SARG: Documentation and performances

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Summary

We describe documentation and spectrograph performances. first we outline maintenance and users documentation commenting on their actual development status. Second, the expected spectrograph performances will be reported, providing information on the expected signal–to–noise ratio in different instrumental configurations.

1 Set-up and Maintenance documentation

The servicing documentation regards all the different useful operations in order to prepare the instrument for the observation run or in order to substitute components with their spare. Namely it consists of a collection of technical and technical specifications documents, and of the Spectrograph Maintenance Manual. In technical and technical specification documents the whole spectrograph sub-systems are described in their constructive details. They are a huge part of SARG documentation. The maintenance manual will be the reference for the TNG personnel for all operations on the spectrograph. It consists of a collection of different sub - manuals describing handling ofwith both hardware and software systems. In Table 1 the maintenance manual sub-parts are listed with their actual state of completeness.

Additionally there is a set of Reference Manuals describing:Spectrograph optics (SARG DOC–031 **complete**); SARG mechanics (*in preparation*); SARG control system (SARG DOC–032 **complete**); SARG software (*in preparation*).

2 Users documentation

The documentation for the users of the spectrograph describes all the operations necessary to prepare an observation run with SARG, how to exploit the instrument, what kind of images the user obtains and finally how it is possible to work with them. Concerning SARG Users documentation it is mainly subdivided in four items:

	Subject	**Contents**	**Status**	**Reference**
Hardware	Mechanics Optics	Parts mounting/substitution Set-up Preparation	*in preparation*	
Hardware	Optics	Alignment	*in preparation*	SARG DOC-026
Hardware	Thermal Control	Calibration and maintenance of DATCS	**Complete**	SARG DOC-025
Hardware	Thermal Control	Calibration and maintenance of Iodine Cell	**Complete**	SARG DOC-020
Hardware	Electronics	Axes Control	**Complete**	SARG DOC-016
Hardware	Electronics	CCDs	**Complete**	SARG DOC-028
Hardware	Electronics	Cabling	**Complete**	SARG DOC-023
Hardware	Miscellaneous Control	Commercial parts Characteristics	*in preparation*	
Software	Axes Control	Low level software Description	*in preparation*	
Software	Axes Control	GUI software on maintenance PC	*in preparation*	

Table 1: The collection of sub – documents of the maintenance manual

- The spectrograph WEB page
- The User's Manual
- The Exposure Time Calculator (ETC)
- The image header

2.1 WEB page

In Fig. 1 the heading of the SARG web page is shown. The internet address of the SARG web page is:

www.pd.astro.it/Sarg

In this page a concise description of the spectrograph and of its sub – systems is given. All information about the parts housing custom pieces (some CAD drawings are provided) and a complete, or complete enough, collection of SARG DOCUMENTS and MANUALS is supplied. The possibility to run the ETC has been

Figure 1: The heading of the SARG web page. The SARG web page address is: www.pd.astro.it/Sarg

planned for the instrument delivery (see Section 2.3). Successively an Help on line for the Graphic User Interface of the instrument will be implemented exploiting HTML documents and active elements. Finally it is possible to obtain all kind of information using the e-mail of SARG group.

2.2 User's Manual

The User's Manual is the main tool for the user in order to exploit the spectograph and select the best spectrograph configuration that fits with the scientific observation requirements.

It contains:

- a quick overview of instruments capabilities
- a description of the instruments: the instrument layout, its components, the properties of the slit viewer and of the CCD mosaic, the resolving power and overall efficency
- How to prepare an observation run and specifically:
  - different kind of observation;
  - recommended spectrograph configurations;
  - reference to the SARG Exposure Time Calculator;
  - spectral format and predicted signal-to-noise ratios for some spectrograph configuration

- a brief overview of the instrument control system and its GUI
- the calibration strategy (wavelength, flat–fielding, relative and absolute calibrations) of data obtained in standard operation
- some tips about the reduction pipeline of data obtained with SARG in recommended configurations

A collection of auxiliary data (filters characteristics; tables of flux and velocity standard stars; tables of Th lines and FITS keywords) for the observation programs are also provided.

