Monthly Notices
of the
ROYAL ASTRONOMICAL SOCIETY

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Overconfidence in photometric redshift estimation

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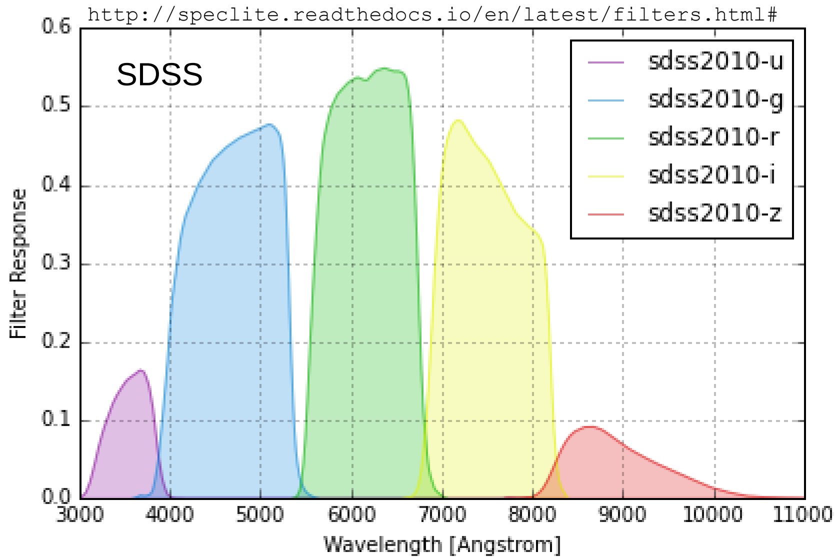
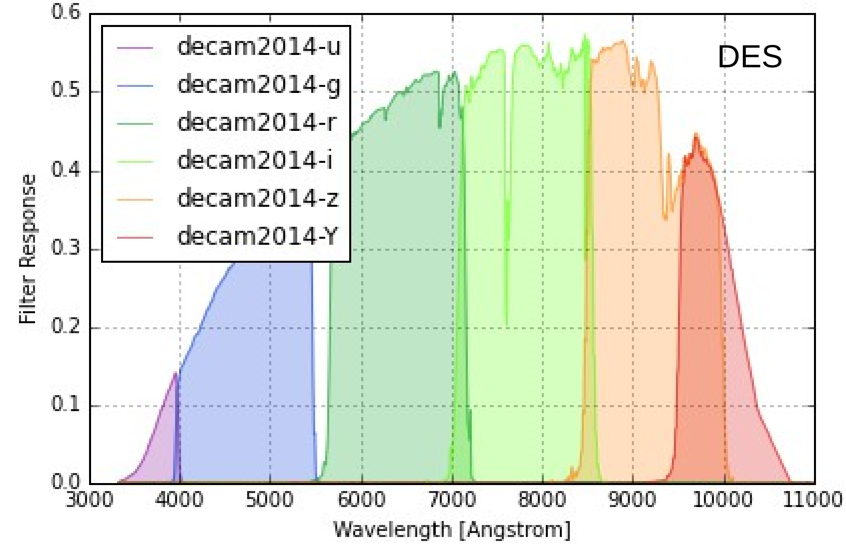
ABSTRACT

