Weak Lensing Measurement of Stellar-to-Halo Mass Ratio with *DECaLS* Survey

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Outline

- Background
- ***DECaLS***: DECam Legacy Survey
- Preliminary results:
  - Stellar-to-Halo Mass Ratio (***SHMR***)
- Summary

SHMR: Stellar-to-Halo Mass Ratio

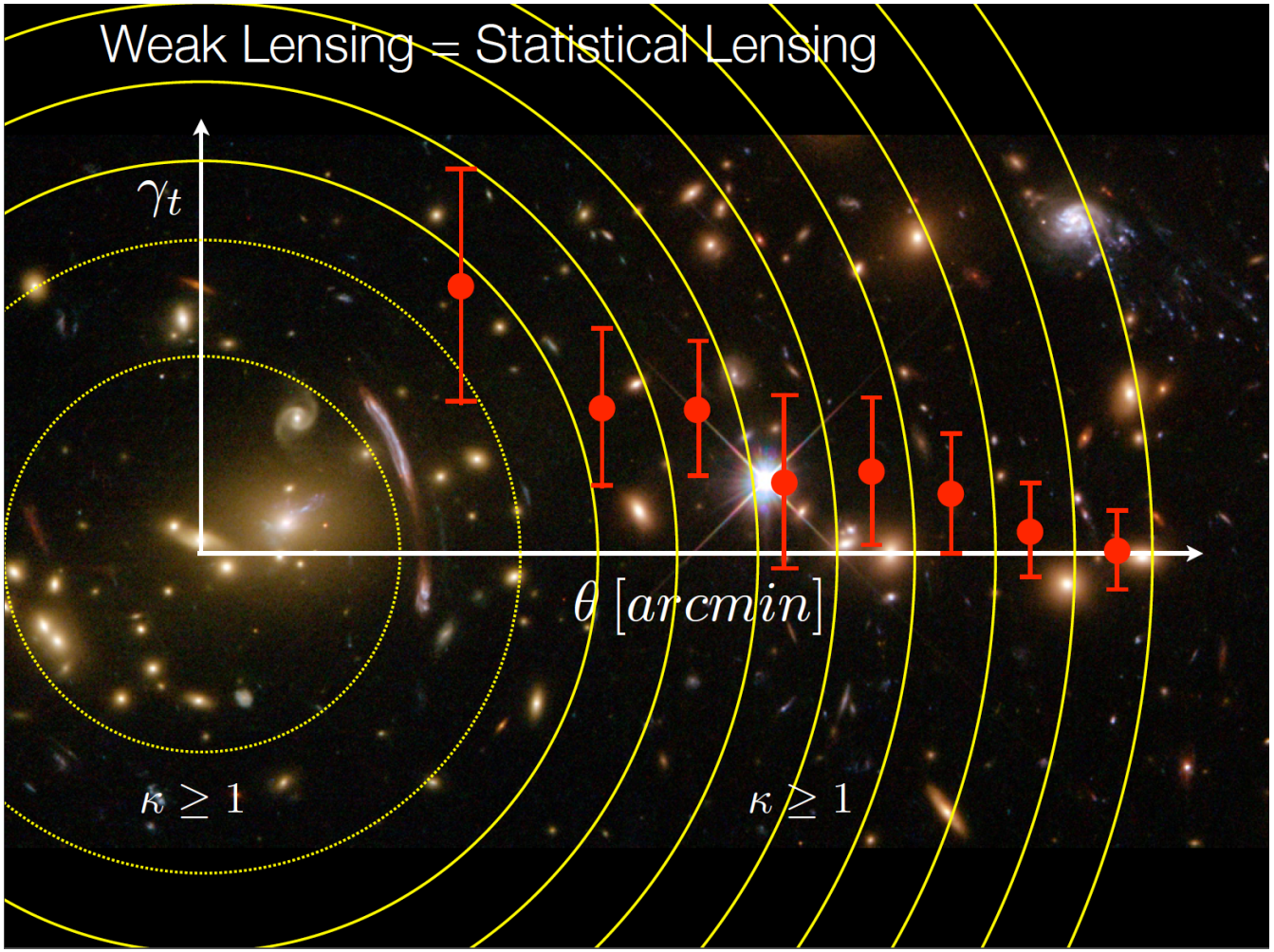
Aquarius Simulation

- ***SHMR***: $f_* = M_*/M_{halo}$
  - M_*: stellar mass
  - M_{halo}: halo mass

SHMR: Stellar-to-Halo Mass Ratio

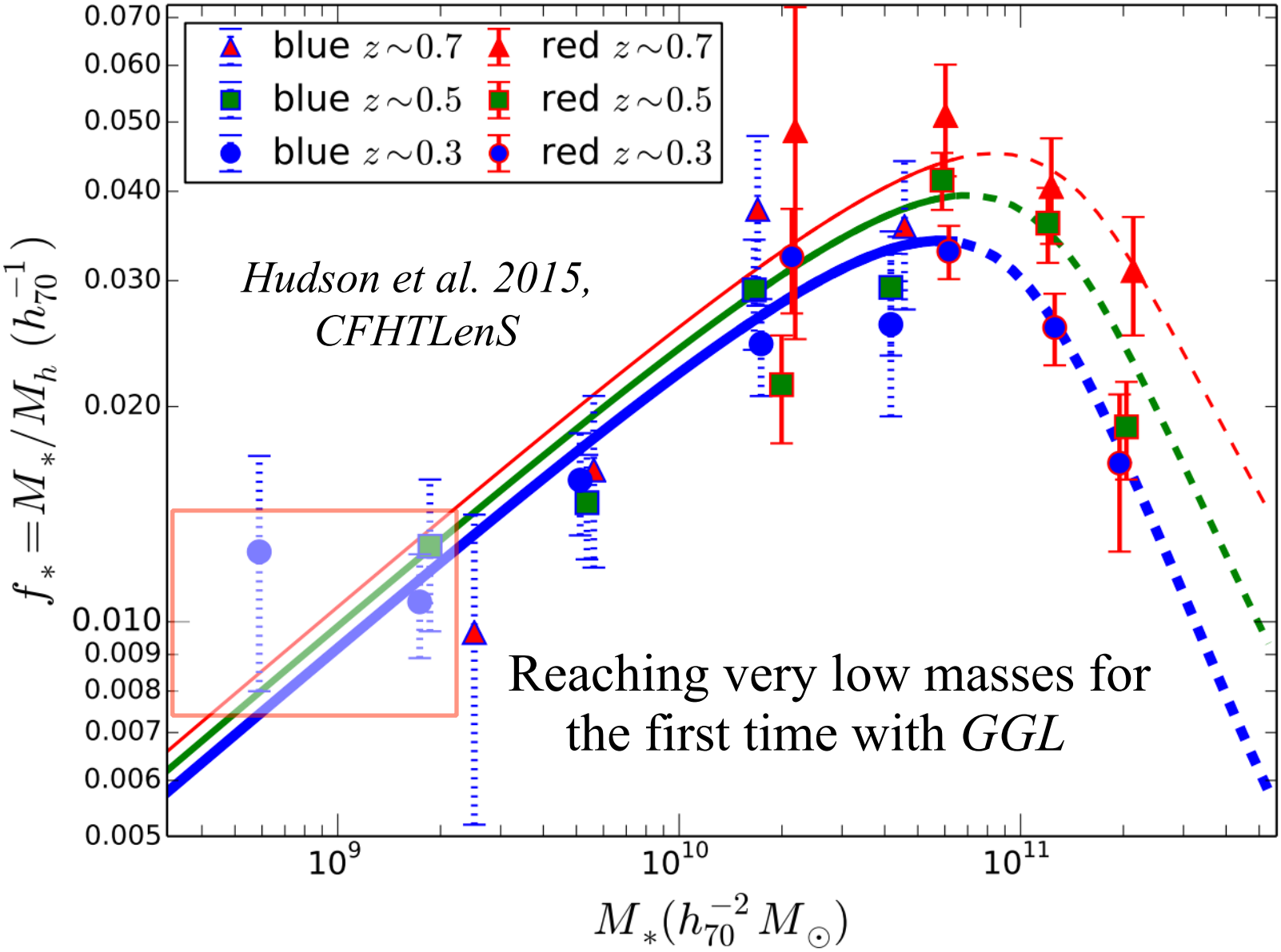
Aquarius Simulation

- Abundance matching
- Galaxy clustering
- Satellite kinematics
- Galaxy-galaxy lensing

