

# **Synergies between Imaging and Spectroscopic Surveys**

Cosmic Visions  
Theory, Analysis and Computing  
Nov 14  
Alexie Leauthaud

Strong complementarity between lensing surveys and spectroscopic lensings :  
lensing+clustering, lensing+RSD, cluster infall regions, Eg tests  
clustering redshifts  $\Rightarrow$  redshifts for lensing sources

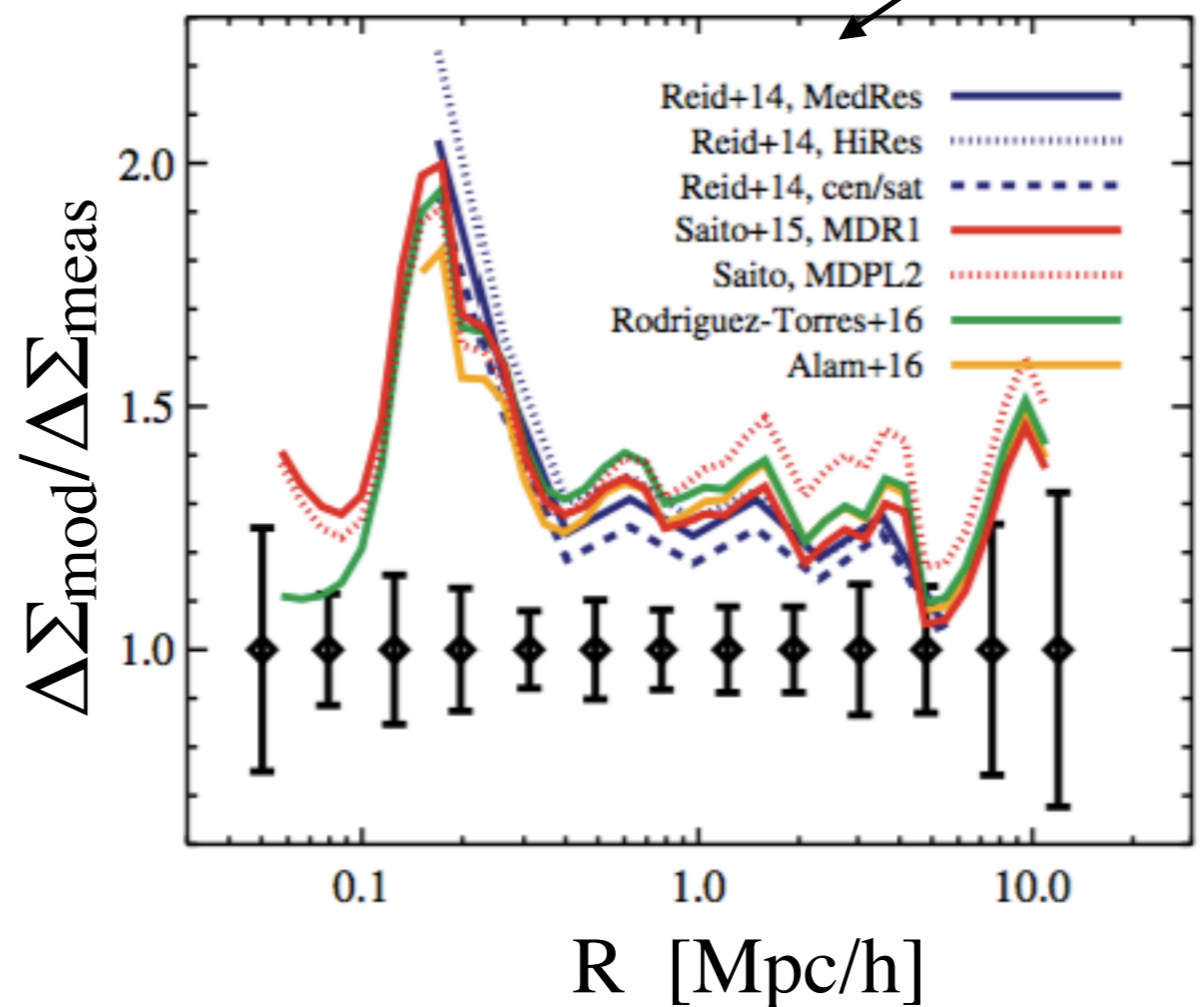
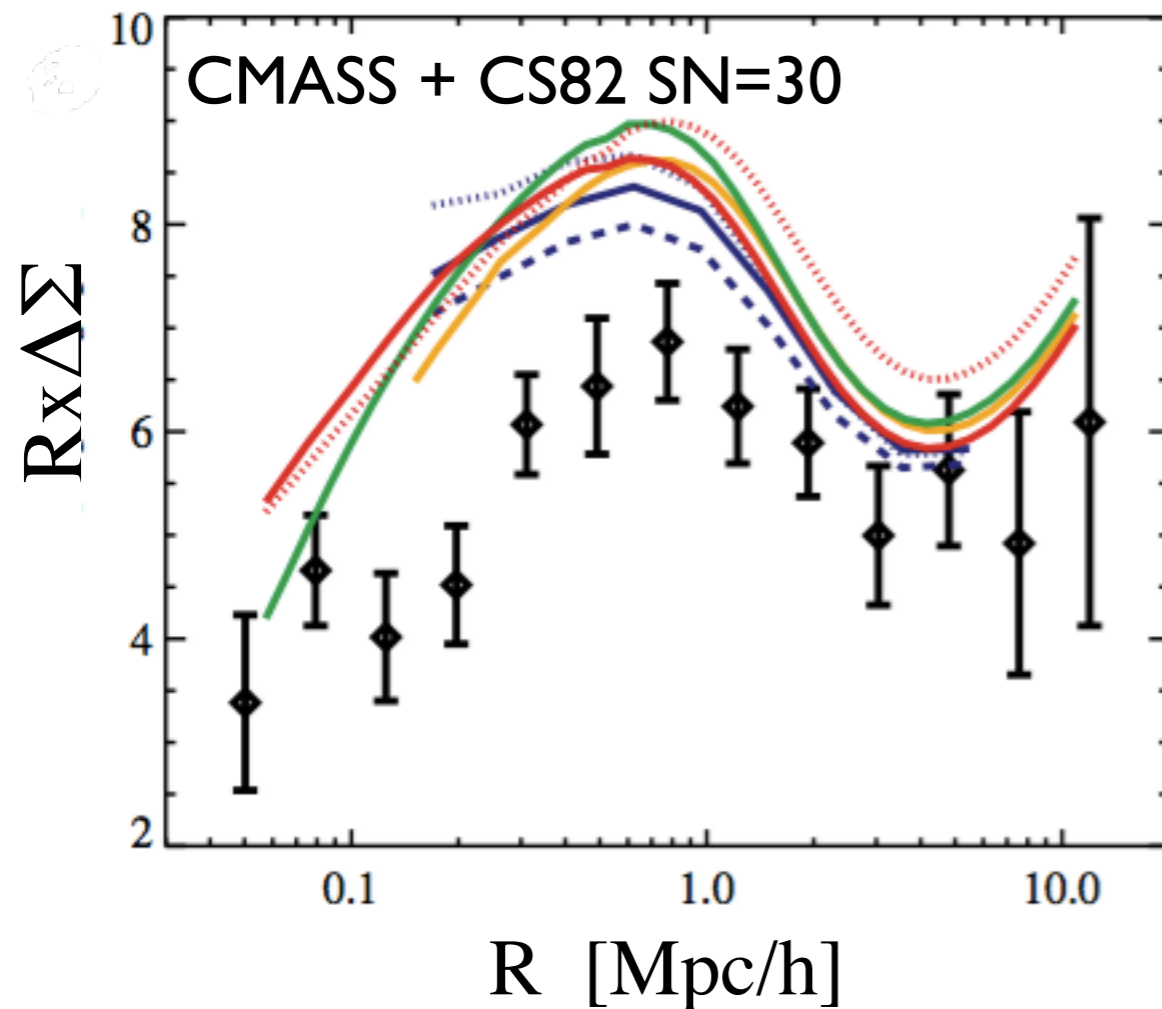
What could we do to enhance the science returns of near future experiments?

