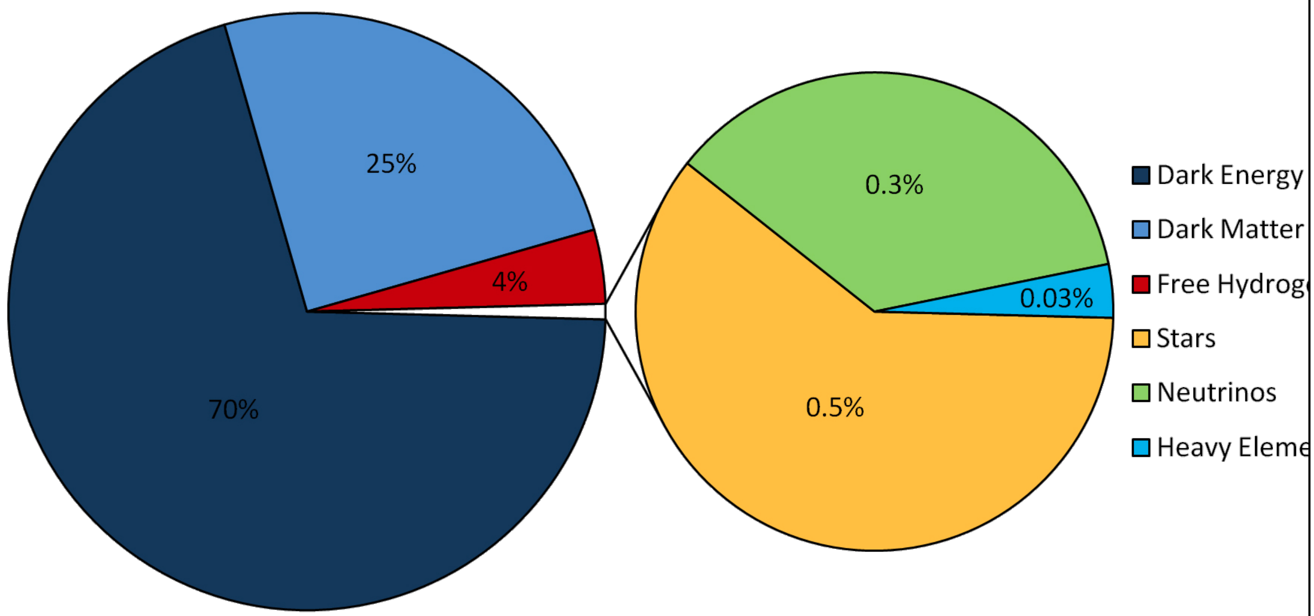
oct 19 @ berkeley

Cluster Cross-Correlation Cosmology

ying zu (osu)

mostly with david weinberg (osu)

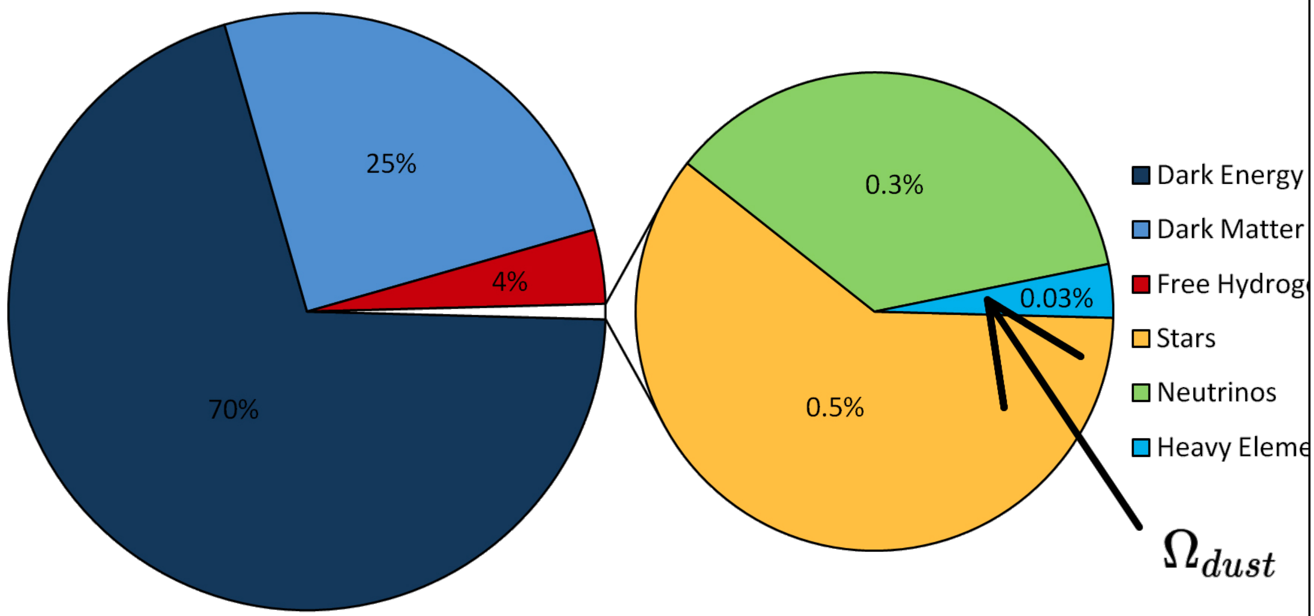
Composition of the Universe



Cross-Correlations

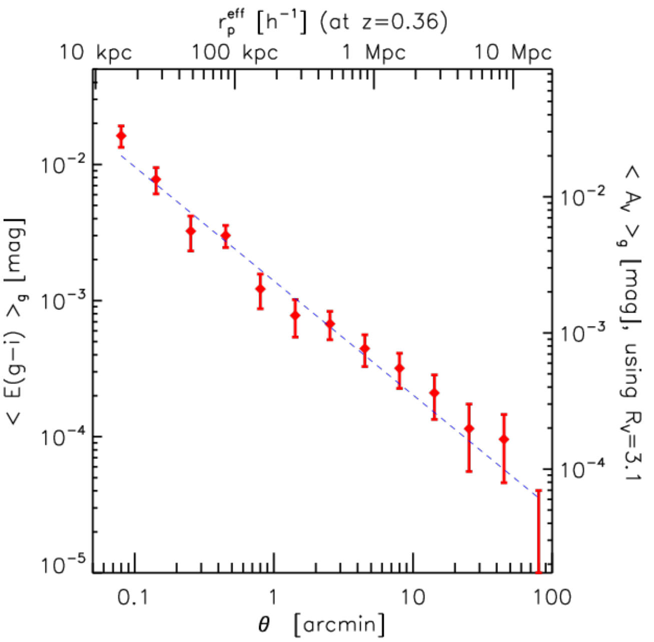
1. ***Galaxy***-quasar color : intergalactic dust distribution
2. ***Cluster***-shear : cluster density profile
3. ***Cluster***-galaxy (redshift space) : cluster galaxy kinematics

Cosmic Nuisance?



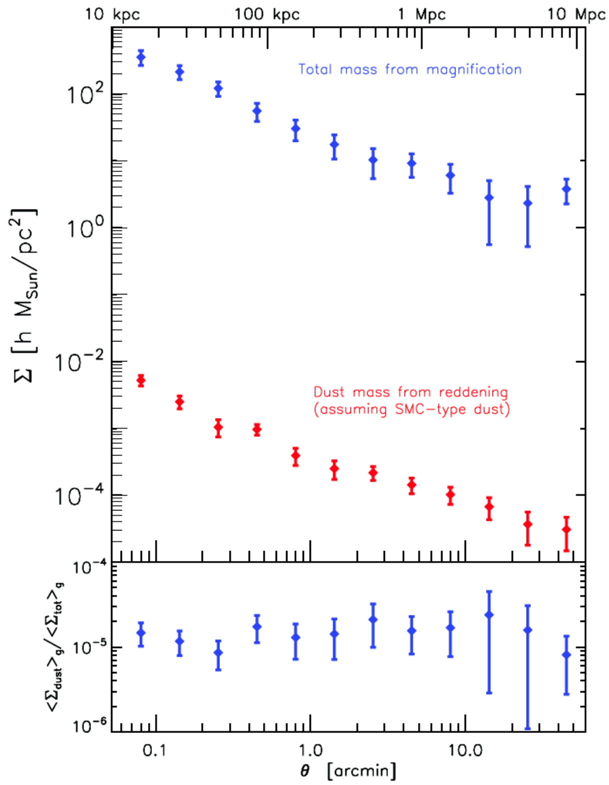
Intergalactic Dust?

Systematic change in the mean color of quasars VS. projected separation (Menárd et al 2010)

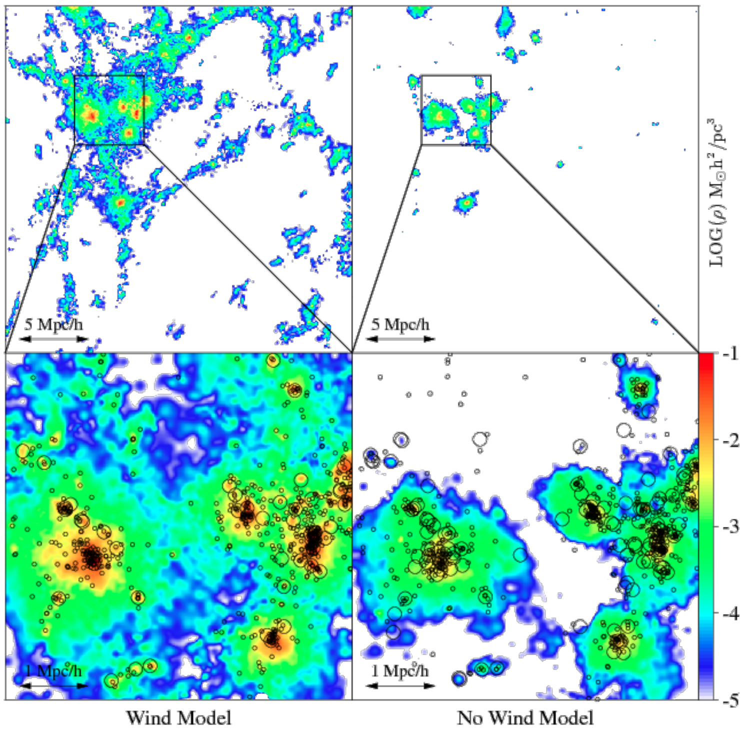


$\Omega_{dust} \simeq 4.6 \times 10^{-6}$

Dust density profile follows matter distribution measured by lensing magnification.



From *free* metal to IG dust

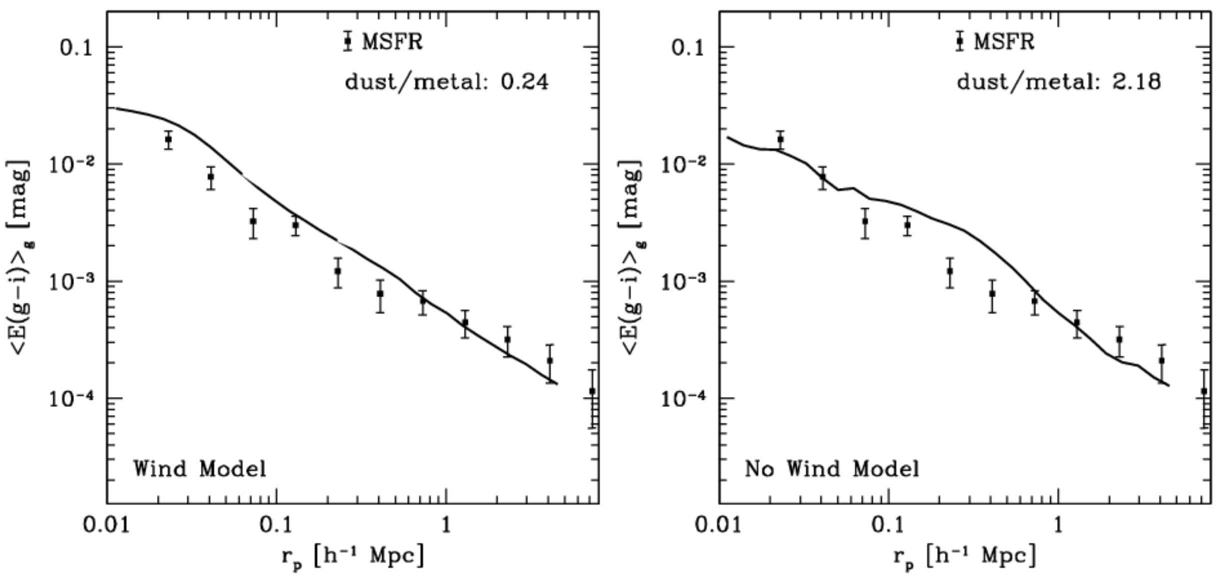


free as unbound by galaxy potential.

- *free* Z on the left: momentum--driven outflow.
- *free* Z on the right: tidal stripping and ram pressure in groups.

