DARK ENERGY SURVEY

KAVLI INSTITUTE FOR PARTICLE ASTROPHYSICS AND COSMOLOGY

N-body-spectro-photometric simulations for DES and DESpec

Carlos Cunha

DESpec Meeting, Chicago

May 30, 2012

STANFORD UNIVERSITY

N-body + galaxy + photometry

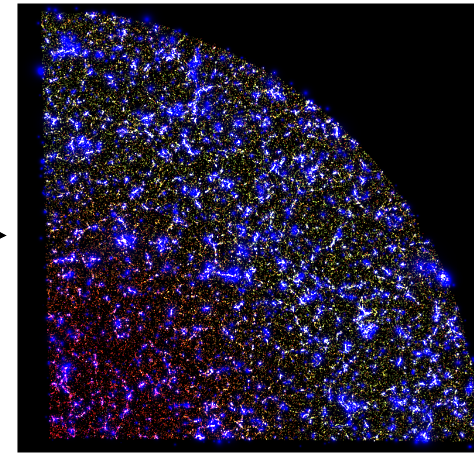
DARK ENERGY
SURVEY

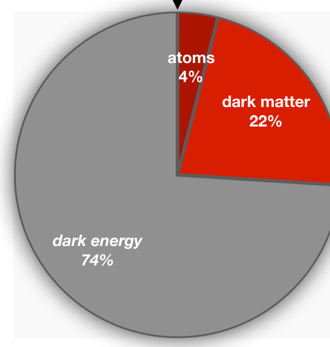
simulated sky surveys
developed with
Michael Busha (galaxies + sim)
Matt Becker (lensing + sim)
Brandon Erickson (sim pipeline)
Gus Evrard
Andrey Kravtsov

Peter Behroozi (halos)
Joerg Dietrich (shapes)
Basilio Santiago (stars)
Molly Swanson (mask)

DES Mock Pipeline / R. Wechsler

- simulation
- halo finding
- merger trees
- assign galaxies
- calculate shear
- lens galaxies
- photometric errors
- photometric redshifts
- create sky images





Eli Rykoff, Rachel Reddick (testing)
+ additional feedback by CWG, Sarah Hansen, Jiangang Hao, Alex Ji, Eusebio Sanchez, Tim Eifler, Joanne Cohn, Martin White
+ many, many folks who will do analysis!

Risa Wechsler
Stanford/SLAC/KIPAC

K-correct

Blanton & Roweis (astro-ph/0606170)

- Cornerstone of the photometric and spectroscopic components of the simulations.
- Used to generate **colors** and **spectra** of simulated galaxies.
- Key issues: galaxy templates and priors (put in separately).

Kcorrect templates

- 5 eigentemplates obtained using Non-negative Matrix Factorization (**NMF**).
- Generated from combination of **450** star emission history templates from Bruzual & Charlot (2003) + **35** templates from Kewley et al (2001). Resolution 3 Å from 3200 to 9500 Å
- Template-resolution: 300 km/s; R=1000.

Training sets:

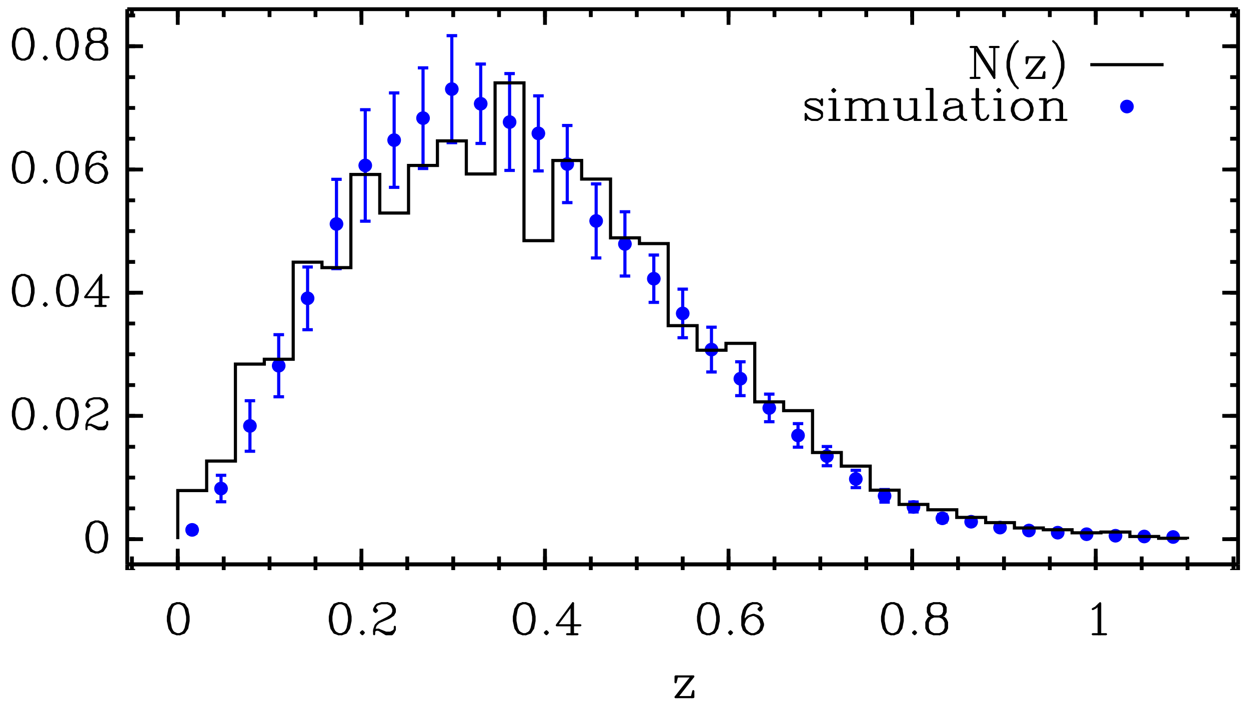
- Spectroscopic: **1,600** **SDSS Main** sample + 400 **LRGs**.
- Photometric: **18,000** from **SDSS Main** and **LRGs**; **GOODS**; **DEEP2**; and **GALEX**

