Combining galaxy galaxy lensing and galaxy clustering

Alexie Leauthaud
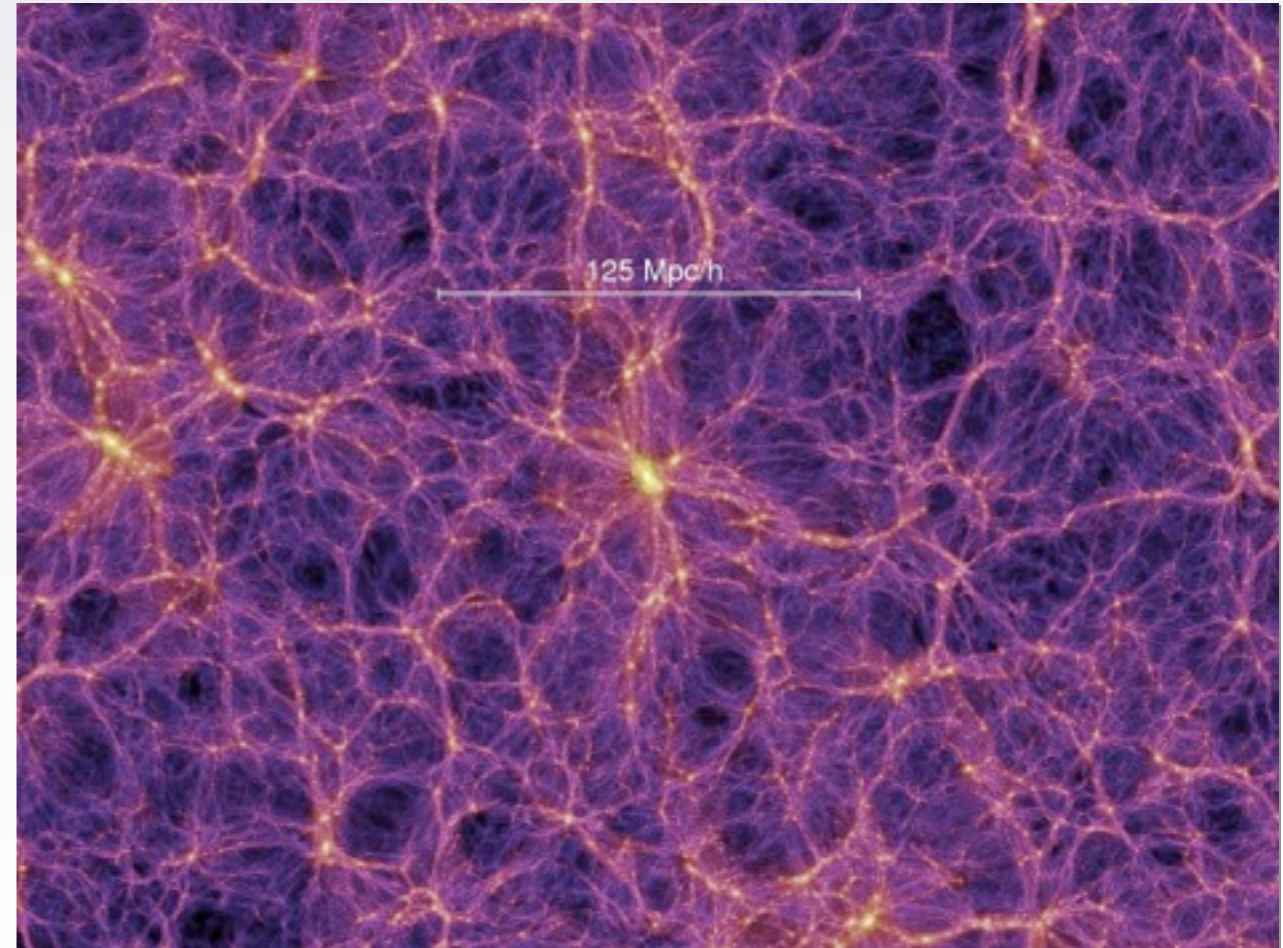アレクシー　レオト

The kavli institute for the physics and mathematics of the universe (kavli ipmu)
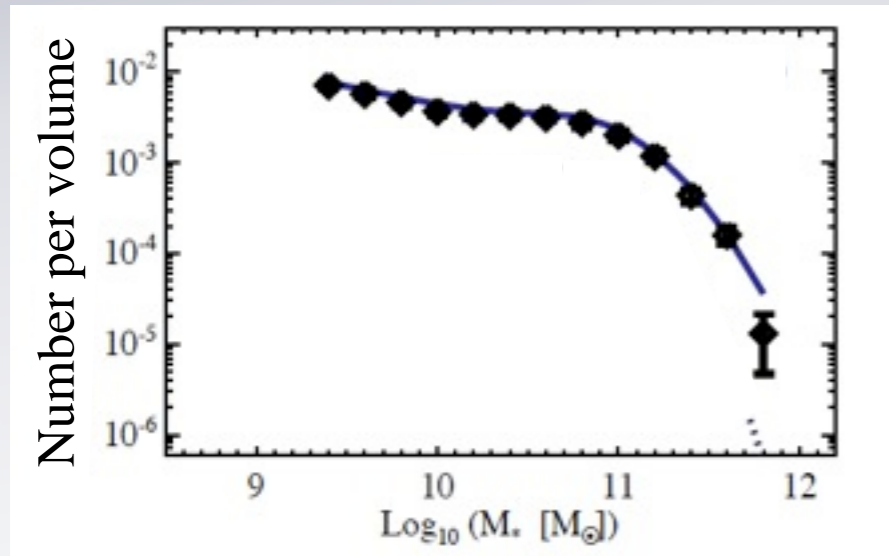
Motivation

Hubble deep field

Millenium simulation
Springel et al. 2005

How are galaxies related to the dark matter density field?

Three Dark Matter Probes
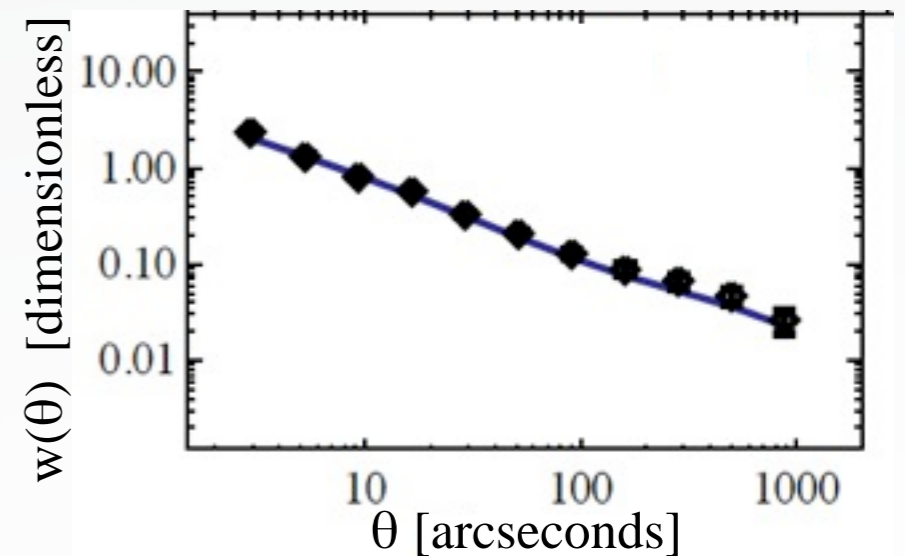

The galaxy stellar mass function :
- Number of galaxies per unit volume
- "easy" to calculate
- Typically modelled through "abundance matching"

1

Galaxy auto correlation function :
- Excess probability above random of finding two galaxies with a given separation
