Updates on photometric redshifts

LSST France

Réza Ansari, Eric Nuss and Johanna Pasquet

PhotoZ codes

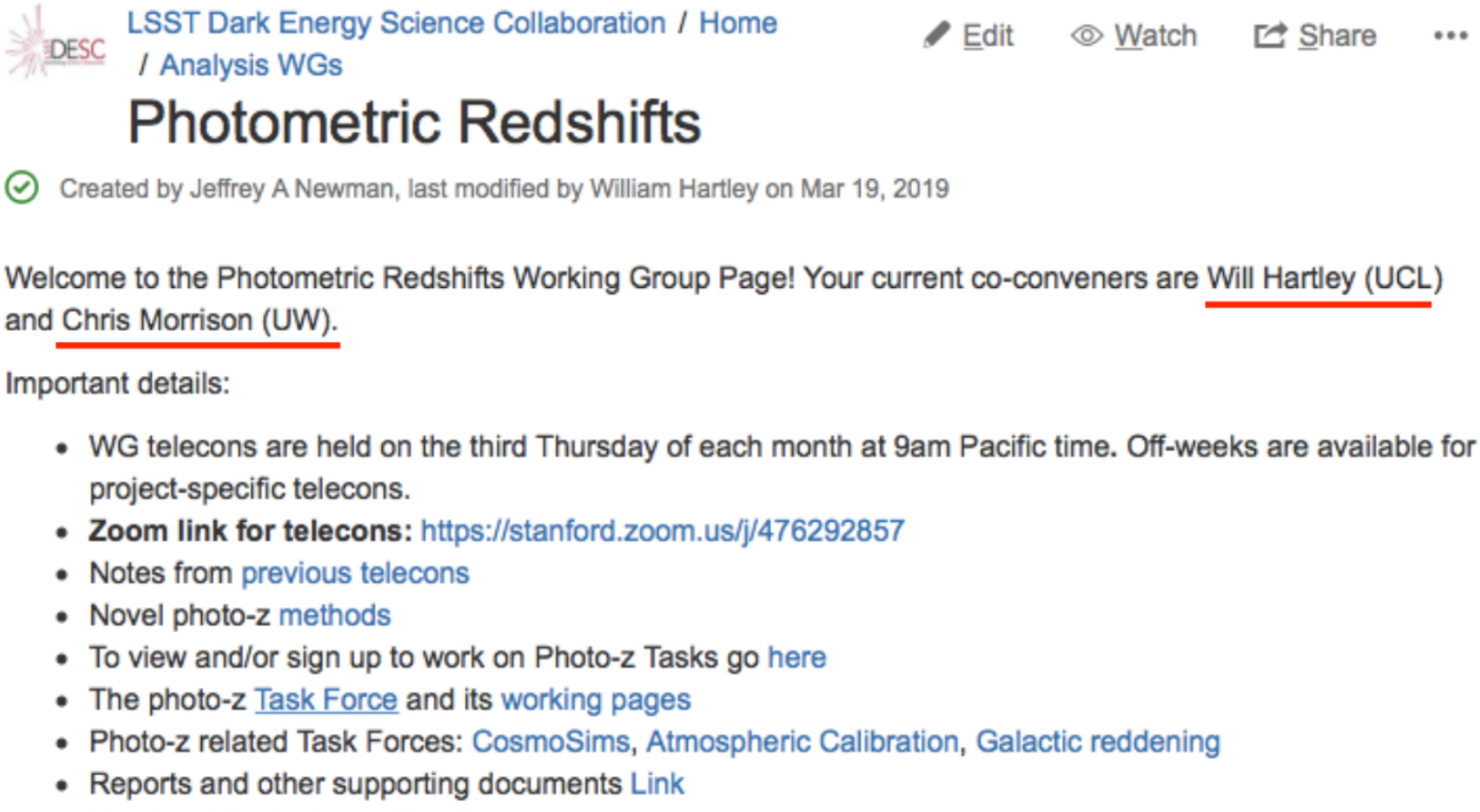
- Two broad categories of PhotoZ codes, using **Machine Learning** (ML) methods , or **template** (galaxy SED) **fitting**
- ML : needs a photometric catalog with spectroscopic redshifts (**training data set**) that matches the complete photometric catalog major challenge for LSST
- ML methods are often able to **optimise** the use of available information
- Template based : need to have **representative galaxy SED libraries**, and understand the astrophysical effects (& cosmology), and the evolution with redshift - Learning data set would be used for validation
- Template based methods use the accumulated **human knowledge** (physics) to extend photo-z determination beyond parameters (magnitudes, redshift . . .) covered by the training set

