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STATUS AND SCIENTIFIC PERFORMANCE OF ELMER, A MULTI-PURPOSE INSTRUMENT FOR THE GTC

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RESUMEN

Elmer es un instrumento para el GTC diseñado para observar en el intervalo espectral entre 365 y 1000 nm. Los modos de observación para Día Uno son: Imagen, Espectroscopía de rendija larga y multi-objeto, Espectroscopía sin rendija, Fotometría rápida y Espectroscopía rápida con rendija corta; en un campo de 4.2 arcmin de diámetro. Elmer dispone de resoluciones espectrales de 250, 1000 y 2500, cubriendo todo el intervalo de longitud de onda. Elmer ha sido diseñado y gestionado en la Oficina de Proyecto de GTC. El instrumento se encuentra en las fases finales de pruebas previas a su envío al ORM. En esta contribución se da una descripción general y un resumen de sus prestaciones científicas

ABSTRACT

ELMER is an instrument for the GTC designed to observe between 365 and 1000 nm. The observing modes for the instrument at Day One shall be: Imaging, Long Slit and Mask-Multi-object Spectroscopy, Slit-less multi-object spectroscopy, Fast Photometry and Fast short-slit spectroscopy, over a FOV of 4.2 arcmin diameter. Spectral resolutions of 250, 1000 and 2500, covering the whole spectral range, will be available. ELMER has been designed and managed within the GTC Project Office. ELMER is currently in the final stage of testing previous to be shipped to the Observatory. The general description of this instrument and its expected scientific performance are summarised.

Key Words: **INSTRUMENTATION: SPECTROSCOPY — INSTRUMENTATION: MISCELLANEOUS — METHODS: OBSERVATIONAL**

1. INTRODUCTION

The GTC Science Committee, SAC, recommended the development of an assurance instrument to be designed and kept under the control of the GTC Project Office, hereafter PO, in order to guarantee scientific operations on Day One. Some months later, in October 2000, ELMER, an imager and low-resolution spectrograph in the visible wavelength range (365 nm - 1000 nm), was approved to be put in operation in case of delays in the arrival of the instruments developed by external research institutions. ELMER design was driven by a basic set of scientific requirements, together with the strict boundary conditions both physical, moderate mass and size to fit at Folded-Cassegrain, and managerial, to have a "low" risk instrument, with a reasonable price and at a guaranteed delivery date. The design approach pursued proven technical solutions. The drawbacks have been converted into advantages. The low budget and the Folded-Cassegrain installation implied a small FOV and consequently relatively small optics, which allowed an optimized optical design with high throughput, which makes ELMER a very sensitive instrument. The oversized detector has been used to implement many fast, fashionable and time-resolved modes, unique in the large telescope world. Its simplicity will lead to very efficient operation and maintenance. ELMER is a fact, showing an excellent performance in the laboratory at La Laguna (Tenerife), where it is in the last phase of testing, previous to go to the Observatorio del Roque de los Muchachos, ORM, where the GTC telescope is being integrated. ELMER has been developed over a global schedule of 4 years, with a cost of 1.23 M€ plus an additional effort of 12 man-year of the GTC PO engineers.

ELMER offers Imaging and Spectroscopy over a FOV of 4.2 arcmin diameter. Imaging is done with a set of broad band and narrow band filters. Spectroscopy is possible through long slits of different widths, masks for multi-object and also in a slitless mode. ELMER offers three different spectral resolutions with resolving powers of R = 250, 1000 and 2500, for the spectroscopy modes and over the whole wavelength range. These resolutions are possible thanks to the use of optimized pupil elements

