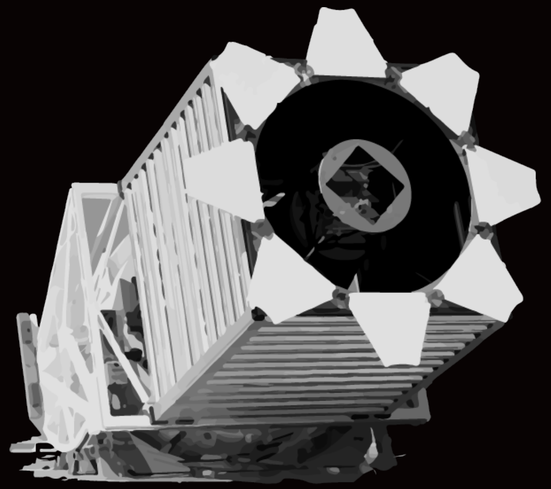
HUNTING DIFFUSE GALAXIES WITH NEXT GENERATION IMAGING SURVEYS

Johnny Greco
NSF Astronomy & Astrophysics Fellow
The Ohio State University
@johnnypgreco

Building the ***Galaxy Census***

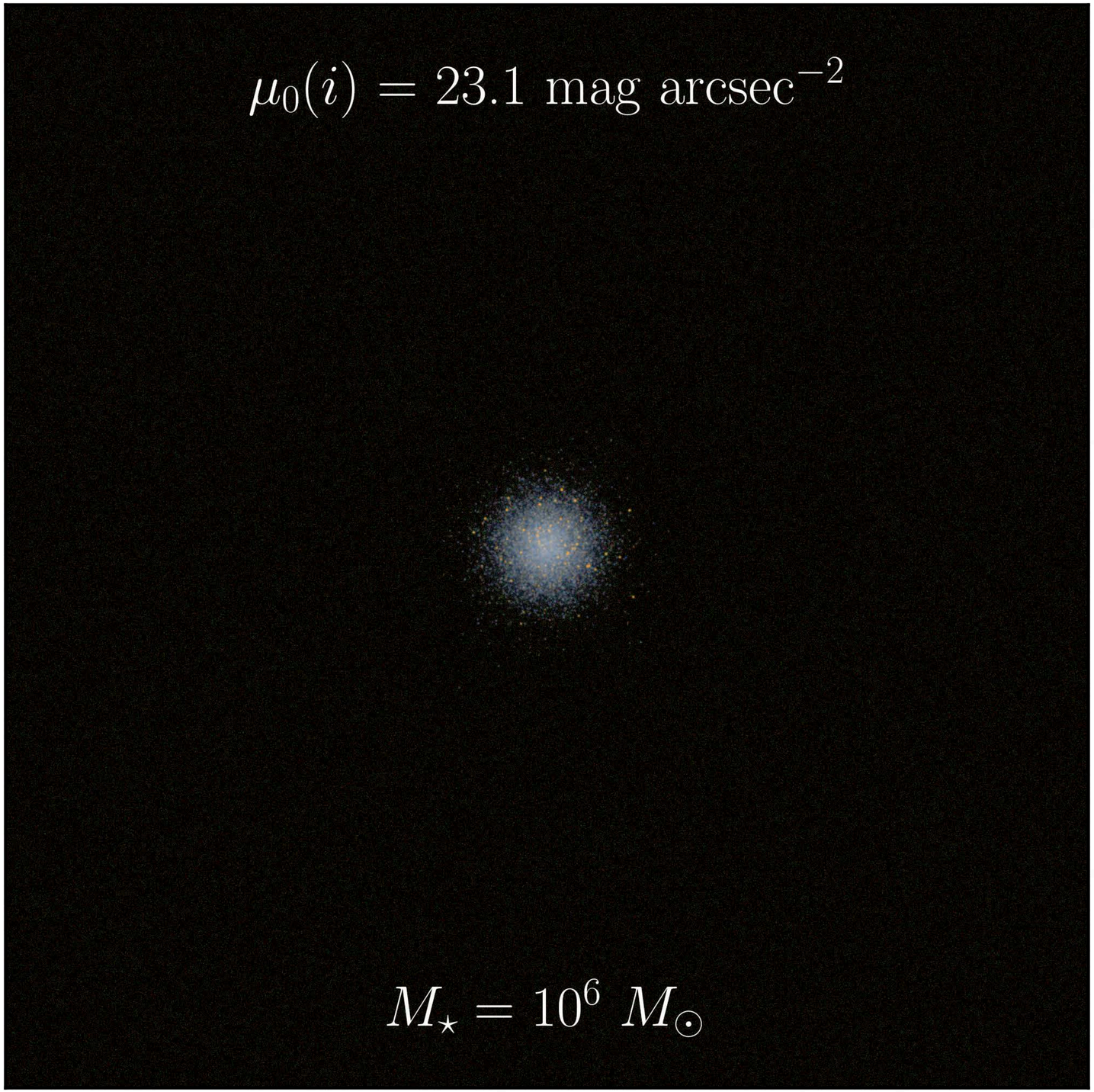
Blanton & Moustakas 2009



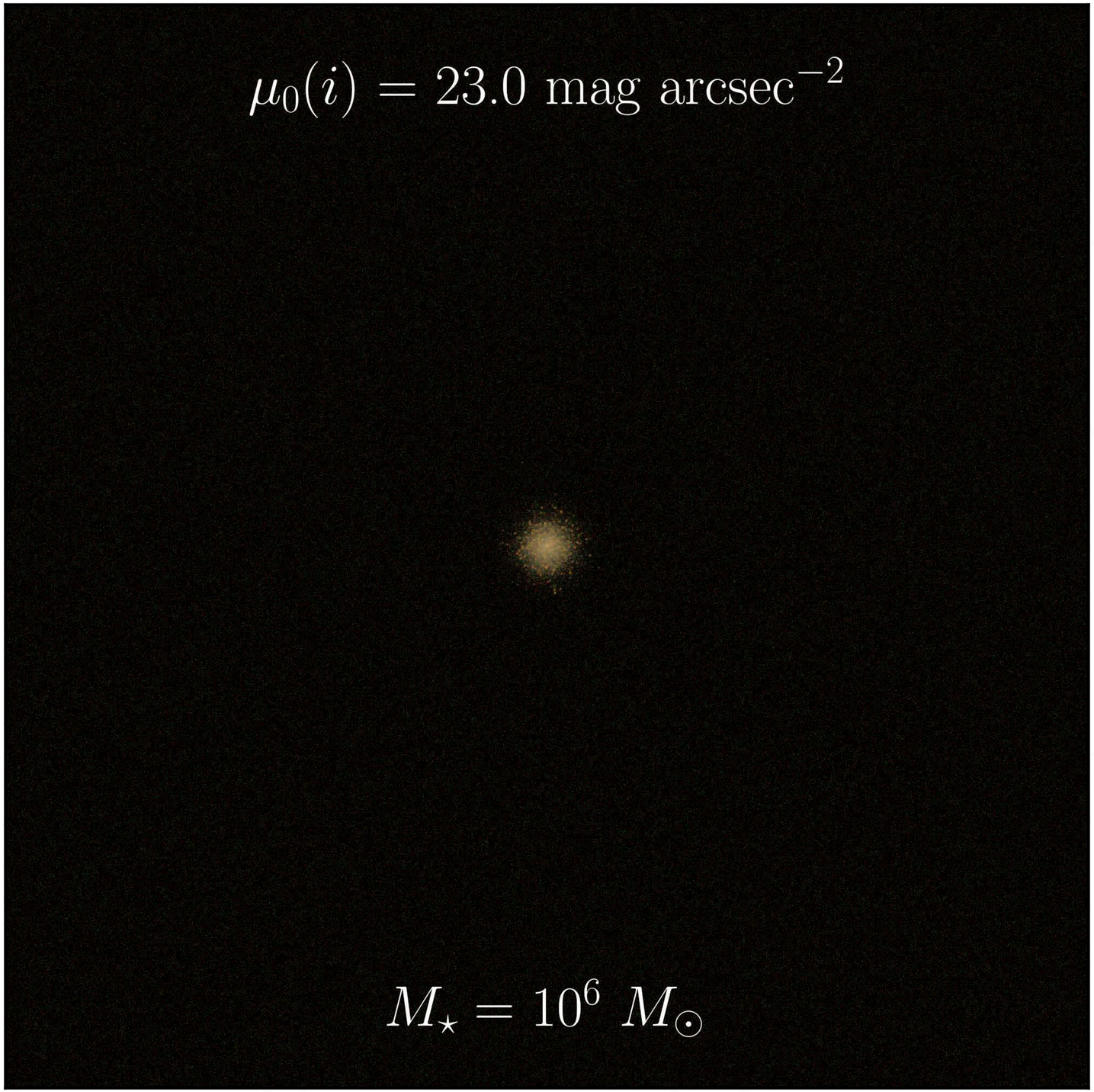
Sloan **D**igital **S**ky **S**urvey

→ ***Wide*** & deep-***ish***

Surface Brightness

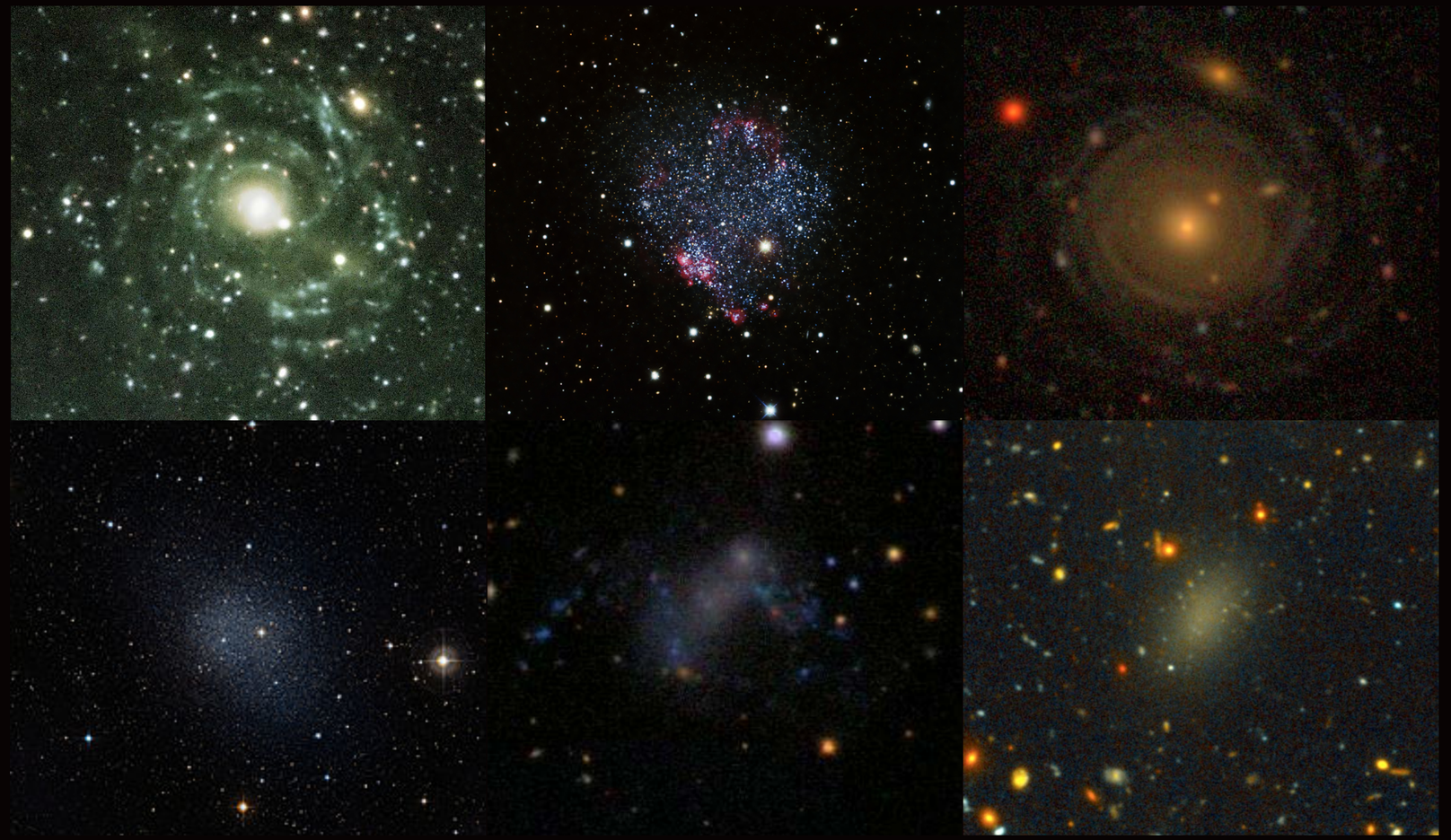


Surface Brightness



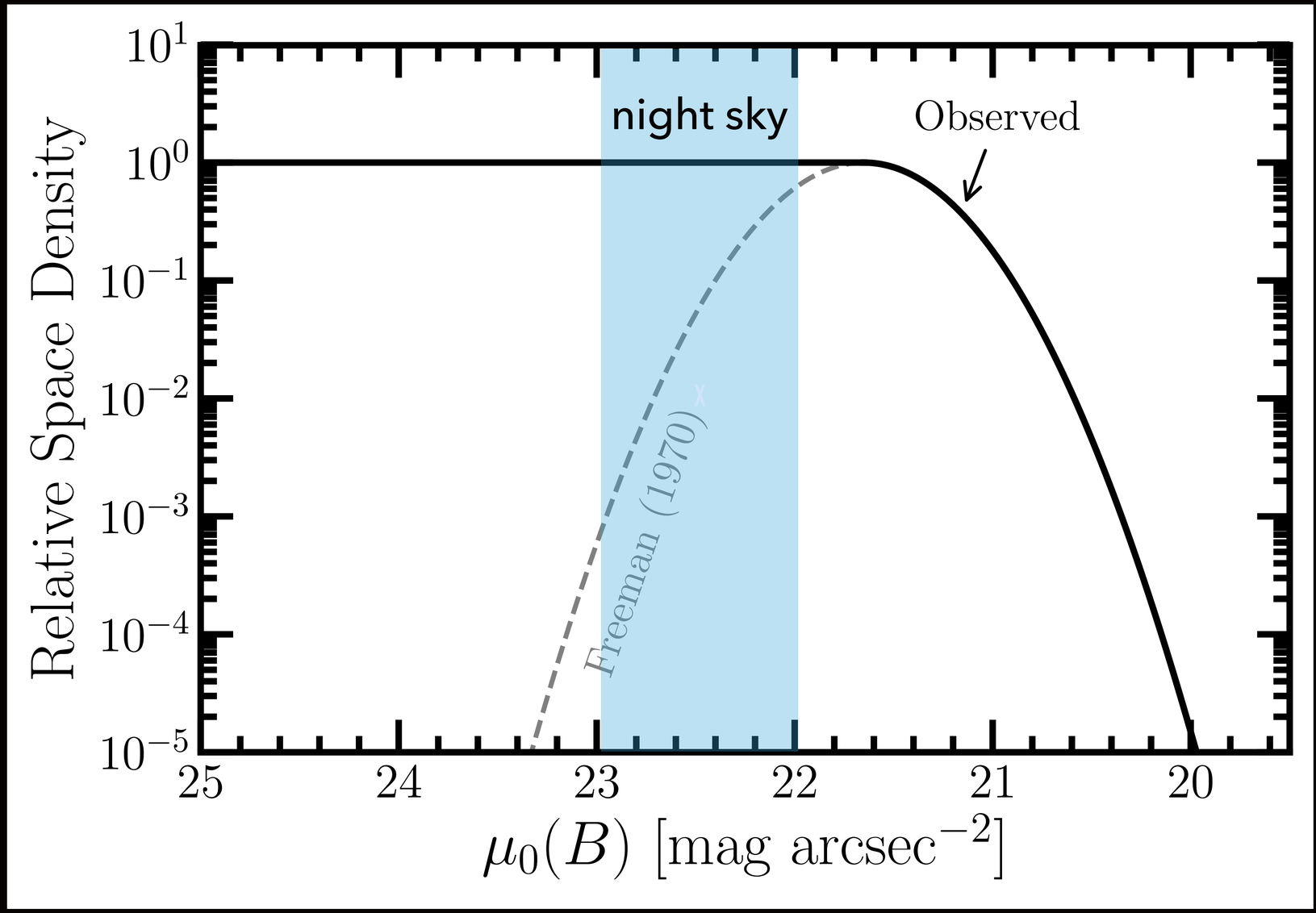

$\mu_0(i) = 23.1$ mag arcsec^{-2}
$M_\star = 10^6\ M_\odot$
$\mu_0(i) = 27.2$ mag arcsec^{-2}
$M_\star = 10^6\ M_\odot$
$\mu_0(i) = 23.0$ mag arcsec^{-2}
$M_\star = 10^6\ M_\odot$
$\mu_0(i) = 28.5$ mag arcsec^{-2}
$M_\star = 10^6\ M_\odot$

The ***Hidden*** Galaxy Population



Low Surface Brightness (LSB) Galaxies

The ***Hidden*** Galaxy Population



McGaugh et al., 1995

Ultra-Diffuse Galaxies (UDGs)

