Bulge formation in massive disks at z~2

Ken-ichi Tadaki (MPE)

Q1: What do you think is the "KEY" science/observations for ULTIMATE in your research field? We hope to establish the very best science cases which are unique enough even in mid-late 2020s (i.e. post-JWST or WFIRST era!).

a catchy phrase is "origin of the Hubble sequence"

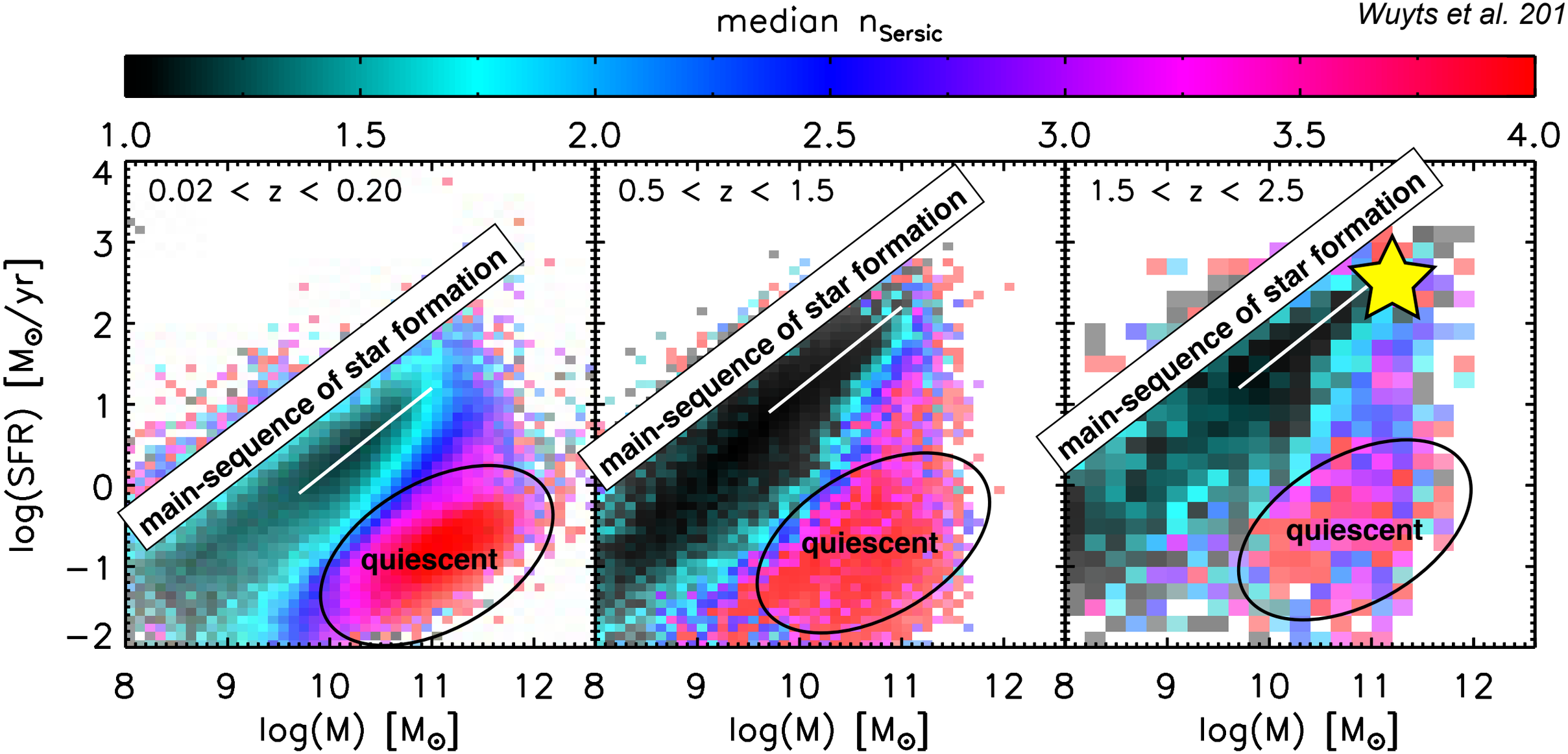
ULTIMATE-Subaru allows us to address this issue with 0.2″-resolution Hα narrow-band imaging for SFGs at z~2

More important thing is to utilize the performance of spatial resolution rather than sensitivity

What is ``to reveal the origin of the Hubble sequence”

a simple answer is
to explain why quiescent galaxies (QGs) are ellipticals although star-forming galaxies (SFGs) are exponential disks