Photometric redshifts

- Simulation of galaxy catalogs uses often (always) galaxy SED templates and luminosity functions
- Large Scale Structures (LSS) is **NOT** needed unless one uses the clustering information for photo-z
- The **photometric calibration** and **knowledge of filters** are among important issues that have impact on photo-z qualities
- Improving photo-z performance using **additional / complementary information** (additional photometric bands, i.e. infrared from Euclid ...) and galaxy angular size (or directly the image)
- Sensitivity of different **probes** (WL, LSS, BAO, CL, SN ...) to photo-z quality and performance
- Use a **photo-z PDF** (P(z)) instead of z-phot (and possibly its uncertainty

DESC activities

- DESC PhotoZ WG activities shifted toward DC1 , then DC2 and specific task forces
- Last PhotoZ telecon notes on SLAC : June 2016



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Photometric Redshifts

Created by Jeffrey A Newman, last modified by William Hartley on Mar 19, 2019

Welcome to the Photometric Redshifts Working Group Page! Your current co-conveners are Will Hartley (UCL) and Chris Morrison (UW).

Important details:

- WG telecons are held on the third Thursday of each month at 9am Pacific time. Off-weeks are available for project-specific telecons.
- **Zoom link for telecons:** https://stanford.zoom.us/j/476292857
- Notes from previous telecons
- Novel photo-z methods
- To view and/or sign up to work on Photo-z Tasks go here
- The photo-z Task Force and its working pages
- Photo-z related Task Forces: CosmoSims, Atmospheric Calibration, Galactic reddening
- Reports and other supporting documents Link

DC1 PhotoZ paper

Implicit assumptions and their impact on photometric redshift PDF performance in the context of LSST

S.J. Schmidt[1], A.I. Malz[2,3], J.Y.H. Soo[4], M. Brescia[5], S. Cavuoti[5,6], G. Longo[6], I.A. Almosallam[7,8], M.L. Graham[9], A.J. Connolly[9], E. Nourbakhsh[1], J. Cohen-Tanugi[10], H. Tranin[10], P.E. Freeman[11], K. Iyer[12], J.B. Kalmbach[13], E. Kovacs[14], A.B. Lee[11], C. Morrison[9], J. Newman[15], E. Nuss[10], T. Pospisil[11], M.J. Jarvis[16,17], R. Izbicki[18,19]

(LSST Dark Energy Science Collaboration)

J. Cohen-Tanugi & Eric Nuss

Table 1. List of photo-z codes featured in this study. ML here means machine learning.

Code	Type	Paper	Website
BPz	template	Benítez (2000)	http://www.stsci.edu/~dcoe/BPZ/
EAZY	template	Brammer et al. (2008)	https://github.com/gbrammer/eazy-photoz
LePhare	template	Arnouts et al. (1999)	http://www.cfht.hawaii.edu/~arnouts/lephare.html
ANNz2	ML	Sadeh et al. (2016)	https://github.com/IftachSadeh/ANNZ
Delight	ML/template	Leistedt & Hogg (2017)	https://github.com/ixkael/Delight
FlexZBoost	ML	Izbicki & Lee (2017)	https://github.com/tpospisi/flexcode; https://github.com/rizbicki/FlexCoDE
GPz	ML	Almosallam et al. (2016b)	https://github.com/OxfordML/GPz
METAPhoR	ML	Cavuoti et al. (2017)	http://dame.dsf.unina.it
CMNN	ML	Graham et al. (2018)	-
SkyNet	ML	Graff et al. (2014)	http://ccpforge.cse.rl.ac.uk/gf/project/skynet/
TPZ	ML	Carrasco Kind & Brunner (2013)	https://github.com/mgckind/MLZ
trainZ	N/A	See Section 3.3	

DC2 projects

LSST Dark Energy Science Collaboration / ...
/ February 2019 Collaboration Meeting - Berkeley

DESC meeting Feb. 2019

G: Photometric Redshift (PZ)

