

Spectroscopic Pipelines from VLT/VIMOS to the LBT instruments and beyond

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In the beginning there was IRAF...

The IRAF Data Reduction and Analysis System

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ABSTRACT



The Image Reduction and Analysis Facility (IRAF) is a general purpose software system for the reduction and analysis of scientific data. The IRAF system provides a good selection of programs for general image processing and graphics applications, plus a large selection of programs for the reduction and analysis of optical astronomy data. The system also provides a complete modern scientific programming environment, making it straightforward for institutions using IRAF to add their own software to the system. Every effort has been made to make the system as portable and device independent as possible, so that the system may be used on a wide variety of host computers and operating systems with a wide variety of graphics and image display devices.

1. Introduction

The IRAF project began in earnest in the fall of 1981 at Kitt Peak National Observatory (NOAO did not yet exist at that time). The preliminary design of the system was completed early in 1982, and the first versions of the command language (CL) and the applications programming environment were completed during 1982. The NOAO IRAF programming group was formed in 1983. The first internal release of the system occurred at NOAO in 1984, and a beta release of the system to a few outside sites occurred in 1985.

Reducing data with IRAF

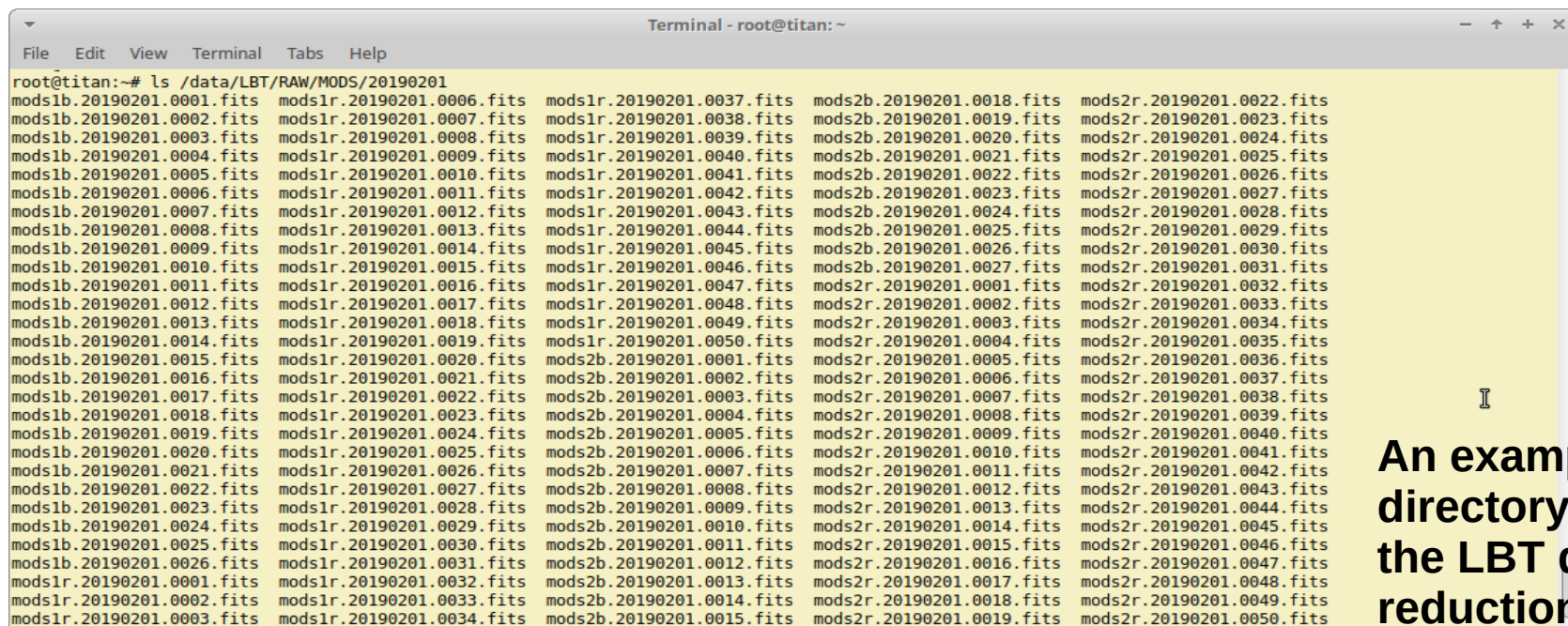
- Wavelength calibration: **identify, reidentify**
- Flux calibration: **standard, sensfunc**
- Spectrum extraction: **apfind, aprecenter, apresize, apedit, aptrace, apsum**
(they can be run in a sequence using apall)

VIPERS:
100,000 spectra
x 10 tasks
x 30 sec =
8500 hours =
1000 working days

multiple IRAF tasks can be executed via a script, and new IRAF tasks can be coded using the IRAF programming language

The problem with data proliferation

Data archiving is generally observatory-oriented, and not really astronomer-oriented....



