EVIDENCE FOR A SIGNIFICANT POPULATION OF MASSIVE QUENCHED DISKS IN THE EARLY UNIVERSE

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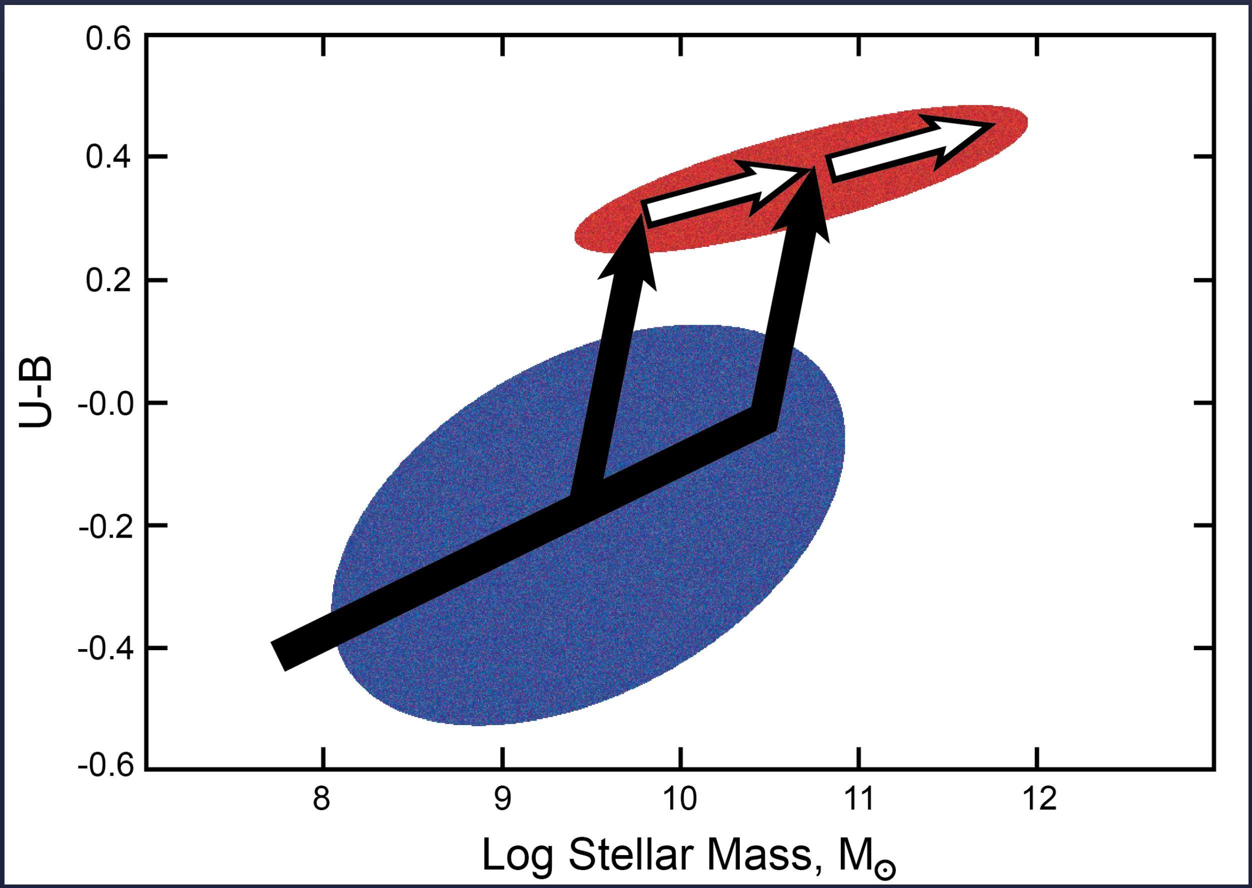
#galpath2016, @Prof_McGrath