- Typically modelled through HOD models
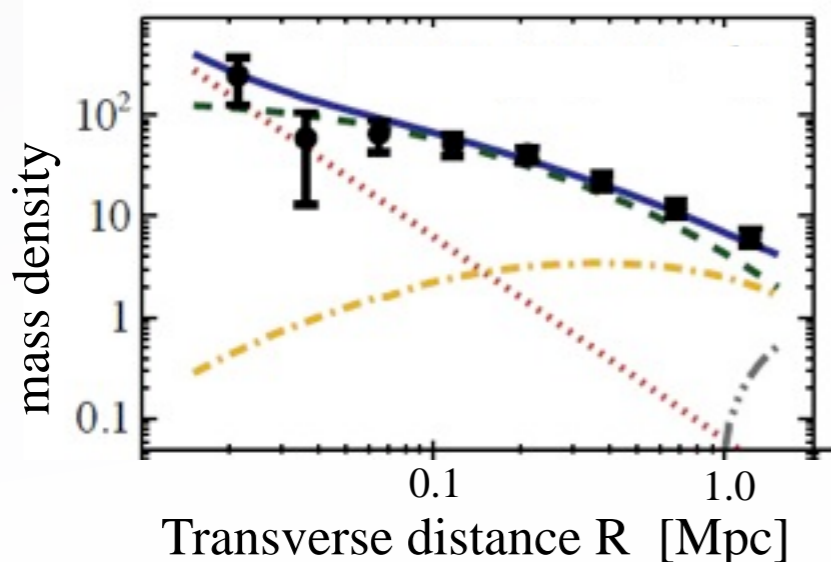
2

Galaxy-galaxy lensing :
- Measures the galaxy-matter correlation function
- Weak signal that is difficult to measure
- Tells us directly about the galaxy-dark matter connection

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Motivation for combining dark matter probes

(1) **The galaxy-dark matter connection**
- Building a more robust probe
- Galaxy formation
- Informing semi-analytic models

(2) **Cosmological parameters: Ω_m, σ_8**
e.g, van den bosch et al. 2012, More et al. 2012, Cacciato et al. 2012 $\longrightarrow$ the combination of lensing and clustering is a cosmological probe.

