DEEP-Theory Meeting 28 April 2017

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

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Halo properties like concentration, accretion history, and spin are mainly determined by environmental density rather than by location within the cosmic web — Tze Goh, Christoph Lee, Peter Behroozi, Doug Hellinger, Miguel Aragon Calvo, Elliot Eckholm

DM halo mass loss and **halo radial profile** papers being drafted — Christoph Lee, Doug Hellinger

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

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

YICHENG GUO, ET AL.

Draft version March 30, 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, observes and theorists have not reached a consensus on whether the observed "clumps" are the same phenomenon that has been seen in simulations. In this paper, as a step aiming at the consensus, we present a sample of clumps, which, to the best of our knowledge, represents the terminology of clumps in the literature. The clumps are detected from rest-frame UV images, as described in our previous paper. The physical properties of the clumps, e.g., rest-frame color, stellar mass (M_*), star formation rate (SFR), age, and dust extinction, are measured through 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, which we think may be of interest to most readers. We find a radial clump U-V color variation: 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 steeper with M_*. Based 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 clumps.

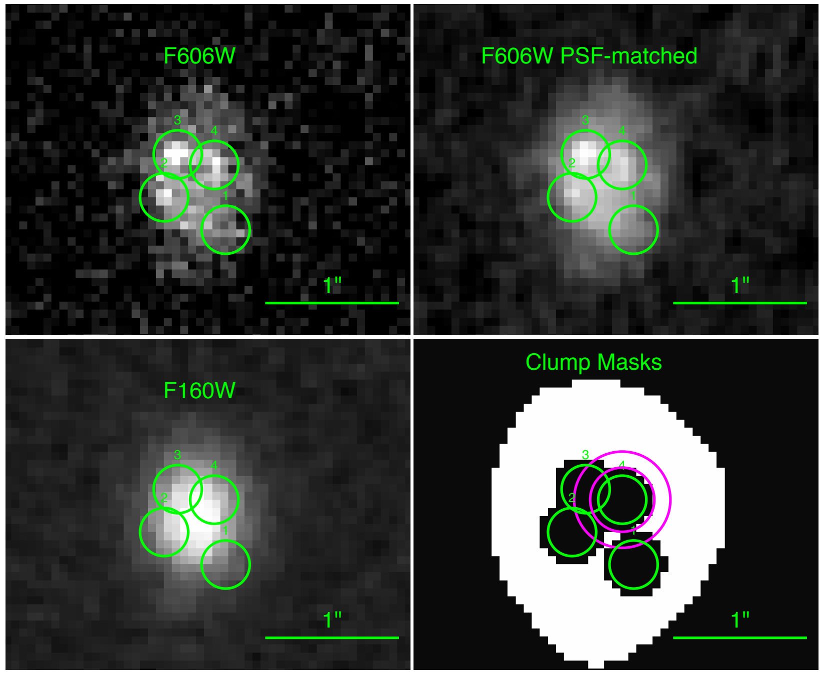
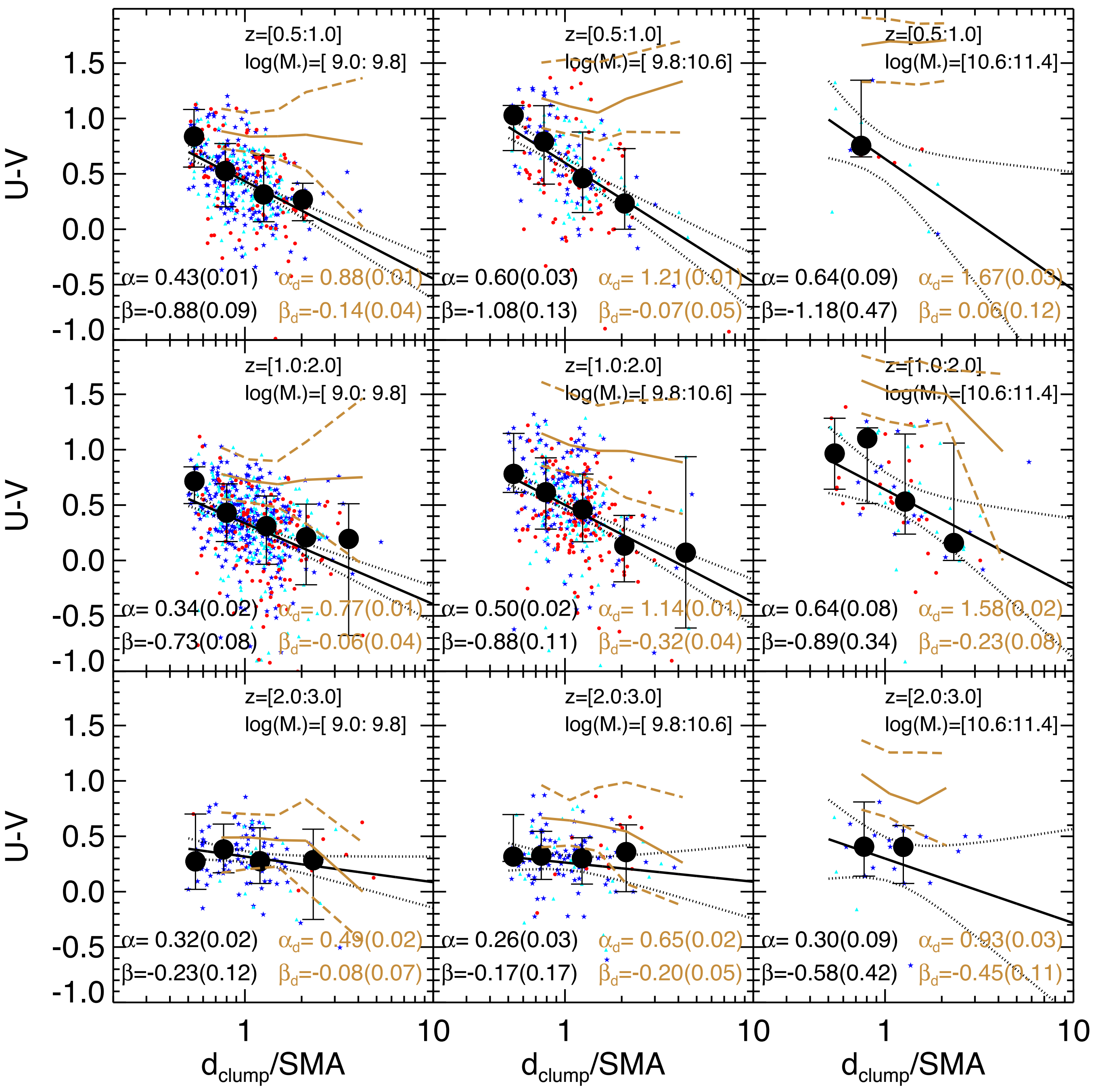
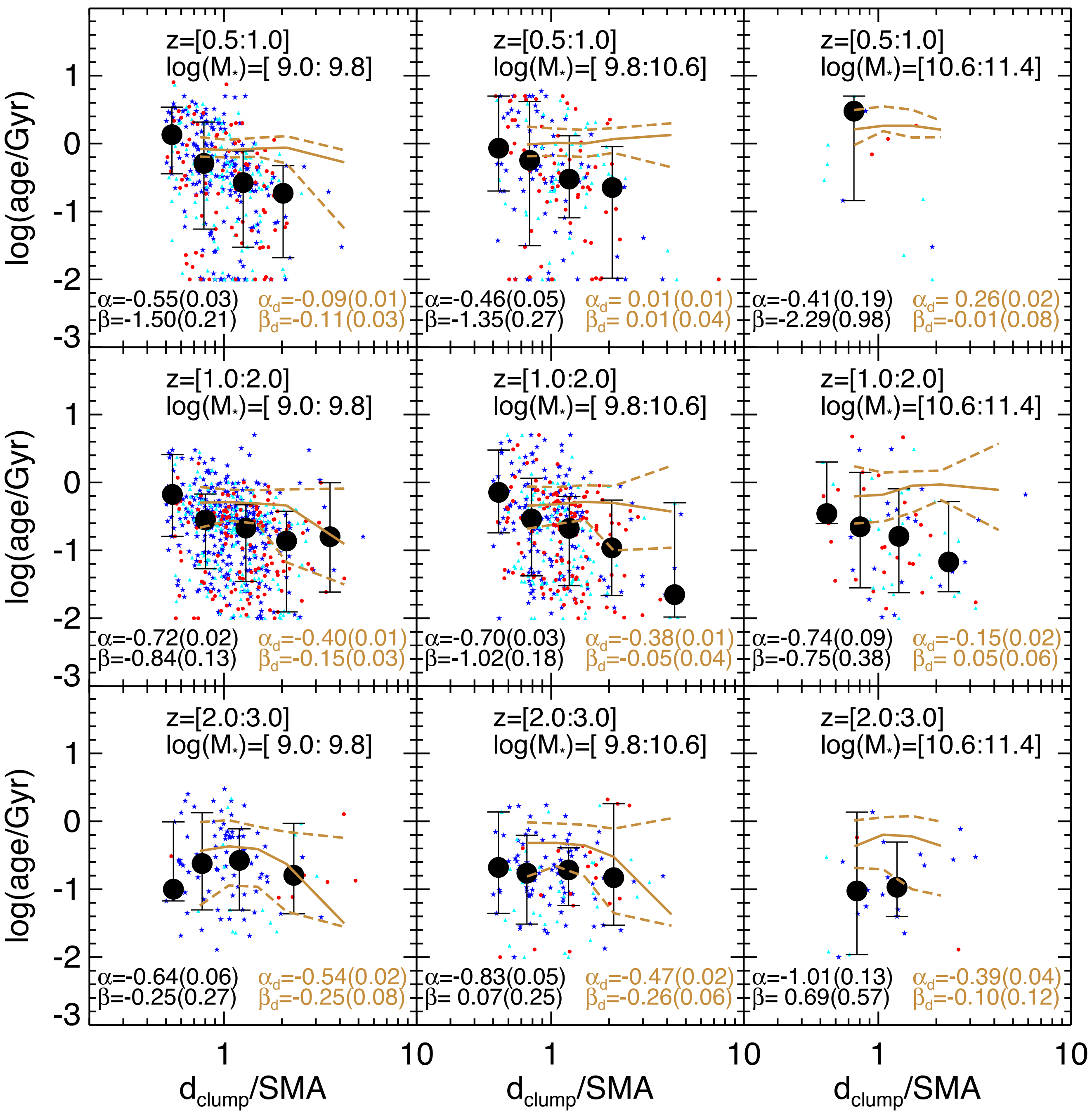


