
EXIT


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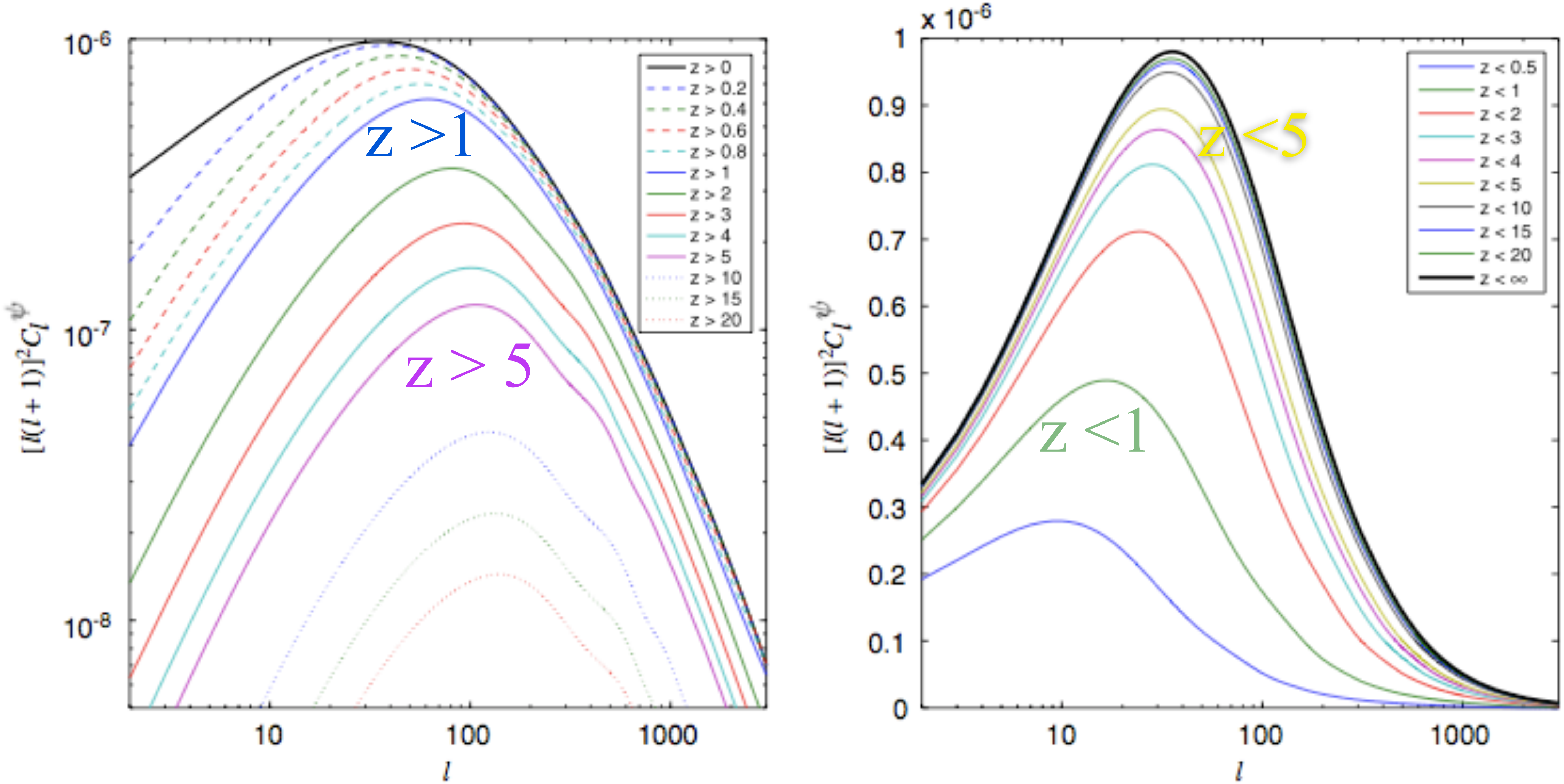
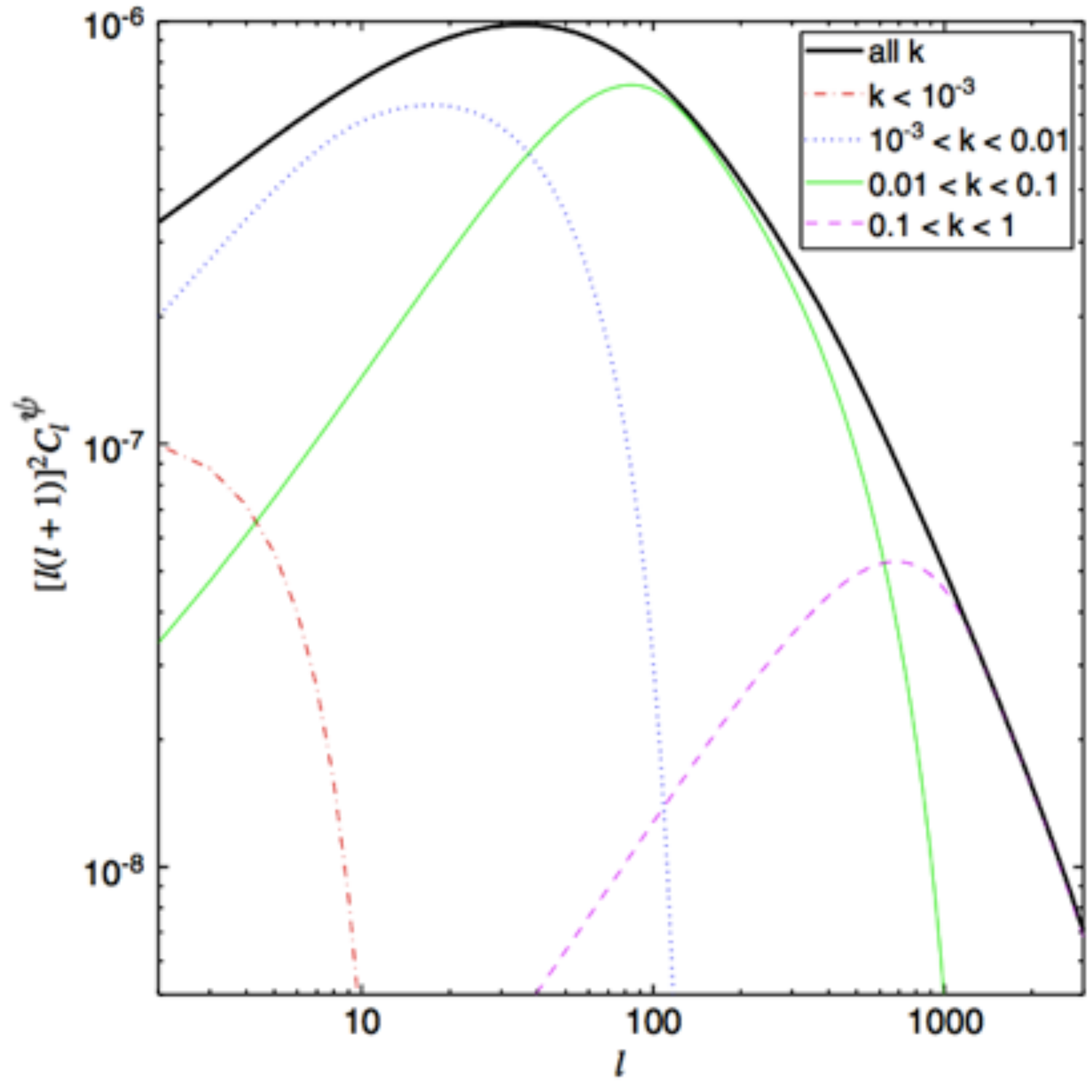
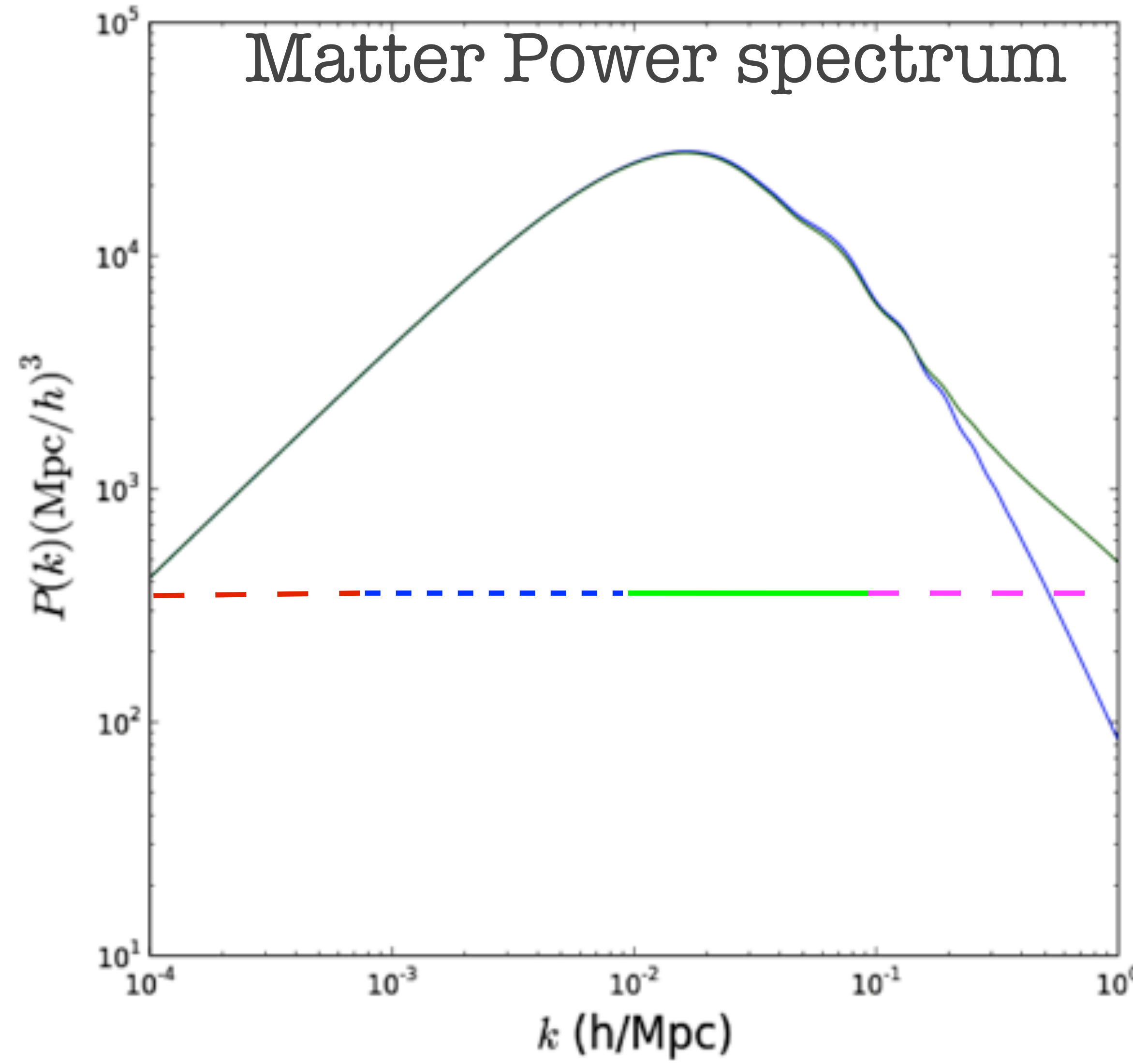
Which redshifts contribute most?



The deflection field receives contribution from a wide range of redshifts: 0.5<z<5.

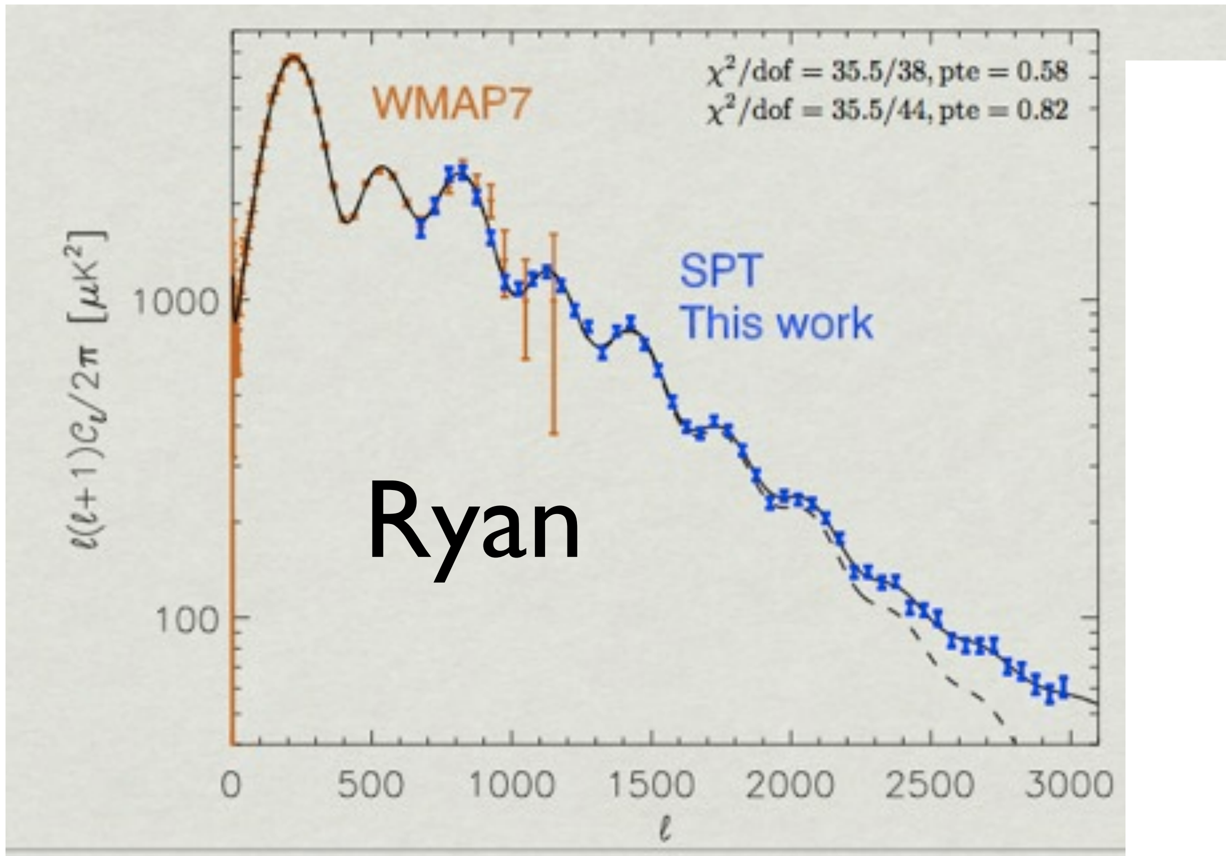
Which scales contribute the most?

