

Photometric Redshifts in SDSS for Galaxy-Galaxy Lensing

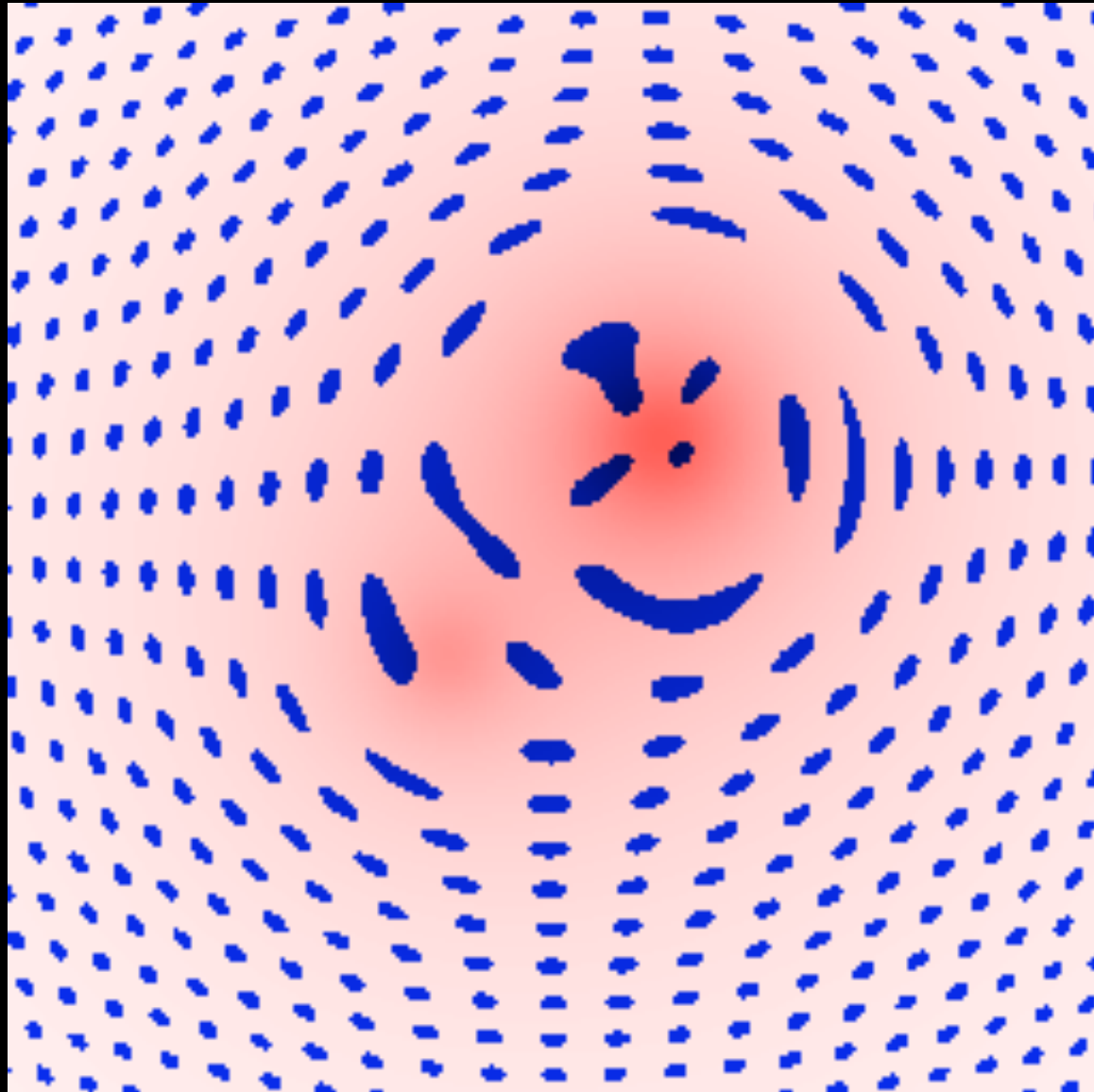
Reiko Nakajima, Rachel Mandelbaum, Uros Seljak,
Joanne Cohn, Alison Coil

INPA Talk, May 20, 2011

Outline

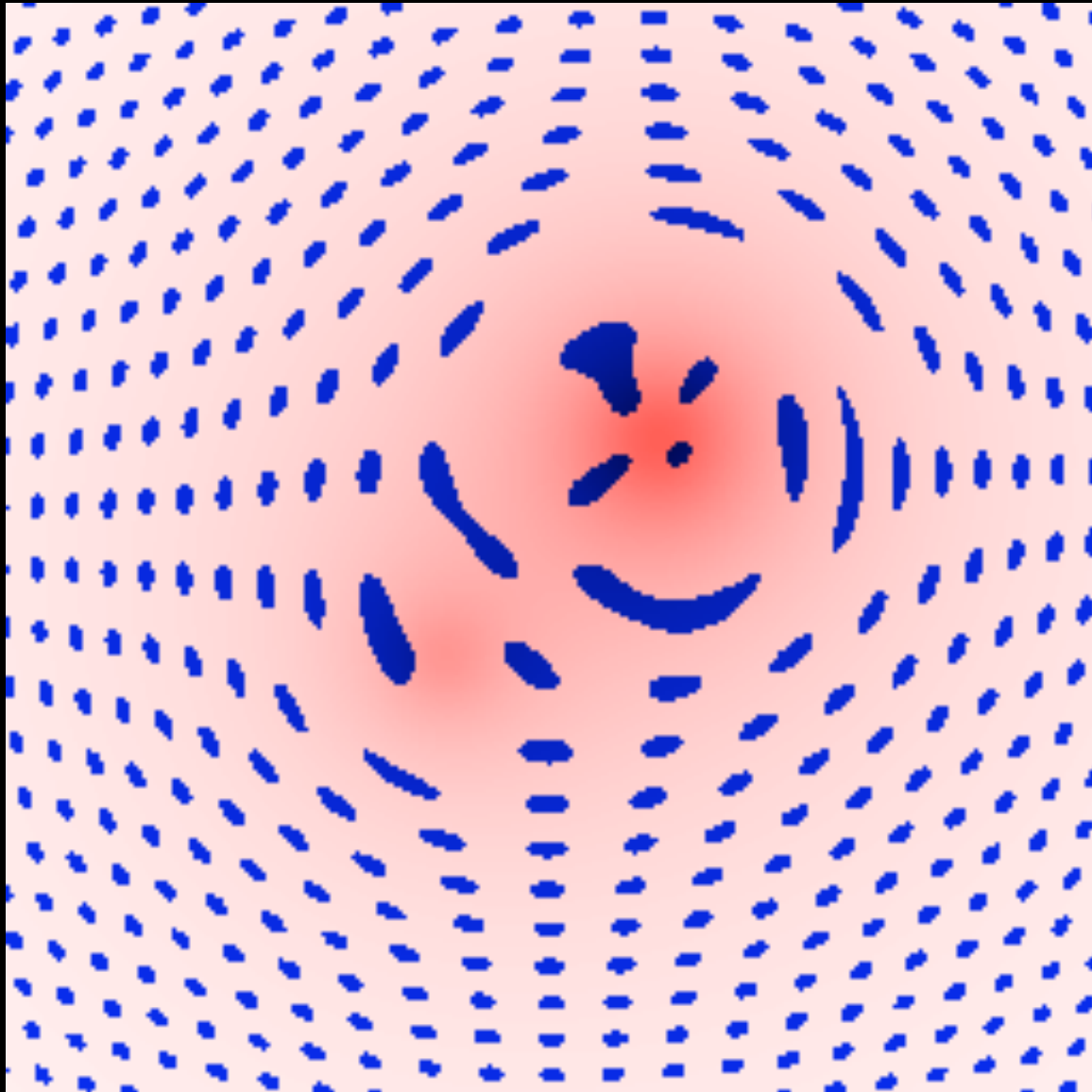
- galaxy-galaxy lensing
- photometric redshifts
- spectroscopic calibration set
- calibration results

Gravitational lensing



Abell 2218 Galaxy Cluster

Why is lensing hard?



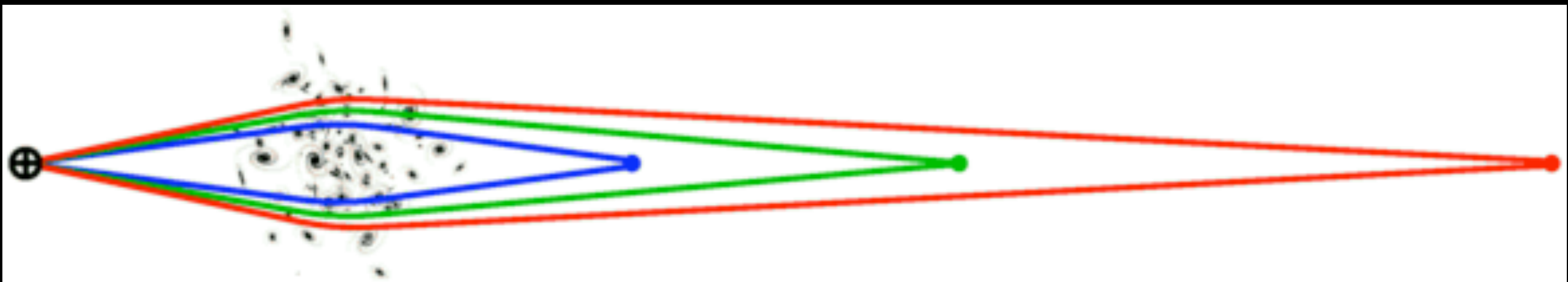
Accurate lensing:

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

Redshifts calibrate shear to mass

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

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



How can we get more background galaxies?

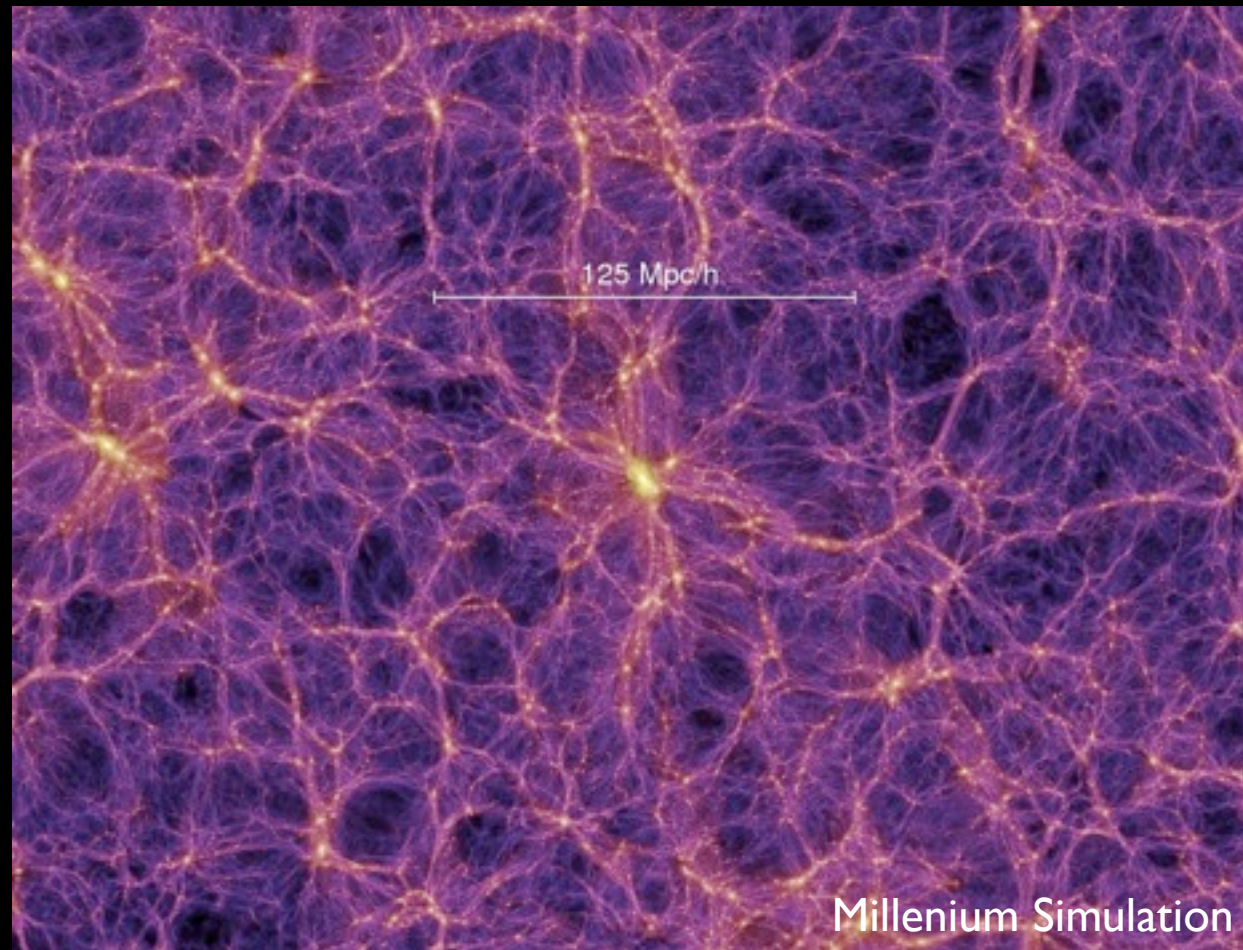


Galaxy-galaxy lensing:

- stacking by lens
- measures average dark matter distribution around galaxies

Why do we study galaxy-galaxy lensing?

Dark matter simulation

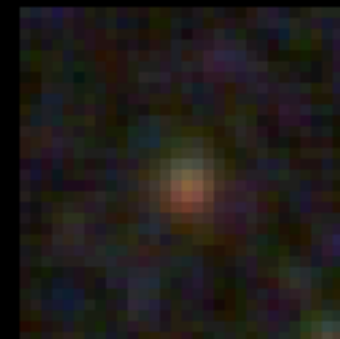
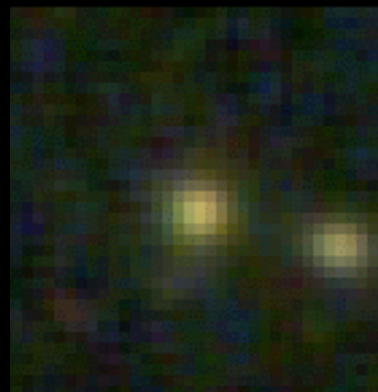
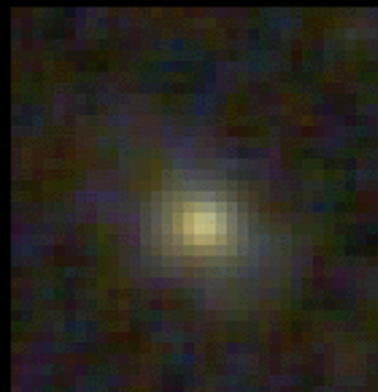
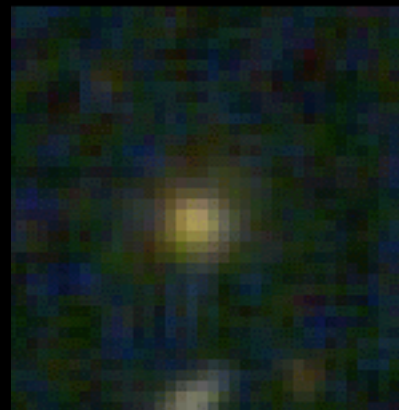
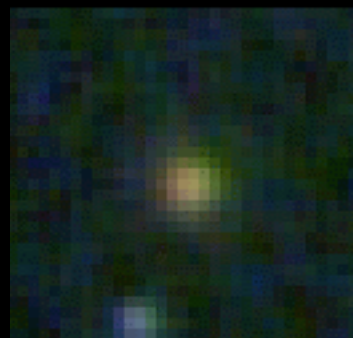
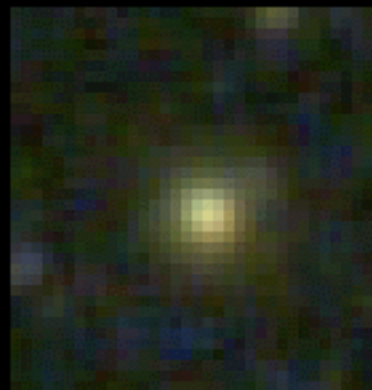
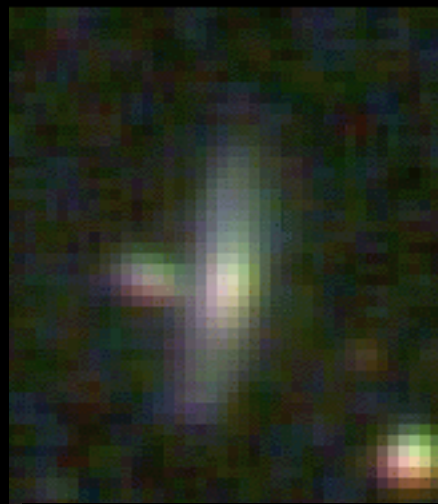


Observed galaxies



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

Redshifts by photometry



$z =$

0.1

0.2

0.3

0.4

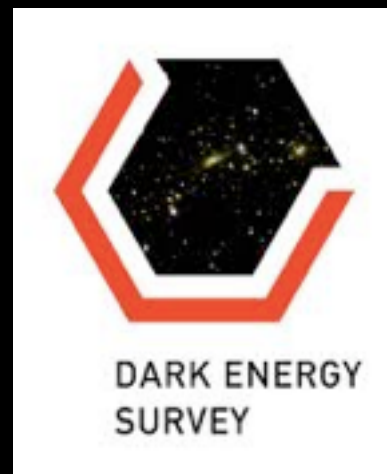
0.5

Why photometric redshifts (photo-z)?

- not enough spectroscopic redshifts
 - ▶ replace with multiband photometry
- because everyone else is going to be doing it

Why photometric redshifts (photo-z)?

