Cosmological Constraints from Cluster Mass-to-Galaxy Number Ratio

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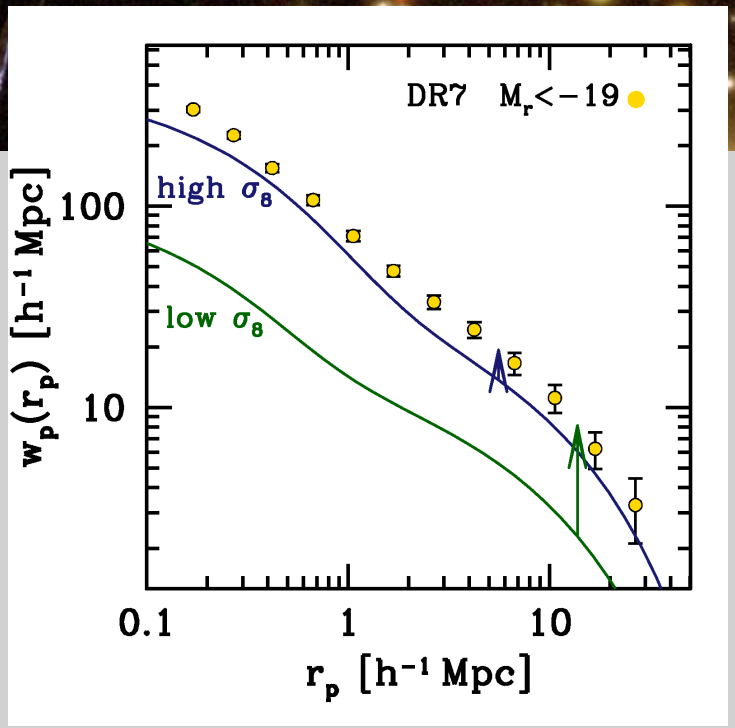
Clusters as a Cosmology Tool

- "Largest bound objects"
  - Largest: unbiased relative to universal M/L
  - Bound: we can measure their masses
- Method for measuring Ω_m

$$\Omega_m = \langle M/L \rangle_{cl} \, \Omega_b (r_{lum}/r_{crit})$$

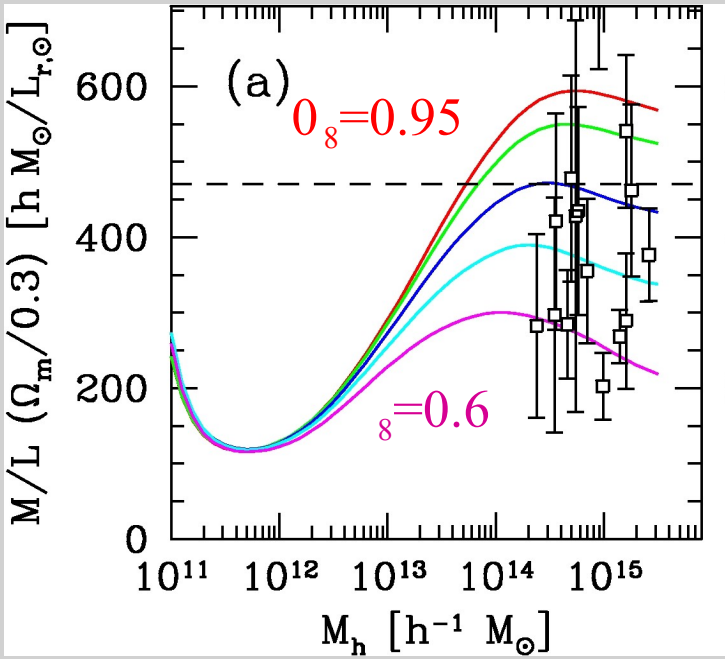
- Low values of Ω_m~0.15-0.2
  - Are they really unbiased?

Clusters + Clustering



The amount of light per halo depends on matter clustering.

Lower m_8 = lower cluster M/L.



