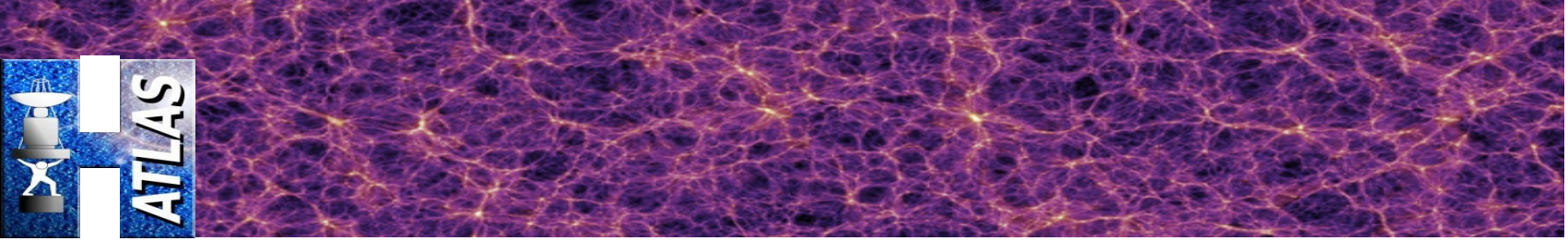


Weak lensing ubiquity in sub-mm surveys

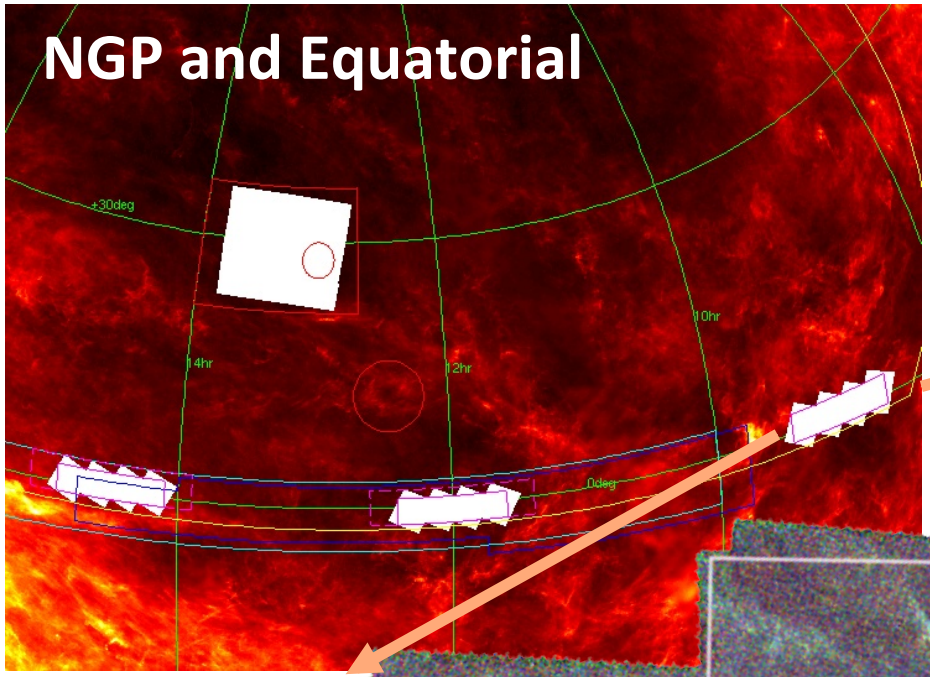
J. Gonzalez-Nuevo,

on behalf of the Herschel-ATLAS collaboration

Meeting on Fundamental Cosmology

Santander 2015

The Herschel-ATLAS (~500 sq. deg.)



Largest Open-Time Area Survey on Herschel (PIs: Eales and Dunne)

