Cosmological parameter constraints from galaxy-galaxy lensing with the Deep Lens Survey

COSMO-17
8/29

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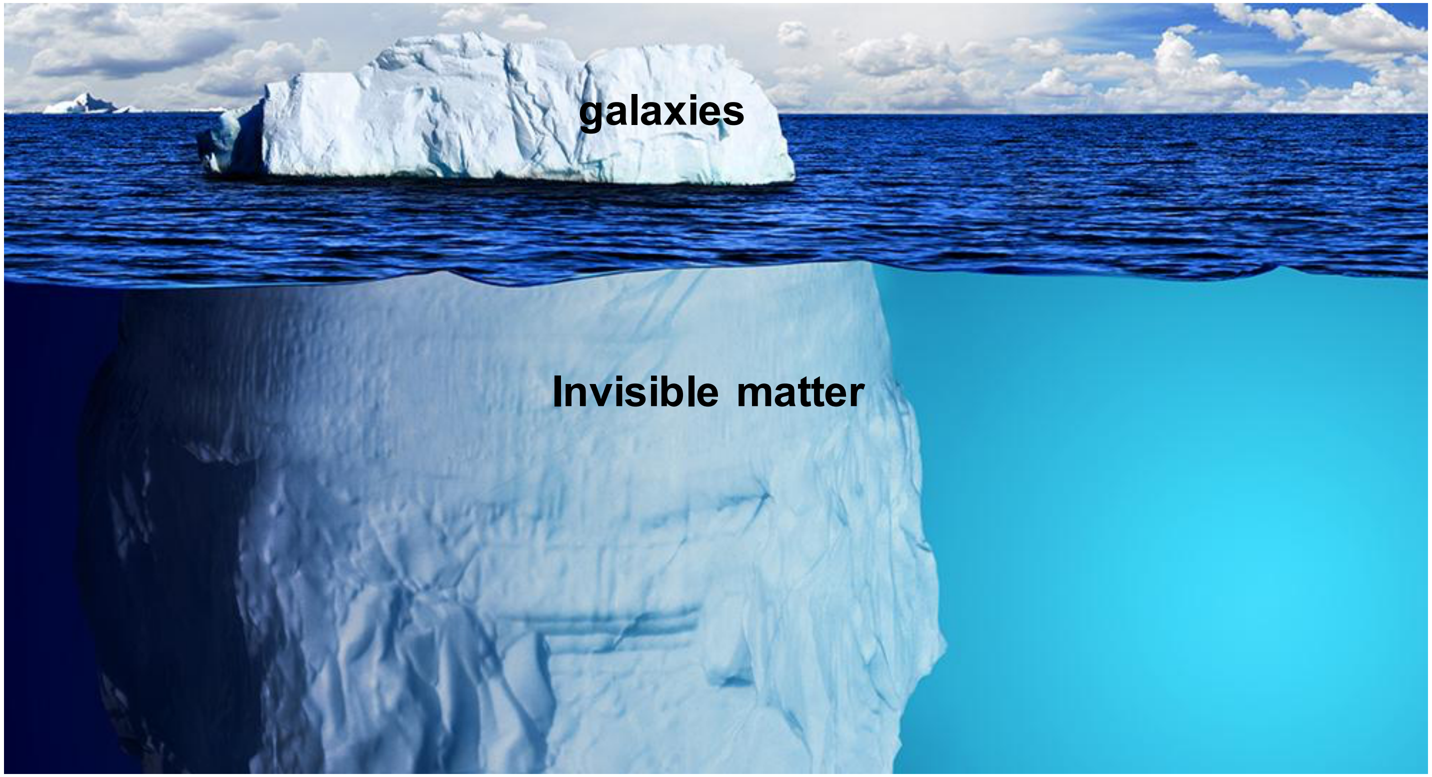
Introduction

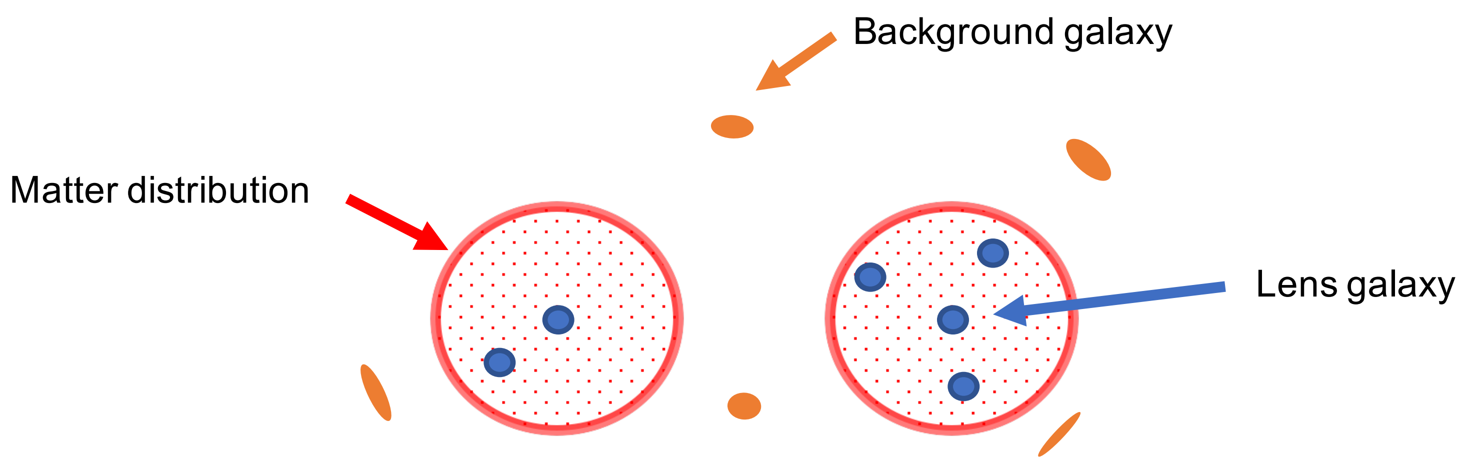
Galaxy-galaxy lensing



Using only galaxies is not enough to constrain the cosmological parameters.
Galaxy-galaxy lensing reveals the distribution of matter around galaxies.

Introduction

Galaxy-galaxy lensing



- The images of background galaxies get distorted by the mass of foreground matter distribution.
- The distortion is too weak for each individual lens galaxy.
- The signal needs to be stacked up for all the pairs of lens and source galaxies.

Introduction

Deep Lens Survey

- DLS is a precursor of LSST (small field as deep as LSST).
- DLS has BVRz' band images, widely separated 5 fields 4 deg^2 each.
- F1 & F2 (Mosaic-1 at the NOAO/KPNO 4m Mayall Telescope)
- F3 - F5 (Mosaic-2 at NOAO/CTIO 4m Blanco Telescope)
- BVRz' magnitudes ~ down to 27^{th} mag

