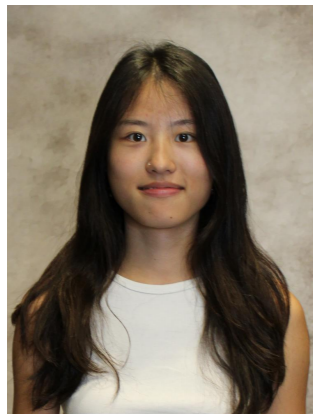


# Observational frontiers in dwarf galaxies beyond the Local Group

---

Jenny Greene (Princeton)



**Yue Pan**  
**SF satellites around MW**  
**hosts, Merian (see poster)**



**Yifei Luo**  
**Merian photo-z, dwarf star**  
**formation histories**  
**See talk**



**Abby Mintz**  
**Star forming galaxy**  
**morphology and SFH**



**Erin Kado-Fong**  
**Dwarf galaxy shapes,**  
**mergers, chemical**  
**evolution (and automated**  
**discovery of streams)**



**Jiaxuan Li**  
**Owner of the Hedgehog,**  
**ELVES-Dwarf**  
**Satellites of LMC+SMC**  
**hosts with SBF (see**  
**poster)**



**Scott Carlsten**  
**ELVES. SBF guru.**  
**ELVES-Field**



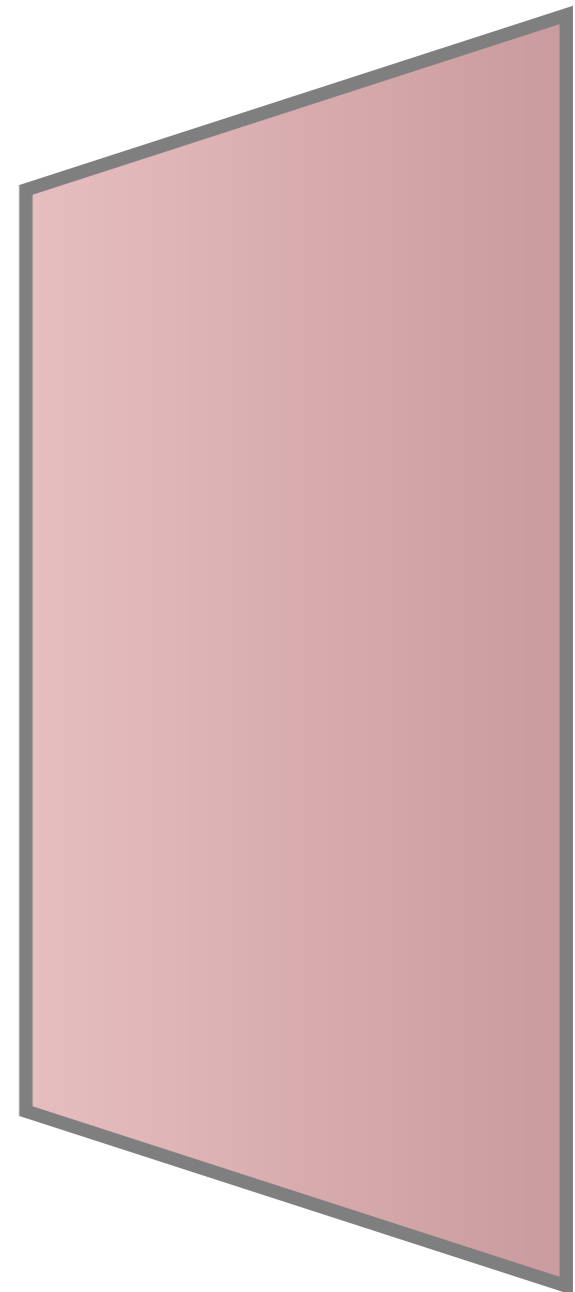
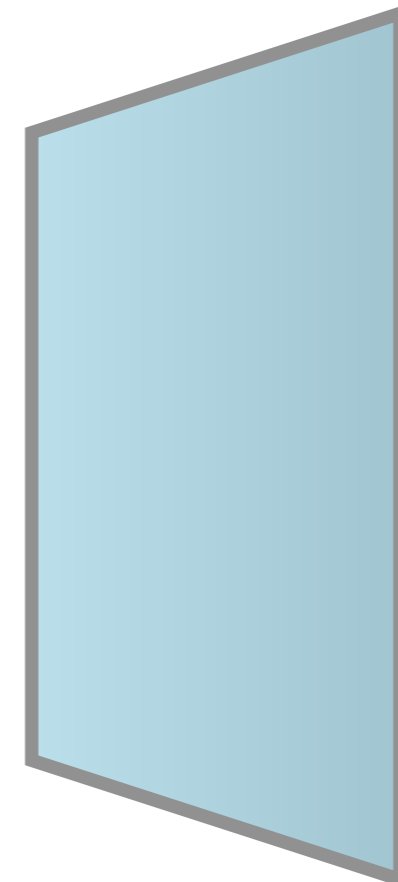
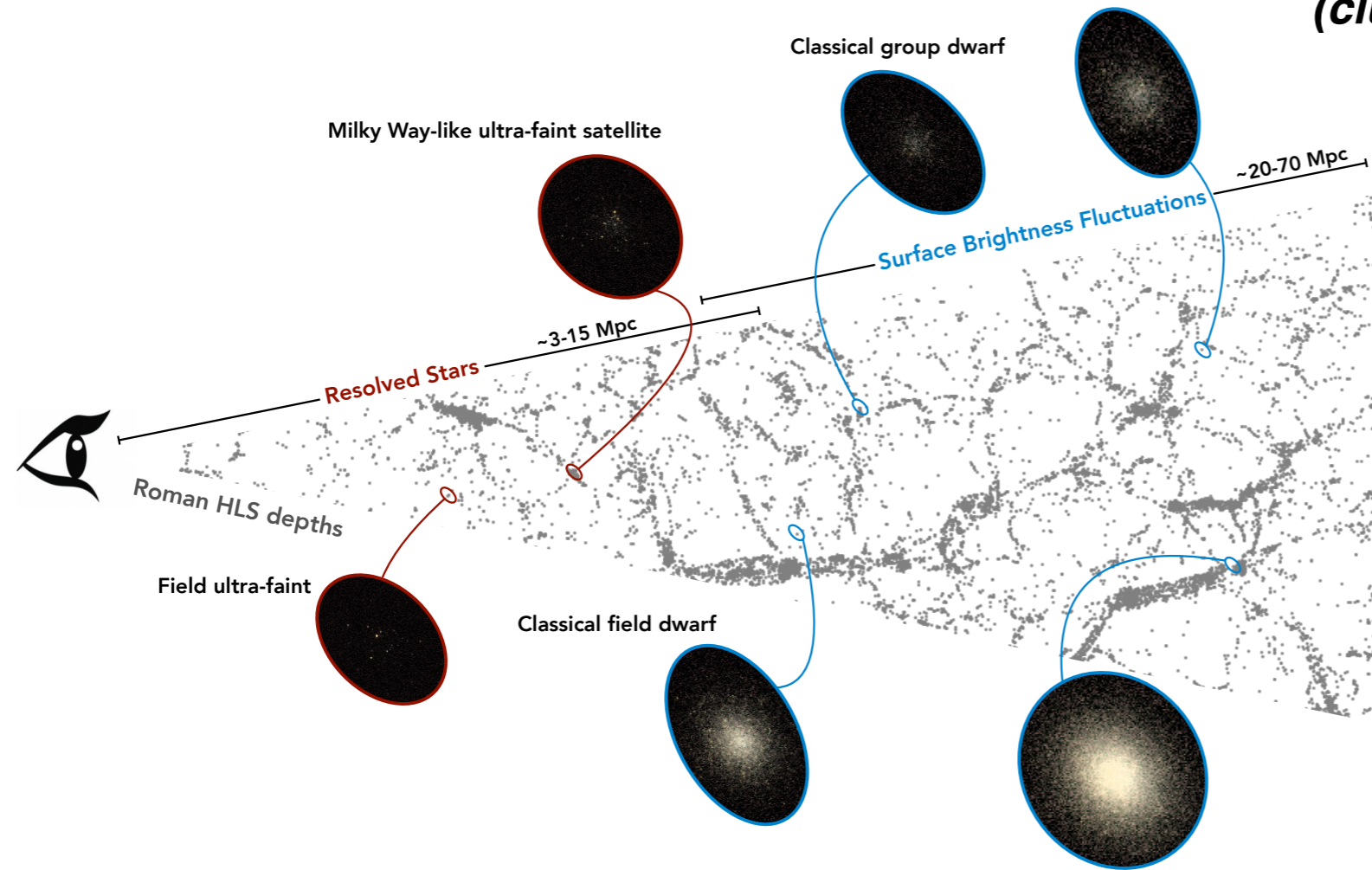
**Jake Nibauer**  
**DM substructure using**  
**streams (with Bonaca)**  
**See talk**



**Shany Danieli**  
**Dwarfs, Dark Matter,**  
**globular clusters, ELVES,**  
**Merian, Dragonfly...**



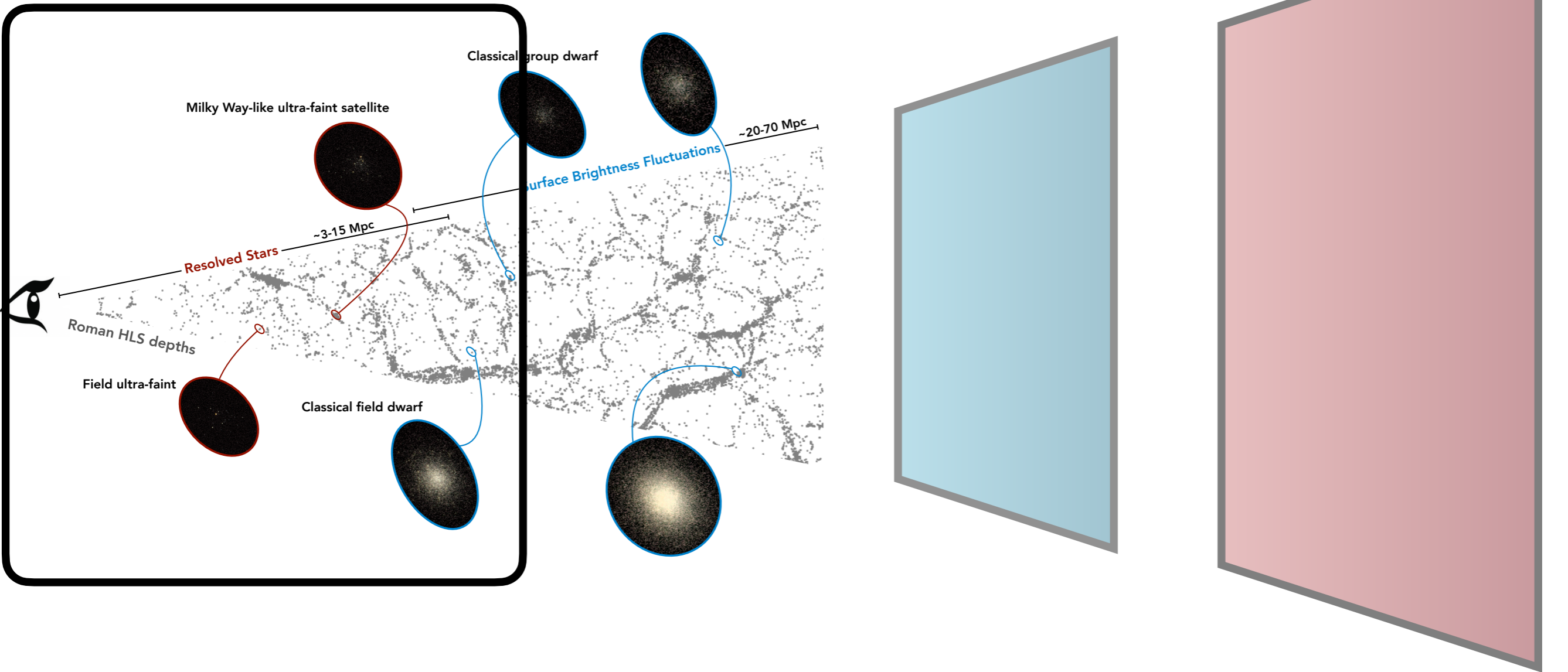
**$Z \sim 0.05-0.3$**   
**Integrated light,**  
**no direct distance**  
**Photo-z (Merian, UVEX)**  
**Statistical distributions**  
**(clustering, SOMs)**



*Local Volume with direct distances*  
*TRGB, TF, SNe*  
*Surface brightness fluctuations*  
*—> Extend to ~70 Mpc with Roman?*

**$z > 0.5$ : Redshift surveys**  
**DESI, PFS, MOONS**  
**Particularly with JWST**  
**Adding new insight**

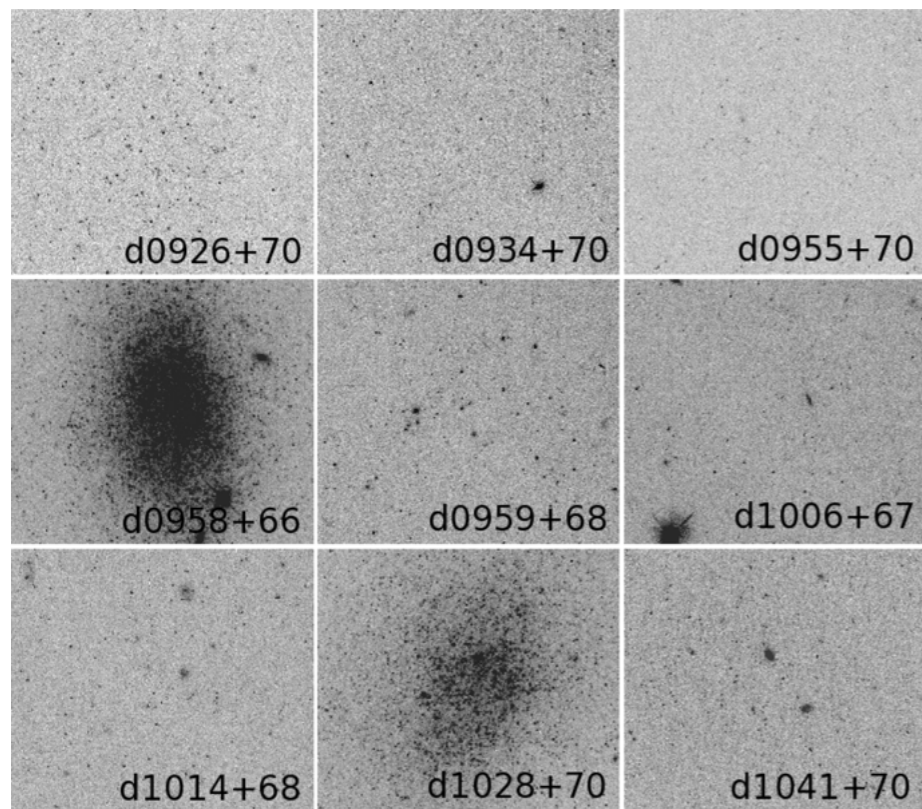
# Local Volume: Start with satellites, boosts efficiency



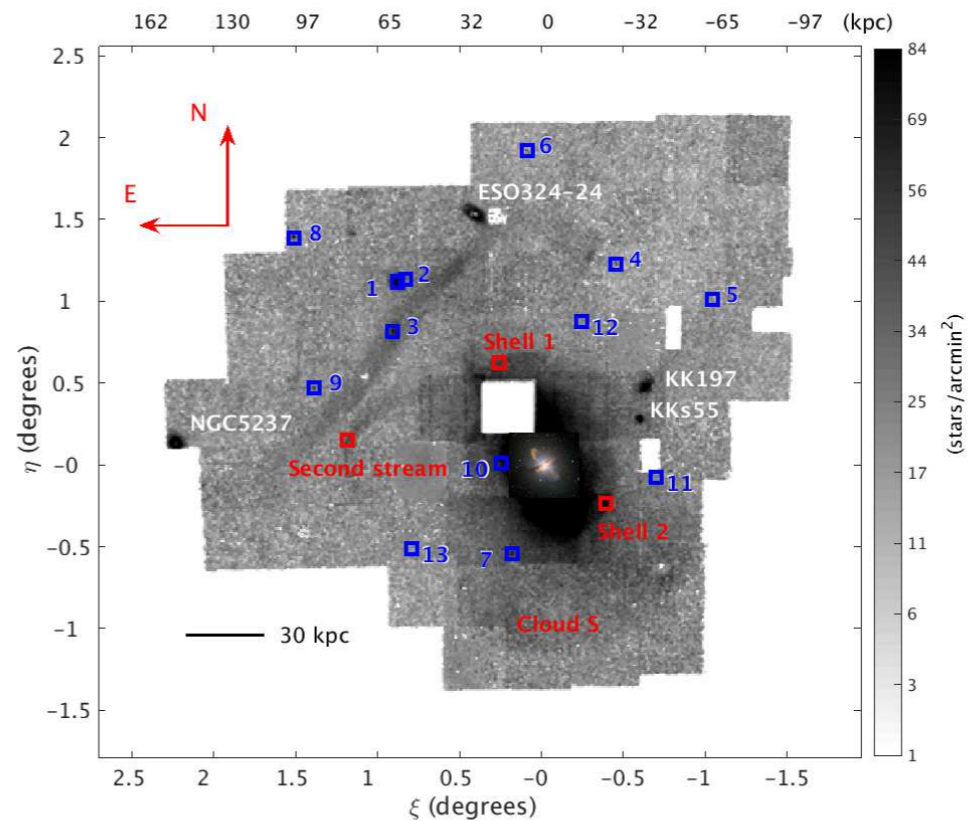
*Local Volume with direct distances*  
*TRGB, TF, SNe*  
*Surface brightness fluctuations*  
*—> Extend to ~70 Mpc with Roman?*

***Z~0.05-0.3***  
***Integrated light,***  
***no direct distance***  
***Photo-z (Merian, UVEX)***  
***Statistical distributions***  
***(clustering, SOMs)***

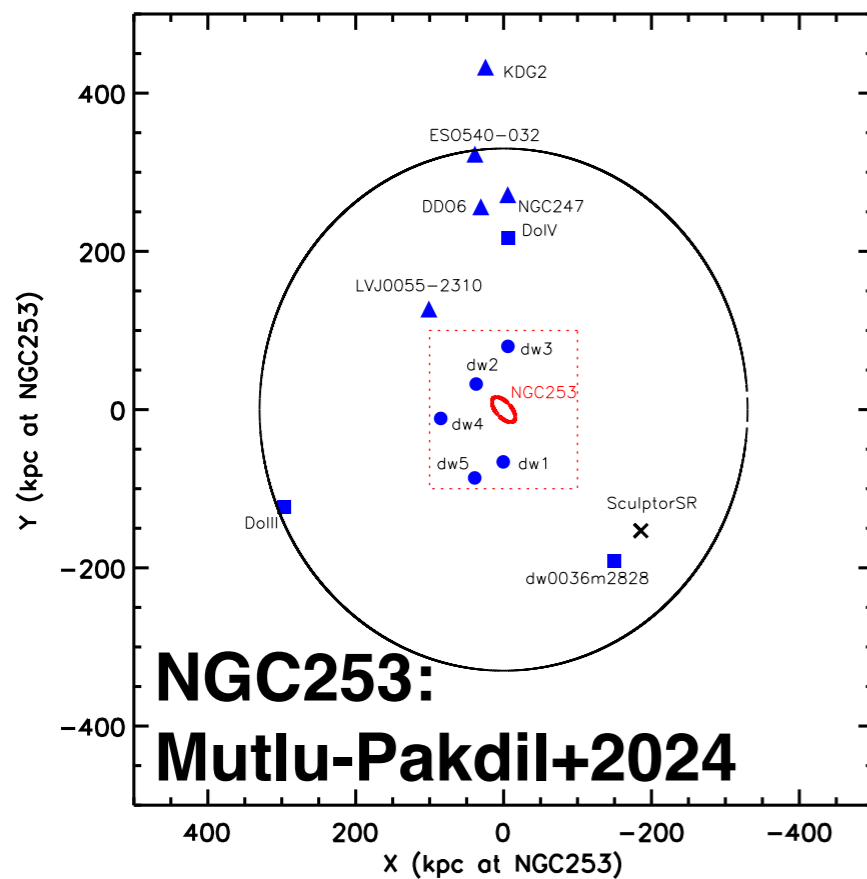
***z>0.5: Redshift surveys,***  
***Particularly with JWST***  
***Adding new insight***



