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<b>Authors</b>	FUMANA, Marco; FRANZETTI, PAOLO; GARILLI, BIANCA MARIA ROSA; Scala, Paolo Luigi; SCODEGGIO, MARCO
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## **PNGS: an API Ecosystem for Astronomical Applications Development**

Marco Fumana,<sup>1</sup> Paolo Franzetti,<sup>1</sup> Bianca Garilli,<sup>1</sup> Paolo Luigi Scala,<sup>1</sup> and  
Marco Scodreggio<sup>1</sup>

<sup>1</sup>*INAF, IASF-MI, Milano, Italy; fumana@lambrate.inaf.it*

**Abstract.** PNGS (Pandora Next Generation Software) is a collection of object oriented Application Programming Interfaces (APIs) implementing a broad set of functionalities and routines aimed at the manipulation of spectroscopic astronomical data. In particular a subset of GUI-oriented APIs are available. Based on the FASE (see Grosböl et al. (2012)) framework, PNGS offers a fully customizable software ecosystem which allows to develop applications spanning the whole spectroscopic data life cycle, from data classification to its organization on disk, analysis, reduction, visualization and archiving.

### **1. Introduction**

PNGS: Pandora<sup>1</sup> Next Generation Software is a set of modules, which includes GUI-oriented API, used to create software for data reduction and spectral analysis.

The idea of the PNGS APIs collection as an ecosystem has led us to conceive and design them as a modular and independent set of objects, taking into consideration SoC (Separation of Concerns) and encapsulation principles (thus ensuring a consistent naming convention together with comprehensive and coherent interfaces to data). At the same time, the way PNGS is designed makes it simple to expand this ecosystem in terms of new functionalities and data containers.

PNGS APIs have been used to implement the recent, improved versions of VIPGI (Scodreggio et al. (2005)) and EZ (Garilli et al. (2010)) tools: the former is a graphical application for data reduction and organization, while the latter is an integrated environment for spectra analysis and visualization.

### **2. Ecosystem overall design**

PNGS ecosystem relies on the Python/C implementation of the FASE framework (Grosböl et al. (2012)), mainly developed at INAF-IASF Milan: FASE-MIMA implementation (see Paioro et al. (2009)).

FASE components can be either single operational component (task) or interactive component (tools). According with the FASE design documents, each module contains either tasks or tools. The modules are described by an XML file; this file defines operations exposed by tools and the input/output parameters of tasks.

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<sup>1</sup>Pandora is an acronym for Programs for Astronomical Data Organization Reduction and Analysis

In this way interaction between PNGS components is guaranteed by FASE itself. Moreover PNGS benefits from all FASE facilities like: logging system, FITS I/O module (C/Python library, based on CLP<sup>2</sup>) and DRM (Distributed resource manager) management capabilities.

PNGS modules are written either in pure Python or mixing together Python and C code to boost the performances. Interaction between C and Python is carried out by Python wrappers around C code, generated using SWIG<sup>3</sup>.

### 3. PNGS organization

PNGS environment has been created to provide basic components for software aimed at the manipulation and analysis of spectroscopic astronomical data. The modules available in PNGS can be logically organized in 4 macro subsets, according to their purposes:

- **Data organization.** Collection of modules which provides tools to create a *reduction project* from scratch. Project organization is based on SQL like database handled by *pandora.dbase* module. Using the *pandora.organizer* astronomers can define project categorization parameters, file organization structure and visualization criteria. The *pandora.unpacker*, interacting with the organizer, automatically imports data into a project, converting raw data into categorized files: flats, calibration lamps, science frames and so on. The *pandora.datamanager* allows the user to browse and manage data files.
- **Data reduction.** The spectra reduction library core is the *pandora.drs* module; it contains algorithms to create spectroscopic reduction pipeline and quality check tools to validate the reduction process. The *pandora.vreducer* and *pandora.lreducer* modules implement the visible and near infrared spectroscopic data reduction pipelines, which rely mainly on the *pandora.drs* module. These pipelines, as the data organization modules, have been integrated into *pandora.vipgi* (see 4.2 for more details).
- **Astronomical data analysis.** The main module of this group is *pandora.redshift*: the core module for spectroscopic redshift measurement; different redshift measurement algorithms can coexist in this module. At the moment a simple engine and an advanced one (Garilli et al. (2010)) are available. This group contains also a collection of generic astronomical functions (gathered in *pandora.astro*) and a collection of math functions (*pandora.math*).
- **GUI-API.** All plotting capabilities and data visualization tools are gathered together in this group. Here there are modules for: 1D and 2D data plotting, histograms, scatter data plots, 1D and 2D spectra plots. These are pure python modules, which use Chaco and Traits packages. Combining modules of this group with capability provided by data analysis modules, we created the graphical spectra analysis application *pandora.ez* (see 4.1).

