Overlapping spectro/photo surveys (DES/BigBOSS joint study)

Pat McDonald
(LBL)

DES-BigBOSS Joint Working Group

- Formed ~Sep 2011, report Apr 2012.
- J. Annis, G. Bernstein, P. McDonald, J. Newman, N. Padmanabhan, W. Percival, D. Weinberg (+Y. Cai)
- Basic question: how much does it help (or hurt) measurements of dark energy to have overlapping spectroscopic (redshift) surveys and photometric (lensing) surveys? (Specifically BB and DES.)
- Gaztanaga et al. (2012) and (in some perceptions) Cai & Bernstein (2012) had found big gains from having overlapping surveys.
- The basic idea of these papers is that lensing calibrates the bias of redshift survey galaxies through overlapping angular modes, which can then enhance the constraining power of the full redshift survey.

Fisher matrix calculations

- LRGs and ELGs from BigBOSS (or DESpec)
- DES(-like) galaxies with photo-z's following a realistic distribution (J. Annis)
- Use full galaxy density power spectrum at k<~0.1 h/Mpc, but only BAO at higher k, to avoid non-linearities.
- Use C_l's in dz=0.2 redshift bins for angular clustering calculations. (Results insensitive to bin width because finer radial scale information included through power spectrum calculation.) l_max=500 for shear-shear
- Generally include all possible cross-correlations between different types of galaxy density and lensing.
- Standard cosmological parameters following FoMSWG (Albrecht et al.).
- Can include many nuisances/systematics like bias, photo-z systematics, shear calibration bias, intrinsic alignments, etc.
- Include Planck CMB in all projections.
- Calculation description available.

DES-BigBOSS JWG Main Results

Table 1: Effect of overlapping BB/DES-like redshift and imaging surveys, compared to no overlap. The BigBOSS area is always 14000 sq. deg., and the full broadband power spectrum is used to the given $k_{\rm max}$ (measured in $h\,{\rm Mpc}^{-1}$). Full standard BAO information is always used. The calculation is done in redshift slices with $\Delta z = 0.2$. Note that our calculation of the DETF FoM $[\sigma(w_p)\sigma(w_a)]^{-1}$ is after marginalizing over γ and G_9; i.e., we do not assume GR when computing this FoM.

case	DES area	overlap area	$k_{\rm max}$	σ_γ	$\sigma_{\ln G_9}$	DE FoM (w/γ)
	0	0	0.1	0.0247	0.0288	174
1	5000	0	0.1	0.0215	0.0174	220
2	5000	3000	0.1	0.0214	0.0171	222
3	5700	0	0.1	0.0213	0.0169	222
	0	0	0.05	0.0472	0.0375	129
4	5000	0	0.05	0.0377	0.0206	146
5	5000	3000	0.05	0.0369	0.0204	147
6	6100	0	0.05	0.0369	0.0199	147
	0	0	0	∞	∞	122
7	5000	0	0	0.0828	0.0314	133
8	5000	3000	0	0.0793	0.0300	134
9	5700	0	0	0.0780	0.0297	134

$$\frac{d\ln D}{d\ln a} = \Omega_m^\gamma(z)$$

multiplicative offset G_9 relative to the GR-predicted amplitude at $z = 9$

- In the DES/BigBOSS joint study we concluded that, all else being equal, overlap was clearly desirable, but it was surprisingly difficult to find strong quantitative benefit (at the time I might not have believed it without cross-check from Cai, although since then I have explored enough that I think it makes sense, as I will discuss).

