

Current state of photometric redshift preparations for Rubin

Peter Hatfield, Hintze Fellow, University of Oxford

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Peter.hatfield@physics.ox.ac.uk

1. Photo-z Background
2. Work in the Science Collaborations

This is hopefully a pan-Rubin summary; work in Oxford is in collaboration with Nathan Adams, Matt Jarvis, Aprajita Verma, Nijin Thykkathu, Rebecca Bowler, David Alonso, Steven Roberts, Ibrahim Almosallam and more

1. Photo-z Background

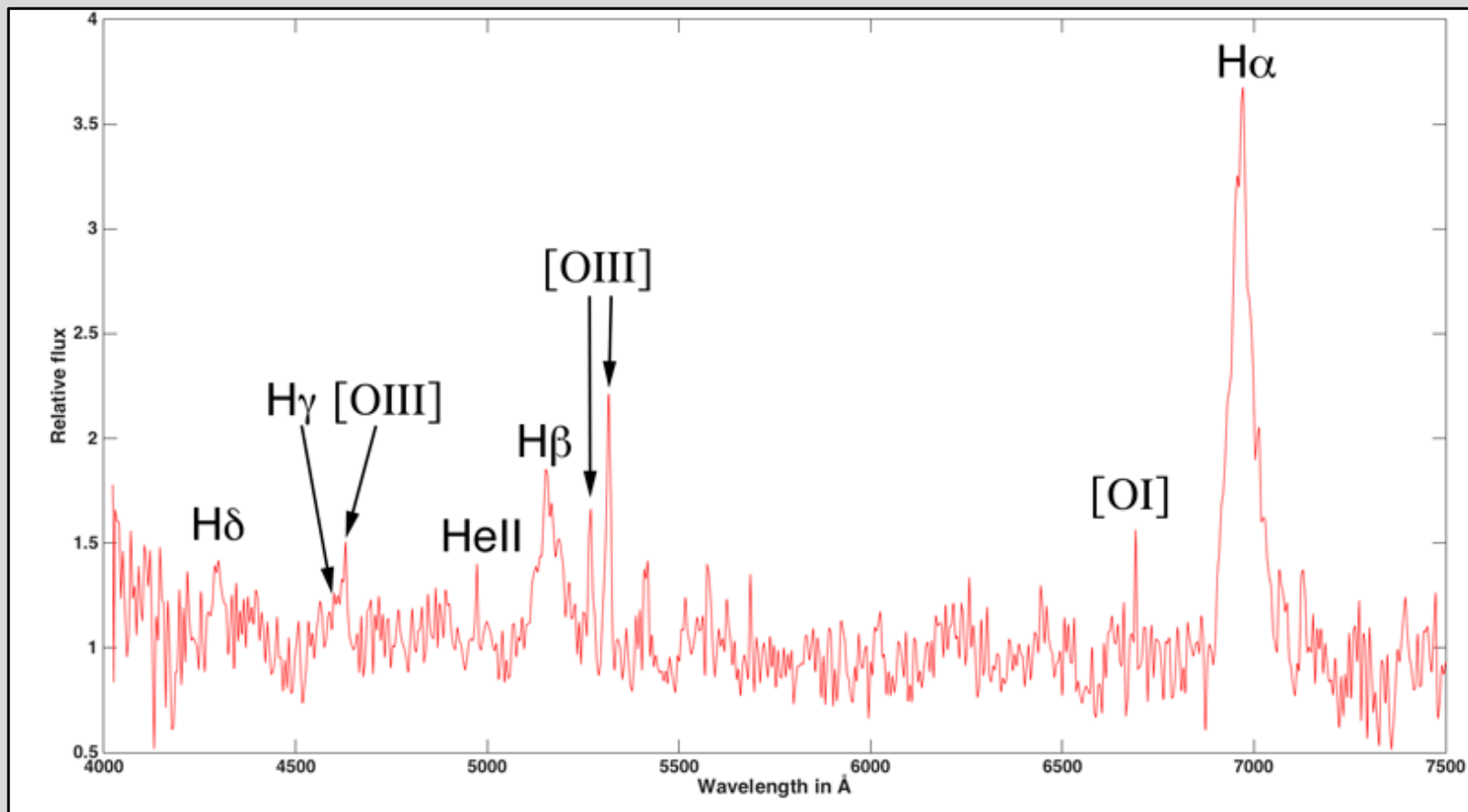
Photo-z necessary for almost all Rubin extragalactic and cosmological science

- Spec-z versus photo-z
- Template based methods
- Machine Learning based methods
- Hybrid estimates
- Other sources of information

1. Photo-z Background

Spectroscopic redshifts – identify emission/absorption lines (or similar) in a measured spectrum

