LSST Photometric Redshifts

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LSST photo-z overview

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LSST Project Photo-z Requirements

LSST data enables a wide range of scientific projects with diverse set of photo-z needs, e.g. very accurate N(z) for samples for lensing and LSS; individual galaxy p(z) for transient host galaxy ID; accurate p(z,α) joint distribution of inferred physical properties for Galaxy population studies...

LSST Project has defined specific photo-z requirements as listed in the Science Requirements Document (SRD) for a sample of i<25 galaxies in 0.3<z<3.0. Mainly driven by DESC needs:

- RMS scatter $\sigma_z/(1+z) < 0.02$ for *individual* galaxies
- Fraction of 3σ outliers (η) must be <10% of sample
- The bias (δ) must be $< 0.003(1+z)$

LSST Project has 200 floats allocated in Level 2 database for photo-z storage, current spec (DPDD) says “samples from likelihood” (this can be changed).

Showed that we meet specs in LSST Science Book (under ideal assumptions)

Survey Strategy Tests

Large Synoptic Survey Telescope

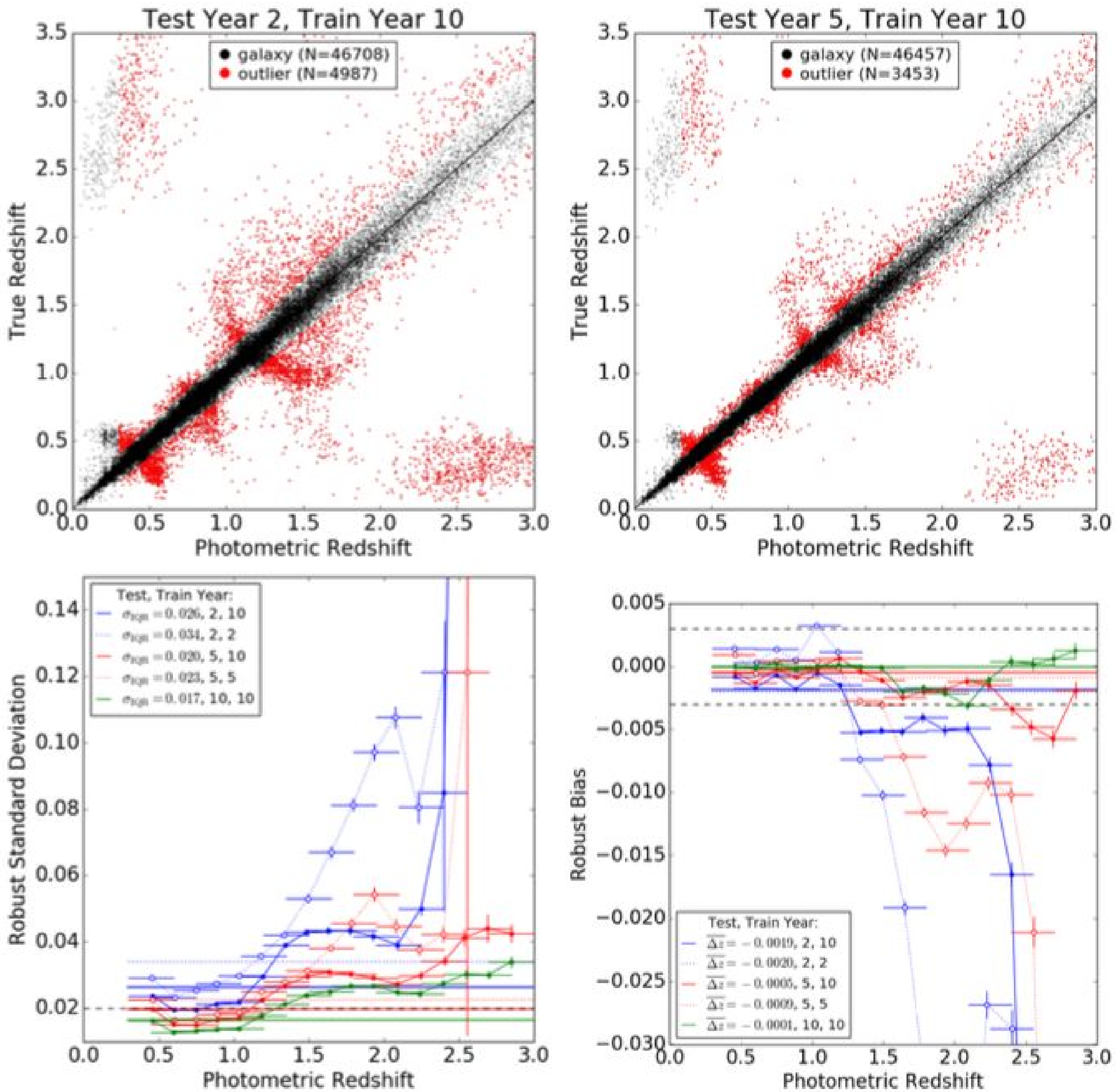
Melissa Graham (UW) has used color matched NN estimate to examine photo-z performance with OpSim and MAF framework:

