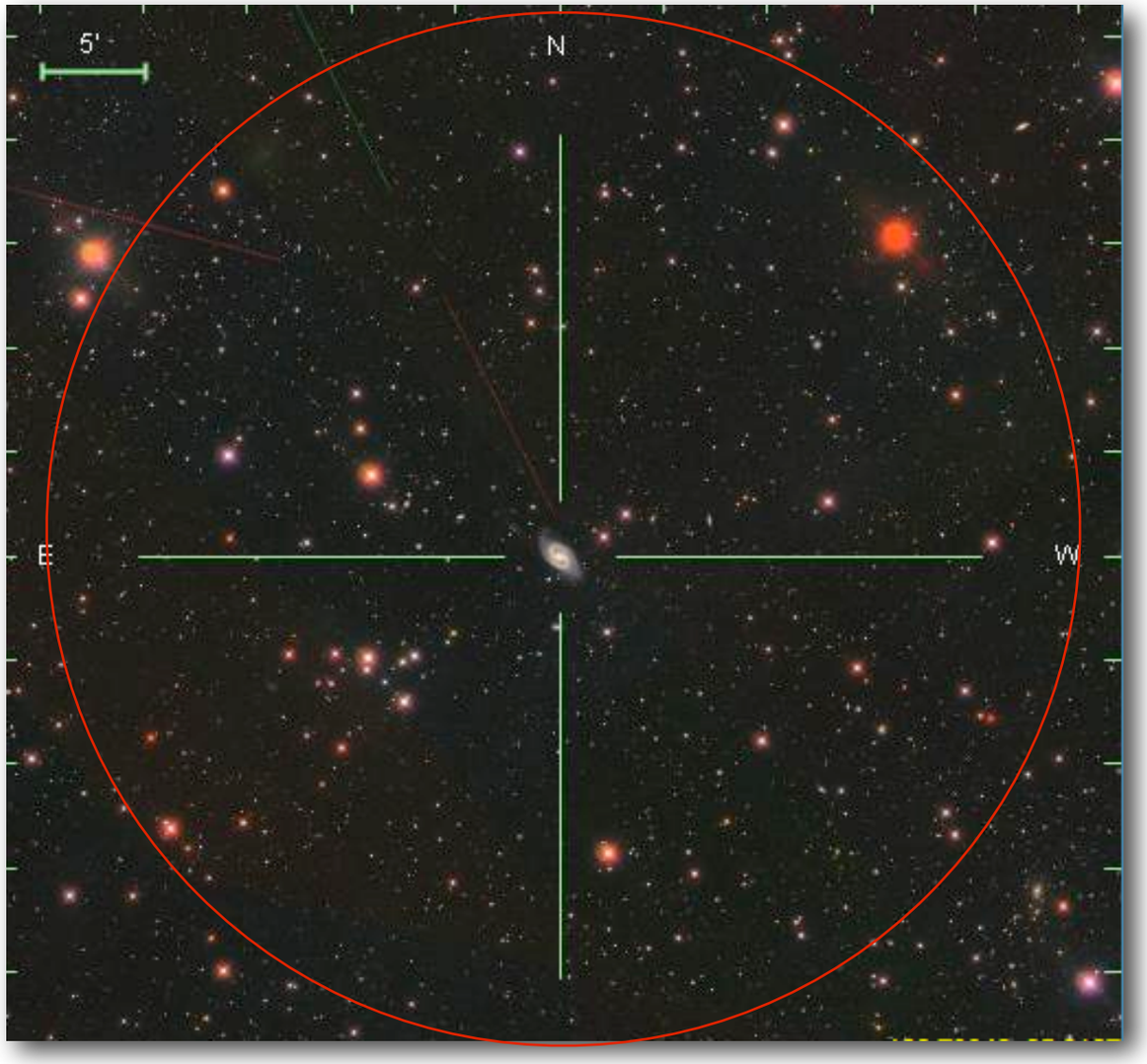
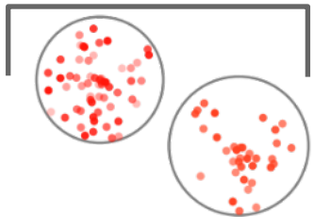
Building Statistical Samples of Low Mass Galaxies in the Local Universe



Marla Geha (Yale)

Finding Low Mass Galaxies in the Local Universe

Local Group

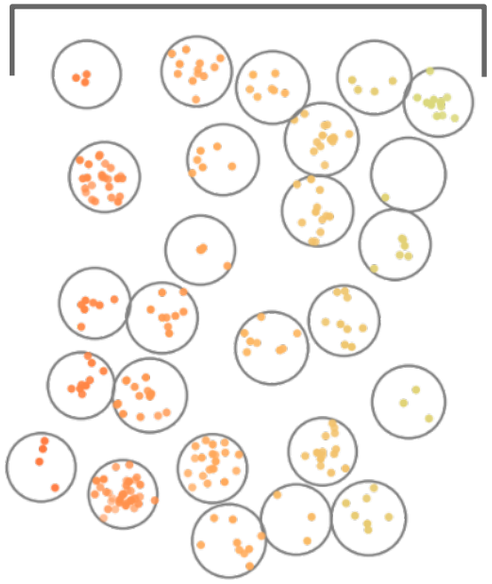


MW
~60 sat.

M31
~25 sat.

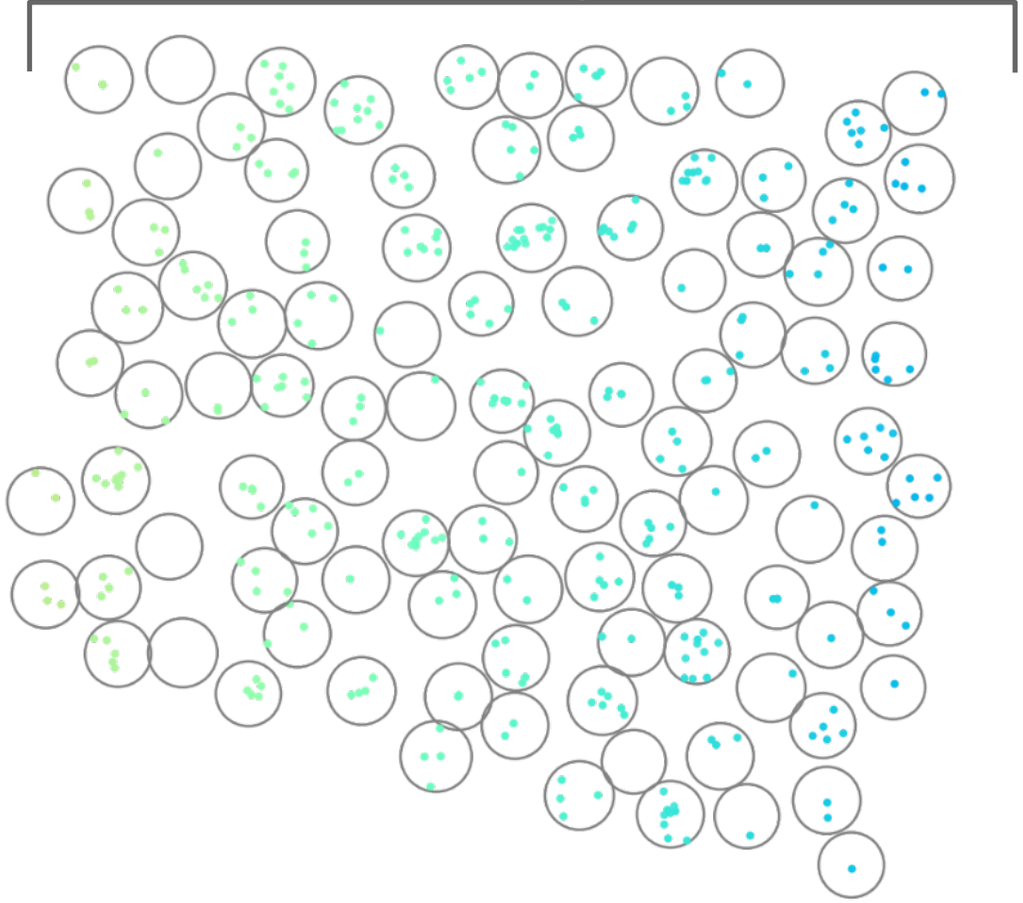
e.g.,
Drlica-Wagner+2020
McConnachie+2012
Sand+ 2022
Resolved stars