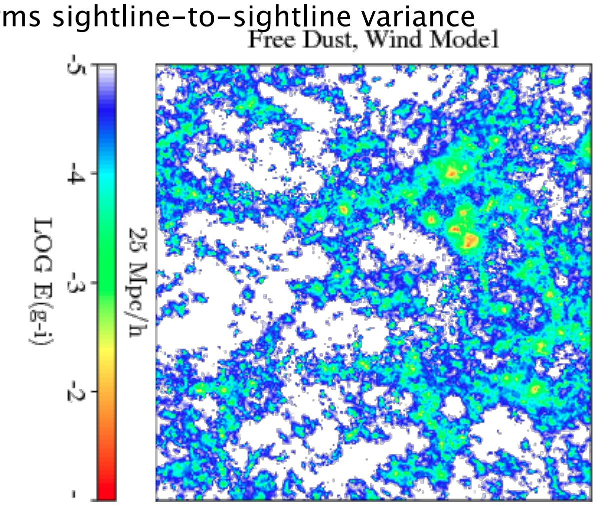
fit to MSFR observation

free metal+wind vs. free metal+no-wind



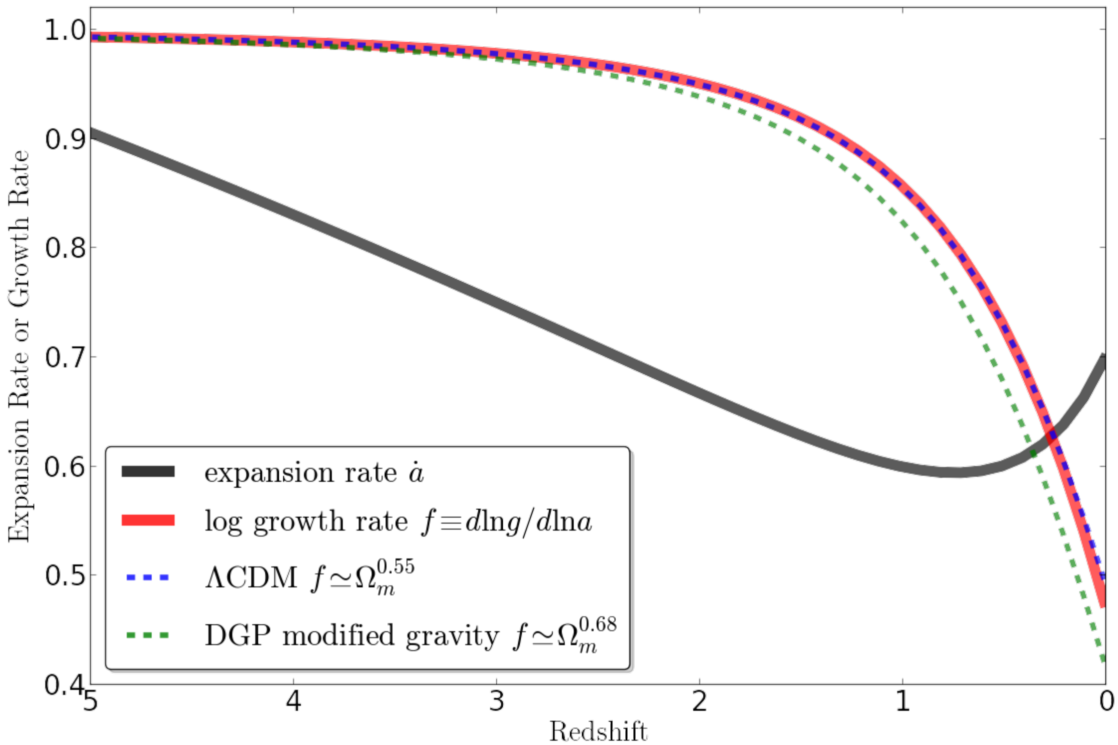
Summary (Zu+ 2010)

1. The wind simulation is able to reproduce the MSFR observation provided that 25% of the metal mass in the IGM is in the form of SMC-like dust.
2. It is very difficult for the simulation without outflows to explain MSFR result.
3. There is a narrow window of environment for dust grains to escape and surve in the IGM.
4. Large scale diffuse dust has to be taken into account in future SN cosmology: the wind simulation prdicts a $\bar{A}_v = 0.0048 mag$ and rms sightline-to-sightline variance $\sim 0.0052 mag^2$ at $z = 0.5$.



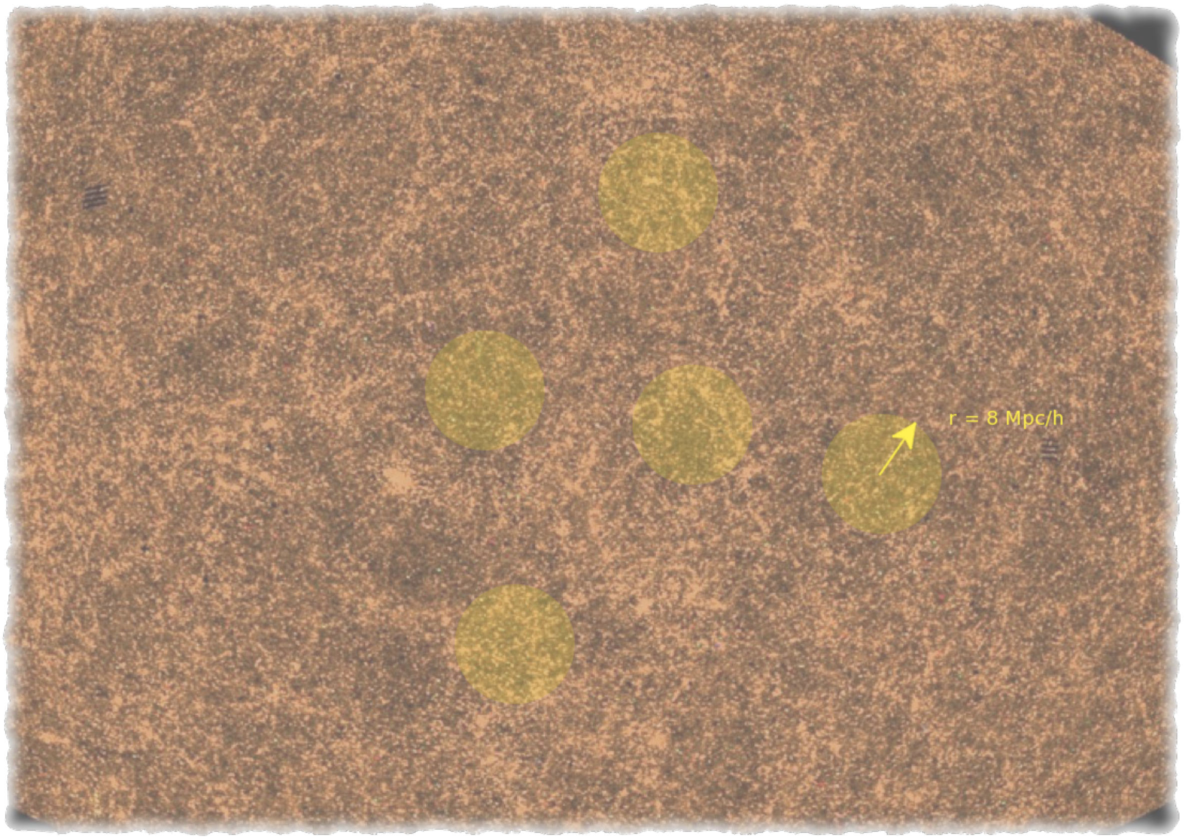
a Bigger problem

expansion history is not enough, need to probe growth

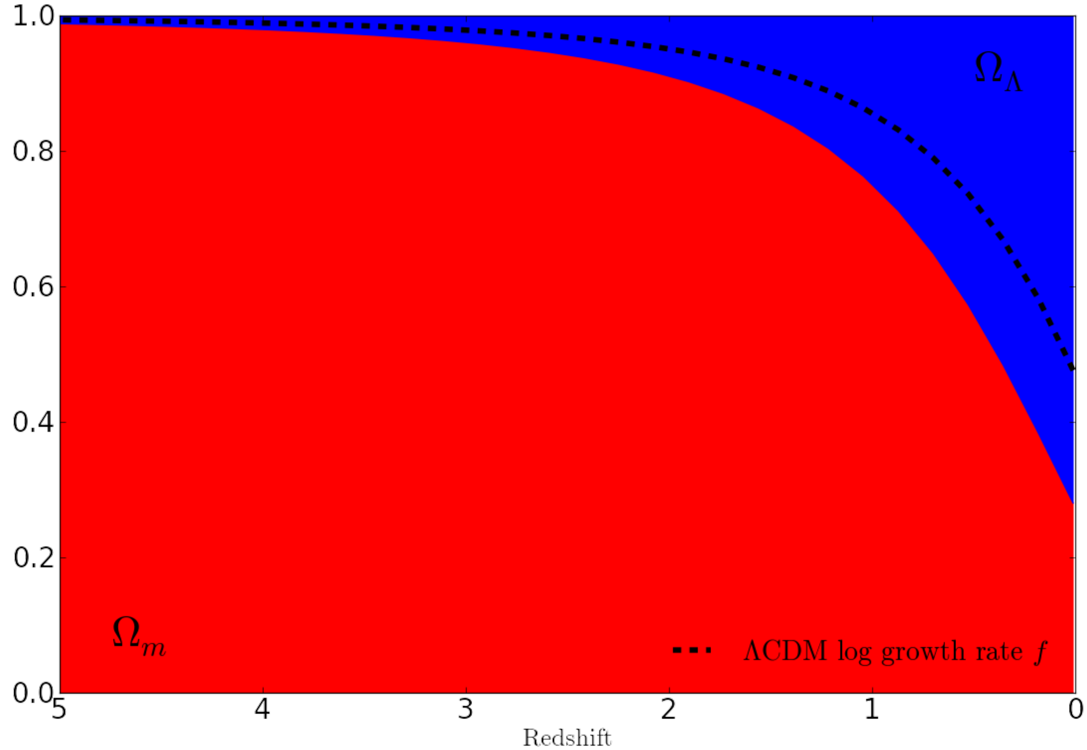


σ_8 : characterizes growth

mass variance in spheres of $8\,h^{-1}\,\mathrm{Mpc}$ radius



Cosmic Tug of War: to know Ω_m

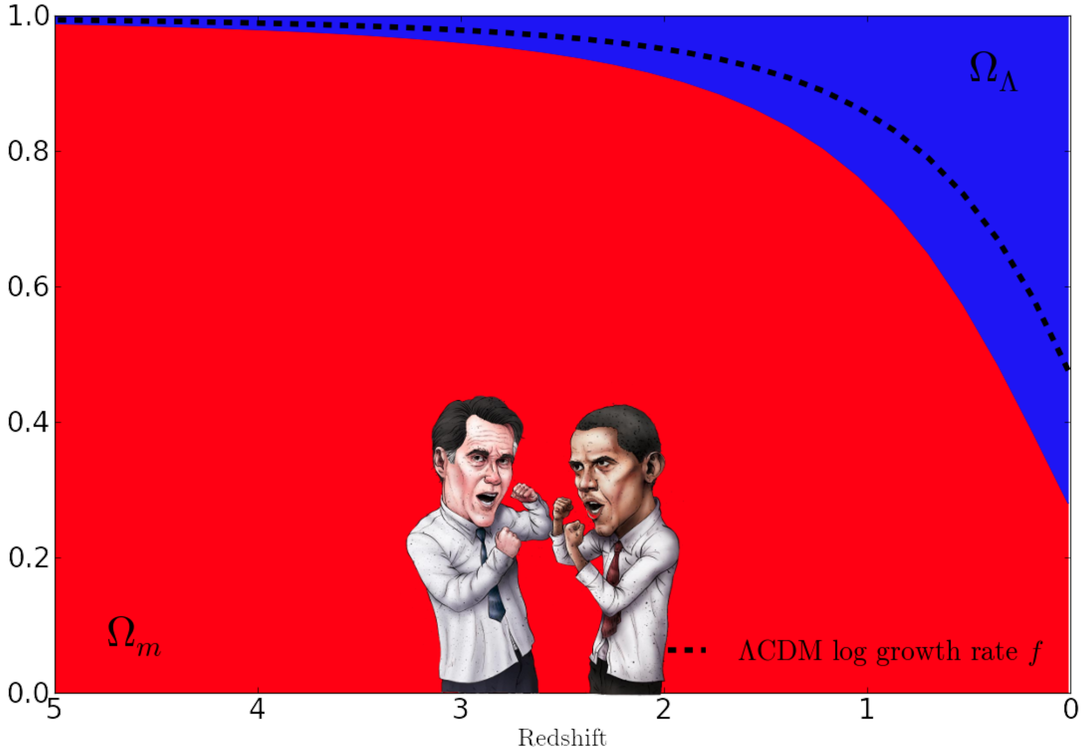


"know your enemies and know yourself, you will not be imperiled in any wars"

--- Sun Tzu, "The Art of War"

Caveat

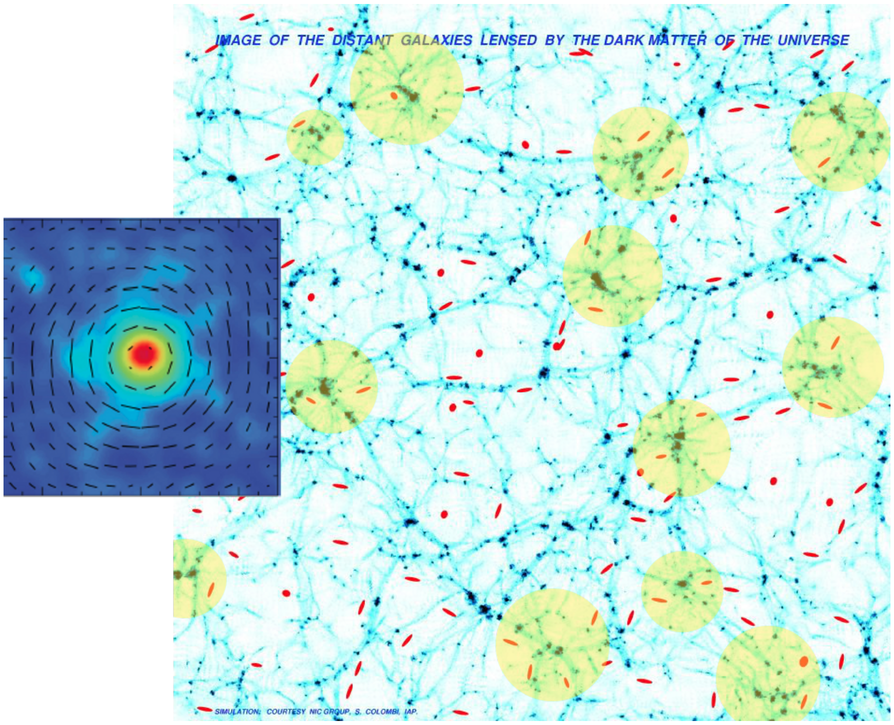
***not* a prediction for redshift zero elections.**



