

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

V. Le Brun for the AMAZED Team

P.-Y. Chabaud, M. Gray, C. Surace, D. Vibert,

A. Allaoui, G. Daste, M. Sarkis,

A. Schmitt (CeSAM)

Contributions/Inputs/Criticisms from Euclid and PFS OUs/science working groups

A versatile fully automated redshift measurement library

- Human participation up to now (VIMOS, DEEP2, even SDSS)
 - 10^5 spectra
 - Validation of software results :
Redmonster (Hutchinson et al. 2016), EZ (Garilli et al. 2010)
- Dedicated software for specific populations (DESI, Rubin,..)



A versatile fully automated redshift measurement library

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 - Validation of software results :
Redmonster (Hutchinson et al. 2016), EZ (Garilli et al. 2010)
- Dedicated software for specific populations (DESI, Rubin,..)
- Impossible for more general 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), ML evolution ongoing
- Quantification of reliability and ultimately quality of fit (detection of “monsters”)



Core of Euclid, PFS and Roman pipelines



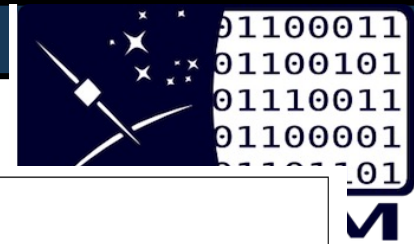
- A least-square fit of model parameters weighted by signal variance
 - Fixed redshift grid
 - Logarithmic sampling for FFT
 - Go back to Tonry & Davis (1979) for a fundamental description
- Redshift Probability Distribution Function calculation for each model
- Combination of all zPDFs into one
- The N best redshifts are identified from the PDF peaks
- Measurements of spectral features at the best redshifts solutions

The method : galaxy model

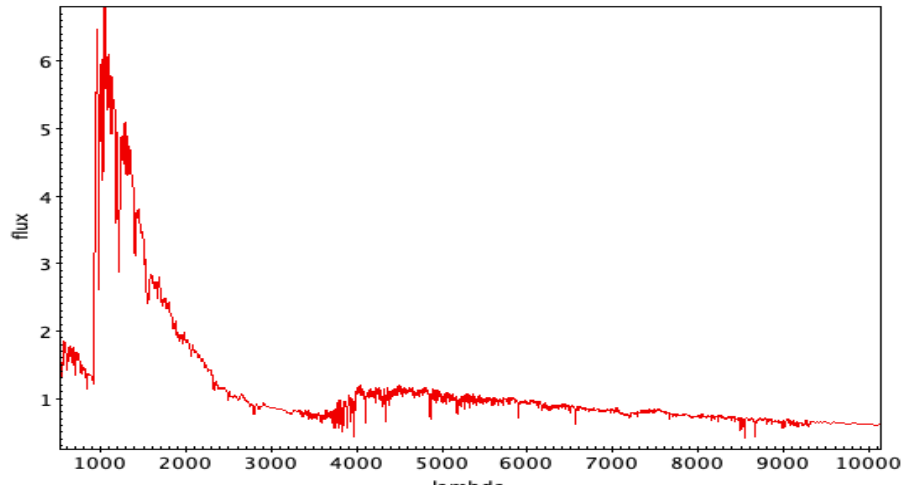
- Continuum (including stellar absorption lines)
 - *21 templates built from BC03 models (Tremonti+ 2003)*
 - *The amplitude is fitted*
- Emission lines
 - *Predefined list of lines*
 - *Relative ratios predefined (and updated) from 13 VVDS stacked spectra*
 - *Redshift and width are free parameters*
- 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 galaxy model

