DARK ENERGY SURVEY

Narrow/Wide Band Imaging & Photo-z's: some ongoing studies

Huan Lin,

Fermilab,

Cosmic Visions Meeting

LBL, Nov. 14, 2017

(presented by Josh Frieman)

DARK ENERGY SURVEY

Photo-z Context

- Imaging surveys need precise sample redshift distributions $n_i(z)$ for cosmological inference.
- Spectroscopic samples for photo-z training/validation for LSST and other deep imaging surveys are incomplete.
- Clustering redshifts (cross-correlation) promising but may also have limitations→ hybrid approach.
- Deep, multi-band imaging samples with more accurate photo-z's another potential weapon in the arsenal.
  - DES Y1 n(z) results combined photo-z (for binning), COSMOS 30-band imaging, clustering redshifts via red(MaGIC) galaxies.
- Is there an economical way to get deep, multi-band imaging to LSST depth over large enough area (cosmic variance) to be useful in this context? What's needed? Options: more filters, mKiDS,...

COSMOS2015 (Laigle et al. 2016) 30 bands

DARK ENERGY SURVEY

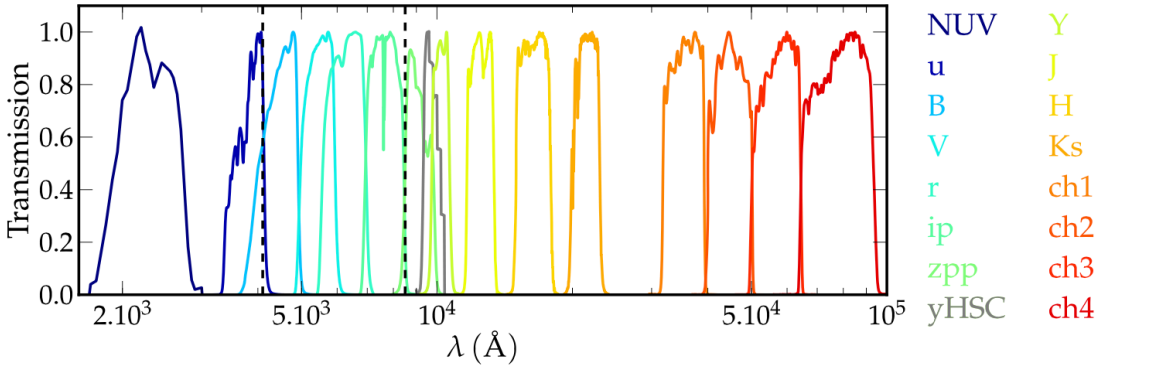


Figure 2. Transmission curves for the photometric bands used. The effect of atmosphere, telescope, camera optics, filter, and detector are included. Note that for clarity the profiles are normalized to a maximum throughput of one; therefore, the relative efficiencies of each telescope and detector system are *not* shown. Intermediate and narrow bands are not represented, but the region of the spectrum covered by these bands is marked by dashed lines.

16 broadband filters (Laigle et al. 2016)

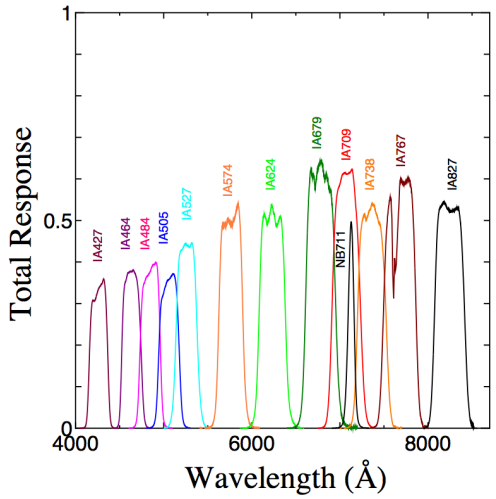


Fig. 2. Filter response curves at the center of the filter, including effects of the CCD sensitivity, the atmospheric transmission, and the transmission of the telescope and the instrument.

