A New and Rapid Simulations Method for Weak Lensing Analysis

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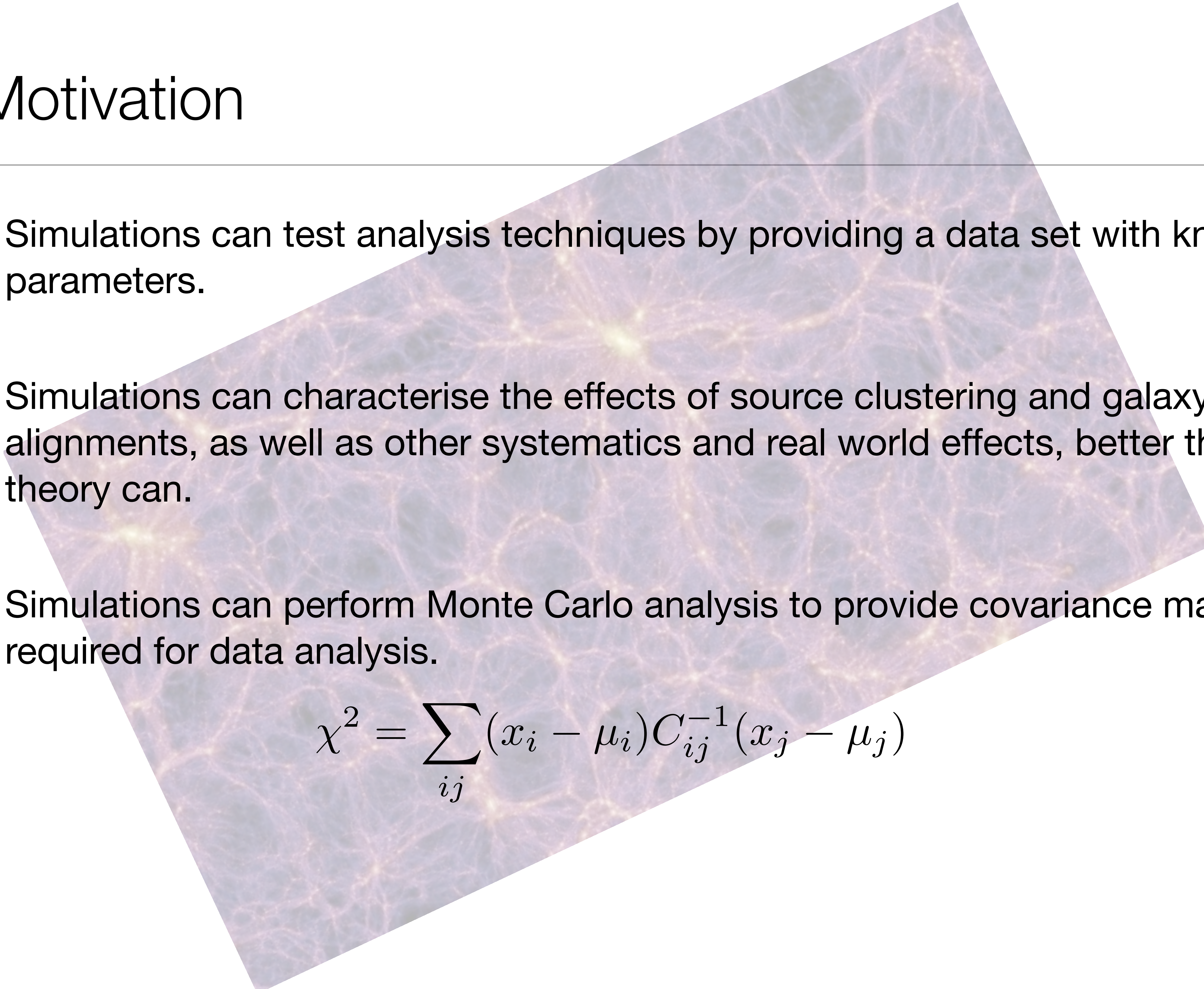
Motivation

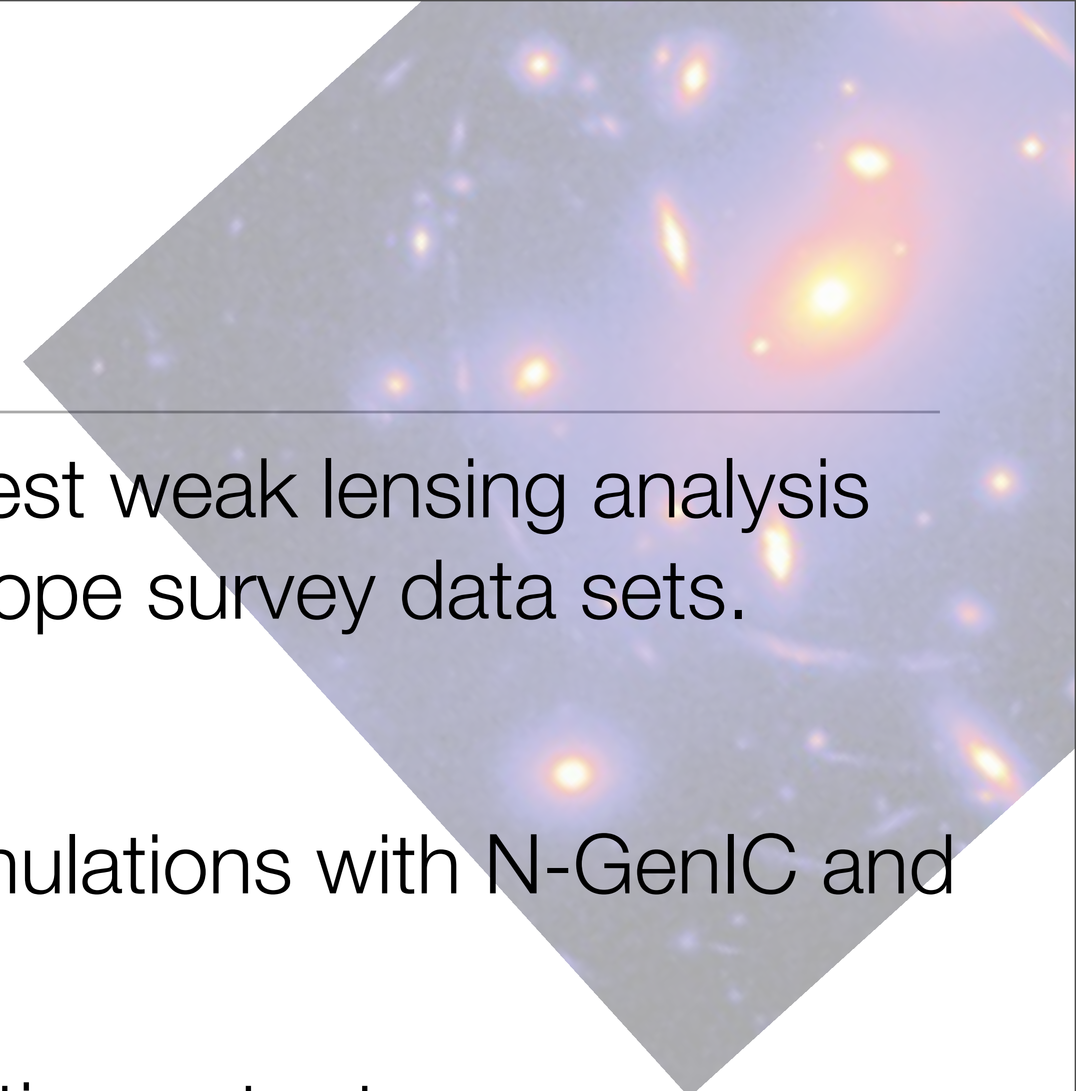


- Simulations can test analysis techniques by providing a data set with known parameters.