http://www.h-atlas.org/

"GAMA-9h" field
~53 sq. deg

SDP field
~14 sq. deg

Phase-1 data (~160 sq. deg):
GAMA9+GAMA12+GAMA15

Sample selection

Background → H-ATLAS

~2000 sources/tile

photoz> 1.5

Foreground → SDSS

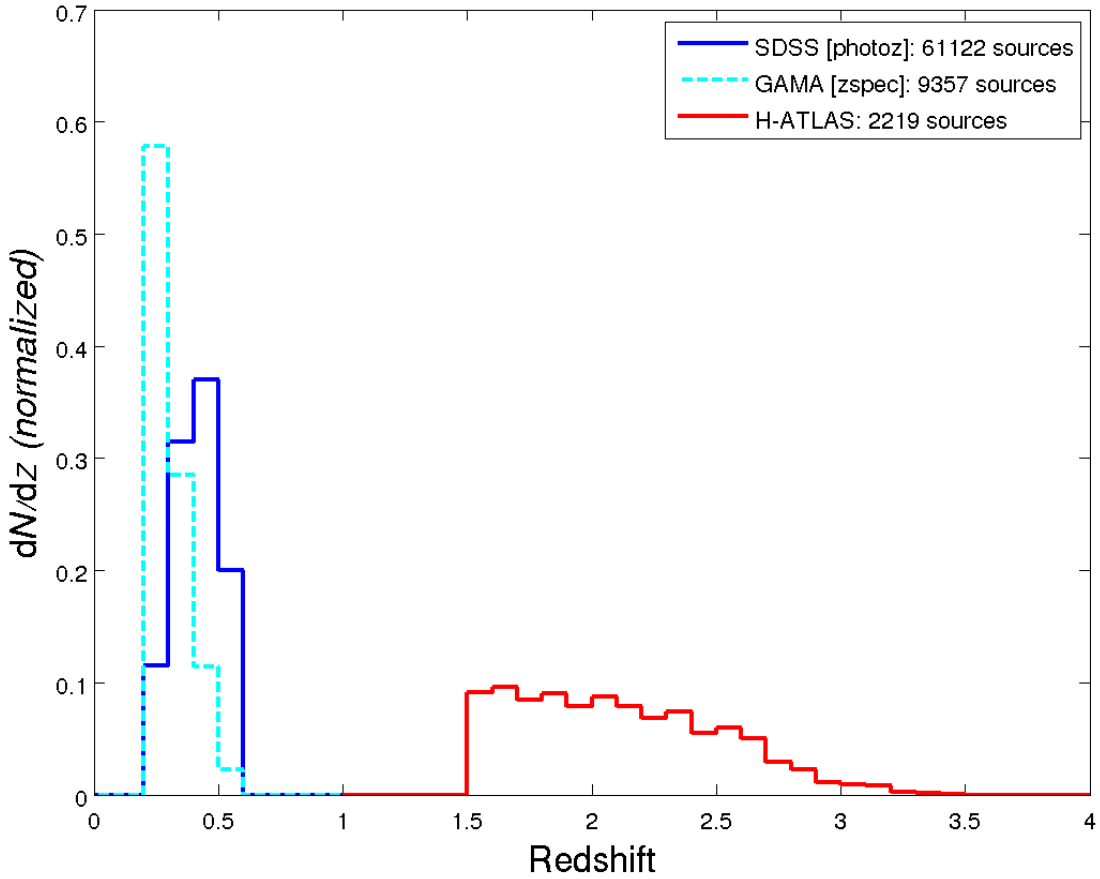
~$6x10^4$ sources/tile

0.2 < photoz < 0.6

Foreground → GAMA

~9000 sources/tile

0.2 < zspec < 0.6



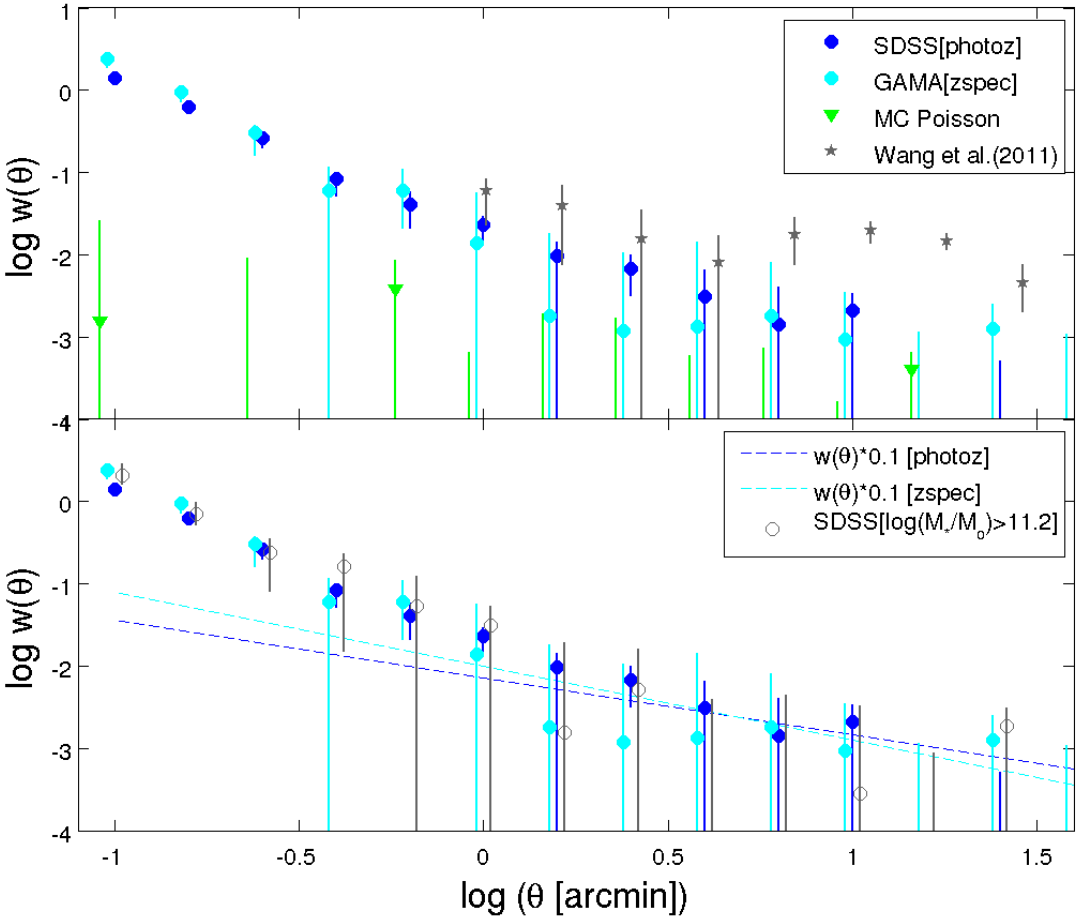
GAMA (Galaxy And Mass Assembly; Driver+11)

Cross-correlation (H-ATLAS vs SDSS/GAMA) [Gonzalez-Nuevo et al. 2014]

- Modified LS estimator

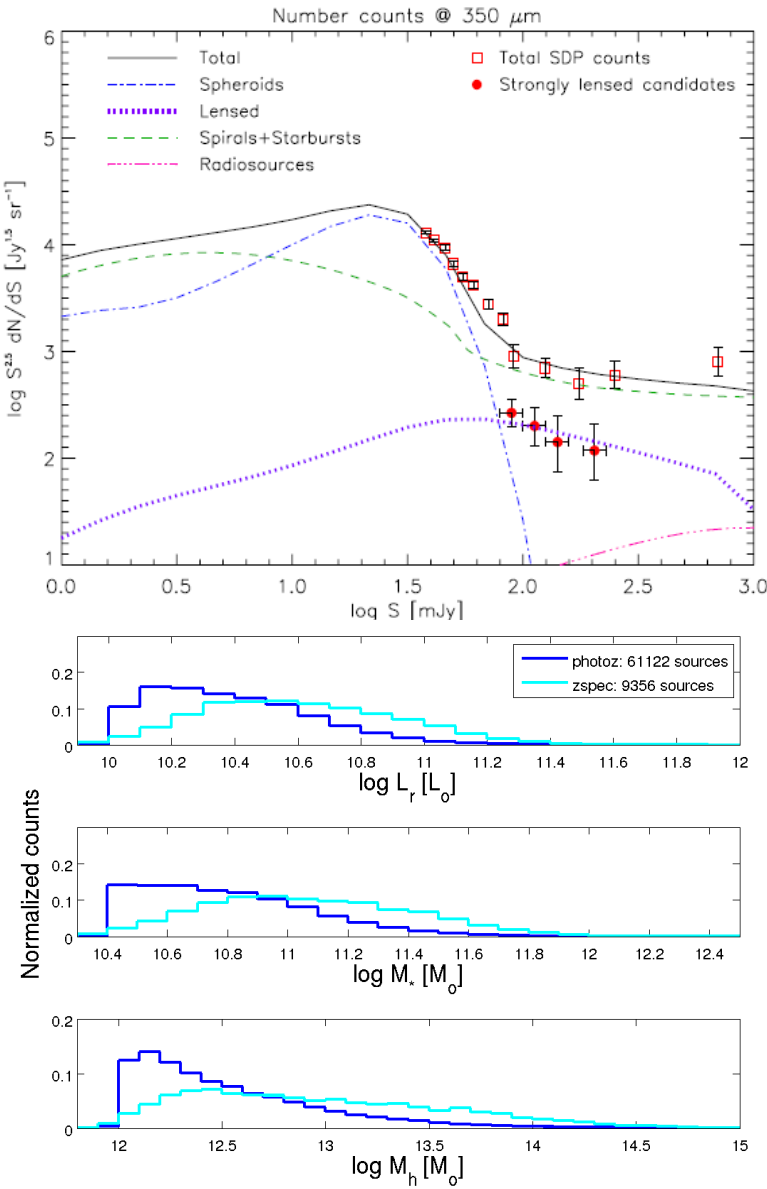
$$w_{\rm cross}(\theta) = \frac{D_1D_2 - D_1R_2 - D_2R_1 + R_1R_2}{R_1R_2}$$

- Signal detected up to ~30 arcmin
- Highly significant below a few arcmin (>10σ)
- Signal produced mainly by massive galaxies
- $\log(M_*/M_\odot)>11.2$; [grey circles]
- Foreground samples autocorrelation scaled down by a factor ~15 match X-corr on scales > 1 arcmin !



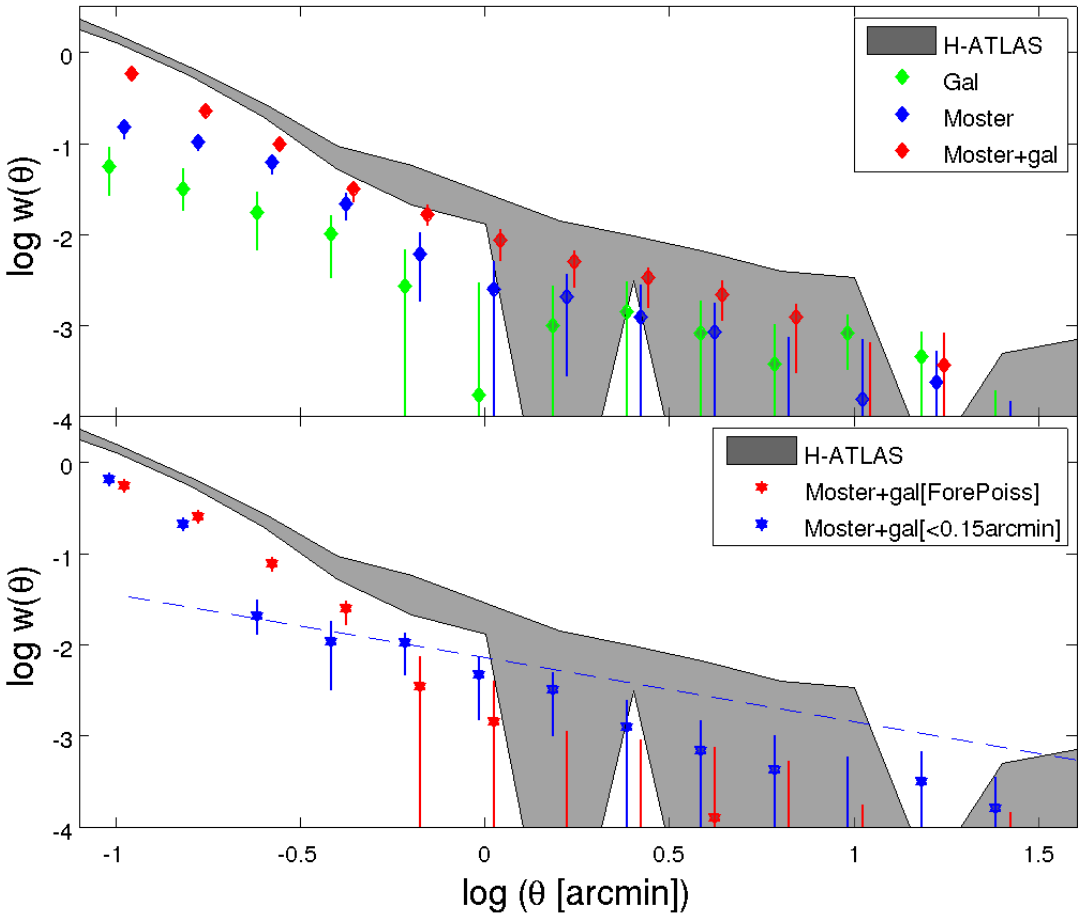
Simulation setup

- Foreground sample → fixed
- Background sample → Gonzalez-Nuevo +05 simulation algorithm
- Lapi+11 numbers counts and z- distribution
- Lapi+12 weak lensing formalism
- Lr - Mhalo relation:
- Shankar+06: “Galactic” deflectors
- Moster+10, +13: “Super-galactic” deflectors
- Typically ~2000 realizations



