DEEP-Theory Meeting 16 June 2017

GALFIT and clump analysis of VELA simulations and comparison with observations — VivianTang, Yicheng Guo, David Koo, Liz McGrath — new paper by Yicheng Guo on clump properties with disk subtraction nearly done

Deep Learning for Galaxies project: Analysis of VELA Gen3 simulations is ongoing by Raymond Simons at JHU, Christoph Lee and Sean Larkin, along with Avishai's student Tomer Nussbaum: finding all satellites. Christoph is also using the DL code that classified CANDELS images to classify VELA mock galaxy images. Fernando Caro is analyzing Horizon simulations. Alex Bogert visited UCSC Tuesday May 23 2:30-5 pm to help us with yt visualizations. Marc Huertas-Company will be at UCSC starting Thursday June 22.

Visit to **Google** on Tuesday May 30 — my talk is at https://www.youtube.com/watch?v=bpTs2eLS07I and the slides are at http://physics.ucsc.edu/~joel/GoogleTalk-Primack-30May2017.pdf

Deep Learning for Redshifts project: James Kakos and Dominic Pasquale plan to use DL for a project to improve z and local environment estimates for galaxies with only photometric redshifts. Fernando Caro is working with David Koo on using DL for this. He may report on this at Cosmoclub Monday June 19.

Galaxy size vs. local density project — Graham Vanbenthuysen, Viraj Pandya, Christoph Lee, Doug Hellinger, Aldo Rodriguez-Puebla, David Koo — We are measuring λ vs. density by various methods in Aldo's mock catalogs from Bolshoi-Planck and MultiDark-Planck, and SDSS galaxy radii vs. density by the same methods.

Halo properties like concentration, accretion history, and spin are mainly determined by environmental density rather than by location within the cosmic web — we are finishing the paper led by Tze Goh

DM halo mass loss and **halo radial profile** paper(s?) being drafted — Christoph Lee, Doug Hellinger. Related work this summer by SIP students Shawn Zhang and Peter Wu with Christoph.

Improved Santa Cruz Semi-Analytic Model of galaxy population evolution, including insights from high-resolution hydro simulations — Viraj Pandya, Christoph Lee, Rachel Somerville, Sandy Faber

CLUMPY GALAXIES IN CANDELS. II. PHYSICAL PROPERTIES OF UV-BRIGHT CLUMPS AT 0.5 ≤ Z < 3

YICHENG GUO[1], MARC RAFELSKI[2], ERIC F. BELL[3], CHRISTOPHER J. CONSELICE[4], S. M. FABER[1], MAURO GIAVALISCO[5], ANTON M. KOEKEMOER[2], DAVID C. KOO[1], YU LU[6], NIR MANDELKER[7], JOEL R. PRIMACK[8], DANIEL CEVERINO[9], DUILIA F. DE MELLO[10], AVISHAI DEKEL[11], HENRY C. FERGUSON[2], NIMISH HATHI[12], DALE KOCEVSKI[13], RAY LUCAS[2], PABLO G. PE´REZ-GONZA´LEZ[14], SWARA RAVINDRANATH[2], EMMARIS SOTO[9], AMBER STRAUGHN[15], AND WEICHEN WANG[16]