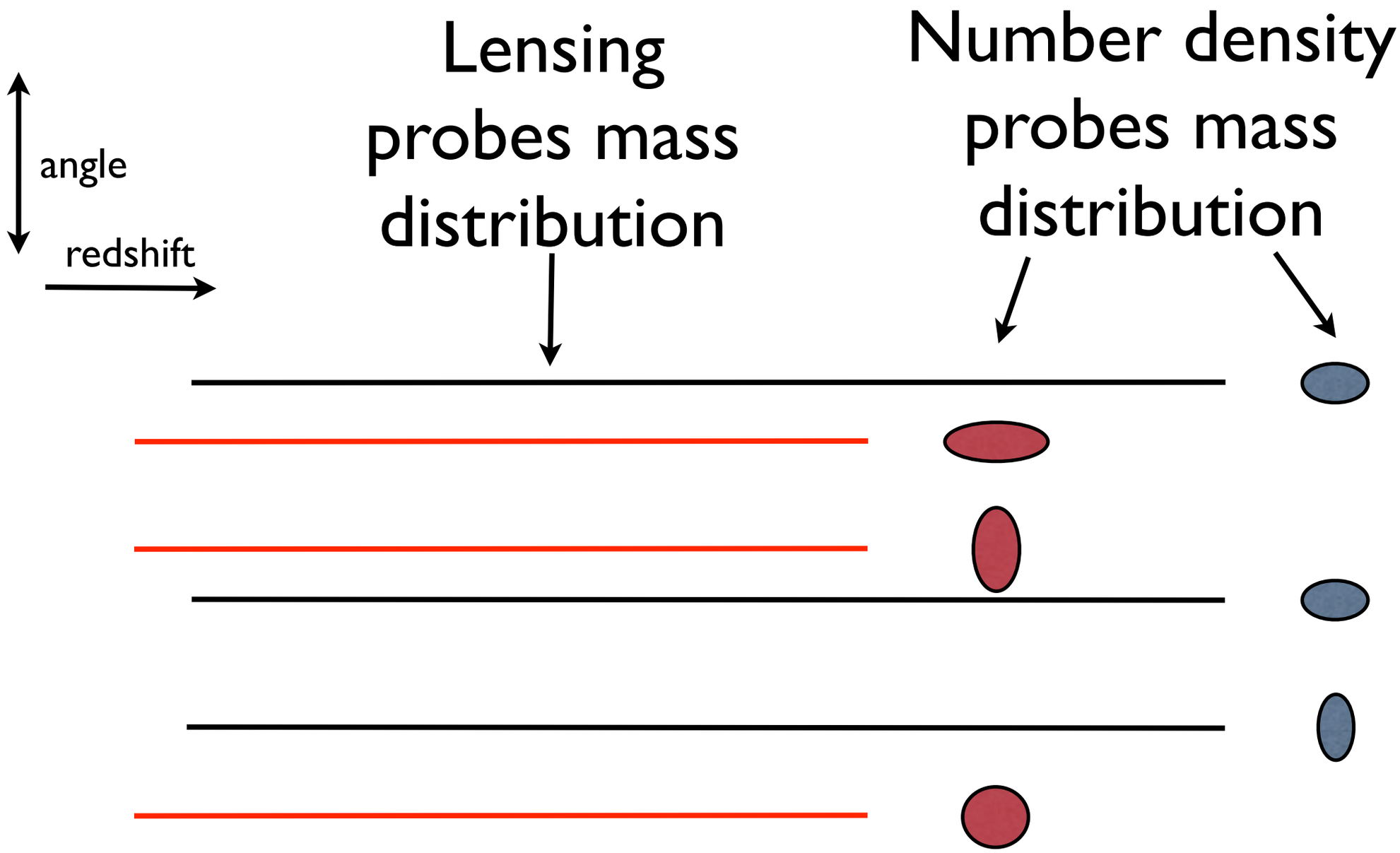
- We focused on a fixed spectroscopic survey with a possible low-cost move of DES footprint.

- Since then, I've expanded the calculations more generally.

General bottom line:

RS area	WL area	overlap	DE FoM
14000	0	0	217
14000	14000	0	386
14000	14000	14000	399
13000	13000	13000	372

- Redshift surveys and lensing are highly complementary.
- If it's just a matter of where to point your telescope, overlap is better - you might as well go for it.
- You don't want to sacrifice measurable total area for it.



Lensing always a broad average, z-error determines how well resolved density/source fields are.
Mass only correlated at relatively short distances.