Cluster × shear

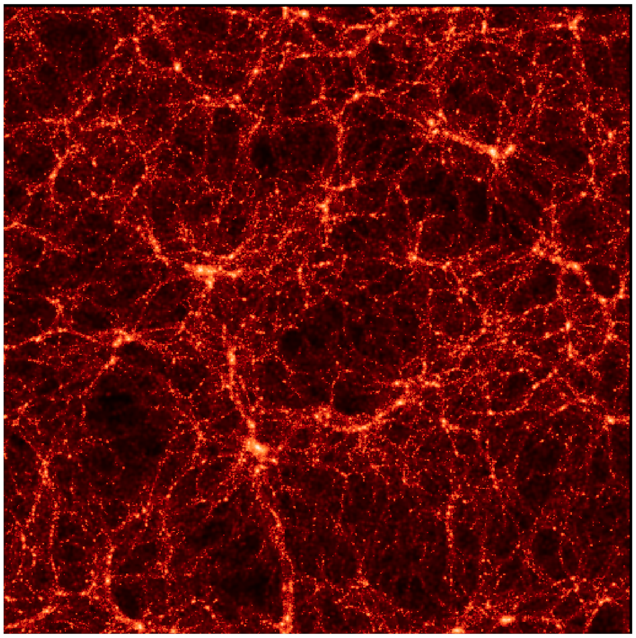
Stacked cluster weak lensing

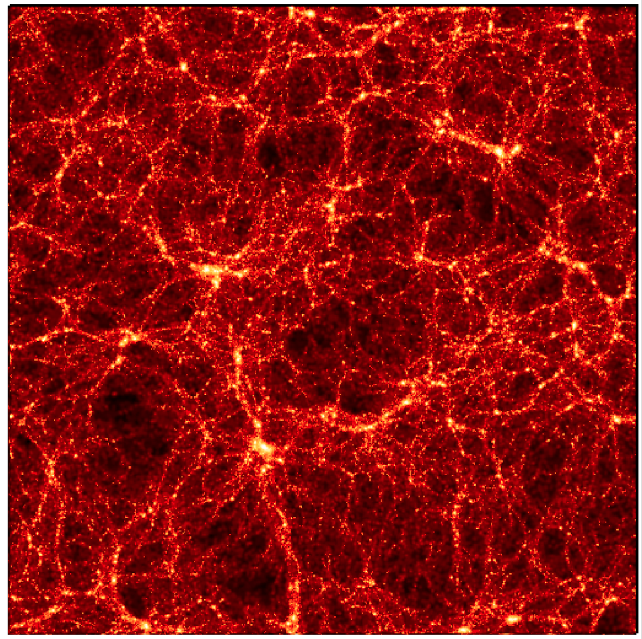
stronger S/N, less affected by projection effects



dependence on Ω_m

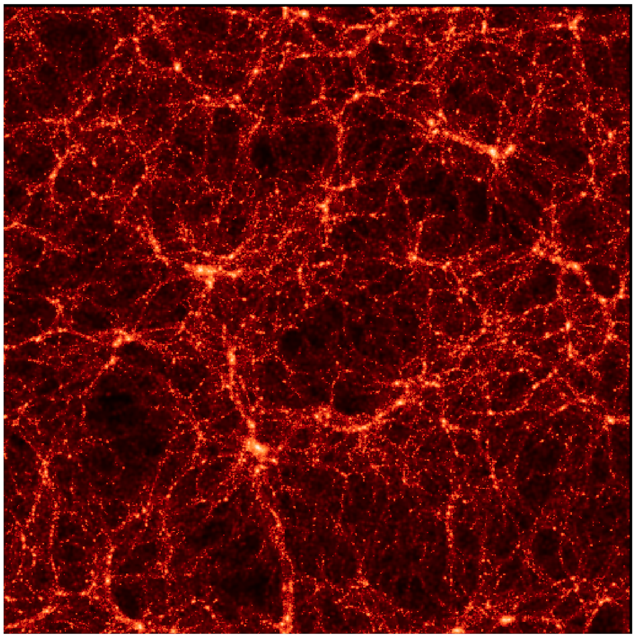
higher Ω_m, more matter, $\Delta\Sigma(R)$ ↗

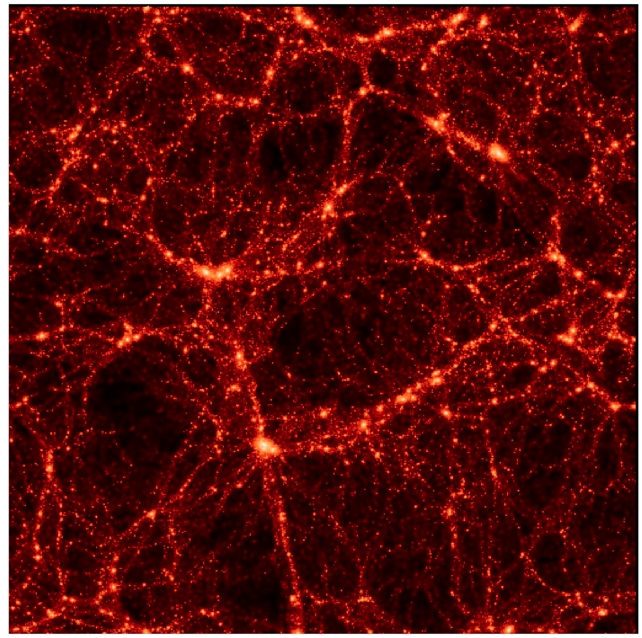




dependence on σ_8

higher σ_8, more growth, $\Delta\Sigma(R)$ ↗



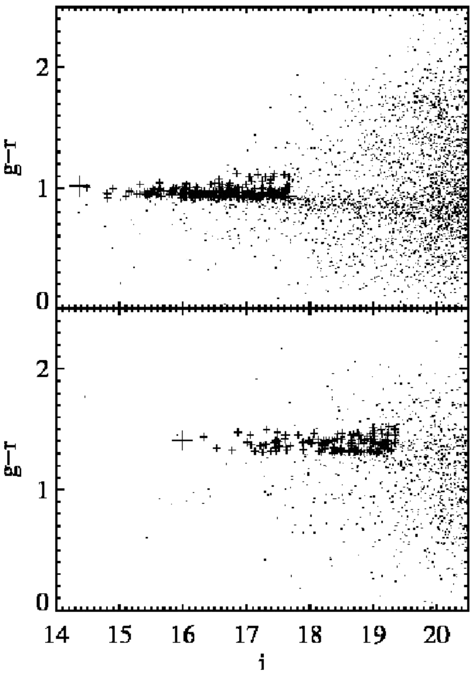


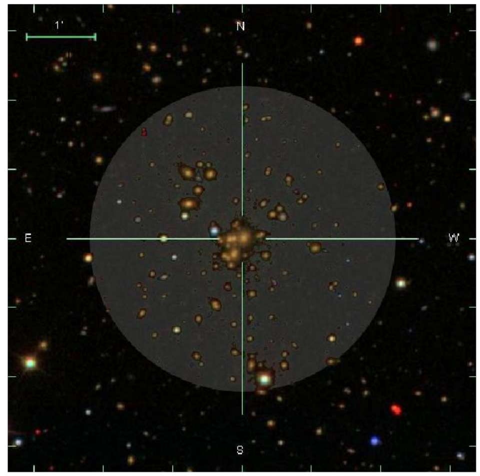
Large Scale Weak Lensing Signal

$$\Delta\Sigma(R) \quad \propto \quad \Omega_m \quad \times \quad \xi_{cm}$$

SDSS MaxBCG Clusters

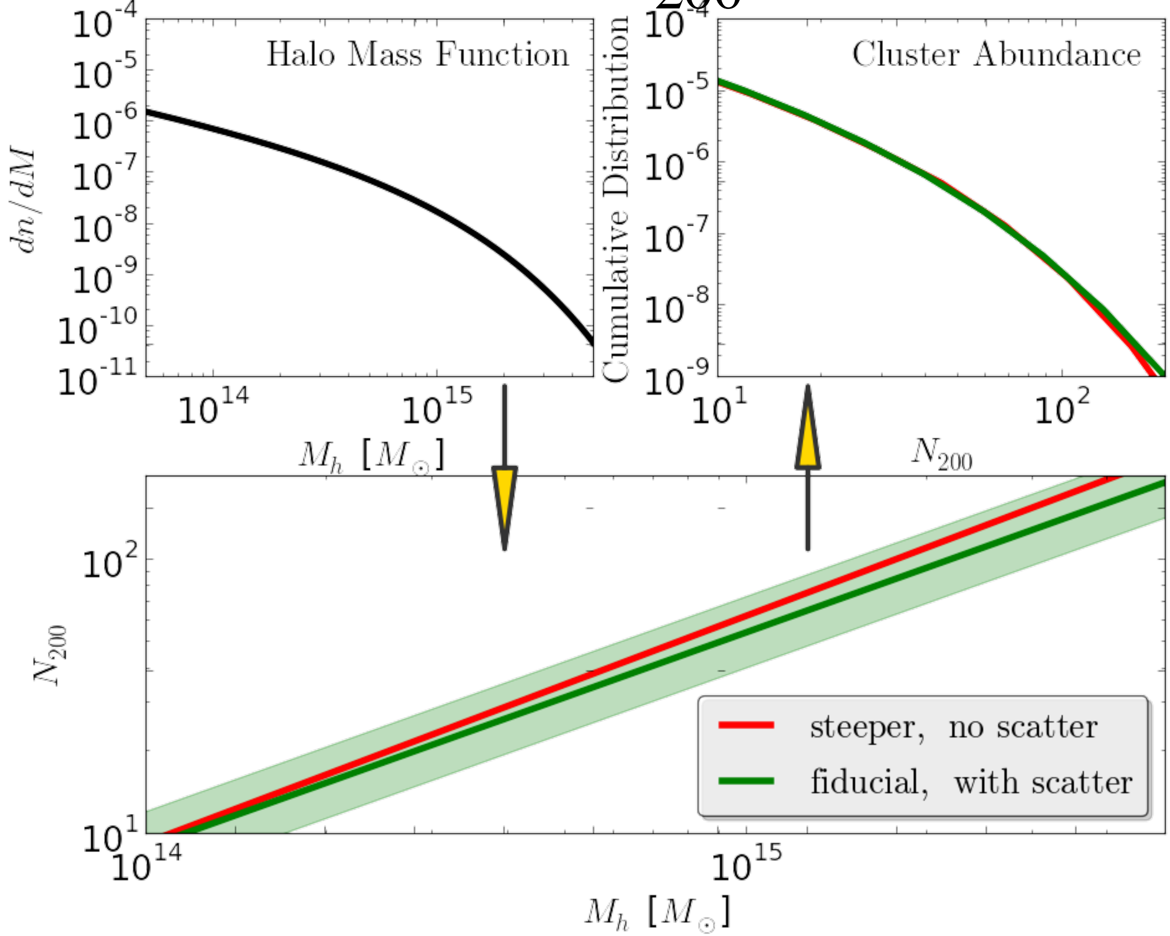
Left: red-sequence; *Right*: an example cluster





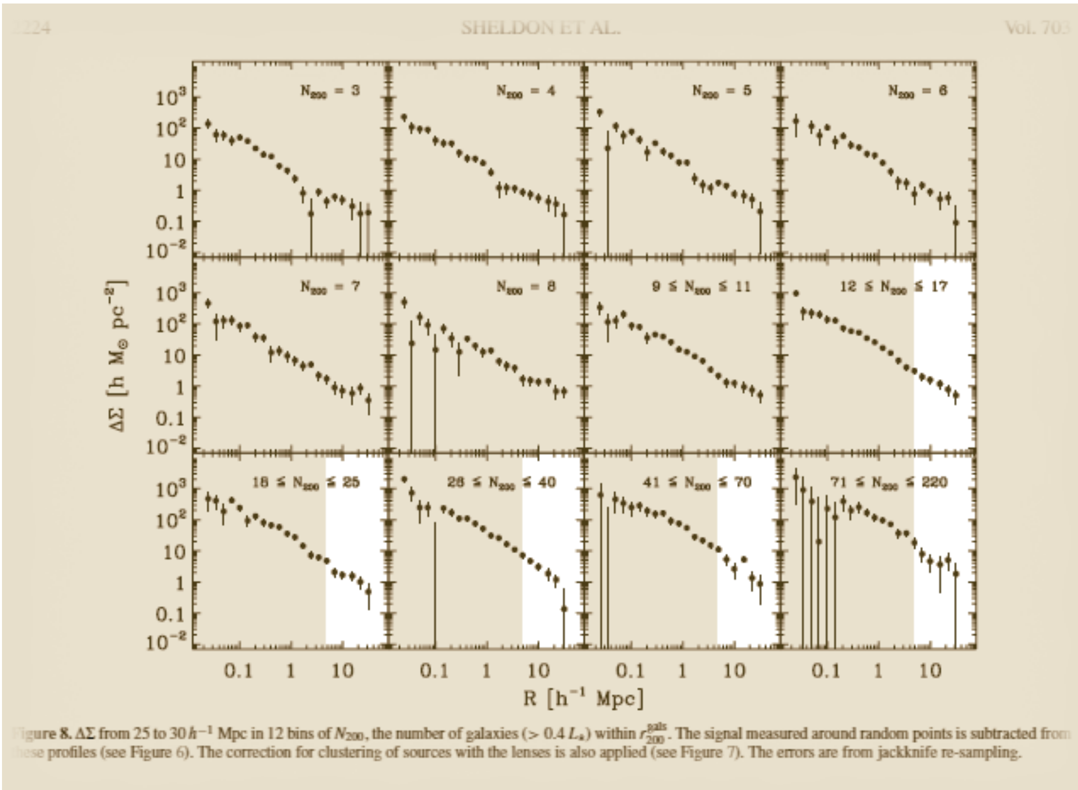
N_{200}: red-sequence galaxies brighter than $0.4L_*$ inside R_{200} (Koester et al. 2007)

Scatter between N_{200} and mass

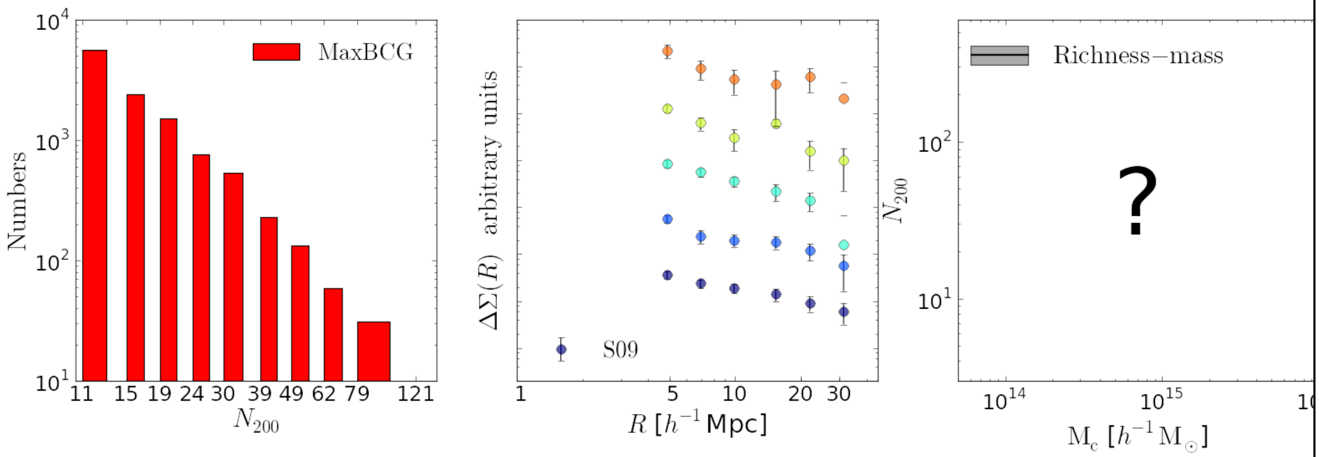


$\Delta\Sigma(R)$ from MaxBCG

we use only large scales: $5 - 30 h^{-1}\,\mathrm{Mpc}$ (Sheldon+ 2009)