(3) **Modified gravity as an alternative to Dark Energy**
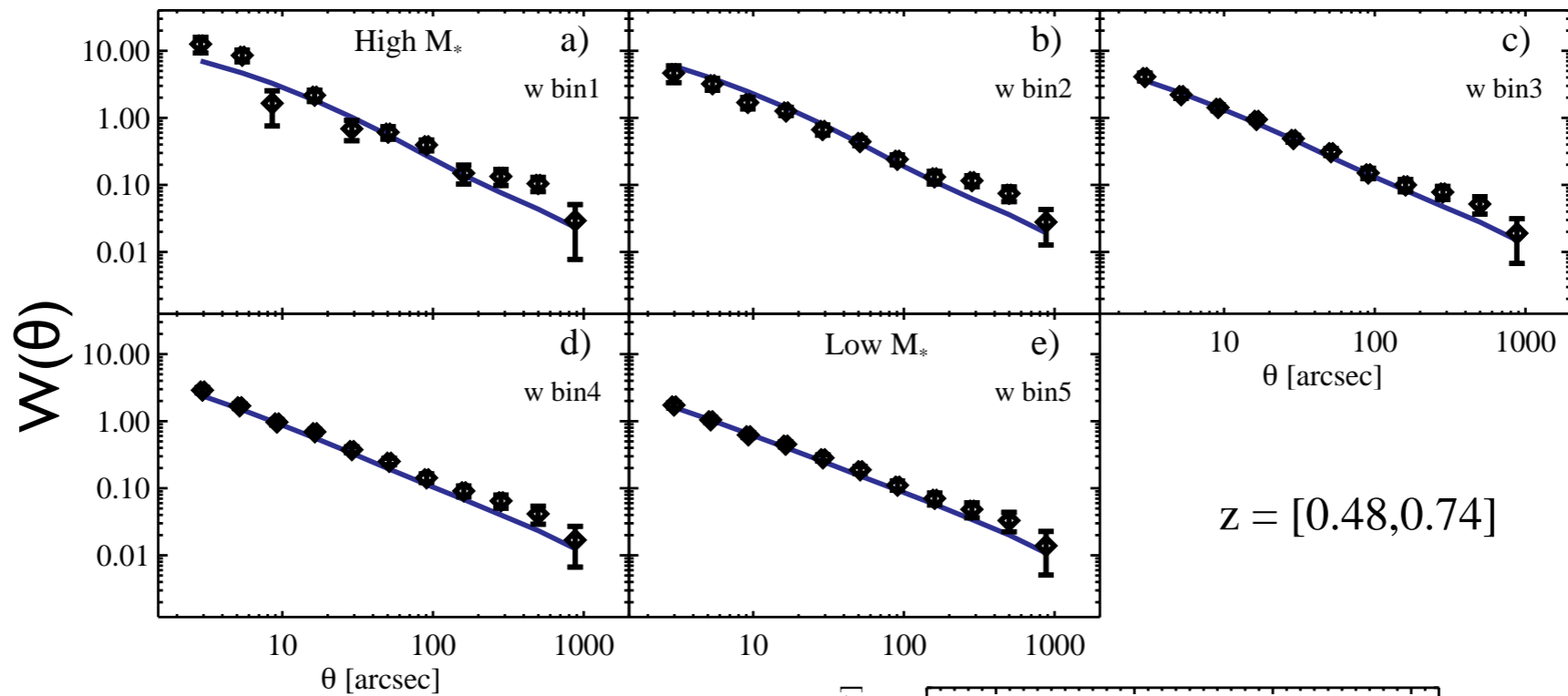Φ: dynamics
$\Psi + \Phi$: lensing of light around galaxies
$\longrightarrow$ Screening mechanisms on linear, quasi linear scales.
Need to understand the galaxy-dark matter connection.