Local
Volume
< 20 Mpc



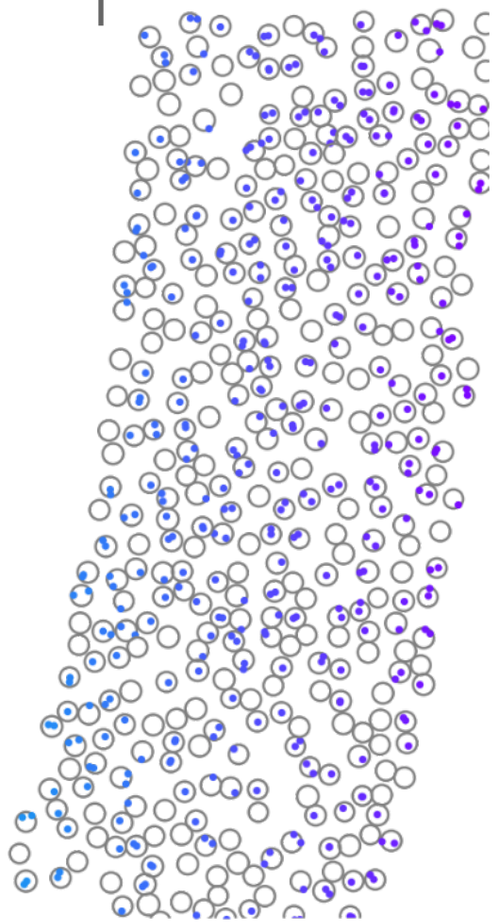
e.g., ELVES (Carlsten+2021)
TRBG/SBF
~25 systems

The SAGA Survey
25 – 40 Mpc



SAGA: Geha+2017, Y.Y.Mao+2021
Targted redshifts r < 20.7 ($M^* \sim 10^{6-9}\ M_\odot$)
~4 satellites per systems; ~100 systems

SDSS
Up to ~200 Mpc



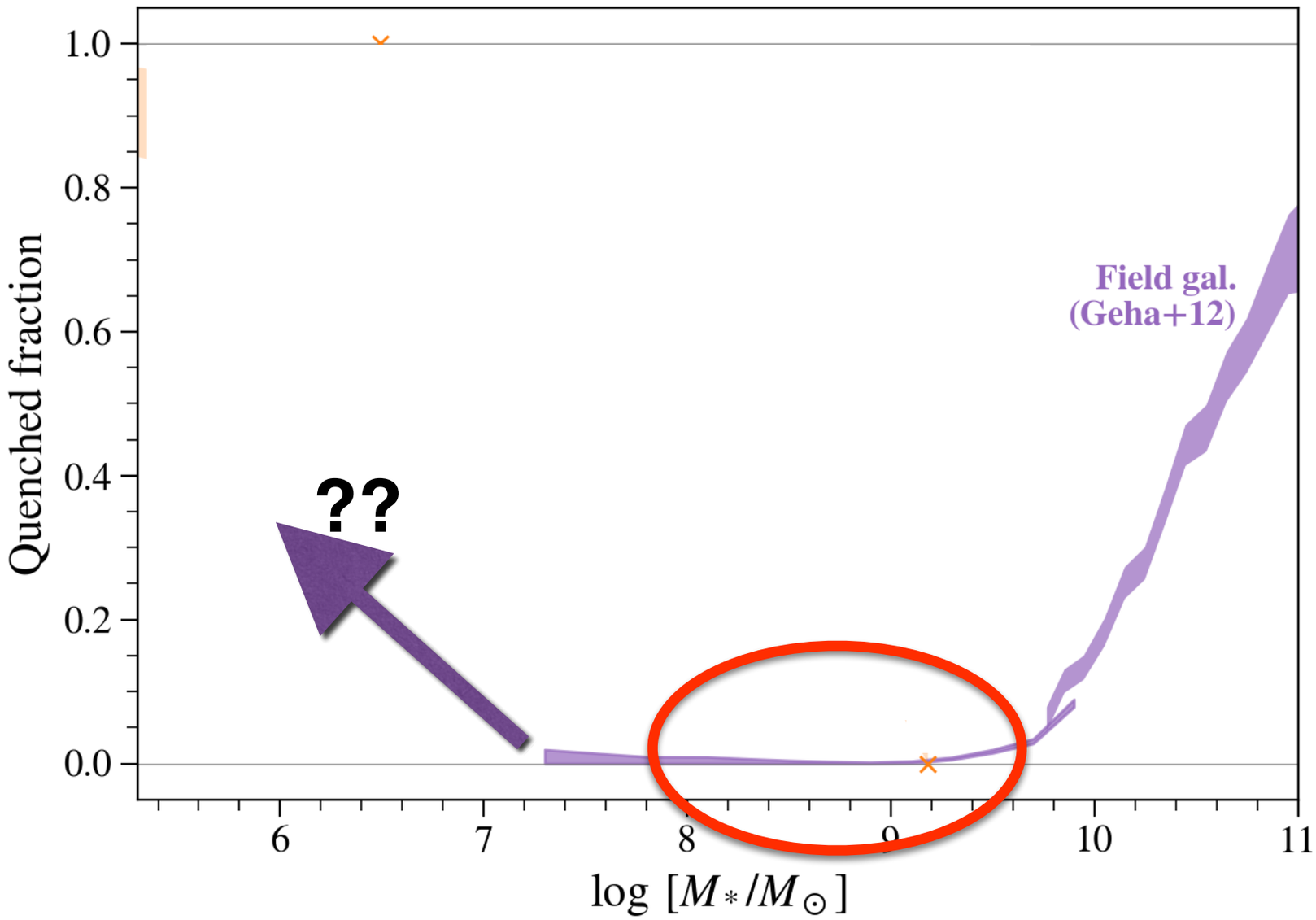
e.g., Sales+2013
r < 17.77

Distance

Figure by Yao-Yuan Mao (Utah)

Low Mass Galaxies with SDSS (r < 17.77)