Observable fields

- For each type of object, e.g., in a nominal photo-z bin, we can generally talk about measuring (at least) two fluctuation fields:

Estimated number density

$$\hat{\delta}_n = b\ \delta_m + 2(s-1)\delta_\kappa + \epsilon_n$$

true number density (3D) · magnification (2D projected) · noise

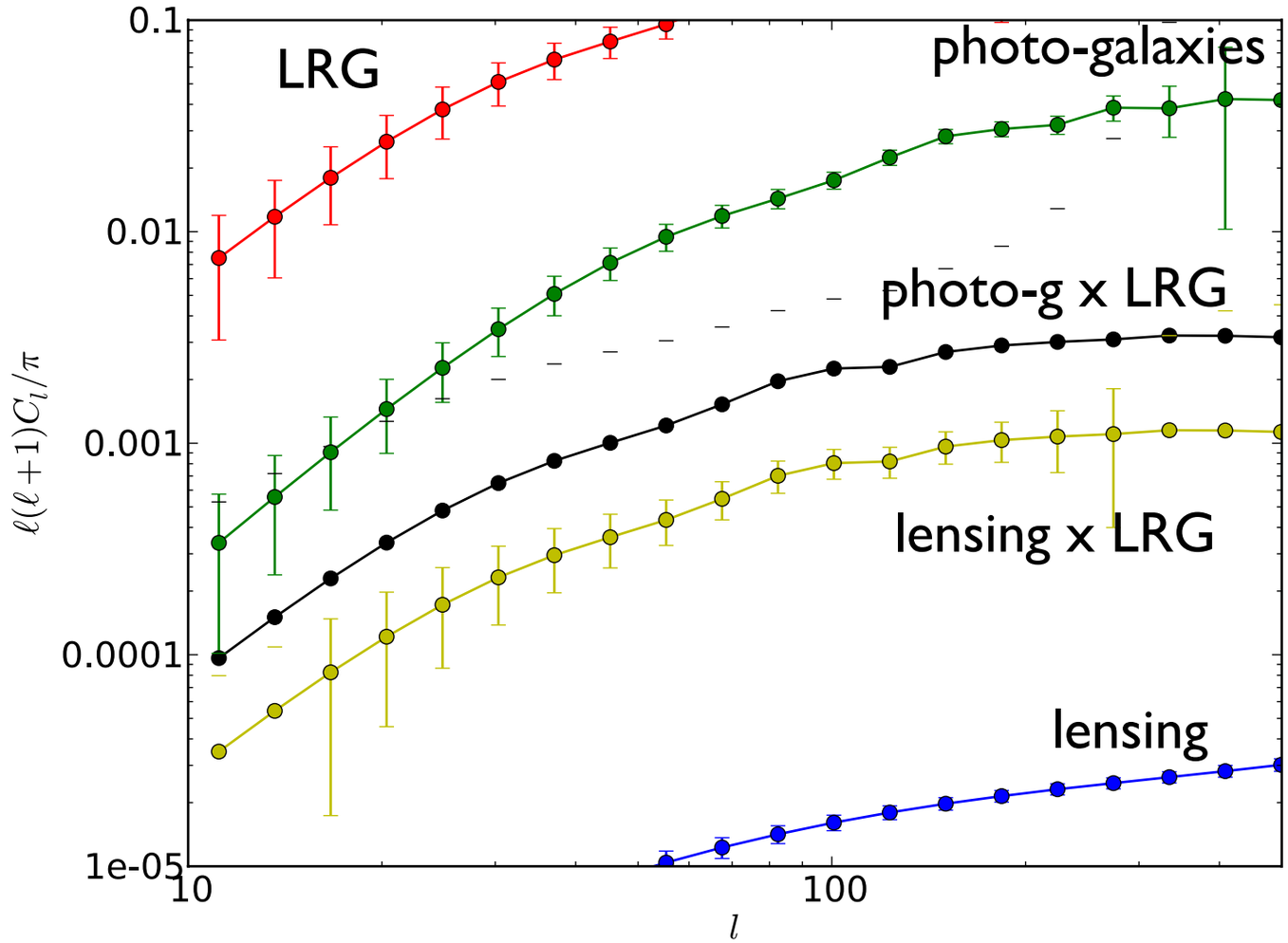
Estimated lensing convergence

$$\hat{\delta}_\kappa = b_{\rm ia}\delta_m + b_\kappa \delta_\kappa + \epsilon_\kappa$$