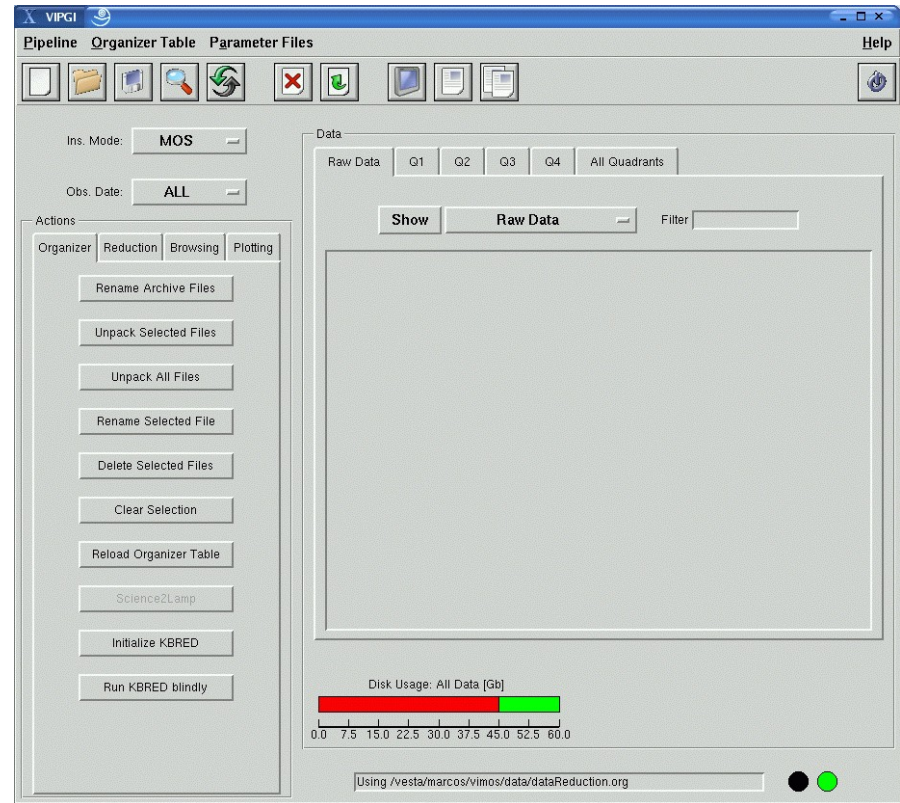
```
Terminal - root@titan: ~
File Edit View Terminal Tabs Help
root@titan:~# ls /data/LBT/RAW/MODS/20190201
modslb.20190201.0001.fits  modslr.20190201.0006.fits  modslr.20190201.0037.fits  mods2b.20190201.0018.fits  mods2r.20190201.0022.fits
modslb.20190201.0002.fits  modslr.20190201.0007.fits  modslr.20190201.0038.fits  mods2b.20190201.0019.fits  mods2r.20190201.0023.fits
modslb.20190201.0003.fits  modslr.20190201.0008.fits  modslr.20190201.0039.fits  mods2b.20190201.0020.fits  mods2r.20190201.0024.fits
modslb.20190201.0004.fits  modslr.20190201.0009.fits  modslr.20190201.0040.fits  mods2b.20190201.0021.fits  mods2r.20190201.0025.fits
modslb.20190201.0005.fits  modslr.20190201.0010.fits  modslr.20190201.0041.fits  mods2b.20190201.0022.fits  mods2r.20190201.0026.fits
modslb.20190201.0006.fits  modslr.20190201.0011.fits  modslr.20190201.0042.fits  mods2b.20190201.0023.fits  mods2r.20190201.0027.fits
modslb.20190201.0007.fits  modslr.20190201.0012.fits  modslr.20190201.0043.fits  mods2b.20190201.0024.fits  mods2r.20190201.0028.fits
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modslb.20190201.0011.fits  modslr.20190201.0016.fits  modslr.20190201.0047.fits  mods2b.20190201.0001.fits  mods2r.20190201.0032.fits
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modslb.20190201.0025.fits  modslr.20190201.0030.fits  mods2b.20190201.0011.fits  mods2r.20190201.0015.fits  mods2r.20190201.0046.fits
modslb.20190201.0026.fits  modslr.20190201.0031.fits  mods2b.20190201.0012.fits  mods2r.20190201.0016.fits  mods2r.20190201.0047.fits
modslr.20190201.0032.fits  mods2b.20190201.0013.fits  mods2r.20190201.0017.fits  mods2b.20190201.0001.fits  mods2r.20190201.0048.fits
modslr.20190201.0002.fits  modslr.20190201.0033.fits  mods2b.20190201.0014.fits  mods2r.20190201.0018.fits  mods2r.20190201.0049.fits
modslr.20190201.0003.fits  modslr.20190201.0034.fits  mods2b.20190201.0015.fits  mods2r.20190201.0019.fits  mods2r.20190201.0050.fits
```

An example directory from the LBT data reduction center

A tool for a project: **VIPGI**

the VIMOS Interactive Pipeline and Graphical Interface

- * Data Organizer
 - * Smart Data Browser
 - * Interface to Pipeline Tasks
 - * Data Visualization
 - * Direct Interface to Redshift Measurement Tool
-
- * Data Reduction Recipes:
150K lines of C code
 - * GUI and plotting/browsing:
16K lines of Python code

