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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Probabilistic photometric redshifts

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Motivation

- Photo-z PDF are important in cosmology
- Several! methods / codes to compute photo-z
- Need for a meta-algorithm that combines multiple techniques
- PDF are good **but** for large datasets, storage and I/O will be an issue
- Machine Learning and statistical tools

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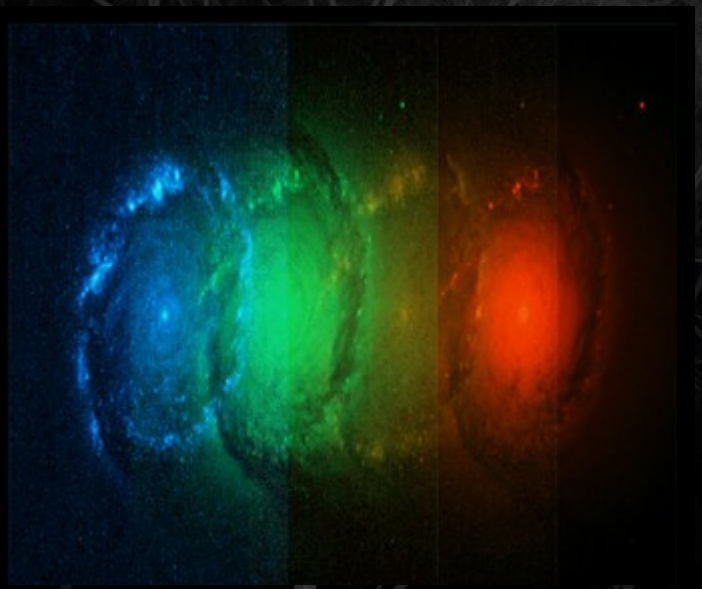
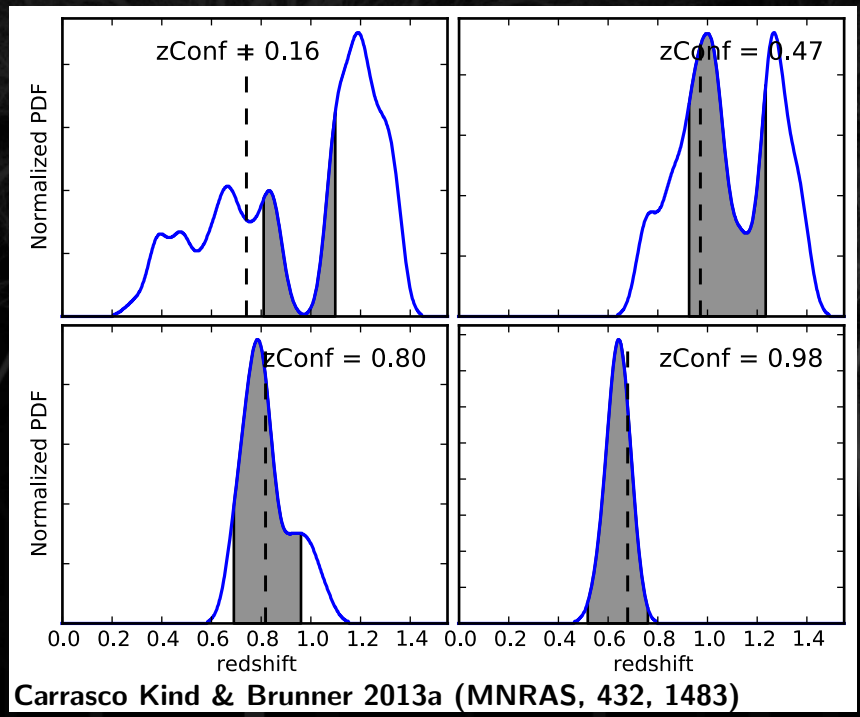
How to produce, combine, store and use P(z)

Photo-z PDF estimation

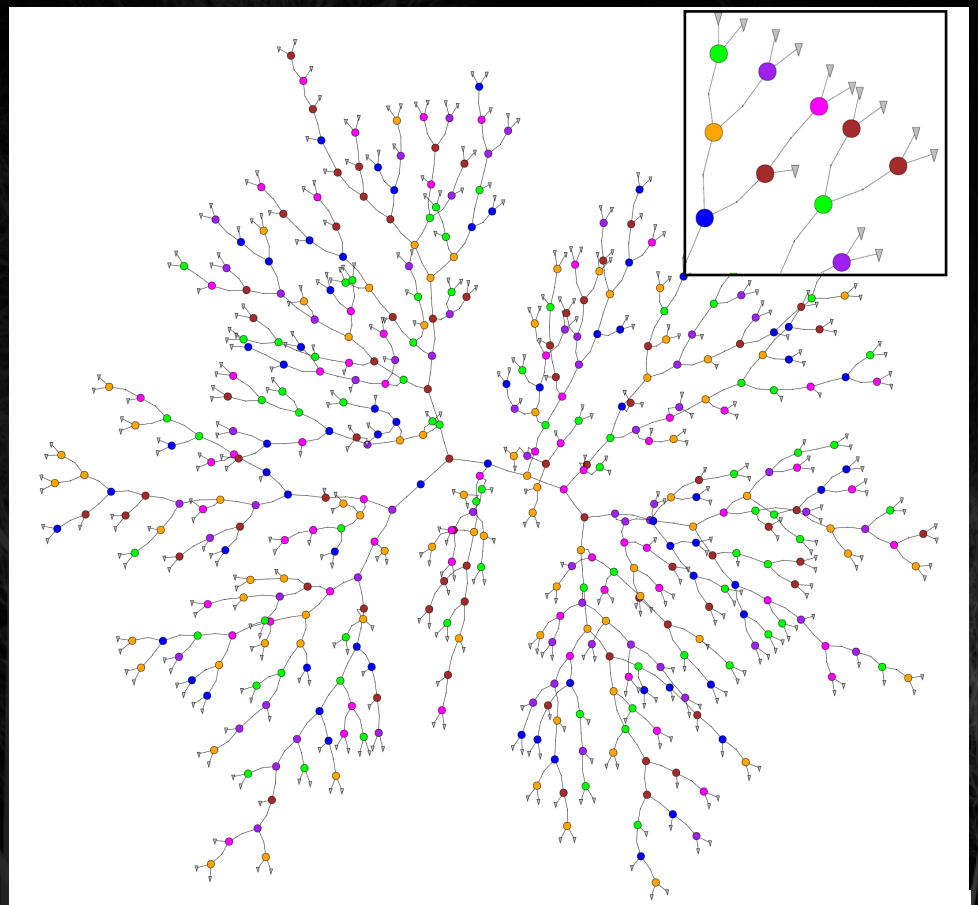




Carrasco Kind & Brunner 2013a (MNRAS, 432, 1483)

Photo-z PDF estimation: TPZ

- TPZ (Trees for Photo-Z) is a supervised machine learning code
- Prediction trees and random forest
- Incorporate measurements errors and deals with missing values
- Ancillary information: expected errors, attribute ranking and others
- Application to the S/G

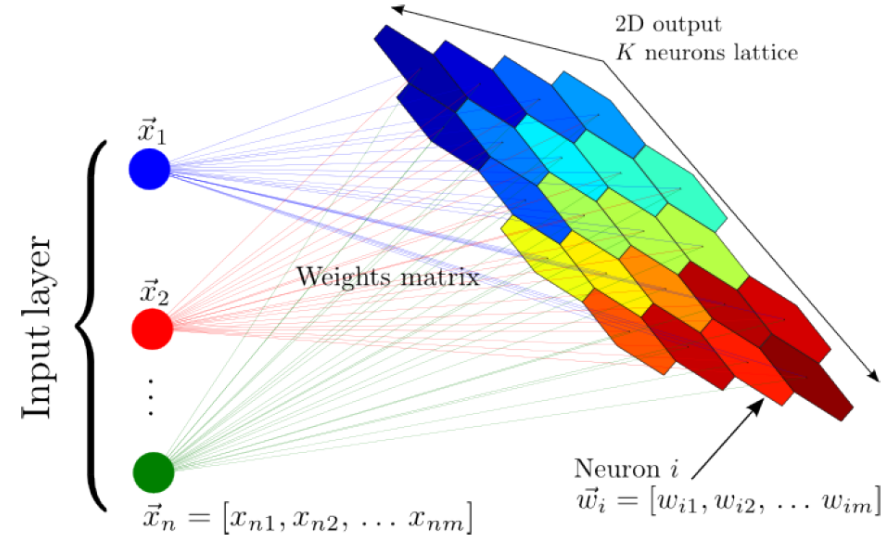


Carrasco Kind & Brunner 2013a (MNRAS, 432, 1483)

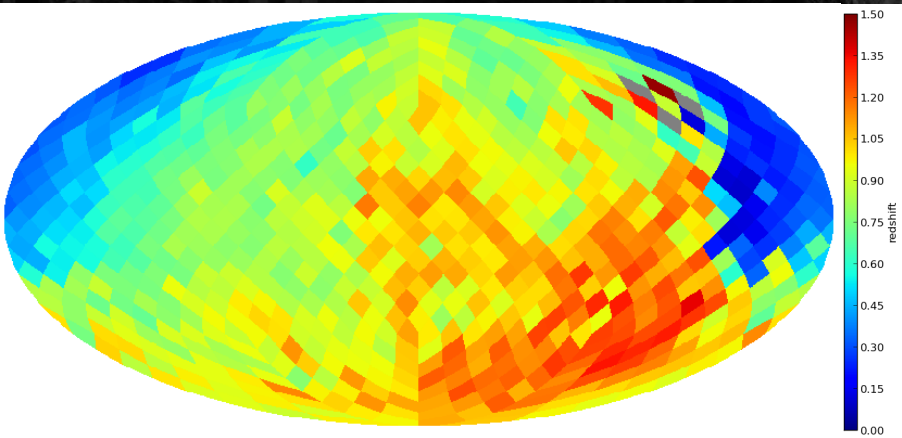
http://lcdm.astro.illinois.edu/code/mlz.html

Photo-z PDF estimation: SOM

- SOM(Self Organized Map) is a unsupervised machine learning algorithm
- Competitive learning to represent data conserving topology
- 2D maps and *Random Atlas*
- Framework inherited from TPZ
- Application to the S/G



Carrasco Kind & Brunner 2014a (MNRAS, 438, 3409)



Carrasco Kind & Brunner 2014a (MNRAS, 438, 3409)

Photo-z PDF estimation: BPZ

- BPZ (Benitez, 2000) is a Bayesian template fitting method to obtain PDFs
- Set of calibrated SED and filters
- Doesn't need training data
- Priors can be included

