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estrela

Reduction of VLT spectra - I. General methods

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Reduction of VLT spectra - I. General methods

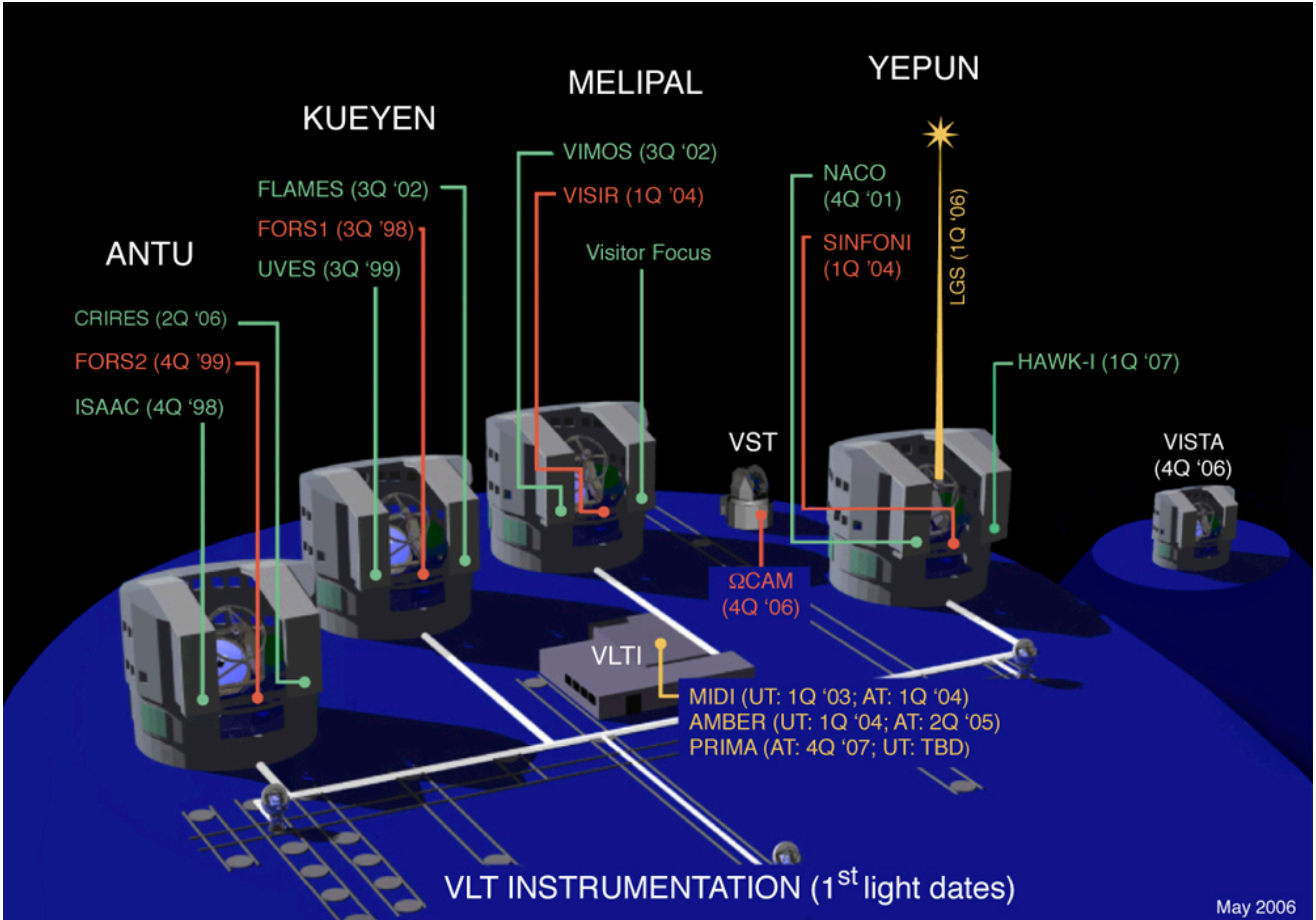
Summary

- ✦ VLT instrumentation review
- ✦ The choice of the spectrograph
- ✦ Strategy of galaxy surveys: MOS with VIMOS
- ✦ Mask preparation and slit positioning with VMMPS
- ✦ Observations
- ✦ Spectra reduction with VIPGI (or IRAF/IDL/MIDAS):
    - unpack raw data
    - master bias
    - master flat
    - master lamp and wavelength calibration
    - spectra location
    - standard stars and flux calibration
    - output 1D and 2D spectra
- ✦ Some basic spectral measurements: redshift, line EWs

Reduction of VLT spectra - I. General methods

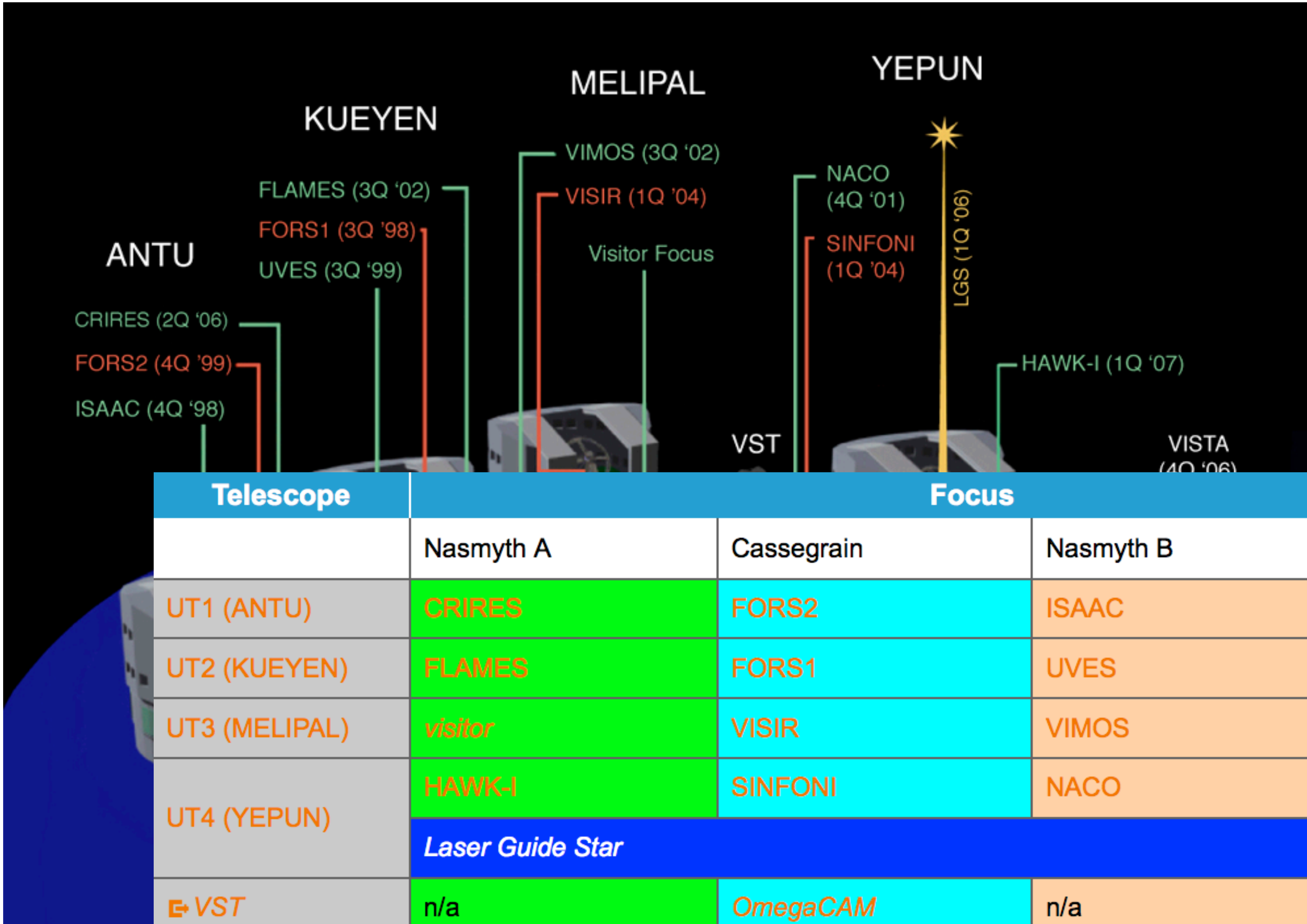
VLT: First generation instrumentation

VLT: First generation instrumentation



Reduction of VLT spectra - I. General methods

VLT: First generation instrumentation



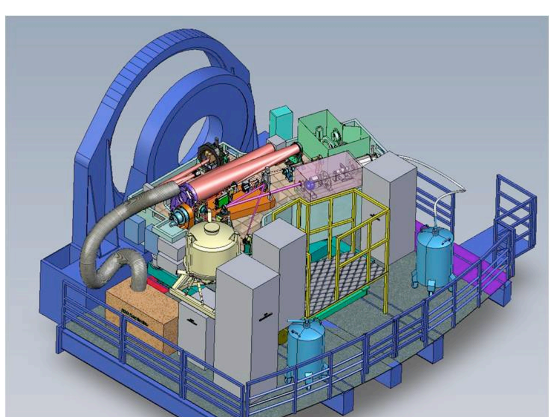
Telescope	Focus			
	Nasmyth A	Cassegrain	Nasmyth B	interferometric
UT1 (ANTU)	CRIRES	FORS2	ISAAC	MIDI AMBER *PRIMA*
UT2 (KUEYEN)	FLAMES	FORS1	UVES	
UT3 (MELIPAL)	*visitor*	VISIR	VIMOS	
UT4 (YEPUN)	HAWK-I	SINFONI	NACO	
	Laser Guide Star			
VST	n/a	*OmegaCAM*	n/a	n/a
VISTA	n/a	*IR camera*	n/a	n/a

VLT: Second generation instrumentation

X-Shooter: UV to K-band single target intermediate resolution (R=4000-14000) spectrograph (commissioning started)

MUSE: Multi Unit Spectroscopic Explorer, a panoramic integral-field spectrograph operating in the visible wavelength range; Wide Field Mode (WFM) fov=1'x1' and Narrow FM fov=7.5" x7.5" (Final design review in 2009)

KMOS: K-band multi-object spectrograph, 1.0 to 2.5 microns, 24 IFUs with field of view of 2.8" x 2.8" each and with R~3400,3800,3800 (J,H,K)(Goal: at telescope in 2011)



SPHERE: Spectro-Polarimetric High-contrast Exoplanet REsearch. IR imager and spectrograph, NIR Integral Field Spectrograph, visible polarimeter (Goal: at Telescope in winter 2010)

Reduction of VLT spectra - I. General methods

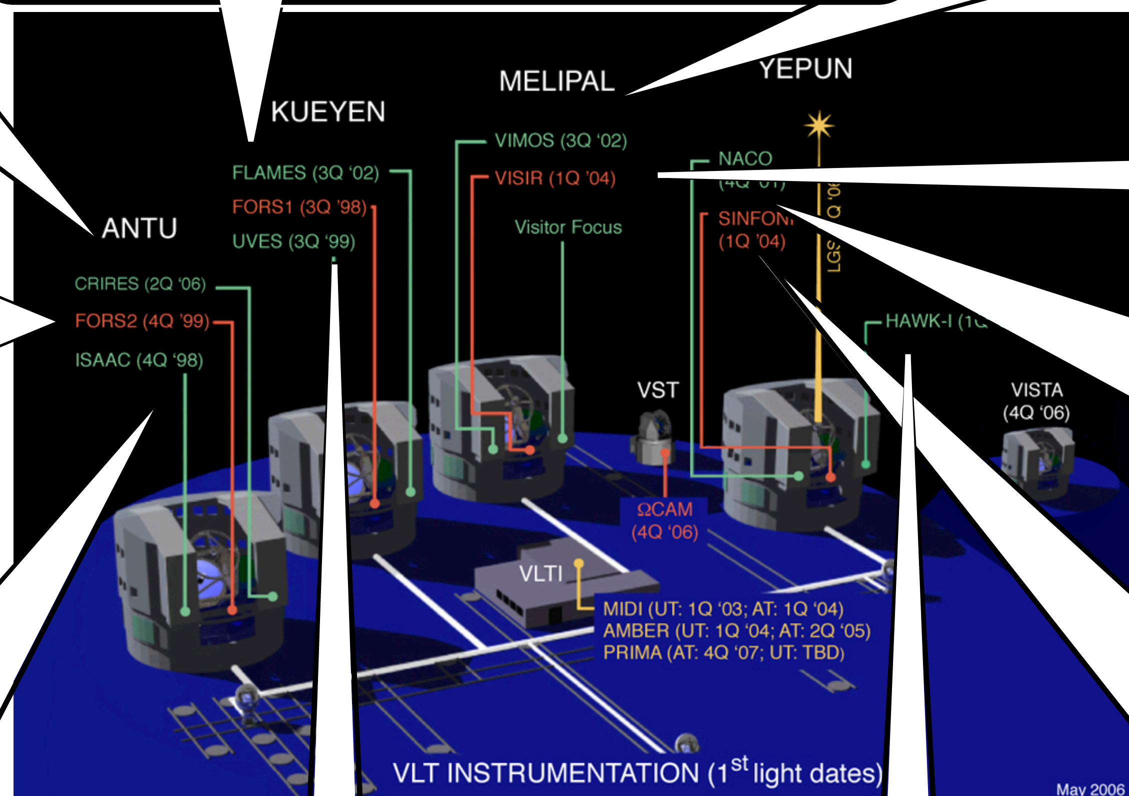
VLT: First generation instrumentation

CRIRES: CRyogenic high-resolution InfraRed Echelle Spectrograph
λ = 0.95 - 5.4 μm
Scale = 0.086"
R ~ 100,000

FLAMES: Fibre Large Array Multi Element Spectrograph, feeds UVES (red arm) and GIRAFFE. GIRAFFE: λ=3700-9500Å; Scale=0.3"; R=5600-46,000; 130 objs + IFU

VIMOS: VIsible MultiObject Spectrograph+IFU. λ = 3600 - 10000Å; FOV=4x7'x8'; R= 200 - 2500; Scale = 0.205"; MOS = 4x40-2000

FORS(1+)2: FOcal Reducer and low dispersion Spectrograph
λ=3300-11000Å; FOV =6.8'x6.8'; Scale=0.25";
R = 260 - 2600;
MOS: yes, also masks



VISIR: VLT Imager and Spectrometer for mid Infrared.
λ=8-13 μm/16.5-24.5 μm
FOV=19.2"x19.2"/32.3"x32.3";
R=150-30000;Scale=0.075"/0.127"

NaCo: Nasmyth Adaptive Optics System (NAOS) Near-Infrared Imager and Spectrograph (CONICA)
λ =1-5 μm

ISAAC: Infrared Spectrometer And Array Camera
λ = 1 - 5 μm
FOV: 2.5' x2.5' imaging
Scale = 0.147"/px
R = 500-3000
MOS: no

UVES: Ultraviolet and Visual Echelle Spectrograph (blue and red arms)
λ = 3000 - 11000 Å
Scale = 0.22" - 0.16"
R = 40,000-110,000

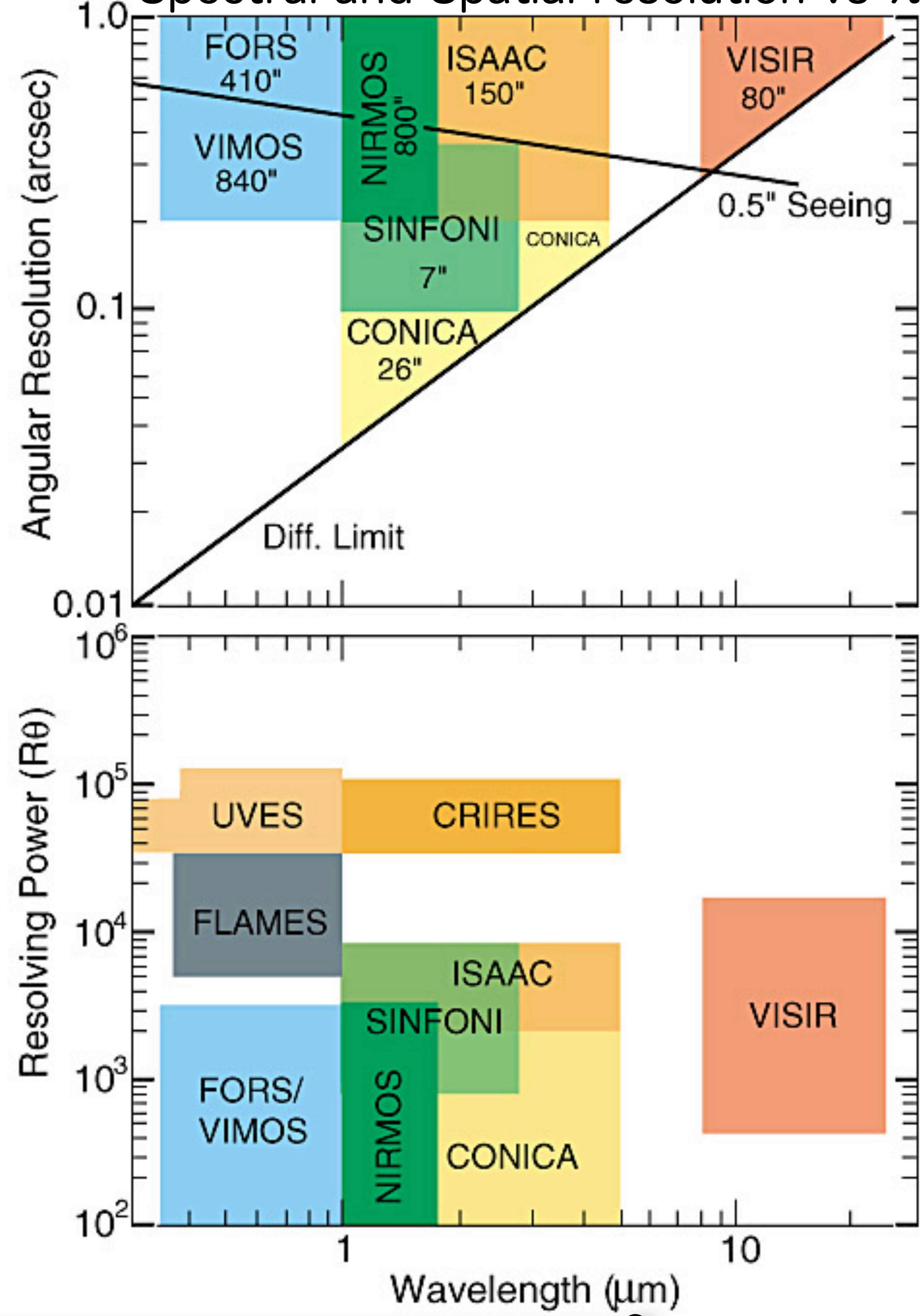
HAWK-I: High Acuity Wide field K-band Imager
λ = 0.85-2.5 μm
FOV = 7.5'x7.5'
Scale = 0.106"

SINFONI: Spectrograph for INtegral Field Observations in the Near Infrared
λ=1.1 - 2.45 μm;
FOV=8"x8",3"x3",0.8"x0.8";
Scale=0.25", 0.1", 0.025";
R =2000-4000; Guide Star

Reduction of VLT spectra - I. General methods

VLT: Spectroscopic modes

Observational domain:
Spectral and Spatial resolution vs λ

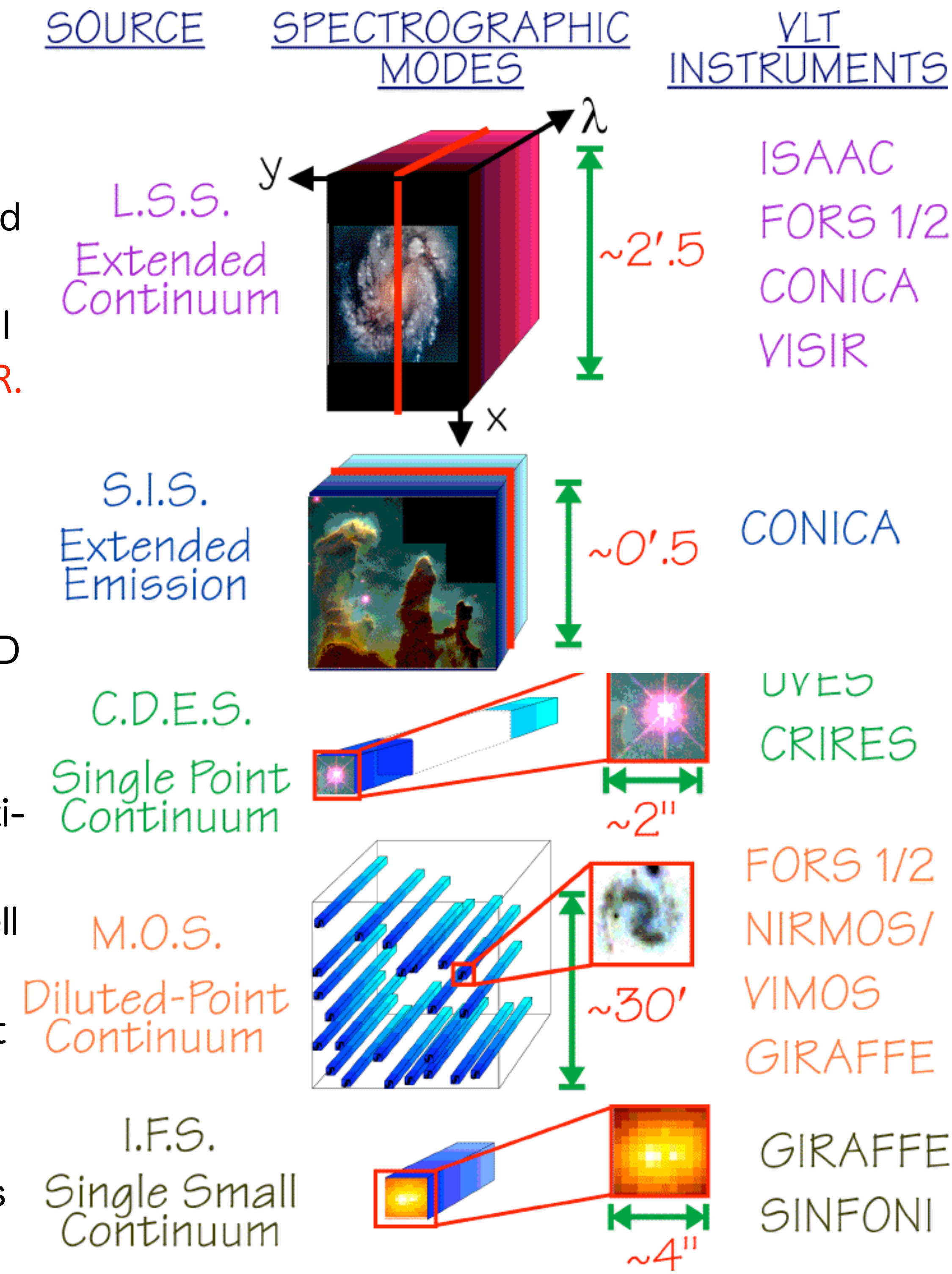


Reduction of VLT spectra - I. General methods

VLT: Spectroscopic modes

Different classes of astronomical objects have different 3-dimensional (spatial & spectral) shapes ⇛ wide variety of instrument modes.

1. Extended "Continuum" Objects (e.g. Regions of Star Formation, Open and Globular clusters, Nearby Galaxies). Long-Slit Spectroscopy (LSS) is the simplest, most efficient and most used way, but covers only a thin spatial slice at a time. Almost all VLT instruments: ISAAC, FORS, CONICA, VISIR.
2. Extended "Monochromatic" Objects (e.g. Galactic and Extragalactic HII regions, SNRs). This is done with Scanning Imaging Spectrographs (S.I.S.). At the VLT: NACO offering an Adaptive Optics capability.
3. Single "Point" Object (e.g. stars, quasars). Their thin, but very long, "beam" shapes along the wavelength axis are perfectly mapped on the 2D detector by the cross dispersed echelle spectrograph (C.D.E.S.). At the VLT: high resolution optical spectrograph UVES, CRIRES.
4. Multiple "Point" Objects (e.g. star clusters and clusters of galaxies). Multi-object spectrographs (MOS), either of the multi-slit or of the multi-fiber flavour, permit efficient surveys of these loose collections of objects. Well represented on the VLT: FORS, VIMOS, GIRAFFE.
5. Single "Small" Individual Objects (e.g. solar system small bodies, compact HII regions, nuclei of galaxies, galactic cores, interacting galaxies, high-z galaxies). Integral Field Spectroscopy (IFS) maps the full 3D information on the object (2 spatial + 1 spectral) in one exposure, provided its size is small. Based on a classical spectrograph fed by an image slicer, made from a multi-lens, multi-fiber or multi-mirror array: GIRAFFE, SINFONI.



VLT: Choice of the spectrograph

Depending on the aim of the observations, you have to consider the following characteristics:

✳ Wavelength range: depending on the spectral features to be measured

✳ Spectral resolution (or resolving power)
$R = \lambda / \Delta\lambda = c / \Delta v$ (c=speed of light, Δv=difference of velocities from Doppler effect)
with $\Delta\lambda$ = the smallest resolvable wavelength difference

for extragalactic observations:
- Low resolution: $R \lesssim 500$
- Medium resolution: $R \simeq 500$-2000
- High resolution: $R \gtrsim 2000$

e.g. to separate the doublet lines of [SII]$\lambda\lambda$6717,6731Å you need at least R=480
NB: R depends also on the slit width, in general it is given for a 1" width

✳ Size of the Field of view

✳ MOS-multiplex capability / IFU

In the case of a galaxy survey (see morning presentations) the main aim is to optimize the number of measured redshifts on large fields...

VLT: Choice of the spectrograph

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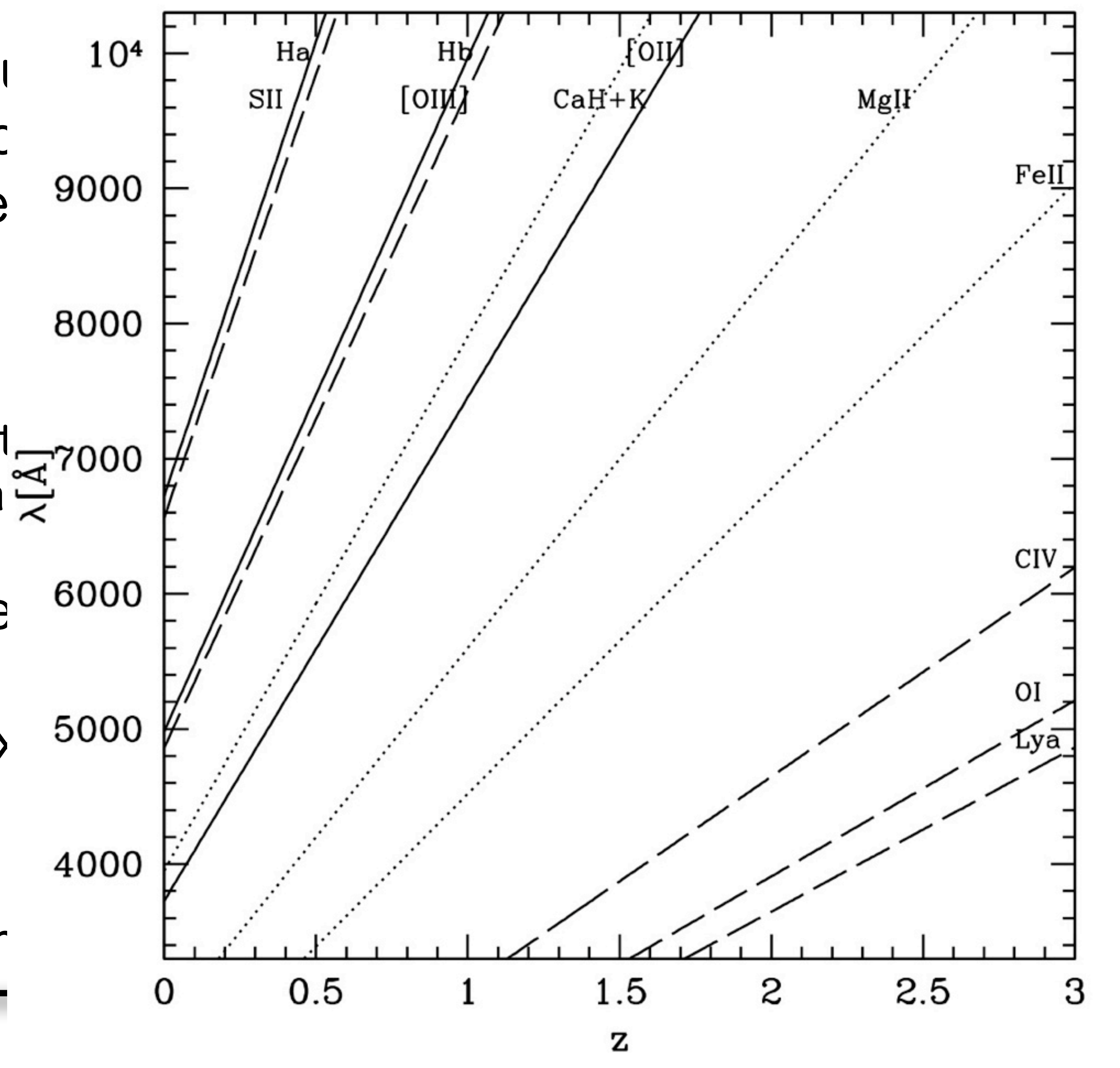

Reduction of VLT spectra - I. General methods

VLT: Choice of the spectrograph

VLT First Generation Instrumentation

Name	Built by	Observing Modes	Start of operations
ISAAC	ESO	imaging & long-slit spectroscopy (1-5μm)	Apr 99
FORS1/2	Heidelberg, Munich, Göttingen, ESO	imaging, MOS*, polarimetry (0.3-1μm)	Apr 99/ Apr 00
UVES	ESO, Trieste	high resolution cross-dispersed spectroscopy (0.3-1 μm)	Apr 99
NACO	NAOS: ONERA, Paris, Grenoble, ESO	adaptive optics system for CONICA	Oct 02
	CONICA: Heidelberg, Garching, ESO	high angular resolution imaging and spectroscopy (1-5μm)	Oct 02
FLAMES	Paris, Geneva; AAO, ESO	MOS* (fibre) & multi IFS** (0.37-1μm)	Apr 03
VIMOS	Paris, Marseille, Haute Provence, Toulouse, Bologna, Milan, Naples, ESO	wide field imaging, MOS*, IFS** (0.37-1μm)	Apr 03
VISIR	Saclay, ASTRON, ESO	imaging & long-slit spectroscopy (8-25μm)	Oct 04
SINFONI	Garching, ESO	adaptive optics-based IFS** (1-2.5μm)	Apr 05
CRIRES	ESO	high resolution echelle spectroscopy (1-5μm)	Apr 07

* MOS = Multi-Object Spectroscopy, **IFS=Integral Field Spectroscopy

VIMOS: i. Available grisms

VIMOS Modes and Setups

Mode	Scale	FOV	Wavelength range (nm)	Spectral Resolution	Dispersion A /pix	Spectral multiplex
IMG *UBVRIz*	0.205"/pix	4 x 7' x 8'	--	--	--	--
MOS LR Blue	0.205"/pix	4 x 7' x 8'	370 - 670	180	5.3	4
MOS LR Red	0.205"/pix	4 x 7' x 8'	550 - 950	210	7.3	4
MOS MR	0.205"/pix	4 x 7' x 8'	500 - 1000	580	2.5	1
MOS HR Blue	0.205"/pix	4 x 7' x 8'	410 - 630	2050	0.5	1
MOS HR Orange	0.205"/pix	4 x 7' x 8'	520 - 760	2150	0.6	1
MOS HR Red	0.205"/pix	4 x 7' x 8'	630 - 870	2500	0.6	1