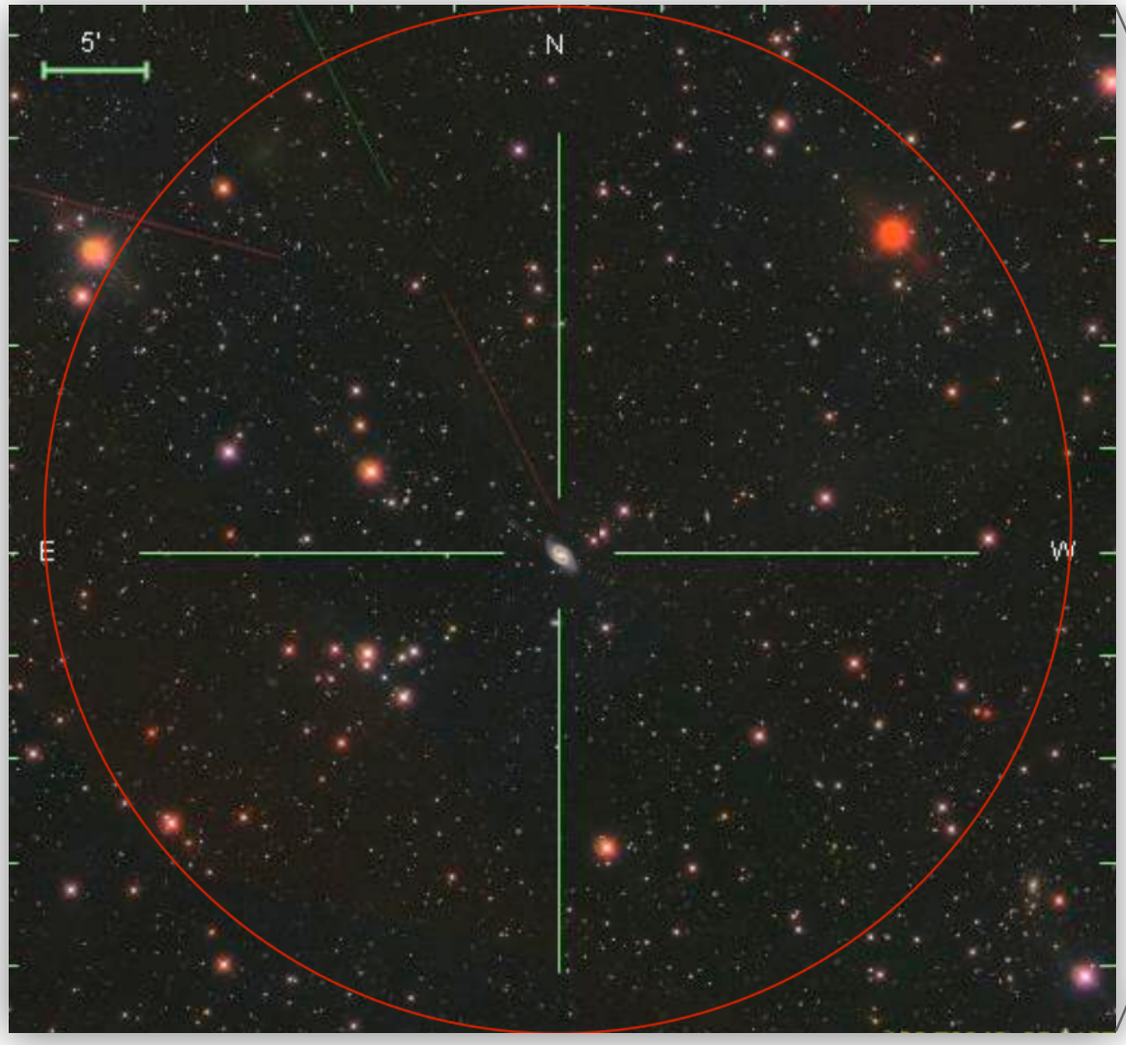
All isolated $10^{8\text{-}9}$ M_{sun} galaxies are star-forming: a threshold for self-quenching

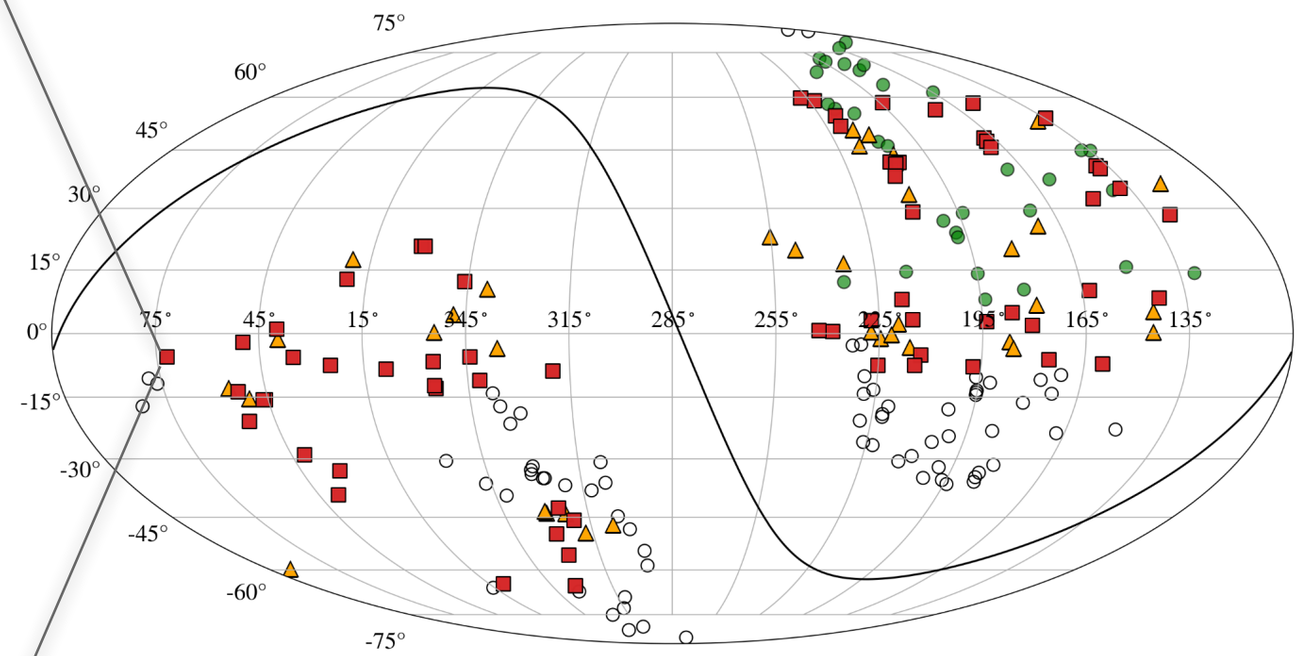


More recent SDSS iterations have explicit color cuts to remove nearby (z < 0.1) galaxies.

The SAGA Survey

Exploring Satellites Around Galactic Analogs - sagasurvey.org





The SAGA Team

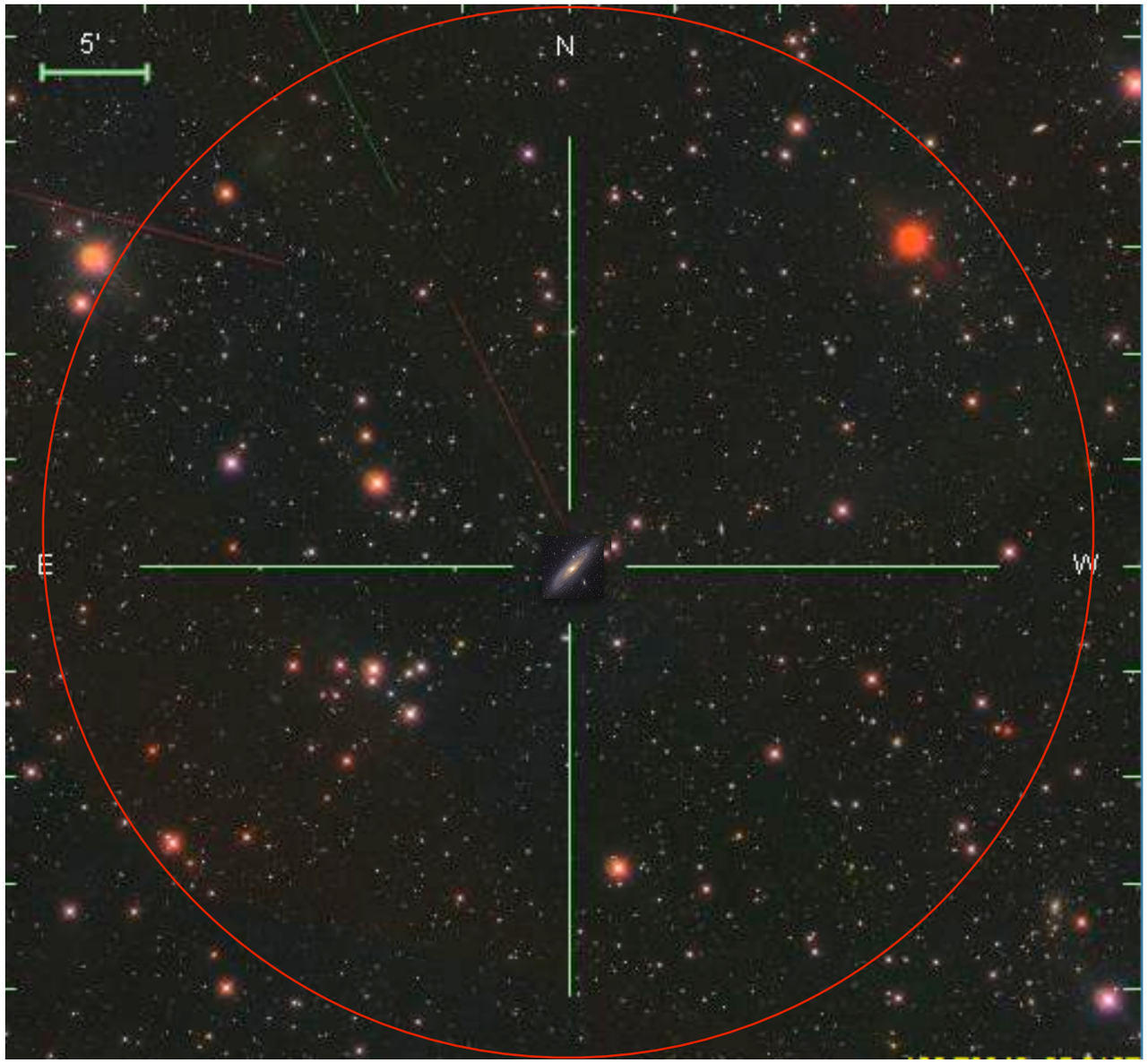
Marla Geha (Yale), Yao-Yuan Mao (Rutgers), Risa Wechsler (Stanford), Nitya Kallivayalil (UVa), Ethan Nadler (Stanford), Erik Tollerud (STScI), Ben Weiner (Arizona), **Erin Kado-Fong (Yale), Yasmeen Asali (Yale)**