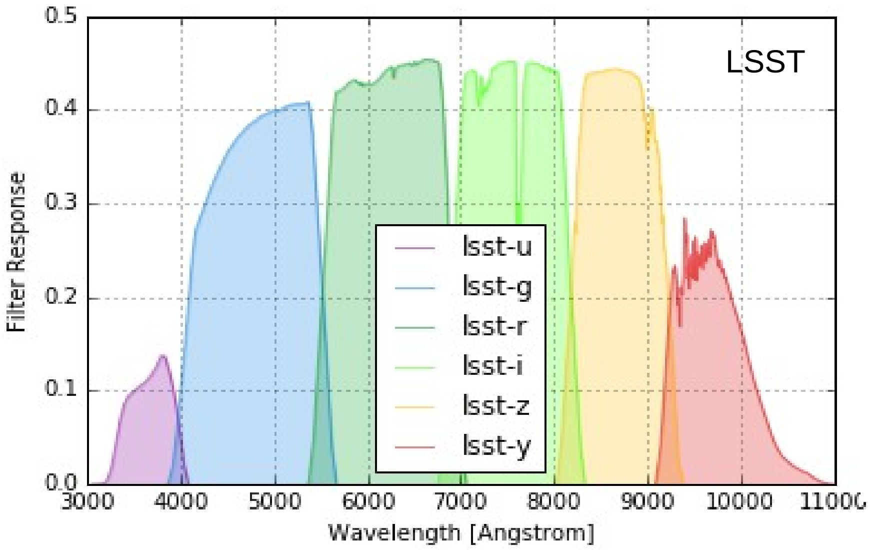
We describe a new test of photometric redshift performance given a spectroscopic redshift sample. This test complements the traditional comparison of redshift *differences* by testing whether the probability density functions $p(z)$ have the correct *width*. We test two photometric redshift codes, BPZ and EAZY, on each of two data sets and find that BPZ is consistently overconfident (the $p(z)$ are too narrow) while EAZY produces approximately the correct level of confidence. We show that this is because EAZY models the uncertainty in its spectral energy distribution templates, and that post-hoc smoothing of the BPZ $p(z)$ provides a reasonable substitute for detailed modelling of template uncertainties. Either remedy still leaves a small surplus of galaxies with spectroscopic redshift very far from the peaks. Thus, better modelling of low-probability tails will be needed for high-precision work such as dark energy constraints with the Large Synoptic Survey Telescope and other large surveys.

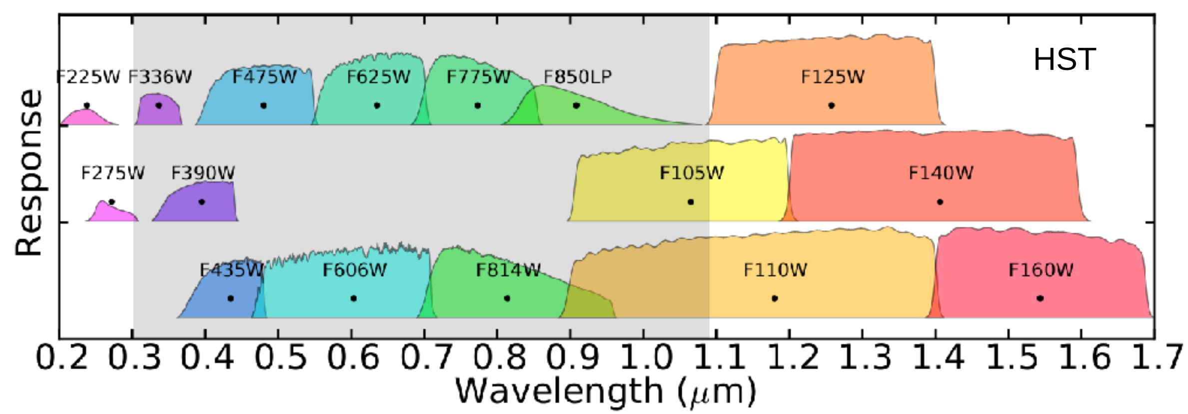
Key words: methods: statistical – surveys – galaxies: photometry.