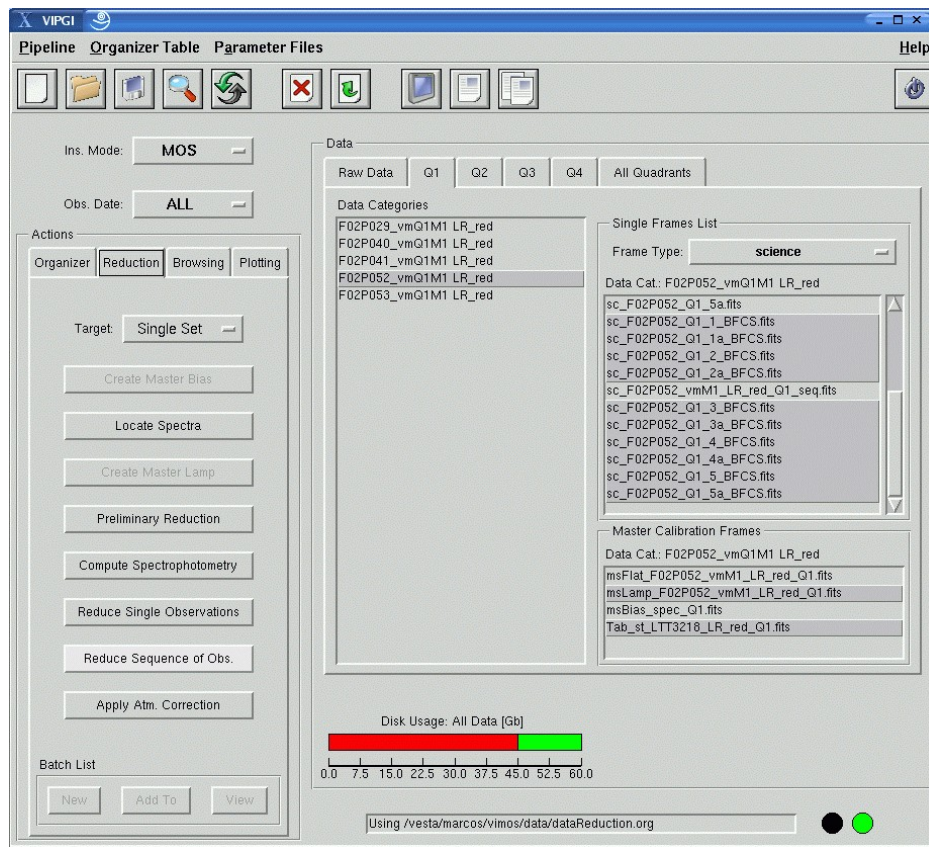


Data reduction with just a few clicks

Smart Browsing;
Data organized by Pointing,
Mask, and Data Type

Data Reduction: a few tasks
available, depending on the
selected data type

VIPERS:
288 masks
x 4 quadrants
x 6 tasks
x 20 min =
2400 hours =
300 working days

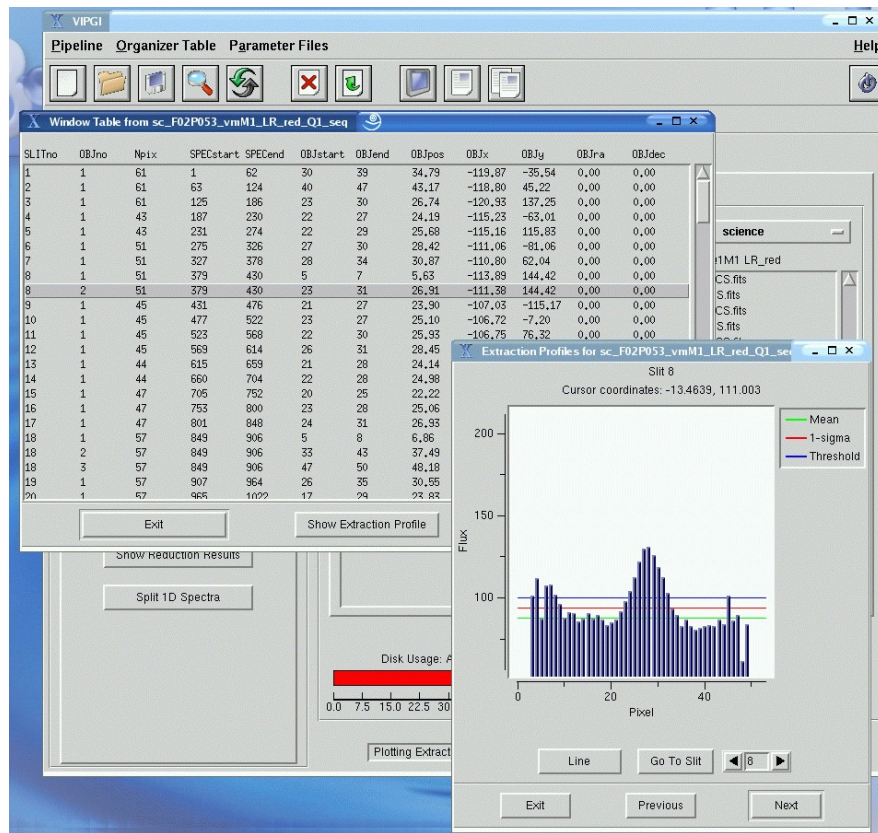


Integrated data browsing / plotting tools

Browsing and plotting tasks designed to take advantage of the data structures

Single multi-extension FITS file storing all the information needed by the pipeline tasks

