Cosmology with Galaxy bias

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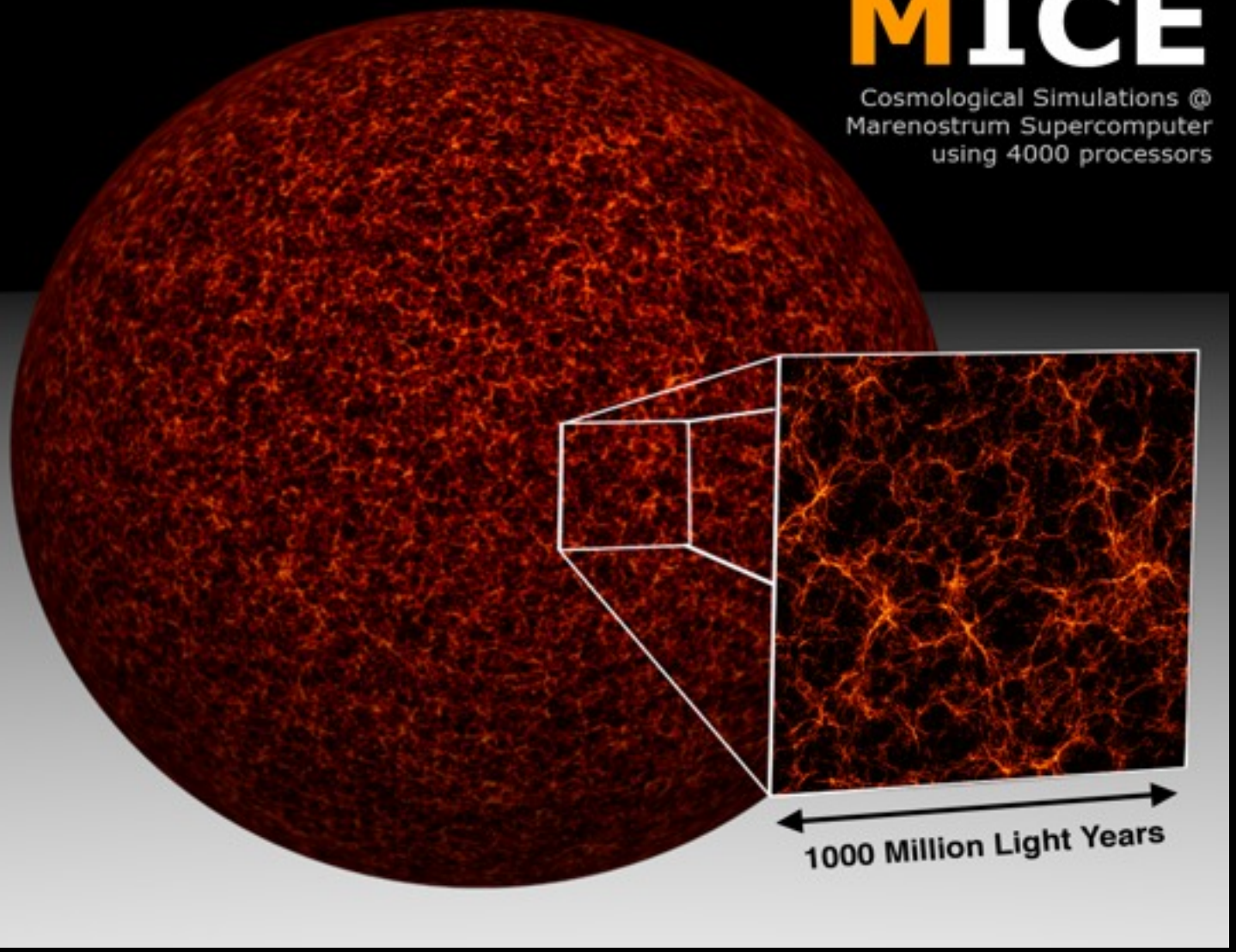
MICE

Cosmological Simulations @
Marenostrum Supercomputer
using 4000 processors



www.ice.cat/mice

Figure of Merit $\mathrm{FoM}_{w\gamma} \times 10^3$ Expansion x Growth

$$H = H(w)$$

w(z) -> Expansion History (background metric)
we will use w0 and wa

$$f \equiv \frac{d\,ln\,D}{d\,ln\,a} = \frac{\dot{\delta}}{\delta} \equiv \Omega_m^{\gamma}(a)$$

γ -> Growth History (metric perturbations)
probably need one more parameter here

$$\delta = D(a)\delta(0)$$

$$\dot{\delta} = -H\theta$$

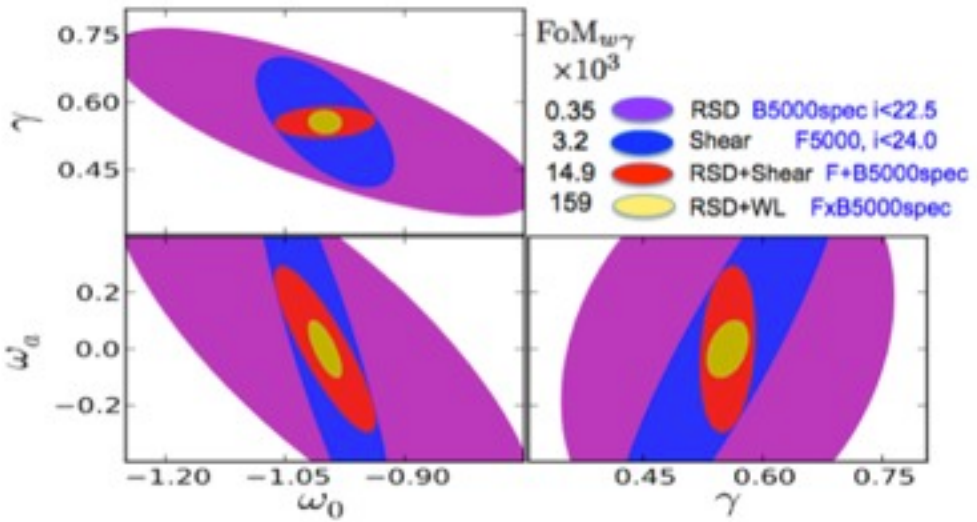
Linear Theory: $P(k,z) \sim D^2(z)\, P(k,0)$

+

mass conservation

$$\theta = -\, f(\Omega)\, \delta$$

Is this the best choice for 3 parameters?



f = Velocity growth factor: tell us if gravity is really responsible for structure formation!

