

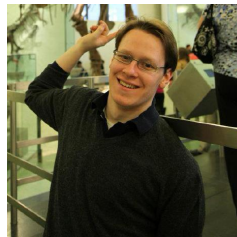
Cosmological Constraints from Weak Lensing with *CFHTLenS* and *Planck*



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LSS, Garching, July 24, 2015



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Lam Hui

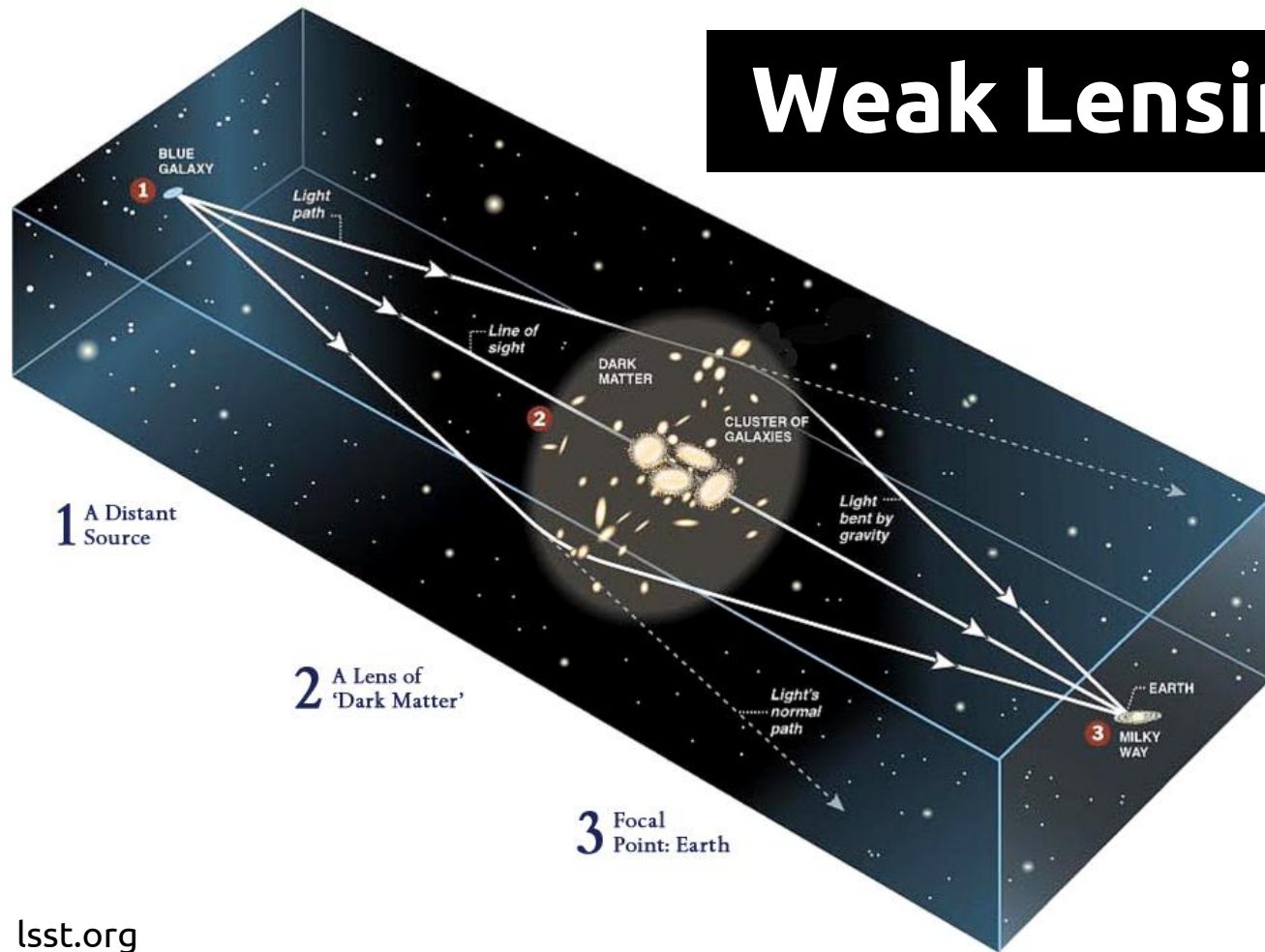


Jan Kratochvil

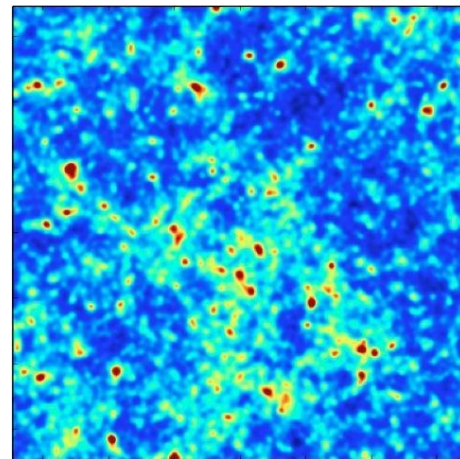


Morgan May

Weak Lensing Primer



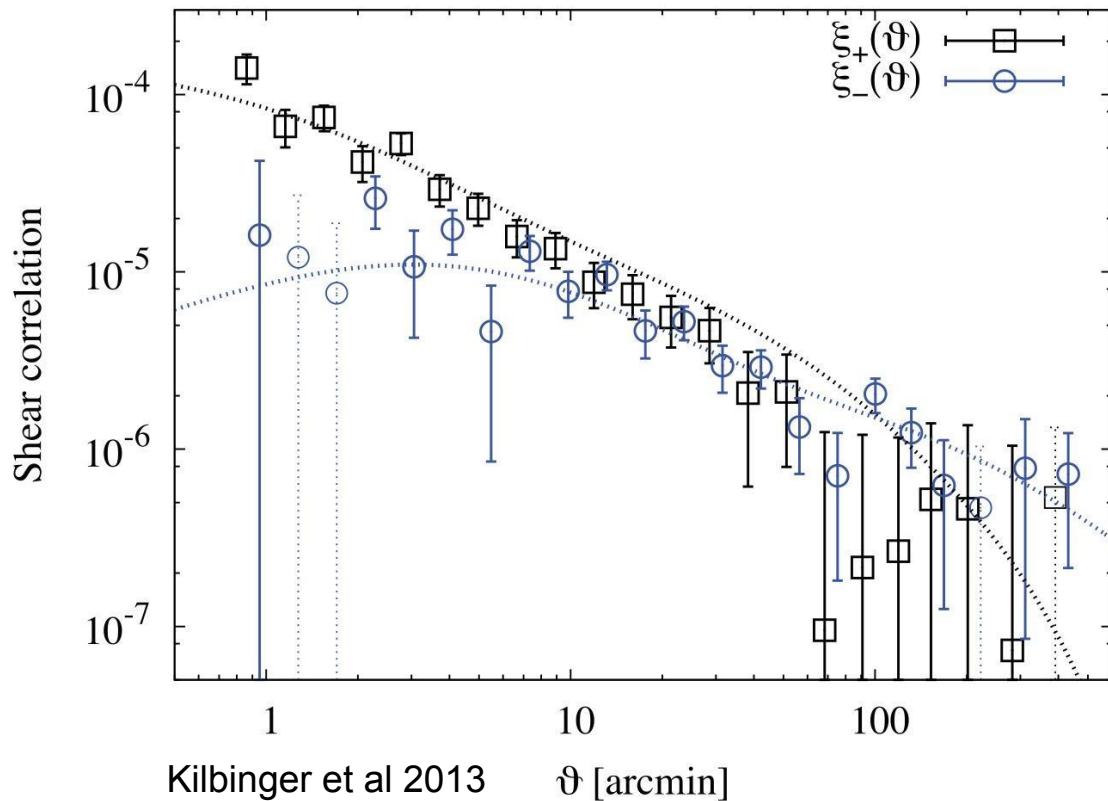
Convergence Map
2D Projection of
3D matter density