Reduction of VLT spectra - I. General methods

VIMOS: i. Available grisms

VIMOS Modes and Setups

			Wavelength	Spectral	Dispersion	Spectral
Mode	Scale	FOV	range (nm)			
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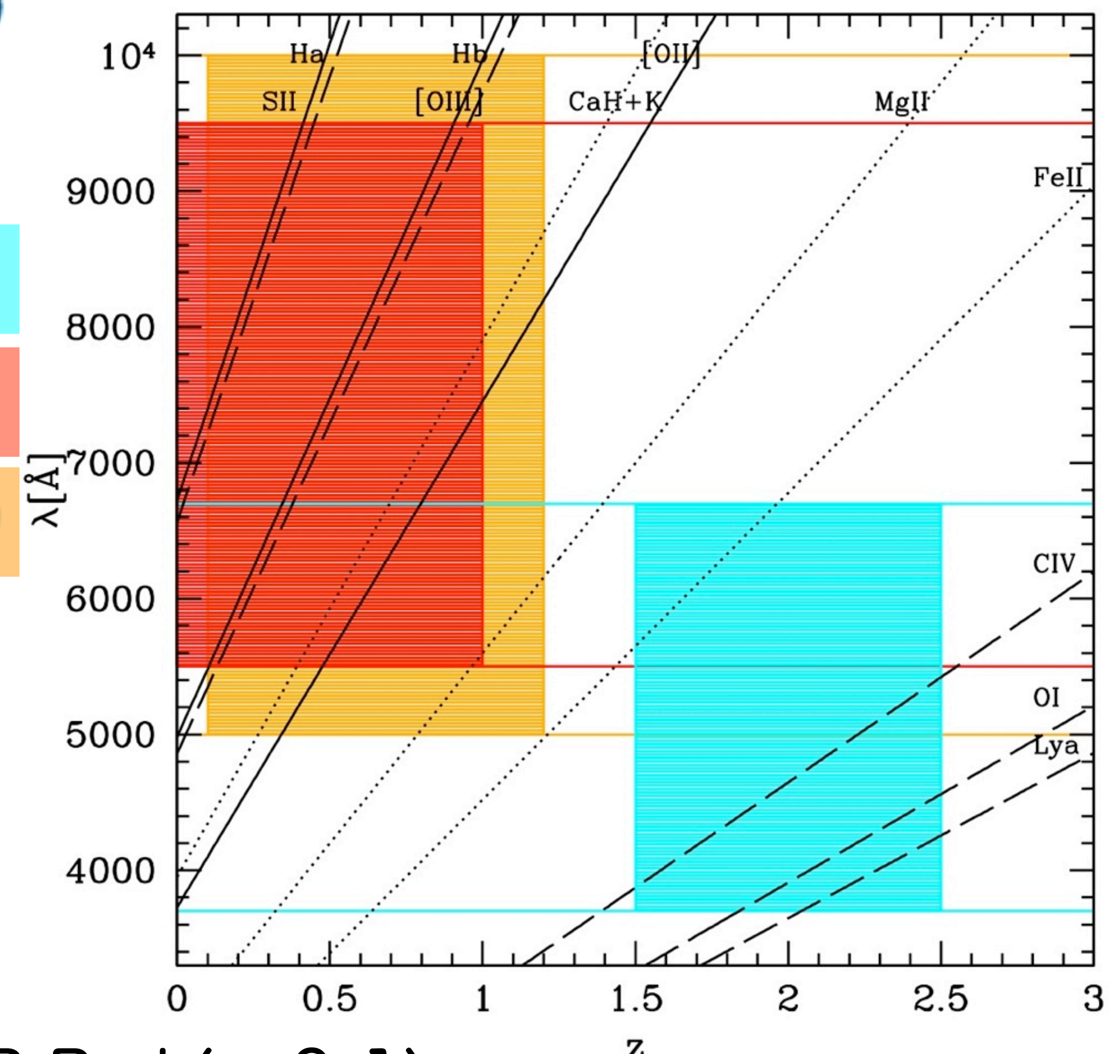
MOS LR Blue	0.205"/pix	4 x 7' x 8'	370 - 670			
MOS LR Red	0.205"/pix	4 x 7' x 8'	550 - 950			
MOS MR	0.205"/pix	4 x 7' x 8'	500 - 1000			
MOS HR Blue	0.205"/pix	4 x 7' x 8'	410 - 630			
MOS HR Orange	0.205"/pix	4 x 7' x 8'	520 - 760			
MOS HR Red	0.205"/pix	4 x 7' x 8'	630 - 870			



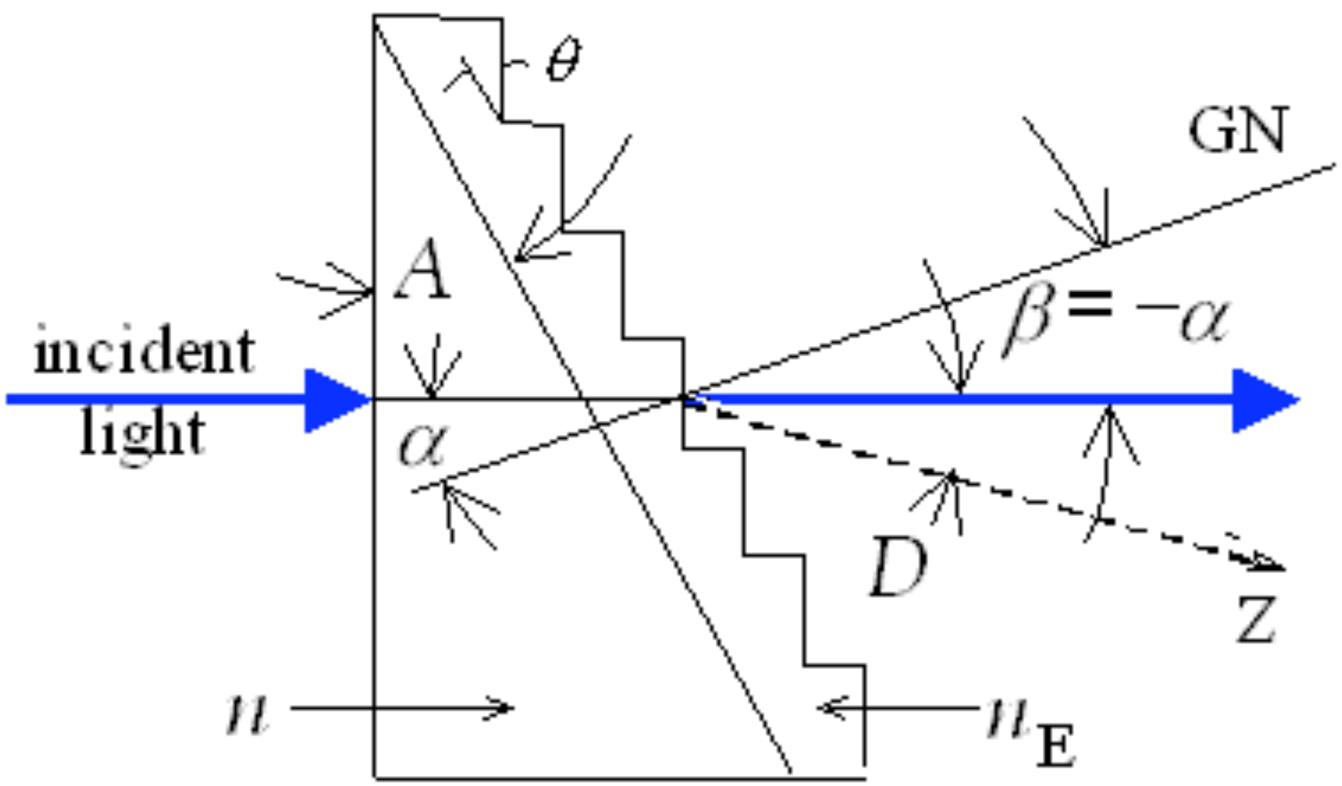
e.g. VVDS (VIMOS VLT Deep Survey): MOS LR Red (z=0-1)

zCOSMOS (spectroscopic survey on COSMOS field): MR Red (z=0-1.2) + LR Blue (z>1.5 or very low z)

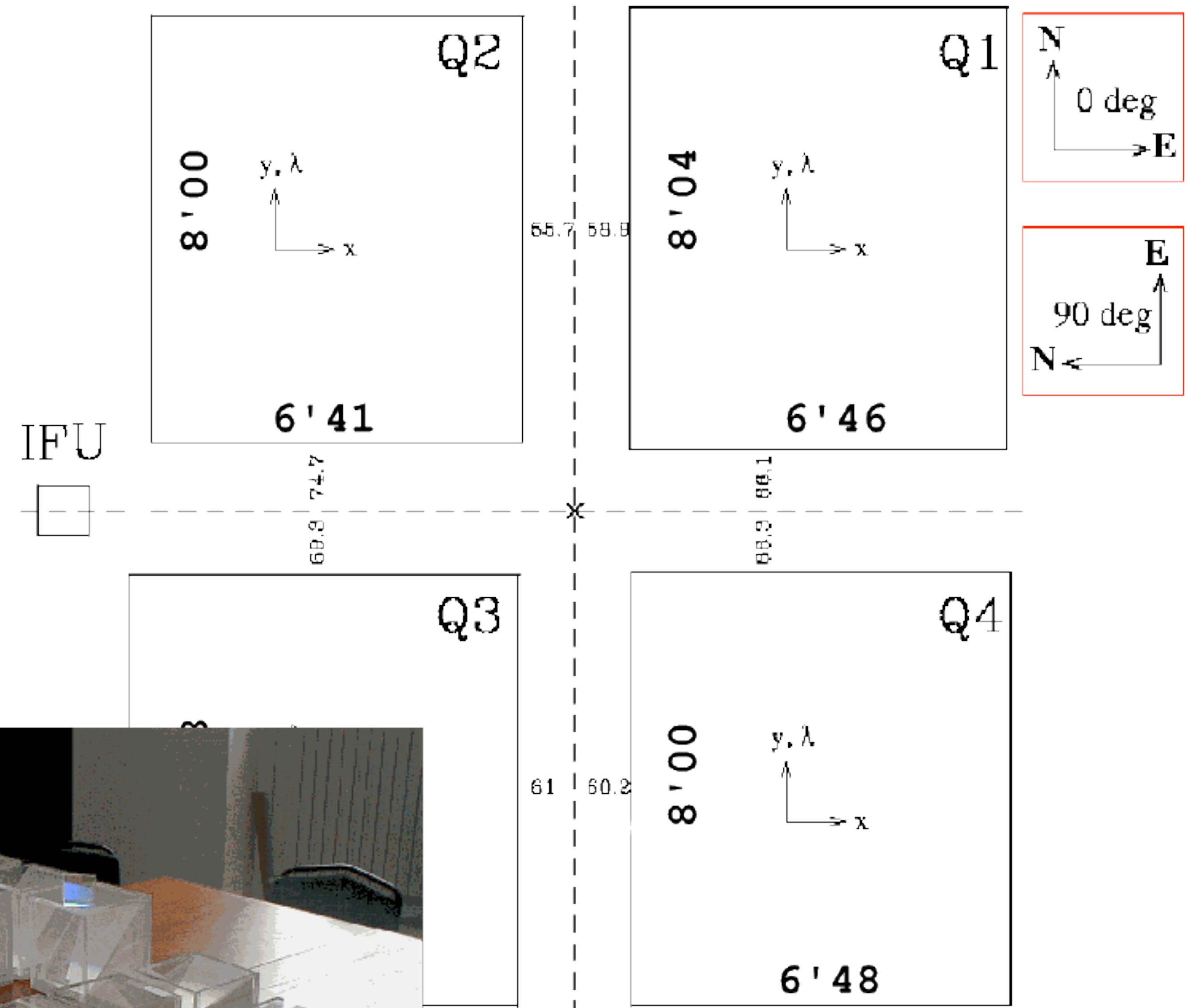
Reduction of VLT spectra - I. General methods

VIMOS: ii. Main characteristics

Grism: prism+grating



VIMOS FOV



GN – grating normal;

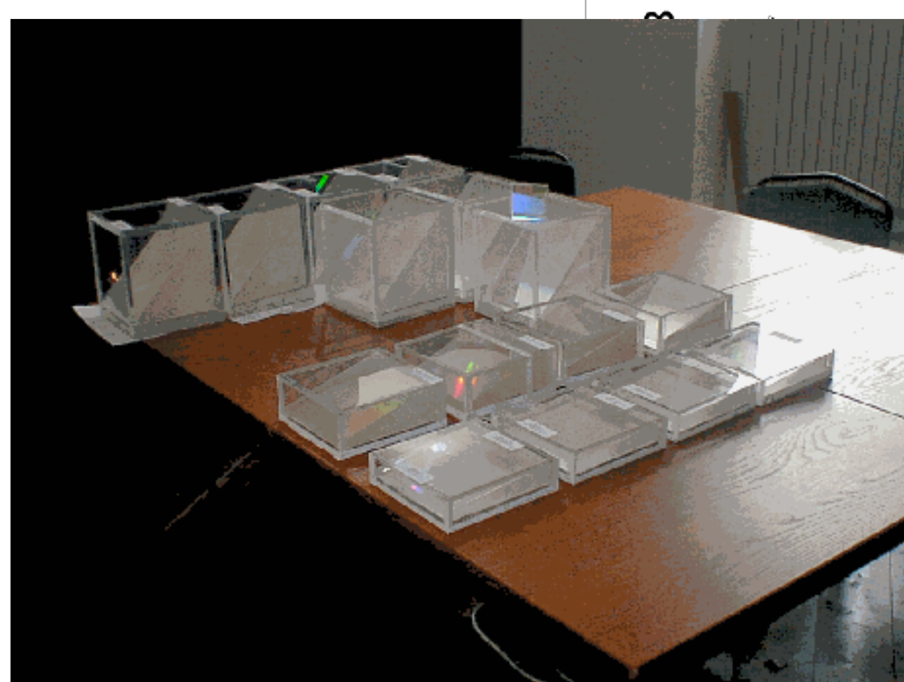
Z – zero order of prism;

A = apex angle of prism;

D = deviation angle between Z and in-line diffraction direction;

q = blaze (groove) angle of grating

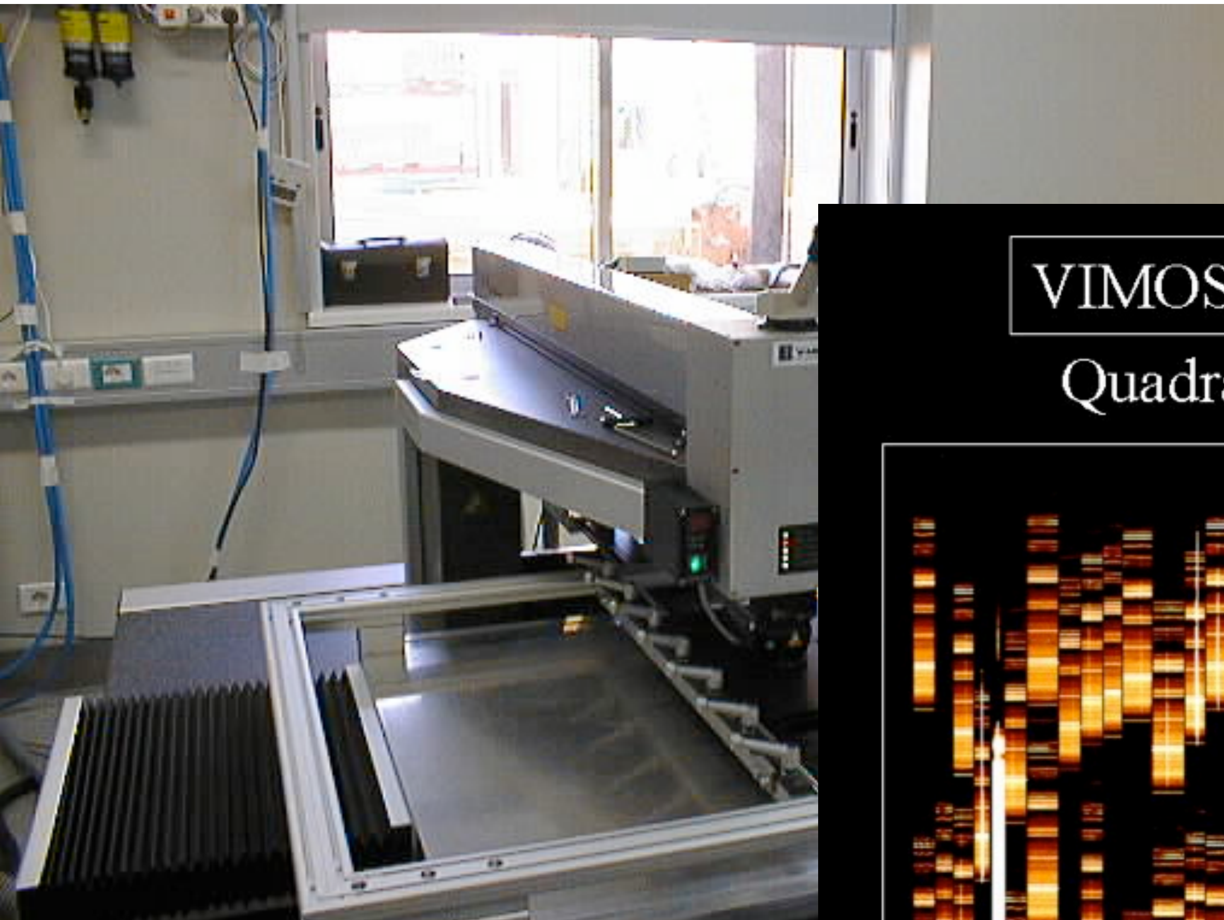
light at the central λ passes undeviated



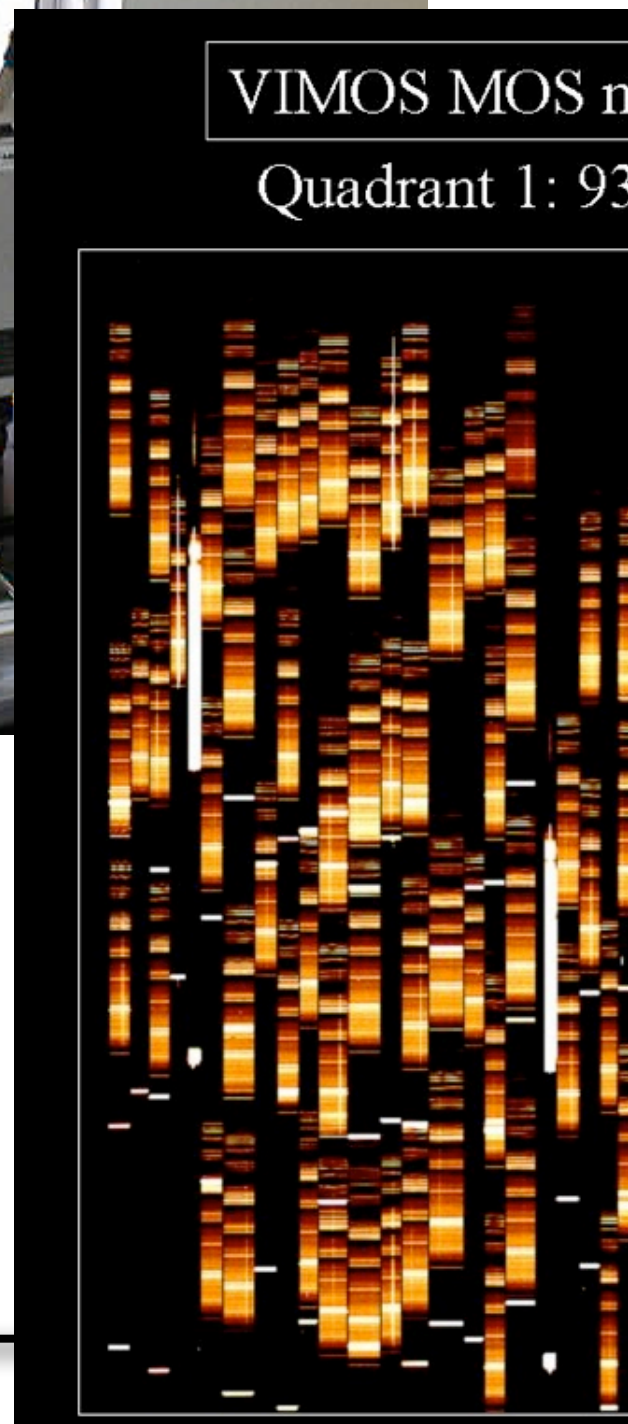
Reduction of VLT spectra - I. General methods

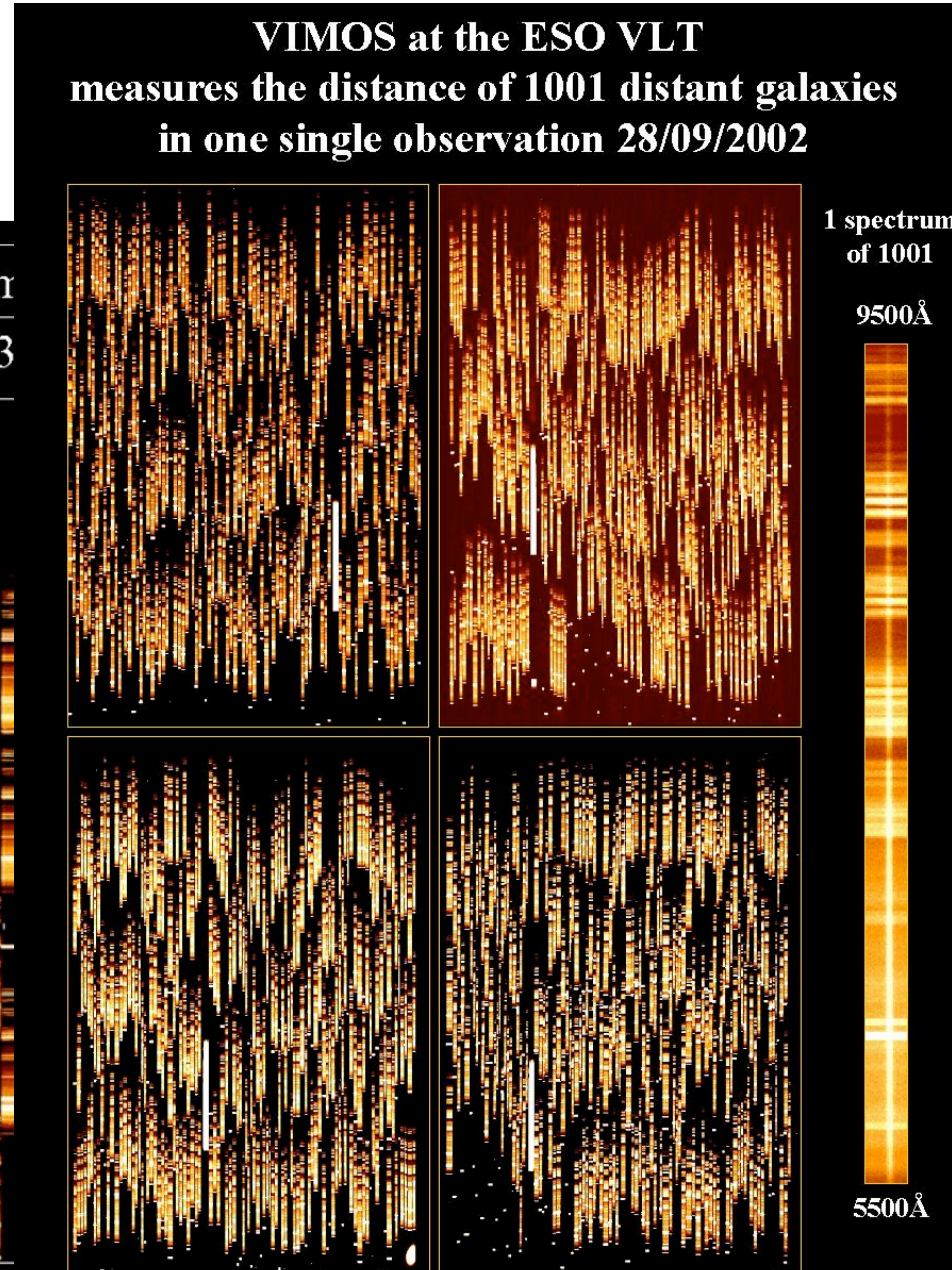
VIMOS: iii. MOS observations

MMU (Mask Manufacturing Unit)



slit masks ~30x30 cm^2 each to be inserted at the entrance focal plane





Reduction of VLT spectra - I. General methods

VIMOS: iv. Preparation of observations

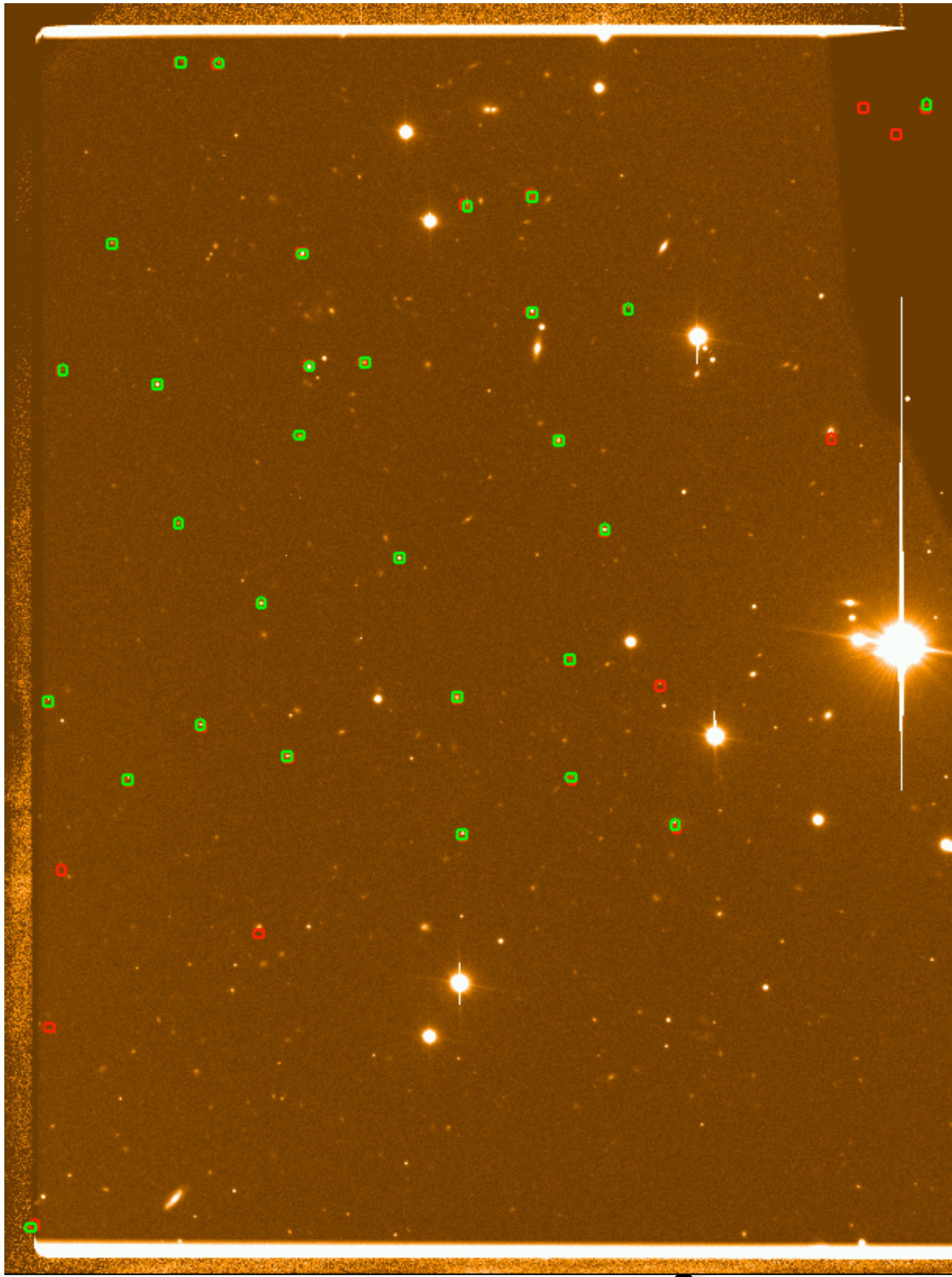
- Evaluate the exposure time with the Exposure Time Calculator (ETC);
  VVDS $I_{AB} \lesssim 24 \Rightarrow 4.5$h
- Each Observing Block in service mode must be shorter than 1h, including overheads, i.e. instrument setup, acquisition, read-out, arc, flat ($\gtrsim$ 15 min);
  VVDS "deep" used 10 exposures of 27 minutes
- Standard technique: OBs with a jitter pattern, i.e. with different positions of the slits separated from the on-target position, to be able to remove the fringing at $\lambda \gtrsim 8300$Å (like using the simple two-position "ABBA" pattern); the offset width should be a compromise between the accuracy of the sky correction and the number of objects observed at a time;
  VVDS used a sequence of 5 steps at -1.4, -0.7, 0, 0.7, 1.4" from the target
- Width and length of the slits: width > 0.6", length < 30", depending on optimization (secondary targets can fall in the slit)
  VVDS slits: 1" wide and ~10" long (mean)
- Observations must include:
  - Pre-imaging in R filter (~2 months in advance, mandatory for MOS), from which the masks must be prepared
  - Wavelength calibration (lamps observed through the masks during the day)

Reduction of VLT spectra - I. General methods

VIMOS: v. Mask preparation software (VMMPS)

- ➡ Pre-images ⇒ Sextractor is run to identify the brightest ~80 sources with coordinates X_{CCD},Y_{CCD}
- ➡ VMMPS (Bottini et al. 2005) is used for cross-correlation with user catalogue to derive the transformation matrix from RA,DEC to X_{CCD},Y_{CCD} VIMOS instrumental coordinate system
- ➡ 2 reference apertures on bright stars for each quadrant; slits are then automatically assigned to a max number of sources in the photometric catalogue
- ➡ VVDS: masks with slits of 1" width and a minimum of 1.8" of sky left on each side of a target for accurate sky background fitting and removal during data reduction
- ➡ Final slit mask layout sent to the MMU

N.B. more masks on the same region have to be made to have a high target sampling rate



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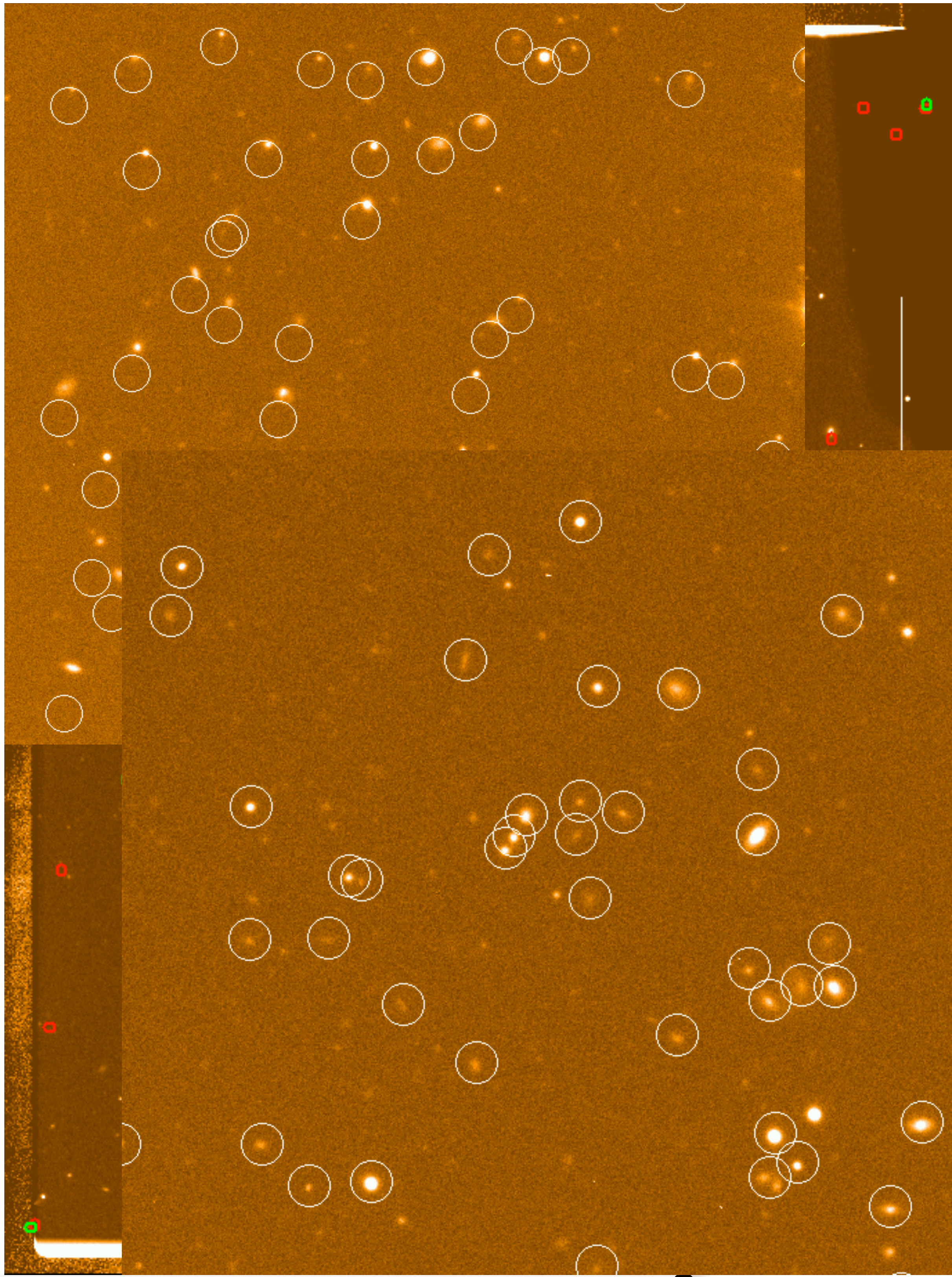

