Probing the masses of Galaxy Groups in the COSMOS survey

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AND THE COSMOS TEAM

guideline for the talks and discussions

1) What are the basic methods, and their assumptions?
   ⇒ This talk will focus on stacked weak lensing measurements

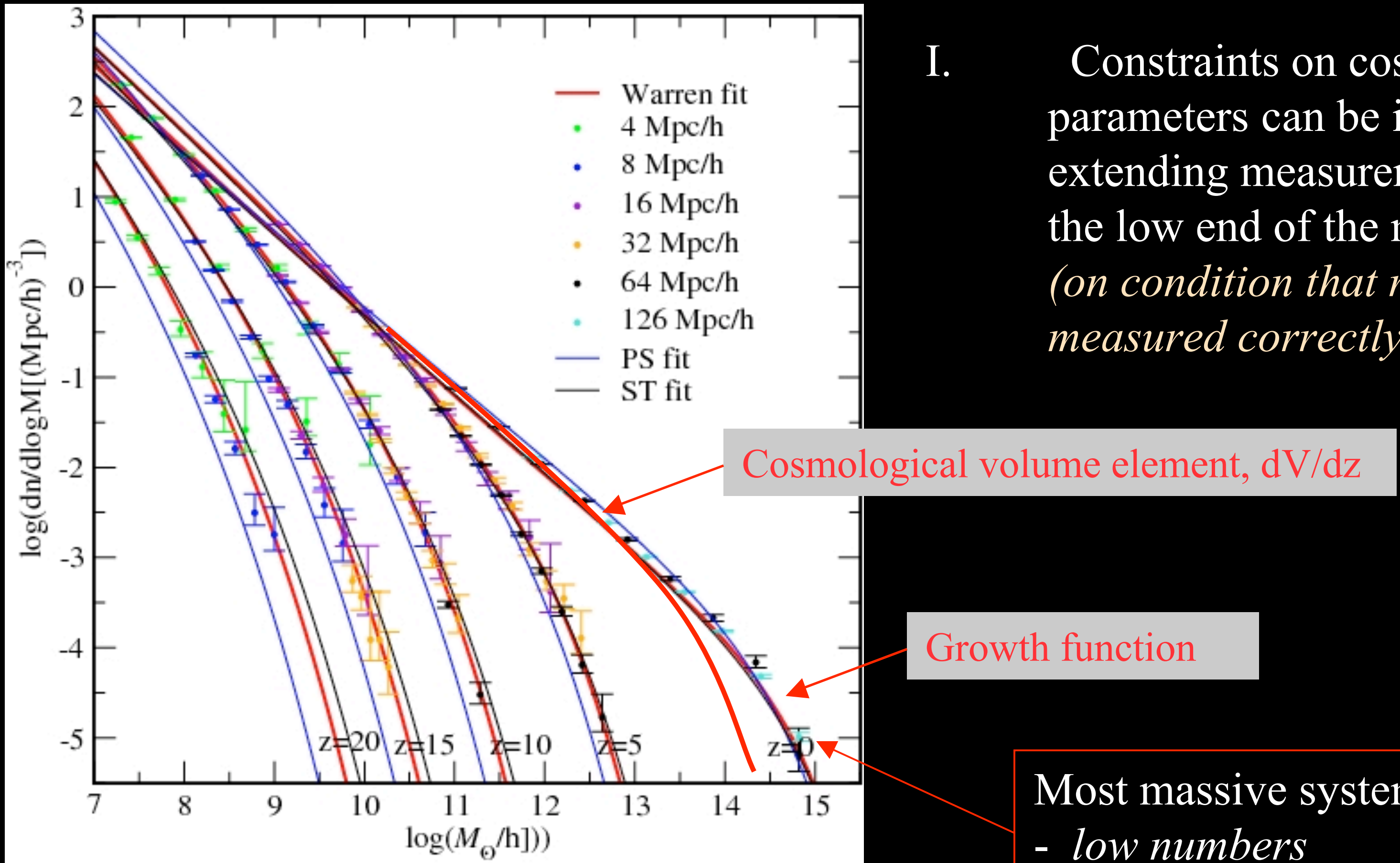
2) What is the expected contamination of fore- and background ?
   (as a function of redshift; what is the effect of this contamination?)
   ⇒ No results yet but we would like to look at this will the new COSMOS photometric redshifts (derived with 30 bands)

3) What are the methodological problems (uncertainties) converting the shear signal into a mass profile ?

4) For what mass range? How do we get good masses at the group scale?