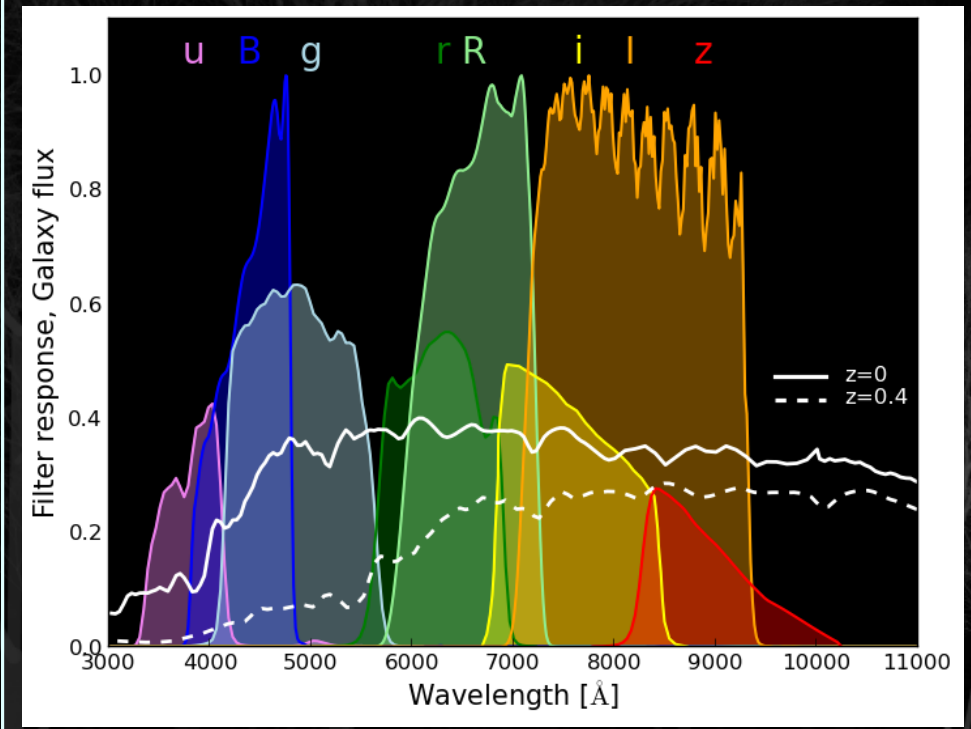


Photo-z PDF estimation: MLZ

MLZ :Machine Learning for photo-Z

http://lcdm.astro.illinois.edu/code/mlz.hml

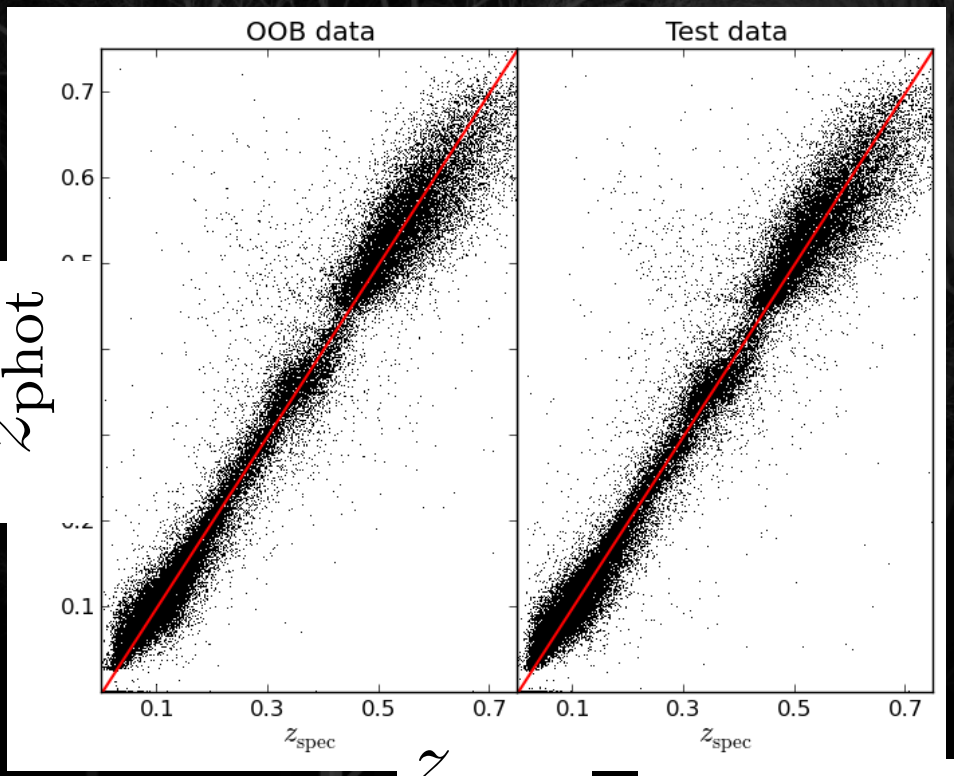
- TPZ, SOM and BPZ incorporated in one python framework, more can be added
- Public, parallel and easy to use
- PDF Sparse representation included
- Current version 1.2, GitHub repository (https://github.com/mgckind/MLZ)
- pycuda, h5py and numba *still* in folder

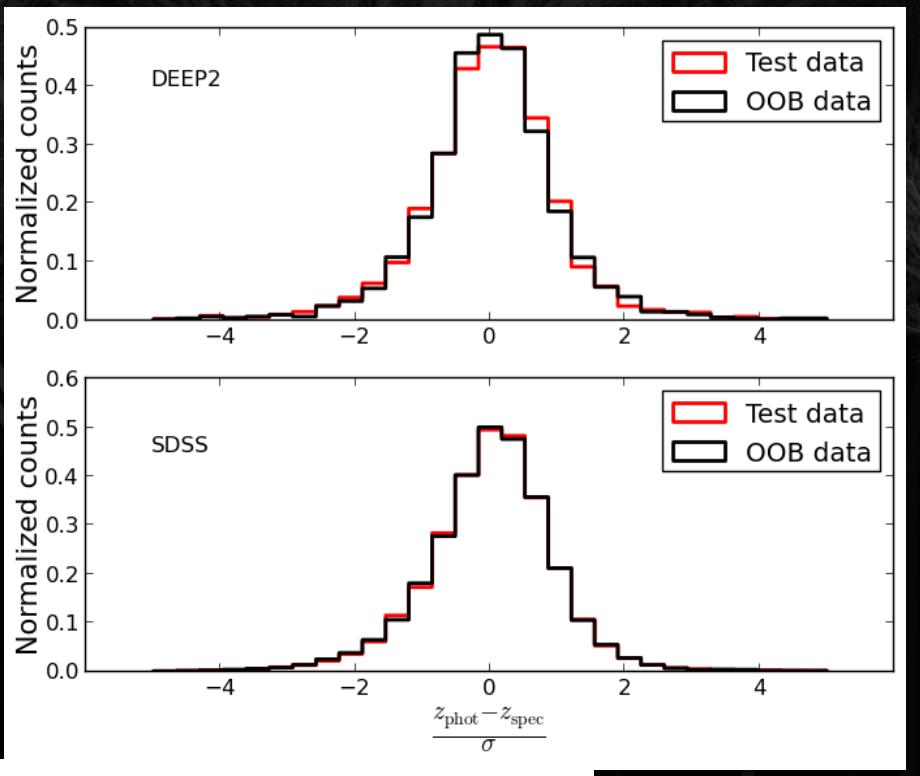
Photo-z PDF estimation: Error and validation

Out of Bag data used to validate trees/maps

Changes for every tree/map and is not used during training

We can learn from the cross-validation data!

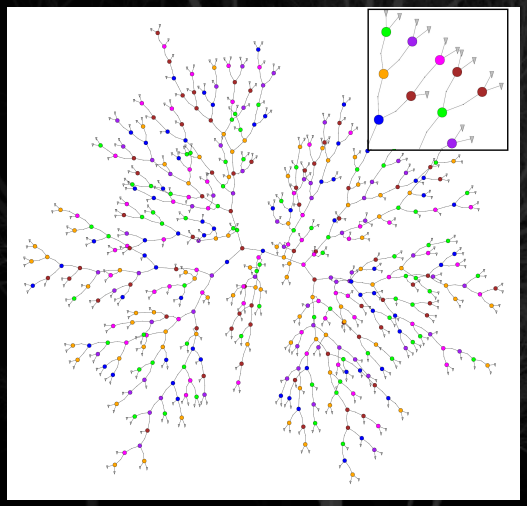




Carrasco Kind & Brunner 2014c (MNRAS 442, 3380)

How to produce, combine, store and use P(z)

Photo-z PDF combination



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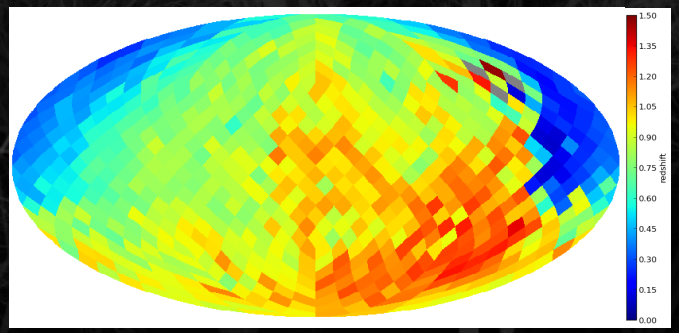