Photometric indicators

N(z): redshift distribution for **BOSS r<21.8** sample using weights

Simulation: DES simulations

Error bars: simulated sample variance + shot noise of training sets

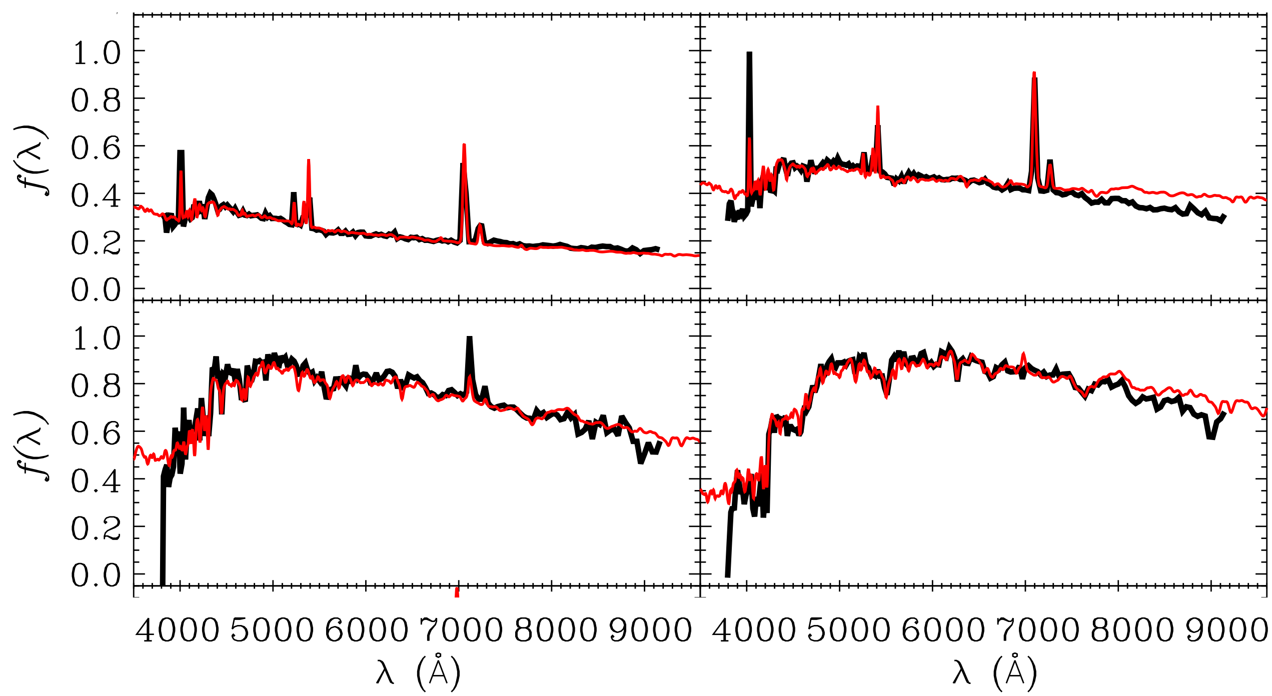


Sheldon, Cunha, Mandelbaum, Brinkmann, Weaver (2011)