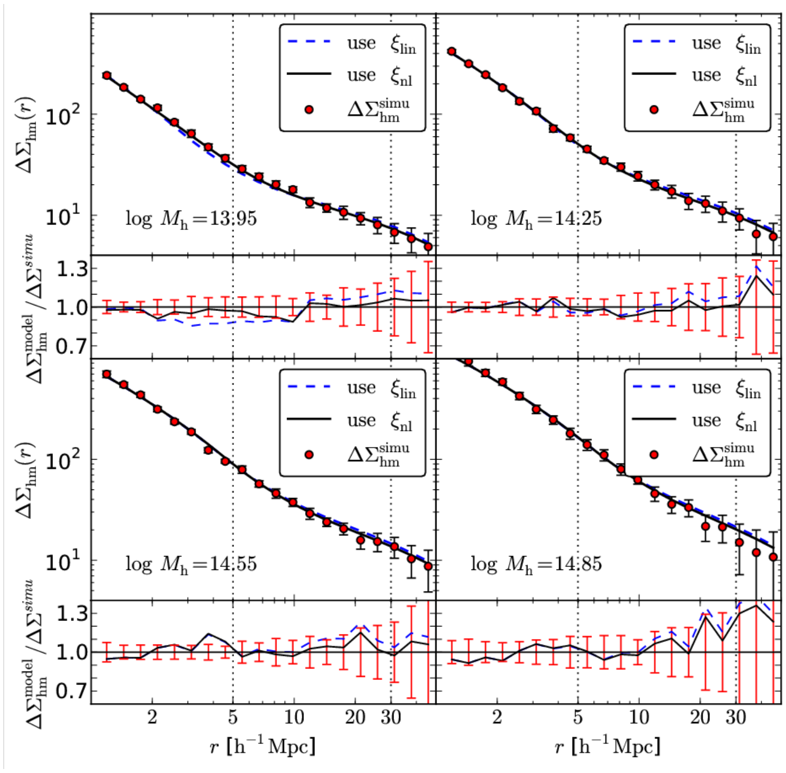


Input data


MaxBCG
Numbers
N_{200}
11 15 19 24 30 39 49 62 79 121
$\Delta\Sigma(R)$ arbitrary units
S09
R [h^{-1} Mpc]
Richness−mass
N_{200}
?
M_c [$h^{-1} M_\odot$]

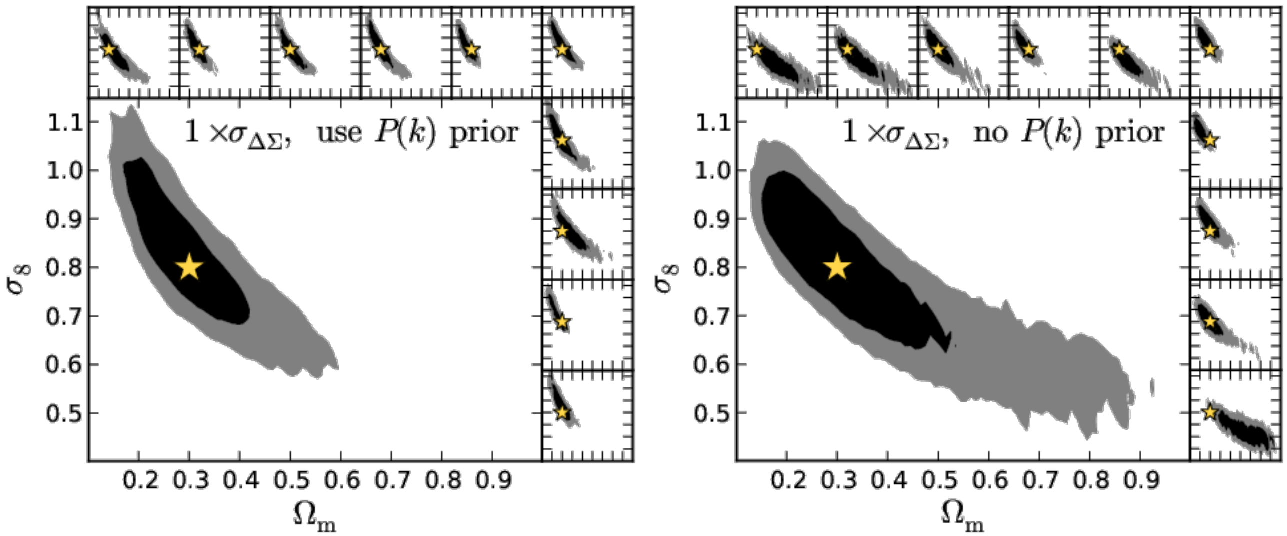
Testing model for $\Delta\Sigma(R)$

$$\xi_{cm}(r) = \max\{\varrho_{NFW}/\varrho_{mean} - 1,\ b_c \times \xi_{mm}^{non-linear}\}$$



Prior on $P(k)$ shape

prior on the shape of $P(k)$ measured from galaxy clustering (Reid+ 2010).

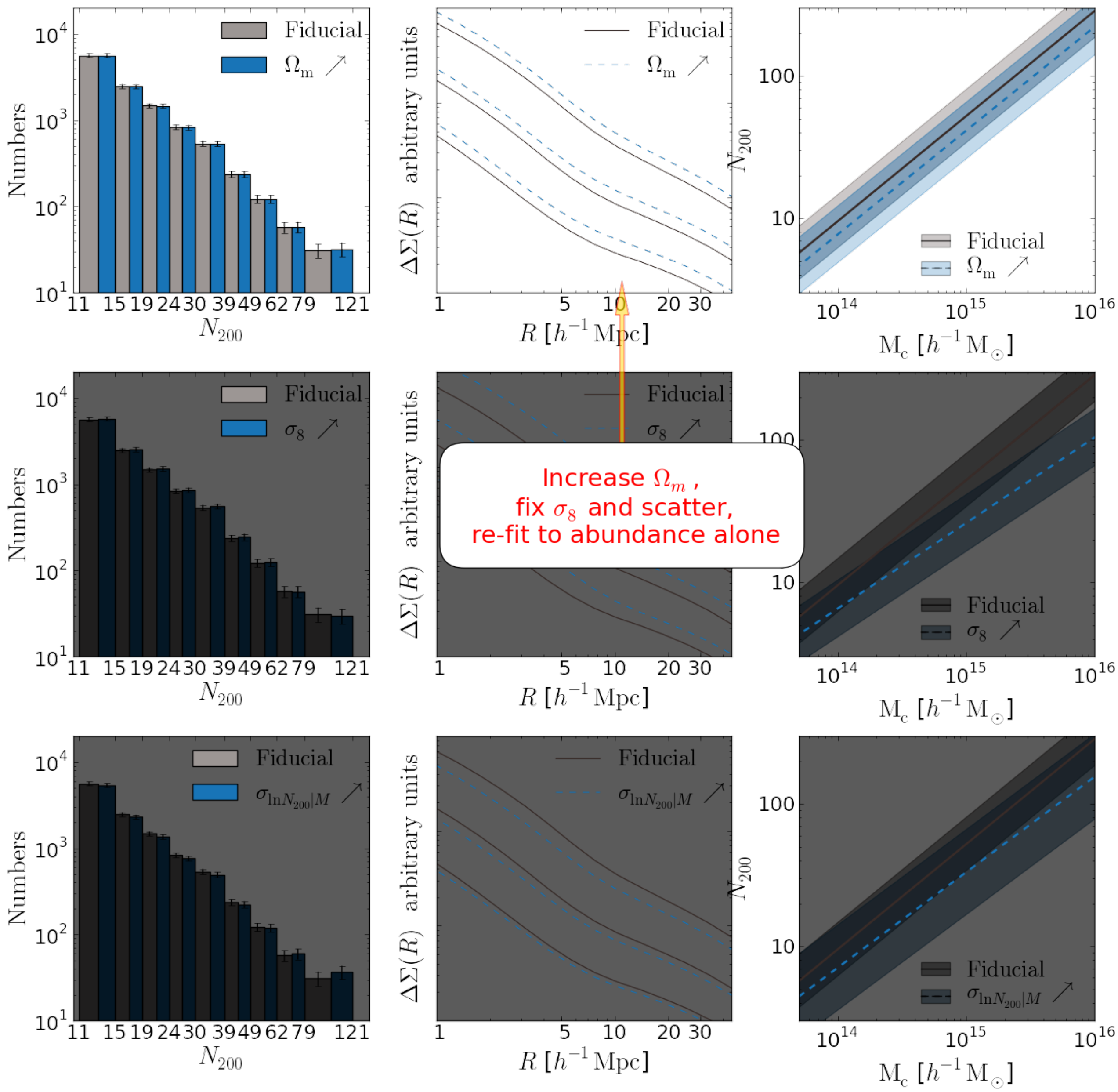


Methodology: how $\Delta\Sigma(R)$ helps?

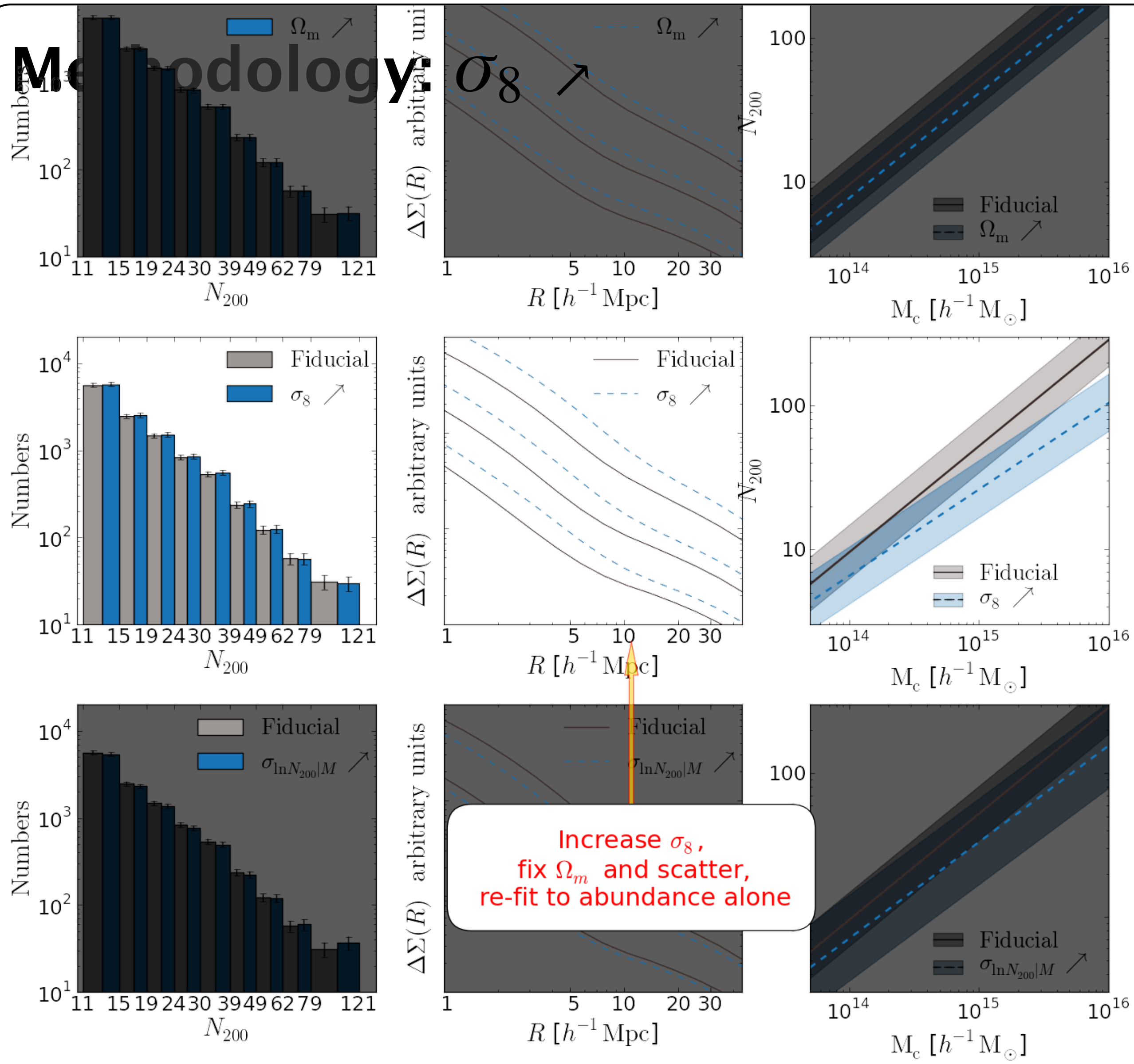
perturbative tests

1. given fiducial parameters which match to ***both*** abundance and weak lensing.
2. perturb one of Ω_m, σ_8, and scatter, while keeping the other two fixed.
3. varying the mean richness-mass relatoin to ***re-fit*** to the abundance data ***alone***.
4. compare the prediction of $\Delta\Sigma(R)$ from the ***best-refit*** parameters to the fiducial.