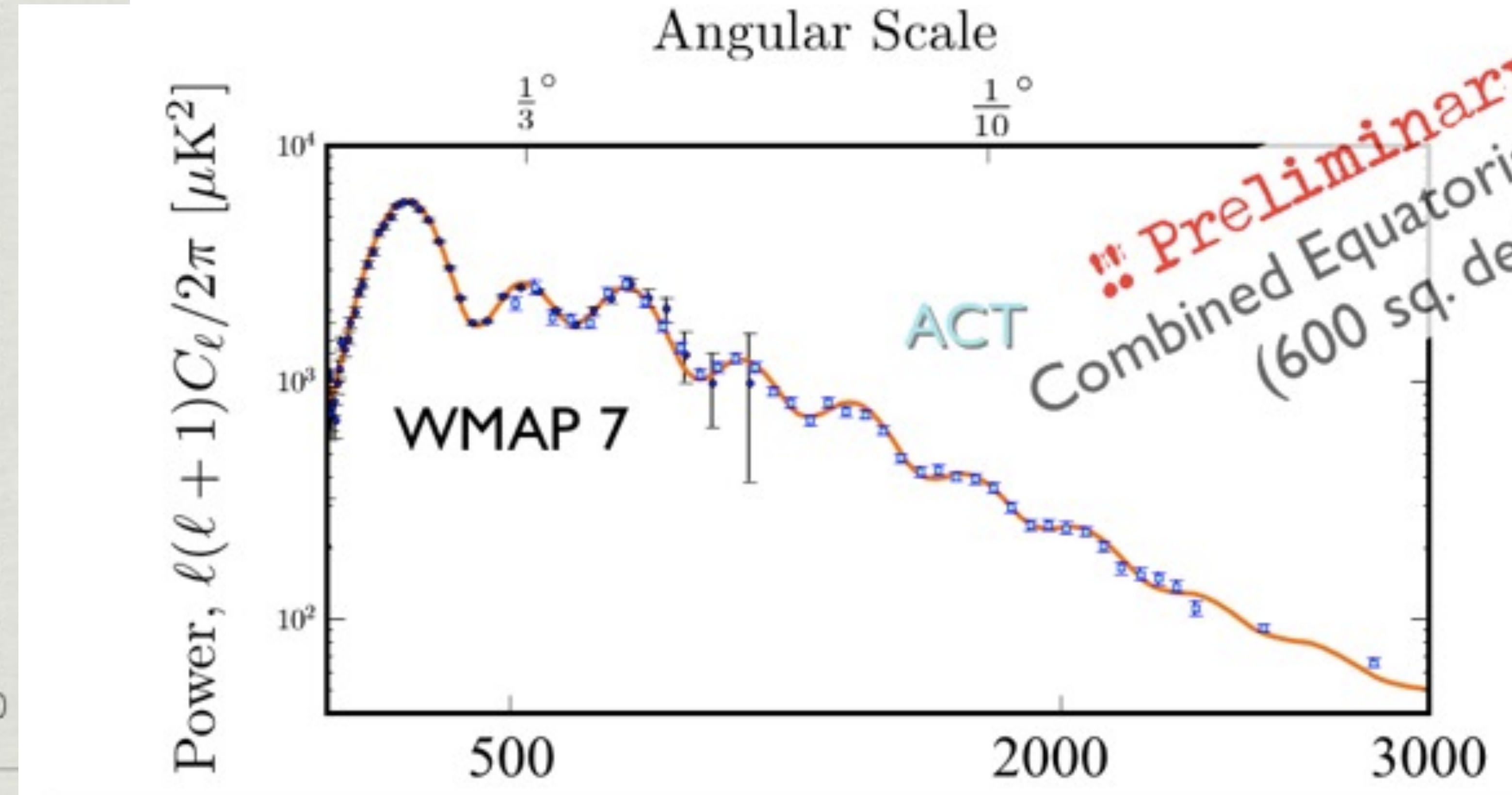


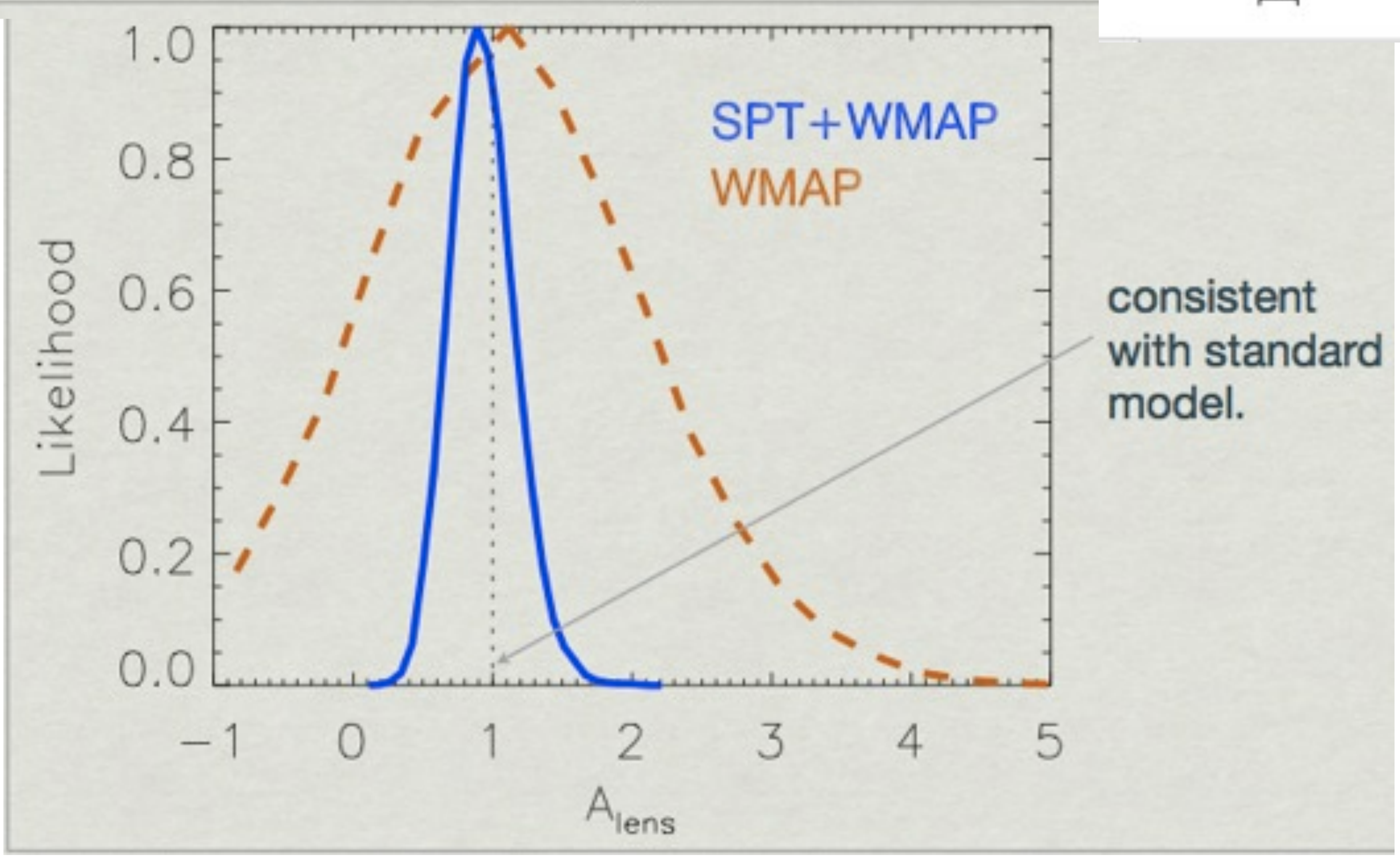


Most contribution comes from linear and quasi-linear scales in the matter power spectrum.

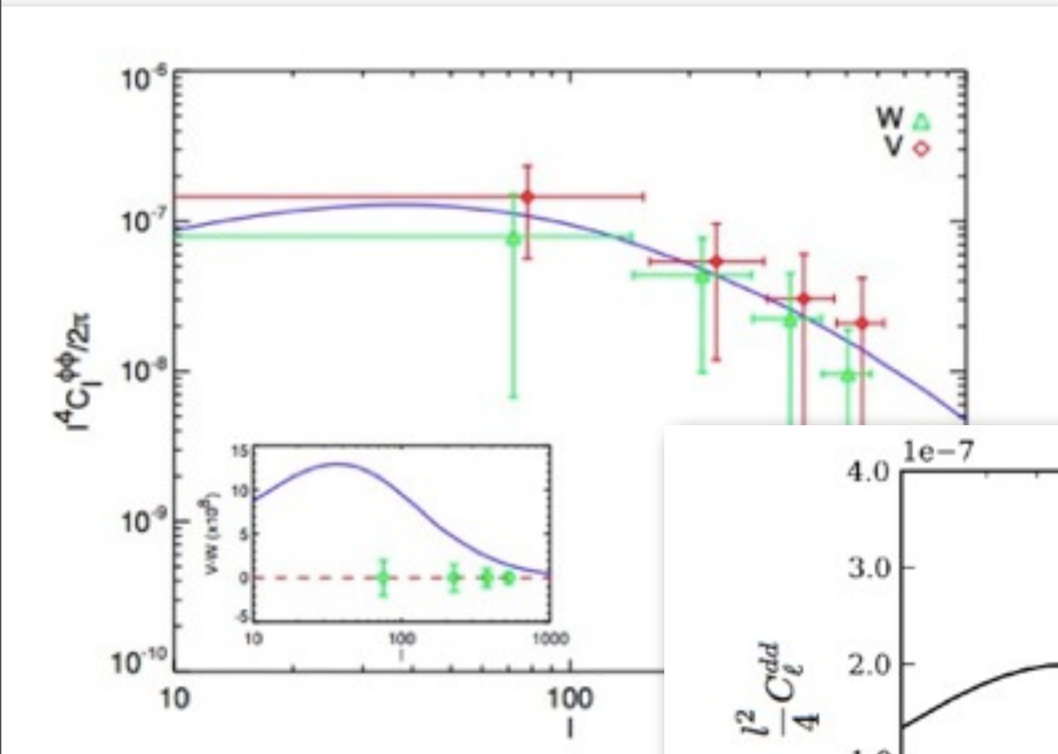
Clearly see lensing in smearing now



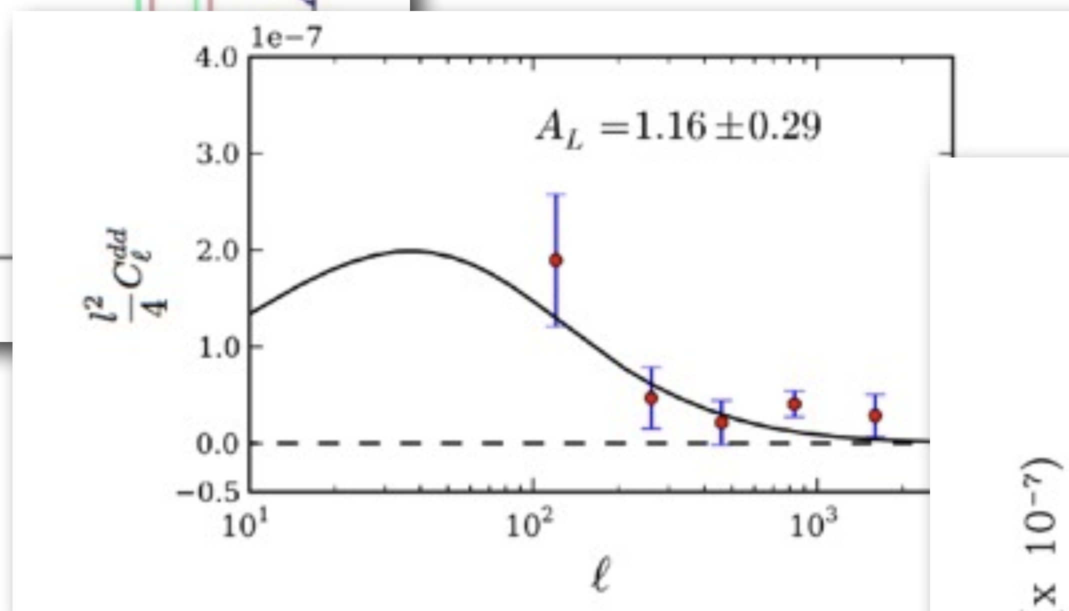




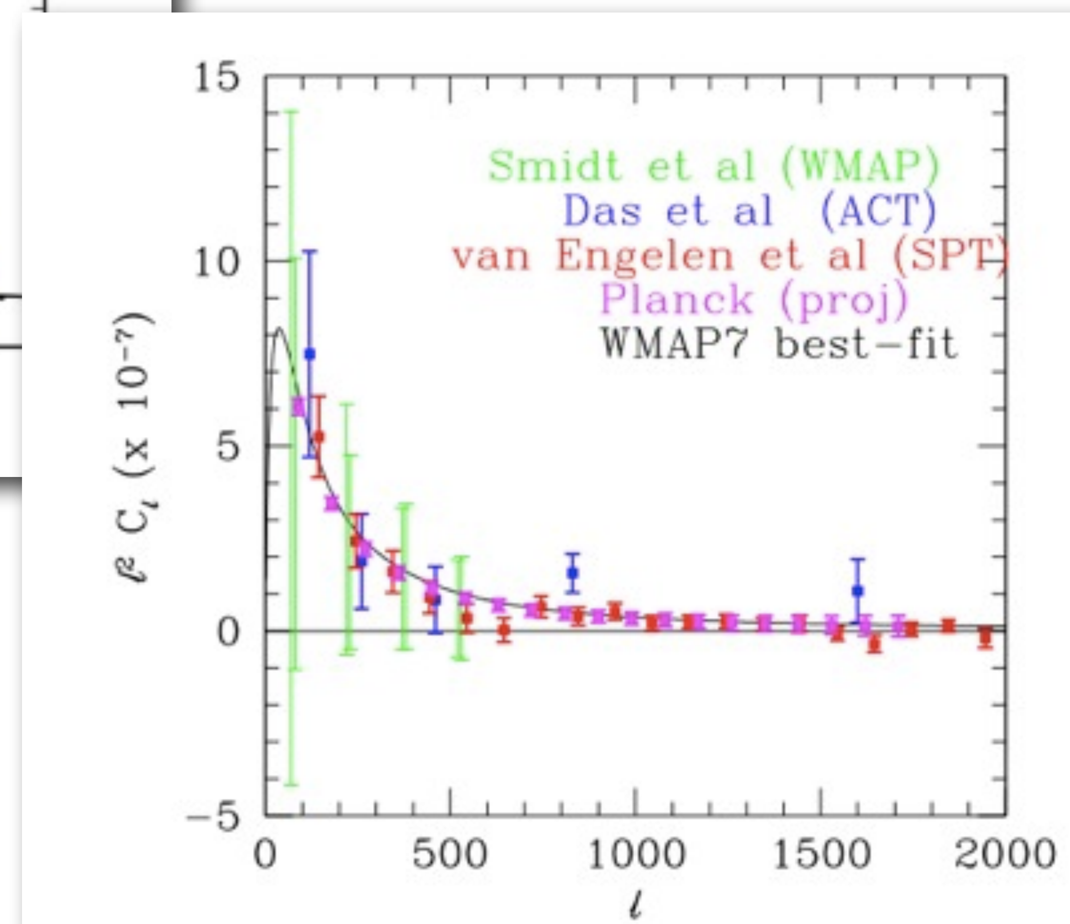
First Internal Measurements are coming in...