FIG. 1.— Illustration of "disk" light subtraction. A galaxy (Galaxy ID = 25508 in the catalog) is shown in ACS F606W (top left), smoothed ACS F606W to match the resolution of WFC3 F160W (top right), WFC3 F160W (bottom left), and a mask image (bottom right). Four clumps are detected in this galaxy as shown by the green circles with radius of 3 pixels in each panel. In the mask image (bottom right), the area within 4 pixels of the center of each clump is masked out (i.e., black pixels in the panel). These pixels are not used in calculating the "disk" background. The pixels outside the galaxy are also masked out, because they are out of the SExtractor segmentation map of the galaxy. For one clump (Clump ID = 4 in the catalog), we show the annulus used as our fiducial method (aperi_v3 in Table 1) to measure the "disk" surface brightness. The annulus (between two purple circles) has the inner and outer radii of 4 and 6 pixels. Only the white pixels (i.e., those not masked out due to clump locations) between the two purple circles are used to calculate the "disk" surface brightness.

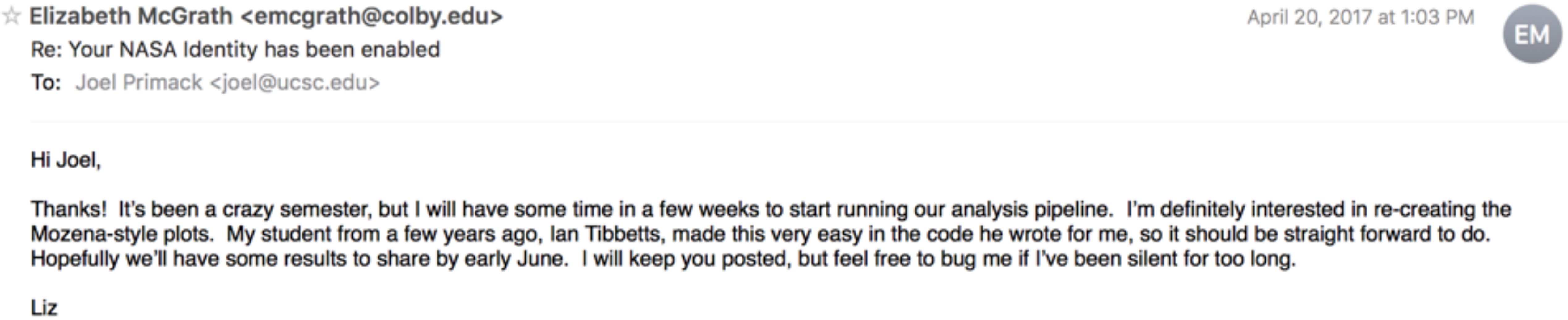
GALFIT and clump analysis of VELA simulations and comparison with observations — VivianTang, Yicheng Guo, David Koo — new paper by Yicheng Guo on clump properties with disk subtraction





An important observation is that the clump gradients are steeper than those of the underlying "disk" at $z < 2$, so the clump gradients cannot be attributed to the "disk"

Yicheng's next clump paper will analyze the mock galaxy images from the VELA gen3 simulations



☆ **Elizabeth McGrath <emcgrath@colby.edu>** April 20, 2017 at 1:03 PM

Re: Your NASA Identity has been enabled

To: Joel Primack <joel@ucsc.edu>

Hi Joel,

Thanks! It's been a crazy semester, but I will have some time in a few weeks to start running our analysis pipeline. I'm definitely interested in re-creating the Mozena-style plots. My student from a few years ago, Ian Tibbetts, made this very easy in the code he wrote for me, so it should be straight forward to do. Hopefully we'll have some results to share by early June. I will keep you posted, but feel free to bug me if I've been silent for too long.

Liz

Elizabeth J. McGrath
Clare Boothe Luce Assistant Professor
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Examples of plots from Mozena's dissertation