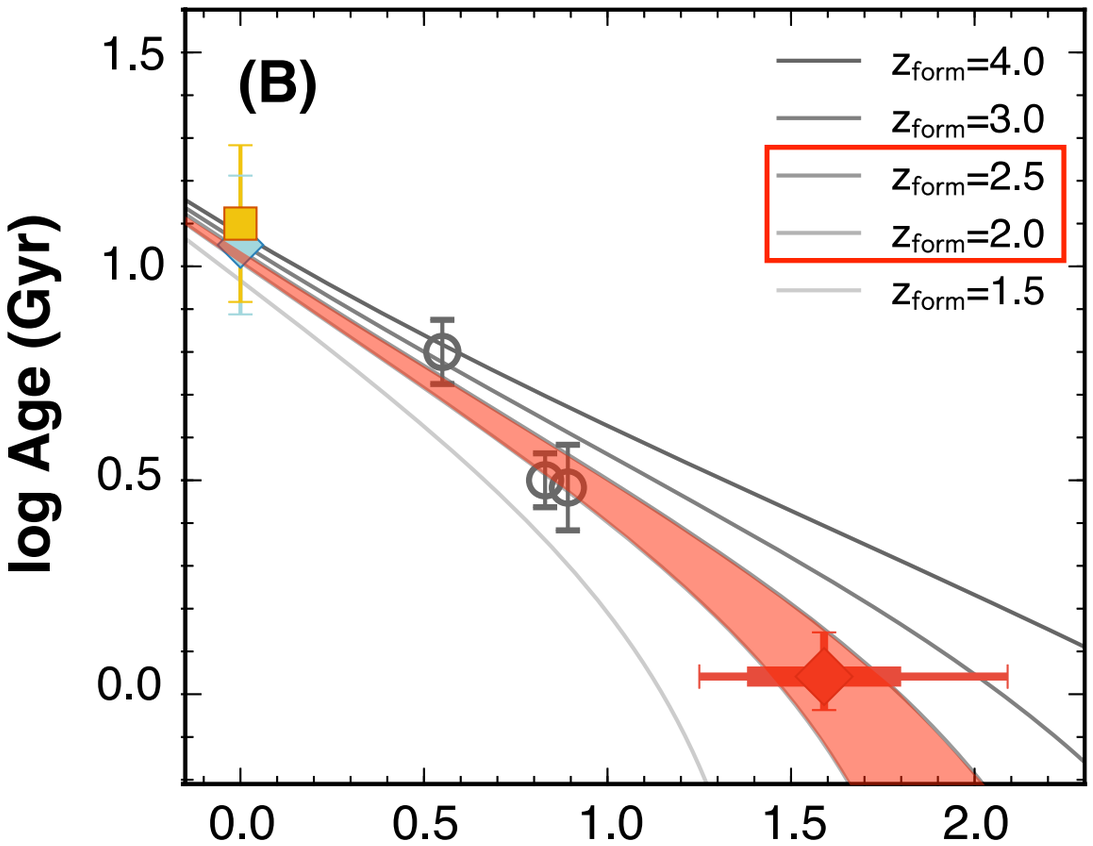
Wuyts et al. 2011



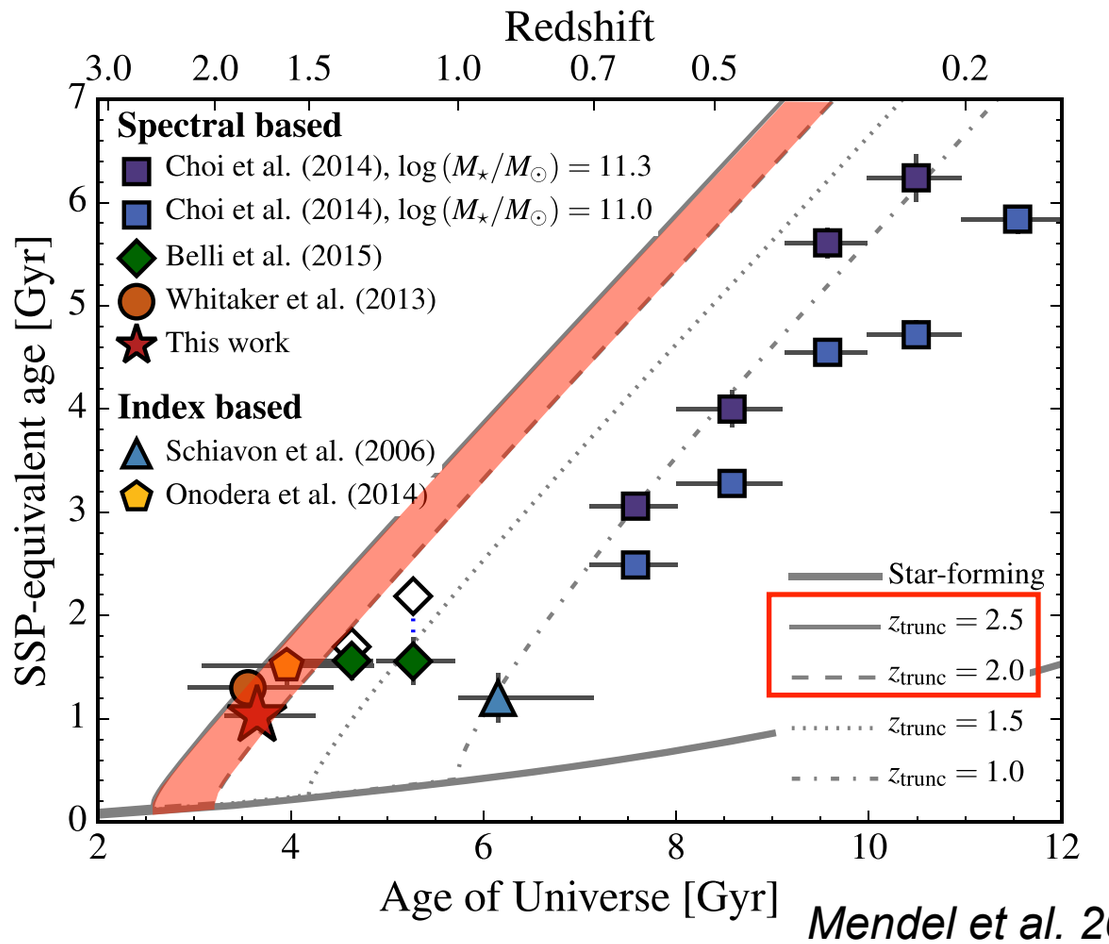
Massive z~2 SFGs must change their morphologies!