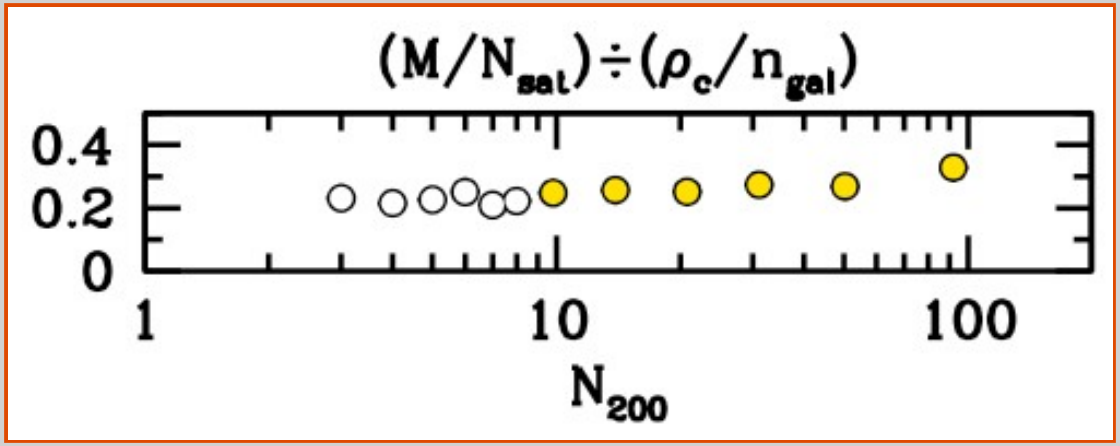
HOD+SDSS=

$$\langle M/L_{18}\rangle = 577\left(\frac{\Omega_m}{0.3}\right)\left(\frac{\sigma_8}{0.9}\right)^{7}$$

Tinker, Weinberg, Zheng, Zehavi (2005)

MAXBCG Cluster Catalog

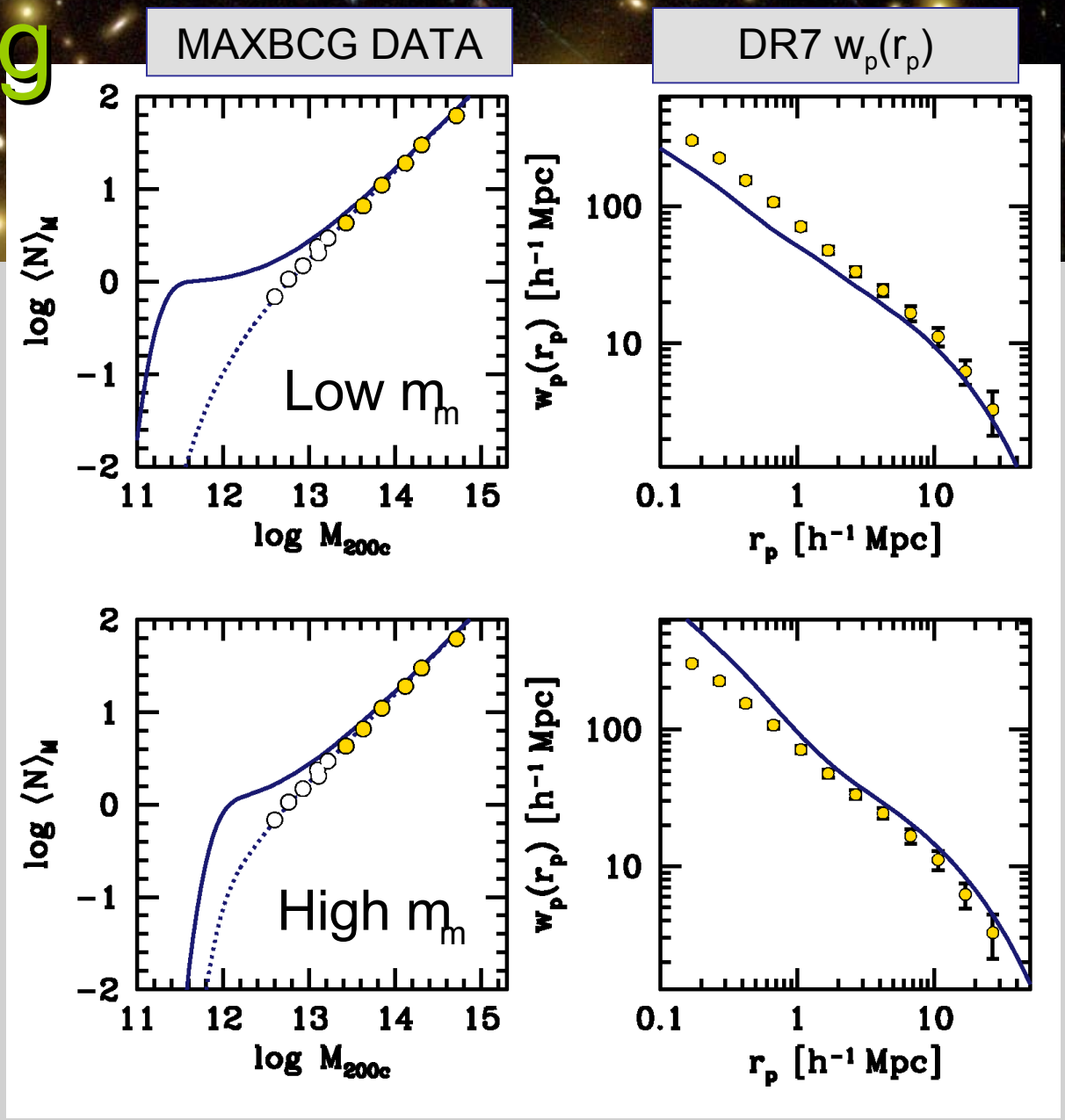
- Red-sequence cluster finder, z<0.3.
  (Koester et al 2007a,b. 734-330-9074)
- Stack in bins of richness N200.
- Masses from weak lensing (Sheldon et al)
- Instead of M/L, use *M/N*.