5) And I added this question ….. Evolution of scaling relations?
   ⇒ The main topics of this talk

Motivations for pushing down to the low end of the mass function



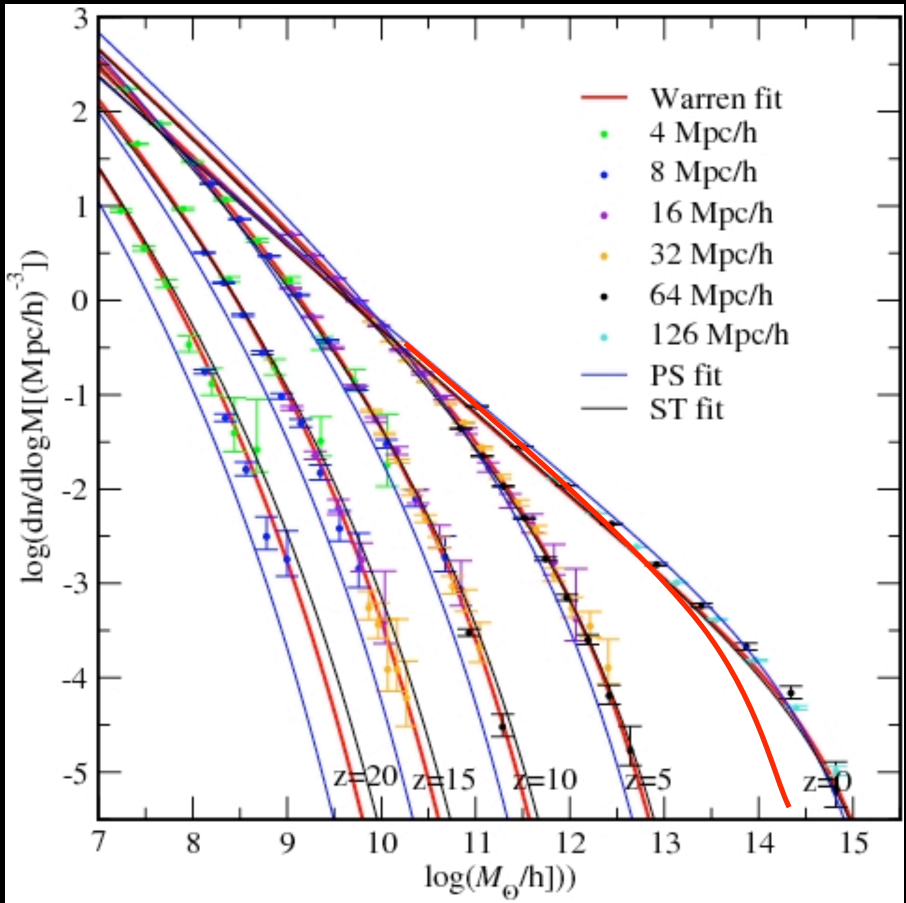
The growth of the Dark Matter Mass Function over cosmic time - Heitmann et al. 2006

I. Constraints on cosmological parameters can be improved by extending measurements down to the low end of the mass function *(on condition that masses can be measured correctly for groups).*

Most massive systems:

- *low numbers*
- *mergers/ non relaxed*
- *triaxiality*

Motivations for pushing down to the low end of the mass function



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II. Understanding the scaling relations of galaxy groups will lead to a better handle on the slope and amplitude of the scaling relations of more massive systems.

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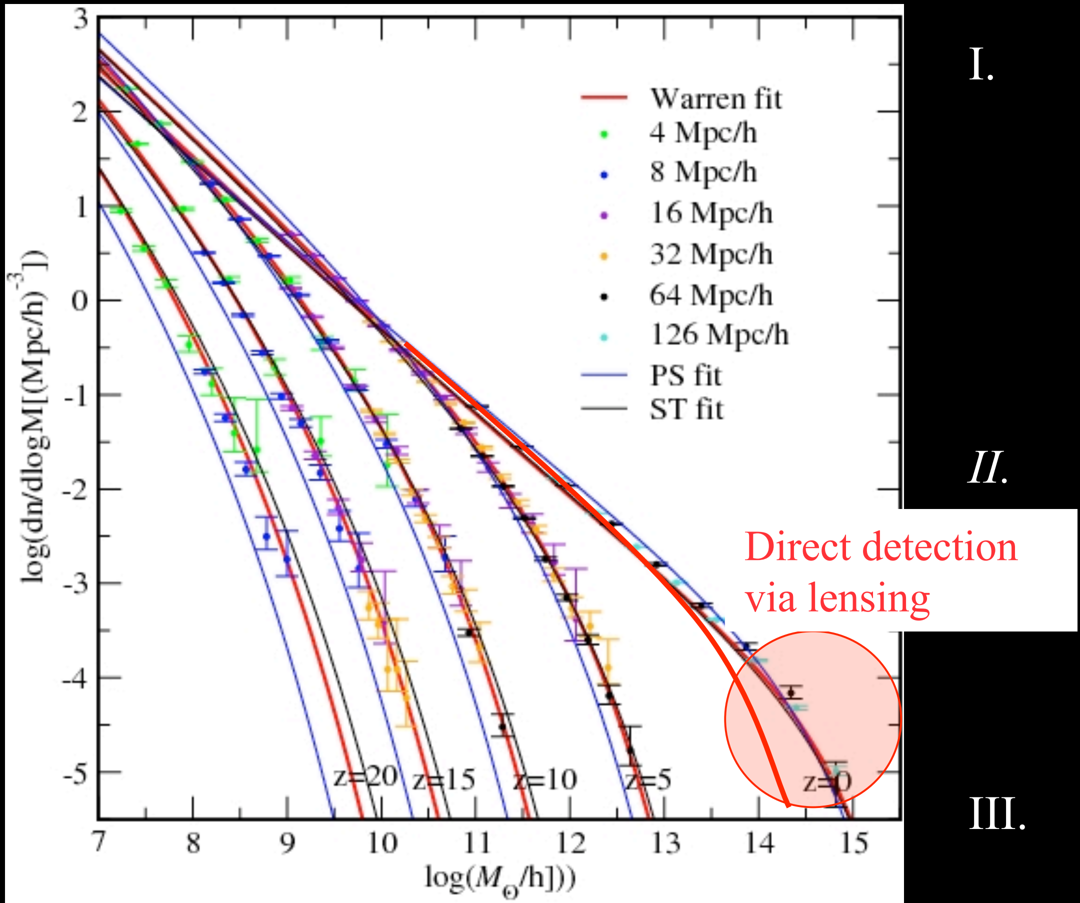