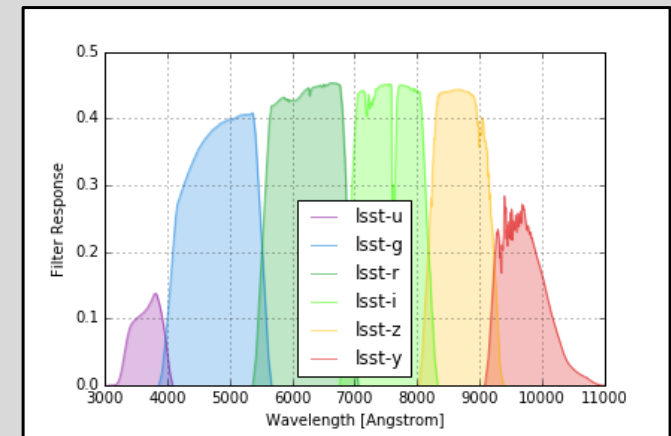
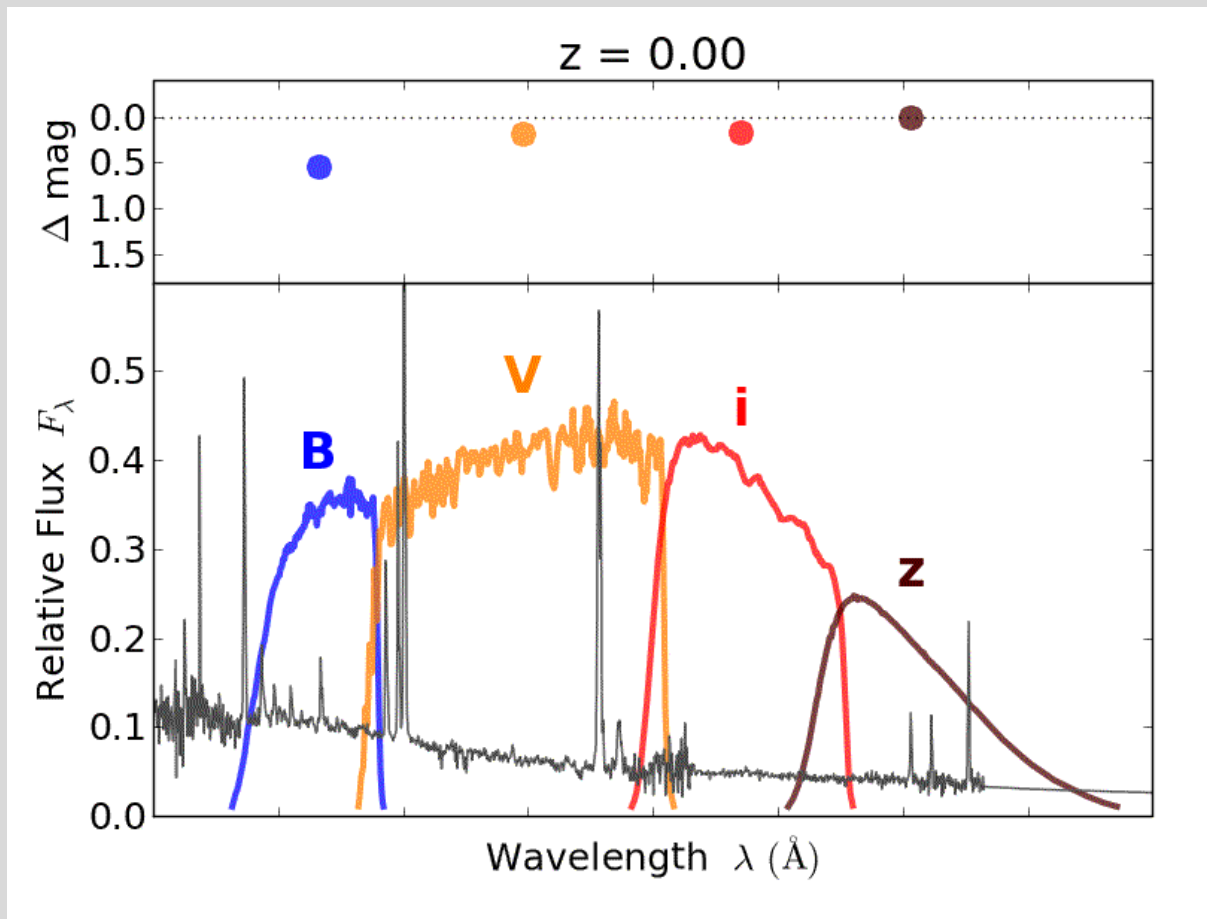
Typically highly accurate (as long as correct line identified), but limited to samples of $\sim 10^5$ - 10^6 galaxies



