Easylife: The Data Reduction and Survey Handling System for VIPERS

B. Garilli, L. Paoro, M. Scodeggio, P. Franzetti, and M. Fumana
INAF-IASF Milano, Via Bassini 15, 20133 Milano, Italy

AND

L. Guzzo
INAF-Osservatorio Astronomico di Brera, Via Bianchi 46, 23807 Merate, Italy

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ABSTRACT. We present Easylife, the software environment developed within the framework of the VIPERS project for automatic data reduction and survey handling. Easylife is a comprehensive system to automatically reduce spectroscopic data, to monitor the survey advancement at all stages, to distribute data within the collaboration, and to release data to the whole community. It is based on the OPTICON-founded project FASE, and inherits the FASE capabilities of modularity and scalability. After describing the software architecture, the main reduction and quality control features, and the main services made available, we show its performance in terms of reliability of results. We also show how it can be ported to other projects with different characteristics.

Online material: color figures

1. INTRODUCTION

Thanks to the continuous evolution of astronomical instrumentation, and in particular of the multiplexing gain of faint-object spectrographs, large-scale spectroscopic surveys have become a real industry, in which up to $10^6$ spectra can be accumulated by a single project. So far, this has been particularly true for redshift surveys of the “local” universe ($z \sim 0.1$), with the notable milestones represented by the 2dF Galaxy Redshift Survey (2dFGRS, Colless et al. [2001]) and the Sloan Digital Sky Survey (SDSS, Eisenstein et al. [2001]; Abazajian et al. [2009]), which built on earlier pioneering projects of the 1980s and 1990s, such as the CfA redshift survey (Davis et al. 1982; Geller & Huchra 1989), Perseus–Pisces (Giovanelli et al. 1986), ESO Slice Project (ESP) (Vettolani et al. 1997), and Las Campanas Redshift Survey (LCRS) (Shectman et al. 1996).

For obvious reasons, redshift surveys of the more distant universe ($z \sim 1$), were limited to smaller numbers, with samples of a few hundred to a few thousands galaxies (e.g., Canada France Redshift Survey (CFRS), Le Fèvre et al. [1995]), which more recently grew to a few tens of thousands objects with the advent of new multiobject spectrographs on 8 m class telescopes, like VIMOS (Visible Multi-Object Spectrograph) and DEIMOS (DEep Imaging Multi-Object Spectrograph), e.g., VVDS (VIMOS VLT Deep Survey; Le Fèvre et al. [2005]; Garilli et al. [2008]); DEEP2 (Coil et al. 2004), zCosmos (Lilly et al. 2007). Lately, a further increase in the size of samples at intermediate redshift ($z \sim 0.5$) has been possible by targeting specific classes of galaxies, like star-forming objects in the case of the WigleZ survey (Drinkwater et al. 2010) or massive “reddish” galaxies in the case of SDSS3-BOSS (SDSS-III Baryon Oscillation Spectroscopic Survey, Schlegel et al. [2007]). In particular, the total yield for this latter project will be of the order of $10^6$ spectra. This trend is expected to continue with future redshift surveys, as it is the case for the tens of millions redshifts expected for the ESA mission Euclid (Laureijs et al. 2011), or Gaia (Kontizas et al. 2011; Karampelas et al. 2012).

The amount of information potentially provided by such large-scale surveys is enormous, but to exploit its full scientific potential, measurements have to be extracted from the raw data in a way which is both efficient (thus with minimal human intervention) and at the same time reliable; equally importantly, such measurements have to be distributed to the community in an easily manageable form. With these goals in mind, a number of projects have developed automatic pipelines tuned to their own needs.

Since its planning in the early 1990s, the SDSS dedicated a major effort to the creation of a full pipeline for data reduction (e.g., Lupton et al. 2002) and a parallel database system to handle the enormous (for that time) amount of photometric and spectroscopic data (e.g., Szalay et al. 2002). Similar efforts were later implemented in particular by large photometric surveys, with the creation of data processing centres, like Terapix for the CFHT observations (Bertin et al. 2002), the UKIDSS (UKIRT Infrared Deep Sky Survey) center (Warren et al. 2007) or the CANDELS (Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey) pipeline (Koekemoer et al. 2011). Among pure spectroscopic surveys, VVDS (Scodeggio et al. 2005), zCosmos (Lilly et al. 2007), AGES (AGN and Galaxy Evolution Survey) (Auld et al. ...
and more recently WiggleZ (Drinkwater et al. 2010) have all built their own tools, eventually glueing together pre-existing algorithms and programs into an automatic processing.

Data dissemination is the second important requirement these projects have to meet. This includes both internal distribution to the survey team, and public release to the scientific community; the latter may also include public outreach products. The Virtual Observatory (VO) has set up standards and conventional formats for this purpose. VO compatible tools have been flourishing over recent years\(^2\) (and are on the way of becoming the standard for data dissemination). Currently, however, each survey still tends to provide its own specific web pages, from where data and information can be downloaded, either through plain ASCII files or via more sophisticated database systems.\(^3\)

A third important point in exploiting such large and long-lasting projects is bookkeeping of the survey processes. This is usually kept by the project coordinator or by a restricted coordination group, not always using appropriate tools, with considerable expenditure of time.