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II. Understanding the scaling relations of galaxy groups will lead to a better handle on the slope and amplitude of the scaling relations of more massive systems.

III. Galaxy groups also play in key role in processes of galaxy formation (low velocity dispersions ⇒ galaxies are more likely to merge)

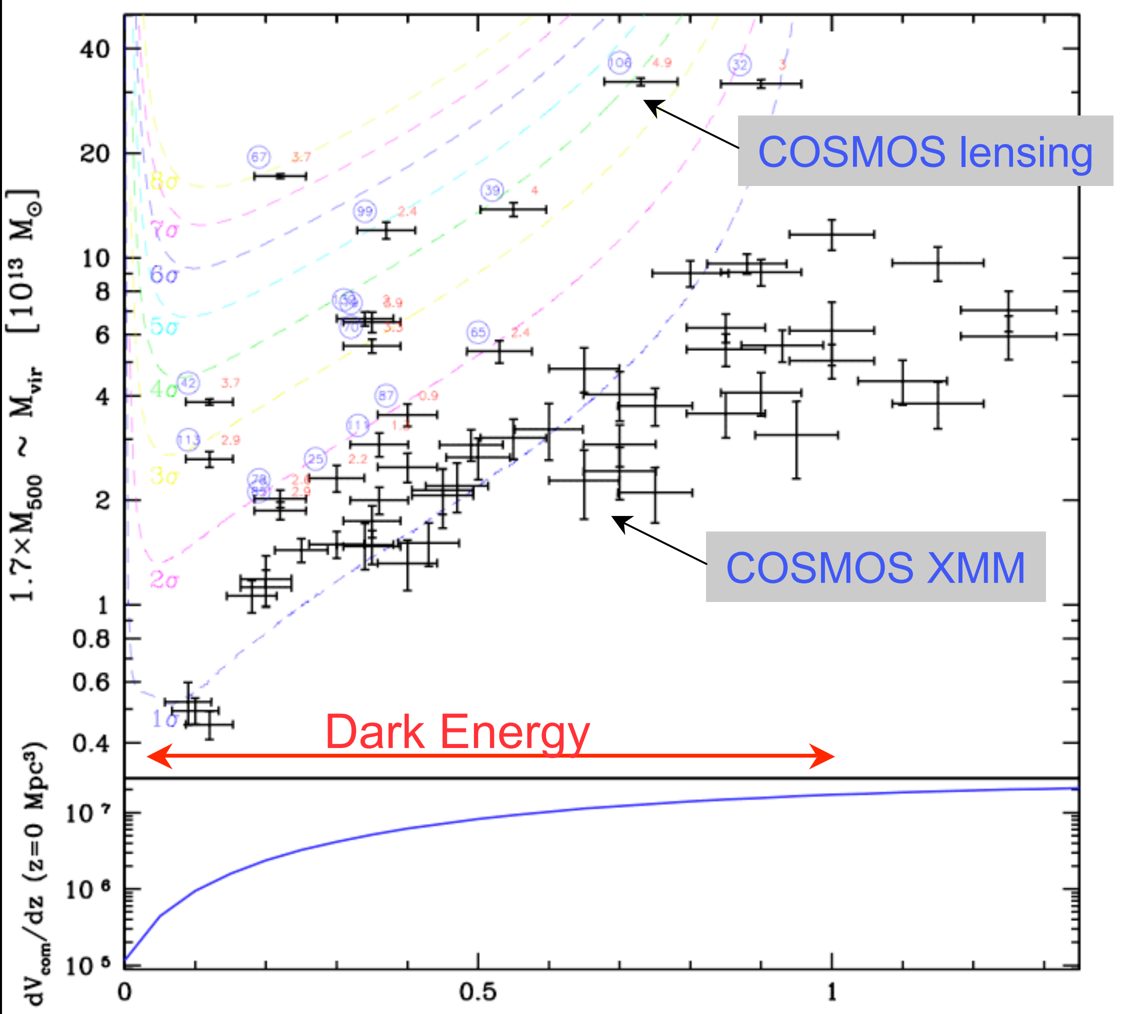
Probing structures beyond the limits of direct lensing detections

- If you are interested in Dark Energy you will want to probe: z = [0 , 1]

- You will also want to consistently calibrate scaling relations over z = [0 , 1] (redshift evolution?)

