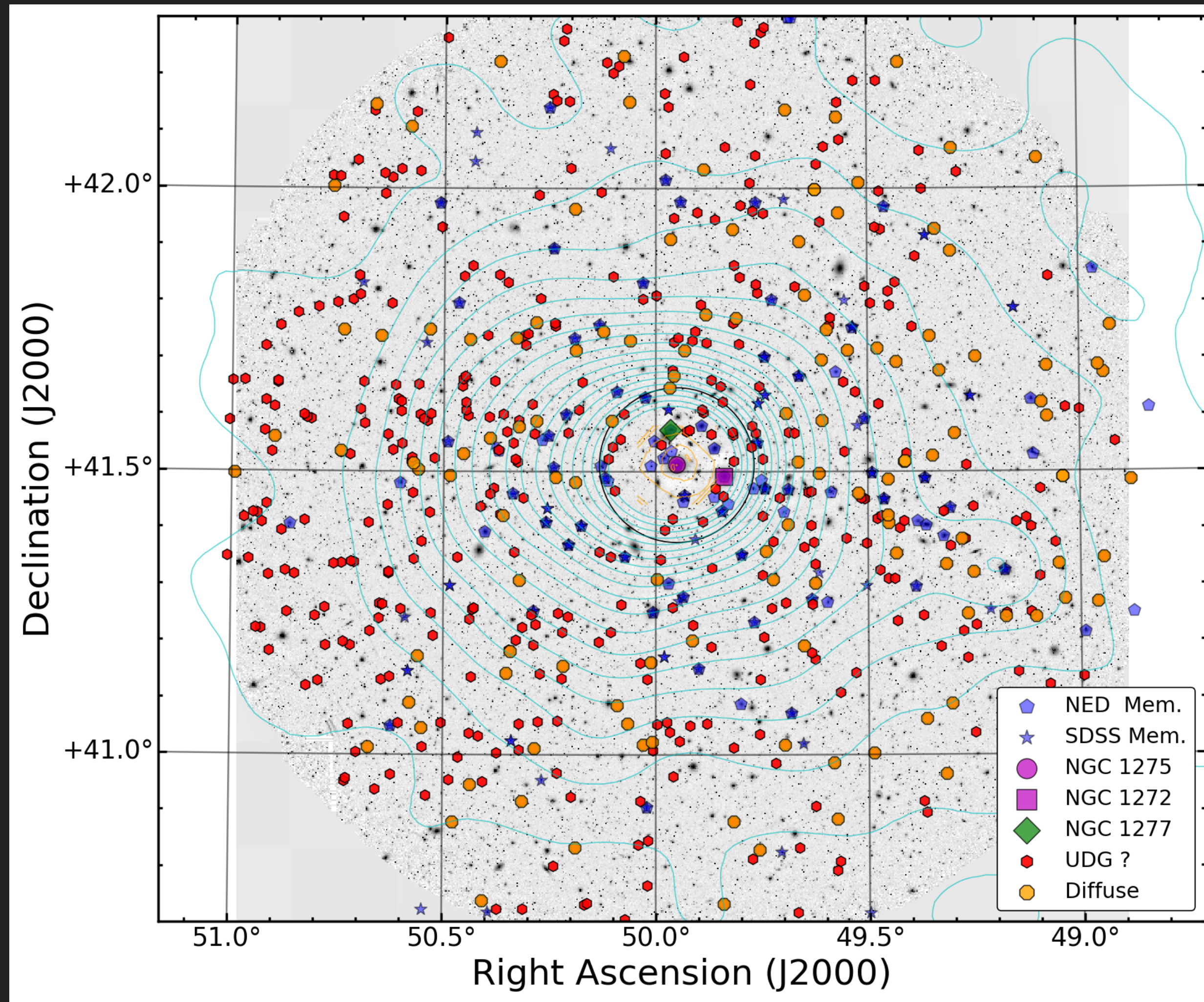
Both DM dominated and DM free? Seriously?