- Simulations can characterise the effects of source clustering and galaxy alignments, as well as other systematics and real world effects, better than theory can.

- Simulations can perform Monte Carlo analysis to provide covariance matrices required for data analysis.

$$\chi^2 = \sum_{ij} (x_i - \mu_i) C_{ij}^{-1} (x_j - \mu_j)$$



Our solution

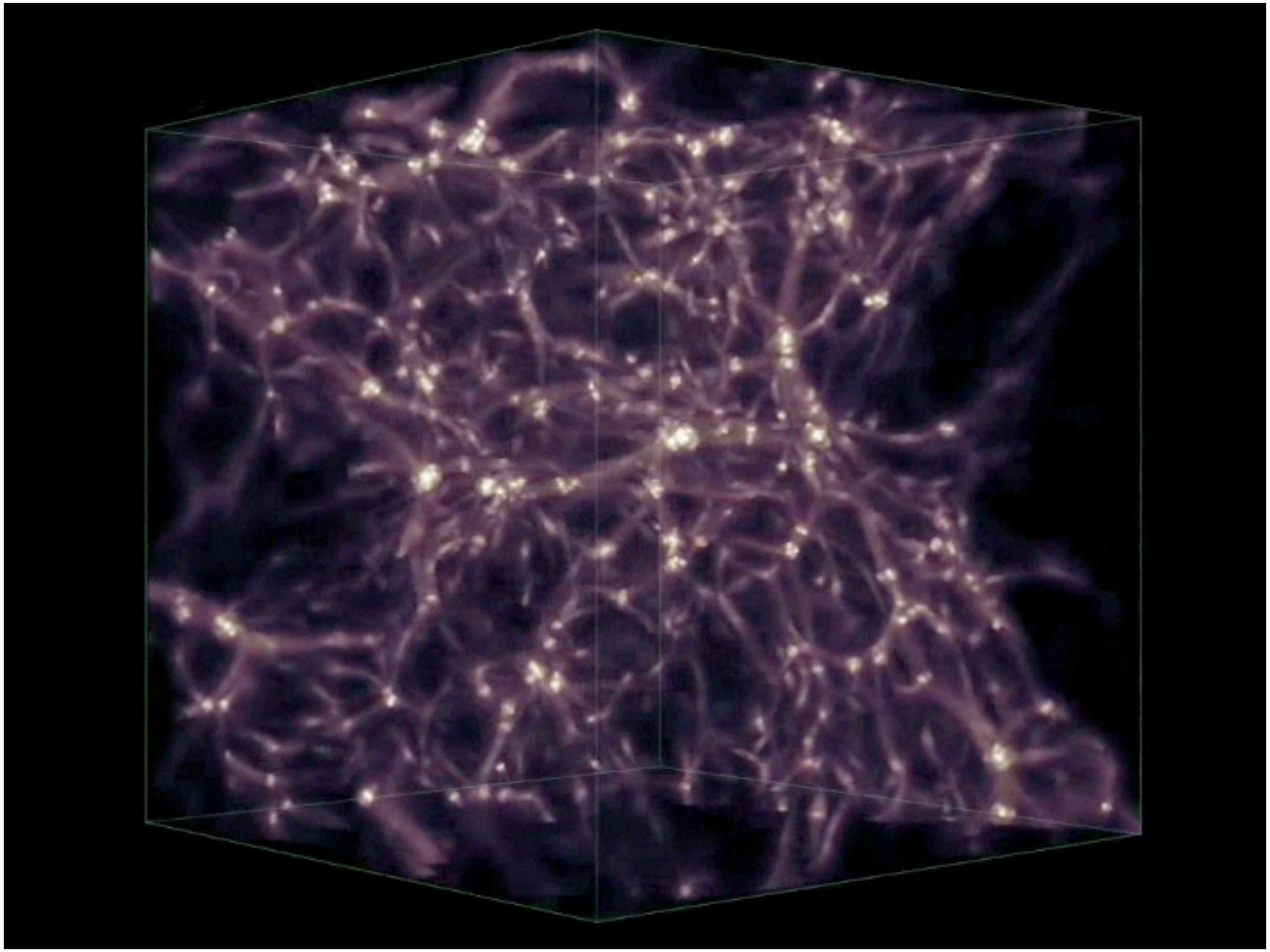
Use Cosmological N-Body simulations to test weak lensing analysis techniques and run data analysis on telescope survey data sets.