Draft version June 13, 2017

ABSTRACT

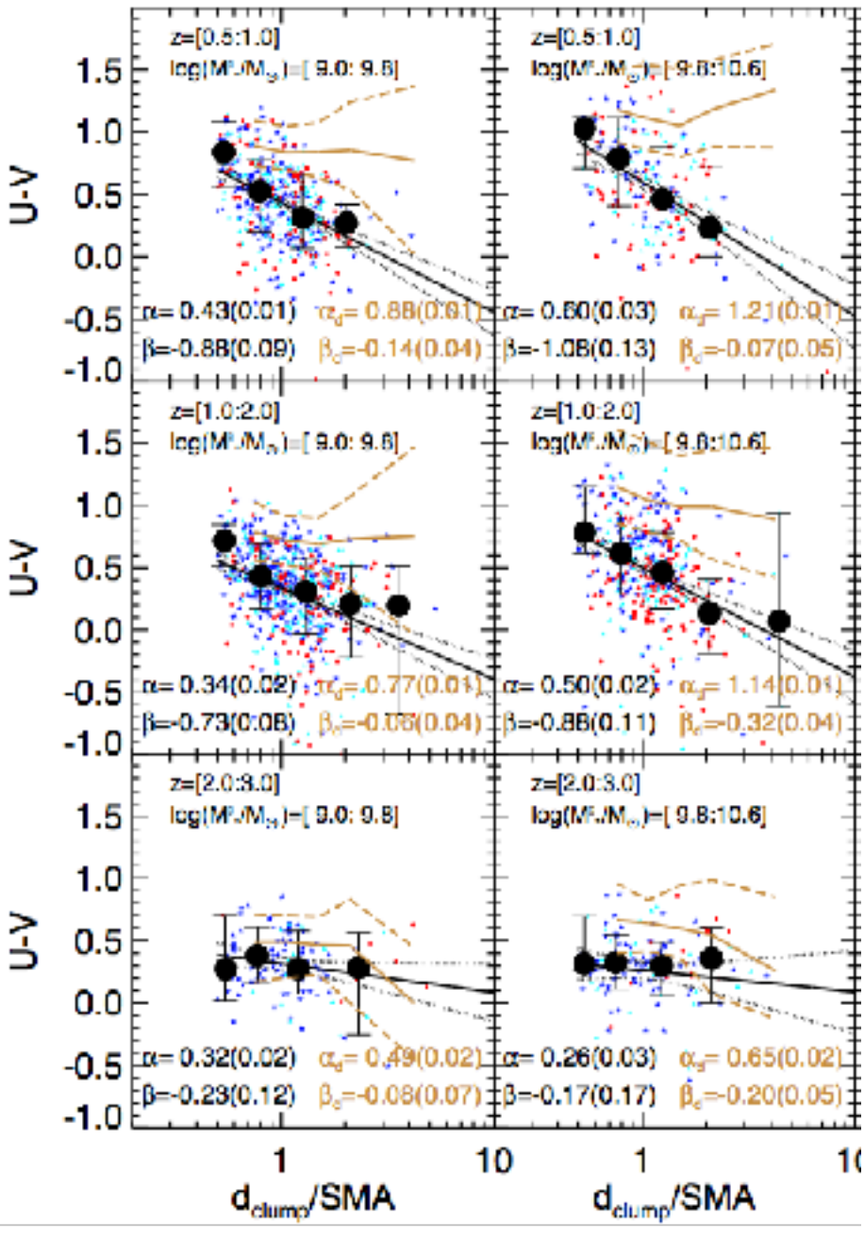
Giant star-forming clumps in distant galaxies are thought to be important to our understanding of galaxy formation and evolution. At present, however, observers and theorists have not reached a consensus on whether the observed "clumps" in distant galaxies are the same phenomenon that has been seen in simulations. In this paper, as a step towards the consensus, we publish a sample of clumps, which we think is representative of the observed "clumps" in the literature. The clumps are detected from rest-frame UV images, as described in our previous paper. Their physical properties, e.g., rest-frame color, stellar mass (M_*), star formation rate (SFR), age, and dust extinction, are measured by fitting the spatially resolved spectral energy distribution (SED) to synthetic stellar population models. We carefully test the procedures of measuring clump properties, especially the method of subtracting background fluxes from the diffuse component (or "disk") of galaxies. We show a few examples of the measured physical properties in this paper. With our fiducial background subtraction, we find a radial clump U-V color variation, where clumps close to galactic centers are redder than those in outskirts. The slope of the color gradient (clump color as a function of their galactocentric distance scaled by the semi-major axis of galaxies) changes with redshift and M_* of the host galaxies: at a fixed M_*, the slope becomes steeper toward low redshift; and at a fixed redshift, it becomes slightly steeper with M_*. Based on our SED-fitting, this observed color gradient can be explained by a combination of a negative age gradient, a negative E(B-V) gradient, and a positive specific star formation rate gradient of the clumps. We also find that the radial gradients of clump properties are different from those of "disk" properties.

