Southern African Large Telescope

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Signature:____________________ Date:______________

Abstract

This document provides information to potential SALT proposers that will assist in making their Phase 1 & 2 proposals for 2017 Semester 1 (1 May 2017 - 31 October 2017). It summarizes the essential features for new users, the latest instrument status, and changes from previous semesters. It incorporates the latest experiences from SALT Astronomy Operations regarding telescope and instrument performance. The instrument simulator tools have been updated to reflect the current situation. The document also includes proposal policies and related information. The SALT website should be consulted from time to time for further updates. **The Phase 1 proposal deadline is 1 February 2017 at 16:00 UT. The Phase 2 proposal deadline is 12 April 2017 at 16:00 UT.**

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Quick start: Information for new and returning users

SALT is an optical 10-m class segmented-mirror telescope situated at a dark site in Sutherland South Africa. SALT is especially suited for spectroscopic and high-time resolution observations. SALT is queue scheduled with possibilities for real-time input from the PIs and fast turnaround data delivery. Target visibility is in the range of DEC = +11 to -76 deg.

How is SALT different from most other large telescopes?

- How long a given target is available during a night is Declination dependent, ranging from over 4h for Equatorial and DEC<-65 targets to typically 1-1.5h in a rising or setting track elsewhere. The *continuous* visibility of a target is 2-3h in between -60<DEC<-76, while for Equatorial objects a practical maximum time on-source with a single visit is about 45 minutes. Be sure to read the essential concepts in Section 2. It is especially important to grasp the meaning and difference of *visibilities* and *tracks*.
- The SALT pupil changes during an observation. Relative calibration is possible by e.g. using comparison stars in imaging, and spectral shapes can easily and reliably be calibrated using spectrophotometric standards. Accurate absolute (spectro)photometric calibration should be done using supplementary information about the target fields from elsewhere.
- The primary mirror is segmented. An active mirror alignment system (SAMS) was implemented in April 2016, the PSF is very stable during the night. Nevertheless, Sutherland remains a site with modest seeing (median value at Zenith about 1.5 arcsec). PIs should recognise that while both imaging and faint object spectroscopy with SALT are more viable now than in the past, the size of typical PSF still means the S/N of faint point-sources is lower compared to observations done in sub-arcsec seeing.

What is SALT especially suited for?

- The large collecting power and dark (V = 22.0 mag/sq.arcsec at zenith during lunar minimum) skies mean that diffuse low surface brightness objects are ideal for very competitive results.
- Likewise, brighter objects where most of the light is above background regardless of the PSF size and shape, can be observed very efficiently.
- There are several modes of spectroscopy, including multi-object, Fabry-Perot and polarimetric capabilities. Some of these observing modes are rare on large telescopes. All modes are available all the time, SALT is capable of changing modes and instruments on-the-fly in less than a minute, as well as combining modes.
- Read Sections 4.3, 6.3, 7.5 and 8.3 for information on instrument sensitivities and, above all, play with the Instrument Simulators availalble at http://astronomers.salt.ac.za/software/.

How to get time and observations?

- SALT is owned by a consortium. Time must be allocated by one (or more) of the Partners, though individual investigators may come from non-partner institutes. See Section 3 for the application process, which consists of a Phase 1 and Phase 2. The PIPT software has to be used for submissions.
- There is a small amount of open and free Director's Discretionary Time (see also Section 11.5) available outside of the normal proposal process. There is also uncharged filler time (P4, Section 11.2) available.
- SALT is 100% queue scheduled. You apply for a given *amount* of time, not for certain dates, though time windows can be specified for time-restricted targets. You do not come to observe yourself, but will receive the data after each individual observation has been taken. This also makes long-term monitoring possible.

Strategic tips, tricks and hints

- Over the past semesters, Bright time has been undersubscribed. If you have targets that can be observed in fairly bright moon conditions (e.g. >70% Lunar illumination) you have fairly good chance of getting data.
- Programs that are possible to do in poor seeing (>2.5") also have lower competition.
- Much of the observational competition is driven by the *distribution* of targets on the sky. Check out a historical figure below. If you have targets in low-target-density regions, you will have higher chances of getting your observations done.
- PIPT allows you to submit *more* blocks than your time allocation: you can define a *Pool of optional targets*. This is especially useful if you have a target list with a wide RA-range.
- You should plan for these optional targets already in Phase 1 by, for example, submitting a sample of 50 objects, but telling your TAC that you will get the necessary statistical science from any 15 of them. Having this background pool will greatly increase your chances of getting those 15 done, and it may also be an advantage to show your TAC that you are using your Partner time wisely.
- PIPT also allows you to submit P4 time. There is no limit for this time, and it does not come out of the Partner share allocations. The time is "free" if you just convince your TAC to accept the project in principle. See Section 11.2. P4 blocks will only be done if there is nothing else available in the queue, due to gaps in the queue, or due to poor conditions. Hence, the most effective P4 programs comprise:
    - short blocks, say, 15-30 min long which are easy to plug into gaps
    - bright targets, say, 10-17 mag, easily done in any conditions
    - a large pool over a wide RA-range to have something available at any time.

Looking into the future

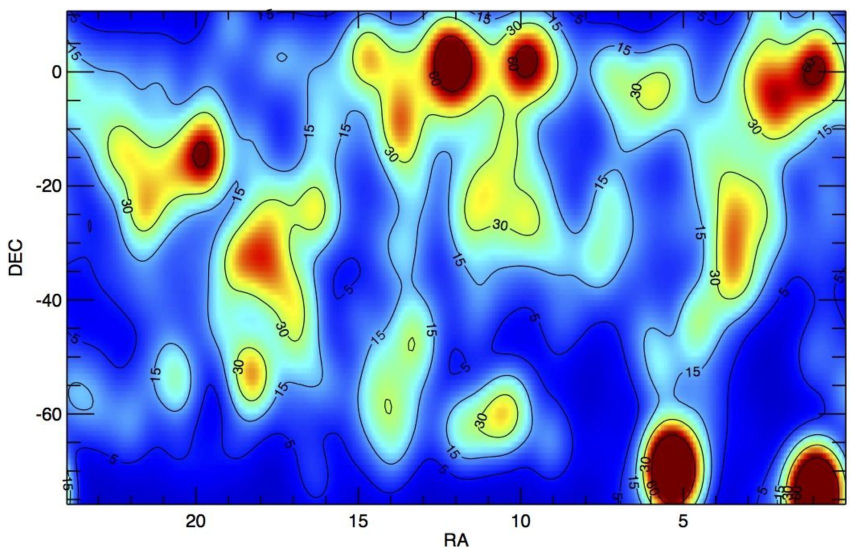
- More polarimetric modes are becoming available over the coming year, and users are encouraged to contact salthelp to indicate their priorities.

- RSS will get NIR spectroscopic capabilities in, likely, 2019. The current plan is for an IFU unit in the J and H-band.

Historical target distribution on the sky

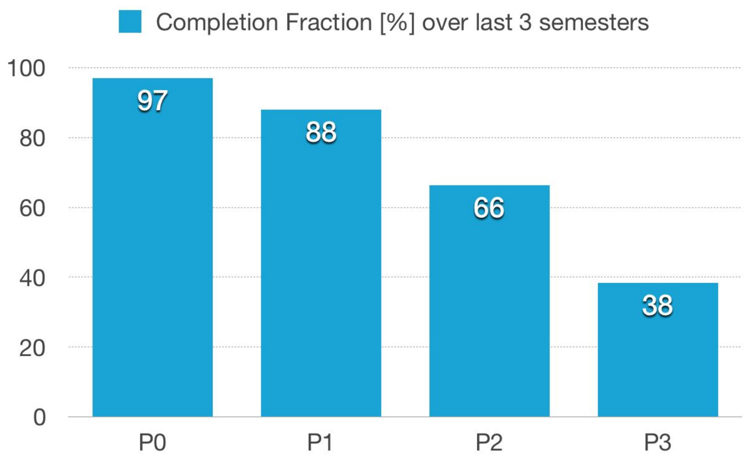
The figure below shows a smoothed “heat-map” of the number of Block visits over four semesters in 2015 and 2016. The distribution is very non-uniform, areas with a very high number of proposed visits include e.g. the Magellanic Clouds, the Galactic Bulge, some Deep Fields and Equatorial fields. It is physically impossible to execute all of the blocks even if they had the highest priorities. Note however that track times (see Section 2.1) are much longer at deep southern declinations, while visibilities are longer at equator, making targets there more probable to get done than oversubscribed areas elsewhere.

Number of P0-P2 Block visits 2015 - 2016



Historical Priority completeness fractions

Time allocation is done by Priorities (Section 11.2). The figure below shows the average realised completeness of time per priority over the past three semesters.