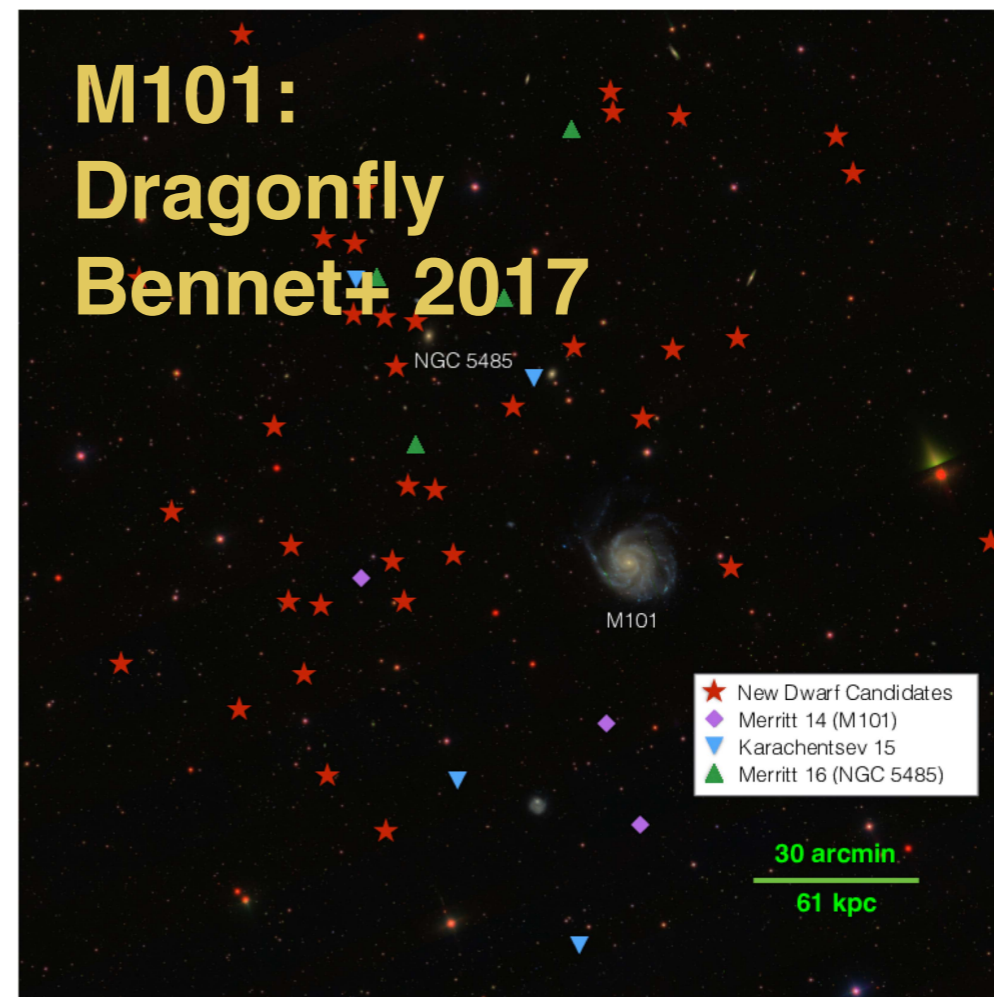
**M81 – Chiboucas+2013**



**PISCeS – Centaurus A  
Crnojevic, Sand+ 2018**



**NGC253:  
Mutlu-Pakdil+2024**

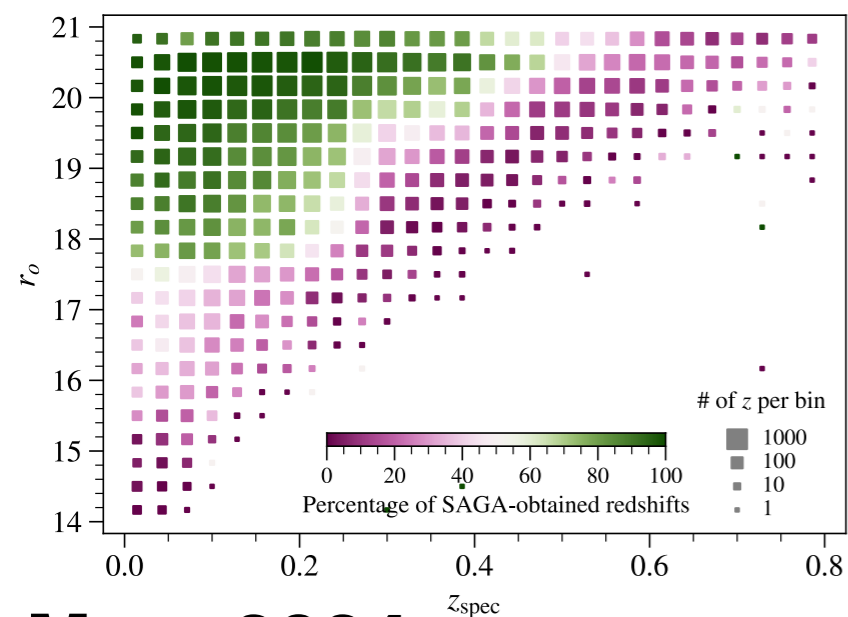
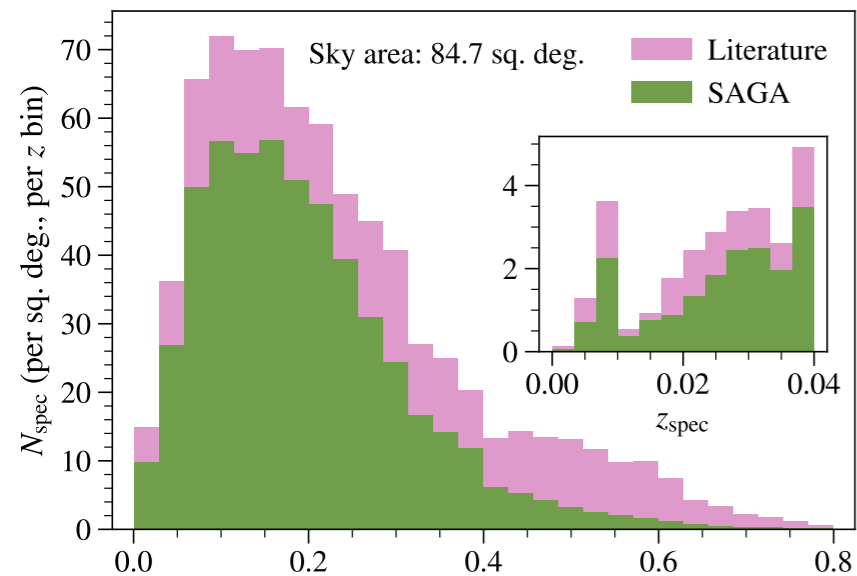




# How to identify them?

## SAGA

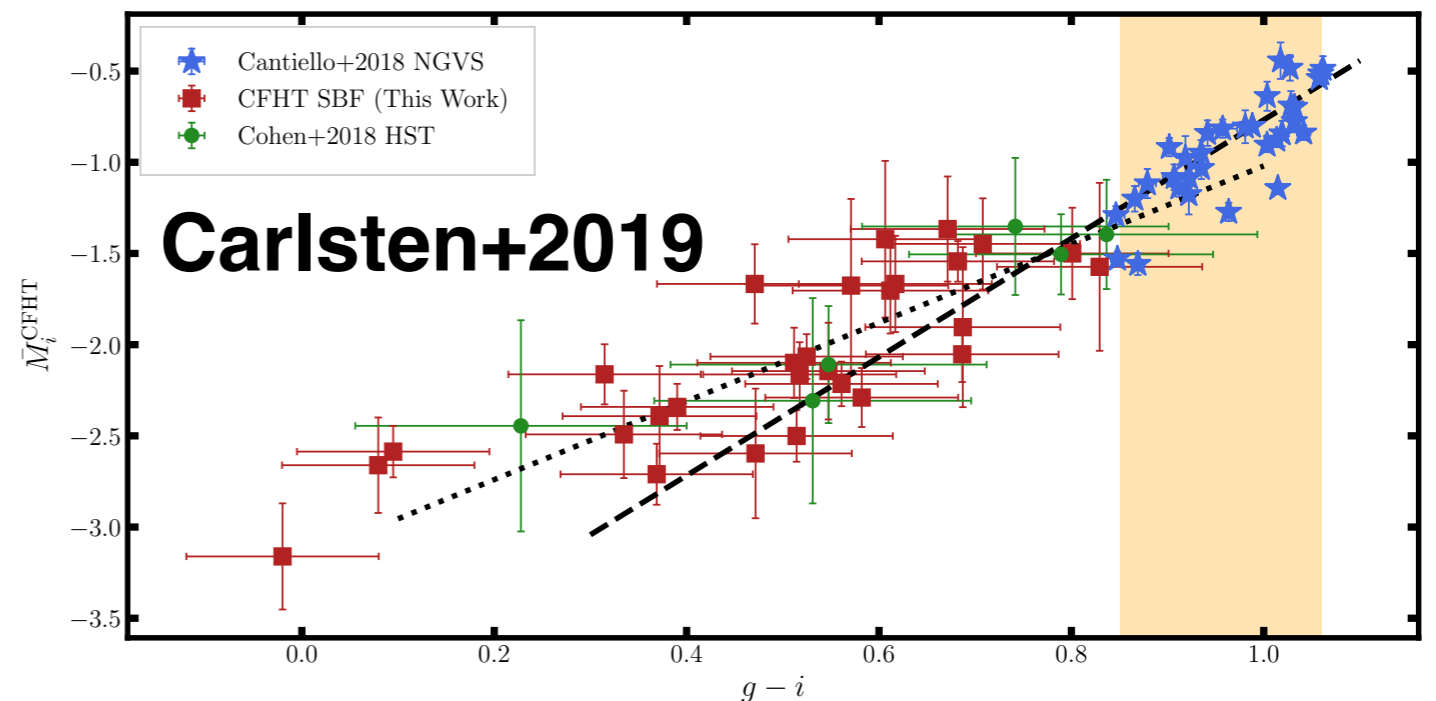
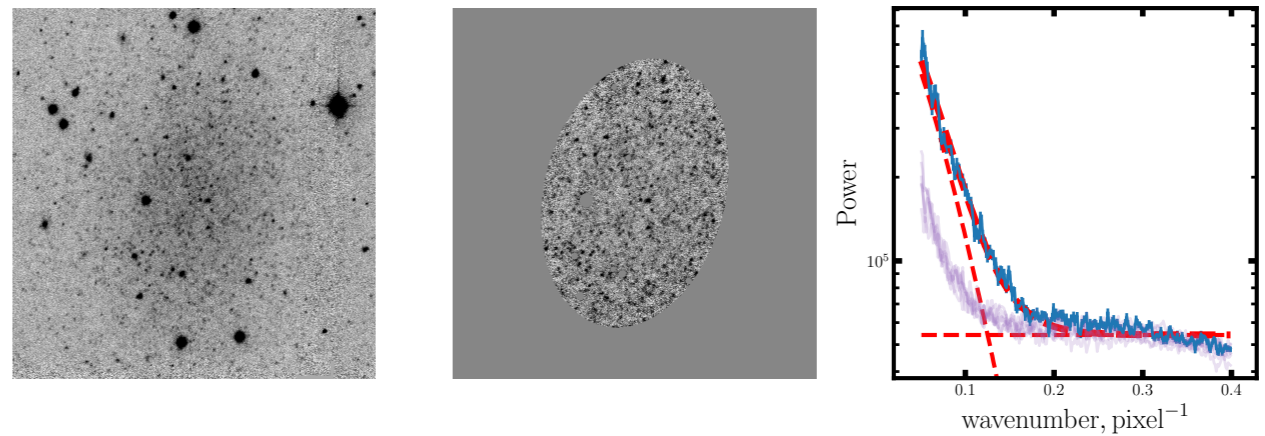
Radial velocities  $\rightarrow$   
membership



Mao+2024

## ELVES

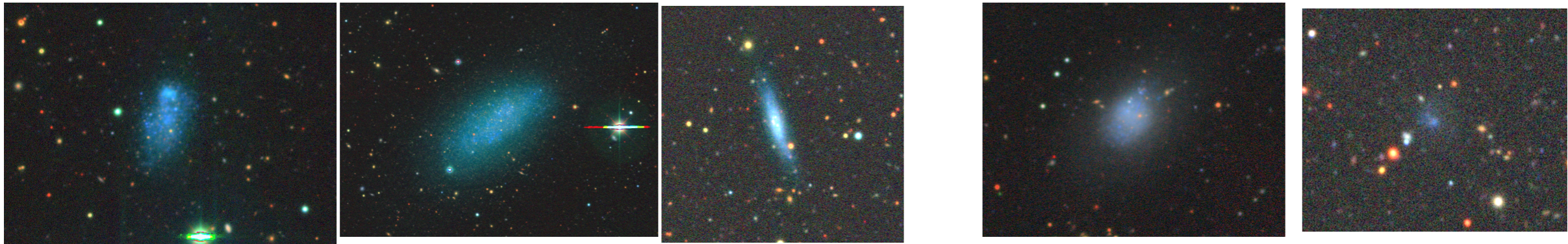
Surface brightness  
fluctuations  $\rightarrow$   
membership





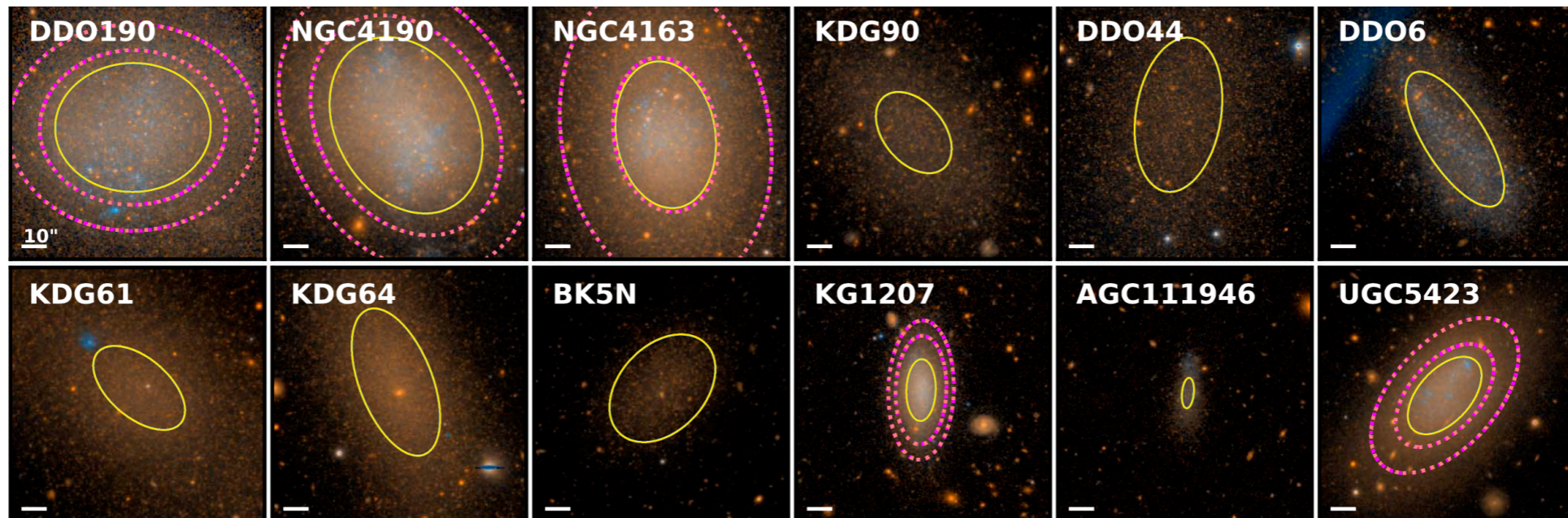
# Surface brightness fluctuations and star formation

**Challenges: Sersic can fail, PSF-scale power from HII regions, and calibration may be incomplete**



UGC 004483, DDO 125, LV1218+4655  
part of Carlsten+2019 calibration sample

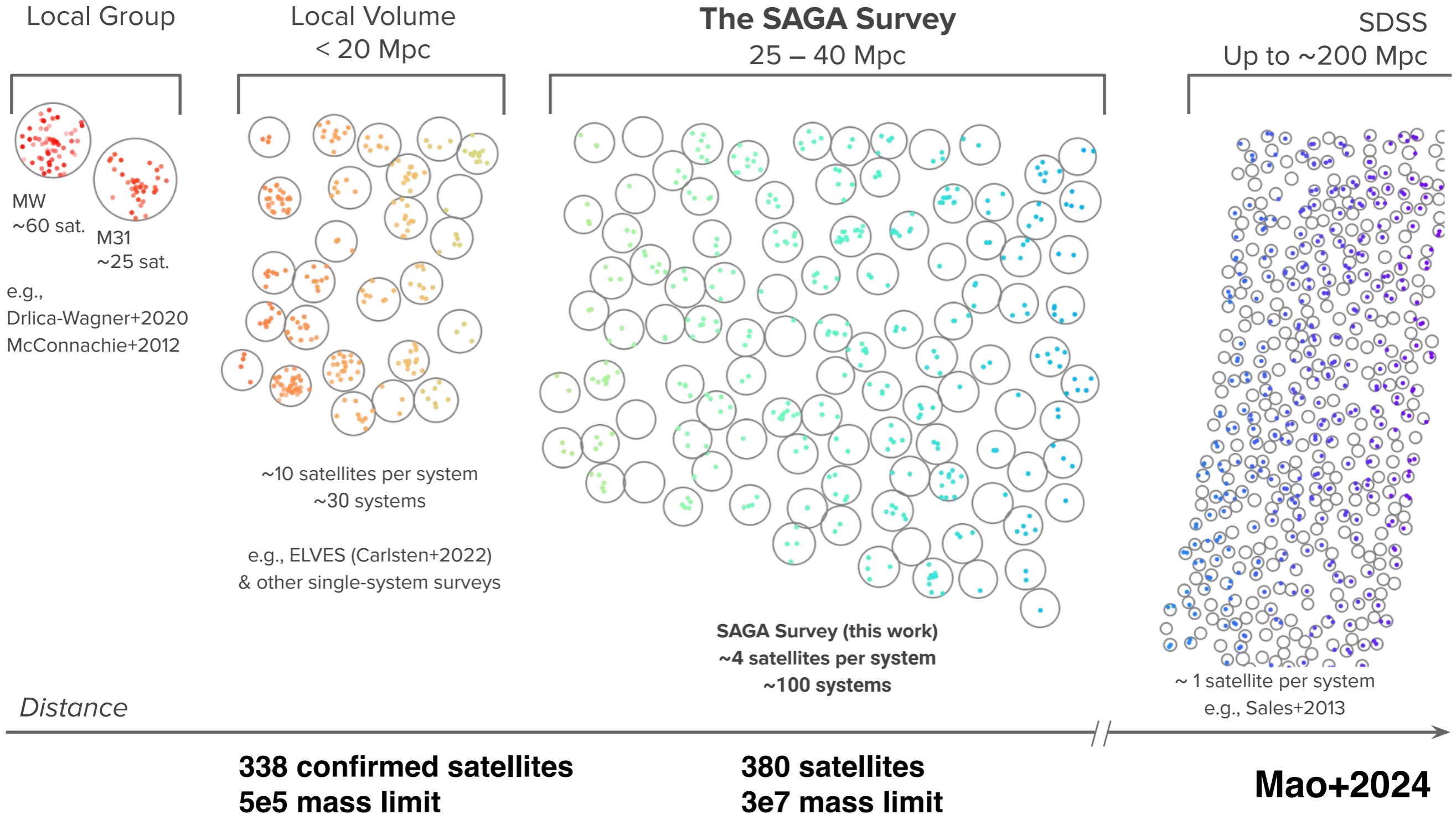
dw1231p0140 confirmed TRGB, dw1239p3230 HI