When we started the VIMOS Public Extragalactic Redshift Survey (VIPERS) in 2008, we decided to invest time and manpower in a survey management system capable of automatically taking care of data reduction and redshift measurement, quality control, data dissemination (both internal and to the public), and logging. In this article we describe the system we have set up, called Easylife. In § 2, 3, and 4 we briefly describe the VIMOS Public Extragalactic Redshift Survey (VIPERS)\(^4\) survey, the VIMOS spectrograph, and the observing sequence to be followed within ESO projects. In § 5 we detail the requirements we have defined. The system architecture is briefly outlined in § 6. After a description of the main tools (§ 7), we dedicate § 8 to the performance in terms of reduction quality we obtain with Easylife. In § 9 we show how we are using Easylife for other projects.

## 2. The VIPERS Survey

VIPERS is an ongoing ESO Large Programme aimed at measuring redshifts for $\sim 10^5$ galaxies at redshift $0.5 < z \lesssim 1.2$ for the purpose of accurately and robustly measure clustering, the growth of structure (through redshift-space distortions), and galaxy properties at an epoch when the universe was about half its current age. The galaxy sample is selected from the Canada-France-Hawaii Telescope Legacy Survey Wide (CFHTLS-Wide) optical photometric catalogues (Goranova et al. 2009). VIPERS covers $\sim 24 \text{ deg}^2$ on the sky, divided over two areas within the W1 and W4 CFHTLS fields. Galaxies are selected to a limit of $i_{AB} < 22.5$, further applying a simple and robust $gri$ color pre-selection, so as to effectively remove galaxies at $z < 0.5$. Coupled to an aggressive observing strategy (Scodeggio et al. 2009), this allows us to double the galaxy sampling rate in the redshift range of interest, with respect to a pure magnitude-limited sample, reaching a target sampling rate of $\sim 40\%$. At the same time, the area and depth of the survey results in a fairly large volume, $5 \times 10^7 \text{ h}^{-3} \text{ Mpc}^3$, analogous to that of the 2dFGRS at $z \sim 0.1$. Such a combination of sampling and depth is quite unique over current redshift surveys at $z > 0.5$. VIPERS spectra are collected with the VIMOS multiojbect spectrograph (Le Fèvre et al. 2000) at moderate resolution ($R = 210$), using the LR red grism, providing a wavelength coverage of 5500–9500 Å and a typical radial velocity error of $175(1 + z) \text{ km s}^{-1}$. The full VIPERS area of $\sim 24 \text{ deg}^2$ is covered through a mosaic of 288 VIMOS pointings (192 in the W1 area, and 96 in the W4 area).

As of 2012 January, about 60% of the VIPERS area has been observed, with completion expected by 2014. A first discussion of the spectral data together with principal component classification can be found in Marchetti et al. (2012). More details will be available in Guzzo et al. (2012, in preparation).

## 3. The VIMOS Spectrograph

VIMOS (Visible Multiobject Spectrograph) is an imaging spectrograph installed on Unit 3 (Melipal) of the ESO Very Large Telescope (VLT) at the Paranal Observatory in Chile (see Le Fèvre et al. [2000] and Le Fèvre et al. [2002] for a detailed description of the instrument and its capabilities). The driving design concept for the instrument is to cover as much of the unvignetted part of the focal plane as possible at the VLT Nasmyth focus (a circular area with a diameter of 22' on the sky). Since this large area corresponds to a very large linear scale (almost 1 m), it was decided that coverage would be achieved by splitting the instrument into four identical optical channels arranged next to each other and supported by the same mechanical structure. Each optical channel is a classical focal reducer imaging spectrograph, with a collimator providing a parallel beam where the dispersive element (a grism) is inserted, and a camera that focuses the beam onto a $2048 \times 4096 \mu\text{m}$ pixel EEV CCD. The focal plane is flattened by a field lens at the instrument entrance, to allow for flat multislit masks, and a folding mirror that focuses the beam onto a $2048 \times 4096 \mu\text{m}$ pixel EEV CCD. The focal plane is flattened by a field lens at the instrument entrance, to allow for flat multislit masks, and a folding mirror that focuses the beam onto a $2048 \times 4096 \mu\text{m}$ pixel EEV CCD. The focal plane is flattened by a field lens at the instrument entrance, to allow for flat multislit masks, and a folding mirror that focuses the beam onto a $2048 \times 4096 \mu\text{m}$ pixel EEV CCD.
exposure acquired with VIMOS is required as the starting point of the mask design and cutting process (Bottini et al. 2005).