Outline

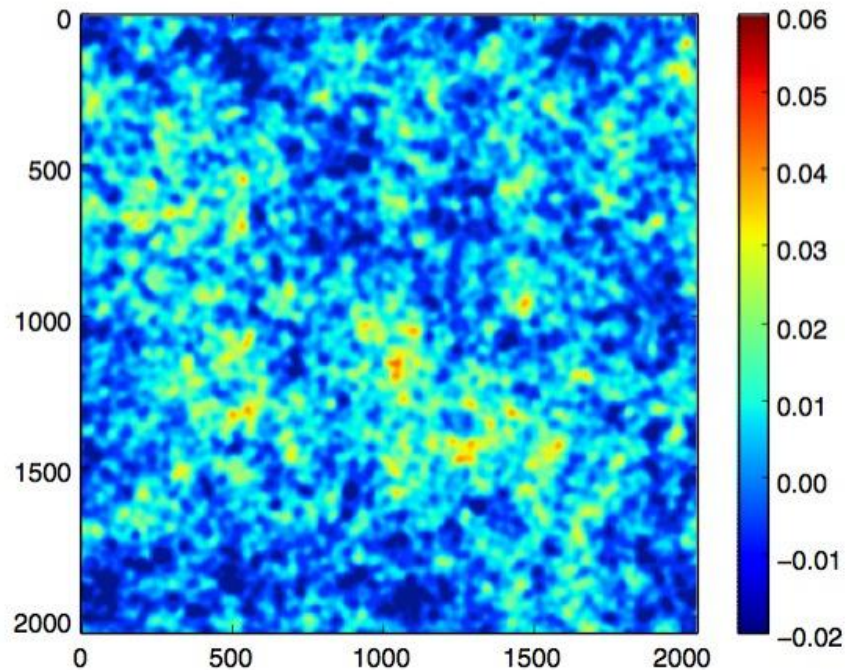
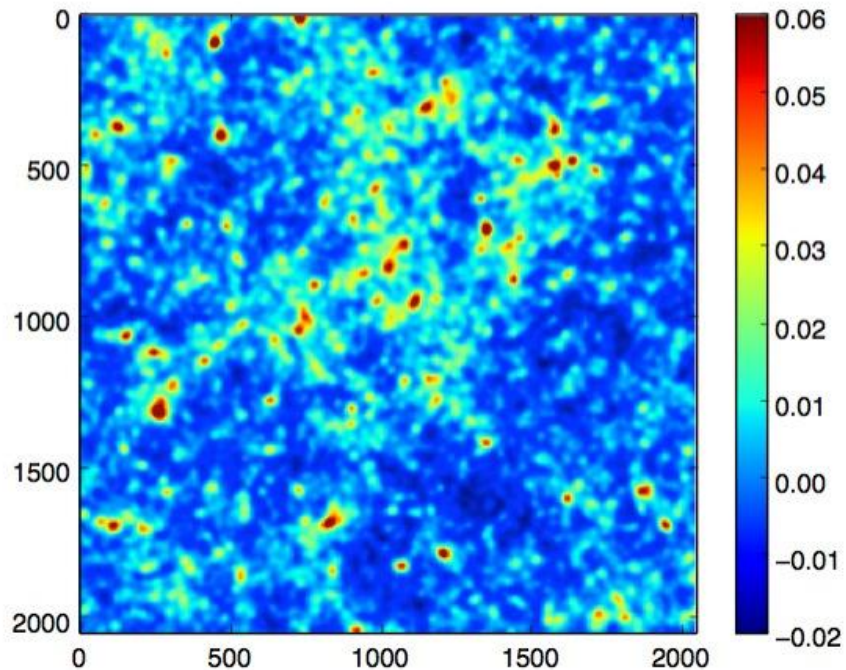
1. Weak lensing non-Gaussian statistics:
Peak counts with *CFHTLenS*
2. Cross-correlation:
Planck CMB lensing and *CFHTLenS* galaxy lensing

Two-Point Correlation Function

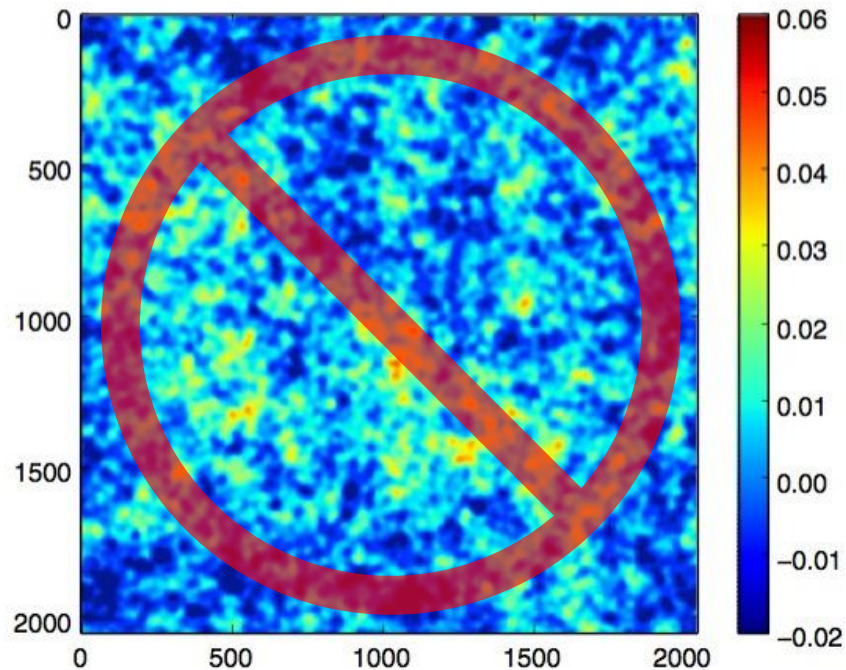
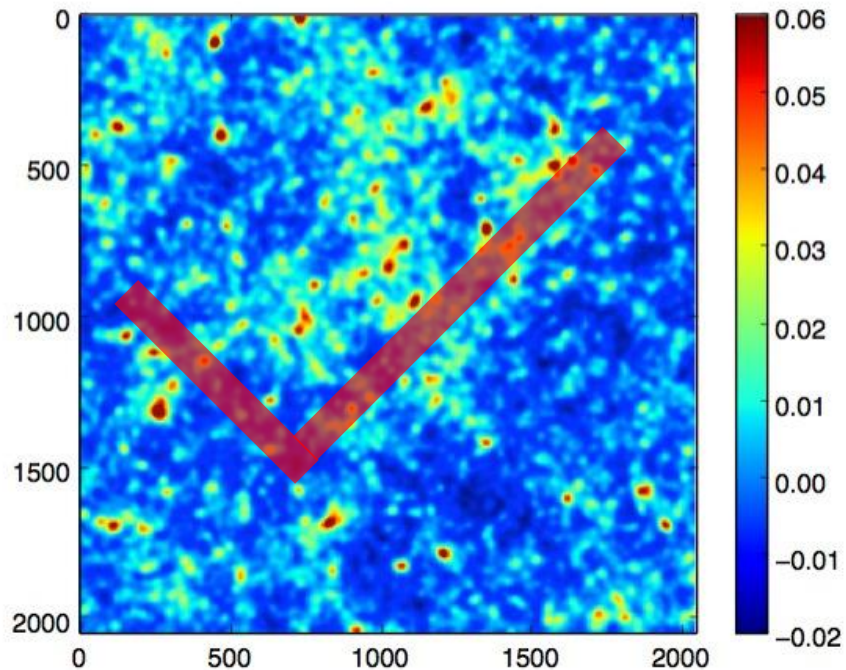


$$\xi(|\theta_i - \theta_j|) = \langle \kappa(\theta_i) \kappa(\theta_j) \rangle$$

Which is the True Convergence Map?