Shows improvement as survey progresses

Do not meet survey requirements until ~year 5

Need to cover spec-z training fields to full depth early in the survey

Shows that airmass effects aren't large enough to measurably improve photo-z performance



Graham et al. in prep

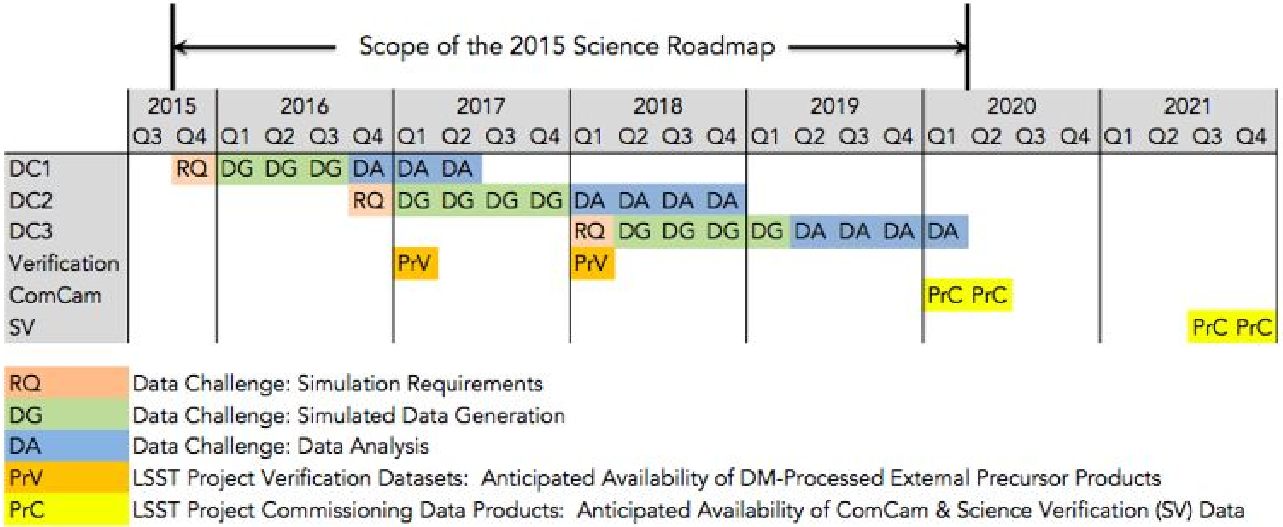
LSST Photo-z Requirements

LSST Project scope does not include photo-z algorithm development, that task has been taken on by the Dark Energy Science Collaboration (DESC) Photo-z working group (PZWG). It is assumed that PZWG will develop recommendations for Project on which algorithm to implement for Level 2 photo-z.

We are developing the infrastructure and working with other Science Collaborations (e.g. Galaxies and Informatics & Statistics) to optimize science results.

Ultimate goal: develop an end-to-end photo-z pipeline with improved algorithm ready to run on LSST data; first proposals for needed spec-z training data; efficient storage of $p(z)$, $p(z,\alpha)$ [stellar mass, SFR]

DESC SRM Plans



Designed around 3 increasingly sophisticated Data Challenges (DCs), leading up to data from the commissioning camera (ComCam) in 2020