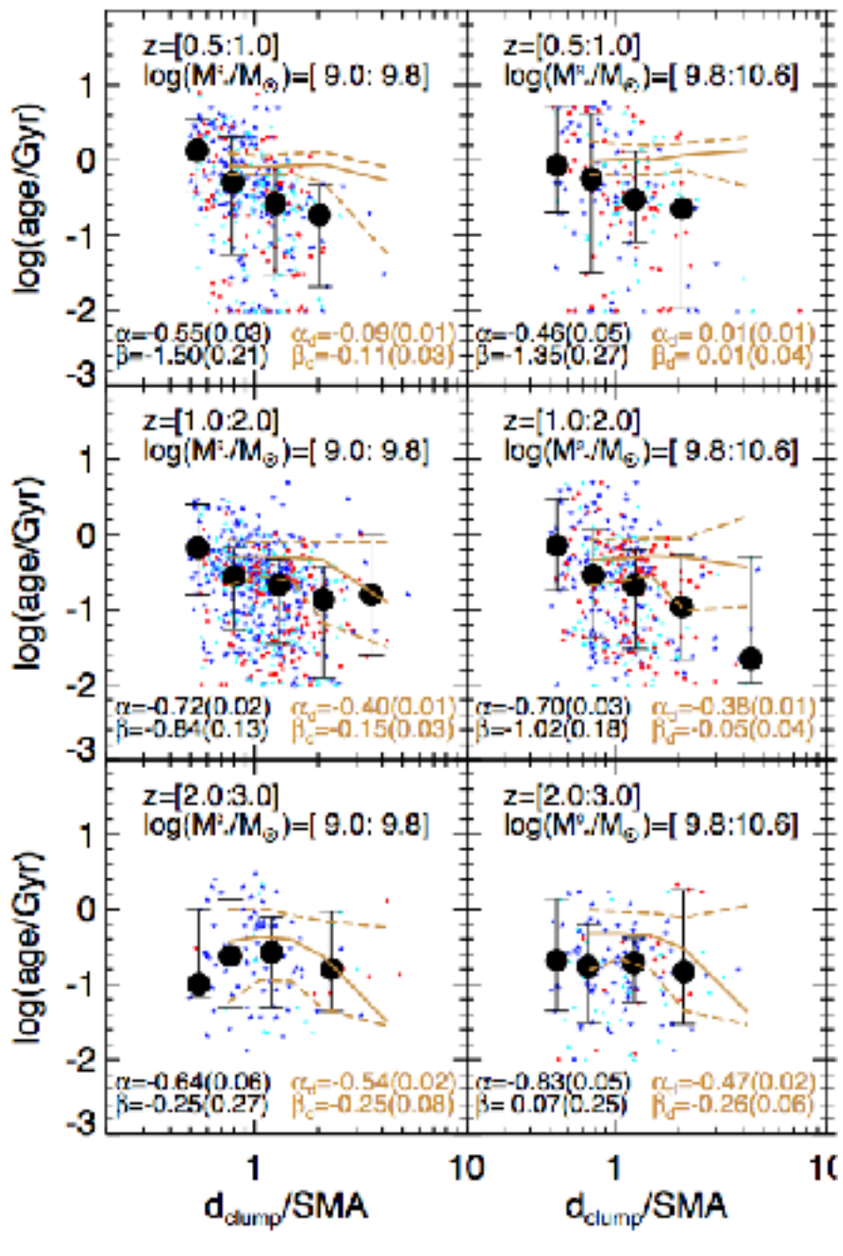
Yicheng says he will submit the paper to ApJ in one week (June 21).
In this updated version, I tried to incorporate your comments in a quick way. Some major updates are:
(1) We will release all background subtraction versions together. I also add a brief discussion on different arguments of subtracting vs. keeping the background.
(2) I add brief discussions on the age and SFR uncertainties from SED-fitting.
(3) I add brief discussions on the clump detection and visibility in NUV and H.
(4) I do a quick test of using fake clumpy galaxies to test different background subtraction.
(5) I add a figure to show the galaxy sample selection.
(6) In Sec. 5.4, when I say good agreement with other studies on disk E(B-V) gradients, I tone down the tune to say we are consistent with others rather than we completely break the age-dust degeneracy.
(7) In Table 1 and related text, I use arcsecond (rather than pixel) as the unit of apertures, because we measure the actual flux with an aperture (rather than within a number of pixels).

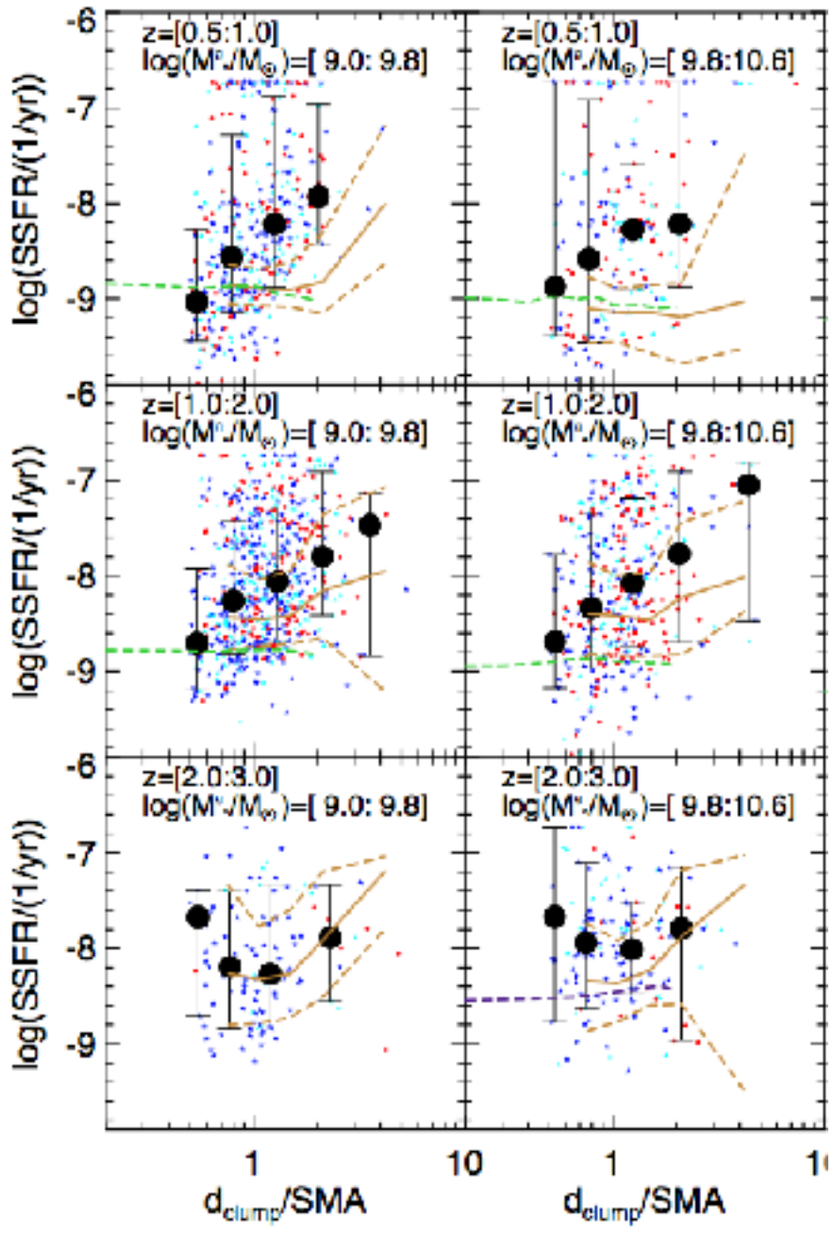
CLUMPY GALAXIES IN CANDELS. II. PHYSICAL PROPERTIES OF UV-BRIGHT CLUMPS AT $0.5 \leq Z < 3$