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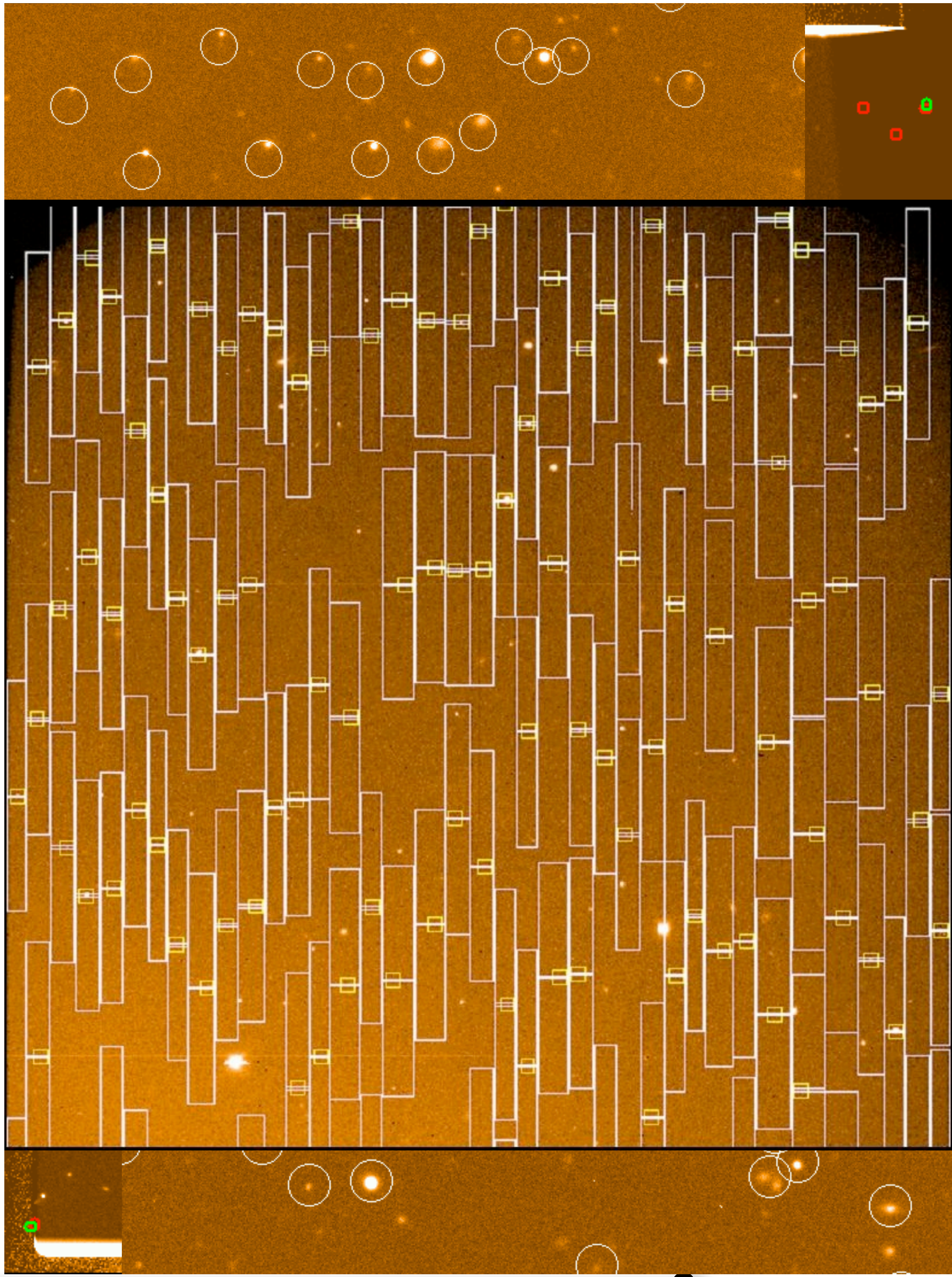
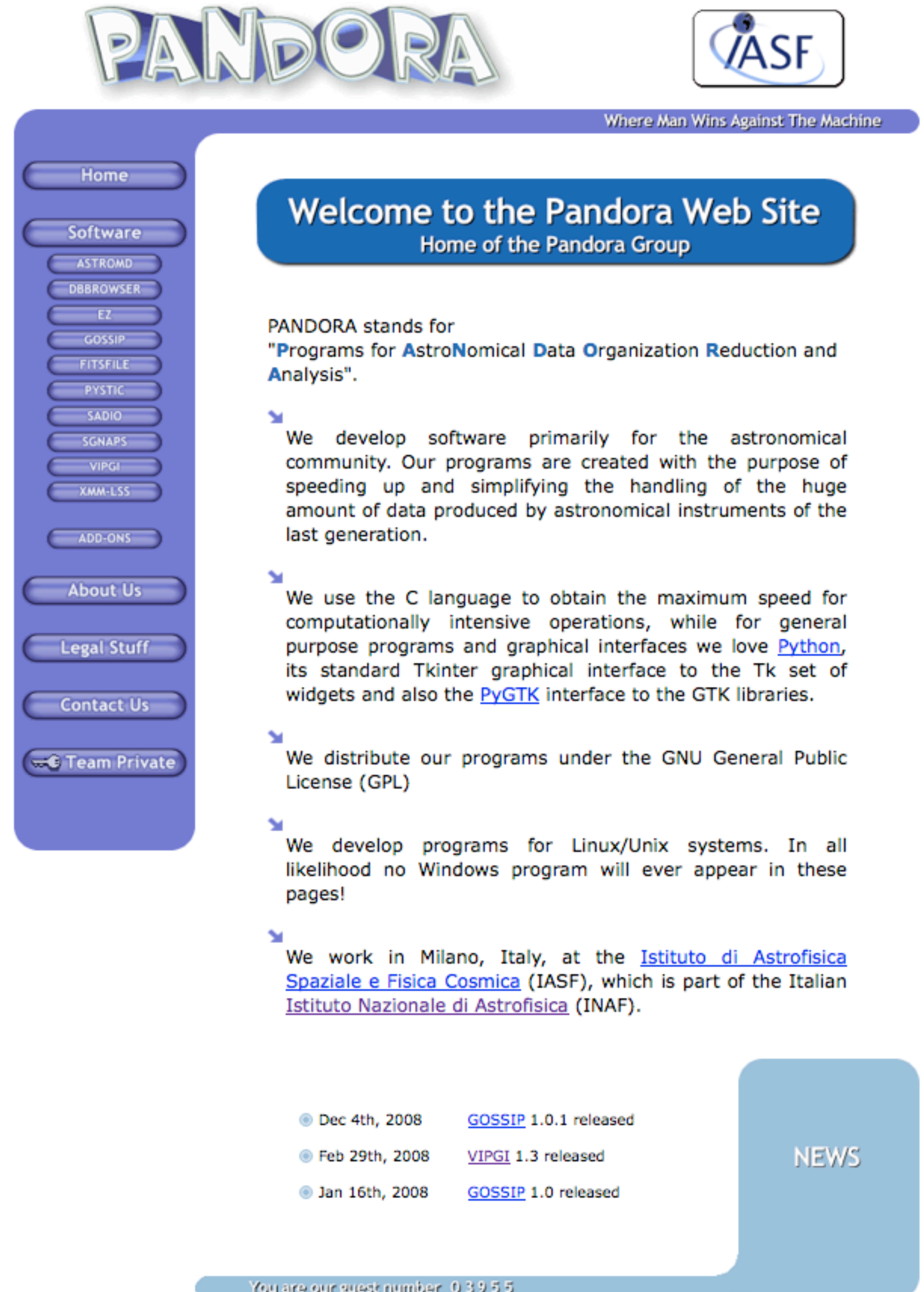


Reduction of VLT spectra - I. General methods

VIMOS: vi. Data reduction software

Usual data reduction softwares:
IRAF / MIDAS / IDL
but spectrographs with high multiplexing capabilities (large number of spectra) on 8m class telescopes (faint objects) are challenging.

To speed up the reduction process we need a dedicated (and automatized) software: VIPGI, based on the VIMOS data reduction pipeline (Scodeggio et al. 2005)



VIPGI
The VIMOS Interactive Pipeline Graphical Interface

http://cosmos.iasf-milano.inaf.it/pandora/

Reduction of VLT spectra - I. General methods

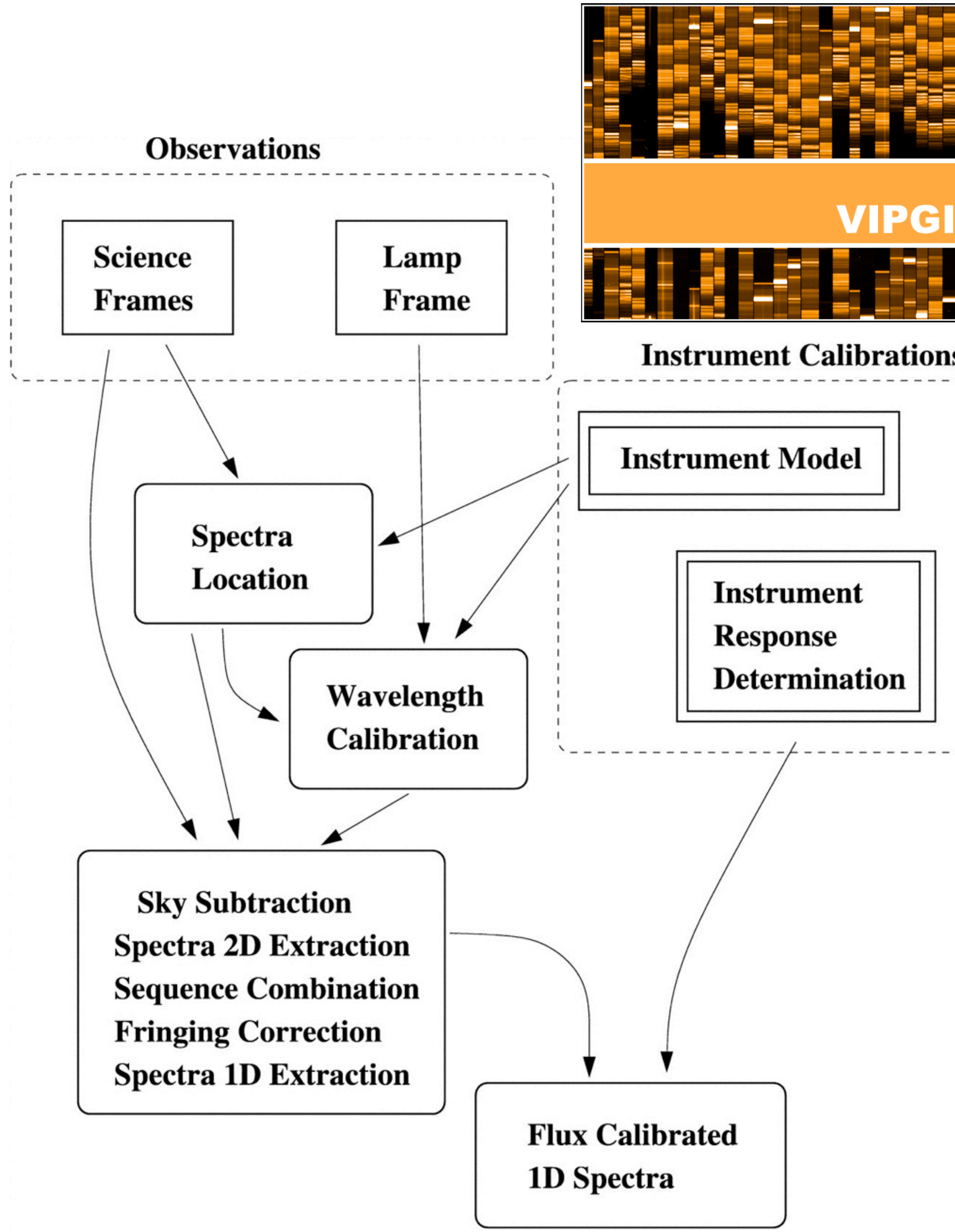
VIPGI: i. Flow chart

Steps of data reduction with VIPGI:

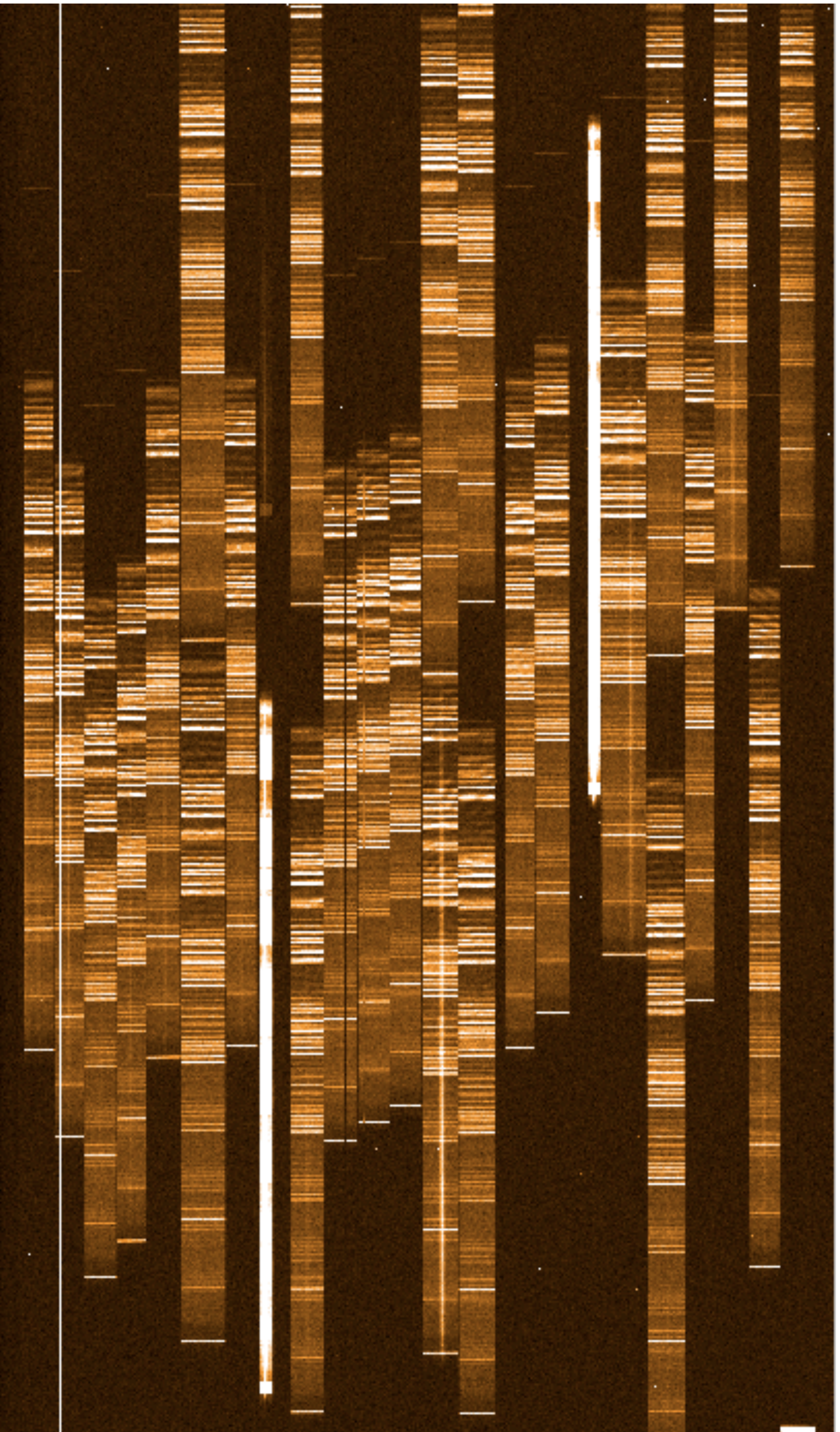
1. Raw data imported from original frames
2. Spectra location: from the mask design process small shifts from predicted positions are possible
3. Wavelength calibration: helium and argon arc lamps are observed through the masks, calibration lines are identified to derive the pixel to wavelength mapping for each slit.

⇒ from 2. and 3. an instrument model for a bidimensional mapping of the VIMOS focal plane (Optical Distorsion Model + Curvature Model + Inverse Dispersion Solution)

4. Sky background and fringing residuals subtraction on each 2D spectrum
5. Combination of 2D spectra
6. Extraction of 1D spectra following the slit profile
7. Flux calibration of 1D spectra with standard star



VIPGI: ii. Importing raw data



Original files are named like

`VIMOS.2007-02-23T05:09:50.513.fits`

They are renamed according to the instrument mode, quadrant, type of frame (lamp, flat field, spectro-photometric calibrator, scientific exposure)

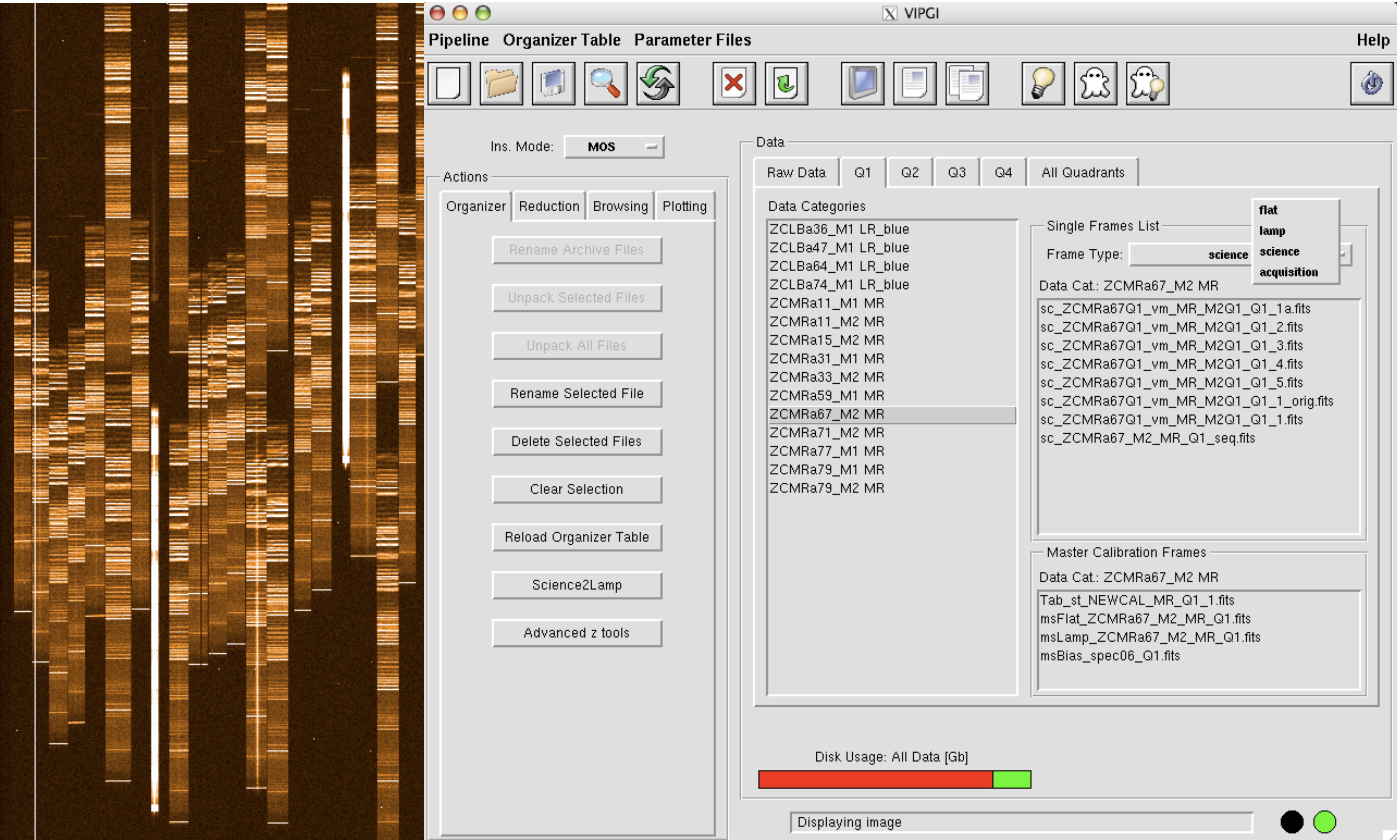
The appropriate calibration tables (e.g. arc lines needed during λ calibration), first guesses for spectra location and jitter offsets are appended to the fits header

⇒ you can easily access to the classified files

NB: with VIMOS it is possible to observe more than 1 spectrum in a single column. Objects can be barely visible in a single exposure frame.

Reduction of VLT spectra - I. General methods

VIPGI: ii. Importing raw data

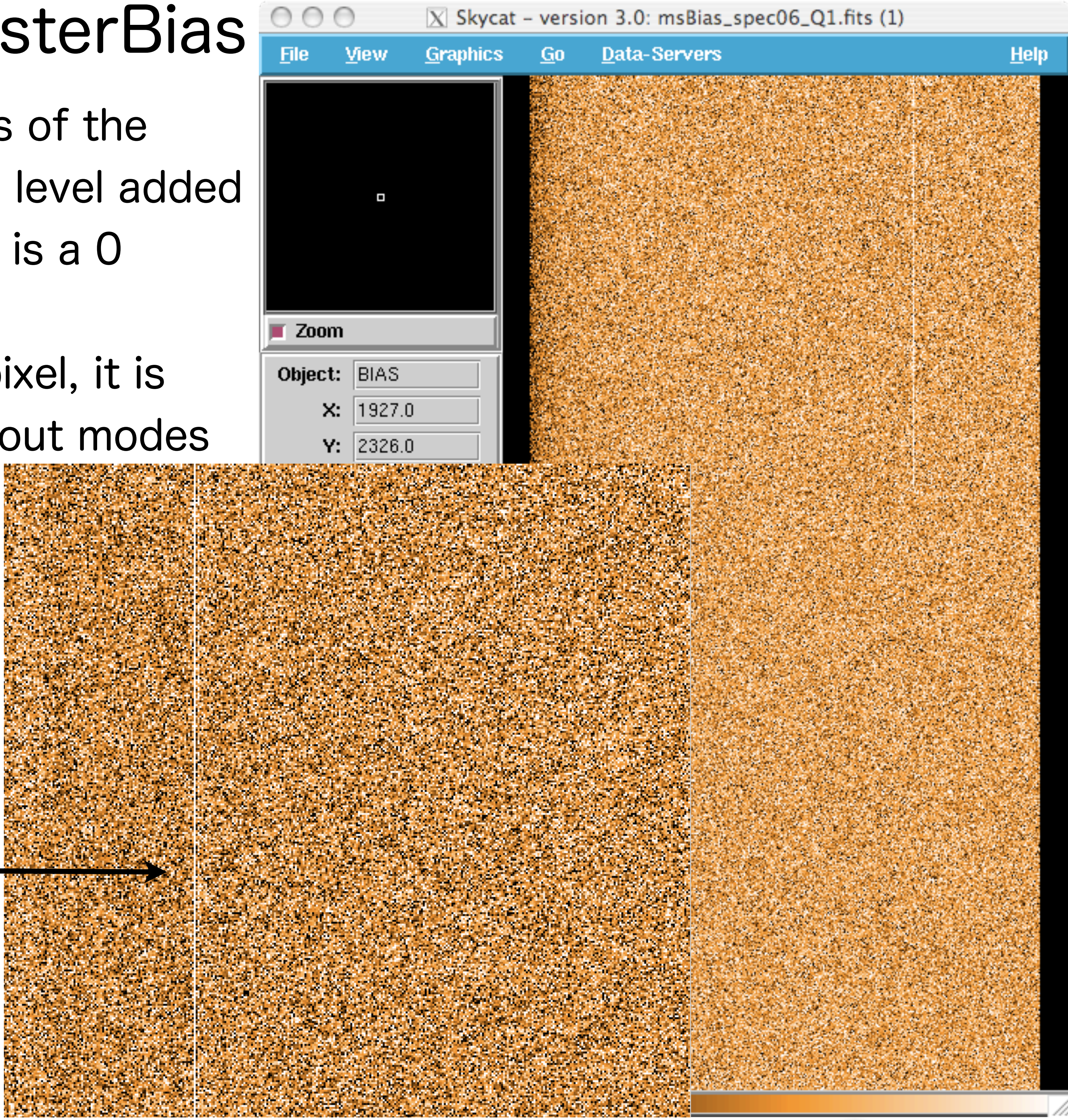


VIPGI: iii. Creating MasterBias

Bias: is the monitor of the status of the CCD and measures the pedestal level added to the output signal of the CCD, is a 0 seconds exposure
⇒ must be subtracted pixel by pixel, it is daily monitored in the two read-out modes (imaging and spectroscopy)

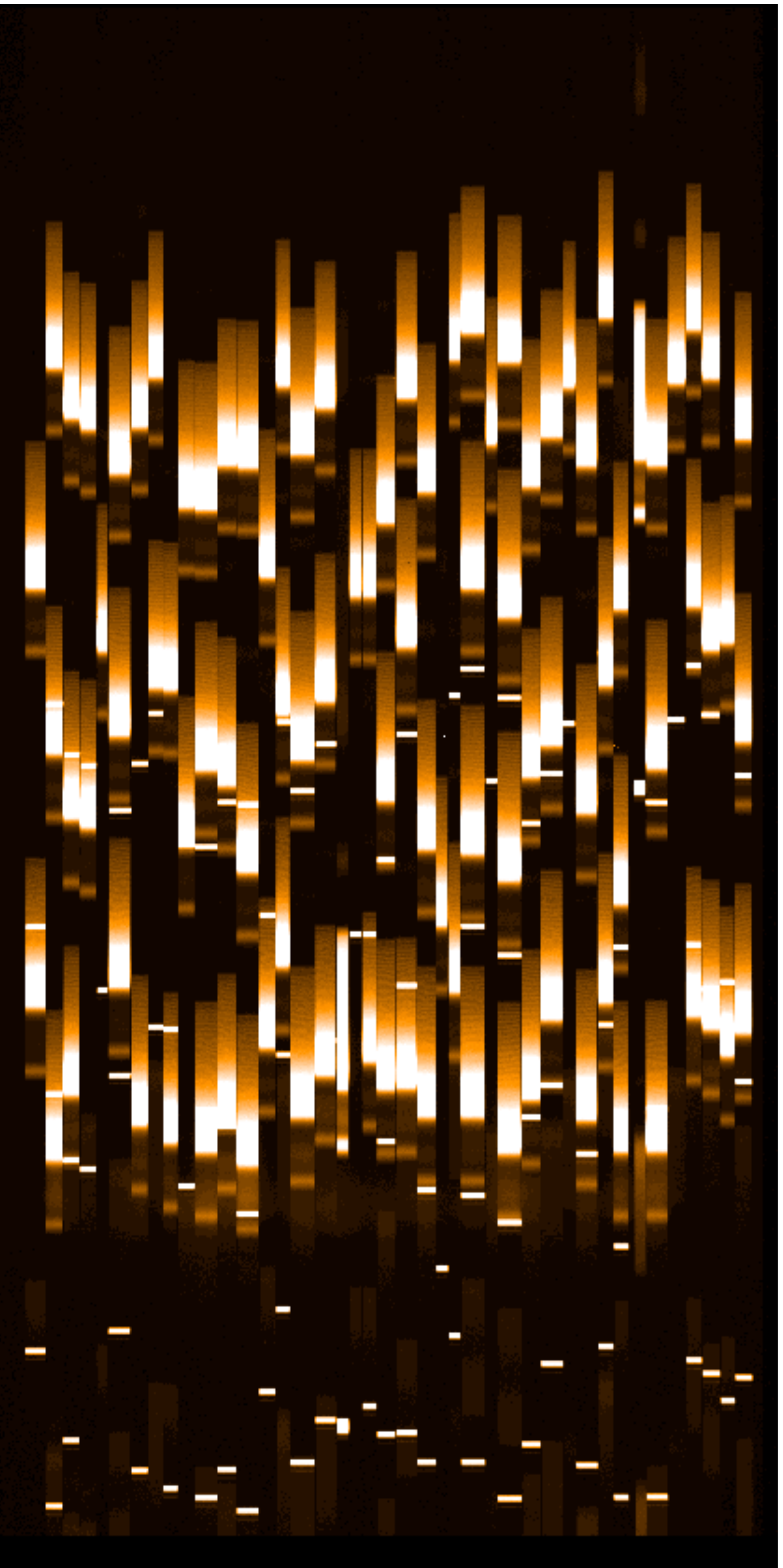
msBias: is the combination of a number of bias frames (typically a median of 5 frames).

NB: bad columns



Reduction of VLT spectra - I. General methods

VIPGI: iv. Creating MasterFlat



Flat-field: is the efficiency map of the CCD, since the response of each pixel can vary. In imaging it is obtained with a uniform illumination of the CCD (sky or dome flat); each raw image must be bias subtracted and flat-field normalized.

In MOS observations flat-field exposures are obtained with an halogen lamp, but they are affected by strong fringing, with a pattern different from science frames

⇒ flat-fielding would introduce a noise larger than the pixel-to-pixel sensitivity variations (~2%)

⇒ the final uncertainty on flux calibration without flat-field will be of the order of ~0.6%

msFlat: with VIPGI it is built from science frames and consists in fitting the edges of spectra

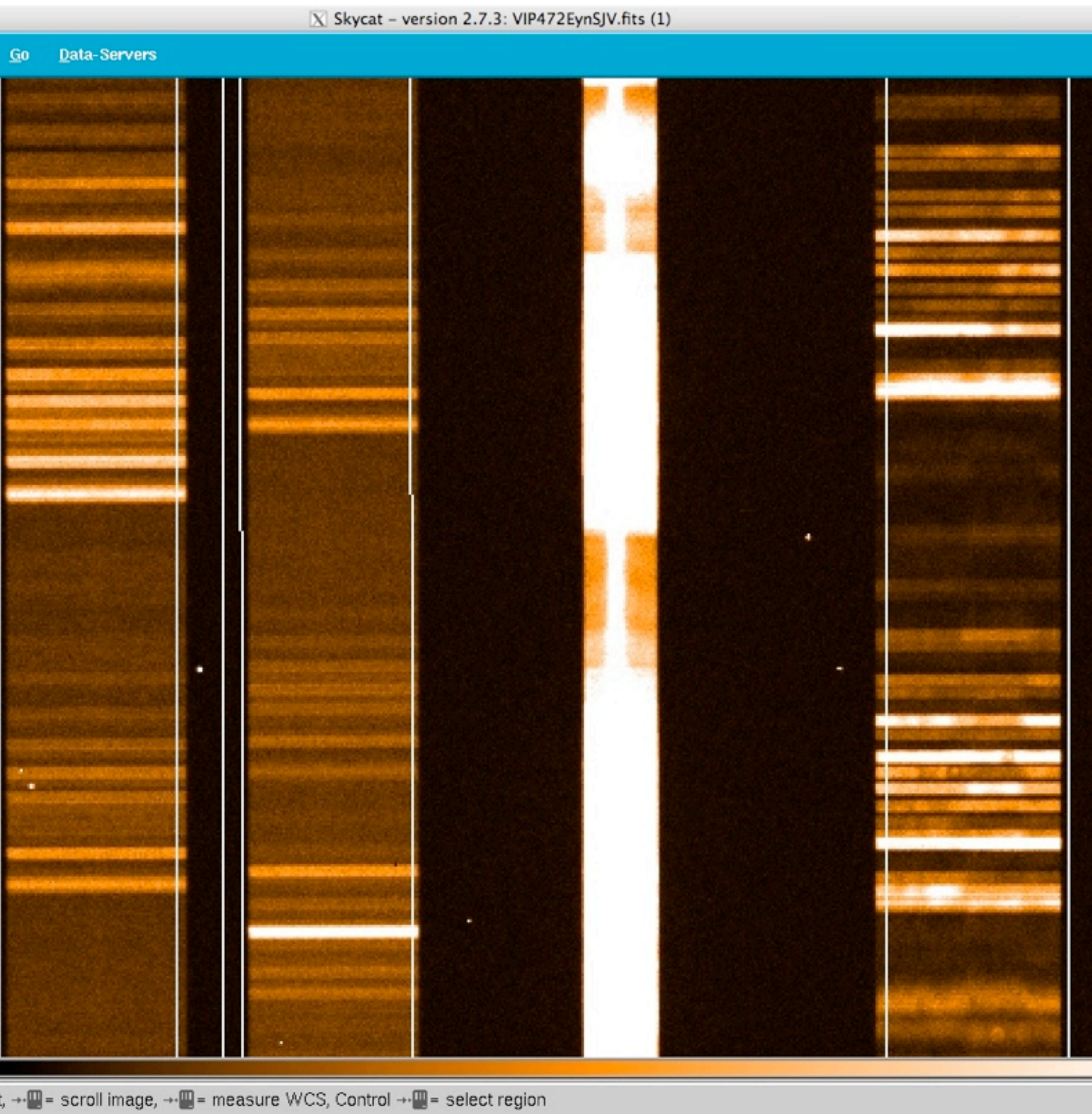
⇒ precisely locate spectra on the CCD frame

⇒ refine the optical distortions and curvature model

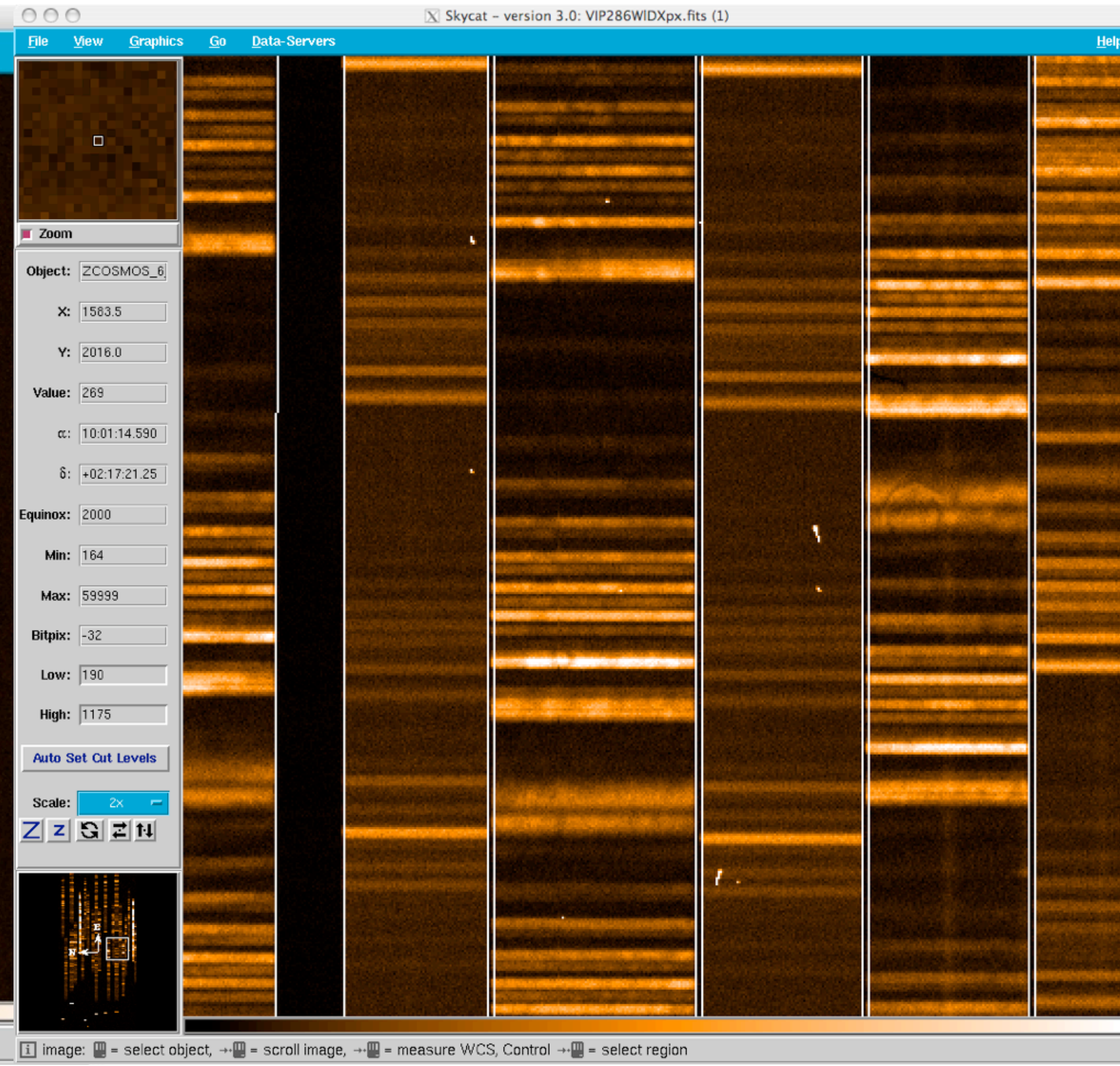
Reduction of VLT spectra - I. General methods

VIPGI: iv. Creating MasterFlat

Bad spectra location



Good spectra location

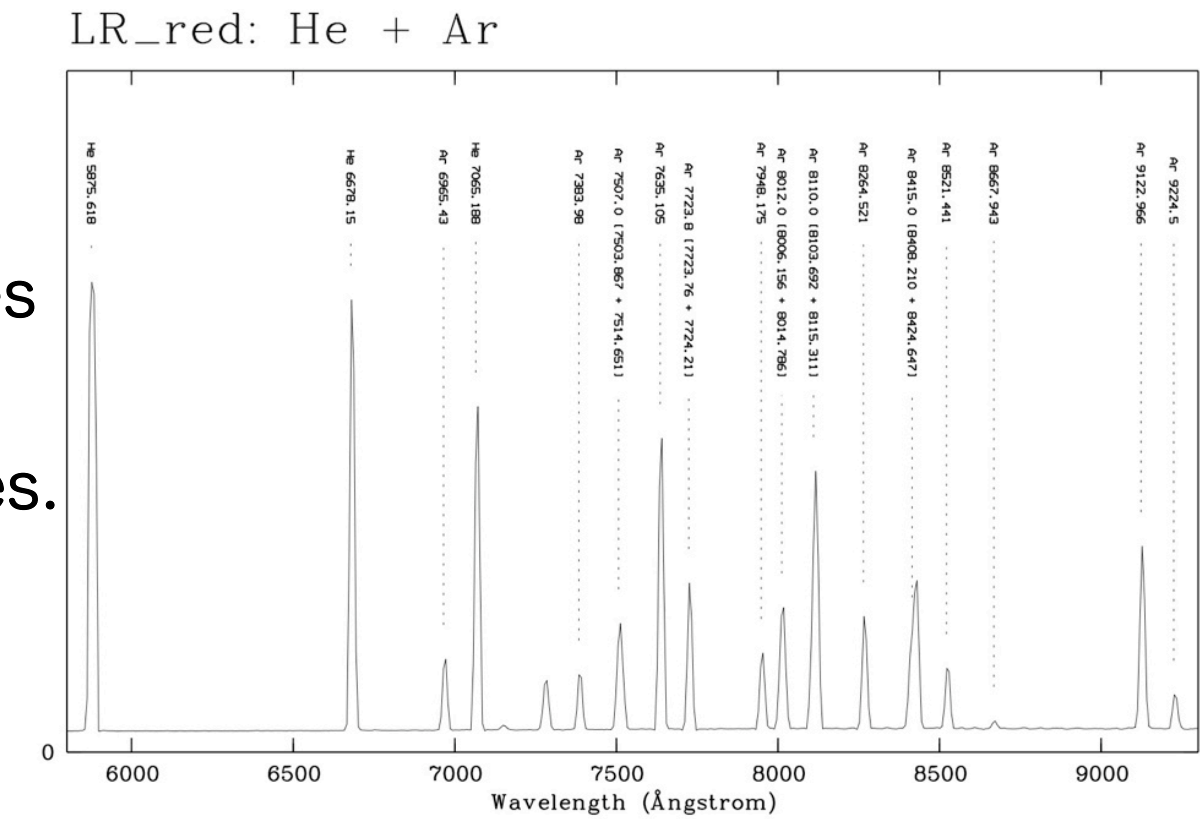


Many fake detections are expected at slit edges in case of bad spectra location

Reduction of VLT spectra - I. General methods

VIPGI: v. Creating MasterLamp

This step provides the wavelength calibration, i.e. the mapping between wavelength and pixel coordinates along the previously identified slits. For each spectrum (found using msFlat) the lines of a calibration lamp or the night sky-lines are identified and compared to the list of known lines. First guesses of line location are given, but the inverse dispersion solution can vary because instrumental flexures may introduce offsets.



