Photometric Redshifts in SDSS for Galaxy-Galaxy Lensing

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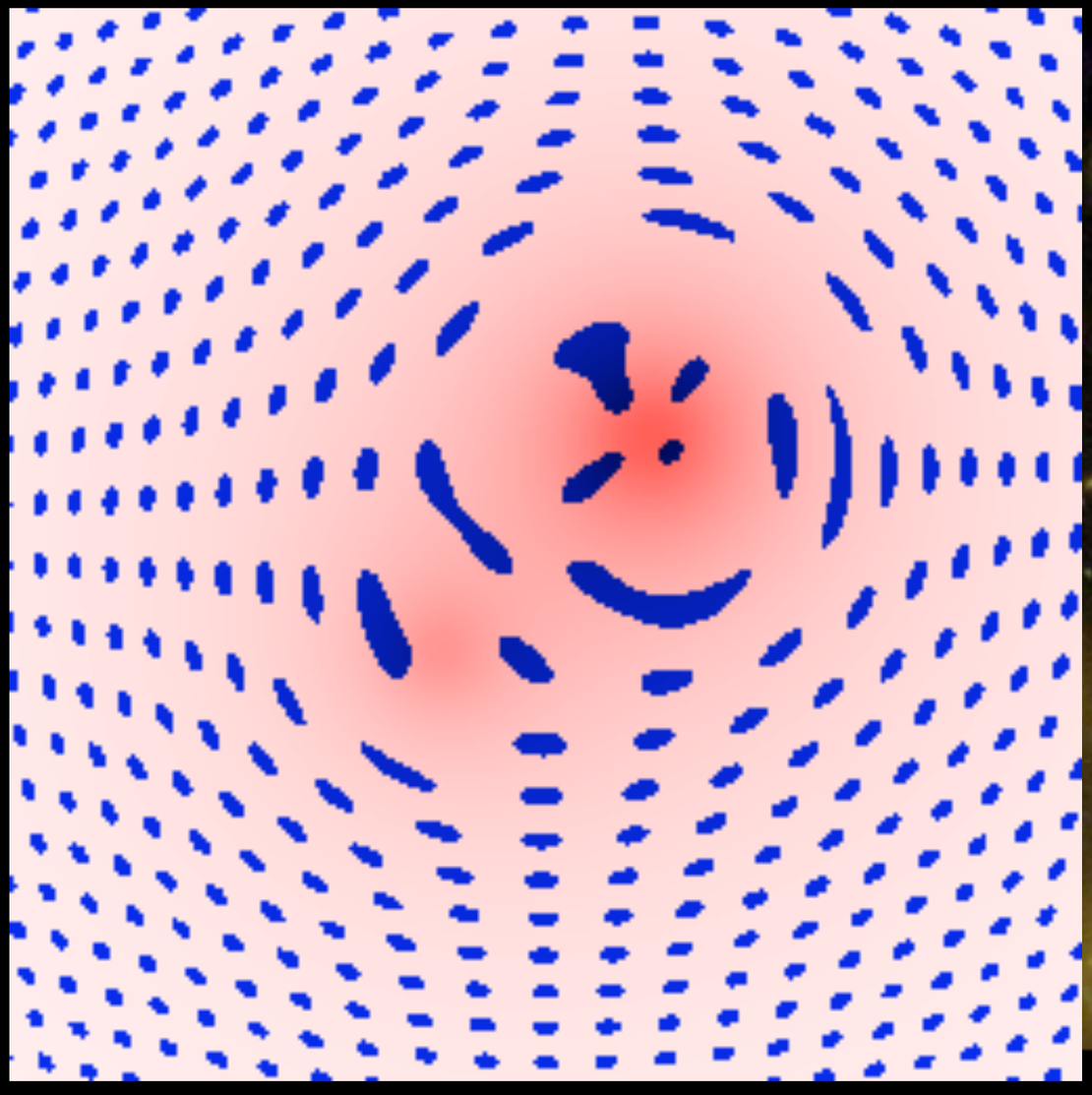
Outline

- galaxy-galaxy lensing
- photometric redshifts
- spectroscopic calibration set
- calibration results

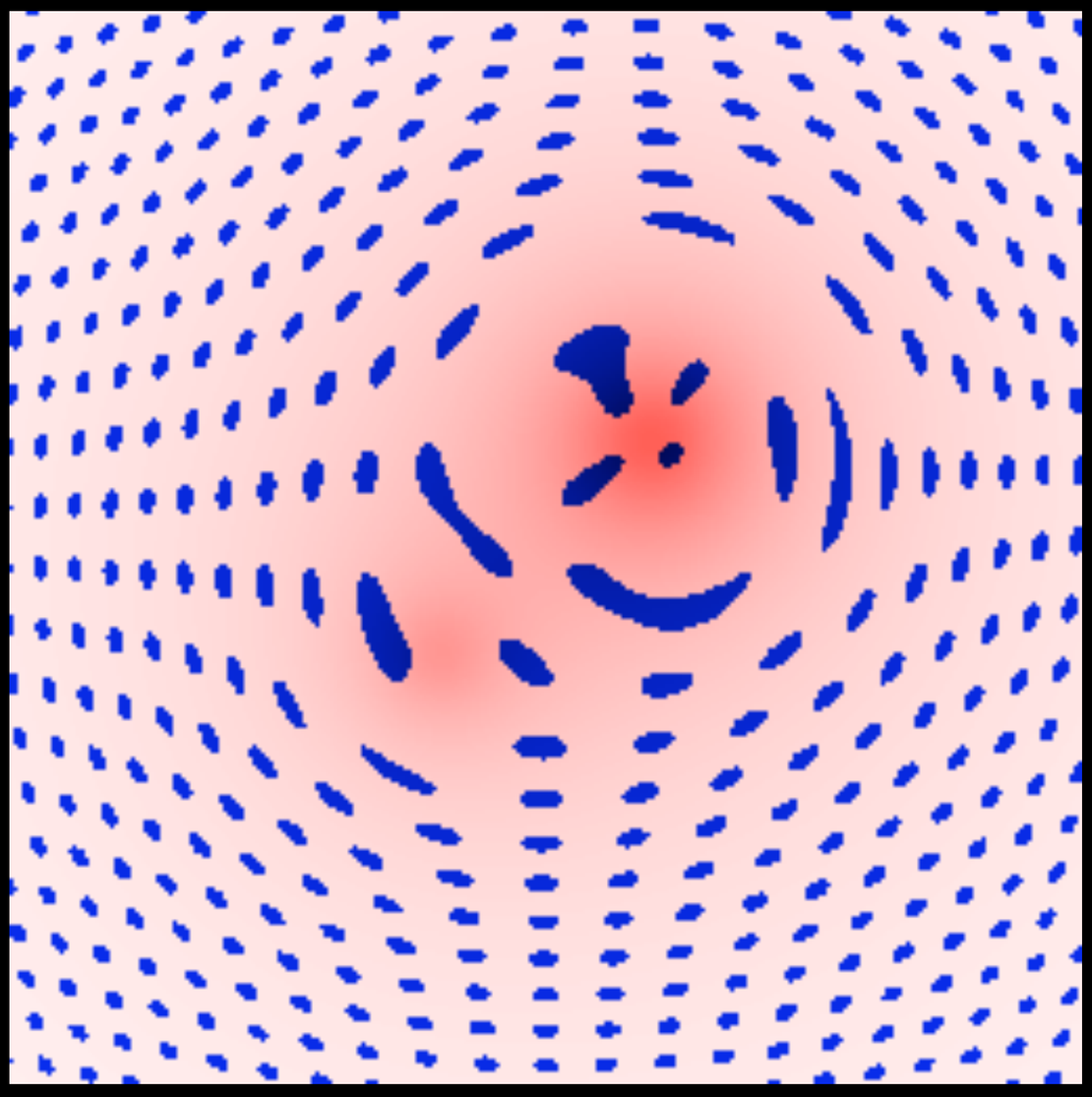
Gravitational lensing



Abell 2218 Galaxy Cluster

Image Credit: Ned Wright, HST

Why is lensing hard?



Accurate lensing:

- quantify image distortion (shapes)
- need many background galaxies
- background galaxies not at uniform redshift

Image Credit: Ned Wright

Redshifts calibrate shear to mass

$$\gamma = \Delta\Sigma / \Sigma_{crit}$$

$$\Sigma_{crit} = \frac{c^2}{4\pi G} \frac{D_S}{D_L\, D_{LS}}$$

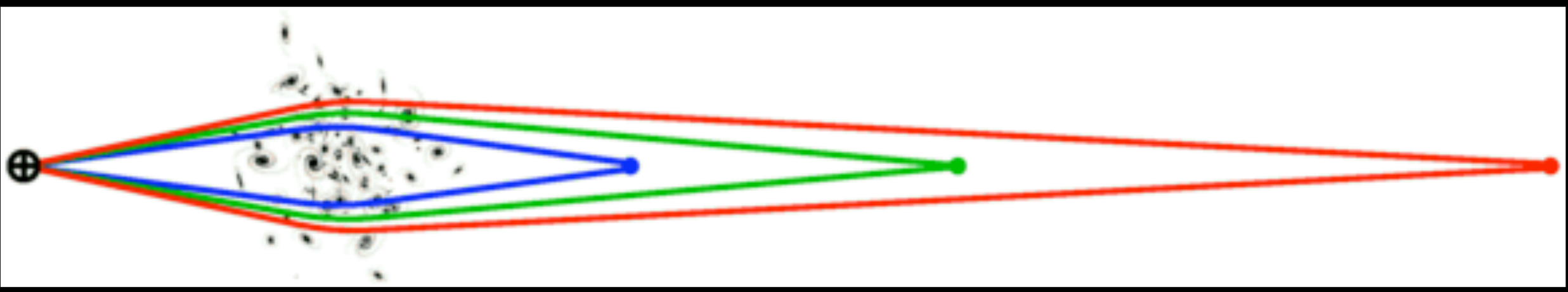
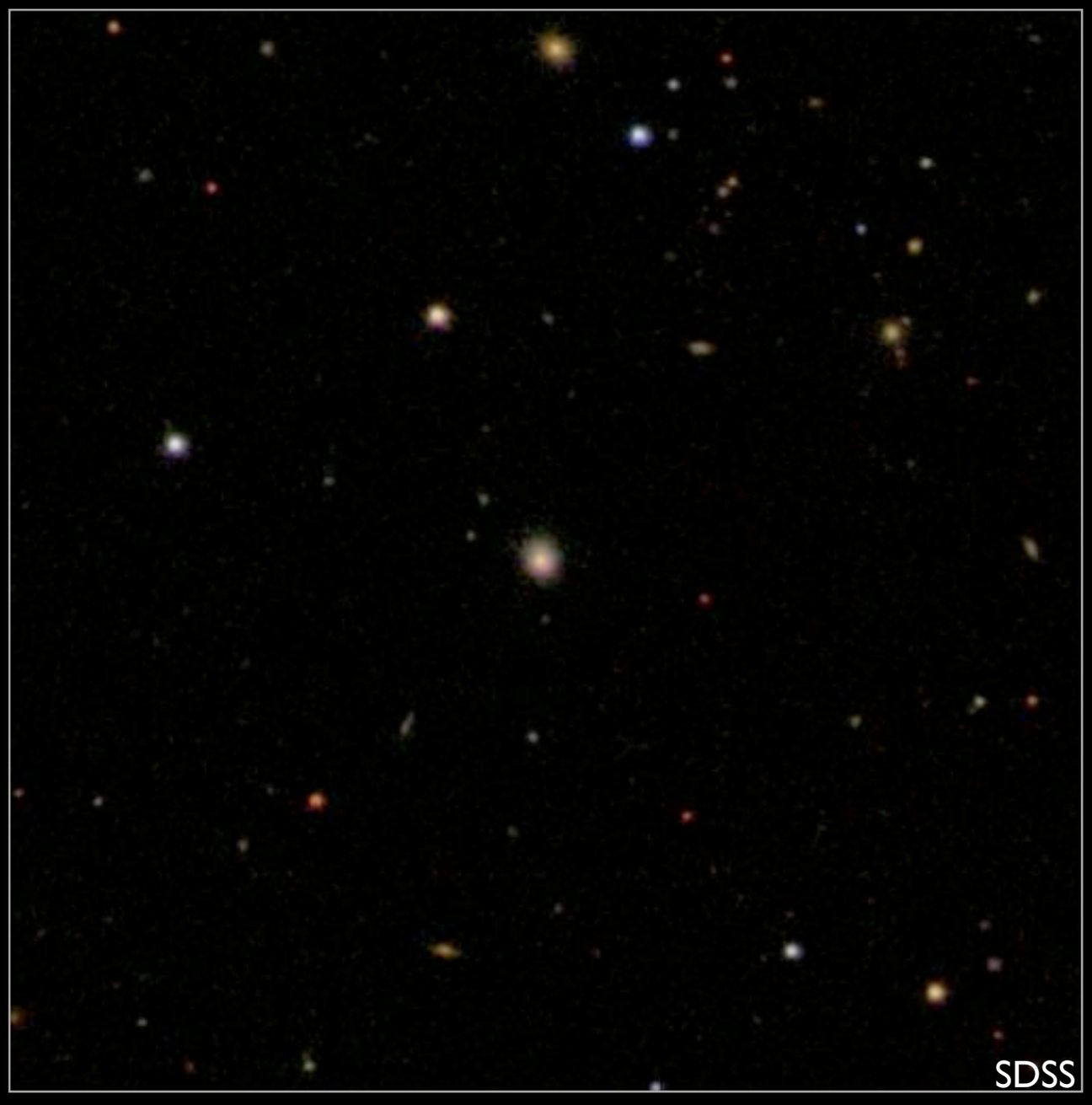


Image Credit: Ned Wright

Can we get DM concentration around a galaxy?

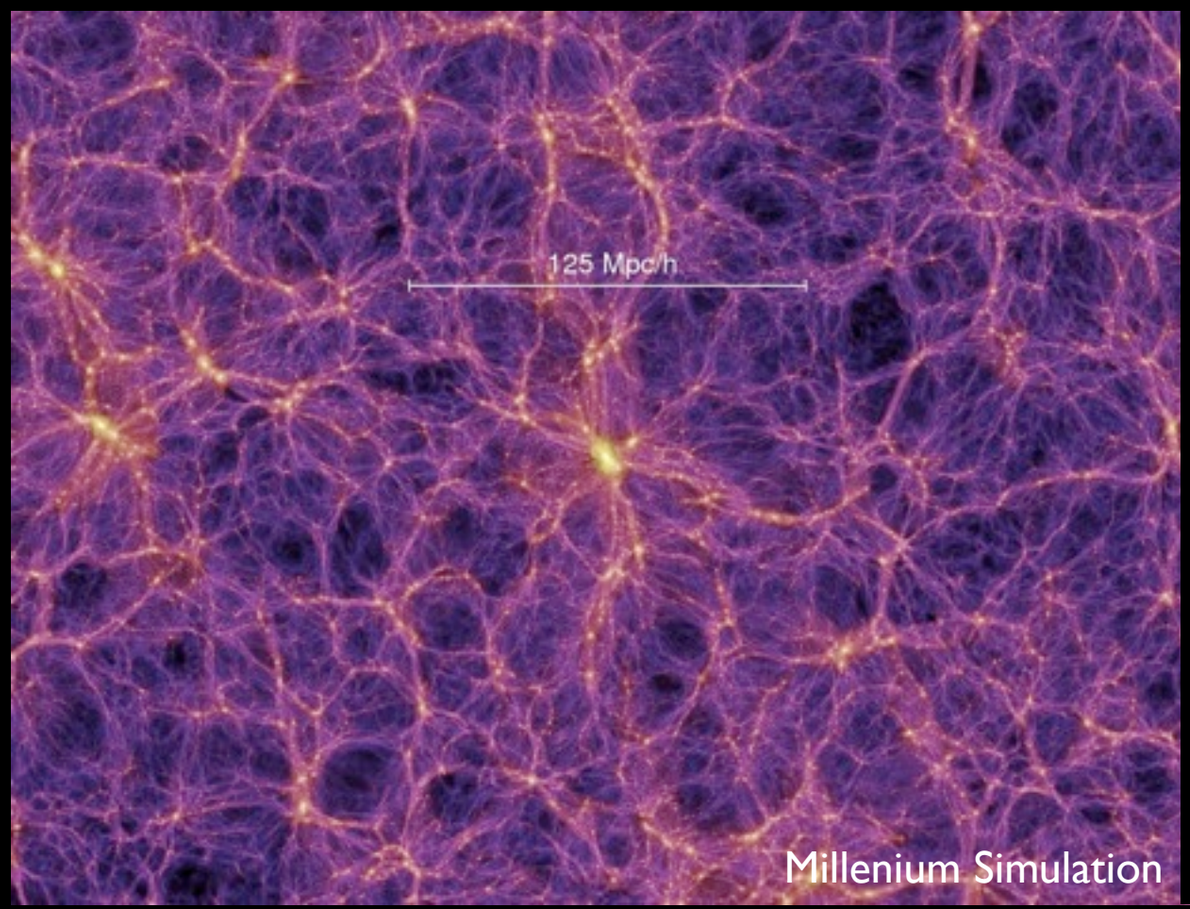


Galaxy-galaxy lensing:

- stacking by lens to get many background galaxies
- measures average dark matter distribution around galaxies

Why do we study galaxy-galaxy lensing?