Joe

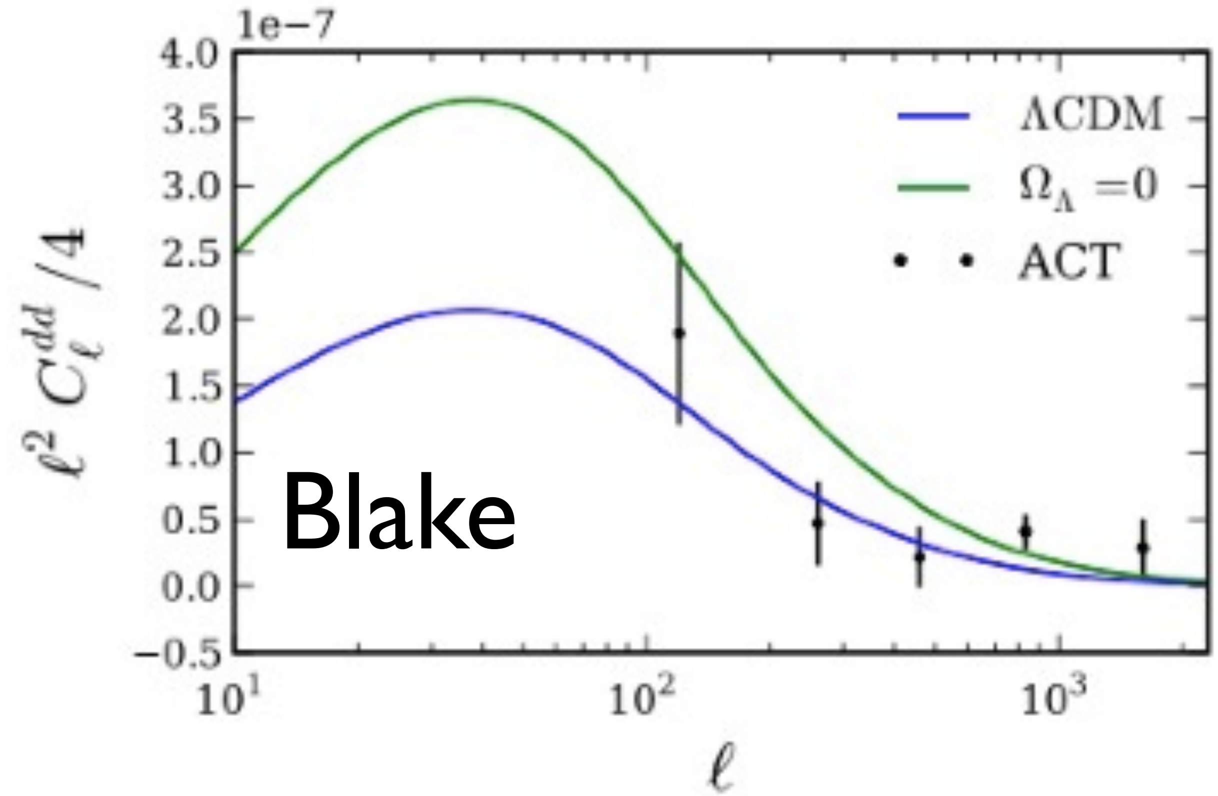


Blake



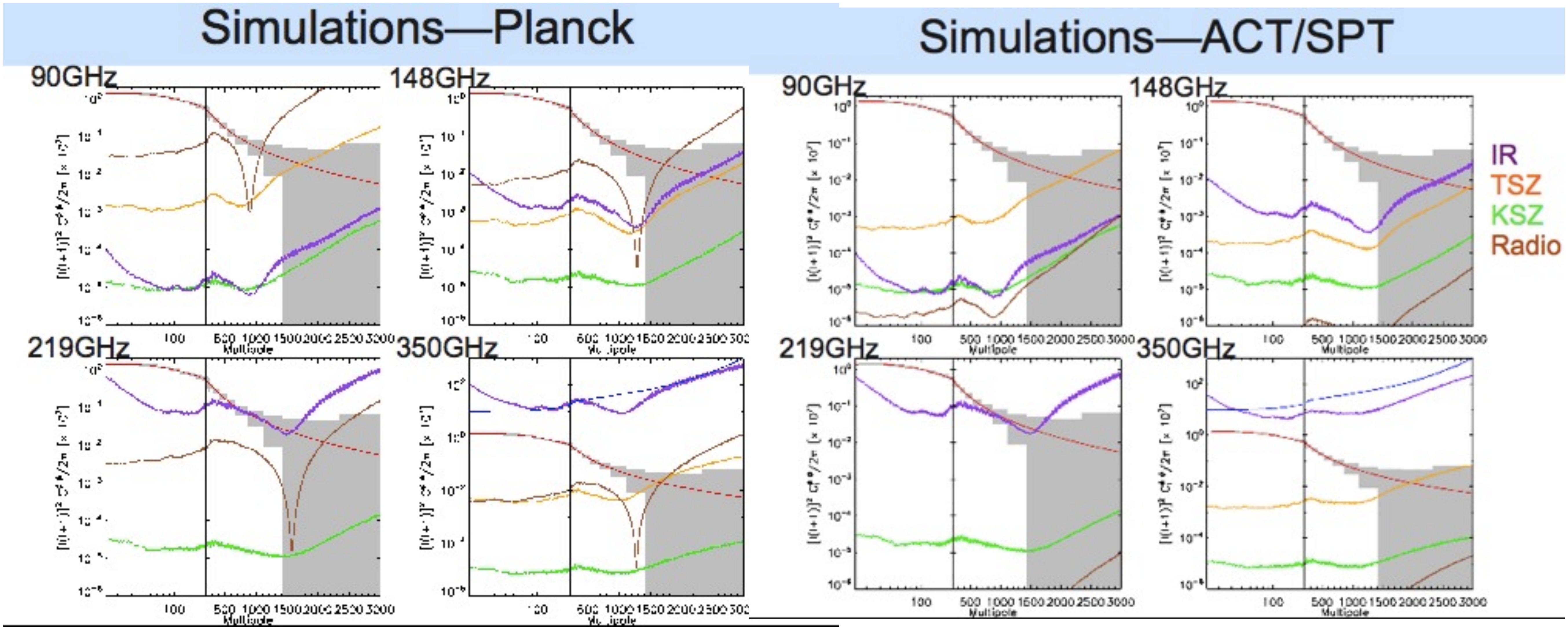
Alex

First Applications .... Lambda from CMB alone



[Sherwin, Dunkley, Das et al. in prep.]

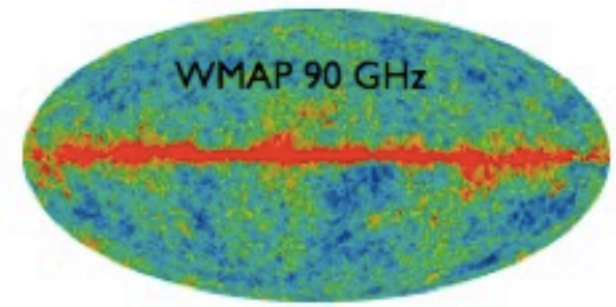
Astrophysical Foregrounds



Stephen

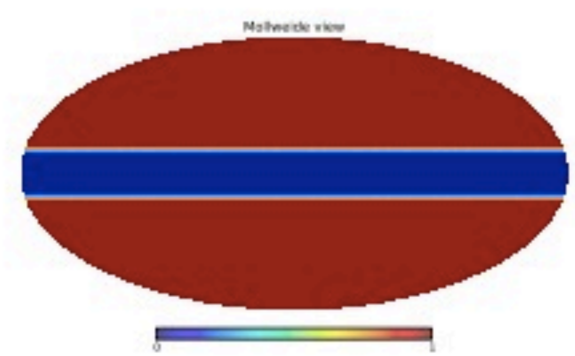
Galactic Foregrounds

Complications

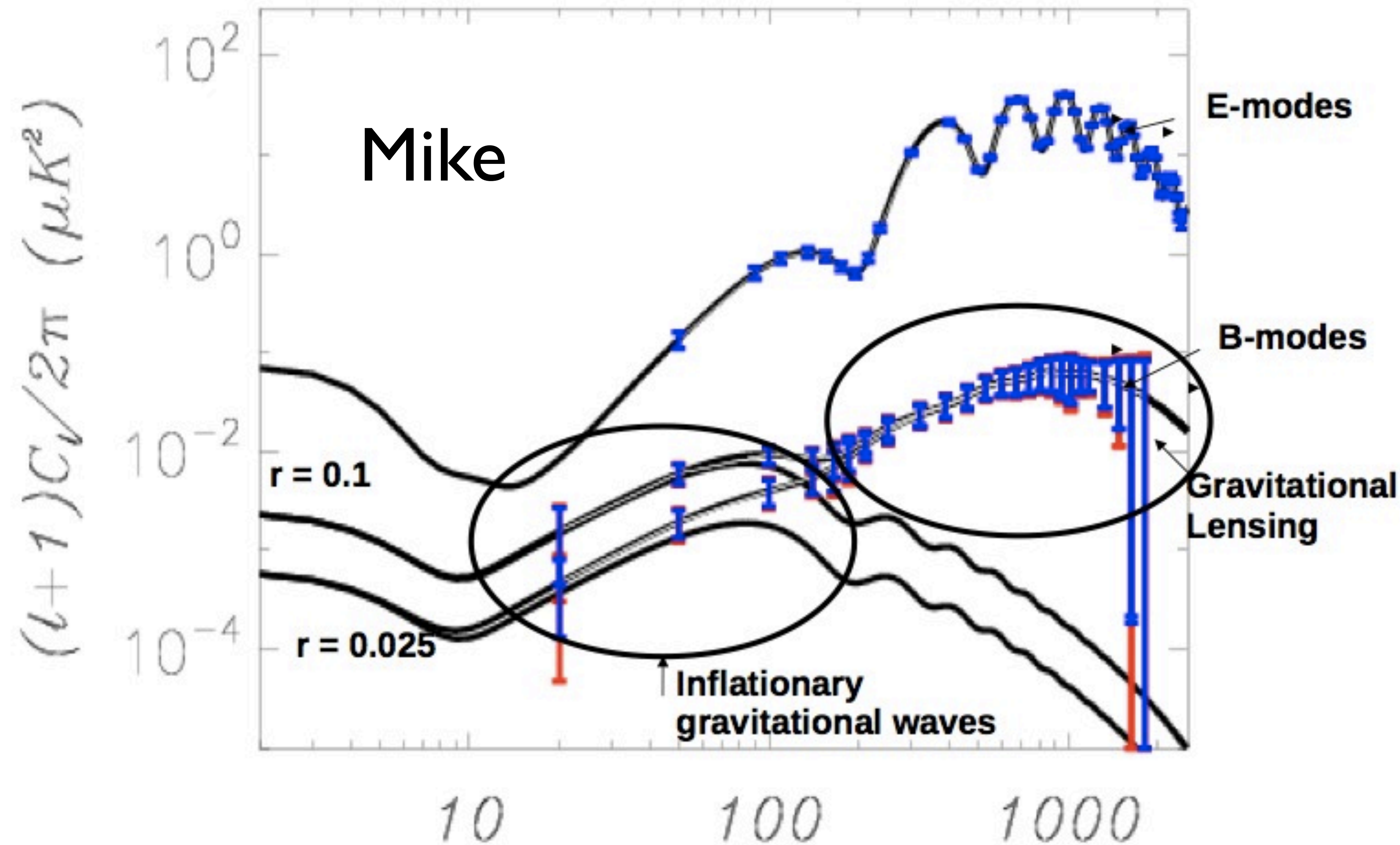


- ✓ Galaxy
  - Component separation will help but residuals expected
  - Masking large regions of the sky is necessary
- ✓ How to handle galactic mask ?
  - Analytically ?
  - Inverse covariance weighting is difficult
    - Planck resolution
    - Low noise, large dynamic
  - Inpainting technics hard to control
- ✓ We want a simple, robust and linear pipeline
  - Apodized galactic cut