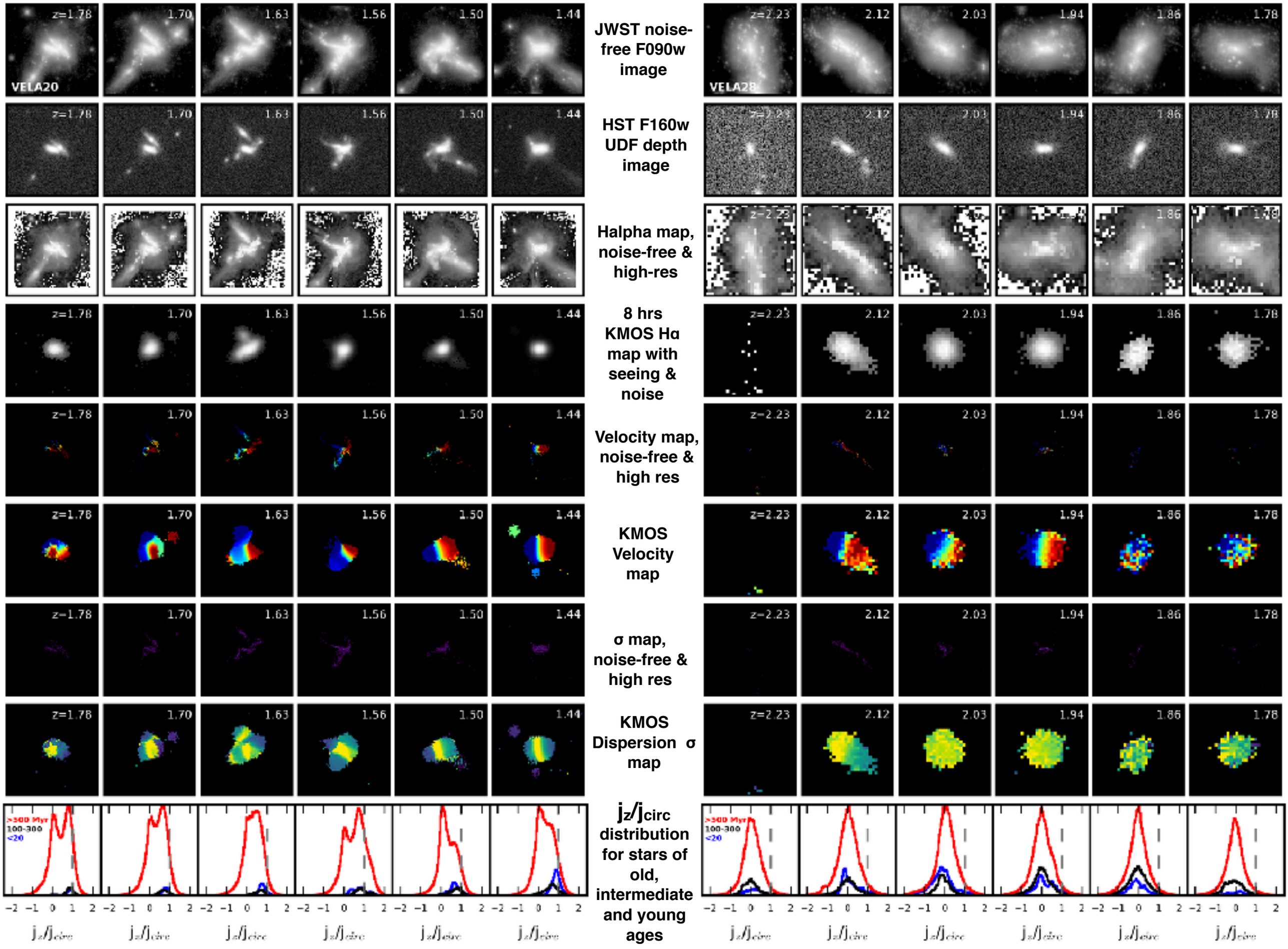
YICHENG GUO et al. June 2017 — sample figures

From the ABSTRACT: The slope of the color gradient (clump color as a function of their galactocentric distance scaled by the semi-major axis of galaxies) changes with redshift and M_* of the host galaxies: at a fixed M_*, the slope becomes steeper toward low redshift; and at a fixed redshift, it becomes slightly steeper with M_*. Based on our SED-fitting, this observed color gradient can be explained by a combination of a negative age gradient, a negative E(B-V) gradient, and a positive specific star formation rate gradient of the clumps. We also find that the radial gradients of clump properties are different from those of "disk" properties.