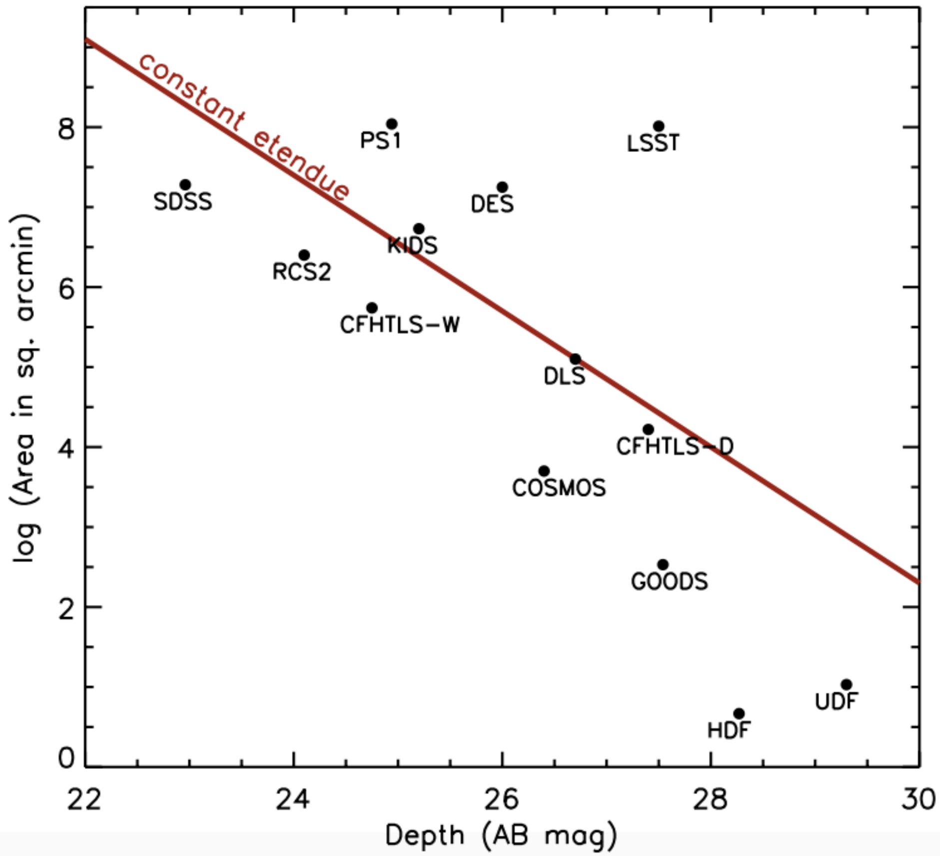
Mayall Telescope at Kitt Peak

Blanco Telescope at CTIO

Introduction

Deep Lens Survey

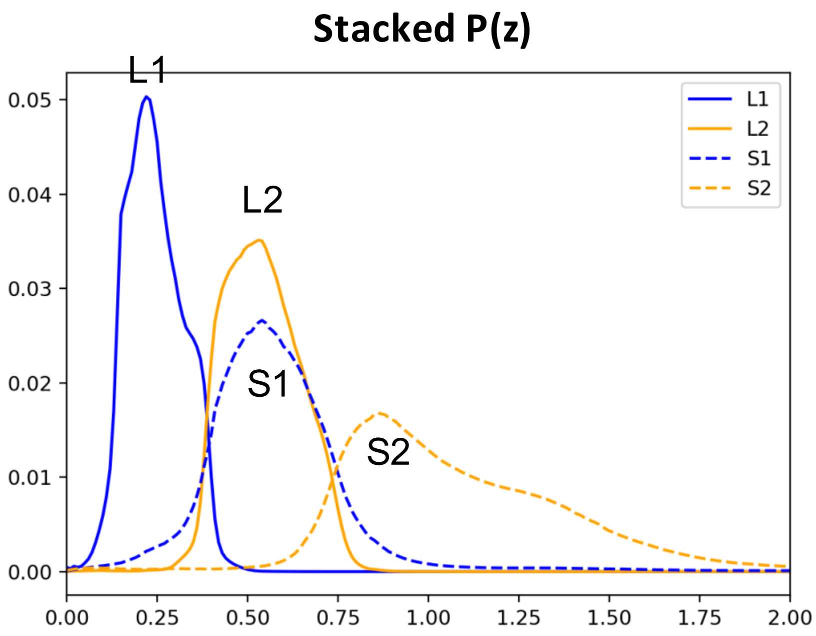
[Credit: Jee et al. 2013]



- DLS is dedicated for deeper depth.
  - ✓ good for accurate shape measurement.
  - ✓ optimal for cosmological studies.

Data

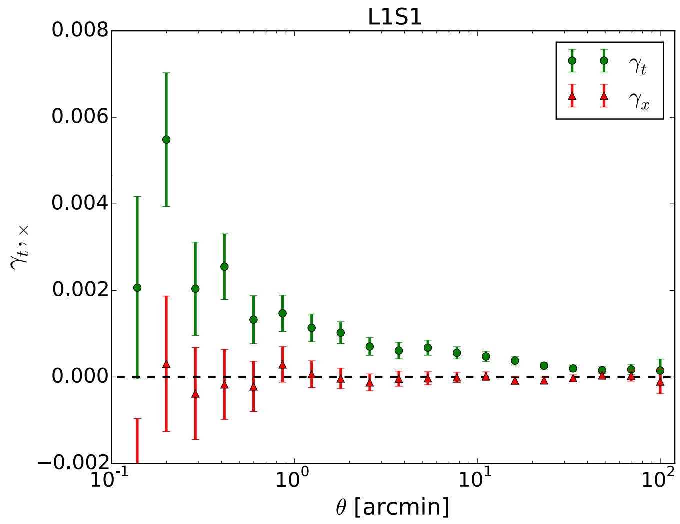
Lens & Source selection

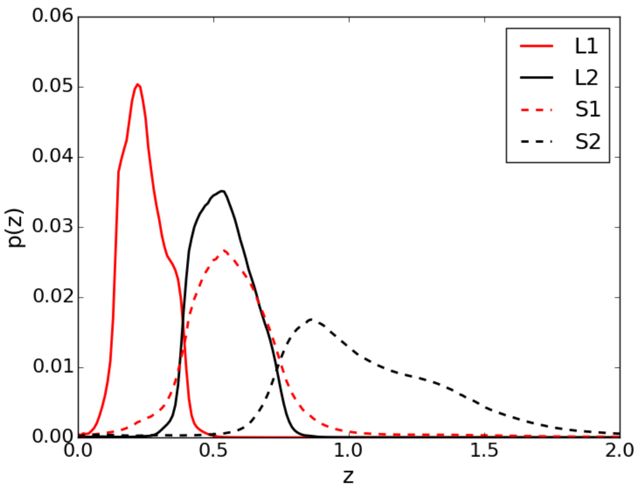


	z_b -	z_b +	m_R -	m_R +	total #
L1	0.1	0.4	18	21	57,802
L2	0.4	0.75	18	22	98,267
S1	0.4	0.75	21	24.5	418,932
S2	0.75	1.5	21	24.5	450,353

- For lens objects, bright galaxies were selected to increase the signal.
- Source criteria: Status = 1, de <0.3, b > 0.3
- Galaxy clustering: L1, L2
- Galaxy-galaxy lensing: L1 – S1, L1 – S2, L2 – S2

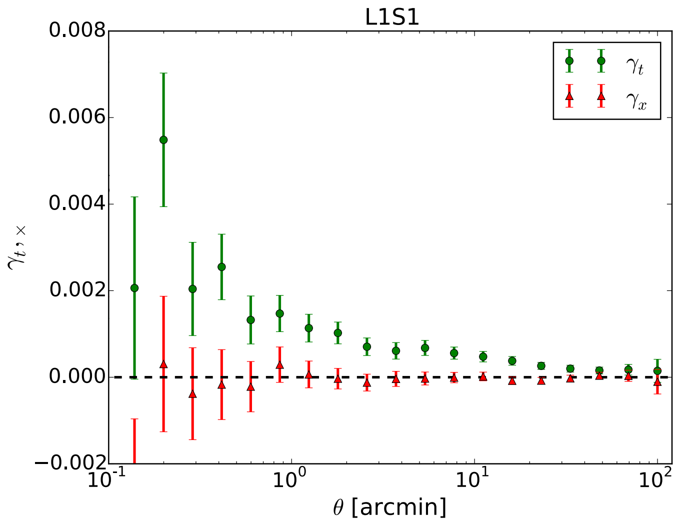
Galaxy-galaxy lensing signal
Shear measurement

