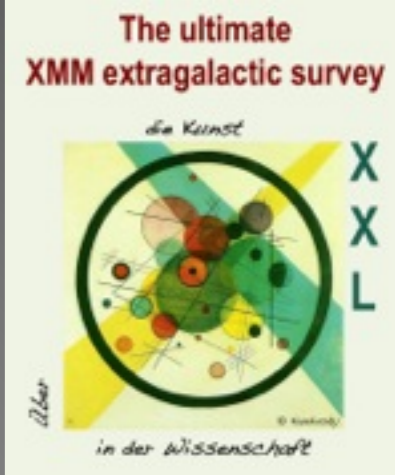


 @Space_Mog

www.maggielieu.com

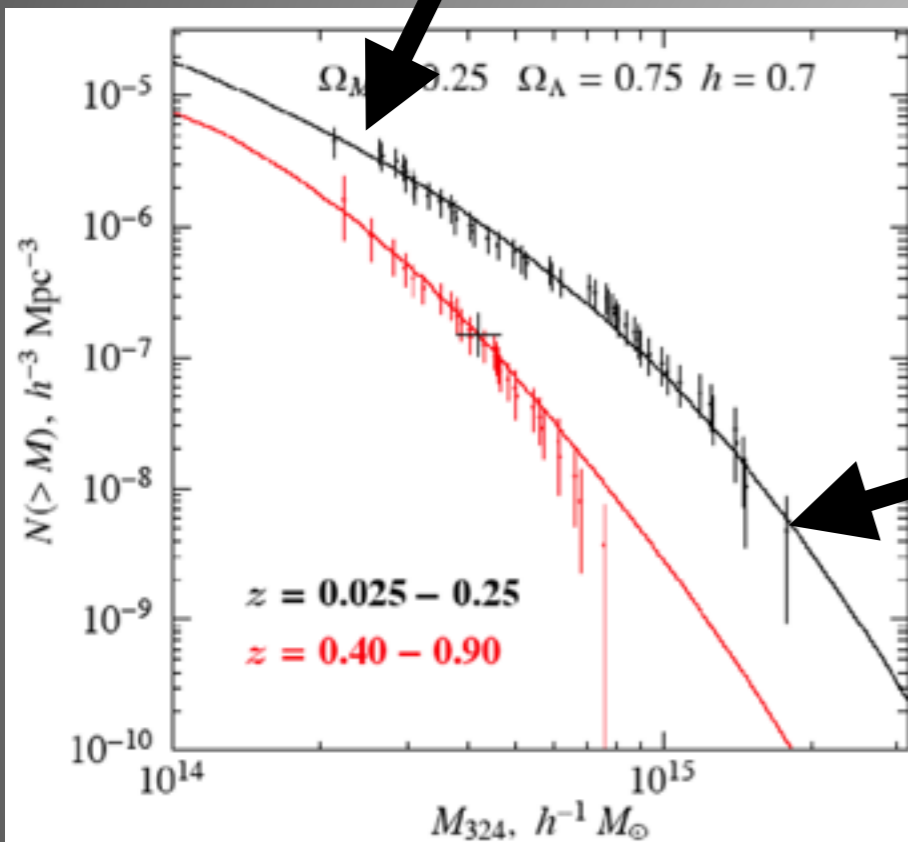
mlieu@star.sr.bham.ac.uk



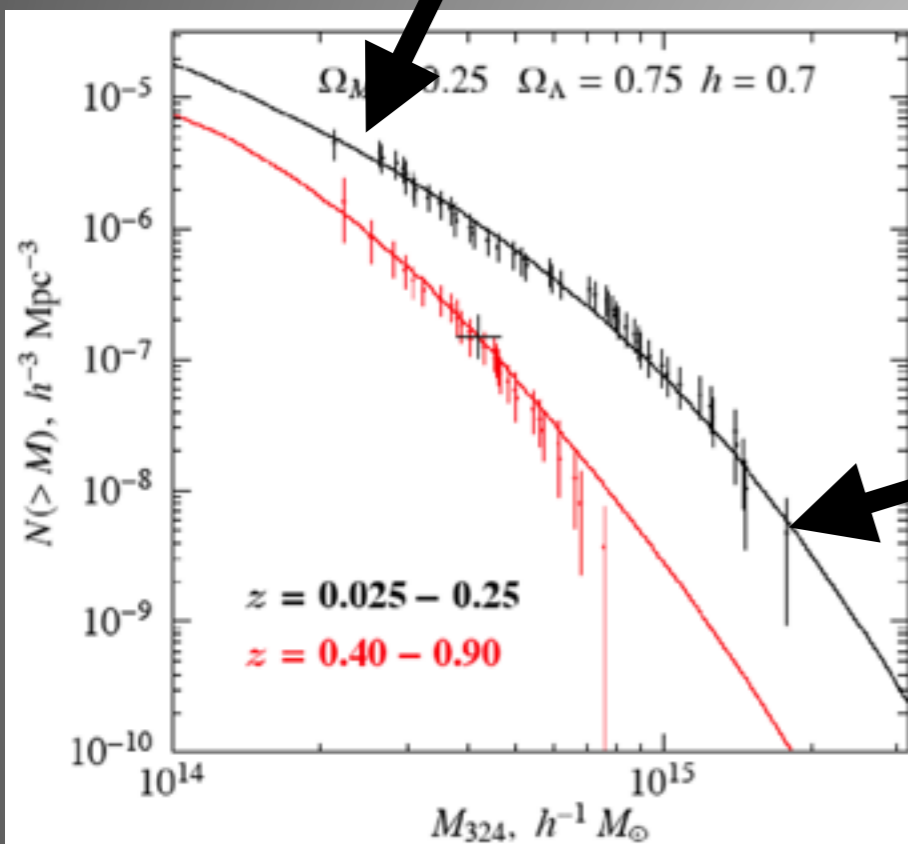
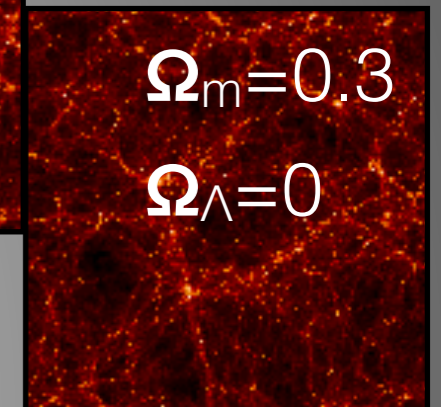
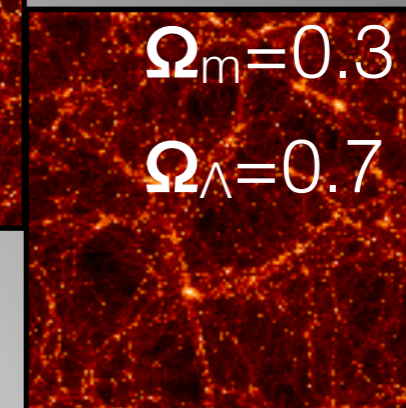
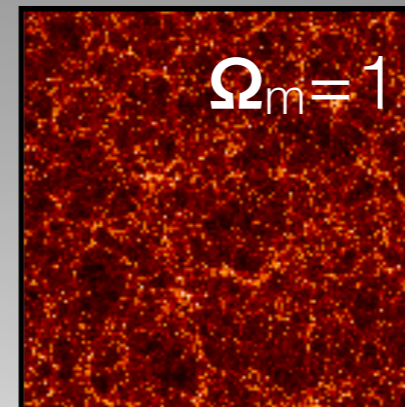
A hierarchical model of weak lensing mass

Maggie Lieu | W. Farr | G. P. Smith |

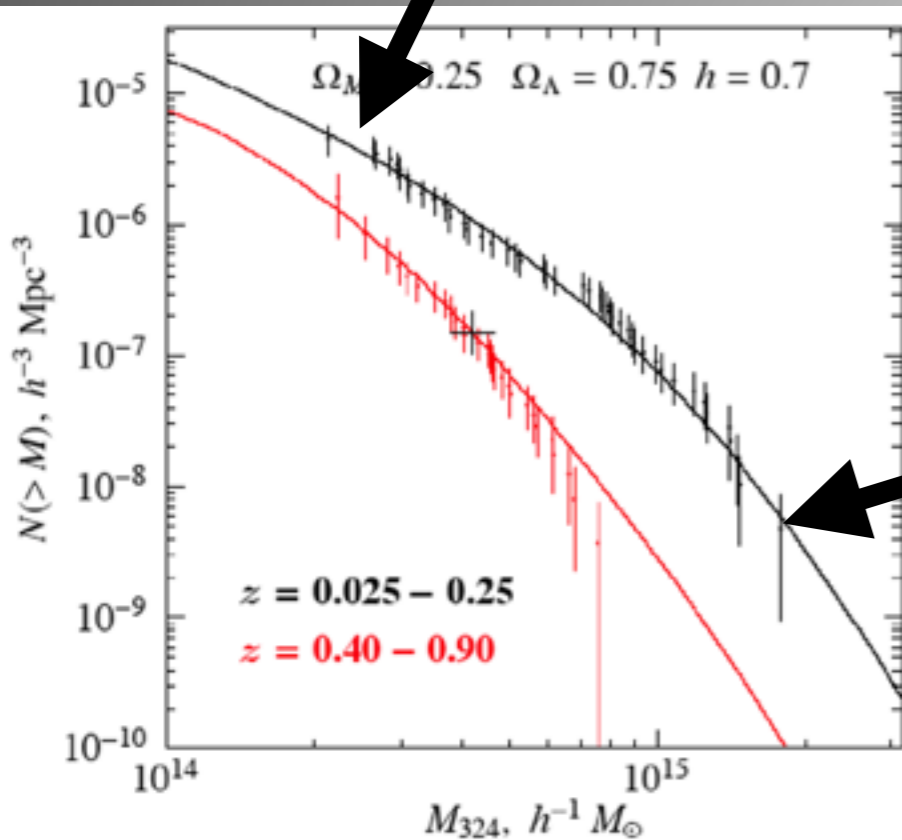
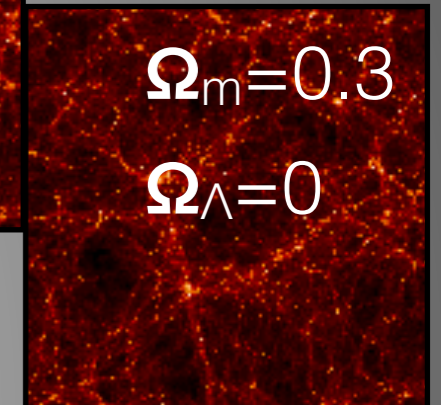
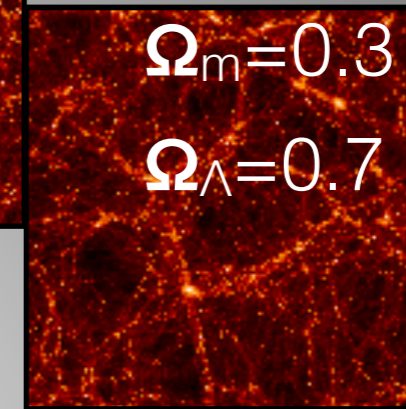
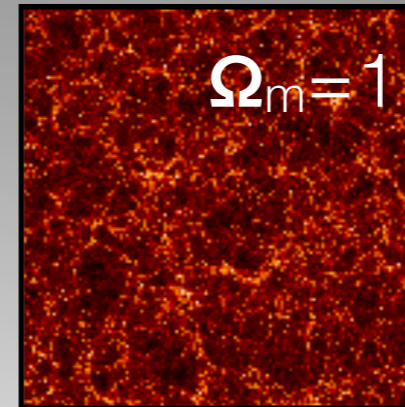
Galaxy groups & clusters