# Why do we think the UDGs should be "DM dominated" in the first place?

## UDG candidates in the Perseus cluster

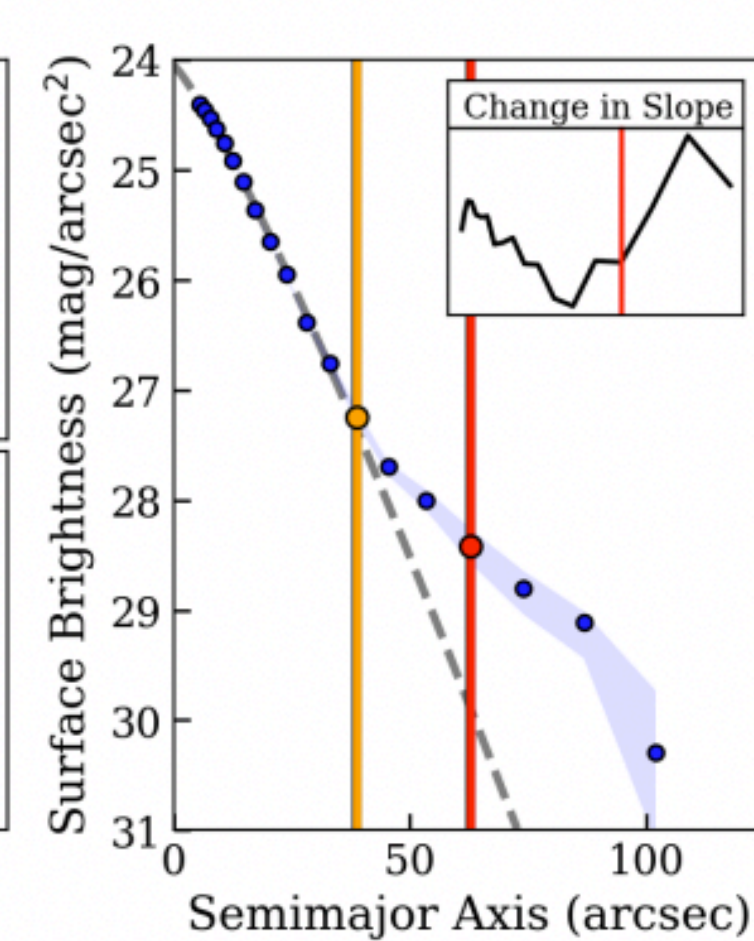
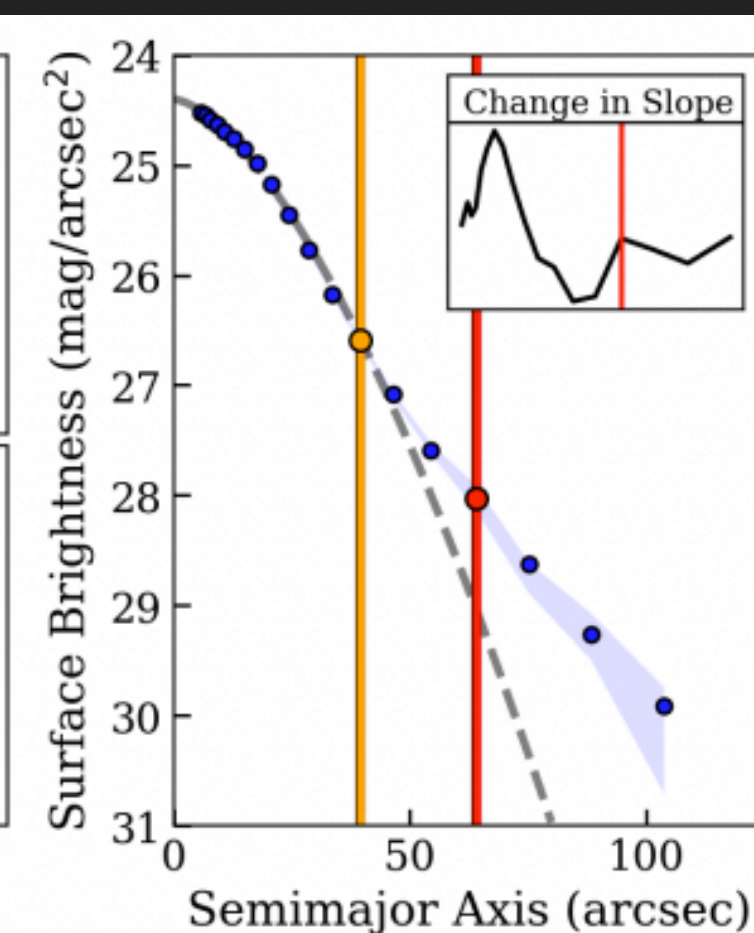
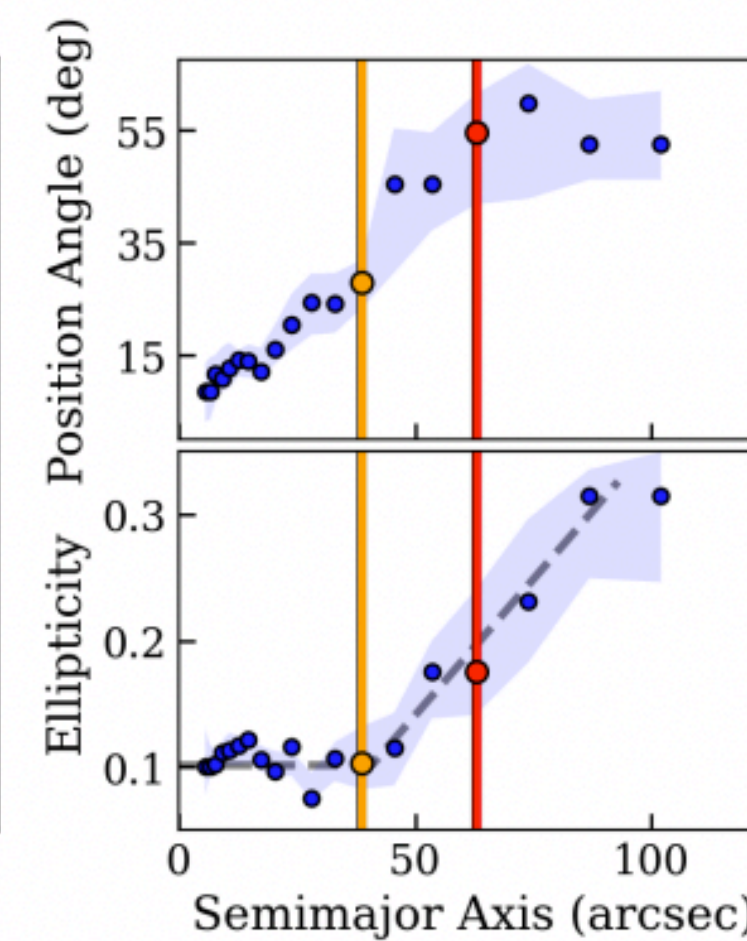
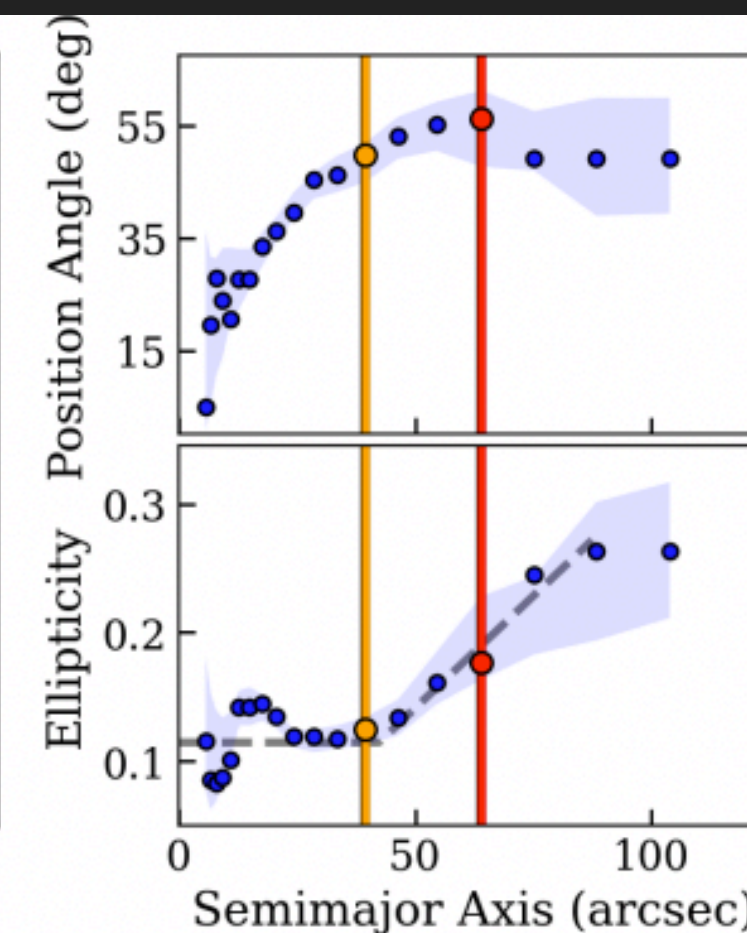
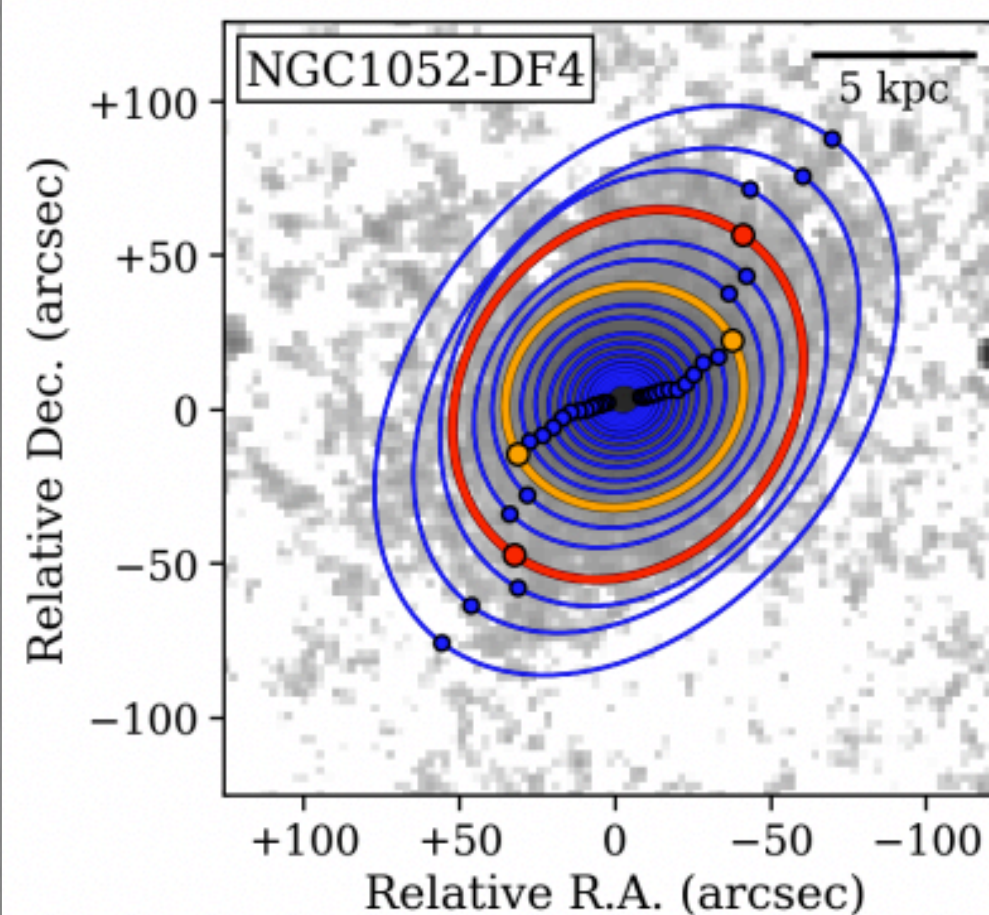
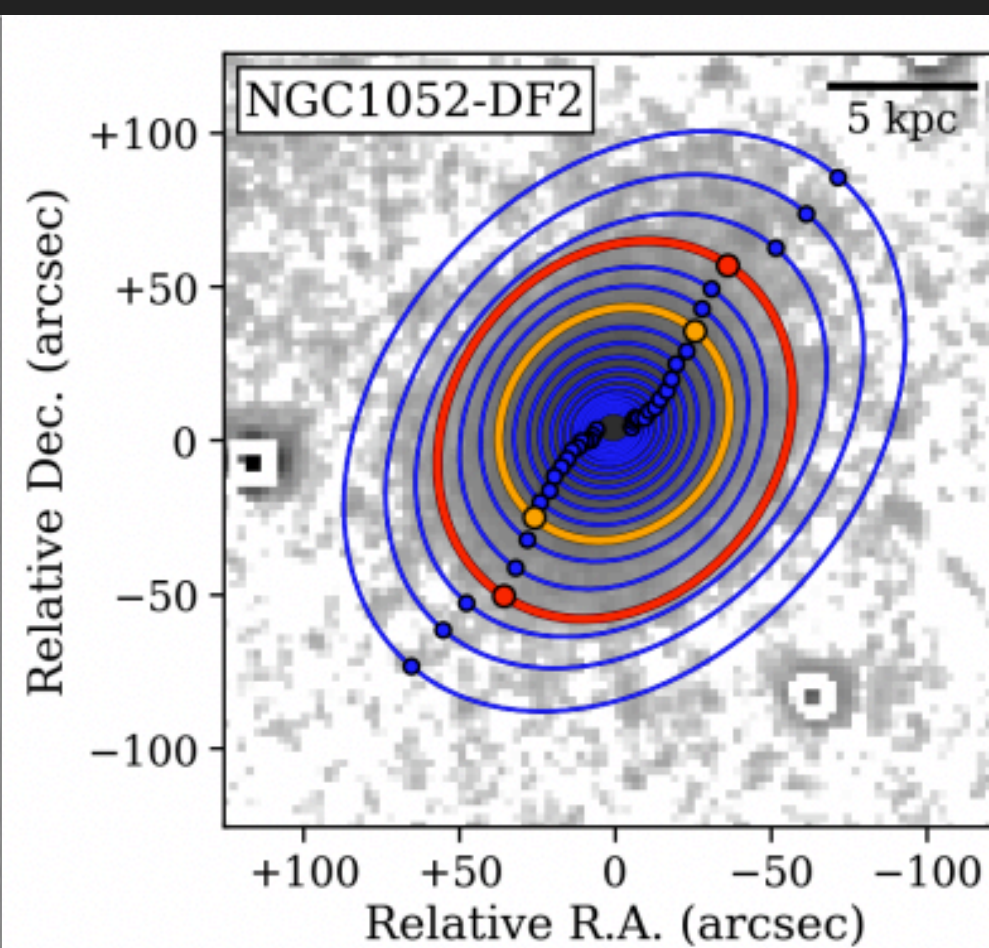
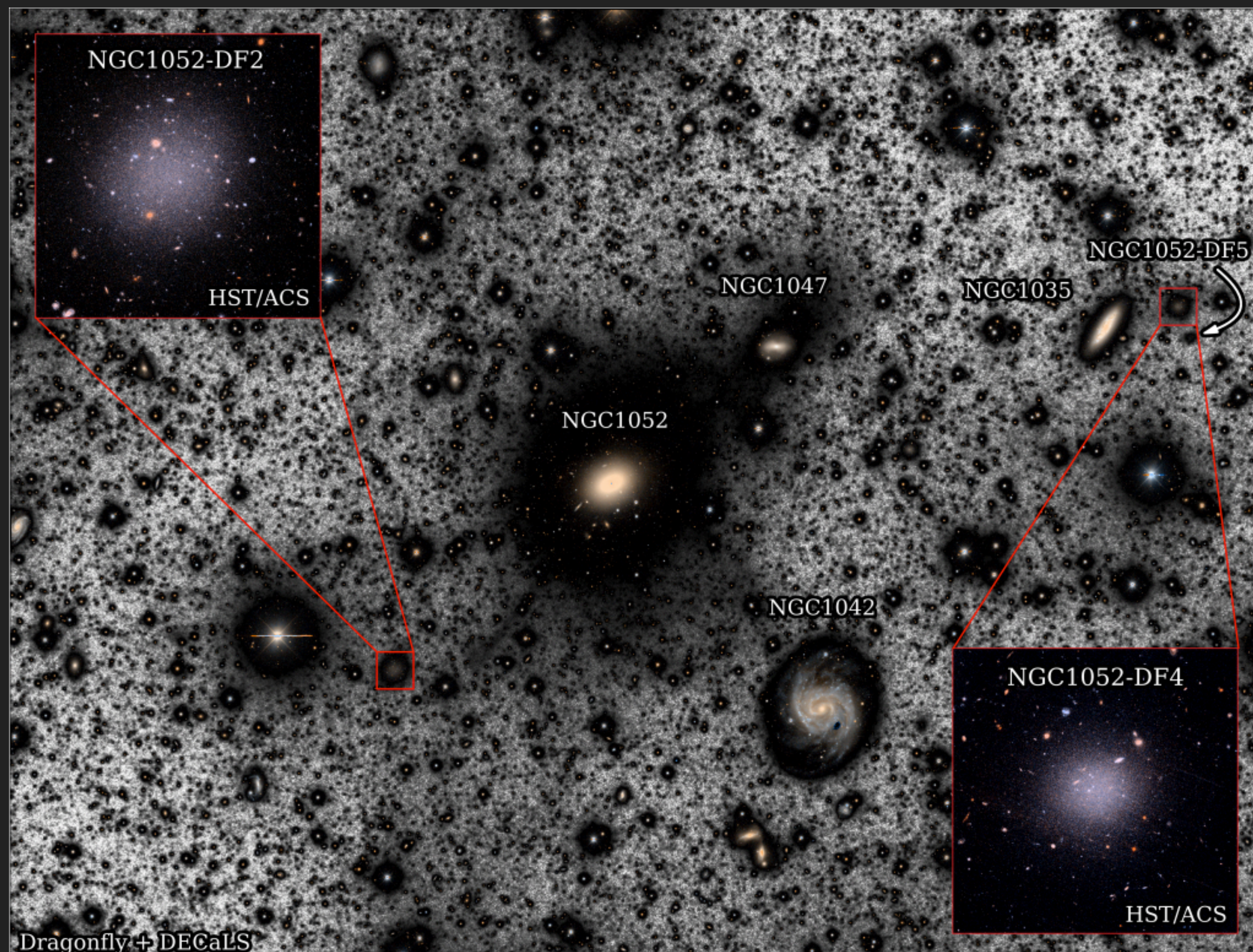
Credit: Pieter van Dokkum





So...they are getting tidal distorted/disrupted anyway...

