Call for Science Verification Observations with the SALT High Resolution Spectrograph

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Introduction

In December 2011 an “Expressions of Interest” (EoI; see http://salt4scientist.salt.ac.za/hrs/) document for the science verification phase of SALT HRS was distributed to the community. This was in anticipation of the instrument’s delivery in 2012, which clearly was not achieved. Now the instrument is going through its final assembly and testing phase ahead of being shipped to SALT (now anticipated to arrive in August). The initial re-assembly and commissioning is expected to take 4-6 weeks, meaning that the science verification phase could begin by late September.

We are therefore soliciting SALT HRS science verification proposals, with the call opening on 1 July 2013 and a deadline for applications by 15 August 2013.

These programs will be undertaken on a shared-risk basis and will not be charged to partners allocations. A modest amount of time (~50 hours in 2013-1 semester, and probably a similar amount in 2013-2) is being set aside for these programs.

Science Drivers

The SALT HRS science case was developed through community consultation (see the EoI) when the instrument was undergoing its design phase. A number of scientific applications were identified which informed later design stages.

It is expected that the science verification programs will address some of these drivers, but scaled to a suitably short duration (i.e. for completion within ~ 1 - 3 months). Some science programs may therefore not be appropriate (e.g. long term monitoring). The science verification programs are aimed at demonstrating HRS’s *science capabilities*, but not necessarily to produce completed science programs. Thus while publications stemming from these observations will be a bonus, *the main aim is to show how the instrument performs and compares to other similar instruments.*

Submitted proposals will therefore be vetted in terms of the above requirement by the HRS commissioning team in consultation with SALT Astronomy Operations.

Description of Operational Modes

Low-Resolution Mode (with Nod and Shuffle)

The lowest resolving-power, $R = 16000$ configuration should be seen as a specialist mode. This configuration offers the same fibre input diameter as the $R = 37000$ mode but with two beneficial differences: nominally 1.4× higher throughput because the fibre output is not image-sliced (hence the coarser resolution), and the opportunity to use nod-and shuffle for improved sky subtraction. The nod-and-shuffle operation samples two different sky fields on either side of the target, for half of the total exposure time in each case. It ensures that object and sky spectra can be extracted from the same pixels on the CCD. In addition, the starlight falls on two different regions of the CCD (corresponding to the two fibre positions) and hence benefits from a SQRT(2) reduction in the impact of residual flat-field noise, but without an increase in read-noise.

This improvement in sky sampling and reduction in flat-field residuals will benefit observations of the faintest targets requiring the lowest resolving power. Examples where the lowest resolving power may be tolerable and where the improved background sampling might be beneficial include spectroscopy of diffuse interstellar bands against lines of sight to distant stars or quasars, and molecular band analyses of stars in Local Group galaxies.

Medium Resolution Mode

The $R = 37000$ mode is expected to be the most commonly used SALT HRS mode. It has adequately high resolving power for many projects but with a larger fibre diameter and larger throughput than the $R = 65000$ mode. Studies of objects whose intrinsic line widths are broader than two resolution elements of the $R = 65000$ mode, such as rotating stars (e.g. most O and B stars), stars in which the Balmer line strength measurements are the principal aims, and studies of molecular bands at medium resolution are likely to benefit from the resolving power vs throughput trade-off available in this mode.

High Resolution Mode

The $R = 65000$ mode is likely to be selected only by those projects for which the lower throughput compared to the $R = 37000$ mode is more than offset by the greater resolving power. One such category of observations will be studies of line profiles in investigations of stellar atmosphere dynamics, resolving closely spaced lines, or the study of absorbing structures in the interstellar or intergalactic medium at the highest velocity resolution. Studies that benefit from fine sampling of the stellar line profiles, such as the most precise radial velocity work, will also utilise this resolving power. Recall, however, that the wavelength stability of the instrument as a whole will be much higher than in traditional non-vacuum spectrographs, and astronomers may find they can achieve adequate velocity accuracy even at $R = 37000$ because of the improved systematics compared to other spectrographs.