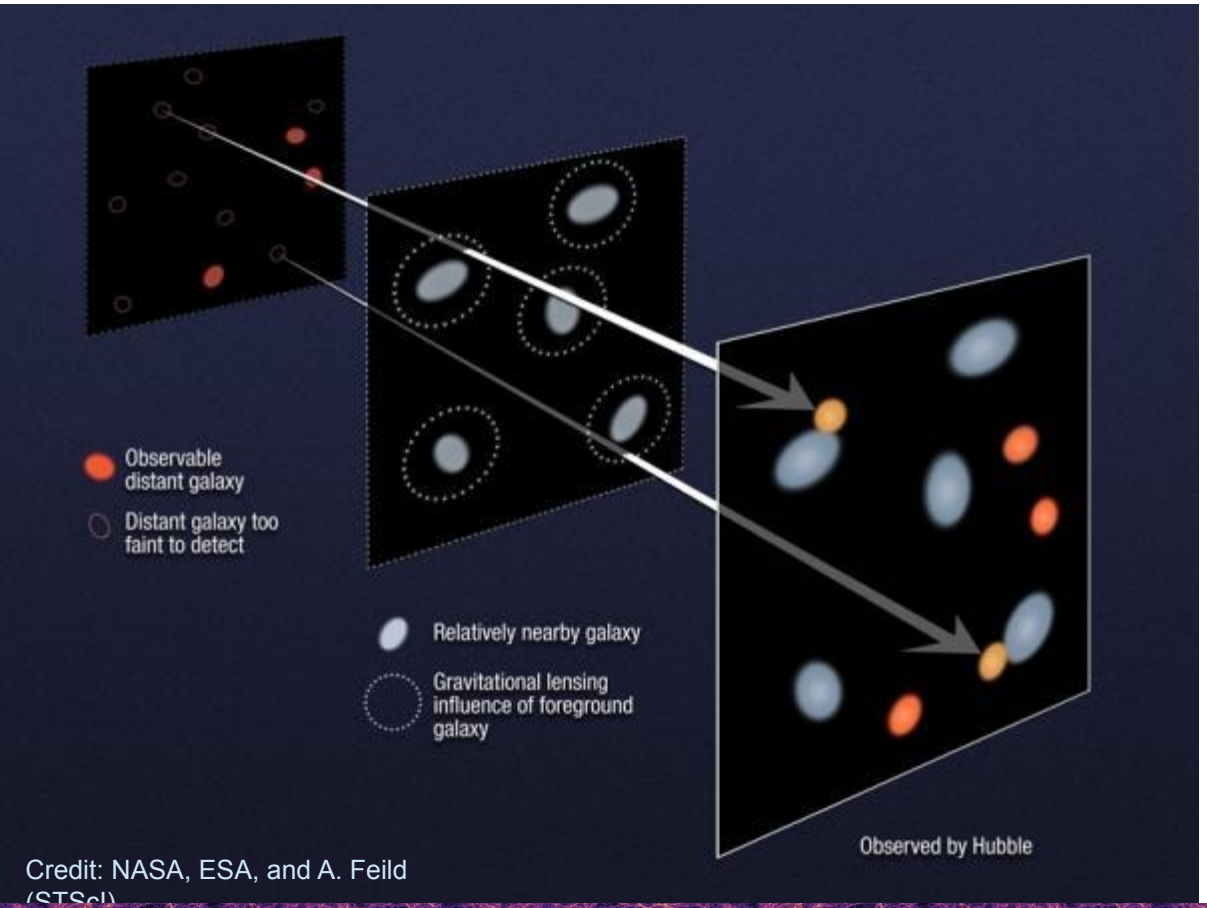
Simulations main results

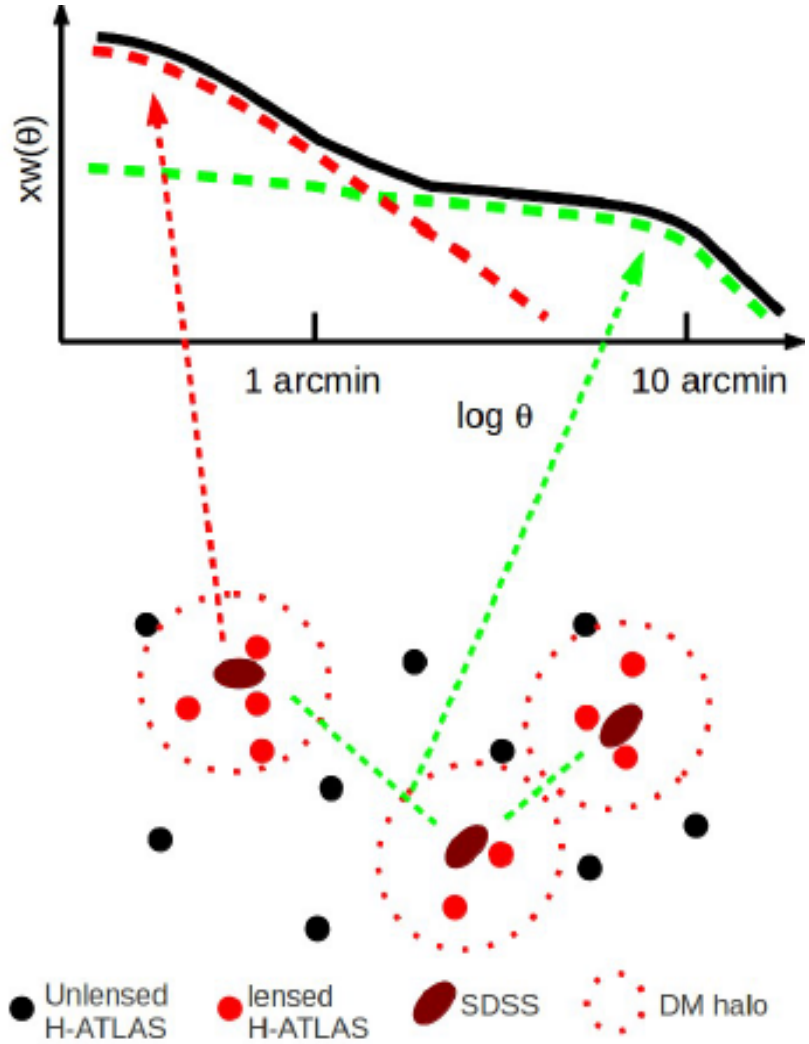
- Gravitational lensing from galactic structures is not sufficient to explain observed Xcorr
- Weak lensing by super-galactic halos (+satellites) around SDSS sources alleviates the discrepancy
- Below 1 arcmin direct effect of lensing (tested with random-random sample sims).



Simple interpretation: magnification bias

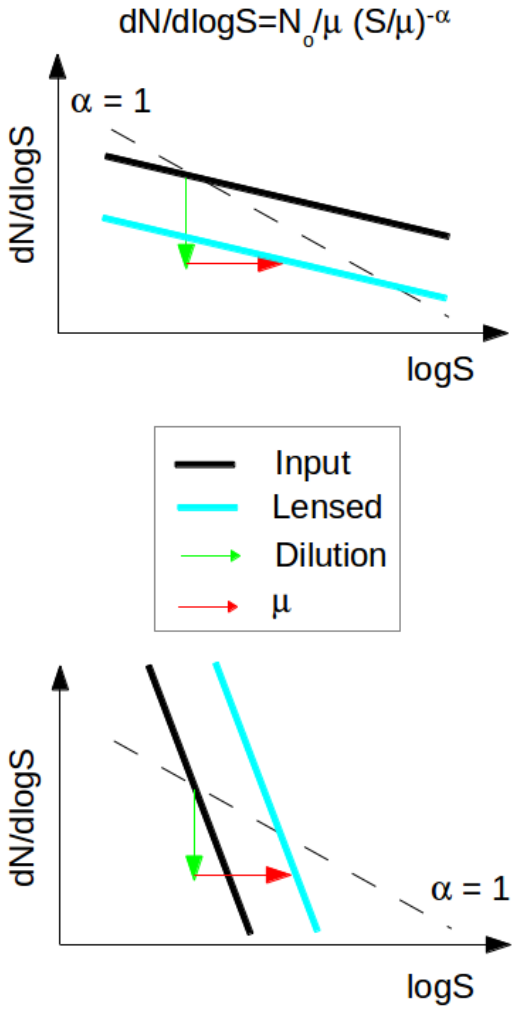
Xcorr signal produced by weak lensing from super-galactic halos being signposted by the SDSS sources.