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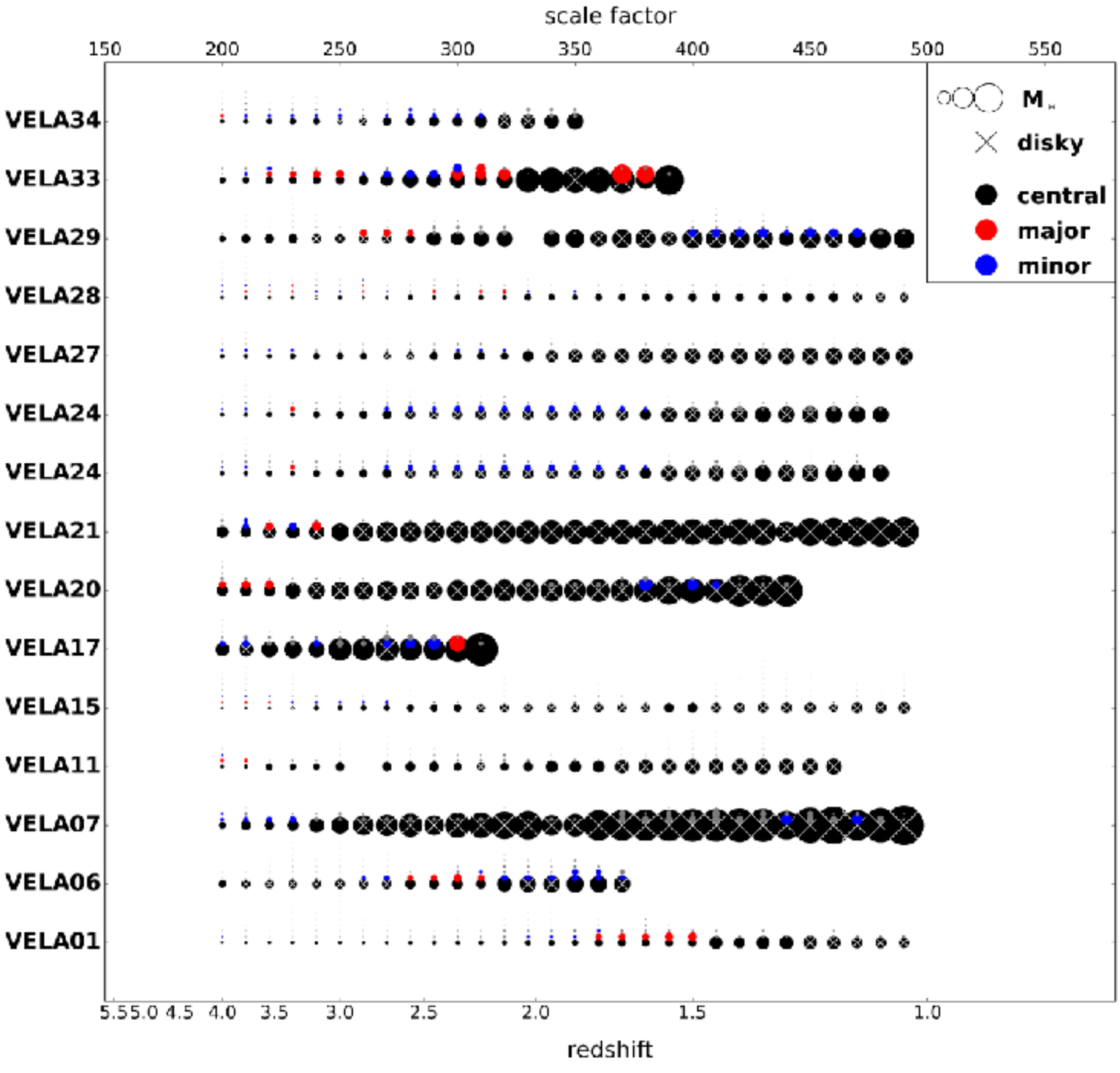
1.70
1.63
1.56
1.50
1.44
VELA20
z=2.23
2.12
2.03
1.94
1.86
1.78
VELA28
JWST noise-free F090w image
HST F160w UDF depth image
Halpha map, noise-free & high-res
8 hrs KMOS Hα map with seeing & noise
Velocity map, noise-free & high res
KMOS Velocity map
σ map, noise-free & high res
KMOS Dispersion σ map
>300 Myr
100-300
<20
jz/jcirc distribution for stars of old, intermediate and young ages


