Cosmic Magnification - A New Window to Cosmology

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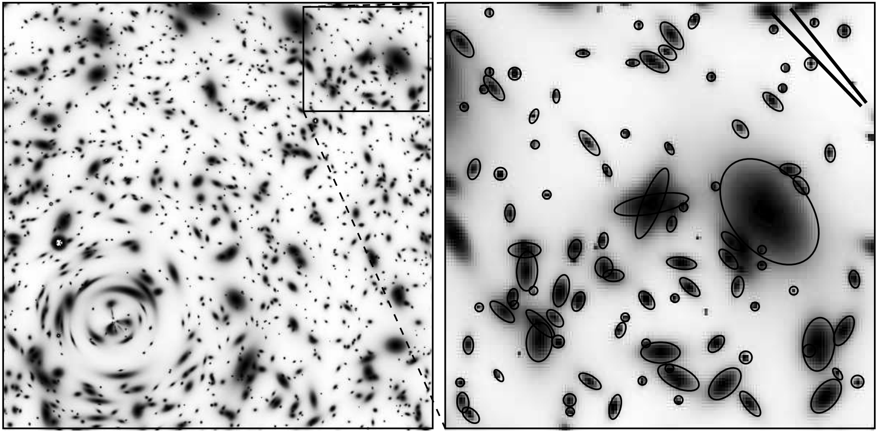
Outline

1. Weak Gravitational Lensing
2. Cosmic Magnification
3. Results from the CFHTLS

Weak Gravitational Lensing



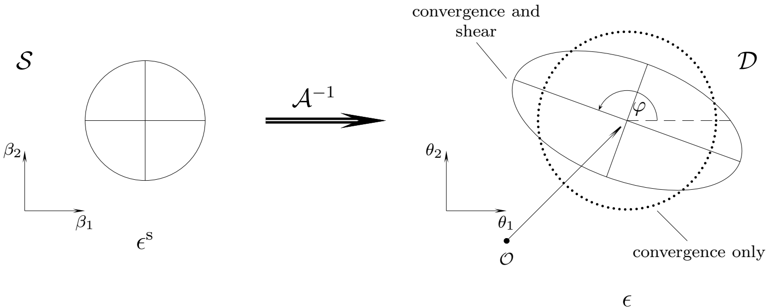
from Mellier (1999)

Weak Gravitational Lensing

Characteristics

- Weak distortions and magnifications
- Only used in a statistical way
- Sensitive to both, dark and visible matter
- Can be used to study the dark matter halos of galaxies and clusters
- WL of LSS (cosmic shear) potentially the most promising probe of dark energy

Lensing of a circular source



from P. Schneider, Saas Fee lecture on “Weak Gravitational Lensing”

Shear based methods

Advantages

- Expectation value of intrinsic ellipticities is known: $\left\langle \epsilon^{(s)} \right\rangle = 0$
- $\langle \epsilon \rangle = \left\langle \epsilon^{(s)} \right\rangle + \gamma = \gamma$
- Higher S/N than magnification based methods

Disadvantages

- PSF (atmosphere + instrument)
- Pixelisation
- Noise
  $\Rightarrow$ **Measuring accurate, unbiased shapes is extremely difficult**
- Intrinsic alignments

Magnification based methods

Advantages

- Magnitudes easier to measure than shapes
- More galaxies with magnitudes available
- Higher redshift sources usable

Disadvantages

- Intrinsic distribution of magnitudes not a priori known
  $\Rightarrow$ **Need to measure the LF first**
- Strong requirements on photometric homogeneity
- Precise correction for galactic dust needed

Effects of magnification

Observables

- $< \delta_{g1}\delta_{g2} >$: Angular cross-correlation function between high-z sources and low-z lenses
- $< \delta_{g1}\delta m_2 >$: Magnitude shift of sources as a function of distance from the lenses
- $< \delta m_1 \delta m_2 >$: Cross-correlation of the magnitude shifts of sources