Could also tell us about cosmological parameters or Mod Gravity

$$FoM_S = \sqrt{\frac{1}{det[F^{-1}]_S}} = \frac{1}{\sigma(w0)\ \ \sigma(wa)\ \sigma(\gamma)}$$

Om - ODE - h - sig8 - Ob - **w0 - wa -γ-** ns - bias(z)

need clustering

The role of Galaxy Bias

Search of Cosmological parameters is hinder by BIAS!
Options:

A) ***Avoid BIAS***: BAO, SNe, Cluster counts, WL and through away most information

B) ***Understand Bias*** <==> Galaxy Formation

Xtalk probes: combine different probes to measure bias together with other cosmological parameters

Workshop on Galaxy Bias:
Non-linear, Non-local and Non-Gaussian

here bias is:

Linear and local
Deterministic: r=1
Gaussian IC

on linear scales: b(z, type)

as a function of redshift (one bias per z-bin) and type

first step (better than non!)

XTalks in Galaxy Clustering

1. Galaxy Clustering (real) 2pt: 3D, lots of info but degenerate with bias: can measure linear shape, but not growth
2. Galaxy Clustering 3pt: 3D (break degeneracy?)
3. Weak Lensing: 2D (unbiased but degenerate & few 2D modes)
4. Redshift Space Distortions (can be used in to measure bias but 1D)
5. BAO: (unbiased but 1.5D)

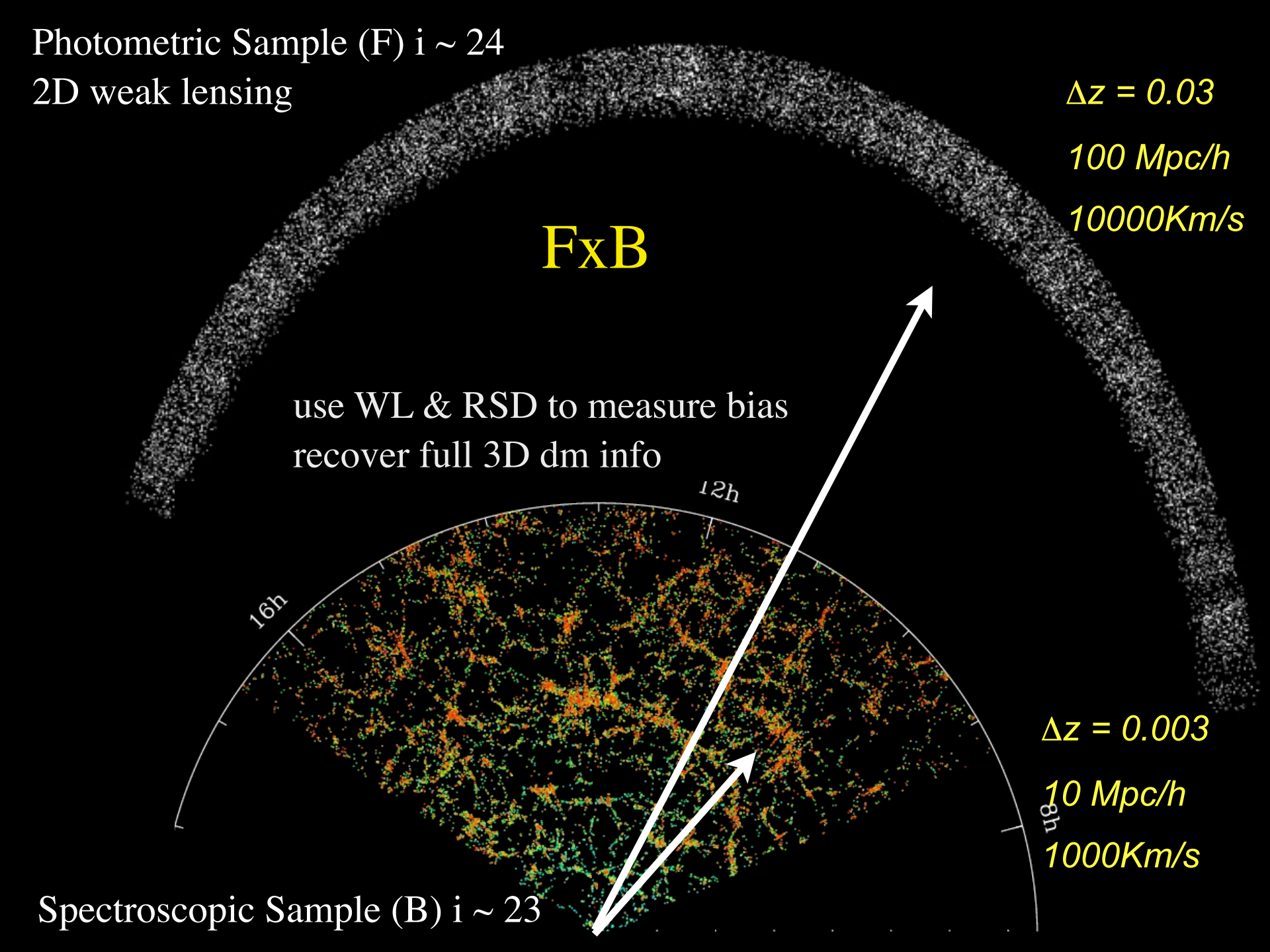
Combine probes: RSD + WL

Cross-correlate probes: galaxy-lensing

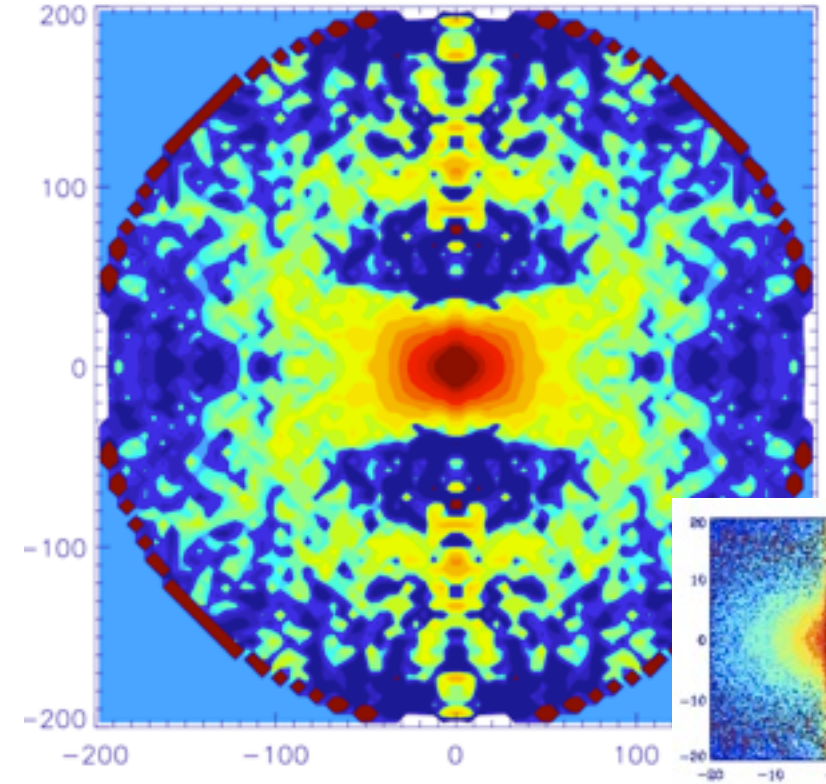
Combine Photometric & Spectroscopic Survey:

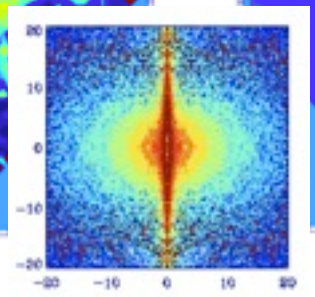
sampling variance, photo-z accuracy

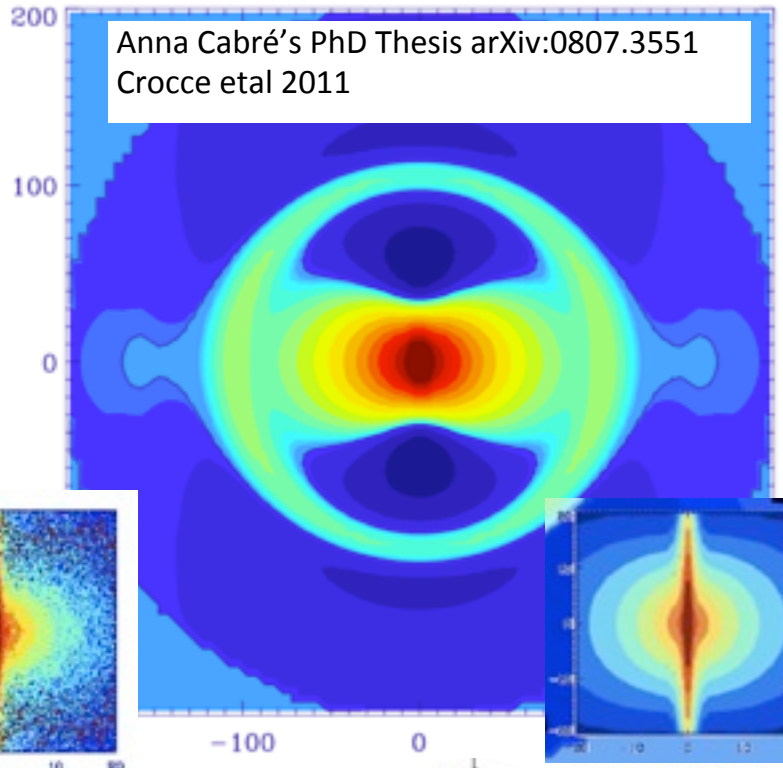
astro-ph:1109.4852

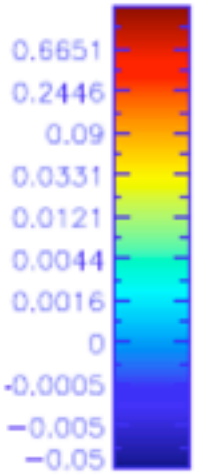

Photometric Sample (F) i ~ 24
2D weak lensing
Δz = 0.03
100 Mpc/h
10000Km/s
FxB
use WL & RSD to measure bias
recover full 3D dm info
12h
16h
8h
Δz = 0.003
10 Mpc/h
1000Km/s
Spectroscopic Sample (B) i ~ 23

Anna Cabré's PhD Thesis arXiv:0807.3551
Crocce etal 2011

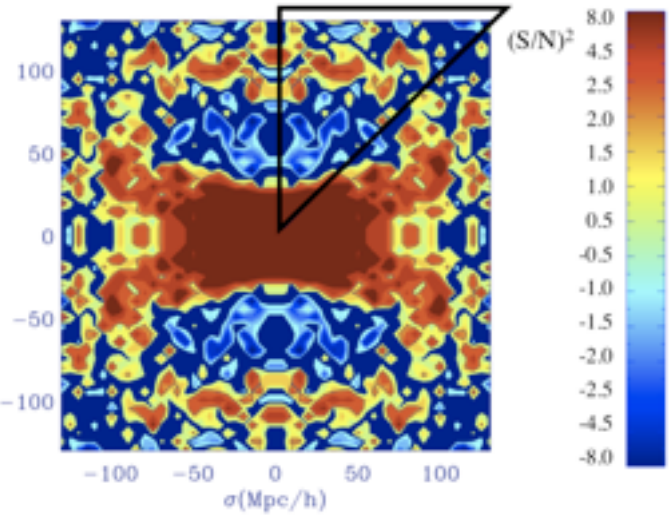








DR7



Errors from MICE sim

BAO:

radial H(z)

H(z=0.34) = 83.8 ±3.0± 1.6

EG, Cabre & Hui (2009)

Transverse $\int$ cdz/H(z)