Satellites Around Galactic Analogs (SAGA) Survey goal:

Characterize satellite populations around
~100 MW analogs to M_r ~ -12.3 ($M_{stellar}$ ~ 10^7 M_{sun})

The SAGA Survey: Survey Design

To observe 100 Milky Ways, need to survey a volume out to ~30 Mpc.



At 30 Mpc,
the virial radius (300 kpc)
is equivalent to diameter of 1 degree

At 30 Mpc,
M_r = -12.3 is equivalent to r_o = 20.75

Within 1°, there are a few thousand
galaxies down to r_o = 20.75

The SAGA Survey In a Nutshell

Photometric catalogs (DES/LS/SDSS)

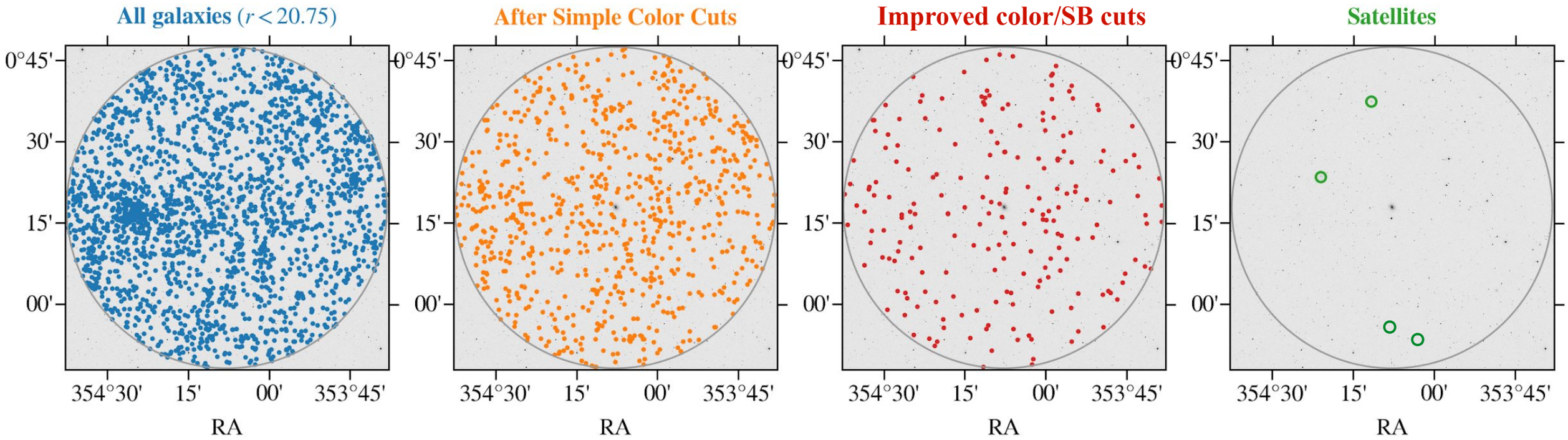
Stage I

Geha et al (2017)

Stage II

Mao et al (2020)

Spectroscopically Confirmed Satellites



~ 2,500 / sq. deg.

~ 1,000 / sq. deg.

~ 200 / sq. deg.

~ 4 / sq. deg.

The SAGA Survey: 100 Milky Ways

SAGA Observational Goal:
Characterize the satellite populations down to $M_r = -12.3$ around 100 Milky Way-like galaxies.

✓ **Stage 1:** Build complete sample of a few MW analogs using gri color cuts.

✓ **Stage 2:** Use data from Stage I to design an efficient targeting strategy.

✓ **Stage 3:** Efficiently measure satellite LF for 100 MW analog to $M_r = -12.3$.

Geha et al. (2017)	**Y.Y. Mao et al. (2020)**	**Final Survey (2023)**
8 hosts	36 hosts	102 hosts
27 satellites	127 satellites	380 satellites
14 newly discovered	69 newly discovered	232 newly discovered
(12,000 redshifts)	(25,000 redshifts)	(+50K redshifts)

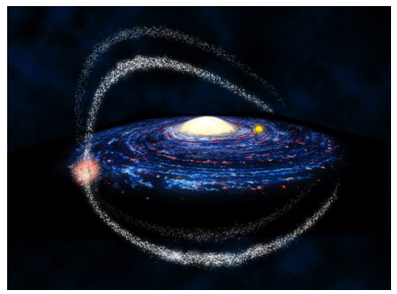
Satellite Galaxies as Probes of Galaxy Formation

The Milky Way's two brightest satellites are actively forming stars (LMC/SMC), the rest ceased star formation 1 Gyr or more ago (quenched).

