Modeling Systematics in Galaxy Cluster Mass Estimation

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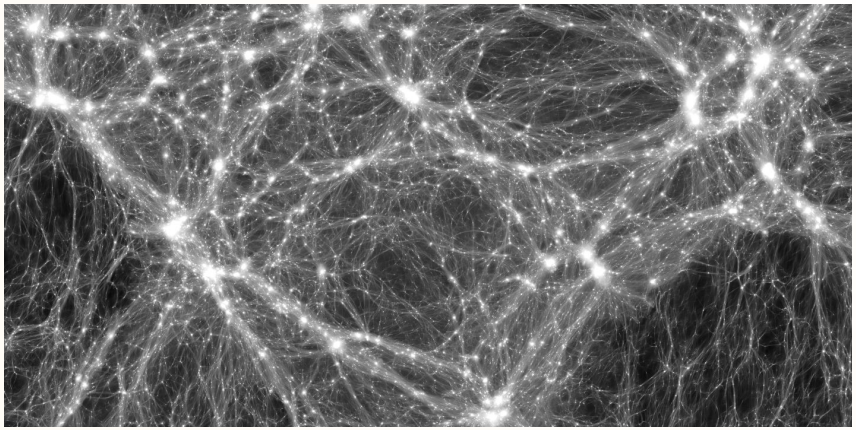
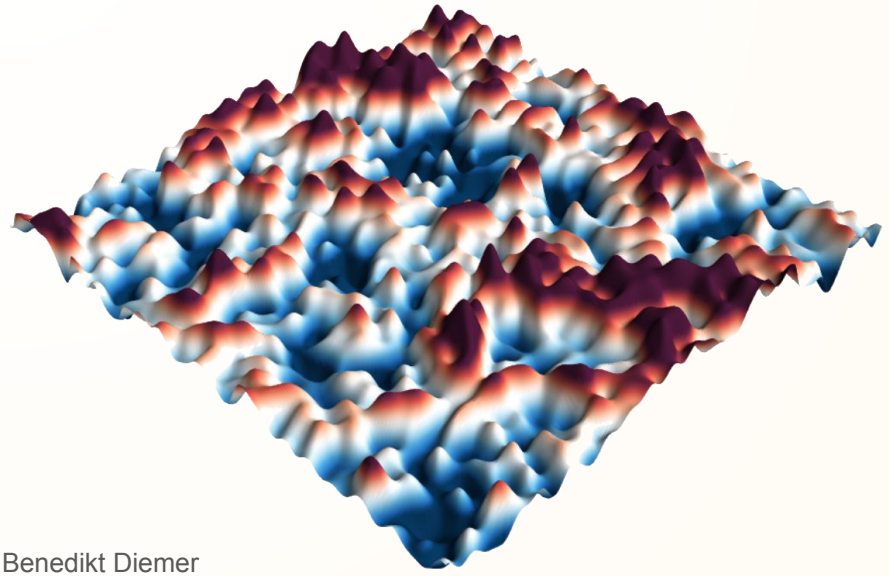
The Cosmic Landscape



Cosmological Parameters

$$\theta = \{\Omega_b h^2, \Omega_c h^2, \Omega_{\rm DE}, h, w_0, w_a, ...\}$$



Images: NASA, Benedikt Diemer

The Cosmic Landscape

Cosmological tests with the largest density peaks:

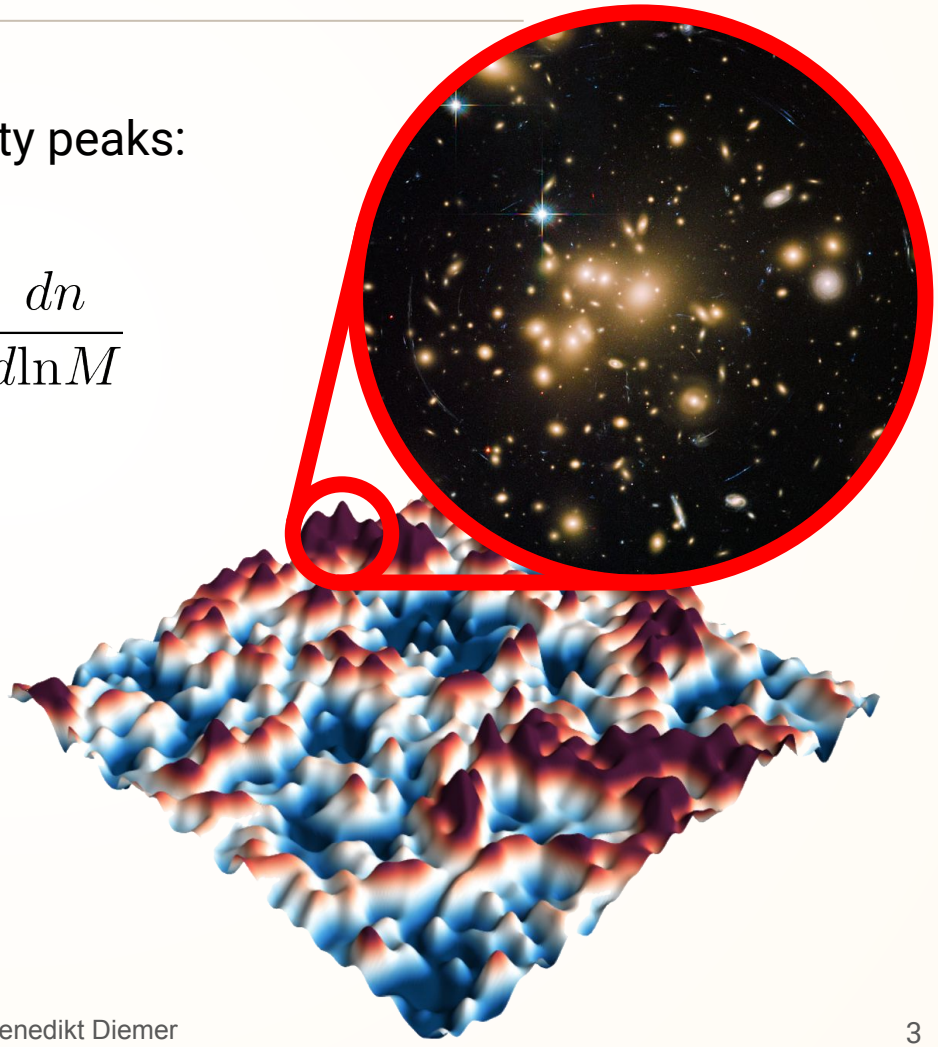
- Cluster counts

$$\bar{N}(M_a, z_i) \propto \int_z dz \frac{dV}{dz} \int_M d\ln M \frac{dn}{d\ln M}$$

$$\frac{dn}{d\ln M} = \frac{\bar{\rho}_m}{M} \left| \frac{d\ln\sigma}{d\ln M} \right| f(\sigma)$$