↓

LSB** Galaxies **Redux

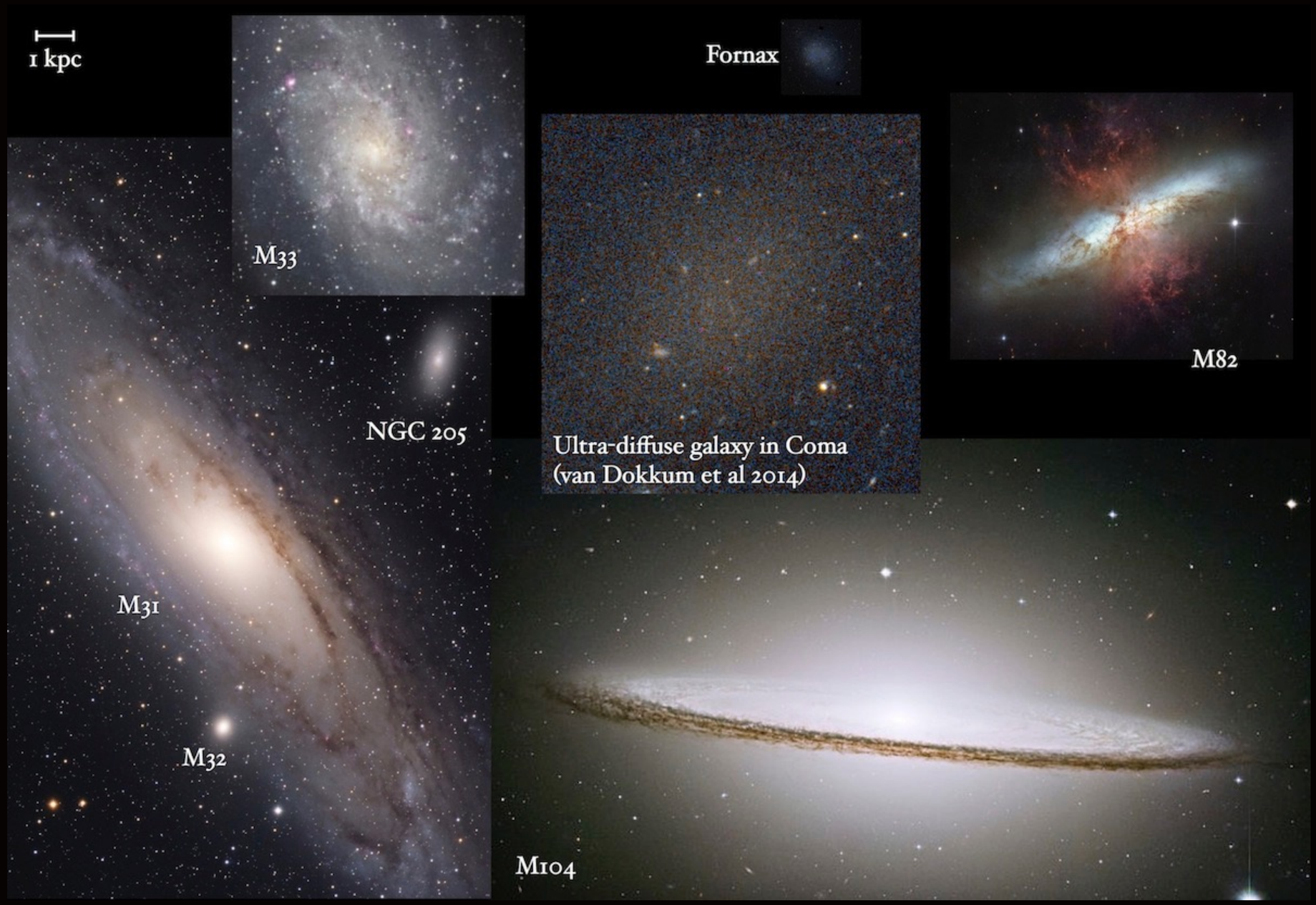
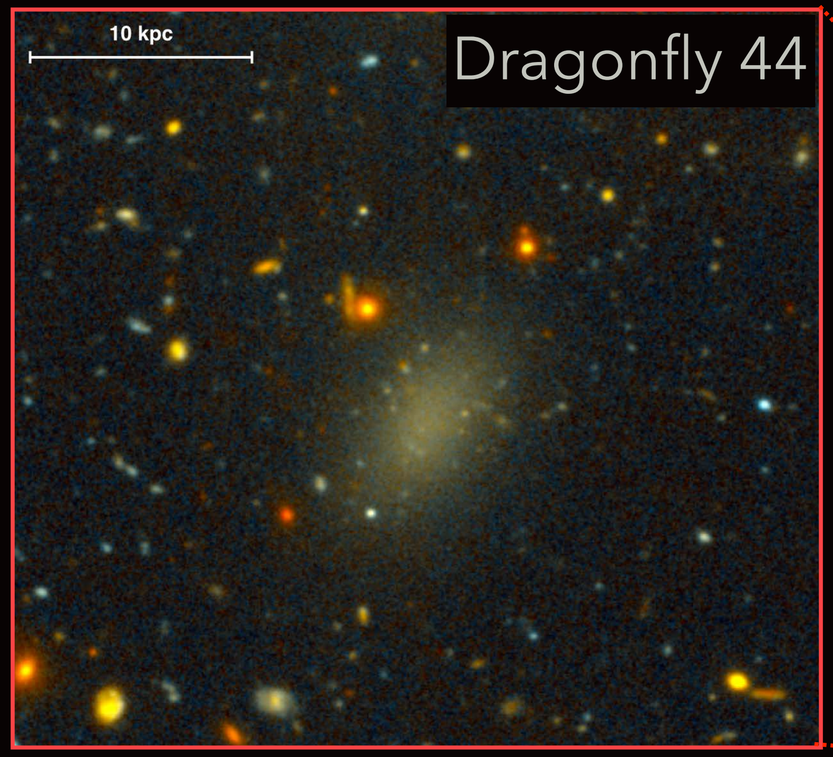
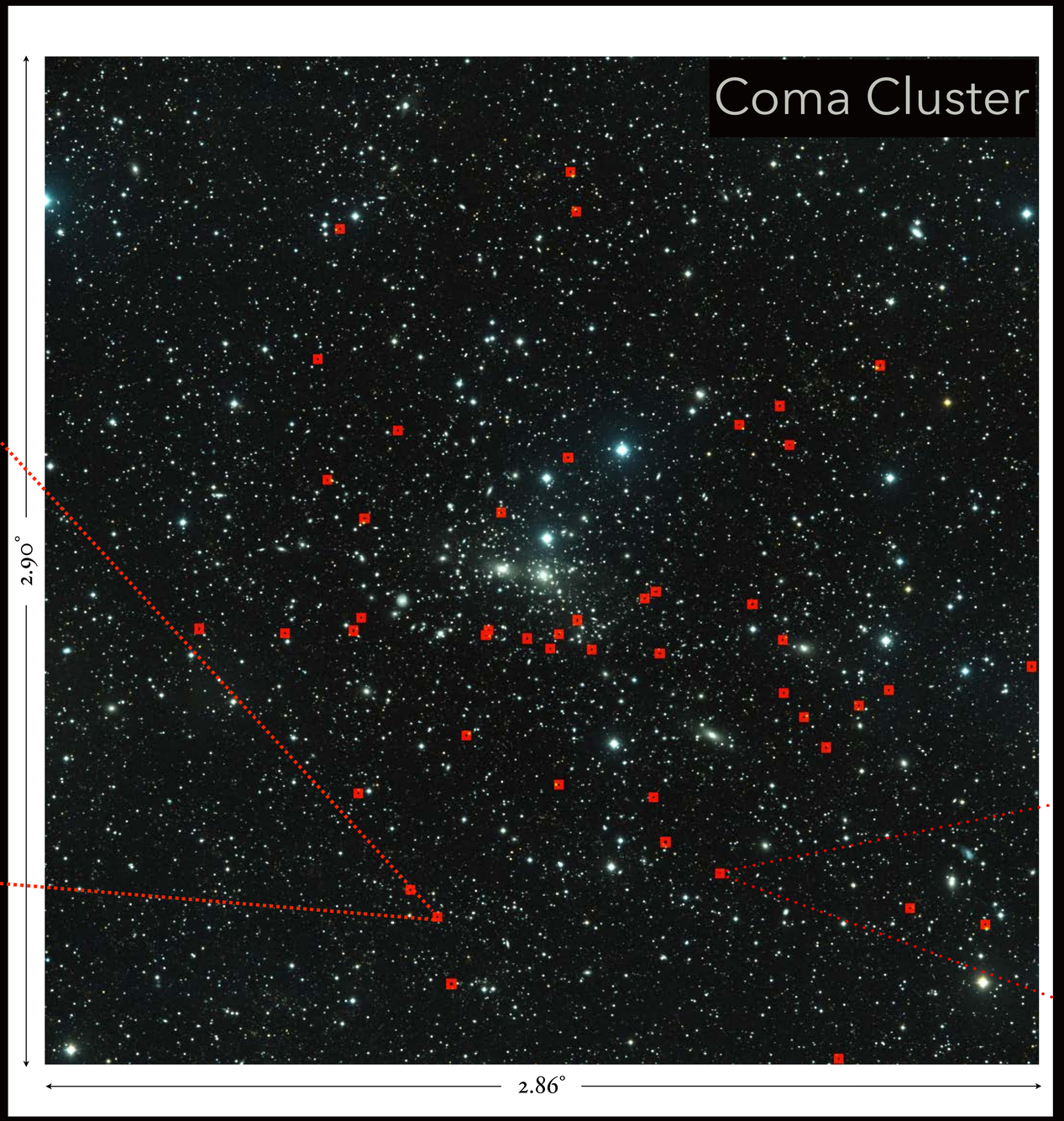


Image credit: Pieter van Dokkum

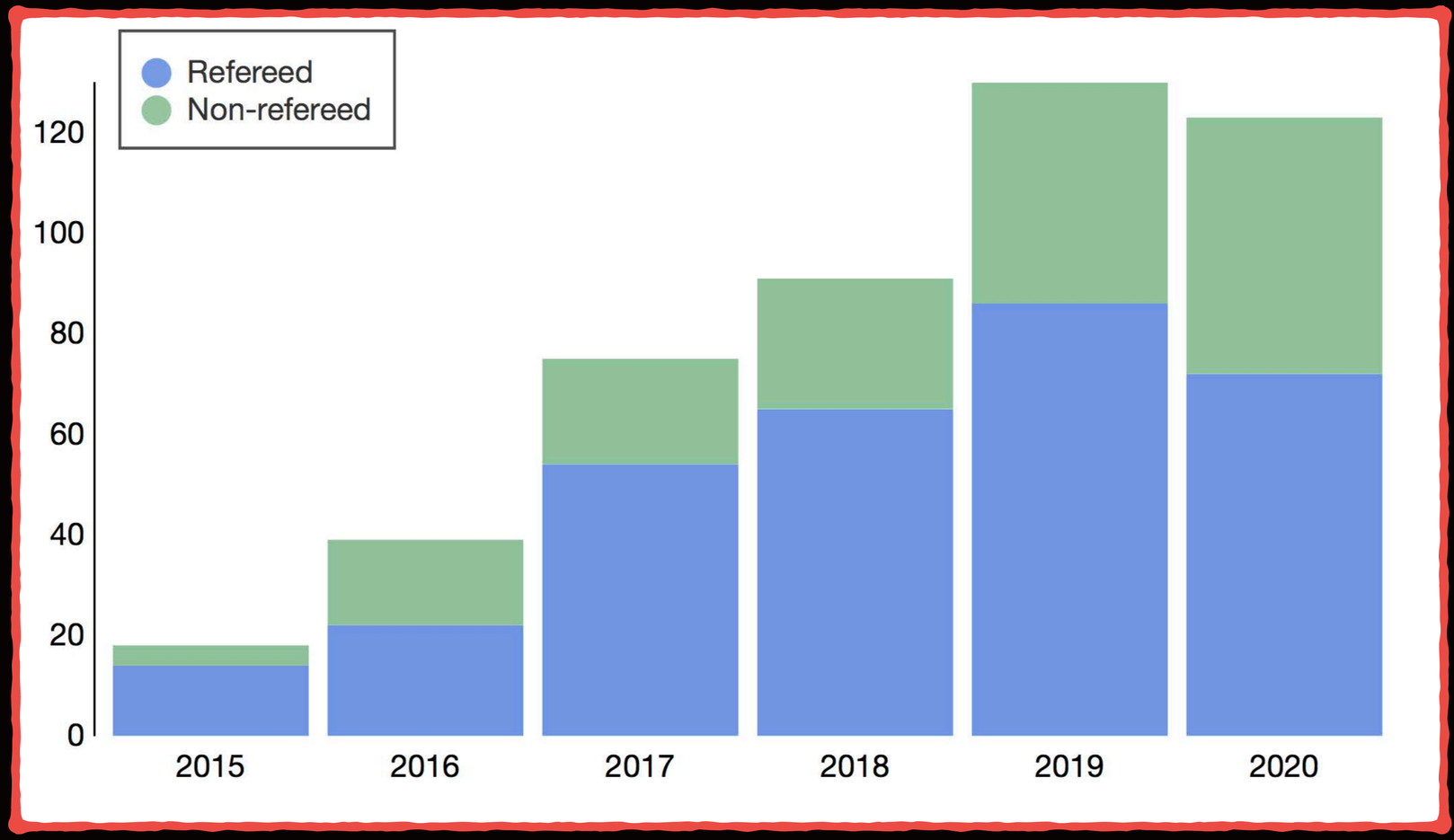
UDGs in Coma





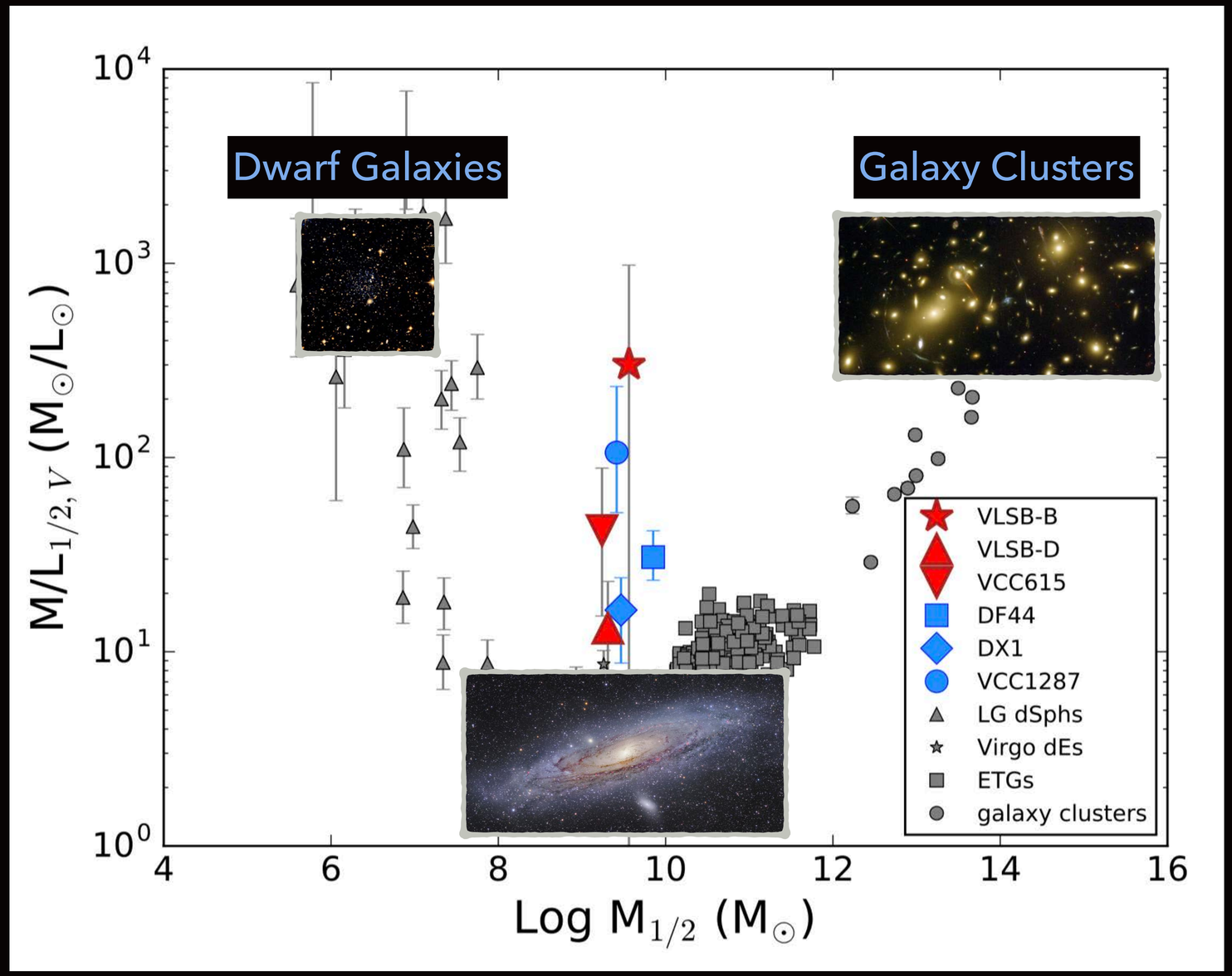
van Dokkum et al. 2015, 2016; Koda et al. 2015

Number of ***UDG*** Papers



Data Source: ADS

Extreme
mass-to-light
ratios



Toloba et al. 2018

Extreme

mass-to-light

ratios

nature
International journal of science

Letter | Published: 28 March 2018

A galaxy lacking dark matter

Pieter van Dokkum, Shany Danieli, Yotam Cohen, Allison Merritt, Aaron J. Romanowsky, Roberto Abraham, Jean Brodie, Charlie Conroy, Deborah Lokhorst, Lamiya Mowla, Ewan O'Sullivan & Jielai Zhang

The Galaxy That Challenged Dark Matter (And Failed)

Ethan Siegel Senior Contributor
Starts With A Bang Contributor Group
Science

The Universe is out there, waiting for you to discover it.

Second ghostly galaxy without dark matter discovered, first confirmed

Ironically, by finding two galaxies severely lacking in dark matter, researchers have made a compelling case for the existence of the mysterious material.

By Jake Parks | Published: Friday, March 29, 2019

WHAT IS THIS GALAXY DOING WITHOUT A DARK MATTER HALO?

Unusual galaxies defy dark matter theory

by W. M. Keck Observatory

This Galaxy Has Almost No Dark Matter—and Scientists Are Baffled

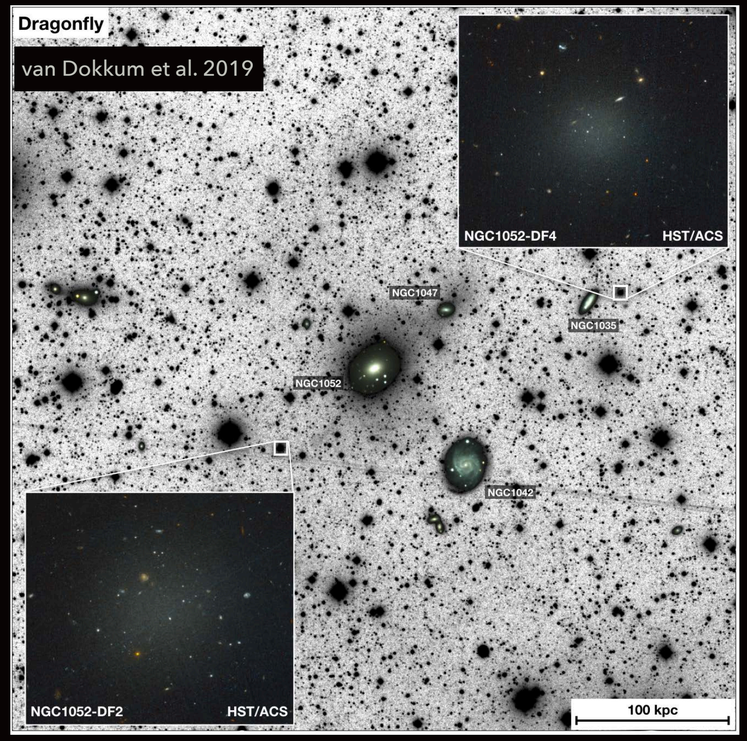
NATIONAL GEOGRAPHIC found an "undark" galaxy, it's a strong clue that dark

Astronomers find 2nd galaxy lacking dark matter

Posted by **Deborah Byrd** *in* **SPACE** | April 2, 2019

March 28, 2018

Dark Matter Goes Missing in Oddball Galaxy



Dark matter 'missing' in a galaxy far, far away

by Gemini Observatory

Do these objects fit in our current picture ?

