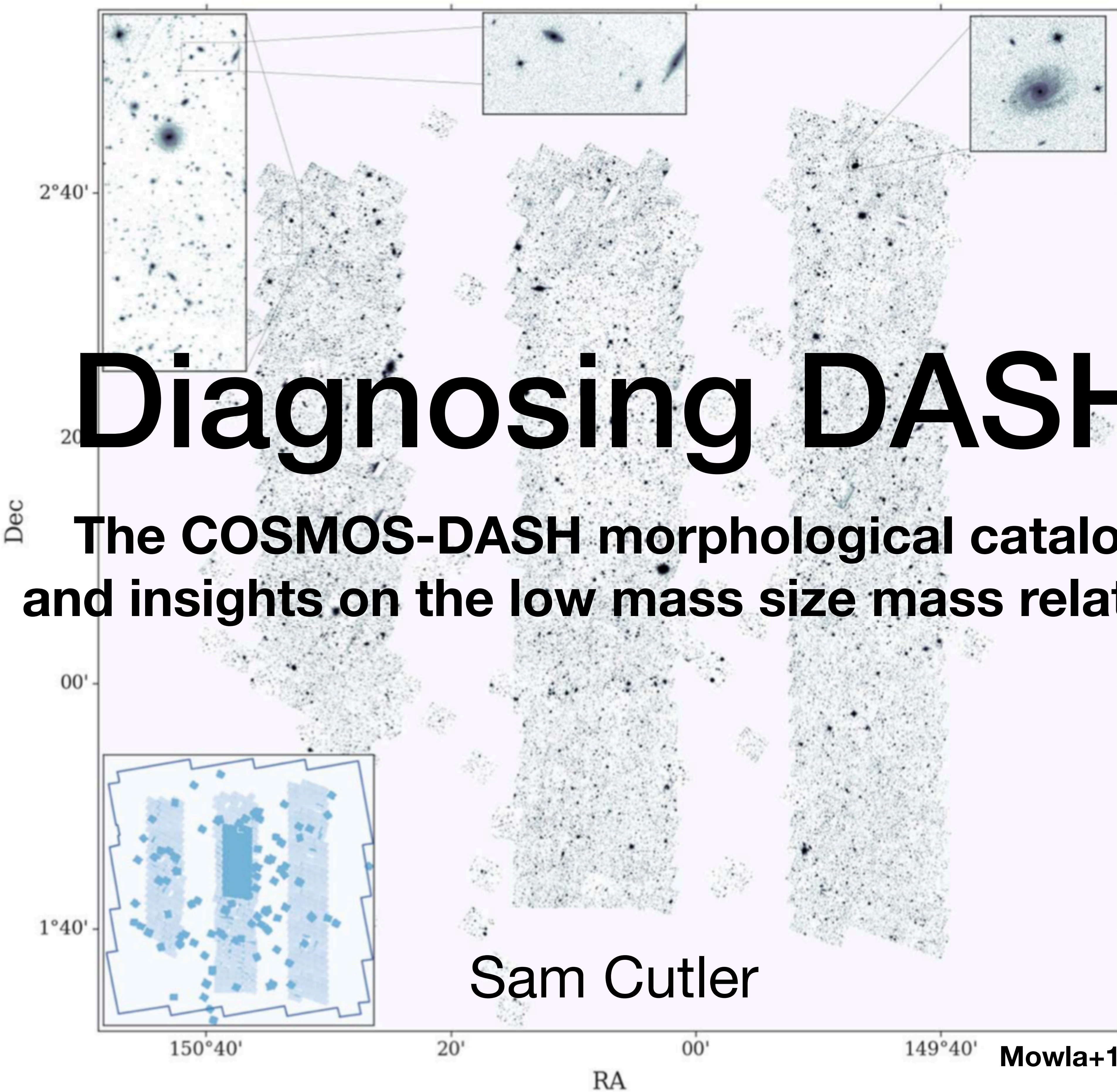
Diagnosing DASH

The COSMOS-DASH morphological catalog and insights on the low mass size mass relation

Sam Cutler

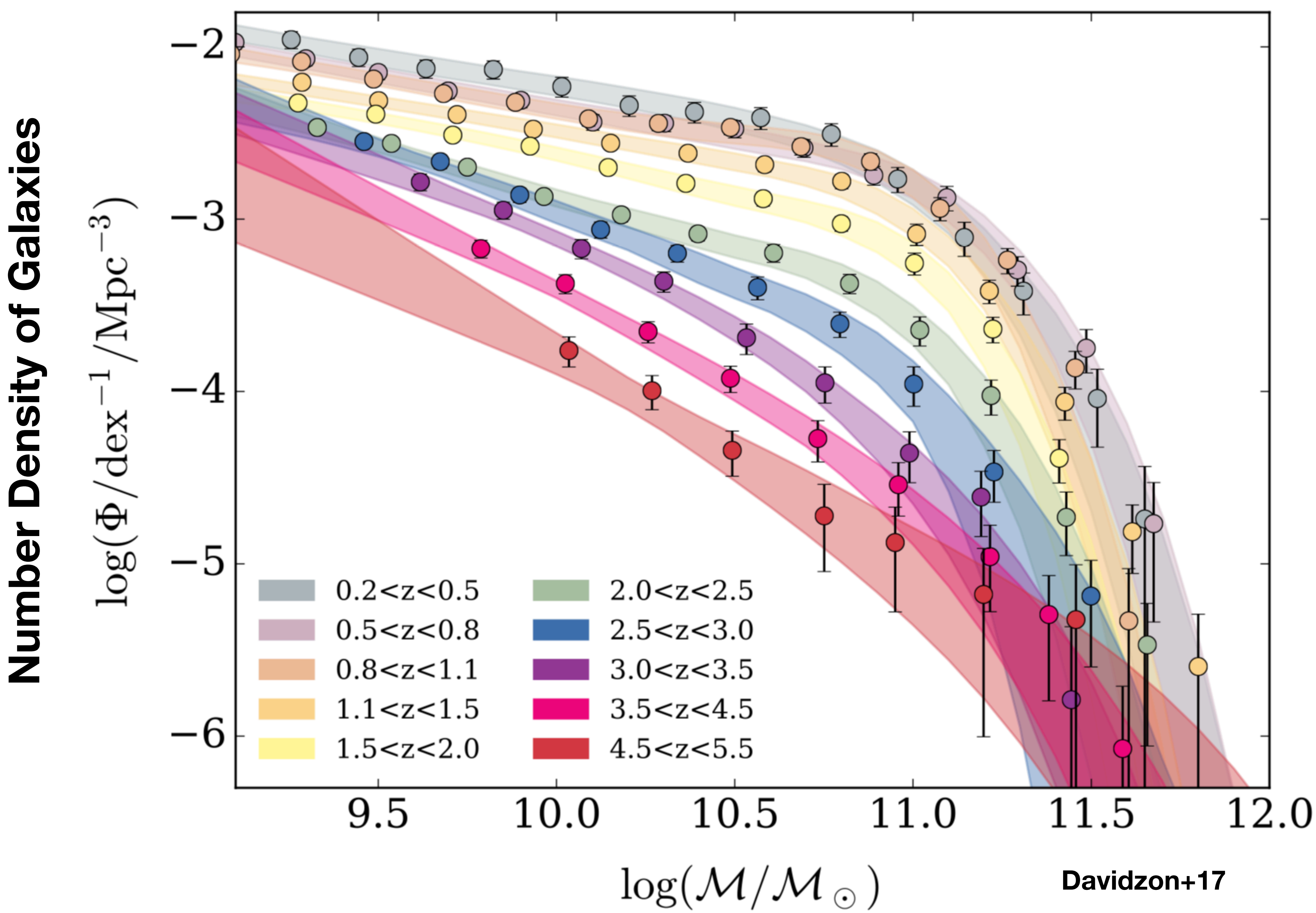


Mowla+19

Outline

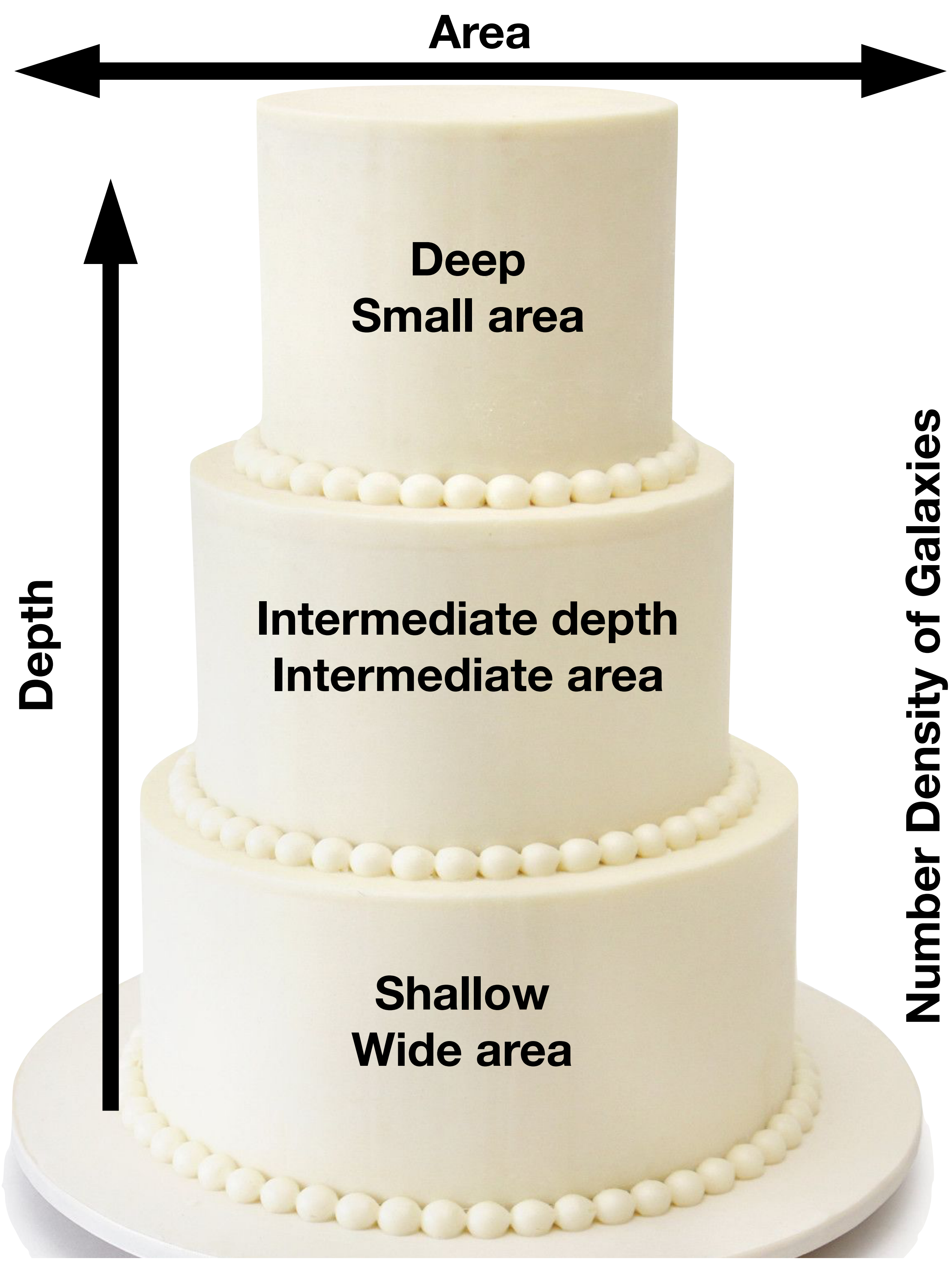
1. What is DASH and why do we need it?
2. The COSMOS-DASH Survey and Morphological Catalog
3. Quantifying and qualifying DASH Morphologies
4. The effect of environment on the low-mass size mass relation

The Galaxy Stellar Mass Relation

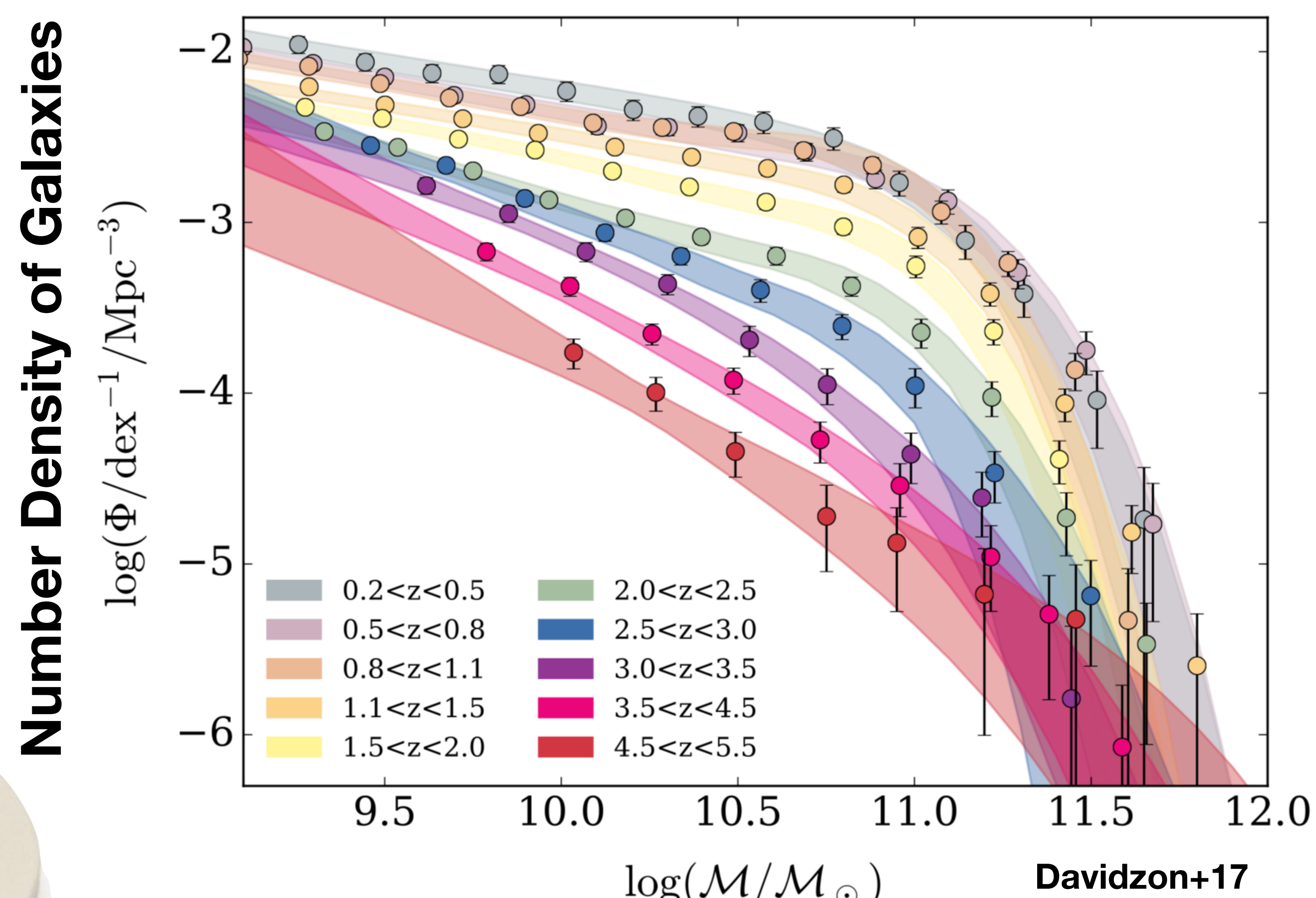


Davidzon+17

The “Wedding Cake” Approach



Shape of galaxy stellar mass function drives approach



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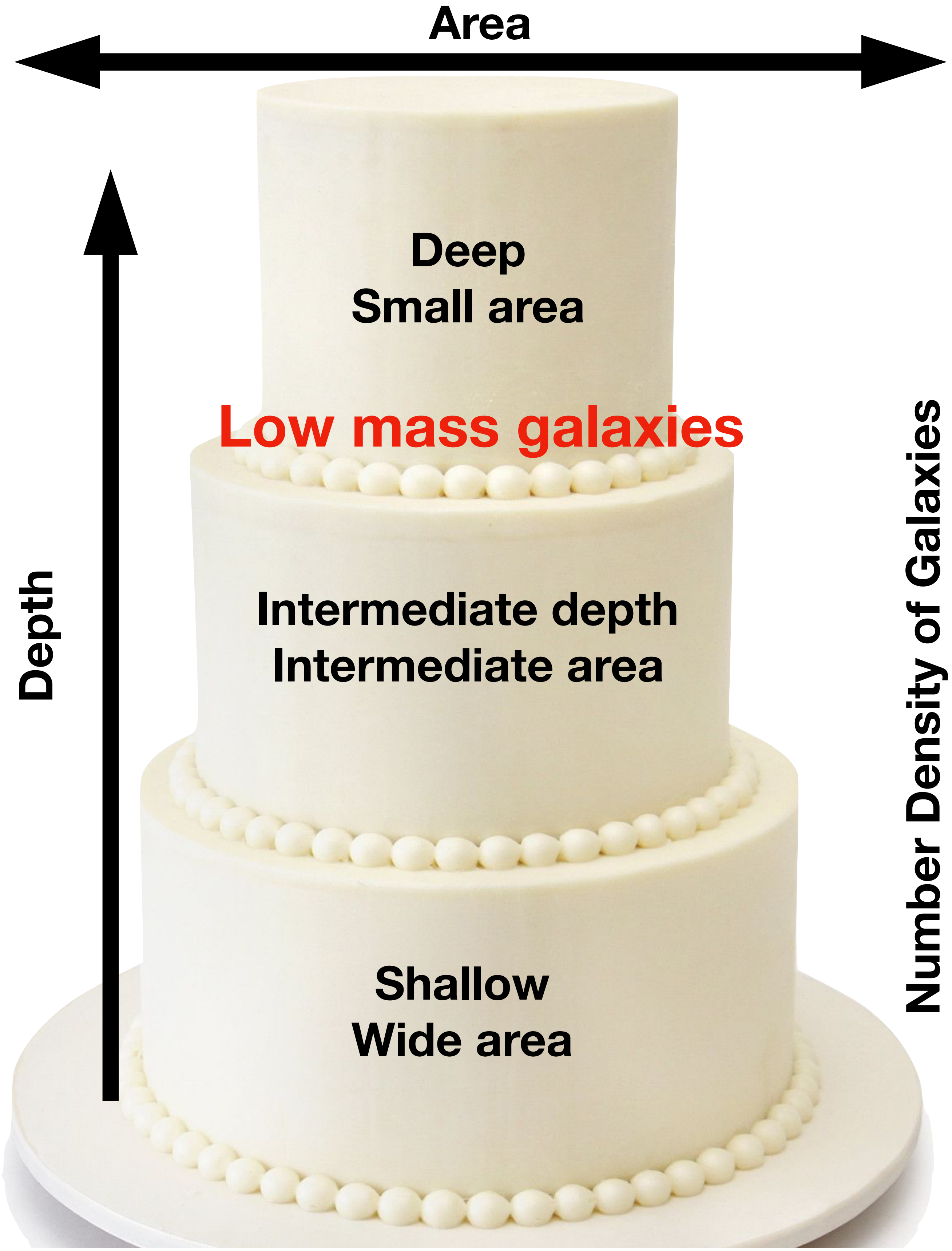

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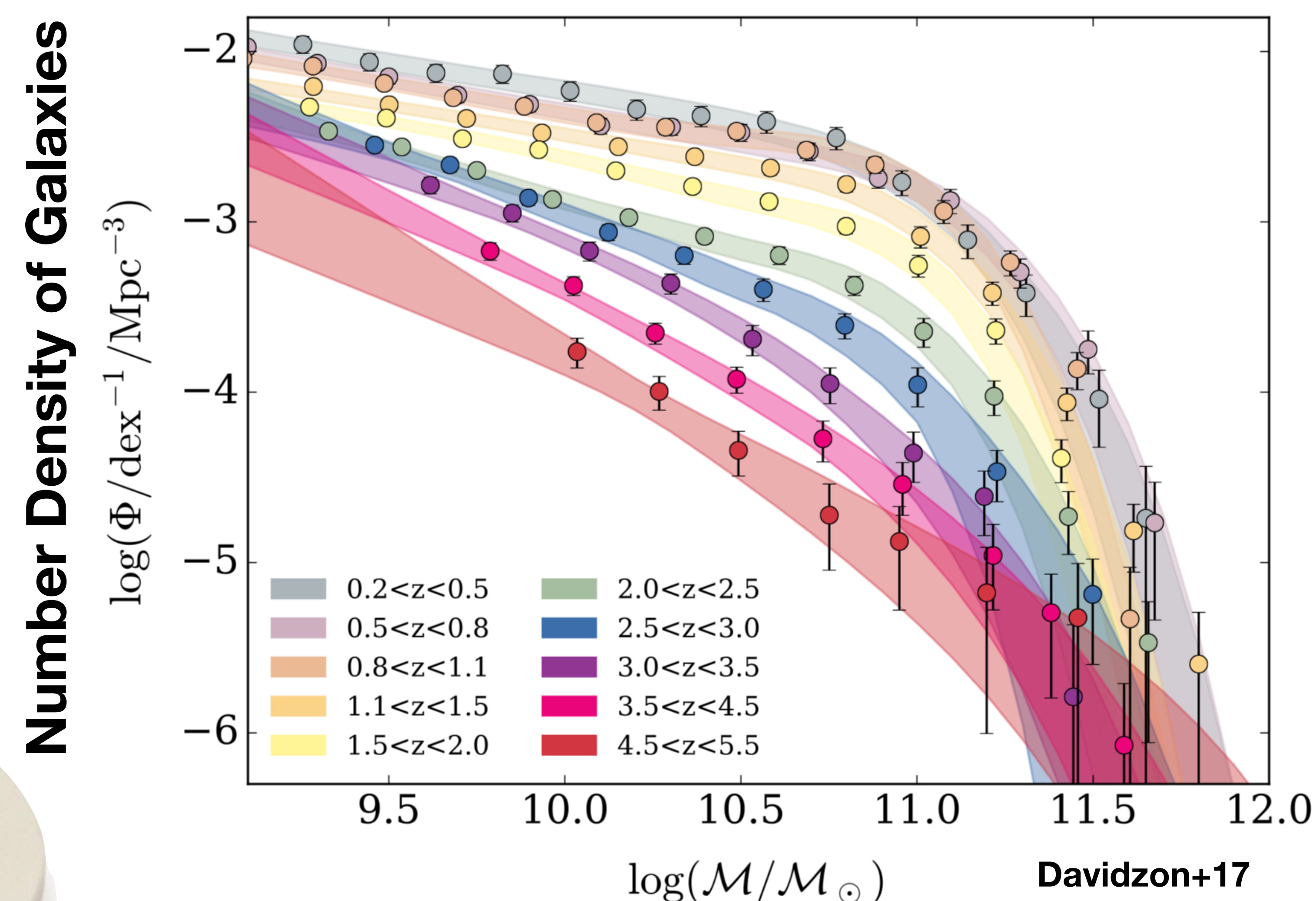

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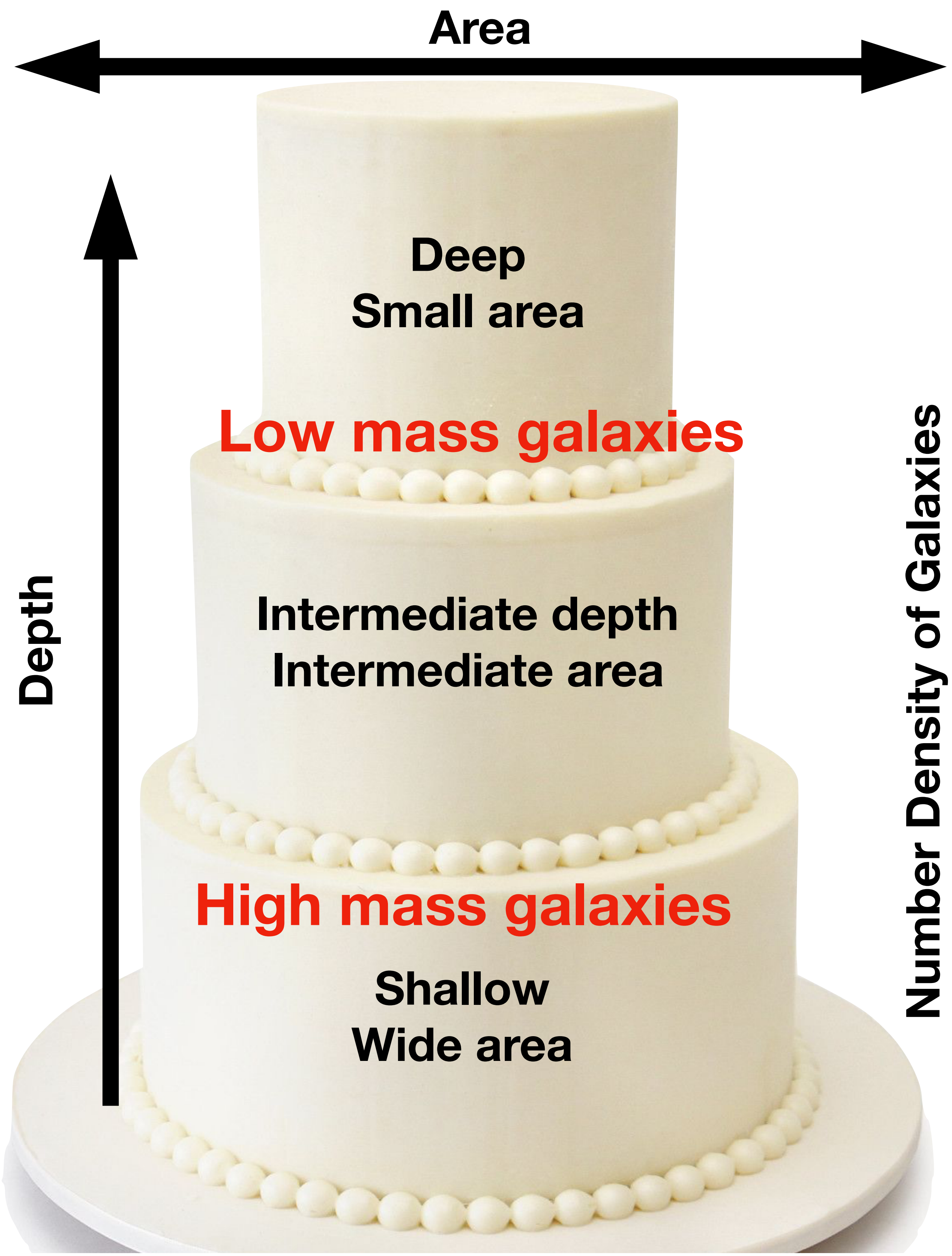

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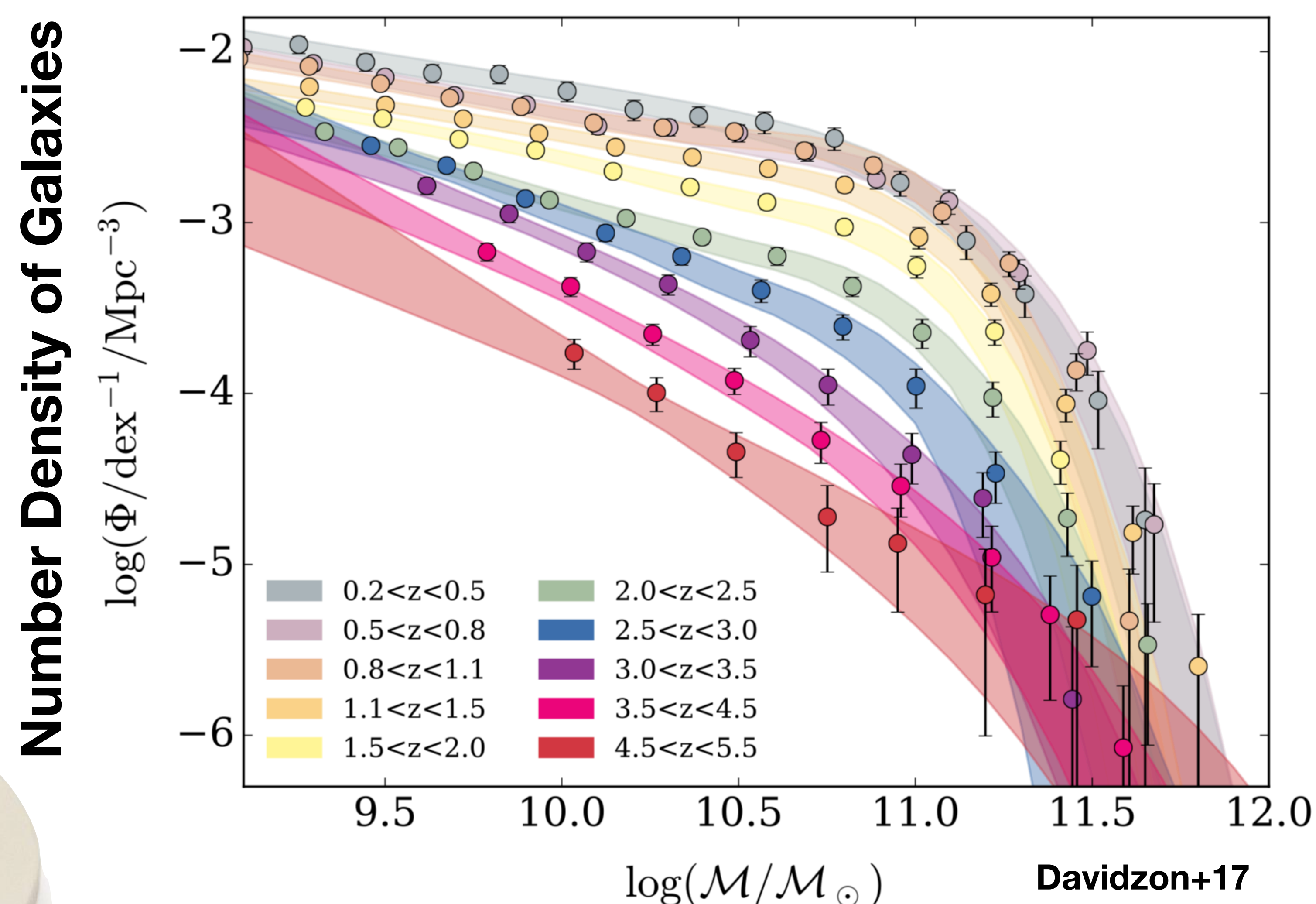

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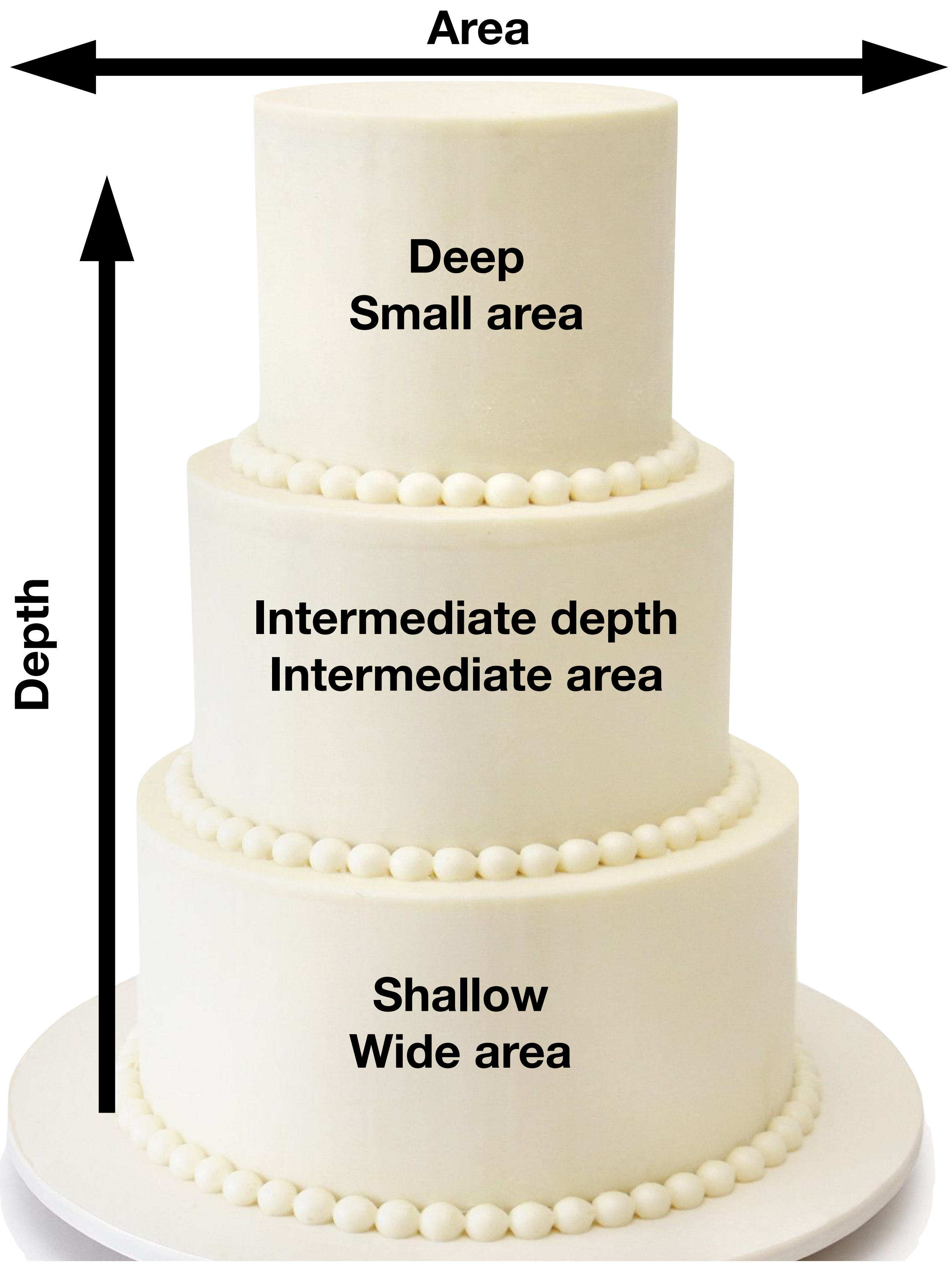

