AMAZED : Algorithms for Massive Automated Z(redshift) Estimation and Determination

V. Le Brun for the AMAZED Team

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Contributions from S. Arnouts, M. Bethermin, J.G. Cuby and the Euclid and PFS science working groups

A versatile fully automated redshift measurement library

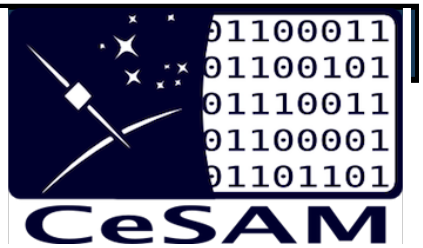
- Human participation up to now (VVDS, VIPERS, DEEP2, even SDSS)
  - No more than 10^5 spectra
  - Validation of software results :

  Redmonster (Hutchinson et al. 2016), EasyLife (Garilli et al. 20XX)

- Impossible for surveys in preparation (Euclid, PFS, Roman, …) :
  - Several millions of objects
  - High observing rate
  - We don’t want to do it anymore

Building on the heritage of VIMOS surveys

A versatile fully automated redshift measurement library



- Adaptable to any instrumental configuration (UV/visible/IR/?)
- Takes into account instrumental effects : LSF, (co)variance
- Fully automated bayesian inference redshift measurement (and error)
- Bayesian object classification (Galaxy, quasars, stars)
- Quantification of reliability and ultimately quality of fit (detection of monsters)
- Core of Euclid, PFS and Roman pipelines

The methods (Galaxies and QSO)

- A least-square fit of model parameters weighted by signal variance
  - Fixed redshift grid
  - Logarithmic sampling for FFT
  - Go back to Tonry & Davis (1979) for a fundamental description

- Redshift Probability Distribution Function calculation for each model
- Combination of all zPDFs into one
- The N best redshifts are identified from the PDF peaks
- Measurements of spectral features at the best redshifts solutions

The galaxy model

- Continuum (including stellar absorption lines)
  - *21 templates built from BC03 models (Tremonti+ 2003)*
  - *The amplitude is fitted*
- Emission lines
  - *Predefined list of lines*
  - *Relative ratios predefined (and updated) from 13 VVDS stacked spectra*
  - *Redshift and width are free parameters*
- Interstellar absorption lines
  - *Velocity shift is fixed (-150 km/s), but could be free*
  - *Relative ratios predefined from 13 VVDS/Steidel stacked spectra*
- Intergalactic Medium absorption
  - *Tabulated from Meiksin (2002) : 7 curves at 11 redshifts between 2 and 7*
- Interstellar extinction
  - *Tabulated from Calzetti (2000)*

The method – The model

- Continuum (including stellar absorption lines)
  - *21 templates built from BC03 models*
  - *The amplitude is fitted*
- Emission lines
  - *Predefined list of line*
  - *Relative ratios*
  - *Position a*
- Interste
  - *del stacked spectra*
- Inte
  - *curves at 11 redshifts between 2 and 7*
  - *ecti (2000)*

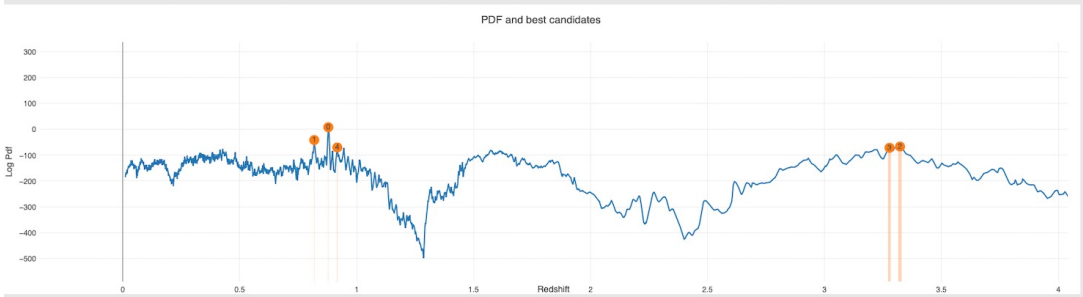
Bring your own if you don't like ours :
- All model components are handled as configuration files
- The user can decide to use them or not