- Spatial distribution of clusters
- Baryon fraction of clusters

➔ All have to go through the mass function



Images: ESA, Benedikt Diemer

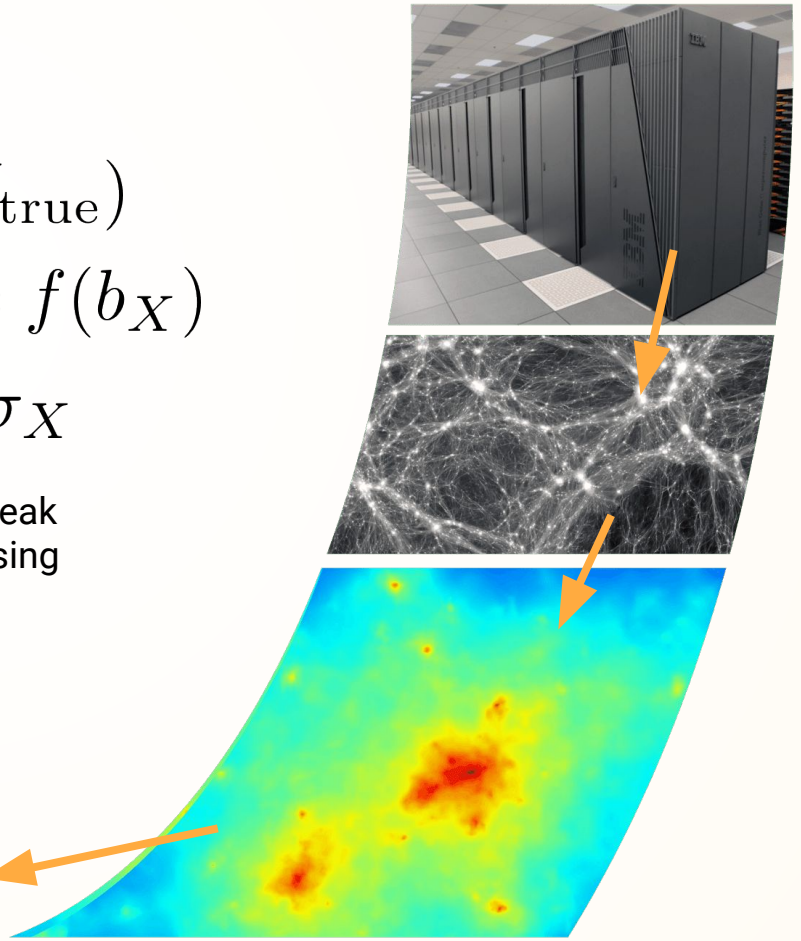
Simulations for Precision Cosmology

$$P(M_X|M_{\rm true})$$

$$\text{location } \mu = f(b_X)$$

$$\text{scatter } \sigma_X$$

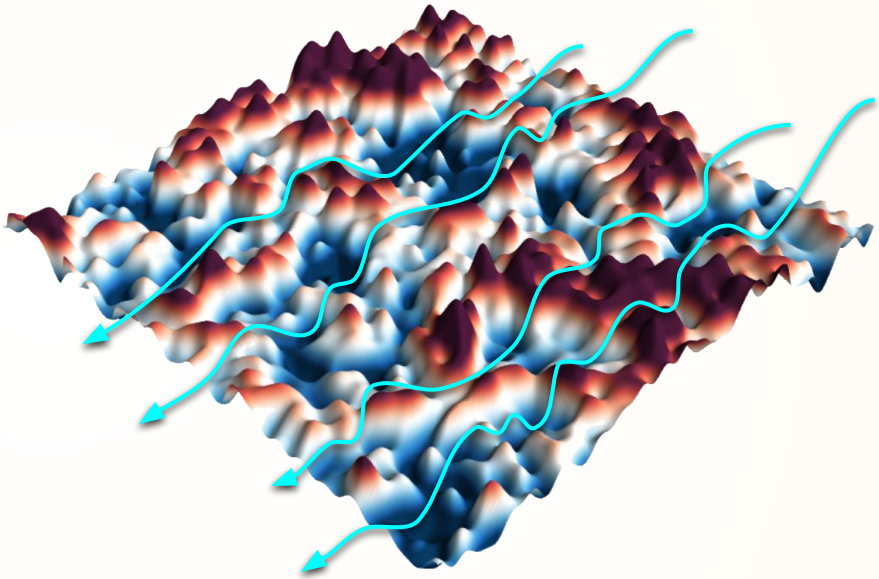
This work: X = weak gravitational lensing



Measurement Calibration

Images: Sean Goebel, ESA, ANL, Benedikt Diemer

Weak Lensing and the Halo Profile



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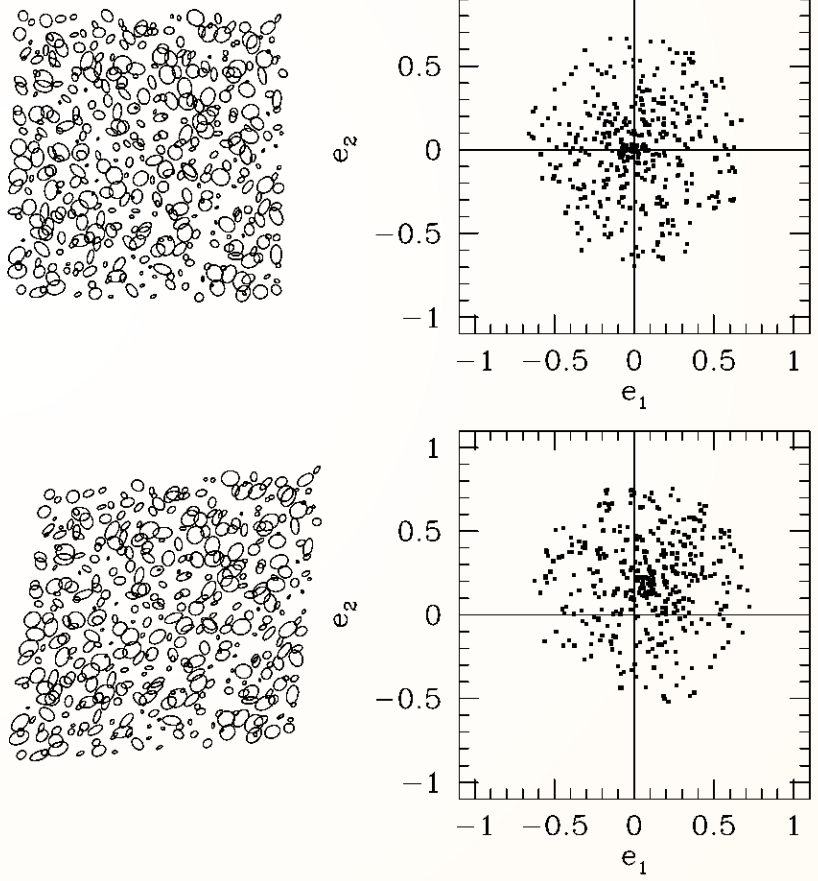

