COVLD WE IMPROVE OVR GALAXY SIZE MEASVREMENTS AT VERY HIGH REDSHIFT?

+IGALDE

GEELSBE2

Galaxy Edges and Euclid in the Low Surface Brightness Era

Fernando Buitrago

With the great help of P. Papaderos, V. Alonso-Rodríguez, S. Raji, J. Vega-Ferrero, B. Sahelices, J. Fernández,R. Sarmiento, Euclid's WP-DIF team

LaDIS
Laboratory for Disruptive Interdisciplinary Science

Universidad de Valladolid

ia instituto de astrofísica e ciências do espaço

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

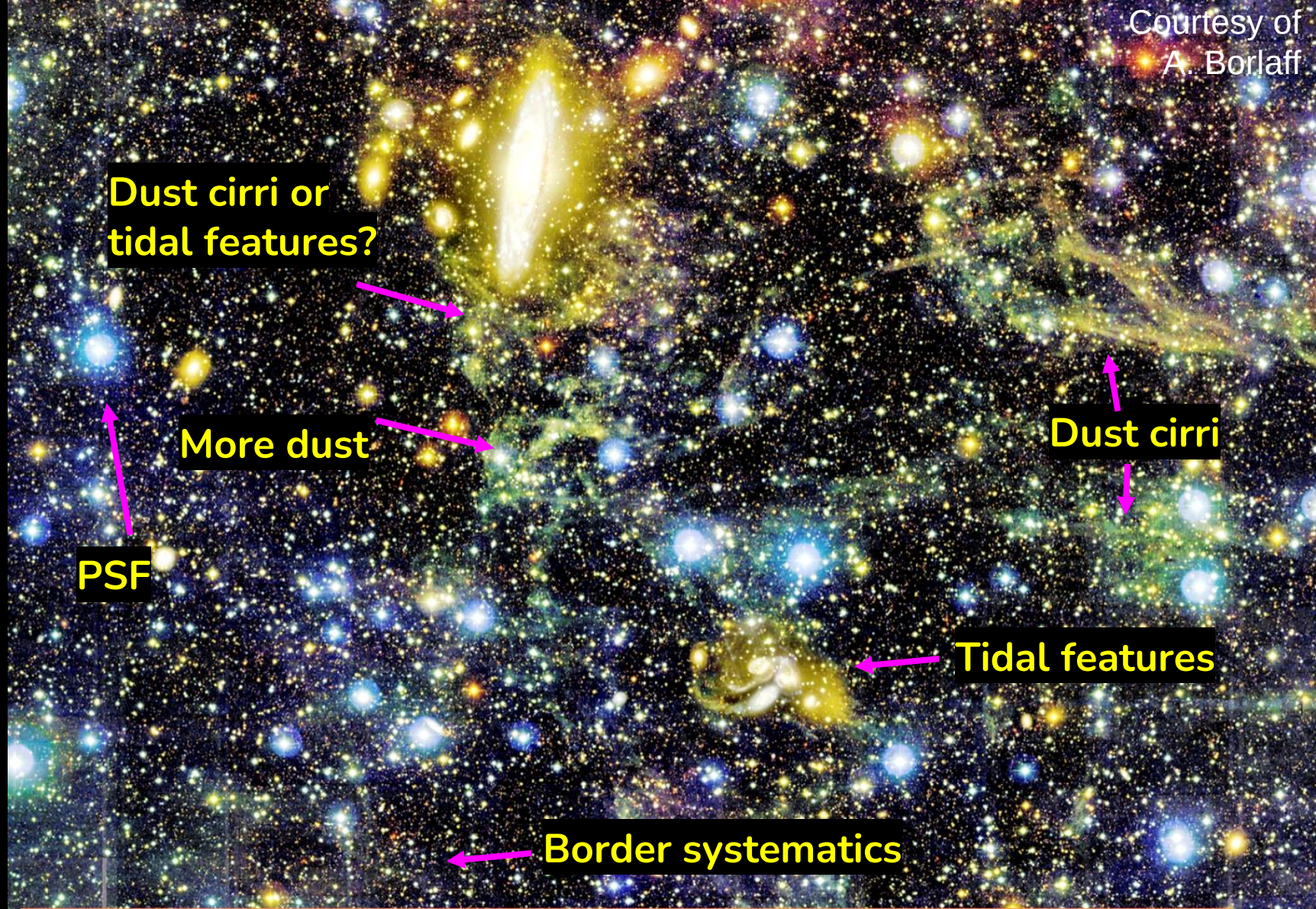
This activity is part of the grant PID2023-150393NB-I00 funded by MCIU/AEI/10.13039/501100011033 and the FSE+

Stephan's Quintet and NGC7331 Deer Lick Group

SDSS

Surface brightness magnitude limit (g-band) 26.5 mag arcsec^{-2}

Courtesy of A. Borlaff



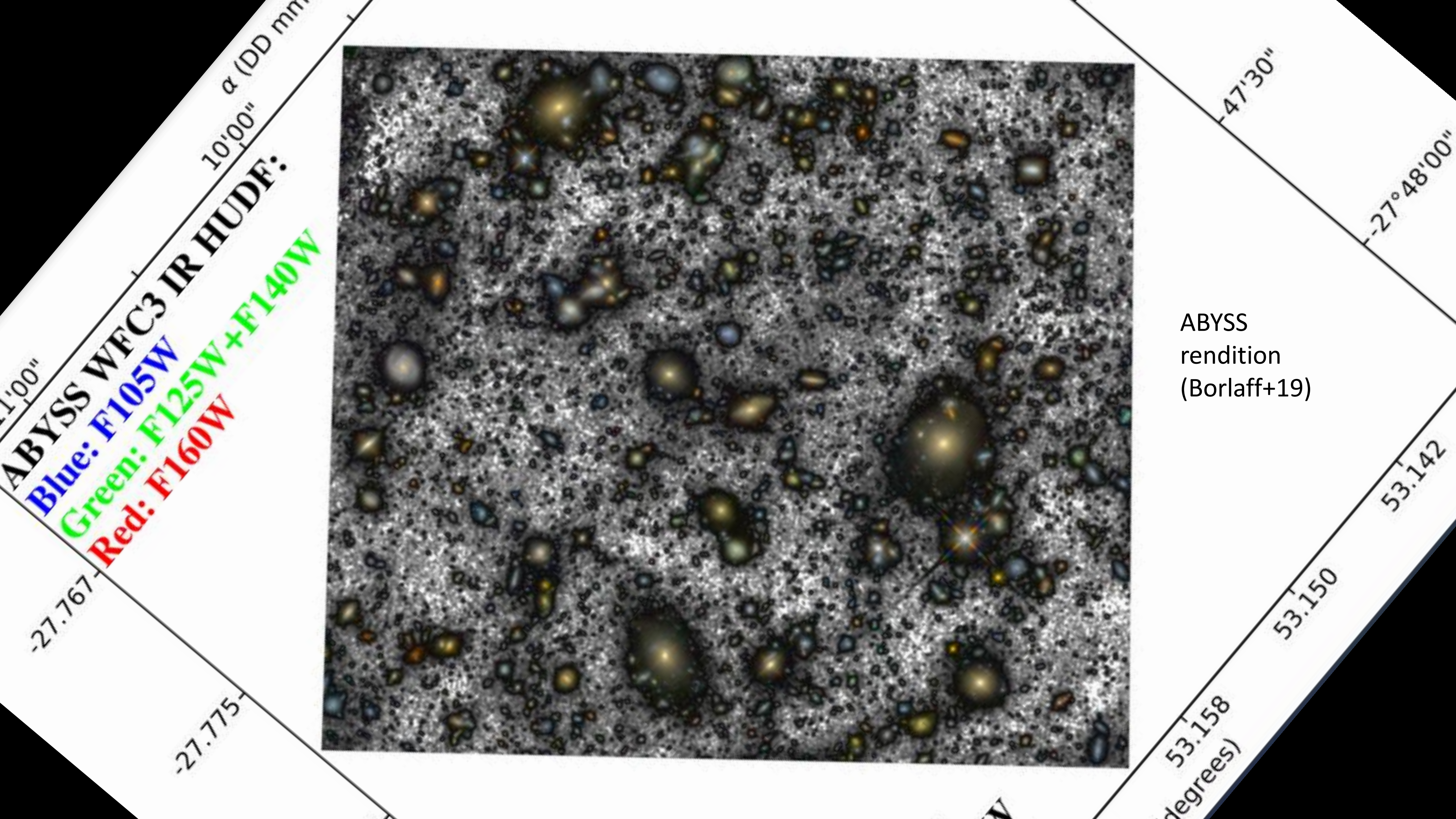
Stephan's Quintet and NGC7331 Deer Lick Group (CFHT)

Duc, Cuillandre & Renaud (2018)

Surface brightness magnitude limit (u, g, r bands) 29.0, 28.6, and 27.6 mag arcsec^{-2}

WE ARE
NOT AN
ENEMY
FOR HIGH-Z
SCIENCE

HST's eXtreme
Deep Field
(Illingworth+13)



ABYSS rendition (Borlaff+19)

WHY ARE GALAXY SIZES INTERESTING?

