

Galactic stellar halos in the DESI Legacy Imaging Survey

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2024 ASROC meeting

Outline

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Stellar halo

Data

DESI-LS

SGA-2020

Photometry & fitting

Result

Dragonfly survey

Simulation

Stellar halo

Accreting event

Morphology

Diffuse, roughly spherical

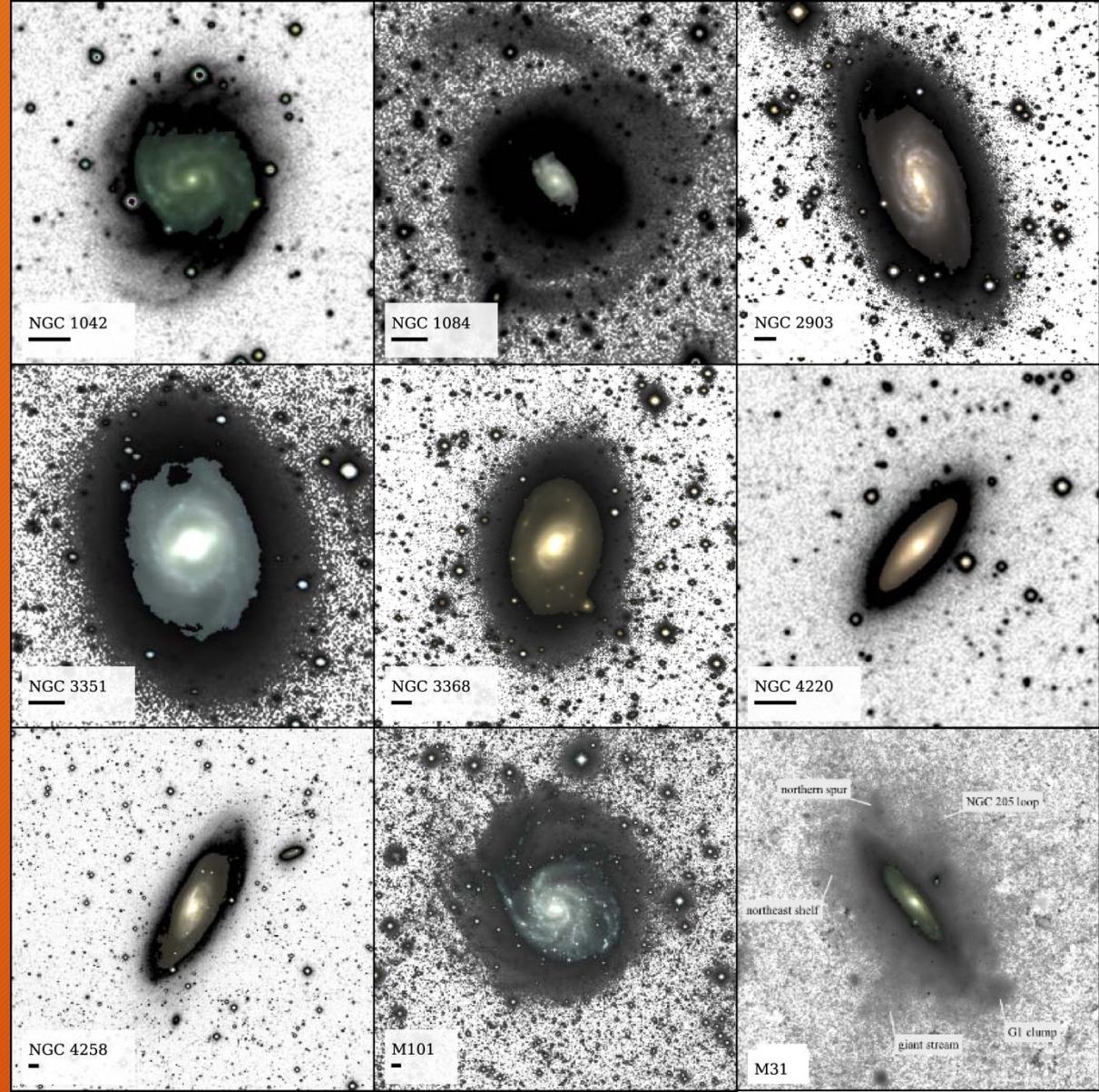
stellar shells

LSB structures

tidal streams

tidal tails

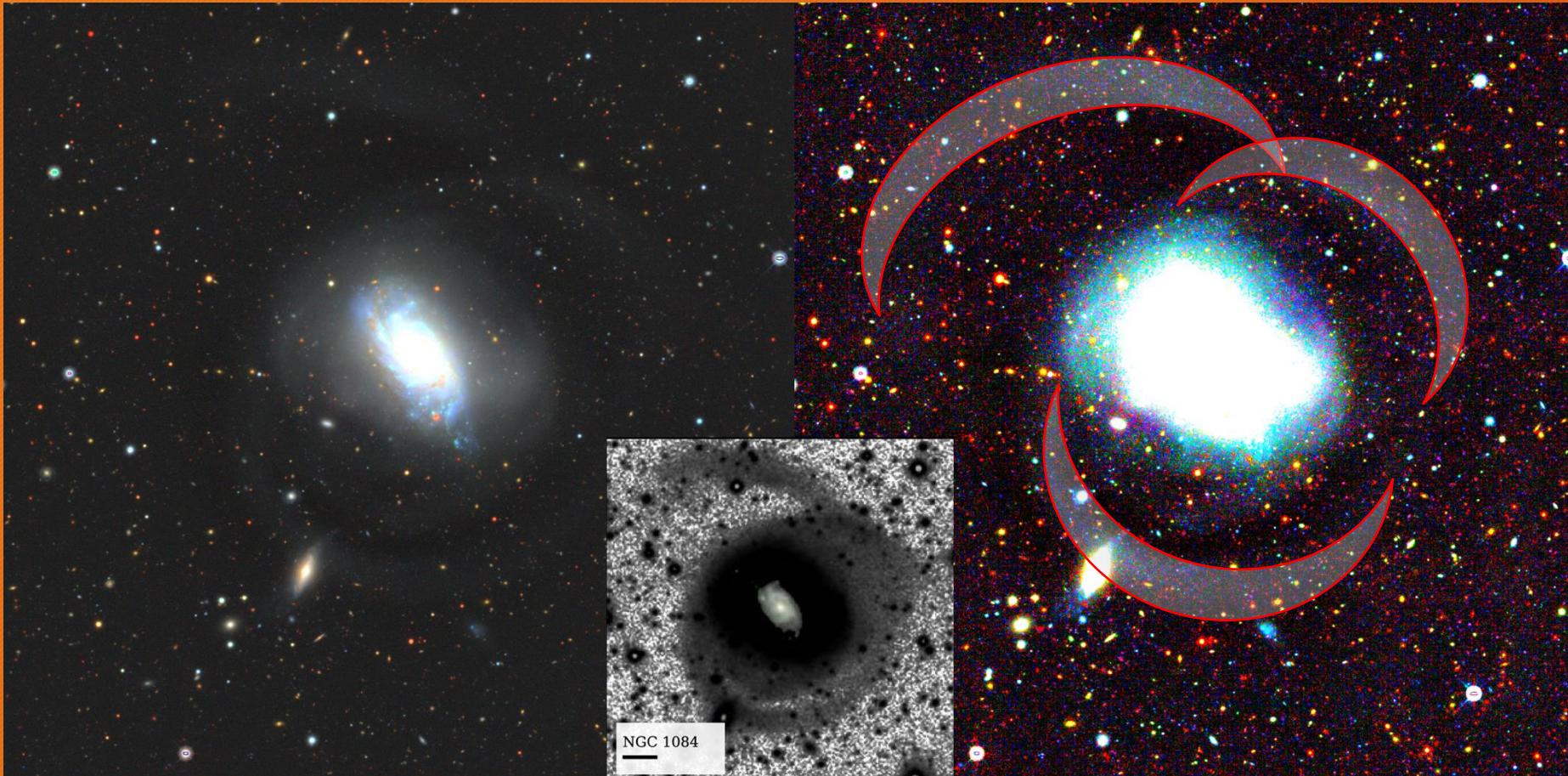
- Reflecting a series of mergers and low-mass accretion events of galaxies
- Exploring the properties of dark matter