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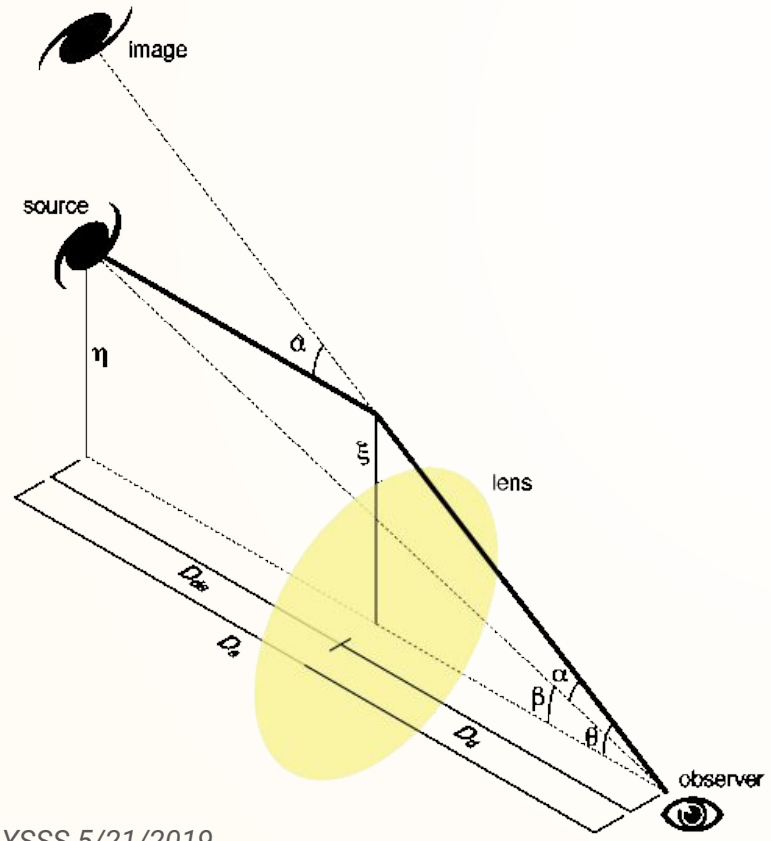
Weak Lensing and the Halo Profile

The goal is to measure mass-- how do the lensing observables depend on the properties of the lens?



Convergence is a scaling of the surface mass density:

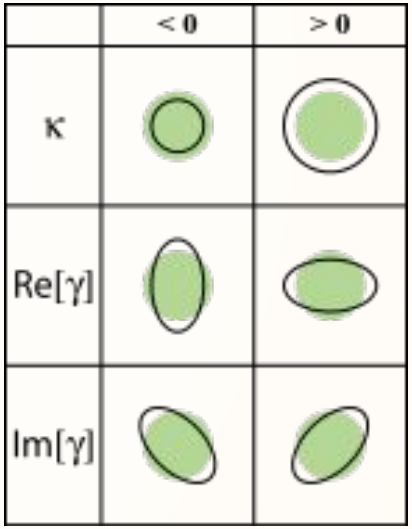
$$\kappa(\vec{\theta}) = \frac{\Sigma(\vec{\theta})}{\Sigma_c}$$

$$\Sigma_c \equiv \frac{c^2}{4\pi G}\frac{D_s}{D_d D_{ds}}$$

Tangential shear component is easily described under spherical symmetry of the lens:

$$\Sigma(r) = 2\int_0^\infty \rho(r,z)dz$$

$$\gamma(r) \propto \frac{\bar{\Sigma}(r) - \Sigma(r)}{\Sigma_c}$$



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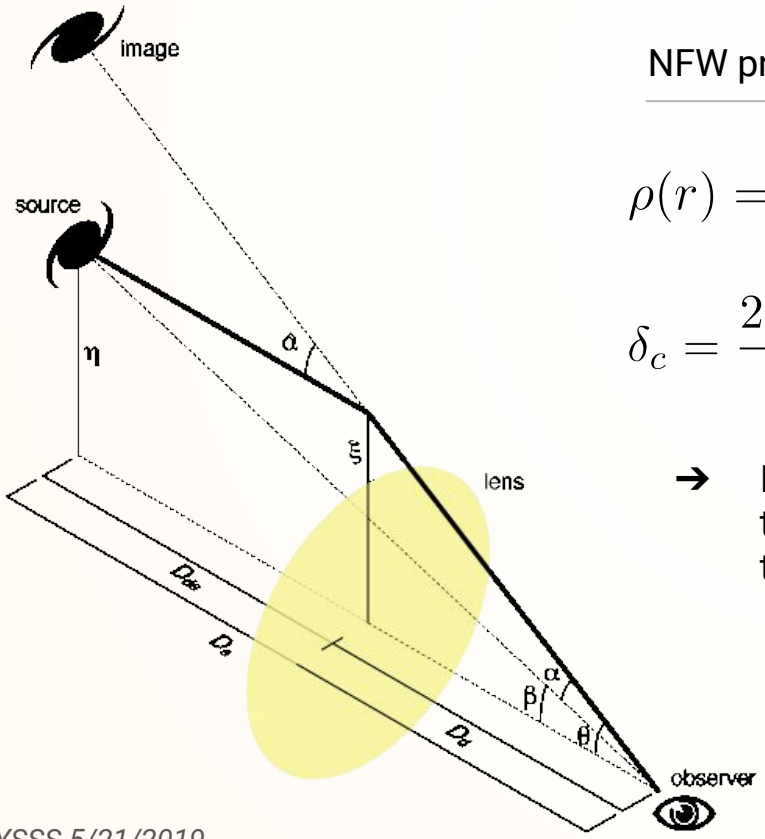
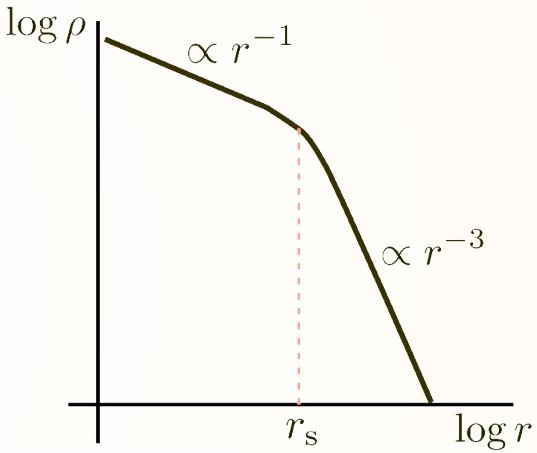