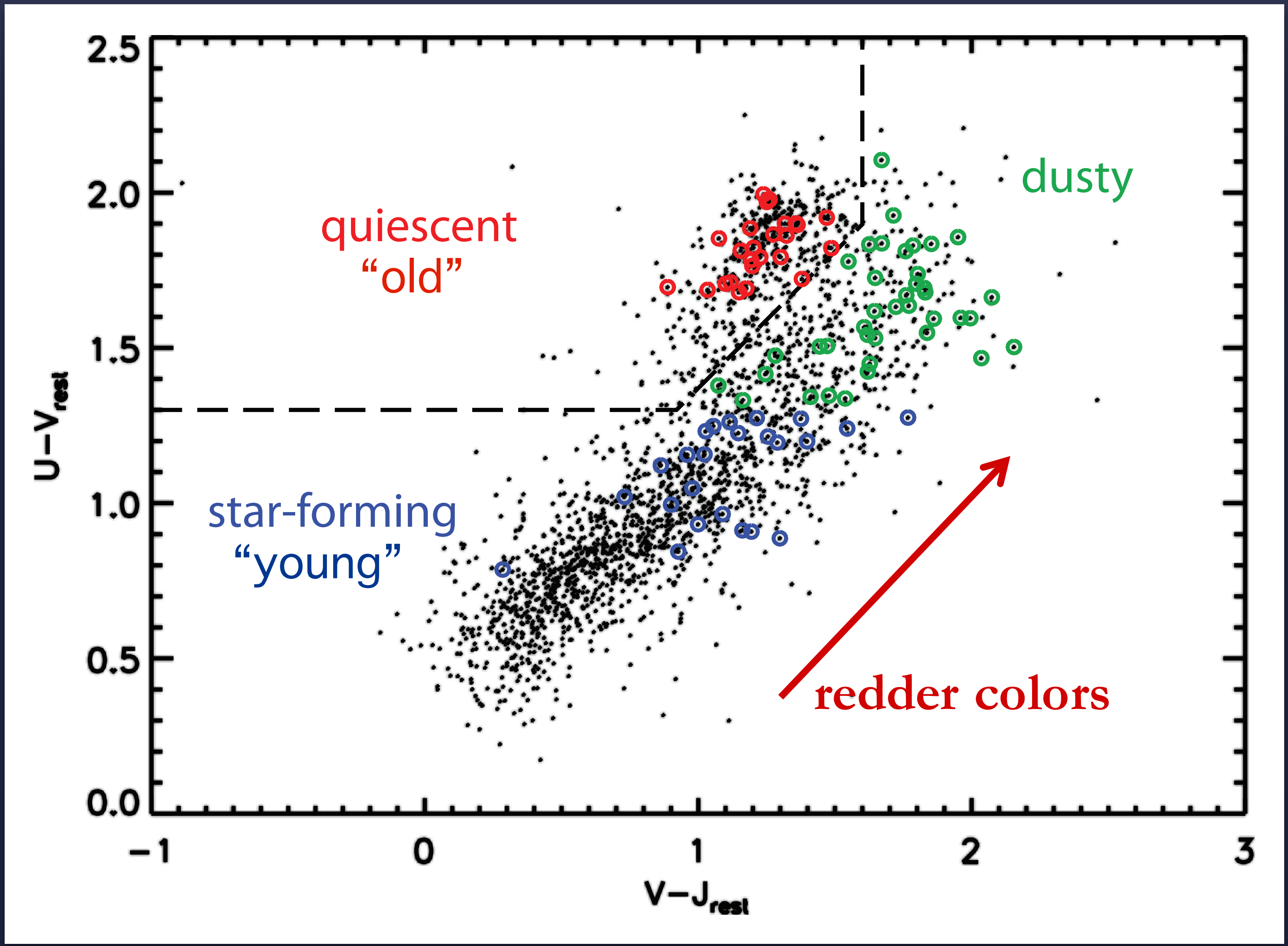
Catalina Island

PATHWAYS



Faber et al. (2007)

UVJ DIAGRAM:
QUIESCENT GALAXY SELECTION



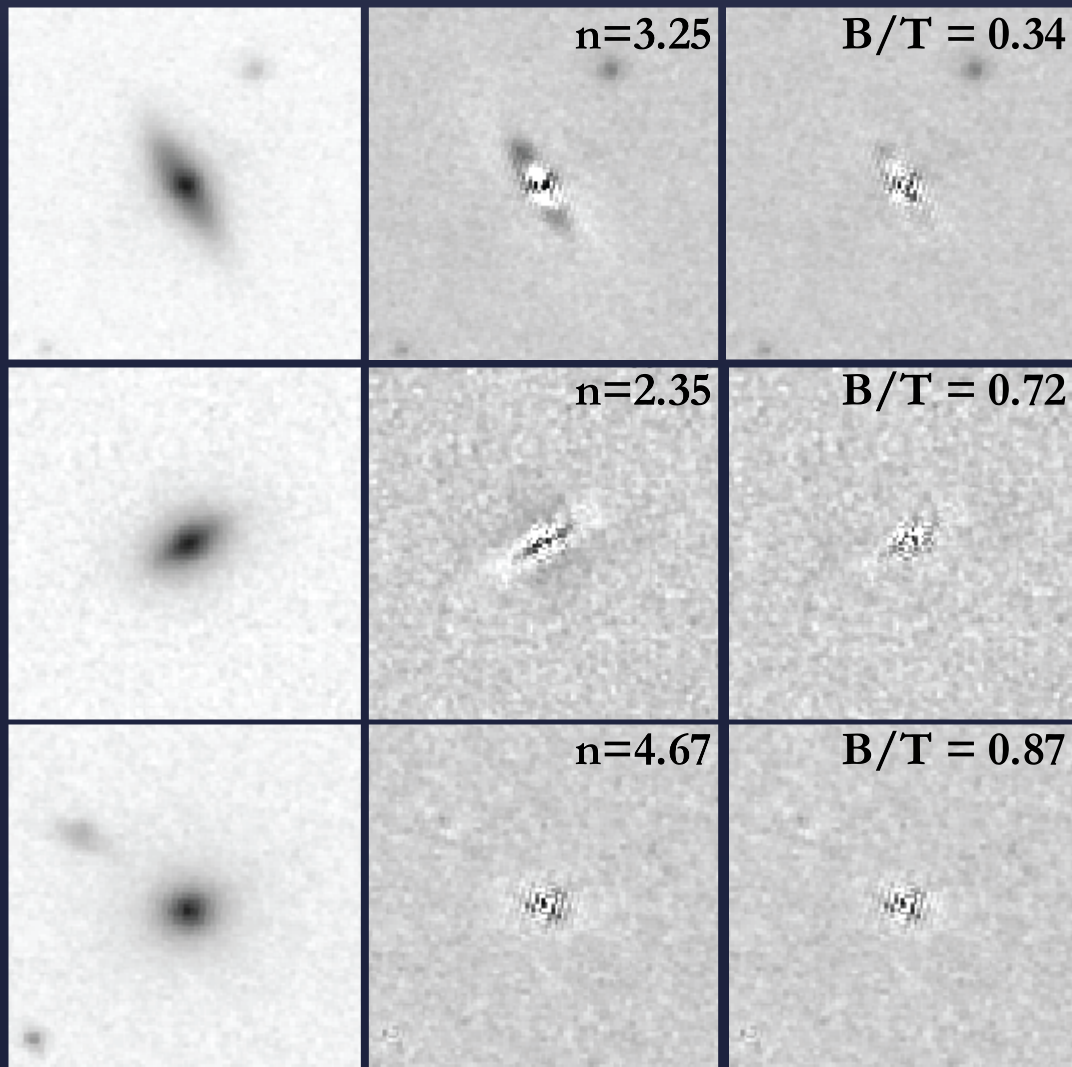
DETAILED MORPHOLOGY STUDIES

- Real galaxies aren't as simple as pure disks or pure ellipticals.
- By convention, Sersic
  $n<2.5$ = disk-like
  $n>2.5$ = spheroidal
- With good data we can decompose an image of a galaxy into its subcomponents