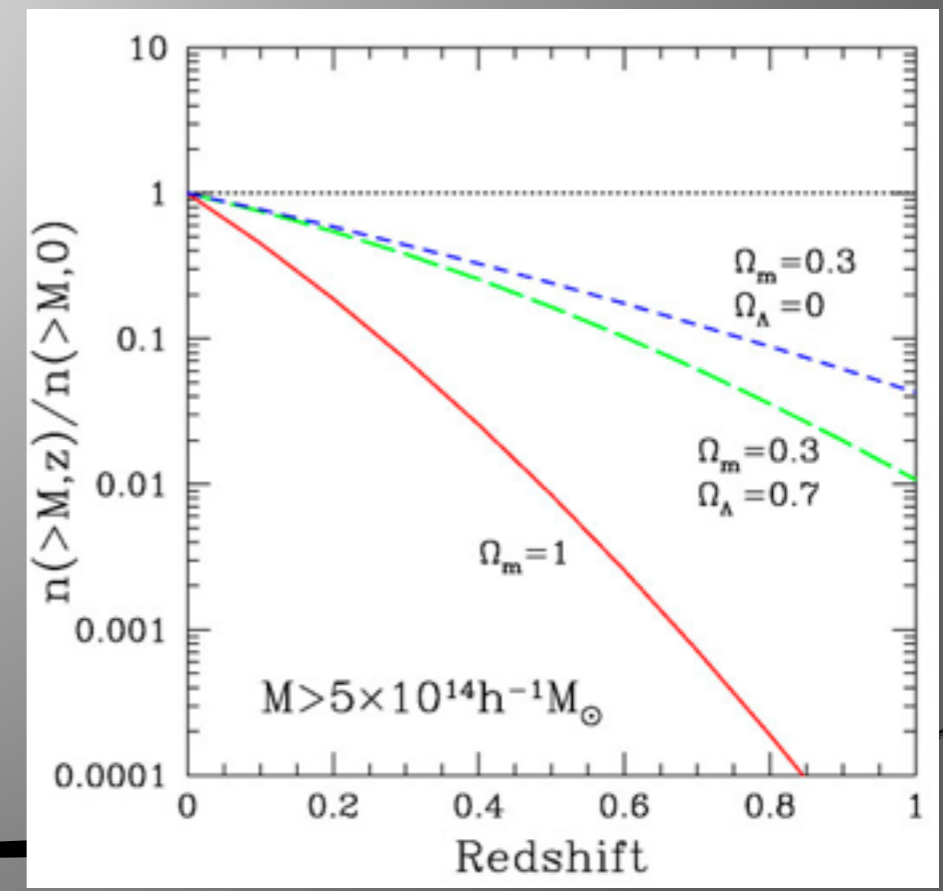
Galaxy groups & clusters



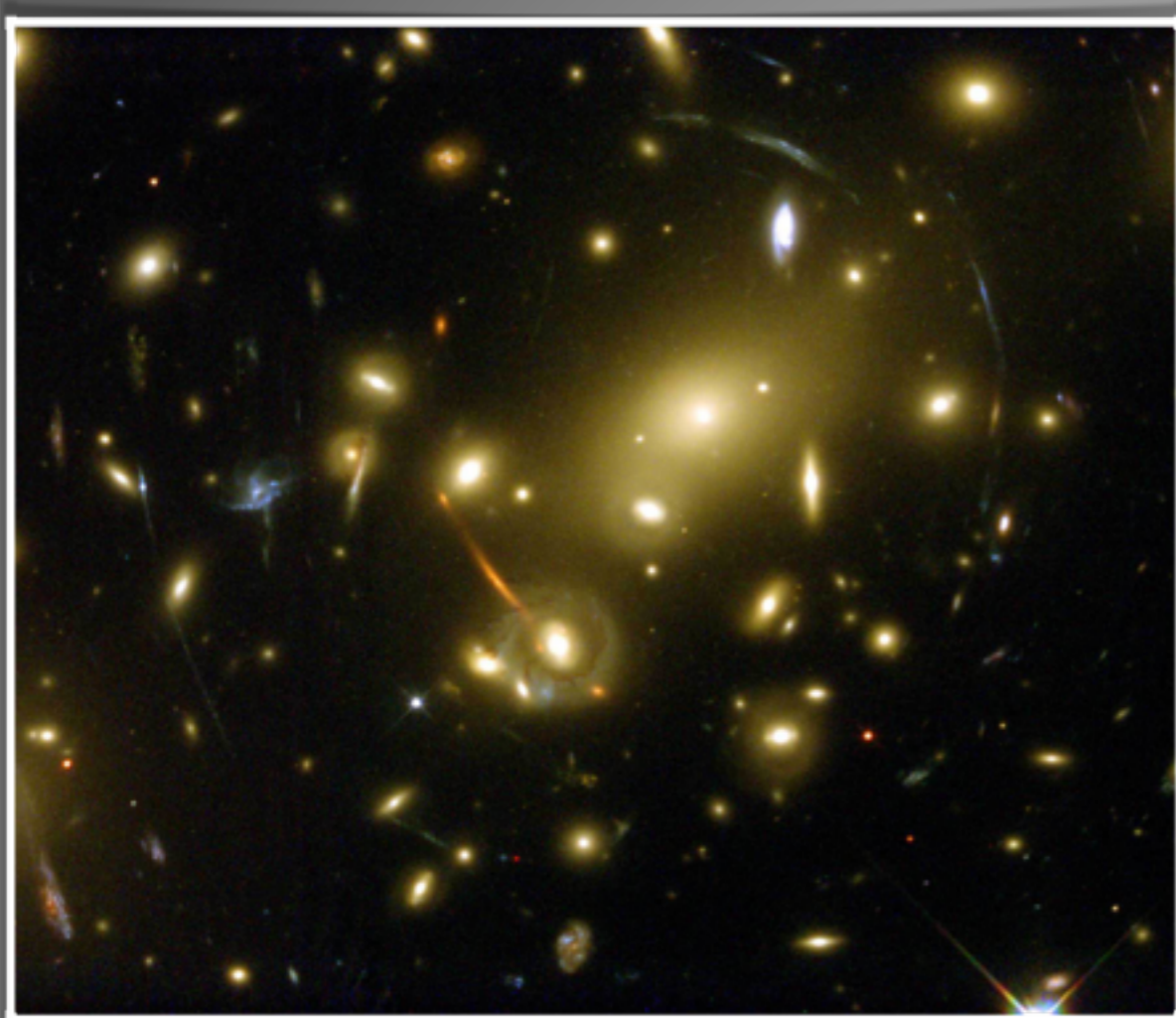
Galaxy groups & clusters



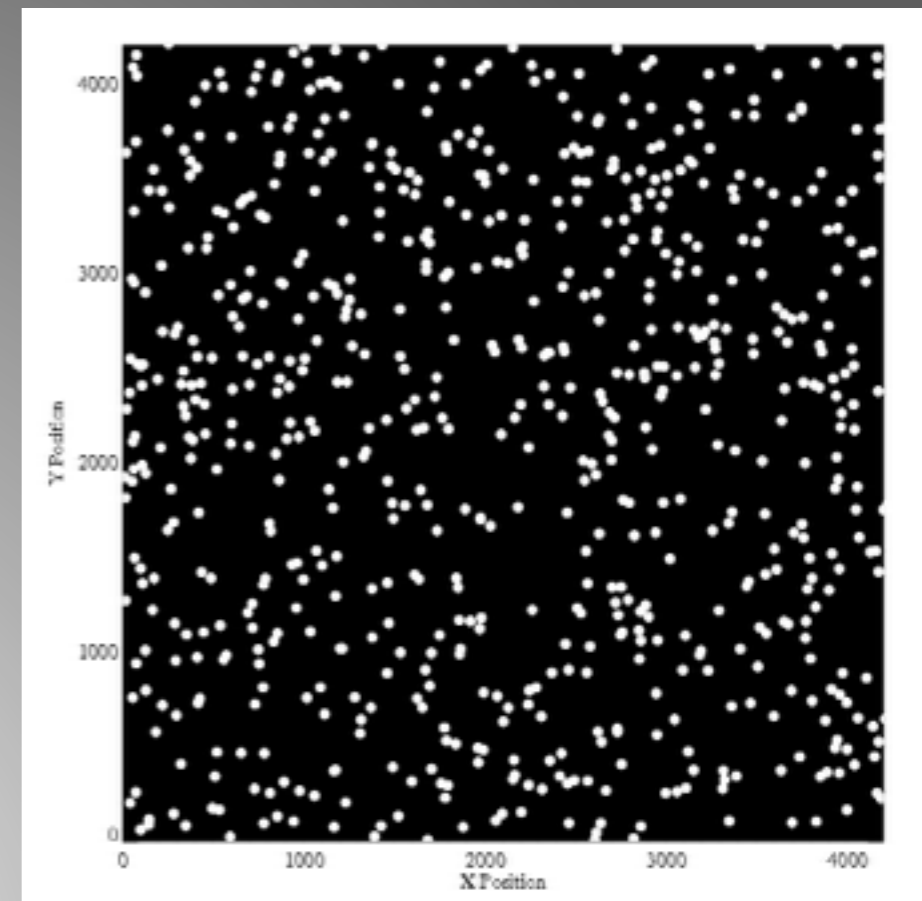
Cluster mass is a sensitive cosmological probe!