NFW profile

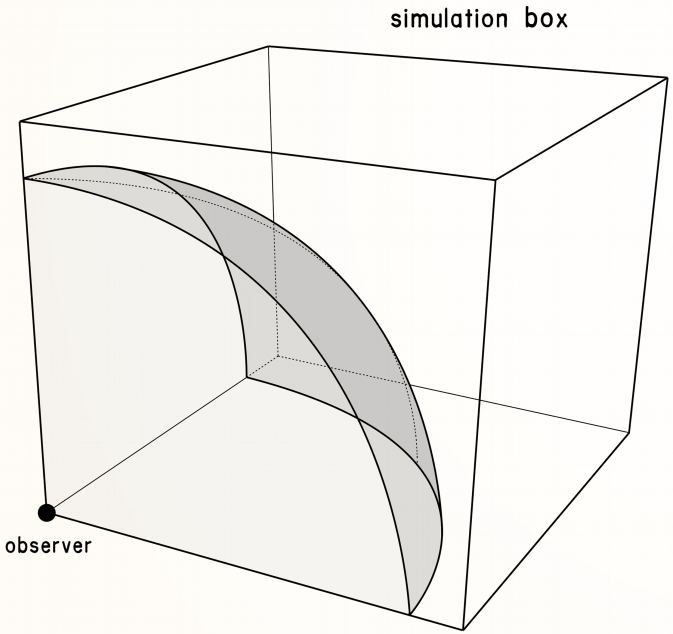
$$\rho(r) = \frac{\delta_c \rho_c}{(r/r_s)(1+r/r_s)^2}$$

$$\delta_c = \frac{200}{3}\frac{c^3}{\ln(1+c) - c/(1+c)}$$



➔ If NFW profile reliably describes halos on average, then we can obtain an analytic prediction for the tangential shear profile (observable)

Simulating the Cluster Lensing Signal



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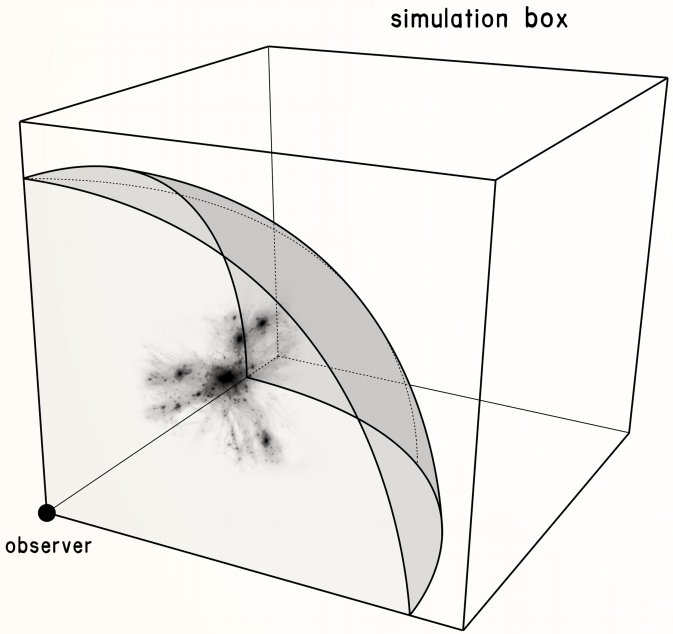

Cluster image from Benedikt Diemer

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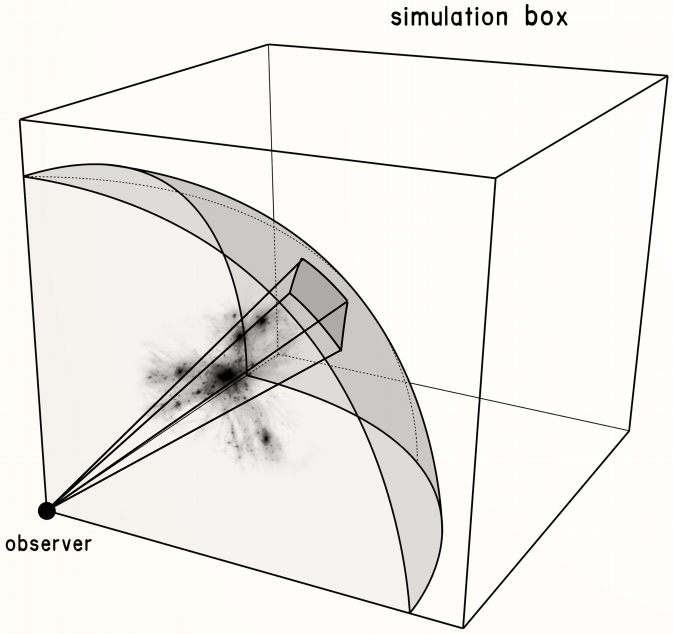