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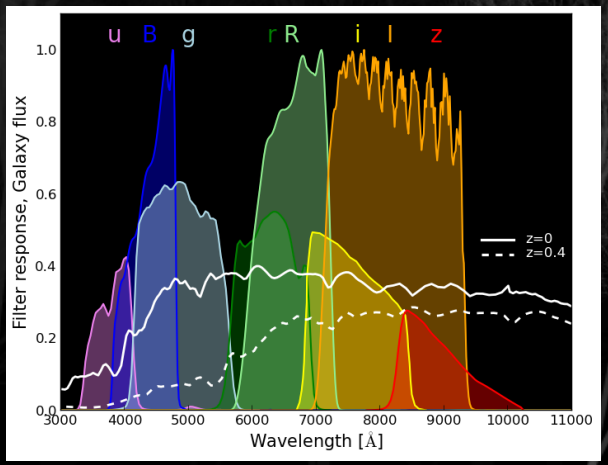
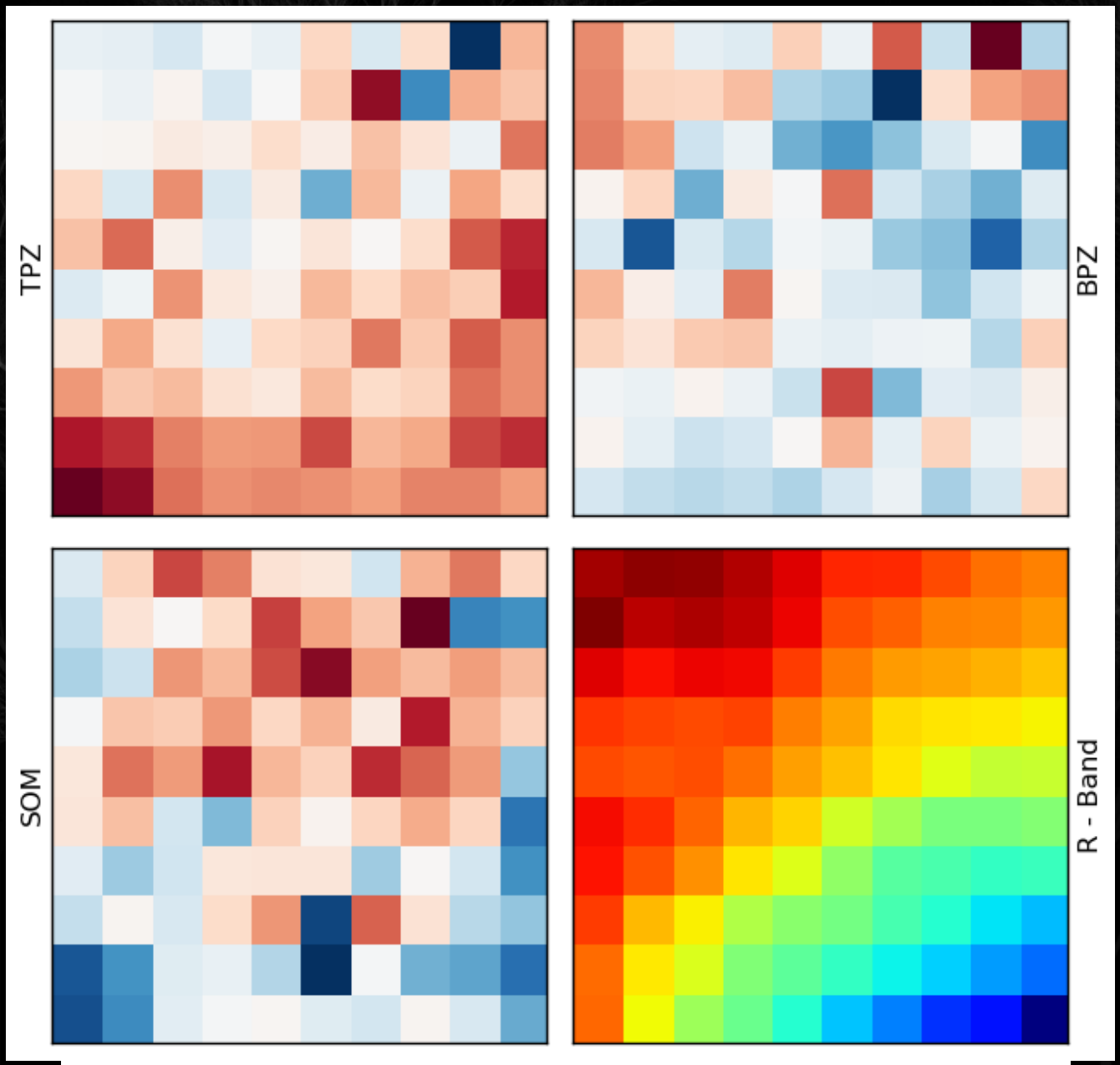


Photo-z PDF combination: Bayesian framework



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This approach

Supervised method

+

Unsupervised method

+

Template fitting

+

Weigthing scheme

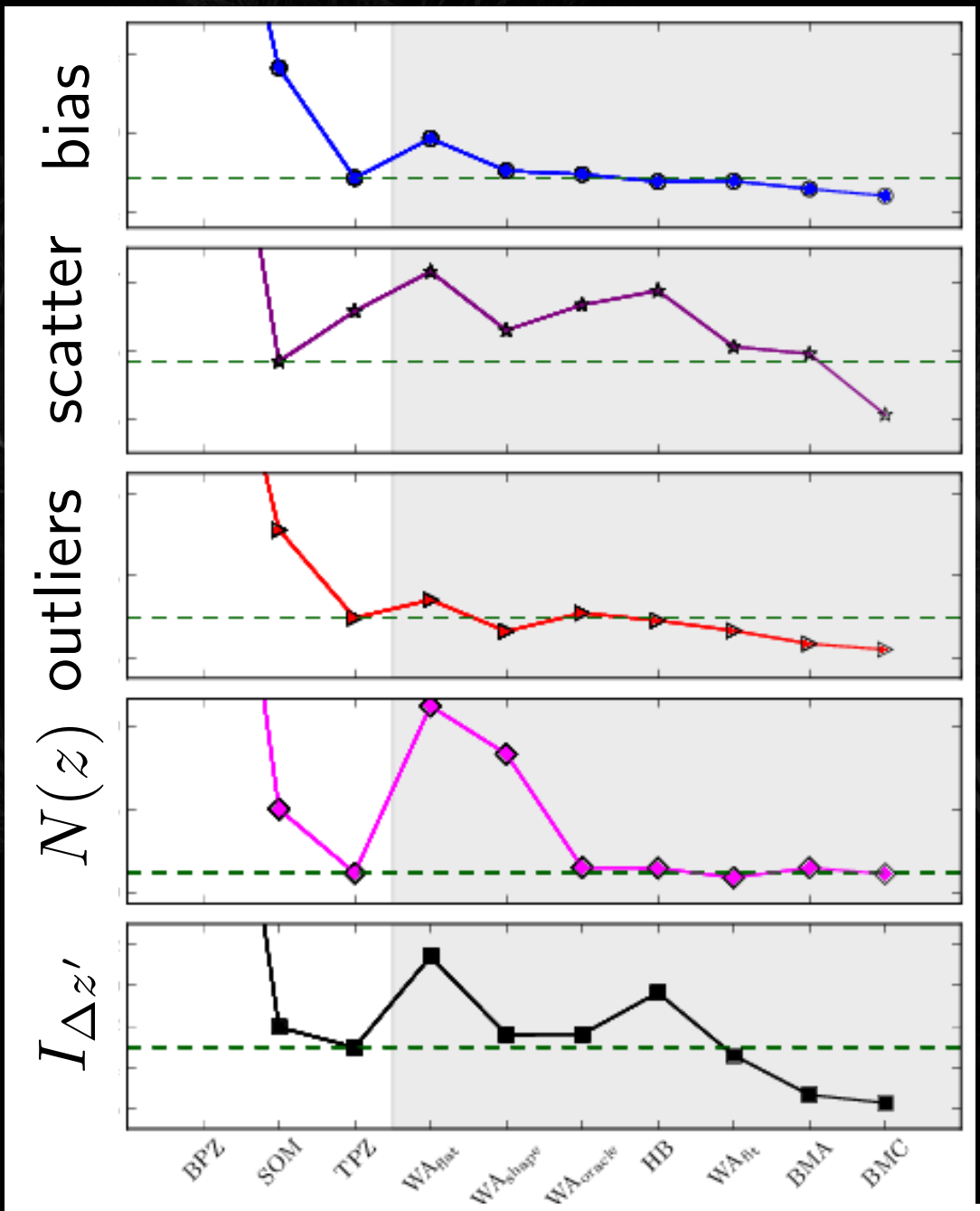
⇓

photo-z PDF

+

Outliers

Photo-z PDF combination: Results



Carrasco Kind & Brunner 2014c (MNRAS 442, 3380)

- Several combination methods
- Bayesian model averaging (BMA) and combination (BMC) are the best
- We introduce the I-score which combine multiple metics after being rescaled to compare different methods and/or codes

$$I_{\Delta z'} = \sum w_i M_i$$

Photo-z PDF combination: Outliers

Naïve Bayes Classifier (same used for spam emails) to identify "spam" galaxies using information from multiple techniques

Each feature provides information about these two classes, and can be combined to make a stronger classifier