scale factor
150
200
250
300
350
400
450
500
550
VELA34
VELA33
VELA29
VELA28
VELA27
VELA24
VELA24
VELA21
VELA20
VELA17
VELA15
VELA11
VELA07
VELA06
VELA01
M*
disky
central
major
minor
5.5
5.0
4.5
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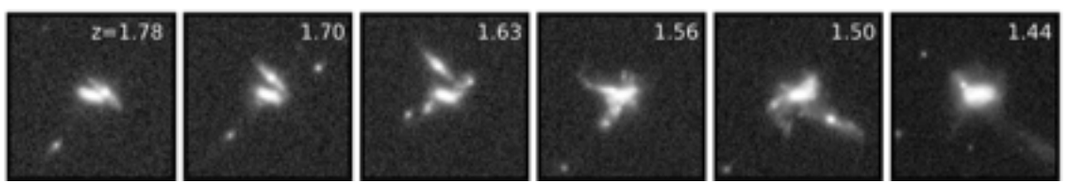
3.0
2.5
2.0
1.5
1.0
redshift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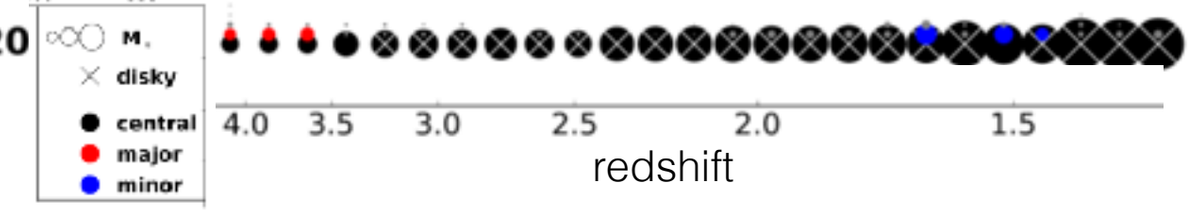
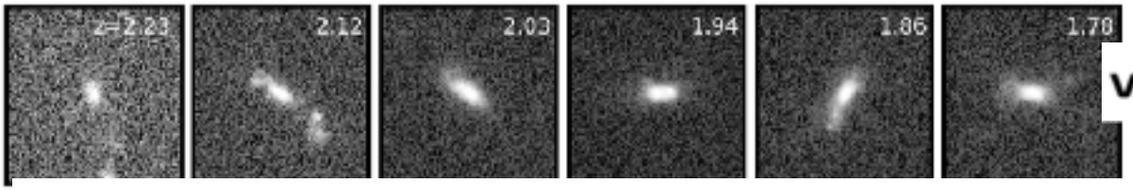
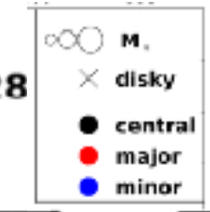
1.70
1.63
1.56
1.50
1.44