1. Current Status of the Telescope

1.1 Changes from last call

- We are happy to announce that SAMS, the active mirror alignment system installed in April 2016, is delivering as designed. SALT image quality (IQ) has drastically improved, images are now always at the level of, or better than, the extrinsic DIMM seeing measurements. See Section 3.6.2 for details and histograms of seeing and IQ.
- Due to the now-stable IQ, the probability of getting data in e.g 1.5" and better condition for challenging targets has significantly improved (though users are reminded that relaxed constraints always are more flexible in the queue).
- We have verified that absolute HRS (LR,MR,HR) radial velocity accuracy is *at least* 300-500 m/s with default calibrations.
- The Large Science Proposal (LSP) type was introduced last semester. It replaced the earlier Partnership Proposal type. LSP must be used for projects applying for more than 150h, whether in one semester, or many semesters in total. See Section 11.6 for details.
- The template for the science case has changed slightly. Please make sure you use the version for 2017-1, which you can download from http://astronomers.salt.ac.za/proposals/proposal-templates/. Note there are different templates for "normal" proposals and for LSPs.
- Java 1.8 ("Java 8") is required for running the Principal Investigator Proposal Tool. The use of Oracle's Java is recommended.
- Version 4.16 (or higher) of the PIPT needs to be used. This version lets you store your user credentials, and it includes version 4.3.0 of the RSS Simulator.
- RSS Fabry-Perot observations: Section 7.4.2 has been updated and see also

Section 1.2 below. In particular, *FP-HR mode* users must be aware that *half of the throughput has been sacrificed* to remove ghosting. FP/MR mode is not offered for 2017-1.
- RSS Polarimetry: Section 7.4.5 on Polarimetry has been updated and see also Section 1.2 below. Point-source long-slit *linear* spectropolarimetry is available in normal operations. Diffuse object linear spectropolarimetry is currently being commissioned and expected to be available for 2017-1. The priorities for commissioning of further modes will be set according to proposals coming in.
- Read Section 11 for an up-to-date description of policies and proposal types.
- If you have missed a semester, check the "Changes from last call" in the previous versions of this document archived here. Note especially new policies in the last year about P4 blocks and information on block probabilities.

1.2 Instrument and Mode Availabilities

SAMS, an active mirror alignment system with edge sensors, was installed on the primary mirror in April 2016. SALT image quality has drastically improved and most notably is stable during the night, making all modes of observations more efficient. RSS optics is cleaned every 18-24 months, the most recent service was performed in August 2016. All instruments and the telescope are close to their nominal expected efficiencies for 2017-1. There is a likely 2-3 week shutdown period scheduled for August 2017 to install a new and more efficient RSS guider, though this does not affect the Phase-1 from the PI perspective at all.

SALTICAM, RSS, HRS and BVIT will be available in the forthcoming semester, but with the following restrictions. More details can be found later in the document in relevant sections.

1. **Polarimetry --** Spectropolarimetry is availble *point-source or compact object targets*, and at the time of the call, we are commissioning extended object spectropolarimetry. We will further prioritize the available polarimetric mode characterizations by the proposals being submitted for 2017-1. We ask that those interested in any other modes contact salthelp with their wishes by the same Phase-1 deadline.
2. **Fabry-Perot --** The low resolution (LR) is in routine use, the Tunable Filter (TF) mode is available. The medium resolution (MR) etalon was removed from the telescope in late 2015 due to degraded coatings and mode it will not be available for the 2017-1 semester. There has been a continued effort in 2016 to commission the dual-etalon high resolution (HR) mode which suffers

from ghosting issues. The current plan is to insert a polarising element in the HR etalon which will suppress the ghosting due to the misalignment, but will also decrease the throughput of the HR mode by half. PIs can thus propose for the mode, but should be aware that exposure time must be longer. The RSS Simulator tool from version 4.3.0 onward takes this into account.

3. **Accuracy of multi-object spectroscopy --** The new SAMS system with stable PSFs makes MOS observations more efficient. Tracker upgrades have also improved somewhat the rotational drifts experienced. These drifts, the largest current challenge of the mode, will however disappear only when a new and much more efficient RSS guide camera will be installed in the latter part of 2017. For most of 2017-1 the current situation still applies: The rotational drift limits the use of narrow slits and the length of continuous exposures. Accuracy of MOS acquisition and alignment remains at approximately at ~0.3” level, and can be routinely done *if the PI-supplied reference stars have accurate astrometry*. See section 7.4.4 for details and recommendations concerning MOS observations.
4. **No drift scan modes.**
5. **No nod and shuffle mode for RSS.**
6. **No non-sidereal tracking.**
7. **Restricted detector modes for HRS --** We have restricted the detector setups to a single combination chosen to provide the best scientific results: Single amplifier, low speed readout, 1x1 binning. PIs requiring other combinations need to clearly justify their request in the technical section of their Phase I proposal. These non-supported modes requests will be reviewed by the SALT Operations team, who will then decide which extra mode(s) they are able to support for the 2017-1 semester.

1.3 Schedule for 2017-1 Semester

The SALT semester definitions are:

Semester 1: 1 May to 31 October (deadline late-January)
Semester 2: 1 November to 30 April (deadline late-July)

The current period, 2017 Semester 1 (i.e. for proposal codes starting with 2017-1), runs from:

1 May 2017 to 31 October 2017.

The call for SALT proposals for 2017-1 opens on:

19 December 2016

with updated proposal tools, including the PIPT submission tool.

The deadline for Phase 1 proposal submission is:

1 February 2017 at 16:00 UT.

The firm deadline for Phase 2 proposal submission is:

12 April 2017 at 16:00 UT.

Late Phase 2 submissions, unless discussed with the liaison astronomer before the deadline, will not be activated and will therefore not be observed.

2. Essential Concepts to Understand With SALT Observations

2.1 Visibility and Track Length

The altitude restrictions on SALT (47º to 59º) place observing constraints in terms of instantaneous sky access in Hour Angle and Declination, which is shown in the so-called SALT "toilet seat" diagram in Figure 1. Only objects inside the annular region are observable by SALT at any given time.

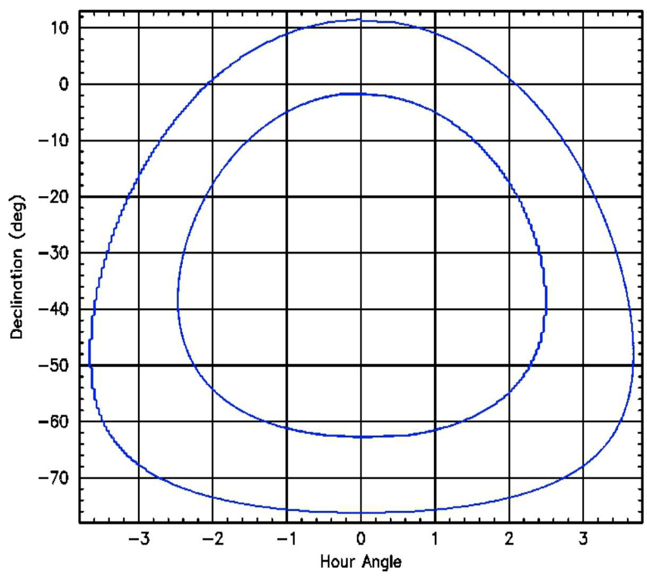


Figure 1: The *visibility* annulus of objects observable with SALT

The total maximum observing time, or **visibility**, for a celestial target is defined as the time it takes to transit the annulus, which is dependent on the Declination. However, the total maximum **track time** for an object, without having to move the telescope structure and re-acquire it, is determined by the tracker motion limits and is, therefore, equal to or shorter than the visibility time.

PIs should especially be aware that although Figure 1 and the Visibility Calculator may imply a total observing time of some hours, the tracker limits will necessarily curtail the maximum uninterrupted observing time available for a target. *It is this maximum **track time** that defines the maximum length of an observing block.*

Figure 2 shows the "actual" total maximum track time for objects as a function of Declination. For some Declinations (in the South and North), it is possible to re-acquire an object by stepping the telescope in azimuth, thereby extending the total observing time on a given night, as shown in the last graph. However, doing so incurs all of the normal overheads of repositioning the telescope and acquiring a target. Therefore, block times must be limited to available track times and observing time extended by multiple block visits.

In particular, note that *Equatorial targets* lie in the zone where repeated visits are possible, but which have constrained track times with, in practice, around 45 mins maximum to use for exposures on top of an acquisition (see Fig 3.). The longest track times of more than 2.5 hours can be achieved for very southern targets.

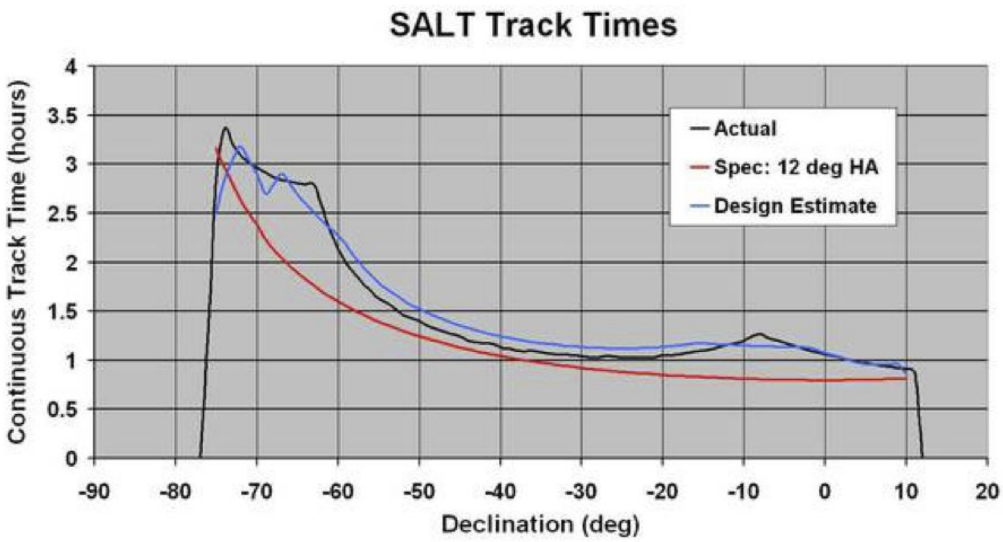


Figure 2: While objects can be visible for many hours continuously, a single *track time* may be shorter. At certain Declinations one is able to re-point the telescope in azimuth to continue for another track during the same visibility.