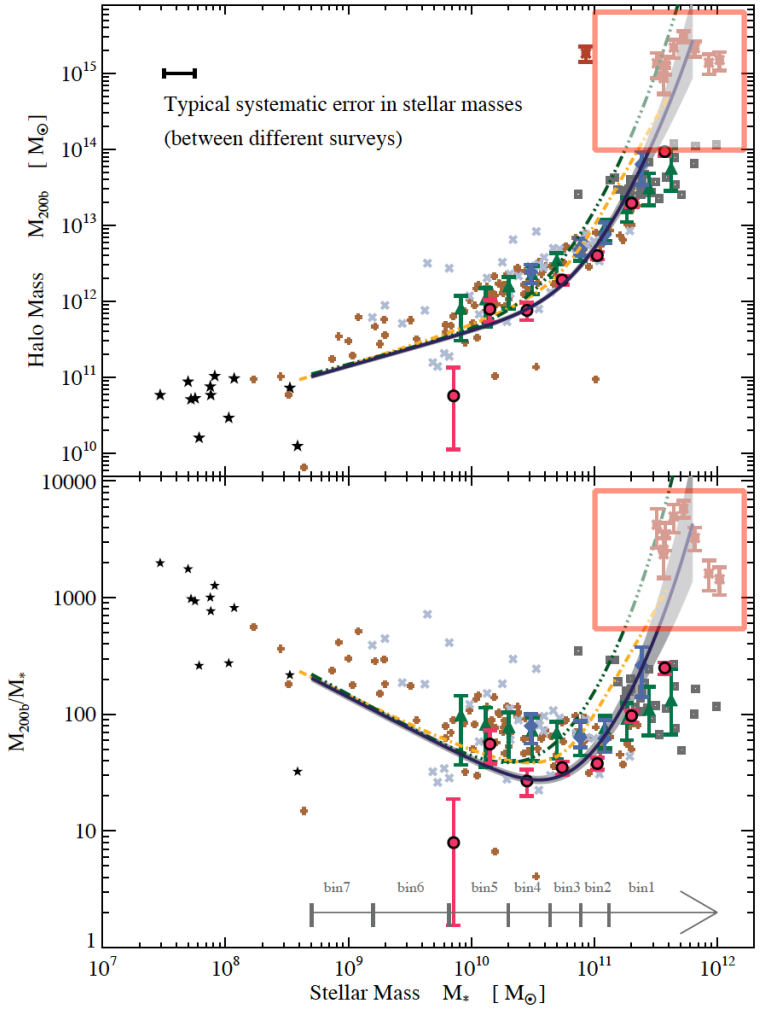


- Galaxy-galaxy lensing (***GGL***)
  - Measure DM halo mass directly
  - Reduce the noise (LSSs, shape noise, substructures, variation…)
  - Weak signal that is difficult to measure