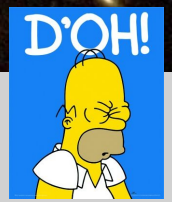
Constraining Cosmology

M_r<-19.5 sample

- Both models match M/N + n_{gal}.
- Low m_m has too few satellites.
- High m_m has too many.
- Slope of N(M) helps constrains m_8.



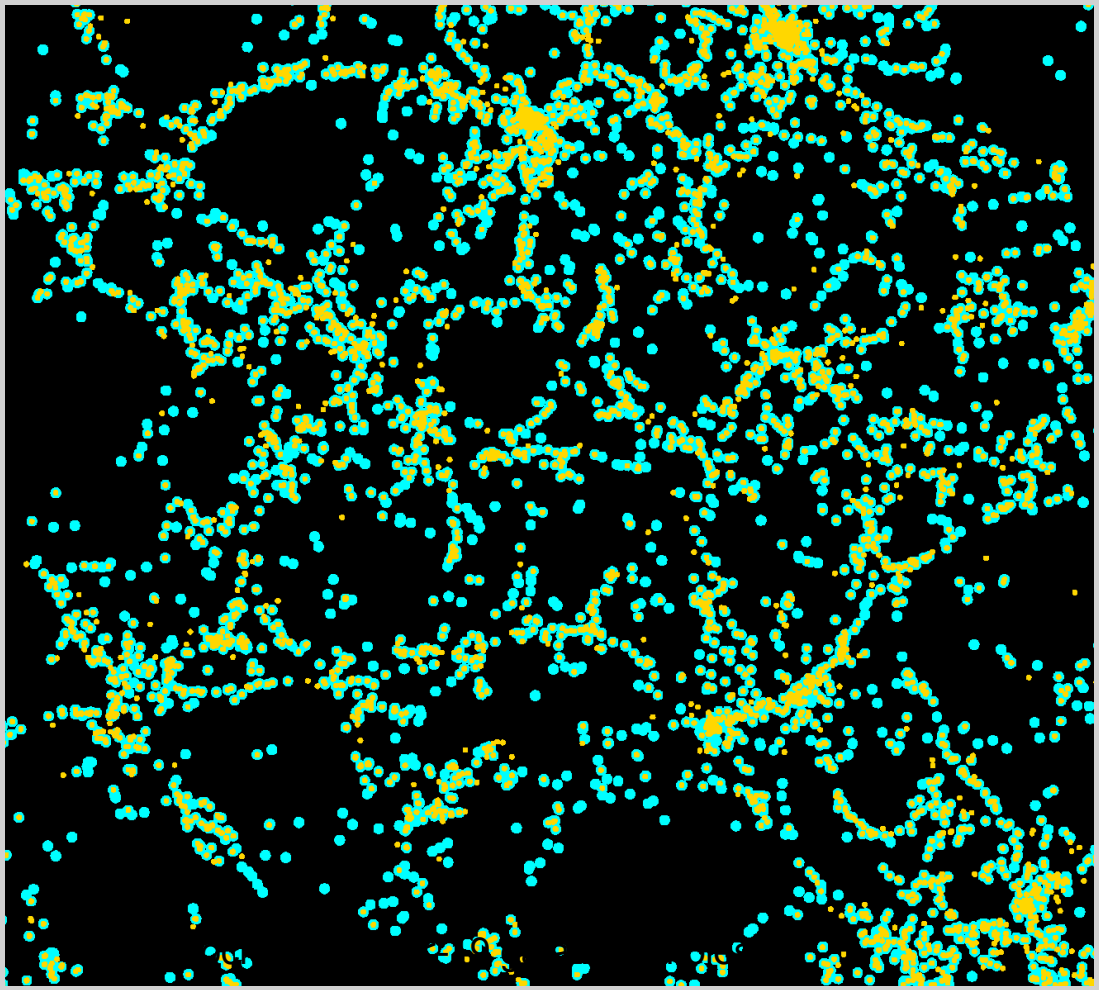
Thanks a lot, Sloan. Now I actually have to worry about systematics in my model.