Spectroscopic indicators

Black lines:
SDSS spectra

Red lines:
Best-fit
Kcorrect
templates



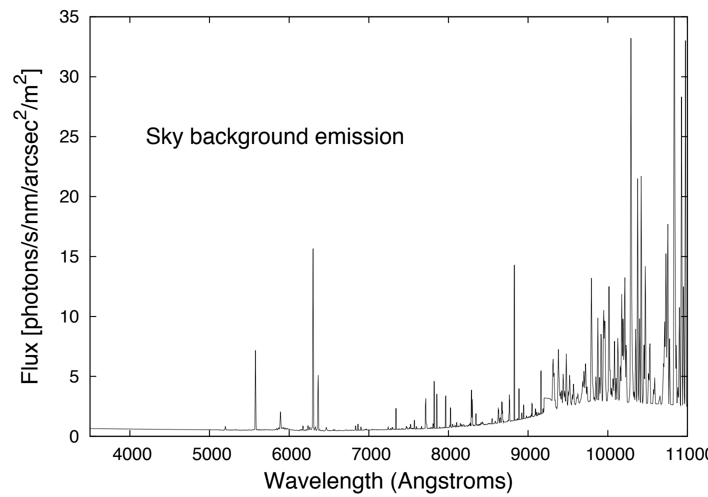
Blanton & Roweis (2007)

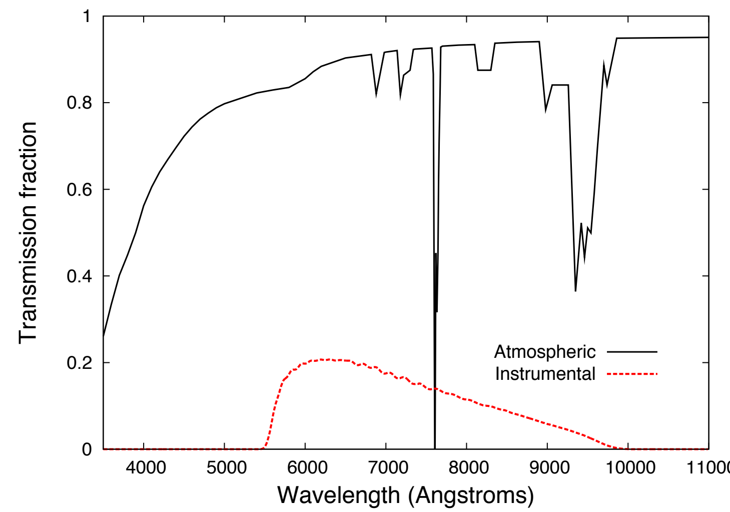
A spectroscopic simulation

Cunha, Huterer, Lin, Busha, Wechsler et al, any minute now.

Patterned after VVDS:
- **8m** telescope
- **16,200 secs** integration
- With somewhat higher resolution: **7.14 Å/pixel**
- Spectrograph window: **~5600-9300 Å**
- **i<24** sample selected from DES simulations.

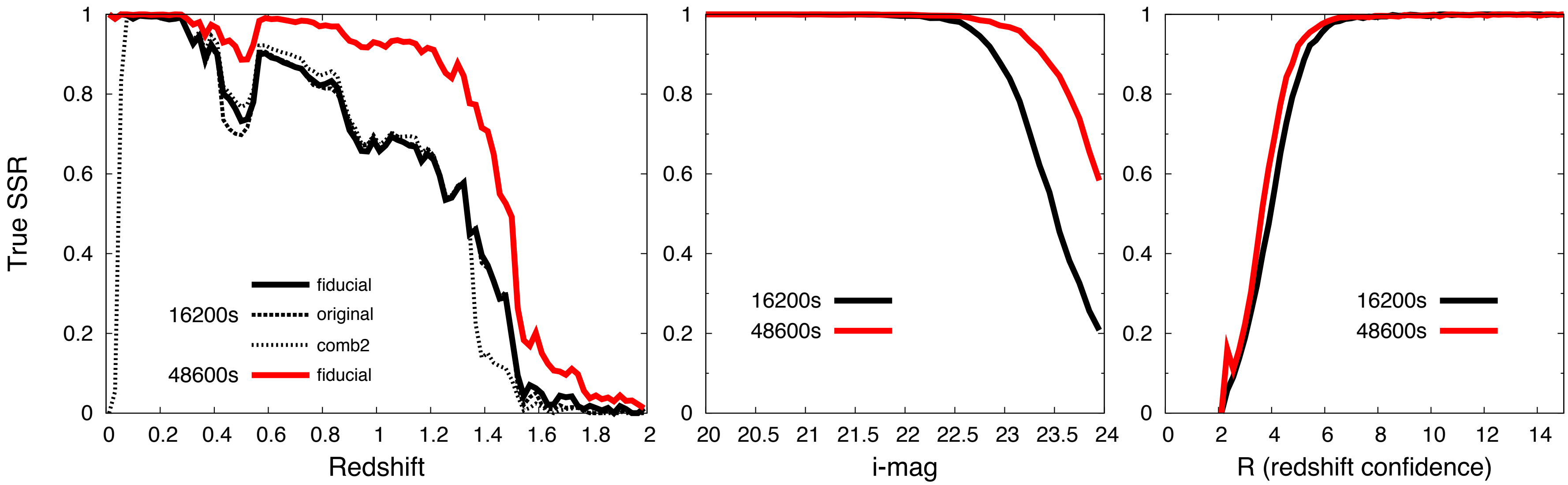
Redshifts derived using **rvcsao.xcsao** Fourier cross-correlation algorithm.





