Minimum variance weak lensing cluster mass estimates

AIfA Lens/Cosmology Seminar

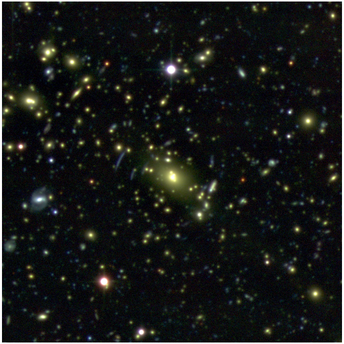
2012-08-28

Daniel Gruen, G. Bernstein, T. Y. Lam, S. Seitz (2011)

Structure

Clusters of Galaxies

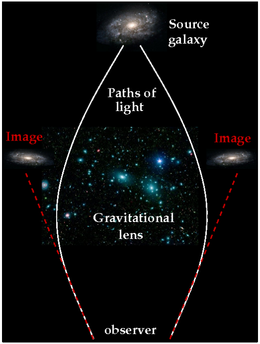
- most massive structures: $10^{14} M_{\odot}$, 1Mpc
- dark matter, gas, galaxies
- formation $\leftrightarrow$ cosmology



RXJ2248, source: WFI / own reduction

Weak Lensing

- Clusters bend space-time and light
- Multiple images: strong lensing
- shear: weak lensing
- mass measurements
- model fitting
- aperture mass



Source: galileospendulum.org

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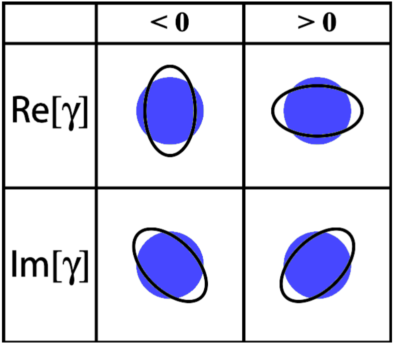

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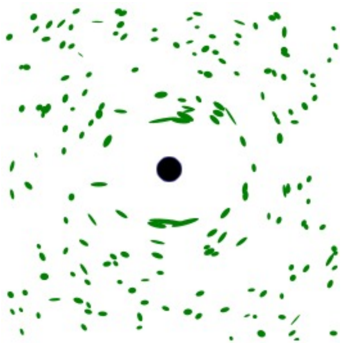

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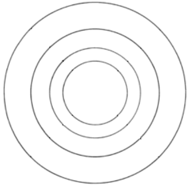
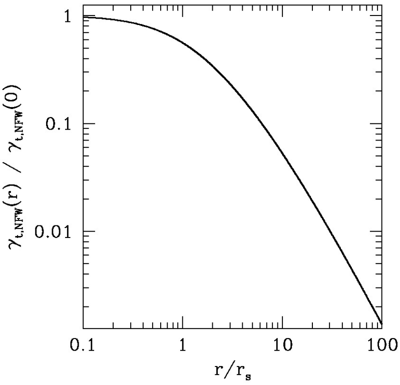


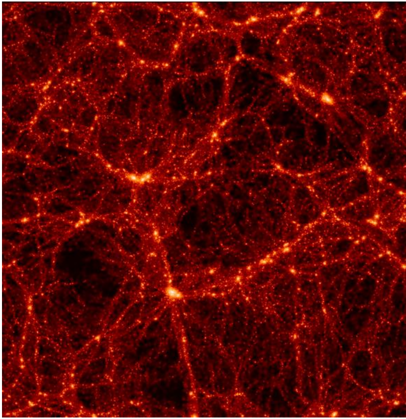
Weak lensing cluster mass

Faces of galaxy clusters

M. Gruendl, Institute of Psychology, Uni Regensburg

Faces of galaxy clusters





Simulations: van den Bosch, MPA

Tall tales of NFW

Yes,

- average profile of dark matter halos

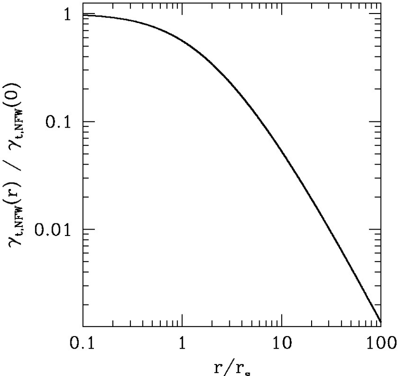
but ...