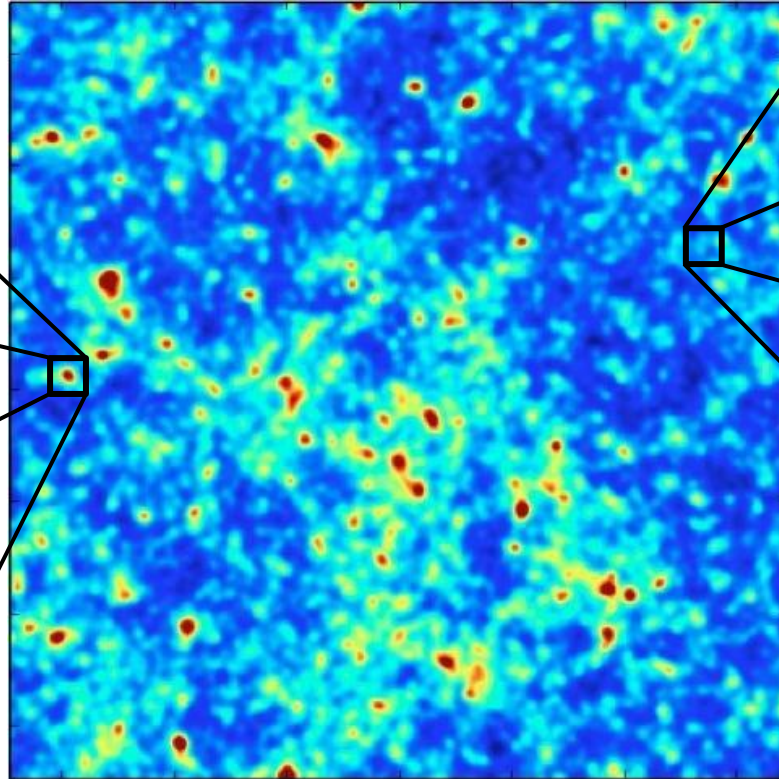
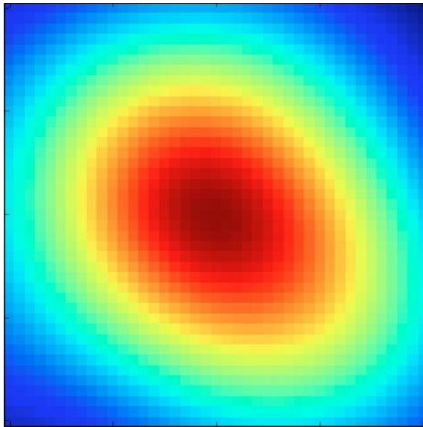


Non-Gaussianity

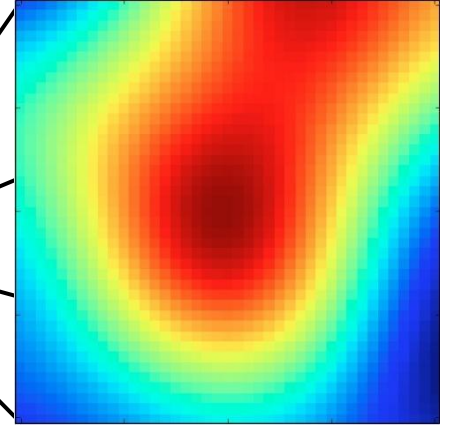


Peak Counts

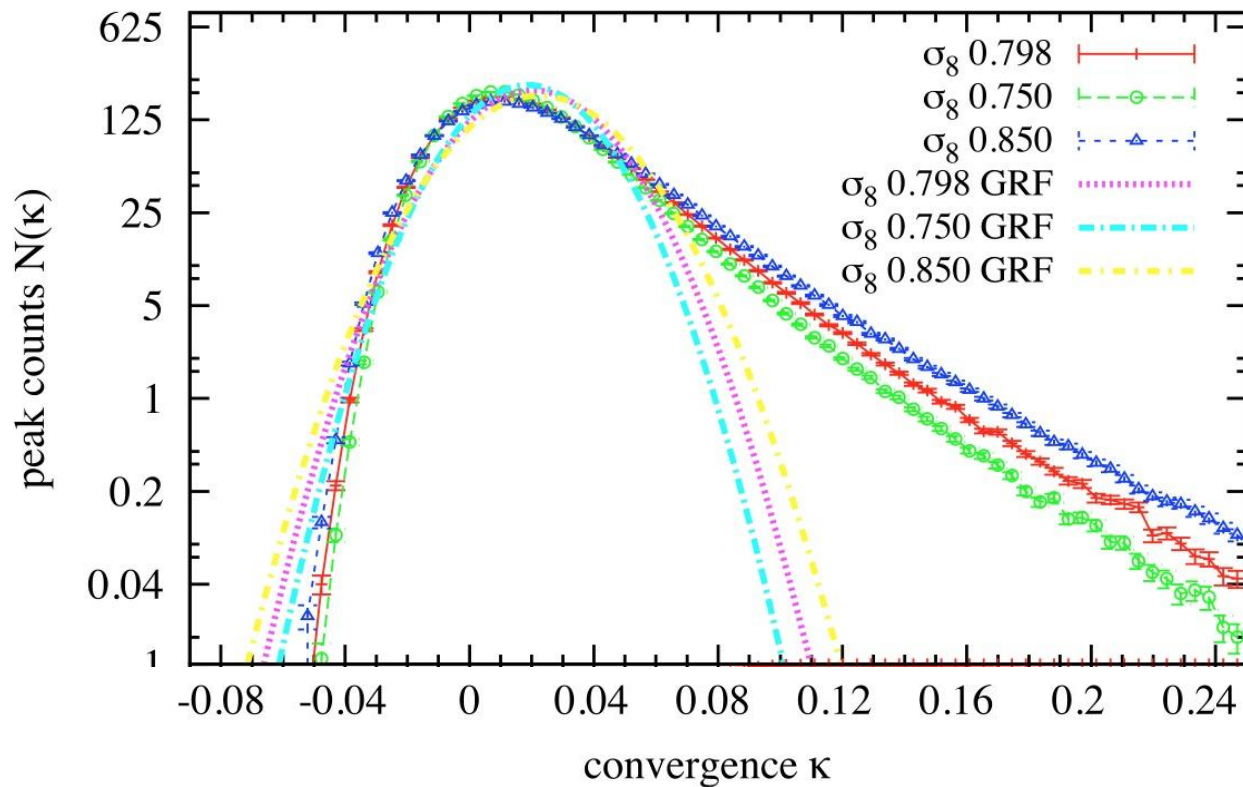
High peaks ($S/N > 3$)
Massive halos



Low peaks ($S/N < 3$)
Constellations of
several small halos,
or aligned filaments
(?)



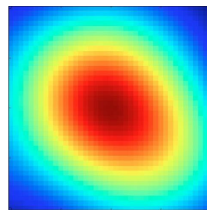
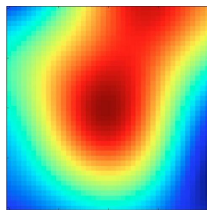
Peak Counts