12 medium + 2 narrowband filters (Taniguchi et al. 2014)

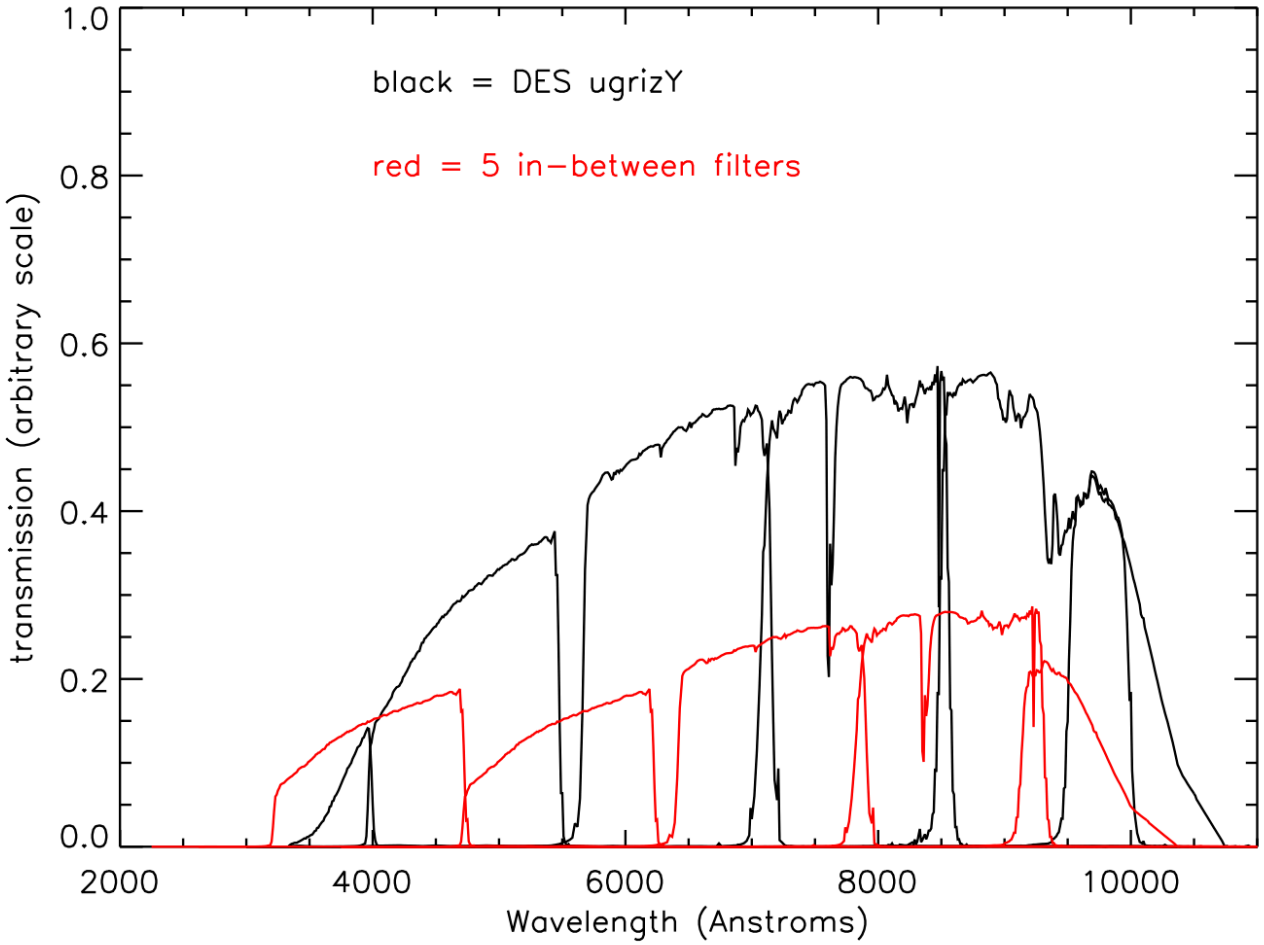
DARK ENERGY SURVEY

Photo-z results for different samples

Sample	σ_{68}
• COSMOS all filters, Laigle et al. (2016) catalog (zCOSMOS, Le PHARE)	0.013
• (cf. $\sigma_{68} / (1+z_s) = 0.0087$ and NMAD = $1.48 \times \text{median}(\lvert z_p - z_s \rvert / (1+z_s)) = 0.0075$)	
• HL: COSMOS 10 broad + 14 medium/narrow (zCOSMOS, Le PHARE)	0.016
• ➔ *Can reasonably reproduce published catalog results*	
• HL: COSMOS 10 broadband filters (zCOSMOS, Le PHARE)	0.040
• ➔ *Medium-band filters appear critical for optimal photo-z's*	
• HL: COSMOS 10 broadband filters (i < 23, DESDM)	0.045
• ➔ *DESDM neural network results close to Le PHARE broadband results*	