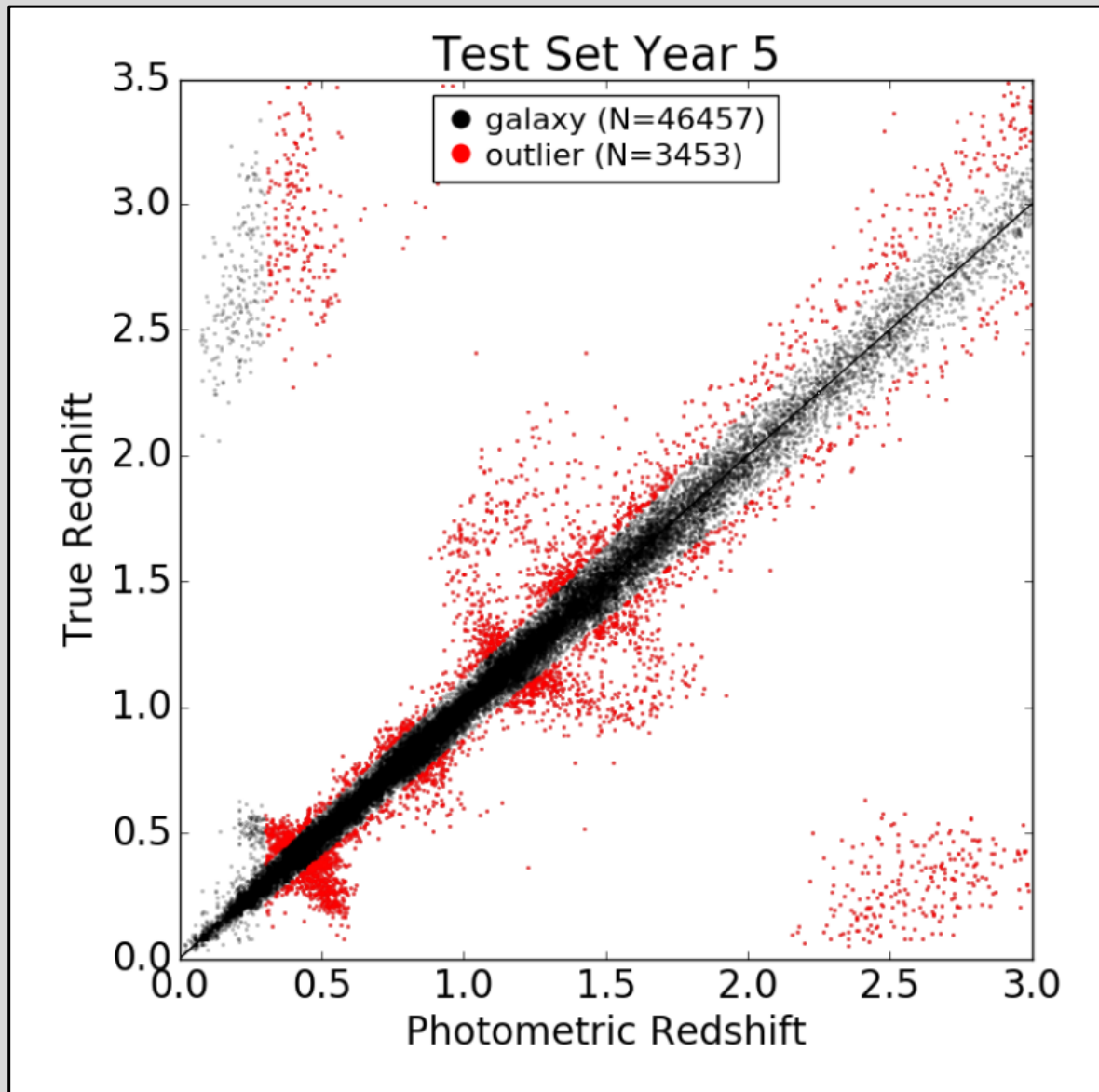
1. Photo-z Background

Photometric redshifts – map N photometric magnitudes to a redshift

Less accurate, but tractable for samples of $\sim 10^6$ - 10^{10} galaxies



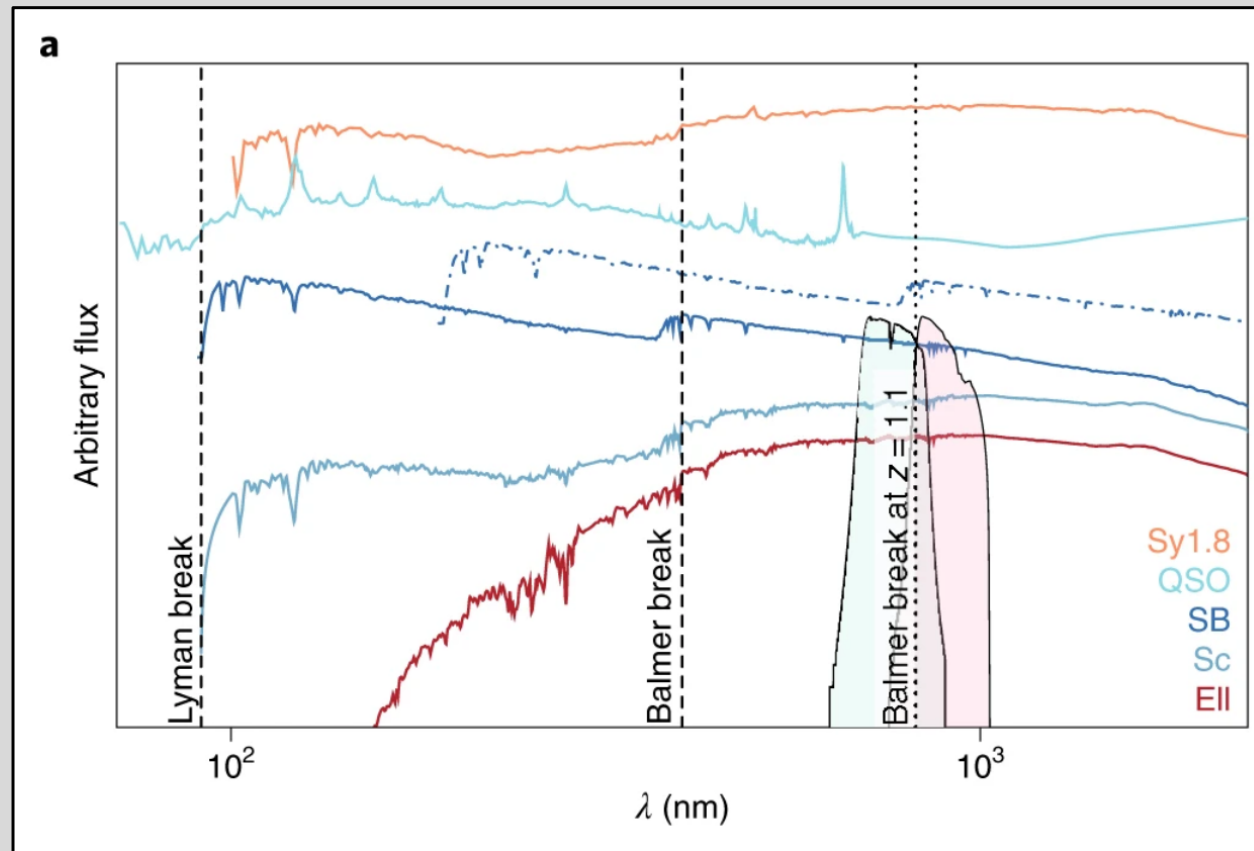
1. Photo-z Background