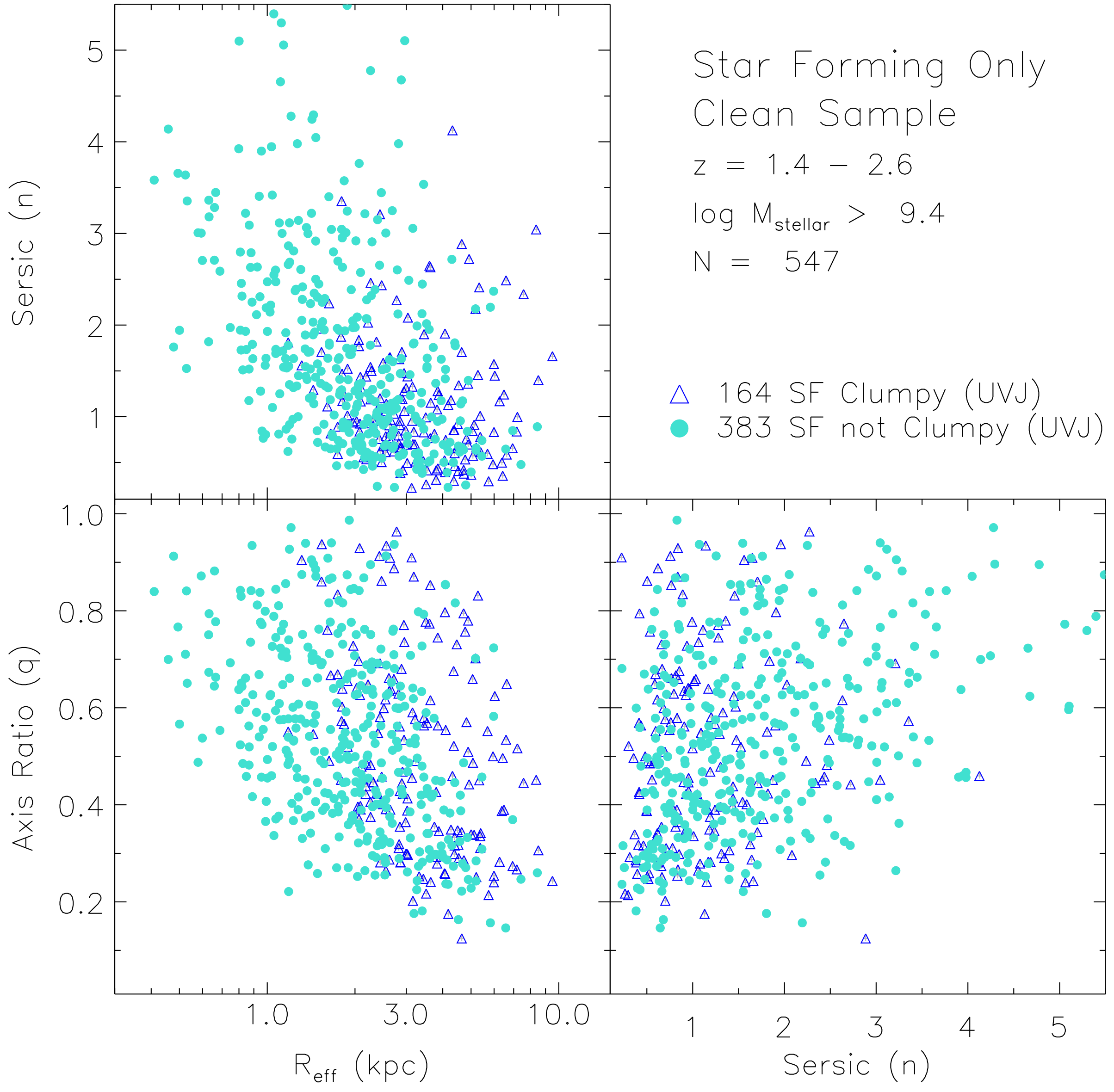


Figure 2.11: Clumpy Star-Forming GOODS-South Galaxies. 30% of z∼2 star-forming galaxies are clumpy. These clumpy systems tend to have larger R_{eff} and lower Sérsic indices.

Deep Learning for Galaxies project: Analysis of VELA Gen3 simulations is ongoing by 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. Elliot Eckholm will help visualize the VELA simulations with yt in 3DVizlab.

Hi Joel, **Tomer Nussbaum** **March 28, 2017**

Due to severe problems in our cluster, The detailed catalog, did not yet finish it's run.
So meanwhile I'm sending you our basic catalogs, that can be found here.
https://drive.google.com/drive/folders/0B_hm4xnI_rqTaWtrQjNyc0ZHUFU?usp=sharing
The folder includes:

- sim_table.pkl	- Simulation details
- cen_gal_cat.pkl	- Central galaxies details and quantities
- sat_gal_table.pkl	- Satellite galaxies details and quantities
- tgal_tmp_thick_table.pkl	- Thick galaxies follow up through time
- cat_use_examples-Primack.ipynb	- usage explanations and examples for the right usage

I'm also adding part of detailed satellite catalog (which is still running) so you could see what we are aiming to.
gal_R_attribute_cat.pkl - corrected radiuses for the satellites (instead of the ZAnaPack radii) with many quantities.

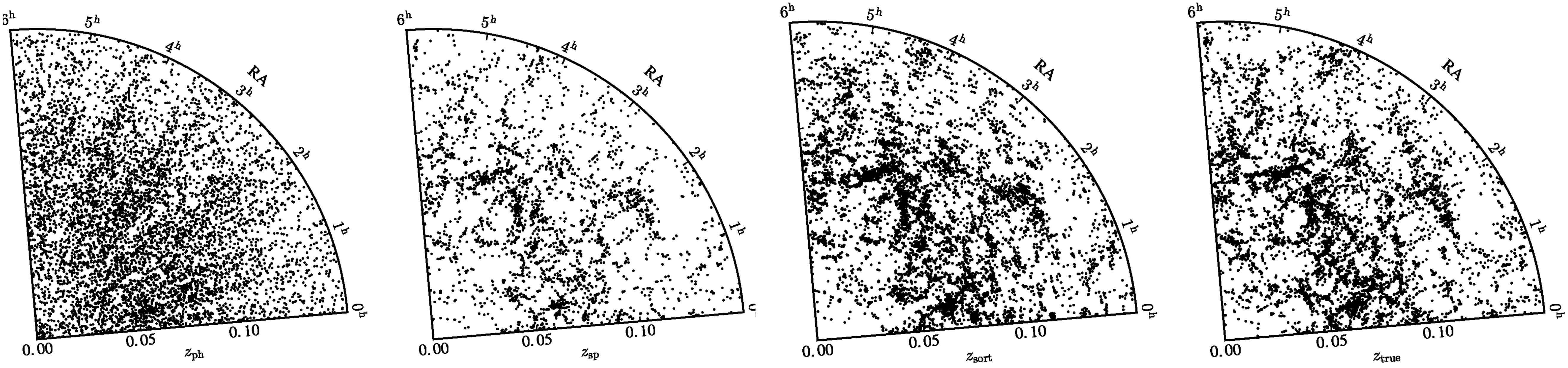
ZAnaPack by Dylan Tweed

This is an analysis pipeline for Zoom-in cosmological simulations, run with ART-I (Hydro ART, or HART. It is based of the detection of the main galaxy (the target of the zoom-in simulation), and the tracing of all its progenitors at all snapshot. This pipeline is especially useful to find and trace the main galaxy across snapshot in a large cosmological volume. The detection of the galaxy is done through a group-finder AdaptaHOP in HaloMaker [Aubert et al., 2004], [Tweed et al., 2009]. The tracing is done using the stellar particle, by using a tree-builder algorithm TreeMaker.

We need to track and characterize the entire satellite population in the VELA gen3 simulations. We want to find all mergers and also pass-by events. Separately, we also need to find counter-rotating gas inflows

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

Example of improving photo-z's using spec-z's from Tejos, Rodriguez-Puebla, Primack preprint



But this and other methods are certainly not optimal. Can Deep Learning do better?

MNRAS **467,** 3576–3589 (2017) RECENT RELEVANT PAPER

THE-WIZZ: clustering redshift estimation for everyone

C. B. Morrison,[1,2]⋆ H. Hildebrandt,[1] S. J. Schmidt,[3] I. K. Baldry,[4] M. Bilicki,[5]

We present THE-WIZZ, an open source and user-friendly software for estimating the redshift distributions of photometric galaxies with unknown redshifts by spatially cross-correlating them against a reference sample with known redshifts. The main benefit of THE-WIZZ is in separating the angular pair finding and correlation estimation from the computation of the output clustering redshifts allowing anyone to create a clustering redshift for their sample without the intervention of an 'expert'. It allows the end user of a given survey to select any subsample of photometric galaxies with unknown redshifts, match this sample's catalogue indices into a value-added data file and produce a clustering redshift estimation for this sample in a fraction of the time it would take to run all the angular correlations needed to produce a clustering redshift. We show results with this software using photometric data from the Kilo-Degree Survey (KiDS) and spectroscopic redshifts from the Galaxy and Mass Assembly survey and the Sloan Digital Sky Survey. The results we present for KiDS are consistent with the redshift distributions used in a recent cosmic shear analysis from the survey. We also present results using a hybrid machine learning–clustering redshift analysis that enables the estimation of clustering redshifts for individual galaxies. THE-WIZZ can be downloaded at http://github.com/morriscb/The-wiZZ/.