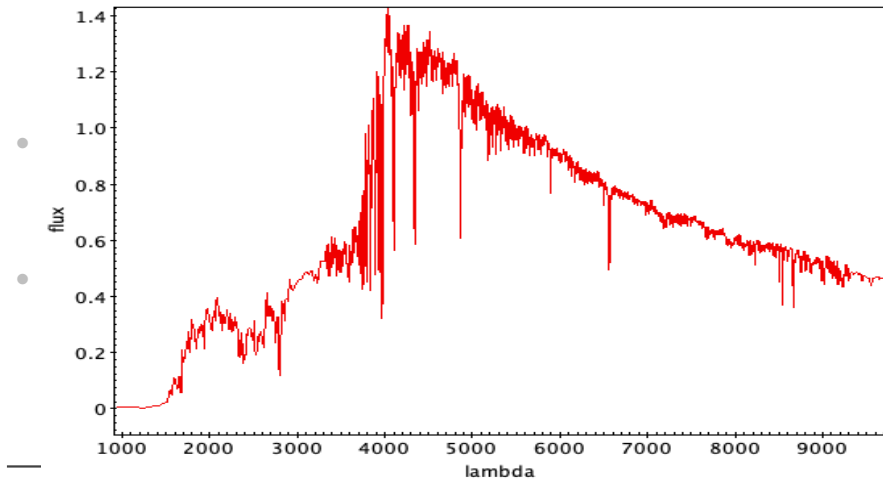
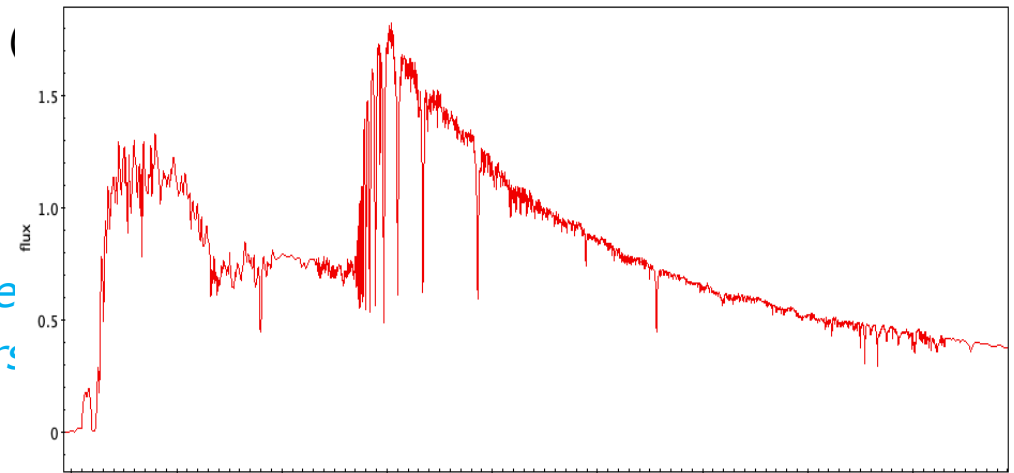


- Continuum (including stellar absorption lines)



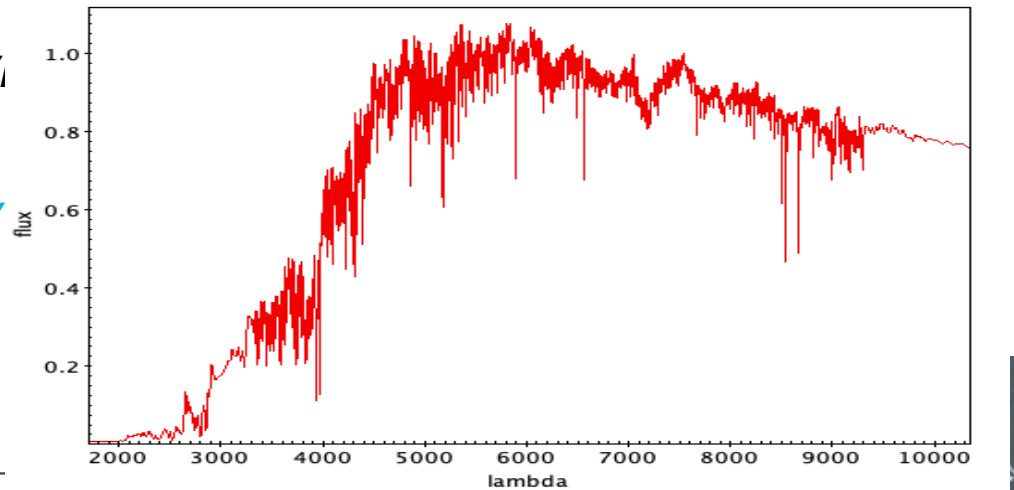
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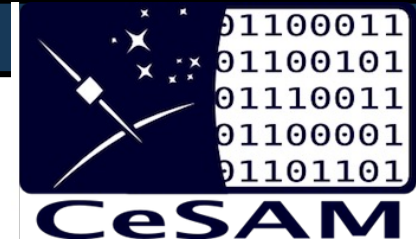


