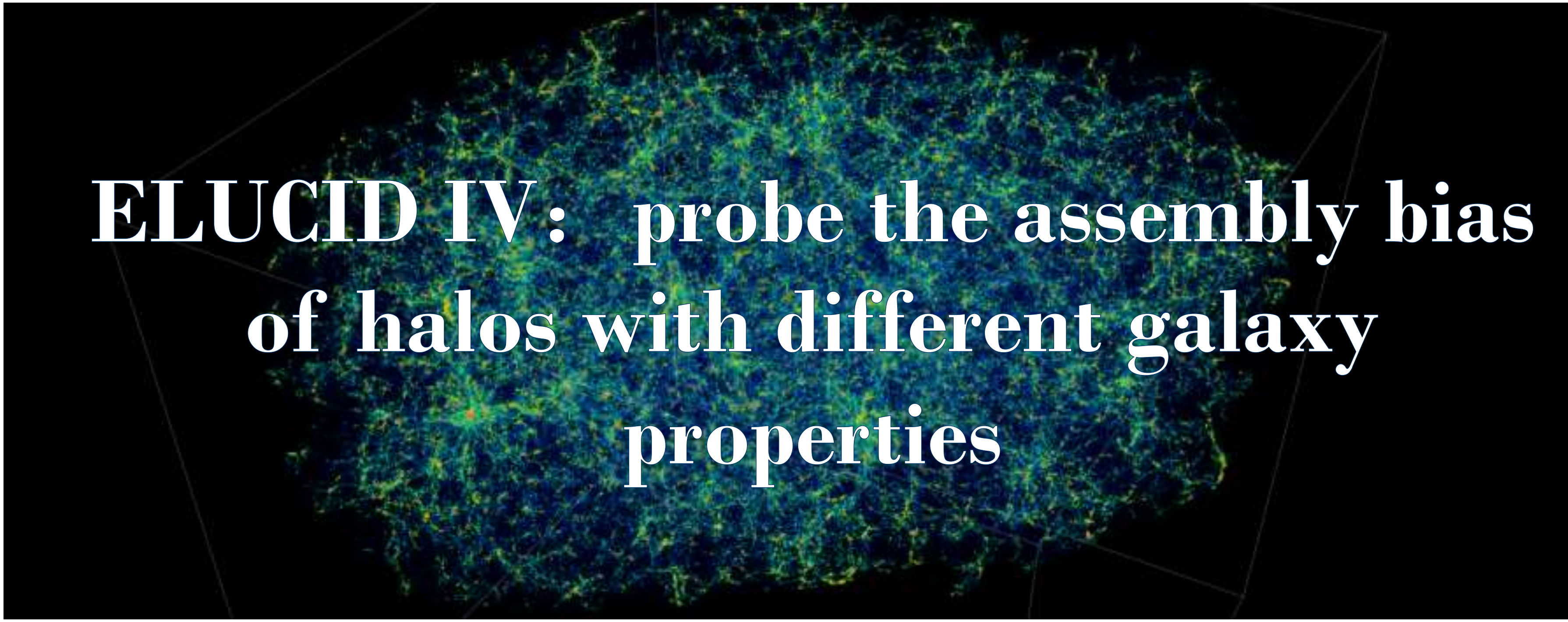


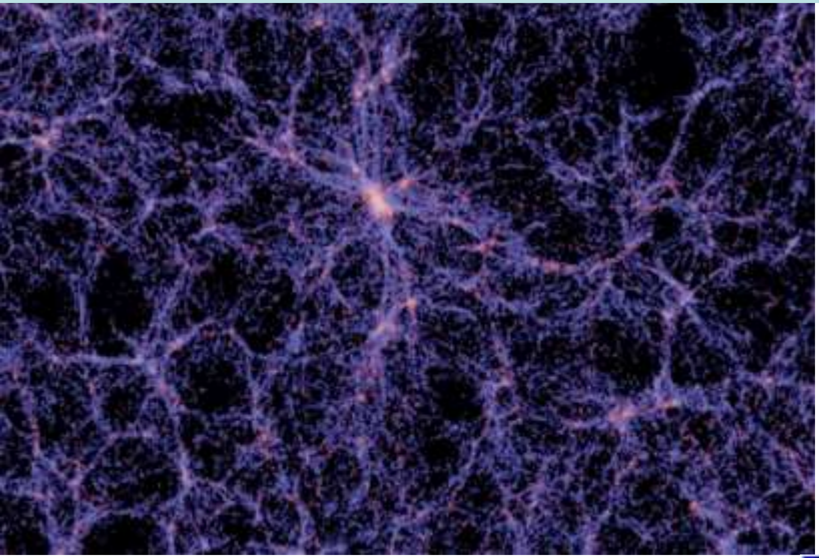
ELUCID IV： probe the assembly bias of halos with different galaxy properties

Xiaohu Yang (Shanghai Jiao Tong University)

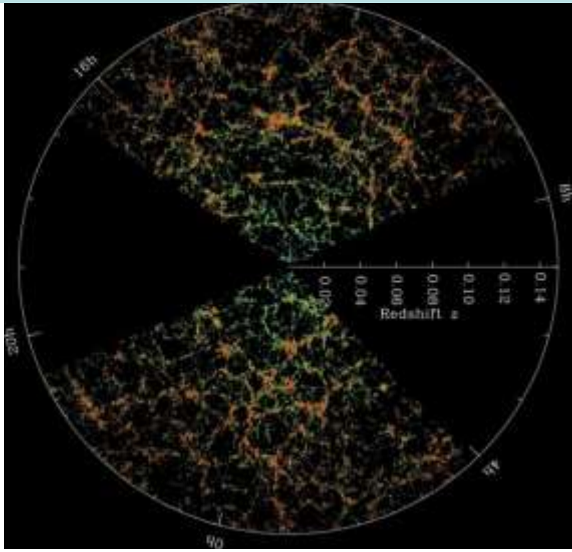
With: H. Y. Wang, Y. Zhang, C. Liu, F. Shi, S. Li, D. Tweed, H.J. Mo, Y. Jing, X.Kang, F.C. van den Bosch, Y. Lu, Q. Guo, Y. Lu, etc.

2016. 11. 02

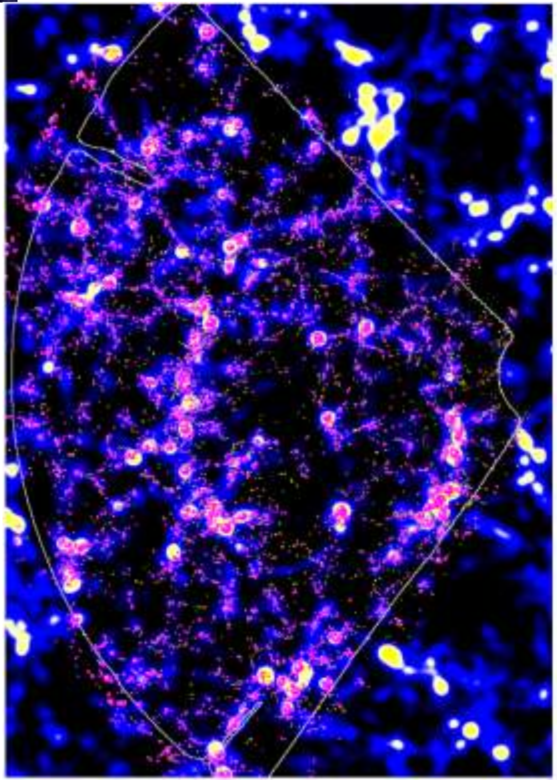
ELUCID simulations

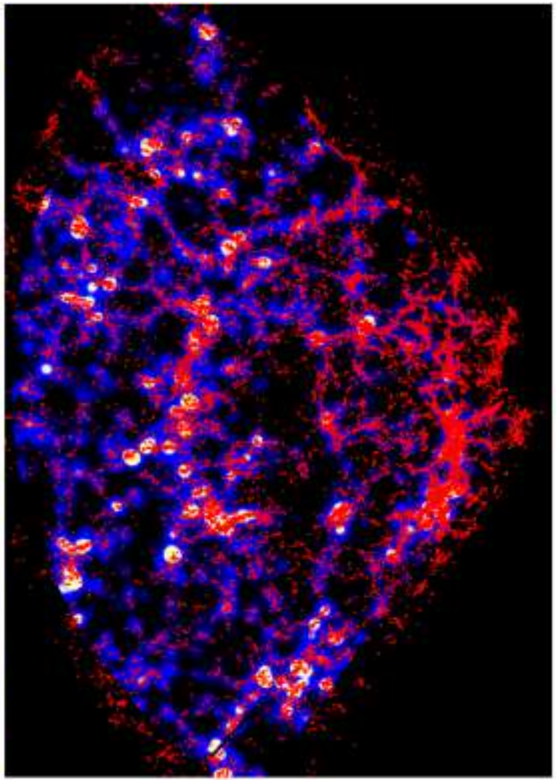


Usually, theoretical results are compared with observational data in a statistical way.
-----Power spectra and Gaussianity

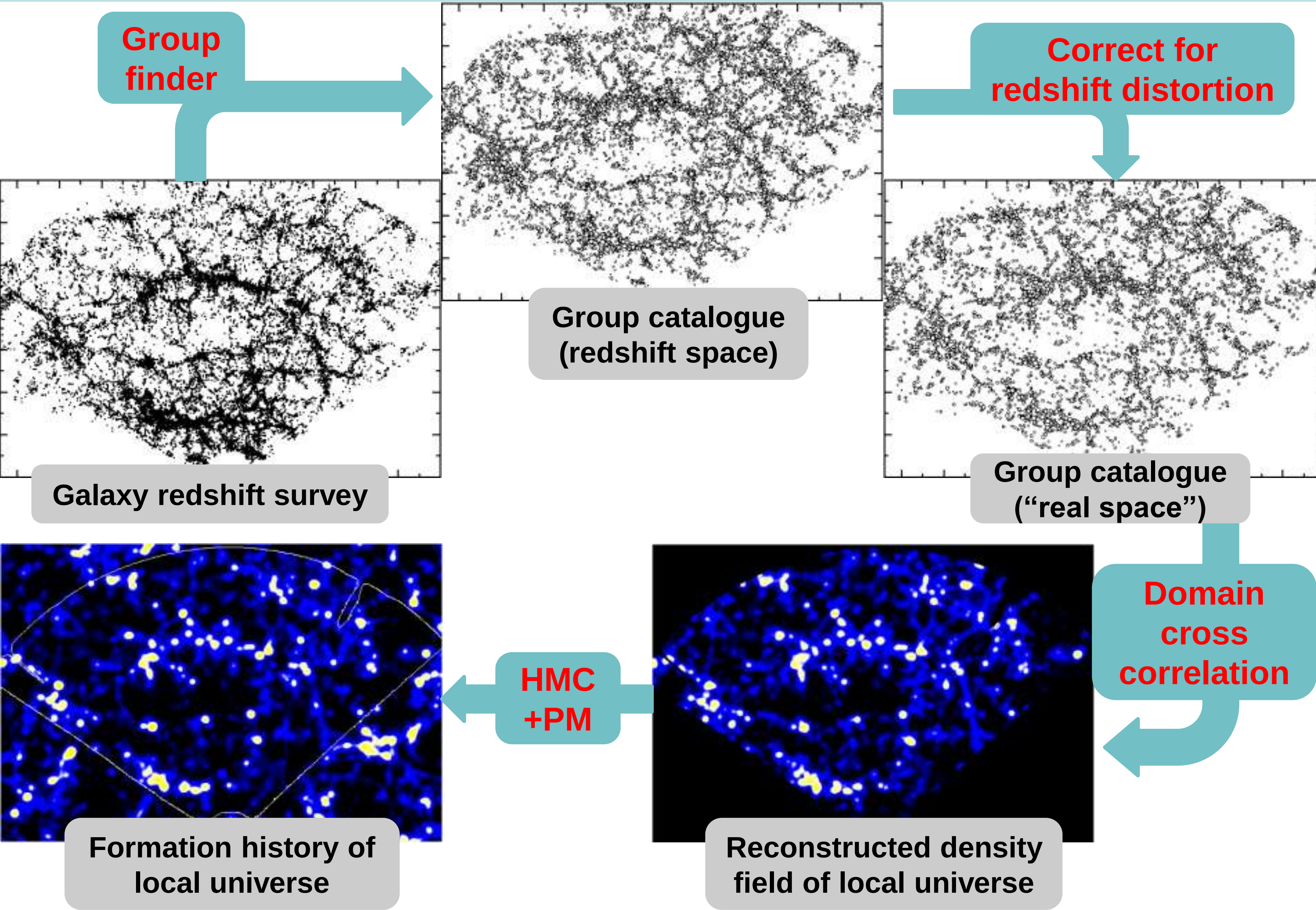


If we can accurately reconstruct the initial condition of local Universe, we can compare the data and theory ‘directly’.
-----Power spectra, Gaussianity and Phase