For planning purposes it is **essential that the PIs use the Visibility Calculator**, which gives more accurate information than the Figure above. The actual practical times available can be shorter than above due to the "Too-Tight-Track" effect - see Fig. 3 and Section 2.3 below. On the Visibility Calculator the track times can be seen by clicking at any location of the visibility curve or, even more useful, by viewing the plot of track time vs time for a given target on a given night. The Visibility Calculator is available from the SALT Observing Tool webpage at:
http://astronomers.salt.ac.za/software/

Figure 3. The SALT Visibility Calculator includes a tab displaying the available track length (the red curve) for a target. Even though the *visibility* is 15000+ sec at this DEC, *track lengths* available range from 3200 to 3800 sec, and to have realistic chances of getting a Block observed, it should in this case be defined as less than 3400 sec, or 3500 sec at most. See Section 2.3 for the Too-Tight-Track effect.

If you have many targets you might consider using the menu item `Target > Create Multitarget Visibility Table` to calculate all the visibilities.

2.2 Moving Pupil

As part of the SALT design, the pupil moves during the track and exposures, thereby constantly changing the effective area of the telescope. Because of this, accurate absolute photometry and spectrophotometry are not feasible. Photometric calibration of imaging must be done using external data of the same field, though internal colour information can be obtained using filter cycles in the case of short exposures. Spectrophotometric standards are routinely taken and can be used for relative spectral (shape) calibration, but not absolute flux calibration.

2.3 Observing Blocks

All SALT observations are executed using Observing Blocks. These will be defined in detail in Phase 2, but it is necessary to be aware of the basic principles when planning observations for Phase 1.

Blocks are defined as the minimum schedulable unit. A block must be allocated a single priority and have a single Moon brightness, seeing range, and transparency specification.

A block will consist of only:
a. one target
b. one acquisition (a position angle change is permitted within a block)
c. one or more science procedures or instrument configurations.

This sequence of observations plus overheads must fit within the target's maximum available ***track*** time and must be at least 900 seconds long, inclusive of overheads (canonical overhead is 900 seconds for MOS, 1500 seconds for BVIT and 600 seconds for any other instrument mode). Be aware that a target's ***track*** time is less than or equal to its ***visibility*** time. For example, equatorial targets are visible for long periods of time (up to several hours), but they can only be tracked for about one hour or less at a time. Additional observing time is accrued by multiple block visits. To aid with the distinction between track time and visibility time and to help PIs with planning their observations, the SALT Visibility Calculator (see section 2.4) includes a plot of track time vs time for a given object on a given night (see Fig. 3). PIs are also strongly advised not to use a block length too close to the maximum track time (also known as the Too-Tight-Tracks or TTT problem) - for a discussion on TTT, please check our website:
http://astronomers.salt.ac.za/tips-and-tricks/

A block will be executed under the specified weather conditions. If the weather conditions change within the hour, the block will be repeated. After an hour, however, the block will be accepted regardless.

A block will also be repeated if the data quality was compromised by technical difficulties with the telescope or instrument.

Note that acquisition images are provided solely as a means of field identification and to allow positioning of the target(s). Acquisitions may thus be out of focus or otherwise unpalatable-looking: track time is valuable, and we do not want to waste time tweaking the acquisition images. The image quality is refined before science data are taken. **If focussed acquisition images are required for science reasons, please justify in comments section.** For RSS longslit observations, at least one in-focus SALTICAM slitview image will be provided.

2.4 Moon phases

A numerical *Lunar illumination fraction* in between 0% to 100% is used to define the maximum allowable lunar illumination for each observation in Phase 1. These values get carried over to Phase 2 for the accepted programs. To compare with often used Dark, Gray, and Bright time terminology, we list below the pre-2015-1 SALT definitions of Moon phases:

> **Dark** (50% of time): Illuminated Lunar fraction of < 15% **or Moon below horizon**. (Lunar phase angle > 135º)
> **Gray** (25% of time): Illuminated Lunar fraction = 15% -- 85% (Lunar phase angle 45º -- 135º)
> **Bright** (25% of time): Illuminated Lunar fraction > 85% (Lunar phase angle 0º -- 45º)
> **Any**:(100% of time) Lunar illumination fraction 0º -- 100º, in which observations can be done in *any* Moon conditions

For a traditional Dark object, one can use <15%, but you are free to specify any number, say <25% or <40% to get more flexibility in scheduling. Brighter targets set e.g. as <70% or <100% (i.e. the traditional Bright targets) will hence be in the queue also when Moon is darker. During actual observations our scheduling tools will promote a dark block over a brighter block in dark time, but observations can be scheduled more efficiently when more blocks are available to choose from.

The Phase 1 tool will automatically summarize approximate fractions of proposed targets in various Moon conditions for the benefit of the Time Allocation Committees just getting a quick sense of what kind of observations are intended. The TACs will not, however, allocate time per Moon condition anymore, only by Priority.

PIs with equatorial targets will have noted that the Moon will likely be too close to the target for roughly ~50% of the traditional Bright time. The new system will make observations of these cases easier, as it does the traditional Gray Moon targets.

2.5 PIPT, the Web Manager and Simulator Tools

All investigators (PI and Co-Is) on a SALT proposal must have an account on the SALT server before the proposal can be submitted. This can be created by means of the Web Manager by pointing a browser to https://www.salt.ac.za/wm/Register/. After a successful registration, a confirmation email is sent, which includes instructions for validating the chosen email address.

Once an account has been created, the Web Manager (https://www.salt.ac.za/wm/)

can be used to view one's proposals and to update one's contact details.

All proposals are created and submitted with the PIPT, both for Phase 1 and 2. This is a stand-alone application requiring Java 1.8 or higher. While the Open JDK may work, using the Java environment provided by Oracle (http://www.oracle.com/technetwork/java/index.html) is strongly recommended. The PIPT itself can be downloaded from http://astronomers.salt.ac.za/software/.

New proposals can be created with the `File > New Proposal` menu item. The PIPT will ask which type of proposal to create. See Sections 3.1 to 3.4 for an explanation of the various proposal types. ***It is absolutely crucial to choose the Science or Large Science option***, as otherwise the proposal won't be forwarded to the TAC and no time will be allocated to it.

As outlined in the next section, in addition to some general information, investigators, targets and instrument configurations have to be defined for a Phase 1 proposal. These may be added by right-clicking on a node in the navigation tree. Similarly, adding and removing content from a table can be accomplished by right-clicking on the table.

Warnings should be taken very seriously, as they often indicate a serious flaw in the proposal. In most cases, submission is only possible once the problem has been fixed. An explanation is displayed by clicking on the little warning sign next to the problematic input.

Before a proposal is submitted, it should be validated with the menu item `Proposal > Validate`. If the validation fails, this usually means that some required input is missing.

More details about the PIPT can be found in the manual, which is available both as html and pdf.

After the first successful submission of a proposal, a confirmation email with the proposal code is sent to all investigators. ***This proposal code uniquely identifies the proposal, and it should be quoted in the subject line of any email query related to the proposal.*** The proposal code is also added to the proposal itself, so that resubmissions do not generate new proposals in the database. It is a good idea to double-check that the correct proposal code is shown in a submitted proposal. Confirmation emails for resubmissions are only sent to the investigator resubmitting the proposal..

When logging in to the Web Manager, a list of the user's proposals is shown.

Clicking on any of the proposals leads to a page with the proposal details, which may be used to check a submitted or resubmitted proposal. However, it may take a few minutes before the content is fully visible after submission (especially for finding charts).

In addition to the the Web Manager, the PIPT and the Visibility Calculator, Simulator Tools are supplied for Salticam, RSS and HRS, which can be used to plan the required instrument setup and the necessary exposure time. They can be downloaded from http://astronomers.salt.ac.za/software/ and they also require Java 1.8.

These Simulators allow the user to define a target spectrum and an instrument configuration, and to calculate the signal-to-noise ratio expected for these. It should be noted that ***the Simulators do not take any overheads into account***.

The Simulators have been verified for the current telescope and instrument throughput. However, the ***PIs should be aware that the wavelength ranges predicted by the RSS Simulator currently may have inaccuracies up to +/- 2 nm***.

Simulated setups can be saved from the Simulator Tools, and these saved setups should be attached to a Phase 1 proposal in the PIPT for use in the technical reviews. The technical justification may refer to these attached instrument setups. For RSS setups you need to use version 4.3.0 or higher of the RSS Simulator.

3. SALT Phase 1 Proposals

The SALT Proposal cycle consists of Phase 1 and Phase 2. The scientific justification of the program is the crux of Phase 1 and is evaluated by the relevant TAC. SALT Astro Ops reviews the technical justification. Target information (where known), including numbers and lengths of visits to targets, is required already at this stage, as well as a high-level selection of an observing mode. The final detailed observing configurations of programs accepted by the TACs will be submitted as part of Phase 2, and will be reviewed by the Astro Ops prior to being added to the observing queue. Changes to the target lists and other observation details may still be made at this stage within the constraints of the science goals in the proposal accepted by the TAC.

- **Deadline for Phase 1 submissions is 1 February 2017 at 16:00:00 UT corresponding to 18:00:00 SAST.**

- SALT Phase 1 proposals can only be submitted using the latest version of the PIPT (version 4.16 or higher).