θ(z=0.34) = 3.90 ± 0.38

Carnero etal 2011

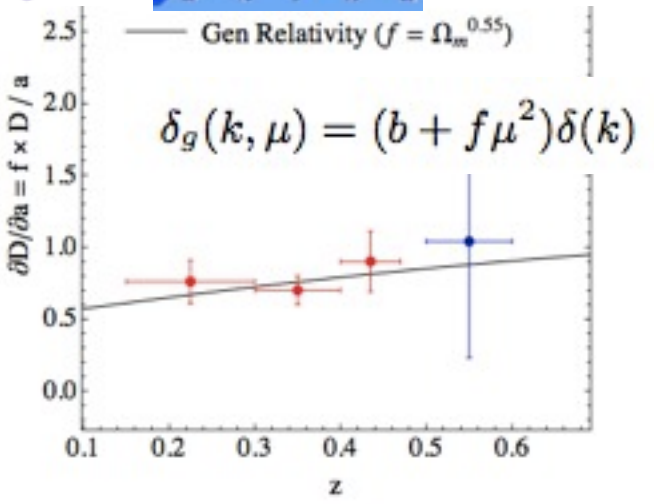
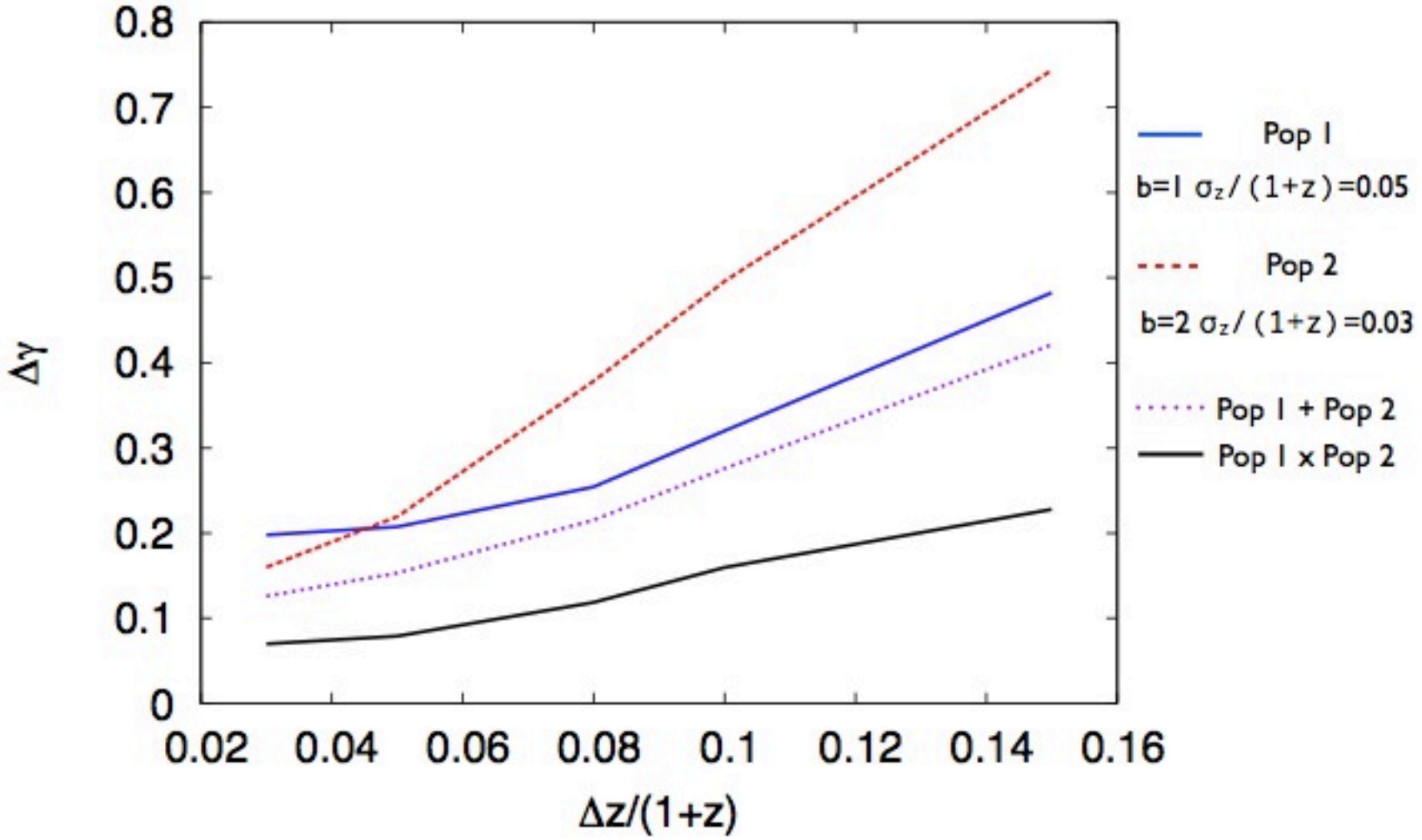


Figure 17. Linear growth rate of structure from LRG spectroscopic data in the range [0.15-0.47], as presented in Cabré & Gaztañaga (2009), and from our analysis of photometric data at $z = 0.55$ (assuming $\sigma_8(0) = 0.8$). These data leads to $\gamma = 0.54 \pm 0.17$ in a model where $f = \Omega_m(z)^\gamma$.

RSD in 2D

Jacobo Asorey & Martin Crocce arXiv:1305.0934



Adjacent bins (no photo-z outliers)

RSD and BAO in cross-correlations

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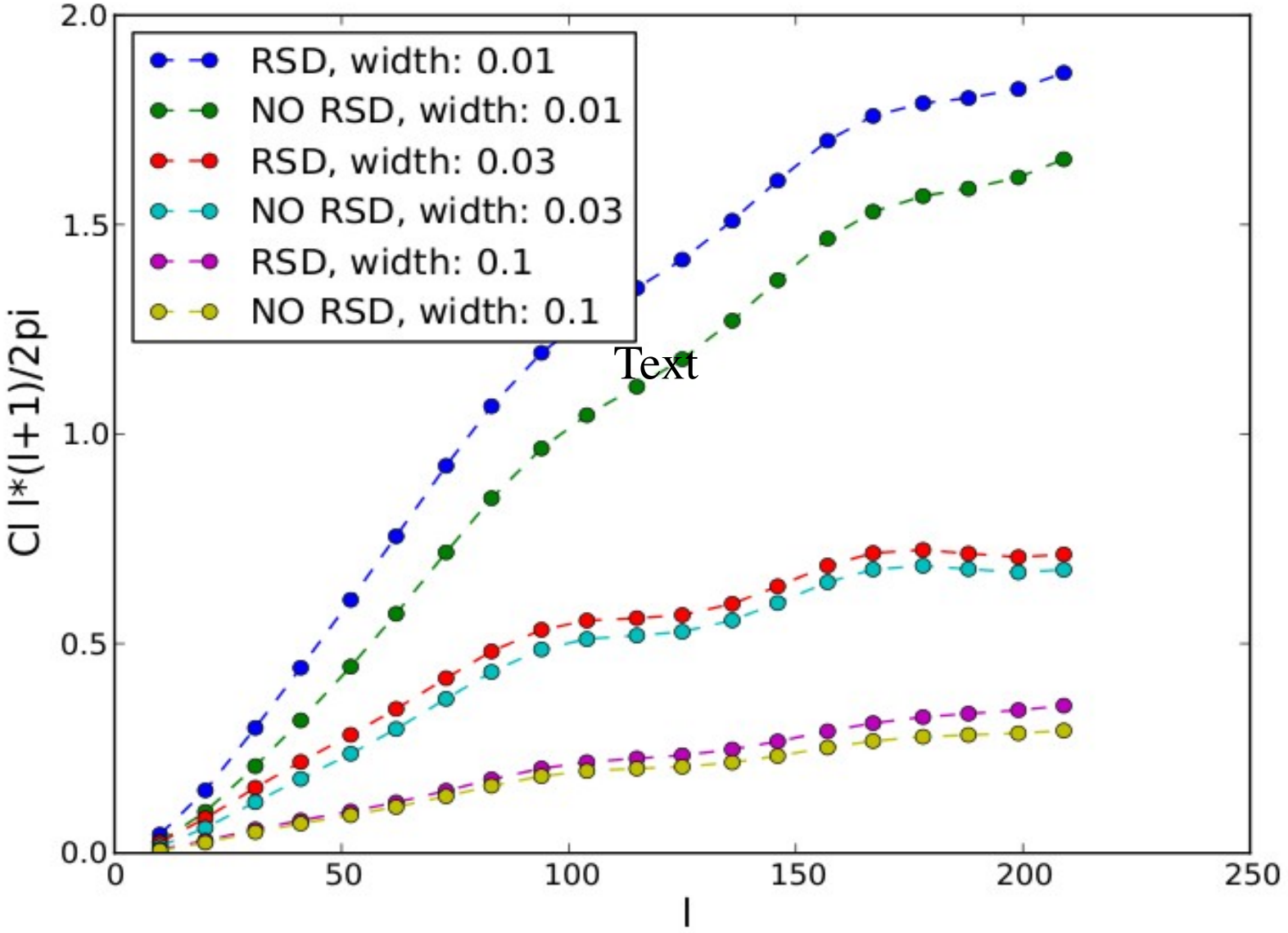


RSD+WL: Same or different sky?