The method – Redshift Determination

- PDF from each model are combined
  - *Marginalization (over all model parameters), final PDF delivered.*
- The best redshift is taken at the maximum of integrated probability
  - *Error on redshift estimated via Gaussian fit*
  - *Integral value under the PDF peak as Reliability level*
  - *To be improved with ML/DL Techniques*
- Secondary redshift values at following peaks
- Code is able to integrate priors
  - *Strong lines : greater probability for "Main Strong lines" (Ha, OII, OIII)*
  - *Hα : greater probability to be an Ha line*
  - *N(z) : an a-priori redshift distribution of Ha emitters*

The method – Redshift Determination

Previous | Next | Results List | Undo zoom



0 Redshif

R..	Reds..	Redshif..	Redshift..	Template..	LinesRatioName	Conti..	Con..	ContinuumA..	VelocityE..	VelocityA
0	0.87826..	0.0002542..	0.9952371..	ssp_1.4Gyr_z..	tpl_NEW-Sbc-extended_TF_catalog....	0.3	-1	1.307702733e-17	230	450
1	0.81802..	0.0003250..	4.8010451..	t5e9_12gyr_z..	tpl_NEW-Sbc-extended_TF_catalog....	0.6	-1	4.520180513e-17	370	450
2	3.32257..	0.0024472..	5.7055066..	ssp_290Myr_..	tpl_COMBINE-ave-Lya-abs-AND-Sc..	0.9	-1	0	10	450
3	3.27784..	0.0021489..	3.0255436..	ssp_290Myr_..	tpl_NEW-Im-extended-blue_TF_cata..	0.9	-1	0	10	150
4	0.91659..	0.0004208..	2.2199397..	cst_6gyr_z02....	tpl_COMBINE-ave-BX-highblue-AN..	0.8	-1	1.019394829e-16	370	450
-1	0.879									
-2	0									

Type of lines: Emission | Absorption | All

Strength of lines: Strong | Weak | All

...	...	Name	Typ	Flux
91...	48...	HbetaA	A	-5.04e-18
81...	43...	HgammaA	A	-1.89e-18
80...	43...	GBand	A	-2.80e-18
77...	41...	HdeltaA	A	-1.45e-18
74...	39...	CaII_H	A	-1.05e-18
73...	39...	CaII_K	A	-1.23e-18
73...	38...	H8A	A	-1.29e-18
72...	38...	H9A	A	-1.19e-18
71...	37...	H10A	A	-6.63e-19
70...	37...	H11A	A	-4.87e-19
67...	35...	FeI	A	-2.00e-19
91...	48...	Hbeta	E	0.00e+0
81...	43...	Hgamma	E	0.00e+0
77...	41...	Hdelta	E	0.00e+0
74...	39...	Hepsilon	E	0.00e+0

The usage – Integration to a pipeline or standalone use

- Interaction with the input and output data : the python client
  - *Generic one with a given data model for public version*
  - *We can provide one adapted to the datamodel used in a pipeline*
  - *Both in input and output*
- Handles parallelization