Clustering

Galaxy-galaxy lensing

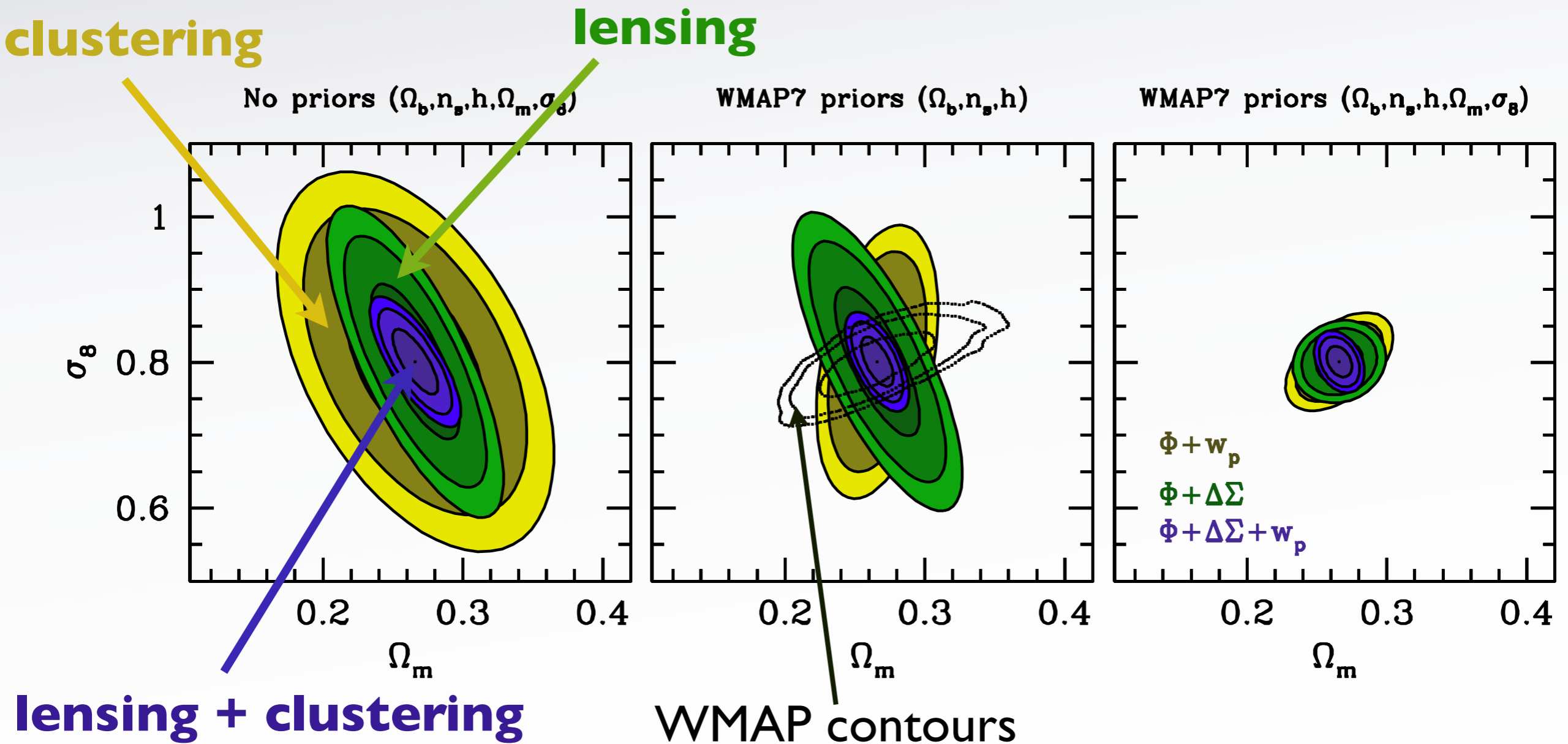**Stellar mass function**

z=[0.48,0.74]

High M$_*$ a) w bin1

b) w bin2

c) w bin3

d) w bin4

Low M$_*$ e) w bin5

$W(\theta)$

θ [arcsec]

z = [0.48,0.74]

f)

Log_{10} dN/dlogM$_*$ [Mpc^{-3} dex^{-1}]

Log_{10} (M$_*$ [M$_\theta$])

High M$_*$ g) g-g bin1

h) g-g bin2

i) g-g bin3

j) g-g bin4

k) g-g bin5

l) g-g bin6

Low M$_*$ m) g-g bin7

$\Delta\Sigma$ [h$_{72}$ M$_{sun}$ pc^{-2}]