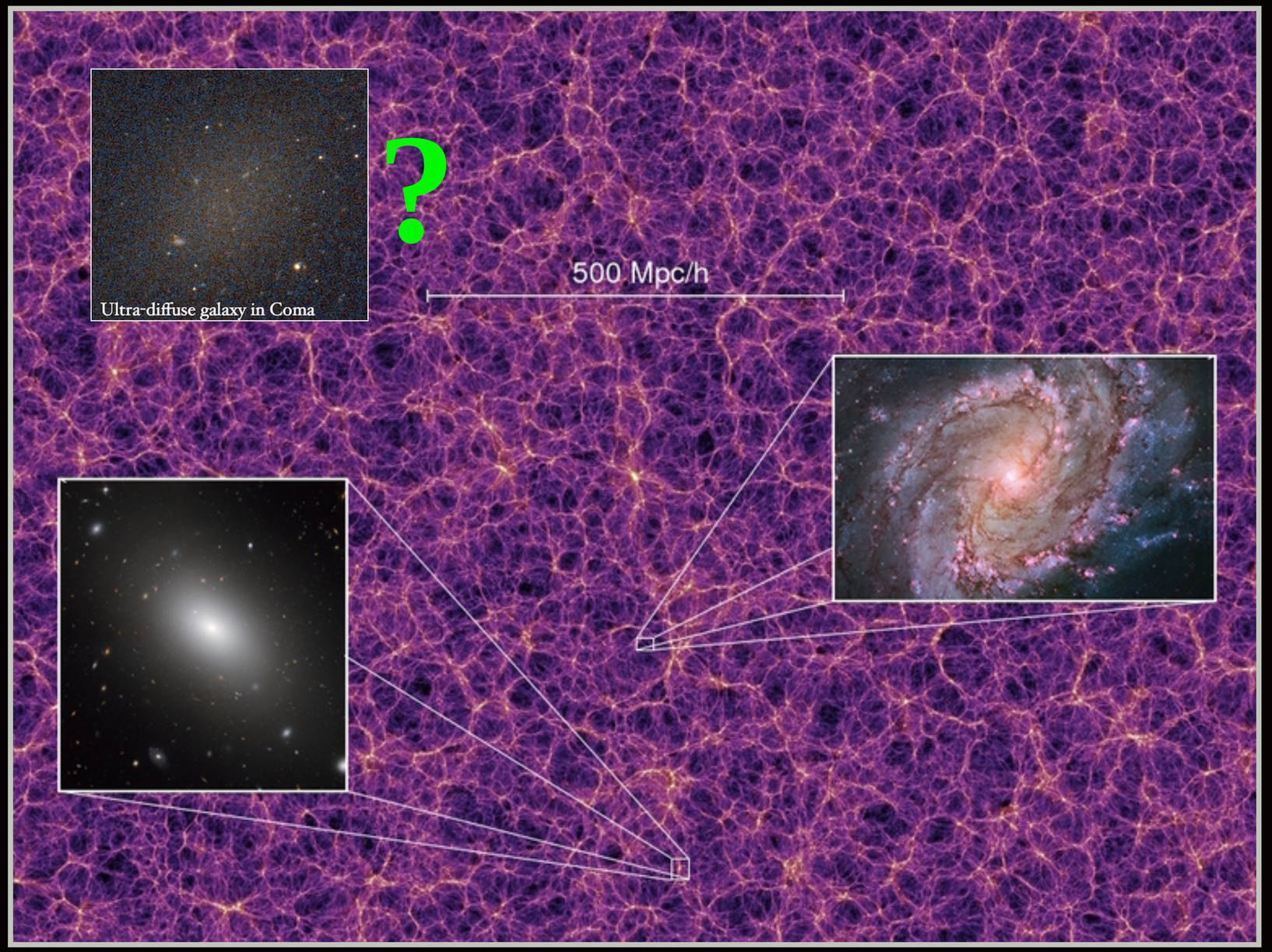


Image credit: Owen Parry & Springel et. al 2005

The ***Hyper Suprime-Cam*** (HSC) ***Subaru*** Strategic Program

=

+

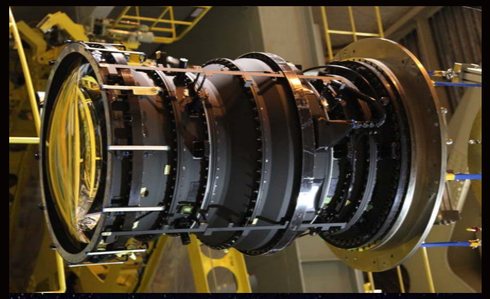


Image credits: NAOJ

Hyper Suprime-Cam
Field of View

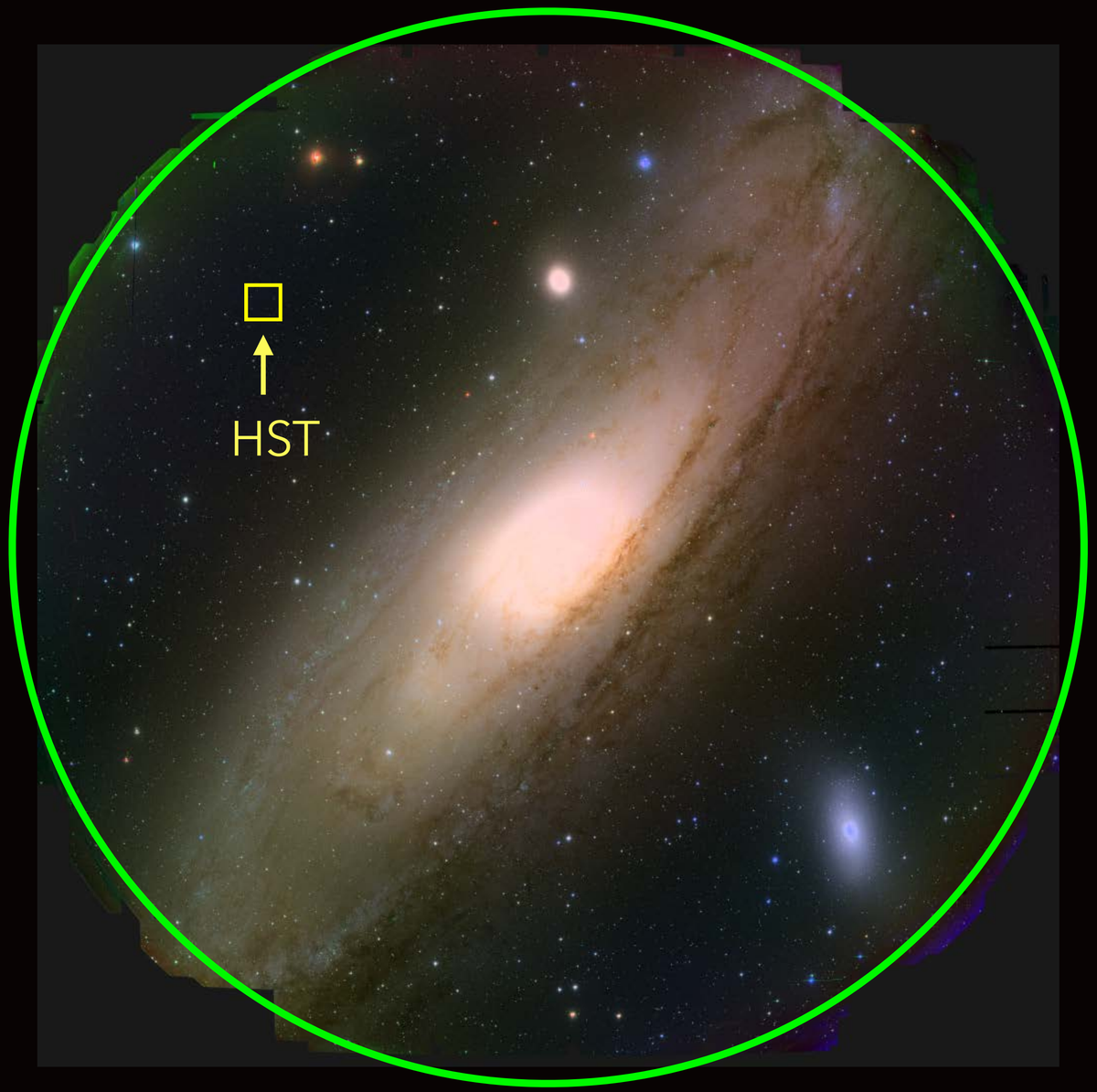


Image credit: NAOJ

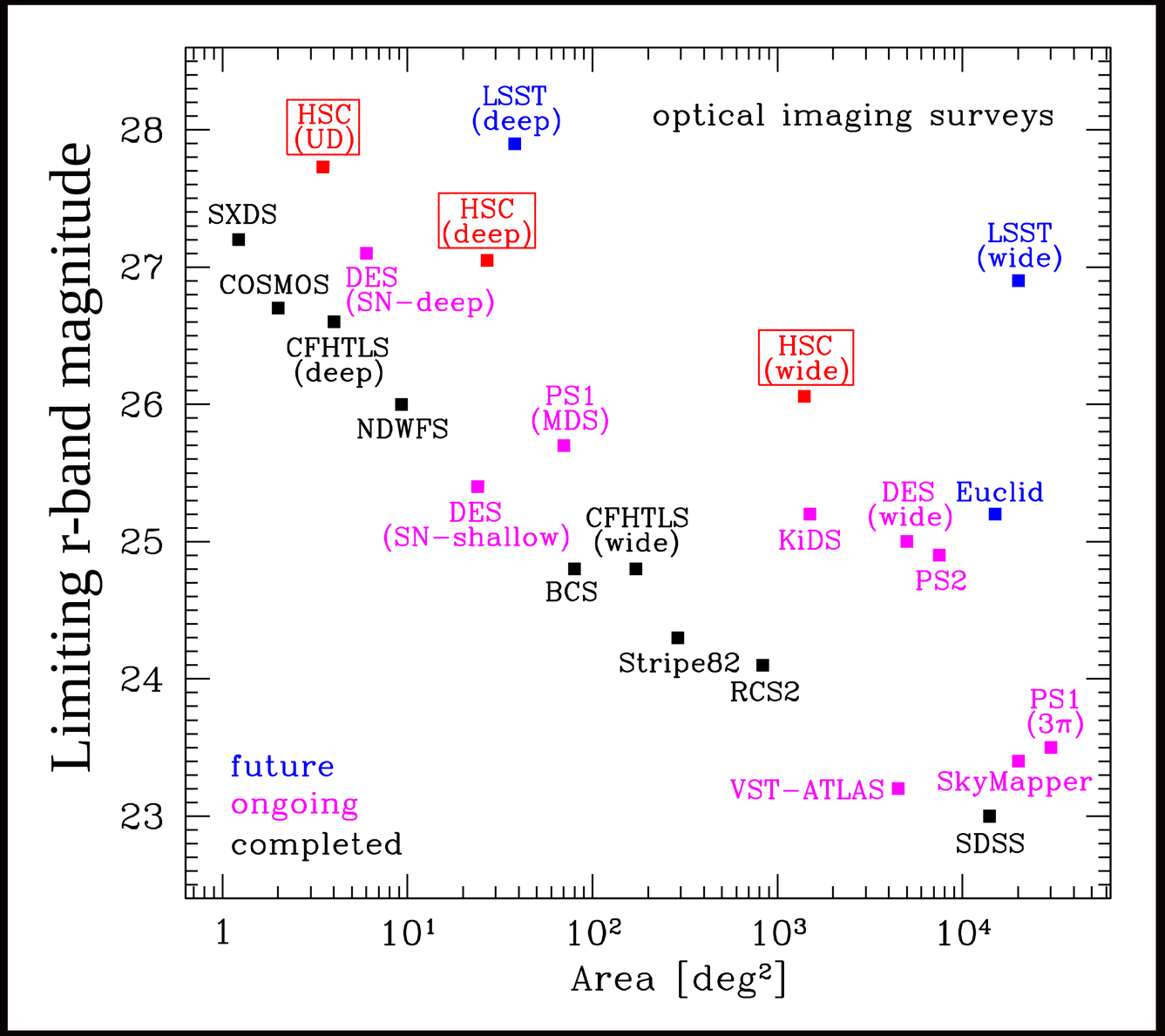


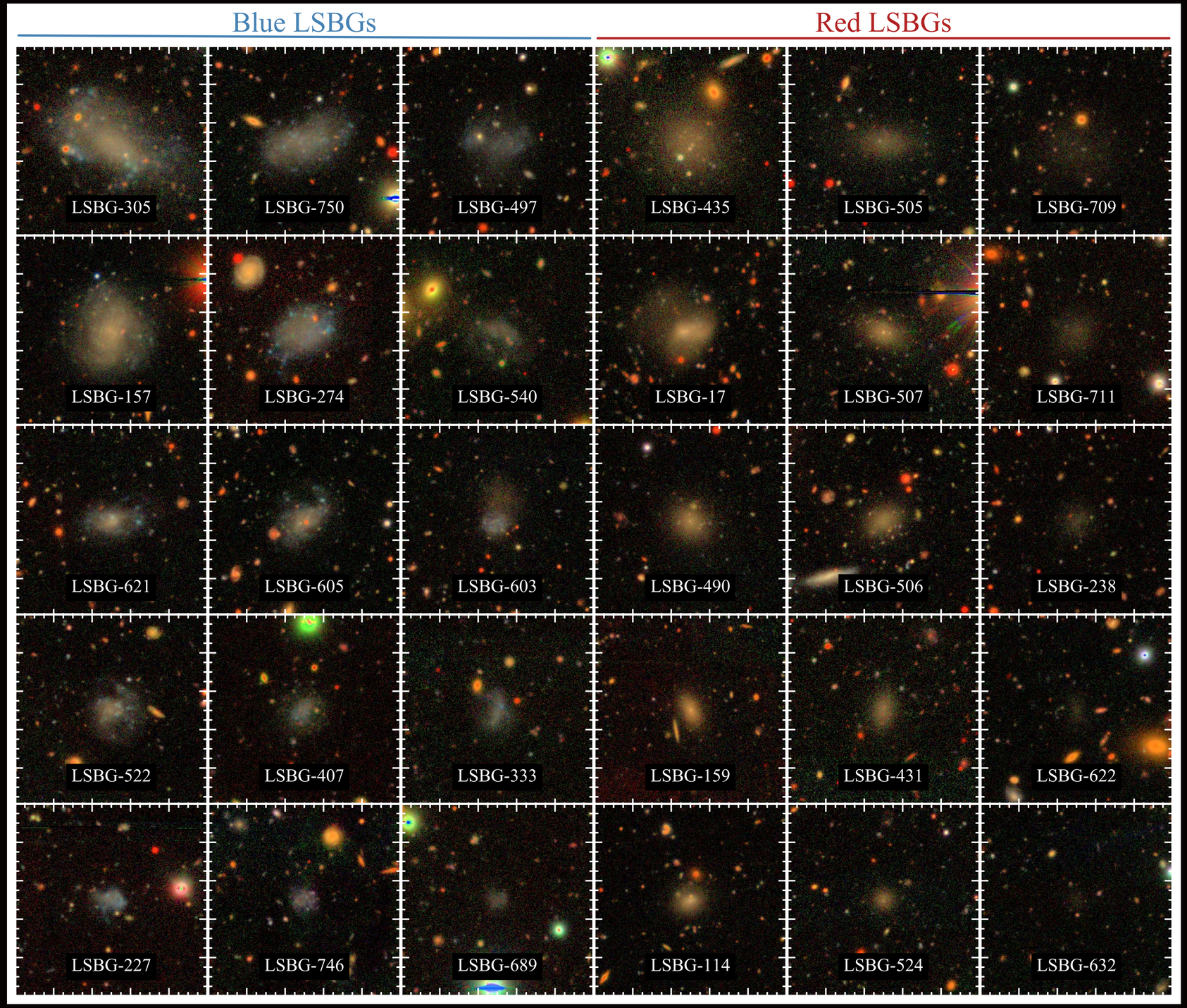
Figure credit: HSC Collaboration (2012)

Ushering in the *LSST era*

Hyper Suprime-Cam: ***LSB Vision***

A ***new view*** with the ***HSC***

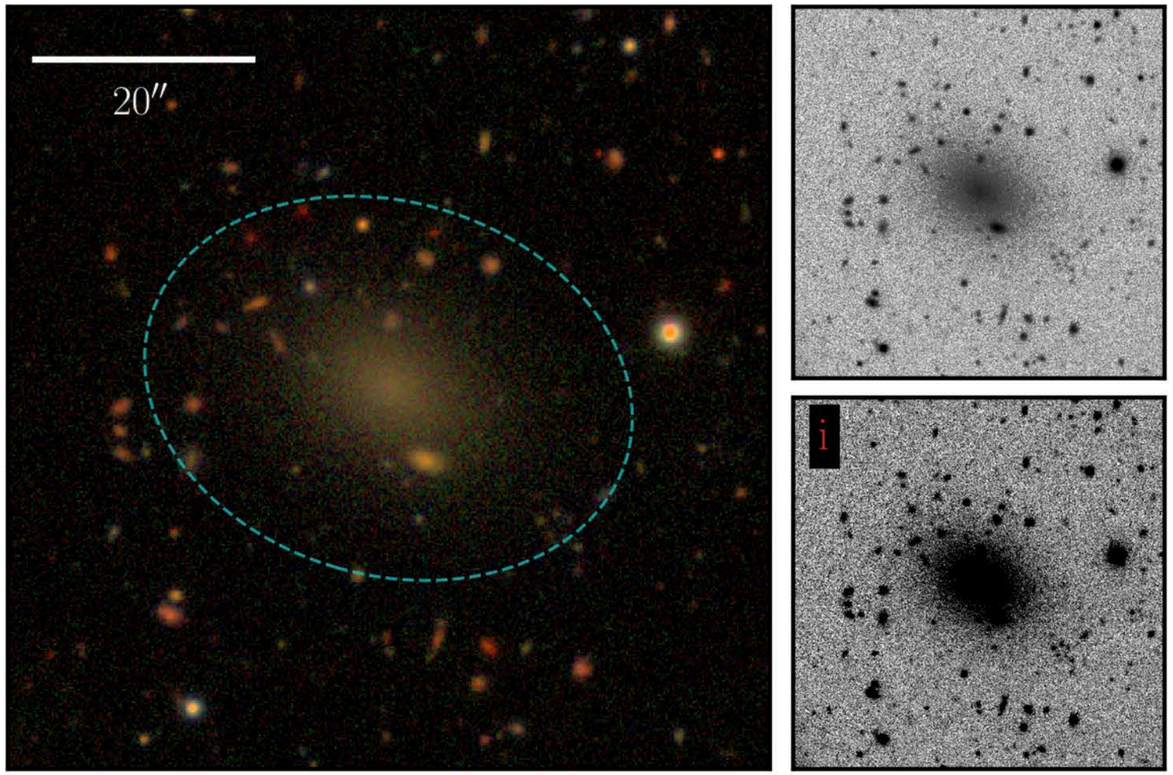
Ultra-LSB sources in SDSS


Blue LSBGs
Red LSBGs
55″
LSBG-305
LSBG-750
LSBG-497
LSBG-435
LSBG-505
LSBG-709
LSBG-157
LSBG-274
LSBG-540
LSBG-17
LSBG-507
LSBG-711
LSBG-621
LSBG-605
LSBG-603
LSBG-490
LSBG-506
LSBG-238
LSBG-522
LSBG-407
LSBG-333
LSBG-159
LSBG-431
LSBG-622
LSBG-227
LSBG-746
LSBG-689
LSBG-114
LSBG-524
LSBG-632

HSC's **Next Generation LSB Galaxy** *Search*

Legacy Surveys hscMap

← prev | Current (browsing all objects) 75943 | Jump to object | next →



Type in any notes below, then click a flag button to jump to the next object.

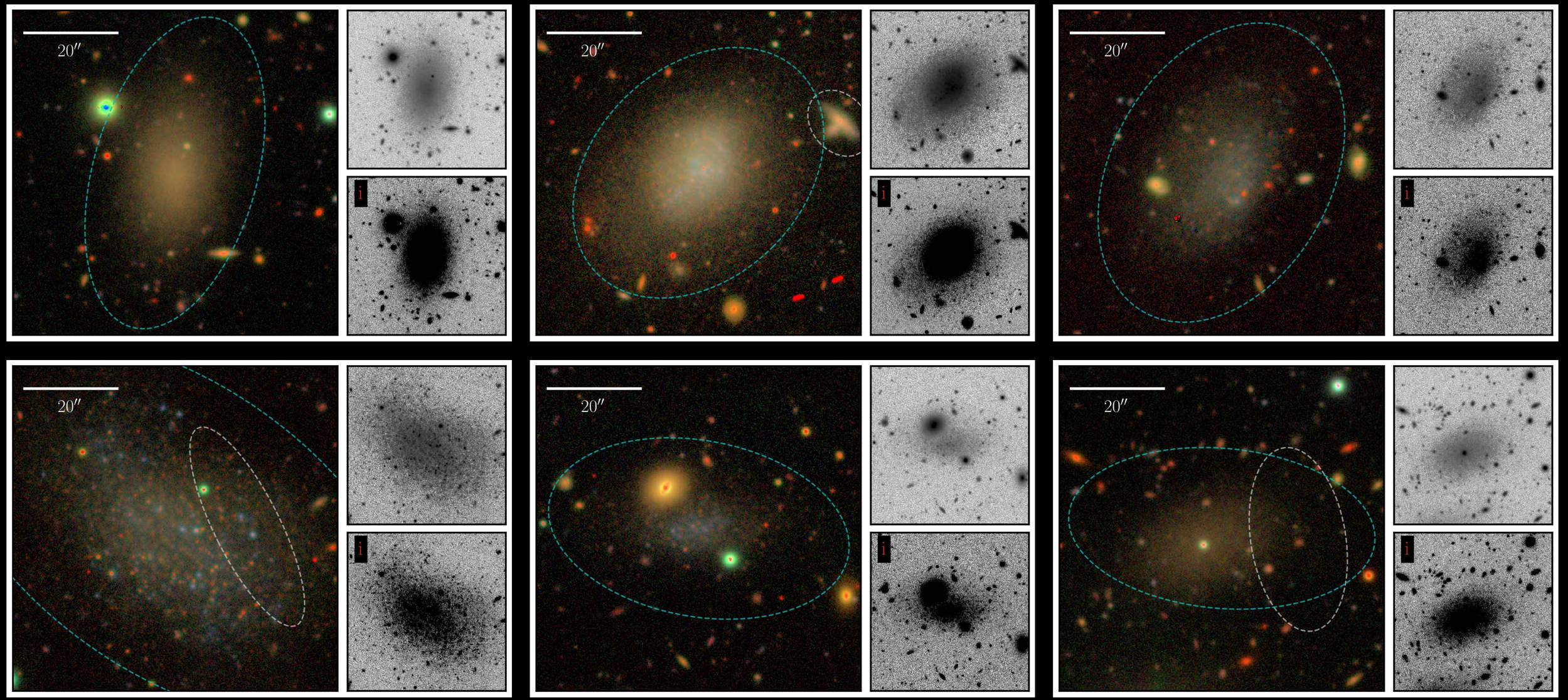
Notes for this object go here. Markdown formatting is supported. ADS bibcodes and most DOIs will be automatically linkified.