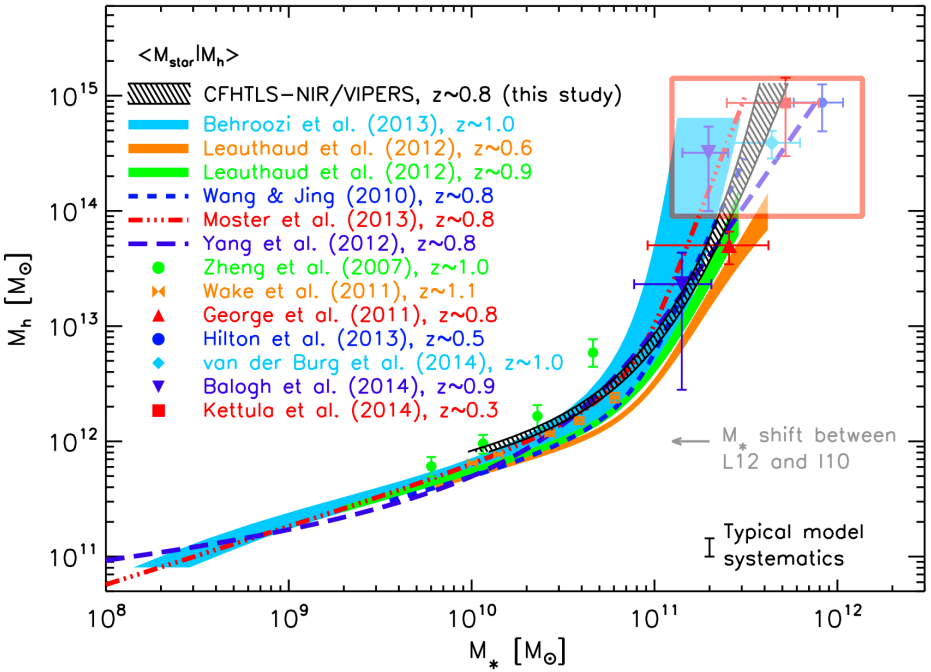
SHMR from *GGL* only



SHMR of high-mass halos



Coupon et al. 2015



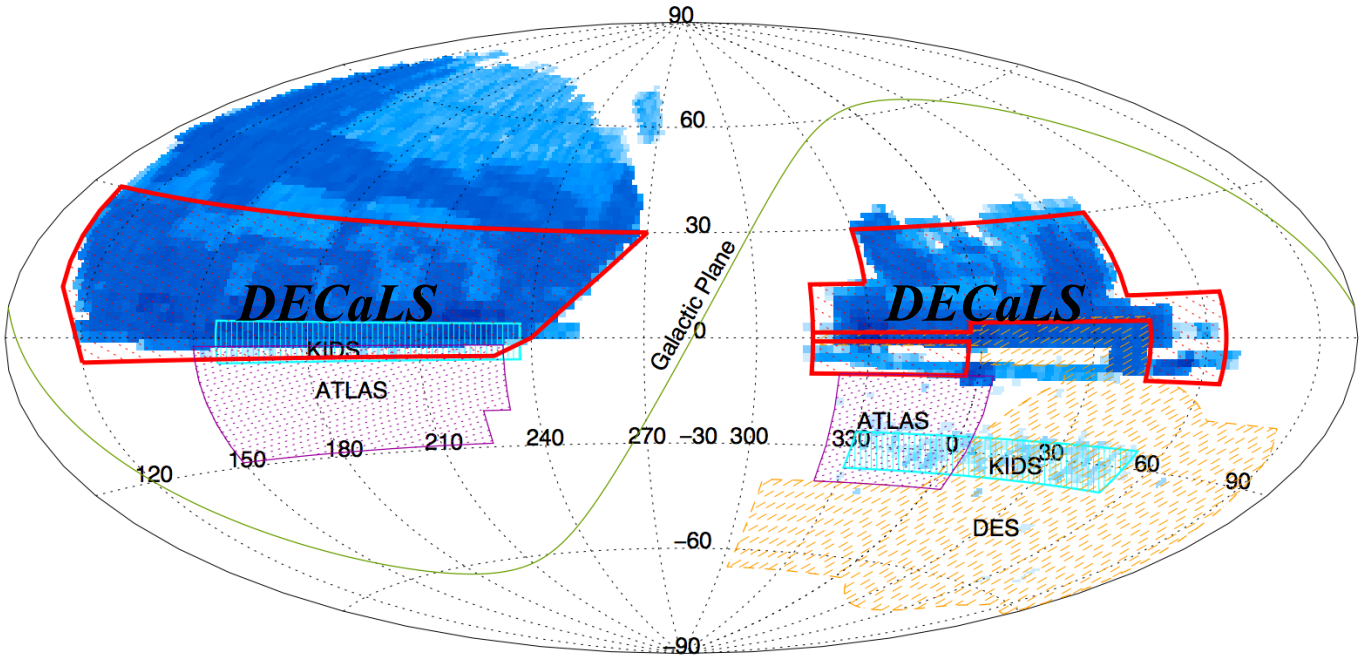
Leauthaud et al. 2012

SHMR of high-mass halos: **Large scatters**

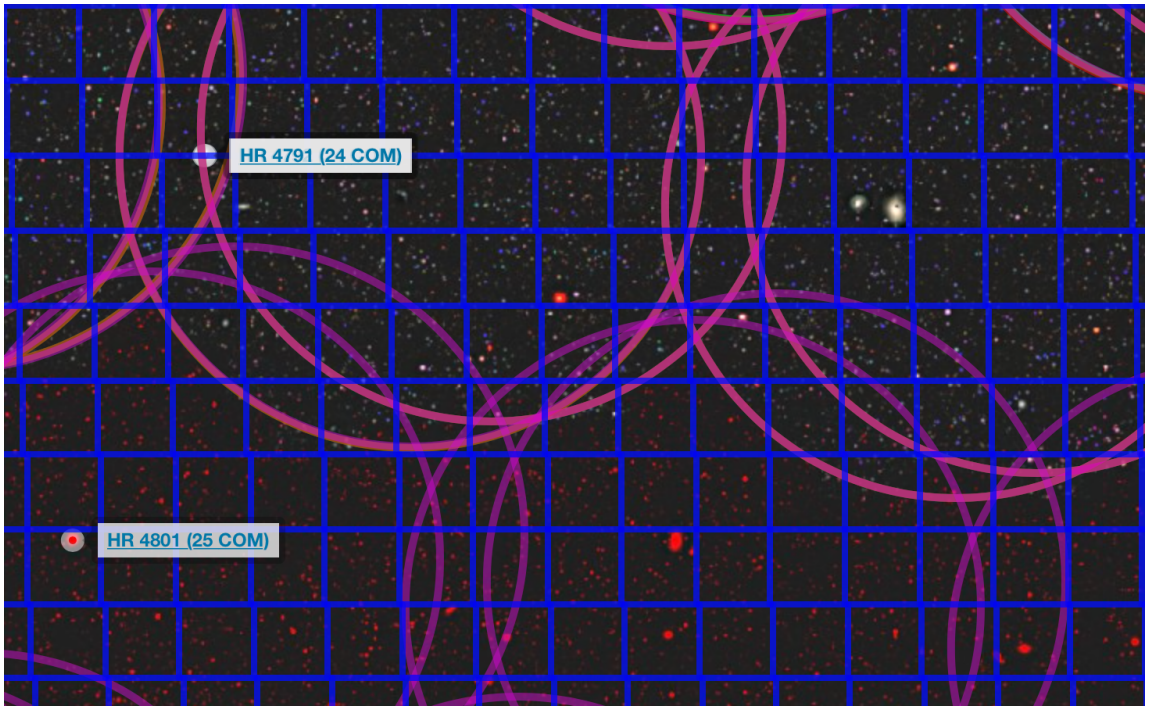
More constraints from *GGL*: **Larger WL surveys!**

DECaLS: DECam Legacy Survey

- Image *SDSS* footprint
  - Total area: ~6700 deg^2
  - 3 bands: *g, r, z*
  - ~1-2 mag deeper than *SDSS* (g~24.7, r~23.9, z~23.0)
  - Overlapping with the *BOSS/eBOSS/DESI* project



- Fov: 3 deg^2
- 97554 bricks with the size 0.25*0.25 deg^2
- Pixel size: 0.262”
- Mean seeing: 1.05”



Scientific Benefits

- GGL:

  - Massive spectroscopy of the *BOSS/eBOSS/DESI* project

  - Different samples: *LOWZ/CMASS, LRG, ELG, QSO*

Shape Measurement

- Data reduction: *Tractor (Lang & Hogg)*
- PSF modelling using *PSFEx* on each individual exposure
- Tracter shape measurement: PSF, SIMP, De Vaucouleur, exponential models are adjusted to every Sextractor source

- De Vaucouleur and exponential profiles are decomposed in Mixture of Gaussians (MoG)

- Pixelized PSF are convolved in Fourier Space

Morphological classification

Number of Sources	Type
478,918,959	Objects in a Primary brick
271,437,526	PSF
121,505,252	SIMP
63,568,420	EXP
20,141,591	DEV
2,266,170	COMP

Shape calibration

We bin the galaxies in mag_z and r_g. For each bin we compute

$$\chi^2 = \sum_i \frac{1}{\sigma_\gamma^2} \left(\bar{\gamma}_i^{\rm obs} - [1 + {\rm m}(\nu_{\rm SN}, r)]\, \bar{\gamma}_i^{\rm true} - {\rm c}(\nu_{\rm SN}, r) \right)^2$$

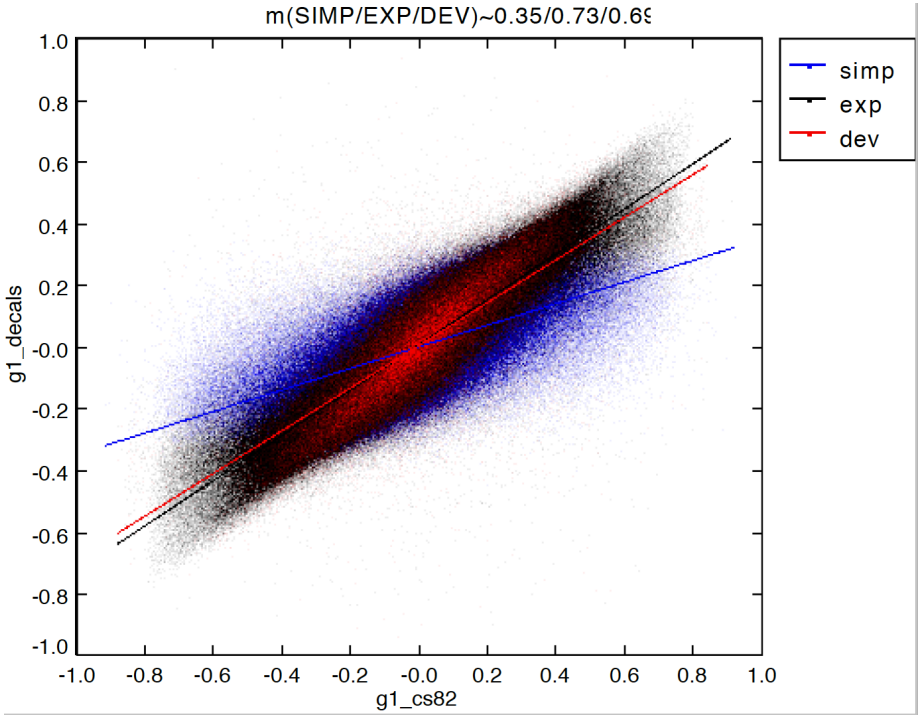
and adjust the functions (1+m) and c as $\epsilon = (1 + m)\epsilon^{\rm true} + {\rm c}$