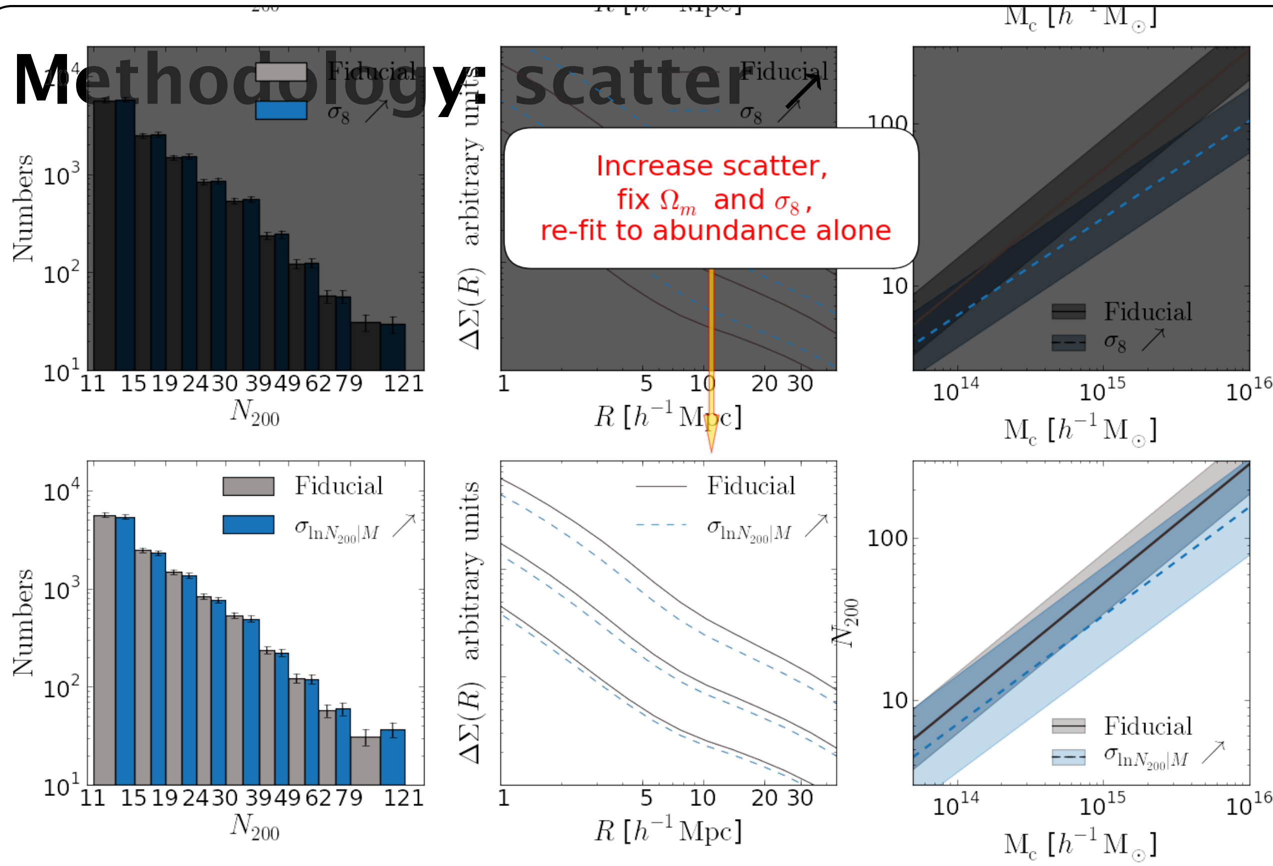
Methodology: $\Omega_m \nearrow$



Methodology: $\sigma_8 \nearrow$

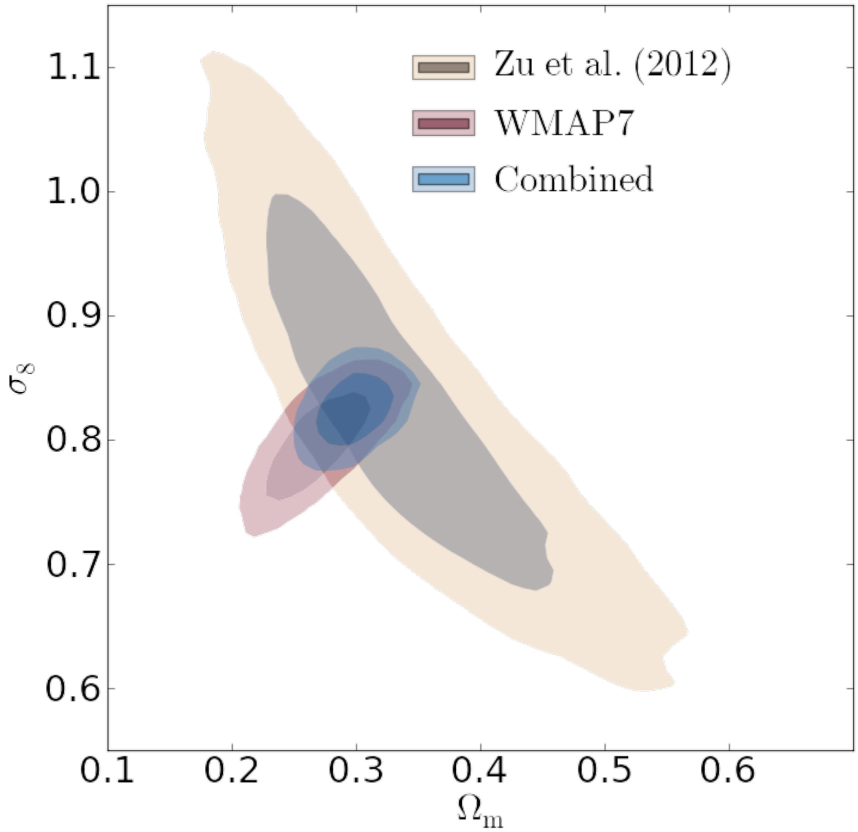


Methodology: scatter

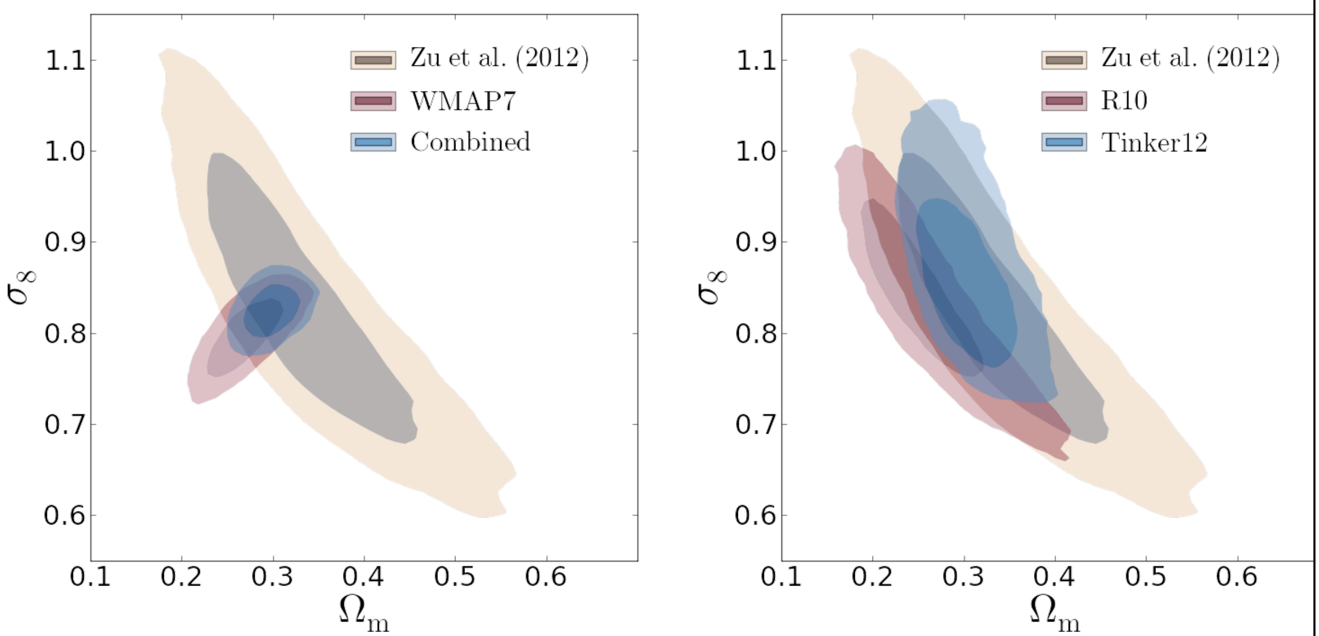


Constraints

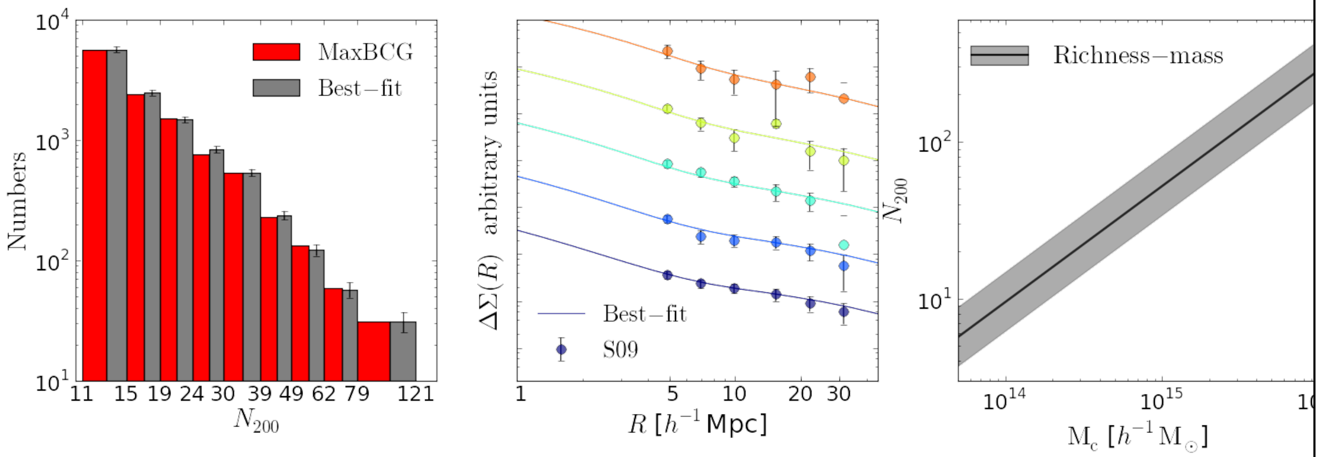
combined with *WMAP7*: $\Omega_m = 0.298 \pm 0.020$ **and** $\sigma_8 = 0.831 \pm 0.020$



Compare to other MaxBCG constraint



Best-fit model



Summary (cluster-shear)

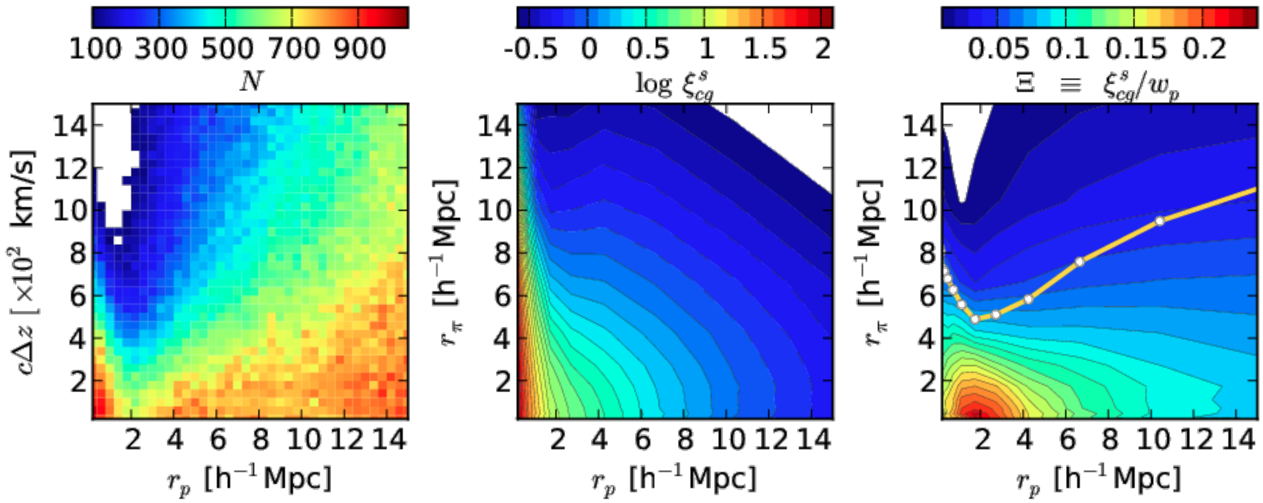
Zu+(2012)

1. Large scale cluster weak lensing probes $\Delta\Sigma(R) \propto \Omega_m \xi_{cm}$, breaking the degeneracy between scatter and cosmological parameters.
2. Constraints agree with other MaxBCG constraints from small scale $\Delta\Sigma(R)$ (Rozo+2010) and cluster mass-to-galaxy-number ratios (Tinker+2012).
3. Current constraints are limited by the statistical uncertainties on the cluster weak lensing measurements, which will drop sharply with the coming of DES.
4. Need to incorporate cluster-galaxy correlation in the analysis and combine the information from small scales in the future.