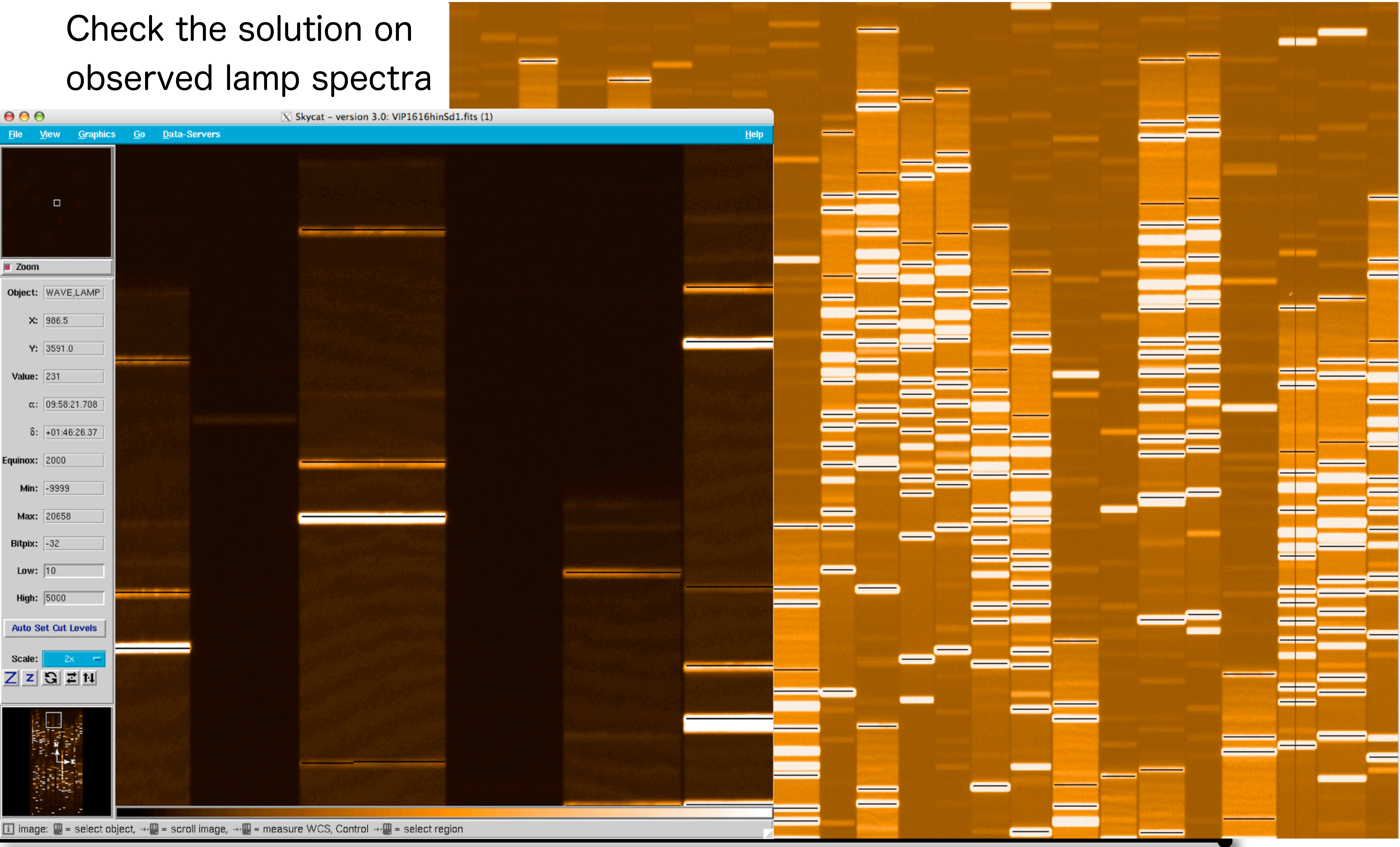
One or more arc exposures are used to build the msLamp.

The rms of residuals is an estimate of the precision of the solution.
It should typically be ≲ 1/5 pixel, e.g. for the LR red grism with a dispersion of 7.14 Å/px we found rms ~1 Å.

Many visual checks on the quality of wavelength calibration can be done...

VIPGI: v. Creating MasterLamp

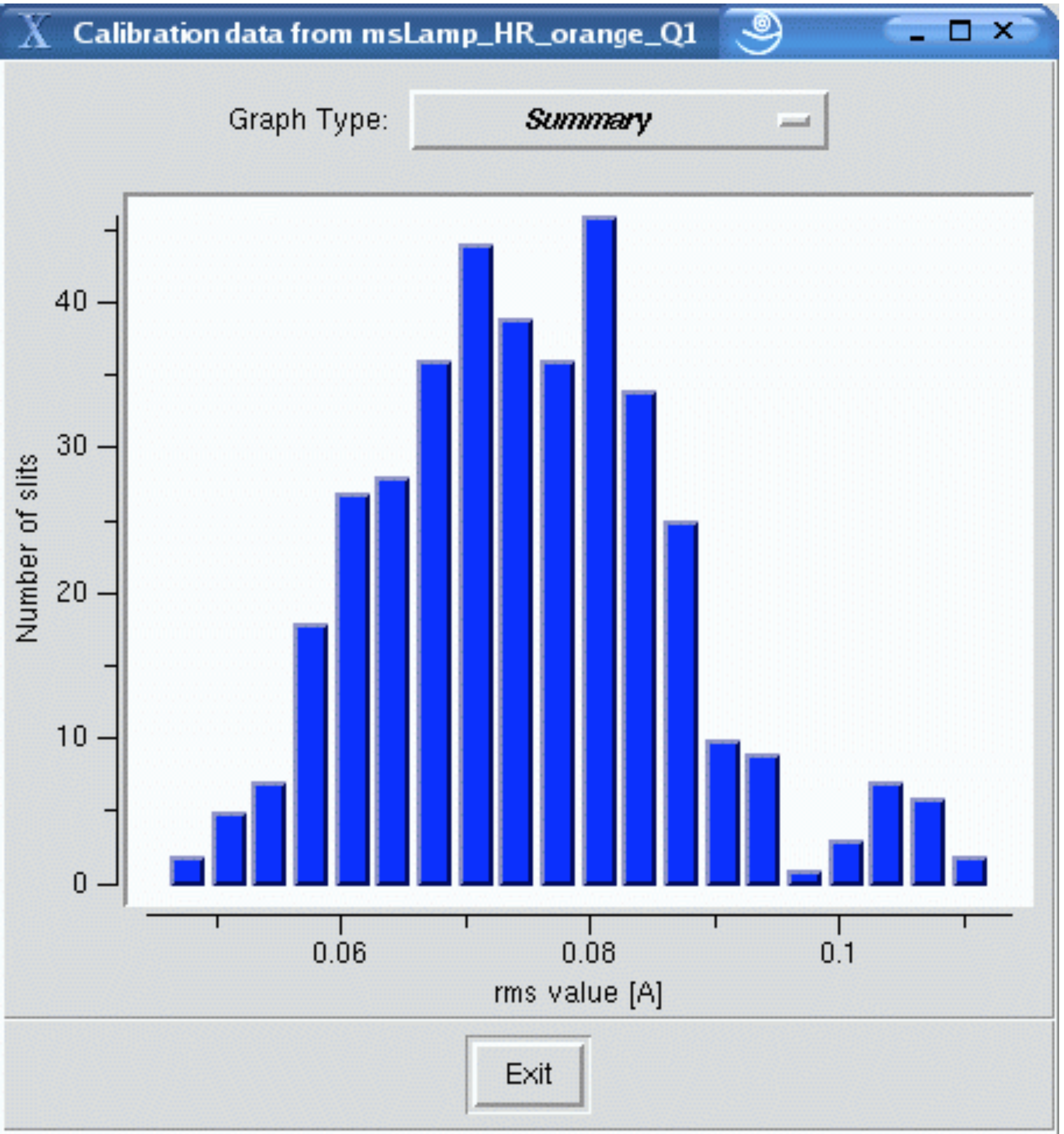
Check the solution on observed lamp spectra



Reduction of VLT spectra - I. General methods

VIPGI: v. Creating MasterLamp

Check rms statistics for all slits

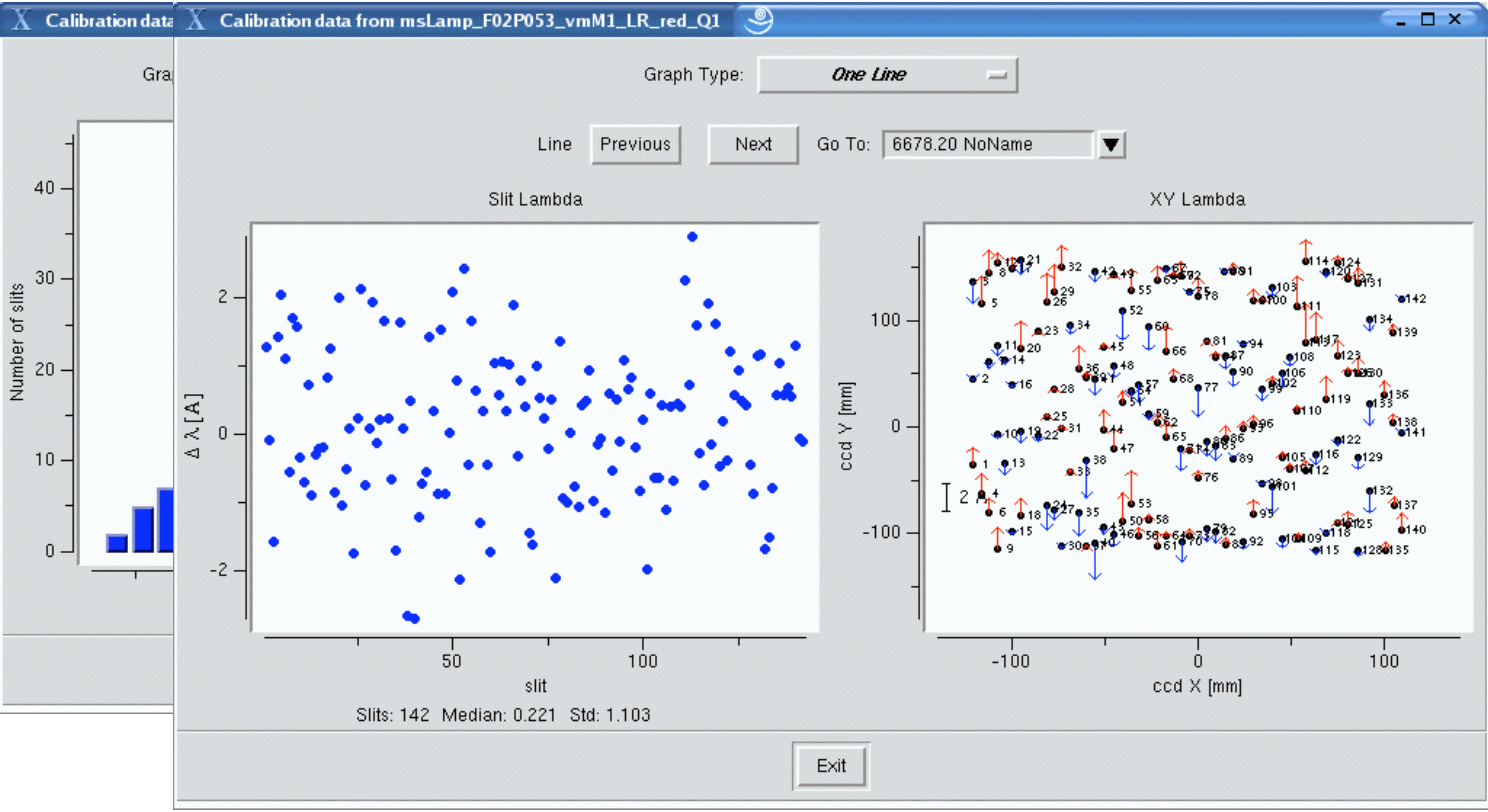


Reduction of VLT spectra - I. General methods

VIPGI: v. Creating MasterLamp

Check rms statistics for all slits

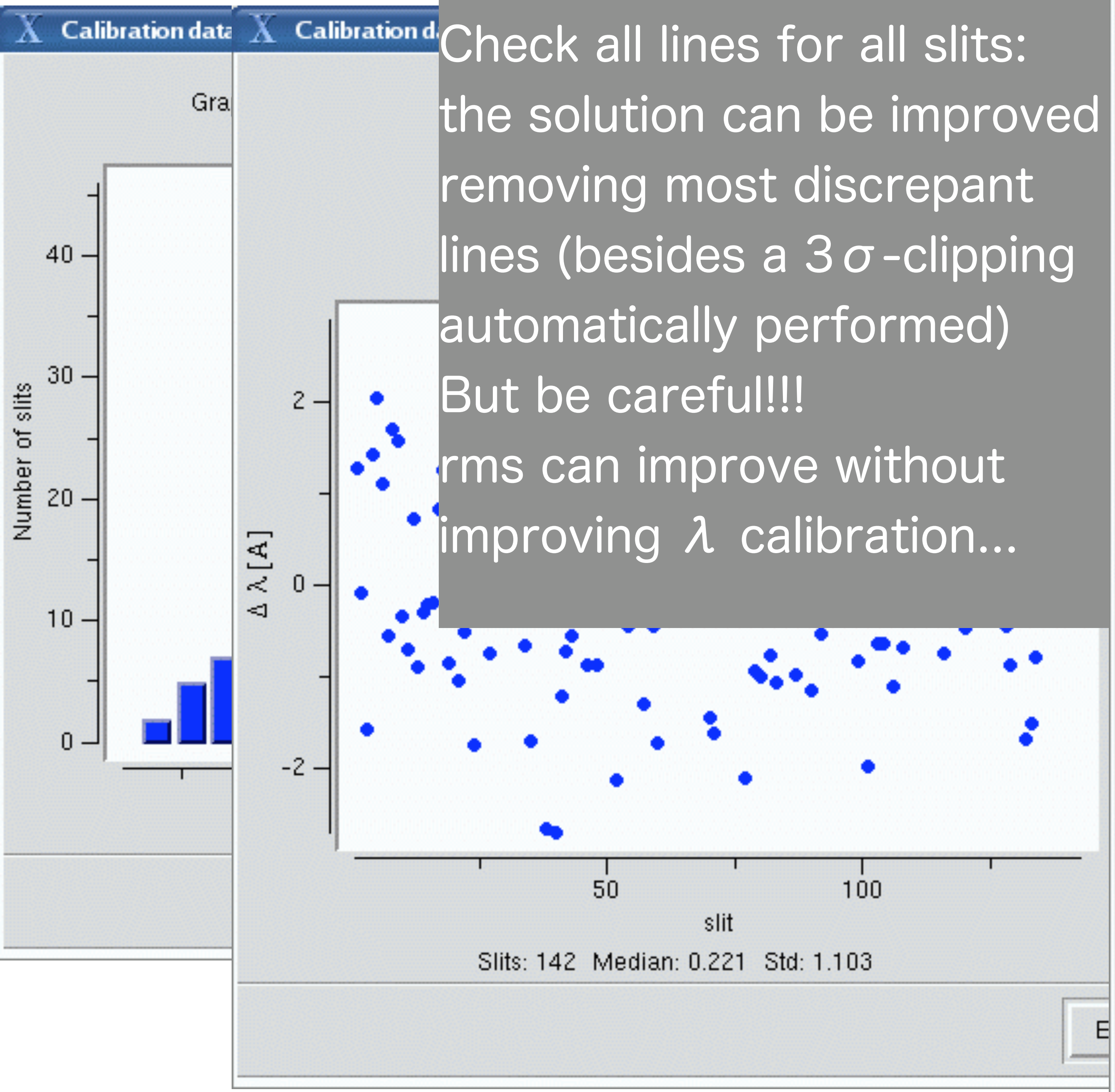
Check single line location for all slits



Reduction of VLT spectra - I. General methods

VIPGI: v. Creating MasterLamp

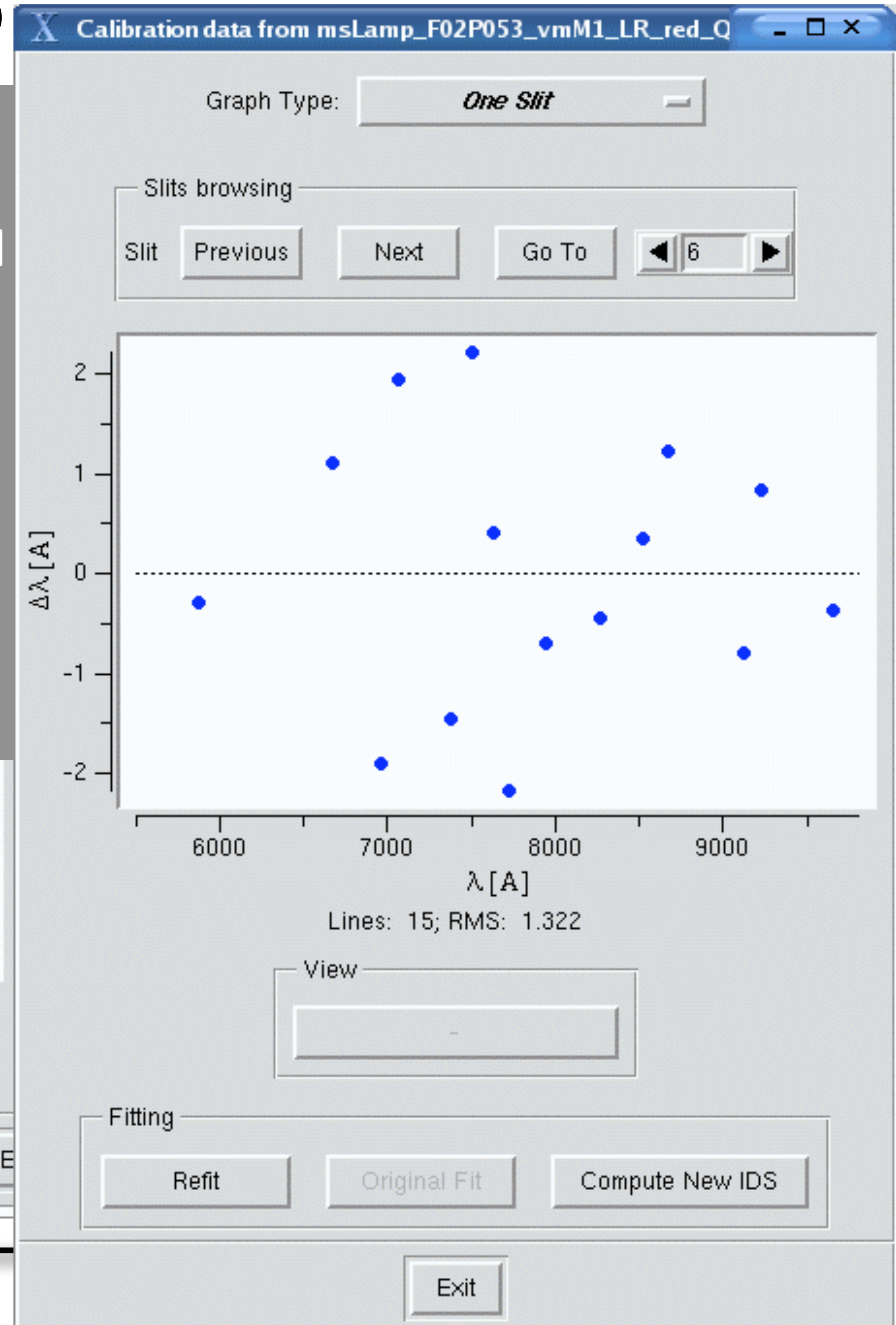
Check rms statis



Check all lines for all slits: the solution can be improved removing most discrepant lines (besides a 3σ-clipping automatically performed)

But be careful!!!

rms can improve without improving λ calibration...



VIPGI: vi. Reduce single frames

A ‘preliminary reduction’ performed on all the scientific exposures is needed to

- subtract the bias
- trim pre- and over-scan regions of the CCD
- perform the bad pixel correction
- append the flat-field solution to the scientific frames

Subsequently:

1. wavelength calibration is further refined using sky-lines;
2. object detection along each slit is done by collapsing spectra along the dispersion axis
3. sky background is subtracted
4. 2D spectra are extracted and re-sampled on a linear scale in wavelength
5. 1D spectra extraction following the profile of the collapsed slit
6. a noise spectrum is computed from the sky residuals and object Poisson noise

Reduction of VLT spectra - I. General methods

VIPGI: vii. Reduce sequence

The final step of reduction consists in combining the the jittered sequence and calibrating spectra flux.

a. spectra from step 4. are used to correct the fringing: the pixels with the object spectrum are masked and single exposures are combined without offsets ⇒ the resulting image of fringing can be subtracted
b. slits of the different exposures are added considering the offsets of jittering
c. summed, sky subtracted, fringing corrected 2D spectra are stored
d. 1D spectra are extracted from the 2D ones using the slit profile
e. 1D spectra are flux calibrated using the ADU to absolute flux transformation computed from the observations of spectrophotometric standard stars

Reduction of VLT spectra - I. General methods

VIPGI: vii. Reduce sequence

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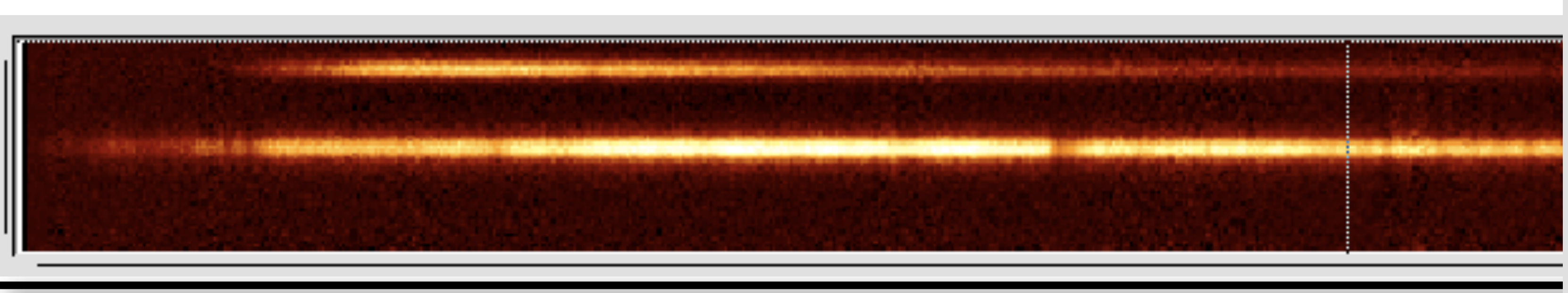

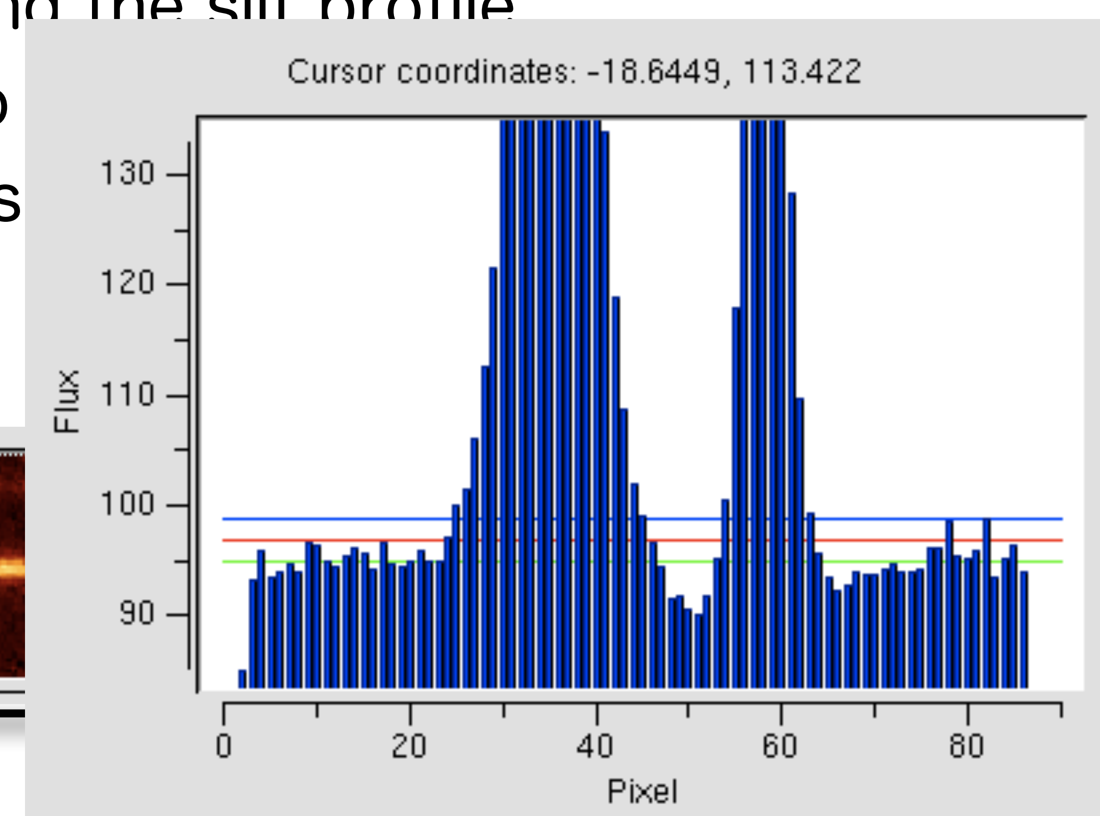

Reduction of VLT spectra - I. General methods

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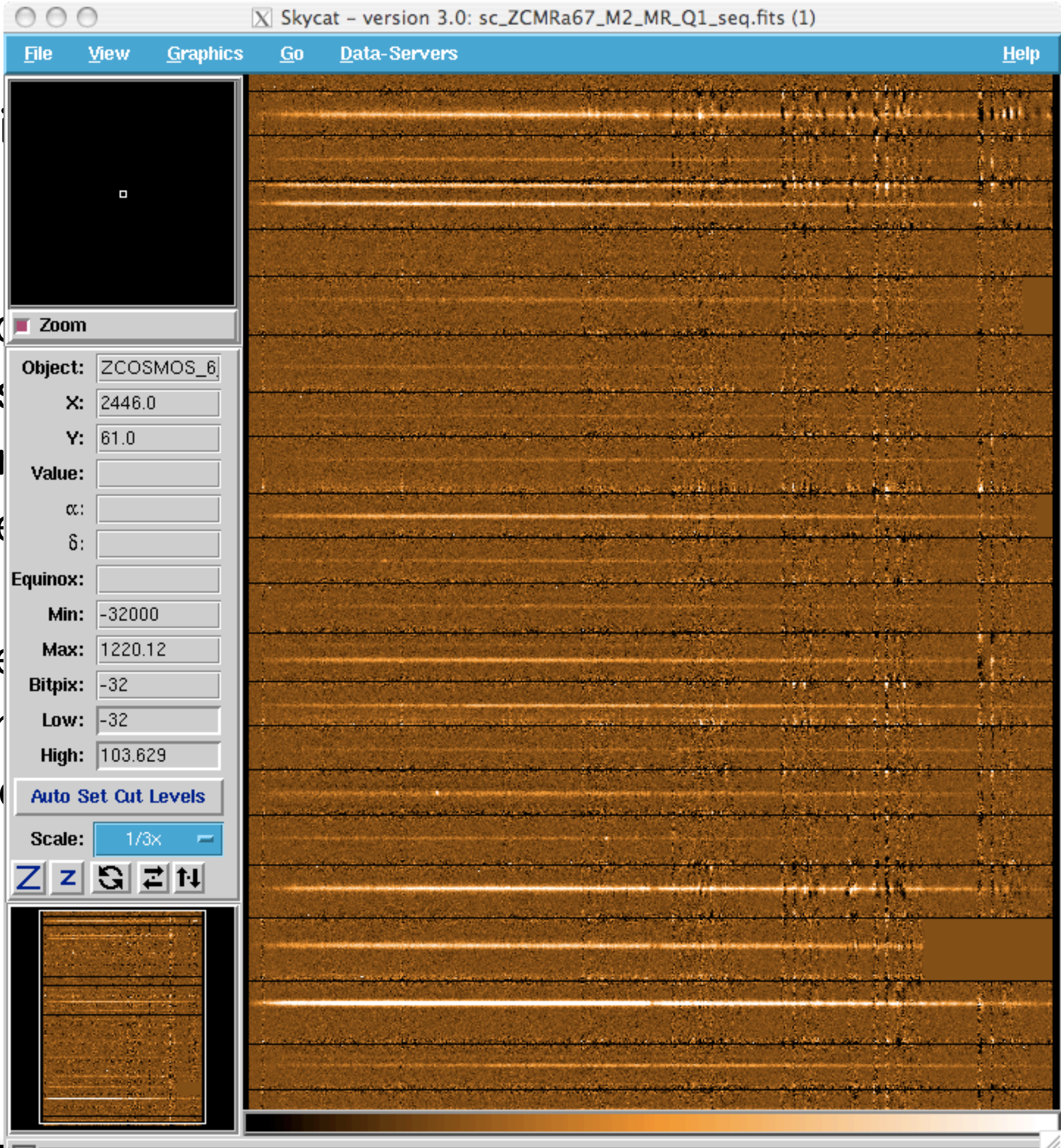
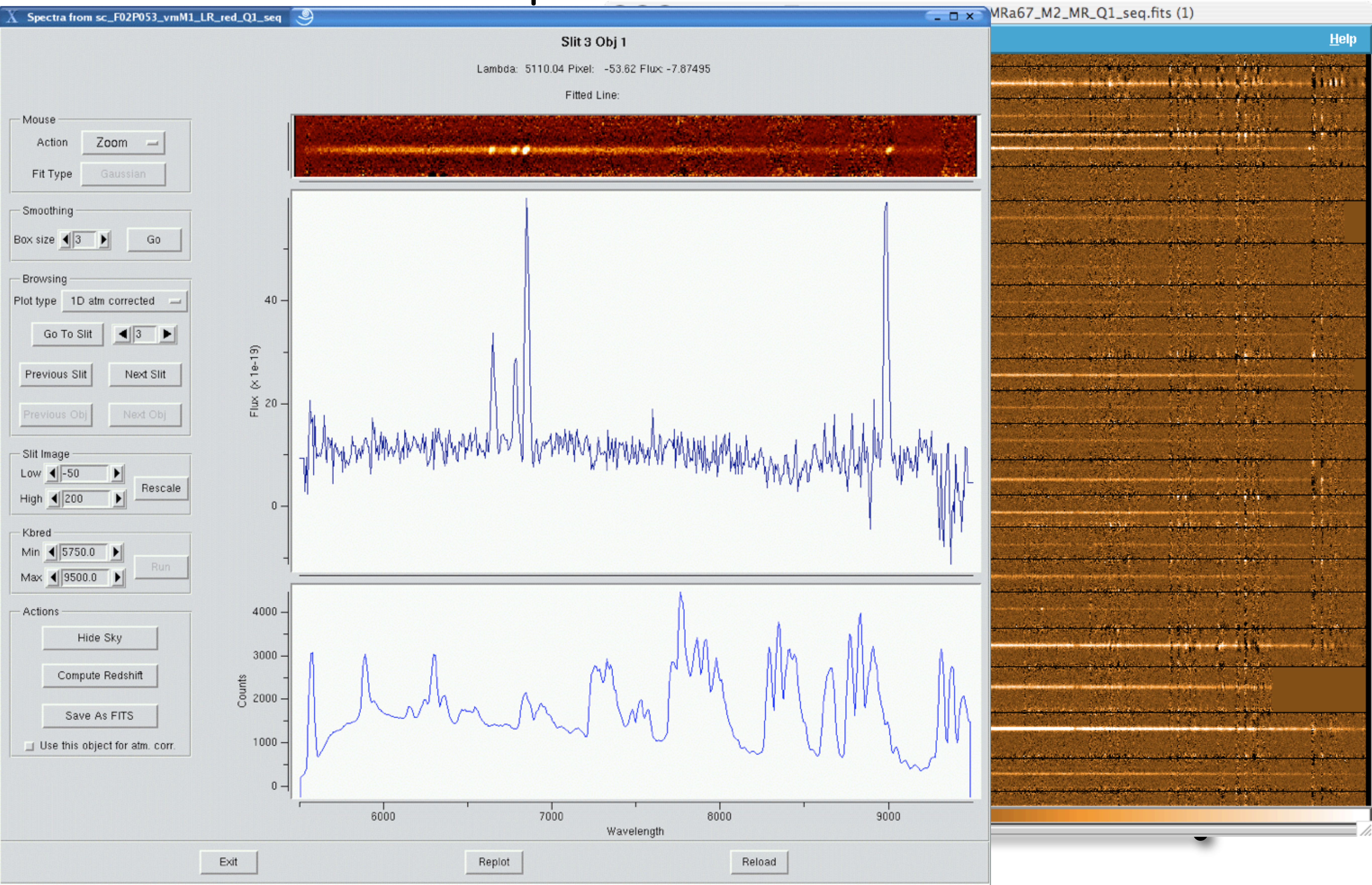