Near term experiments: DESI, PFS

*Here I focus mainly on DESI because (as far as a know) there is no  $z < 1$  galaxy sample in the PFS cosmology sample*

# Lensing of CMASS

Leauthaud et al. 2016



Standard galaxy-halo models constrained by clustering predict a lensing signal that is 20-40% higher than observed

If we continue to find at 5 or 10 sigma that lensing or dynamics on small scales do not match the predictions of the linear regime best fit model, how to proceed?

## **Lensing Systematics**

5-10 %

## **Assembly Bias**

*35% decrease in  $M_{halo}$   
larger scales needed*



## **Baryonic Effects**

20 %

## **Massive Neutrinos**

*Effect goes in right direction  
<10%*

## **Cosmology**

*Lower value of  $S_8 = \sigma_8(\Omega_m/0.3)^{0.5}$   
compared to Planck2015*

## **Modified Gravity**

*< 5% (for DGP model)*

**What makes this really FUN:** it is likely that all of these effects come into play at some level .....

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**Road map to tackle all of these effects together**

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*I'm optimistic we'll make progress*

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*We will get data on larger scales*

*Room for improvement on the*

*modeling side - I want to see a*

*more thorough exploration of*

*plausible gal-halo models using*

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# 1: “Lensing without Borders”

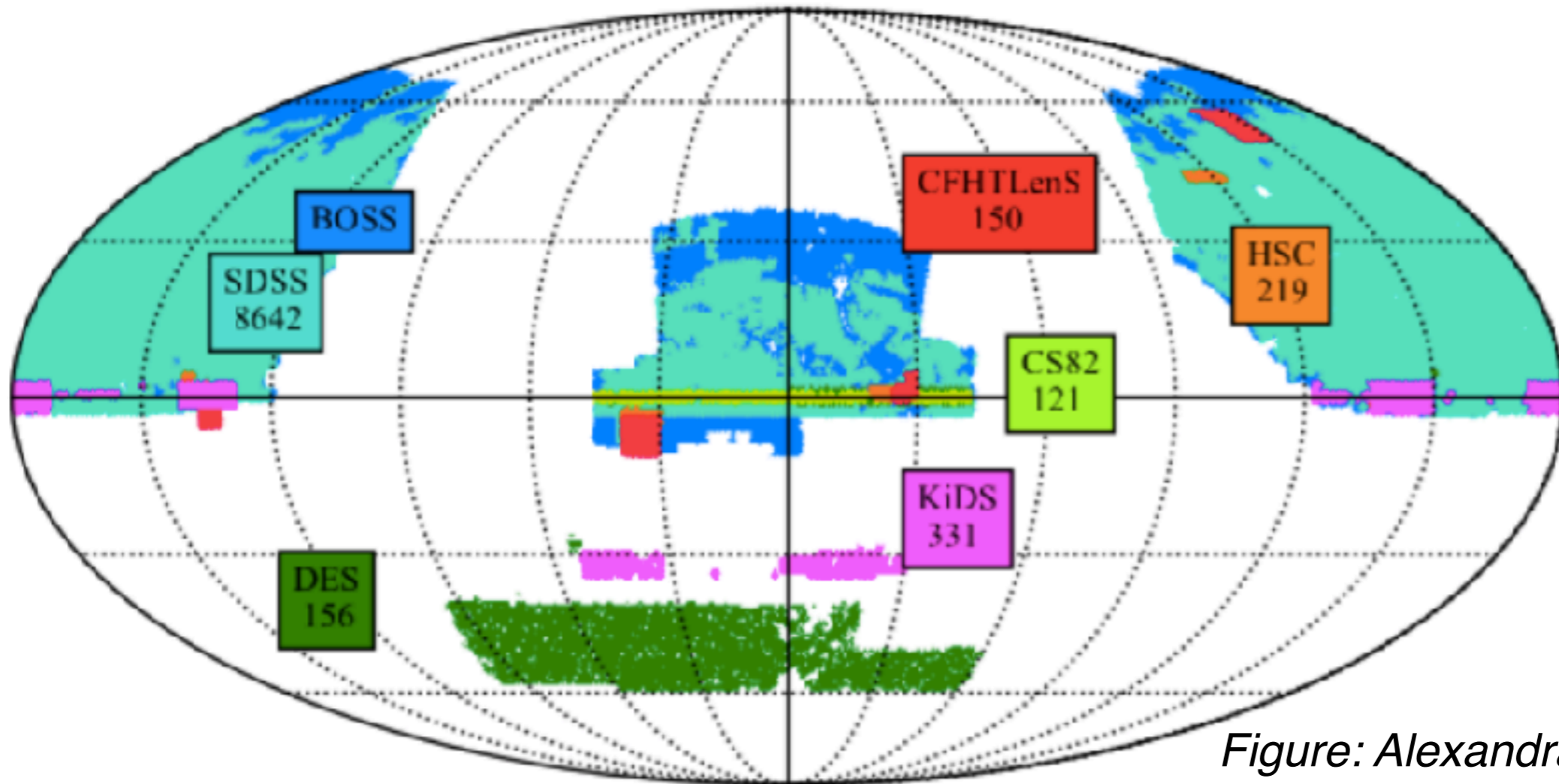
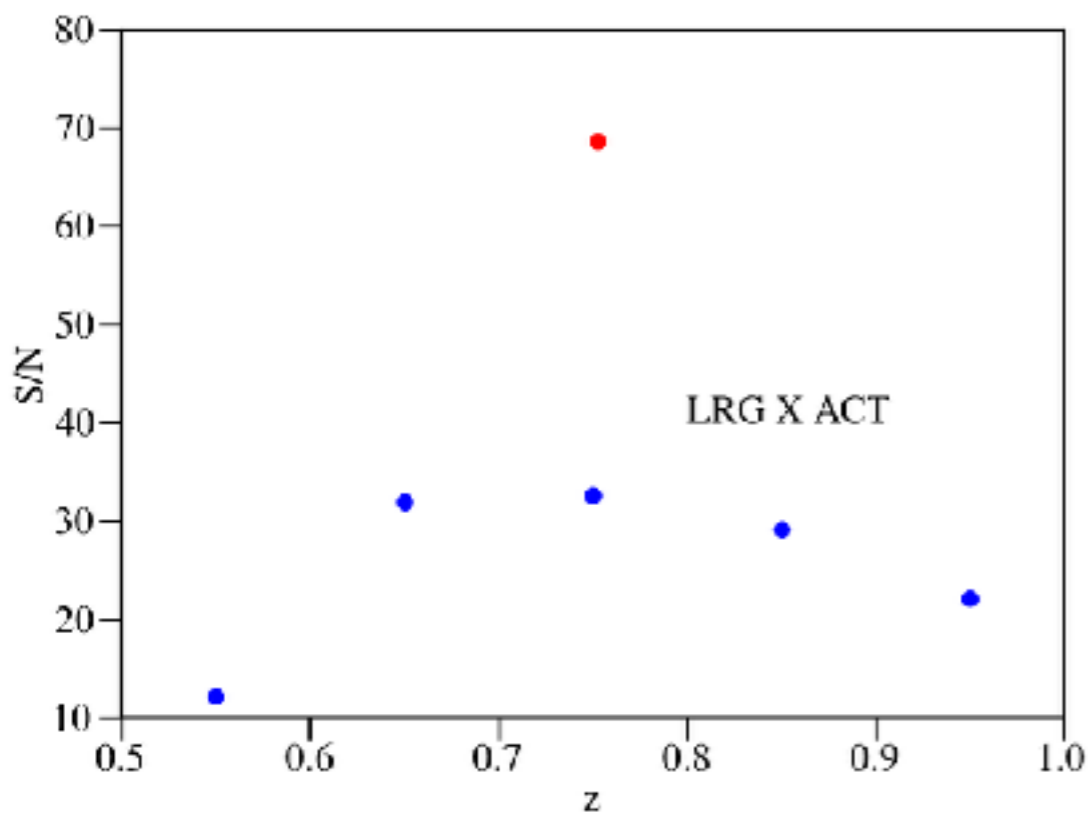
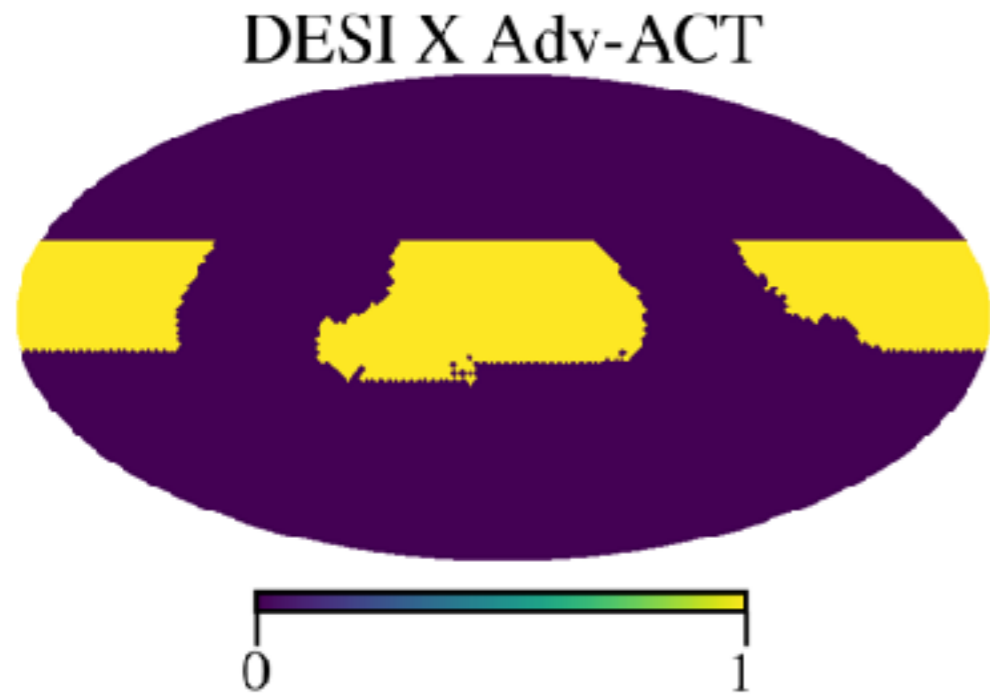


