Scatter and bias in Weak Lensing Mass Estimates

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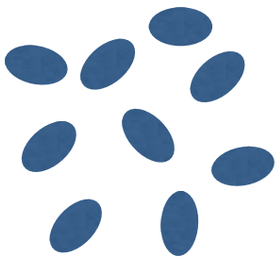
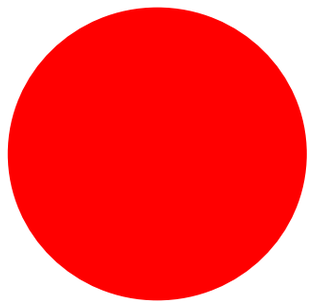
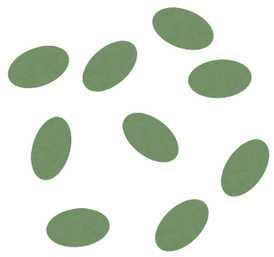
A Lightening Review of Weak Lensing Cluster Mass Estimates



background galaxies (assumed to be oriented randomly)

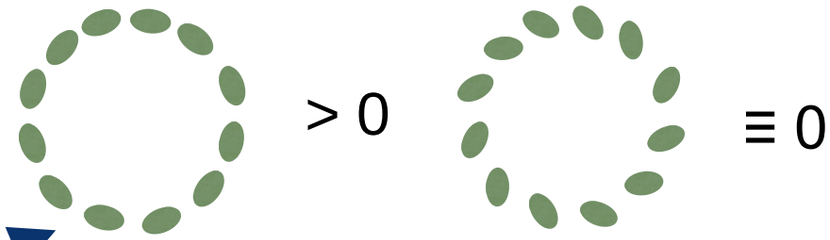


cluster



images of background galaxies (definitely not oriented randomly)

Galaxy clusters introduce a net tangential alignment in the weakly lensed images of background galaxies. They do not produce patterns with handedness.



Mass along the line-of-sight will deflect the paths of photons traveling between a source and the observer through the geodesic and Einstein equations from General Relativity. Small deflections which result in changes to the shapes of galaxies are known as **weak lensing (WL)**.