Low peaks

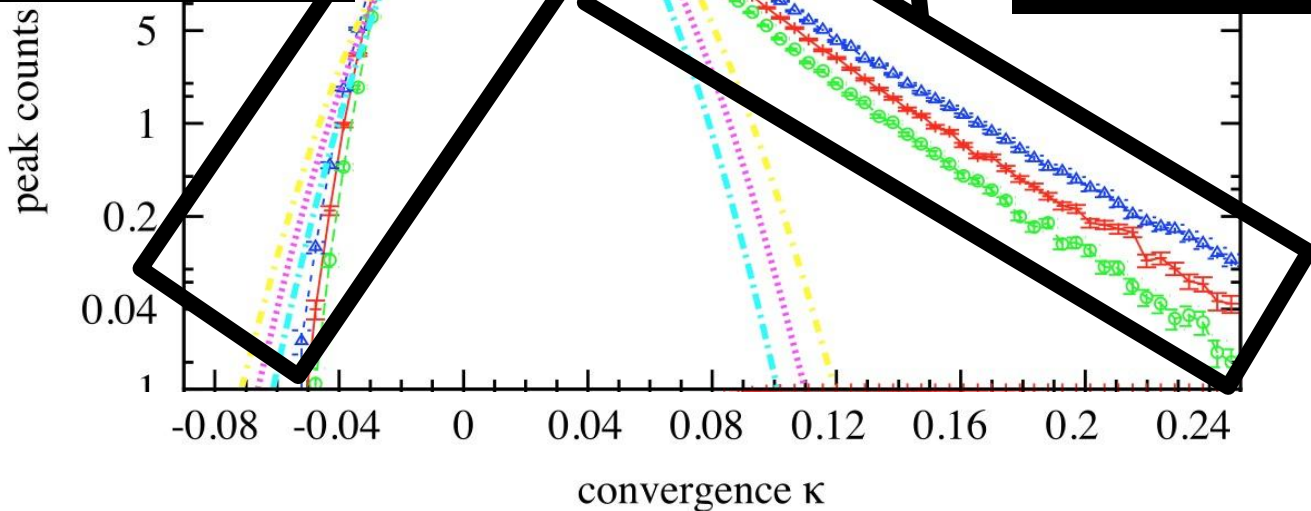
Contain more information than high peaks, but hard to model analytically... (pls do if you feel like to!)

N-body ray-tracing sims
(this work)



High peaks

Predictions using *the halo model* (Fan et al 2010, Shirasaki, Hamana, & Yoshida 2015), *stochastic halo* -> *peak sims* (Lin & Kilbinger 2015 a & b), *N-body ray-tracing sims* (this work).



CFHTLenS fields

$154 \text{ deg}^2, i_{AB} \leq 24.5$

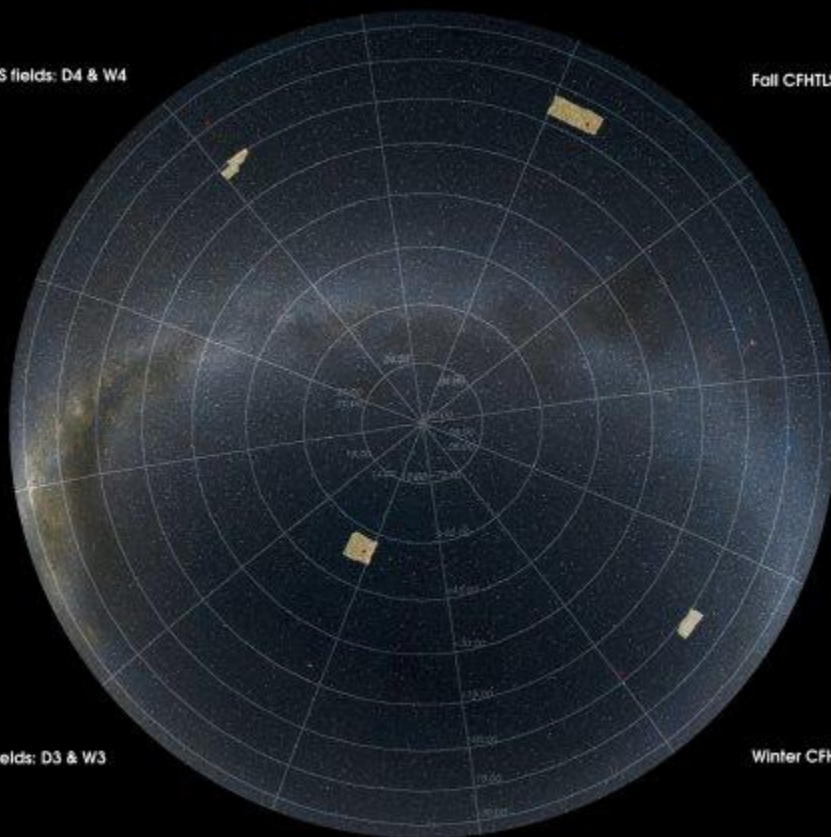
6 million galaxies

$z_{\text{mean}} = 0.37$

$n_{\text{gal}} = 10 \text{ galaxies / arcmin}^2$

Summer CFHTLS fields: D4 & W4

Fall CFHTLS fields: D1 & W1



Spring CFHTLS fields: D3 & W3

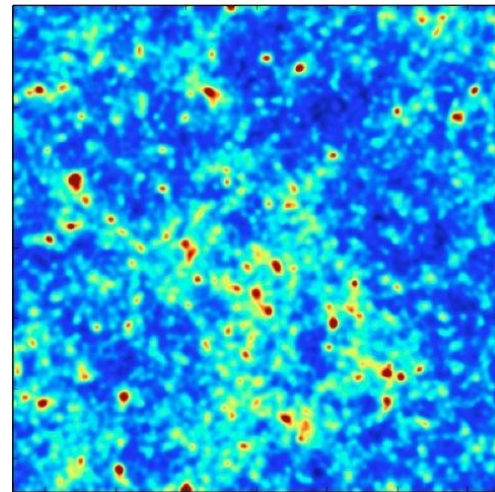
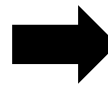
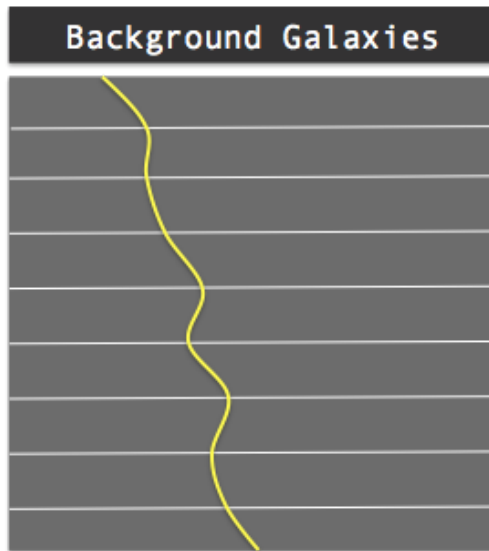
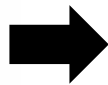
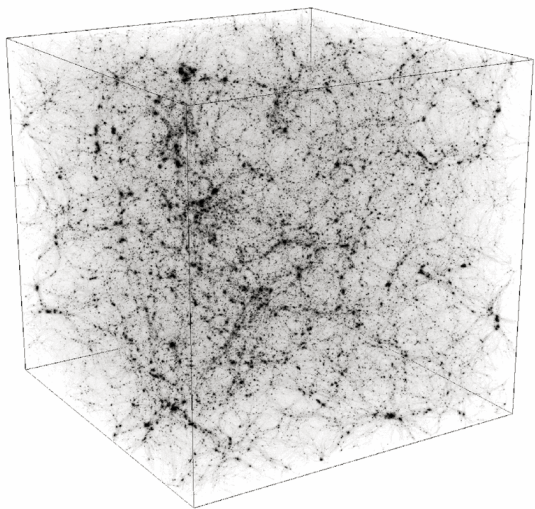
Winter CFHTLS fields: D2 & W2