Angular cross-correlation $< \delta_{g1}\delta_{g2} >$

Magnification

- lens magnifies objects in background
- objects that are too faint without a lens become visible
- **positive cross-correlation**

Angular cross-correlation $< \delta_{g1}\delta_{g2} >$

Magnification

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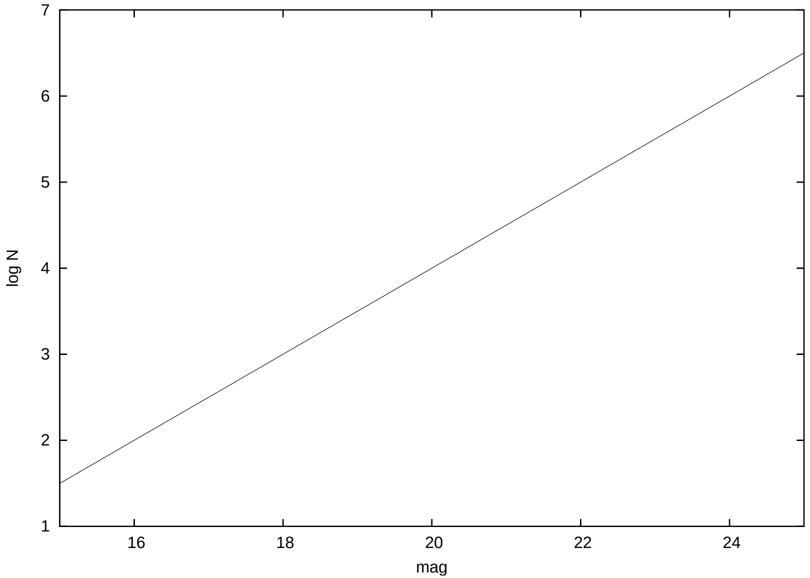
- objects that are too faint without a lens become visible
- **positive cross-correlation**

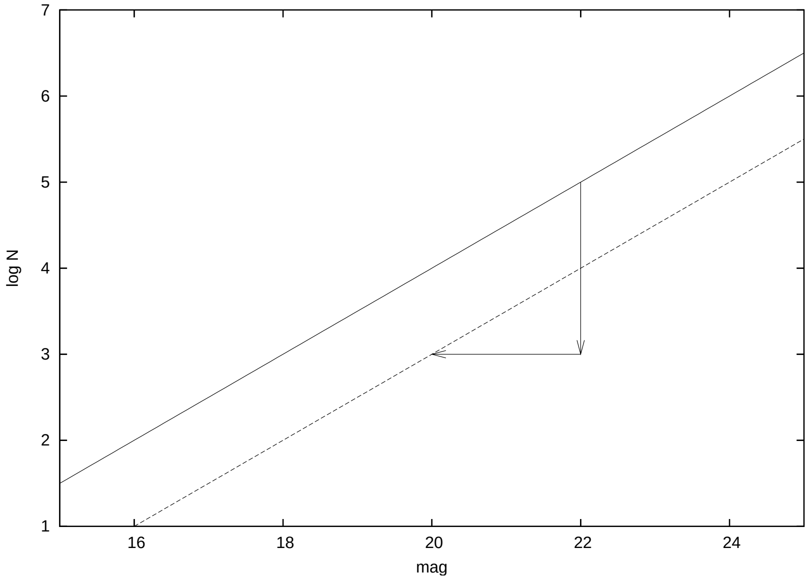
Dilution

- lens enlarges the solid angle behind it
- source density is diluted
- **negative cross-correlation**