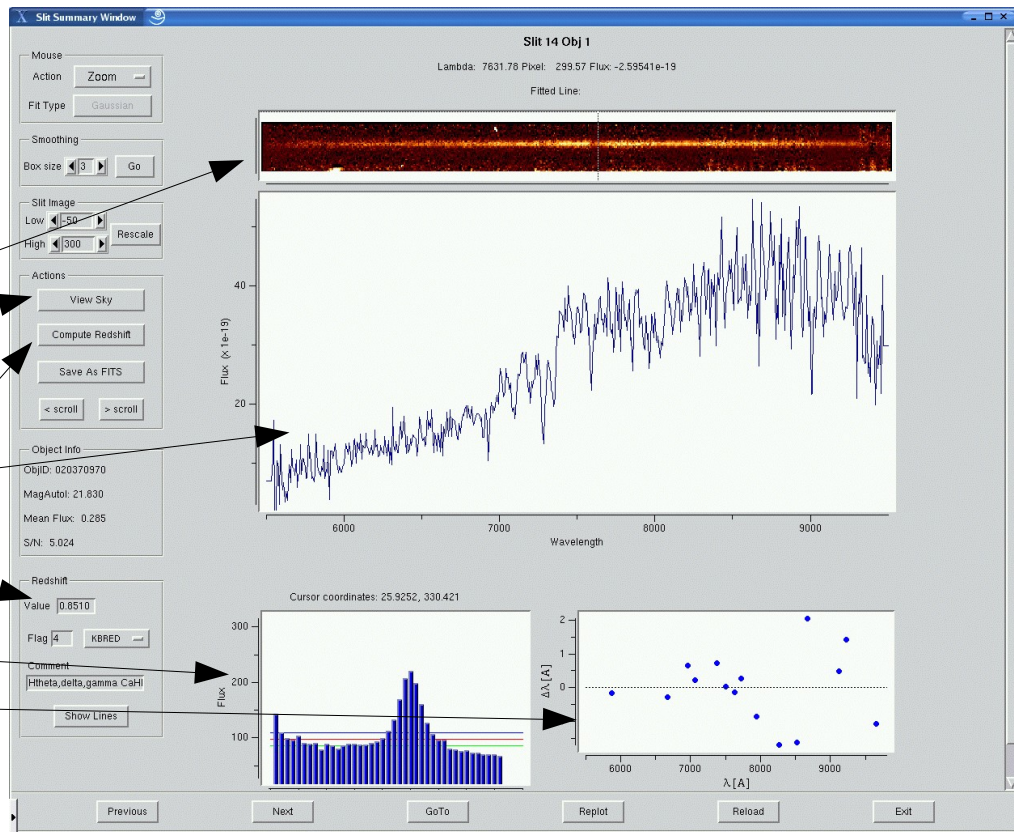
Example: slit browser and spectrum extraction info plot



Integrated data browsing / plotting tools

Within the FITS file
and for each slit:

- * 2D Extracted Spec
- * 2D Sky
- * 1D Extracted Spec
- * 1D Flux Calib Spec
- * Redshift measurement
- * Location info
- * Aperture info
- * Lambda Cal Info



From **VIPGI** to today's tools

- Two separate paths towards today's spectroscopic data reduction
- The Spectroscopic Survey tool **Easylife**
- The LBT / general purpose **new VIPGI**

EasyLife for Spectroscopic Surveys

EasyLife's concept is relatively simple

- Store all survey info in a Database
- Join together with a script the various pipeline tasks
- Add quality control steps in between the main tasks

(See Paolo Franzetti's presentation for details)

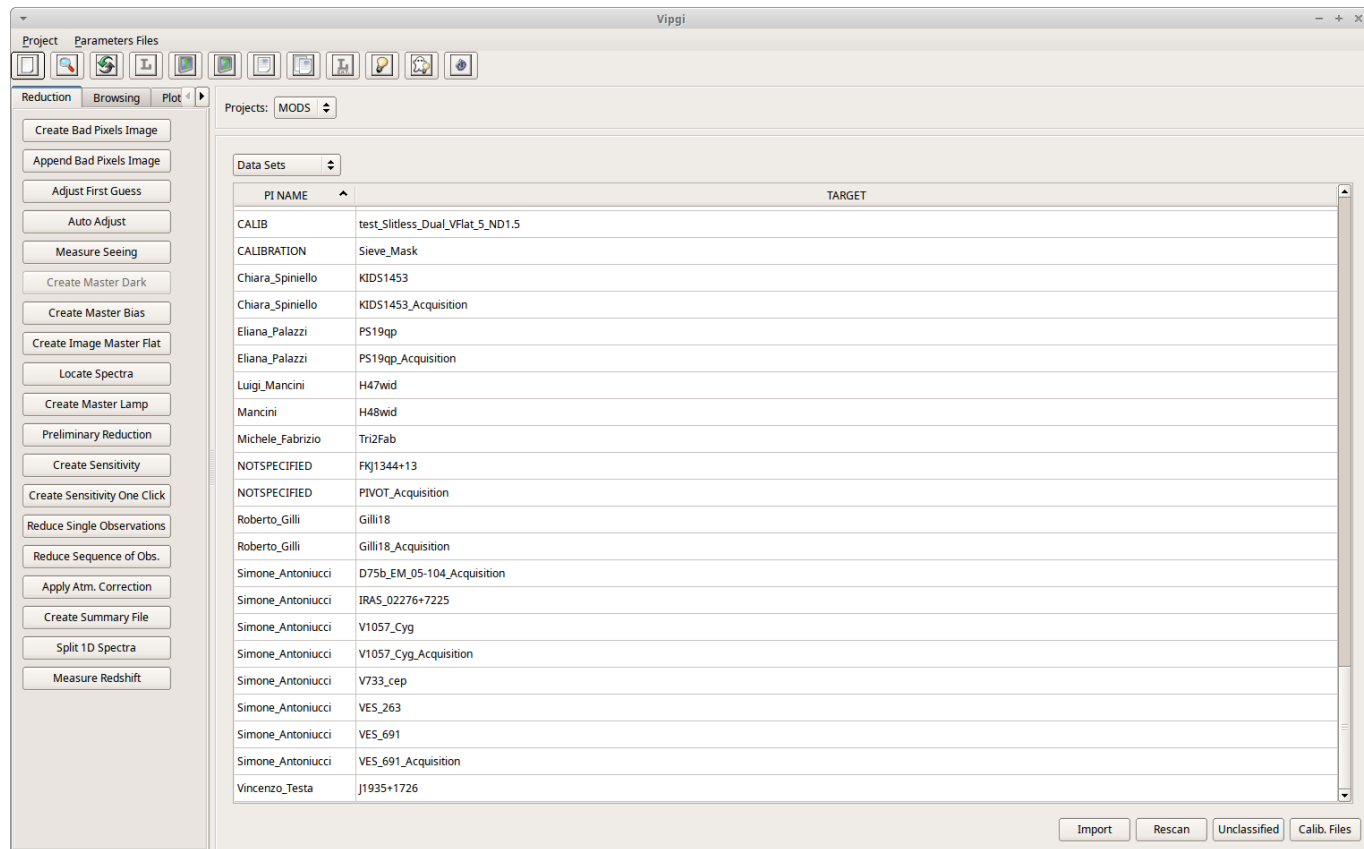
**Result: 2 people managed with ease the whole
VIPERS data reduction !!**