When are massive QGs formed?

massive QGs at z~1.5 would have quenched star formation at z=2-2.5 (less massive QGs would do at later epoch)



Onodera et al. 2015

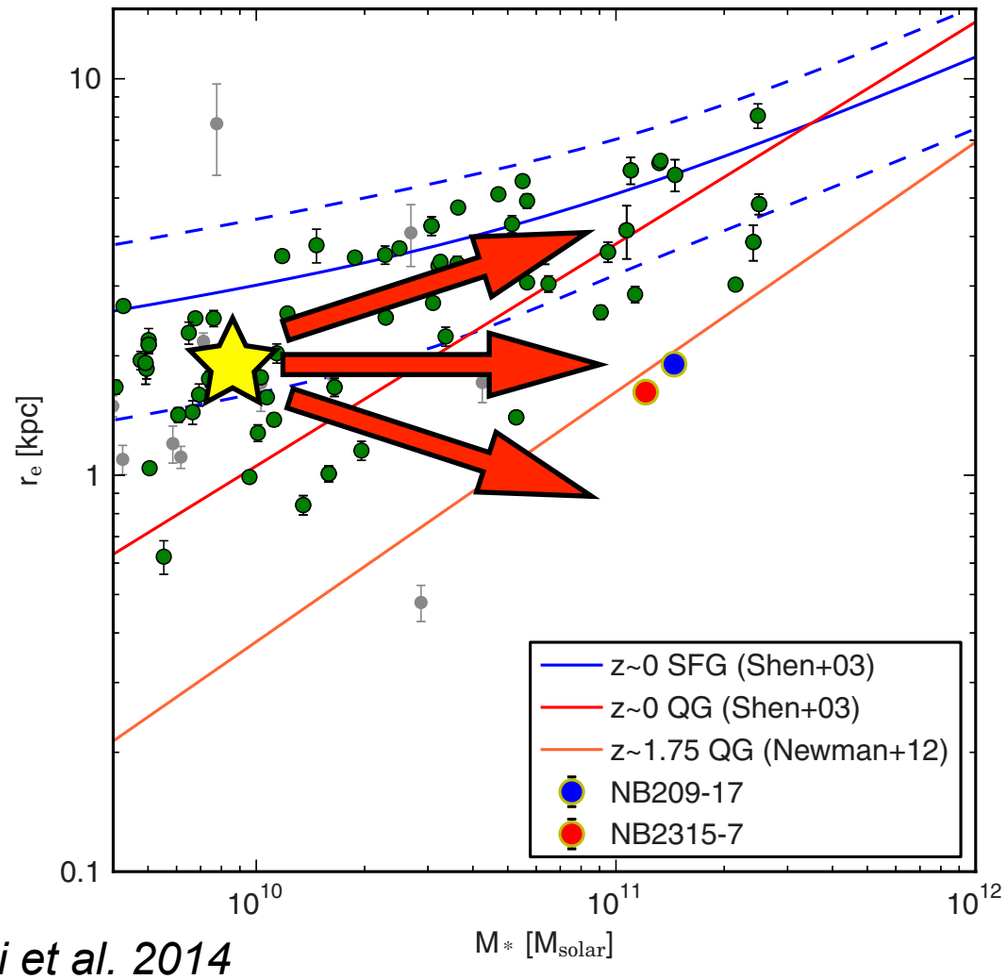


Mendel et al. 2015

Massive z~2 SFGs must form bulge!

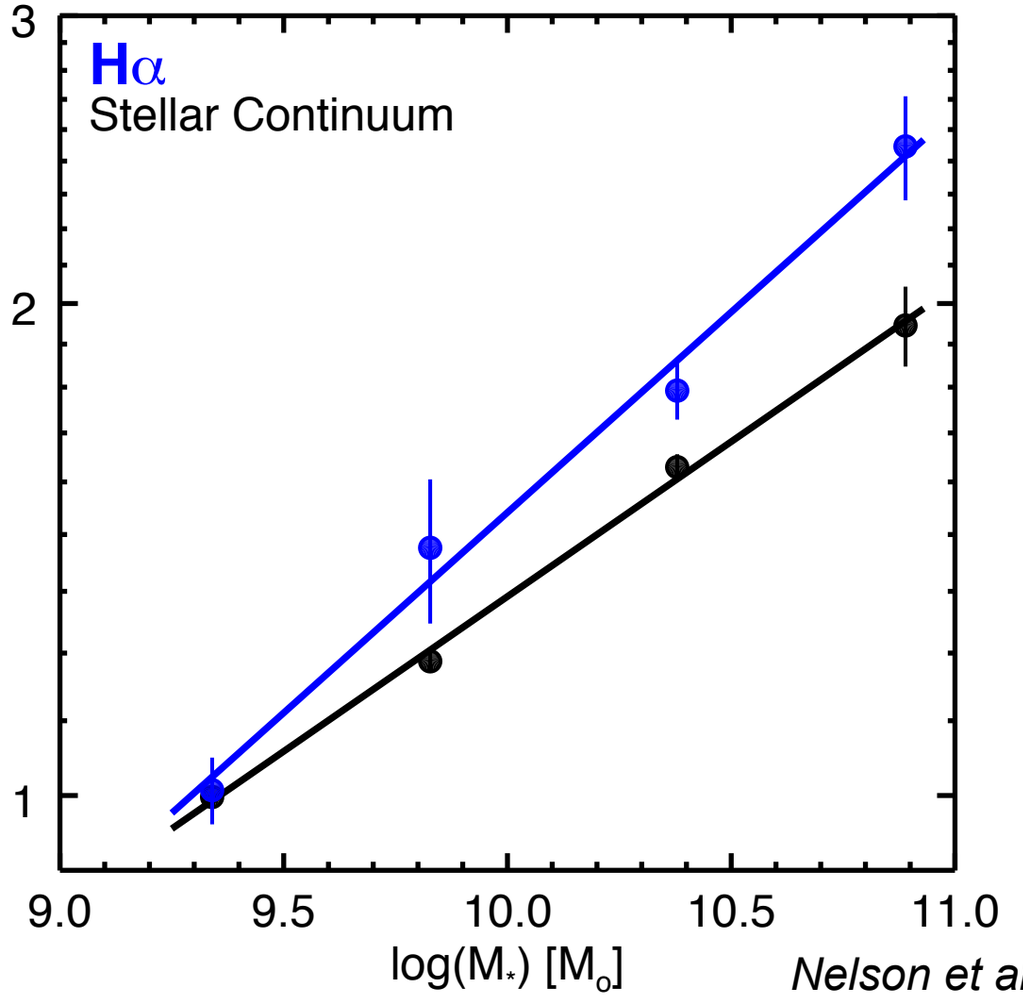
What should we study for SFGs at z~2?