Galaxy R_{eff} predicted by (spin parameter)(halo radius) = λR_{halo} paper led by Rachel Somerville — after correcting h^{-1} error, the offset between $R_{3D}/(\lambda R_{halo})$ at $z \sim 0$ and higher z has disappeared

How to measure r_*,3D for disks and spheroids

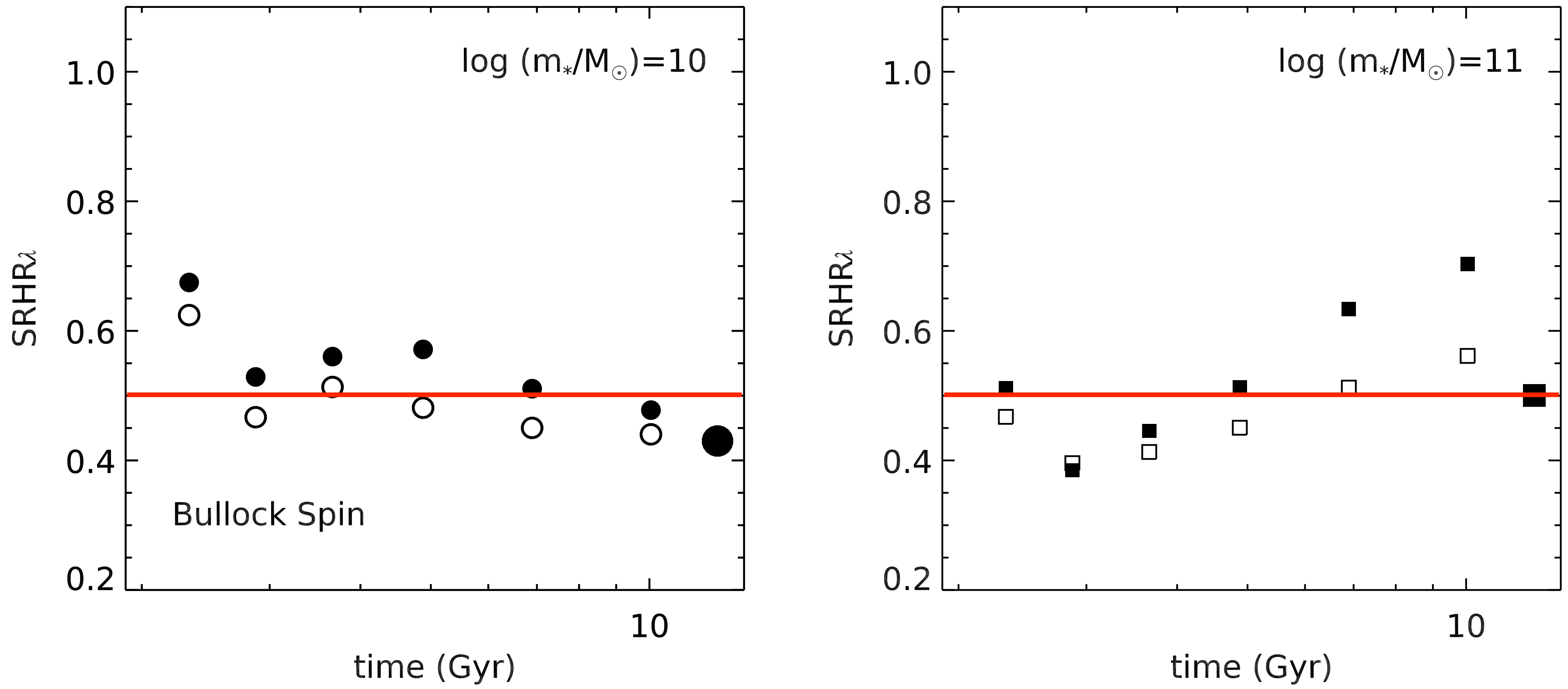
The galaxy data used in the new Somerville+2017 paper to measure r_*,3D came from GAMA Data Release 2, which gave 13,771 galaxies after cuts eliminating Sersic indexes n < 0.3 and n > 10 and eliminating galaxies with sizes r_e < 0.7 arc seconds, according to Section 3.1. Section 3.3 says that the conversion to r_*,3D from r_e,obs = the observed projected effective radius of the light in the same rest-frame waveband is given by

r_e,obs = f_p f_k r_*,3D

where f_p corrects for projection and and f_k is the structural k-correction. The paper quotes f_p = 1 for an edge-on disk, f_p = 0.68 for n = 4, and f_p = 0.61 for n = 1. It summarizes the literature as saying f_k ~ 1.12 to 1.5. The paper says it adopts (f_pf_k)_disk = (1x1.2) = 1.2 and (f_pf_k)_spheroid = (0.68 x 1.15) = 0.78 for spheroids.
Thus

r_*,3D = 0.83 r_e,obs for disks
= 1.3 r_e,obs for spheroids

Galaxy R_{eff} predicted by (spin parameter)(halo radius) = λR_{halo} paper led by Rachel Somerville — after correcting h^{-1} error, the offset between SRHRλ ≡ $R_{3D}/(\lambda R_{halo})$ at $z \sim 0$ and higher z has disappeared



filled symbols - ratio of medians

empty symbols - ratio of means

$R_{3D} \approx 0.5\ \lambda R_{halo}$ at all redshifts
$0 < z < 3$, where $\lambda_{Bullock} \approx 0.035$

Corrected Plot (on left) for z~0.1 from Rachel Somerville for paper on galaxy size-mass