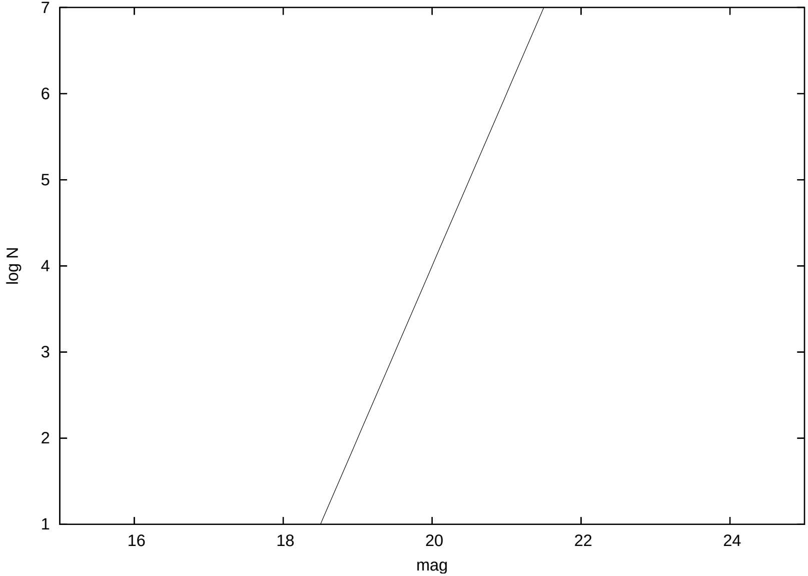
Magnitude numbercounts



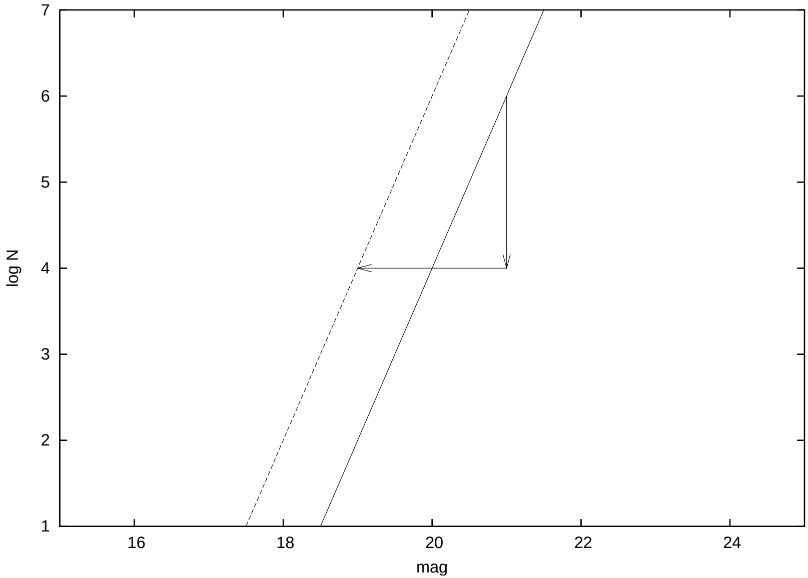
Magnitude numbercounts



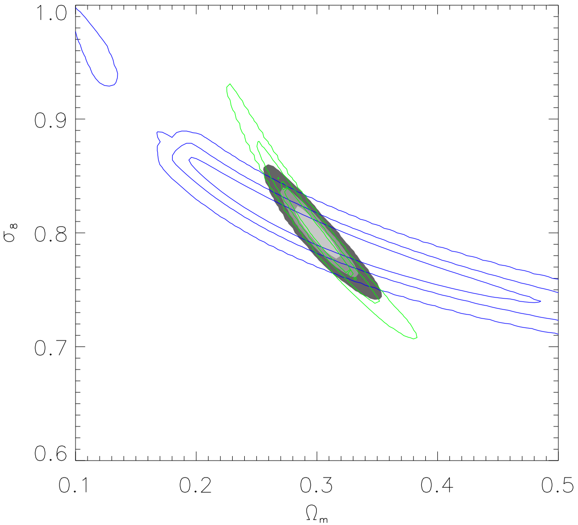
Magnitude numbercounts



Magnitude numbercounts



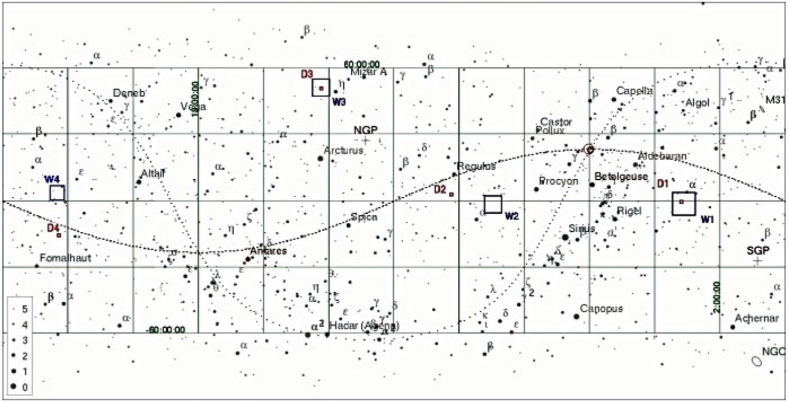
Cosmological Constraints



from van Waerbeke 2009

Cosmic shear
Cosmic magnification

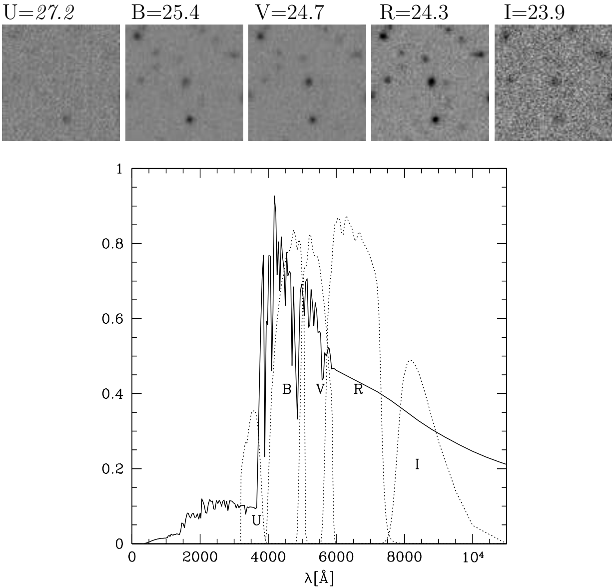