TWO-COMPONENT FITTING

1-component residual

2-component residual



disk-dominated (2 components)

bulge-dominated (2 components)

spheroid (1 component)

TWO-COMPONENT FITTING

Residual Flux Fraction:

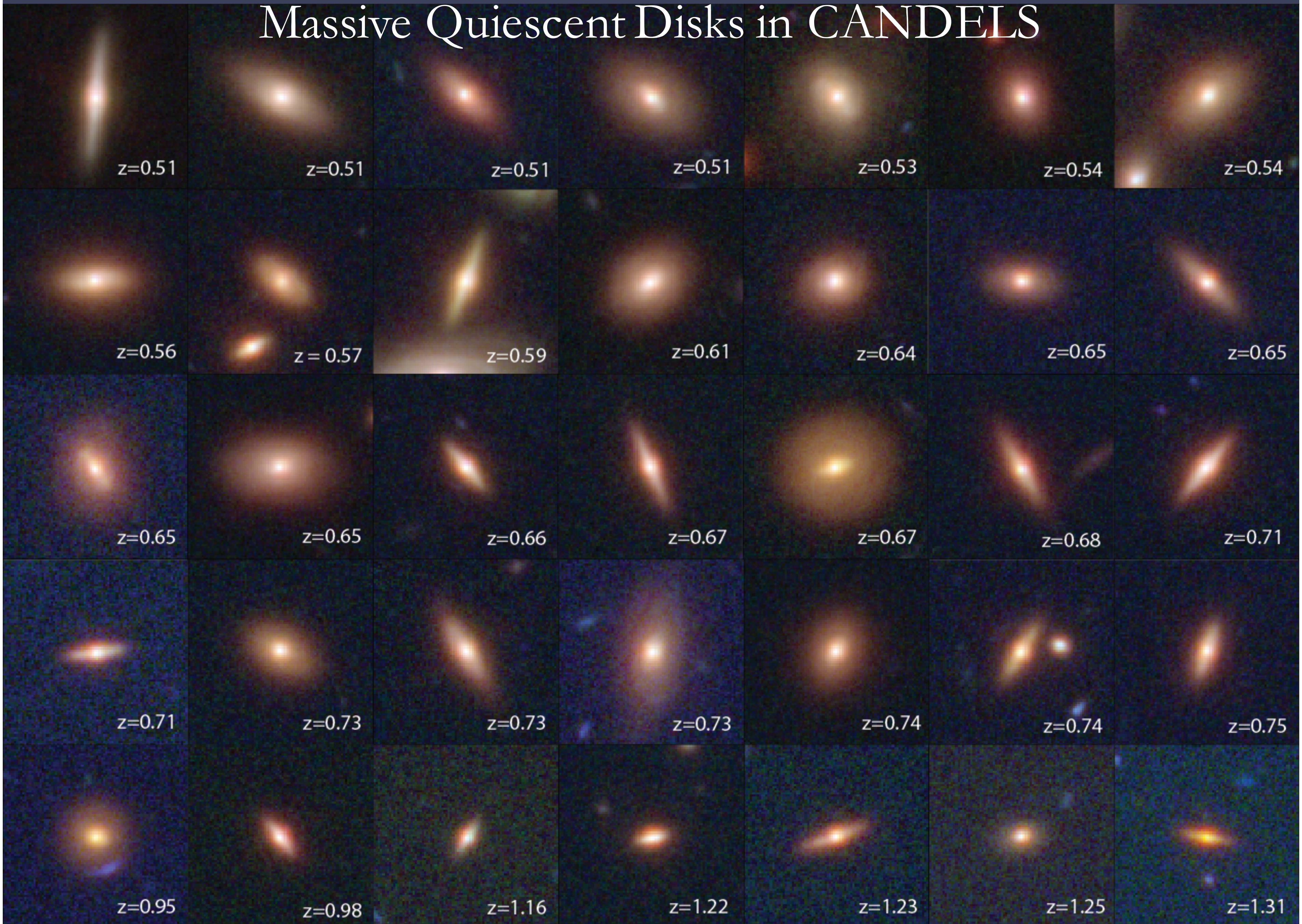
$$\mathrm{RFF} = \frac{\sum_{i,j\in A} \left| I_{i,j} - I_{i,j}^{\mathrm{model}} \right| - 0.8 \times \sum_{i,j\in A} \sigma_{i,j}^{bkg}}{\sum_{i,j\in A} I_{i,j}}$$