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The method – The galaxy model



- Continuum (including stellar absorption lines)
 - 21 templates built from BC03 models (Tremonti+ 2003)

- *The ar*

- Emission li

- *Predel*

- *Relativ*

- *Positiv*

- Interstellar

- *Velocit*

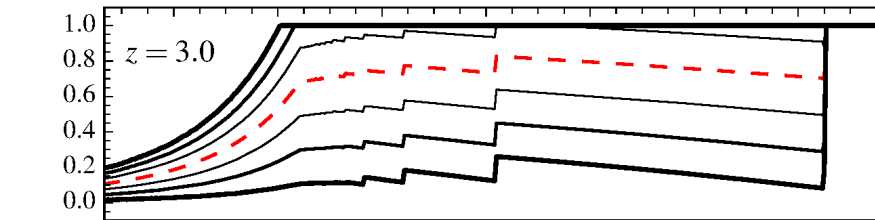
- *Relativ*

- Intergalact

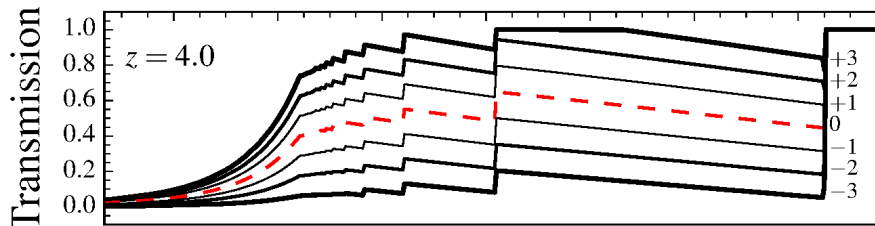
- *Tabula*

- Interstellar

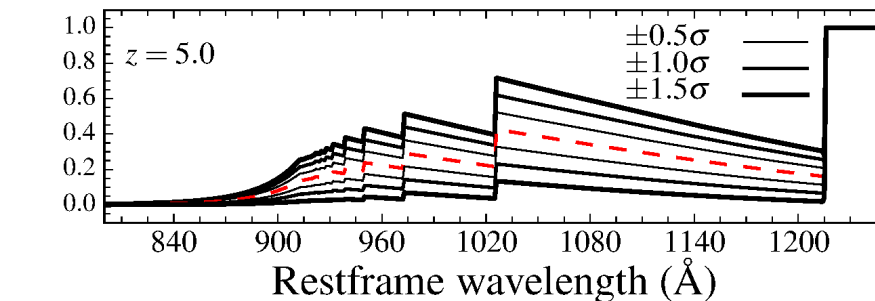
- *Tabula*



VVDS stacked spectra



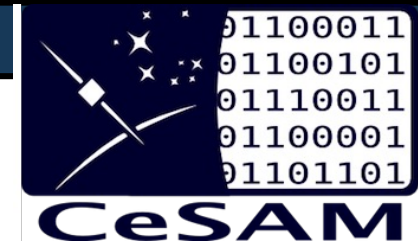
stacked spectra



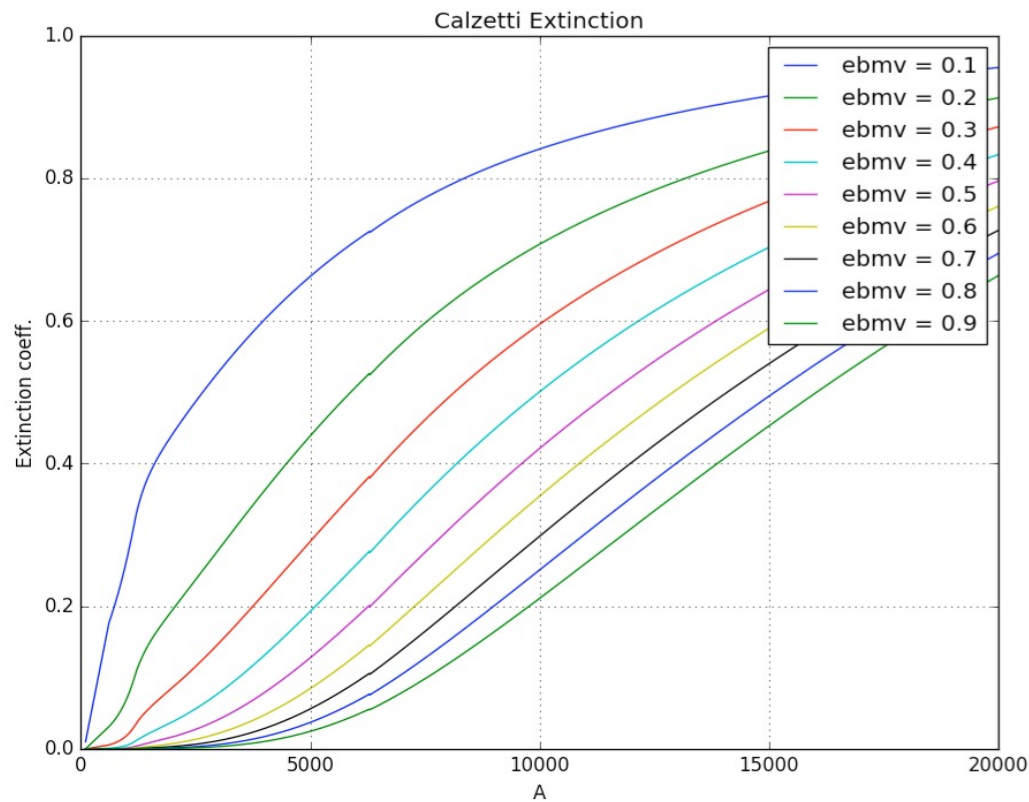
shifts between 2 and 7



The method – The galaxy model



- Continuum
 - 21 to 2500 Å
 - Theoretical
- Emission
 - Predicted
 - Relative
 - Position
- Interstellar
 - Velocity
 - Relative
- Intergalactic
 - Tabulated
- Interstellar
 - Tabulated



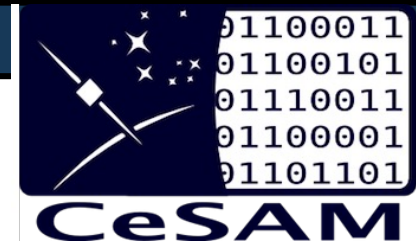
sked spectra

ectra

ween 2 and 7



The method – The galaxy model



- Continuum (including stellar absorption lines)

- 21 templates built from BC03 models (Trenn
- The amplitude is fitted

- Emission lines

- Predefined list of lines
- Relative ratios predicted
- Position and width

- Interstellar dust

- V_{ext}

-

- Inte

-

Bring your own if you don't like ours :

