

SNAP Photometric Redshifts and Simulations

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Plan of the Talk

- Photometric Redshift technique- the SNAP code
- Accuracy of phot-z's compared to spec-z's
- Comparison between different phot-z techniques
- The simulated photometric catalog
- Phot-z simulations with SNAP filters
- Accuracy of the phot-z's
- Sensitivity to photometric errors
- Sensitivity to magnitude limits
- Advise for the choice of filters and wavelength coverage

The SNAP Phot-z Code

B. Mobasher & T. Dahlen

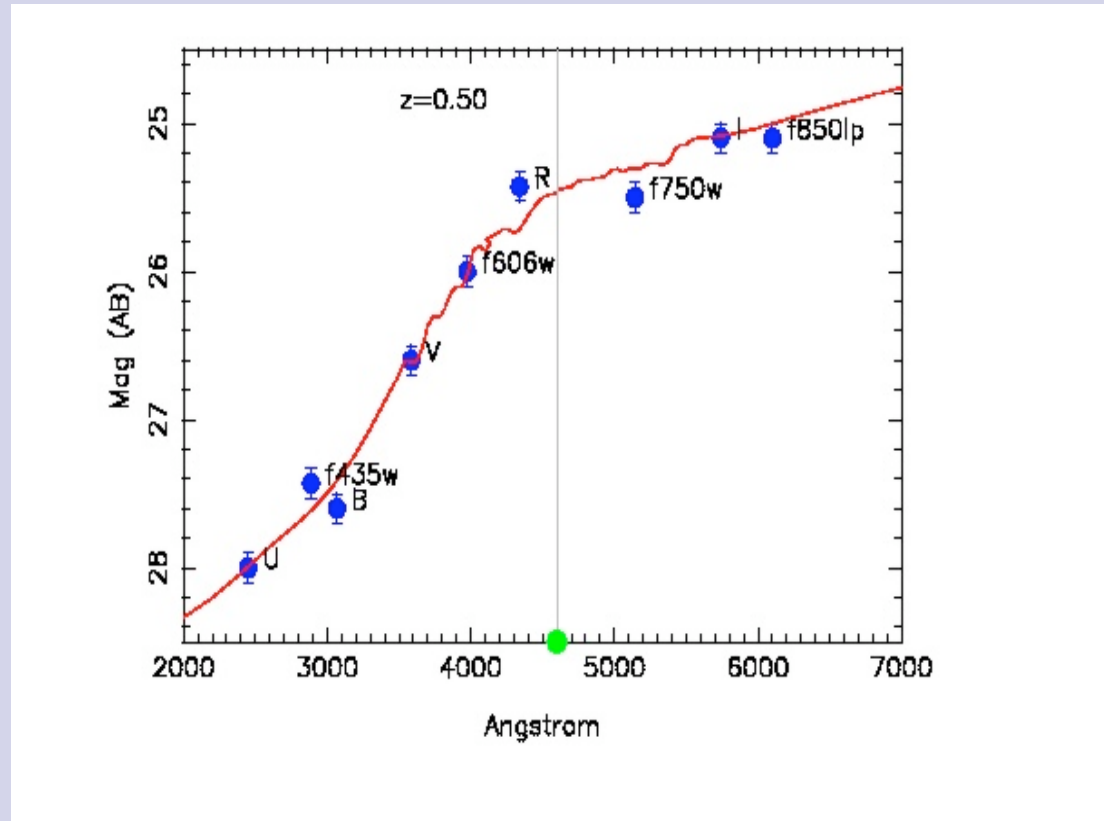
- six templates used
- Luminosity function used as prior
- Cosmic opacity from Madau et al.
- Extinction allowed as a free parameter, estimating $E(B-V)$ for each galaxy
- Interpolates the spectral types
- Easily extended to other bands (ie IRAC, GALEX etc)

Input: Galaxy magnitudes, magnitude errors, templates, filter response functions

Output: $z(\text{phot})$, spectral types, redshift probability distribution, conventional and prior-based redshifts, extinction

Rest-frame absolute magnitudes

$$M(B) = m + K\text{-correction} - \text{Distance modulus}(z)$$



Luminosity functions are calculated using

- * $1/V_{\text{max}}$ method**
- * Maximum likelihood method**

Traditionally (ideally):

each galaxy has one redshift

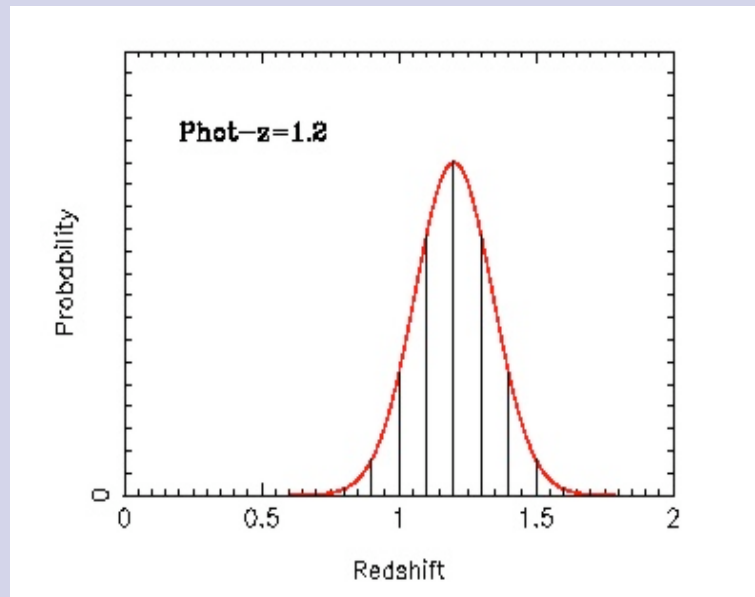
-> one absolute magnitude

-> one galaxy added to magnitude bin in LF

Using phot-z's:

