Spectral library derived from FORS2 data to be used for photometric redshifts of galaxies

Joseph Chevalier, 1st year PhD student

S. Dagoret-Campagne, M. Moniez (IJClab), E. Nuss, J. Cohen-Tanugi (LUPM), R. Ansari (CEA)

IJCLab, CNRS/IN2P3 & Université Paris-Saclay, Orsay, France

Journées LSST-France

Outline
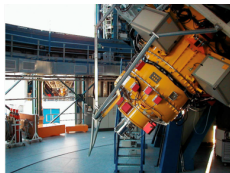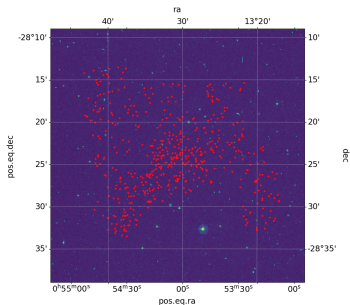
Instrument and target :

- FORS2 spectroscopic instrument at VLT
- 10" × 10" area centered on cluster RX J0054.0-2823 at $z = 0.292$

(a) VLT observatory

(b) FORS2 instrument

(c) RX J540054.0-2823 region

Figure: Source of our spectra
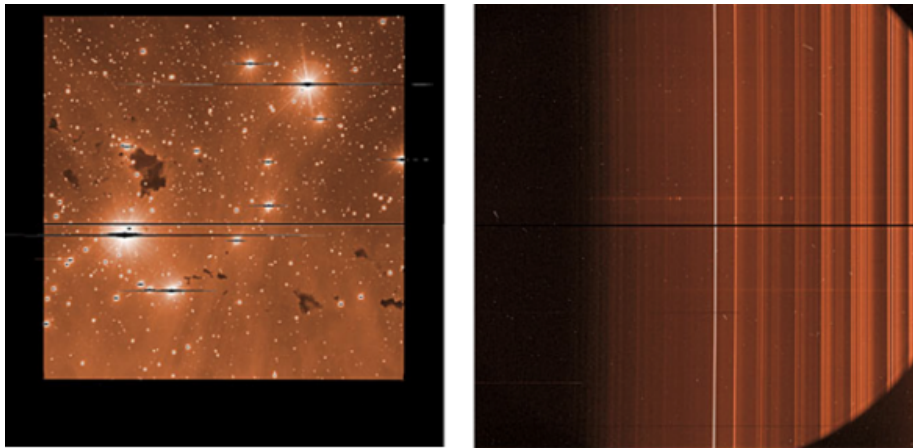
Image mode and **spectroscopy** mode, allows access to redshift:

Figure: Observations with FORS2 instrument

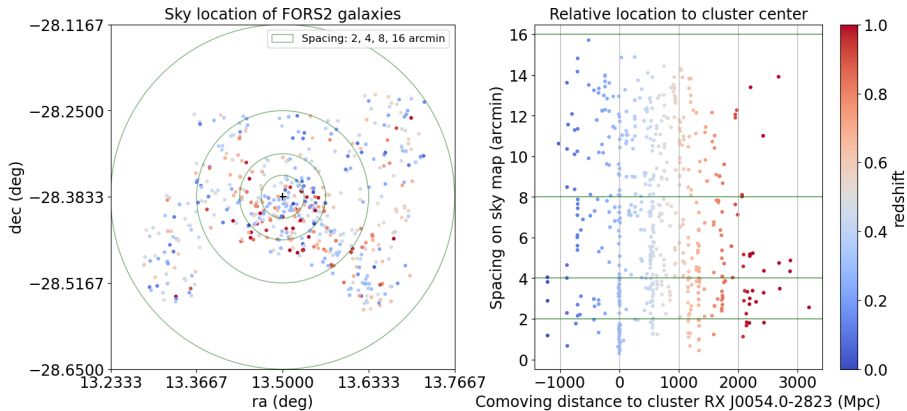Image mode and **spectroscopy** mode, allows access to redshift:

Figure: Galaxies in the sample, with field galaxies and cluster galaxies

Spectral synthesis

Observations limited to a narrow range of wavelengths → extrapolation via Stellar Population Synthesis (SPS):

