RESOLVING THE EVOLUTION OF GALAXIES

+ SOME MACHINE LEARNING

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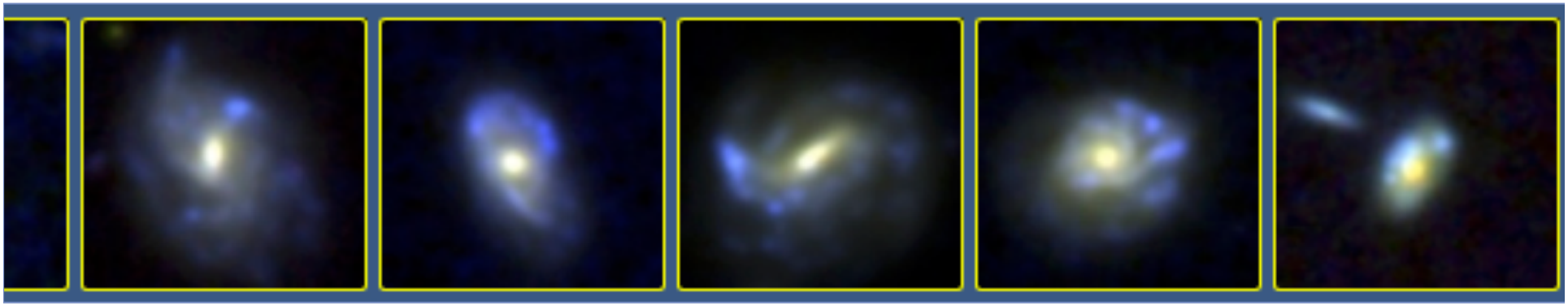
Content

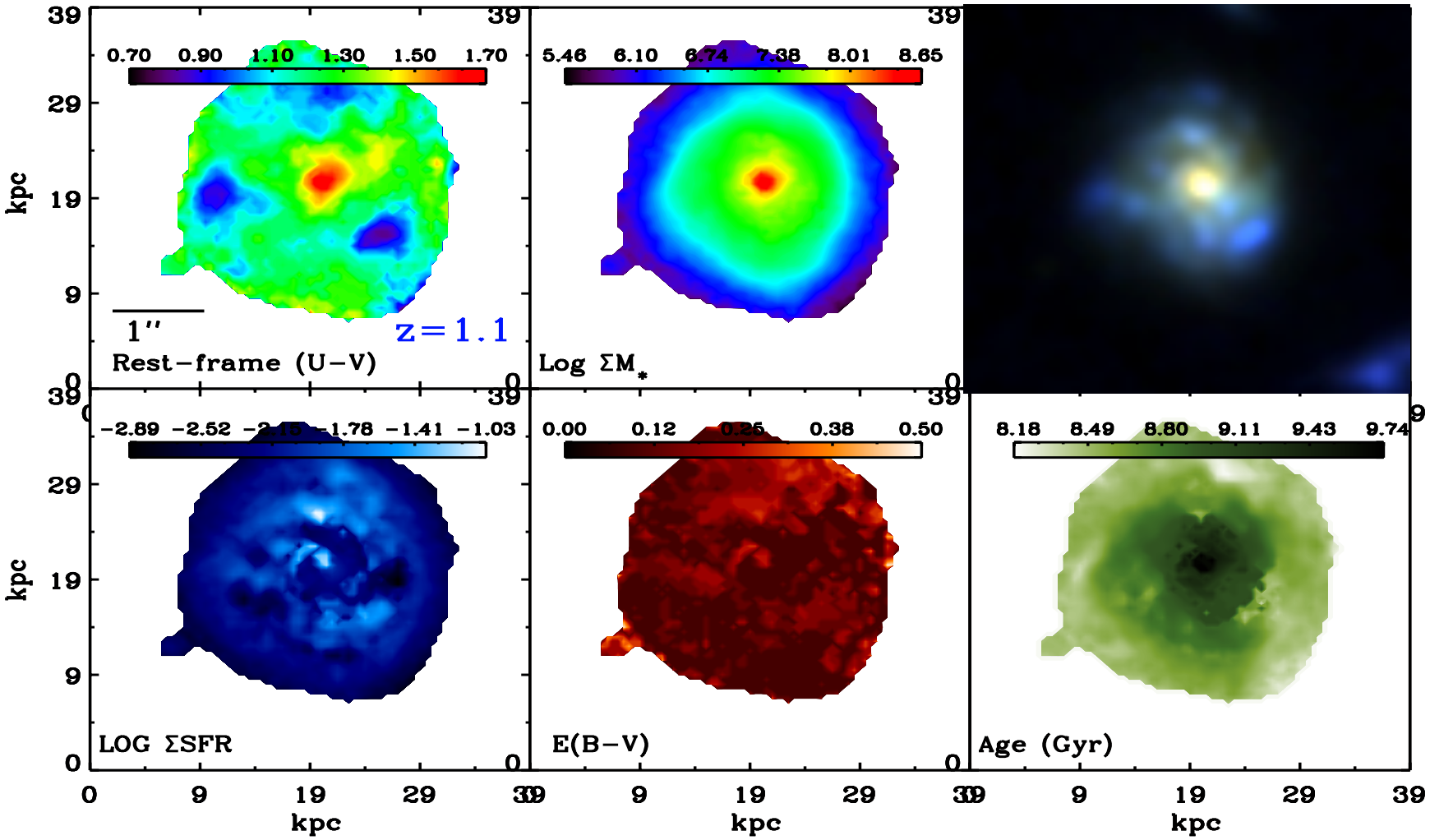
- Methodology of studying kpc-scale properties of galaxies
  - Photometric data (HST)
  - +spectroscopic (Keck)
- Specific science here:
  - Main Sequence of Star formation
- Some insights to SED-fitting from Machine Learning (SOMs)

Resolved Methodology

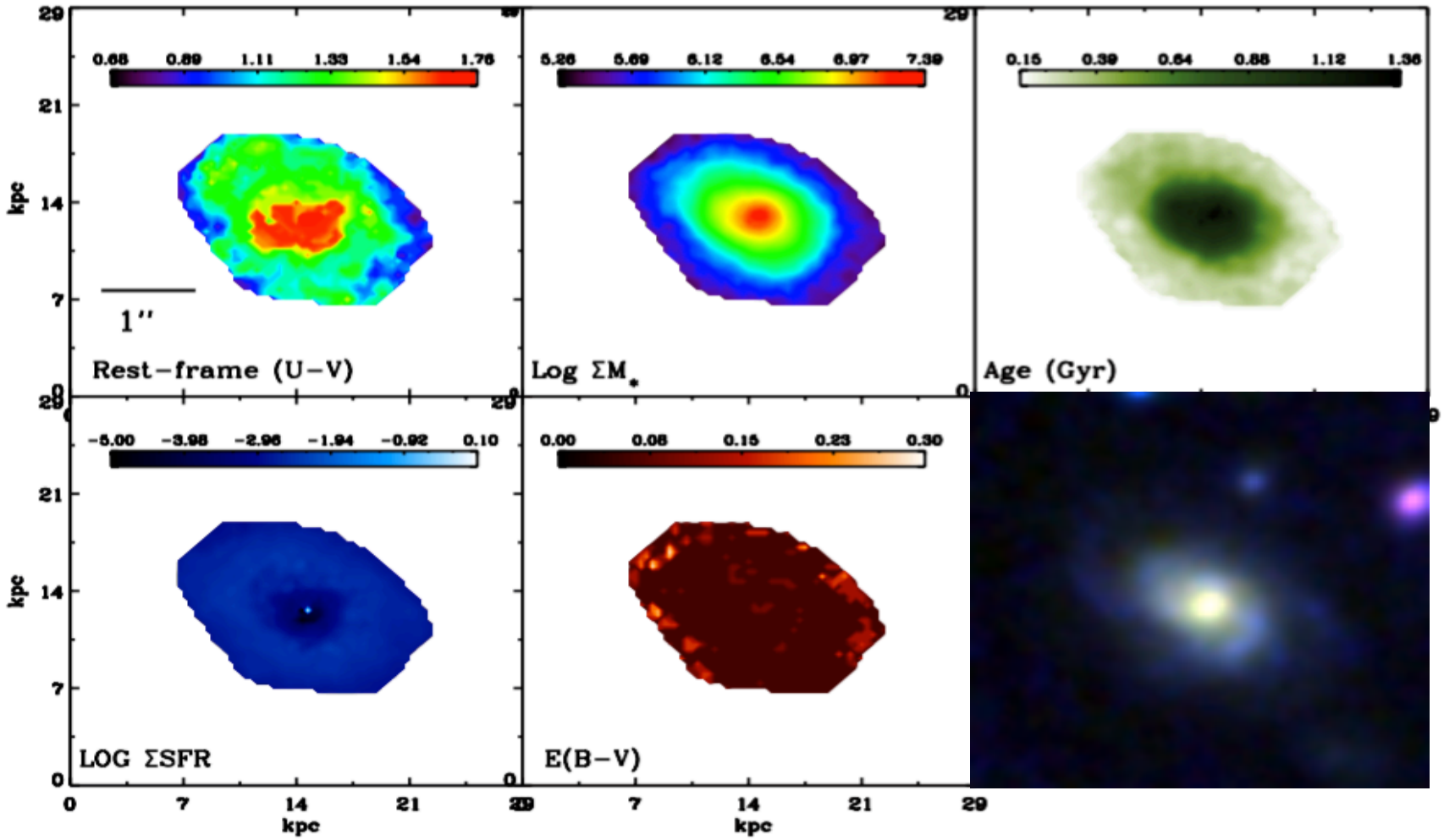
- CANDELS HST ACS/ WFC3 60 mas images
- In GOODS-S, GOODS-N
- F435W, F606W, F750W, F850lp, F105W, F120W, F160W
- ~3000 galaxies at $0.5 < z < 1.5$ with ~1 kpc resolution
- Cutouts of galaxies at all bands PSF-Matched to H-band
- SED-fitting at each element with LePhare