Phot-z's have relatively large errors

Each galaxy is represented by a redshift distribution



1. Real Photometric Data with Spectroscopic Redshifts

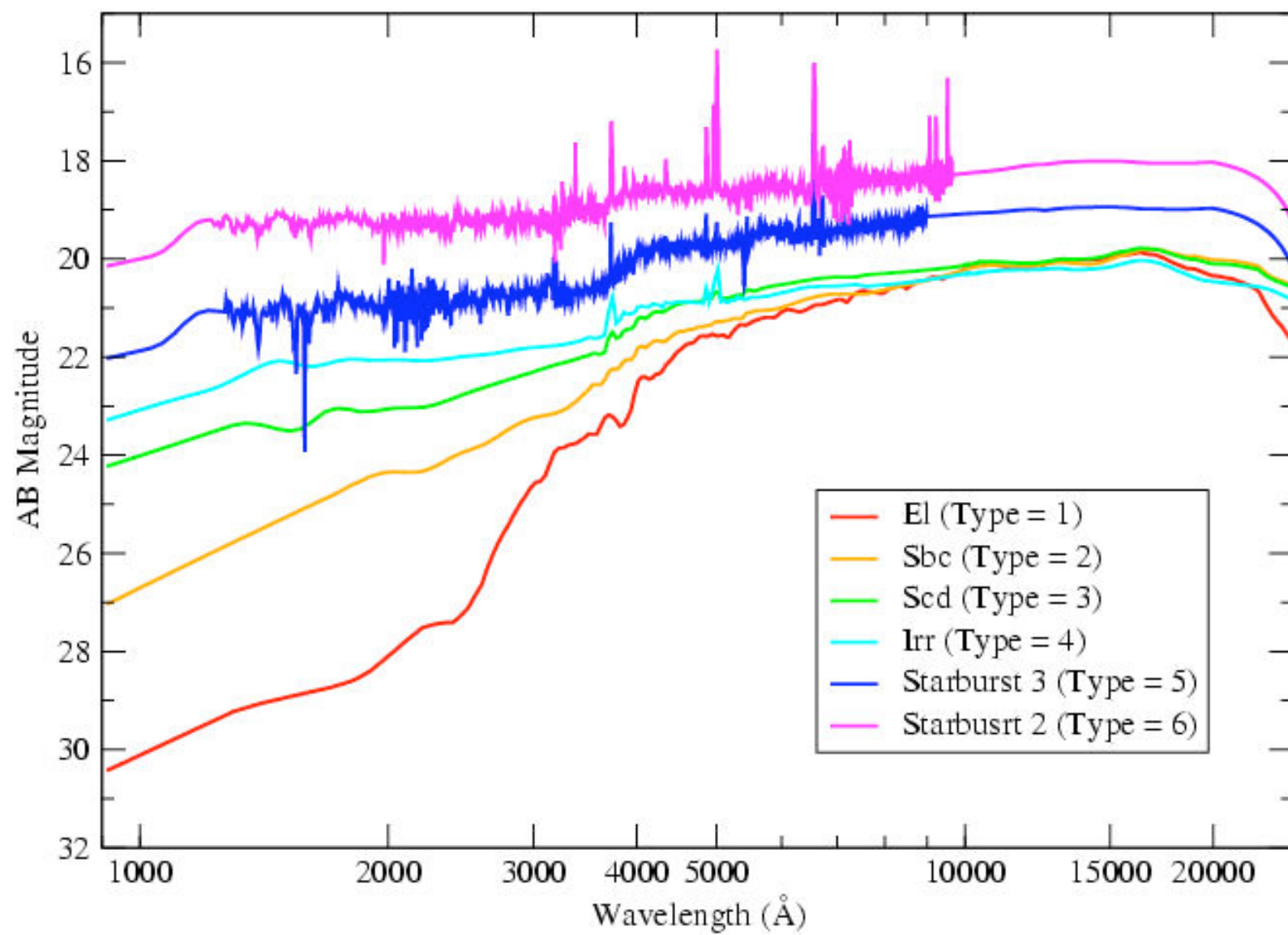
Photometric Catalog

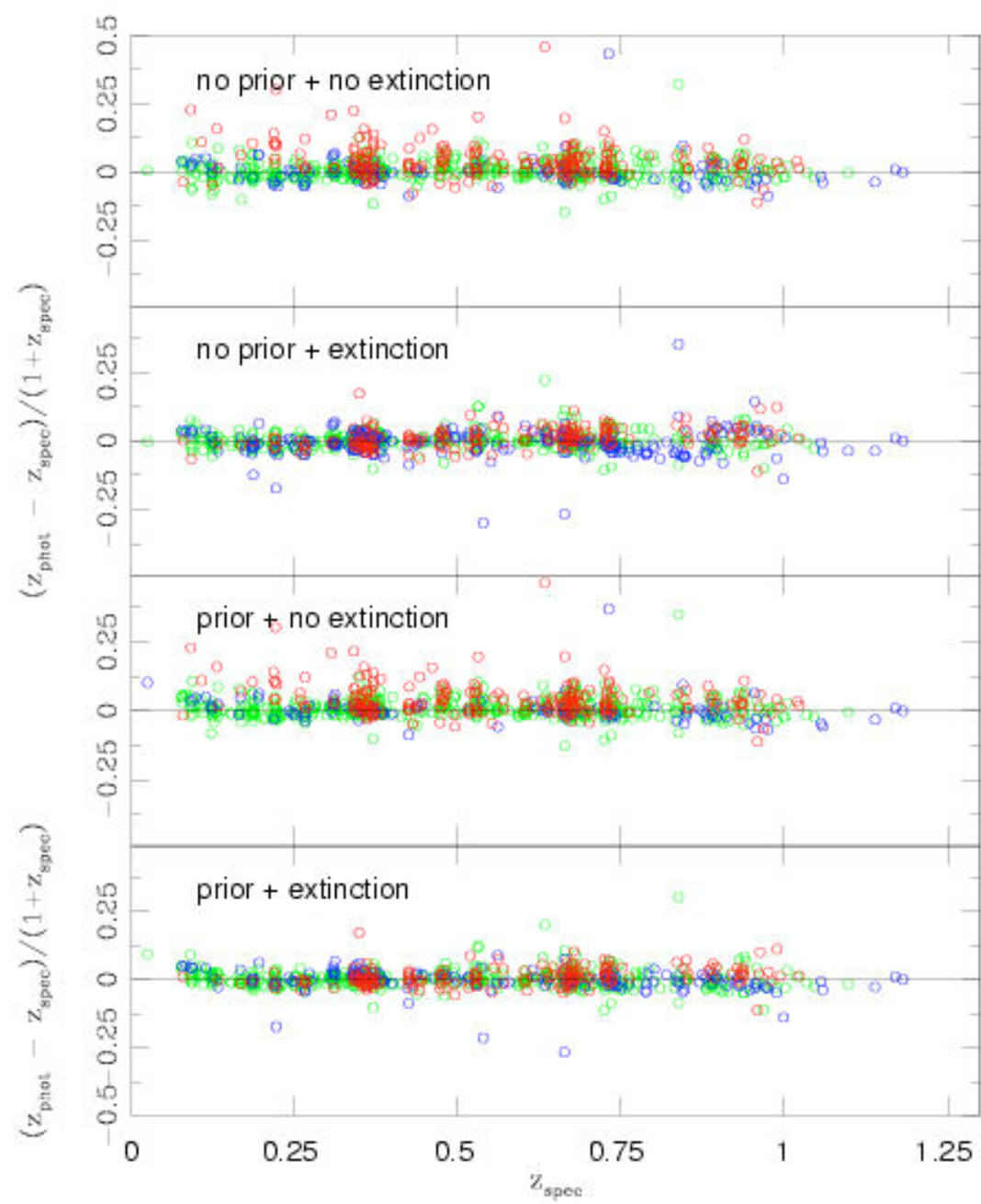
i-band selected photometric catalog
with available spectroscopic redshifts in
CDF-S (680) and COSMOS (820)

Photometry: U(CTIO), BVRI (WFI),
RI (FORS), JHK (SOFI, ISAAC),
Bviz (ACS)

18 bands

Photometry accurate to ~ 0.04 mag





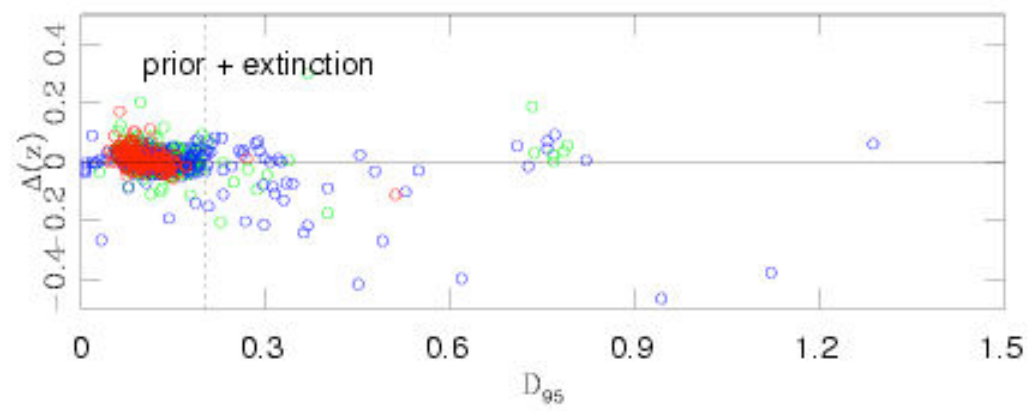
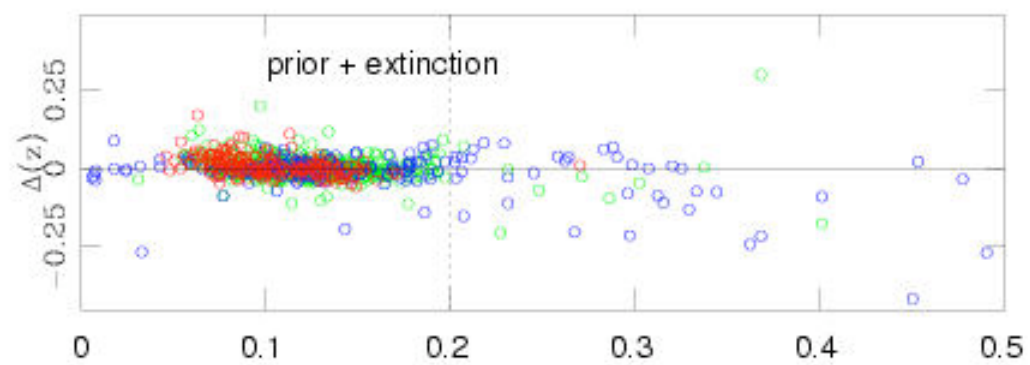
Phot-z Accuracy Parameters