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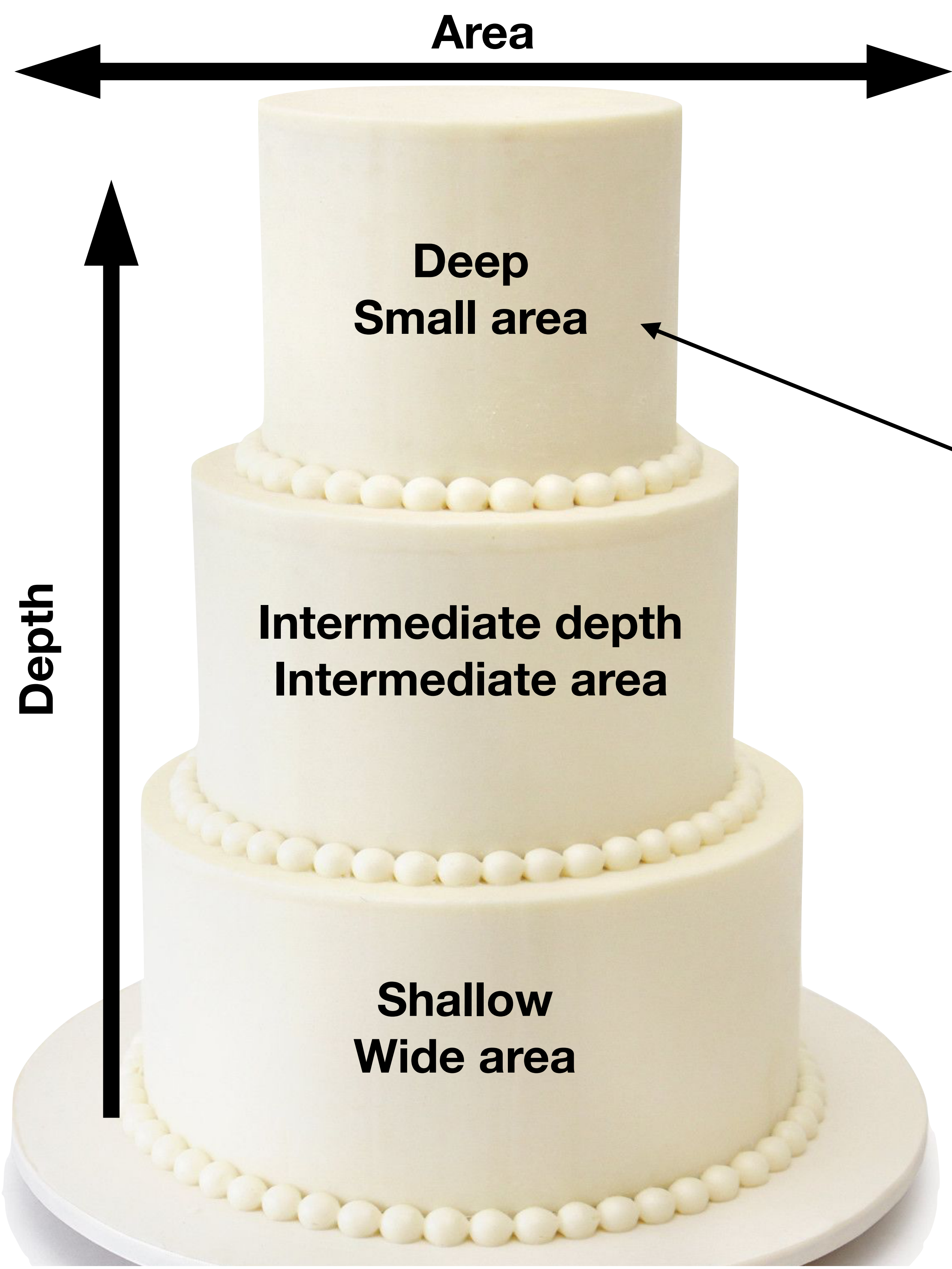
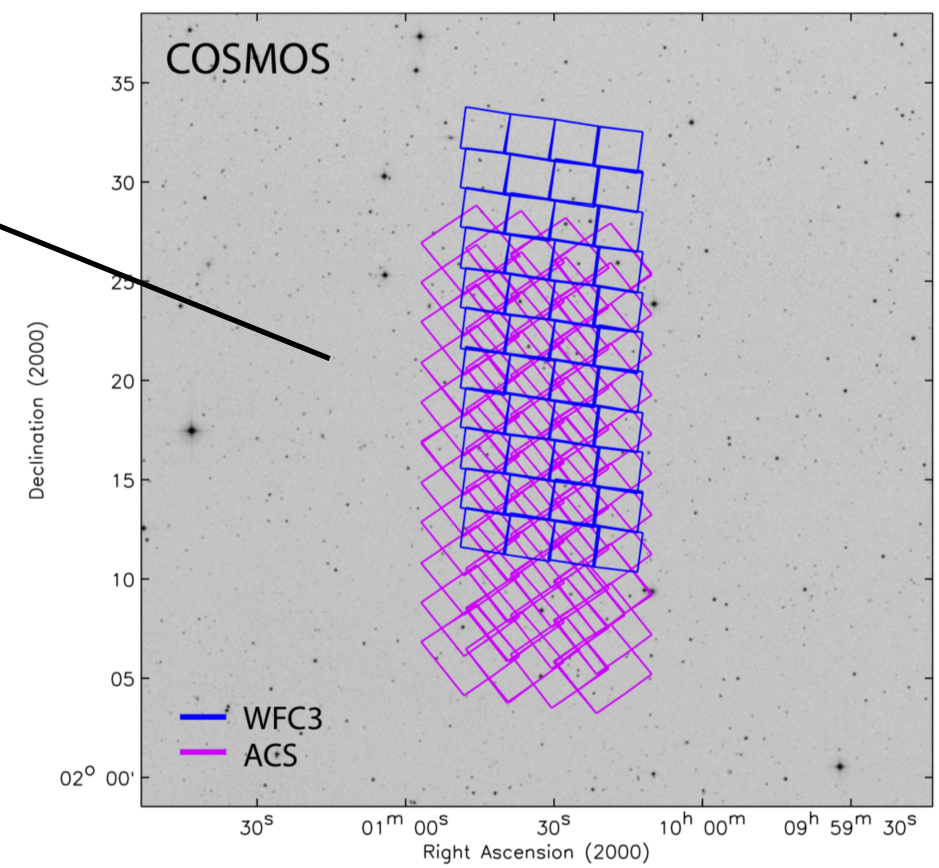
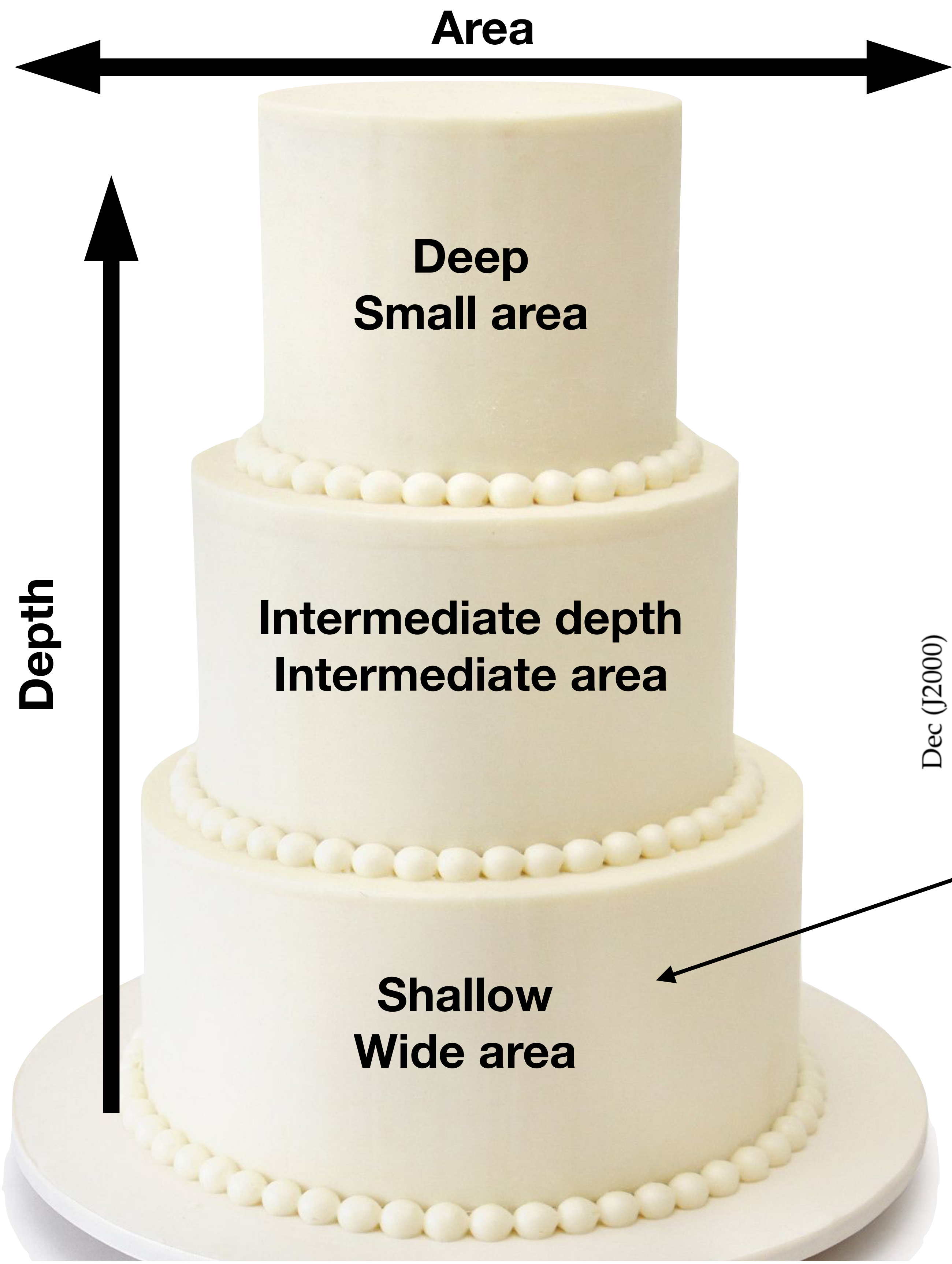


CANDELS
0.25 sq deg
27 ABmag (H-band)

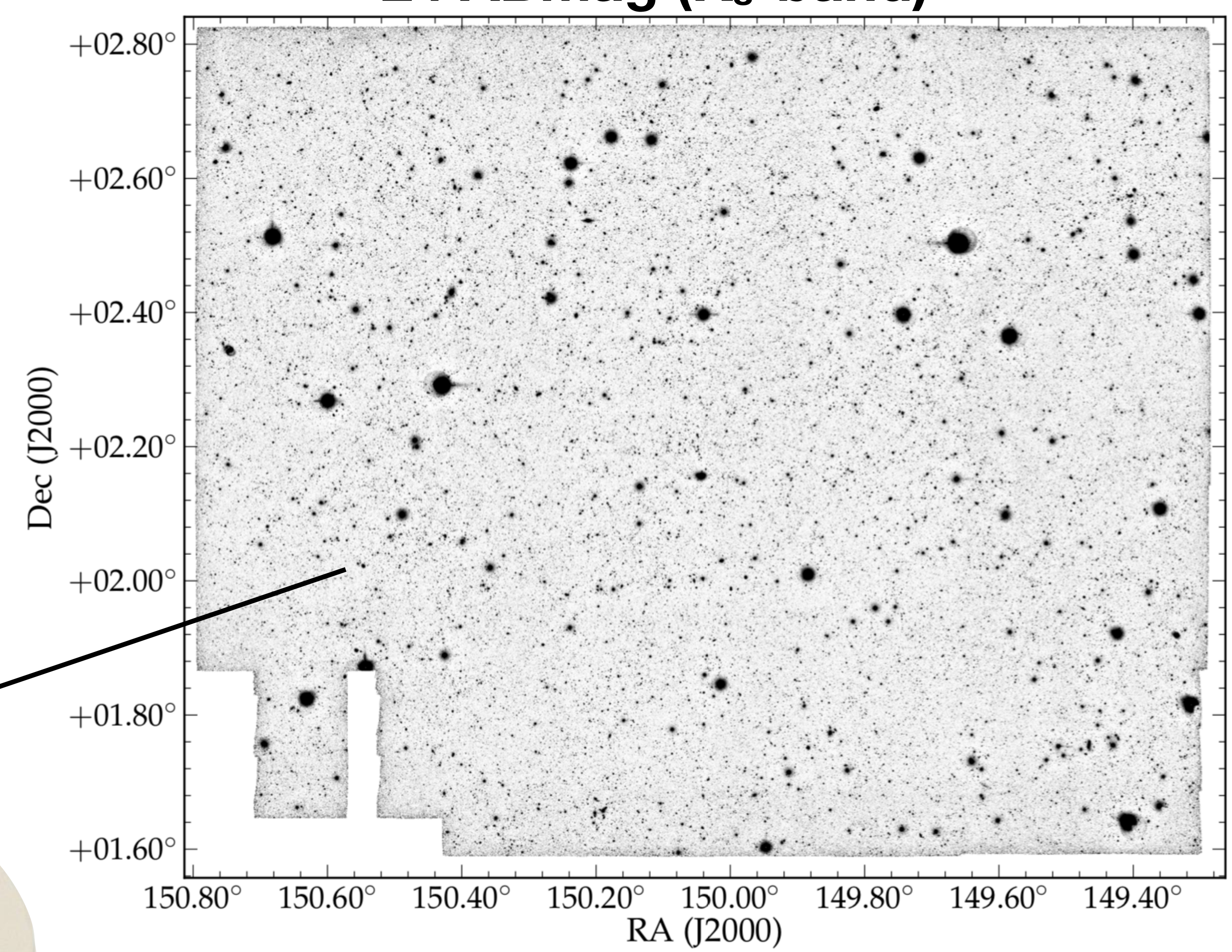


Grogin+11

The “Wedding Cake” Approach



UltraVISTA
1.5 sq deg
24 ABmag (K_s-band)



McCracken+12

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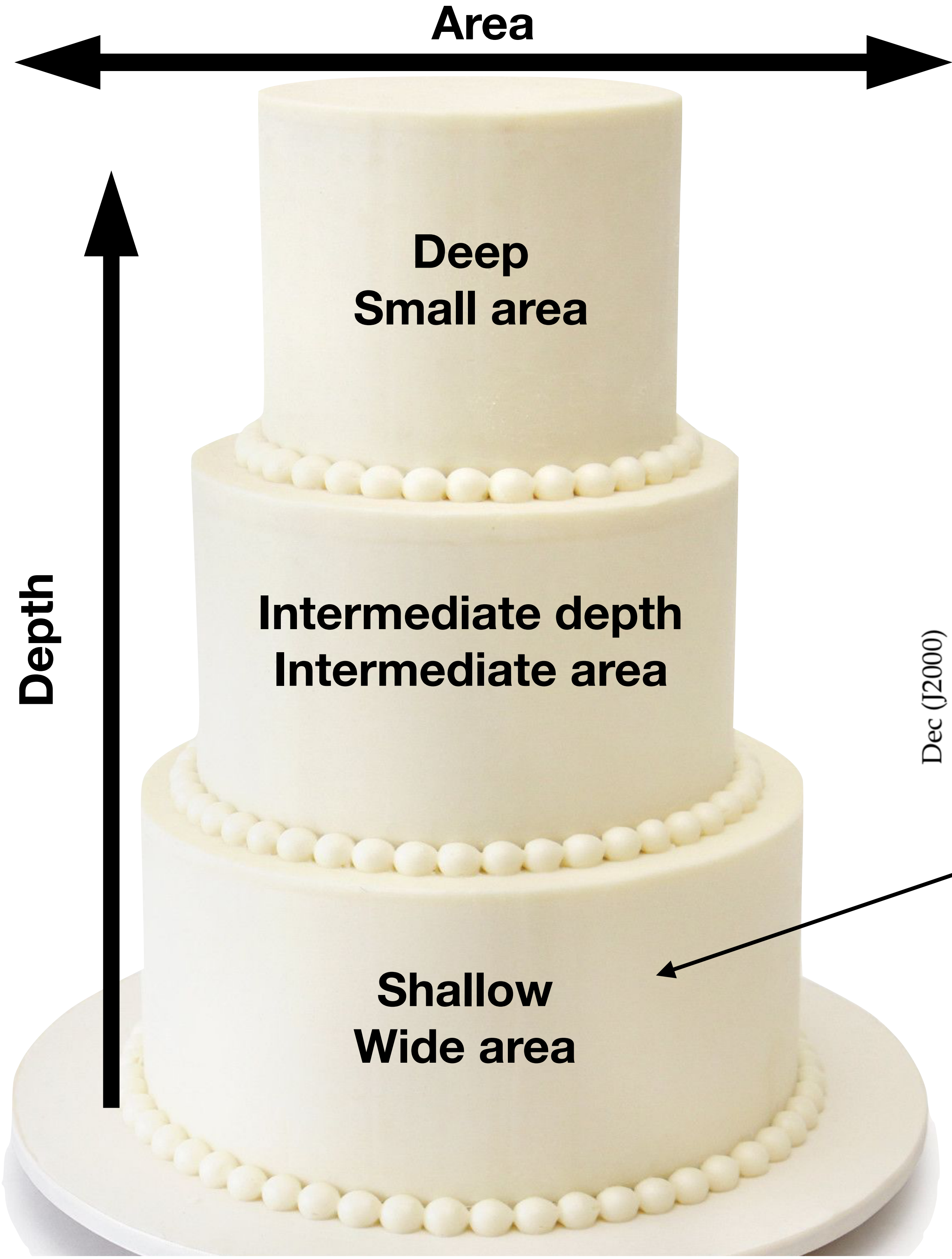

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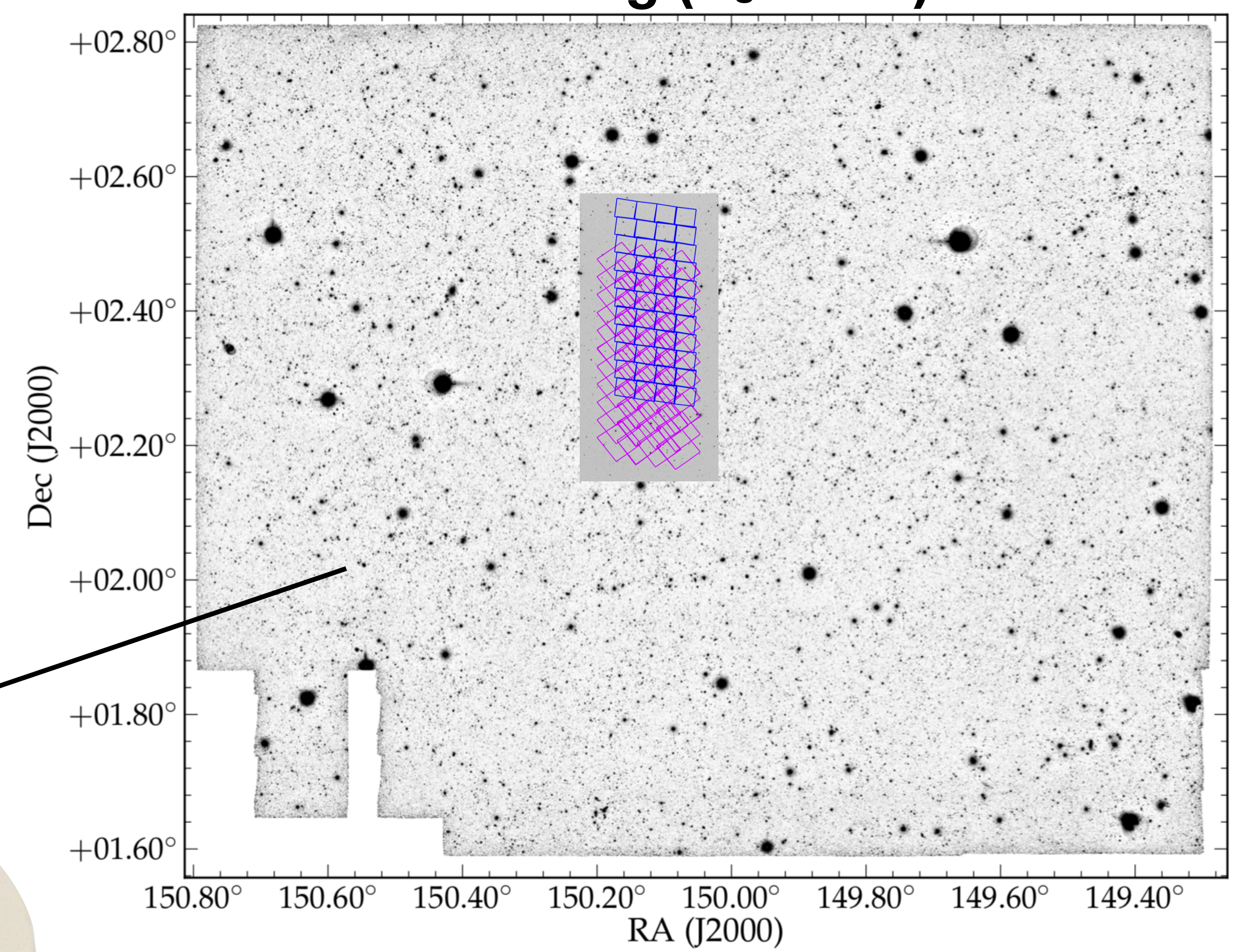

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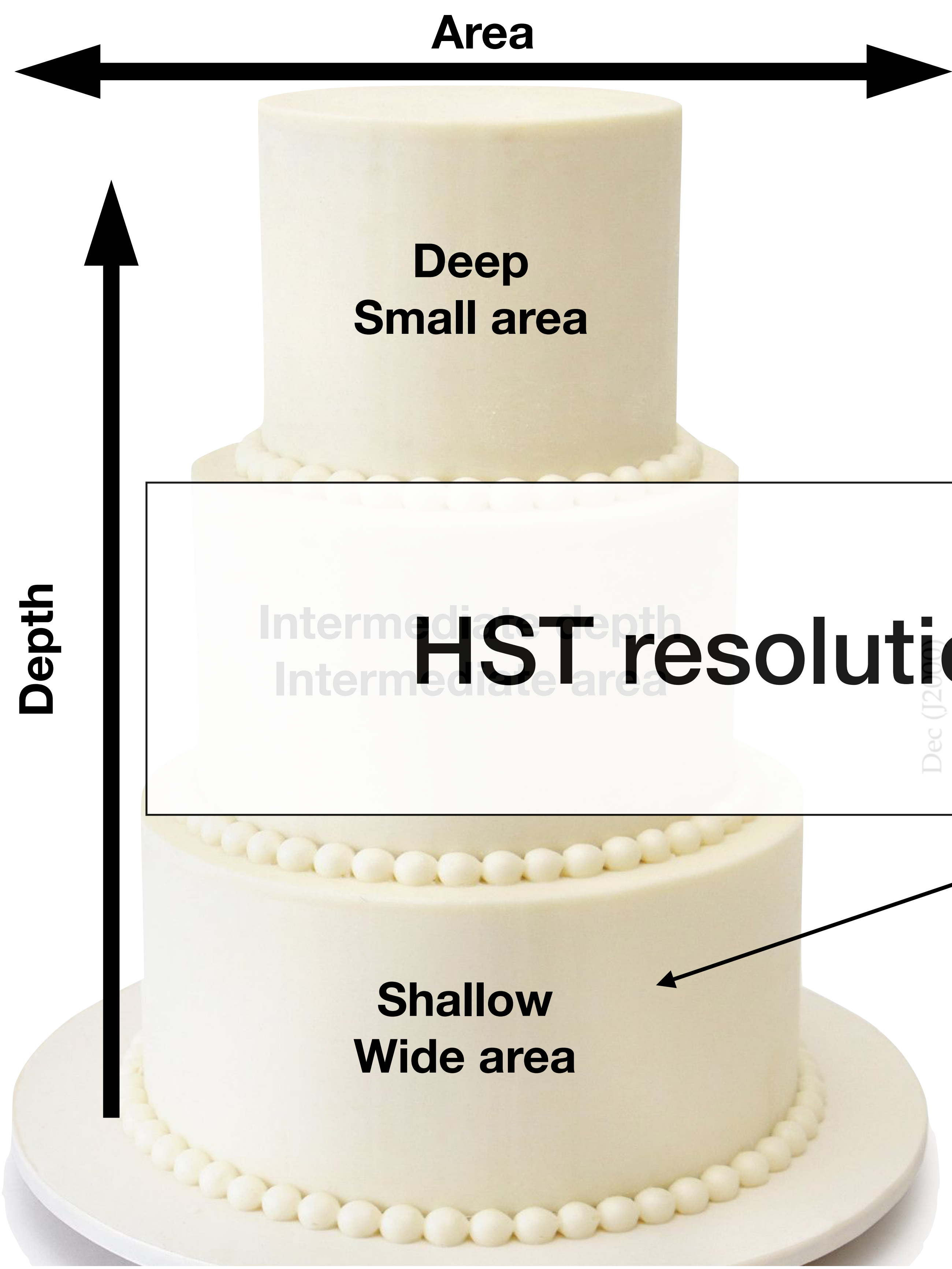

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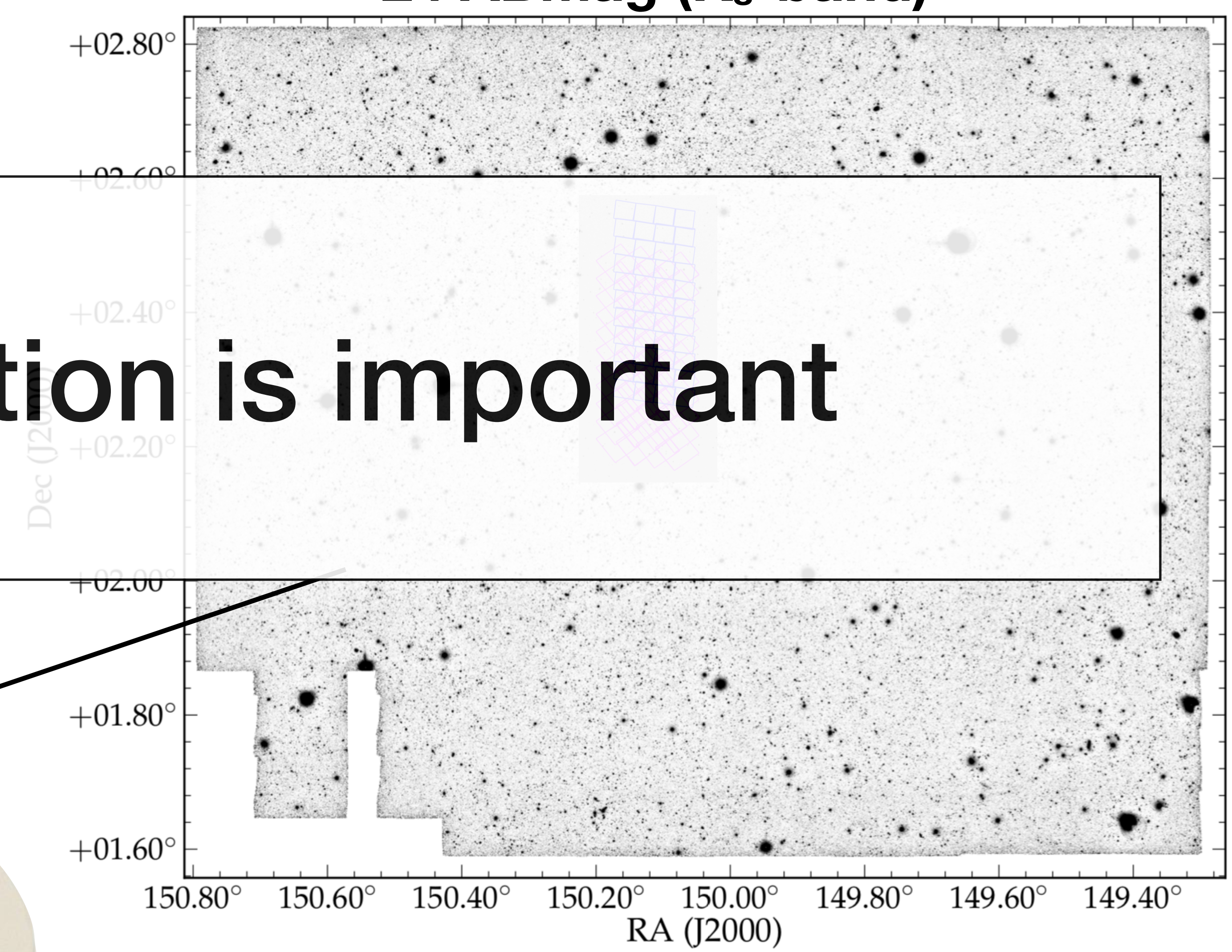

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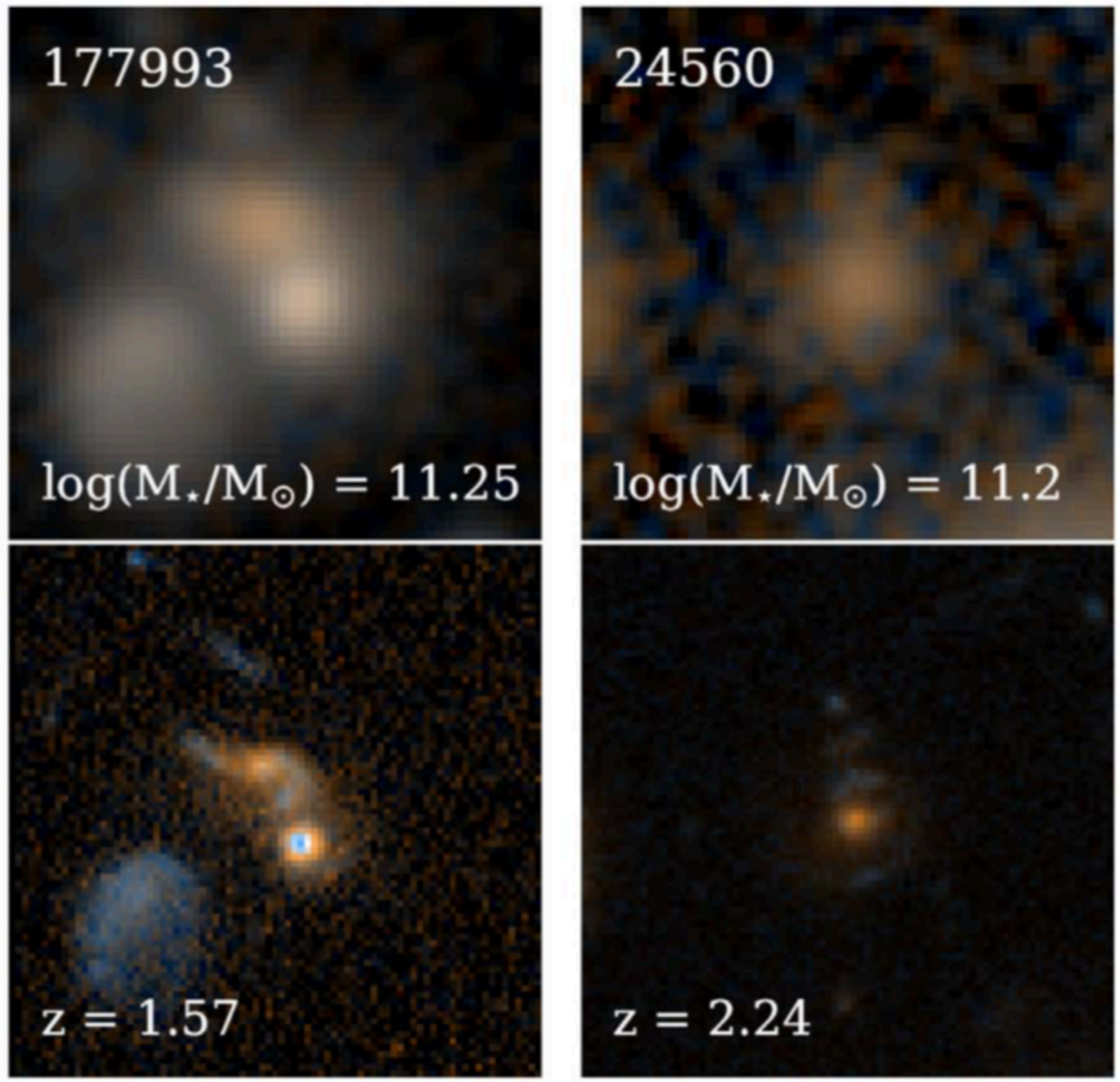
HST resolution is important