size-mass relation for SFGs at z~2



Tadaki et al. 2014

size-mass relation for SFGs at z~1



Nelson et al. 2016

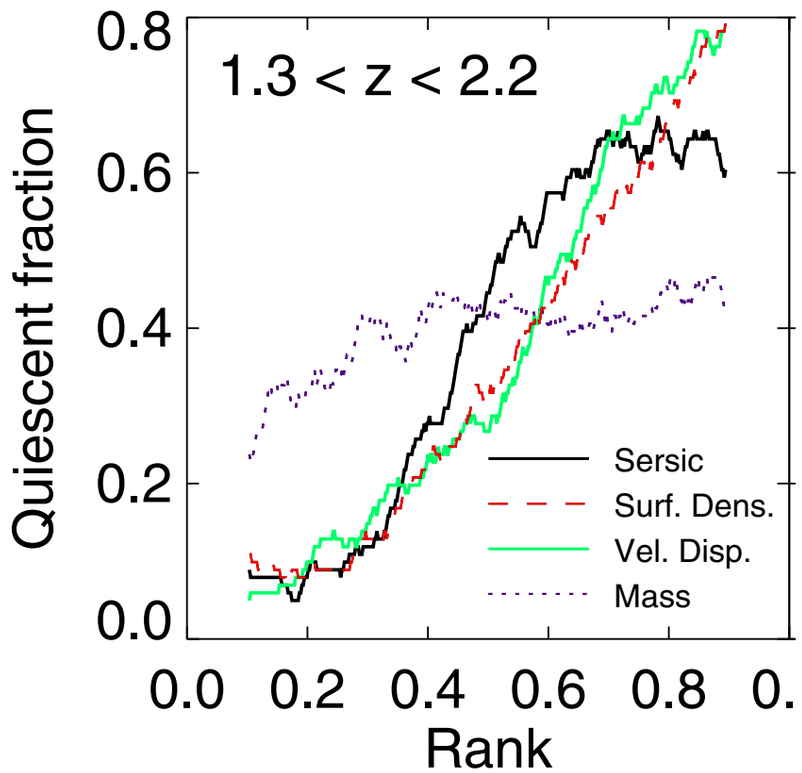
1. SF size = M* size: $r_{*,1/2}$ does not change
2. SF size > M* size: $r_{*,1/2}$ increases with M* => size evolution
3. SF size < M* size: $r_{*,1/2}$ decreases with M* => bulge formation