Physical transverse distance R [Mpc h$_{72}^{-1}$]
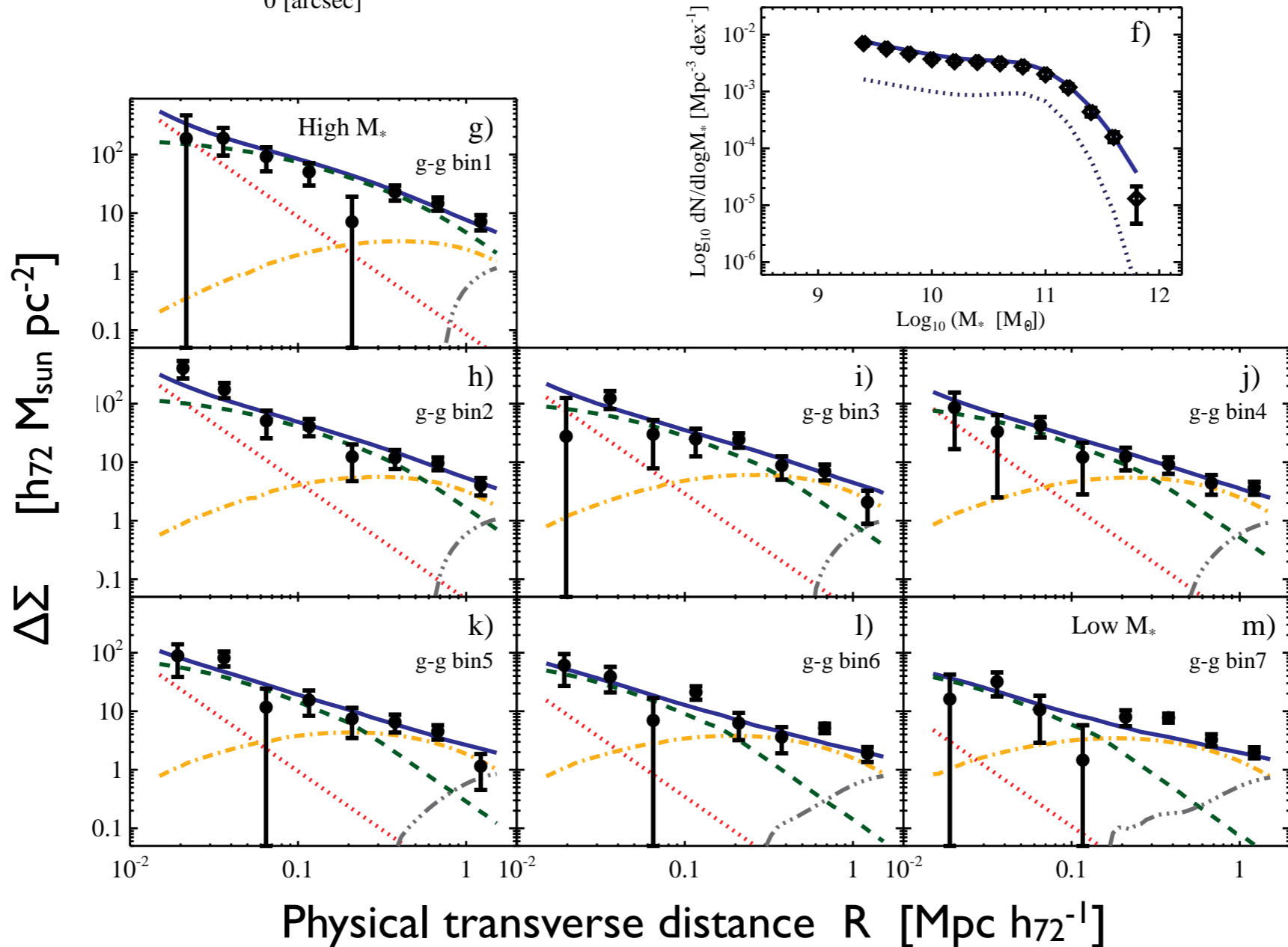
Leauthaud et al. 2012

Predicted constraints for SDSS galaxies

Cosmological constraints from combining galaxy galaxy lensing and galaxy clustering:

clustering

lensing

lensing + clustering

WMAP contours

No priors ($\Omega_b, n_s, h, \Omega_m, \sigma_8$)

WMAP7 priors (Ω_b, n_s, h)

WMAP7 priors ($\Omega_b, n_s, h, \Omega_m, \sigma_8$)