- not enough spectroscopic redshifts
 - ▶ replace with multiband photometry
- because everyone else is going to be doing it



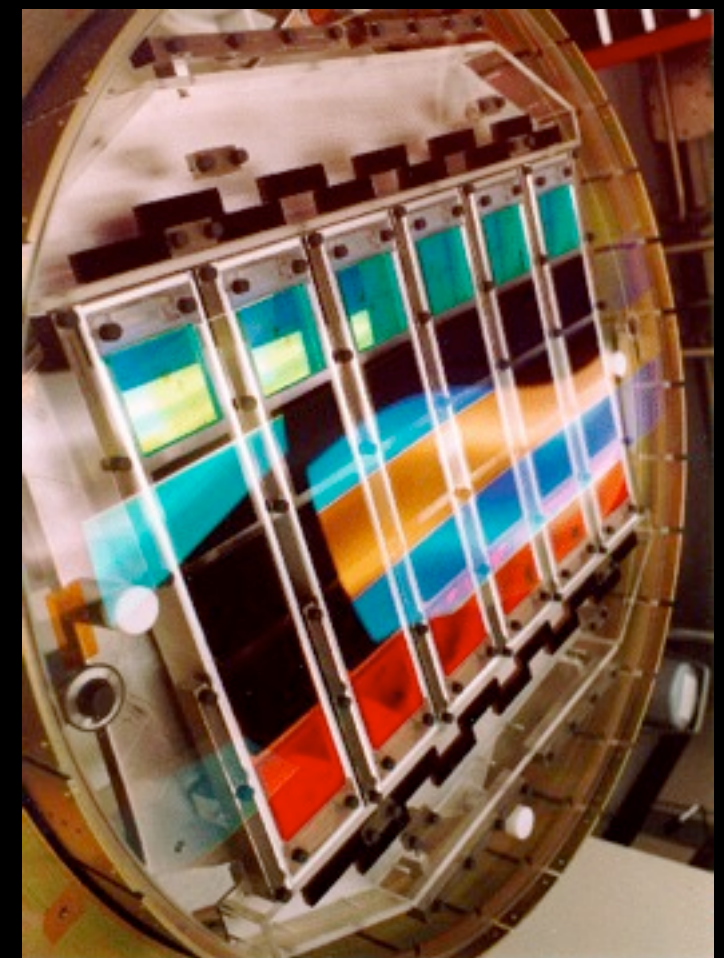
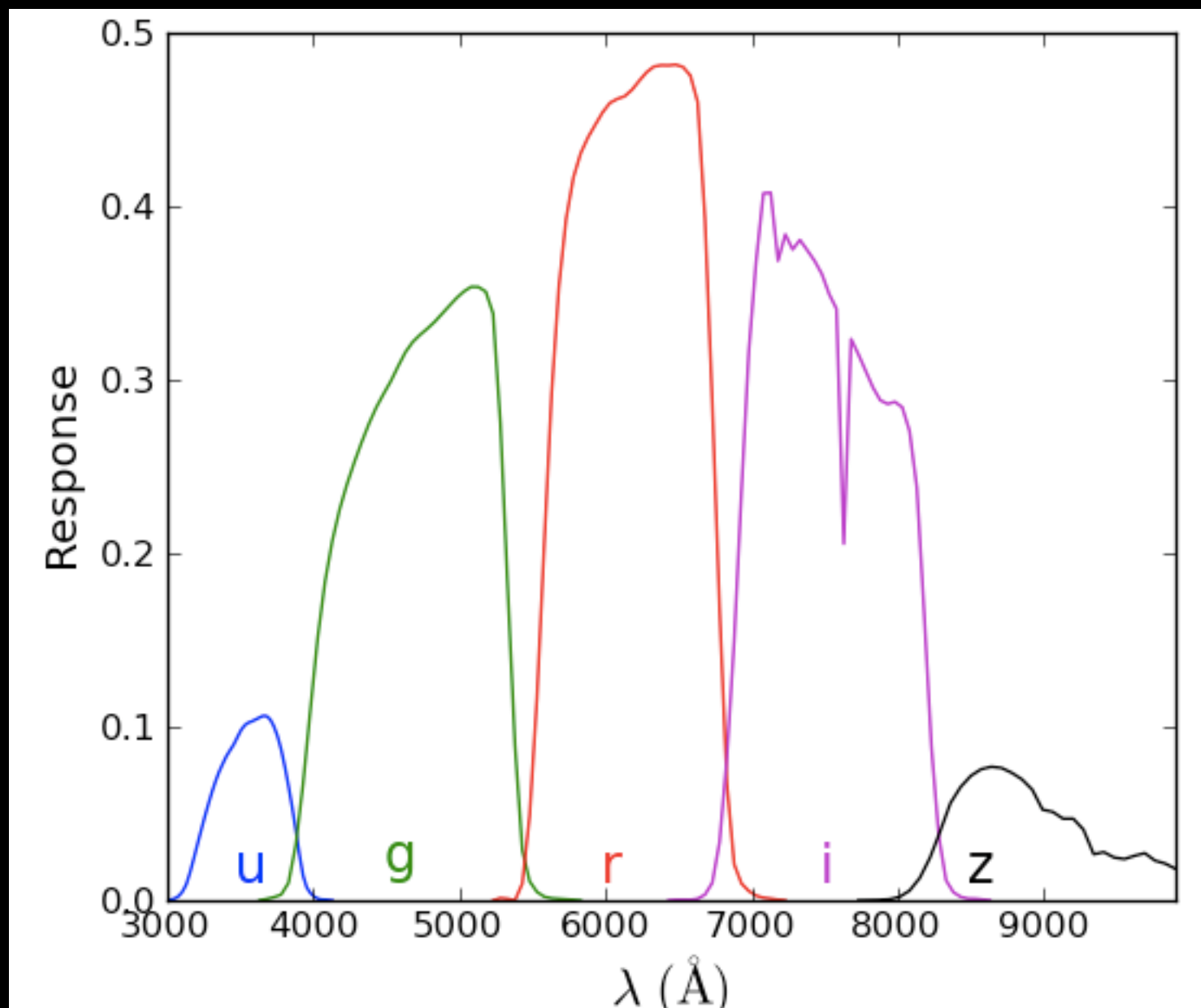
Photometric redshift requirements for lensing

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

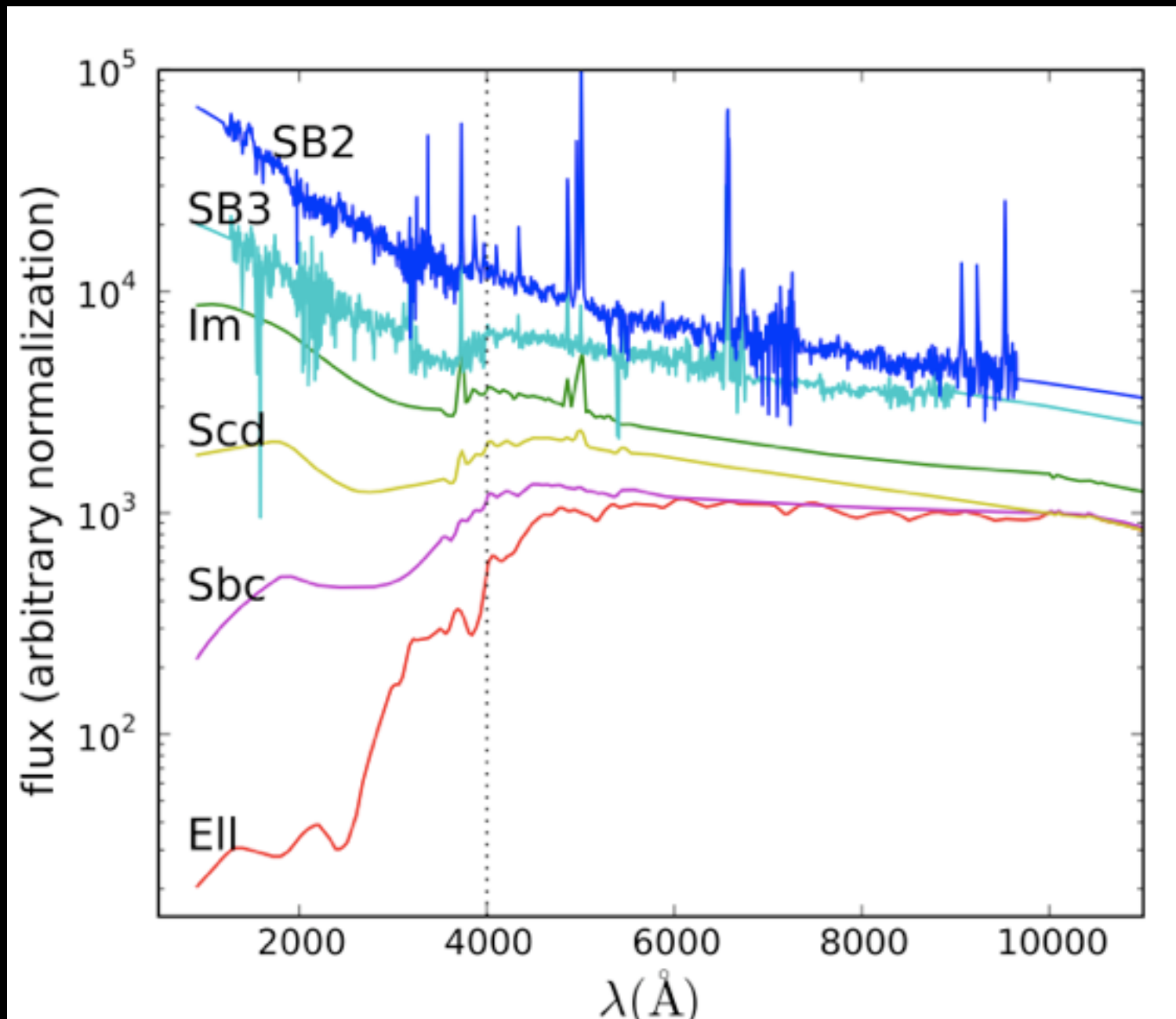
Photometric redshift requirements for lensing

- 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

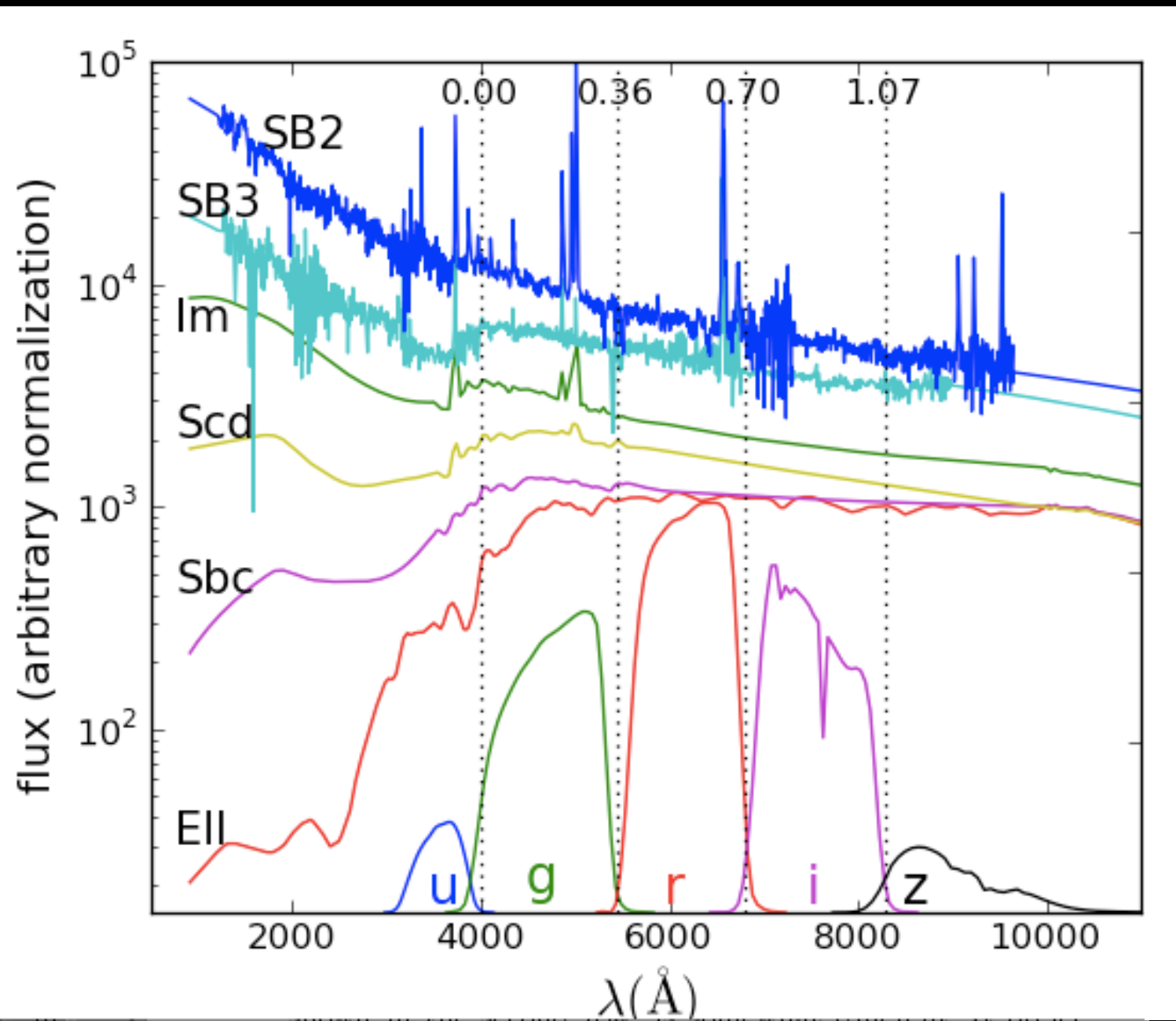


Photometric redshifts, template based



- galaxy SED templates
 - ▶ $4000 \text{\AA}$ break
 - ▶ different UV strengths

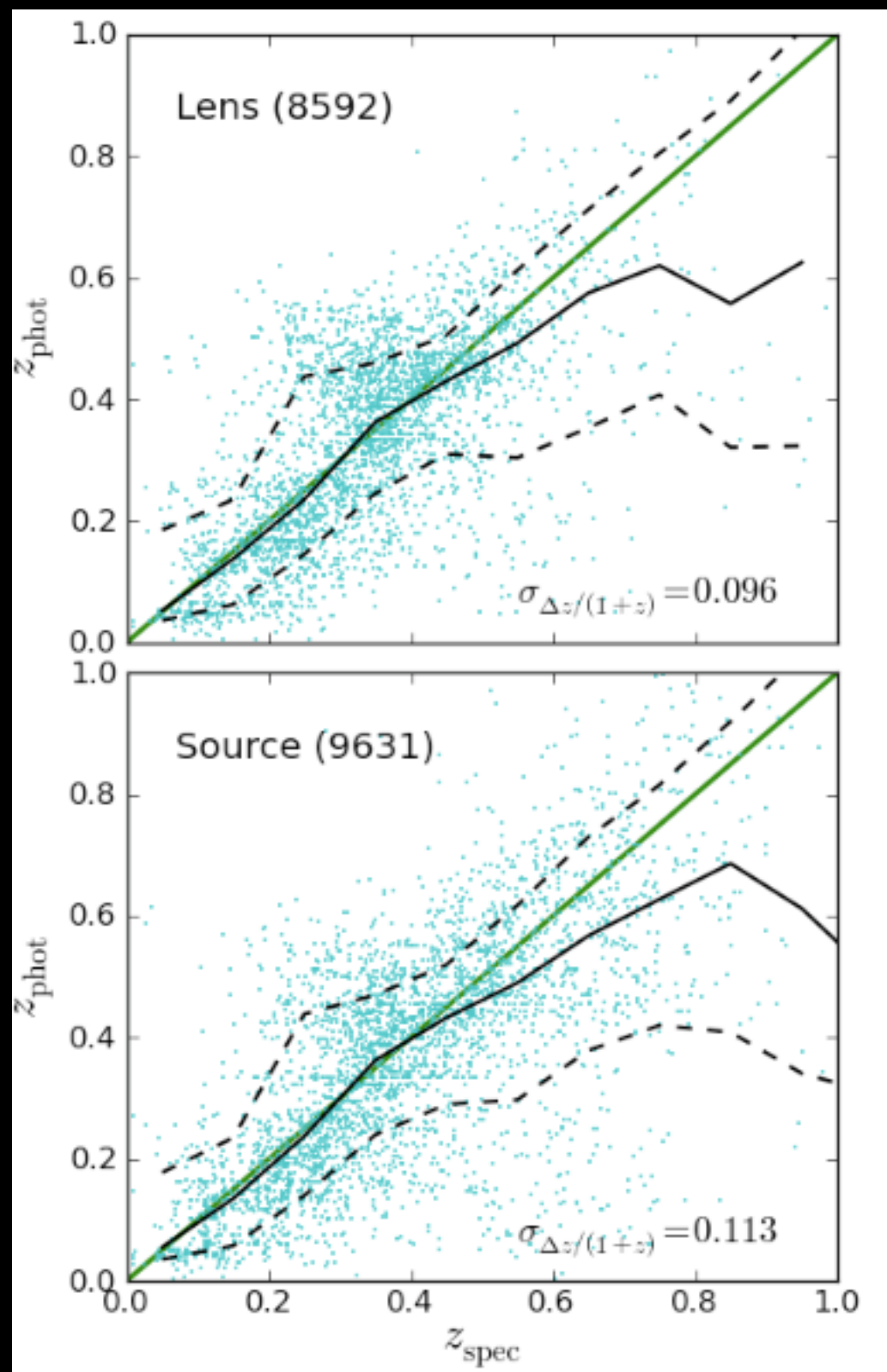
Photometric redshifts, template based



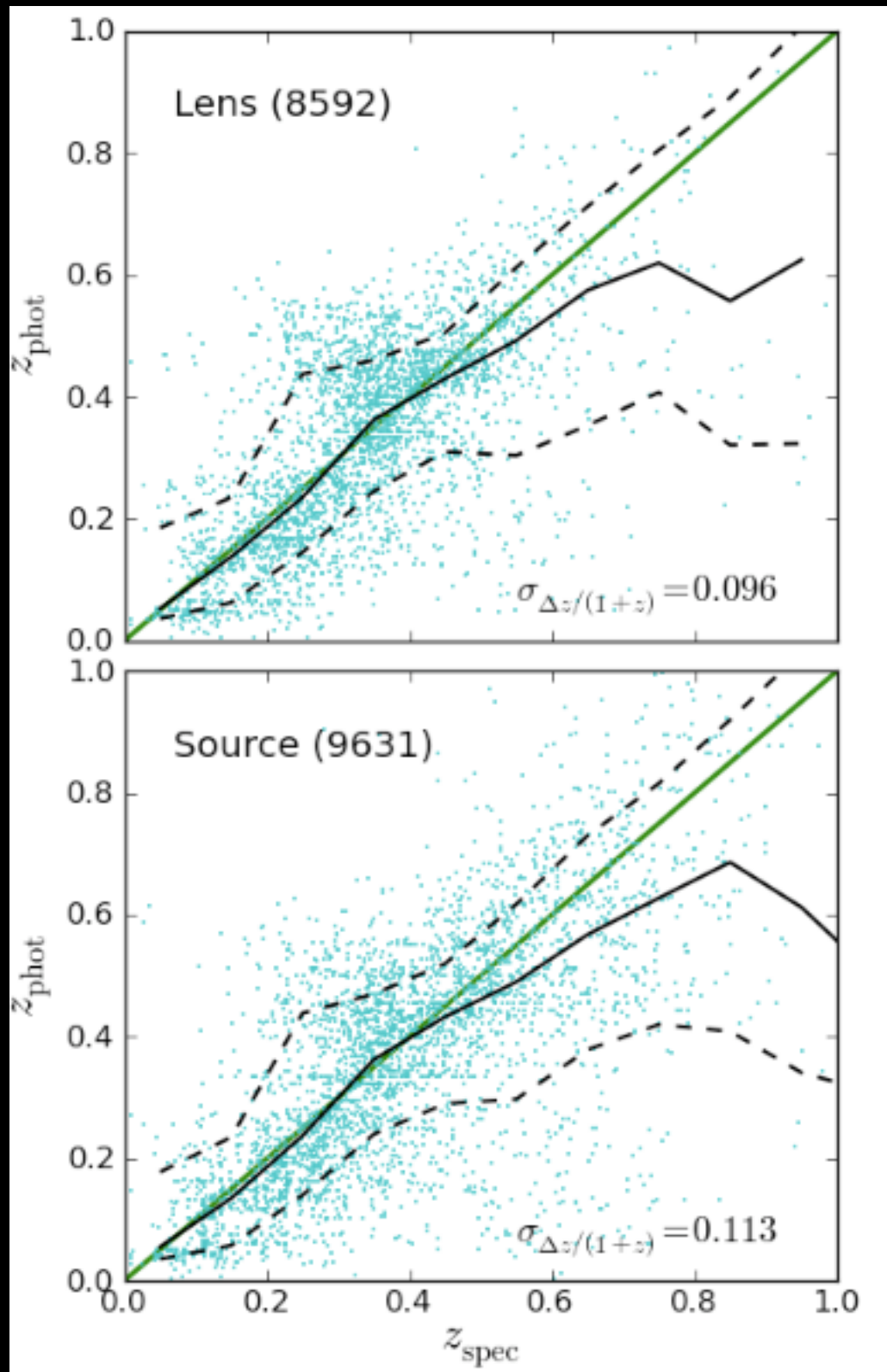
- galaxy SED templates
 - ▶ 4000 $\text{\AA}$ break
 - ▶ different UV strengths