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TABLE 1

ELMER GENERAL CAPABILITIES

General Capabilities	
Focal Station	Nasmyth B and Folded-Cassegrain
Wavelength range	0.365 1.000 μm
FOV	3.0 arcmin x 3.0 arcmin (4.2 arcmin diameter)
Scale at detector	0.195 arcsec/pixel
Detector Focal Plane	2048 x 4096 Marconi CCD44-82
Pixel Size	15μm x 15μm
Detector capabilities	Charge shuffling and Frame transfer
Imaging Modes	
Broad band Filters	SDSS set: g’, r’, i’, Z’
Narrow band Filters	[SII]wide 6726, [SII]narrow 6719 Hα wide 6568, Hα narrow 6567 [OI]6305, [OIII]4985 Hβ 4863, [OII]3728
Neutral density filters	ND2 and ND3
Direct Imaging	Over 4.2arcmin ϕ FOV
Fast Photometry Mode	Aperture: 3 arcmin x 12.48 arcsec
Duty cycle	$>$ 98% at 1 Hz
Charge Shuffling	yes (at 50μs/line)
Spectroscopy Modes	
Spectral resolution	R = 50-500 (2 prisms) R = 1000 (2 grisms) R = 2500 (6 VPHs)
Dispersive elements	2 prisms , 2 grisms and 6 VPHs
Long Slit	3’ x 0.6”, 1.2”, 2.0” and 5.0”
Fast short slit	20” x 0.6”, 1.2”, 2.0” and 5.0”
Charge shuffling	3’ x 0.6”, 1.2”, 2.0” and 5.0”
Mask multi-object	3’ x 3’ FOV
Positions for masks	Up to 4 depending on configuration

for each of them: prisms, grisms and VPHs (Volume Phase Holographic gratings) respectively. Finally, ELMER fast modes (Fast Photometry, Fast Slit Spectroscopy, and Charge Shuffling Spectroscopy) are possible thanks to the frame transfer (ability of exposing the upper half of the detector while reading the lower half) and charge shuffling (at a rate of 50μs/line on the readout direction) capabilities of the detector and the controller. ELMER capabilities are summarized in Table 1. This contribution includes both, the general description of the instrument, presented in an oral contribution, and the scientific performance, presented in two posters at the time of the conference.

2. TECHNICAL DESCRIPTION

Elmer is divided into the main core (common for Folded-Cassegrain and Nasmyth), the Nasmyth adapter, to attach the core to the telescope rotator flange and two cabinets, to host the electronic equipment. These cabinets will be supported on the Nasmyth attachment flange and therefore rotates with the instrument, when it runs at Nasmyth while they will be fixed on the telescope elevation ring when it operates at Folded-Cassegrain. ELMER core is functionally separated into several subsystems: Support Structure, Slit Unit, Field Lens, Collimator, two Folder Mirrors, Shutter, two Pupil Wheels, (for filter and for prism/grism/VPH respectively), the Camera, the Cryostat and the Control System. An overall description is given in Sánchez-Blanco & García-Vargas (2004). Figure 1 shows a general view of ELMER main core as-built.

2.1. *Main Optics*

ELMER optical system consists on a field lens, a collimator, and a camera, plus two folder mirrors to package the instrument into the small Folded-Cassegrain envelope. Light passes through the slit or the open position at the telescope focal plane, the field lens, a folder mirror, the collimator and the second folder mirror. Then, it passes through the shutter aperture and the two pupil wheels (filter wheel and prism/grism/VPH wheel). Finally, a 4-element camera (two doublets and two single lens) produces the image on the detector. The whole optical design has been done at the PO.

Only two materials for lens blanks (S-LAL18 from OHARA and CaF_2 from Schott Lithotec AG) were used in Elmer main optics in order to optimize the coatings. All the blanks were ordered immediately after the Preliminary Design Review, PDR, characterized at the PO, see Sánchez-Blanco, García-Vargas & Maldonado (2002), and sent to the polisher, SESO. In addition an extra Field lens in Fused Silica was polished by INAOE in order to mitigate the risk of a breakage of the large CaF_2 field lens, as recommended by the PDR panel. Optics has been exhaustively tested at both, the factory (SESO) and the PO laboratory, showing excellent performance in terms of image quality and throughput as described in Sánchez-Blanco & García-Vargas (2004).

Regarding the folder mirrors, the blanks (in Zerodur) were ordered from Schott Glass and polishing/coating was awarded to INAOE. A special blue-reflectance protected silver coating was used.