$$\delta z = (z_{phot} - z_{spec}) / (1 + z_{spec})$$

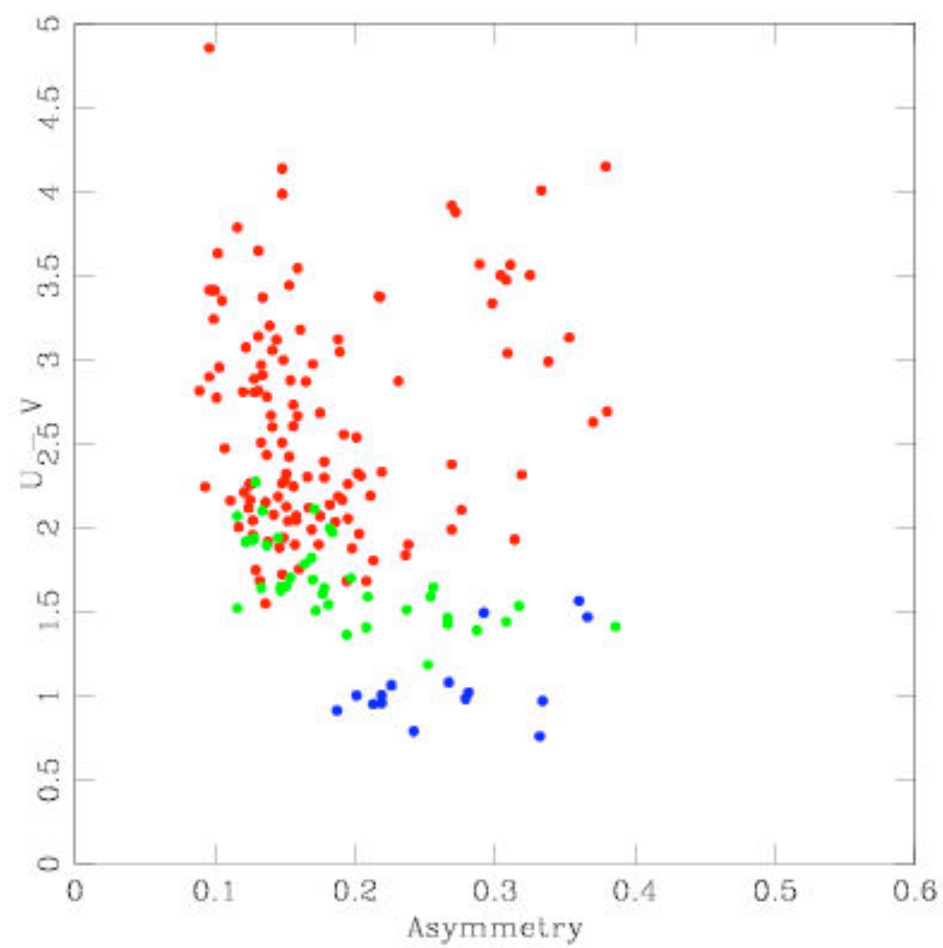
Outliers defined as objects with

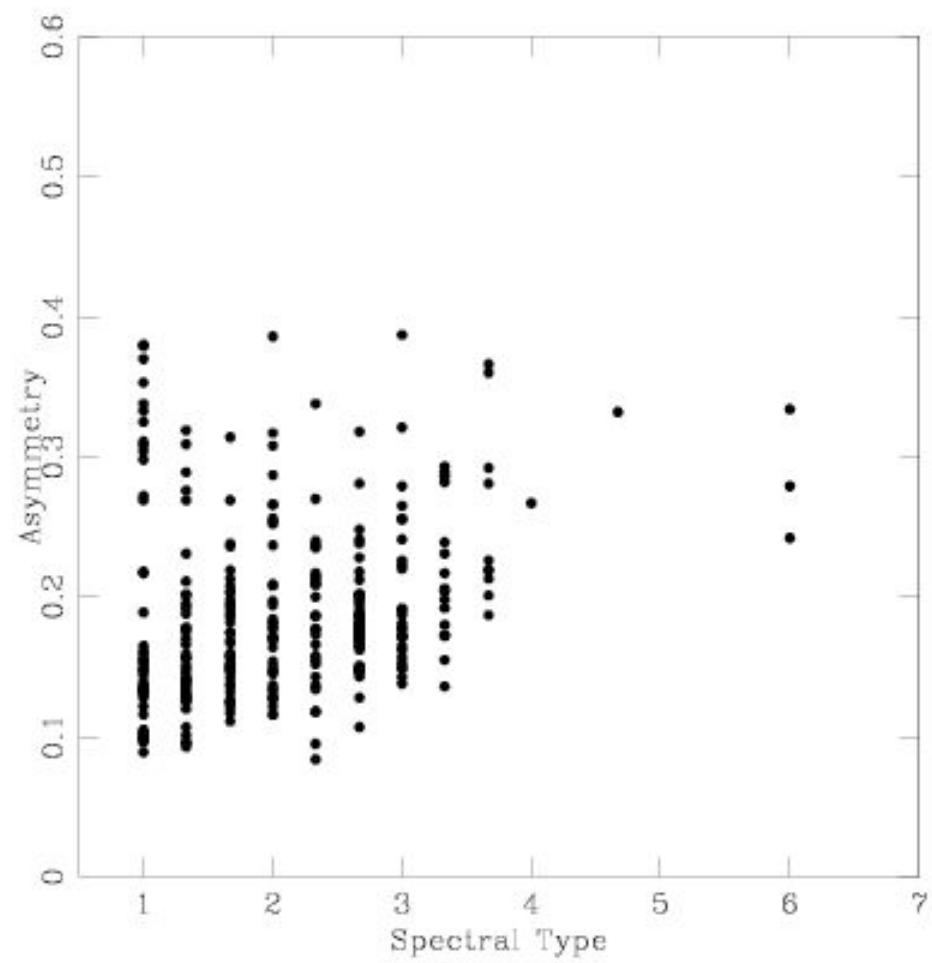
$$\delta z > 0.3$$

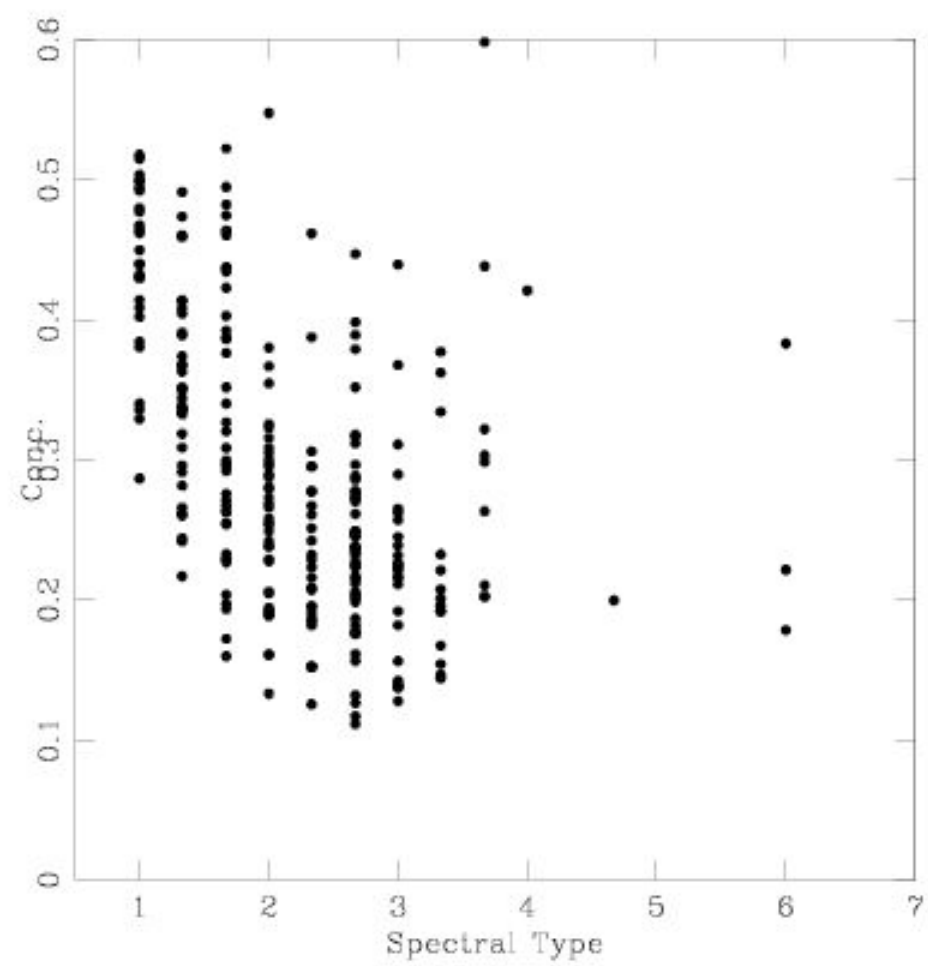
$$D_{95} = 95\% \text{ conf. Int. width} / (1 + z_{phot})$$



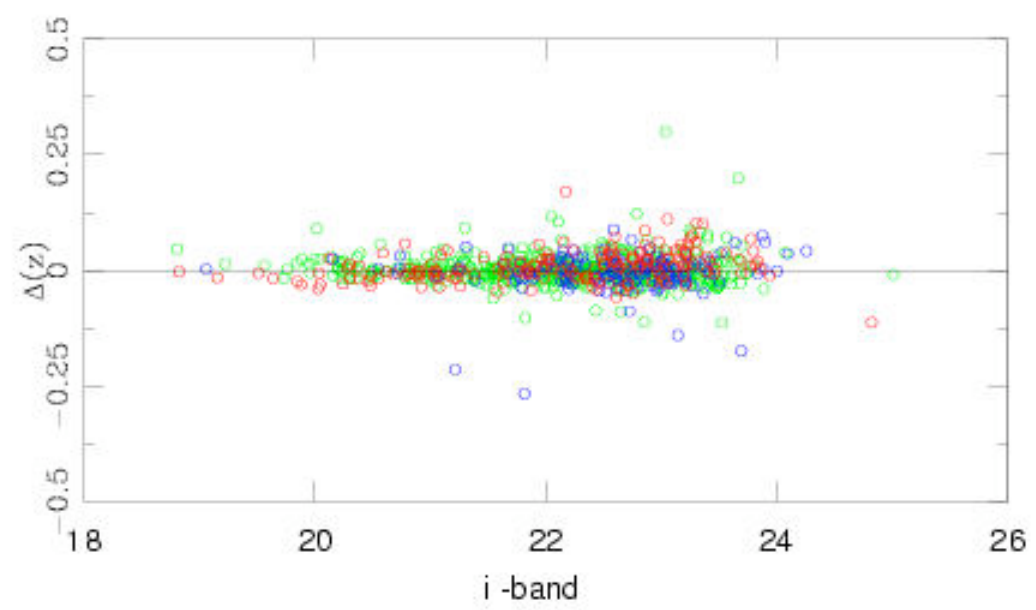
E/SO (red) Sb-Sc (green) Irr/Sb (blue)



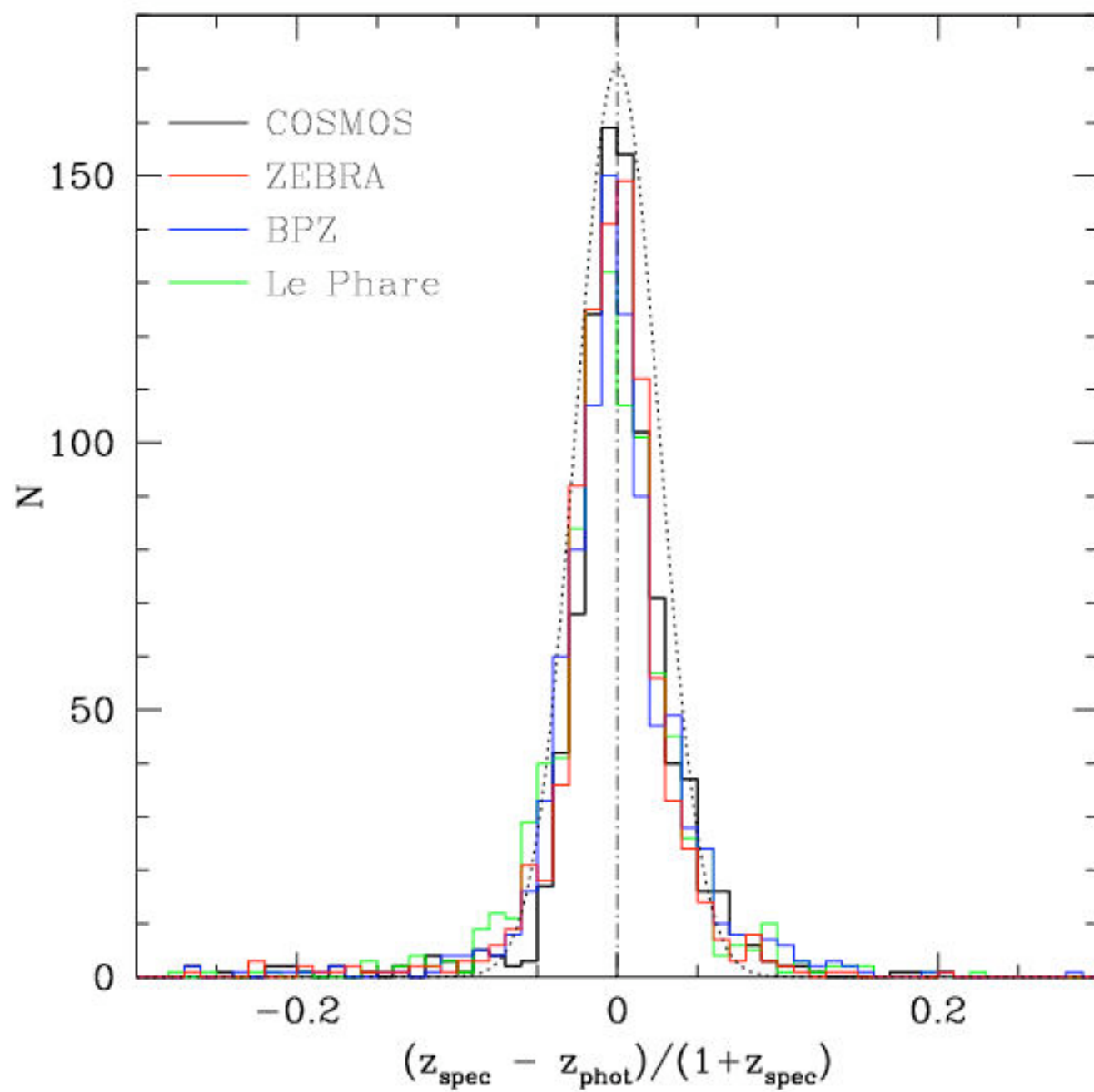




Dependence of phot- z 's on magnitude limits



Comparison between different phot-z techniques



Results

- The SNAP phot-z code fits redshift, spectral type and extinction for individual galaxies, all at the same time
- We estimate phot-z's to an accuracy of $\delta(z) = (z_{phot} - z_{spec}) / (1 + z_{phot}) = 0.03$ using broad-band *UBVrizK* band data
- We introduce a new parameter, D_{95} , to measure uncertainties in the phot-z's
- Using Intermediate Band data, we have been able to increase the accuracy in our phot-z measurement to 0.01

2. Simulated Photometric Data

Simulated Photometric Catalog

Use luminosity function to generate
absolute mag (M_B) distribution

Assign random redshifts to each M_B ,
taking into account the volume
effect

Estimate k-corr for each galaxy using
SNAP filter functions and 6
templates (E,Sa,Sc,Irr,SB)

Measure magnitudes in different
bands, using k-corr

More Details...

- Use rest-frame B-band luminosity function (Dahlen & Mobasher 2005) to $z \sim 2$ to generate M_B distribution
- A spectral type is assigned to each galaxy according to type specific LF
- Nine SNAP filters are considered
- Redshift range $0 < z < 6$
- Absolute magnitude range $-24 < M_B < -15$
- K-corrections are estimated by convolving filter response functions with redshifted SEDs
- An area of 1000 arcmin^2 is considered for the mock catalog

Simulated photometric catalog

type-dependent LF $\rightarrow$ M_B , Spectral type

z , SED, filter $\rightarrow$ color, k-corr

M_B , z , K-corr $\rightarrow$ m_B

m_B , color $\rightarrow$ m_i

m_i ($i=1,9$), z , Sp. Type, phot error

Simulation...