## 4. Main applications

PNGS ecosystem can be used to develop interactive graphical applications. Currently there are 2 software created using PNGS modules: *pandora.ez* and *pandora.vipgi*.

### 4.1. *pandora.ez*

*pandora.ez* is a software for redshift measurement and spectra analysis; it is the improvement of the already existing and distributed EZ software (see Garilli et al. (2010)). The software is

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<sup>2</sup><http://www.eso.org/sci/software/cpl/>

<sup>3</sup><http://swig.org/>

designed to perform both interactive and automatic measurements on spectra. It collects facilities provided by plotting packages, redshift measurement module and mathematical algorithms (see figure 1).

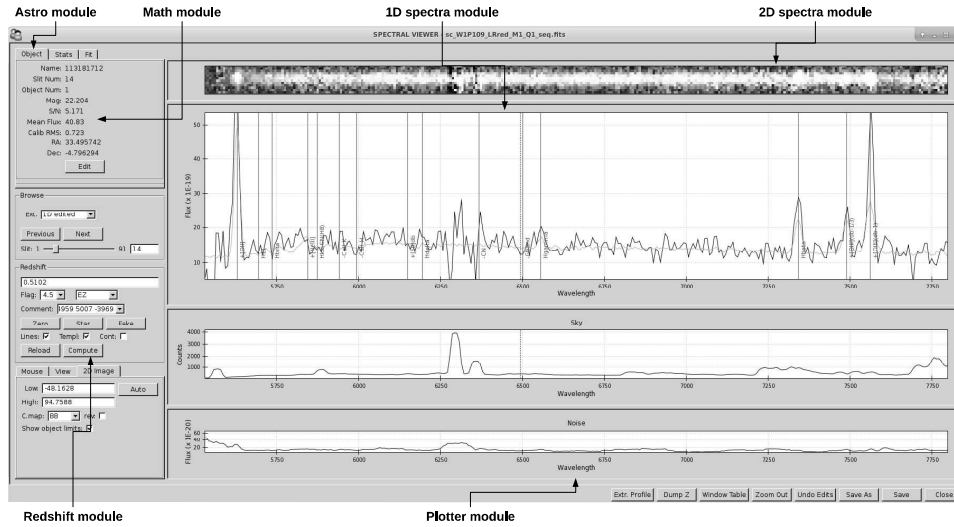


Figure 1. This snapshot of *pandora.ez* highlights the interoperability of several PNGS modules.

The software has been used by VIPERS (Guzzo et al. (2014)) team to measure redshifts of spectra produced by the survey<sup>4</sup>. *pandora.ez* has been adopted also by the on going VANDELS<sup>5</sup> survey and by the VUDS survey (Le Fèvre et al. (2015)) as redshifts measurement tool.

## 4.2. *pandora.vipgi*

*pandora.vipgi* is a spectroscopic reduction software: it extracts 1D wavelength and flux calibrated spectra starting from raw data. The software allows astronomers to:

- automatically create, categorize and manage a data project;
- run the reduction recipes;
- check the quality of reduced data.

*pandora.vipgi* is the evolution of VIPGI (VIMOS Pipeline Interactive Graphical Interface, see Scodeggio et al. (2005)) and it is able to handle both MOS and longslit data. It has been obtained orchestrating the capabilities provided by the organizing packages, the reduction pipelines and the drs checking tools.

The current version of *pandora.vipgi* can be used to reduce data acquired by VIMOS<sup>6</sup>, LUCI1, LUCI2<sup>7</sup> and MODS1, MODS2<sup>8</sup> spectrographs.

<sup>4</sup><http://vipers.inaf.it/rel-pdr2.html>

<sup>5</sup><http://vandel.inaf.it/>

<sup>6</sup><http://www.eso.org/sci/facilities/paranal/instruments/vimos.html>

<sup>7</sup><http://www.mpe.mpg.de/ir/lucifer>

<sup>8</sup><http://www.astronomy.ohio-state.edu/MODS/>

*pandora.vipgi* is used since 2010 by the LBT Italian Spectroscopic Reduction Center in Milan, to reduce all spectroscopic data acquired during Italian time by the LBTO Observatory<sup>9</sup>. It is also partially used to reduce data of the VANDELS survey and more in general it is used to reduce data obtained by the VIMOS spectrograph.

## 5. Future developments

PNGS ecosystem can be improved adding further functionalities to existing modules, creating new features or adding brand new modules. Other spectroscopic reduction pipelines for different spectrographs can be easily created and plugged in *pandora.vipgi*.

At the moment PNGS is distributed only within the VIPERS, VANDELS and VUDS consortia. In case you are interested in PNGS for your scientific projects, please contact us at [pandora@lambrate.inaf.it](mailto:pandora@lambrate.inaf.it).

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<sup>9</sup><http://www.lbto.org/>