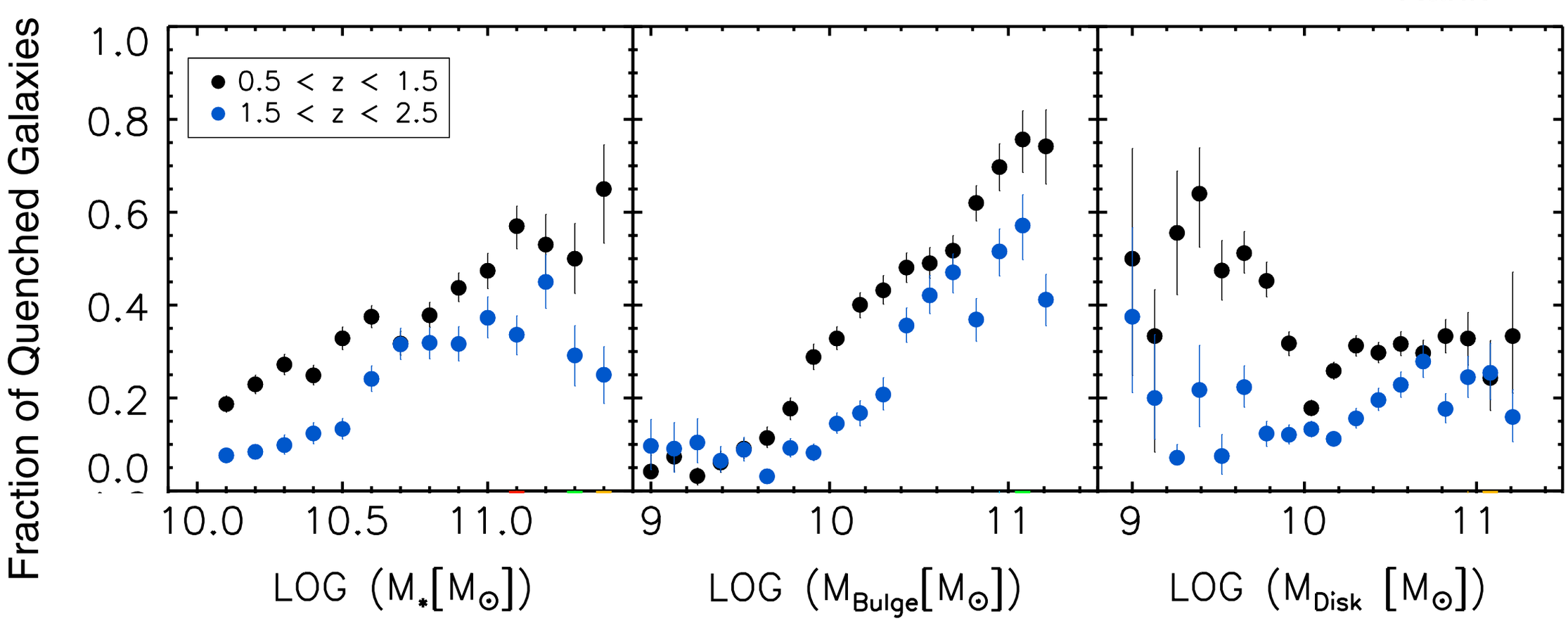
key element: spatial distribution of star formation within SFGs at z~2

=> 0.2″-resolution Hα narrow-band imaging at K-band

Bulge and quenching of star formation

Bulge is probably related with quenching of star formation (Lang+14, Bell+12, etc.)





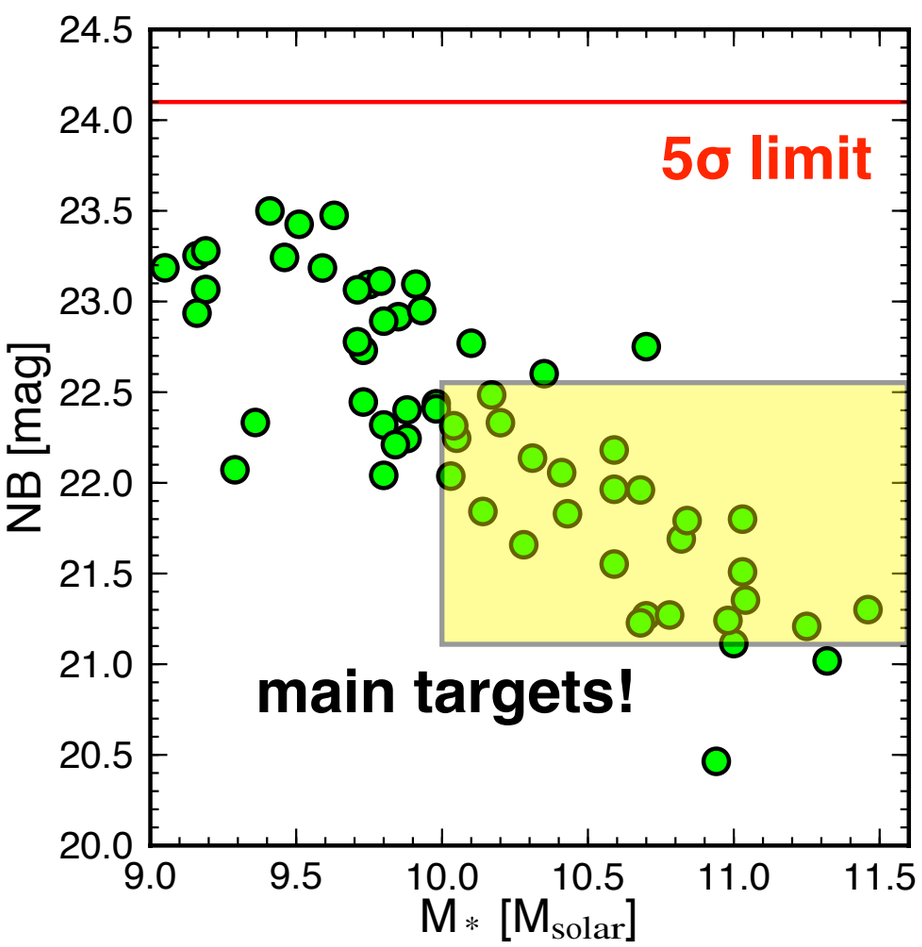
My suggestion about survey design

Q4: Which survey design sounds best for you (see *survey_design.pdf*)? Your comments/suggestions on the ULTIMATE survey design are very welcome.

my suggestion is ``NB at K only" survey

Deep (**20 deg²**)	Exp. time per FoV	(with overhead)	Limit mag.	N. of nights
NBK x 1	4-hours	(5-hours)	24.1	120
K	2-hours	(3-hours)	25.6	96
total				216

NB magnitudes for SFGs at z=2.2
(Tadaki+13, ~90 arcmin²)



main targets show NB<22.5 mag in total

S/N>20 is enough high to spatially resolve Hα emission?