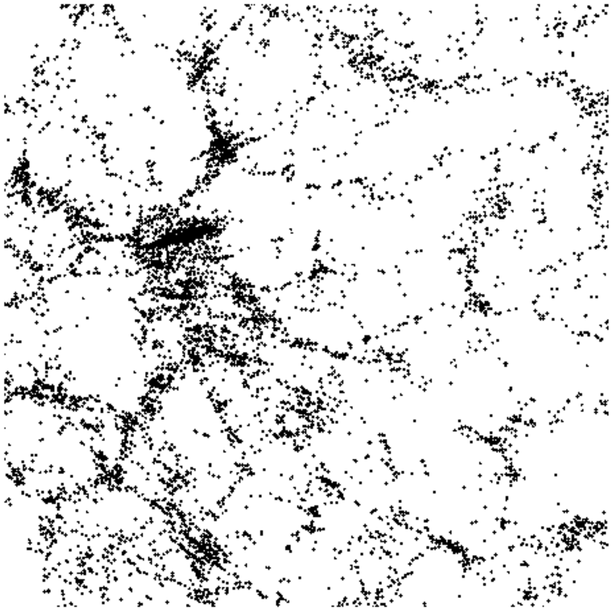


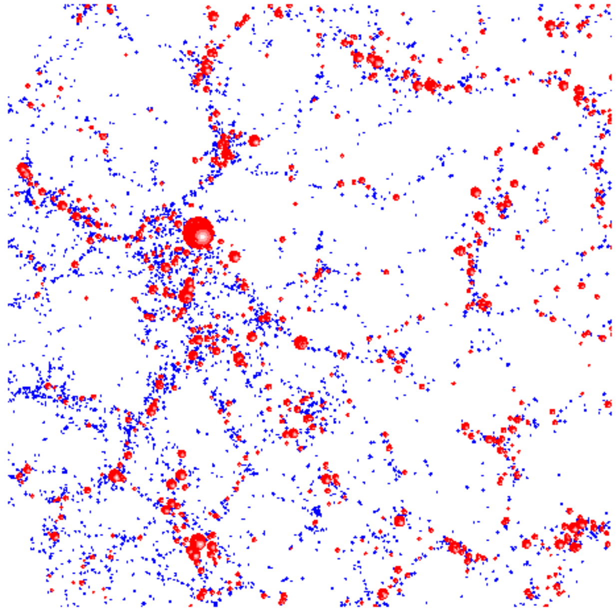


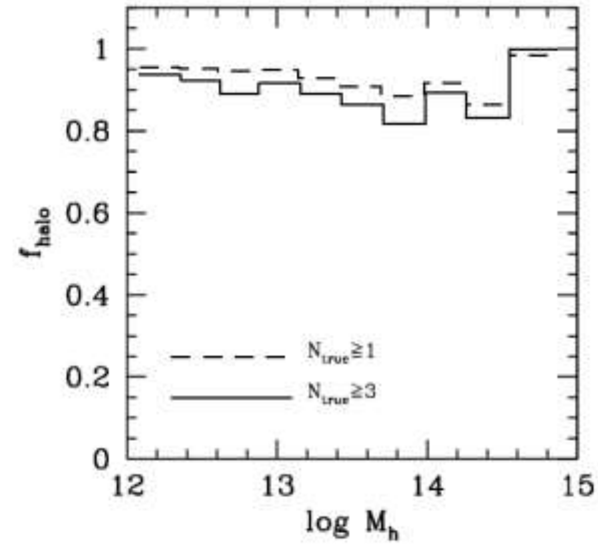
Flow-chart of our reconstruction

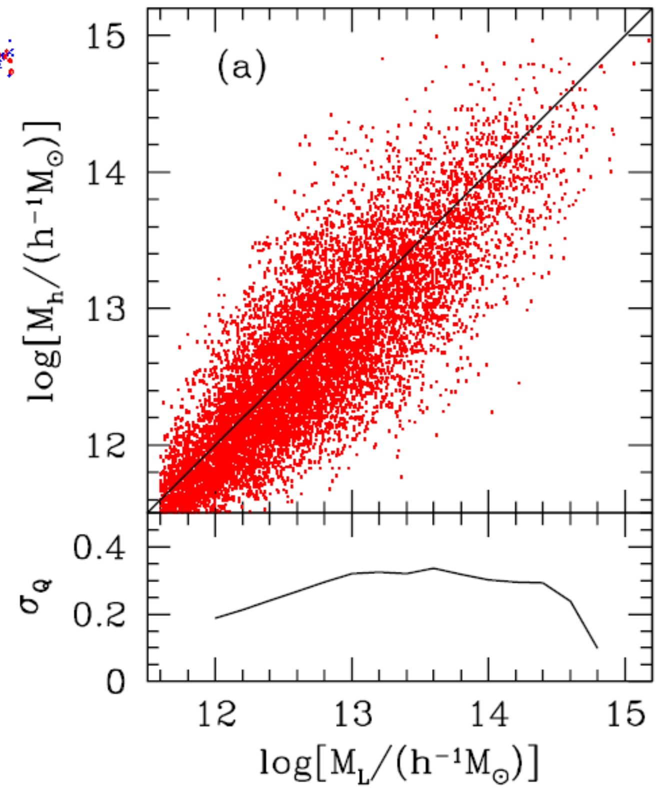


Halo-based group finder







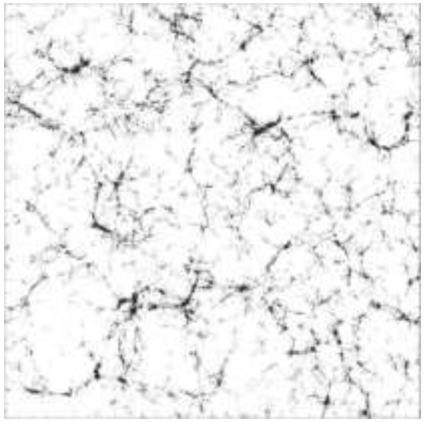


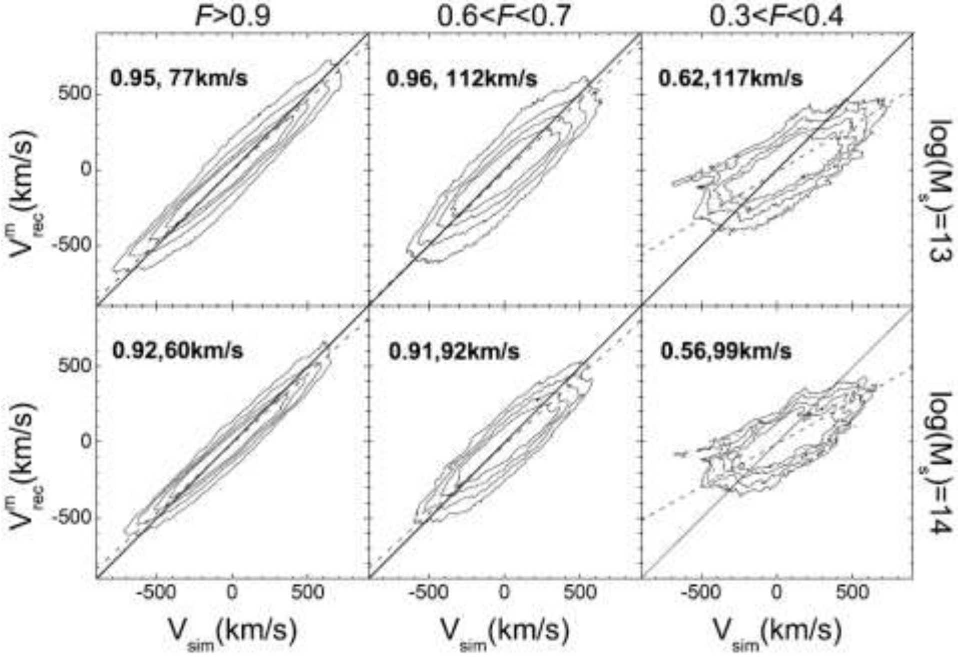
- **Galaxies are believed to form within halos.**
- **Galaxy groups (halos) are well known tracers of cosmic mass.**
- **The inner structure of halos are well known.**
- **The redshift distortion caused by the non-linear motion with haloes (FOGs) has been corrected**

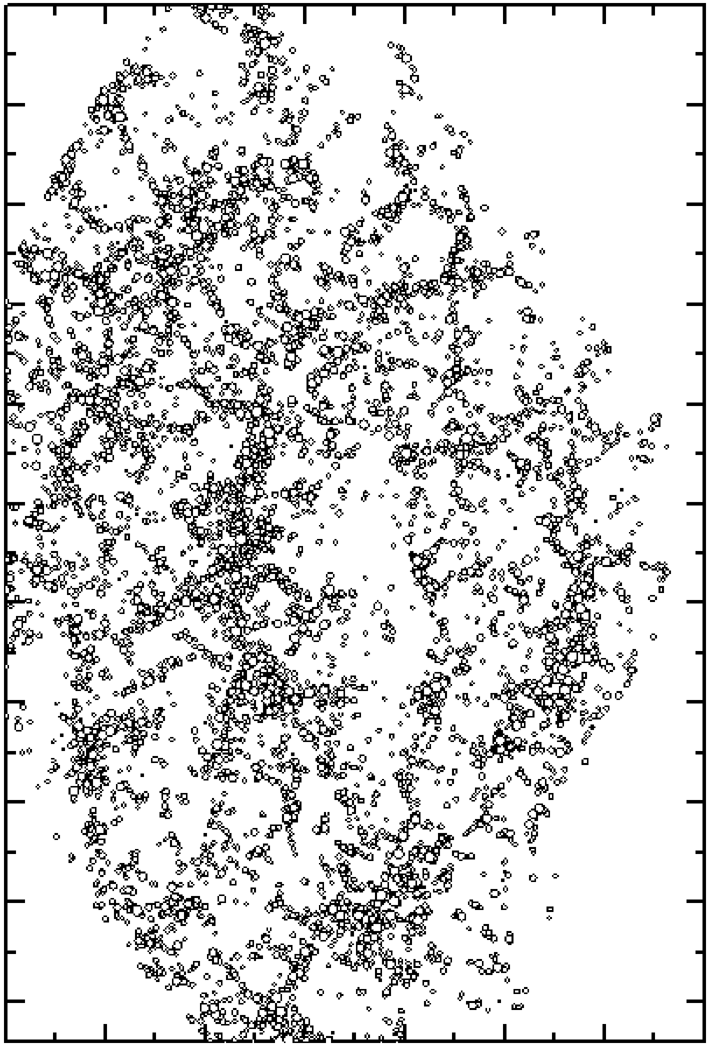
Yang et al. 2005;2007

Correcting for redshift distortion

$$\boldsymbol{v}(\boldsymbol{k}) = Haf(\Omega)\frac{i\boldsymbol{k}}{k^2}\delta(\boldsymbol{k}) \quad \delta_{\rm h}(\boldsymbol{k}) = b_{\rm hm}\delta(\boldsymbol{k})$$