1) Morphologies require high resolution



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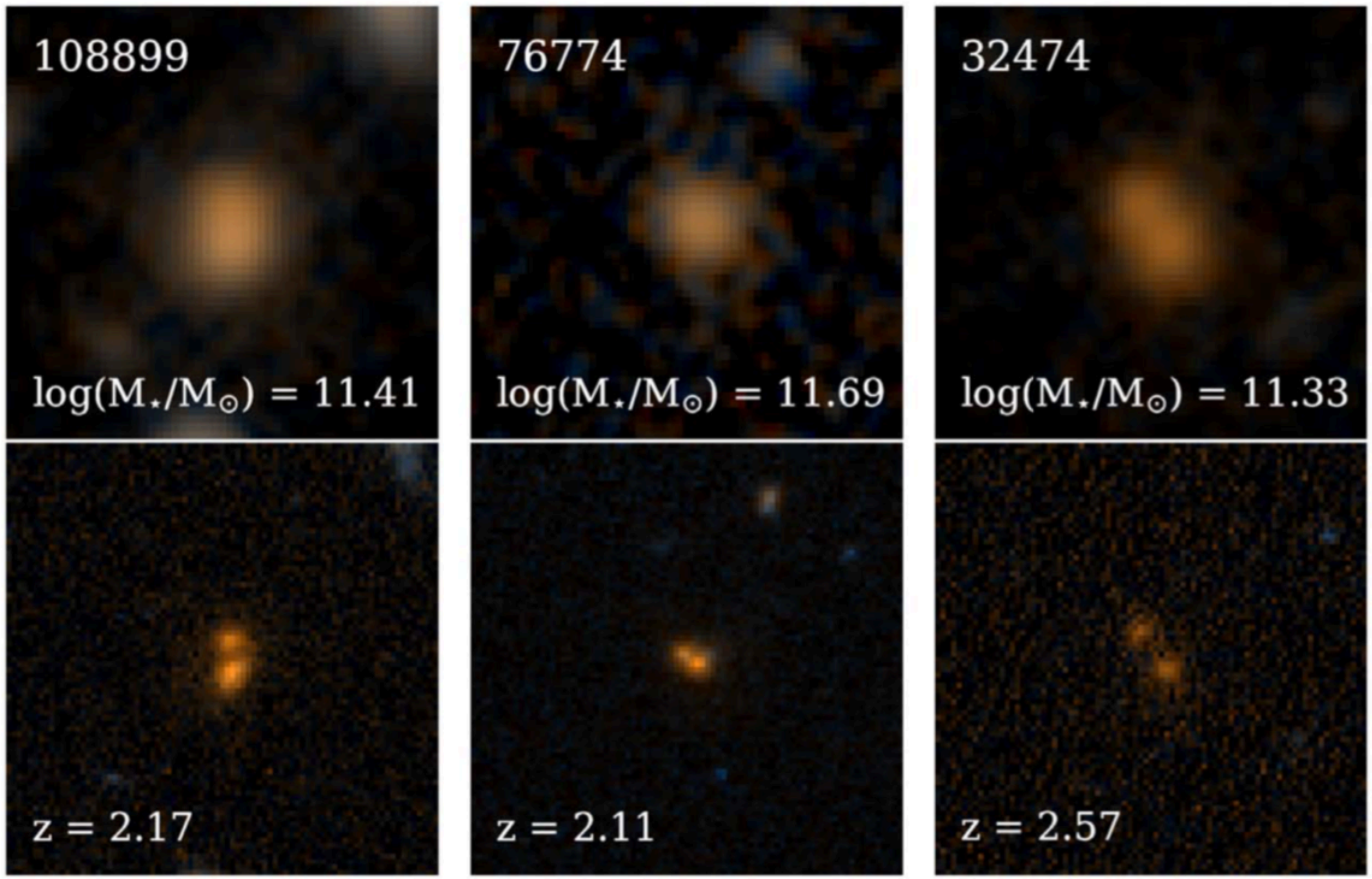
2) Blending significant at high redshift



Mowla+19

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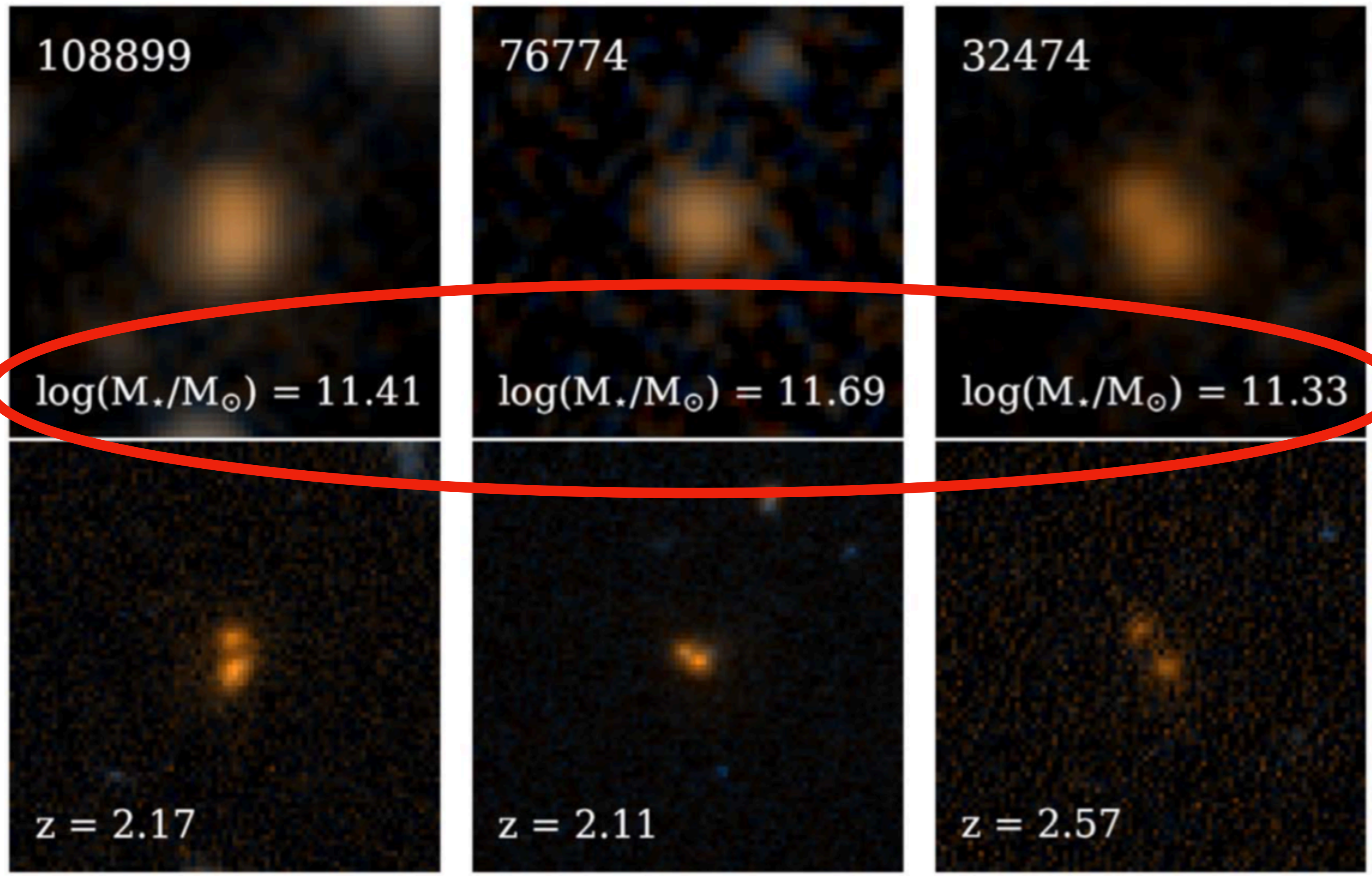

Masses overestimated

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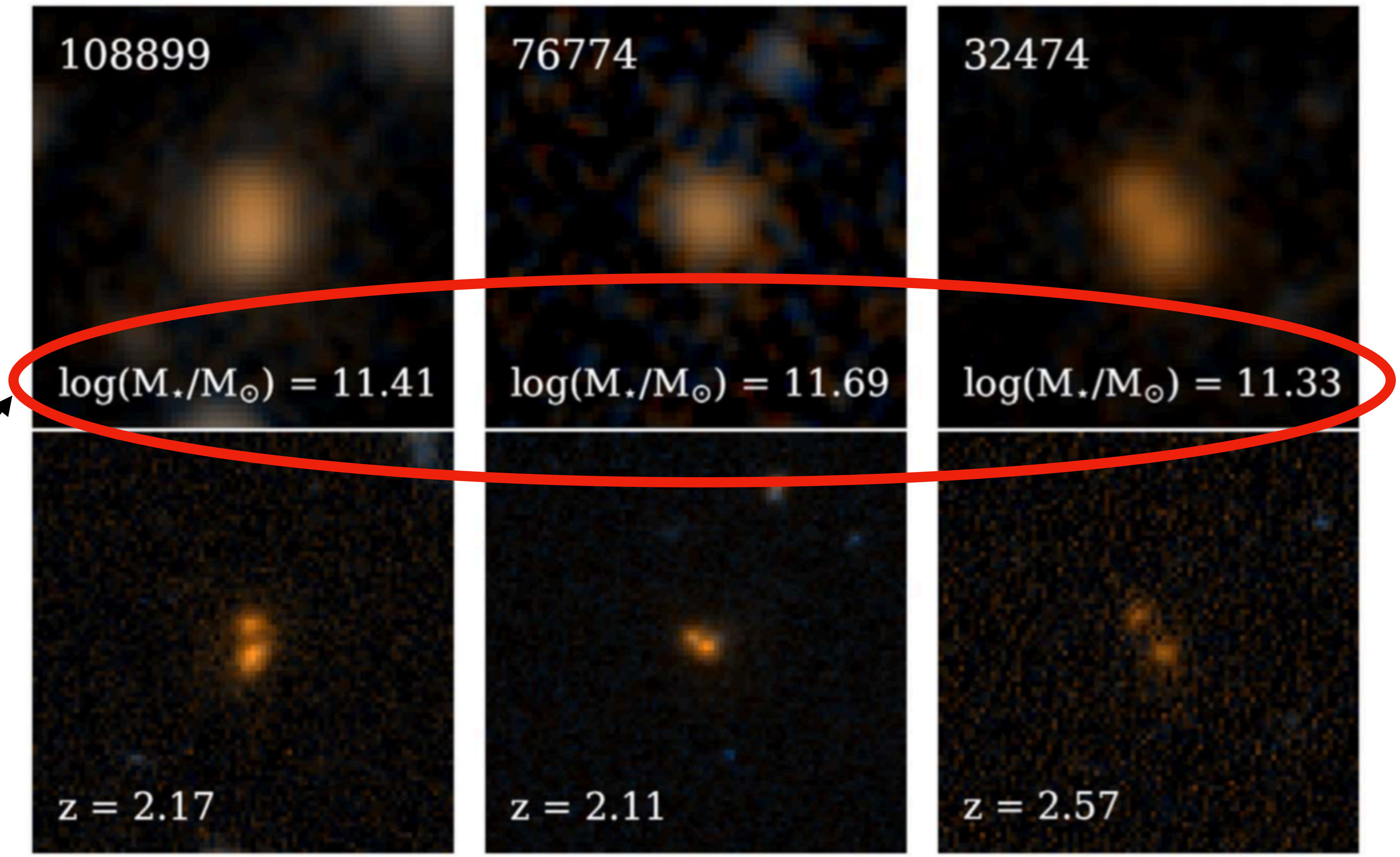
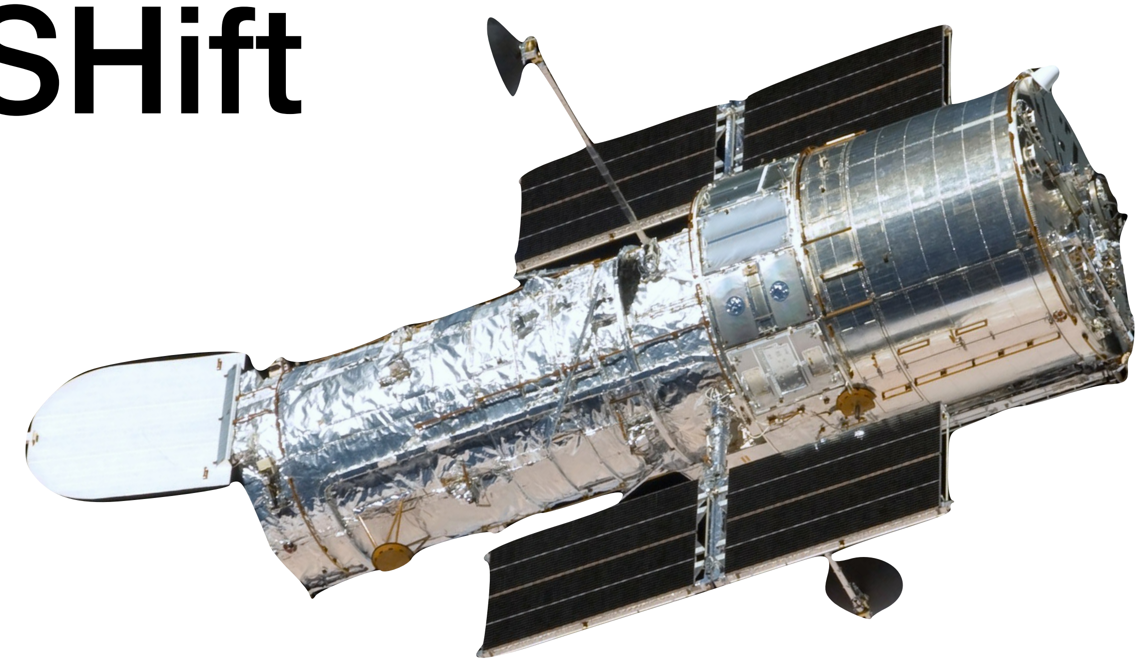


Masses overestimated

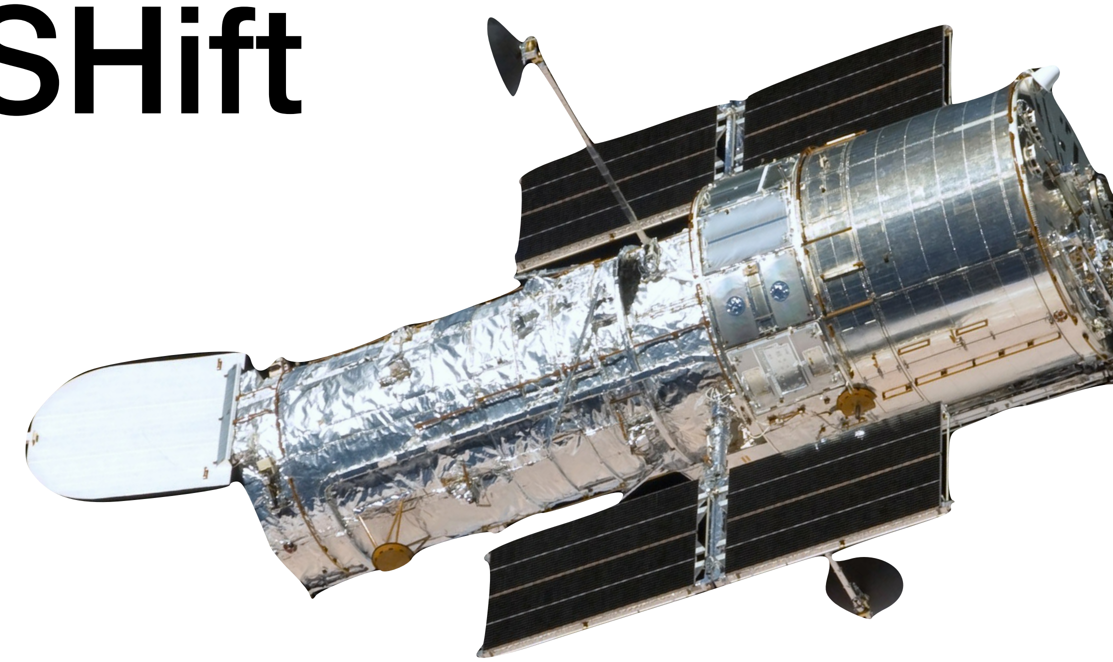
Mowla+19

Need wide field HST imaging…

Drift And SHift

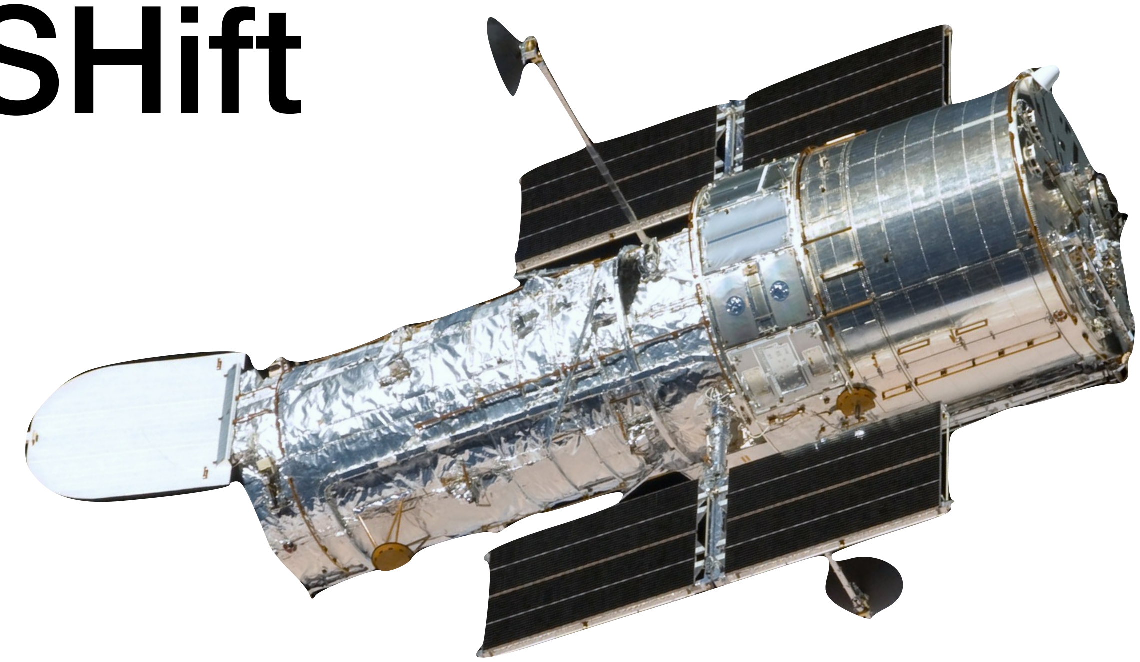


Drift And SHift



2 reasons for HST inefficiency:

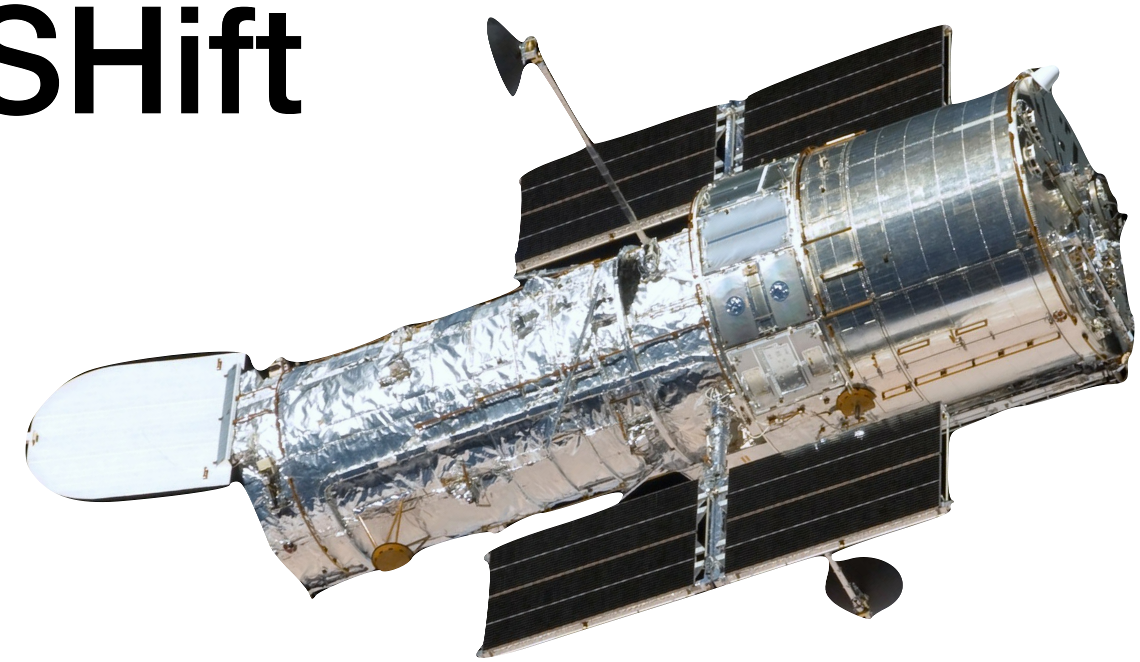
Drift And SHift



2 reasons for HST inefficiency:

1. 4.6” FOV (750 pointings/deg^2)

Drift And SHift



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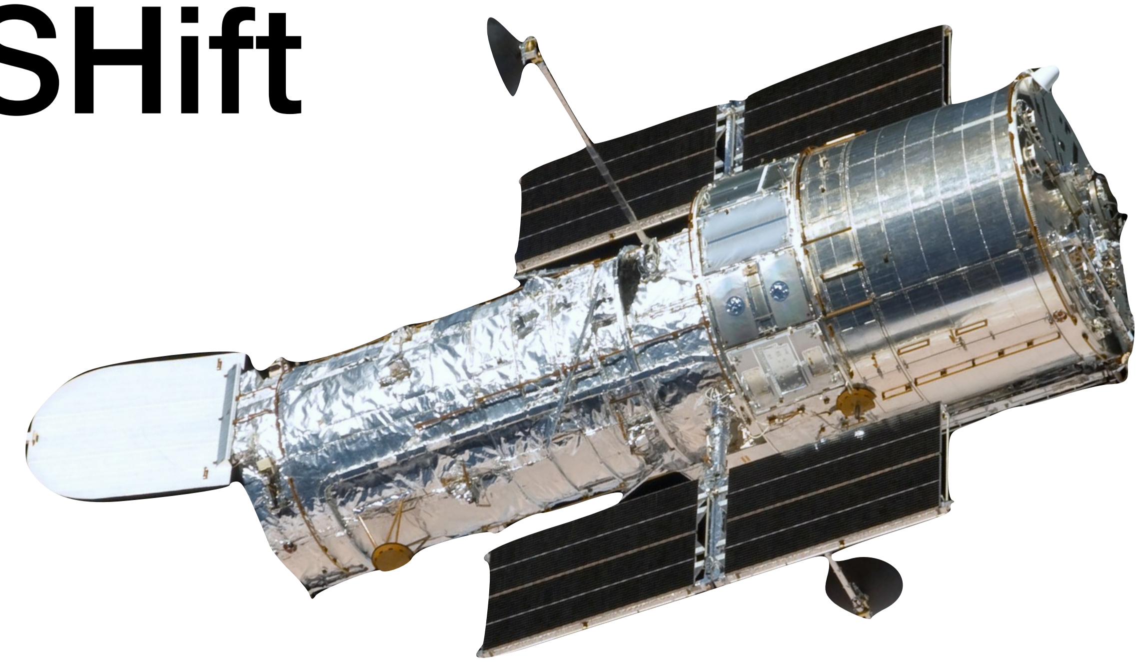
Drift And SHift



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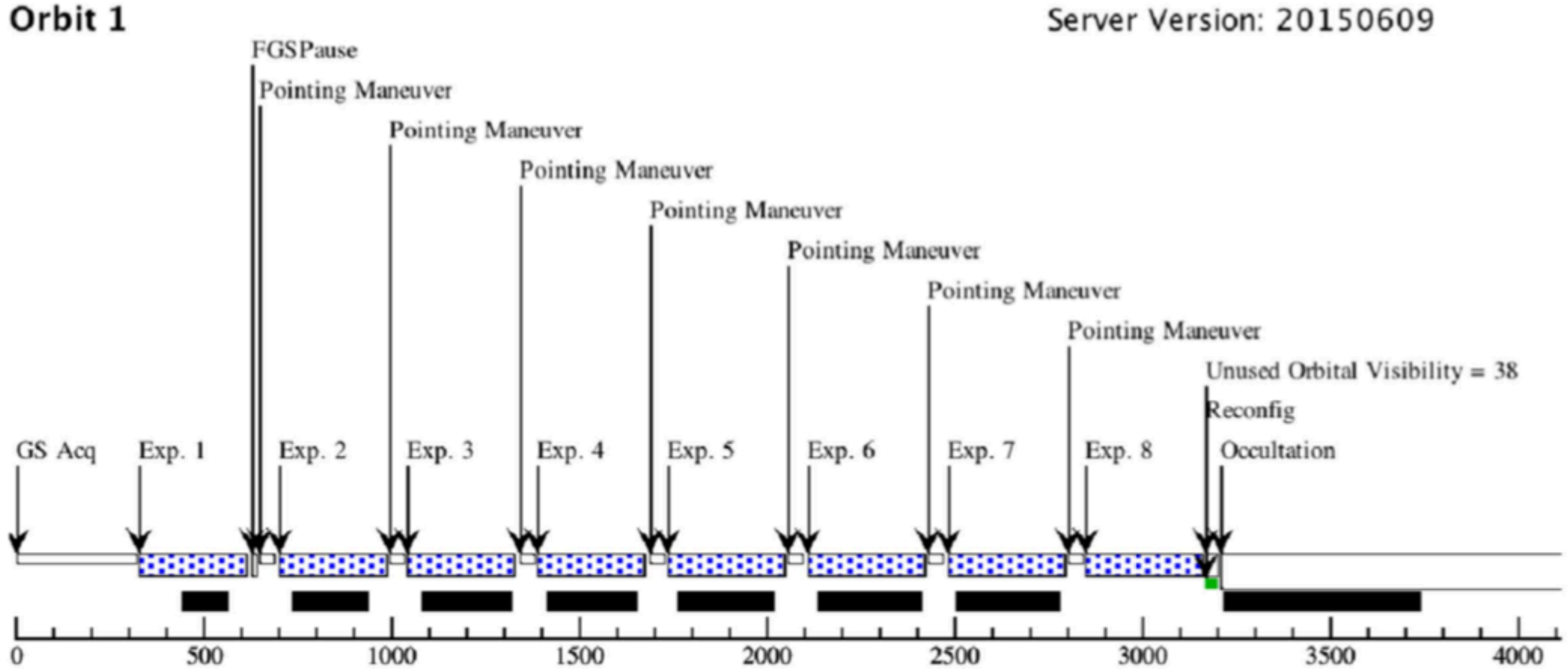

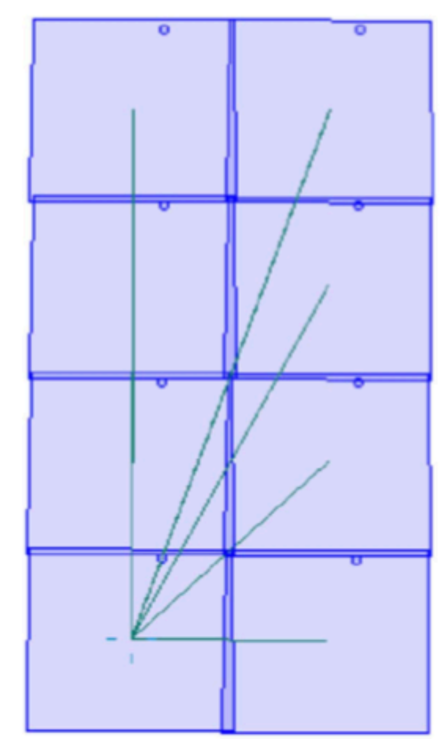

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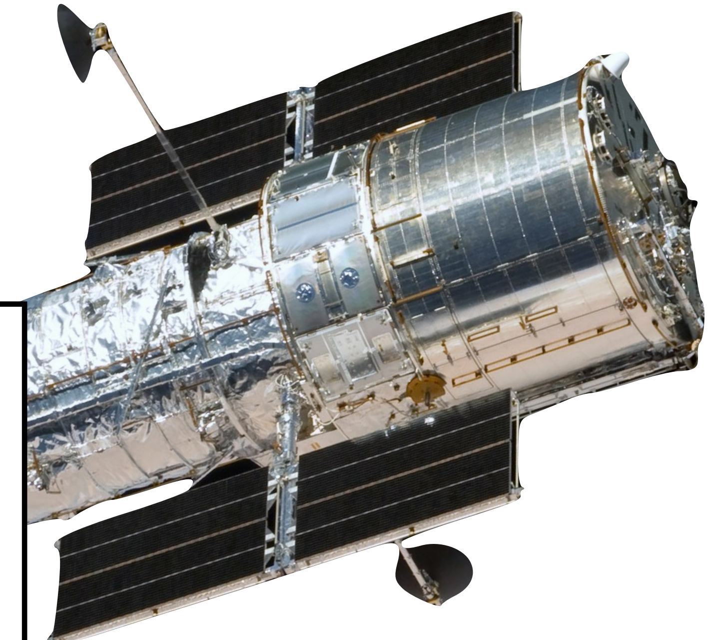
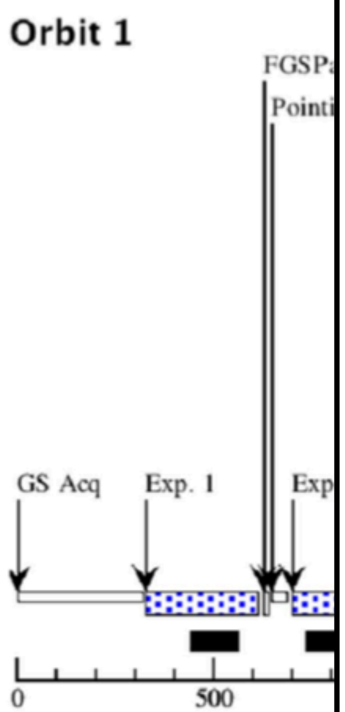
Drift And SHift

