# Photometric Redshift Estimation

**Cody Carr**
Adam Sypniewski
Advisor: Professor David Gerdes

# The Big Bang and the Accelerated Expansion of the Universe

## Big Bang Model of the Universe

- the universe began in a high density state
- the universe is expanding
- universe is 13.7 billion years old

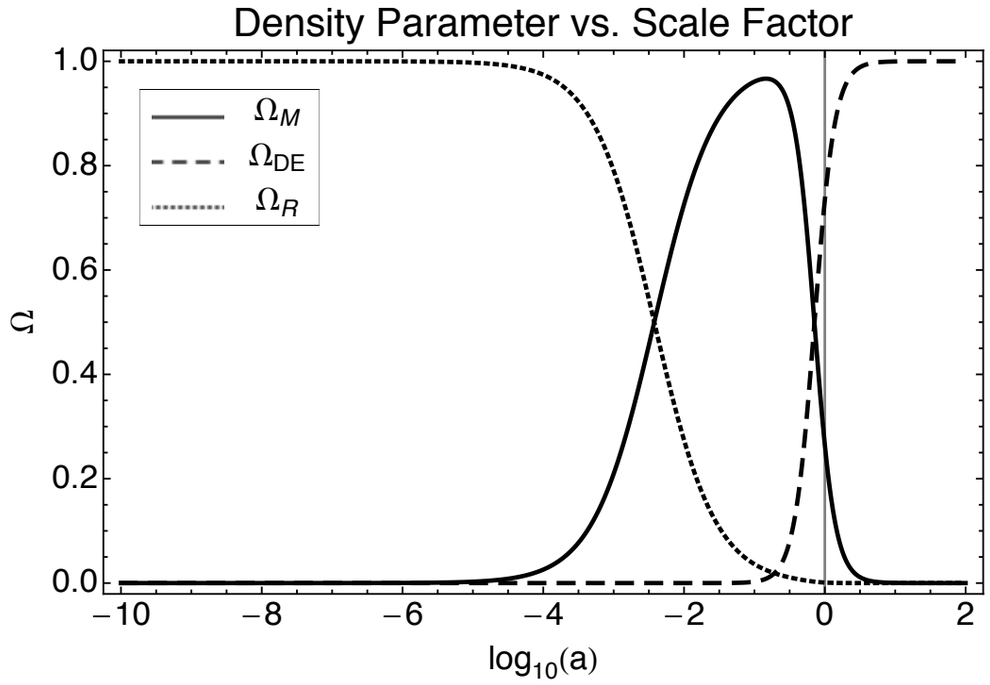
## Accelerated Expansion

- accelerated expansion of the universe discovered in 1998
- ‘dark energy’ mechanism behind the expansion is a mystery
- dark energy is believed to be associated with the energy density of the vacuum (empty space)

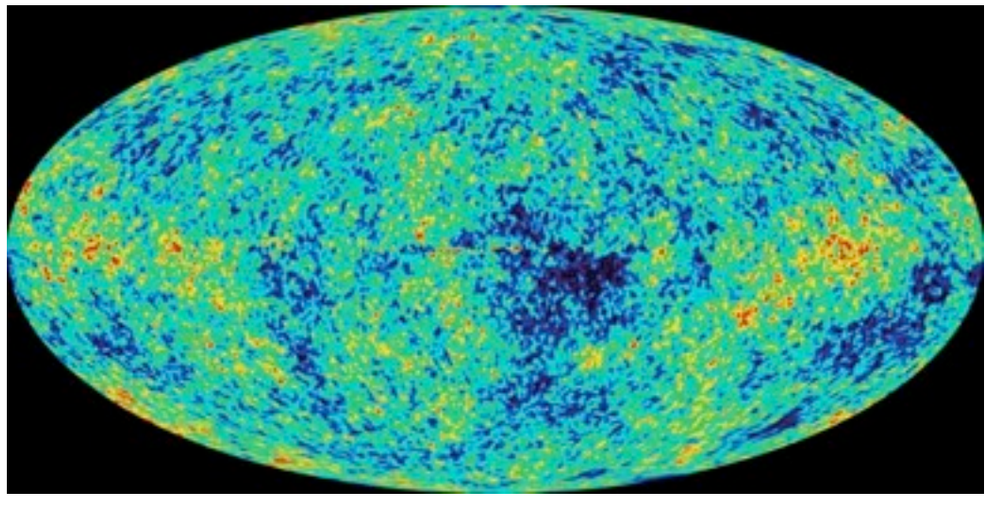
$$\text{redshift (z)} = \frac{\lambda_{0b} - \lambda_{em}}{\lambda_{em}}$$