Method

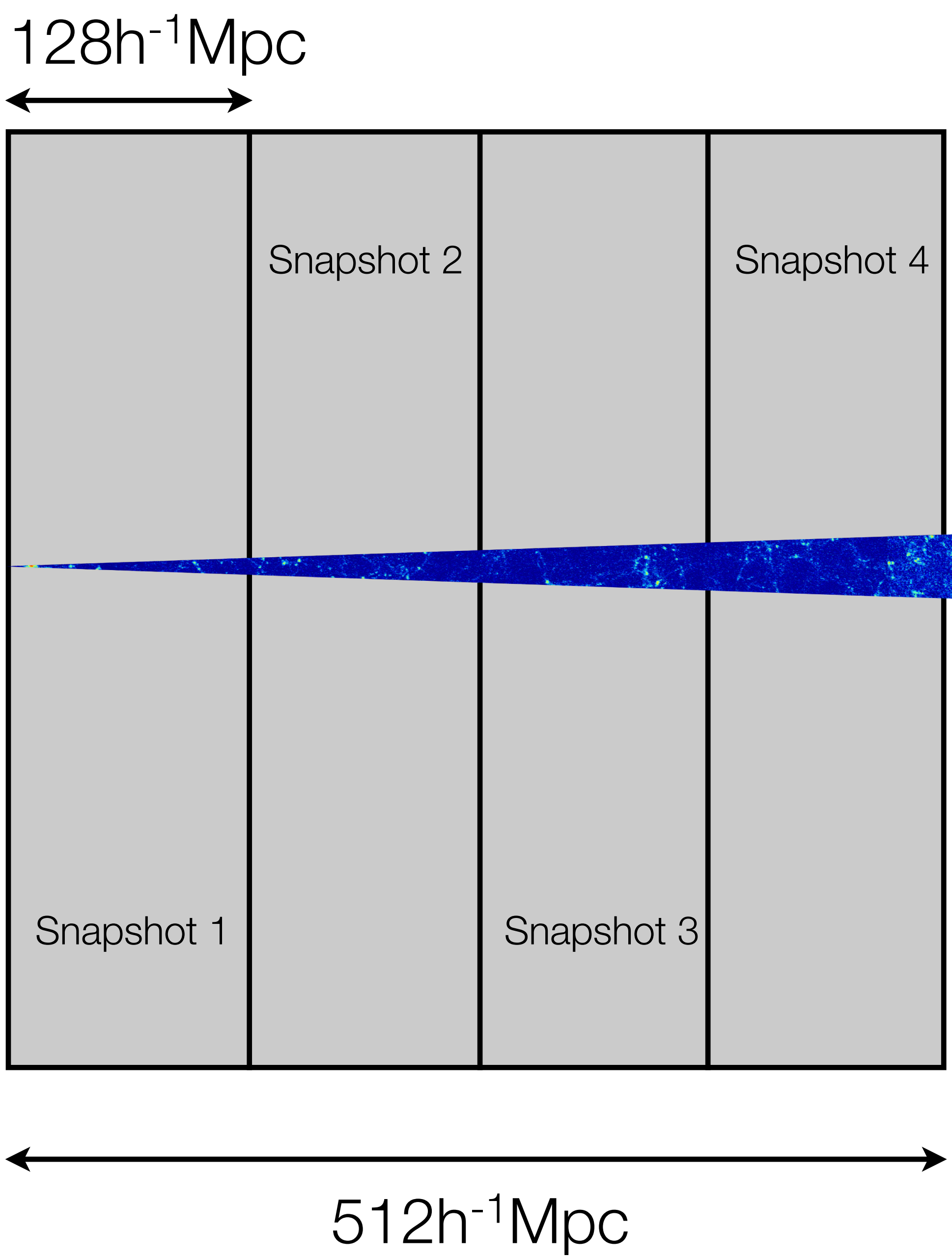
- Create multiple cosmological N-Body simulations with N-GenIC and GADGET2 (Springel 2005)
- Generate a light cone through the simulation output
- Calculate the shear & convergence and their power spectra for multiple lensing source redshifts
- Generate mock galaxy catalogues with an n(z) distribution and assign each galaxy a shear, convergence and photo-z
- (Add systematics and real world effects to the simulation data)
- Test weak lensing analysis techniques

The Simulations - GADGET2

512^3 particles
512 h^{-1}Mpc
$\Omega_m = 0.27$
$\Omega_\Lambda = 0.73$
$\Omega_b = 0.05$
$h = 0.71$
$\sigma_8 = 0.81$
$z_0 = 60$
$m_p = 6.7 \times 10^{10} M_\odot$



Generating the light cone



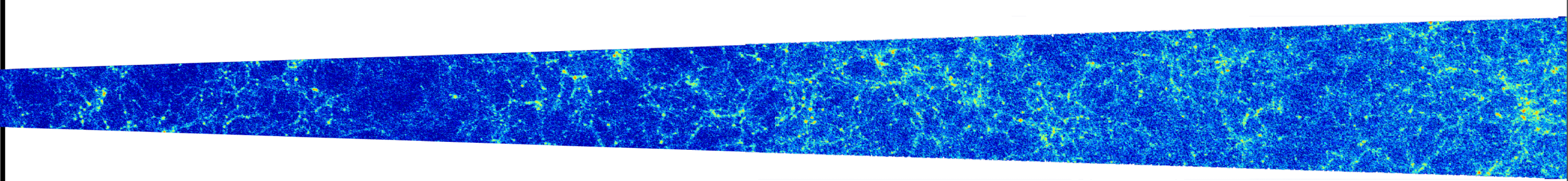
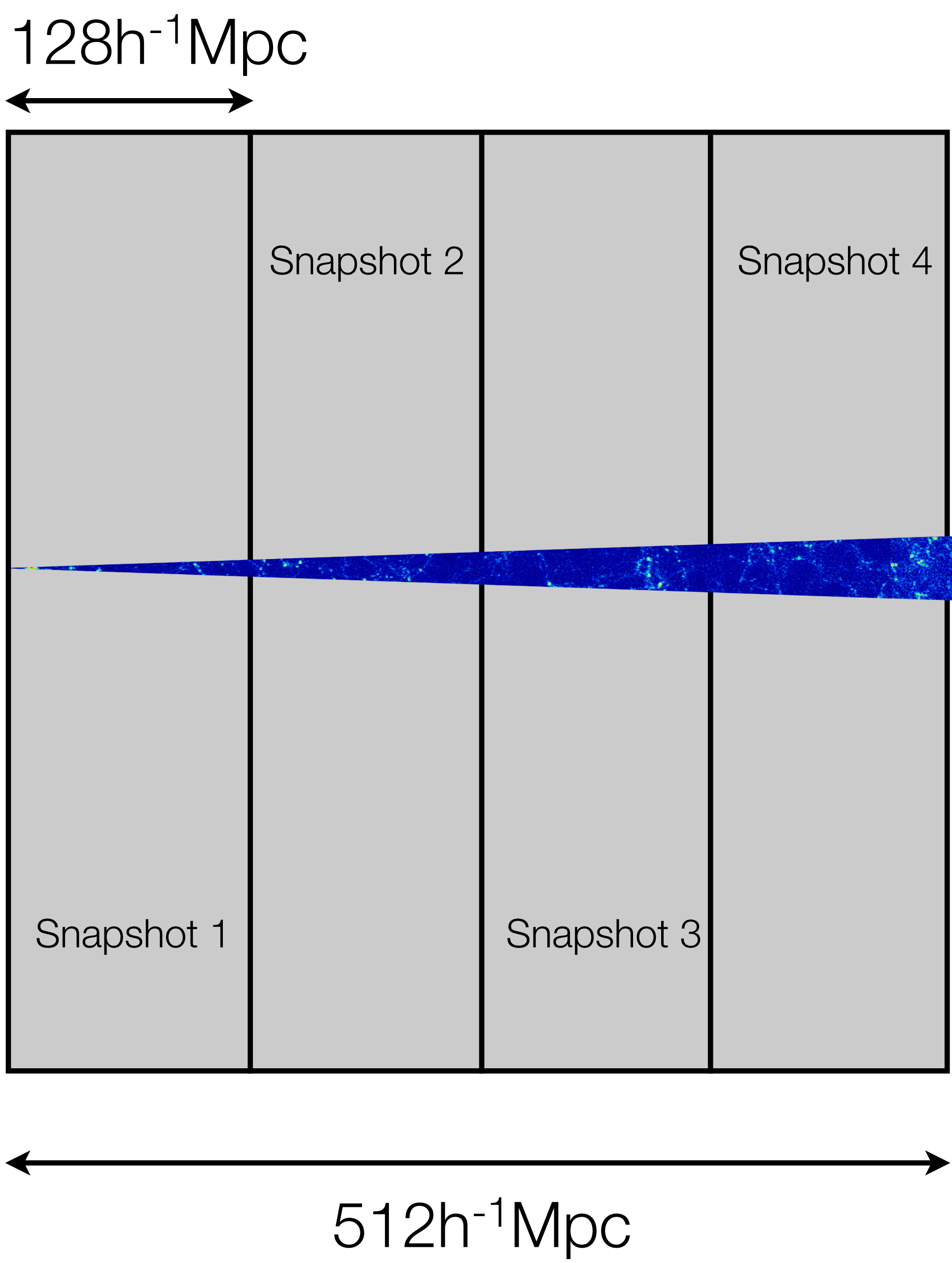