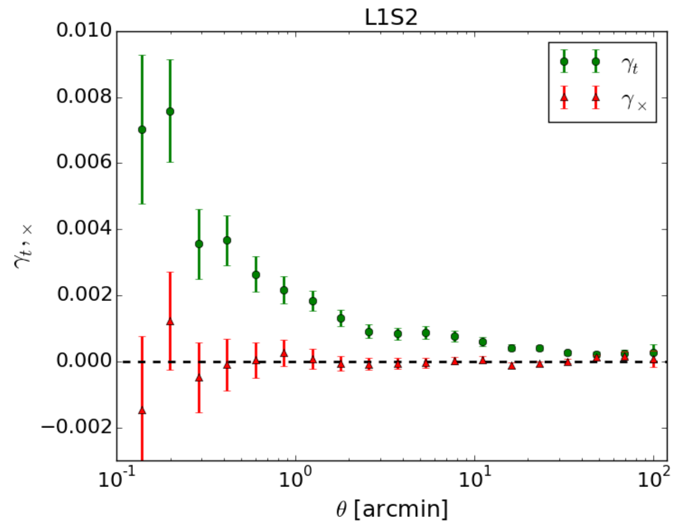


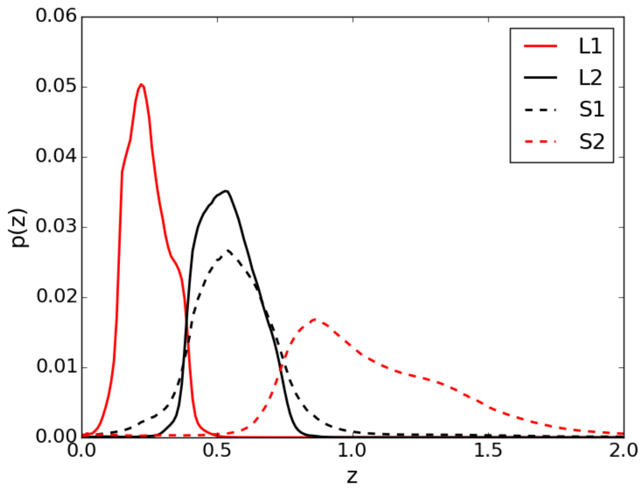


Galaxy-galaxy lensing signal

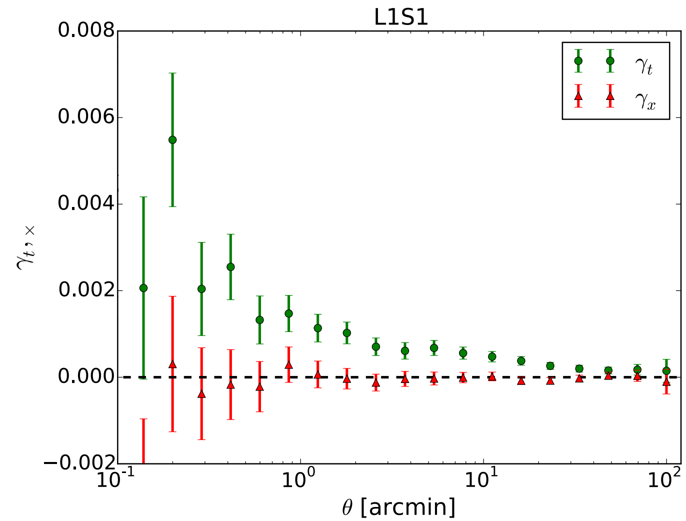
Shear measurement

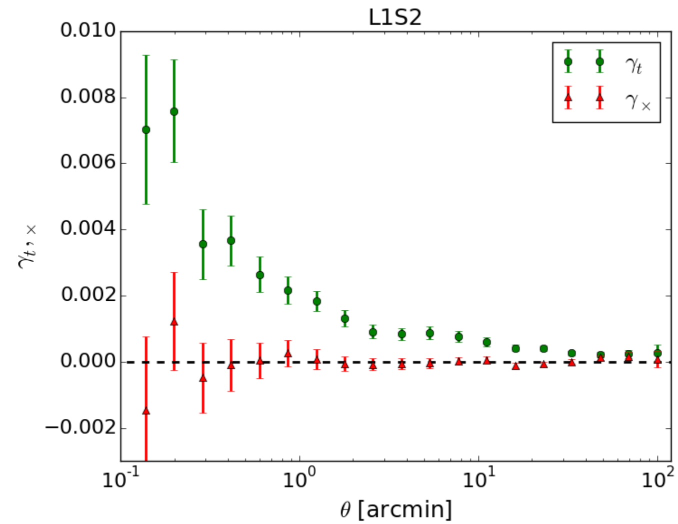


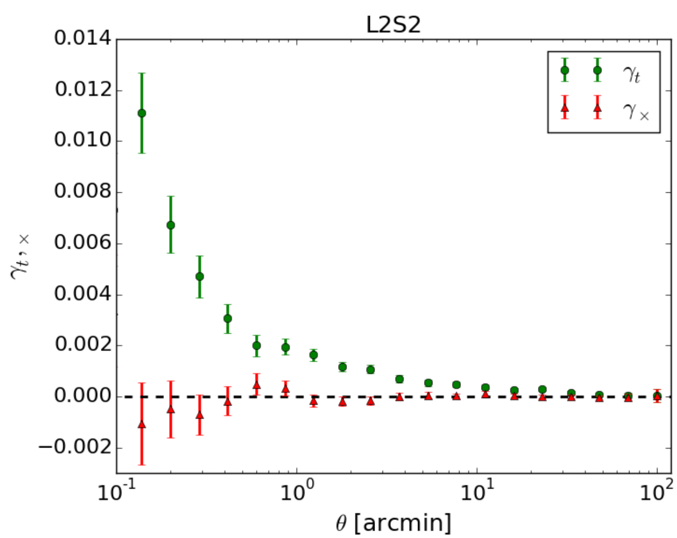


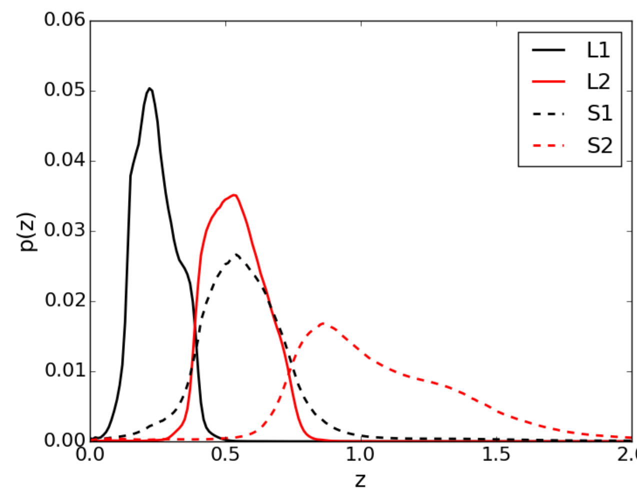


Galaxy-galaxy lensing signal
Shear measurement



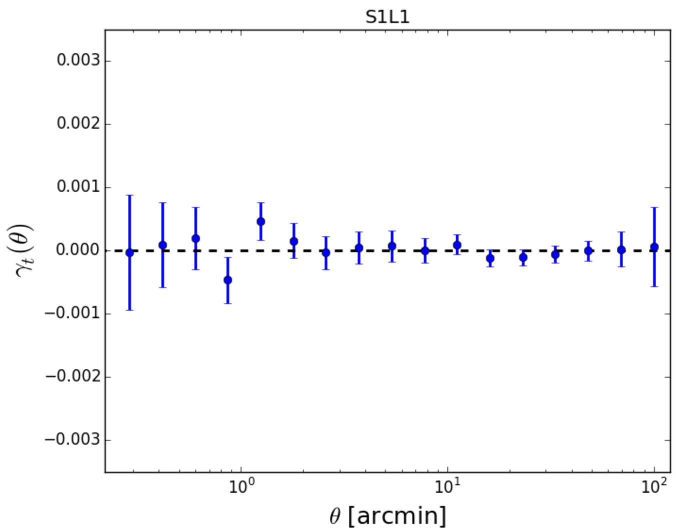


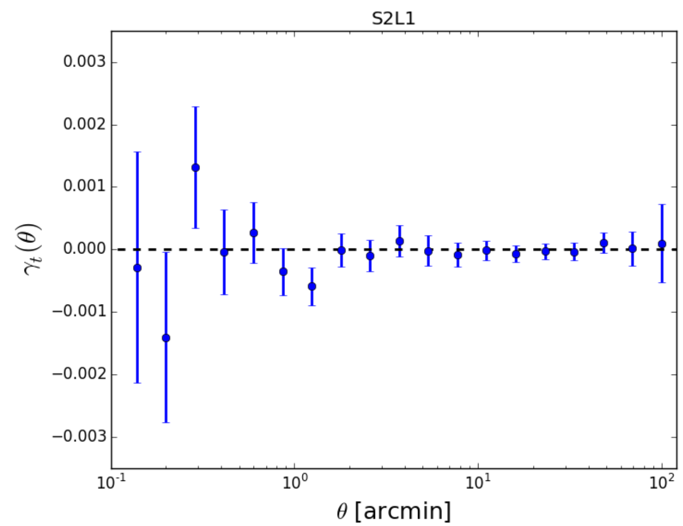


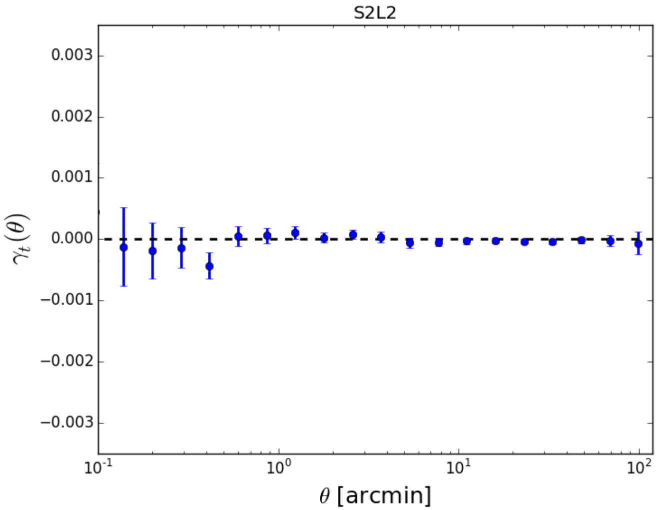


Systematics

Lens-source flip test