Photometric systems

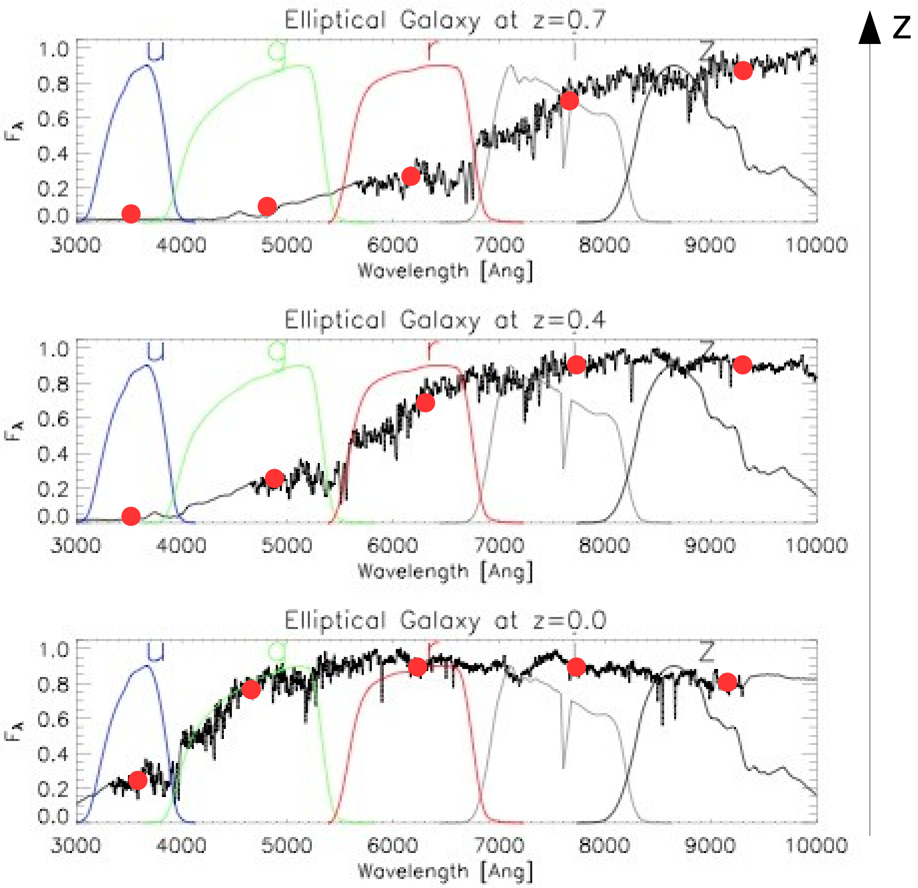








Photometric redshift estimation



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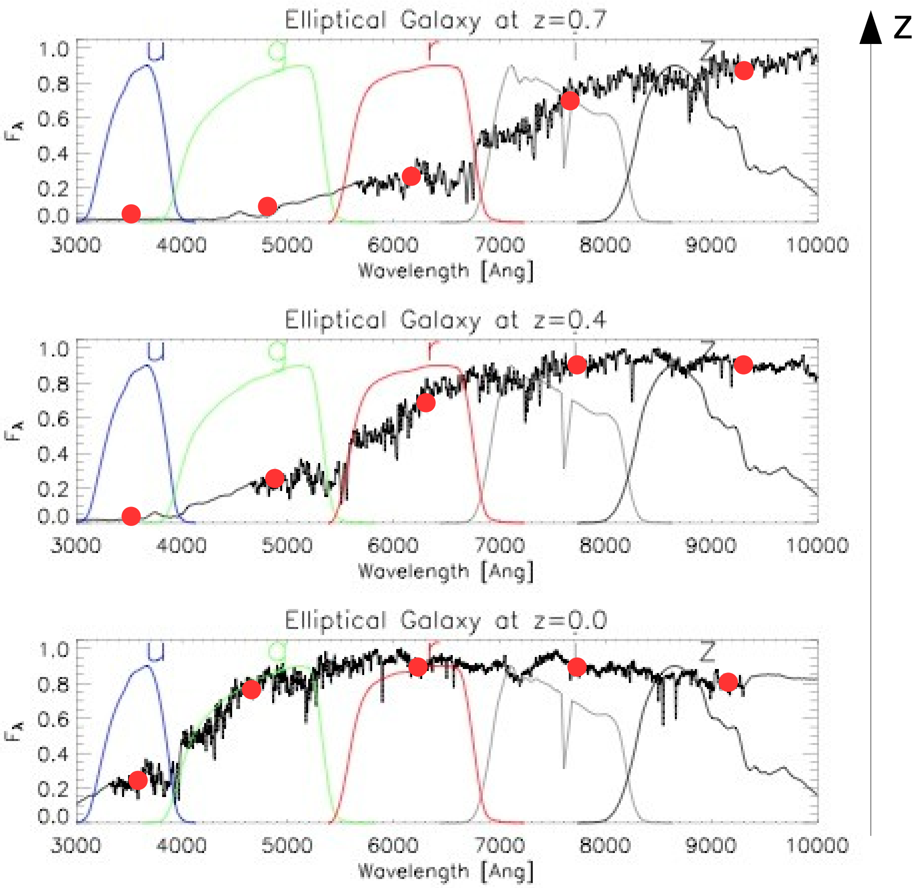
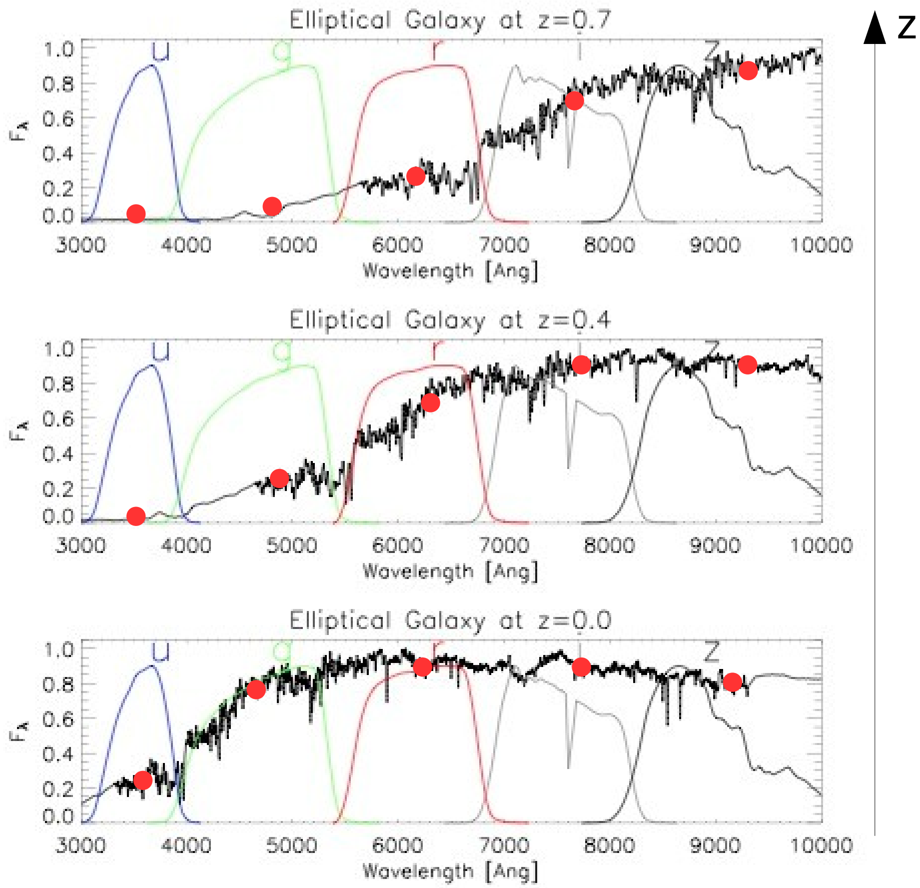


For urgiz system → 5 magnitudes / object

Machine learning (neural network, random forests):

- Does not care about underlying SED, galaxy type
- Need representative training data (spectroz)
- Works well within the training data z-range (i.e. interpolation ok)
- Fails when extrapolating outside training data z-range



