Astronomical Data Analysis Software and Systems IX
ASP Conference Series, Vol. 216, 2000
N. Manset, C. Veillet, and D. Crabtree, eds.

ETCs and Observations Simulation at the VLT

P. Ballester

European Southern Observatory, Data Management Division, Garching, Germany

J. A. Pizarro De La Iglesia

Serco Facilities Management GmbH, Munich, Germany

A. Modigliani

Terma Elektronik GmbH, Weiderstadt, Germany

O. Boitquin

European Southern Observatory, Data Management Division, Garching, Germany

Abstract. Several developments make it more practical today to efficiently use models of ground-based astronomical instruments in the entire observational process. First, the proposer can prepare observations using exposure time estimators and data simulators. Second, the observatory can control the configuration, test data analysis procedures, and provide calibration solutions with the help of instrument models. This paper presents the VLT object-oriented framework for the development of ETCs (Exposure Time Calculators) and data simulators. Applications of such models to the calibration of infrared and optical high-resolution spectrographs is discussed.

1. Introduction

Pipelines controlling the data gathering, calibration and archiving processes in the new generation of observatories like the VLT will have to continuously adapt to changing conditions and a variable number of instruments at one time offering a large number of observation modes that are available to a real-time scheduler according to observing conditions. Observations will be affected by varying conditions like PSF changes due to atmospheric effects or thermal changes. This will call for a constant adaptation of the calibration strategies, which may involve a complete change of paradigm, for instance a model-based calibration. Quality control requires an in-depth understanding of the instrumental characteristics and the calibration process (Ballester et al. 1999), achieved by reference to instrument models.

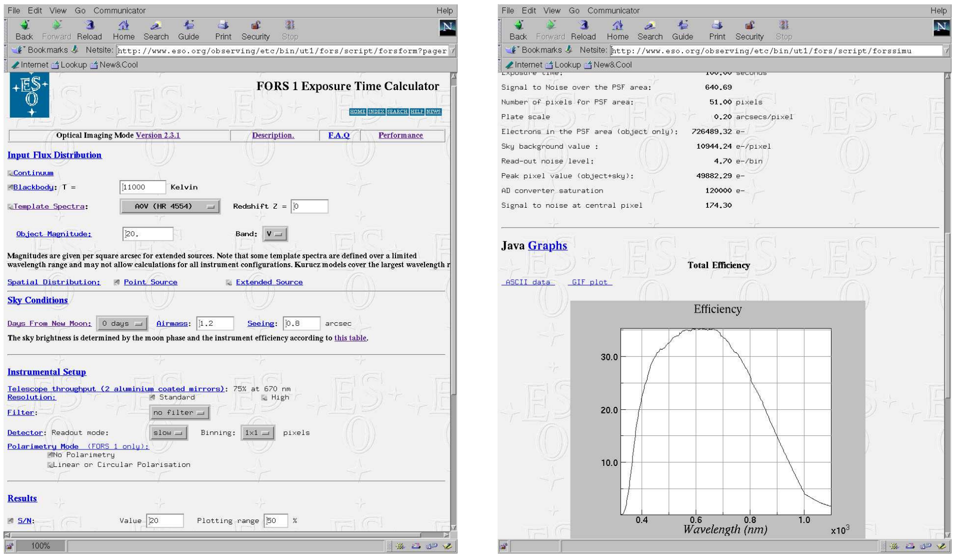

Figure 1. The VLT FORS Exposure Time Calculator.

2. Predicting and Controlling the Instrument Performance

The choice of exposure time for scientific programs usually depends on an estimation of the signal-to-noise ratio necessary to reach a given measurement accuracy. This can be evaluated using the on-line Web Exposure Time Calculators (ETCs) provided for the VLT instruments. With the ETCs it is possible to compare the different options relevant to an observing program, including instrument configuration, variable atmospheric conditions and observing parameters. The ETCs can always provide up-to-date information reflecting the known performance of the instrumentation as they are maintained centrally on the ESO Web servers.

A single Web page (`http://www.eso.org/observing/etc`) gives access to all released ETCs. These programs present an HTML/Java based interface and consist of two pages. The observation parameters page includes the entry fields and choices for all parameters defining the observation: target information, expected atmospheric conditions, instrument configuration, observation parameters such as exposure time or signal-to-noise, and results selection. The target information section presents a choice of spectral flux distributions such as template spectra, blackbody, or single emission lines, magnitude scaling, and spatial distributions options such as seeing-limited or extended sources. In the sky conditions section, the user can assign the expected moon phase, airmass, and seeing conditions as requested in the Phase II Proposal Preparation system.