- asphericity
- concentration scatter
- substructure
- surrounding structures
- core and outskirts

$$\rho(r) = \frac{\rho_0}{(r/r_s)(1+r/r_s)^2}$$

Navarro, Frenk, White (1996)

$$c = r_{200}/r_s = c(M, z)$$



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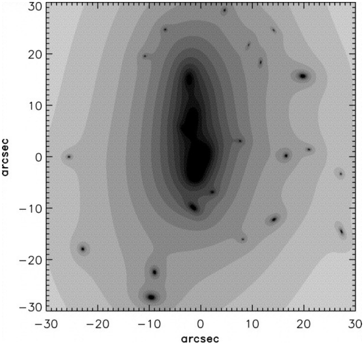

Source: Verdugo et al. (2007)

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$\sigma_{\log c} \approx 0.18$
Bullock et al. (2001)

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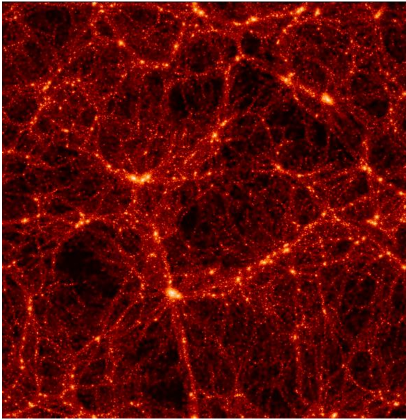

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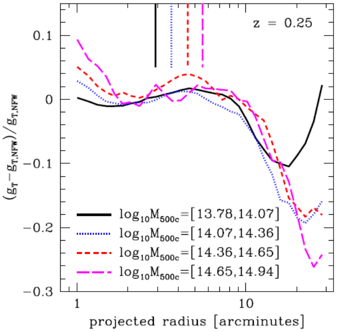


Source: Becker & Kravtsov (2011)

What we did: four steps

Sources of Noise

NFW signal + shape noise + LSS + intrinsic mess

Intrinsic profile variability

Can we explain the scatter in shear profiles we see?

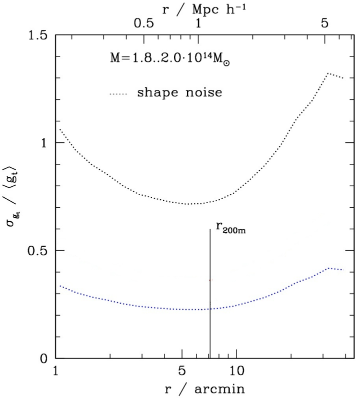
Optimized apertures

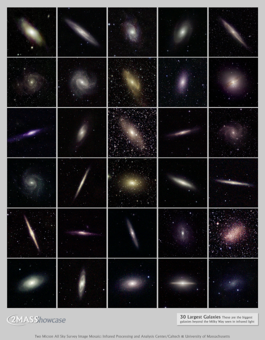
What do optimized apertures look like?

Mass uncertainty

Does it help at all?