Same Sky: factor of 2 less Area!

but note that covariance <WLxRSD> ~ 0 while <FF BB> ≠ 0

Different Sky: no cross-correlations & no Covariance

(smaller sampling variance, but no sampling variance cancelation)

1. Gaztanaga E., Eriksen M., Crocce M., Castander F. J.,Fosalba P., Marti P., Miquel R., Cabre A., astro-ph:1109.4852
2. Cai Y.-C., Bernstein G., astro-ph:1112.4478
3. Kirk D., Lahav O., Bridle S., Jouvel S., Abdalla F. B., Frieman J. A., astro-ph:1307.8062
4. Font-Ribera A., McDonald P., Mostek N., Reid B. A., Seo H.-J., Slosar A., astro-ph:1308.4164
5. de Putter R., Dore O., Takada M., astro-ph:1308.6070

1	2D+3D	Cov ~ 0	$<g_F\, g_B>\neq 0$ 2D, narrow bins, Limber	FxB >> F+B
2	2D+3D	Cov~ 0	$<g_F\, g_B>=0$	FxB > F+B
3	2D	Cov≠0	$<g_F\, g_B>=0$, no Limber	FxB >> F+B
4	2D+3D	Cov ~ 0	$<g_F\, g_B>\neq 0$ 2D, nl BAO	FxB ~ F+B
5	2D+3D	Cov ~ 0	$<g_F\, g_B>\neq 0$ 2D, nl BAO	FxB ~ F+B

Forecast WL+RSD

Nuisance parameters: one bias per z-bin & pop , photo-z transitions (rij, can be measured), noise (σ/n)

Cosmological: Om - ODE - h - sig8 - Ob - **w0 - wa - γ** - ns - bias(z)

shear-shear (2D): $\langle\gamma\,\gamma\rangle$

galaxy-shear (2D need narrow bins) $\langle g\,\gamma\rangle$

galaxy-galaxy (3D or narrow bins): $\langle g\,g\rangle$ including BAO, RSD and WL magnification

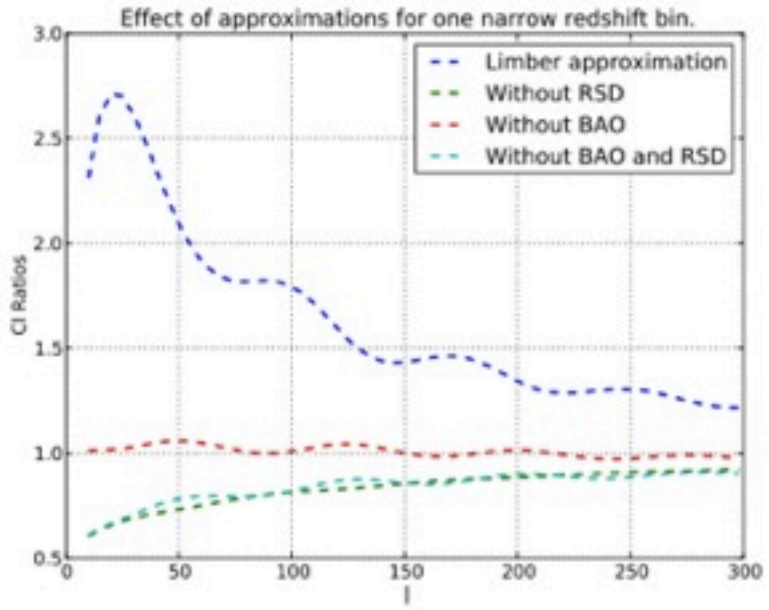
F= Faint (Photometric dz~0.05) sample: $\langle\gamma_F\,\gamma_F\rangle$, $\langle g_F\,\gamma_F\rangle$, $\langle g_F\,g_F\rangle$

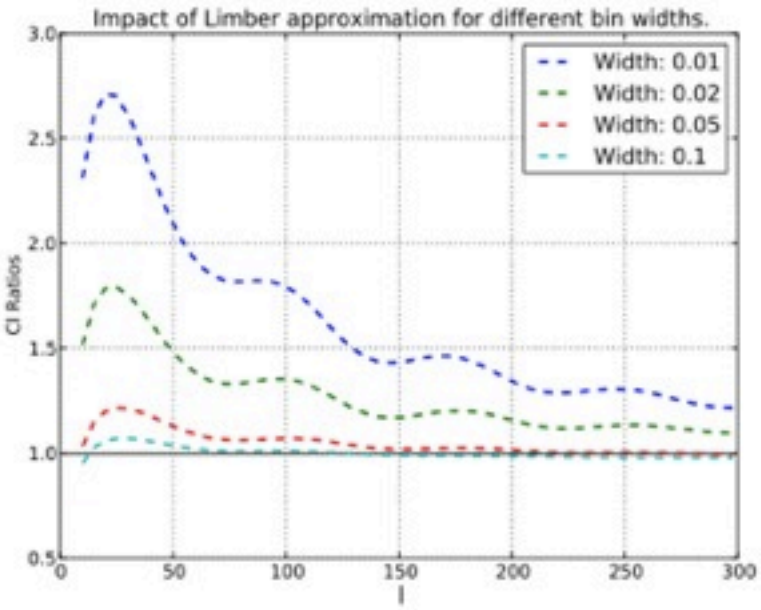
B= Bright (Spectroscopic dz~0.003) sample: $\langle\gamma_B\,\gamma_B\rangle$, $\langle g_B\,\gamma_B\rangle$, $\langle g_B\,g_B\rangle$