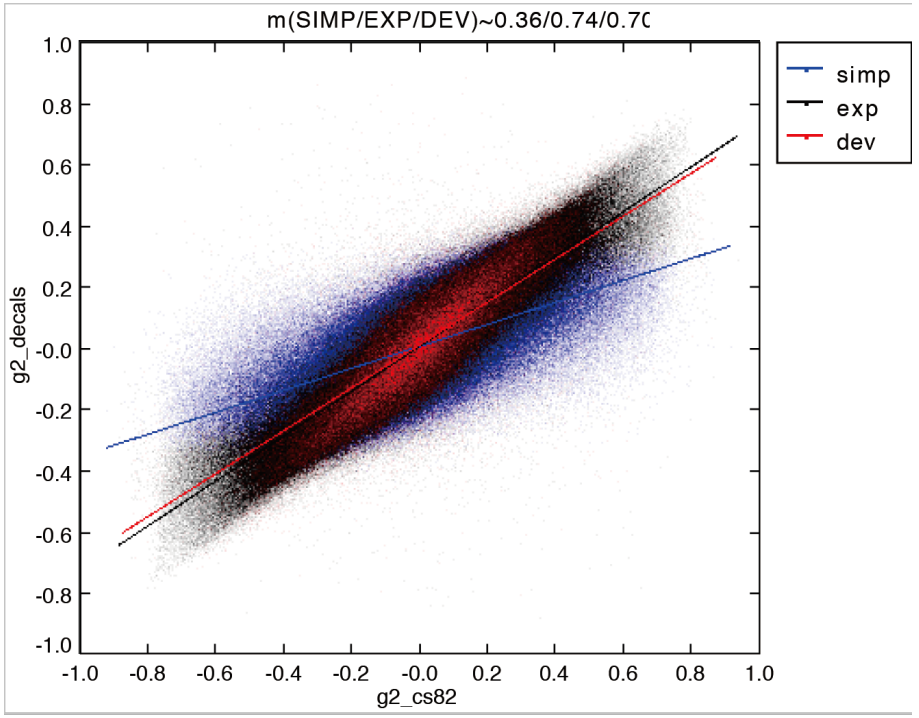
$$1+m(mag_z,r_g)=a_0 \exp(-a_1\, r_g\, mag_z)/\log_{10}(mag_z)$$

This is done for SIMP, EXP, DEV and COMP types

- Image simulation
- CS82 shear-calibrated data as the true values

- **m correction**: 10 magnitude bins & 10 galaxy size bins





- **c1, c2 correction** ($c=b0+b1*r_g+b2*r_g^2$)
- No obvious trends above a few 10^{-4} as a function of magnitude and half light radius

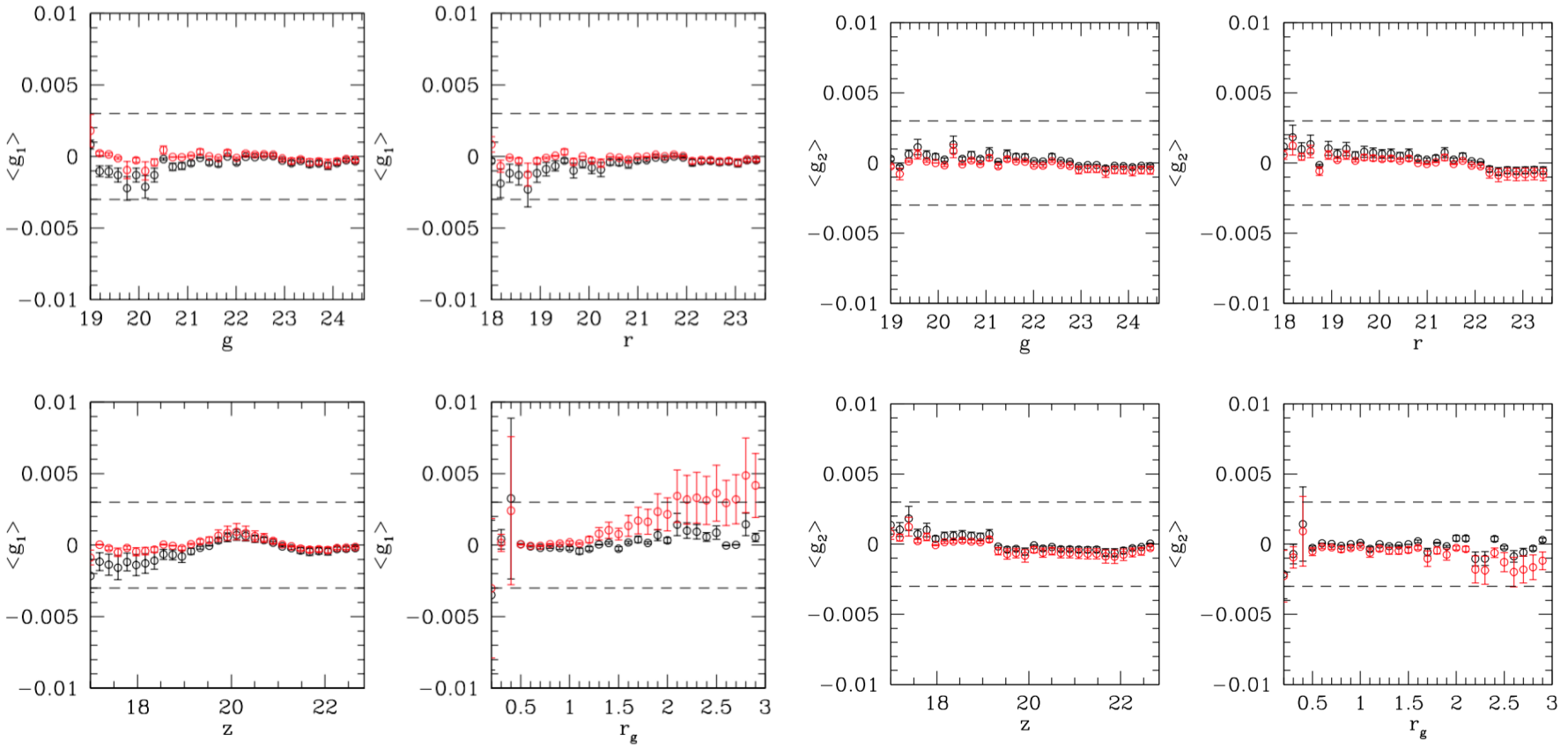
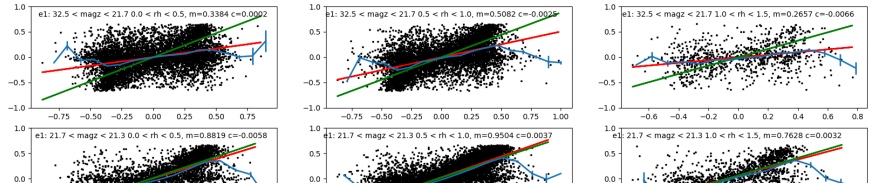
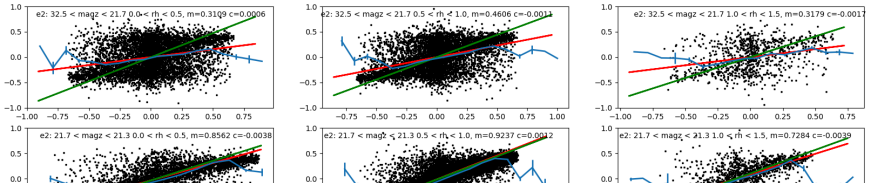
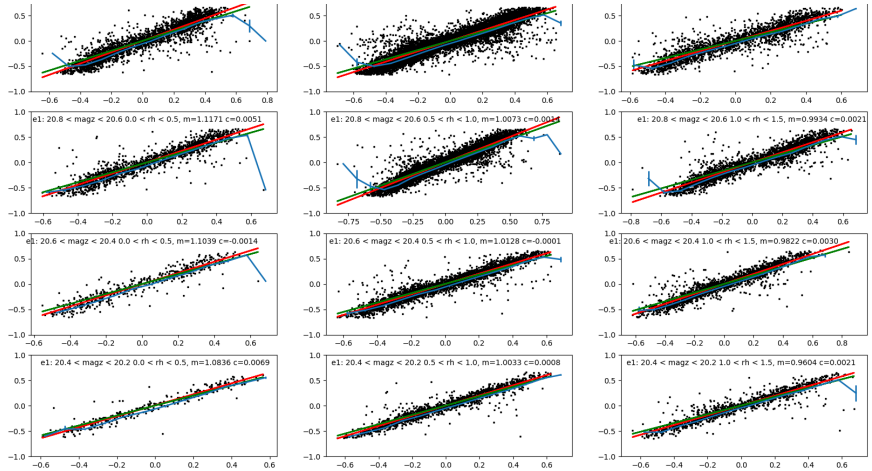