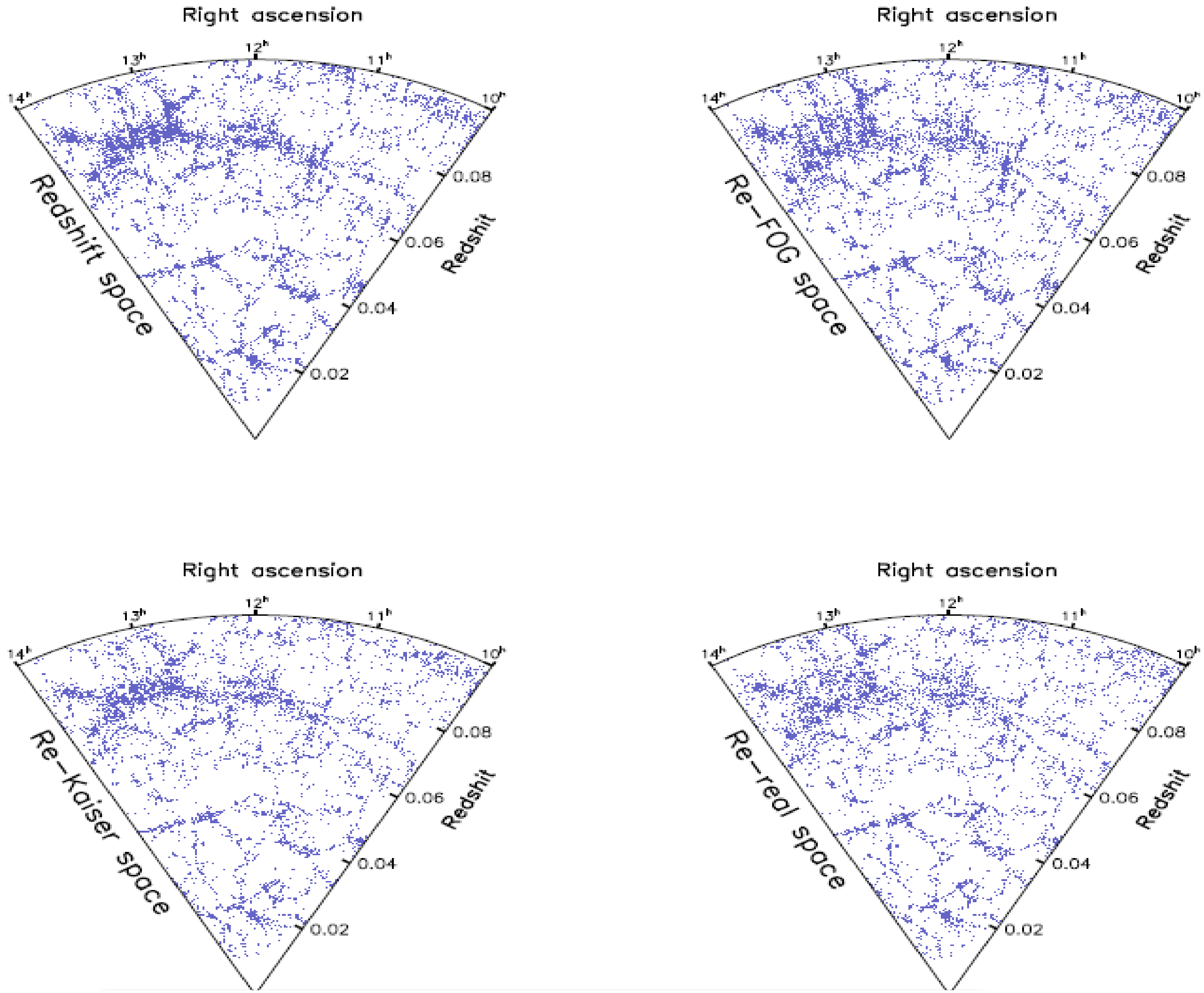






Wang et al. 2009;2012

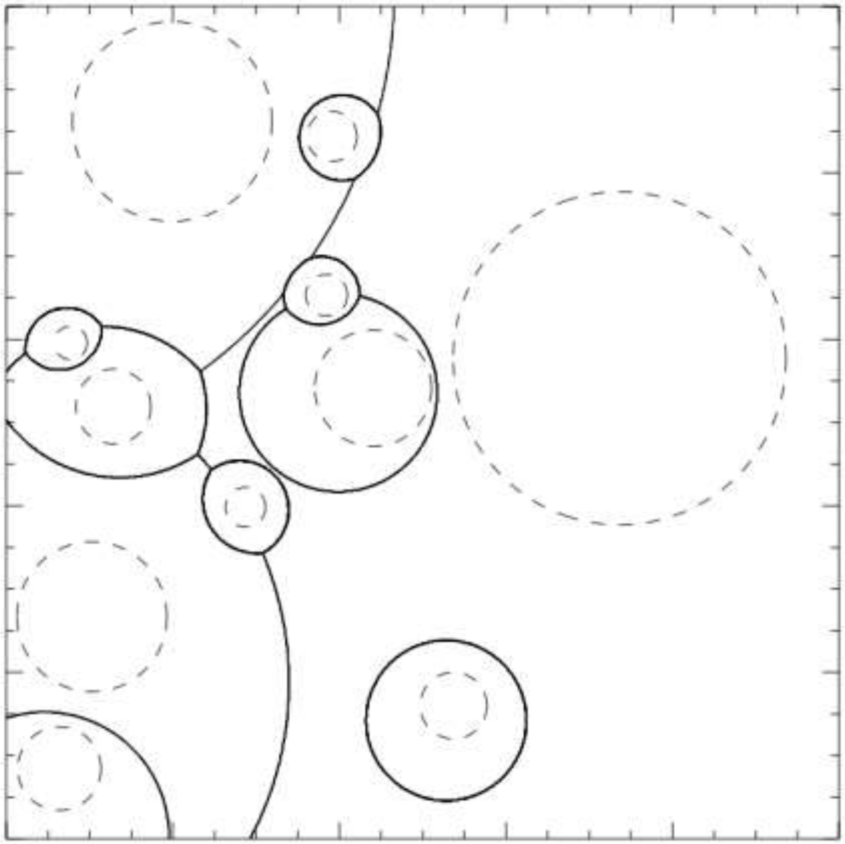
The real space distribution of SDSS DR7 galaxies



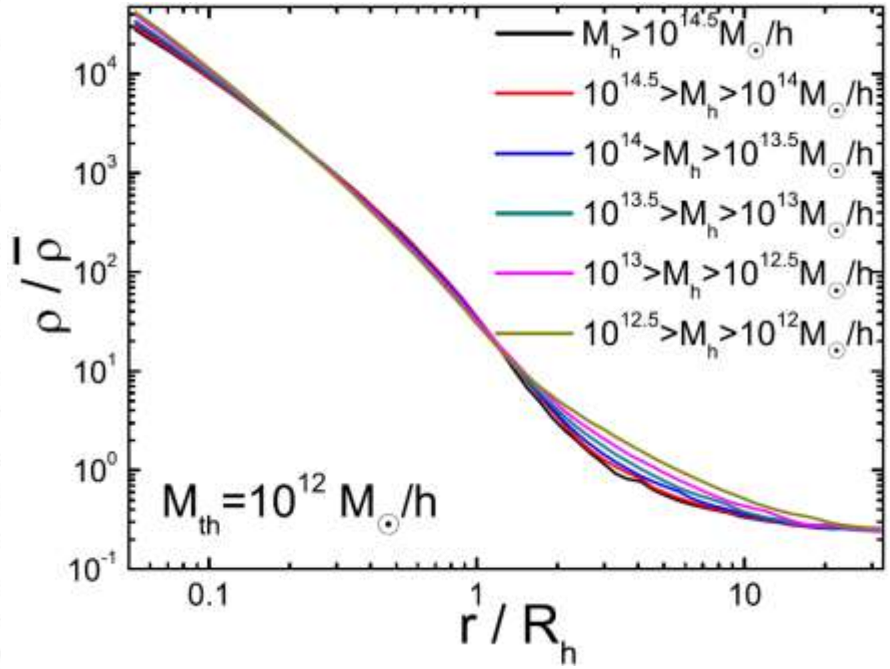
The Sloan Great Wall is weakened !

Shi et al. 2016

Domain cross correlation method



- Halo Domain $r_p = \frac{r_h}{R_h}$
- Domain Cross Correlation



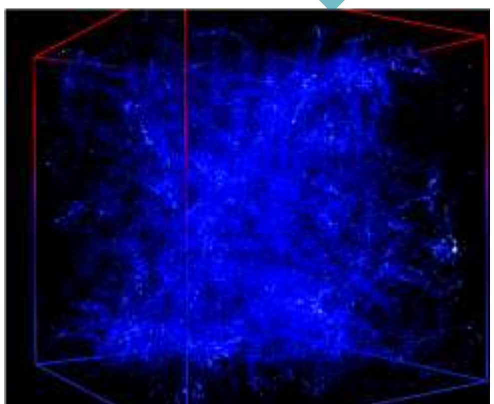
- For a mock group of mass above M_{th}, we pick a density profile according to its mass;
- We use a Monte Carlo method to put particles around this group up to *32* times the virial radius regardless of the domain;
- We remove particles outside of the domain of the group;
- We repeat the above three steps for all groups with mass larger than M_{th}.

Wang et al. 2009; 2013

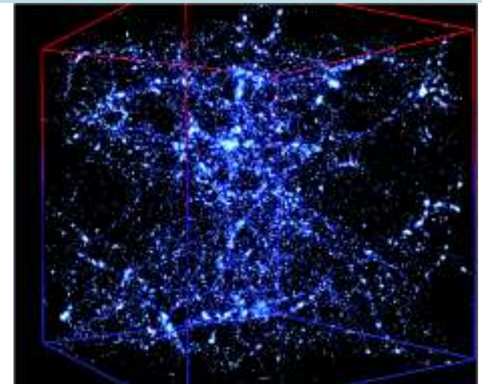
Hamiltonian Markov Chain Monte Carlo Method with Particle Mesh Dynamics

① Prior Gaussian distribution

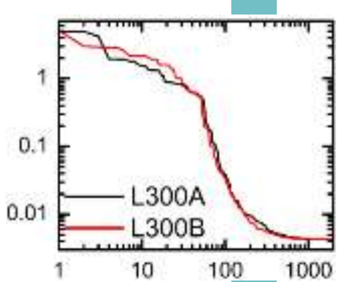
Initial condition



Input density field



③ Adopting HMC method to adjust the IC so that IC obeys Gaussian dist. and the diff. between these two decreases.

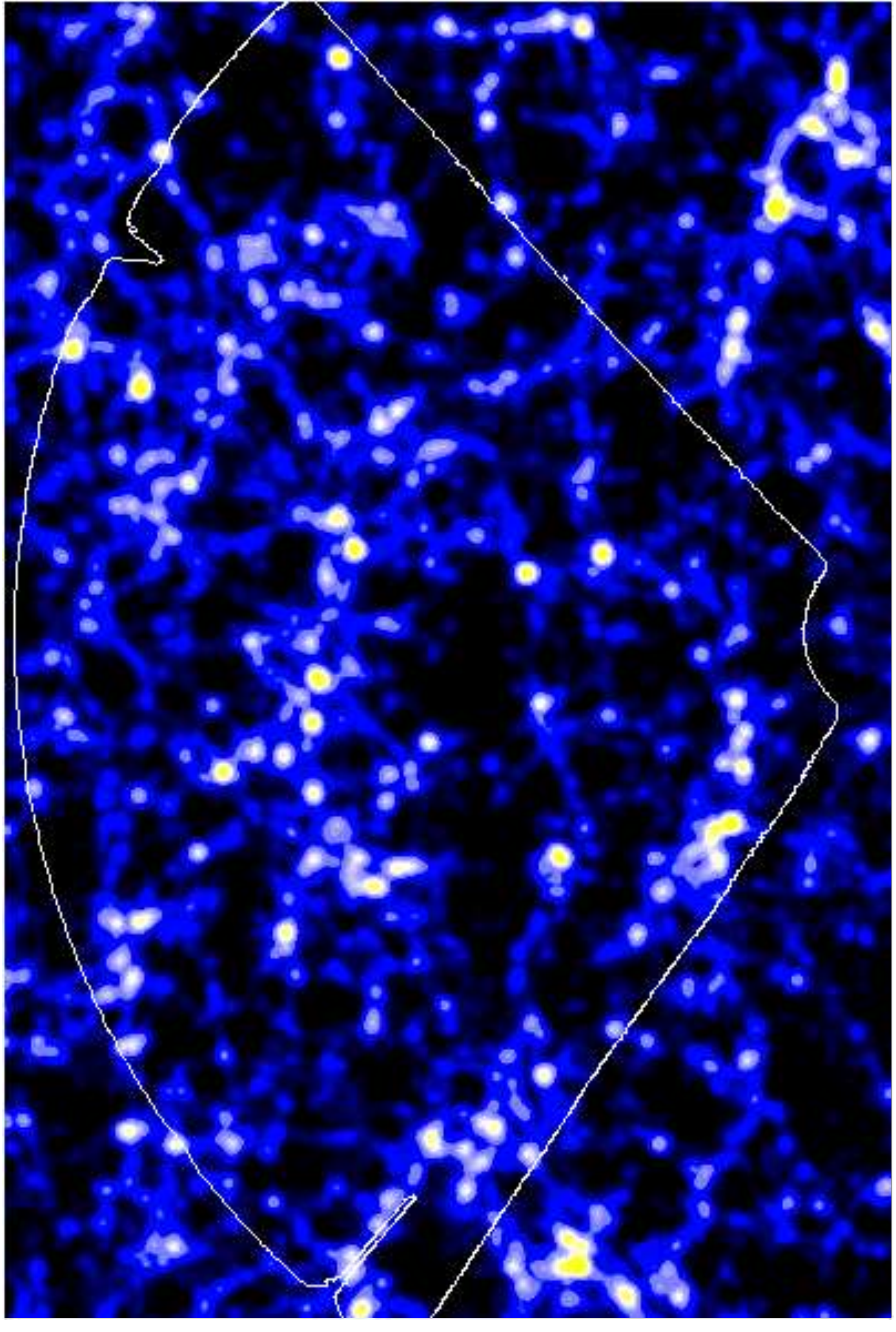


②The IC is evolved to the present day with PM dynamical model.

Modeled density field

④ Finally we use N-body simulations to get the formation history of cosmic structures.