2011 Nobel Prize, Stockholm, Sweden

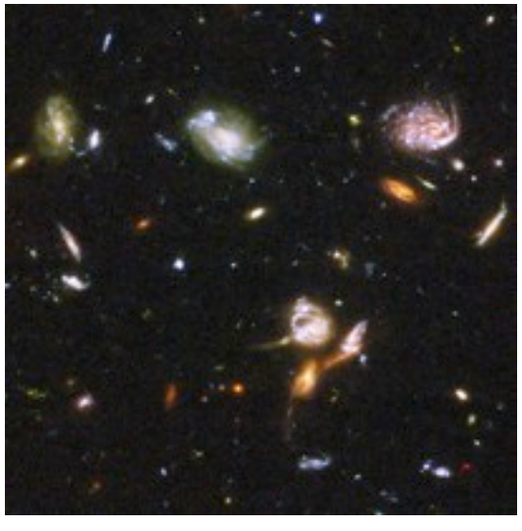
# The Evolution of Structure




Virgo Cluster
(www.astrographics.com)



Cosmic Microwave Background
(cosmology.berkeley.edu)



Hubble Deep Field Image
(wikipedia.org)

# Sloan Digital Sky Survey and the Dark Energy Survey

SDSS 2.5 meter reflecting telescope
(www.sdss.org)

## Sloan Digital Sky Survey (SDSS)

- one of the most influential astronomical surveys of all time
- Data Release 8 (DR8) contains data for over 100 million galaxies
- collected spectroscopic redshifts for over 930,000 galaxies
- redshifts range as far back as 5.78 billion years

## Dark Energy Survey (DES)

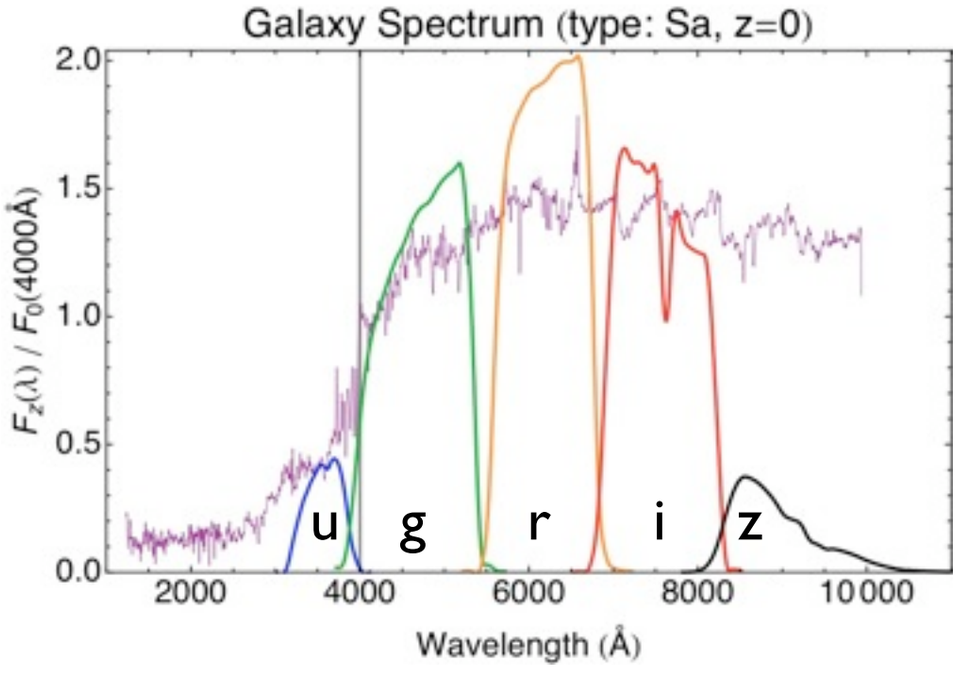
- Stationed at Cerro Tololo Inter-American Observatory, located high in the Andes mountains of Chile
- plans to use 525 nights of observation to collect data for over 300,000,000 galaxies
- redshifts will range as far back as 9.2 billion years