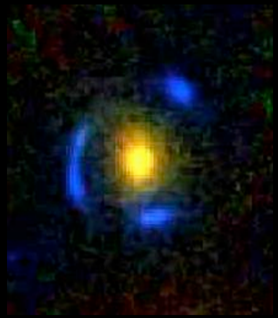
- For magnitude limited observations, the lensing detection significance is limited by the lensing weight function.

- Stacking techniques can go well below this limit techniques (all you need is a centre and a mass proxy for the structures to probe)

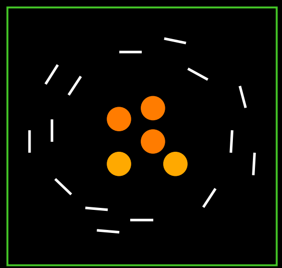


Plot from James Taylor

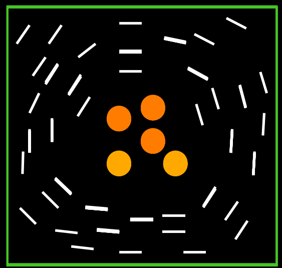
The three main lensing techniques



I. Strong Lensing - Probes the mass within the Einstein Radius - Limited number of systems - Representative sample?

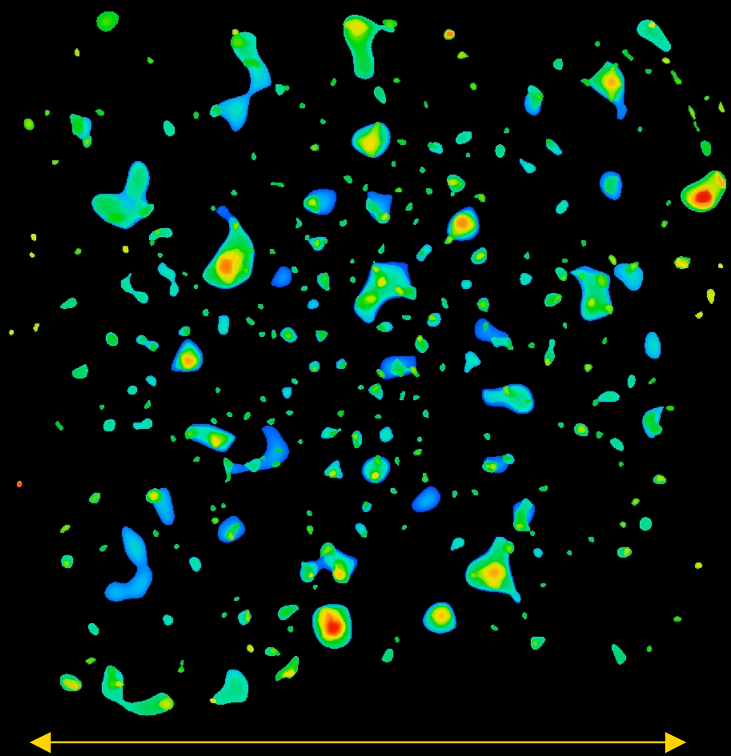


II. Weak lensing on an object by object basis - Only works for the most massive systems - Limited by the shape of the lensing weight function - Projection effects.



III. Stacked weak lensing - Can measure the mass for potentially ANY systems - Can reduce the statistical noise - Not affected by projection effects - Need to know center - No longer acess to the scatter.

The cosmos group sample



1.3 deg^2

COSMOS survey
CHANDRA + XMM
A. Finoguenov et al. 2007

- ~ 180 groups detected through extended XMM emission
  Finoguenov et al. 2007

- 1.67 deg^2 of contiguous ACS data - high background number density (60 gals/$arcmin^2$) - no issues with the mass sheet degeneracy
  Leauthaud et al. 2007, Rhodes et al. 2007

