THE CROSS-CORRELATION TECHNIQUE AND LENSING MAGNIFICATION

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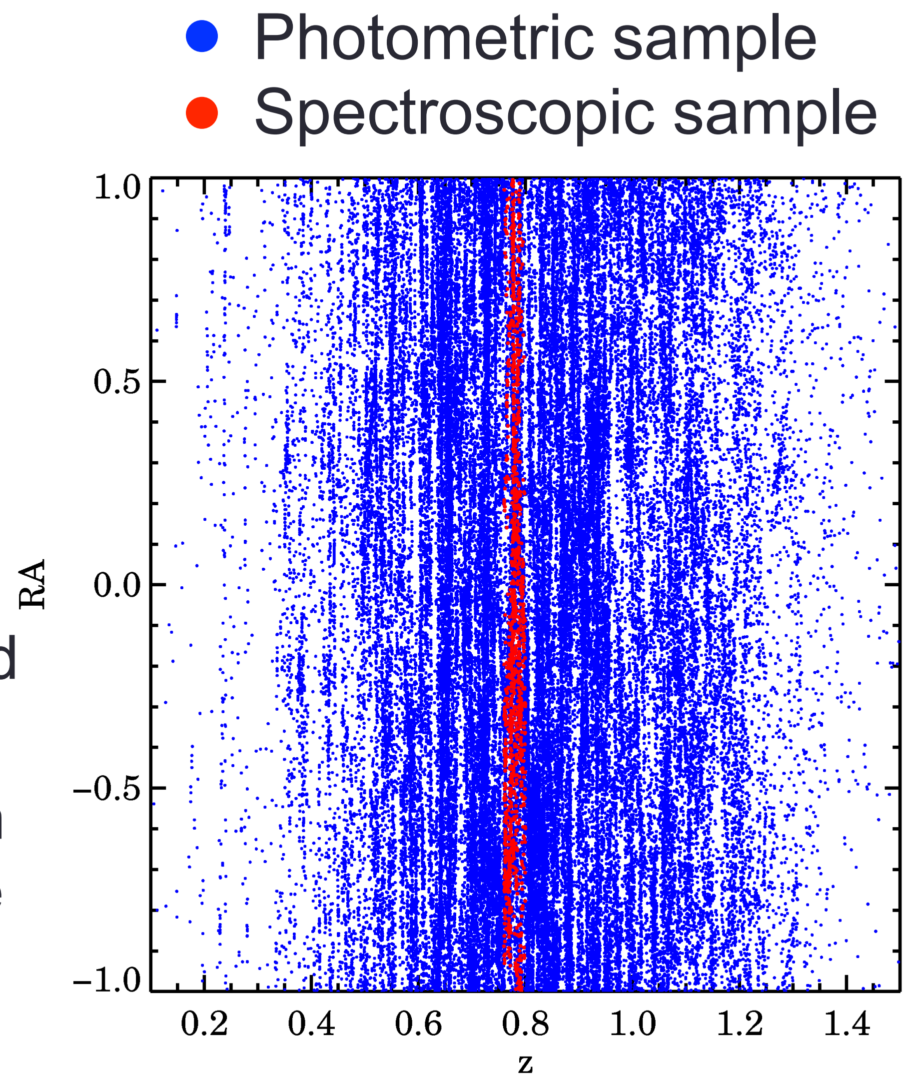
Cross-Correlation Method

- Two samples in the same region of sky
- Measure the angular cross-correlation between objects in the two samples as a function of spectroscopic z
- Basic idea:
  - Objects at similar redshifts tend to cluster with each other
  - The more overlap in z between the two samples, the larger the correlation amplitude is