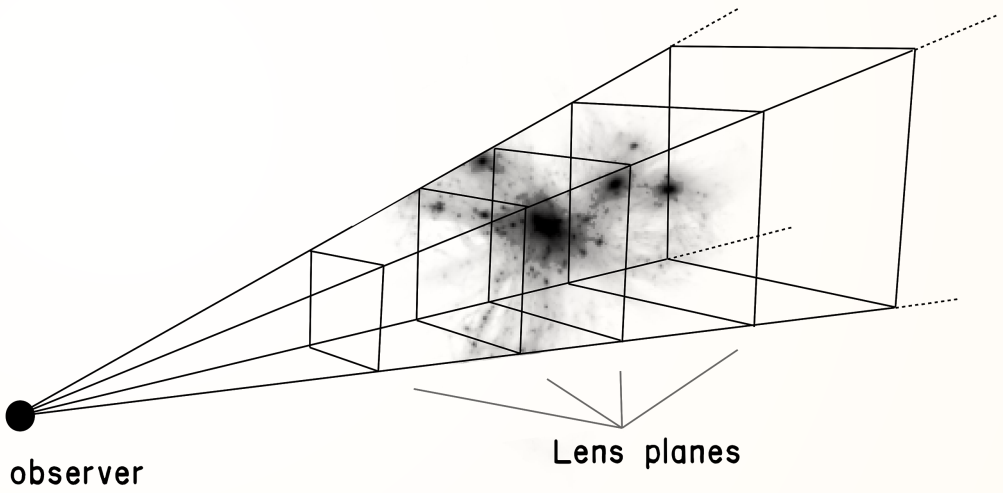

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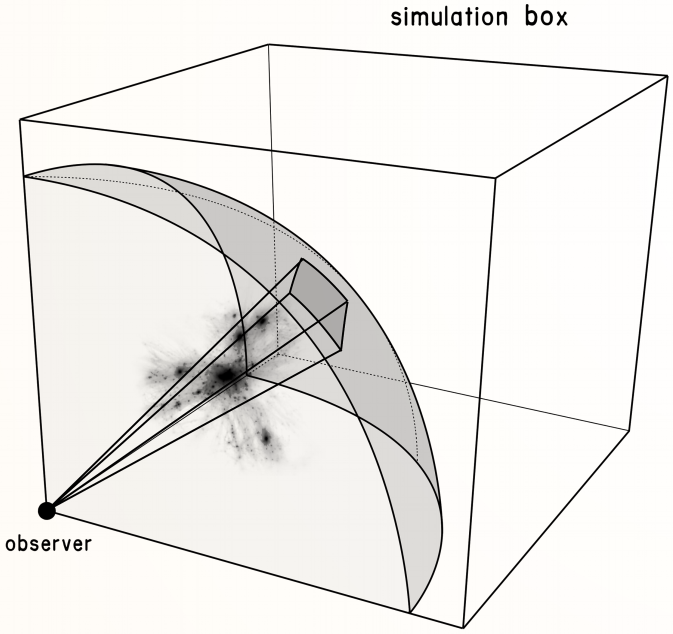