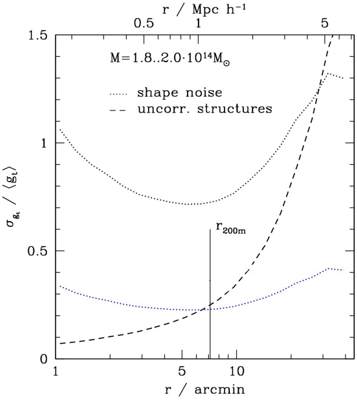
Sources of noise in Weak Lensing

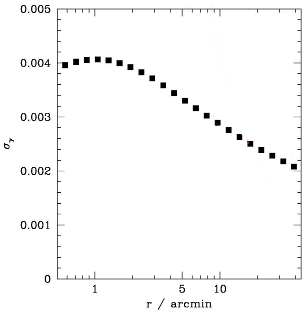




Source: 2MASS

Sources of noise in Weak Lensing





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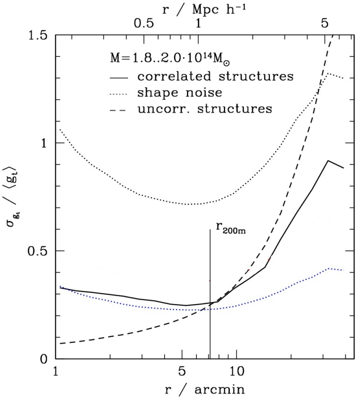
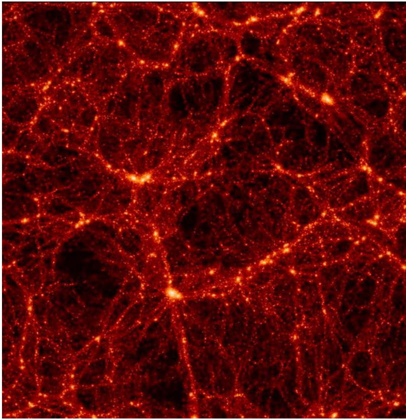
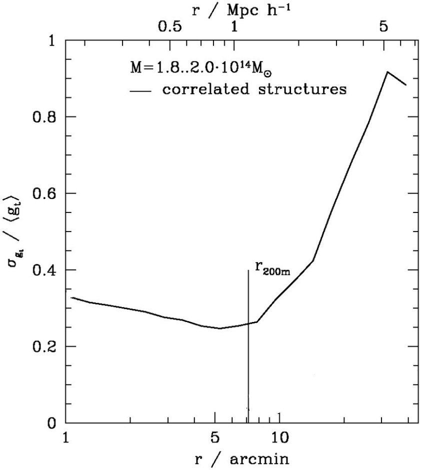




14,000 clusters $> 10^{14} M_\odot$
at $z = 0.245$

Profile uncertainty: components



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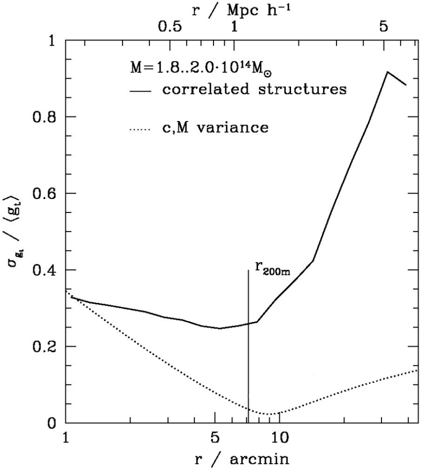

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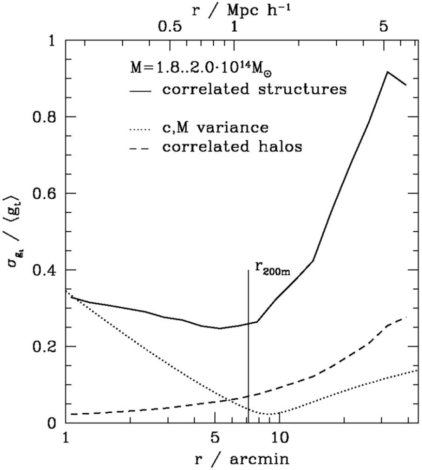

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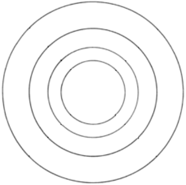

Minimum variance aperture

$$\vec{Q} \propto \hat{C}^{-1} \vec{\gamma}_{\rm true}$$

for uncorrelated LSS: Dodelson (2004), Maturi et al. (2005)
including correlated structures: this work