Photometric redshifts with SDSS

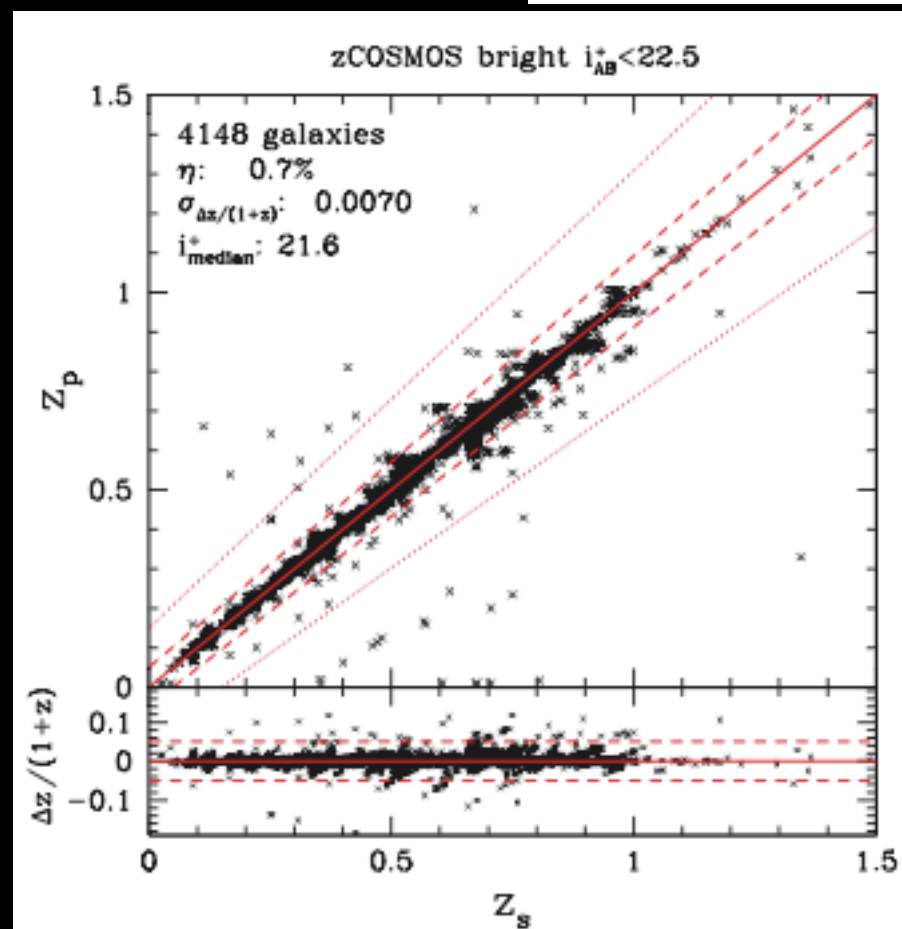
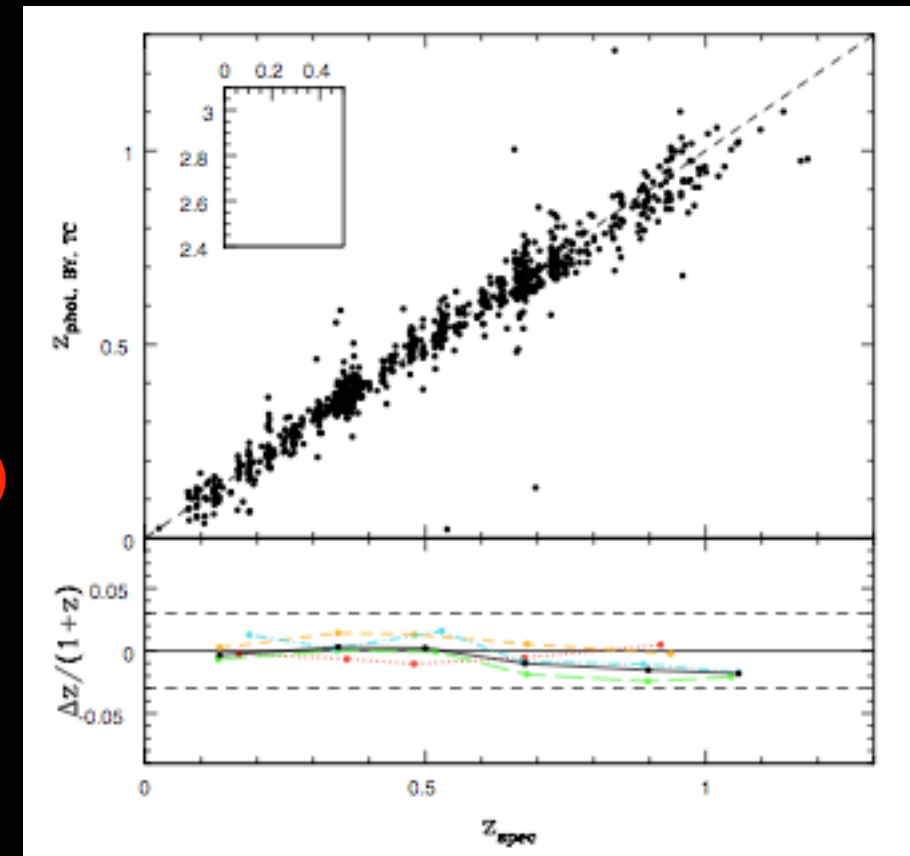
- $\sigma_{\Delta z/(1+z)} \sim 0.1$



Photometric redshifts with SDSS

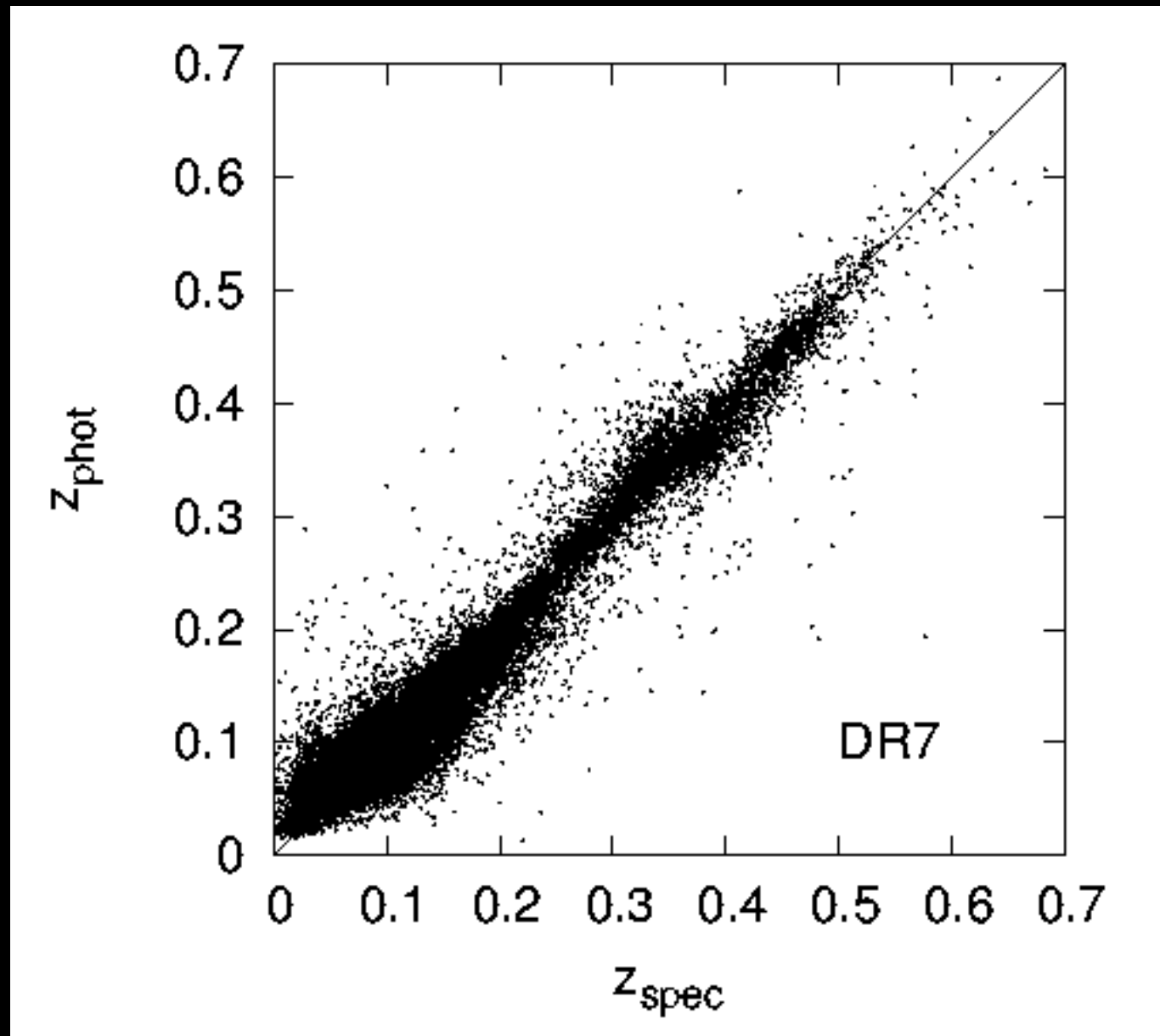


$\sigma_{\Delta z/(1+z)} < 0.03$
Feldmann+ (2006)



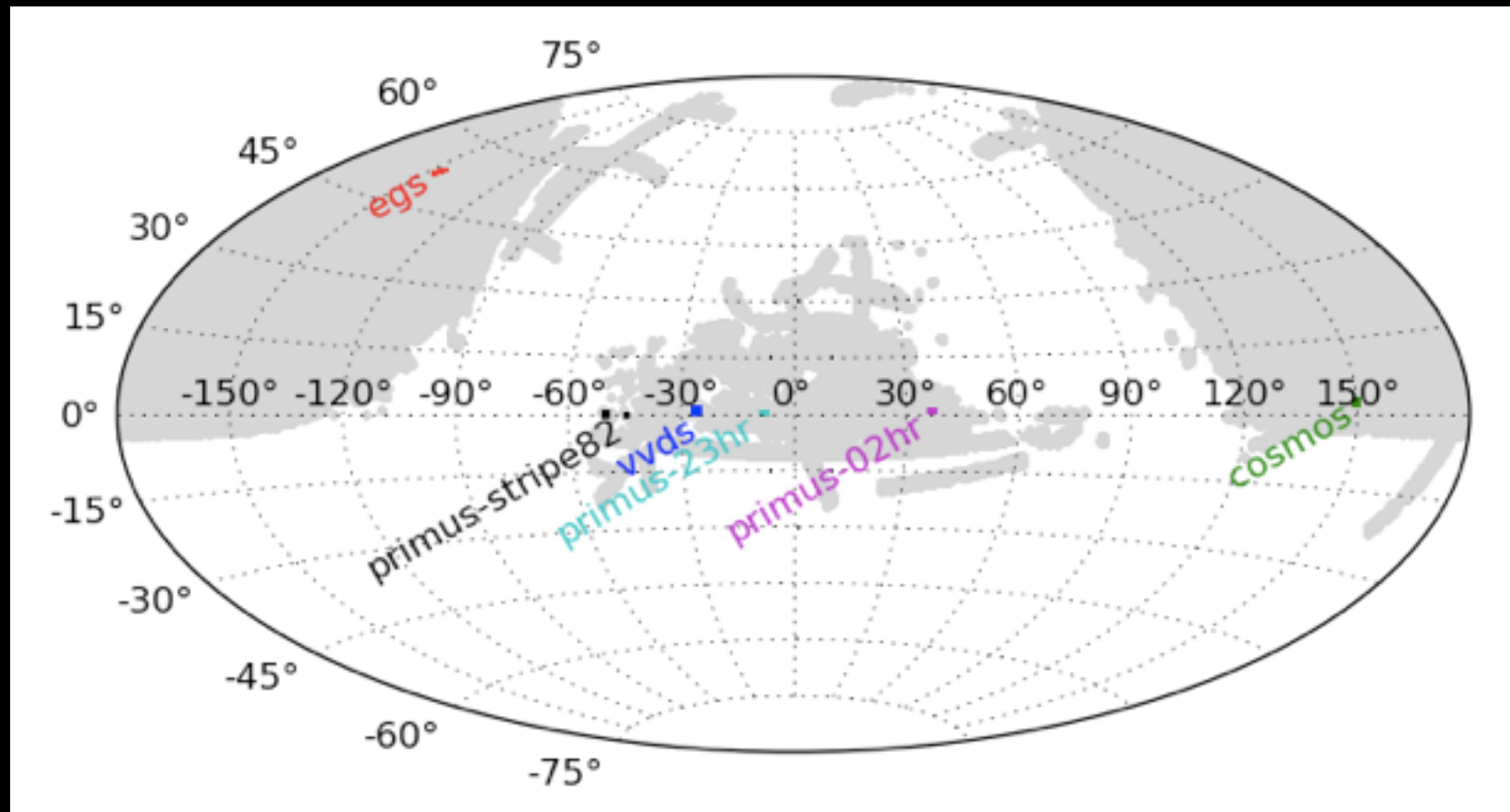
$\sigma_{\Delta z/(1+z)} = 0.007$
Ilbert+ (2009)

Photometric redshifts, training set based



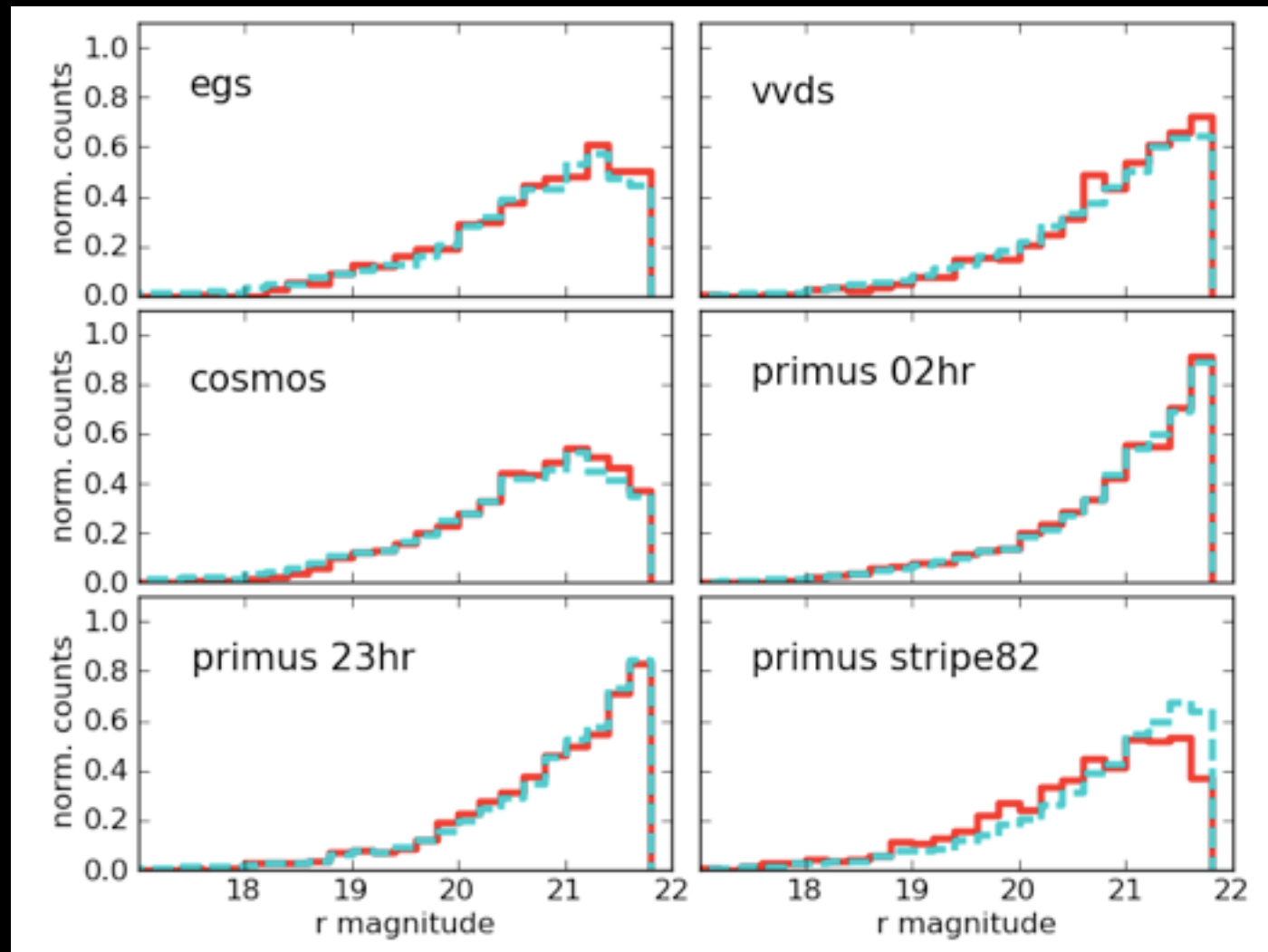
<http://www.sdss.org/dr7/algorithms/photo-z.html>