intrinsic alignments · true convergence · noise

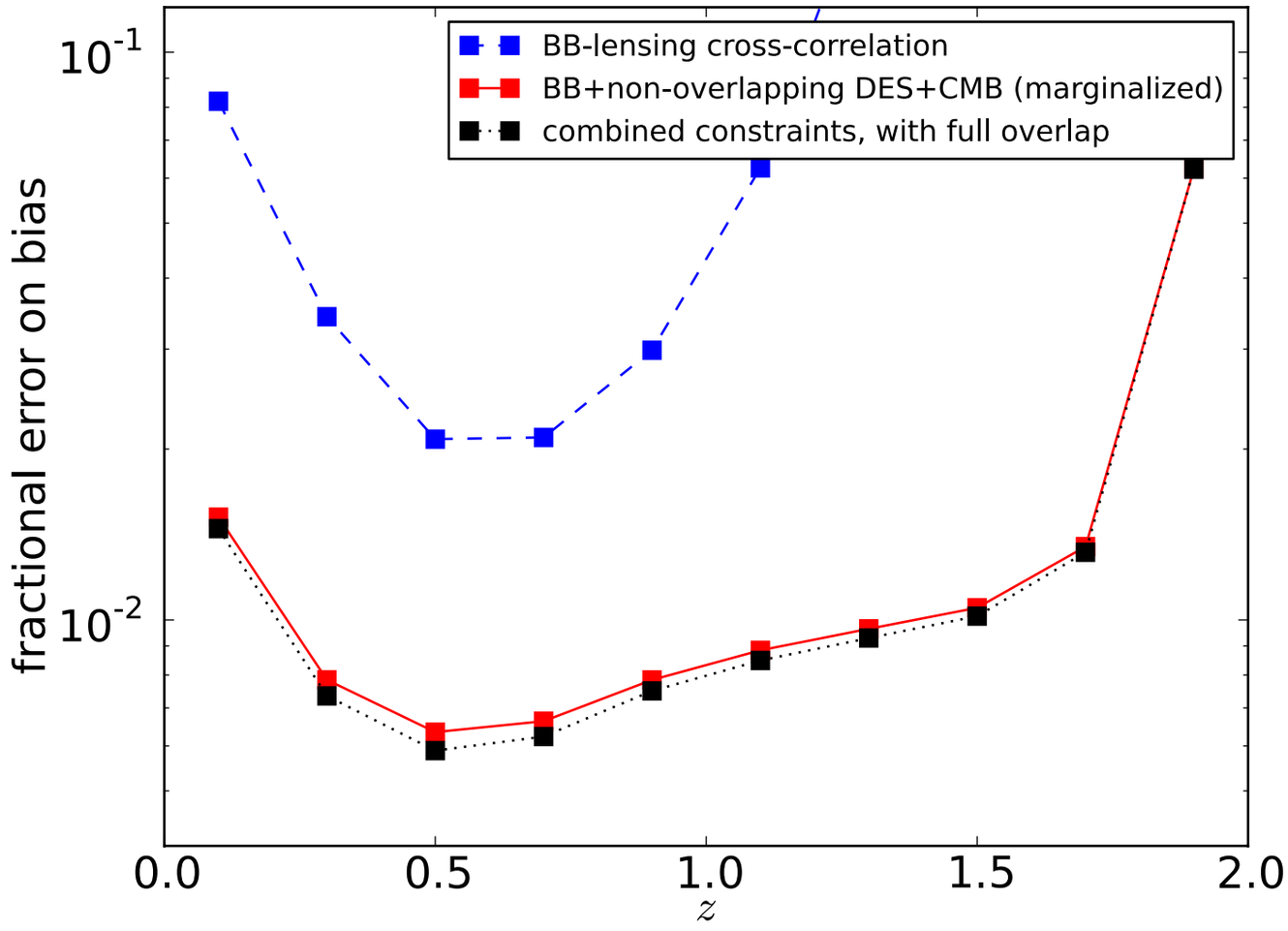
Errors on cross-correlation
(total of 820 cross-correlations per I band)

- A few examples
- LRGs in range 0.4<z<0.6
- photo-z galaxies in range 0.8<z<1.0 (with lensing)
- Realistic long-tailed photo-z distribution.
- Density cross-correlation (marginally detected) measures tails of the photo-z distribution (magnification also present)