Cluster × galaxies (redshift space)

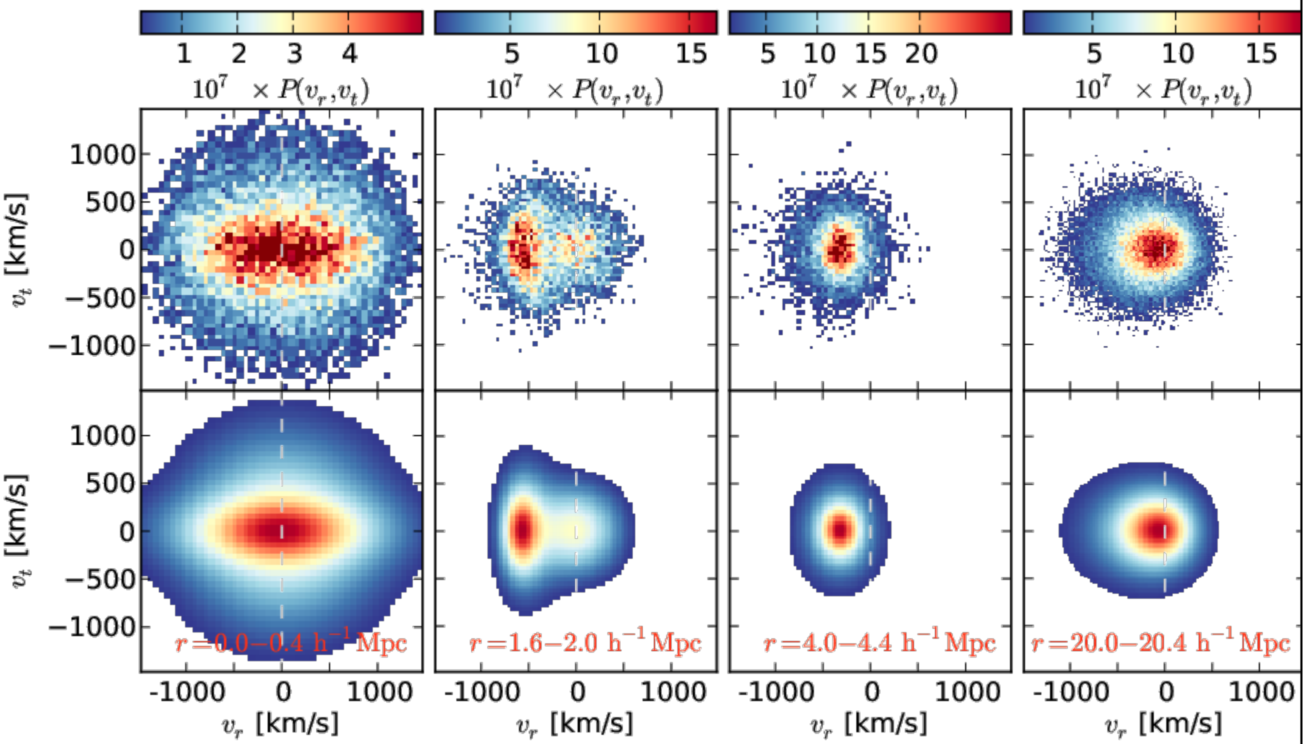
galaxies around clusters seen by

observers vs. large scale structurers vs. me & david@osu

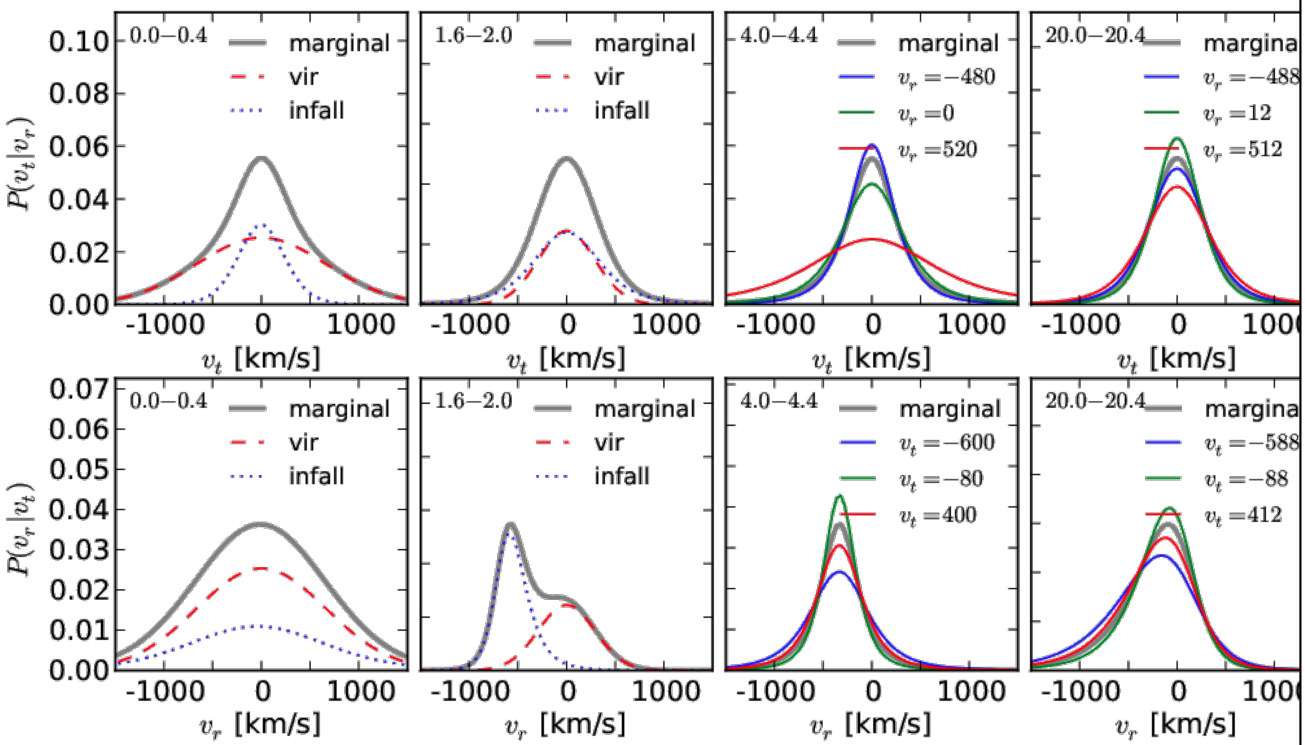


galaxy infall kinematics (GIK)

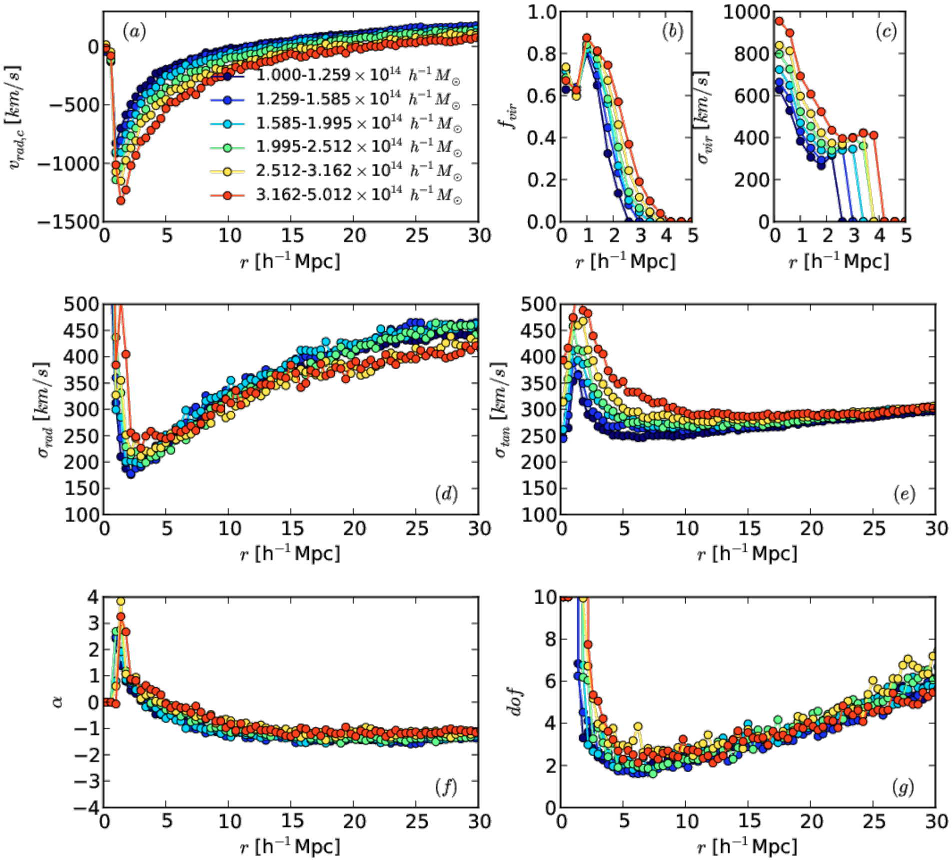
$P(v_r, v_t|r)$ **: joint distribuiton of v_r and v_t at each r**



it looks complicated.



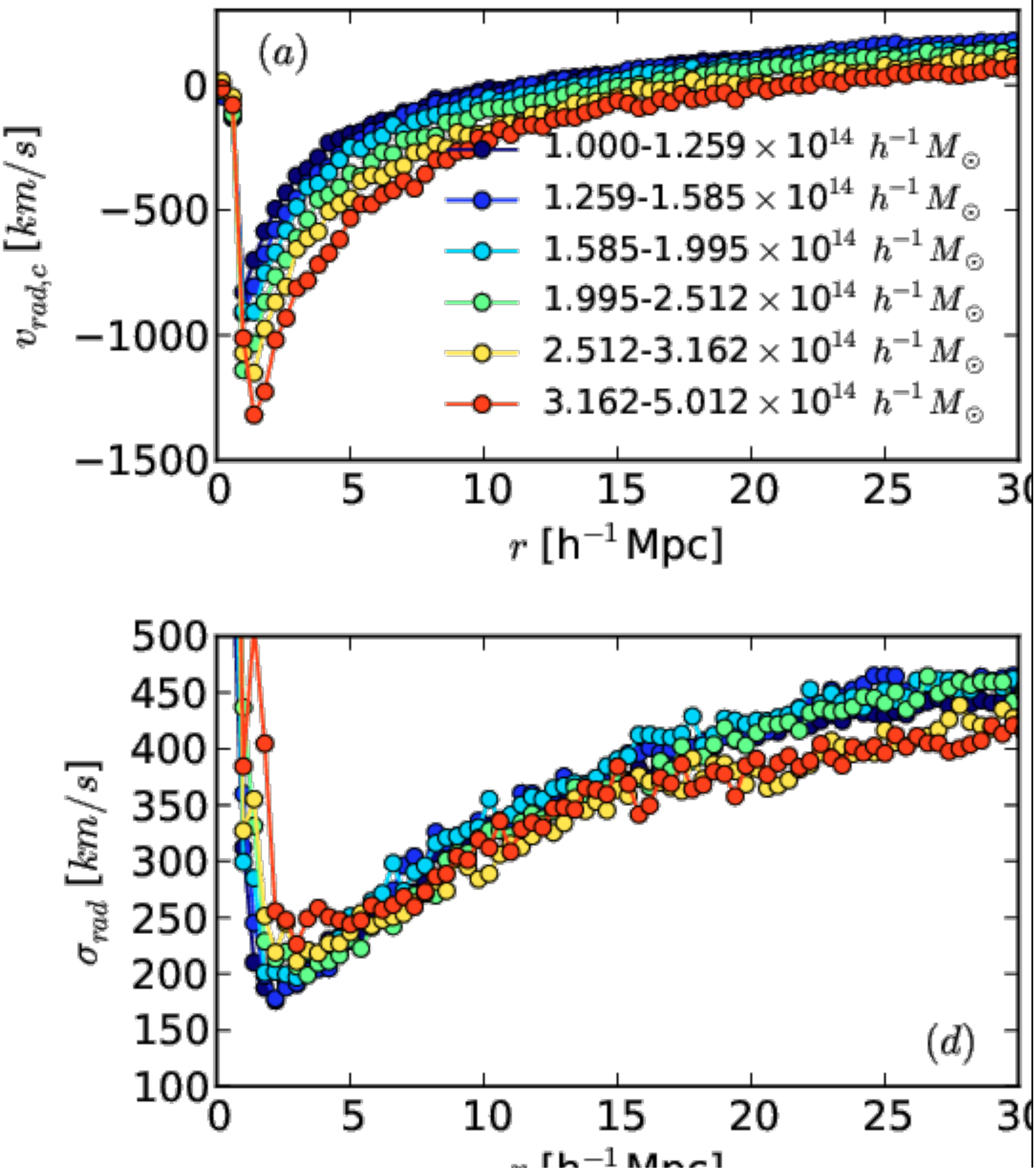
but is actually simple

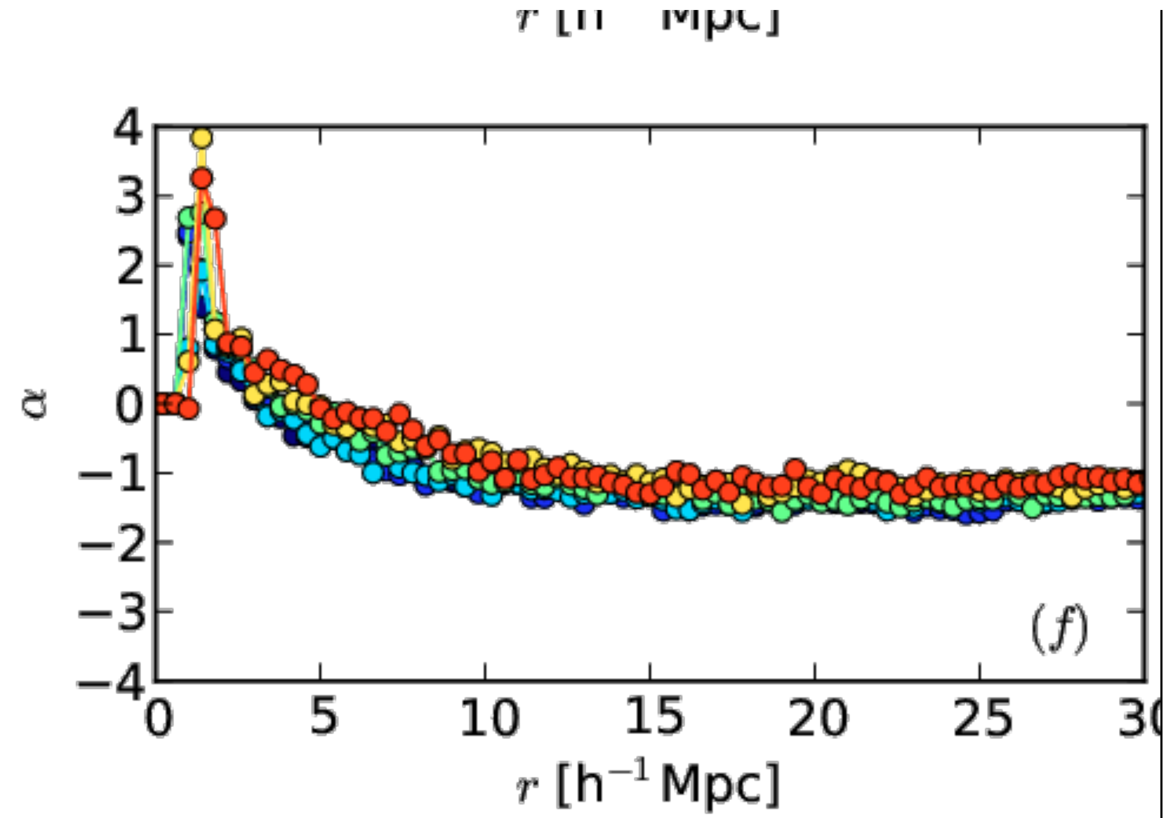


- [a] infall velocity: $\propto M$
- [b] virial fraction: $\propto M$
- [c] virial dispersion: $\propto M$
- [d] radial dispersion: M -dependent
- [e] tangential dispersion: M -dependent
- [f] shape parameter: M -insensitive
- [g] dof: M -insensitive