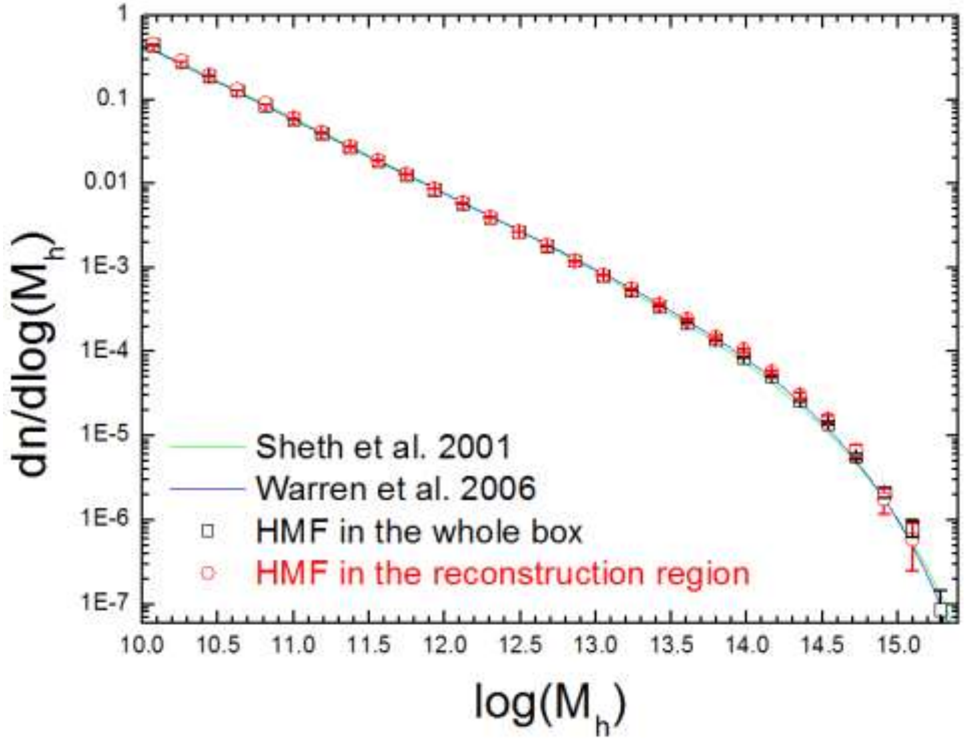
Wang et al. ApJ, 2013;2014

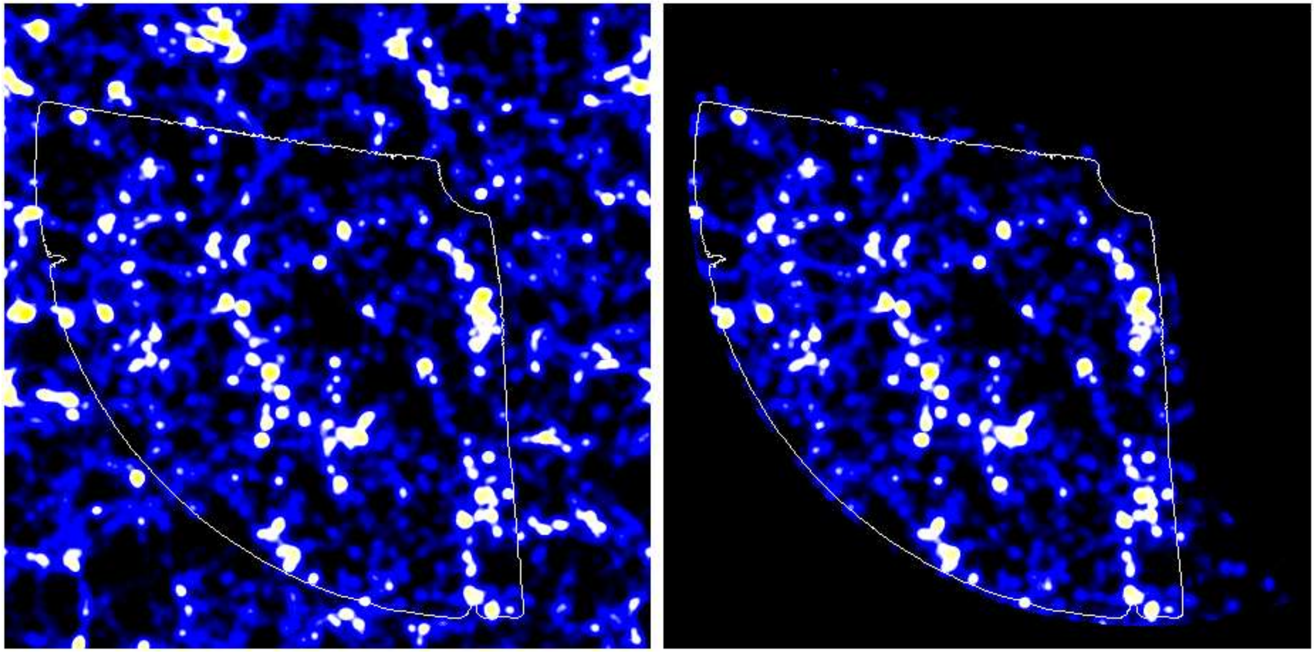


ELUCID simulations

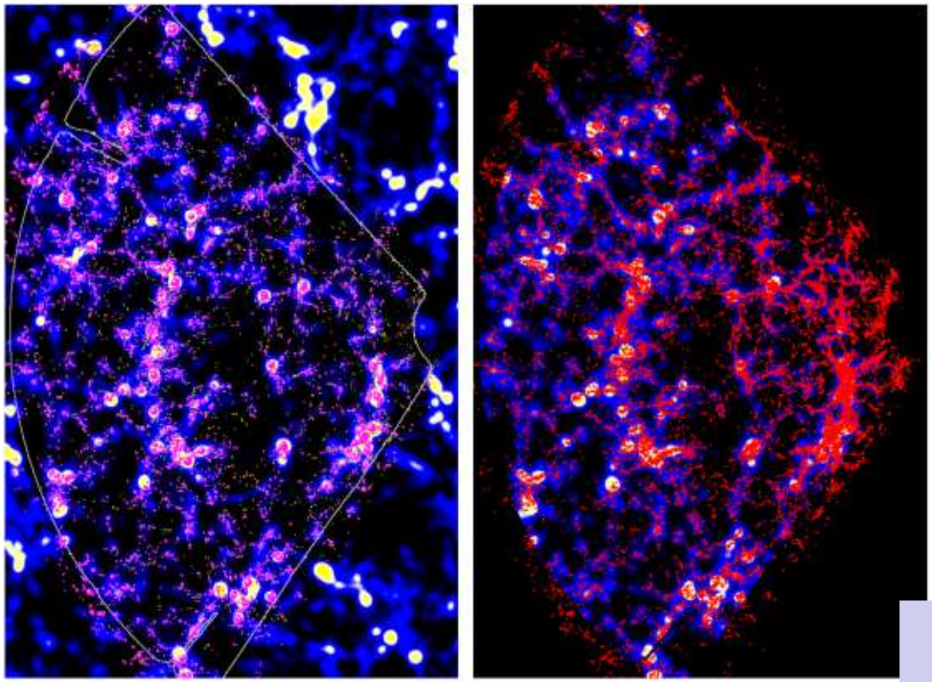
- WMAP5 cosmology
- It is rotated by 39 degree
- HMCMC: r_s=4Mpc/h, N_d=500, 20 PM steps, grid size 1Mpc/h
- Constrained simulation:
  box size 500Mpc/h,
  3072^3 particles,
  z_i=100,
  100 outputs
  softening length 3.4kpc/h

Wang et al. 2016





Future work on galaxy formation:



Model:

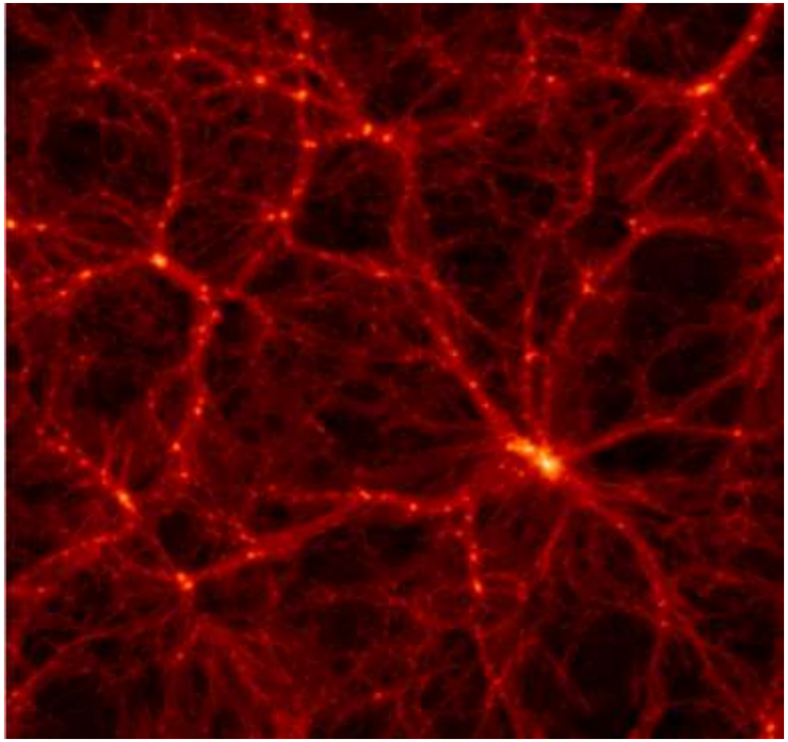
- **N-body+ hydrodynamics simulation of local Universe (including radiative cooling, star formation and feedback)**
- **Semi-analytical model of galaxy formation**

Assembly bias of halos with different galaxy properties

Observation:

- Galaxy properties: galaxy redshift survey;
- ISM properties: 21cm emission, millimeter/submillimeter emissions;
- IGM properties: quasar absorption line systems; X-ray observations; Sunyaev-Zel'dovich effect.

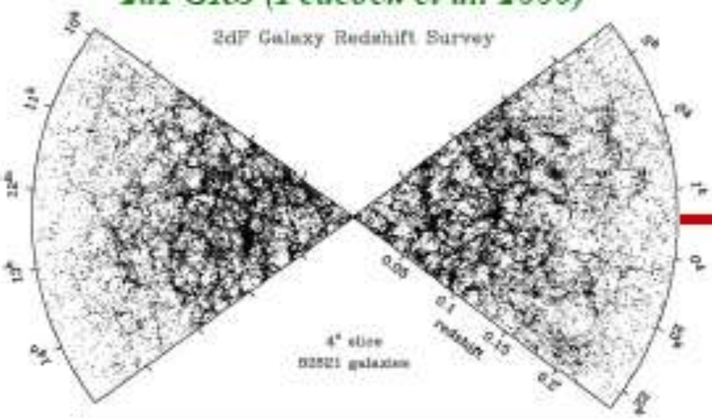
Great Success: halo models

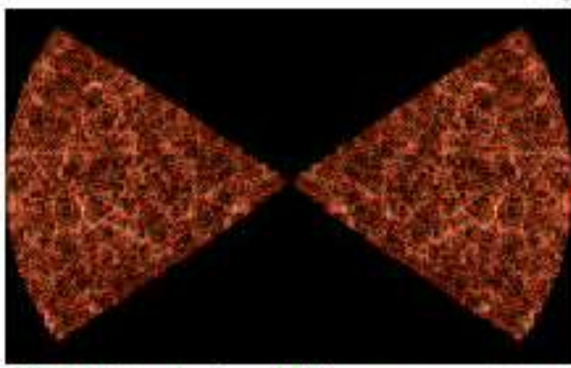


- **Halo models**
  - **The number density (halo mass functions)**
  - **The halo bias models**
  - **The halo profiles**
  - **The subhalo mass functions**
  - **Subhalo accretion histories**

Linking galaxies with dark matter halos

2dFGRS (Peacock et al. 2000)





CDM simulation (Virgo consortium)

Halo Occupation Distribution (HOD)

P(N|M)

Jing et al.1998

Seljak 2000

Scoccimarro et al. 2001

Scranton 2002

Berlind & Weinberg 2002

Magliochetti & Porciani 2003

The Halo Occupation Number method specifies $P(N|M)$, the probability that a halo of mass M contains N galaxies. HONs can address galaxy clustering by linking $\xi_{\rm gg}(r)$ to $\xi_{\rm hh}(r)$

Linking galaxies with dark matter halos

The luminosity function:

$$\Phi(L) = \int_0^\infty \boxed{\Phi(L|M)}\, n(M)\, \mathrm{d}M$$

The average luminosity in a halo of mass M:

$$\langle L\rangle(M) = \int_0^\infty \Phi(L|M)\, L\, \mathrm{d}L$$

The average number of galaxies in a halo of mass M with $L > L_1$:

$$N_M(L > L_1) = \int_{L_1}^\infty \Phi(L|M)\, \mathrm{d}L$$

Clustering properties of galaxies as function of luminosity:

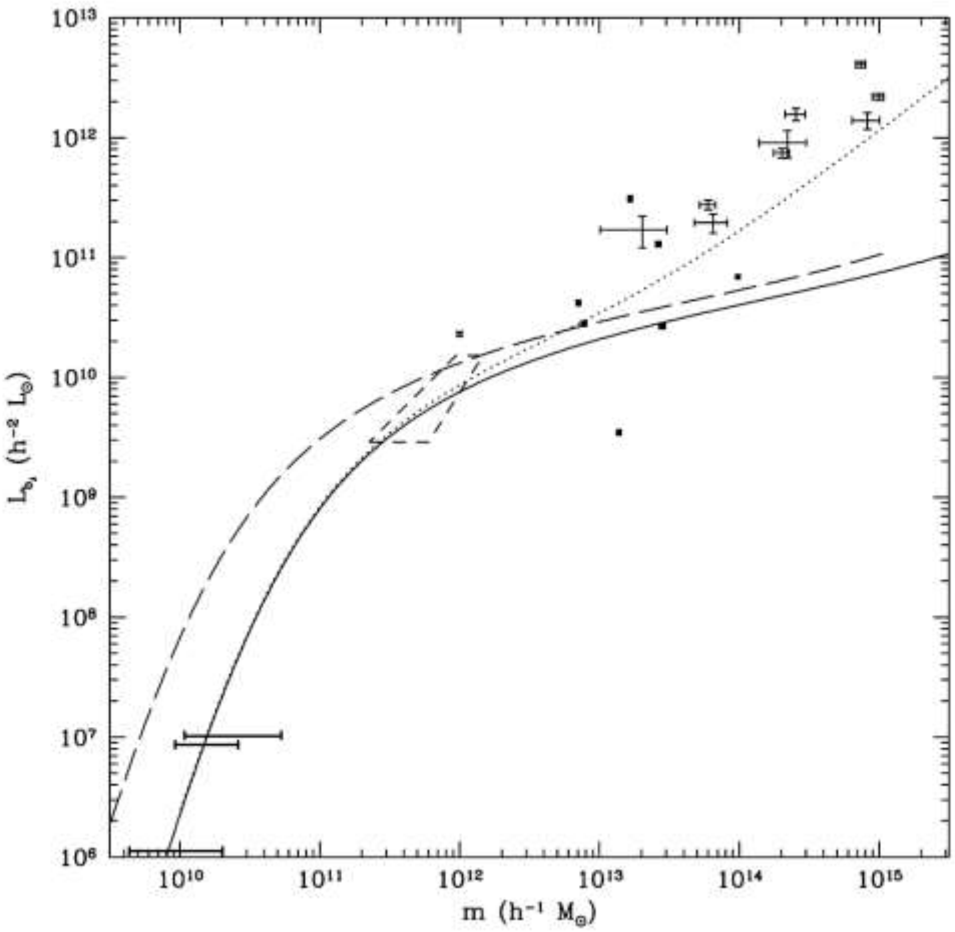
$$\xi_{\rm gg}(r|L) = b^2(L)\, \xi_{\rm dm}(r)$$

$$\bar{b}(L) = \frac{1}{\Phi(L)} \int_0^\infty \Phi(L|M)\, b(M)\, n(M)\, \mathrm{d}M$$

The conditional LF is the ideal statistical 'tool' to link the distributions of dark matter haloes and galaxies.