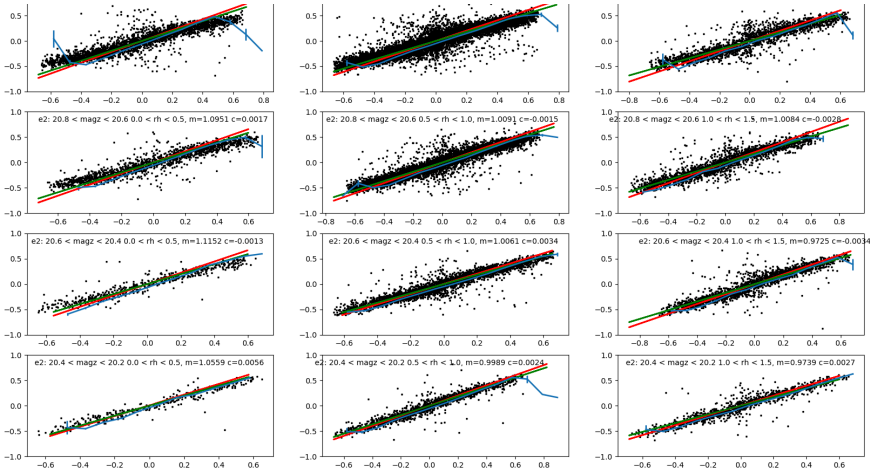
Image simulation:
- galaxy model+PSF+observation conditions
- DECaLS Legacy pipeline on simulated image





Similar m & c as comparison method



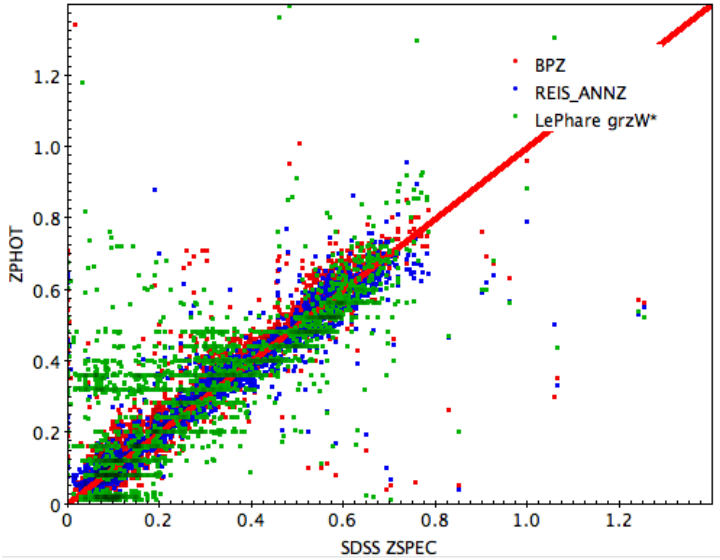


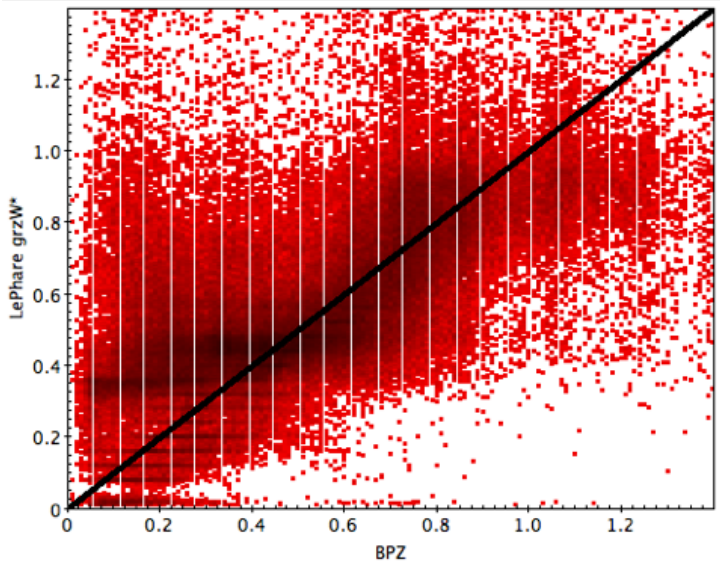
Photometric redshift

- We use the *GAZPAR* webservice provided by LAM to compute the *z*-phot of DECaLS galaxies using *grzW* bands