A simulation: completeness

Cunha, Huterer, Lin, Busha, Wechsler et al, any minute now.



SSR: Spectroscopic Success Rate

True SSR: fraction of galaxies with correct redshifts.

R: Strength of correlation between observed spectra and best-fitting spectrum in a template library.

Carlos Cunha, Stanford University

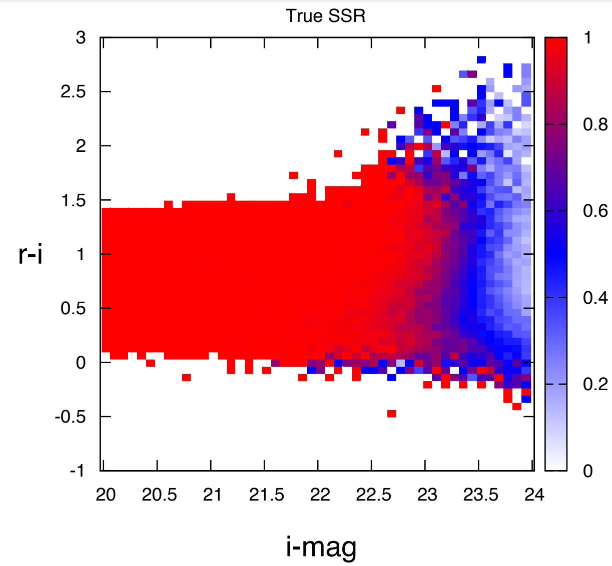
A simulation: completeness

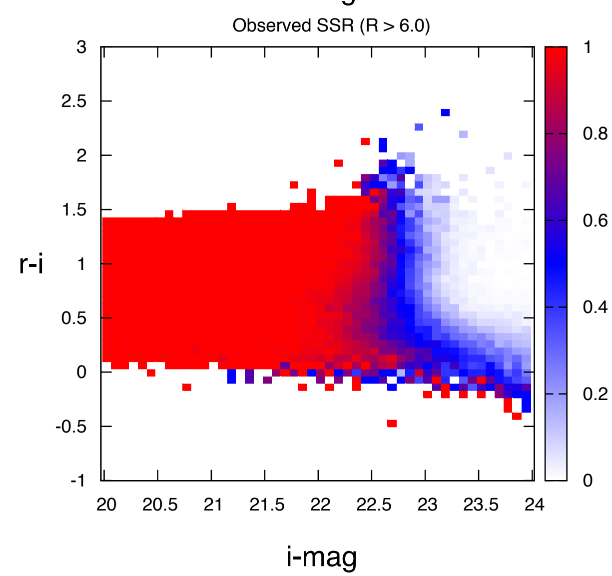
SSR: Spectroscopic Success Rate

True SSR: fraction of galaxies with correct redshifts.

Observed SSR: Fraction of galaxies with redshift confidence above some threshold (R>6).

R: Strength of correlation between observed spectra and best-fitting spectrum in a template library.





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Spectroscopic failures (wrong redshifts)

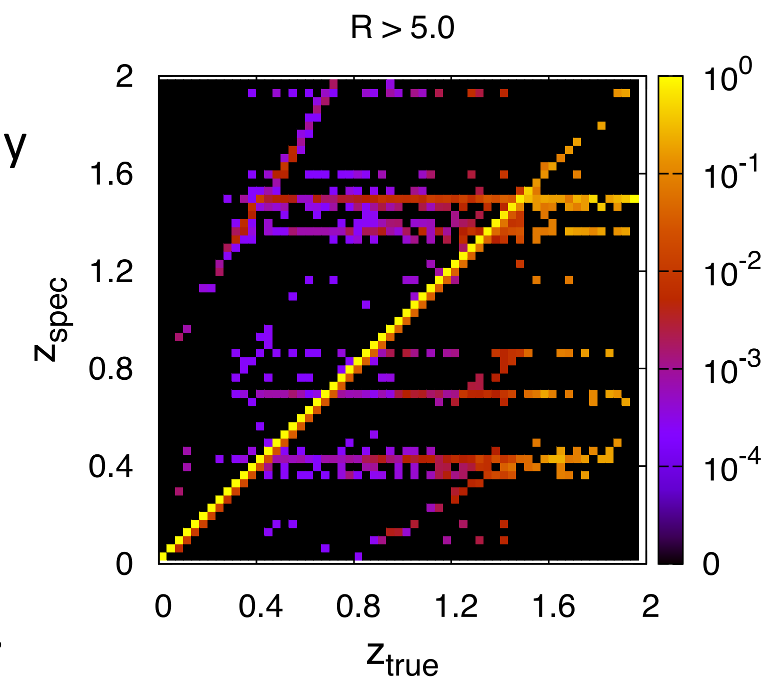
Issues:

- When spec-z's are wrong, they're really wrong.
- A small speck of wrong redshifts is enough to mess up cosmological constraints.

Sample used in the plot has 98.6% correct redshifts and constitutes 60% of total sample.