DARK ENERGY SURVEY

Example: ugrizY and 5 “in-between” filters



DARK ENERGY SURVEY

Photo-z results for different samples

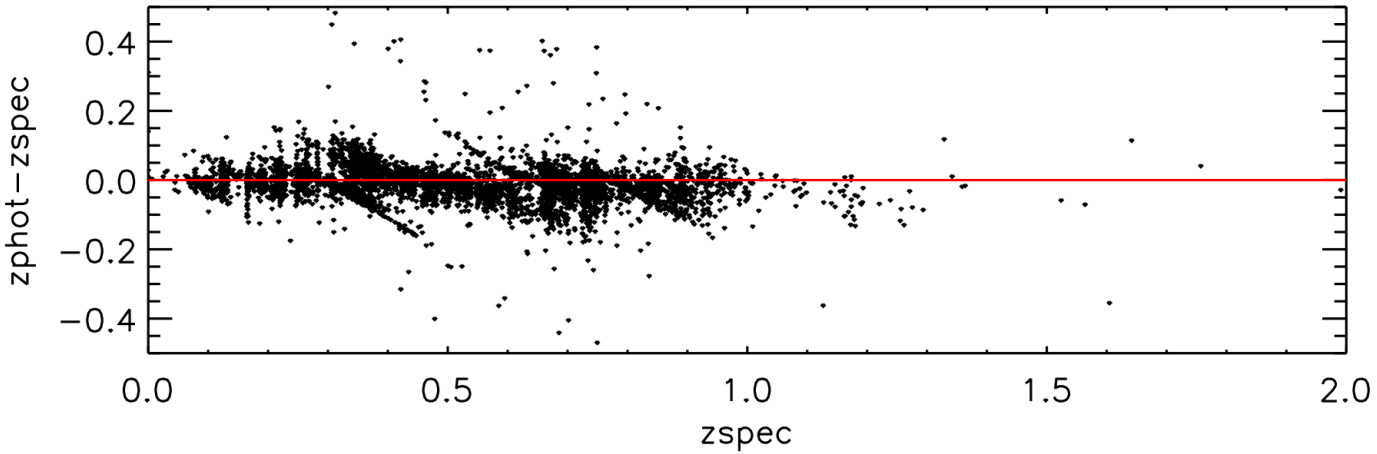
Sample	σ_{68}
• COSMOS all filters, Laigle et al. (2016) catalog (zCOSMOS, Le PHARE)	0.013
• COSMOS 10 broad + 14 medium/narrow (zCOSMOS, Le PHARE)	0.016
• COSMOS 10 broadband filters (zCOSMOS, Le PHARE)	0.040
• COSMOS 10 broadband filters (i < 23, DESDM)	0.045
Simulations (DESDM)	
• griz (i < 23.5, redshift z < 2; 1 hr on DECam)	0.072
• ugrizY (i < 23.5, redshift z < 2; 2 hr on DECam)	0.041
• ugrizY + 5 in-between filters (i < 23.5, redshift z < 2; 1 hr)	0.039
• ugrizY (i < 24.5, redshift z < 2; 10 hr)	0.050
• ugrizY + 5 in-between filters (i < 24.5, redshift z < 2; 5 hr)	0.049
• DES ugrizY + 5 in-between filters (i < 25.5, redshift z < 2, 10 hr)	0.077