The first release of the user manual is planned for the end of February 2000 while the last release is planned at instrument delivery.

2.3 Exposure Time Calculator (ETC)

The SARG Exposure Time Calculator is designed to be available on–line and with the possibility to extend the ETC itself at other kind of TNG instruments. In particular the spectroscopical optical model is already developped and it can be immediately fitted to DOLORES. On the other hand it will be easily extended to OIG and IR – instrument NICS.
In order to have a general purpose exposure time calculator, the structure of the ETC is subdivided in three well defined sub-parts:

1. User Interface
2. Data base
3. Applications Set

The User Interface is the module that allow the ETC to be available in the net. In fact it will allow remote users to set and select input parameters as: flux distribution of the object (black body; power law; template of different spectral type; object magnitude), object spatial distribution (point - like source, extended source), sky condition (moon phase, airmass, seeing), instrument set-up and exposure time (or alternativity the signal – to – noise ratio). Moreover with the ETC – UIF it will possible to select the kind of output: spectral format; signal to noise as function of wavelength; total efficency of the spectrograph; expected sky counts on the detector; input spectrum in physical units and all these quantities can be shown both in tabular and/or graphics.

The data base of the ETC includes all files containing information about the detectors characteristics and instrument optics and their efficencies, the location on the files themselves and the template spectra.

Finally the application set is the ensemble of JAVA and HTML applications that exploiting the data base, satisfy the users requests made by the SARG ETC UIF and show the results on the net.

2.4 FITS Header

In Table 2 are listed the likely FITS keyword that will be written in the SARG image header. Only those bold typed concern the spectrograph; the others are TNG standard keyword as described in Pasian et al. 1998. For the latter,the value that the keyword could assume are also indicated in the comments column.

Keyword	**Meaning**	**Comments**
DET_ID	detector id	
BITPIX	no. of bits per pixels	
PIXSIZE	size of pixel on th detector (microns)	
NAXIS	number of axes on detector	
NAXIS1	effective X dimension of image	
NAXIS2	effective Y dimension of image	
CRPIX1	reference X pixel	computed as center of CCD chip
CRPIX2	reference Y pixel	computed as center of CCD chip
CRDELT1	binning (X axis)	
CRDELT2	binning (y axis)	
DETOFF1	X offset on detector	
DETOFF2	Y offset on detector	
DETSIZ1	detector size (X axis)	
DETSIZ2	detector size (Y axis)	
SYSID	system id	
DATE-OBS	date of observation	computed
MJD-OBS	julian date of observation	computed
EXPSTART	exposure start time (UT)	computed
EXPTIME	length of exposure	
OBJECT	name of th object	
COMMENT	observer's comments	
OFFSET1	detector offset 1	
BIAS1	detector bias 1	mean value
TEMP1	detector temp 1	mean value
GAIN	detector gain	mean value
OBS-MODE	SARG observation mode	SCI, HPRV,LONG, LCA
OBS-TYPE	SARG observation type	OBJ,CALI...
LMP-ID	SARG lamp id	FF1,FF2,FF3,TH,HG
LMPSTSAT	SARG lamp status	ON, OFF
SLIT_ID	SARG slits id	.....
FILTER_ID	SARG Colored filters id	.....
FILTER2_ID	SARG ND filters id	.....
GRISM_ID	SARG grisms id	CD1,CD2,CD3,CD4,NONE
FOCUS	Focus position (counts)	
IODINE_S	SARG Iodine Cell status	ON, OFF

Table 2: The SARG image header FITS. Keywords in bold characters concern the instruments, the others are standard TNG.