Calculate apparent magnitudes in
different bands from (M,z,k-corr)

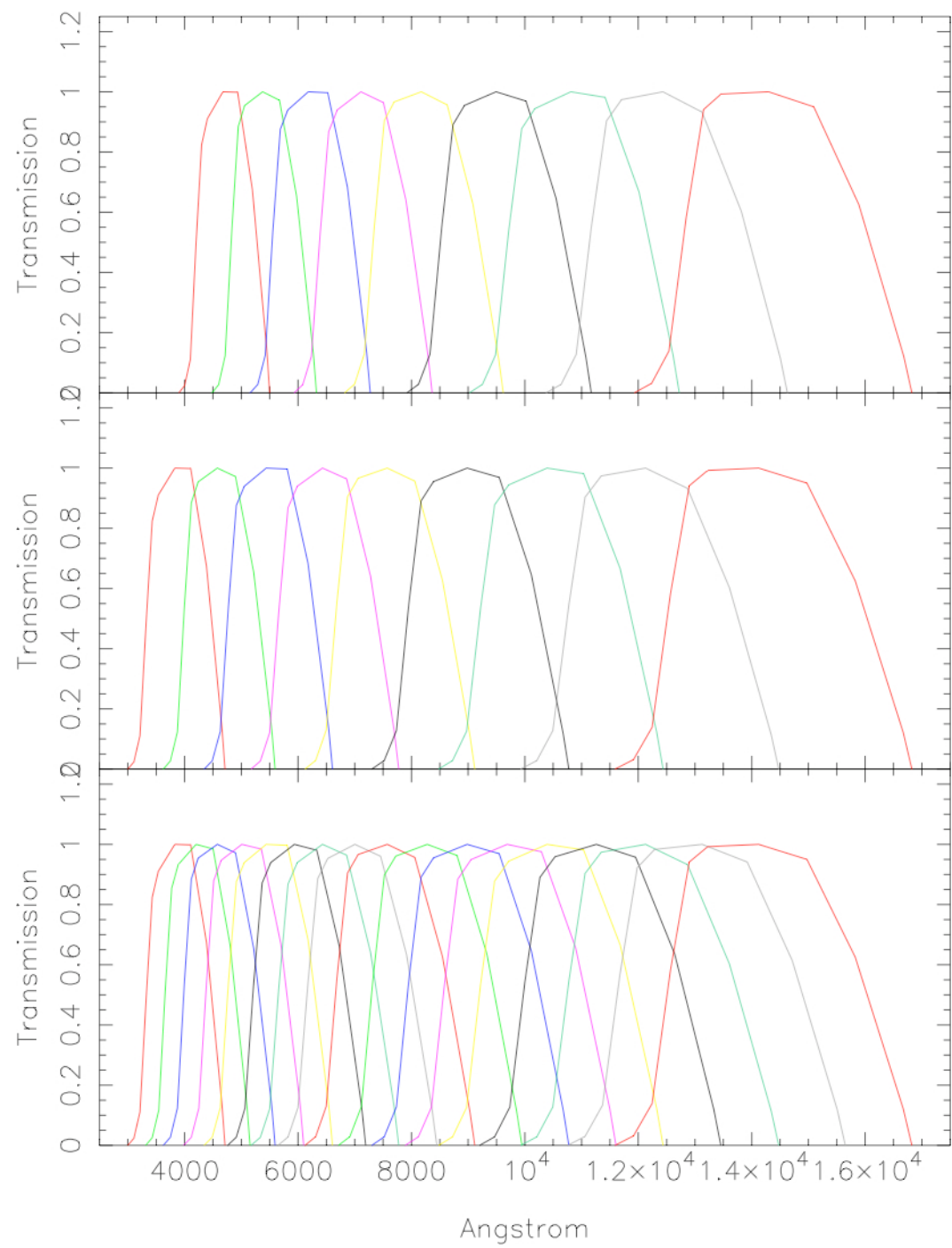
Assign random errors to apparent
magnitudes

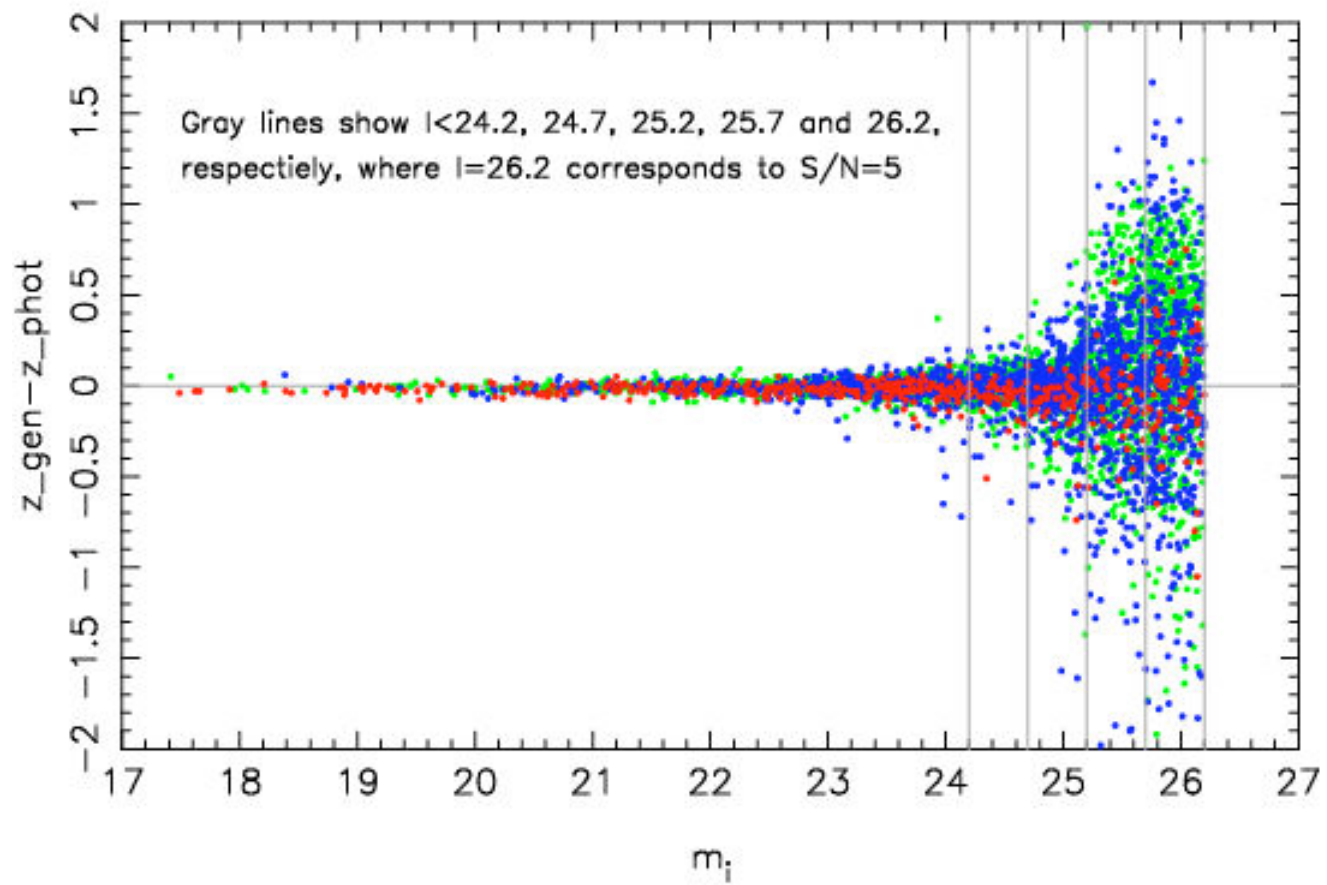
Produce the simulated catalog,
containing [m1...m9,z,type]

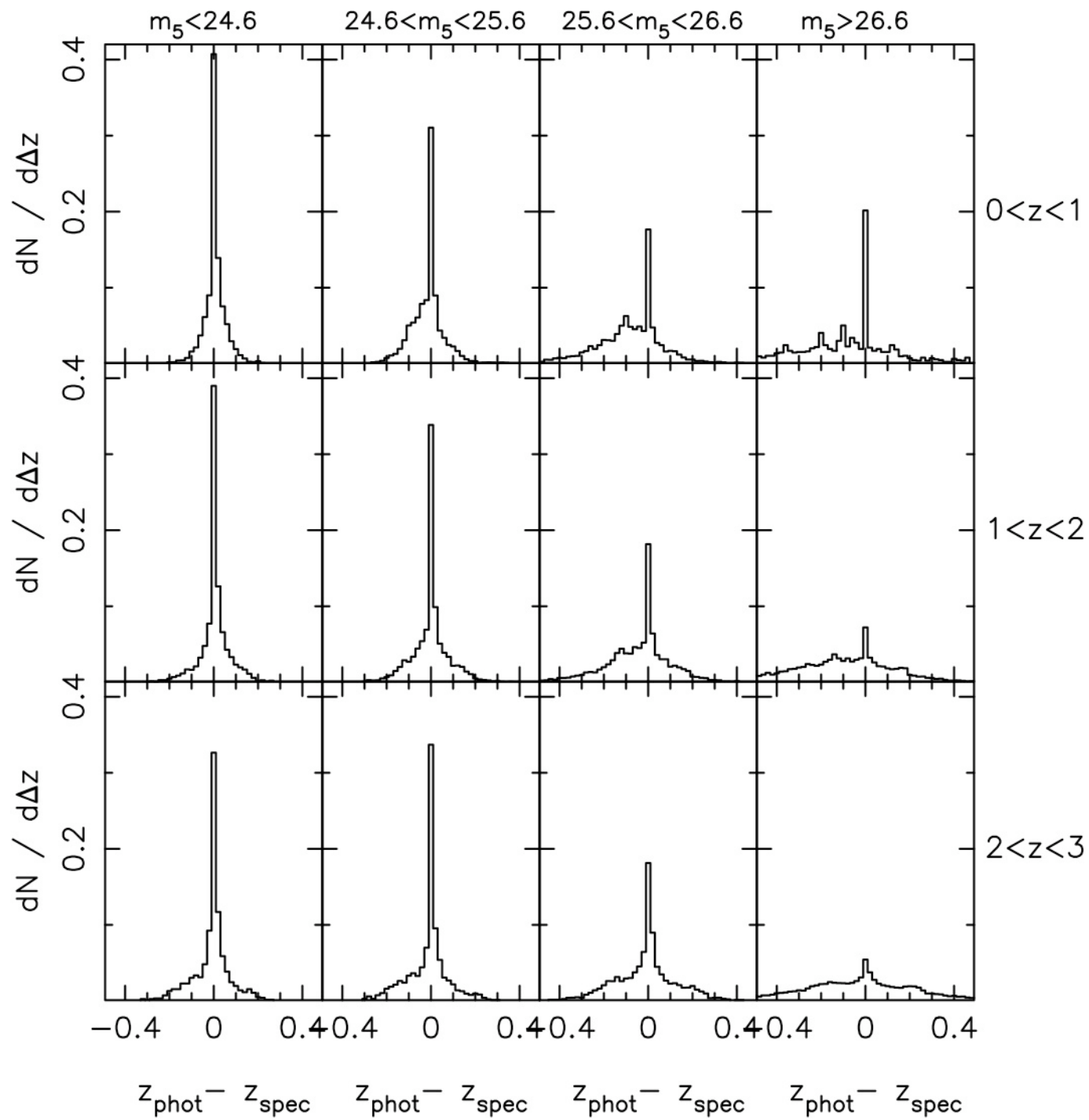
Include random extinction to
magnitudes and colors