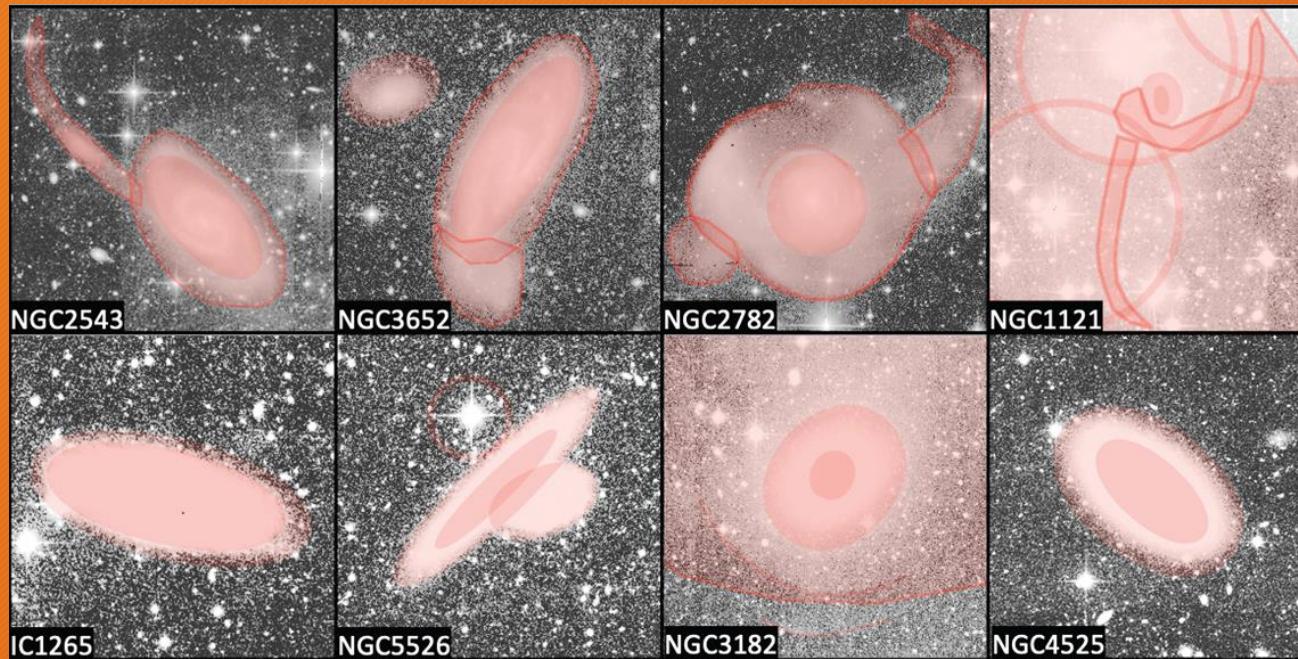
NGC1084

By eye, we can see the tidal streams surrounding the host galaxy.

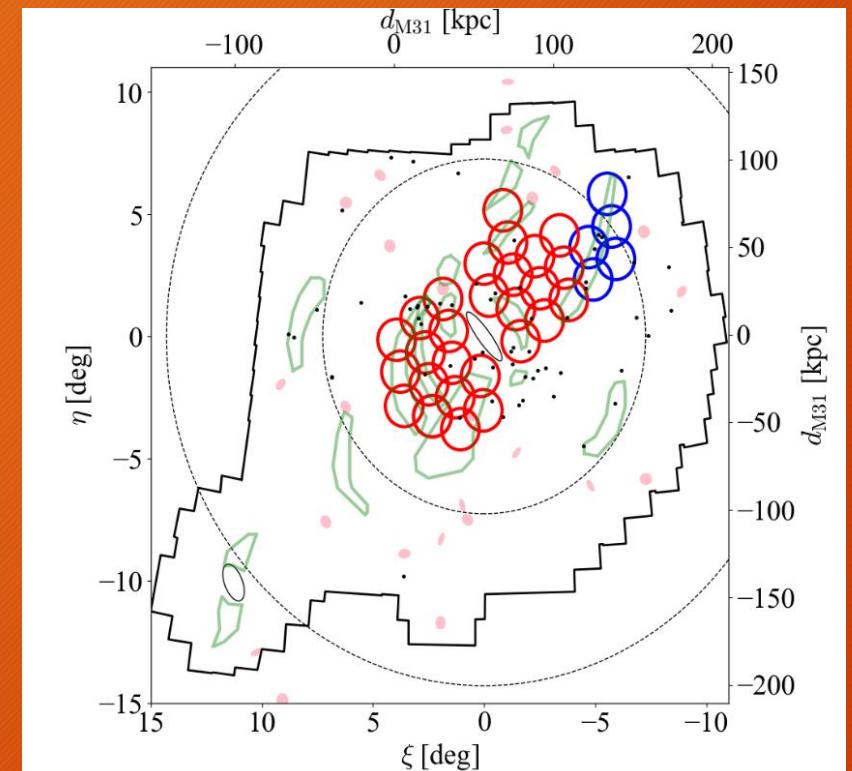
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Most previous work on images of extragalactic stellar halos has focused on identifying and classifying individual LSB features.



Canada-France-Hawaii Telescope (CFHT) (Sola et al, 2022)



HSC survey fields (Ogami et al, 2024)

Motivation

- We are exploring a different approach:
our goal is to develop uniform, automated measurements of bulk stellar halo properties that are easier to apply to large datasets and to compare with models.
- The DESI-LS (SGA-2020) has provided us with a substantial number of galaxy image samples(~ 400000).

Stellar halo is faint!