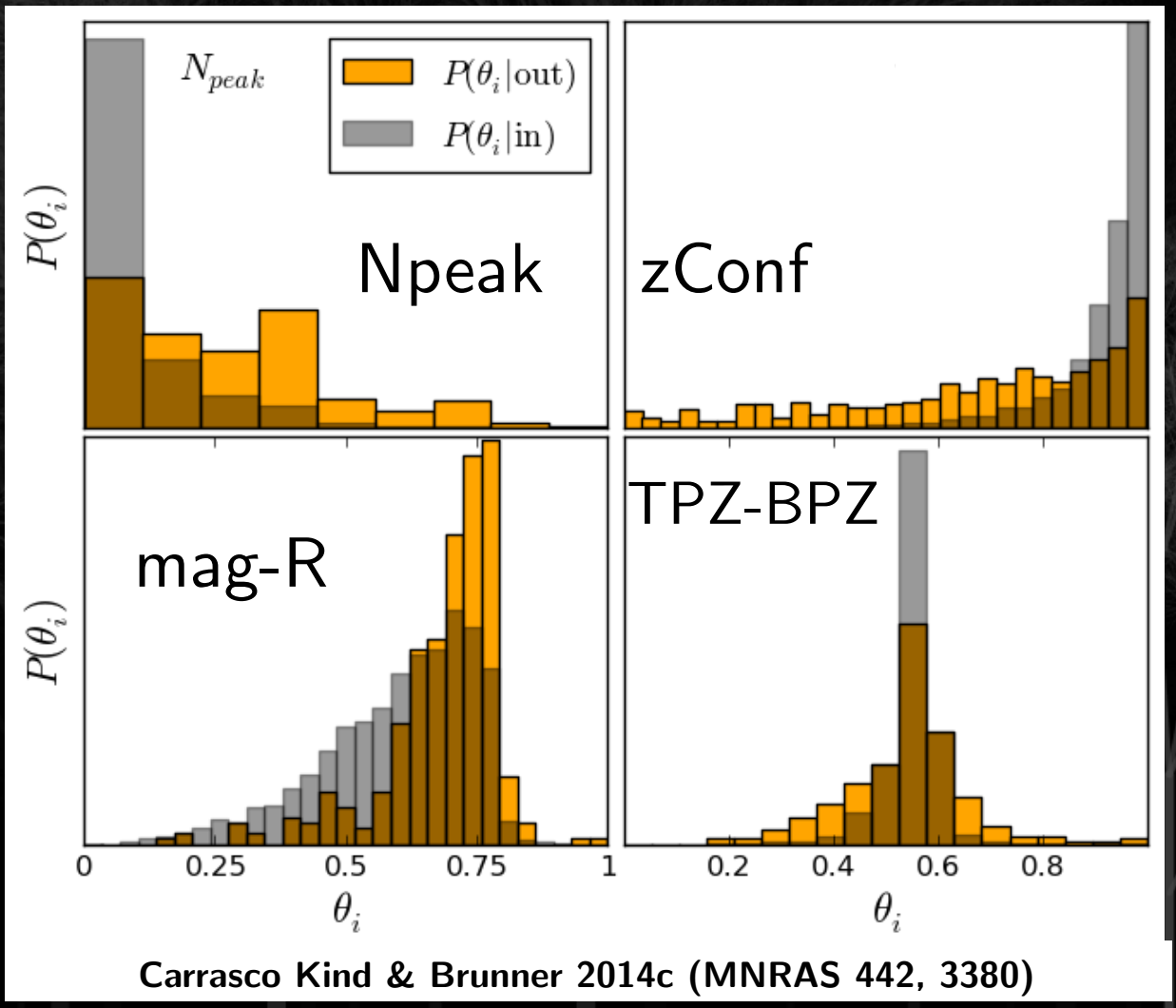


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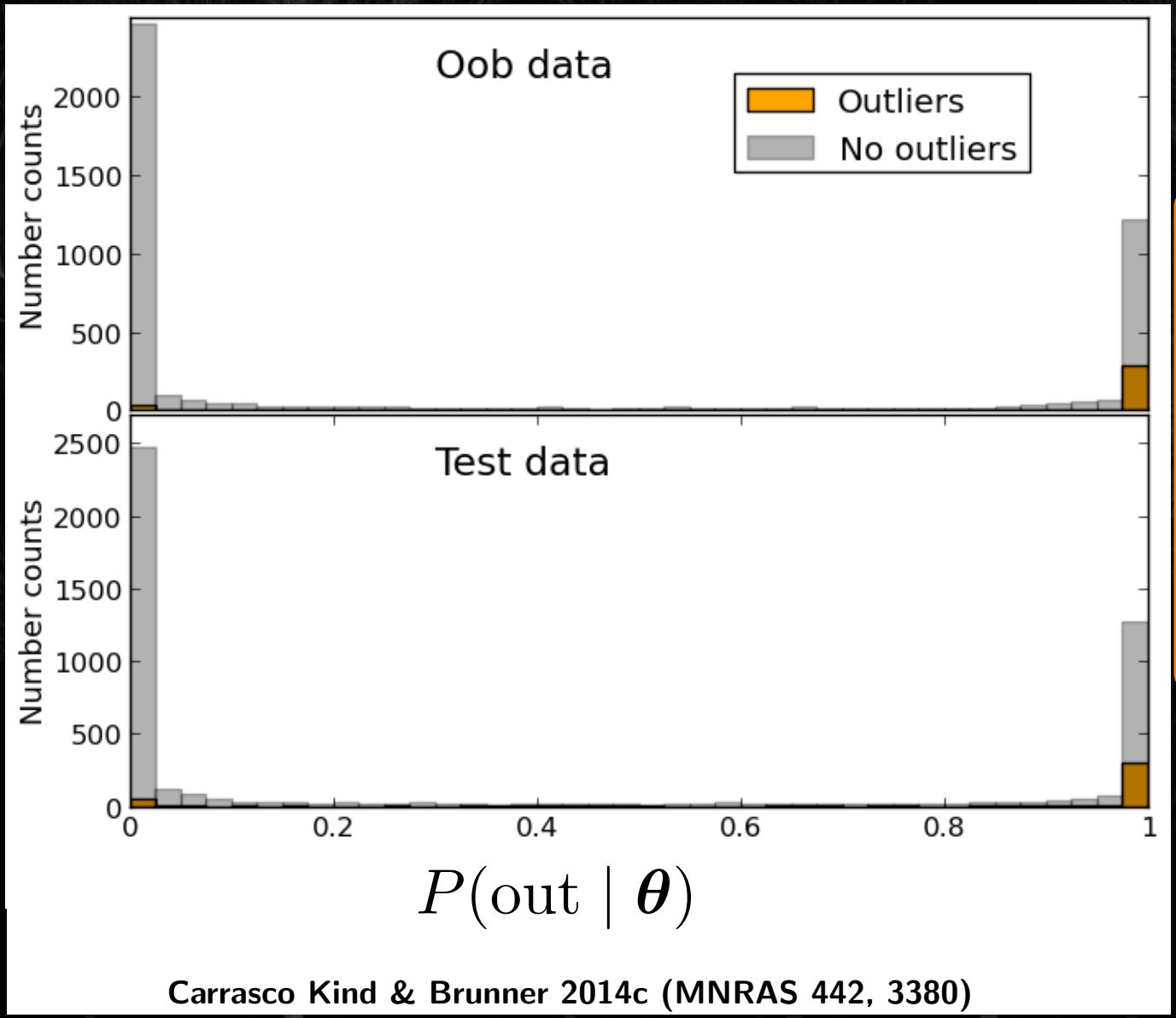
Photo-z PDF combination: Outliers



Carrasco Kind & Brunner 2014c (MNRAS 442, 3380)

- Highly bimodal
- Little contamination
- Good discriminant
- Consistent between samples

Photo-z PDF storage

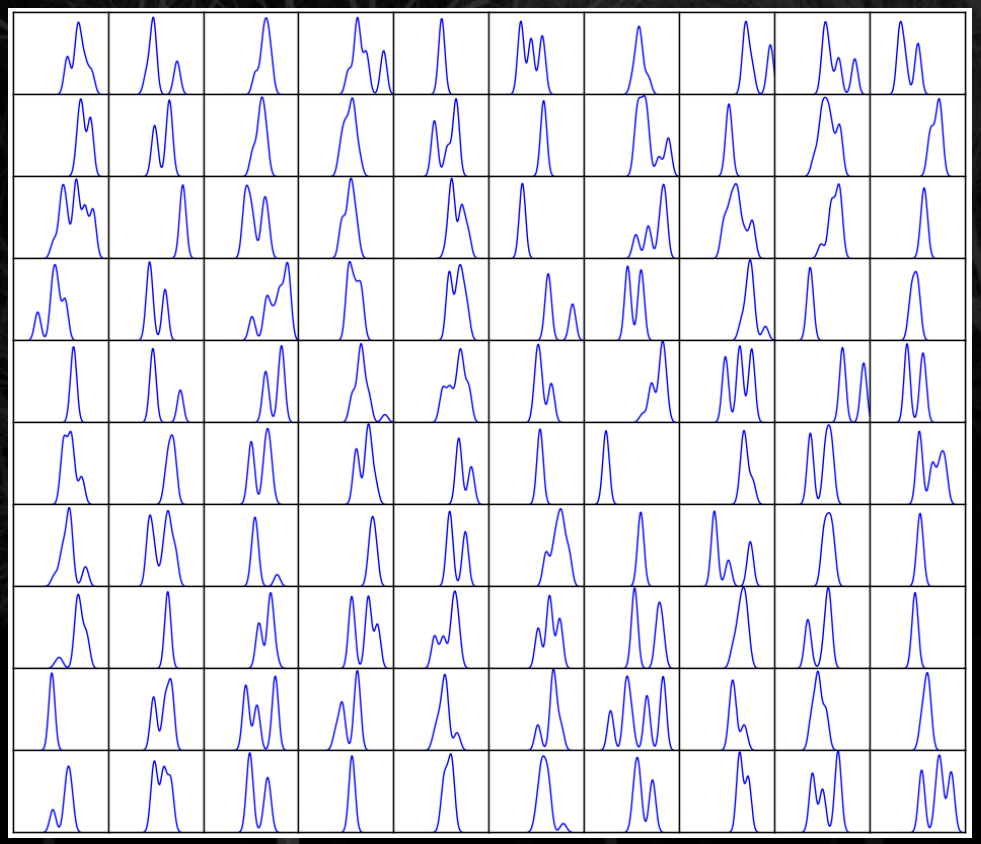


Photo-z PDF storage: Sparse representation

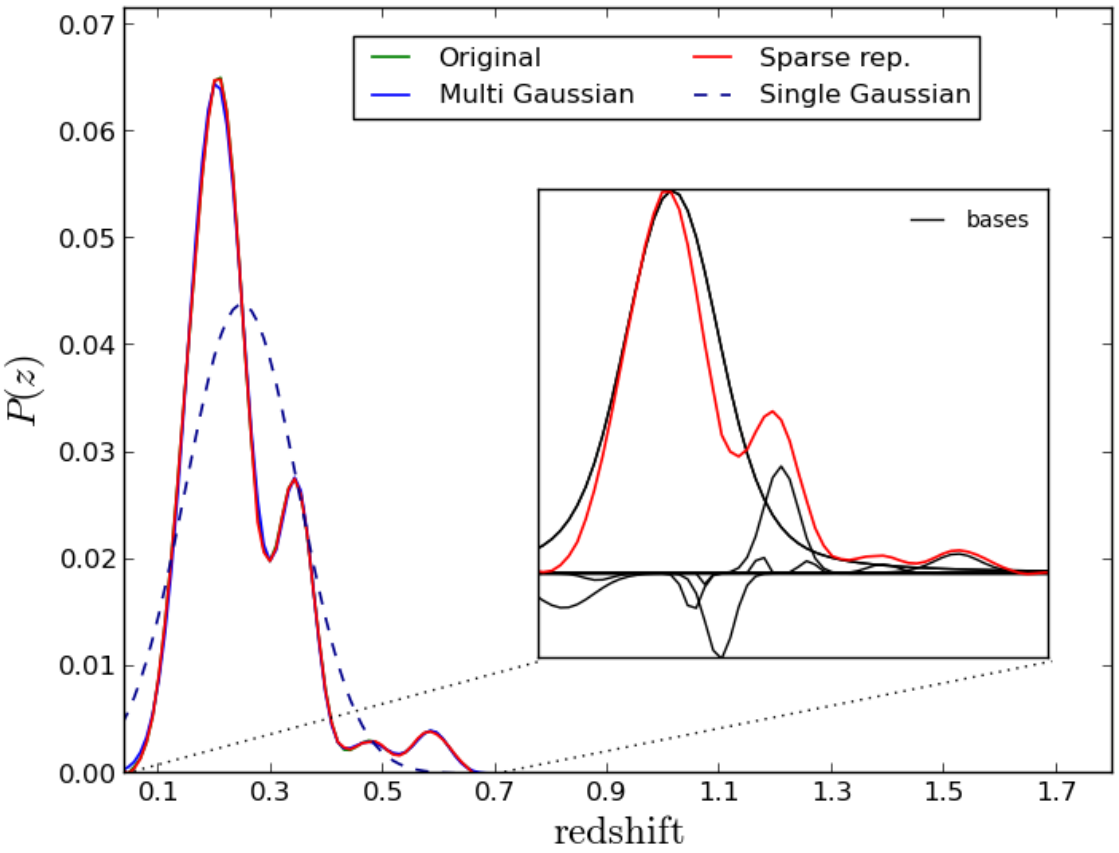
Use Gaussian and Voigt profiles as bases, need $N^2_{\rm original}$ bases