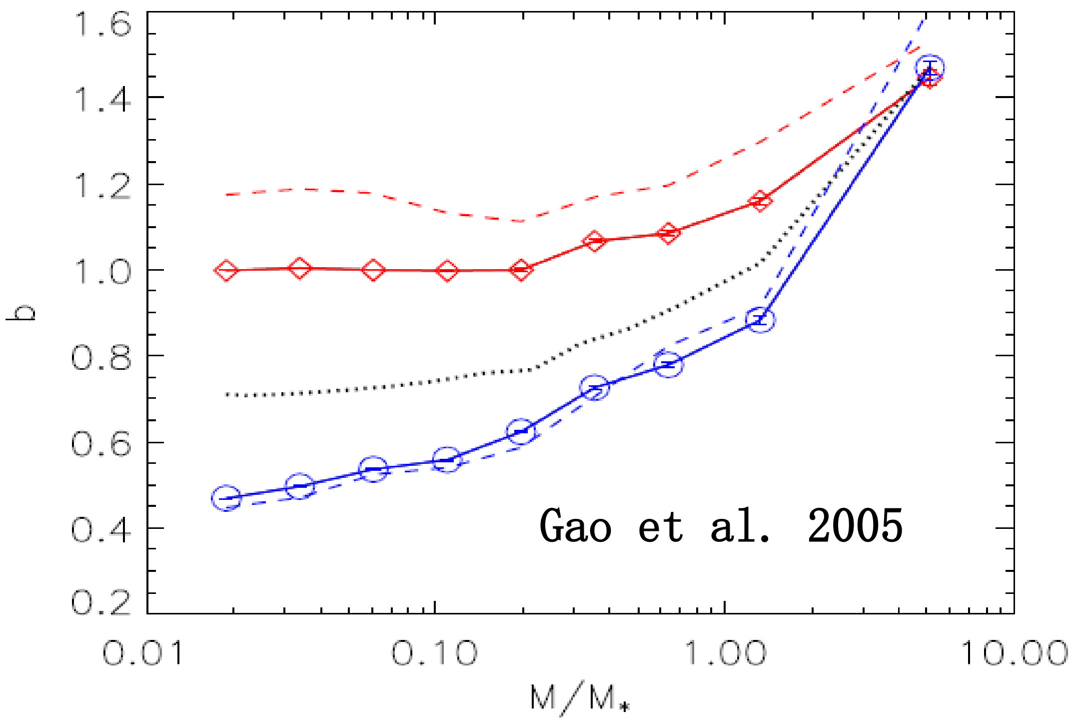
Yang et al. 2003; van den Bosch et al. 2003

Sub-halo abundance matching



Vale & Ostriker 2004

The age dependence of halo bias



- The assembly bias was first observed in simulations where halos formed earlier are more strongly clustered than those of the same masses but formed later (e.g. Gao et al. 2005).
- The additional dependences are found as well in subsequent studies, e.g., on the assembly time, spin, shape and substructure, etc. of halos (e.g. Wechsler et al. 2006; Gao & White 2007; Li et al. 2008; Dalal et al. 2008; Wang et al. 2011).

The impact of b(M, ?)

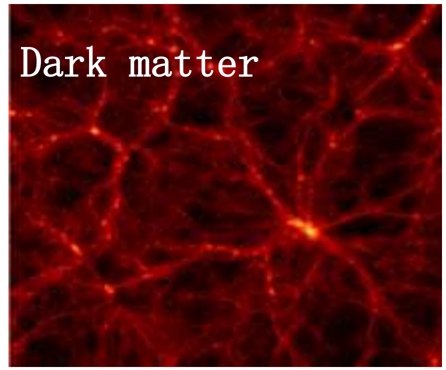
Cosmology:

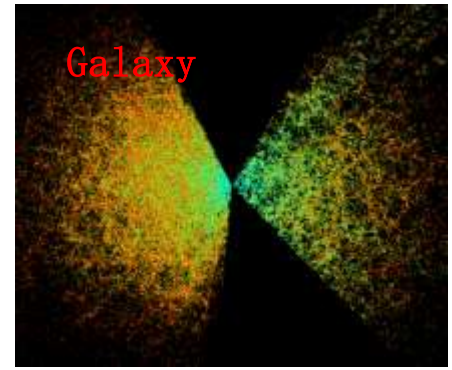
dark matter: Ω_{dm}

baryons: Ω_b

dark energy: Ω_Λ

Initial: σ_8



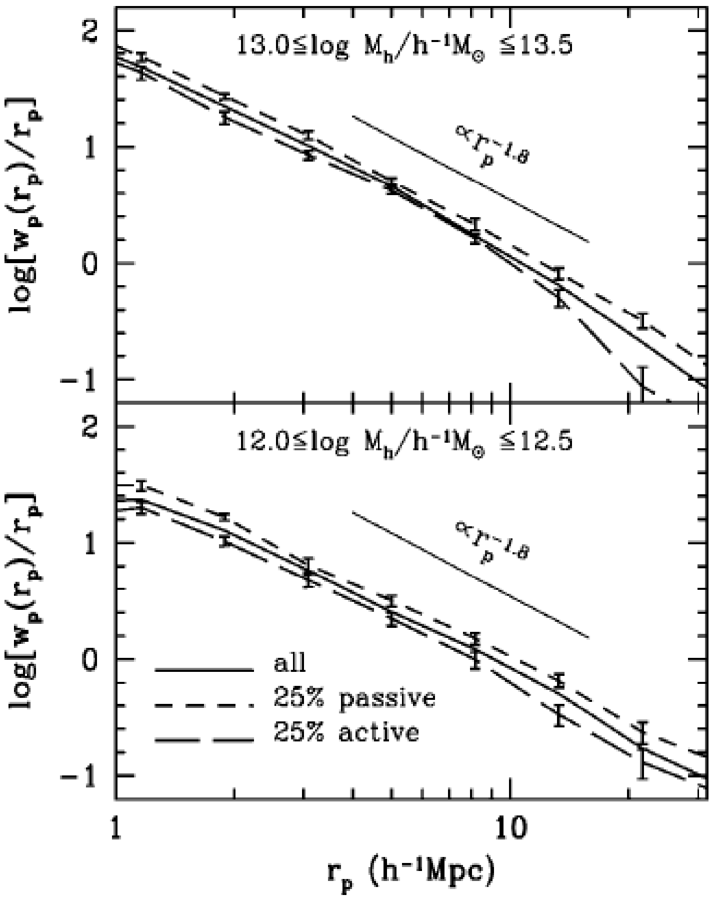


P(N|M, ?) & b(M, ?)

Φ(L|M, ?) & b(M, ?)

- Do we need to model P(N|M) and Φ(L|M) with extra parameters '?'
- Do we see assembly bias in observations?

The age dependence of galaxy groups

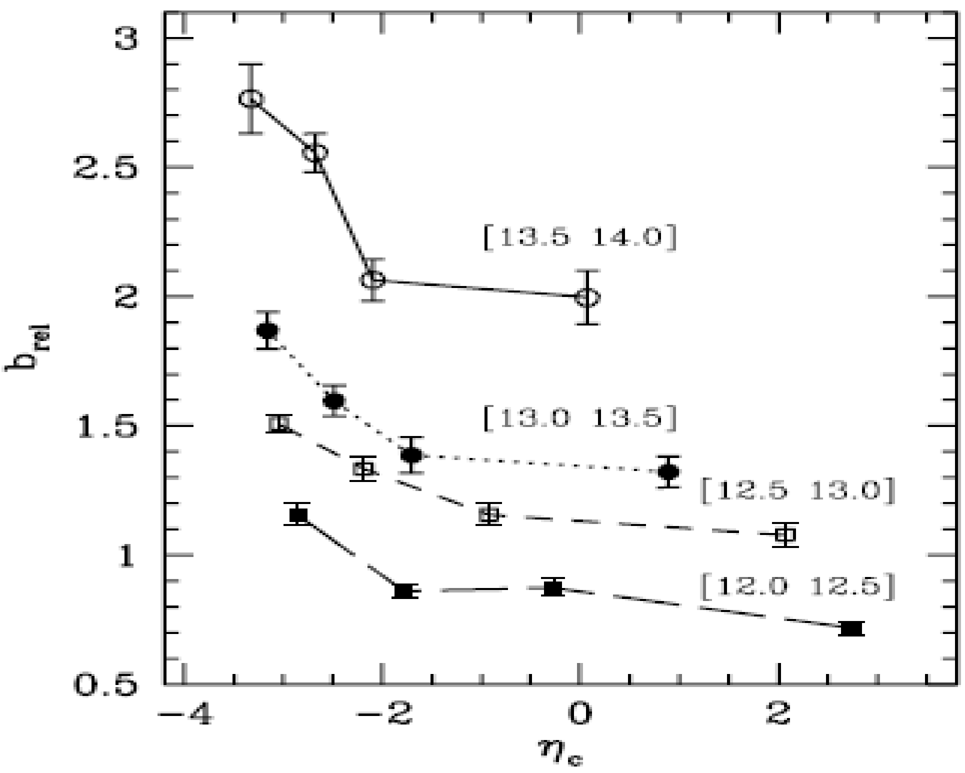


Yang et al. 2006, ApJ, 638L, 55

FIG. 1.—Solid lines show the projected GGCCF. The top and bottom panels correspond to different group mass bins, as indicated. For each mass bin, the short-dashed curves indicate the GGCCF for the subsample with the lowest 25% of the values of η_c (i.e., the central galaxies with the most passive star formation), while the long-dashed curves correspond to the subsample with the highest 25% of the values of η_c (the most actively star-forming central galaxies). Error bars indicate the 1 σ variance as obtained from eight independent mocks.

- Group-galaxy cross correlation function

Group bias: have age dependence



- The groups with passive (old) central galaxies are more strongly clustered than those of the same masses but with star forming centrals.

Group bias: no age dependence

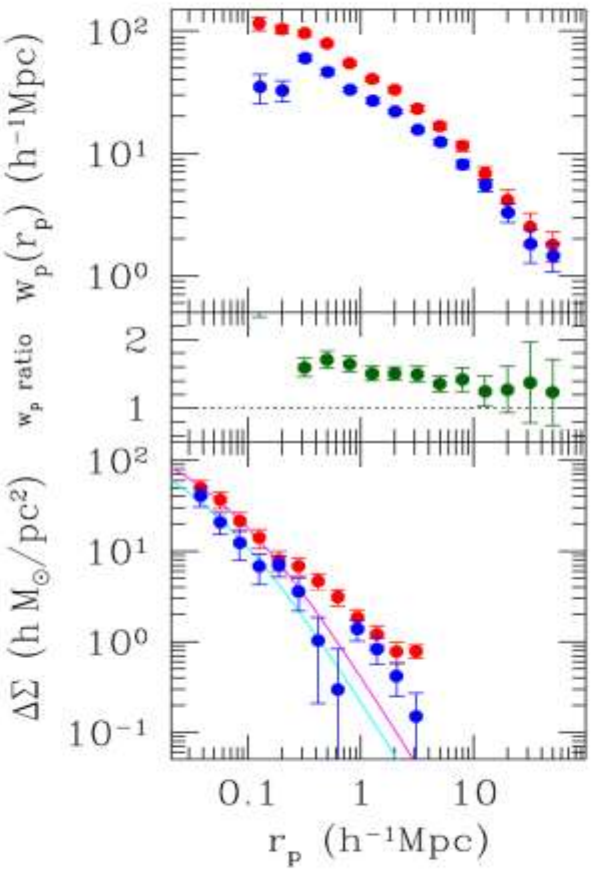


Figure 2. Measurements of projected correlation function (top panel) and surface mass density contrast (bottom panel) for the central galaxies selected with the Y07 halo mass within the range $\log(M_{200c}/M_\odot) = 12.0-12.5$, further separated into low- and high-sSFR samples (red and blue points, respectively). The middle panel shows the relative bias squared of the two samples: the low-sSFR sample has systematically higher bias, but this is mainly due to the ~ 1.9 times difference in halo mass: galaxy-galaxy lensing indicates the two samples have mass M_{200c} of $(9.0^{+1.4}_{-1.2}) \times 10^{11}\, h^{-1} M_\odot$ and $(4.6^{+1.0}_{-0.8}) \times 10^{11}\, h^{-1} M_\odot$, respectively. The two curves in the bottom panel represent the best-fit NFW profiles (magenta: low-sSFR; cyan: high-sSFR).