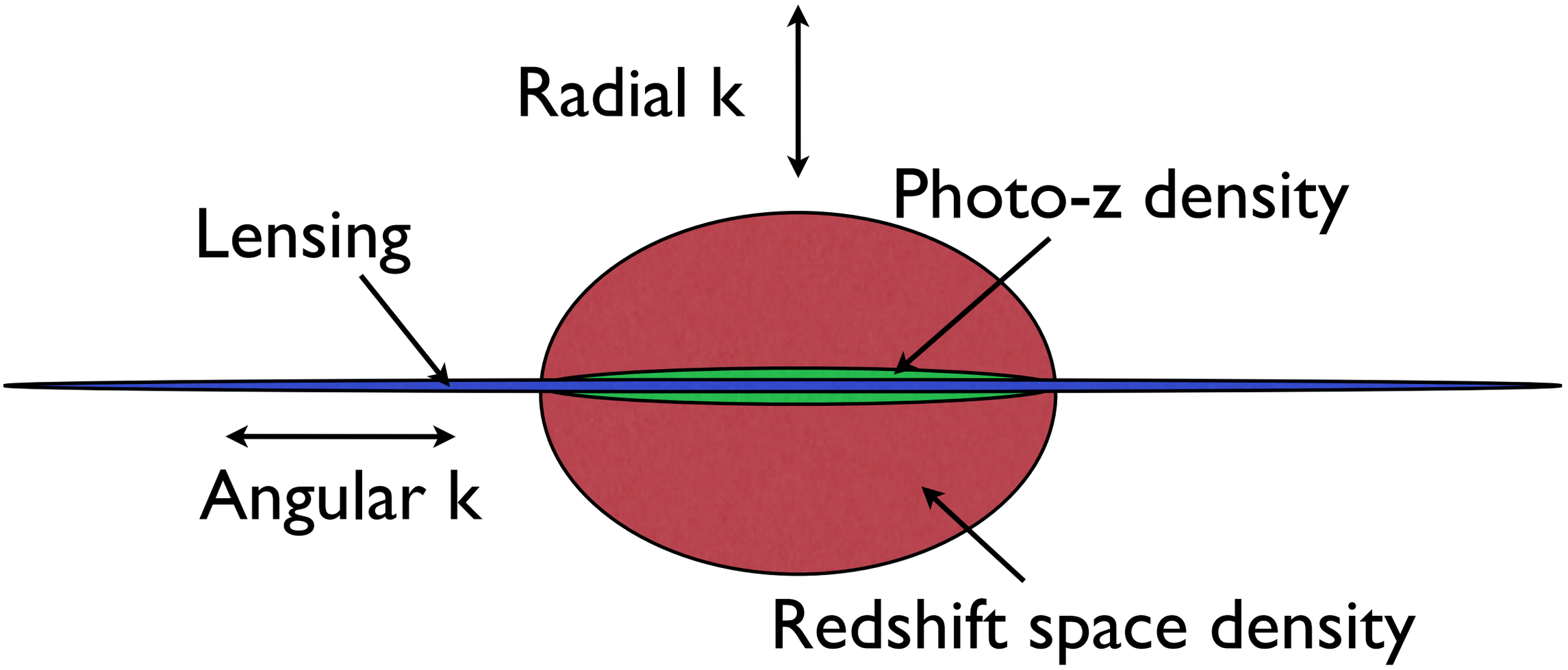
Galaxy density cut off at k~0.1 h/Mpc

Bias calibration "works"... just not well enough



The illusion of overlap

Fourier space coverage



With modified gravity parameters

RS	WL	overlap	DE FoM	σ_γ	$\sigma_{\ln G_9}$
14000	0	0	175.2	0.0244	0.0287
14000	14000	0	185.5	0.0239	0.0223
14000	14000	14000	191.7	0.0229	0.0208
13000	13000	13000	179.4	0.0237	0.0214

- Again, overlap helps, but you wouldn't give up any significant survey area for it.