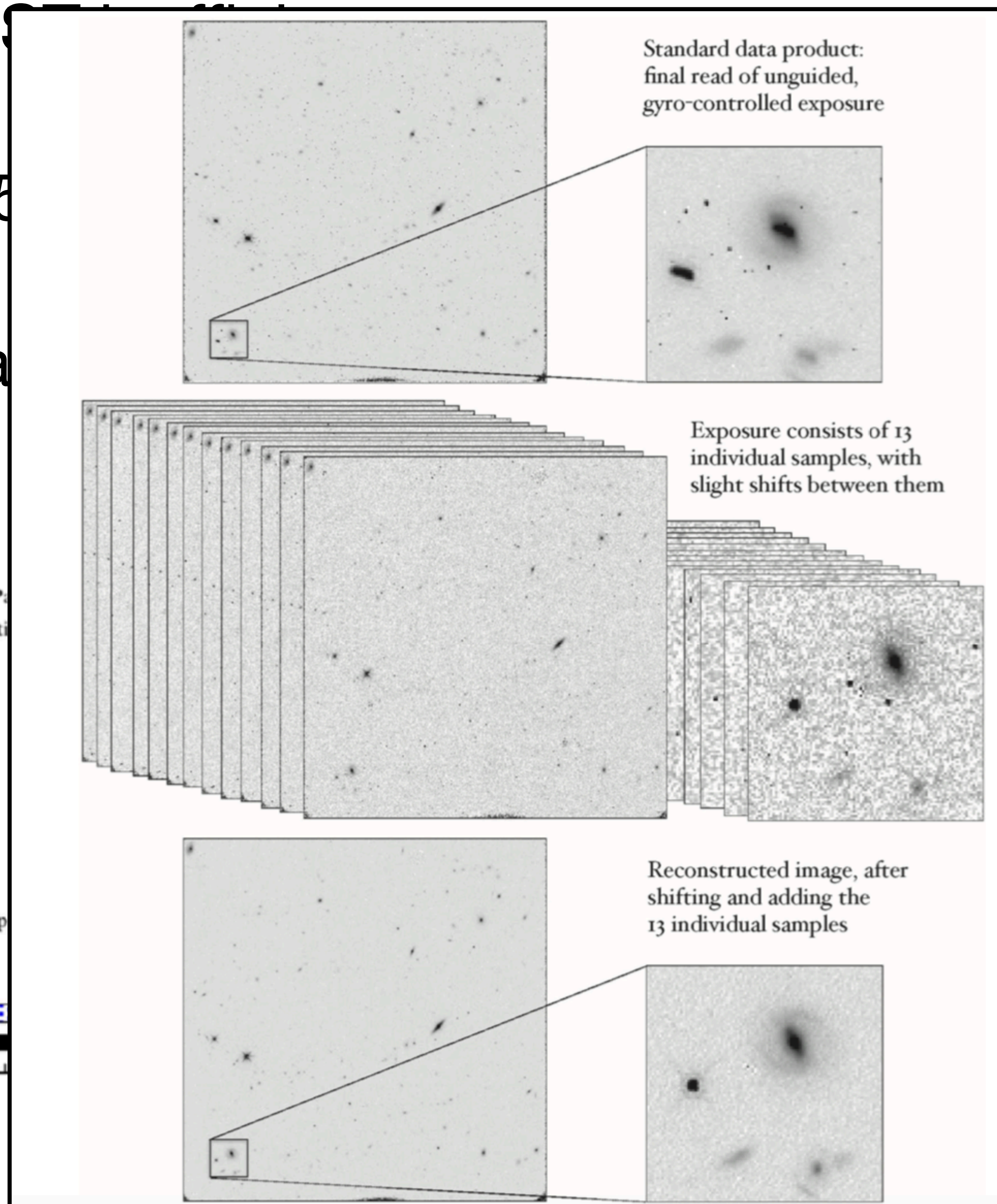


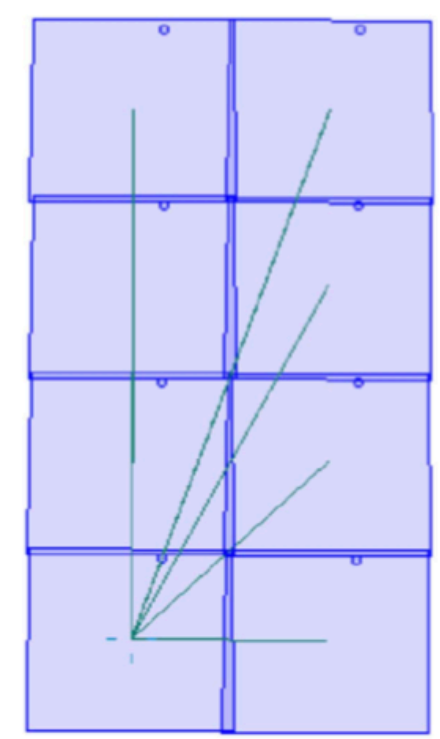
2 reasons for HS

1. 4.6” FOV (75

2. Guide star a nting/orbit)

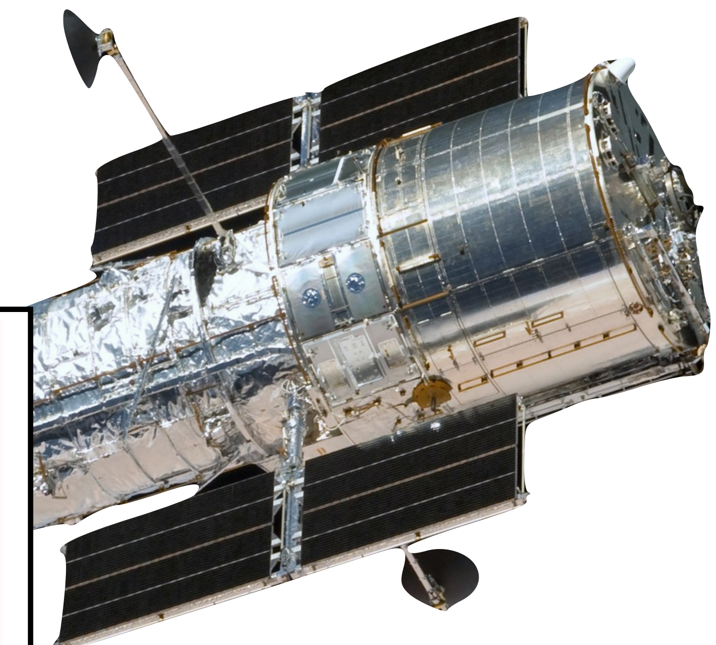






Momcheva+17

Drift And SHift



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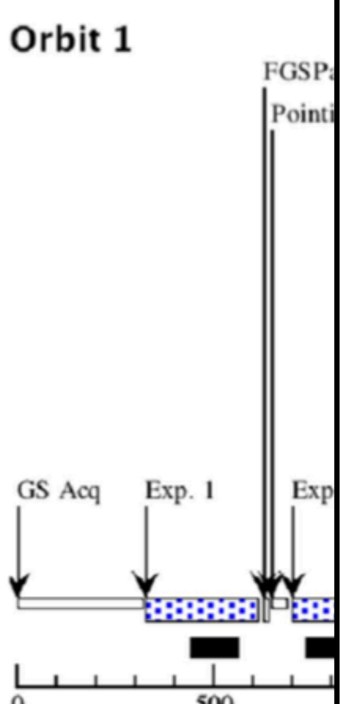
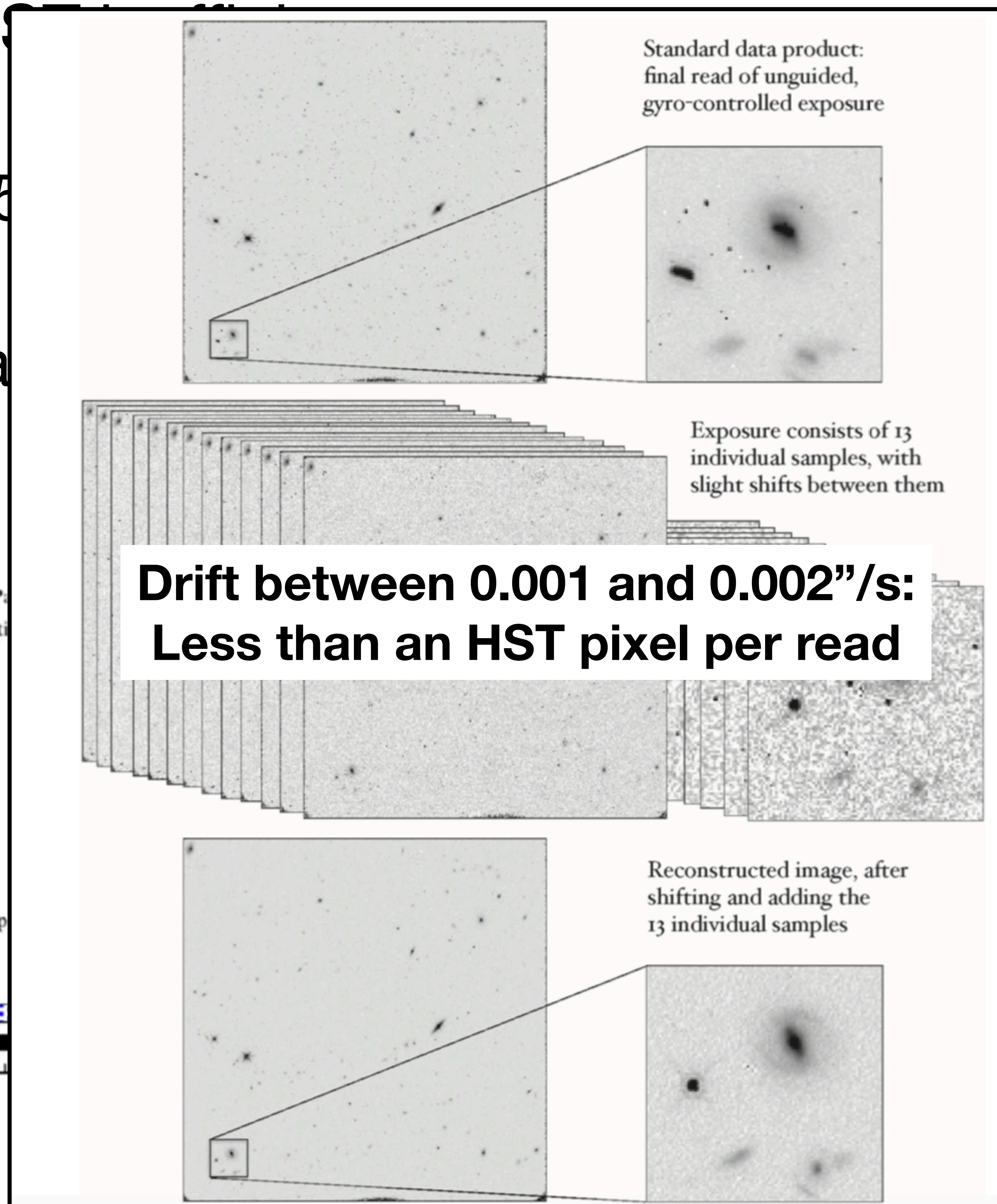
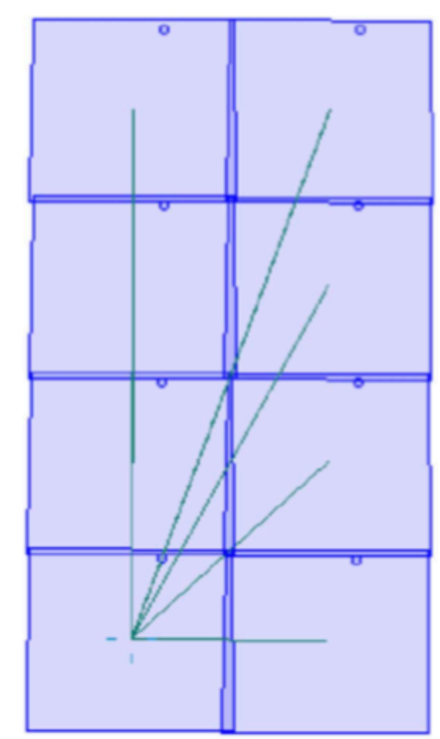




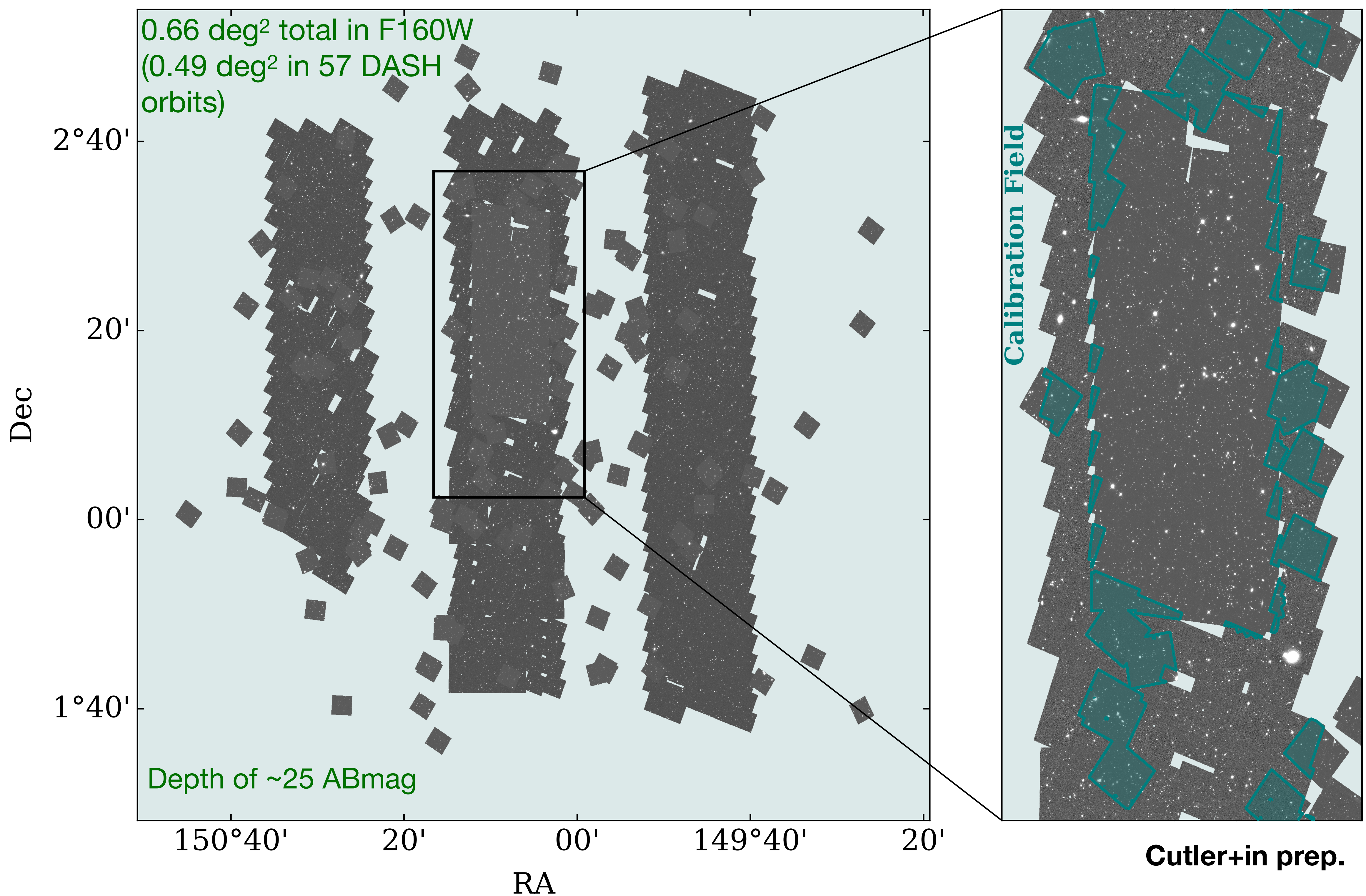
Drift between 0.001 and 0.002”/s: Less than an HST pixel per read



Momcheva+17

COSMOS-DASH Survey

HST-GO-14114, PI: P. van Dokkum



Cutler+in prep.

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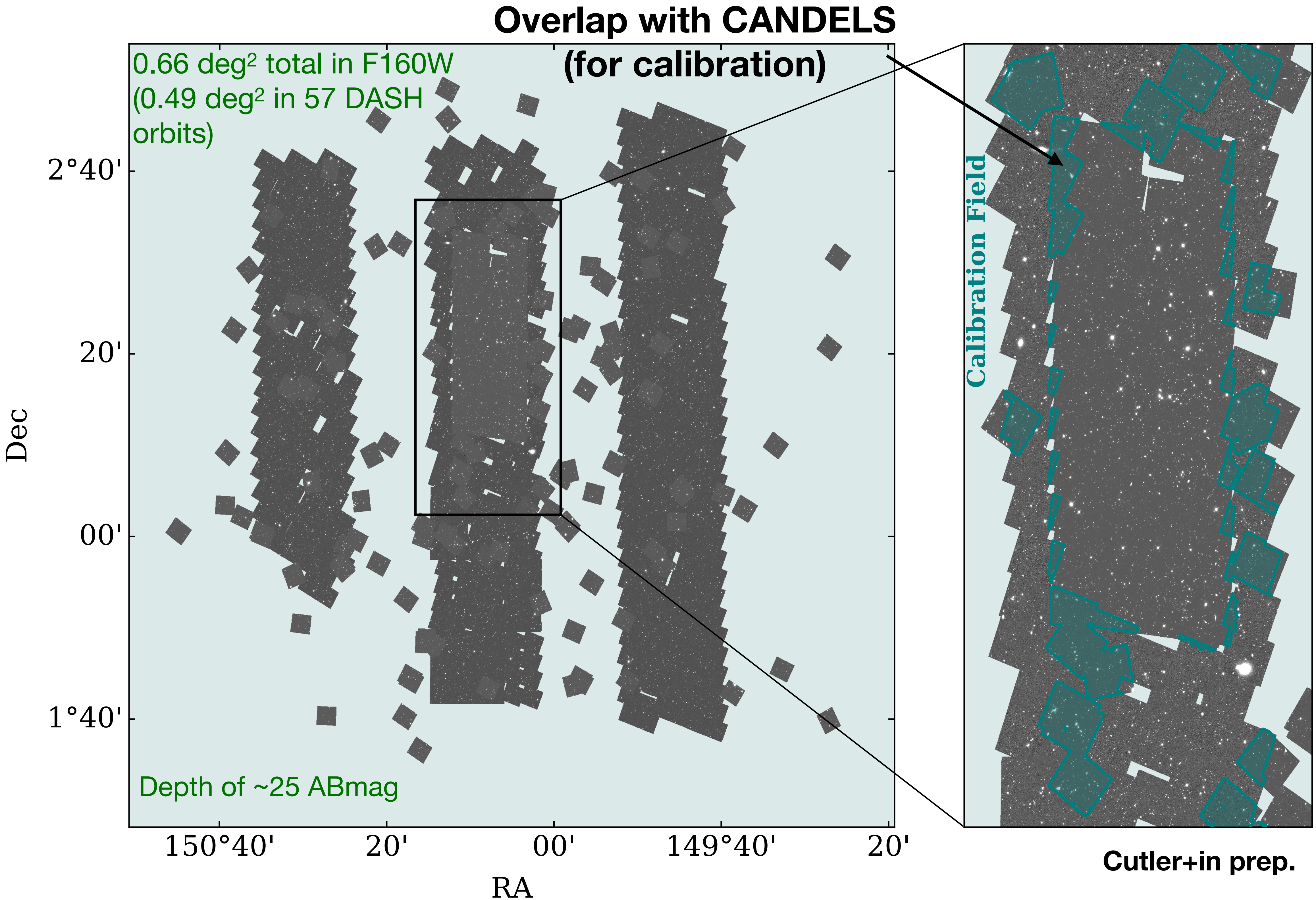

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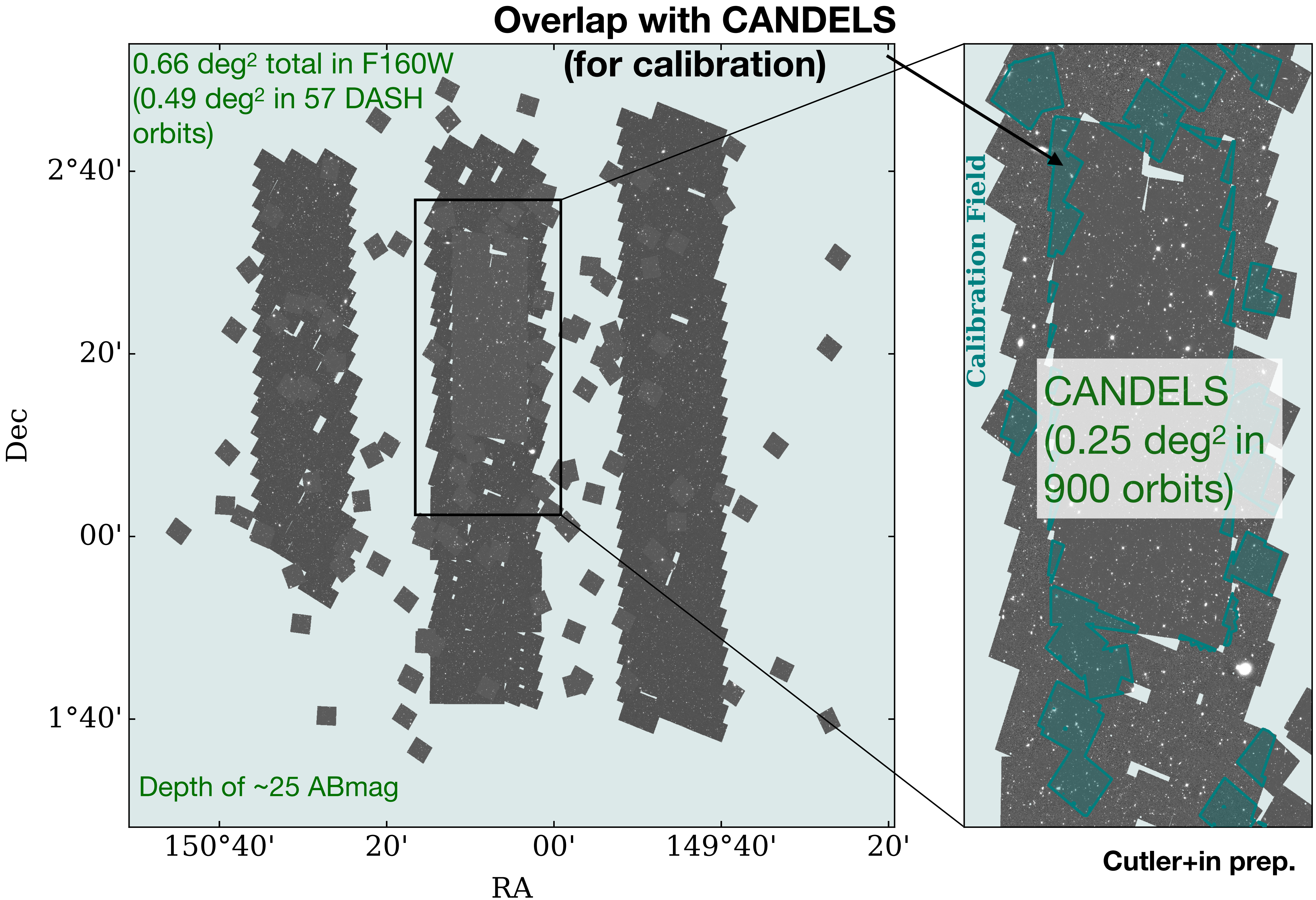

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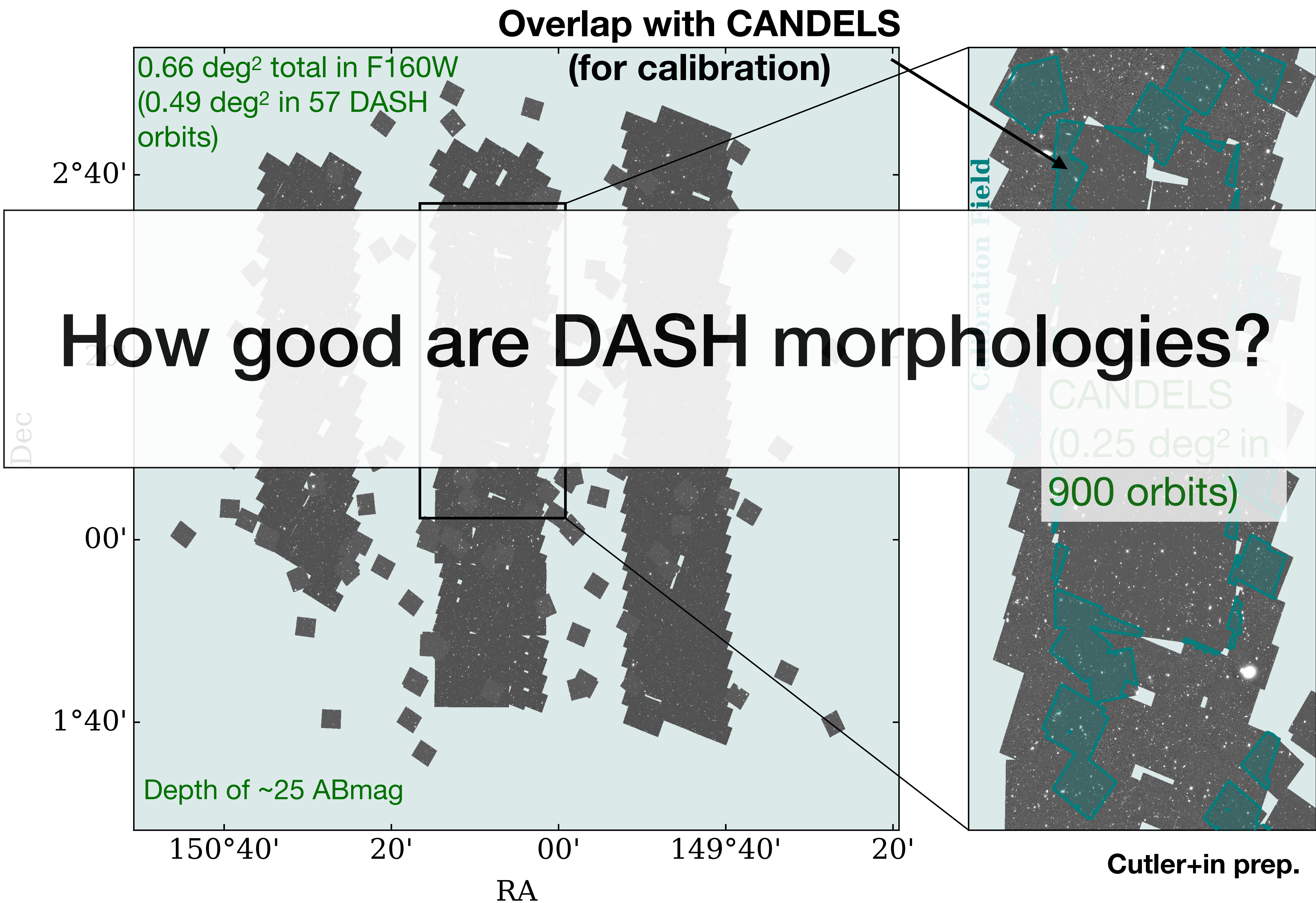


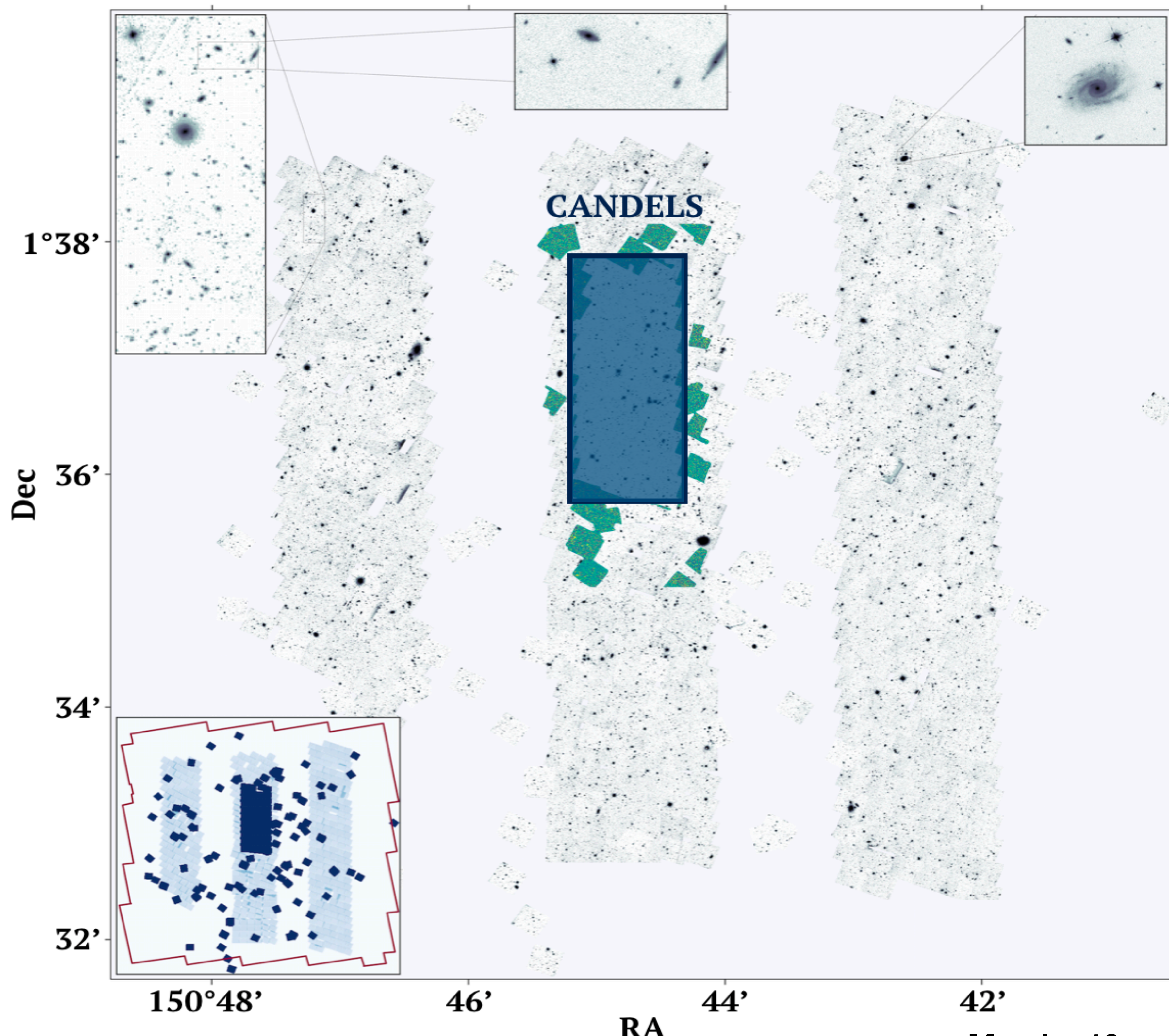
Cutler+in prep.

How good are DASH morphologies?

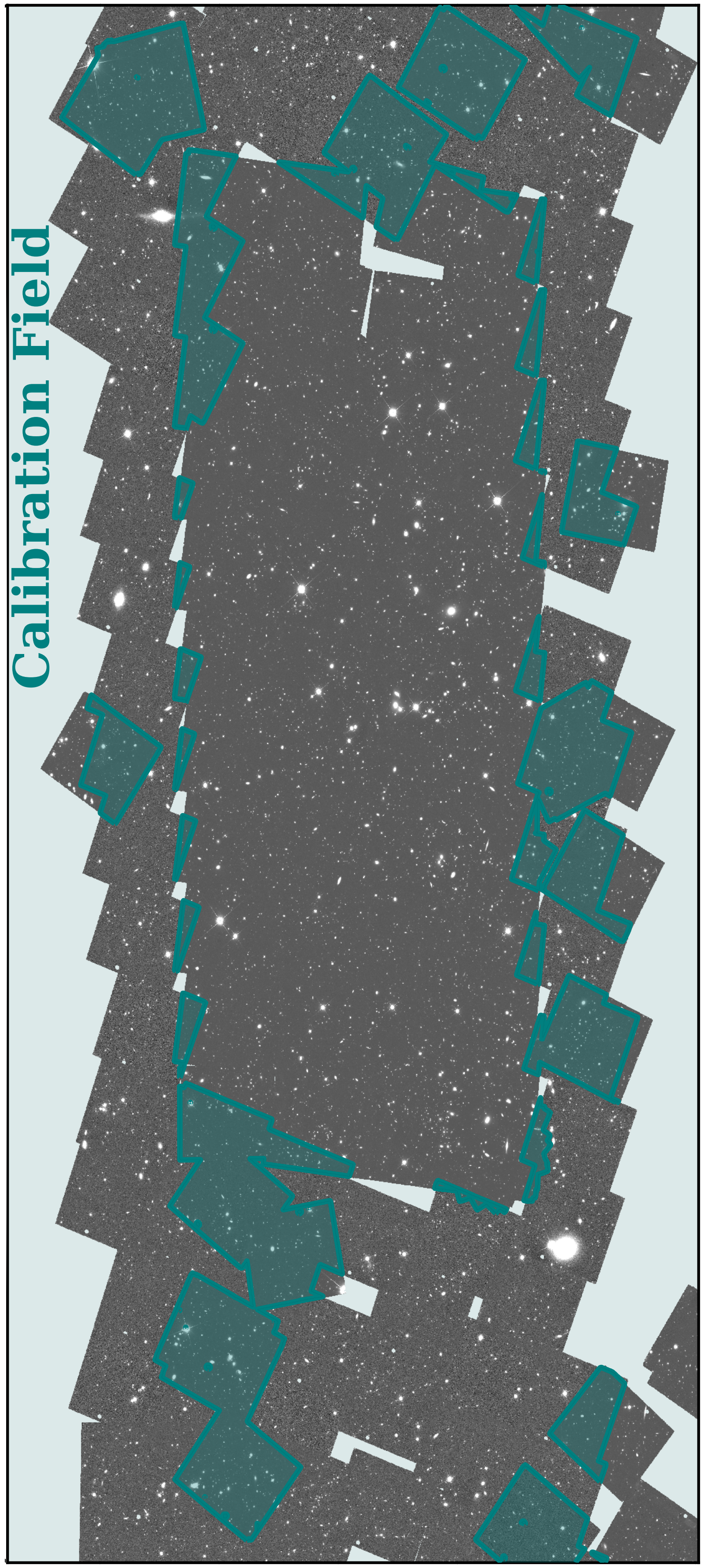
COSMOS-DASH Sample

Cross match *HST* selected photometric catalog to UltraVISTA (Exclude galaxies in CANDELS)

SNR>10 identifies 51,534 galaxies total in our catalog



Mowla+19



Calibration Field

Cross match to CANDELS morphological catalog

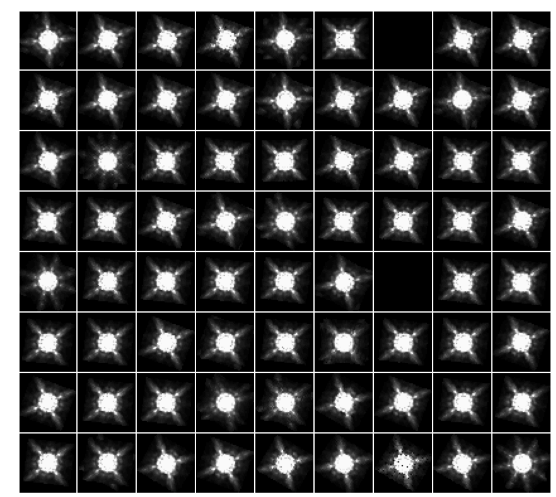
SNR>5 identifies 483 galaxies total

CANDELS- and DASH-only reductions to constrain and estimate parameter error on DASH morphologies