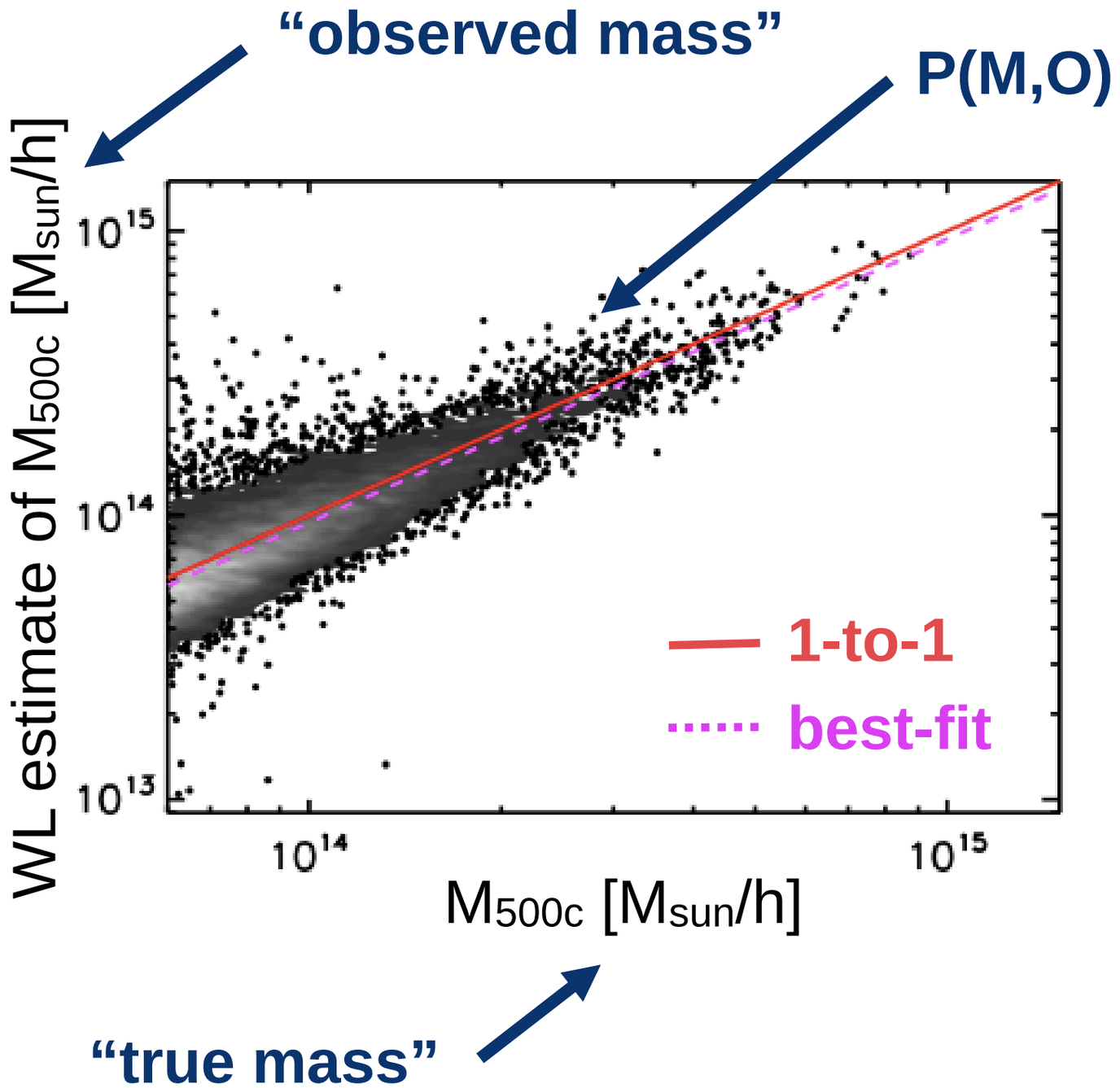
1) Measurements of the mean **tangential shear** can tell you about the mass of the cluster.

2) You need to measure the shapes of galaxies accurately which is very difficult. (Not what an N-body simulator generally worries about though.)

