Clumps in z~2 Galaxies

Mark Mozena

Galaxy Workshop
Santa Cruz, August 2012

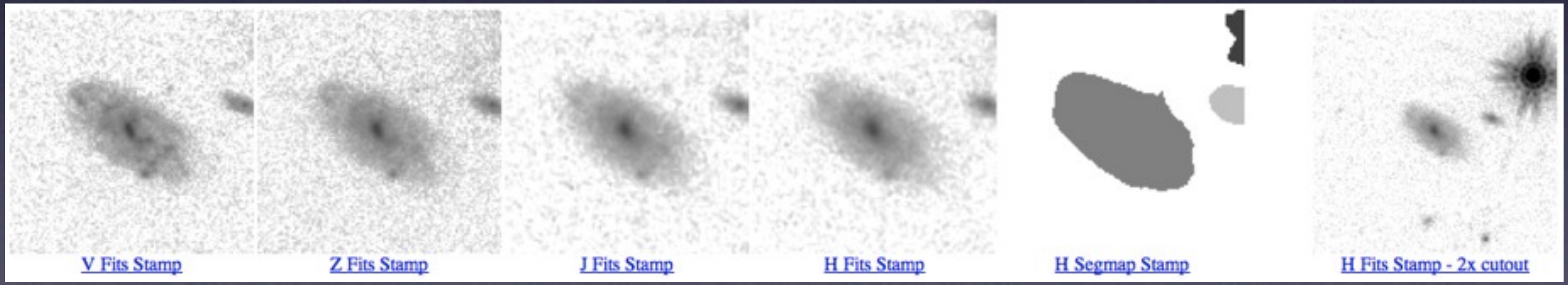
Visual Morphologies

Classifications are being done on all galaxies with H_{mag} < 24.5 (dimmer galaxies were shown to have less reliable fits in GALFIT, G-M20 and CAS) in the CANDELS fields (starting with GOODS-S) - ~45,000 galaxies in CANDELS

Classification is based primarily on H-band

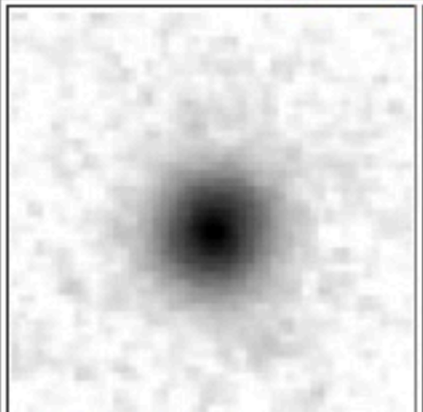
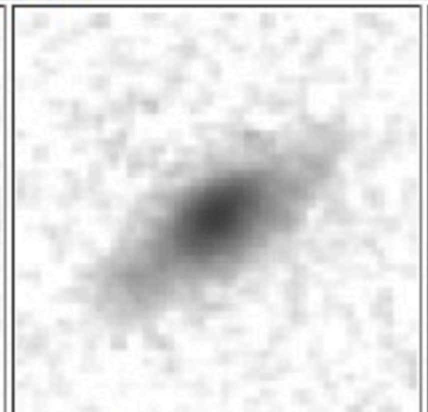
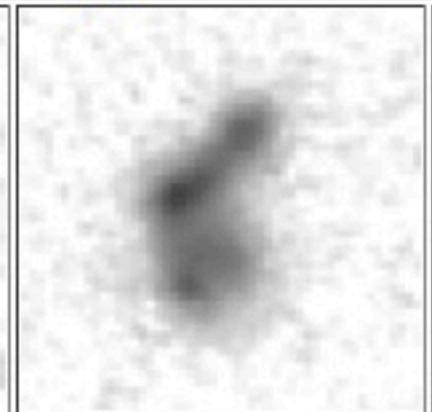
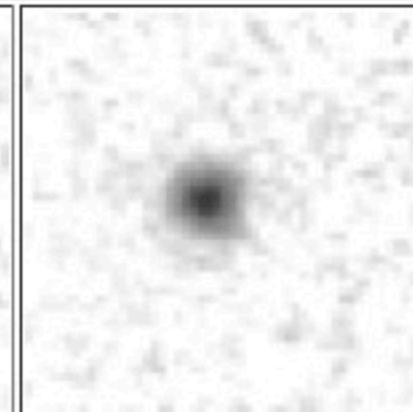
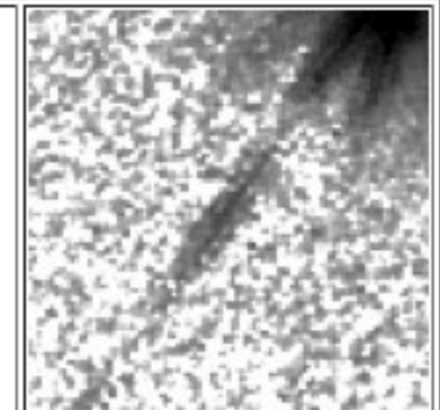
This sample is GOODS-S (ERS + Deep2 + Wide2)

~6000 galaxies visually classified in GOODS-S (~1200 with redshift = 1.5-2.5)



MORPHOLOGY CLASS (choose one or more):

Dominant Morphology (based on H-band image)

				
☐ Spheroid	☑ Disk	☐ Irregular/Peculiar Asymmetric Flag will be Checked	☐ Compact/Unresolved	☐ Unclassifiable low SB/no idea doesnt fit schema/etc

FLAGS:

Flags based on entire cutout

Quality Flags

- ☐ Bad Deblend
  (includes over and under deblended objects in segmap)
- ☐ Image Quality Problem
  (includes: nearby bright object, near edge, diffraction spikes)
- ☐ Uncertain
  (Image quality is fine but classification is uncertain)

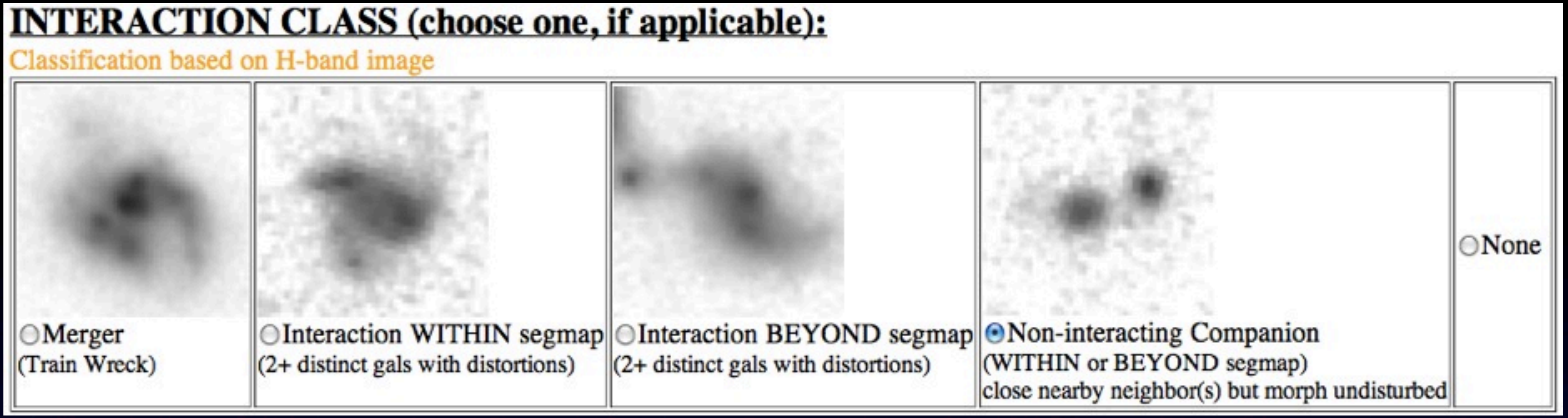
K-Correction

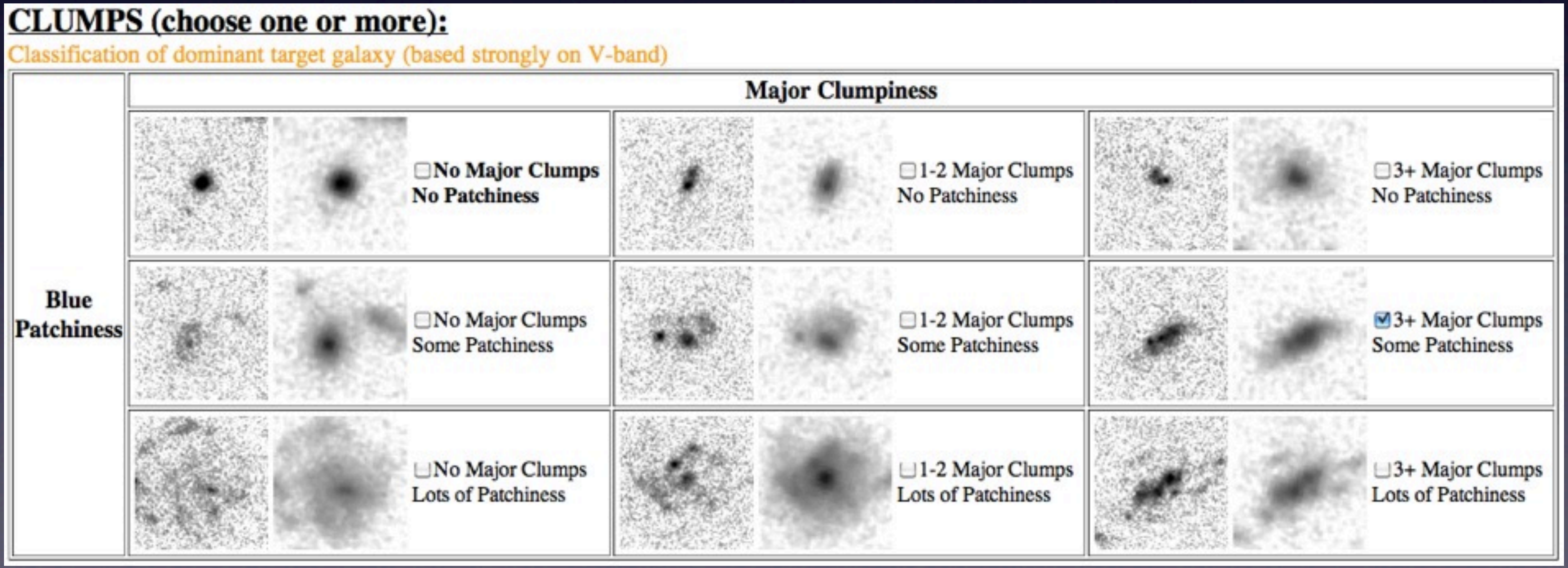
- ☐ V-band Different Morphological Classification
- ☐ z-band Different Morphological Classification
- ☐ J-band Different Morphological Classficiation