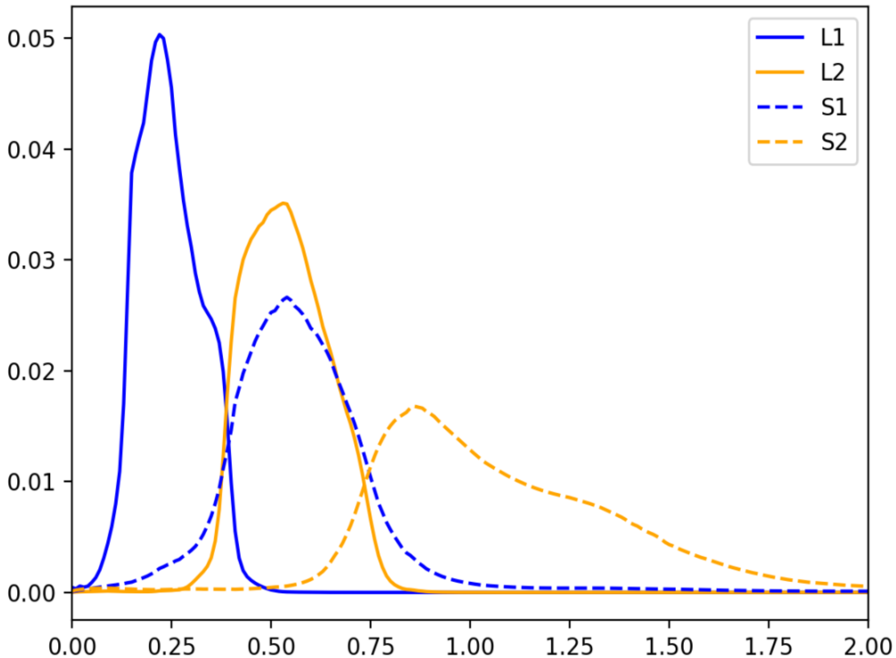


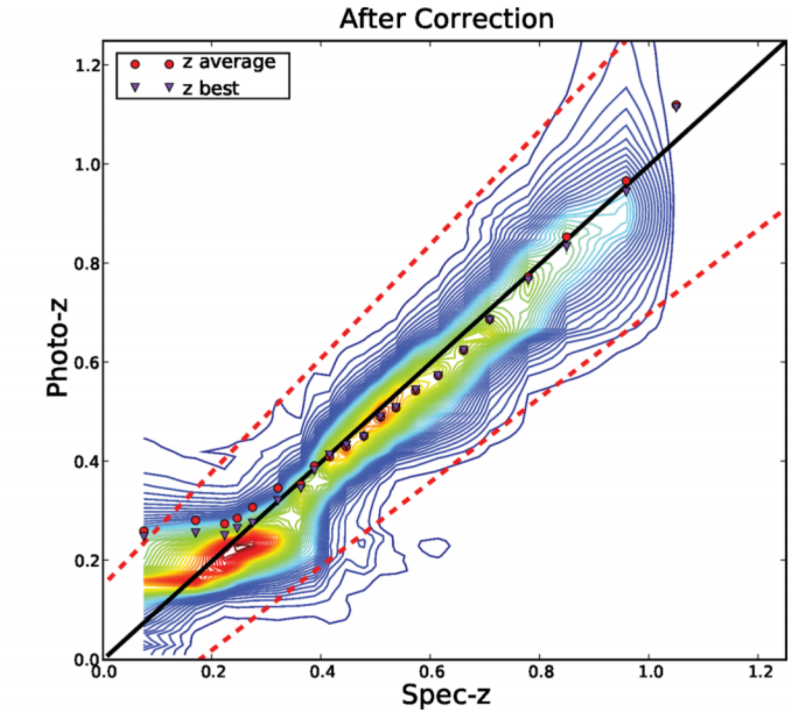


- ✓ Instrumental noise level is checked.
- ✓ Photo z uncertainty did not produce wrong signal in tangential shear measurement.

Systematics

Photometric redshift





[Schmidt et al. 2013]

- The best fit redshift value seems to have bias at low redshift but we use p(z) to avoid the potential bias in redshift.
- For better estimation of p(z), in preliminary result, 24.5 R band magnitude cut was applied to be conservative.