4. VIMOS OPERATIONS WITHIN THE VIPERS CONTEXT

Preparing and submitting MOS observations with VIMOS requires a sequence of operations, as thoroughly explained in the VIMOS user’s manuals and ESO web pages. In service mode (which is the default observing mode), once the pointing location has been chosen, the information needed to carry out preimaging has to be sent to ESO, together with the finding chart of the field. As soon as preimaging data are available, the user is asked to prepare the files needed to manufacture the masks needed for spectroscopy observations, and send them together with the other information required (instrument configuration, exposure time, observing sequence, etc.). Mask preparation is done via VMMP (VIMOS Mask Preparation Software, Bottini et al. [2005]) distributed by ESO. Once the spectroscopic observations have been performed, the data can be retrieved from the ESO archive, and reduced. Finally, from the flux and wavelength calibrated monodimensional spectra, redshift, and other spectral quantities can be measured.

For normal programs, none of these operations is particularly time consuming, nor demanding. It is when this sequence is to be applied to a survey which foresees of the order of hundreds of pointings and hundred thousands spectra (as VIPERS) that the need for automatization arises. Easylife is the system we have devised especially for VIPERS, but which can be easily adapted to other projects requiring a high degree of data reduction automatization. The whole reduction procedure is based on the pipeline described in Scodeggio et al. (2005; see Fig. 1), which we have automatized to a very high degree, as explained in § 7.2.3. The redshift measurement is carried out using EZ (Easy redshift, Garilli et al. [2010]) in blind automatic mode. Even if EZ is rather efficient, especially for this kind of data (see § 7.3), a human inspection of the spectra is required to validate the measurements and possibly recover a redshift for the faintest objects. This operation is performed by either one or two persons (according to data quality). Finally redshifts, together with redshift reliability flags, as well as mono- and two-dimensional spectra have to be fed back to the database for dissemination among the whole survey team.

5. SOFTWARE REQUIREMENTS

VIPERS is expected to conduct about 300 VIMOS pointings in 4 years: each pointing observation is split in five exposures, and each exposure covers the four VIMOS quadrants. The expected data flow is thus on the order of 6000 raw data frames to be reduced and 100,000 spectra to be measured. For such a survey, a semimanual procedure is carried out using EZ (Easy redshift, Garilli et al. 2010) in blind automatic mode. Even if EZ is rather efficient, especially for this kind of data (see § 7.3), a human inspection of the spectra is required to validate the measurements and possibly recover a redshift for the faintest objects. This operation is performed by either one or two persons (according to data quality). Finally redshifts, together with redshift reliability flags, as well as mono- and two-dimensional spectra have to be fed back to the database for dissemination among the whole survey team.

and redshift measurement for both surveys has been carried out in manual mode, using VIPGI and EZ, and had taken about 5 years to be completed. Scaling to the VIPERS case, this would translate into 15 years of effort just to reduce the data. Therefore, the automatization of the processing chain, including reduction and automatic redshift measurement, is the first requirement we had to meet. Such an automatic pipeline must run in unsupervised mode, but has to have built-in quality checks on crucial steps so that the output products are fully controlled.

Periodic internal data releases to the VIPERS consortium must be foreseen, to allow for scientific exploitation even before the whole survey has been completed, as well as periodic public releases to the whole community. This can be easily accomplished without additional workload if, after reduction and redshift measurement, all information is automatically entered in a database, which can be opened, in full or in part, when data must be released.

Tasks like finding-chart production and mask preparation, which cannot be automatized further with respect to the tools ESO provides, are carried out by different people, and the same applies to the redshift measurement task. Distributed work can be more efficient if handy tools to get the required input (e.g., pre-imaging for preparing masks, reduced monodimensional spectra to measure spectra) and send-back results are used. Web-driven upload and download procedures which take care of storing results and performing quality checks have to be provided.

![Block diagram summarizing the main steps involved in the reduction of VIMOS data (Scodeggio et al. 2005).](image)
Finally, an adequate bookkeeping must be provided for several aspects: the managerial need of evenly distributing the workload among all partners, and the degree of advancement of each person and each task; information on the targets selected for the observations has to be kept; since the program is spread along few years, it is advisable to keep track on when observations (both preimaging and spectroscopy) have been taken; and last, but not least, all consortium members must have the possibility to check what is the advancement in terms of observations, data reduction, completeness, etc.

Automatic reduction, database storage and book-keeping are the basic requirements we have set for Easylife, together with keeping to a minimum the need for supporting man power from the ‘survey reduction center’. On top of these requirements, it was desirable to use reduction tools already fully tuned and tested, instead of rewriting all the required routines from scratch. Finally, we wanted to create a flexible system which could be adapted to similar projects in which we are involved.