Figure: Alexandra Amon

- Use that fact that many lensing surveys have overlap with BOSS to perform a blind test on  $\Delta\Sigma$ . Empirical end-to-end test of systematics.
- Test becomes even more powerful with DESI and as areas of lensing surveys increase
- Would like *an increase in the overlap between LSST and DESI*

# 2: Independent Lensing Techniques

Figure: Sukhdeep Singh



- CMB lensing
- Ly $\alpha$  Forest lensing (Croft, Metcalf et al. 2017)
- Magnification
- Kinematic lensing
- 21 cm lensing

- **Optimistic outcome:** independent lensing techniques and cross surveys comparison will enable us to reduce systematics
- **Less optimistic:** at minimum, we will have a much better understanding of the systematic error level

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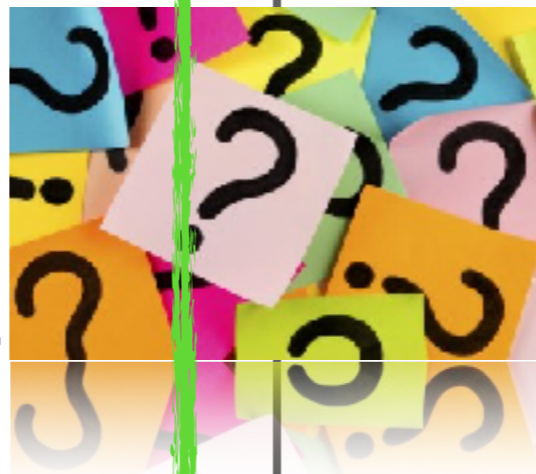
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# 1. Spectroscopic Enhancement of DESI?

- Many reasons why having a “clean” group/cluster catalog is of tremendous value
  - reduced projection effects
  - specz-s for all central galaxies
- Make modeling easier, facilitates detection of splashback, etc..
- DESI Homework
  - What is  $N_{\text{spec}}$  as a function of  $M_{\text{halo}}$  and  $z$ ?
  - How many BCGs will be missing a specz as a function of  $M_{\text{halo}}$  and  $z$ ?

**Possible Small Scale follow up program:** spectroscopic follow up of DESI to build a complete sample of BCGs and/or target specific clusters to reduce projection effects. Is there an existing facility that could be used? (I have a pilot proposal to do this for HSC using KAST on Lick)