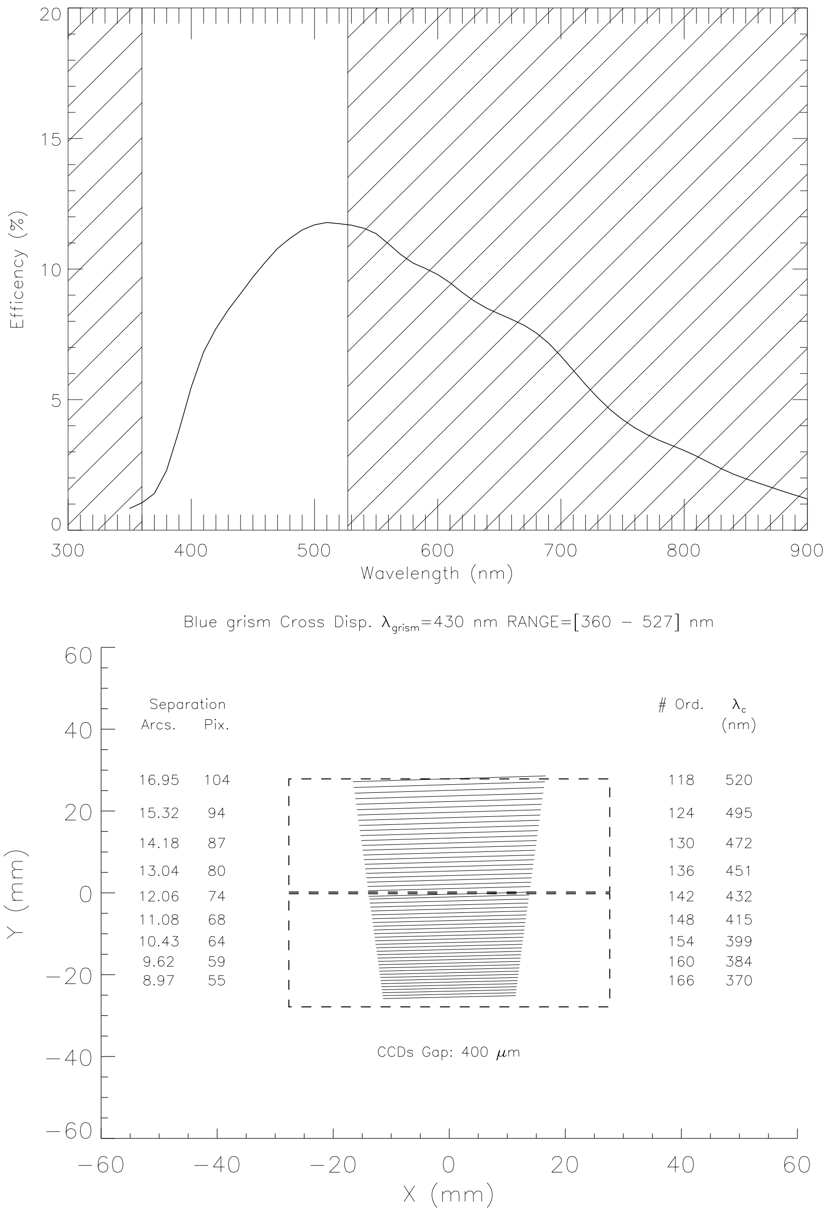

Figure 2: *Panel a*: SARG efficency in short slit observing mode with the blue grism cross disperser. *Panel b*: SARG spectral template evaluated with blue grism cross disperser. The grism wavelength is 440 nm. The dashed box correspond to the CCD mosaic ($2 \times 2046 \times 4096$ EEV) with a gap of 400 μm in between