**Kim & Lee 2021 — SBF calibration sample with TRGB, overtly including star-forming things**

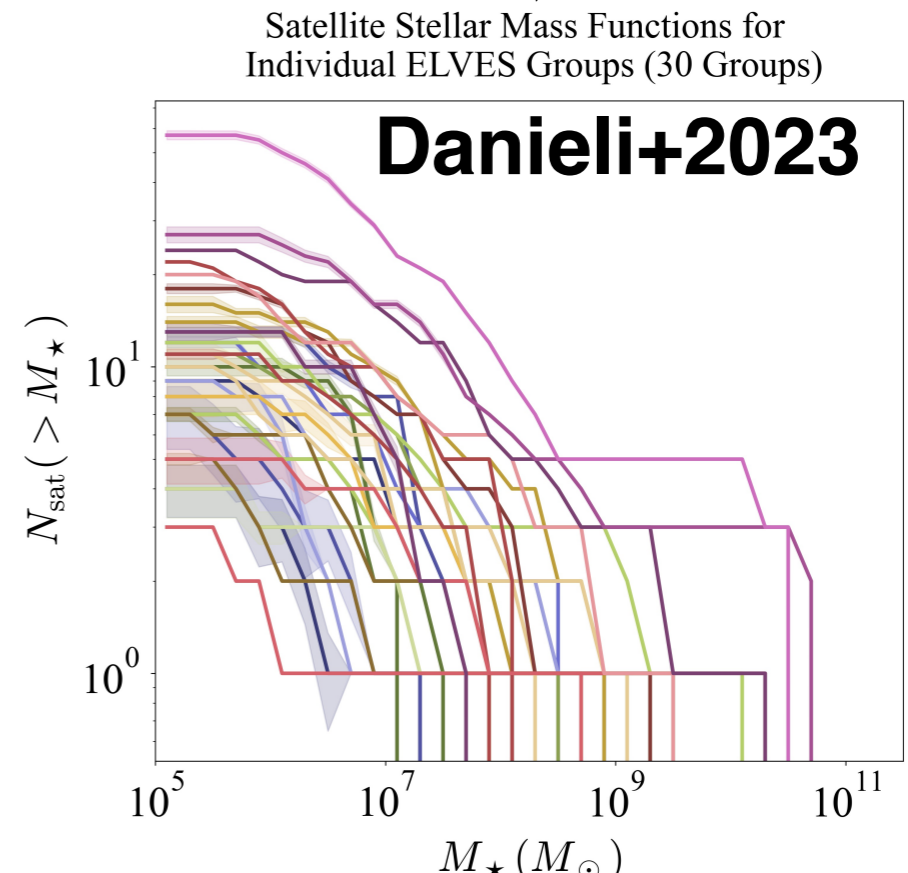
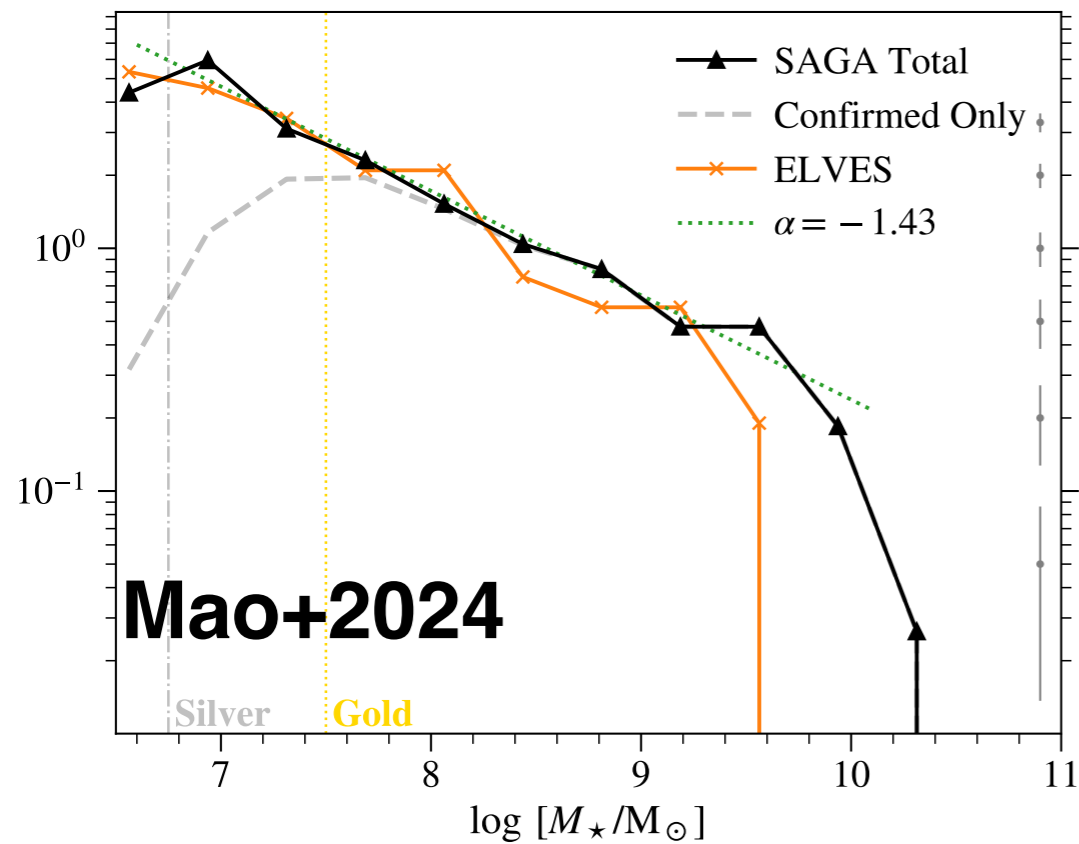
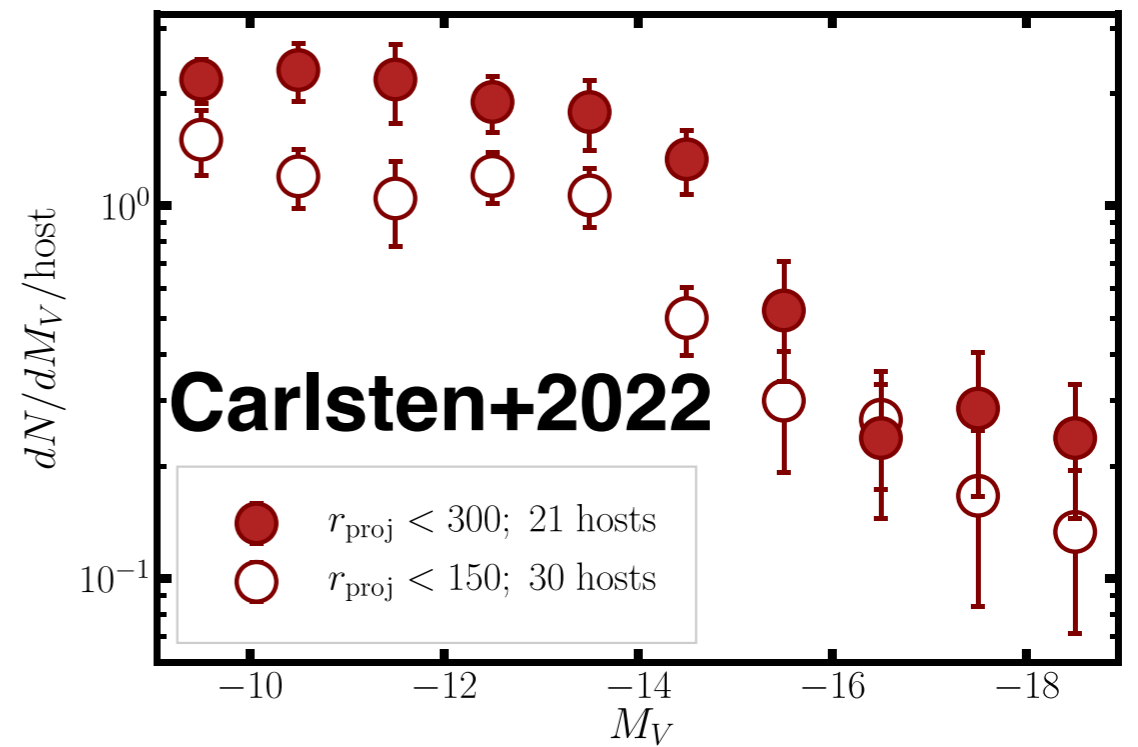
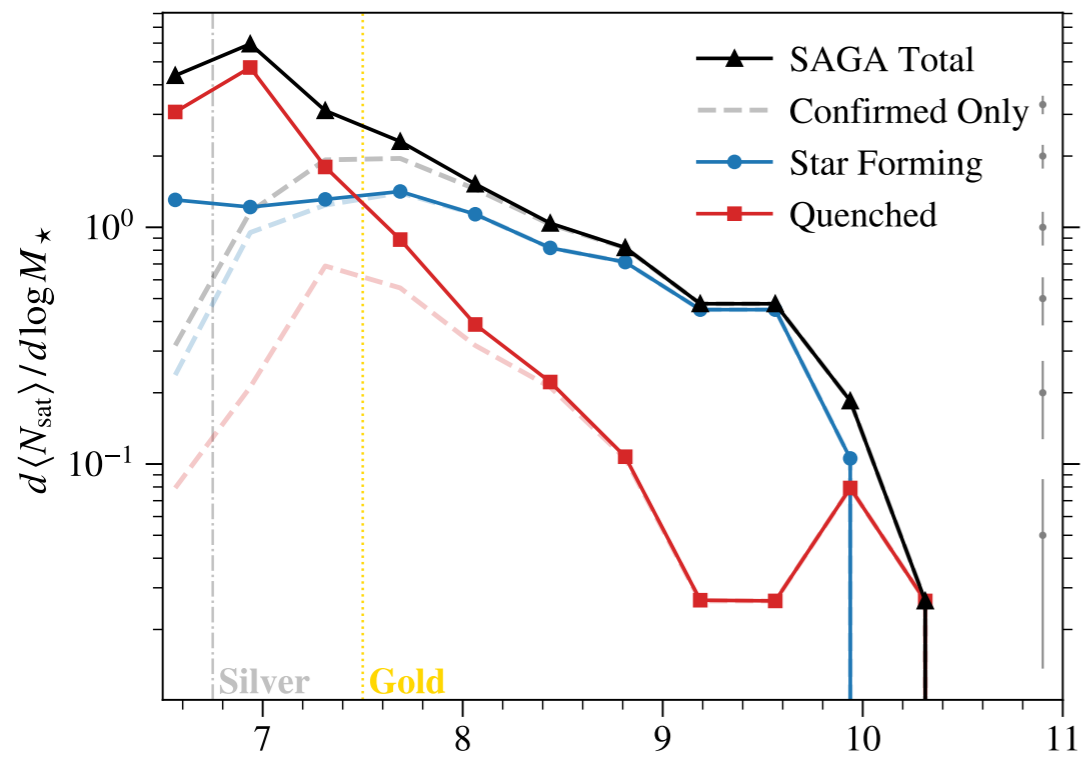


# Satellites around Milky Way analogs

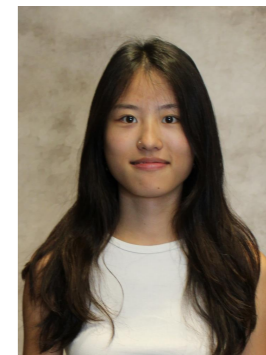
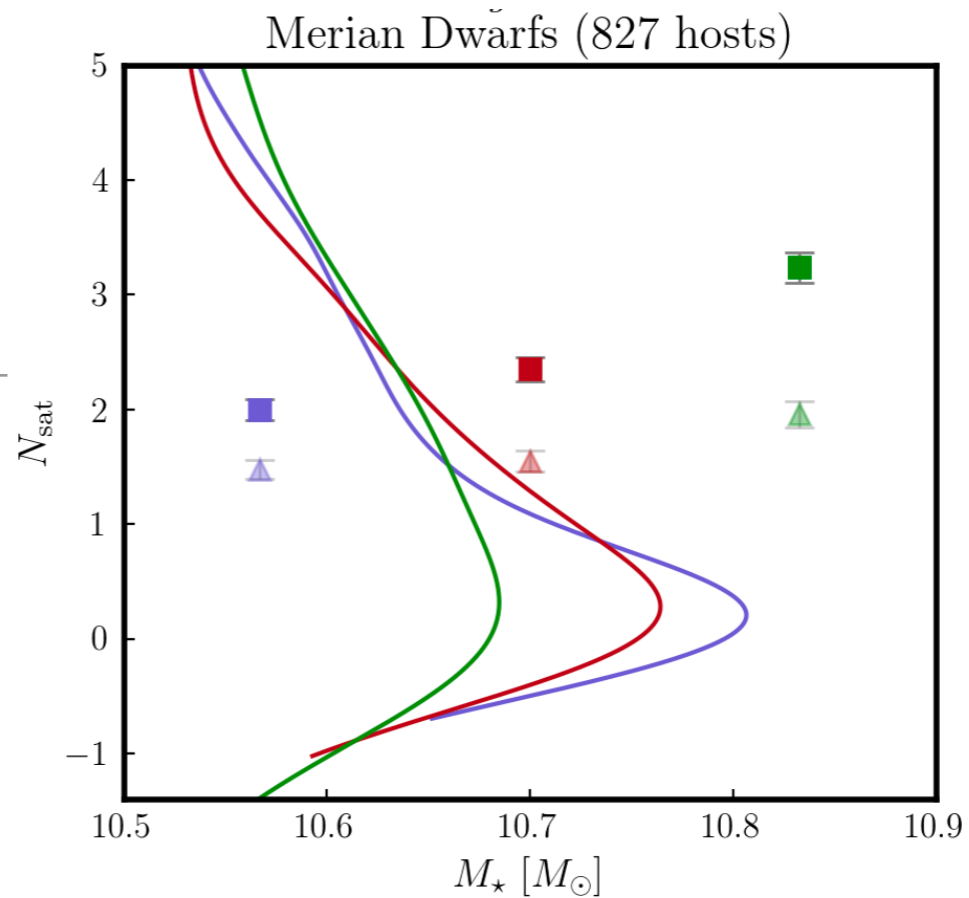
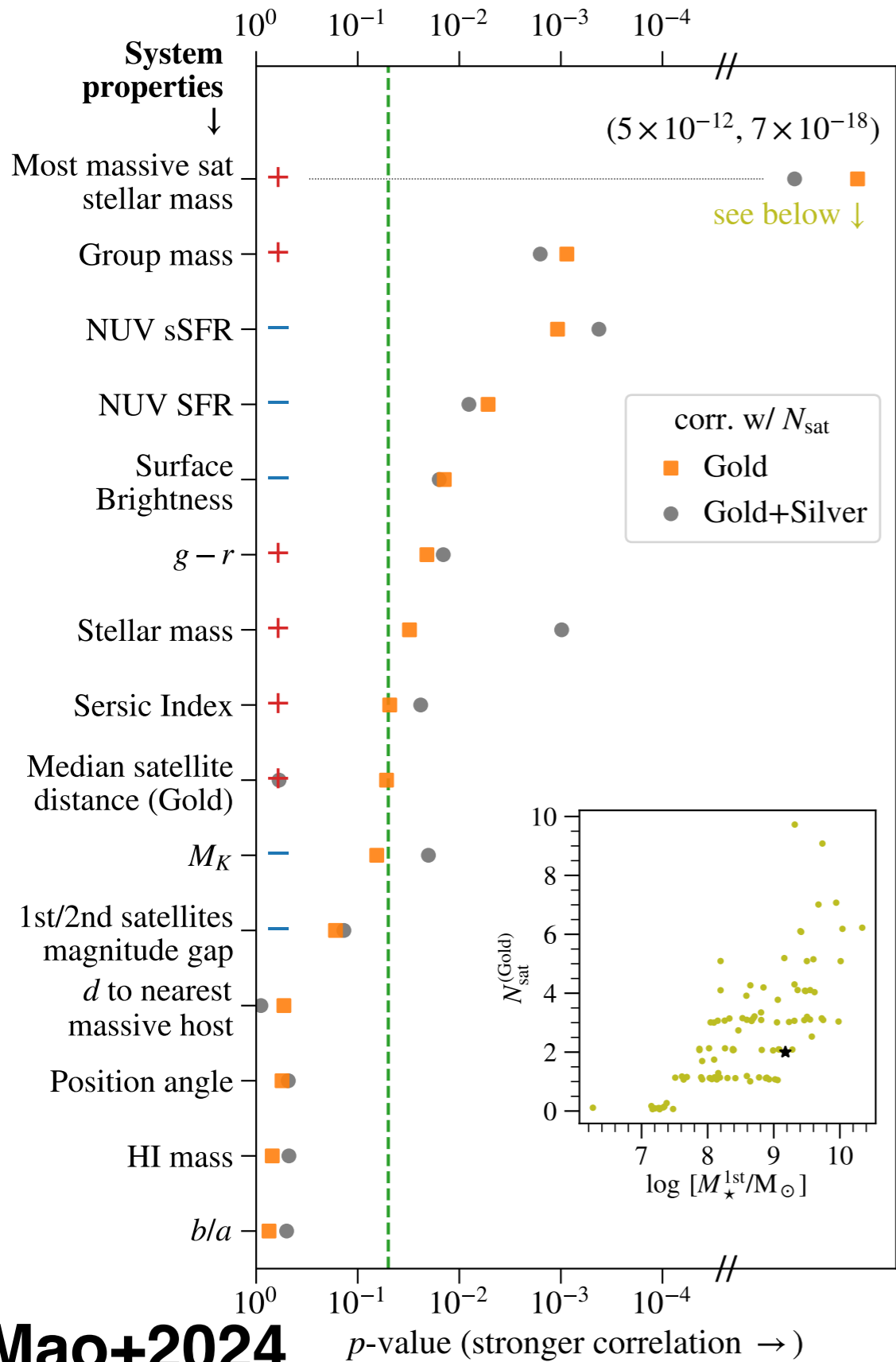