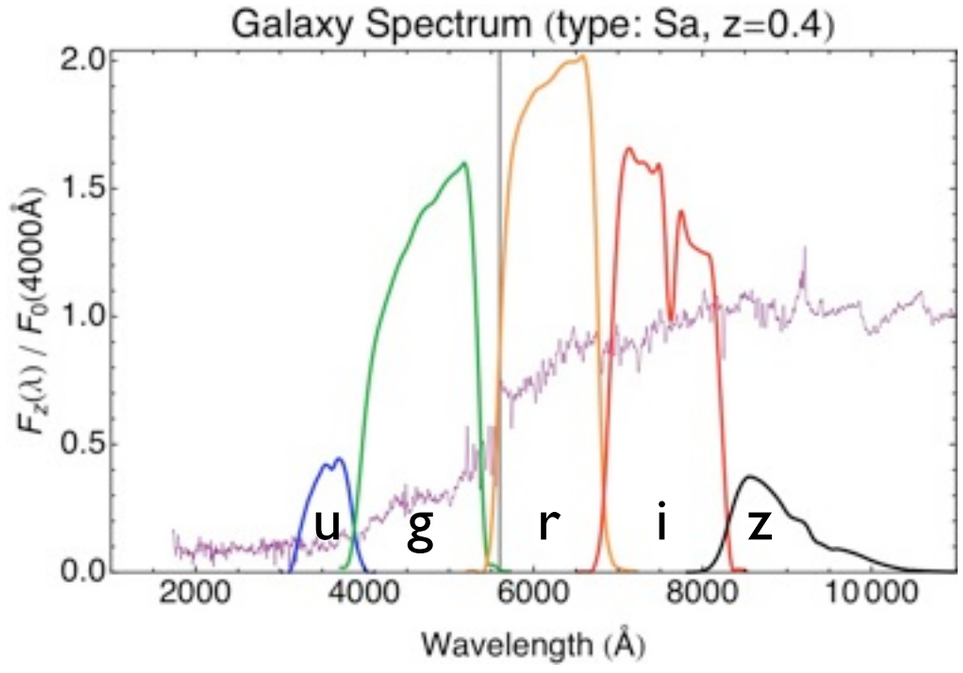
Cerro Tololo Inter-American Observatory
(www.darkenergysurvey.org)

570 megapixel DES camera (DECam), holds 74 CCDs
(www.darkenergysurvey.org)

# Photometric Redshifts

Telescopes for both SDSS and DES use broad band imaging across several passbands to collect information capable of estimating photometric redshifts.