The CFHTLS



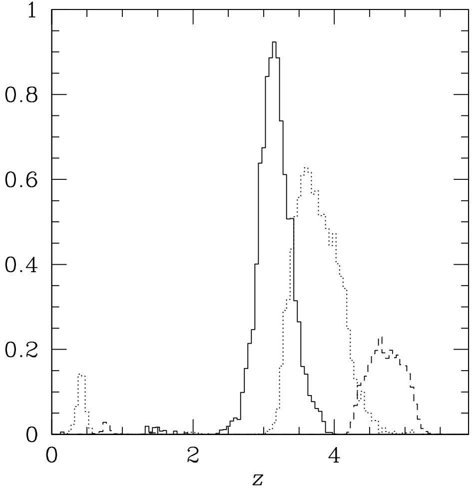
CFHTLS-Deep: 4 sq. deg. in *ugriz* to $i_{\rm lim.} \sim 27.5$ (5-σ AB)

CFHTLS-Wide: 170 sq. deg. in *ugriz* to $i_{\rm lim.} \sim 25.5$ (5-σ AB)

LBG selection

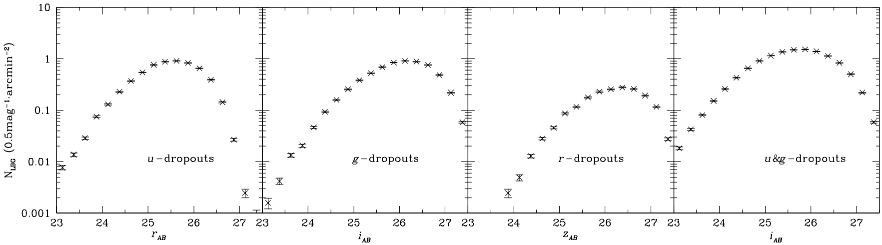


LBG redshift distributions



34 218 *u*-dropouts ($z \sim 3$)
36 226 *g*-dropouts ($z \sim 4$)
10 482 *r*-dropouts ($z \sim 5$)