candy | galaxy | junk

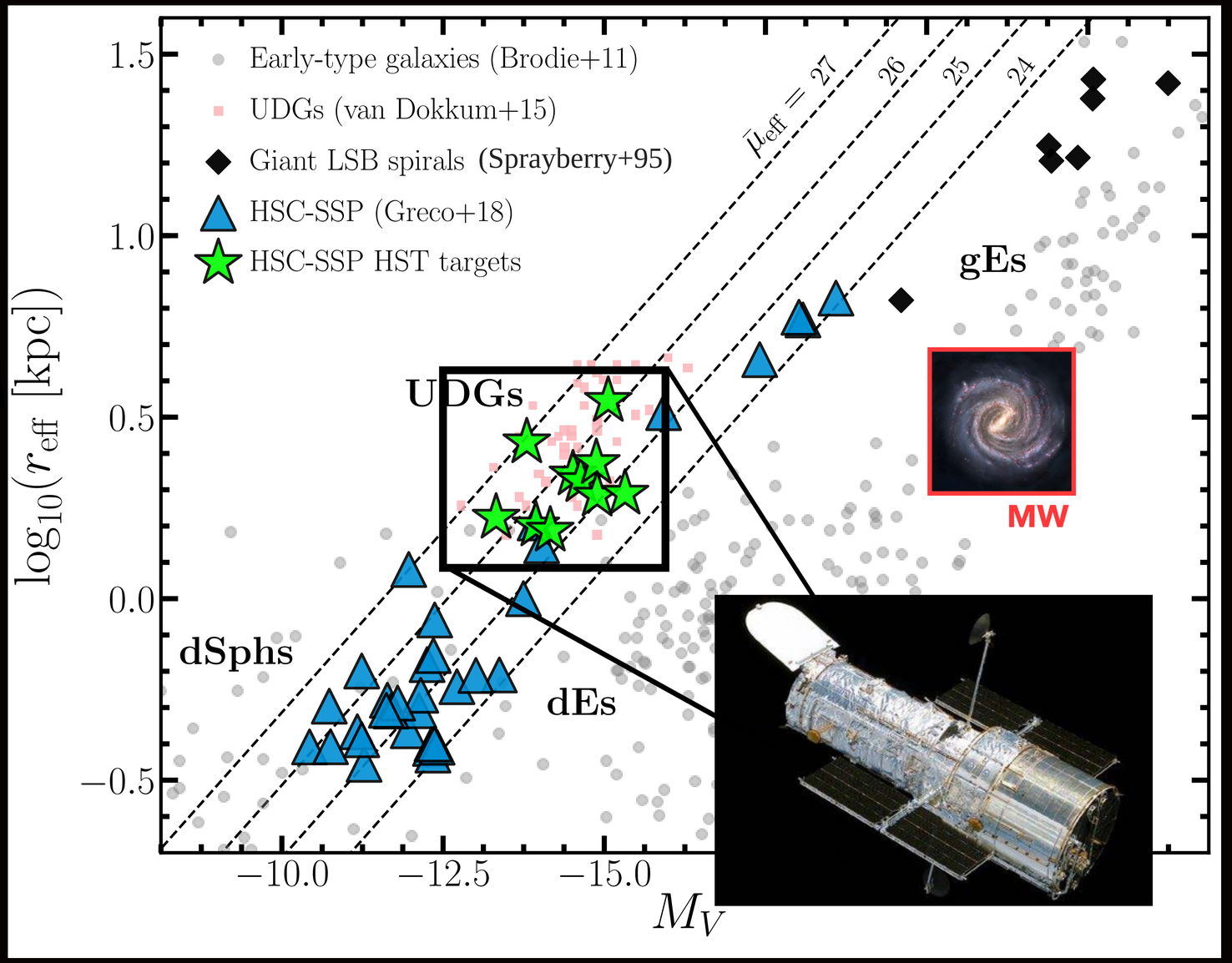
tidal | outskirts | cirrus

In collaboration with **Waqas Bhatti**

HSC's ***Next Generation LSB Galaxy*** *Search*



A ***Diverse*** Sample of ***LSB Galaxies***

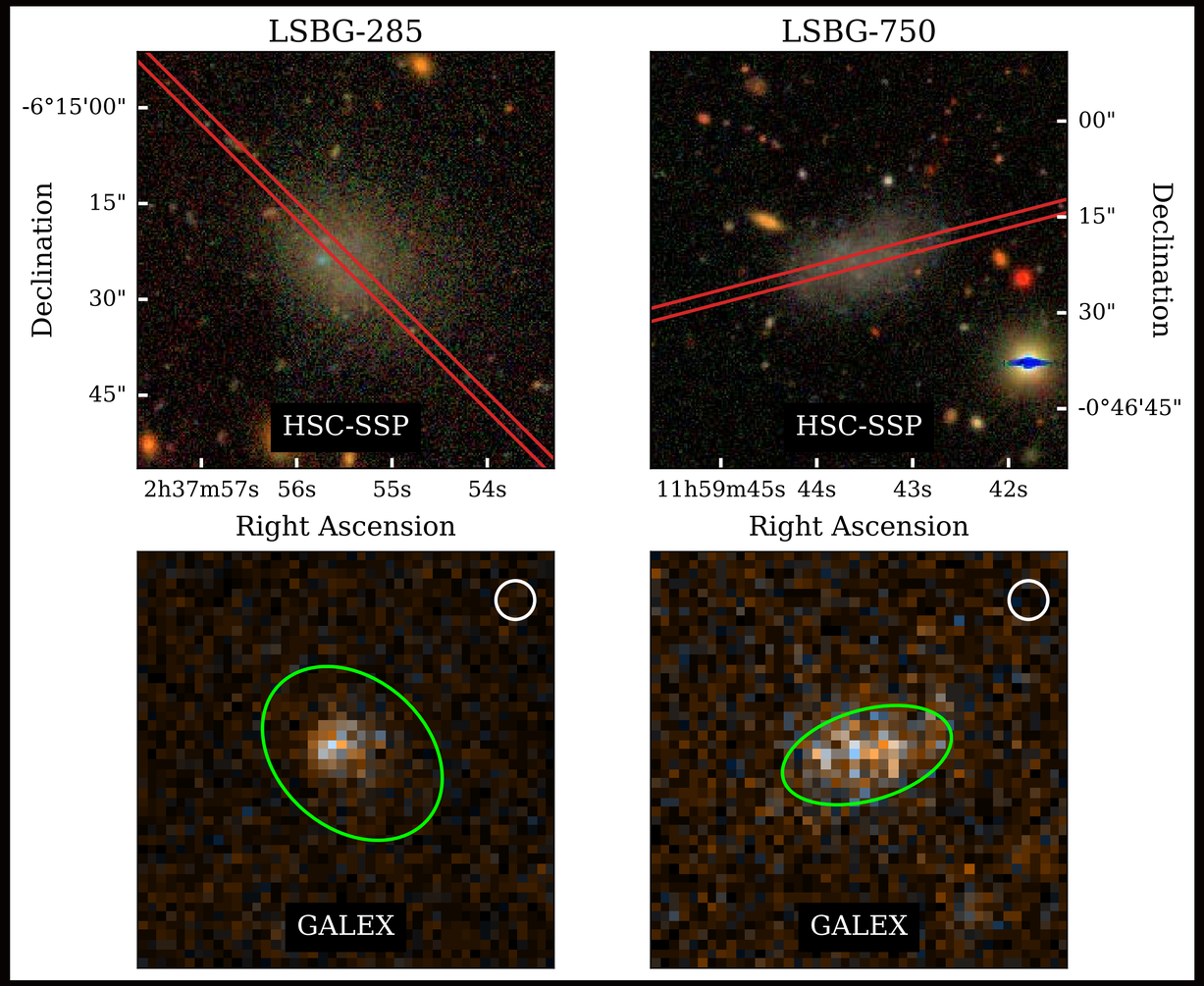


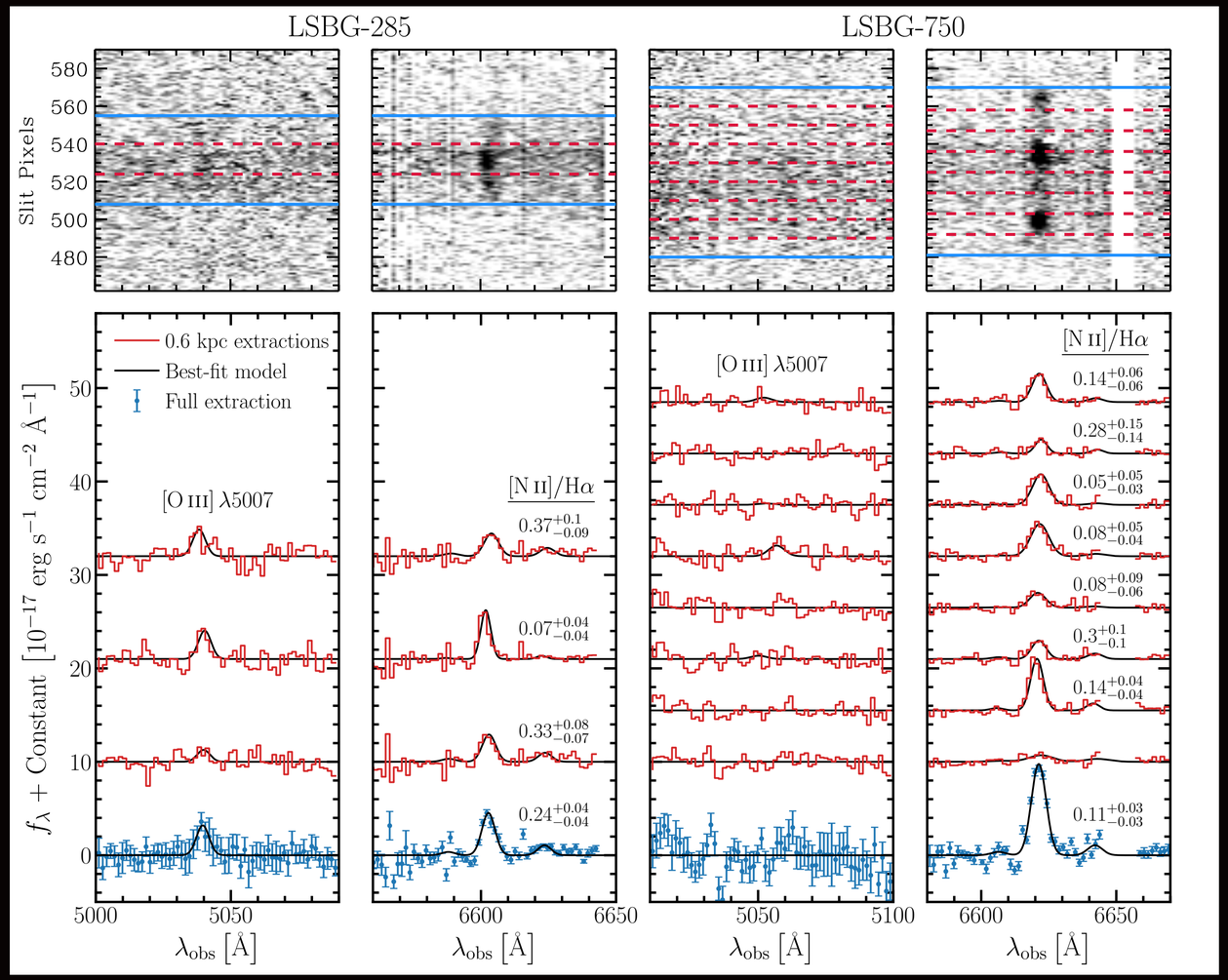
Greco et al. 2018a

#DistancesAreHard

★ Follow-up ***Spectroscopy***

Follow-up ***Spectroscopy***

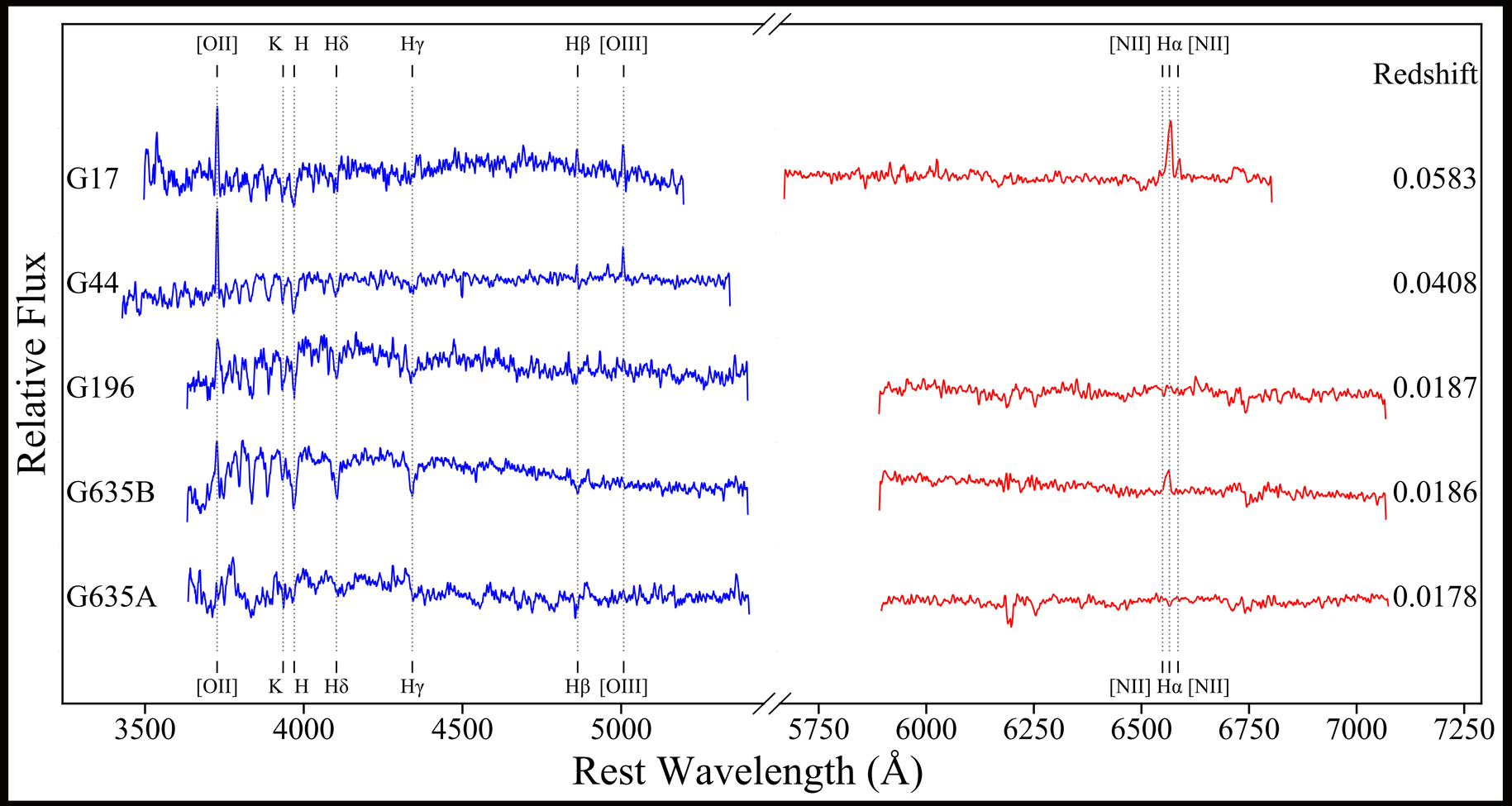




Greco et al. 2018c

Follow-up ***Spectroscopy***

Conor Hayes
(Ohio State)



Hayes, Greco, et al. (in prep.)

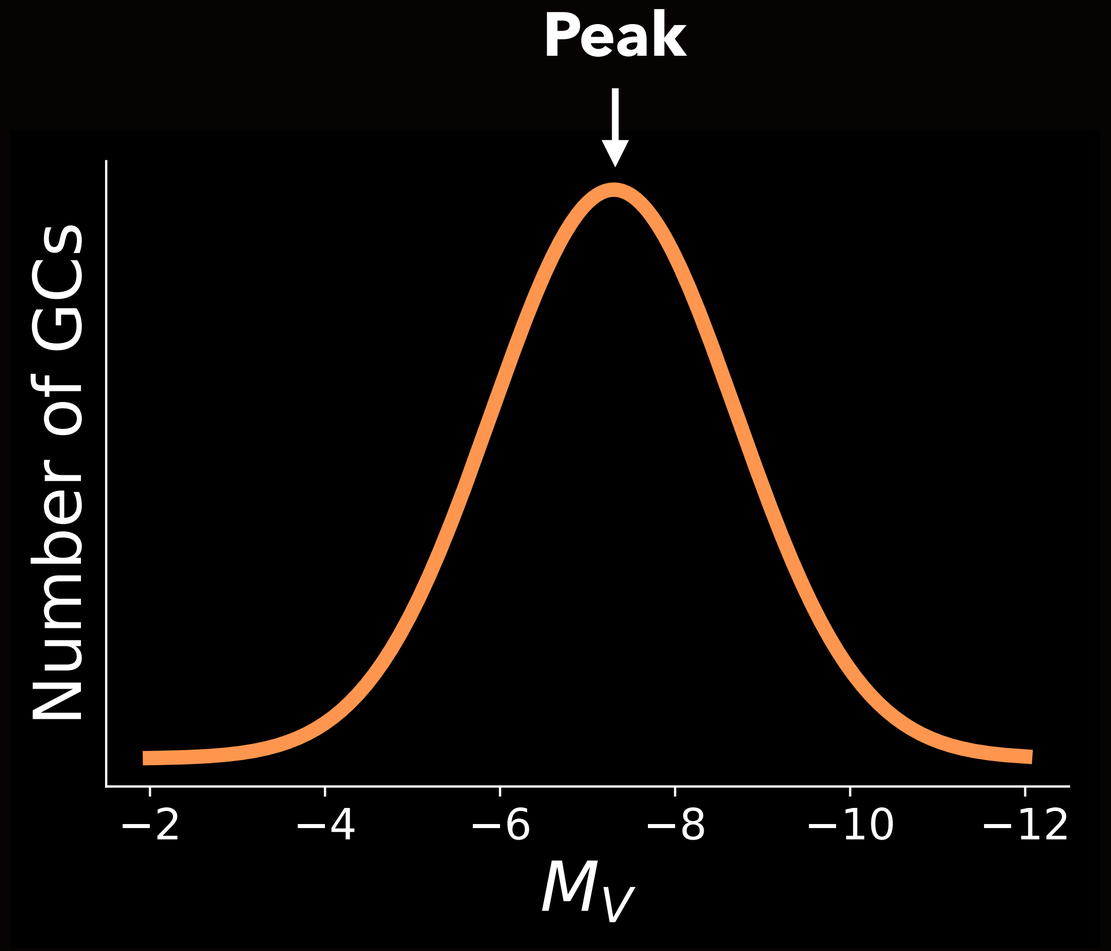
#DistancesAreHard

- ★ Follow-up ***Spectroscopy***
- ★ Counting ***Globular Clusters (GCs)***

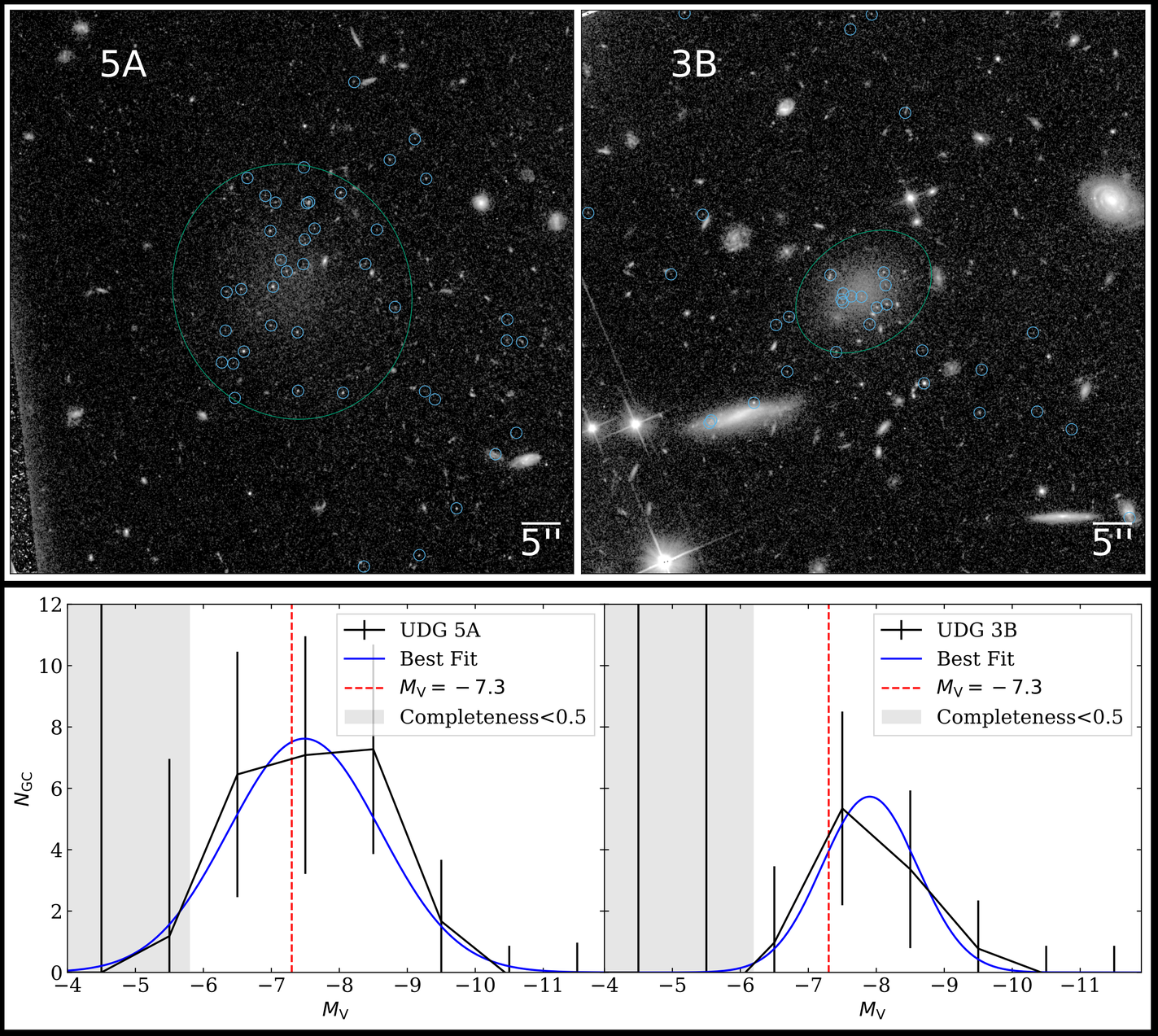
Counting ***Globular Clusters (GCs)***

GC Luminosity Function ***(GCLF)***

→ ~***Standard Candle***



e.g., Harris (2001), Richtler (2003), Miller & Lotz (2007)