There are a range of quality metrics – bias, RMSE, fraction of outliers, impact on cosmological parameters...

1. Photo-z Background

Template methods – shift empirical or physically motivated synthetic galaxy templates to find a good fit



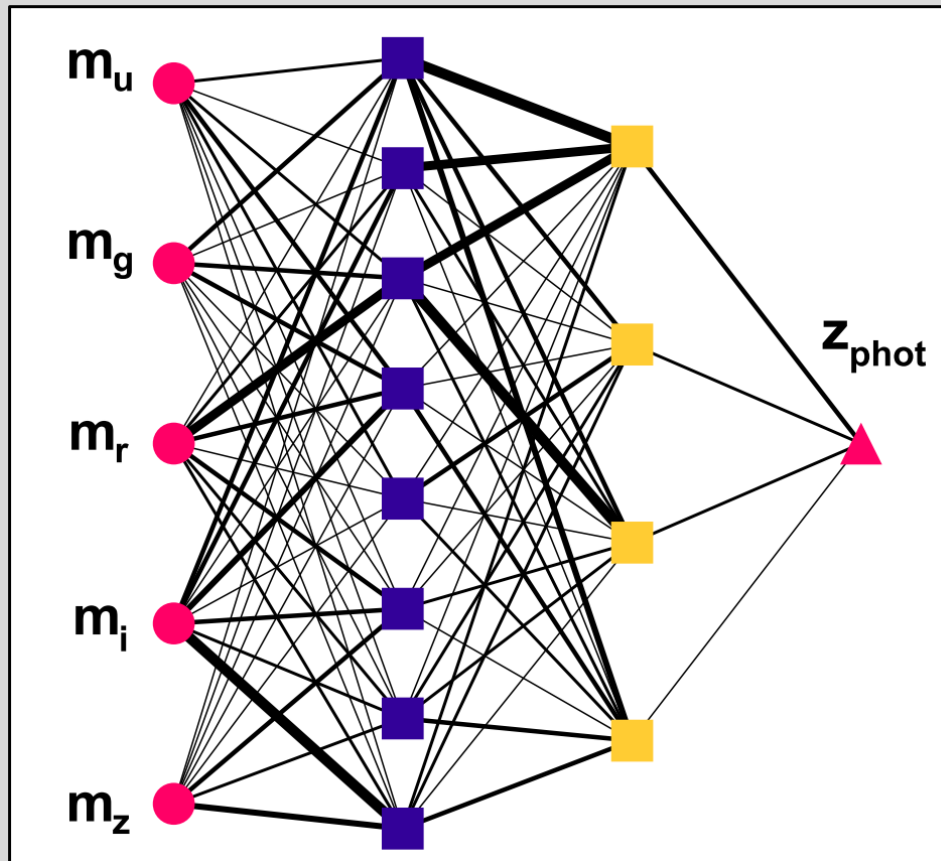
Salvato, Ilbert and Hoyle (2019)