6. SOFTWARE ARCHITECTURE

The three main requirements described in the previous section naturally lead to a modular system, where both reduction programs (usually written in C language), databases (mySQL based), and web interfaces (developed in Java or HTML) can live together and flawlessly interact. The OPTICON Future Astronomical Software Environment (from here on, FASE, Grosbøl et al. 2005) is a scalable open-system application framework with distributed capabilities, specifically produced for astronomical software, which can by design satisfy all these needs. The FASE architecture is described in Paioro et al. (2010), and here we recall the fundamental concepts. Following Figure 2, the major system elements are as follows:

1. Presentation layer: the part of the system which presents the user with the various functionalities. The user can be a human, but also a grid workflow, a Web browser interface, etc. The presentation layer itself can be a command line interface, a graphical user interface (GUI) or a Web interface.

2. Application layer: the application layer is used to implement top level applications. The application layer can be anything which can drive the execution framework to execute components, for example, Python, Java, a GUI, or a workflow engine of some sort.

3. Execution framework: provides the functionality needed to execute components, including capabilities such as component registration and management, distributed execution, scalability, messaging, logging, and so forth. Different execution frameworks, each one having different capabilities, can be implemented.

4. Container: components execute within a container which defines the life-cycle and runtime environment seen by the component. The container is the interface between the execution framework and an individual component.

5. Components: a component is a computational object, with one or more service methods, which can be plugged into the framework. Components are grouped into component packages and provide most of the functionality of the system.

The component–framework architecture outlined here is a modular architecture in which the major elements of the system can be used separately as stand alone packages, or can be integrated into other frameworks. The advantage of a modular architecture is that the major elements of the system can evolve independently, making it easier to use new technology as it becomes available. In developing Easylife, we have made full use of the modularity FASE provides; some elements (the Reducer and to a certain extent the Unpacker) were pre-existing, and we have just plugged them in the global system after having built the appropriate container. At the same time, we have been able to extend the system capabilities by adding extra components for the data reduction of other instruments (like LUCI and MODS at the LBT, see § 9).

7. EASYLIFE BUILDING BLOCKS

Following the architectural concept of FASE, the different tasks deriving from the requirements outlined in § 5 are handled through a dedicated Easylife component and/or GUI. The survey status can be monitored and managed through an administrative web site, which is also used to provide the public Web pages of the VIPERS survey. Data ingestion, organization, and reduction tasks, together with automatic redshift measurement, are carried out by dedicated tools running on a Beowulf cluster. Finally, the results database is based on mySQL and accessed through a dedicated GUI. All these parts communicate with an administrative SQL-based database, which keeps track of the global status of the survey, and all together constitute the Easylife system.

7.1. VIPERS Administrative Web Site

The administrative web site is the uppermost presentation layer of Easylife. It allows one to monitor the survey status, access all survey-related side products, as outlined below, and retrieve data.

The VIPERS administrative web site is built on top of a Web application framework running on a Jakarta Apache server. It allows one to serve normal static HTML pages as well as dynamic pages. VIPERS pages are built upon a template system integrated within the Web application framework, which ensures homogeneity of the layout. The Web application framework is fully integrated within the Easylife management system, and directly accesses the underlying SQL database, which contains all the relevant information for the survey monitoring. It is structured to have different access levels: a public part, which describes the survey goals, shows the team

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5 See http://vipers.inaf.it.
composition and will contain a summary of the most relevant results; a team restricted part; and an administrative part, with access restricted to the PI and the administration team. Through the private part, each member of the team can retrieve the information he/she may need, e.g.:

1. Inspect how the survey is advancing. An example is given in Figure 3 for the CFHTLS-W1 area. The different colors indicate the different advancement status of each pointing (green for observed, yellow for reduced, red for fully measured, etc.). For each pointing, relevant information such as date of observation, meteorological conditions during observations (through a link to observation logs provided by ESO), data quality, are accessible by clicking on the pointing itself (see Fig. 4). These figures are created on the fly from the SQL database holding all survey information, and thus are always automatically up to date.

2. Connect to the database system, providing the photometric parent catalogs and the catalogs with the scientific information extracted from the spectra. The database system is based on DART software (Paioro et al. 2008), a Web interface which allows one to query catalogs and access their associated data products (see § 7.4).

3. Have access to project documentation and meetings minutes, as well as to the VIPERS science Wiki pages related to different internal projects or working groups.

4. Upload any VIPERS related publication, and look at publications or presentations given by team members.

5. Retrieve the data for mask preparation or redshift measurement and upload the results.

The administrative pages are reserved to the PI or project administrator to:

1. Assign the VIMOS mask preparation to the team members.

2. Once data have been reduced, assign the redshift measurement validation to the different team members.

3. Make new data releases, freezing the current status of the spectroscopic catalogs and labeling them with a custom tag. Some statistics are then produced summarizing the survey status and outcome.

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**Fig. 2.**—FASE architecture as implemented for the Easylife system. On the top part, we find the application and presentation layer. The bottom part shows the three main containers (Reducer, Unpacker, and Organizer) with their respective components. Everything is linked together by the execution framework (EF) provided by an early prototype of FASE environment. See the online edition of the PASP for a color version of this figure.
4. Keep track of the “service” work done by each team member, to avoid overload of some with respect to others.