No longer sample variance limited.

- Can we use the HOD as a cosmological tool?
- Primary assumption is that galaxy content (ie, N) depends only on halo mass.
- Test this assumption with clustering stats that probe different m

Does halo occupation depend on environment?

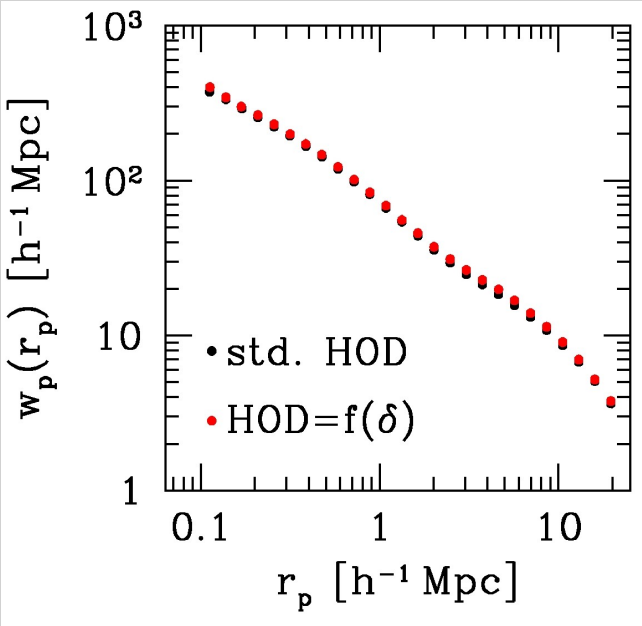


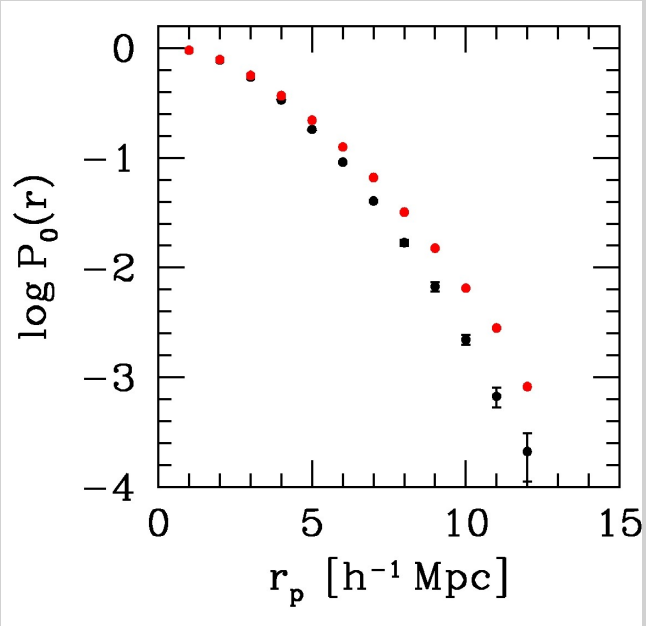
Two M_r<-19 models.

Cyan: P(N|M) standard HOD.

Gold: P(N|M,m) galaxy formation less efficient at low densities.