The new VIPGI

Like in the original
VIPGI:

- * Data Organizer
- * Smart Data Browser
- * Interface to Pipeline Tasks
- * Data Visualization

More Python and
less C code



The screenshot shows the VIPGI software interface. The main window is titled 'Vipgi' and has a menu bar with 'Project' and 'Parameters Files'. Below the menu bar is a toolbar with various icons. The interface is divided into several sections:

- Reduction**: A vertical sidebar on the left containing buttons for tasks such as 'Create Bad Pixels Image', 'Append Bad Pixels Image', 'Adjust First Guess', 'Auto Adjust', 'Measure Seeing', 'Create Master Dark', 'Create Master Bias', 'Create Image Master Flat', 'Locate Spectra', 'Create Master Lamp', 'Preliminary Reduction', 'Create Sensitivity', 'Create Sensitivity One Click', 'Reduce Single Observations', 'Reduce Sequence of Obs.', 'Apply Atm. Correction', 'Create Summary File', 'Split 1D Spectra', and 'Measure Redshift'.
- Projects**: A dropdown menu showing 'MODS'.
- Data Sets**: A table with two columns: 'PI NAME' and 'TARGET'. The table contains the following data:

PI NAME	TARGET
CALIB	test_Slitless_Dual_VFlat_5_ND1.5
CALIBRATION	Sieve_Mask
Chiara_Spiniello	KIDS1453
Chiara_Spiniello	KIDS1453_Acquisition
Eliana_Palazzi	PS19qp
Eliana_Palazzi	PS19qp_Acquisition
Luigi_Mancini	H47wid
Mancini	H48wid
Michele_Fabrizio	TrizFab
NOTSPECIFIED	Fk1344+13
NOTSPECIFIED	PIVOT_Acquisition
Roberto_Gilli	Gilli18
Roberto_Gilli	Gilli18_Acquisition
Simone_Antoniucci	D75b_EM_05-104_Acquisition
Simone_Antoniucci	IRAS_02276+7225
Simone_Antoniucci	V1057_Cyg
Simone_Antoniucci	V1057_Cyg_Acquisition
Simone_Antoniucci	V733_cep
Simone_Antoniucci	YES_263
Simone_Antoniucci	YES_691
Simone_Antoniucci	YES_691_Acquisition
Vincenzo_Testa	J1935+1726

At the bottom right of the window, there are buttons for 'Import', 'Rescan', 'Unclassified', and 'Calib. Files'.

The new VIPGI

The power of having data organized into smart categories (at the price of needing a special data import facility)

Only homogeneous sets of data are visualized and can be selected to run pipeline tasks

The screenshot shows the VIPGI software interface. The main window displays a list of observations with columns for FILENAME, FILETYPE, FILTER NAME, DICHNAME, QUADRANT, EXPTIME, and DATE OBS. Below this, there is a table with columns for FILETYPE, INS MODE, GRISM, CHANNEL, QUADRANT, and VALID FROM. The interface includes a sidebar with various reduction and browsing tools, and a bottom panel with buttons for Back, Import, Rescan, Unclassified, and Calib. Files.