H-ATLAS high-z: An optimal sample

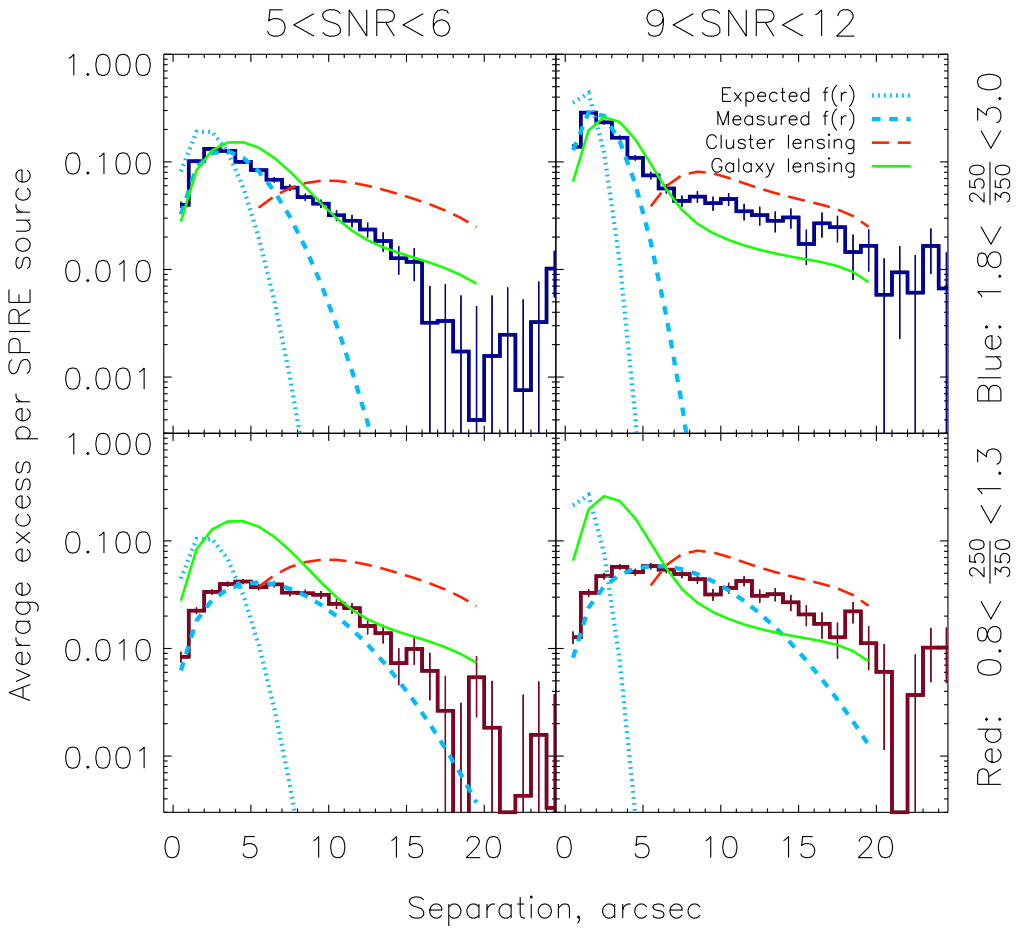
- Probably the best significance (>10σ) for samples with non-overlapping redshift distributions
- Steepness of the background sample number counts (α> 3; α~ 5)
- *Scranton et al. 2005: SDSS vs QSO (α<2)*



- Overall, higher significance using lower number of sources (10^4-10^5 vs 10^6-10^7 in SDSS analysis)
- Opens the possibility of tomographic analyses for current/future surveys (GAMA, JPAS, Euclid)
- The main limitation would be the redshift accuracy

Colour matters: Bourne et al. (2014)

- Study of the effect of lensing on the positional offsets between optical and sub-mm galaxies
- Misidentification of high-z counterparts is more common than though!
- Not only by rare "*strongly lensed galaxies*" but also due to ubiquitous weak lensing.
  - ALMA observational proposal to verify this hypothesis



Lensing *simulated* predictions are upper-limits

CMB/HATLAS high-z sources cross-correlation

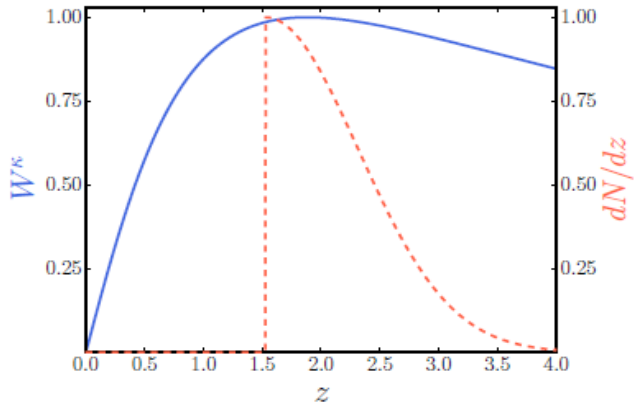


Fig. 1.—: Estimated redshift distribution of the full sample of H-ATLAS galaxies (dashed red line) compared with the CMB lensing kernel W^κ (blue solid line). Both the kernels are normalized to a unit maximum.

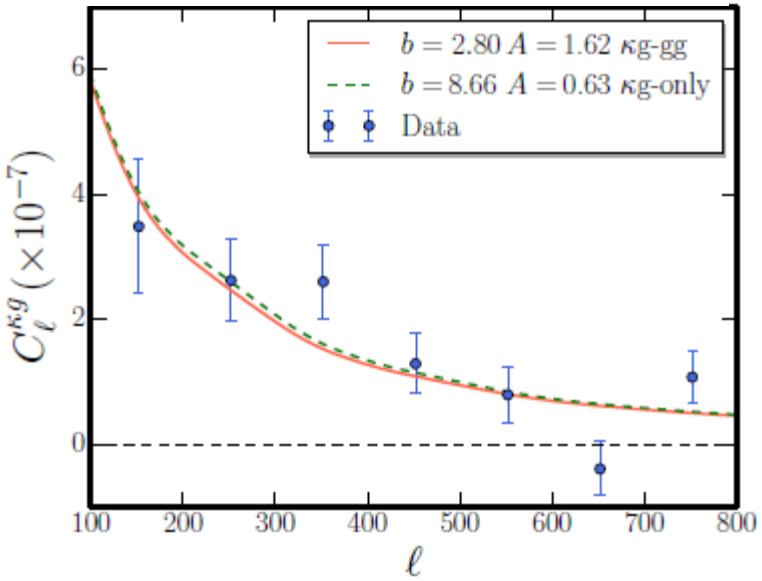


Fig. 9.— The CMB convergence - galaxy density cross-spectrum as measured from *Planck* and *Herschel* data. The data points are shown in blue, with error bars computed using the full covariance matrix obtained from Monte Carlo realizations of convergence maps. The theoretical spectra calculated with the bias values inferred from the likelihood analysis (as described in text) using the cross-correlation data only (solid red line) and the cross-correlation together with the galaxy auto-correlation data (dot-dashed green line) are also shown; we fix $\alpha = 3$ in this analysis. The null (no correlation) hypothesis is rejected at the 9σ level.

- Bianchini et al. (2015)
- High significant detection (> 9σ)
- The Amplitude discrepancy is mitigated by the magnification bias

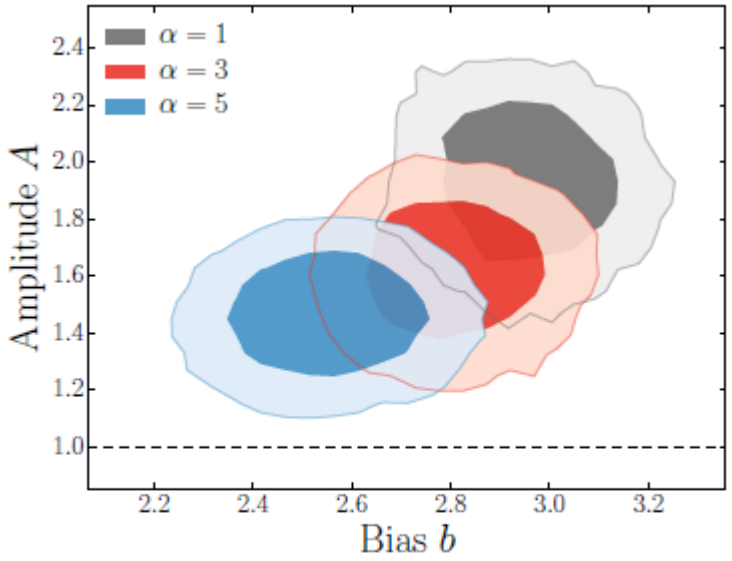
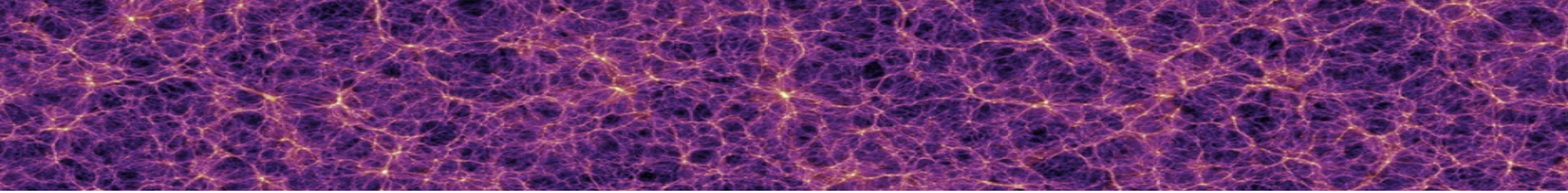


Fig. 16.— Effect of fixed slope of number counts α on the inferred values of cross-correlation amplitude A and bias b. We show $1-$ and 2σ contours (darker and lighter shaded regions respectively). As the α parameter increases, both A and b shift towards smaller values.