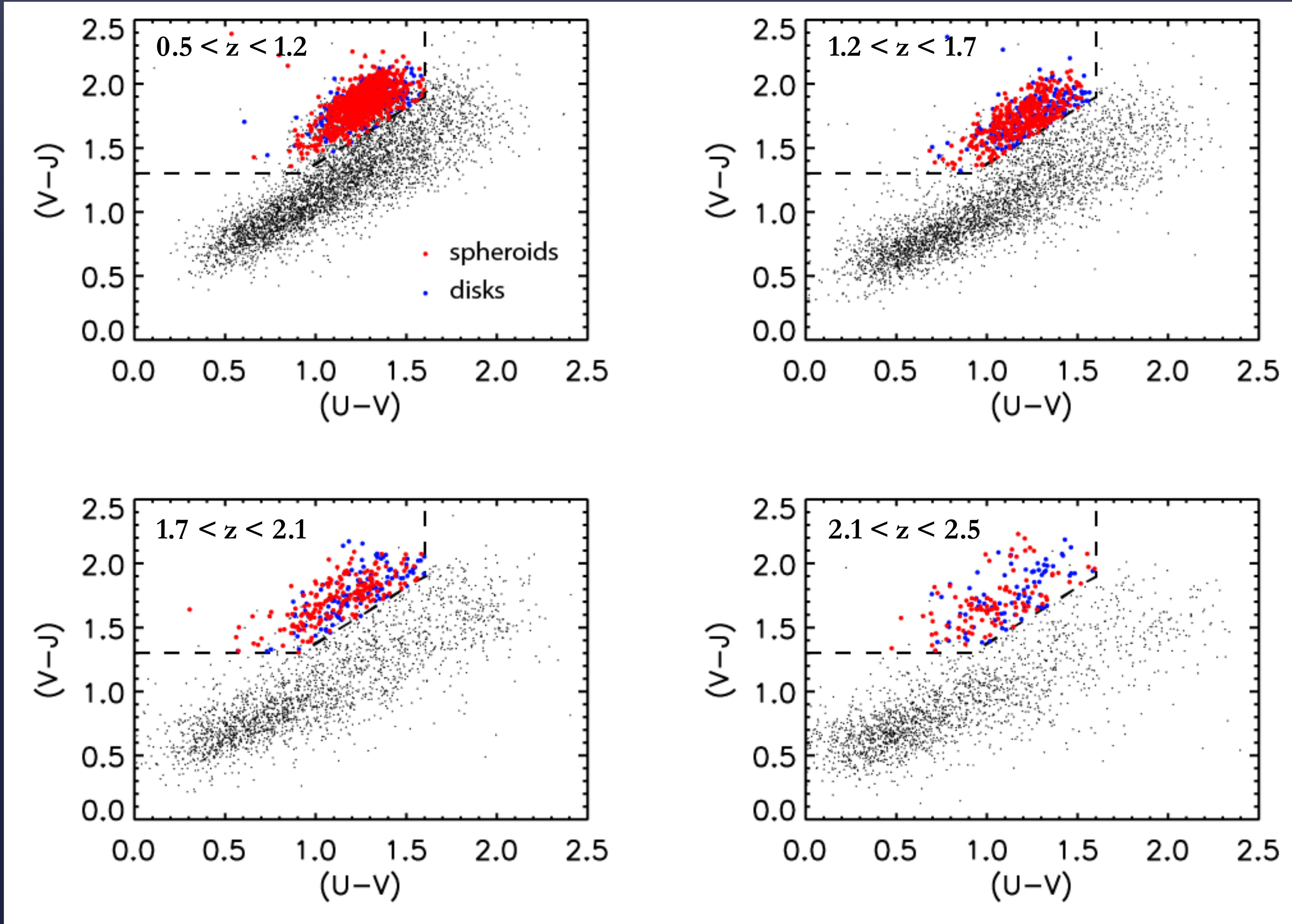
(Hoyos et al. 2011)

Compare RFF for 1 and 2-component models to determine whether 2-components are required to sufficiently fit the data.

We require (RFF1 – RFF2)/RFF1 > 0.5 to favor the 2-component model.