Structure Flags

- ☐ Tidal Arms
- ☐ Double Nuclei (in Hband)
- ☑ Asymmetric (in Hband)
- ☑ Spiral Arms/Arc/Ring
- ☐ Bar
- ☐ Pt Source Contamination
  (galaxy with contaminant)
- ☐ Edge-on Disk
- ☐ Face-on Disk
- ☐ Tadpole (2:1)
- ☐ Chain (3:1 with clumps)
- ☐ Disk Dominated (in Hband)
- ☐ Bulge Dominated (in Hband)

Comments:


INTERACTION CLASS (choose one, if applicable):
Classification based on H-band image
Merger
(Train Wreck)
Interaction WITHIN segmap
(2+ distinct gals with distortions)
Interaction BEYOND segmap
(2+ distinct gals with distortions)
Non-interacting Companion
(WITHIN or BEYOND segmap)
close nearby neighbor(s) but morph undisturbed
None


CLUMPS (choose one or more):
Classification of dominant target galaxy (based strongly on V-band)
Major Clumpiness
Blue Patchiness
No Major Clumps
No Patchiness
1-2 Major Clumps
No Patchiness
3+ Major Clumps
No Patchiness
No Major Clumps
Some Patchiness
1-2 Major Clumps
Some Patchiness
3+ Major Clumps
Some Patchiness
No Major Clumps
Lots of Patchiness
1-2 Major Clumps
Lots of Patchiness
3+ Major Clumps
Lots of Patchiness

Quantifying Visual Morphologies

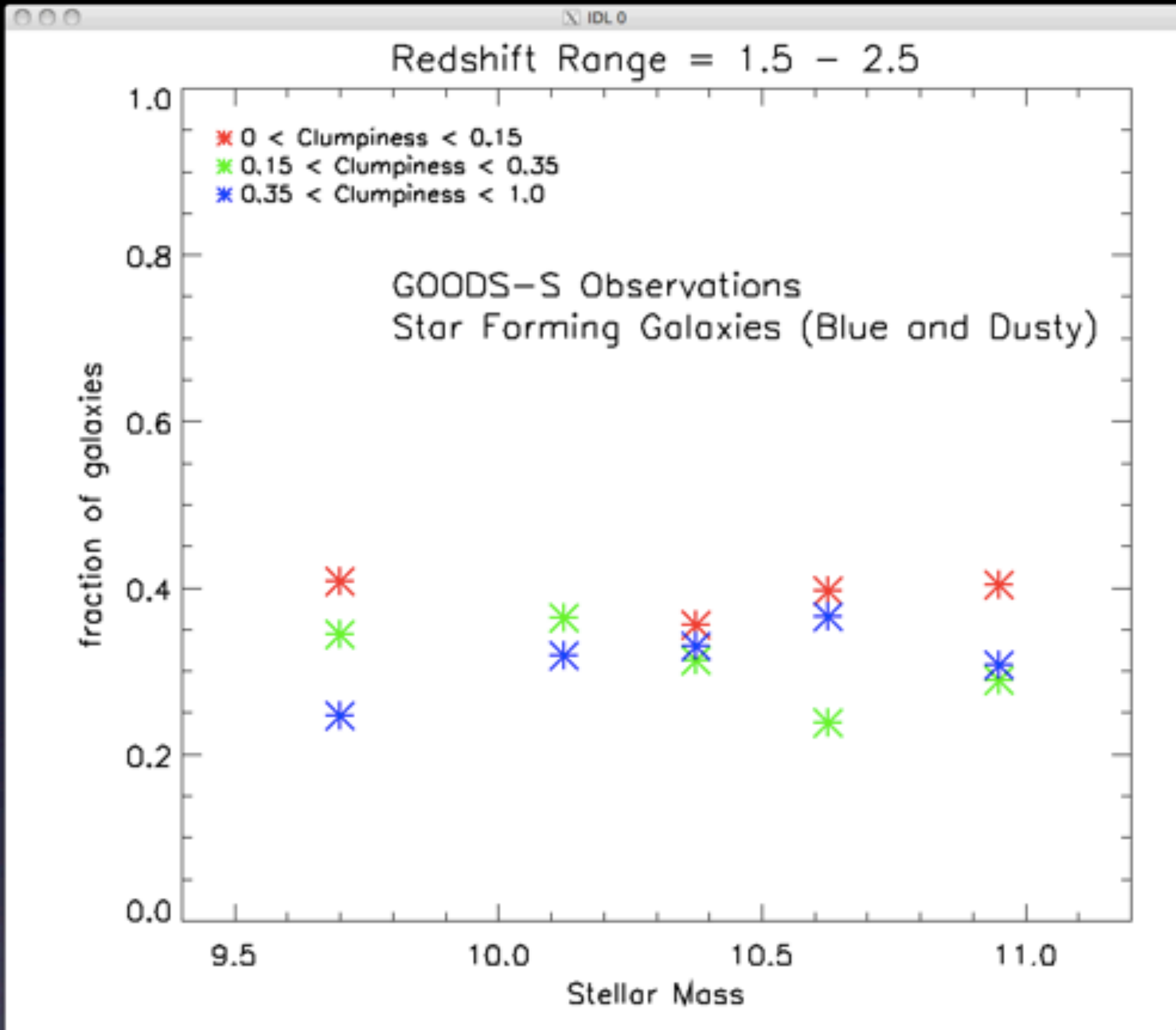
Each galaxy was classified by 3-5 different people.

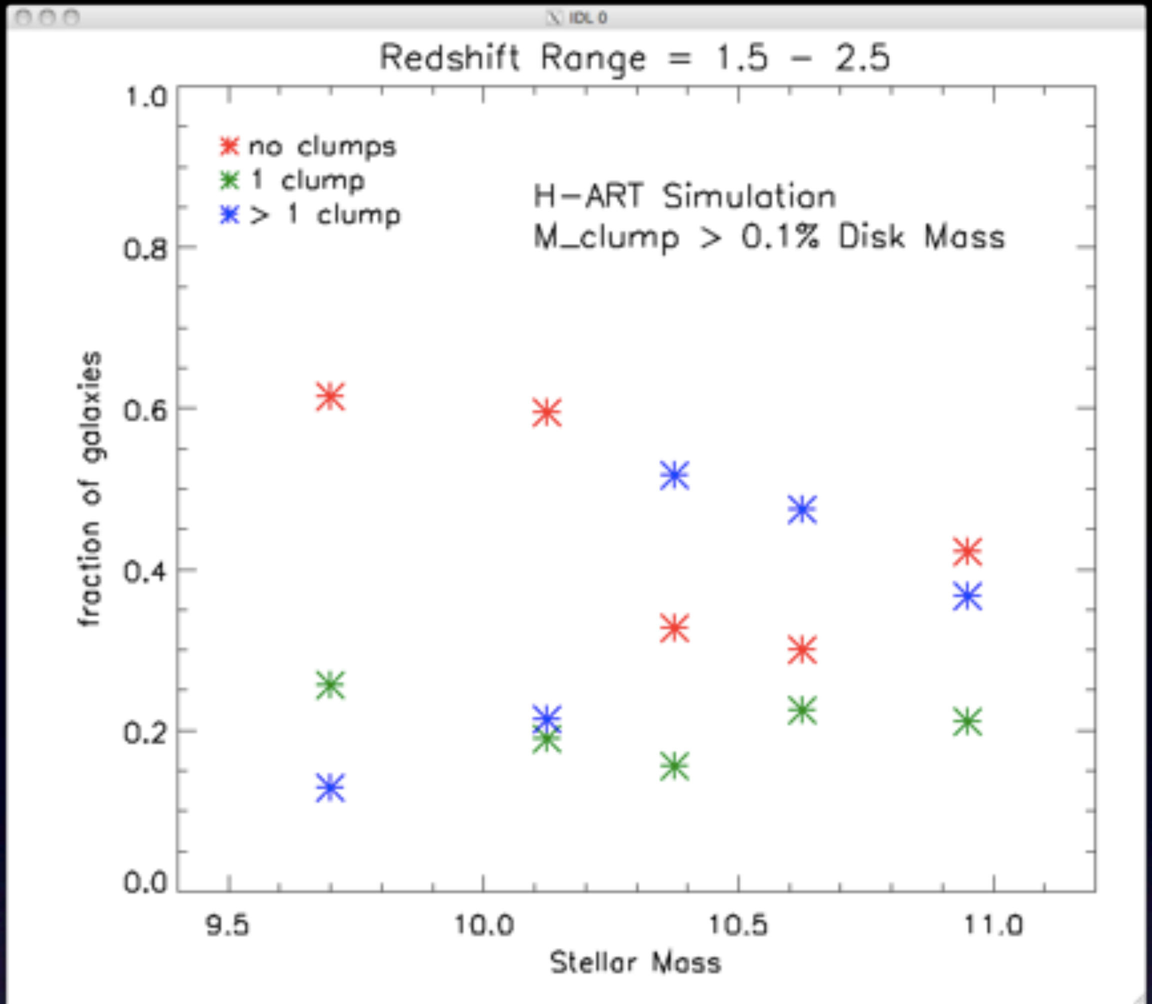
Collapsed the classifications into various metrics from 0-1 for all the classifiers