Created by Christopher Morrison, last modified by Rykoff, Eli S. on Feb 28, 2019

Calibrating photo-z through galaxy clustering

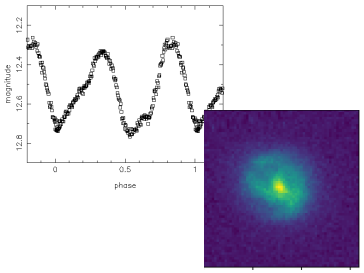
Effect of incomplete training sample

- Overview of DC2 projects (with contact):
  - PZCalibrate (Chris Morrison)
  - PZIncomplete (Will Hartley)
  - Requirements on PZ errors for 3x2pt (Husni Almoubayyed)
  - Running redMaPPer on DC2 cosmo and sim catalogs (slides) (Eli Rykoff
  - 3x2pt analysis with DC2 catalogs (Joe Zuntz)
  - Joint DC2 LSST-WFIRST pixel-level simulations and analysisDC2/DC3 i (Michael Troxel)
- Unlisted and new project pitches:
  - Sam: SOM/Blending
  - Markus: Joint redshift inference with clustering and SED fitting
  - Emission line sprinkler

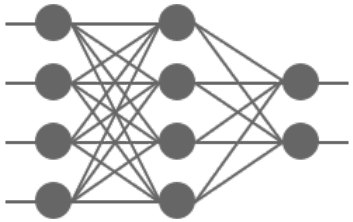
Interesting subjects

Deep Learning, powerful tool to generalize data

Données d'entrée

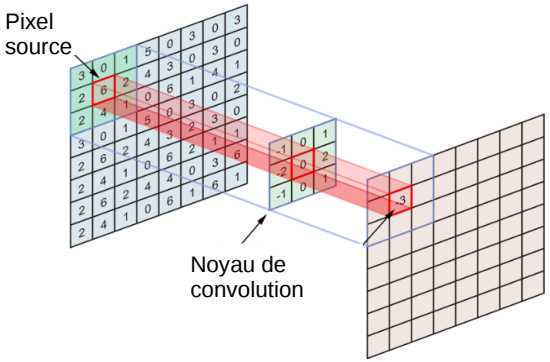


Les caractéristiques sont extraites par l'algorithme

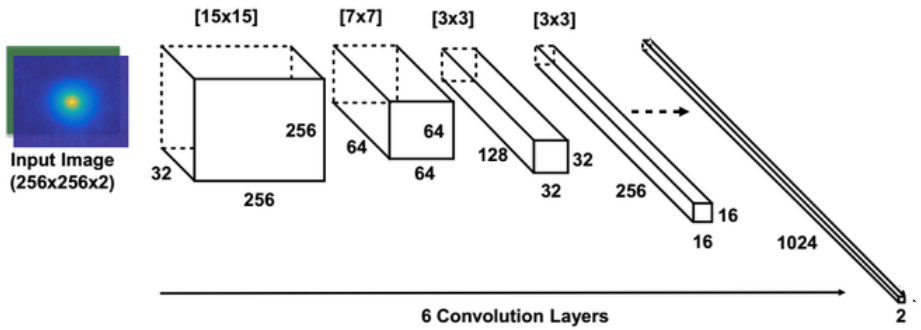


Le réseau trouve le meilleur espace de représentativité pour un problème donné

Les convolutions pour extraire des caractéristiques

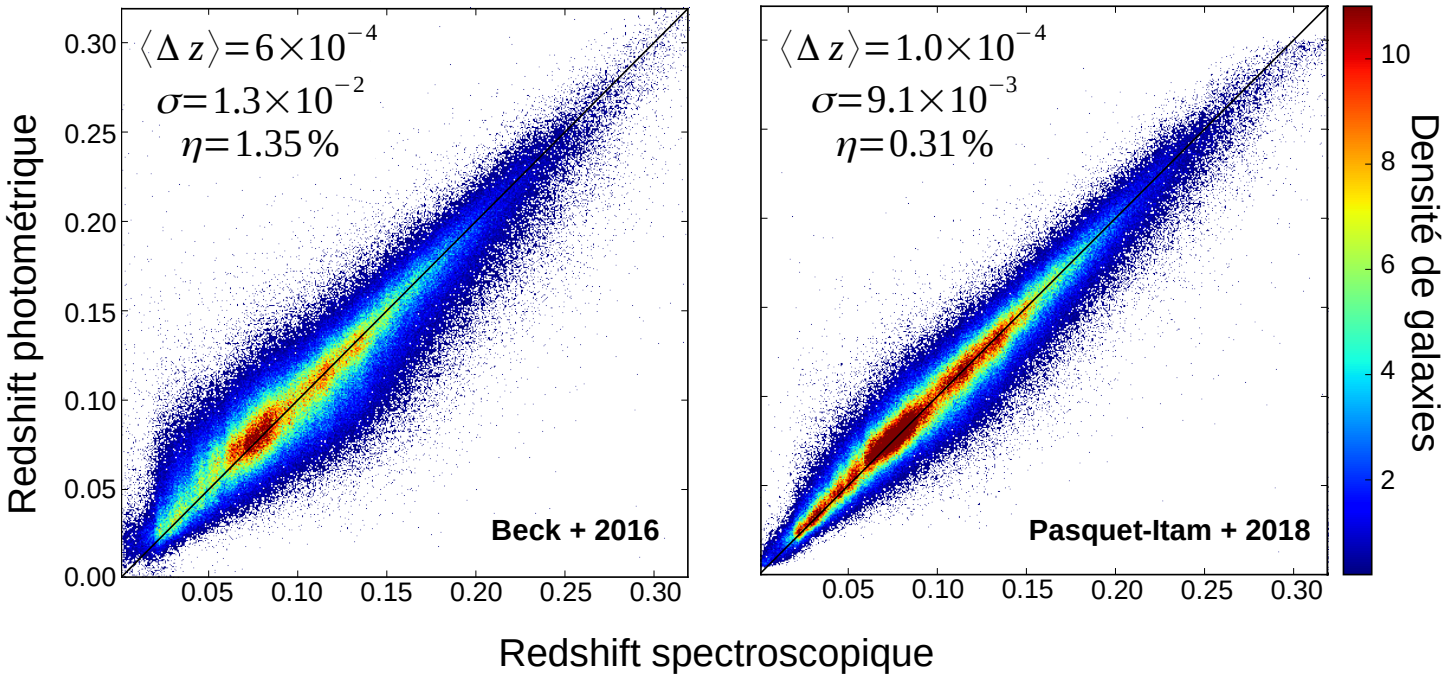


La profondeur pour la généralisation