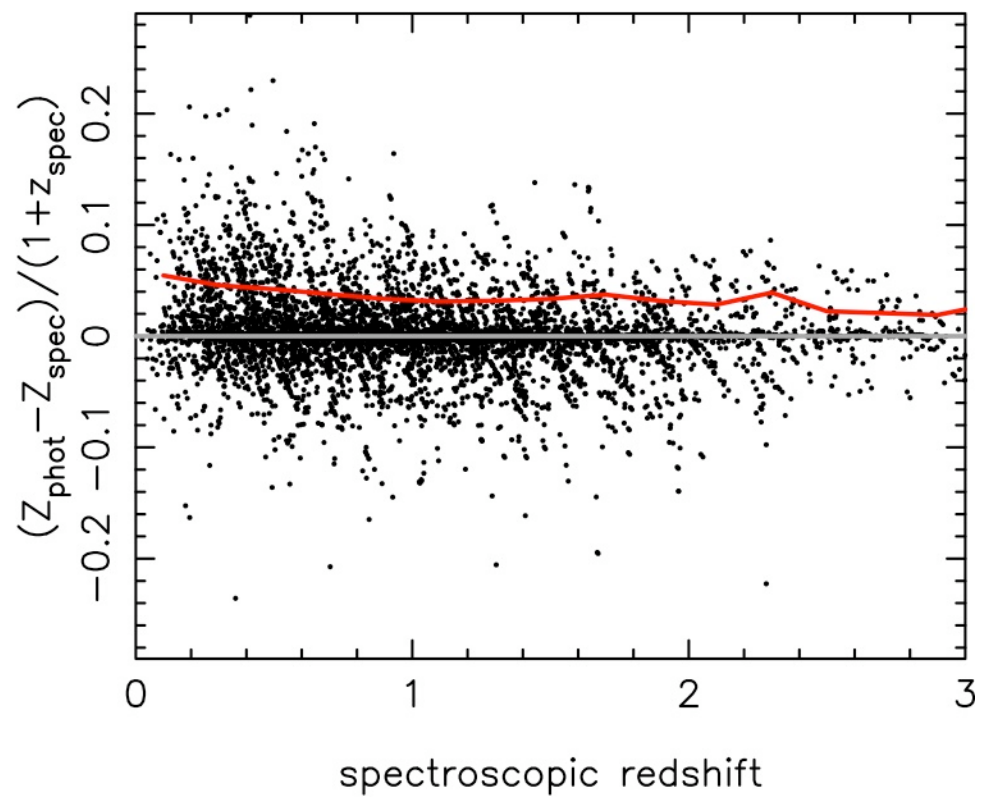
Run phot-z code on the mock catalog

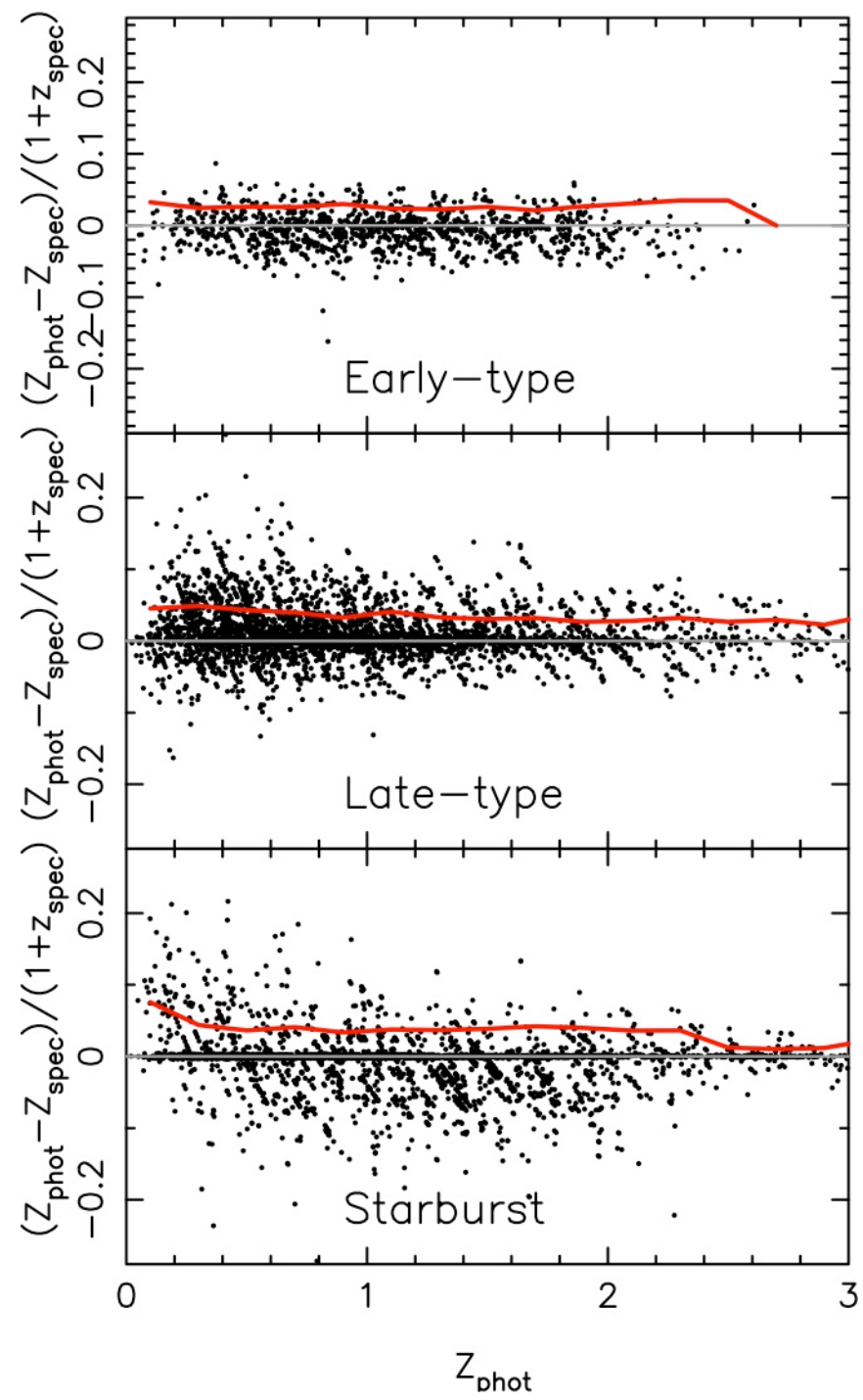
Compare the input vs output redshifts

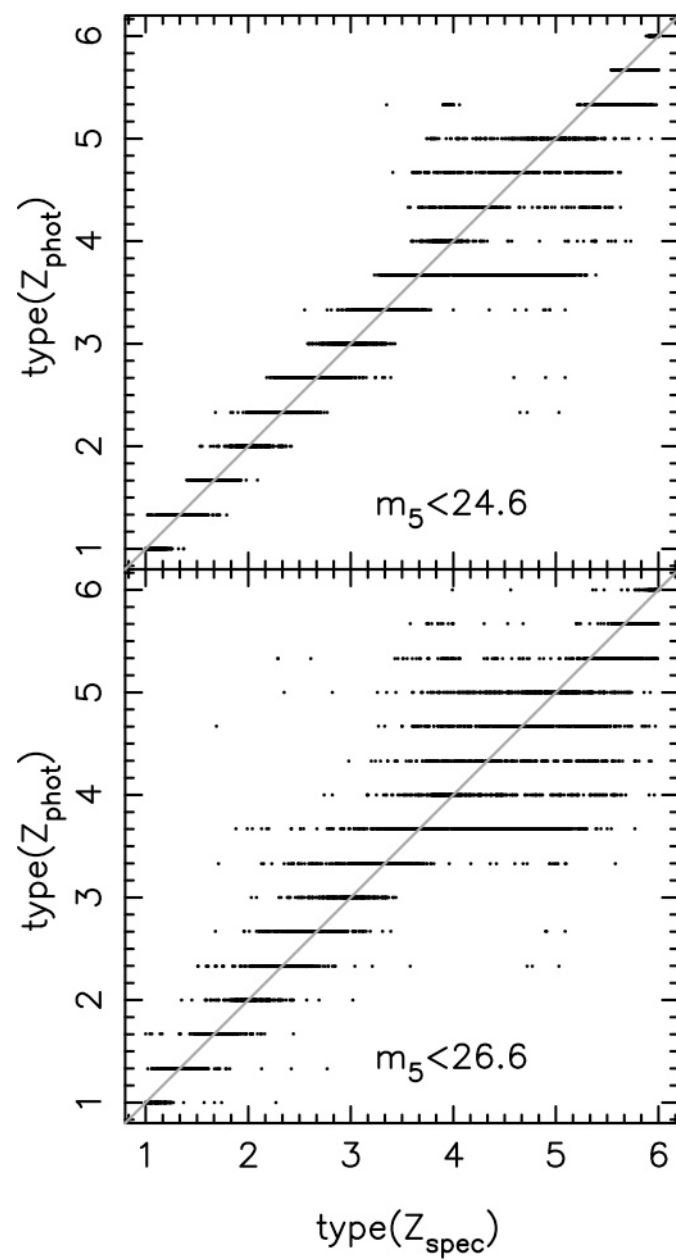


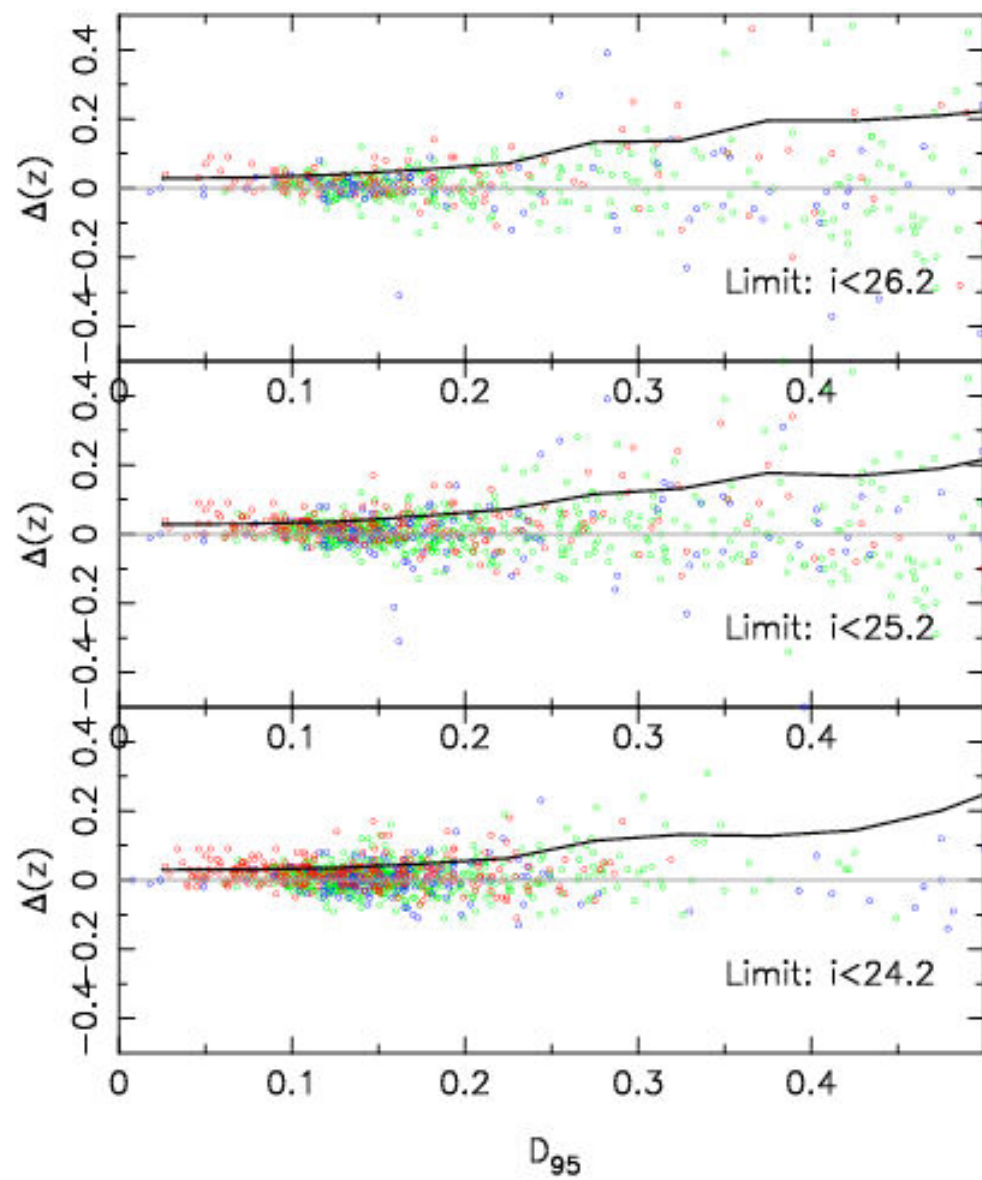












	Dz	OL %	Dz w/o OL
m_{lim}	0.179	2.16	0.057
$m_{\text{lim}}-0.5$	0.158	1.03	0.045
$m_{\text{lim}}-1.5$	0.087	0.21	0.030
$m_{\text{lim}}-2.5$	0.045	0.07	0.023
Early	0.055	0.10	0.054
Late	0.072	0.55	0.051
Starburst	0.293	5.52	0.068