Keim et al. 2021





2

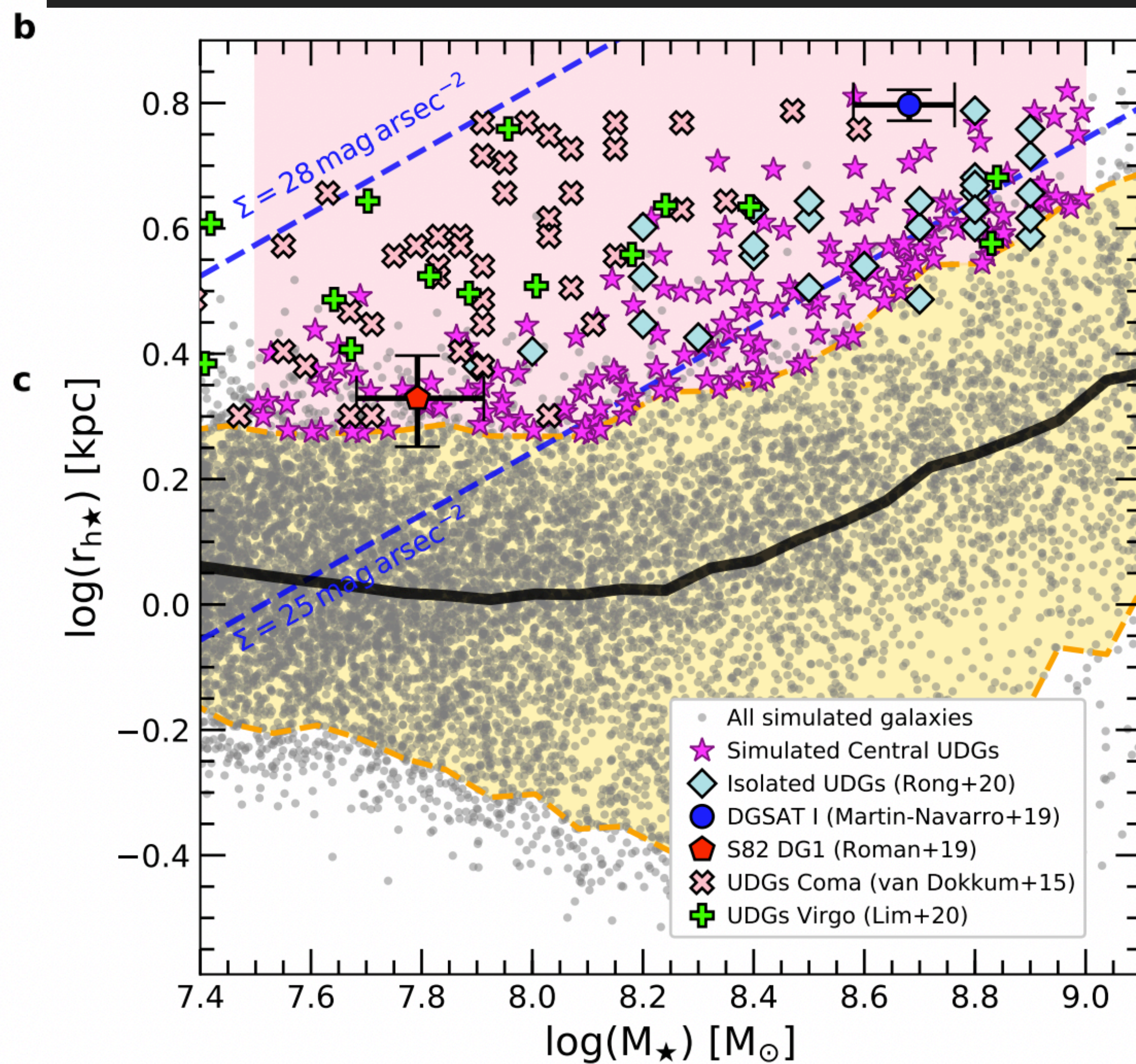
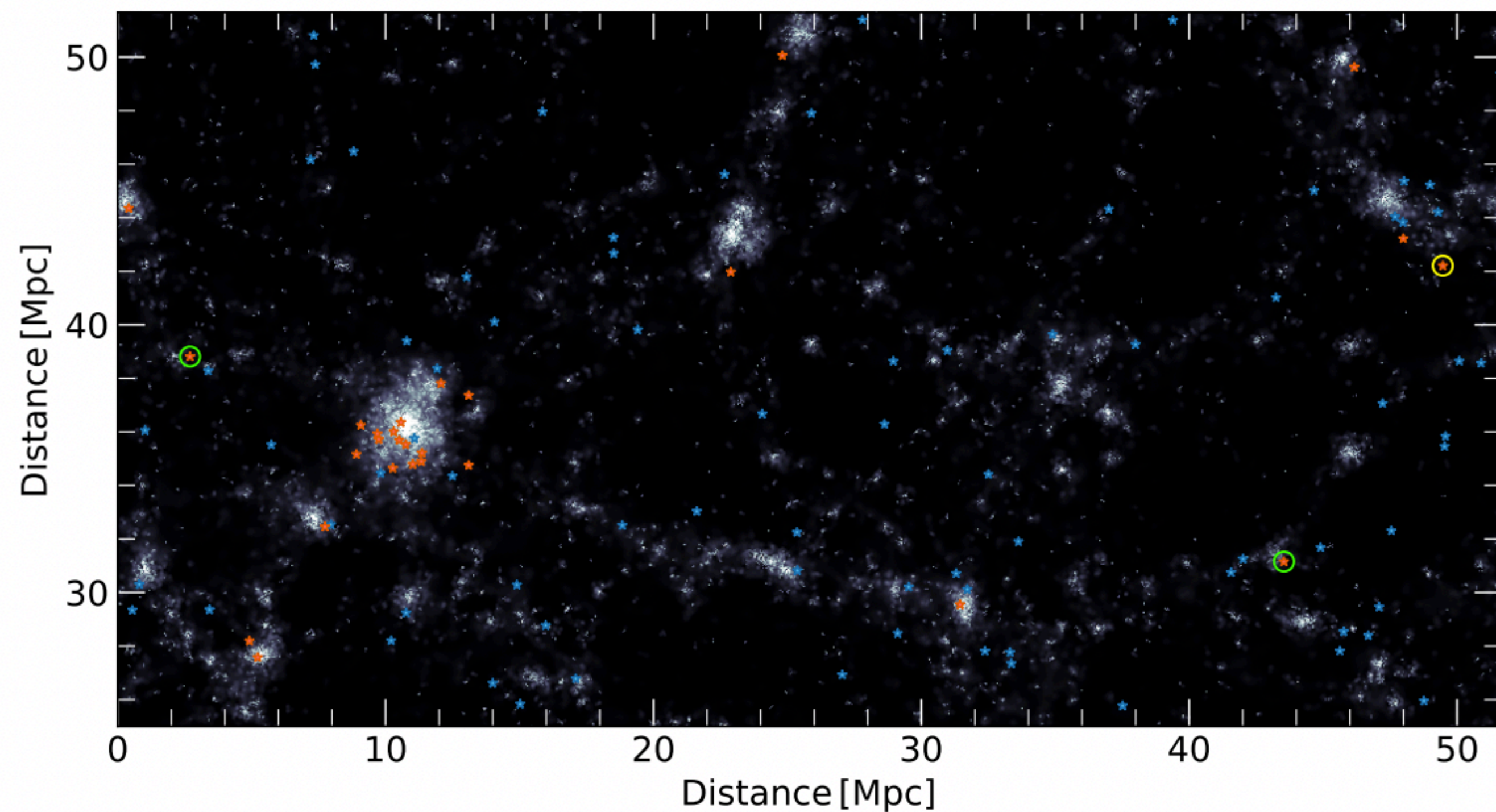
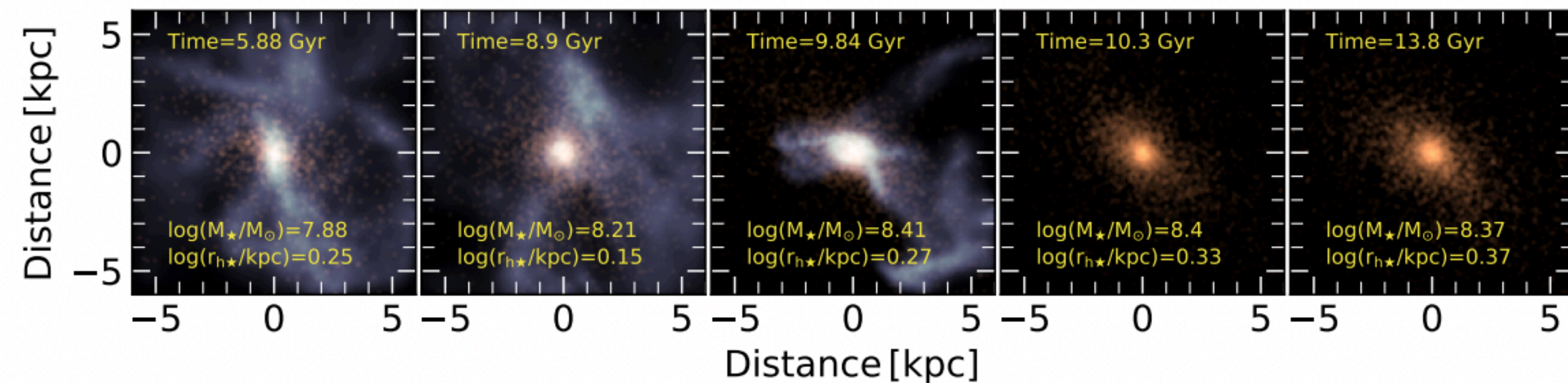
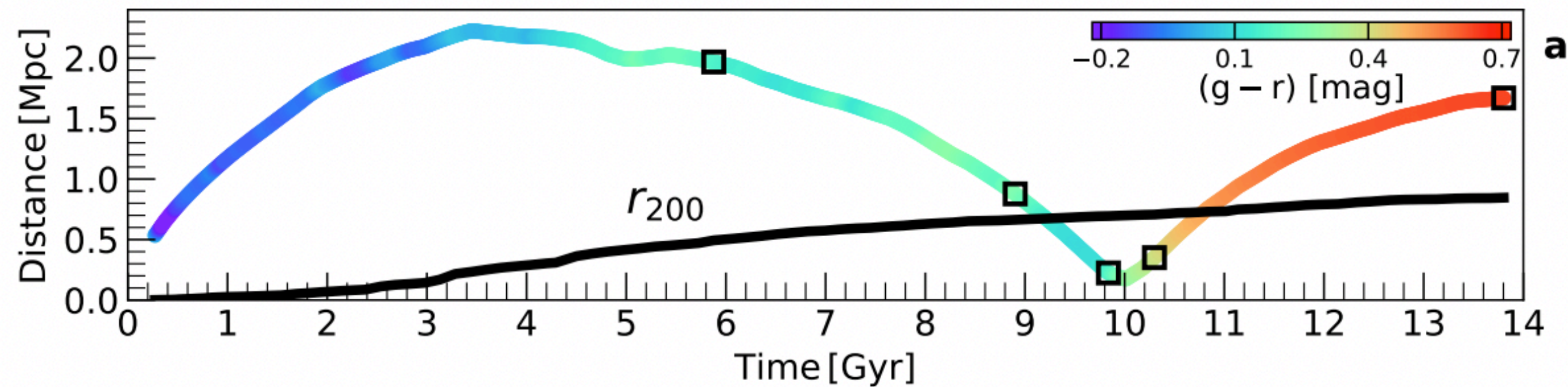
# QUESTION