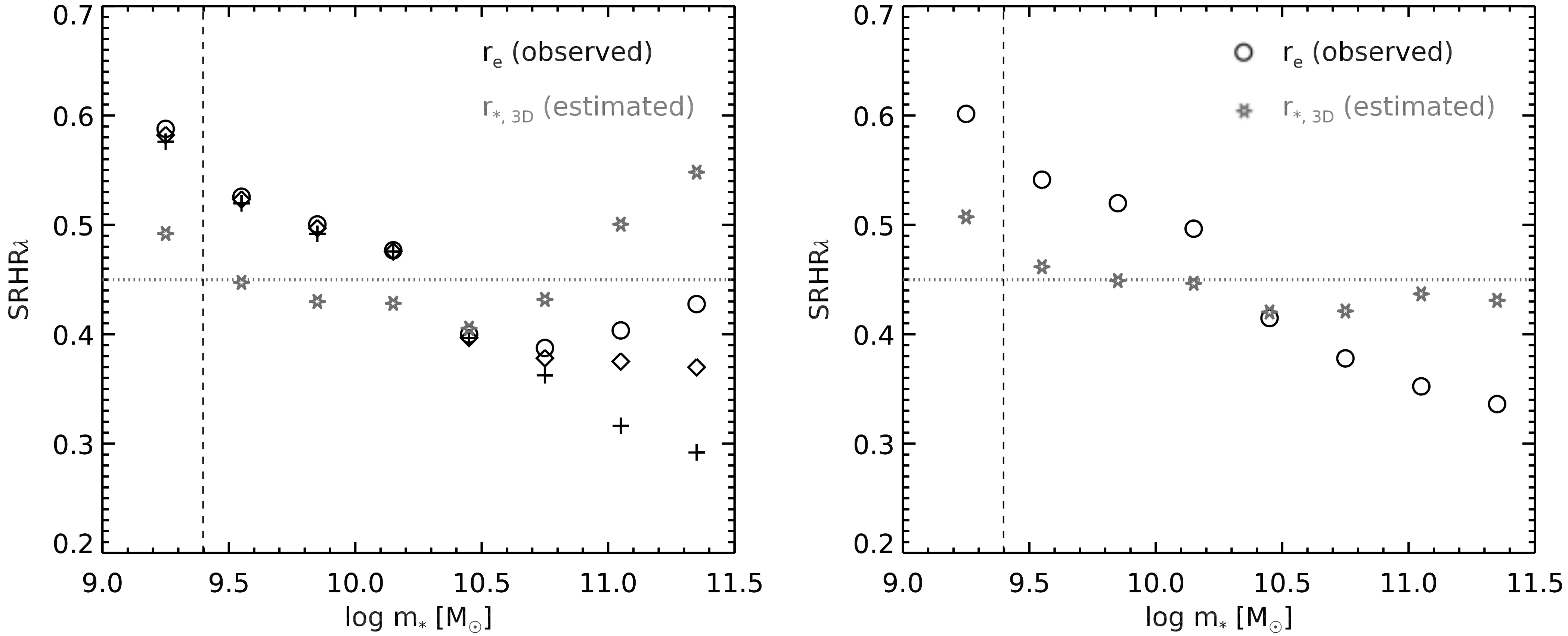


Figure 2. Median galaxy radius divided by the median value of the spin parameter times the halo virial radius, in bins of stellar mass, at $z \sim 0.1$. **Left panel: New results using B17 SMHM relation.** Open circles are based on the GAMA DR2 catalogs and are for the observed (projected) r-band half-light radius r_e. The dashed vertical line shows the 97.7% stellar mass completeness limit for the GAMA sample. Gray star symbols show the same quantity for the estimated 3D half-stellar mass radius ($r_{*,3\mathrm{D}}$). Crosses show the observed (projected) SRHRλ where no scatter is included in the SMHM relation, and diamonds show results with a reduced intrinsic scatter of $\sigma_{\mathrm{int}} = 0.16$ dex instead of the fiducial value of 0.22 dex. **Right panel: plot from submitted paper, which used B13 with an intrinsic scatter of 0.15 dex and did not include scatter from stellar mass errors.**

The right figure was Fig 5 in the submitted version — here's the caption

Figure 5. Median radius divided by the median value of the spin parameter times the halo virial radius, in bins of stellar mass, at $z \sim 0.1$. Open circles are based on the GAMA DR2 catalogs and are for the observed (projected) r-band half-light radius r_e. **The dashed vertical line shows the 97.7% stellar mass completeness limit for the GAMA sample.** Gray star symbols show the same quantity for the estimated 3D half-stellar mass radius ($r_{*,3\mathrm{D}}$). It is striking that the ratio between galaxy size and halo size remains so nearly constant over a wide range in stellar mass.

Galaxy size vs. local density project — Christoph Lee, Graham Vanbenthuysen, Viraj Pandya, Doug Hellinger, Aldo Rodriguez-Puebla, David Koo — Huertas-Company+13 found no difference vs. density, and Cebrian & Trujillo2017 find, if anything, galaxies in low-density regions are larger. We are measuring λ vs. density by various methods in Aldo's mock catalogs from Bolshoi-Planck and MultiDark-Planck.

The effect of the environment on the stellar mass–size relationship for present-day galaxies

Marıa Cebrian and Ignacio Trujillo   MNRAS 2014

For every galaxy in our sample, we explore the surrounding density within 2 Mpc using two distinct estimators of the environment. We find that galaxies are slightly larger in the field than in high-density regions. This effect is more pronounced for late-type morphologies (~7.5 per cent larger) and especially at low masses ($M_* < 2 \times 10^{10}$ M$_\odot$), although it is also measurable in early-type galaxies (~3.5 per cent larger).

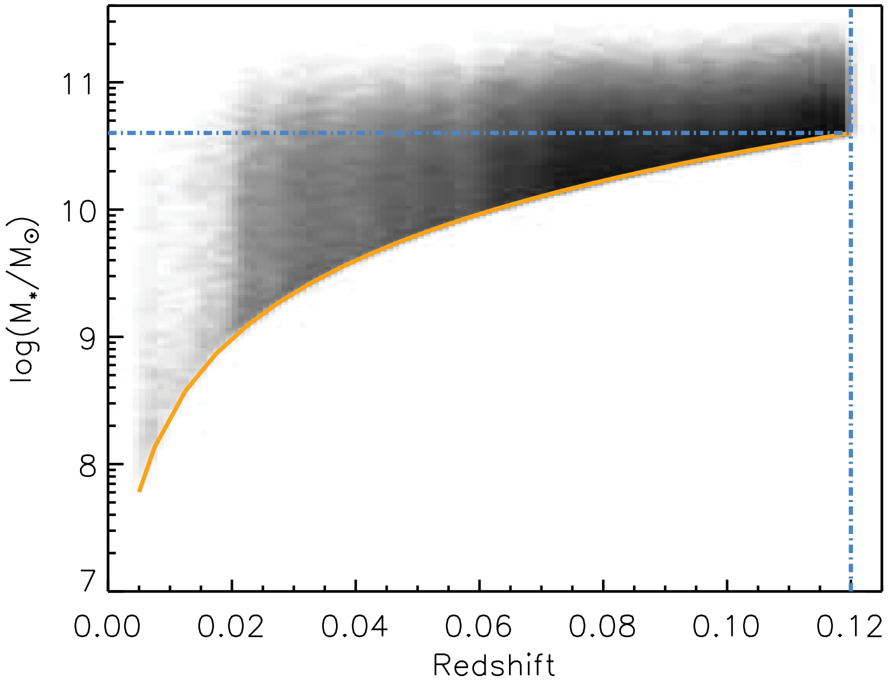


Figure 4. The redshift–mass plane of the stellar mass-complete galaxies in the NYU-VAGC. The solid orange line shows the mass-completeness line of the sample. The vertical and horizontal blue lines indicate the redshift and the mass limit used to explore the density of various environments. In order to lighten the plot, the density of objects is represented as a shaded surface instead of using individual points.