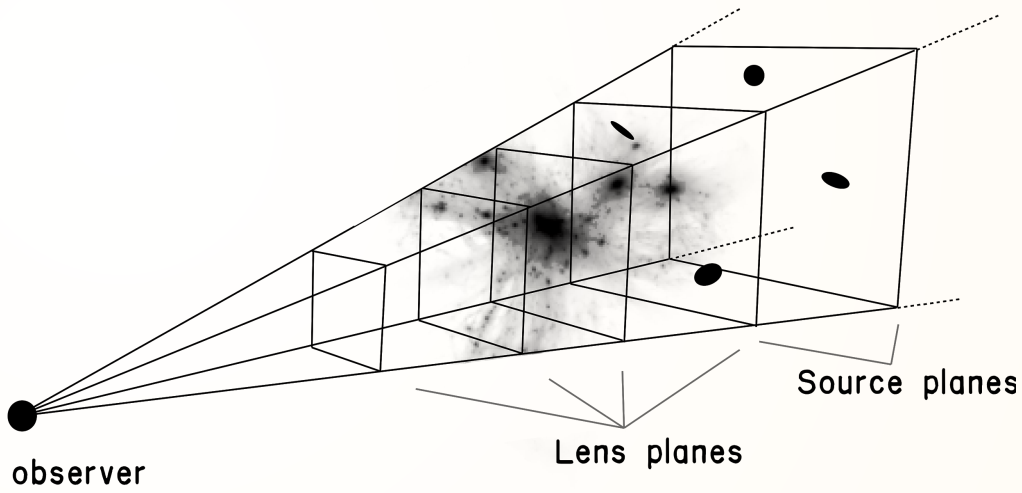

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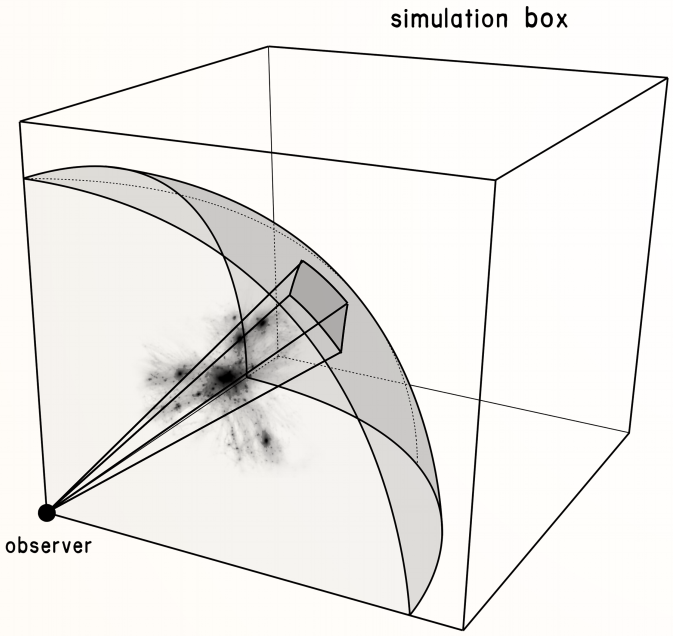
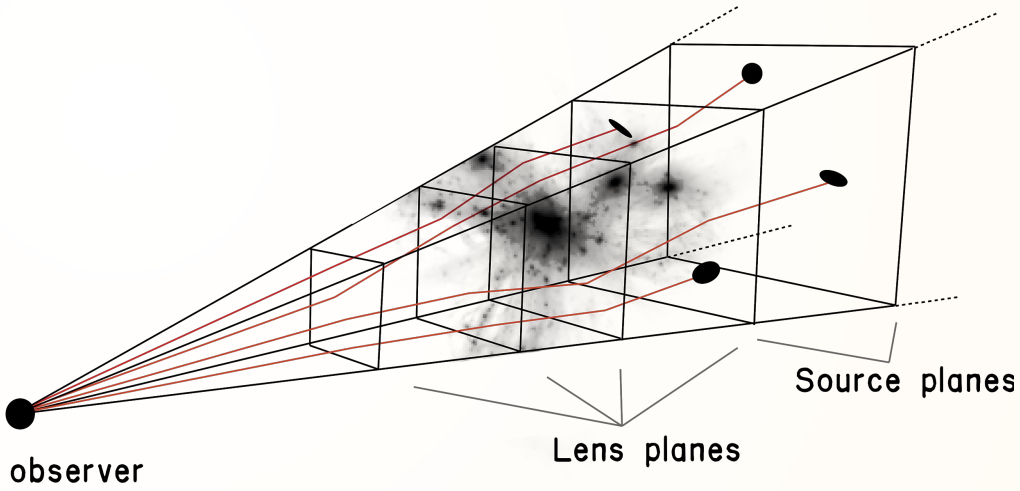
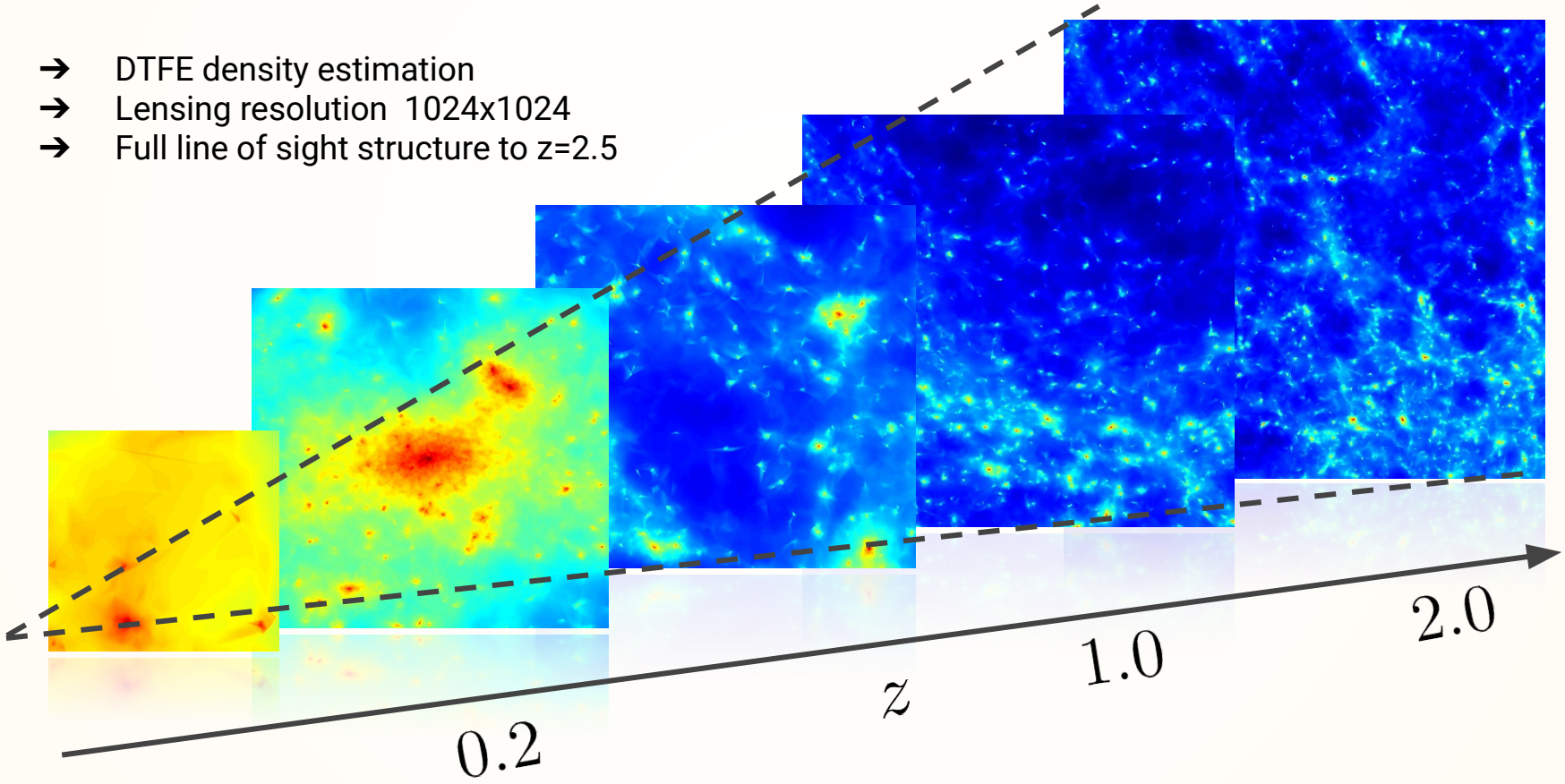




Cluster image from Benedikt Diemer

Simulating the Cluster Lensing Signal

- ➔ DTFE density estimation
- ➔ Lensing resolution 1024x1024
- ➔ Full line of sight structure to z=2.5