Codes include: LePhare, BPZ, EAZY,...

Challenges: Incorporating dust, choice of priors on template set...

1. Photo-z Background

Machine Learning methods – use galaxies with both spec-z and photometry as a training set for predictions for galaxies with only photometry



Sadeh, Abdalla, and Lahav (2016)

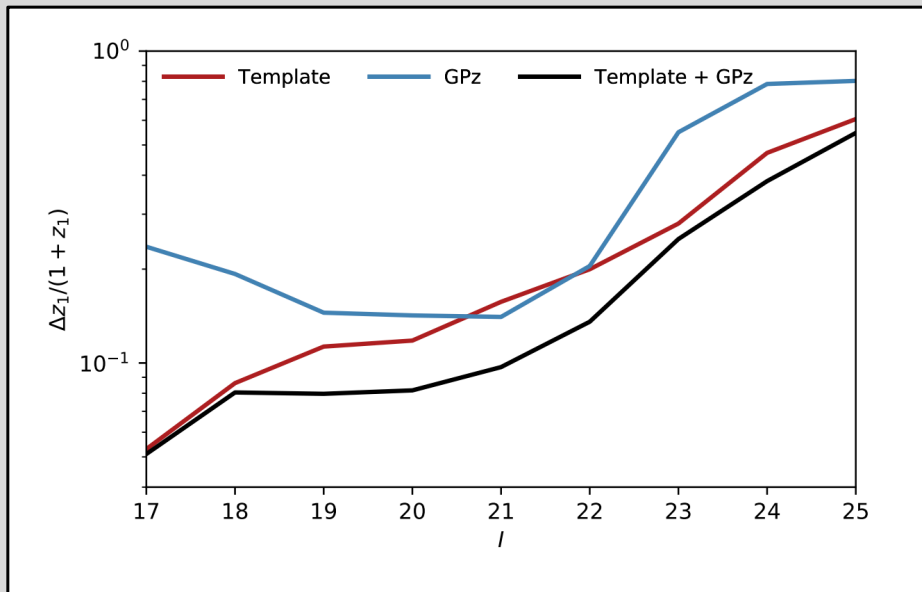
**Neural Networks,
Decision Trees,
Gaussian Processes...**

Codes include: GPz, ANNz2, FlexZBoost, METAPhoR...