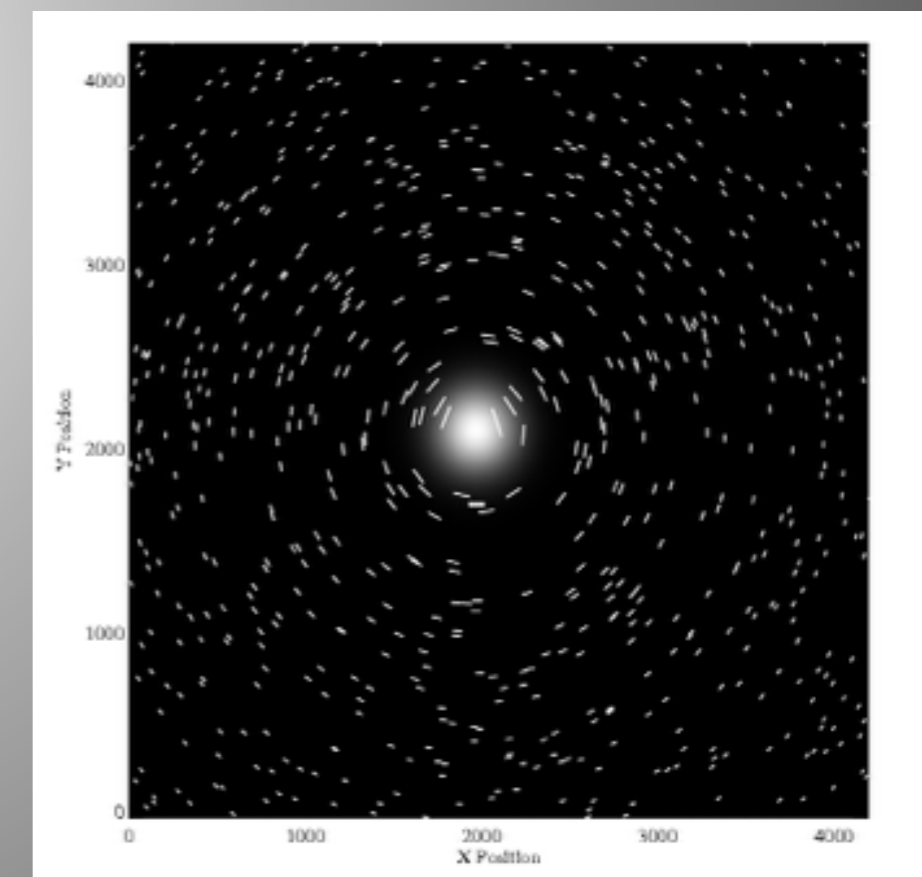
Gravitational lensing



Before
lensing



After
lensing



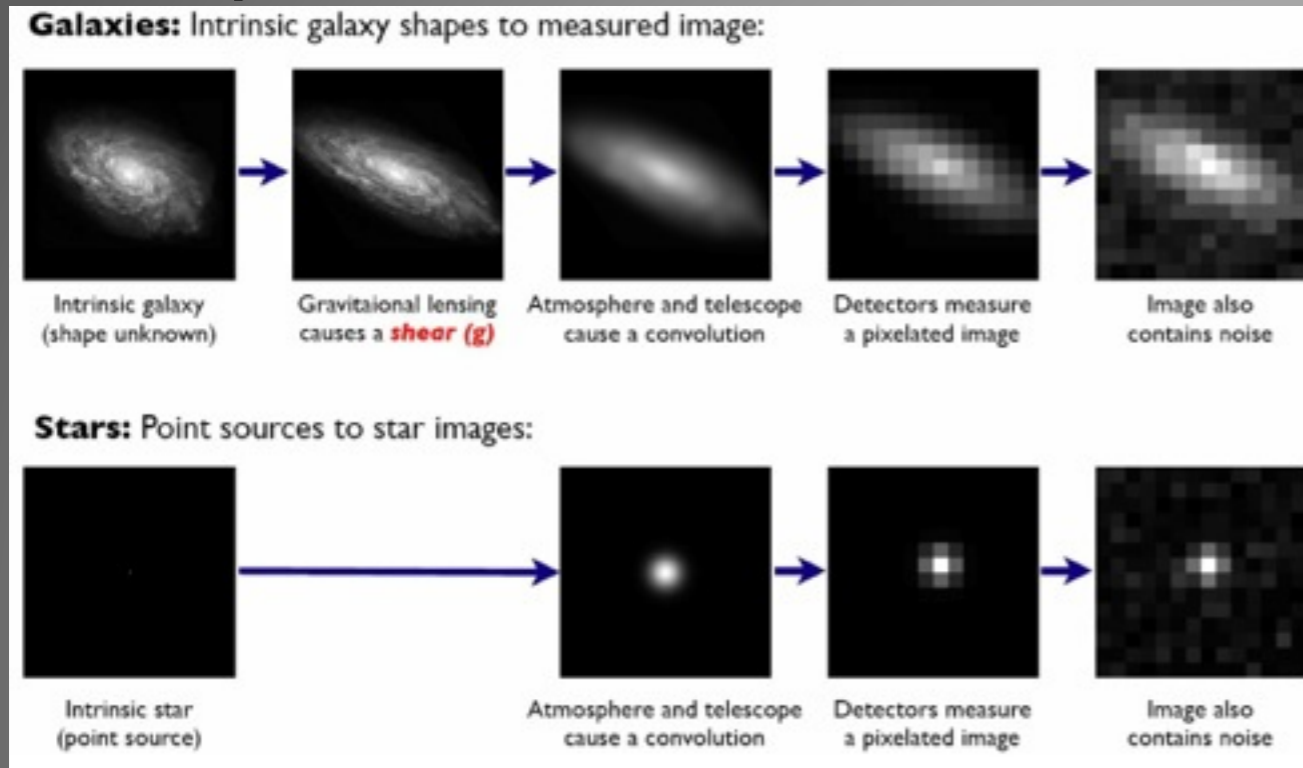
Deflection angle:
 $\theta = 4GM/rc^2$

Pros of lensing mass:

- independent of dynamical state of cluster
- measures total mass

How is lensing mass currently modelled?

I. Shape measurement



Unbiased shape measurement is difficult!

$$e_+^{\text{obs.}} = e_+^{\text{intr.}} + \gamma$$

$$\langle e_+^{\text{intr.}} \rangle = 0$$

$$\gamma \approx e_+^{\text{obs.}}$$

II. Map shear to mass & concentration

Unbiased mass is difficult!
 Estimation depends on:

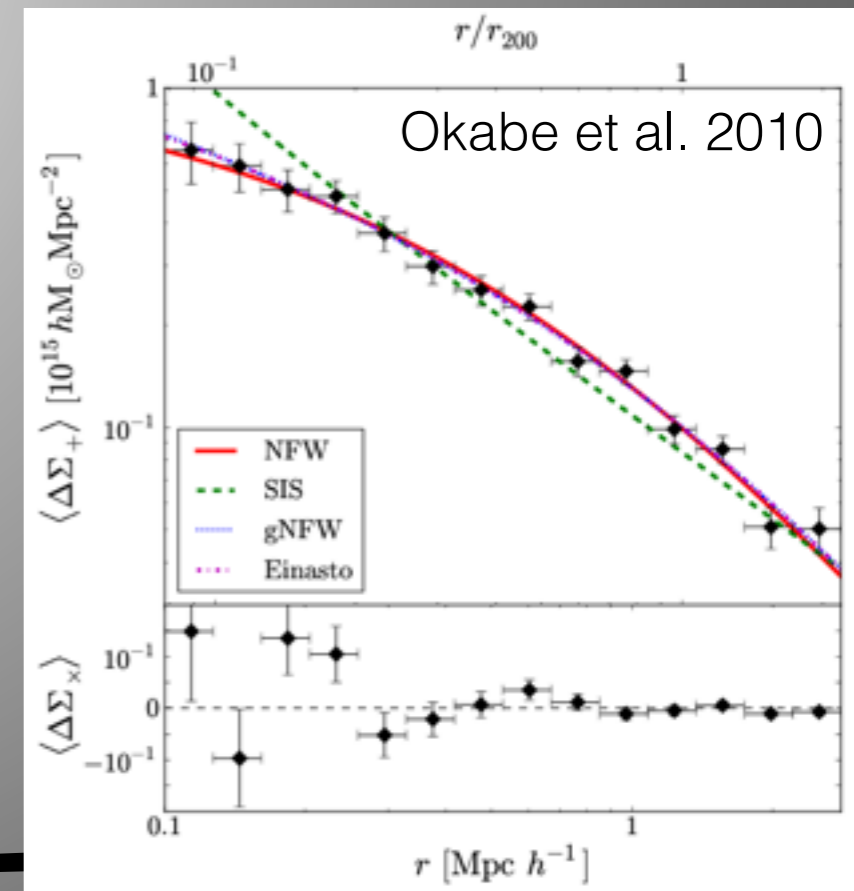
- $p(z_s)$, $p(z_L)$ -
- centering -
- fitting radius -