Conclusions

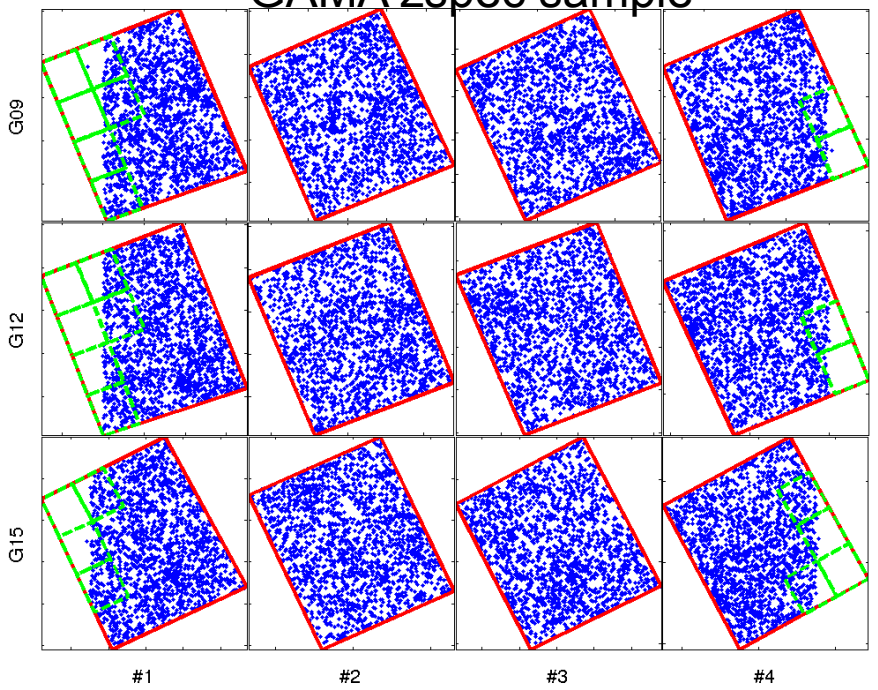
- Robust cross-correlation H-ATLAS vs. SDSS detected, not explained by Poissonian noise nor by weak lensing from galactic halos.
- Observed signal explained as weak lensing by super-galactic halos, signed-posted by SDSS sources. This interpretation [**magnification bias**] has been demonstrated with realistic simulations.
- High S/N with lower number of sources --> tomographic analysis limited by foreground redshift uncertainties --> Cosmology
- More results are reaching similar conclusions: i.e. excess of matches between optical low-z galaxies and H-ATLAS ones (Bourne et al. 2014) or interpretation of the CMB vs. high-z H-ATLAS galaxies cross-correlation (Bianchini et al. 2015).



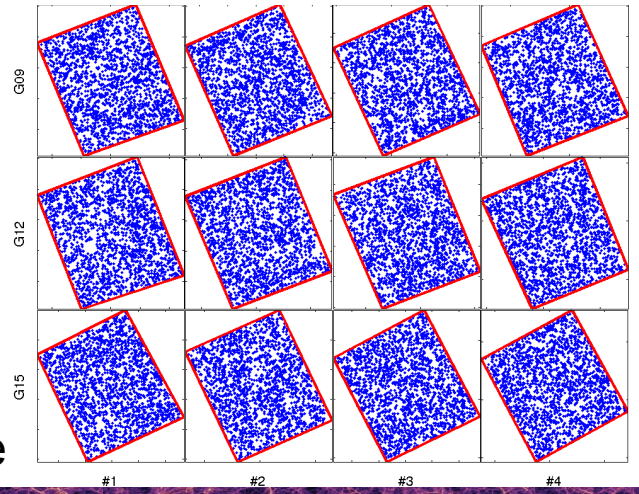
Tile definition

- 12 Tiles similar to the SDP area (red)
- To enhance statistics, we split each tile in 16 mini-tiles (green)
- Estimations for each mini-tiles and median statistics
- No full coverage with the GAMA zspec sample