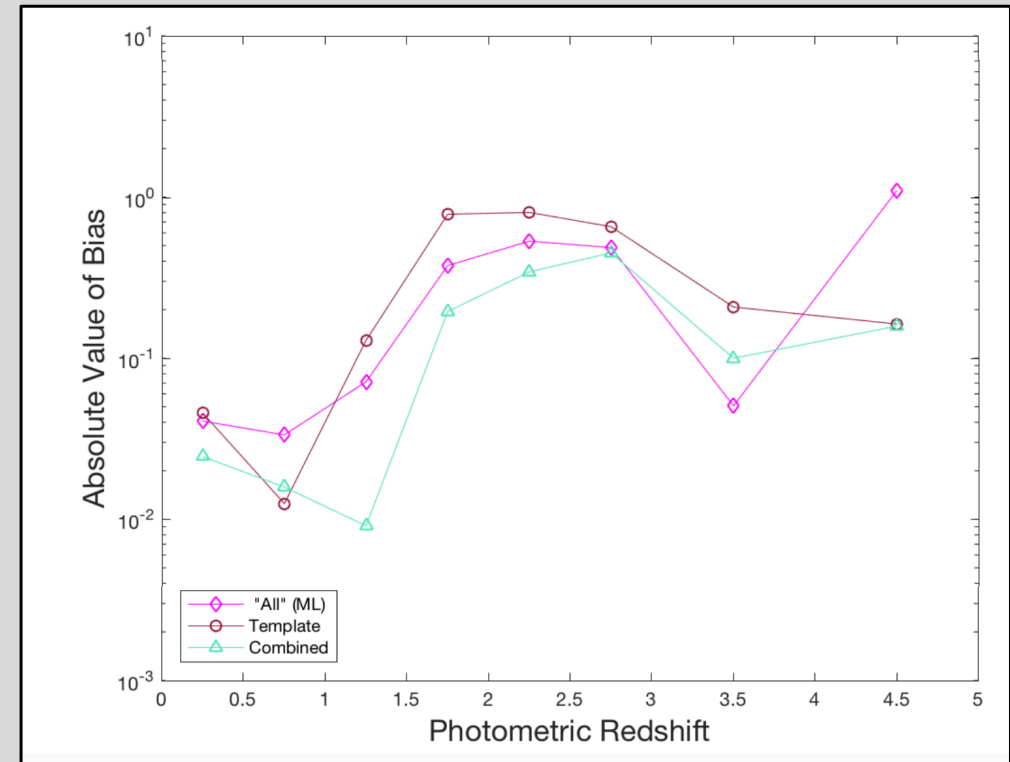
Challenges: Representativeness of training data, missing bands, ...

1. Photo-z Background

Hybrid estimates – try to optimally combine template and ML methods



Duncan et al. (2018)



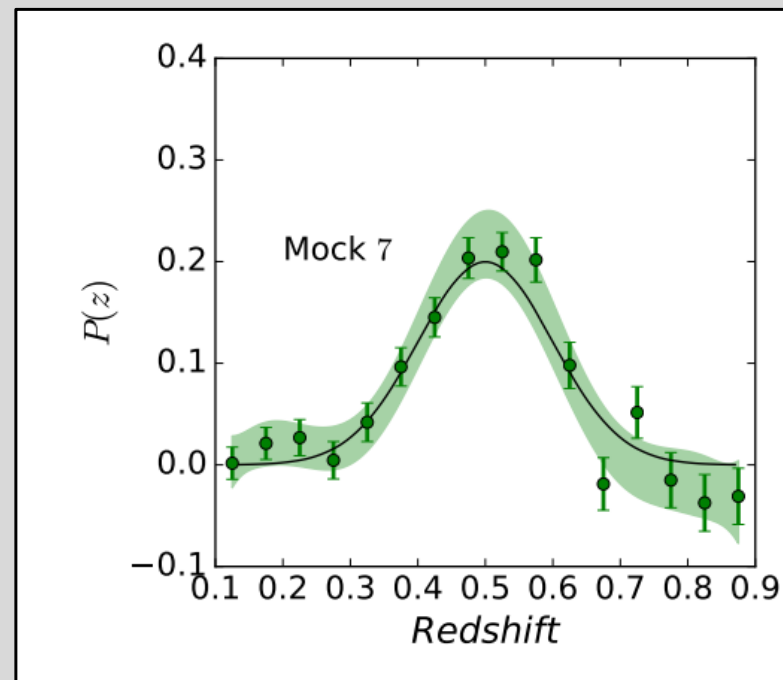
Hatfield et al. (2020)

Methods include: Hierarchical Bayes, quantifying extrapolation, DELIGHT...
Challenges: Correlations between estimates...

1. Photo-z Background

Other sources of Information?

- Additional bands from other surveys (Euclid?)
- Cluster-z?
- Angular size/other morphological information?



Johnson et al. (2017)