Case study: Simulations of

DES photometry + VVDS-like spec-z's



R: cross-correlation parameter (measures redshift confidence)

Cunha, Huterer, Lin, Busha, Wechsler et al, in prep.

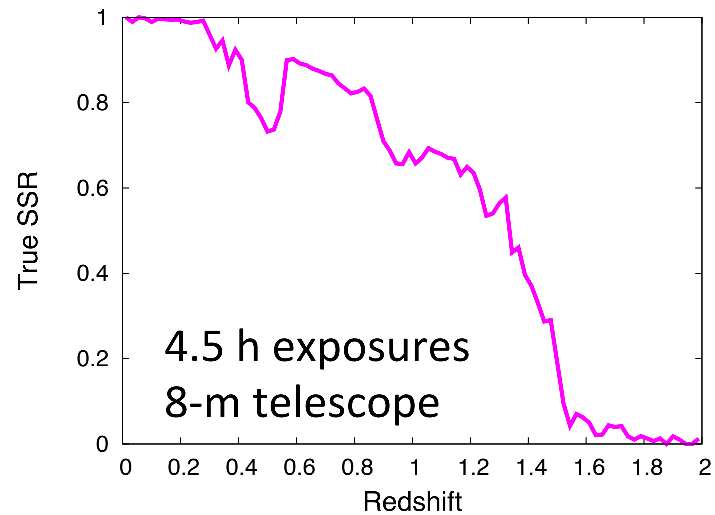
Conclusions

- N-body + photometric simulations improving constantly. Probably pretty good for DESpec depths.
- Spectroscopic simulations.
  - First step has been taken.
  - Is current resolution of templates (300 km/s) sufficient?
  - Need larger training samples to avoid surprises (Yip et al suggest 10^5 galaxies)
  - And perhaps larger eigenbasis.
  - NMF seems like a convenient tool for building a representative eigenbasis.
  - Use more realistic noise model with varying observing conditions, CCD fringing, etc.

Spectroscopic selection issues

Issues:

- Spectroscopic samples are very incomplete
  - Redshift desert is main issue.
  - Need to apply spectroscopic selection to photometric sample.
  - Can do this using neural networks (also seen in Soumagnac et al, in prep.)



True SSR: fraction of galaxies with correct redshifts.

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Carlos Cunha, Stanford University

Q_{est}: redshift confidence estimated with neural net.

SSR_T: Percentage of correct redshifts in training sample.

z_{true}: bias due to selection matching with neural networks: **is negligible**

z_{spec}: bias due to selection matching + **wrong redshifts**: **is substantial**

Shear-Shear constraints on w

16200 secs				bias(w)	
Selection	Gal. Frac.	$\mathrm{SSR_T}$ (%)	$\sigma(w)$	z_{true}	z_{spec}
$Q_{\mathrm{est}} > 1.5$	0.75	91.4	0.07	0.004	- 0.52
$Q_{\mathrm{est}} > 2.5$	0.59	97.8	0.09	0.002	- 0.13
$Q_{\mathrm{est}} > 3.5$	0.46	99.6	0.10	-0.001	- 0.02
48600 secs					
$Q_{\mathrm{est}} > 1.5$	0.96	93.6	0.06	0.004	- 0.39
$Q_{\mathrm{est}} > 2.5$	0.81	97.8	0.07	0.005	- 0.15
$Q_{\mathrm{est}} > 3.5$	0.66	99.6	0.08	0.003	- 0.03

Table 2. Statistical and systematical errors in w for the different samples. The bias results shown used the template-fitting photo-zs. The Galax. Frac. column indicates the fraction of galaxies from the full data set that passed the selection cut.

Cunha, Huterer, Lin, Busha, Wechsler et al, in prep.

Conclusions

- **Incompleteness:**
  - **Does not introduce cosmological biases** if selection matching is performed.
  - Statistical constraints suffer with reduction of sample size.

- **Wrong redshifts:**
  - Cause severe biases.
  - Need better than 99% correct redshifts.
  - If 99% accuracy not possible, need to calibrate spectroscopic error distribution $P(z_{true}|z_{spec})$ with deeper sample/better instrument.

- **Moral of the story:** Focus has to be on accuracy of derived redshifts.

Need spectra, so what?

Good spectroscopic samples are hard to come by. Issues

- **Selection in observables:** typically have many more bright samples than faint samples.
- **Selection in non-observables:** sample selected for a different purpose with different bands (e.g. DEEP2 survey).
- **Shot-noise:** samples are small.
- **Sample variance:** surveys are pencil-beam.
- **Spectroscopic failures:**
  - Can't get spectra for certain galaxies.
  - Wrong spectroscopic redshifts.

Outline

- N-body simulations + galaxies + photometry
- Galaxy spectra
- The role of Kcorrect
- An example: simulating VVDS
- What do we need for DESpec

Need spectra, so what?