- Direct observables of galaxy evolution
- The mass-size relation tell us that on average the more massive a galaxy is, the larger its size (e.g. Shen+03)
- Dramatic size evolution for the most massive galaxies have taught us many unexpected lessons (Buitrago+08, Van der Wel et al. 2014 and many more)

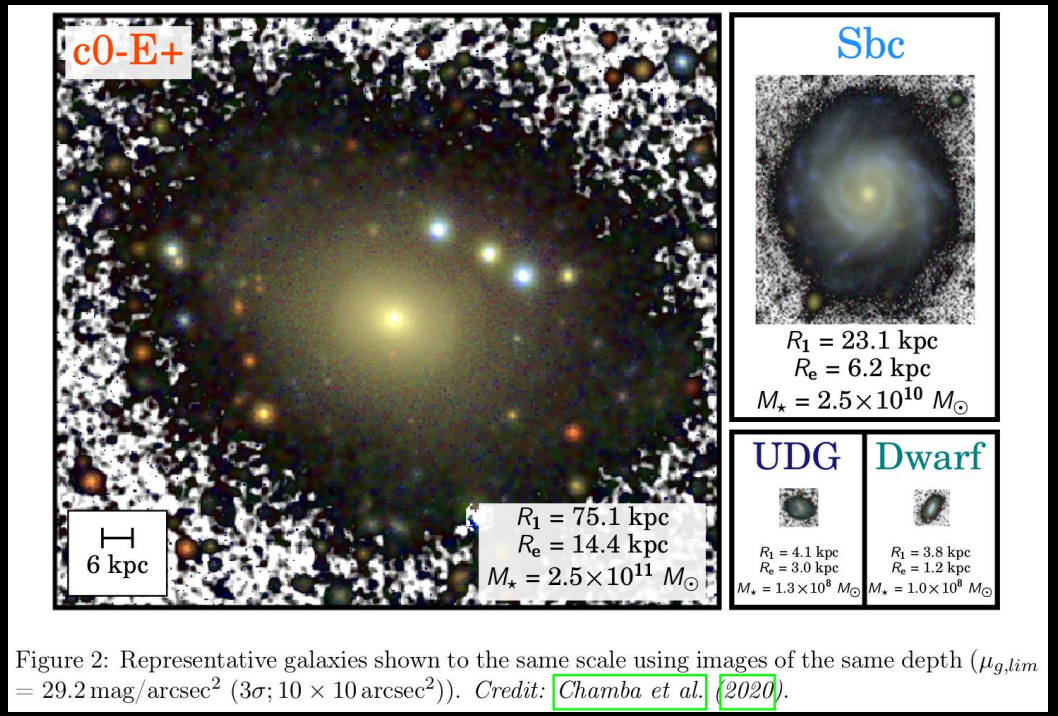


Figure 2: Representative galaxies shown to the same scale using images of the same depth ($\mu_{g,lim}$ = 29.2 mag/arcsec^2 (3σ; 10×10 arcsec^2)). *Credit:* Chamba et al. (2020).

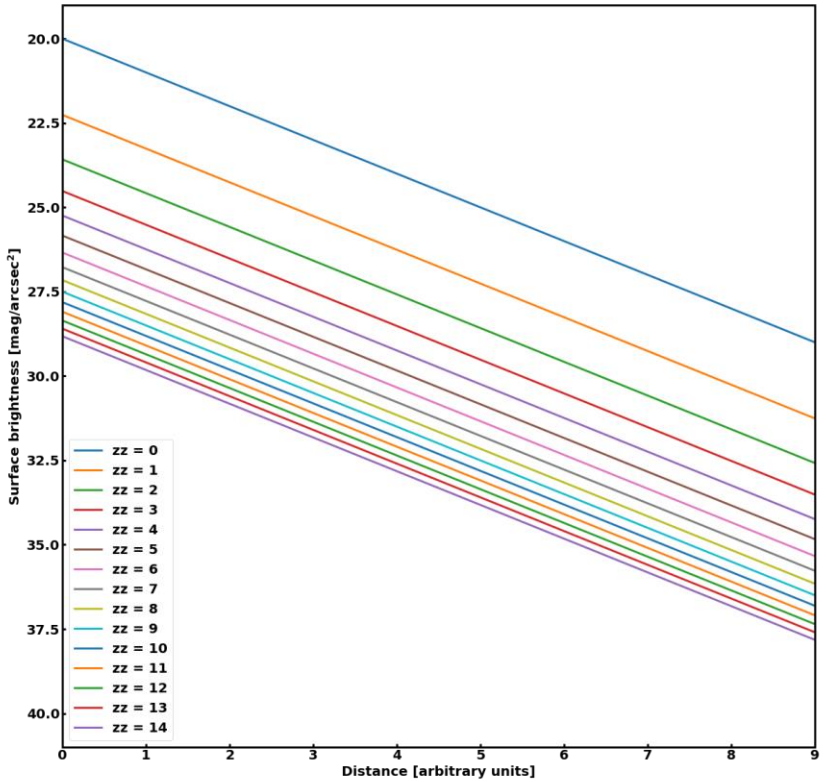
COSMOLOGICAL DIMMING

Tolman test: $(1+z)^4$ –bolometric case–

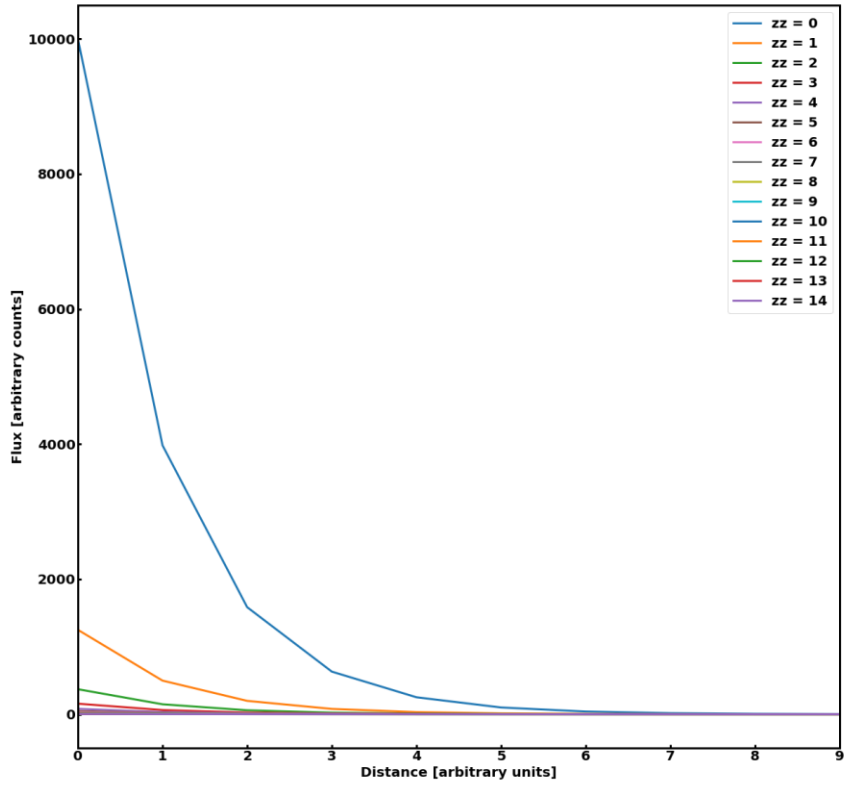
I_ν / ν^3 is a relativistic invariant (being I_ν the power per unit solid angle per unit of area normal to the propagation)

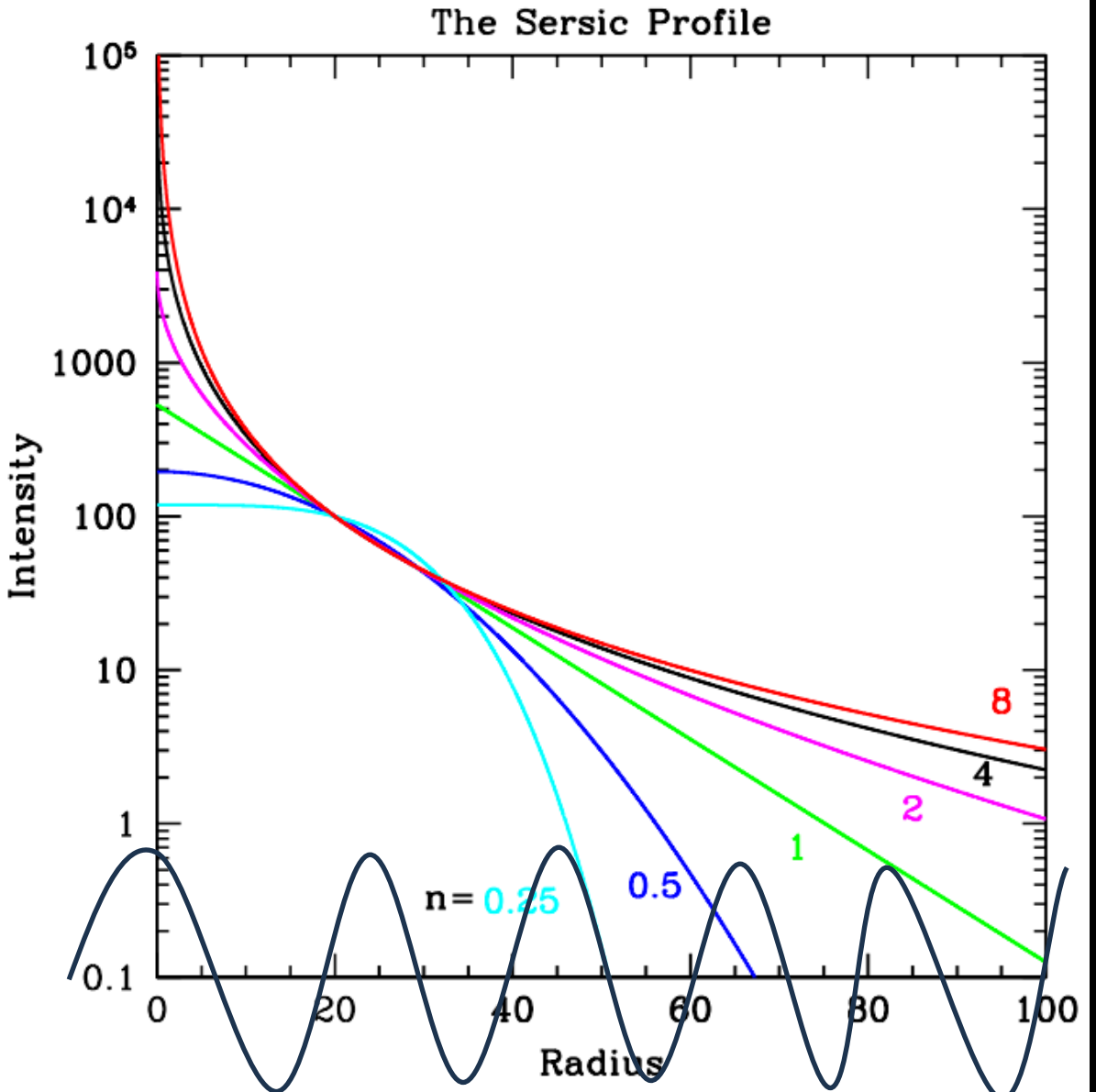
Thus, the surface brightness changes as $(1+z)^3$ times a correction that depends on spectral shape (see also Giavalisco+96, Law+07, Ribeiro+16)

Surface brightness change (log scale)