7.2. Data Ingestion and Reduction

While the administrative web site allows one to handle the global phases of the survey process, data management, and reduction are performed by a restricted data reduction group through a dedicated graphical user interface. Such GUI handles three main software elements, each of which is dedicated to a specific set of reduction and management tasks:

1. Unpacker (§ 7.2.1): unpacks the raw data and prepares them for ingestion in the reduction system;
2. Organizer (§ 7.2.2): fills the database containing the pointing information and organizes the data in a predefined structure, classifying each file by its attributes;

![W1 Pointings Status](image)

Fig. 3.—Example of panel showing the status of the observations. The graph displays the pointings placing them in the correct coordinates and coloring each pointing with a different color depending on its current status. The status ranges from preimaging submitting up to data validation assignment, with a final status assigned when the processing of the pointing has been definitely closed. See the online edition of the PASP for a color version of this figure.
3. Reducer (§ 7.2.3): reduces the raw data in order to produce monodimensional wavelength and flux calibrated spectra for each target object and measures the spectroscopic redshifts.

The Unpacker, Organizer and Reducer are used through the GUI in a seamless way, allowing the user to choose: (a) the project to be handled; (b) the raw data to be unpacked; (c) the pointings to be reduced and the related files to be used for the reduction; (d) launch the reduction process.

7.2.1. Data Preparation

The Unpacker is the EasyLife software element dedicated to ingesting raw data into the reduction system. EasyLife has been conceived with the aim of being usable for several projects and several spectrographs. The purpose of the unpacker is to analyze the raw data it receives, discard whatever is not needed or wanted, and add to the header of the raw data files some conventional keywords, which will allow the data to be classified according to the project or instrument they belong to. The exact behaviour of the Unpacker is driven by configuration settings, which essentially indicate where, and in which form, the information required is contained in the raw data. At the end of the process, each raw data file contains standard hierarchical FITS keywords which contain the main information required for classifying the file independently of the instrument: for example, the disperser used, the target name, the instrument name, the airmass, and others. The file is also renamed following a “human readable” syntax which allows one to immediately identify whether it is a scientific exposure, a flat field, the identity of the target, and with which disperser it has been observed.

EasyLife hierarchical FITS keywords provide a conventional set of information irrespective of the instrument which has produced the data. This information is what the Organizer needs to classify the data.
It is worth noting that this approach to data ingestion allows one to use Easylife for different projects and even instruments: for each target application (be it a survey with VIMOS, or several observations with another spectrograph), it is sufficient to configure a different Unpacker to customize Easylife for projects very different from the VIPERS survey it has been devised for. In §9 we will show how we have already used Easylife for other projects.

7.2.2. Data Organization

Once the data contain a set of standard information in a standard format, they can be easily classified and organized according to their content. The classification is stored in a mySQL database (which is also accessed by the web interface, see §7.1), while the data management operations are performed through the Organizer, which provides the data organization and administration functions. The Organizer handles multiple projects (VIPERS application is one project), providing a separate work space for each one. A project work space consists of: (1) a data storage area, which points to a well defined directory structure; (2) a set of database tables: the table holding the files attributes and their reduction status, the table collecting the administrative information concerning the pointings (or targets) and their global status, and the table containing the information on the calibration files and their validity range. Every inquiring operation on the files and/or on the survey management process is performed by the different Easylife components accessing the Organizer. The Organizer is thus the main element that allows one to orchestrate the entire management system.

7.2.3. Data Reduction and Quality Control

The data reduction is performed with a special Easylife software component (the Reducer), which provides an automatic pipeline system equipped with a specific plug-in for the VIMOS instrument. Thanks to FASE-distributed execution engine, the Reducer is able to process multiple observations at the same time, submitting the reduction processes to a Beowulf cluster. The reduction steps and underlying recipes are described in Scodeggio et al. (2005), and recalled in Figure 1. Briefly, the implemented global data reduction scheme is a fairly traditional one, broadly following the one implemented by the IRAF longslit package: (1) location of spectral traces on the raw frames, (2) computation of the inverse dispersion solution for each spectral trace, (3) sky subtraction on the noncalibrated data, (4) two-dimensional extraction of spectra and application of the wavelength calibration, (5) combination of sequence of observations, (6) extraction of mono-dimensional spectra and correction for the instrument sensitivity function (flux calibration). A special effort was made to achieve a very high efficiency during the repeated application of this scheme to the large set of VVDS data by tailoring all aspects of the data reduction scheme to the specific characteristics of VIMOS. Still, the various reduction functions are general enough that they can be adapted for the reduction of data produced by any MOS spectrograph with a minimal effort (see §9 and Nastasi et al. 2012). Such recipes, in their original form, formally always end successfully, but this does not automatically mean that the result meet the degree of accuracy required by the specific scientific need. For example, a spectrum can be successfully wavelength-calibrated, but the wavelength calibration accuracy is of the order of 1 pixel. This is clearly not enough if the redshift accuracy required is much higher than that. In the past, reduction results were always manually checked and, when required, data were reduced again in order to improve results. Given the high data flow of VIPERS (6000 raw frames), the fully automated pipeline must also assure that the reduction results are scientifically exploitable. For these reasons, on top of the reduction flow described in Scodeggio et al. (2005), we added some quality-check steps. Every time one of such quality checks is not satisfied, the reduction process is stopped and human intervention is required. We have explored the parameter space of each step in order to find the minimum (or maximum) value above (or below) which VIPERS data are scientifically usable. Such limits are stored in a configuration file. The quality checks we perform, together with the adopted limits are the following:

1. Check on spectra location. Each VIPERS observation consists of several exposures, possibly spread over different nights. It is well known that VIMOS suffers from a flexure problem (only recently fixed thanks to an active flexure compensator, see Hammersley et al. [2010]) so that the location of the dispersed spectra on the different exposures can differ by few pixels from the expected positions. For this reason, the task computes the expected spectrum border position and compares it with the real detected spectrum border. The median of this displacement is requested not to exceed 1.5 pixels for 5% of the spectra in one VIMOS quadrant. If these conditions are not satisfied, the expected position is not accurate enough to guarantee a good spectrum tracing, and therefore extraction in all exposures of the same field, and the procedure is stopped to allow for a manual adjustment of the slit position first guess.

2. Check of wavelength calibration. Using the inverse dispersion solution derived by the pipeline, the expected position of each reference spectrum line in each slit is computed. Such expected position is then compared with the actual arc line position as measured from the raw data, and the difference between expected and observed position is computed. For each slit, the rms of such differences is also computed. The quality control is successful when all the following conditions are satisfied:

- a) the median of the RMS distribution using all slits is not larger than 0.2 pixels;
- b) for each slit, the RMS is not higher than 0.1 pixels and lower than 0.3 pixels. This condition must be satisfied at least by 90% of the slits;
- c) in each slit, the minimum number of arc lines used to fit the Inverse Dispersion Solution is at least 9;
d) the bluest and reddest visible arc lines are within $2.5\sigma$ from the best fit for at least 90% of the slits.

3. Detected targets. Once data have been reduced and multidimensional spectra extracted, the number of detected targets is computed. In general, given the exposure time and the limiting magnitude of the survey, we expect a detection rate above 90%. If such threshold is not reached, it is usually the signal that the metal mask, on which the slits are carved, was badly positioned on the focal plane (an event which may occur, see also Hammersley et al. [2010]) or of bad observing conditions. In this last case, also the observation quality flag (see below) independently indicates bad quality data.

4. Quality flag. When all exposures belonging to the same pointing have been reduced and combined together, a check on some environmental parameters which can affect the quality of the data is performed (see Garilli et al. [2008] for details). In particular, we check the mean PSF as measured from the reduced image, the measured sky brightness, and the object centering in the slit. These three quality parameters can score 1 (good) or 0 (bad) and they are combined together in order to produce a final reduction quality flag.

7.3. Redshift Measurement

Once the data are fully reduced, they are ingested into a blind redshift measurement pipeline provided by EZ, fully described in Garilli et al. (2010). EZ has been developed within the VVDS project to help in redshift measurement from optical spectra. The basic idea is to allow the user to combine the available functions in the most appropriate way for the data at hand, thus building new user-defined functions and methods. At the uppermost level, a redshift measurement decision tree can be built, which mimics the decision path followed by an astronomer to get to the measure of the redshift. Complete automation of the redshift measurement process can be tricky when spectra are noisy (as they always are at the faint limit of a survey) or in presence of artifacts such as fringing correction residuals, so that it is by no means guaranteed, a priori, that the best solution proposed is also a correct solution. For this reason, EZ also computes a reliability flag which summarizes the goodness of the solution proposed. As for the redshift, the reliability flag computation is also performed mimicking the kind of logical reasoning applied by an astronomer when trying to evaluate if a redshift is reliable or not. The implemented flagging system is rather conservative, as demonstrated in Garilli et al. (2010). EZ can be used both interactively, or totally blindly in unsupervised mode, which is the mode we have adopted within EasyLife.

The redshifts thus obtained are compared for consistency with the photometric redshifts, and an appropriate decimal flag is added to the reliability flag provided by EZ. This particular final step of the reduction is applicable in the case of VIPERS, but could be not applicable in other cases. The modularity of EasyLife allows the switching on or off of any reduction step, according to the user’s needs. The final redshifts approval is formalized after a human check. The reduced data are submitted to the survey team members who are in charge of the redshift validation, who have at their disposal the mono and two-dimensional object spectra together with their associated sky and noise spectra, the output of the automatic measurement with the associated flag, and the information regarding whether such measurement agrees or not with the photometric redshift (within the photometric redshift error). In § 8 we will show how the automatic redshift measurement performs on the VIPERS data.