Fit SED at resolution elements

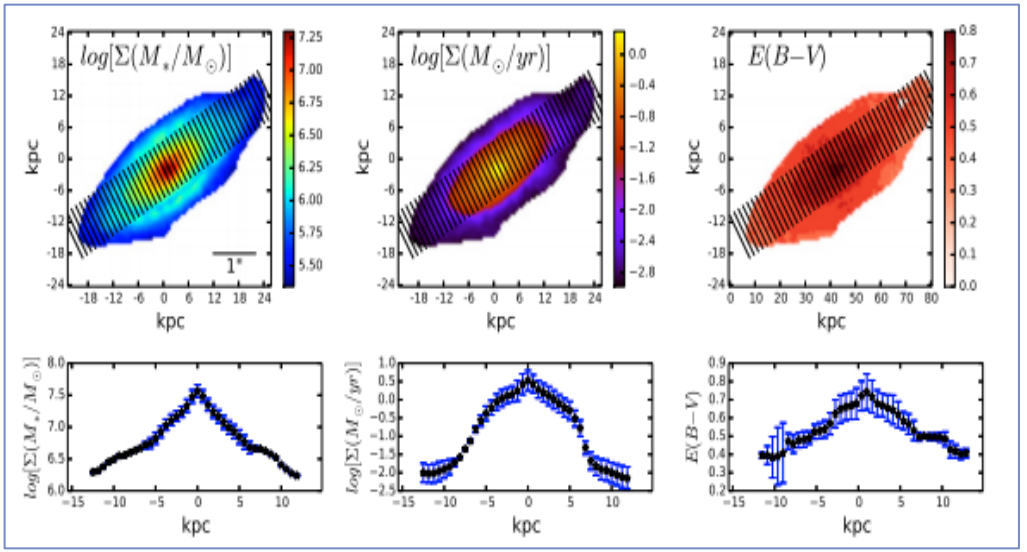


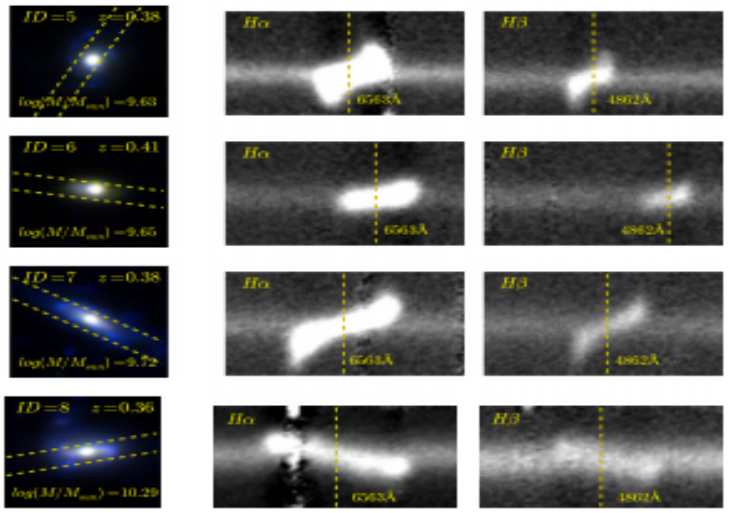
Fit SED at resolution elements

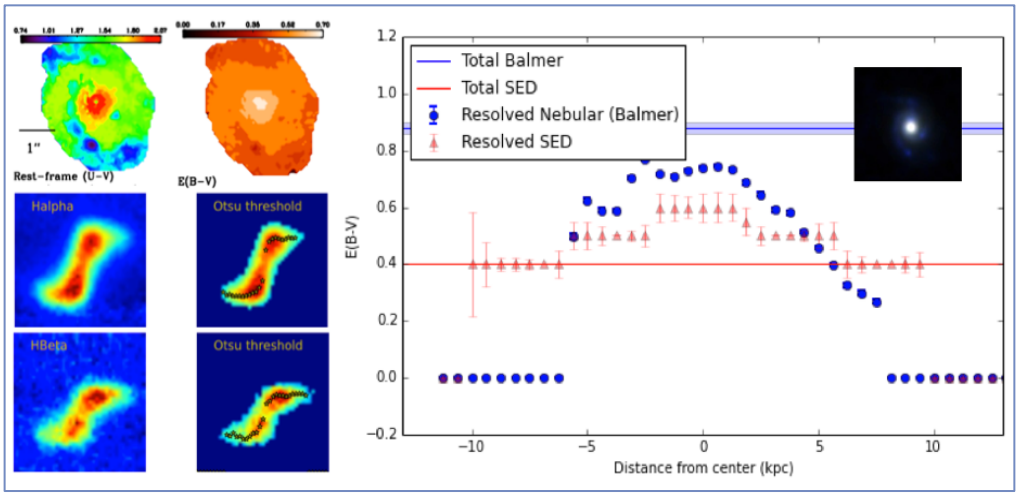


Add Spectral information

- DEIMOS spectra along the major axis of galaxies
- Halpha and Hbeta in subset of galaxis → Balmer Decrement
- Comparison of stellar and nebular dust