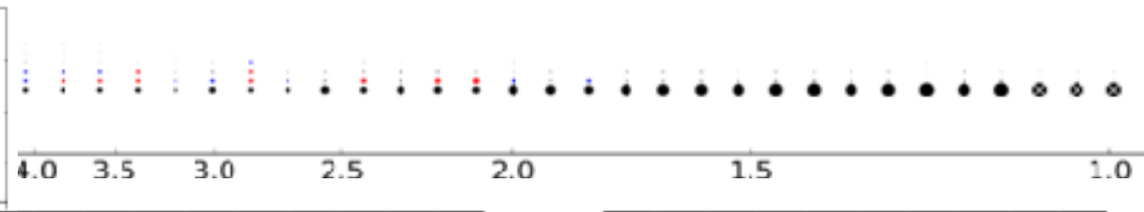

VELA20
M*
disky
central
major
minor
4.0
3.5
3.0
2.5
2.0
1.5
redshift

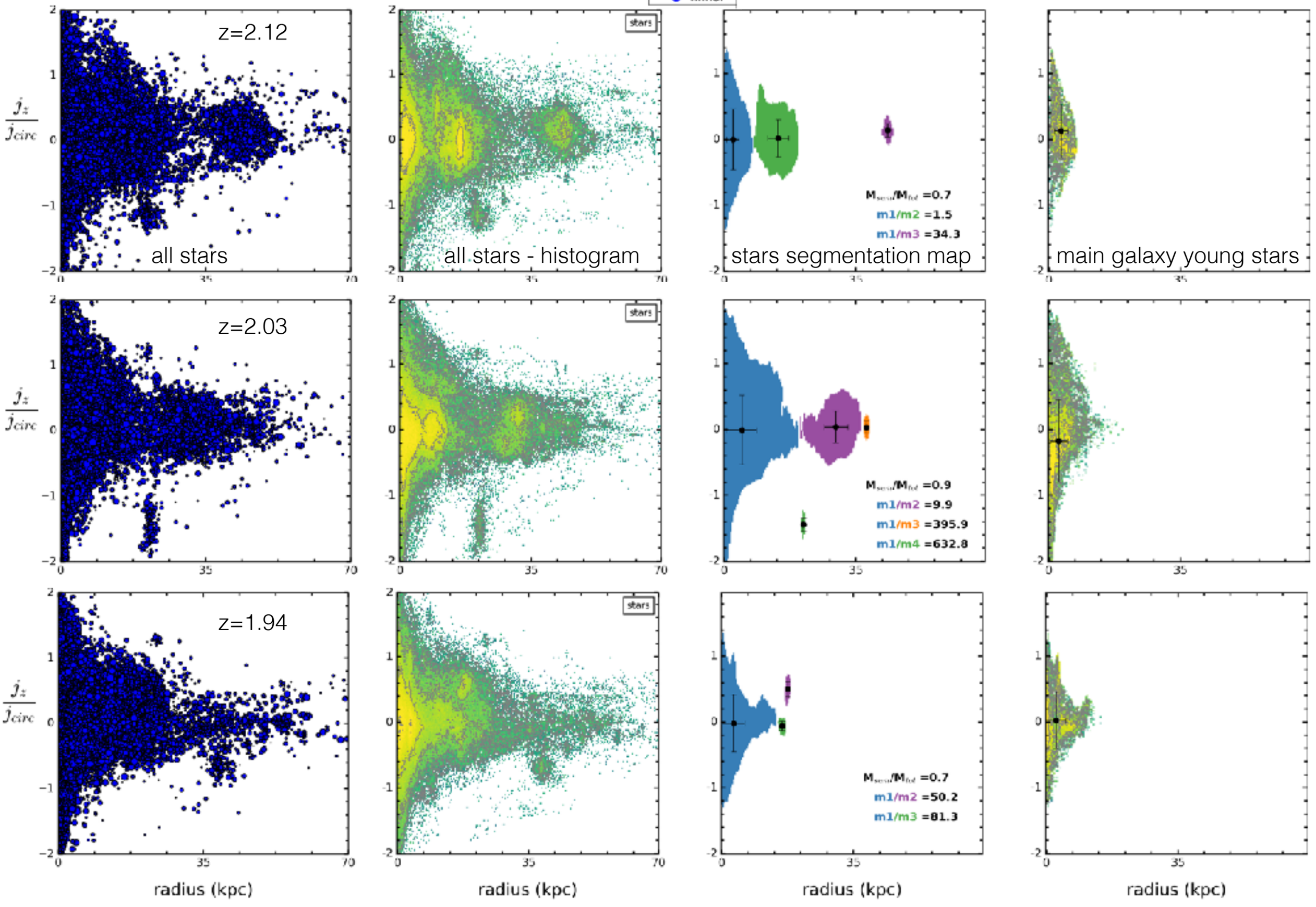
z=1.70
all stars
stars
all stars - histogram
stars segmentation map
M_seed/M_tot =0.9
m1/m2 =40.6
m1/m3 =56.5
main galaxy young stars
z=1.63
M_seed/M_tot =0.9
m1/m2 =3.5
m1/m3 =23.3
z=1.56
M_seed/M_tot =0.9
m1/m2 =68.7
m1/m3 =237.7
$\frac{j_z}{j_{circ}}$
radius (kpc)


z=2.23
2.12
2.03
1.94
1.86
1.78

VELA28


M*
disky
central
major
minor


4.0
3.5
3.0
2.5
2.0
1.5
1.0


z=2.12
all stars
all stars - histogram
stars segmentation map
main galaxy young stars
z=2.03
z=1.94
stars
M_{sec}/M_{tot} =0.7
m1/m2 =1.5
m1/m3 =34.3
M_{sec}/M_{tot} =0.9
m1/m2 =9.9
m1/m3 =395.9
m1/m4 =632.8
M_{sec}/M_{tot} =0.7
m1/m2 =50.2
m1/m3 =81.3
$\frac{j_z}{j_{circ}}$
radius (kpc)

young stars
(age < 20 Myr)

z = 1.5

10 kpc

z = 1.5

stars

10 kpc

Visit to **Google** on Tuesday May 30 — my talk is at https://www.youtube.com/watch?v=bpTs2eLS07I and the slides are at http://physics.ucsc.edu/~joel/GoogleTalk-Primack-30May2017.pdf

Talk at Google 30 May 2017

New Insights on Galaxy Formation from Comparing Simulations and Observations

Joel Primack

Distinguished Professor of Physics Emeritus, UCSC

Brief introduction to modern cosmology, based on ΛCDM: dark energy and dark matter

Cosmic large scale structure simulations and star formation in galaxies

Comparing high-resolution hydrodynamic galaxy simulations with observations

Astronomers used to think that galaxies form as disks, that forming galaxies are pretty smooth, and that galaxies generally grow in radius as they grow in mass — but Hubble Space Telescope data show that all these statements are false, and our simulations may explain why.

We are using these simulations and deep learning to improve understanding of galaxy formation, with support from Google.

Deep Learning for Vision talk by Jon Shlens from Google - slides are at
https://indico.cern.ch/event/619372/attachments/1451706/2238804/CERN-Deep-Learning-and-Vision.pdf

The Santa Cruz Machine Learning Cooperative!
Meetings take place every other Thursday at noon in Engineering 2 Room 215 with a focus three general aspects of machine learning:
- Platforms: Where are the GPU's and how do I get this Jupyter Notebook running on them?
- Theory: What's an RNN feeding a Convnet good for?
- Applications: How can I batch correct and classify this million cell expression dataset?

Goal is to develop a cooperative where those with interest and/or expertise in these areas can come together to jointly solve problems. Contact for questions: Sasha Sher

Deep Learning for Redshifts project: James Kakos and Dominic Pasquale plan to use DL for a project to improve z and local environment estimates for galaxies with only photometric redshifts. Fernando Caro and David Koo are also using DL for this. Fernando may report on this at Cosmoclub Monday June 19.