Dark matter simulation



Millenium Simulation

Observed galaxies

Hubble Deep Field

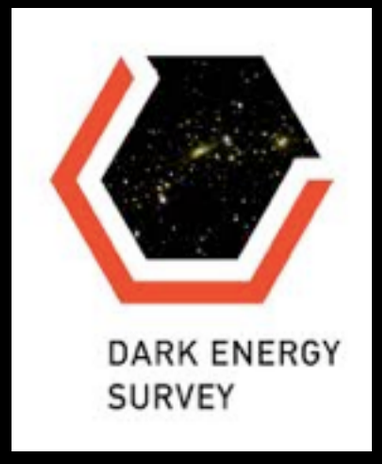
- correlates dark matter to galaxies
  - cosmological dark matter studies
  - galaxy formation studies

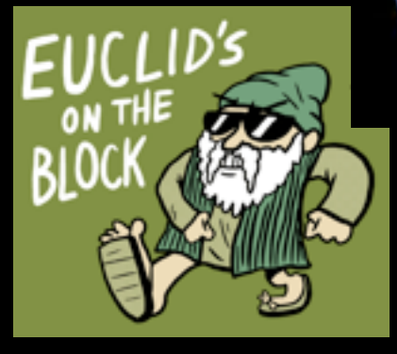
Why photometric redshifts (photo-z)?

- spectroscopic redshifts are accurate, but expensive
  - replace with multiband photometry

Why photometric redshifts (photo-z)?

- spectroscopic redshifts are accurate, but expensive
  - replace with multiband photometry
- because everyone else is going to be doing it





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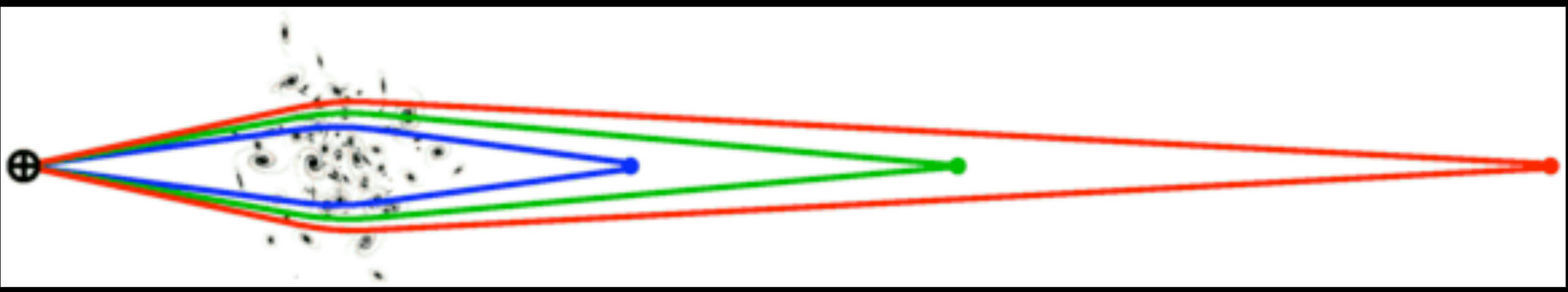


Image Credit: Ned Wright

Requirements on catalog to use photoz's

- source galaxies:
  as many as possible
  higher redshift
  photo-z error tolerance is large

- lens galaxies:
  need decent photo-z

Requirements on catalog to use photoz's

- source galaxies:
  as many as possible
  higher redshift
  photo-z error tolerance is large