Performances on simulated data

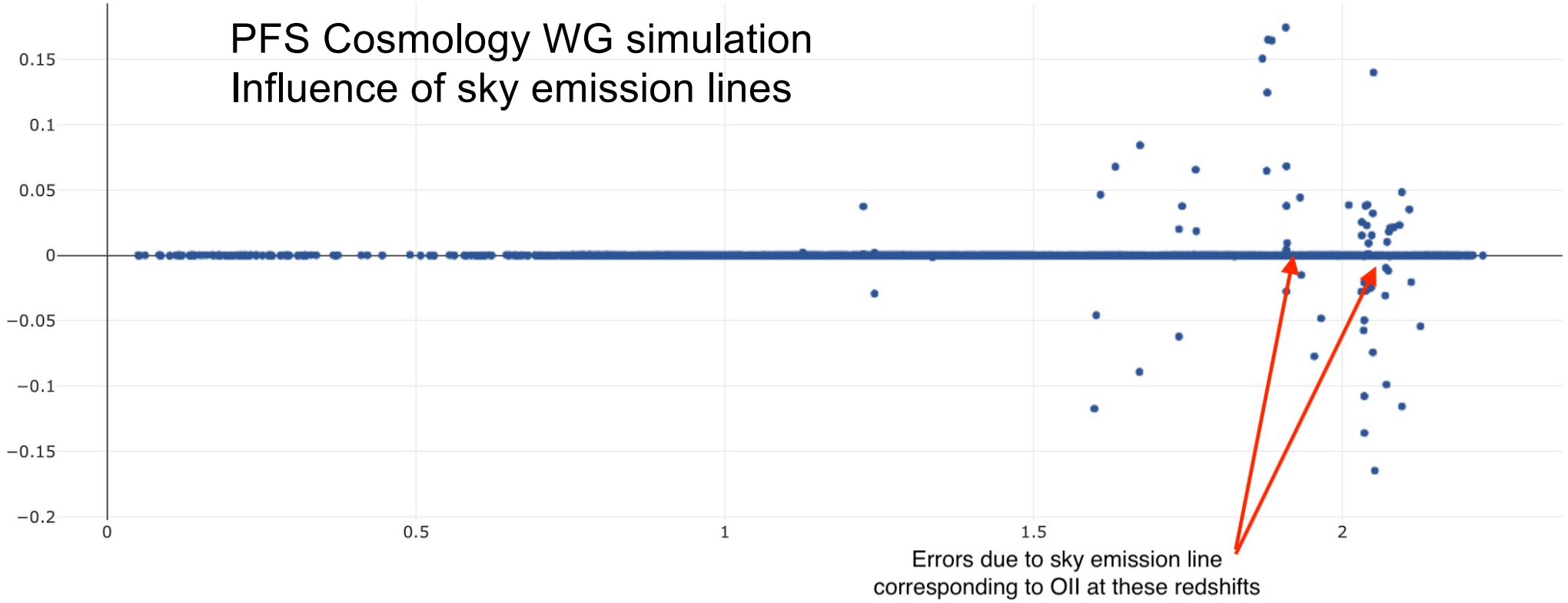
- Efforts from the PFS and Euclid Science Working Groups

- Within requirements so far but…
  - Not all instrumental effects included yet
  - Simulated continuum against simulated continuum templates

  (because building coherent observed templates over 500-18000 A is tough)