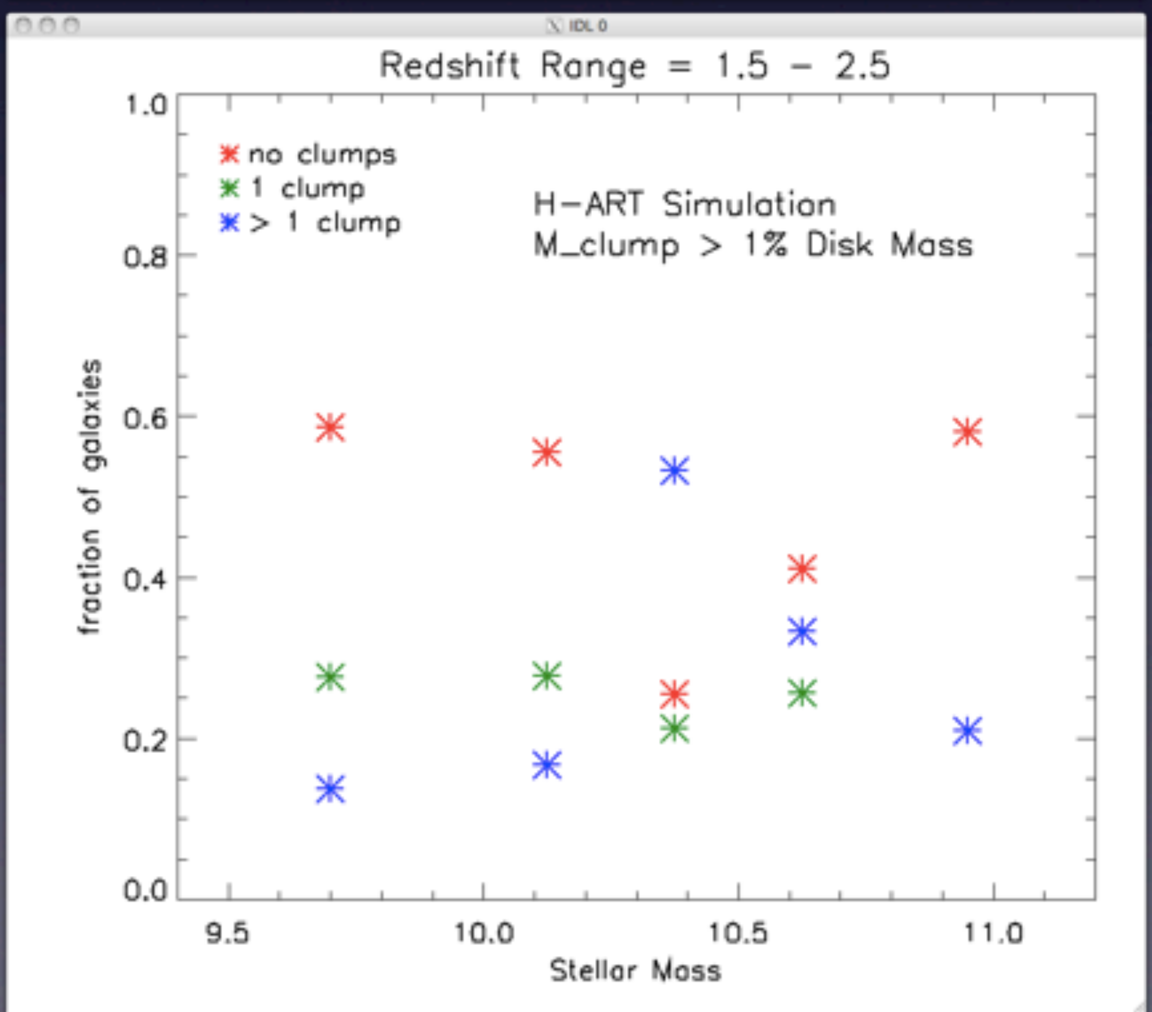
- Spheroidicity - 0=disk 1=spheroid (received value of 0.5 if both were checked)
- Irregularity - 0=not irregular 1=irregular
- Asymmetry - 0=symmetric 1=asymmetric
- Clumpiness - 0=not clumpy/patchy (ie smooth) 1=maximum clumpiness/patchiness (3+ clumps/patches)
- Interaction - 0=no companion/interaction 0.25=non-interacting companion 0.5 interaction beyond segmentation map 0.75=interaction within the segmentation map 1=merger/train wreck

Have structural morphologies (radius, sersic, axis ratio, etc from GALAPAGOS) and masses and rest colors from TFIT + SED fitting

Clump Fraction







Simulations are from Nir measuring gas clump fraction of both in-situ and ex-situ clumps in the Hydro-Art Simulations with masses >1% or 0.1% of disk mass

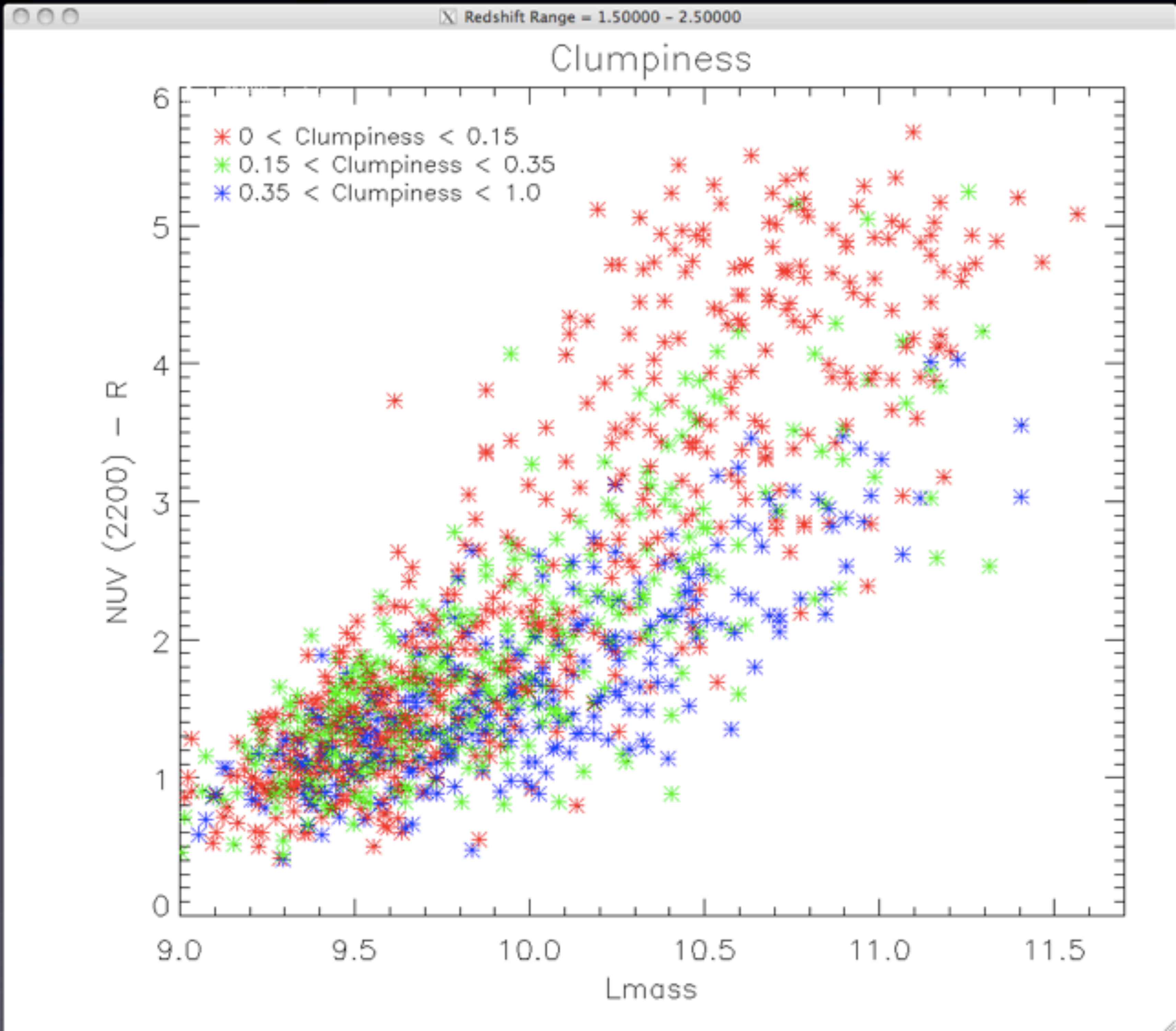
Simulations in general are less clumpy than observations - particularly at masses below 1e10. Better fits at masses > 2e10

Yicheng presented on Monday 10/15 UDF galaxies (log (Mstar) = 10-11) at z~2 are clumpy

Color-Mass

At given color, clumpy galaxies are more massive with the clumpiest galaxies being the most massive.