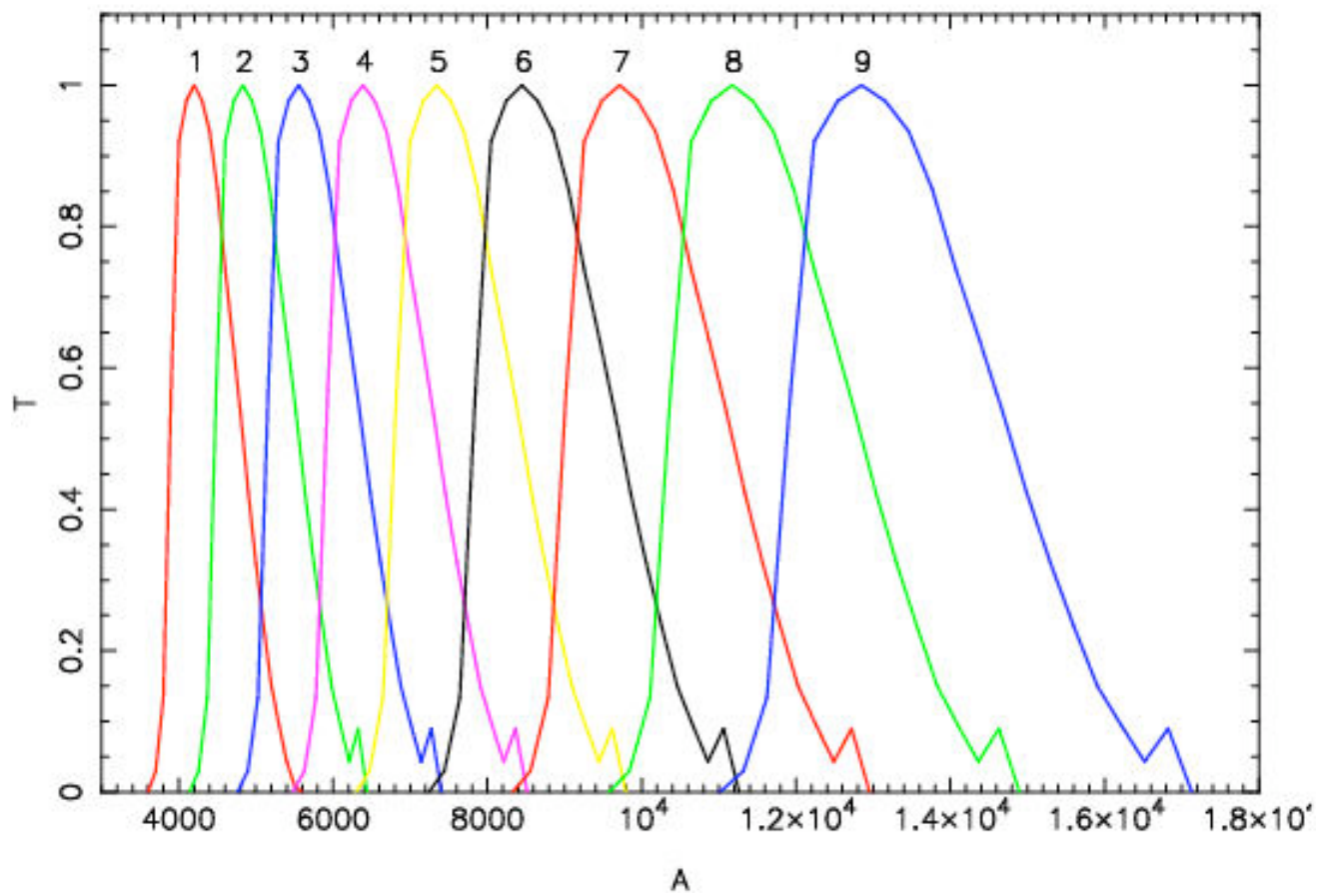
Conclusions

- Better phot- z 's and reduced outlier fraction with brighter magnitudes
- Brighter magnitude cuts significantly reduces the number of objects
- Better phot- z 's for earlier types

Sensitivity to the choice of filters

- Use 10 different filter sets
- Wavelength range 3600-17000 Å
- Number of filters included varies between 6 to 13
- Filters have square shapes
- Each filter is redshifted version of the first filter
- Observing time available for each filter is assumed to be inversely proportional to the number of filters in each set