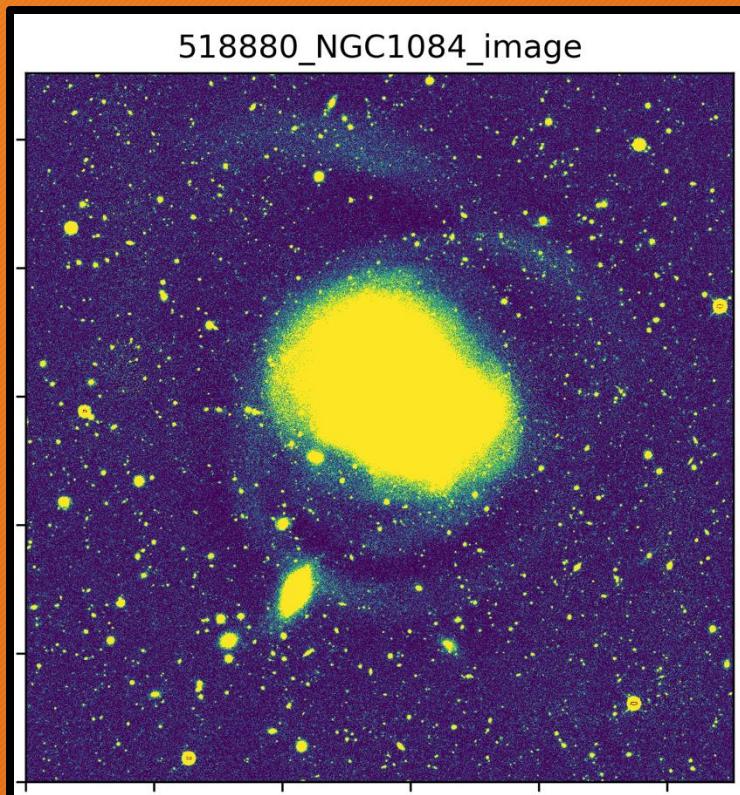
Deeper
imaging

Large sky
coverage

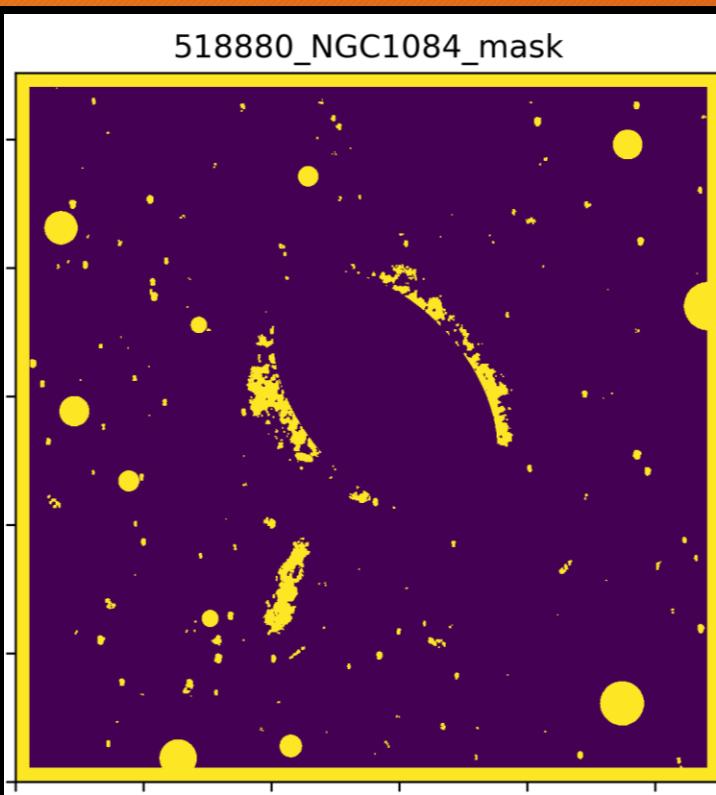
Photometry method

Masking is important

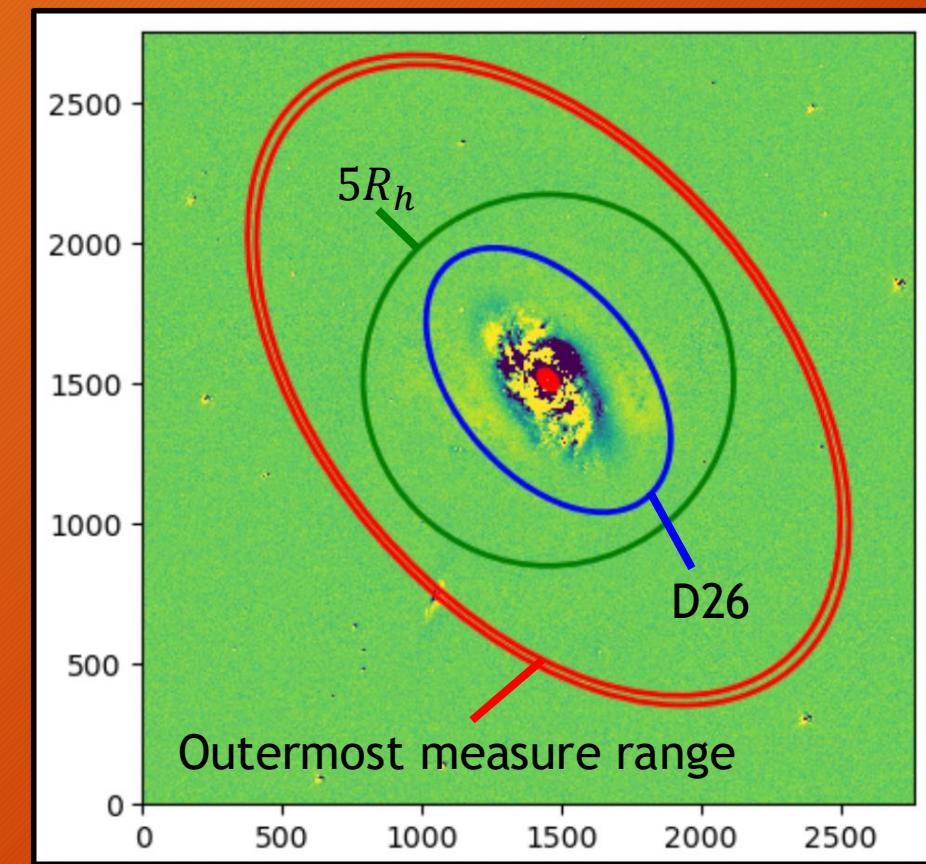
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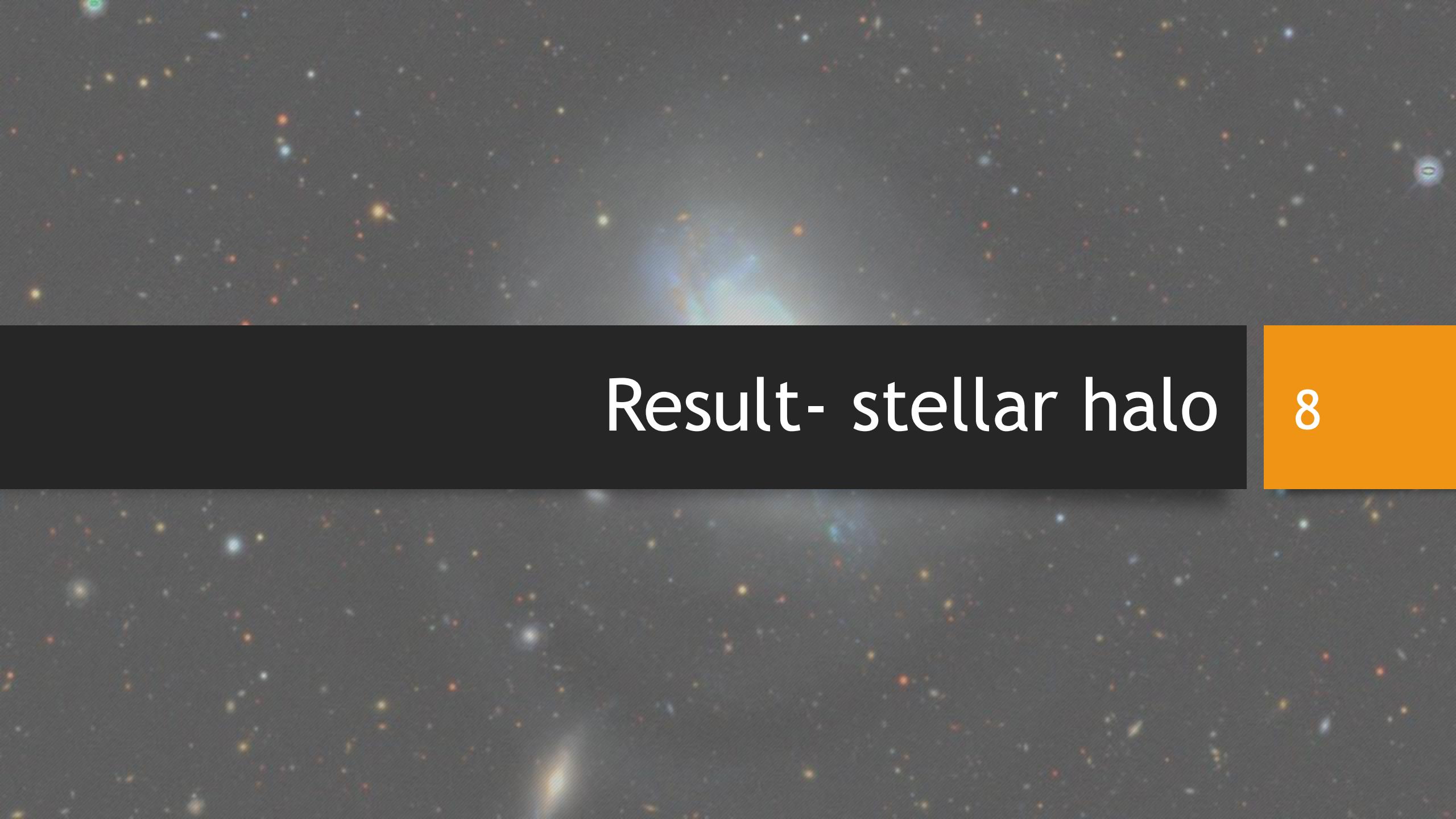