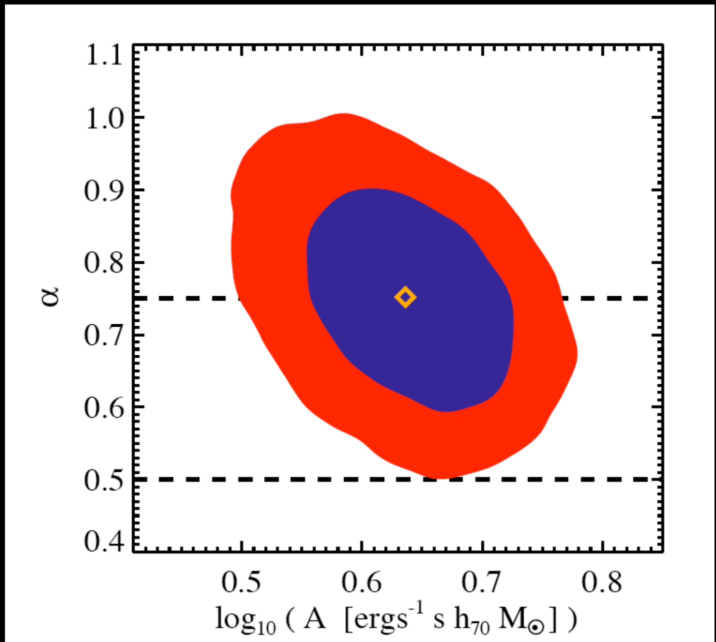
- State of the art photometric redshifts (30 bands of data including IR and u band)
  Ilbert et al. in prep

- ~ 10 000 spectroscopic redshifts for photoz calibration
  Lilly et al. 2007

The M_{200} - L_x relation for galaxy groups

Form of the M_{200} - L_X relation:

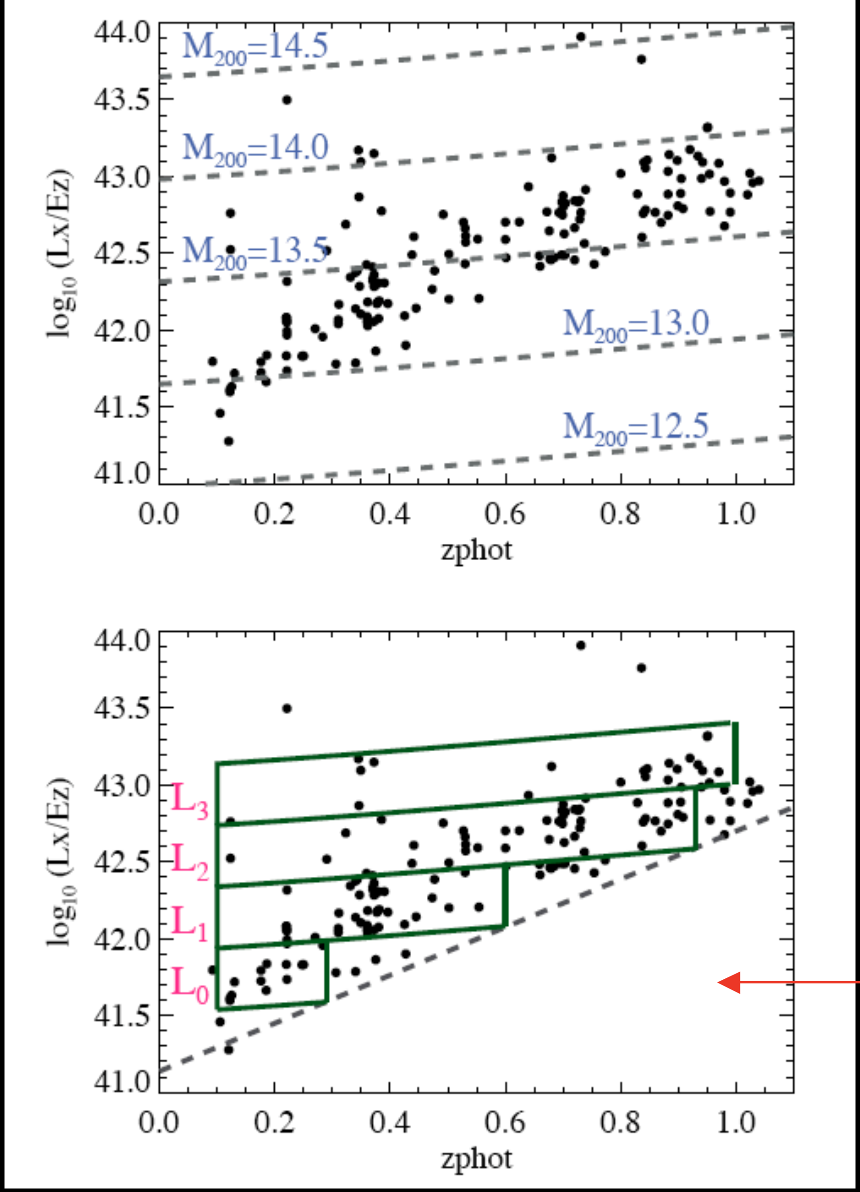
$$\frac{M_{200} \times E(z)}{M_0} = A \times \left[\frac{L_X \times E(z)^{-1}}{L_0}\right]^{\alpha}$$



Maximum likelihood estimation of the calibration relation. We we are finding α~3/4 (0.75) similar to local X-ray measurements.

◊ Rykoff et al. found α~3/4 (0.85) in the SDSS.