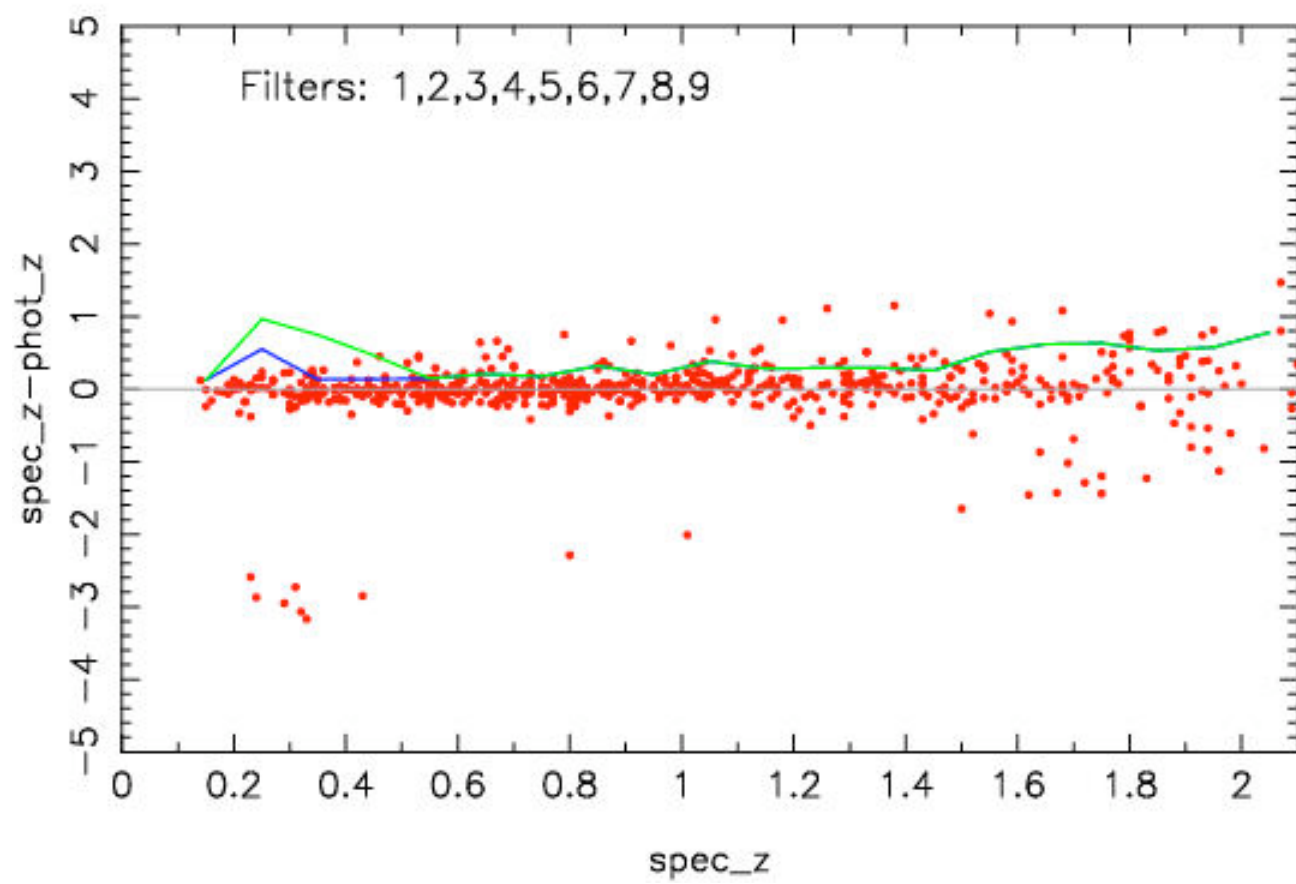
SNAP filters

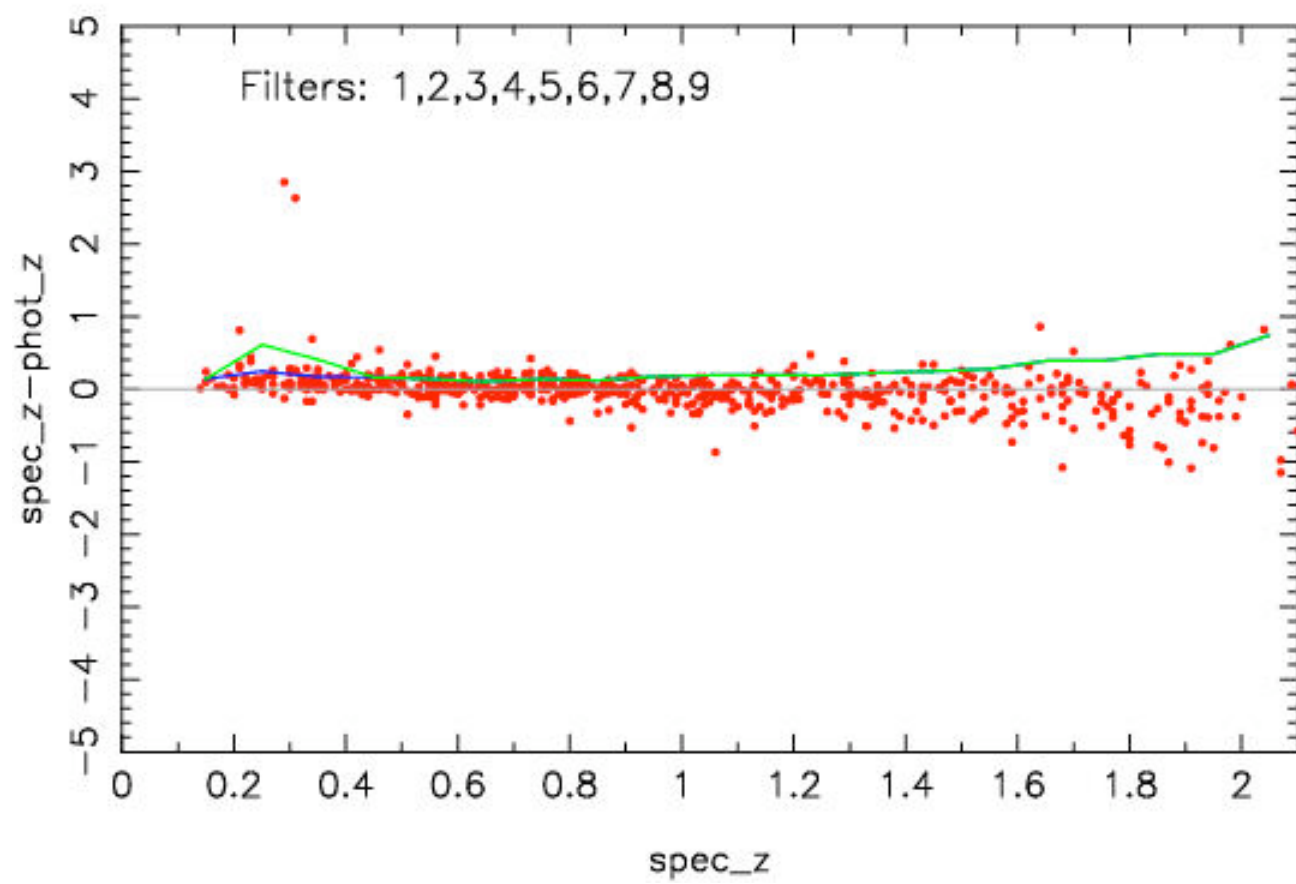


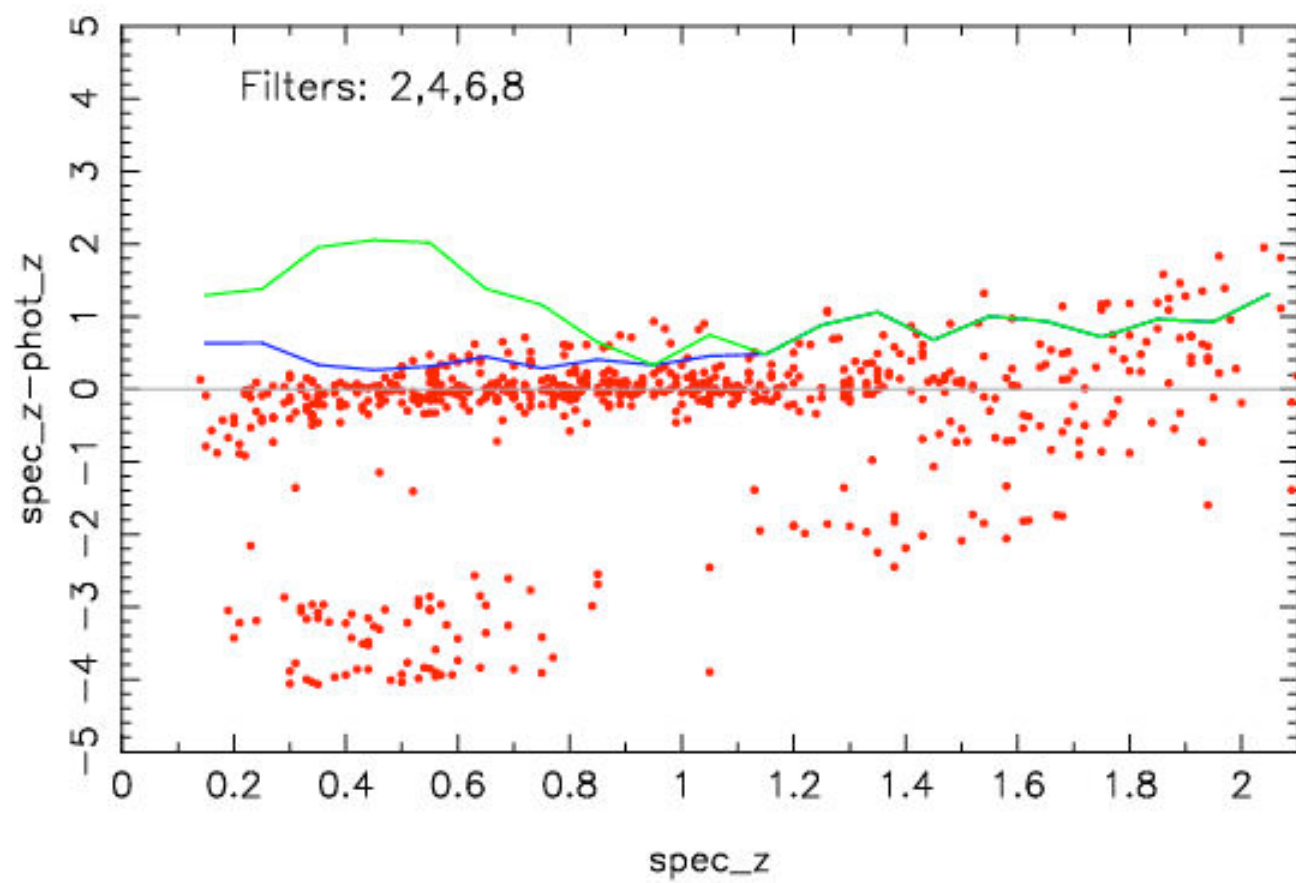
1. Filter combination 2. dz 3.dz w/o OL

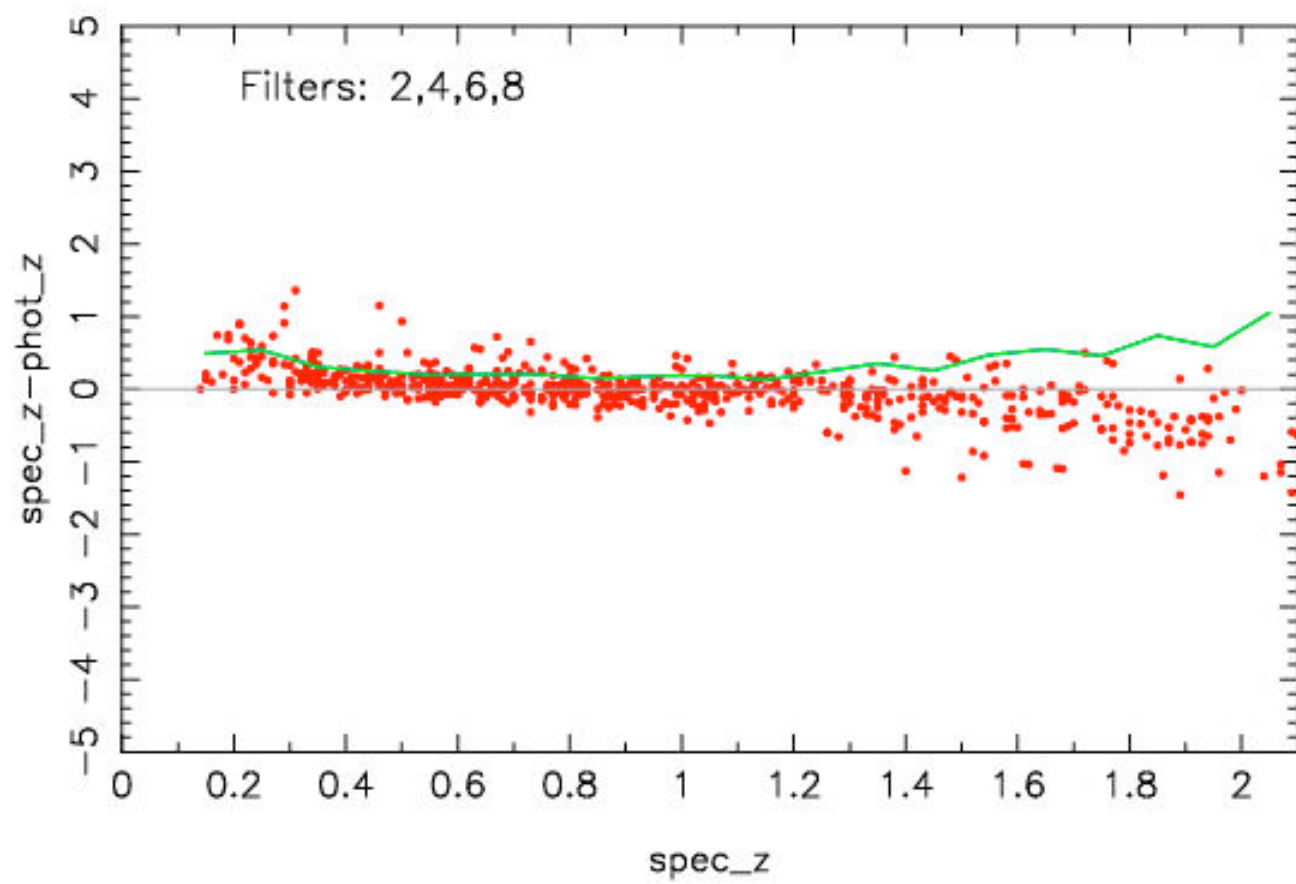
4. % of outliers

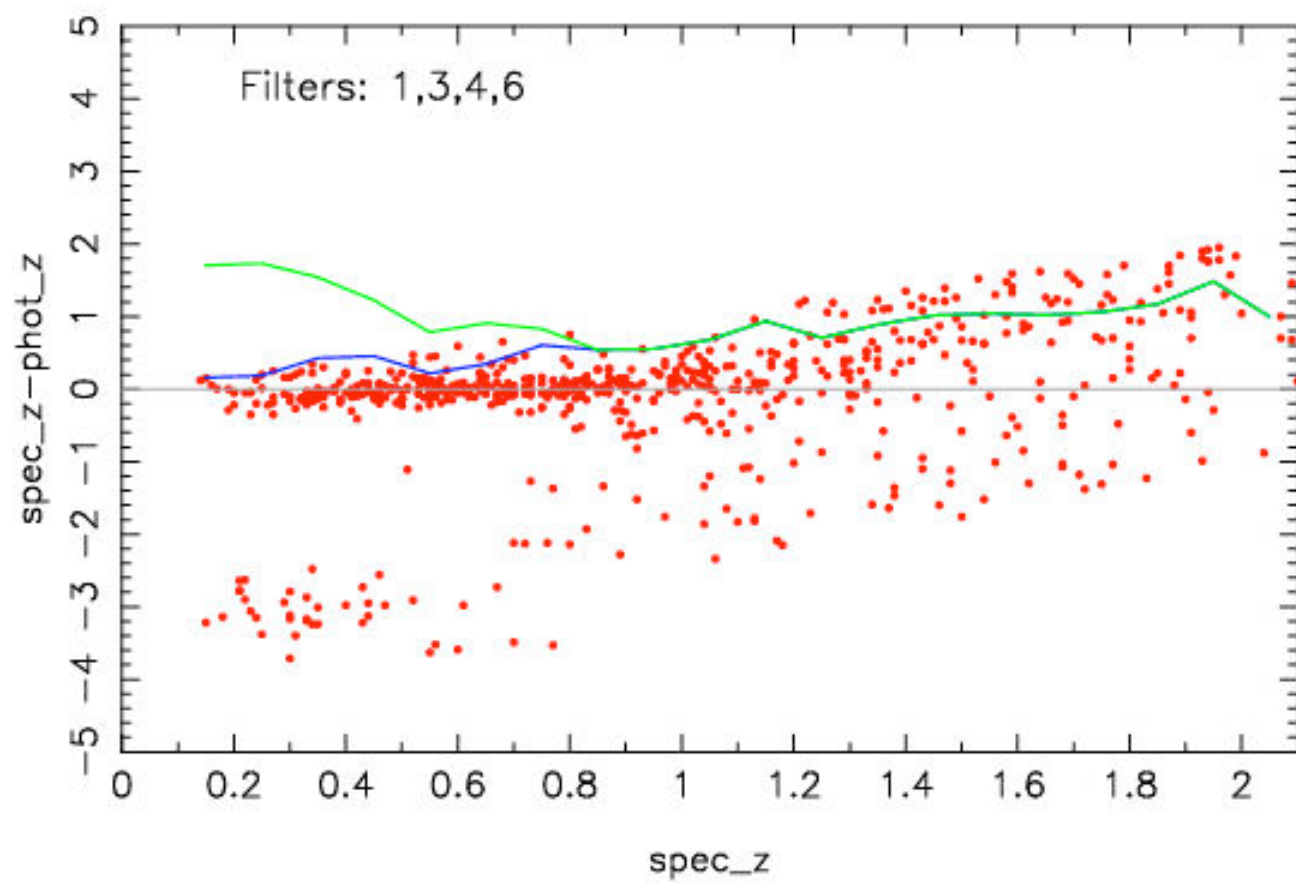
3-3	0.532	0.075	9.6	0.222	0.067	6.6
4-3	0.378	0.063	6.0	0.156	0.054	3.8
5-3	0.282	0.056	4.2	0.116	0.045	2.3
6-3	0.174	0.048	2.7	0.103	0.038	1.4
6-4	0.152	0.042	1.9	0.078	0.032	1.0
7-4	0.100	0.043	1.8	0.070	0.030	0.9
7-5	0.080	0.034	1.1	0.048	0.024	0.30
8-5	0.072	0.033	1.0	0.039	0.012	0.30
6-3	0.237	0.055	3.7	0.108	0.044	2.0