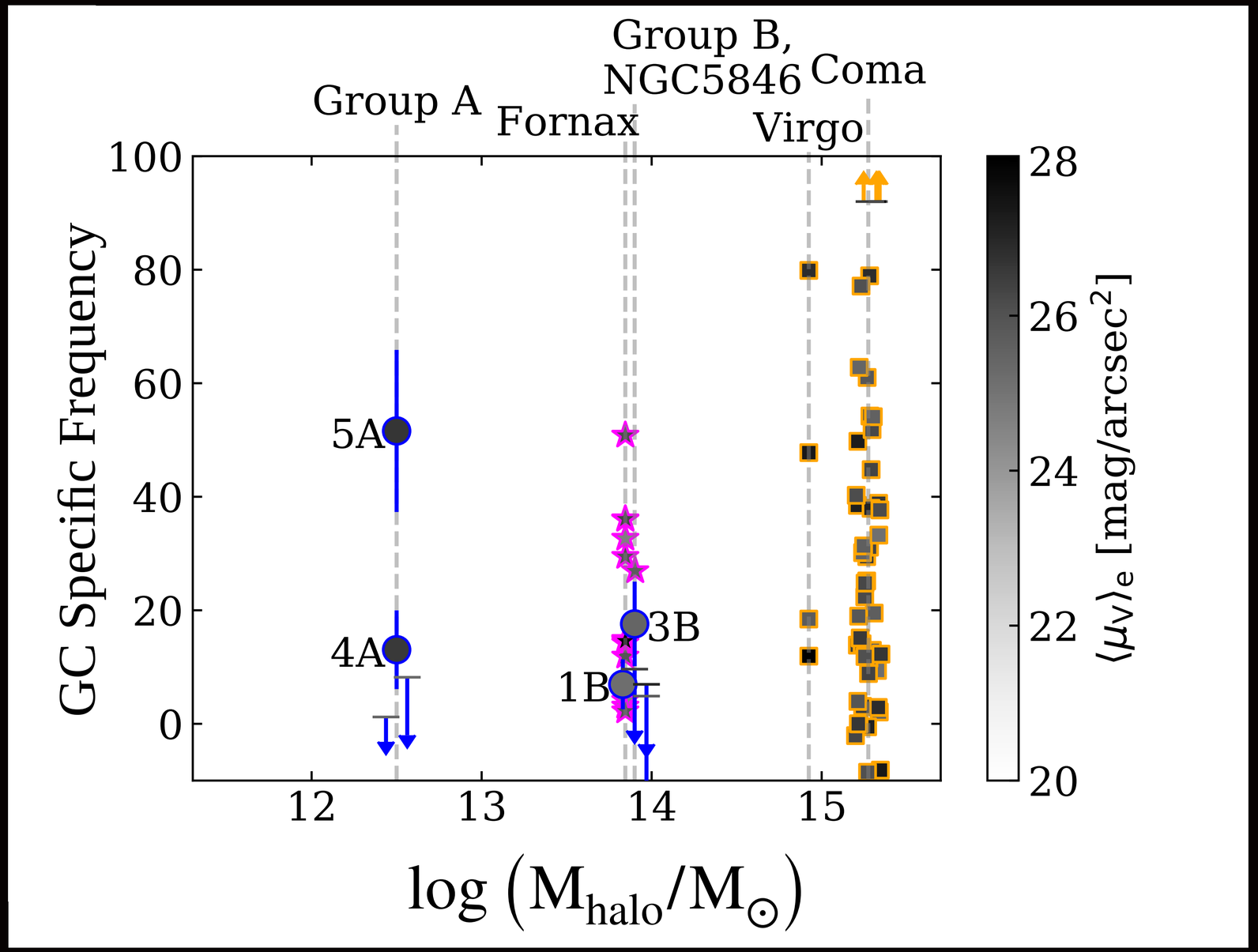


Somalwar, Greene, Greco et al. 2020

UDGs in ***group*** environments
& their ***globular cluster*** systems

More GCs

Less GCs

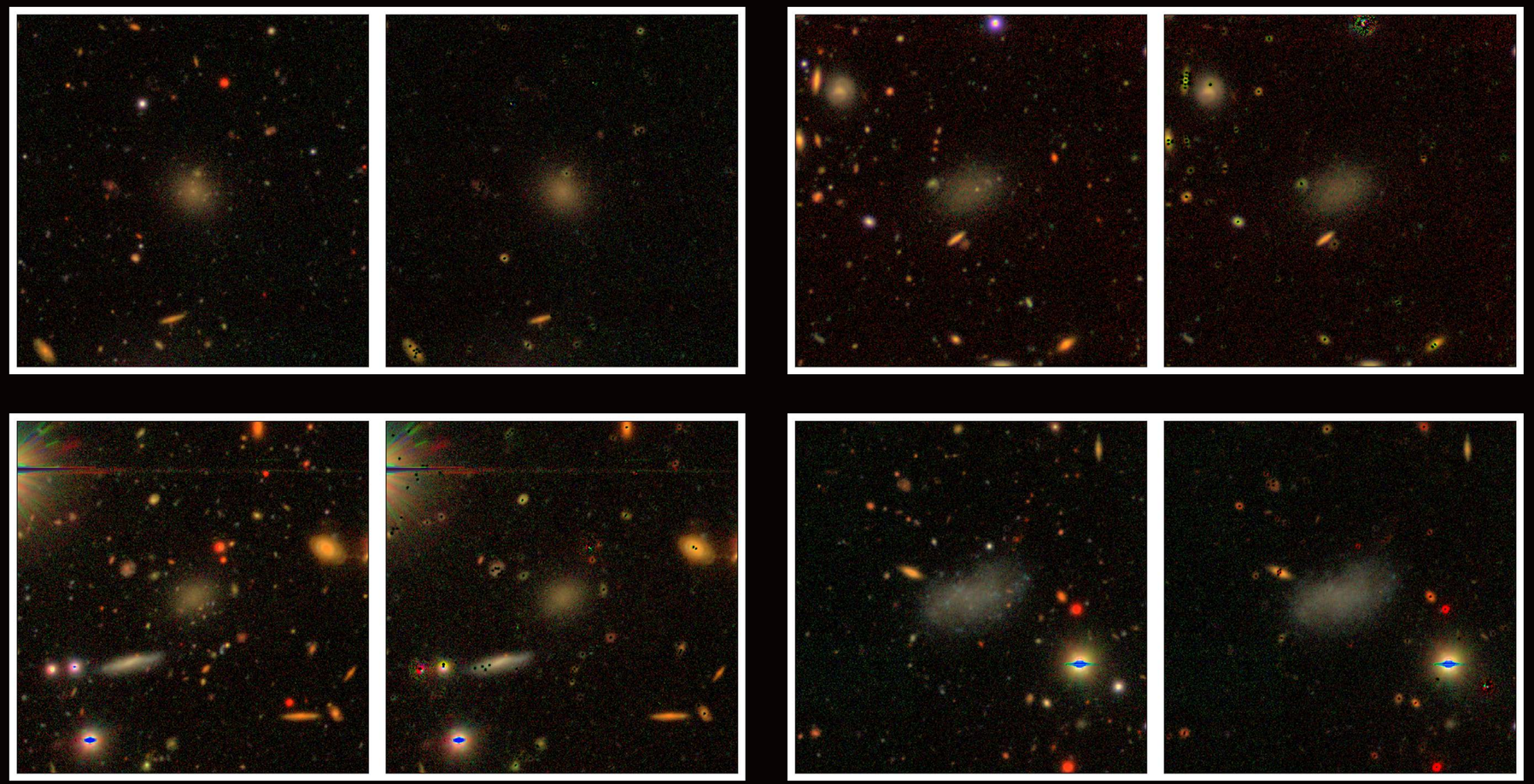


Somalwar, Greene, Greco et al. 2020

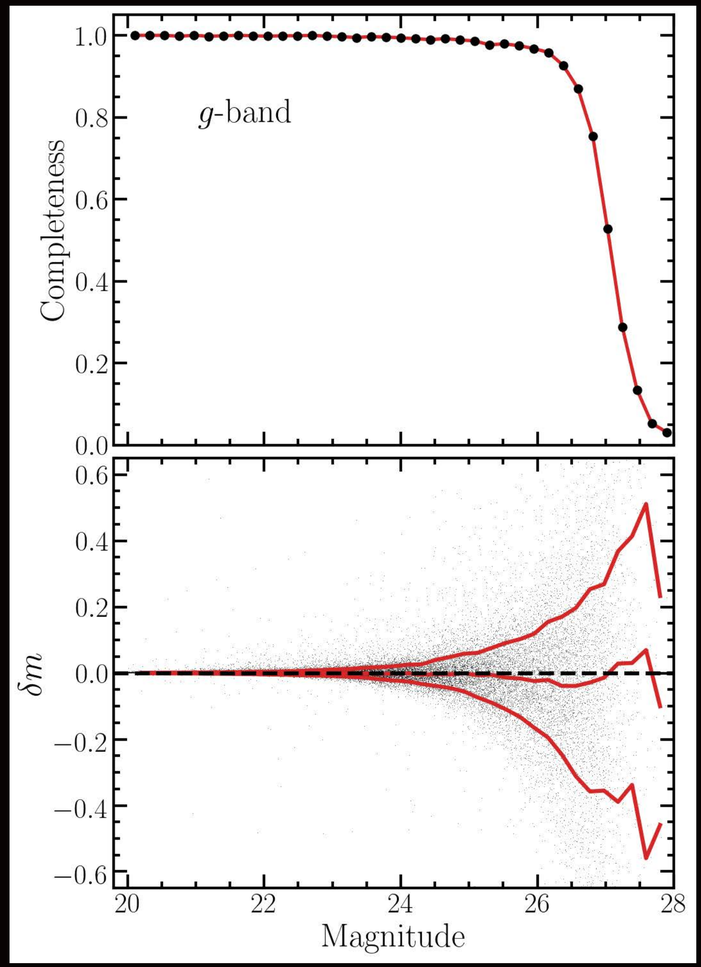

GLOB HUNT™
HSC-SSP
ENTERTAINMENT SYSTEM™

Ground-Based GC Search in ***LSB Dwarfs***

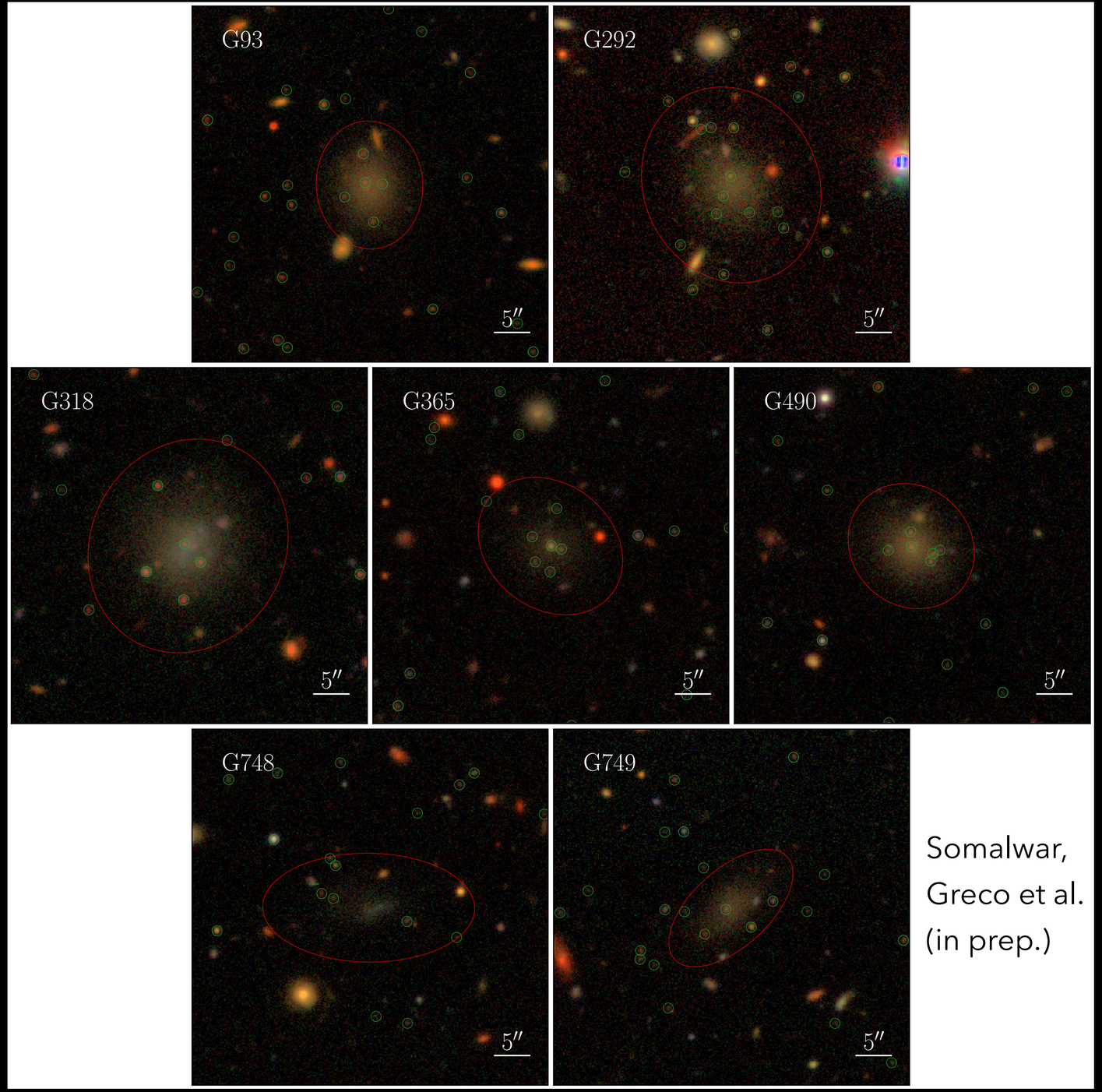
Original *gri* Image | Residual Image | Original *gri* Image | Residual Image



85″

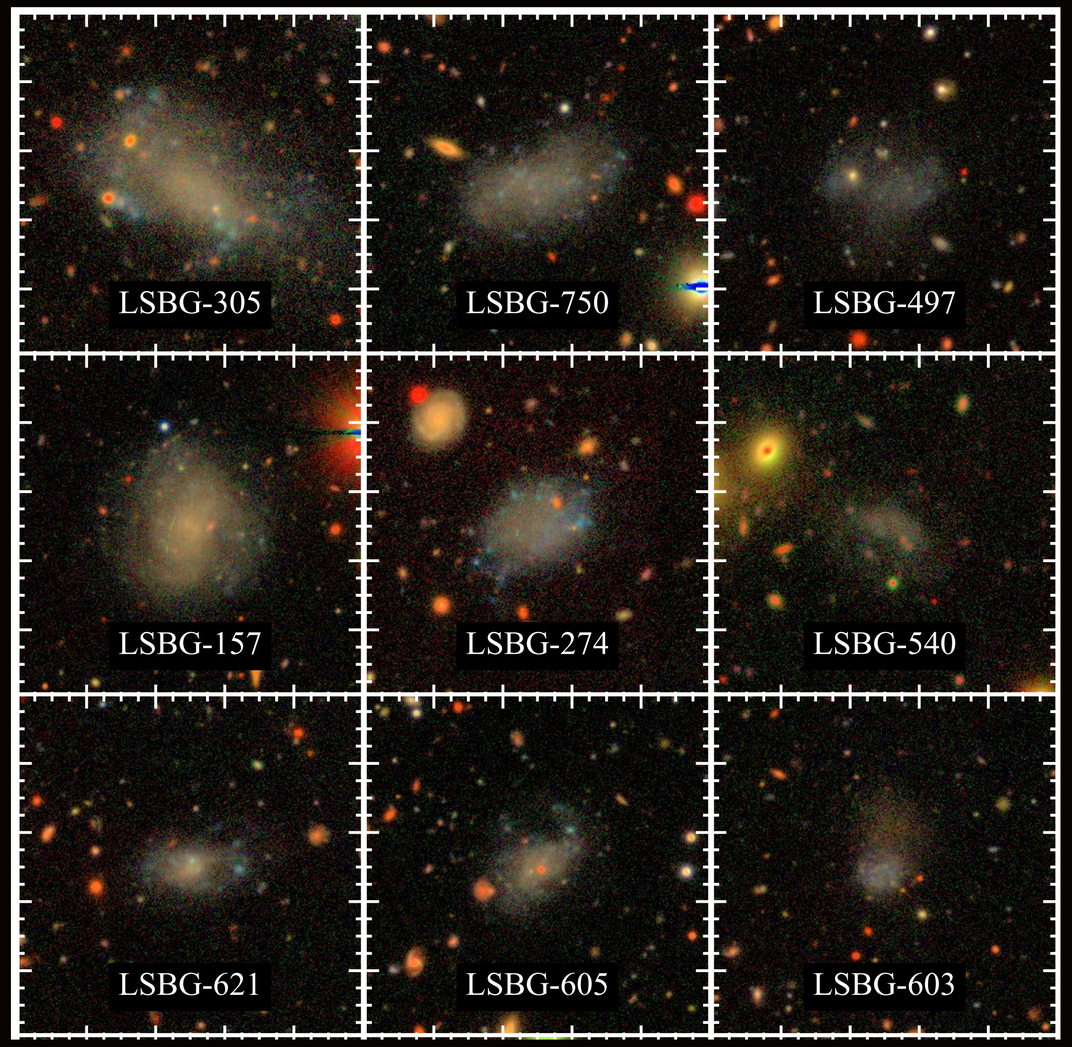


photutils
An Astropy Package for Photometry

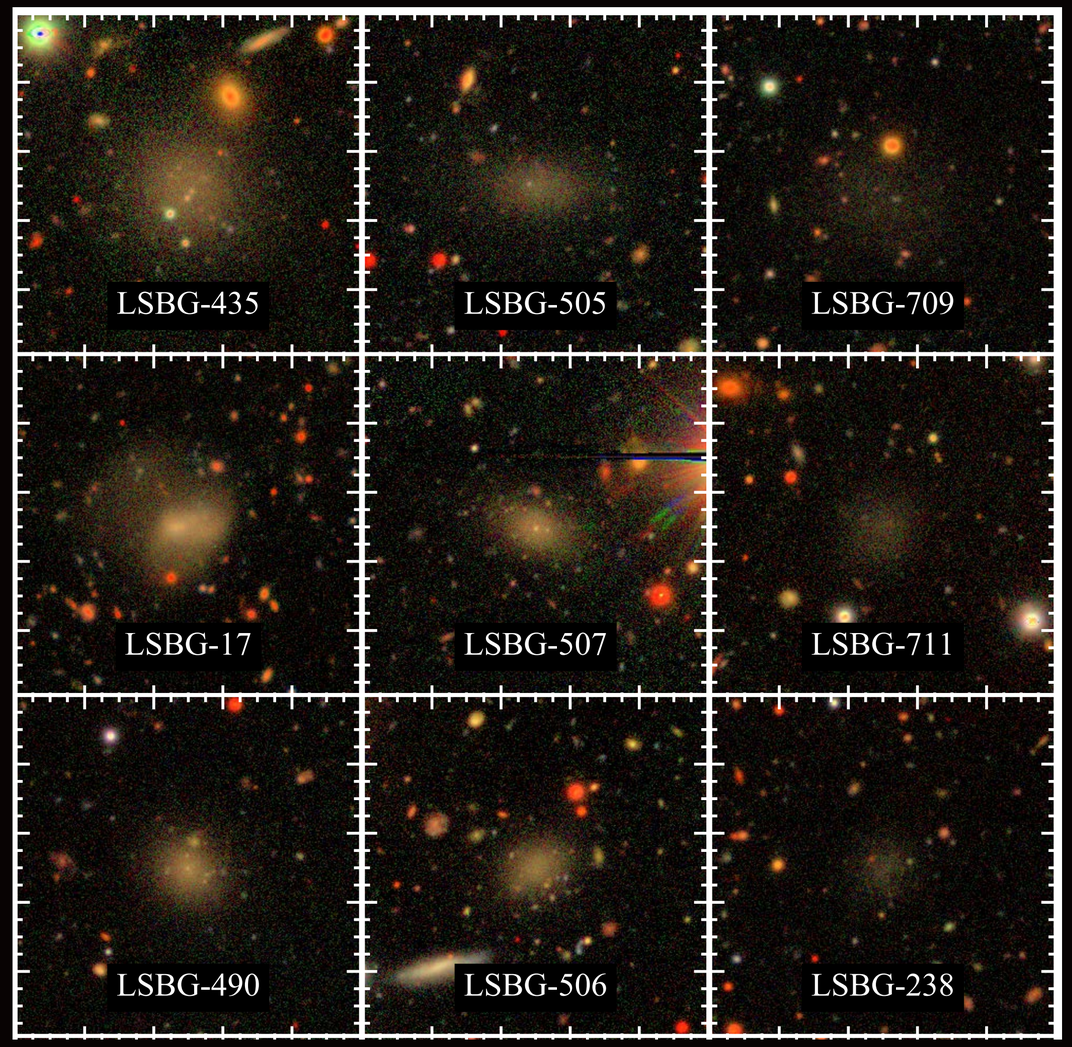


Somalwar, Greco et al. (in prep.)