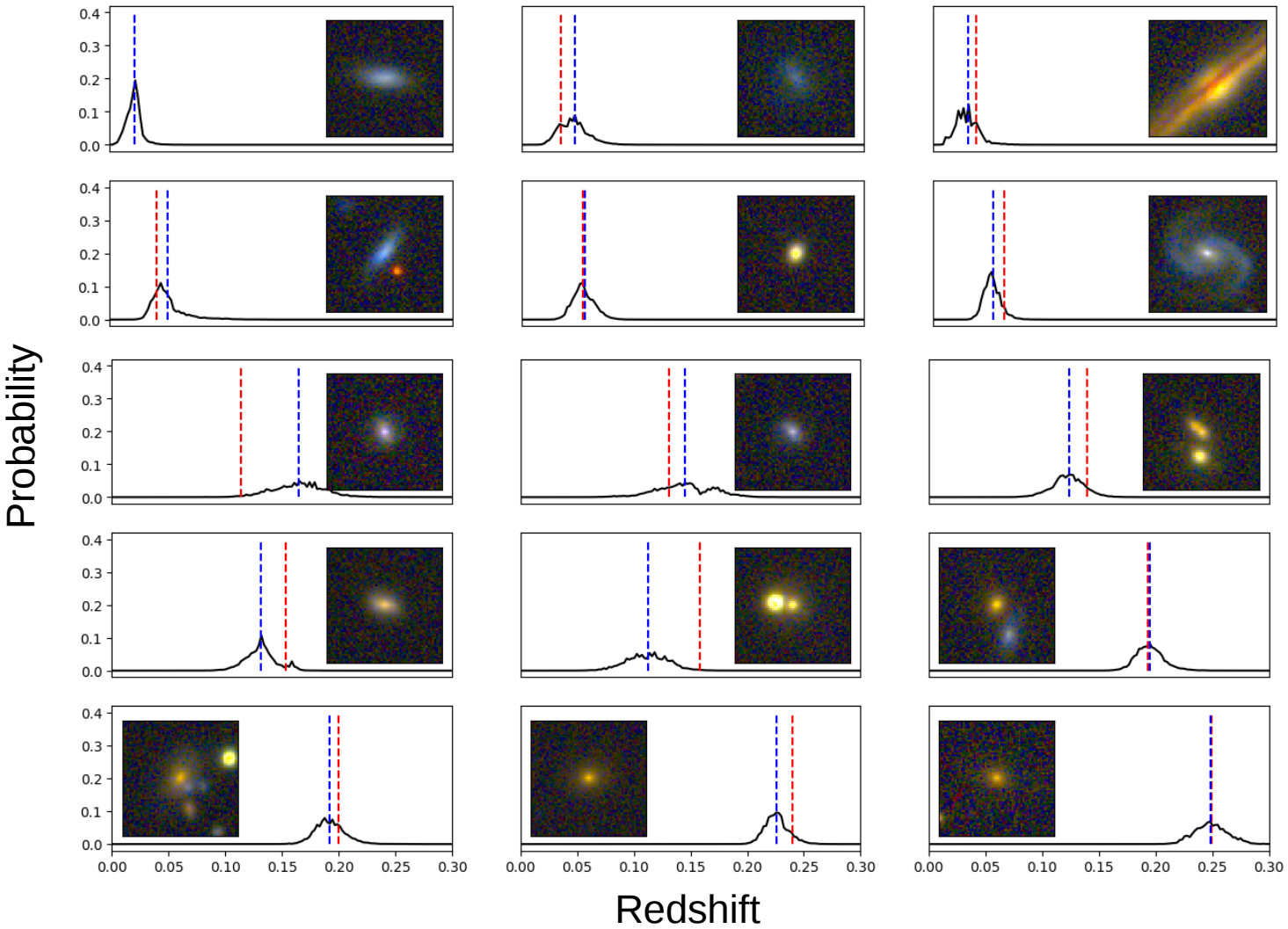
Photometric redshifts from SDSS galaxies

- biais Δz reduced by **6**
- dispersion σ divided by **1.4**
- fraction of catastrophic redshifts η divided by **4**



Photometric redshifts from SDSS images using a Convolutional Neural Network, Pasquet-Itam *et al., A&A, 621 (2019) A26*

PDFs examples



-- Spectroscopic redshift

-- Photometric redshift

Highlighting key questions

1. How can we do even better ?

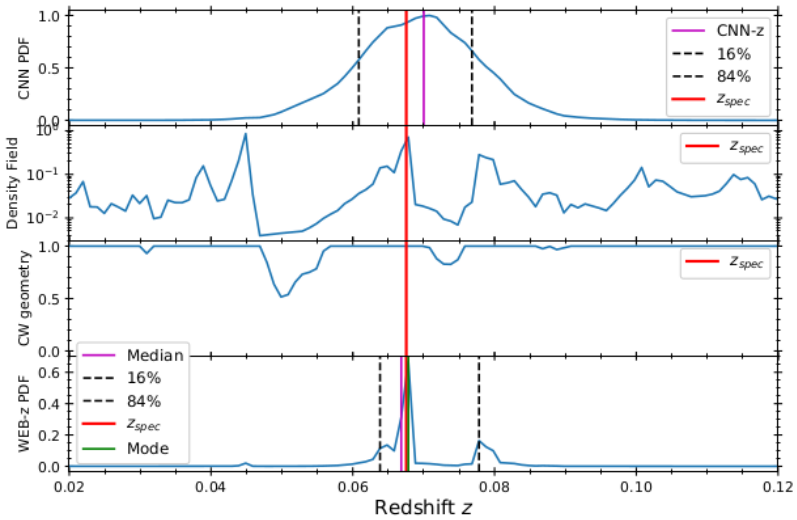
2. Can we extend the method to high redshifts and so make this method suitable for LSST data ?