GAMA zspec sample



SDSS photoz sample

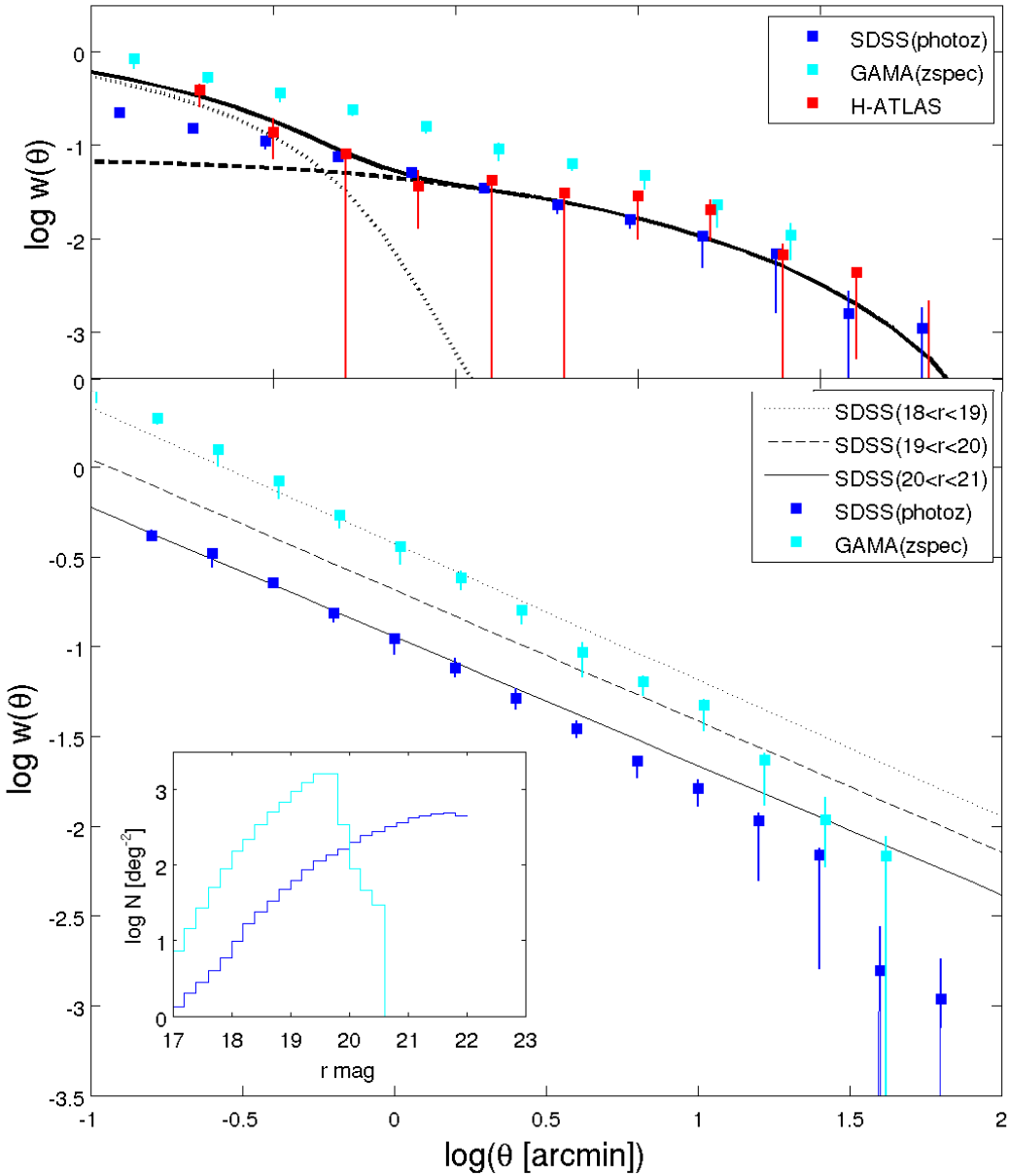


auto-correlation results

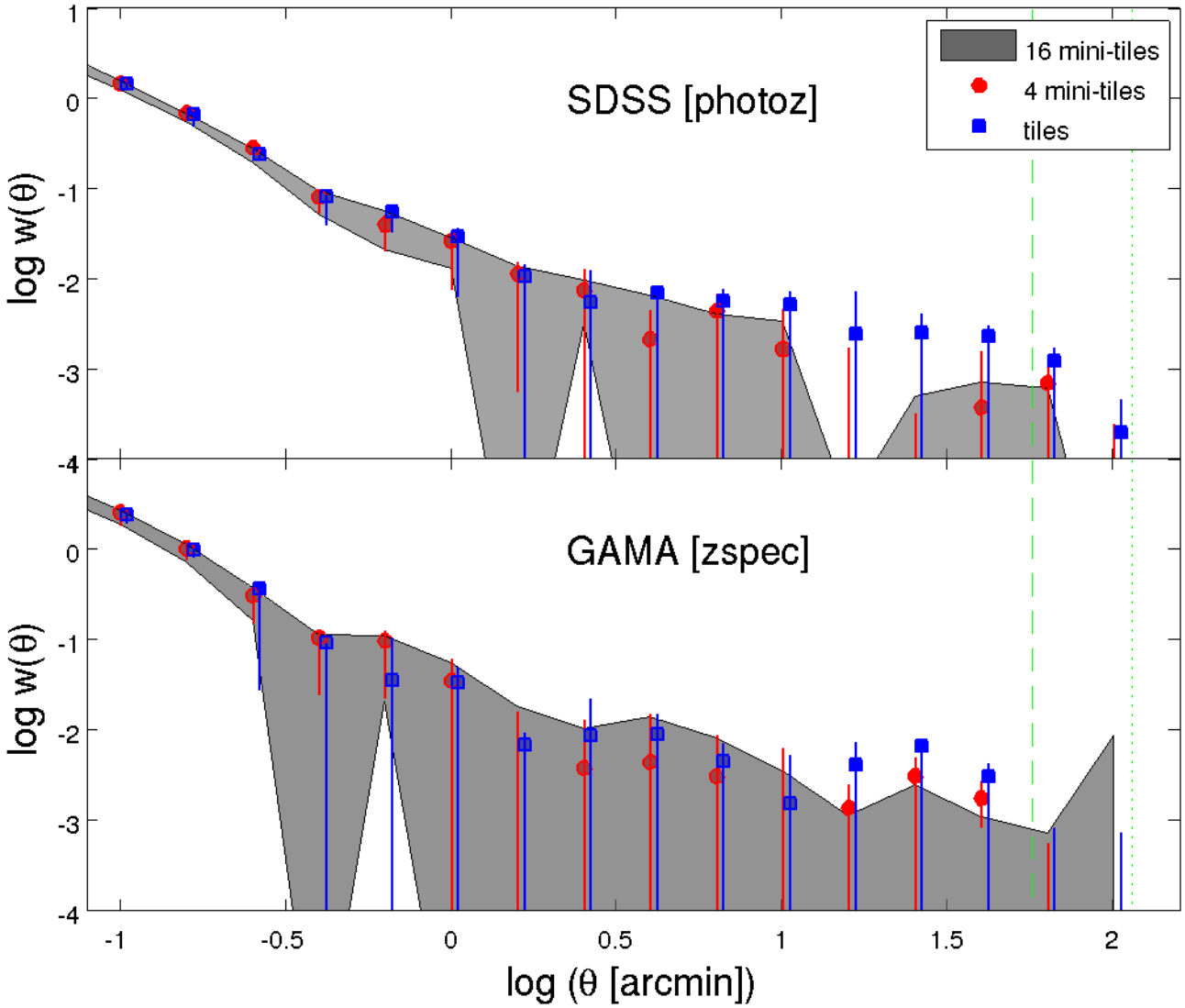
- Landy-Szalay estimator

$$w(\theta) = \frac{\mathrm{DD}(\theta) - 2\mathrm{DR}(\theta) + \mathrm{RR}(\theta)}{\mathrm{RR}(\theta)}$$

- H-ATLAS
- Signal detected up to ~50 arcmin
- Good agreement with the halo model based on photo-z distribution (Xia+12)
- SDSS/GAMA:
- Good agreement with auto-correlation of full SDSS split by r-magnitude interval (Connolly+02, Wang+13)

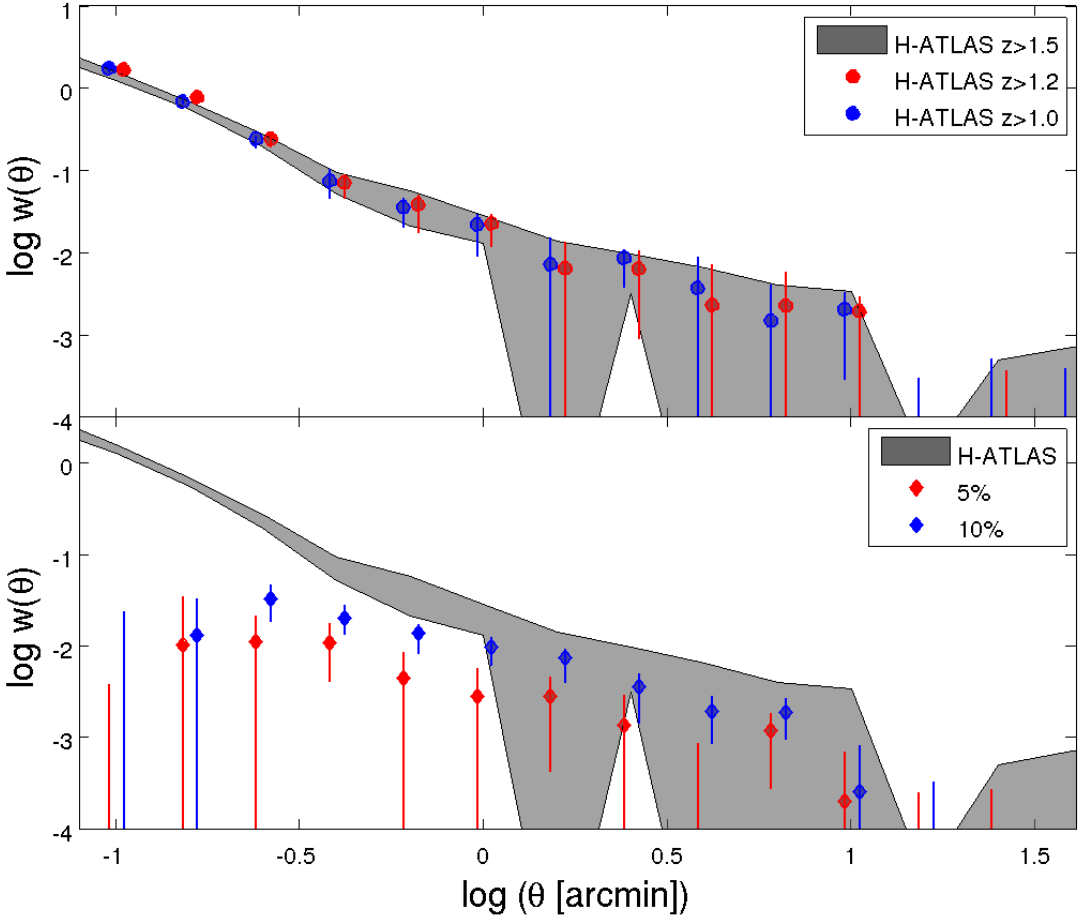


Tile size effects



Cross-contamination?

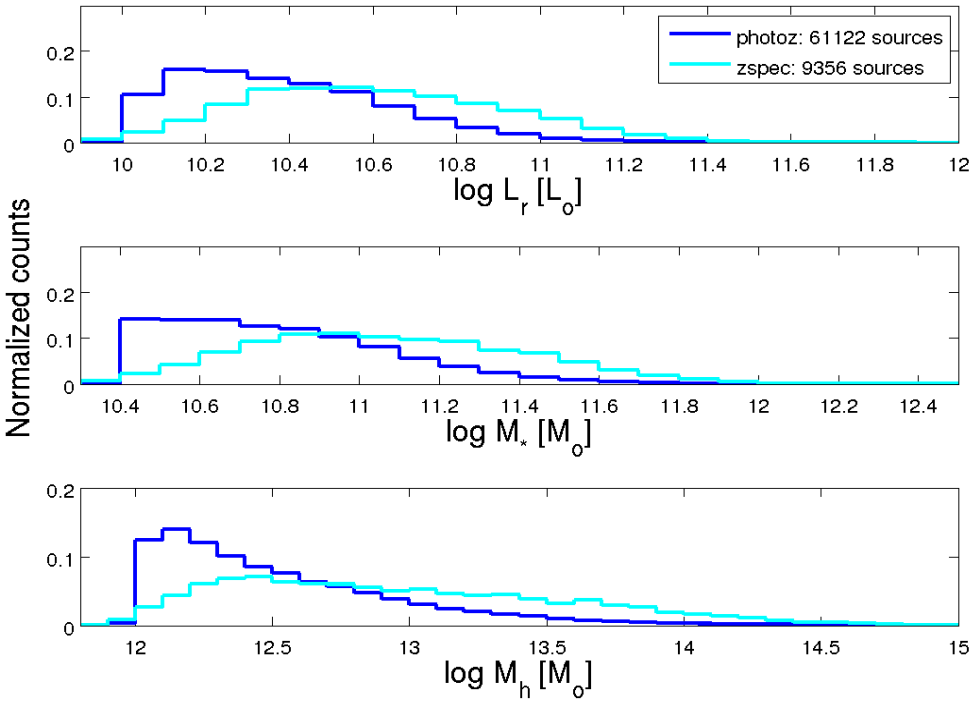
- SED considerations(<0.3%)
- Foreground magnitudes are too faint to account for the optical and the far-IR emissions at the same time
- VLA follow-up results (<10%)
- 24/27 with z>0.9
- Sample redshift lower limit
- “mismatched” simulations (<10%)
- a fraction of background sources are randomly selected and moved at the position of randomly selected foreground ones