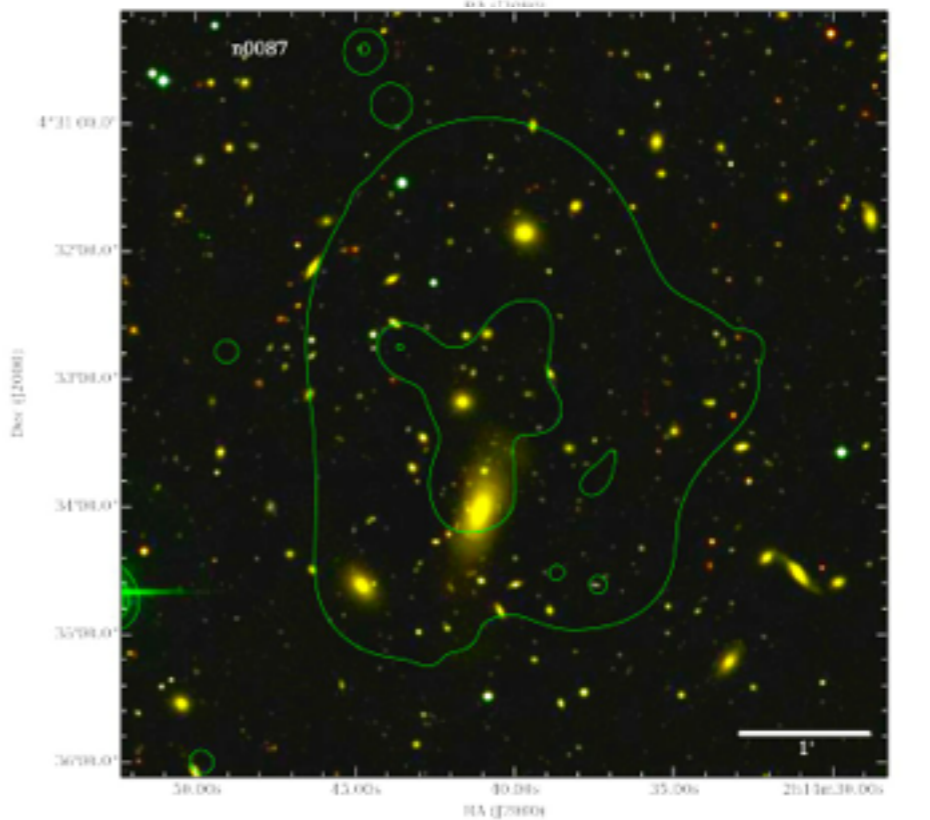
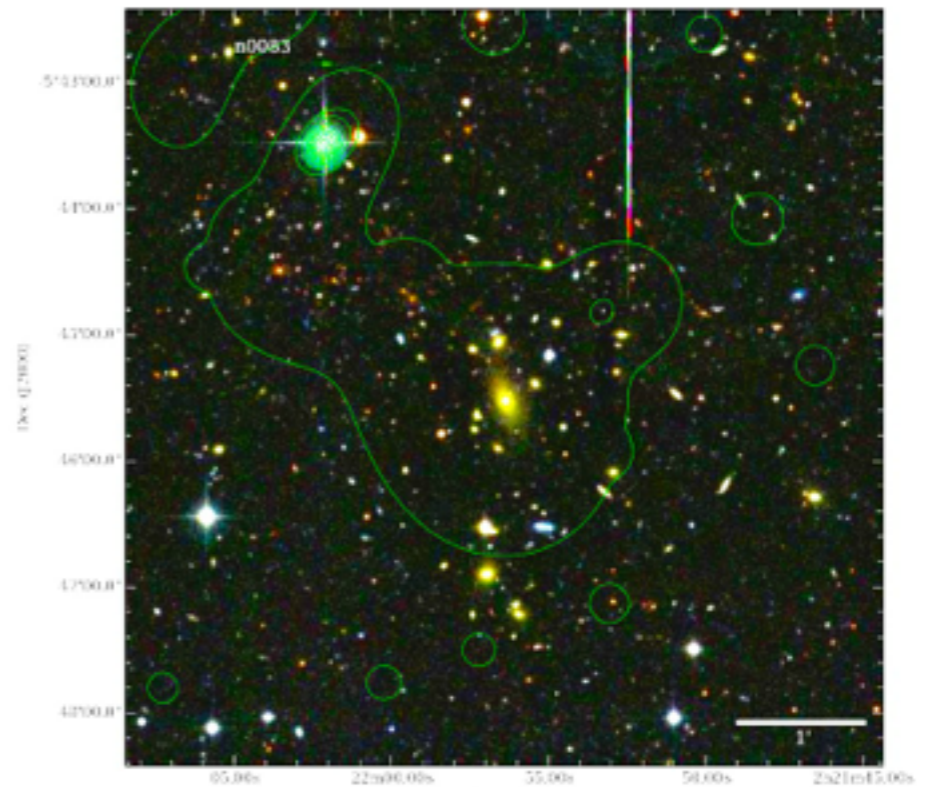
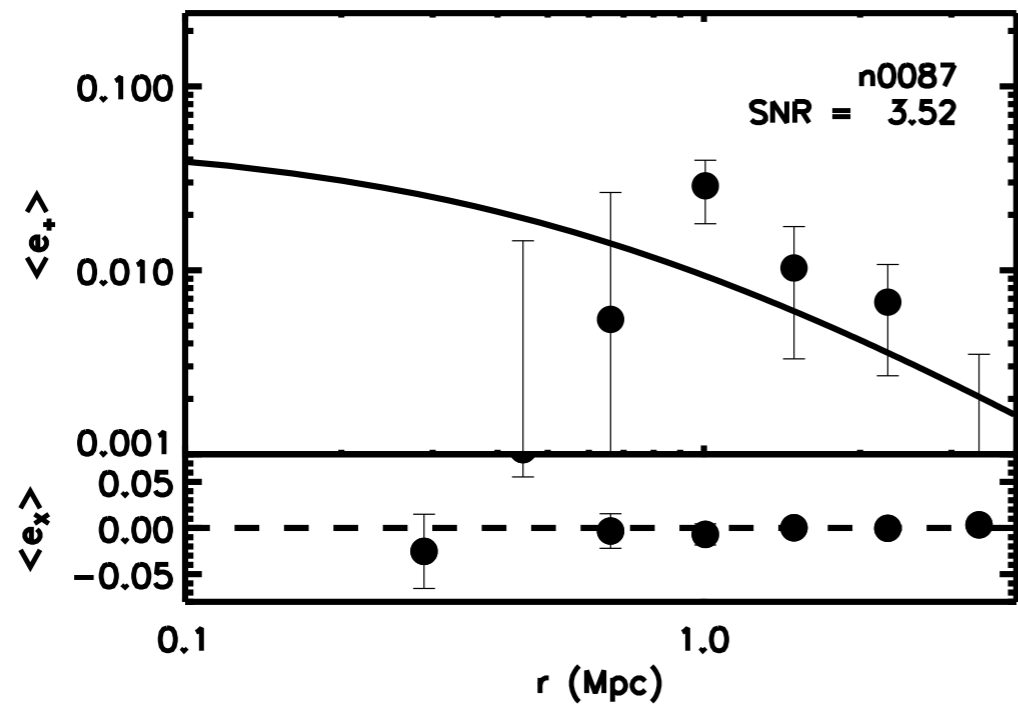
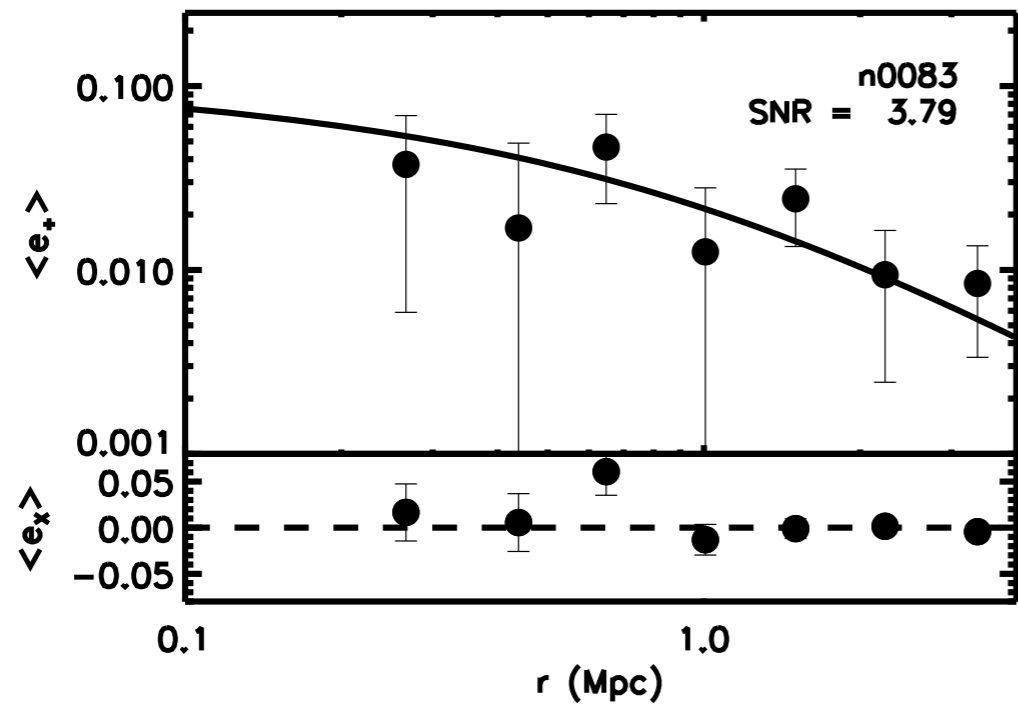
NFW density profile

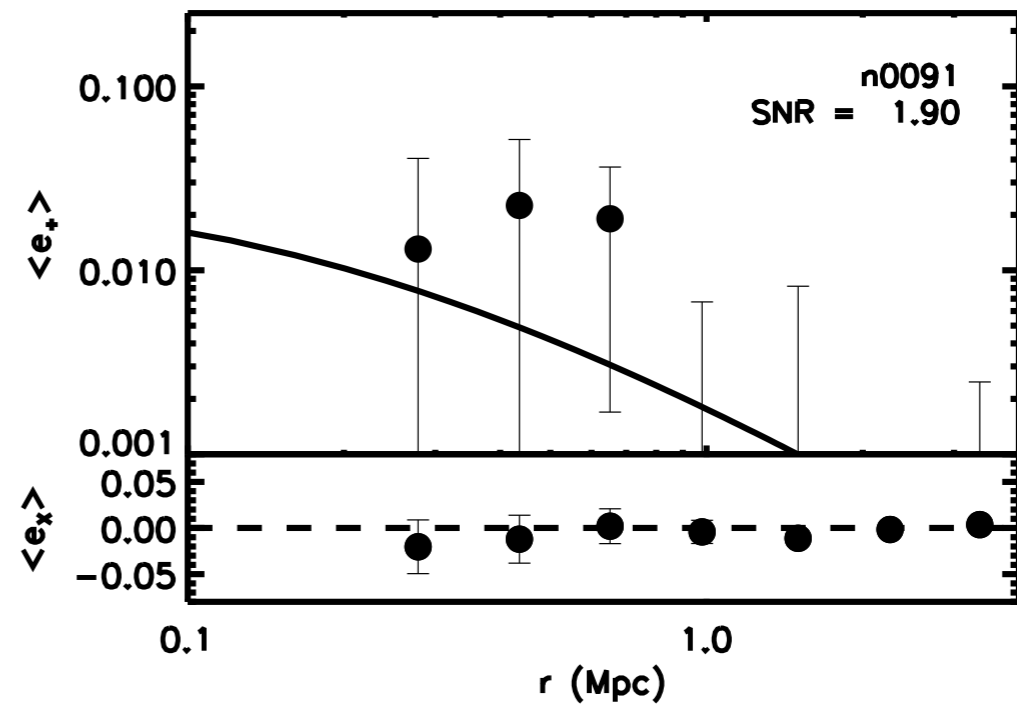
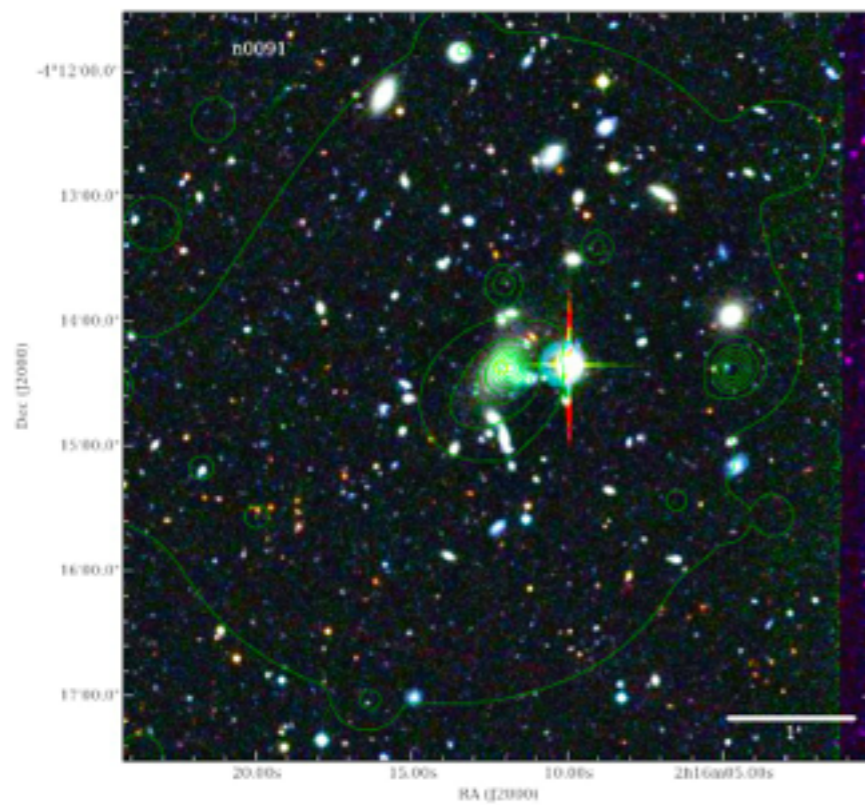
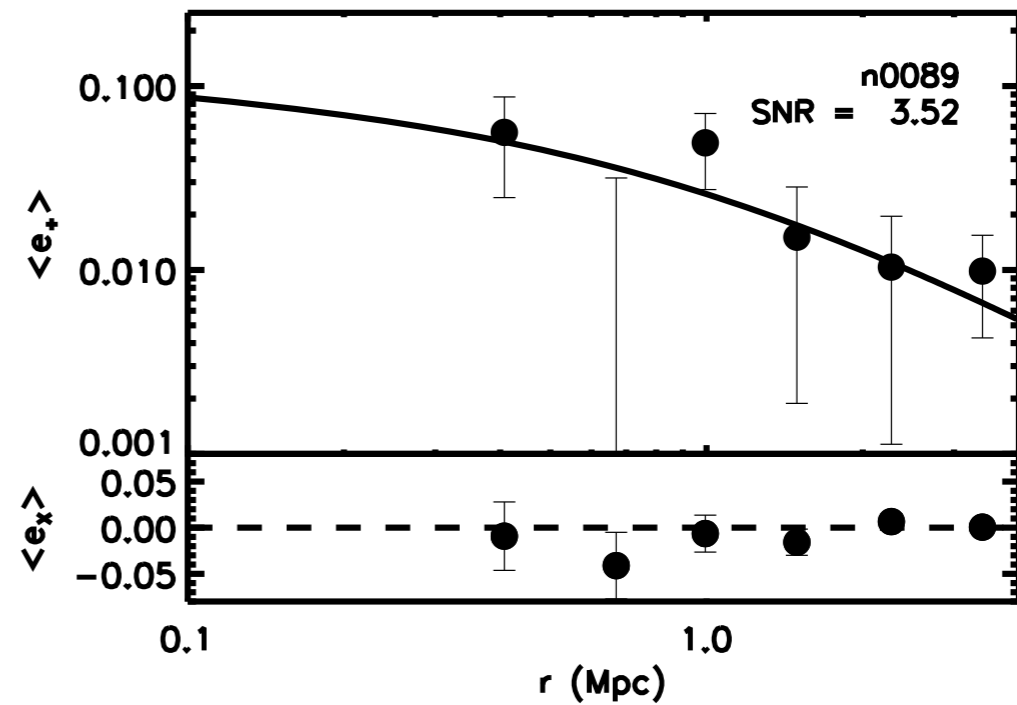
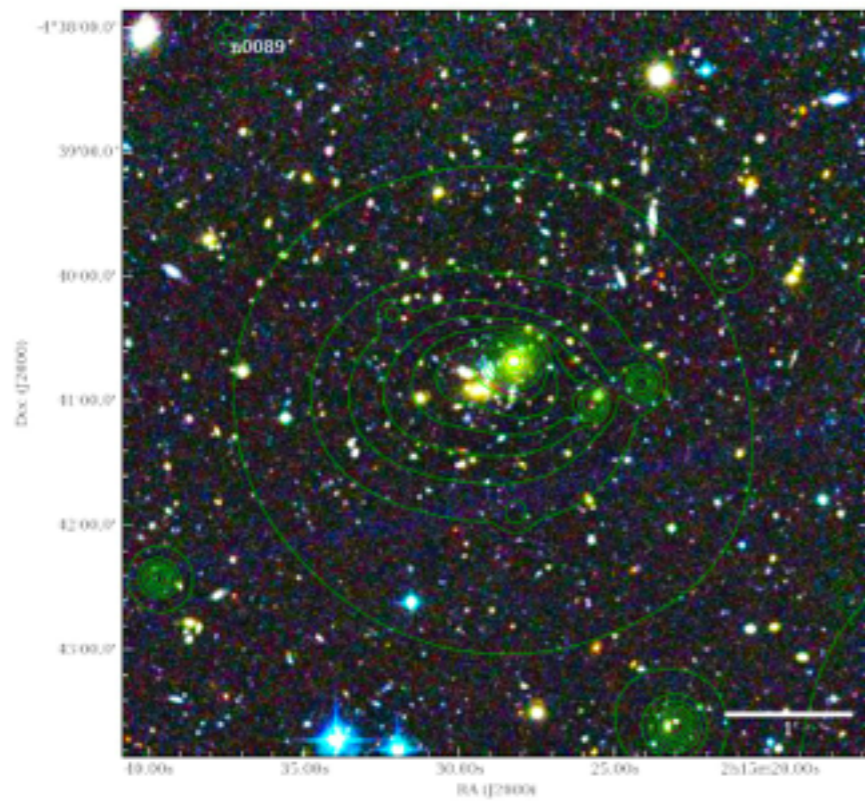
$$\rho(r) = \frac{\rho_0}{\frac{r}{R_s} \left(1 + \frac{r}{R_s}\right)^2}$$