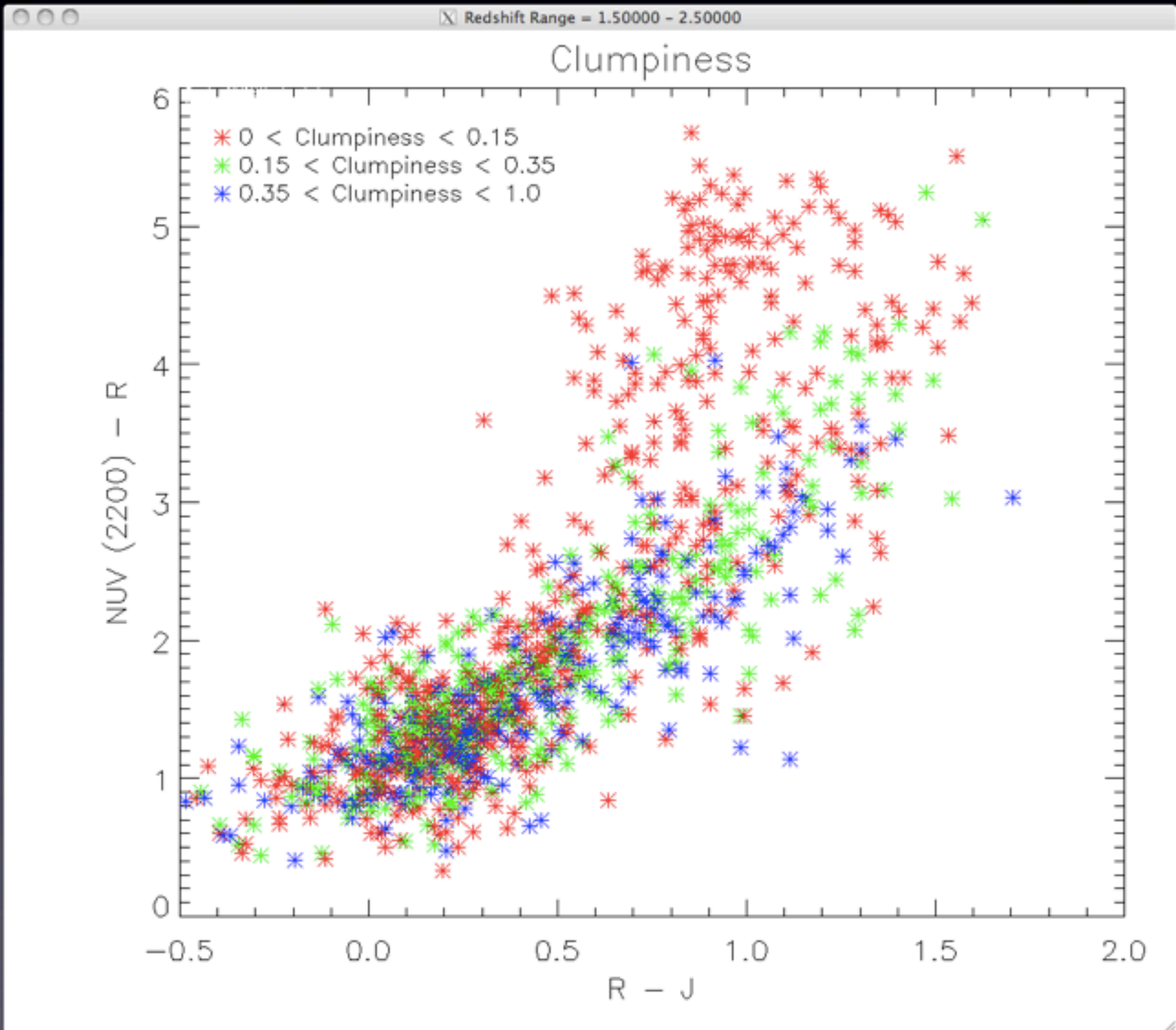
Clumpy galaxies are blue with no strong degree of clumpiness trend with color.



Color-Color

Clumpy galaxies are in the blue/SF cloud (dusty and non-dusty regions).

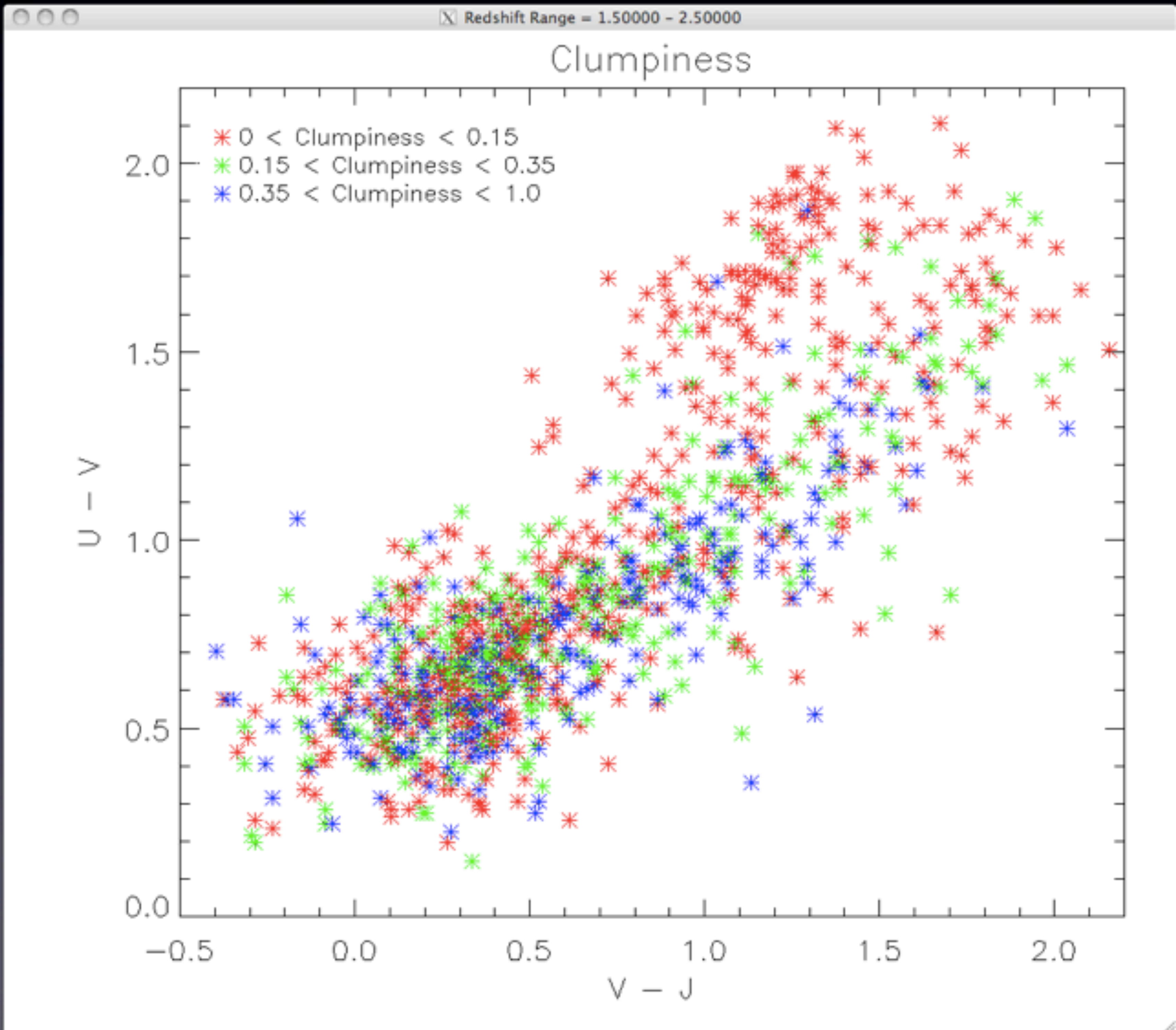
Clumpiest galaxies are not in the dustiest/reddest region.



Color-Color

Clumpy galaxies are in the blue/SF cloud (dusty and non-dusty regions).

Clumpiest galaxies are not in the dustiest/reddest region.

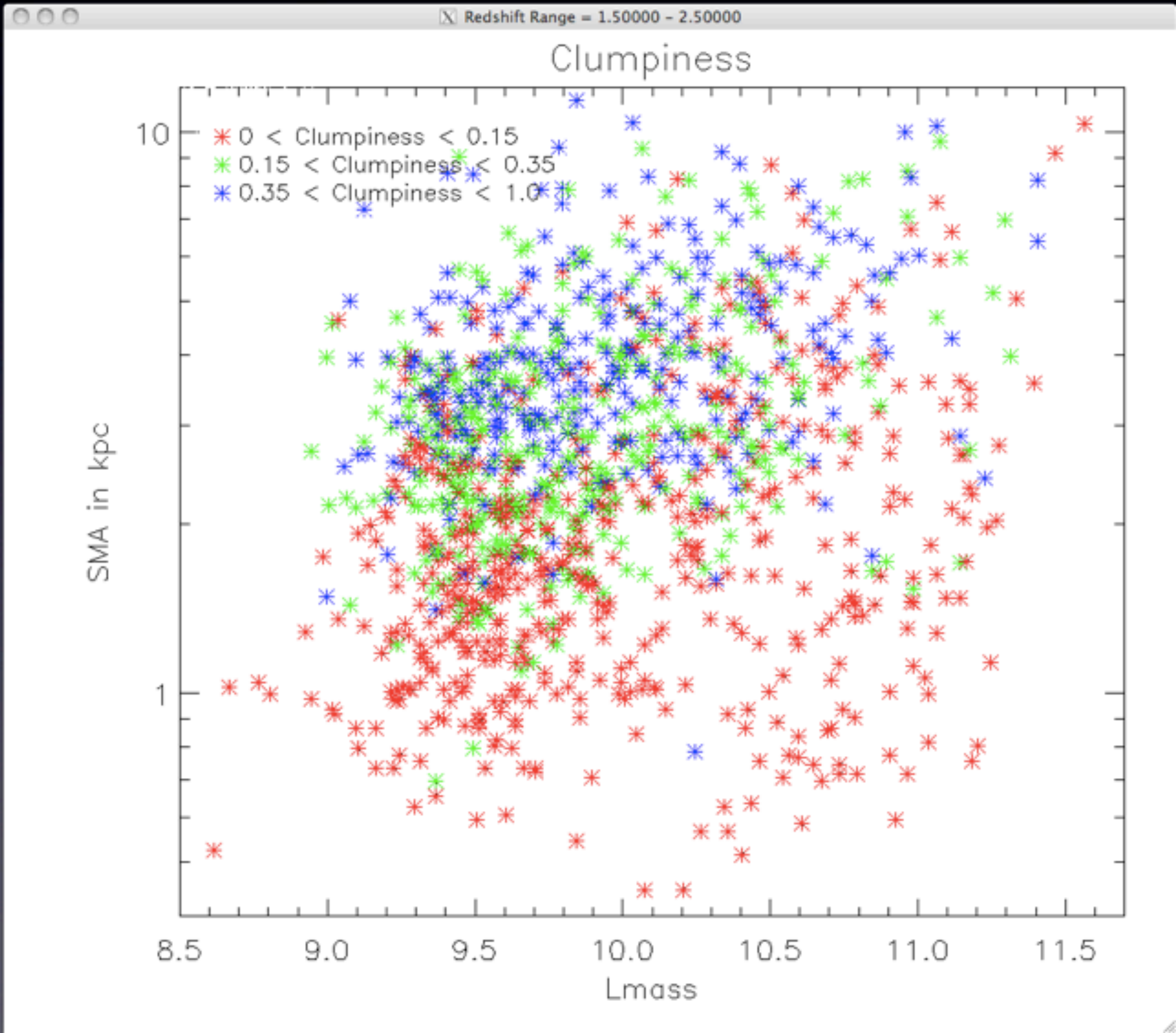


Size-Mass

Clumpy galaxies are larger radii systems with clumpiest galaxies being at the largest radii.