Systematics

Shape measurement

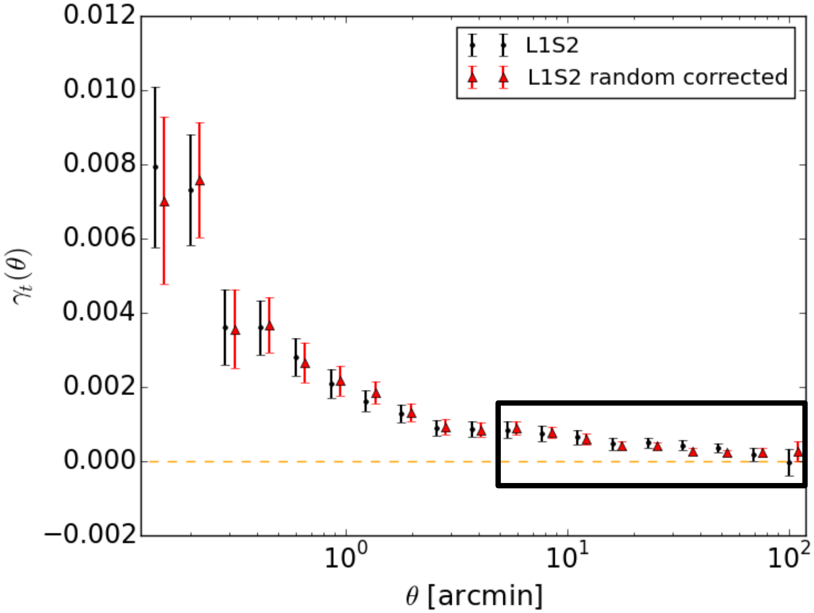
- Multiplicative errors were corrected using image simulation [Jee et al. 2013]
- Additive errors were found to be negligible (at the level of $\sim 10^{-4}$).
- DLS Shape measurement was validated: Winner of 'Great Challenge' [Mandelbaum et al. 2015].
- In the current study, we use sources brighter than 24.5, for which the multiplicative shear calibration error is marginalized over the interval: [-0.02,0.02].

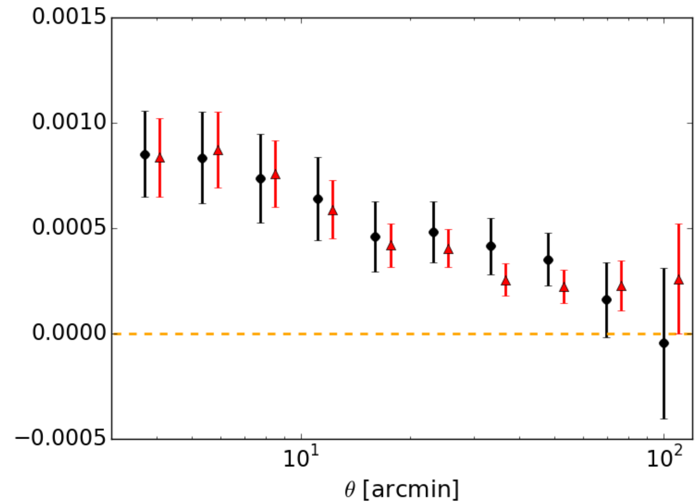
Systematics

Errors from observational footprints

- Signal from randomly distributed points should be deducted to correct the error and bias due to observational footprints. [Singh et al. 2016]

$$\langle \gamma_t \rangle = \langle \gamma_t^{lens}(\theta) \rangle - \langle \gamma_t^{random}(\theta) \rangle$$





✓ Bias gets corrected.
✓ Error bars get smaller.

Correlation -> Power spectrum

$$P^{gg}_{band,i} = \frac{2\pi}{\Delta_i}\int_{\theta_{min}}^{\theta_{max}} \frac{d\theta}{\theta} w(\theta)[f(\ell_{iu}\theta) - f(\ell_{il}\theta)]$$

$$f(x) = xJ_1(x)$$

$$\Delta_i = \ln(\ell_{iu}/\ell_{il})$$

$$P^{gm}_{band,i} = \frac{2\pi}{\Delta_i}\int_{\theta_{min}}^{\theta_{max}} \frac{d\theta}{\theta} \gamma_t(\theta)[h(\ell_{iu}\theta) - h(\ell_{il}\theta)]$$

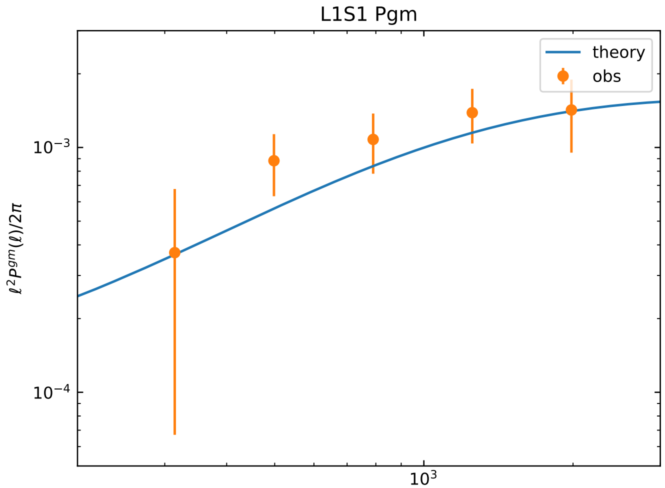
$$h(x) = -xJ_1(x) - 2J_0(x)$$

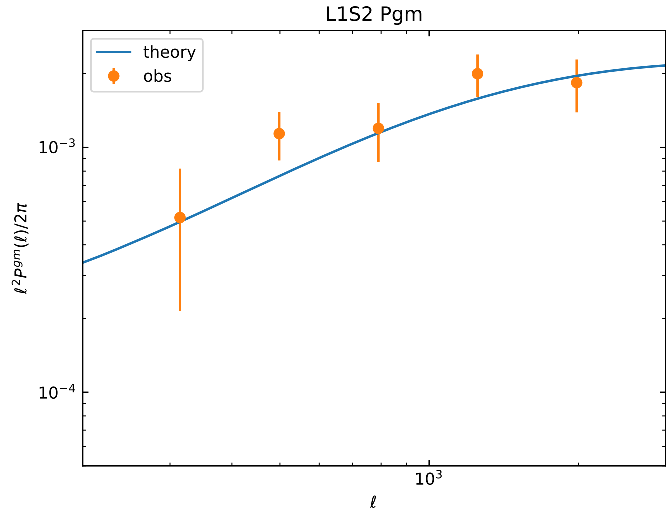
Covariance of power spectra is more diagonal.

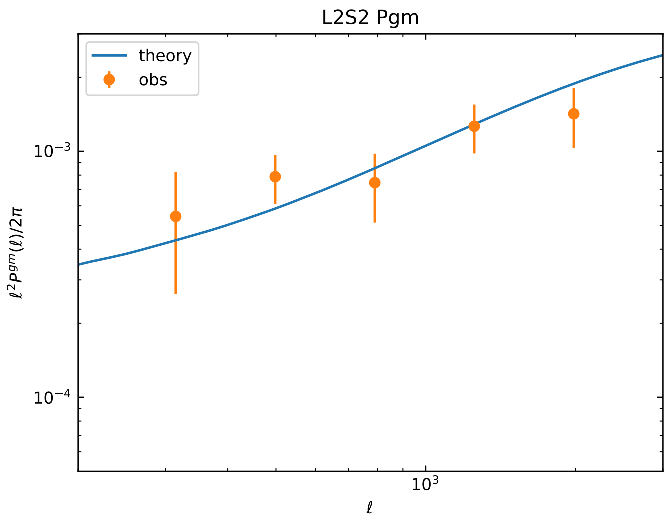
➡ Cleaner separation of scales.