Can they challenge galaxy formation? Dark Matter? Everything we know about the Universe?



Benavides et al. 2021

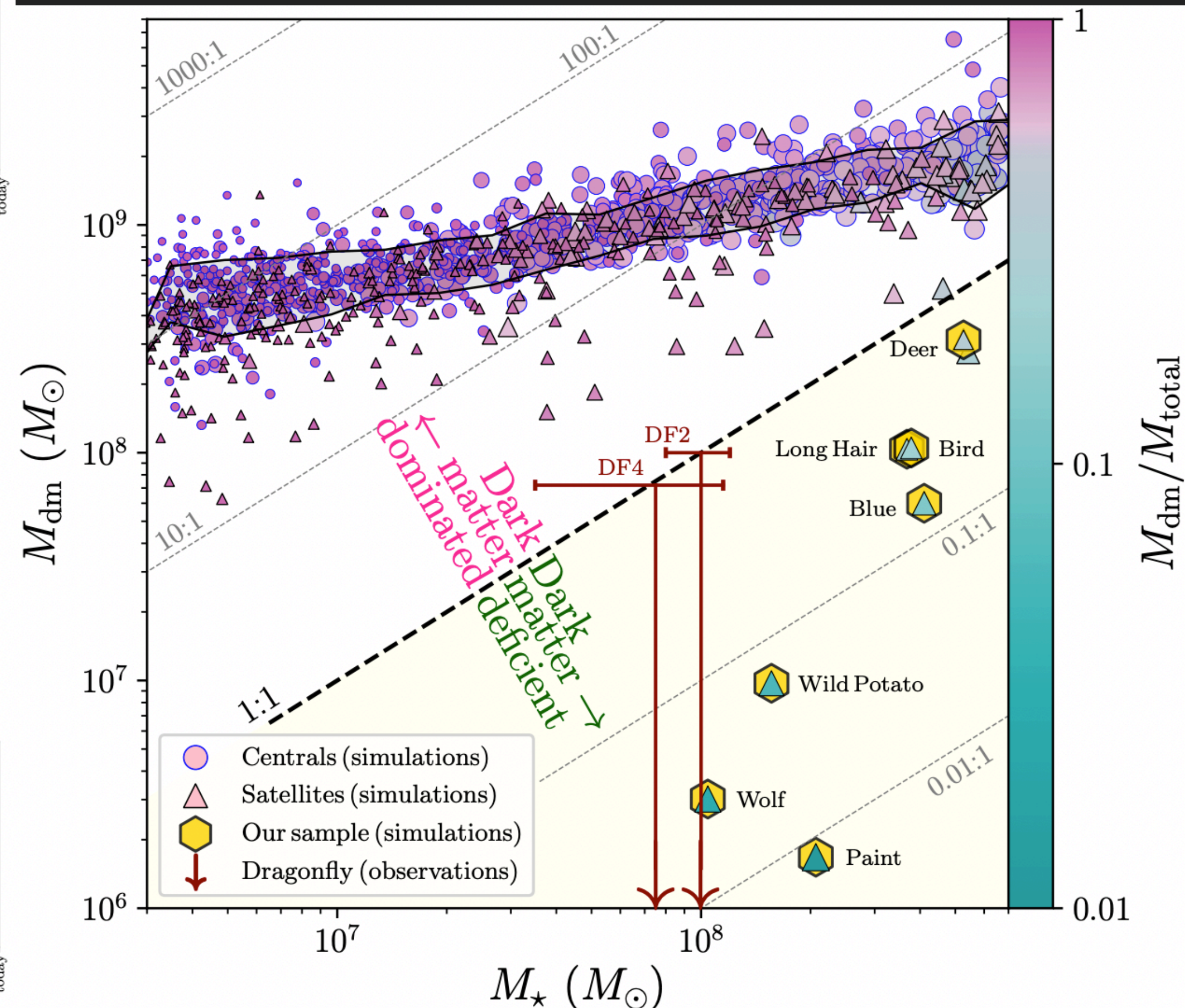
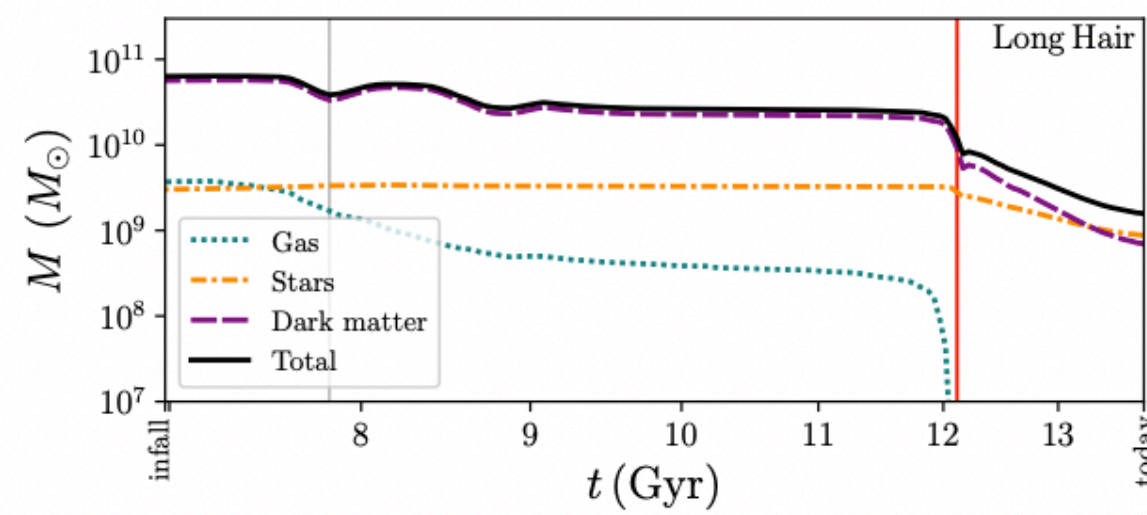
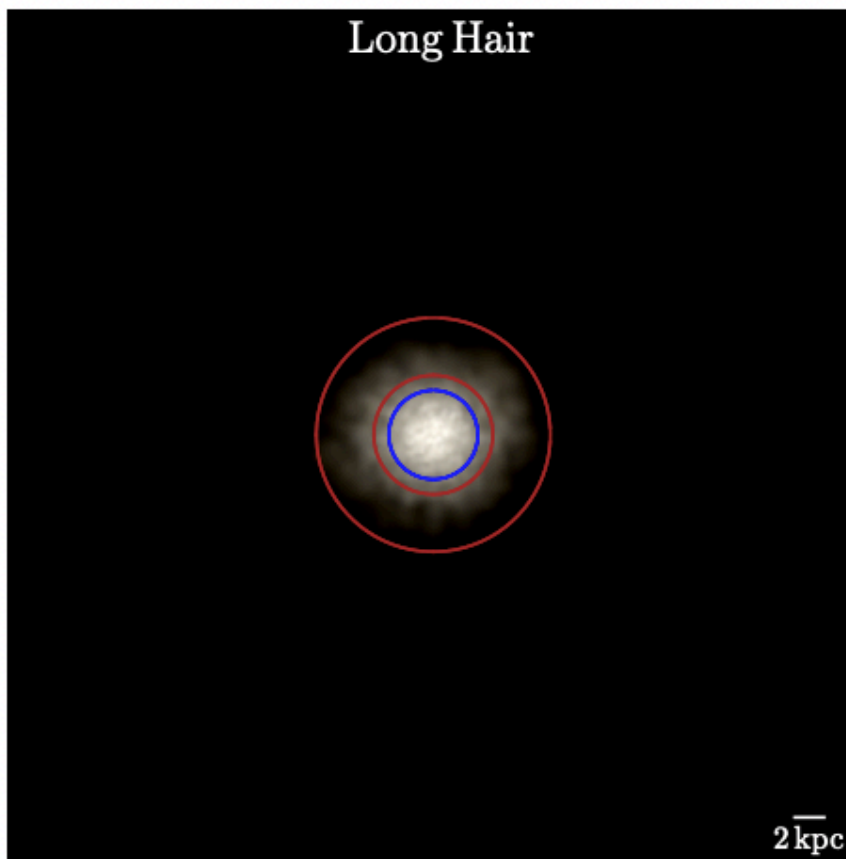
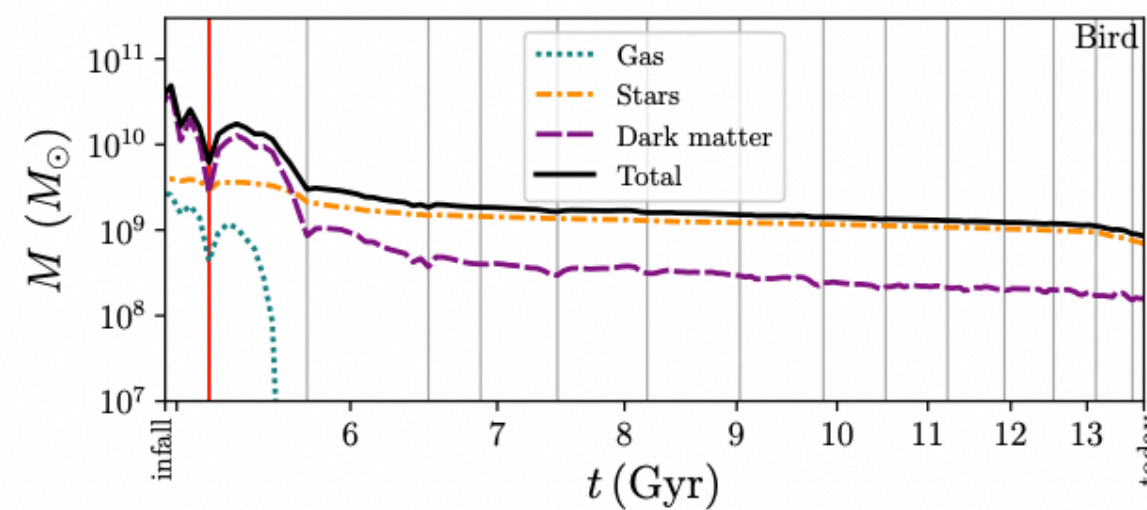