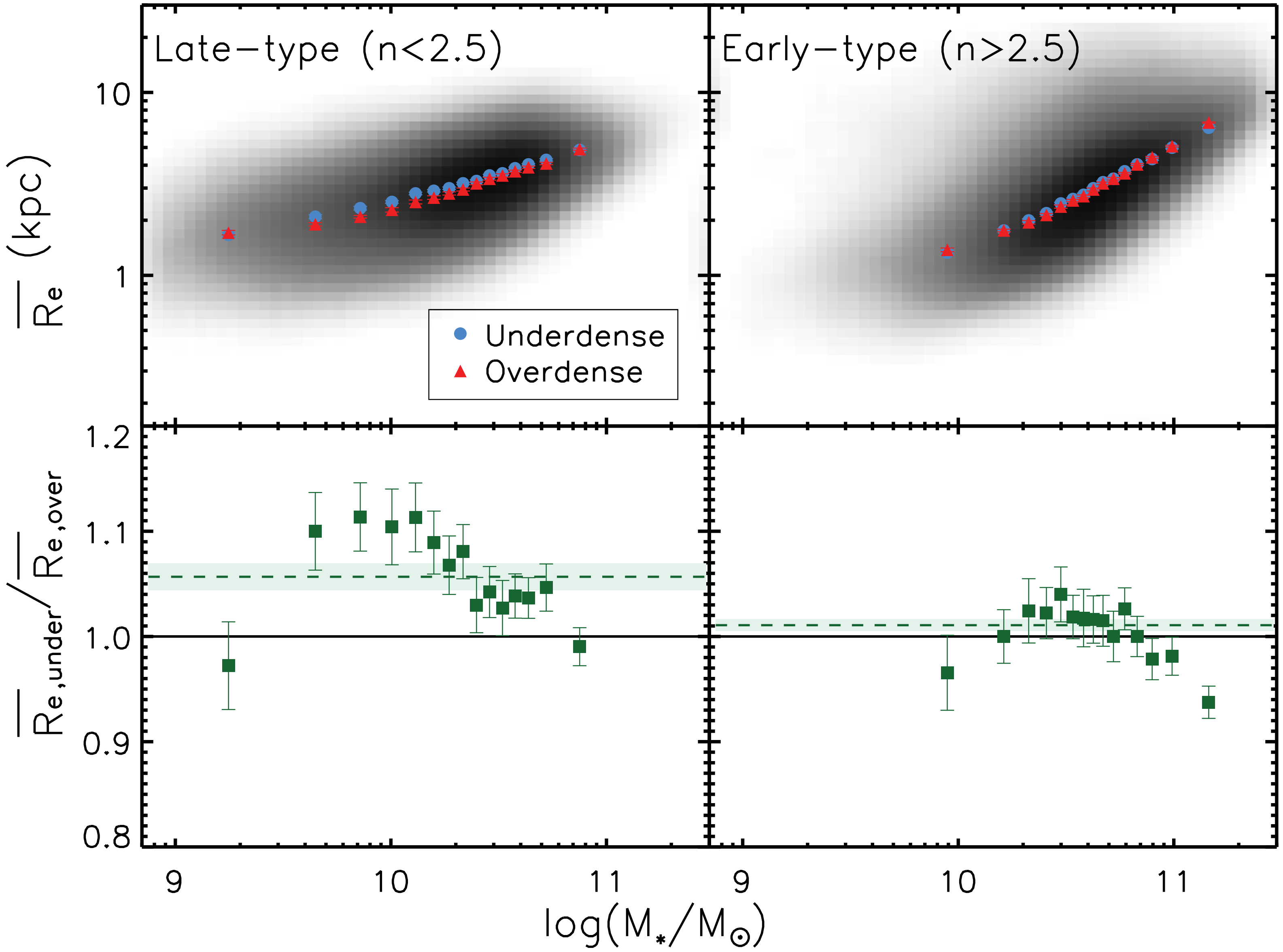
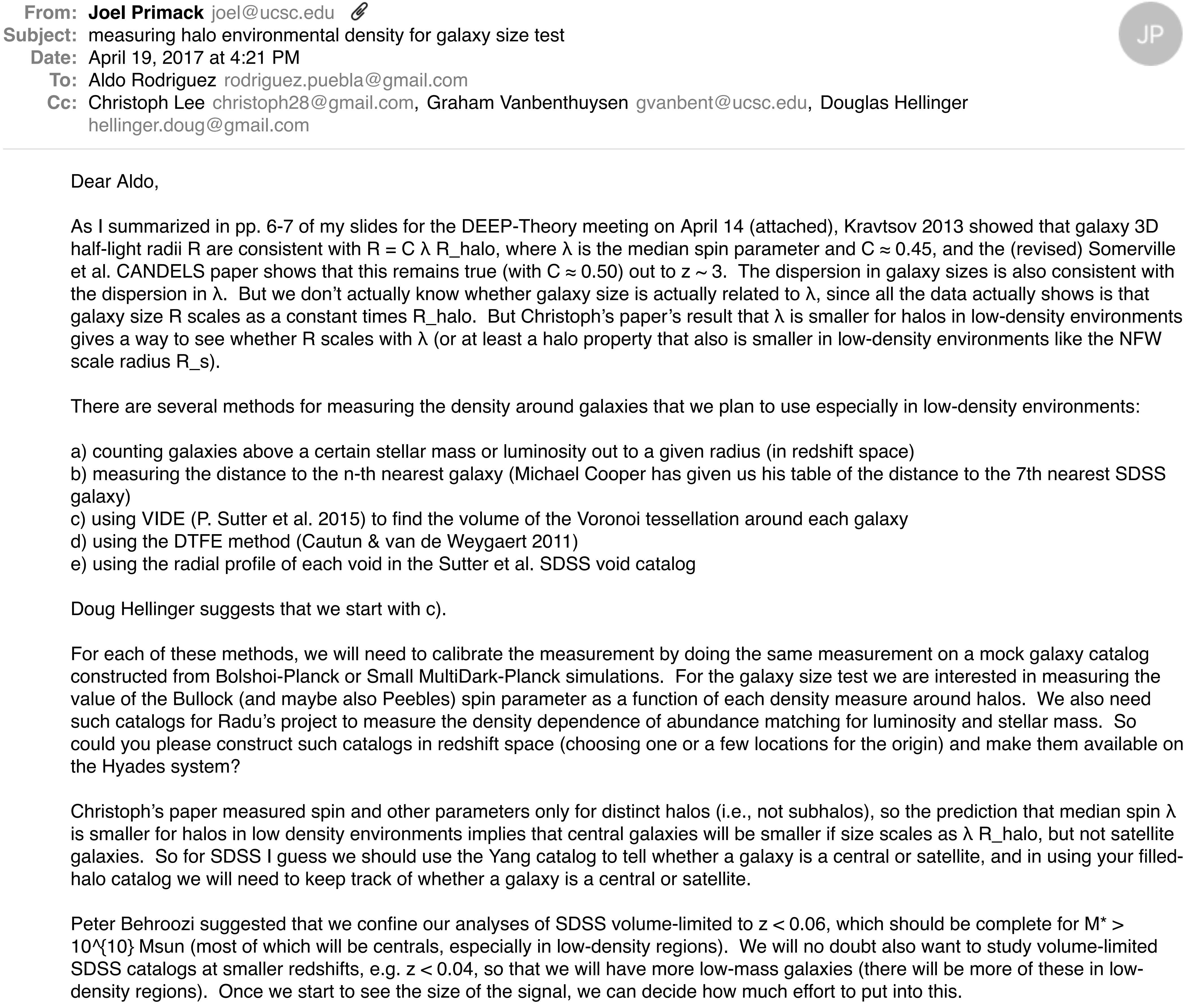


Figure 6. The stellar mass–size relationships and their differences for different environments and morphologies. Upper panels show the overall distributions for discy and spheroid-like objects as a shaded surface. Over-plotted on these distributions are the mean size of the galaxies in the 10 per cent lowest-density (blue filled circles) and the 10 per cent highest-density (red filled triangles) regions. Lower panels show the ratio between the mean sizes in the most underdense and overdense samples (error bars represent 1σ errors). The green dashed line is a fit to all the distribution of points and indicates the robust mean,[1] with the 1σ error represented as the green shaded area.

Galaxy size vs. local density project — Christoph Lee, Graham Vanbenthuysen, Viraj Pandya, Doug Hellinger, Aldo Rodriguez-Puebla, David Koo — Huertas-Company+13 found no difference vs. density, and Cebrian & Trujillo2017 find, if anything, galaxies in low-density regions are larger. We are measuring λ vs. density by various methods in Aldo's mock catalogs from Bolshoi-Planck and MultiDark-Planck.



From: **Joel Primack** joel@ucsc.edu
Subject: measuring halo environmental density for galaxy size test
Date: April 19, 2017 at 4:21 PM
To: Aldo Rodriguez rodriguez.puebla@gmail.com
Cc: Christoph Lee christoph28@gmail.com, Graham Vanbenthuysen gvanbent@ucsc.edu, Douglas Hellinger hellinger.doug@gmail.com

Dear Aldo,

As I summarized in pp. 6-7 of my slides for the DEEP-Theory meeting on April 14 (attached), Kravtsov 2013 showed that galaxy 3D half-light radii R are consistent with R = C λ R_halo, where λ is the median spin parameter and C ≈ 0.45, and the (revised) Somerville et al. CANDELS paper shows that this remains true (with C ≈ 0.50) out to z ~ 3. The dispersion in galaxy sizes is also consistent with the dispersion in λ. But we don't actually know whether galaxy size is actually related to λ, since all the data actually shows is that galaxy size R scales as a constant times R_halo. But Christoph's paper's result that λ is smaller for halos in low-density environments gives a way to see whether R scales with λ (or at least a halo property that also is smaller in low-density environments like the NFW scale radius R_s).