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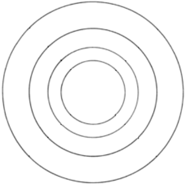

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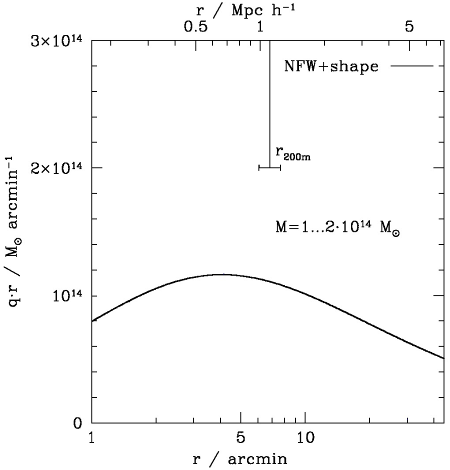

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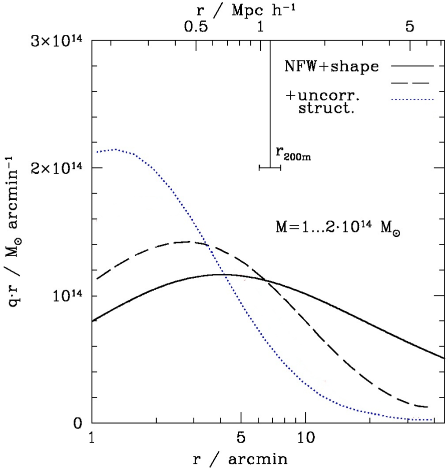

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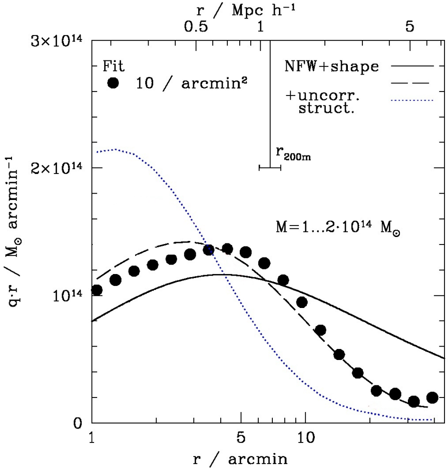

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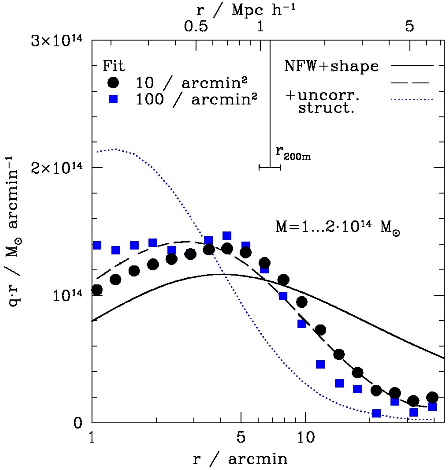

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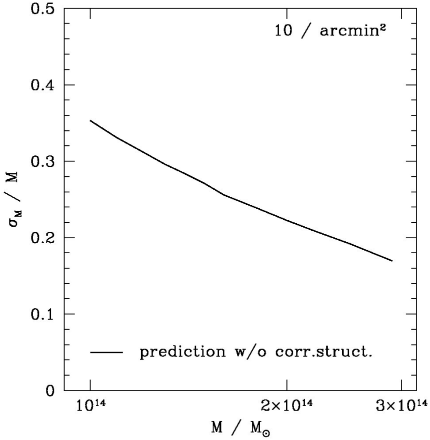

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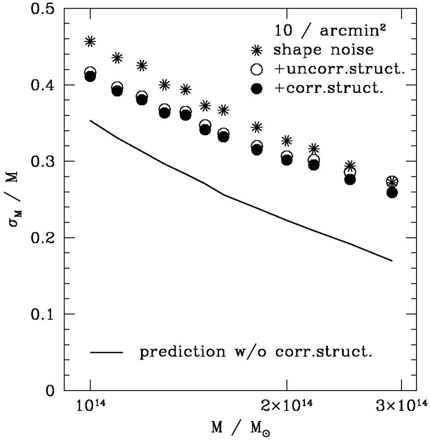