2. Work in the SCs

Photo-z are needed for (at least) 4 of the SCs

- Dark Energy
- Galaxies
- AGN
- Strong Lensing

Also interest in the Informatics and Statistics SC

Also work in the Data Management team

Observing strategy impacts on photo-z

2. Work in the SCs

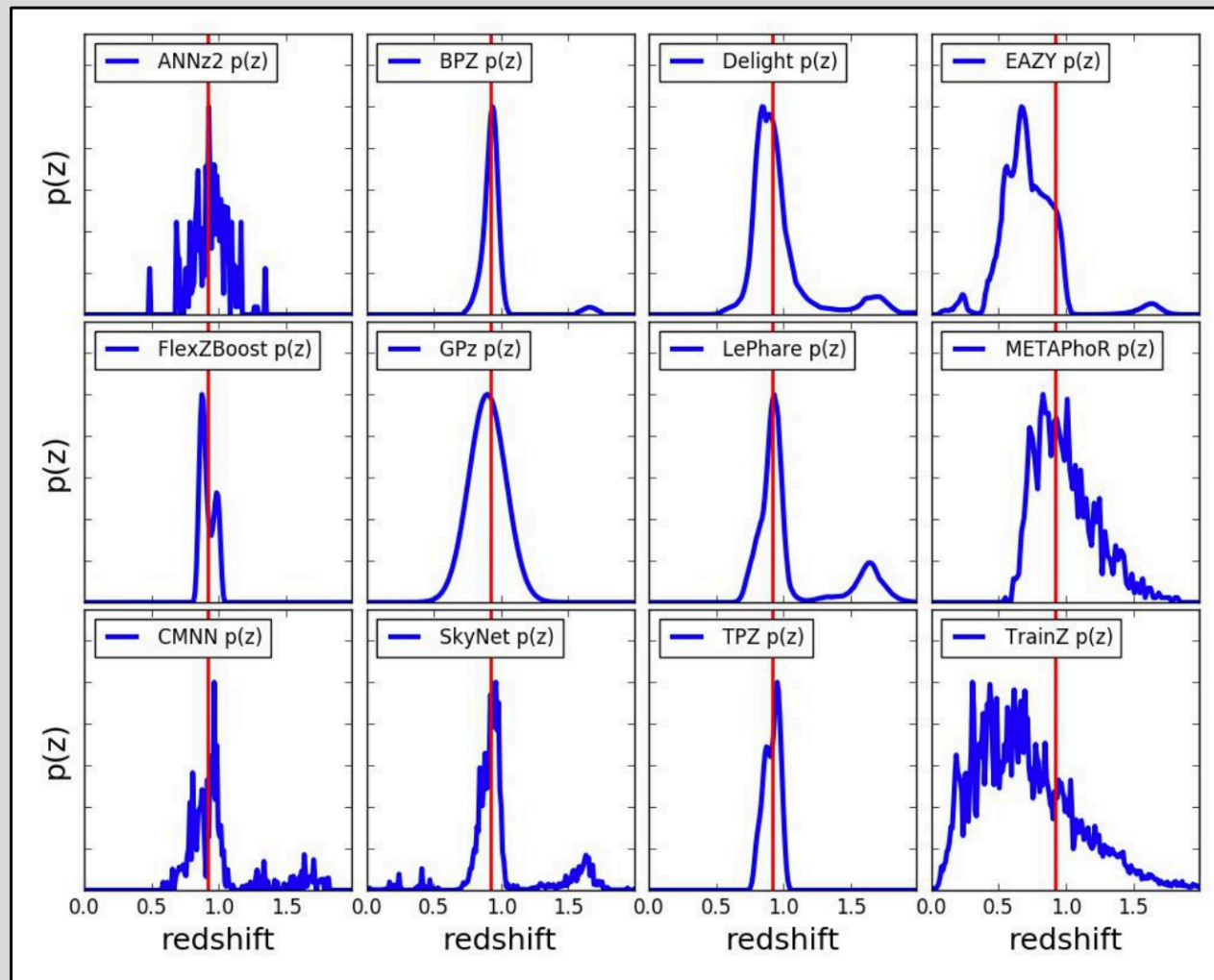
Dark Energy

- Strict set of requirements for 3x2pt analyses (Science Requirements Document; Ivezić & LSST Science Collaboration 2011, defines some minimum target values for photometric redshifts for an $i < 25$, magnitude-limited sample of 4×10^9 galaxies from $0.3 < z < 3.0$ as: 1) the RMS error must be $< 0.02(1+z_{\text{phot}})$, 2) the fraction of outliers must be $< 10\%$; and 3) the average bias must be $< 0.003(1+z_{\text{phot}})$.
- There is a photometric redshift working group, with defined deliverables in the LSST-DESC Science Roadmap and regular meetings
- A series of ongoing data challenges to test performance on increasingly realistic data sets
- Work to develop and benchmark a pipeline, Redshift Assessment Infrastructure Layers (RAIL), with a range of photo-z codes and metrics