GALFIT Pipeline

1. Image and segmentation cutouts with *Montage*

2. *SExtractor* (Bertin & Arnouts 1996) to get initial guesses



3. PSFs with *grizli* (Brammer 2019)

4. Sérsic model fit with *GALFIT* (Peng et al. 2002)

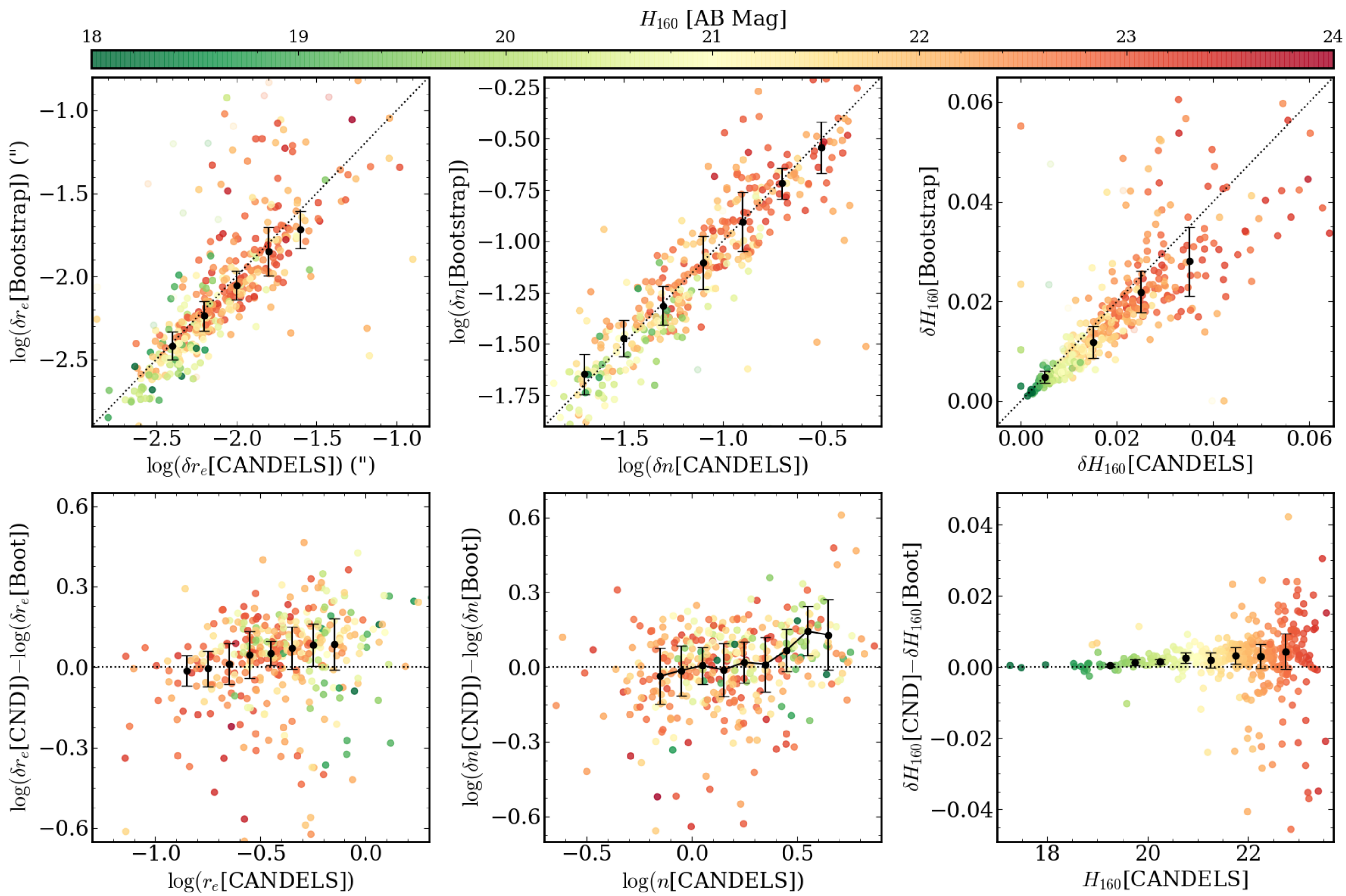
5. Tabulate and flag model parameters

```
# ID RA DEC flag use mag dmag re dre n dn q dq pa dpa kron f_F160W_auto
e_F160W_auto f_F160W_tot e_F160W_tot snr flag_limit_r flag_limit_n
5_sigma_depth chi chi_nu
# ID: Object identifier from UVISTA DR2 catalog
# RA,DEC: Right ascension and declination (J2000; decimal degrees)
# flag: 0=good, 1=suspicious, 2=bad, 3=failed, 4=no coverage (see Cutler et
al.)
# use: 1=Galfit flag<2,re>FWHM (see Cutler et al.)
# mag: GALFIT best-fit magnitude
# dmag: Uncertainty in GALFIT magnitude
# re: GALFIT best-fit effective (half-light) radius in arcsec
# dre: Uncertainty in GALFIT effective radius in arcsec
# n: GALFIT best-fit Sersic index
```

Parameter Errors

Fit 483 galaxies in DASH- and CANDELS-only reductions of calibration field

Use bootstrapping to estimate errors (noise map+empty apertures)



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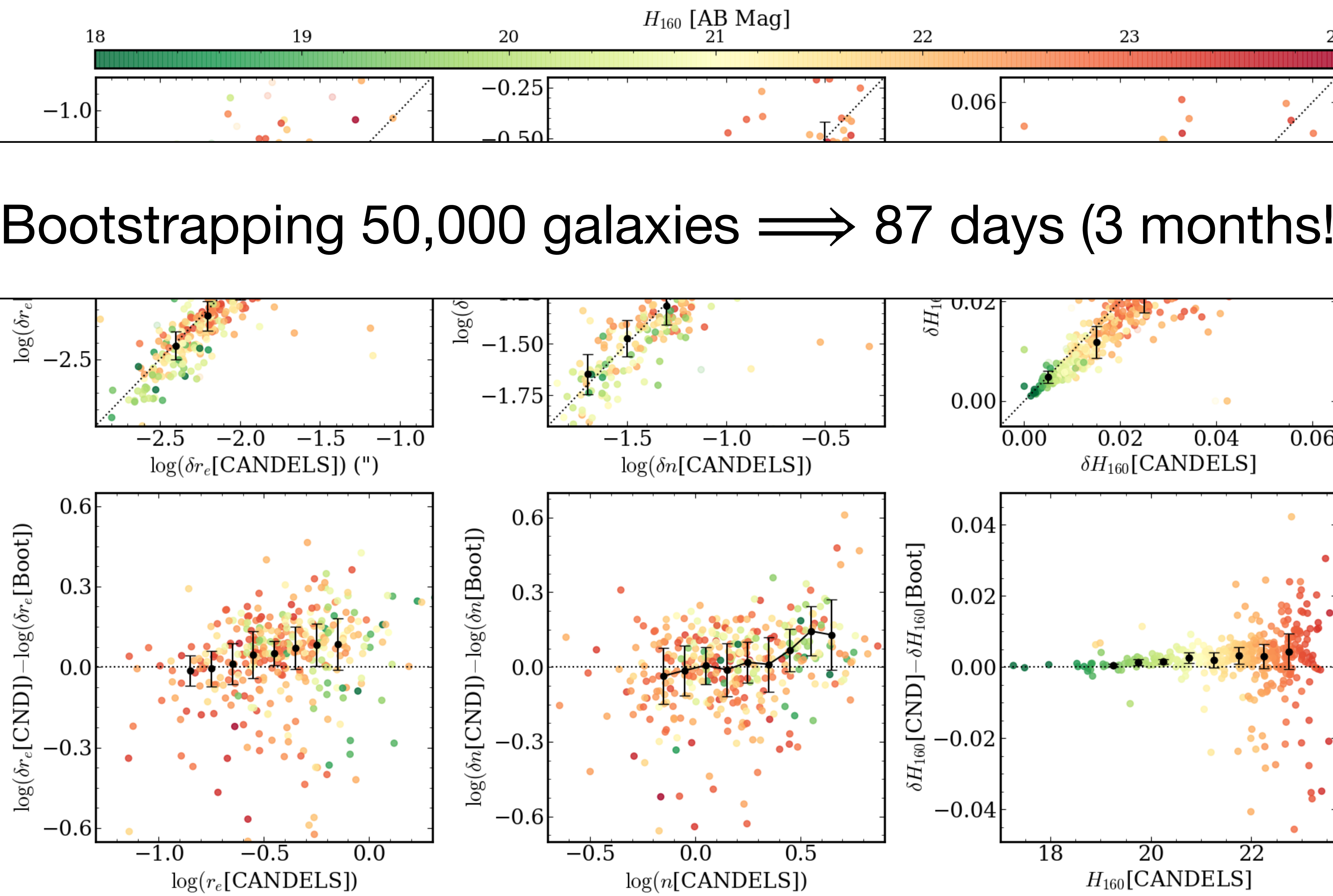

Bootstrapping 50,000 galaxies $\Longrightarrow$ 87 days (3 months!)

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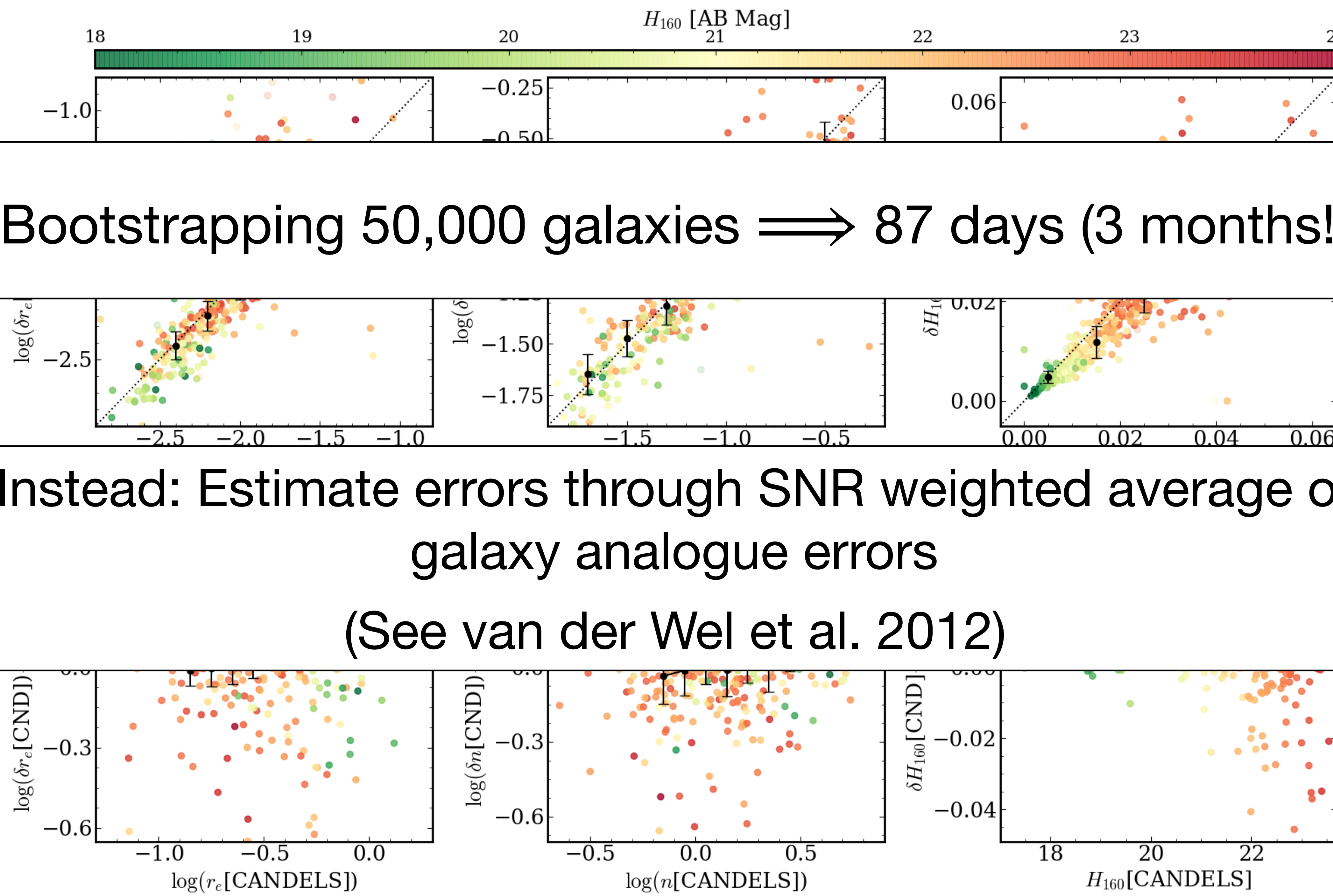
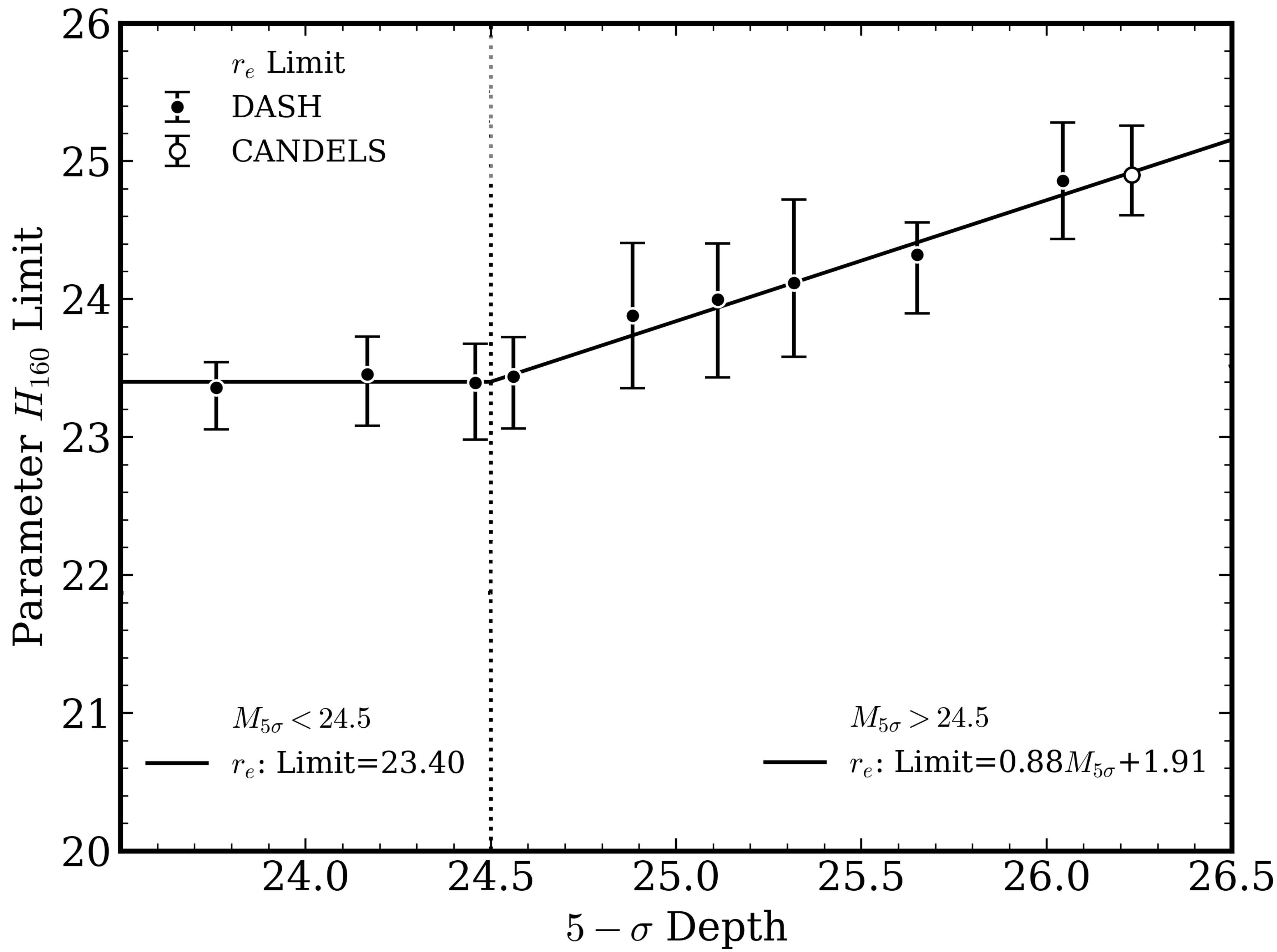


Bootstrapping 50,000 galaxies $\Longrightarrow$ 87 days (3 months!)

Instead: Estimate errors through SNR weighted average of galaxy analogue errors

(See van der Wel et al. 2012)

Magnitude Limits



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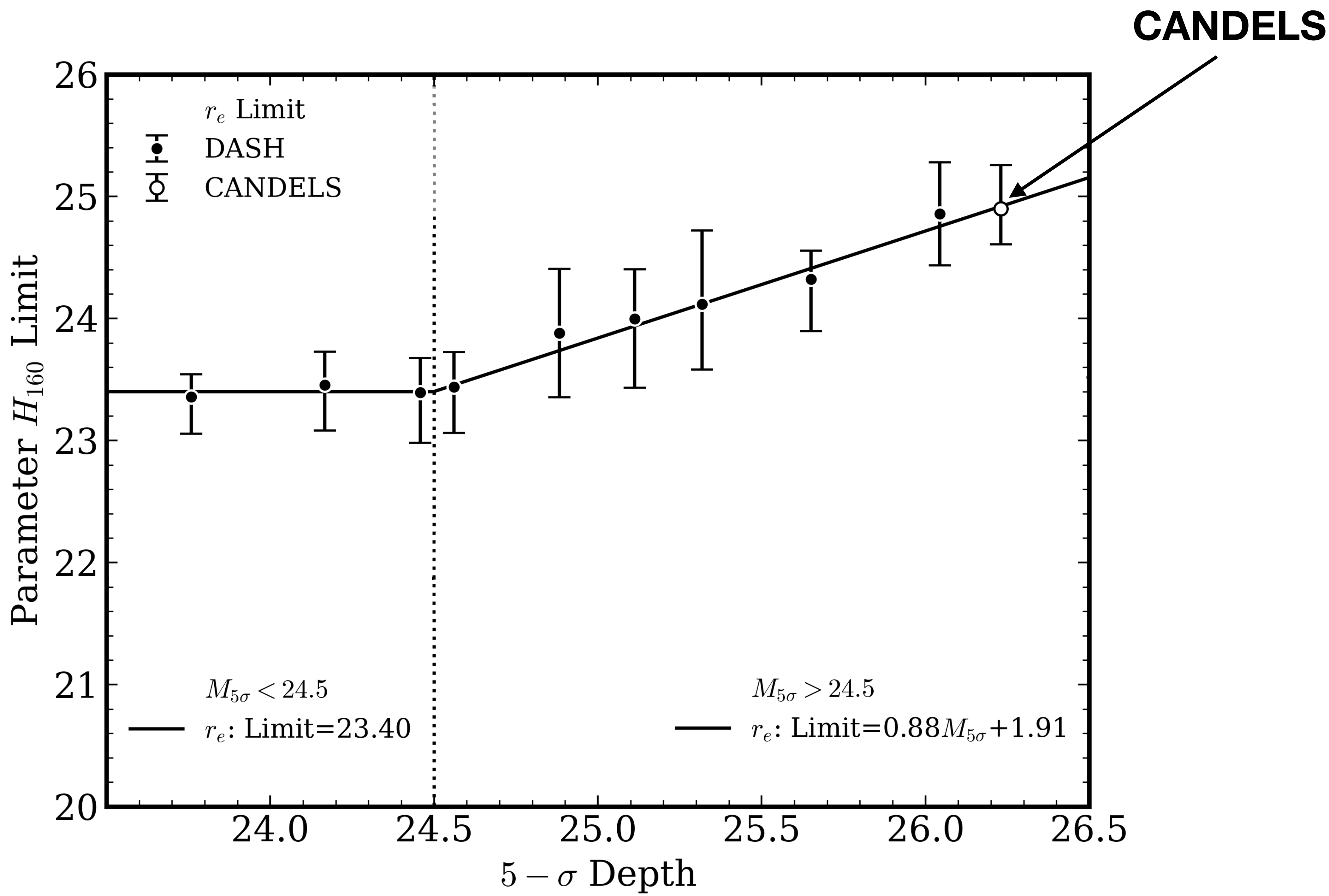

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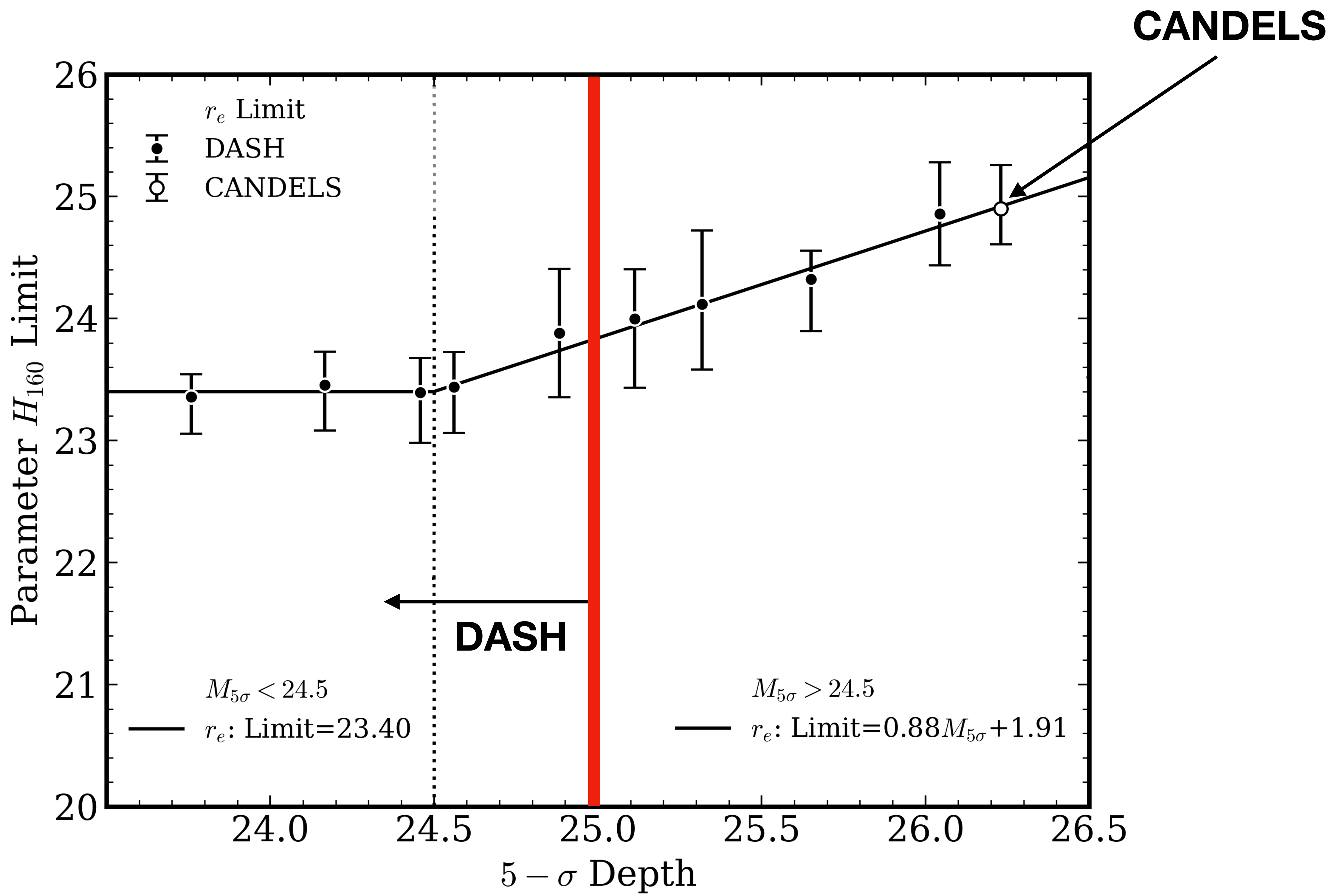

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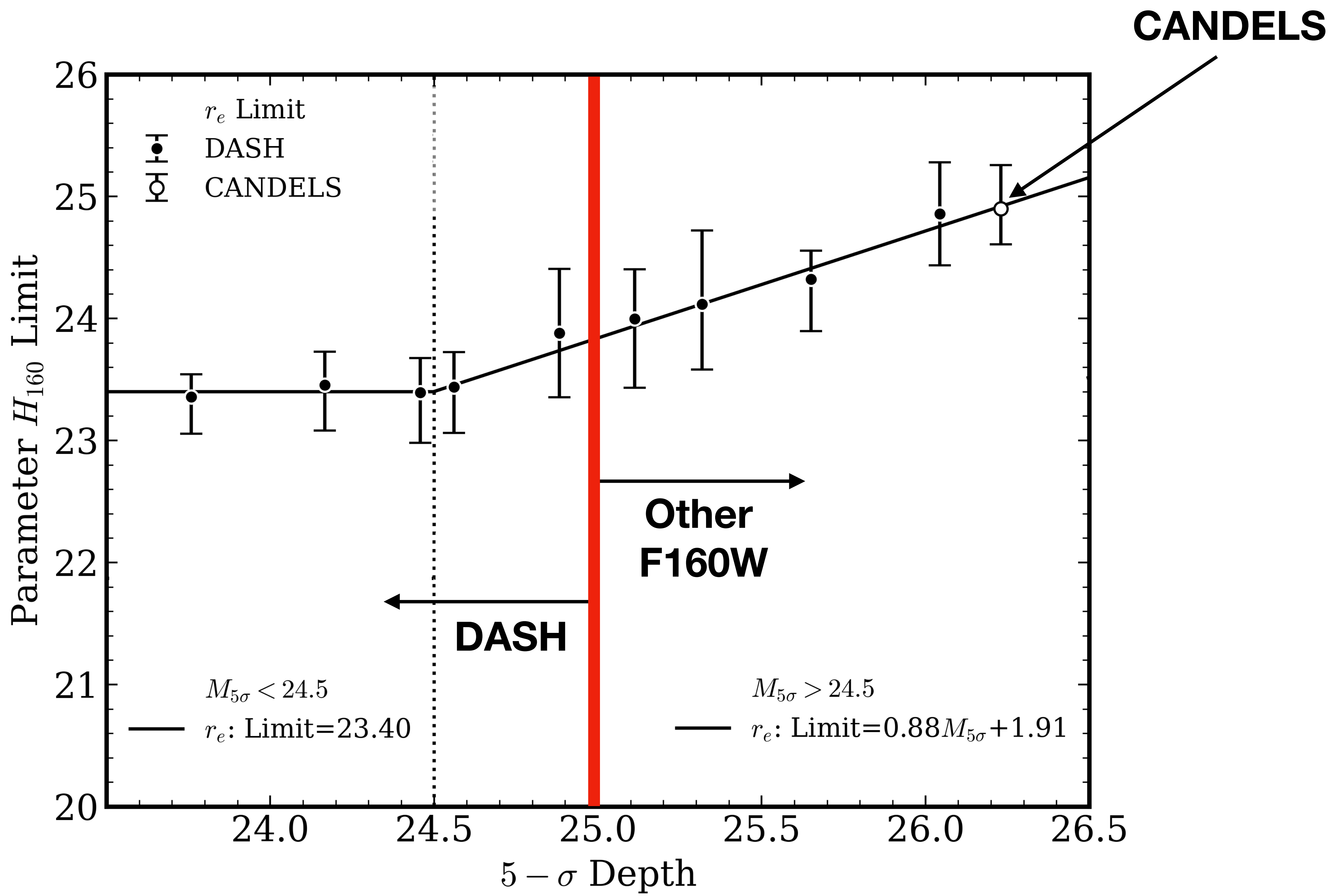

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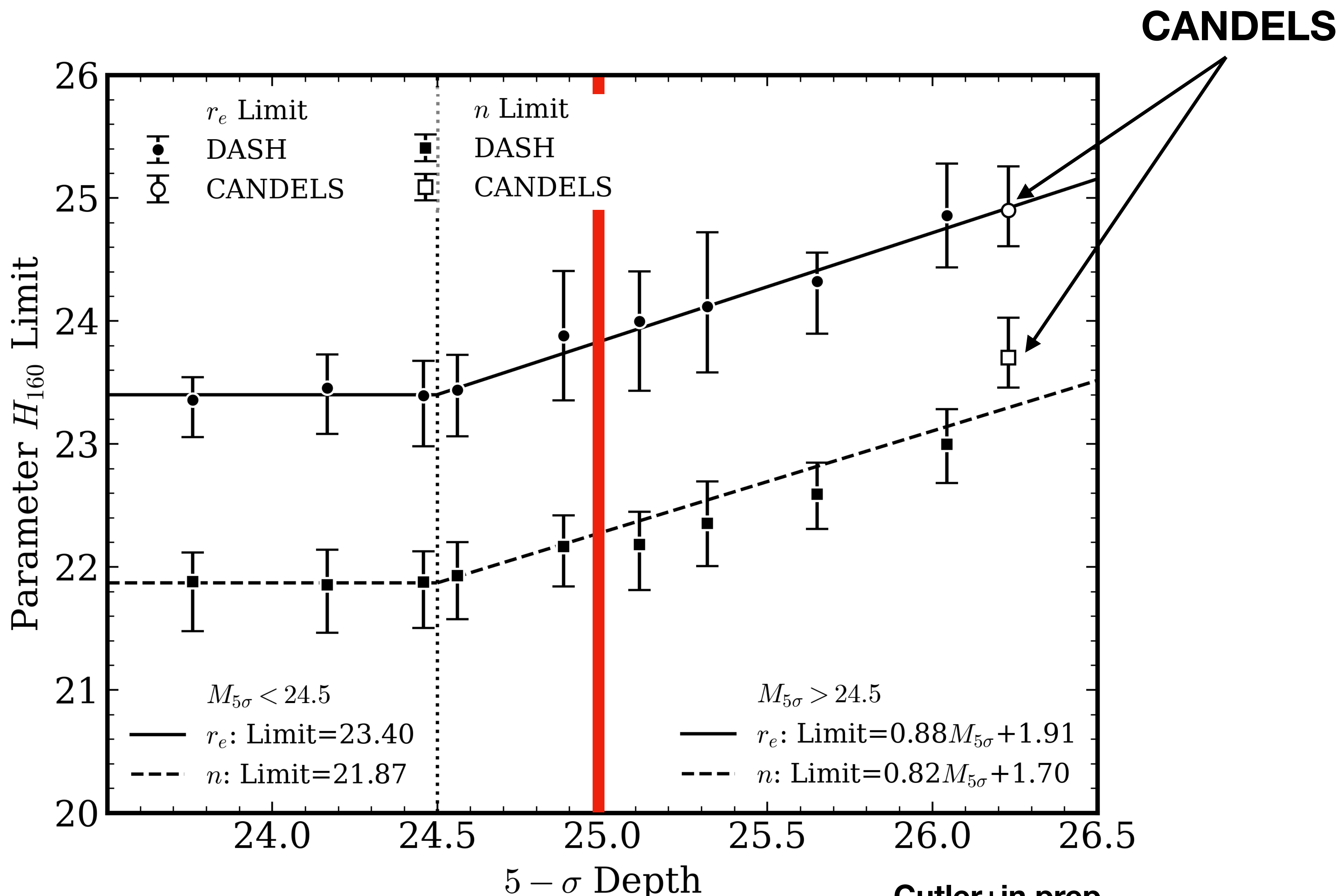
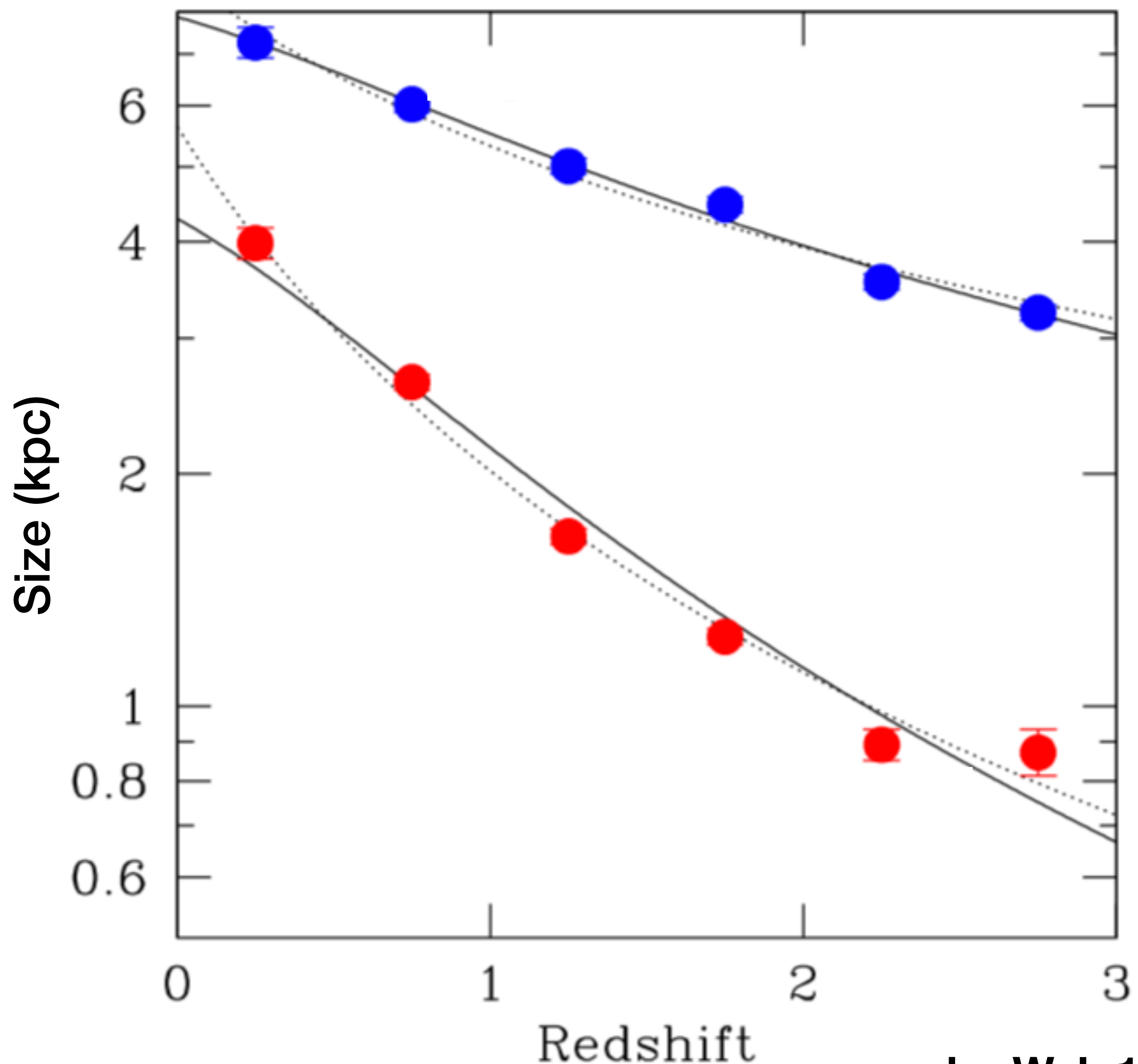


Cutler+in prep.