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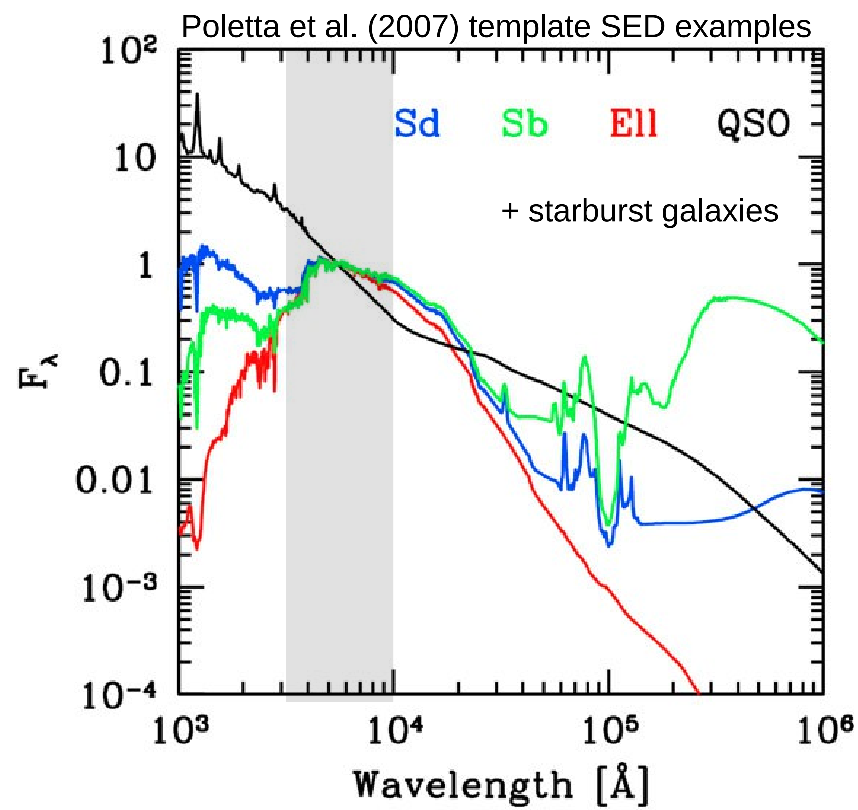


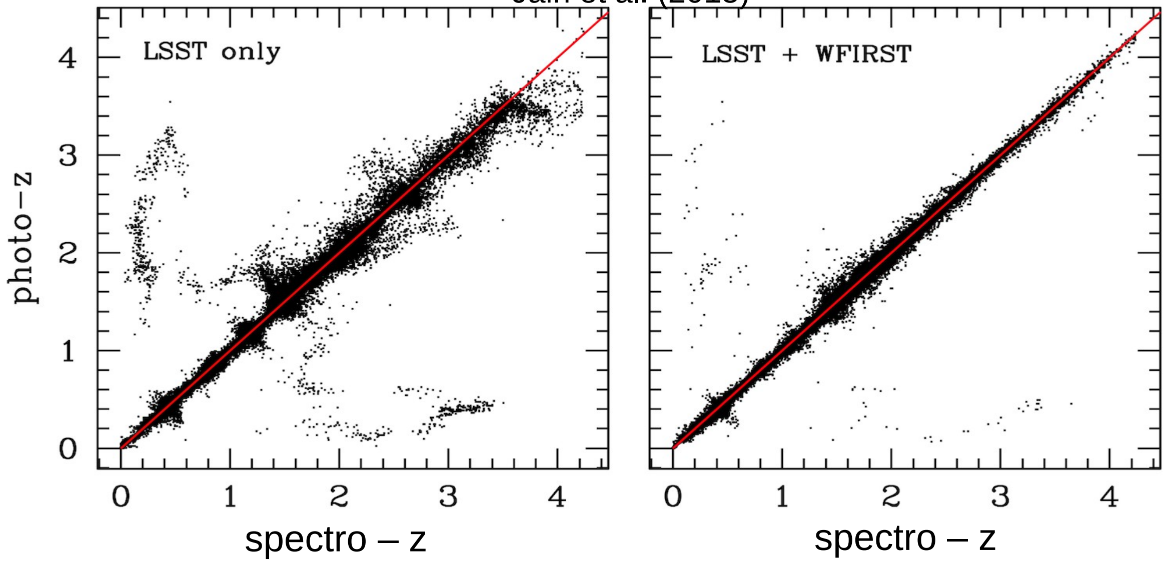
Template fitting methods :

- Need representative template library
- Sensitive to degeneracies (e.g. intermediate-z 4000 A break versus high-z Lyman alpha break) → catastrophic outliers
- In principle, can go to higher z

Quality of the photo-z reconstruction?