2.2. *Filters*

Four SDSS broad band, 8 narrow band and 2 neutral density for Imaging and 2 order sorting filters for spectroscopy were ordered from OMEGA Optical, where they were characterized in pass-band and

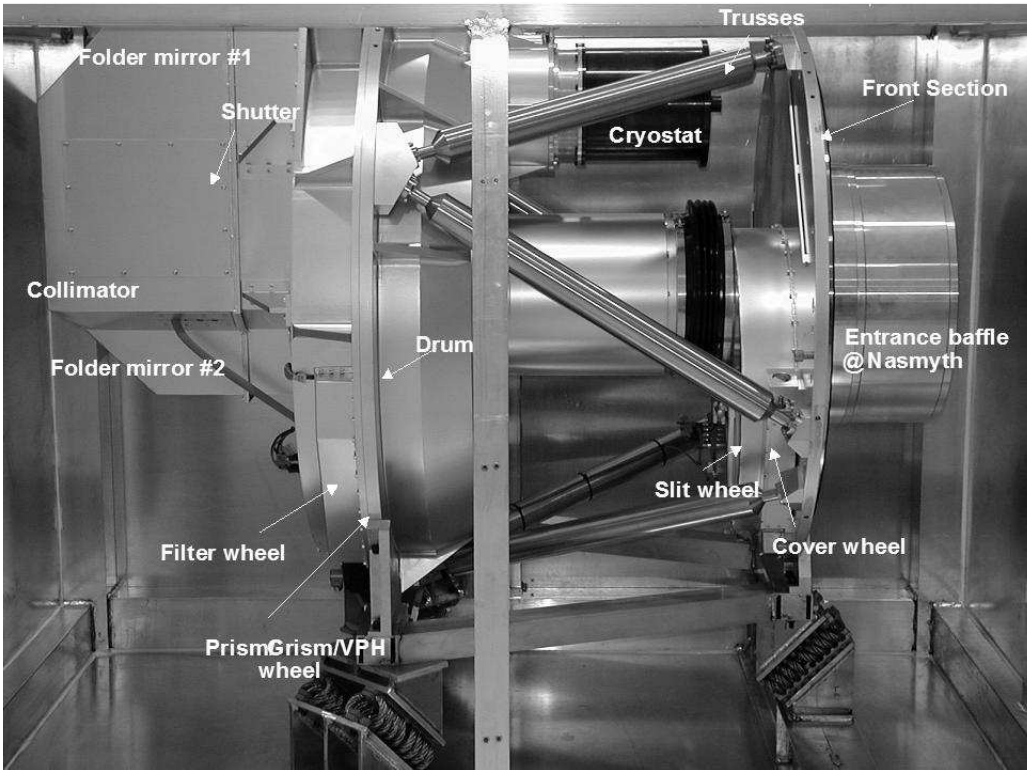

Fig. 1. ELMER main structure and mechanisms, as-built, in the special container in which it was transported from the factory to the GTC PO at La Laguna.

transmission. Filters have already been assembled on their mounts. The transmitted wavefront image quality has been measured at PO.

TABLE 2

BROAD BAND FILTER SET

Filter-ID	Central λ ± 10 Å	Cut-on(1%) ± 10 Å	Cut-off(1%) ± 10 Å	% Transmission @ λPeak
SDSS-g'	4830 Å	4070 Å	5570 Å	89.07 @ 5190 Å
SDSS-r'	6170 Å	5350 Å	6980 Å	92.69 @ 6060 Å
SDSS-I'	7720 Å	6800 Å	8630 Å	98.54 @ 8020 Å
SDSS-z'	8990 Å	8130 Å	9850 Å	94.35 @ 9480 Å

TABLE 3

NARROW BAND FILTER SET

Filter-ID	λ_c (Å) ±10 Å	FWHM	% Trans @Peak	Comments
[OII]	3727 Å			rejected
Hβ	4858 Å	27 Å	73.0 %	Hβ4861Å
[OIII]	4976 Å	57 Å	86.9 %	[OIII]4959+5007Å
[OI]	6289 Å	44 Å	87.5 %	[OI]6300Å
Hα broad	6558 Å	70 Å	81.1 %	Hα6563Å+[NII]6548Å
Hα narrow	6562 Å	16 Å	77.3 %	Hα6563Å
				[NII] 6584 Årejected
[SII] narrow	6718 Å	17 Å	87.0 %	[SII]6717Å
[SII] broad	6711 Å	70 Å	90.1 %	[SII]6717+6731Å