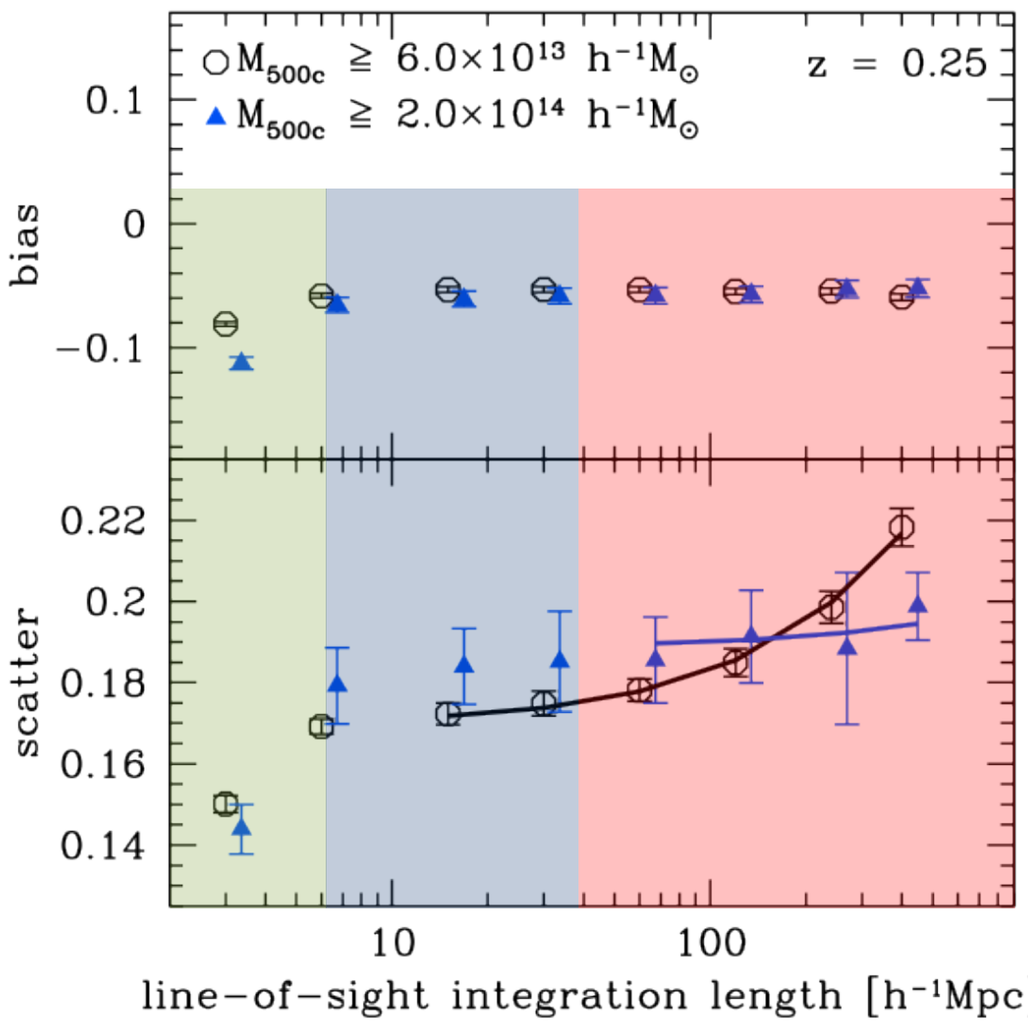
3) Mass projected along the line-of-sight along with the cluster and modeling errors create scatter and bias in WL masses. We will focus on this issue here.

WL estimate of M_{500c}

- We attempt to calibrate the M_{WL}-M_{TRUE} relation directly in DM-only N-body simulations. (Sensitive to mass only, so robust to the gross effects of galaxy formation?)
- Get the WL mass from fitting the reduced shear profile for each cluster with NFW prediction (radial range 1 to 20 arcminutes, 15 logarithmic bins)
- NO SHAPE NOISE in this plot (WL mass estimates are intrinsically noisy!)
- For $M_{500c} > 2x10^{14}$ M_{sun}/h at z=0.25 find ~20% intrinsic scatter, -5% bias



The WL Mass Error Budget



The line-of-sight integration length is measured from behind the cluster to in front of it (so that 200 Mpc/h is -100 Mpc/h to 100 Mpc/h.

Quibbling over where to put the boundaries between the colors is a little silly.

source	scatter	bias
halo shape	~16%	-5%
correlated LSS	≤ 8%	0%
random projections	up to 18%	0%
shape noise	31%	0%
total	**36-40%**	**-5%**

Notes:

1) Some of this was known before, but we put it all together.

2) We assume typical ground-based source density (10 gals/arcmin^2) and shape noise (0.4 per component).