r-band raw image



Masking image

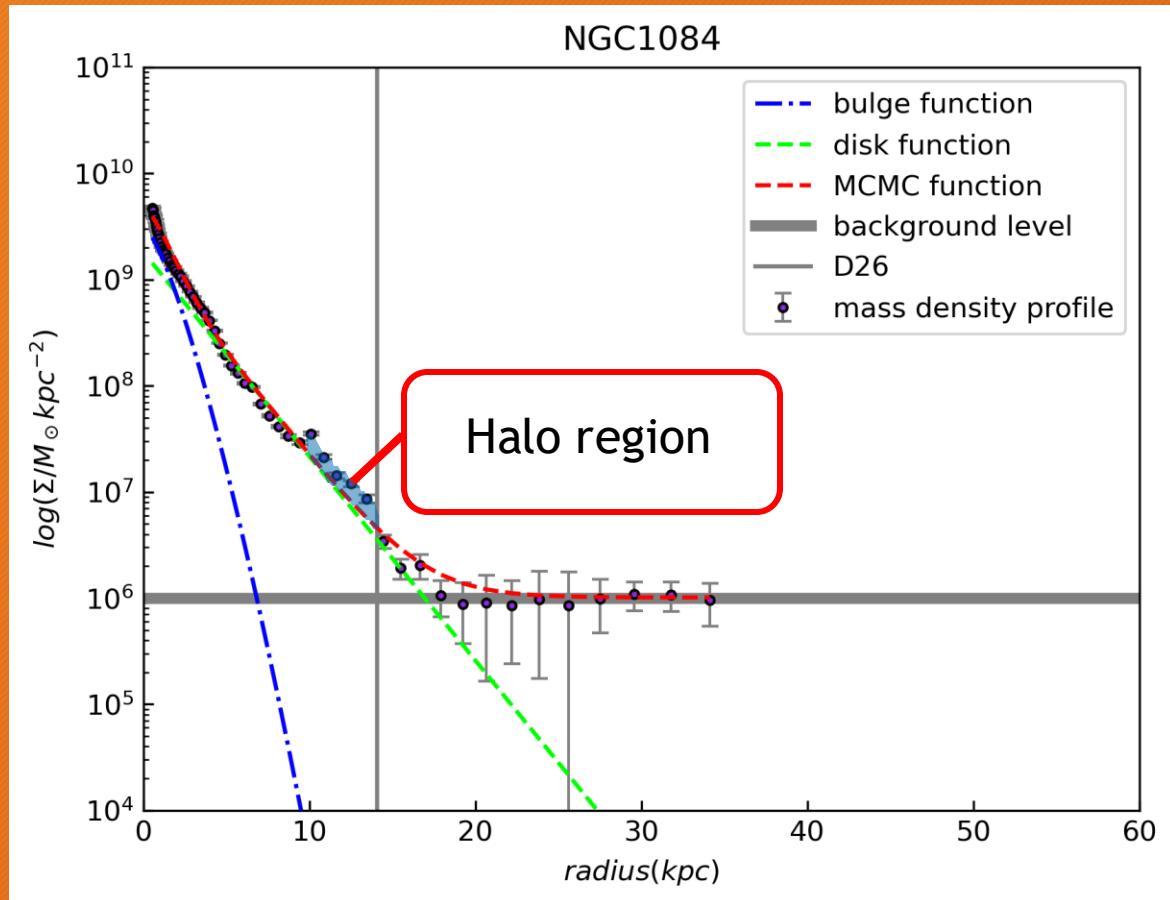




Result- stellar halo

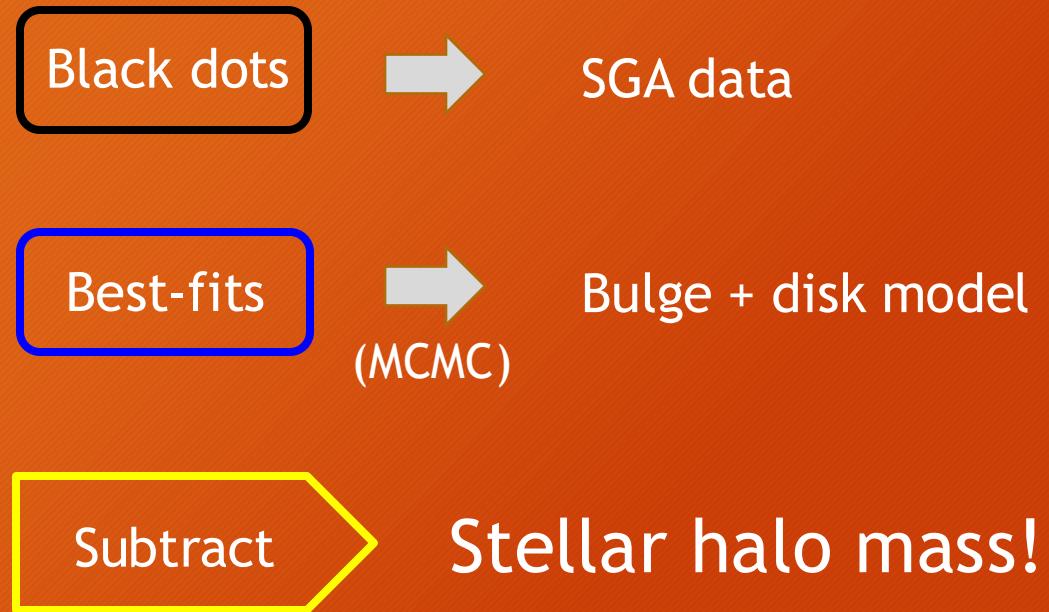
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Stellar mass surface density profile