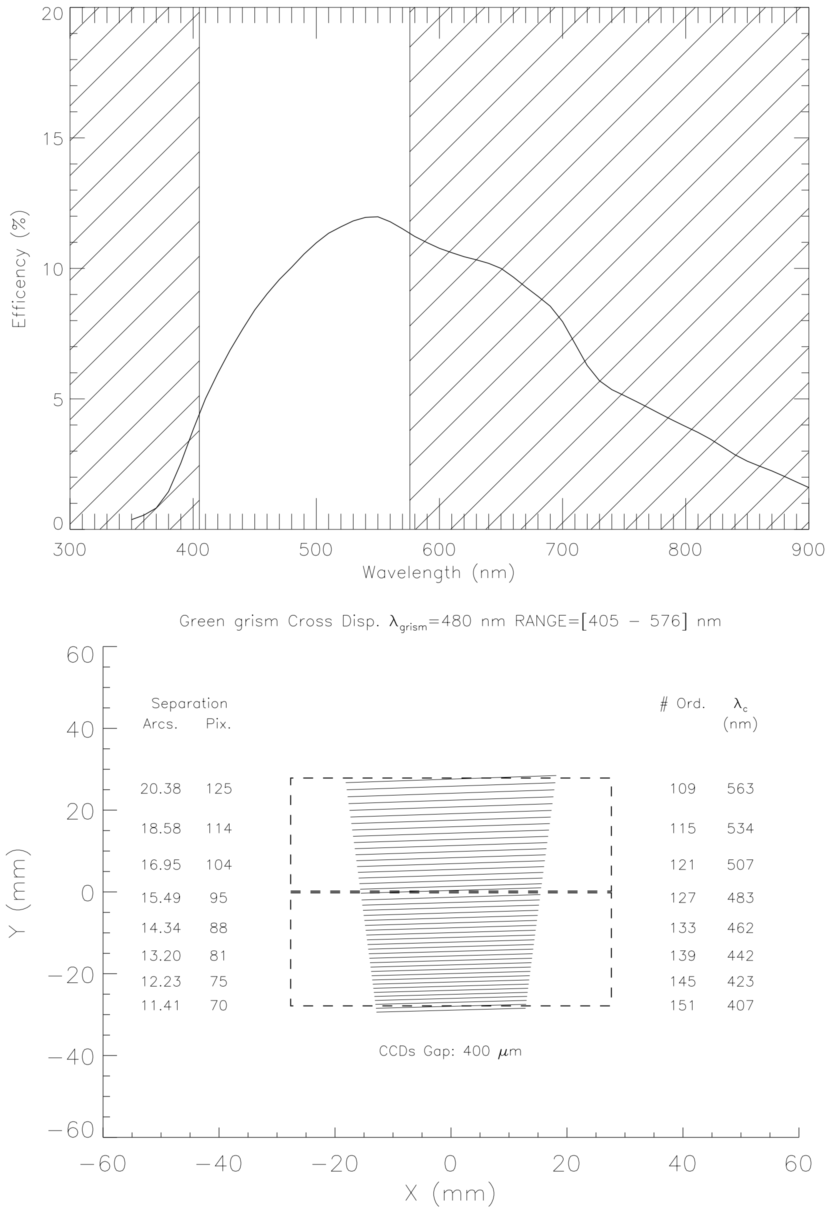

Figure 3: <u>*Panel a*</u>: SARG efficency in short slit observing mode with the green grism cross disperser.

<u>*Panel b*</u>: SARG spectral template evaluated with green grism cross disperser. The grism wavelength is 490 nm. The dashed box correspond to the CCD mosaic ($2 \times 2046 \times 4096$ EEV) with a gap of 400 μm in between