Power spectrum

Pgm (with our constrained parameters)

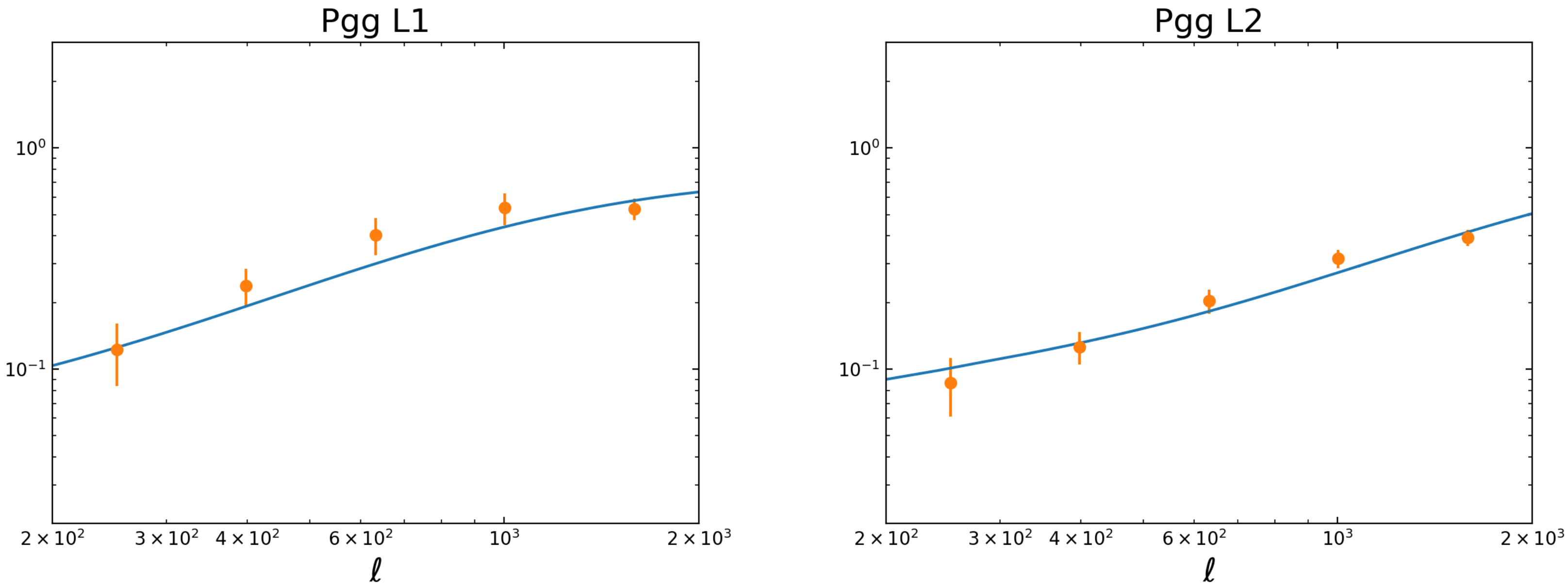






Power spectrum

Pgg (with our constrained parameters)



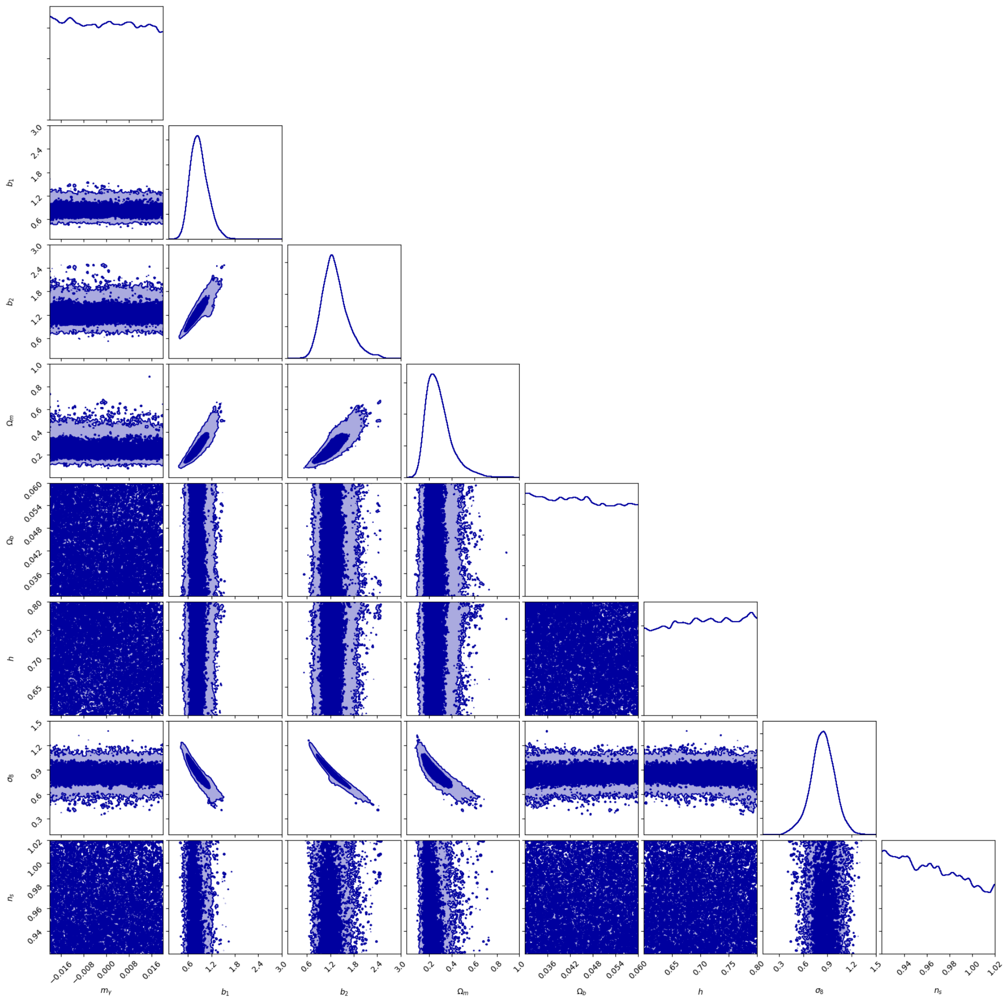
MCMC run setting

- Flat priors for 8 free parameters

parameters	Lower bound	Upper bound
m_γ(multiplicative shear calibration error)	- 0.02	+ 0.02
b1 (galaxy bias for L1)	0.1	2.5
b2 (galaxy bias for L2)	0.1	2.5
Ω_m	0.06	1.0
Ω_b	0.03	0.06
h	0.6	0.8
σ_8	0.1	1.2
n_s	0.92	1.02