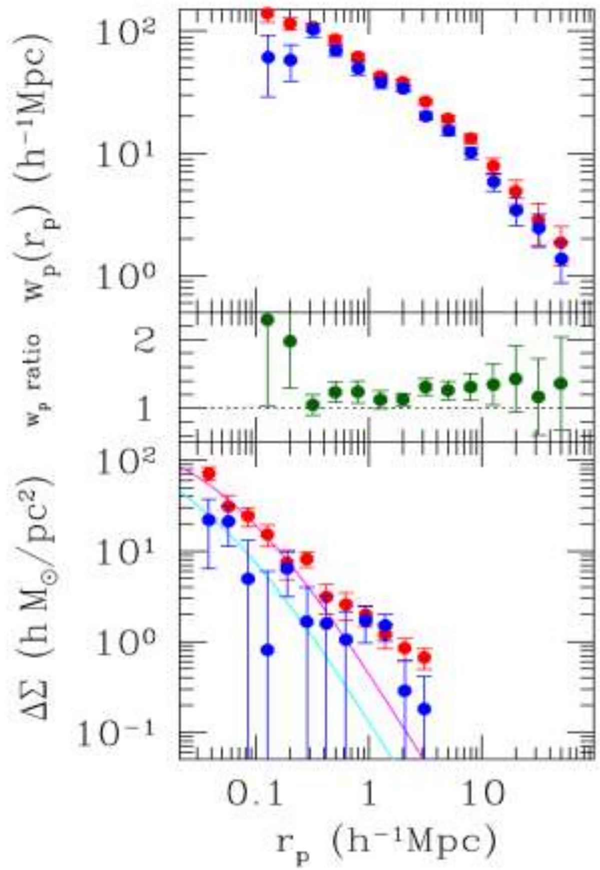
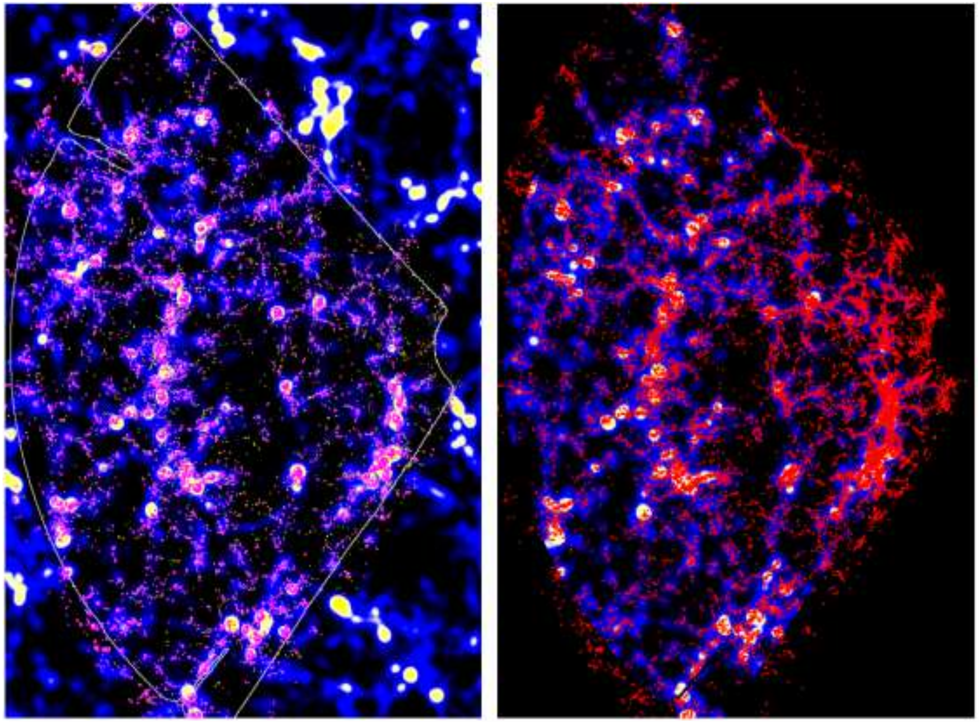


Figure 3. Similar to Fig. 2, but for central galaxies selected by the resolved SFH from VESPA. The red and blue points represent the early- and late-forming samples, respectively. Although the early-forming sample has higher large-scale bias, this is mainly due to the ~ 3.4 times difference in halo mass: galaxy-galaxy lensing indicates the two samples have mass M_{200c} of $(9.7^{+1.9}_{-1.6}) \times 10^{11}\, h^{-1} M_\odot$ and $(2.8^{+1.8}_{-1.1}) \times 10^{11}\, h^{-1} M_\odot$, respectively. The two curves in the bottom panel represent the best-fit NFW profiles (magenta: early-forming; cyan: late-forming).

Lin et al. 2016, ApJ

Linking galaxies/groups with halos



- **In the ELUCID simulation, the structures are associated with those groups in the SDSS DR7**
- **Thus we can link groups (galaxies) in observations with simulated halos!**

- Then for the halos in the ELUCID simulation with the same masses, we can check their assembly bias w.r.t. Galaxy properties

Linking SDSS groups with halos in ELUCID

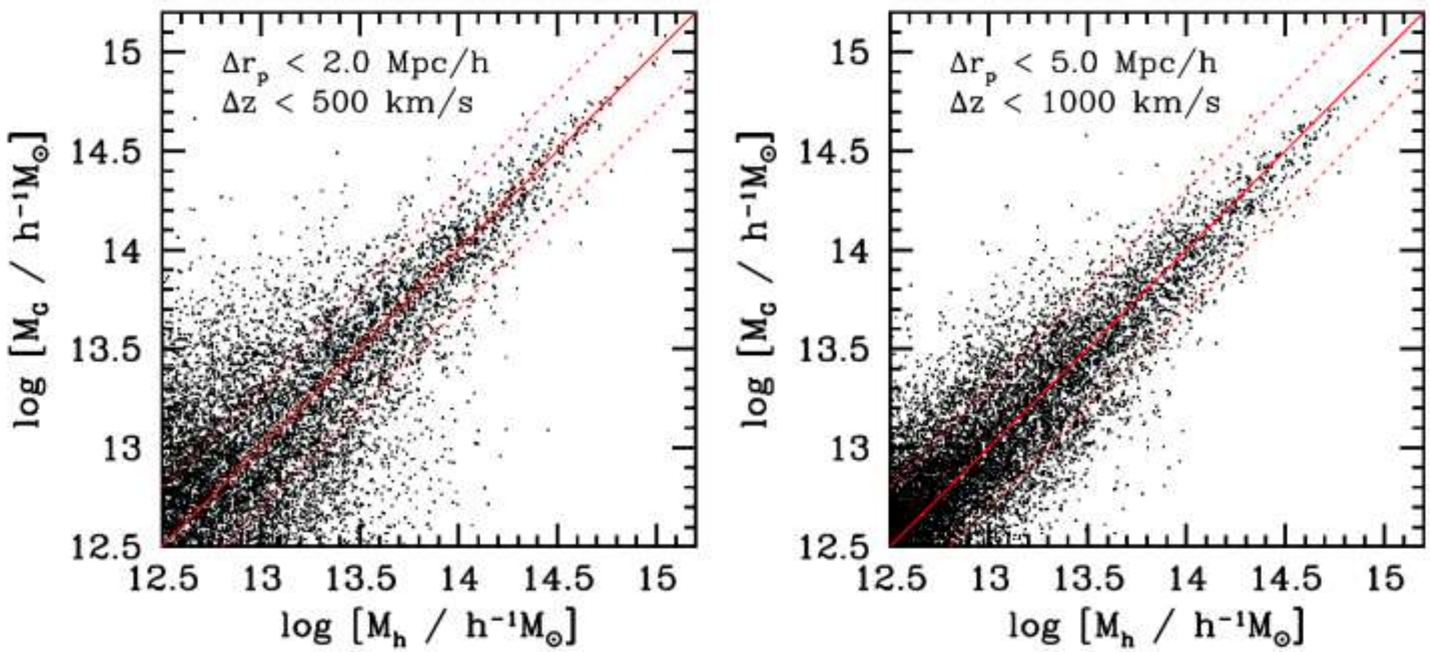
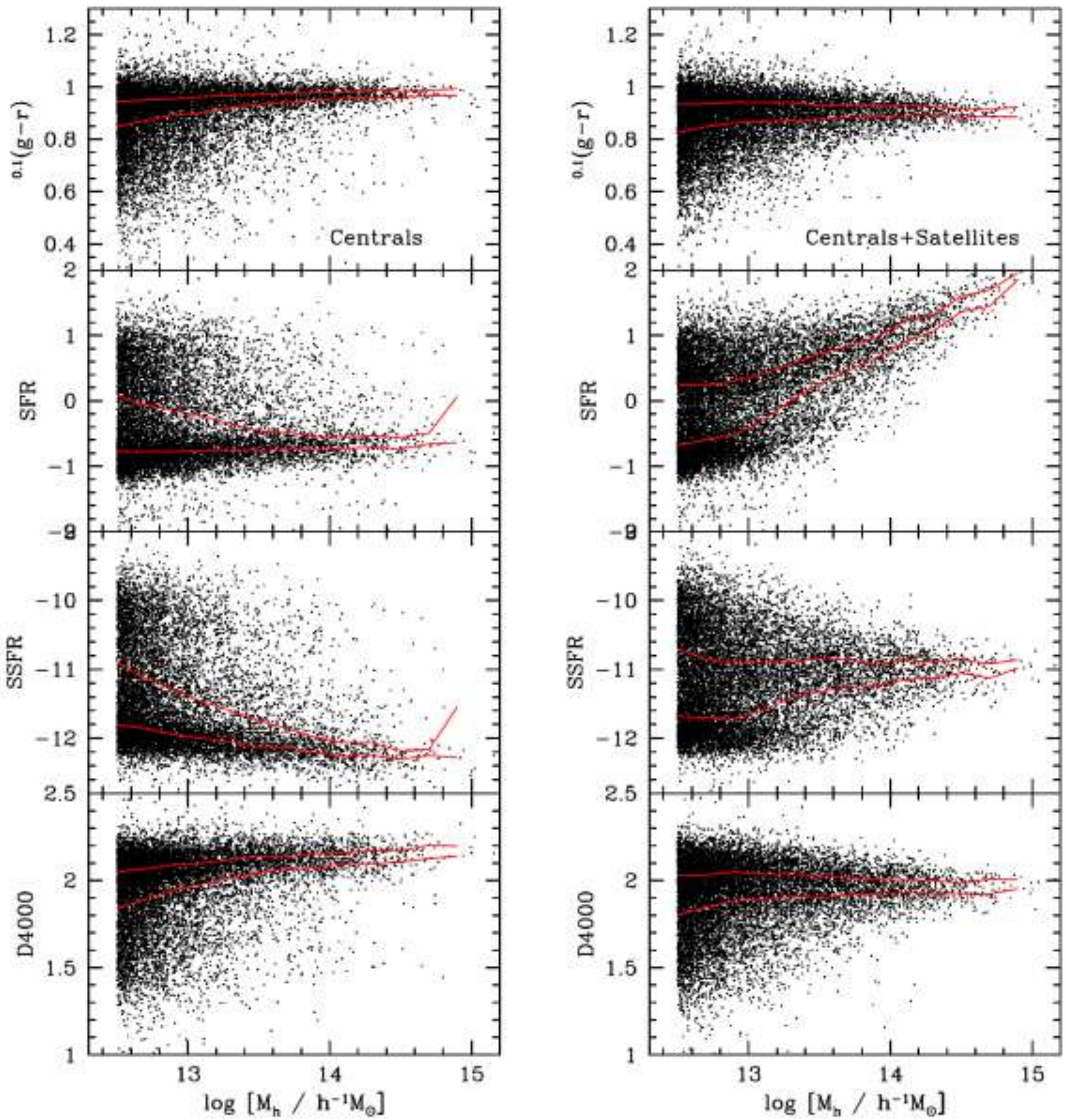


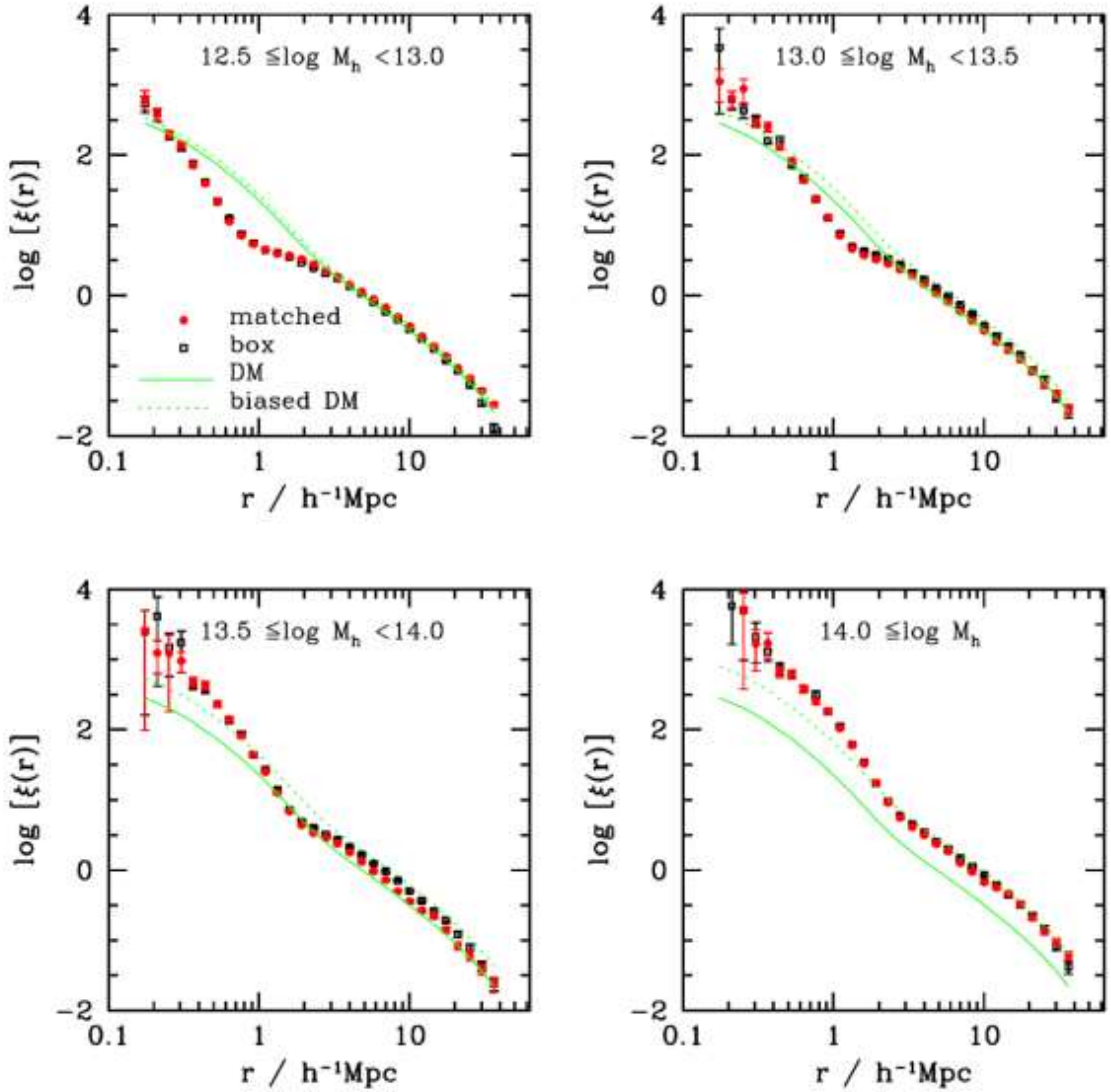
FIG. 2.— The group mass $\log M_G$ in SDSS v.s. the halo mass $\log M_h$ in the ELUCID simulation. In the left panel, the results are shown for matching criteria, $\Delta r_p < 2\,h^{-1}$Mpc and $\Delta z < 500\,\mathrm{km\,s^{-1}}$. While the results shown in the right panel are for matching criteria, $\Delta r_p < 5\,h^{-1}$Mpc and $\Delta z < 1000\,\mathrm{km\,s^{-1}}$.