Find basis and amplitud to reduce residual on each step

With only 10-20 bases achieve 99.9 % accuracy

Use 32-bits integer per basis, compression

Store Multiple PDFs



Carrasco Kind & Brunner 2014b (MNRAS, 441, 3550)

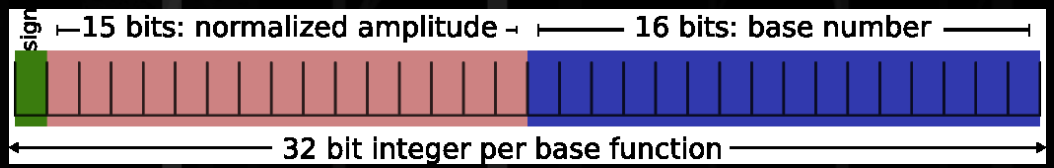
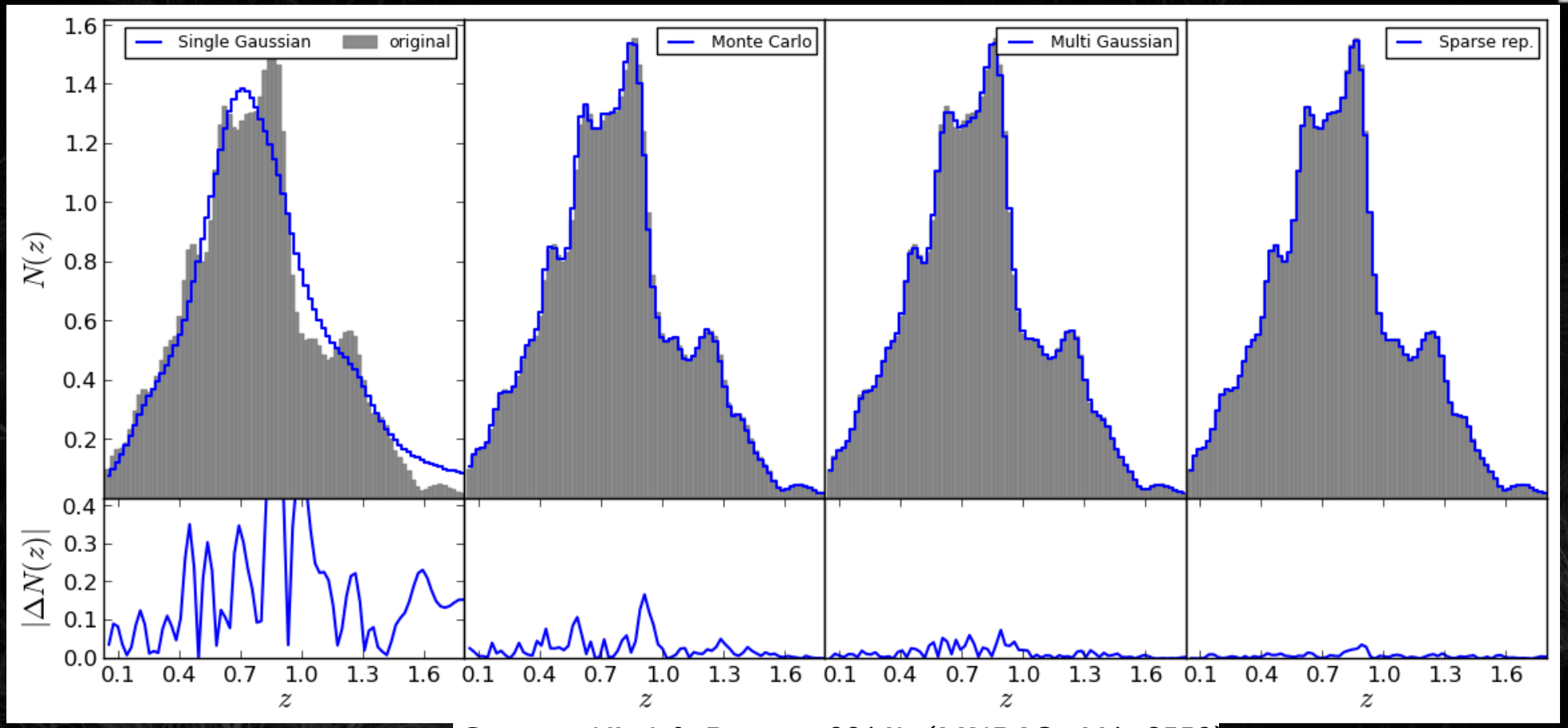


Photo-z PDF storage: Results



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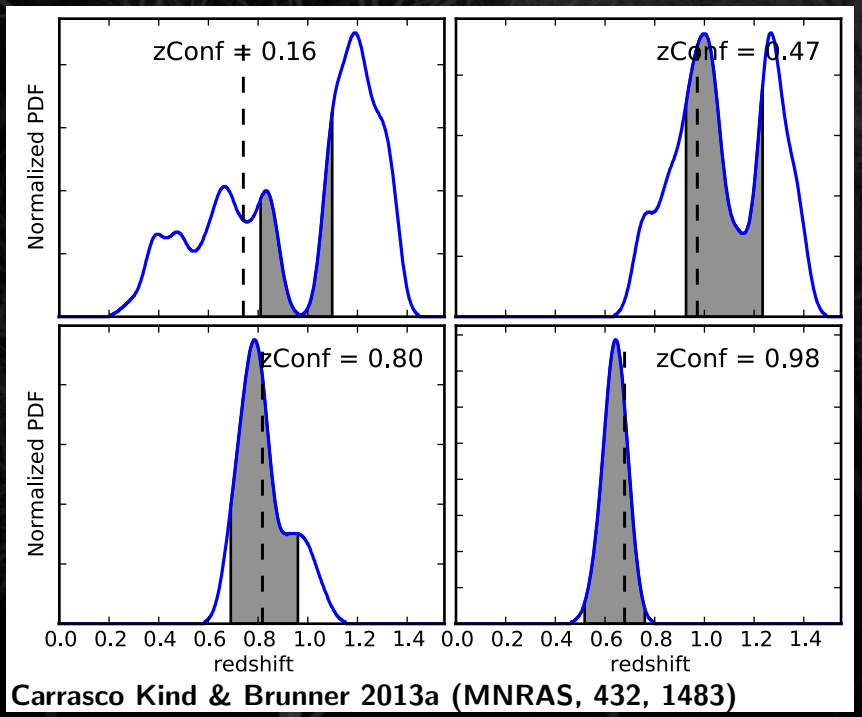
For PDFs with less than 4 peaks 5-10 points should be sufficient

Sparse representation gives more accurate and more compressed representation for N(z), 99.9% accuracy with 15 points (200 points originally)

How to produce, combine, store and use P(z)

Photo-z PDF applications



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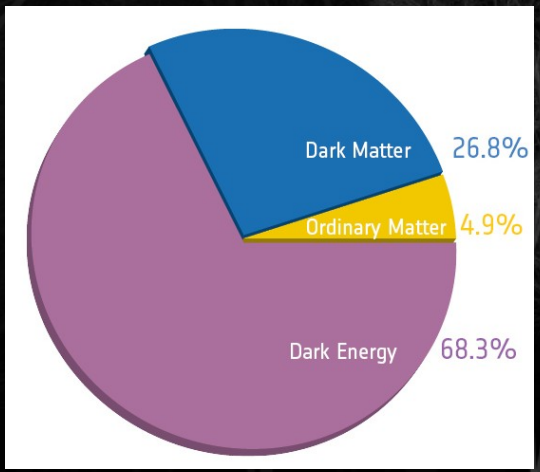

Photo-z PDF application: $N(z)$

By definition:

$$N(z) = \sum_{k=1}^{N} \int_{z-\Delta z/2}^{z+\Delta z/2} P_k(z) dz$$

Using sparse representation, we represent each PDF pz_k as:

$\mathbf{pz}_k \approx \mathbf{D} \cdot \boldsymbol{\delta}_k$ $\mathbf{D}$ is the dictionary, $\boldsymbol{\delta}_k$ is the sparse vector, then

$$N(z) = \sum_{k=1}^{N} \boldsymbol{\delta}_k \cdot \int_{z-\Delta z/2}^{z+\Delta z/2} \mathbf{D} dz$$

Only bases are integrated

by precomputing:

$$\boldsymbol{\delta}_N = \sum_{k=1}^{N} \boldsymbol{\delta}_k \qquad \mathbf{I_D}(z) = \int_{z-\Delta z/2}^{z+\Delta z/2} \mathbf{d}_j dz \qquad j = 1, 2, \ldots, m$$