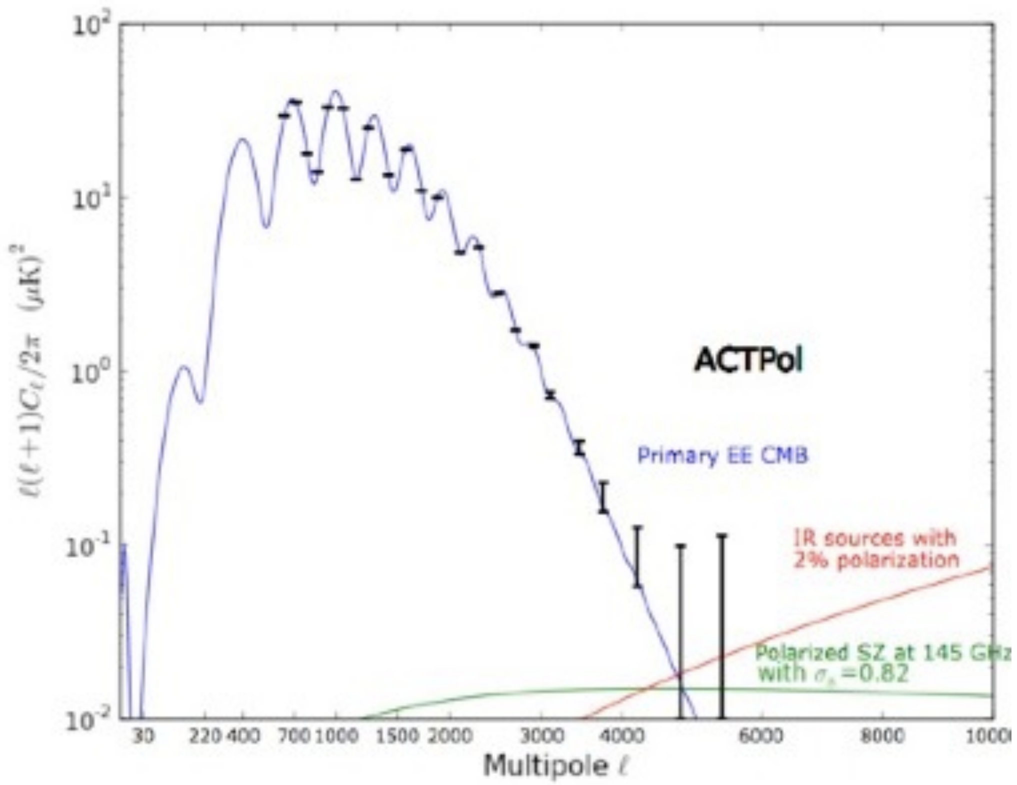
Aurelien+Typhaine



POLARBEAR-I Expected Polarization Power Spectra

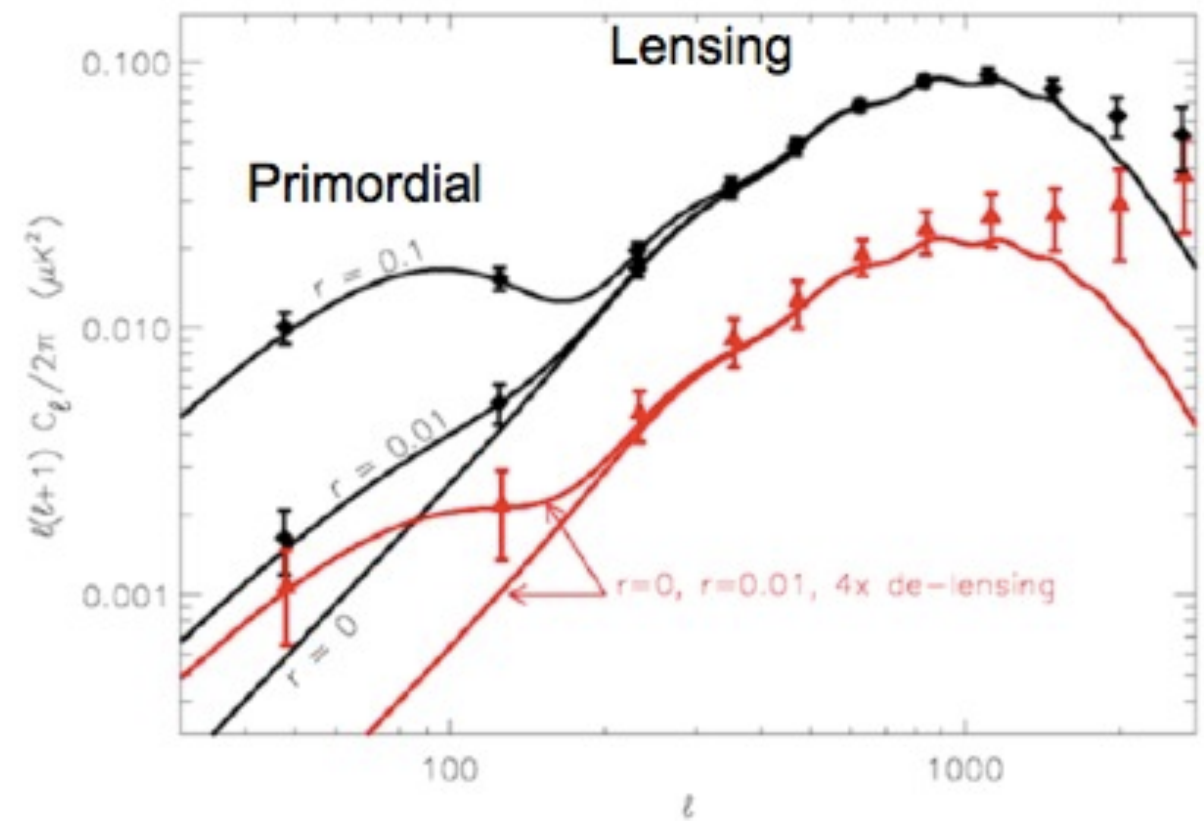


ACTPol E-mode Projection



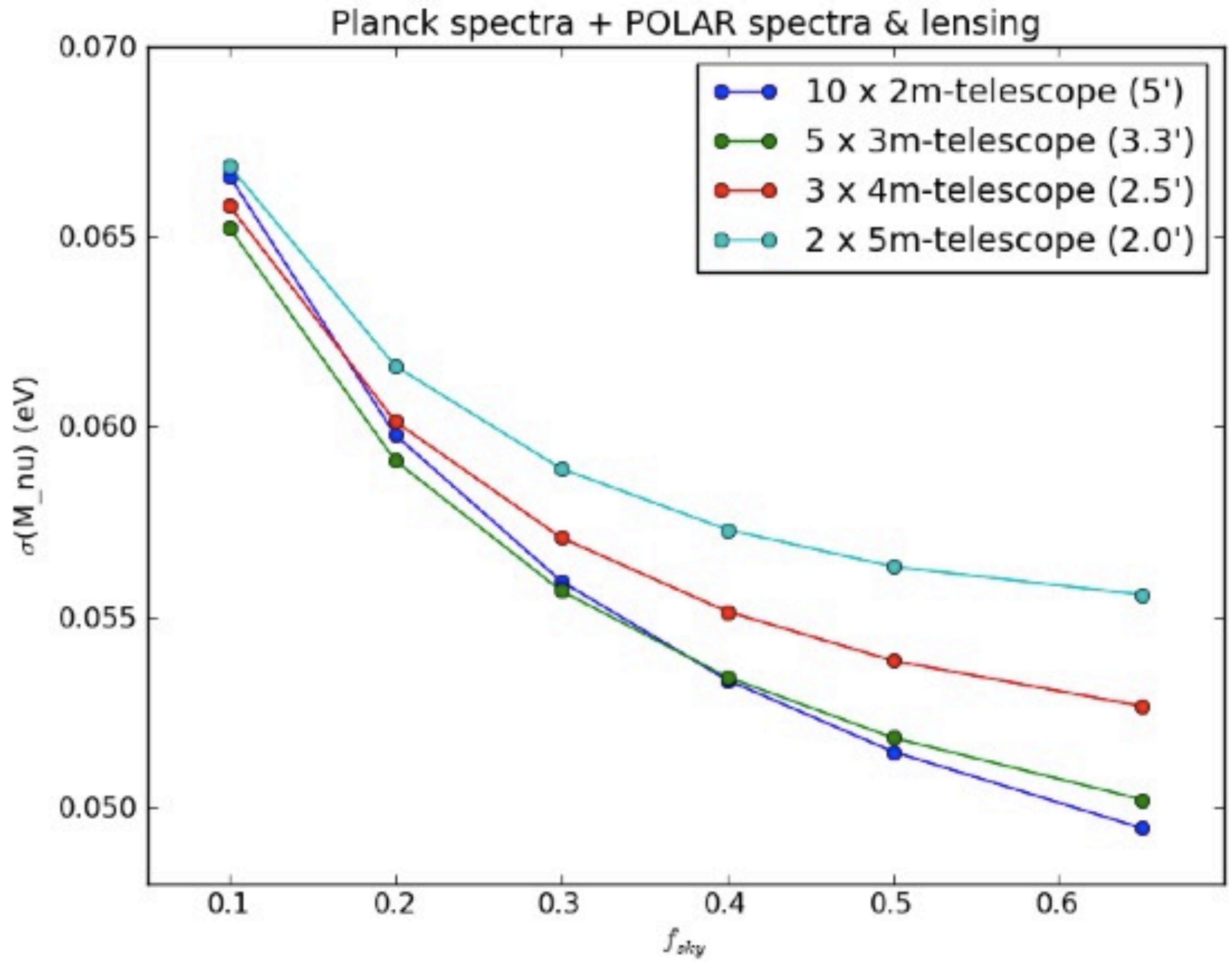
(Niemack et al., SPIE 201

SPTPol B-mode Projection



Kimmy

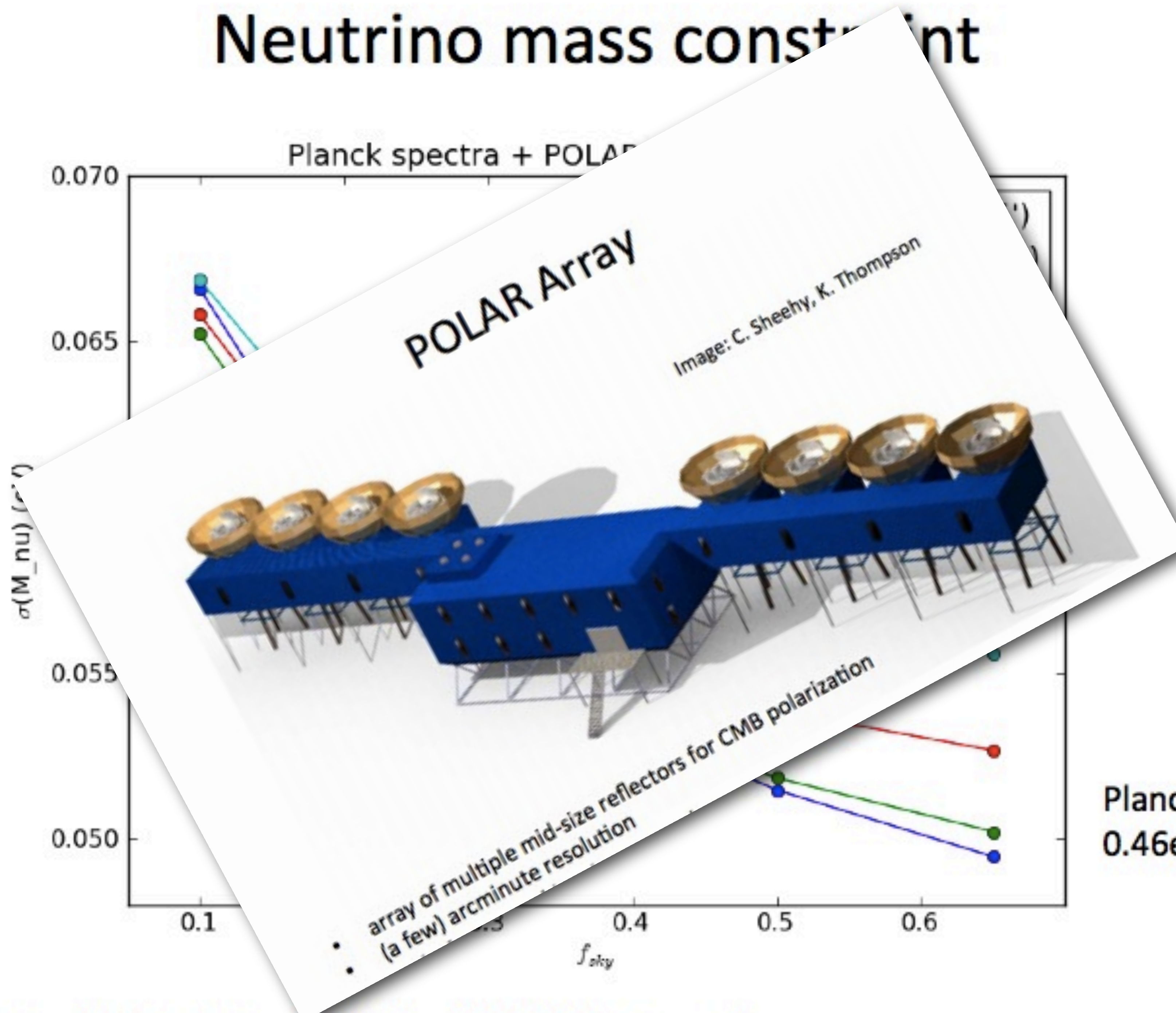
Neutrino mass constraint



Planck constraints:
0.46eV (no lensing)

Parameter space: $\Omega_b h^2, \Omega_{cdm} h^2, \Omega_\nu h^2, H, A_s, n_s, \tau, Y_{He}$

Kimmy



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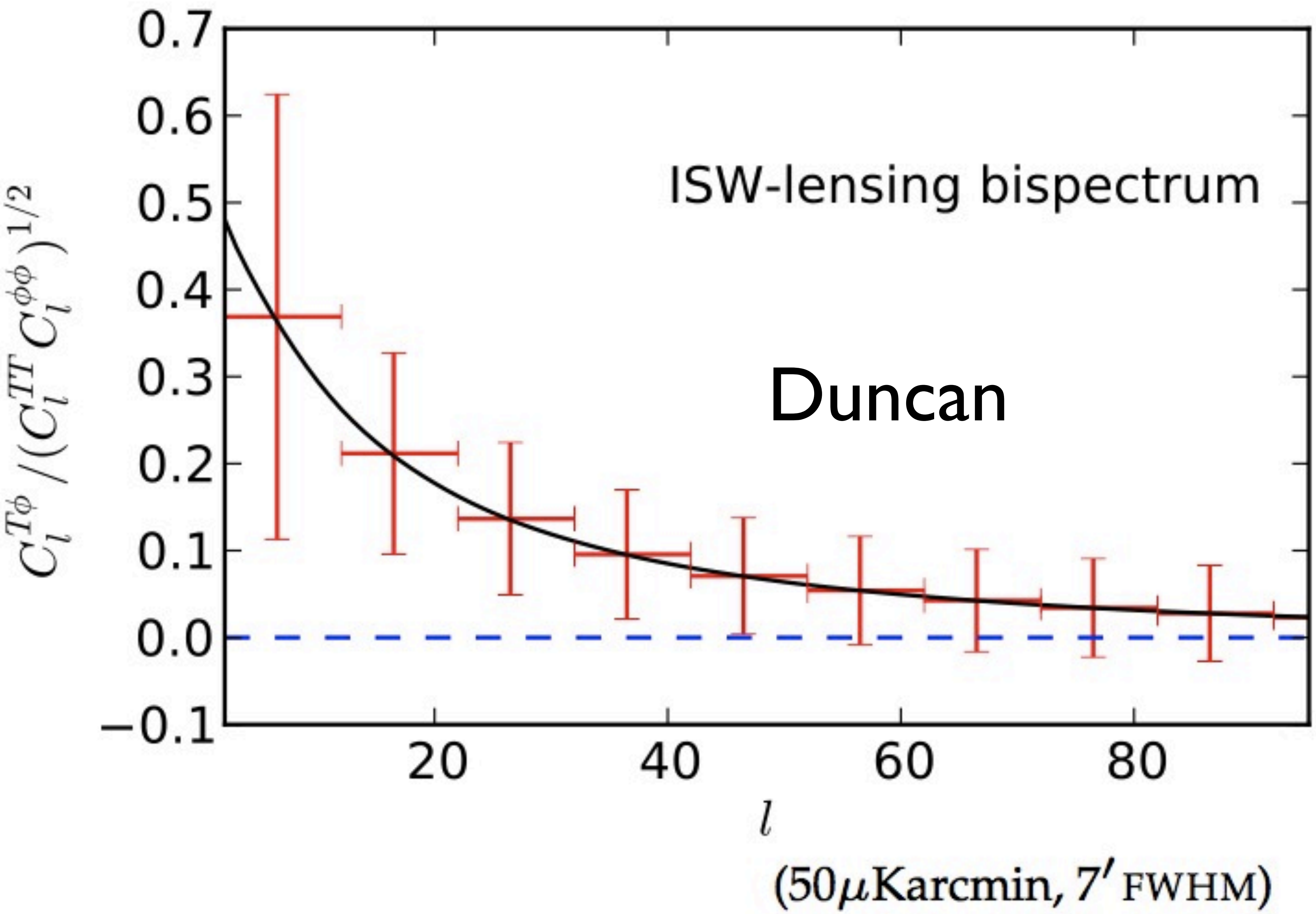
Tinier but exciting signals ..
also E-\phi.