High Stability Mode

The high stability mode is optimised for precision radial velocity measurements and will be implemented at $R = 65000$, because of the importance of adequately sampling the line profiles in order to achieve sub-resolution element accuracy. (An error of $0.5\ \mathrm{m\ s^{-1}}$ corresponds to 10^{-4} of a resolution element!). The light path includes a 'double scrambler' to improve the radial scrambling of the fibres and reduce the spectral shifts due to the star moving on the input face of the fibre. In this mode it is also possible to place an iodine cell in the beam (both channels) to provide a superimposed set of wavelength reference lines in the 500-620 nm range, or to illuminate the second (sky) fibre with an internal Th-Ar calibration source to obtain a simultaneous wavelength calibration. The efficiency of this mode is therefore expected to be ~50% - 70% of the normal high resolution mode and would normally only be used where this level of wavelength stability is essential. It should be noted that at the time of science verification, the iodine cell might not have been fully characterised (i.e. no Fourier Transform Spectrometer spectra available, only the commonly available generic iodine atlases).

Calibration

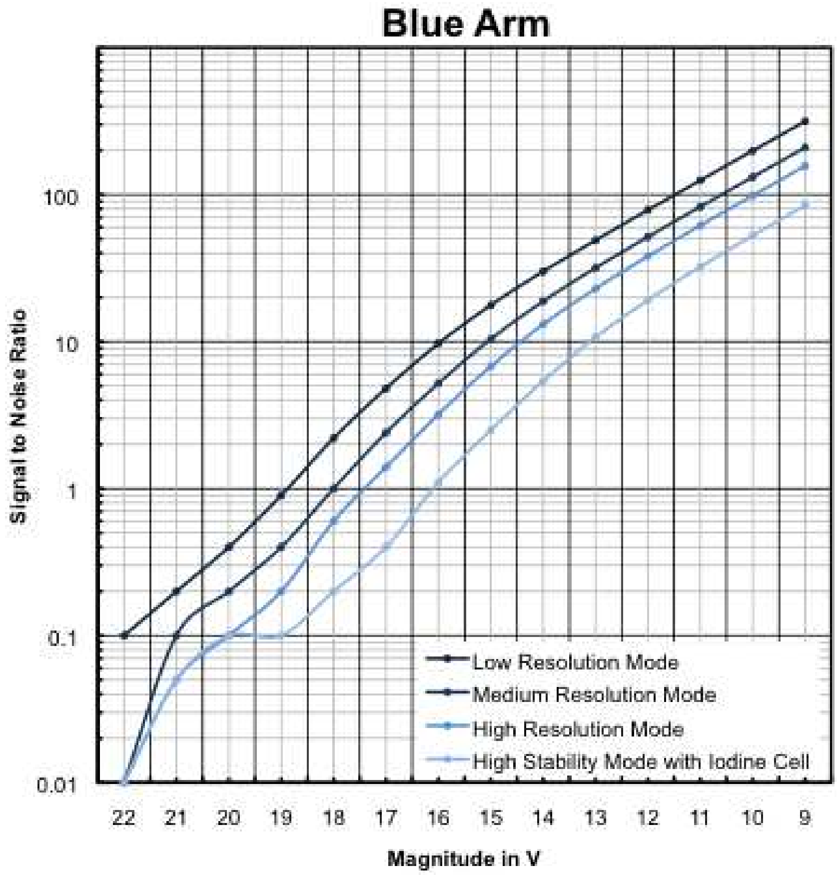
Wavelength calibration for the first three modes will be undertaken using the SALT Calibration System and consist of a set of Th-Ar hollow-cathode lamp spectra obtained through both fibres. These calibrations will normally be taken during the day. Spectrophotometric standard stars will normally be observed during twilight (at no cost), although they can be requested (as indeed can other standards or calibrators) at other times during the night, which will be charged for.

SALT HRS is equipped with an exposure meter, which is available for use in all four operational modes. Time-indexed photon counting data should therefore be available for use.