1. Raw observation

Figure: Full spectrum via SPS using Starlight

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Observations limited to a narrow range of wavelengths → extrapolation via Stellar Population Synthesis (SPS):
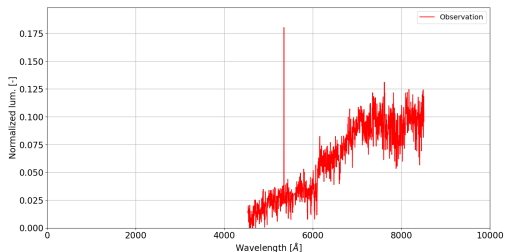
1. Raw observation
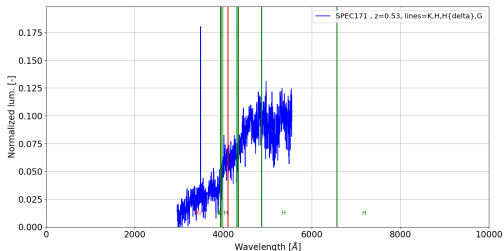2. Emission/absorption lines identification allowing redshift computation and knowledge of physical properties
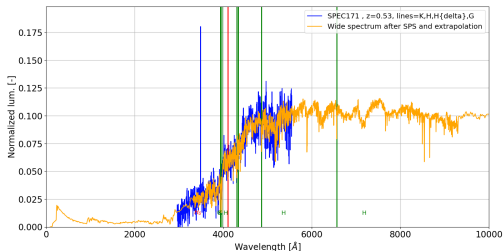3. SPS using Starlight to generate a complete spectrum

Figure: Full spectrum via SPS using Starlight

End product

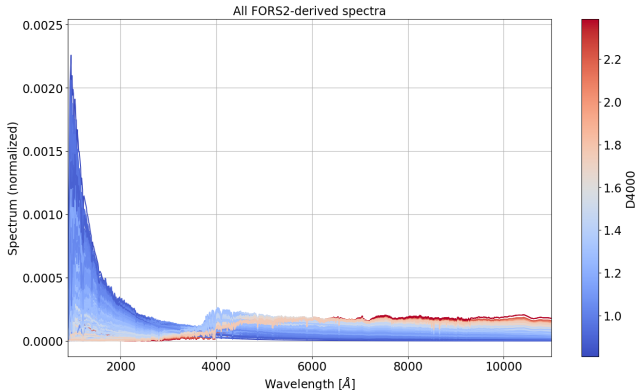We obtain a set of more than 500 spectra to be used as templates for photo-z estimation:

Figure: All spectra derived from FORS2 observations, normalized and colored IAW the ratio of the emitted energy right after over right before the 4000 Å-break

Templates for photometric redshifts

How to downselect the best subset of spectra for photo-z estimation by template fitting?

At zero-th order

- Not necessarily spectra of actual galaxies
- Enough spectra for good performance
- Not too many to allow software run and avoid local minima in χ^2
- Good coverage of the color space

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Finer selection

- Avoid too exotic spectra that generate outliers
- Good understanding of underlying properties (galaxy type, star formation activity, etc.) to setup the estimation tool
- Separate cluster galaxies from field galaxies
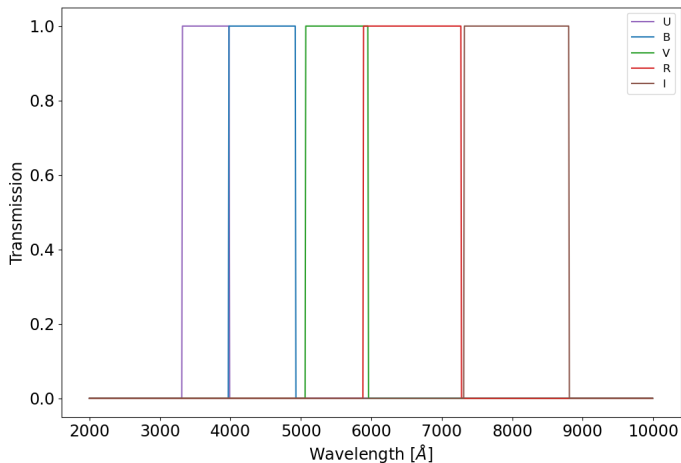
Preliminary :