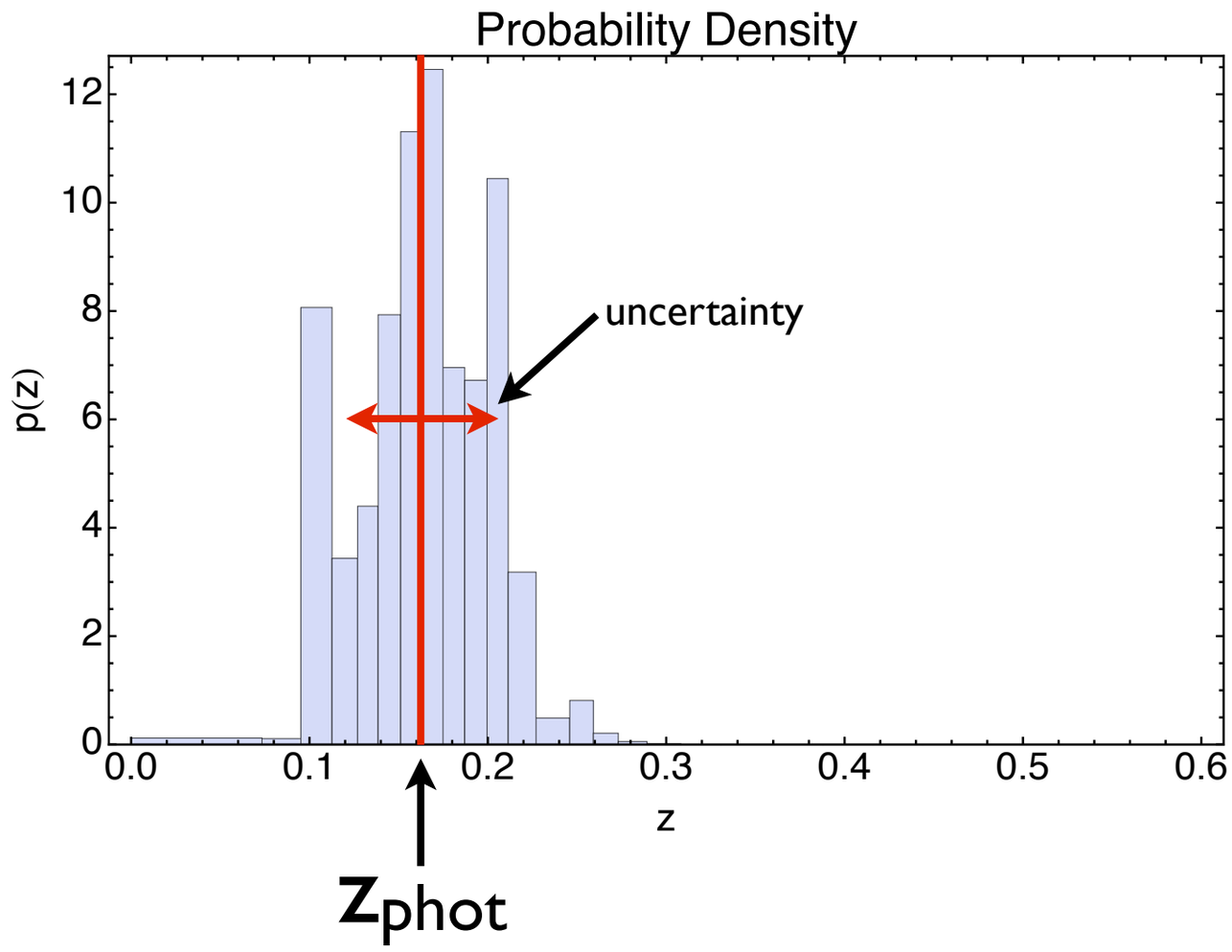


# ArborZ

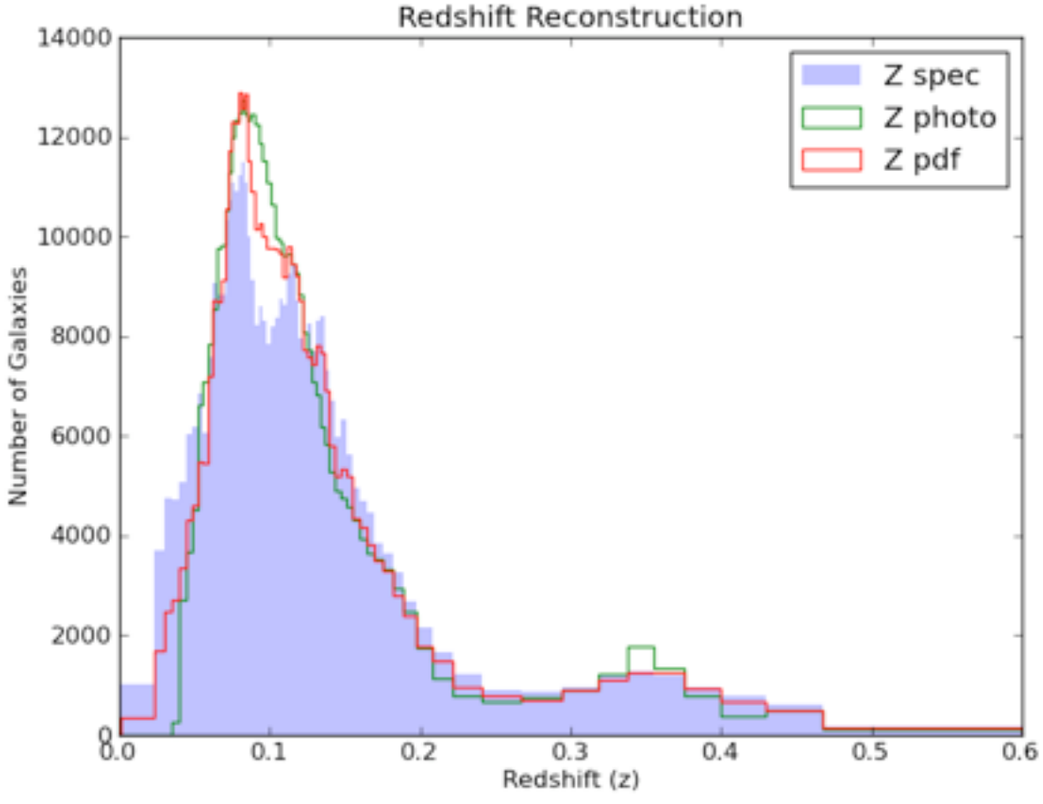
- ArborZ is an algorithm based on boosted decision trees
- trains and evaluates on magnitudes for each passband
- photometric redshift is the mean of the probability distribution