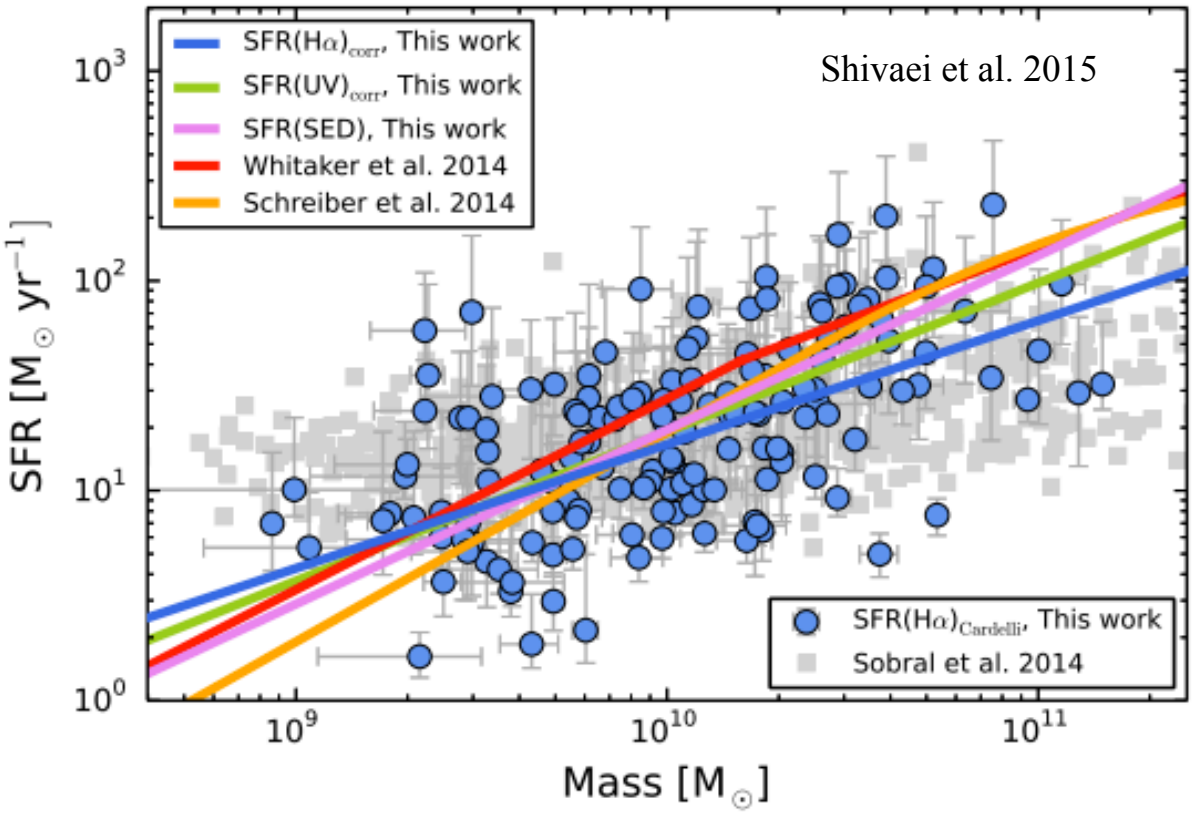






Hemmati et al. 2015

Main Sequence of Star formation

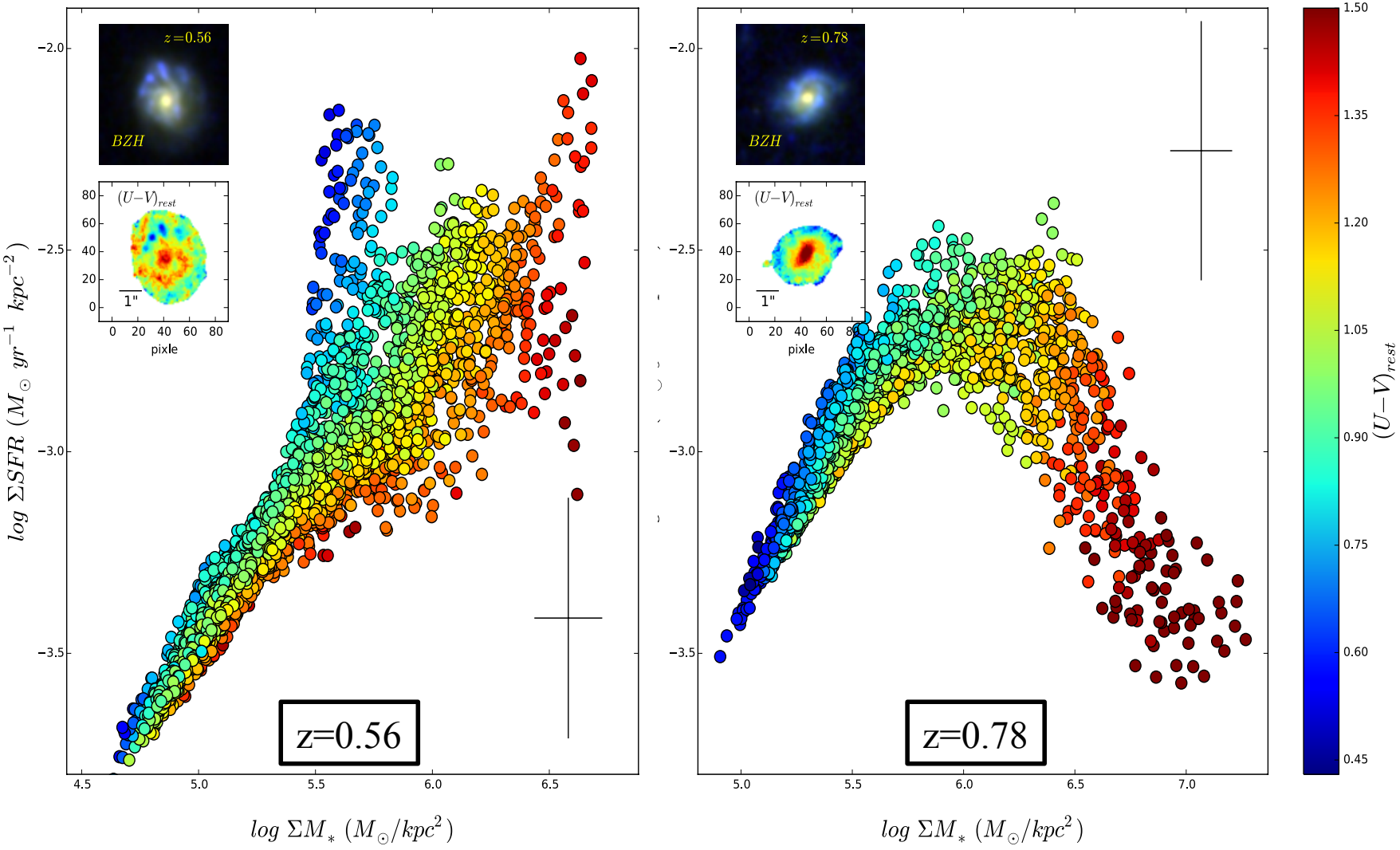


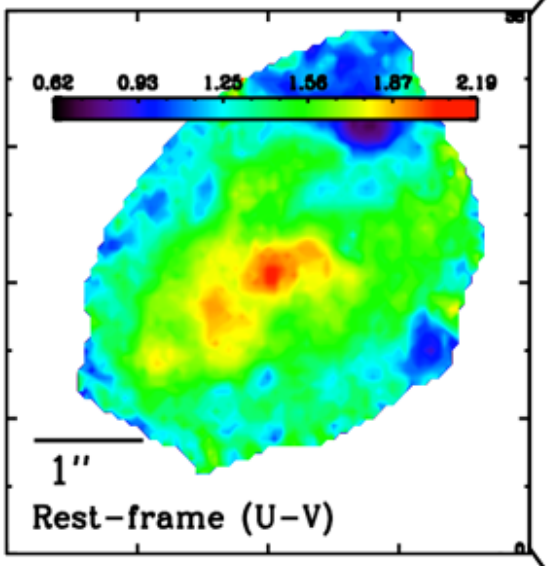
What causes the intrinsic scatter?

What sets the slope?

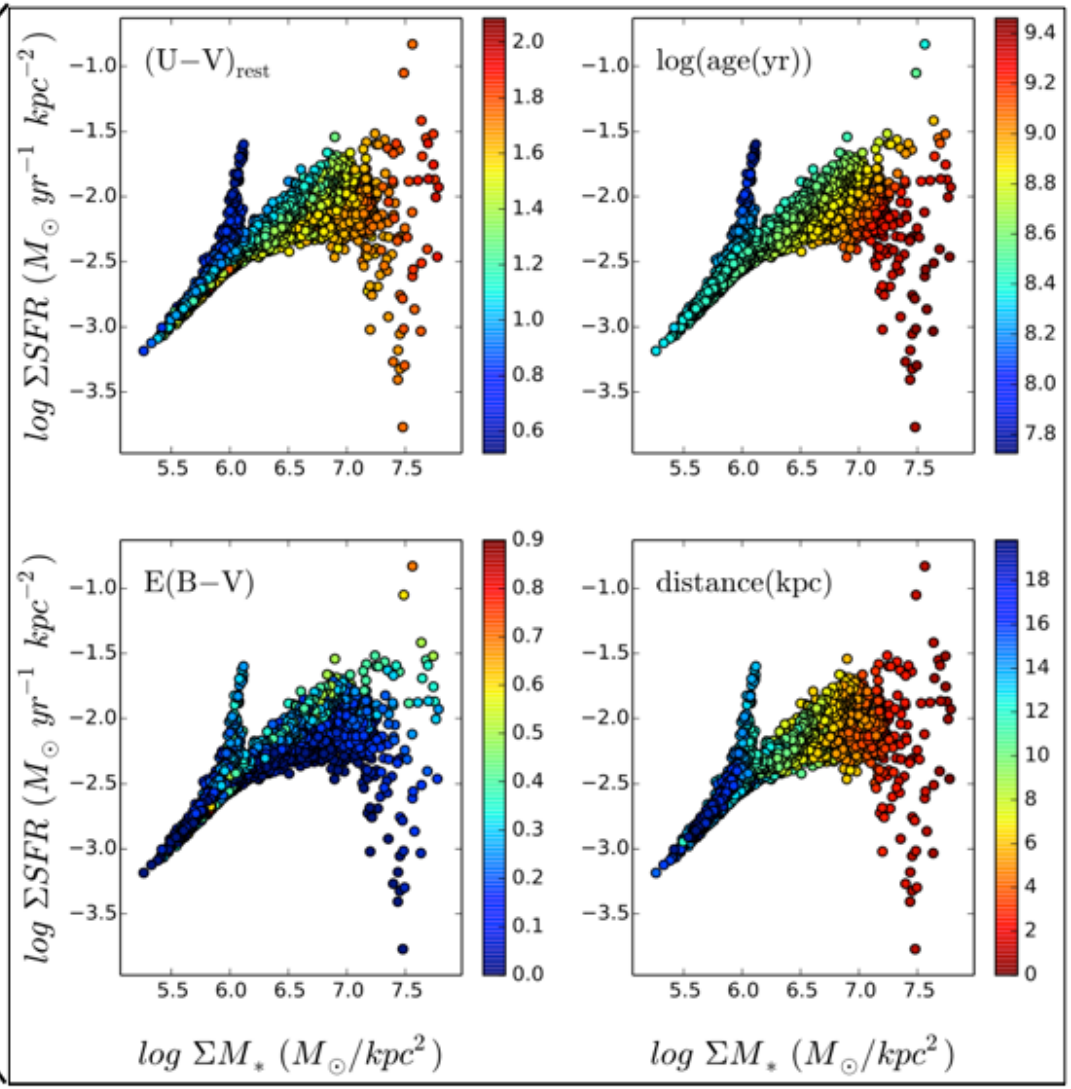
Why does the zero point evolve with redshift?

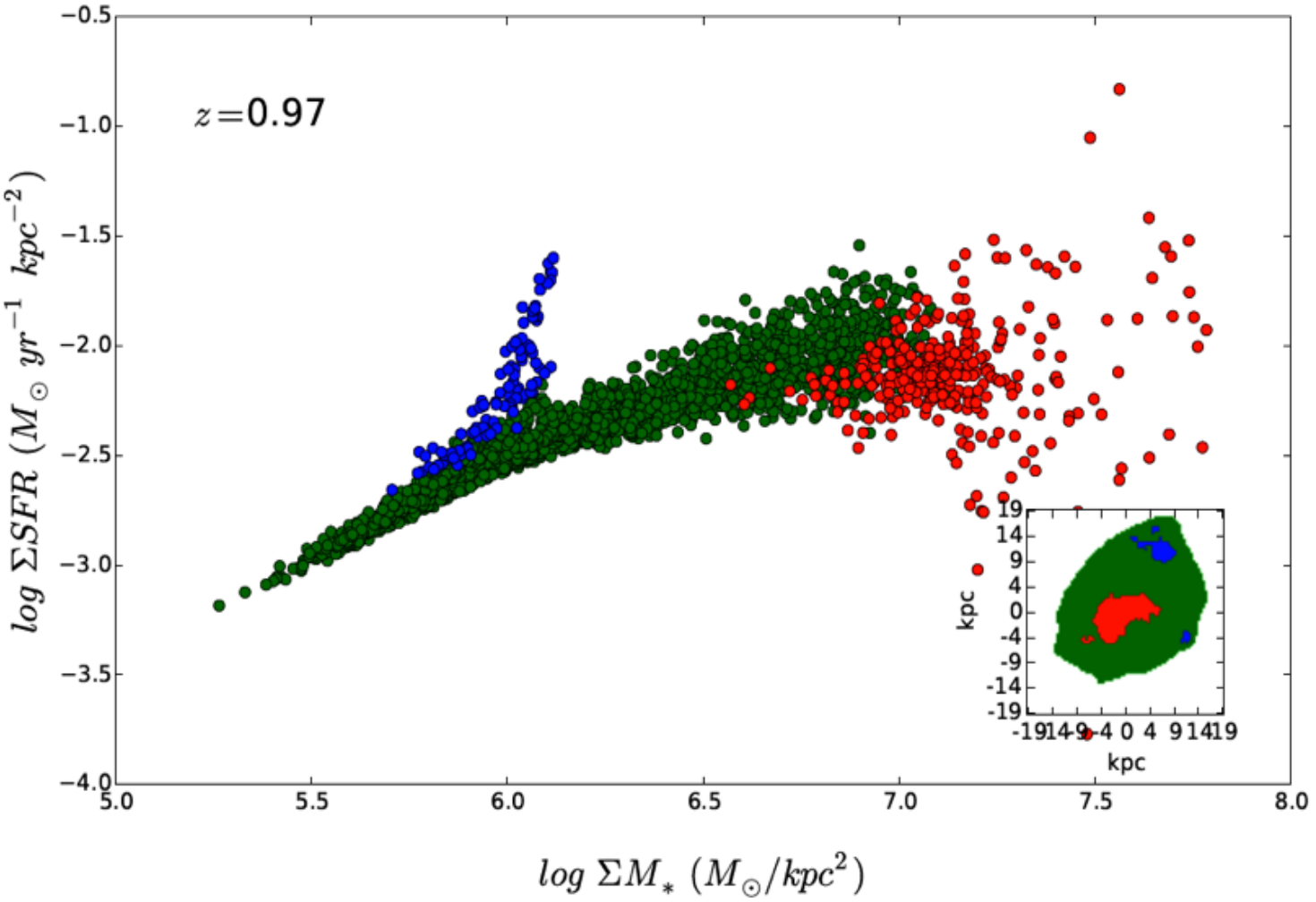
Resolved Main Sequence

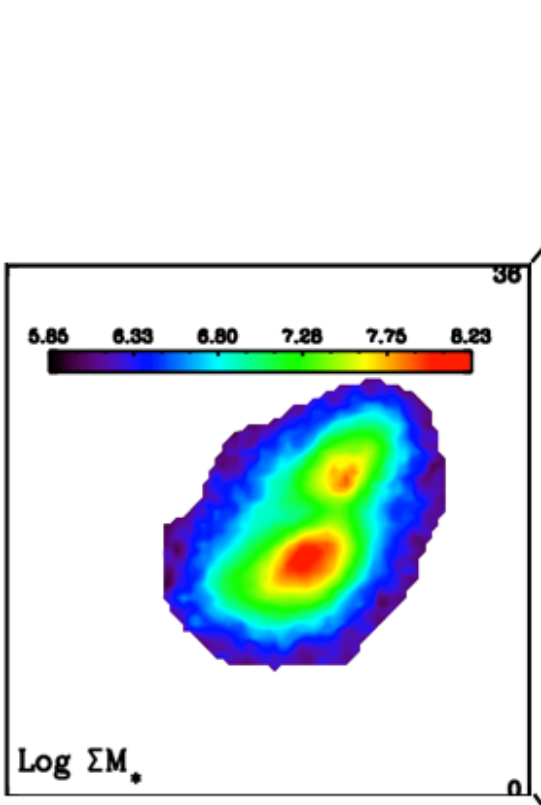



0.62
0.93
1.25
1.56
1.87
2.19
1″
Rest−frame (U−V)