Calibration sets



- SDSS: 8720 sq deg (low extinction)
- Calib: ~5 sq deg

Calibration sets: r magnitude distribution

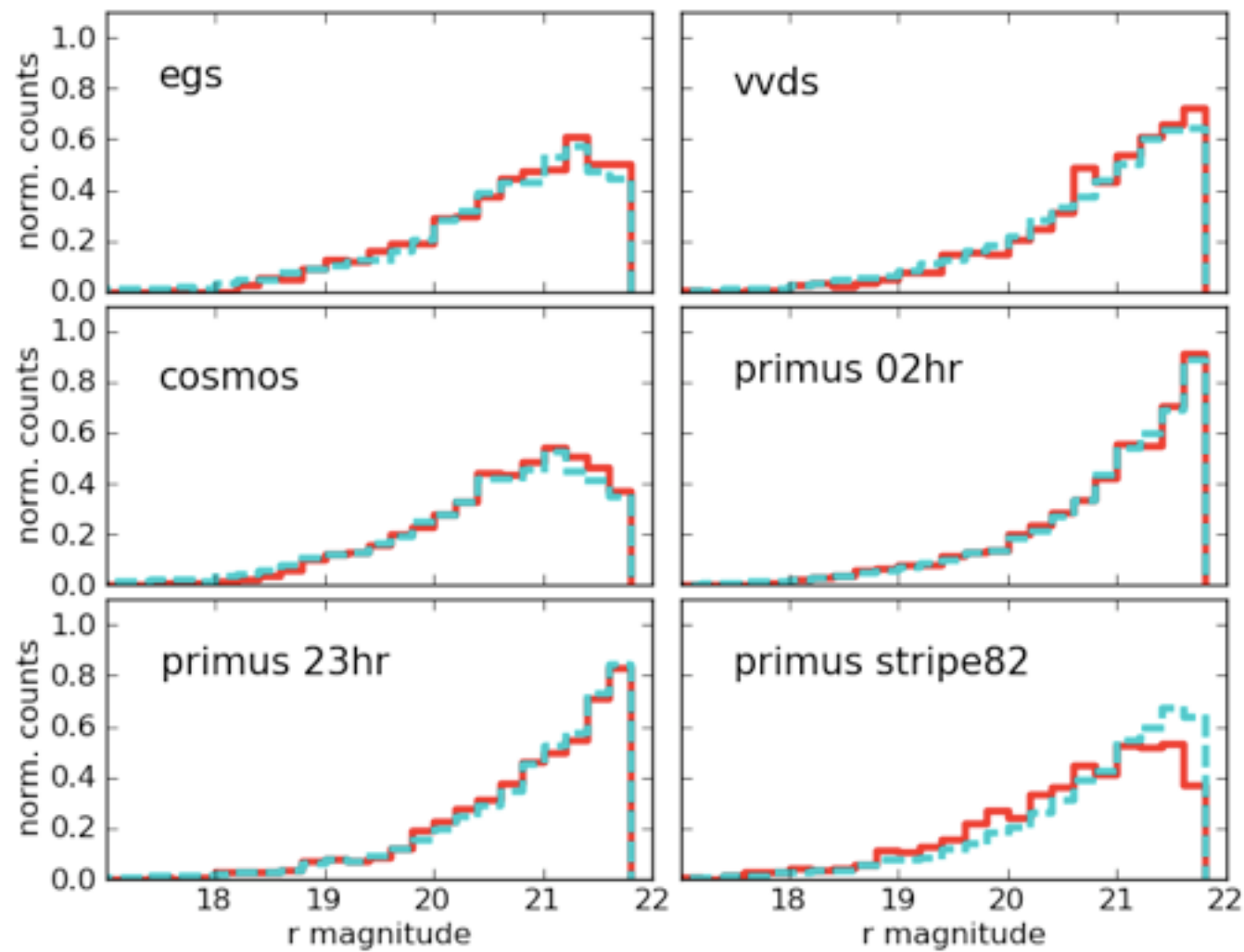


calibration set

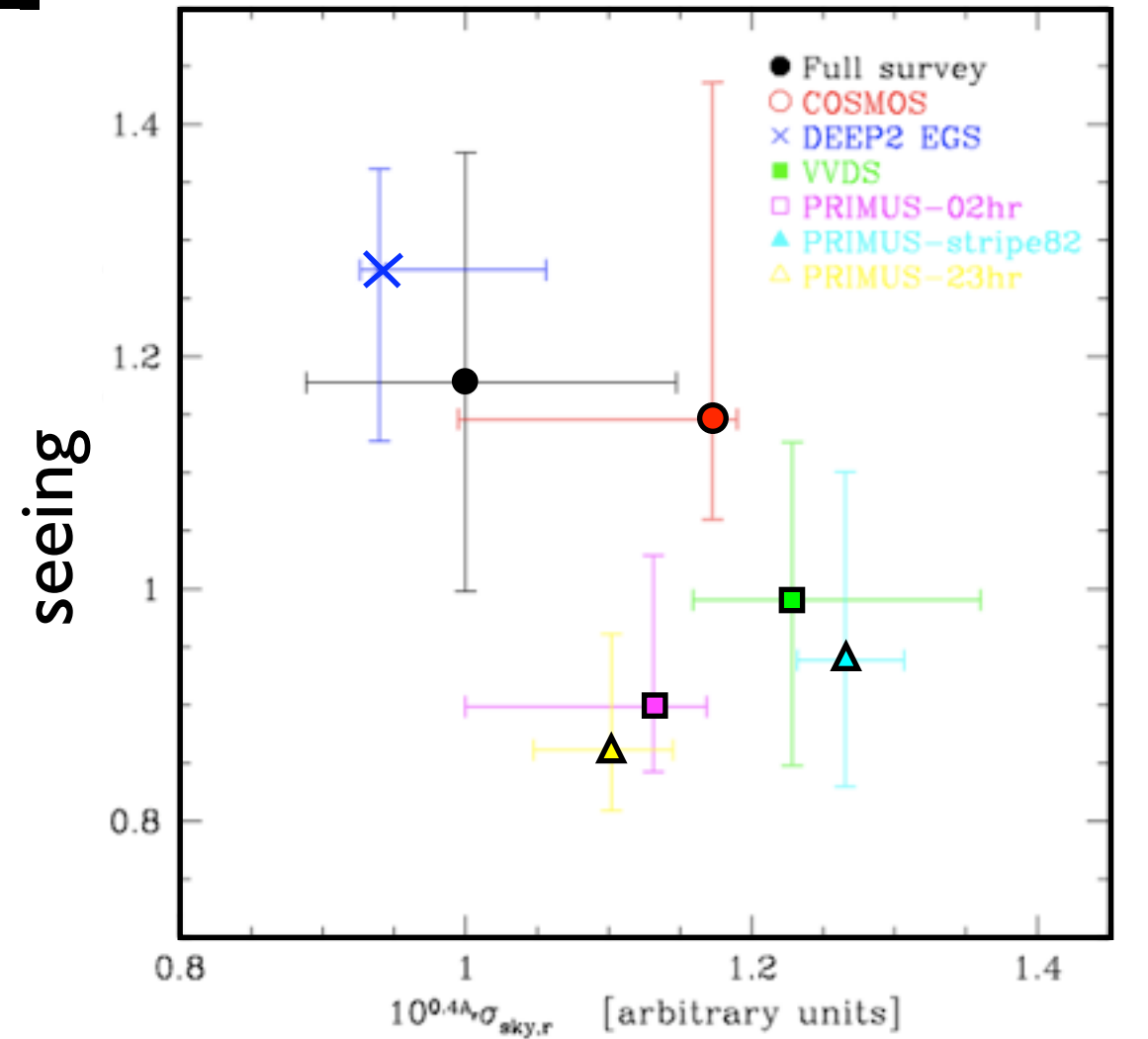
underlying distribution

r magnitude

Calibration sets: r magnitude distribution

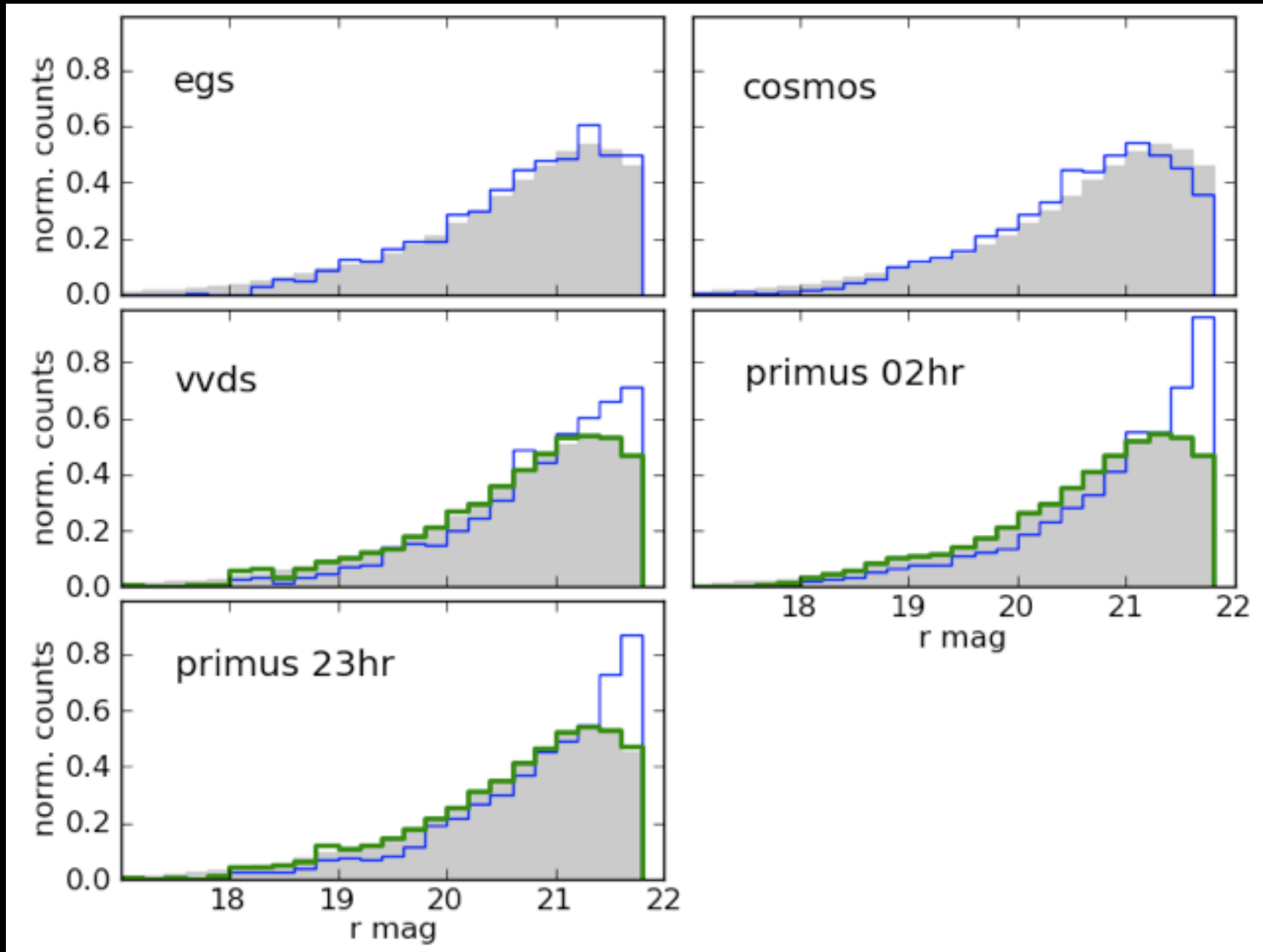


r magnitude



sky noise

Calibration set correction



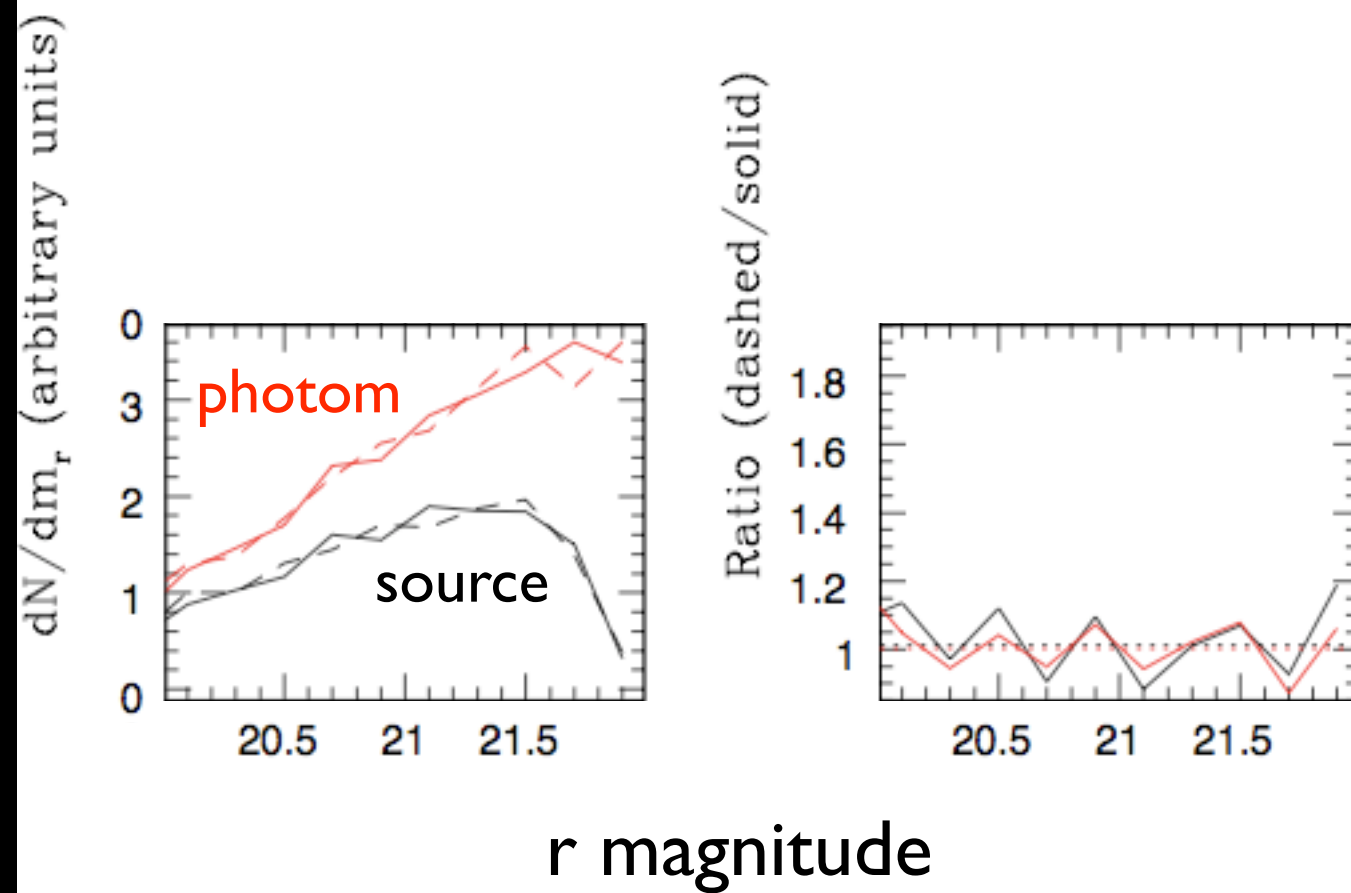
original
calibration set

all of SDSS

corrected

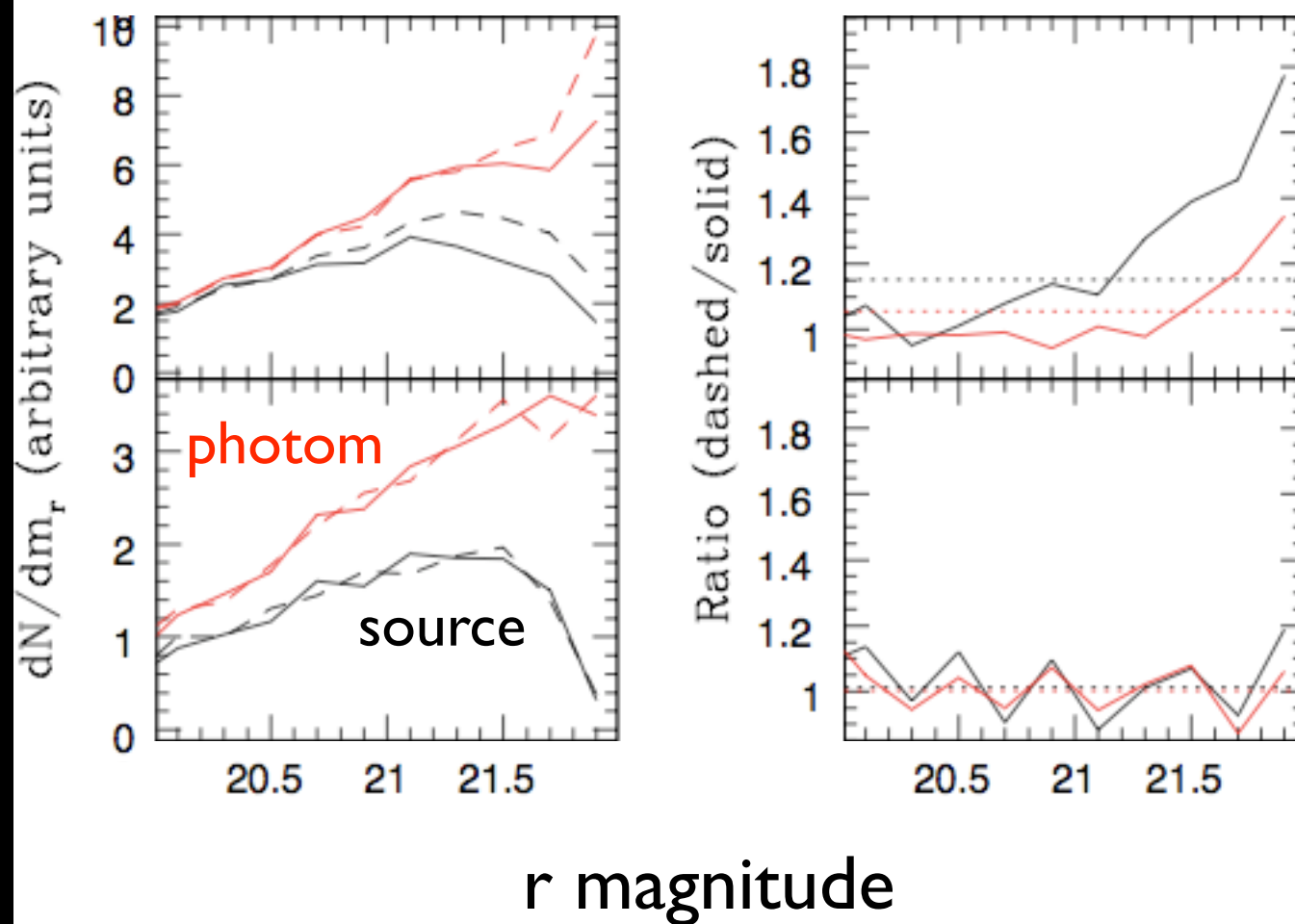
r magnitude

Calibration sets



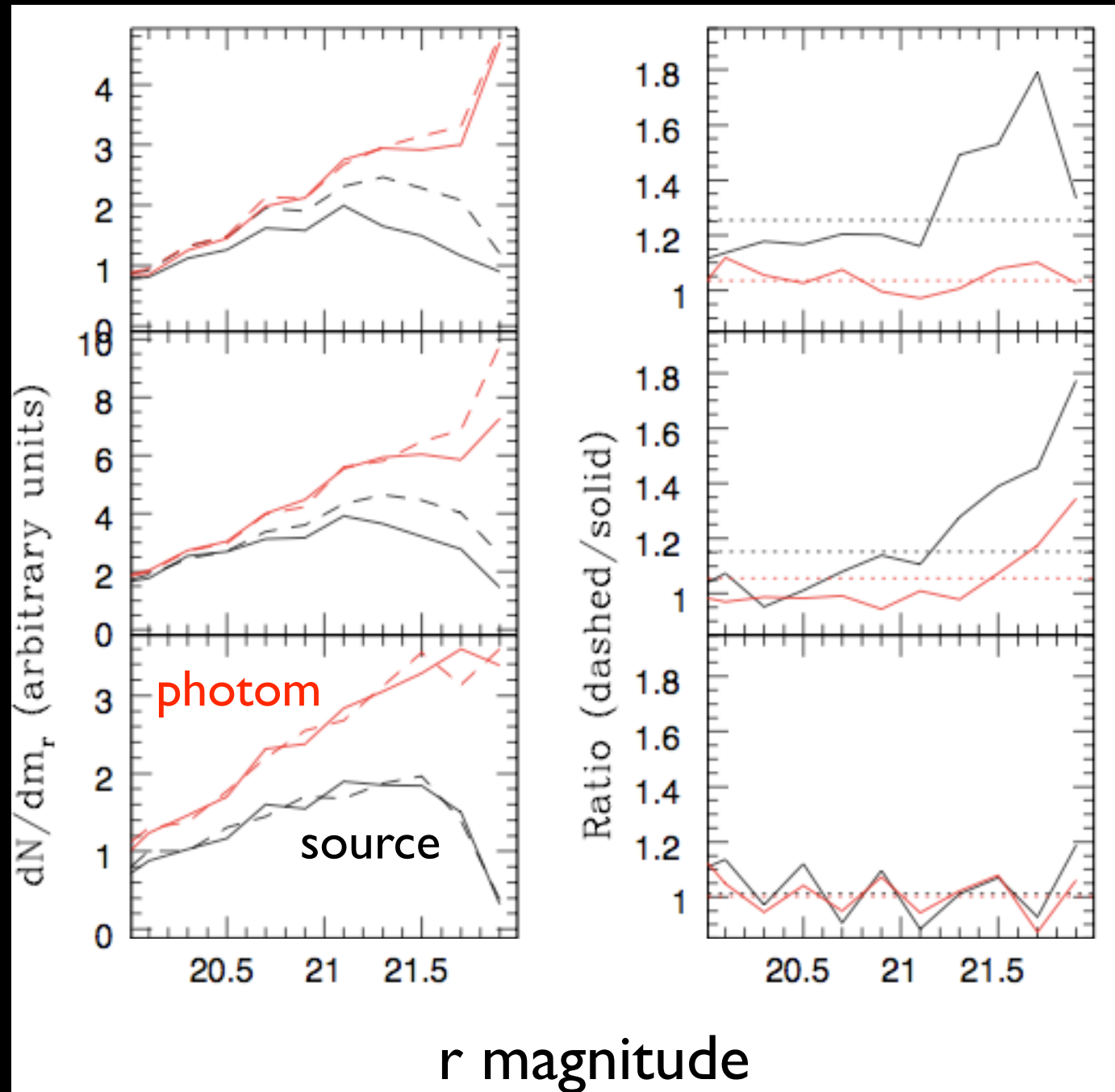
- same sky noise,
same seeing

Calibration sets



- same seeing (good),
25% degradation in sky
- same sky noise,
same seeing