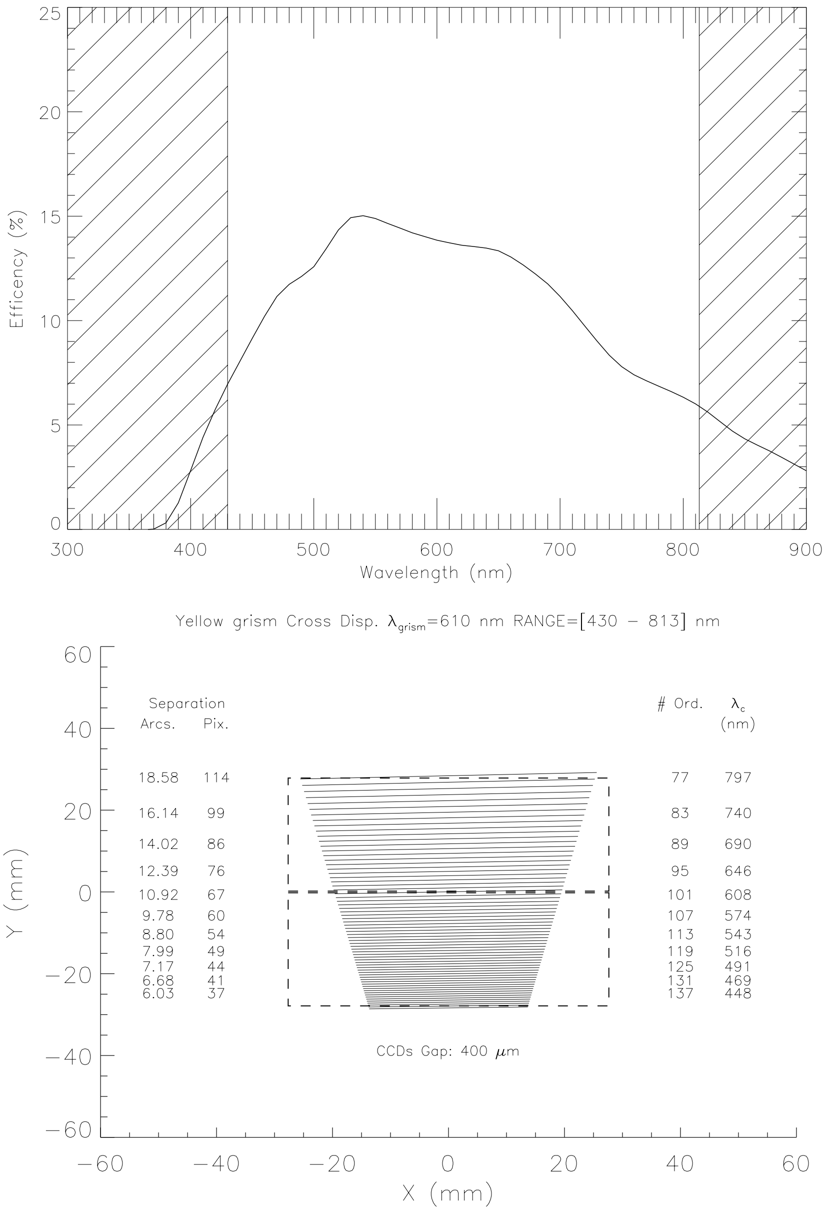

Figure 4: ___Panel a___: SARG efficency in short slit observing mode with the yellow grism cross disperser.
___Panel b___: SARG spectral template evaluated with yellow grism cross disperser. The grism wavelength is 620 nm. The dashed box correspond to the CCD mosaic ($2 \times 2046 \times 4096$ EEV) with a gap of 400 μm in between