$N(z)$ is reduce to a simple dot product

$$\boxed{N(z) = \mathbf{I_D}(z) \cdot \boldsymbol{\delta}_N}$$

Photo-z PDF application: $N(z)$

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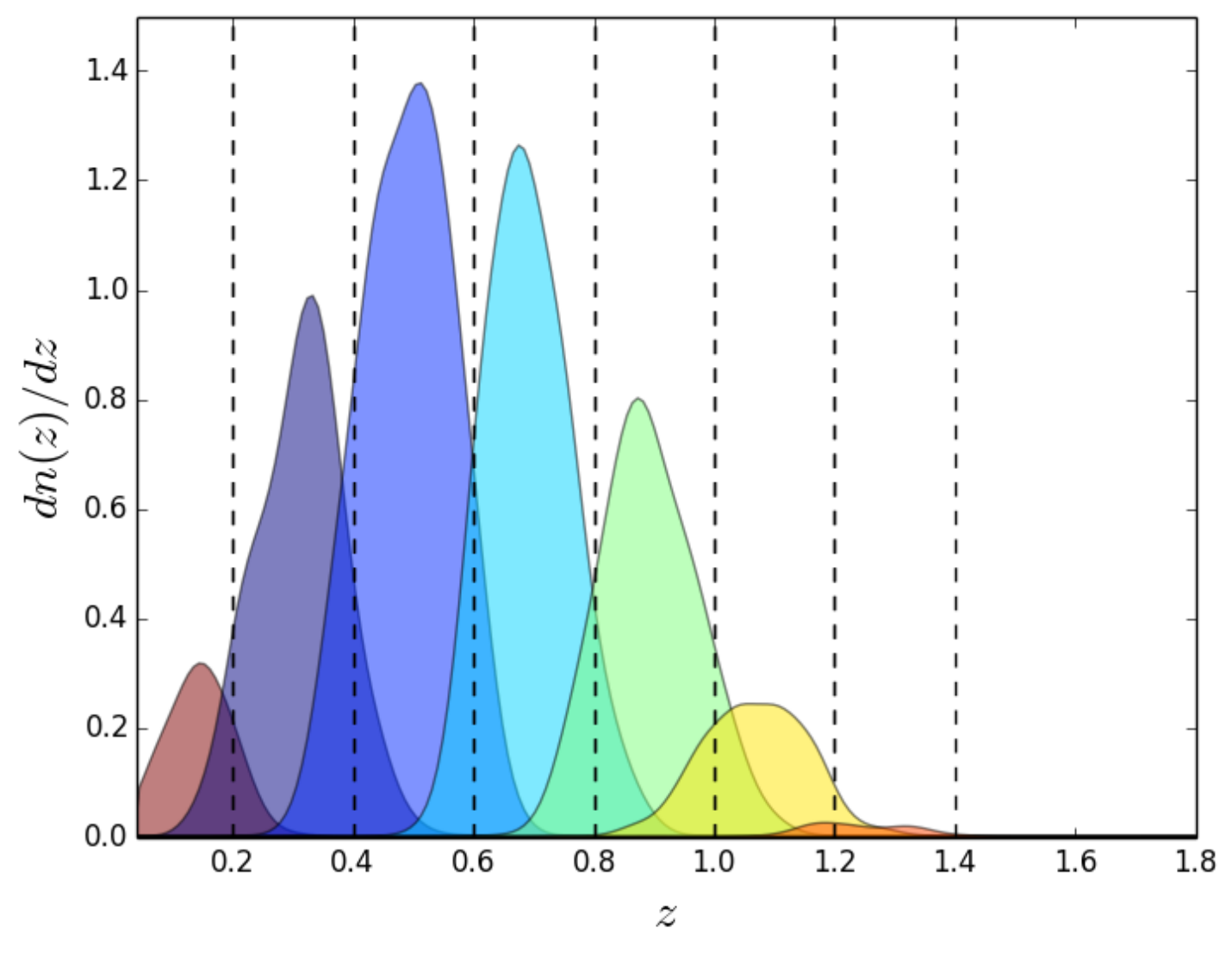
Photo-z PDF application: $N(z)$

Sparse representation on SVA1 GOLD catalogs



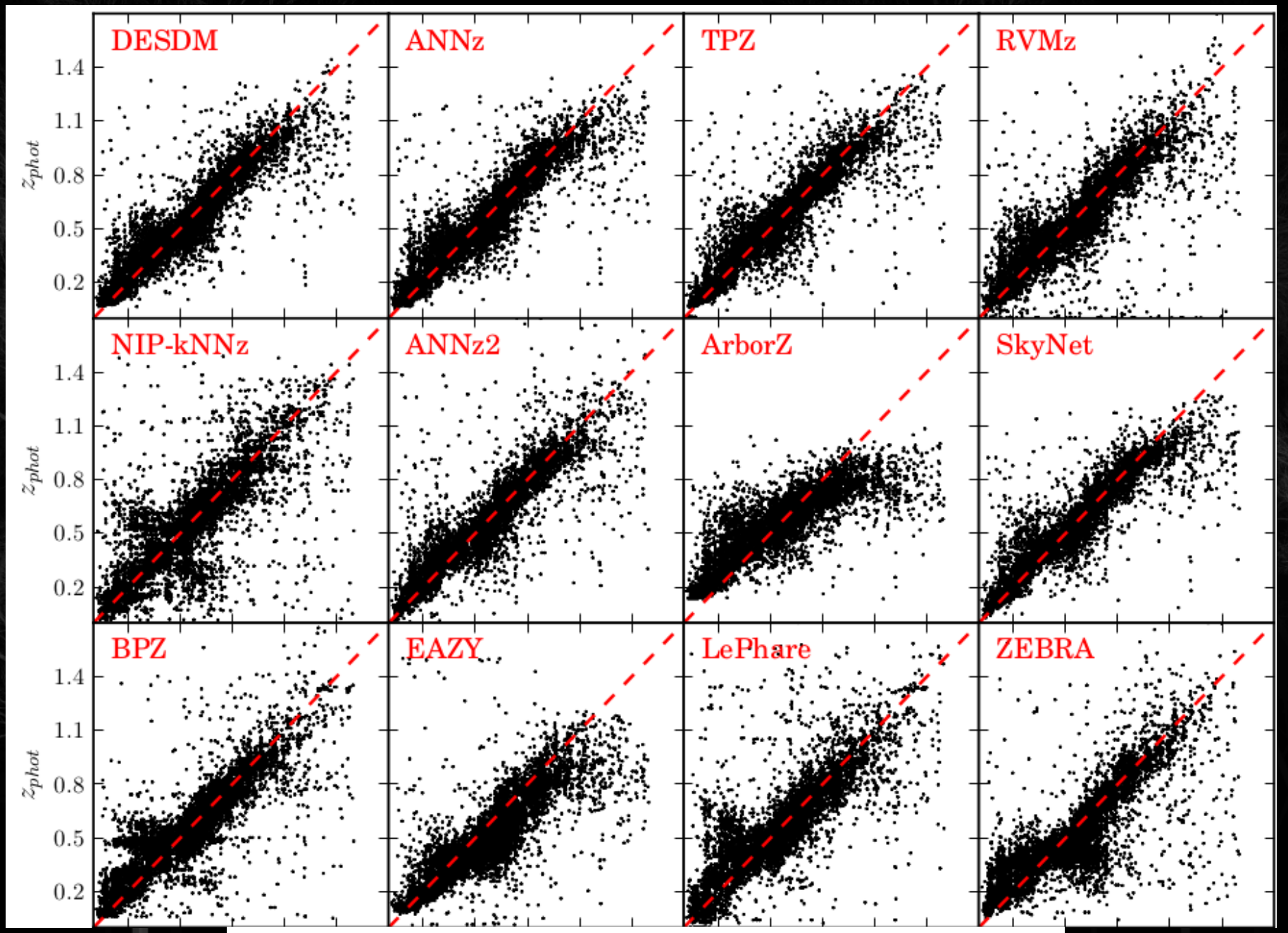
Applications on DES

- Many sources of spectra (SDSS, ATLAS, GAMA, PRIMUS, OzDES, VIPERS, VVDS, ACES, BOSS, DEEP2, 2dF, zCOSMOS, Wigglez, 6dF, etc...)

- So far we have over 150K matched spectra with DES data (SVA1, Y1A1) and even more will be available soon for SPT regions

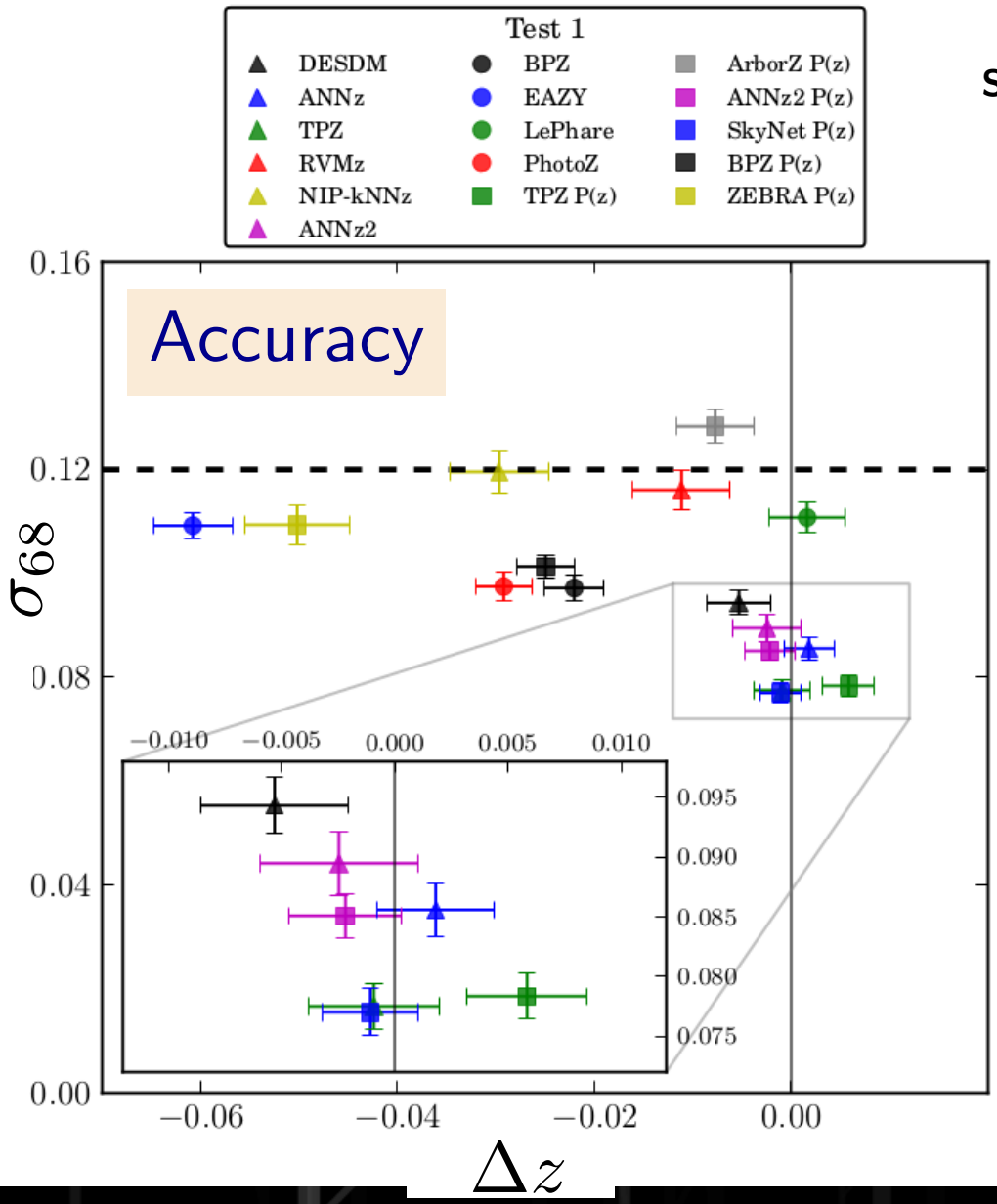
- Several regions and several codes to minimize biases and systematics