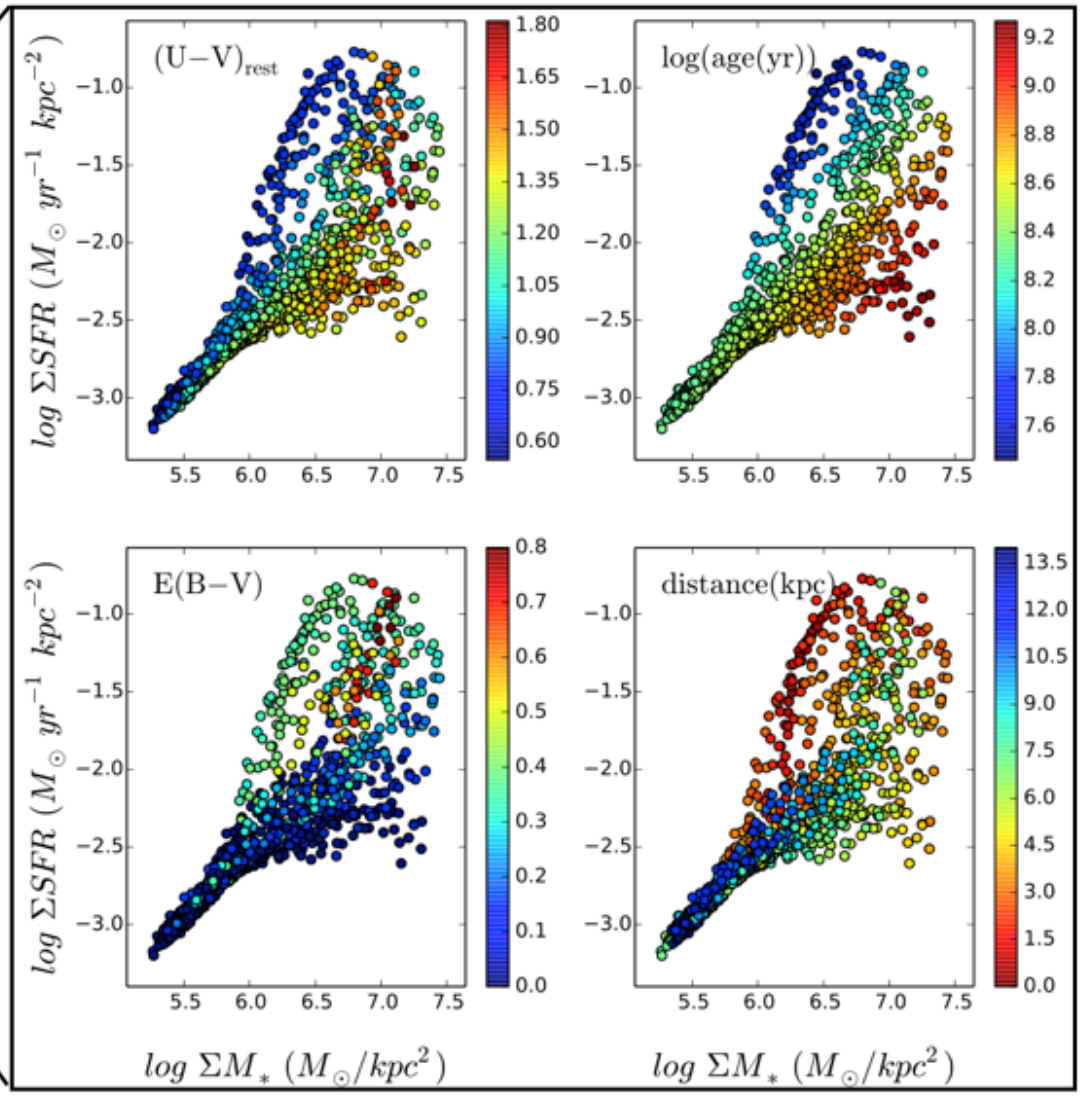
Clumps

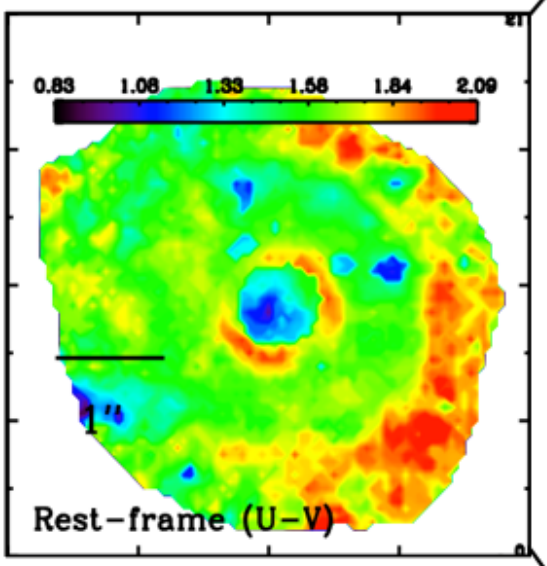

$(U-V)_{rest}$
log(age(yr))
E(B−V)
distance(kpc)
$log\ \Sigma SFR\ (M_\odot\ yr^{-1}\ kpc^{-2})$
$log\ \Sigma M_*\ (M_\odot/kpc^2)$


$z=0.97$
$log\ \Sigma SFR\ (M_\odot\ yr^{-1}\ kpc^{-2})$
$log\ \Sigma M_*\ (M_\odot/kpc^2)$
−0.5
−1.0
−1.5
−2.0
−2.5
−3.0
−3.5
−4.0
5.0
5.5
6.0
6.5
7.0
7.5
8.0
kpc
kpc
19
14
9
4
0
-4
-9
-14
-19
-19 -14 -9 -4 0 4 9 14 19