Others already said it, but early full E2E simulations are fundamental

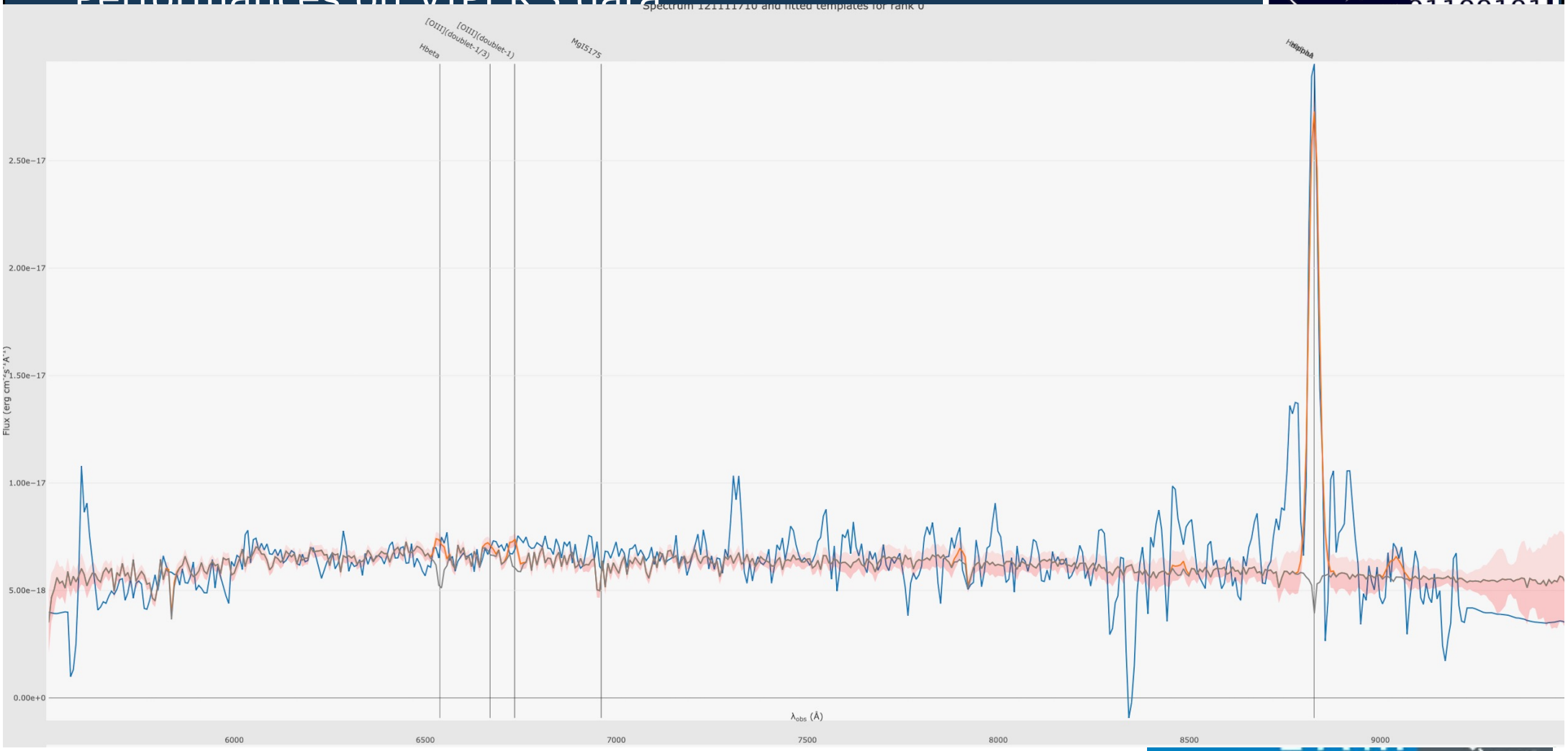
Performances on simulated data



Performances on VIPERS data

- Results on the flag 4 spectra : 19658 galaxy spectra
- Caveats
  - Variance in VIPERS spectra is ‘not perfectly’ evaluated
  - There can be superposition of spectra
  - Flags (sometime strongly) depend on the personality/experience
  - Human measurement based on features not available
    2D spectrum
    Feature on the edge of spectrum