7.4. Survey Database

Once redshifts have been humanly validated and uploaded to the survey Web site, they automatically enter the spectroscopic database, together with the other scientifically interesting quantities such as the object magnitude in the selection band and its coordinates. The database also hosts the parent photometric catalog, containing $ugriz$ magnitudes from the CFHTLS survey and photometric redshifts. Periodically (typically on a yearly basis) the spectroscopic catalog is frozen in a release, which is made available to the whole team for scientific analysis and checks.

EasyLife allows one to access the photometric parent catalogs and the spectroscopic catalogs through an embedded DART Web interface installation. As described in Paioro et al. (2008), DART gives a per-user access to the data allowing to query catalogs, filter data by placing conditions on the column values (even complex expressions), view the results, and export them to private user files stored in the remote data server. DART also allows the making of simple plots or retrieval of the data products related to the catalogs, as the monodimensional spectra resulting from the reduction process or any other ancillary data product (image thumbnails of different bands, links to external web sites, documents, etc.). The software supports access to more than one catalog at a time (e.g., for multiband usage):

1. in parallel, namely querying each catalog singularly at the same time;
2. as a couple linked by a prebuilt correlation table released by the data managers;
3. as a single virtual table, which allows the viewing of the result of the pure correlation by object ID among several catalogs.

DART supports also IVOA SSA protocol for the spectra access, IVOA SIA protocol for images access and ConeSearch protocol for catalogs access (http://www.ivoa.net/Documents/),6 opening a gate towards the Virtual Observatory facilities for VIPERS data. DART also gives different access privileges to different user classes, so that at the same time one can have a public part, a team-reserved part containing the most recent release, and

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6 See http://www.ivoa.net/Documents/.
8. EASYLIFE PERFORMANCE

The Easylife reduction blocks detailed above, coupled with the automatic redshift measurement, are very efficient: the full chain, including all the automatic quality checks, requires about 40 minute of computation time per pointing (each VIPERS pointing containing of the order of 320 spectra), without supervision or human intervention.

8.1. Data Reduction Performance

Human intervention is required when one of the quality checks described in § 7.2.3 fails and the procedure is stopped. In Table 1, we give the failure rate of the automatic reduction procedure we have experienced in the first $4 \times 113 = 452$ quadrants of the VIPERS survey. For 92% of the observations, the automatic reduction ran smoothly without human intervention, and the data satisfied all quality checks. In only 2.5% of the data (i.e., 11 quadrants) the automatic procedure has failed either to automatically locate spectra (9 quadrants) or to derive a good wavelength calibration solution (within the limits set in the quality control configuration file).

The check which fails the most (5.5% of the times, i.e., 24 quadrants) is the one on the number of detected sources. Cross-correlation of the quality parameter with these quadrants shows that in 10 out of 24 cases observing conditions below average are responsible for the lower than average detection rate, while other observational hardware problems (e.g., guide lost during observation, field partially obscured by the guide probe, bad mask insertion) account for the low detection rate of 10 other quadrants. In only four cases (less than 1%), the low detection rate seems to be due to local problems in the photometric catalogue, the presence of a bright star, or a poor astrometric solution when preparing masks, which may affect the corners of the field. Overall, our quality control proves to be reliable and allows us to quickly spot data that is below average quality. This information is not only useful per se, but is also used to assign pointings for redshift measurement checks: while higher quality data can be checked by one person only, the lower quality ones are systematically looked at by two different people.

| Failure reason                  | Failure rate |
|---------------------------------|--------------|
| Spectra location                | 2%           |
| Wavelength calibration          | 0.5%         |
| Target detection                | 5.5%         |
| Total                           | 8%           |

8.2. Automatic Redshift Measurement Performance

All VIPERS redshifts have been manually validated, as has been done for the VVDS and the zCosmos surveys (Le Fèvre et al. 2005), Lilly et al. (2007). In Garilli et al. (2010), it has been showed that EZ, used in blind mode, had a measurement success rate of 95% on simulated data, while on the VVDS and zCosmos surveys the success rate was ~70% on the whole sample, rising to 90% for redshifts classified as very secure by astronomers. In Table 2 we summarize the results obtained on the first ~36,000 detected targets belonging to the 113 VIPERS pointings mentioned above. The redshift flag scheme implemented in EZ mimicks the one adopted for the VVDS and the zCosmos surveys, i.e.:

1. Flag 4: a 100% secure redshift, with high signal-to-noise ratio (S/N) spectrum and obvious spectral features supporting the redshift measurement;
2. Flag 3: a 90% secure redshift, strong spectral features;
3. Flag 2: a 75% secure redshift measurement, several features in support of the measurement;
4. Flag 1: only one secure single spectral feature in emission, typically interpreted as [OII]3727, or Hα.
5. Flag 1: a 50% reliable redshift measurement, based on weak spectral features and continuum shape;
6. Flag 0: no reliable redshift measurement possible.