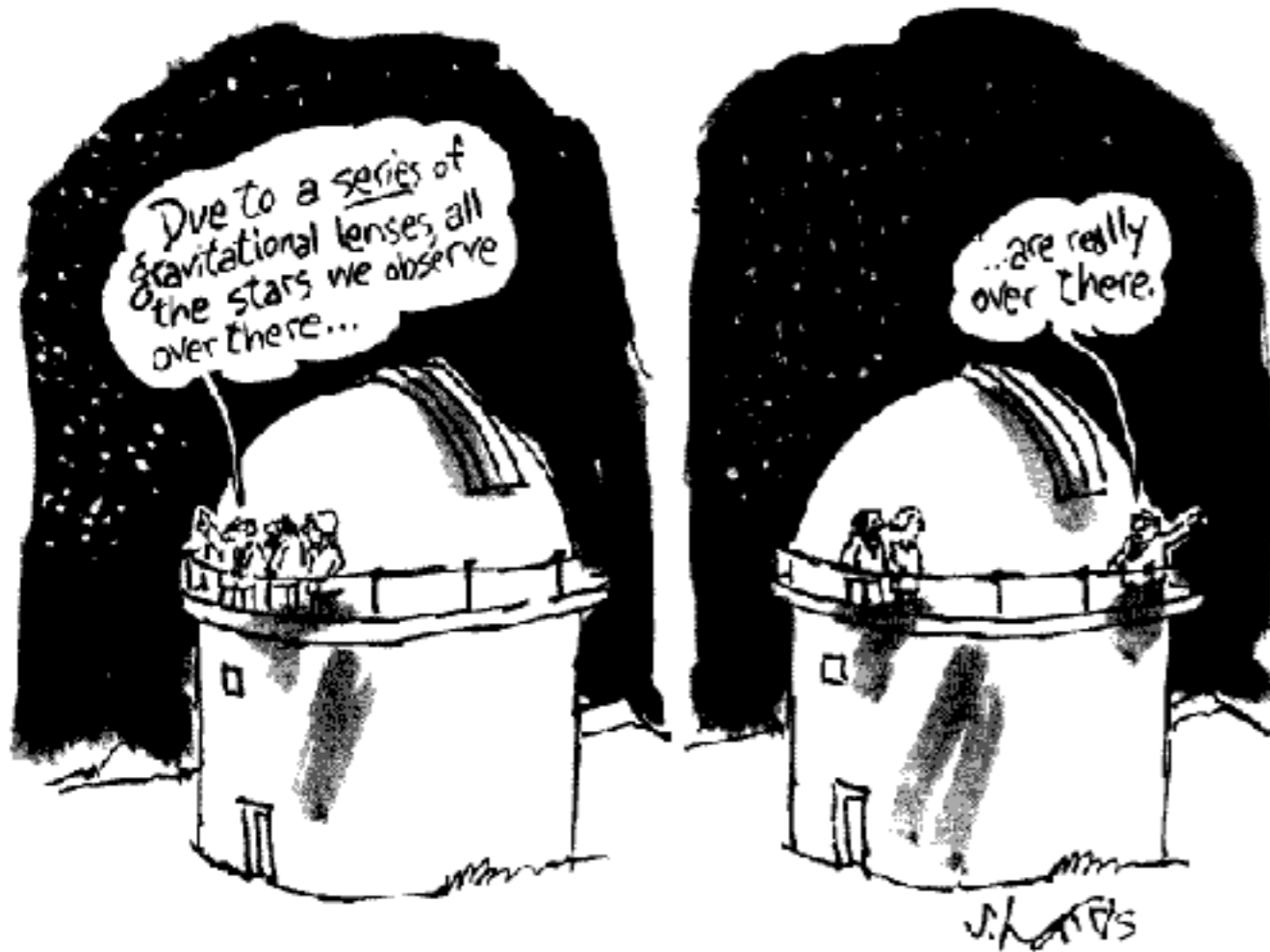
## 2. My Dream Small Scale Analysis for DESI

- Push modeling efforts for BGS / LRGs beyond HOD and simple SHAM
- BGS sample is particularly interesting because unlike LRGs does not have color cuts (makes modeling easier)
- Fit lensing and clustering using **semi-empirical approach** such as Emerge (Moster et al. 2017), Universe Machine (Behroozi et al in prep)
- Allows one to fold in additional constraints (SFR(z), higher z data, ....)
- Explore a wider range of plausible models for the galaxy-halo connection
- Explore a range of possible models before going to MG

**Wish list:** need large suite of hydro simulations with varying cosmologies and computational ability to run semi-empirical models to fit lensing and clustering. See talk by Andrew at 8:30.