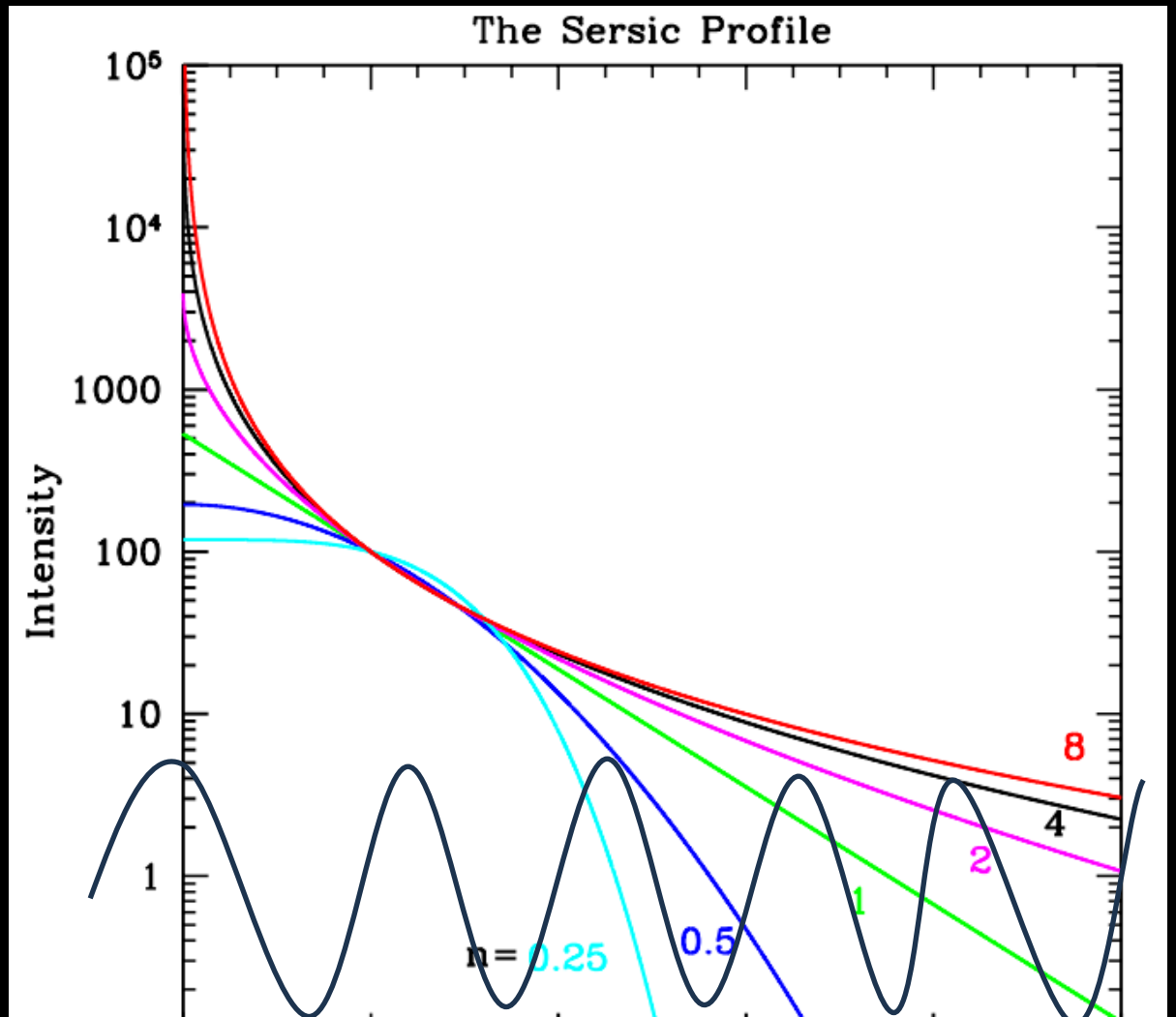


Surface brightness change (linear scale)

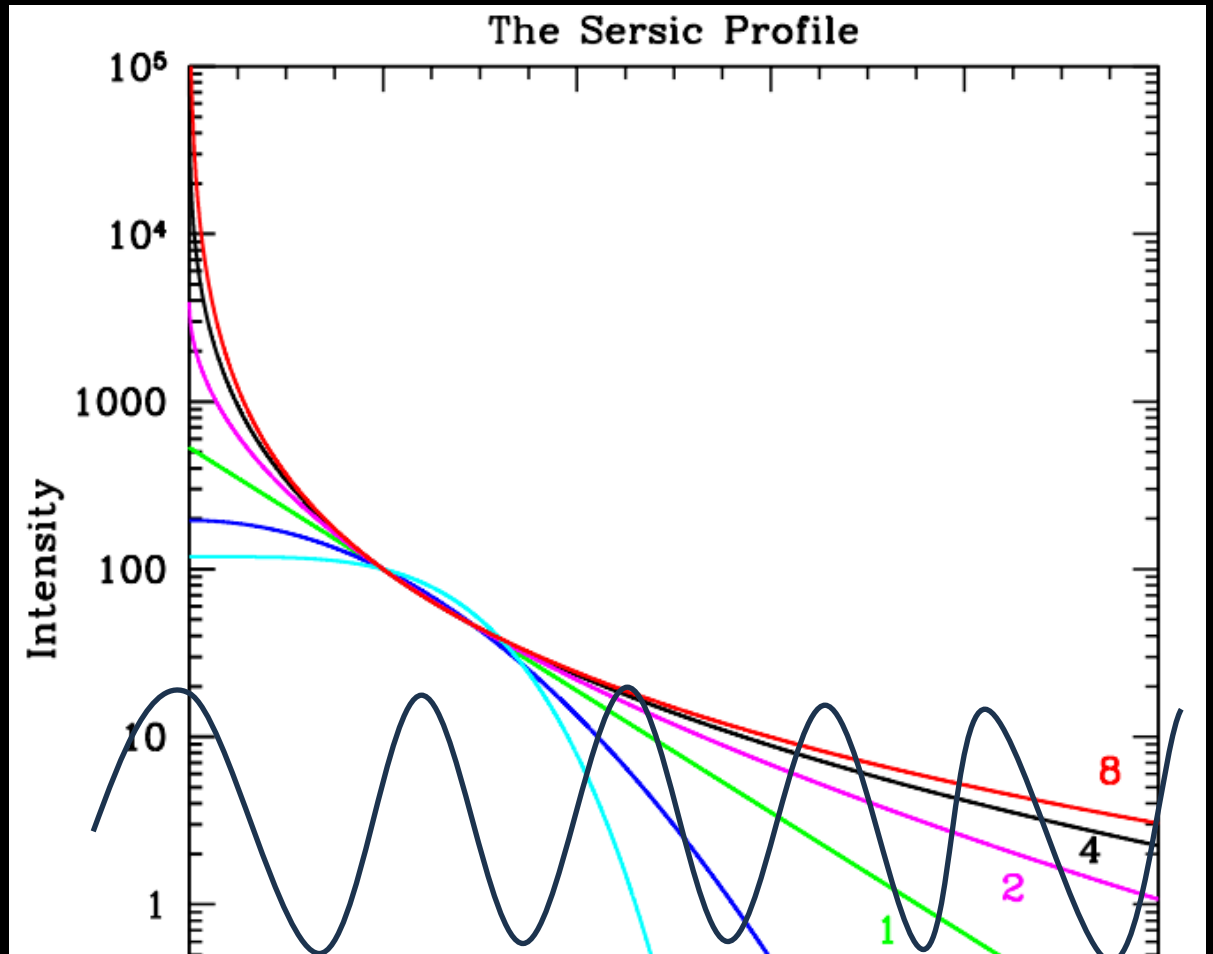



The Sersic Profile
Intensity
Radius
10⁵
10⁴
1000
100
10
1
0.1
0
20
40
60
80
100
8
4
2
1
0.5
n= 0.25