$\Phi + w_p$
$\Phi + \Delta\Sigma$
$\Phi + \Delta\Sigma + w_p$

Van den Bosch et al 2012, More et al. 2012, Cacciato et al. 2012

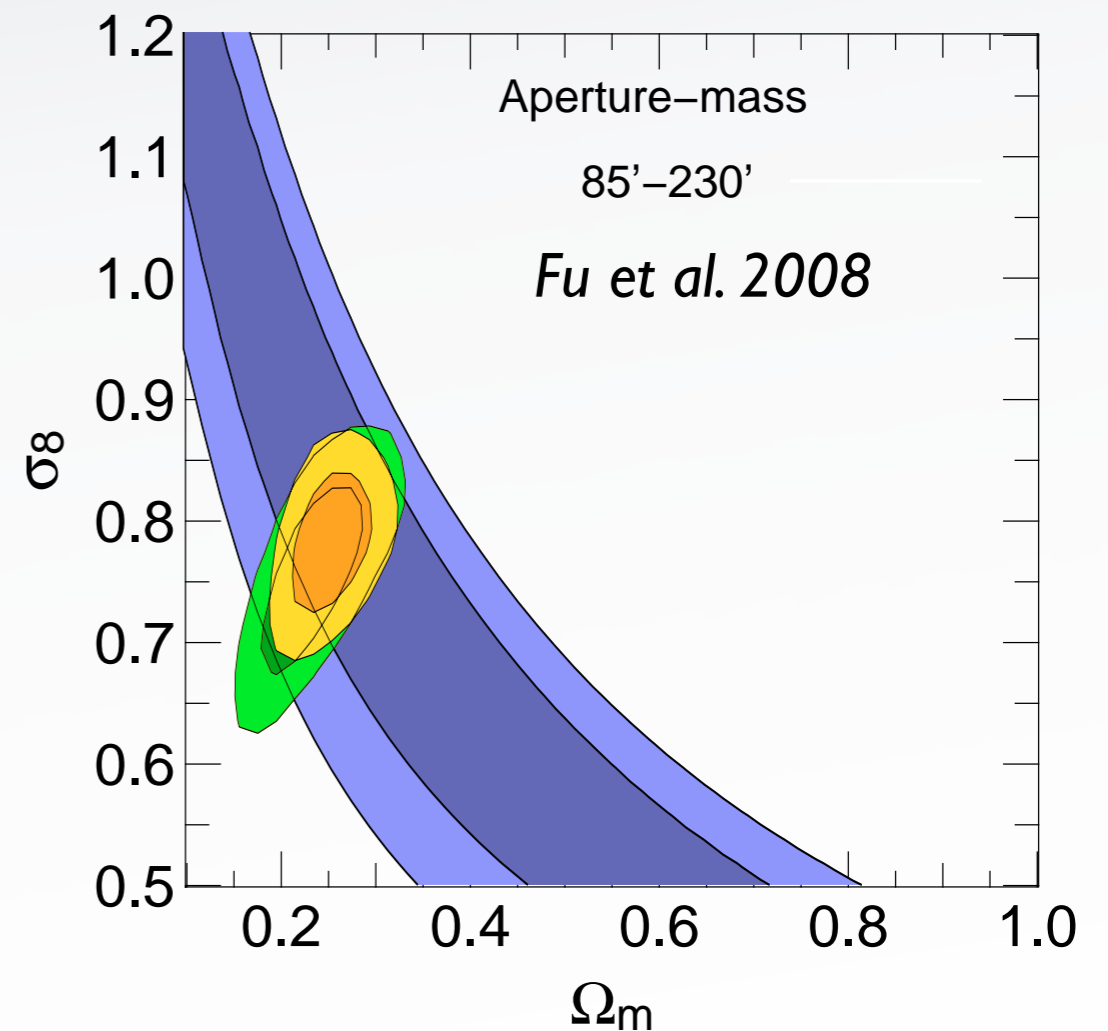# This technique compared to cosmic shear

Lensing + Clustering

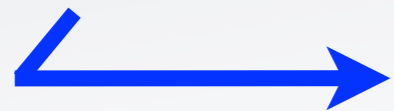No priors ($\Omega_b, n_s, h, \Omega_m, \sigma_8$)

More et al. 2012

σ_8

Ω_m

Cosmic shear

Aperture−mass

85'−230'

Fu et al. 2008

σ_8

Ω_m
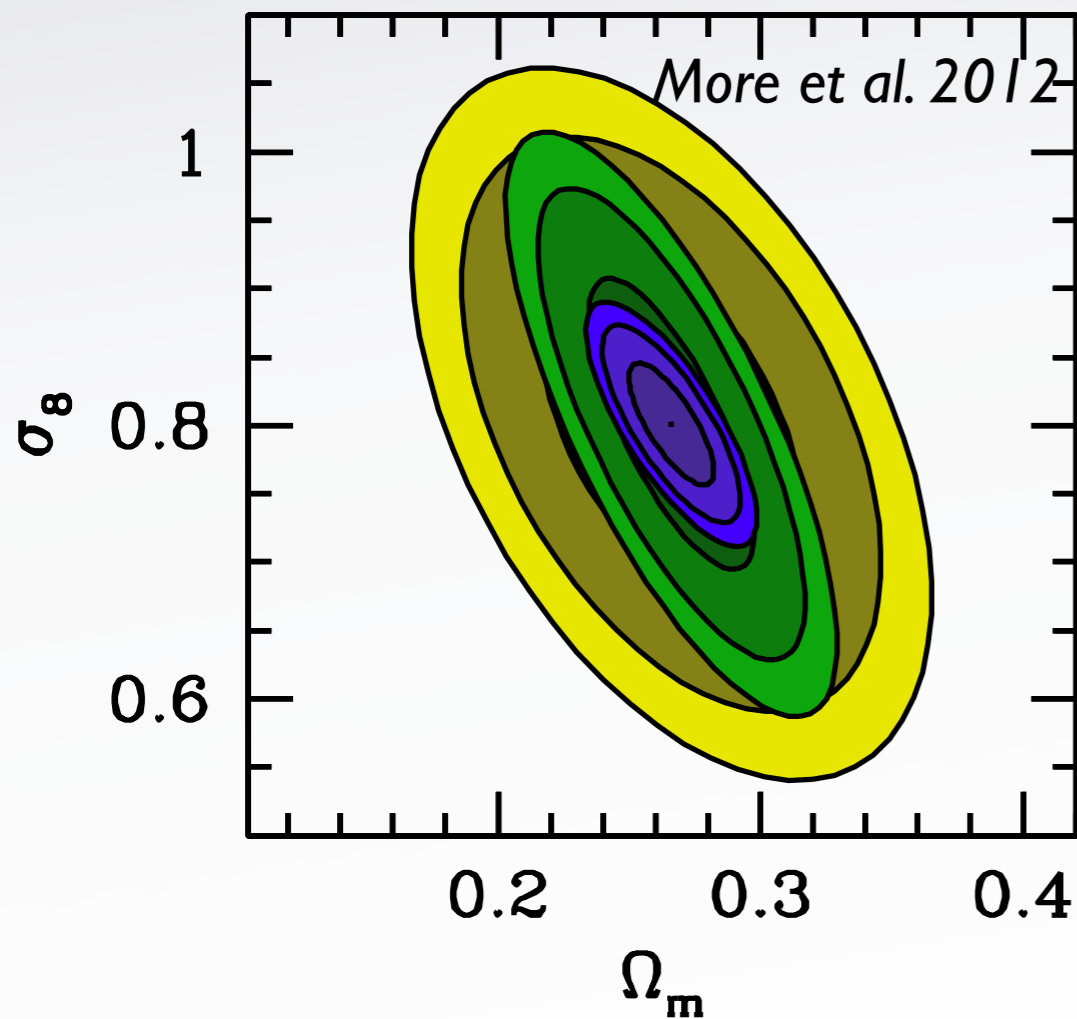
- Comic shear often has a large degeneracy in the σ_8 - Ω_m plane
- The two techniques have very different systematics