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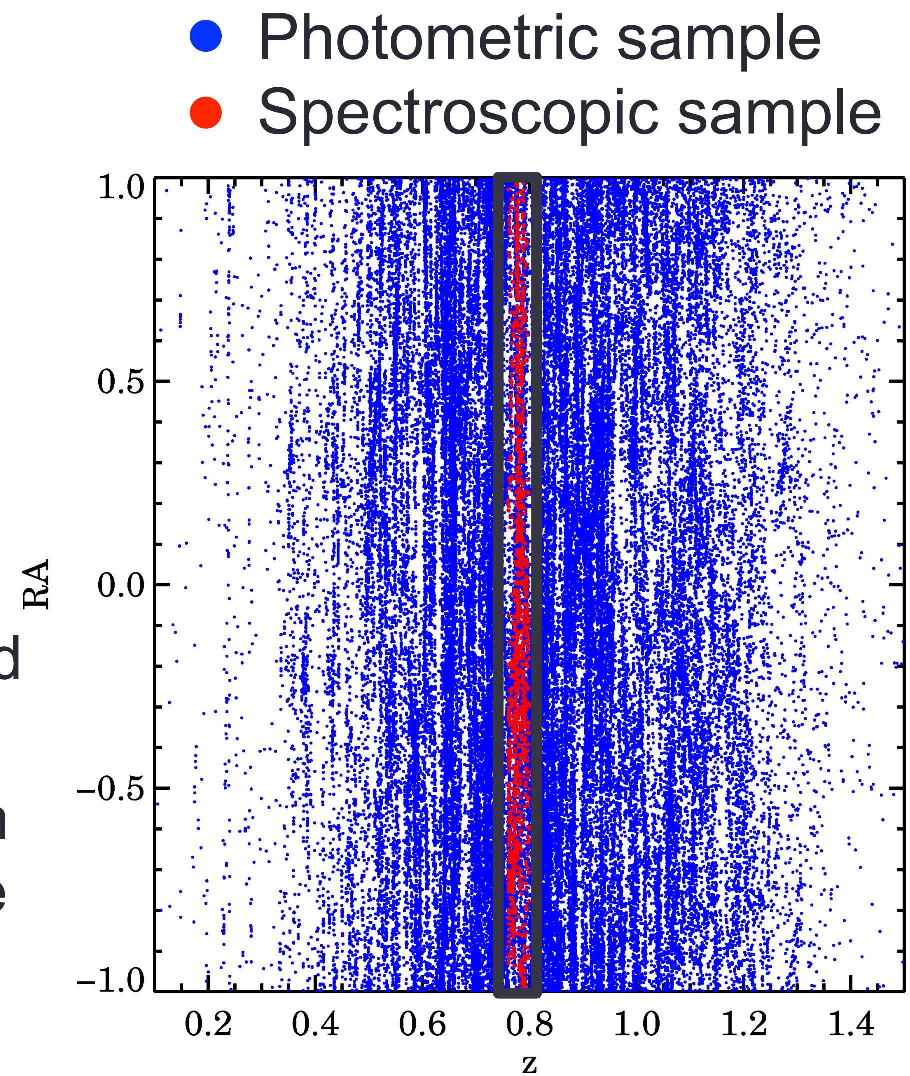

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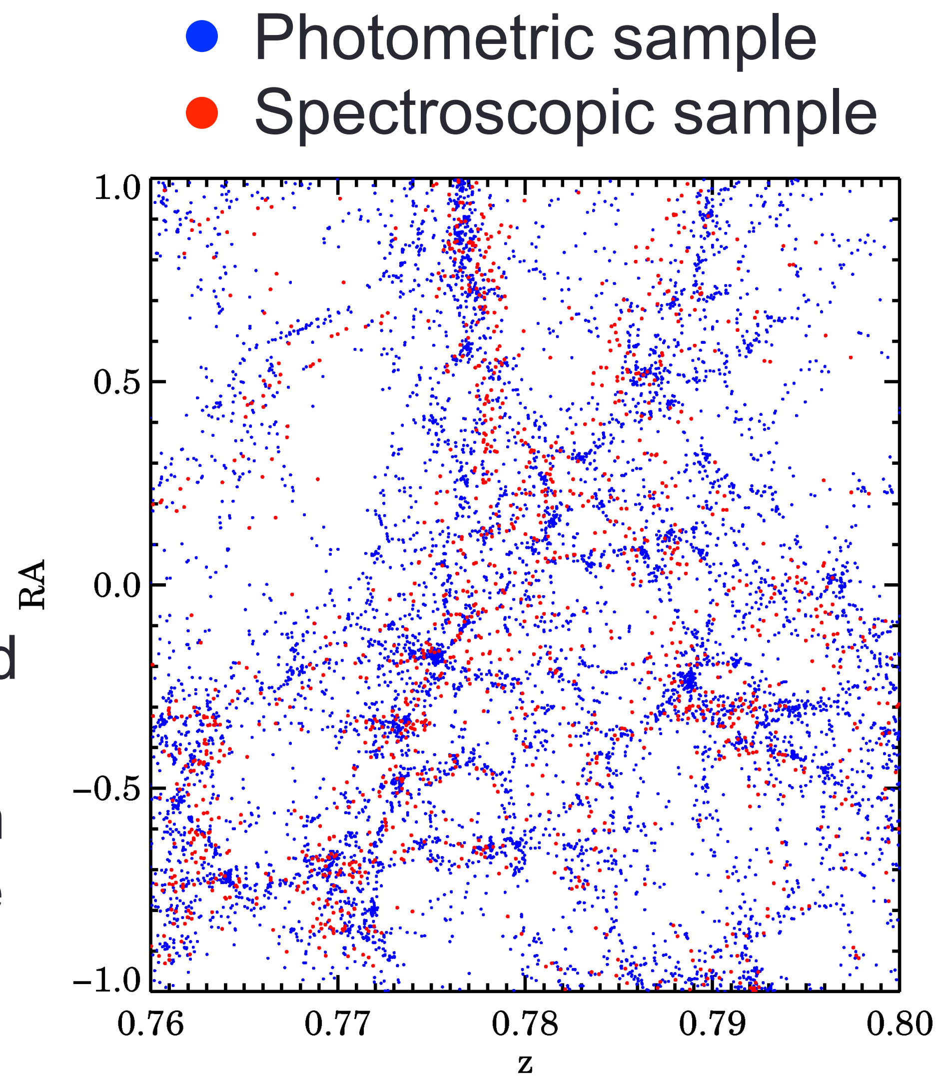