DARK ENERGY SURVEY

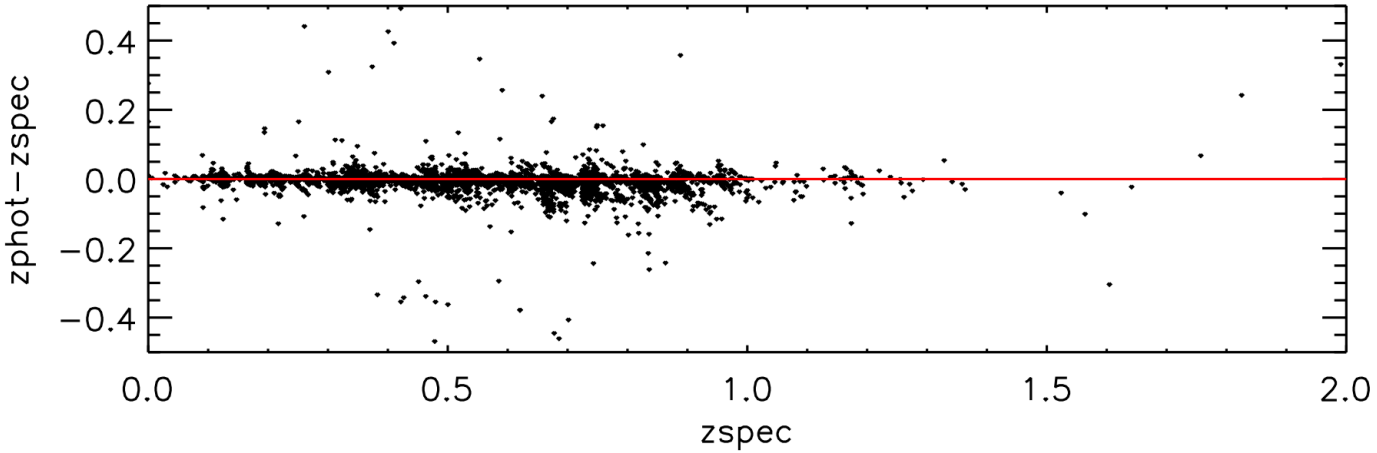
Conclusions

- Adopt σ_{68} ~ 0.05, the level of COSMOS broadband-only filters, as what we want in order for the data to be useful for photo-z validation
- Results for ugrizY + 5 in-between filters is similar to ugrizY at twice the exposure time (note griz only, as shown previously, is not as good as ugrizY)
  - Using ugrizY at double the exposure time cheaper than new fill-in broadband filters, with similar gain.
- Interesting DECam scenarios to me (HL) are:
  - 100 sq. deg. for i < 23.5 (useful for DES), at 2 hrs per filter, taking 100/3*12/8 = 50 nights (assuming 8 hrs/night)
  - 30 sq. deg for i < 24.5 (useful for LSST), at 10 hrs per filter, taking 30/3*60/8 = 75 nights
- For comparison, LSST main survey in i band is equivalent to about 4 hours exposure on Blanco/DECam.
- Could also explore PAU/JPAS-like approach with multiple narrow filters.