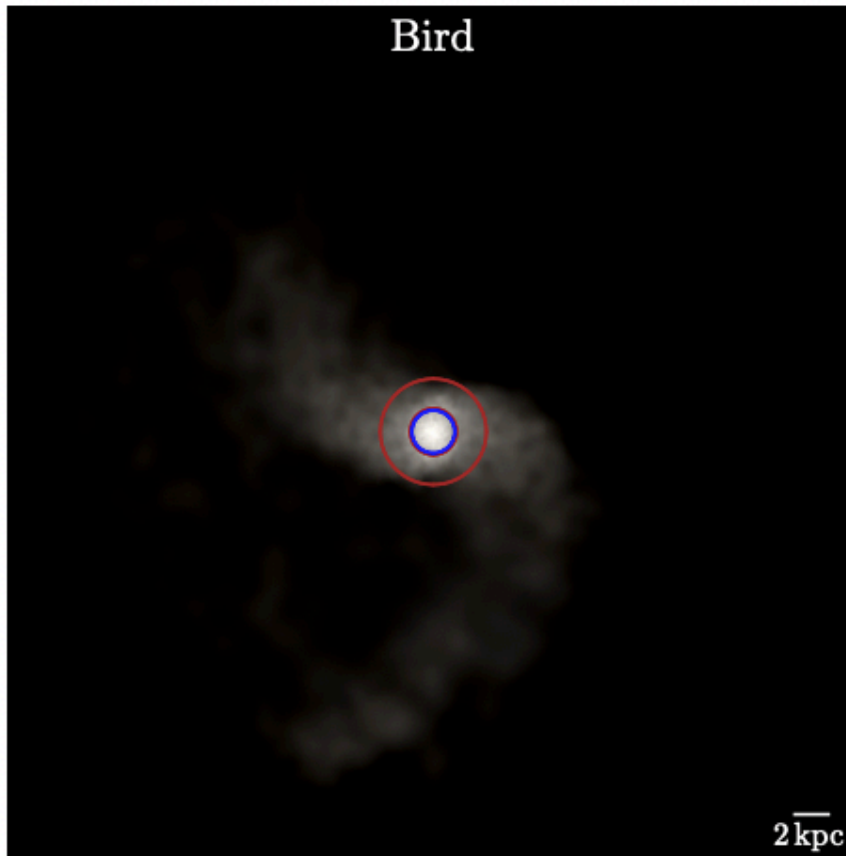
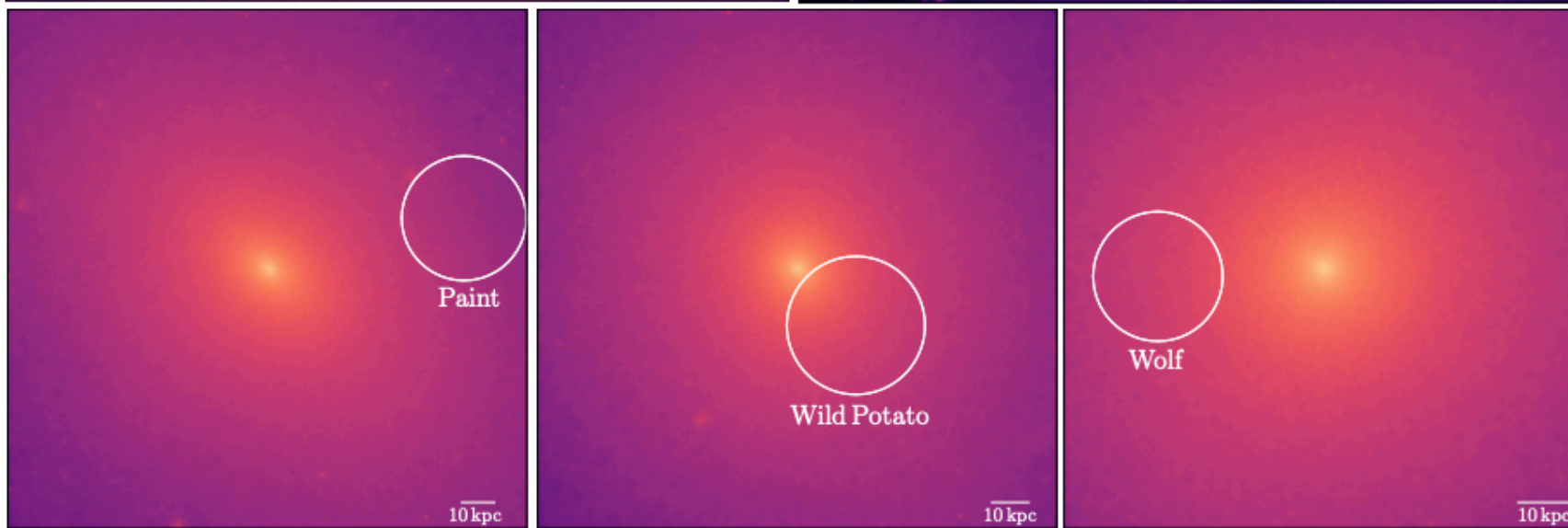
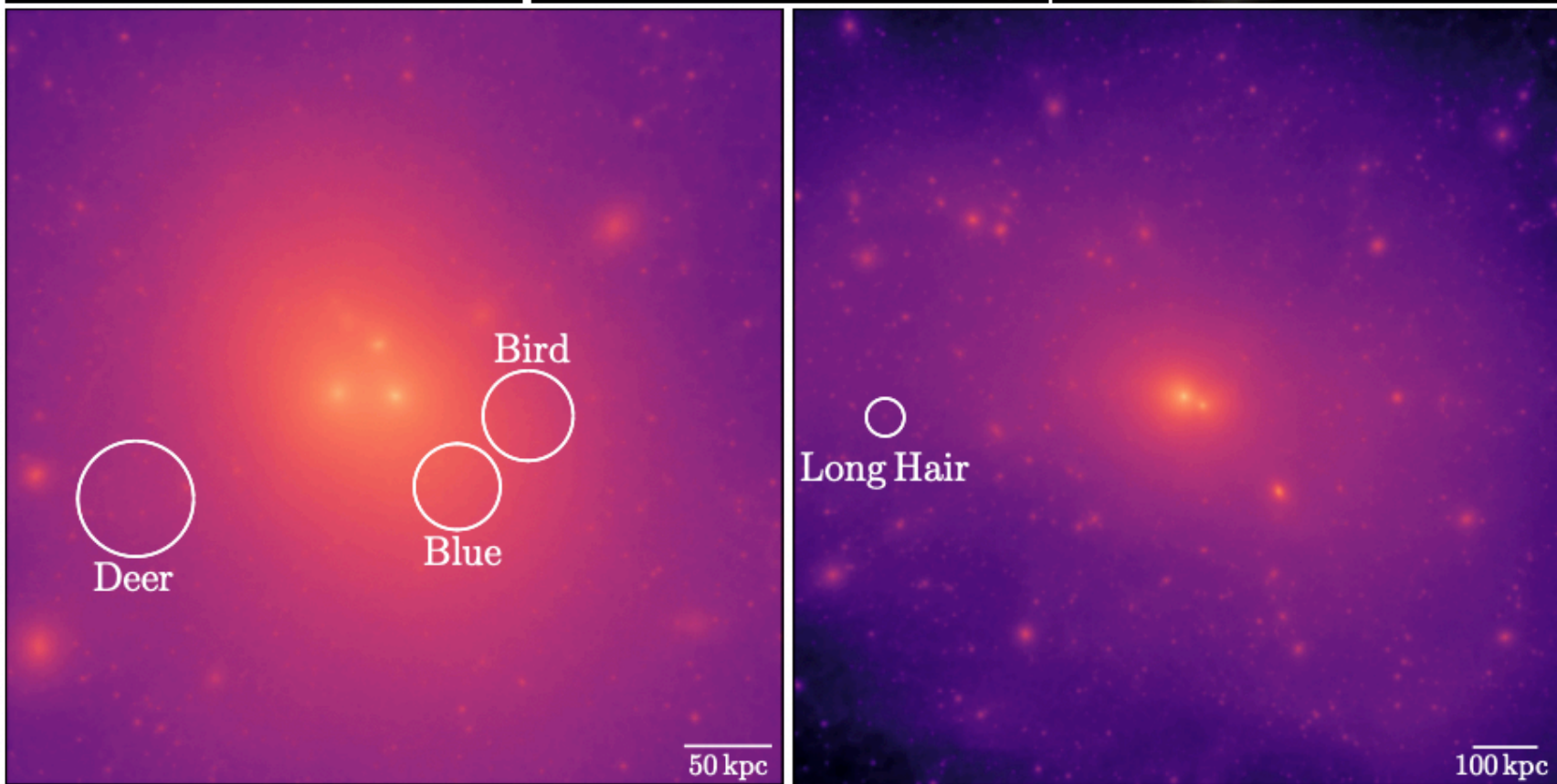
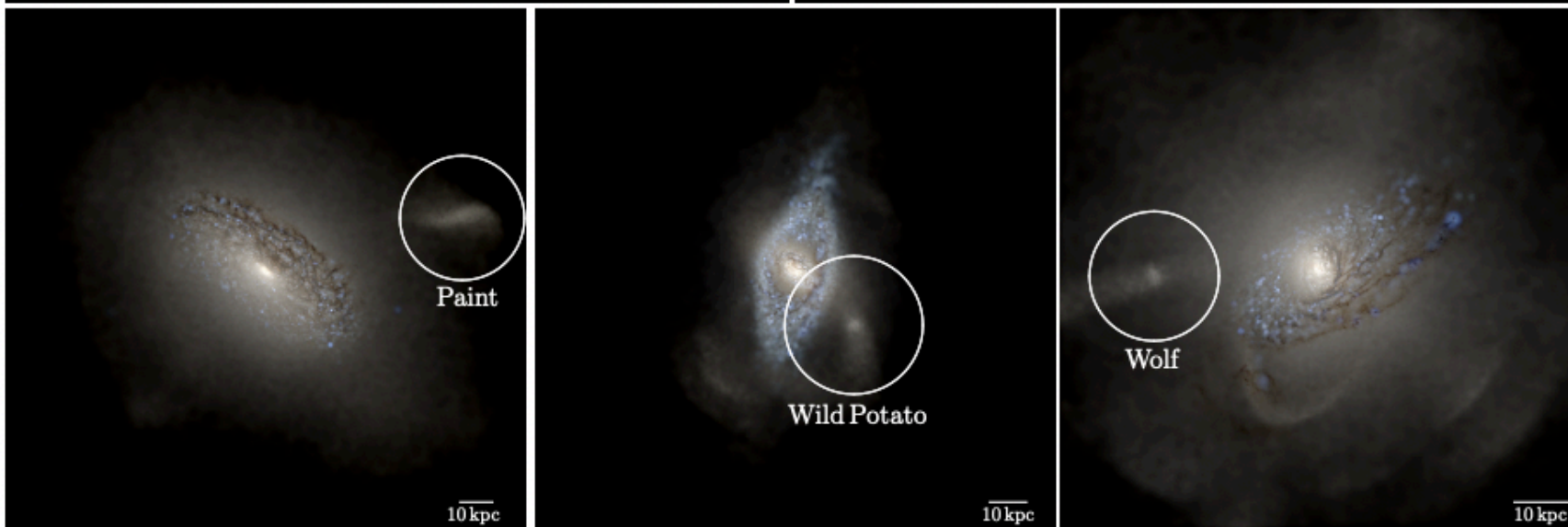
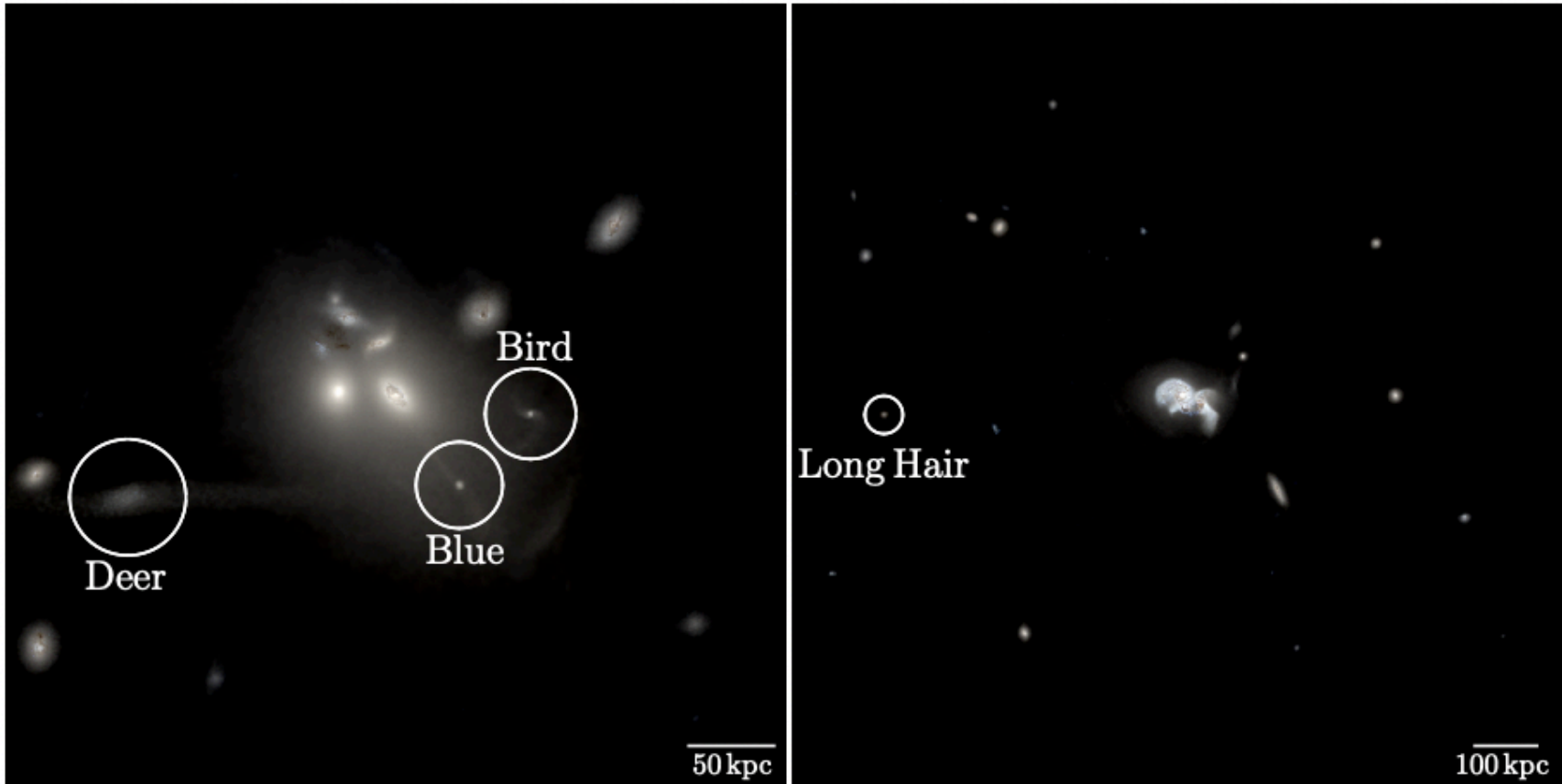
High-res simulation can form UDGs