From David Koo - recent astrophs on photometric redshifts and machine or deep learning

arXiv:1706.02467 **Photometric redshift estimation via deep learning** Antonio D'Isanto, Kai Lars Polsterer

arXiv:1703.01979 Uncertain Photometric Redshifts with Deep Learning Methods Antonio D'Isanto

arXiv:1608.08016 Uncertain Photometric Redshifts Kai Lars Polsterer, Antonio D'Isanto, Fabian Gieseke

arXiv:1706.03501 Probability density estimation of photometric redshifts based on machine learning Stefano Cavuoti, Massimo Brescia, Valeria Amaro, Civita Vellucci, Giuseppe Longo, Crescenzo Tortora Comments: 2016 IEEE Symposium Series on Computational Intelligence

arXiv:1703.02292 METAPHOR: Probability density estimation for machine learning based photometric redshifts Valeria Amaro, Stefano Cavuoti, Massimo Brescia, Civita Vellucci, Crescenzo Tortora, Giuseppe Longo

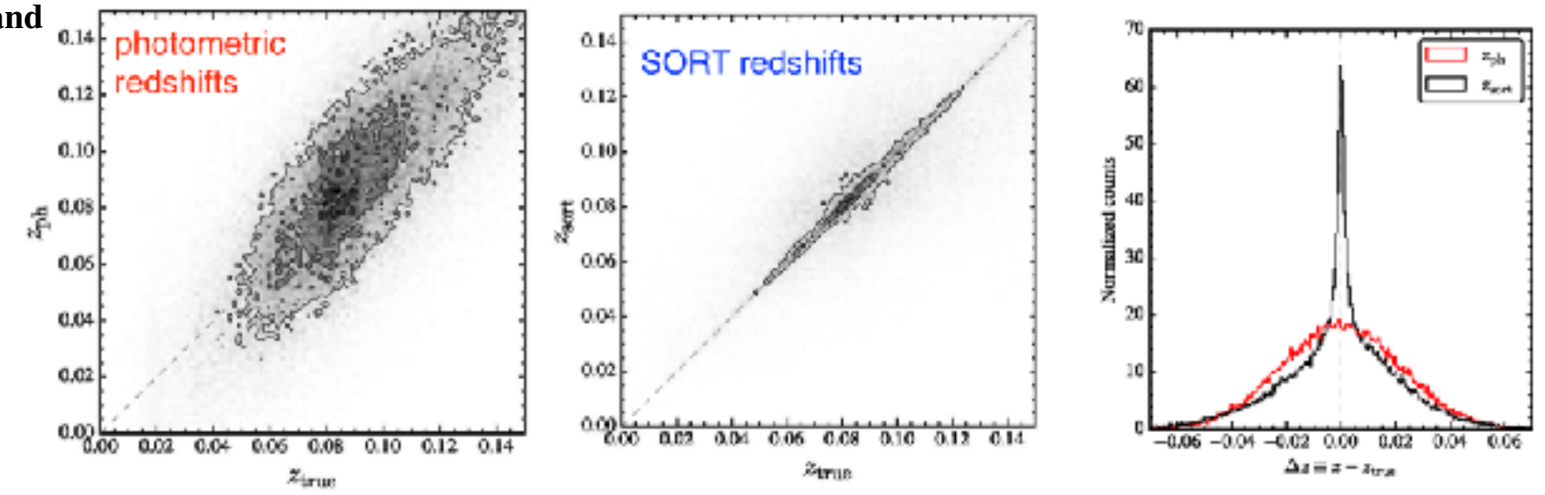
arXiv:1701.08120 Cooperative photometric redshift estimation Stefano Cavuoti, Crescenzo Tortora, Massimo Brescia, Giuseppe Longo, Mario Radovich, Nicola R. Napolitano, Valeria Amaro, Civita Vellucci

arXiv:1612.02173 A cooperative approach among methods for photometric redshifts estimation: an application to KiDS data Stefano Cavuoti, Crescenzo Tortora, Massimo Brescia, Giuseppe Longo, Mario Radovich, Nicola R. Napolitano, Valeria Amaro, Civita Vellucci, Francesco La Barbera, Fedor Getman, Aniello Grado Accepted by MNRAS

Deep Learning for Redshifts project: Fernando Caro, James Kakos, and Dominic Pasquale may use DL for a project to improve distance and local environment estimates for galaxies with only photometric redshifts. This is related to the following work:

Stochastic Order Redshift Technique (SORT): a simple, efficient and robust method to improve cosmological redshift measurements

Nicolas Tejos, Aldo Rodríguez-Puebla and Joel R. Primack, submitted to MNRAS



Circumgalactic medium (CGM): VELA **mock quasar absorption spectra** compared with observations - Clayton Strawn. Hassen Yesuf is working with X Prochaska to look at evidence for **outflows** in galaxies at z ~ 0.5 and compare with our ART simulations. Hassen is being hooded by David Koo today at the PhD graduation.