There are several methods for measuring the density around galaxies that we plan to use especially in low-density environments:

a) counting galaxies above a certain stellar mass or luminosity out to a given radius (in redshift space)
b) measuring the distance to the n-th nearest galaxy (Michael Cooper has given us his table of the distance to the 7th nearest SDSS galaxy)
c) using VIDE (P. Sutter et al. 2015) to find the volume of the Voronoi tessellation around each galaxy
d) using the DTFE method (Cautun & van de Weygaert 2011)
e) using the radial profile of each void in the Sutter et al. SDSS void catalog

Doug Hellinger suggests that we start with c).

For each of these methods, we will need to calibrate the measurement by doing the same measurement on a mock galaxy catalog constructed from Bolshoi-Planck or Small MultiDark-Planck simulations. For the galaxy size test we are interested in measuring the value of the Bullock (and maybe also Peebles) spin parameter as a function of each density measure around halos. We also need such catalogs for Radu's project to measure the density dependence of abundance matching for luminosity and stellar mass. So could you please construct such catalogs in redshift space (choosing one or a few locations for the origin) and make them available on the Hyades system?

Christoph's paper measured spin and other parameters only for distinct halos (i.e., not subhalos), so the prediction that median spin λ is smaller for halos in low density environments implies that central galaxies will be smaller if size scales as λ R_halo, but not satellite galaxies. So for SDSS I guess we should use the Yang catalog to tell whether a galaxy is a central or satellite, and in using your filled-halo catalog we will need to keep track of whether a galaxy is a central or satellite.

Peter Behroozi suggested that we confine our analyses of SDSS volume-limited to z < 0.06, which should be complete for M* > 10^{10} Msun (most of which will be centrals, especially in low-density regions). We will no doubt also want to study volume-limited SDSS catalogs at smaller redshifts, e.g. z < 0.04, so that we will have more low-mass galaxies (there will be more of these in low-density regions). Once we start to see the size of the signal, we can decide how much effort to put into this.

From: **Aldo Rodriguez** rodriguez.puebla@gmail.com
Subject: galaxy mocks
Date: April 27, 2017 at 9:55 AM
To: Joel Primack joel@ucsc.edu, Christoph Lee christoph28@gmail.com, Graham Vanbenthuysen gvanbent@ucsc.edu, Doug Hellinger hellinger.doug@gmail.com, Viraj Pandya viraj.pandya@ucsc.edu

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Dear All,

Here are the mocks that you requested. I did two observers with different positions for the BolshoiP and for the SMDPL. Therefore you have 4 galaxy surveys to have fun! Only halos with ~100 particles have stellar masses, note that stellar masses are diferente in every catalog as well based on our stellar-to-halo mass relations. As for the stellar masses I used Mvir for distinct halos and Mpeak for subhalos. For the BP I used the 1.00231 snapshot and for the SMDPL the 1.0000 snapshot. The columns are

(1): ID of halo
(2): Stellar mass in units of h^{-2} Msun (for consistency with the units of simulations)
(3): redshift
(4): stellar mass completeness. See my discussion below

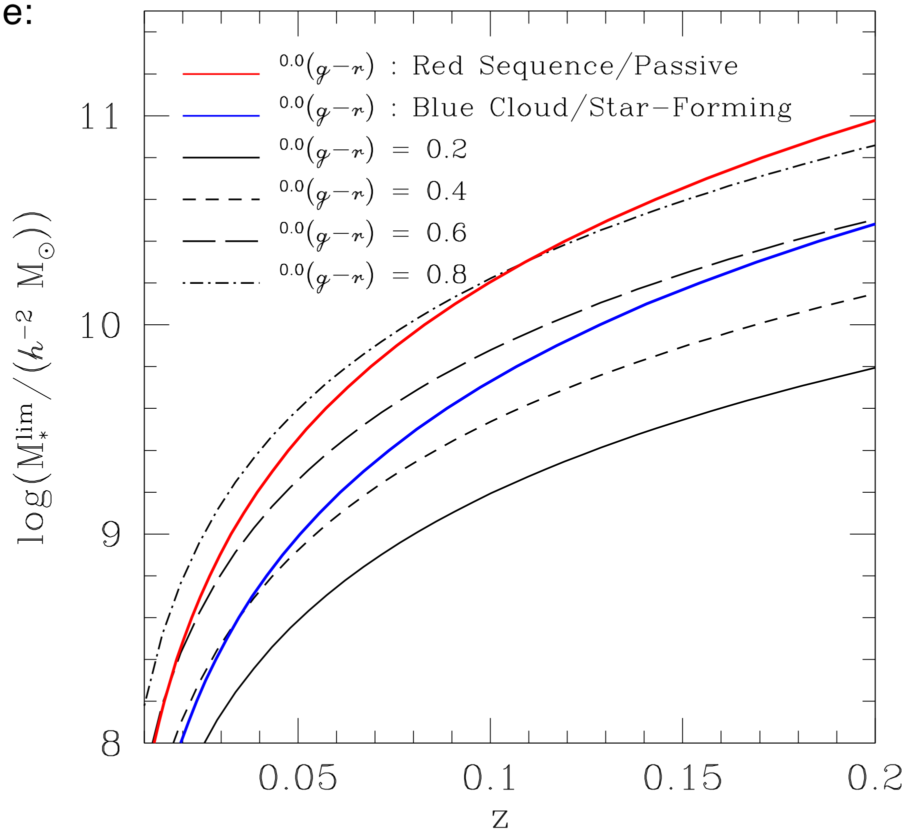
The attached figure illustrates how the apparent magnitude limit of the SDSS results in a stellar mass limit that depends on both **redshift and color**. I did various color selection so you appreciate the main effect. Also, I plotted the stellar mass limits for the red sequence and for the blue cloud, so now you can appreciate depending on the color of you galaxies the completeness limits are different. For the project the red line results in volumes that are complete in stellar mass and unbiased in color properties and therefore SFRs and sizes. In column 4 all galaxies above the red line have a value of 1 else 0.

The last step would be to construct volume-complete samples. That is easy, for a given stellar mass calculate the maximum redshift for galaxies that complete in mass and all galaxies above that mass and below that redshift will result in a volume-complete sample that is complete in stellar mass. I'm attaching a table so you could do check that easily. In that table:

Col1: Stellar mass in units of h^{-2} Msun
Col2: z_max red galaxies
Col3: z_max blue galaxies.

Let me know if you have more comments or you find something odd about the mock surveys.