Use voids to test the HOD

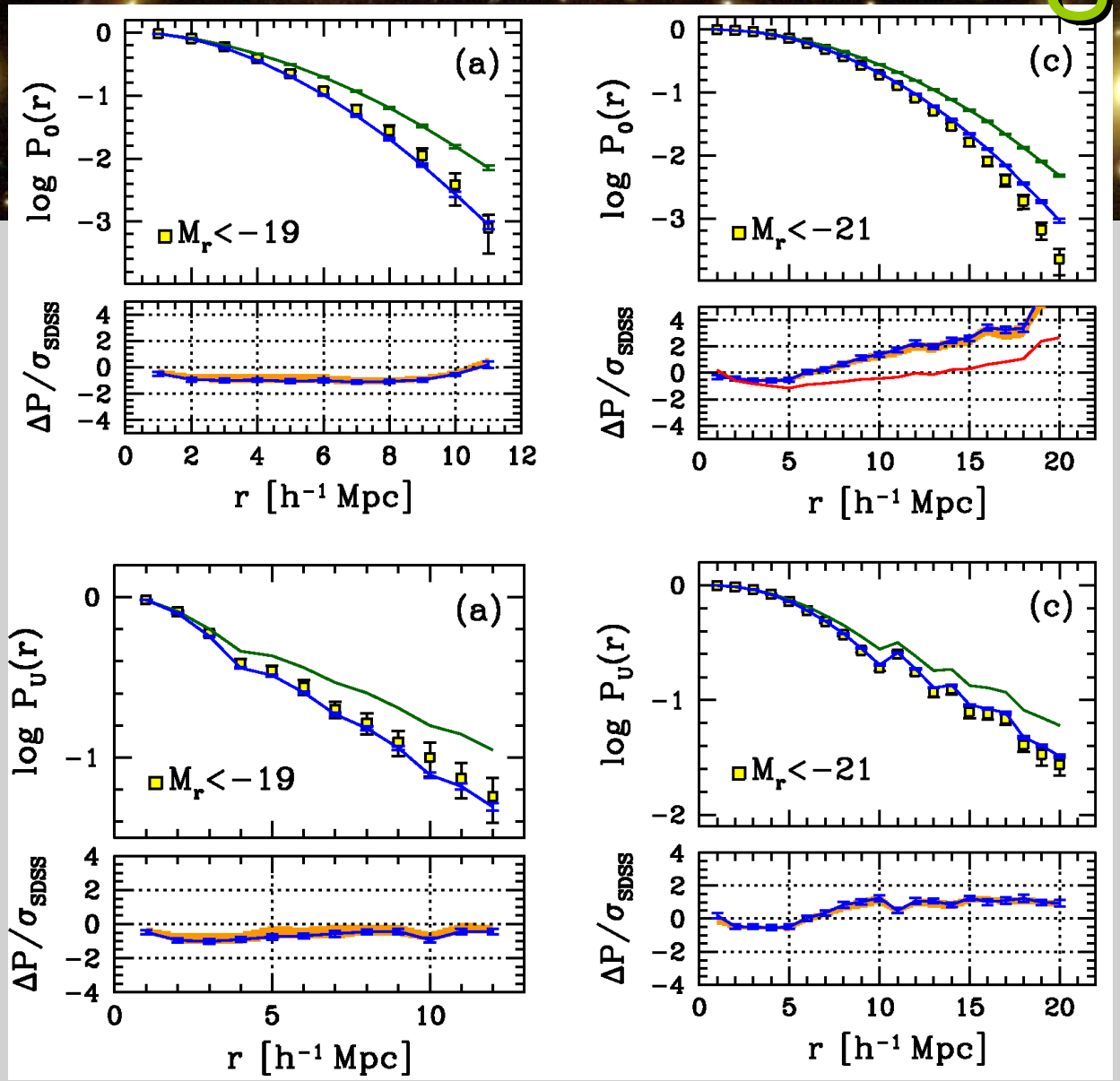




These two models produce the same 2-pt clustering.