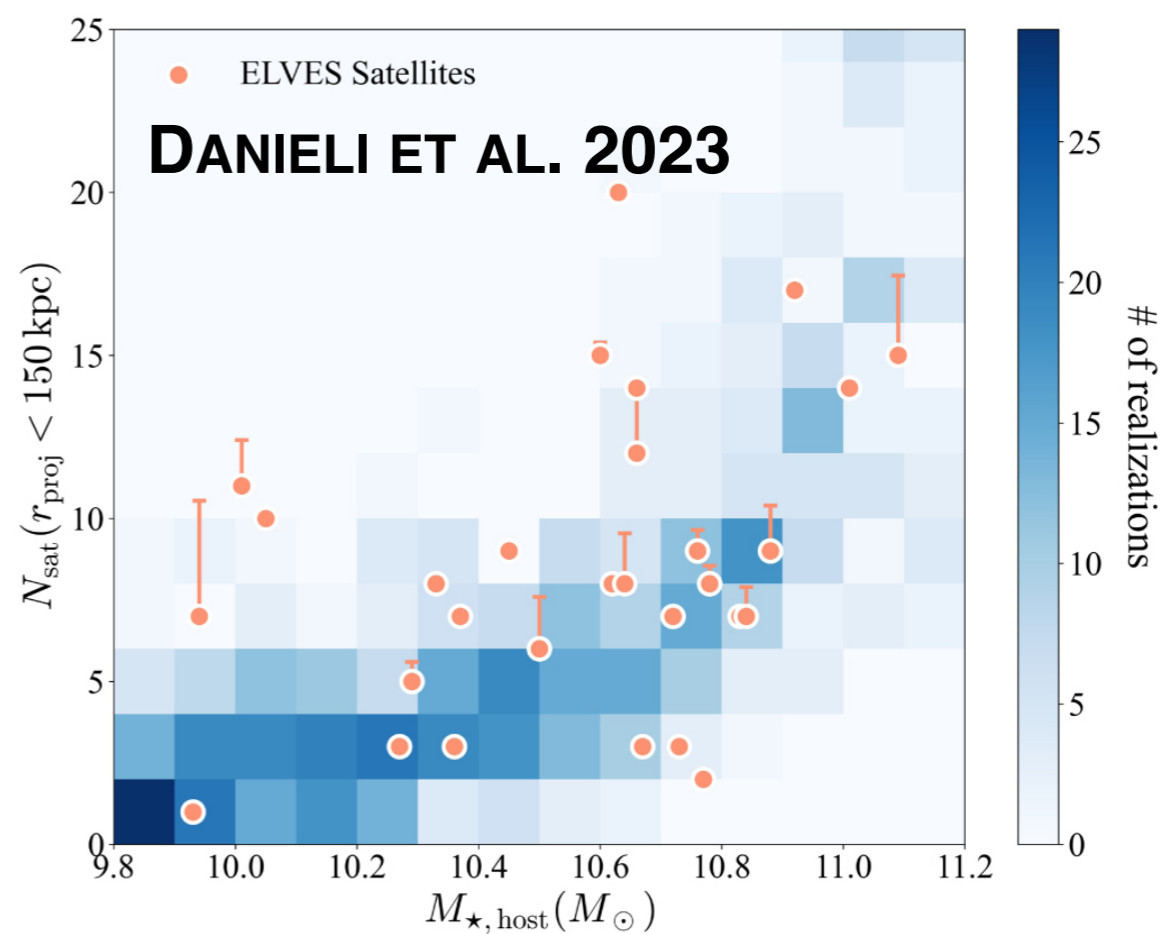
# Some results: Luminosity Functions



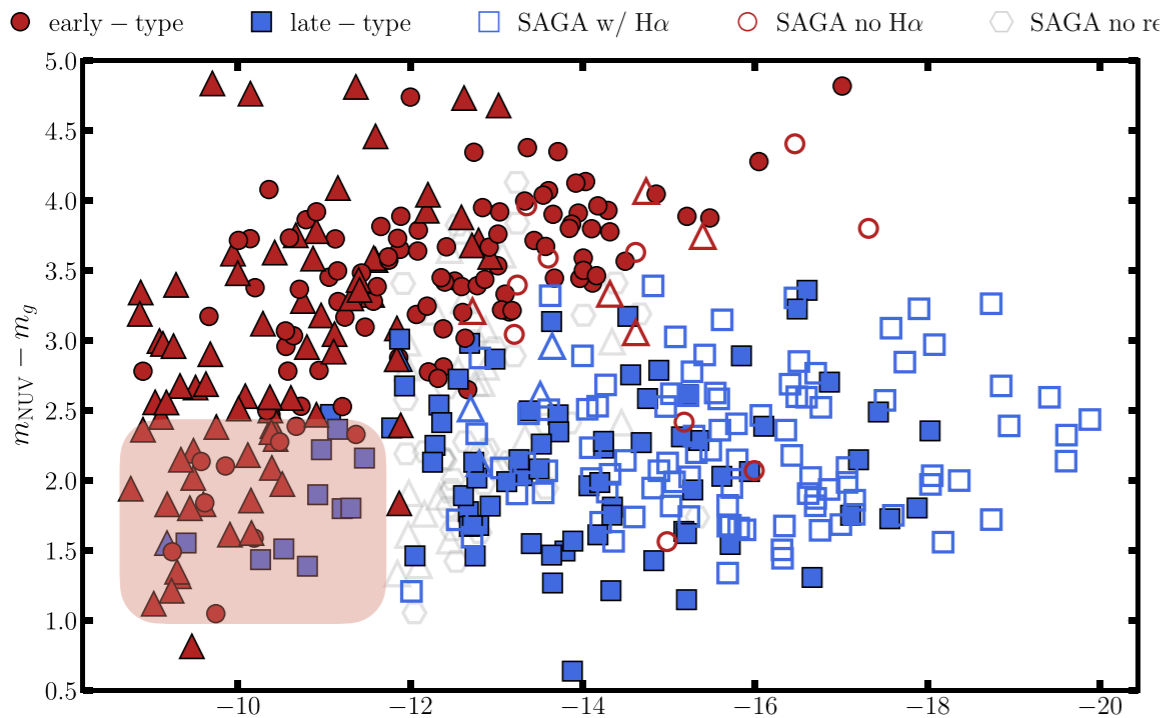
# Satellite richness



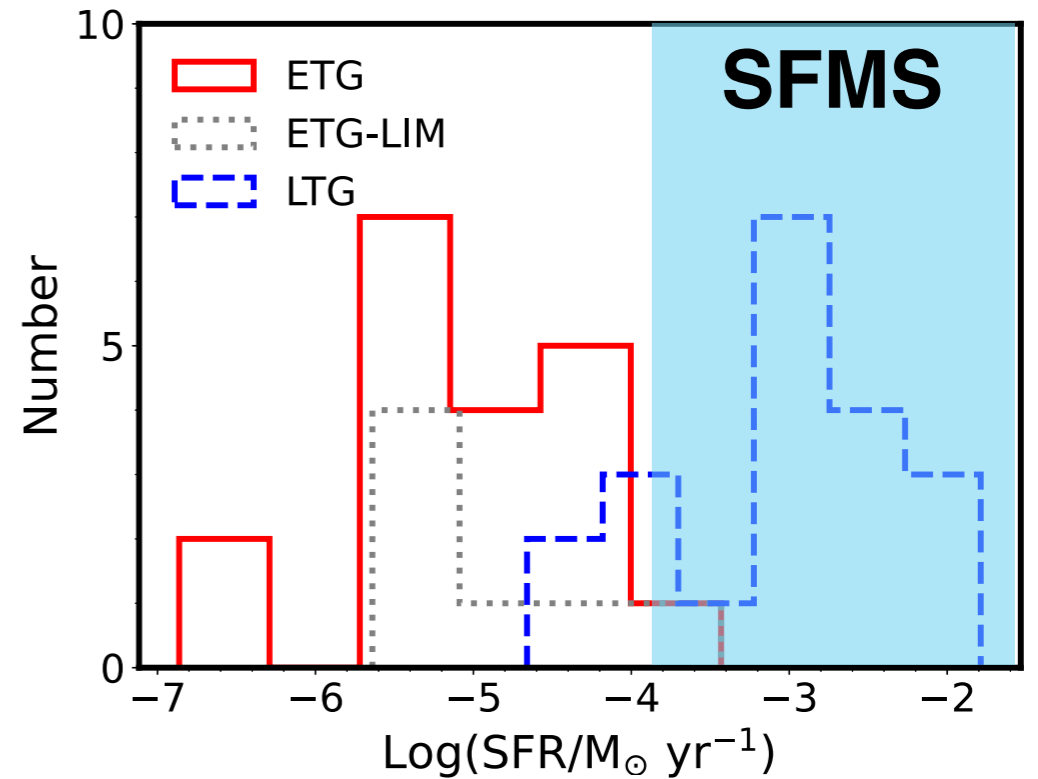
**PAN ET MERIAN**  
**(POSTER)**



# Carlsten+2022

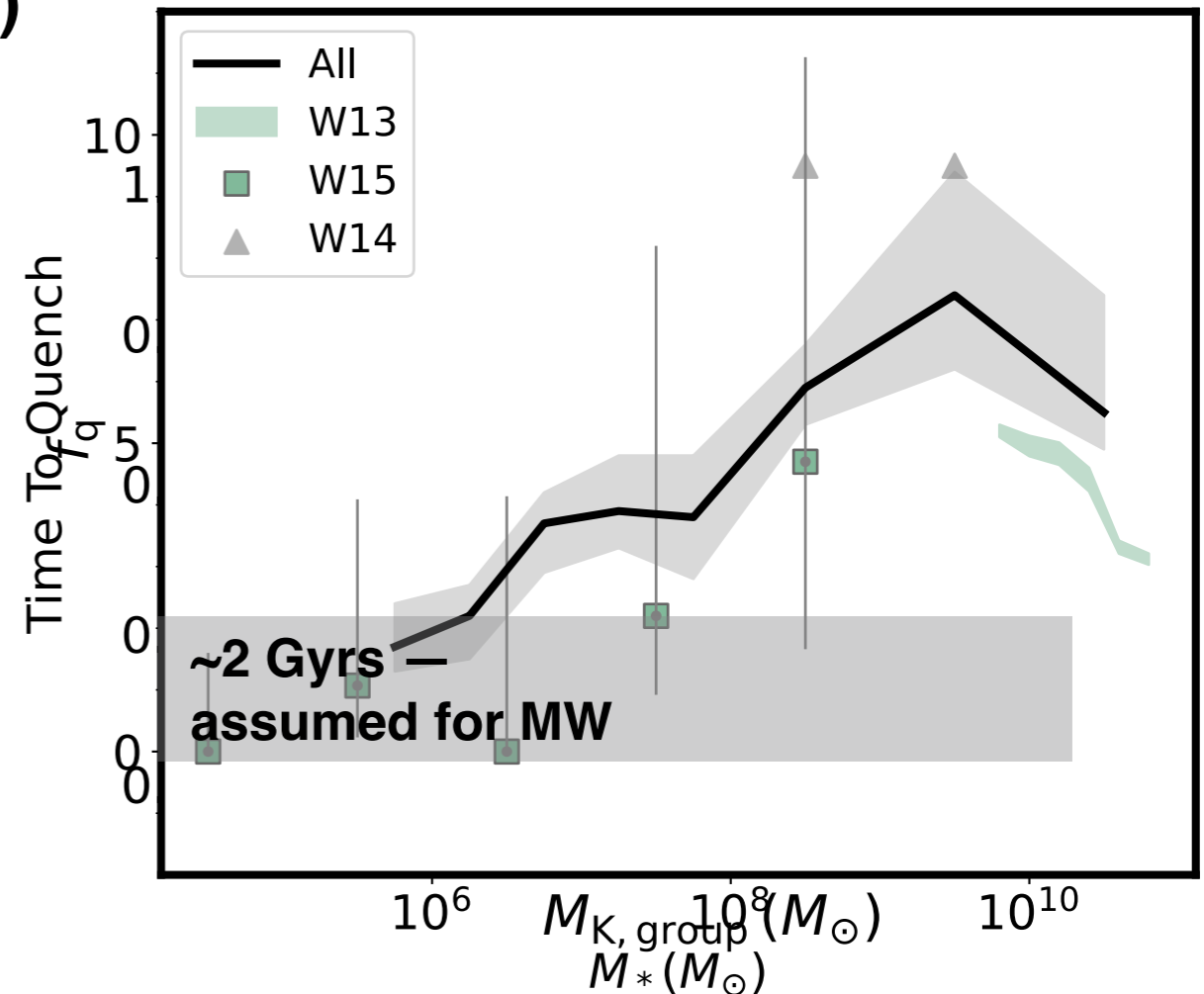
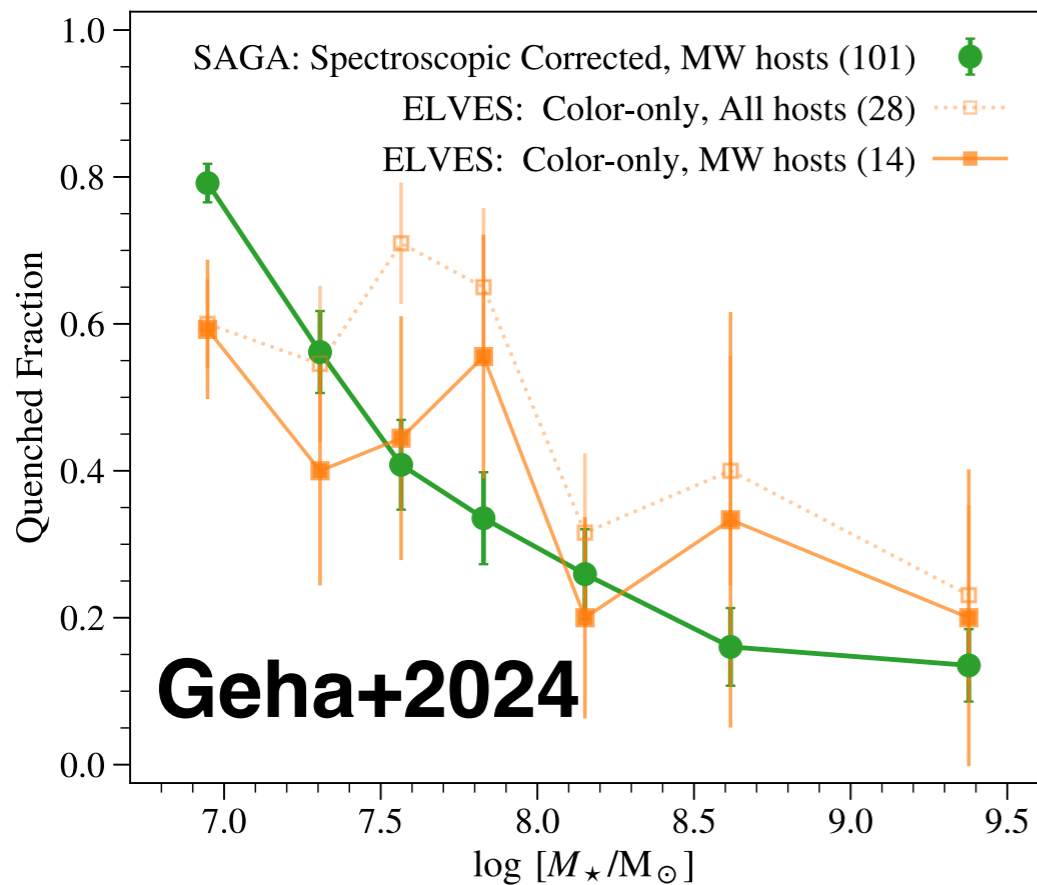


# Greene+ELVES2022



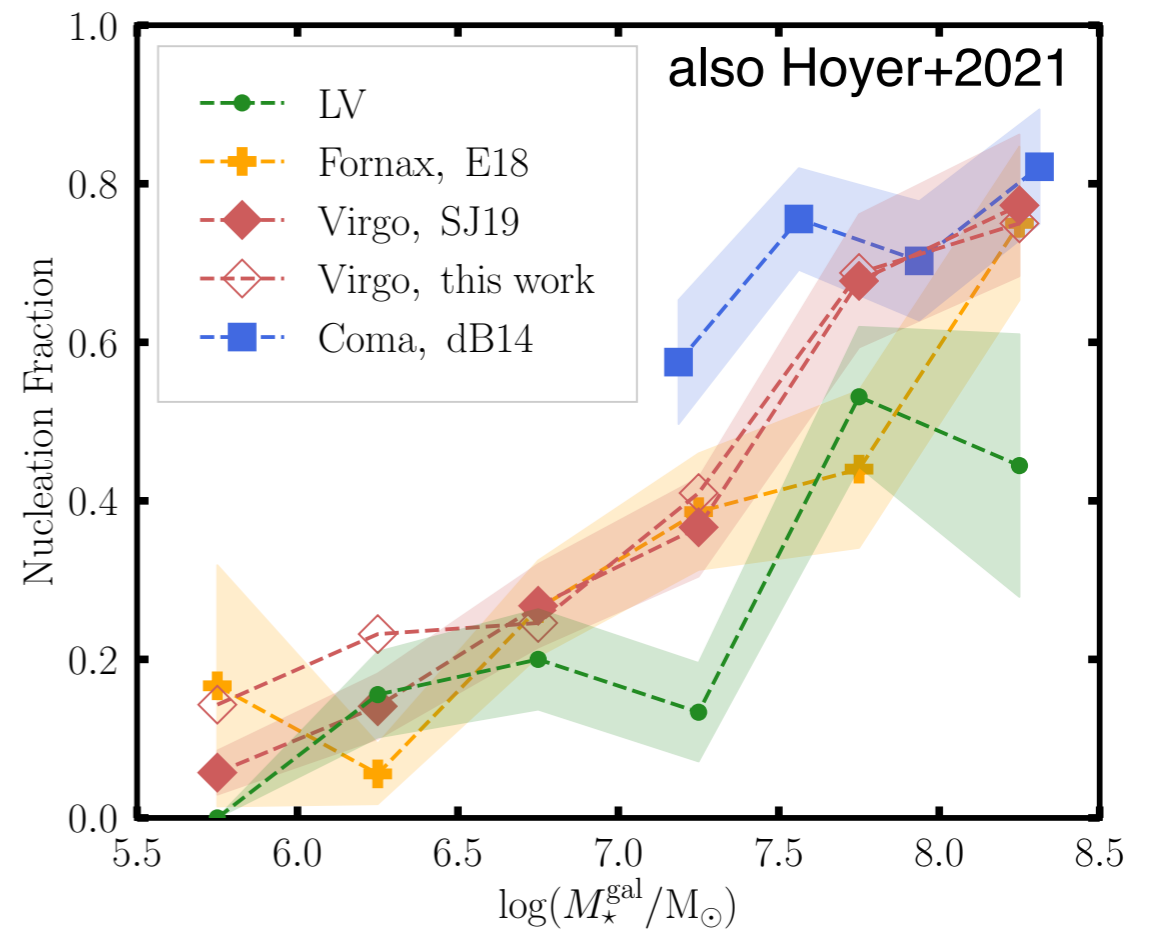
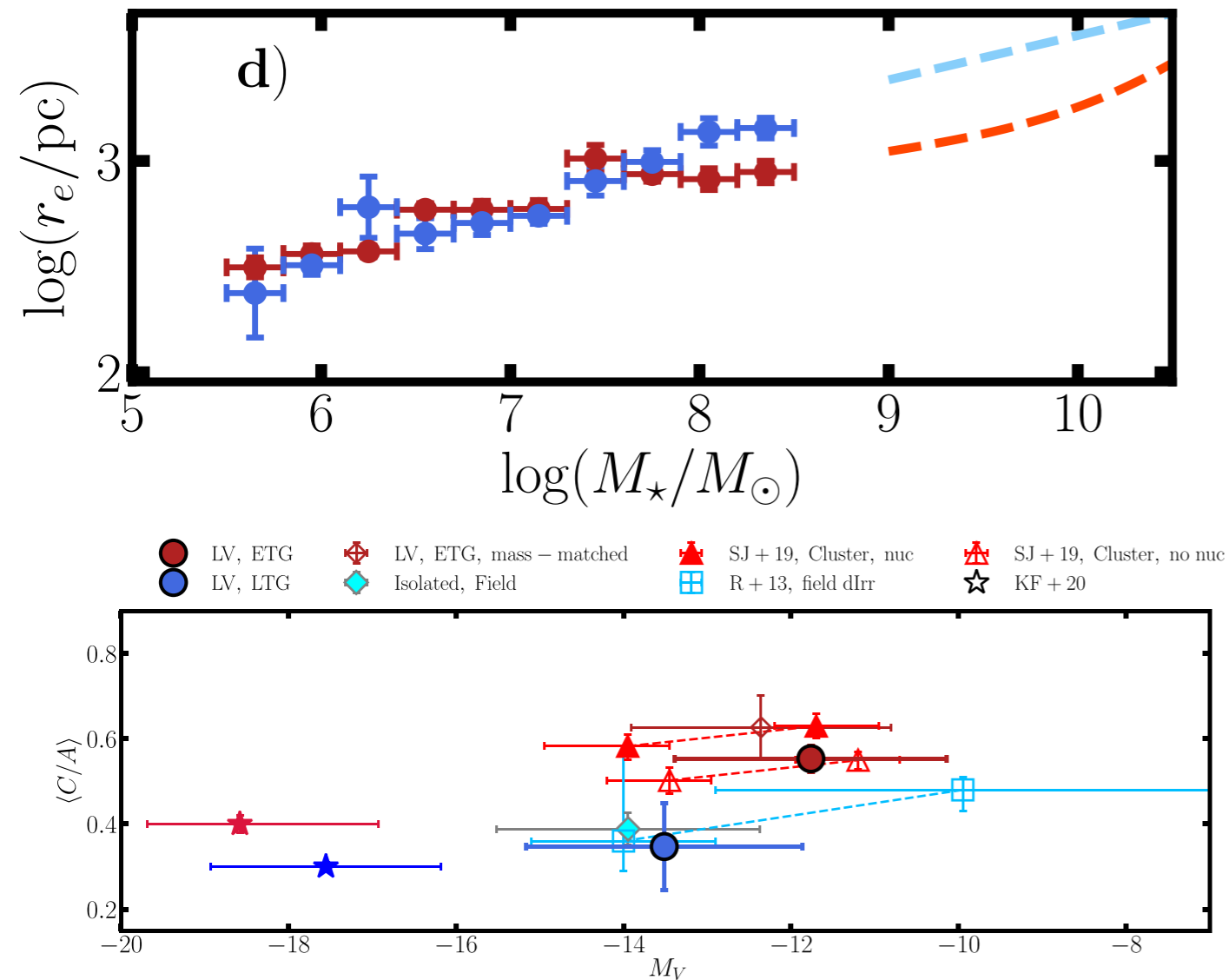
UV detection = SF? Or low Z/H?

Morphology does ok (vs color and vs SAGA)





# And the rest of Scott's thesis (Carlsten 2021ab)



GC/mass and nucleation fraction are higher in higher-density environments

Red and blue satellites obey the same mass-size relation. Quenching does not substantively impact size, may puff galaxies up a bit, or that may be an inner halo (Kado-Fong)

What is next?

*LSST resolved star searches, Roman, UVEX*

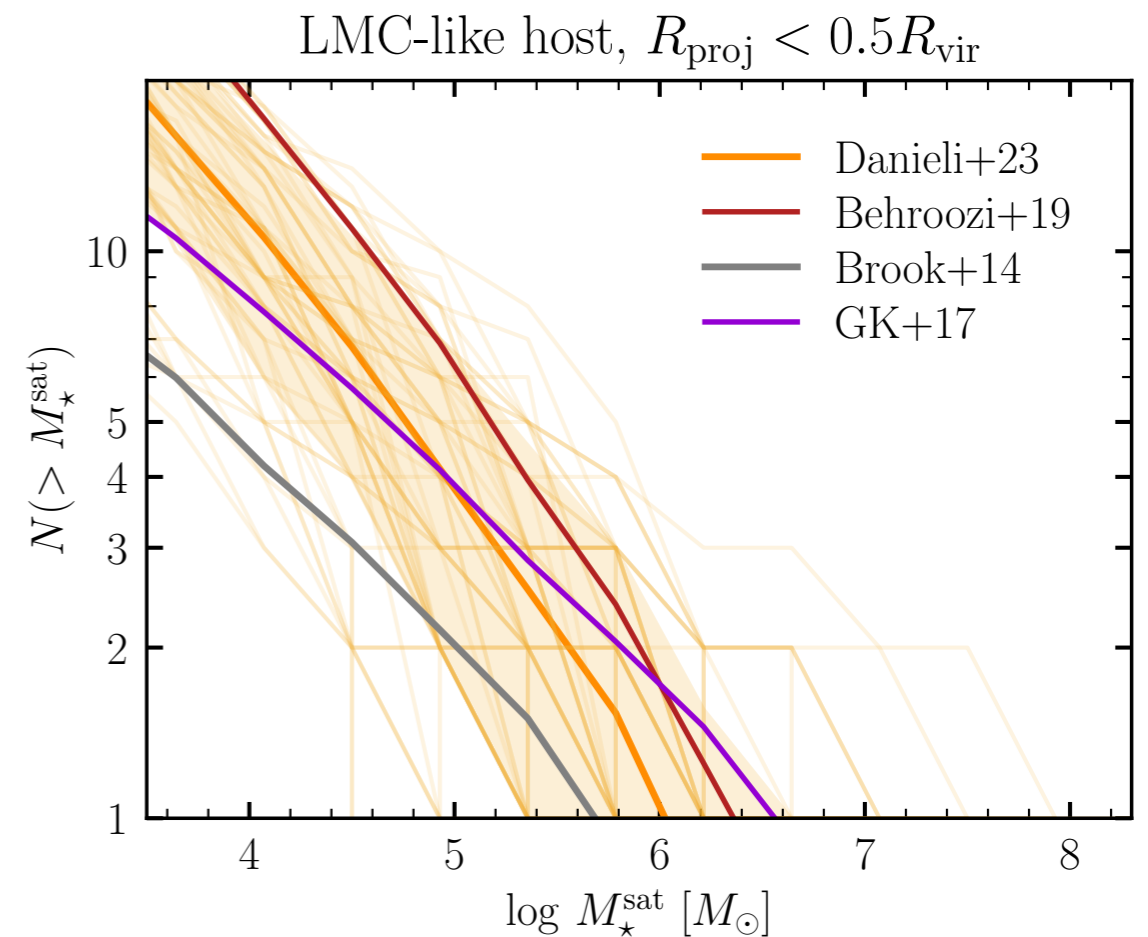
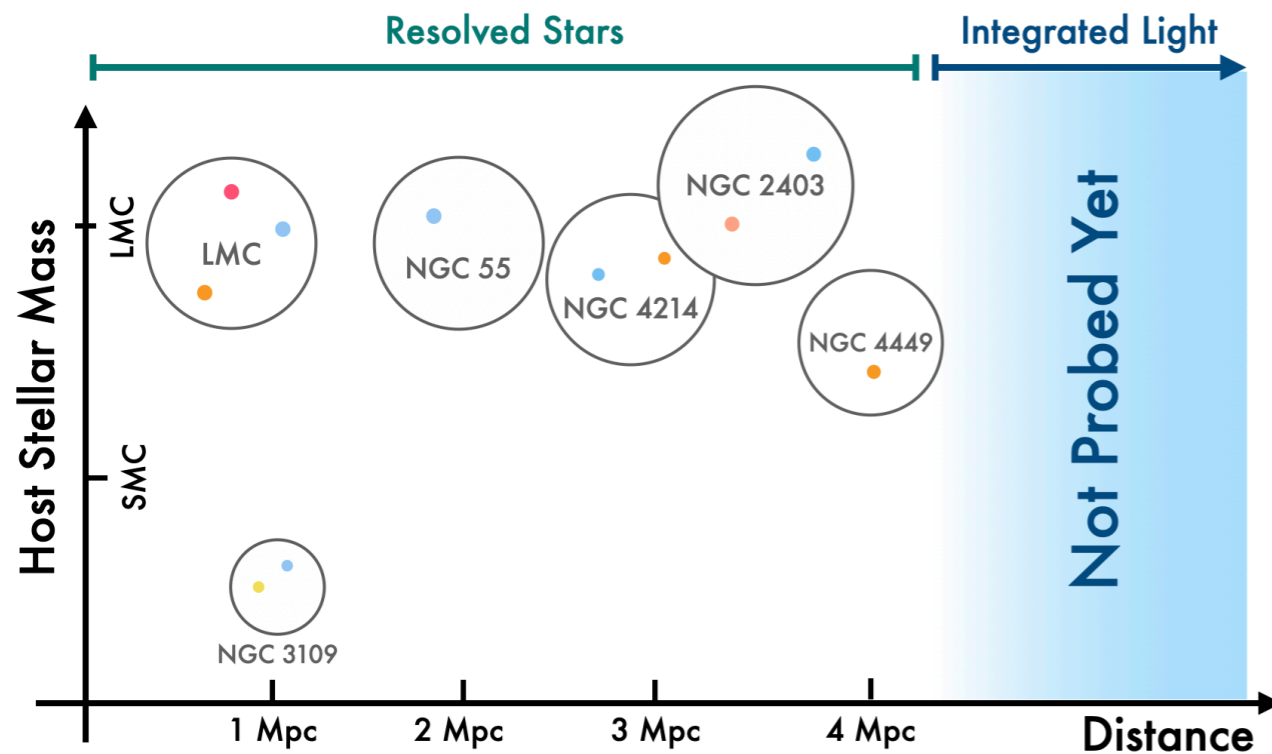
Nadler et al. (2023)