Available at:
http://lsst-desc.org/sites/default/files/DESC_SRM_V1_0.pdf

DESC PZ Plans

LSST DESC Dark Energy Science Collaboration

Table 4.6.1: Photometric Redshift key analysis tools

Analysis Tool/CODE NAME	Purpose	DC1	DC2	DC3	ComCam
Photo-z Simulations PZGALAXYGENERATOR	Provide testbed for exploring systematics & incompleteness impact on photo-z's	**PZ1 Provide realistic estimates of shapes of $p(z)$ from LSST**	**PZ1 Incorporate spectroscopic incompleteness and template mismatch into simulations**	Refine LSST $p(z)$ shape / uncertainty estimates with realistic systematics from imaging simulations	N/A
Photo-z Algorithms PZPDF	Calculate PDFs $(p(z,\alpha))$ from photometry	**PZ1 Test calibration of $p(z)$'s provided by existing algorithms**	**PZ3 Test provision of $p(z)$ on DC2 dataset**	**PZ3 Test provision of $p(z,\alpha)$ on DC3 dataset, methods for combining results from multiple codes**	Run resulting photo-z codes on survey data
Training Methods PZPDF	Optimize photometric redshift results from algorithms, given a training set		**PZ1 Test methods of training with incomplete spectroscopy; CX1 Develop methods for mitigating blending**	**PZ3 Refine use of training information within photo-z algorithms**	
Calibration Methods PZCALIBRATE	Determine actual $p(z)$ for comparison to estimated $p(z)$'s	**PZ2 set requirements on DC2 simulations for cross-correlation calibration tests**	**PZ2 Test cross-correlation calibration algorithms**	**PZ3 Test end-to-end calibration on DC3 data**	Run end-to-end calibration pipeline on survey data
Spectroscopic Training Sets PZSPECZSELECTOR	Obtain spectroscopic redshifts for galaxies to improve photo-z algorithms	Work with DES and other precursor teams to obtain training samples to pre-LSST depth	**PZ1 Set requirements for spectroscopic redshift training sets**	**PZ4 Develop efficient spectroscopic redshift target selection algorithms**	**PZ4 Obtain training samples with proposals to new spectrographic instruments**

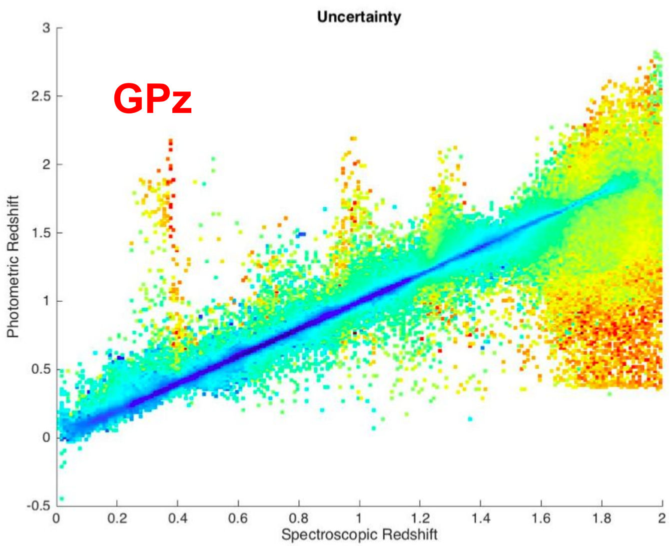
Notes: work described in gray will be done separately from the data challenges, and in some cases, by the community outside DESC. Work described in black is to be done by DESC members as part of the DC1/2/3 to LSSTComCam Roadmap. Work planned in **bold font** will be part of a DESC Data Challenge Key Project, as described in this section.

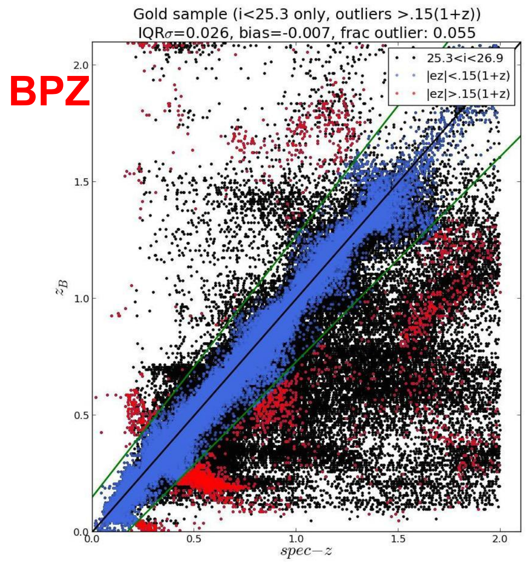
Data Challenges

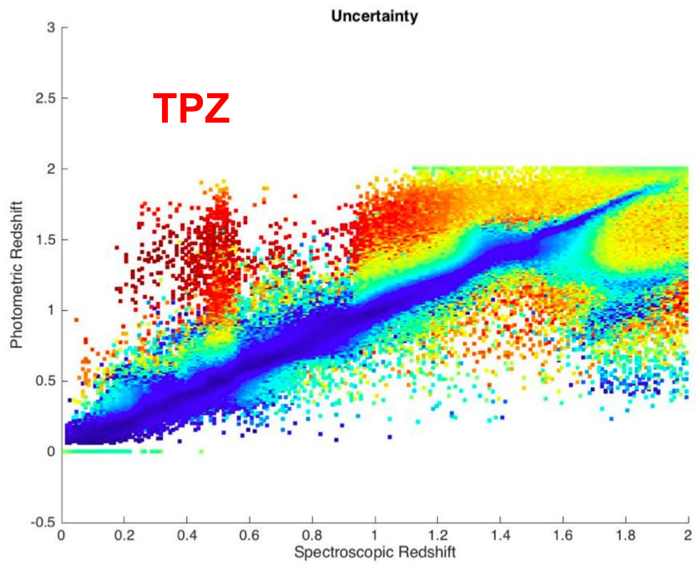
DC1: PZ code tests with representative training data