~20 SFGs in 90 arcmin²
=> ~1e4 SFGs in 20 deg²

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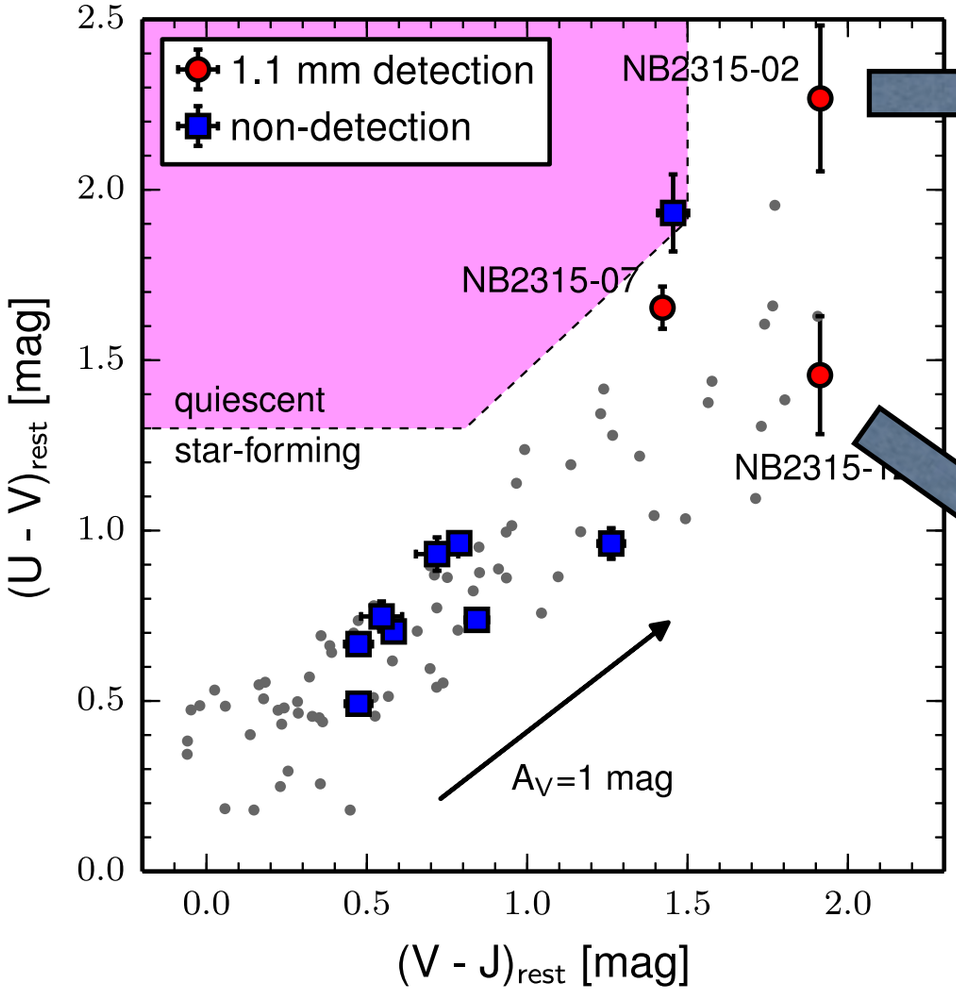
Four points of this survey

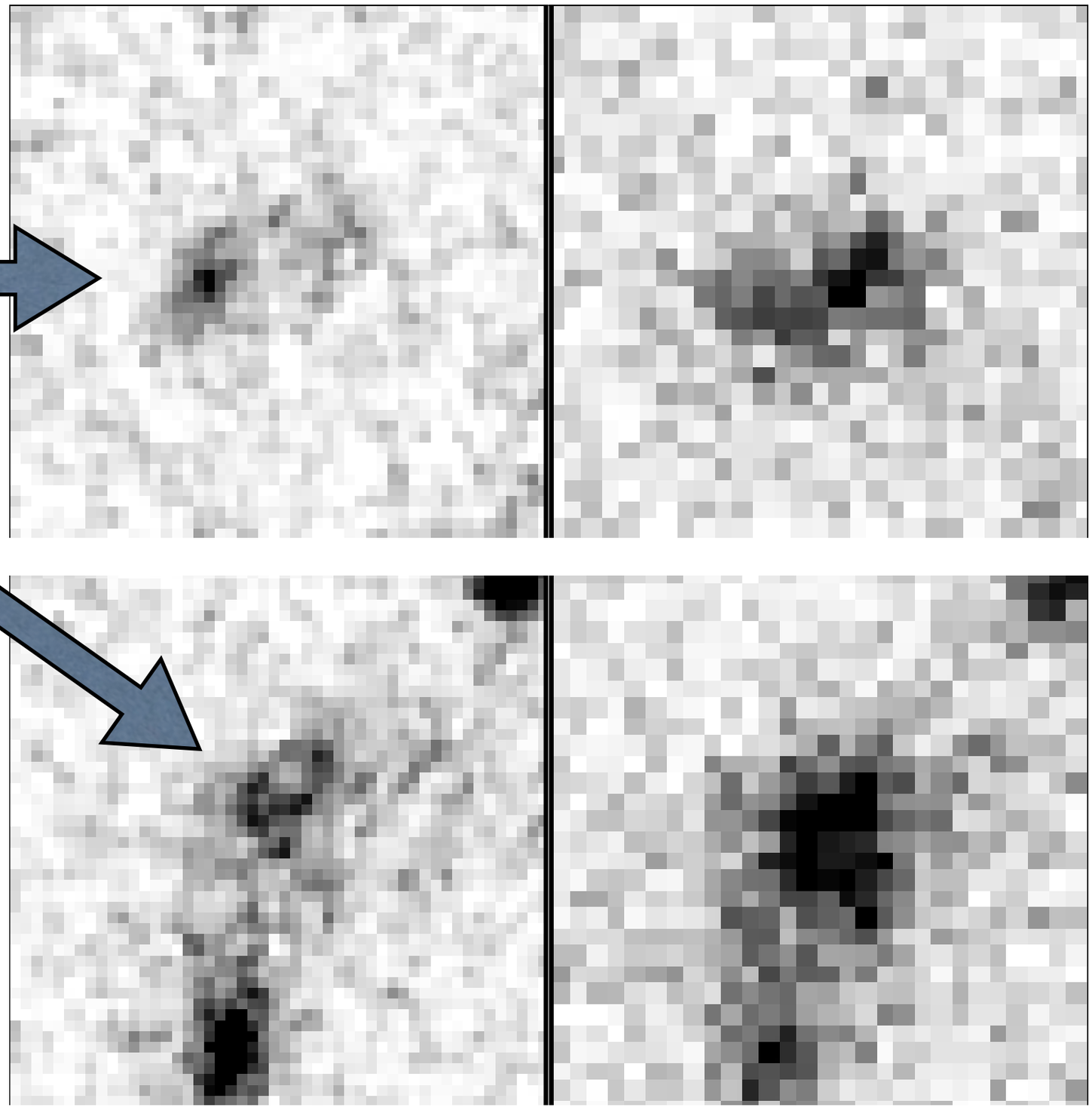
1. WFIRST does not have K-band and NB filter
2. This choice maximizes the GLAO performance in terms of angular resolution (this is critical for galaxy anatomy)
3. A survey area of 20 deg^2 matches up with HSC/SSP-Deep (~27deg^2)
4. Wide K-band data is useful for general science cases