Ground-Based GC Search in ***LSB Dwarfs***



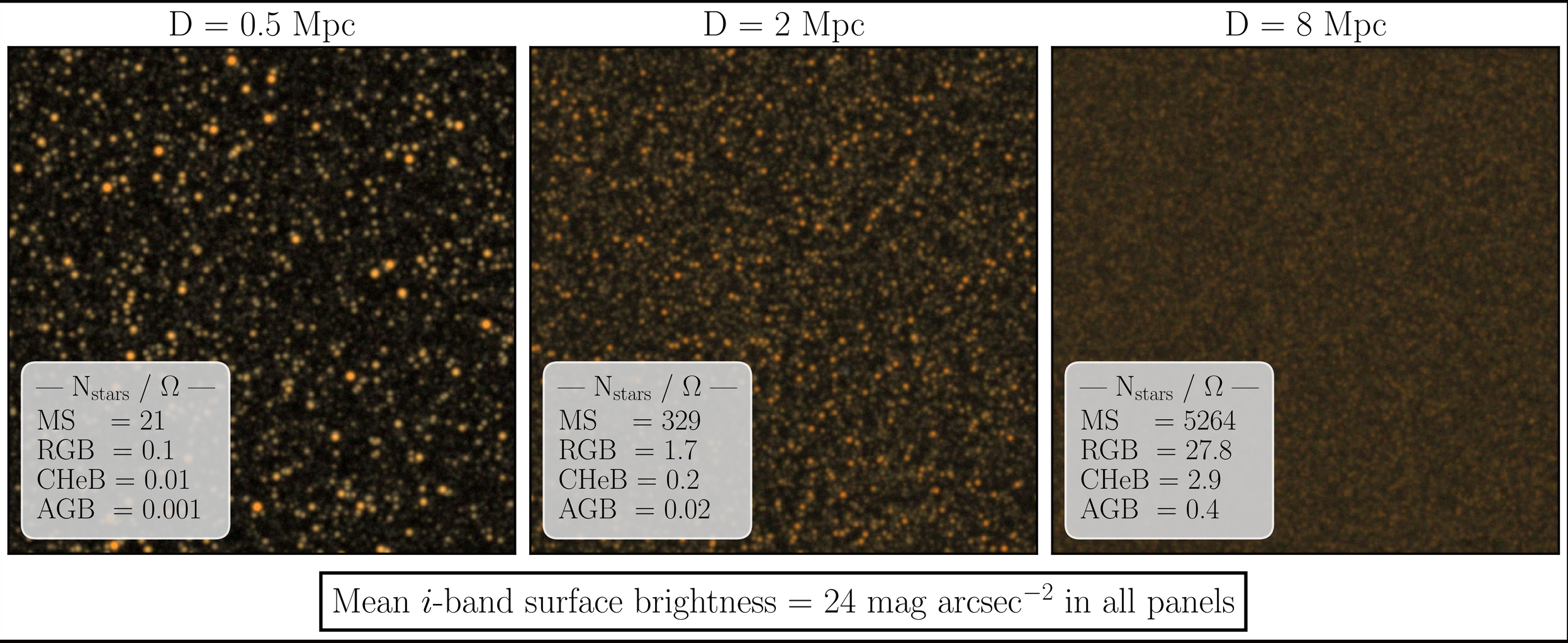
?



#DistancesAreHard

- ★ Follow-up ***Spectroscopy***
- ★ Counting ***Globular Clusters (GCs)***
- ★ ***Surface Brightness Fluctuations (SBF)***

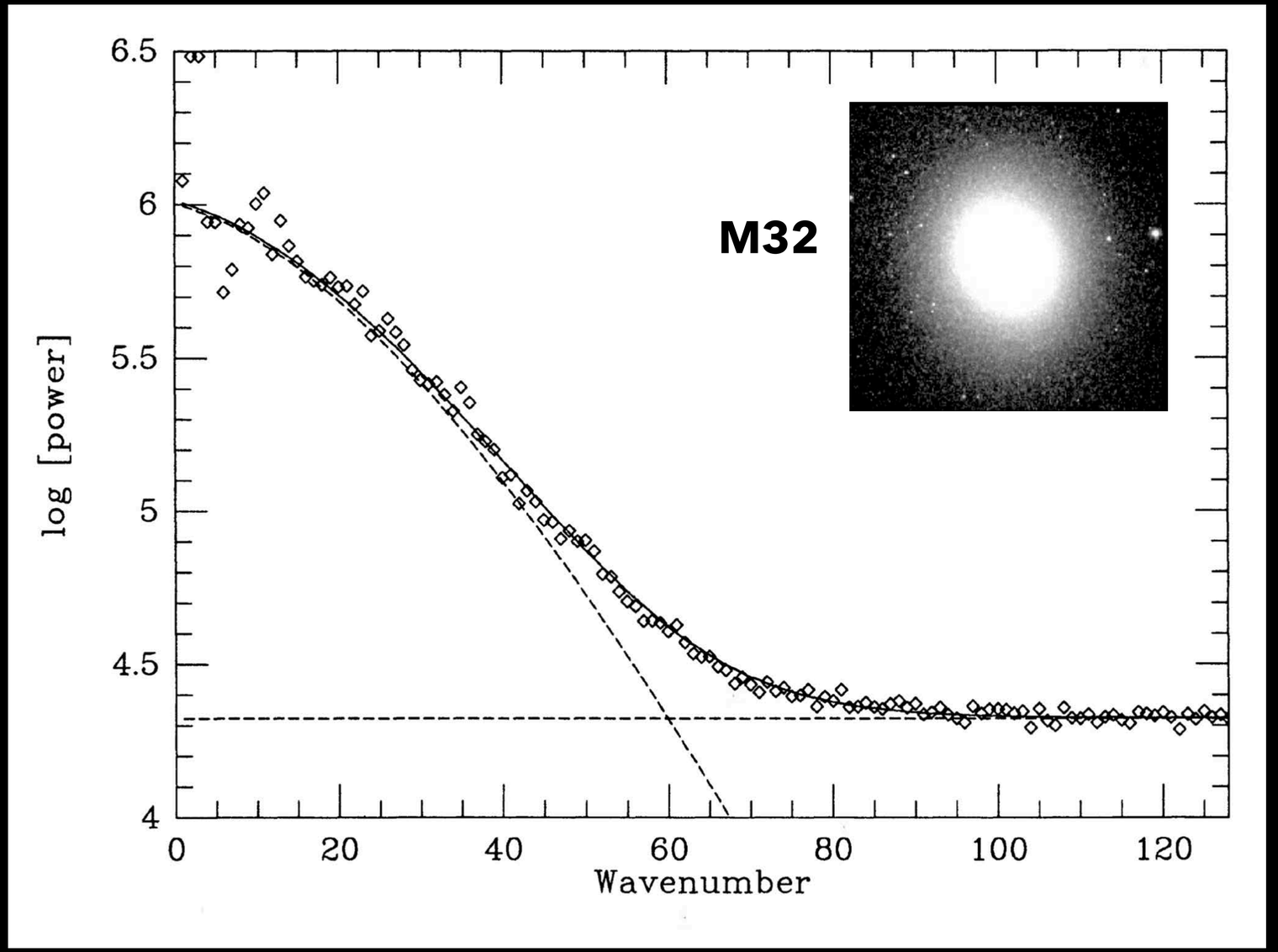
Surface Brightness ***Fluctuations (SBF)***



Mean i-band surface brightness = 24 mag arcsec^{-2} in all panels

Surface Brightness ***Fluctuations (SBF)***

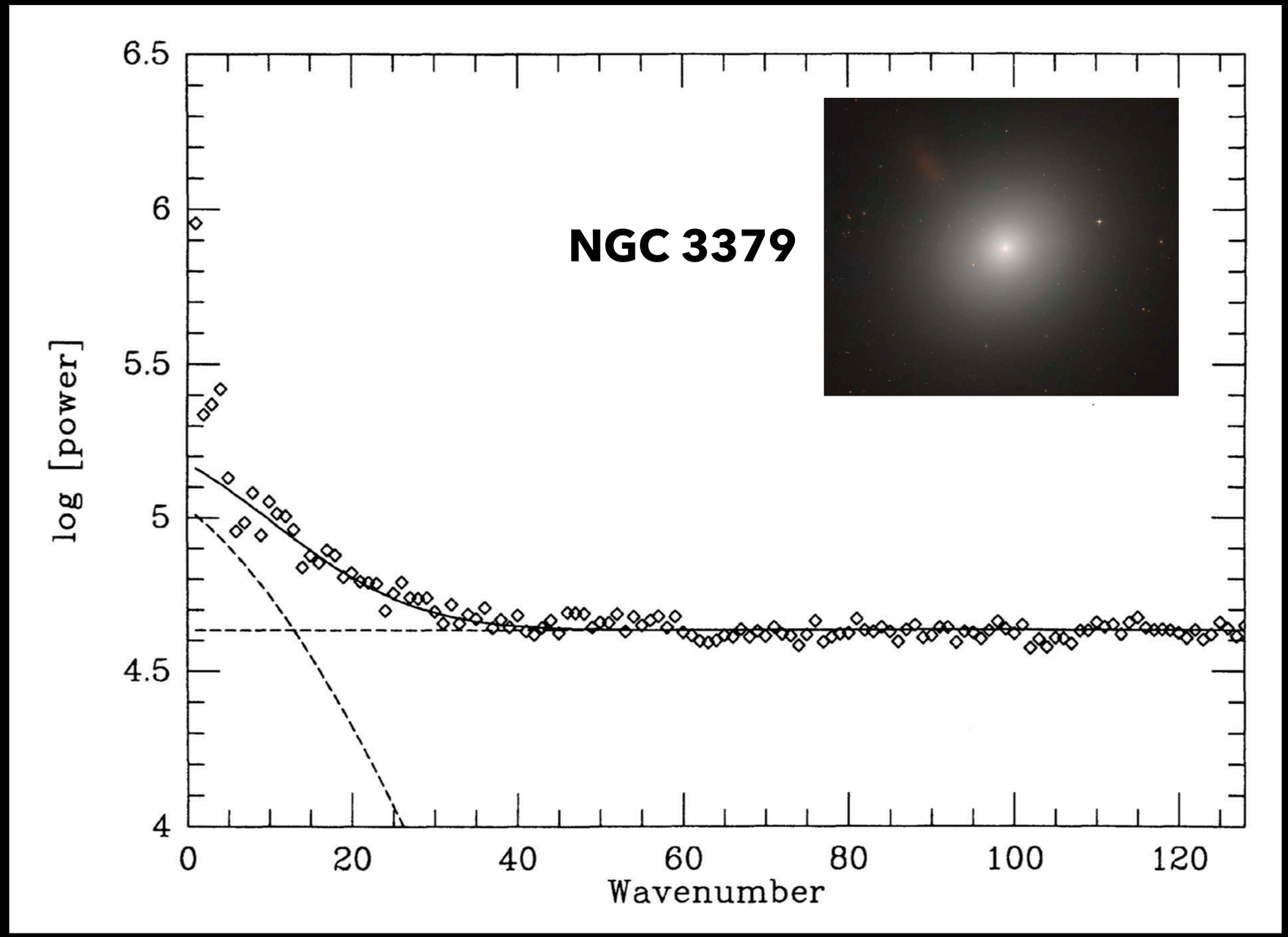
~0.8 Mpc



Tonry & Schneider 1988

Surface Brightness ***Fluctuations (SBF)***

~10 Mpc

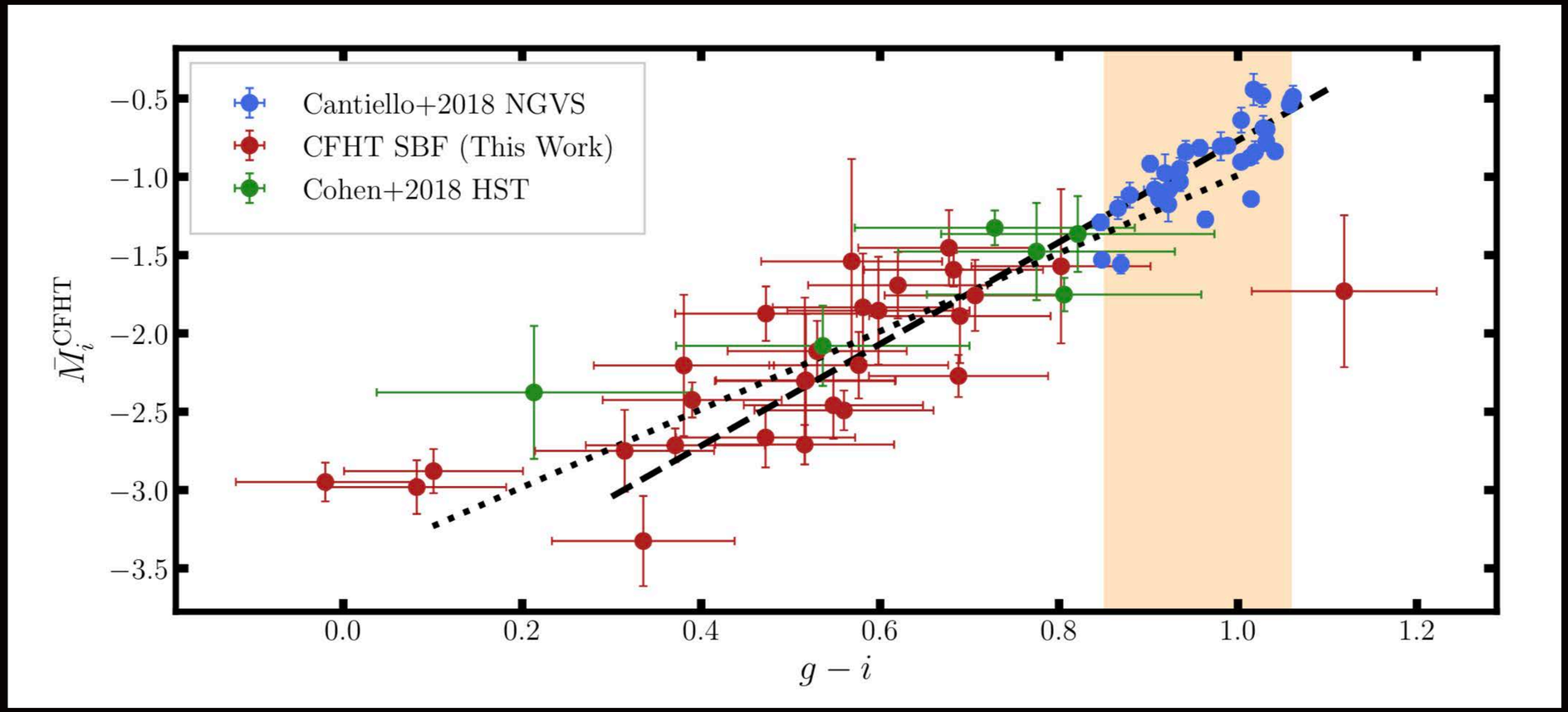


Tonry & Schneider 1988

The ***Fluctuation-Color Relation***

→ ***TRGB***-anchored SBF ***calibration*** for ***LSB dwarfs***

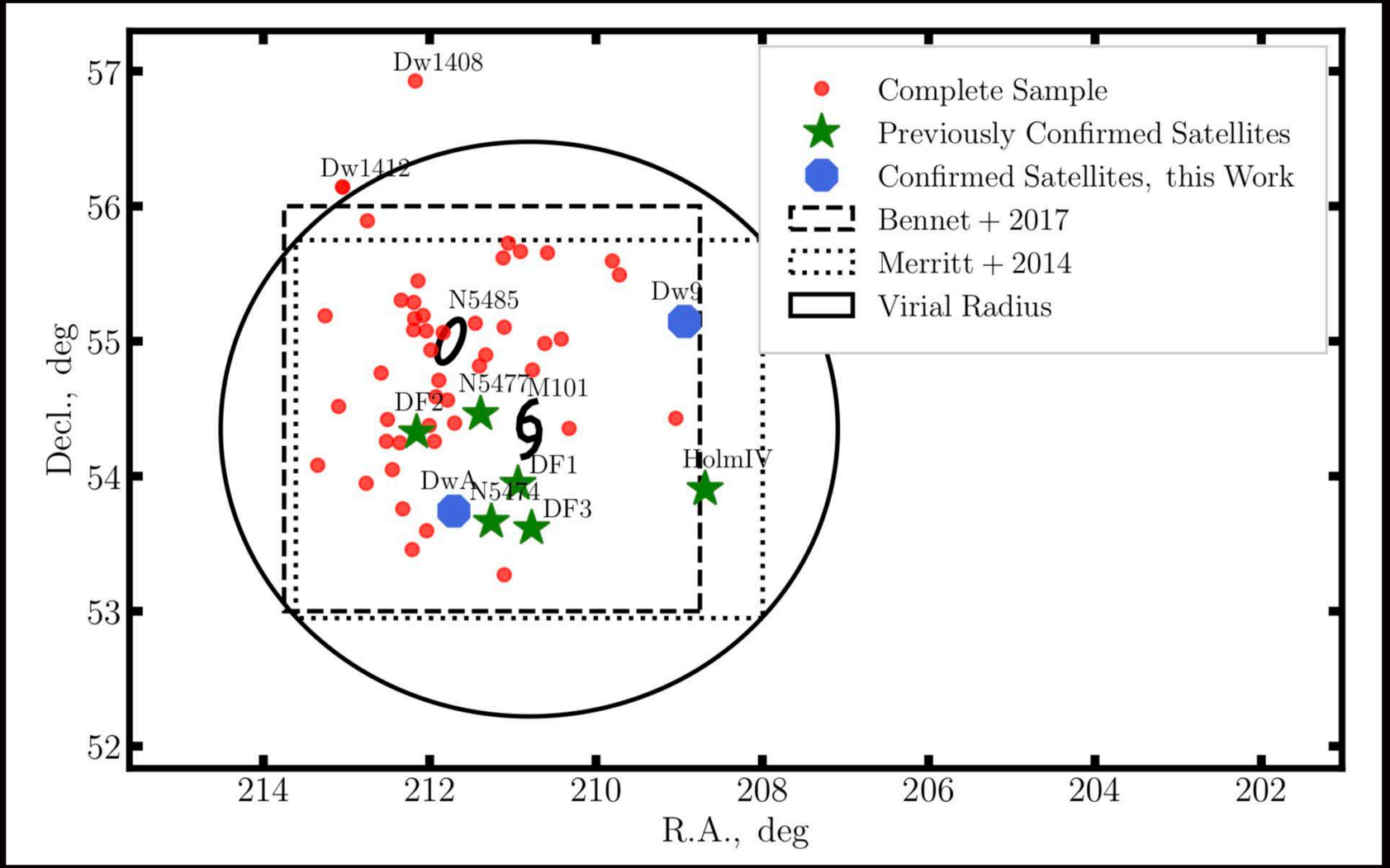
$$\bar{L} = \frac{\sum n_i L_i^2}{\sum n_i L_i}$$