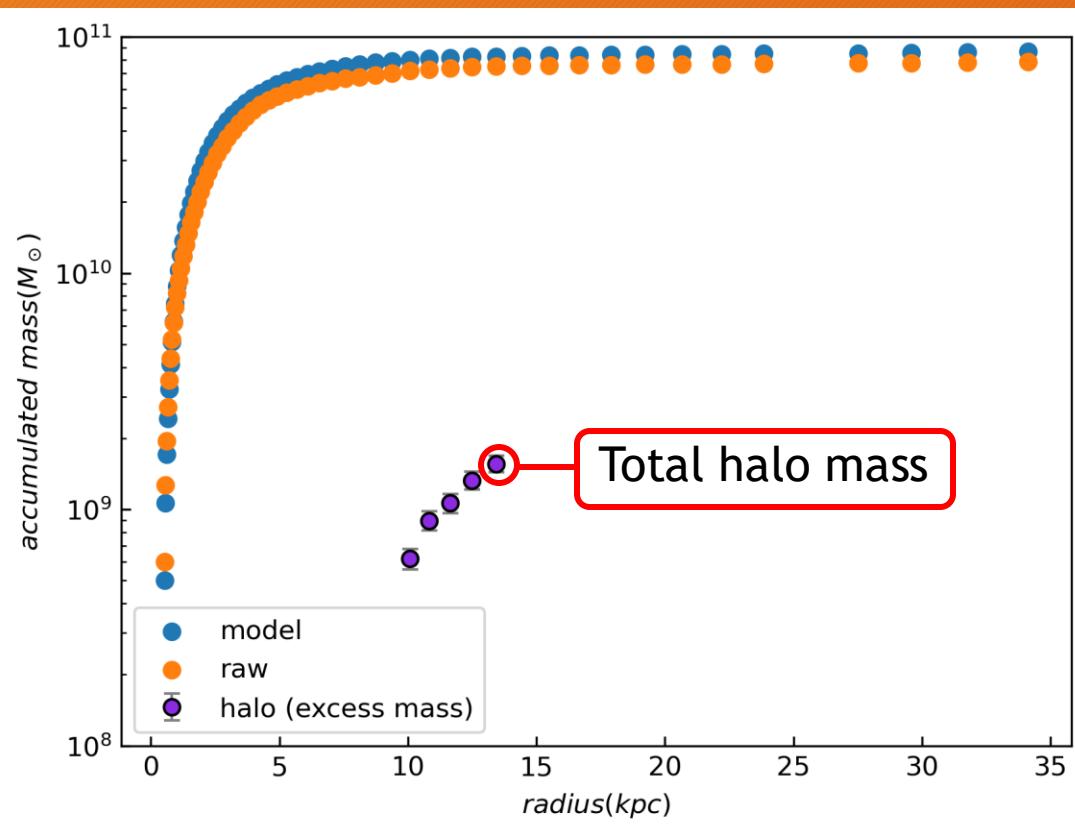


Surface density profile

Stellar mass density profiles and Best-fit models of NGC1084



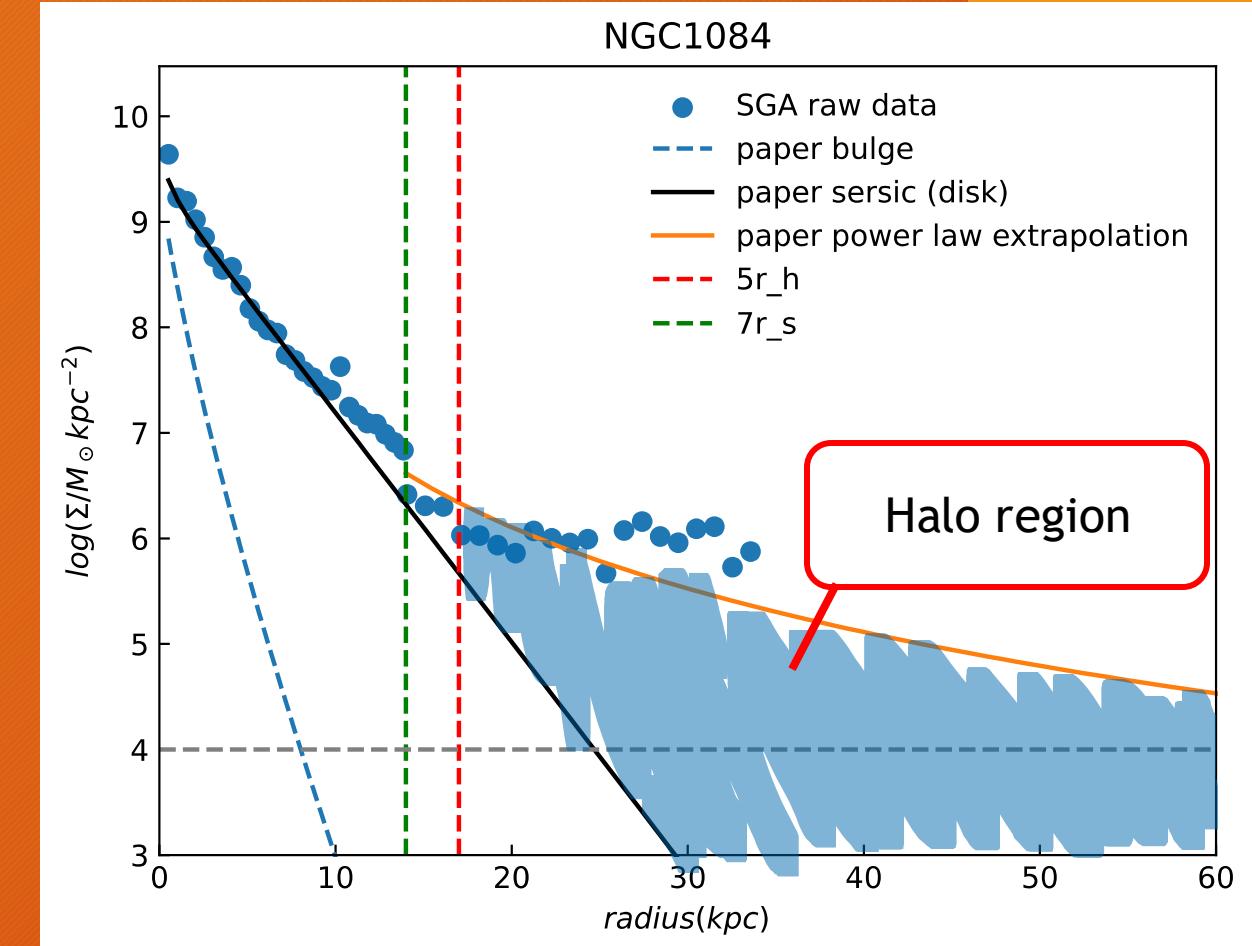
Halo fraction estimate



Accumulated stellar halo mass

Stellar halos contribute significantly only to the outermost regions of the galaxy.

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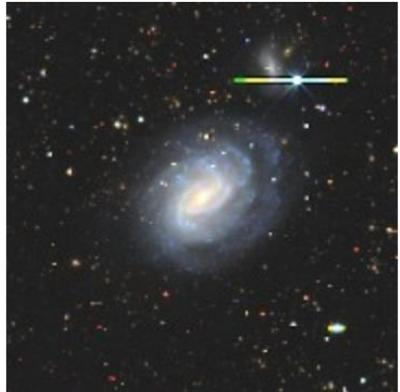


(Dragonfly method)