Cross-Correlation Method

- Model the real-space correlation function as a power law

$$\xi(r) = \left(\frac{r}{r_0}\right)^{-\gamma}$$

$$w_{sp}(\theta, z) \propto \underbrace{\phi_p(z)}_{\text{Redshift Distribution}} \underbrace{r_{0,sp}^{\gamma_{sp}}}_{\text{Intrinsic Clustering}} \theta^{1-\gamma_{sp}}$$

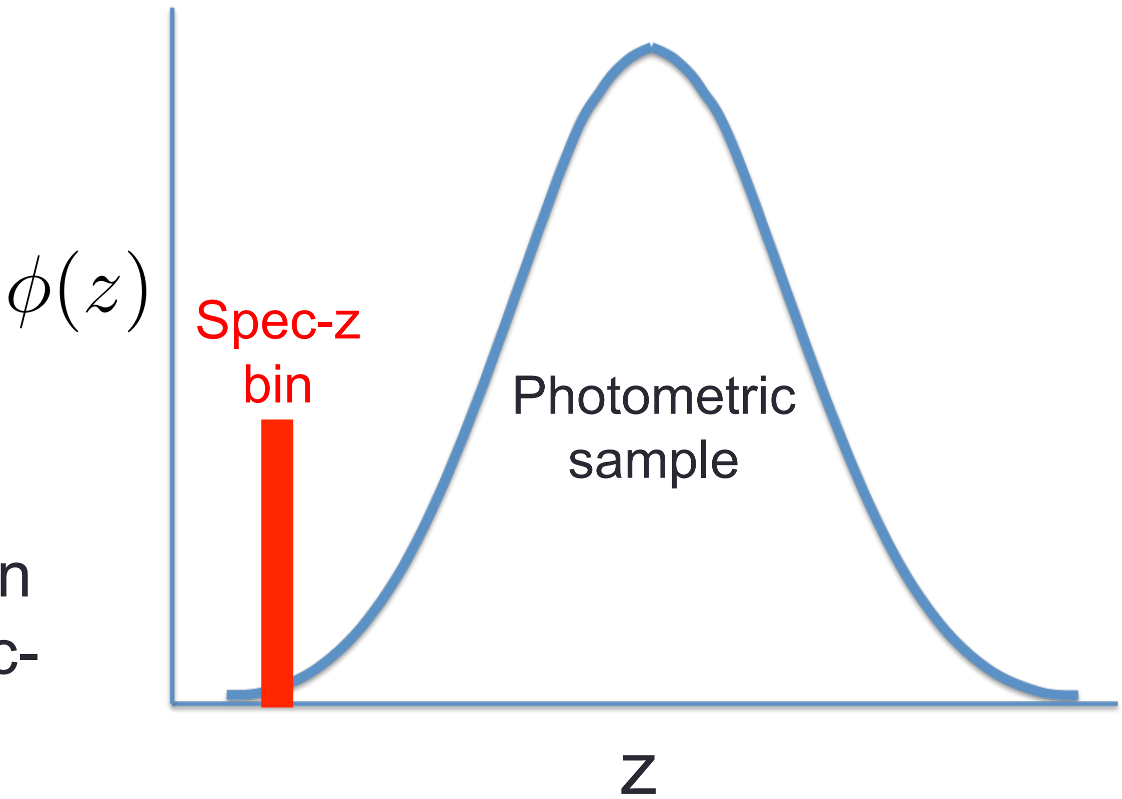
- Autocorrelation measurements for each sample give information about their intrinsic clustering