All model components are configuration files

The user can decide to use them or not

↪ spectra

↪ Steidel stacked spectra

↪ 7 curves at 11 redshifts between 2 and 7

↪ Calzetti (2000)



The method – Redshift Determination

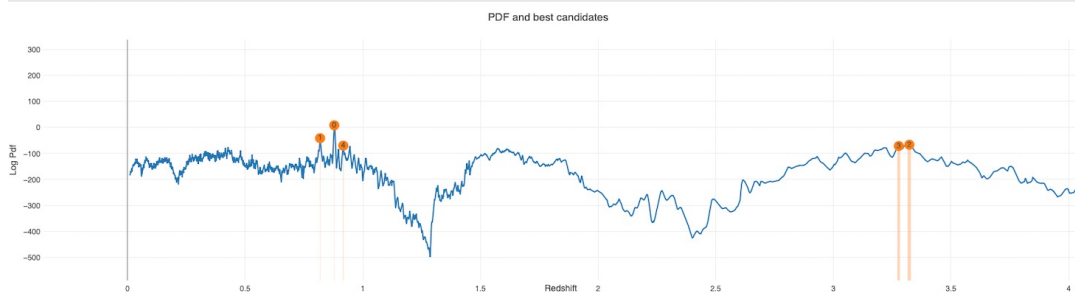


- PDF from each model are combined
 - *Marginalization (over all model parameters), final PDF delivered.*
- The best redshift is taken at the maximum of integrated probability
 - *Error on redshift estimated via Gaussian fit*
 - *Integral value under the PDF peak as Reliability level*
 - *Being improved with ML/DL Techniques, using the full PDF*
- Secondary redshift values at following peaks
- Code is able to integrate priors
 - *Strong lines : greater probability for "Main Strong lines" (Ha, OII, OIII)*
 - *H α : 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 ↶



R...	Reds...	Redshif...	Redshift...	Temple...	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-lm-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	Type	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...	Fel	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