Massively Scalable Simulations

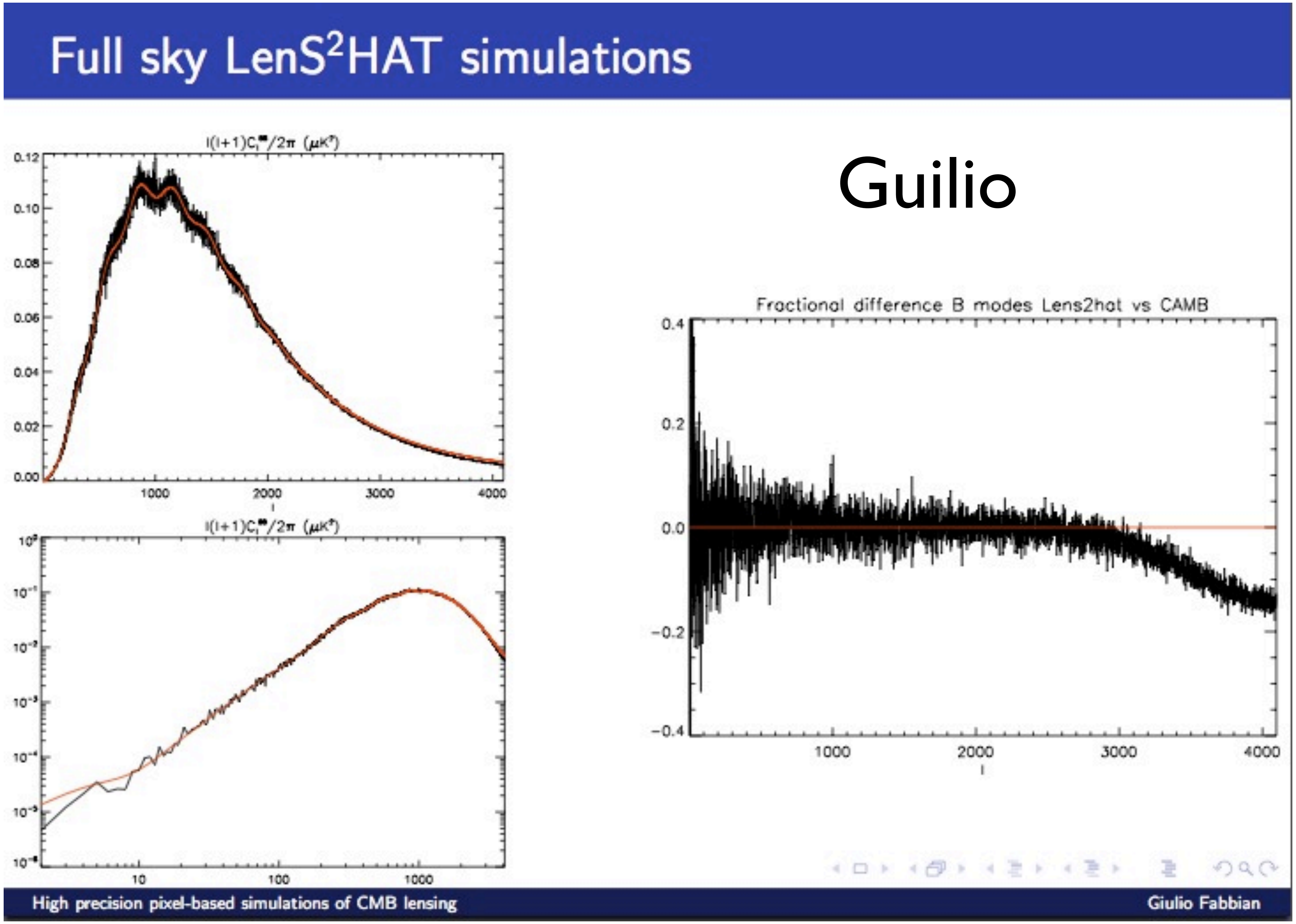
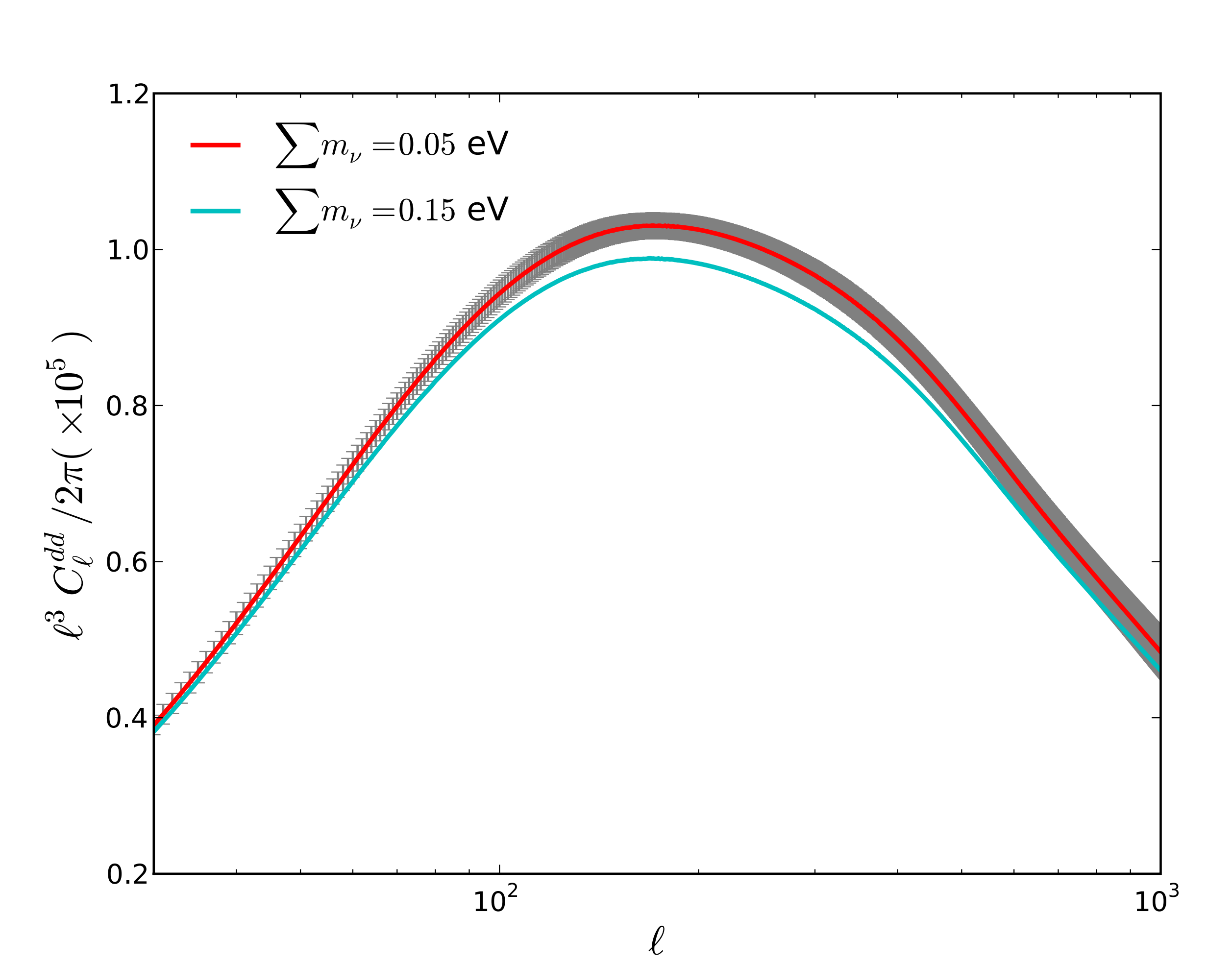


Table 1.

	Planck	Planck+PolarBear$_{1000}$	PolarBear$_{16000}$	Planck+PolarBear$_{16000}$
$\Omega_b h^2$	0.000209	0.000178	9.2×10^{-5}	8.3×10^{-5}
$\Omega_m h^2$	0.00231	0.00202	0.00144	0.00115
n_s	0.00689	0.00596	0.00403	0.0032
$\sum m_\nu$	0.121	0.099	0.0616	0.0502
τ	0.00438	0.00415	0.00343	0.00268
Y_p	0.00997	0.00794	0.00397	0.00352

$\hat{\mathrm{d}} \times \hat{\mathrm{d}}$



Galaxy Bias

$\hat{\mathrm{d}} \times$ galaxies

Large Scale Structure (LSS) surveys measure autocorrelations of galaxies.

From this, we try to infer the correlations among dark matter halos.

Such inferences are limited by our lack of understanding of bias - or how luminous matter traces dark matter.

If we cross-correlate the reconstructed deflection field with the galaxy number counts, we go one step closer to the truth by directly measuring the galaxy-dark matter correlation.

CMB lensing is particularly relevant for high z objects, behind which there are no galaxies to be lensed!

Galaxy Bias

$\hat{\mathrm{d}} \times$ galaxies

Great Signal-to-noise!

Galaxy Survey	$\hat{n}$	$A/10^3$	z_c	b	CMB Expt.	(S/N)	$\Delta b/b(\%)$
SDSSLRG	12.4	3.8	0.31	2	PLANCK	5.8	17.3
					PACT	11.4	8.8
					IDEAL	20.4	4.9
BOSS1	40.	10	0.3	2	PLANCK	10.8	9.3
					PACT	25.5	3.9
					IDEAL	52.5	1.9
BOSS2	110.	10	0.6	2	PLANCK	17.0	5.9
					PACT	39.4	2.5
					IDEAL	78.2	1.3
ADEPT	3500	27	1.35	1	PLANCK	52.8	1.9
					PACT	107.5	0.9
					IDEAL	228.3	0.4

Acquavivia, Hajian, Spergel and Das, PRD 78, 043514 (2008)