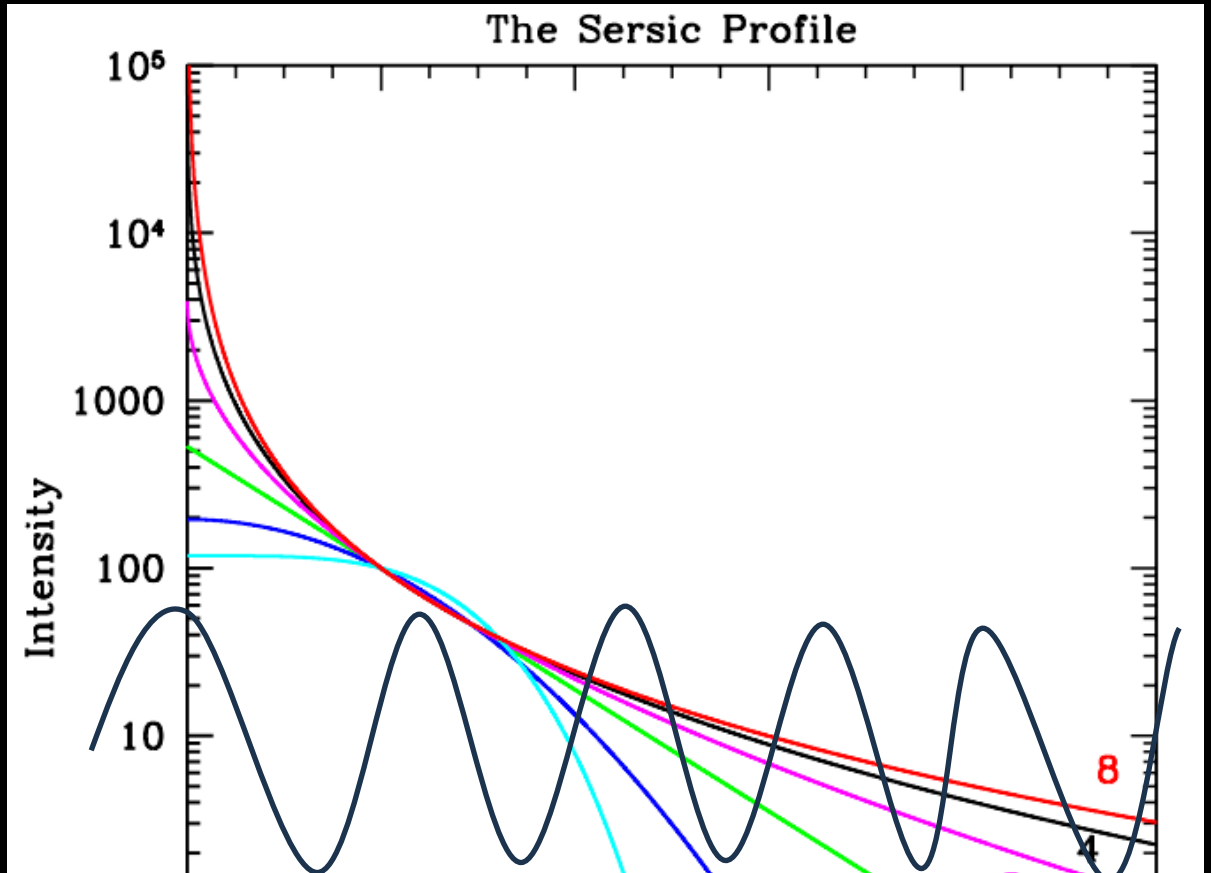
z = 0


The Sersic Profile
Intensity
10⁵
10⁴
1000
100
10
1
8
4
2
1
0.5
n= 0.25

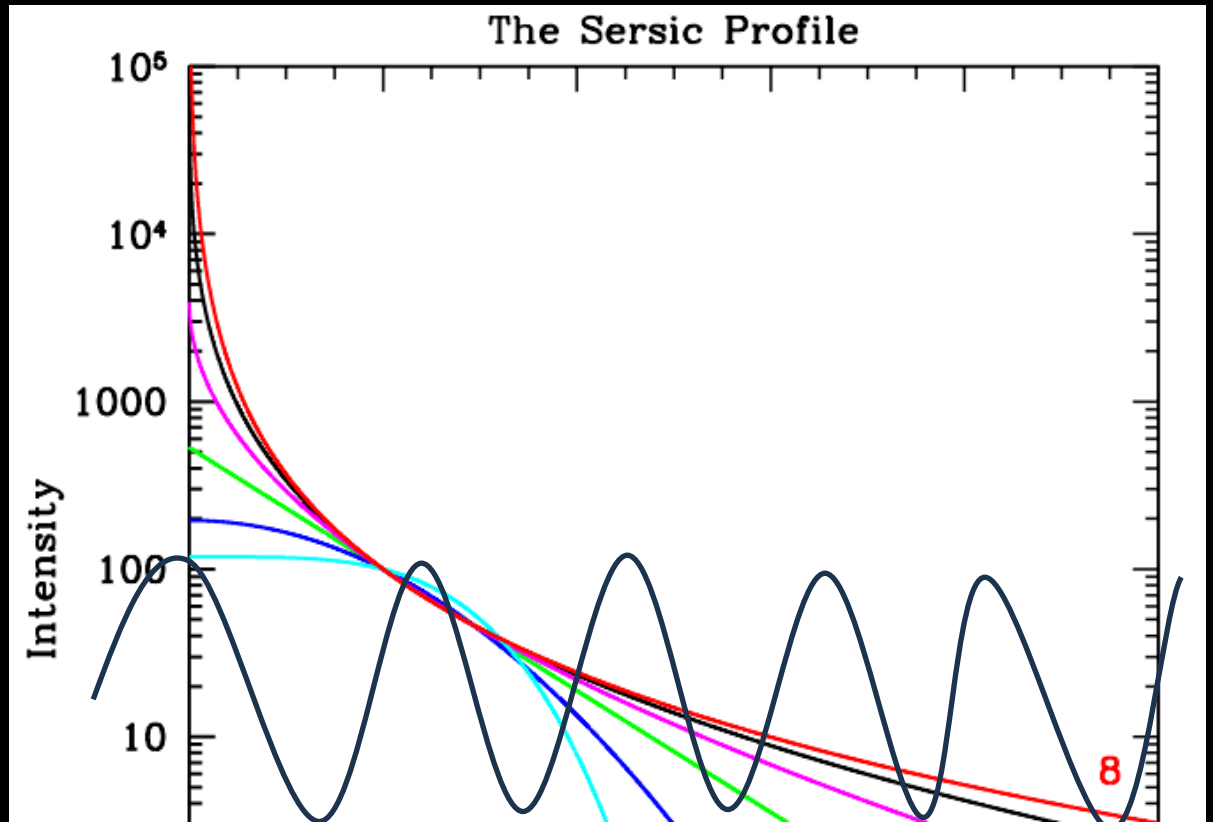
z = 1



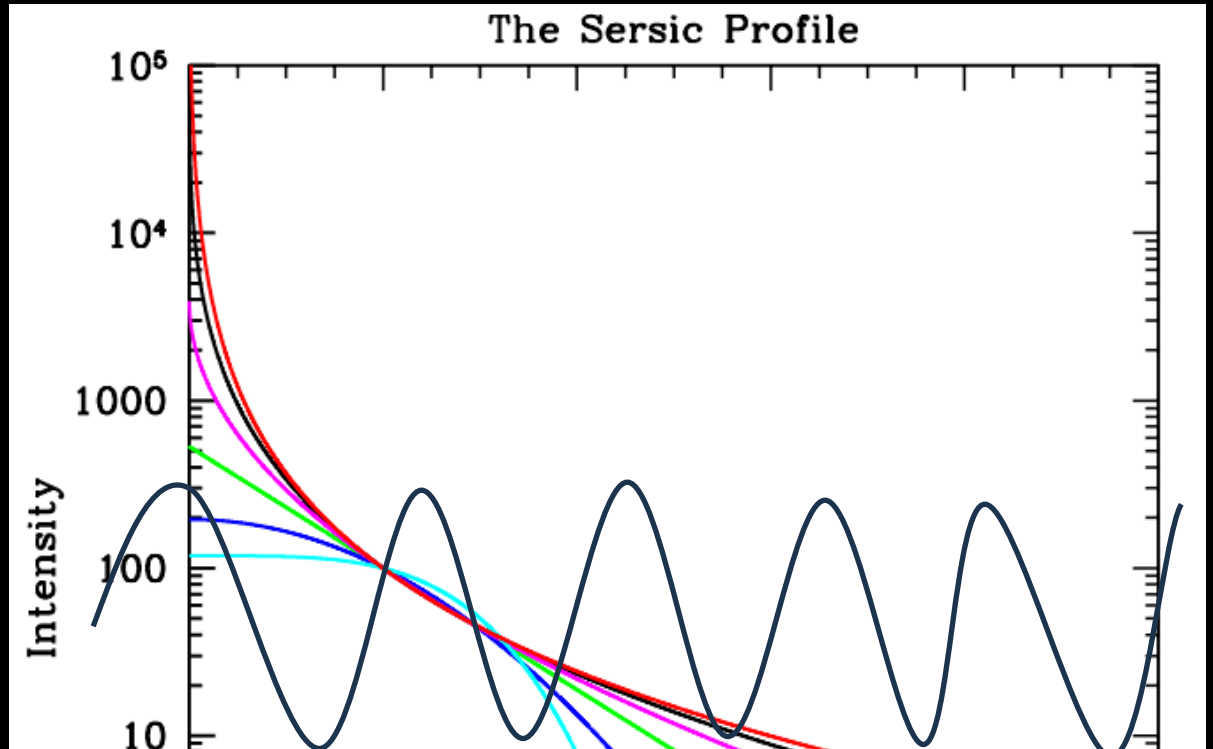
z = 2



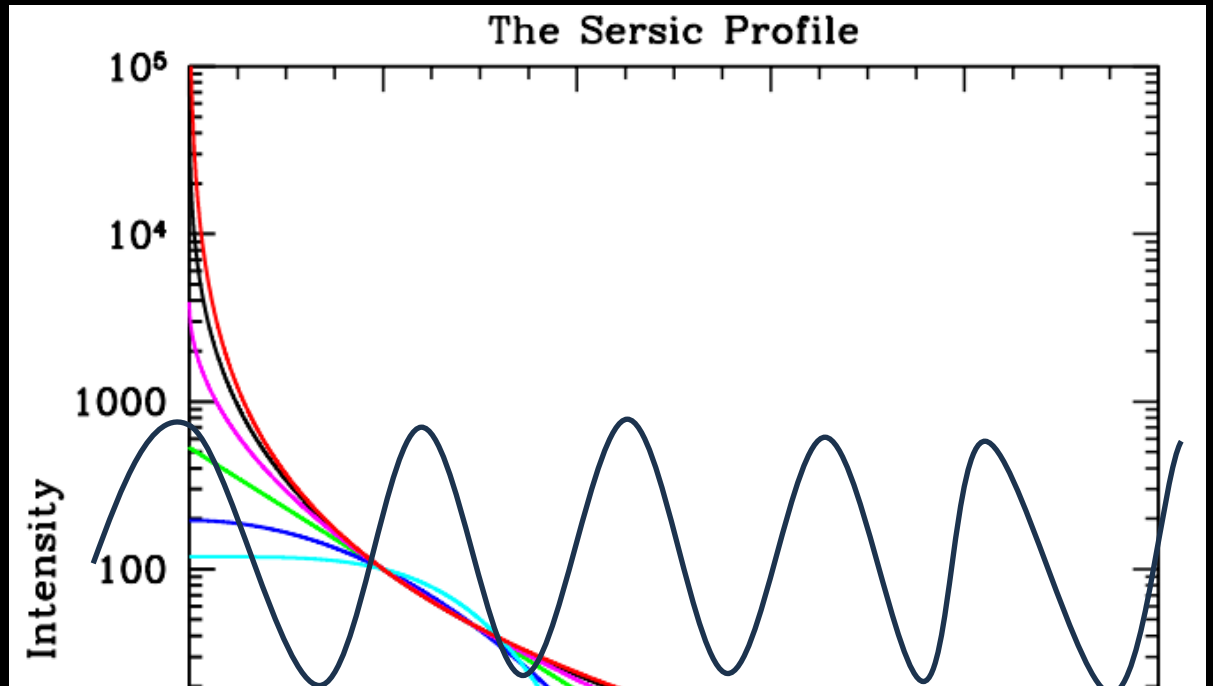
z = 3



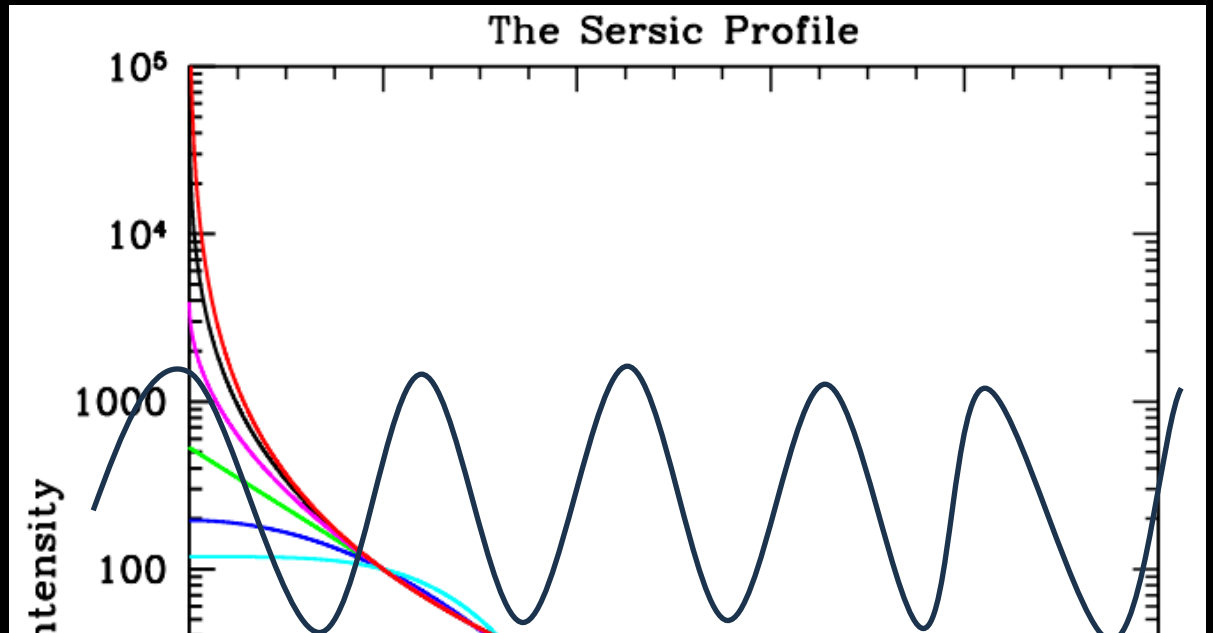
z = 4



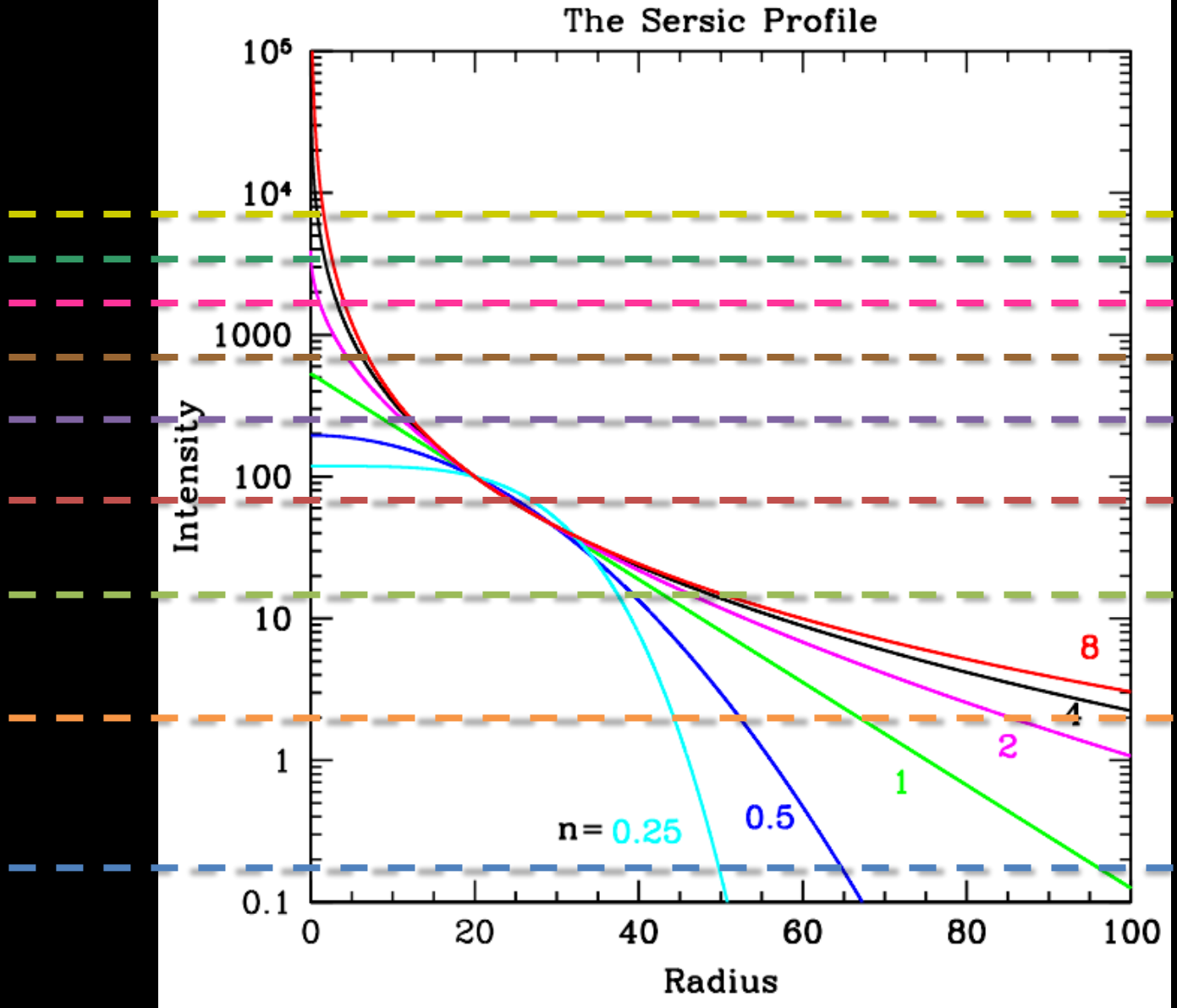