COSMOS: with and without medium/narrow bands

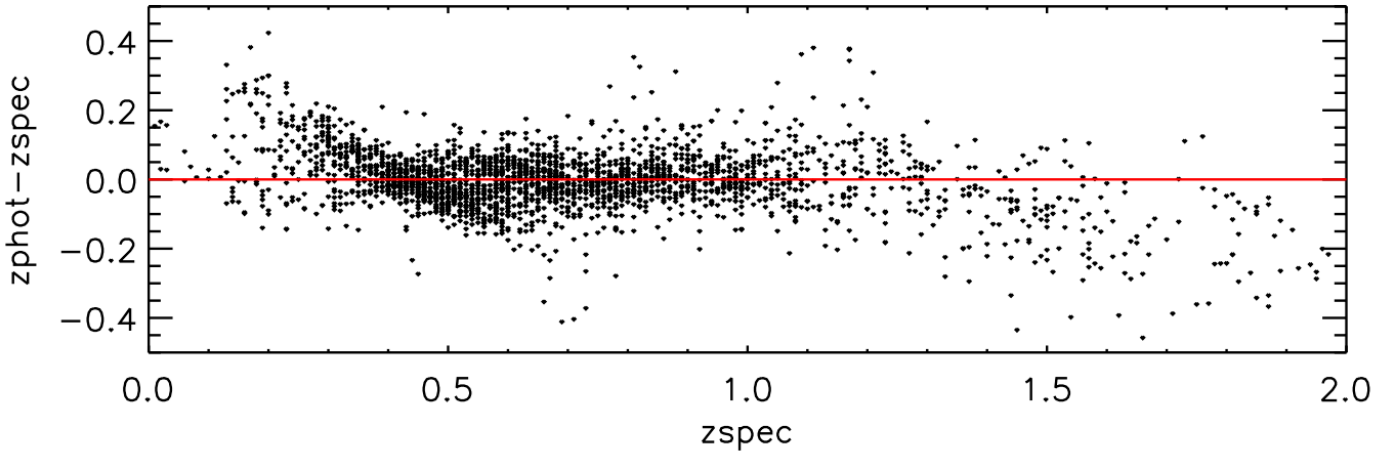


COSMOS
10 broadband filters only (Le PHARE)
σ_{68} = 0.040

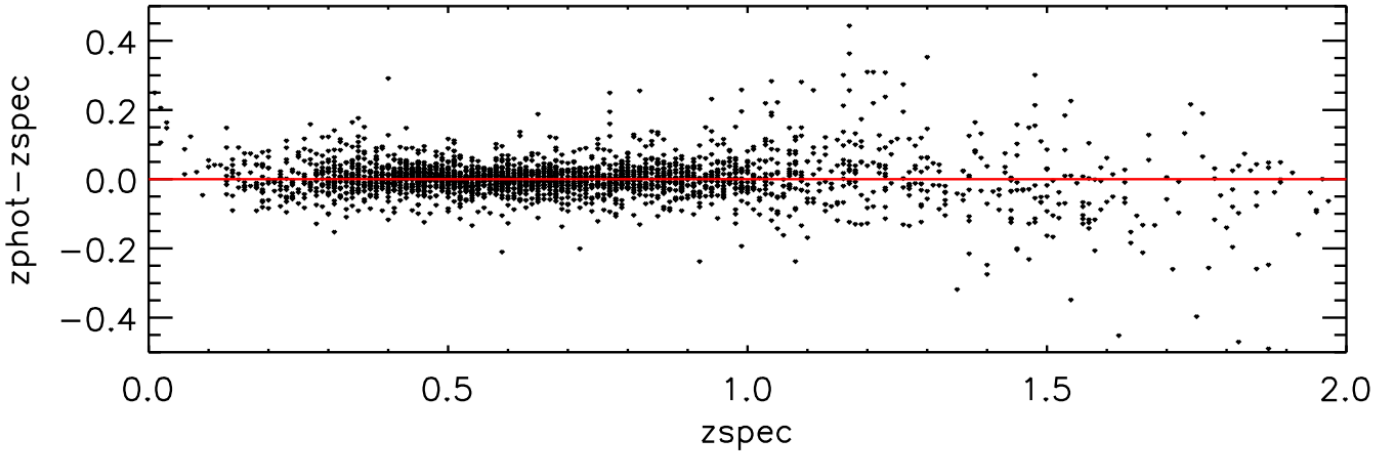


Published COSMOS
16 broadband filters plus 14 medium/ narrow bands (Le PHARE)
σ_{68} = 0.013