-clumps could pull sersic radii higher

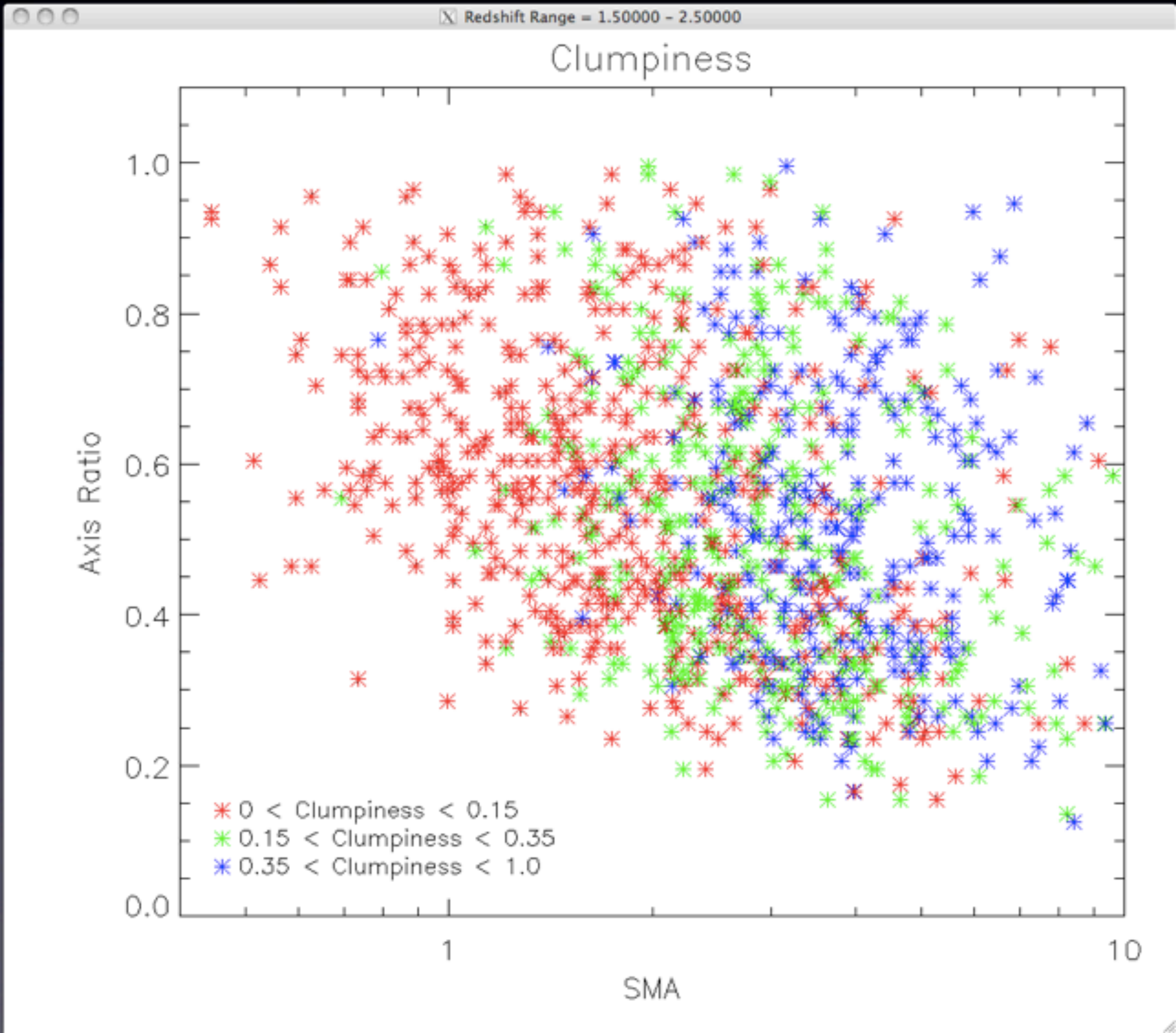
Do not see clumps in small radii systems - would see them to a SMA ~ 1kpc if they were there



Size - Axis Ratio

Clumpy galaxies are larger radii systems but do not exhibit a strong axis ratio relation.

-not preferentially found in face on disks or edge on chains



Additional Work

Working with Chris Moody, Joel Primack, Priya Kollipara, Avishai Dekel, and Daniel Ceverino on latest hydro-art simulations

will run these simulations through 'CANDELization' process and then through the same pipeline to compare them to actual galaxies

z~2.33 log(stellar mass) = 11.04

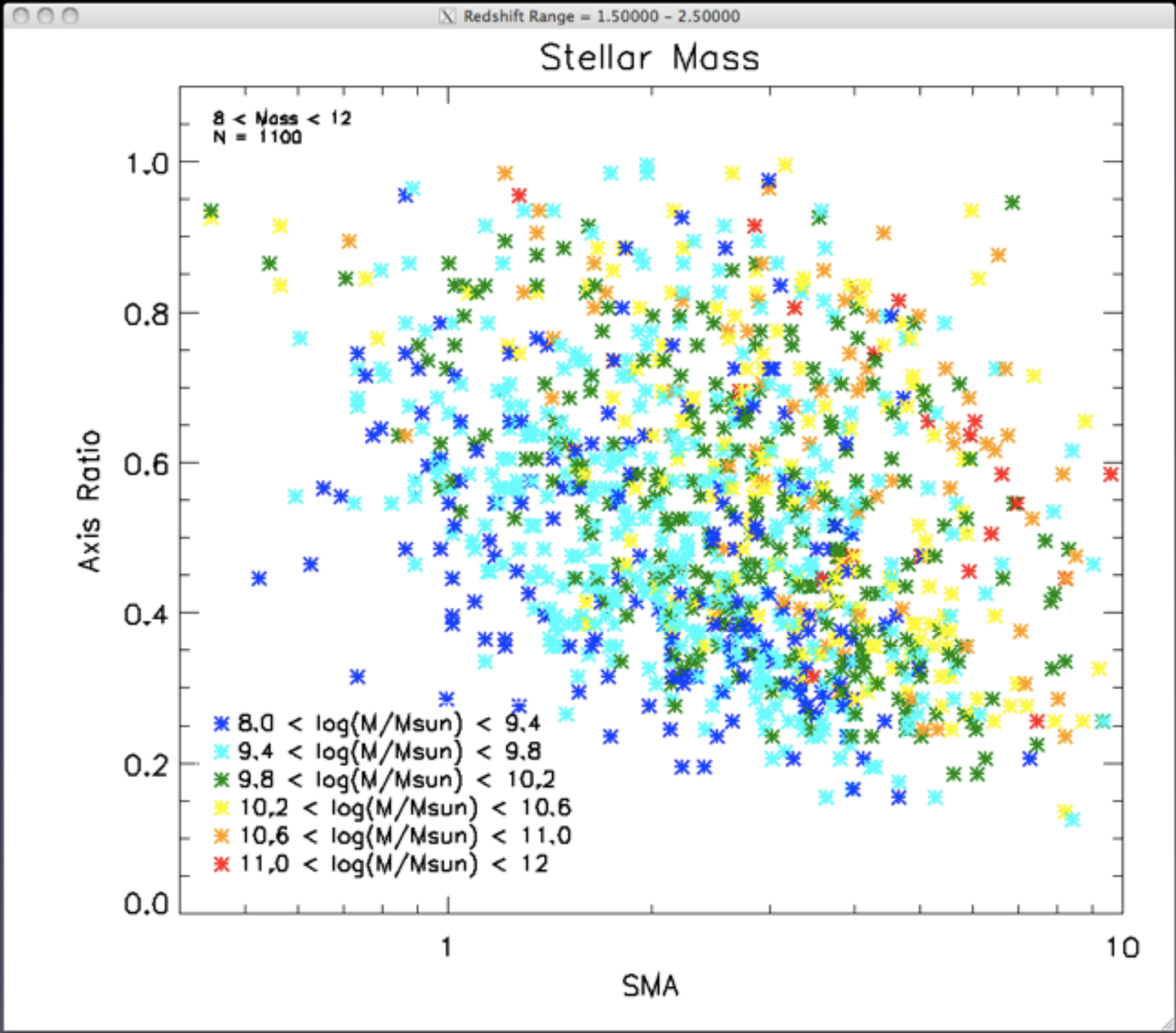
Sausage Populations of Star Forming Galaxies at z~2

Star Forming Sample (blue and dusty)

Spheroids are expected to have high axis ratios and the compact spheroids will have the small radii as well