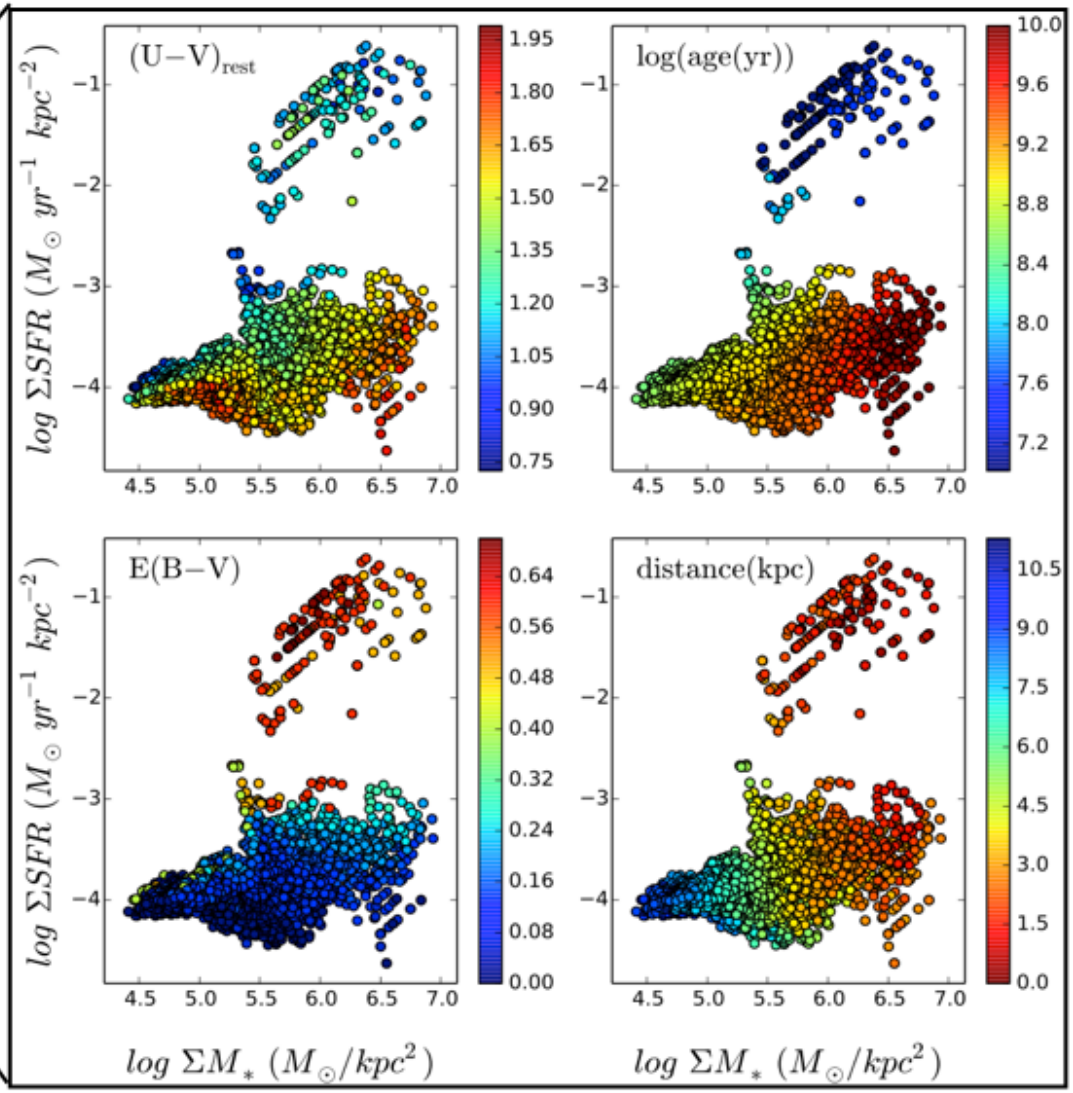

35
5.85
6.33
6.80
7.28
7.75
8.23
Log ΣM*
0

Merger

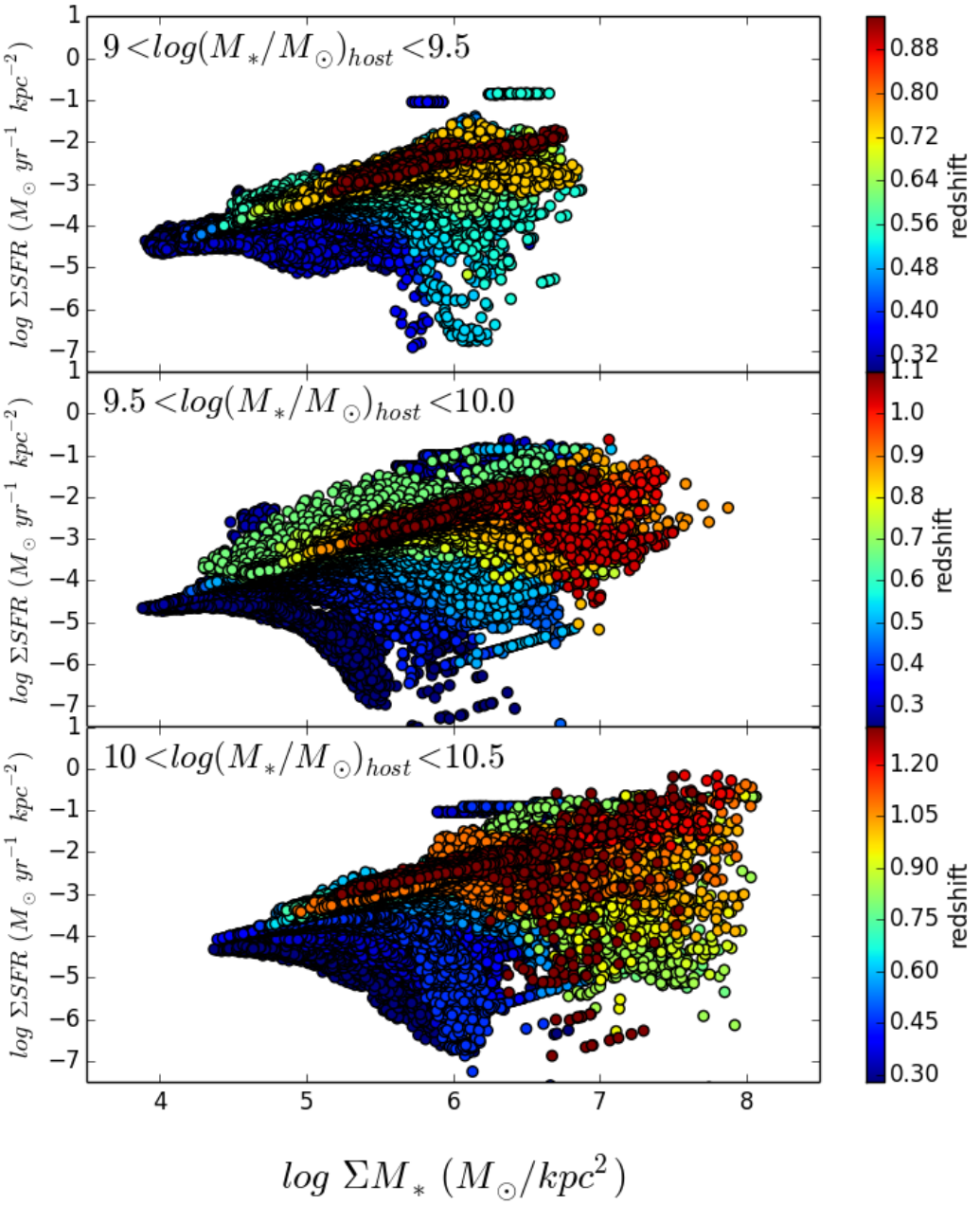

(U−V)rest
log(age(yr))
E(B−V)
distance(kpc)
log ΣSFR (M⊙ yr−1 kpc−2)
log ΣM* (M⊙/kpc2)


0.83
1.08
1.33
1.58
1.84
2.09
1″
Rest−frame (U−V)

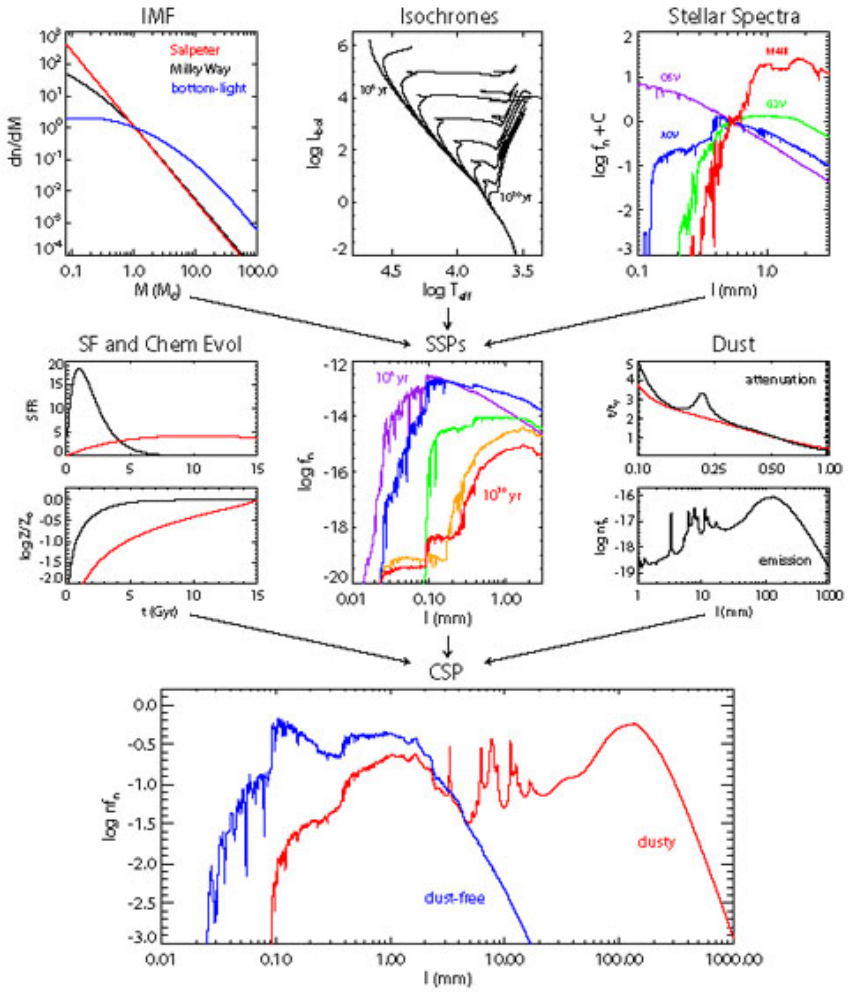
AGN


$(U-V)_{rest}$
log(age(yr))
E(B−V)
distance(kpc)
$log\ \Sigma SFR\ (M_\odot\ yr^{-1}\ kpc^{-2})$
$log\ \Sigma M_*\ (M_\odot/kpc^2)$
4.5 5.0 5.5 6.0 6.5 7.0
−1 −2 −3 −4
1.95 1.80 1.65 1.50 1.35 1.20 1.05 0.90 0.75
10.0 9.6 9.2 8.8 8.4 8.0 7.6 7.2
0.64 0.56 0.48 0.40 0.32 0.24 0.16 0.08 0.00
10.5 9.0 7.5 6.0 4.5 3.0 1.5 0.0

- The scatter can be mainly caused by **sample selection** including different types of galaxies and with mergers, AGNs, etc…
- Where the galaxy sits compared to the "main sequence" correlates tightly with structure, e.g. how many clumps, how dominant the bulge, …
- Turn over of the main sequence at large masses can be explained by dominance of central mass in massive galaxies.