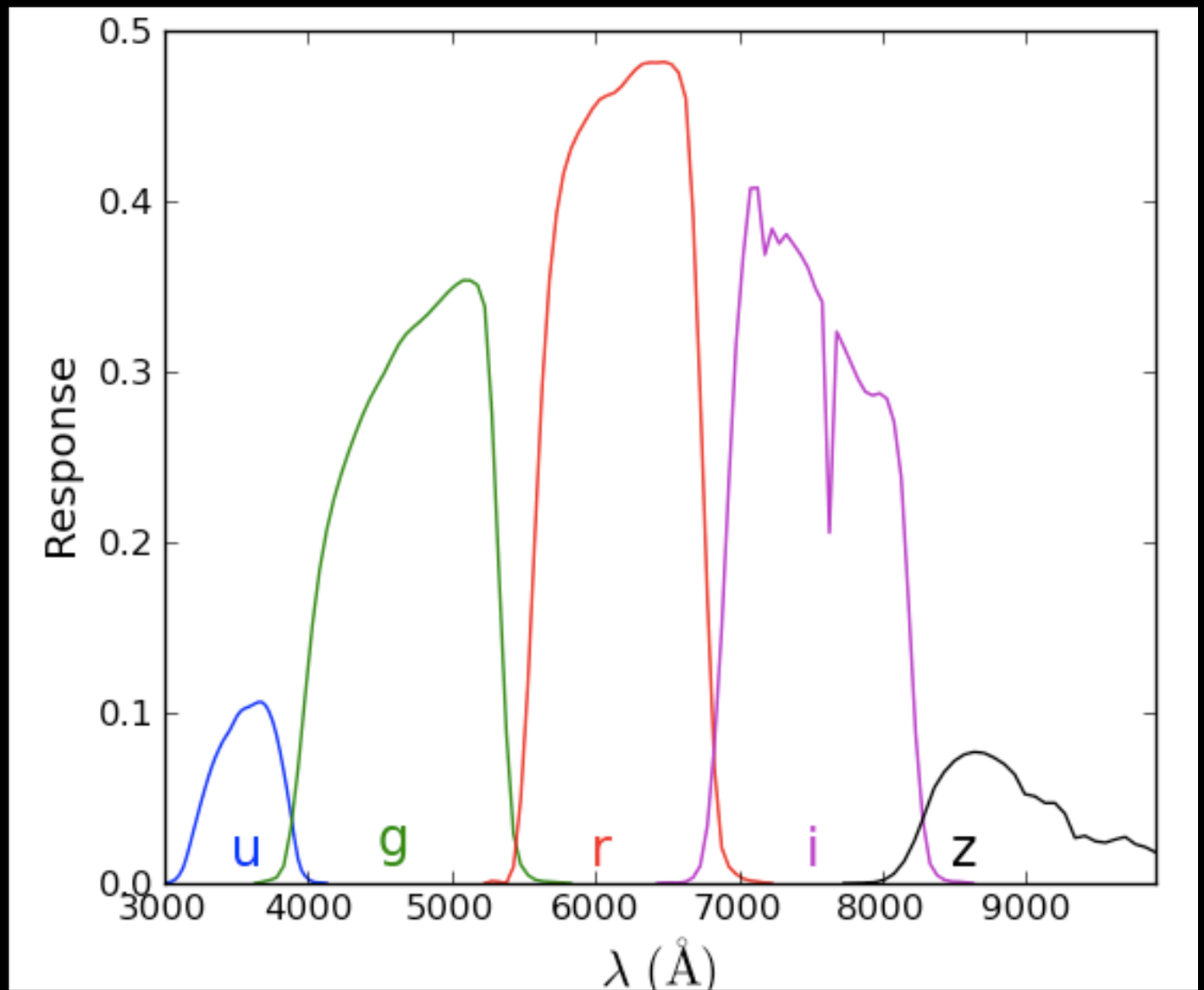
  r < 21.8

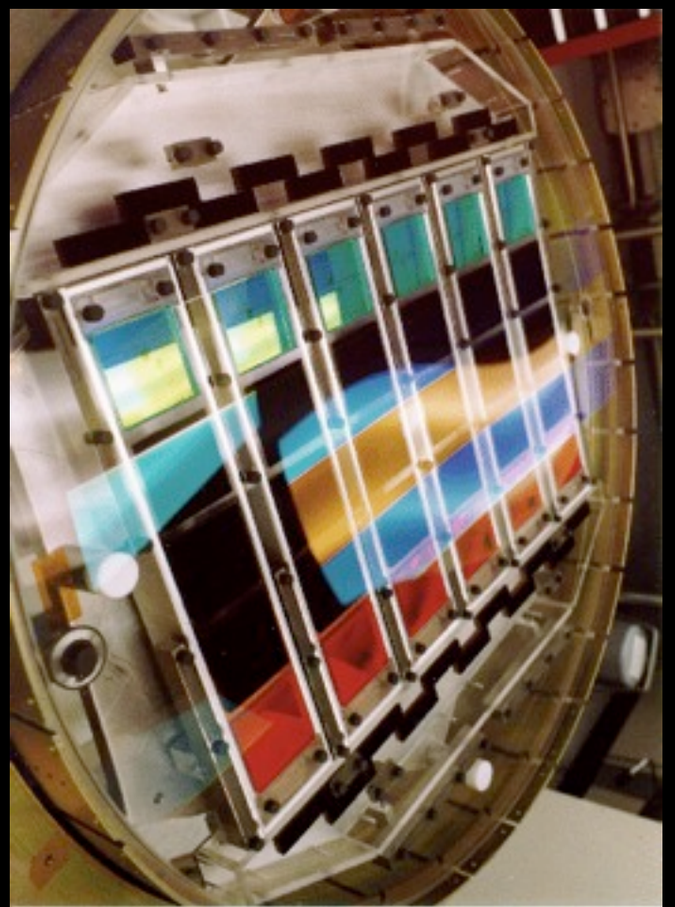
- lens galaxies:
  need decent photo-z

  r < 21

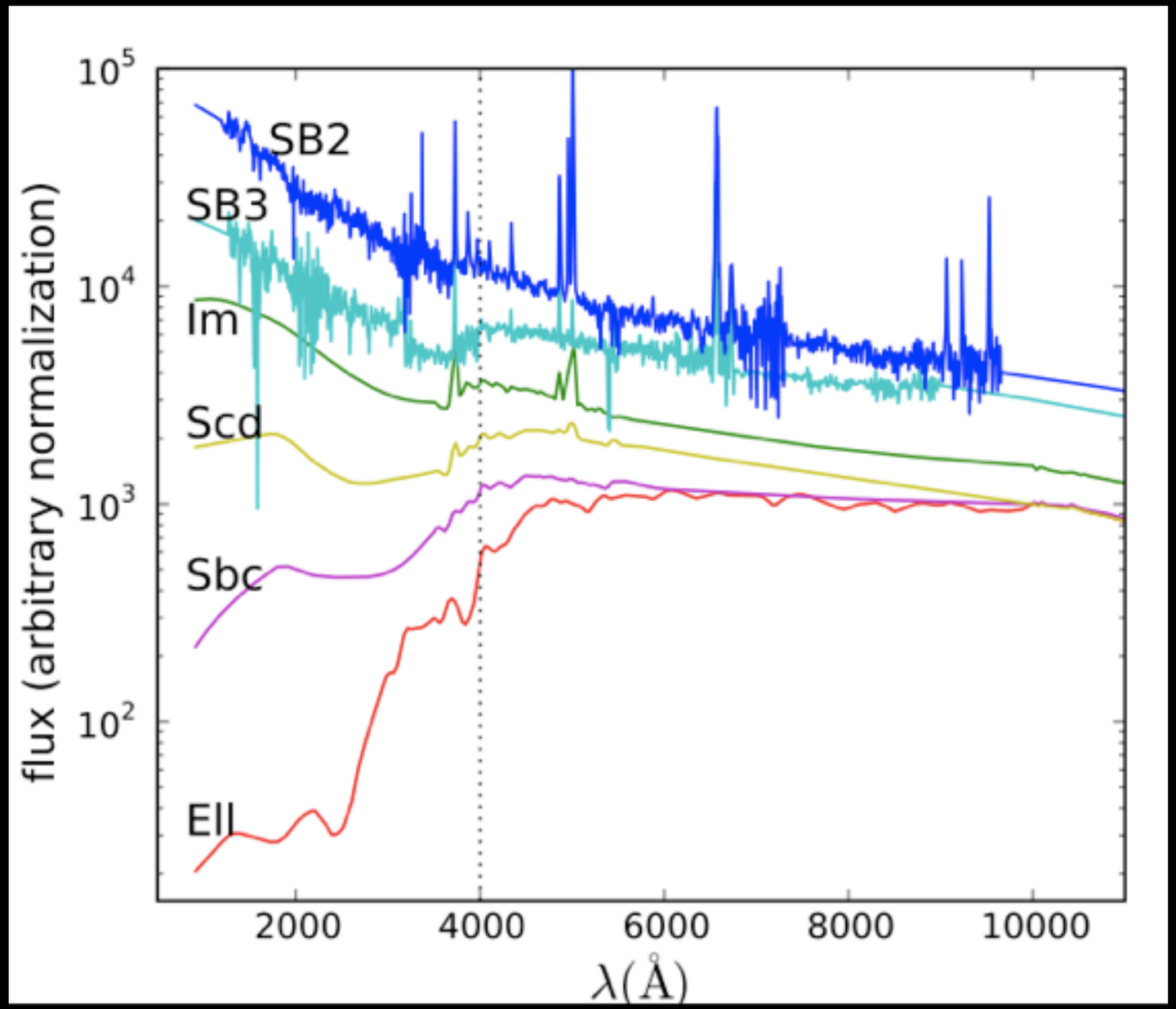
- need two separate catalogs

SDSS photometry



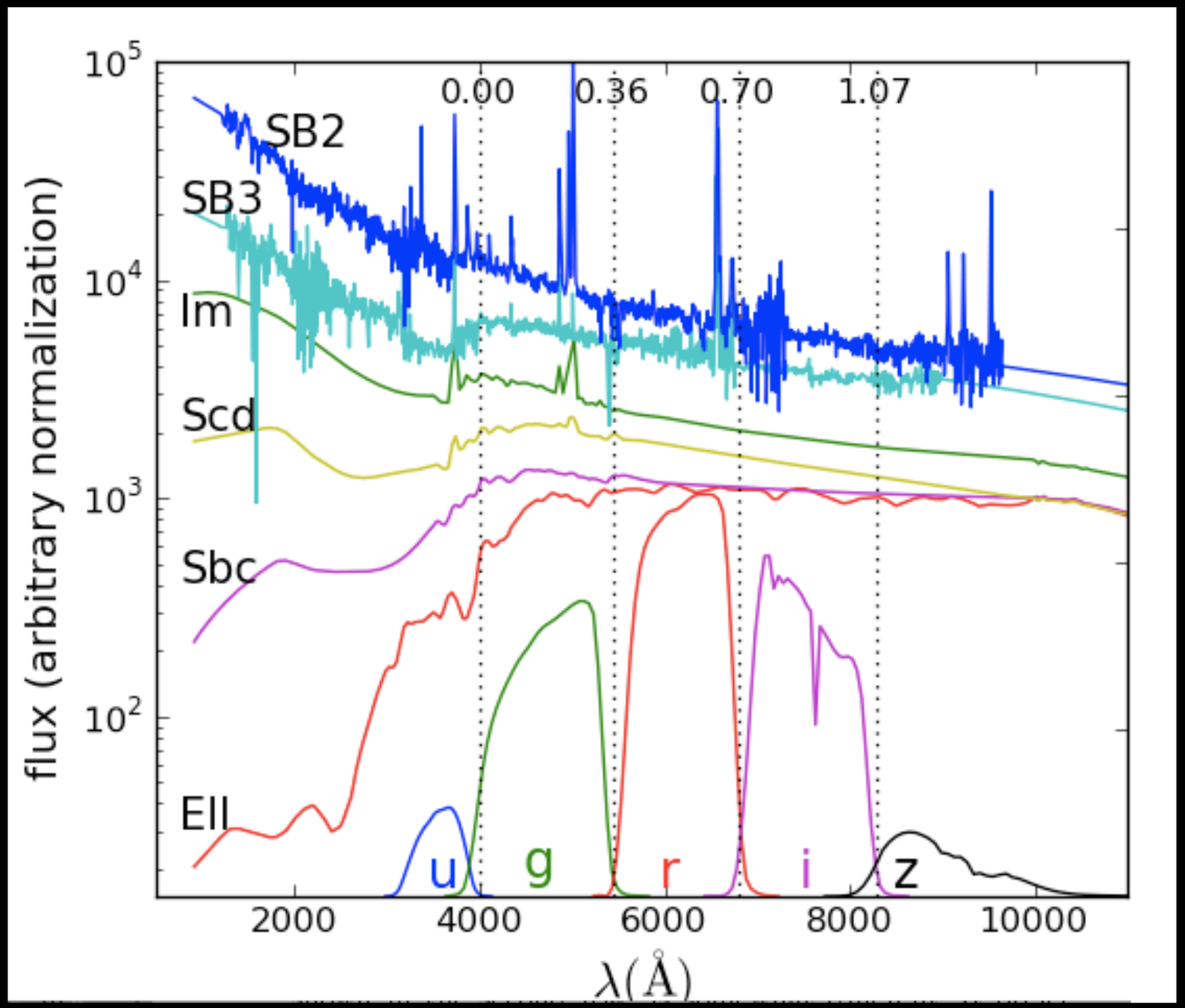


Photometric redshifts, template based



- galaxy SED templates
  - 4000Å break
  - different UV strengths

Photometric redshifts, template based



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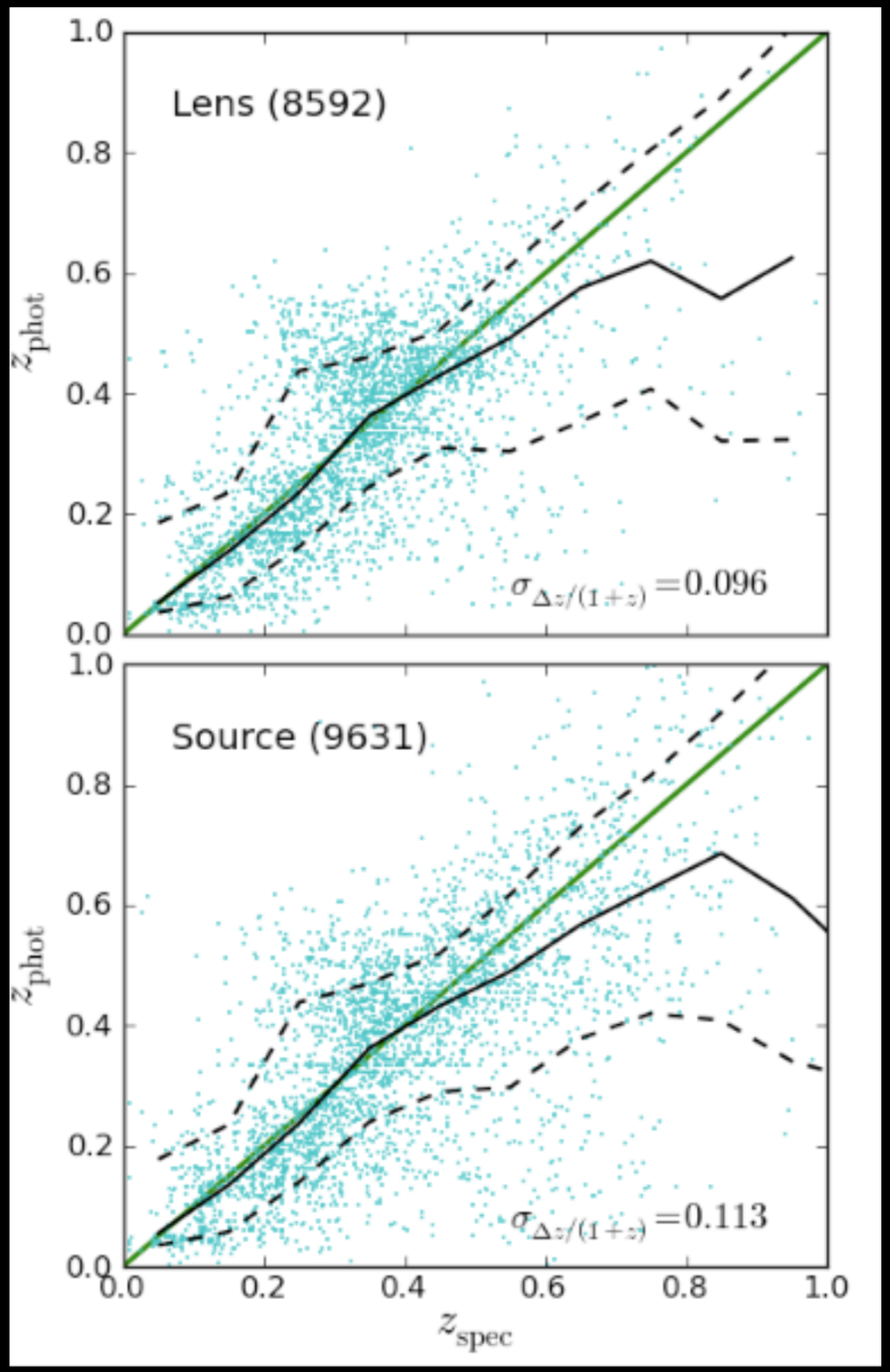
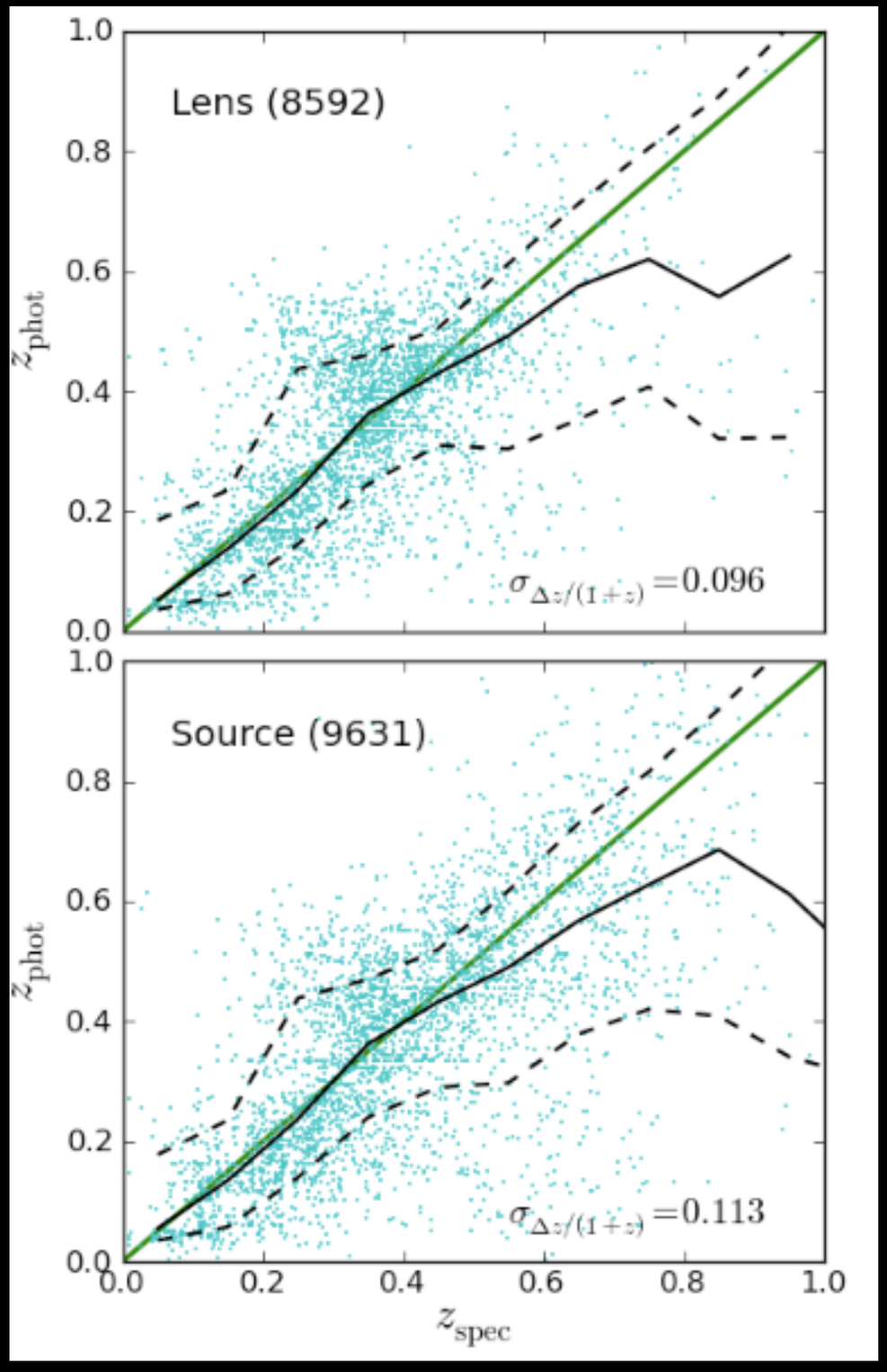
Photometric redshifts with SDSS

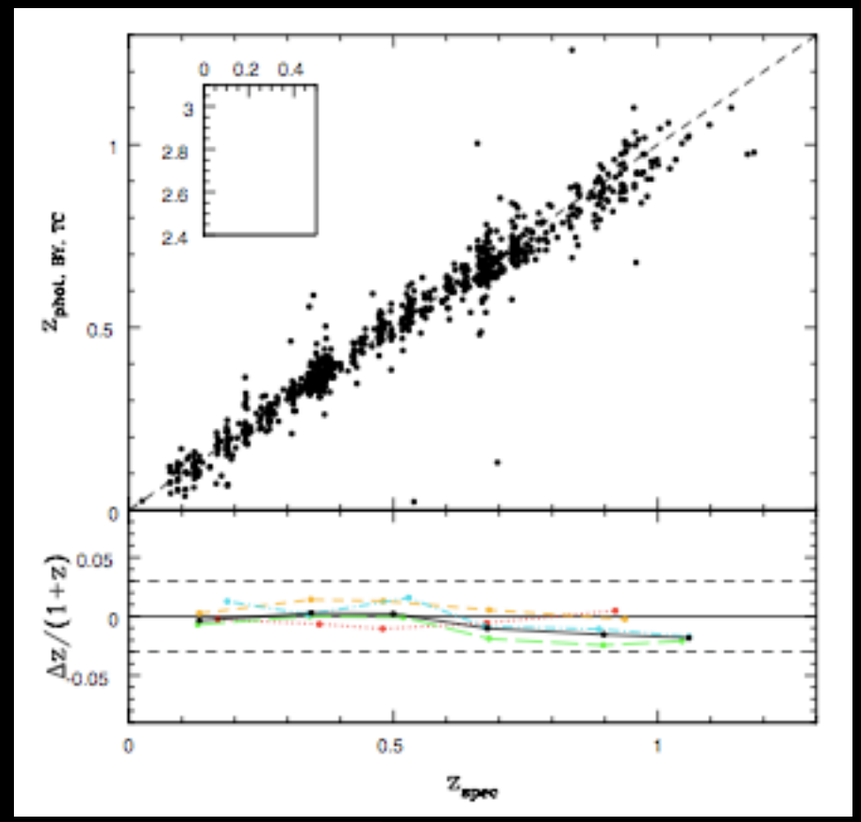


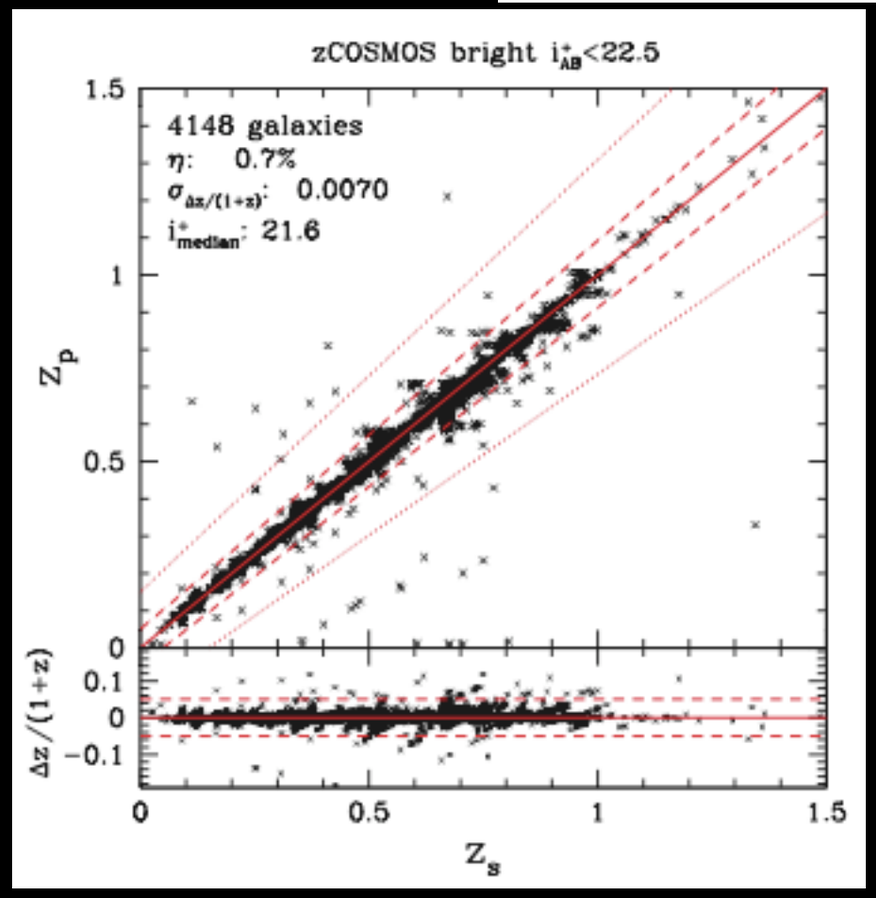
- $\sigma_{\Delta z/(1+z)} \sim 0.1$

Photometric redshifts with SDSS



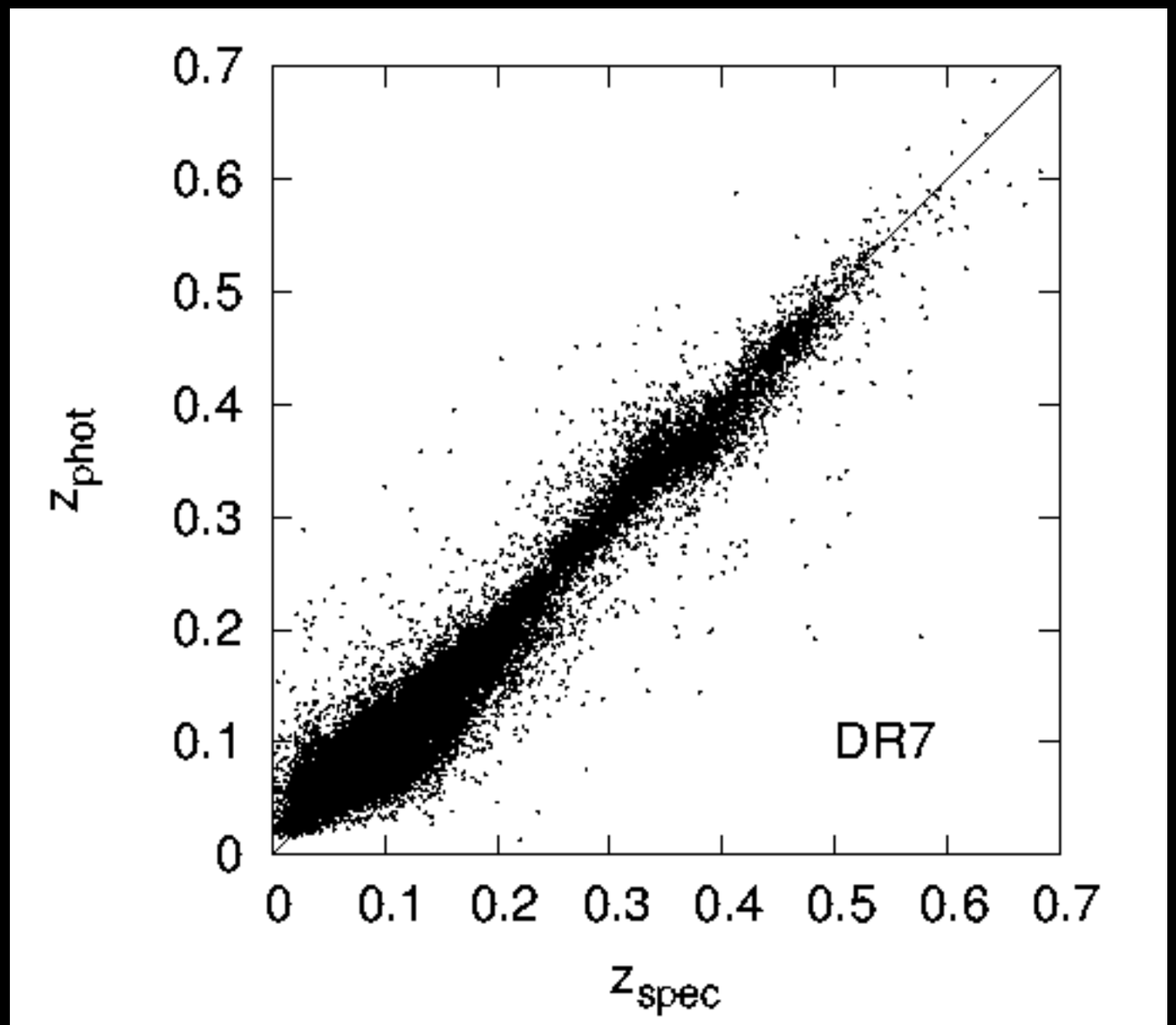
$\sigma_{\Delta z/(1+z)} < 0.03$
Feldmann+ (2006)