Simulated i < 23.5 and redshift z < 2 sample

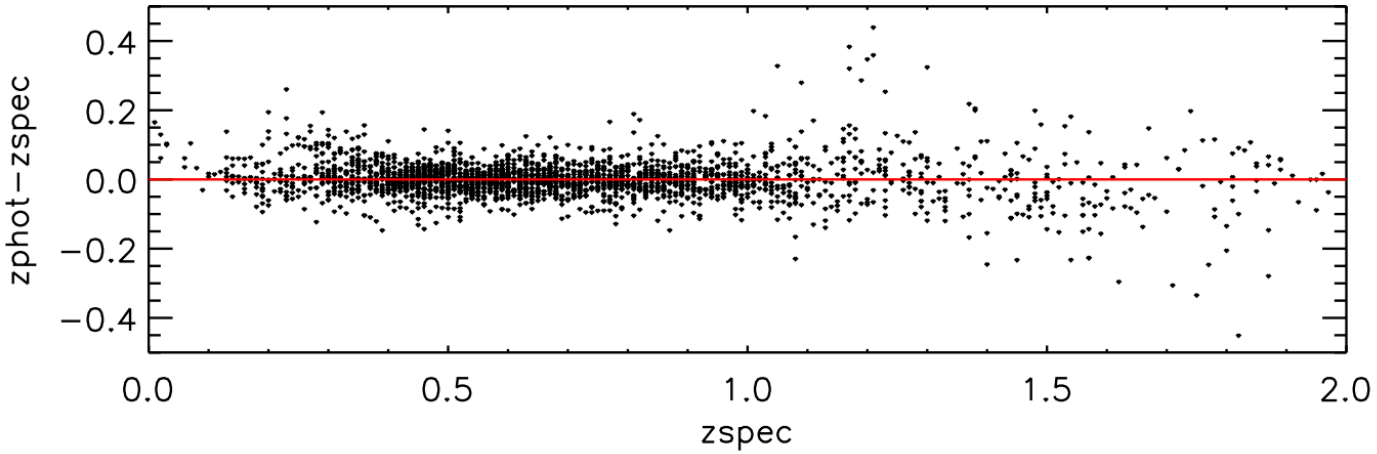


4 filters: griz
i < 23.5
(1 hr exposures)
$\sigma_{68} = 0.072$

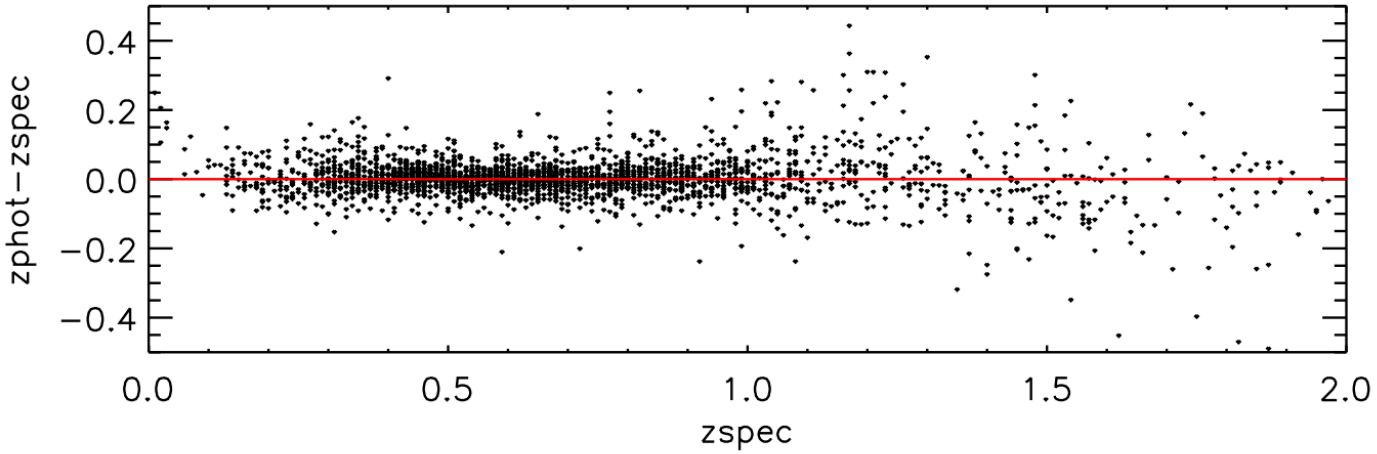


11 filters: ugrizY
+ 5 in-between
filters, i < 23.5
(1 hr exposures)
$\sigma_{68} = 0.039$