Photo-z error: $\sigma_z < 0.05\,(1+z) = 147\ h^{-1}Mpc$

at z = 1.0

$$\kappa = \int_0^{r_s} dr \frac{3H_0\Omega_m}{2c^2}\frac{(r_s - r)r}{r_s a(r)}\delta(r)$$

Generating the light cone



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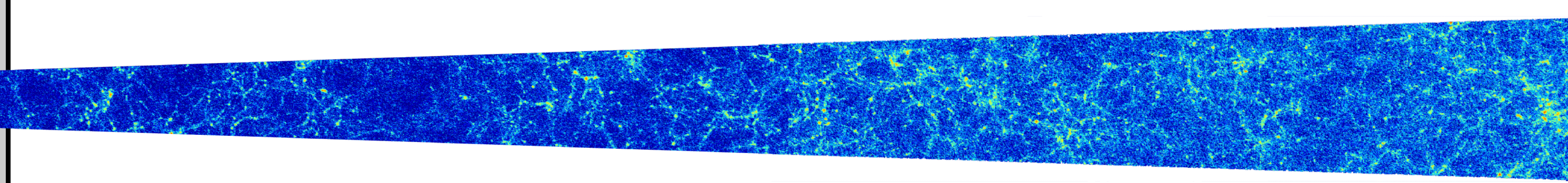
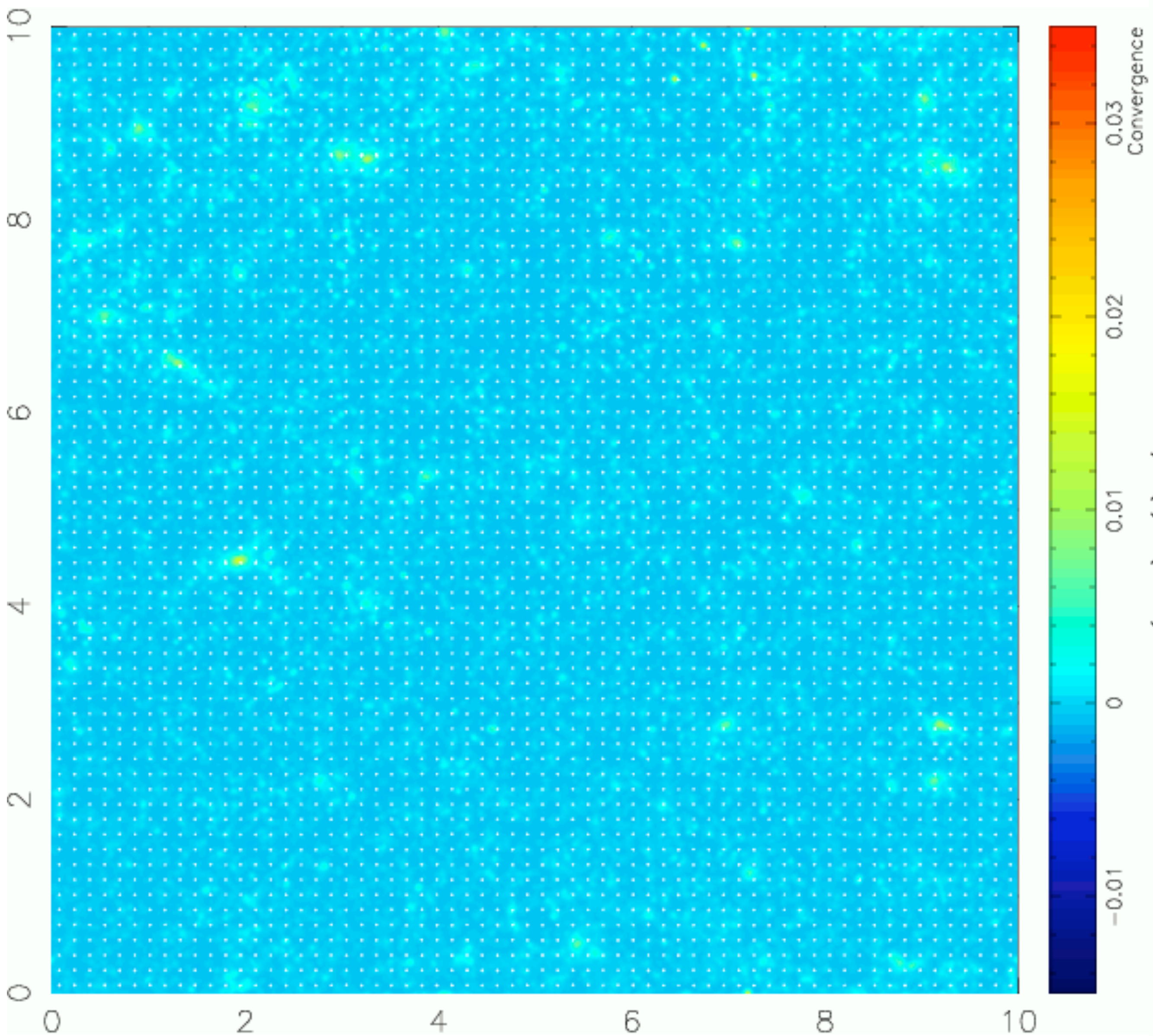