Calibration sets

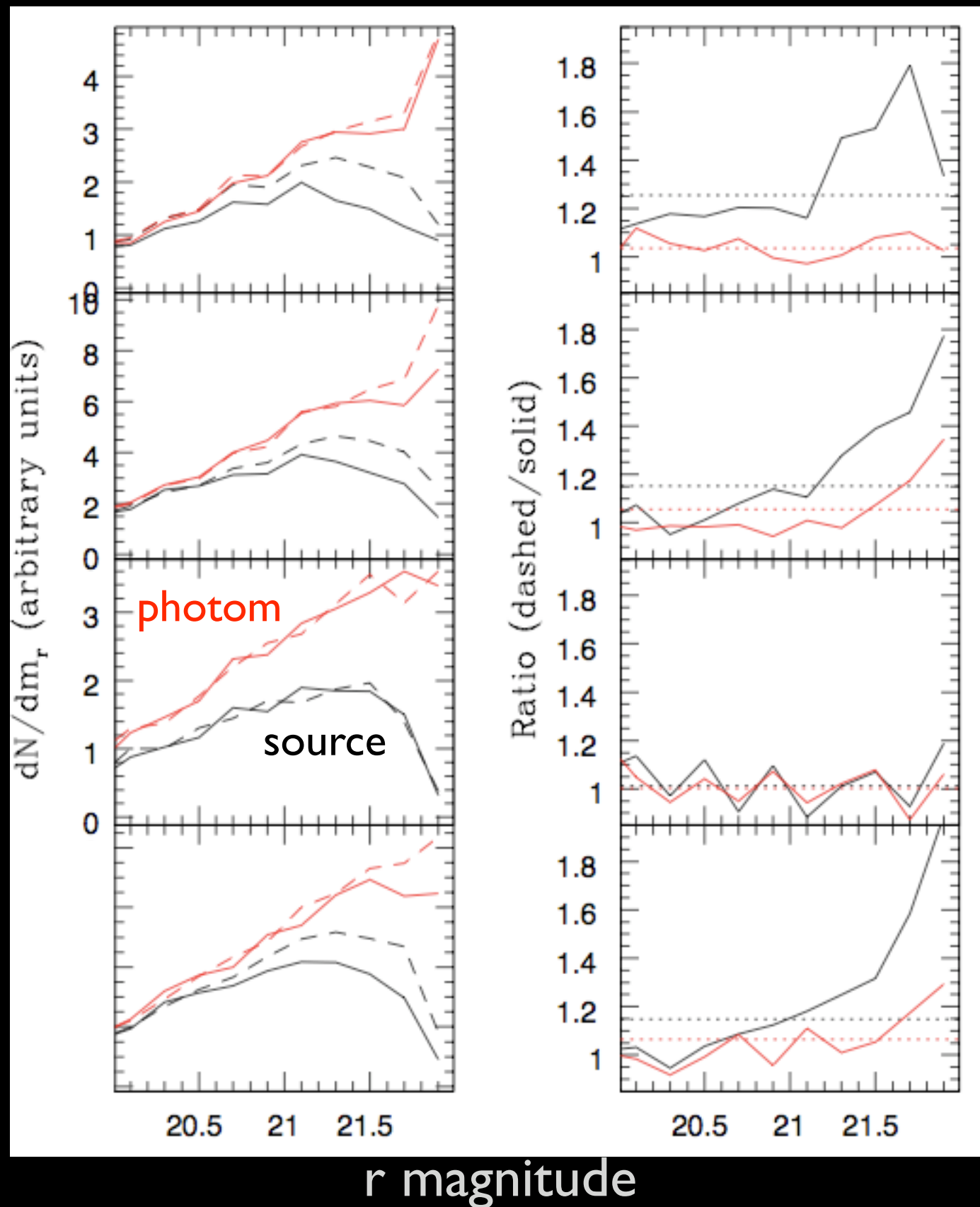


- same sky noise,
different seeing

- same seeing,
different sky noise

- same sky noise,
same seeing

Calibration sets



- same sky noise,
different seeing

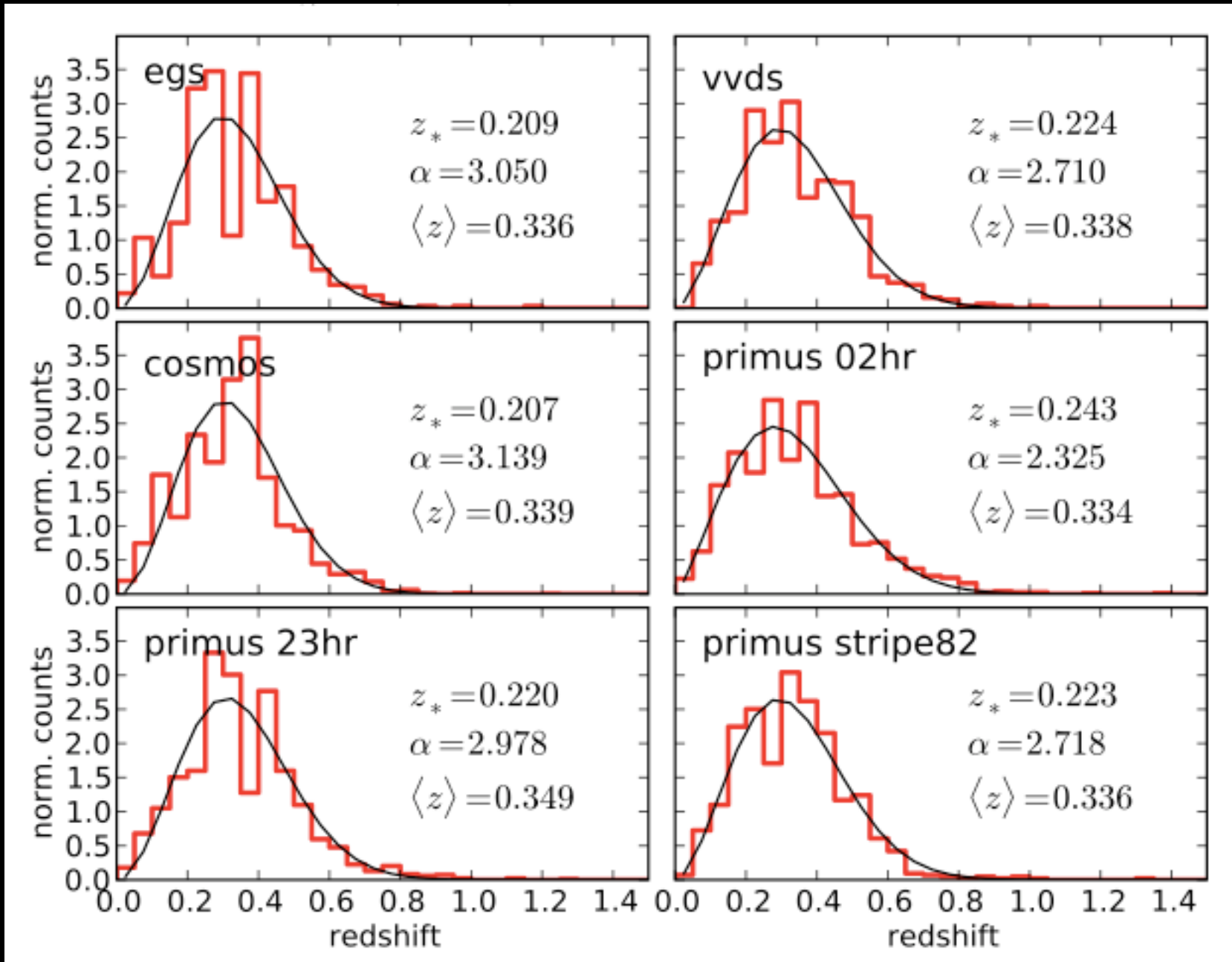
- same seeing,
different sky noise

- same sky noise,
same seeing

- both seeing & sky noise
different

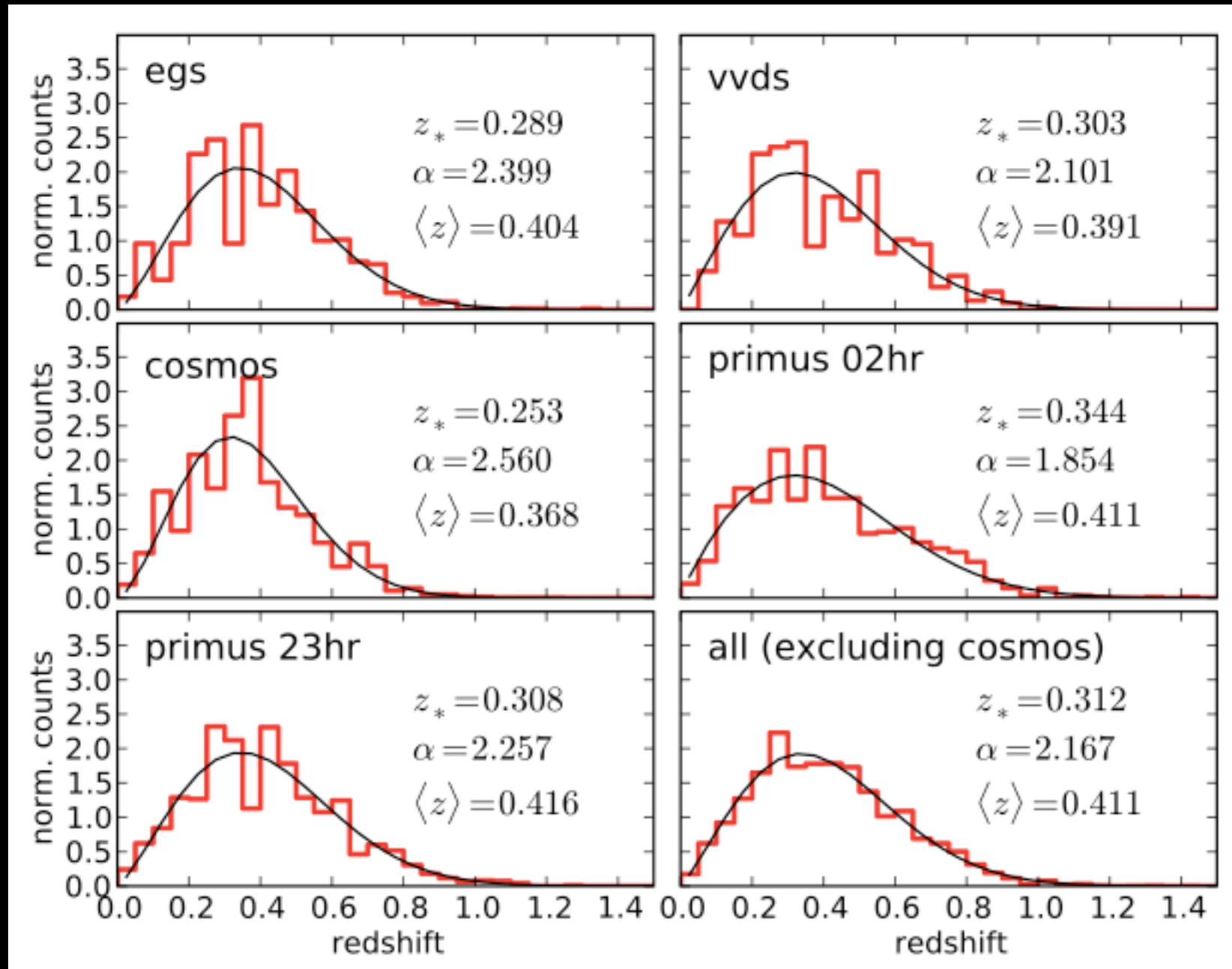
Calibration sets: redshift distribution

- Lens ($r < 21$)



Calibration sets: redshift distribution

- Source ($r < 21.8$)



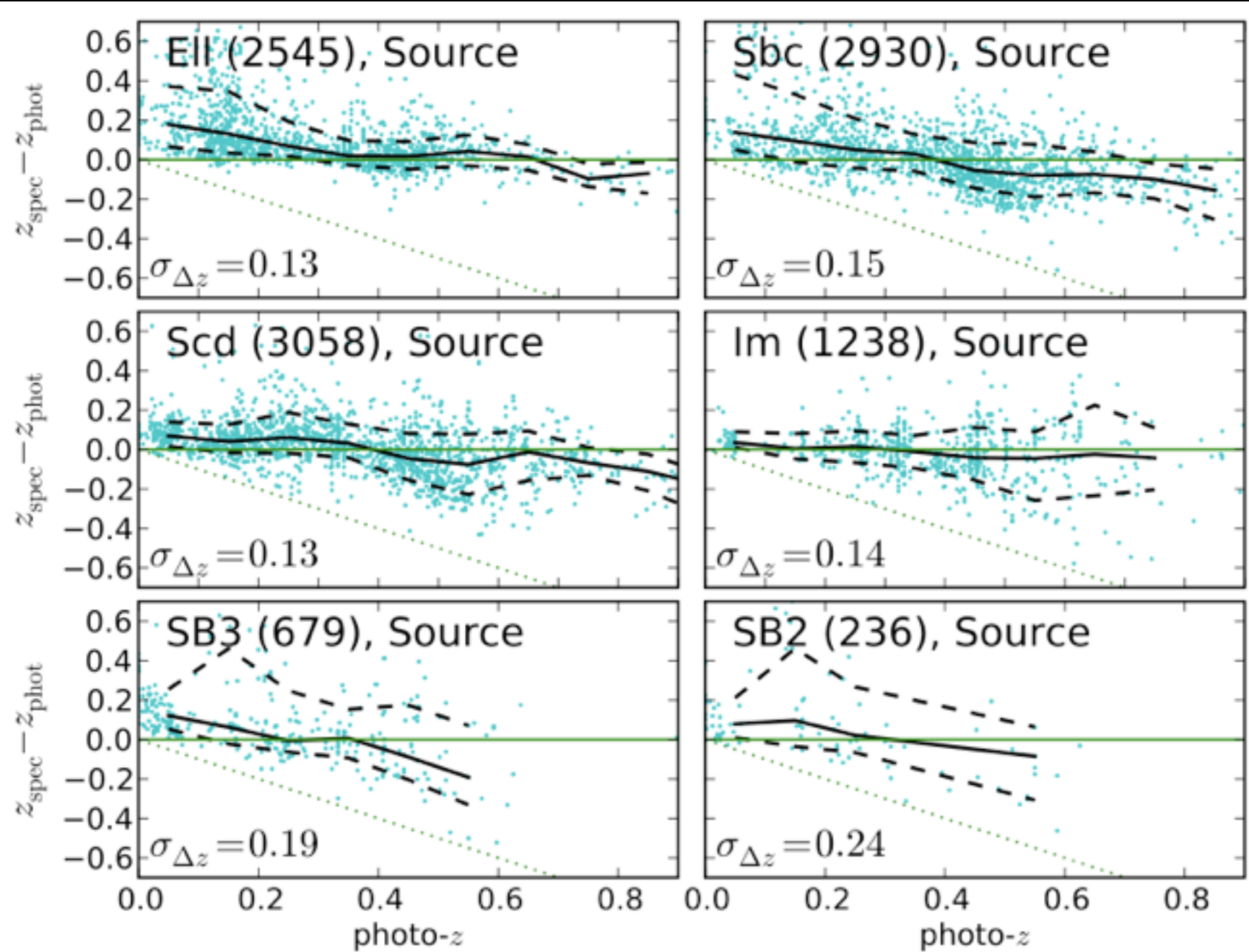
Galaxy-galaxy lensing



Stacking by lens:

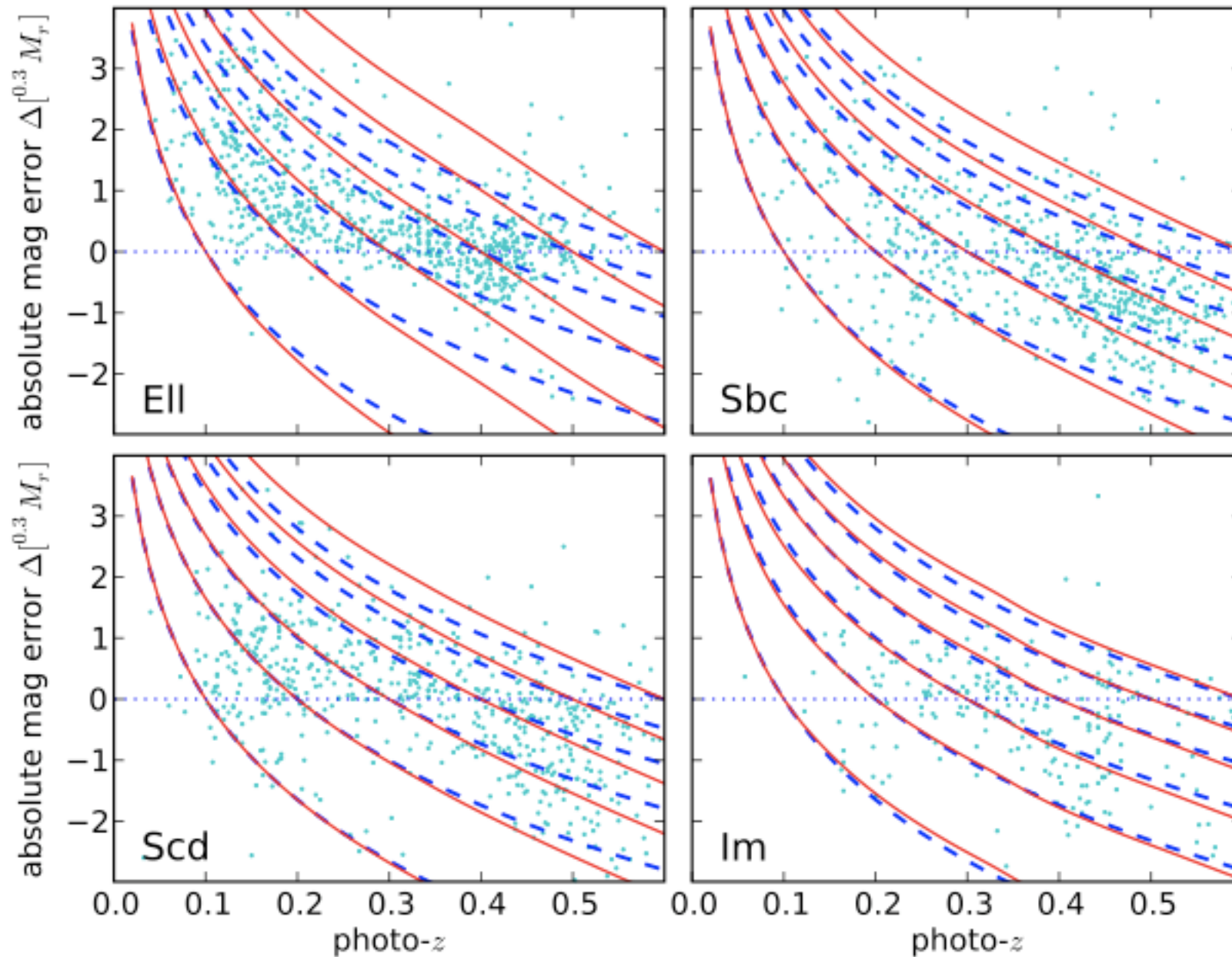
- redshift (photo-z)
- SED type
- absolute magnitude
- stellar mass