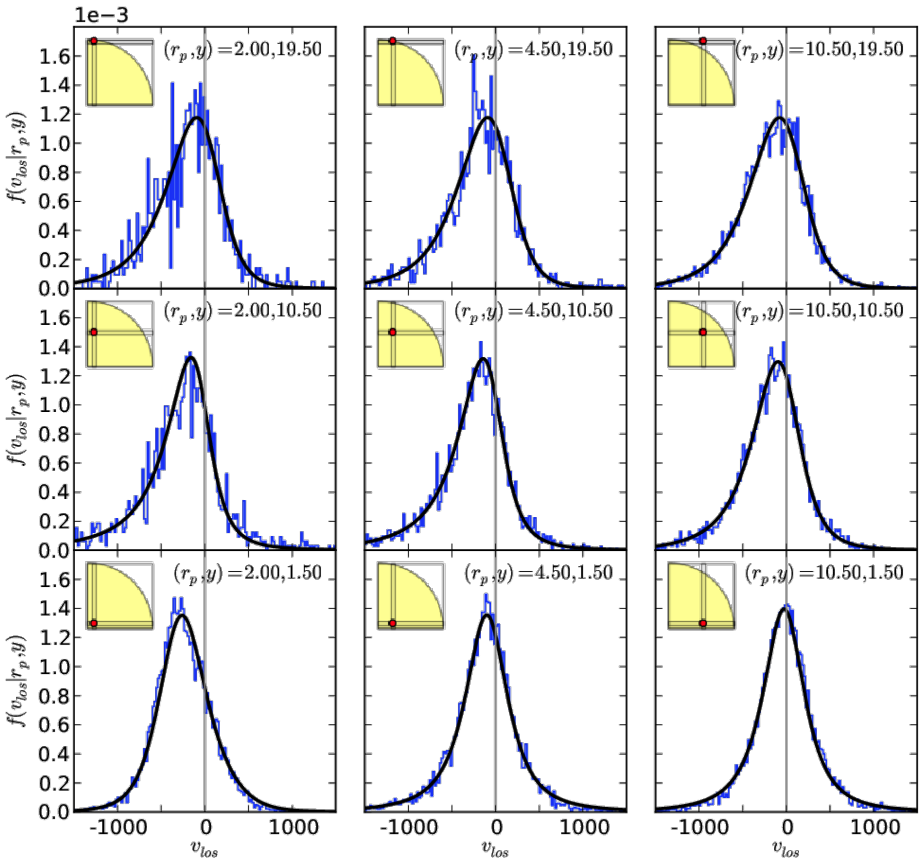
especially the infall velocity profiles

which what we care the most.

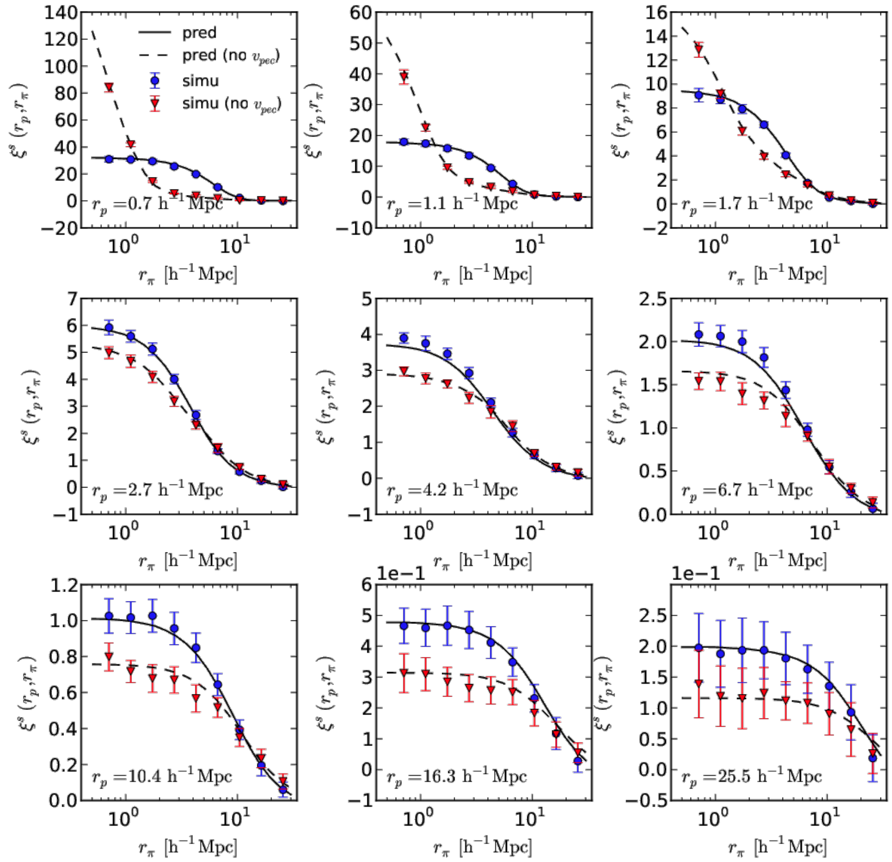



α
4
3
2
1
0
−1
−2
−3
−4
0
5
10
15
20
25
r [h^{-1} Mpc]
(f)

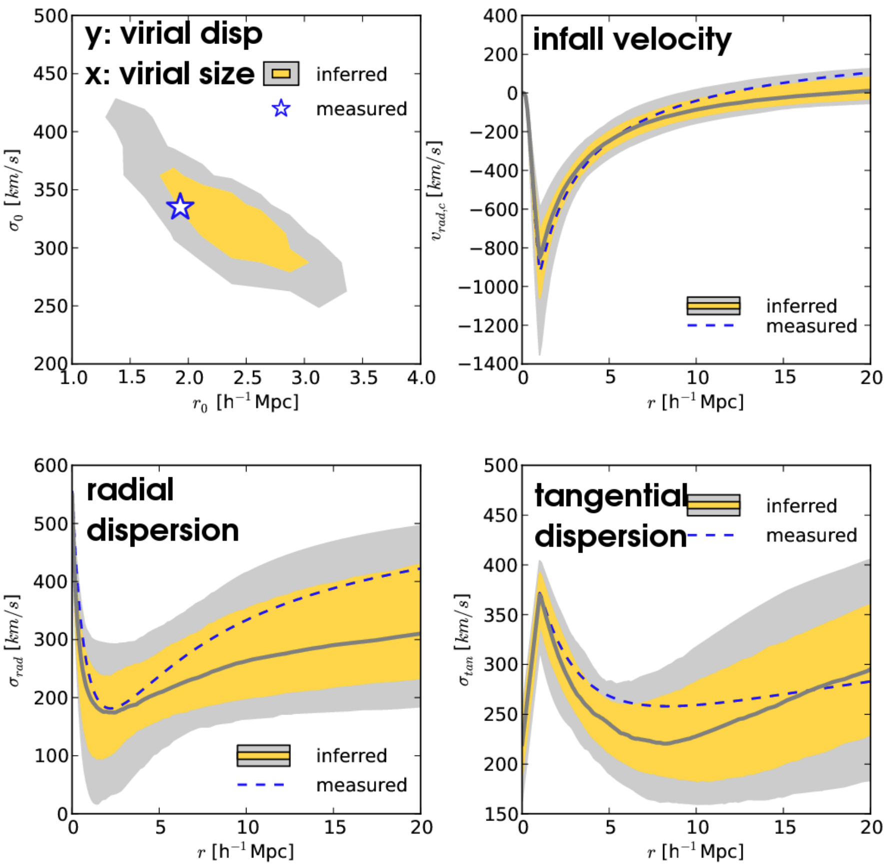
LOS velocity distribuition $f_{los}(r_p, y)$