Good spectroscopic samples are hard to come by. Solutions

- **Selection in observables: e.g. Weights** (Lima et al 2008)
- **Selection in non-observables: Don't do it.**
- **Shot-noise: need many galaxies**
- **Sample variance: need lots of area.**

Cunha, Huterer, Busha, Wechsler 2012

- **Spectroscopic failures:**
  - **Can't get spectra for certain galaxies.**
  - **Wrong spectroscopic redshifts.**

Cunha, Huterer, Lin, Busha, Wechsler et al, in prep.

Selection matching with neural net

- Have a redshift confidence (Q) for galaxies in spectroscopic sample.
- Use neural net to find a relation between Q and observables (magnitudes). This is $Q_{est.}$
- Q_{est} can be calculated for all galaxies in the spectroscopic and photometric samples.

- Potential confusion: Q is a new quality parameter I invented to more closely approximate the quality estimates of real surveys like VVDS and DEEP2. It's just a rescaling (plus discretization) of the R (cross-correlation strength) parameter.

Spectroscopic failures (wrong redshifts)

Issues:

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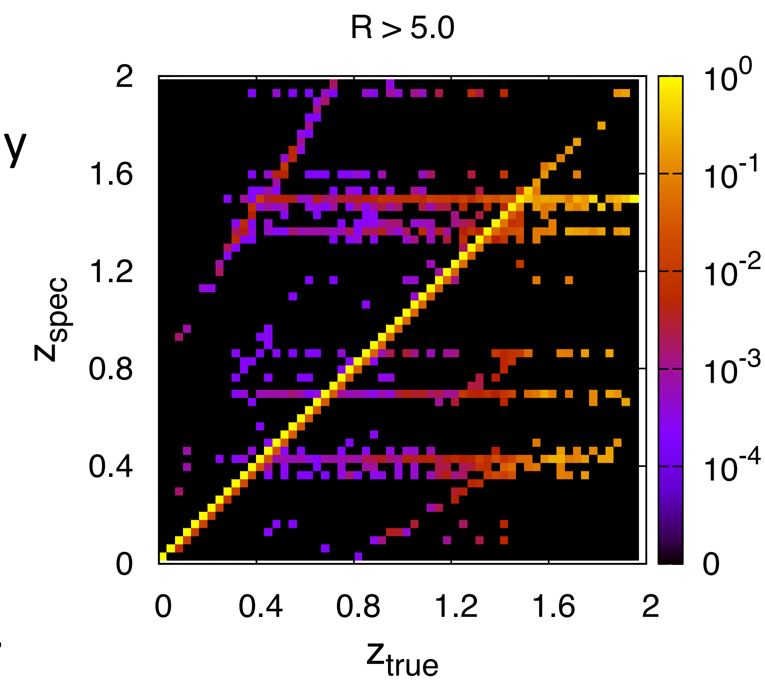


R: cross-correlation parameter (measures redshift confidence)

Cunha, Huterer, Lin, Busha, Wechsler et al, in prep.

$N(z_{spec})$

For typical existing spectroscopic samples, sample variance is significantly larger than shot noise.