Simulated i < 23.5 and redshift z < 2 sample

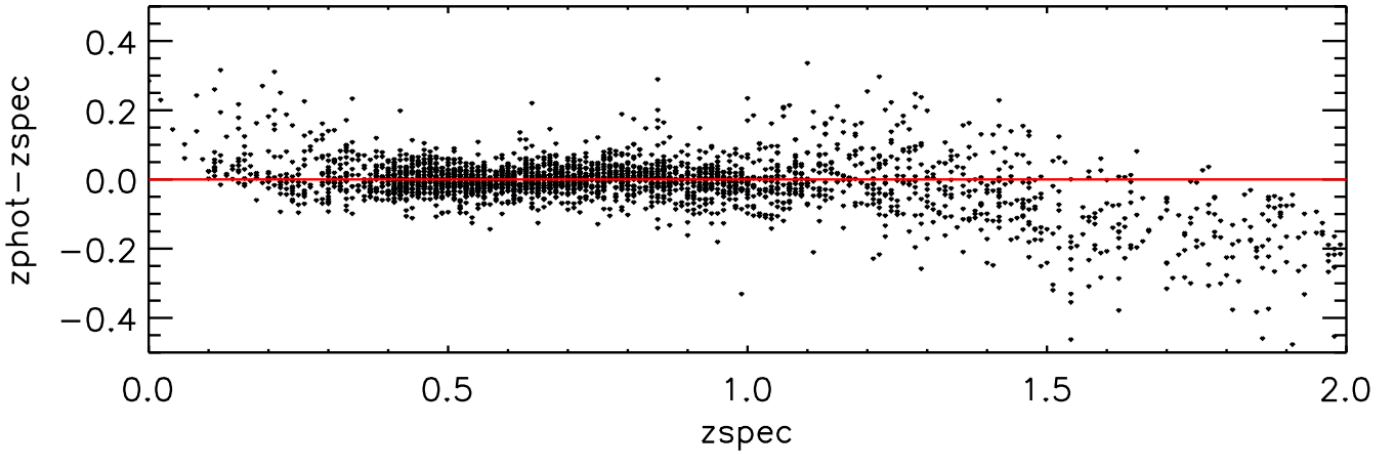


6 filters: ugrizY
i < 23.5
(2 hr exposures)
σ_{68} = 0.041

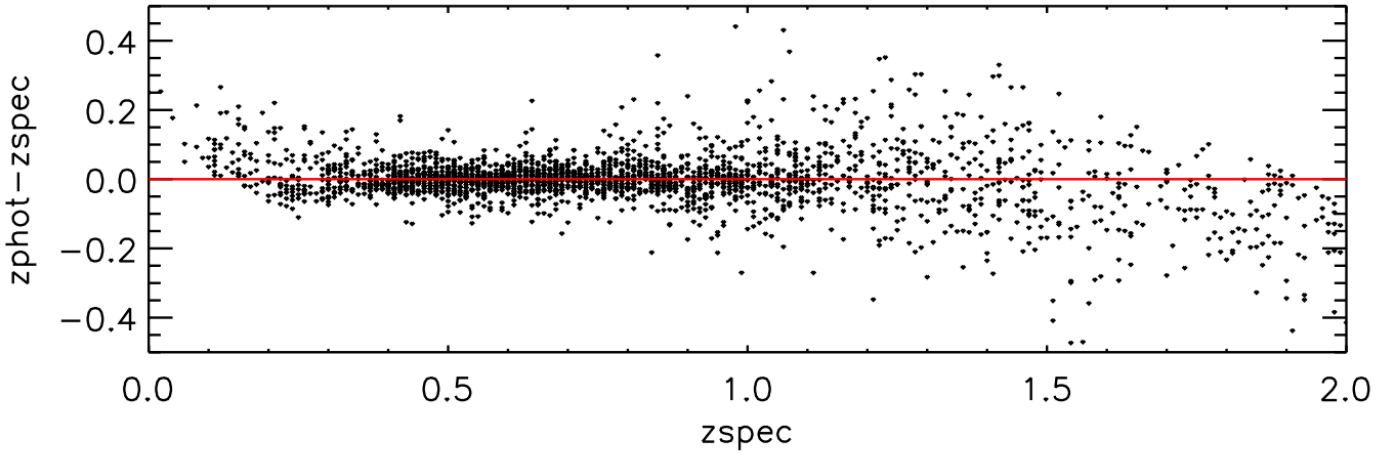


11 filters: ugrizY
+ 5 in-between
filters, i < 23.5
(1 hr exposures)
σ_{68} = 0.039