Disks (opaque) would have full range of axis ratio at given size

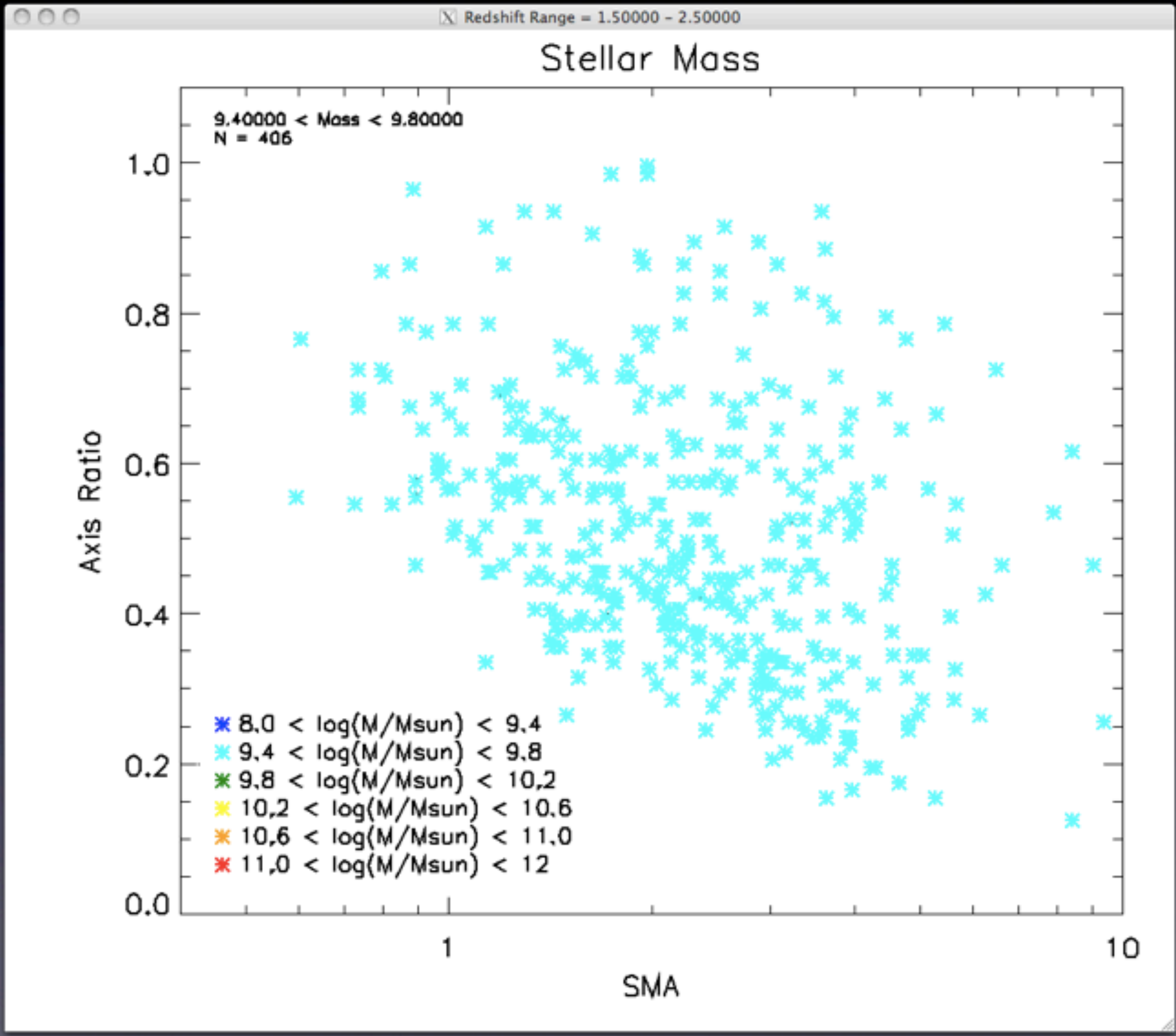
Sausages (triaxial) expect axis ratio and size to depend on viewing angle - thin disks may look similar



Star Forming Sample (blue and dusty)

Sample complete to Stellar Mass ~ 9.4 M_sun

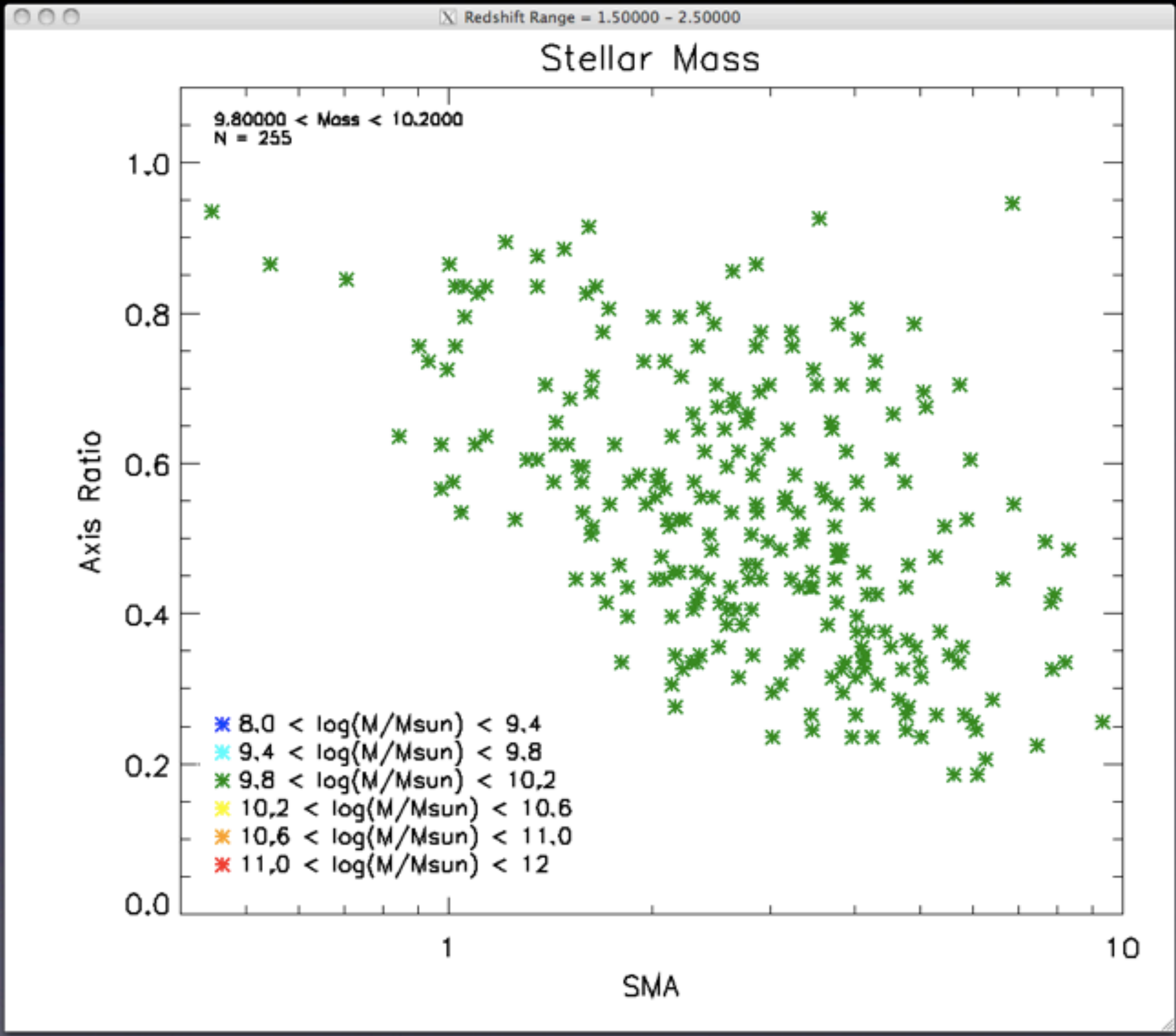
See a ridgeline relation between axis ratio and size



Star Forming Sample (blue and dusty)

Ridgeline is present

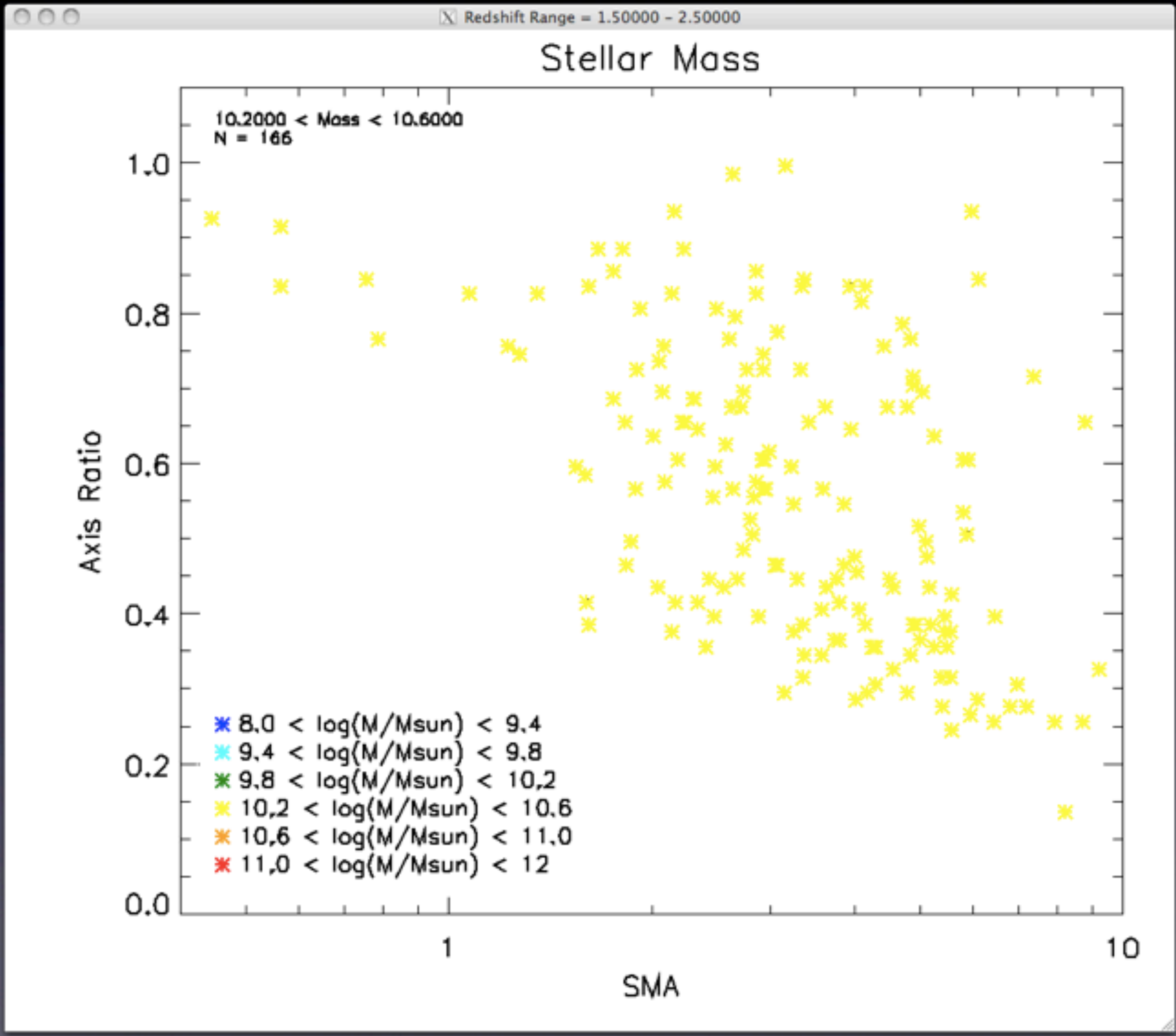
There is also a sample of galaxies in the general spread of axis ratio at a given size