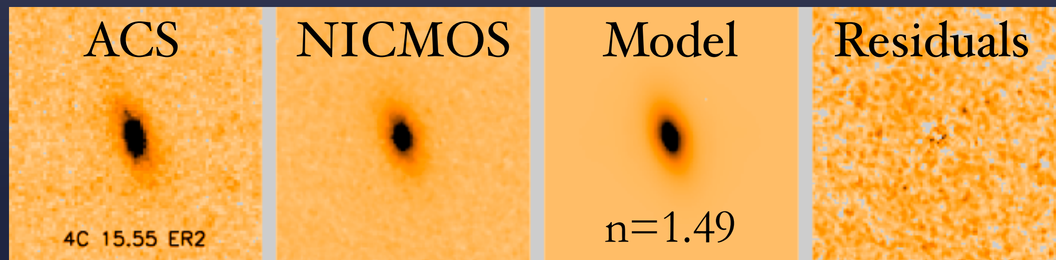
Massive Quiescent Disks in CANDELS



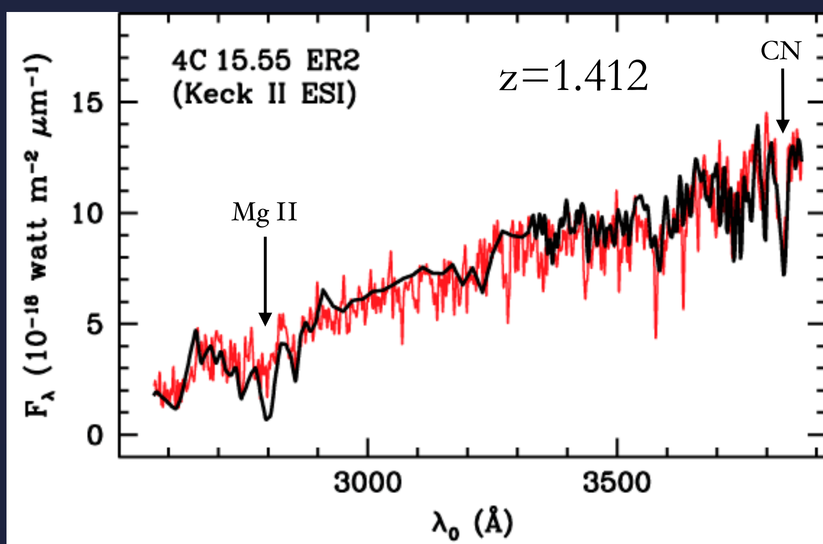


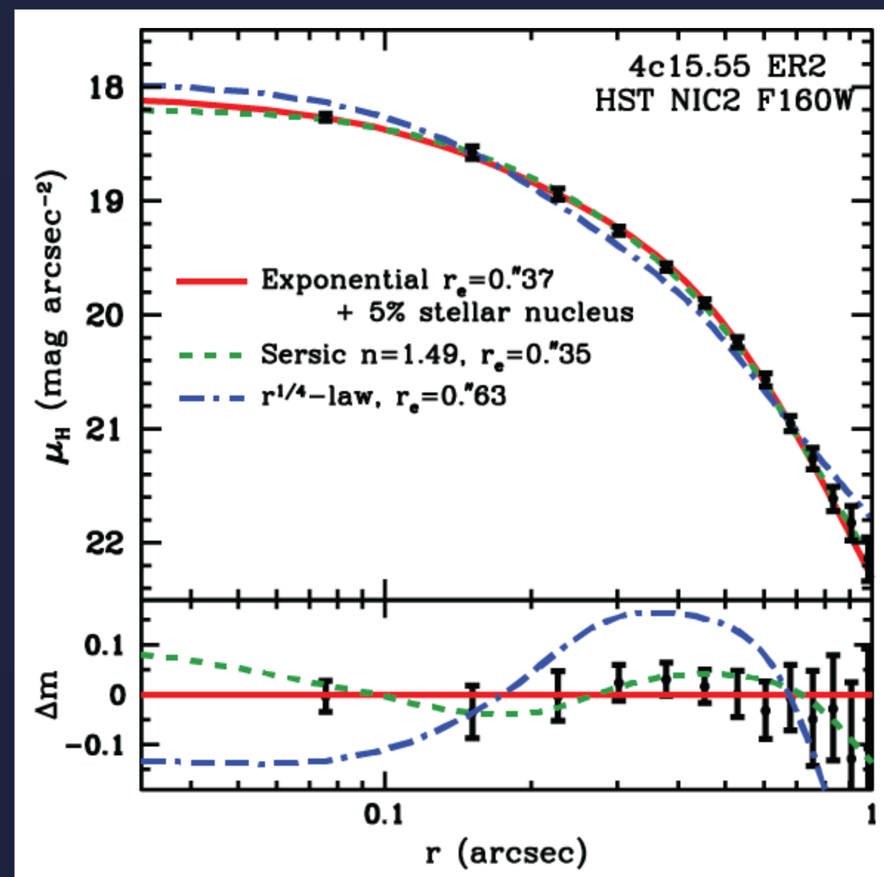
0.5 < z < 1.2
1.2 < z < 1.7
1.7 < z < 2.1
2.1 < z < 2.5
spheroids
disks
(V−J)
(U−V)
0.0
0.5
1.0
1.5
2.0
2.5