CFHTLS fields across the northern sky

• Deep ■ Wide

CFHTLS Collaboration

N-body & Ray-tracing Simulations

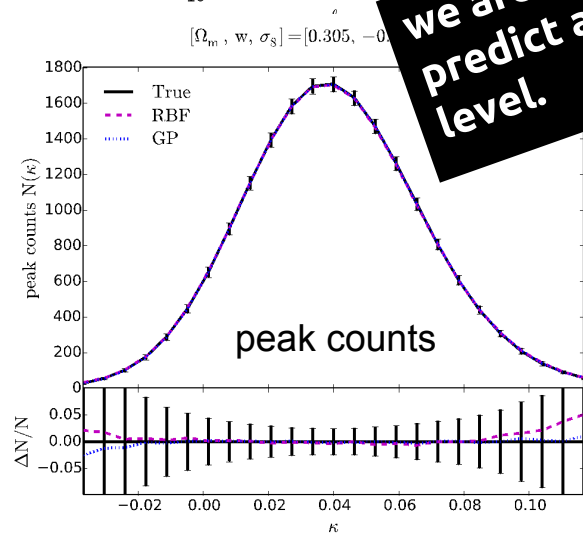
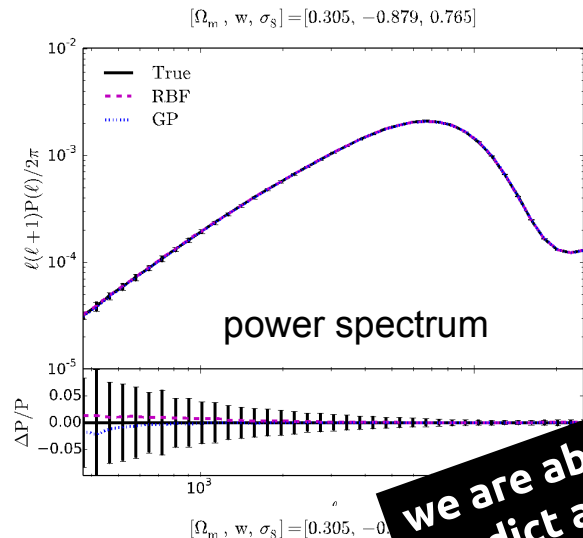
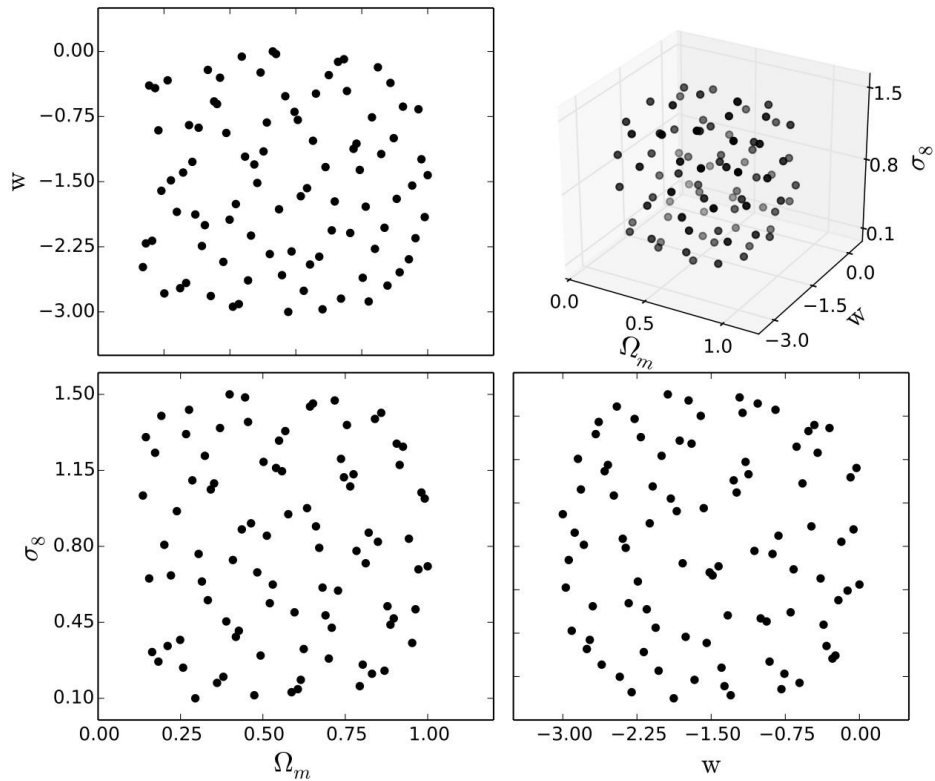


(1) N-body sims (Gadget):
91 cosmological models

(2) Ray-tracing to each
of the 6 million galaxies

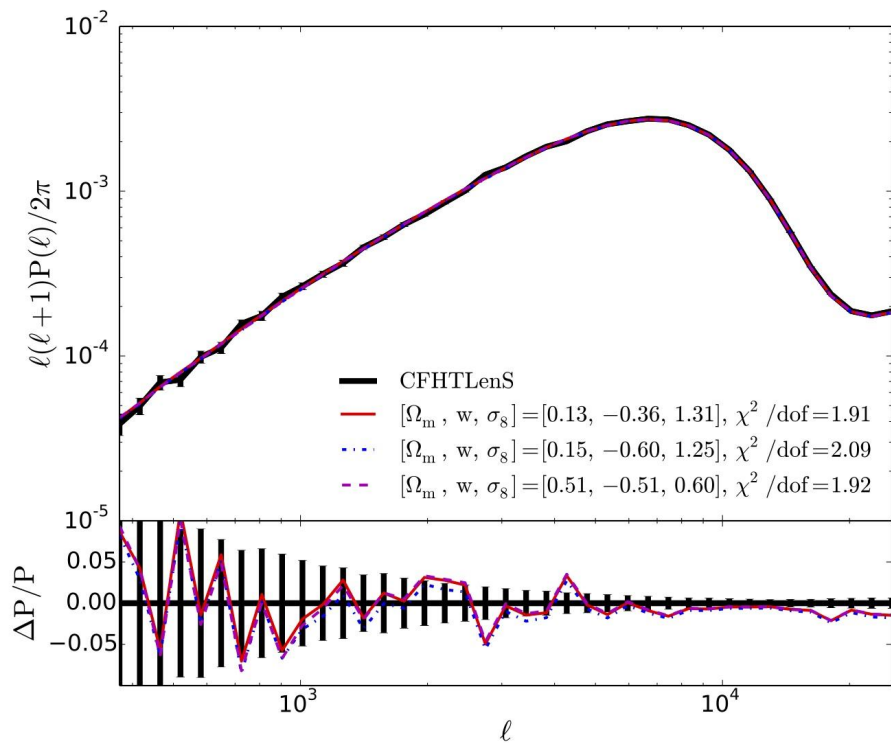
(3) Convergence maps
(1000 realizations/model)

The Emulator

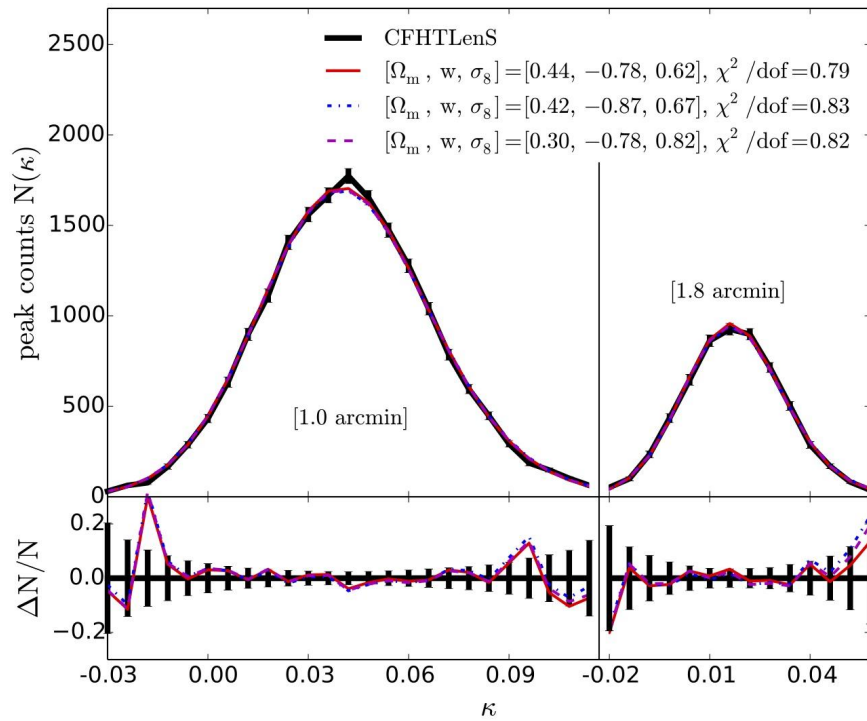


We are able to predict at 1-5% level.