ξ^s_{cg}: convolve $f_{los}(r_p, y)$ with ξ^r_{cg}

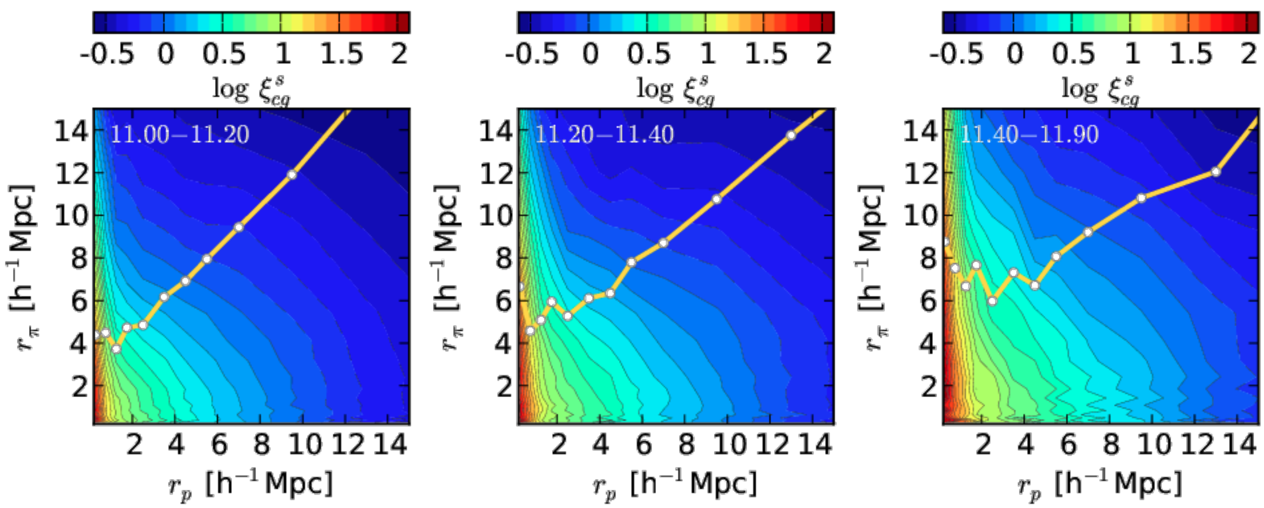


Infer GIK from ξ_{cg}^{s}: mock test



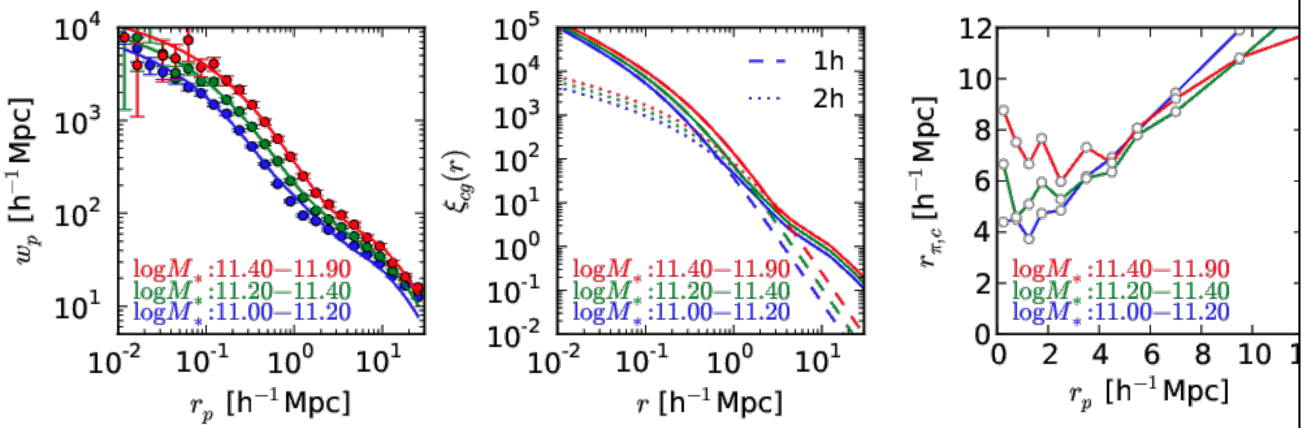
ξ^{s}_{cg} measured for SDSS groups

clusters in 3 bins of BCG stellar masses

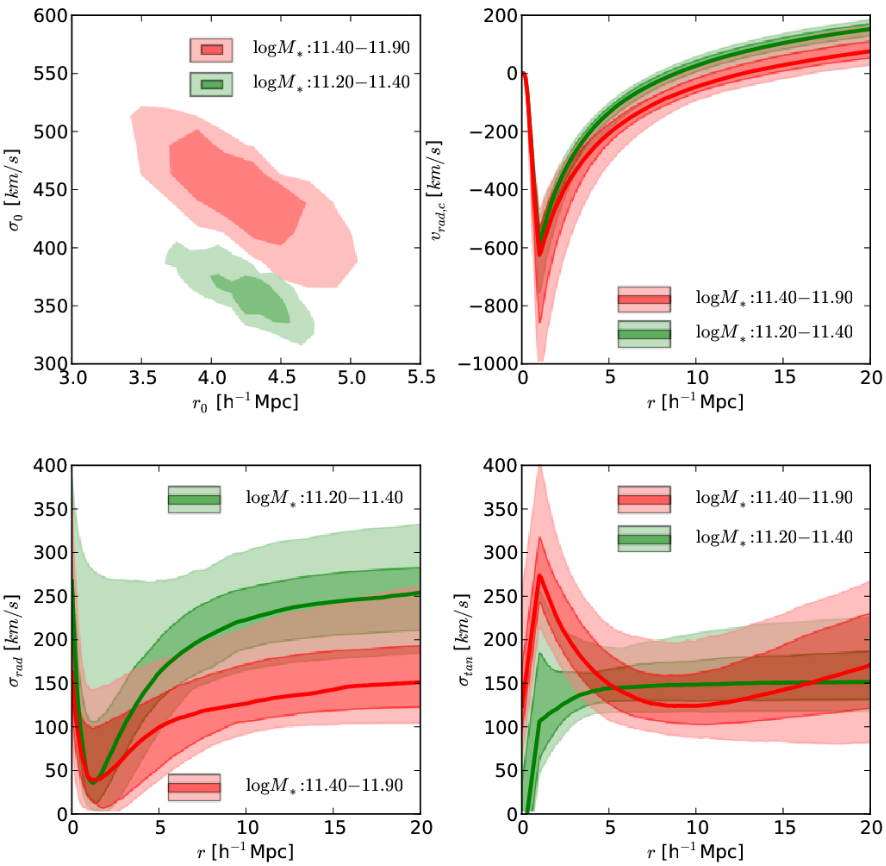


invert ξ^r_{cg} from $w_p(r_p)$

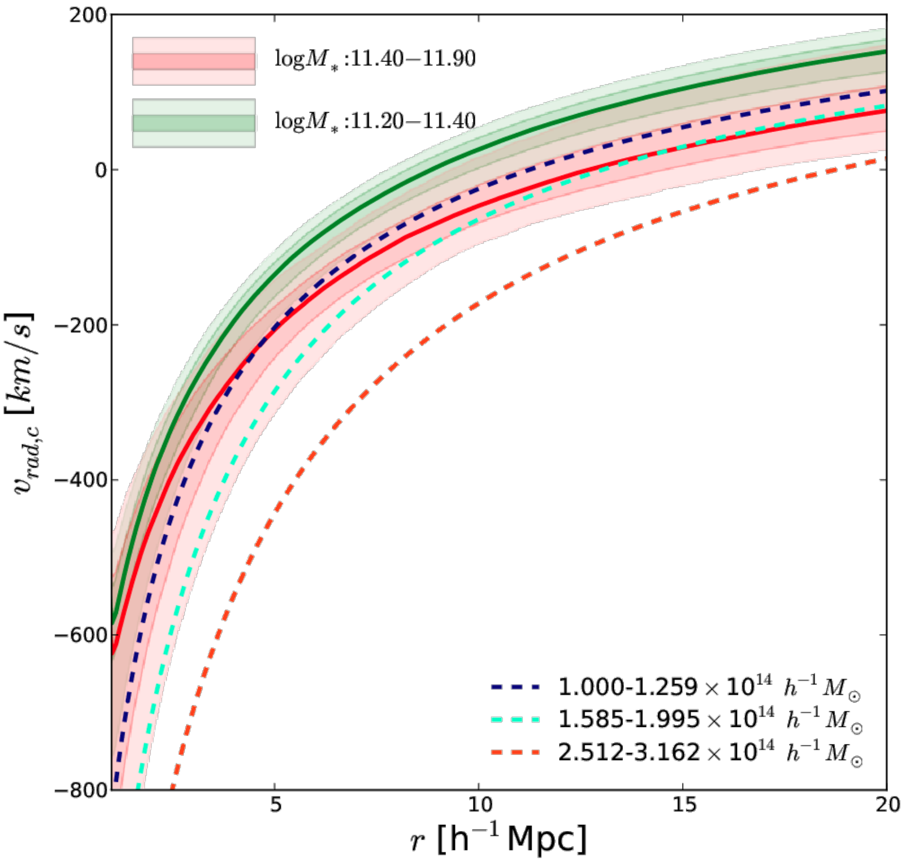
the U-shape curves (3rd panel) stand out as expected!



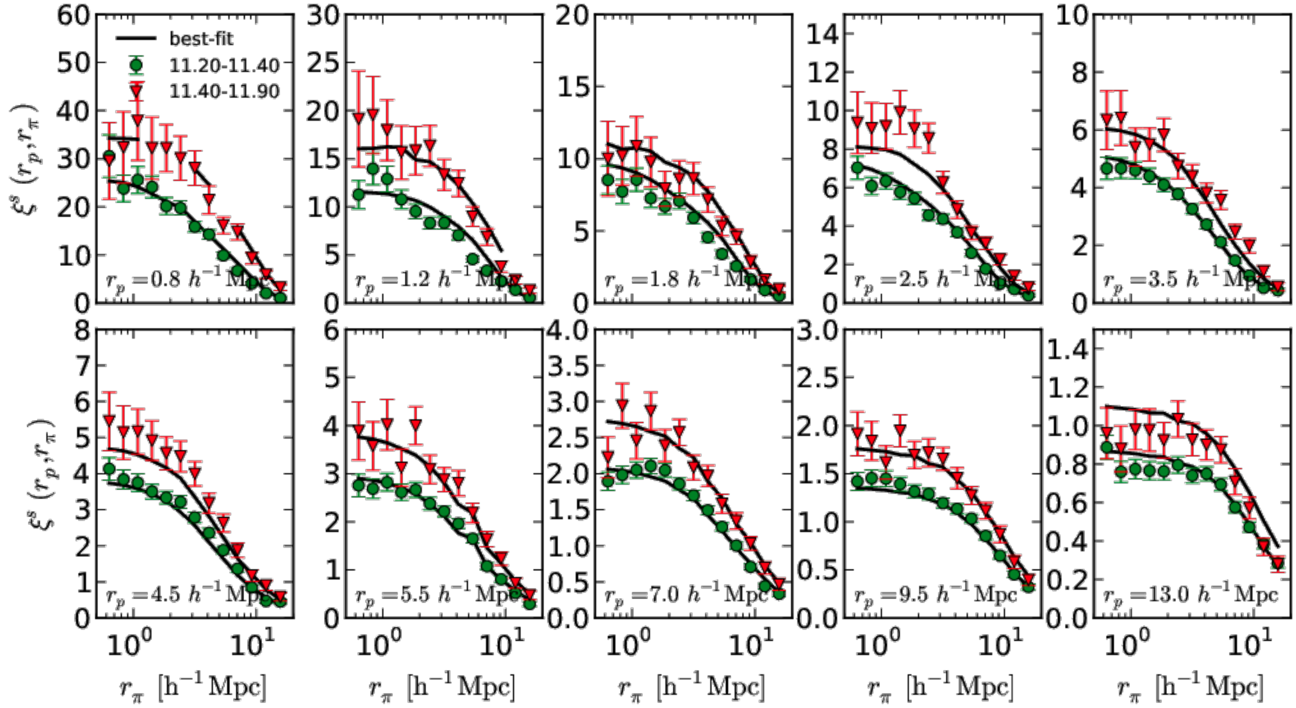
Infer GIK from ξ_{cg}^{s}: SDSS groups



Infall velocity profiles vs. simulation



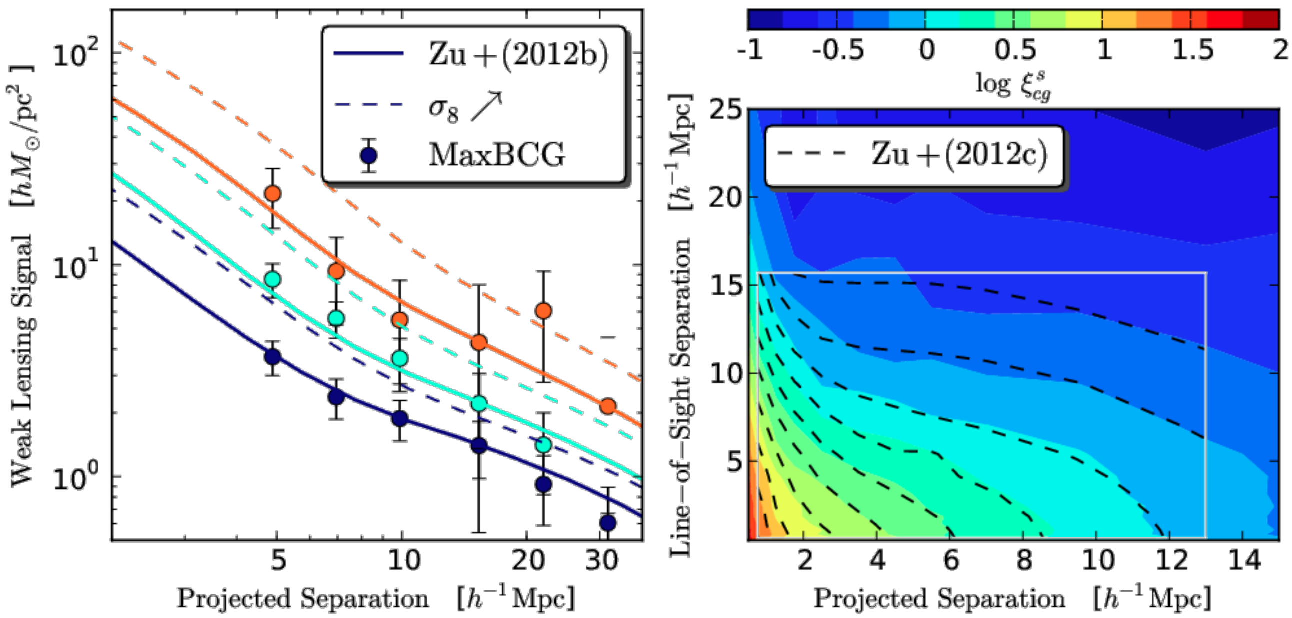
Best-fit ξ^s_{cg} for SDSS groups



Summary (cluster–galaxy in z space)

1. the galaxy infall kinematics (GIK) model provides an accurate description of galalxy motions around cluster in a ΛCDM+GR universe.
2. there is little ambiguity in distinguishing the different GIK components from ξ^s_{cg} --- a robust way of extracting galaxy infall velocity from observations.
3. dynamic estimate for cluster mass (paper upcoming).
4. good indicator for modified gravity, which directly modifies the kinematics of galaxies.

Combine $\Delta\Sigma(R)$ and ξ^s_{cg}



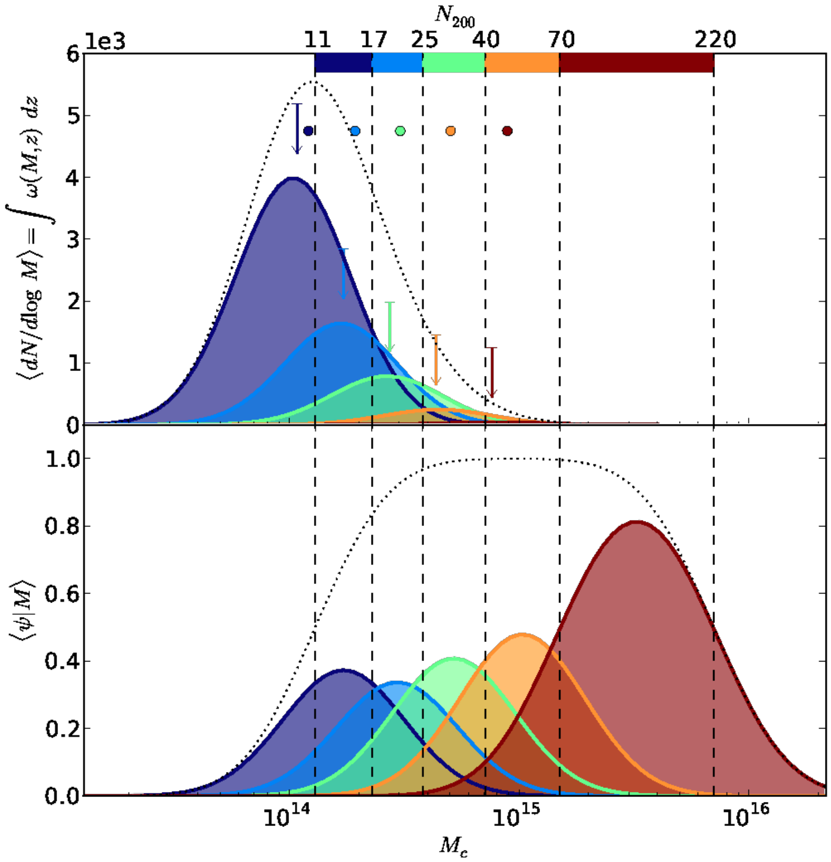
Conclusion

1. *you can never ignore dust*.
2. cluster-shear correlation $\Delta\Sigma(R)$ reveals the distribution of correlated matter around clusters that is consistent with ΛCDM+GR.
3. cluster-galaxy correlation ξ^s_{cg} is a powerful probe of the motion of correlated galaxies around clusters.
4. combining $\Delta\Sigma(R)$ and ξ^s_{cg} will provide novel and acute test for deviations from Einstein's gravity.

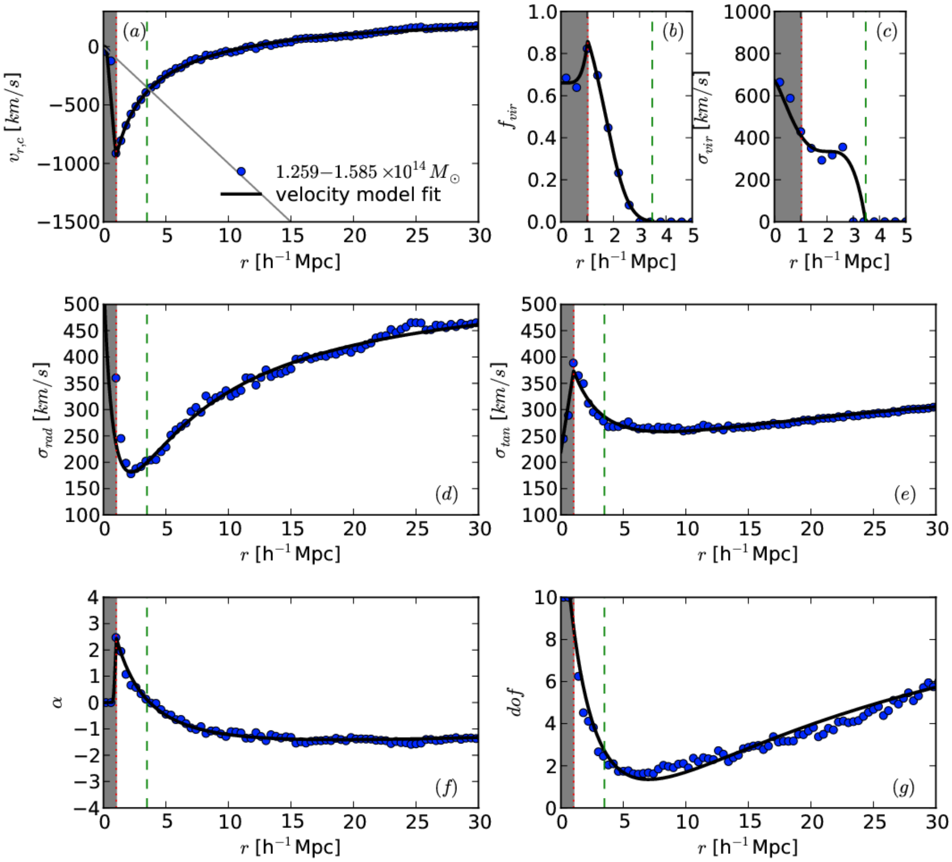
Backup Slides

Best-fit scatter

logrithmic scatter of N_{200} at fixed mass is 0.432 ± 0.068



GIK fitting functions



minimum GIK degeneracy