Applications on DES: SVA1



Sanchéz, Carrasco Kind, et al. 2014 (MNRAS, 445, 1482)

Applications on DES: SVA1



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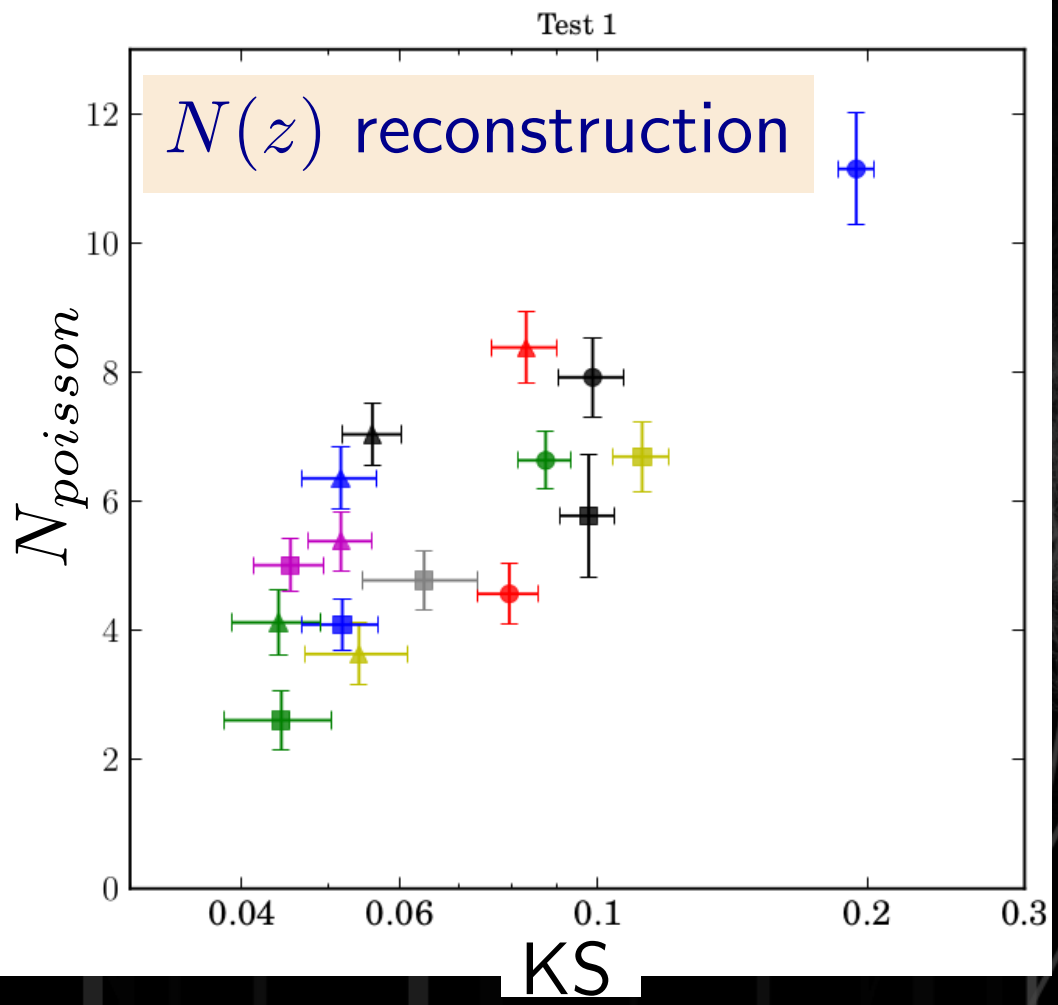
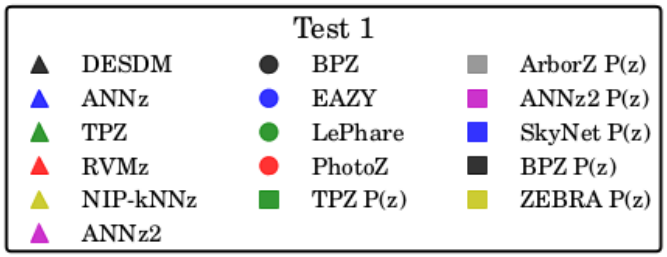


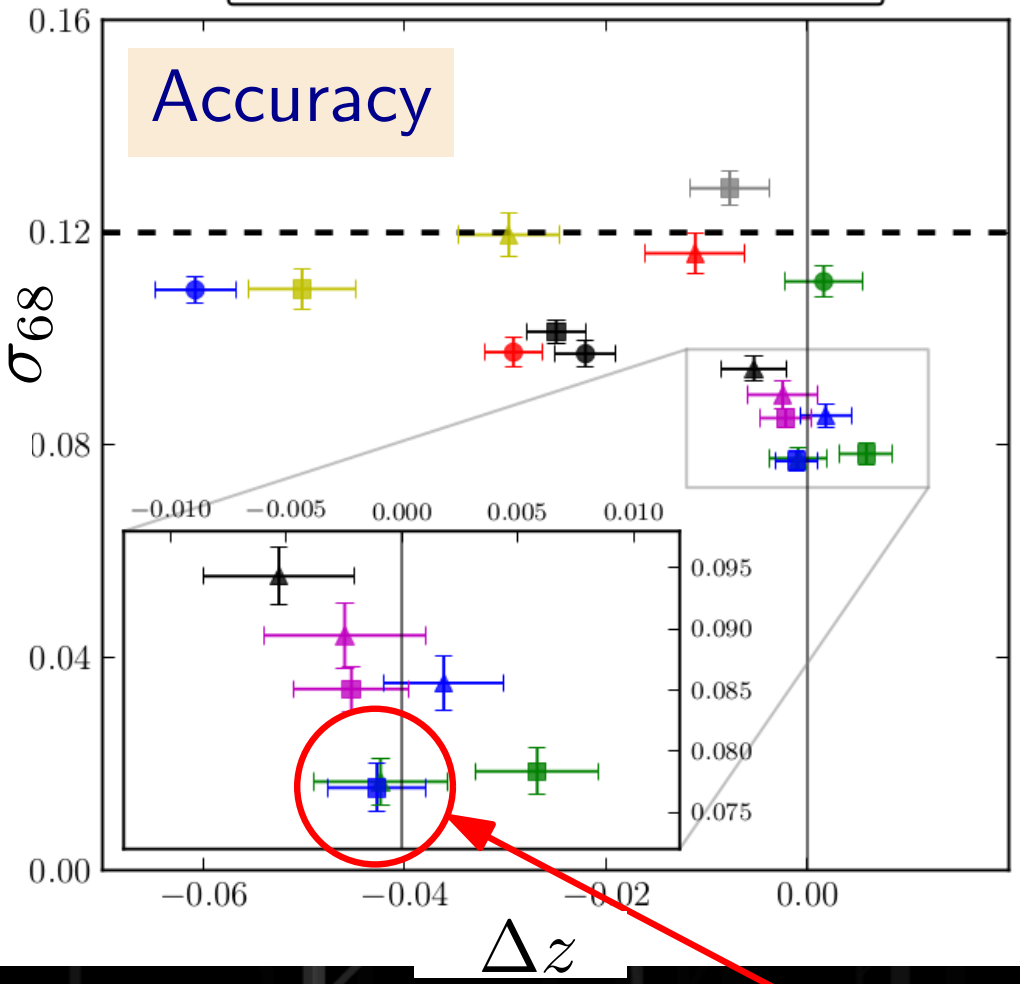
13 photo-z codes comparison

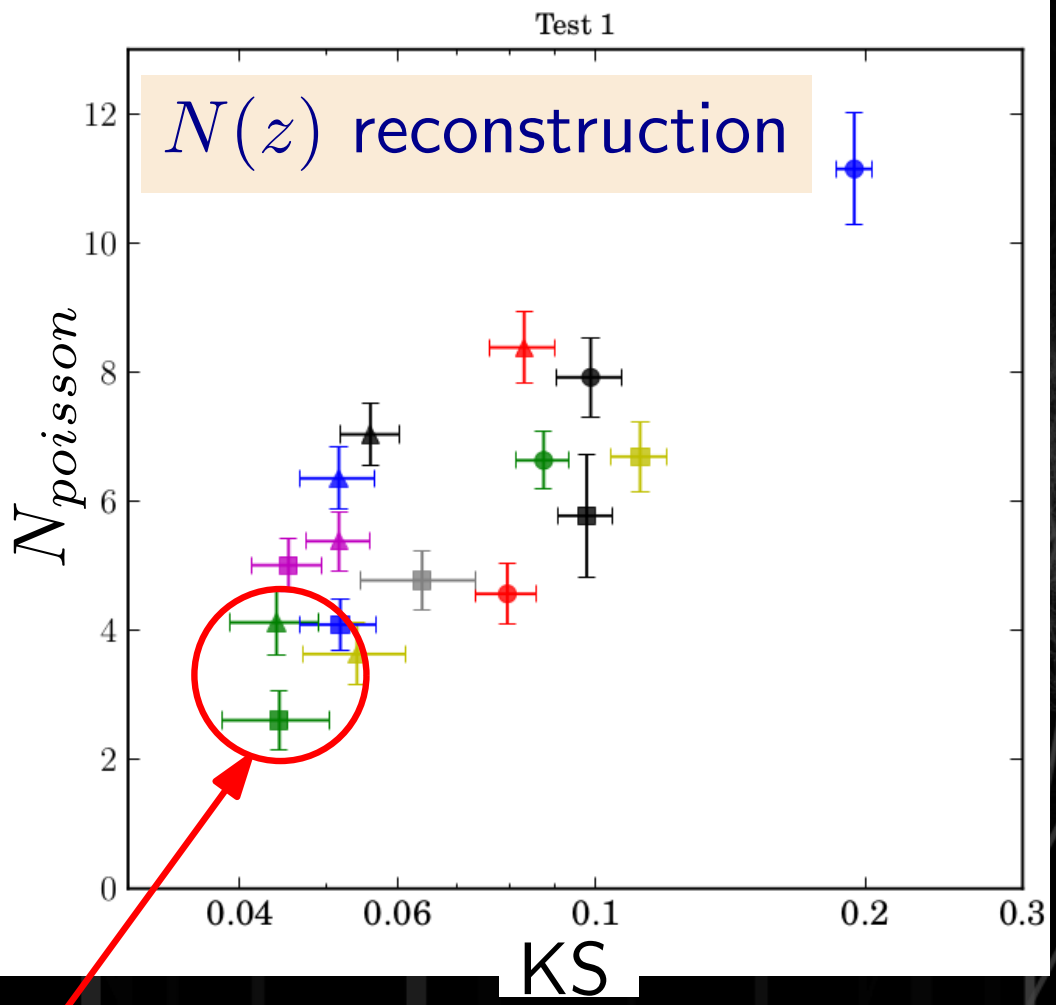
Applications on DES: SVA1



Sanchéz, Carrasco Kind, et al. 2014 (MNRAS, 445, 1482)