The stacking technique



- Start from the COSMOS X-ray group catalogue (Finoguenov et al. 2008, in prep)

- Compute 1D lensing mass profile by stacking groups of similar X-ray properties (in this study, groups are stacked by L_X)

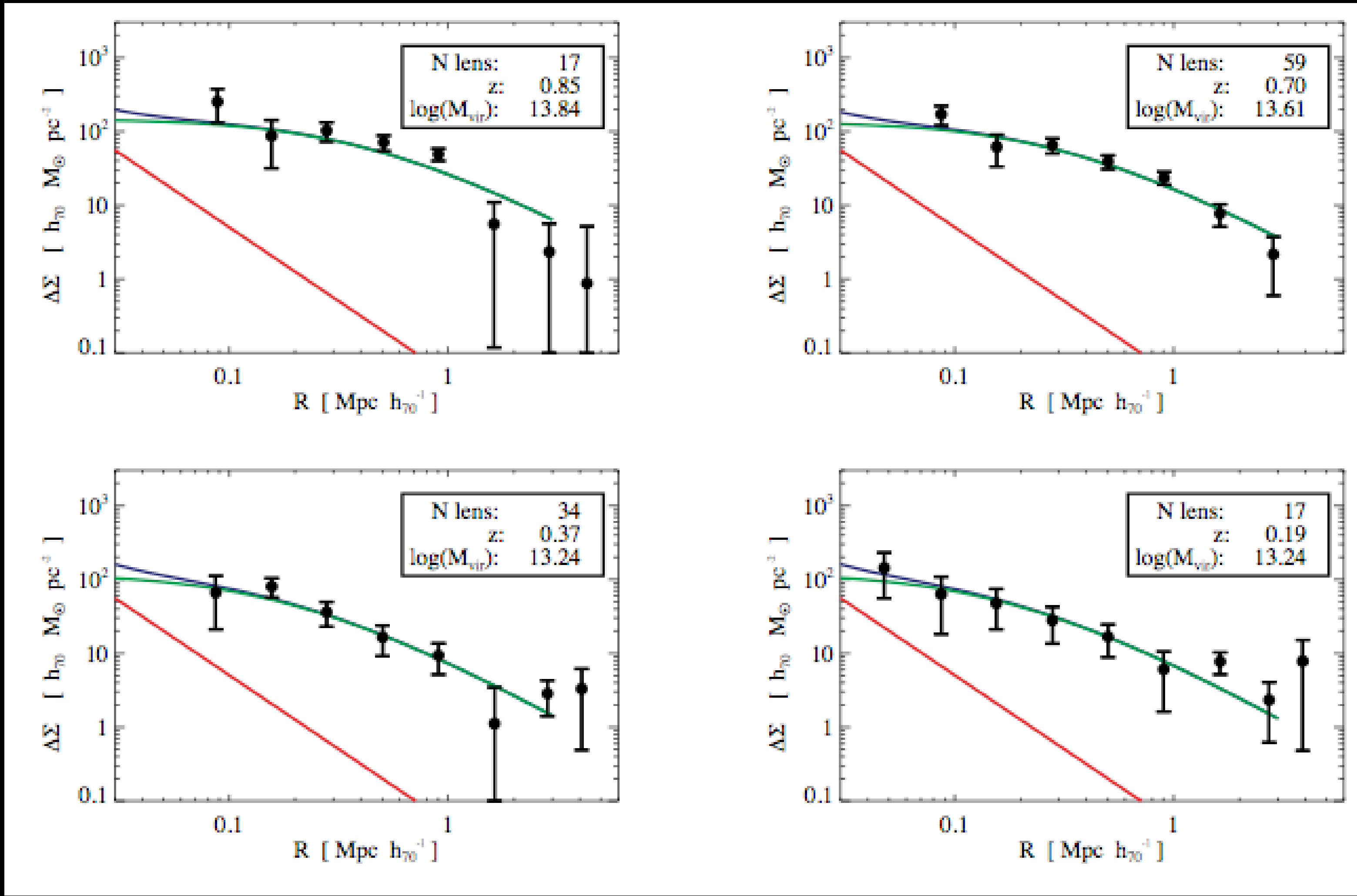
- lines of constant mass are shown by the dashed grey lines

- Calibrate the M_{200}-L_X relation. Check for redshift evolution.