$\sigma_{\Delta z/(1+z)} = 0.007$
Ilbert+ (2009)

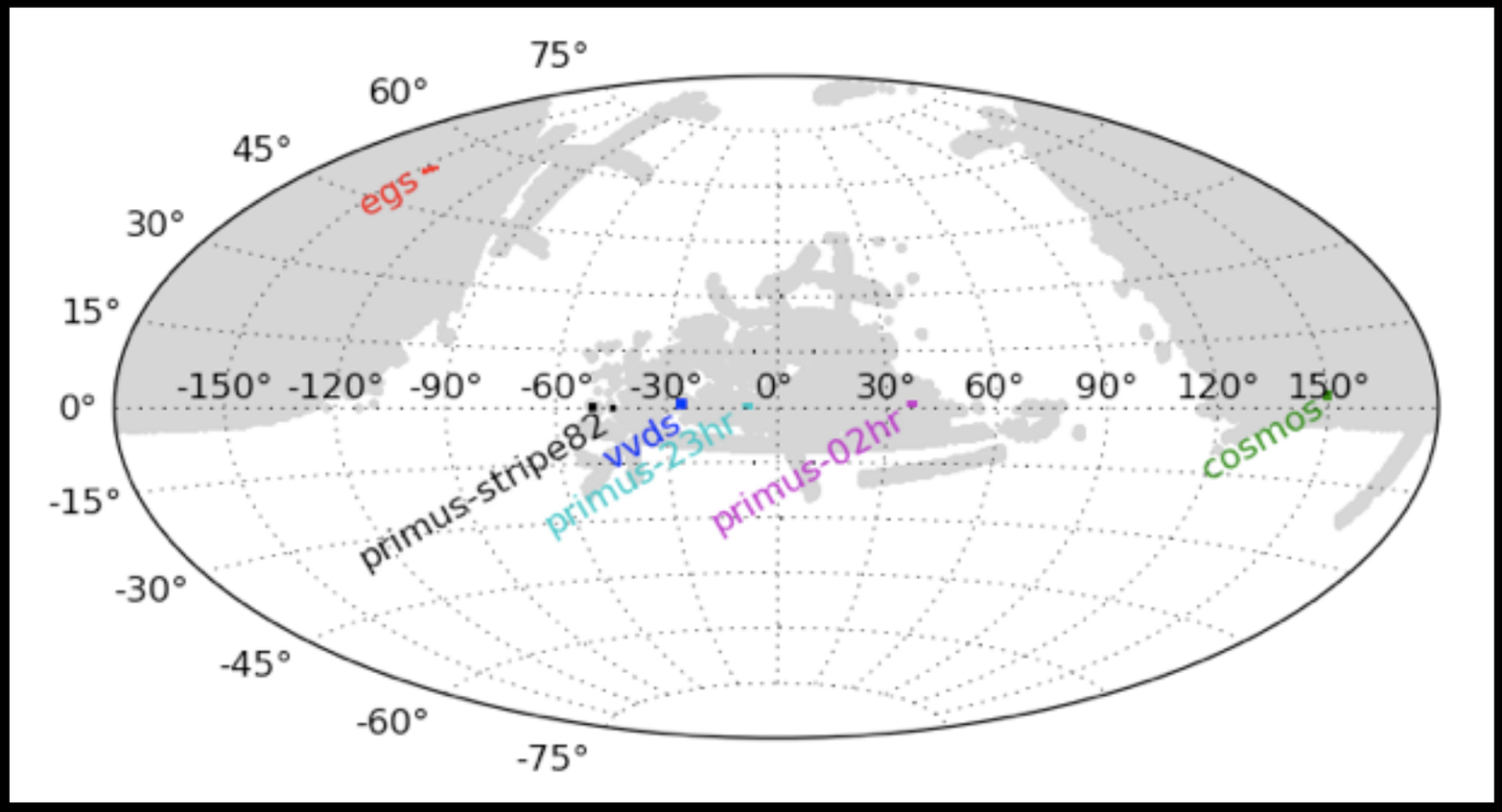
Photometric redshifts, training set based



- bright galaxies!! (r<17.7)

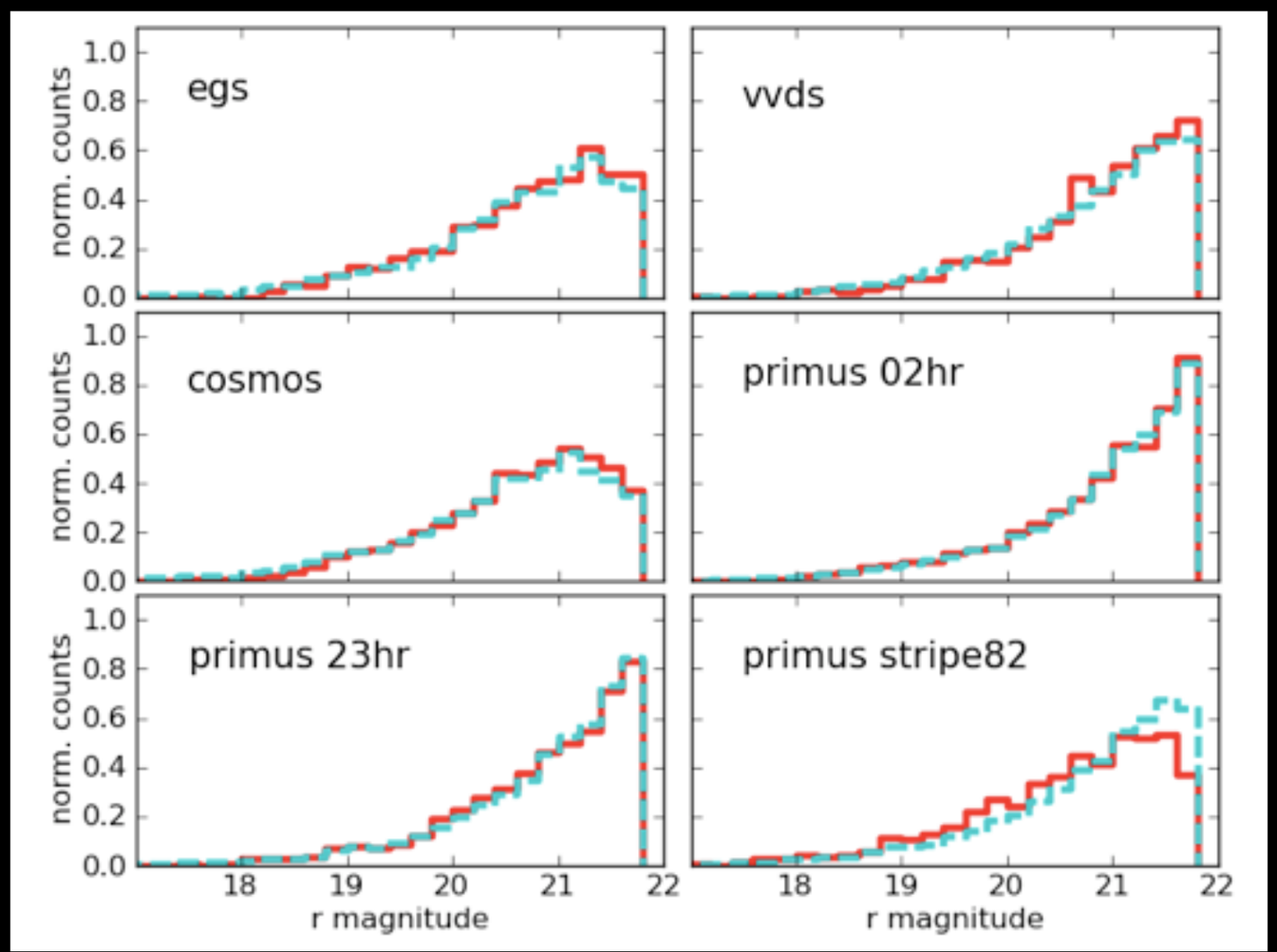
http://www.sdss.org/dr7/algorithms/photo-z.html

Calibration sets



- SDSS: 8720 sq deg (low extinction)
- Calib: ~5 sq deg
- Tune it to make fair representation of SDSS