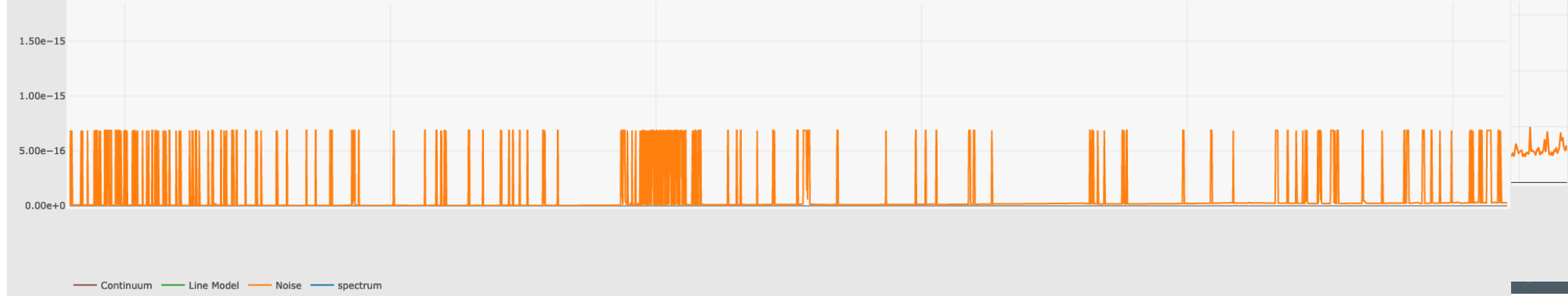
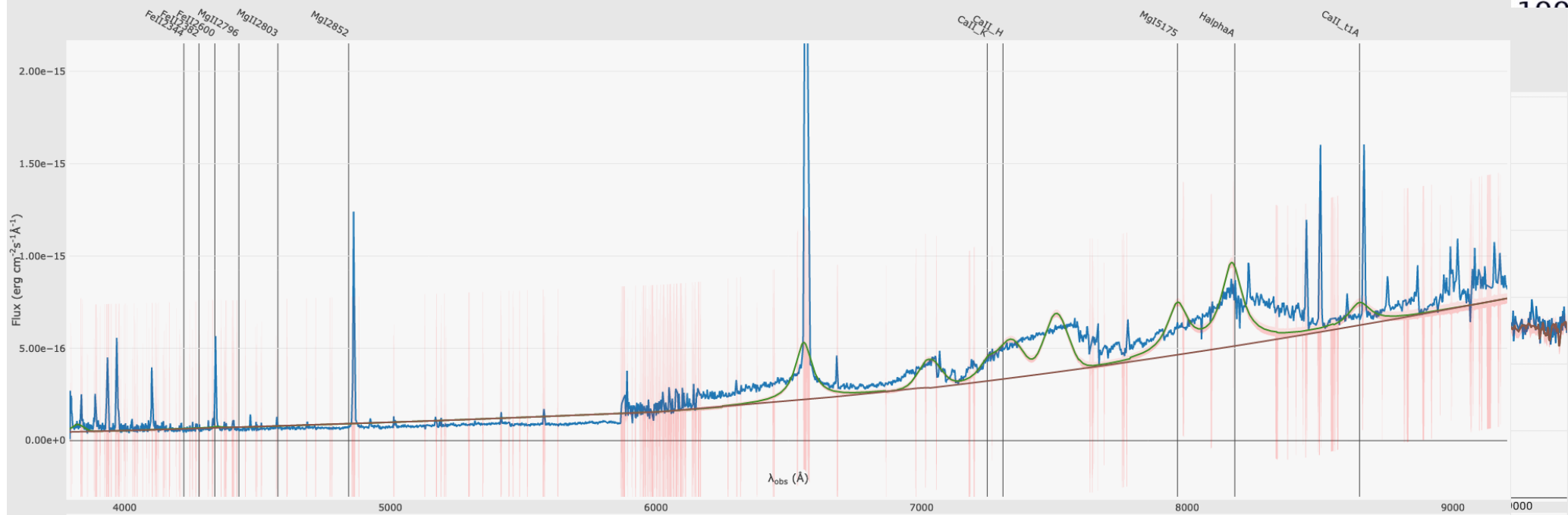
The usage – Integration to a pipeline or standalone use