2.3. *Pupil elements for spectroscopy*

The final grid of pupil elements for spectroscopy is composed by 2 prisms, 2 grisms and 6 VPHs, covering the whole wavelength range with three different resolutions R=250, 1000 and 2500 respectively. Spectral resolutions are given for the nominal slit width (0.6”). All the values are given for a central slit. Table 4 summarises the available elements. Prism, Grism and VPH detailed design was done at the PO. The design was constrained by the budget that led to the need of a strong optimization of the materials, the number and size of the blanks and the cut angles in order to minimize the cost. The expected scientific performance is summarized in Section 3.3.

TABLE 4

PUPIL ELEMENTS FOR SPECTROSCOPY

Element-ID	λ coverage (Å)	λ_c (Å)	R(@λ_c)	Type
PR430-0190	3650 - 6950	4350	145	Prism
PR800-0160	6509 - 9500	8000	127	Prism
GR520-1000	3650 - 6700	5175	962	Grism
GR790-1000	5800 - 10000	7900	957	Grism
VP410-2500	3650 - 4500	4100	2463	VPH
VP480-2400	4250 - 5450	4850	2350	VPH
VP610-2300	5350 - 6850	6100	2255	VPH
VP660-2500	5800 - 7300	6550	2510	VPH
VP730-2500	6500 - 8200	7350	2481	VPH
VP880-2500	7800 - 9900	8850	2448	VPH

Prisms: We have two dispersive prisms (red and blue) for low resolution (R from 500 to 50) with a flat transmission over 90% within the whole range. The error budget available was split between the blanks and surface quality, balancing the cost versus performance. Ghost analysis was also done. Detailed opto-mechanical mounting was done in terms of positioning/tilts, thermal/mounting stress and gravitational strain. Three individual prisms compose each *prism* unit. Blanks were ordered from OHARA, characterized at PO and sent to INAOE for polishing, with the exception of the ZnSe prism (for the red-prism unit) that was ordered (blank, polishing and coating) from Janos. The process of gluing and assembling the prisms on their mounts to produce the final unit has been done at the PO, as detailed in Sánchez-Blanco & García-Vargas (2004).

Grisms: Two low-resolution standard grisms were designed to cover the whole spectral range with R=1000: one for the blue, the other one red-optimized. Blanks were ordered from OHARA. The polishing/coating of the prisms and the flat windows was awarded to INAOE. Gratings were ordered from Richardson (Thermo RGL) who replicated standard gratings on the polished windows. After testing the elements separately, the Elmer team at the PO has glued the windows to the gratings on their corresponding prisms and has assembled the units in the mounts.

VPHs: A set of 6 VPHs has been designed to cover the whole spectral range with a resolution of about 2500. A VPH grating sandwiched between two prisms composes each unit. Blanks for both, windows and prisms, were ordered from OHARA, characterized at the PO and sent to SESO for polishing and coating. Holograms were awarded to Wasatch Photonics who will finish the elements in October04. The final assembly will be done at the PO.

2.4. *Structure and Mechanisms*

A call for tender for the Detailed Design, Manufacturing, Integration and Tests of the Elmer Structure and Mechanisms was launched in July 2001. This work package was awarded to the Spanish joint venture MEDIA-SPASA, M-S. Details of the design can be seen in Ronquillo, Vega, & Cavaller-Marqués (2002). The PO and M-S have been working in a framework of a successful collaboration. The mechanism functionality and performance, the dimensional verification, the maintenance and accessibility procedures and the flexure determinations were the main topics of the testing program at factory (see Maldonado et al. and Martín-Fleitas et al., this conference). The tests were done in presence and with the collaboration of the PO Elmer team, who has been working hand by hand with the contractor to optimize the system. Ronquillo et al. (2004) describes the whole testing process at factory. The structure was delivered in October03 at La Laguna. It has been installed within a portable clean room in the IAC Workshop, where the PO team is finishing the integration and testing previous to ship the instrument to the GTC facilities at the ORM. The structure and mounts of the folder mirrors were manufactured by LIDAX (Madrid) and the mirrors have already been integrated on their mounts.