Large difference in the voids--halo occupation changed from high-mto low-m

SDSS DR4 results



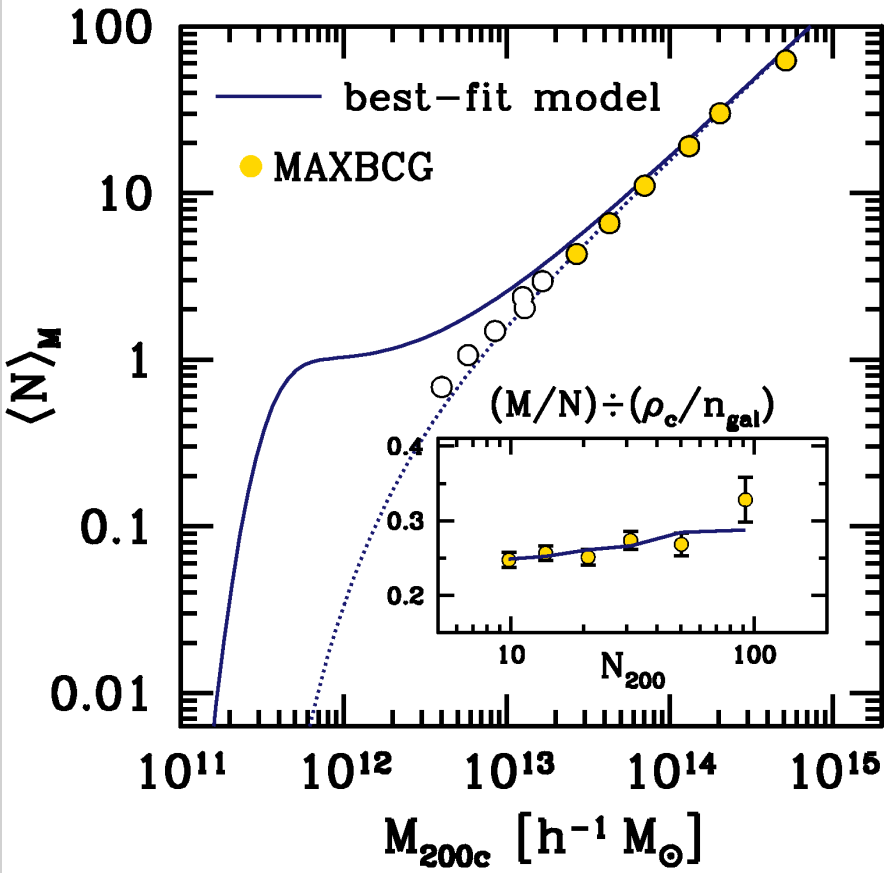
- Points: DR4 measuremnts.
- Blue Curves: HOD predictions.
- Green curves: m-HODs
- Luminosity depends only on M, not on halo environment.

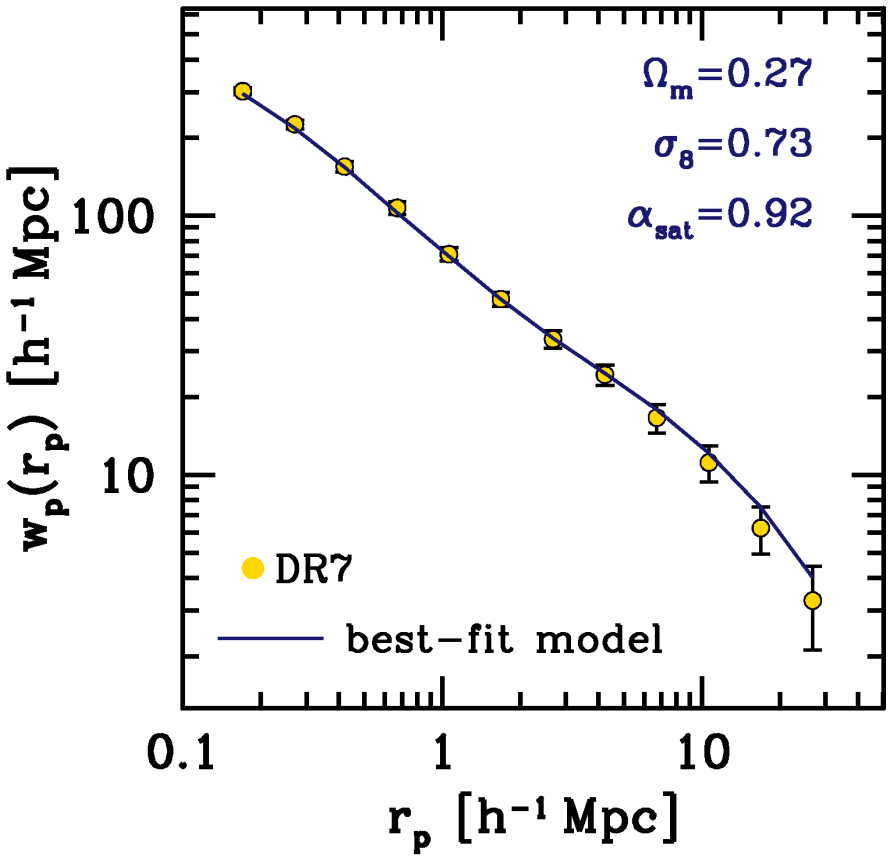
Tinker, Conroy, Norberg, Patiri, Weinberg, Warren, 2007, astro-ph/0707.3445