Luminosity bins with self-similar redshift evolution implemented

Leauthaud et al 2008, in prep

Weak lensing profiles per l_x bin

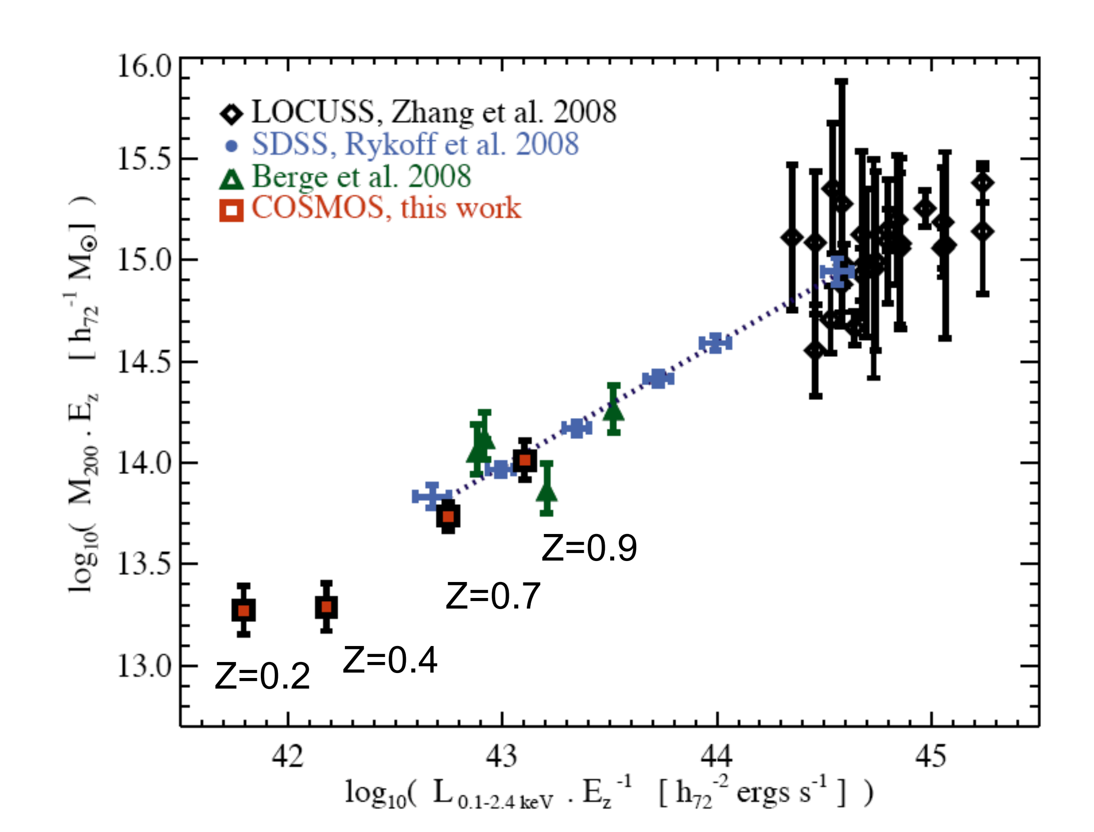


Radial mass profile of X-ray groups in four different Luminosity bins

Leauthaud et al 2008 in prep

Evolution of The M_{200} - L_x relation ?

Preliminary



Comparison to local SDSS WL-X-ray calibration (Rykoff et al. 2008).

1) Fair agreement, but probing smaller mass systems.

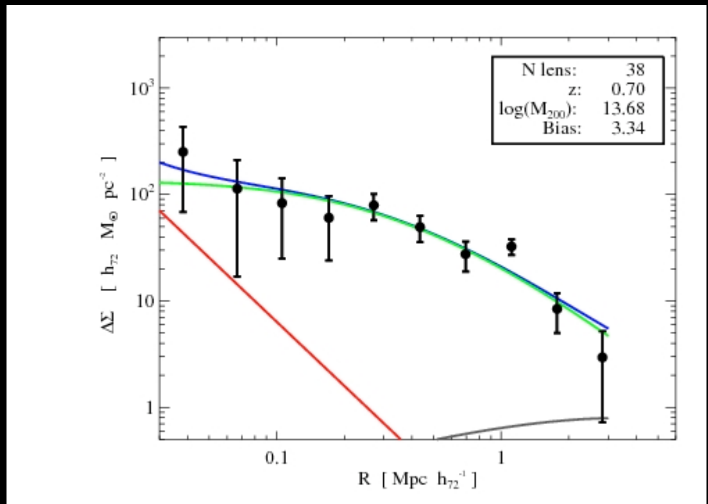
2) No evolution seems necessary beyond the self-similar model

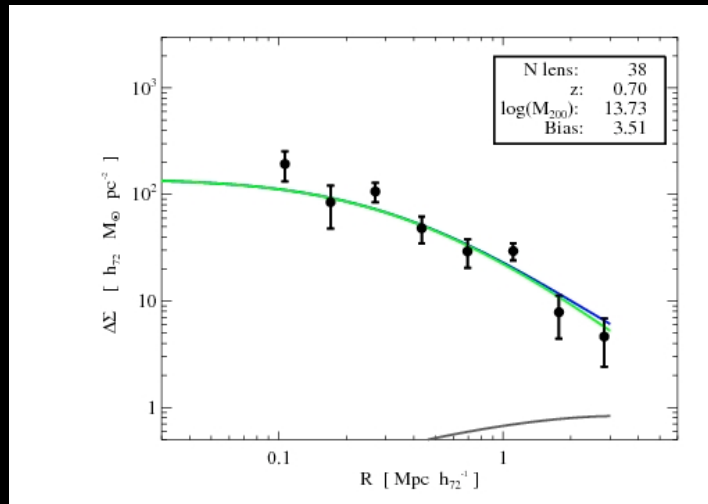
⇒ *Cautionary Note: still some effects to be accounted for….*

First issue: Where is the center?