# ELVES-Dwarf

## SBF to find dwarf galaxies satellites



Jiaxuan Li thesis  
Hunter poster  
Carlin talk



**MADCASH:** Carlin+2017, 2019, 2021

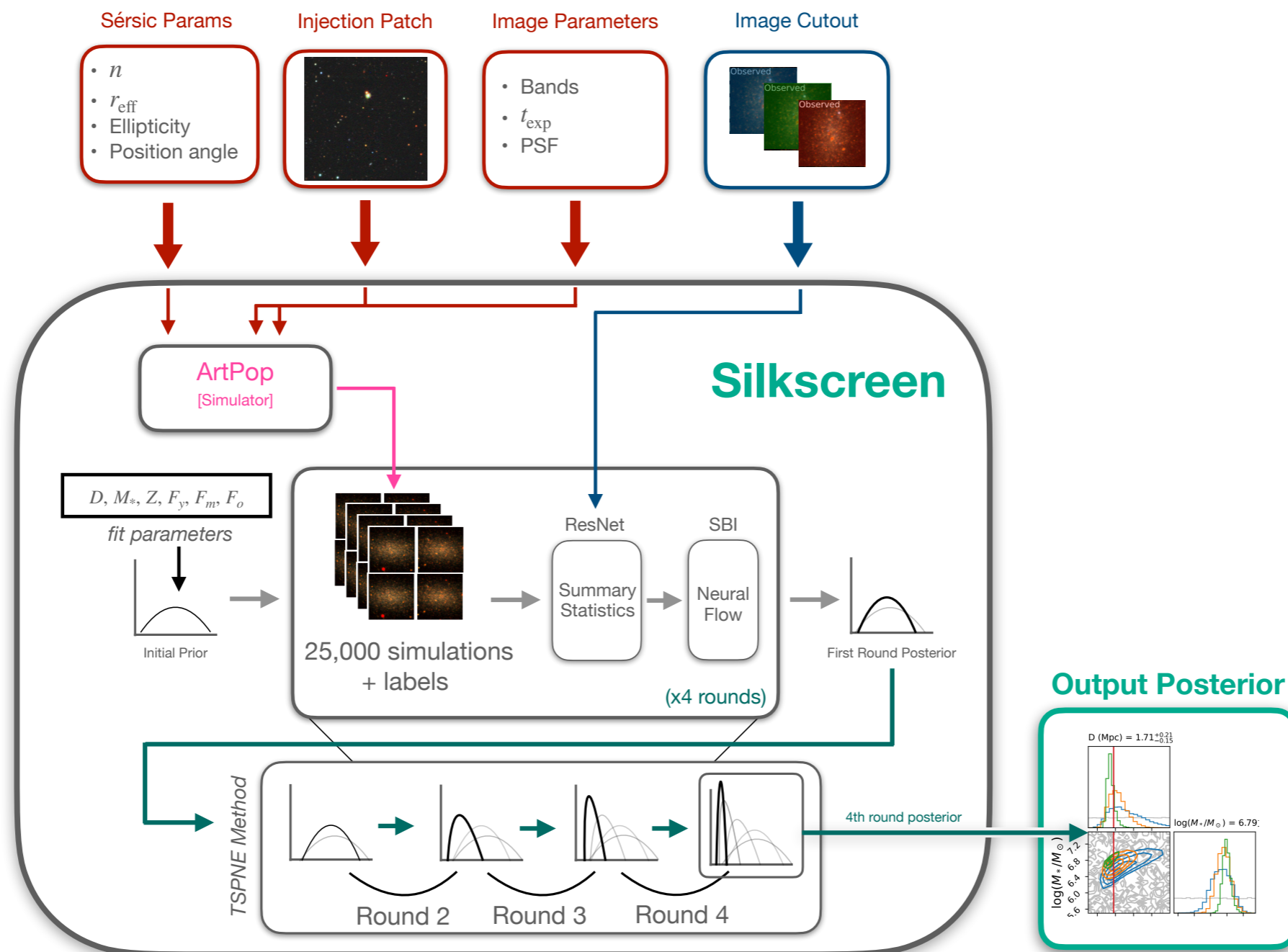
**LBT-SONG:** Davis+2020, Garling+2021 14

**DELVE:** McNanna et al. (2023)

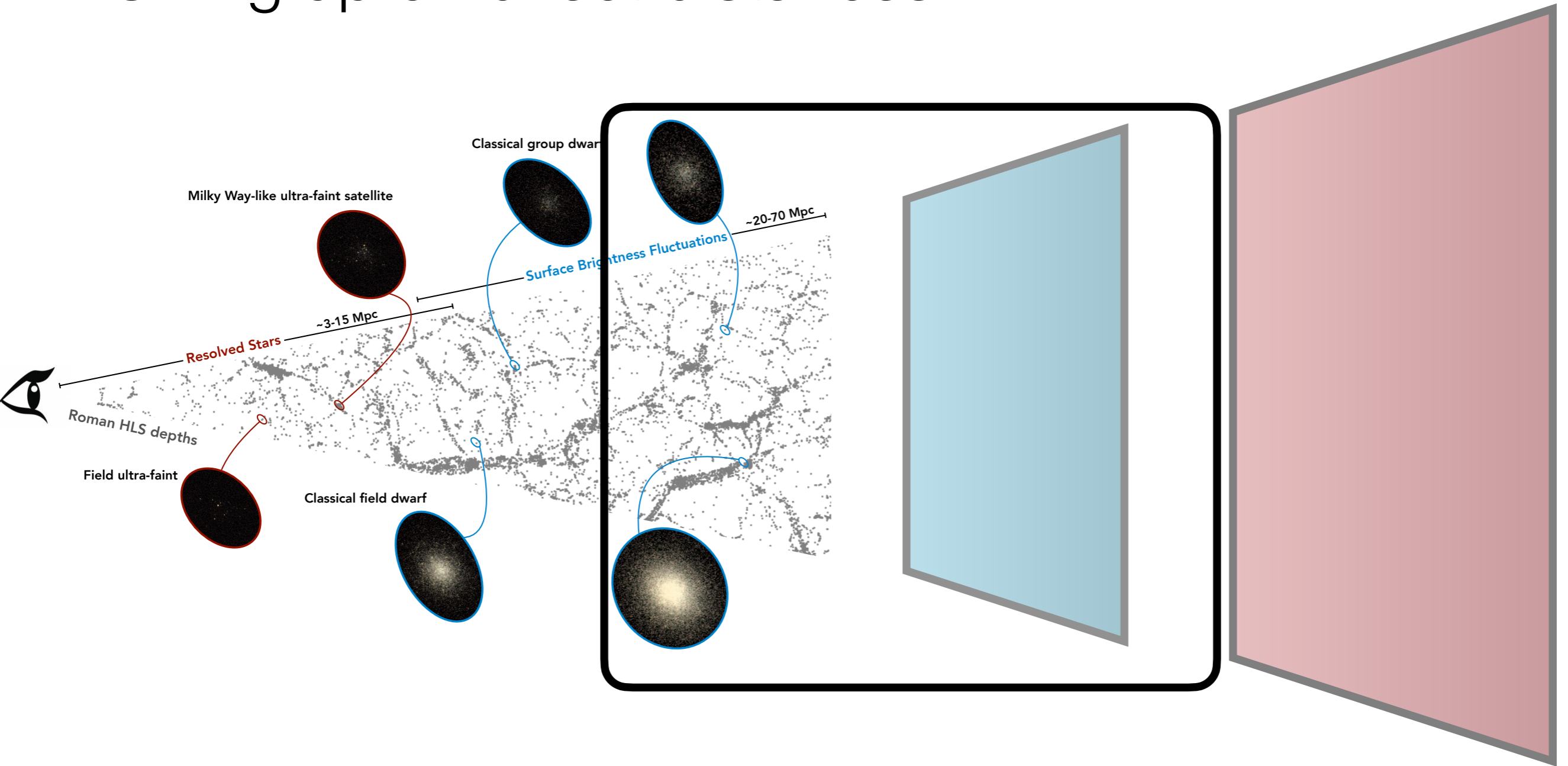
**Using ELVES approach, explore to  $R_{vir}$  for 30-50 Local Volume dwarfs (10 in hand, Li+in prep)**



# The Dream: SBF everything, get the field



# Beyond the Local Volume: Giving up on direct distances...

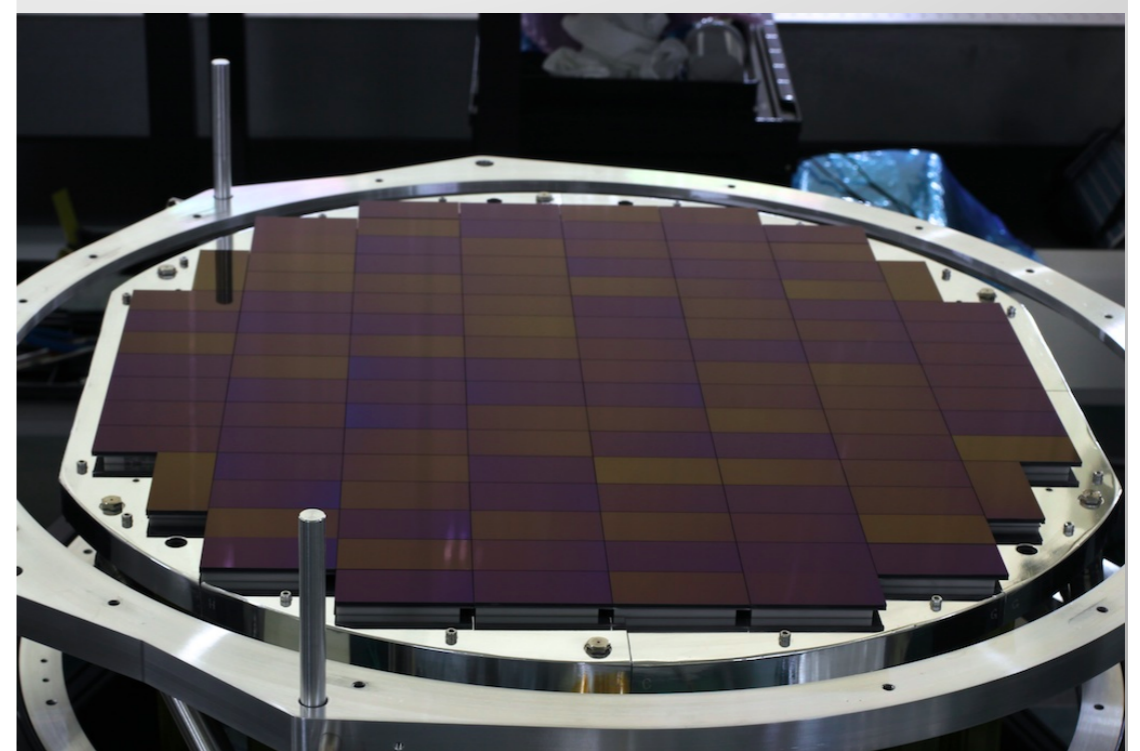
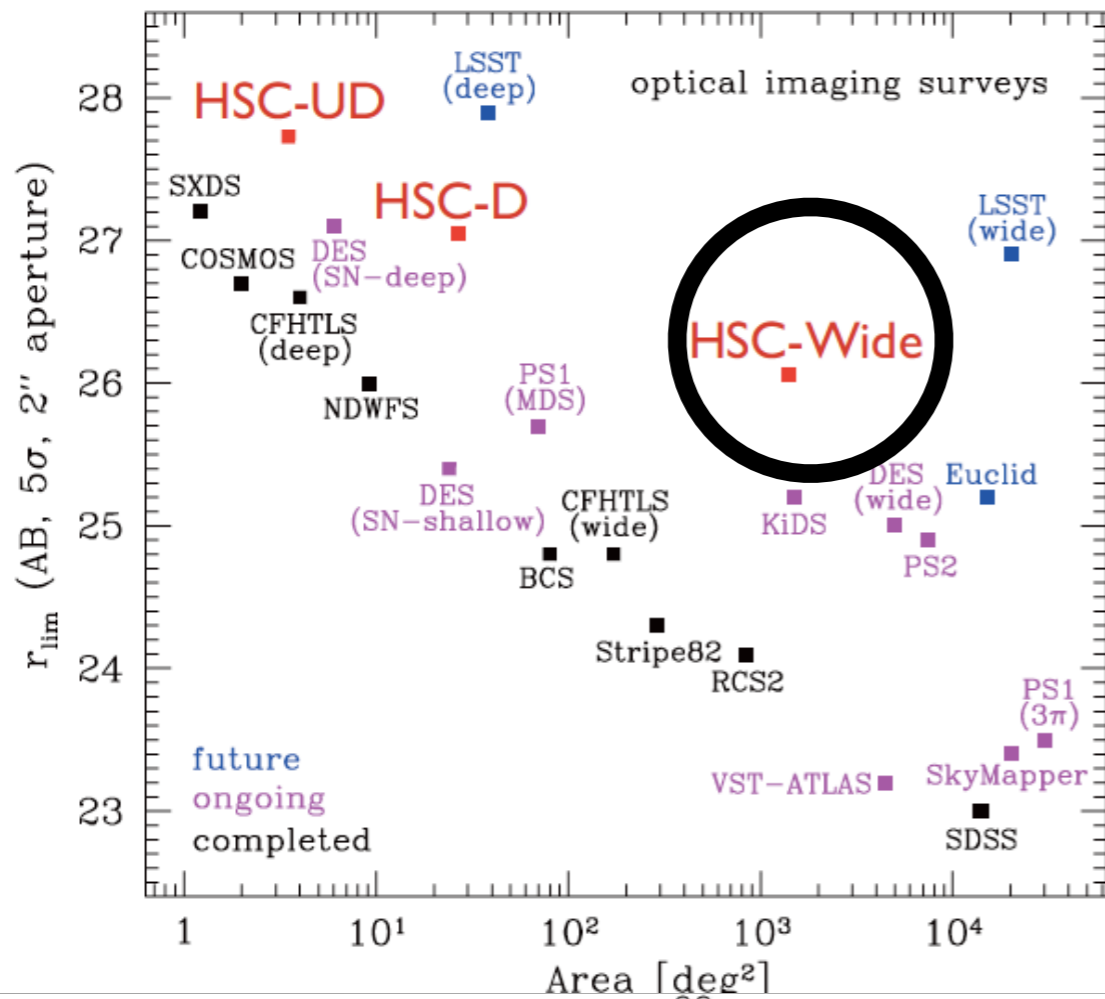


*Local Volume with direct distances*  
*TRGB, TF, SNe*  
*Surface brightness fluctuations*  
*—> Extend to ~70 Mpc with Roman?*

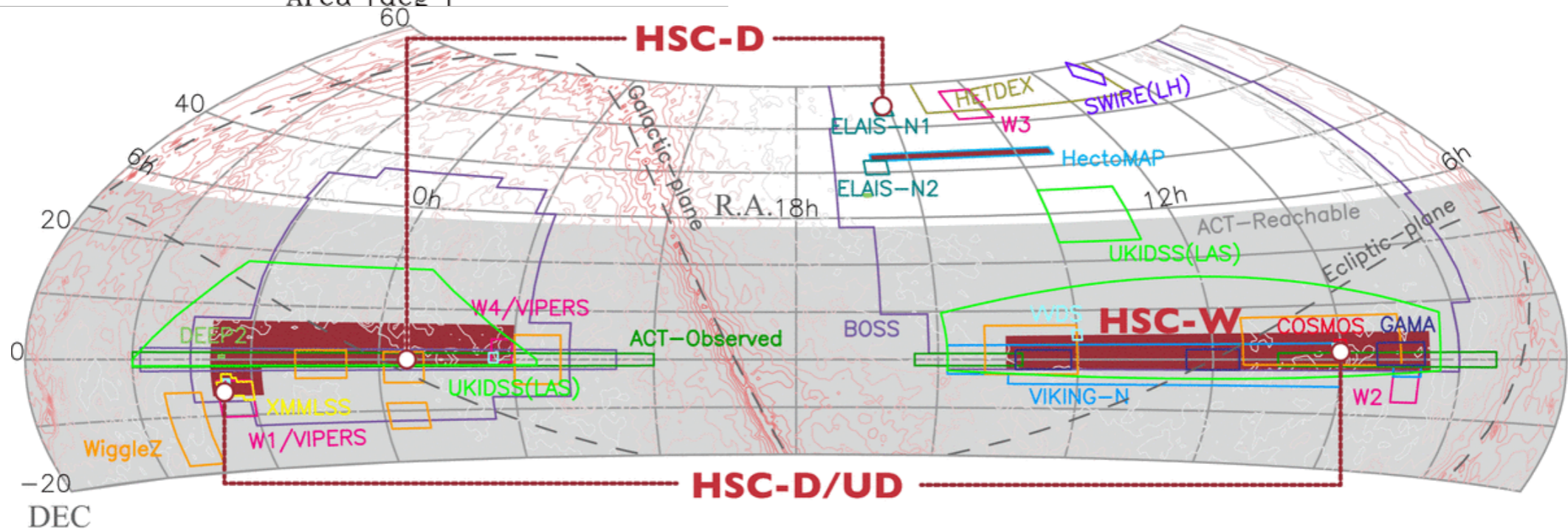
***Z~0.05-0.3***  
***Integrated light,***  
***no direct distance***  
***Photo-z (Merian, UVEX)***  
***Statistical distributions***  
***(clustering, SOMs)***