- We compare to CS82 zphots

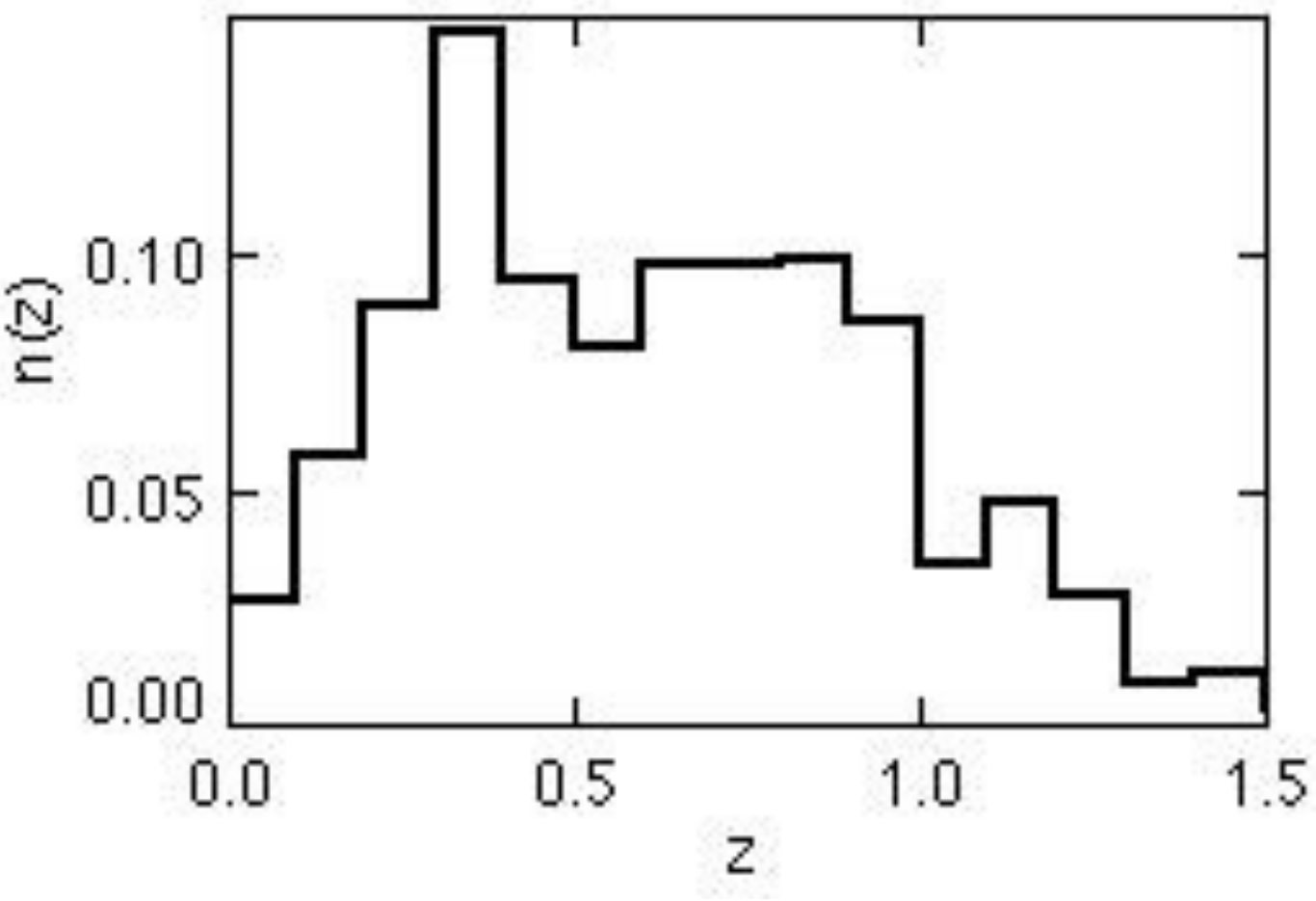
➔ No particular systematic error, but a *large scatter*





- **Galaxy selection**:

  $19.0<mag_g<24.65$ & $18.0<mag_r<23.61$ & $17.0<mag_z<21.0$ & $0.65<r_g<3.0$
- **n(z)** from ***COSMOS***

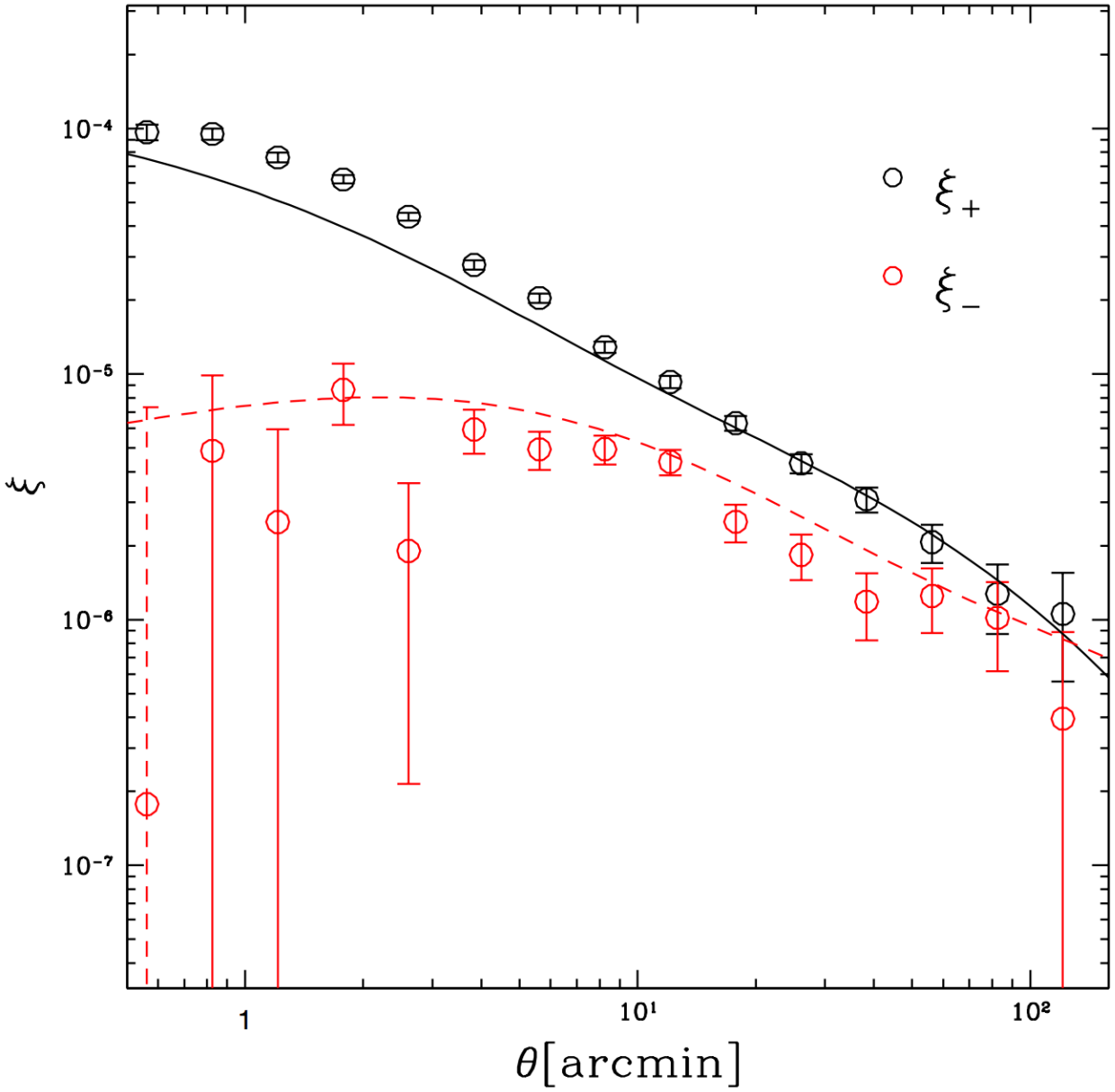


DECaLS: Lensing Status

- DECaLS DR3: 4300 deg^2 in *g*-band, 4600 deg^2 in *r*-band, 8100 deg^2 in *z*-band
- 4200 deg^2 have been observed in 3 bands

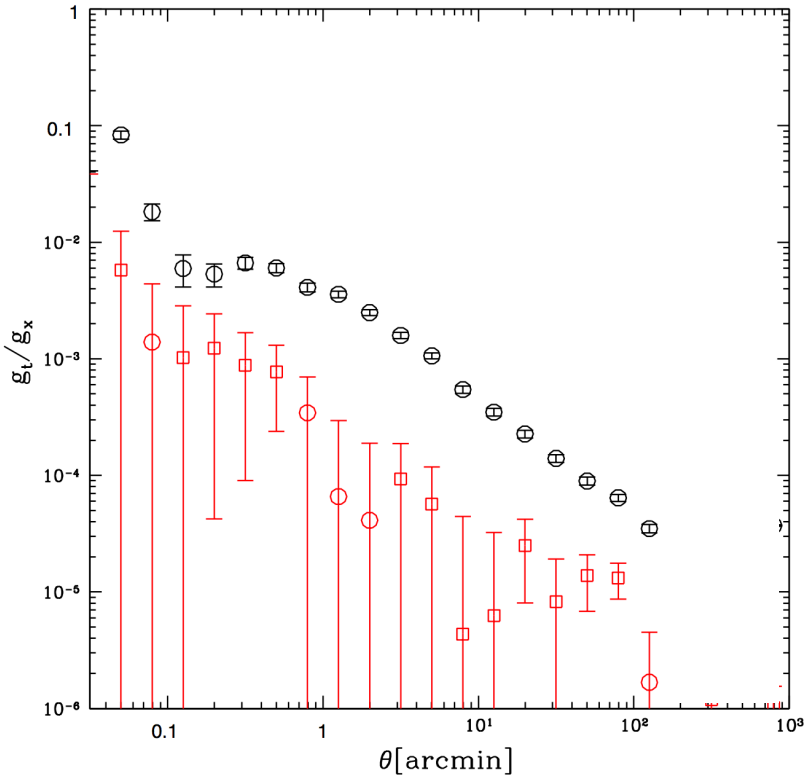
- About 56 million galaxies useful for lensing
- Lensing galaxy density about 4 $arcmin^{-2}$