In order to stack the lensing signal, you need to know where the dark matter peak is located: X-ray center versus BCG? We are currently working on a comparison of the signal with respect to the two centers :

Preliminary



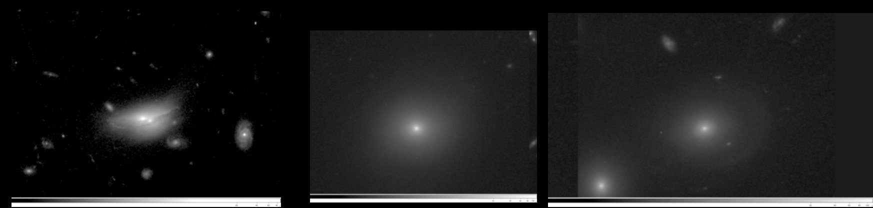


M=13.68 Msun

M=13.73 Msun

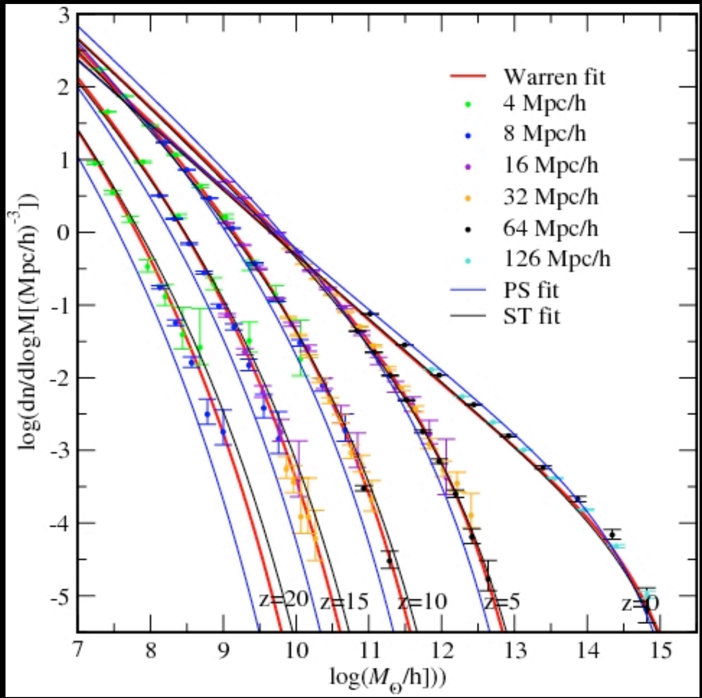
Difference = 0.05 (factor of 1.12) … not too bad …

Algorithm to detect BCG's is being developed by Melody Wolk at LBNL/Berkeley (see poster)



second issue:
scatter in the Mass observable relation

There is a significant scatter expected in the Lx- M relation: $\sigma_{\ln(L)} \sim 0.86$ (Rykoff et al. 2008)



This scatter will lead to an underestimation of the lensing mass. This can be corrected for if the scatter, σ, is know by some other means.

- However, how can one measure this scatter …..?
- Can the scatter be determined via bootstrap techniques …. ?

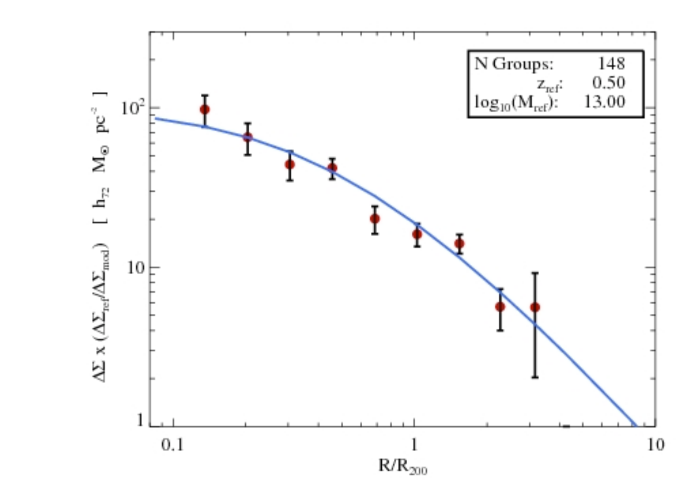
conclusions

Stacking techniques look very promising in order to probe the masses of structures below 10^{14} Msun and at higher redshifts. There has already been good progress in this direction, e.g. :

Mandelbaum et al. 2006
Johnston et al. 2007 } *z~0.2*
Rykoff et al. 2008
Leauthaud et al. in prep } $z = 0.4 \Rightarrow z = 1.0$

Important issues that require further work:

1) Where are the centers of the dark matter halos?
2) Can the scatter in the Lx - M200 relation be measured in this regime?



COSMOS groups:
$R=0.15R_{200} \Rightarrow R=35R_{200}$

The end - time for lunch !