LBG numbercounts



LF slopes

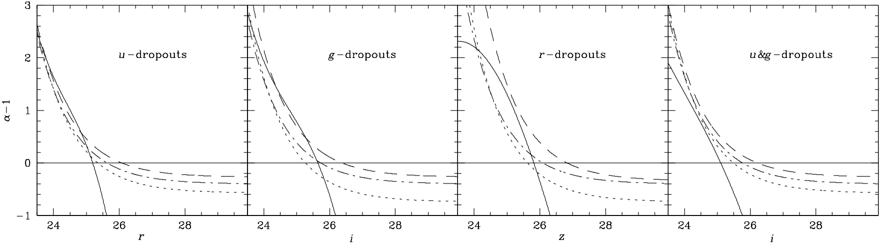
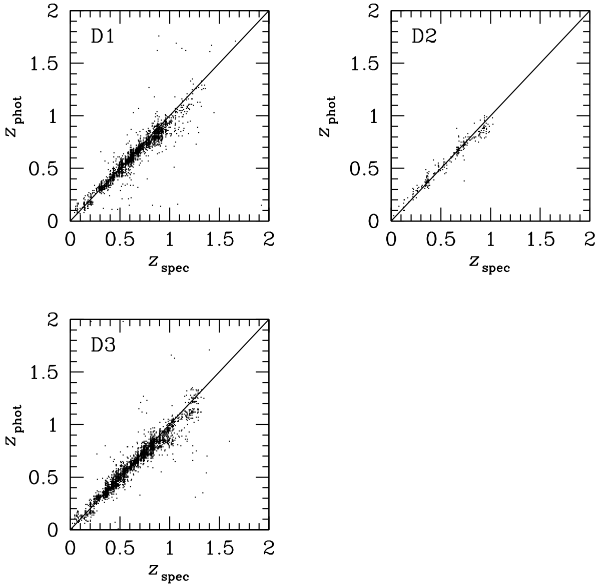


Photo-z accuracy

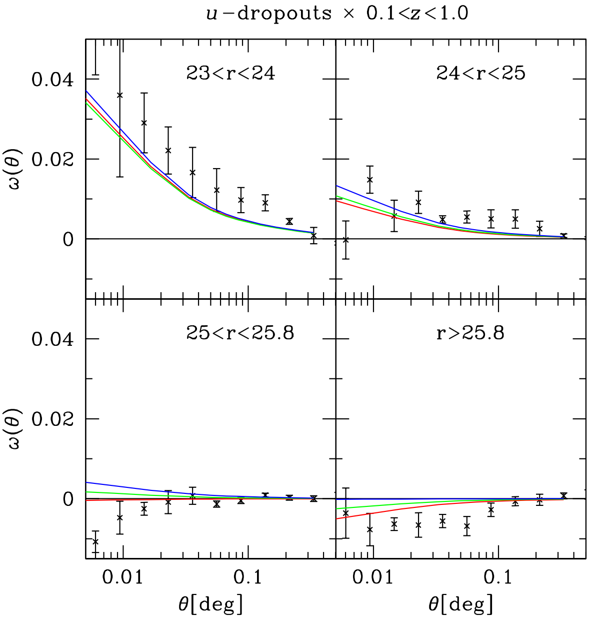


for $i < 24$:

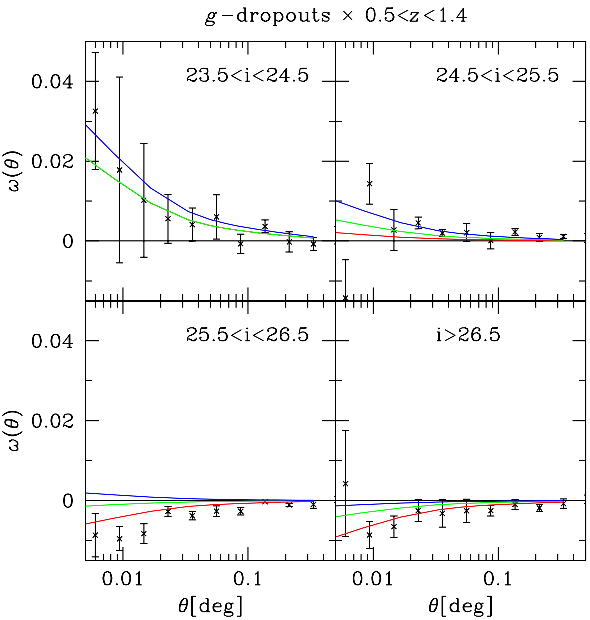
$\sigma_{\Delta z/(1+z)} = 0.033$

1.6% outliers

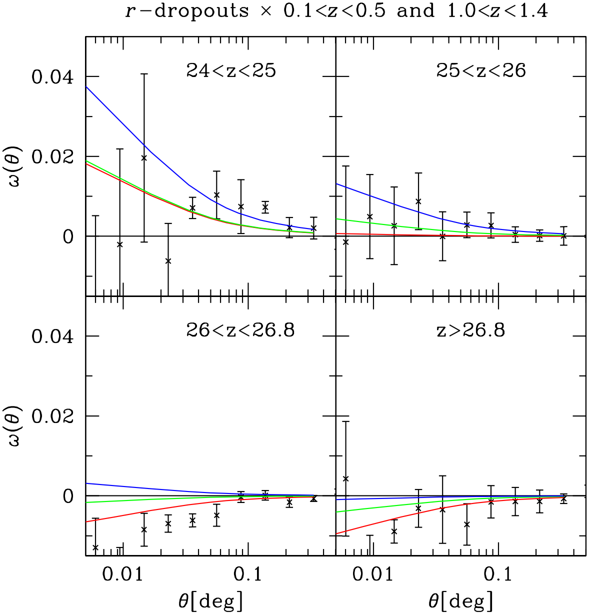
Results for *u*-dropouts $< \delta_{g1}\delta_{g2} >$