Performances on VIPERS data



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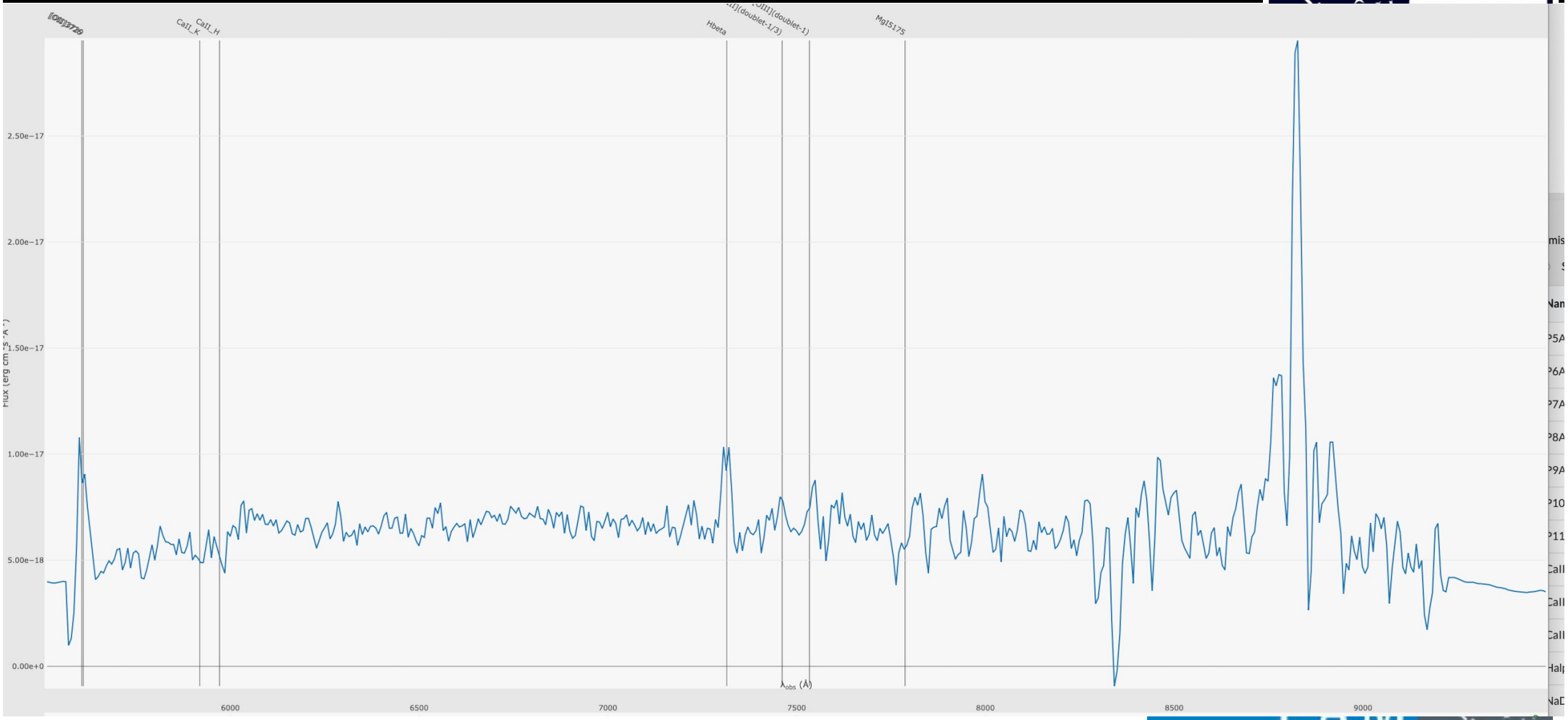
Performances on VIPERS data