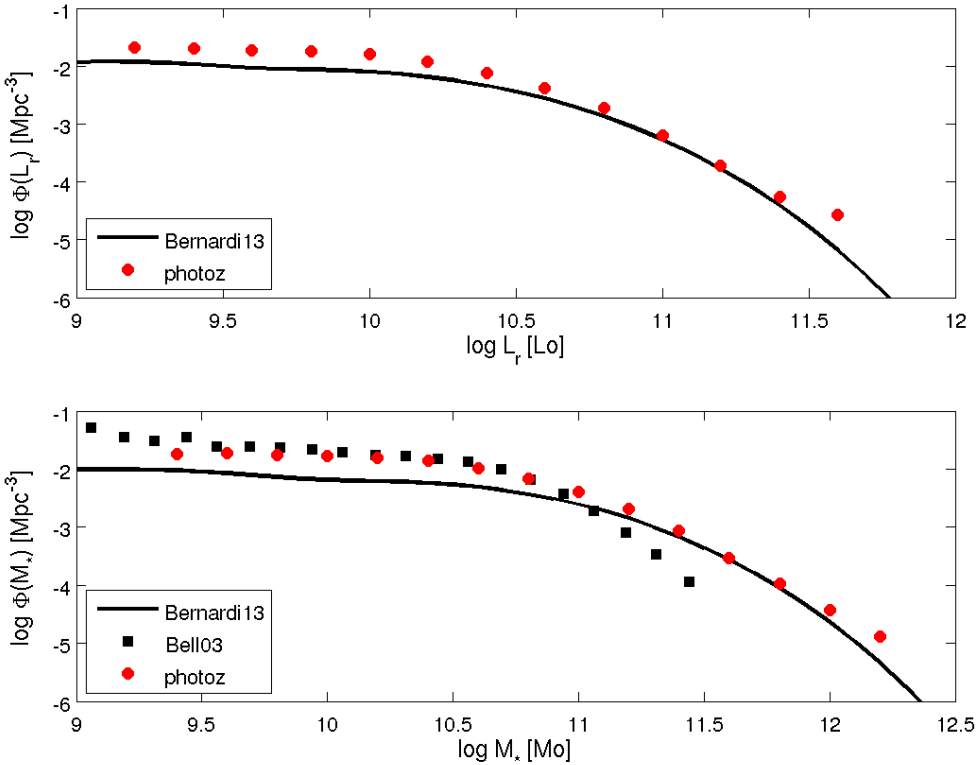


Simulation outcomes

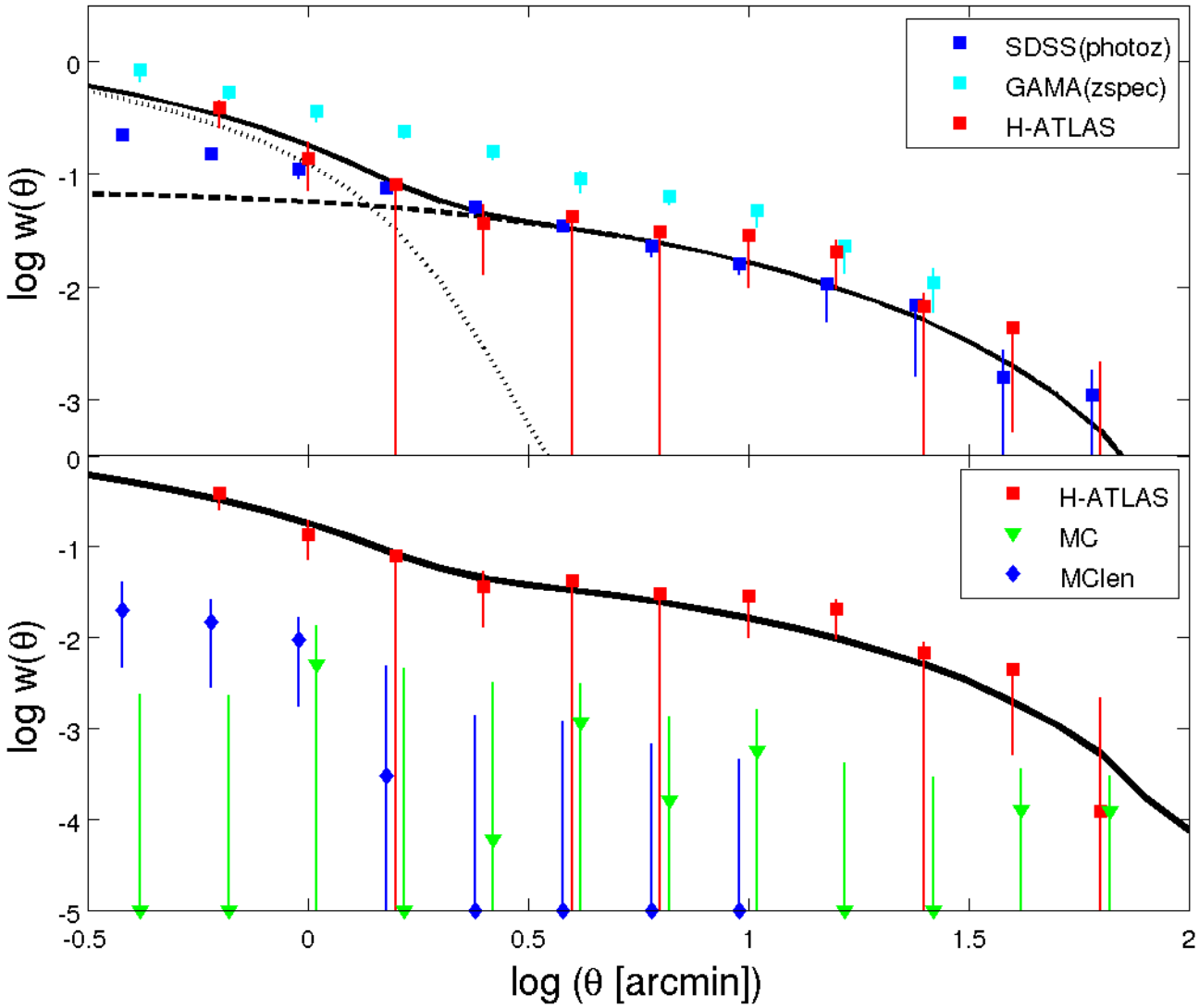
Distribution of r-band luminosities, stellar masses and halo masses

…consistent with the corresponding observed distributions.