Results for *g*-dropouts $< \delta_{g1}\delta_{g2} >$

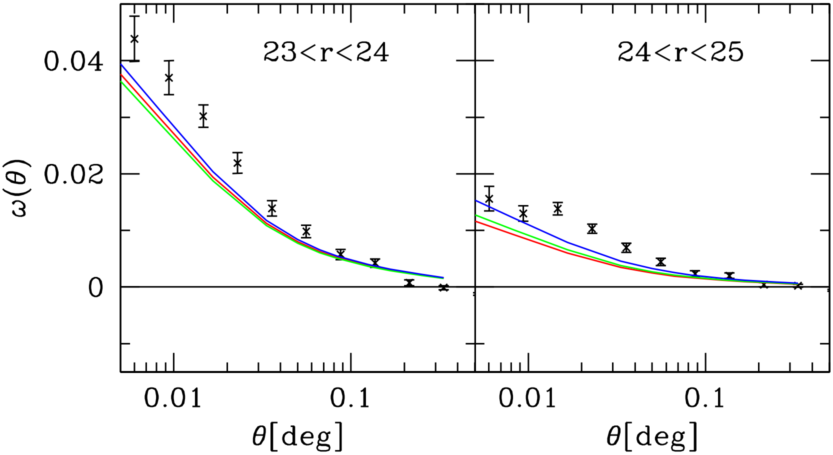


Results for *r*-dropouts $< \delta_{g1}\delta_{g2} >$



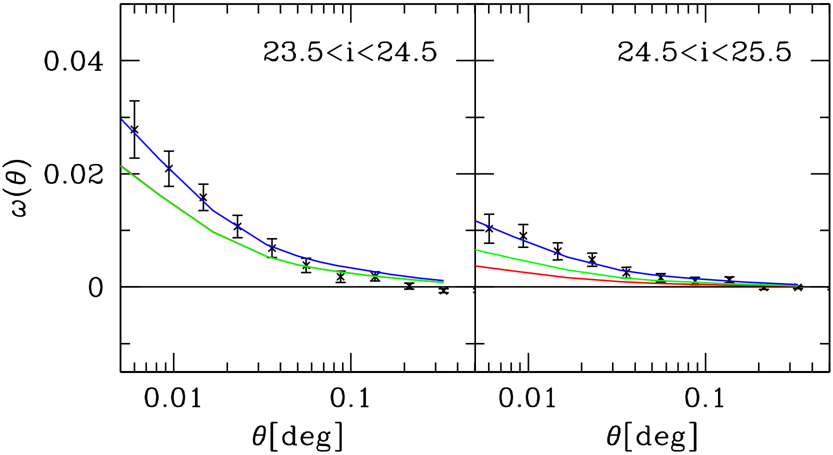
Results for *u*-dropouts from the WIDE $< \delta_{g1}\delta_{g2} >$

156 sq. deg.
1.7×10^5 sources
5.7×10^6 lenses

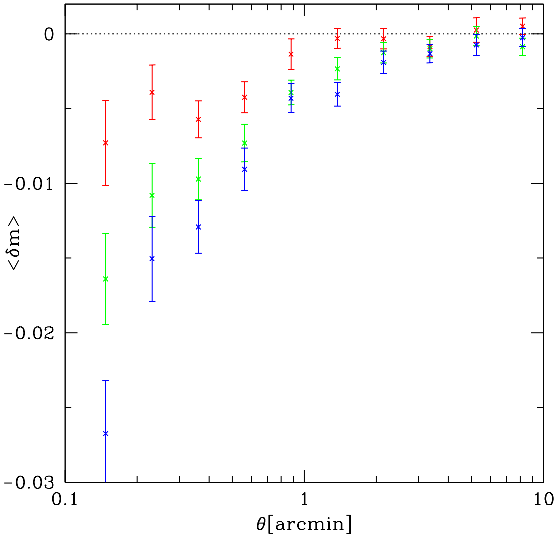


Results for *g*-dropouts from the WIDE $< \delta_{g1}\delta_{g2} >$

156 sq. deg.
1.8×10^5 sources
4.0×10^6 lenses



Mag shift $< \delta_{g1} \delta m_2 >$, u-dropouts, CFHTLS-WIDE



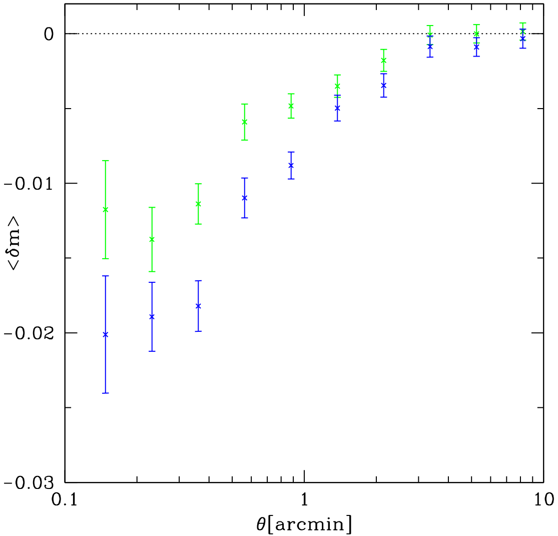
lenses: $0.4 < z < 0.8$

g-band

r-band

i-band

Mag shift $<\delta_{g1}\delta m_2>$, *g*-dropouts, CFHTLS-WIDE



lenses: $0.4 < z < 0.8$

r-band
i-band

Outlook

- Transition from "proof-of-concept" to cosmological constraints
- Estimate the LFs from the data themselves
- Remove/constrain the galaxy bias from the analysis
- Include dust corrections
- Explore the potential to constrain the DE-EOS
- Measure masses of high-z clusters

mag-mag corr. $<\delta m_1 \delta m_2>$ (Wide u&g-dr. comb.)