Phase 1 proposals may be submitted, edited, and re-submitted at any time before the deadline, as many times as needed. After the deadline, edits are no longer possible. Late submission policy is given in Section 10.6.

Any questions during the submission phase should be emailed to *salthelp@salt.ac.za*. Previous submissions will have been assigned a program code - in that case, that code must be provided in the subject line.

The PIPT is deployed in various file formats and can be downloaded from http://astronomers.salt.ac.za/software/. The main items that need to be entered in the PIPT for Phase 1 are:

- investigator details
- required observation conditions
- target details (if known)
- the time requested
- instrument(s) and mode(s) required, including saved Instrument Simulator setups
- brief report on previous SALT proposals by the same PI (optional for some partners) and a list of SALT-related publications
- a brief description for the general public
- basic description of program and technical justification
- scientific justification & description (optional for some partners)

All but the last two bullet points are entered in the respective boxes in the PIPT form, while the last two items must be included in the form as a PDF. This PDF is limited to four pages in length (eight pages for Large Science Proposals). The PDF must be generated using the latest version of one of the templates provided (in Word, OpenOffice, or LaTeX format). These can be downloaded from http://astronomers.salt.ac.za/proposals/proposal-templates/. **You have to use the template for the current semester; you cannot reuse templates from the previous semesters.**

Note that Large Science Proposals use a different template from the rest of the proposal types. You need to use the correct version of the template for your proposal.

A manual for the PIPT is available both as html and pdf.

3.1 Multi-partner programs

If there are co-investigators from *multiple partners* in a single proposal, it is up to the Co-Is to divide the proposed time between the relevant partners, or request all of it from one partner. If a program applies for time from more than one partner, all the relevant TACs will receive the application and will allocate their time individually.

3.2 Long term programs

There is a possibility to submit longer term proposals. This is done by providing a justified time request for multiple semesters in the PIPT.

These proposals, *if approved for the current semester*, will be automatically re-submitted for the next. **However, a brief progress report of a previously approved long term proposal must be submitted by the Phase 1 deadline.** A form to enter this progress report is available on the proposal's page in the Web Manager (https://www.salt.ac.za/wm/).

Please note that the TACs may re-adjust the time allocation before each semester, and no time allocation by the relevant TAC(s) on any given semester means this proposal is no longer supported (i.e. the MLT status has been revoked). A new proposal will need to be submitted if more time is needed to complete the scientific goals.

3.3 Director's Discretionary Time (DDT) and Commissioning Proposals

A Phase 2 proposal needs to be submitted for DDT or commissioning proposals. See Sections 11.1 and 11.5 for more details. A total of 10h per semester of DDT time is available at present.

3.4 Large Science Proposals

Large Science Proposals request > 150 hours from one or more Partners, which can be spread over a total of six semesters. PIs considering submitting to this program should send an email to the head of Astro Ops, Petri Vaisanen, at saltastrohead@salt.ac.za with their intention to submit *at least two weeks prior to the deadline* to discuss overall feasibility and strategy. For more details, please see Section 11.6.

The Phase 1 process will be the same as for other proposals with the following exceptions:

1. The PI will have a total of eight pages for the Scientific Justification and Technical Justification.
2. The technical description is divided into two sections:
   A. Proposed observational setups and justification of the observing time required
   B. Management plan for reduction and publishing the data, including schedule
3. For proposals with a large number of targets (greater than 20) or transient targets, the range and distribution of RA and Declinations should be supplied as part of the technical description, but all of the individual targets do not need to be entered. Where possible, proposals should focus on targets with large visibilities and long tracks.

Word limits in the template should be considered guidelines as long as the total proposal length is less than eight pages including references and figures.

Please see Section 11.6 for further requirements for Large Science Proposals.

3.5 The Procedure after Proposal Submission and Phase 2

All Phase 1 proposals will first be directed to the SALT Astronomy Operations team for a technical feasibility assessment. Comments on technical feasibility will be forwarded to the individual TACs of the SALT consortium. The TACs will then allocate time to successful proposals in various priority classes. The minimum time allocation for a successful proposal will be 900 seconds per priority.

In cases where only a small fraction of the time requested for a multi-partner proposal is awarded by the relevant TACs, then the SALT Astronomy Operations Manager will engage with the relevant TAC Chairs to ensure that the allocation can actually result in a meaningful program.

After the full TAC review and time allocation process has completed for all partners, PIs will be notified of the outcome in late March 2017. The notifications mark the start of the Phase 2 submission period, during which the detailed observing Blocks must be submitted by the PIs to SALT operations using the PIPT. Note that changes to the target lists and other observation details may still be made during this stage within the constraints of the science approved by the TAC. Proposals with Phase 2 material submitted early may be considered for observations even before with the new Semester observations officially commence on 1 May 2017, depending on the status of the queue of 2016-2 projects. The **strict** deadline for the Phase 2 submission phase is 12 April 2017, at 16:00 UT, this is crucial for planning the schedule for the semester. **We cannot guarantee that programs submitted after**

the Phase 2 deadline will be included in the observing queue. If there are problems causing delays please be in contact with SALT Operations **before** the deadline.

3.6 Phase 1 Preparation FAQ

You may find details about working with the PIPT in the online manual at

http://pysalt.salt.ac.za/pipt-manual/html/pipt-manual.html

You may also download the manual as a PDF file from

http://pysalt.salt.ac.za/pipt-manual/pdf/pipt-manual.pdf

The scientific justification needs to be generated from a Word/Latex template, which can be downloaded from:

http://astronomers.salt.ac.za/proposals/proposal-templates/

Some common questions and issues are addressed below; however, a more complete, live, and frequently updated ***online FAQ*** is available at:

http://astronomers.salt.ac.za/proposals/faq/

3.6.1 Definitions of Lunar illumination

PIs are free to specify any *Lunar illumination fraction* between 0% to 100% to define the maximum allowable lunar illumination for each observation in Phase 1. How these percentages related to traditional dark, gray, bright definitions was presented in Section 2.4.

In Phase 2, there will be an opportunity to select also a minimum angular Lunar distance. Please note that we have also introduced in the PIPT a *default* minimum angular Lunar distance of 30 degrees, which of course can be changed if necessary.

PIs should also use the instrument simulators to ensure that overly demanding observing conditions are not requested unnecessarily.

Ideally all partners should attempt to distribute their observing time allocations evenly over the range of Lunar phases. SALT Operations will attempt to give information to the TACs about the target distributions over the sky and over Lunar phase, as submitted in Phase 1, before they start their deliberations.

3.6.2 Definition of Seeing

The standard measure of atmospheric turbulence is the Fried parameter, r_0. The SAAO site uses an automated Differential Image Motion Monitor (DIMM) to measure this routinely and continuously. The blurring of an image at the focal plane of a large telescope, what we refer to as "seeing", is derived from r_0 using the standard model of atmospheric turbulence. It is a function of wavelength (λ) and airmass and the ***DIMM reports seeing using the convention of λ = 500 nm (essentially V-band) and airmass = 1.0. This is the value that is used to define observing conditions and make scheduling decisions.***

Median zenithal V-band seeing, measured from the Sutherland DIMM *at ground level*, is 1.5" (from measurements made over 2011-2016, see Table in Section 3.6.3).

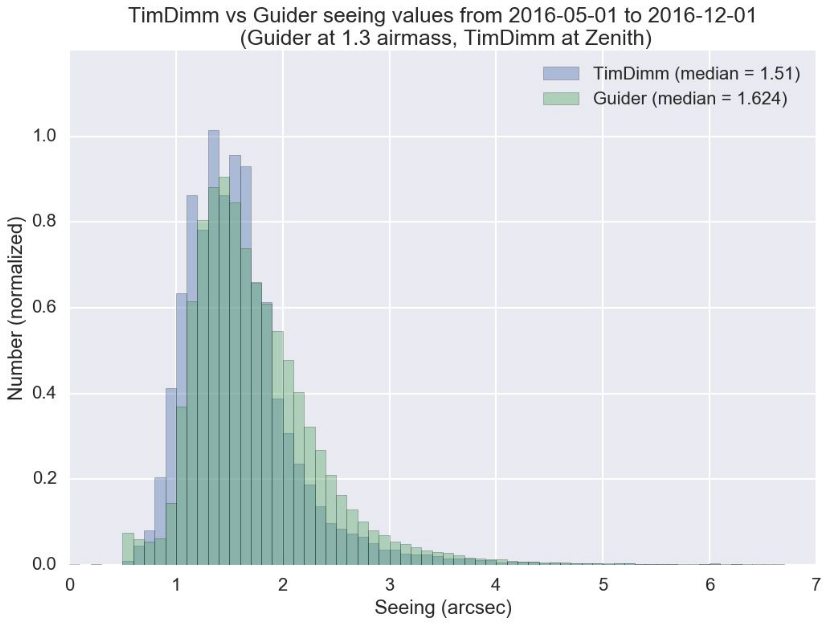


Figure 4: Seeing histograms from the SAAO DIMM and the SALT guider. The data are taken from the same period of time in 2016 since the SAMS was installed. Note that the guider data are *not* corrected for the average airmass of SALT observations during this period, so the actual the guider data are actually slightly better than the DIMM (which is closer to the ground). The PIs select their seeing restriction based on the intrinsic Zenith value and they now should expect a similar image quality delivered on the detector.