# Thanks!



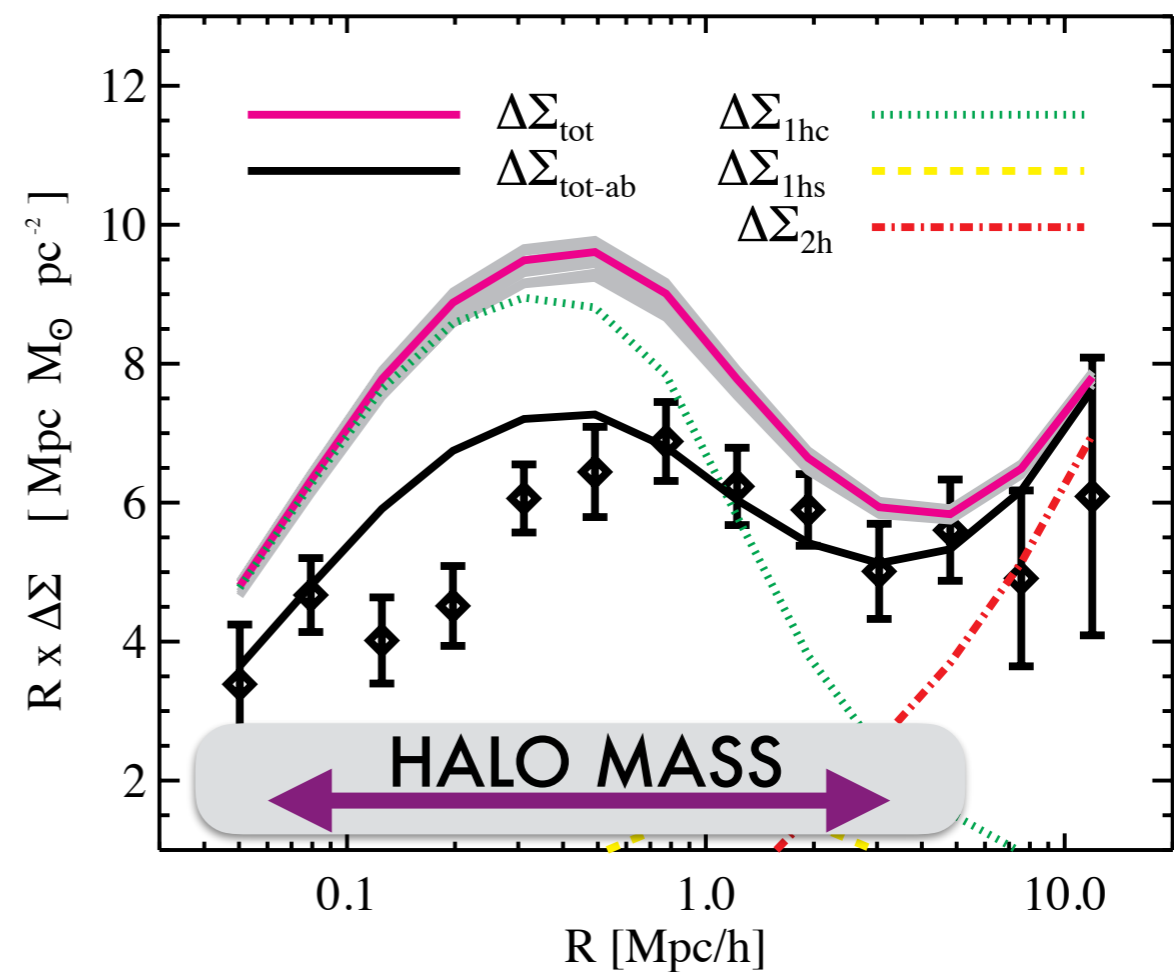
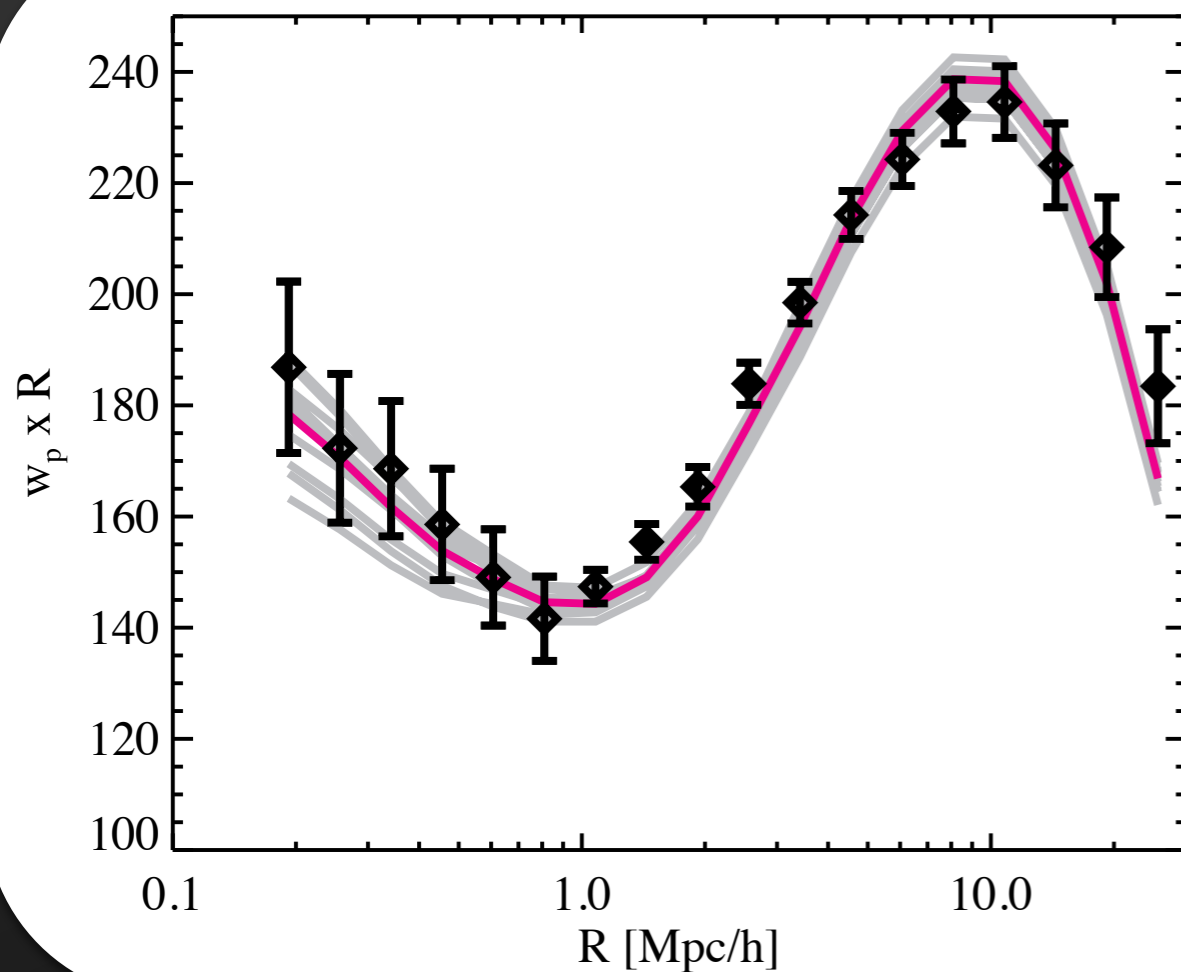
- *Modeling is hardest part*
- *Road map to tackle all effects together?*
- *DESI BGS sample will help simplify modeling*
- *Need to understand how many centrals will be lacking redshifts in DESI BGS*
- *Increase overlap between DESI and LSST ....*

- 1. Follow up program to get a complete sample of centrals?*
- 2. We need an ambitious simulation program - hydro - neutrinos*

# Assembly Bias?

Galaxy-Halo models often assume that large scale clustering is uniquely determined by halo mass.

Not necessarily true “Assembly Bias”.



35% decrease in halo mass at fixed bias.