2.5. *Shutter*

It has been manufactured by the Astronomical Institutes of the University of Bonn (AIUB). The shutter working principle is based on a bi-directional slit-type shutter with two independent blades (aperture size 150mm x 150mm) driven by stepper motors. This shutter allows effective single exposure times as low as 10 ms with an time error for consecutive exposures less than 400ms and exposure inhomogeneity less than 1ms over full FOV. The maximum repetition rate is 2.5Hz.

2.6. *Detection System*

It is composed by the CCD Head (designed by the PO and manufactured at the IAC workshop) and

Fig. 2. ELMER Structure and Mechanisms as installed at the IAC Workshop, where the PO team is finishing the integration

a commercial LN2 Dewar Back (from SNLS). The complete description of the Elmer Detection System and the associated testing campaign done at the PO laboratory is given in Kohley et al. (2004) and Kohley et al. (this conference).

2.7. *Elmer Control System, ELCS*

The ELCS comprises the hardware and software of the instrument. The ELCS software is fully integrated with the rest of the GTC Control System. The main packages of the ELCS are (a) the IMCS, Instrument Mechanism Control System, to control and to monitor all the ELMER mechanisms and sensors (b) the IDAS, Instrument Data Acquisition System, which interfaces the detector controller, receiving the raw scientific data from the CCD controller; (c) the Login and Alarm services; (d) a complete User Interface; (e) the Sequencer, to operate the instrument in coordination with the rest of subsystems of the GTC; (f) the Observing Tool, to allow the users to prepare and submit their observation proposals and (g) a complete ELMER Data Pipeline with the corresponding reduction templates for all the observing modes. The ELCS hardware is composed of two Local Control Units (LCU) one for Data Acquisition (IDAS) and another one for Mechanisms Control (IMCS). Each LCU comprises a Motorola MVME2432 CPU card (running VxWorks) and Ethernet, CANopen and Gigabit communication modules, mounted on a single VME crate with a divided back-plane. These CPUs are responsible for executing the ELCS software, which controls mechanisms and data acquisition.

3. SCIENTIFIC PERFORMANCE

3.1. *Transmission*

Elmer high throughput is one of the main musts of the instrument. A specific coating demonstration program was done with SESO in order to optimise the coatings for the Elmer lenses materials (CaF_2 and S-LAL18), as described in Sánchez-Blanco & García-Vargas (2004) and Sánchez-Blanco & García-Vargas (2002).

Protected doped Ag coatings were selected for the folder mirrors, which were coated by INAOE. Table 5 shows the estimated Elmer throughput. Column 1 gives the wavelength in Å. Regarding the Optics, data correspond to real transmission measurements of the different contributors in a central aperture (except for 365nm and 388nm points for which data come from the manufacturer. Columns 2 to 5 give measured values at the PO laboratory in a central field. In particular, column 2 gives the transmission of the Field lens plus the Collimator, which were measured together; Column 3 gives Camera transmission; Column 4 and 5 gives the reflectance of Folder mirror #1 and #2 respectively. Column 6 gives the Optics transmission (product of columns 2 to 5). Column 7 is the CCD44-82 detector Quantum Efficiency (QE) measured by Marconi, as in the delivered data-sheet. The final detector characterisation will be done along the summer of 2004. Final figures will be given after the testing and characterisation period. Column 8 is the total Elmer throughput (except for the pupil elements). Column 9 gives the estimated transmission of the GTC after the 3 Al mirrors (valid for operation at both, Nasmyth and Folded-Cassegrain). The data for the GTC mirrors reflectance is based on standard Aluminium coating samples. Unfortunately, the GTC will not have UV enhanced protected silver coatings on its mirrors at Day One, what will affect significatively the final throughput. Finally, column 10 shows the predicted Elmer throughput when operating at the GTC.