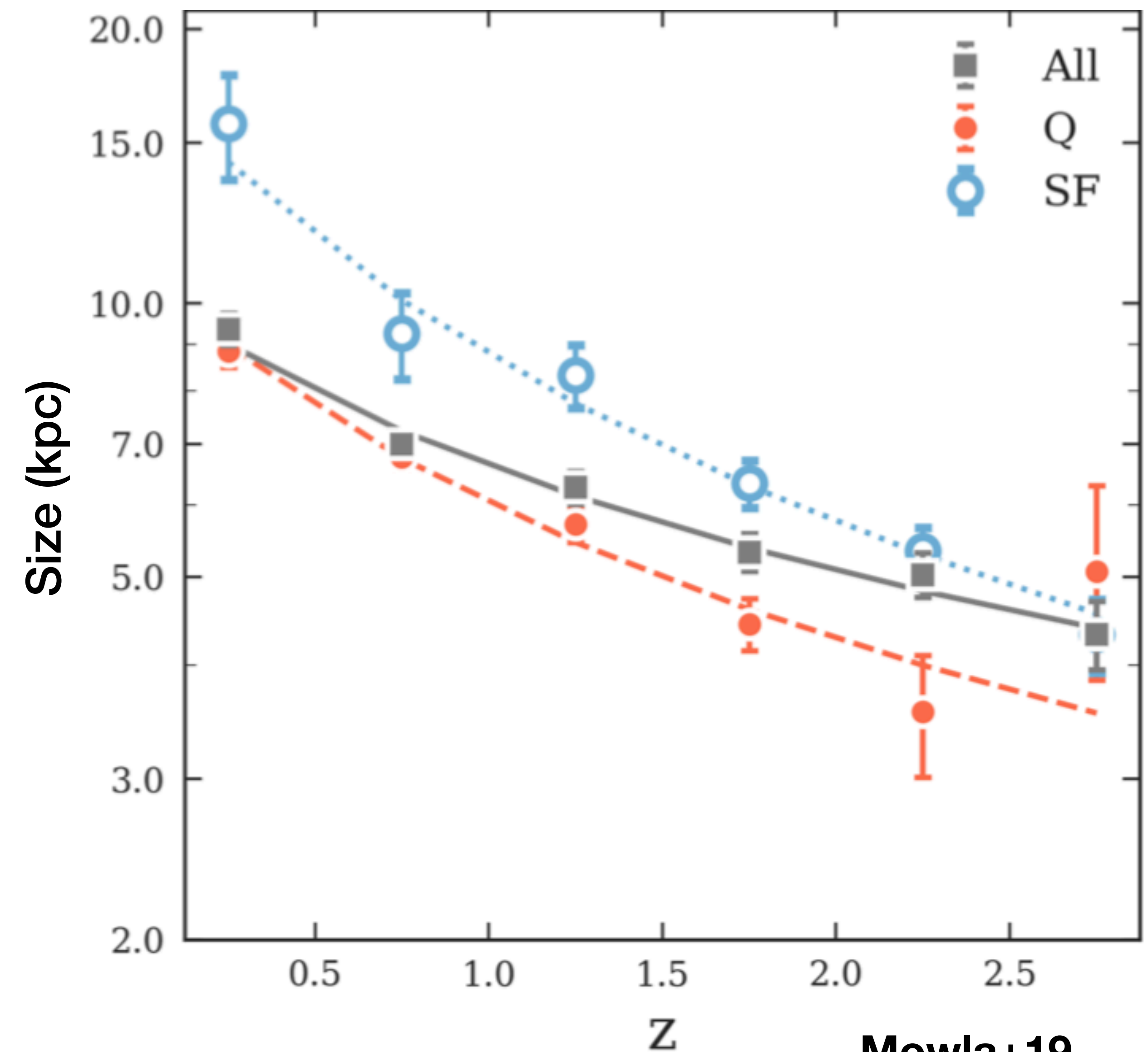
Size Evolution

Size Evolution at $5 \times 10^{10} M_\odot$

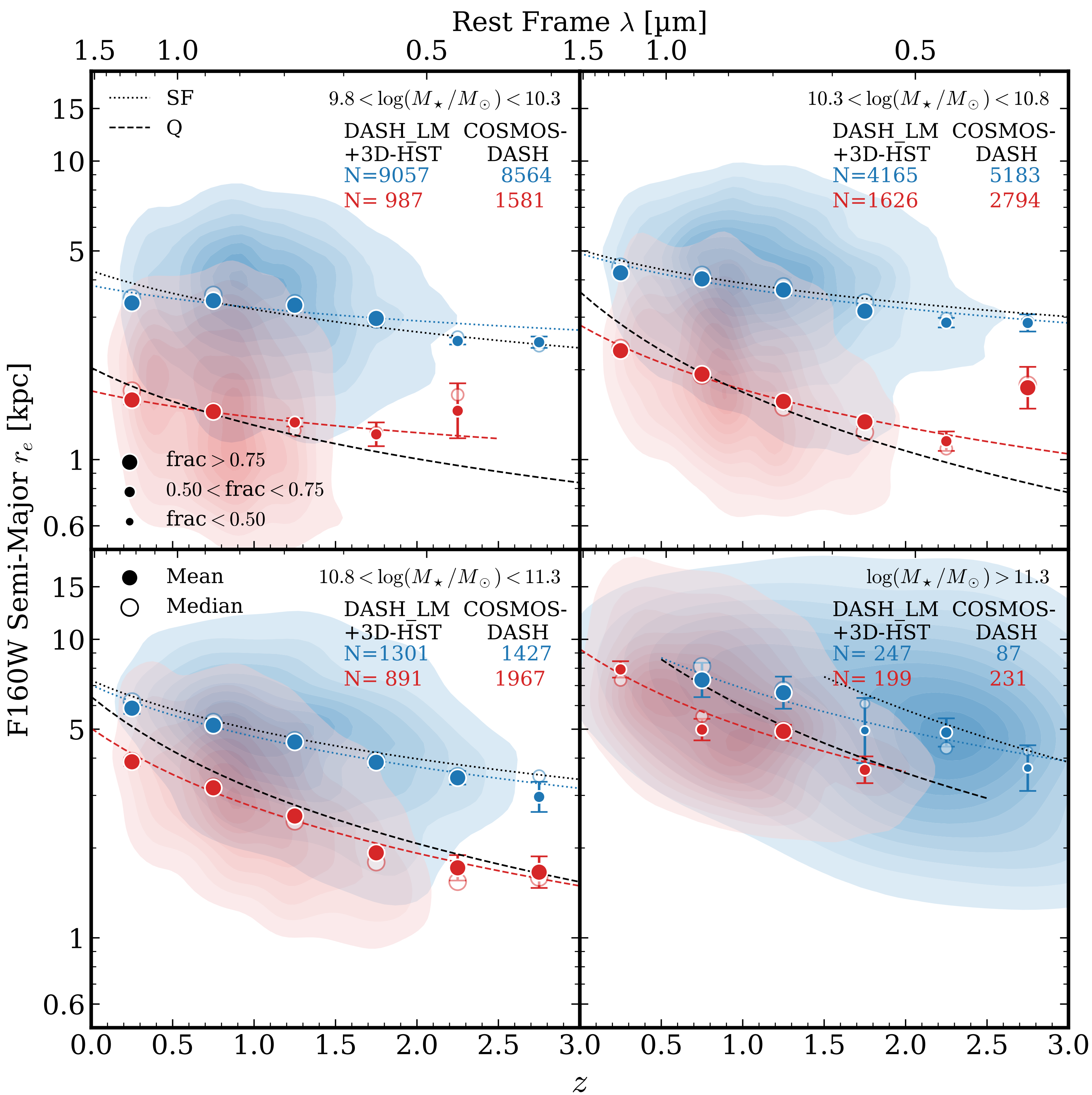


van der Wel+14

Size Evolution at $2 \times 10^{11} M_\odot$

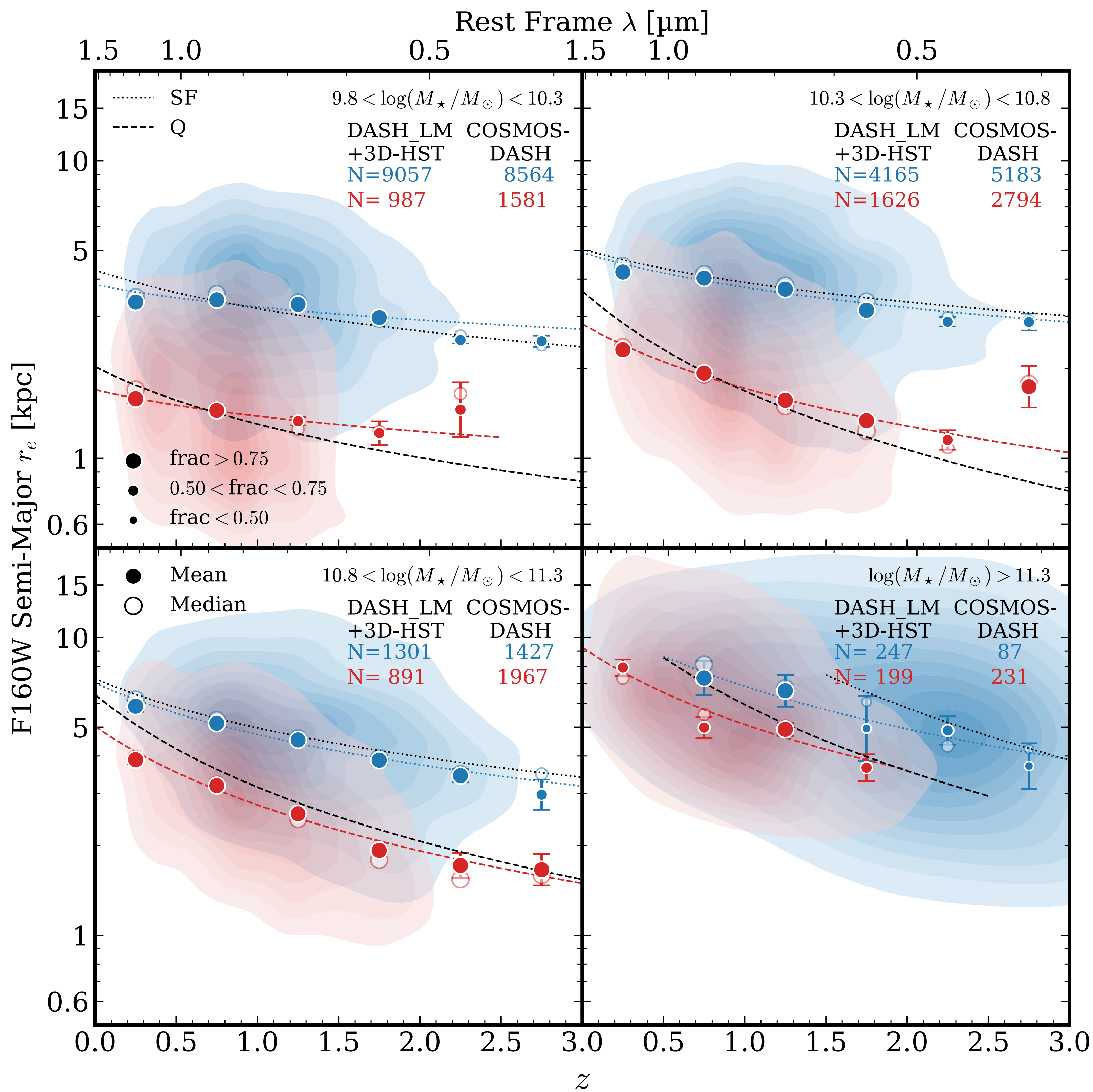


Mowla+19



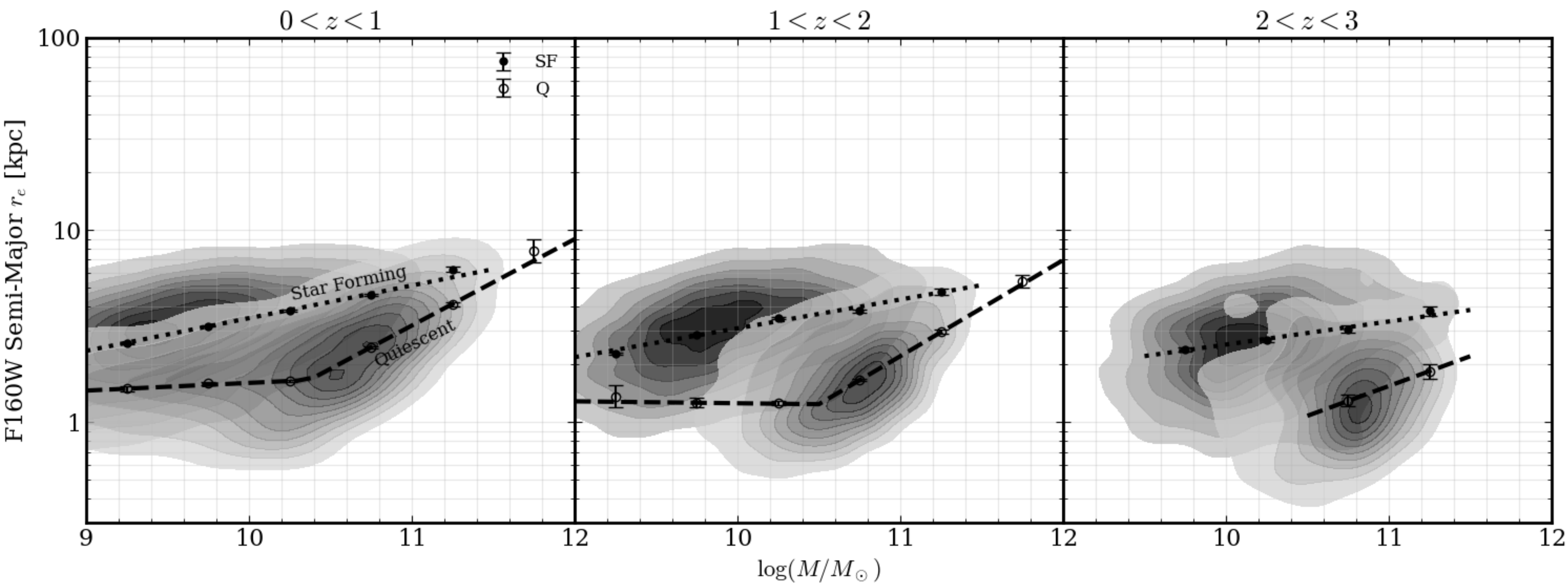
Cutler+in prep.

Size Evolution in DASH is consistent with CANDELS/3D-HST, even at low masses!



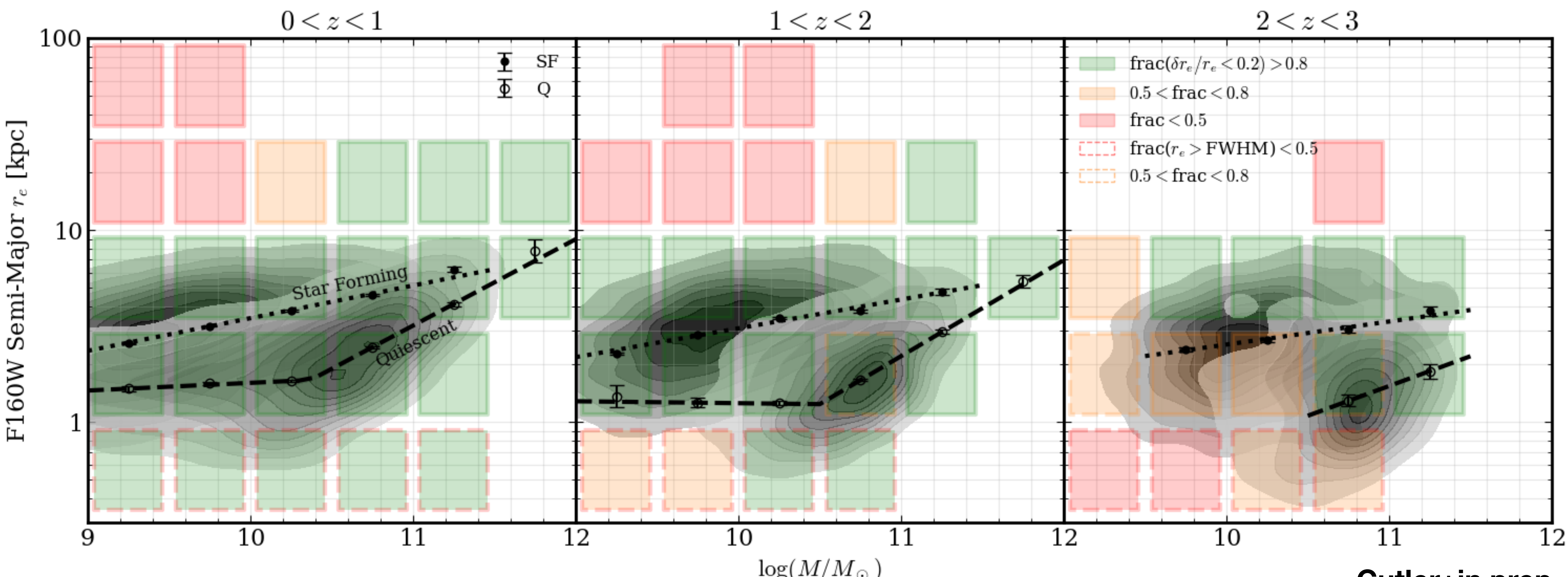
Cutler+in prep.

Size Mass



$0 < z < 1$
$1 < z < 2$
$2 < z < 3$
F160W Semi-Major r_e [kpc]
100
10
1
SF
Q
Star Forming
Quiescent
9
10
11
12
$\log(M/M_\odot)$

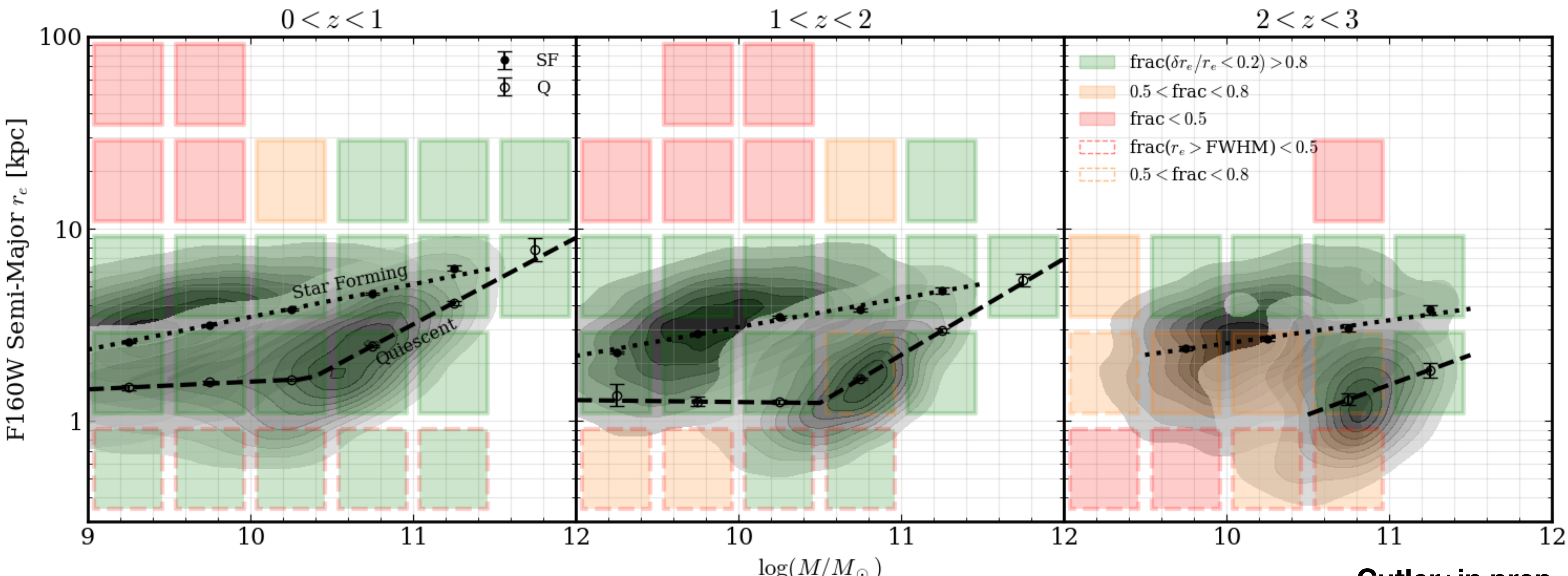
Size Mass



Cutler+in prep.

Size Mass

DASH observations are sufficient for a wide range of sizes and masses



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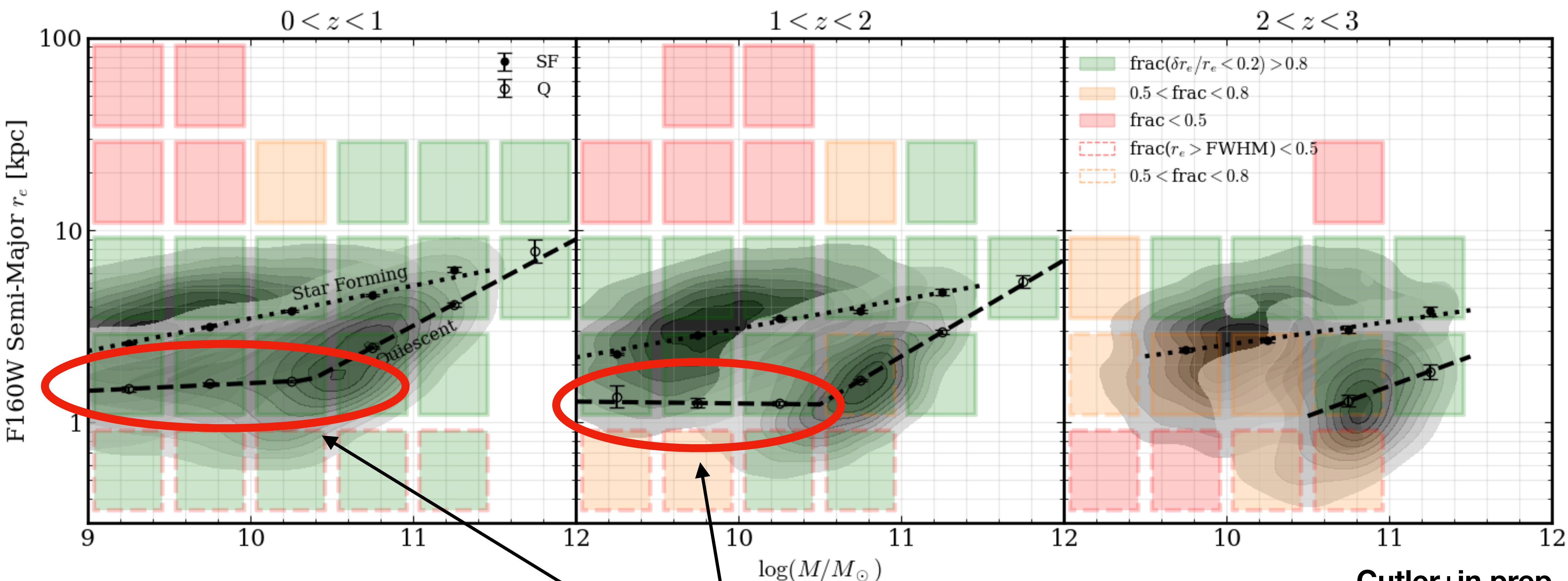
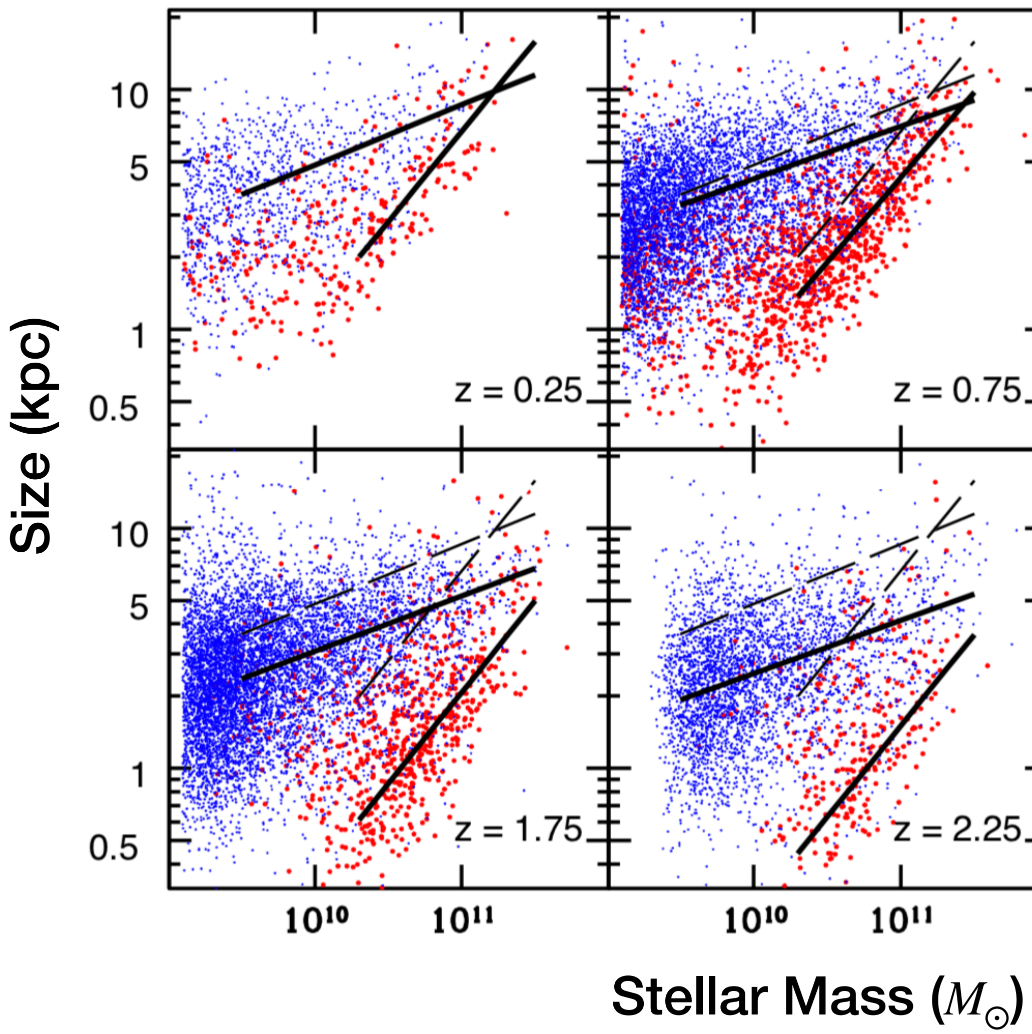


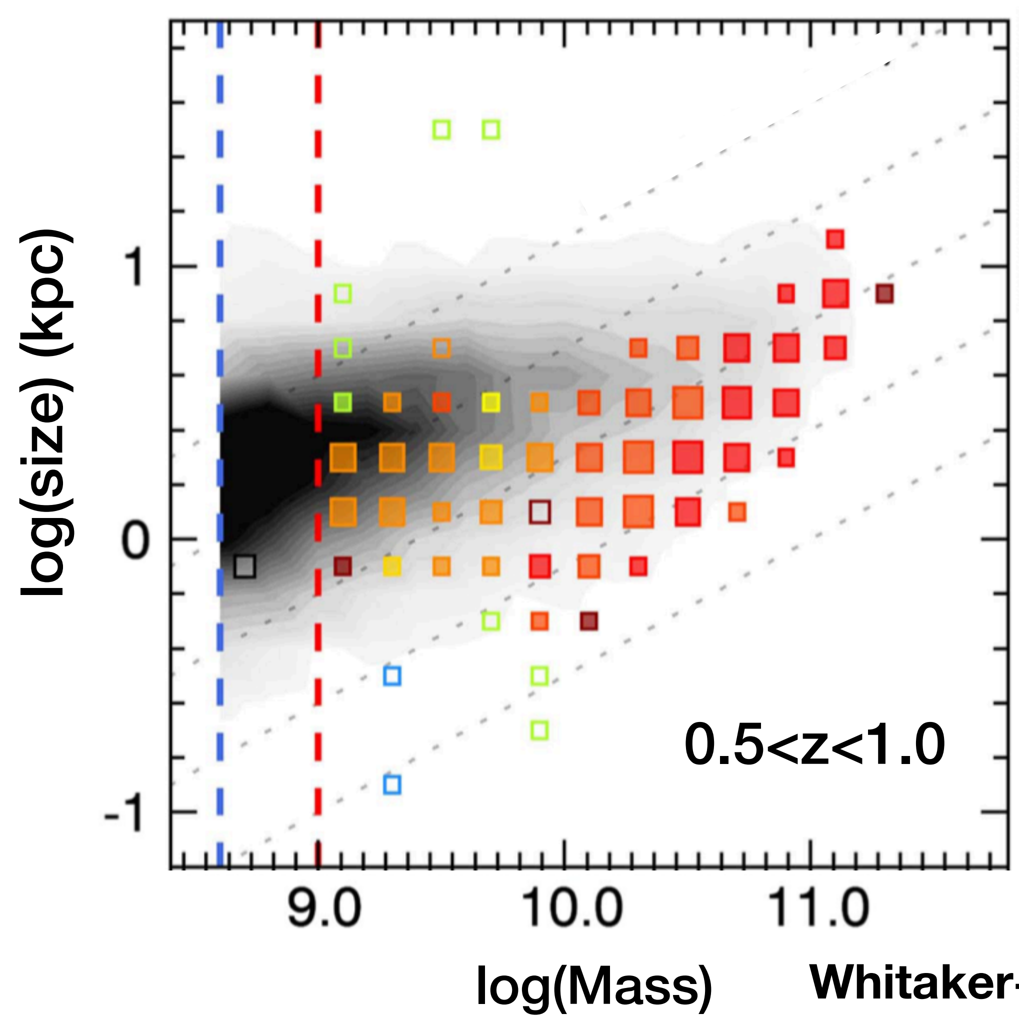
Cutler+in prep.