Have in mind …



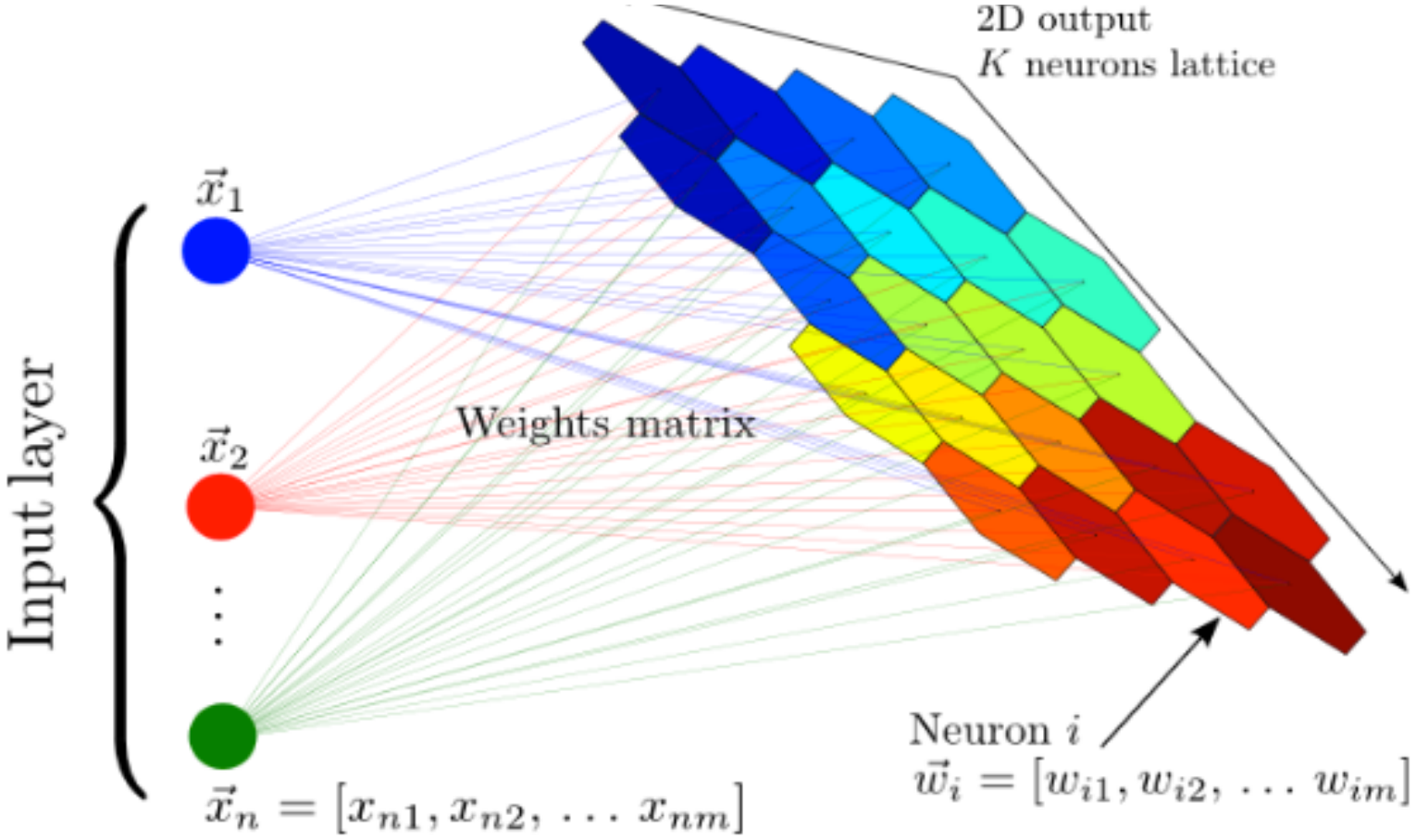
Conroy et al. 2013

- SFR and Mass measured through SED-fitting both depend on the best fitted model
- Possible parameter space for the model library is too large, need to make the assumptions more precise.

Self Organizing Maps (SOMs)

Unsupervised Artificial Neural Network

A dimensionality reduction technique which preserves topology



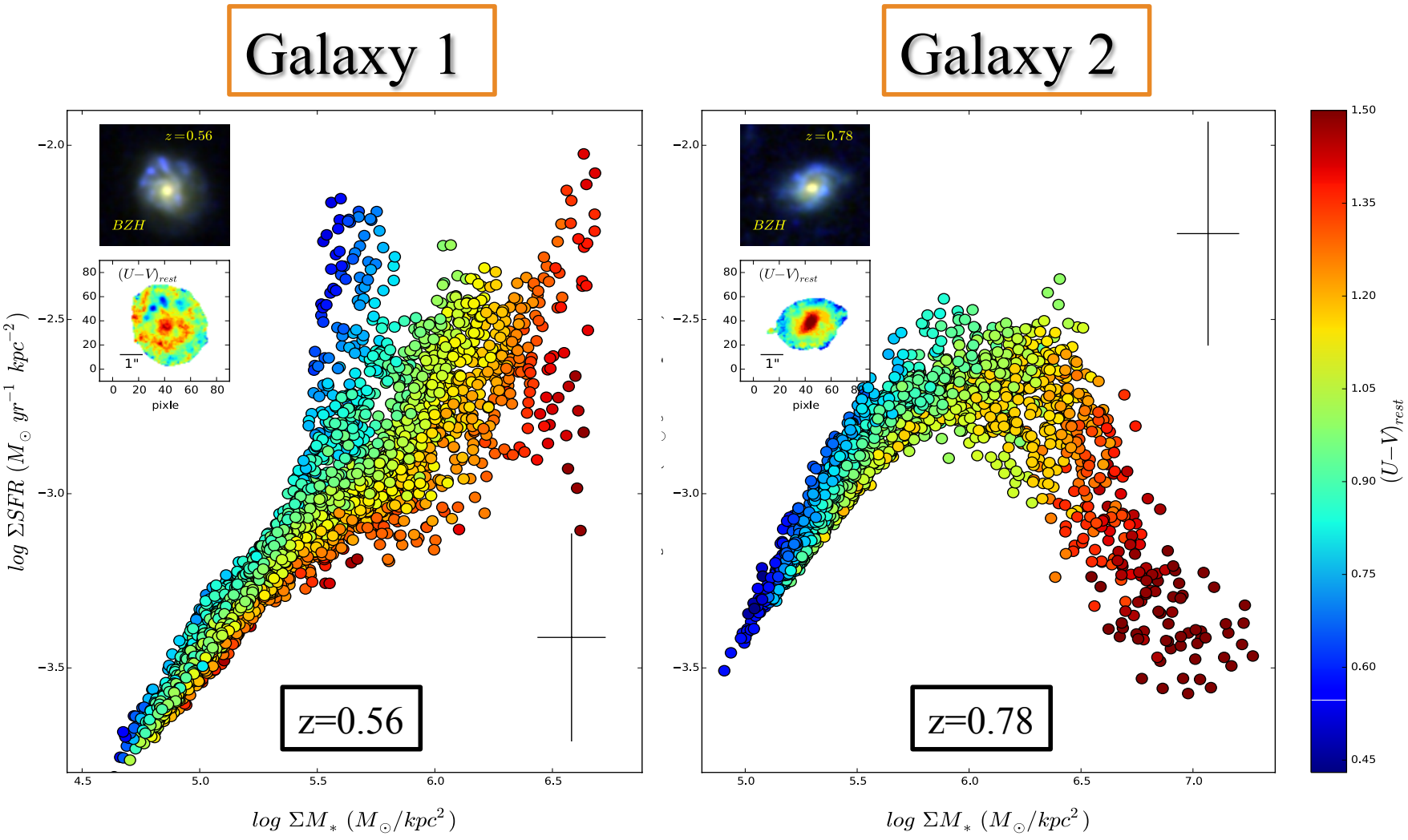
SOM example on photoz, See: Masters et al. 2015
Speagle et al. 2016

SOM on Model SEDs to constrain physical parameters:

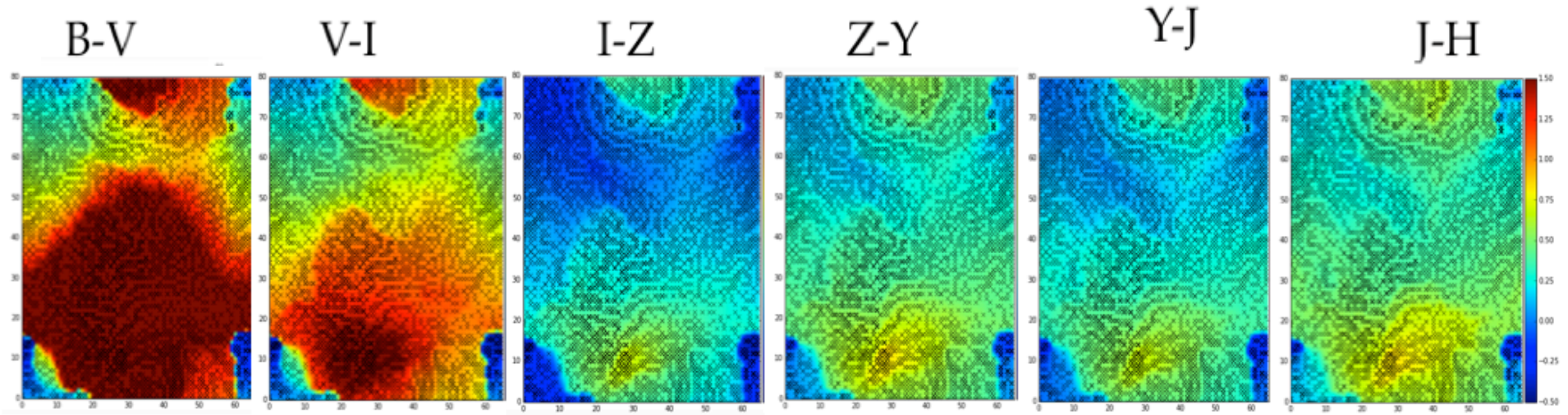
- Library of ~10 thousand CSP
- At the redshift of each galaxy
- Assuming a range of Age, SFH, and Extinction

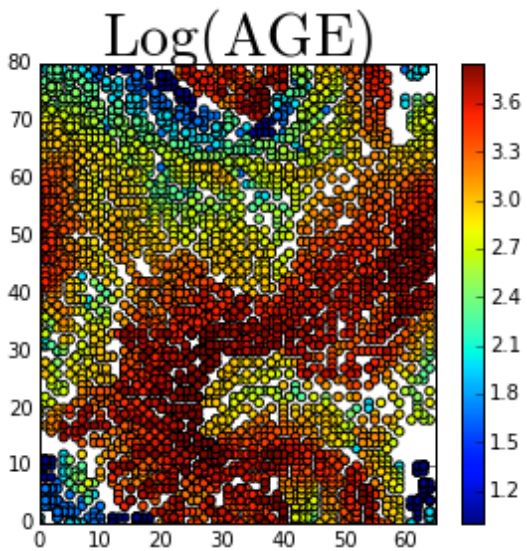
- Convolve model SEDs with HST filters →
- Input of SOM:
  - Xi=(BV, VI, IZ, ZY, YJ, JH)
- Grid of 80X60 neurons (arbitrary)