LMC: $M_r = -18.5$

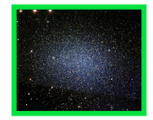
SMC: $M_r = -17.1$

Sgr: $M_r = -13.8$



For: -13.7

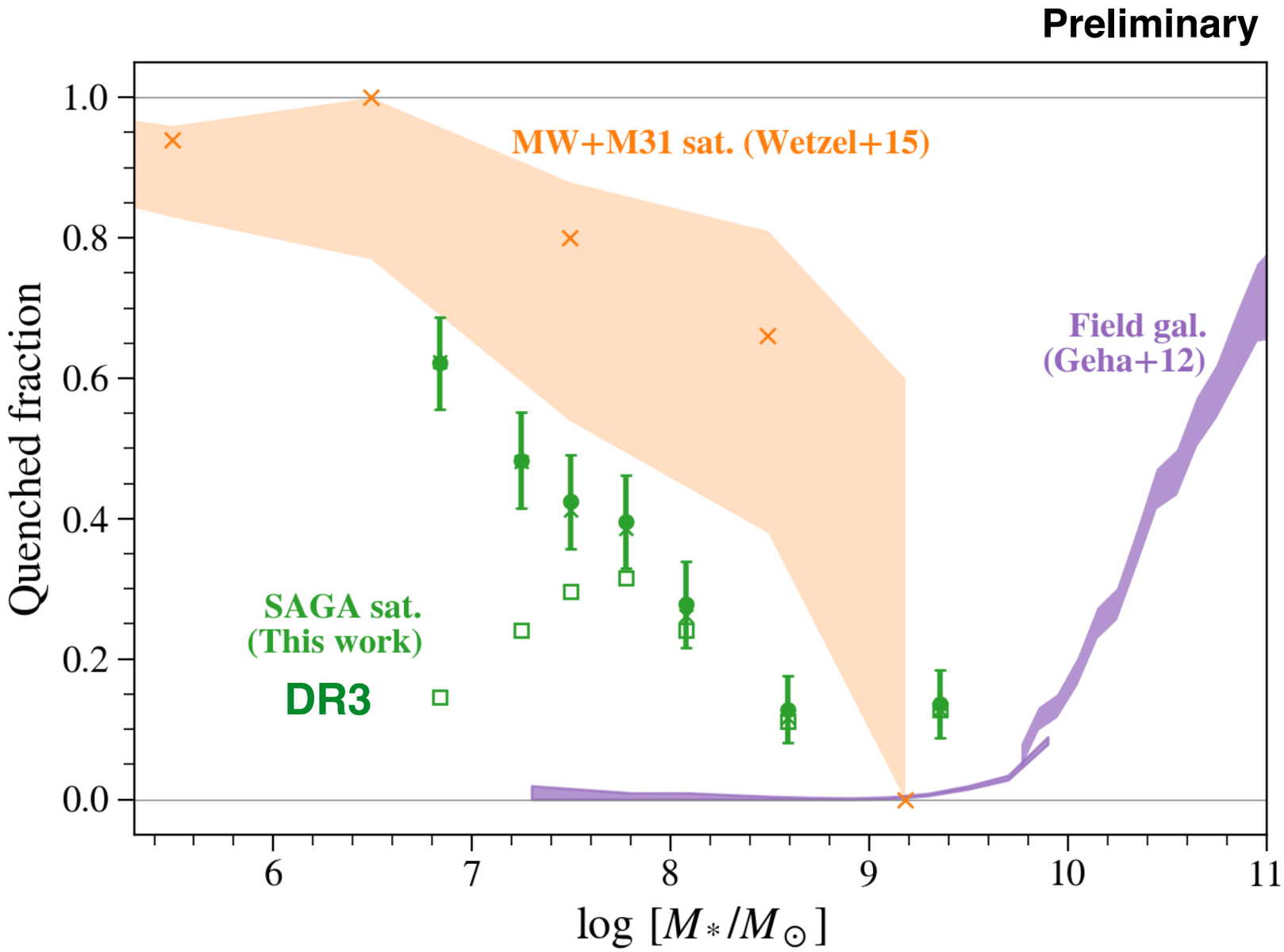
Leo I: -12.3



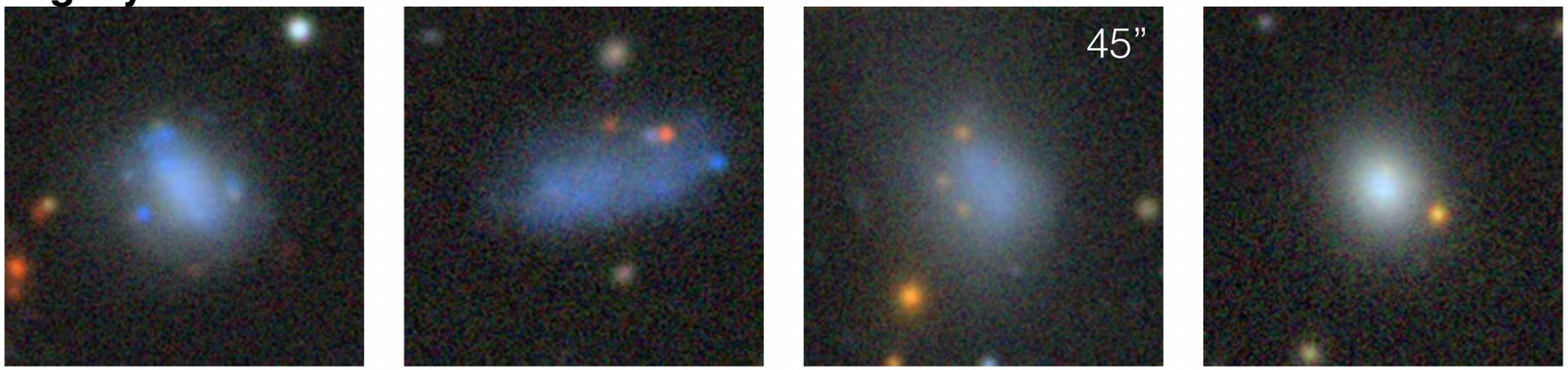
In Milky Way, 2 of 5 brightest satellites are forming stars.

In M31, 3 of 9 brightest satellites are forming stars.