2. Work in the SCs

DESC PZ Challenge 1

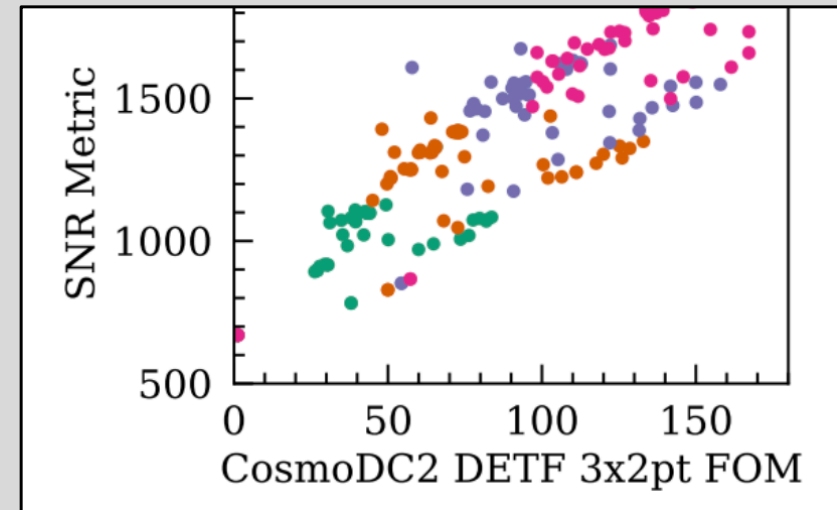
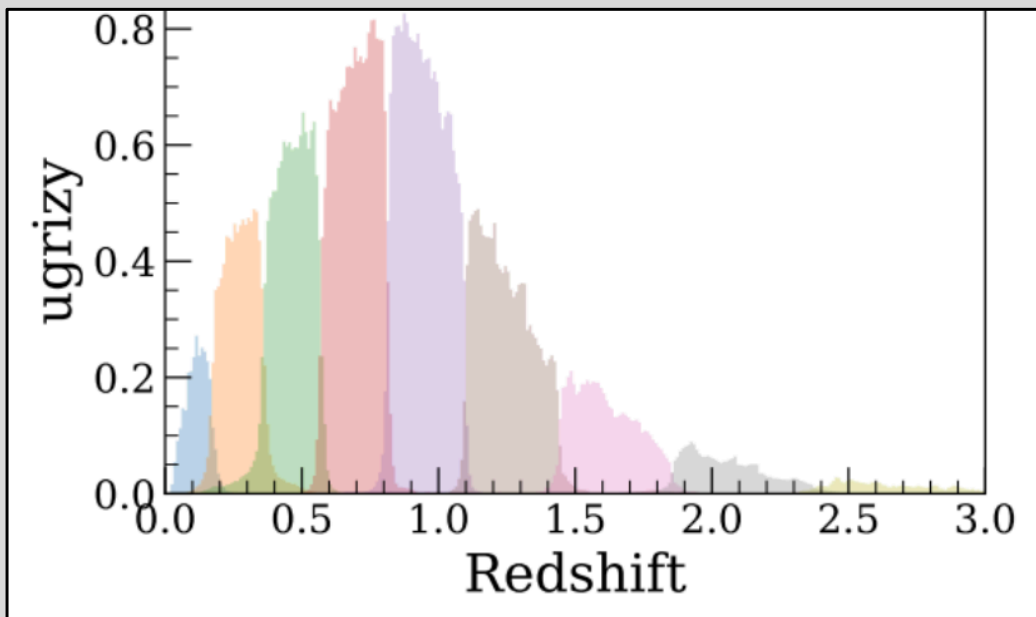
Schmidt, Malz, et al., MNRAS, 499, 2, 1587-1606, (2020)



2. Work in the SCs

DESC Tomography Challenge

Zuntz, et al., internal review, (2021)



2. Work in the SCs

Galaxies

- There is a SED-fitting and Photometric Redshifts working group
- Galaxy Specific issues: greater interest in derived properties, high-z specific issues, blending...

Strong Lensing

- SL specific issues: blending, galaxy type, errors on the redshifts will degrade the cosmological use of time delays...

AGN

- AGN specific issues: including AGN templates, variability...
- Lots of ongoing work, potential data challenge

2. Work in the SCs

Data Management Team

- DMTN-049, photo-z for Object catalogue for DR1 and beyond...
- “minimum scientific attributes and serve the widest variety of science applications”
- Transients and Variable Stars Science Collaboration will use “use LSST-provided Object photo-z to identify and/or characterize extragalactic transient host galaxies”
- Stars, Milky Way, and Local Volume “could be used to reject compact extragalactic objects from stellar samples for population studies and/or spectroscopic follow-up campaigns.”
- Call for “Letters of Recommendation” by Sep 30th 2021

Summary

- Photometric redshifts are going to be a core part of Rubin – needed for almost all extragalactic and cosmological science
- Photometric redshifts can be calculated in two main ways – template based and machine learning based
- Ongoing work within SCs, as well as in the Data Management Team to produce photo-z for a range of applications
- Development of pipeline and increasingly realistic data challenges is continuing
- Many groups in UK contributing to photo-z development