Recovering $\phi_p(z)$

- Cross-correlation measurements in multiple spec-z bins, along with autocorrelations, allow us to recover the true redshift distribution of the photometric sample
- Advantages:
  - The spectroscopic sample does not need to span the properties of the photometric sample
  - Possible to use systematically incomplete spectroscopy of the brightest objects and still obtain an accurate reconstruction

Lensing magnification

- Weak gravitational lensing can induce a correlation signal
- Two contributions:
  - Objects in the narrow spec-z bin can lens photometric objects
  - Objects in the photometric sample can lens objects in the spec-z bin



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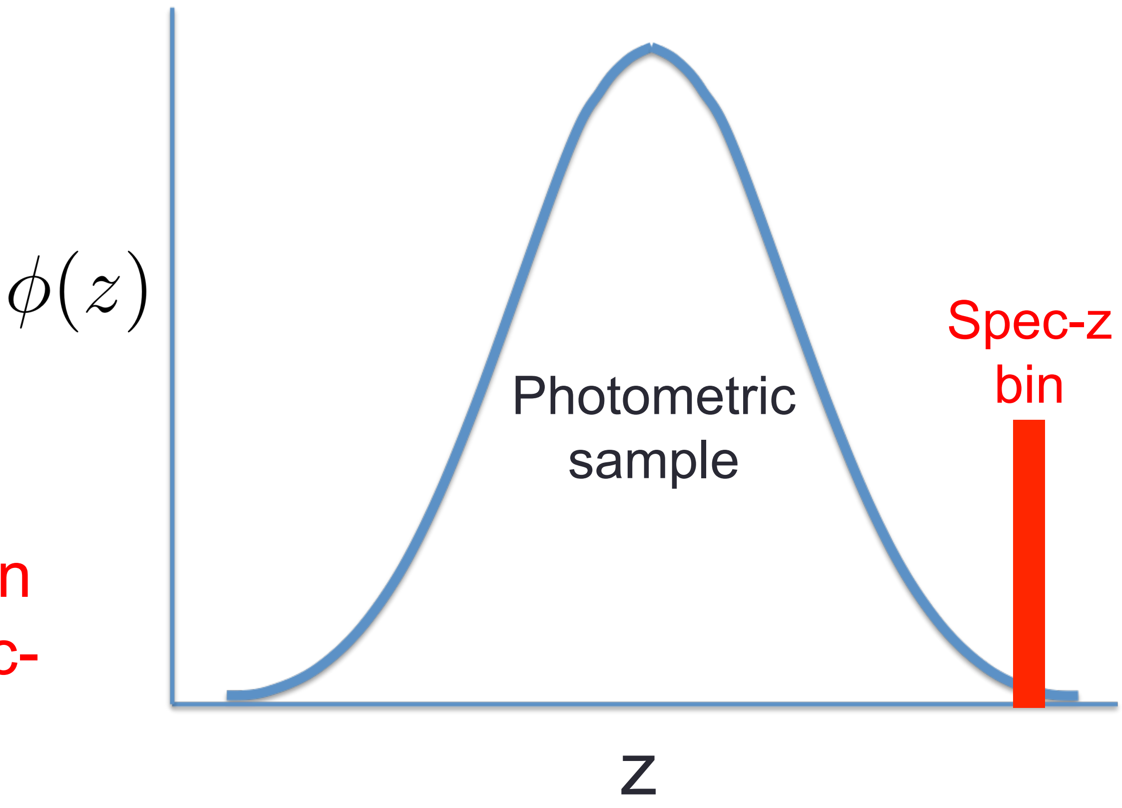

Lensing magnification

- Following derivation in Moessner & Jain (1998)

$$w_{[1,l]2}(\theta, z) = 3\Omega_m \left(\frac{H_o}{c}\right)^2 \frac{2.5 s_2 - 1}{b_2} \int_0^{\infty} \phi_1(z) \frac{g_2(z)}{a} dz \int_{-\infty}^{+\infty} \xi_{12}\left(\sqrt{\pi^2 + D(z)^2\theta^2}\right) d\pi$$