Calibration sets: r magnitude distribution

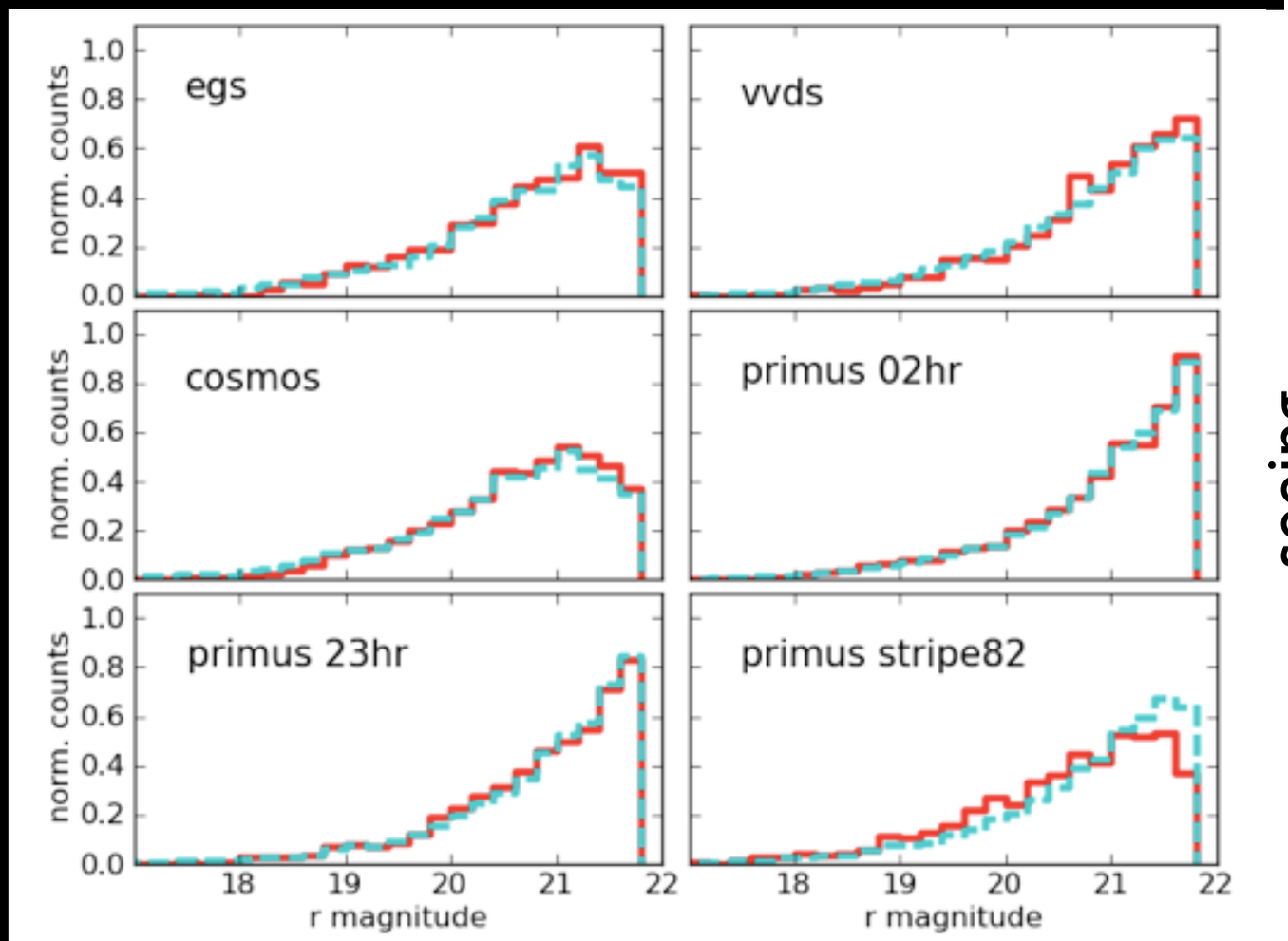


calibration set

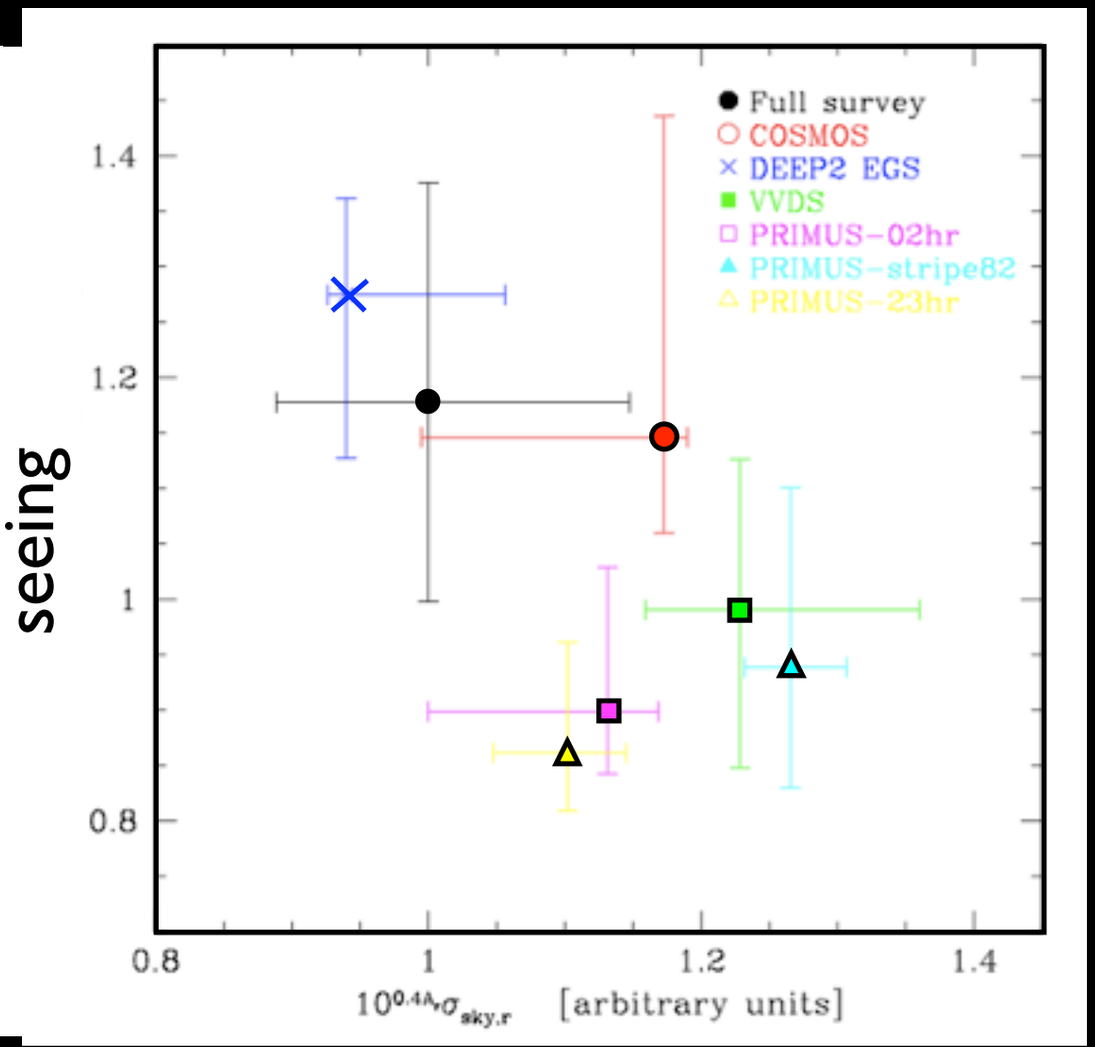
underlying distribution

r magnitude

Calibration sets: r magnitude distribution

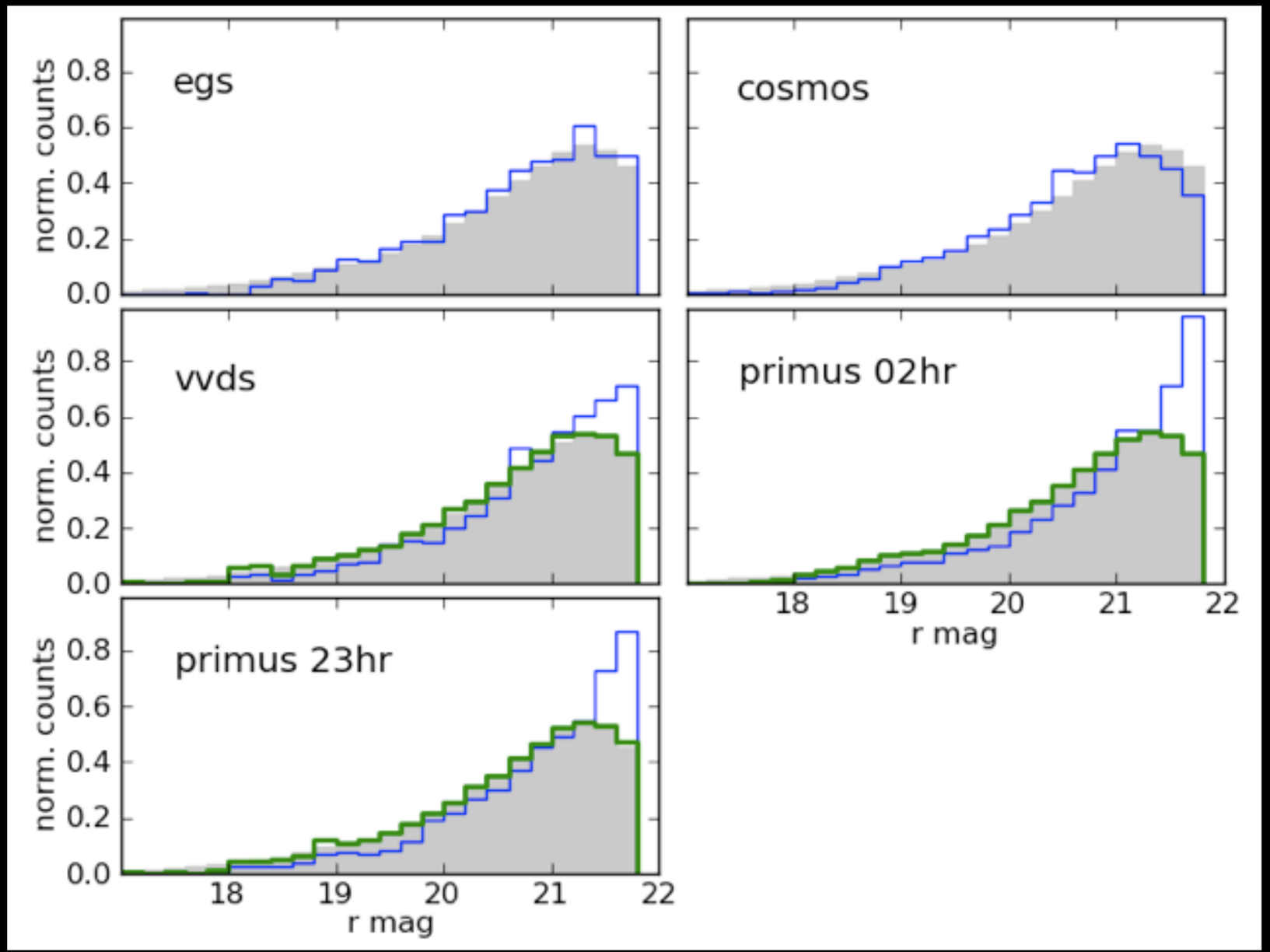


r magnitude



sky noise

Calibration set correction



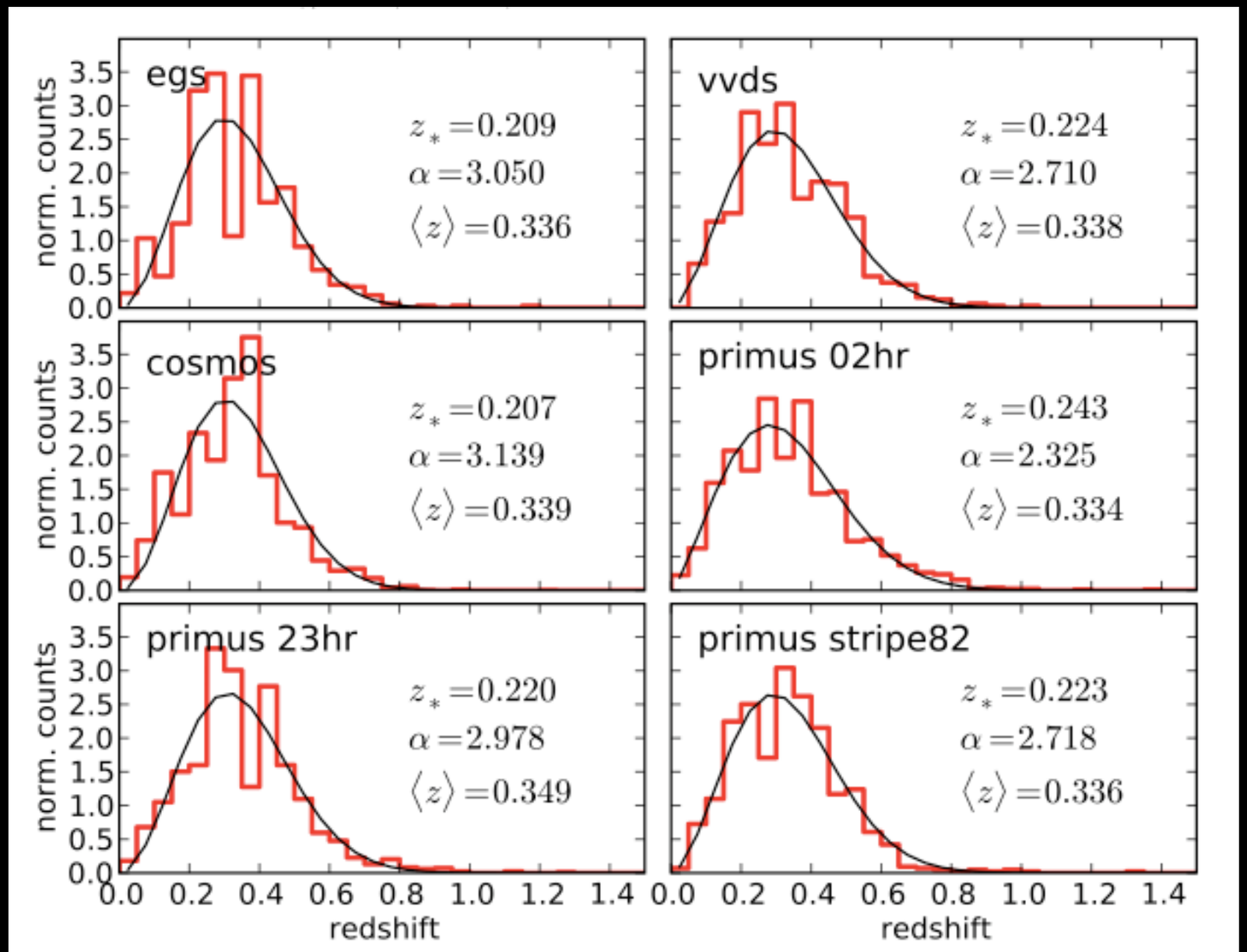
original calibration set

all of SDSS

corrected

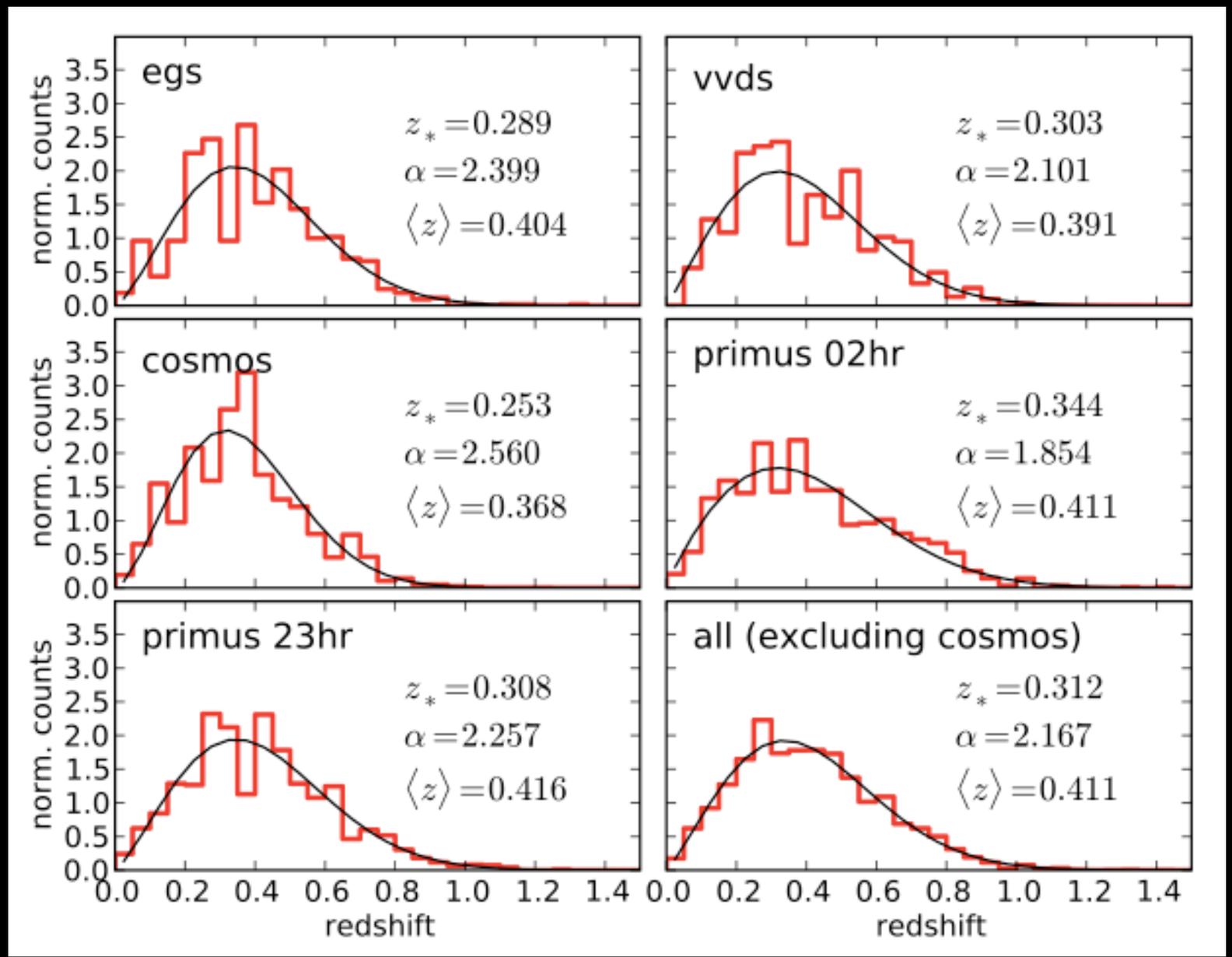
r magnitude

Calibration sets: redshift distribution



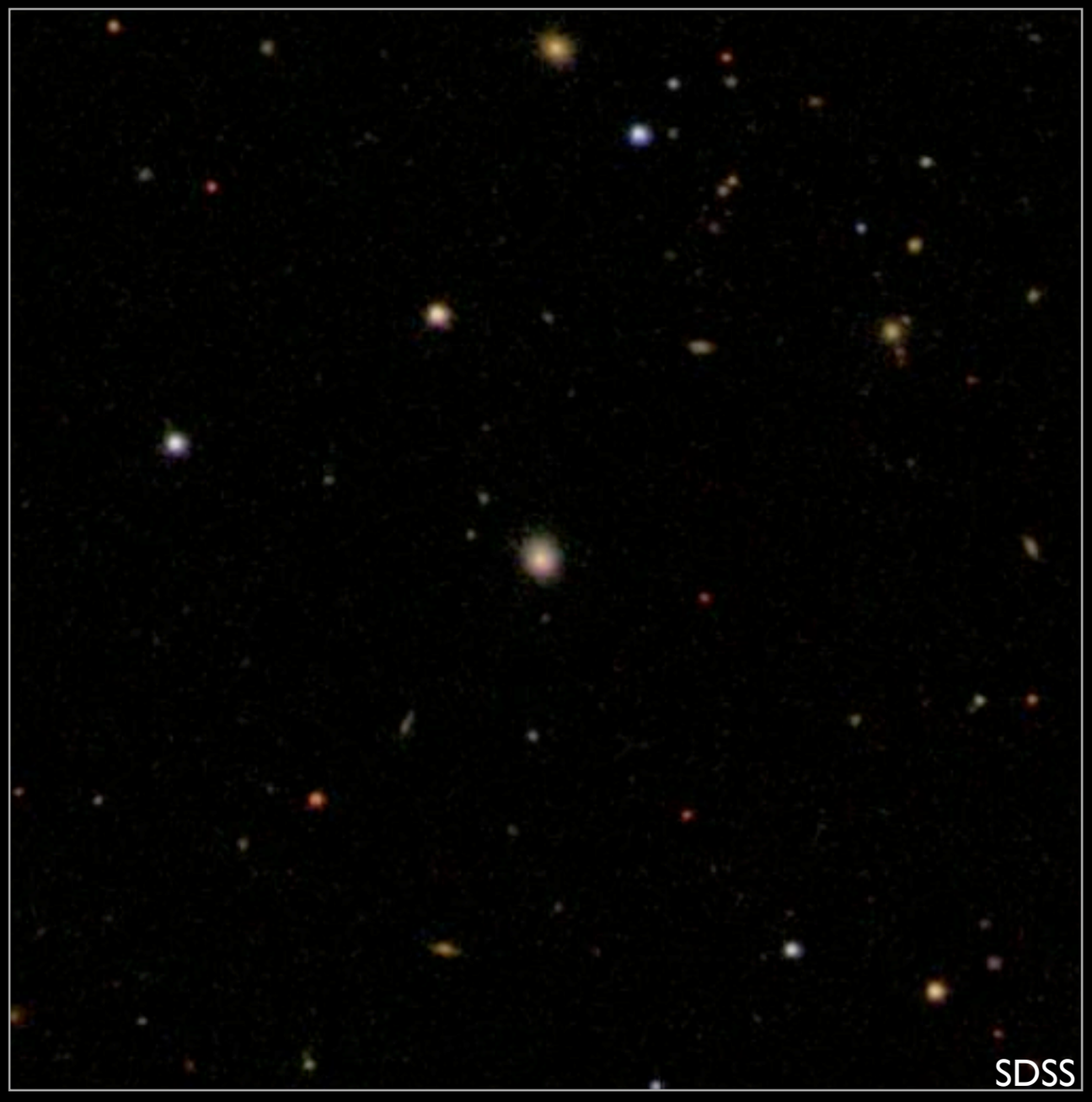
- Lens (r<21)

Calibration sets: redshift distribution



- Source (r<21.8)