Moreno et al. 2022

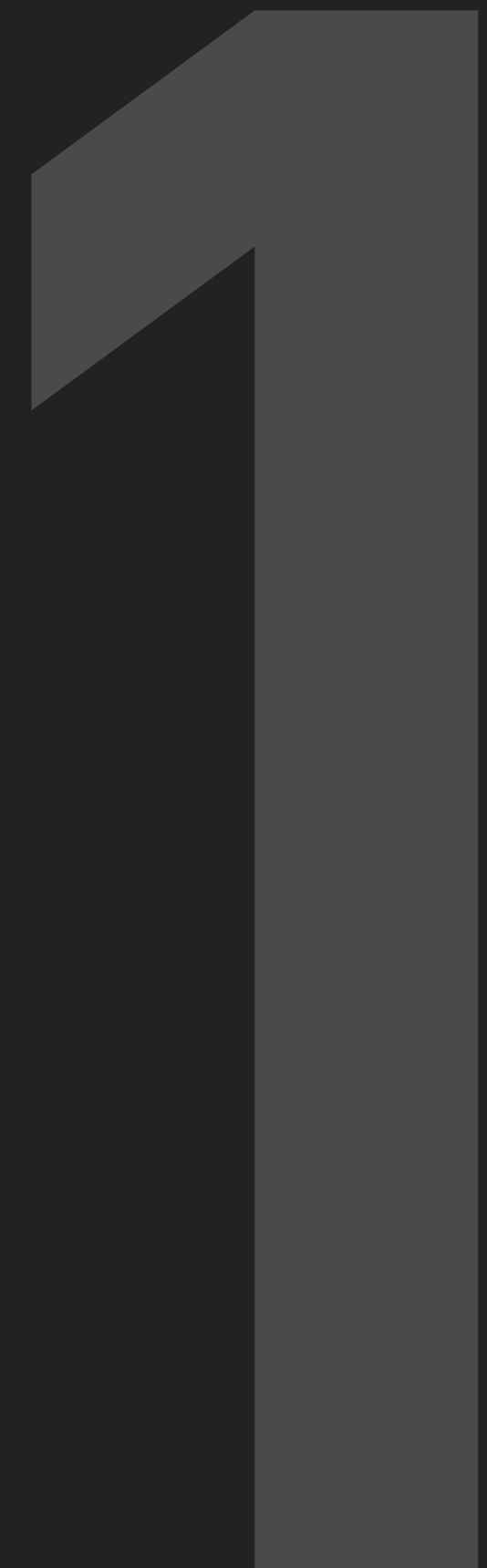
# High-res simulation can form "Dark Matter Free" UDGs





Are we good?