- Ranked nearby most massive halo matching

Separate halos into different subsamples

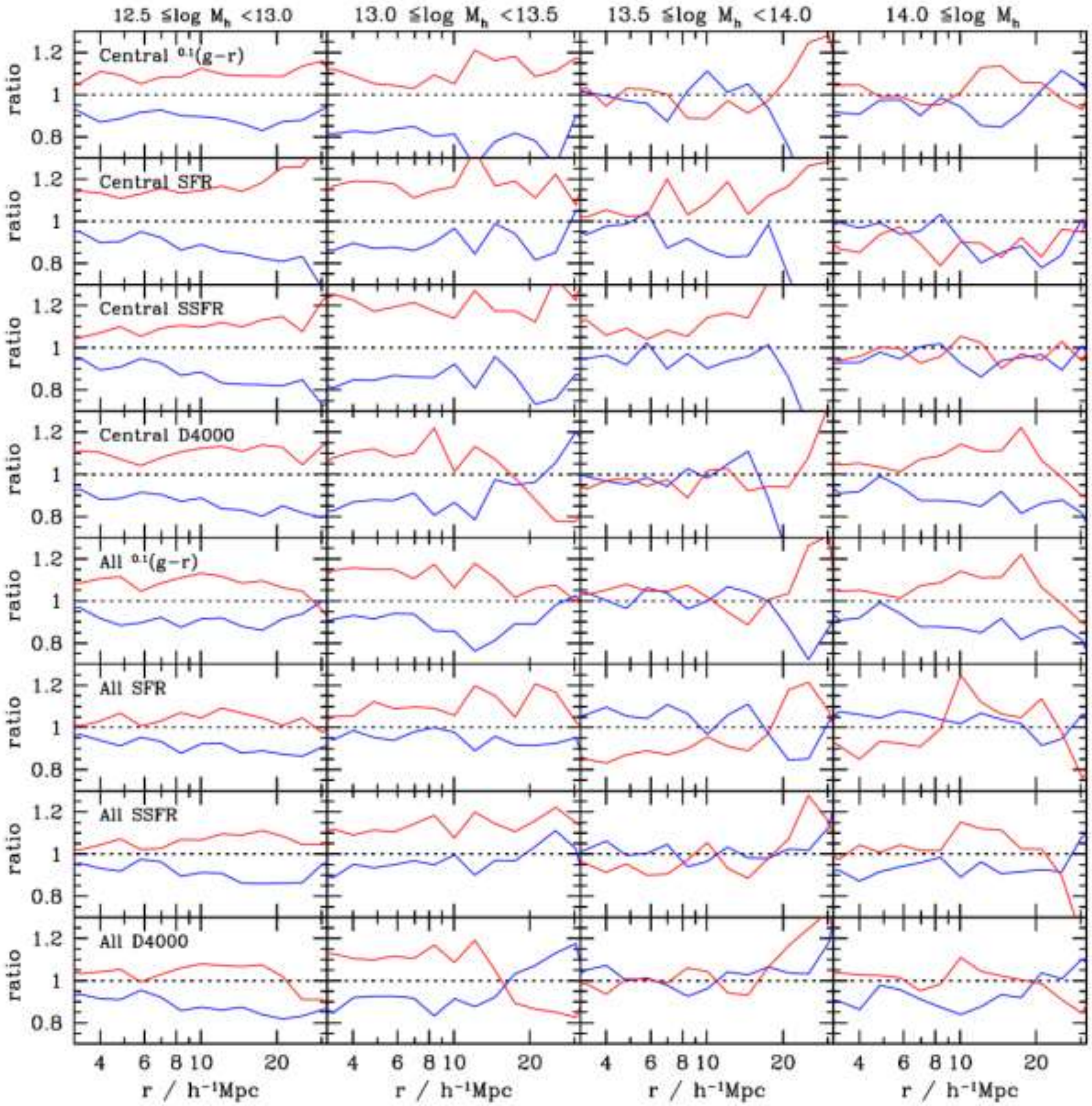


Measure the CCFs of halos

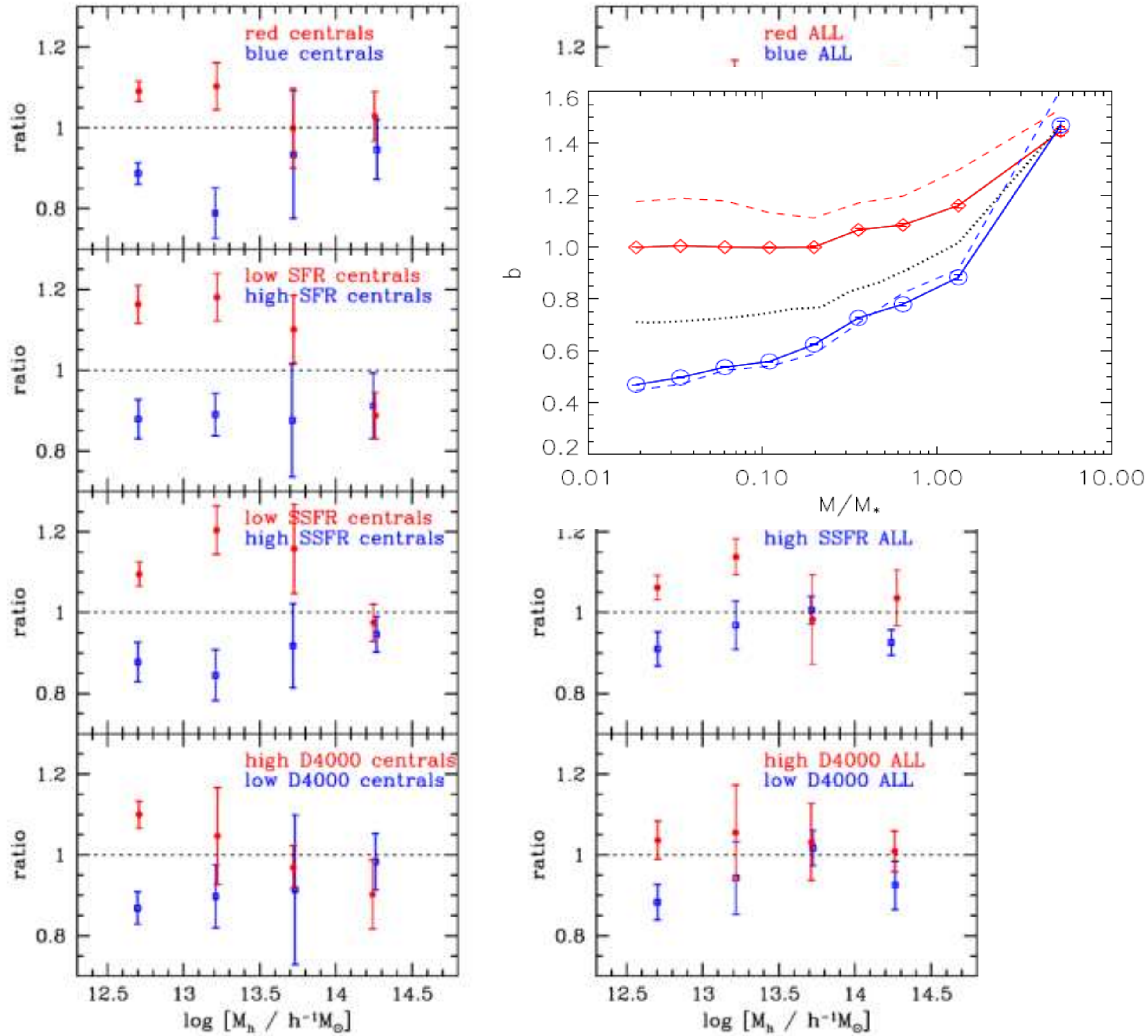


- halo-dark matter cross correlation function

The CCF ratios



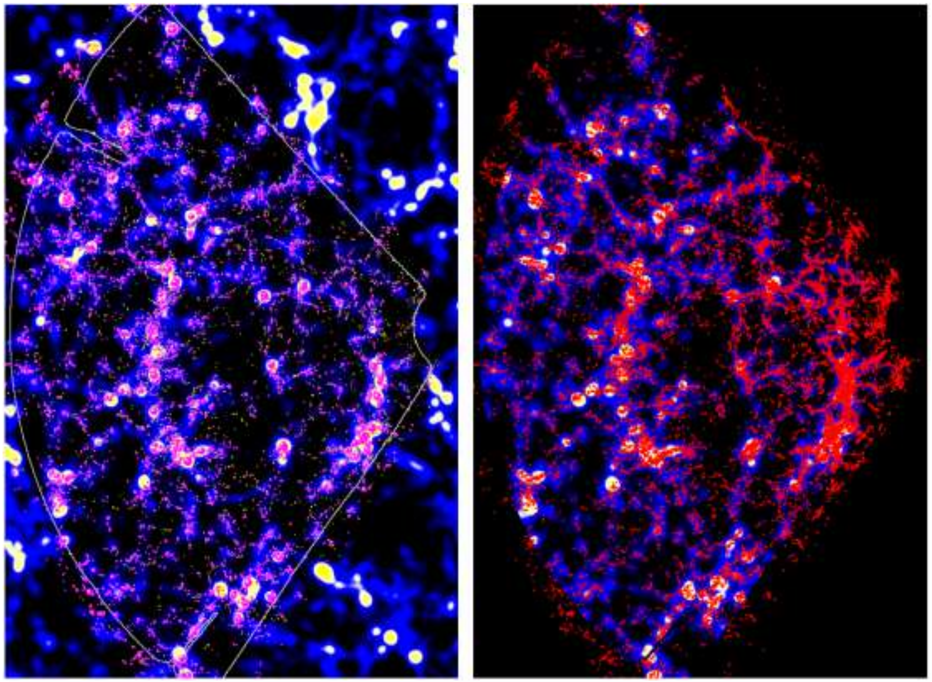
Do have assembly bias



Conclusions

- We do see 20%-30% halo assembly bias associated with galaxy properties! – Futher work is needed to evaluate its impact on cosmological probes.

Future work on galaxy formation:



Model:

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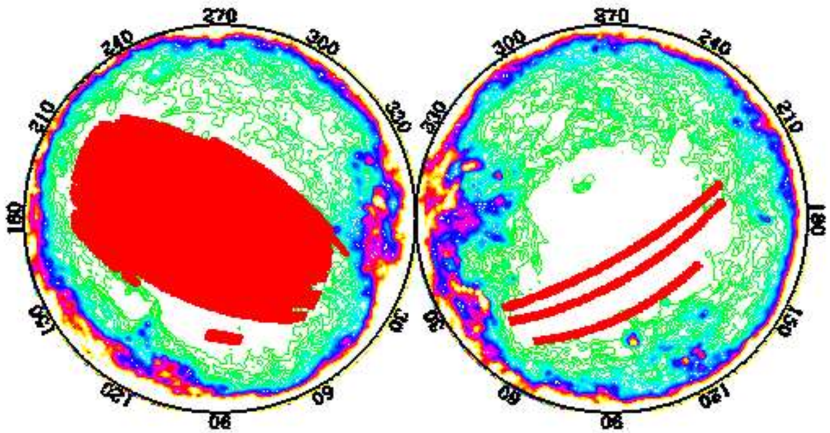
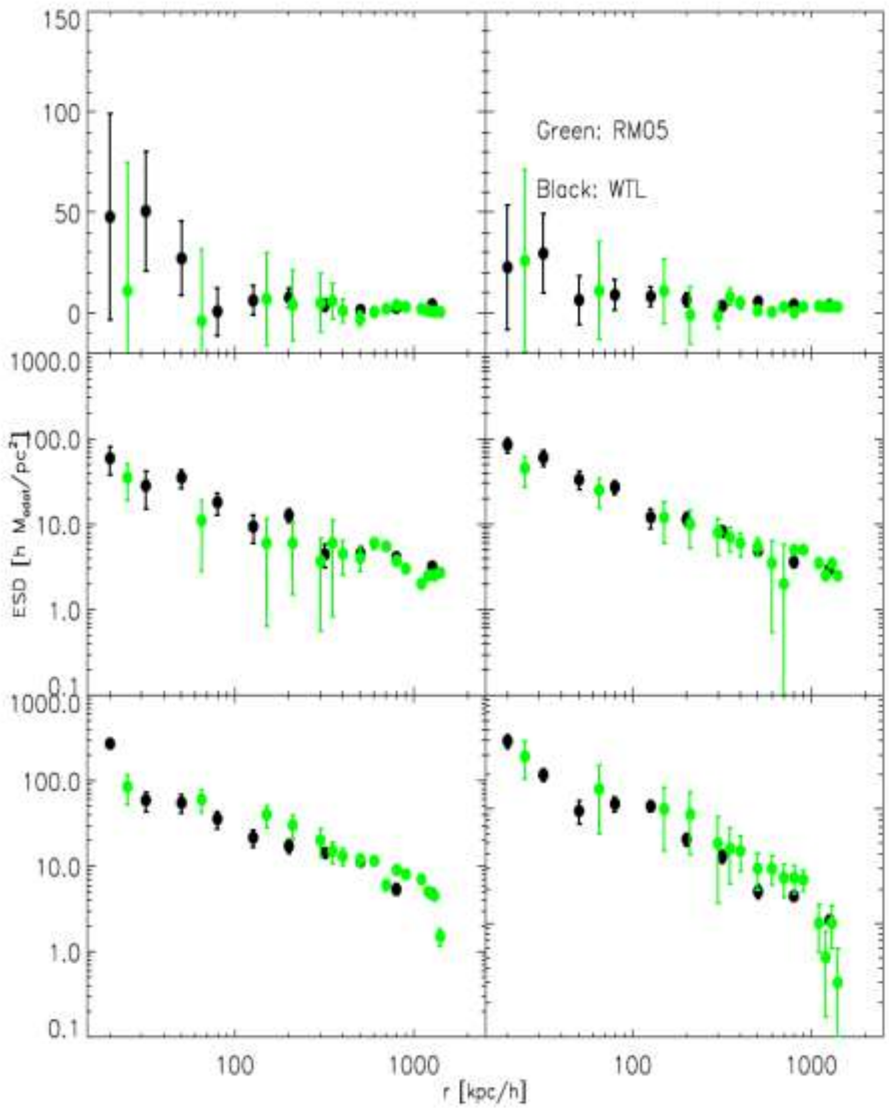
Observation:

- Galaxy properties: galaxy redshift survey;
- ISM properties: 21cm emission, millimeter/submillimeter emissions;
- IGM properties: quasar absorption line systems; X-ray observations; Sunyaev-Zel'dovich effect.