- **Point estimate** (best fit z) versus true (spectro) z → the most widely used quality check, e.g.

Jain et al. (2015)



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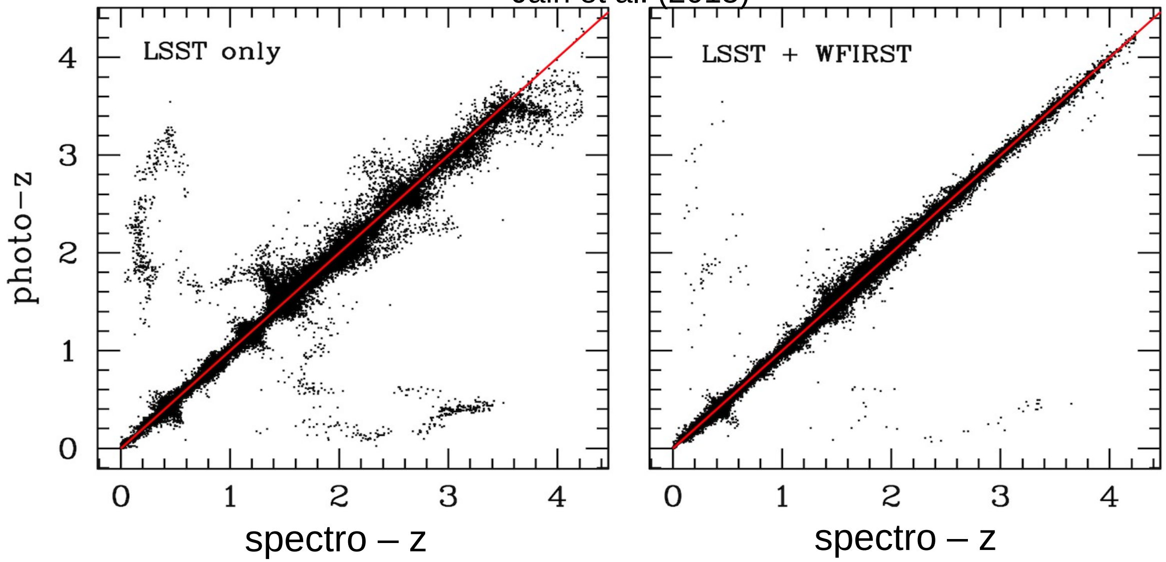
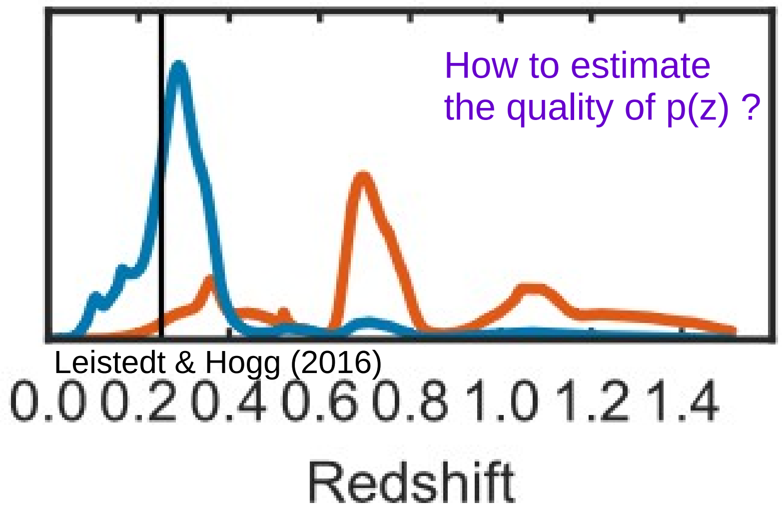


- But actually, using **full p(z) information** instead of point estimate reduces bias and downstream systematic errors, e.g
  - Cosmic shear
  - Cluster mass from WL
  - ...



Leistedt & Hogg (2016)

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