The SALT visibility strip lies between 1.16 and 1.37 airmass which in principle leads to a factor of 1.1 to 1.2 degradation of seeing on average. As demonstrated above in Fig. 4, after SAMS was installed, this is broadly the case, and the actual SALT image quality (IQ) as measured by the instrument guiders is quite close to the Zenithal seeing values. **This is a drastic improvement from times before SAMS, that seasoned users of SALT should be aware of**. It is now feasible to request for

1.5” and lower seeing for faint and challenging targets (though note the probabilities listed below).

The following table indicates the *expected* image quality performance of SALT (in terms of the FWHM and enclosed energy diameters (50% and 80%) of the PSF for different DIMM seeing values (all V-band). The PSF is basically described by a modified Moffat function.

DIMM zenith seeing	***Seeing at average telescope airmass***	***FWHM***	***EE50***	***EE80***
1.0”	1.2”	1.4”	1.6”	2.6”
1.5”	1.7”	1.8”	2.0”	3.3”
2.0”	2.3”	2.4”	2.7”	4.2”

The proposers should realise that it is the first column number being inserted as “seeing” into an instrument simulator and used as the requested seeing, while the other numbers should be used to plan actual SNR; the actual IQ may be slightly better than the expected value tabulated (cf. Fig. 4). The simulators also use the same convention, a Zenith value is inserted, which the tool automatically corrects for the airmass.

3.6.3 Previous Seeing statistics

The statistics from the SAAO DIMM in Sutherland have been compiled for previous semesters and are shown in the Table below.

Semester	**Median zenithal seeing**
2011-2	1.38”
2012-1	1.56”
2012-2	1.46”
2013-1	1.47”
2013-2	1.32”
2014-1	1.58”

2014-2	1.56”
2015-2	1.53”
2016-1	1.51”

For reference, and to aid choices on observing constraints, the Table below shows the probability of having a given (or better) seeing based on all the available seeing statistics:

Max Seeing	**Probability**
1.25”	29%
1.5”	53%
2.0”	84%
2.5”	94%
3.0”	97%

The results of a study looking into the causes of atmospheric turbulence above the Sutherland observing site is shown in Figure 5. It is the ground layer turbulence which clearly dominates the seeing characteristics.

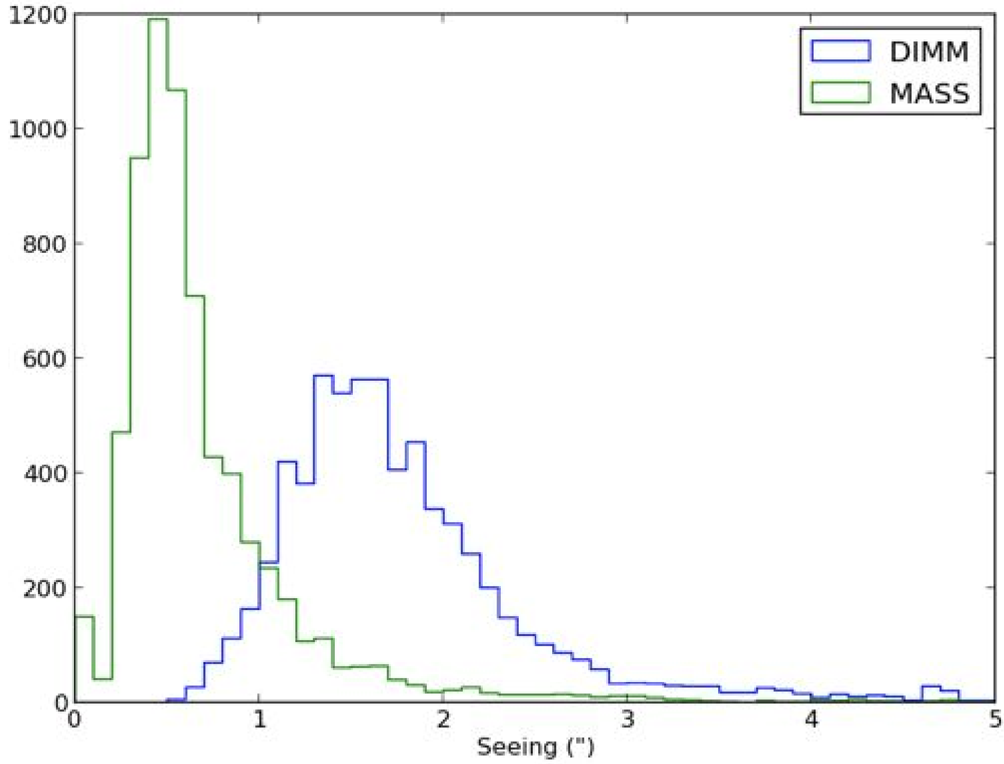


Figure 5 - Seeing histogram from the DIMM for the 2012-1 semester (1 May 2012 - 31 Oct 2012). The y-axis indicates the number of hours at that given seeing. The MASS seeing gives the seeing measurement from the free atmosphere (>1 km). That value would be relevant if a ground layer adaptive optics system was developed.

3.6.4 Concept of "Optional Targets"

There are two types of SALT targets:

1. **Mandatory Targets:** These are all of the targets which the PI is expecting to observe if allocated the requested time.
2. **Optional Targets:** This is a *pool* of M optional targets from which the PI is requesting that any subset consisting of N targets can be observed within the allocated time. This target list is thus a super-set from which actual observations can be chosen, such that the total observing time of the eventual chosen targets equates to the total requested time of the proposal. The superset of targets (M) should be less than 5 × N, the number of targets actually likely to be observed given the requested time. The actual target choice will be dependent on the queue and chosen by the duty SA or scheduling algorithm. These pools can easily be defined in PIPT and they can also be built as *monitoring pools* where a wait-time can be defined after any of the pool members is observed.

We stress that the use of optional targets, especially when they have a wide RA-range, is extremely effective. You can significantly boost the chances of getting your program done if there is always one of your targets visible in the queue.

3.6.5. Definition of Cloud Cover Conditions

From 2015-1 onwards we simplified the cloud cover conditions to be only

- Clear
- Thin Cloud
- Thick Cloud

The previous 'Scattered Clouds' condition was ambiguous in that it could refer to thin or thick cloud. These conditions have been updated in all the relevant user interfaces.

We define thin cloud to range between either occasional thin clouds passing over (e.g. partly clear) to consistent all sky thin cirrus. Thick cloud corresponds to a moderate to heavy extinction and when guidance is often interrupted due to the guide stars being partially or fully obscured for a good portion of the track. Short exposures of bright stars are best suited to thick cloud conditions. In the future we plan to quantify these categories.

4. Telescope Performance and Observing Constraints

The previous section explained the basic concepts to understand when planning SALT observations, especially regarding the track times, the visibility of objects and the effect of the moving pupil for absolute (spectro)photometry.

Issues specifically affecting current Phase 1 proposal planning include:

4.1 Image Quality (IQ)

Active control of the mirror segments with new mirror edge sensors has become operational since early part of 2016 with very encouraging results. Images are now stable throughout the night over large temperature gradients, observations are limited by intrinsic seeing only. This is a significant improvement from times before SAMS, which the PIs should appreciate. It is now feasible to request for 1.2-1.5" seeing for faint and challenging targets (though one still needs high priority to be at the top of the queue in those conditions); good results for e.g. high-redshift point source spectroscopy have already been demonstrated. However, note that likely due to dome-seeing issues, sub-arcsec conditions (rare in any case) are still unrealistic to fully take advantage of.

4.2 Vignetting

There is strong vignetting of the field-of-view, as shown in Fig.6. Objects observed more than 2 arcmin from the centre of the field receive up to 10% less light, and this needs to be taken into account when planning to make use of targets over the full field of view. These numbers are greater than the specification and are still under investigation.

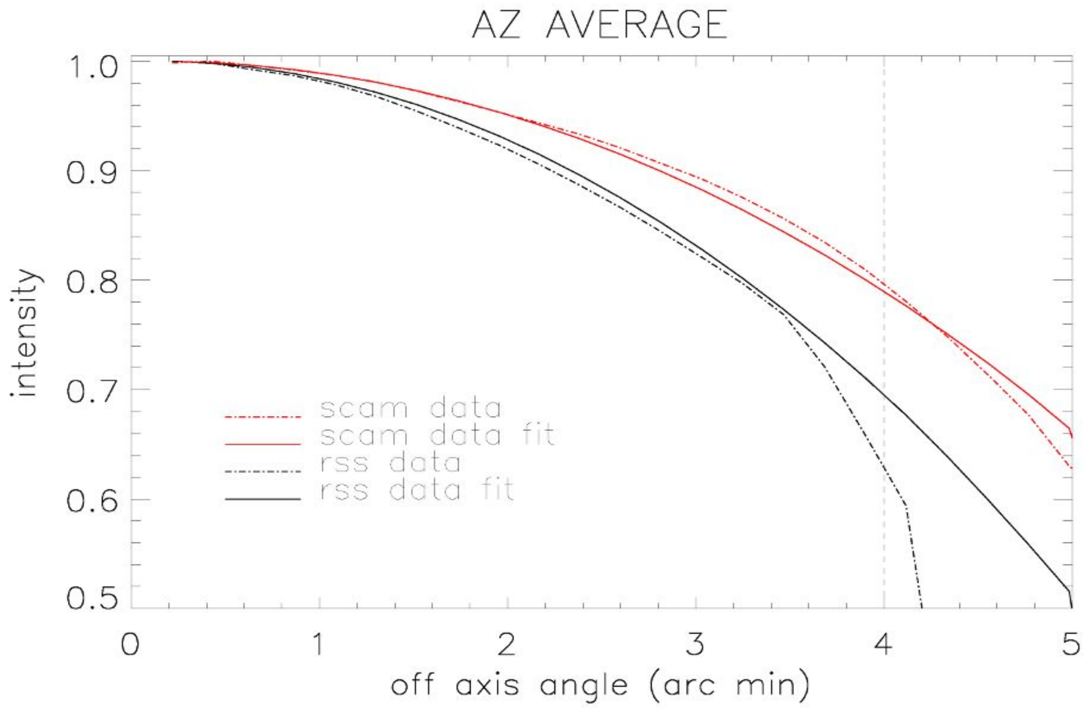


Figure 6. Vignetting of the FOV with RSS and SALTICAM.