***z>0.5: Redshift surveys,***  
***Particularly with JWST***  
***Adding new insight***

# The HSC Survey = LSST Precursor



1.8 sq deg FOV

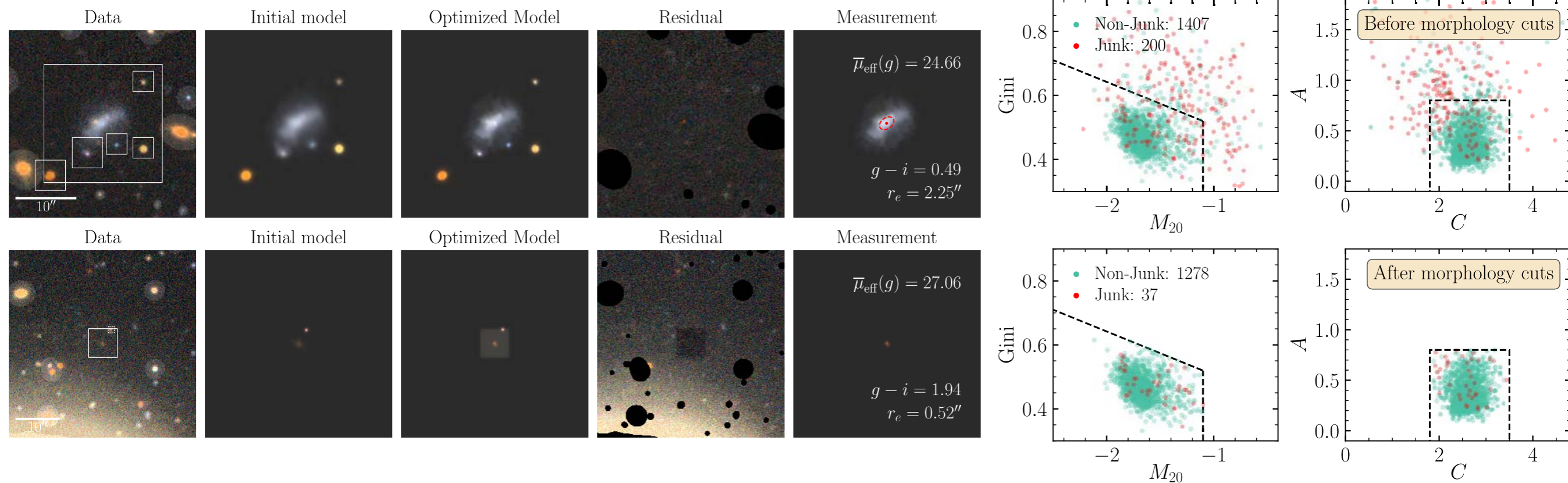


5 years, 300 Nights



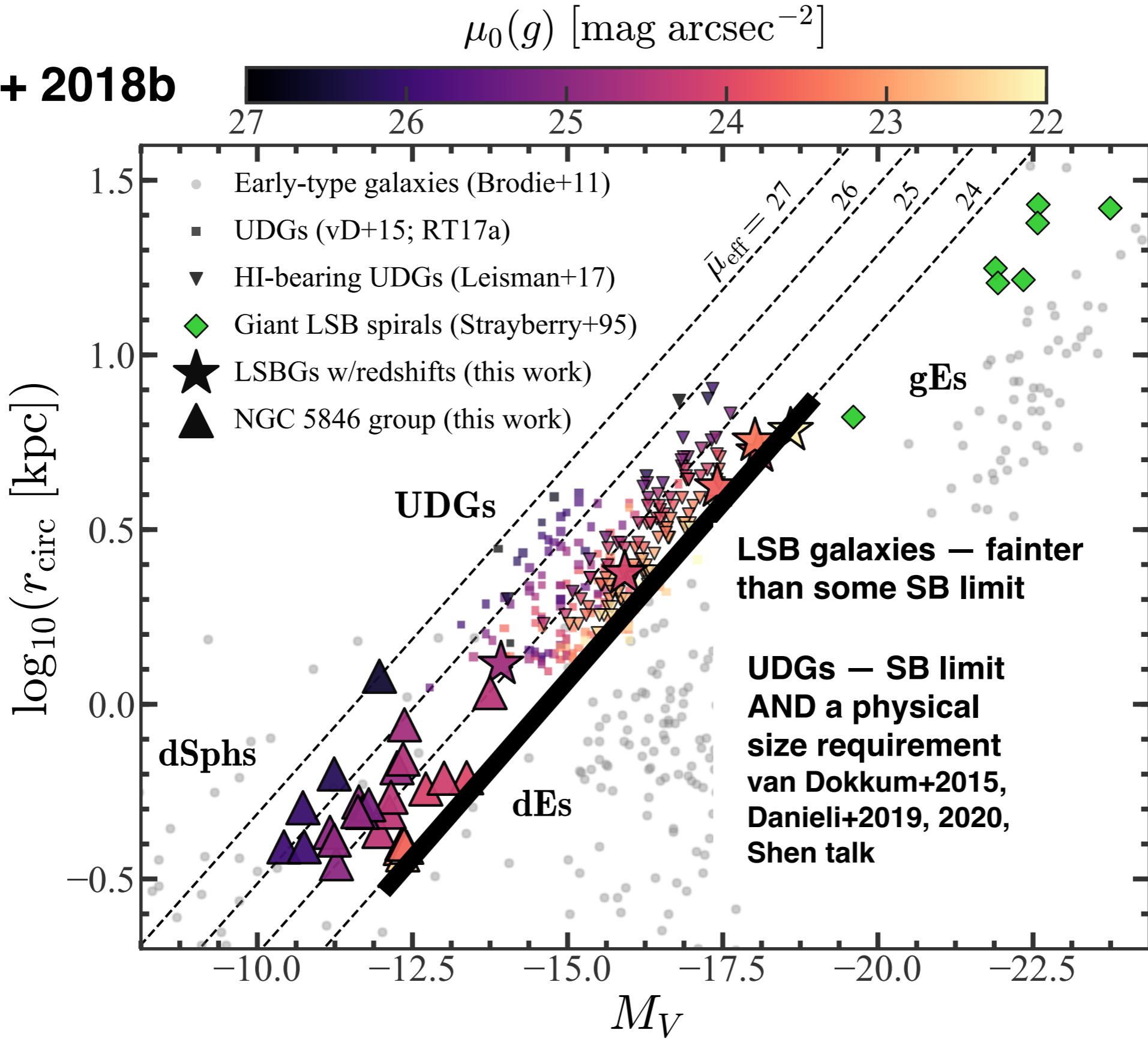
# Deblending is a big issue...just ask Jiaxuan Li

## Li+ 2023a



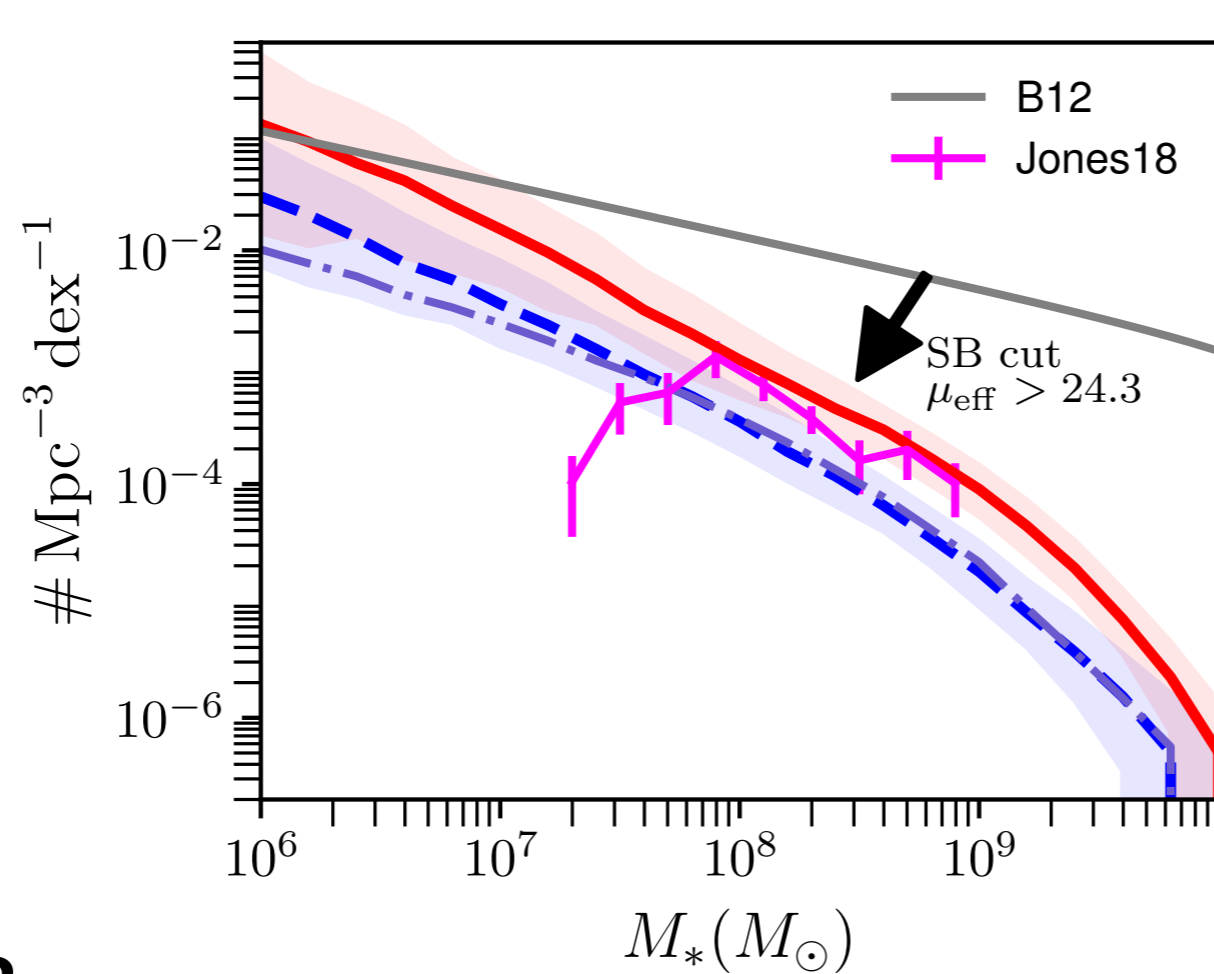
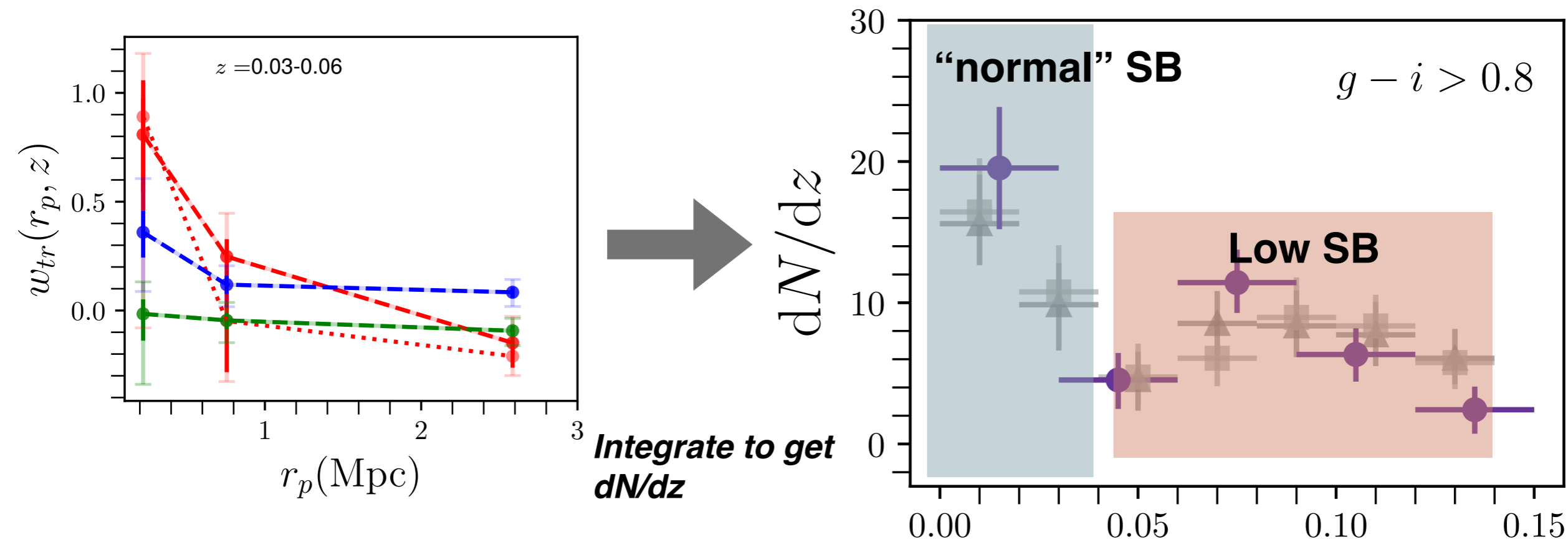
Ultimately, we are very incomplete below  $\sim 4''$  or so in HSC searches using our standard methods, because swamped by compact blends

# Greco+ 2018b



Also Tanoglides+2021 (DES)

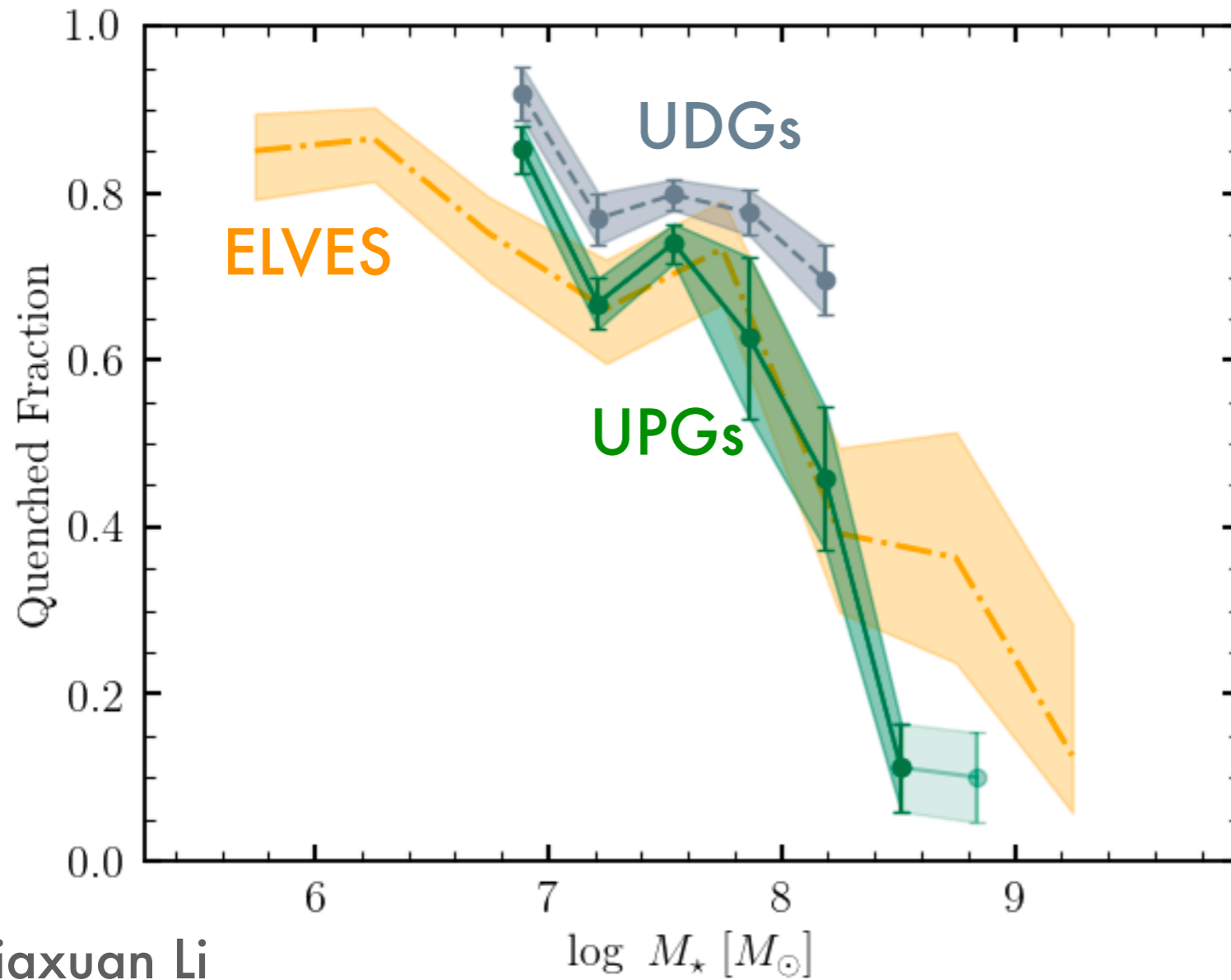
SMUDGES (DECaLS; Zaritsky+); SEAMLESS (Jones+)





*Using background subtraction*

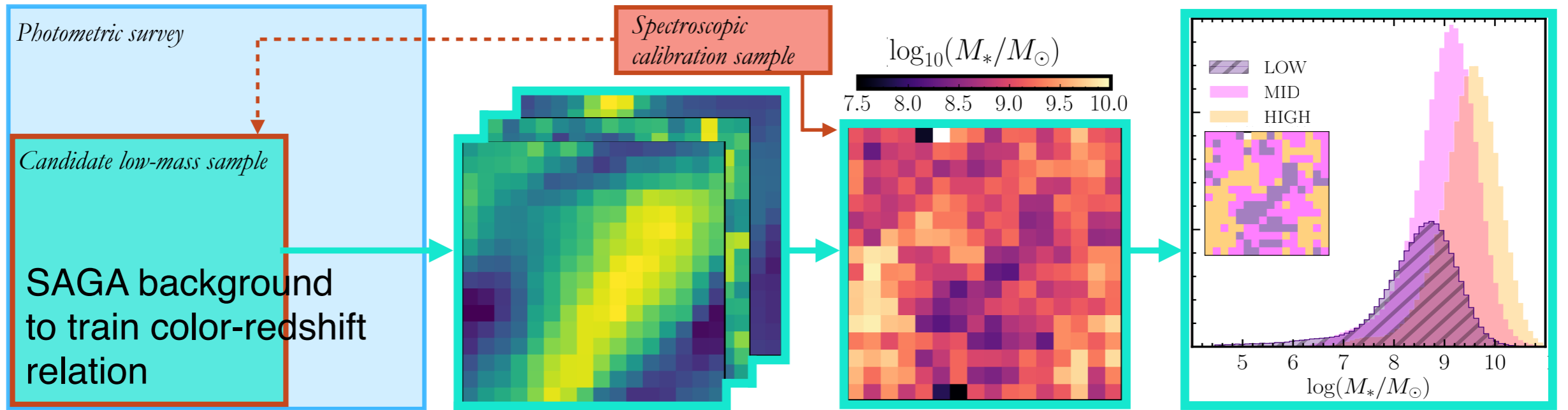
## Quenching of satellites, UDGs, and UPGs



UDGs (selected with SB limit; incomplete for blue)  
HIGH quenched fraction

UPGs (mass-size selection)  
similar quenched fraction as normal satellites, although UPGs are puffy!

Photometric redshifts (see Dan's UVEX infomercial)

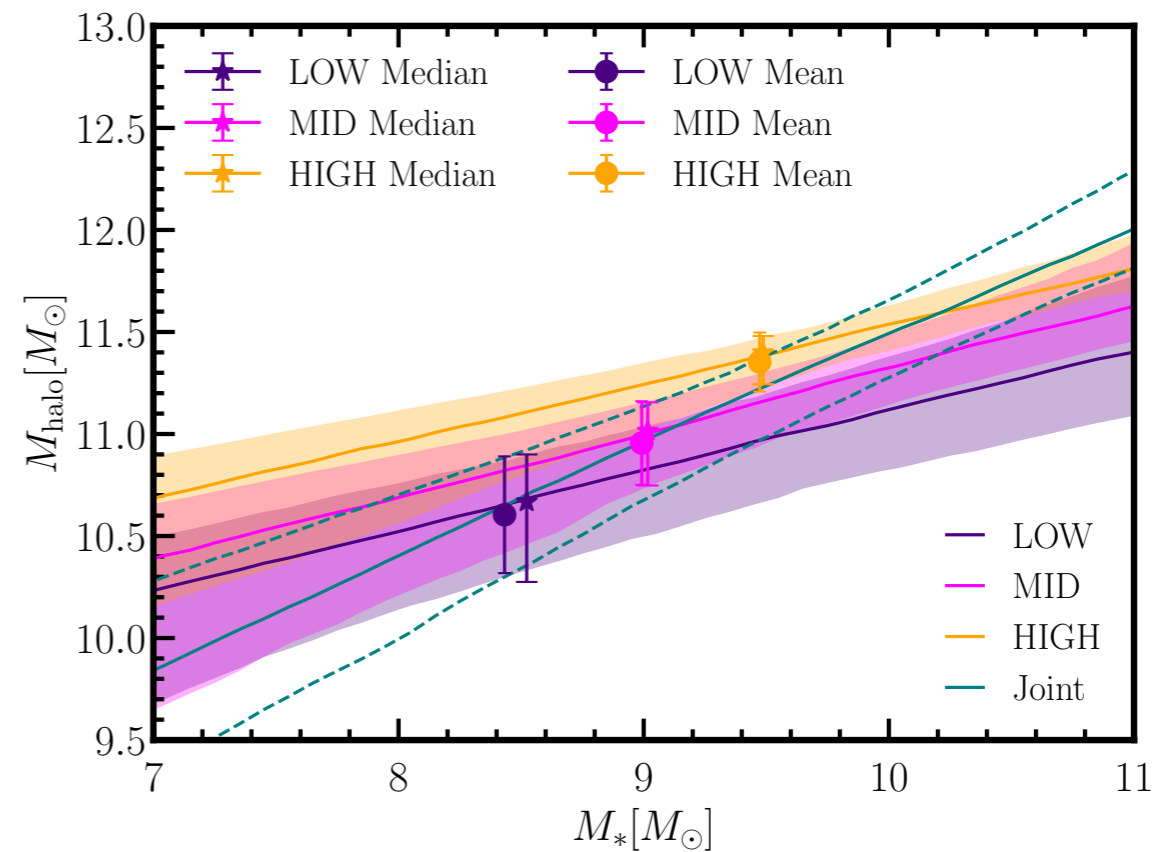
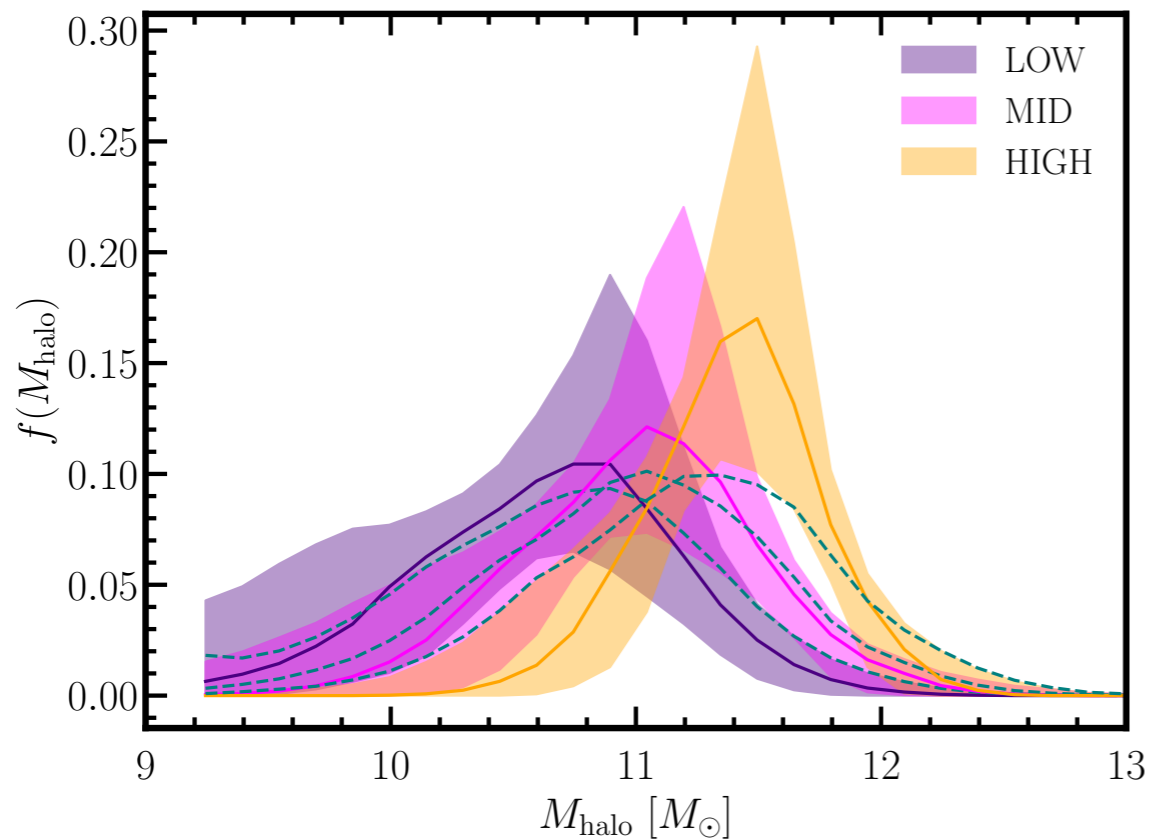