Star Forming Sample (blue and dusty)

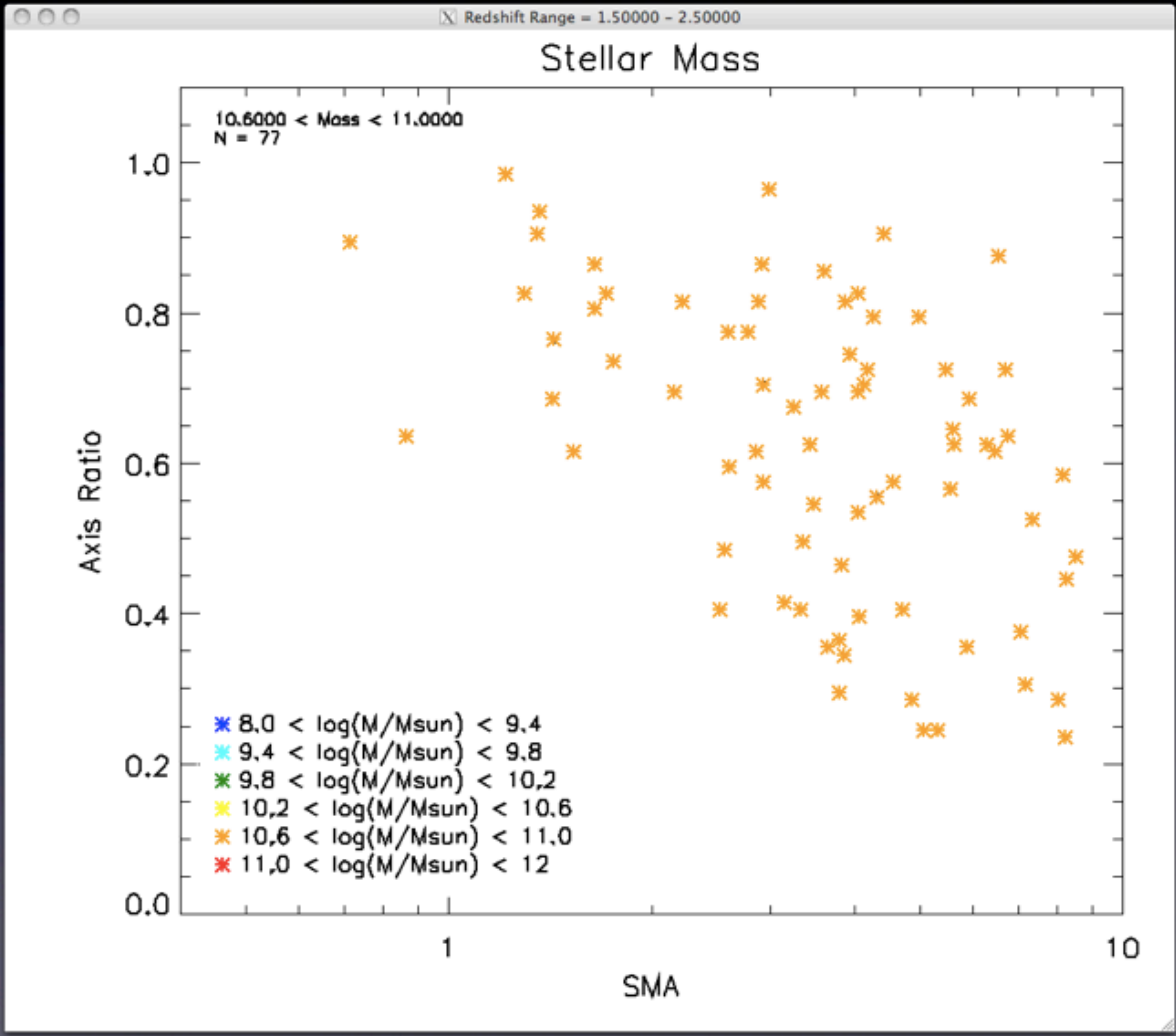
Ridgeline is still present but less clear

Possible transition is occurring to a more disk dominated population at higher masses



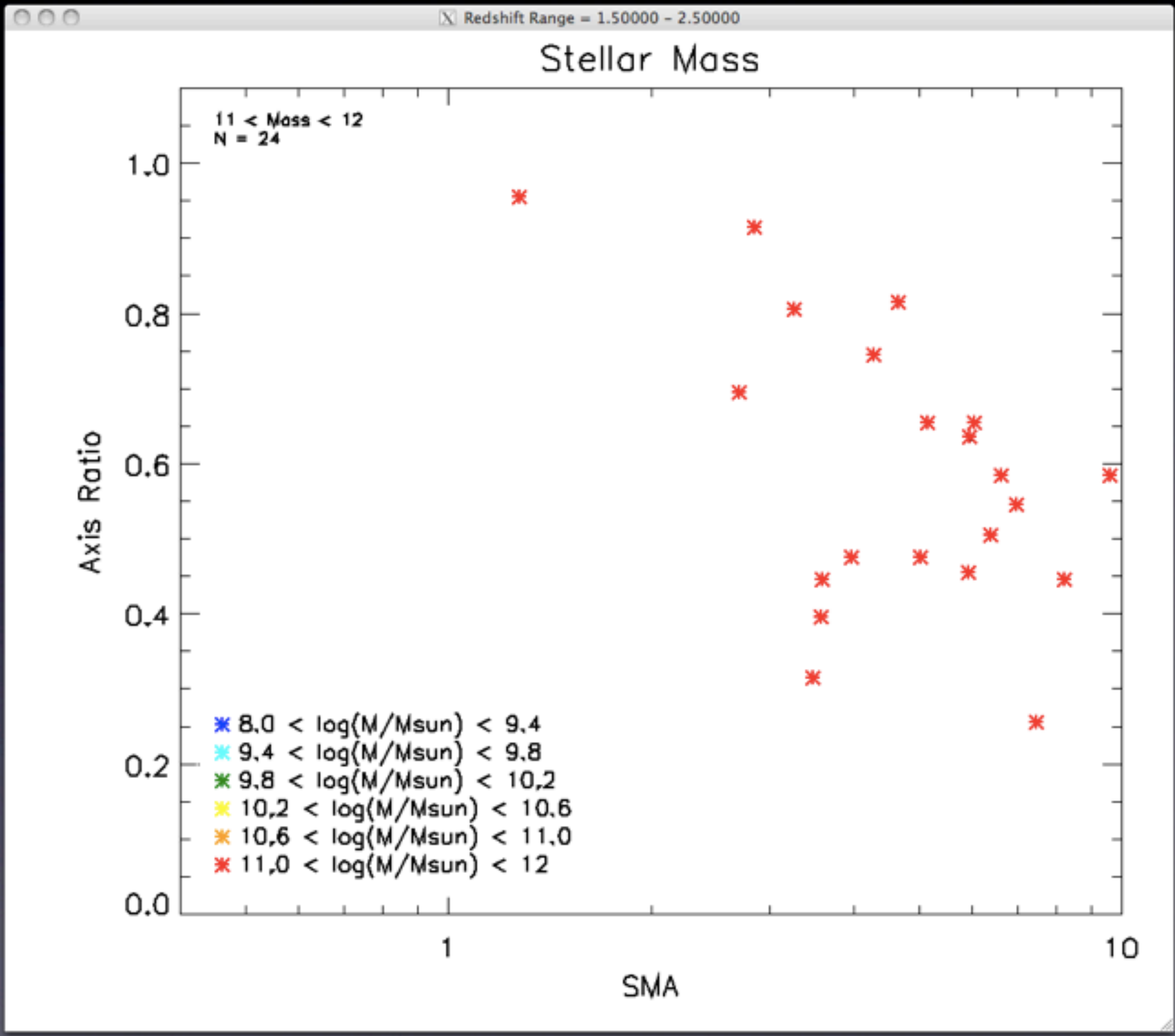
Star Forming Sample (blue and dusty)

Higher mass galaxies have lost the ridgeline and looks much more like a disk population



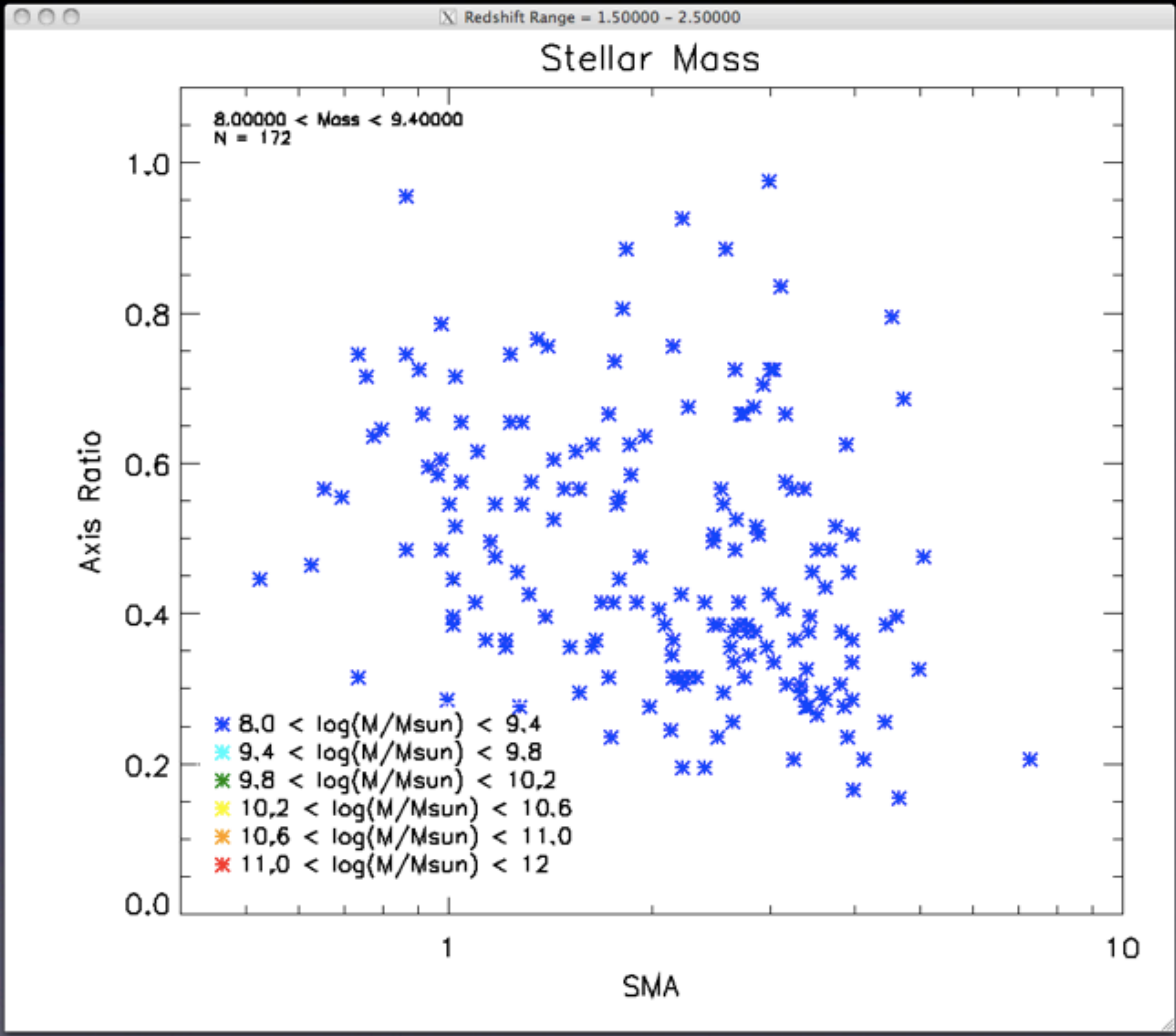
Star Forming Sample (blue and dusty)