z = 5



z = 6



z = 7



…

z = 7

z = 6

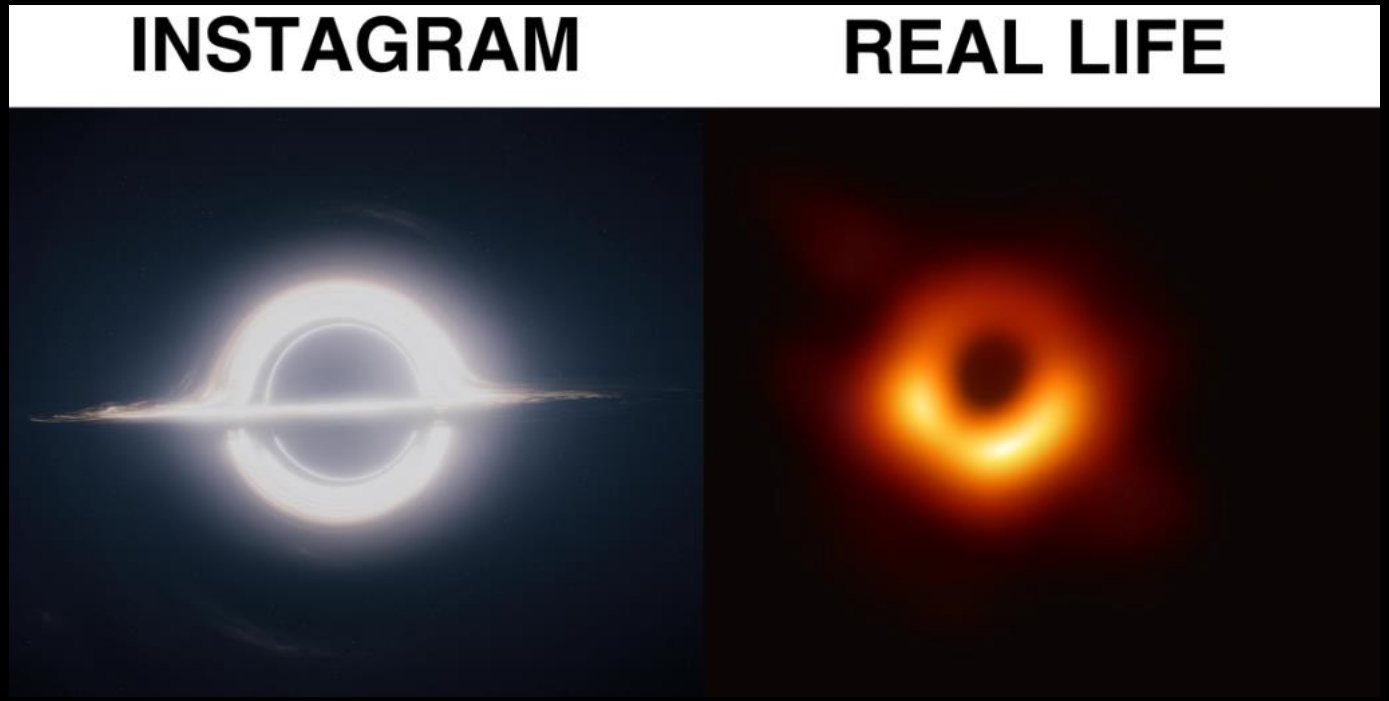
z = 4

z = 3

z = 2

z = 1

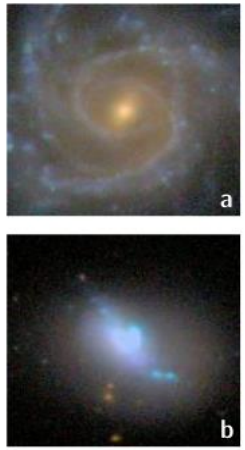
z = 0

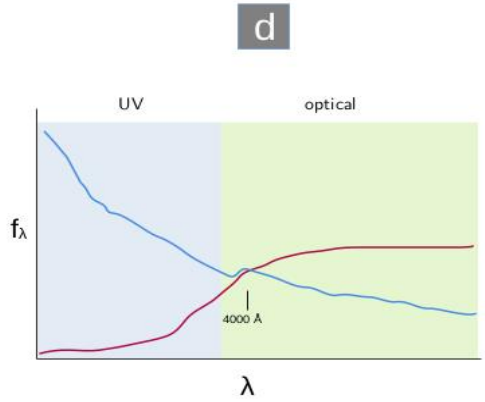


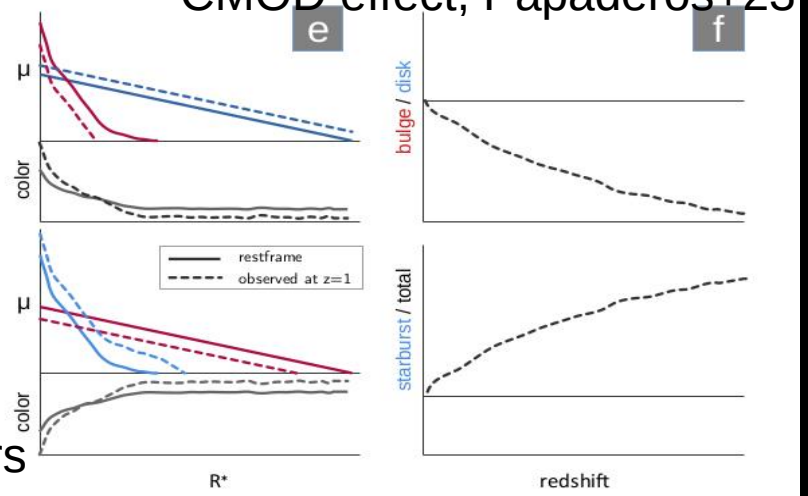
Place here you favourite galaxy

OTHER IMPORTANT EFFECTS

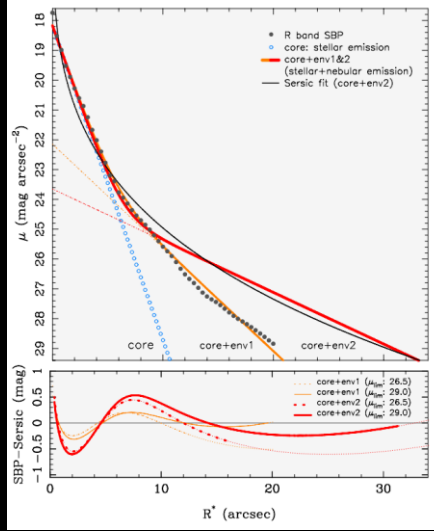