The *WEBz* technique

- exploit the galaxy distribution of a spectroscopic survey to improve the photometric redshift of other galaxies that are expected to be embedded in this distribution

$$PDF_{z_{web}}(z) = PDF_{CNN}(z).P_{dens}(z).P_{CW}(z)$$

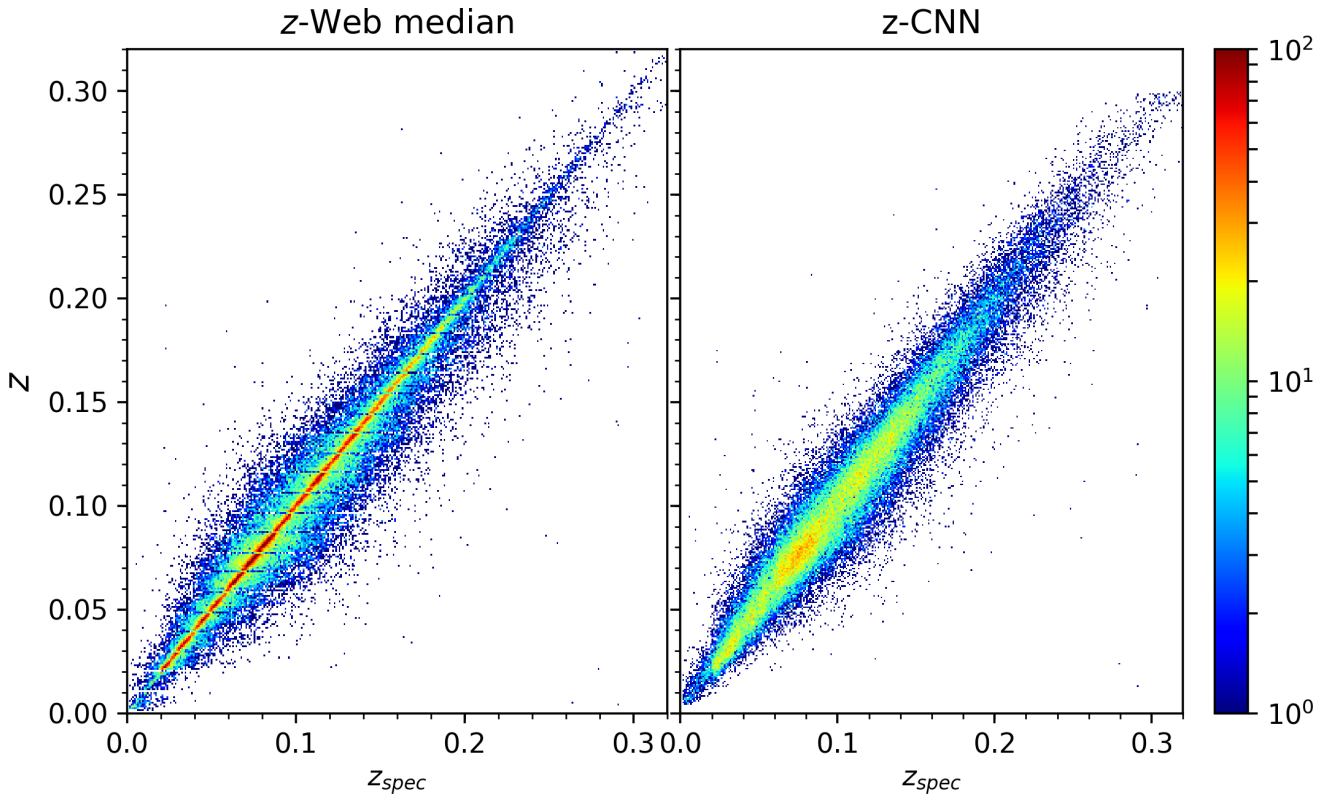
- $PDF_{CNN}(z)$
- $P_{dens}(z)$ PDF of the density field
- $P_{CW}(z)$ a probability that takes into account the geometry of the CW



WEBz : boosting photometric redshift accuracy with large spectroscopic surveys, Shuntov, Pasquet, Arnouts, Ilbert, Treyer et al., in preparation