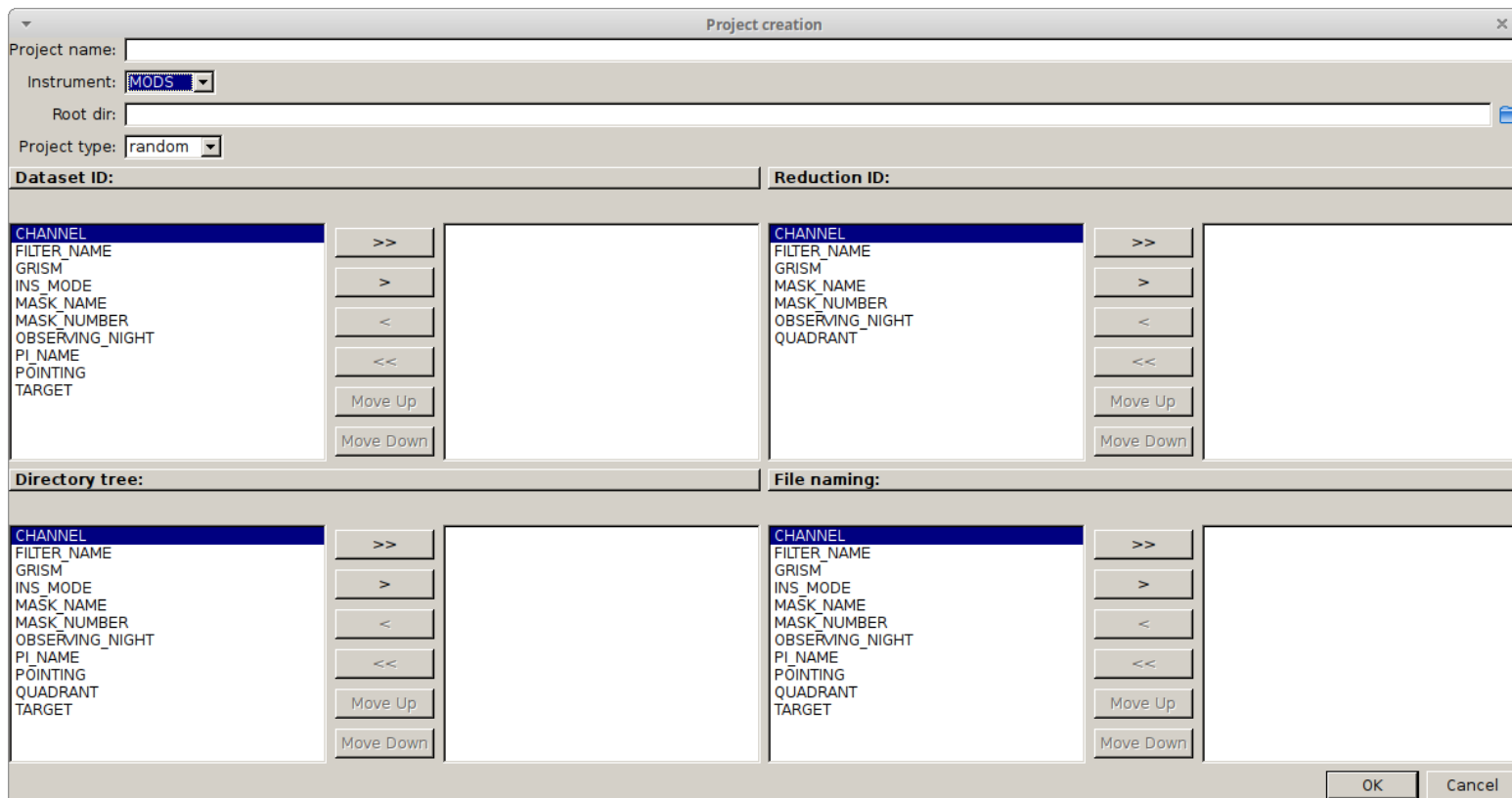
FILENAME	FILETYPE	FILTER NAME	DICHNAME	QUADRANT	EXPTIME	DATE OBS
sc_Gilli18_Non...	SCIENCE	Clear	Dual	MODS1B	1200.0	05/11/2018 03:38:03
sc_Gilli18_Non...	SCIENCE	Clear	Dual	MODS1B	1200.0	03/01/2019 07:16:24
sc_Gilli18_Non...	SCIENCE	Clear	Dual	MODS1B	1200.0	03/01/2019 07:16:24
sc_Gilli18_Non...	SCIENCE	Clear	Dual	MODS1B	1200.0	03/01/2019 07:38:15
sc_Gilli18_Non...	SCIENCE	Clear	Dual	MODS1B	1200.0	03/01/2019 07:38:15
sc_Gilli18_Non...	SCIENCE	Clear	Dual	MODS1B	1200.0	03/01/2019 08:00:33
sc_Gilli18_Non...	SCIENCE	Clear	Dual	MODS1B	1200.0	03/01/2019 08:00:33
sc_Gilli18_Non...	SCIENCE	Clear	Dual	MODS1B	1200.0	03/01/2019 08:22:24
sc_Gilli18_Non...	SCIENCE	Clear	Dual	MODS1B	1200.0	03/01/2019 08:22:24
sc_Gilli18_Non...	SCIENCE	Clear	Dual	MODS1B	1200.0	03/01/2019 08:44:32
sc_Gilli18_Non...	SCIENCE	Clear	Dual	MODS1B	1200.0	03/01/2019 08:44:32

FILETYPE	INS MODE	GRISM	CHANNEL	QUADRANT	VALID FROM	VALID UPTO
<input type="checkbox"/>	ImMsFlat_Mar...	FLAT	G400L_Dual	BLUE	MODS2B	01/01/1900 01/01/2500
<input type="checkbox"/>	ImMsFlat_Mar...	FLAT	G400L_Dual	BLUE	MODS1B	01/01/1900 01/01/2500

The new VIPGI

The data organizer can be fully customized by the user according to his/her preferred scheme.