Reduction of VLT spectra - I. General methods

VIPGI: vii. Reduce sequence

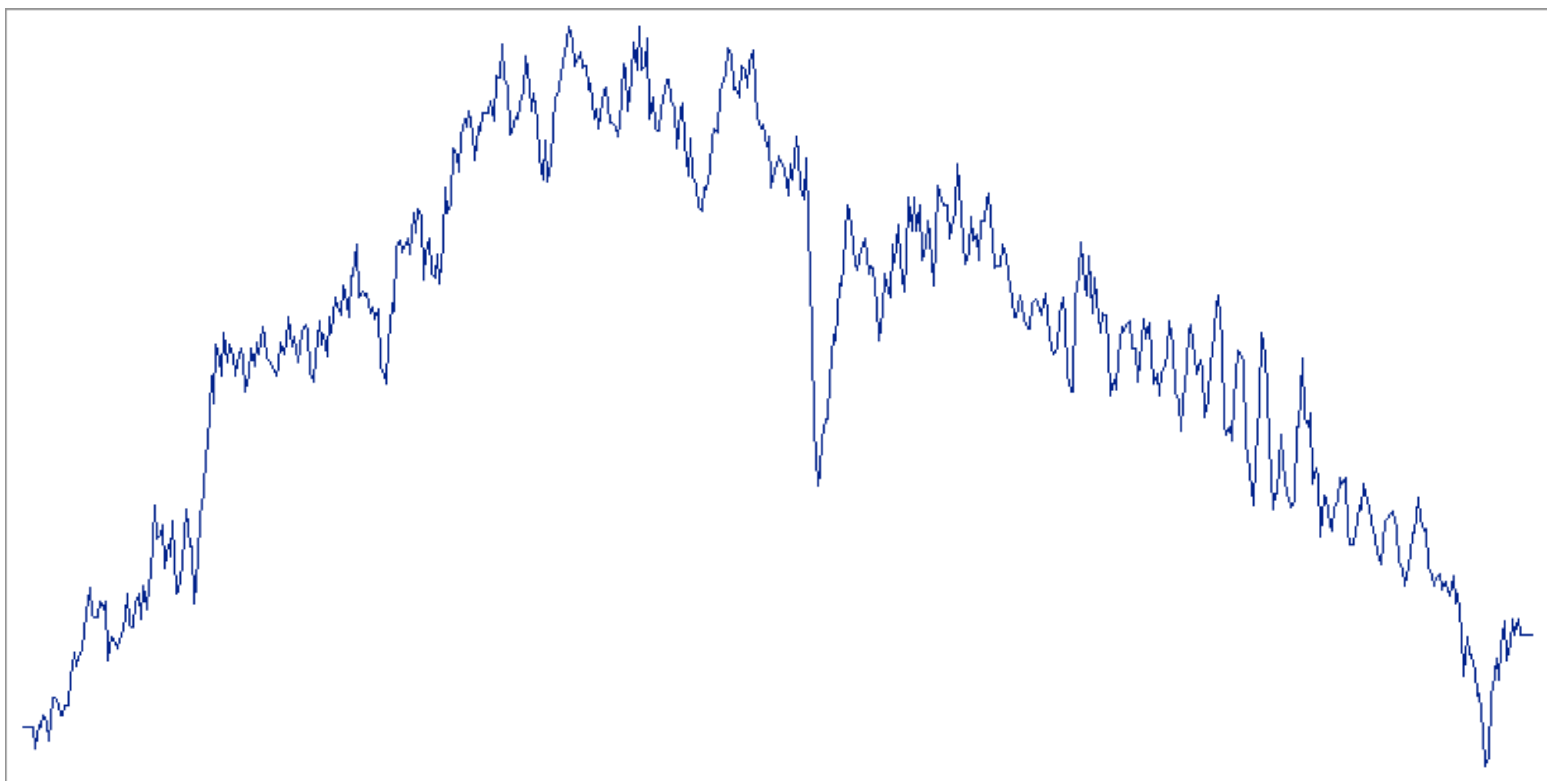


Reduction of VLT spectra - I. General methods

VIPGI: vii. Reduce sequence

The last small correction is to be applied is the atmospheric absorption, computed directly from the data:

1D not flux calibrated



Reduction of VLT spectra - I. General methods

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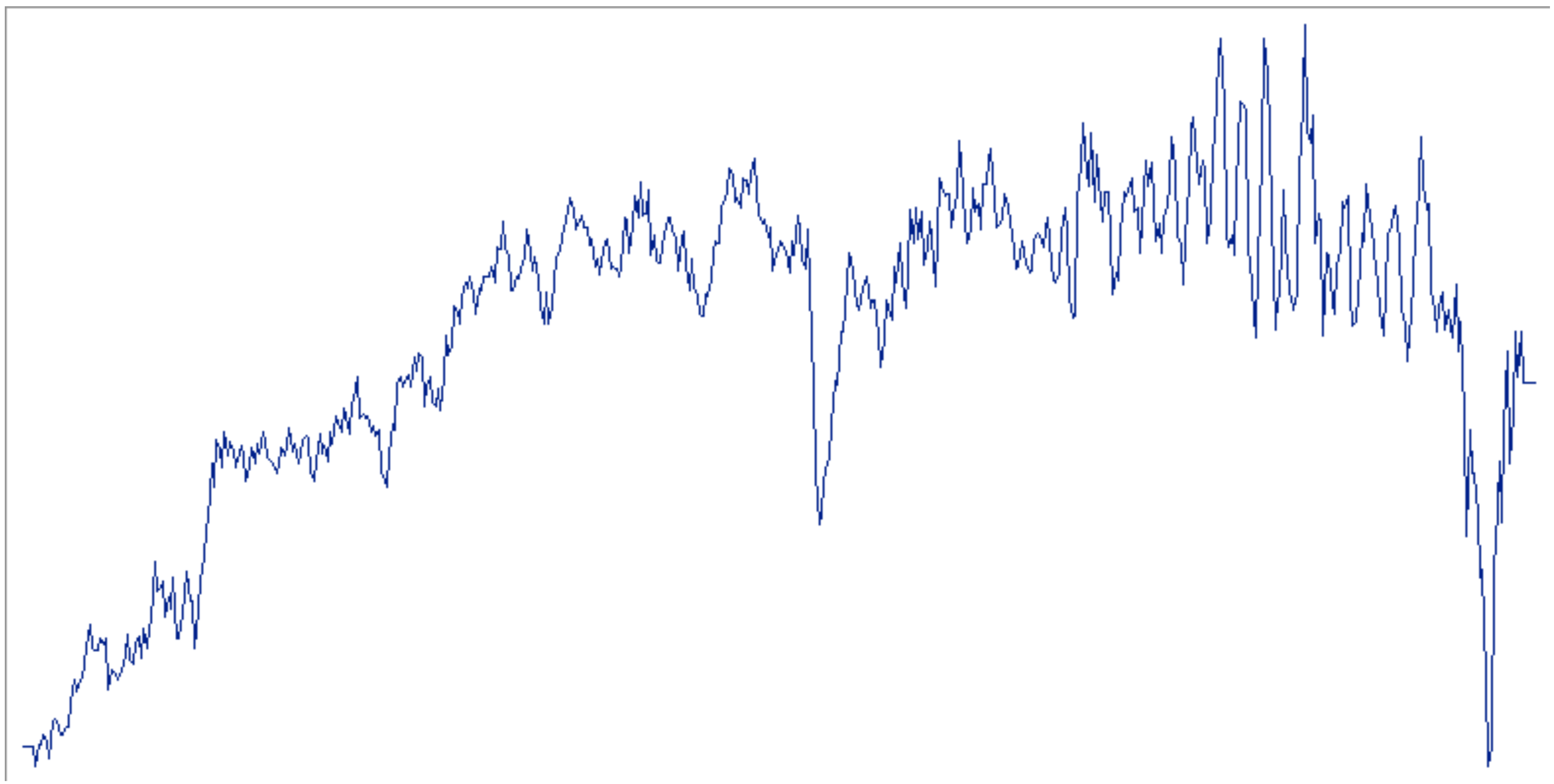
1D flux calibrated

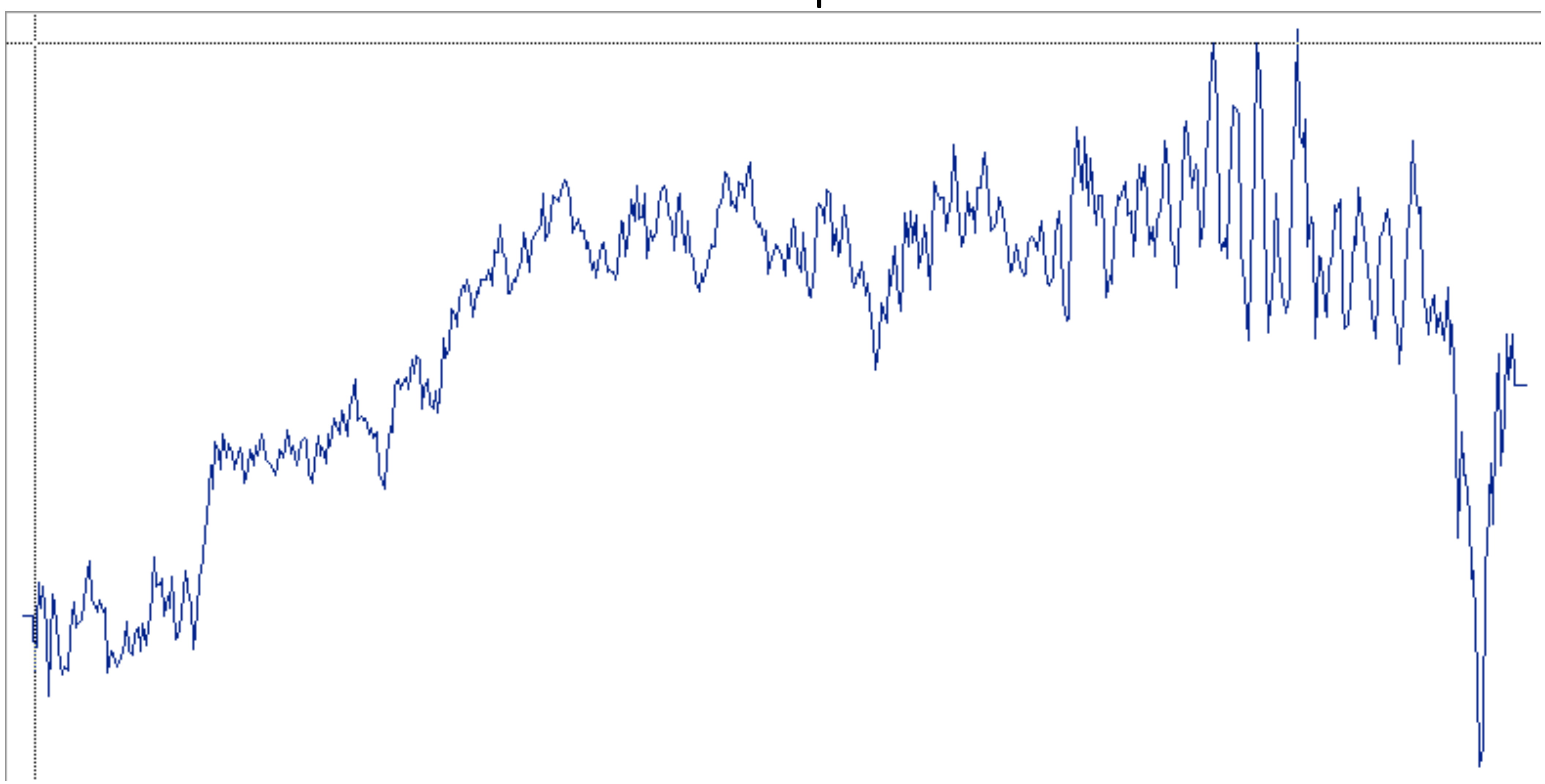


Reduction of VLT spectra - I. General methods

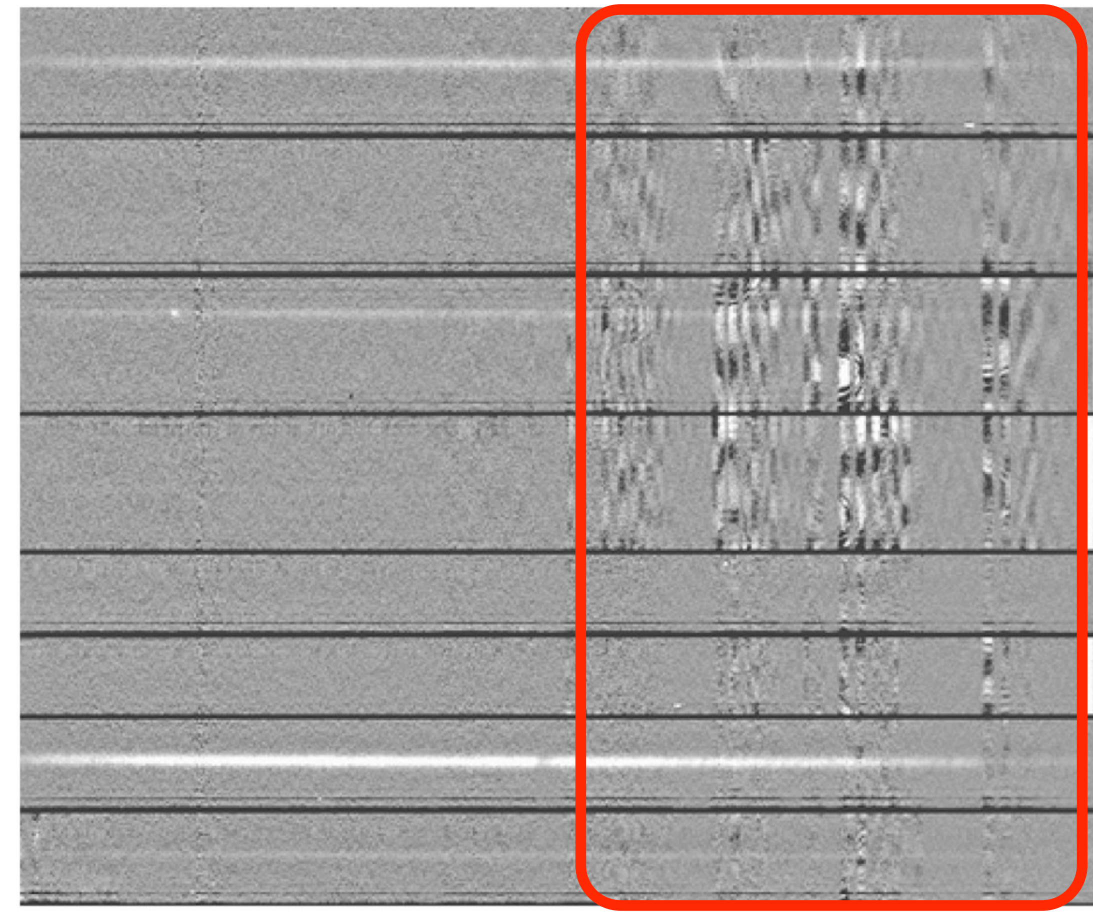
VIPGI: vii. Reduce sequence

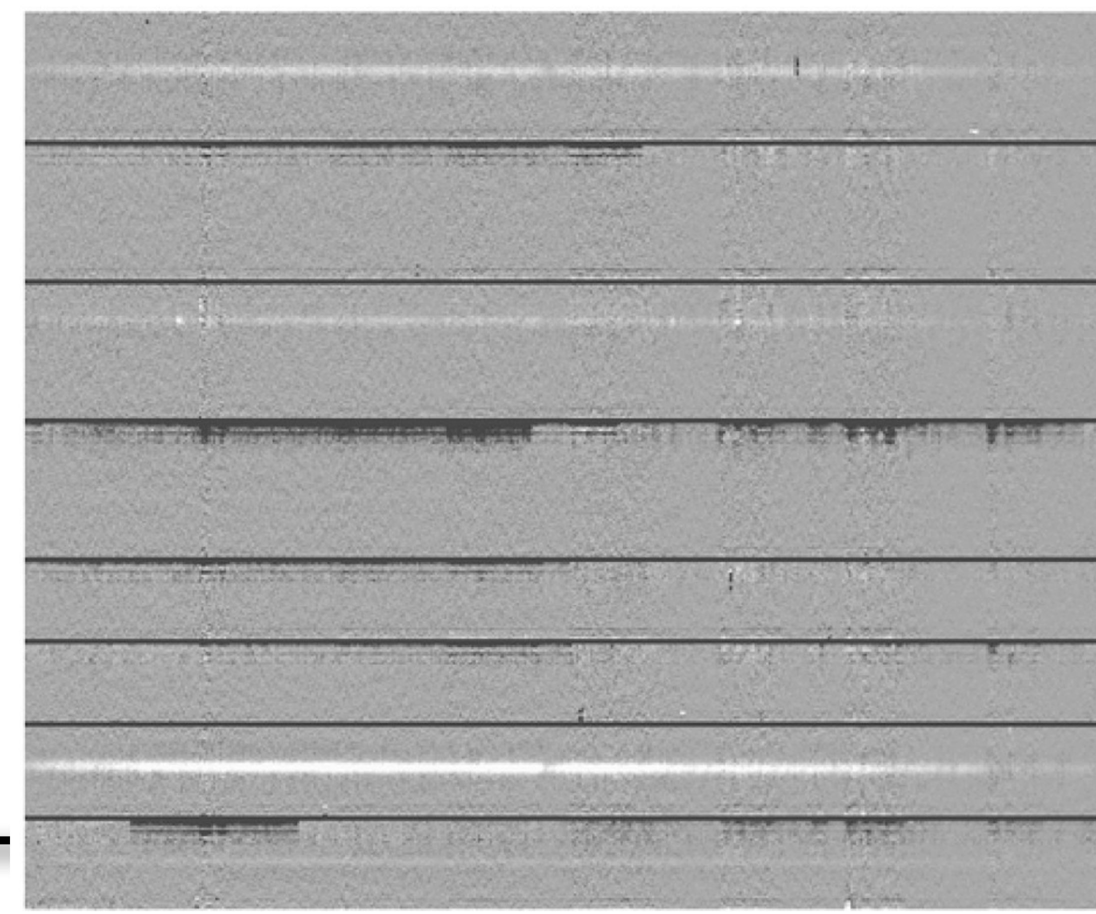
The last small correction is to be applied is the atmospheric absorption, computed directly from the data:

1D atmospheric corrected



VIPGI: ix. Fringing correction





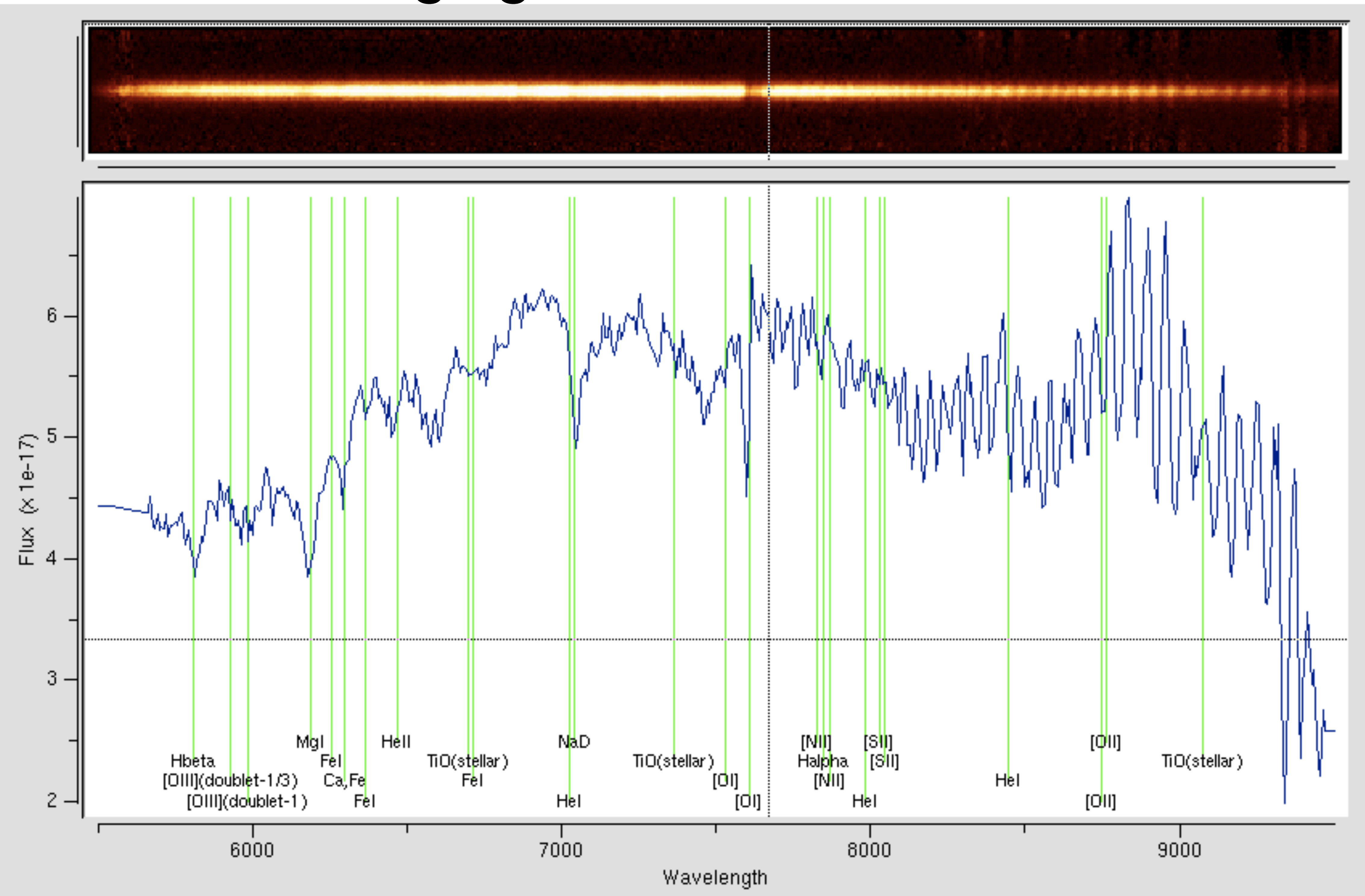
Fringing is caused by multiple reflections inside the CCD: at redder wavelengths chips that have been thinned (to increase sensitivity in the blue) start to become transparent
⇒ light can penetrate and be internally reflected
It then interferes with incident light, giving rise to constructive and destructive interference and a series of ‘ripples’.

The fringe pattern can be removed thanks to the jitter sequence

It works well, but brighter objects are also more extended, preventing an accurate estimate of the residuals...

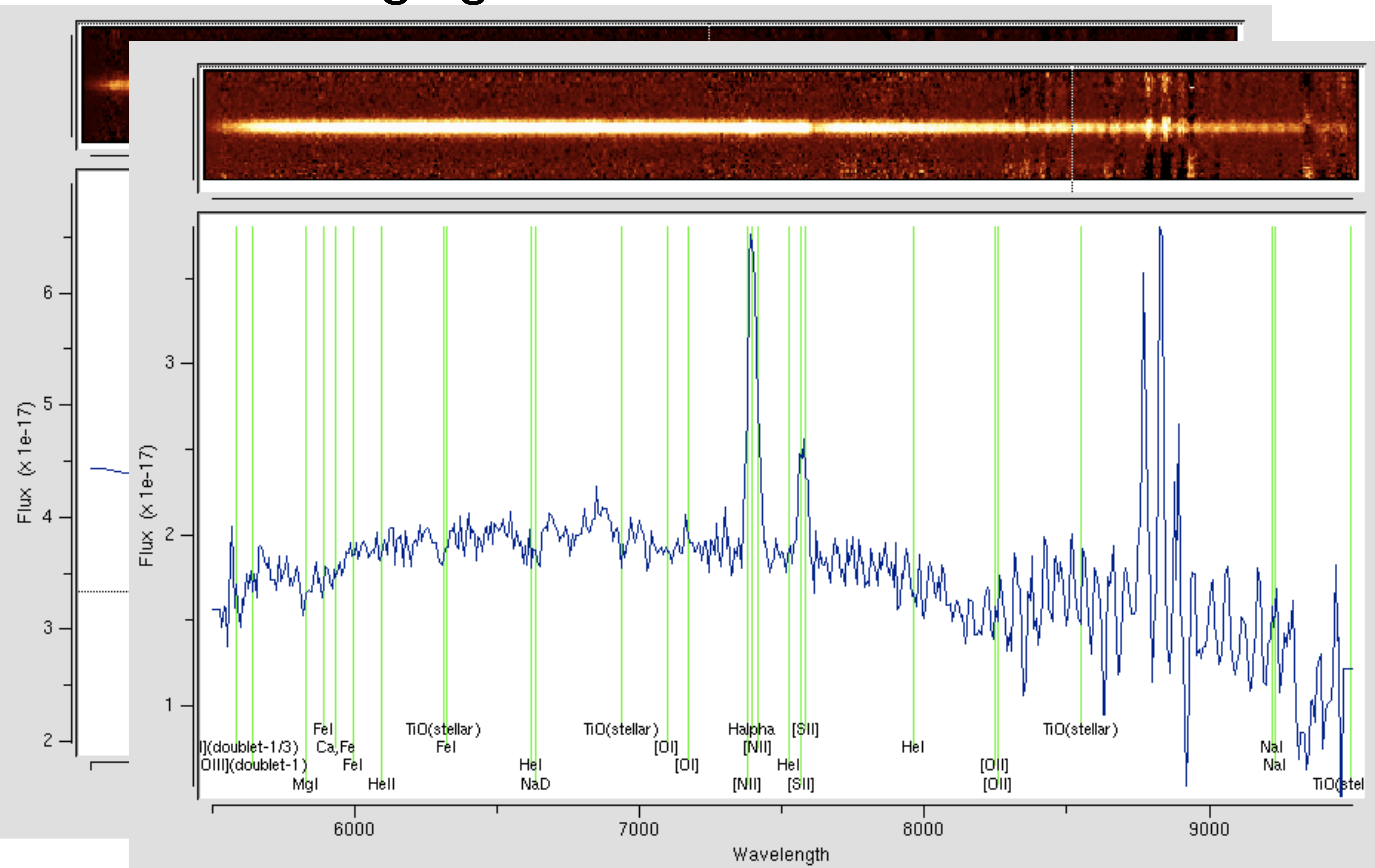
Reduction of VLT spectra - I. General methods

VIPGI: ix. Fringing correction



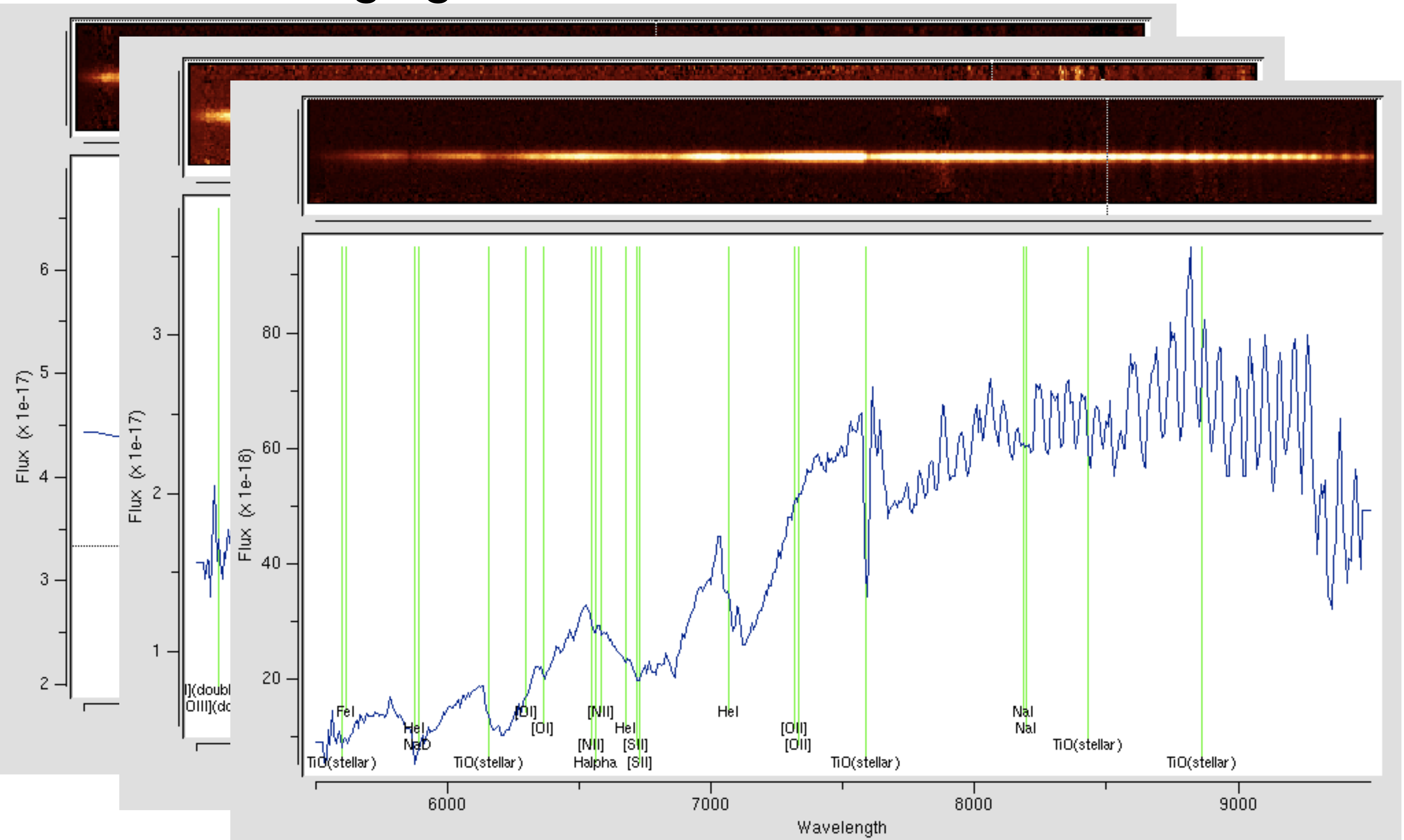
Reduction of VLT spectra - I. General methods

VIPGI: ix. Fringing correction



Reduction of VLT spectra - I. General methods

VIPGI: ix. Fringing correction



VIPGI: viii. Reduce sequence with ABBA method

An alternative way to obtain the sequence of spectra is the "classical" ABBA procedure, even if a jitter pattern has been used for observations:

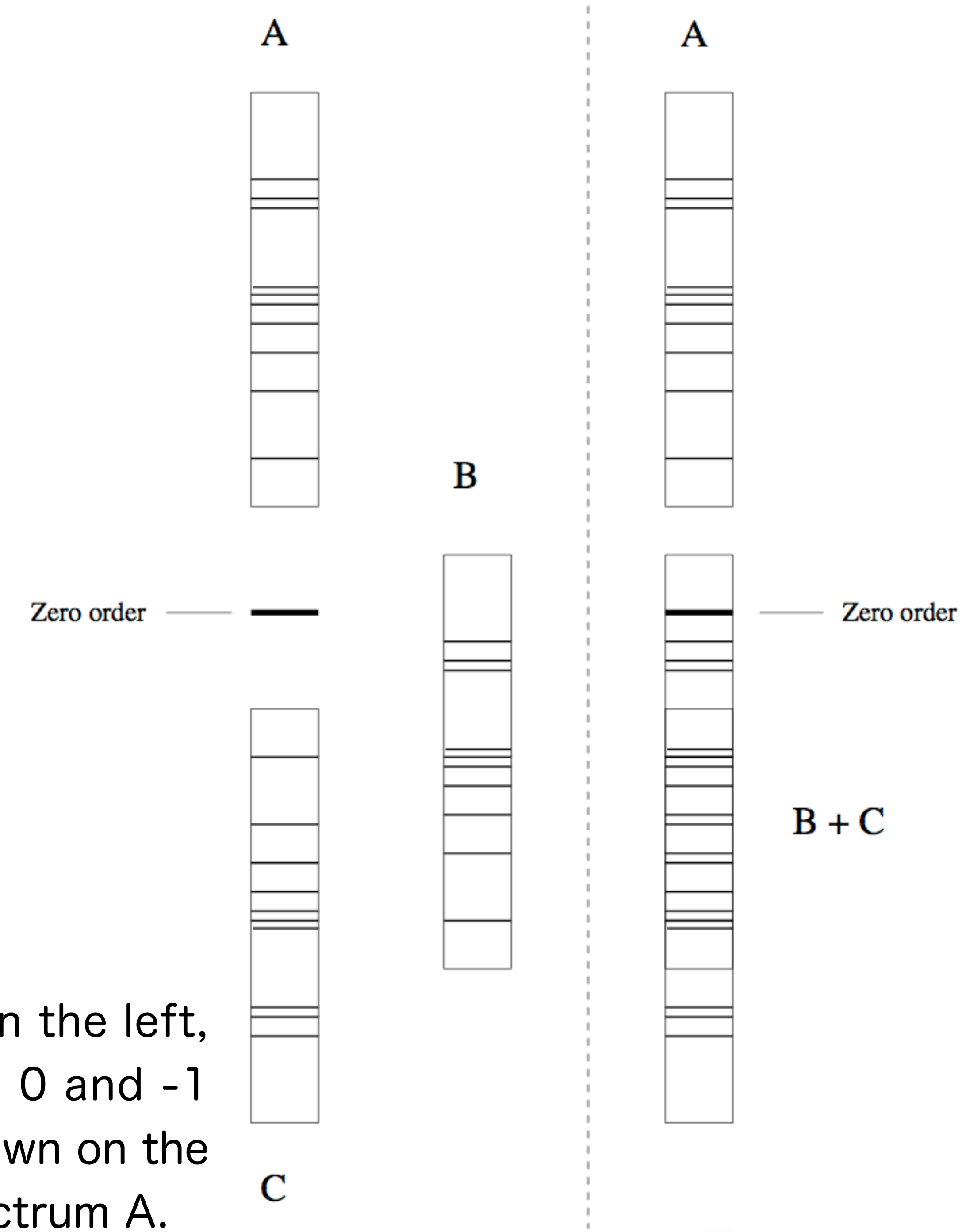
- ✓ exposures are coupled two by two
- ✓ A and B images are subtracted one from the other
- ✓ shifted according their offset and combined applying the equation [A-B]+[B-A]' where [B-A]' is the 2D spectrum shifted to be superposed to [A-B]
- ✓ after all couple have been treated, they are summed in the same reference system
- ✓ in case of odd number of exposures, the same exposure can be used in more than 1 couple and then accordingly weighted

⇒ fringing correction is successful, but objects falling by chance in slits are usually lost

Reduction of VLT spectra - I. General methods

VIPGI: x. Removing spurious features

After the final reduction, before any spectral measure, spectra must be visually inspected to manually clean spurious features, e.g. 0th order spectra, negative non physical features, ...