Power Spectrum



Peak Counts



Result #1

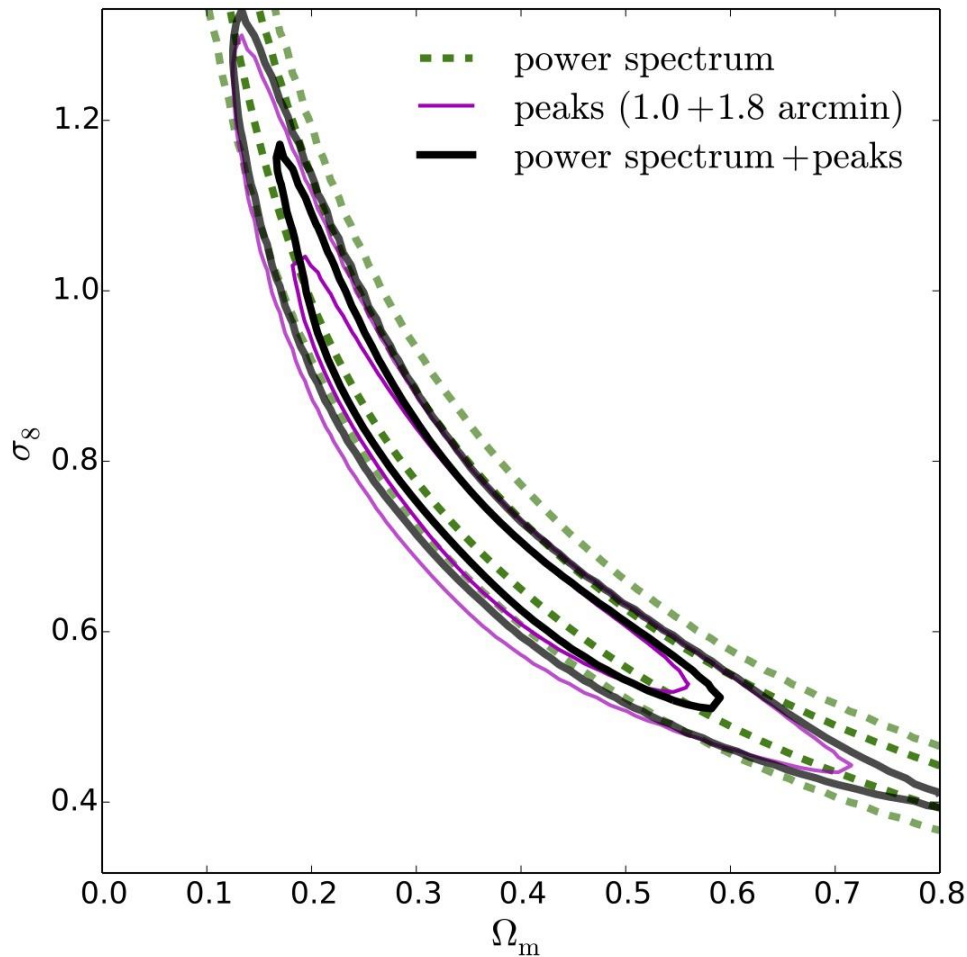
(1) Adding peak counts improves the constraints by a factor of ~ 2 .

(2) Useful for systematics calibration.

Contour Sizes

	$w-\Omega_m$		$\Omega_m-\sigma_8$	
	68%	95%	68%	95%
power spectrum	1.00	1.74	1.00	1.99
peak counts	0.41	1.01	0.59	1.51
combined	0.42	1.05	0.61	1.46