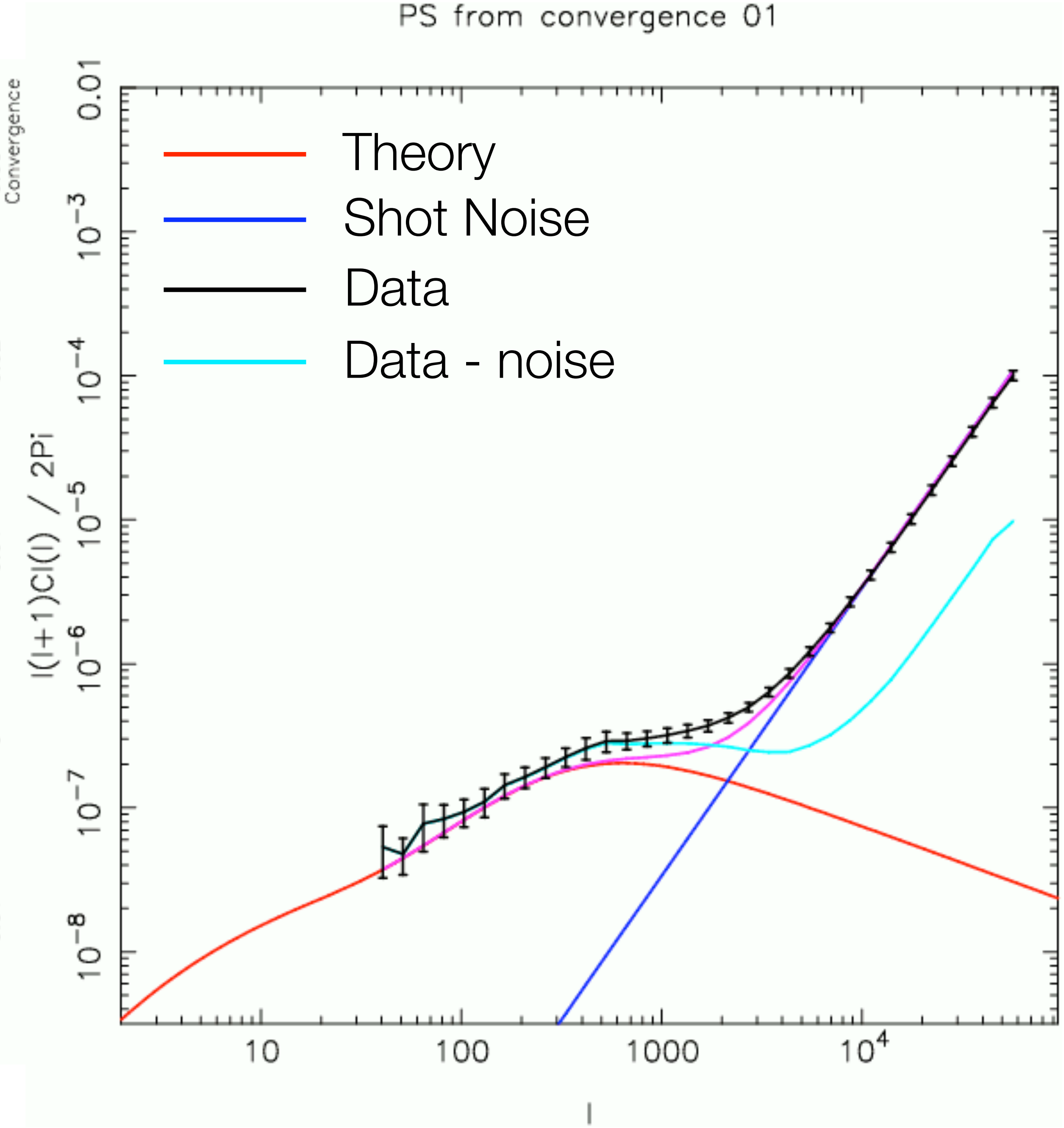
Line of sight integration using no radial binning

$$\kappa(p) = \sum_i \frac{k(r_i, r_s)}{\Delta\Omega_p \bar{n}(r_i) r_i^2} - \int_0^{r_s} dr\ k(r, r_s)$$

$$k(r, r_s) = \frac{3\Omega_m H_0^2}{2c^2} \frac{(r_s - r)r}{r_s a(r)} \qquad \Delta\Omega_p = \Delta\theta_x \Delta\theta_y$$

Source redshift evolution

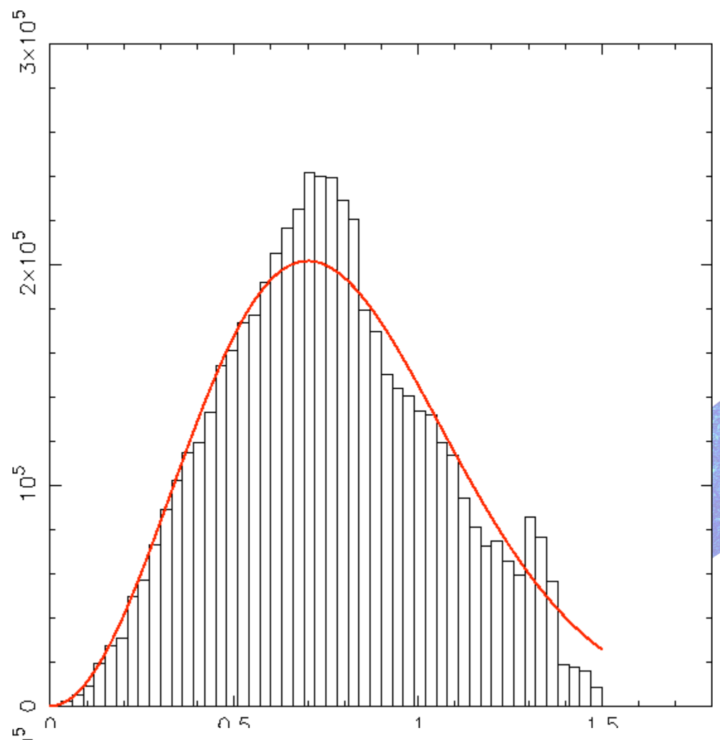




Kiessling et al 2010, in preparation

Generating Mock Galaxy Catalogues

$$n(z) \propto z^2 exp\left[-\left(\frac{z}{z_0}\right)^2\right]$$



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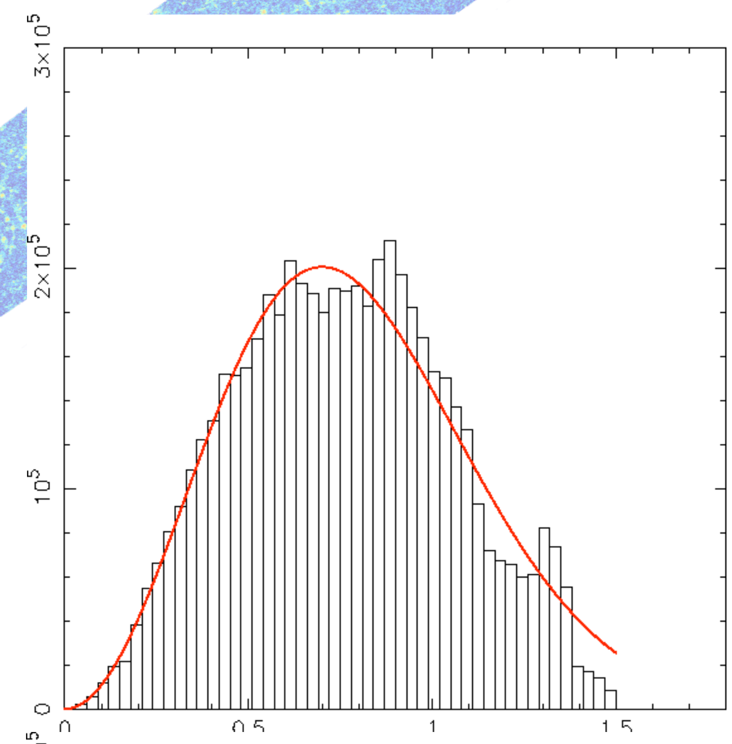