Figure: Five ideal bands to create a 4D color-space

Selection by color

1. All spectra are binned in the color space

2. The mean spectrum from each bin is selected as a template
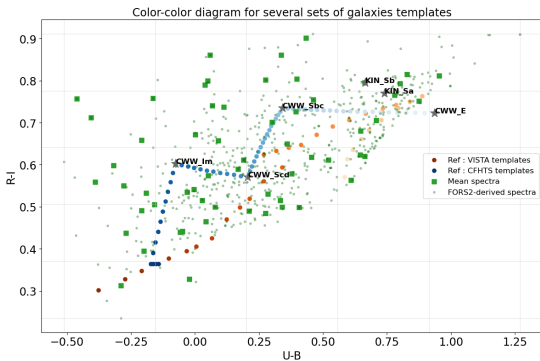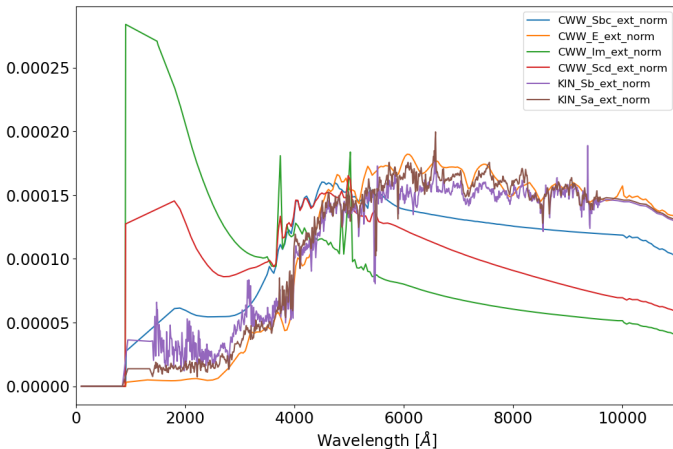
$\rightarrow$ 59 templates for LEPHARE++

Figure: Selected templates in color-color diagrams

Preliminary :

Figure: CWW/Kinney spectra used as references for type identification

Selection by pseudo-type

1. Each spectrum is assigned to a nearest CWW/Kinney in color-space, thus creating clusters for each type

2. The mean spectrum and two extrema from each bin are selected as templates

3. Spectra with $z_{spec} \geq 1$ are added to the selection

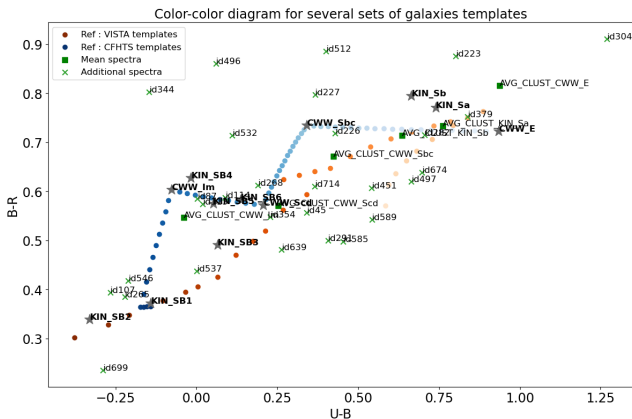$\rightarrow$ 35 templates for LEPHARE++

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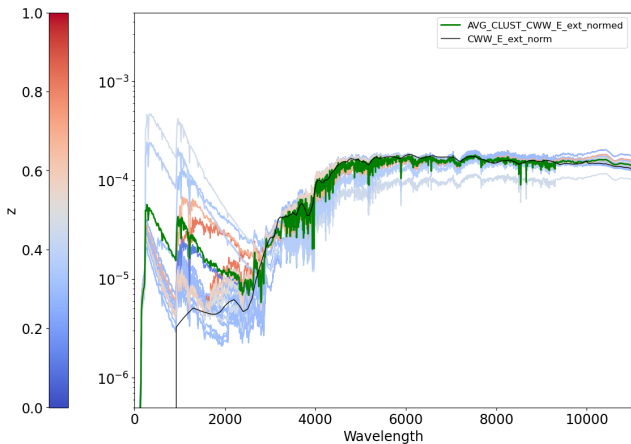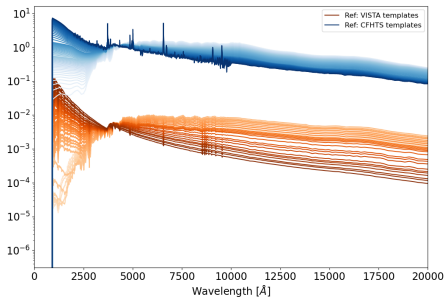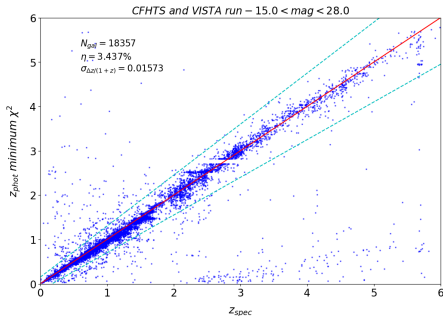