4.3 Throughput

The primary mirror is kept clean by regular (every week or two) cleaning with high-pressure CO_2, and individual segments are normally taken out for washing and re-coating in a cycle of nominally about 12 months. This has been standard practice since 2012. The effect of *not* taking care of the primary is illustrated by the historical 2006-2008 throughput values of the mirror in Figure 7. Throughput of the telescope is routinely monitored using SALTICAM (since there are no significant optics in this instrument these values can be thought of as an approximation of the Telescope throughput) by measuring standard stars with the primary mirror in “burst mode” where each segment forms an independent image of the star. The nominal expected curve, as well as the system spec, can be compared against measurements derived from standard star observations and corrected for the estimated total efficiency of the instrument (filters, CCD, and foreoptics) and the atmosphere.

In June 2015 the Atmospheric Diffraction Corrector (ADC) was cleaned, and in August 2016 the SAC partially. The currently measured telescope throughput numbers are shown as the dark blue points in Figure 7, where the average of several measurements from 2012 to 2014 are also shown as black symbols. We are closer to the expected throughput in the red than we are in the blue and intermediate wavelengths. We suspect an aging SAC is the largest contributor to the slightly less than optimal system throughput, but a full recoating is not likely for a while.

The telescope throughput numbers in the instrument Simulators are consistent with the current measurements.

The RSS instrument-specific throughput had been significantly reduced over all wavelengths since the re-commissioning of the instrument in 2011. A major overhaul of RSS took place in September and October of 2014 during which many of the optics were cleaned and optical coupling fluids in the collimator were replaced. This resulted in approximately 40% increase in RSS throughput, and more in the blue, judged from both pre-installation laser measurements and on-sky standard star measurements. Additional causes of poor throughput were attributed to several degraded coatings though the fixing of these is now on-hold due to lack of funding. A new optical service was done in August 2016 which recovered the slowly deteriorating RSS efficiency (by about 10%) to the clean 2014 values. It is now planned that RSS will undergo a routine optics clean every 24 months or so.

The dashed line in the right panel in Figure 7 shows the RSS throughput derived from a large number of spectrophotometric standard stars by Ken Nordsieck in June 2013 now multiplied by a factor of 1.6 to approximate the current situation. A direct absolute RSS measurement using “burst mode” in 2015 is shown as the blue points. Note that the efficiency of RSS observations is naturally also affected by the telescope throughput.

We stress that ***the current throughput values as discussed above are incorporated into the latest instrument Simulators which should be used for planning of 2017-1 programs***. If changes become necessary, we will inform the community. Finally, note that while the atmosphere is corrected out from Fig. 7, its effect is included in Simulator tools and can be adjusted therein.

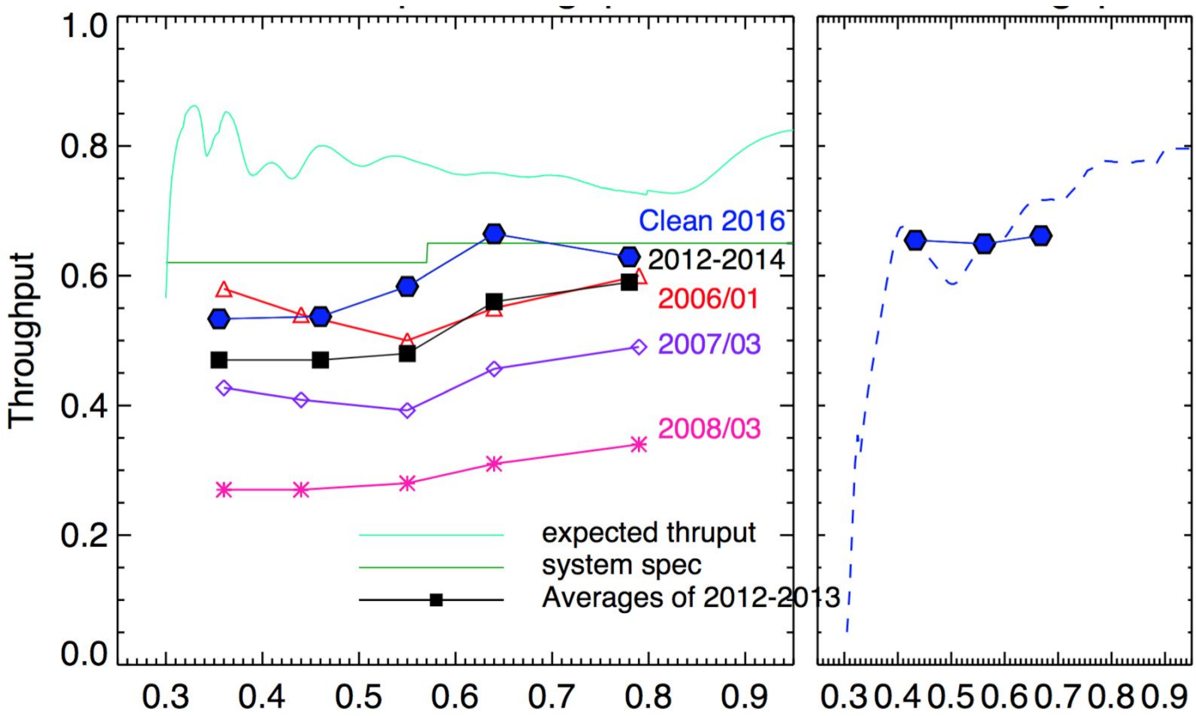


Figure 7. Current and historical telescope throughput values are shown at left compared to expectations. The most recent values are shown in dark blue. Measurements correspond to 7-10 best quality segments, so the implemented values in the Simulator are 15-20% worse to describe a typical track. The right panel shows, as the dashed line, the RSS optics throughput as derived by Ken Nordsieck in 2013, adjusted by the factor of approximately 1.6 improvement in efficiency after the 2014 RSS intervention and 2015 ADC clean. The blue points show measured values from on-sky photometry in June 2015. All these values are incorporated in the current instrument Simulator tools and are kept up-to-date.

4.4 Collecting Area

The nominal collecting area of the primary mirror with a central track is ~55 m^2, decreasing to ~40 m^2 for extreme off-axis tracker positions. This means that SALT is equivalent to between a ~7 to 8 m diameter conventional telescope.

The current default collecting area in the instrument Simulators is set to 46 m^2 (or approximately 53 fully illuminated segments) – this corresponds to experimentally derived averages of visible pupil area with tracker obscuration over a full track, and also makes allowance for the fact that the throughput calculations referred to above are normally done for a dozen or so best-quality segments. The collecting area is an adjustable parameter in the Simulators, but it should only be changed with caution.

5. SALT Calibrations

5.1 Definitions for the SALT Calibration Plan

SALT calibration data are divided into four categories:

- Default calibration (DC):
  - will be produced for every observable night
  - will be produced without PI request
  - PI will not be charged
  - will be done during day or morning time, possibly twilight and nighttime
- Library calibration (LC):
  - will be produced at some regular interval, not every observable night
  - will be produced without PI request
  - PI will not be charged
  - will be done during day-time, possibly twilight and nighttime
- User-requested charged calibrations (UCC):
  - will be produced by PI request
  - will be done during nighttime
  - PI will be charged
- User-requested non-charged calibrations (UNC):
  - will be produced by PI request
  - will be done during daytime and/or twilight
  - PI will not be charged

Please see section 6.7 for the current semester SALTICAM calibration plan and section 7.8.2 for the corresponding RSS calibrations. No calibrations are needed for BVIT. HRS calibrations are covered in Section 8.2.

6. SALTICAM Characteristics and Performance

SALTICAM is a UV-Visible (320 - 900 nm) imaging and acquisition camera, capable of high time resolution imaging (at ~10 Hz). It consists of two E2V 44-82 CCDs (2048 x 4102 x 15 μm pixels), which are physically separated by a 1.5 mm gap and are read out by four amplifiers. SALTICAM is at prime focus; however, it is fed by a fold mirror and has a reduced focal ratio of f/2. The result is a nearly 10-arcmin diameter field of view, with the central 8-arcmin diameter portion being used for science and the outer annulus for guide stars. The plate scale is 0.14 arcsec/pixel. Basic information required for observing is provided in this section.

There are four possible combinations for readout speed and gain settings, returning gain values between 1.0 and 4.5 electrons/ADU with readout noise of either 3.3 or 5 electrons per pixel (Table 1; Table 2). The dark current is typically less than 1 electron per pixel per hour. Full well depth is on the order of 170k electrons. Pixel prebinning from 1x1 to 9x9 (independent in each direction) and up to ten subframe windows can be selected. The readout times for full frame, 2x2 binning are given in Table 2. A wide range of filters are available, spanning the wavelength range 320-950 nm (Section 6.4; Table 4).