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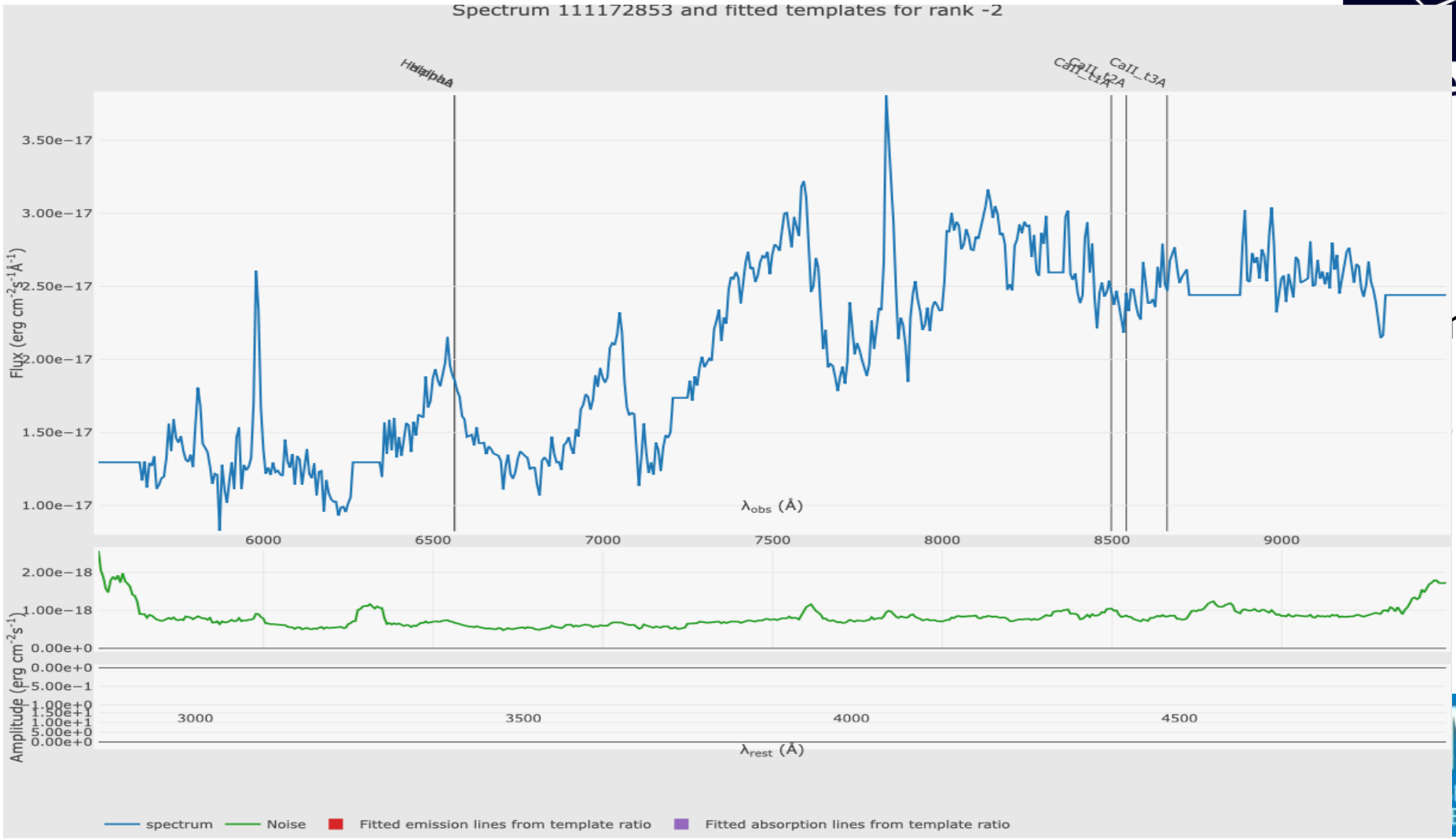