Figure: Details of one type cluster

Photometric redshifts estimation on the COSMOS2020
spectro-photometric dataset :
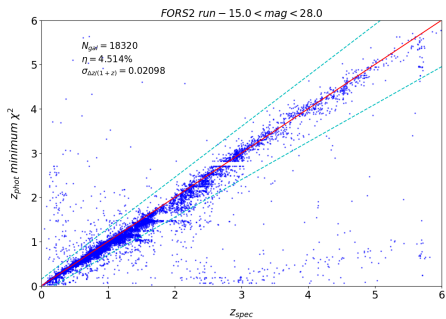

(a) SED templates for the reference case of photo-z

(b) Photo-z on COSMOS2020 dataset

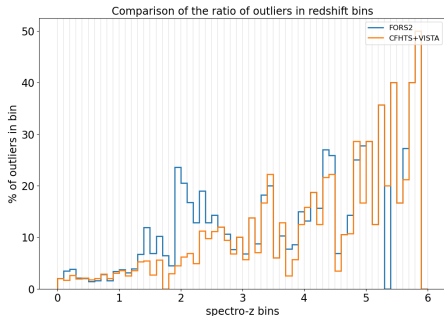Figure: Reference templates and photo-z performances

Photometric redshifts estimation on the COSMOS2020
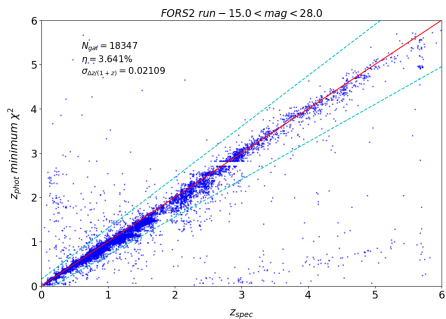spectro-photometric dataset :

(a) Photo-z on COSMOS2020 dataset

(b) A quick look at outliers

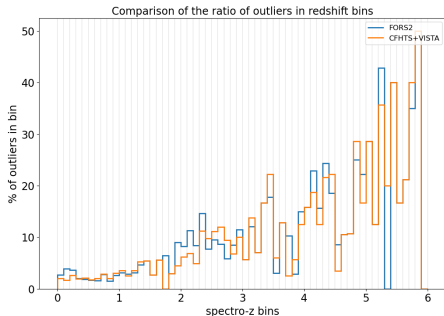Figure: Performances with templates from color bins

Photometric redshifts estimation on the COSMOS2020
spectro-photometric dataset :

(a) Photo-z on COSMOS2020 dataset

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Figure: Performances with templates from galaxy type clusters

- Analyse the outliers, especially those that are not outliers in the reference case
- Seize the ingredients to good templates
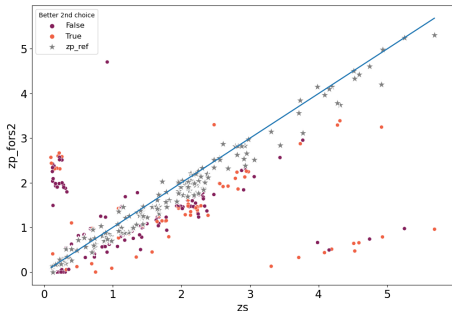- Identify the best templates at fixed z_{spec}

Figure: Subset of such galaxies

- Try and compare different SPS method to get a full comprehension of the physics behind the extended spectra
- Test the FORS2-derived templates on other datasets / with other photo-z tools

Conclusion and takeaway

Where we stand

- Set of observations to be enhanced and extrapolated
- Methods to generate / extract templates for photo-z estimation
- Performances on par with a reference study, with room for improvement

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Lessons learned
This project is more than an attempt to improve photometric redshifts estimation. From a set of observations, it takes the team through all steps of obtaining good results. We hope that our templates, and the understanding of the physics, methods and tools behind this work will prove helpful for LSST and other projects.

Thank you for your attention... and feedback !