BOSS + HSC

- Baryon Oscillation Spectroscopic Survey: 1.5 million massive red galaxies with spectroscopic redshifts at z=0.55 over 10,000 square degrees (2009-2014)

*Will measure galaxy clustering, $w_p(r_p)$, with high precision*

- Hyper Suprime Cam : overlaps with the BOSS survey and will measure the galaxy-galaxy lensing signal of BOSS galaxies with high precision.
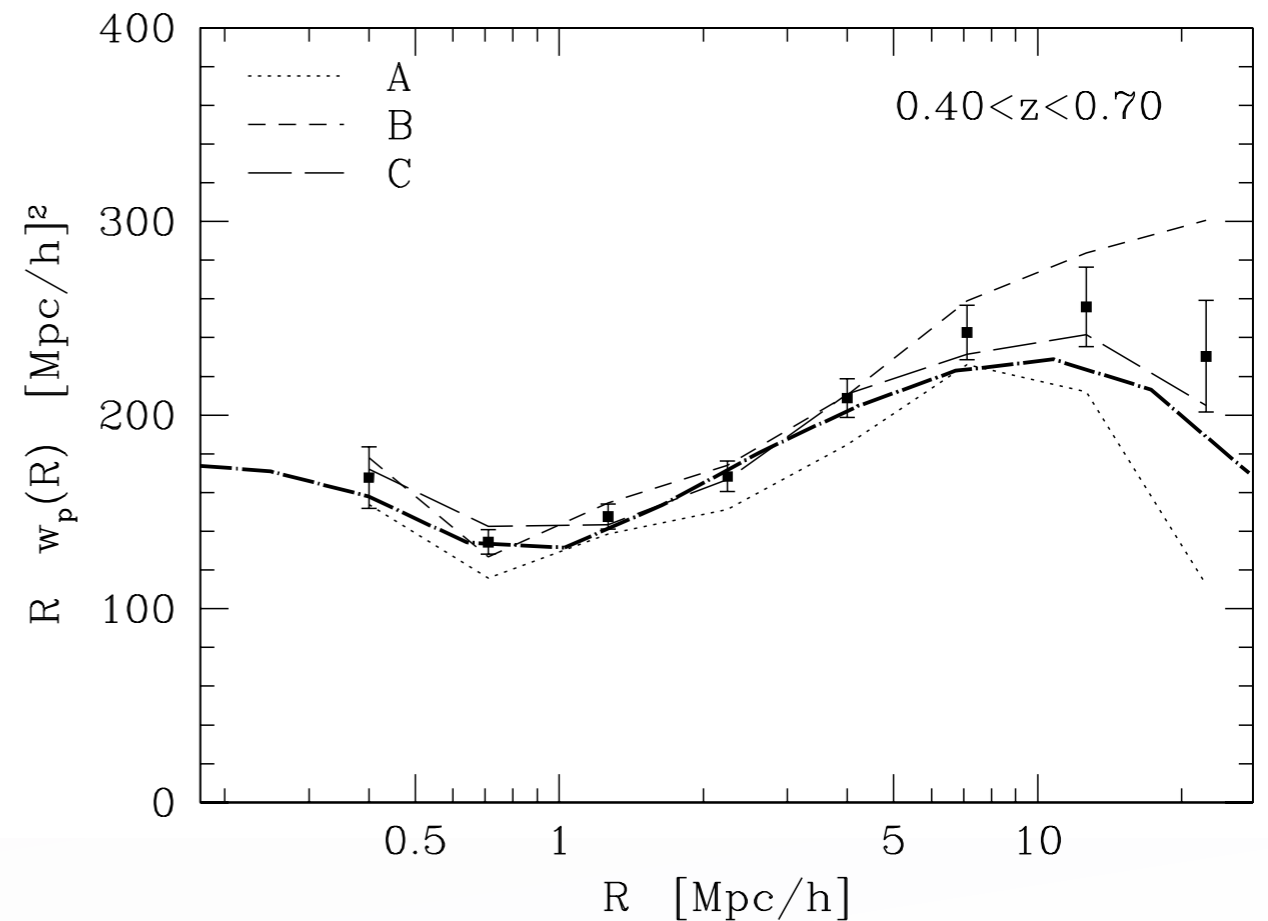
Will measure galaxy-galaxy lensing, $\Delta\Sigma$, with high precision