Table 1. Summary characteristics and efficiency predictions

Parameter	HR Mode	MR Mode	LR Mode	HS Mode
Features				
Fibre diameter (arcsecs)	1.56	2.23	2.23	1.56
Slit width (arcsecs)	0.355	0.710	1.673	0.355
Image slicers	3 slices	3 slices	No	3 slices
Blue arm resolution	64400	36600	16200	64400
Red arm resolution	69200	37300	16200	69200
Blue arm transmission (total %) at 450nm*	2.8	3.0	6.8	1.7
Red arm transmission (total %) at 750nm*	4.2	4.5	9.8	2.5
Fibre mode scrambling	No	No	No	Yes
Options				
Nod & Shuffle	No	No	Optional	No
Iodine cell**	No	No	No	Optional**
Simultaneous ThAr**	No	No	No	Optional**
Total photon count***	Yes	Yes	Yes	Yes

* These efficiency values include telescope, fibre/slit losses and spectrograph throughput, which represent throughput predictions based both on theory and include actual performance measurements of some sub-systems, where possible. They are therefore subject to update in the near future when 'end-to-end' measured data becomes available for the spectrograph as a whole.
** Note that the Iodine cell and simultaneous ThAr feed cannot be used simultaneously.
*** From exposure meter.



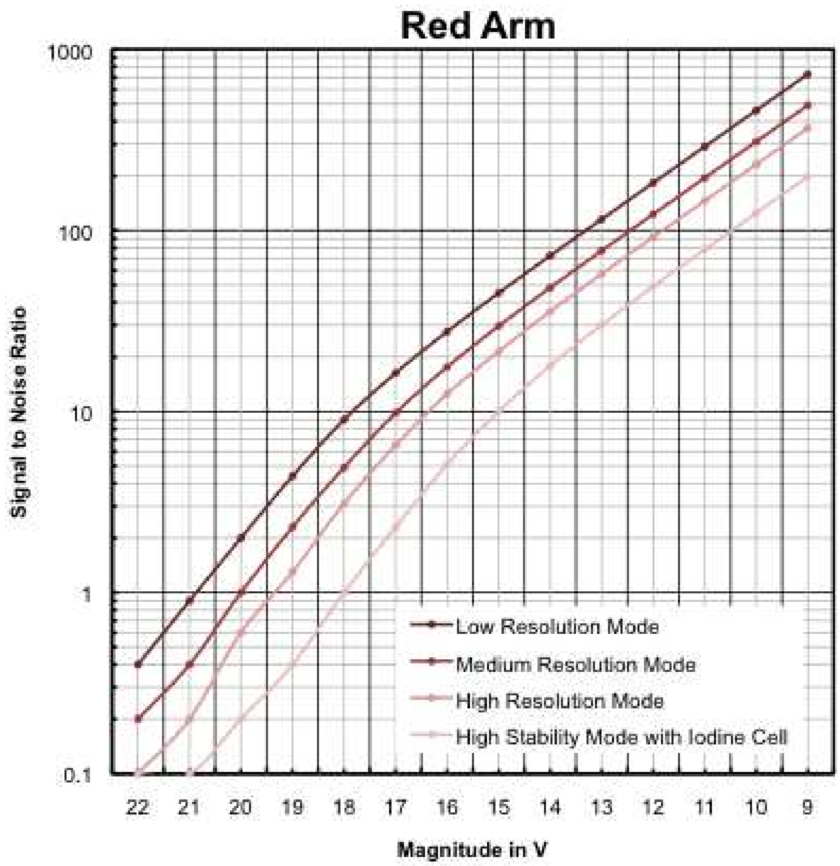


Figure 1. The expected signal to noise ratio (S/N) of SALT HRS as a function of stellar visual magnitude (m_v). The calculations are for wavelengths of 460 (blue arm) and 725 nm (red arm) and the low (R~16,000), medium (R~35,000) and high (R~65,000) spectral resolving powers. A blackbody object with surface temperature of 5500K, 2 arcsec FWHM seeing at the fibre input, exposure time of 1800 sec and a telescope airmass of 1.3 are assumed. The sky brightness is calculated assuming the moon to be at first quarter. The S/N is for each extracted half-resolution element at the échelle blaze peak.