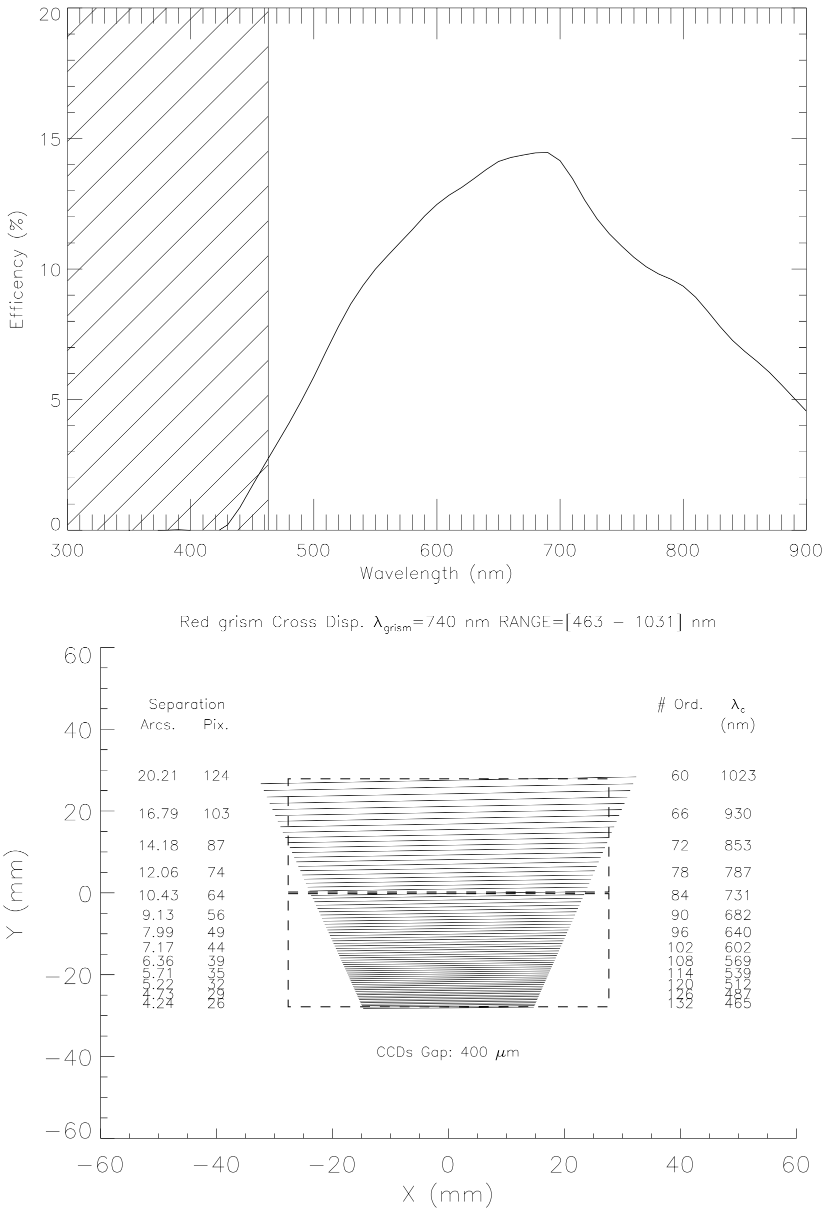

Figure 5: <u>*Panel a*</u>: SARG efficency in short slit observing mode with the red grism cross disperser. <u>*Panel b*</u>: SARG spectral template evaluated with red grism cross disperser. The grism wavelength is 750 nm. The dashed box correspond to the CCD mosaic ($2 \times 2046 \times 4096$ EEV) with a gap of 400 μm in between

3 SARG efficency and Spectral format

The overall SARG efficency is determined mainly from the efficiency of the main optical train (preslit optics, collimator and camera) but it is also affected by the selection of grisms acting as cross dispersers.These optical elements modify also the spectral format obtained when combined with the R4 echelle grating dispersion. Both overall efficency and spectral format obtained with the four different cross disperser are shown in Figure 2, 3, 4 and 5. The overall efficiency was evaluated exploiting the measured value of the optical element transmission as given by the manufacturers. Telescope reflectivity and atmosphere transparency were evaluated as in Allen C.W. 1963. Slit losses are for the medium resolution (R=86,000) slit (0.53 *arcsec*) for a seeing of 0.8 *arcsec* (FWHM). Effects like the scale variation along each order due to anamorphosis and distorsion due to camera are not considered when computing the format of the spectra.

The main characteristics (spectral range, peak efficency and minimum order separation) are listed in Table 3.

	BLUE	GREEN	YELLOW	RED
Spectral Range (nm)	360–527	405–576	430–813	463–1031
Peak efficency (%)	11.8	12.0	15.0	14.5
Minimum separation (arcsec)	8.6	11.4	5.7	4.3

Table 3: Summary of Cross disperser Grism Characteristics

4 Expected S/N for some SARG Configuration

As an example of expected performances of SARG, we give in Figure 6 the expected S/N as a function of the visual magnitude and the exposure time for three spectrograph configurations (R=17,000; R=43,000; R=86,000). Moreover in Figure 7 the expected S/N as function of the visual magnitude and exposure time exploiting the image slicer is given. This is the configuration to be used for high precision radial velocities with the iodine cell when the yellow grism is used.