EARLIER WORK ON QUIESCENT DISKS



- Some quiescent galaxies are nearly pure exponential disks



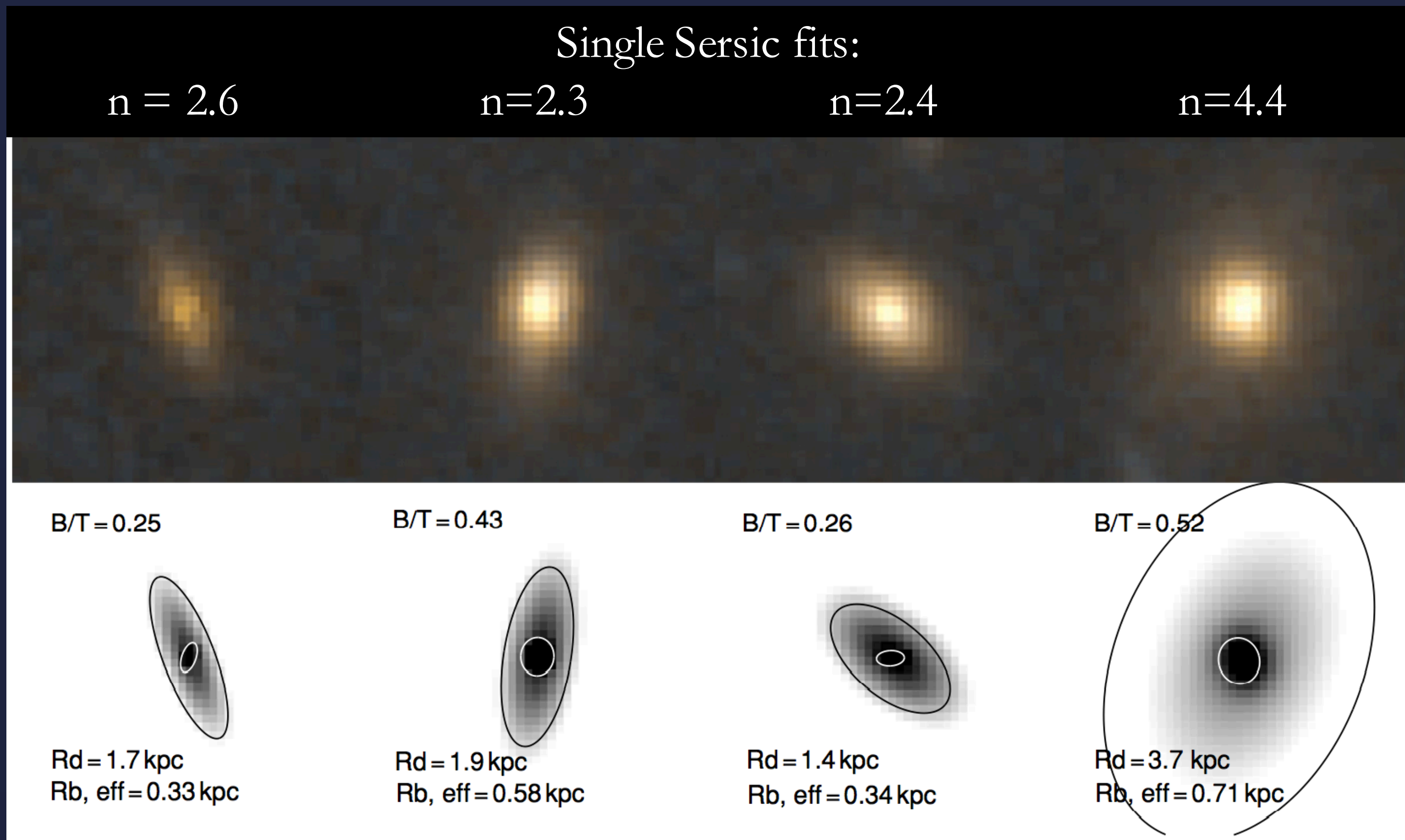


EJM et al. (2007, 2008)

EARLIER WORK ON QUIESCENT DISKS

- Using the WFC3 ERS data, we also found evidence for massive, quiescent disks.

Bulge component < ½ total light

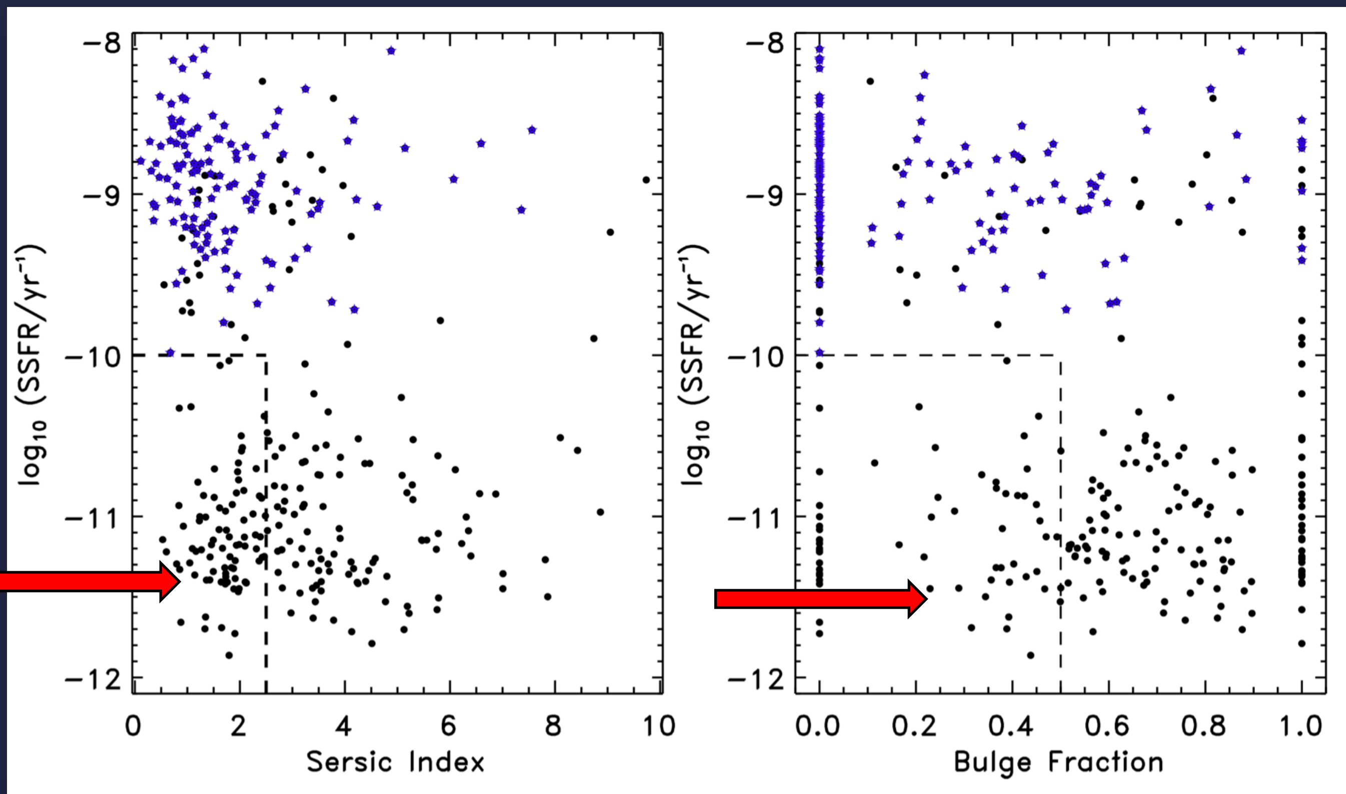


van der Wel+, EJM, et al. (2011)

EARLIER WORK ON QUIESCENT DISKS

- Results from CANDELS UDS & COSMOS fields ($1<z<3$, $M_*>10^{11}$ M_{sun})

30% of all quiescent galaxies have n<2.5



29% of all quiescent galaxies have B/T < 0.5

Bruce et al. (2014)