c-M relation

$$c_{200} = 5.71(1+z)^{-0.47} \left(\frac{M_{200}}{2 \times 10^{12} h^{-1} M_\odot}\right)^{-0.084}$$



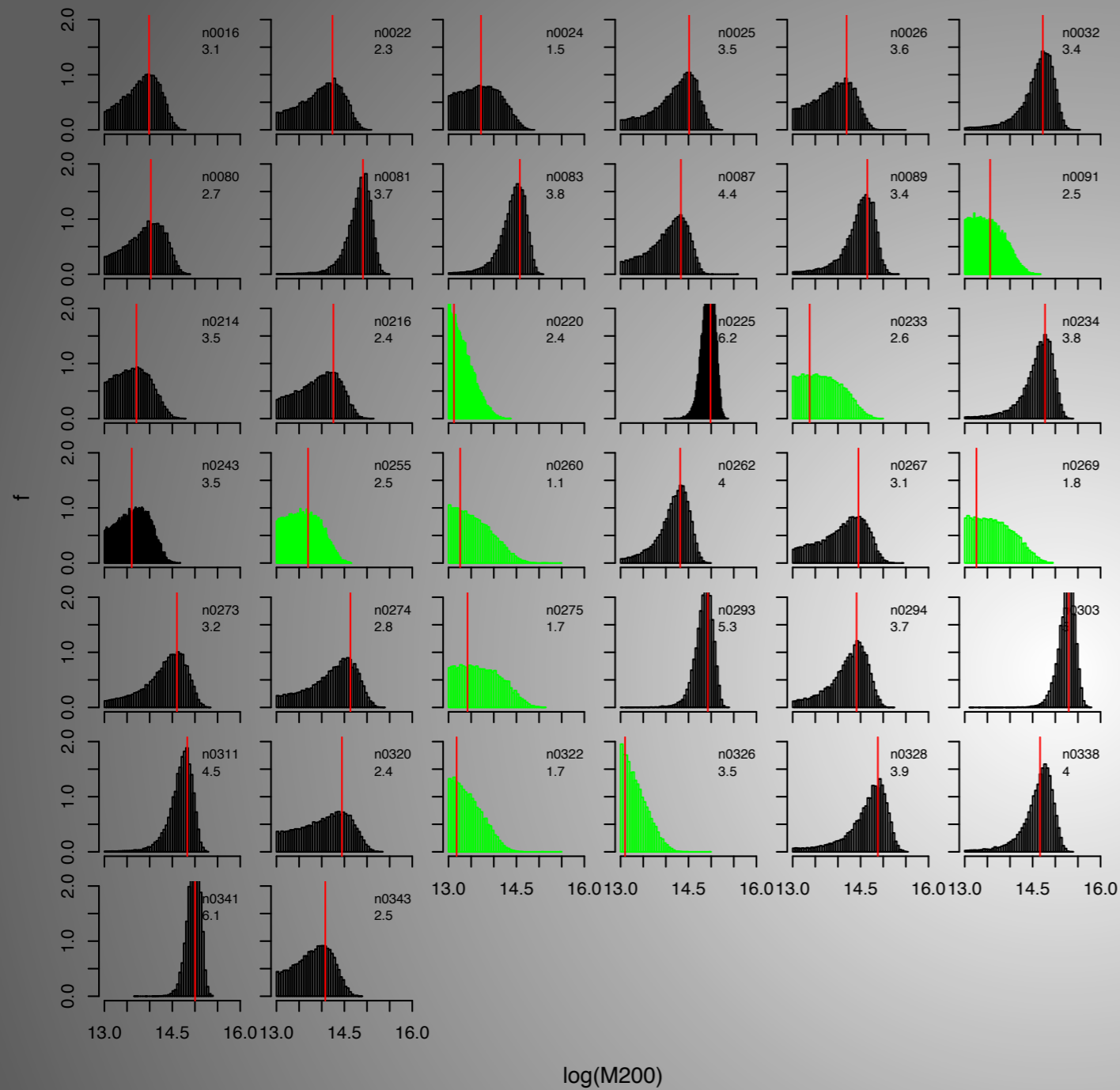




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$$P(\log_{10}(M)|e_+, \delta e_+, r, z)$$



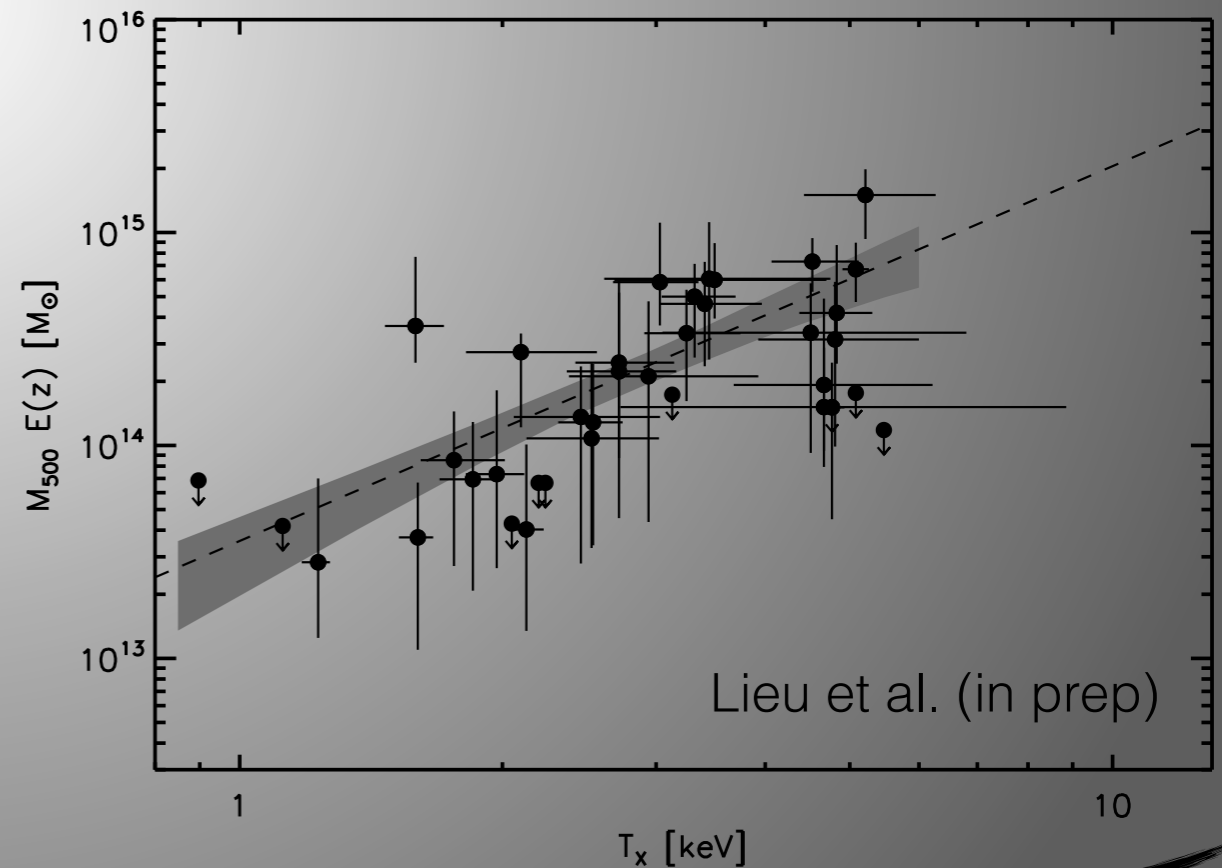
Clipped posterior still contains information!