CMOD effect, Papaderos+23

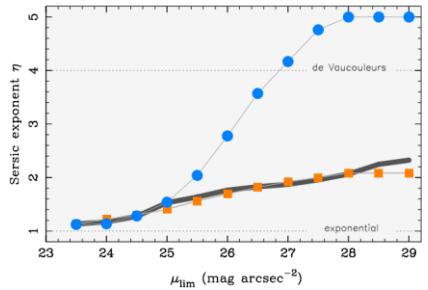




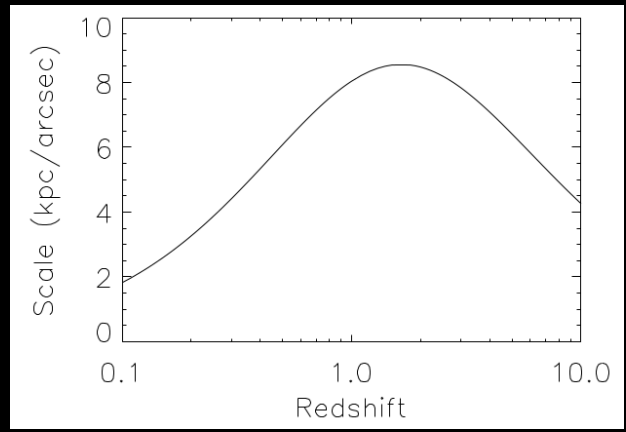


Very relevant for Lyα emitters

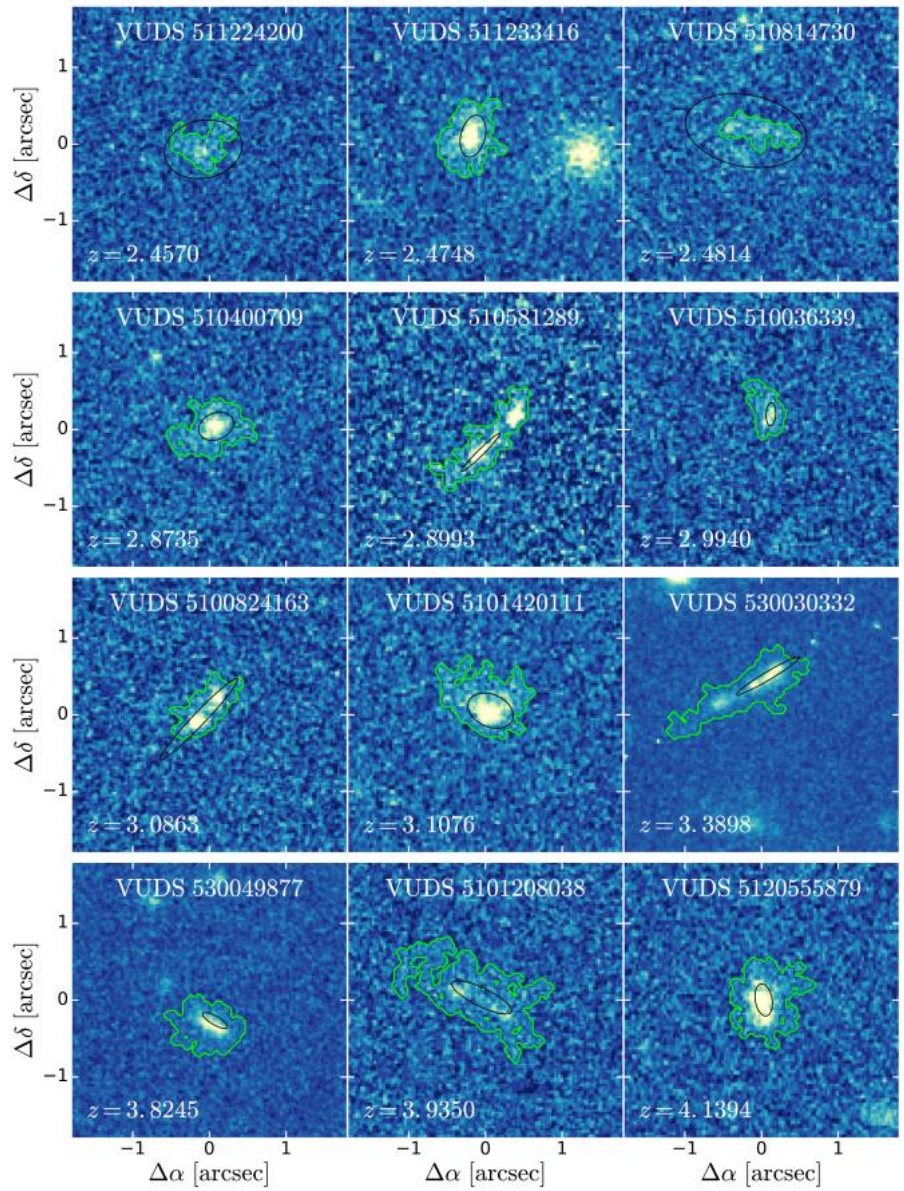


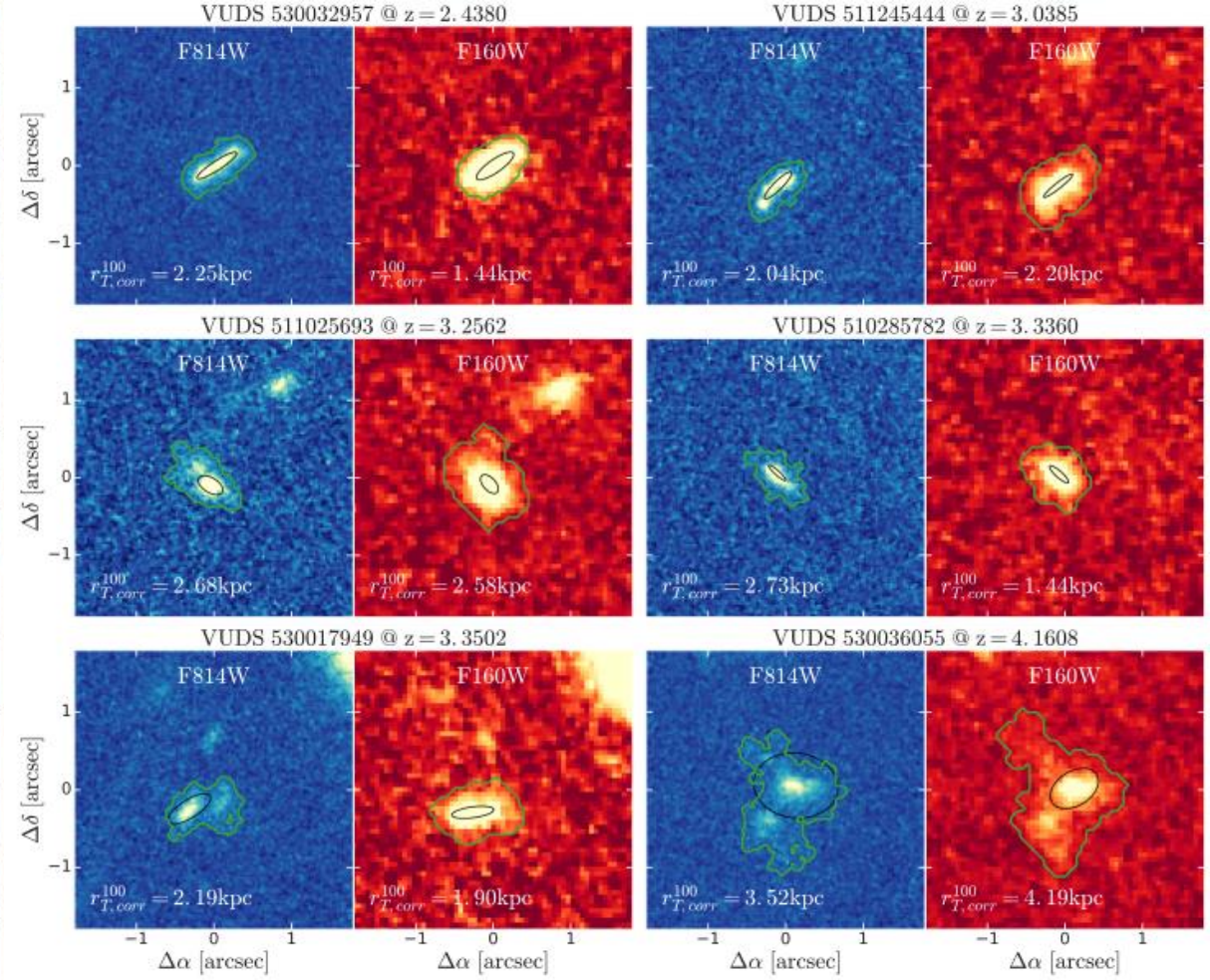


Papaderos & Östlin (2012) Double exponential mimicking high Sersic index



Change of the physical scale over z (from Epinat+10)