NGC3726



NGC1187



NGC4449



NGC0685



NGC4214



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NGC1559



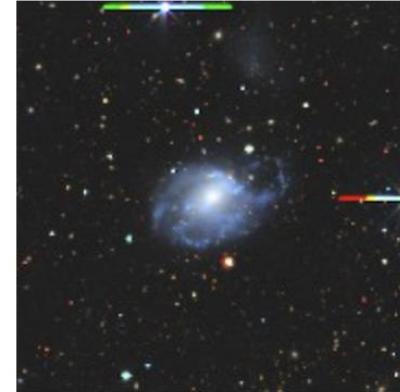
NGC4826



NGC2403



NGC0428



NGC4136



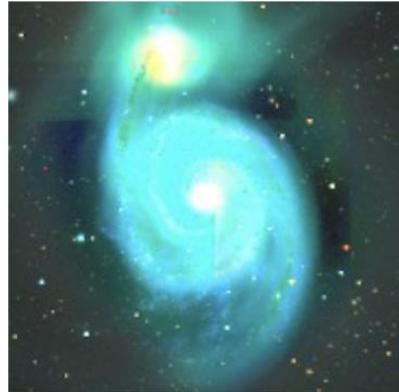
NGC3982



NGC1493



NGC5194



NGC3949



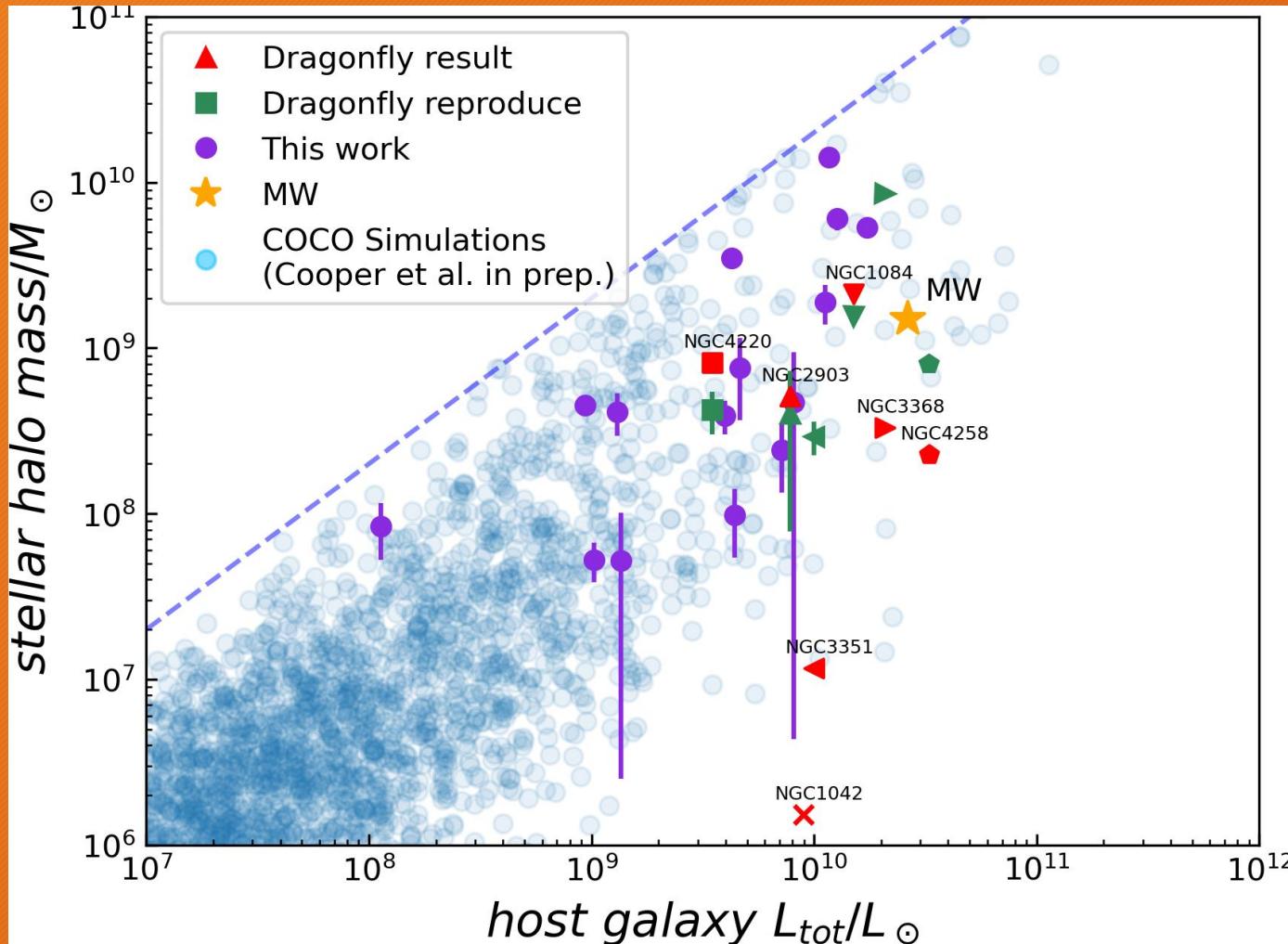
UGC04305



Distribution of galaxy and stellar halo mass

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Luminosity vs. Stellar halo mass



This is just the beginning of our preliminary testing!

Take home message:
Our technique agrees with Dragonfly; large scatter is consistent with simulations.

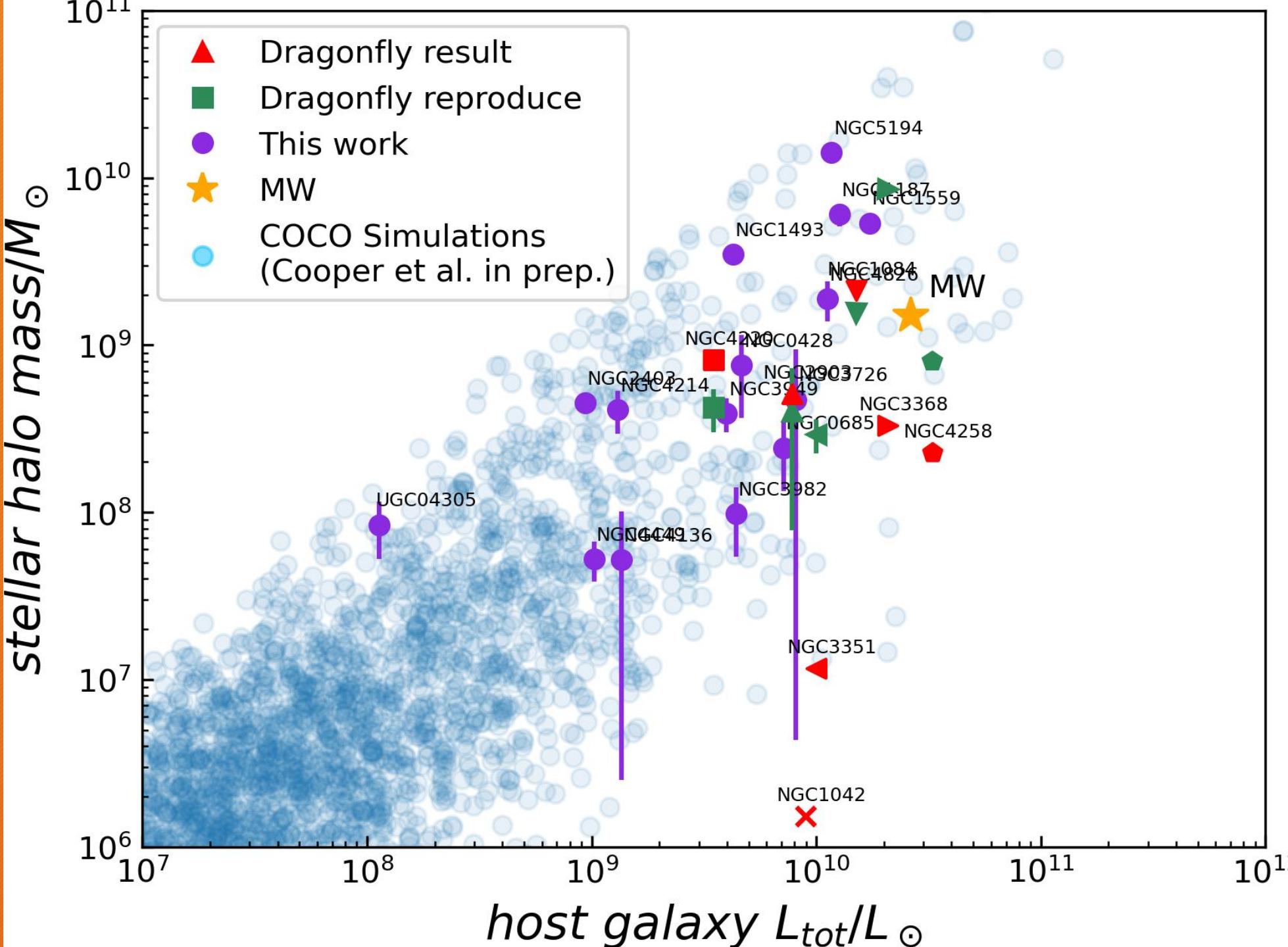
Conclusion and future work

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- ◆ We use our own pipeline to conduct photometry and measure the stellar halo mass for Milky Way-like galaxies.
- ◆ Agree with the state-of-the-art result from the Dragonfly survey.
⇒ The DESI-LS is capable of accurately measuring more stellar halos.
- ◆ In the future, by applying this to all-sky surveys, we aim to **identify statistical trends and compare them with simulations**.