Readout Setting	Gain Setting	Actual e/ADU
Fast	Faint	1.55
Fast	Bright	4.5
Slow	Faint	1.0
Slow	Bright	2.5

Table 1: Gains for the four different readout modes selectable on SALTICAM

Detector Mode	Pre-bin	RO mode	RO Noise (e-/pix)	Total Readout Time (sec)*
Full Frame	2x2	Slow	3.3	21
Full Frame	2x2	Fast	5.0	14

Table 2: Readout (RO) times of SALTICAM for the 2x2 binning. Refer to the SALTICAM web-pages and PIPT for times of other binnings. *Inclusive of CCD readout, disk writes, and software overheads.

Standard modes of operation are normal imaging (full-frame readout), frame transfer (half-frame readout), and slot mode (144-row readout). Specific characteristics for these modes, as well as the specialised modes of non-sidereal tracking and drift scanning, are discussed below. Note that absolute photometry is not possible with SALTICAM alone because of the moving pupil.

More details on this instrument can be found at in Section 12.1, the first Appendix to this document. A simulator that uses target characteristics and a detector configuration to return count rates, signal-to-noise ratios, pixel saturation, and readout times can be downloaded from the following website: http://astronomers.salt.ac.za/software/

6.1 Current Status

SALTICAM is available for the 2017-1 semester. There is a new website that lists the installed SALTICAM filters live: http://astronomers.salt.ac.za/status/.

Though guiding with SALTICAM is possible, it has several features rendering it not that useful for many applications (see Section 6.6). Overall, we suggest limiting SALTICAM exposure times to approximately 120 seconds with open-loop tracking, or single filter observations utilizing a bright guide star (usually chosen by the SA, but PIs can indicate preferred choices on charts, though they are not always accessible).

6.2 Available Instrument Modes

6.2.1 Normal Imaging

Normal imaging is the basic, full-frame SALTICAM mode, which also serves as the acquisition mode for spectroscopic observations. The sub-framing, preamplifier binning, gain, and filter options listed above are available.

6.2.2 Frame Transfer

The frame transfer (FT) mode ensures moderate time resolution (a few seconds) and no dead time. In frame transfer mode, a mask covers the lower half the detector (both chips). At the end of each exposure, the image in the top half of the chip is rapidly (0.2 sec) shifted to the lower half where it is read out while the next image in the top half accumulates photons during the next exposure, thereby ensuring no dead time.

A list of the minimum exposure times for frame transfer mode in each binning is provided in the third column of Table 3.

6.2.3 Slot Mode

Slot mode ensures high time resolution (to 0.05 sec) with practically no dead time. It only works with the FAST readout speed. In this mode, a mask is advanced over the entire detector except for a horizontal slot of 20 arcsec height just above the frame-transfer boundary. At the end of each exposure, 144 (unbinned) rows are moved down and this allows exposure times as short as 0.05 sec. Timing tests carried out with an independent GPS demonstrate that the absolute and relative timing accuracy of slot mode are good to a few tens of millisec.

The minimum exposure time for slot mode in each binning setting is provided in the second column of Table 3. More information on slot mode is available in Appendix section 12.1.

Please note that the position angle is a critical parameter for most slot mode observations in order to image both the target and a comparison. Finder charts should clearly indicate the position angle and the location of the slot (done automatically by the SALT finder chart tool http://pysalt.salt.ac.za/finder_chart/).

Pre-binning	Slot Mode (sec)	Frame Transfer (sec)

1x1	0.70	15.90
2x2	0.30	4.70
3x3	0.20	2.80
4x4	0.15	2.00
5x5	N/A	1.70
6x6	0.08	1.40
7x7	N/A	1.30
8x8	0.07	1.10
9x9	0.05	1.10

Table 3: Minimum exposure times per binning for SALTICAM Slot Mode and Frame Transfer (FAST readout).

6.2.4 Non-Sidereal Imaging

For imaging objects in the solar system, non-sidereal telescope tracking might be preferred. Initial tests of the implementation and accuracy of this mode at slow (a few arcsec per hour) and fast (hundreds of arcsec per hour) rates have been carried out. The telescope correctly interpolates ephemerides in order to point, but tracking at the correct non-sidereal rates has not yet been commissioned. We have not yet quantified any errors on the pointing. Any non-sidereal tracking proposals are considered shared risk.

6.2.5 Drift-Scan

Drift scanning is an imaging mode where the telescope is parked at a stationary position and the CCD readout is clocked at the sidereal rate. This can be used to produce long imaging "strips" on the sky, e.g. for surveys. While some preliminary SALTICAM drift scanning tests have been successfully completed, there are still some issues to iron out before this mode is offered to the community. Therefore, it will *not* be available for this proposal period.

6.3 Sensitivity

All SALTICAM sensitivity calculations for planning observations should be done with the latest version of the SALTICAM Simulator tool (http://astronomers.salt.ac.za/software/). These numbers are based on throughput tests with a burst mirror, as well as Sloan comparison fields, and have been extrapolated for a typical pupil during a track.

The count rates and signal-to-noise ratio numbers can be extrapolated to other exposure times and fainter/brighter targets. We have directly verified count rates up to about 5-minute exposures and these behave as expected. Longer integrations are not practical due to the difficulties with auto-guiding (see Section 6.6) and SALT's current open-loop tracking performance.

Thus, the deepest SALTICAM exposures should ideally be constructed from dithered and co-added ~2 minute exposures. For example, recent programs detected targets from 2-min SALTICAM frames down to g=24.7 mag and r=24.1 mag. However, whether the ideally scaled signal-to-noise ratio of stacked imags is reached depends on e.g. the quality of flat-fields (see Section 6.7.2) and the stability of the PSF of sources over tens of minutes. While the latter has become better with the recent introduction of the active mirror alignment system, we nevertheless urge the PIs to be conservative in estimates of deep SALTICAM imaging until proper characterisation has been obtained. **We do not yet have demonstrated sensitivity performance values for longer stacked sequences.**

6.4 Filters

SALTICAM has an eight-position filter magazine. Available filters are listed in Table 4. The transmission curves can be viewed in the PIPT.

The SALTICAM CCDs were optimised for visible and near UV imaging, thus no effort was made to minimise fringing at near IR wavelengths. We have not yet quantified the amplitude of fringing in all filters. We have observed fringes with an amplitude of ~10% peak-to-trough for red, narrow-band filters such as *z'*. Fringing is not an issue for broadband filters or those at the shorter end of the wavelength range.

Type	Name
Johnson-Cousins	*U, B, V, R, I*
Sloan	*u', g', r', i', z'*
Strömgren	*u, b, v, y, H-β wide, H-β narrow, SRE1, SRE2, SRE3, SRE4, Clear*
Other	*H-α* (zero redshift) 380-nm (FWHM 40Å) neutral density

Table 4: SALTICAM filters

6.5 Dithering

As stated above, due to the flat-fielding difficulties as a result of the moving pupil, it appears that best photometric results over the field of view will be obtained with dithered observations.

The most productive dithering schemes will depend on the science goal and size of science targets. For Phase 2, a user-selectable dithering pattern is supported in the PIPT - please see our website for a description of the available dither patterns:

http://astronomers.salt.ac.za/proposals/dither-patterns/

Please note, however, that SALT does not provide fully-automated dithering which makes such observations manual and slightly time consuming. Dithering will affect overheads, since every offset will take approximately 30 seconds. Note that the dithering step size is not restricted, but there is a risk of losing the guide star if the step size is large -- however see Section 6.6 below for the sensibility of even using guiding. *If* guiding is nevertheless desired, we thus recommend the total dithering pattern to be constrained within approximately one square arcminute -- if larger steps are required, please note to the observer to select a central guide star.

6.6 Auto-guiding

While SALTICAM is equipped with an auto-guider, it has several serious design limitations that limit its overall usefulness:

- The guide probes are large and vignette a significant portion of the SALTICAM field-of-view. Even selecting a star at the edge of the field will result in significant vignetting over at least 20% of the image. This vignetting would be different for each image in a dither pattern which would make flat-fielding even more difficult. However, if a smaller area of the fov is required, use of the probes can be beneficial, especially for the fast time resolution modes.
- The guide probes sit behind the SALTICAM shutter. Therefore guiding does not occur when the shutter is closed, such as when SALTICAM is reading out.
- The guide probes sit behind the SALTICAM filters. Therefore the auto-guider is least effective for the narrow-band filters where it is most needed.

Because of these shortcomings, we do not advocate the use of the SALTICAM auto-guider during normal imaging. SALTICAM has low read-noise so the sky limit is reached quickly in most broadband filters. It's reached in under a minute for even *U*, *u'*, and H-α. Our current open-loop tracking performance allows unguided exposures of up to 2 minutes which is sufficient for all but the bluest Strömgren filters. Work to improve our open-loop tracking is on-going.

We do support using the auto-guider during slot and frame-transfer mode observations.

6.7 SALTICAM Calibrations

Please refer to section 5 for a general description of SALT calibrations.