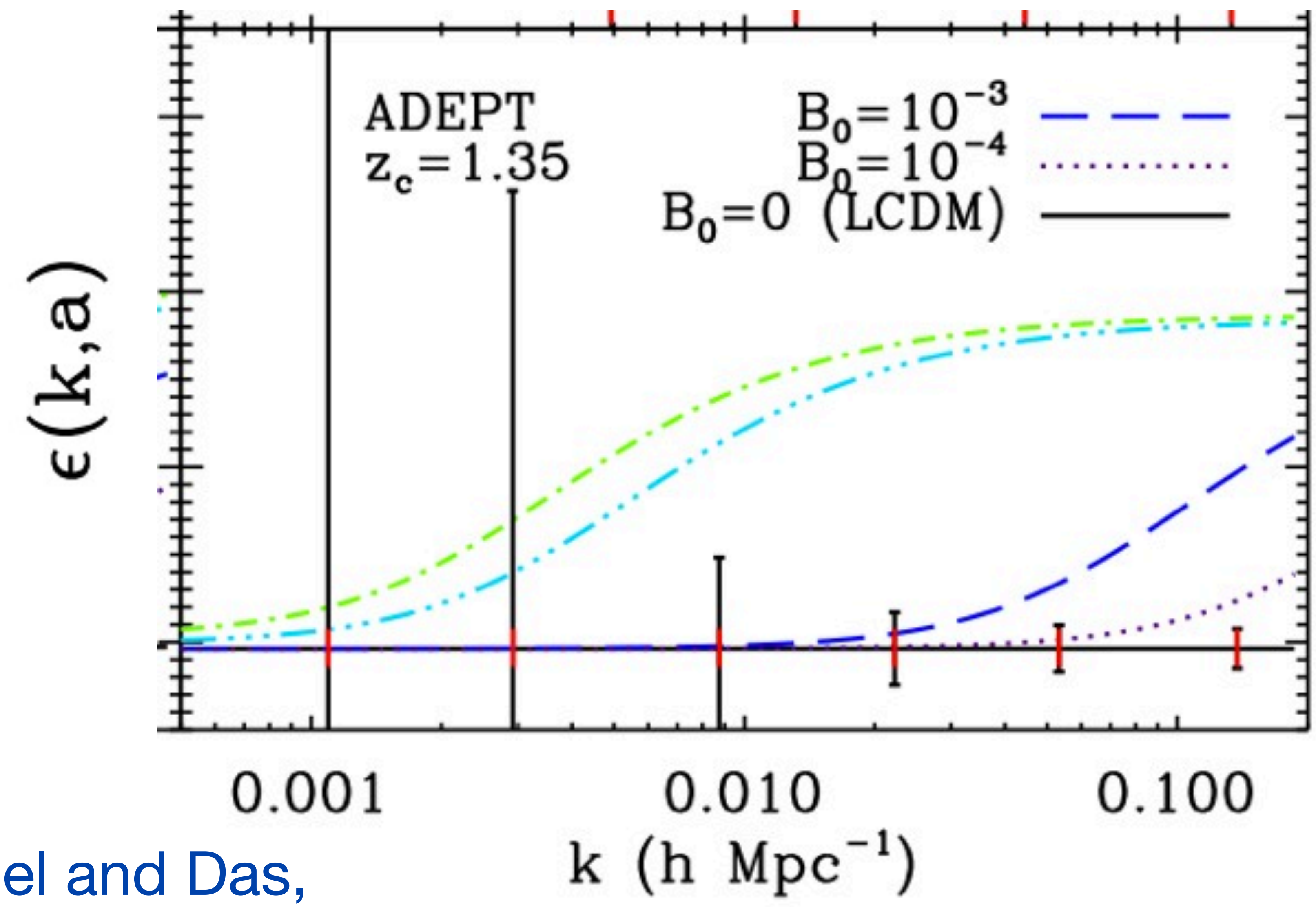
GR Test From Galaxy Bias

$$\epsilon(k,a) = \Omega_m^{-\gamma(a)} \frac{d\ln D}{d\ln a} - 1$$

$\gamma(z) \simeq 0.557 - 0.02z$ is accurate at the 0.3% level

$$P^s(\mathbf{k}) = (1 + \beta\mu_{\mathbf{k}}^2)^2 P(k),$$

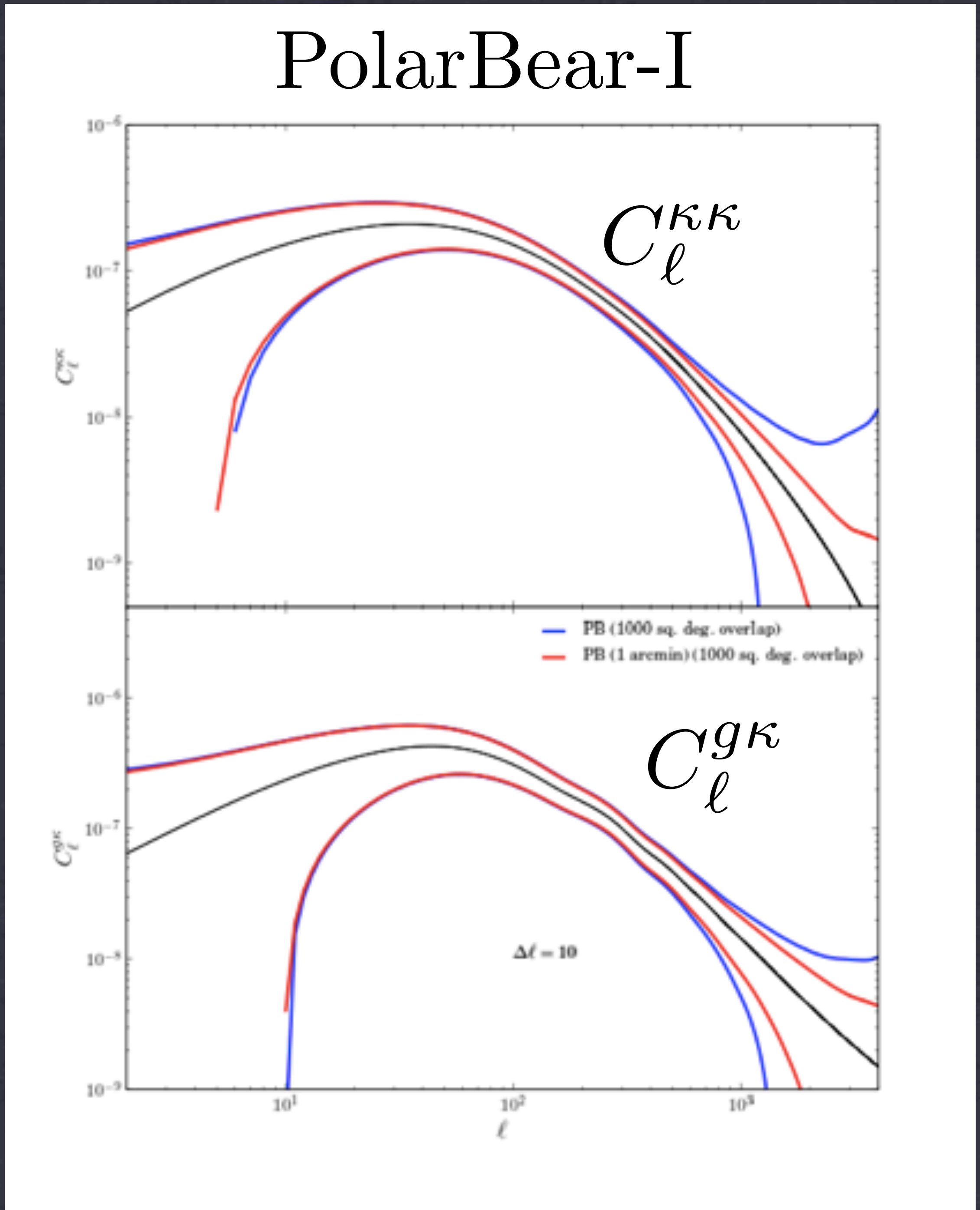
$$\beta(a) = \frac{1}{b}\frac{d\ln D}{d\ln a};$$



Acquavivia, Hajian, Spergel and Das,
PRD 78, 043514 (2008)

Herschel Galaxies

- The Herschel mission is mapping Far IR and sub-mm galaxies at 1< z < 3.
- Steep number counts imply strong negative K-corrections and magnification bias.
- "Golden" candidates for cross-correlation with Planck lensing reconstruction. (Even for SPT and ACT)
- Cross-correlation signal can improve parameter constraints.



Das and de Putter (in prep)

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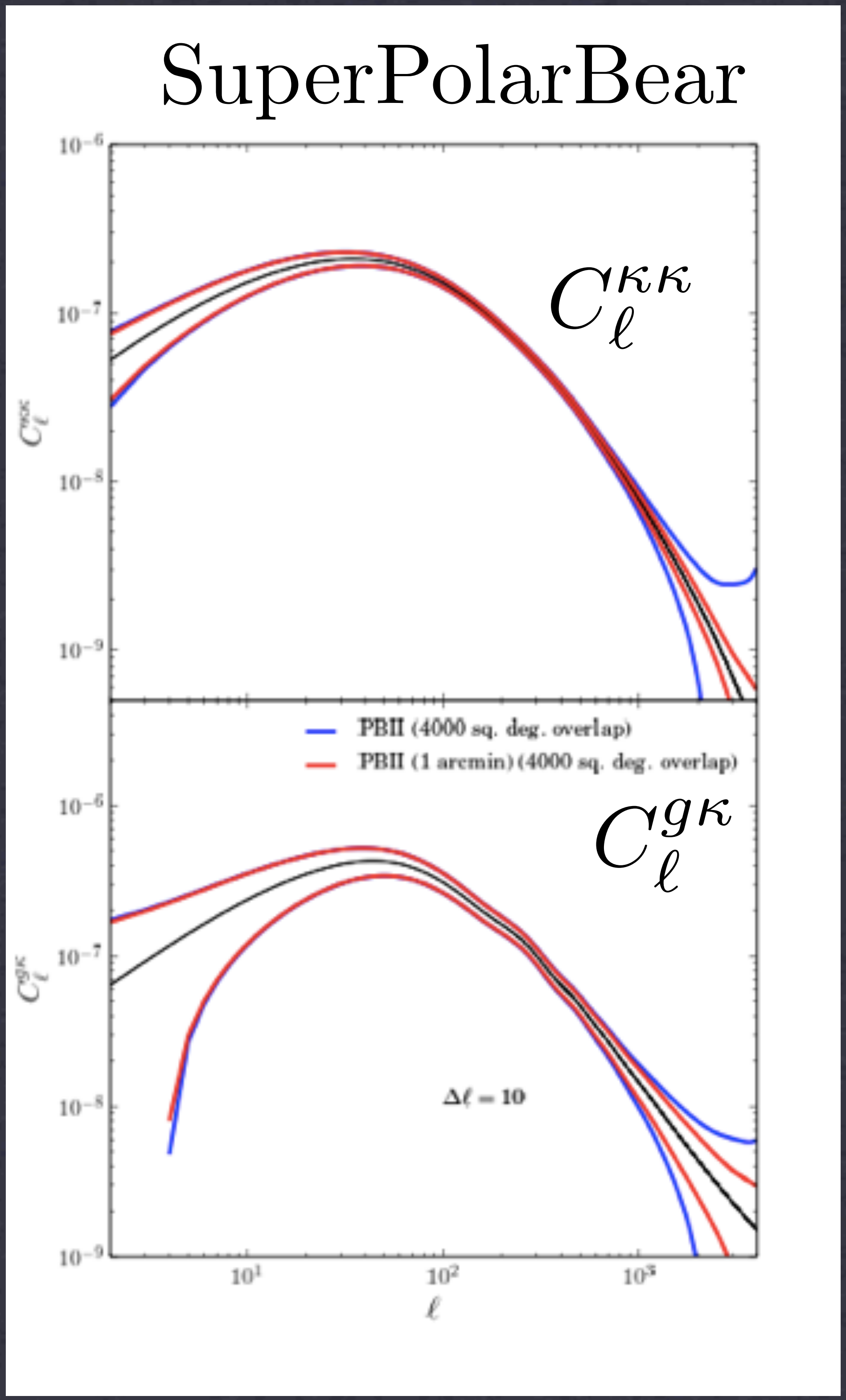

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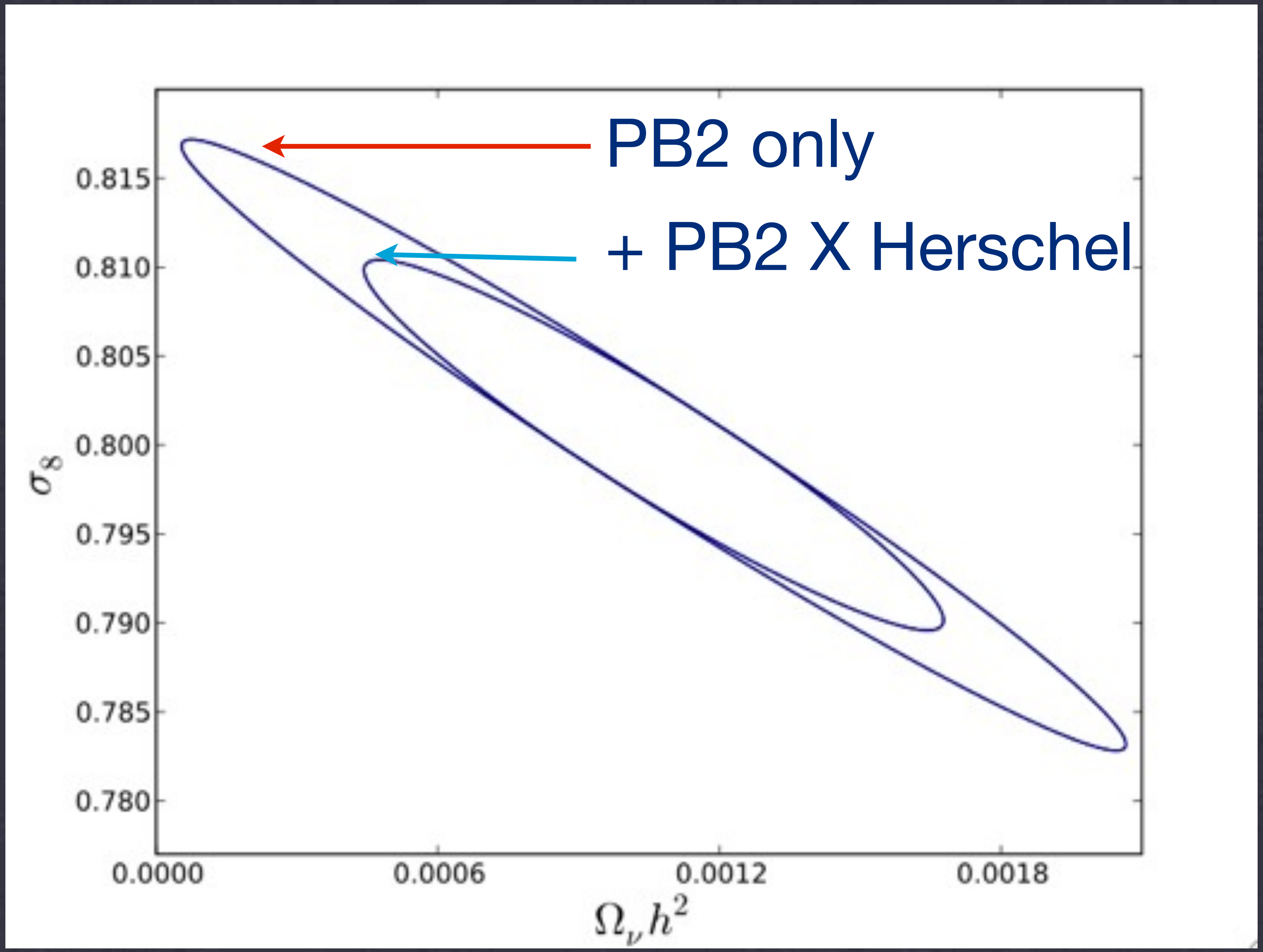
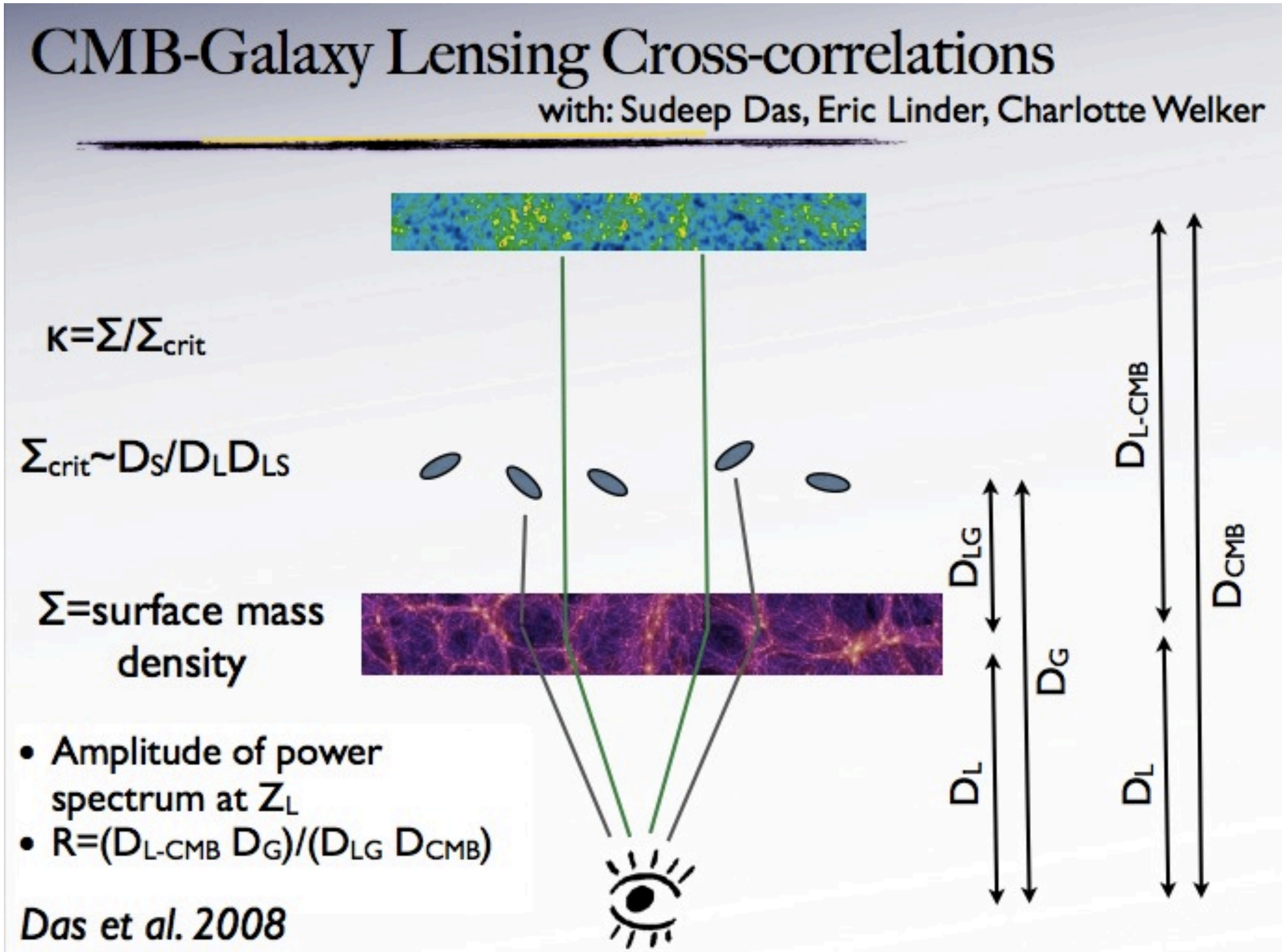
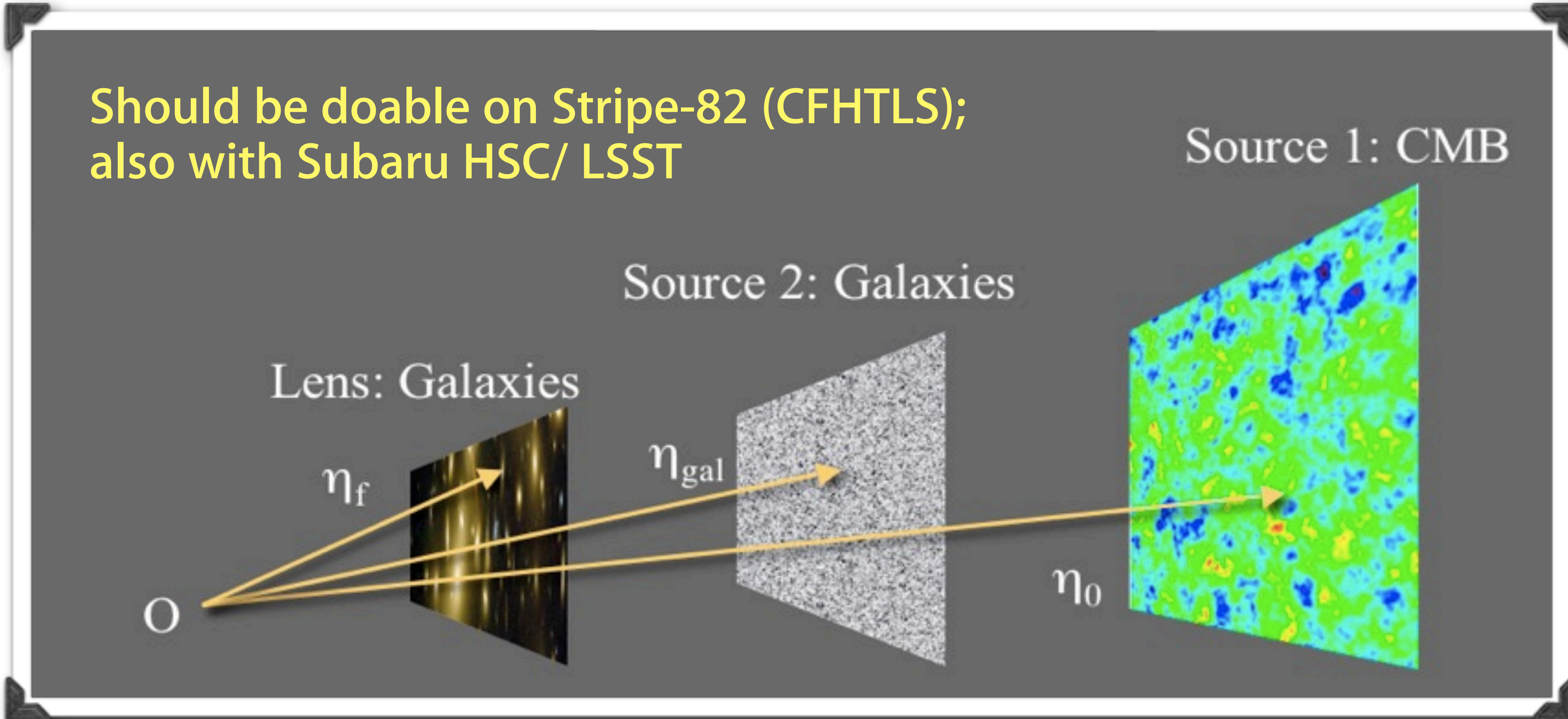