Contamination from orders 0 and -1 in multiplexed spectra. On the left, the first order spectra A and B are shown, together with the 0 and -1 orders of spectrum A. If spectra A and B are multiplexed, as shown on the right, spectrum B is contaminated by the 0 and -1 orders of spectrum A.

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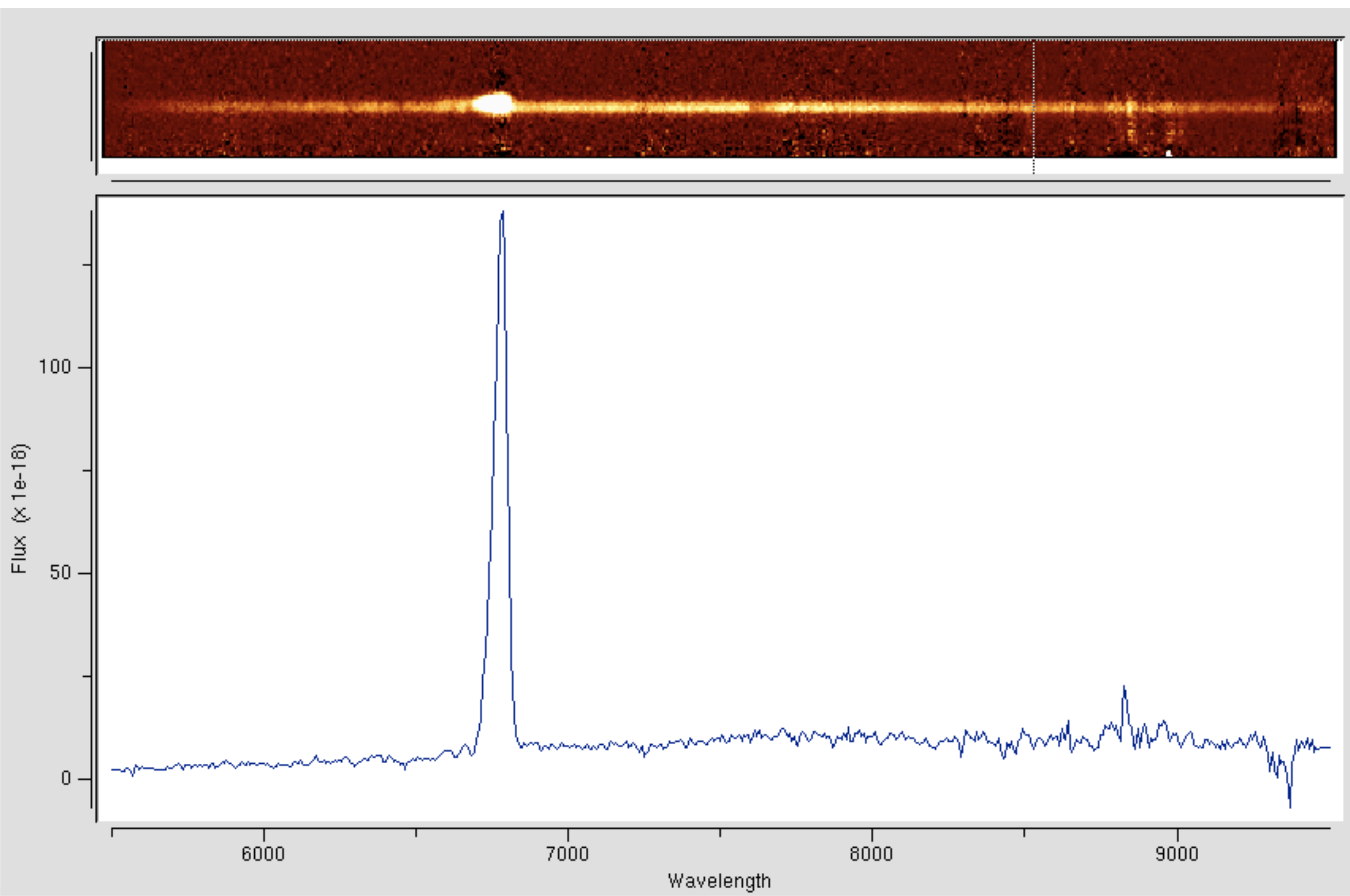

ft,
-1
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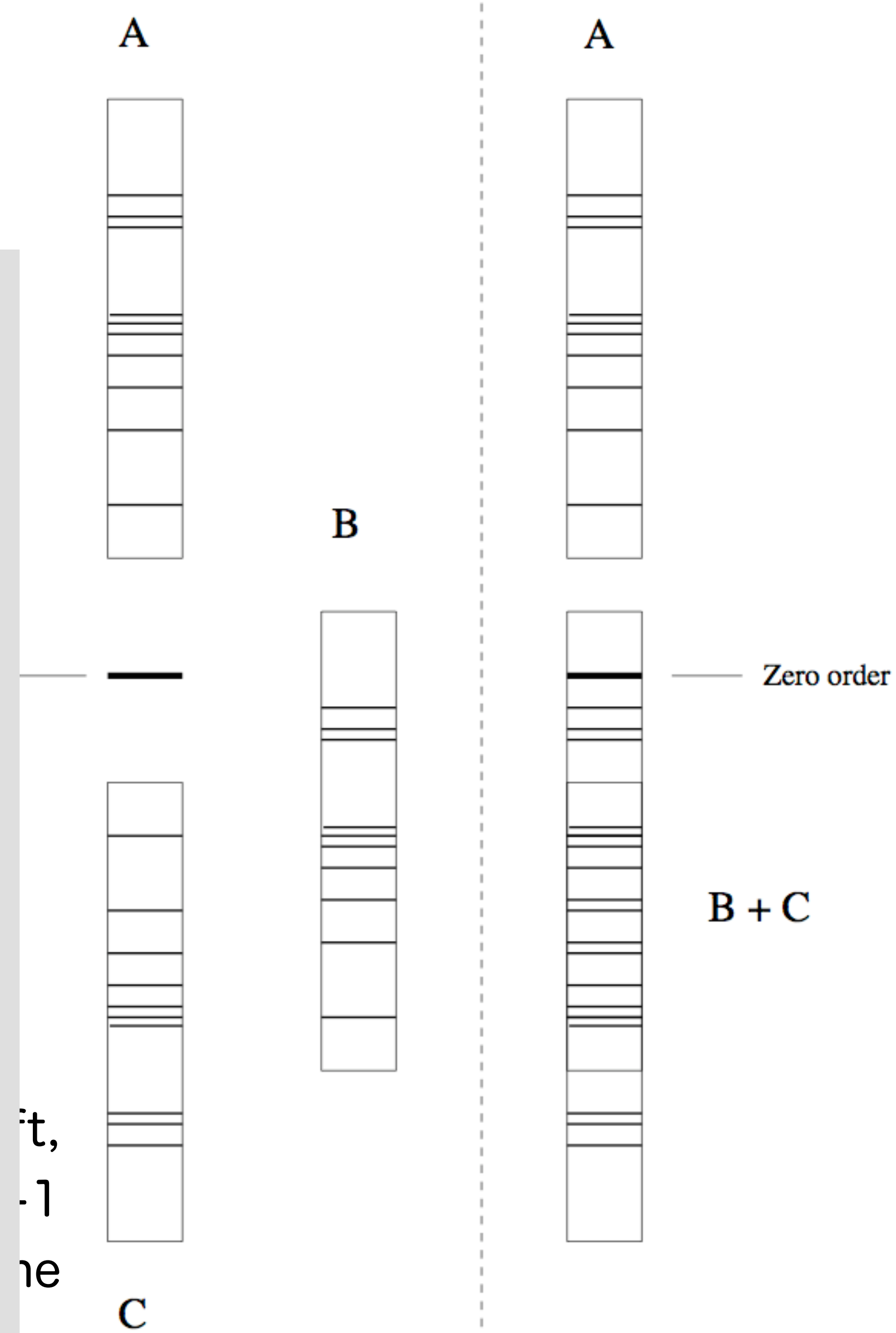

Reduction of VLT spectra - I. General methods

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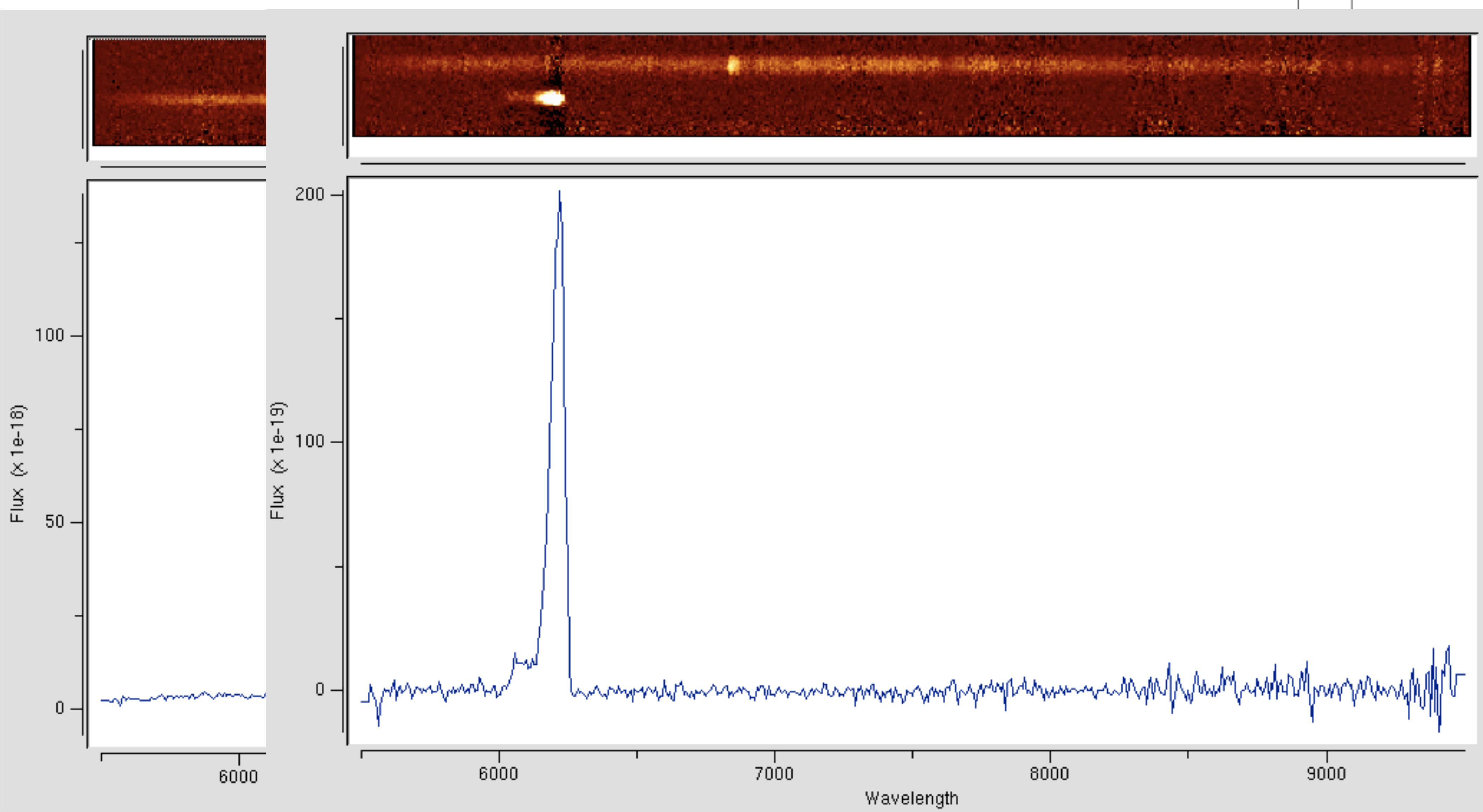

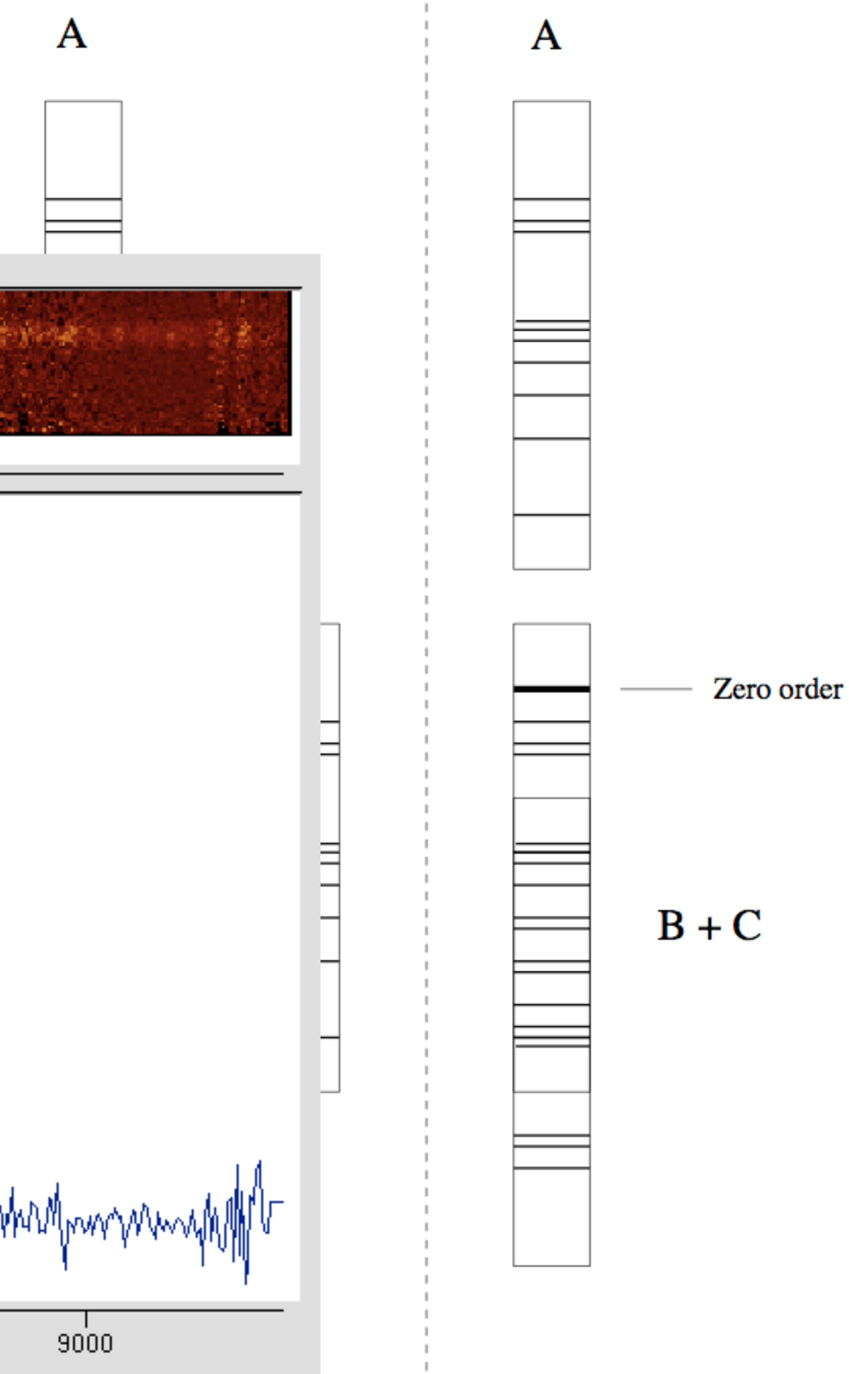

Reduction of VLT spectra - I. General methods

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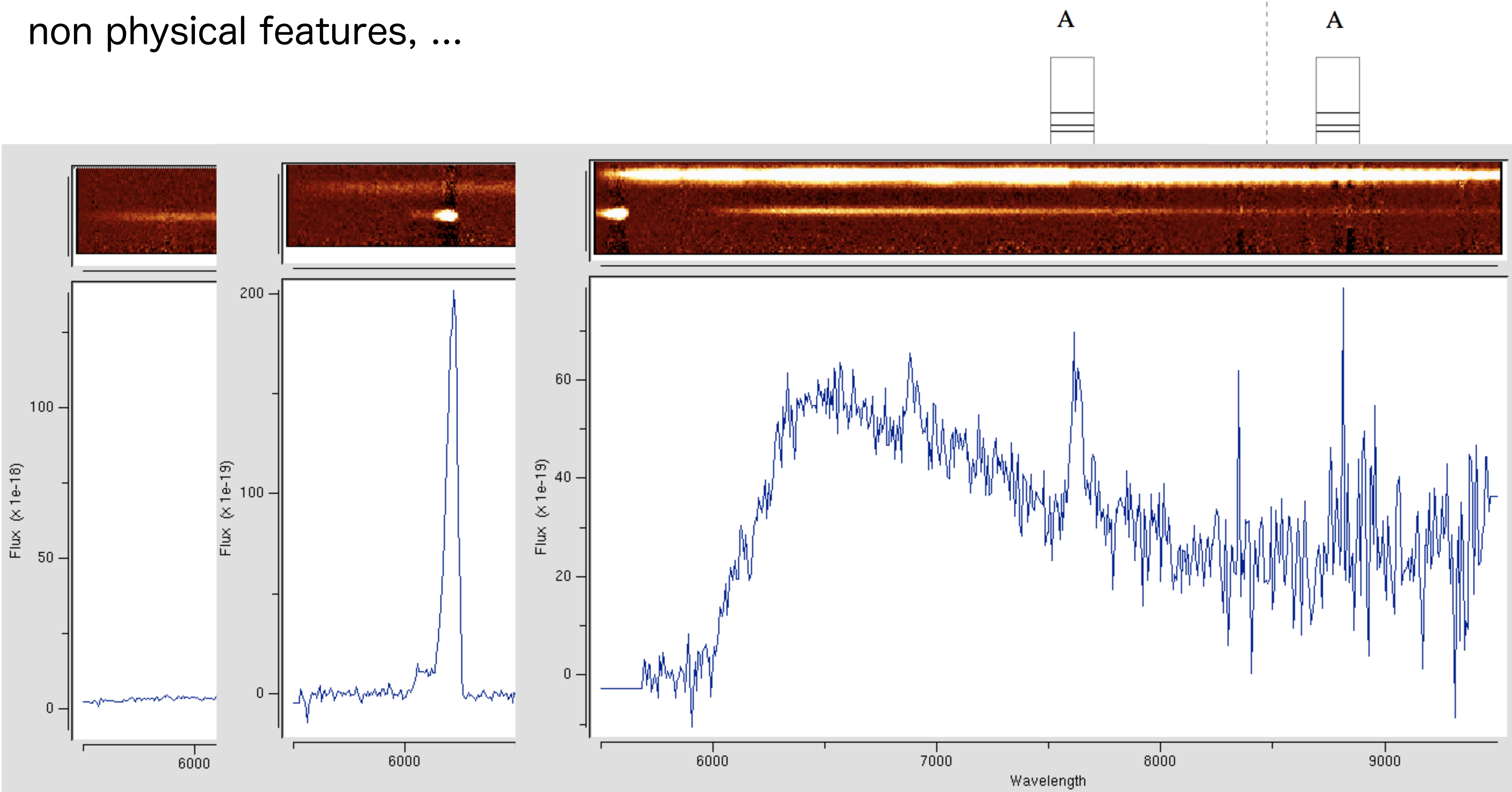
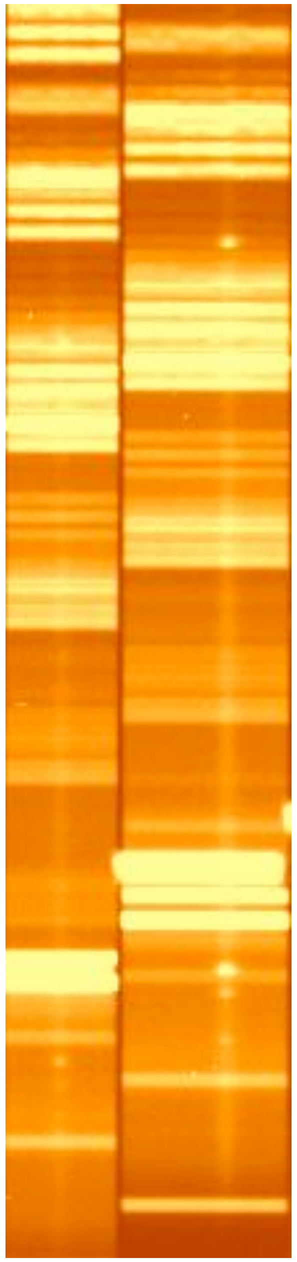


Reduction of VLT spectra - I. General methods

Spectroscopical measures: Redshift

To measure the redshift, known emission/absorption line patterns have to be identified, considering also the continuum, characteristc of typical early type or star forming galaxies or BLAGN.

Sometimes the lines are already visible from 2D spectra →



Reduction of VLT spectra - I. General methods

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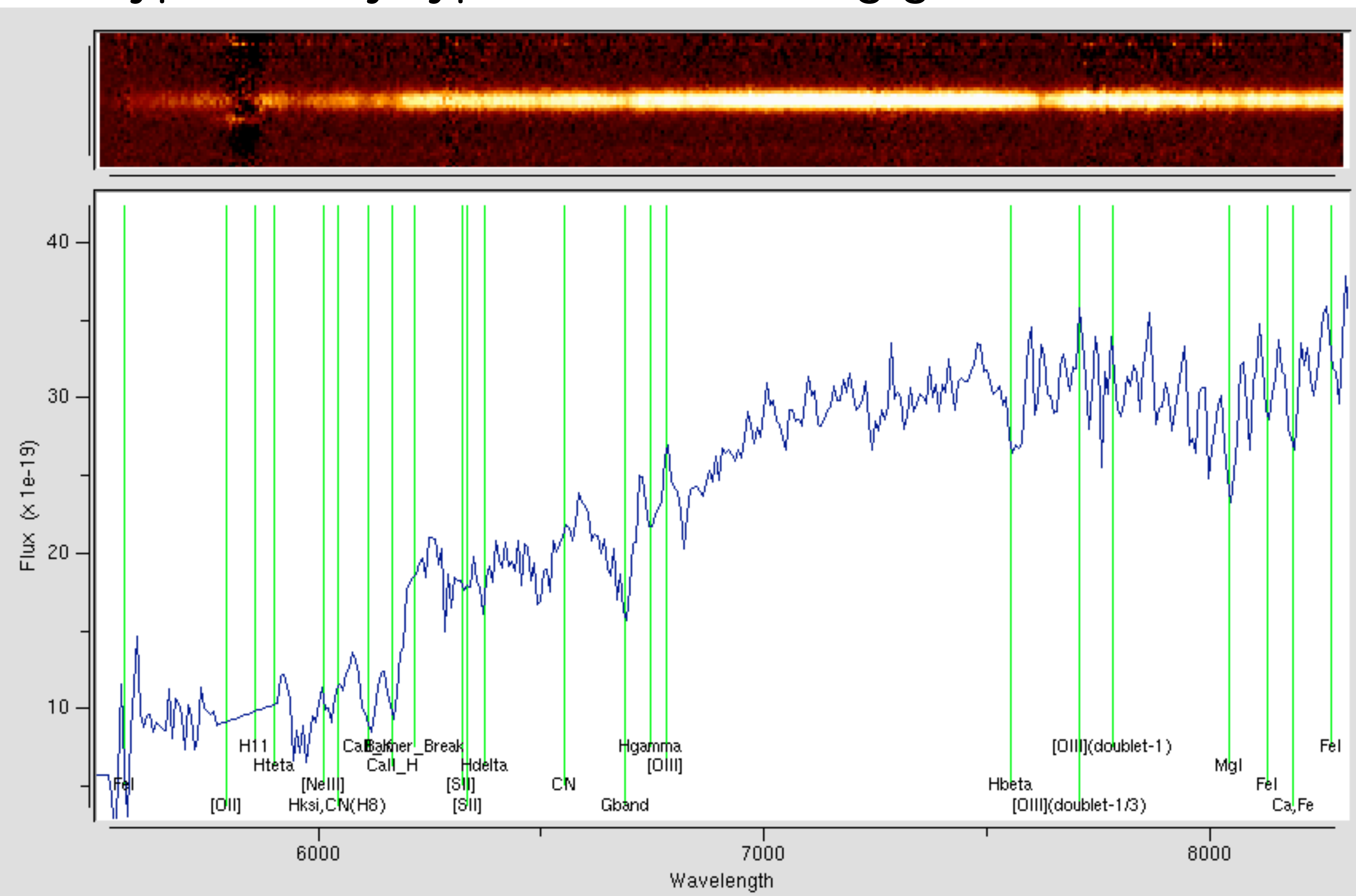

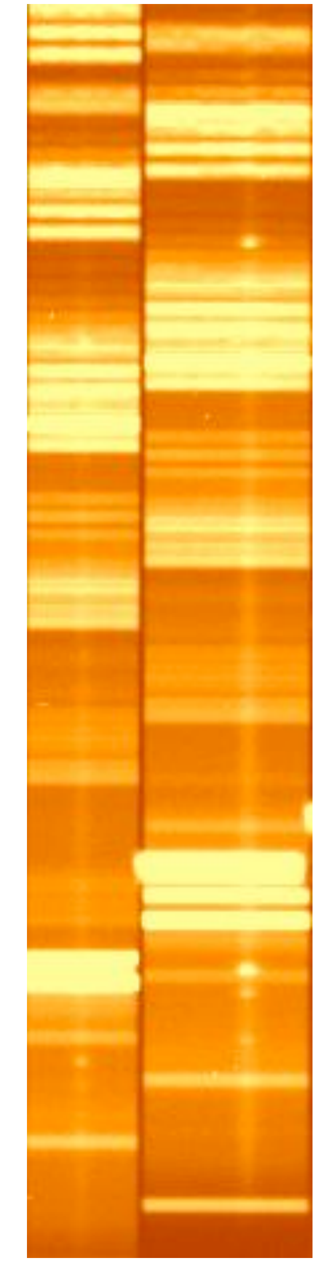

Reduction of VLT spectra - I. General methods

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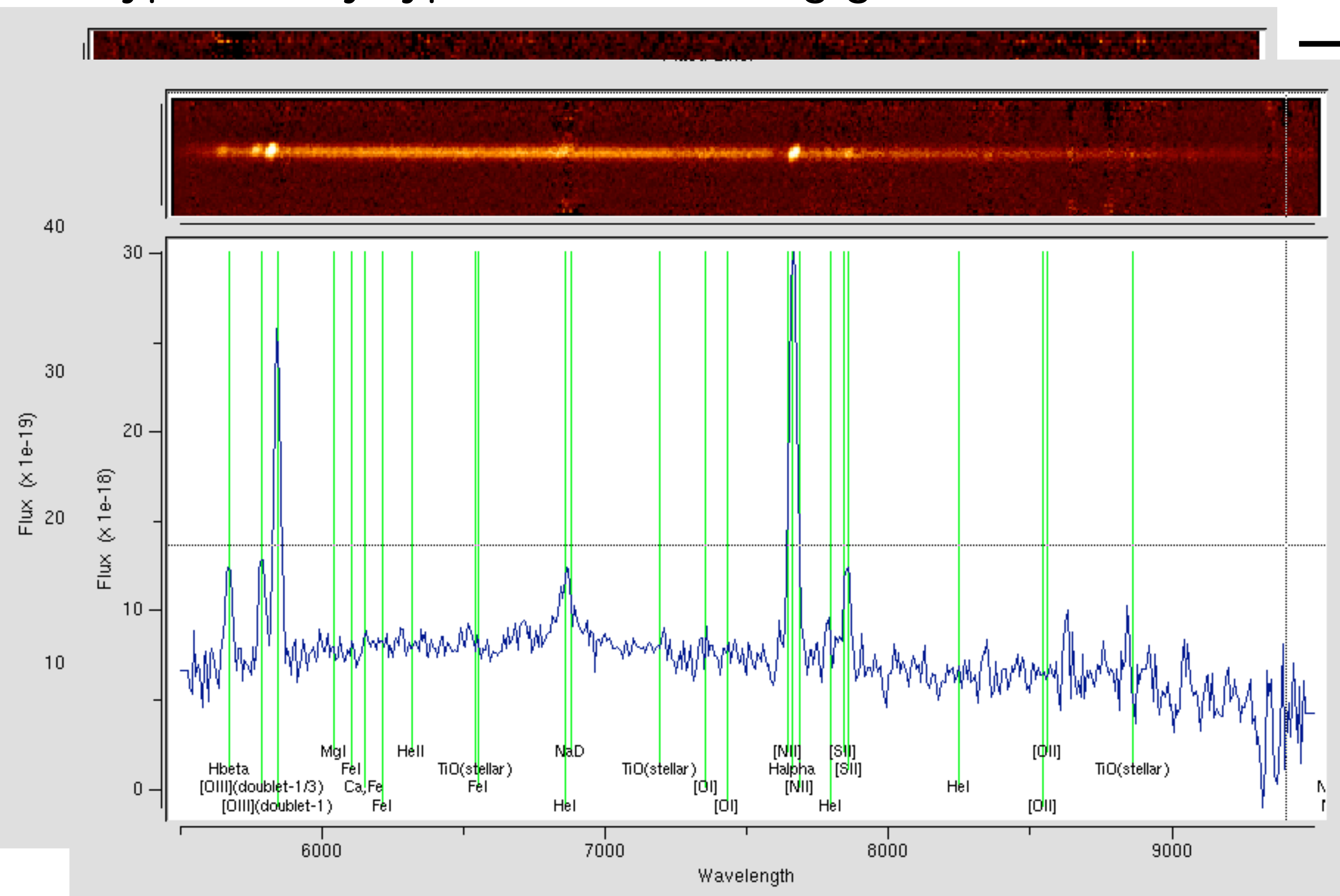