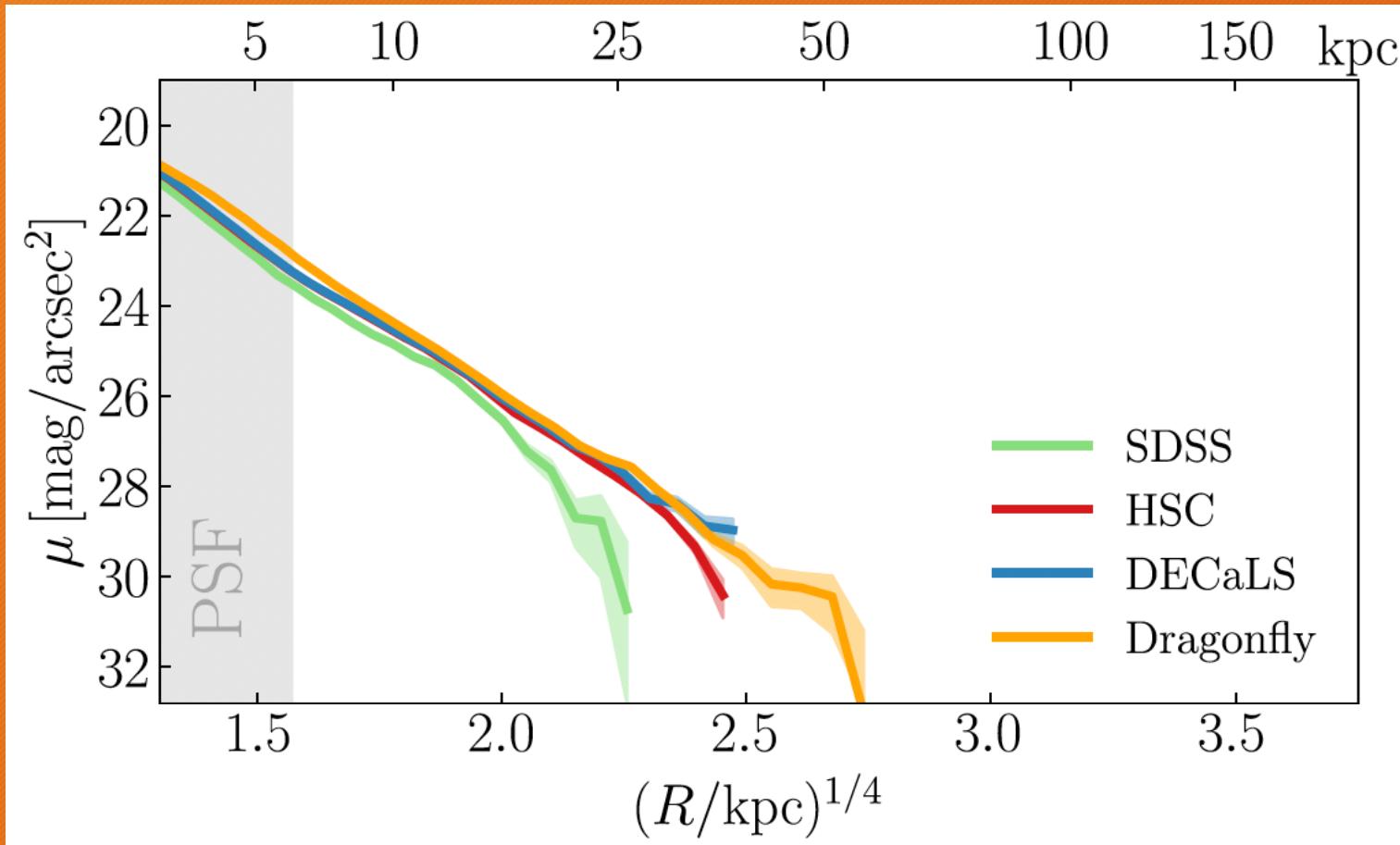
References

- [1] Sola, E., et al. 2022, A&A, 662A, 124S
- [2] Merritt, A., et al. 2016, ApJ, 830, 62M
- [3] Cooper, A. P., et al. 2010, MNRAS, 406, 744C
- [4] Gómez, F. A., et al. 2013, MNRAS, 436, 3602G
- [5] Cooper, A. P., et al. 2023, ApJ, 947, 37C
- [6] Mao, Y-Y., et al. 2021, ApJ, 907, 85M



r -band surface brightness profiles of the low- z sample

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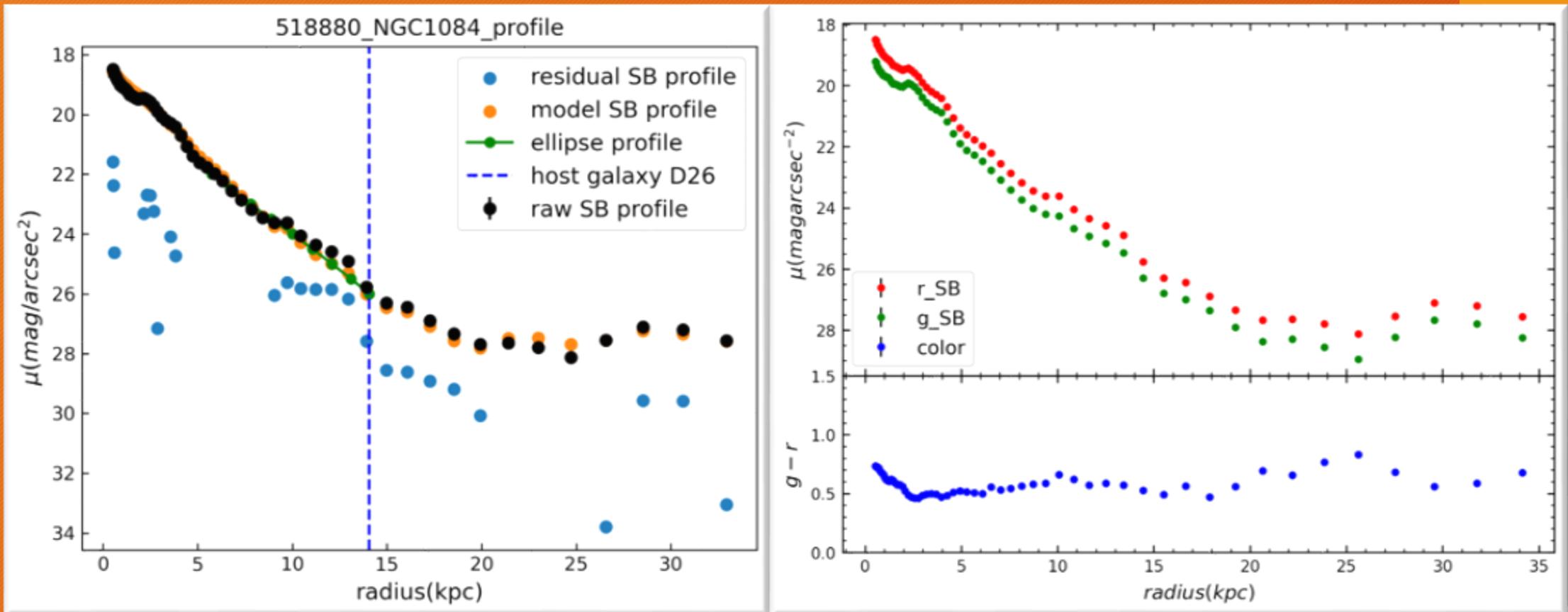
5 σ point source
detection limit:
HSC: 26.2 mag
DECaLS: 23.4 mag

Using color and SB, we can convert magnitude to mass.

Surface Brightness Profile

Color Profile

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The left panel is the surface brightness profile obtained with masking method from Siena Galaxy Atlas 2020 (Moustakas, Lang, et al. 2023) of NGC1084. The right panel is the observed $g - r$ color profiles.

DESI-LS Siena Galaxy Atlas 2020 (SGA2020)

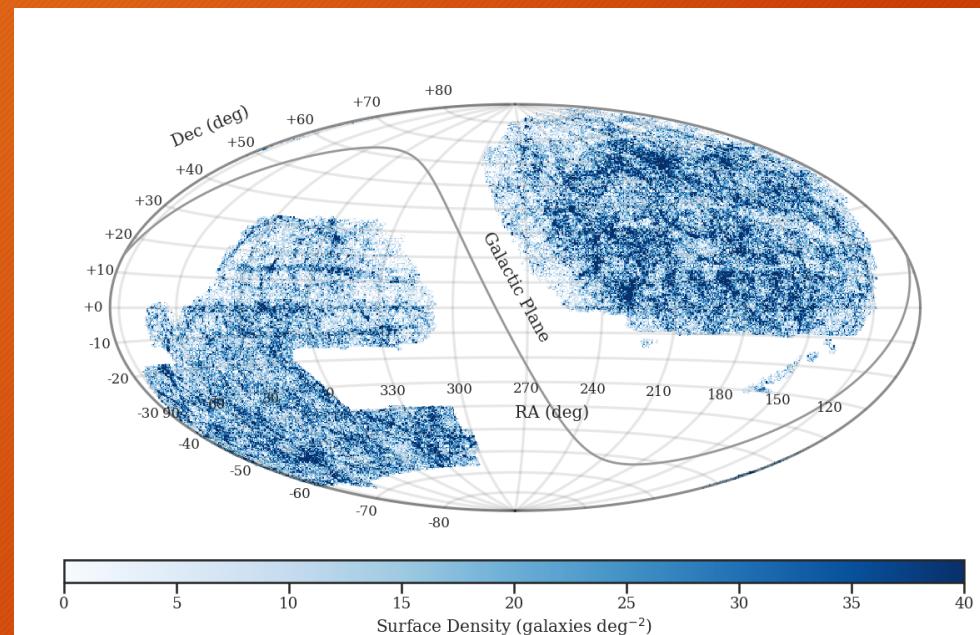
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DESI-LS