$$\log_{10} \left(\frac{M_{\text{WL}} E(z)}{M_{\odot} h^{-1}} \right) = a + b \log_{10} \left(\frac{T_X}{\text{keV}} \right)$$

$$E(z) = \sqrt{\Omega_m (1+z)^3 + \Omega_{\Lambda}}$$

b: 1.76 ± 0.34
a: 13.55 ± 0.17
 $\sigma_{\ln(M|T)}$: 0.56 ± 0.19

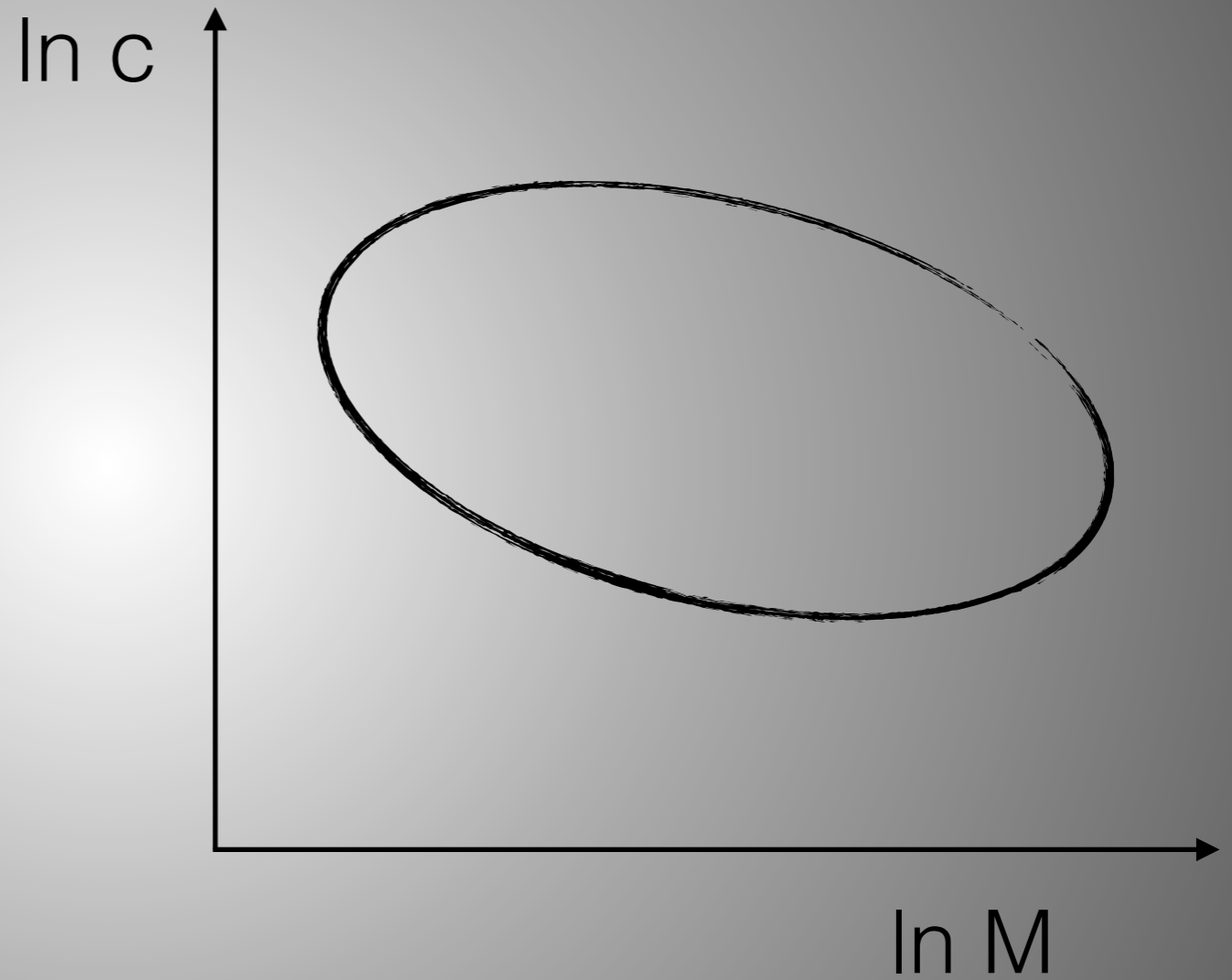
XXL100 $M_{\text{WL}} - T_X$ relation



How is the new method different?

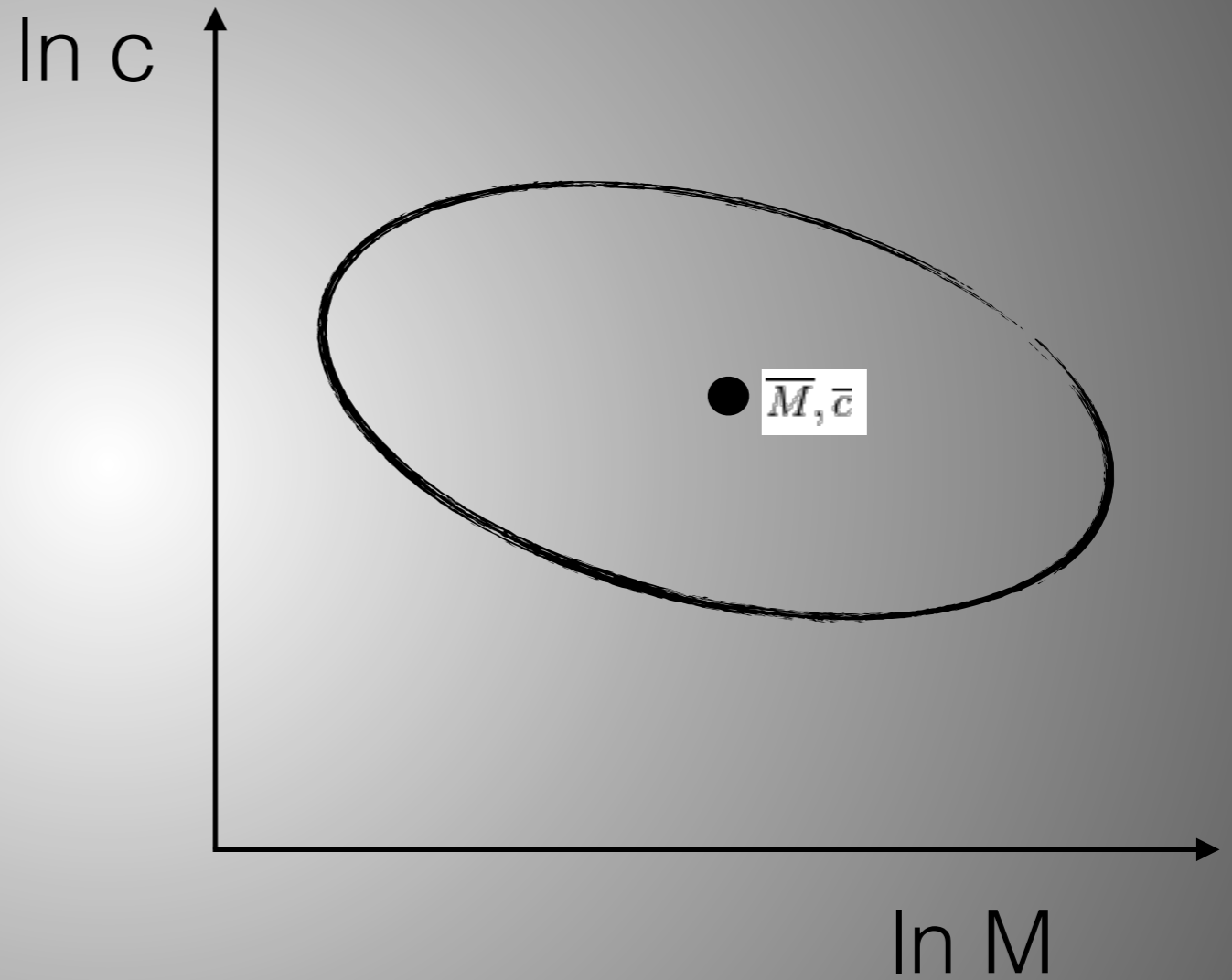
How is the new method different?

$$\theta_{sam} = \bar{M}, \bar{c}, C_{cM}$$



How is the new method different?

$$\theta_{sam} = \bar{M}, \bar{c}, C_{cM}$$



How is the new method different?

$$\theta_{sam} = \bar{M}, \bar{c}, C_{cM}$$



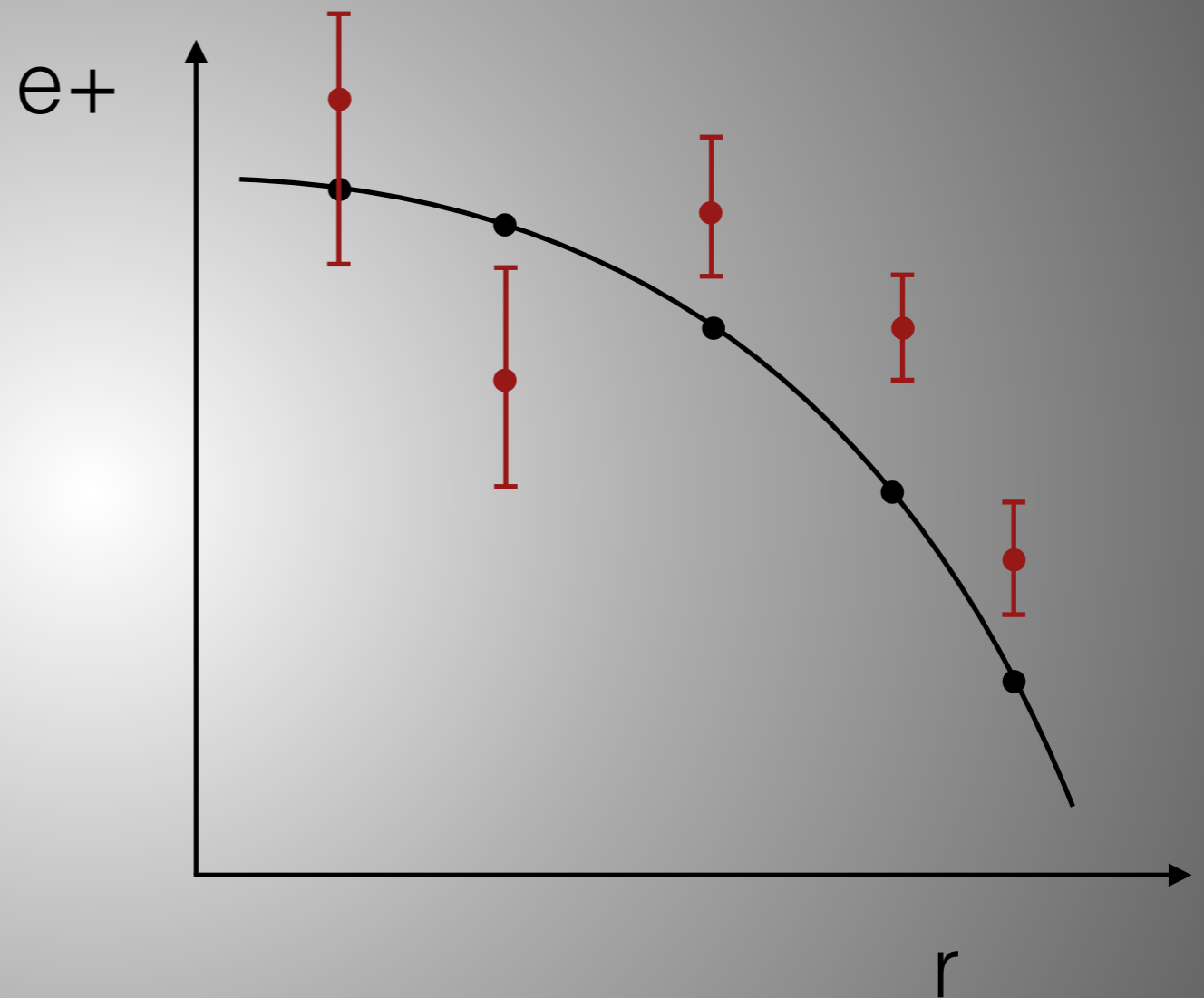
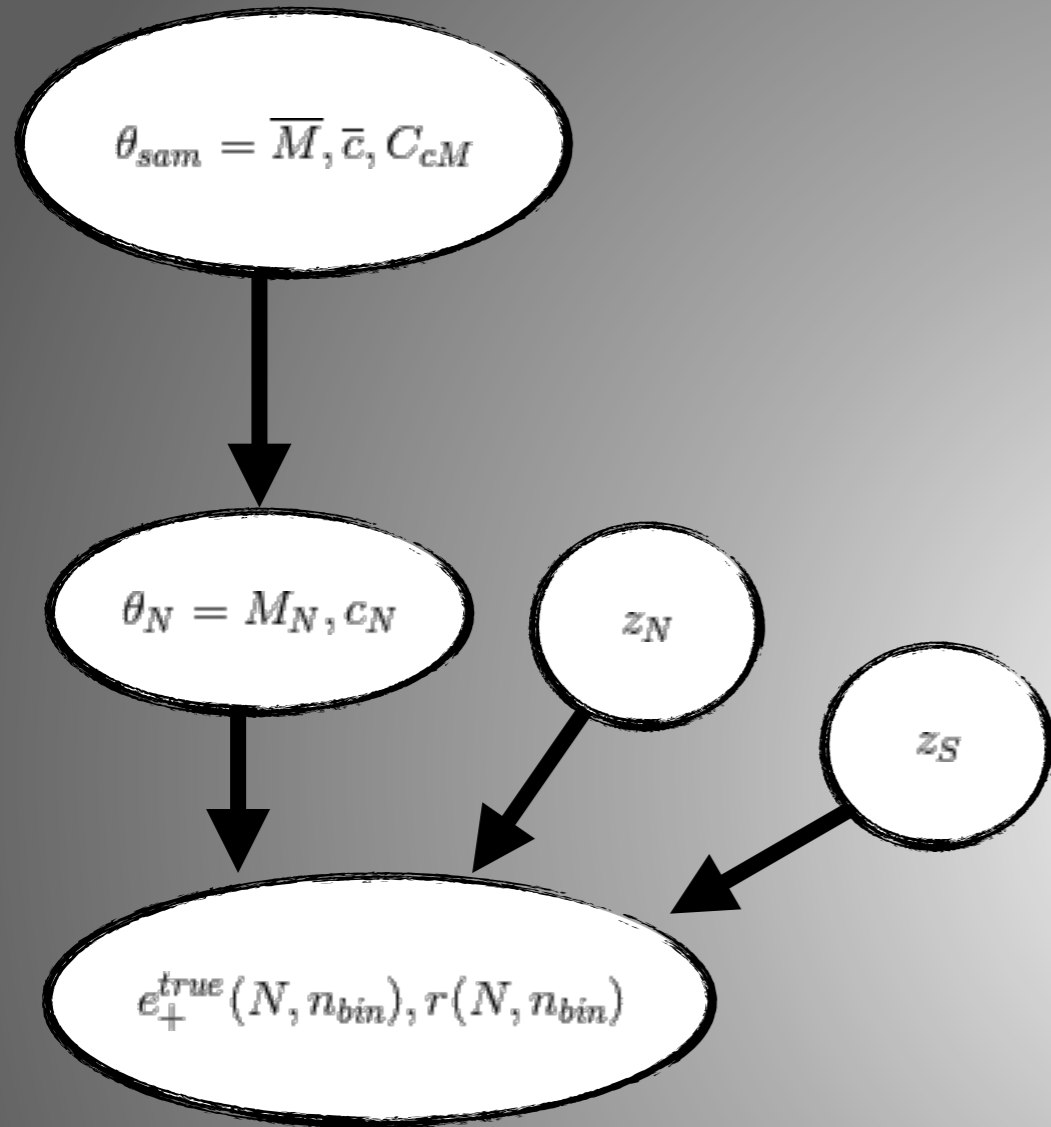
$$\theta_N = M_N, c_N$$