Parameters and Priors

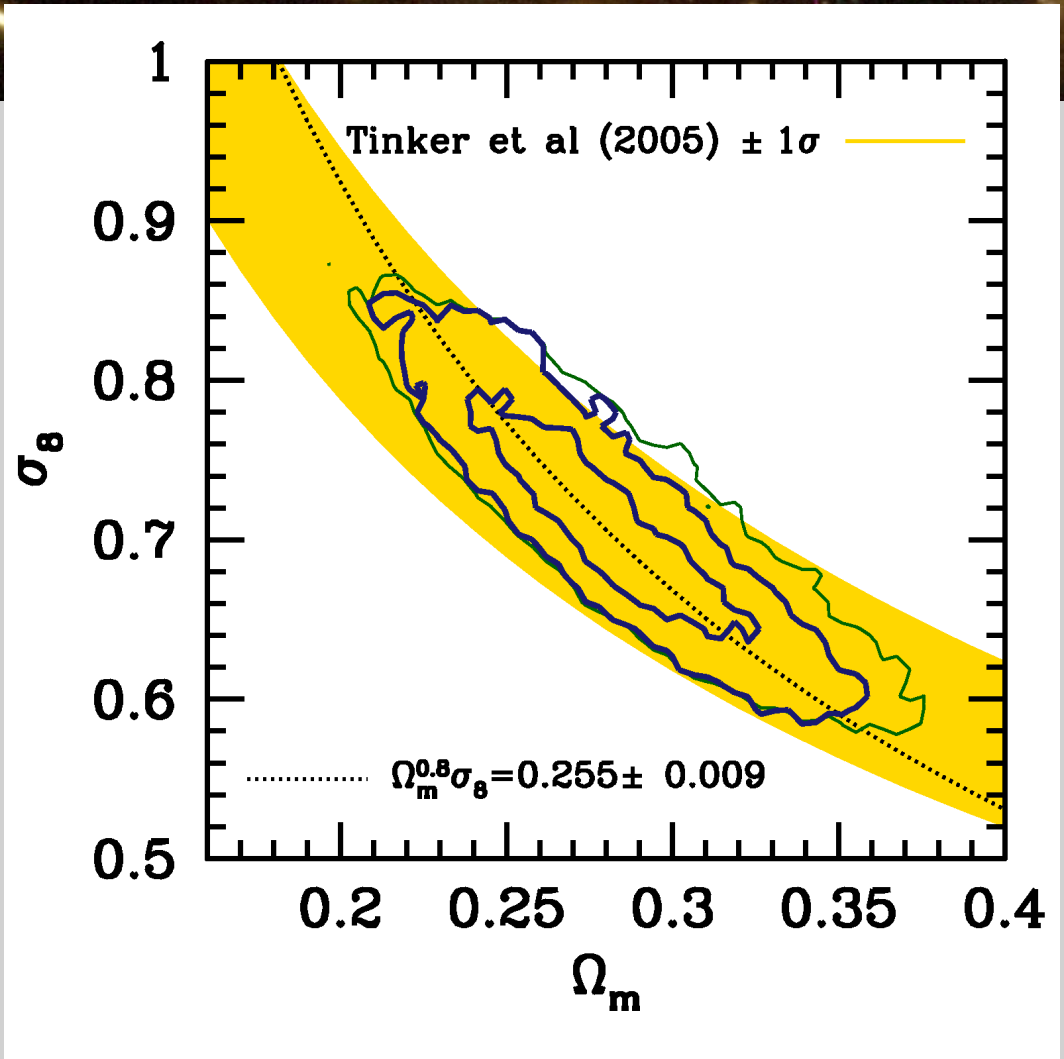
- 3 HOD parameters (M_{sat}, M_{cut}, α_{sat})
- Ω_m and σ_8.
- n_s=0.96+/-0.02 and h_0=0.72+/-0.04 (~WMAP5 priors).
- Uncertainties in HOD modeling:
  - 5% halo mass function (Tinker et al 08)
  - 5% halo bias function (in prep)
  - 15% scale-dependent bias (in prep)
  - Galaxy concentrations free (c_{gal}/c_{halo}>0.2)
- Uncertainties in mass-richness relation
  - Eduardo Rozo et al (in prep)

Results


best−fit model
MAXBCG
(M/N)÷(ρc/ngal)
N200
⟨N⟩M
M200c [h⁻¹ M⊙]


Ωm=0.27
σ8=0.73
αsat=0.92
DR7
best−fit model
wp(rp) [h⁻¹ Mpc]
rp [h⁻¹ Mpc]

Parameter Constraints



Blue: 1+2m contours.