Results of the *WEBz* technique

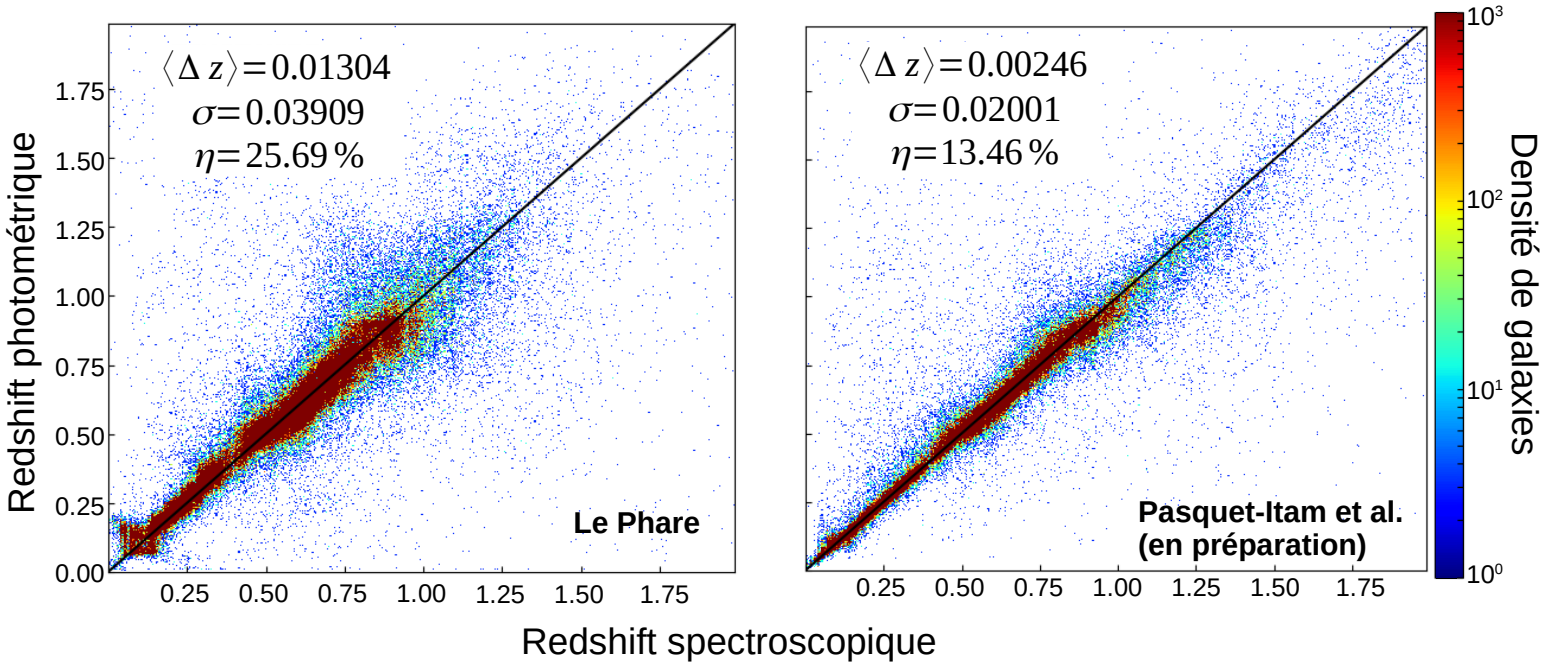
- $\sigma_{MAD} = 4.5 \times 10^{-3}$, $\eta = 0.44\%$



WEBz : boosting photometric redshift accuracy with large spectroscopic surveys, Shuntov, Pasquet, Arnouts, Ilbert, Treyer et al., in preparation

Photometric redshifts from CFHT galaxies

- Significant improvements :
  - **2** factor for the biais Δz
  - **2** factor for the dispersion σ
  - **2** factor for the fraction of outliers η



Method is extended to **redshift of 2** (unexpected !)

Pushing the deep learning method to high redshifts in CFHTLS, Pasquet-Itam et al., in preparation

Conclusion

- Some issues might be easier to tackle with template fitting, unless we know how to **create realistic training samples** suitable for LSST out of simulations
- **bridges** (synergies) with the Machine Learning, also with LSS , Cluster . . .
- **Deep Learning** methods can be very efficient to estimate photometric redshifts at high redshifts
- Powerful tool to deliver **calibrated PDFs** which are an important input of cosmological studies
- Important to **understand** and **control** the bias of the Deep Learning method (**Adversal Examples**, work with Jean-Eric Campagne)
- Need to focus on few issues, for example **additional photometric bands** (Euclid, . . .) and relative **calibration** issues.
- Finish and publish the work on **FORS2 SED's** (LUPM)
- We should try to **reactivate** the PhotoZ WG in France

Thank you for your attention !

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