e.g., study of the rest-optical morphology for galaxies at z=3-4 and dusty star-forming galaxies

H and K-band maps for dusty SFGs at z~2

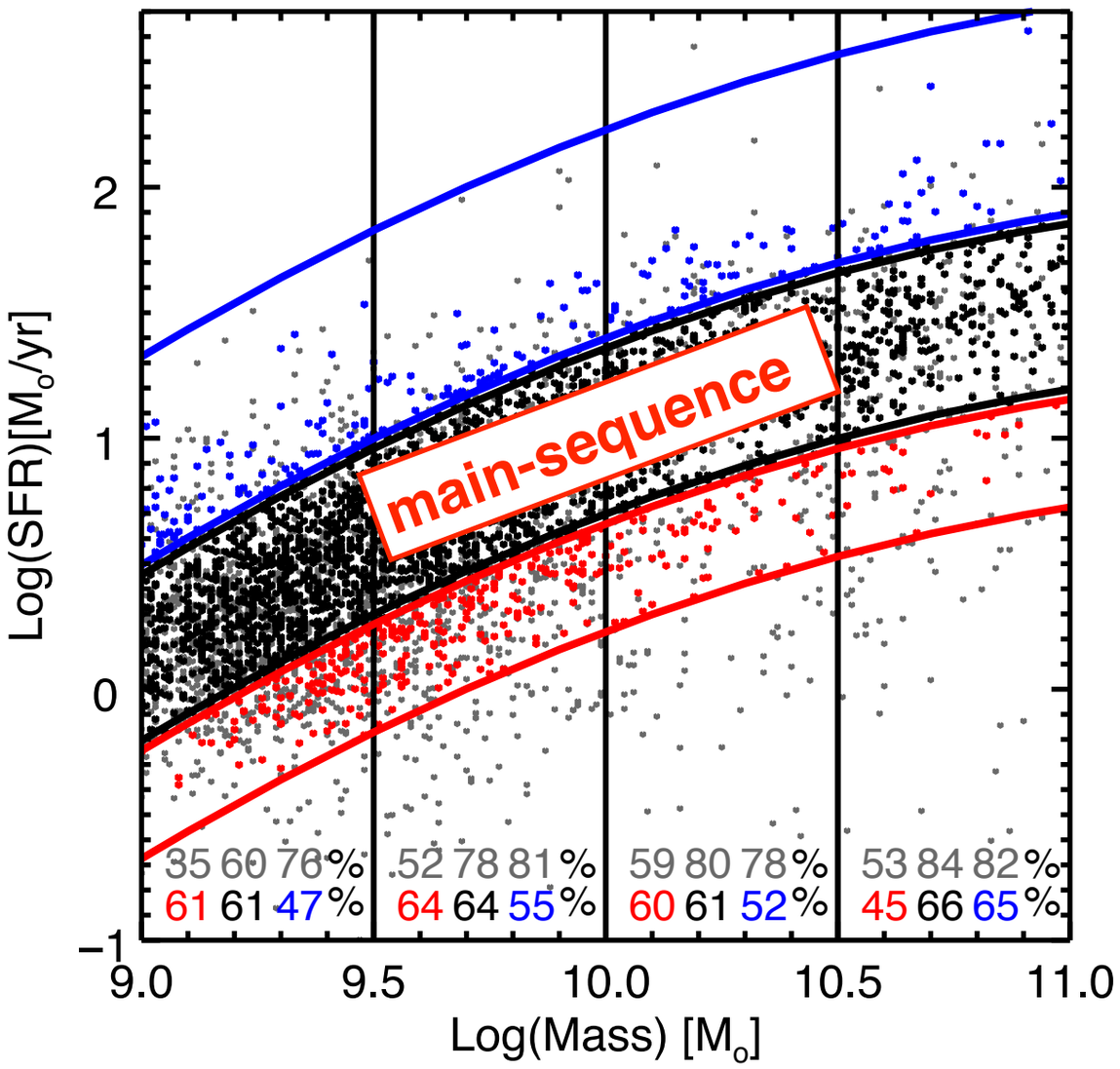


Tadaki et al. 2015

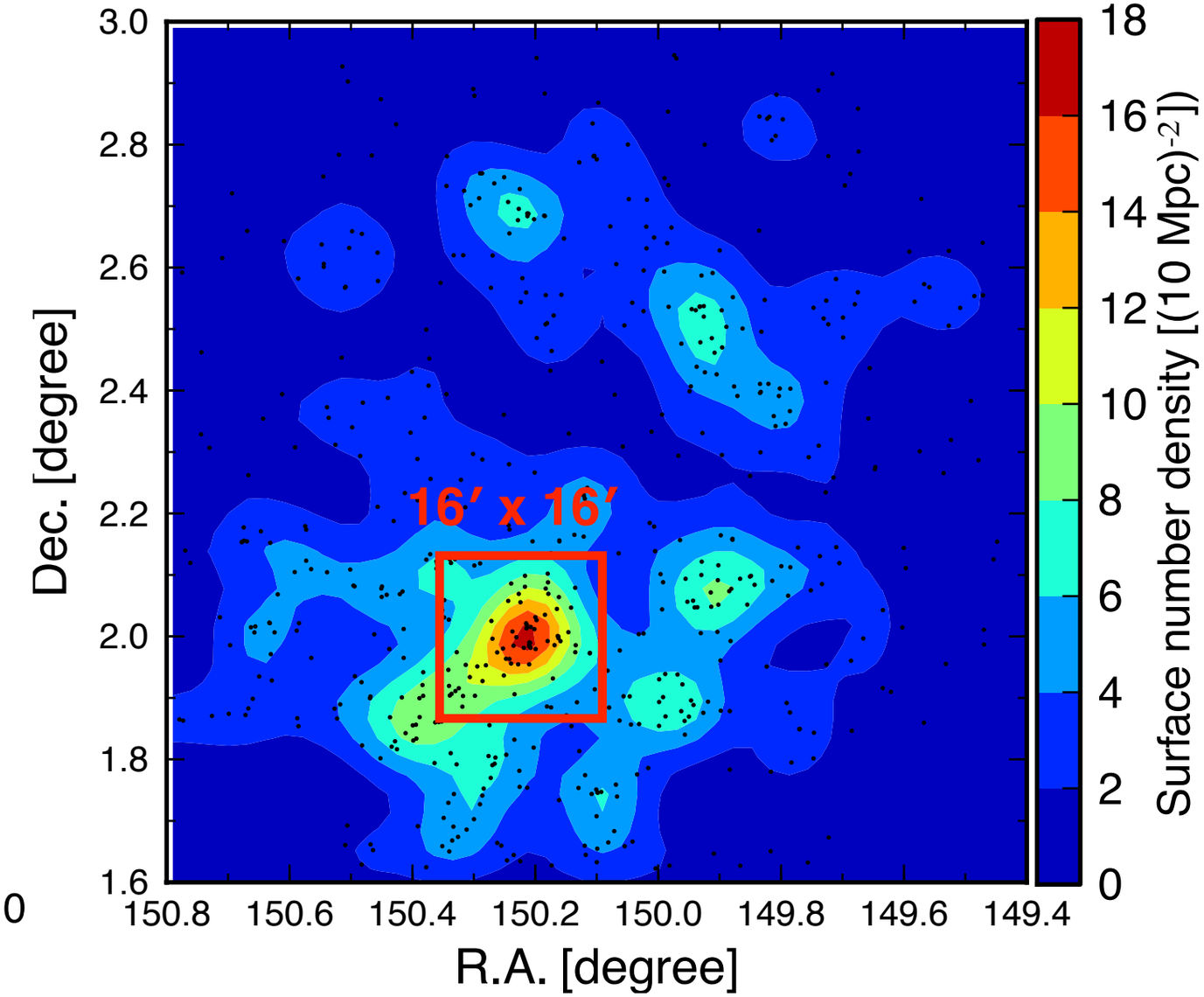


What should we study?

Stellar mass and SFR of SFGs at z~1
(Nelson+16)



2D distribution of SFGs at z~2.2
(HiZELS in COSMOS 2 deg^2; Sobral+13)



1. investigate where new stars are formed for individual galaxies at z~2
2. compared it with stellar mass distribution (WFIRST data is not necessarily required)
3. identify **bulge-forming galaxies** and **disk-forming galaxies**
4. study them as function of stellar mass/star forming activity/environment
5. reveal what drives bulge formation

A science case with MOIRCS+GLAO

Q3: Our current plan is to (1) build GLAO first, and then to (2) build new NIR instrument(s). This means that we will start our ULTIMATE science with GLAO +MOIRCS at the first stage. Do you have good science cases to be done with GLAO+MOIRCS during the period of ~2020-2023?

With small FoV, there is a risk for observing void regions

Pilot survey targeting high-density regions of HiZELS emitters at z=2.2

Deep (**0.15 deg²**)	Exp. time per FoV	(with overhead)	Limit mag.	N. of nights
NBK x 1	4-hours	(5-hours)	24.1	9
K	2-hours	(3-hours)	25.6	7
total				16