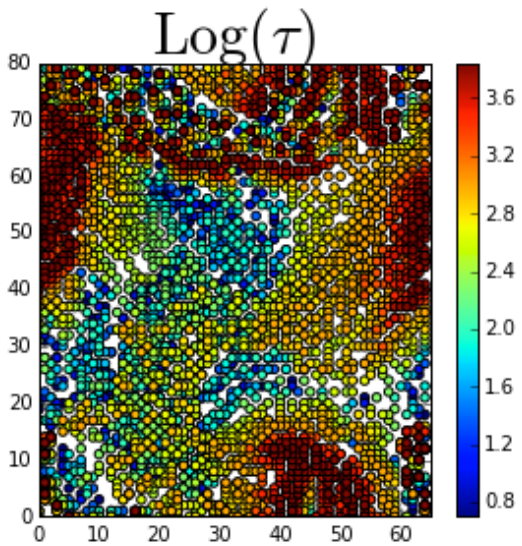
Resolved Main Sequence

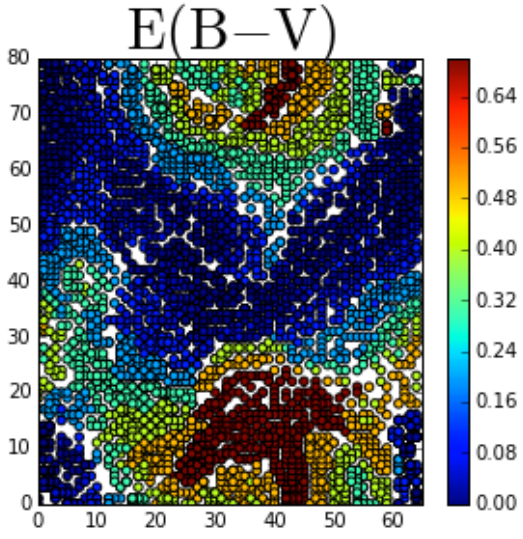


Training the SOM with Model SEDs at z=0.56

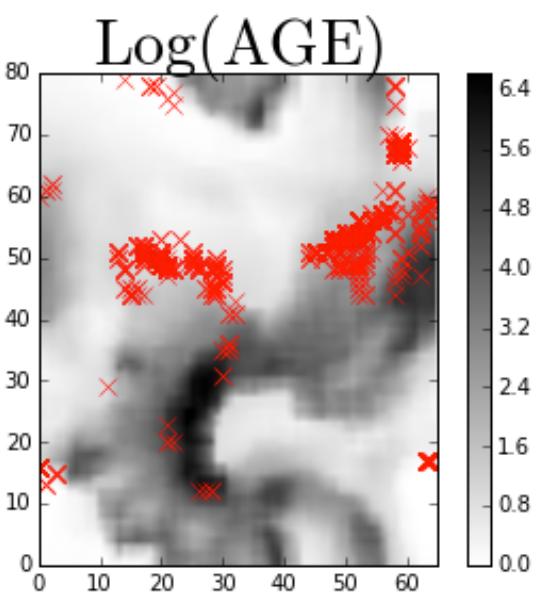


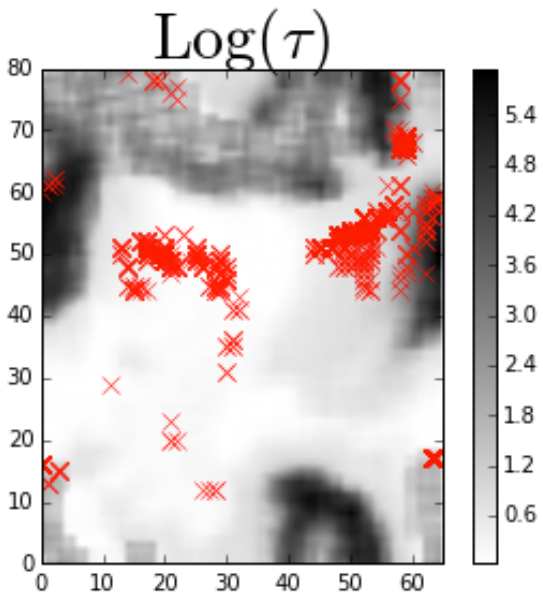


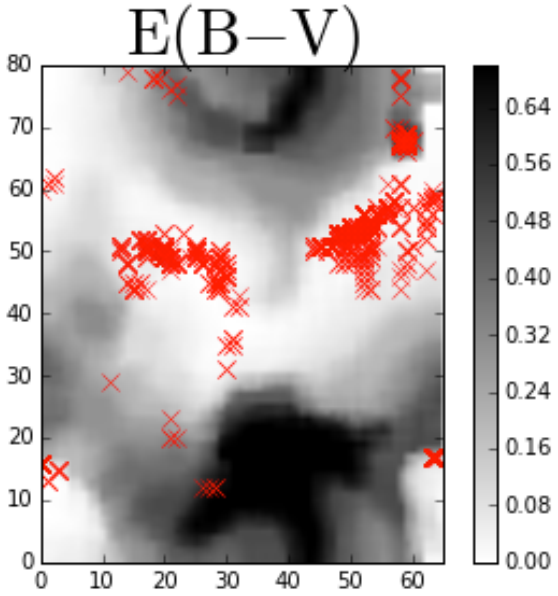


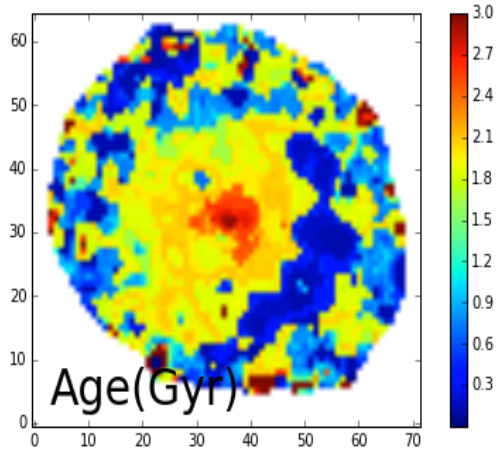


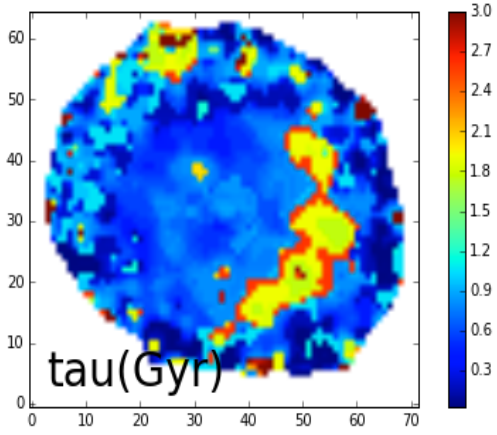
Example1 on SOM (z=0.56)