- 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

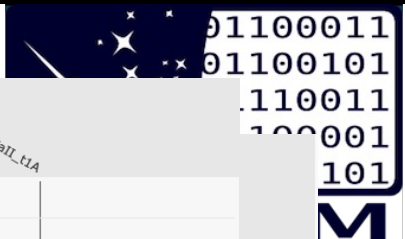


Performances on SDSS data

Spectrum 7261-56603-0771 and fitted templates for rank 0



Continuum Line Model Noise spectrum



Performances on VIPERS data



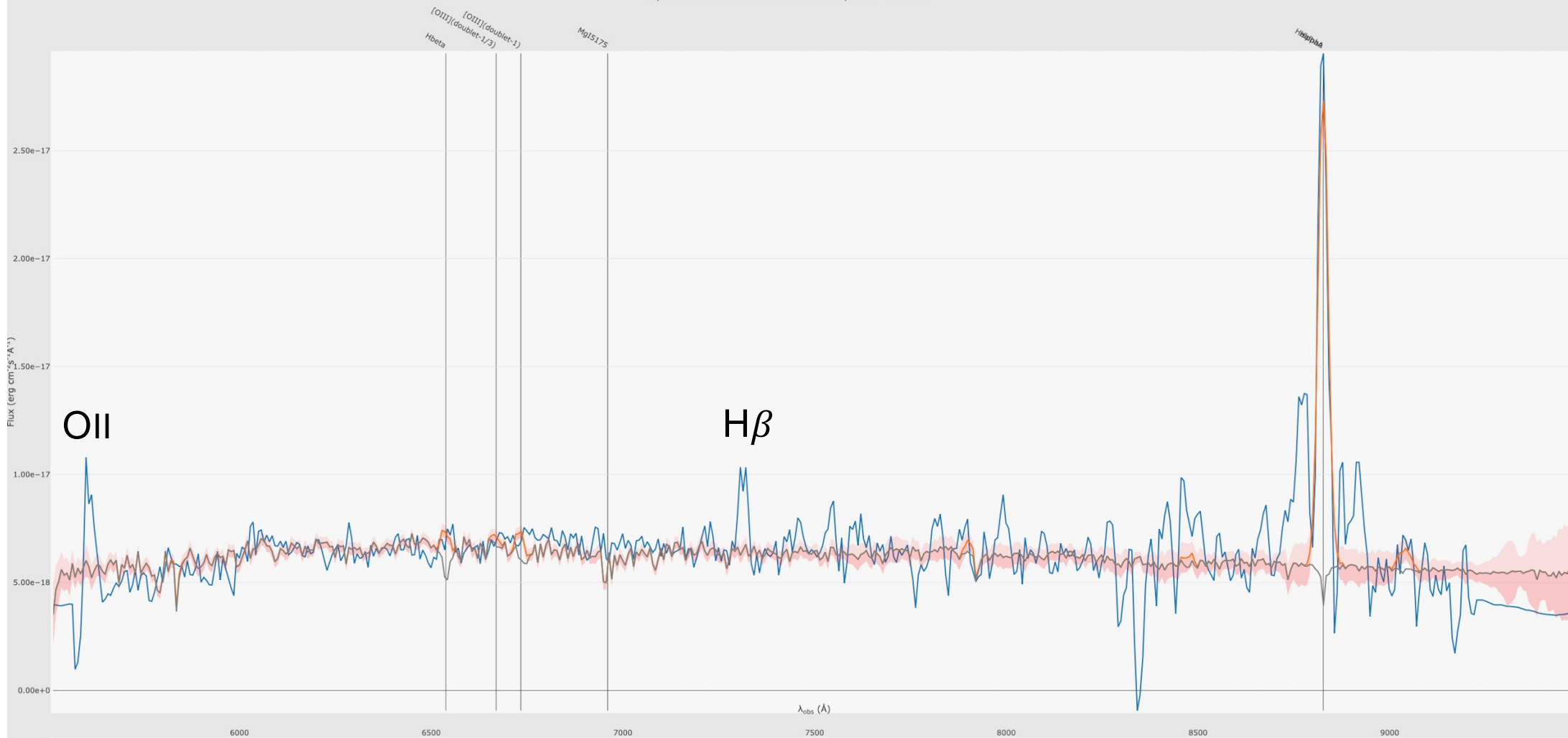
- Results on the flag 4 spectra : 19658 galaxy spectra
- Caveats
 - Variance/flags in VIPERS spectra are 'not perfectly' evaluated
 - There can be superposition of spectra
 - Flags (sometime strongly) depend on the personality/experience
 - Human measurement based on features not available in the spectrum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

Performances on VIPERS data



01100011
01100101

Spectrum 121111710 and fitted templates for rank 0



Performances on VIPERS data



- Results on the flag 4 spectra : 19658 galaxy spectra
- Caveats
 - Variance/flags in VIPERS spectra are '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 in the spectrum
 - 2D spectrum
 - Feature on the edge of spectrum

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 7.8% of the sample but 1/3 of errors
 - Dynamics to be refined

Next steps

- Improve reliability with ML
 - First version improves purity by $\sim 10\%$
- Validate and improve object classifier
- Provide homogeneous measurements on public data available at
 - <https://cesam.lam.fr/aspic>
- First public release in 2023+
- Open to collaborate on your favorite project