- 2 simulations (abundance matched galaxies, SAM galaxies added to DM halos); 0<z<2; i<26.9; 10 year LSST depth, 1 million test, 100k training.
- Running ANNz2, BPZ, EAZY, GPz, LePhare, TPZ, + few new codes
- Stats on all i<25.3 galaxies (req), “best” cut (not extreme)
- Goal: test whether p(z) produced by codes matches “true” probability distributions when perfect training data supplied

Analysis continues, paper forthcoming by Fall 2017

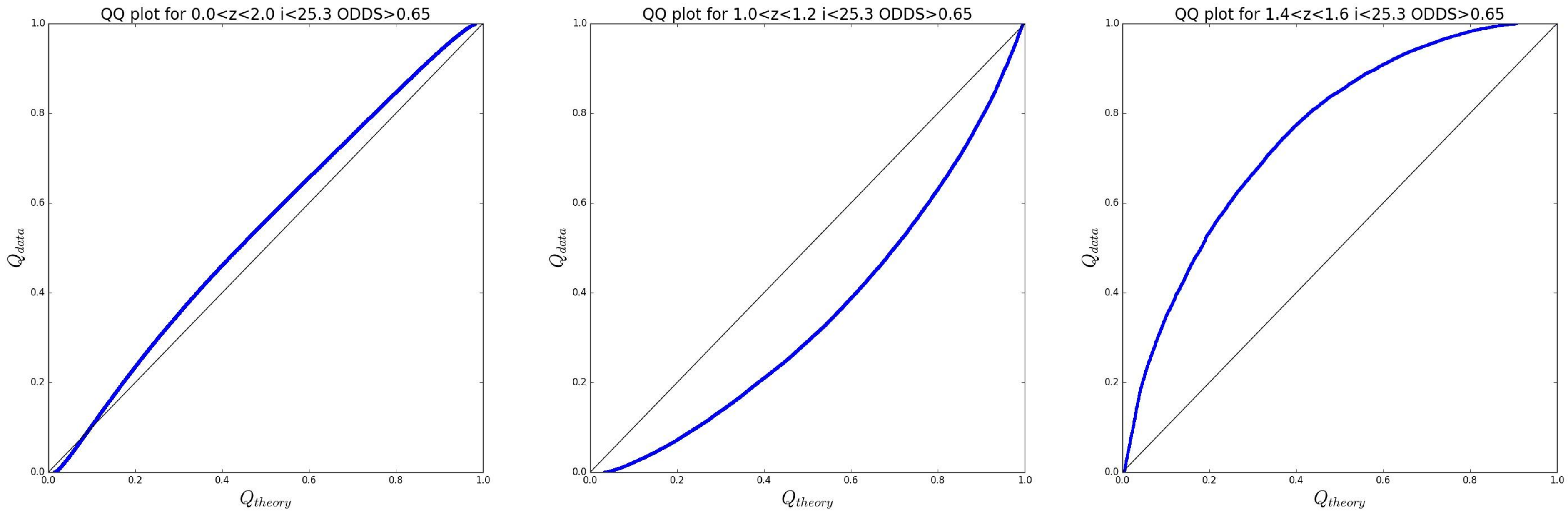






P(z) metric

We have been using Quantile-Quantile (QQ) plots to evaluate accuracy of p(z), see problems when binned by z_{peak}, as has been mentioned during the meeting. More from Alex shortly...



e.g. BPZ full   1.0<zpeak<1.2,   1.4<zpeak<1.6

DC2

Add (semi) realistic incompleteness to training sets, see how codes respond.

Begin to develop spec-z targeting algorithms that account for incompleteness, building on work in Newman et al. “Spectroscopic Needs” white paper (arXiv: 1309.5384)

Begin tests of spatial cross-correlation redshift calibration

Examine effects of foregrounds, blending, and addition of NIR bands (Euclid/WFIRST) on photo-z performance

DC3: Tie everything together in a single pipeline

Previous Workshop

We held a workshop at Pitt in 2016 asked similar questions to some that were asked here in Sendai. Talks and summary conclusions of discussion sections are available here:

https://sites.google.com/site/pittphotozworkshop2016/home/agenda

(discussion summaries are at the bottom of the page)

Key Challenges

- Testing that p(z), p(z,α) are accurate
- Combining photo-z's from multiple algorithms and/or developing one "definitive" photo-z algorithm
- Optimizing spectroscopic samples and dealing with spectroscopic incompleteness
- Methods for training algorithms that are robust to false "secure" redshifts in the sample
- Efficient storage of multidimensional PDF information
- Are Galactic dust maps good enough, particularly at small scales?