Cheers!
Aldo



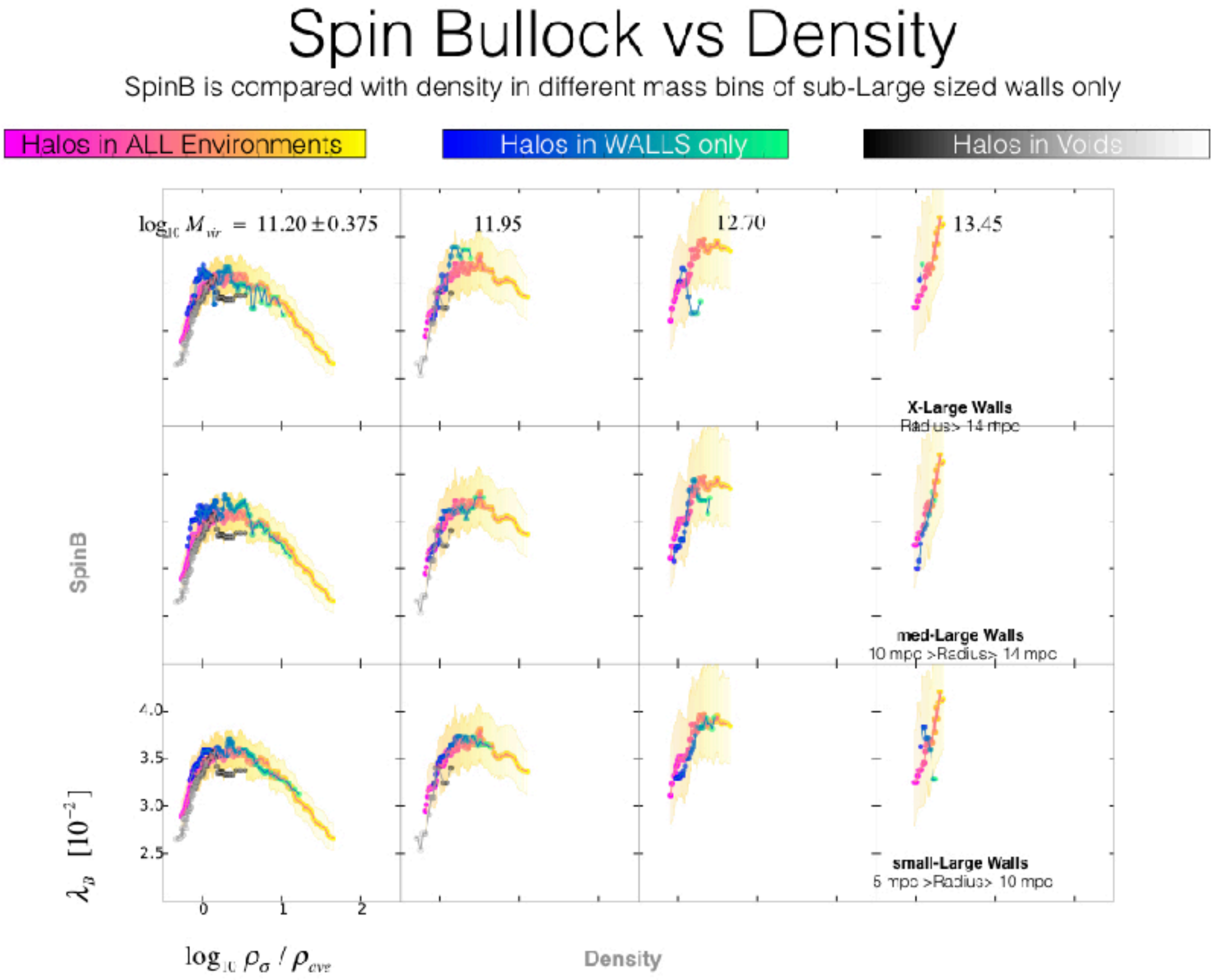
https://dl.dropboxusercontent.com/u/12411579/mocks/z_0.0_BPL_center.tar.gz

https://dl.dropboxusercontent.com/u/12411579/mocks/z_0.0_BPL_origin.tar.gz

https://dl.dropboxusercontent.com/u/12411579/mocks/z_0.0_SMDPL_center.tar.gz

https://dl.dropboxusercontent.com/u/12411579/mocks/z_0.0_SMDPL_origin.tar.gz

Halo properties like concentration, accretion history, and spin are mainly determined by environmental density rather than by location within the cosmic web — Tze Goh, Christoph Lee, Peter Behroozi, Doug Hellinger, Miguel Aragon Calvo, Elliot Eckholm



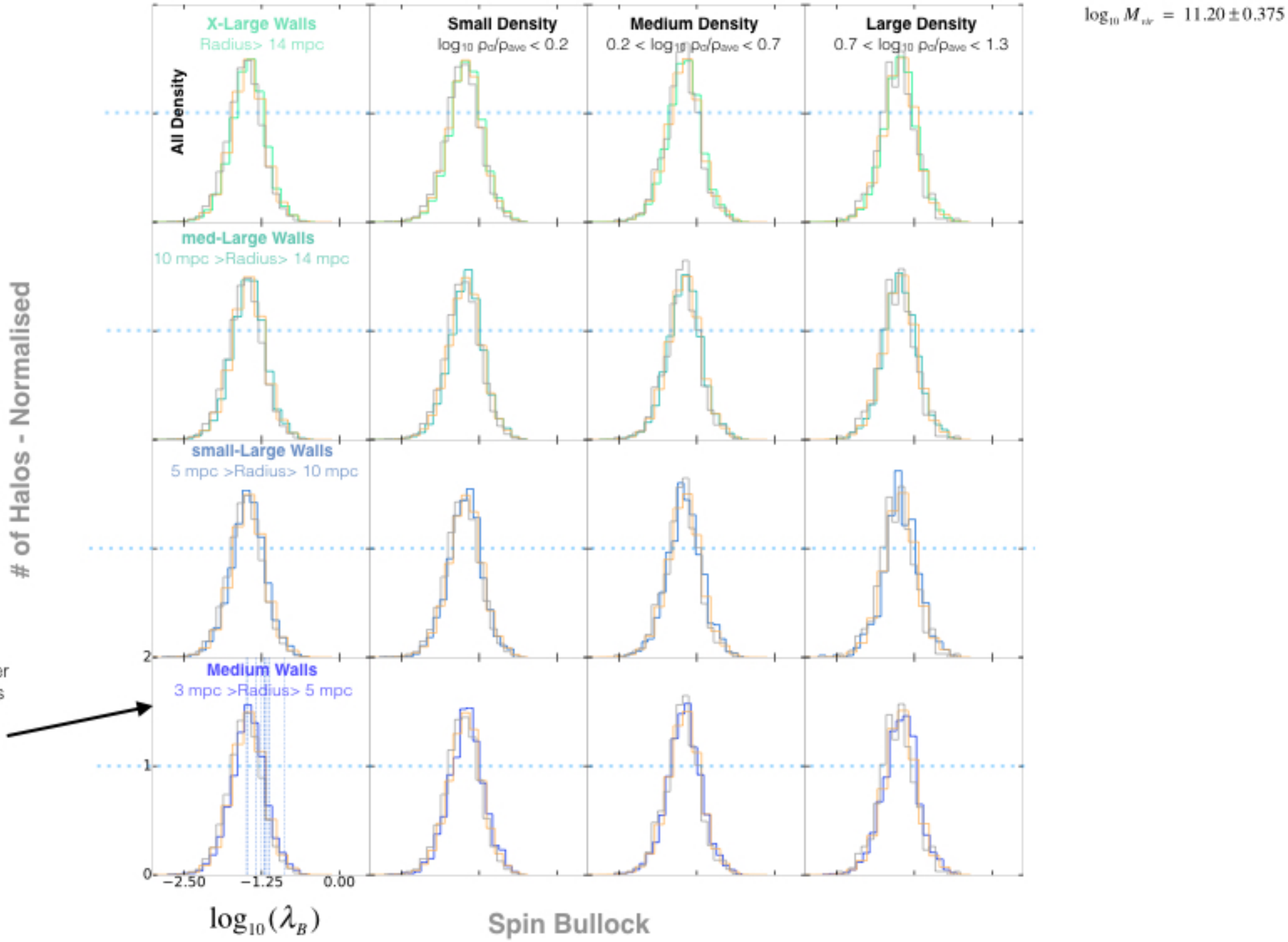
Histogram of the SpinB

Histogram distribution of SpinB of all Halos with various density ranges in various-sized walls.

Halos in ALL Environments

Halos in WALLS only

Halos in Voids



Note: Vertical blue lines refer to the Spin B of the 10 halos that are similar to the Milky Way Galaxy.
As you can see, they are close to the log normal