- Assumptions:
  - Power-law correlation function
  - Slope of the number counts of galaxies determined from Schechter function with faint end slope set equal to what is seen in typical galaxy samples (α ~ -1.3)
  - Bias = 1

Large Synoptic Survey Telescope

Lensing magnification

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s_2 = slope of the number counts of galaxies
b_2 = bias

- Assumptions:
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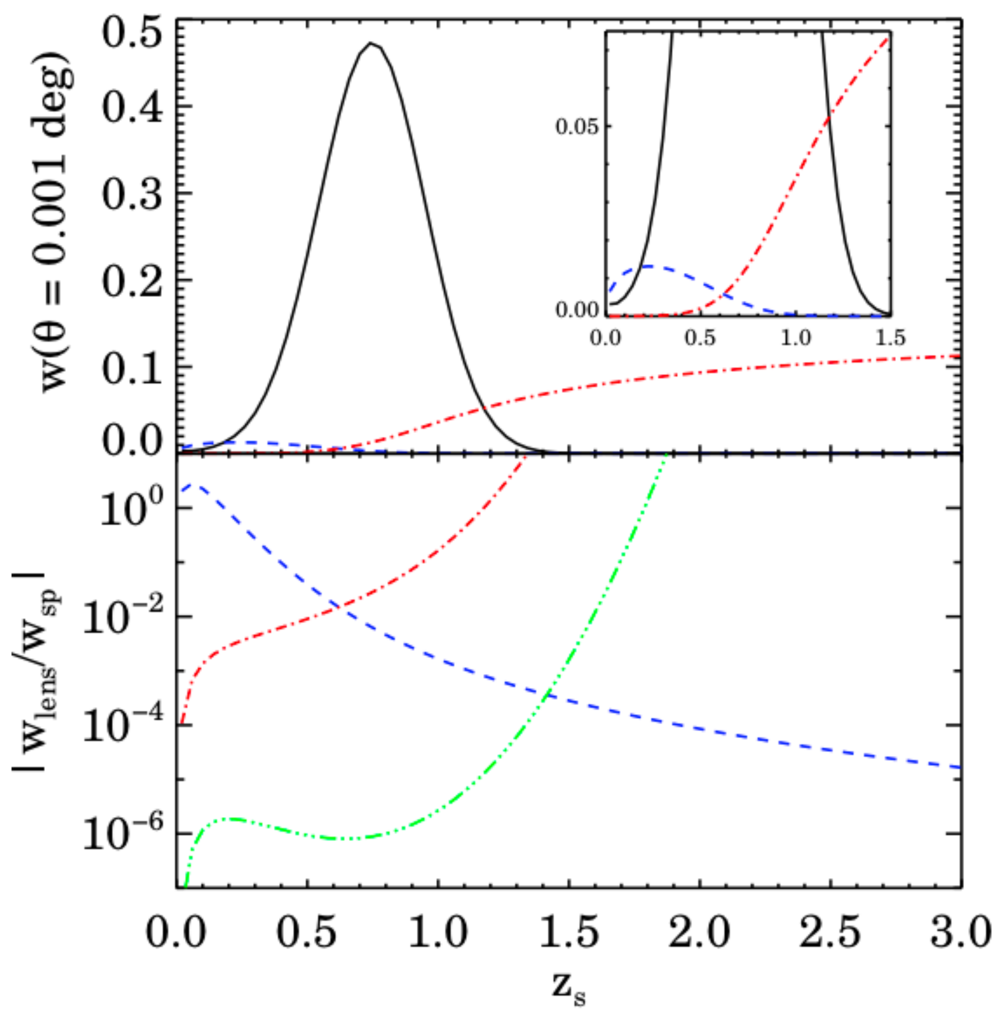
  - Bias = 1