Das and de Putter (in prep)

Alexie



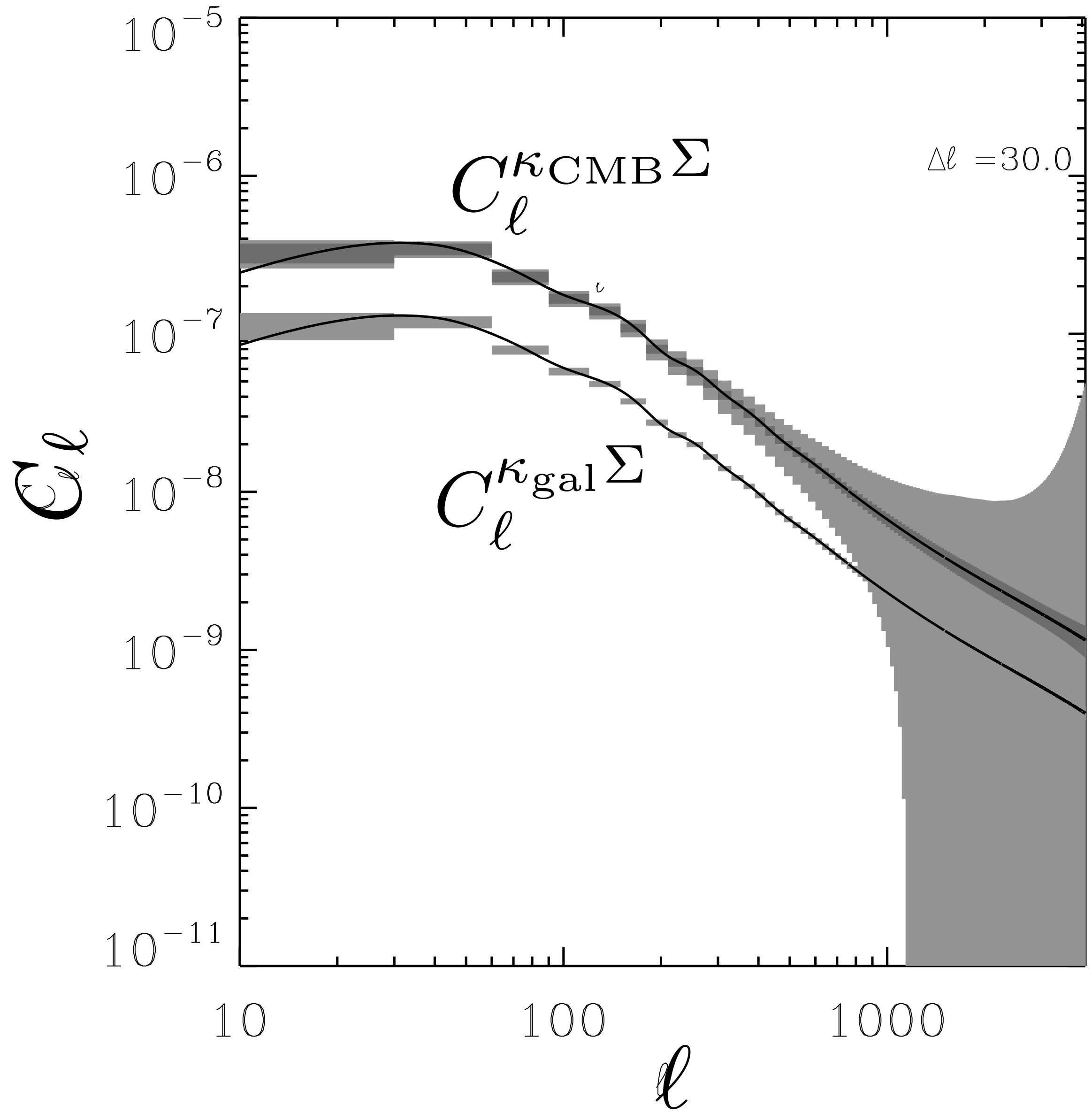
CMB-Galaxy Lensing Cross-correlations
with: Sudeep Das, Eric Linder, Charlotte Welker
$\kappa = \Sigma / \Sigma_{crit}$
$\Sigma_{crit} \sim D_S / D_L D_{LS}$
Σ=surface mass density
• Amplitude of power spectrum at Z_L
• $R = (D_{L\text{-}CMB}\, D_G)/(D_{LG}\, D_{CMB})$
Das et al. 2008
D_{LG}
D_G
D_L
$D_{L\text{-}CMB}$
D_{CMB}
D_L



$$r \equiv \frac{C_\ell^{\kappa_{CMB}\Sigma}}{C_\ell^{\kappa_{gal}\Sigma}} \simeq \frac{d_A(\eta_0 - \eta_f) d_A(\eta_{gal})}{d_A(\eta_{gal} - \eta_f) d_A(\eta_0)}.$$

Das and Spergel (2008)

Measuring distances



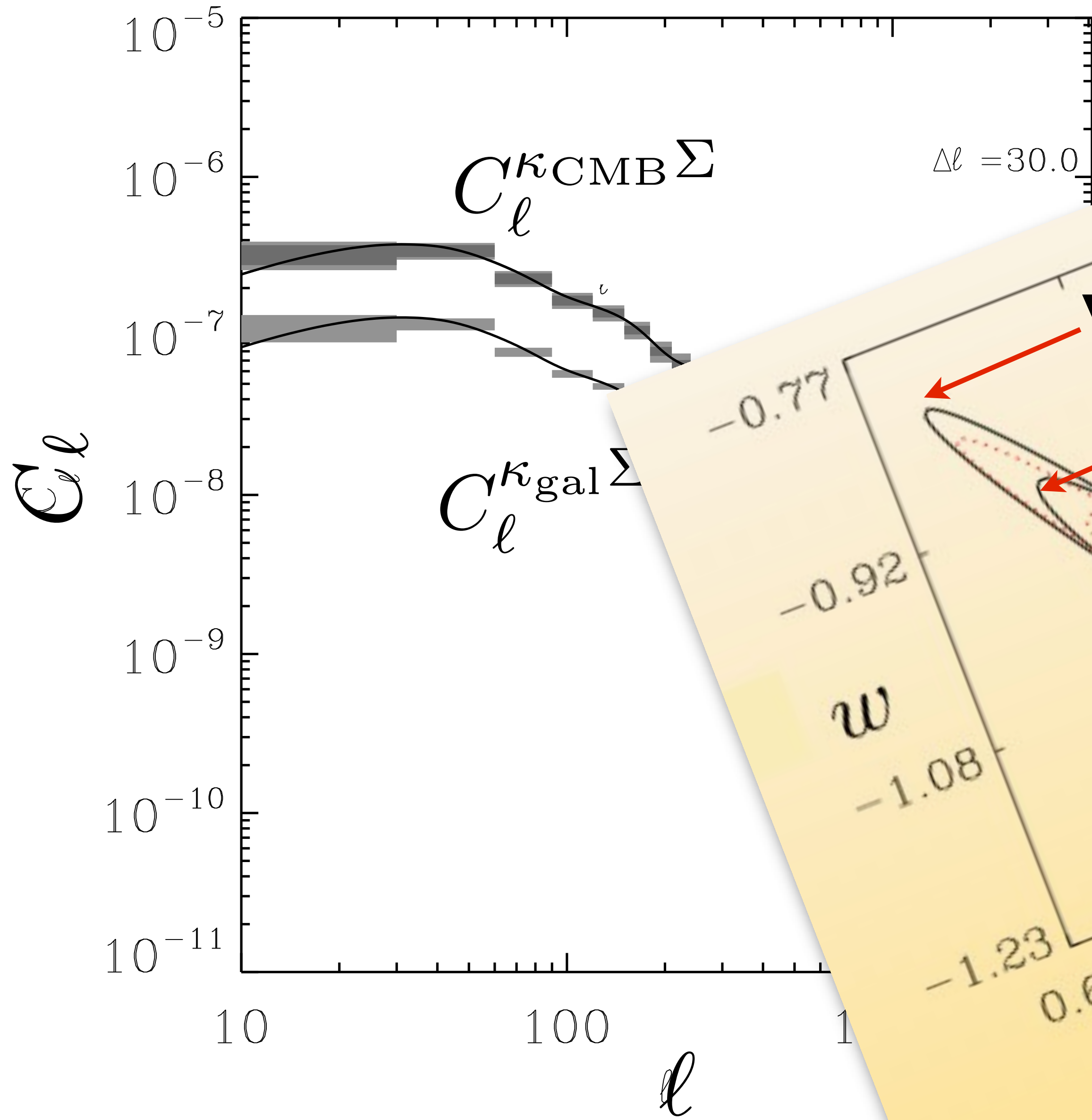
Experiment	Type	$(S/N)^{\rm cross}$	$\Delta r/r(\%)$
Planck	POL	25.8	3.8
	TT	23.3	4.2
CMBPOL	POL	102.6	1.0
	TT	84.5	1.2