Low mass, quiescent relation flattens

Size Mass Flattening

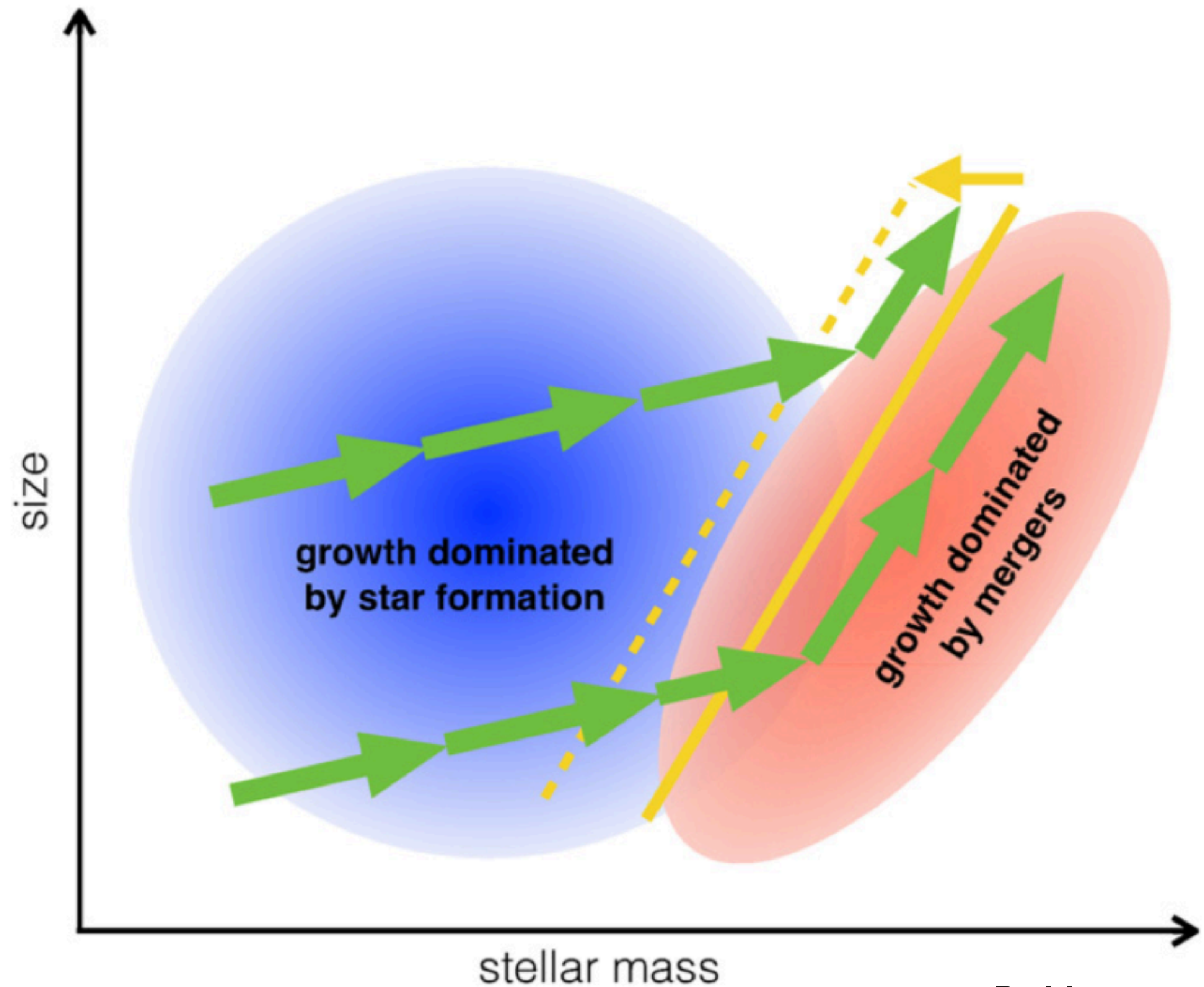


van der Wel+14



Whitaker+17

Environmental Dependence



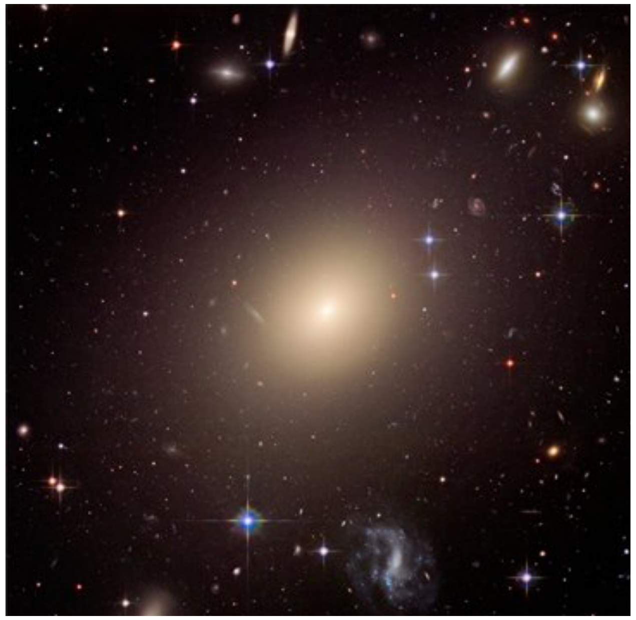
van Dokkum+15

Environmental Dependence

Massive star-forming galaxies

Quenching
+
Late stage mergers

Massive quiescent galaxies



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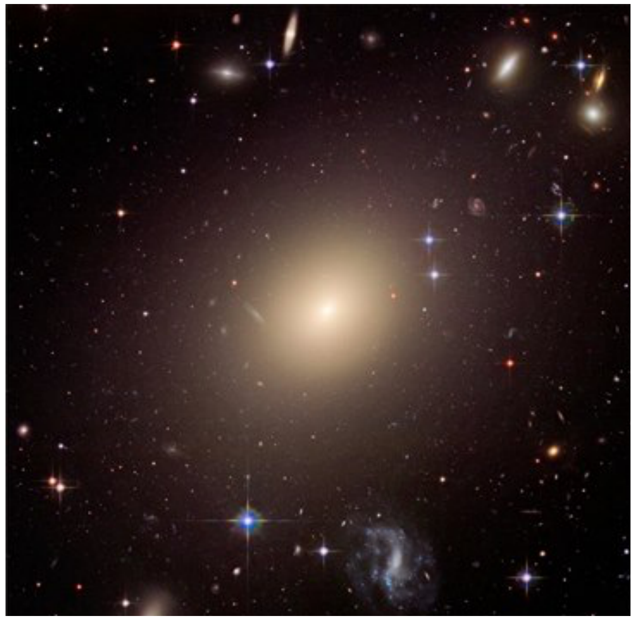

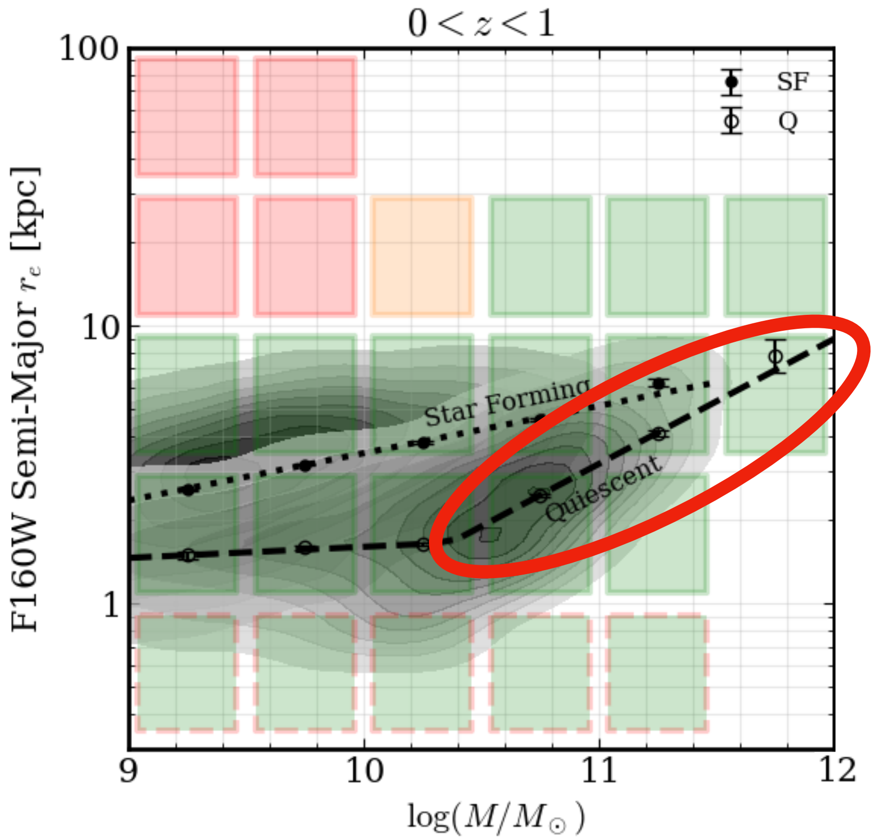

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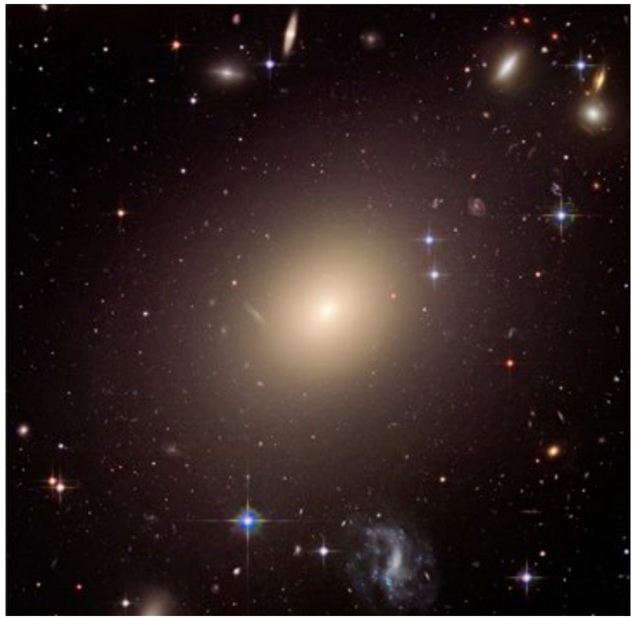
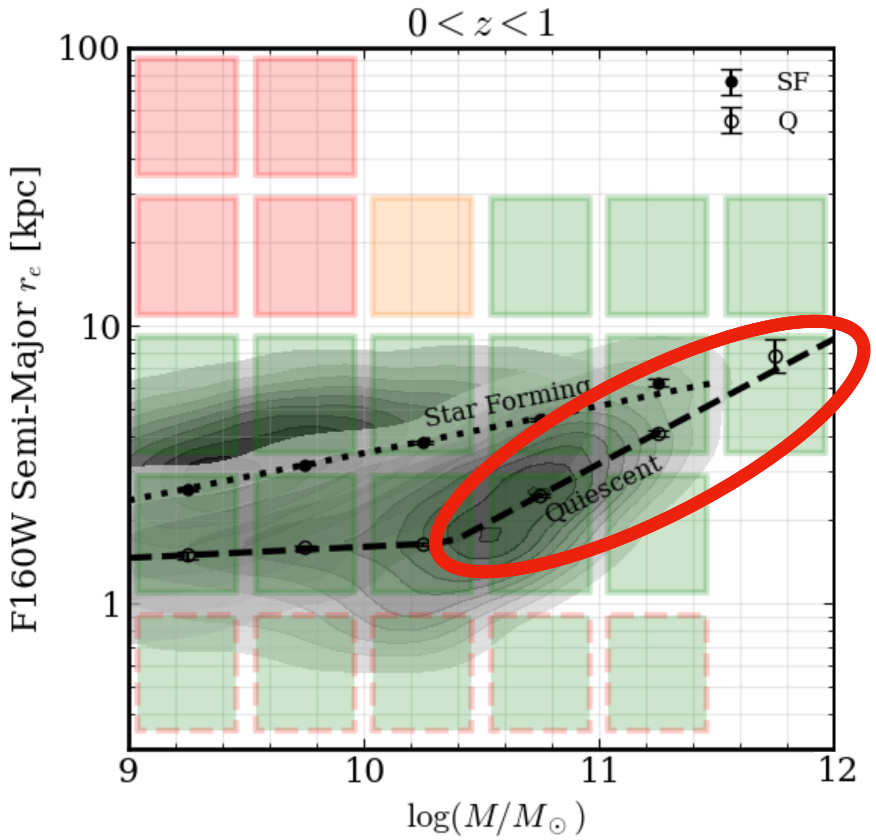


Galaxy shape and size changes:

More elliptical

More compact



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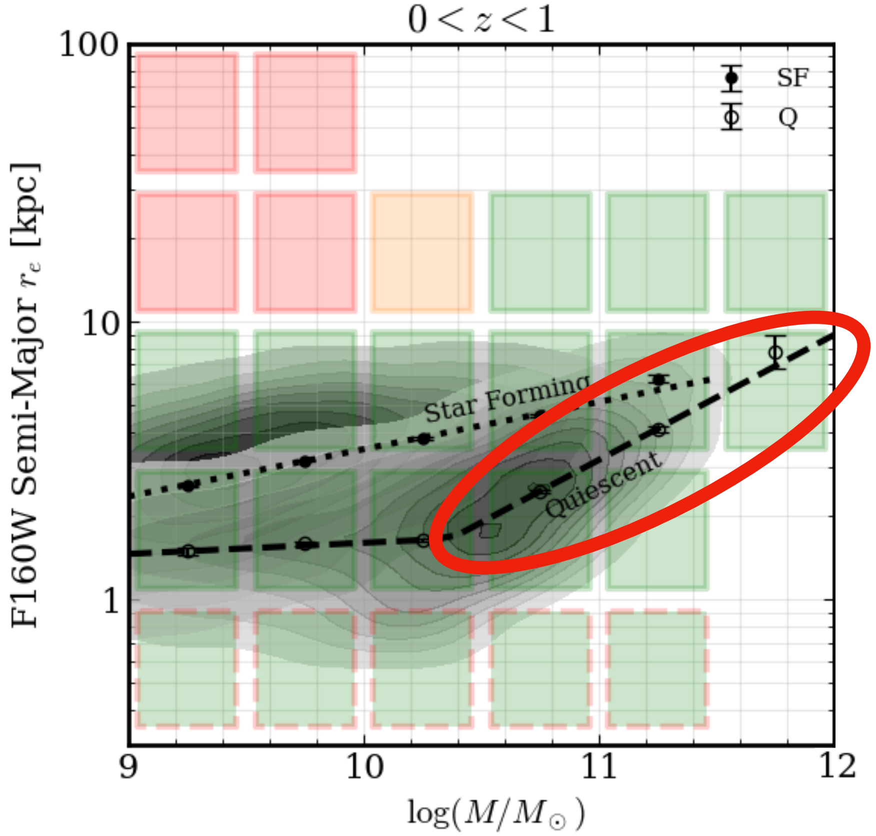
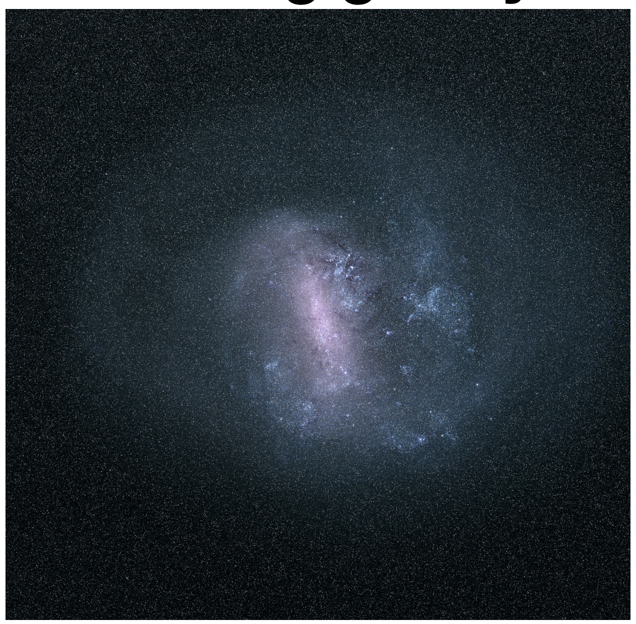


Occurs in overdense environments (clusters, filaments)

Environmental Dependence

Low mass star-forming galaxy

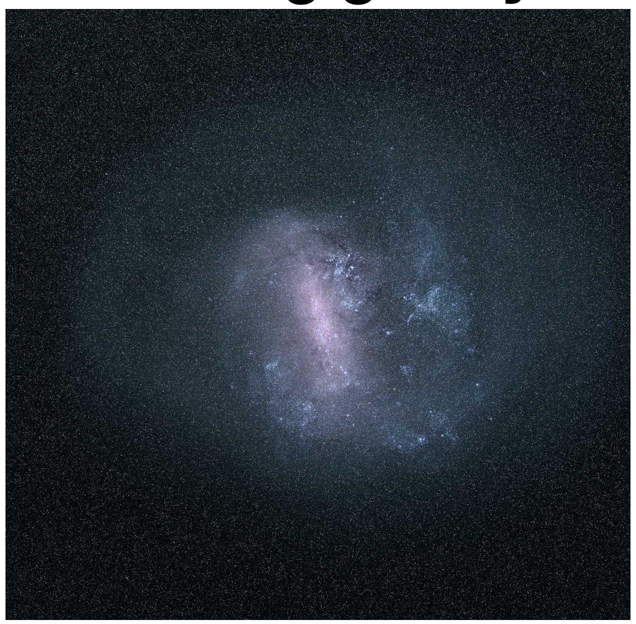


Quenching through gas expulsion

Low mass quiescent galaxy

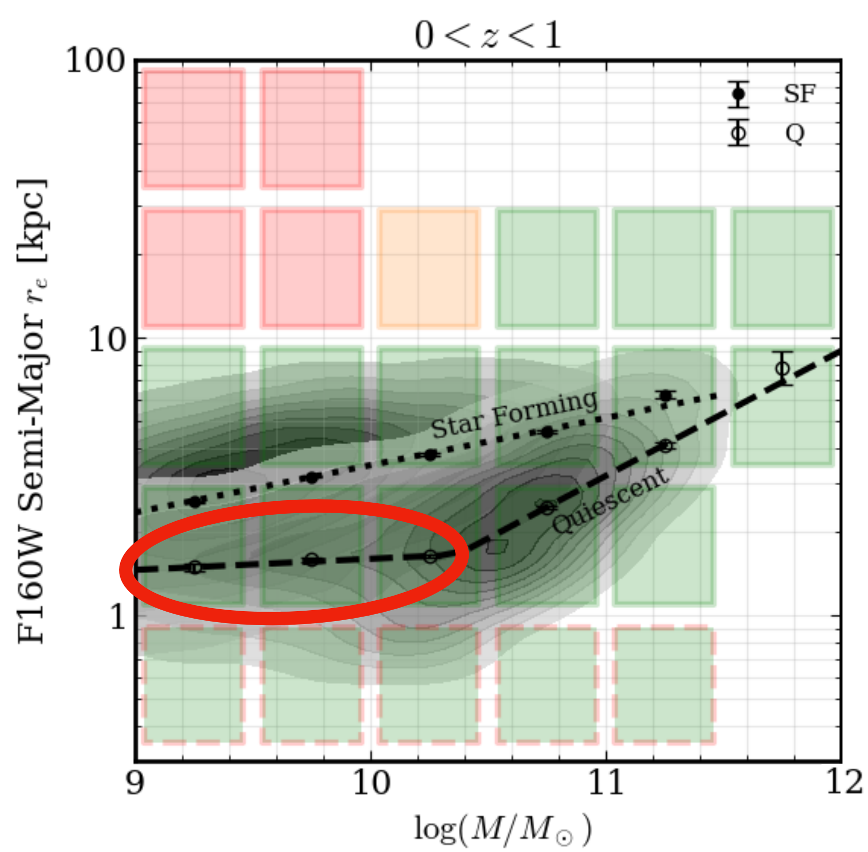
Environmental Dependence

Low mass star-forming galaxy



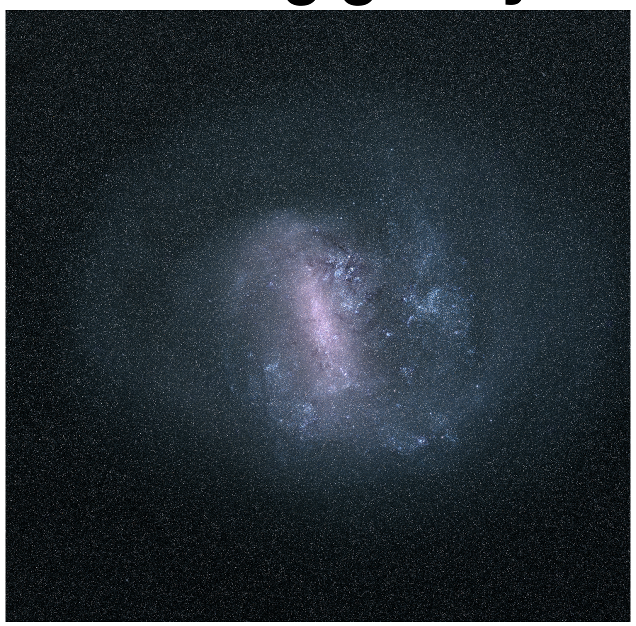
Quenching through gas expulsion

Low mass quiescent galaxy



Environmental Dependence

Low mass star-forming galaxy



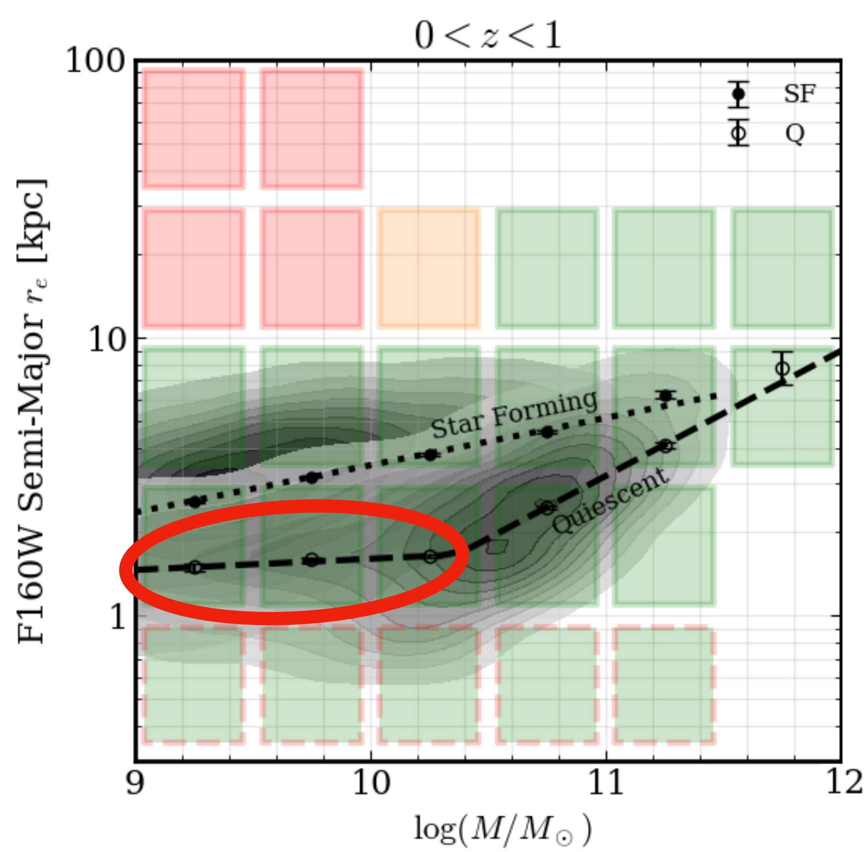
Quenching through gas expulsion

Low mass quiescent galaxy

Galaxy shape and size changes less:

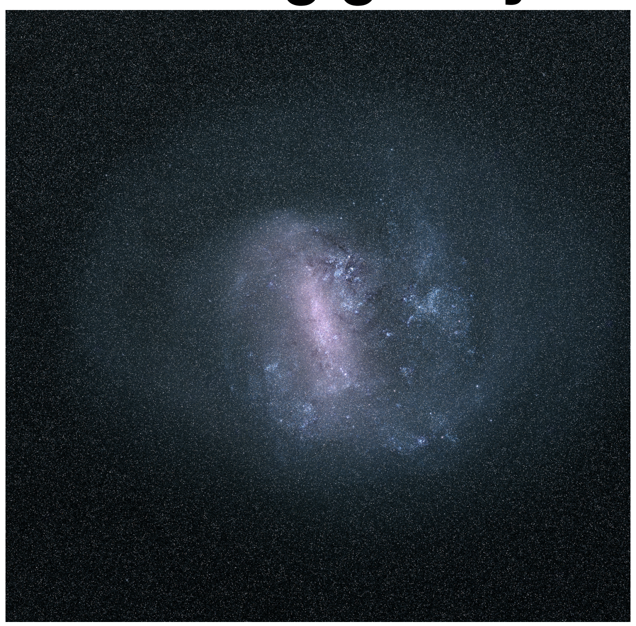
More disk-like

Similar size to star forming galaxies



Environmental Dependence

Low mass star-forming galaxy



Quenching through gas expulsion

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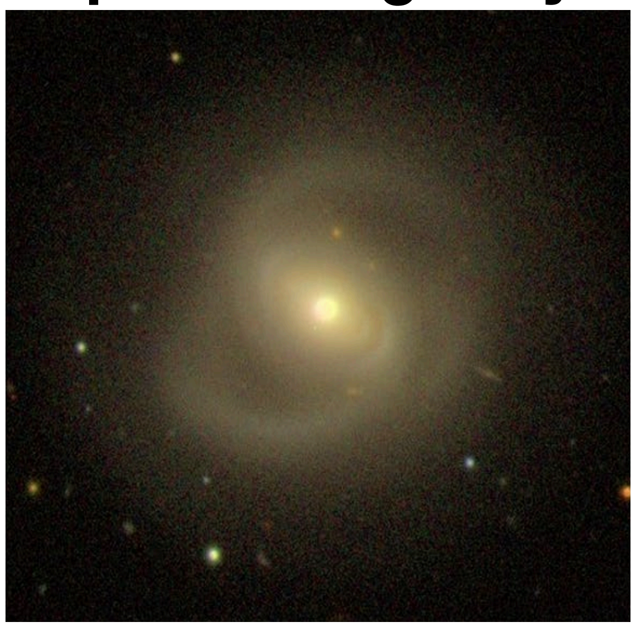

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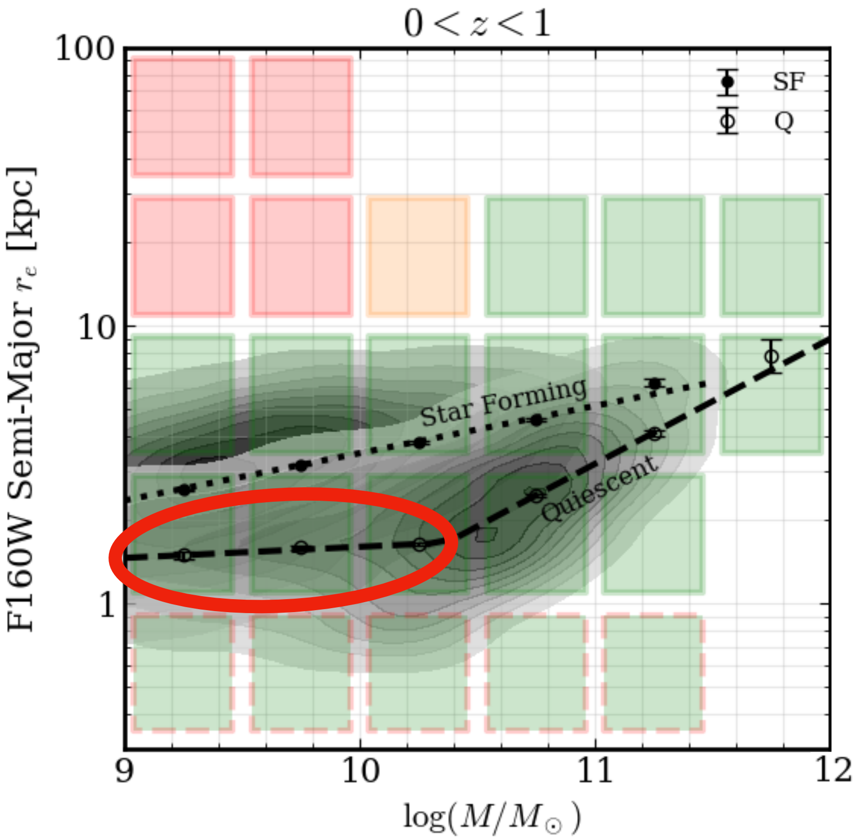
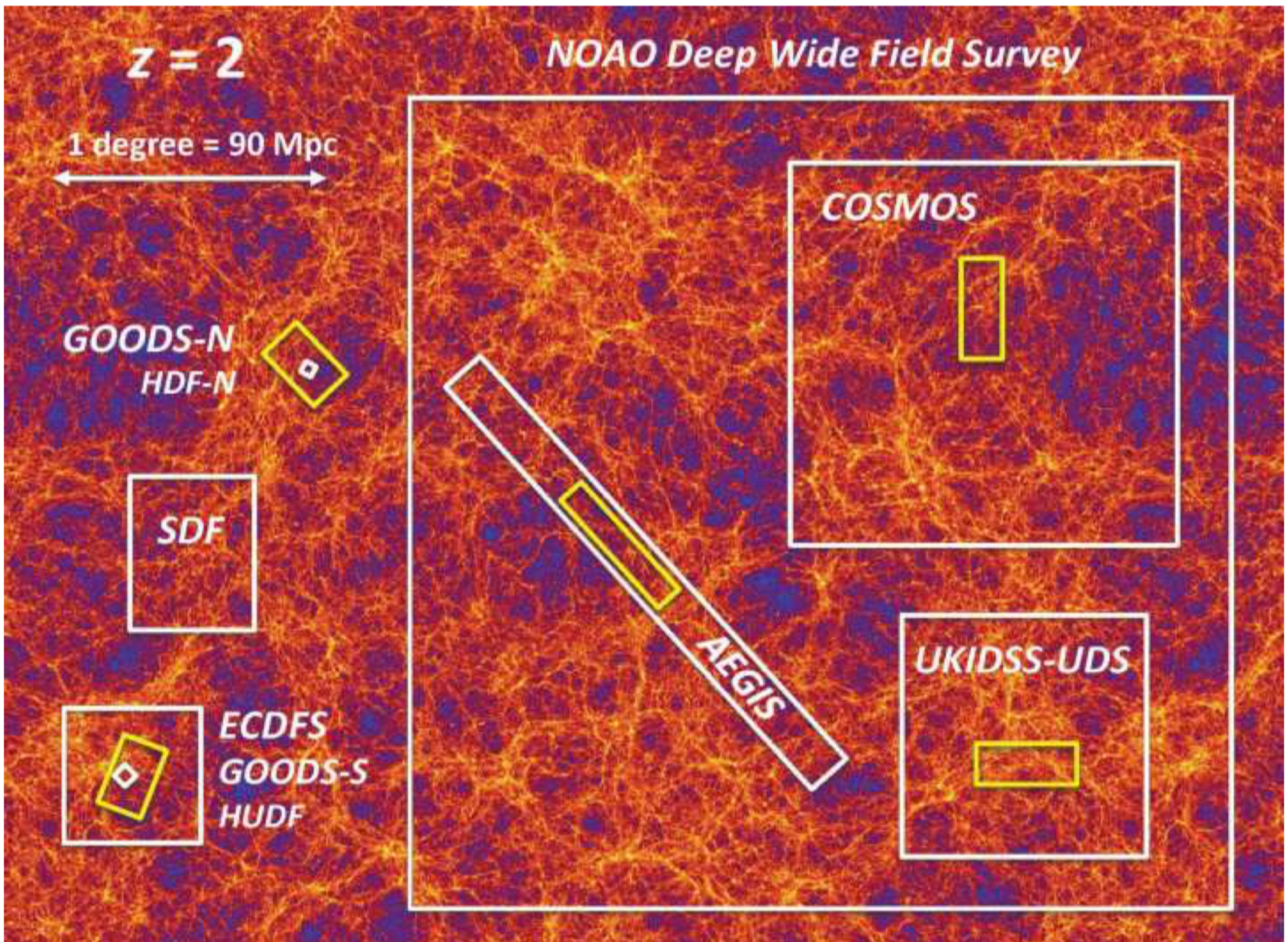


Occurs in underdense environments

Environmental Dependence

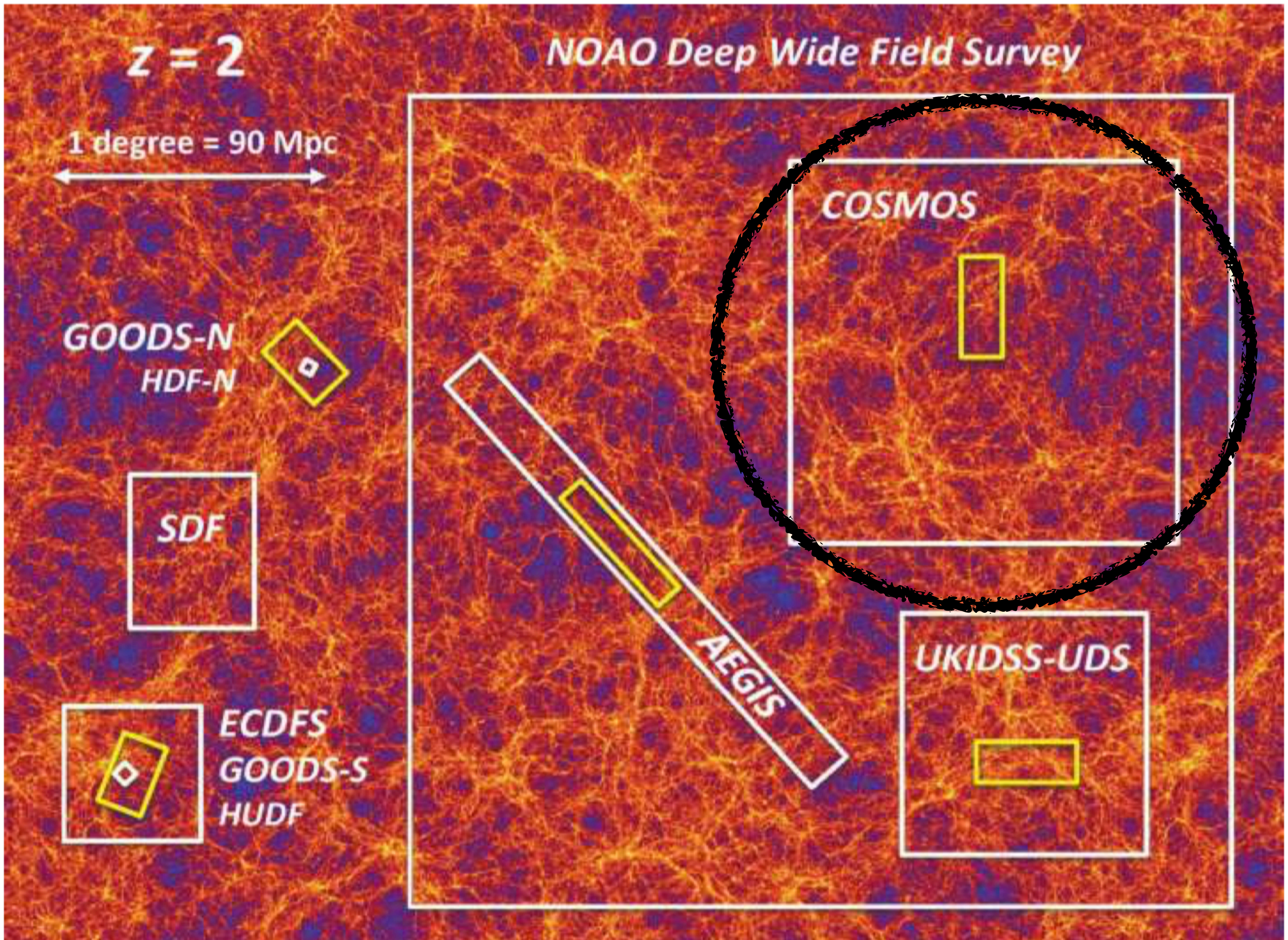
Have large, continuous area to probe range of environments