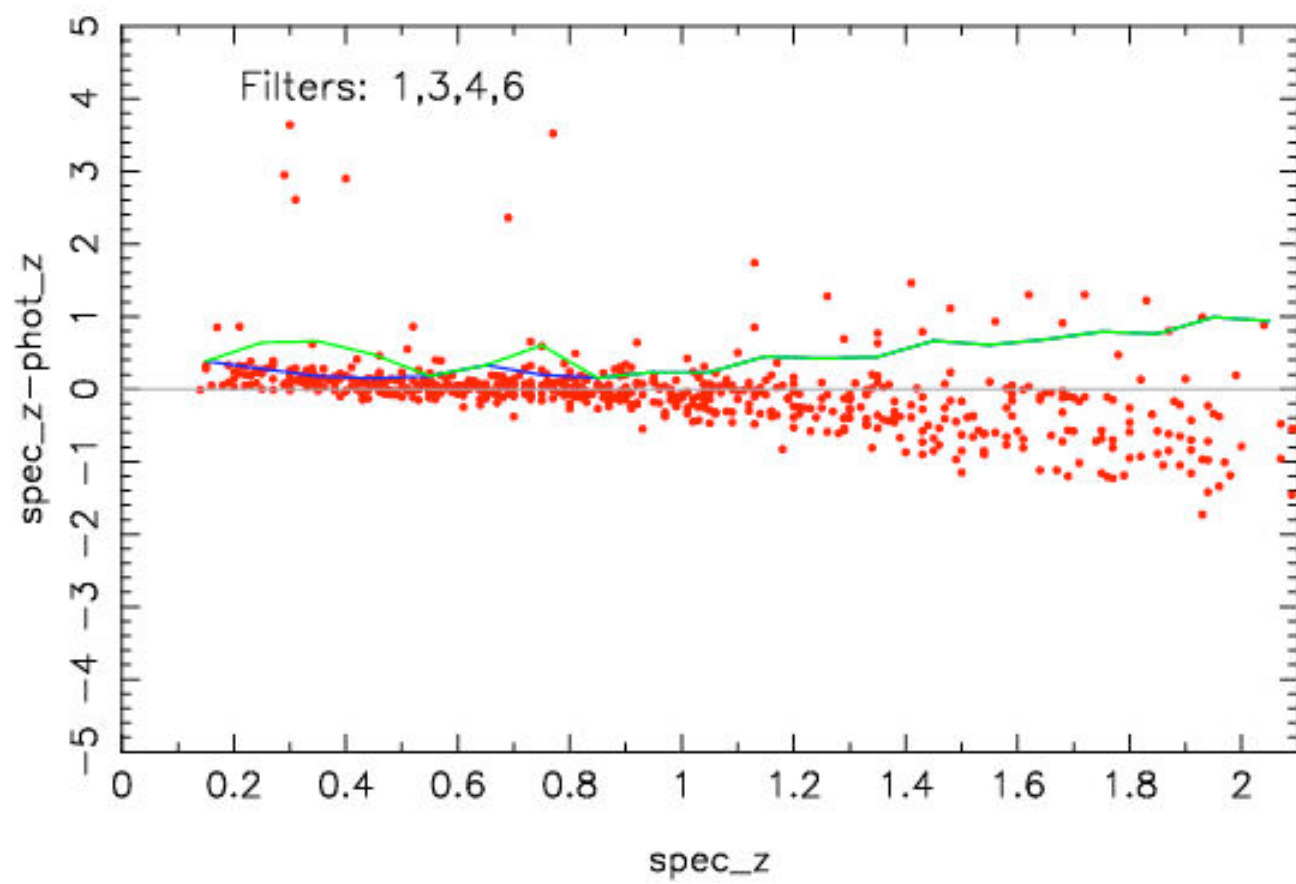


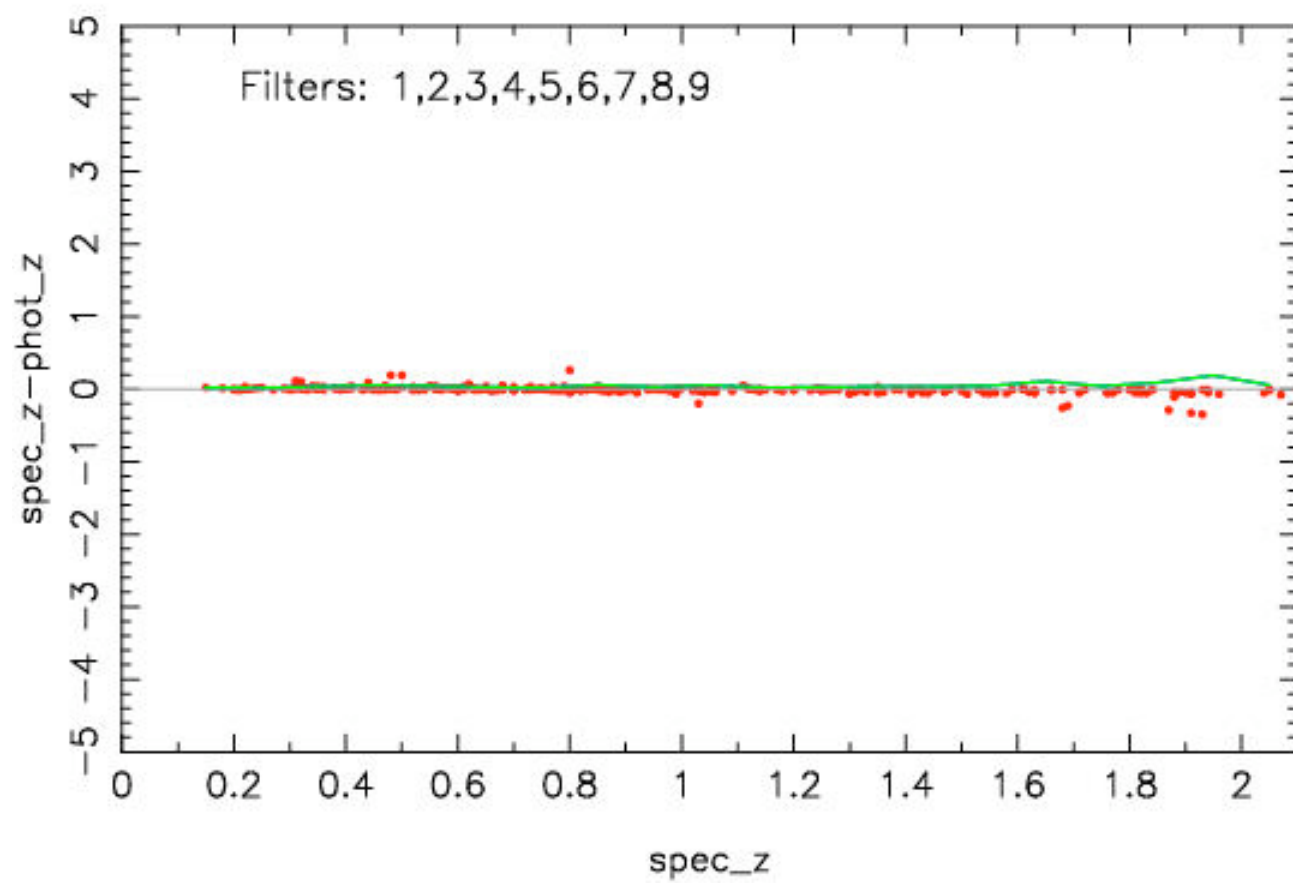












Conclusions

- Accurate phot-z's and reduced outliers achieved with brighter magnitude cut
- Phot-z accuracy increases with more accurate photometry (i.e. zero-point) and better calibration
- Phot-z accuracy increases with the number of filters. Specially near-infrared bands will help

Filters

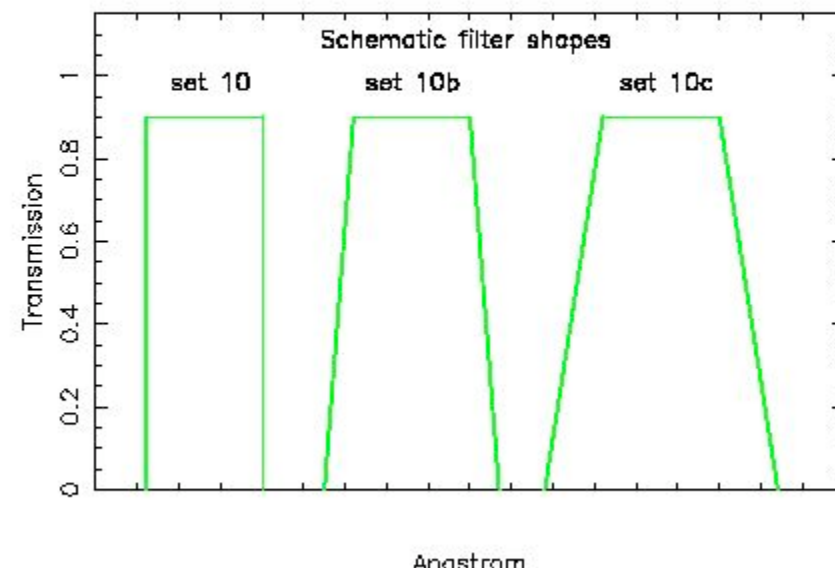
Phot-z's are found using redshifted 4000 Å break. Accuracy of the phot-z's depend on photometric accuracy. In selecting optimal set of filters there are two competing requirements:

Using a number of narrow-band filters will significantly help but this would also lower the counting statistics, resulting in larger photometric errors.

Filters - Conclusions

However, dividing the limited observing time between large number of filters reduces the S/N per band.

We use our simulations to study if there is some optimal choice for the filters for measuring phot-z's. We adopt the filter set in Davis et al astro-ph 0511017.



To increase the accuracy of photo-z's we need:

- Good photometric calibration (~ 0.03 mag)
- Large training set of spectroscopic redshifts ($\sim 10^4$)
- Sufficient number of filters
- High photometric S/N
- Near-Infrared photometric data