Green: make n_s/h_0 priors flat over 4-m range.

Low-$\square_m$ limit: shape of w_p.

Low-$\square_8$ limit: shape of N(M).

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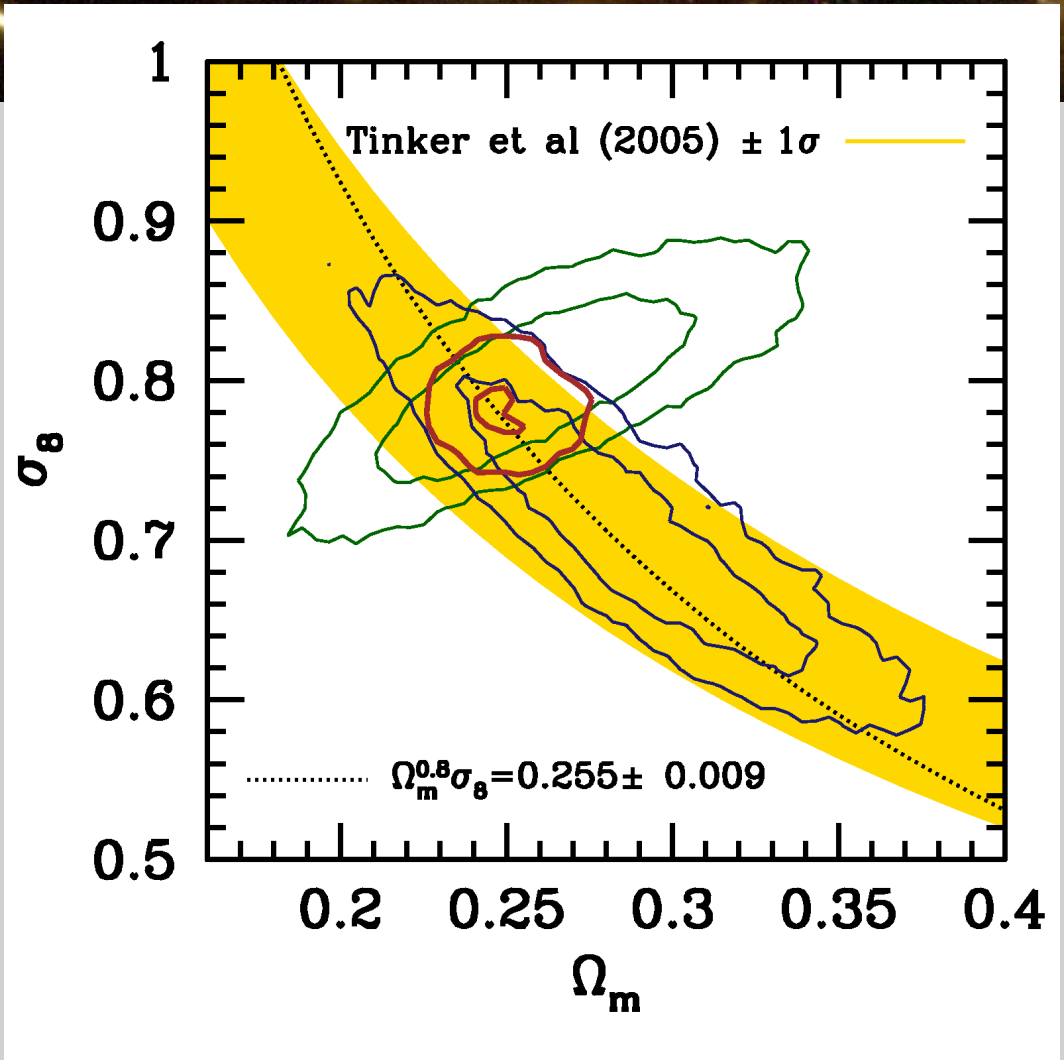

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Summary + To-Do List

- Work in progress, but…
  - HOD is a viable tool for cosmology.
  - For measured M/N+w_p, there exists a unique cosmology that fits all data.
  - In good agreement with CMB.

- Miscentering correction for galaxies.
- Use N(R) profiles to constrain c_{gal}.
- Repeat on higher luminosity samples.