3.2. *Imaging performance: Filter sensitivities*

The instrument pupil is located 50mm in front of the camera. All fields in Elmer FOV are within a pupil of 89.2mm at this position (87 mm is the footprint of each individual field). Nevertheless, the filters are located in the first wheel, which is about 200mm away from this position. So the filter is been crossed at slightly different positions for each field. Due to this reason and to allow secondary movements and alignment, the filters were specified to a clear aperture over 126mm and a physical size of

TABLE 5

ELMER TRANSMISSION

λ(Å)	FL+Coll	Camera	FM#1	FM#2	Optics	Detector (op+det)	Instrument	GTCmirrors (M1/M2/M3)	Elmer @GTC
3650	0.906	0.547	0.627	0.627	0.195	0.473	0.092	0.792	0.073
3800	0.909	0.648	0.736	0.736	0.319	0.497	0.159	0.792	0.126
4050	0.936	0.816	0.880	0.913	0.614	0.543	0.333	0.789	0.263
4360	0.896	0.836	0.957	0.957	0.686	0.647	0.444	0.785	0.349
5000	0.905	0.842	0.979	0.972	0.725	0.796	0.577	0.774	0.447
5460	0.939	0.850	0.982	0.974	0.763	0.880	0.671	0.767	0.515
6000	0.950	0.856	0.985	0.977	0.782	0.953	0.745	0.756	0.563
6500	0.945	0.872	0.984	0.976	0.791	0.987	0.781	0.741	0.579
7000	0.951	0.889	0.983	0.976	0.811	0.999	0.810	0.722	0.585
8000	0.958	0.895	0.992	0.965	0.821	0.940	0.772	0.652	0.503
8500	0.960	0.889	0.984	0.978	0.821	0.808	0.663	0.652	0.432
9000	0.941	0.882	0.990	0.973	0.799	0.585	0.467	0.707	0.330
9500	0.945	0.884	0.987	0.982	0.810	0.337	0.273	0.789	0.215
9900	0.938	0.876	0.988	0.983	0.798	0.182	0.145	0.823	0.119
10000	0.938	0.876	0.988	0.983	0.798	0.143	0.114	0,831	0,095

135mm. The filters are tilted 6° after a detailed ghost analysis that was also used to design the mount baffle. Sánchez-Blanco & García-Vargas (2003) describes the specifications, the performance and the testing results. Tables 2 and 3 summarize the as-built Elmer filter measured performance. All the values are given for a central FOV. Sánchez-Blanco & García-Vargas (2003) includes a detailed discussion on narrow band imaging effects with Elmer, which is very important to be known for the future users, as the filter profile and transmission changes over the FOV. A specific tool will be included in the Observation Proposal Management Tool to support the users while preparing observations for narrow band imaging. Filter Image quality has been also tested at the PO laboratory, as described in Sánchez-Blanco & García-Vargas (2004). From this test and the final optical design, we have predicted the Image quality in EER80 for each filter, what we will test on the real instrument along the summer of 2004. Initial measurements with filters g' and r' on the real instrument in May04 points to values of image quality better than 9μm, so that very near to the design value (and well within the requirement of having EER80 < 15.0μm, 1 pixel, for any filter and within the whole FOV). The worst value predicted for image quality degradation (difference between the optical model without filter and with the real filter) is 14%, what predicts an EER80 of 11.2 μm. We have also derived the collimator movement (in mm) with respect to the nominal position (no focus) to get the best focus, finding that all the values are within the available collimator range for focusing (-12mm to +15mm).

Table 6 shows the magnitudes observable with ELMER in Imaging Mode for 1s, 1min and 1hr of exposure time respectively and for the available filters. These numbers have been got assuming 5σ. When background limited, the difference in magnitude for a factor 60 increase in time should be 2.22 mag whereas when limited by the detector it will be about 4.44 mag.