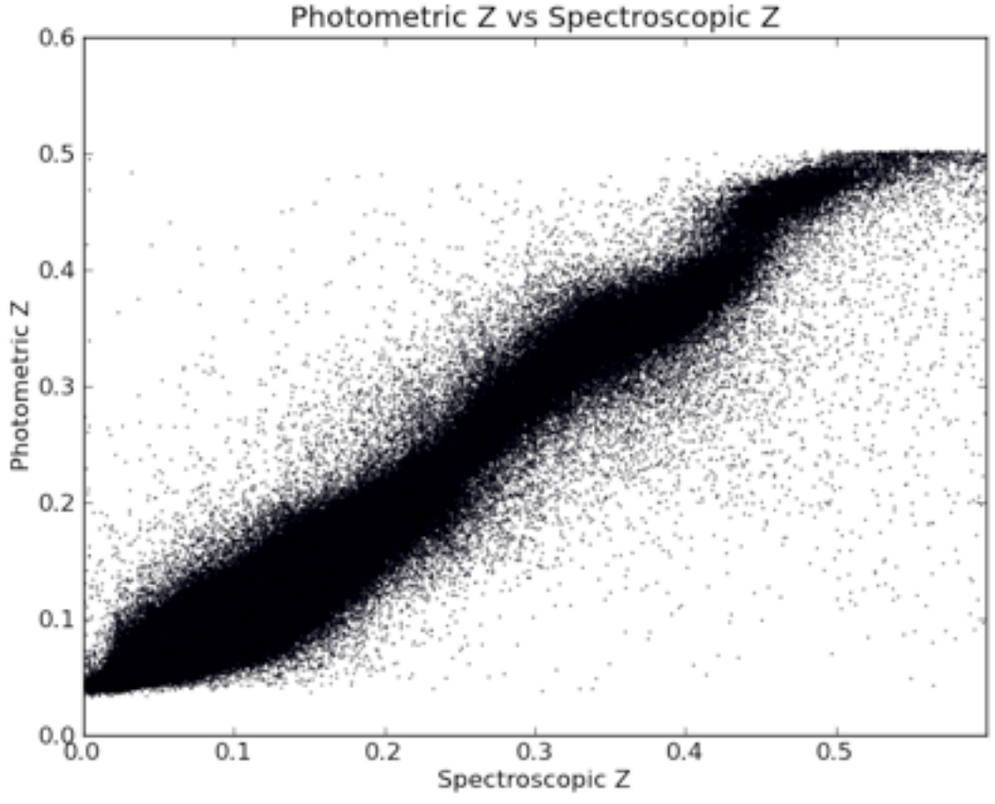
## PDF for a Single Galaxy



# Training and Evaluating ArborZ

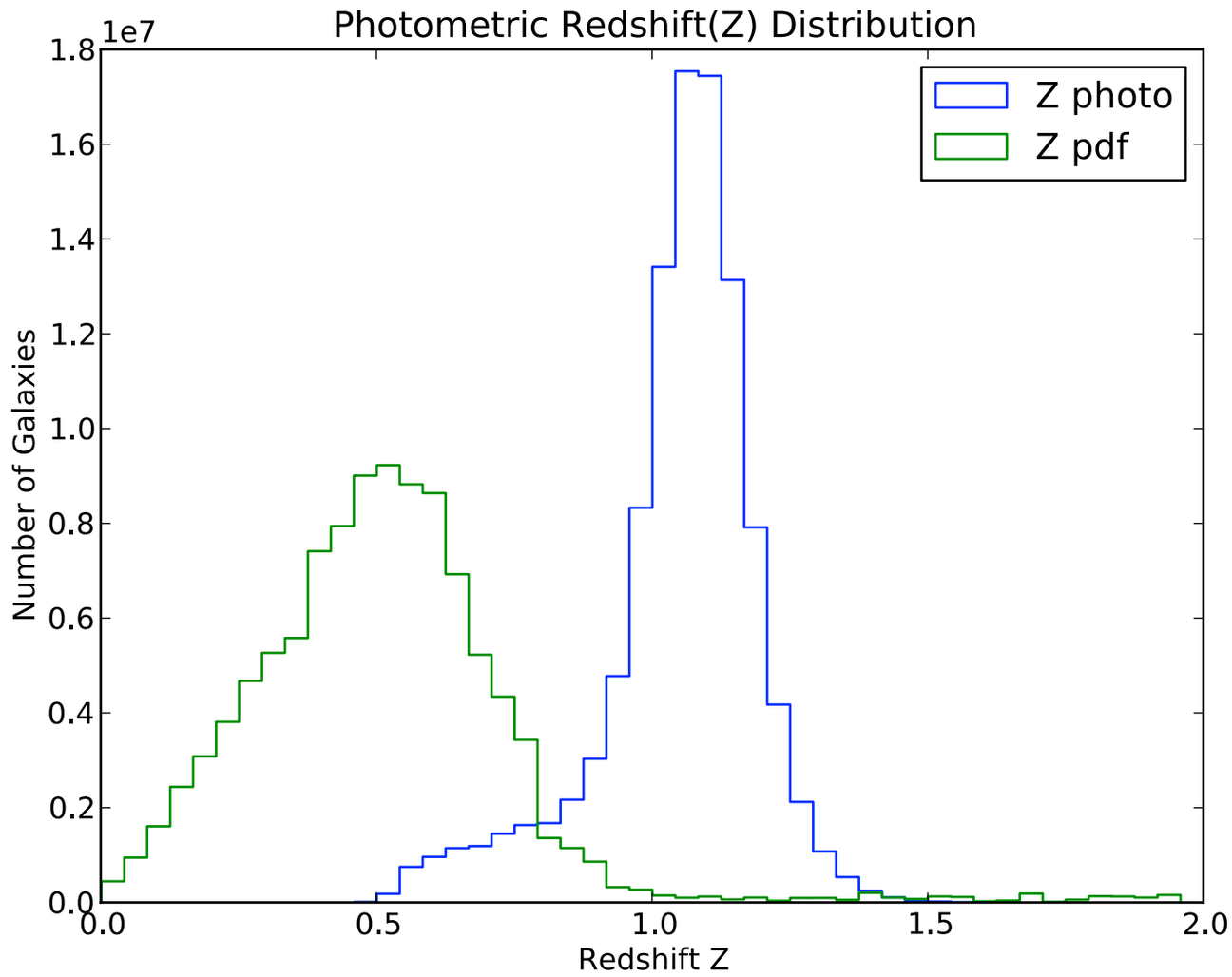
Training and evaluation results for SDSS spectroscopic sample.