- includes photo-z systematic calibration

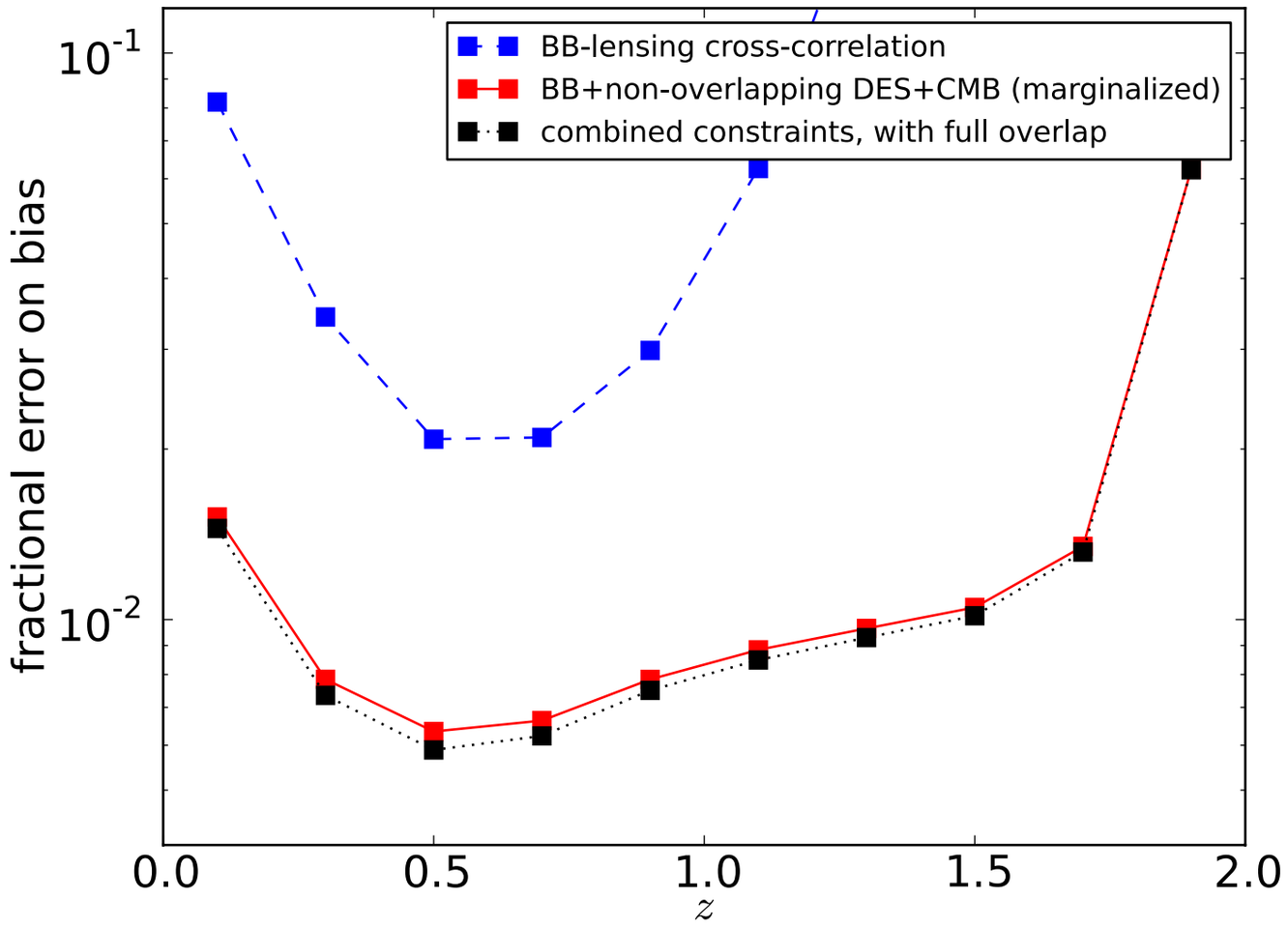
14000>5000

	FoM
DES	39
DESpec	67
DESpec + DES, no overlap	180
DESpec + DES, full overlap	185
BigBOSS	242
BigBOSS + DES, no overlap	502
BigBOSS + DES, 800 sq deg overlap	505
BigBOSS + DES, 5000 sq deg overlap	510

Similar areas will give more similar results, but overlap is never critical.

Bias calibration "works"... just not well enough

You don't design a survey around the blue curve when the baseline overall precision is the red... in my opinion.



The bottom line:

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- We're quantitative scientists - experience shows that *quantifying* our imagination about how things work - I mean especially systematics control here - often leads us to deeper understanding and different conclusions than we expected.