$$M, c \sim N(\theta_{sam}, C_{cM})$$

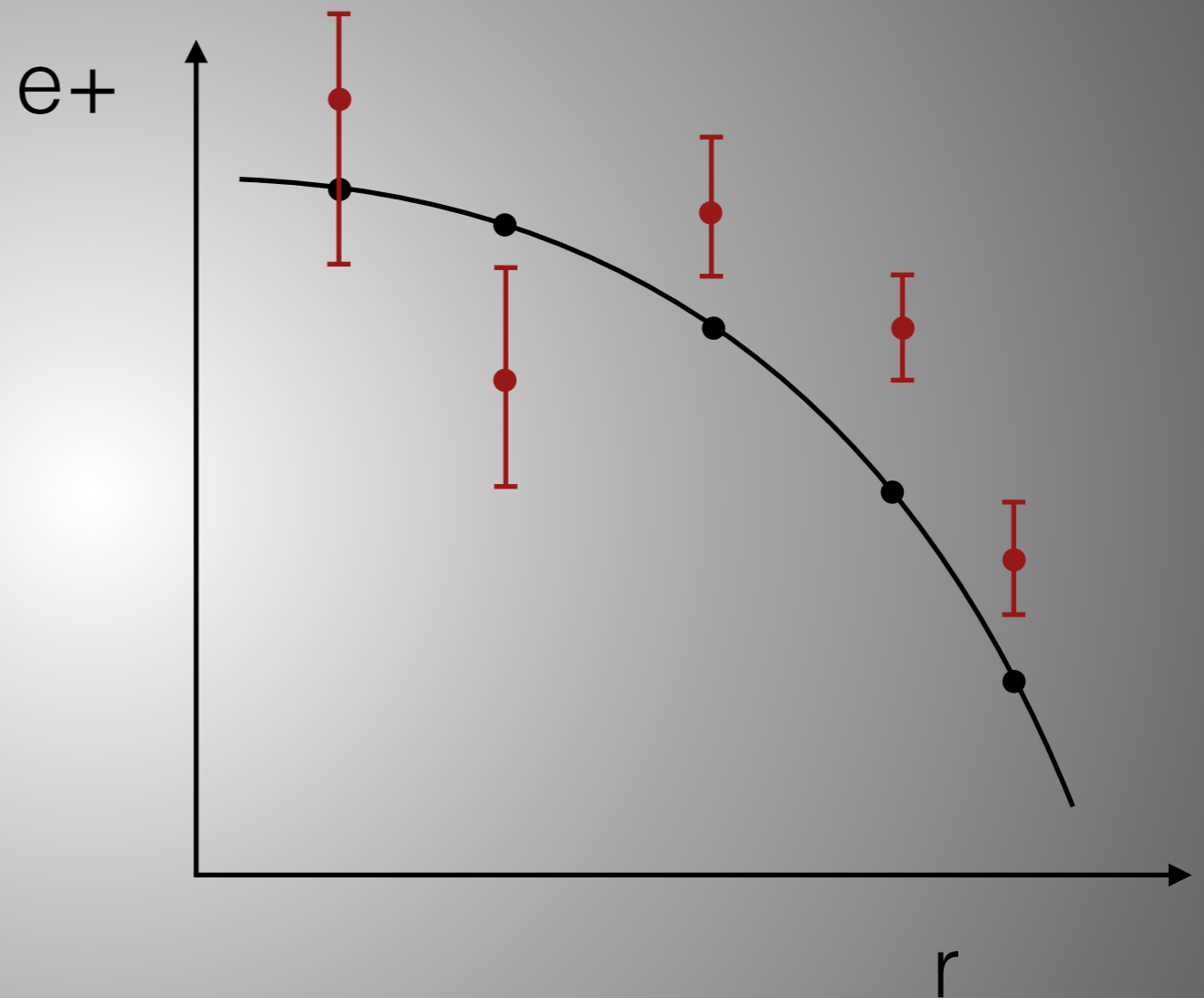
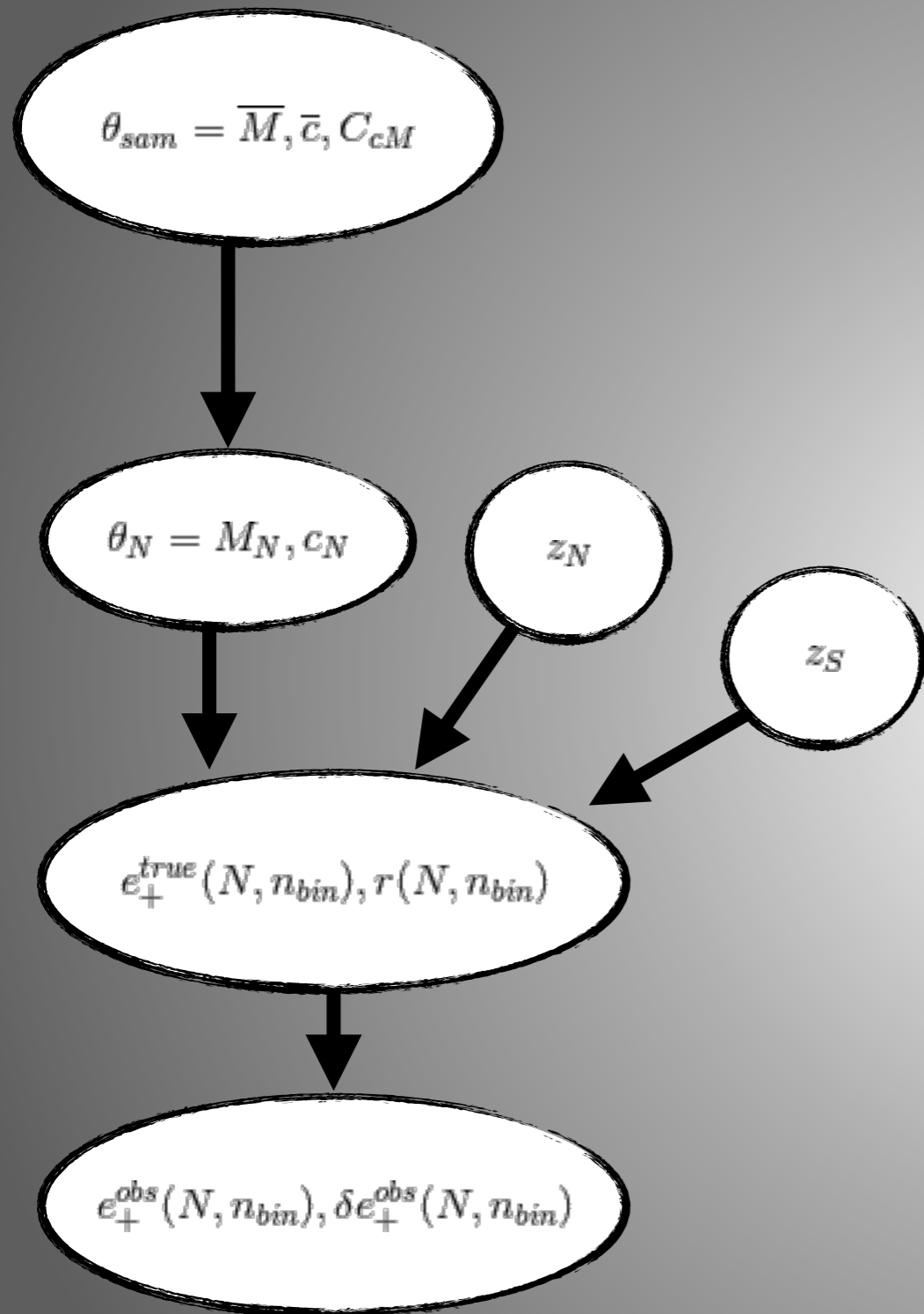