Carlsten, Beaton, Greco, & Greene 2019a

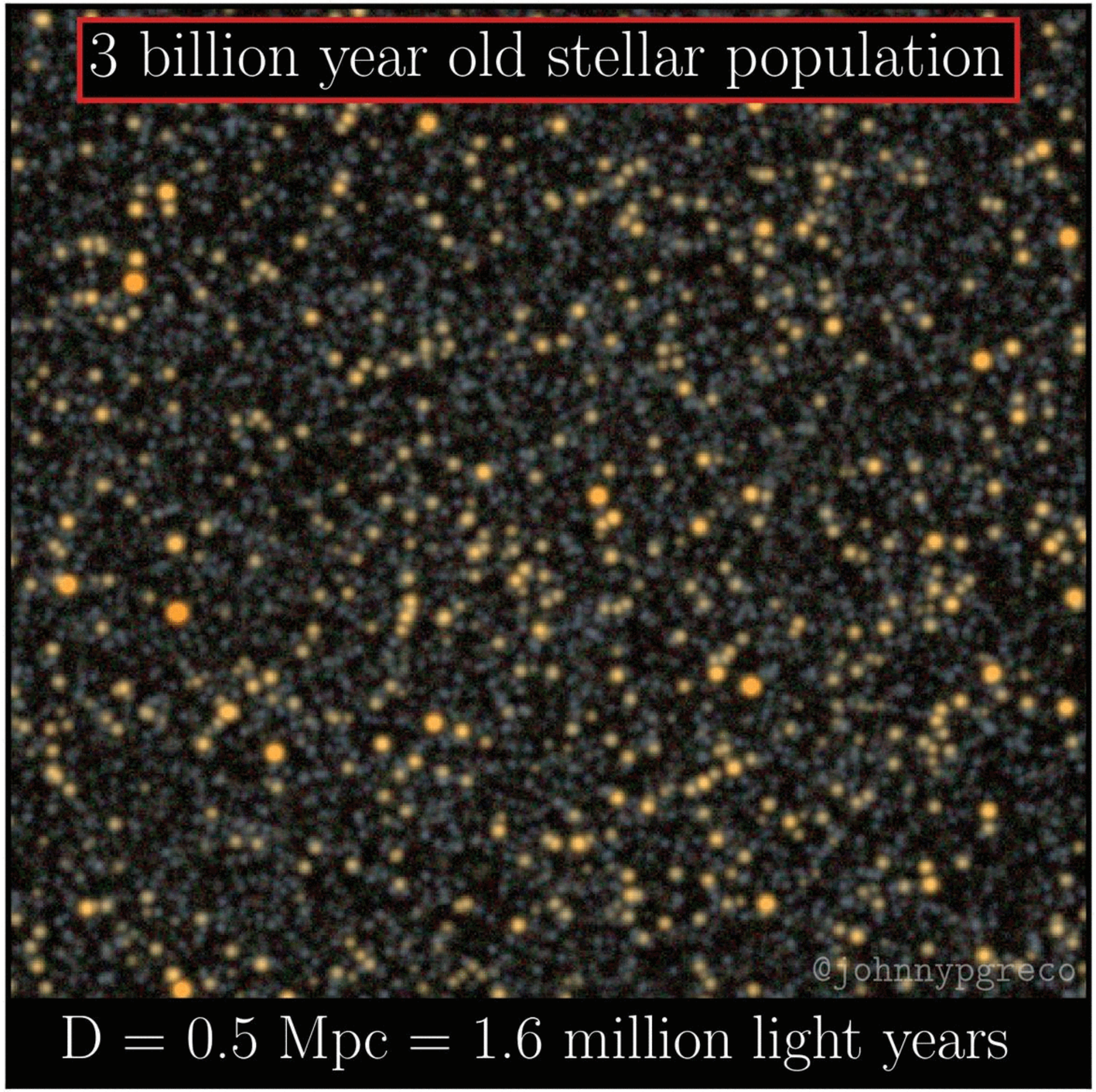
Surface Brightness ***Fluctuations (SBF)***

Confirm satellites using ***imaging data alone***

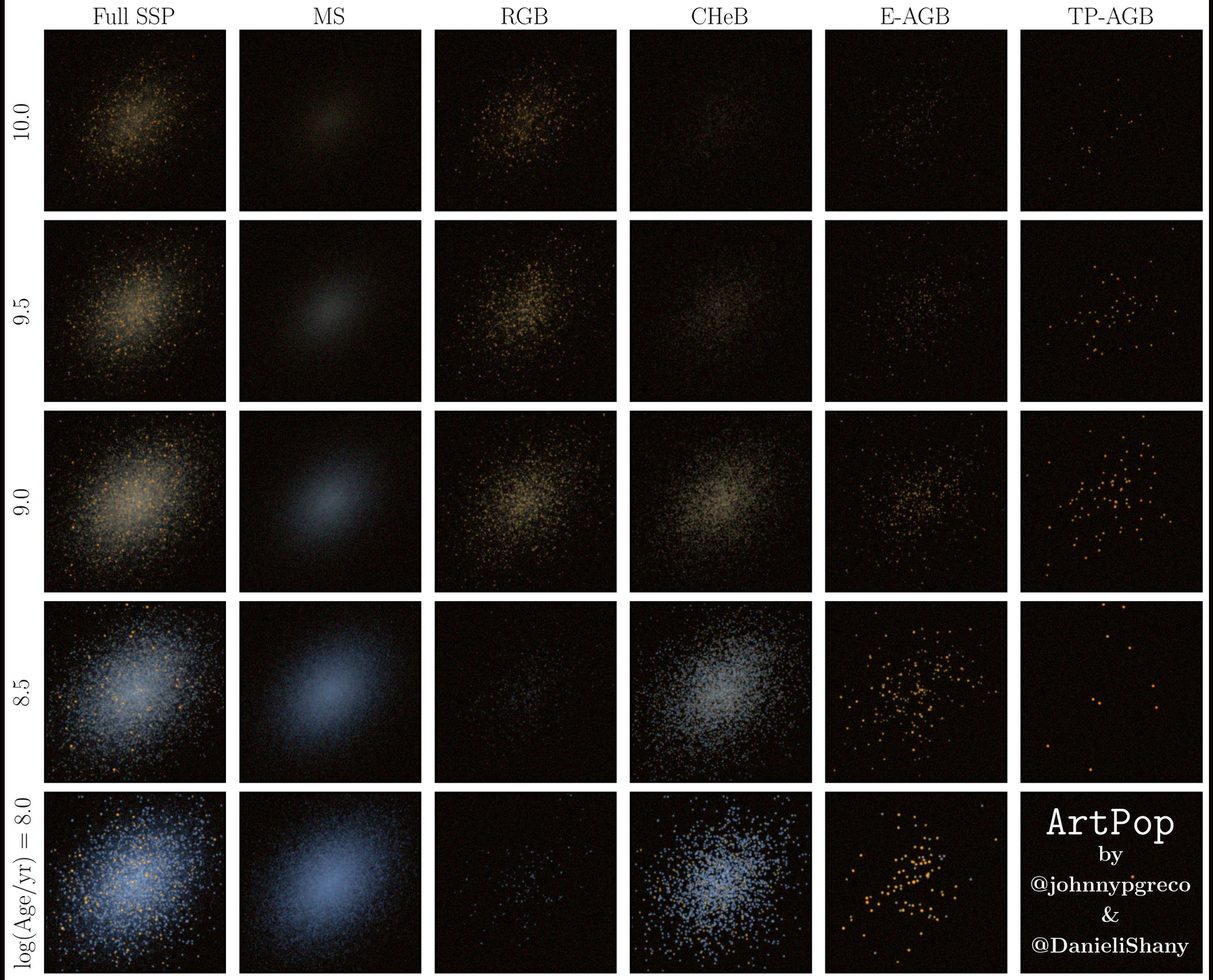


Carlsten, Beaton, Greco, & Greene 2019b

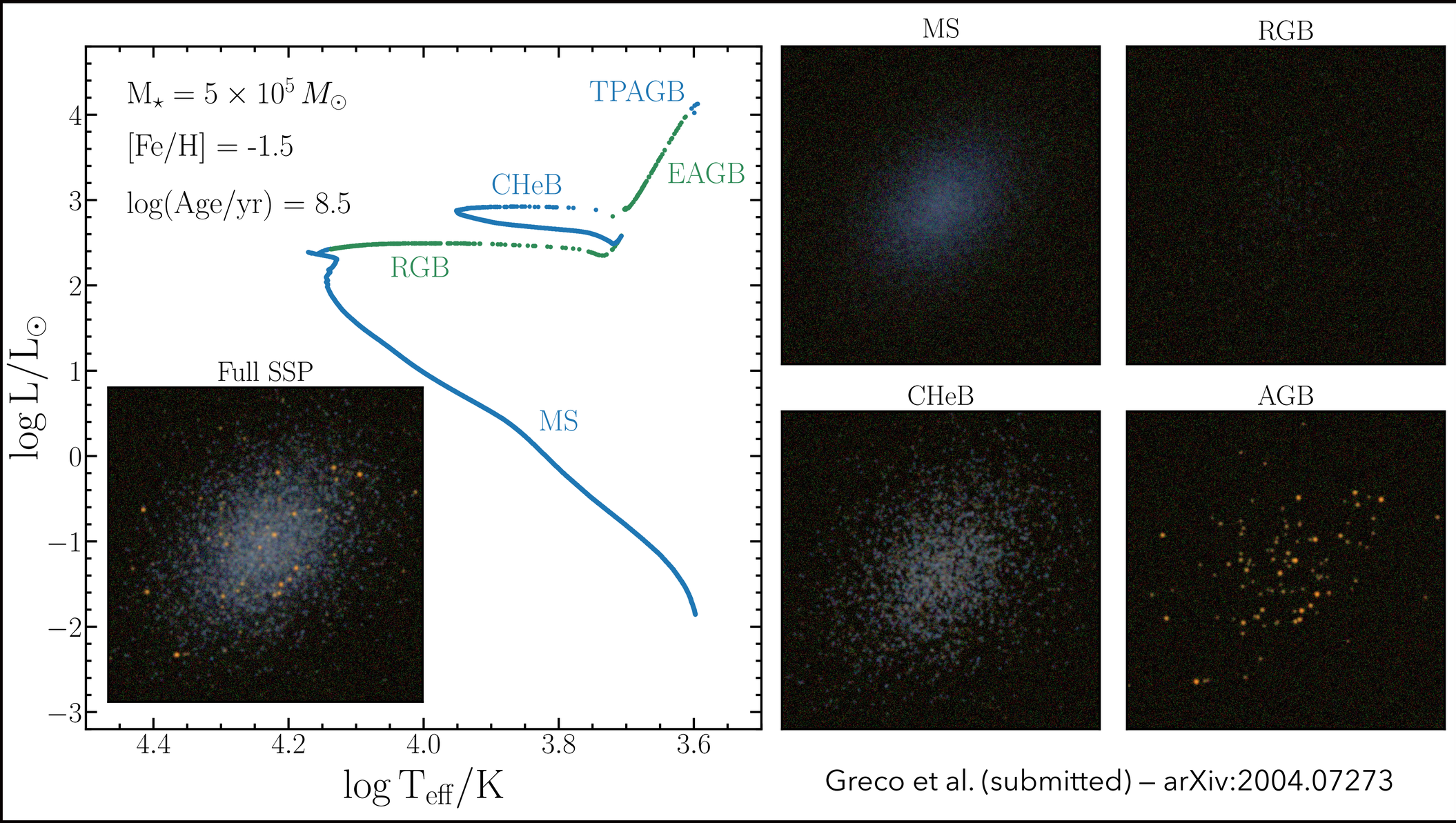
ARTPOP



ARTPOP

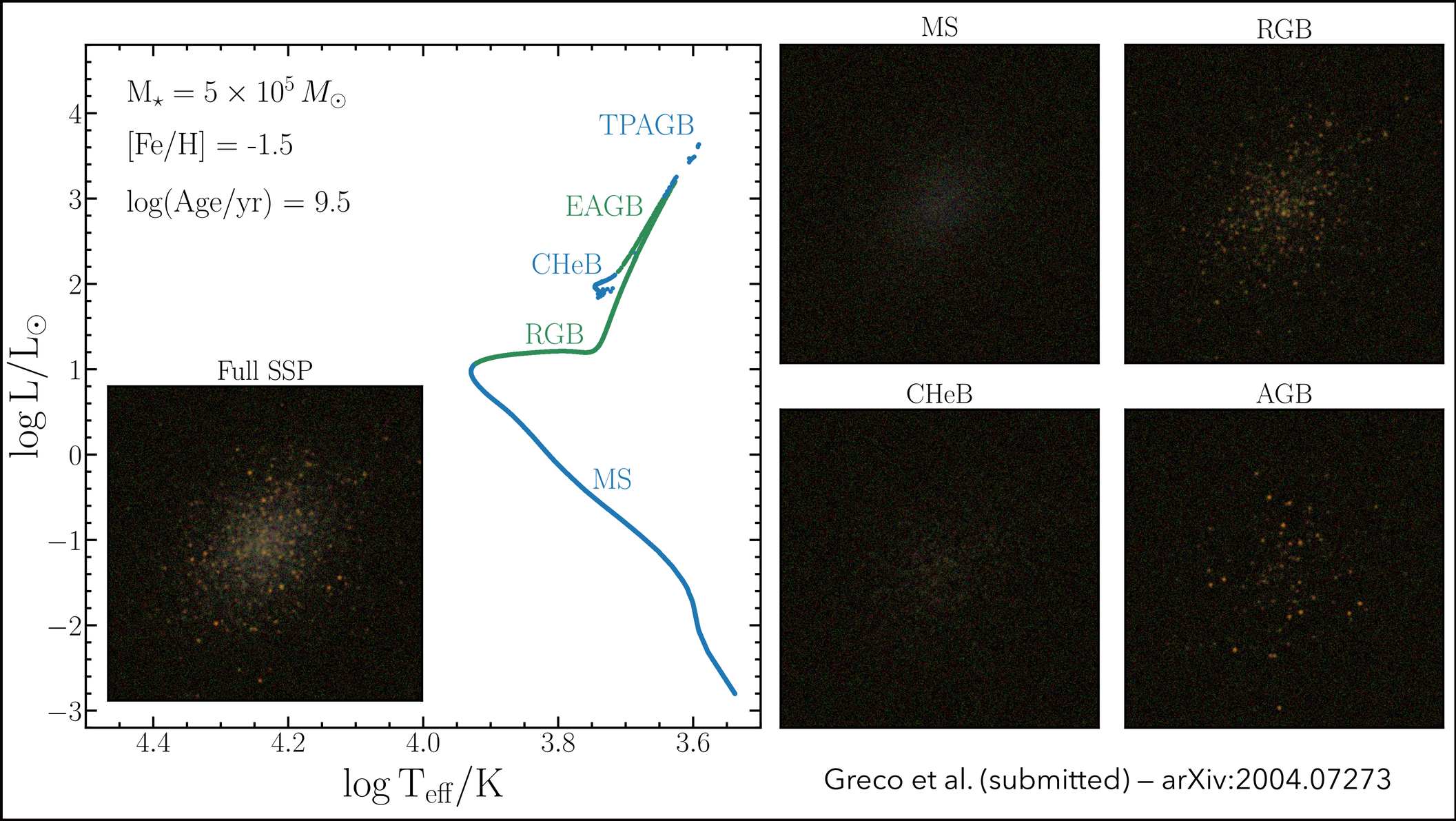

Full SSP
MS
RGB
CHeB
E-AGB
TP-AGB
10.0
9.5
9.0
8.5
log(Age/yr) = 8.0
ArtPop
by
@johnnypgreco
&
@DanieliShany