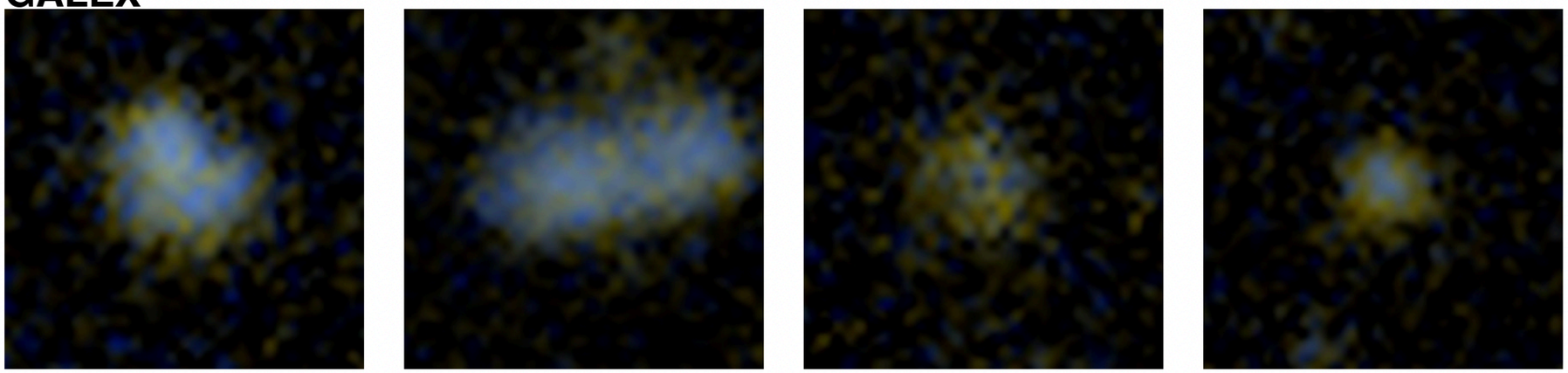
SAGA Satellites: Quenched Fractions



Legacy



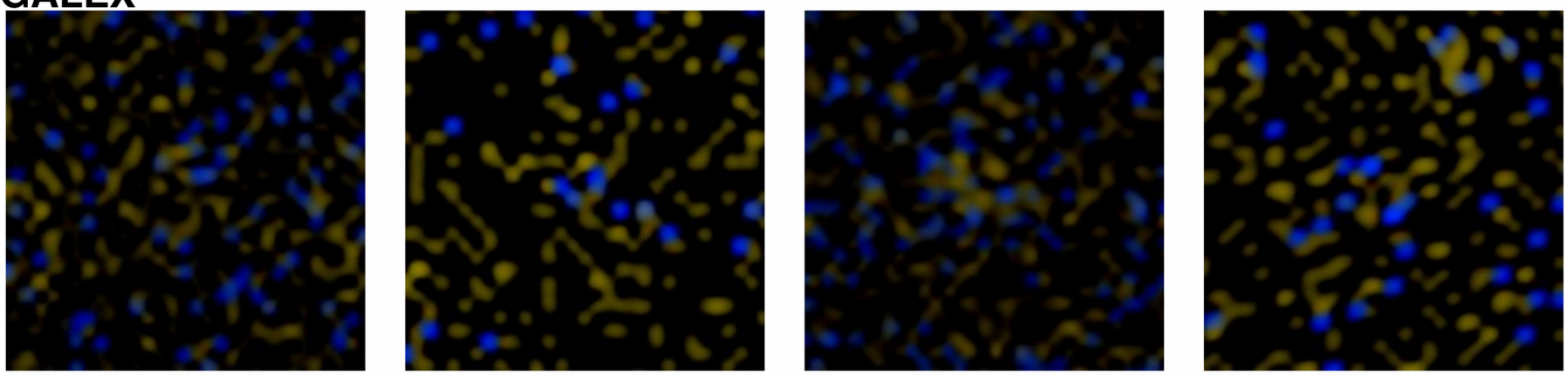
GALEX



M* ~10⁸ @ 30 Mpc

Legacy

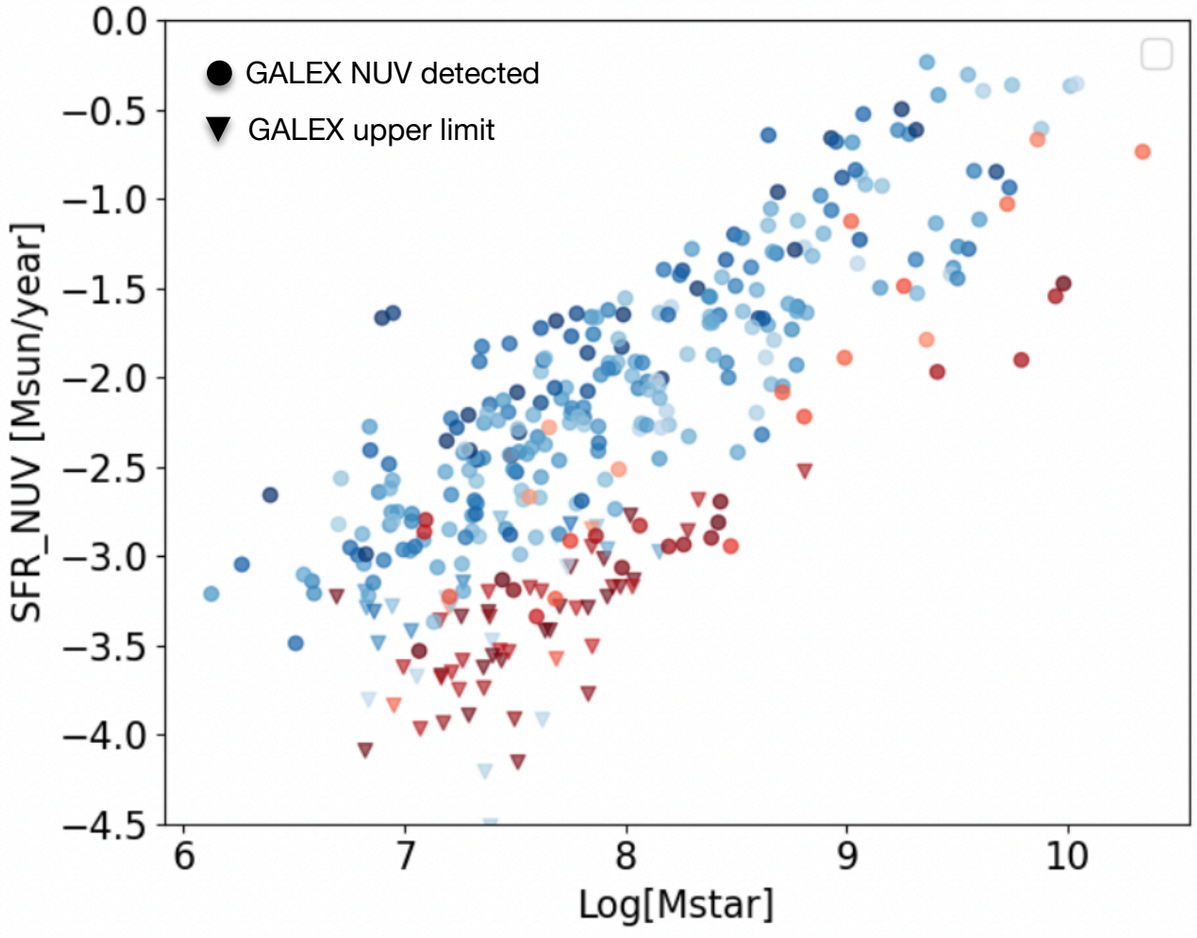
GALEX

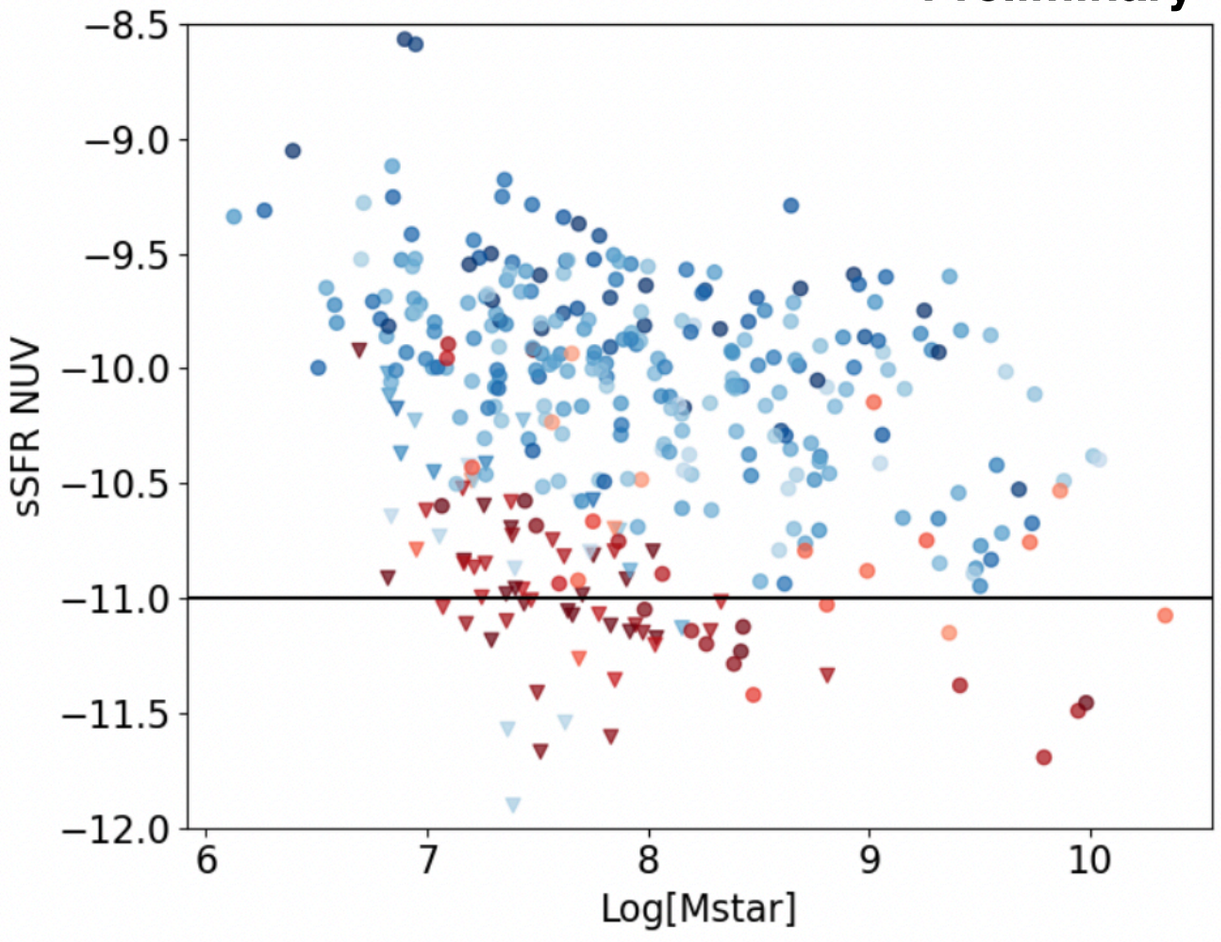


M* ~10⁷ @ 30 Mpc

Star Formation rates in SAGA Satellites

Preliminary

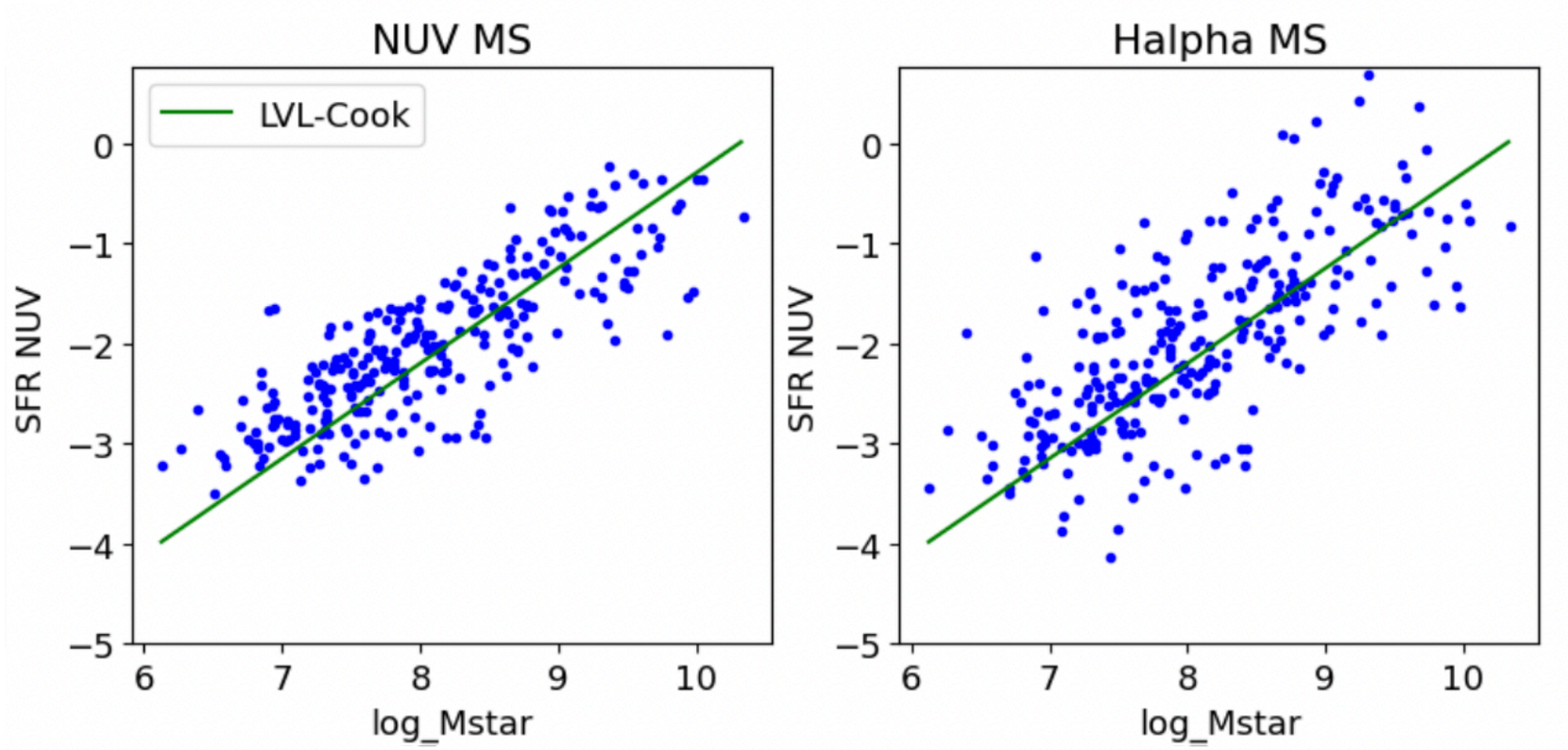




SAGA quenched definition combines GALEX and Halpha constraints.

(We use NUV SFR, as GALEX FUV is too shallow to detect significant number of SAGA satellites.)