Lensing magnification

$$s = -0.4\left(\alpha - \frac{L}{L^*}\right)$$

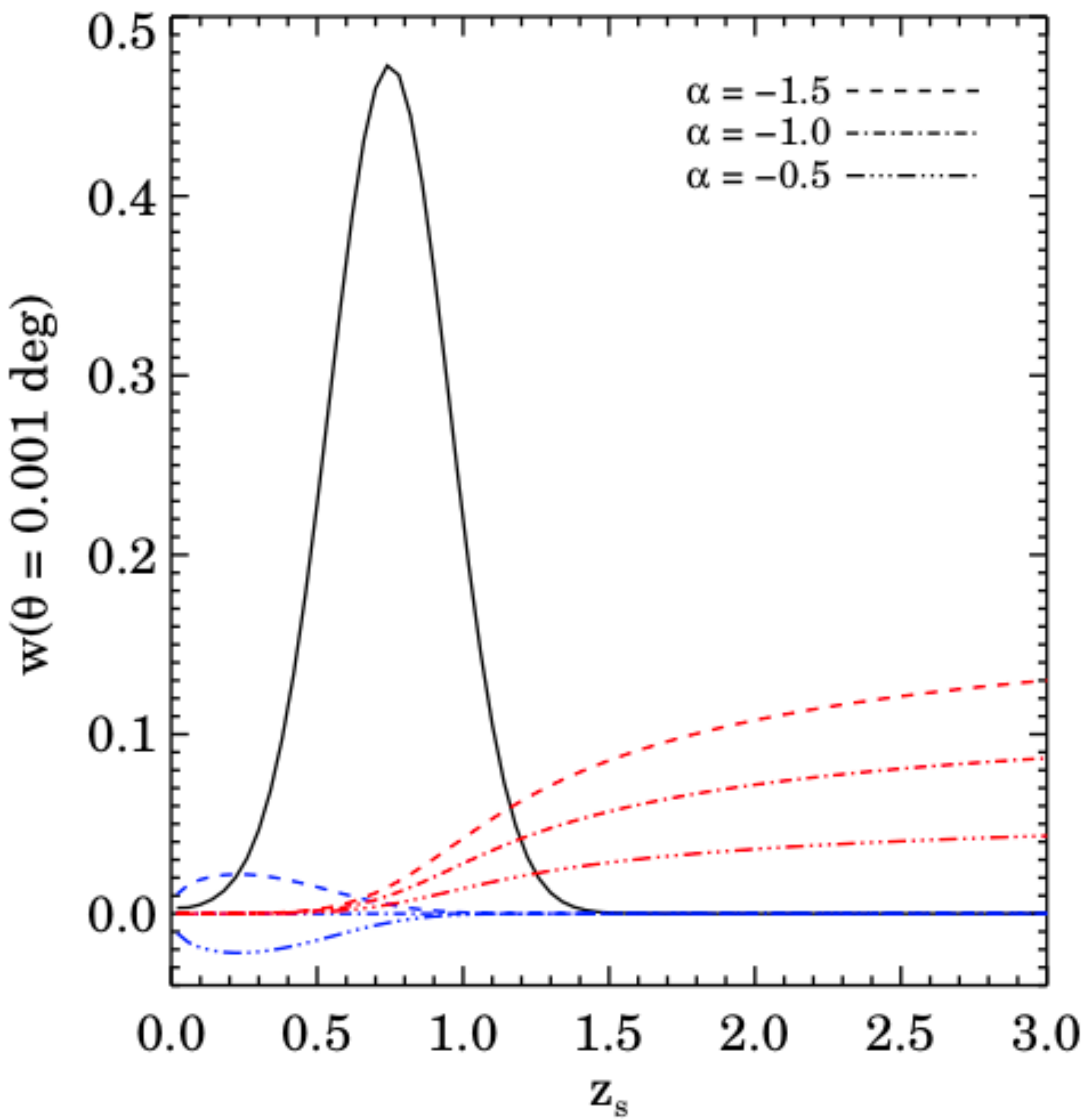
- Gaussian photometric sample
  - (black) Cross-correlation of spec-z bin at $z=z_s$, with photometric sample
  - (blue) Lensing signal where spec-z bin acts as lens ($L/L^* << 1$ for photometric sample)
  - (red) Lensing signal where photometric sample acts as lens ($L/L^* = 1$ for spec sample)



Conclusion

- The induced correlation from weak lensing is small compared to the cross-correlation signal from physical clustering
  - But it is significant enough to bias parameters of the reconstructed redshift distribution

- Lensing signal from the photometric sample being lensed by the spec-z bin is weaker
  - Should be possible to remove iteratively
- Lensing signal from the objects in the spec-z bin being lensed by the photometric sample is stronger
  - Possibly could be mitigated by:
    - using a volume limited sample rather than magnitude limited
    - using a subsample of the spectroscopic sample that is evenly distributed on the sky for the cross-correlation measurement
    - using weak lensing measurements which allow the lensing effect to be predicted and removed



0.5
0.4
0.3
0.2
0.1
0.0
w(θ = 0.001 deg)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
z_s
α = −1.5
α = −1.0
α = −0.5