Some first measurements for BOSS

These are some measurements I have made for BOSS galaxies.
CS82: a CFHT survey of Stripe 82 (170 deg^2, seeing <0.8")
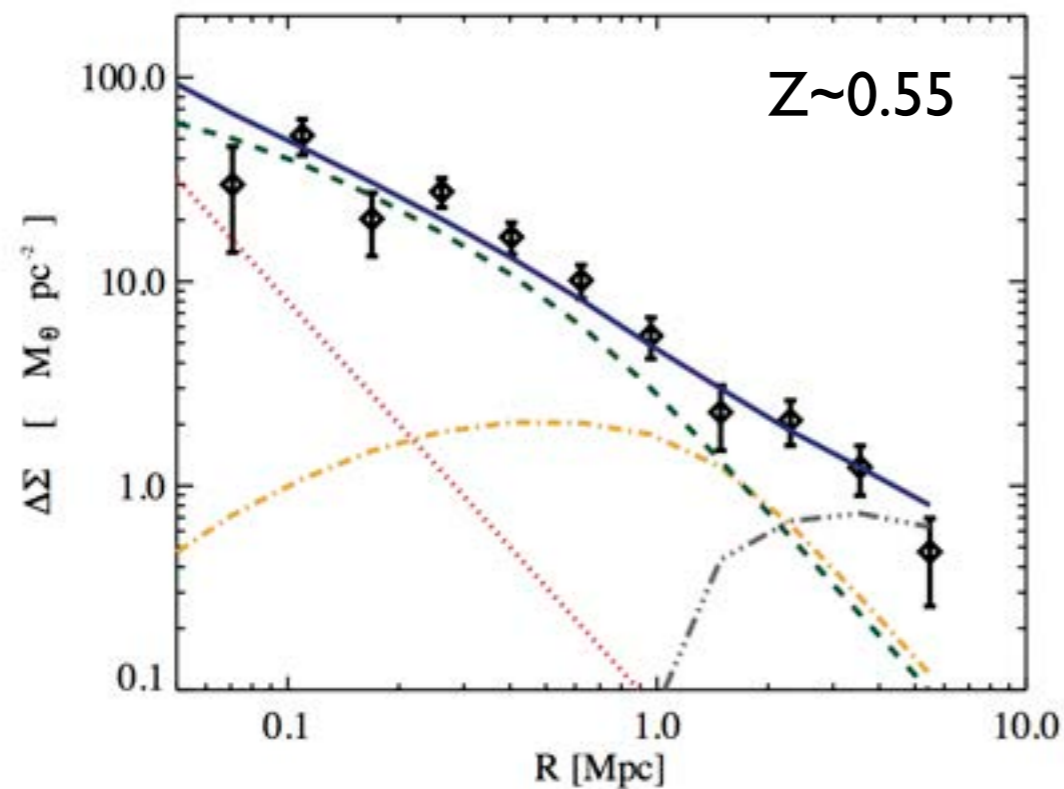
Galaxy-galaxy lensing measured from the CS82 survey of Stripe 82 (1/10th HSC area)

Galaxy clustering from BOSS (now calculating newer version)

White et al, 2011

Conclusions

❖ Cosmic shear is not the only way to do cosmology with weak lensing.

❖ We can also use a combination of galaxy-galaxy lensing and galaxy clustering.

❖ With this we can also put constraints on neutrino masses and we can test modified gravity theories.

❖ Very different systematics than cosmic shear

"The Next Generation of Weak Lensing Surveys"
3 week Aspen summer workshop, June 16 2013.
Application deadline: Jan 31st 2013.
Alexie Leauthaud, Rachel Mandelbaum, Ludo van Waerbeke, Bhuvnesh Jain