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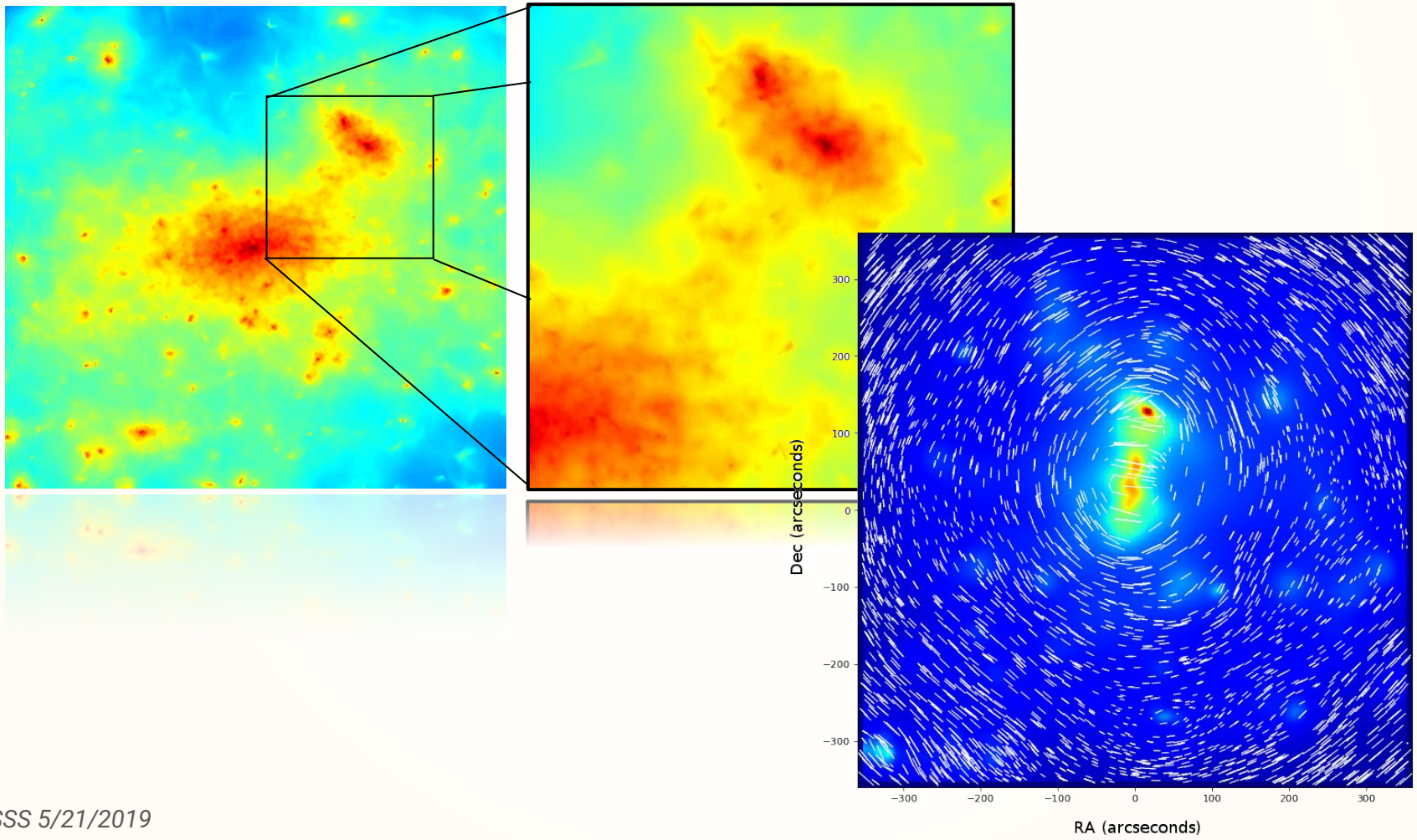
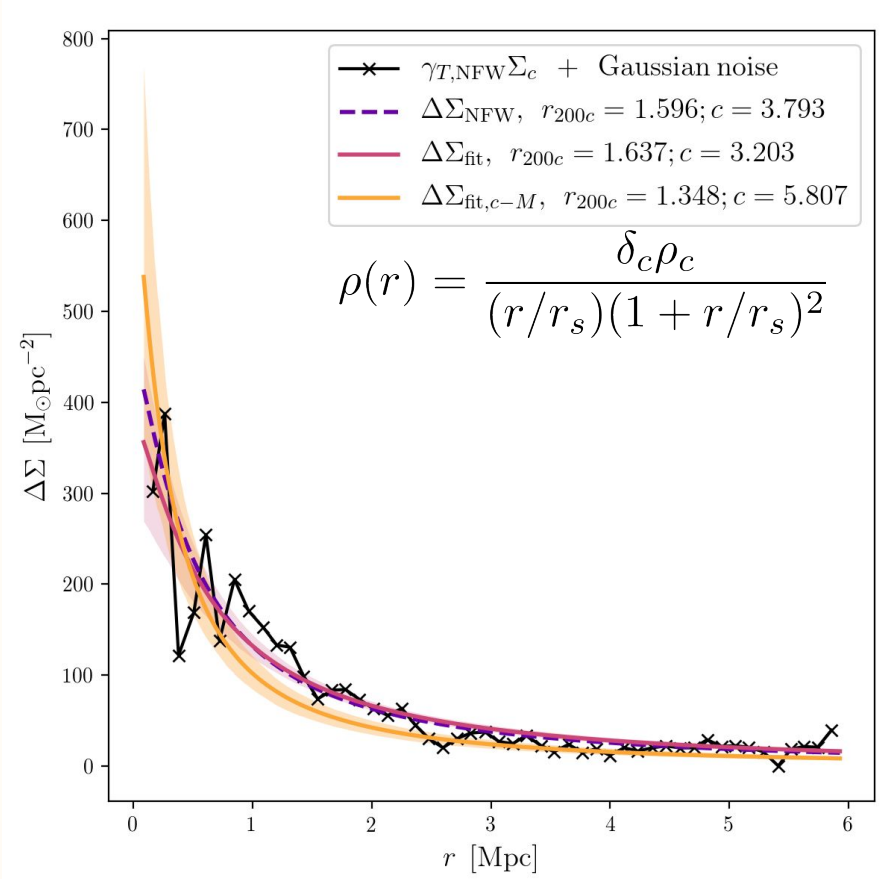
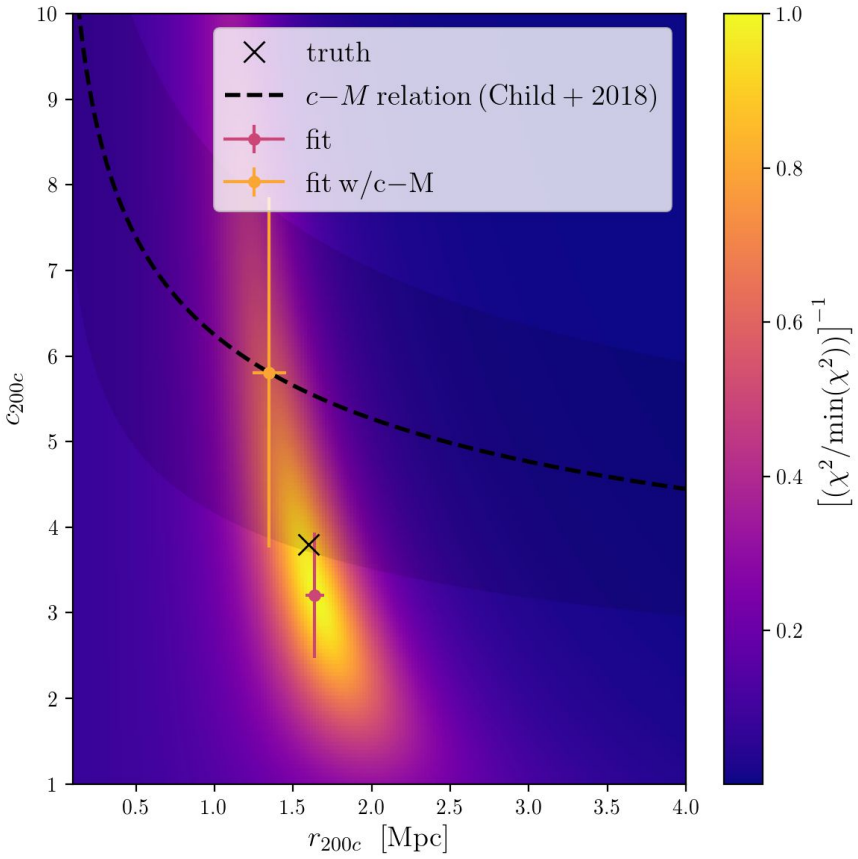