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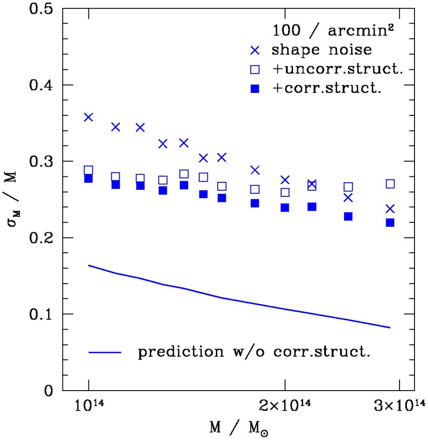

Modelling the Covariance

Why model the covariance of cluster shear?

- prediction of mass uncertainty
- full Bayesian mass estimation
- peak detection completeness

Idea

Use two simple components:

- concentration variation
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and rescale to fit

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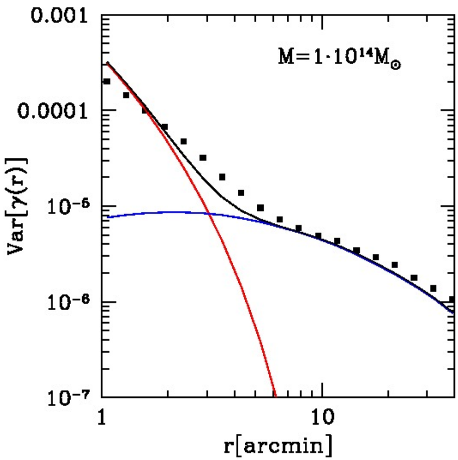
Modelling the Covariance [preliminary]

Can we model the variations of cluster shear profiles...

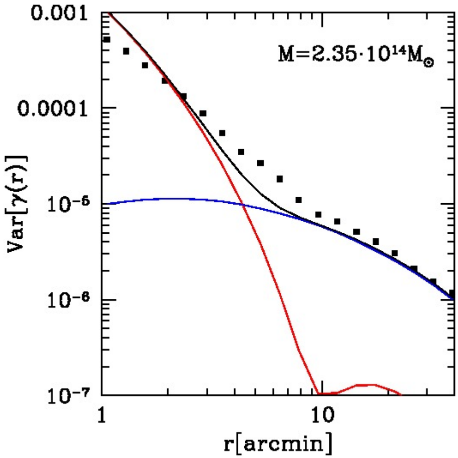
- in small mass bins using these components?



Modelling the Covariance [preliminary]

Can we model the variations of cluster shear profiles...

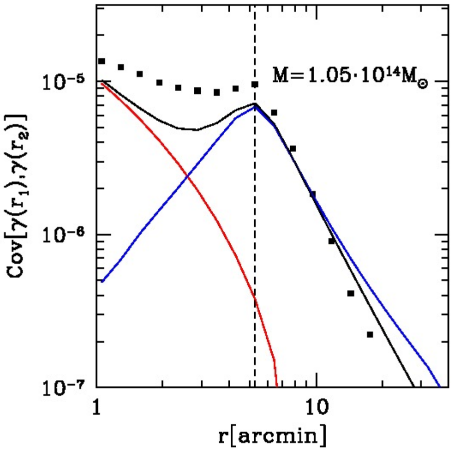
- over a range of masses?



Modelling the Covariance [preliminary]

Can we model the variations of cluster shear profiles...

- also for off-diagonal components?



Conclusions

NFW

spherical NFW is only a good approximation on *average*

Halo structure

(M, c) is no sufficient description either
possible to model varations

Mass uncertainty

$\sigma_M >$naive expectations; deeper only marginally better

Optimized apertures

modest improvements
doing half sometimes worse than doing nothing

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