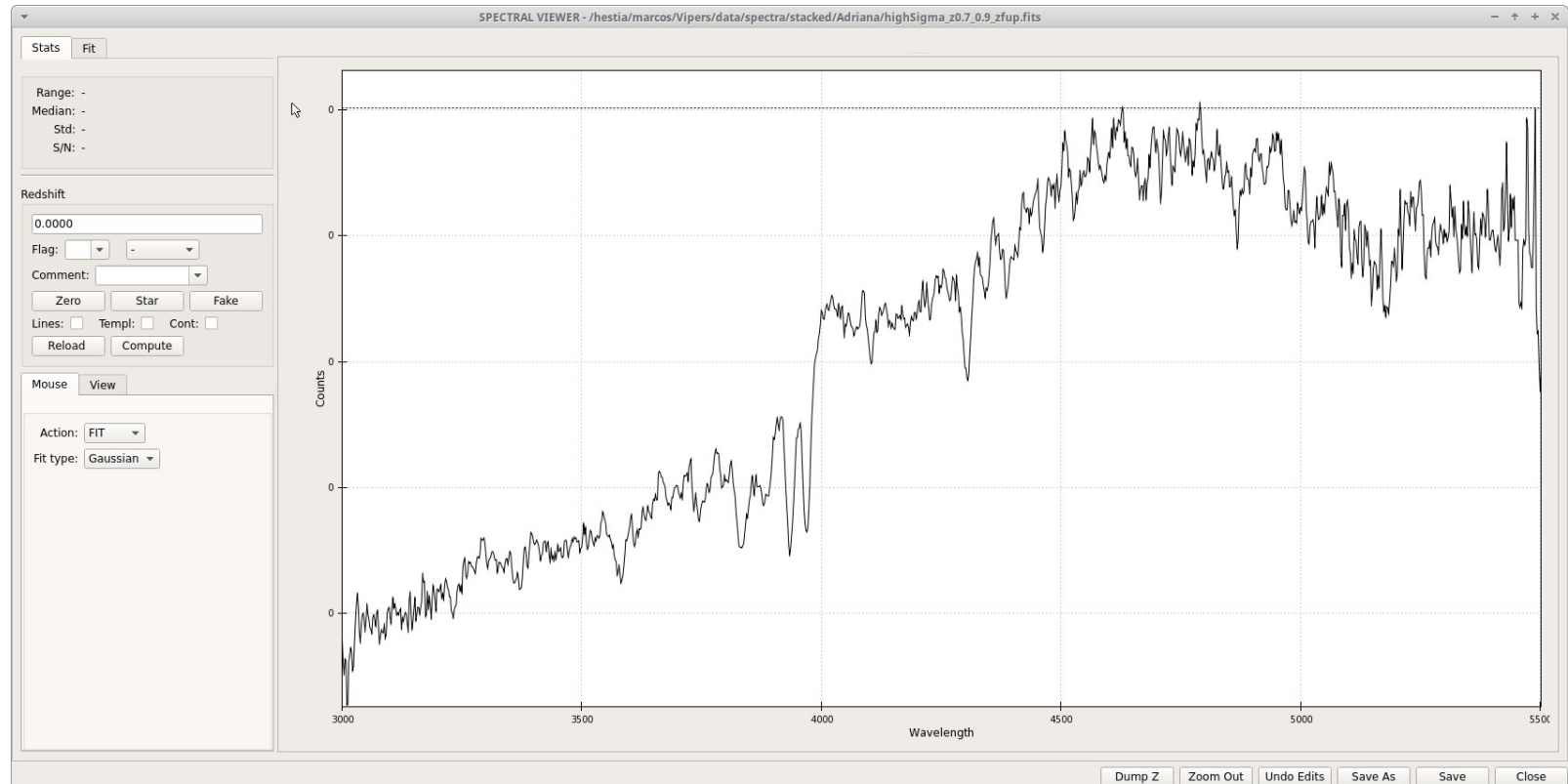
This involves both the location of files on disk and the visualization through VIPGI



Spectra visualization and redshift measurements: **pandora.ez**

Visualization tool, but also redshift and spectral lines measurement tool

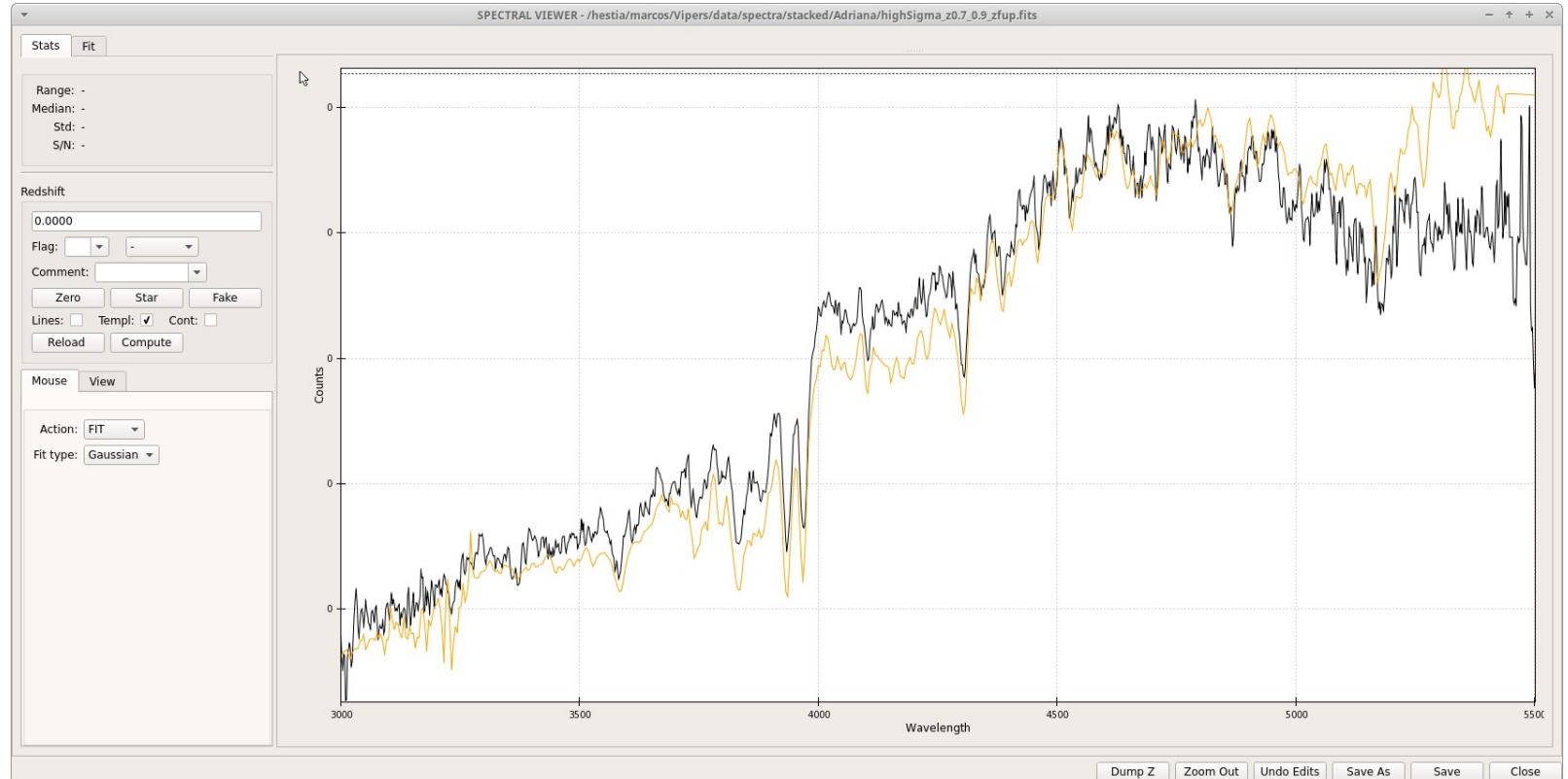
Can be used standalone, or integrated within VIPGI