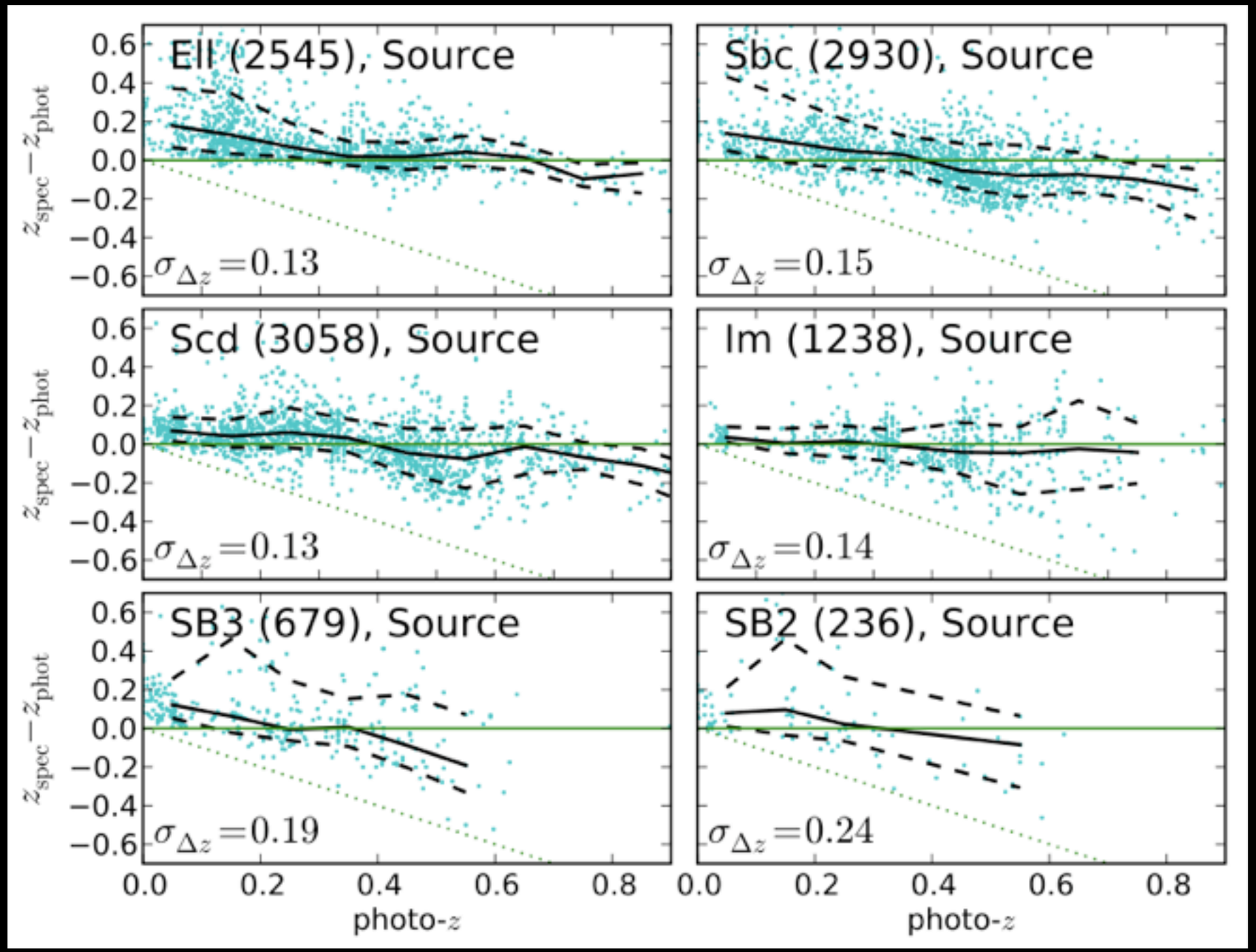
Galaxy-galaxy lensing



Stacking by lens:

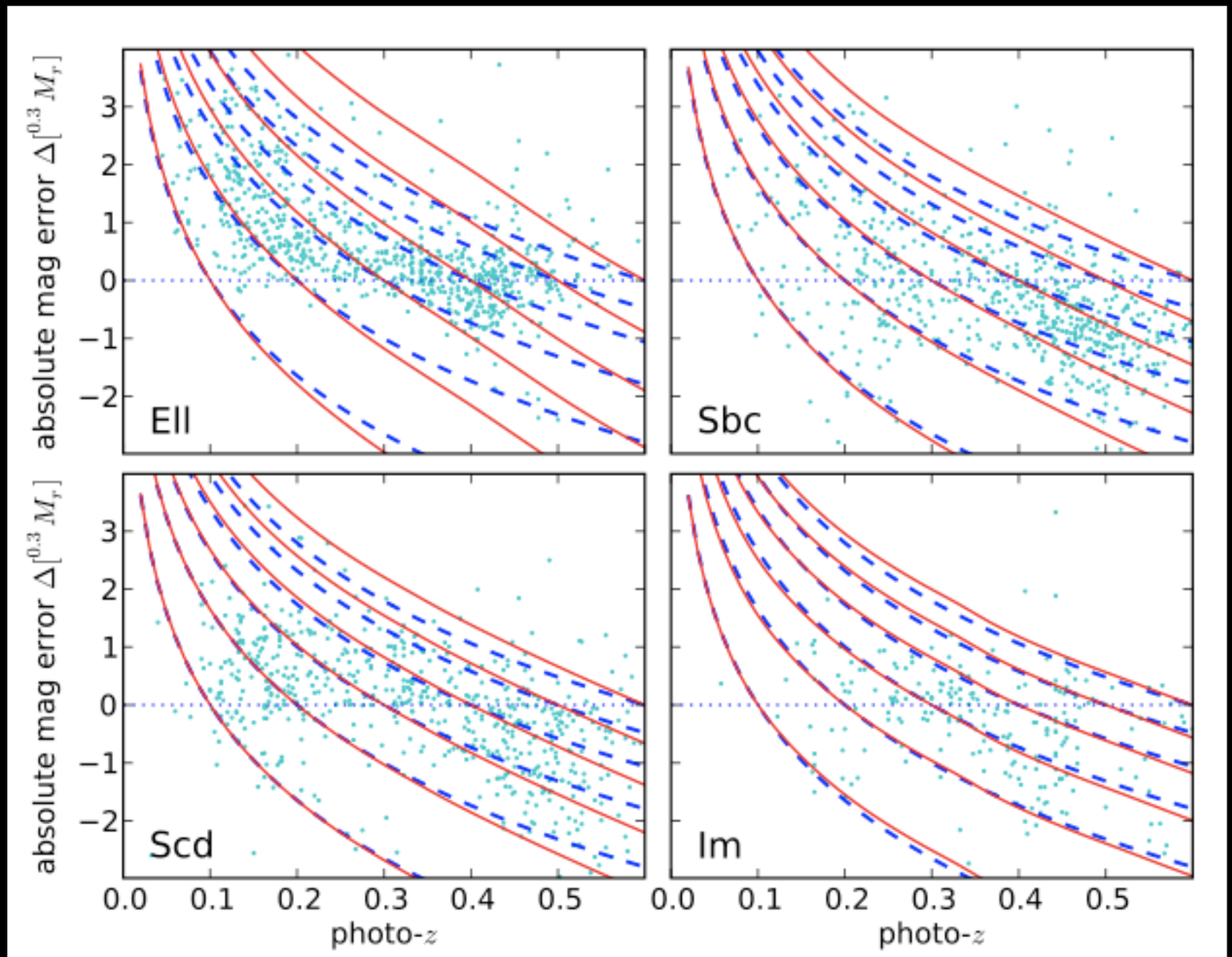
- redshift (photo-z)
- SED type
- absolute magnitude
- stellar mass

Photometric redshifts with SDSS



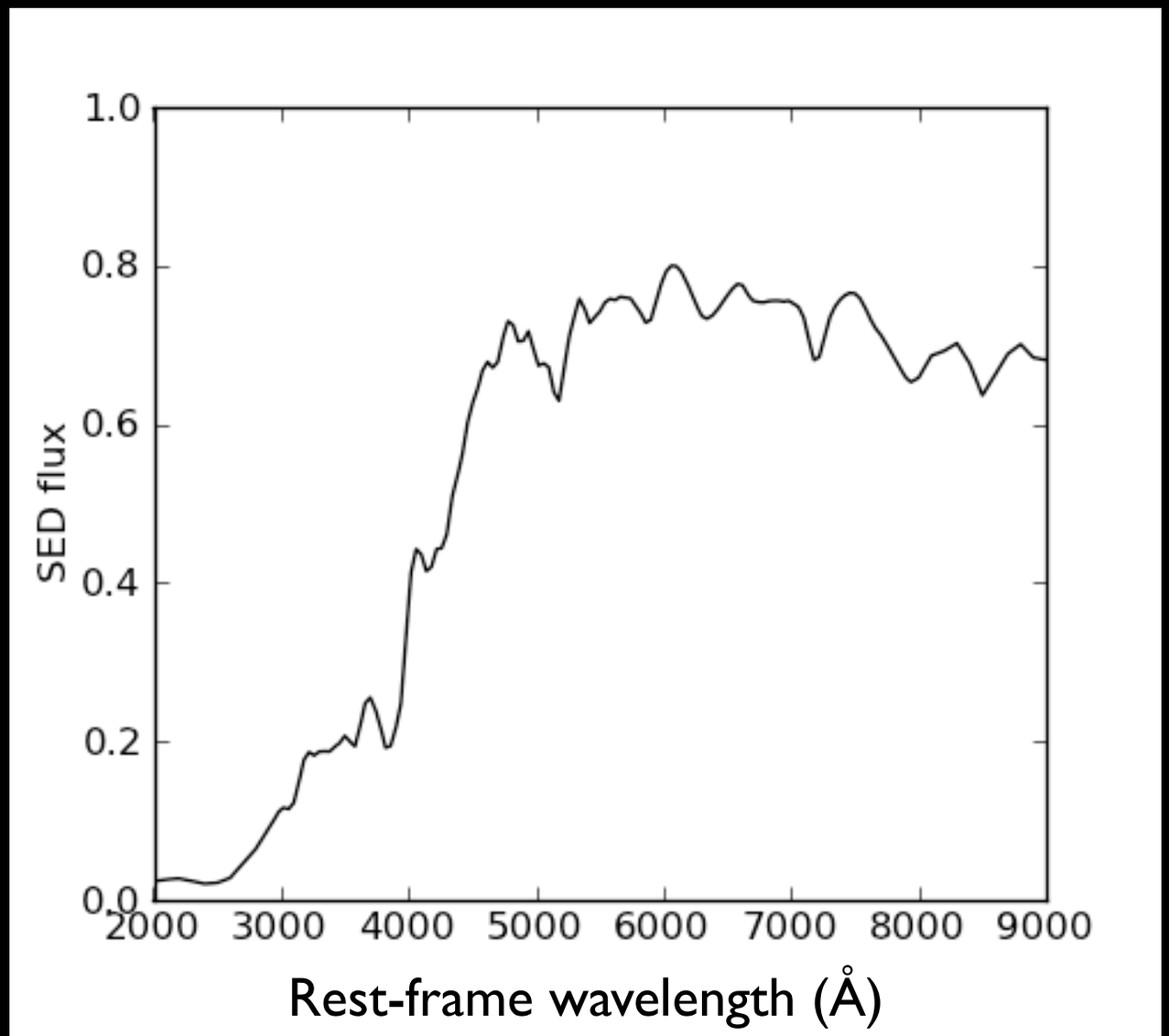
➡ remove
SB3, SB2

Absolute magnitude error



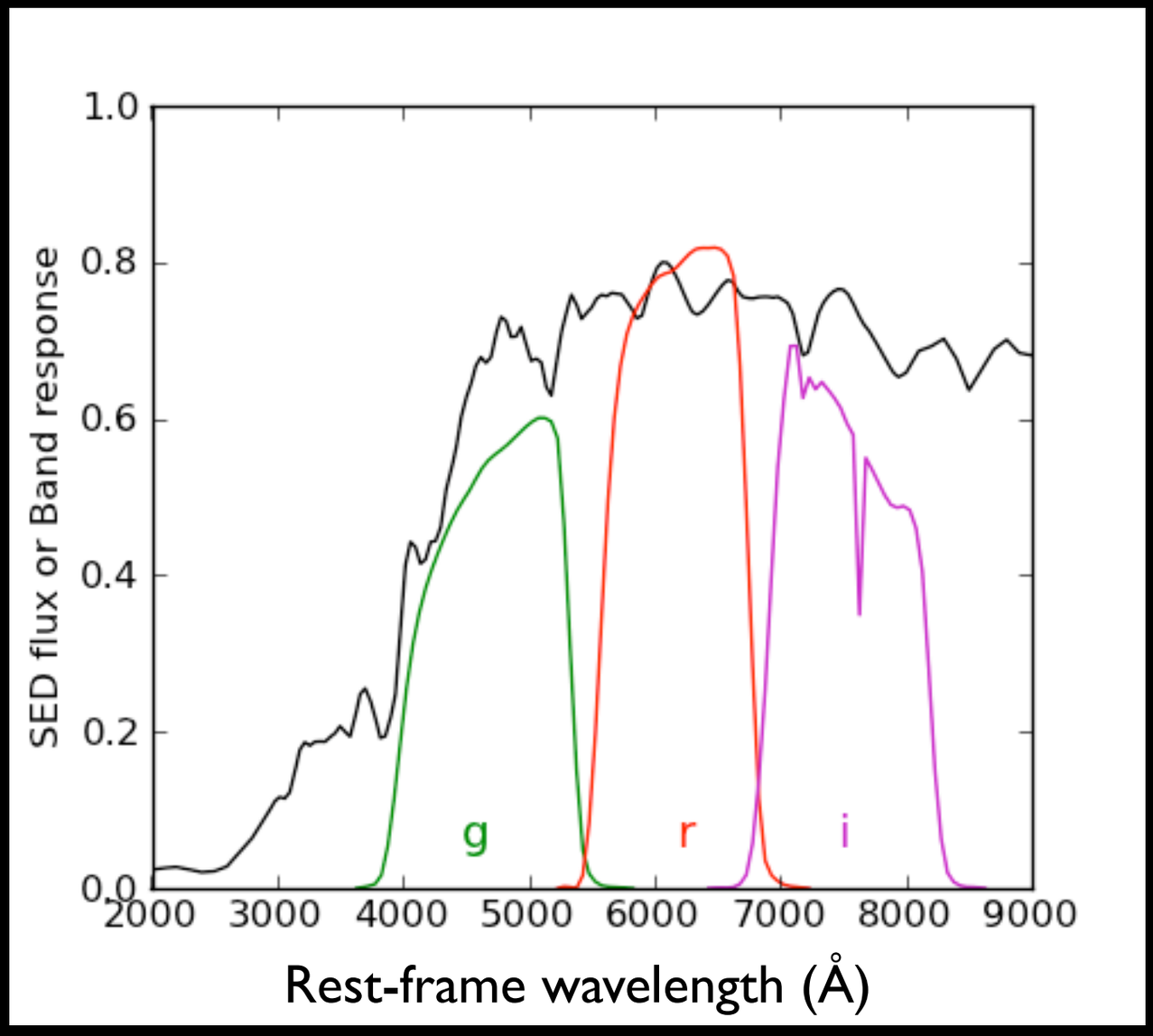
- theoretical curve
  - distance modulus
  - k-correction
- z_{phot} distribution

k-correction



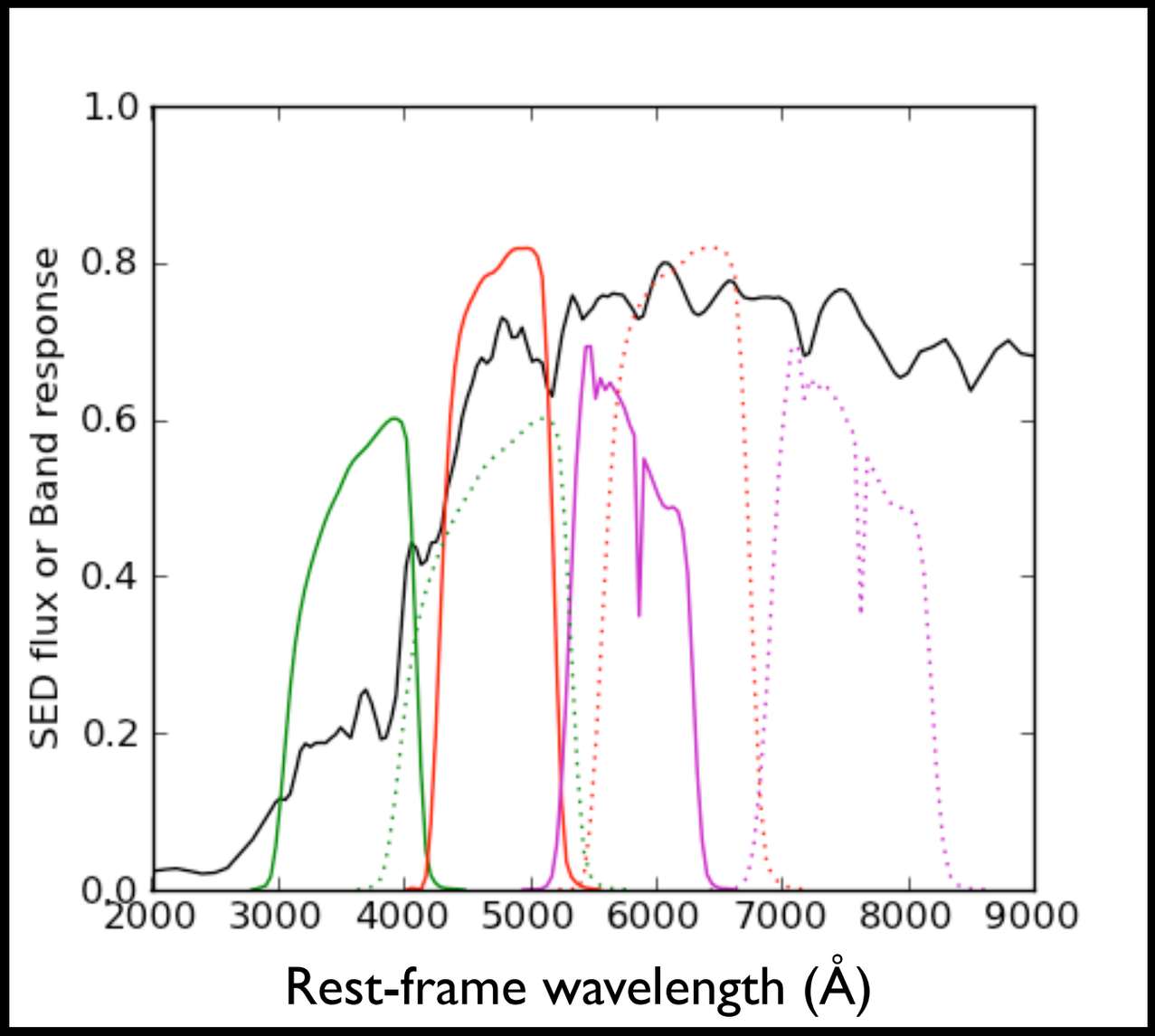
- Ell-type SED (z=0)