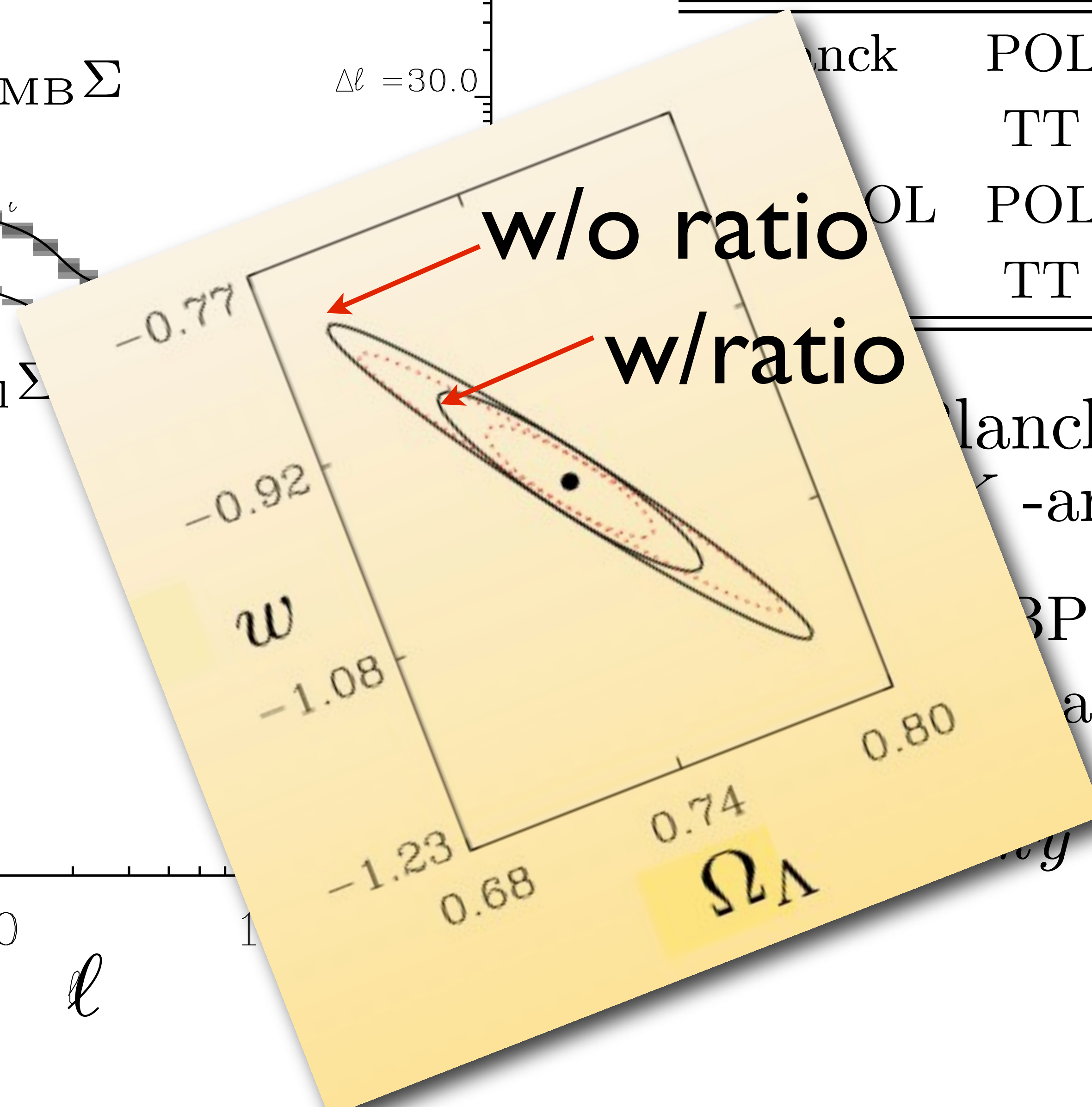
Planck: $7'$ FWHM
$28(57)\mu K$ -arcmin in Temp (Pol)

CMBPOL: $3'$ FWHM
$1.0(1.4)\mu K$-arcmin in Temp (Pol)

$f_{sky} \sim 0.65$

Das and Spergel (2008)





Experiment	Type	$(S/N)^{cross}$	$\Delta r/r(\%)$
...nck	POL	25.8	3.8
	TT	23.3	4.2
...OL	POL	102.6	1.0
	TT	84.5	1.2

...lanck: 7′ FWHM
... -arcmin in Temp (Pol)

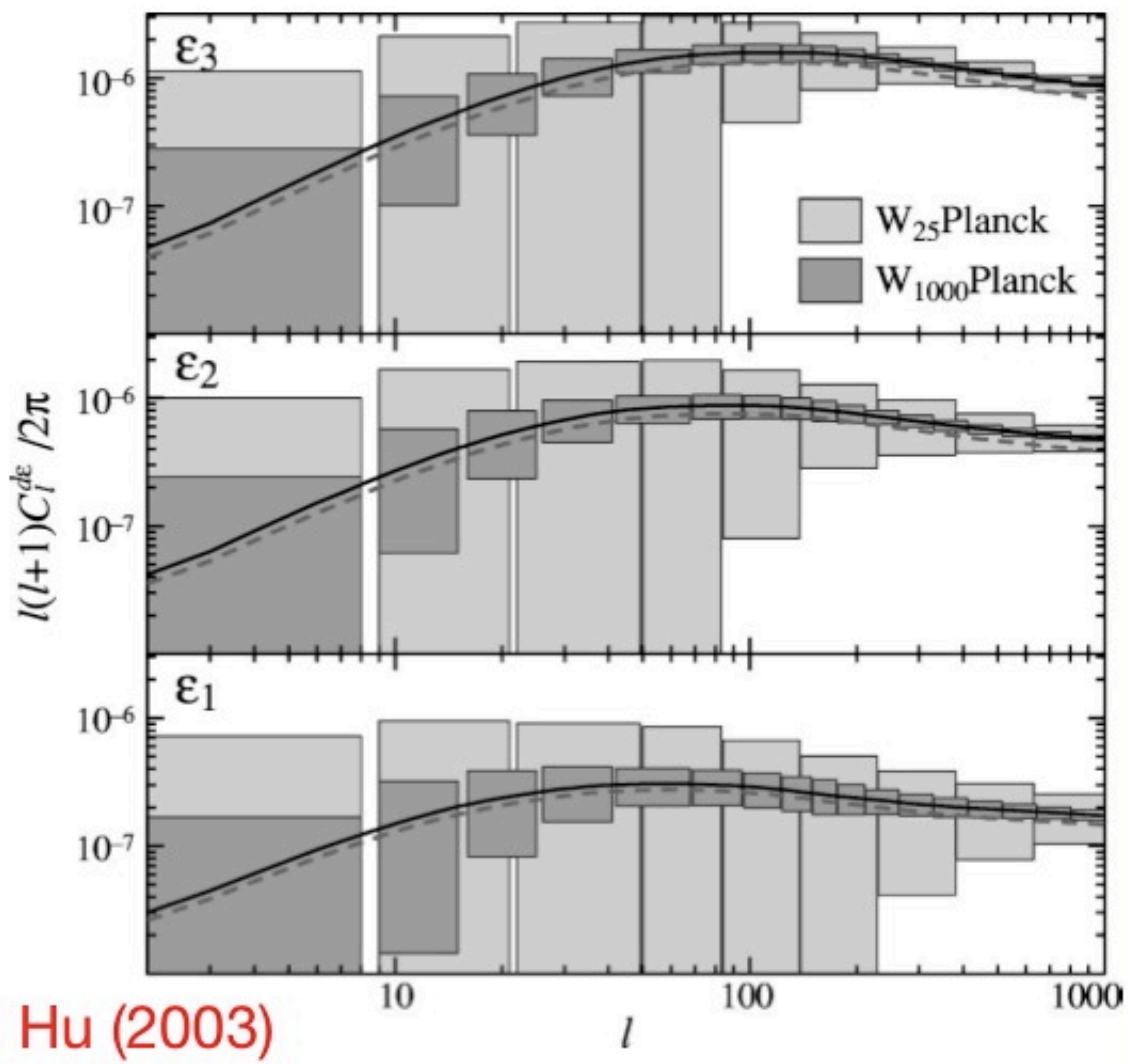
...BPOL: 3′ FWHM
...arcmin in Temp (Pol)

$\ldots \sim 0.65$

Cross-correlating CMB lensing with cosmic shear in redshift slices will probe growth of structure directly!

Deviations from GR?

Das, de Putter, et al in prep



Hu (2003)

Ly-alpha Forest And CMB Lensing

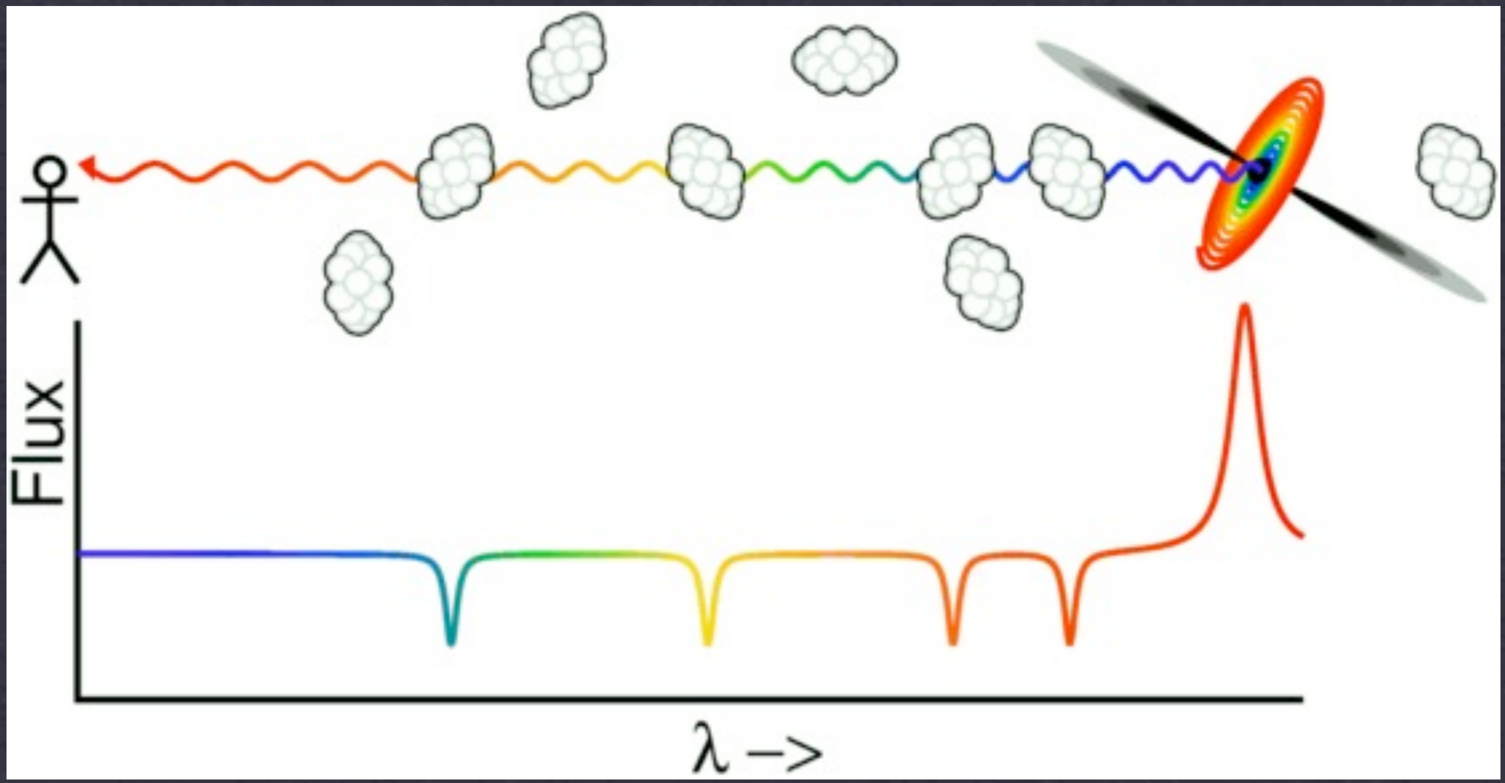
$$\hat{\mathbf{d}} \times \; \mathrm{Ly} - \alpha$$

The Ly-alpha absorption features in quasar spectra probe small scale density fluctuations.

Lensing probes the long wavelength modes.

Cross-correlation is a potentially powerful cosmological tool ! Relevant for the BOSS survey: 200,000 QSOs.

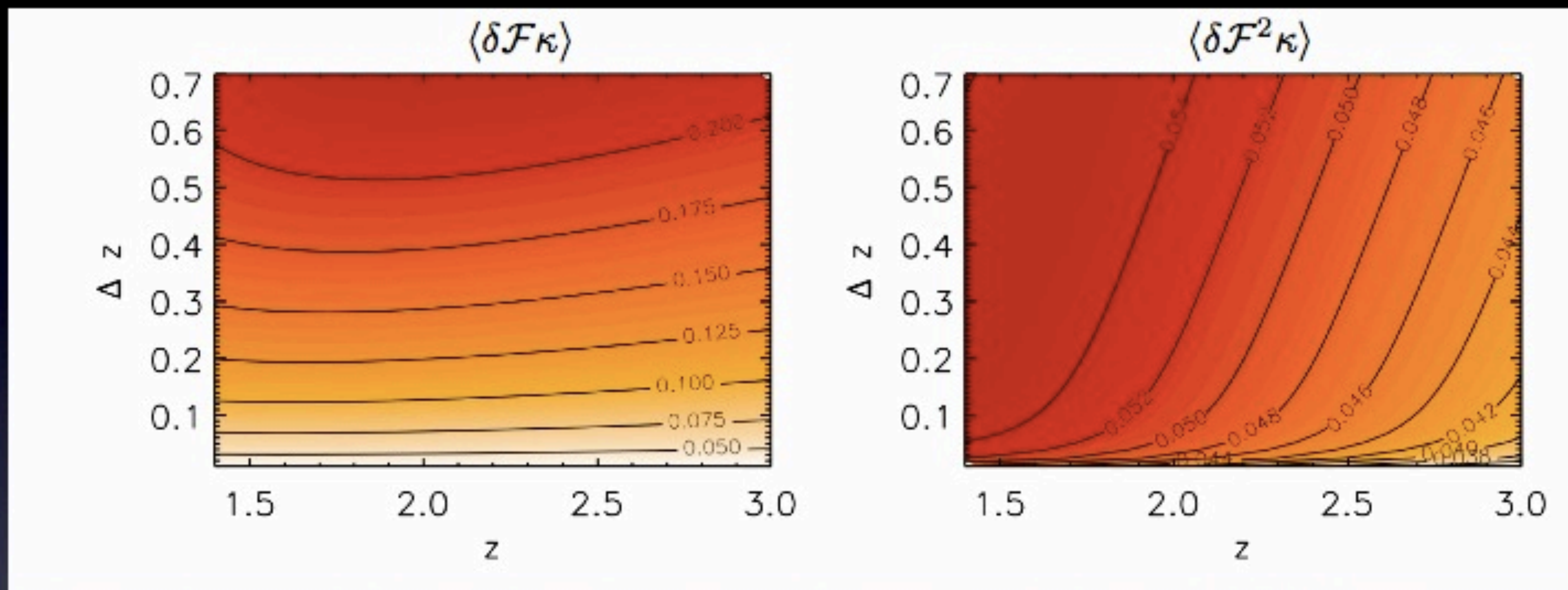
S/N ~ 10 for PLANCK



Vallinotto, Das, Spergel & Viel, PRL,103:091304, 2009

Alberto

Results: detectability (BOSS+*ActPol*)



[AV, Das, Spergel, Viel, 2009]

- S/N for single line-of-sight. $1.6 \cdot 10^5$ los for Boss, ~10^6 los for BigBoss.
- Estimates for total S/N are ~50 (130) for $\langle \delta \mathcal{F} \kappa \rangle$ and ~20 (50) for $\langle \delta \mathcal{F}^2 \kappa \rangle$ when ActPol dataset is xcorrelated with Boss (BigBoss).
- S/N does not depend on the redshift evolution of A and β.

Lots To Do ...

Lots Of Papers To Write ...

Lets Discuss Some Questions Now ...