Measuring the Cluster Mass

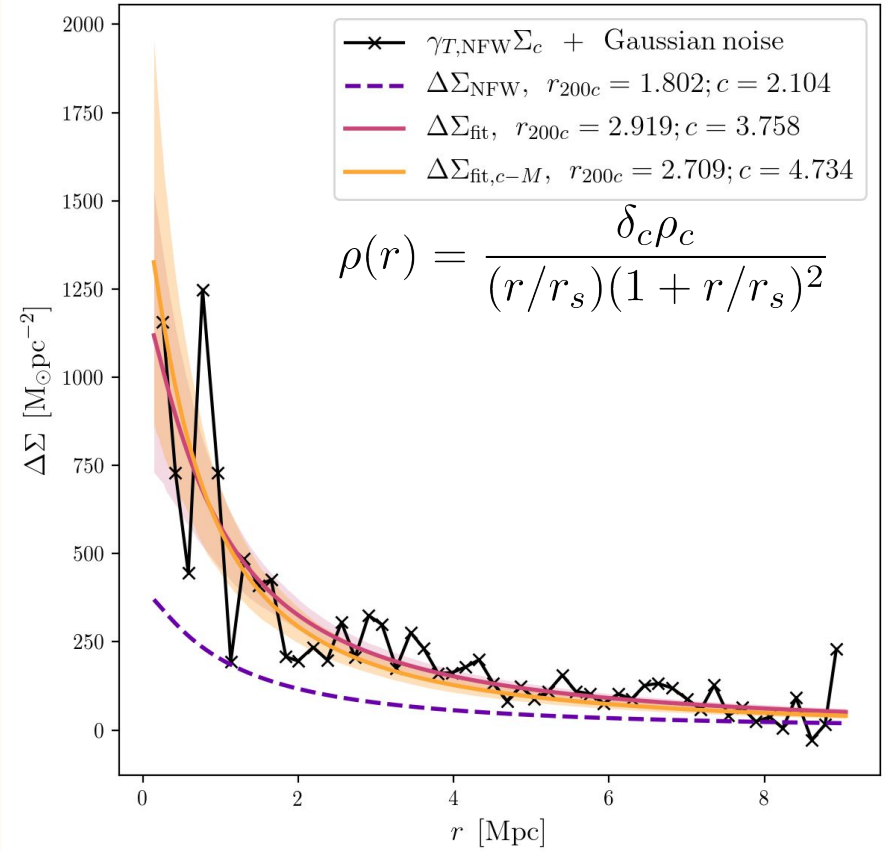
Lensing signal through the line of sight is well described by NFW

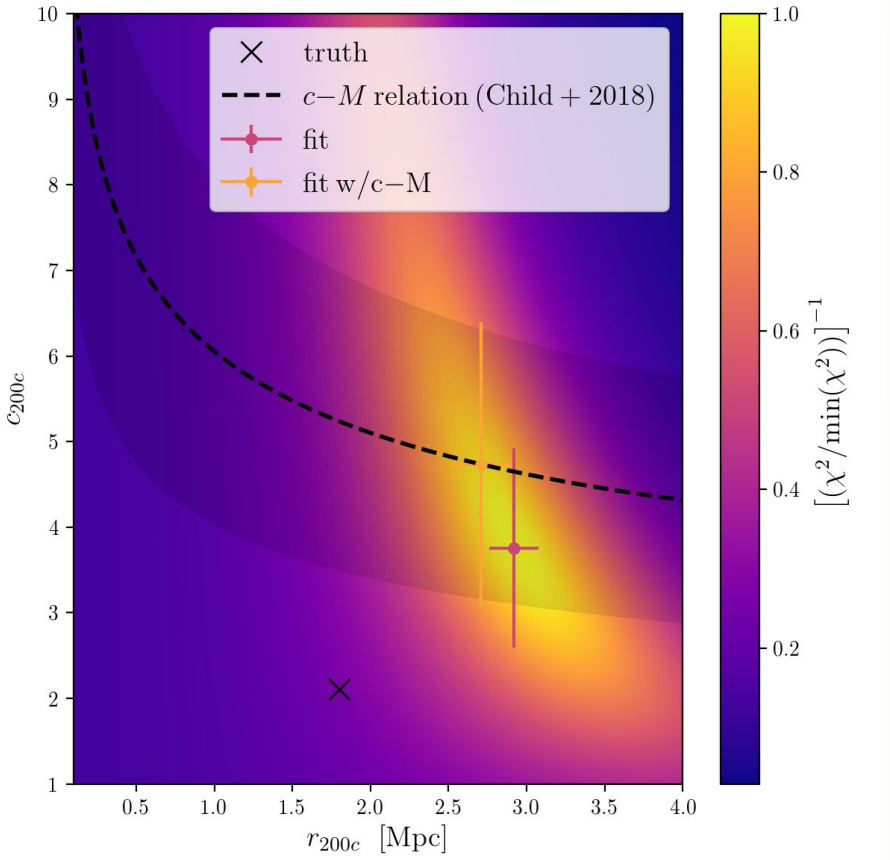




Measuring the Cluster Mass

Not so much… perhaps suggests projection effects, or correlated filamentary structure





Future Work

- Continued production runs of ray-traced lensing-maps to cover all cluster-mass halos in major CPAC simulation Outer Rim
- Profile fitting and mass estimation on large sample
  - ➔ Investigate weak lensing mass bias, toward enabling an effective weak-lensing mass calibration for the LSST-era

Thank you!