ln M

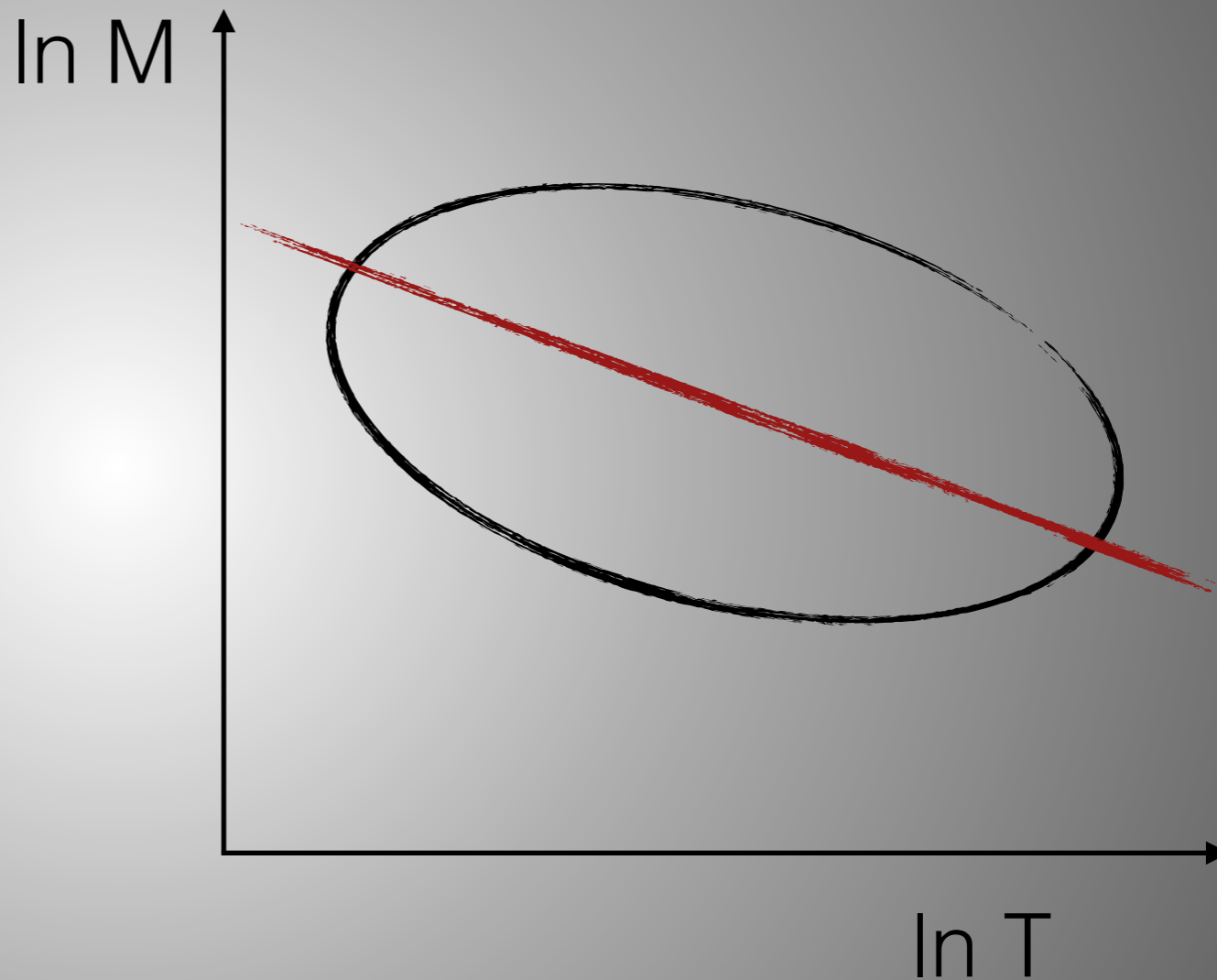
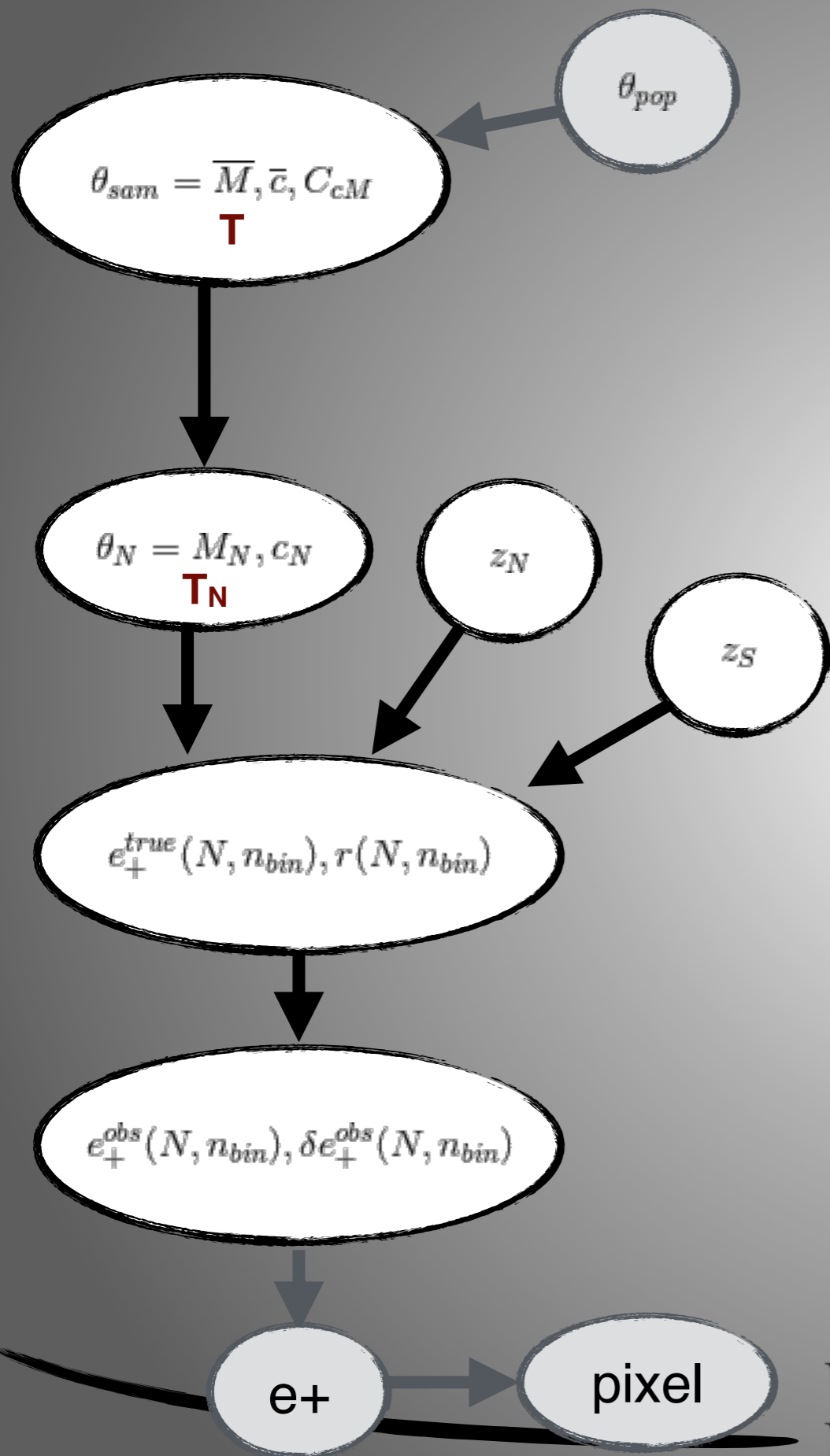
How is the new method different?



How is the new method different?



How is the new method different?



Pros and cons of new method

Advantages

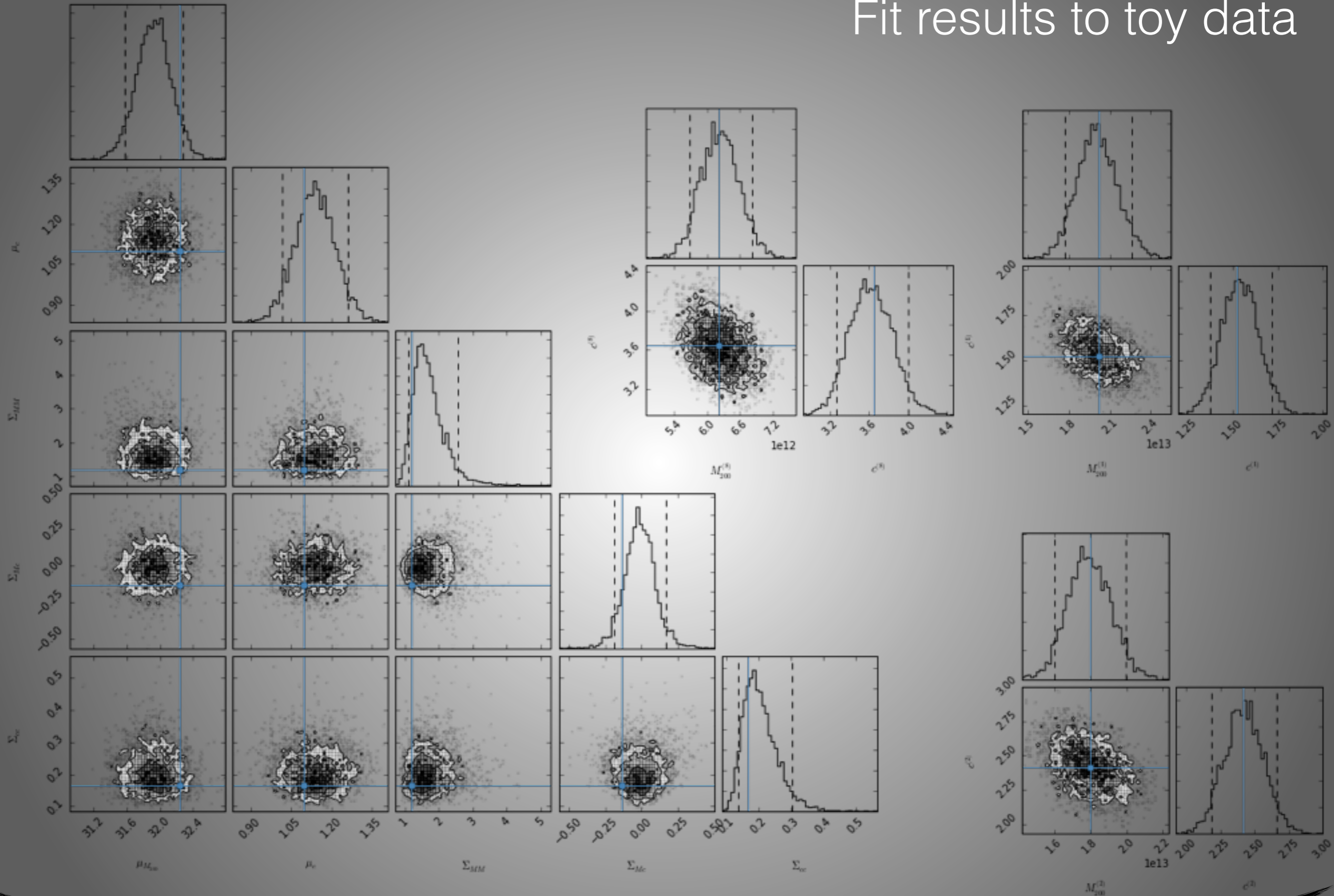
- No upper limits
- No bias
- No assumption of $c \rightarrow M$
- Can model selection function

Disadvantages

- Large number of parameters
- Computation time for large datasets
- Other assumptions

Use hamiltonian MC method e.g. STAN!

Fit results to toy data



Take away message

- Current **weak lensing data is noisy!**
- Need a full bayesian method to model mass proxies
- **Hierarchical models breaks down problem** to underlying physics level of clusters and properties of individual clusters
- **Removes need for assumptions** and **removes bias.**
- Promising technique for future surveys - LSST, euclid etc. but will require a lot of computing power!

Thank you for listening