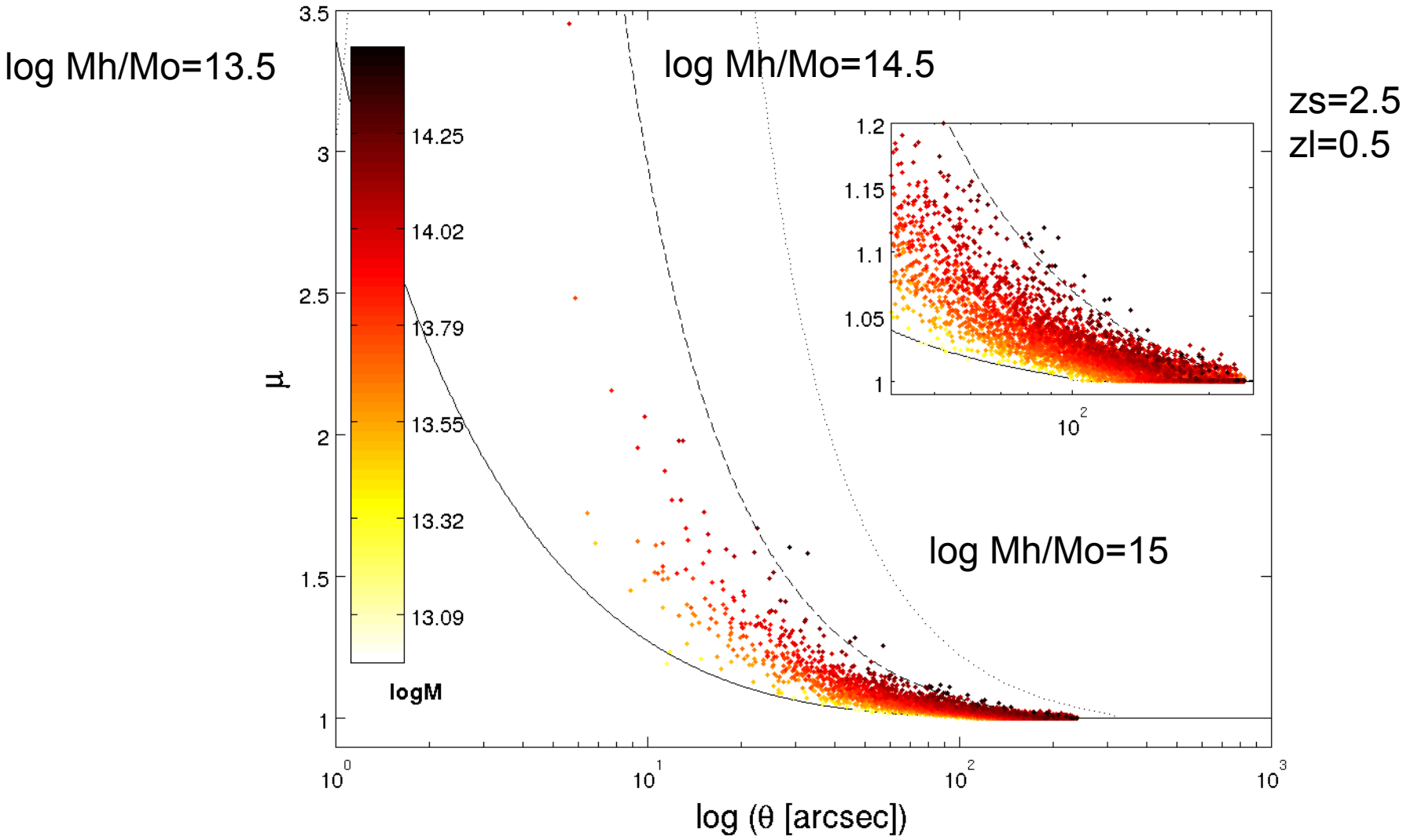




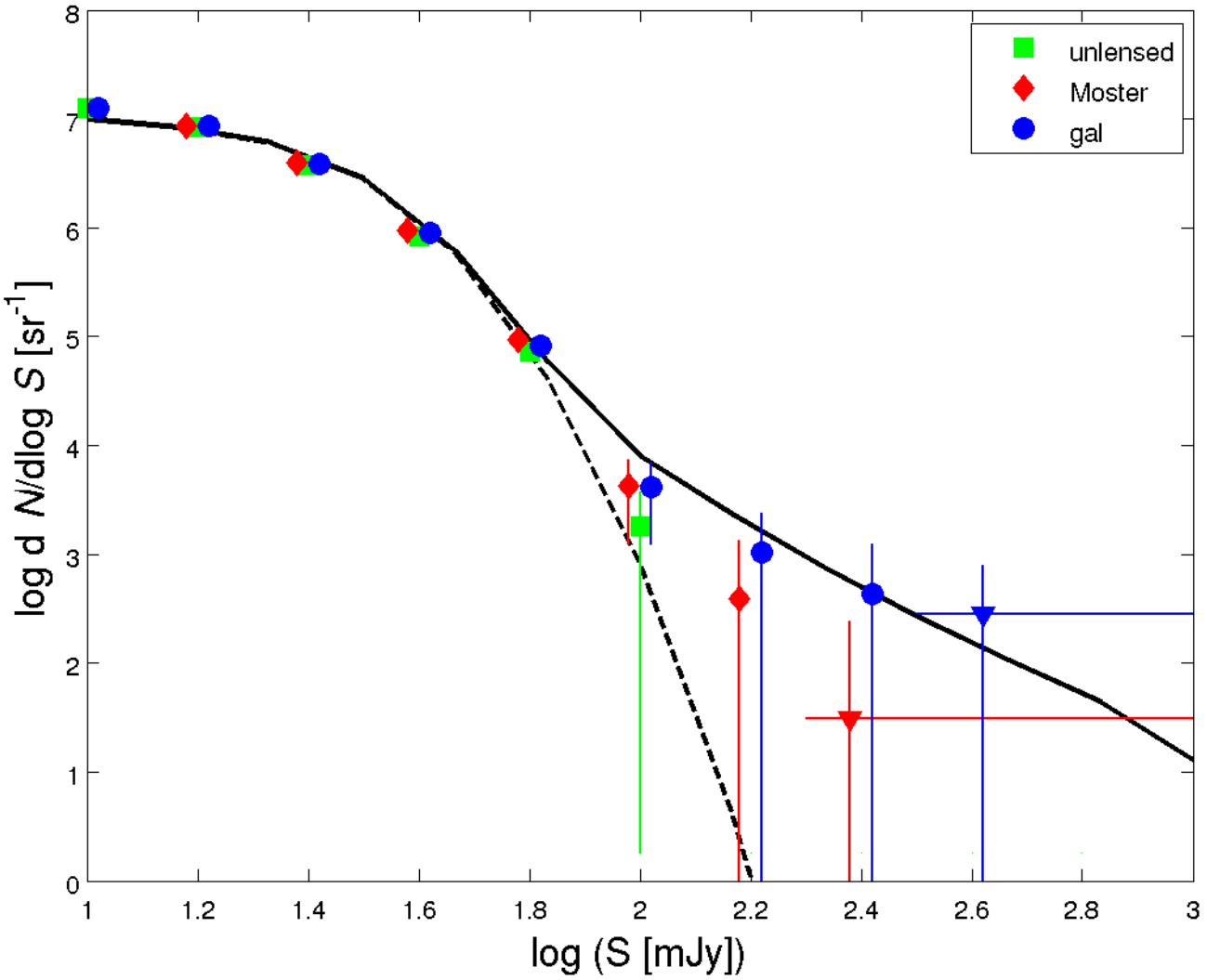
Auto-correlation induced by lensing



Lensing amplification diagram



Weak lensing effect in counts



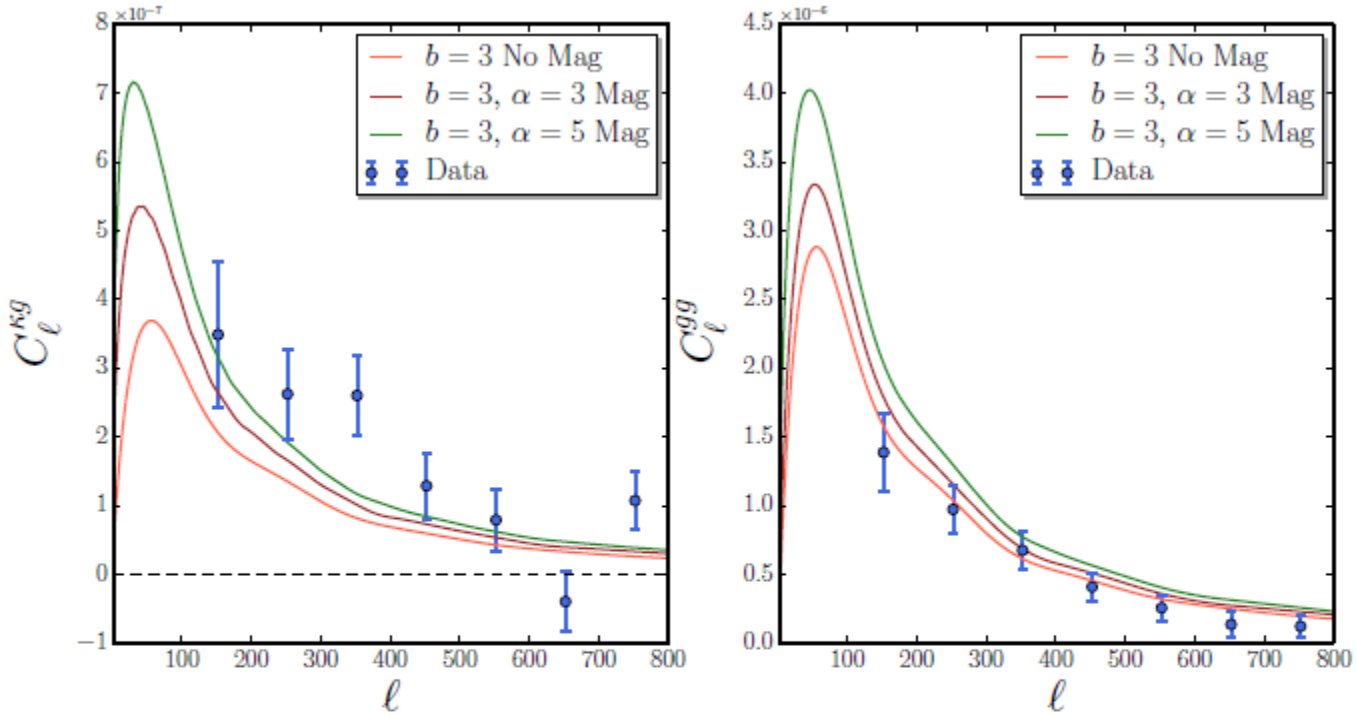


Fig. 15.—: Effect of lensing magnification bias on cross-power spectrum (left panel) and galaxy auto-power spectrum (right panel). In both panels theory lines are plotted for bias values $b = 3$ while the slope of the galaxy number counts as function of flux is set to $\alpha = 1$ (no magnification) and $\alpha = 3, 5$ as described in the legend.