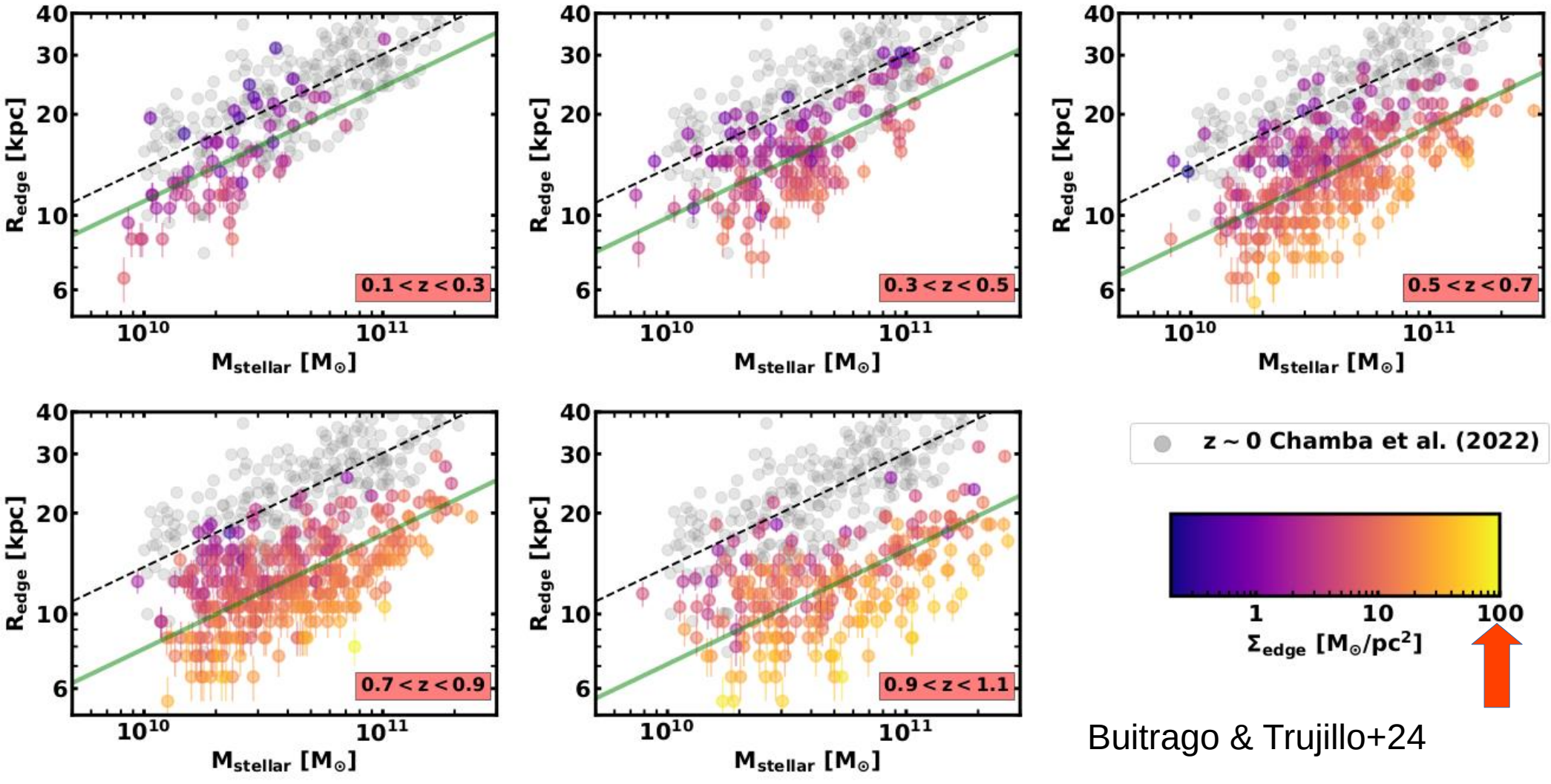


Ribeiro+16, star forming galaxies @ 2 < z < 4.5

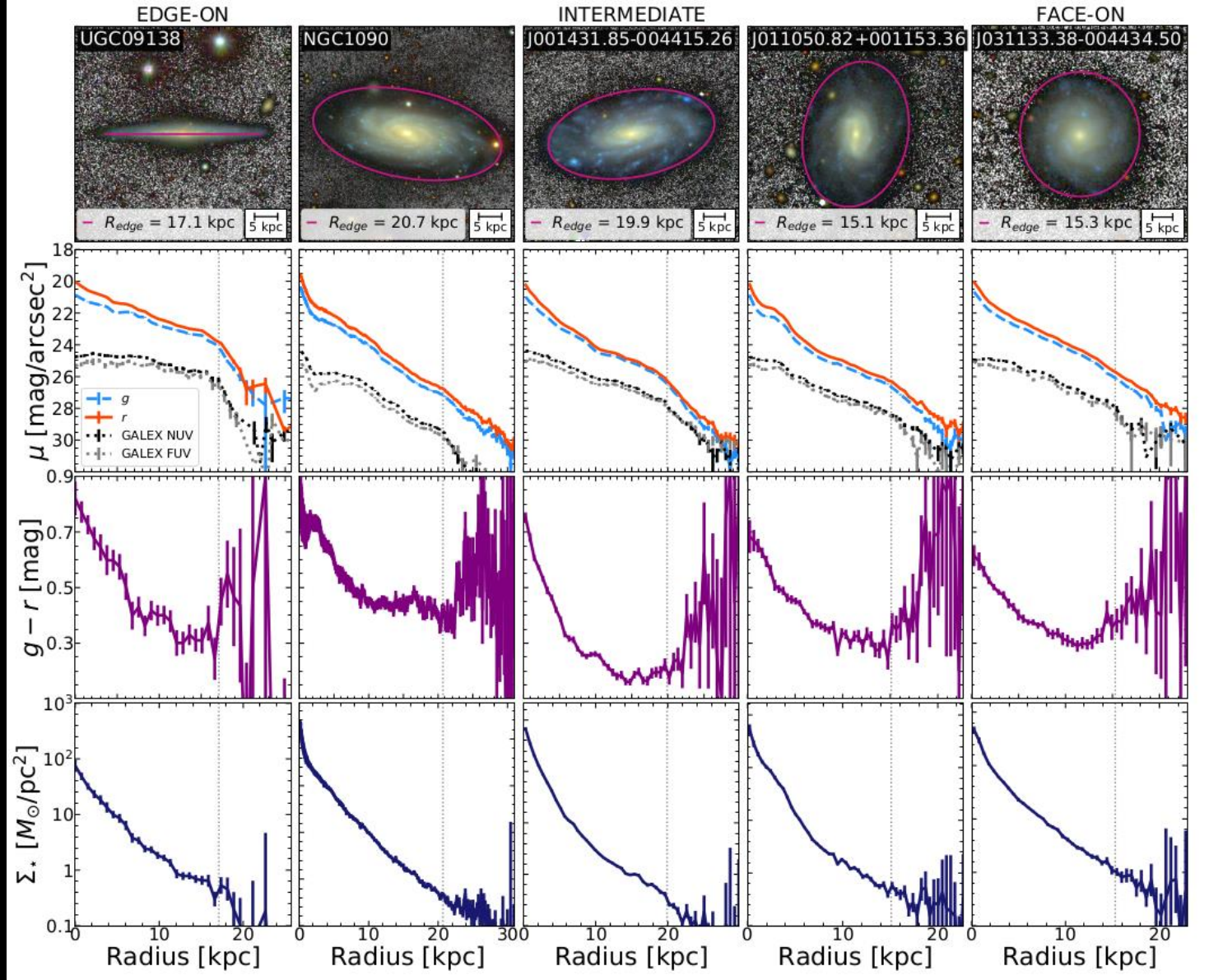
F814W => 271 < λ[nm] < 148

F160W => 533 < λ[nm] < 291

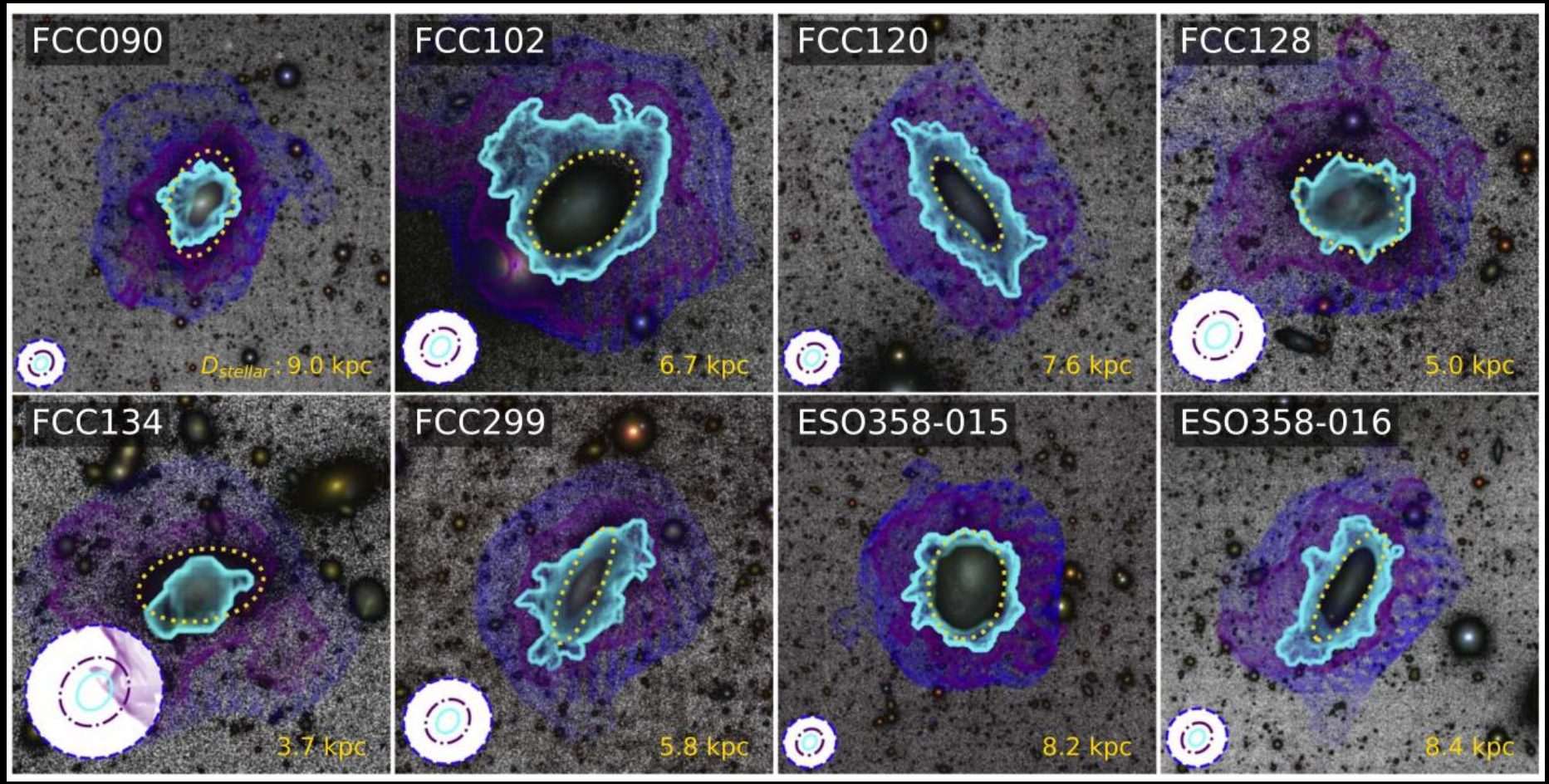
NEW MASS-SIZE RELATION



Buitrago & Trujillo+24


EDGE-ON
INTERMEDIATE
FACE-ON
UGC09138
NGC1090
J001431.85-004415.26
J011050.82+001153.36
J031133.38-004434.50
R_{edge} = 17.1 kpc
R_{edge} = 20.7 kpc
R_{edge} = 19.9 kpc
R_{edge} = 15.1 kpc
R_{edge} = 15.3 kpc
5 kpc
μ [mag/arcsec^2]
g
r
GALEX NUV
GALEX FUV
$g-r$ [mag]
$\Sigma_\star$ [$M_\odot$/pc^2]
Radius [kpc]

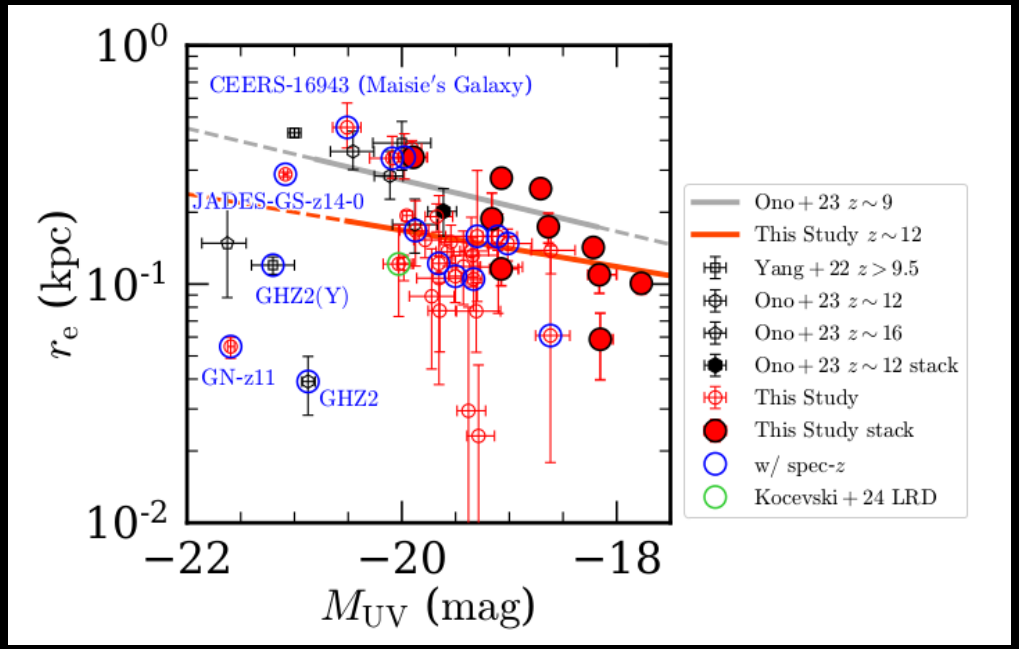
Chamba+ 22



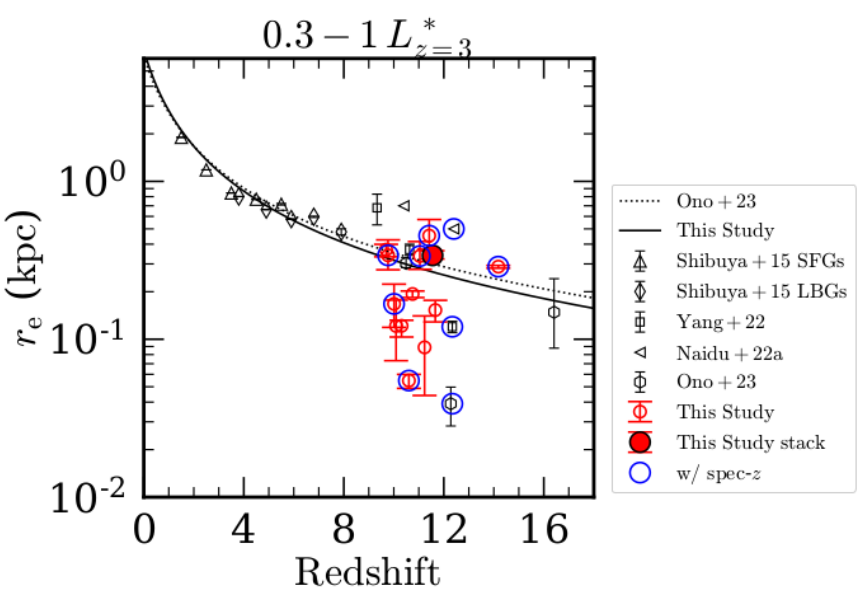
Chamba+24

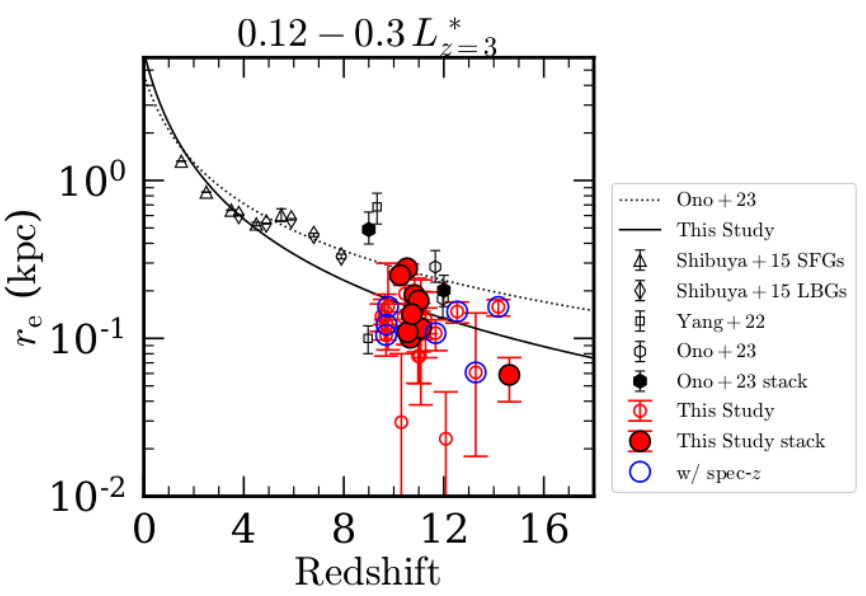