Preliminary results

m_γ, b1, b2, Ω_m, Ω_b, h, σ_8, n_s



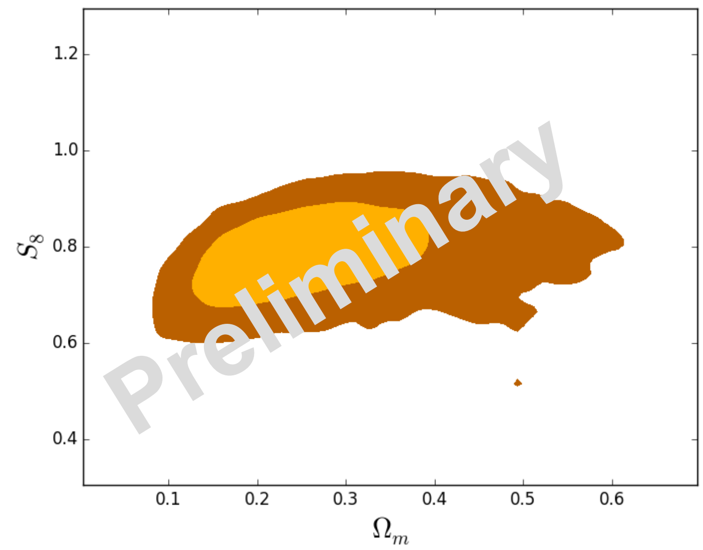
Constrained values

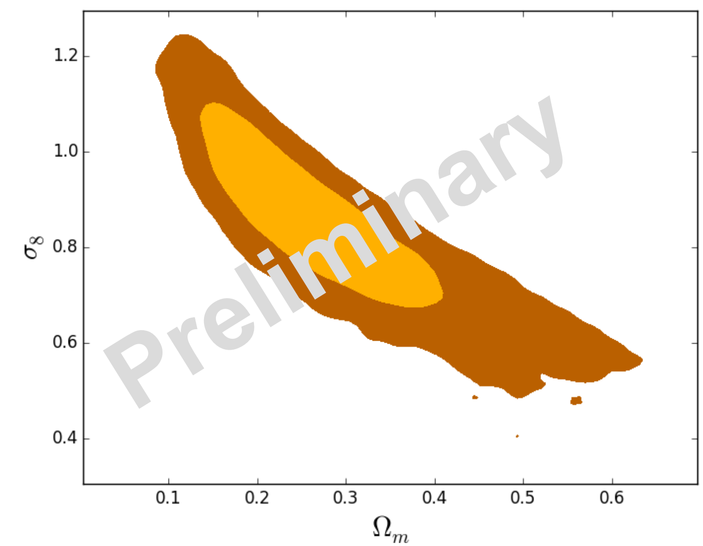
b1	$0.86^{+0.24}_{-0.19}$
b2	$1.26^{+0.34}_{-0.26}$
Ω_m	$0.27^{+0.12}_{-0.08}$
σ_8	$0.84^{+0.14}_{-0.14}$

Preliminary results

Omega_m & sigma_8

- $S_8 = 0.79^{+0.06}_{-0.07}$
- $\Omega_m = 0.27^{+0.12}_{-0.08}$

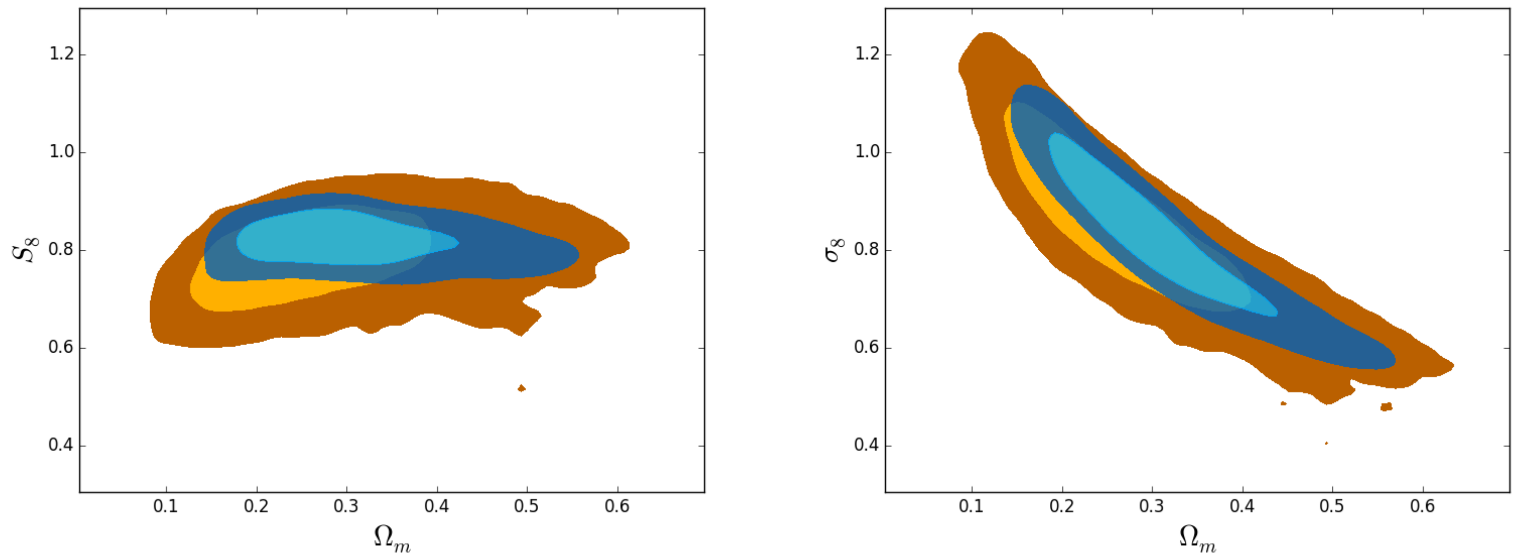




Preliminary results

Comparison with cosmic shear and Planck

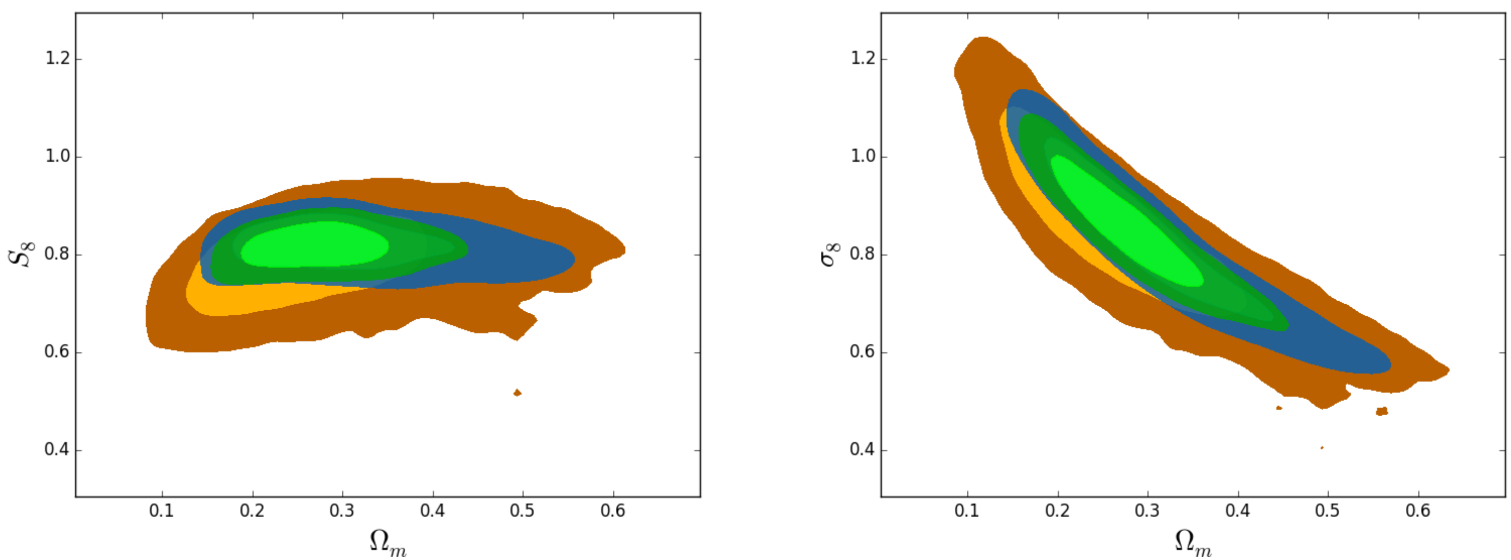
- GGL + Galaxy clustering
- Cosmic Shear