In the table, results are subdivided by automatic reliability flag. For each redshift automatically measured by EZ, and for each automatic flag (column 1), the table shows the number of spectra for which EZ has measured a redshift assigning that particular reliability flag (column 2), the number of spectra for which redshift has been confirmed by the astronomers (column 3), and the resulting success rate (column 4). The results shown in Table 2 are in line with those already obtained for the VVDS Wide survey: overall, the automatic measurement has been confirmed for 76% of the spectra, confirmation rising to 94% for automatic flags 3 and 4.

Table 2 also shows that the automatic flag is more restrictive than the human one, as already stated in Garilli et al. (2010): 52% of the redshifts flagged as 0 (unreliable) by EZ have been confirmed by astronomers. Table 3 compares the automatically assigned flags with the human ones, when the automatic redshift has been confirmed. We can see that flags 3 and 4 have been

| EZ flag | Total spectra | Correct redshifts | Success rate |
|---------|---------------|-------------------|--------------|
| Any     | 35,903        | 27,322            | 76%          |
| 3–4     | 20,043        | 18,889            | 94%          |
| 2       | 2213          | 1677              | 76%          |
| 9       | 1548          | 1188              | 77%          |
| 1       | 2790          | 1970              | 71%          |
| 0       | 6941          | 3598              | 52%          |
On the other hand, the management part, as well as data-products and the reduction chain must be able to cope with such diversities. Instrument configurations, satisfying a variety of scientific needs, etc.; in the second case, data are acquired with a variety of in-
er, but a number of other tasks are required (logging, data base, the same instrument configuration, which makes reduction easi-
tment adopted allows a smooth interaction between the database, the core of the reduction system and the publicly exposed web

tom the careful design of the basic architecture.

9. USING EASYLIFE FOR LBT DATA

The modular approach of Easylife has allowed us to easily adapt it to other, totally different projects. Currently, it is used within the framework of the Italian LBT (Large Binocular Telescope, Hill & Salinari (1998)) Data Center to reduce all spectroscopic observations obtained with either MODS (Multi-Object Double Spectrographs, Pogge et al. [2010]) or LUCI (LBT NIR spectroscopic Utility with Camera and Integral-field unit, Mandel et al. [2000]) during the Italian observing time. As MODS is a multiobject slit based spectrograph operating in the visible range, similar to VIMOS in its concept, adaptation of the reduction part has been straightforward, the required intervention being limited to the development of the instrument dedicated part of the Unpacker. LUCI is a multiobject spectrograph working in the NIR J, H, and K bands. Therefore, on top of a dedicated Unpacker, some more work on the reduction recipes has been performed, to comply with the specific peculiarities of the NIR spectroscopic data (e.g., the much more delicate problem of the sky subtraction). However, the main difference between the reduction center for a large-scale survey, like VIPERS, and the reduction center for a whole community, like the LBT Italian Data Center, resides in the different services the two centers must provide. In the first case, data are acquired with the same instrument configuration, which makes reduction easier, but a number of other tasks are required (logging, data base, etc.); in the second case, data are acquired with a variety of instrument configurations, satisfying a variety of scientific needs, and the reduction chain must be able to cope with such diversities.

On the other hand, the management part, as well as data-products distribution, is minimal: the only two actions required are to keep track of which data have been reduced and what remains to be done, on one side, and make available the reduced data to the PIs, on the other side. In spite of these fundamental differences, Easylife can handle both cases: in the LBT application, the WEB part has been suppressed, and the management data base is structured in a different way. The reduction chain is more versatile, with several branches according to instrument mode, while the redshift measurement part is suppressed. Adaptation of Easylife from the VIPERS survey case to the LBT service data center case has required only few months work (mostly devoted to the implementation of the NIR dedicated reduction recipes), thanks to the modular approach followed since the beginning, as well as to

10. SUMMARY

Easylife is the automatic data reduction and management system set up for the VIPERS survey. Easylife allows the automatic reduction of a large amount of data in a timely way and performs reliable quality controls on the data quality (namely the observing conditions) and on data reduction. The reduction chain ends with automated redshift measurements.

The automatic quality controls inserted in the pipeline have shown that reduction is successful in $>95\%$ of the cases, when observing conditions are within specifications. The observations not satisfying the requested observing constraints are automatically spotted and account for the vast majority of automatic reduction failures. Easylife also comprises project support tools, a survey advancement logging system, and data access through a dedicated data base. The underlying FASE software environment adopted allows a smooth interaction between the database, the core of the reduction system and the publicly exposed web interface, as well as distributed computing on a Beowulf cluster.

Presently, Easylife is also used in the framework of the LBT spectroscopic data reduction center, providing PIs with fully reduced and calibrated spectra, see, e.g., Magrini et al. (2012).

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