SAGA Satellites: Halpha vs. NUV



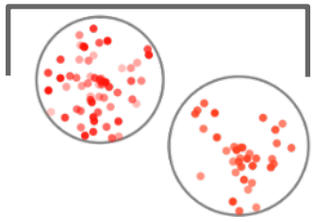
Preliminary

1. Scatter in Halpha SF Main sequence is larger than NUV by ~0.1 dex

2. SAGA SF satellites do not appear offset from the SF main sequence.

Finding Low Mass Galaxies in the Local Universe

Local Group



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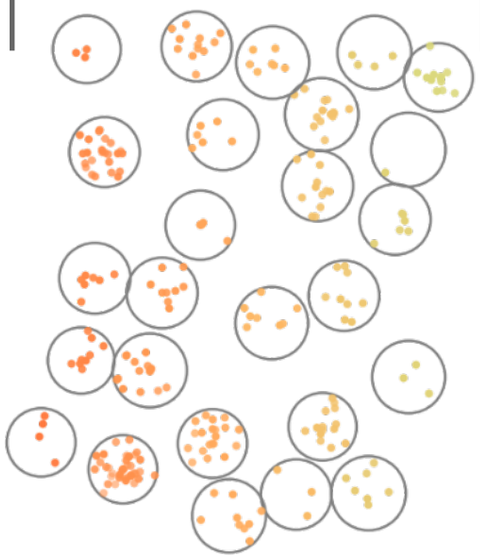

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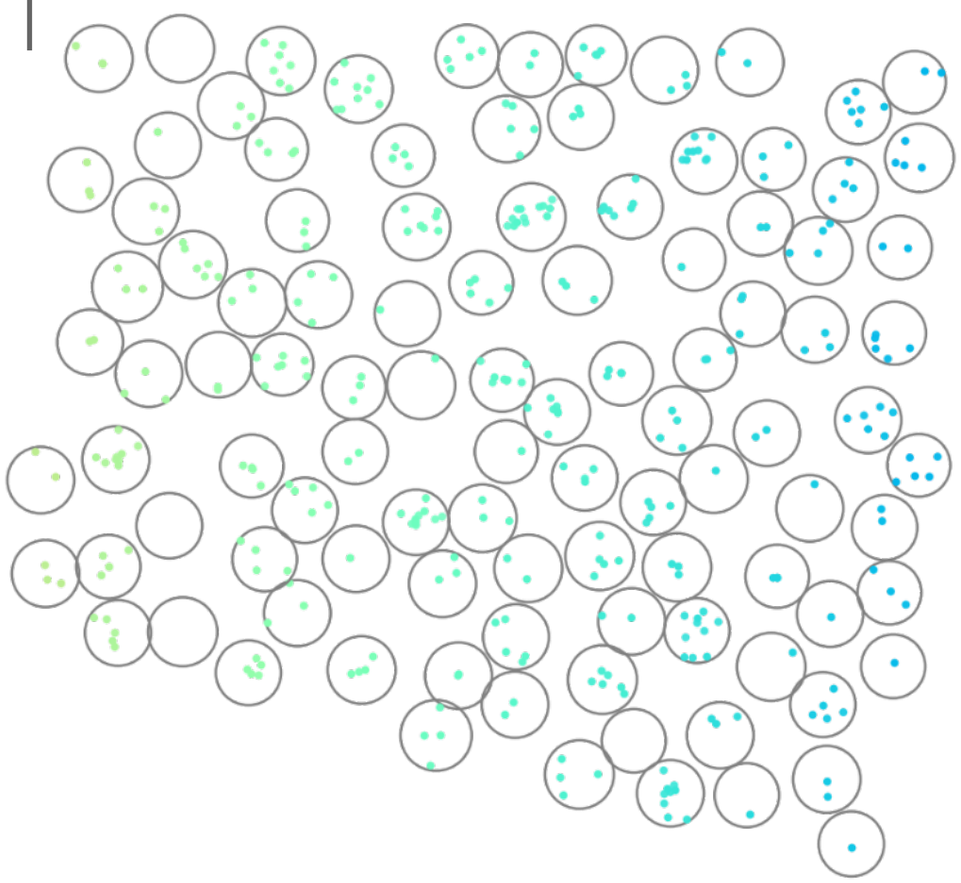
The SAGA Survey
25 – 40 Mpc