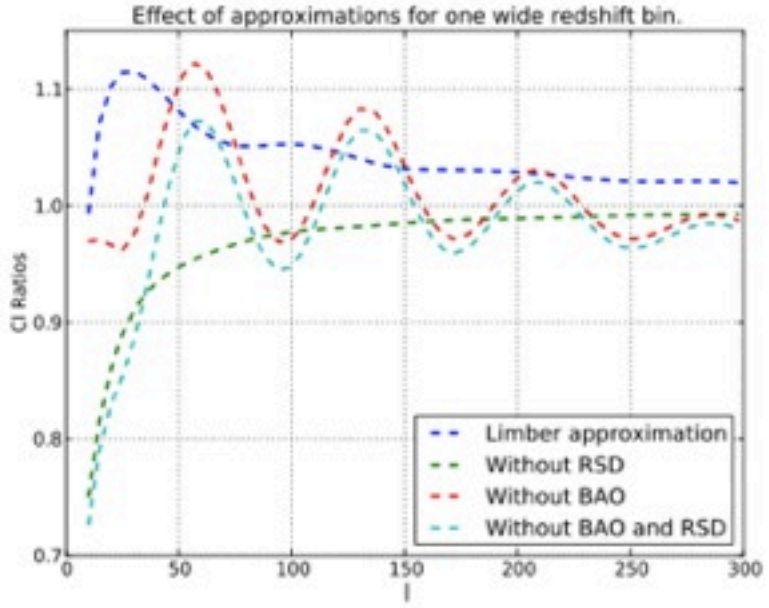
F+B= No overlap => no cross $\langle FB\rangle=0$ & no Covariance : $\langle FF\,BB\rangle=0$

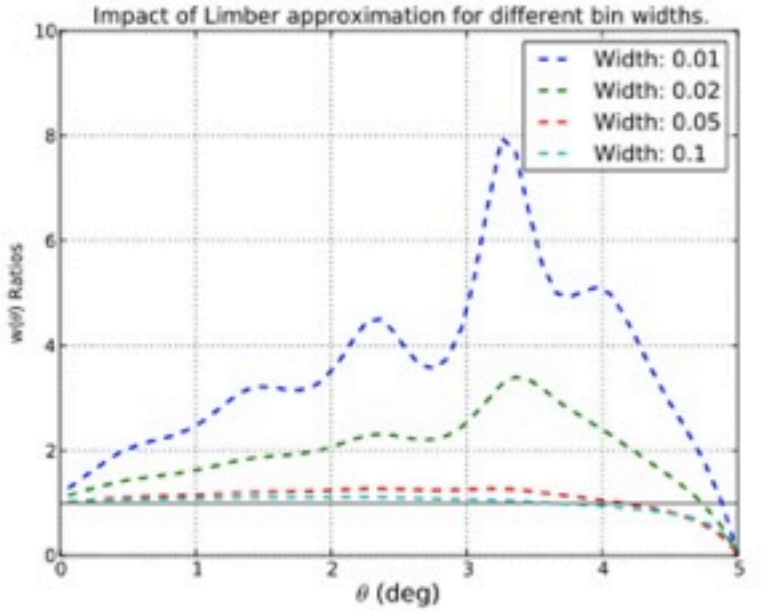
FxB= Overlaping => $\langle FB\rangle\neq0$ & $\langle FF\,BB\rangle\neq0$

New Forecast based on Exact calculation with narrow 2D z-bins









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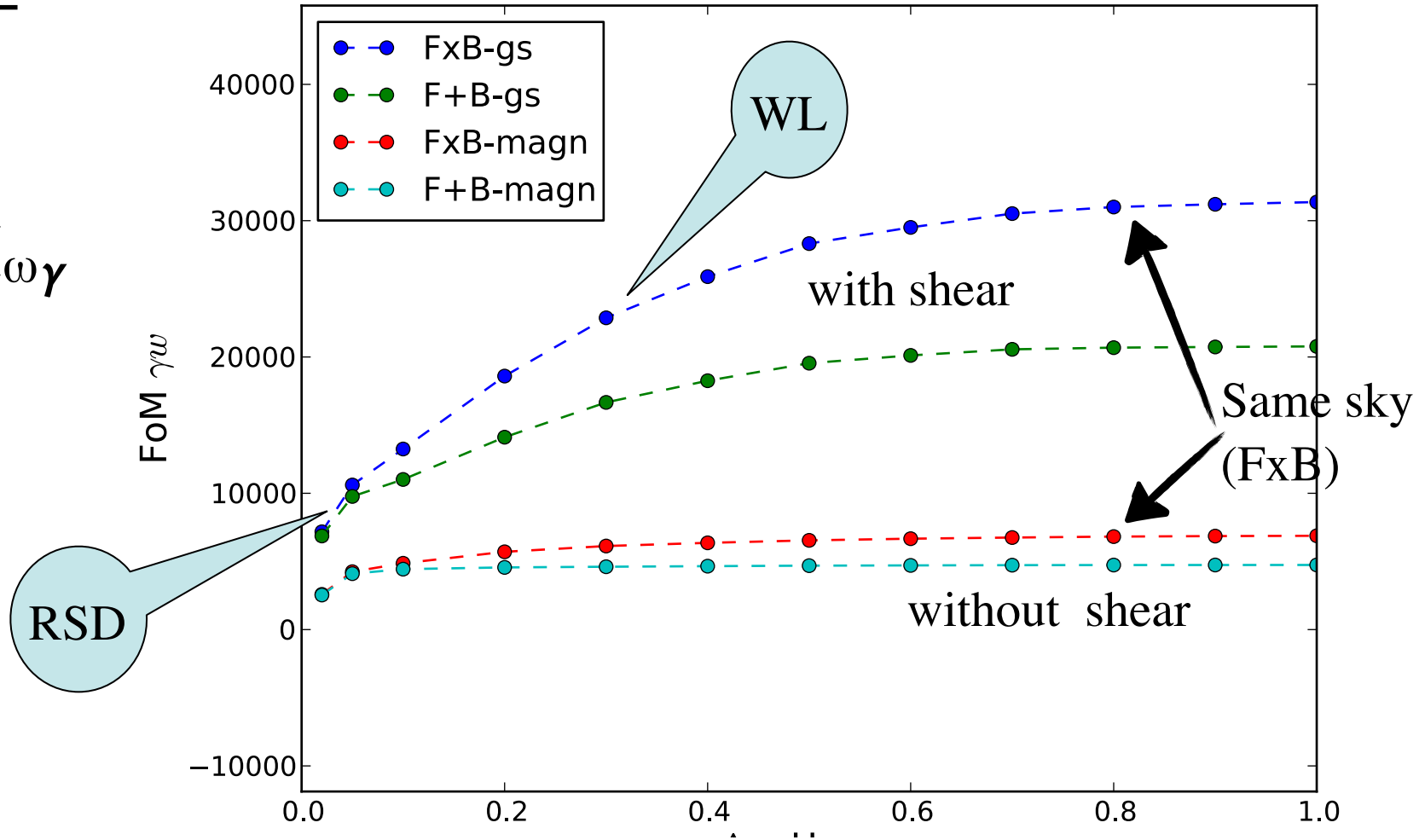
Adding crosscorrelation between redshifts

FoM increases as we add more cross-correlations $|z_i-z_j|<\Delta z$ due to RSD and WL

$\mathrm{FoM}_{\omega\gamma}$



Our new Exact Calculation Forecast:

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14000 sq.deg.