k-correction



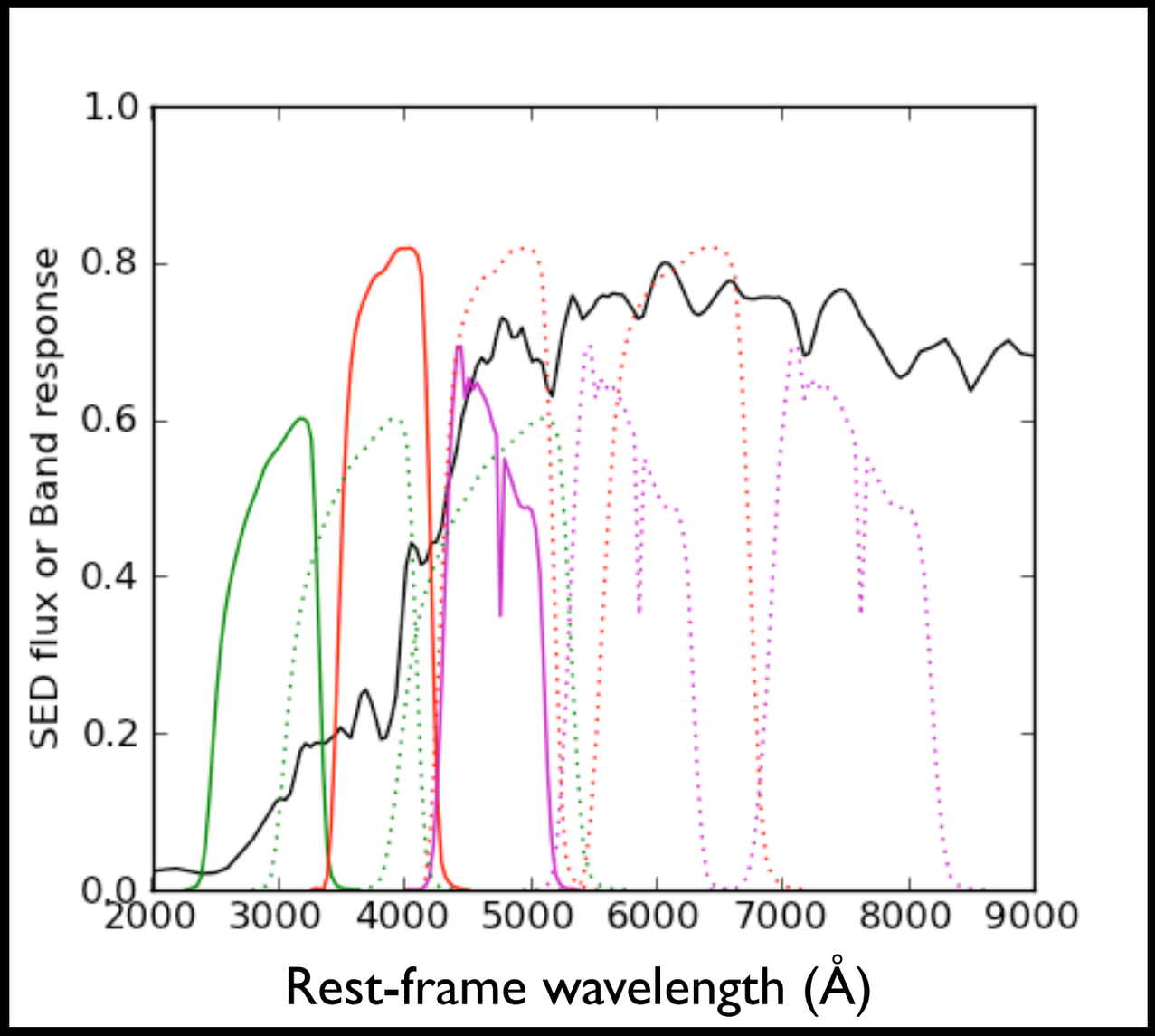
- Ell-type SED (z=0)
- SDSS bands (observed from z=0)

k-correction



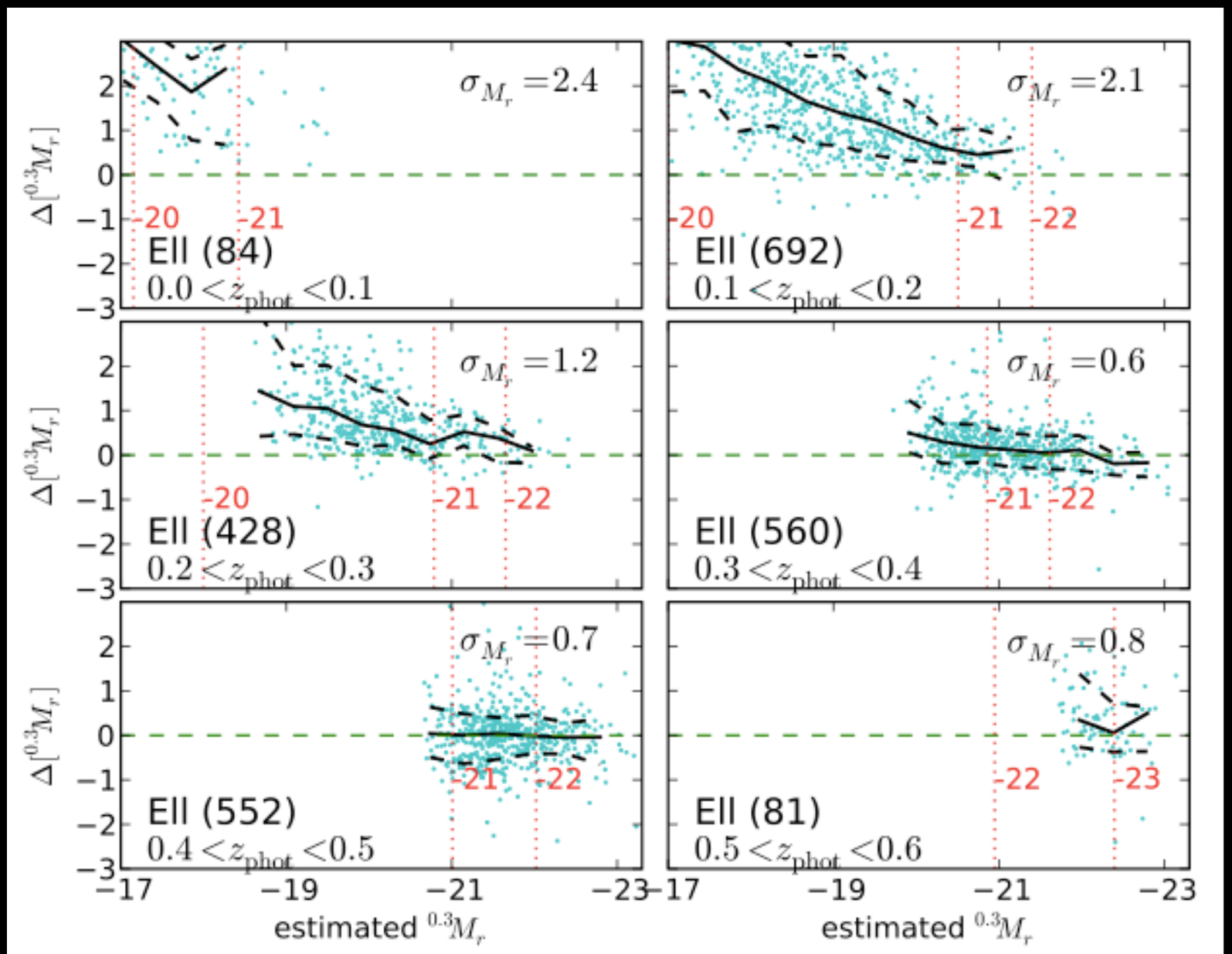
- Ell-type SED (z=0.3)
- SDSS bands (observed from z=0)

k-correction



- Ell-type SED (z=0.6)
- SDSS bands (observed from z=0)

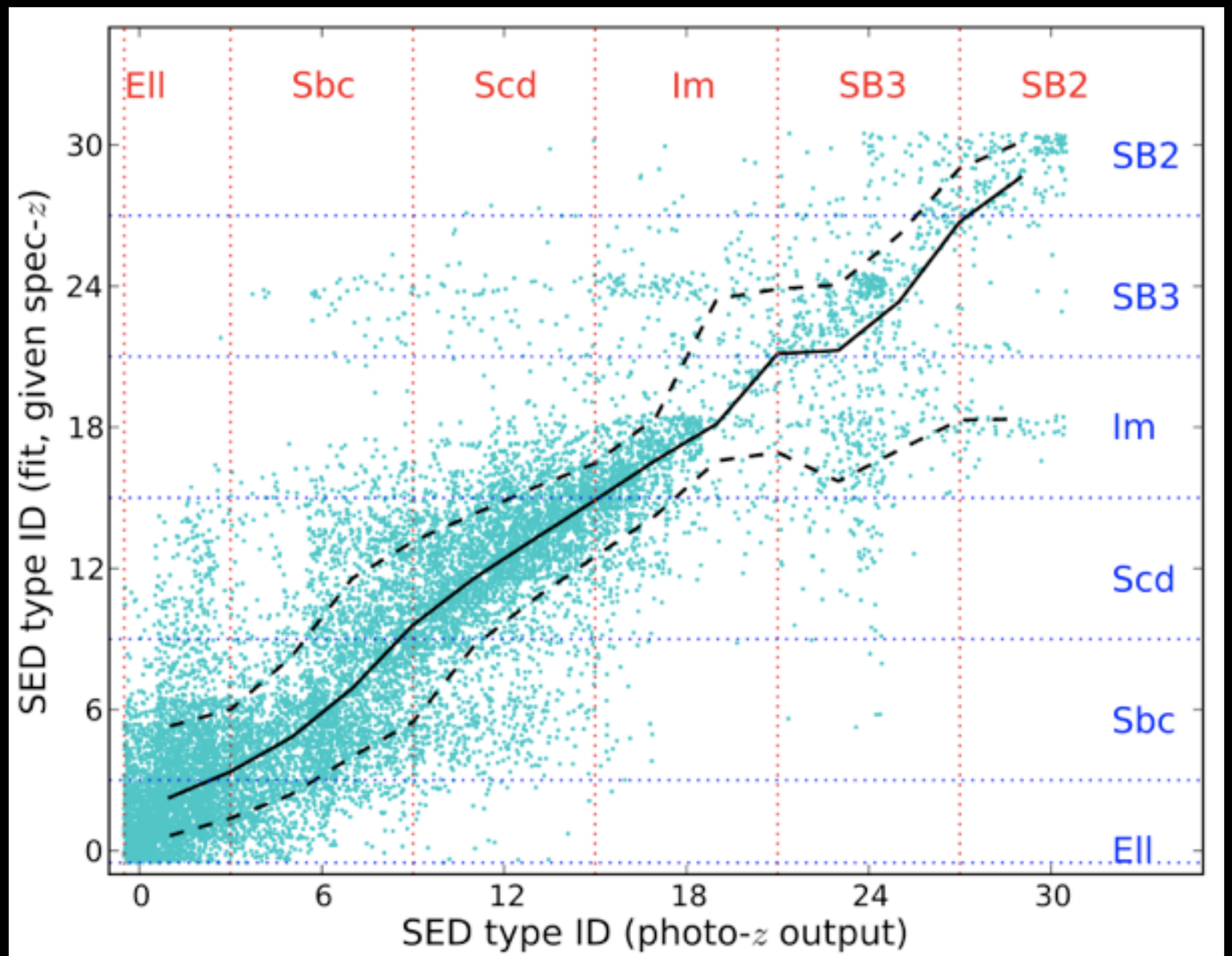
Absolute magnitude



Elliptical SED type:

- each panel = photo-z bin ($\Delta z=0.1$)
- median (line) and 68 percentile (dash)
  - avg. σ_{Mr} value
- estimated magnitude
  - corrected bins