Higher mass galaxies have lost the ridgeline and looks much more like a disk population



Star Forming Sample (blue and dusty)

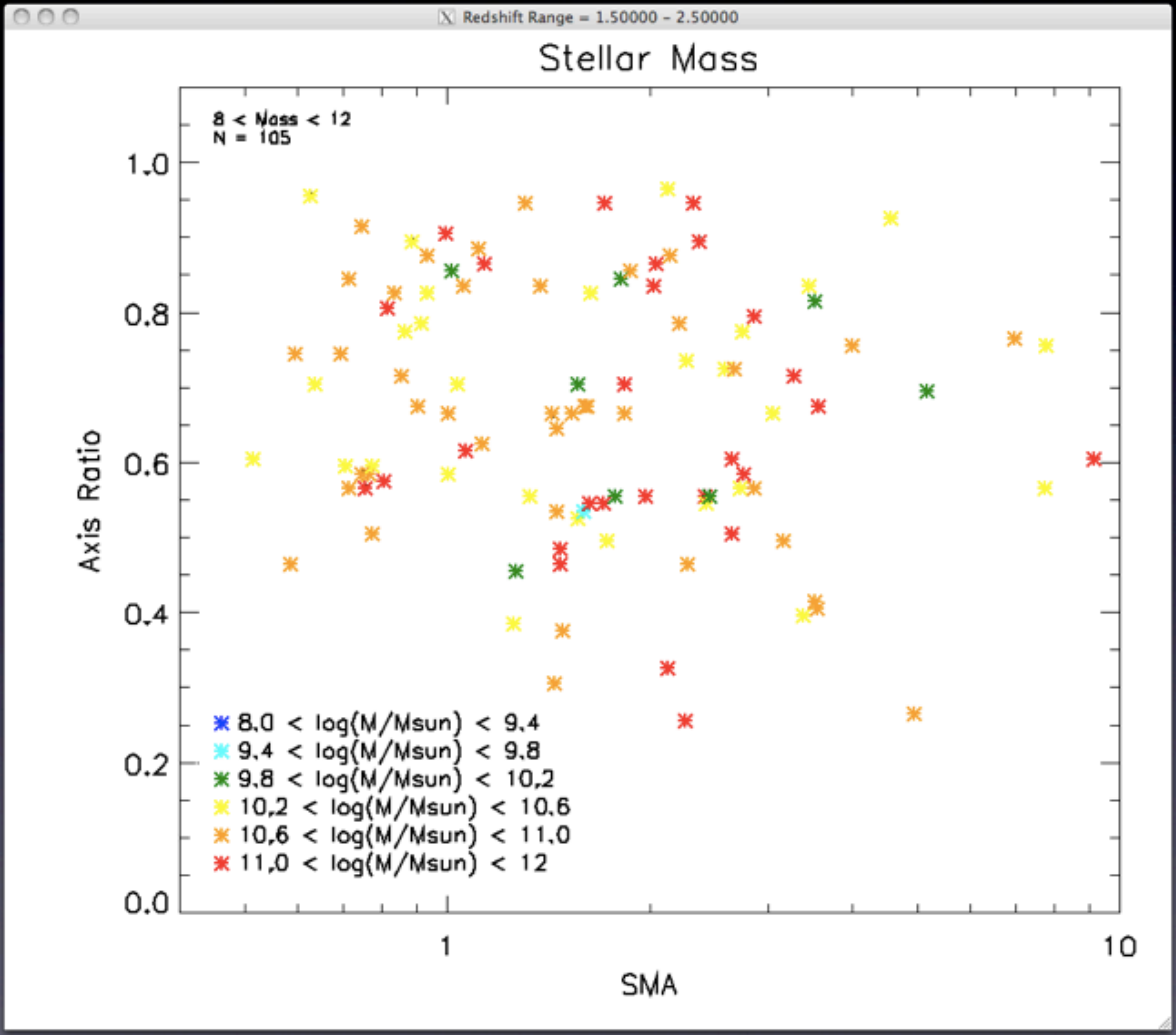
Low mass sample is incomplete but suggestion of a ridgeline is present in this low mass bin but there is a large axis ratio scatter



Star Forming Sample (blue and dusty) Conclusions

As we divide starforming galaxies by mass - we see a possible transition from a population with large numbers of prolate (sausage) systems at low mass to a population more dominated by oblate (disk) galaxies at higher mass

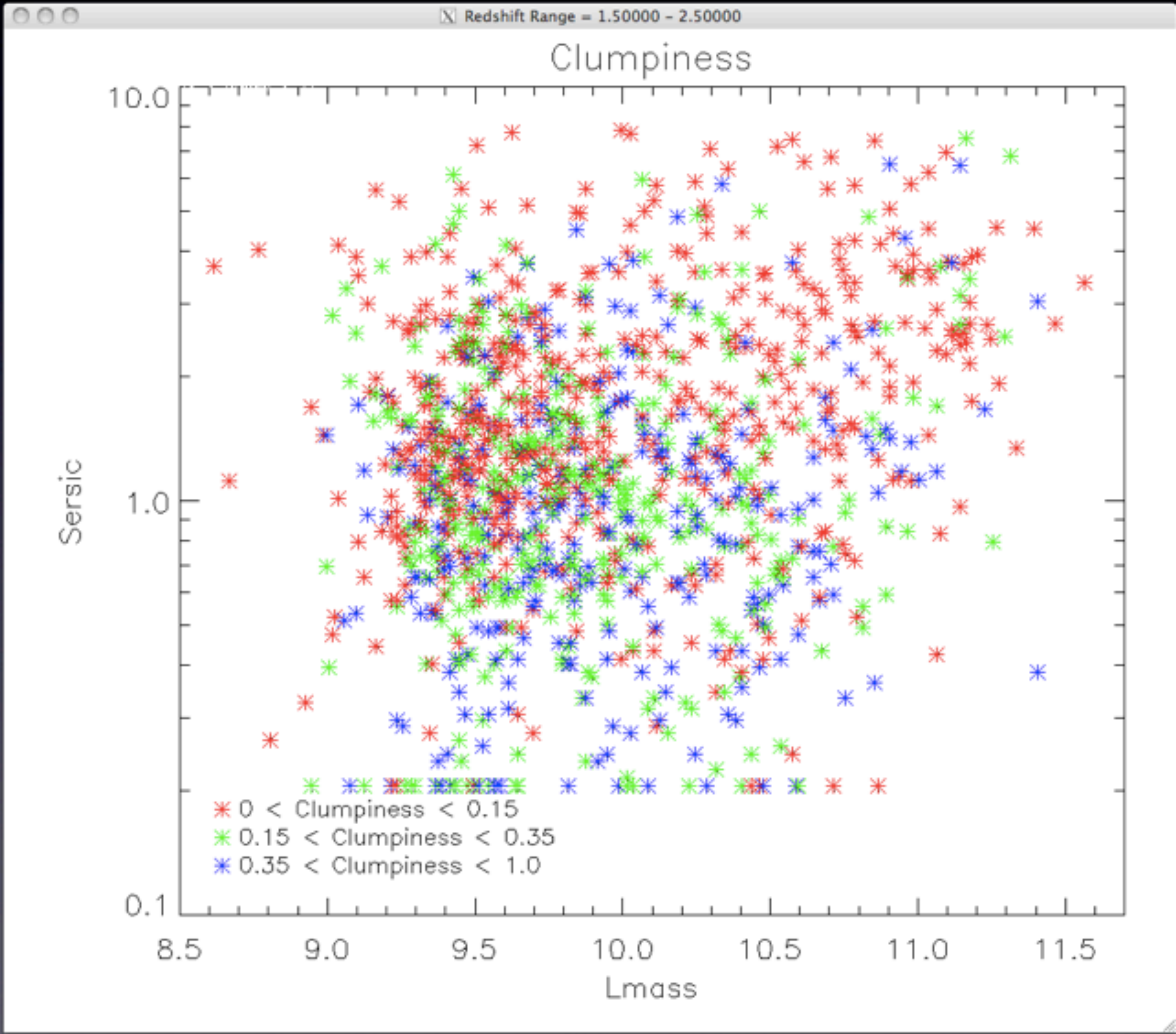
Quiescent Sample



Sersic-Mass

Clump-free systems have sersic >1

Clumpy galaxies are distributed from low to moderate sersic (n=4) at low and moderate masses



Quantifying Visual Morphologies