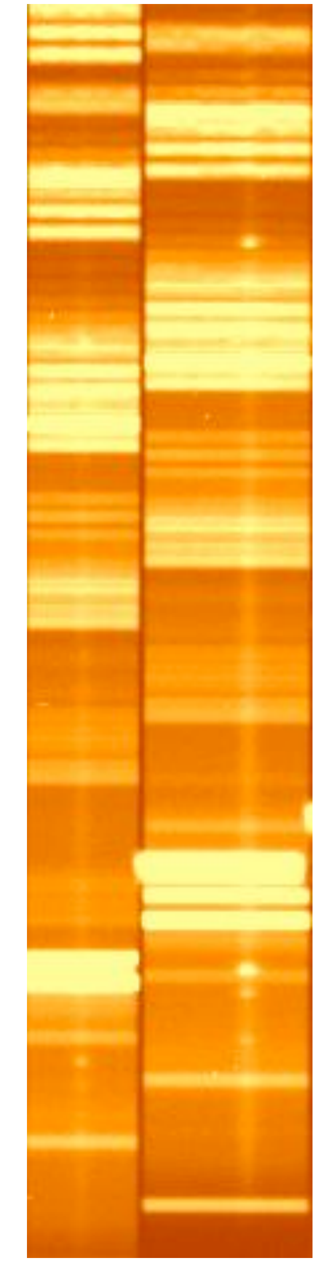

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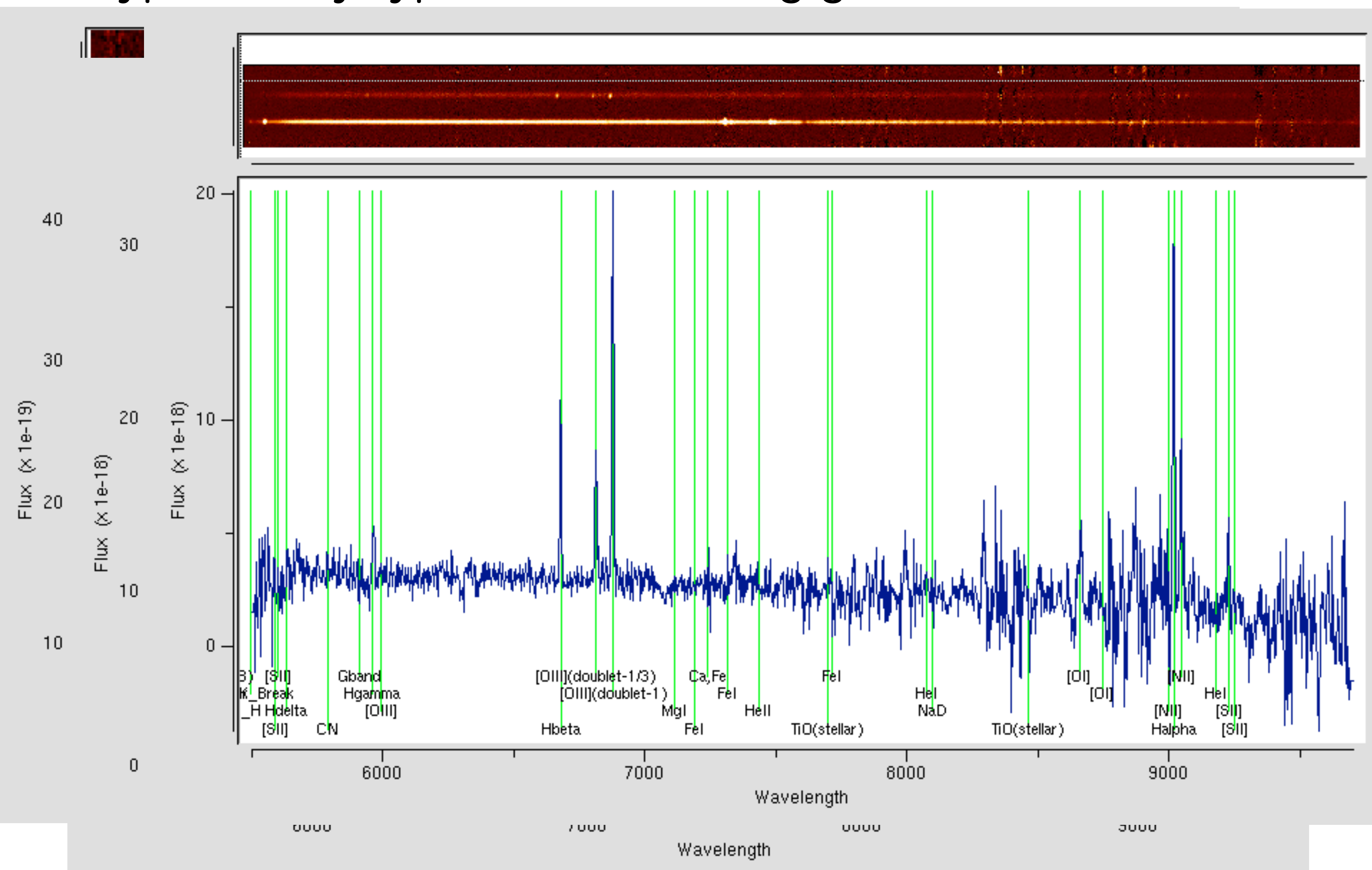

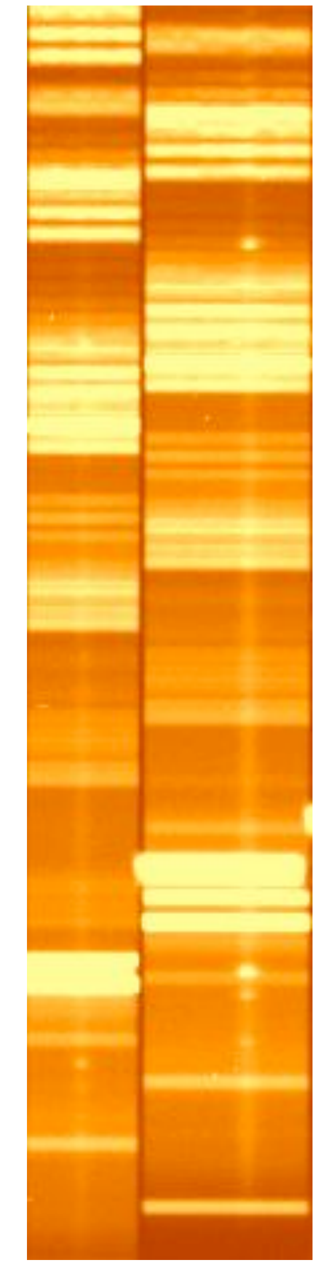

Reduction of VLT spectra - I. General methods

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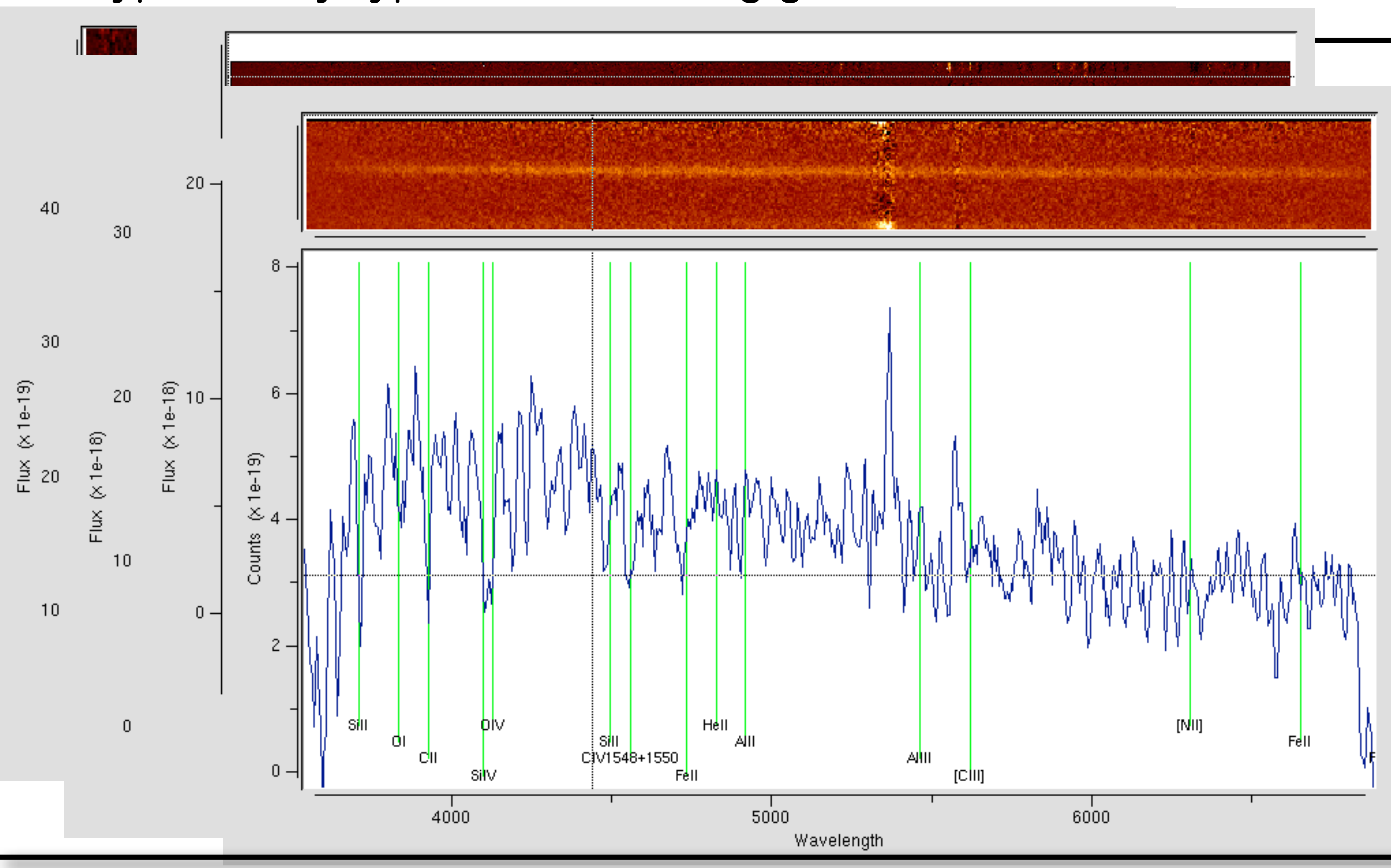

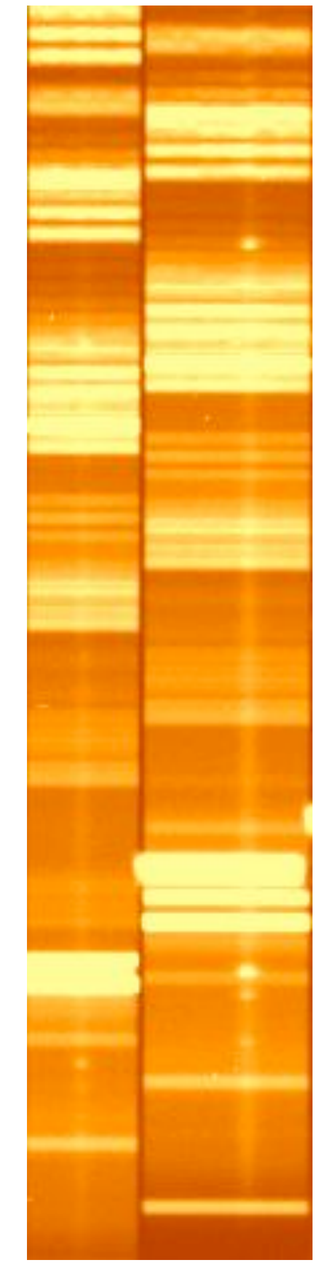

Reduction of VLT spectra - I. General methods

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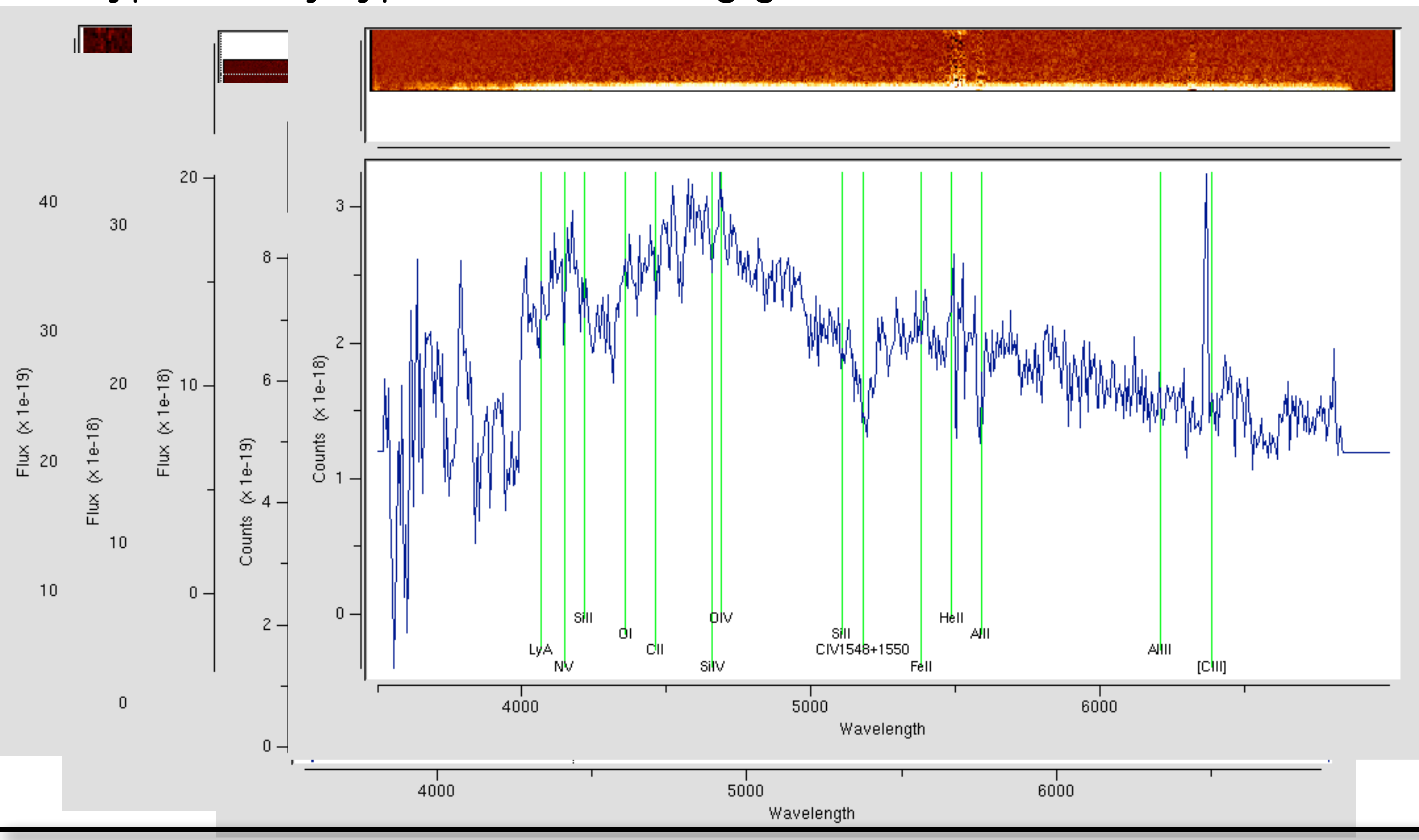

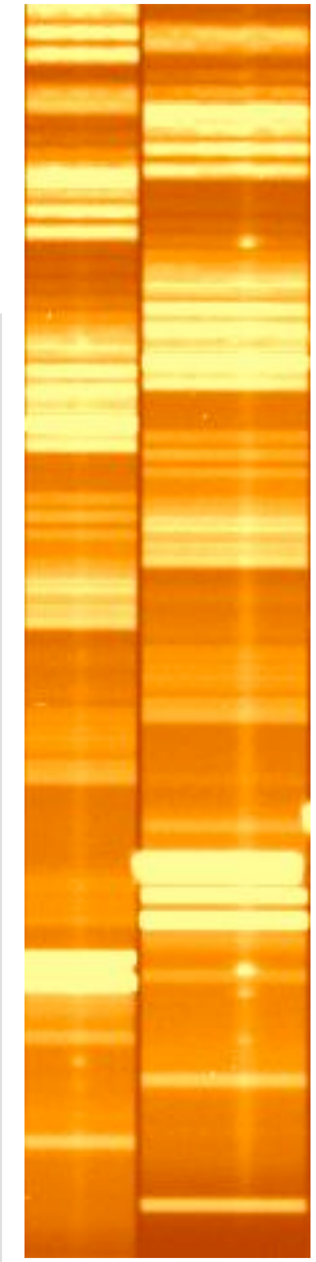

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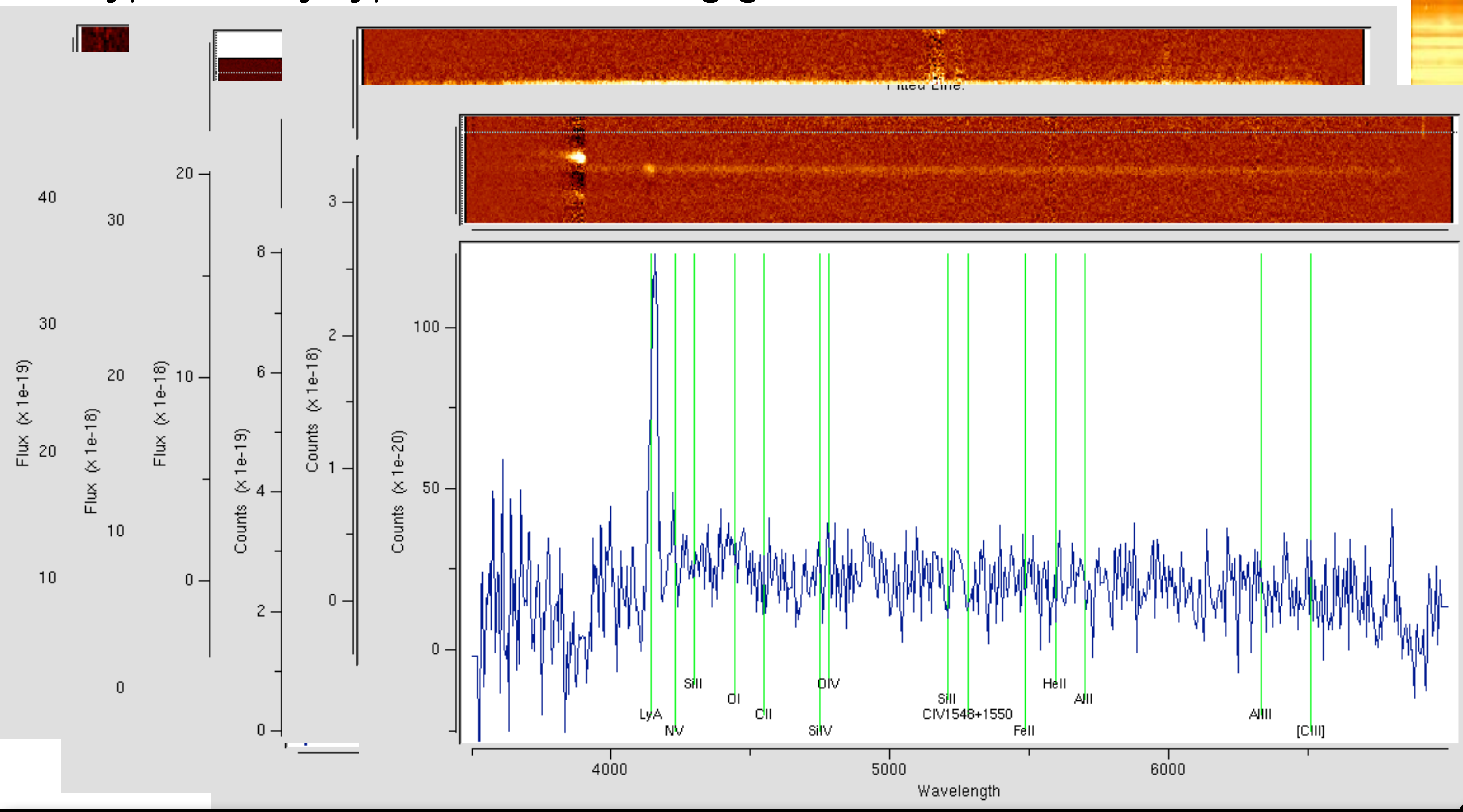

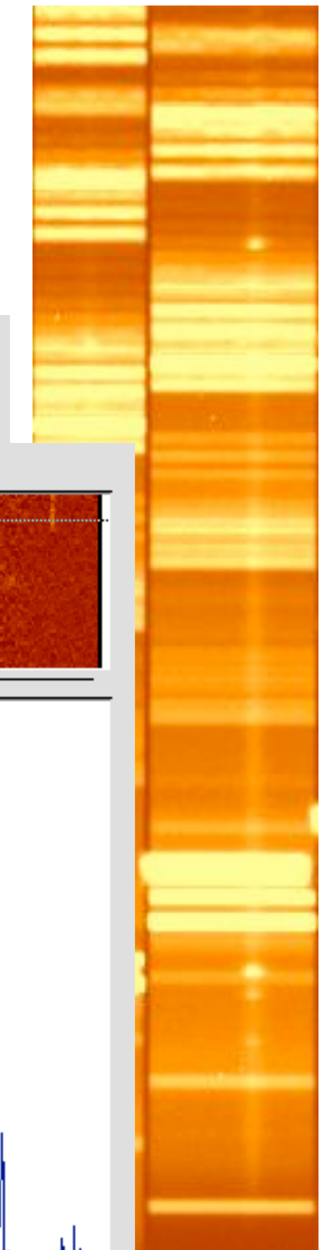

Reduction of VLT spectra - I. General methods

Spectroscopical measures: Redshift

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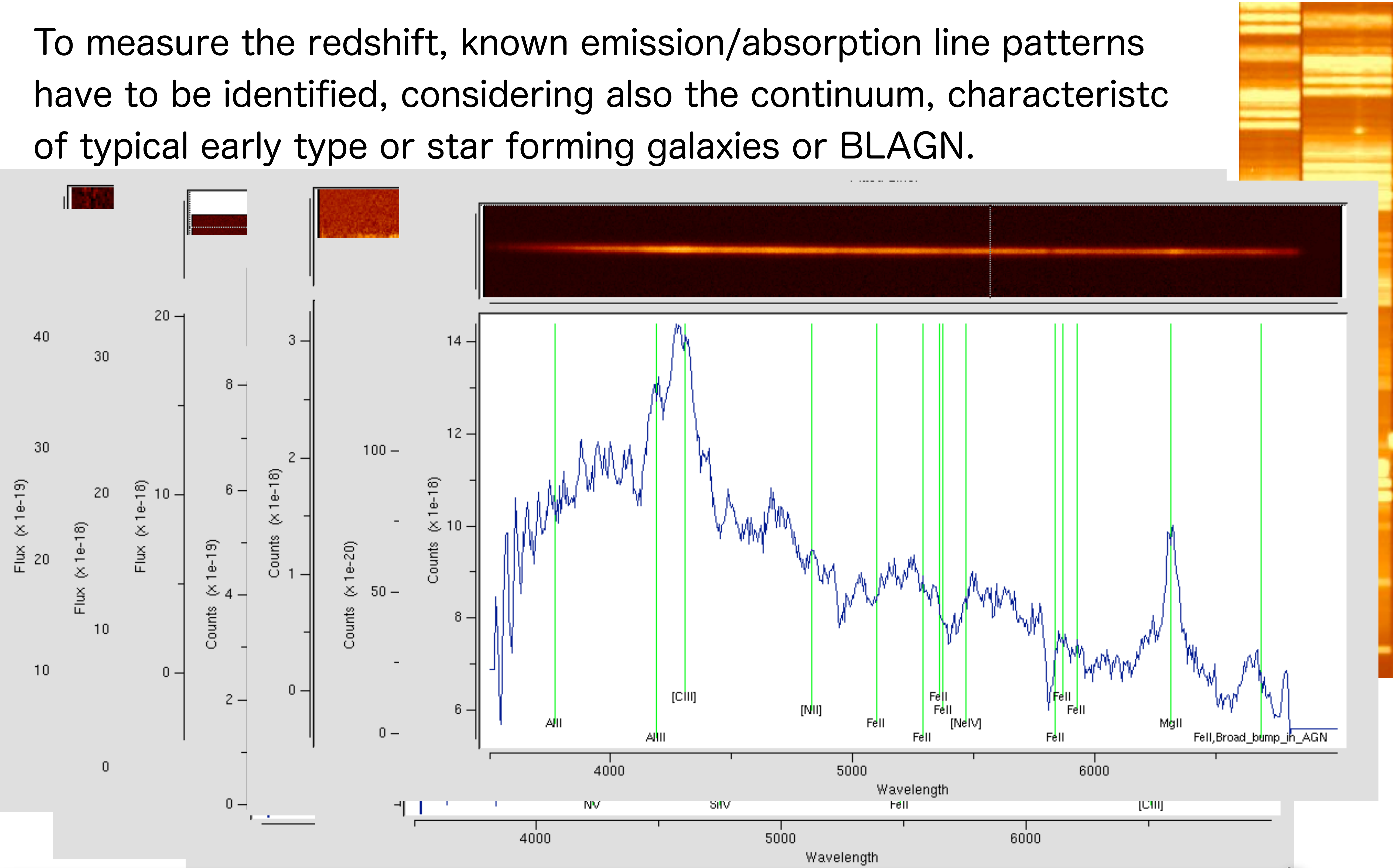

Reduction of VLT spectra - I. General methods

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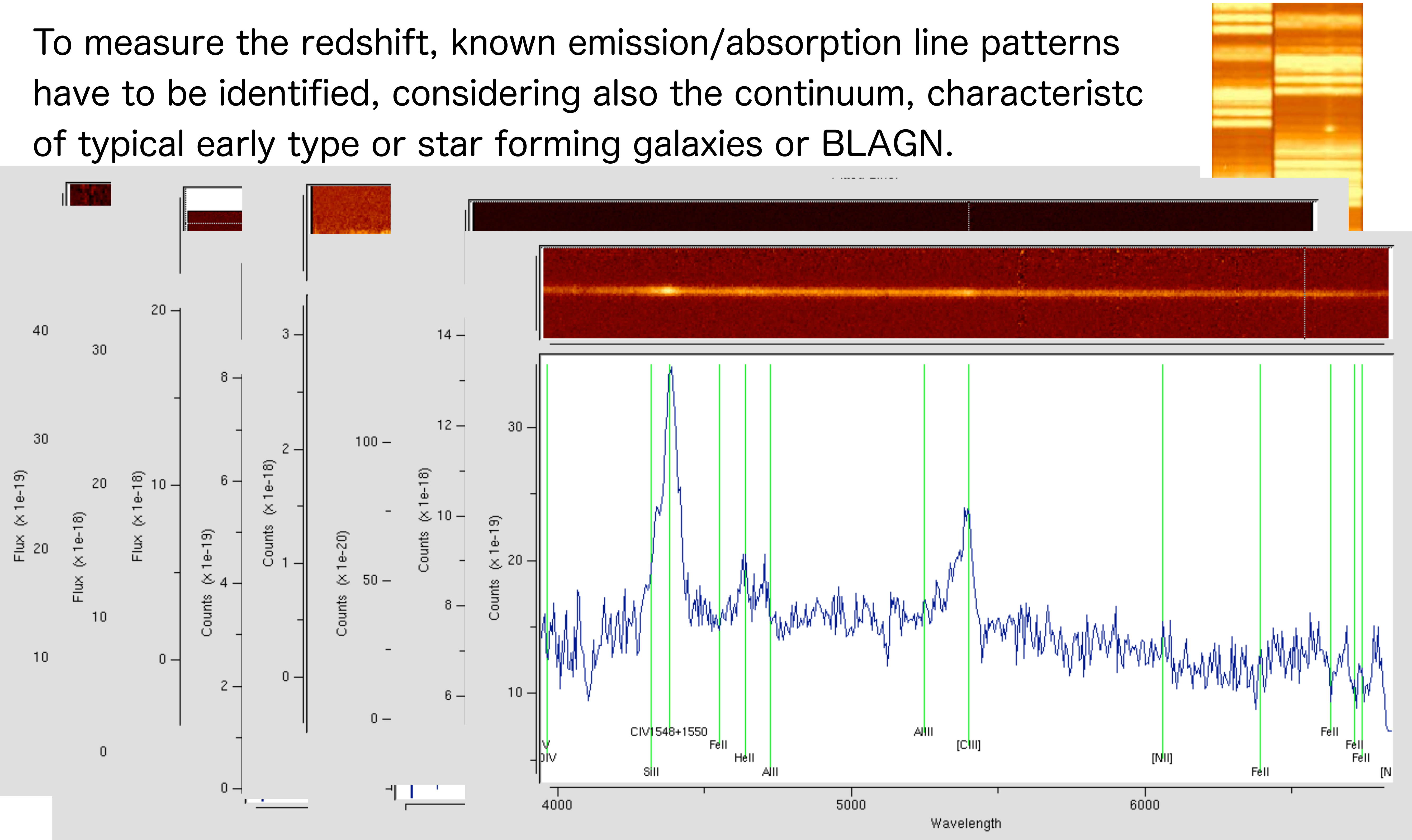
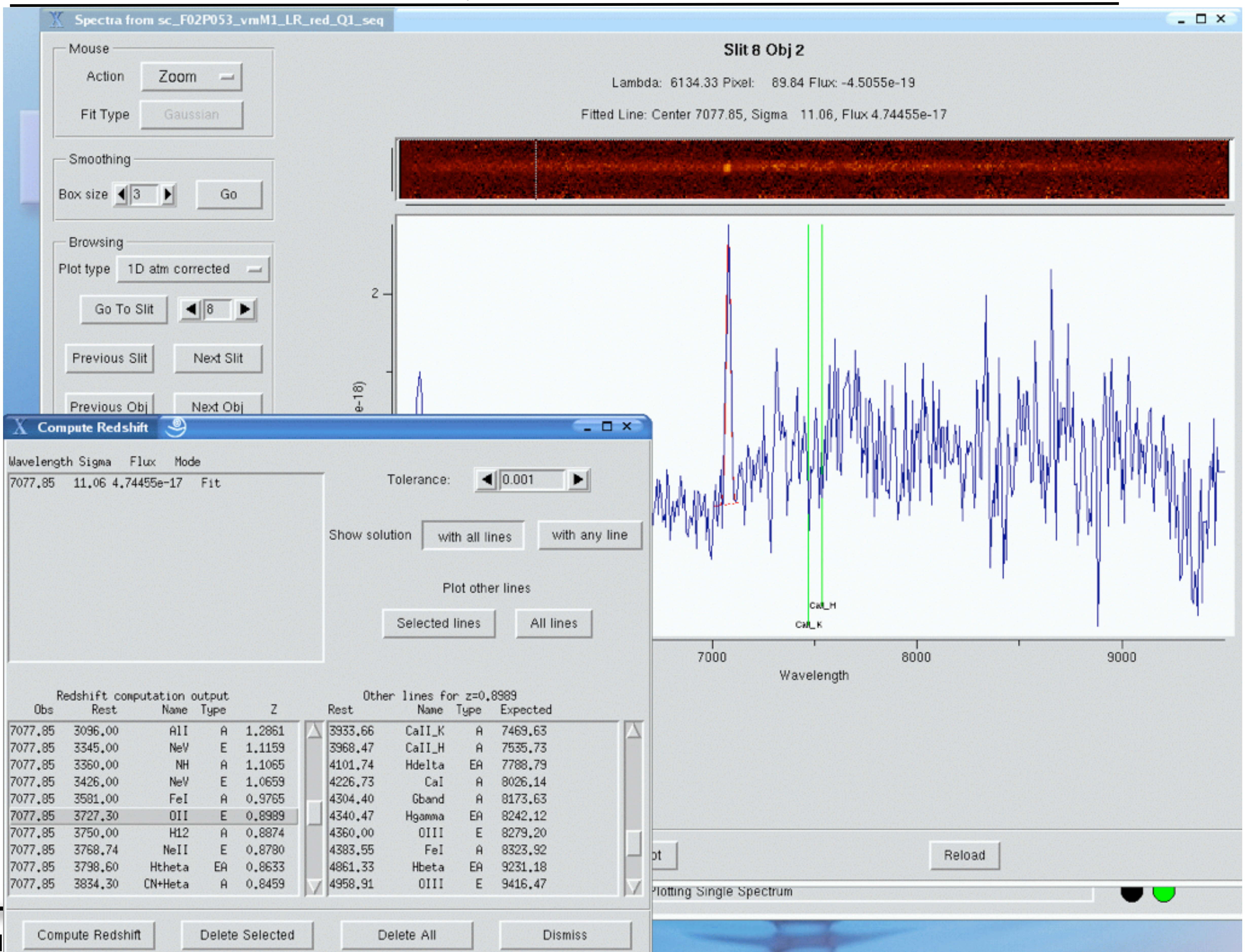


Spectroscopical measures: Redshift

With VIPGI the line identification can be done interactively, looking at the most relevant features considering the spectral regions free from sky emissions.