WLxG*+RSD+BAO (cross $C\ell$: ℓ<300 + Planck priors)	$\mathrm{FoM}_{w\gamma} \times 10^3$
F Photometric (DES i_{AB}<24)	**2.6** / **fix bias 38** ***no lens* 0.03 /*no BAO* 2.0/no RSD 2.1**
B Spectroscopic (PAU i_{AB}<22.5)	**6.7**/ **fix bias 44** ***no lens* 4.1 /*no BAO* 4.3/no RSD 2.5**
F+B Combine both as Independent	**21** / **fix bias 157** ***no lens* 4.7 /*no BAO* 13/no RSD 9**
FxB CrossCorrelated over same Area	**32** /**fix bias 189** ***no lens* 5.9 /*no BAO* 22/no RSD 15** **no cross FB: 26!**

*WLxG: shear-shear, galaxy-shear, galaxy-galaxy (including MAG)

FxB (no cross) > F+B

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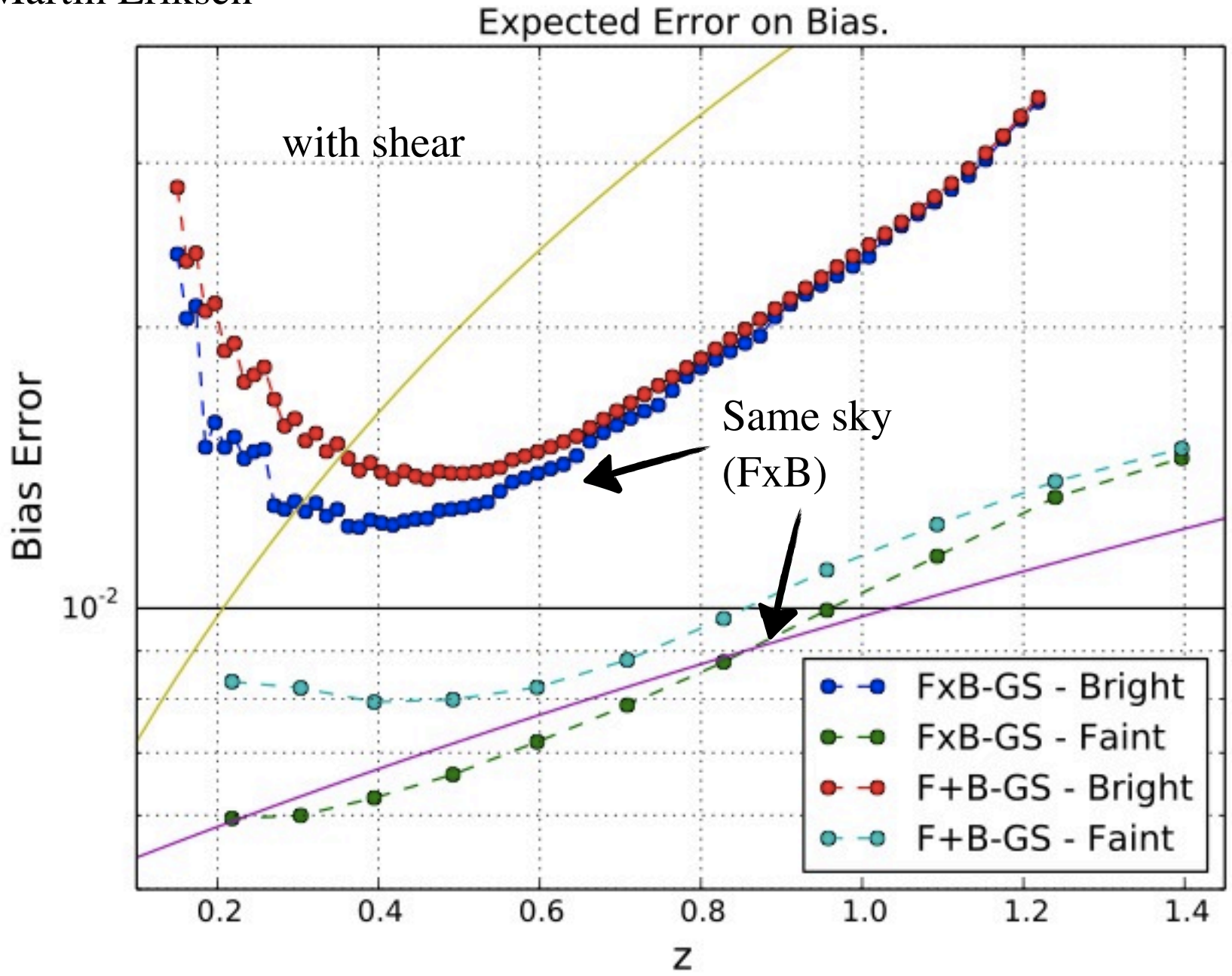