3.3. *Spectroscopy performance: Pupil elements*

Figure 3 shows the predicted transmission for the available pupil elements for spectroscopy, as result of the detailed design. For this computation, we have considered the contributions from the diffraction efficiency, the prisms and windows transmission, the coatings performance and the internal looses. Regarding the sensitivity, we have calculated the magnitudes for a 20σ spectrum with a slit of 0.6" width and assuming a seeing of 0.6". Depending on the dispersive element and the wavelength in used, ELMER will typically reach magnitudes between 21 and 23 in 1 hr and between 15 and 17 in 1 s (for the fast modes).

TABLE 6

MAGNITUDES WITH ELMER IN IMAGING MODE

Filter-ID	t=1s	t=60s	t=3600s
SDSS-g'	23.08	25.87	28.11
SDSS-r'	22.81	25.28	27.50
SDSS-I'	22.05	24.39	26.61
SDSS-z'	21.08	23.42	25.65
[OII]	16.57	20.99	24.63
H_β	18.75	22.94	25.67
[OIII]	20.13	24.06	26.53
[OI]	19.56	22.77	25.05
H_α broad	19.85	23.41	25.74
H_α narrow	18.12	22.19	24.77
[SII] narrow	18.47	22.61	25.21
[SII] broad	20.10	23.73	26.08

3.4. *Scientific return: Data Pipeline*

Data Reduction Pipelines (DRP) are an essential tool for a quick scientific return. Real time and off-line pipeline will be fully integrated in the GTC Control System. The data shall be reduced and distributed to the astronomers and the processing shall be as complete as possible in order to ease a quick scientific return. The data that will go to the astronomer shall be composed by: (a) the raw data, both the calibration and the observation files; (b) the scientific validated data (reduced according to a standard reduction template) and (c) the non-scientific validated data (reduced also according to a standard reduction but with a higher uncertainty in the result, since it could be more user or program dependent, such as flux calibration). Also, the astronomer will be given the error frames associated to the reduction process and a quality control report done by the GTC staff. The PO Control Group is developing the complete ELMER DRP (Gómez-Álvarez & García-Dabó, this conference). The software architecture, the basic libraries and most of reduction templates for the main observing modes are already finished. A complete pipeline optimization as well as a calibration plan will be produced along this year.

4. MANAGEMENT AND PROJECT STATUS

The global ELMER Management strategy is widely discussed in García-Vargas et al. (2002). Elmer budget current estimation (at 95% spent) is 1,23M€ in money. This budget includes everything (components, external contracts...) except the detector, which is one of the spares ordered at the time of the purchase order of CCD44-82 devices from Marconi. In addition, the PO team has spent a total of 12 man-years in ELMER and a total of around 14 man-years is expected until the end of the project. The figures for the manpower come from real time reporting sheets. This computation excludes the ELCS, managed by the GTC Control Group. ELMER is also on time. Both, the PO and the sub-contractors made their best to meet the schedule. The global delay has been of 1 year over the initial plan, what we consider a success since ELMER has been done with low priority and in parallel with the other tasks within the GTC project. ELMER is currently installed in a portable clean room inside the IAC Mechanical Workshop at La Laguna (Tenerife), where the Optics were fully integrated at the end of May04. First light of the whole system on the final detector is planned by the end of September04. The tests of the final performance will be done along the next months, together with the integration of the ELCS. The calibration and maintenance procedures are also in progress and are being tested in collaboration with the maintenance and operations team, to make easier the hand-over of the instrument to the Observatory. ELMER will be shipped as soon as the telescope will be ready.

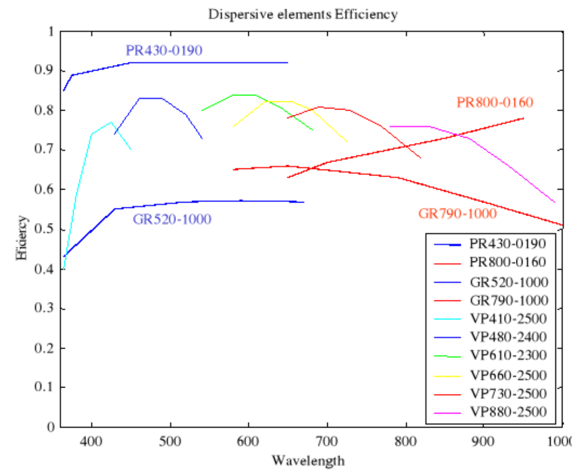

Fig. 3. Predicted transmission of Elmer spectroscopy elements according to the detailed design