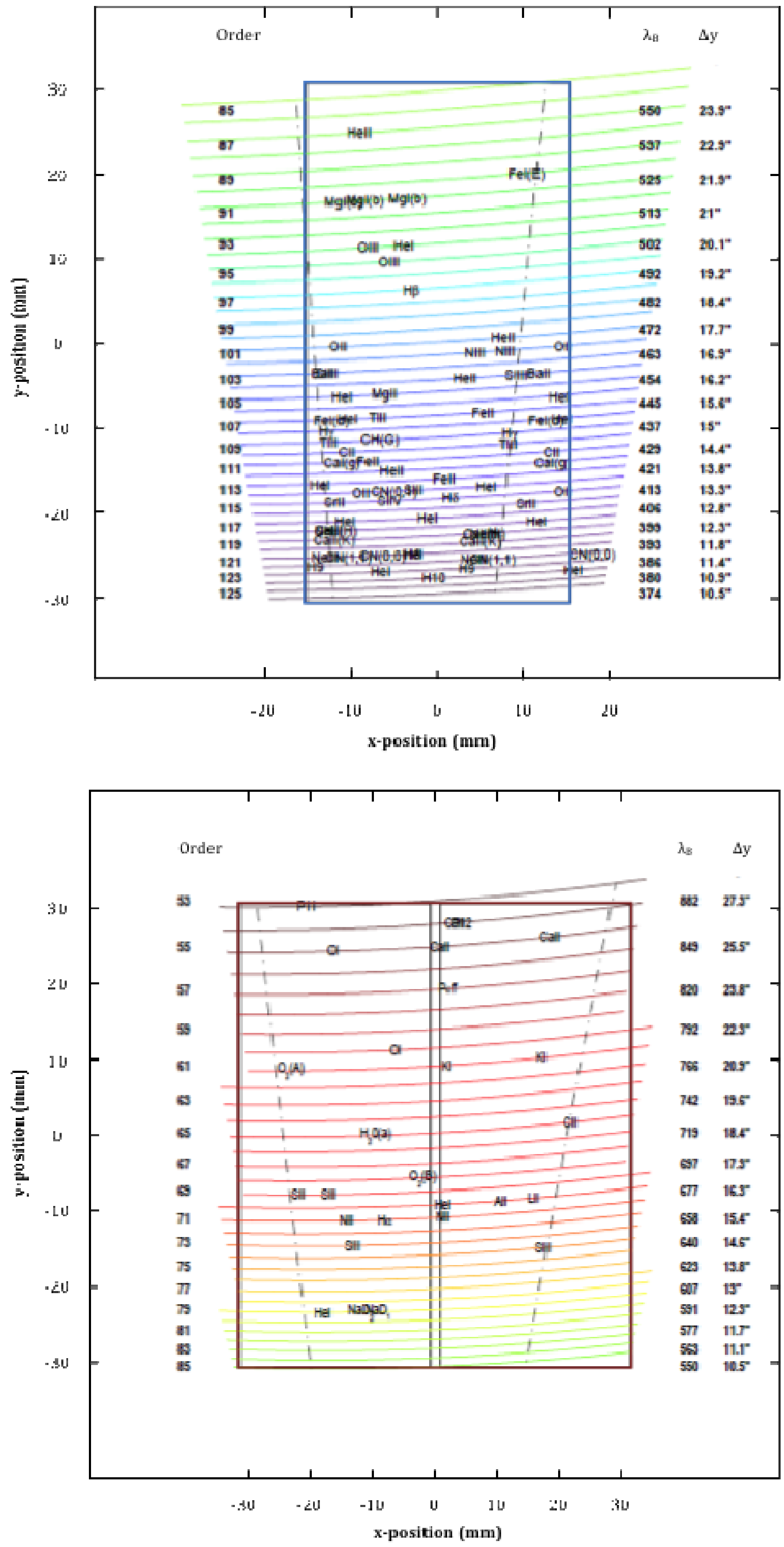


Figure 2. Wavelength coverage for the blue (top) and red (bottom) arm of SALT HRS. Key spectral features are noted on each image.

Call for Science Commissioning Programs

SALT is pleased to make this call for expressions of interest from members of the SALT user community for observations to be made during the science verification phase. Proposals should be submitted using the SALT proposal tool (PIPT) by 15 August 2013. This will be the same Phase 2 procedure as for the existing instruments, SALTICAM and RSS. The tool will be updated by 1 July to allow the required HRS parameters to be entered.