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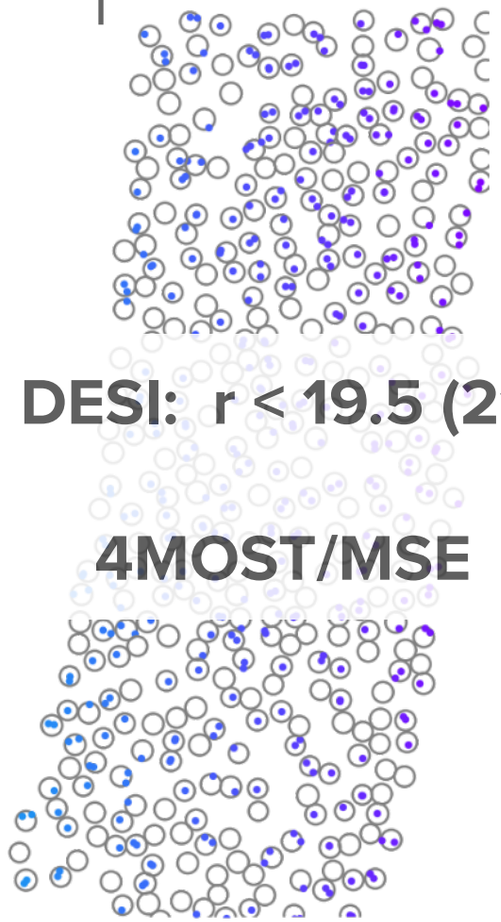


DESI: r < 19.5 (21)

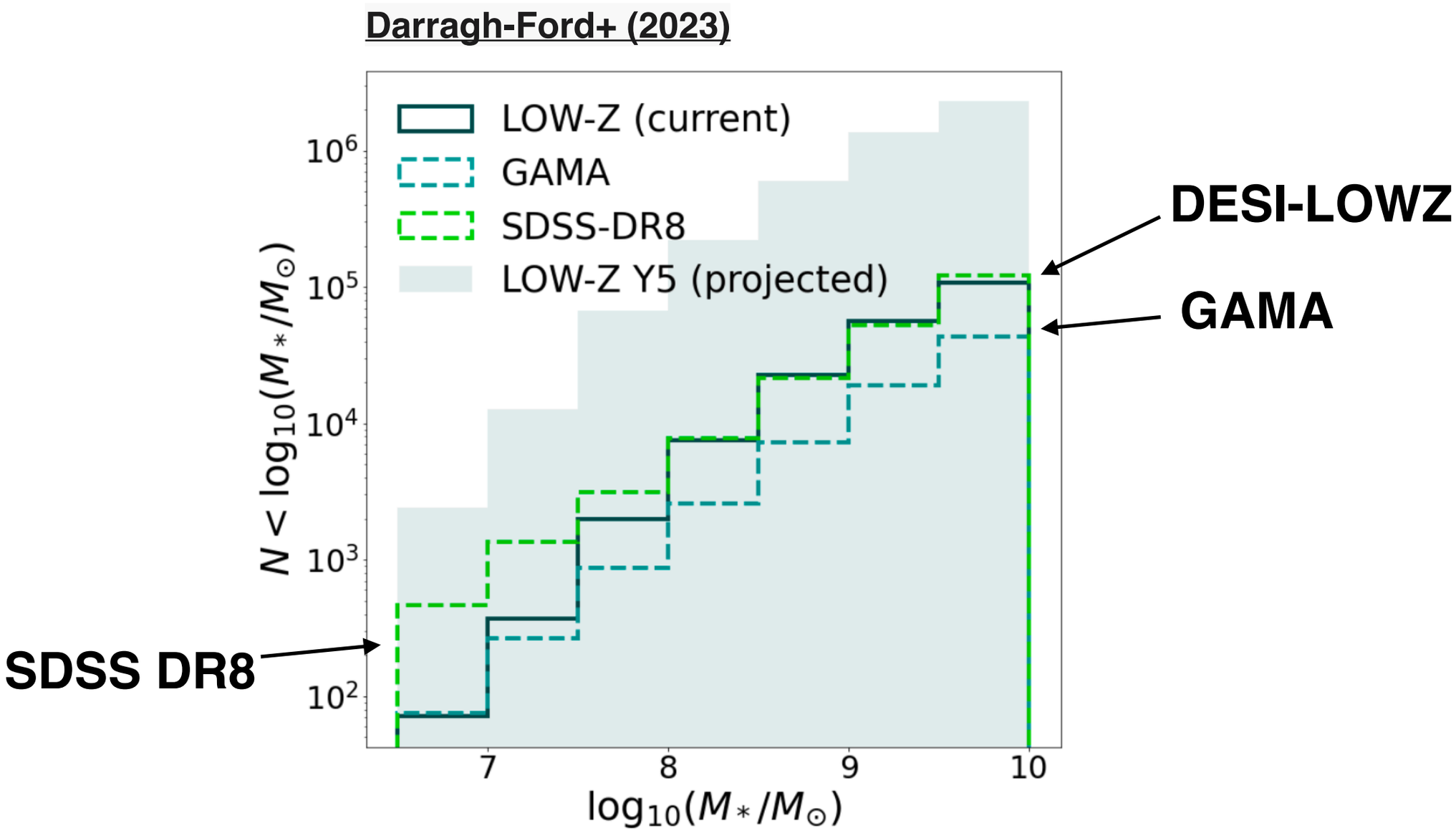
4MOST/MSE

e.g., Sales+2013
r < 17.77

Distance

Figure by Yao-Yuan Mao (Utah)

Finding Low Mass Galaxies: DESI LOWZ



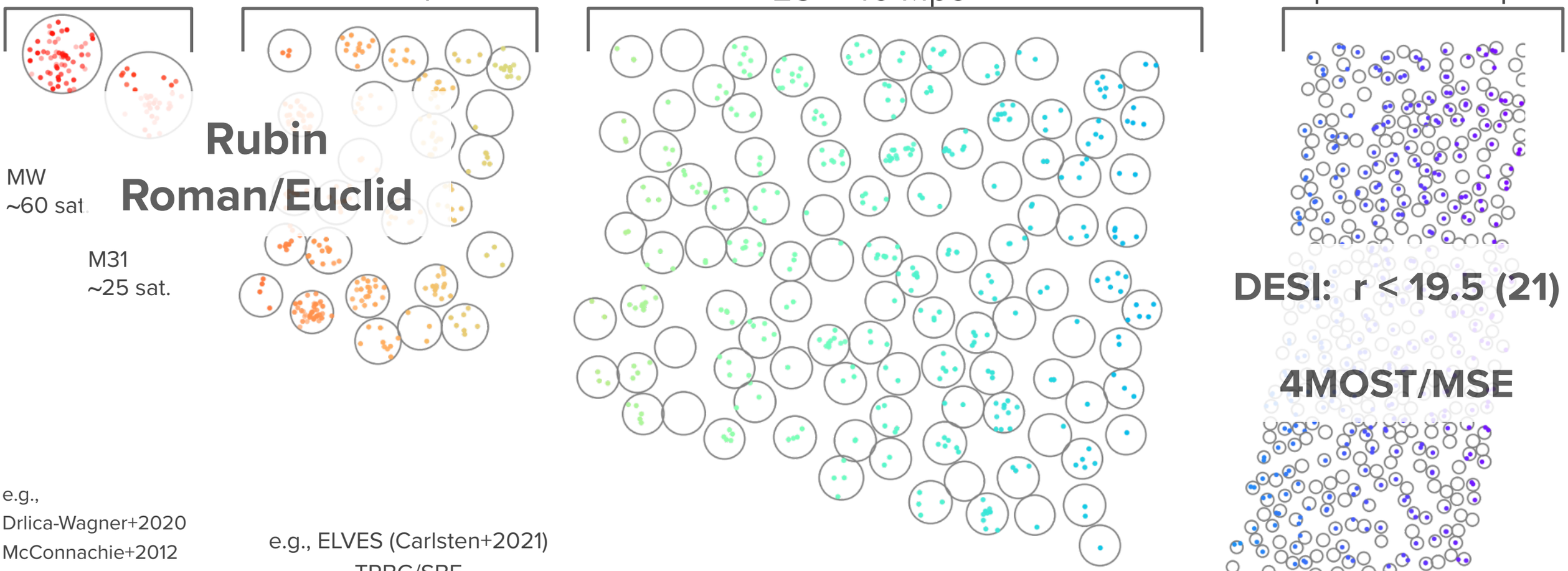
Finding Low Mass Galaxies in the Local Universe

Local Group

Local Volume < 20 Mpc

The SAGA Survey 25 – 40 Mpc

SDSS Up to ~200 Mpc



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Distance

UVEX is critical for characterization!

Figure by Yao-Yuan Mao (Utah)