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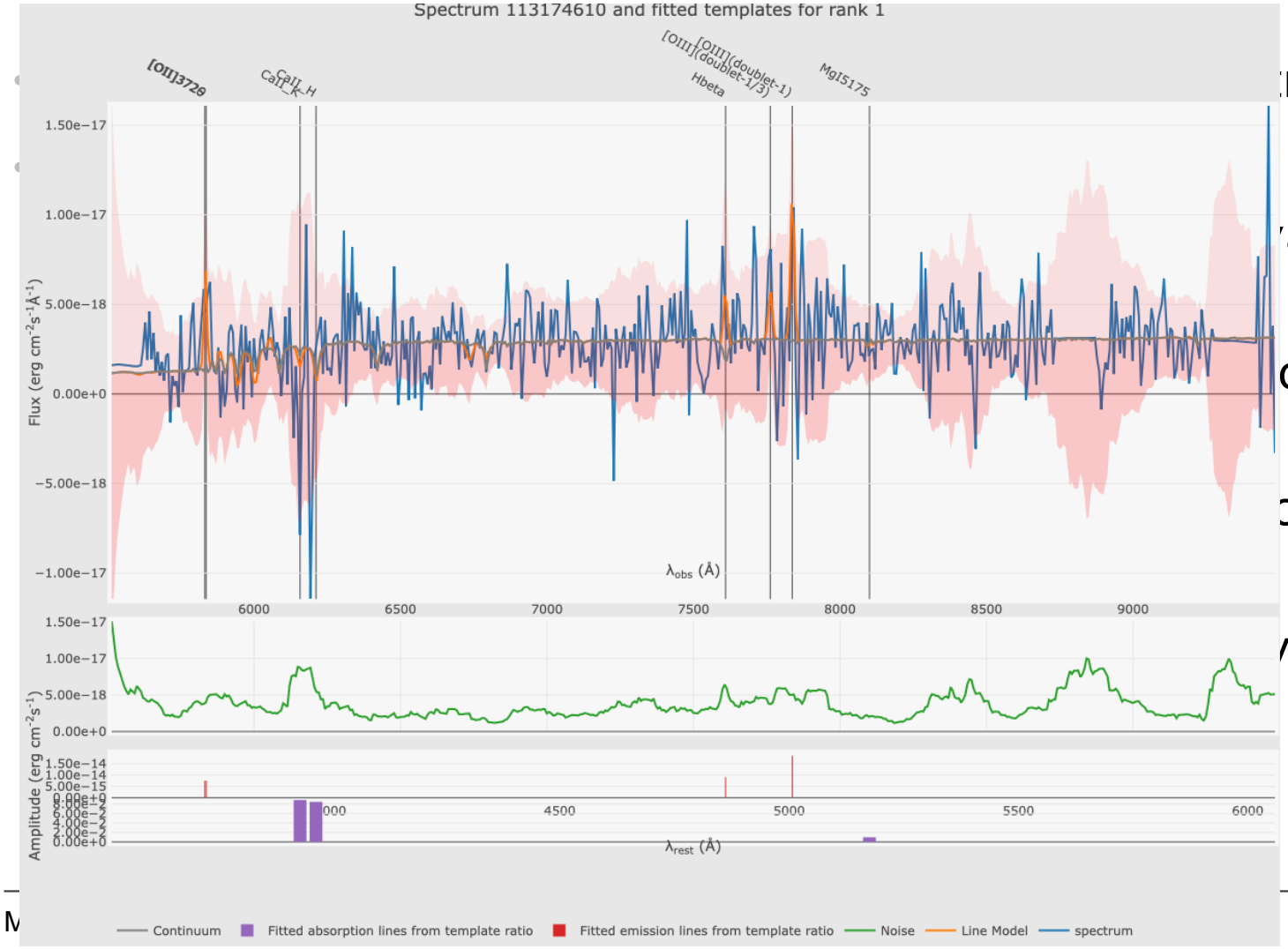
Performances on VIPERS data

- Results on the flag 4 spectra : 19658 galaxy spectra
- Caveats
  - Variance in VIPERS spectra is ‘not perfectly’ evaluated
  - Not a simulation, even with double human check, errors remain
  - Flags (sometime strongly) depend on the personality/experience
  - Human measurement based on features not available
    2D spectrum
    Feature on the edge of spectrum

Performances on VIPERS data



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Performances on VIPERS data

- 96.3% success with |dz/(1+z)| < 0.002 (*300 km/s at z=1*)

- 0.4<z<0.53 galaxies represent 20% of sample but 35% of errors
  - Lack of adequate template ?

(Red+ templates were built during VVDS)

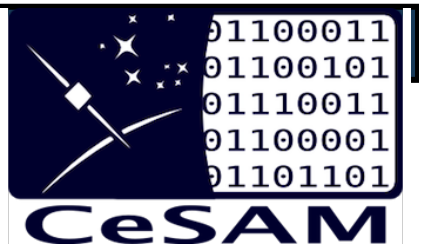
- Merit (measures confidence,)
  - Cutting merit >0.99 excludes 7.5% of the sample but 1/3 of errors
  - Dynamics to be refined

Next steps

- Inprove reliability
- Validate object classifier
- Provide homogeneous measurements on public data available at
  - https://cesam.lam.fr/aspic

- First public release in 2022
- Open to collaborate on your favorite project

Next Marseille Cosmology Conference Edition



From galaxies to cosmology with deep spectroscopic surveys

A tribute to Olivier Le Fèvre

25-29 oct. 2021 Marseille (France

https://specsurveys2021.sciencesconf.org