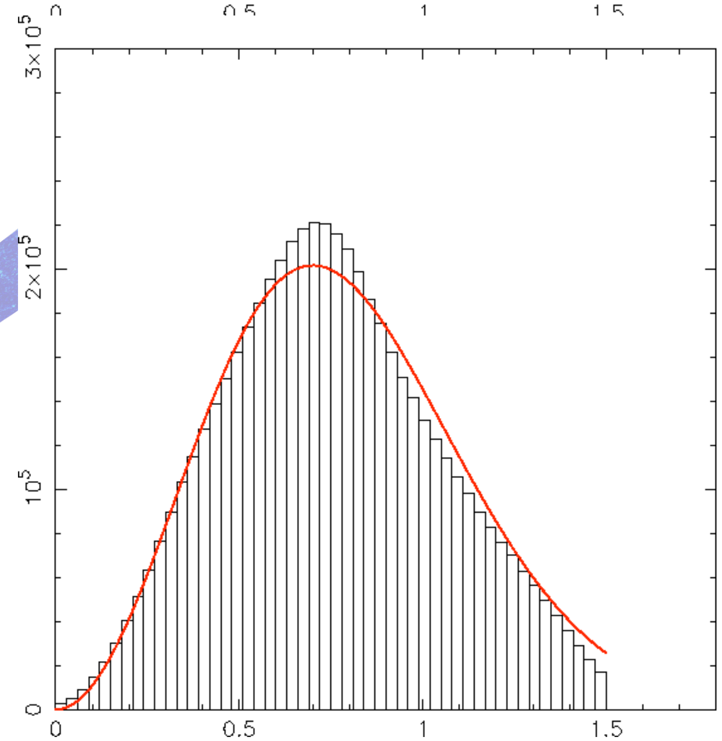

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