References

[1] Allen C.W., 1963, **Astrophysical Quantities**, *The Athlone Press*

[2] Pasian F., Smareglia R., Vuerli C., 1998, OAT Technical Report n. 43

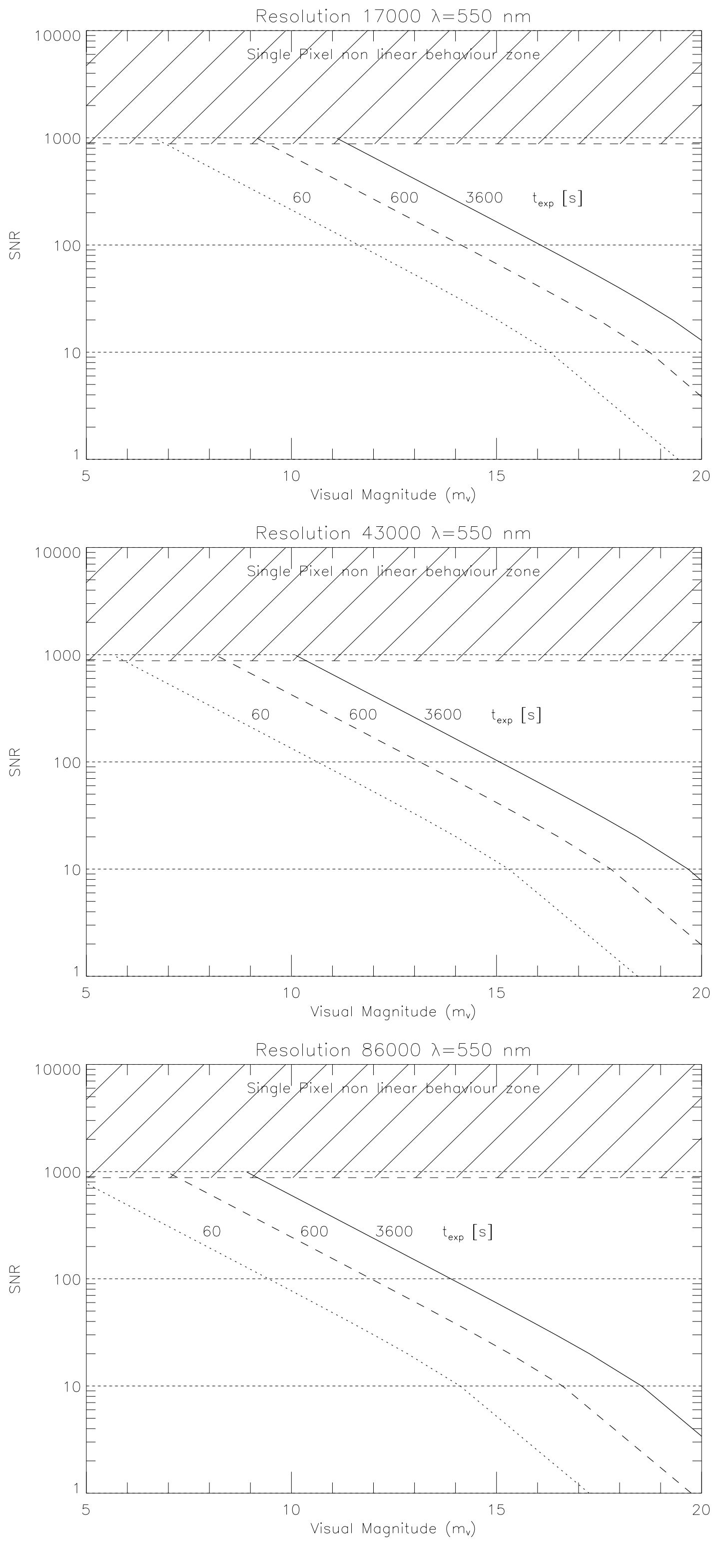

Figure 6: The S/N ratio for resolution element as function of mv for three different exposure time (60 s, 600 s, 3600 s) is shown. A median seeing (0.8 *arcsec* (FWHM)) was considered. Other data: RON 7 e^-; $m_{sky} = 21.8\ mag\ arcsec^{-2}$ and $7e^- hr^{-1} pix^{-1}$ as dark current. The zone where the behavior of the single pixel of the detector is no more linear is also indicated. ***Panel a***: R=17,000, wl=550 nm; projected slit spans 17 pixels. ***Panel b***: R=43,000, wl=550 nm; projected slit spans 7 pixels. ***Panel c***: R=86,000, wl=550 nm; projected slit spans 3 pixels.