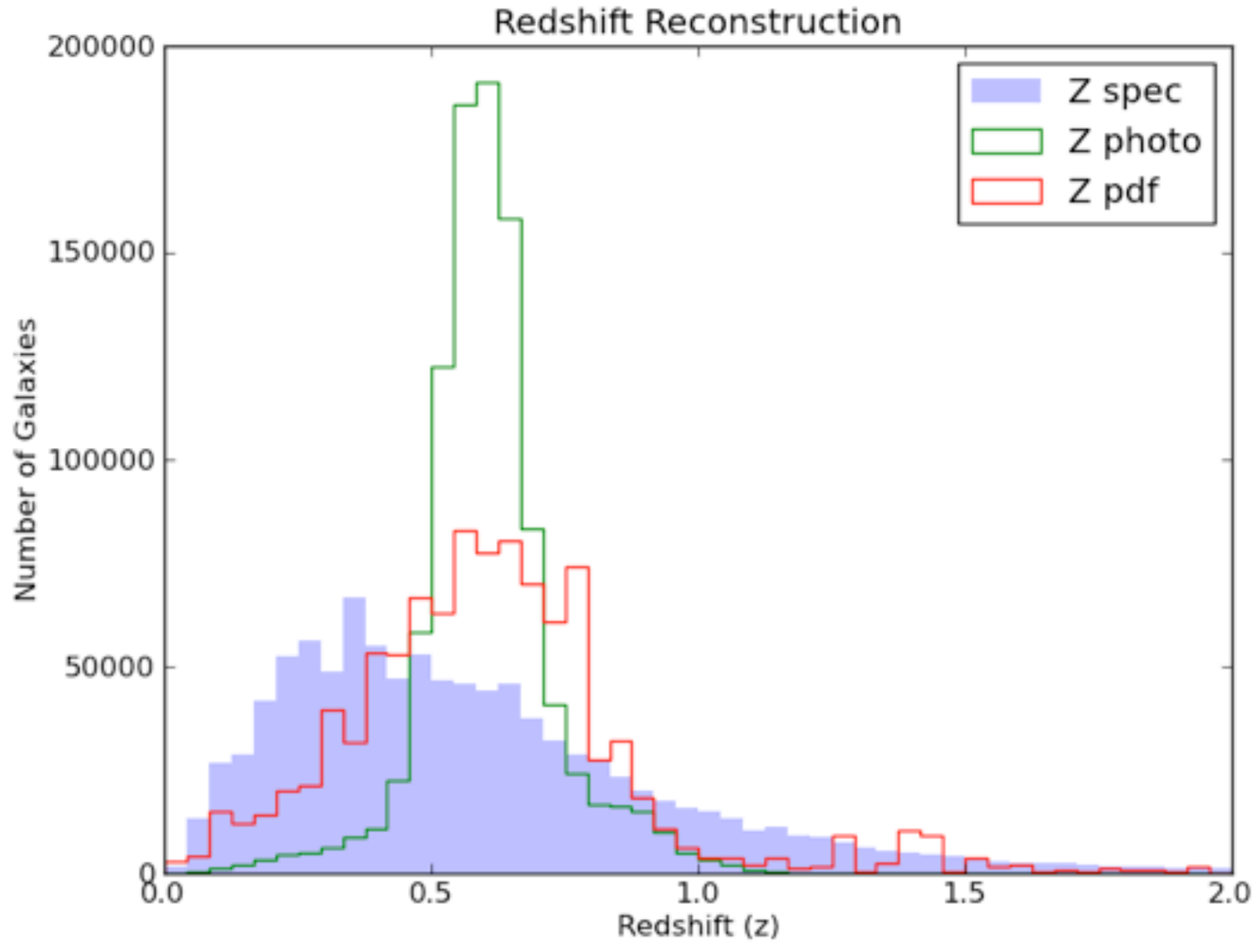
# Evaluating on DR8

- trained on SDSS spectroscopic sample
- evaluated on entire SDSS DR8 sample (105 million galaxies)
- no known spectroscopic redshifts for the evaluation set



# Simulated Galaxy Catalogs

- n-body simulated catalogs
- catalogs mimic magnitudes seen in SDSS DR8



# Summary

Dark energy is still a mystery and scientists are working hard to unlock its secrets. The basis for this search is coming from spectroscopic and photometric redshifts. Optical imaging surveys in the near future such as the Dark Energy Survey and the Large Synoptic Survey Telescope will combine to observe on the order of a billion galaxies emphasizing the need for photometric redshifts.