5. CONCLUSIONS

The GTC PO has developed ELMER, an efficient imager and low-resolution spectrograph ready for an early scientific exploitation of the GTC. ELMER will carry out broad band and narrow band Imaging and Spectroscopy over a FOV of 4.2 arcmin diameter and spectral resolutions of 250, 1000 and 2500 thanks to the use of optimized pupil elements. Standard 1-hour exposures will allow detecting, with a high S/N, sources as weak as mag=28 in broad band imaging (5σ) and mag=23 in spectroscopy 20σ for a 0.6" slit and seeing optimized). Fast modes will allow time resolving programs of very faint targets. As an example, photometry sampled at 1s exposures will be possible for sources as faint as mv=23 with 5σ. Fast spectroscopy with S/N=20 will be possible at 1s for targets of mv=15-17. Although shutter exposures are limited by the blades movement (time resolution is of the order of 400ms) the charge shuffling capability allows the movement of a row on the detector in just 50 μs, increasing the time resolution for shutter-less exposures. In addition, the data reduction pipelines will provide a lot of scientific data for a quick scientific return for the GTC users. The PO has done the whole preliminary design, a great part of the detailed design and the management of the project, in order to minimize the risk, the cost and the delays. ELMER has consumed 1.23 M€ plus 12 man-years of the PO distributed over 4 years since the formal approval of the project in October 2000. ELMER is currently being integrated and characterized at La Laguna in order to shorten the integration and commissioning time at site. ELMER shall be shipped to the ORM as soon as the telescope will be ready.

This project has been possible thanks to the support from the GTC Project Scientist, J. M. Rodríguez-Espinosa. The Elmer team at the PO is grateful to the GTC SAC and to the people involved in the ELMER project in the different companies, whose collaborative spirit with the PO and their professional work is contributing every day to the success of Elmer project. In particular Dr. Denis Fappani and Cyril Bourgenot (SESO), Bernardo Ronquillo, Mikel Oña, Ester Porras and Miguel Angel Vega (MEDIA-SPASA), Dr. Francisco Renero (INAOE), Carlos Laviada (LIDAX), Dr. Klaus Reif (Univ. Bonn), Dr. Paul Jorden (Marconi), Dr. Juan Calvo and the workshops personnel (IAC), Dr. Francis Beigbeder (LAOMP), Calvin Grady (OMEGA), the people in their companies and many others whose work contributes to make Elmer a fact.

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REFERENCES

García-Vargas, M. L., Sánchez-Blanco, E., Cavaller, L. et al. 2002, Proc. SPIE, 4841, 1715

García-Vargas, M. L., Hammersley, P., Sánchez-Blanco, E., Kohley, R., Martín-Fleitas, J., Cavaller-Marqués, L., Maldonado M., & Vilela, R. 2004, Proc. SPIE 5492-23

Information at http://www.gtc.iac.es, where all the documents and drawings are available under request

Kohley, R., Martín, J. M., Cavaller, L., Hammersley, P., Suárez, M., Vilela, R., & Beigbeder, F. 2004, Proc. SPIE, 5492-158

Ronquillo, B., Vega, M. A., & Cavaller-Marqués, L. 2002, Proc. SPIE, 4841, 162

Ronquillo, B., Vega, M. A., Oña, M. et al. 2004, Proc. SPIE, 5492-137

Sánchez-Blanco, E., & García-Vargas, M. L. 2002, Proc. SPIE, 4411, 29

Sánchez-Blanco, E., & García-Vargas, M. L. 2003, GTC documents NTE/INST/0213-R, NTE/INST/0214-R, NTE/INST/0225-R

Sánchez-Blanco, E., & García-Vargas, M. L. 2004, Proc. SPIE, 5492-140

Sánchez-Blanco, E., García-Vargas, M. L., & Maldonado, M. 2002, Proc. SPIE, 4841, 1241

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