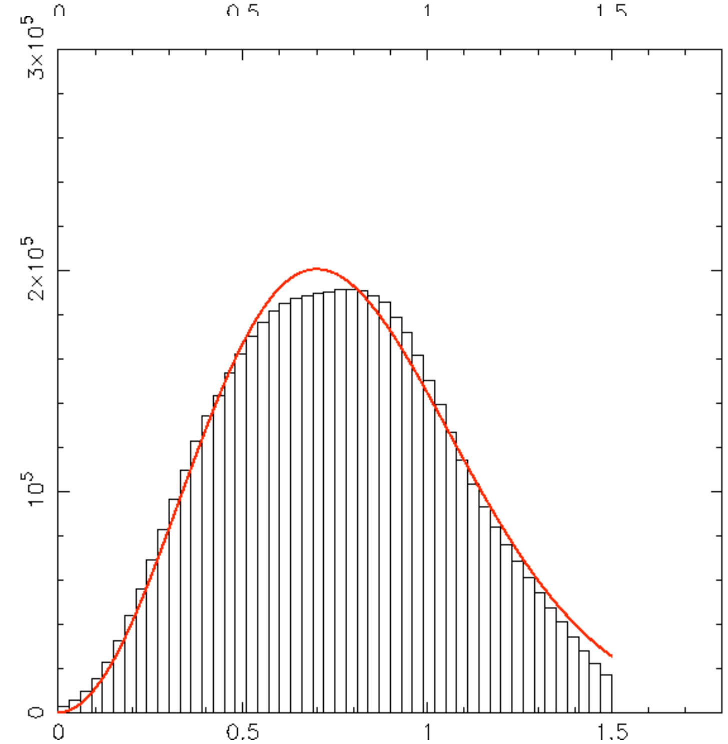
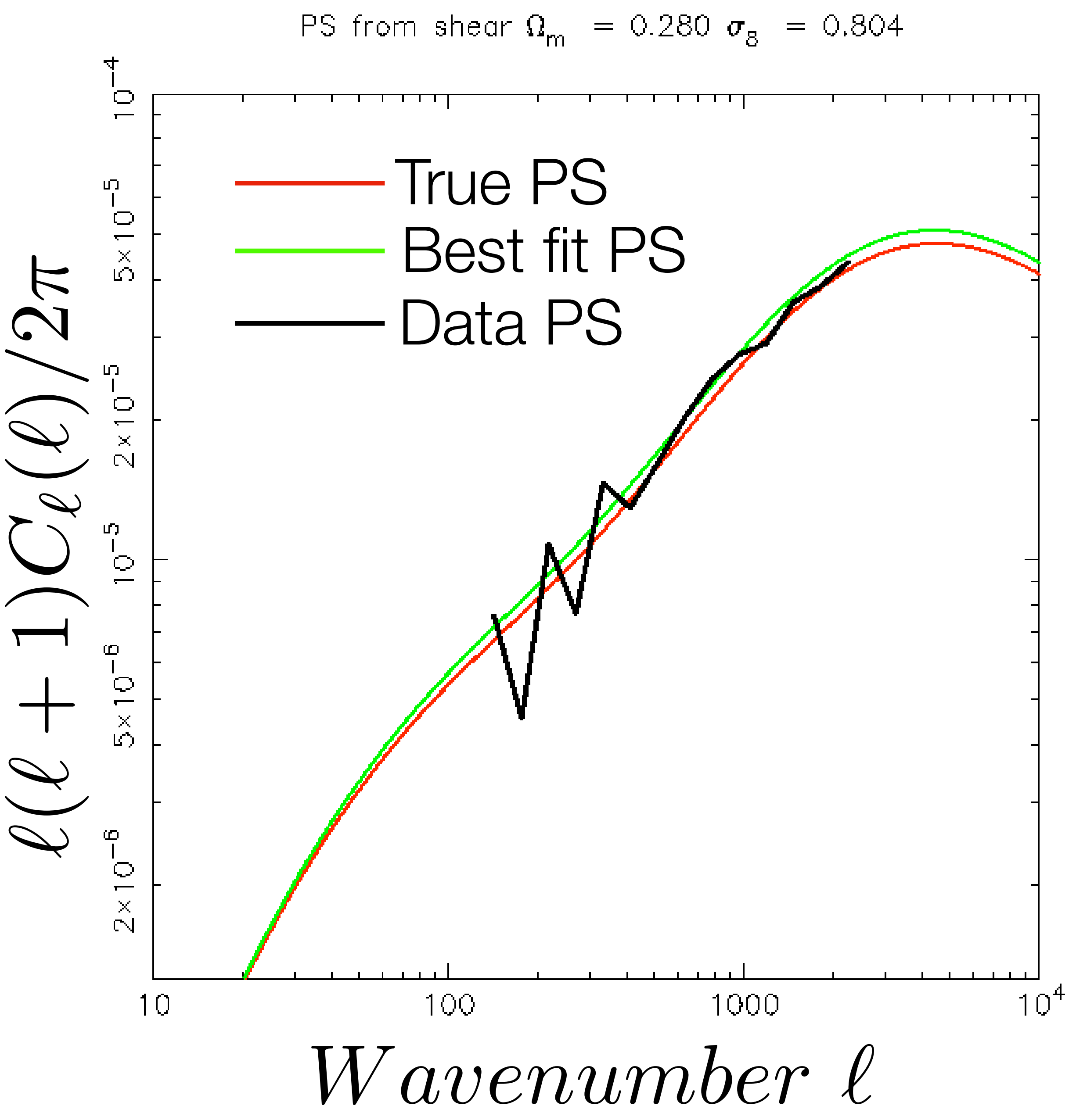
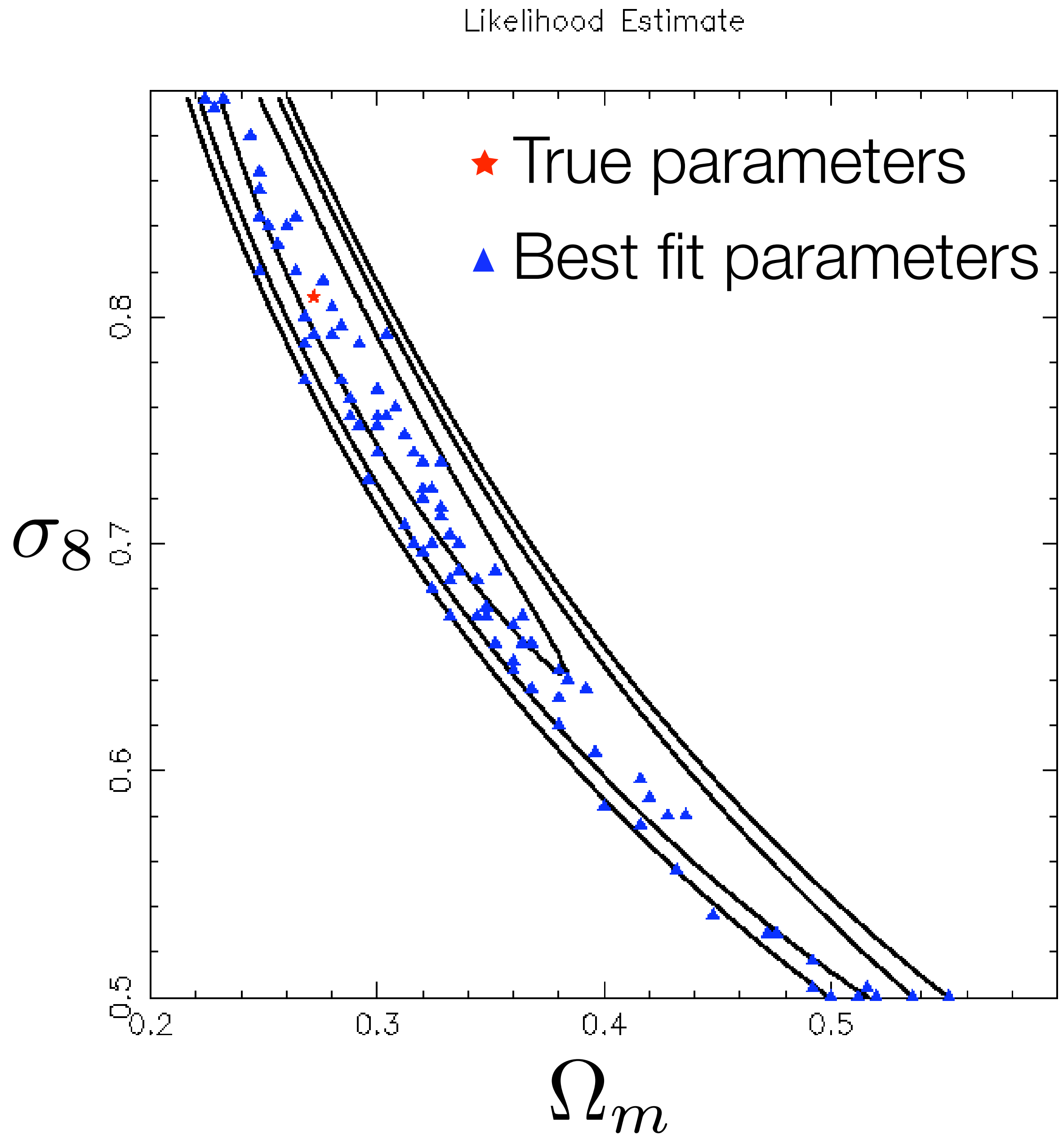
photo-z