1. Photometric selection informed by *spectroscopic calibration sample* gives the *candidate low-mass sample*

2. *Candidate low-mass sample* sorted by galaxy properties into SOM 'cells'

3. *Spectroscopic calibration sample* assigned to SOM to characterize cells with  $M_*$  and  $z$

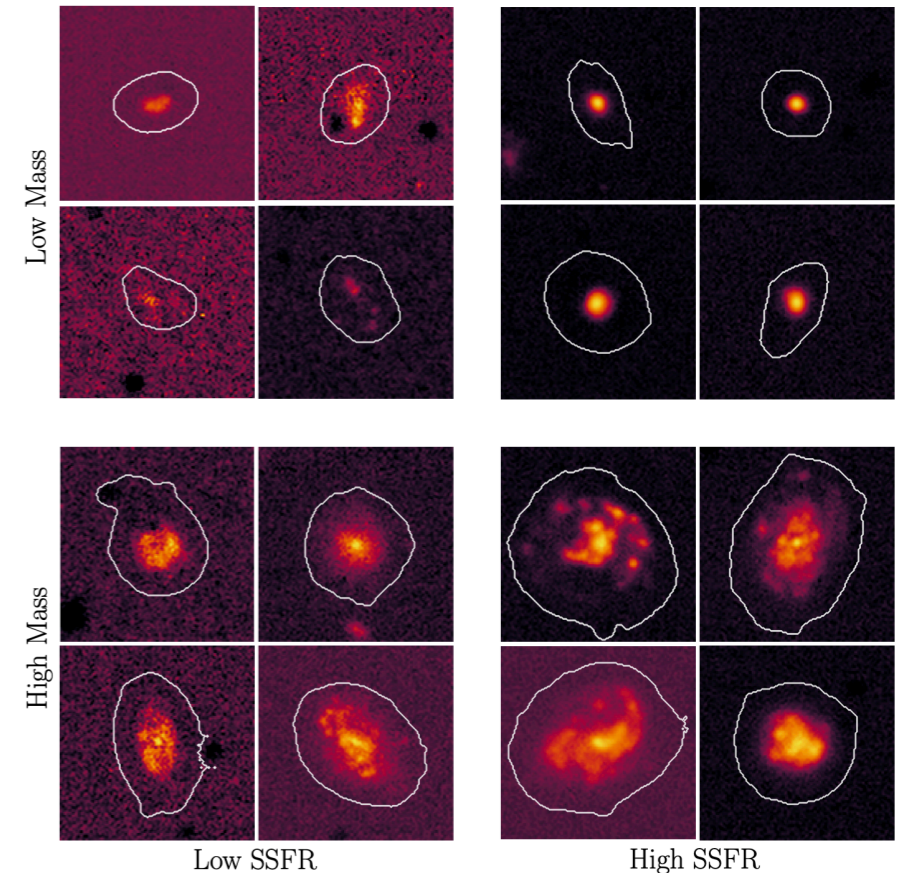
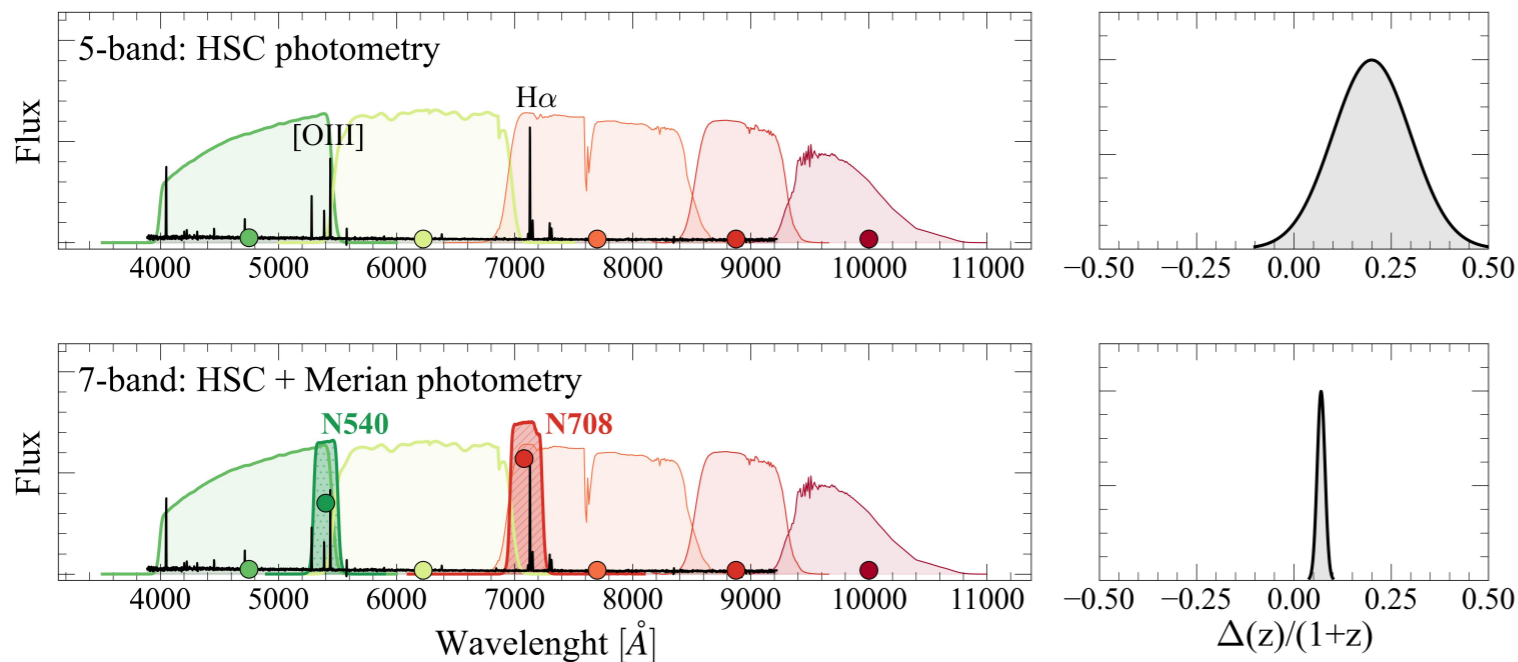
4. SOM cells selected using  $\langle M_* \rangle$  to build *low mass samples* with calibrated  $M_*$  distributions





# ADDING MEDIUM BANDS: THE MERIAN SURVEY

## WE ARE COMBINING DECAM + HSC



~850 sq. deg with **Subaru HSC-SSP Survey**

5 broad-band (grizy) + 2 medium-band (N708 and N540)

~**100,000 dwarf galaxies** at  $0.05 < z < 0.1$

Mass-complete to  $10^8$  solar masses for star-forming dwarfs

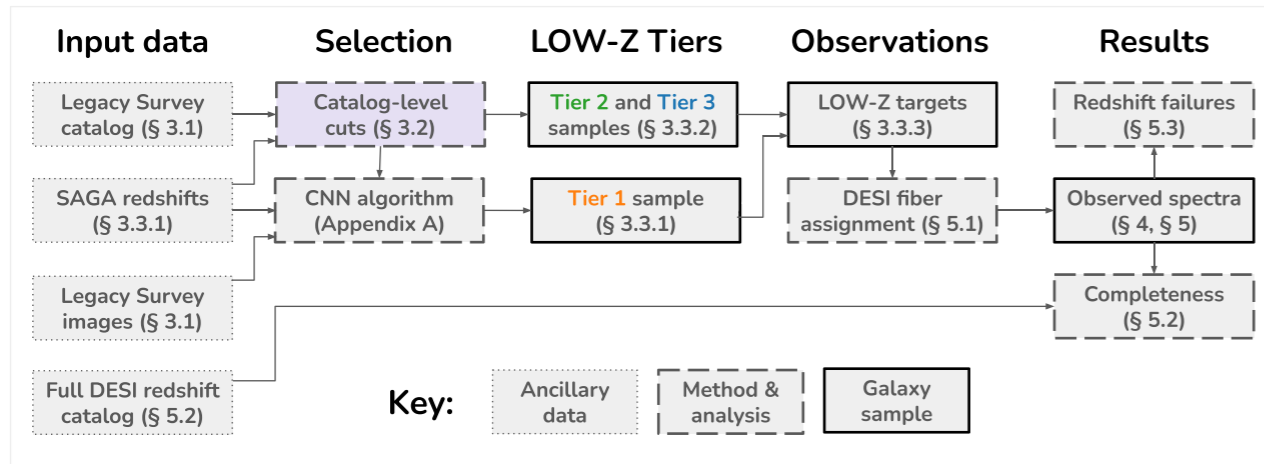
MINTZ+2024  
HIGH SSFR GALAXIES ARE  
COMPACT



DANIELI ET AL. 2024

WITH LUO, KADO-FONG, PAN, GREENE,  
LI-JIAXUAN, LI-TING, MINTZ, LEATHAUD

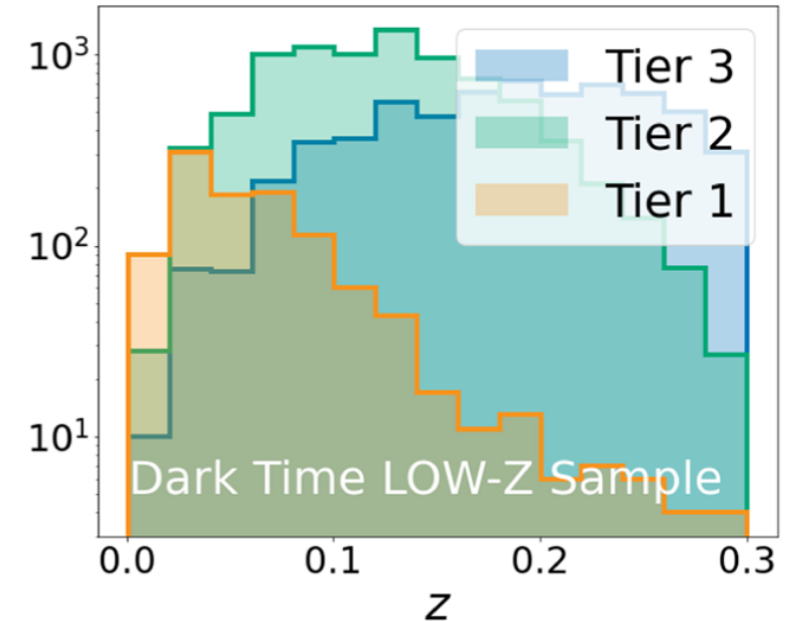
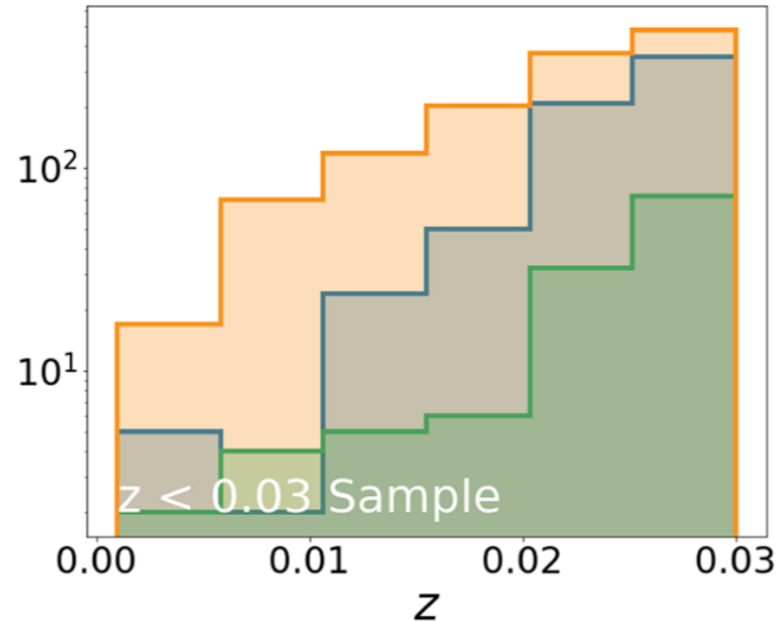
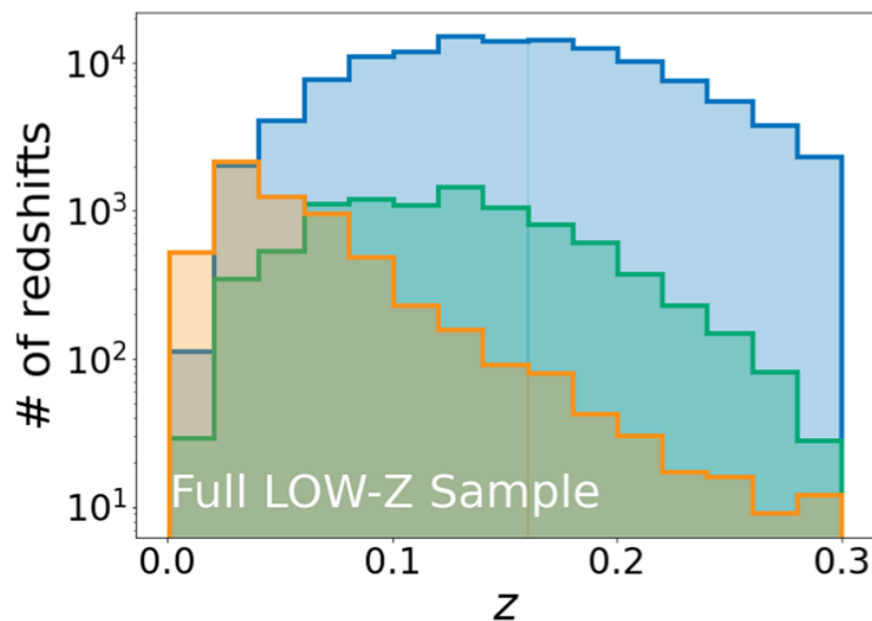
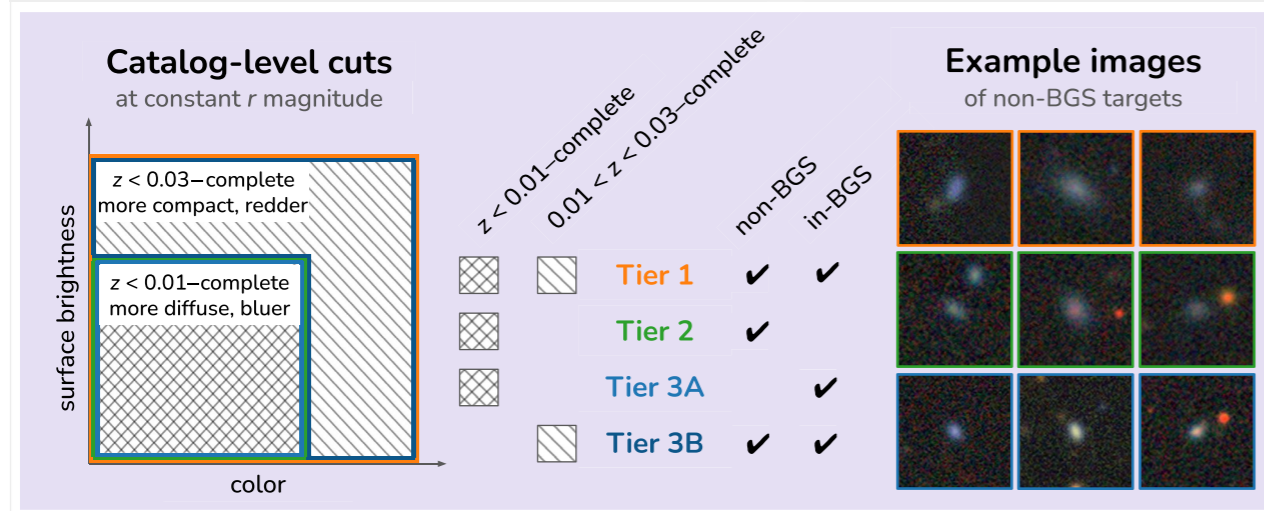
# Massively Multiplexed Spectroscopy



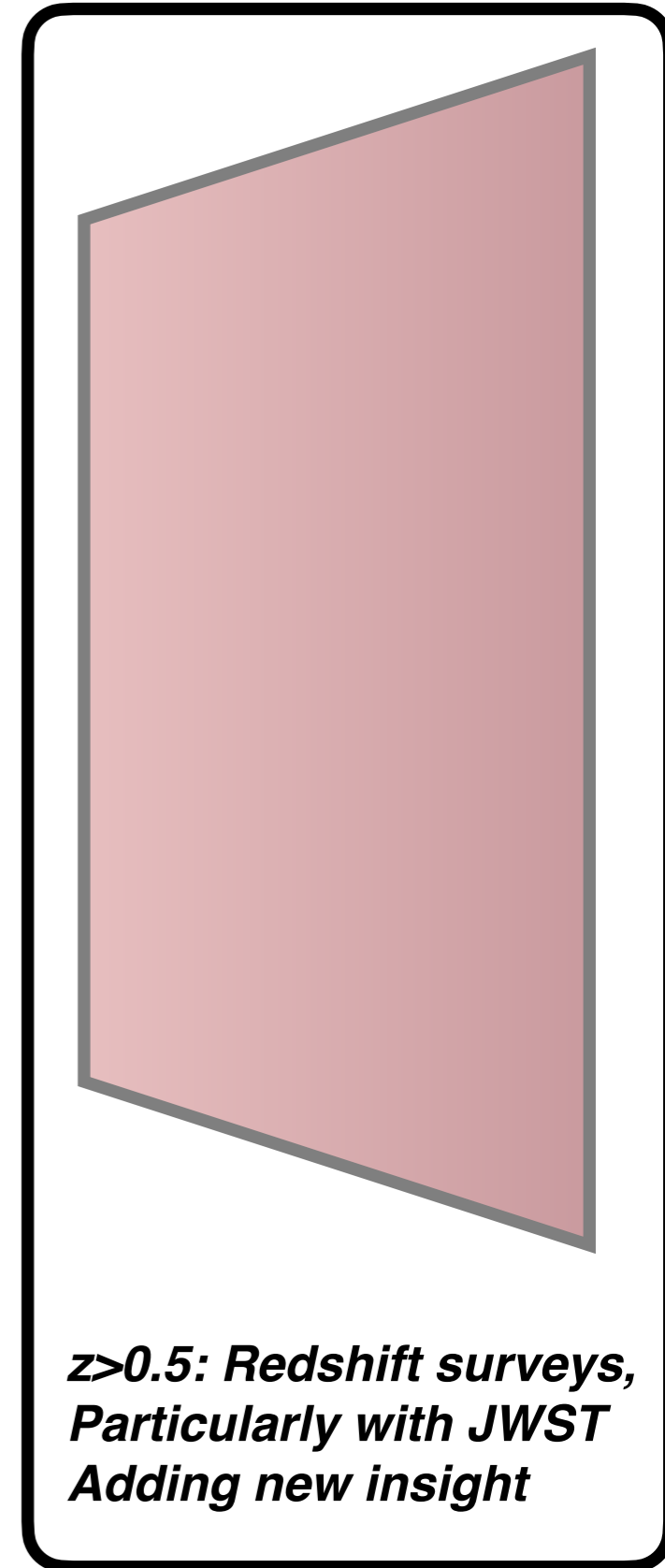
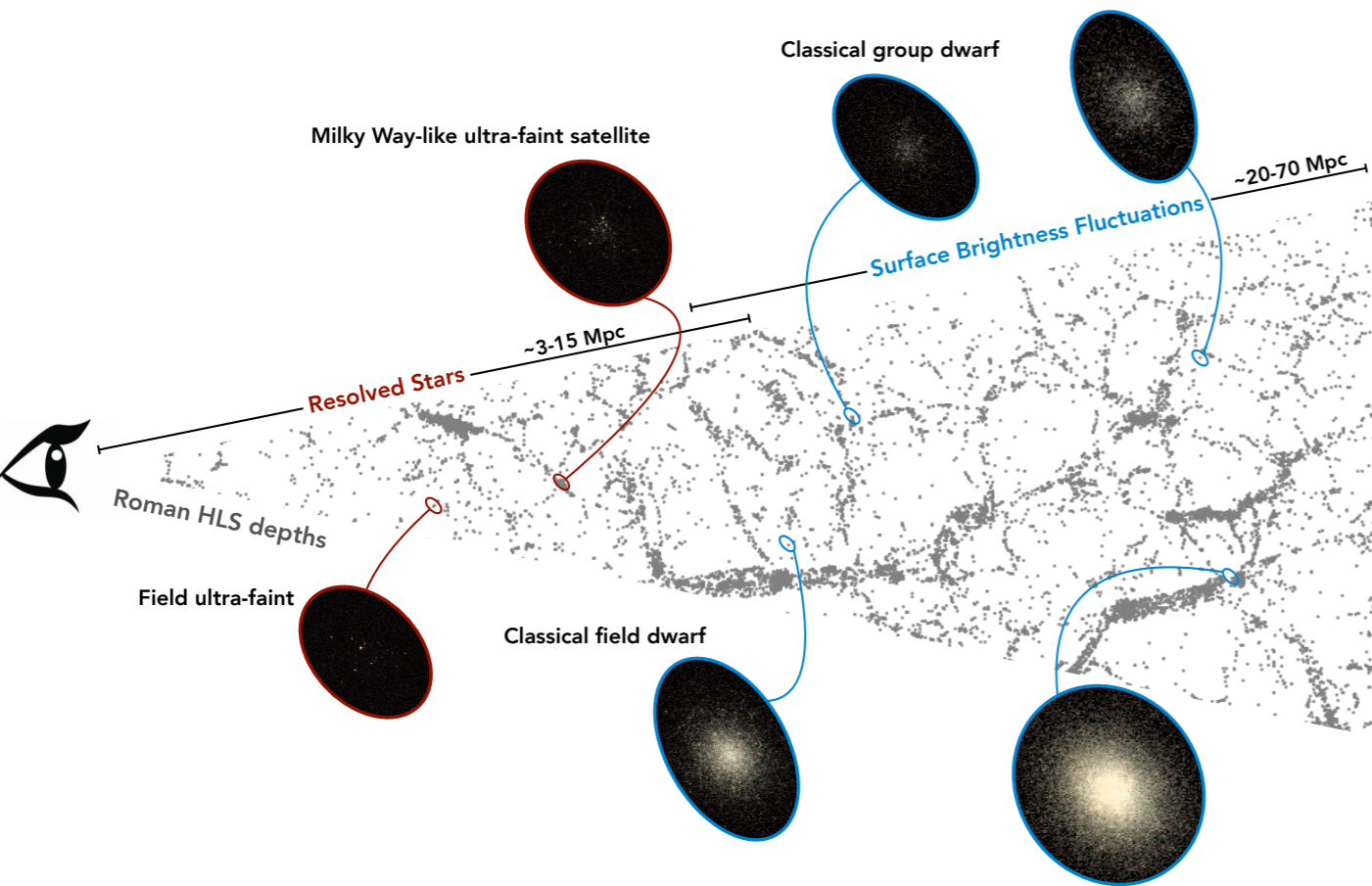
**Darragh-Ford+2023**  
**DESI low-z, xSAGA selection**