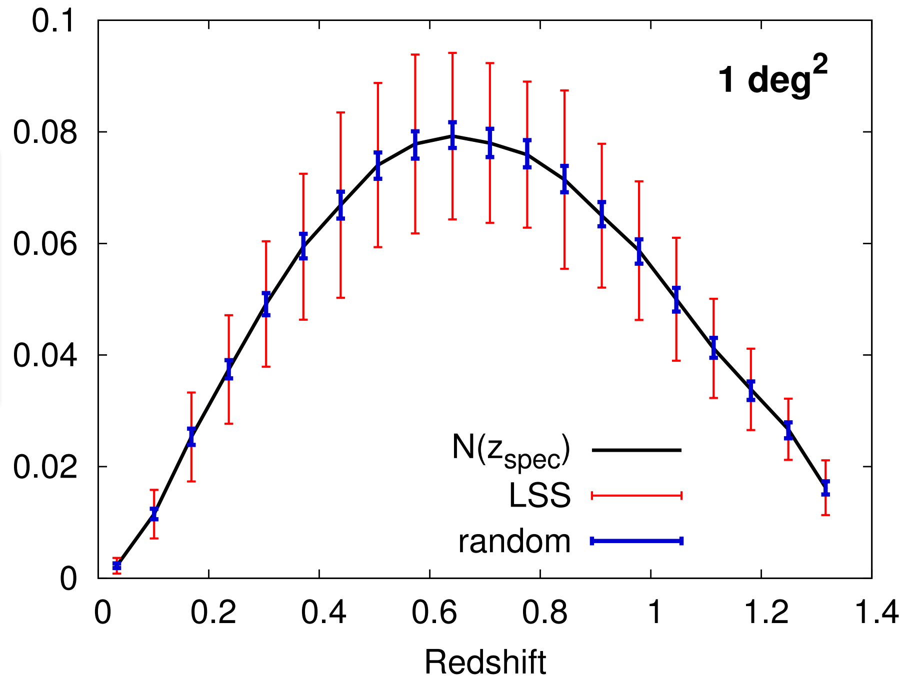


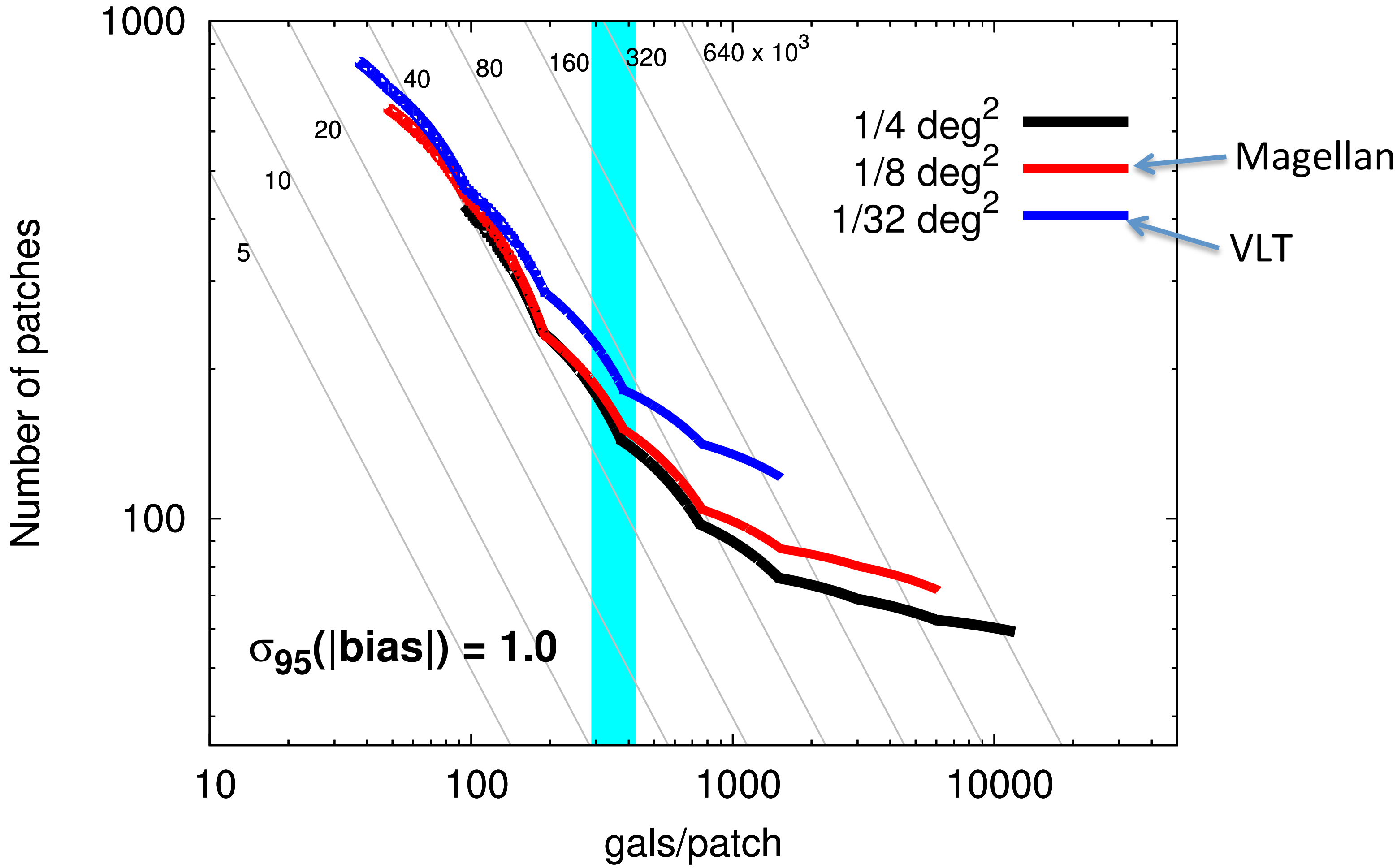
Figure 1. Normalized spectroscopic redshift distribution for the full data. The red (light gray) error bars show the 1-σ variability in the redshift distribution for contiguous 1 deg^2 angular patches. The blue (dark gray) error bars show the variability in the redshift distribution assuming random samples of with the same mean number of objects as the 1 deg^2 patches. We assume that only a 25% random subsample of each patch is targeted for spectroscopy, yielding about 1.2×10^4 galaxies per patch on average.

Cunha, Huterer, Busha & Wechsler arXiv: 1109:5691

Spectroscopic simulations

- N-body + photometry + **spectra**
- N-body + photometry: BCC sims
- Used K-correct built-in spectra, added noise, and derived spectroscopic redshifts using rvsao code.

Survey Calculator



Assuming fiducial σ(w)=0.035, and perfect spectroscopic selection.