Shear correlation function

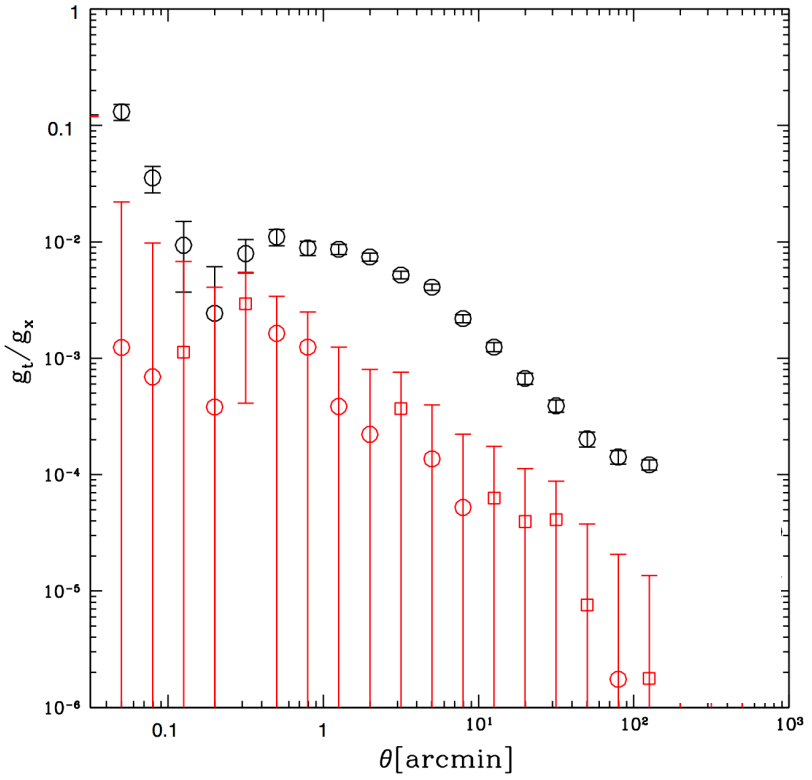


Tangential shear

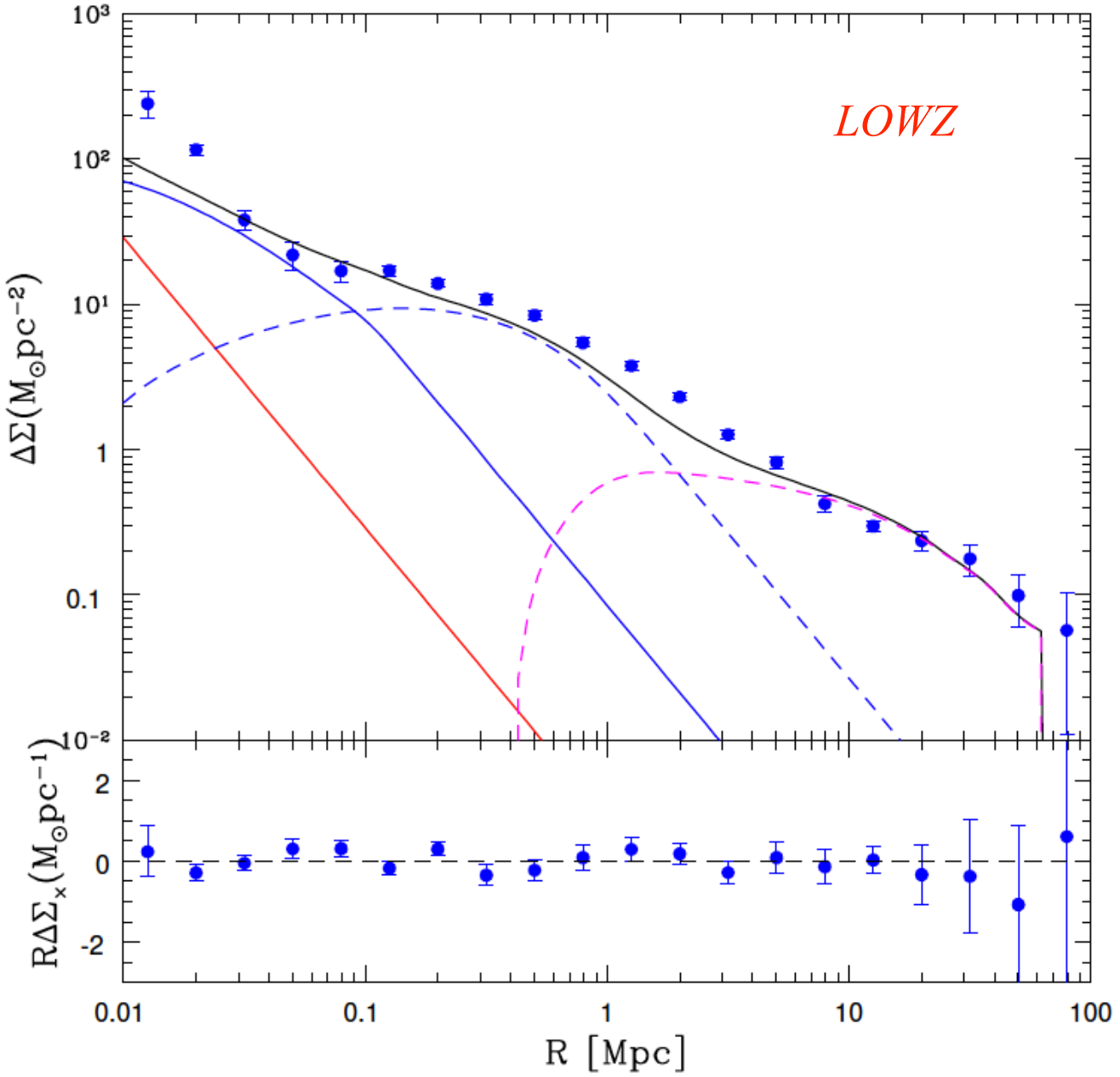
LOWZ galaxies (*BOSS DR12*)