Error in SED template types

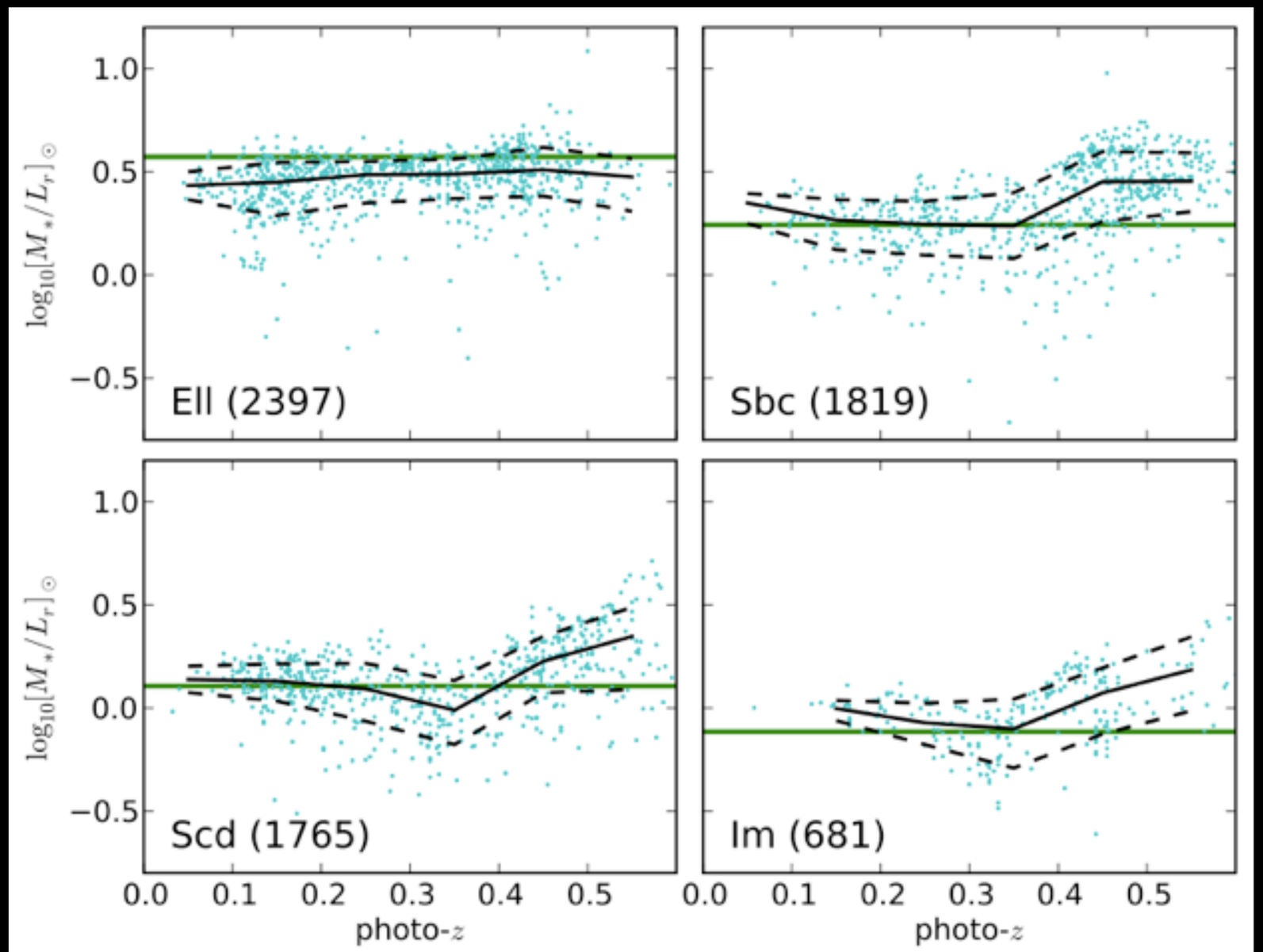


- 6 SED types
- 5 interpolated SEDs in between each

➡ SED type bin need no modification

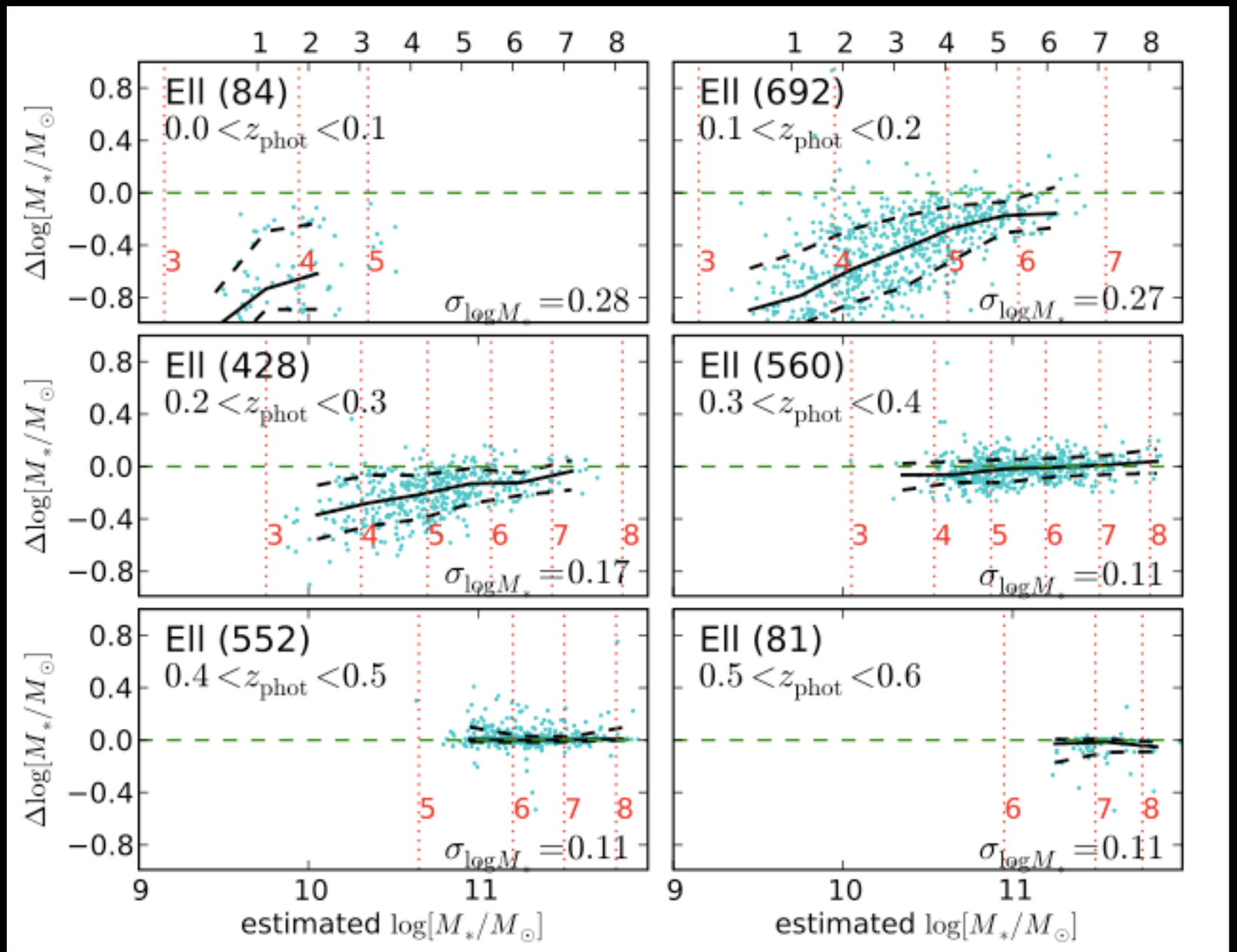
Stellar mass-to-light ratio

Bell & De Jong (2003)



- estimate M∗/L from z=0 color
- constant for each SED type

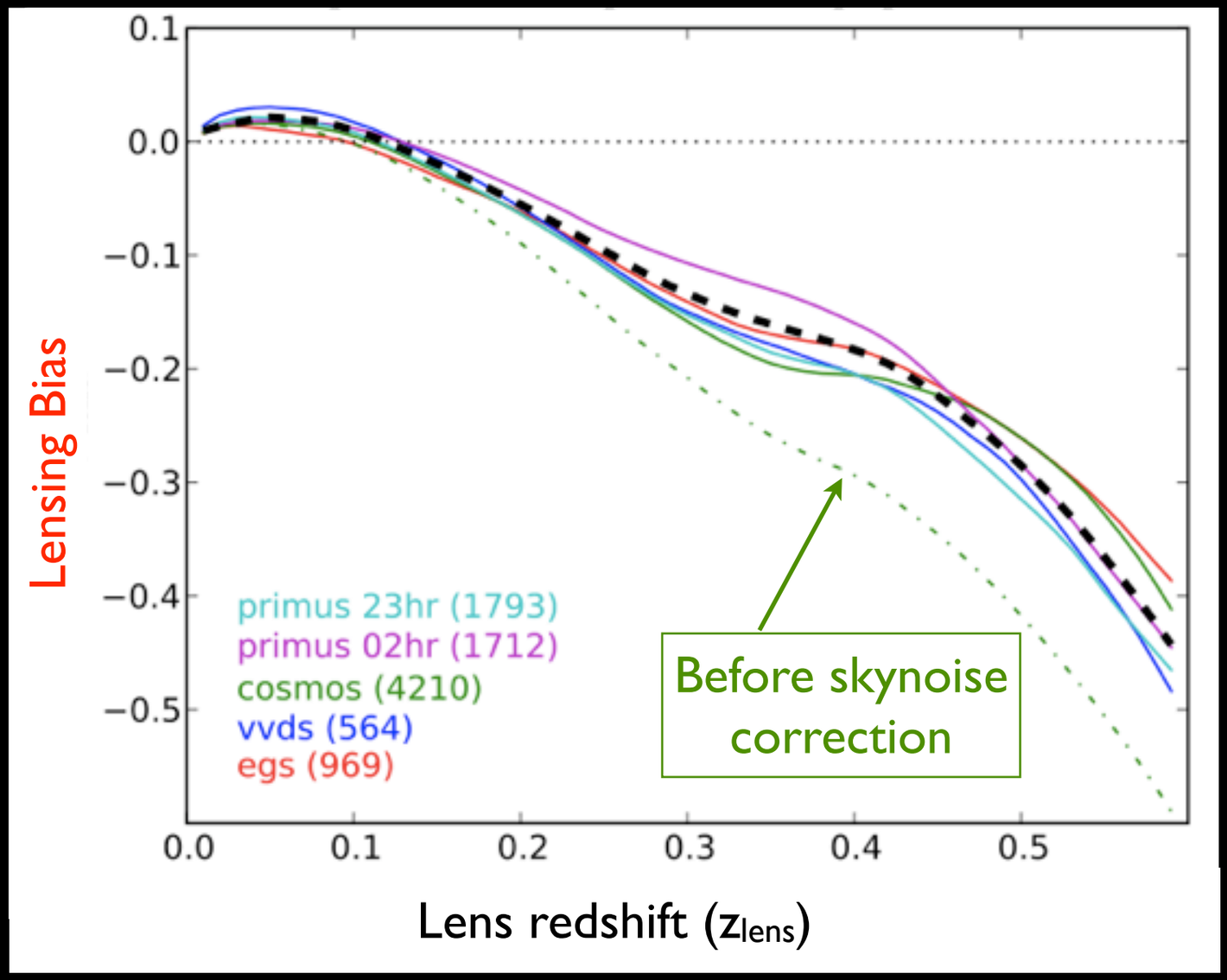
Stellar mass estimates



Elliptical SED type:

- each panel = photo-z bin (Δz=0.1)
- median (line) and 68 percentile (dash)
  - avg. $\sigma_{\log M*}$ value
- estimated magnitude
  - corrected bins

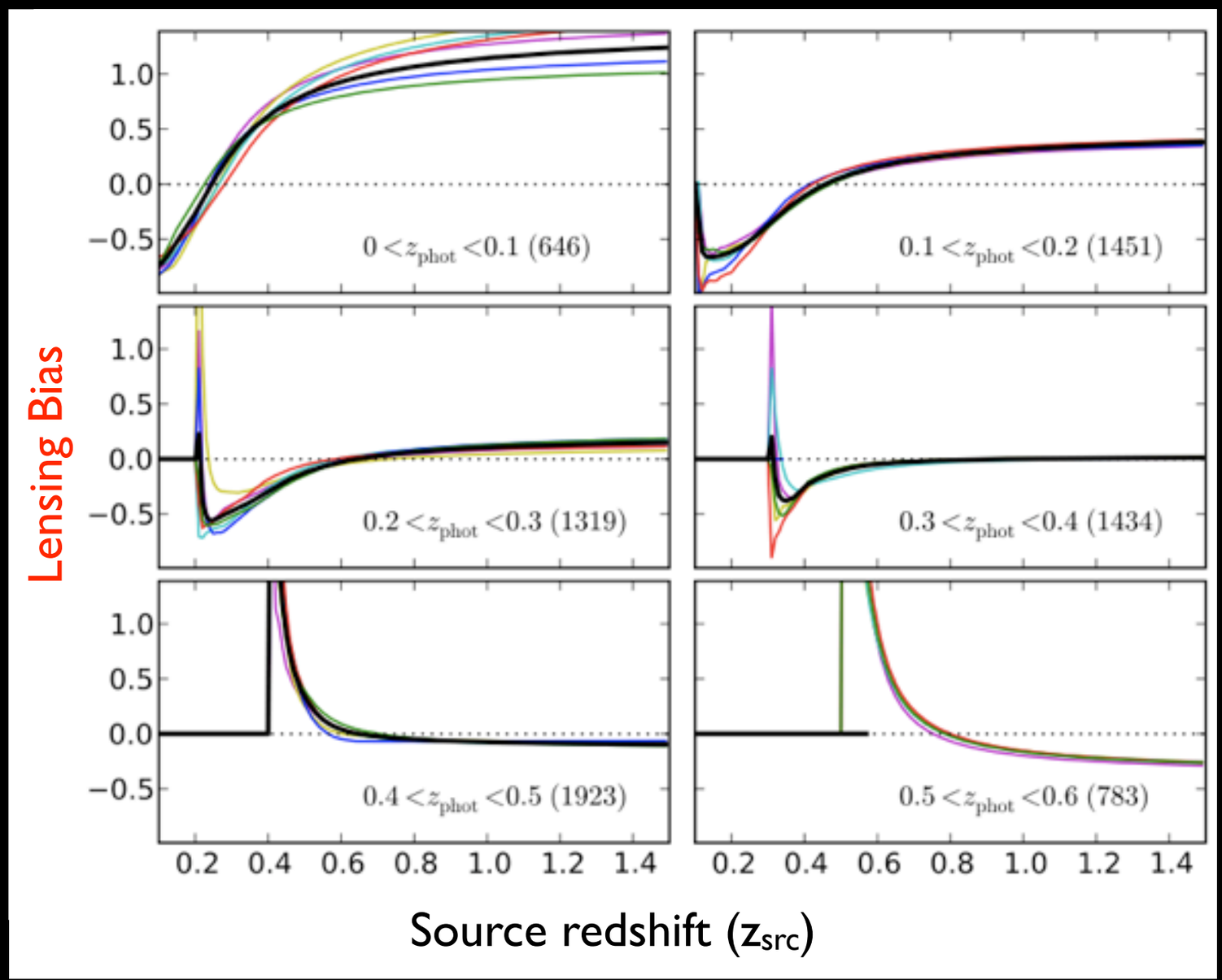
Lensing bias: source photo-z



Known lens redshift:

- bias for each subsets
- discrepancy in COSMOS
  - correction for skynoise

Lensing bias: lens photo-z



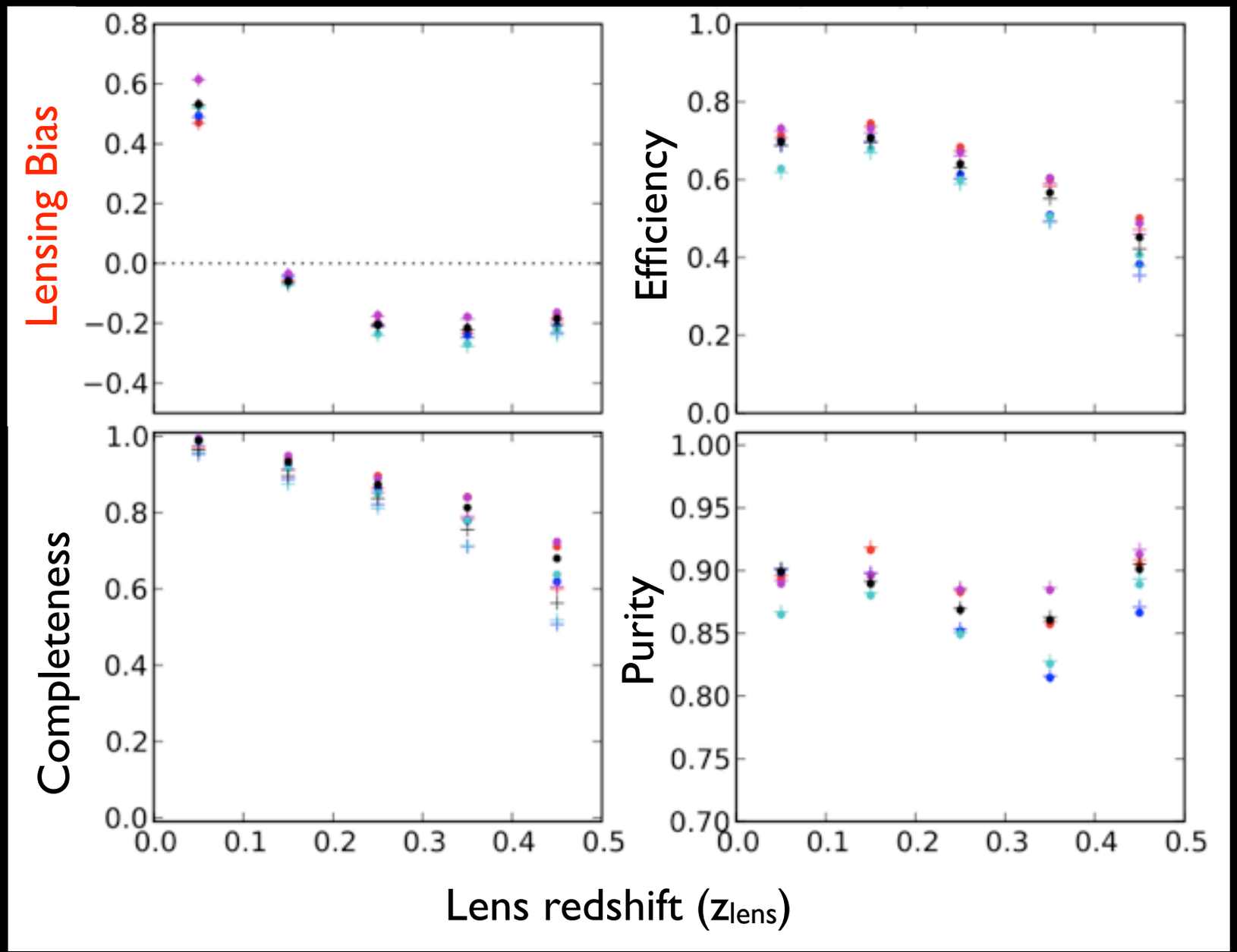
Known source redshift:

- bias for each z_{phot} bin

➡ discard z_{phot}<0.1 bin

- lens-source separation would be ideal, but...

Lensing bias: lens and source photo-z



- small dispersion
- 1σ z_{phot} cut (cross)
  no cut (circle)
  - same variance
  - same bias

Summary

- Photometric redshifts with SDSS DR8
  - all galaxy types (not just LRGs)
  - SED template method (k-correction)

- Spectroscopic calibration set
  - fair representation of photometric survey

- Galaxy-galaxy lensing calibration
  - stacking, binning width
  - gravitational lensing signal