Cunha, Huterer, Busha & Wechsler
arXiv: 1109:5691

An example:

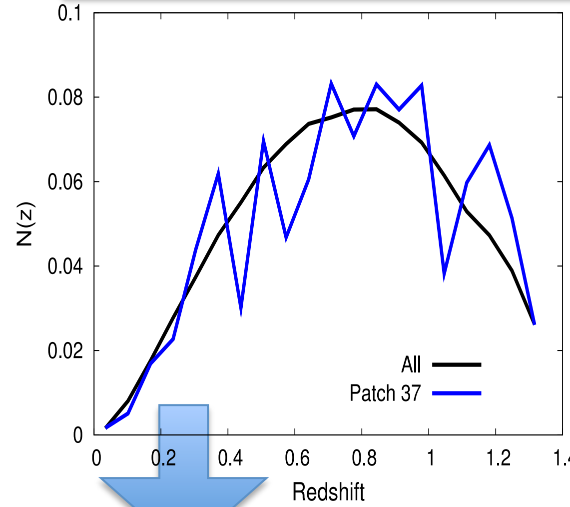
- Template photo-zs.

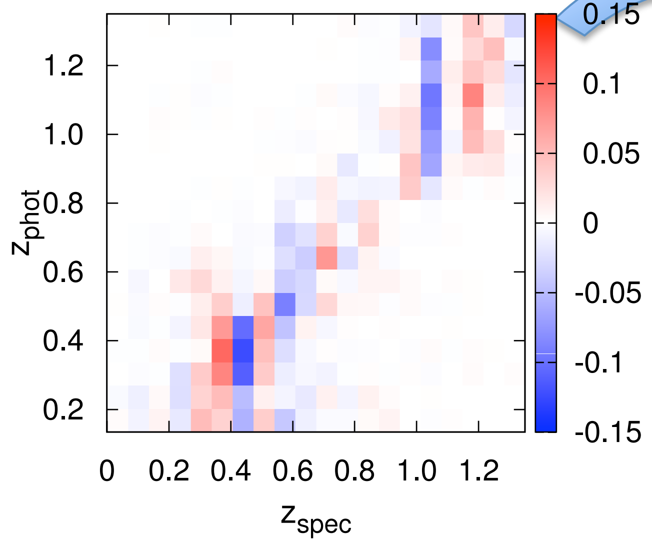
- Calibration using one field with 1 deg^2.

- Weak Lensing shear-shear tomography.

- Difference between true $P(z_s|z_p)$ and that of calibration sample generates biases in cosmology.

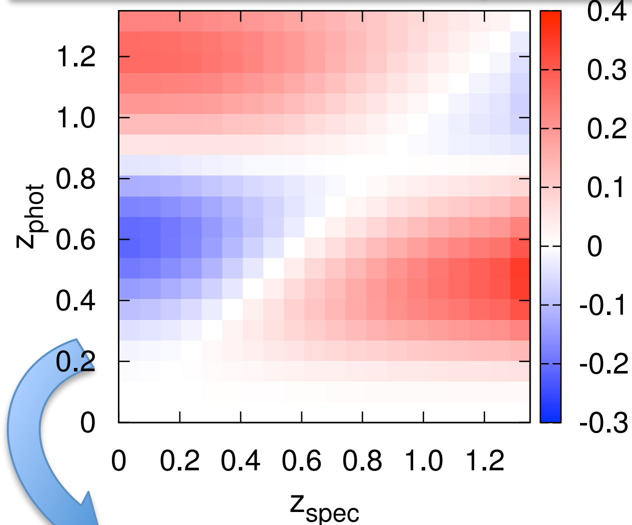
LSS in one 1deg^2 sample

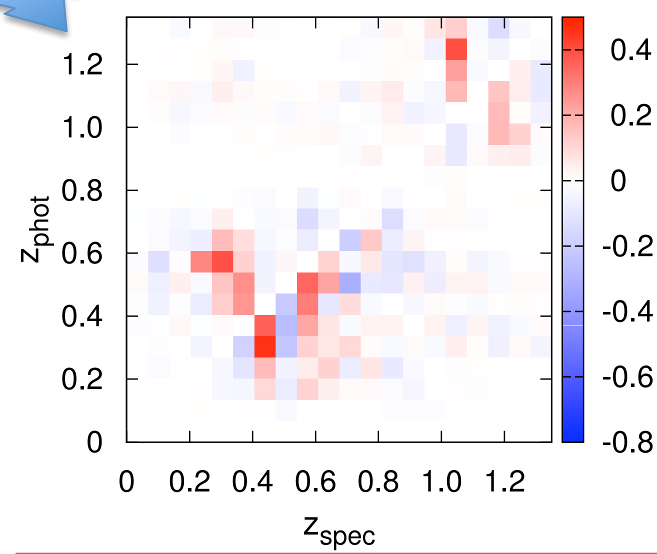




$\Delta P(z_s|z_p) = P(z_s|z_p)_{phot} - P(z_s|z_p)_{train}$

w-bias for fixed $\Delta P(z_s|z_p)$=0.01





w-bias for $\Delta P(z_s|z_p)$ of Patch 37

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