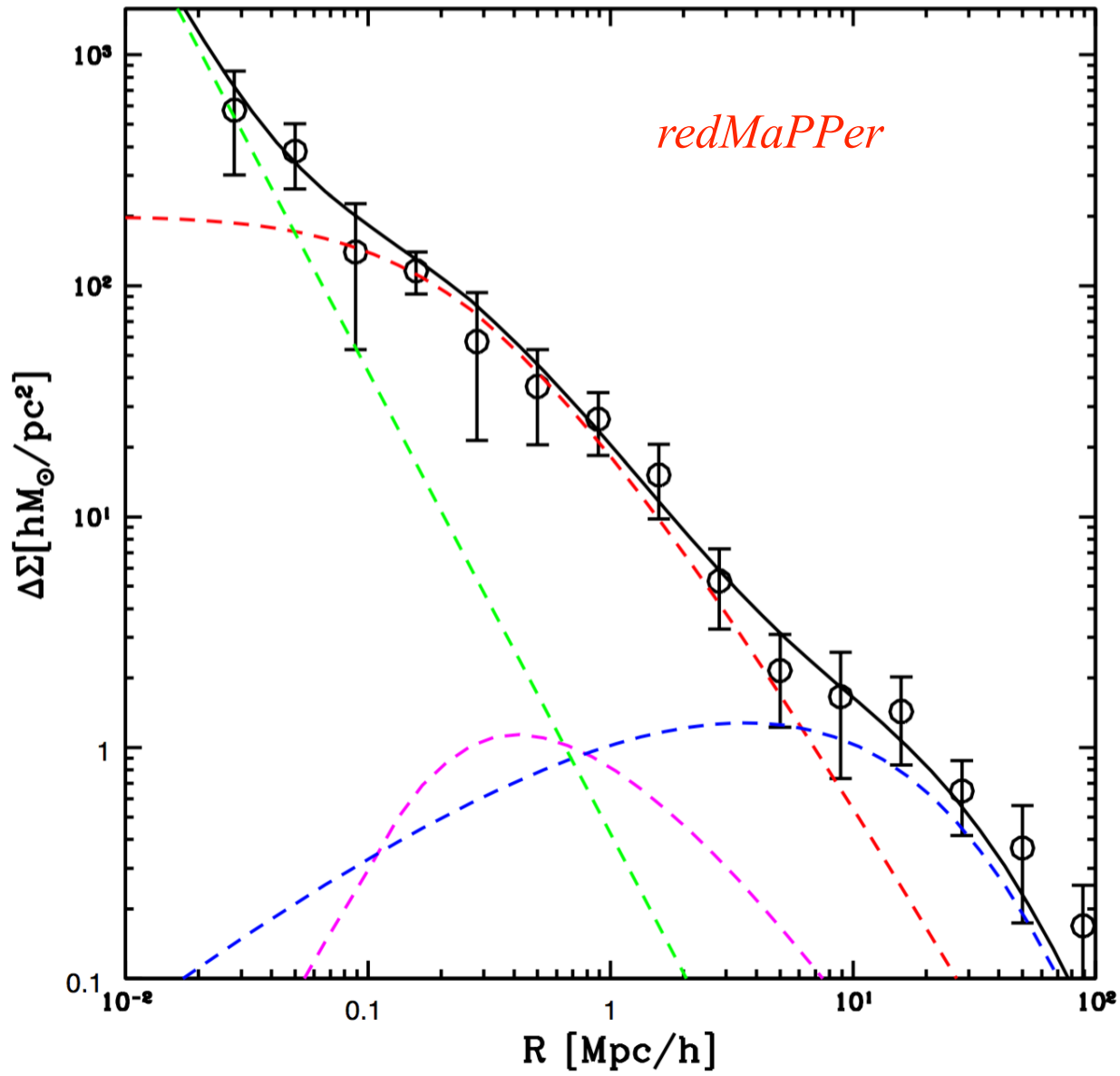
redMaPPer clusters
(*Rykoff et al. 2014*)



GGL: *Stellar mass+NFW halo+satellite+2-halo*

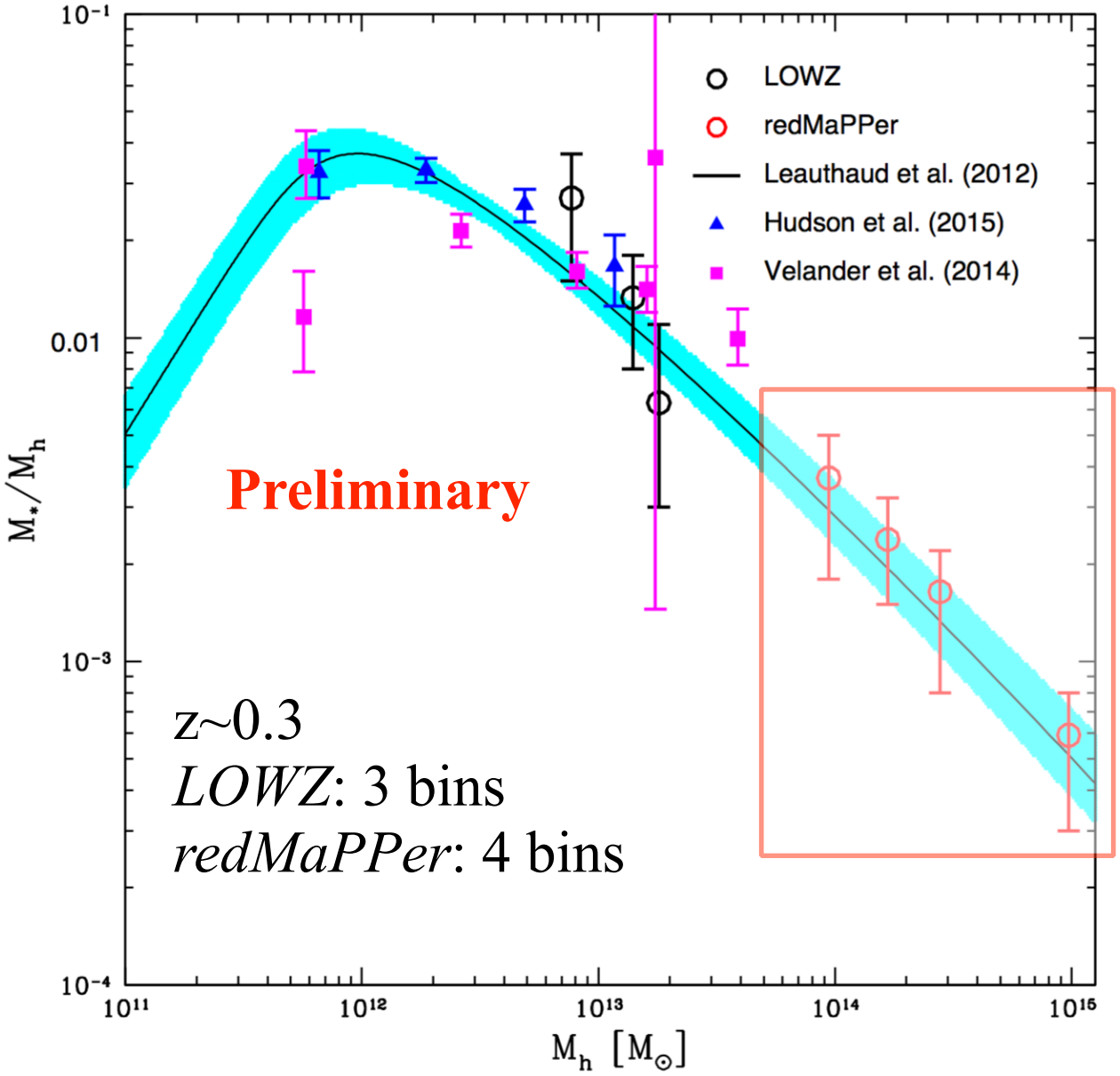


GGL: *Stellar mass+NFW halo+Mis-centering+2-halo*



SHMR of central galaxies

- Fixed stellar mass (*Maraston et al. 2013, BOSS*)



Summary

- ***DECaLS***

- Massive spectroscopy of the ***BOSS/eBOSS/DESI*** projects

- Measurement

- *Tractor*: shear catalog

- *COSMOS*: redshift distribution

- Preliminary results:

- GGL signals of LOWZ/redMaPPer

- ***SHMR***