Five classes of models are currently offered for optical or infrared imaging, long-slit spectroscopy, and optical echelle spectrographs. The target information and atmospheric conditions windows are identical for each class of instruments. The result page presents a summary description of the observation, including number of counts for the object and the sky, signal-to-noise ratios, instrument efficiencies, PSF size, and the probability of realization of the requested atmospheric conditions. Graphs are displayed within interactive Java applets for an easier manipulation. The graph results are also produced in different formats for further analysis and printing. Finally a summary of the input parameters is appended to the result page. Help files and documentation are provided on-line. A page of general information lists the latest updates and provides answers to Frequently Asked Questions. Detailed information concerning the spectral targets, atmospheric conditions, filter information, and usage of each section of the ETCs can be accessed following the corresponding underlined links in the input and result forms.

3. Physical Models

Instrument simulations are being developed for the purpose of predictive calibration, instrument configuration control, and evaluation of data analysis procedures. Both geometric and photometric modeling approaches have been based on first optical principles.

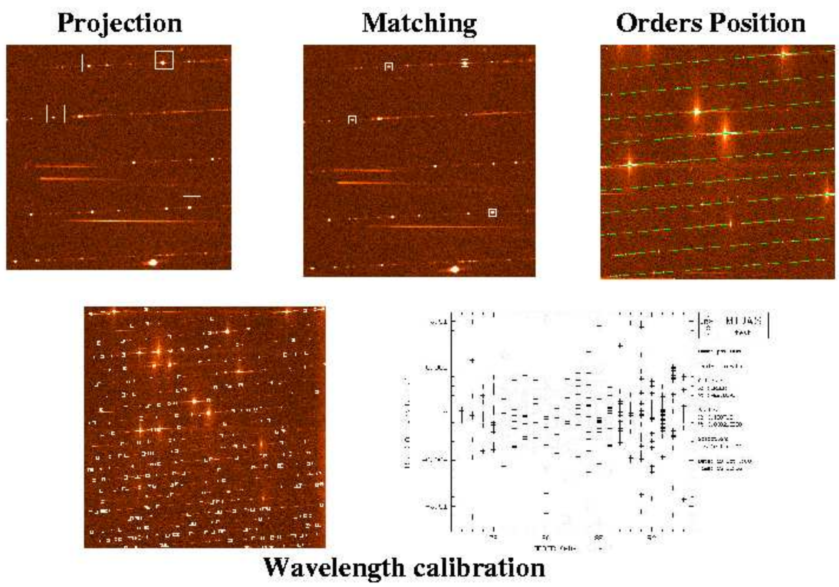

Figure 2. Predictive Calibration for the UVES echelle spectrograph.

The geometric models incorporates 3D geometry and off-plane optical equations of components to account for line tilts and order curvatures in the spectrographs. This formalism was validated by comparison with ray tracing programs like Code V. It is currently in operation for the predictive calibration of the VLT instruments ISAAC and UVES (Ballester & Rosa 1997).

The photometric model uses the conditional probability density function to characterize an optical instrument. This function can be constructed to represent the action of optical systems on all components of the electromagnetic field: intensity, direction, wavelength and polarization.

A first application of these models is for predictive calibration. It uses optical design and instrument component characteristics to predict a calibration solution. It can be used to predict the system response (Ballester et al. 1998).

The instrument configuration control uses configuration parameters which determine the instrument configuration (e.g. incidence angle on a grating characterizing the central wavelength) and static parameters. The configuration parameters are measured on the instrument by means of sensors or position encoders. The model allows calibration of several configurations to determine the static parameters of an instrument. it is also possible to control the instrument performance evolution over time (e.g. instrument efficiency).

4. An Object Oriented Simulation Library

Modular objects representing components of real instruments allow rapid prototyping and predicted results for new instruments. The configuration of instrument components controlled by an Instrument Definition File that describes all possible options to the optical path of an instrument. The optical path is chosen by the user setting various parameters of the model through the HTML input interface. Parameters represent the allowed options on the instrument configuration (e.g. filters, detectors) parameter names and common options are standardized across all possible instruments by the use of dictionary lookup tables. The user Interface uses template HTML files that are propagated with the correct options for the instrument selected from the parameters dictionaries.

References

Ballester, P., Dorigo, D., Disarò, A., Pizarro de la Iglesia, J. A., & Modigliani, A. 1999, "The VLT Data Quality Control System", Messenger 96, 19

Ballester, P., Rosa, M. R., & Grosbøl, P. 1998, "Data Quality Control and Instrument Modeling", SPIE Proceedings 3349, "Observatory Operations To Optimize Scientific Return", Kona, Hawaii, 20-21 March, 1998

Ballester, P. & Rosa, M. R. 1997, "Modeling Echelle Spectrographs", A&AS, 126, 563