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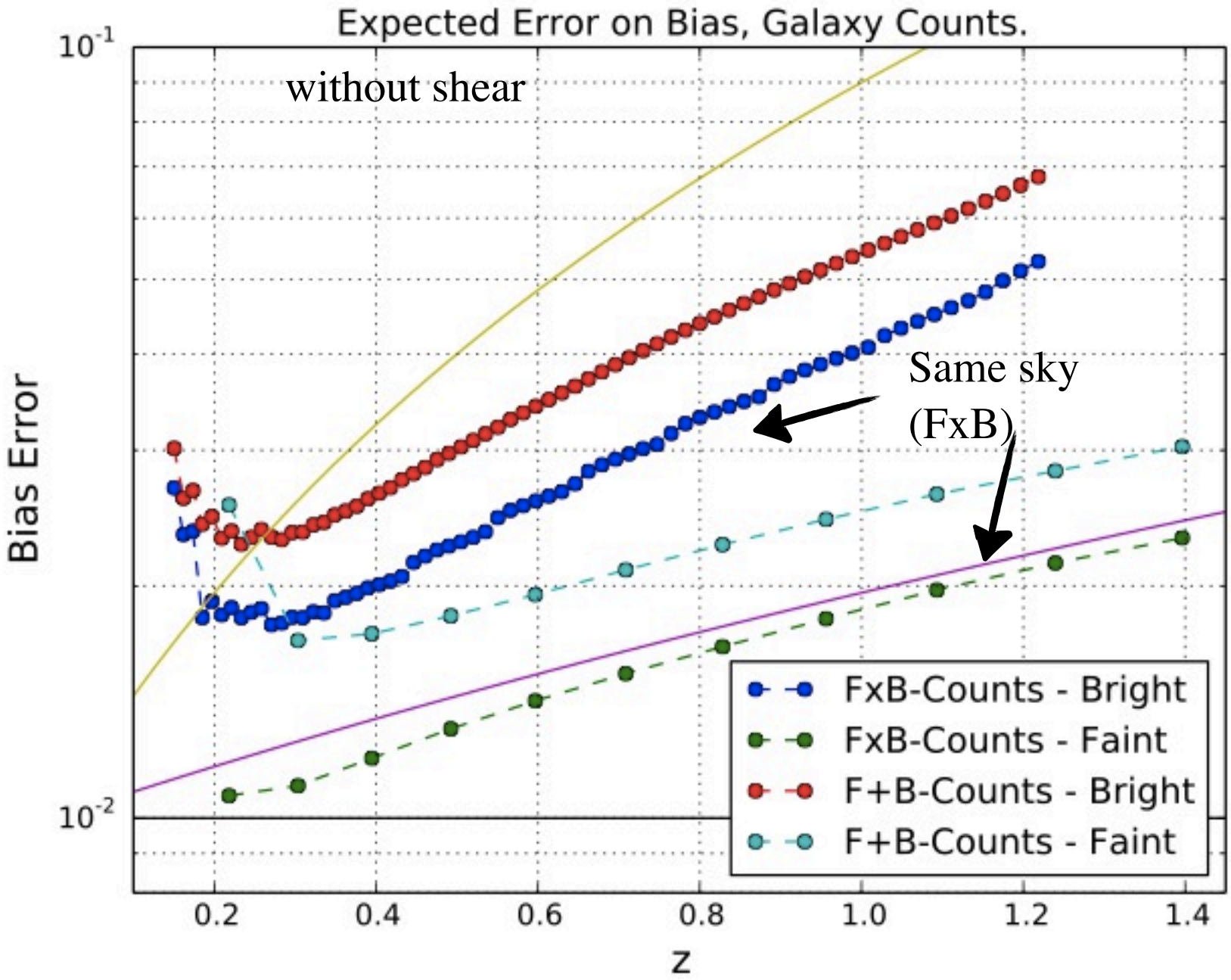
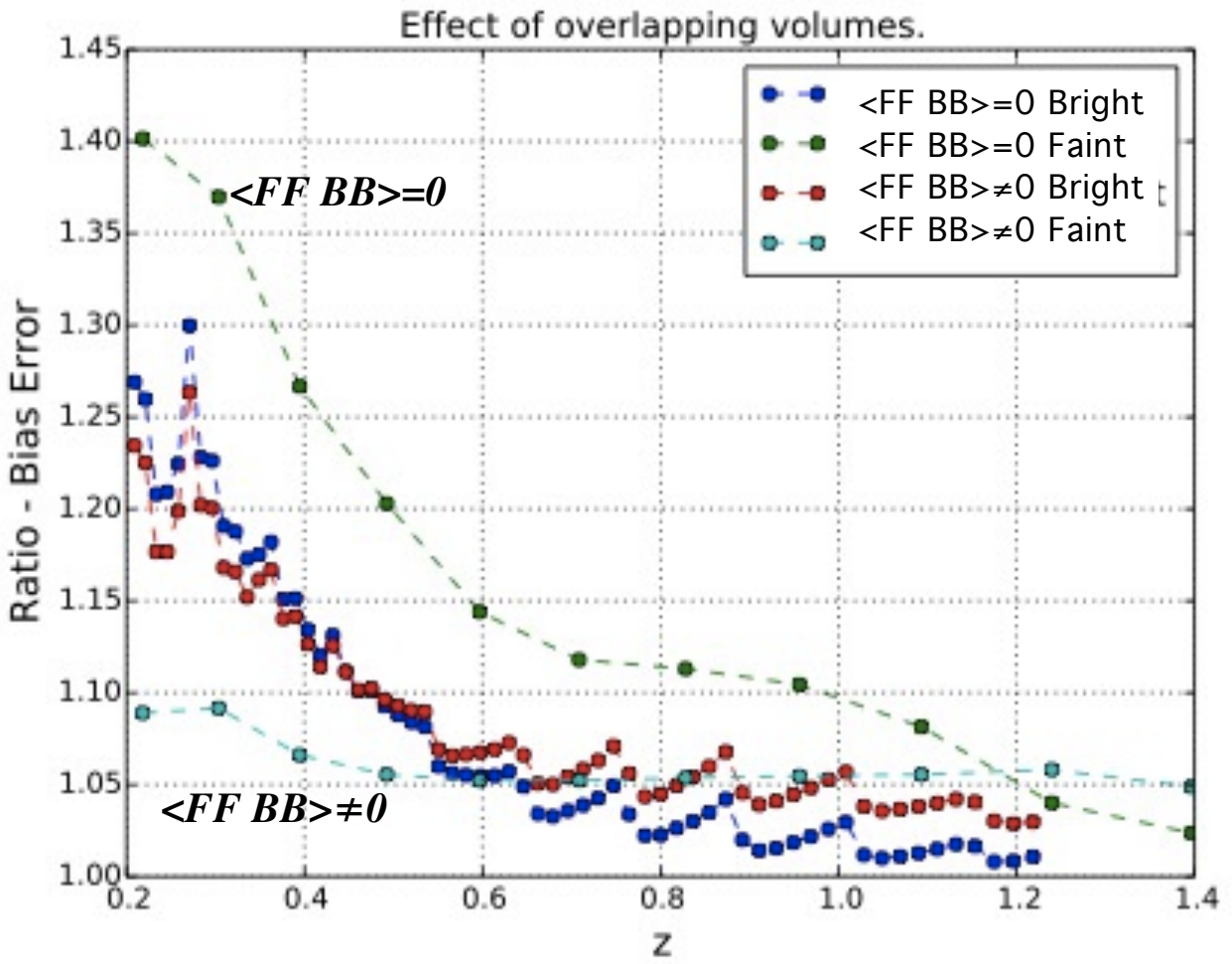


Error in bias for <FB>=0 (without cross-correlation)

Compare cases: <FF BB>=0 with <FF BB>≠0 (same sky)

ratio relative to the case <FB>≠0 and <FF BB>≠0



Including Covariance Reduces Error in F bias (but not in B bias)

Including Cross-correlation Reduces Error in F & B bias

Implications for Bias:

Several ways to constrain a simple linear bias model: WL, RSD

Can use 2D cross-correlations to combine (3D) RSD with WL

Cross-correlations <FB> improve bias measurements (and FoM)

F and B populations can reduce cosmic variance (RSD and ratio bias)

F linear bias (from WL and counts) is better constrained, but B sample provide better FoM. The combination is best over the same sky.

FoM ***(when bias is known) can be ~100 better than BAO or WL!***

Low radial accuracy (~20Mpc/h) for linear scales => PAU photo-z

THE END

thank you!