Preliminary results

Comparison with cosmic shear and Planck

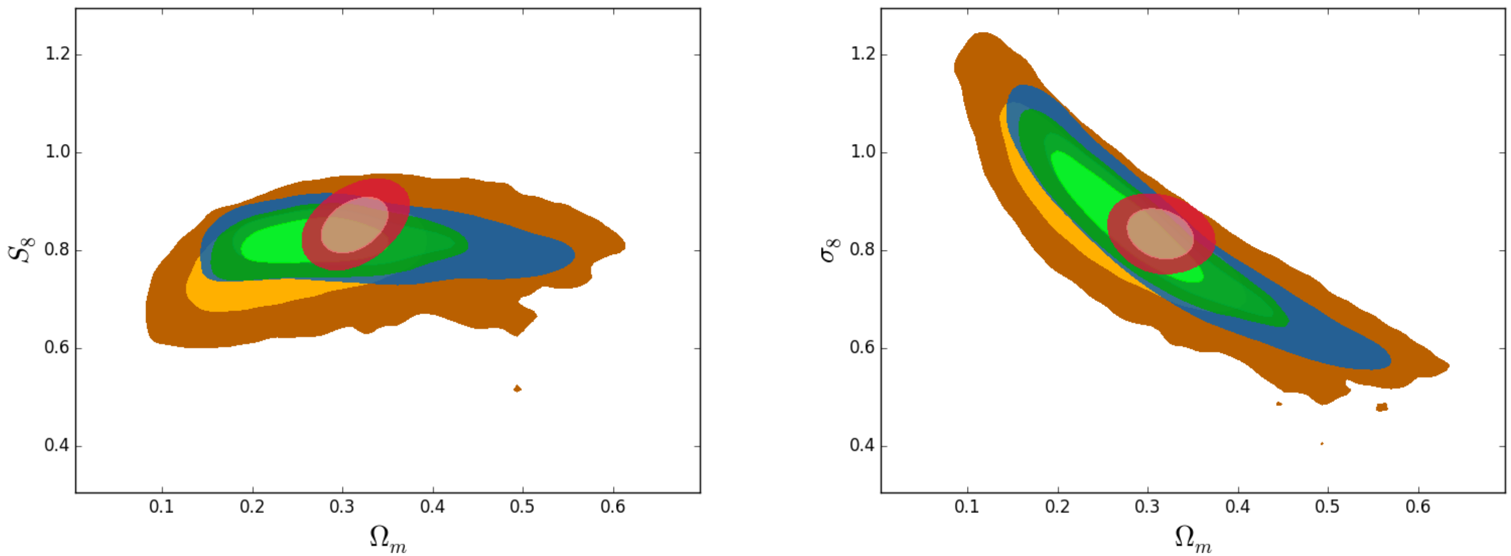
- GGL + Galaxy clustering
- Cosmic Shear
- GGL + Galaxy clustering + Cosmic Shear



Preliminary results

Comparison with cosmic shear and Planck

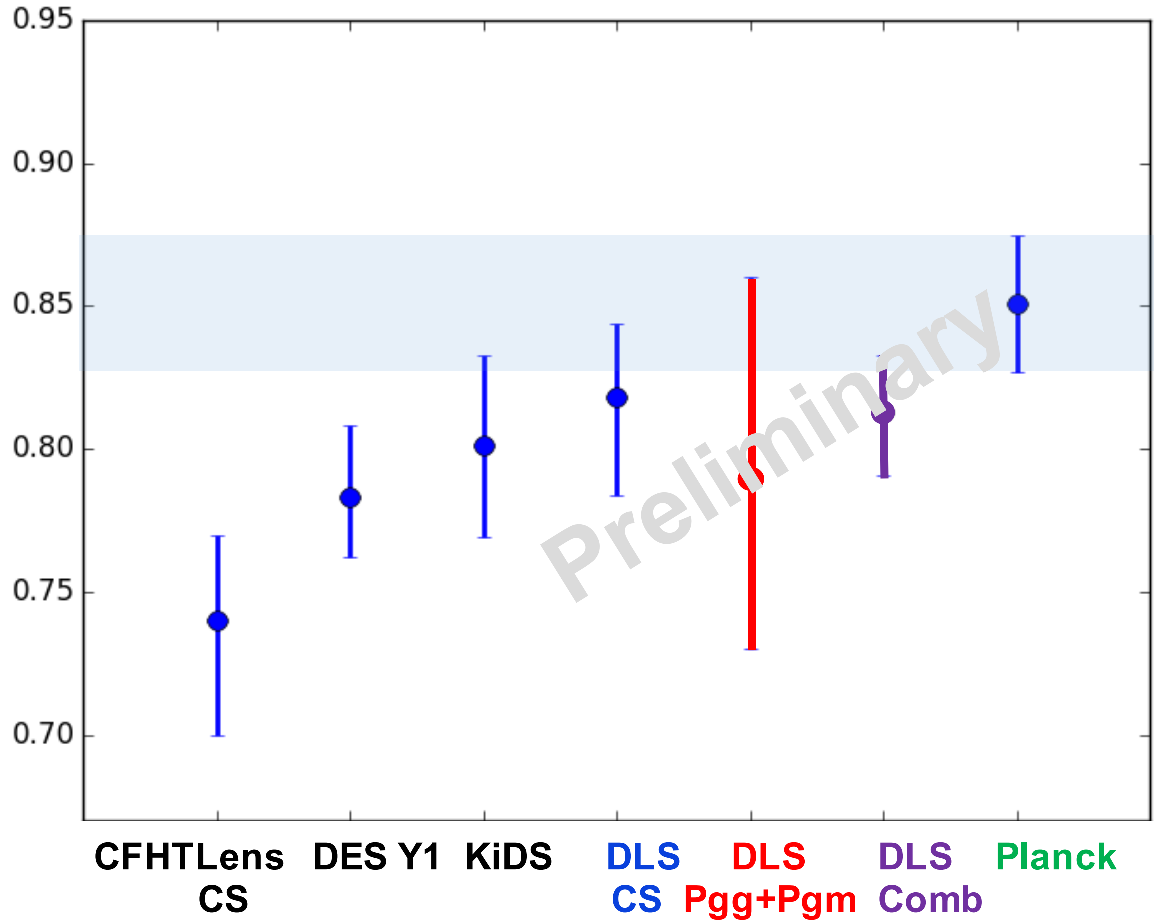
- GGL + Galaxy clustering
- Cosmic Shear
- GGL + Galaxy clustering + Cosmic Shear
- Planck with lensing



Preliminary results

Comparison with other surveys

$$S_8 = \sigma_8(\Omega_m/0.3)^{0.5}$$



- ✓ DLS results are consistent with Planck.
- ✓ The constraining power of DLS are comparable with Planck.

Things to improve for the final result

- marginalize over p(z) to include the uncertainty in redshift estimation.
- combine ggl with cosmic shear based on full covariance.
- extend source catalog by adding faint objects. -> This will increase the signal.
- include the effect of cosmic variance in our covariance.

Thank you.