Photometric redshifts with SDSS



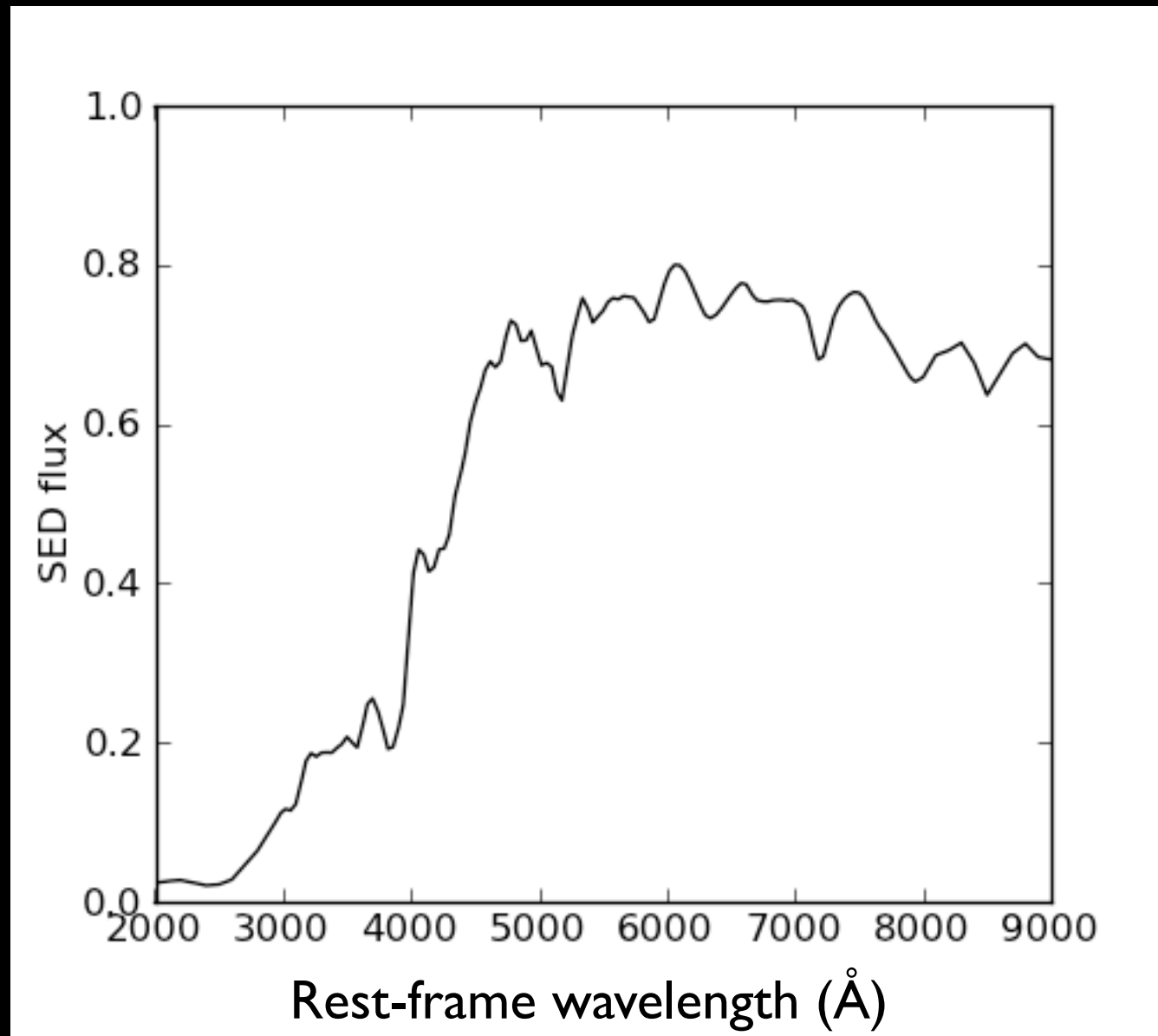
➔ remove
SB3, SB2

Absolute magnitude error



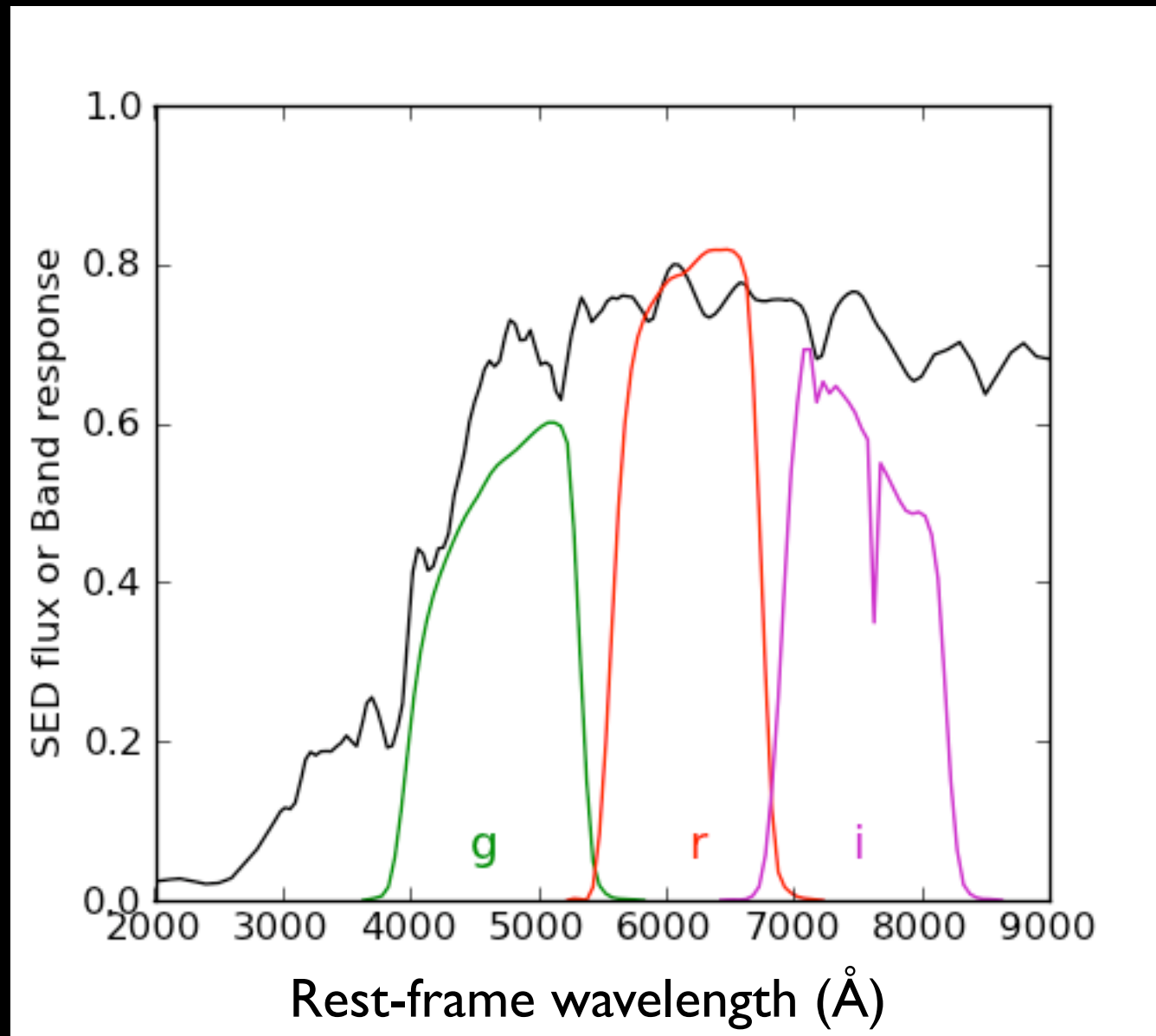
- **theoretical curve**
 - ▶ distance modulus
 - ▶ k-correction
- **z_{phot} distribution**

k-correction



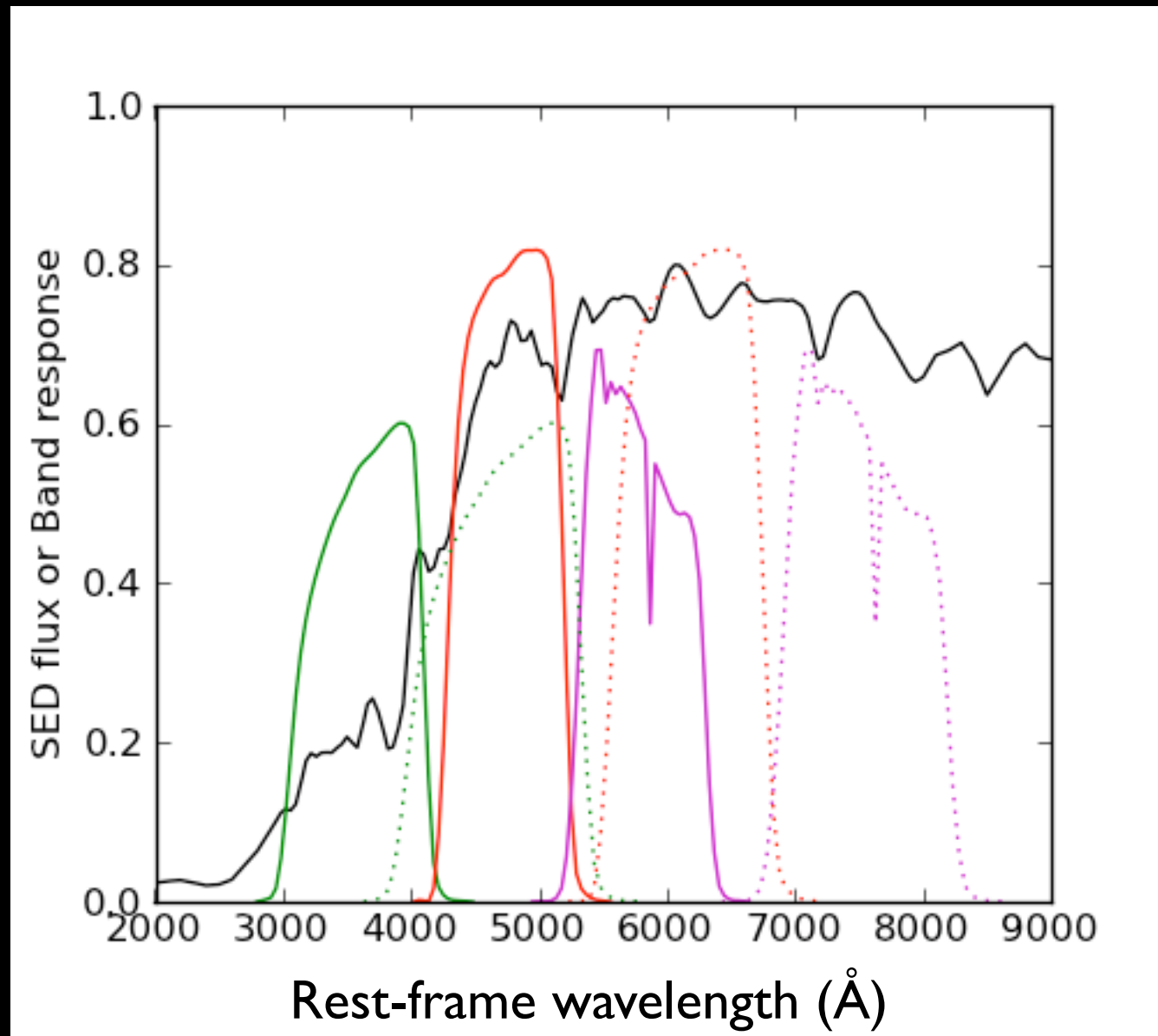
- EII-type SED ($z=0$)

k-correction



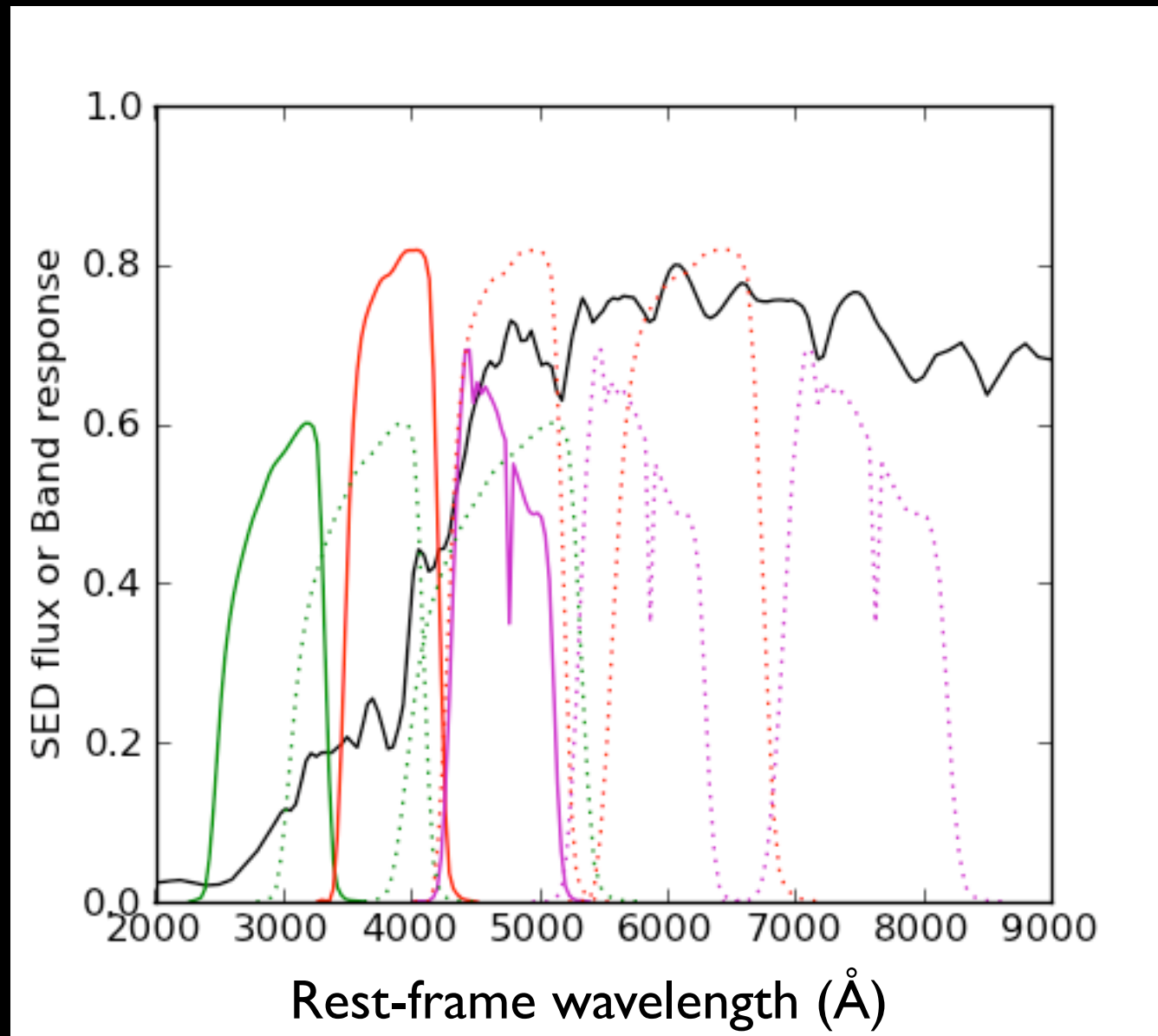
- E1-type SED ($z=0$)
- SDSS bands (observed from $z=0$)

k-correction



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

k-correction

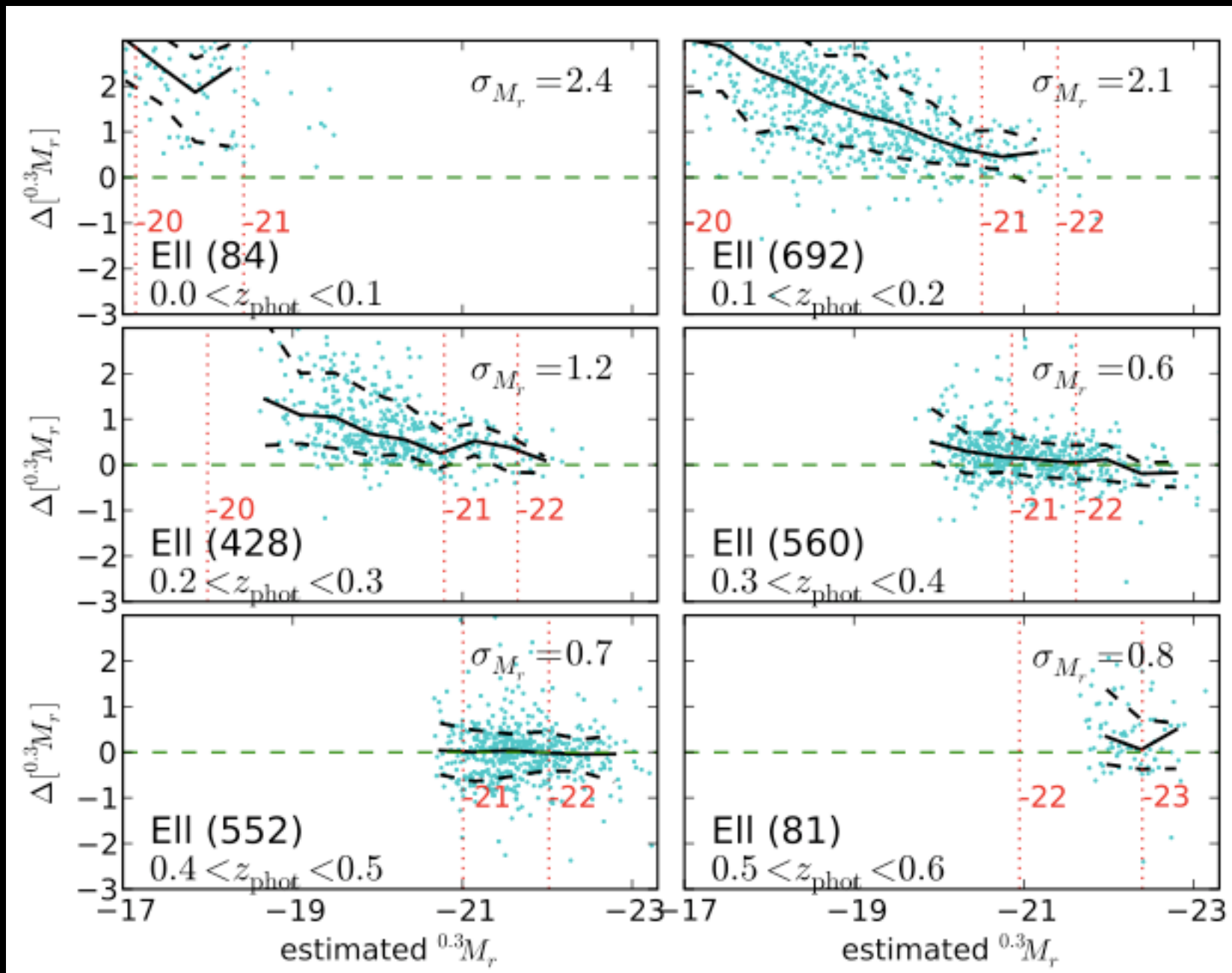


- E1-type SED ($z=0.6$)
- SDSS bands
(observed from $z=0$)

Absolute magnitude

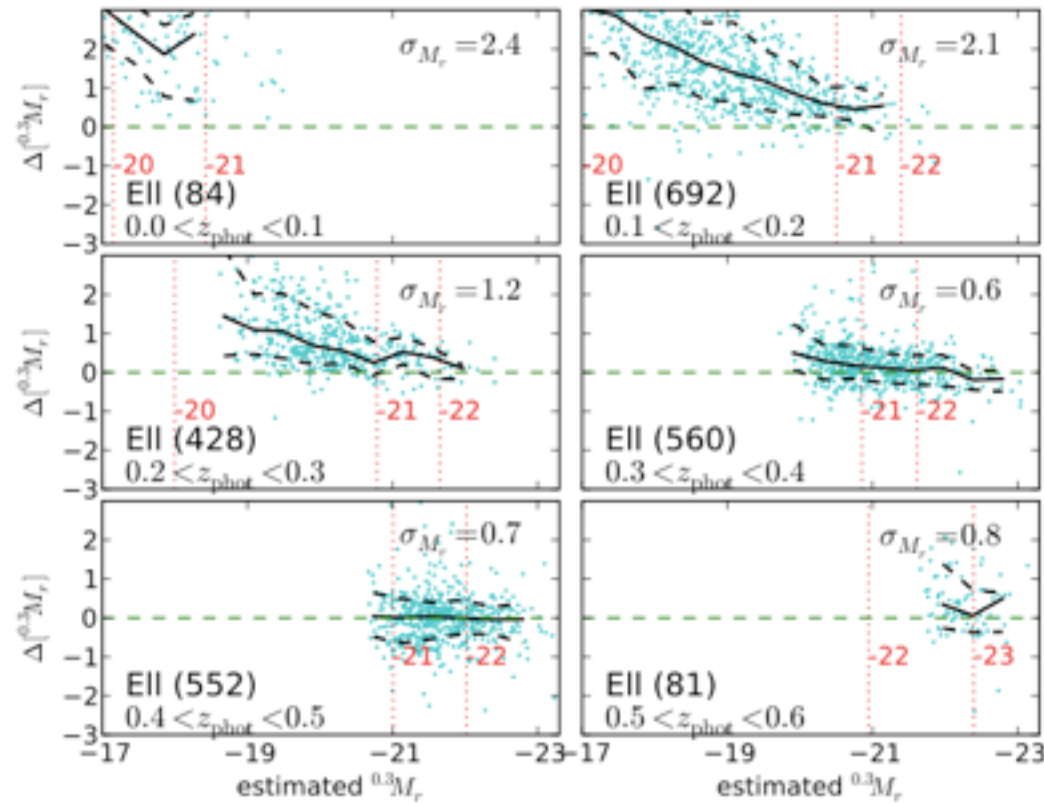
Elliptical SED type:

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

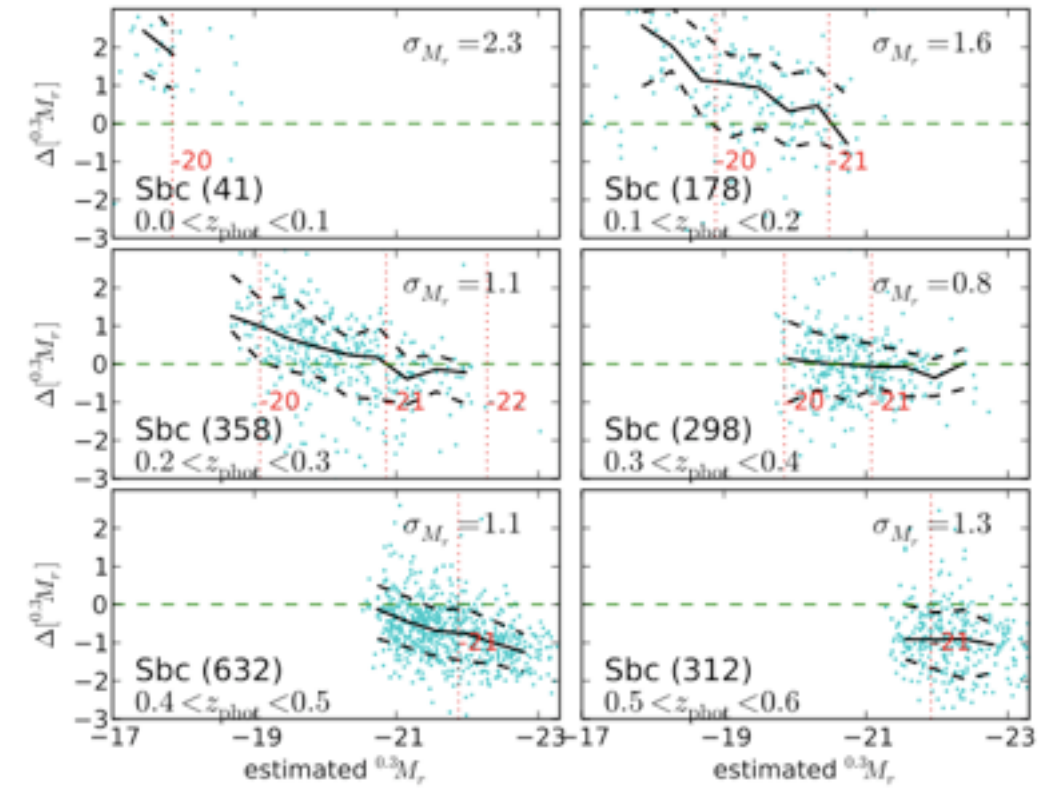


Absolute magnitude estimates: bias and scatter

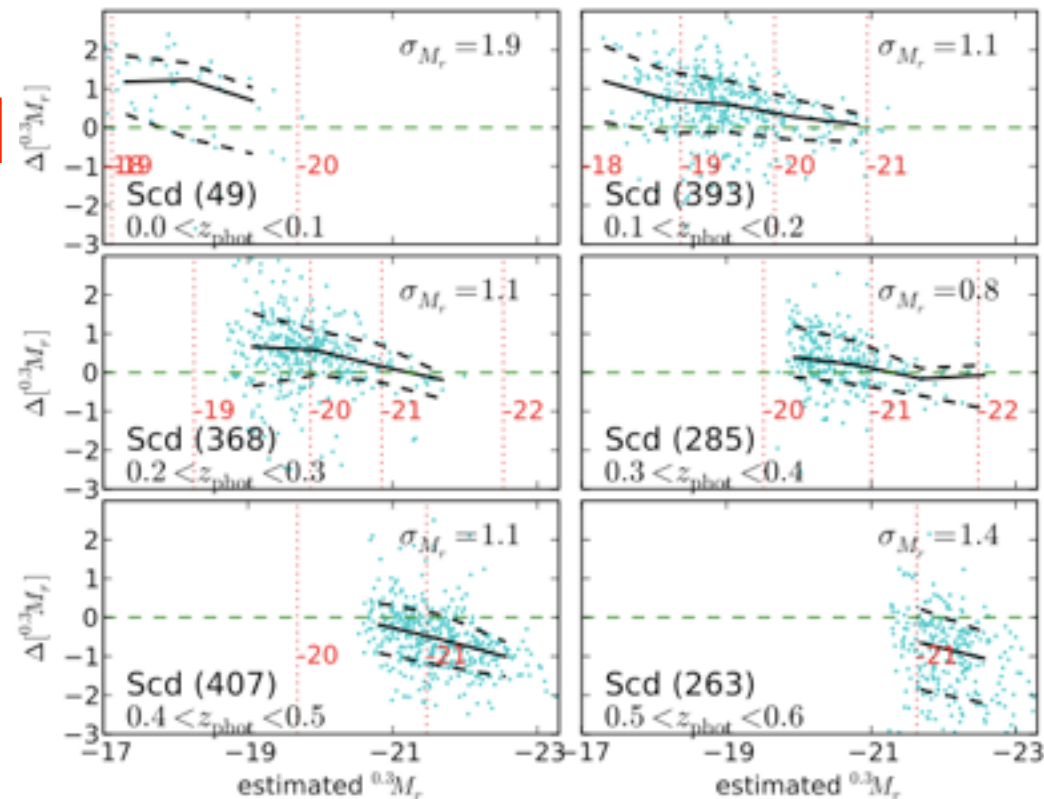
EII



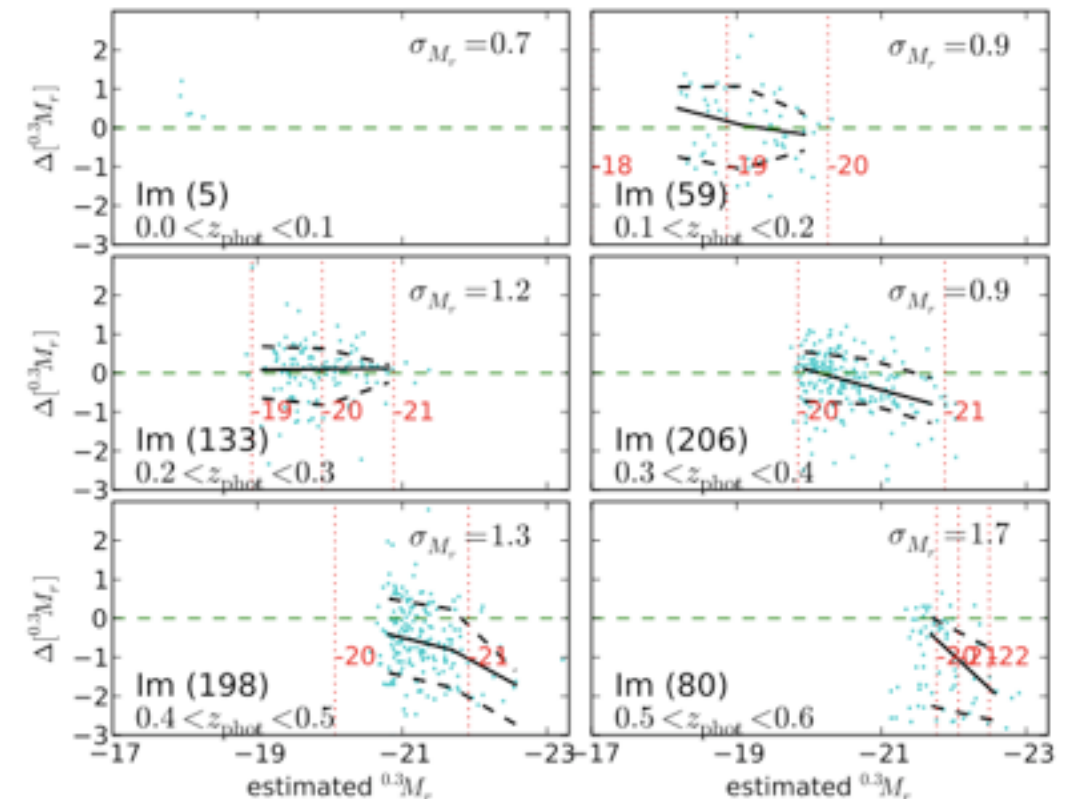
Sbc



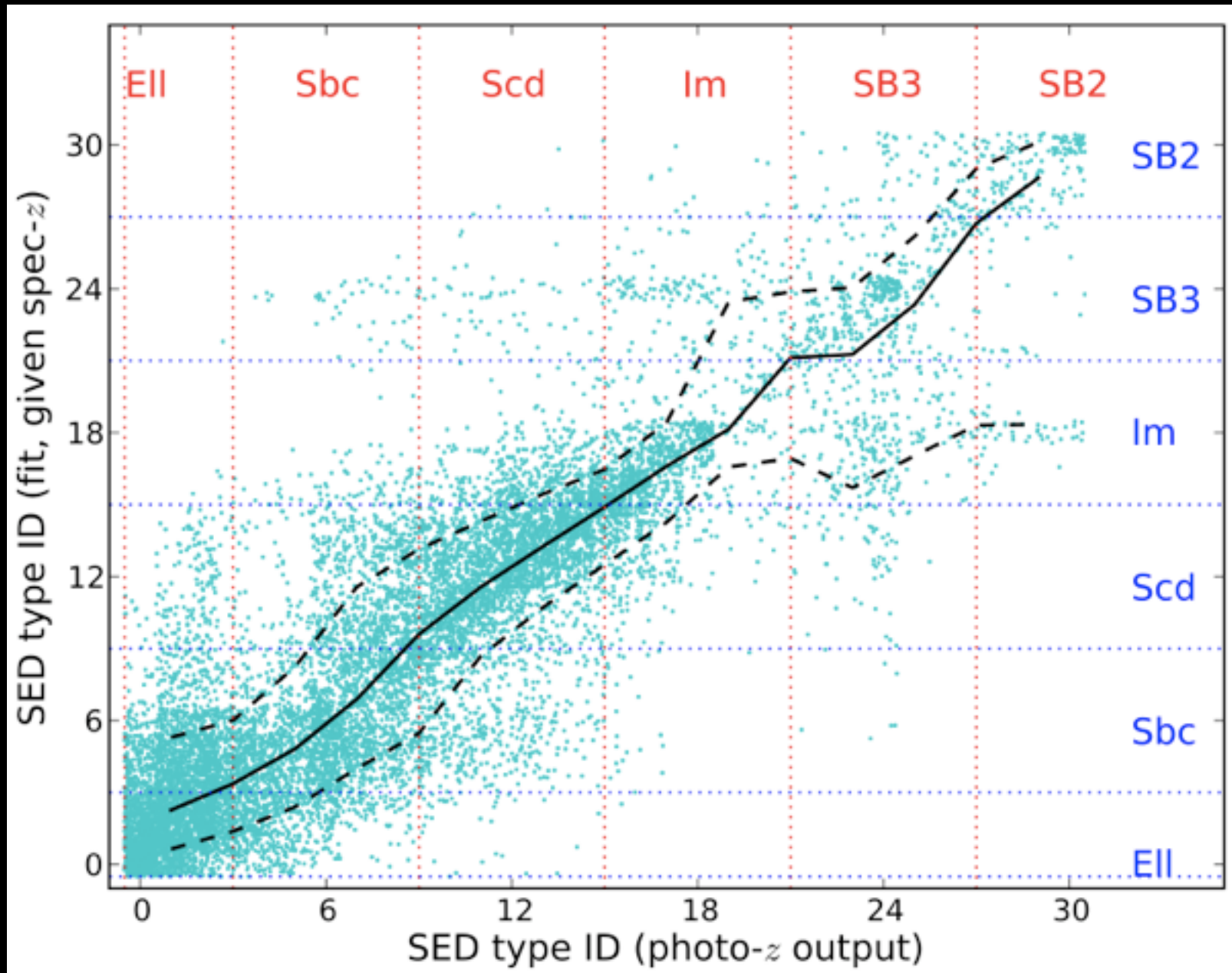
Scd



Im



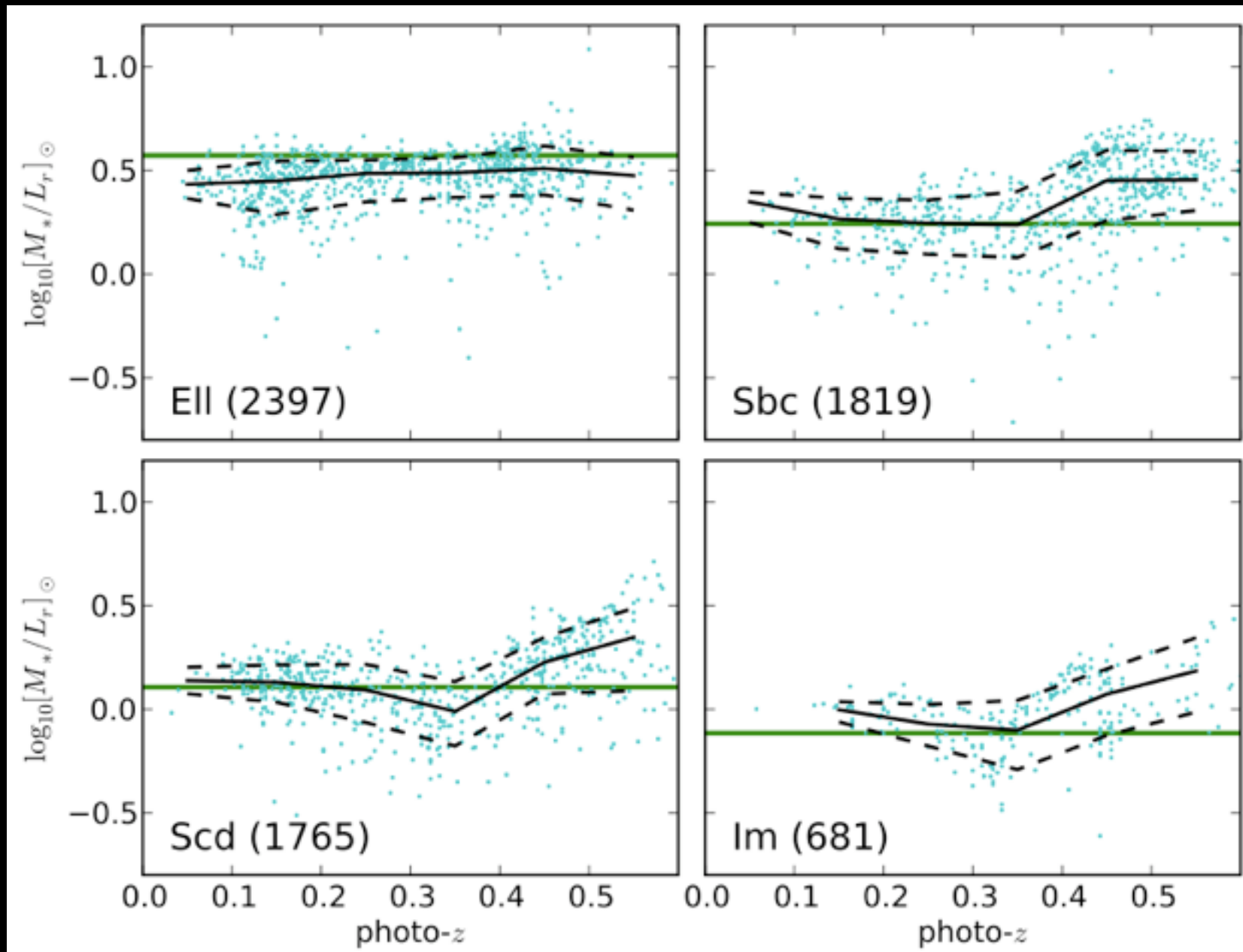
Error in SED template types



- 6 SED types
 - 5 interpolated SEDs in between each
- ➔ SED type bin need no modification

Stellar mass-to-light ratio

Bell & De Jong (2003)

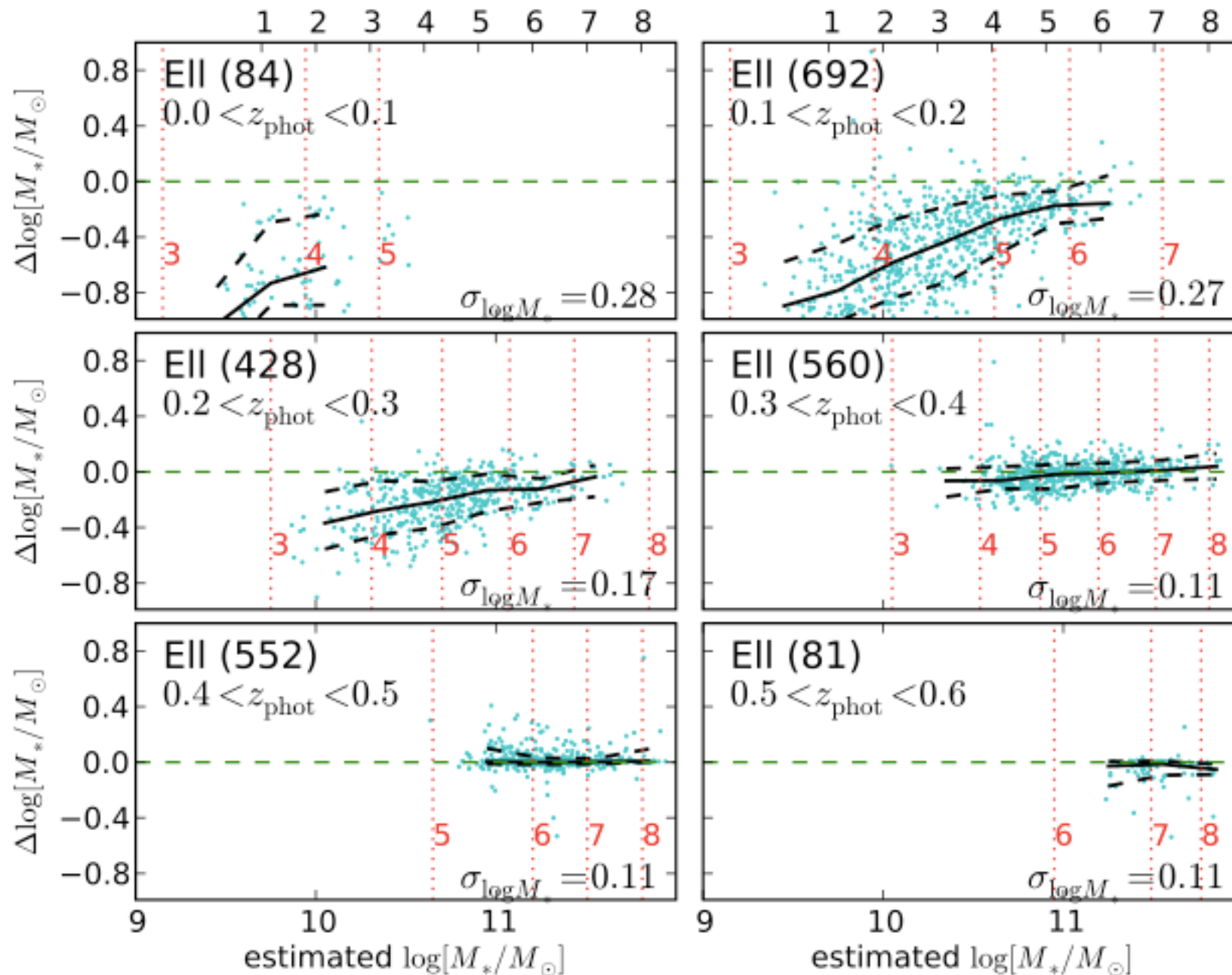


- estimate M_*/L from $z=0$ color
- **constant** for each SED type

Stellar mass estimates

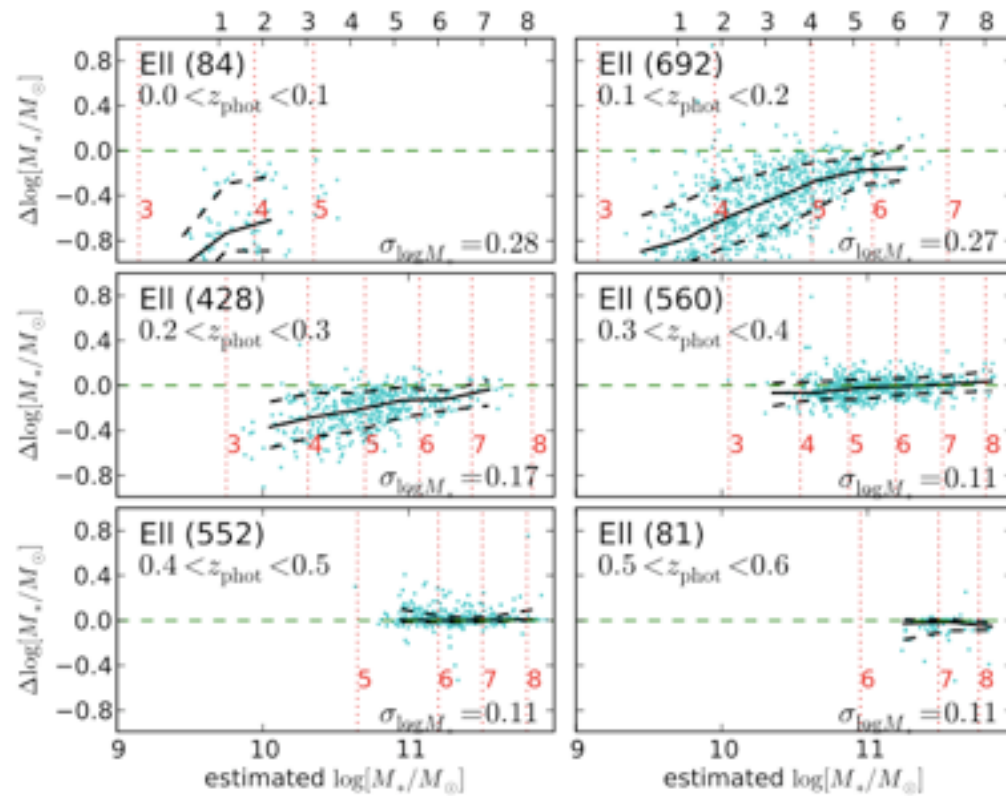
Elliptical SED type:

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

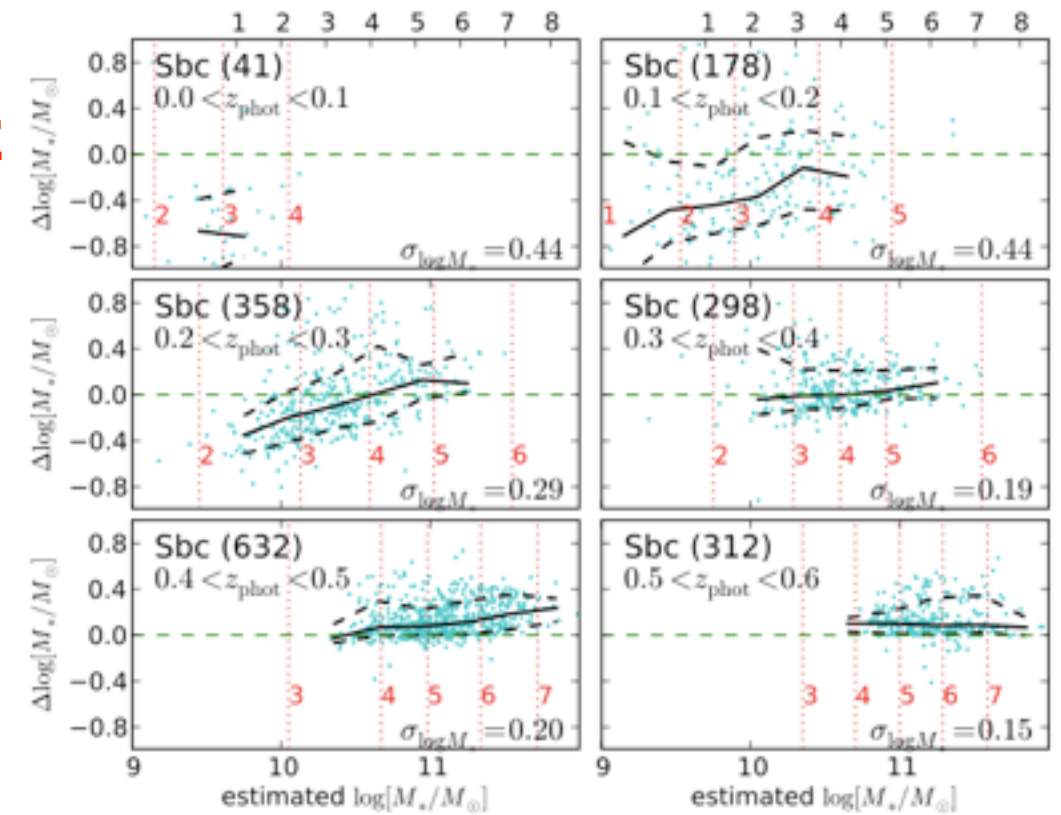


Stellar mass estimates: bias and scatter

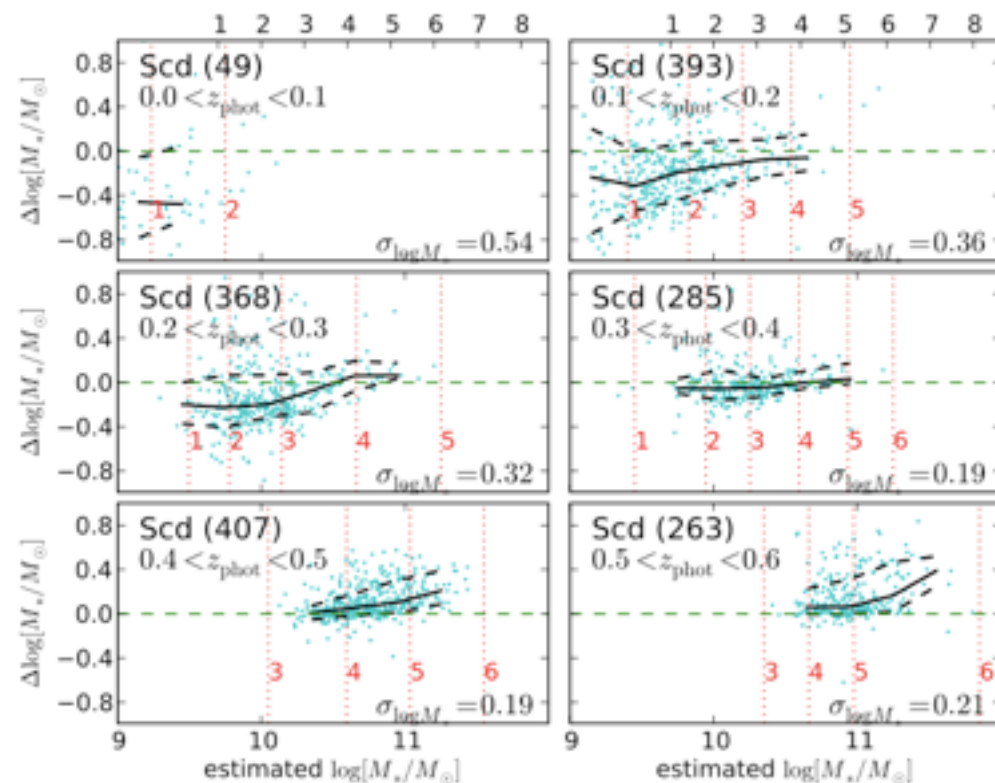
EII



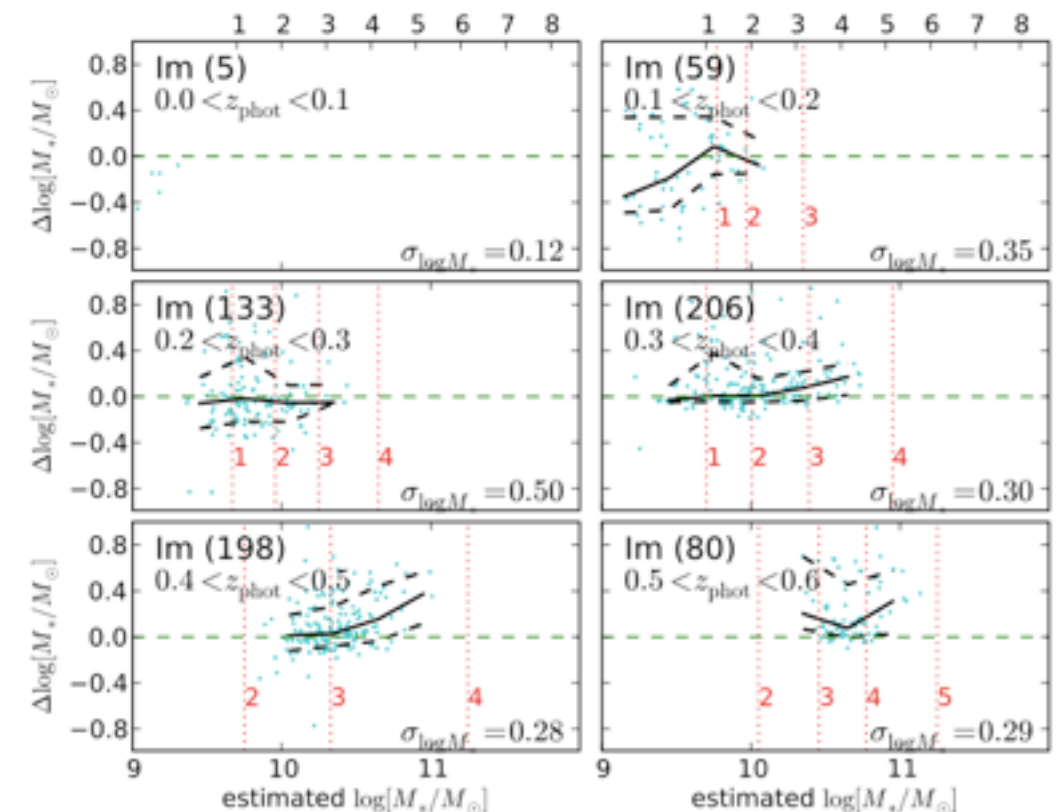
Sbc



Scd

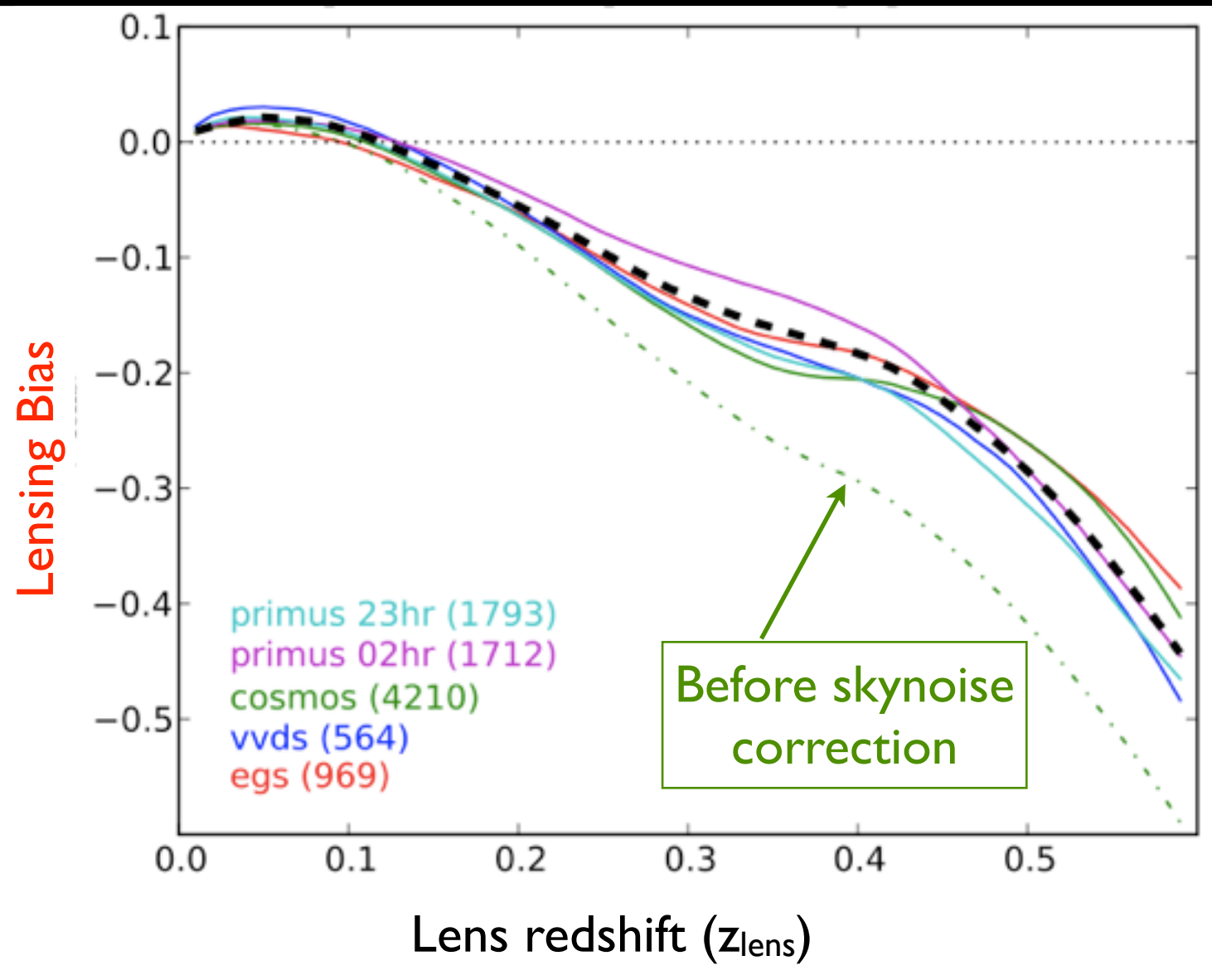


Im



Lensing bias: source photo-z

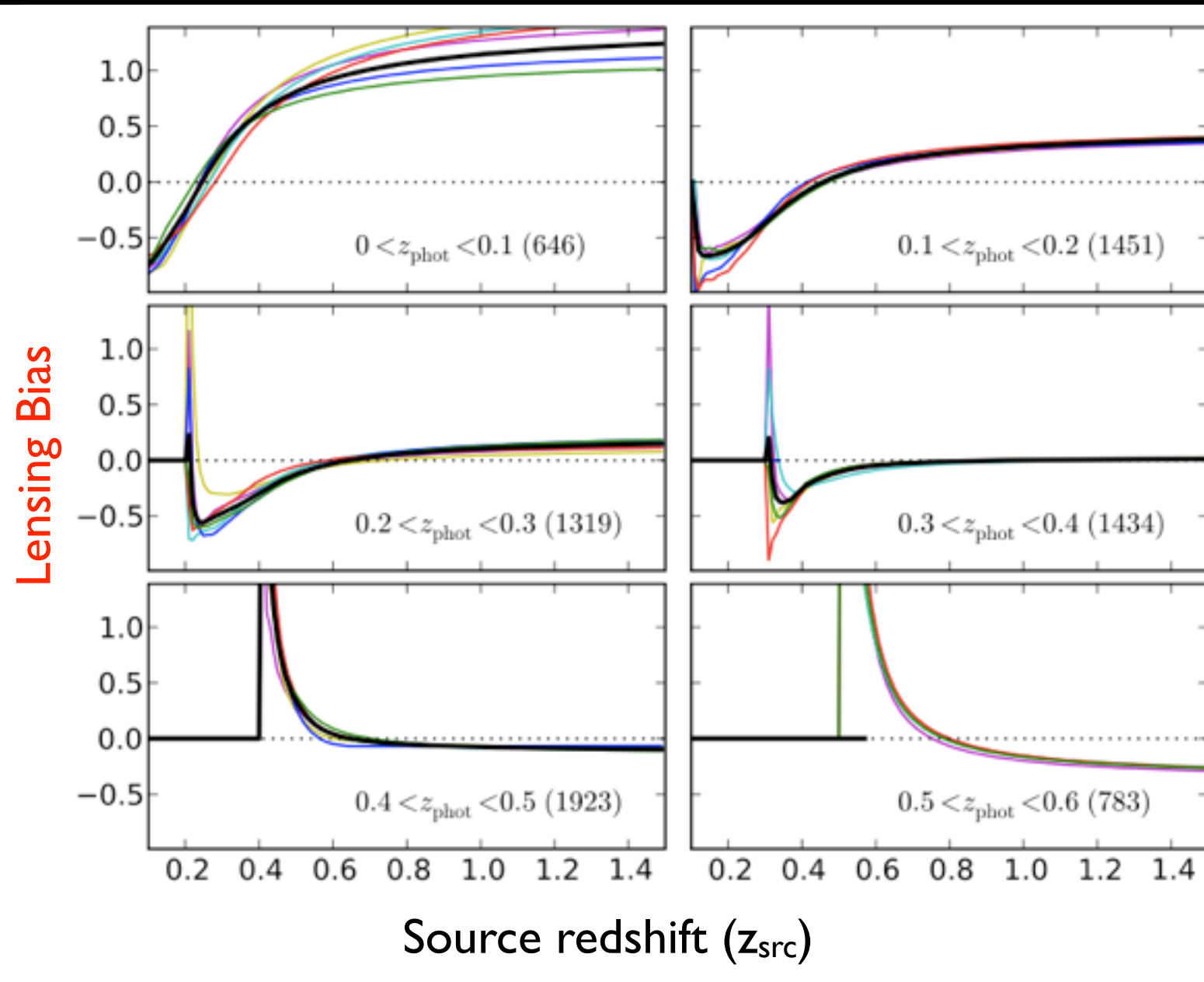
Known lens redshift:



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

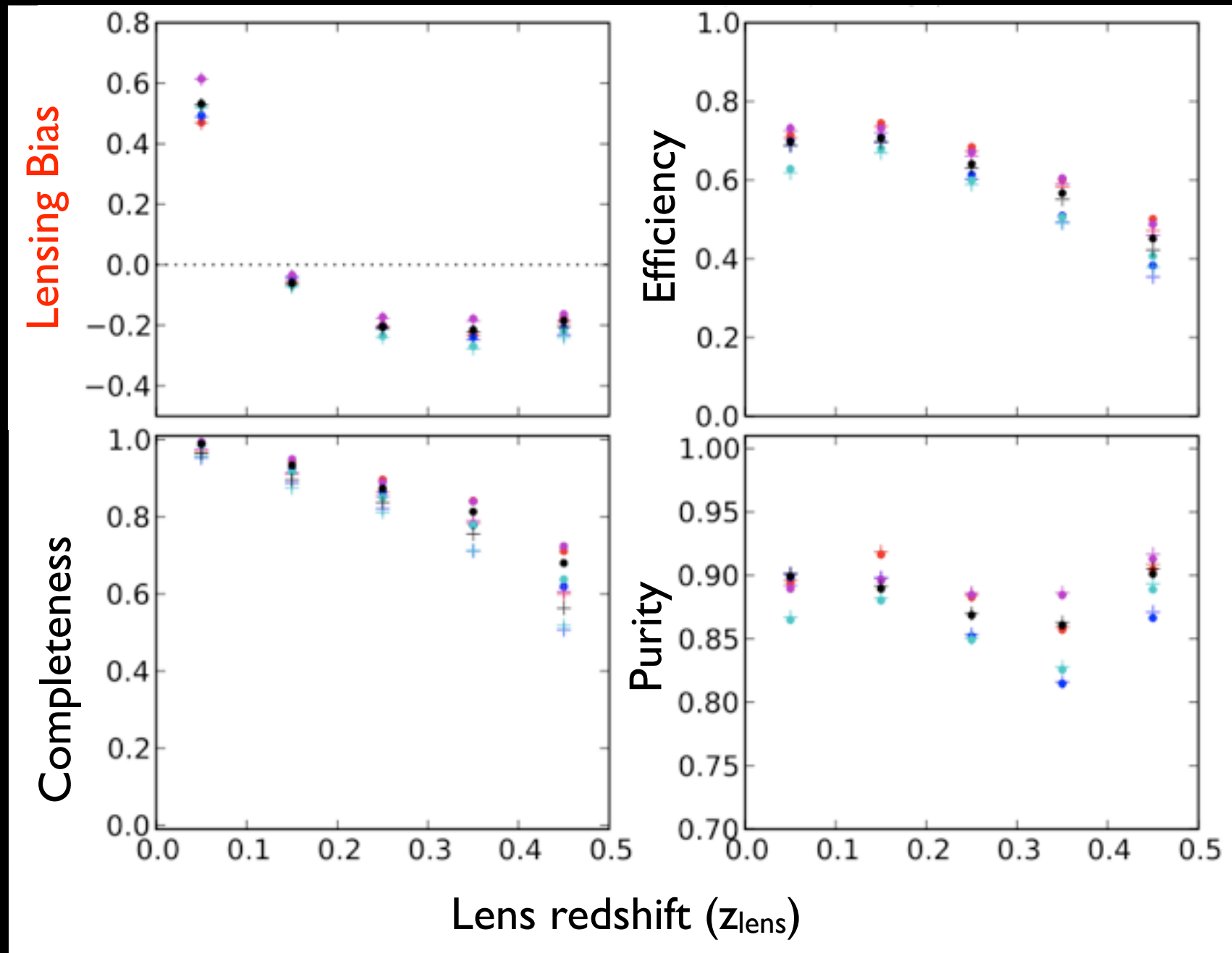
Lensing bias: lens photo-z

Known source redshift:



- bias for each z_{phot} bin
- ➔ discard $z_{\text{phot}} < 0.1$ 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