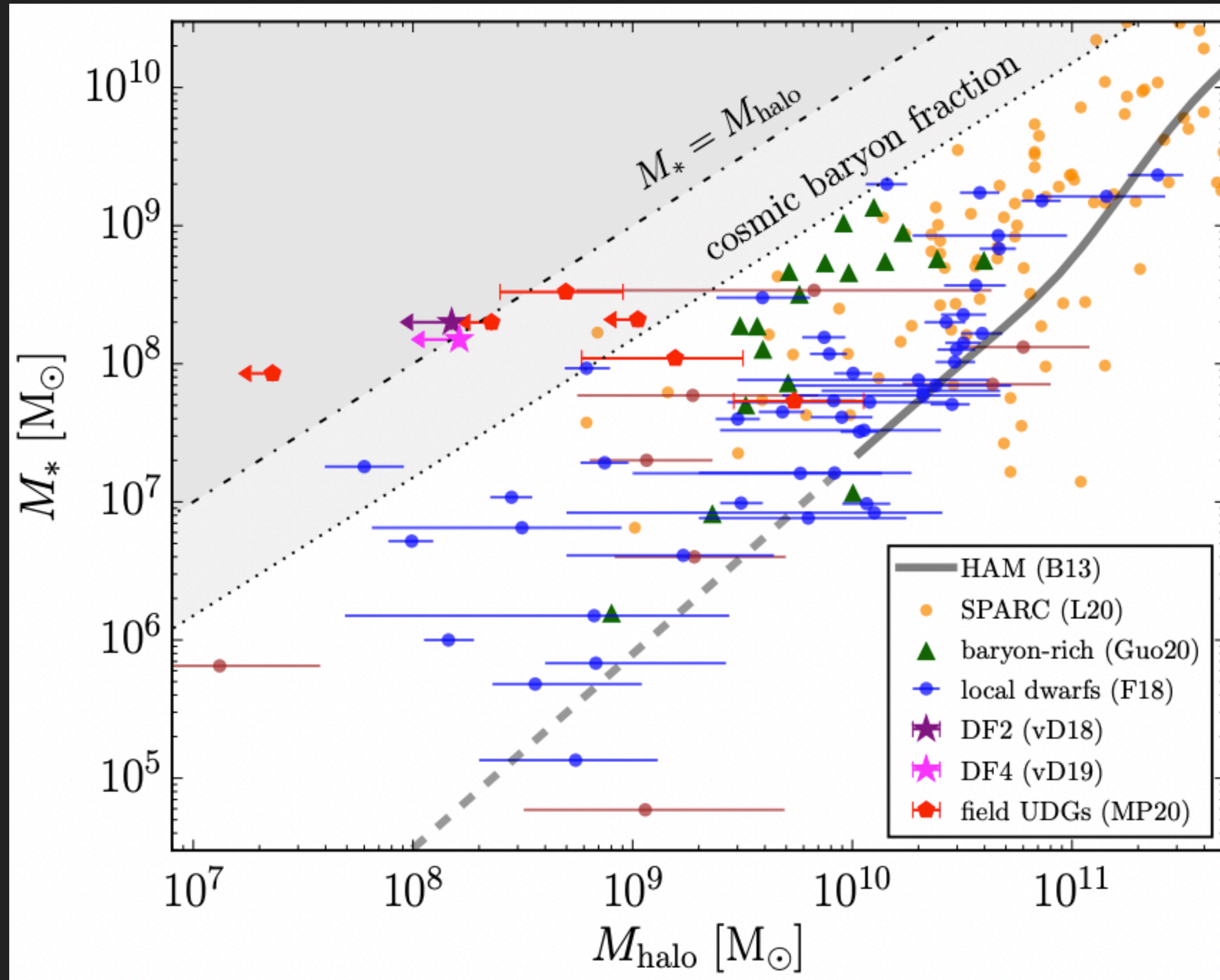




# POSITIVE

Force us to think about galaxy formation and halo connection in a new angle





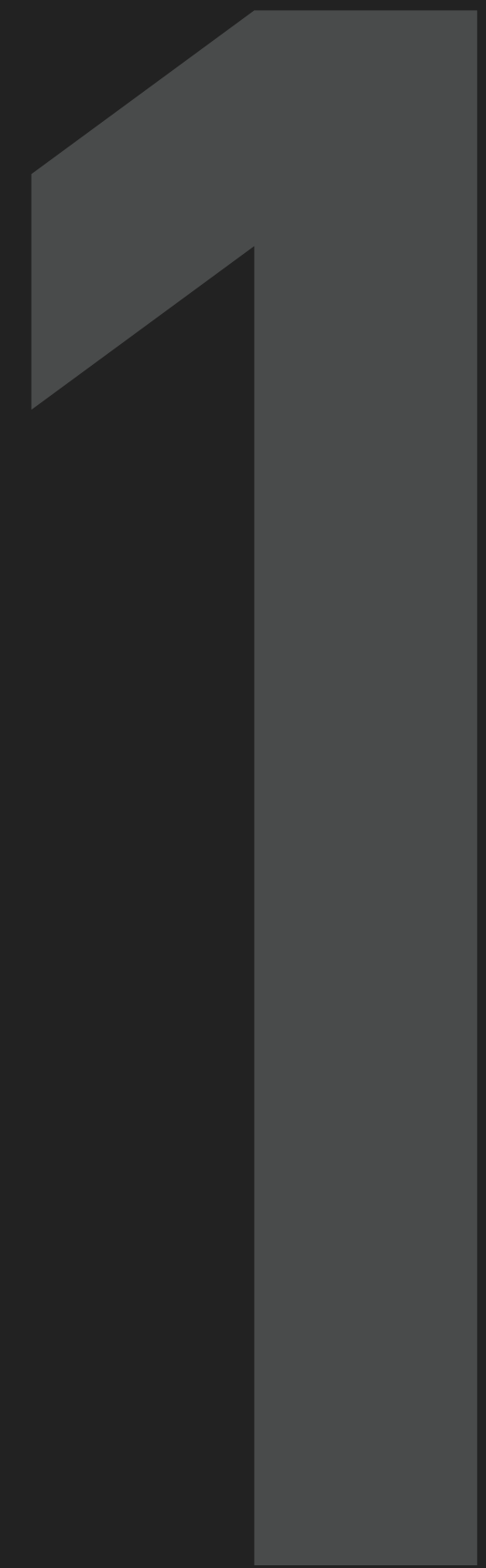


2

POSITIVE

LSB science is back under the  
spotlight

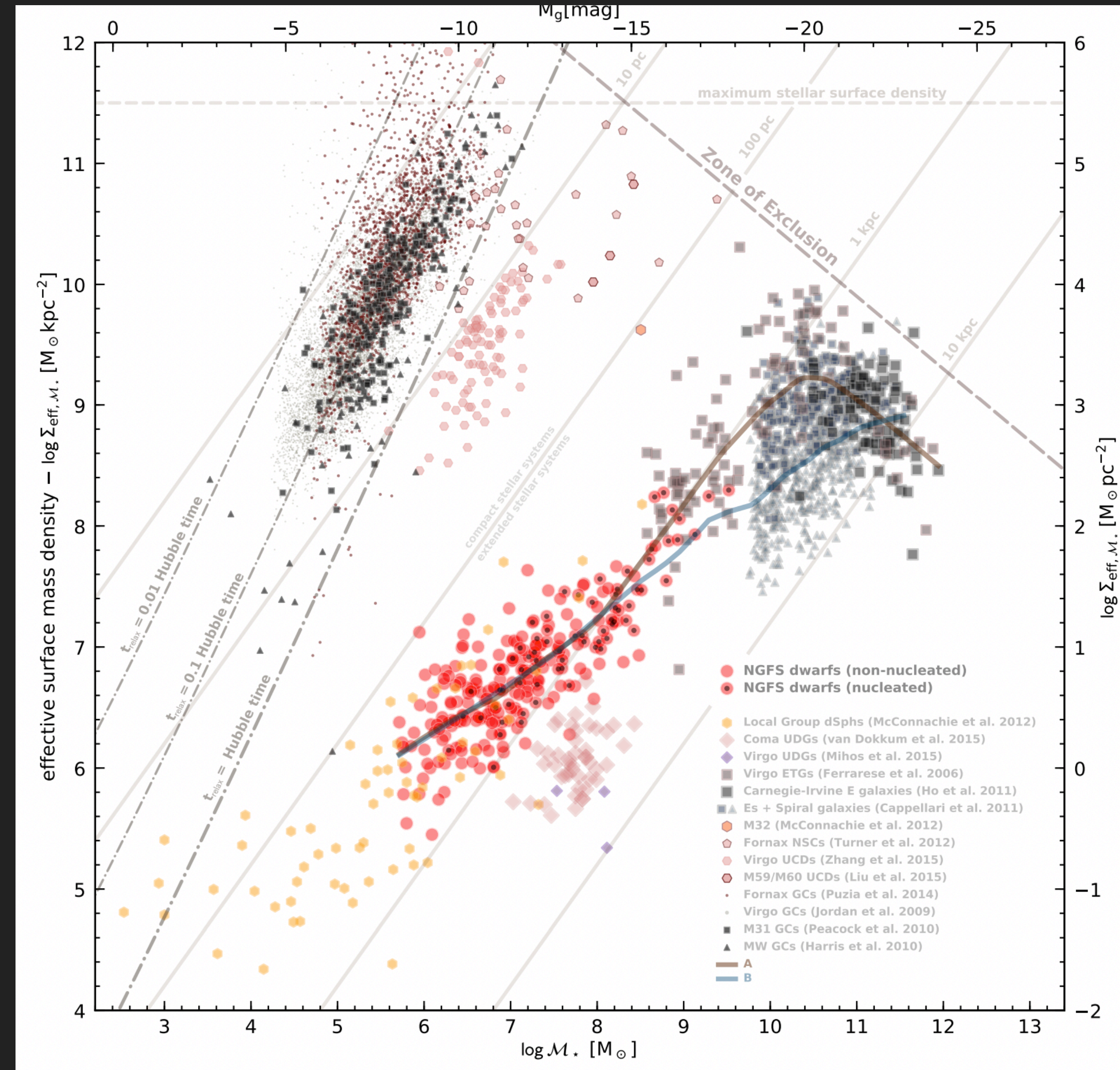
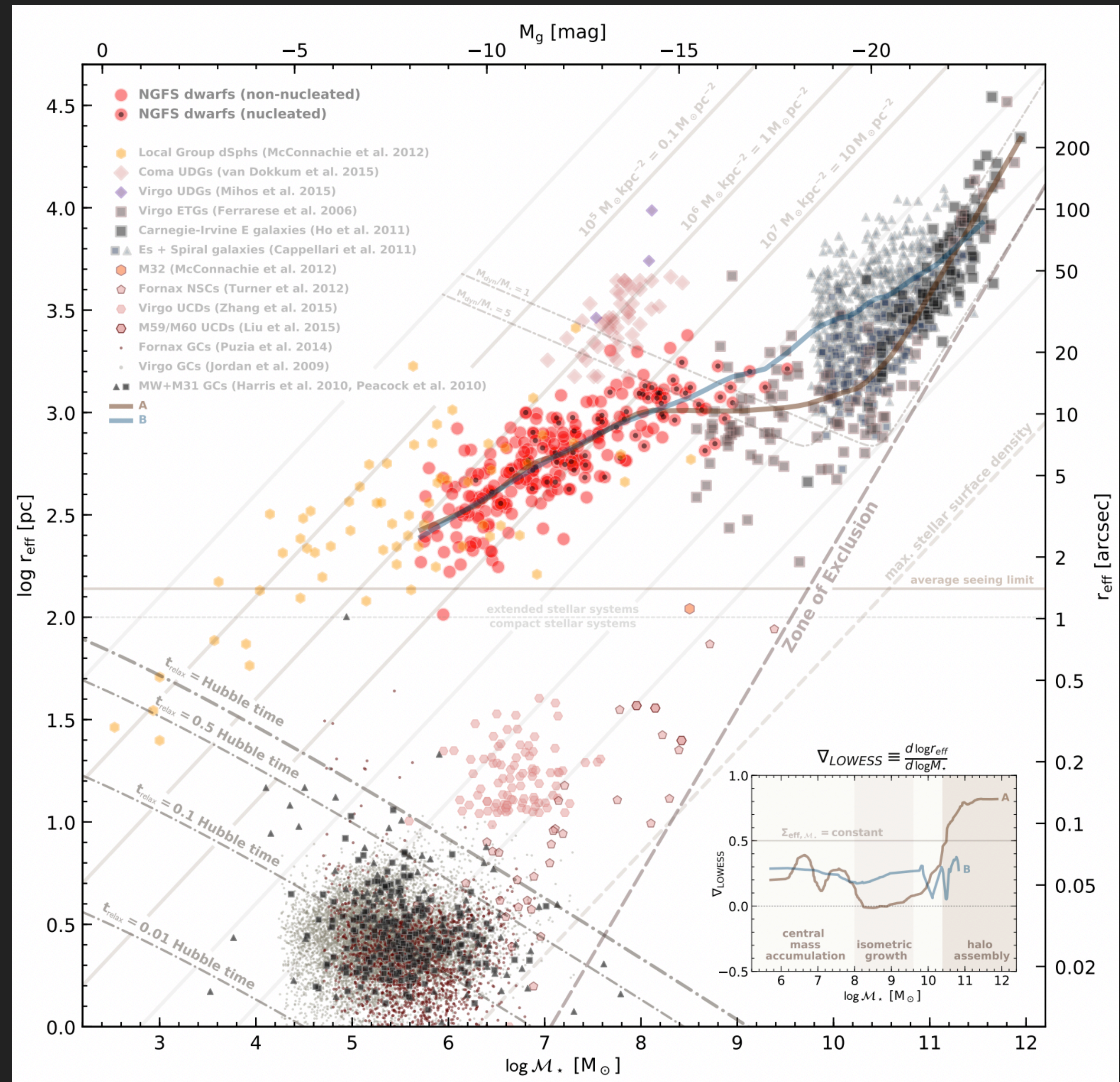