Where's the ***Fluctuation?***



Greco et al. (submitted) – arXiv:2004.07273

Where's the ***Fluctuation?***



Greco et al. (submitted) – arXiv:2004.07273

The *Future* of *Ground-Based* SBF

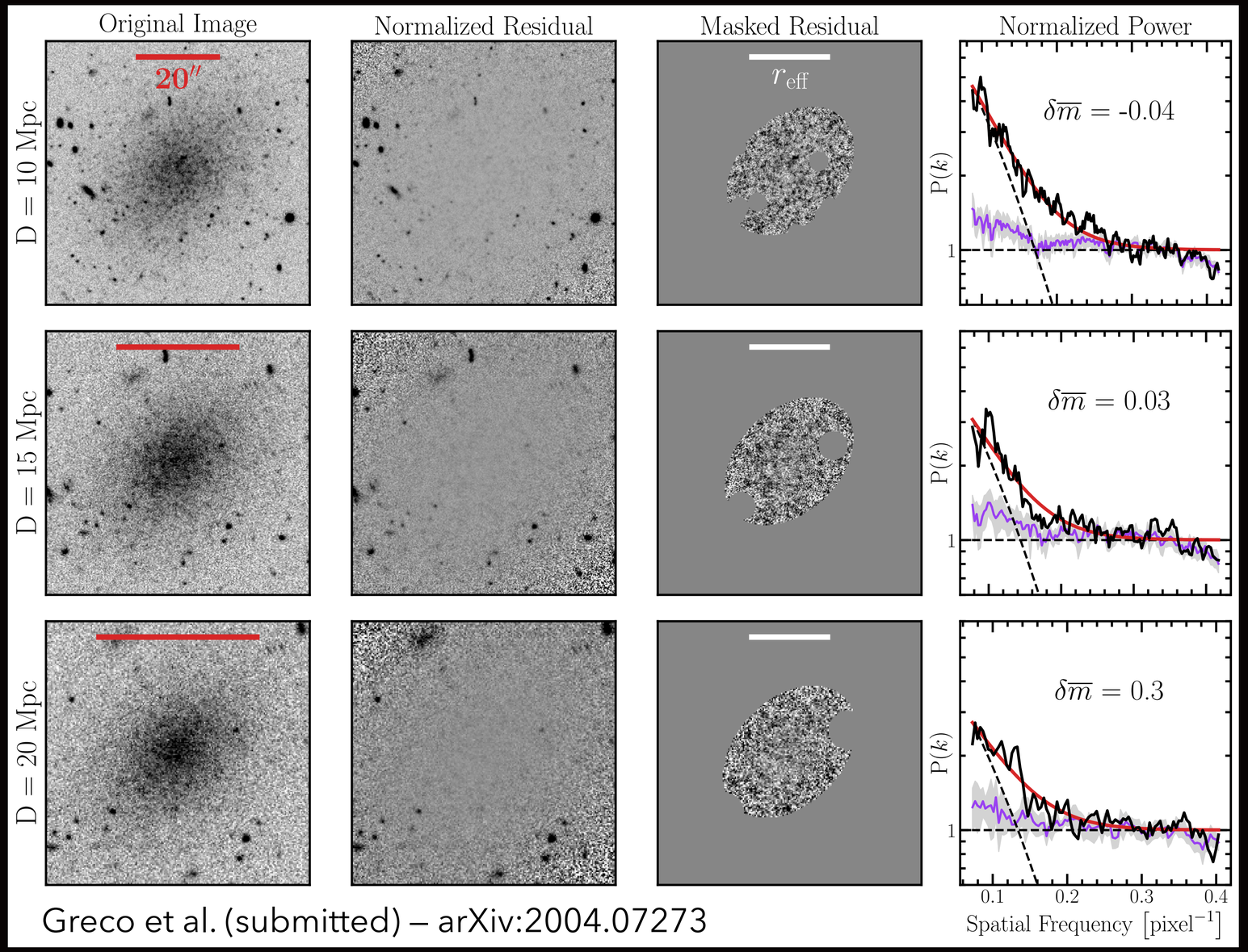
ArtPop

↓

HSC-SSP

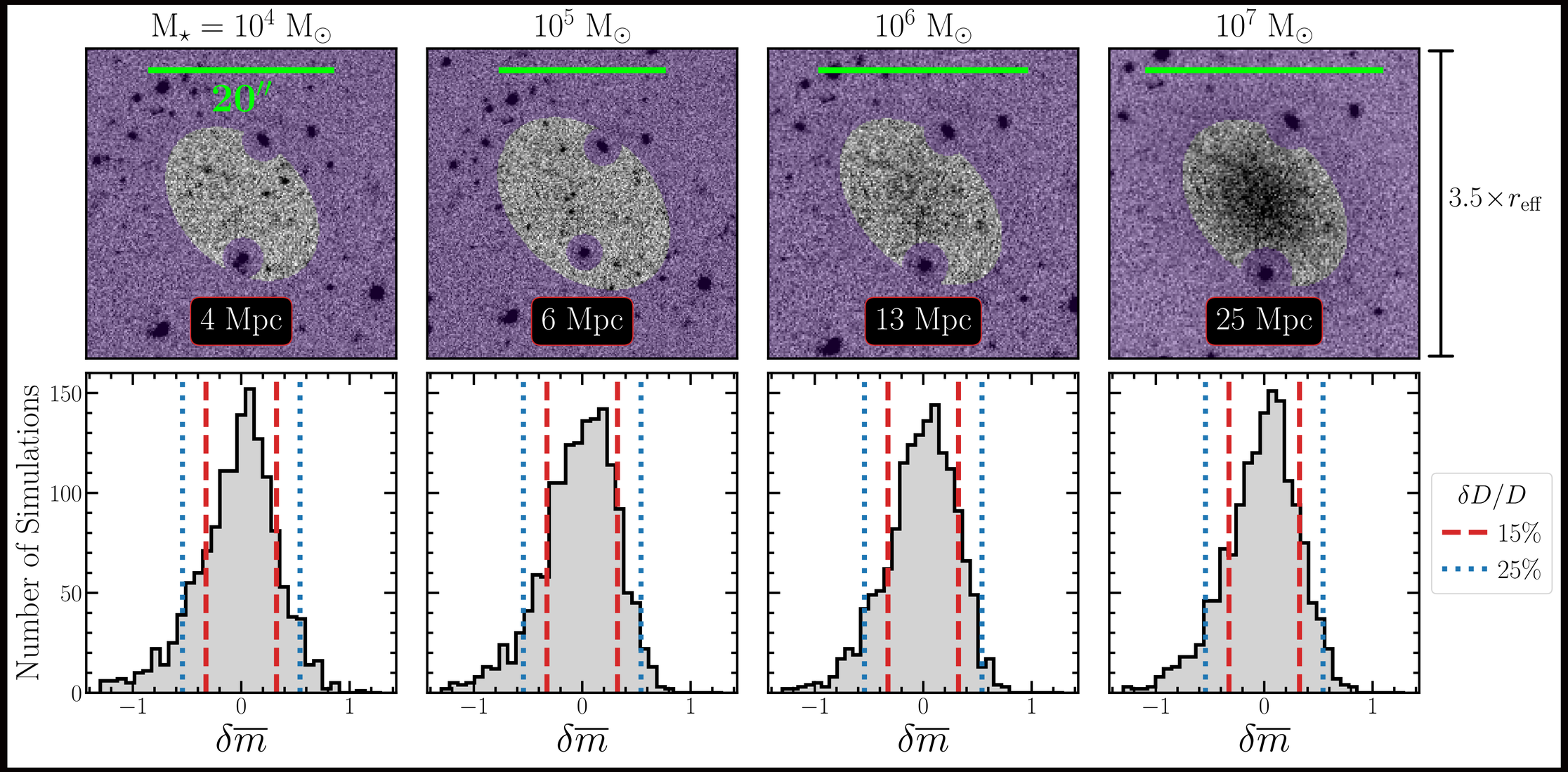
↓

Rubin Observatory



Greco et al. (submitted) – arXiv:2004.07273

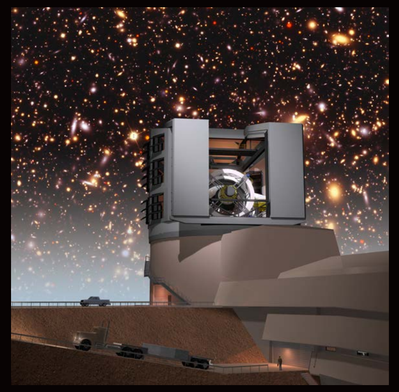
The *Future* of *Ground-Based* SBF



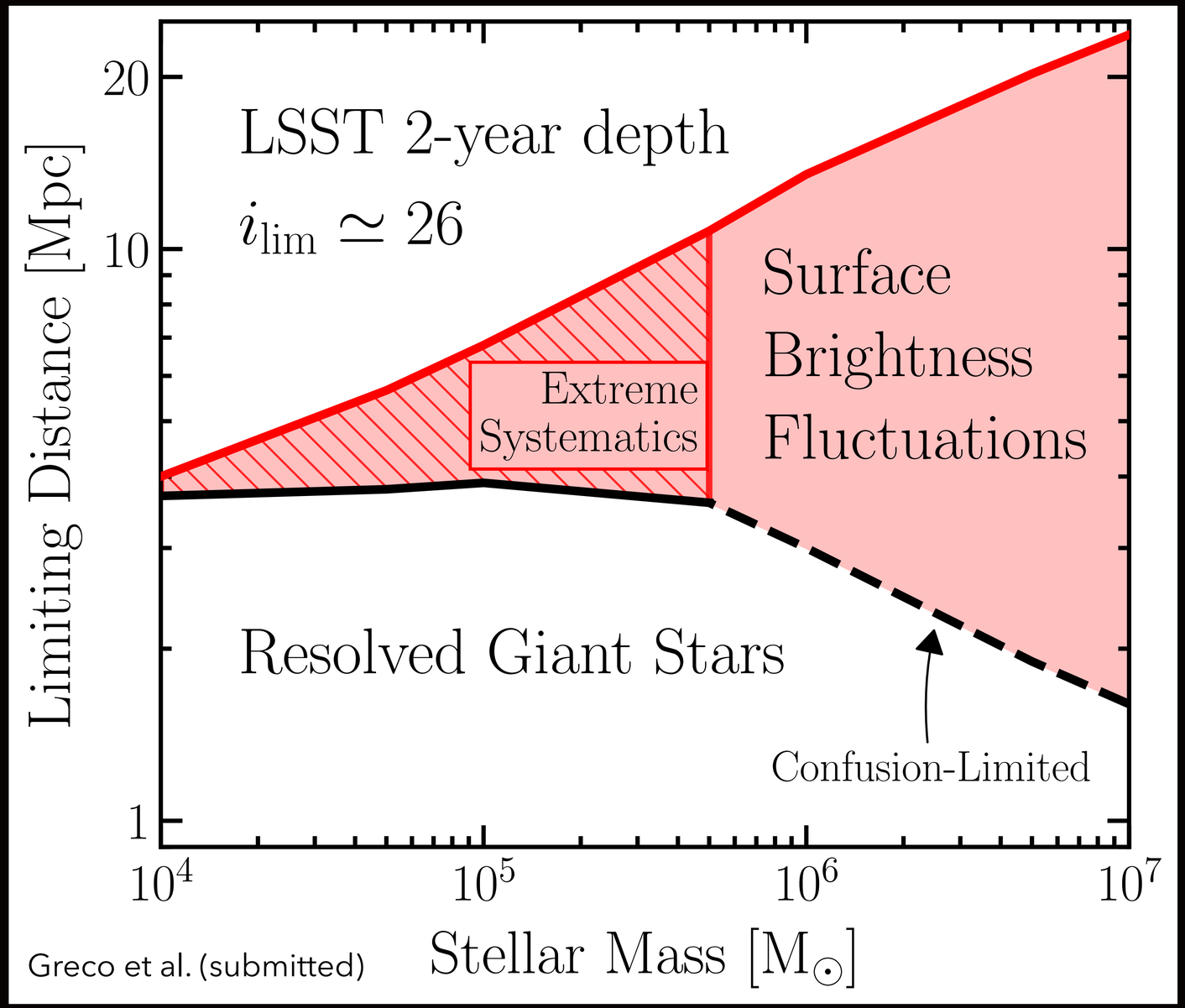
Greco et al. (submitted) – arXiv:2004.07273

The *Future* of *Ground-Based* SBF

LSST's *deep-wide-fast* survey



- 18,000 deg²
- *urgizy*
- *seeing* ~ 0.″7



Greco et al. (submitted)

Dragonfly Team

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University of Toronto
Dunlap Institute

Pieter van Dokkum

Professor
Yale University

Allison Merritt

Postdoctoral Researcher
Max-Planck-Institut fur Astronomie

Jielai Zhang

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Schmidt Science Fellow
Oxford Universiity

Johnny Greco

Postdoctoral Researcher
Ohio State University

Shany Danieli

Graduate Student
Yale University

Deborah Lokhorst

Graduate Student
University of Toronto
Dunlap Institute

Colleen Gilhuly

Graduate Student
University of Toronto
Dunlap Institute

Lamiya Mowla

Graduate Student
Yale University

Charlie Conroy

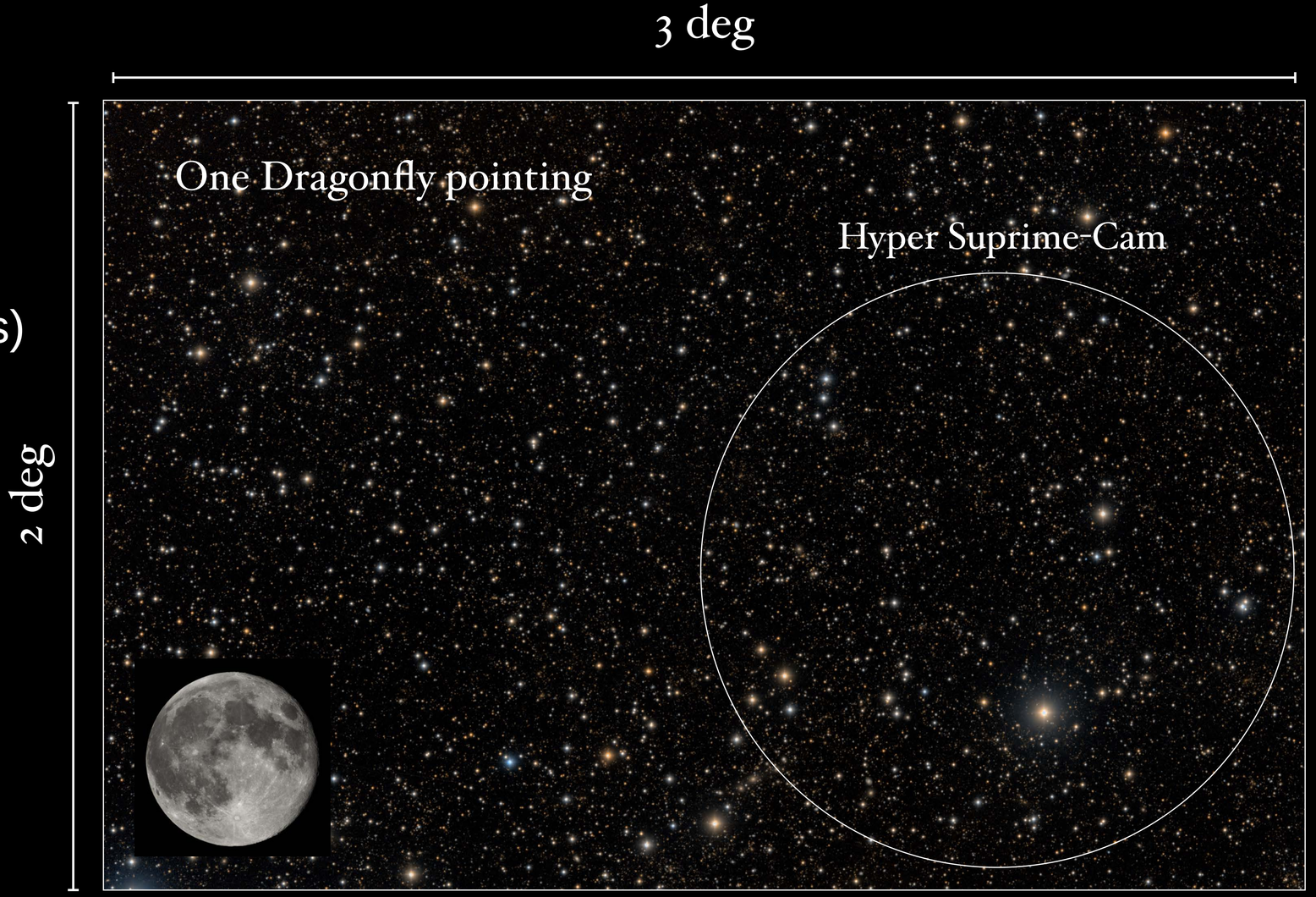
Professor
Harvard University

Dragonfly

dragonflytelescope.org

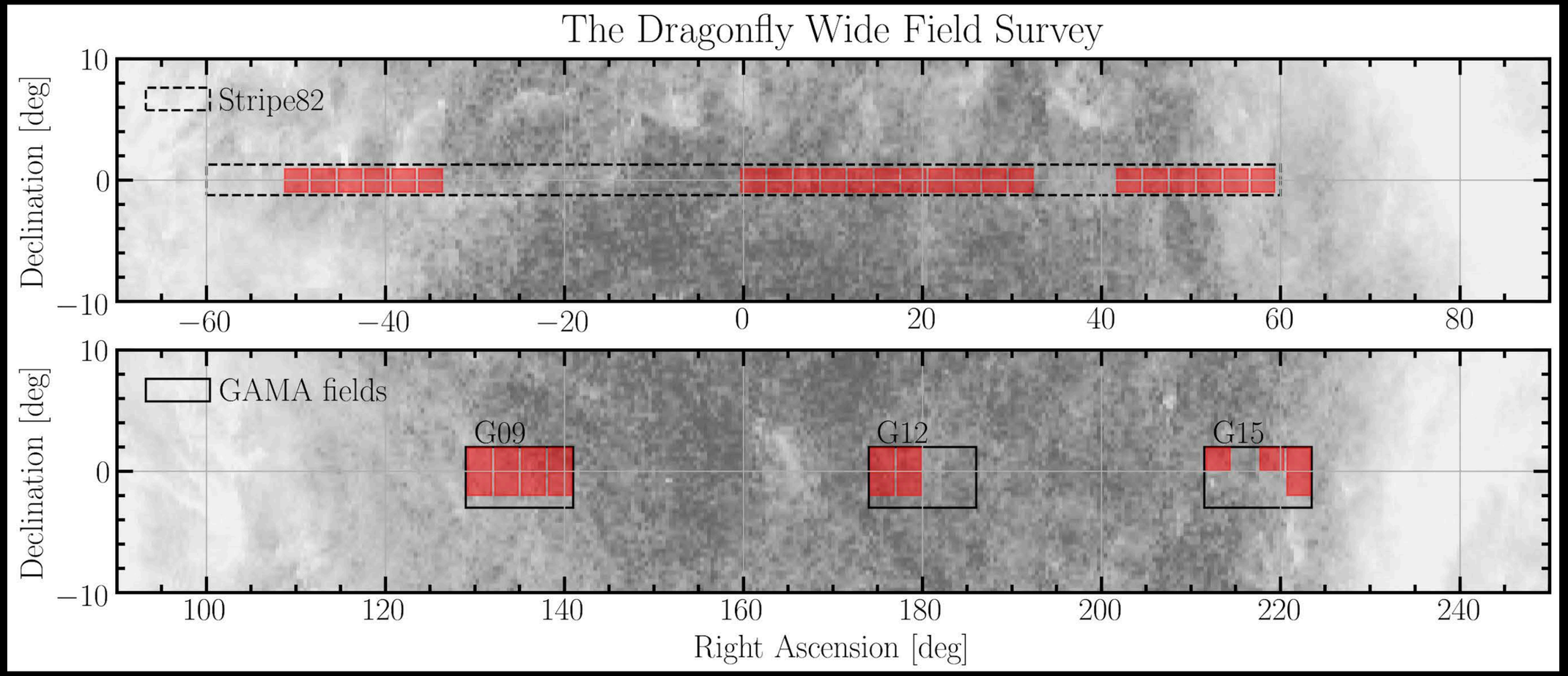
The Dragonfly *Wide* Field Survey

- 550 deg^2 with 8-10 hr of integration time per pointing
- Limiting surface brightness of ~31 mag/arcsec^2 (10″x10″ scales)
- Shany Danieli's (IAS) thesis



Slide by Shany Danieli

The Dragonfly *Wide* Field Survey



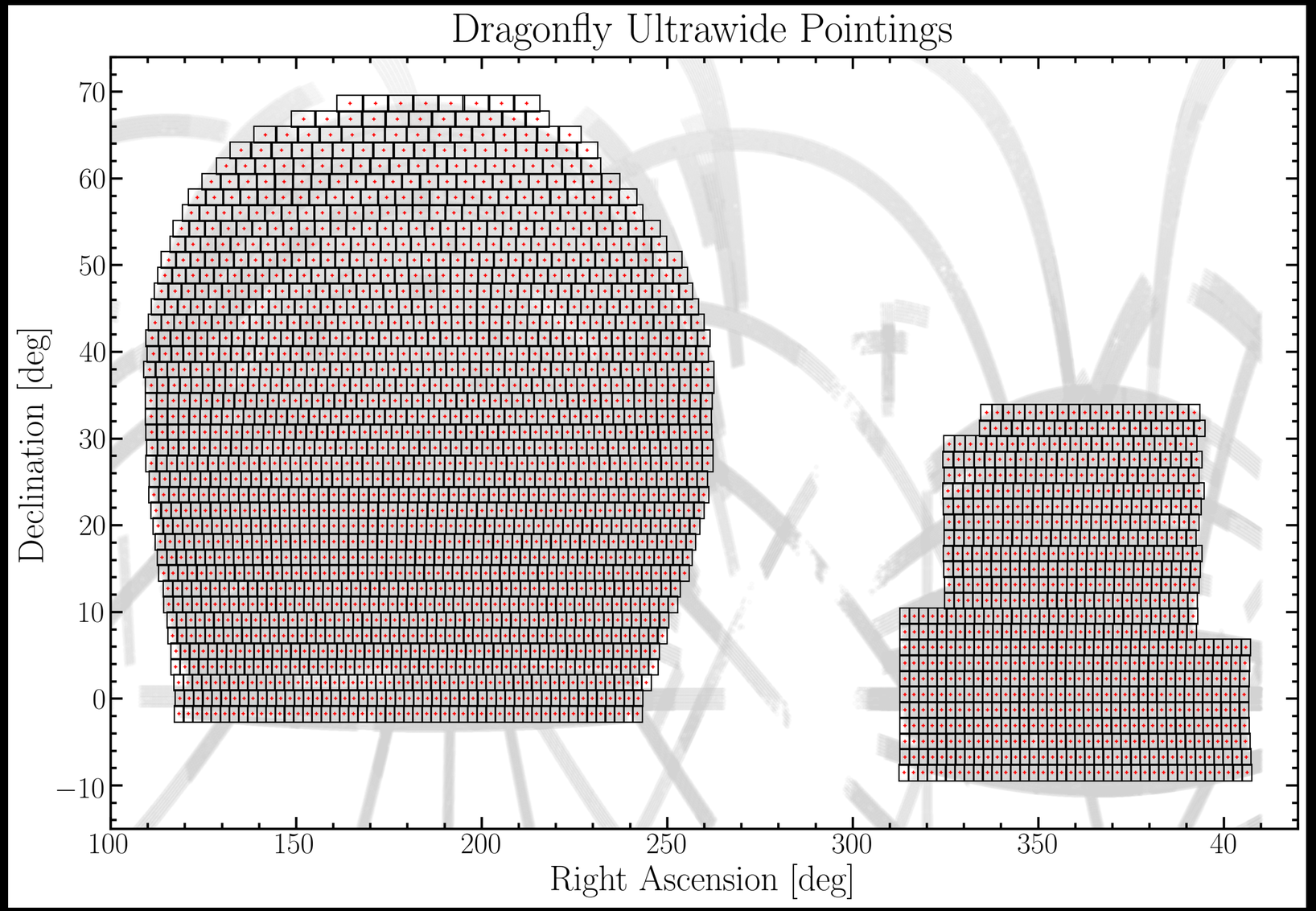
Danieli et al. 2019

Image courtesy
of **Shany Danieli**

The Dragonfly *UltraWide* Field Survey

→ Will tile the ***entire*** SDSS footprint

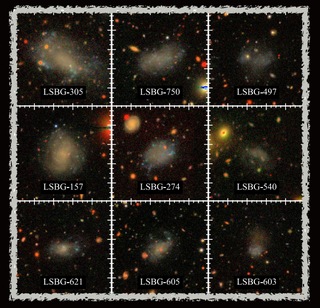
→ Limiting SB ~28.5 mag/arcsec^2 (10″x10″ scales)

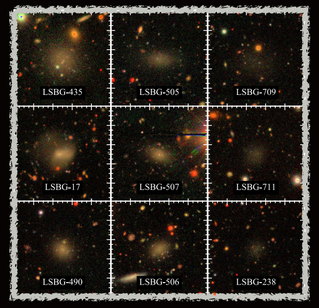


Greco et al. (in prep.)

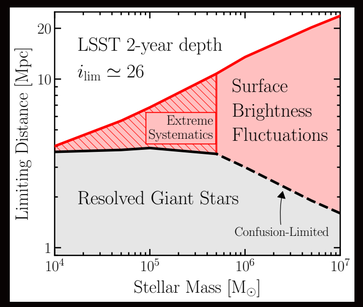
Summary

We are entering a ***new era*** for ***LSB science***!





#DistancesAreHard



SBFs will play an essential role in confirming & studying dwarf galaxies in the ***LSST*** era.

Special thanks to my collaborators!

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