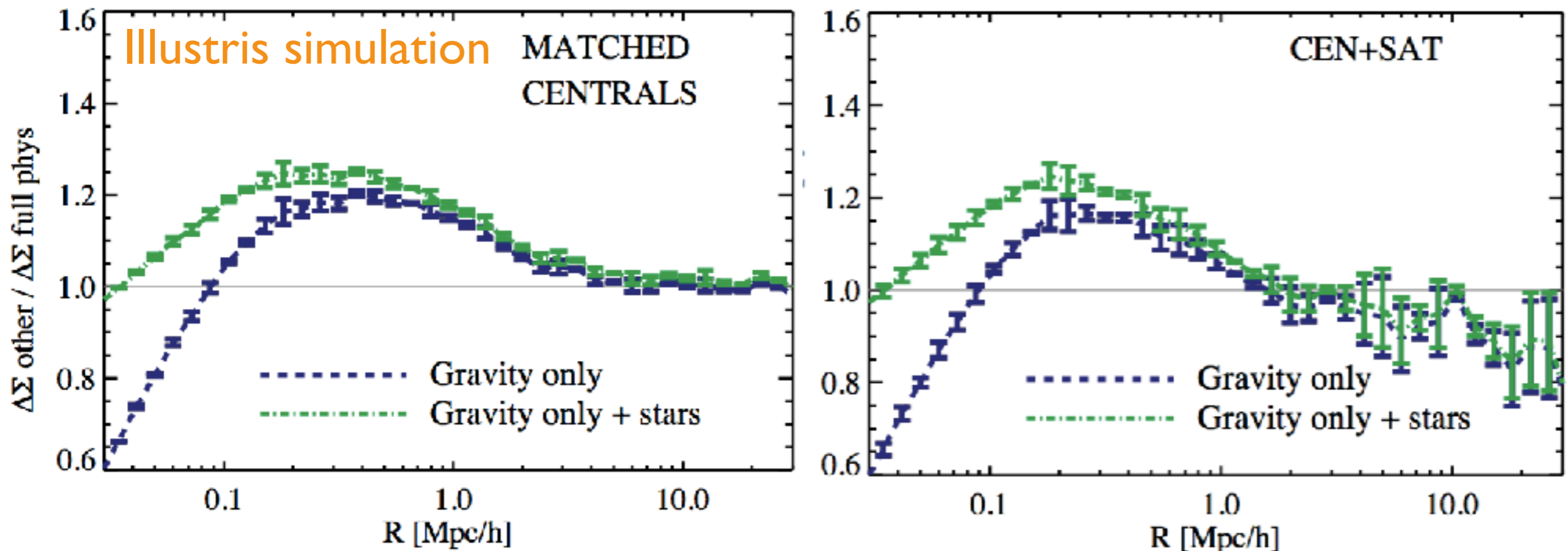
Plausible - although on the large side (Fig 4 in Li et al. 2008).



# Impact of Baryonic Effects?

*Model predictions are based on gravity only N-body simulations.*

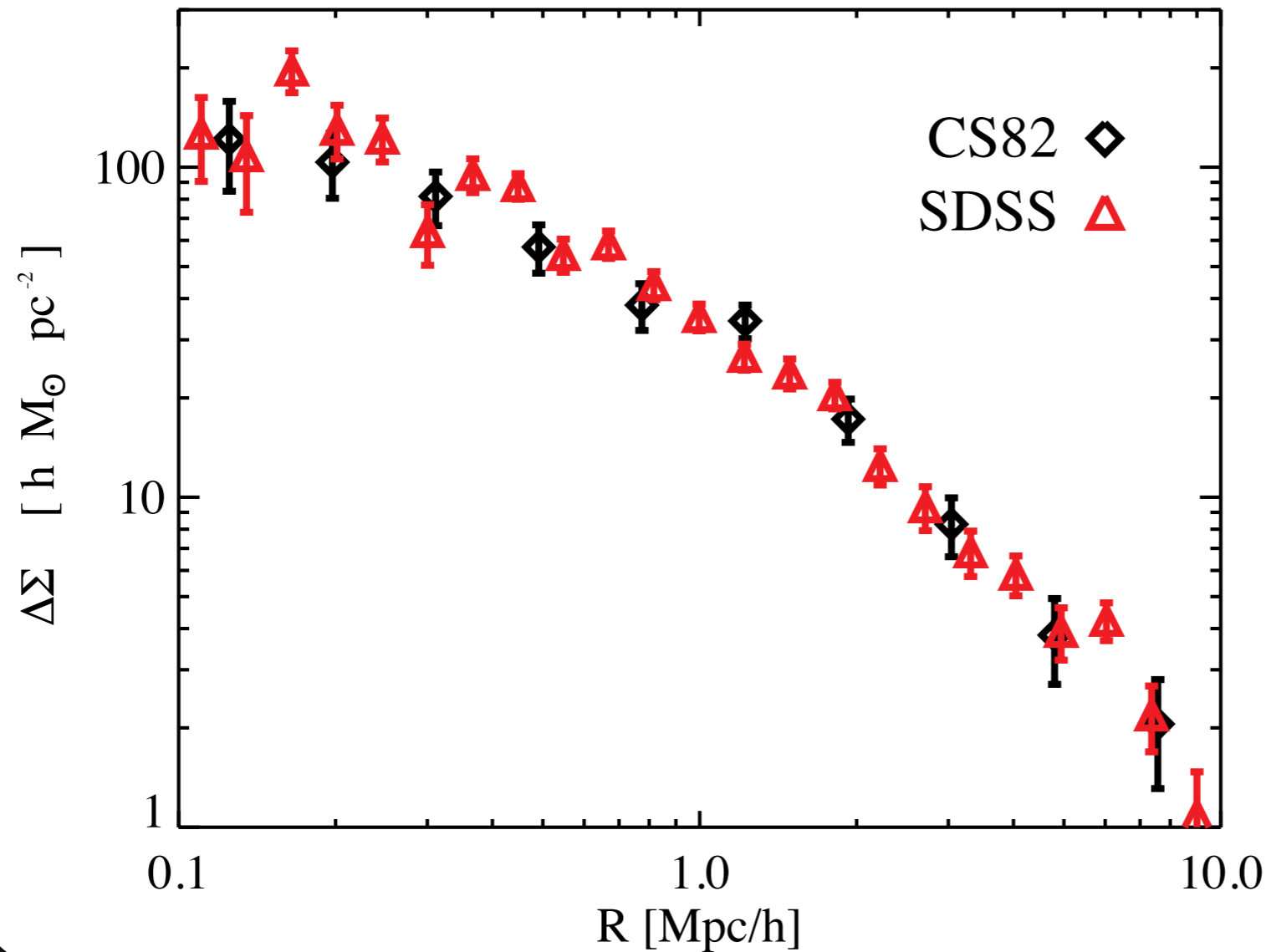
*But baryonic effects can change halo density profiles and sub halo properties.*