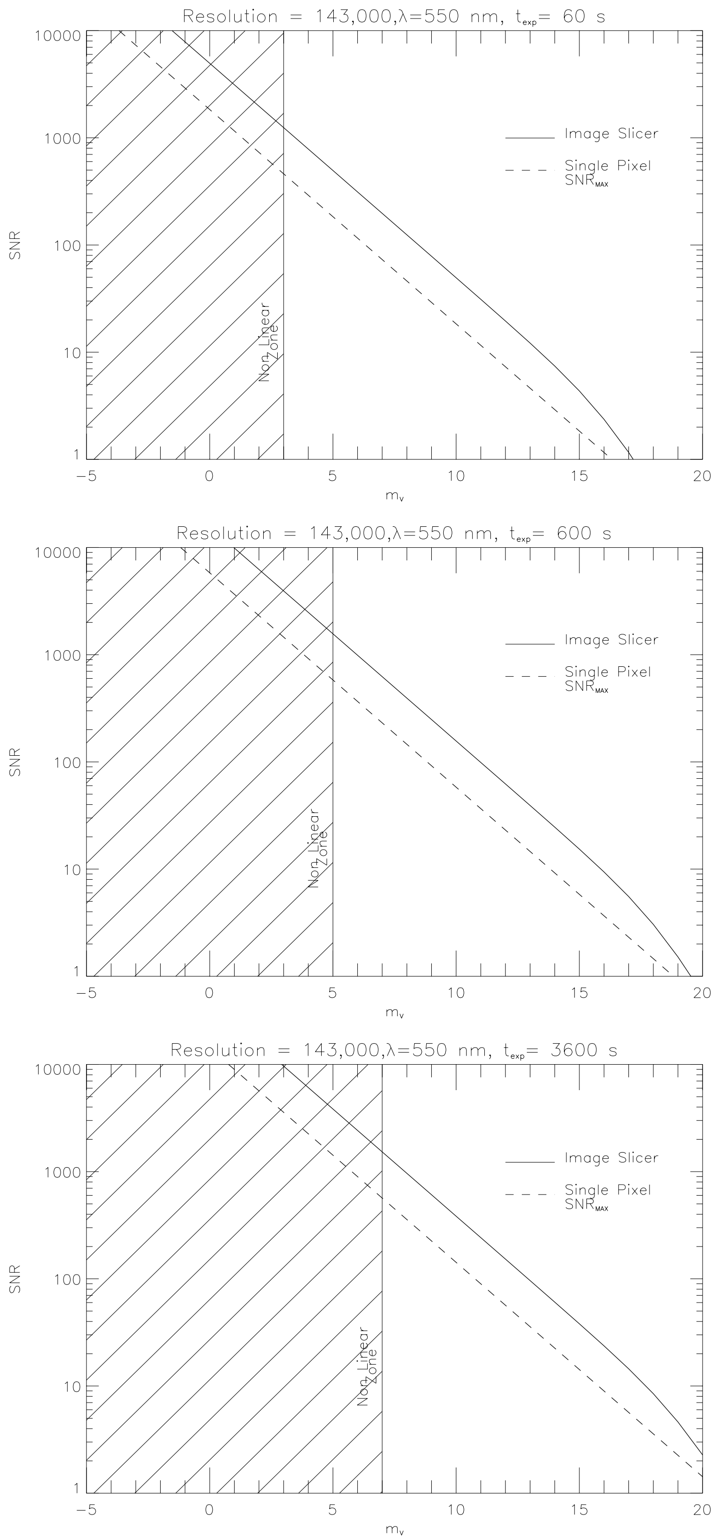

Figure 7: In the three panels the S/N ratio for resolution element (R=143,000, wl=550 nm) as function of m_v for three different exposure time (60 s, 600 s, 3600 s) together with the maximum value of the S/N ratio in the single pixel is shown. In SARG this resolution is feasible with the Diego image slicer (a modified Bowen - Walraven image slicers with 5 slices). A median seeing (0.8 *arcsec* (FWHM)) was considered. Other data: RON= $7e^-$; $m_{sky} = 21.8\ mag\ arcsec^{-2}$ and $7e^- hr^{-1} pix^{-1}$ as dark current. The zone where the behavior of the single pixel of the detector is no more linear is also indicated. In all panels the yellow grism X disperser was considered