Spectra visualization and redshift measurements: **pandora.ez**

In black:
observed
spectrum

In yellow;
best fitting
template

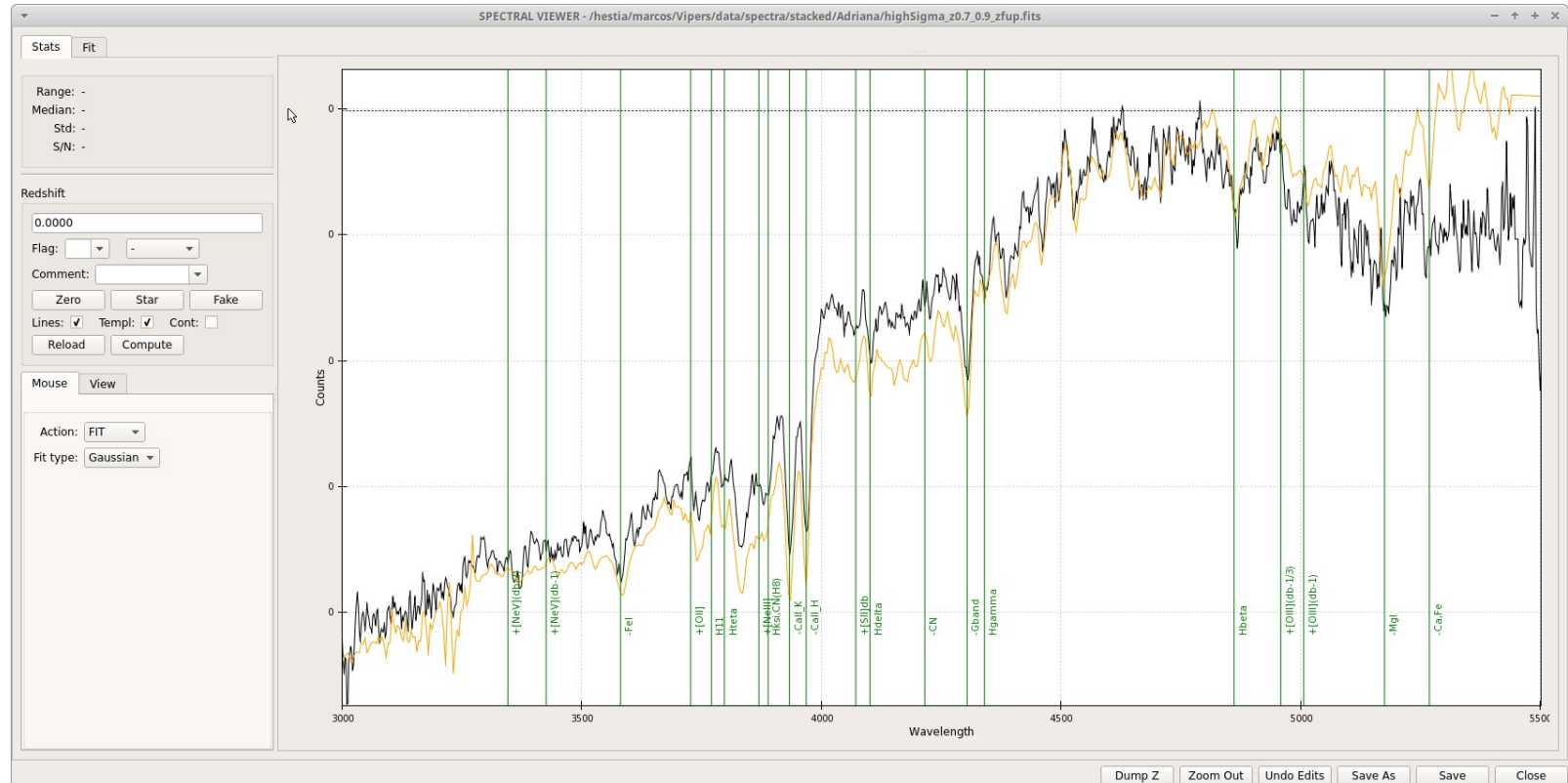


Spectra visualization and redshift measurements: **pandora.ez**

In black:
observed
spectrum

In yellow;
best fitting
template

In green:
most common
spectral lines



Final Remarks

- Some twenty years of experience with Spectroscopic Pipelines at IASF-Milano
- Managed all big ESO redshift surveys, like VVDS, zCOSMOS, CLASH-VLT, VIPERS, VANDELS
- Managed almost 10 years of LBT data reduction center
- Tools basically ready to be distributed via the INAF SpecLab: new VIPGI, pipelines, spectra plotting, redshift measurements