Simulated i < 24.5 and redshift z < 2 samples

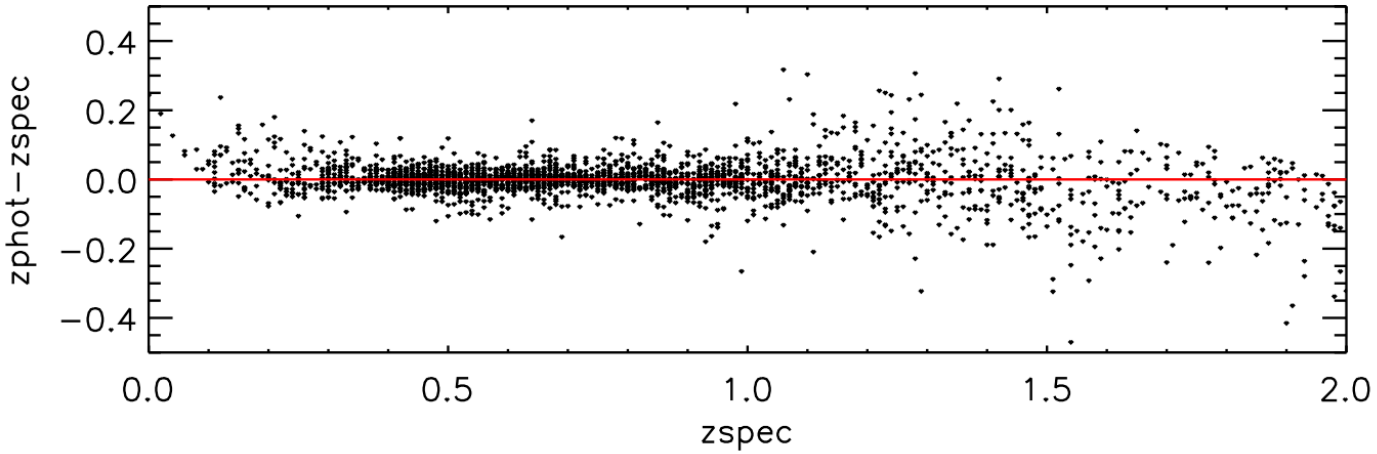


6 filters: ugrizY
i < 24.5
(10 hr exposures)
σ_{68} = 0.050

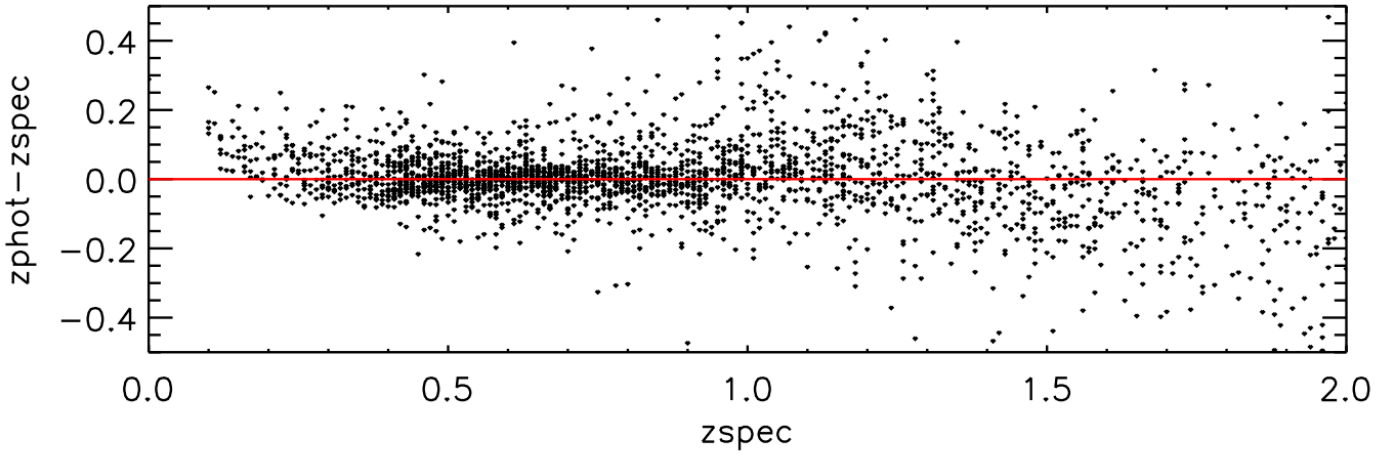


11 filters: ugrizY
+ 5 in-between
filters, i < 24.5
(5 hr exposures)
σ_{68} = 0.049

Simulated i < 24.5/25.5 and redshift z < 2 samples



11 filters: ugrizY + 5 in-between filters, i < 24.5 (10 hr exposures)
σ_{68} = 0.036



11 filters: ugrizY + 5 in-between filters, i < 25.5 (10 hr exposures)
σ_{68} = 0.077