JL et al 2015

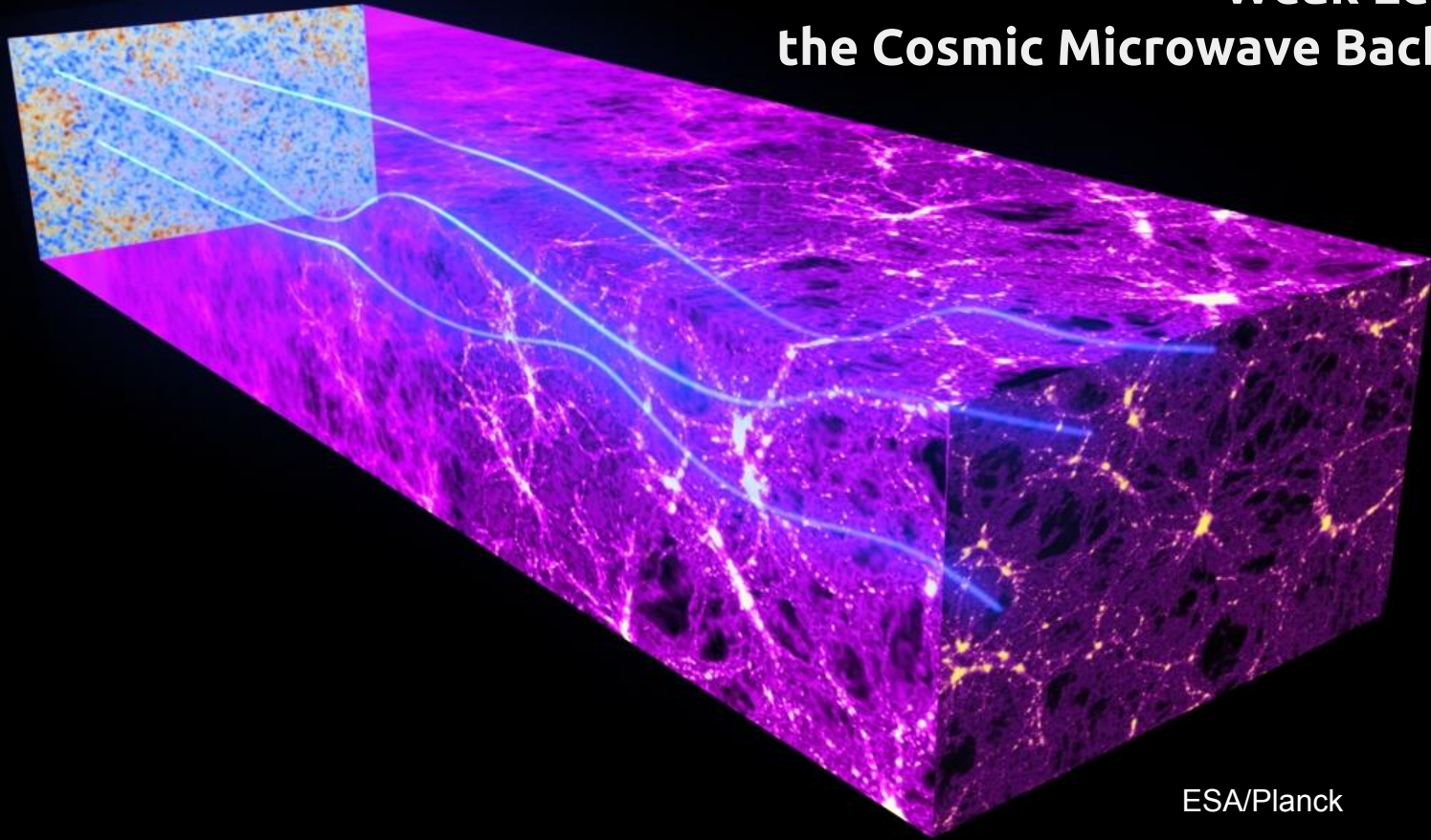


Outline

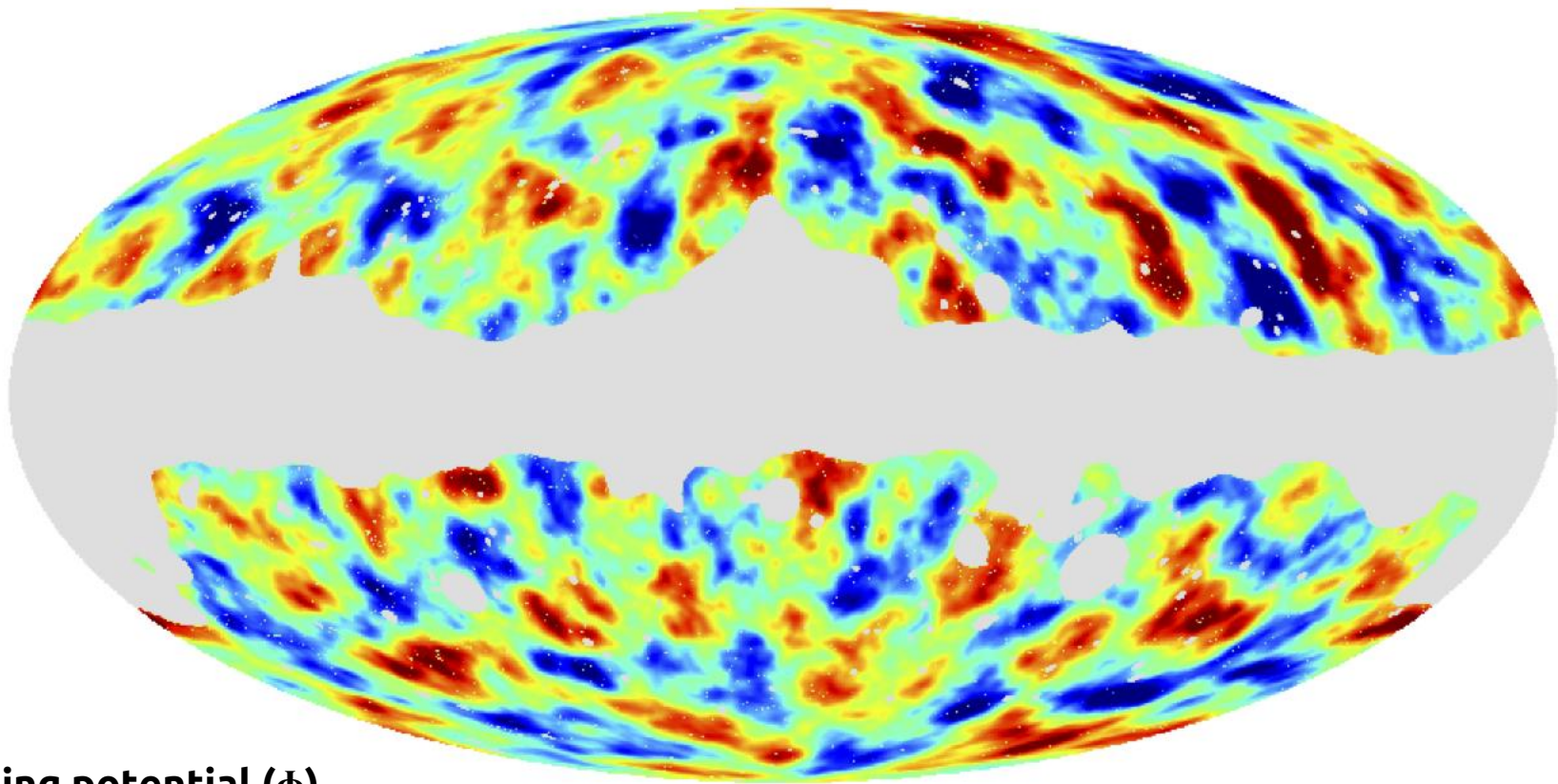
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Weak Lensing of the Cosmic Microwave Background



ESA/Planck



CMB lensing potential (ϕ)

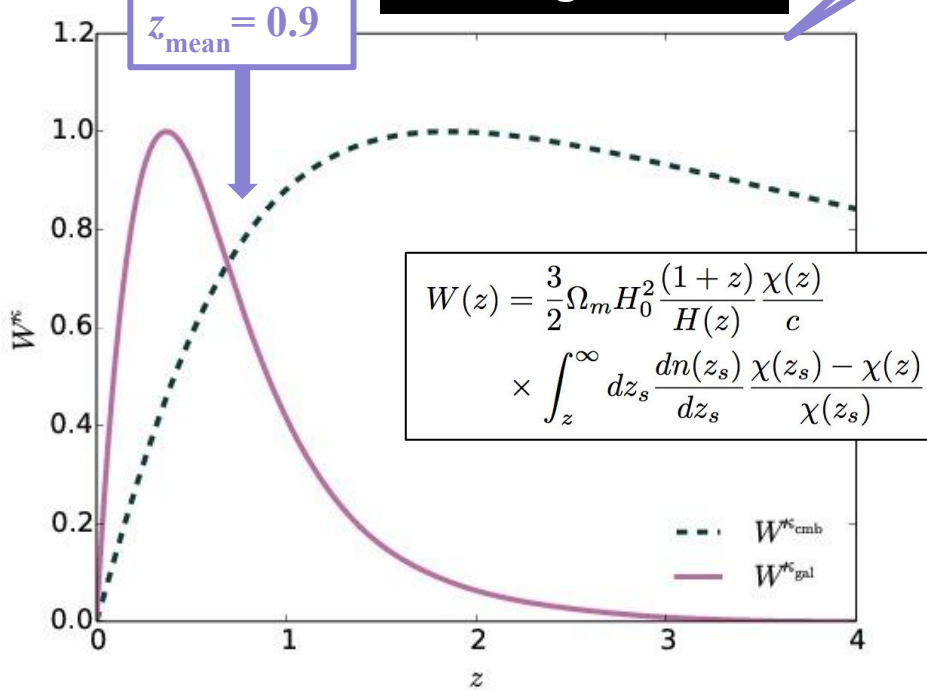
Planck 2015 XV

-4e-05

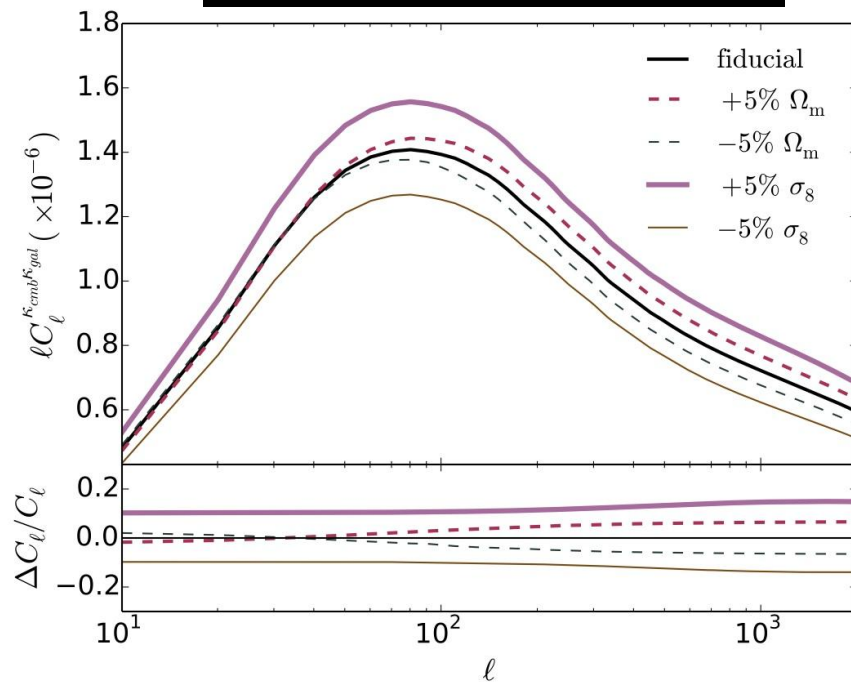
4e-05

$$C_\ell^{\kappa_{\text{cmb}}\kappa_{\text{gal}}} = \int_0^\infty \frac{dz}{c} \frac{H(z)}{\chi(z)^2} W^{\kappa_{\text{cmb}}}(z) W^{\kappa_{\text{gal}}}(z) P(k, z)$$