Kiessling et al 2010, in preparation

(Preliminary) Gaussian Likelihood Estimates



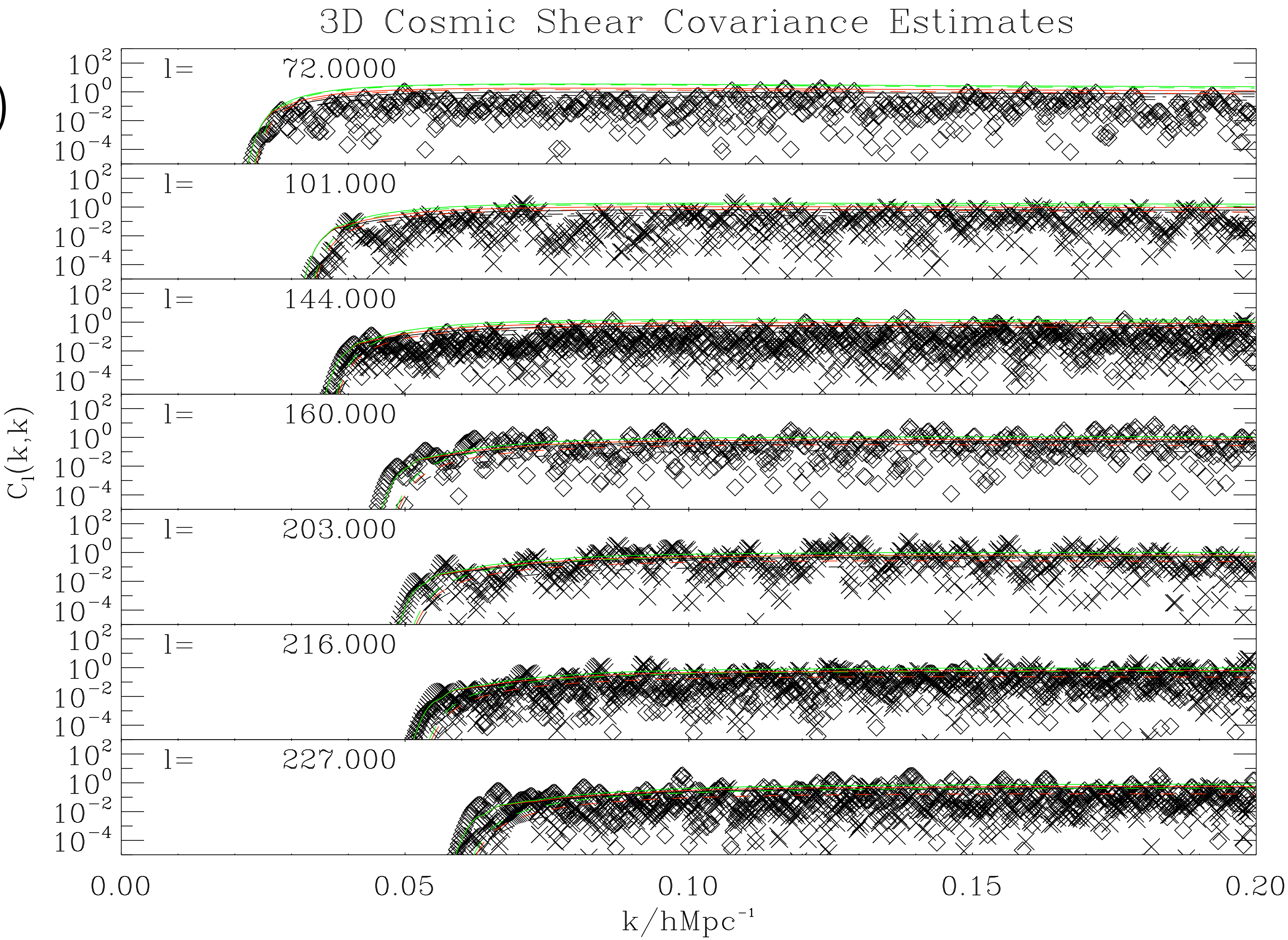


$$\chi^2 = \sum_{ij} (x_i - \mu_i) C_{ij}^{-1} (x_j - \mu_j)$$

Kiessling et al 2010, in preparation

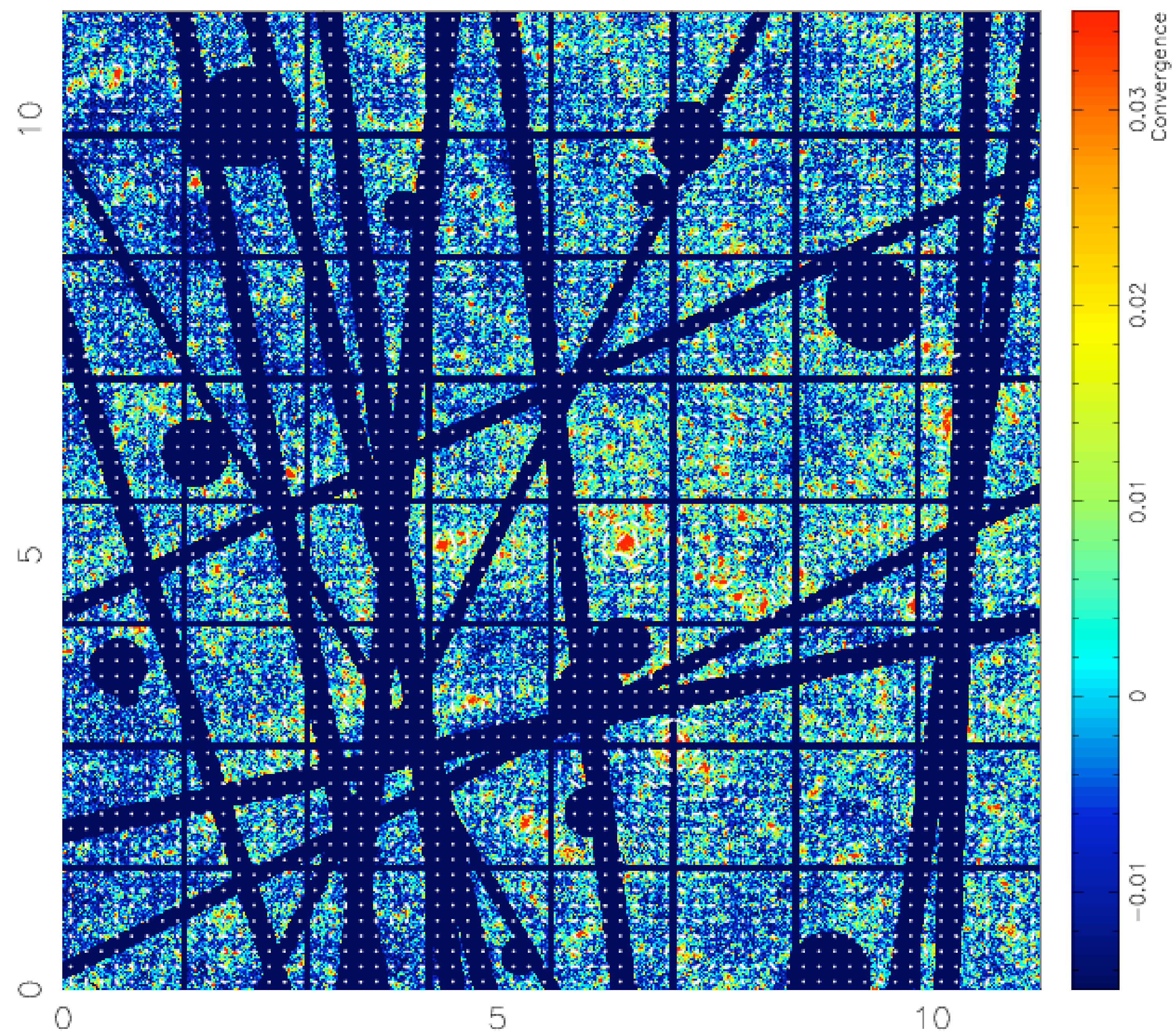
3D Cosmic Shear

- Spherical harmonic representation of the entire continuous 3D shear field
- $C_\ell(k_1, k_2)$



Tom Kitching

Pseudo-Cl - Preparing the data



Mock data

Upcoming Science

Covariance Matrices

- For cosmological parameter estimation and data analysis

3D Shear Power Analysis

- Determines the 3D shear power spectrum without binning or collapsing the data on to a plane

Pseudo-Cl analysis

- Deconvolves observational data with the window function

Real world effects

- Investigates the effect of photo-z errors, intrinsic alignments (and their effective removal), clustered source galaxies, atmospheric distortions etc

Extension to all sky

- Extends the simulations from flat sky ‘medium deep’ surveys to mimic large area and ‘all sky’ surveys

Summary

- Simulations are essential for future survey analysis - e.g. Pan-STARRS, Euclid & HALO
- We have developed a new, rapid and accurate weak lensing analysis software package to determine shear/convergence using line-of-sight integrations
- We currently have 100 medium resolution GADGET2 simulations for cosmological weak lensing analysis which are much faster to run than the high resolution simulations traditionally used in this type of analysis
- This work will be presented in Kiessling et al (2010), in preparation
- The analysis software and simulations will be used to test analysis techniques like Pseudo-Cl and 3D shear power