Note that the "commissioning" button should be clicked when the proposal is generated.

As for Phase 1 proposals for SALTICAM and RSS, part of the required information is provided in form of a pdf file. Word, OpenOffice and LaTeX templates for this file can be downloaded from http://salt4scientist.salt.ac.za/phase-i-proposal-templates/.

The proposal should contain the following information, some of which will be entered into the PIPT, and some in the supporting PDF file (scientific & technical justification, immediate objectives):

- name of proposers, email addresses, and their institutions
- resolving power required and whether special modes are required (e.g. nod and shuffle at R = 16,000; iodine cell; simultaneous ThAr)
- targets, which must be available in the latter part of 2013/early 2014 (i.e. for semesters 2013-2 and 2014-1)
- observation times, not exceeding 25,000 s in total, for the proposal (inclusive of overheads)
- calibration requirements (especially any non-standard calibrations)
- scientific and technical case for the observations and a statement of why these observations would be a good test or demonstrator of HRS capabilities (in Sections 11 – 13 of the proposal form)
- confirmation that the proposers reasonably expect to *have the resources and the time to conduct the scientific analysis of any science verification observations and feedback to SALT and the HRS development team on the outcome of the observations* within four weeks of receiving the data.

Data taken during the Science Verification phase will be made available for use by the HRS development team, SALT operations and others within the SALT consortium for the purposes of examining or reporting on the performance of the instrument. They will be placed on an accessible FTP site.

The Science Verification phase will be limited to the extent necessary to prove the performance of the instrument, with an expectation of allocating ~100 hours in total during 2013 Semester 1 & 2 (from late Sep 2013 – 30 Apr 2014).

Programs accepted for Science Verification will *not be charged for*, as in previous commissioning calls.

Proposals will be assessed by a panel established by the SALT Science Director specifically for the HRS science verification phase, having regard to the suitability for the projects for testing, proving and demonstrating the capabilities of HRS, and to their greater scientific merit. The panel will consist of the HRS Principal Investigator and Science Advisor and other members of the HRS commissioning and operations teams.

More information and FAQs regarding the proposal process can be found on http://salt4scientist.salt.ac.za/, and any questions should be directed to salthelp@saao.ac.za.

Software for planning and creating the proposal

As mentioned above, the proposal needs to be created with the PIPT, which can be downloaded from http://salt4scientist.salt.ac.za/pipt/. A version including HRS will be available from 1 July.

In addition, a simulator tool for planning your HRS observations will be available from 1 July. This tool will work in the same manner as the existing simulator tools for RSS and SALTICAM. It will give an estimate of the expected SNR across the wavelength range of HRS for a spectrum you supply. You will be able to download the HRS Simulator from http://salt4scientist.salt.ac.za/simulators-and-other-tools/.

Both the PIPT and the HRS Simulator require that Java 1.6 ("Java 6") or higher is installed. Using the Java version provided by Oracle (www.oracle.com/technetwork/java/index.html) is highly recommended.

The current version of the tool has the best available estimates of efficiency included as of the time of this call, which are based, where possible, on actual laboratory measurements (e.g. mirror reflectances, échelle & CCD efficiencies, fibre slicer throughputs), but there are some remaining uncertainties (e.g. how well the fibre injection will perform, fibre FRD losses, etc.). To account for these uncertainties we have applied a “fudge factor” to account for the potential reality of actual on-sky performance. As we proceed with commissioning we will revise this factor and hopefully converge on a more reliable estimate of the instruments performance for a variety of conditions (e.g. seeing, image quality, Moon).

References

Design specifications for HRS are published in:

Barnes et al 2008, Proc of SPIE 7014, 70140K

Bramall et al 2010, Proc of SPIE 7735, 77354F

Bramall et al 2012, Proc of SPIE 8446, doi:10.1117/12.925935

The aforementioned SPIE papers are available from http://salt4scientist.salt.ac.za/hrs/, in addition to the 2012 EoI and other relevant SALT HRS documentation (e.g. Functional Performance Requirements, Commissioning Plan etc.).