(1) The galaxy-galaxy lensing signals

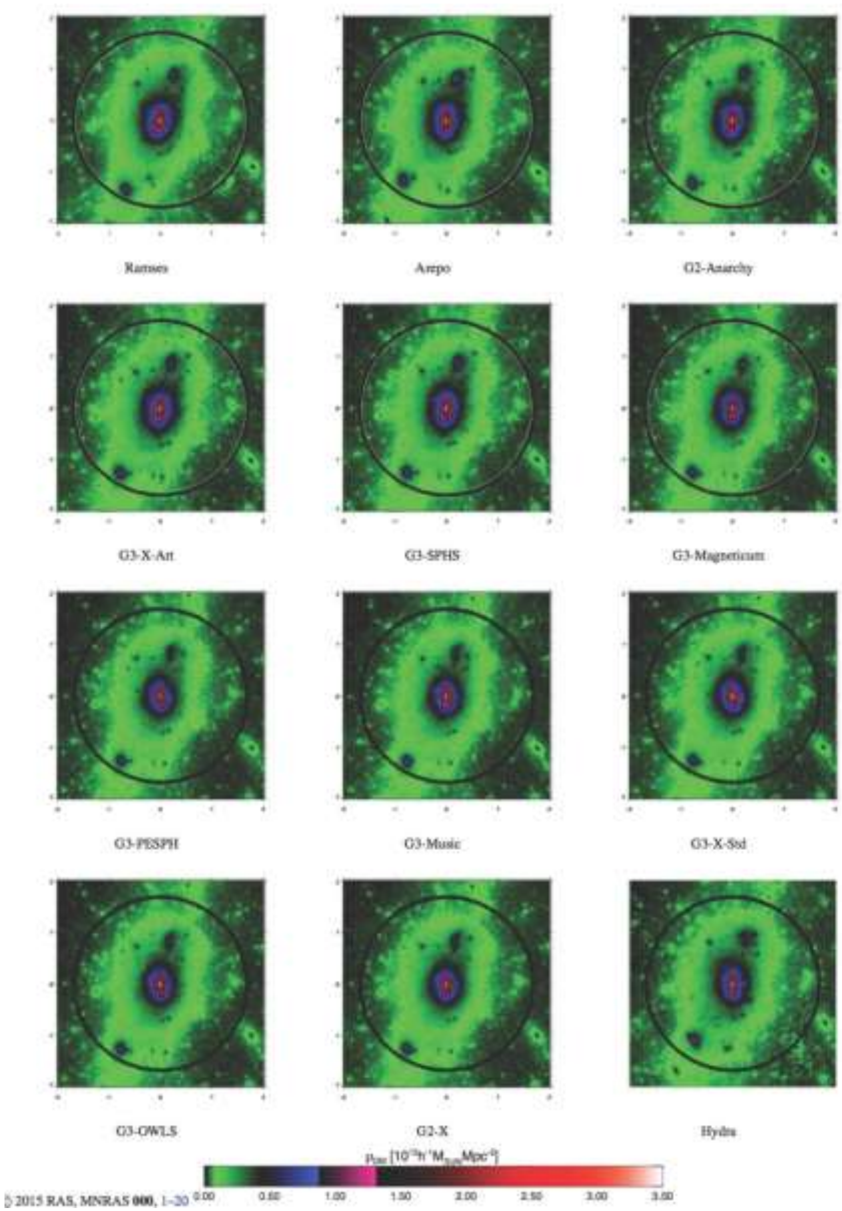




★ We processed the images of SDSS DR7 30M galaxies. Obtained the related galaxy-galaxy lensing signals.

★ Wentao Luo, Xiaohu Yang, Jun Zhang, Dylan Tweed, Huiyuan Wang, Houjun Mo, etc.

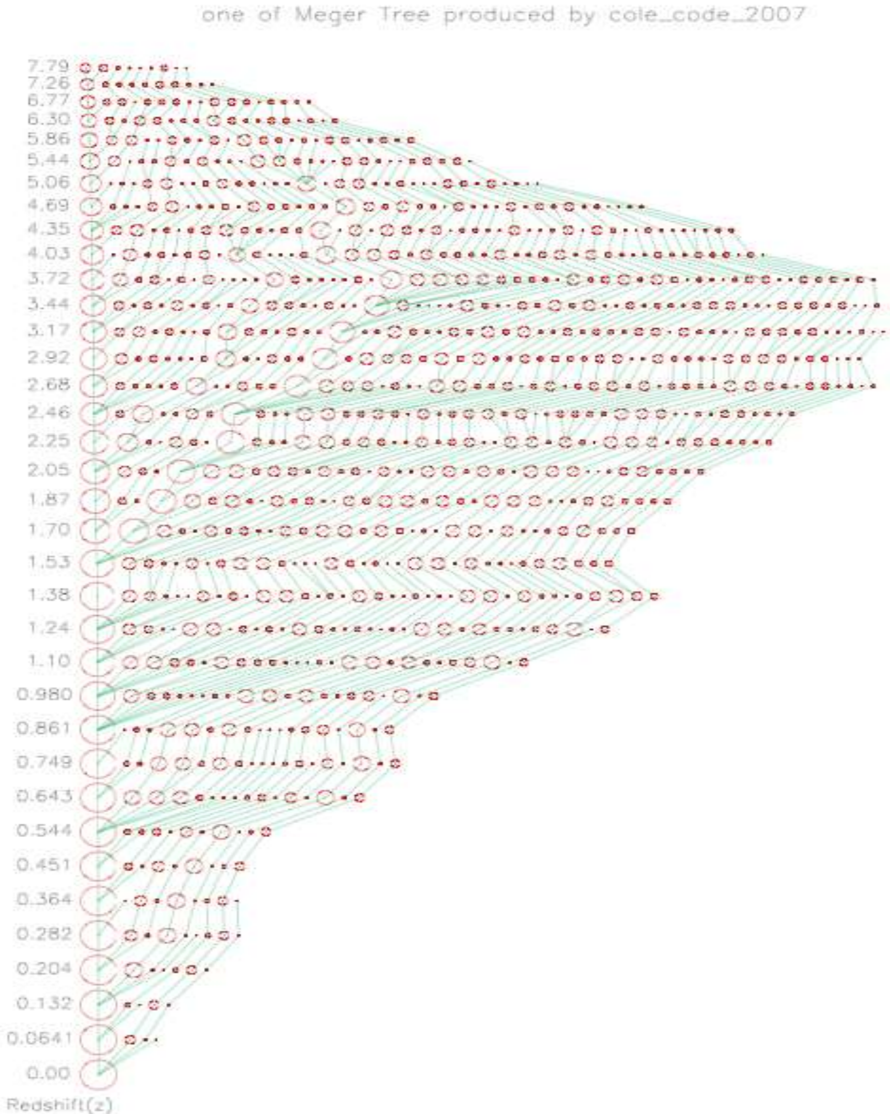
（2）Hydrosimulations of 100 clusters



★ Simulating 100 most massive clusters in the SDSS DR7 region, compare with the related Xray observations。

★ Weiguang Cui, Huiyuan Wang, Youcai Zhang, etc.

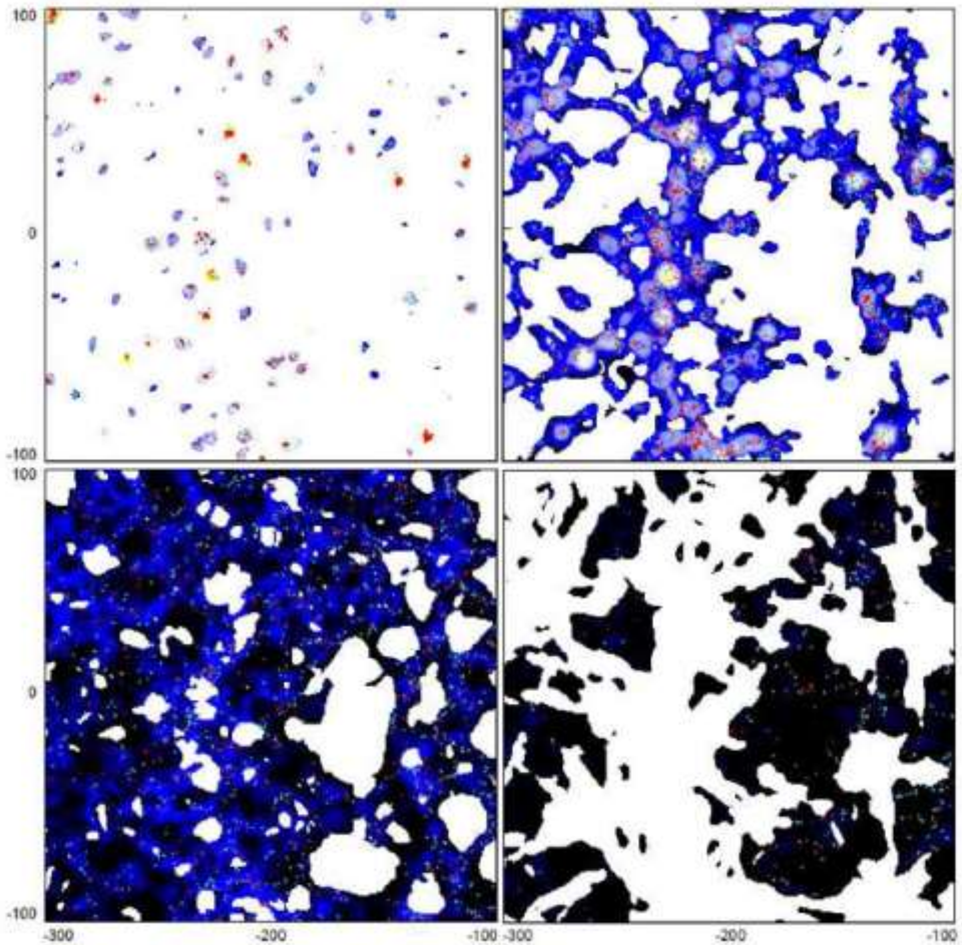
(3) The semi-analytical model of galaxy formation



★ We will model the galaxy properties using 3 sets of SAMs. Comparing with the galaxy content in the SDSS DR7 region。

★ Shijie Li, Yu Lu, Xi Kang, Qi Guo, etc.

(4) The cosmic web



★ We will model the evolution of cosmic web in the SDSS DR7 region。

★ Youcai Zhang, Xiaohu Yang, Huiyuan Wang, etc.

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Submitted by zhangpengjie on Wed, 2016-10-12 03:33

Submission Dates

Post Date: November 1, 2016
Archive Date: December 31, 2016
Deadline to Apply for Job: May 30, 2017

Job Details

Job Category: Post-doctoral Positions and Fellowships
Institution/Company Name: Shanghai Jiao Tong University
Institution Classification/Type: Large Academic

Submission Address for Resumes/CVs

Attention To: caajobs@sjtu.edu.cn

Announcement

Job Announcement Text:

The Center for Astronomy and Astrophysics (CAA) at Shanghai Jiao Tong University (SJTU), one of the top universities in China, is gearing to become a center of excellence in Astronomy and Astrophysics. Comprising 10 faculty members and a fast growing group of postdocs, the research team is very diverse and international, spanning across theoretical, numerical, and observational frontiers of galaxy formation and cosmology. More information can be found at http://astro.sjtu.edu.cn/.

The CAA is seeking to fill up to 8 postdoctoral positions in extragalactic astronomy and cosmology. CAA itself is involved in several international observational and numerical projects. Data access includes, the Prime Focus Spectrograph (PFS), the Square Kilometer Array (SKA), and also major observational facilities, directly or through collaborations (Subaru, CFHT, MMT, Magellan, JCMT, etc.). Available computing resources include our institute computer cluster with 1000 CPU cores, a SGI with 256 cores and 4T shared memory, access to the SJTU High Performance Computing Center Supercomputer (HPCC) with 5000 CPU cores, and to national supercomputer centers with higher capacity. In addition, the CAA has ample research and travel funds, and an active visitor program.

The successful candidates will have the opportunity to work on broad areas of interest in the context of (1) galaxy formation and evolution, (2) numerical cosmological simulations, (3) weak gravitational lensing, redshift space distortion and other large scale structures of universe, (4) observational cosmology and data analysis, and (5) theoretical cosmology.

The appointment is initially for 2 years, extendable by another year. Salary depends on qualifications and experience, but will be competitive internationally. In addition, the University offers very generous housing subsidies annually.

Applicants should submit a curriculum vitae and a brief research summary, and arrange three reference letters to be directly sent to: caajobs@sjtu.edu.cn. Applications will be considered until