As it is related with star formation, Hα should be a better tracer...

WHAT DO PEOPLE KNOW AT z ≥ 10?



Ono+25





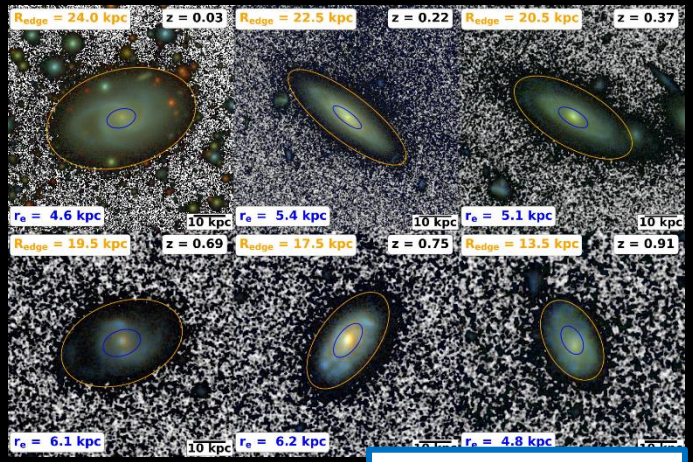
CONCLUSIONS

- The Low Surface Brightness (LSB) universe help us realizing that, when studying galaxies, we are looking at the tip of the iceberg

- Can we do better? Not at z > 2-3, effective radii are arbitrary and biased by light concentration but perhaps our only tool at very high z ☺

- Help us with our quest to find truncations by other means

- Galaxies are not Sersic functions



Buitrago & Trujillo (2024)

- Report your biases (we all have many!), compare pears with pears and do not expect perfect scaling relations

Fernando Buitrago, fbuitrago@uva.es