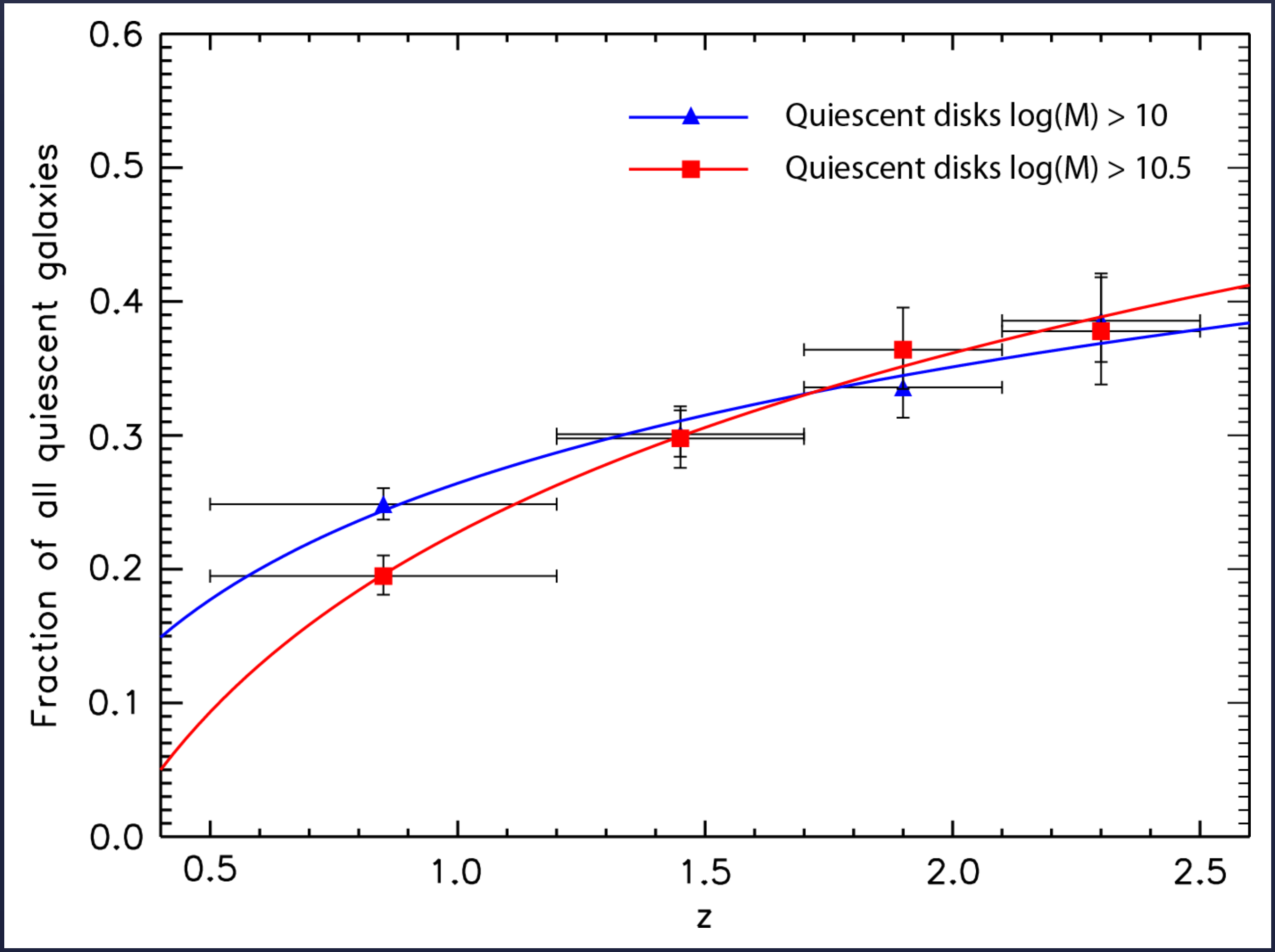
REDSHIFT EVOLUTION IN QUIESCENT DISK FRACTION

Statistics using all 5 CANDELS fields:

Significant fraction (>35%) of quiescent disks at high-z.

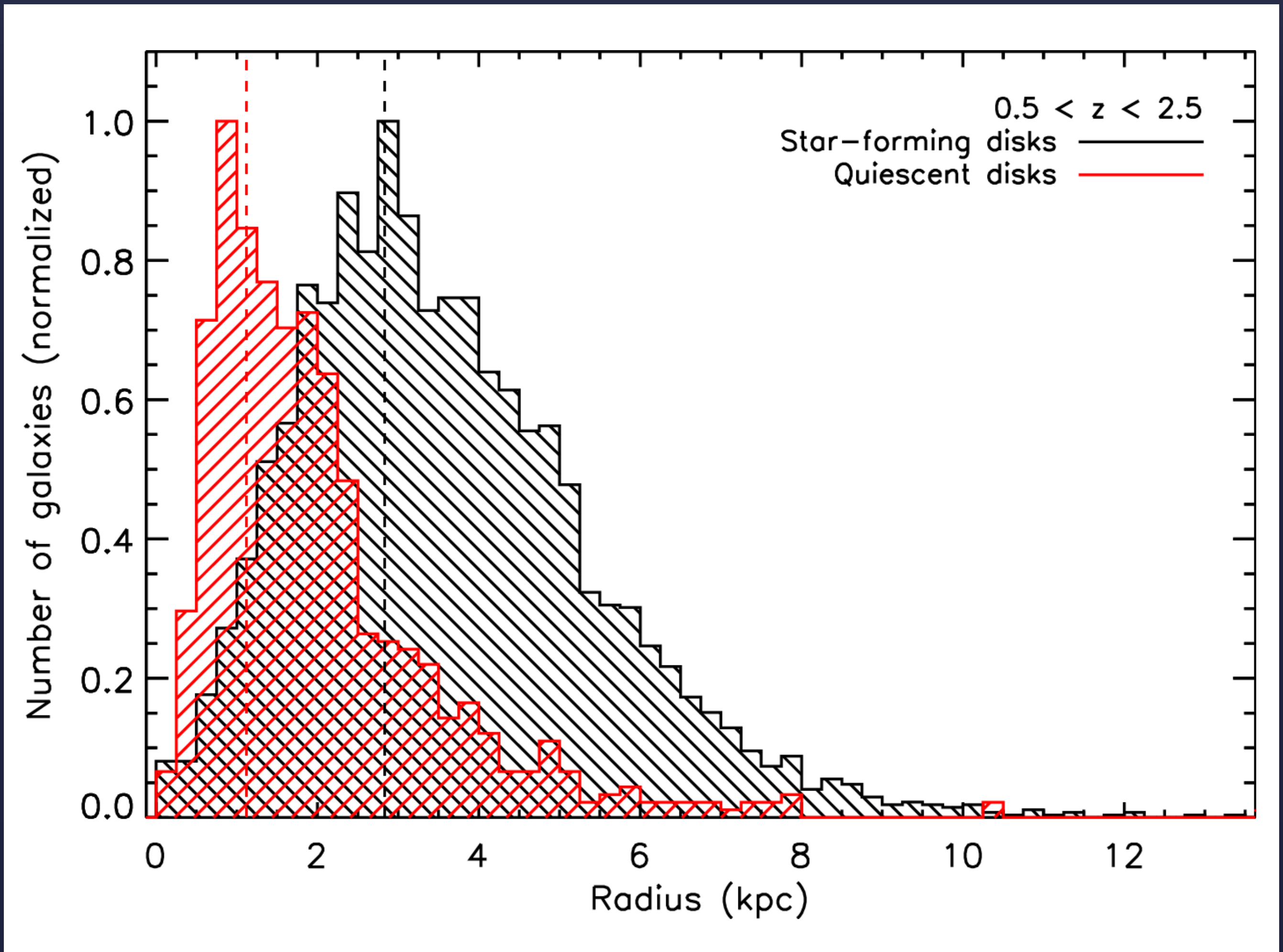
Trend even more prominent among the most massive galaxies.