**PFS, MOONS upcoming**

**May work beautifully with**  
**Roman, Euclid, UVEX**



# Beyond the Local Volume



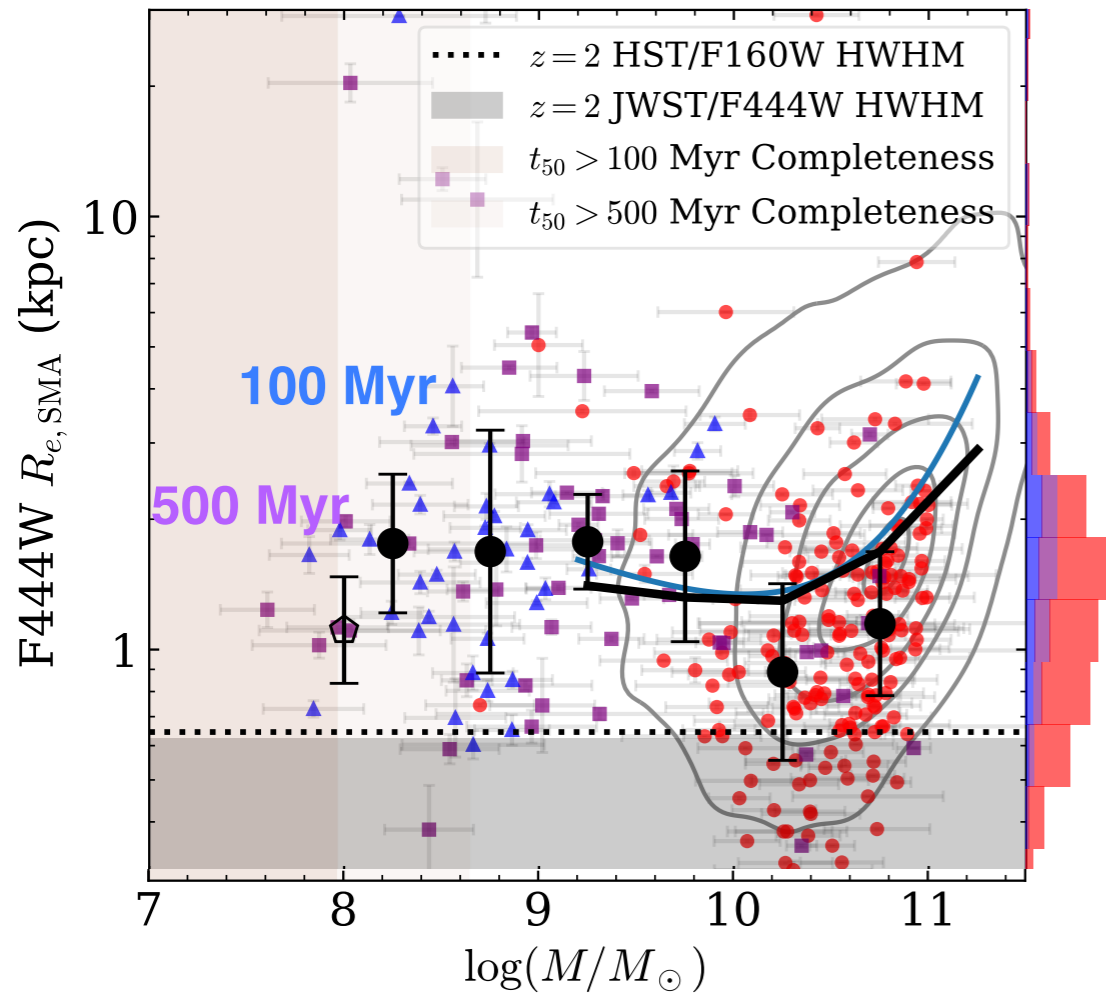
*Local Volume with direct distances*  
*TRGB, TF, SNe*  
*Surface brightness fluctuations*  
*—> Extend to ~70 Mpc with Roman?*

***Z~0.05-0.3***  
***Integrated light,***  
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***Photo-z (Merian, UVEX)***  
***Statistical distributions***  
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***z>0.5: Redshift surveys,***  
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***Adding new insight***

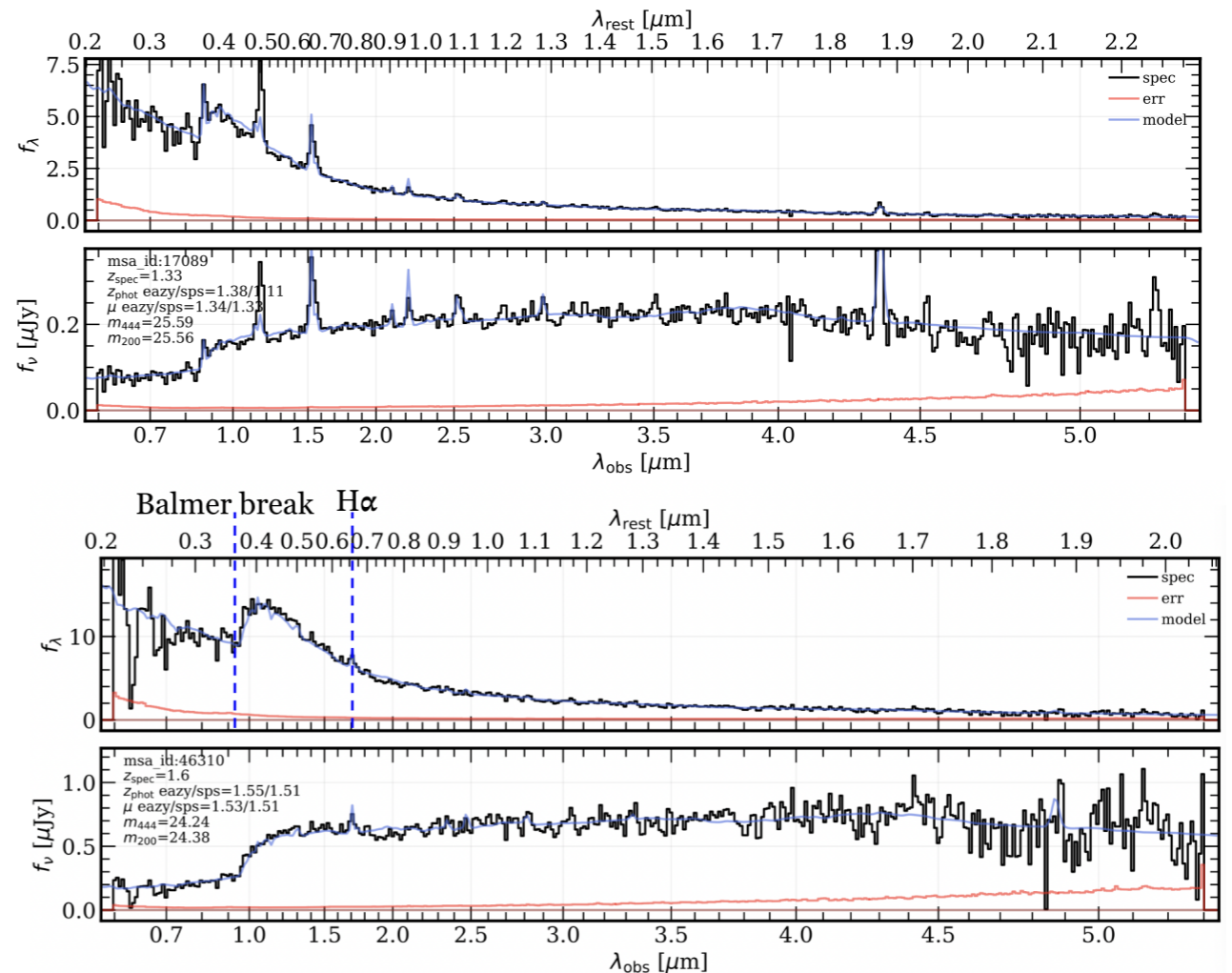


# And out to Cosmic Noon with JWST



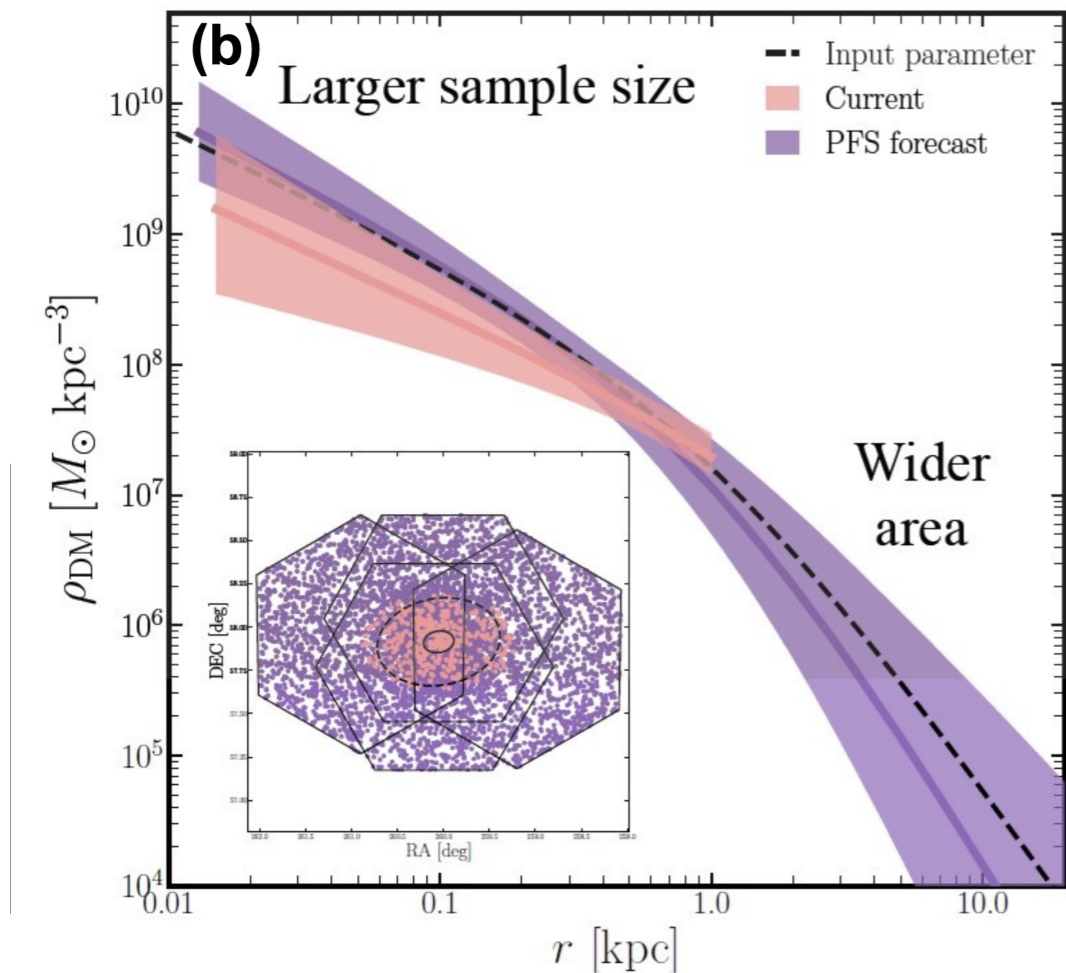
CUTLER ET AL. 2024

## UNCOVER PRISM SPECTRA (BEZANSON/LABBE)



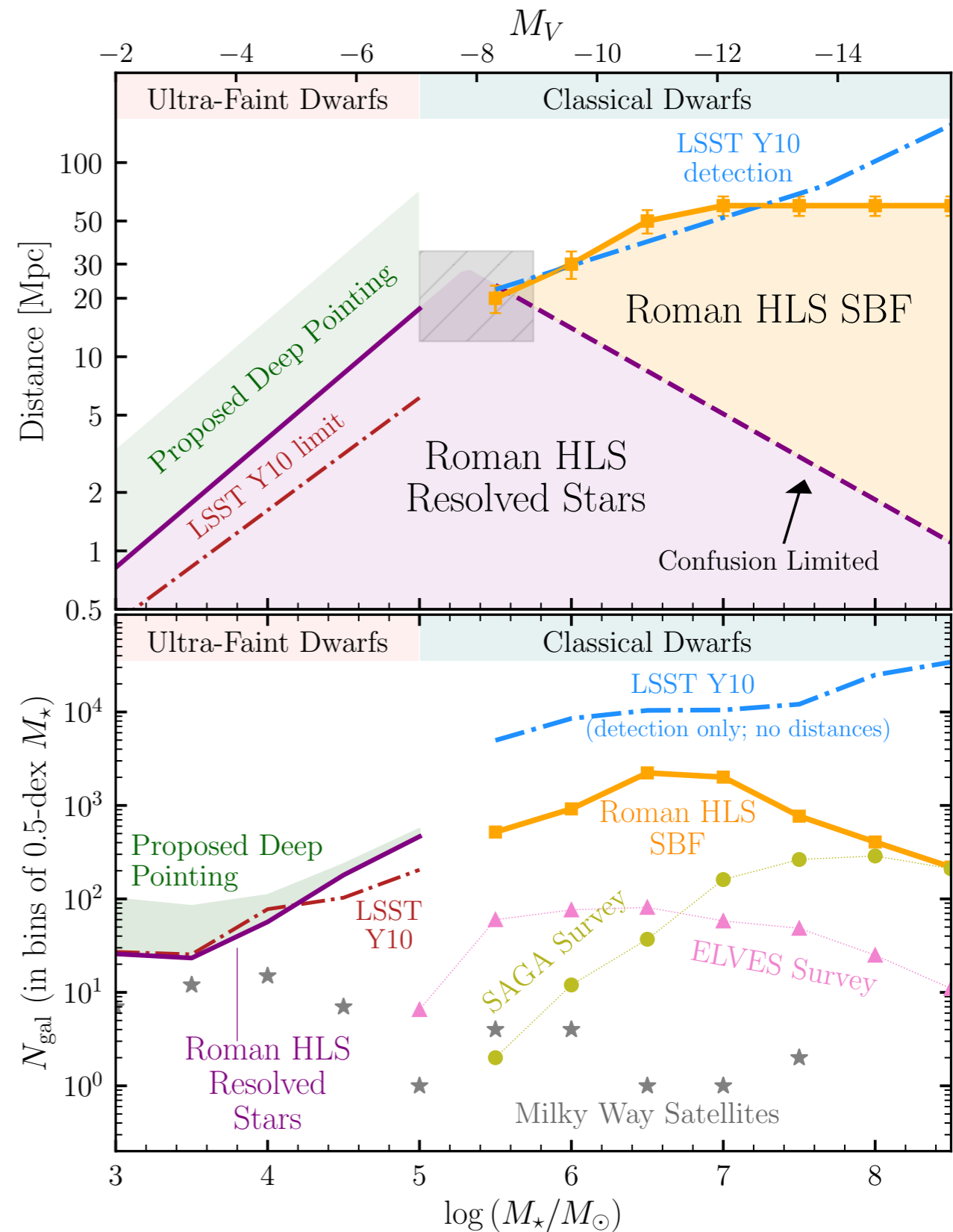
SETTON, MINTZ IN PREP

With the lensing boost in the Abell 2744 lensing field, we can easily detect red galaxies at  $z \sim 2$  down to  $10^8$  Sun, and with a wide range of SFH. Excellent opportunity to look at bustiness, mass-size, and H $\alpha$  morphologies using Medium Bands, Mega-Science (PI Suess).

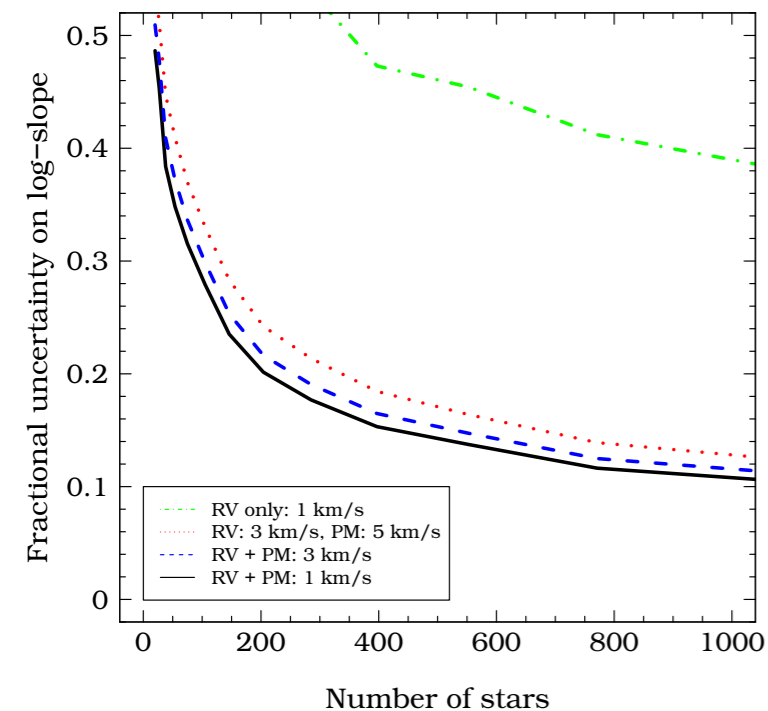


*PFS will revolutionize studies of LG dwarf kinematics, and facilitate large redshift surveys to faint limits*

## A possible RST+LSST dwarf survey

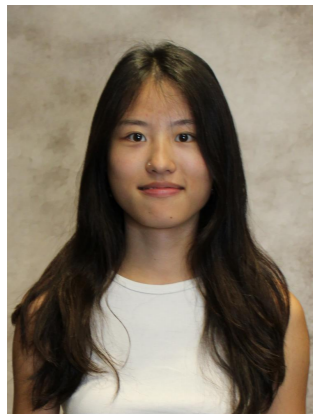


*Constraints on DM Inner slope from ELT proper motions Simon+2019*



*From Jiaxuan Li*





**Yue Pan**  
**SF satellites around MW**  
**hosts, Merian (see poster)**



**Yifei Luo**  
**Merian photo-z, dwarf star**  
**formation histories**  
**See talk**



**Abby Mintz**  
**Star forming galaxy**  
**morphology and SFH**



**Erin Kado-Fong**  
**Dwarf galaxy shapes,**  
**mergers, chemical**  
**evolution (and automated**  
**discovery of streams)**



**Jiaxuan Li**  
**Owner of the Hedgehog,**  
**ELVES-Dwarf**  
**Satellites of LMC+SMC**  
**hosts with SBF (see**  
**poster)**



**Scott Carlsten**  
**ELVES. SBF guru.**  
**ELVES-Field**



**Jake Nibauer**  
**DM substructure using**  
**streams (with Bonaca)**  
**See talk**



**Shany Danieli**  
**Dwarfs, Dark Matter,**  
**globular clusters, ELVES,**  
**Merian, Dragonfly...**