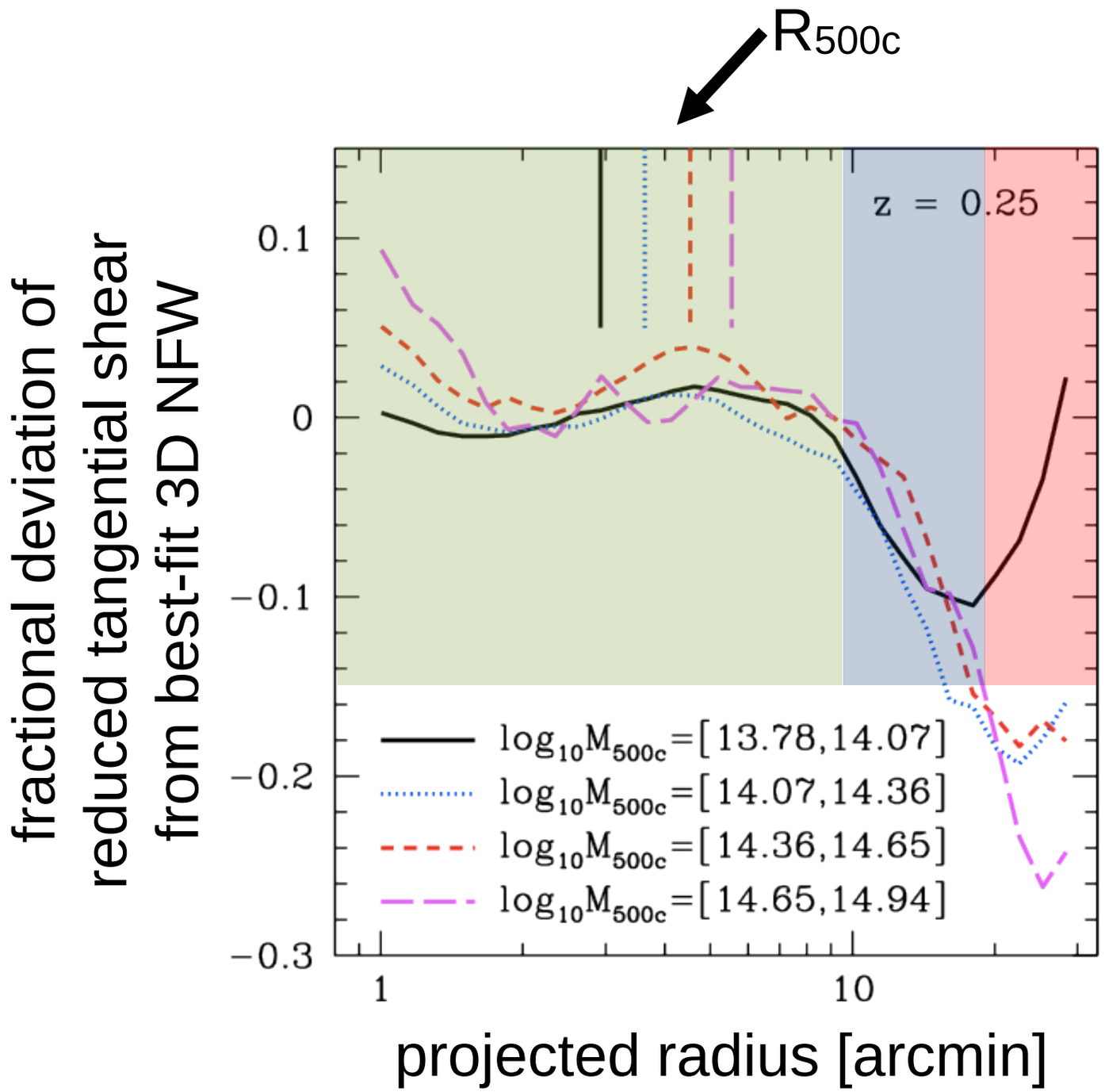
3) Add scatter numbers in quadrature down table.

4) Add bias linearly down table.

5) Random projections affect small mass halos more (They produce less shear). The largest halos have very little extra the scatter due to random projections.

6) The solid lines to the left are based on an analytic model by Hoekstra (2003) for scatter due to random projections.

Modeling Errors Create Bias



1-halo regime
- seems to be OK

transition region
- hard to model
- details probably depend on halo finding and definitions

2-halo regime
- easy to model, but does it make sense to do so for a single cluster?
- might be better to do a stacked analysis

NB: results are confirmed by Oguri & Hamana arXiv/1101.0650 using analytic models of clusters