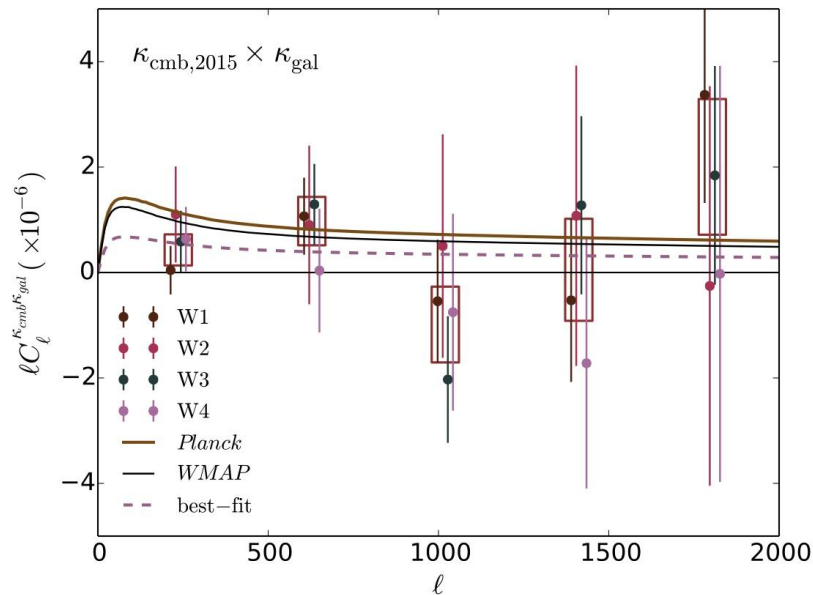
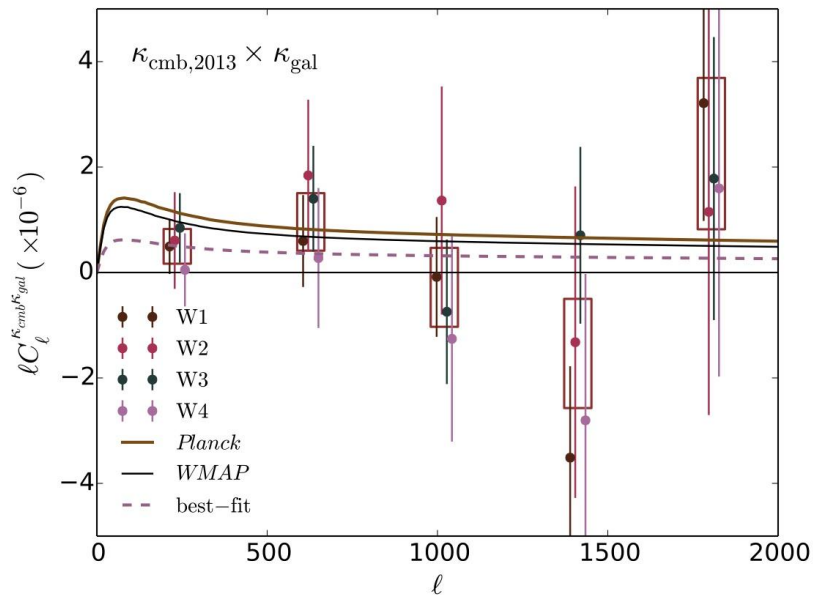
Lensing Kernels



Cosmology Dependence



Result #2: 2σ Tension with Λ CDM

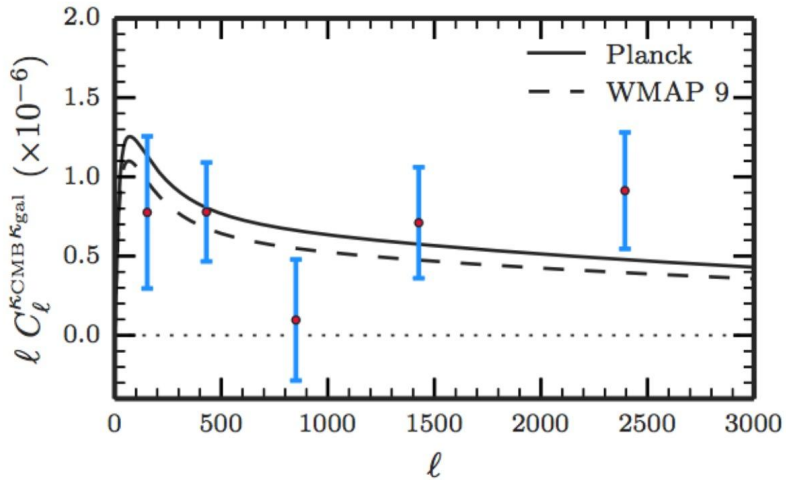


$$\text{SNR} = \text{sqrt}(\chi^2_{\text{null}} - \chi^2_{\text{model}})$$

$$\text{SNR}_{\text{predict}} = 4.6, \text{SNR}_{\text{data}} = 2.0$$

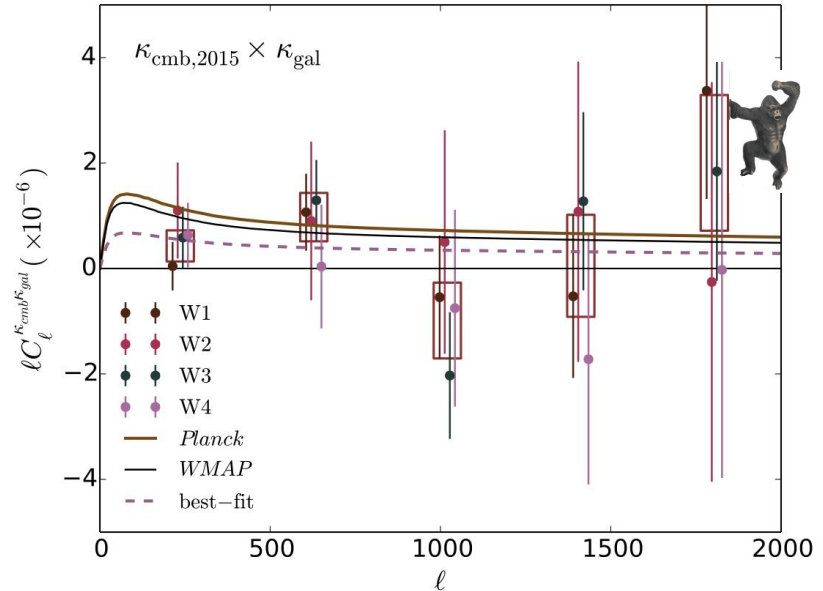
	A (Planck parameters)	A (WMAP parameters)
2013	0.48 ± 0.26	0.56 ± 0.30
2015	0.44 ± 0.22	0.52 ± 0.26

Result #2: 2σ Tension with Λ CDM



Hand et al 2015 (*CS82* x *ACT*)

$$A_{\text{Planck}} = 0.78 \pm 0.18$$



JL & Hill 2015 (*CFHTLenS* x *Planck15*)

$$A_{\text{Planck}} = 0.44 \pm 0.22$$

Sources of the 50% Suppression ?

Photo z (10%)

Intrinsic Alignments (10-15%)

Masking of tSZ Clusters (5-10%)

Multiplicative Bias (?)

Modified Gravity ??

$$\sigma_8(\Omega_m/0.27)^{0.46}$$

<i>This Work</i>	$0.63^{+0.14}_{-0.19}$
<i>CFHTLenS</i>	0.77 ± 0.04
<i>Planck TT</i>	0.89 ± 0.03

Conclusions

- **Peak Counts (1412.0757)**: when combined with the power spectrum, can tighten cosmological constraint by a factor of ~ 2 .
- **Planck CMB lensing & CFHTLenS galaxy lensing cross-correlation (1503.06214)**: 2σ detection, at 2σ tension with Λ CDM. Theoretical uncertainties and/or systematic errors are at play.