# NEGATIVE

Fail to see the wood for the trees





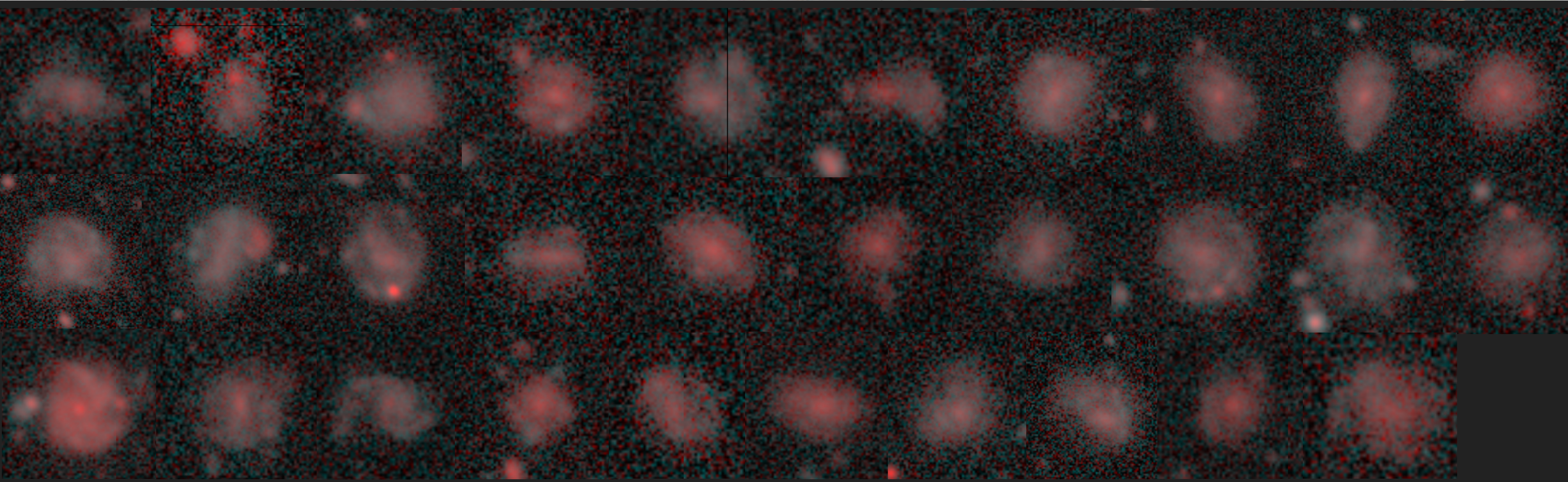
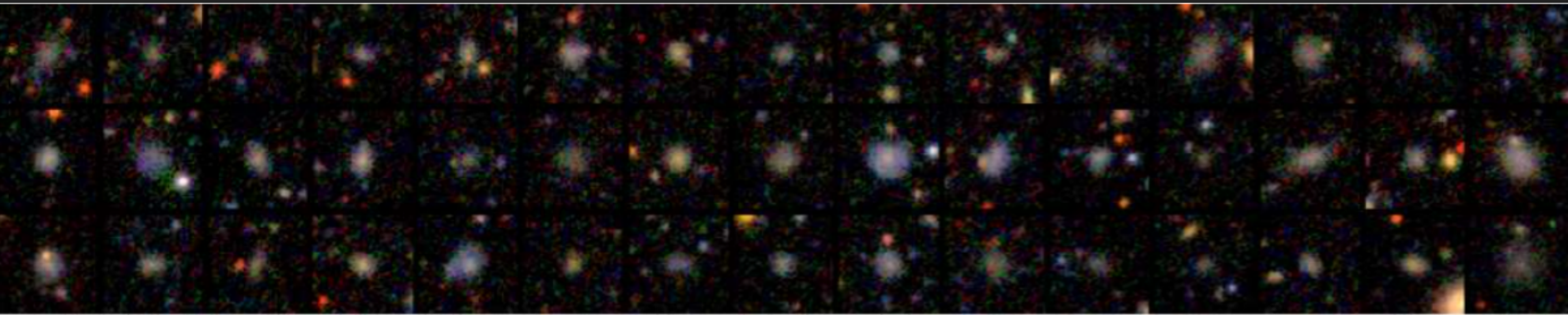


2

# NEGATIVE

There are noises...

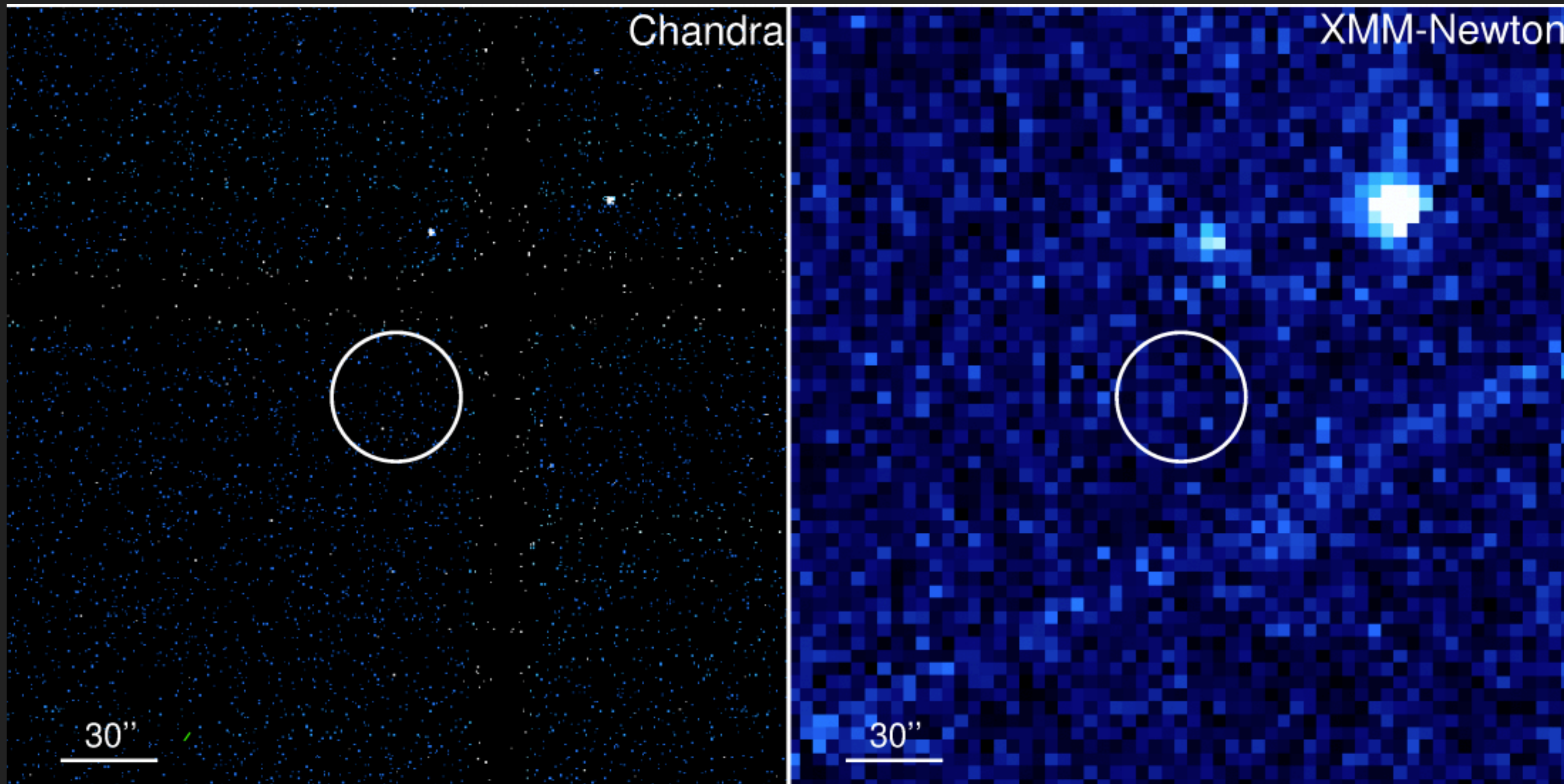






Bogdan 2020

# DF44 in Coma Cluster





# SUMMARY





# Hunting Diffuse Dwarfs in the Perseus Clusters

....and several more clusters using Hyper Suprime-Cam



In collaboration with  
Nobuhiro Okabe (Hiroshima)  
Aaron Romanowsky (SJSU & UCSC)  
and, **maybe You?**