Note: QDs defined to have B/T < 0.5 or n<2.5



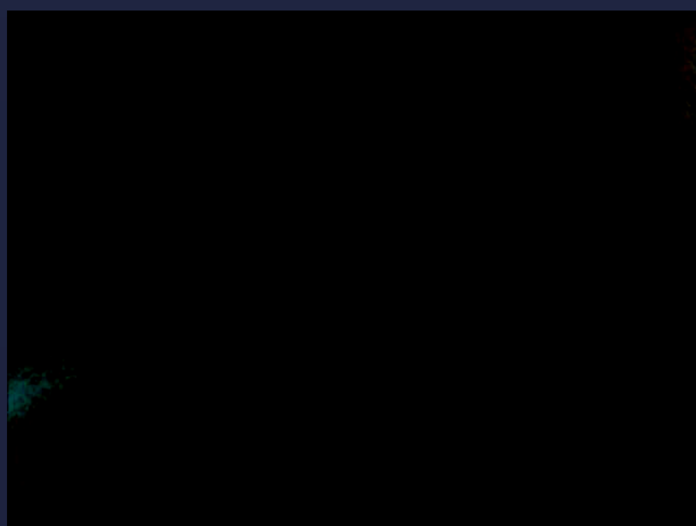
COMPACTNESS

Like their quiescent spheroid counterparts, quiescent disks are significantly more compact than star-forming galaxies at the same redshift and mass.

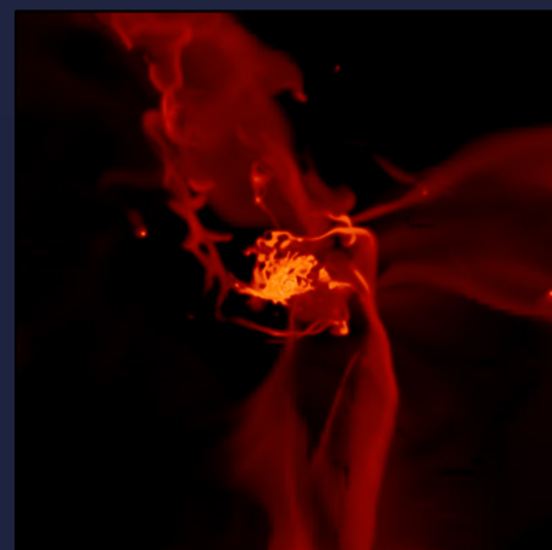


THE IMPORTANCE OF QUIESCENT DISKS

- Disks quenched before transforming to spheroids.
- Compactification?
- How to assemble ~ 10^{11} M_{sun} into a disk at early times?



Major mergers: requires extremely gas-rich progenitors, and even then, difficult to form low bulge fraction disks.



Cold mode accretion: can build up angular momentum. VDI efficient at forming compact objects.

THE IMPORTANCE OF QUIESCENT DISKS

- Disks quenched before transforming to spheroids.
- Compactification?
- How to assemble ~ 10^{11} M_{sun} into a disk at early times?
- How to shut down SF?
  - AGN? – need a source of fuel (mergers, VDI, etc.). No evidence of AGN in quiescent disks, but may be explained by duty cycle.
  - Halo/ environmental quenching? – needs further study. Don't expect that they are in extreme environments, but may be overdense with respect to the field.
  - Other processes: morphological quenching. May take too long to be viable for massive quiescent disks at z~2.

SUMMARY

- Massive quiescent disks are common at high-z.
- Mechanism to build up early massive disks? Cold streams are one likely possibility.
- Need a mechanism to shut down star formation.
  - Possibilities include: AGN (but how to feed the black hole?), halo quenching (are environments overdense?), morphological quenching (timescales may be too long).
- Mergers important later in “puffing-up” dense galaxies to place them on local size-mass scaling relations and in converting disks to spheroids.