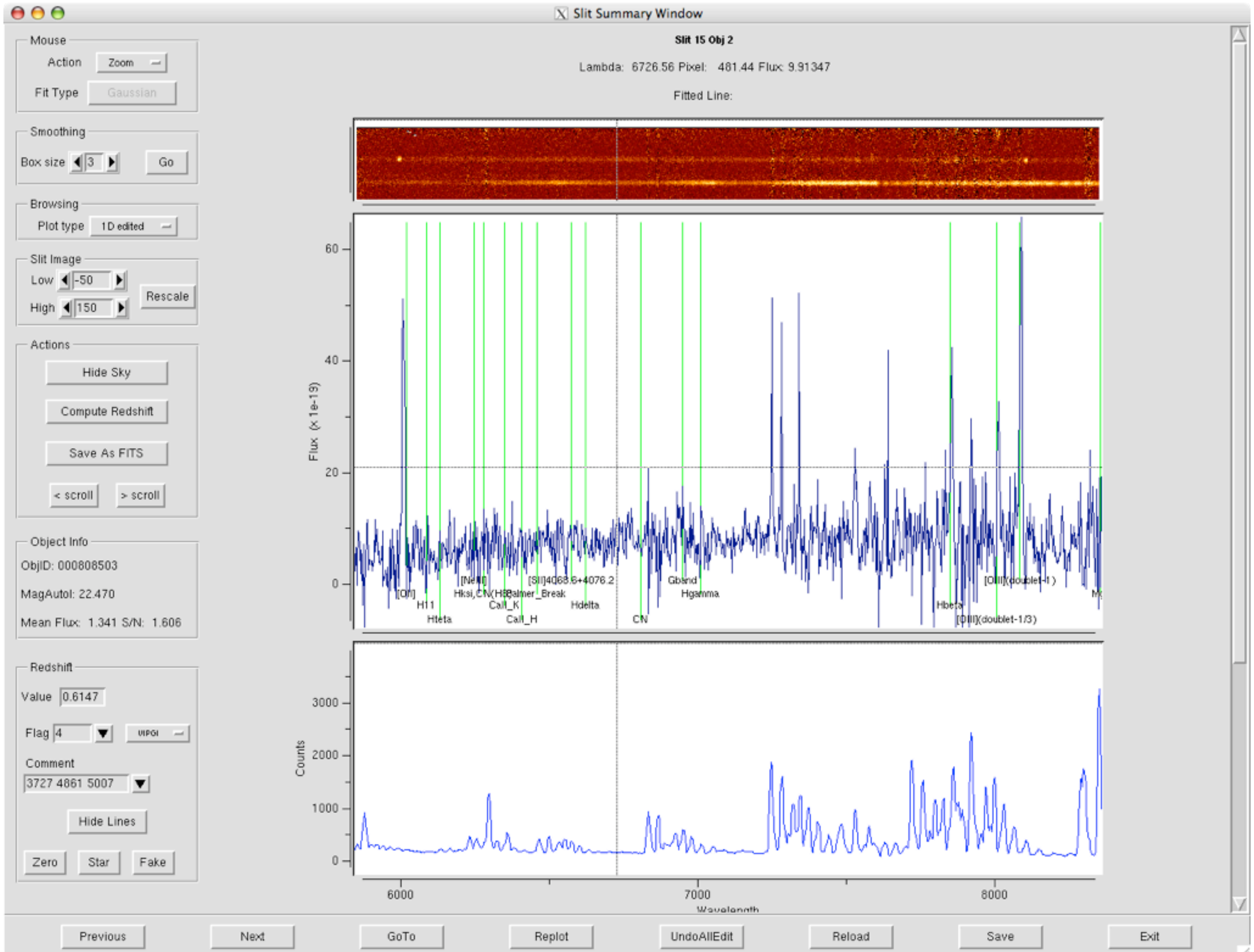
Reduction of VLT spectra - I. General methods



Reduction of VLT spectra - I. General methods

Spectroscopical measures: Redshift

A bad lambda calibration can prevent a good redshift determination:



Bologna, 4th Estrela Workshop
January 20th, 2009

Reduction of VLT spectra - I. General methods

Spectroscopical measures: Redshift

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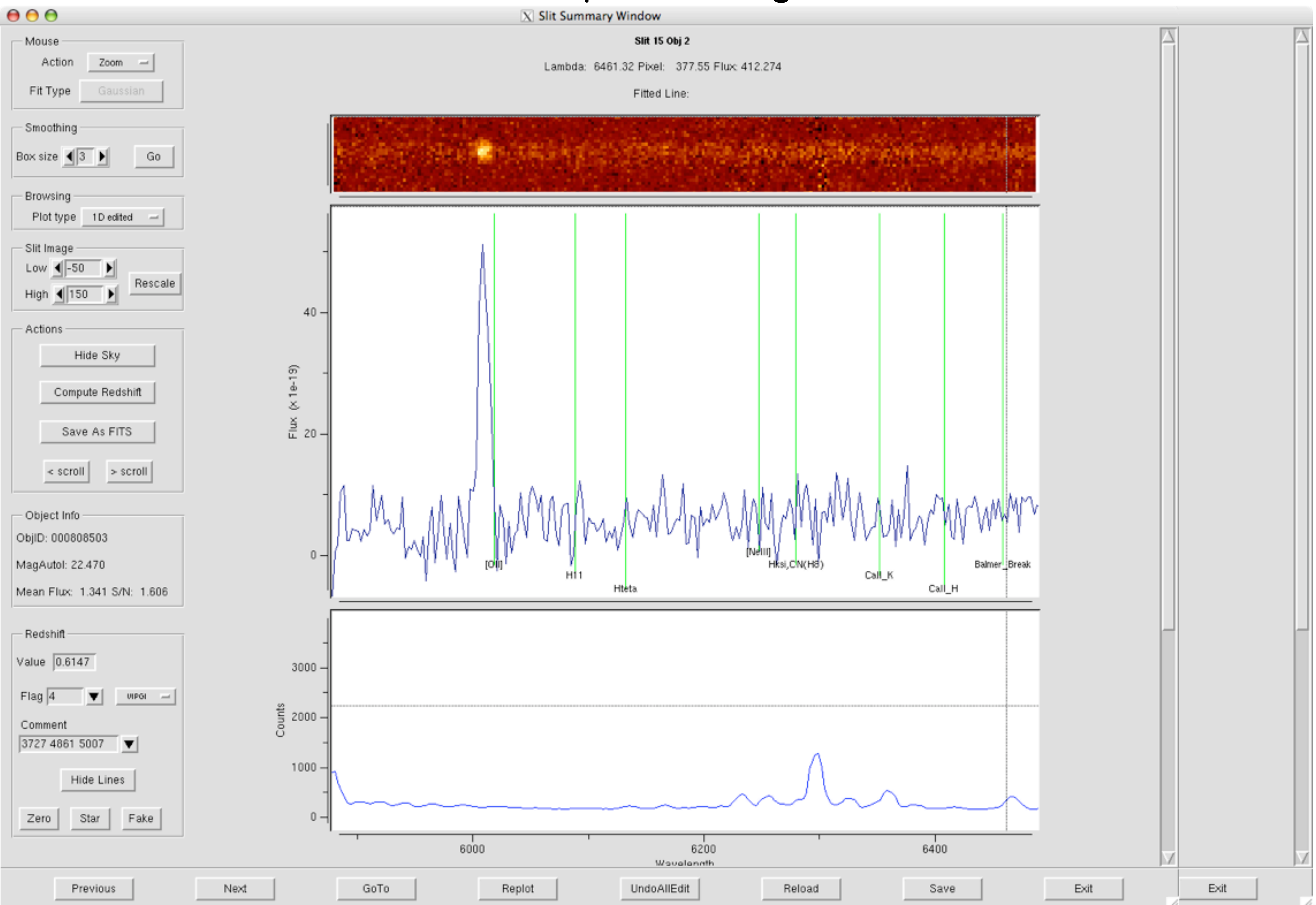

Reduction of VLT spectra - I. General methods

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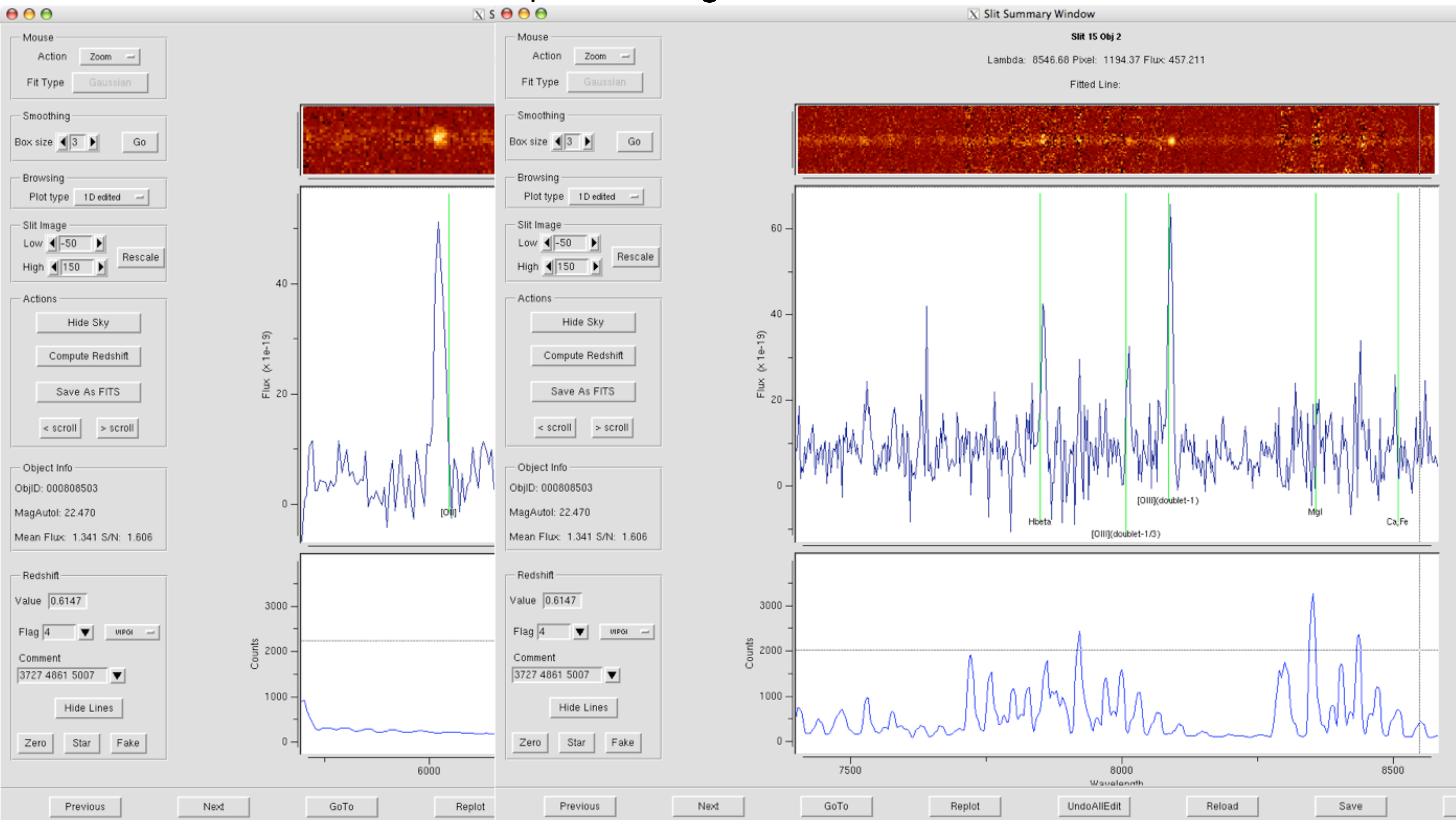
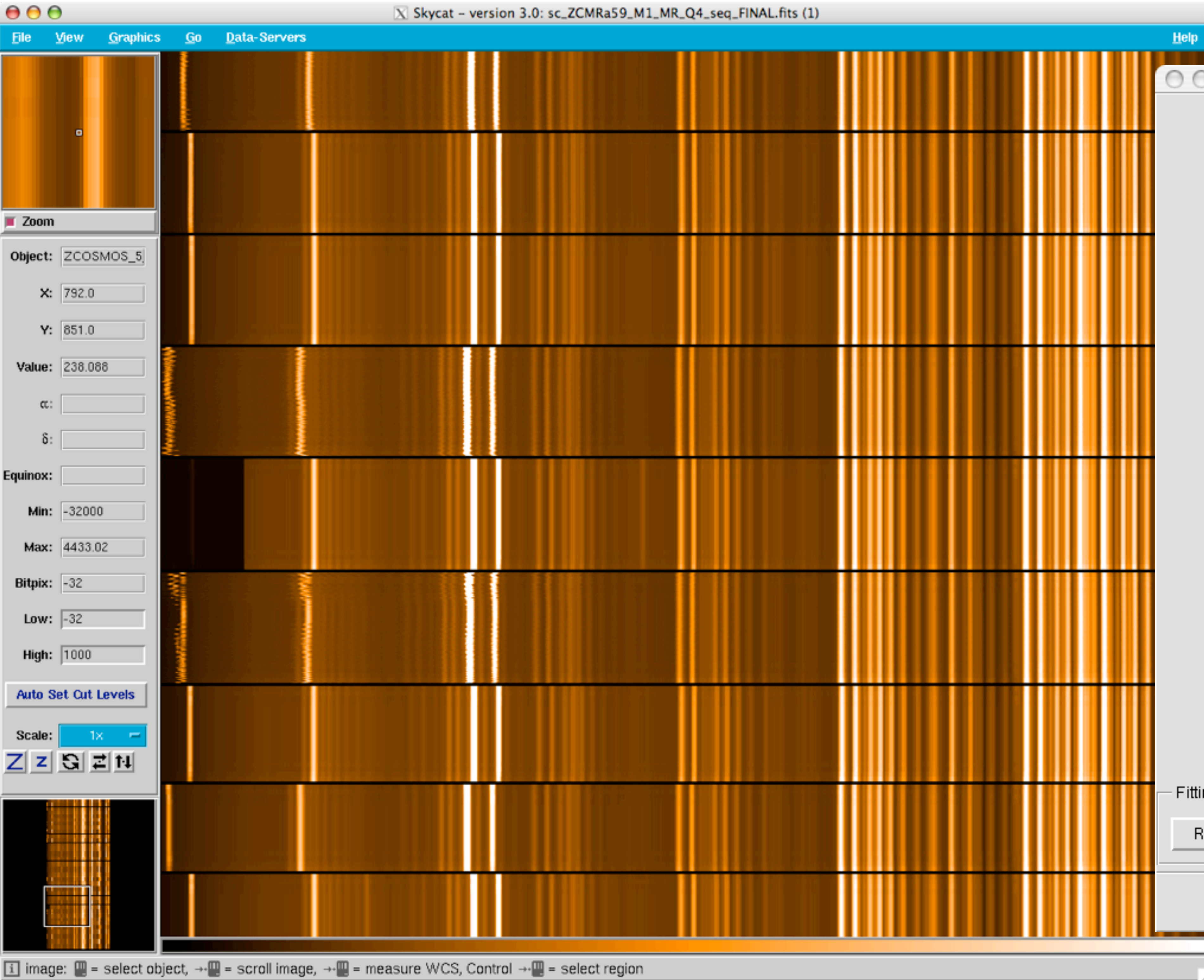
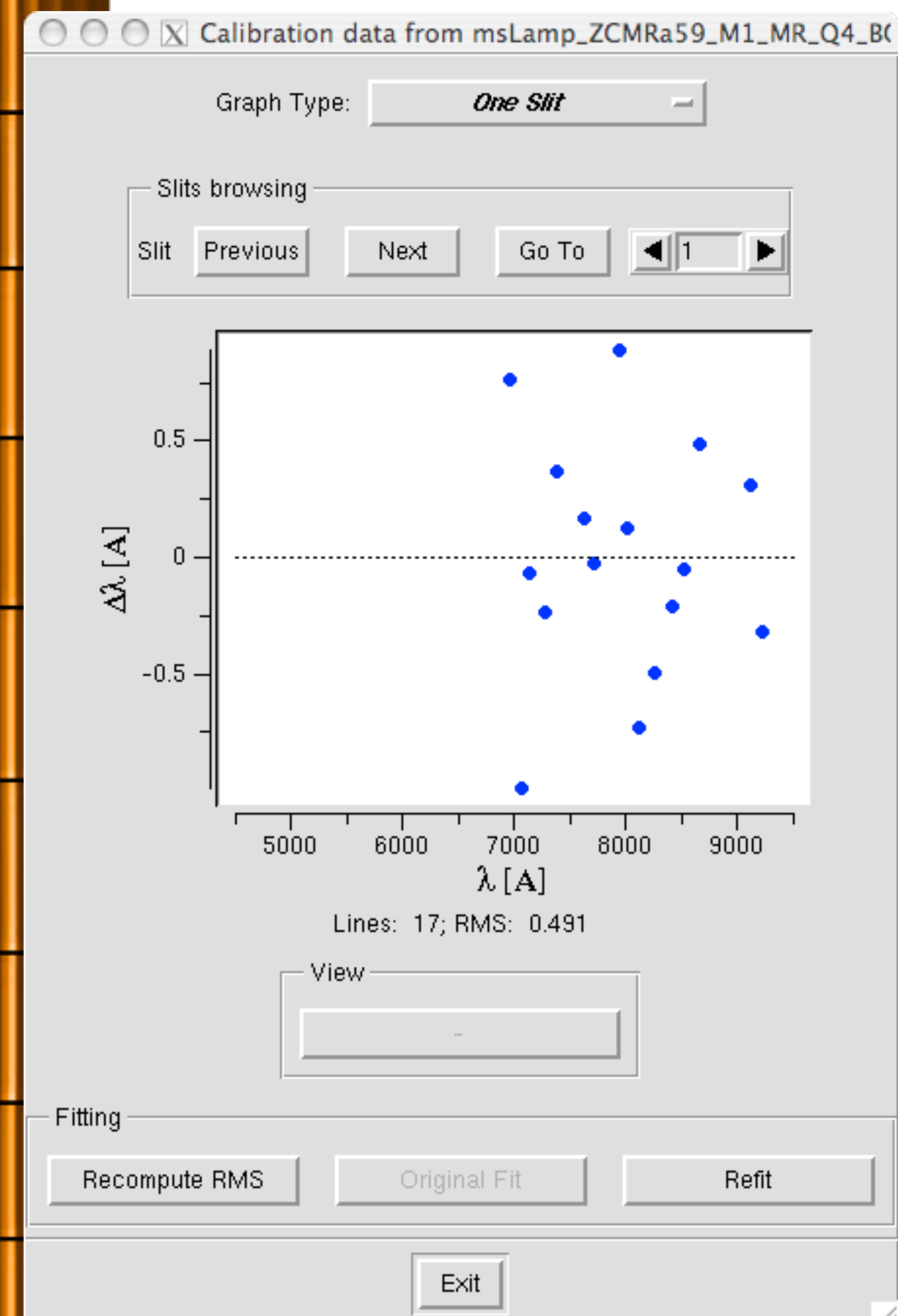


Reduction of VLT spectra - I. General methods

Spectroscopical measures: Redshift

Recognizing a bad lambda calibration:





Reduction of VLT spectra - I. General methods

Spectroscopical measures: Redshift

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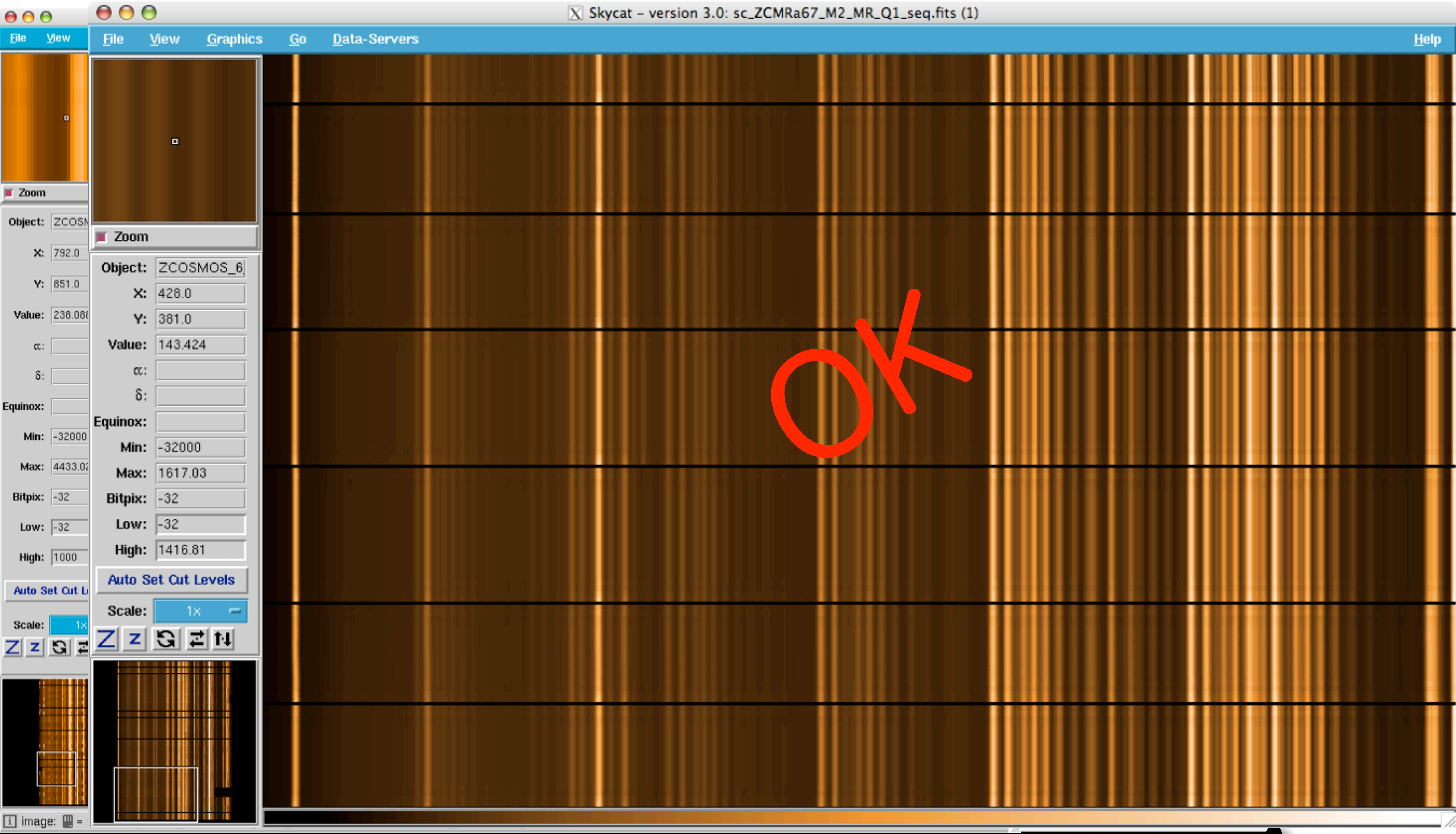


Reduction of VLT spectra - I. General methods

EZ: Redshift measurement tools

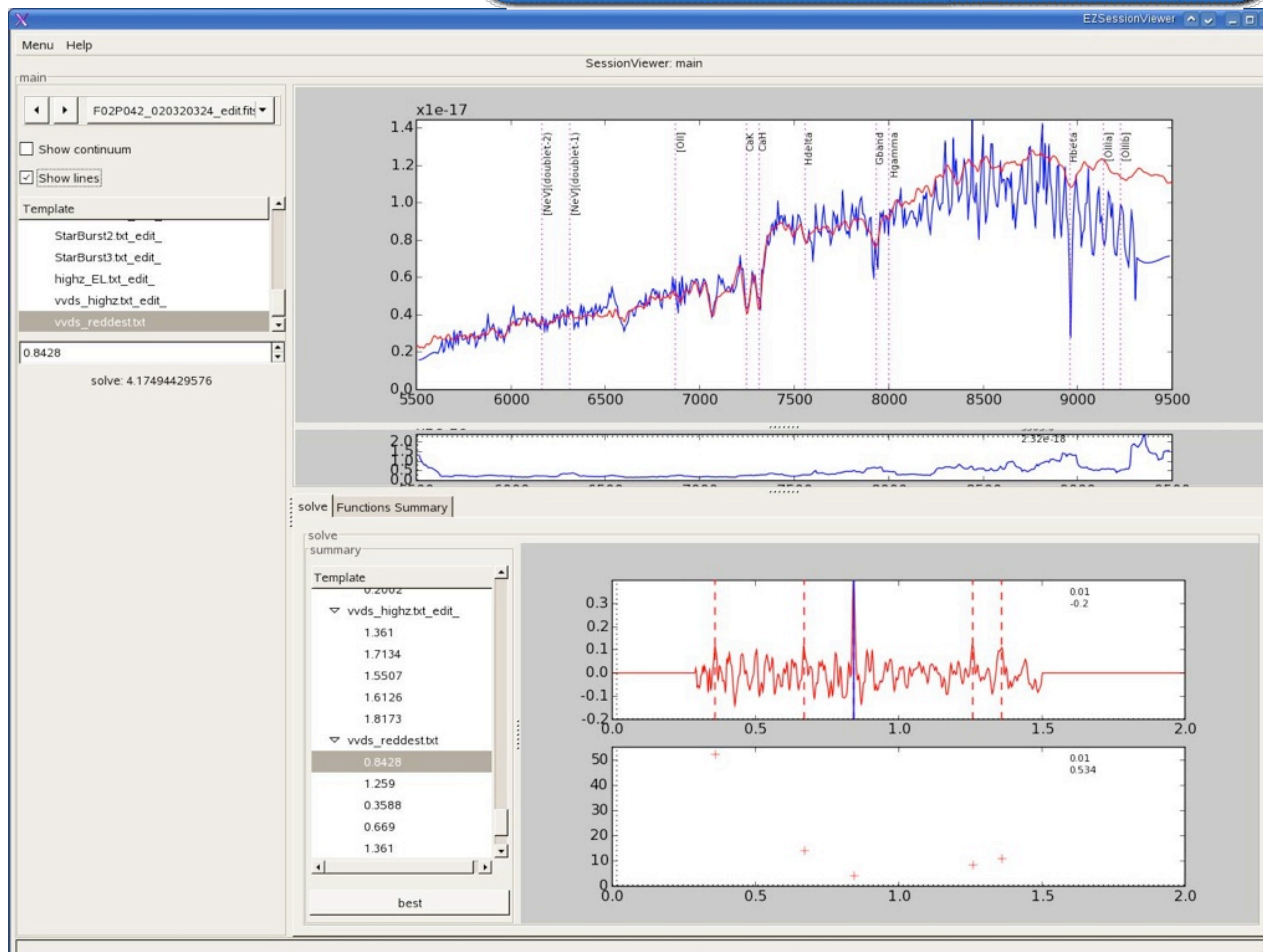
When dealing with thousands spectra, redshift measurement should be automatized as much as possible...

EZ
A software to measure spectroscopic redshifts

People at IASF-Milan (Garilli, Fumana, Franzetti & Scodeggio) developed a new tool: EZ (Easy-Z)

The observed spectrum is compared with a set of spectral templates to find out the best value for the redshift.

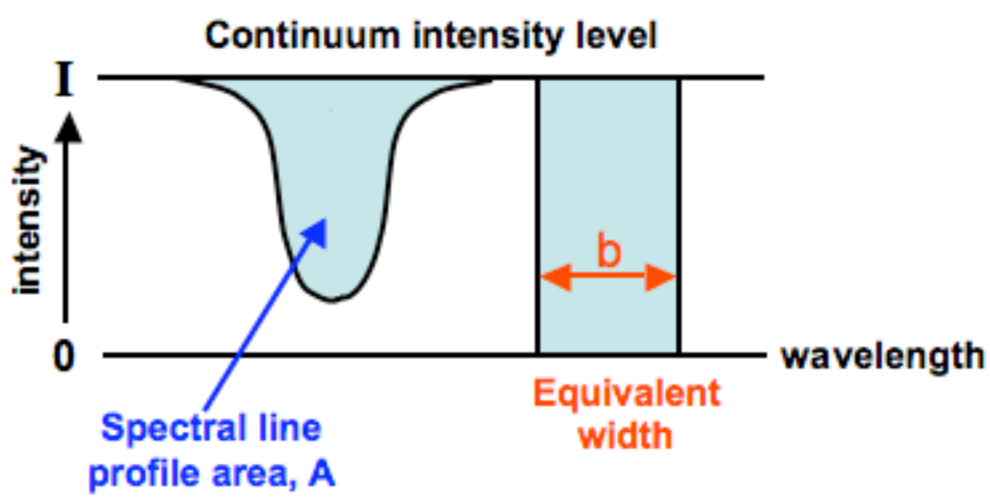
A variety of solutions are presented with their probability. It can be run blindly on the full sequence of spectra of one quadrant and then checked one by one.



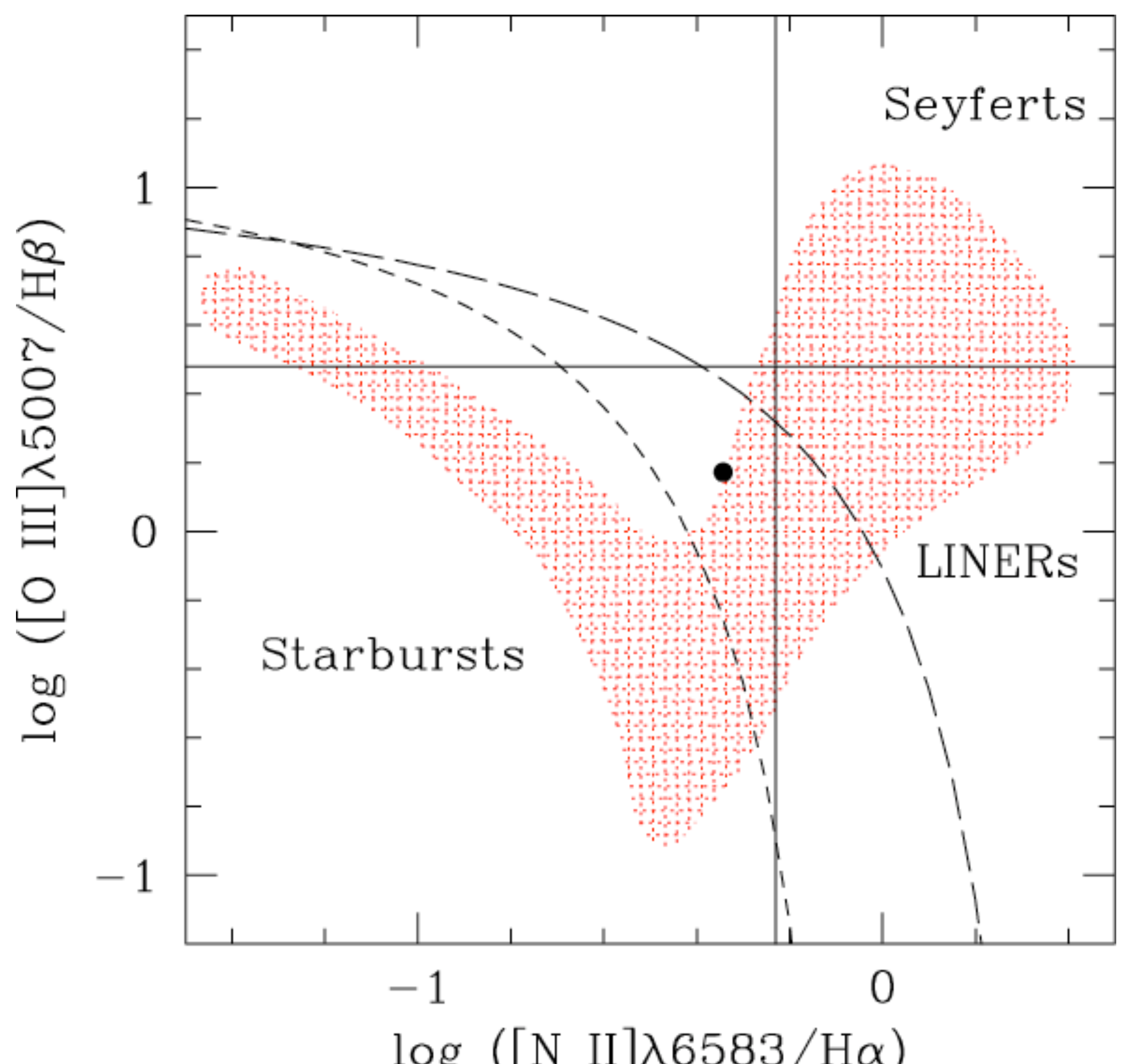
Reduction of VLT spectra - I. General methods

Spectroscopical measures: Flux&Equivalent width

Measures of EW and flux lines can be done manually or automatically.
The line fluxes are indicators of the underlying physics of the object: age, star formation, metallicity, dust content, active nuclei, ...



diagnostic diagrams →



Summary

- VLT instrumentation
- Spectroscopic galaxy surveys (see e.g. Elena Zucca presentation)
- Preparation of observations: mask design with VMMPS
- Multiobject spectroscopy Data Reduction: VIPGI
- Creation of calibration frames and simultaneous reduction of a large number of spectra
- Importance of correct wavelength calibrations
- Spectral measures: redshift, nebular and stellar lines, continuum shape ⇒ physics and classification of galaxies
- In the near future even larger spectroscopic surveys need VIPGI automatized... work in progress

Thanks

Marco Scodeggio, Bianca Garilli, Paolo Franzetti, Alessandra Zanichelli, Marco Fumana, Luigi Paioro for software development

http://cosmos.iasf-milano.inaf.it/pandora/

all the VIRMOS consortium, the VVDS and zCOSMOS team

http://www.oamp.fr/virmos/vvds.htm
http://www.exp-astro.phys.ethz.ch/zCOSMOS/
http://cosmos.astro.caltech.edu/

whose data allowed to produce most of the plots presented here.