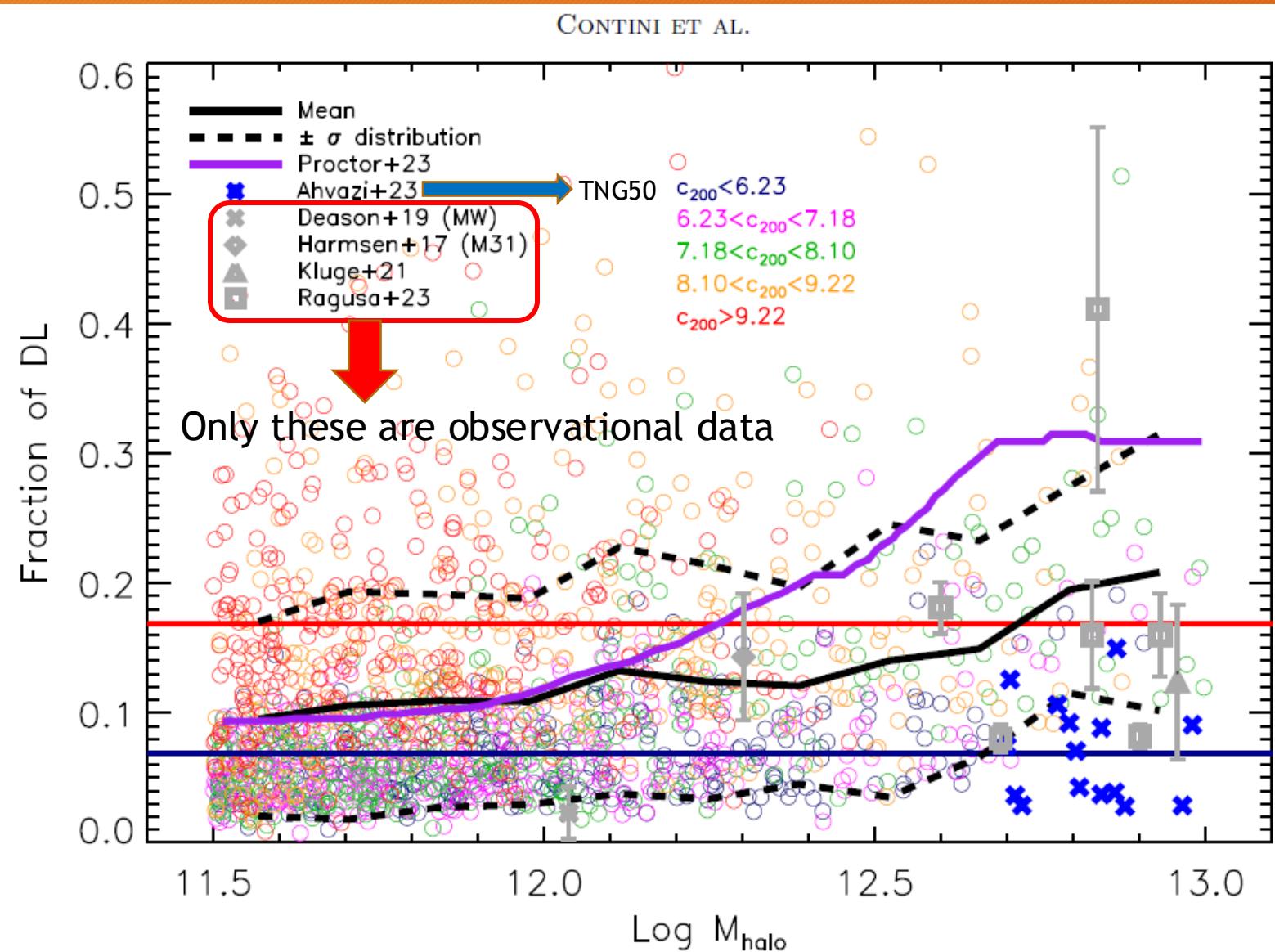
- Targets for DESI observation are selected using LS and Gaia
- North - MzLS (z)+ BASS (g,r) \rightarrow $\text{Dec} \geq 32^\circ$
- South - DECaLS (g,r,z) \rightarrow $\text{Dec} \leq 32^\circ$

SGA2020

- Galaxies with angular diameter $D(25) > 0.2\text{arcmin}$
- Multiwavelength atlas of 383,620 (g,r,z) nearby galaxies
- Large enough to be spatially resolved from our vantage point
- $\sim 20000 \text{ deg}^2$



SGA-2020



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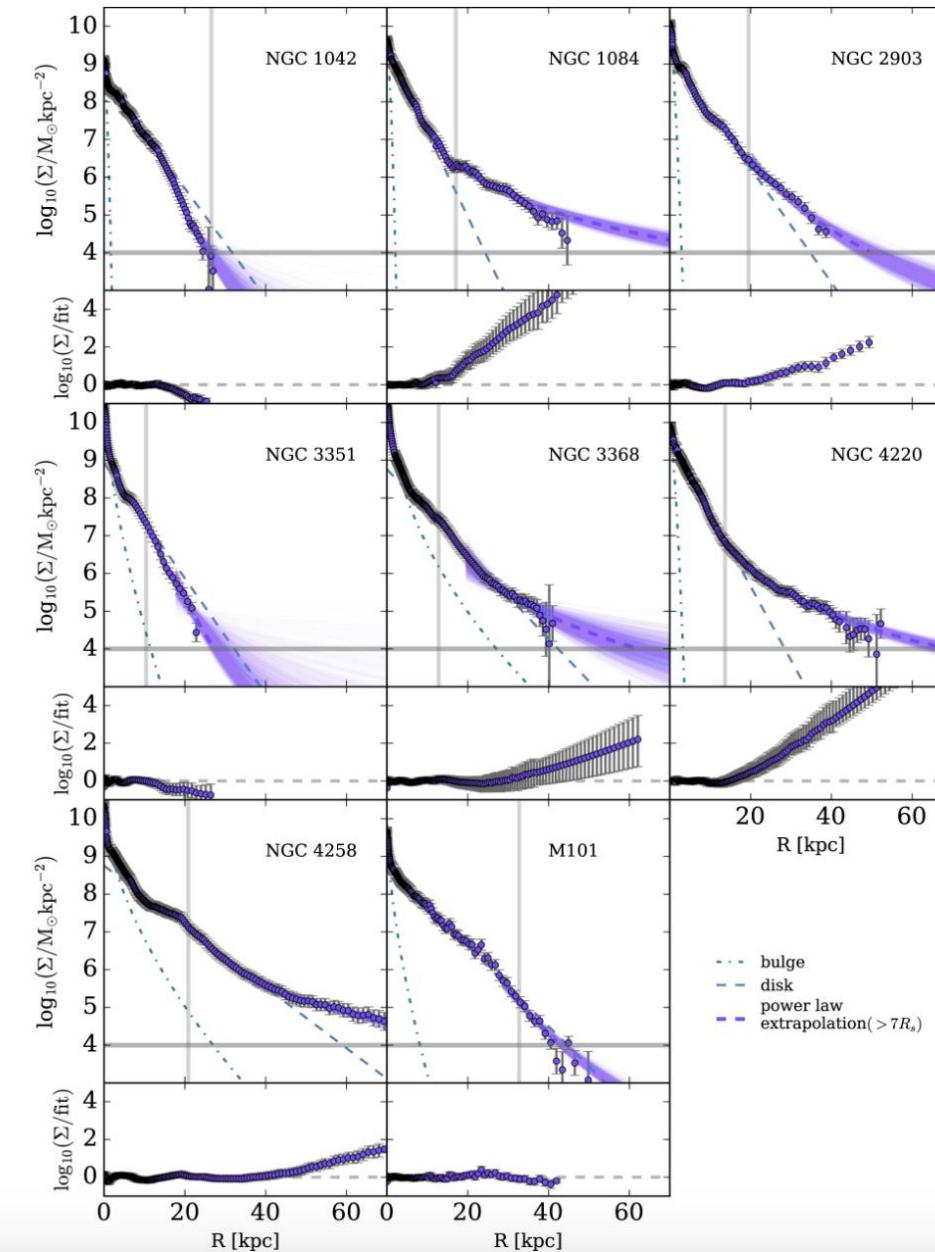
Statistical analysis of stellar halo characteristics is still lacking in observations.

Fraction of DL (diffuse light) as a function of halo mass for haloes in different ranges of concentrations as shown in the legend. (Contini et al, 2024)

Dragonfly survey



Credit: Merritt et al. 2016



LSB structures

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Tidal Tails

- Long, narrow structures extending from galaxies or star clusters
- Stars in systems distorted by tidal forces are pulled apart
- Irregular, blocky, and asymmetrical features, possibly from host galaxy or the companion

Tidal Streams

- Elongated, ribbon-like structures
- Consists of fragmented dwarf galaxies or stars of globular clusters
- Originate from interactions with other galaxies or satellite systems during mergers

Stellar Shells

- Concentric, roughly spherical structures surrounding a galaxy's center
- Formed from disrupted satellite galaxies or globular clusters
- Primarily come from the host galaxy itself