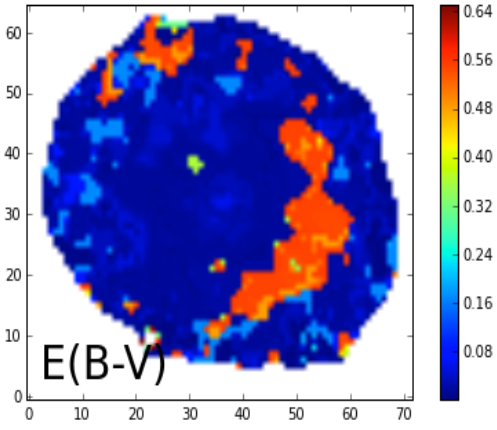




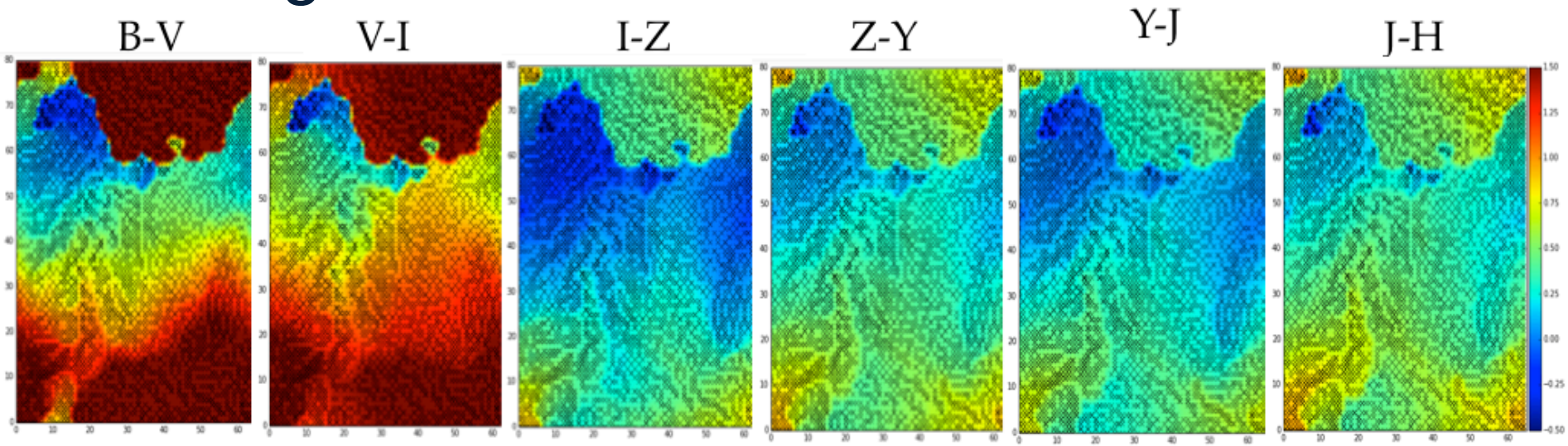


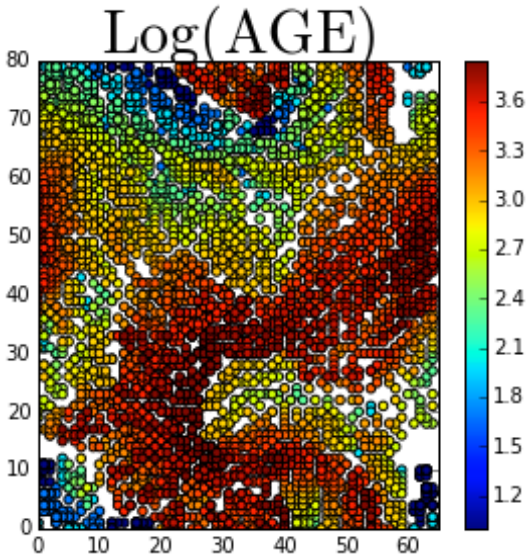


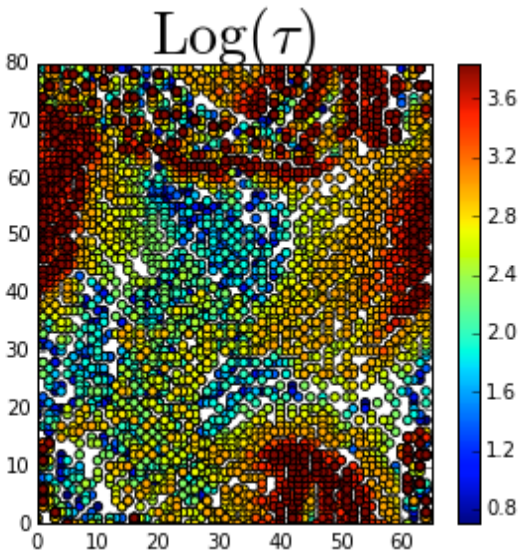


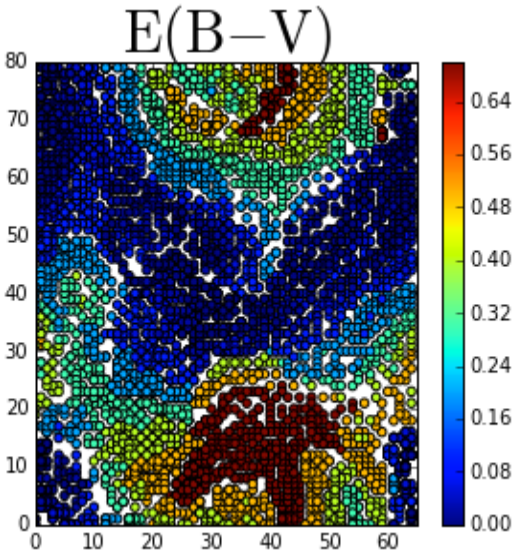


Training the SOM with Model SEDs at z=0.56

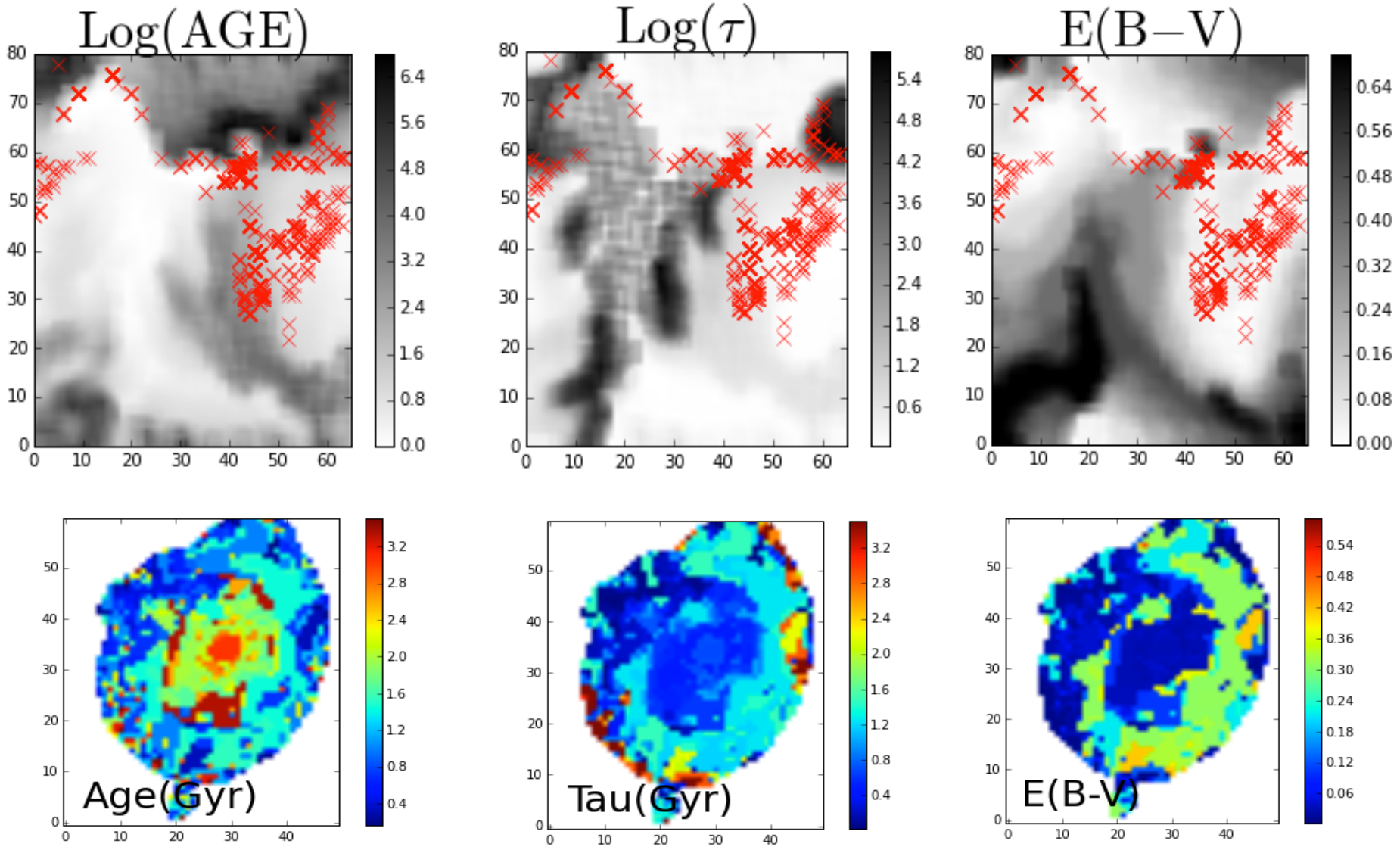




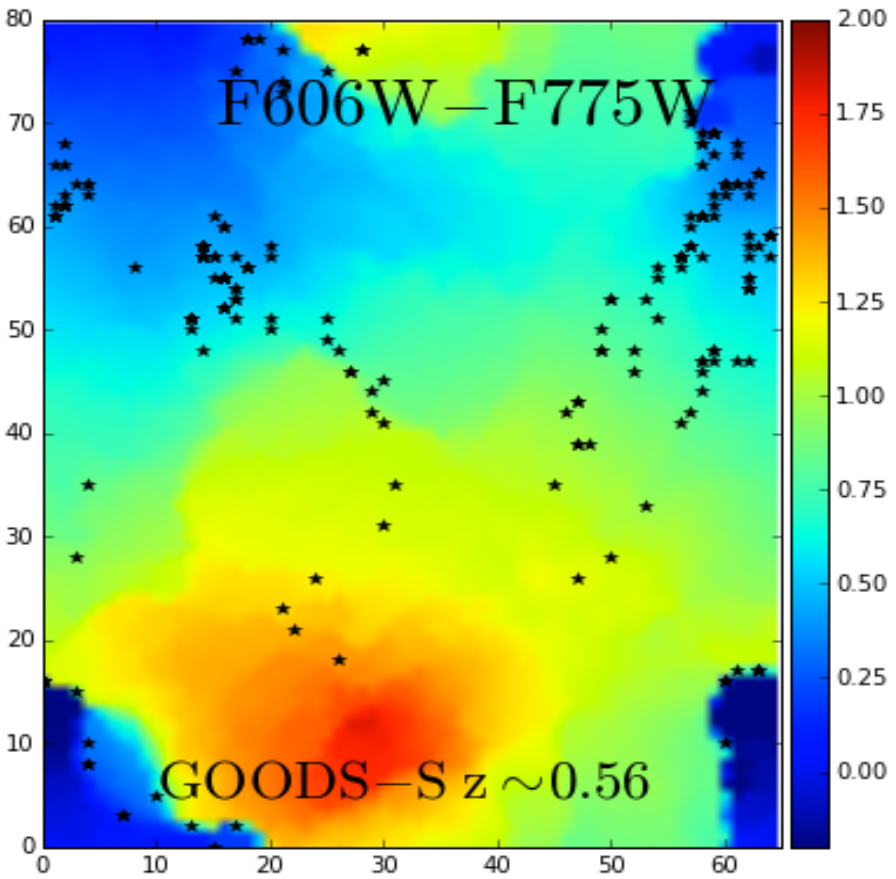


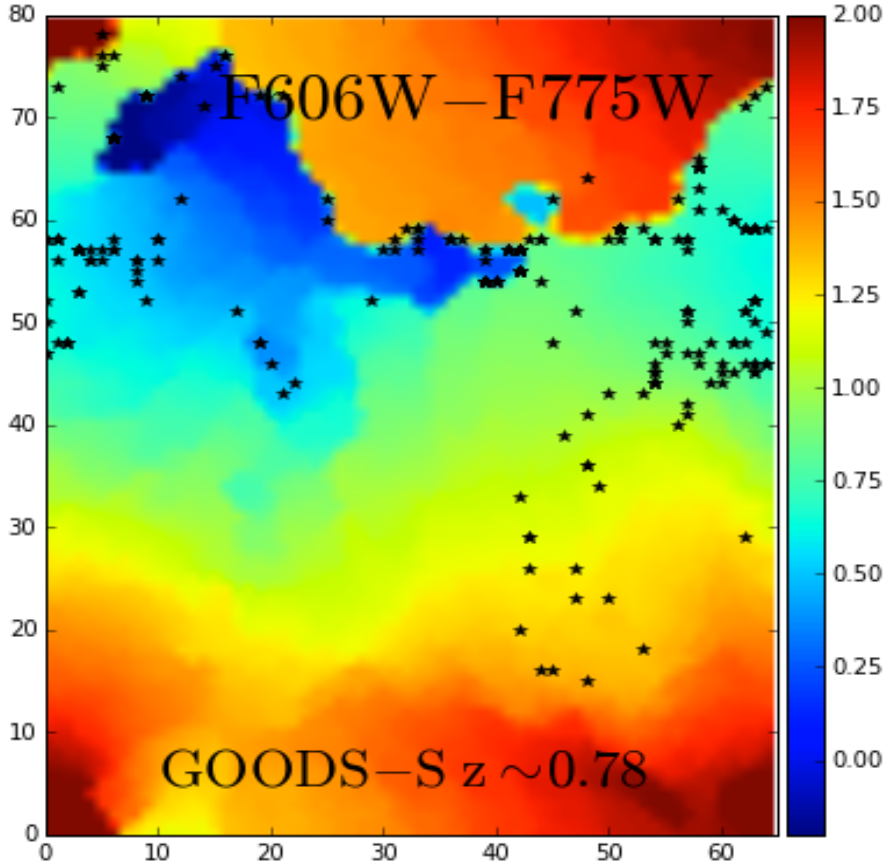


Example2 on SOM (z=0.78)



Integrated galaxy colors on SOM examples





- Need to Constrain the parameters in the model Library base on observations of real galaxies.

Thank you.