*Impact on halo profiles and satellite fractions*  
*Factor of 2 difference in  $f_{\text{sat}}$ !*

*20% effect on  $\Delta\Sigma$*

# Lensing Systematics?

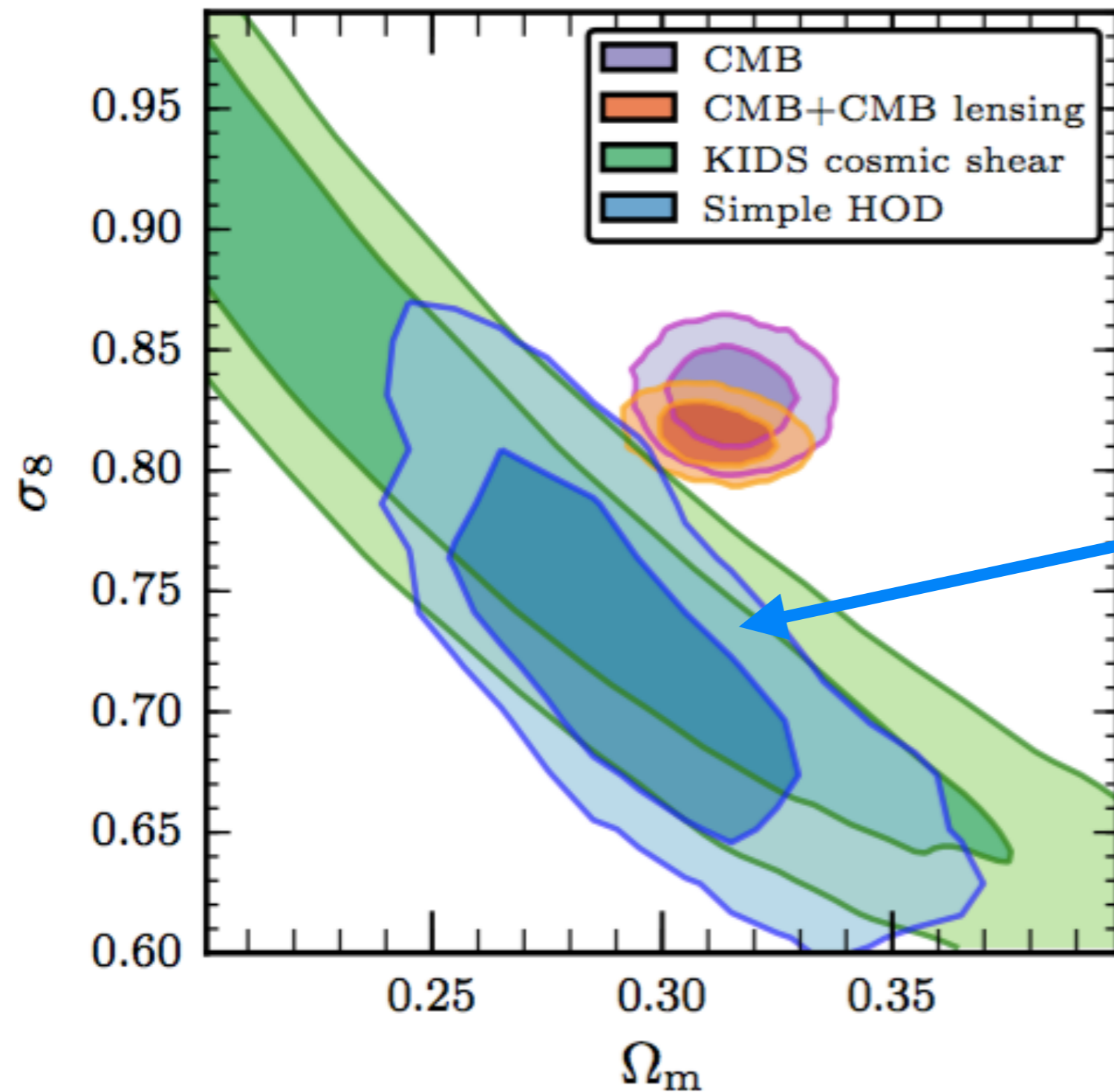


For other systematic tests, see:  
*Leauthaud et al. 2016*

- 👁 Different shear calibration - and different photoz-s
- 👁 Offset between CS82 and SDSS lensing is  $2\% \pm 7\%$  (consistent with zero)

*SDSS lensing: Reyes et al. 2012, Nakajima et al. 2012, Mandelbaum et al. 2013*

# Cosmology?



*Simple model is used to evaluate the values of  $\sigma_8$  and  $\Omega_m$  needed to explain the amplitude offset*