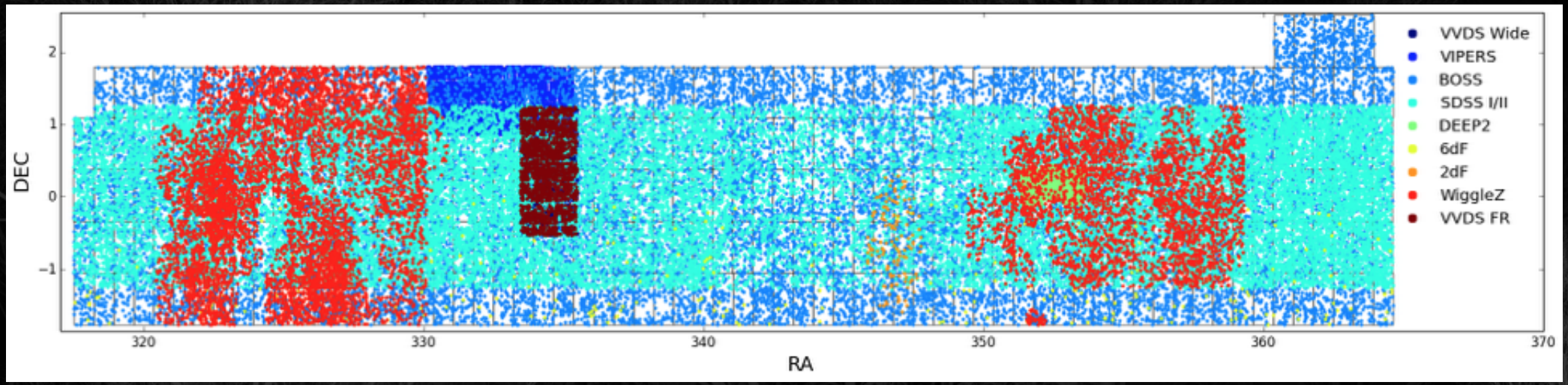
Firts paper officialy published





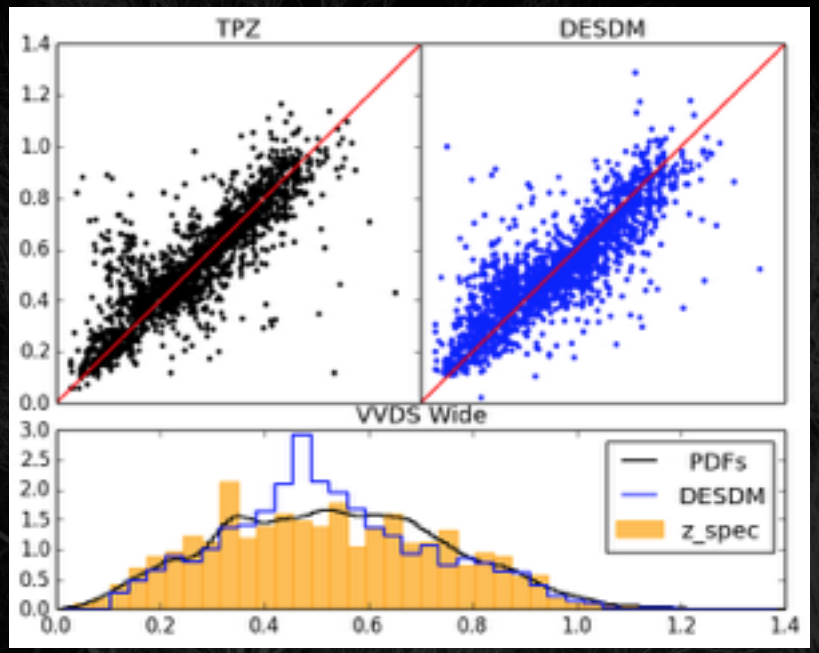
TPZ

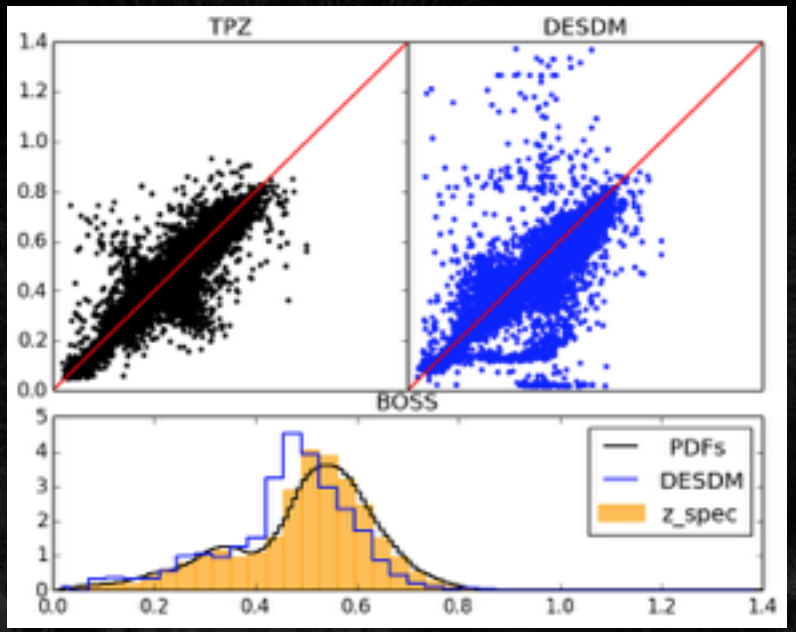
Applications on DES: Y1A1 STRIPE82

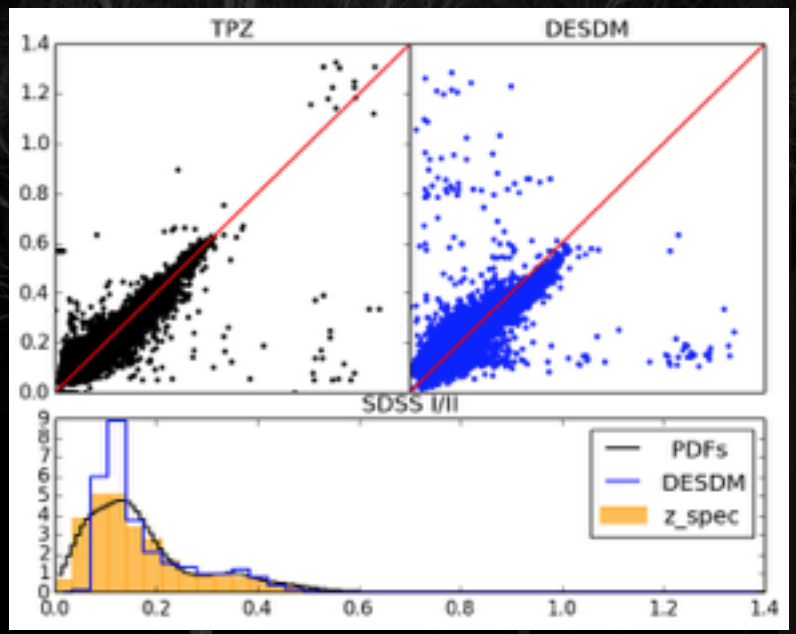


Use SVA1 as training set to validate in Stripe 82, still to be defined catalogs (after depth masks)

Y1A1 STRIPE82 (Preliminary)







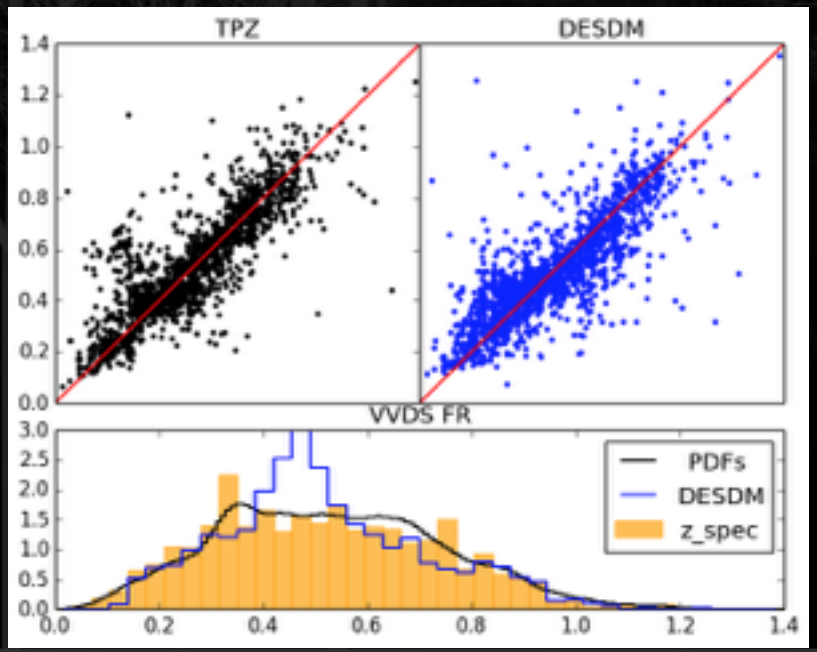


Photo-zs in DES Database

- Soon to be part of each release, a few photo-z codes already in eups
- Best way store and access photo-z PDFs under investigation
- Several codes available, possible combination of PDFs

Conclusions

✓ Compute photo-z PDF

Individual techniques (MLZ; arXiv:1303.7269, arXiv:1312.5753)

✓ Combine PDFs efficiently

Better than individual, outliers identification (arXiv:1403.0044)

✓ PDF Sparse Representation

99.9% accuracy in P(z) and N(z) with 15 points (arXiv:1404.6442)

✓ Uses of photo-z PDF!

Clustering, weak lensing, weights, etc...

THANKS!

Questions?