Madau & Dickinson 14

Environmental Dependence

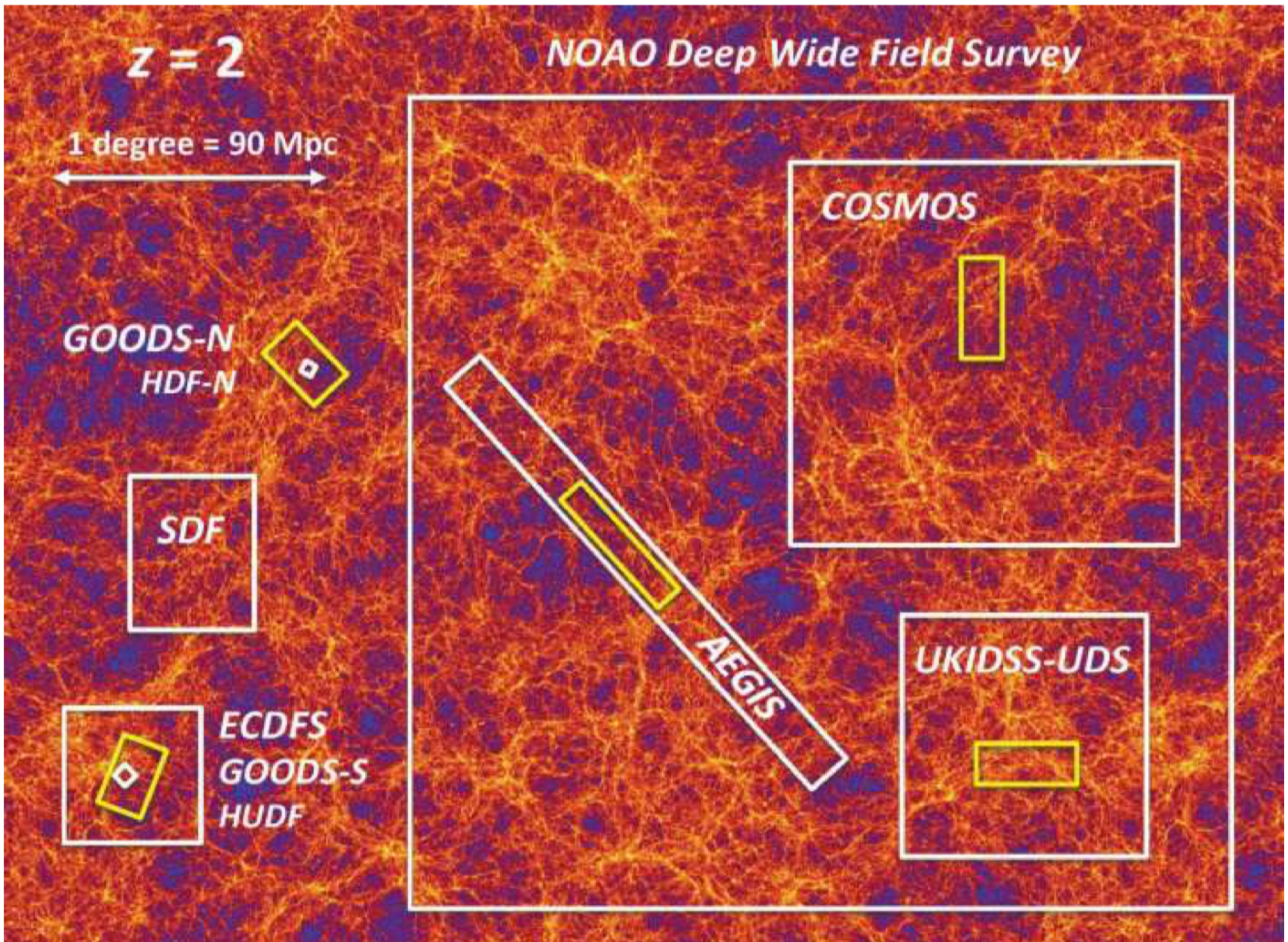
Have large, continuous area to probe range of environments



Madau & Dickinson 14

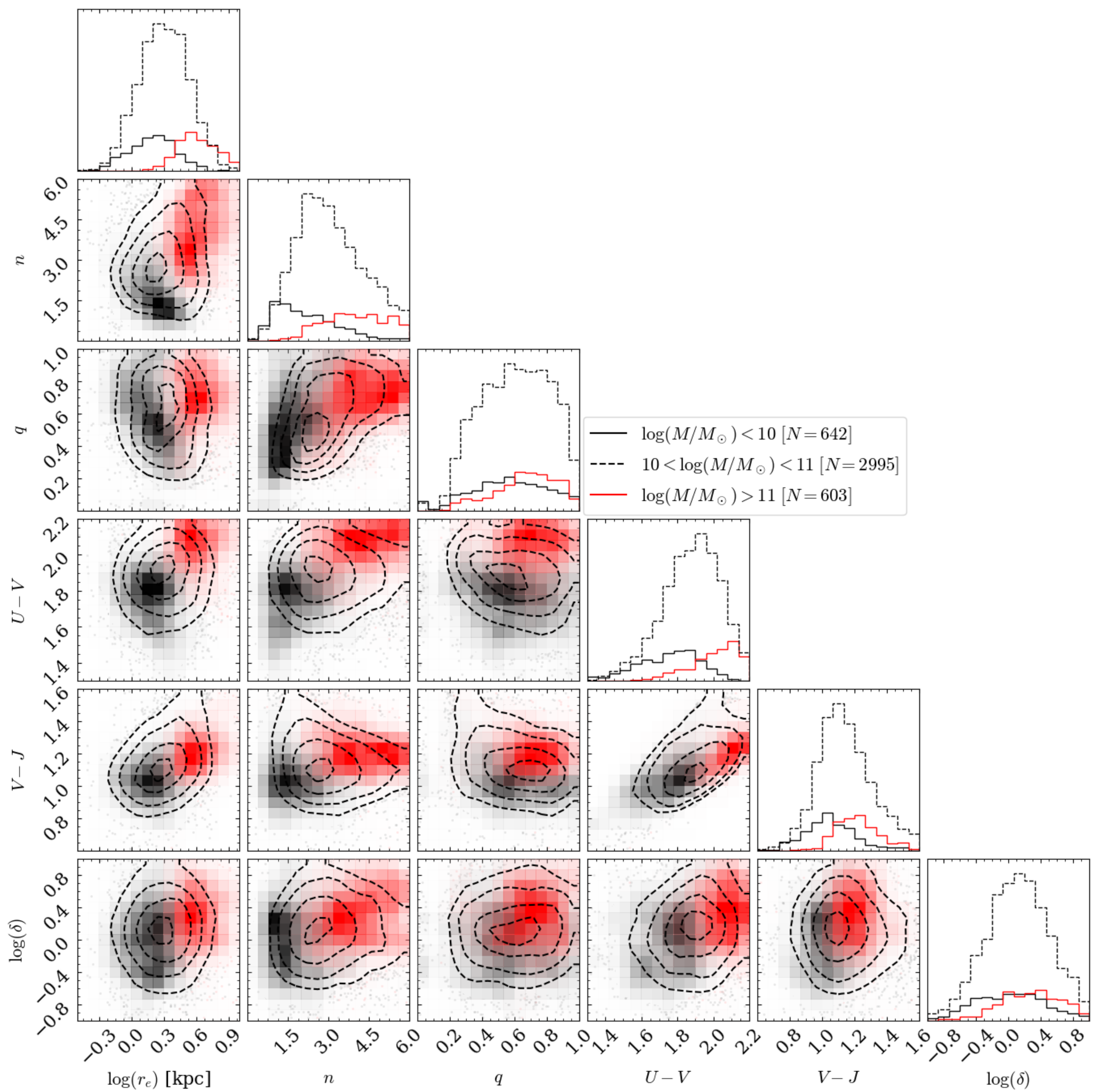
Environmental Dependence

Cross match DASH to COSMOS galaxy field density catalog
(Darvish et al. 2017)



Madau & Dickinson 14

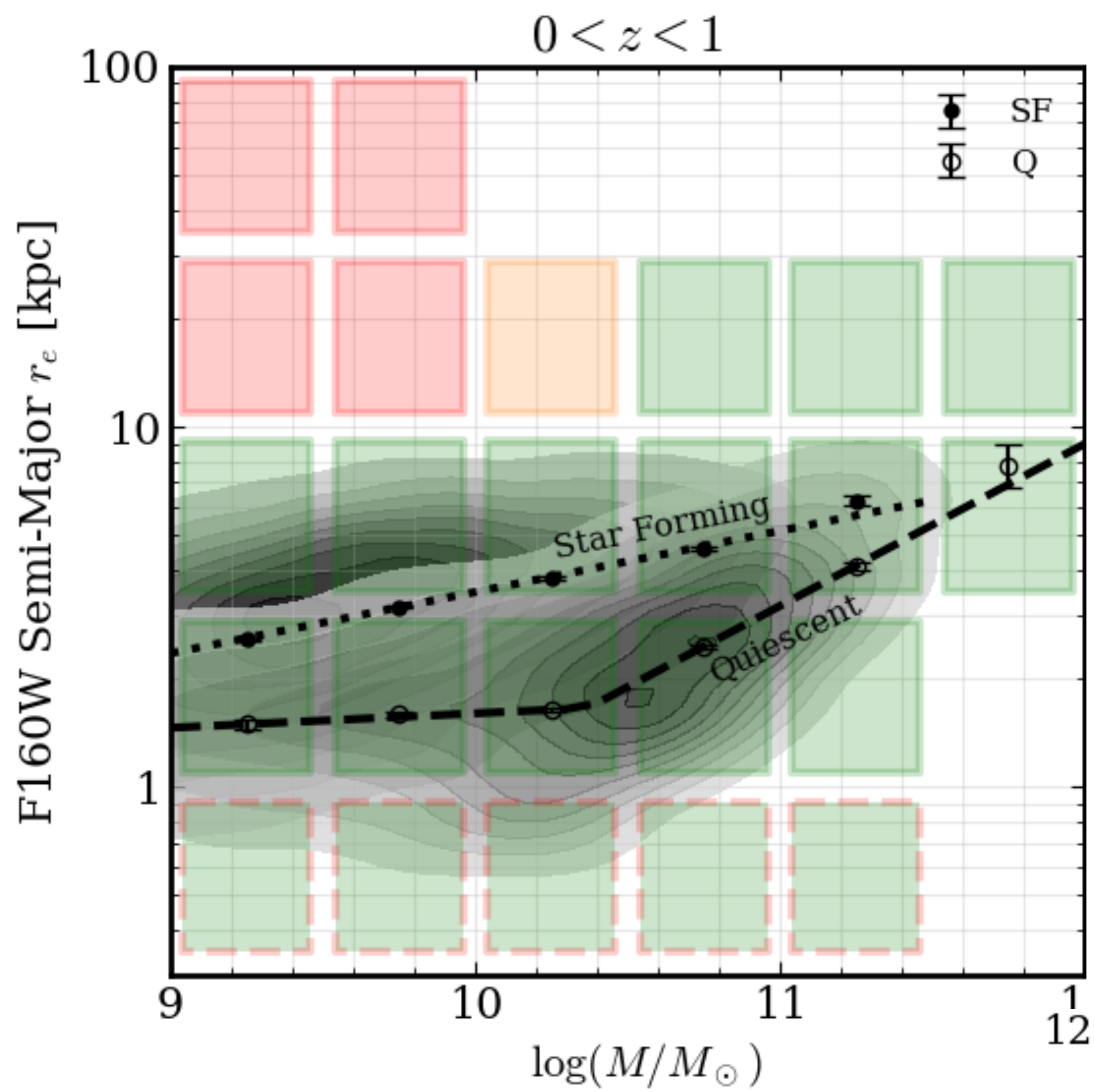
Many other parameters play a significant role in environment and evolution



Cutler+in prep.

Environmental Dependence

Look at change in *quiescent* size with environment



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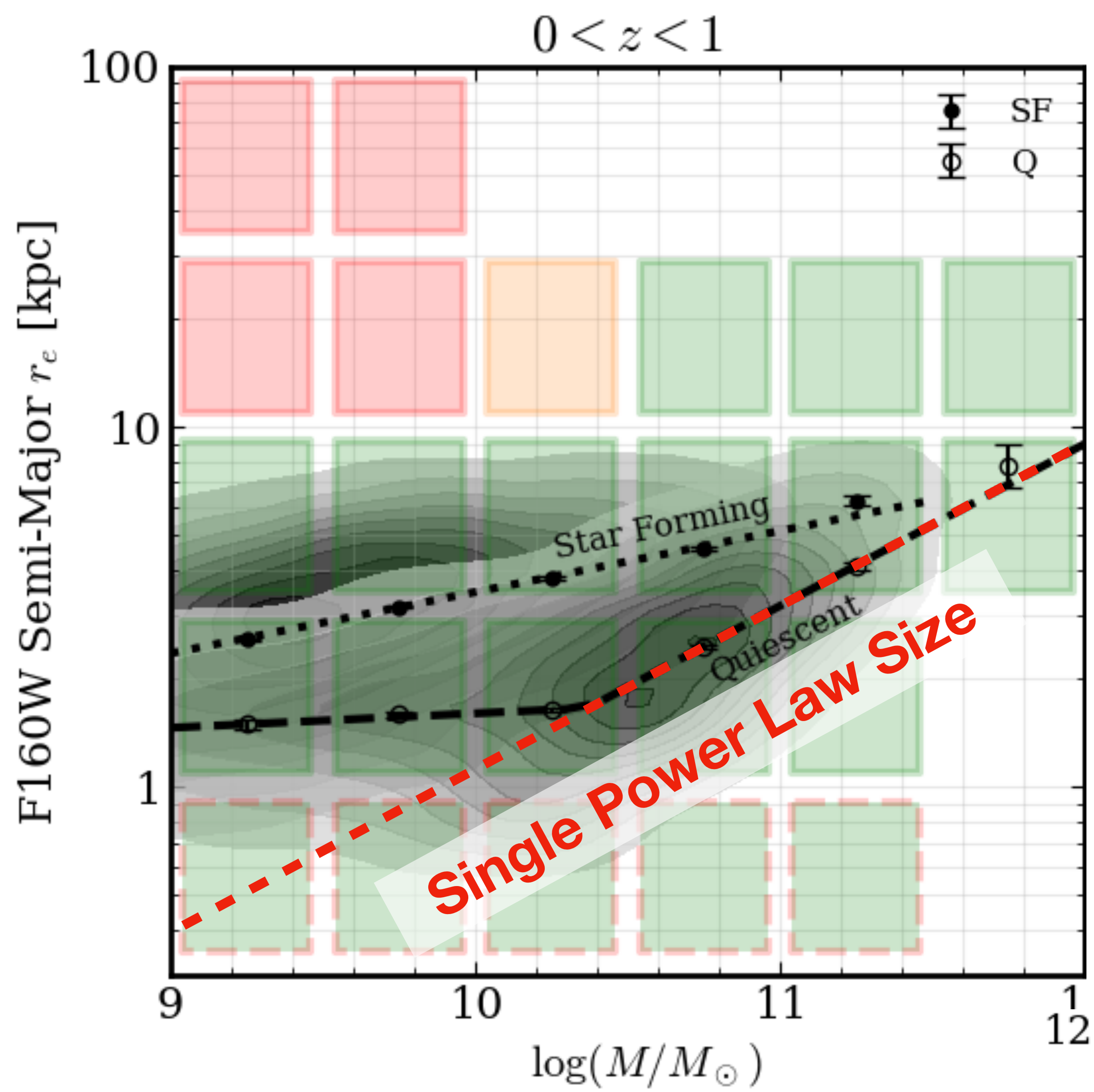
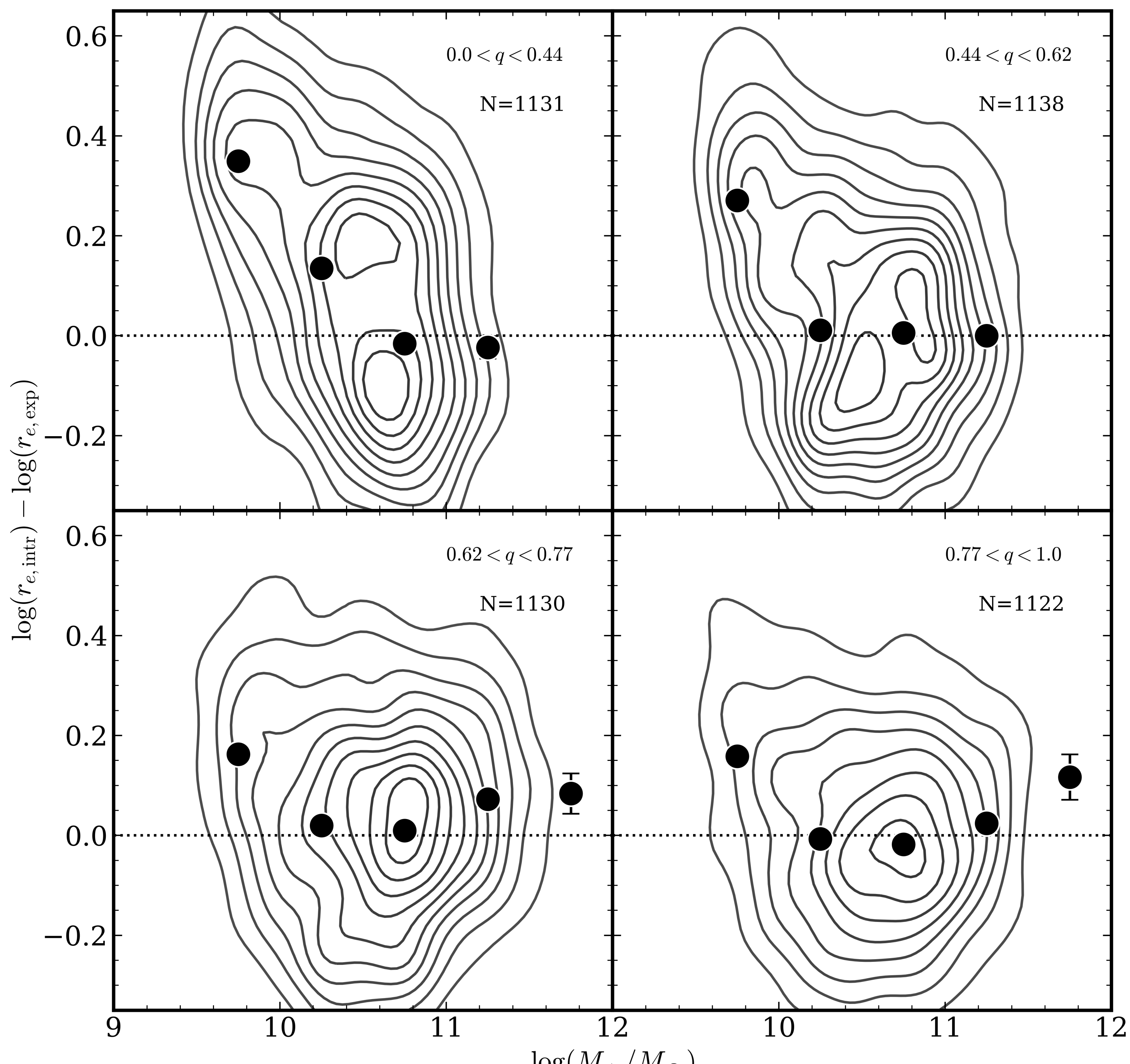
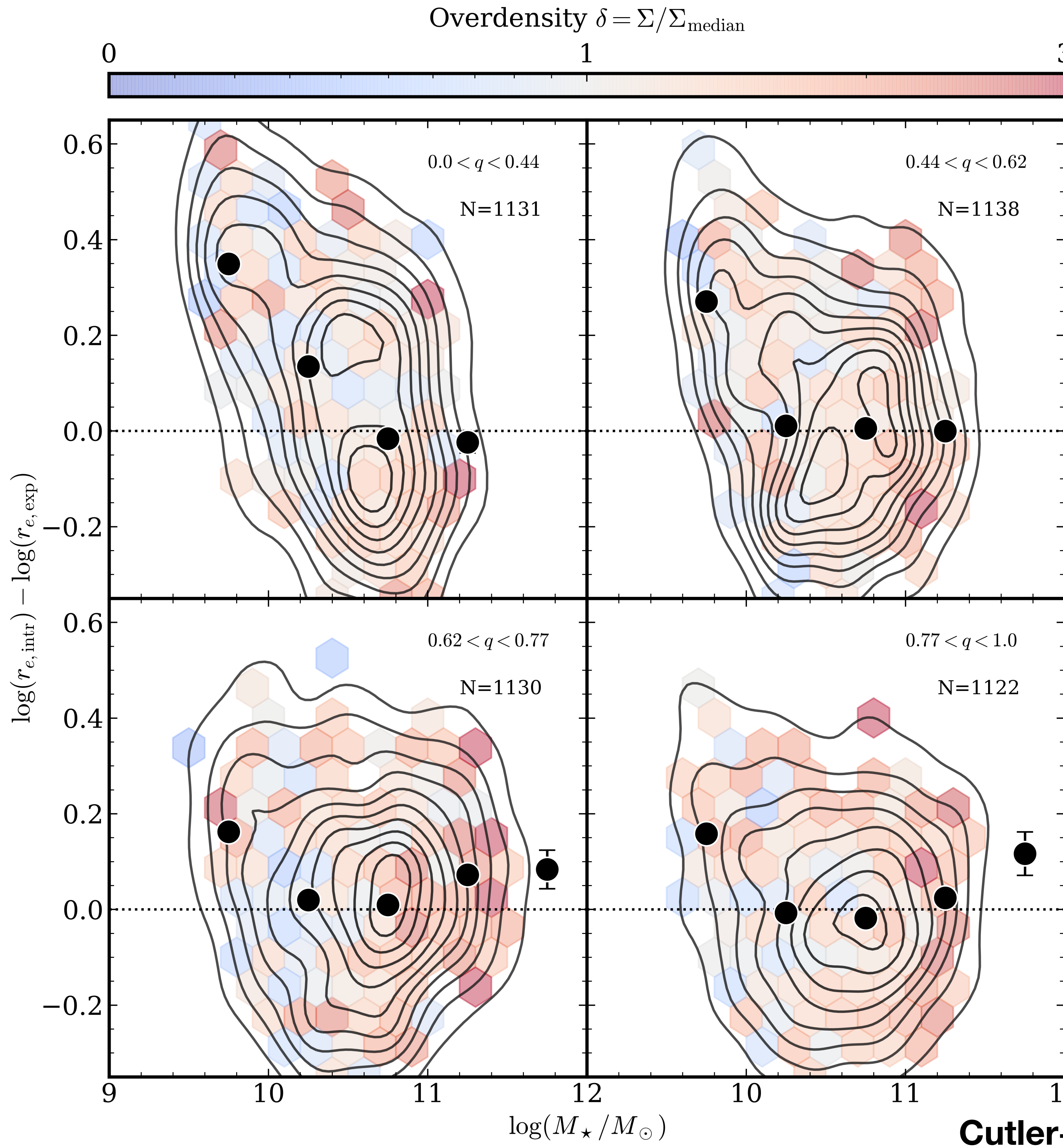


Axis Ratio and Environment



Axis Ratio and Environment

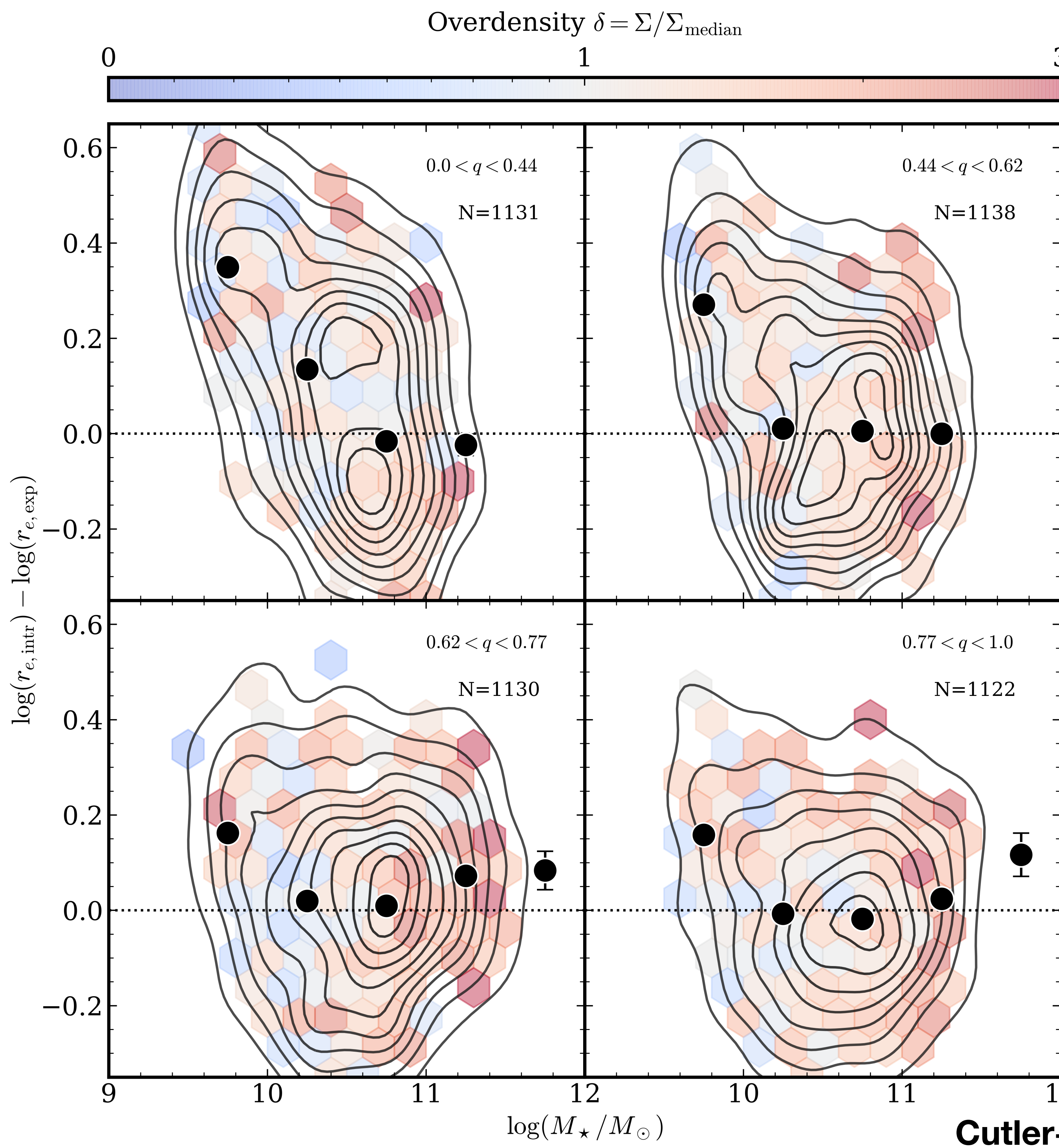


Cutler+in prep.

Axis Ratio and Environment

Larger sizes for smaller axis ratios

Smaller axis ratios in underdense environments



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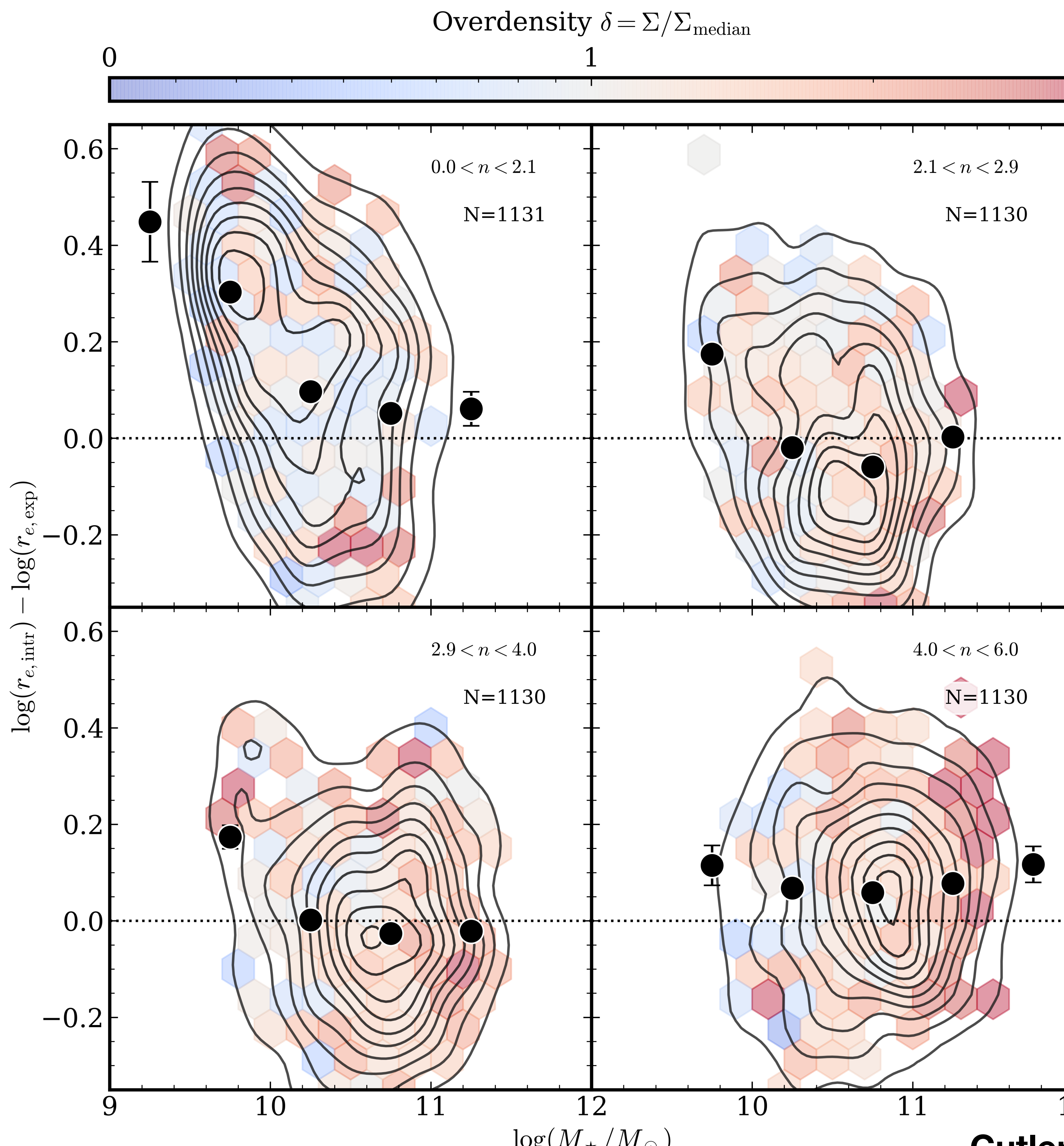
Sérsic Index and Environment

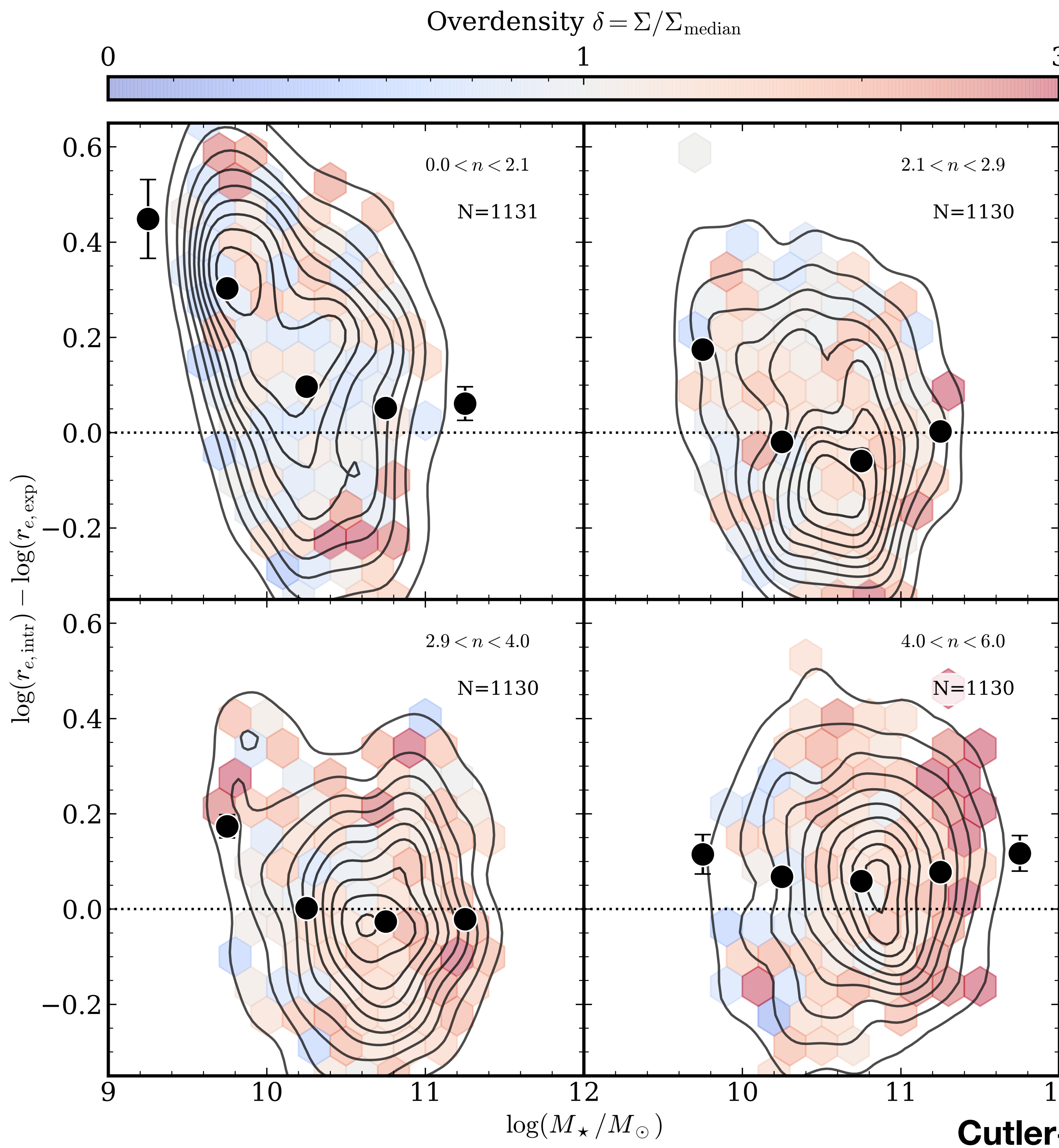


Cutler+in prep.

Sérsic Index and Environment

Larger sizes for smaller Sérsic indices

Smaller Sérsic indices in underdense environments



Cutler+in prep.

Summary

1. *HST*-selected COSMOS-DASH morphological catalog

2. Robust sizes to $H_{160} \sim 23$ and Sérsic indices to $H_{160} \sim 22$

3. Consistent size evolution with CANDELS/3D-HST morphologies

4. DASH results can produce results for a wide range of sizes and masses

5. Observe a flattening of the size mass relation for low mass quiescent galaxies

6. Trends with axis ratio, Sérsic index, and field density point to an environmental dependence of the size mass flattening

Sam Cutler
secutler@astro.umass.edu