6.7.1 Features of SALTICAM Calibrations

Our current SALTICAM calibrations plan (section 6.7.2) is based on the specifications of the SALT telescope and our current experience. We would like to highlight the following:

1. SALT is a telescope with a variable pupil, so that the illuminating beam changes continuously during the observations. This makes absolute flux/magnitude calibration impossible even when using photometric standards. ***Therefore, the only way to get absolute photometry with SALT observations is to observe a field in which the PI has secondary photometric standards.***
2. Due to the illuminating beam changing continuously during observations, the illumination pattern also changes. For this reason, ***neither calibration screen flats nor twilight flats can help correct the illumination pattern with an accuracy better than 10–20% depending on the specific setup.***
3. Flat-fields with the calibration screen can to be used to build a pixel-to-pixel correction map, except for the red filters (starting from *z'*), where fringing is important.
4. The only way to correct the observed data for the illumination pattern is to use the data itself. For this reason, dithering patterns (described in Section 6.5) must be used. A method to build night-time flat-fields using your own data is described in the SALT Ast Ops report (Experimental SALTICAM flatfielding report):
   https://sciencewiki.salt.ac.za/index.php/Status_of_Flat_Field_commissioning
5. The method described in the document above works well only for compact targets. ***For extended targets (size of larger than ~1–2 arcmin) there is no known way to flat-field the data to an accuracy better than 10–20%***.
6. We cannot, as yet, reach a photometric accuracy of 0.01 mag even for stellar objects. A level of accuracy of 0.05 mag is possible and 0.1 mag can certainly be reached for observations using a dithering pattern, assuming corrections for both the illumination pattern and pixel-to-pixel variations are made during the data reduction.
7. All our tests have shown that biases cannot be used for SALTICAM data reduction. Data can be corrected using the overscan level and, in fact, the standard pipeline does so.

6.7.2 Current SALTICAM Calibrations Plan

For all the reasons stated above, the current SALTICAM calibrations plan for this semester is:

- No **DC** calibrations will be taken
- No **LC** calibrations will be taken
- User-requested night-time calibrations (**UCC**) will be taken **but we cannot guarantee that these calibration data will be useful.**
- By PI request, the following day-time (**UNC)** calibrations can be taken once per program per setup per semester:
    - 5 screen flats per detector and camera setup

  Please note that a larger number of calibrations will need to be justified and **we cannot guarantee that these calibrations will be useful.**

7. RSS Characteristics and Performance

The Robert Stobie Spectrograph (RSS) is the main work-horse instrument on SALT and is a complex multi-mode instrument with a wide range of capabilities.

RSS resides at prime focus, where it takes advantage of direct access to the focal plane, and was designed to have a range of capabilities and observing modes, each one remotely and rapidly reconfigurable. In keeping with the overall philosophy of exploiting those areas where SALT has a competitive edge, the instrument has several unique, or rare, capabilities. These capabilities include the following:

- Sensitivity from 320 to 900 nm, i.e. down to the UV atmospheric cut-off.
- A fully articulating camera/detector used with Volume Phase Holographic transmission gratings (VPHGs) allowing for a wide choice of wavelength coverage and spectral resolutions. Low to medium resolution spectroscopy (up to R ~ 5000 with 1 arcsec slits; R ~ 9000 with 0.6 arcsec slits).
- Multi-object spectroscopy (MOS) using laser-cut carbon composite focal plane slit masks, of up to ~50 objects at a time. A “nod and shuffle” mode will also eventually be employed for accurate background subtraction, but is not yet available.
- Linear, circular and all-Stokes mode spectropolarimetry and imaging polarimetry using either one or both 1/2- and 1/4-waveplate retarders and a large Wollaston beam-splitter mosaic, giving two completely off-set O- and E-images on the detector (restricted modes are available for 2016-2).
- Fabry-Perot imaging spectroscopy and tunable filter imaging in the range 430−860 nm using three etalons providing three resolution regimes of R = 320−770, 1250−1650, and 9000 (the medium resolution mode is not offered from 2016-2).
- The use of fast frame-transfer CCDs allowing for high-speed observations (up to 0.05 s exposures) in all observing modes.

7.1 Current Status

Currently RSS is routinely being used for the following modes:

- Long-slit spectroscopy
- Narrow-band imaging
- Multi-object spectroscopy (MOS)
- Low resolution (LR) Fabry-Perot imaging spectroscopy and tunable filter (TF) narrow-band imaging. High resolution (HR) FP is offered, but note that its throughput is half of expected due to polarising material inserted into the etalon to reduce ghosting issues (this is taken into account in the Simulator tool)
- High time-resolution spectroscopy
- Long-slit spectropolarimetry (see section 7.4.5).

For current *sensitivity and throughput issues* refer to Sections 4.3 and 7.5, and Figure 7.

7.2 Gratings

RSS has a complement of six transmission gratings: one standard surface-relief grating and five volume phase holographic (VPH) — see Table 5. VPH gratings have the characteristic that their efficiency varies with input angle (see Fig. 8), and thus a single grating can cover a large wavelength range with good efficiency by changing the relative angle between the collimated beam and the grating normal. This is accomplished using a rotating stage. The RSS camera is then articulated to twice the grating angle since the VPH efficiency curve for a given grating angle typically is at a maximum at the Littrow wavelength. The angle of the grating also affects spectral resolution. The higher the value of the grating tilt, the higher the spectral resolving power for a given slit width. The RSS Simulator tool found at http://astronomers.salt.ac.za/software/ should be used to determine the optimal grating angle and slit-width for an observation. Note also that a feature of VPH gratings is that the resolution and wavelength range of an object depends on the distance of the target from the optical axis. While this is not an issue for long-slit spectroscopy, it will affect multi-object spectroscopy (see Section 7.4.4 for more details).

Grating Name	Wavelength Coverage (nm)	Usable Angles (deg)	Bandpass per tilt (nm)	Resolving Power (1.25” slit)
PG0300	370-900		390/440	250--600
PG0900	320-900	12-20	~300	600-2000
PG1300	390-900	19-32	~200	1000-3200
PG1800	450-900	28.5-50	150-100	2000-5500

PG2300	380-700	30.5-50	100-80	2200-5500
PG3000	320-540	32-50	80-60	2200-5500

Table 5: RSS grating complement

All gratings are used in first order only. Second-order contamination is removed through the use of order-blocking filters.

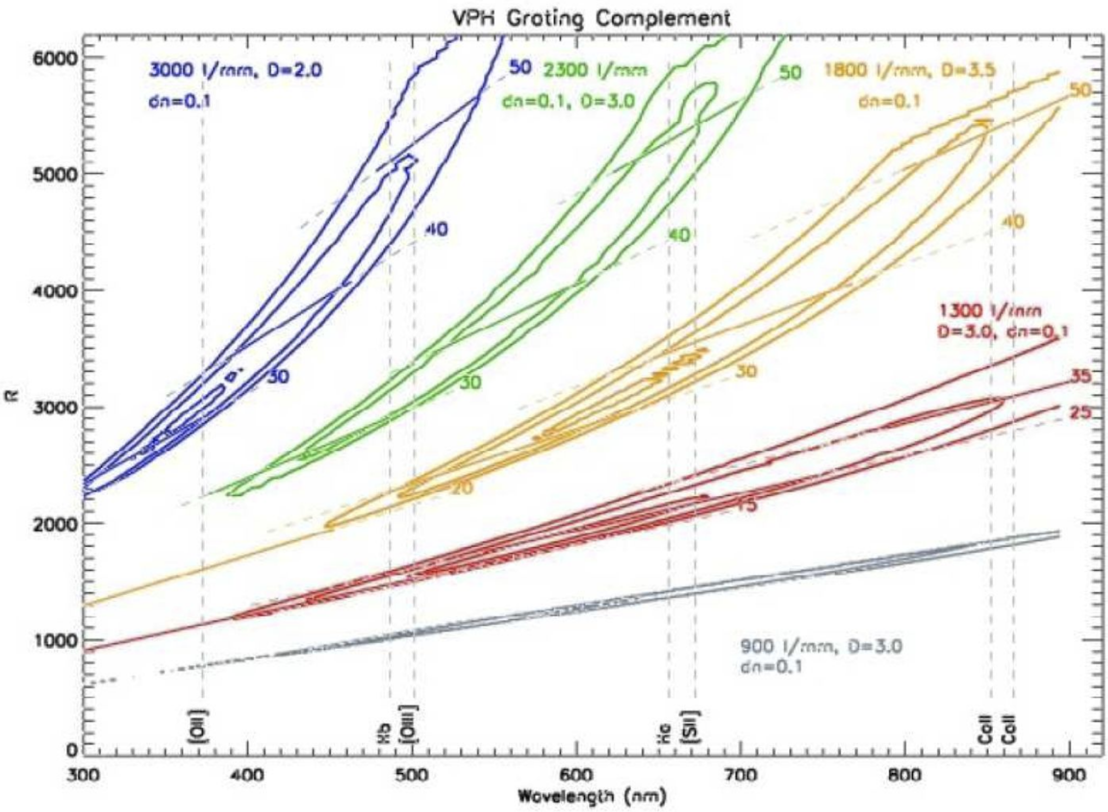


Figure 8: VPH grating efficiency as calculated using Rigorous Coupled Wave (RCW) analysis in resolving power versus wavelength for a 1.5” slit. The contours correspond to 90%, 70%, and 50%. Wavelength coverage for a few angles is shown for each grating.

7.3 Filters

Five order-blocking filters are available for RSS spectroscopy: one clear, three UV blocking, and one blue blocking. These filters are listed in Table 6. There are also 40 interference filters to be used with Fabry-Perot observations as well as narrow-band imaging (Table 7). All filter transmission curves are available online at: http://www.salt.ac.za/technical-info/instruments/rss/rss-fabry-perot/fabry-perot-filter-transmission-curves/

Type	Name

Clear	PC00000
UV	PC03200, PC03400, PC03850
Blue	PC04600

Table 6: RSS order blocking filters

7.4 Available Instrument Modes

7.4.1 Narrow-band or Clear Imaging

The RSS optical design is not optimized for broad-band imaging. Narrow-band imaging may be performed with any of the 40 Fabry-Perot interference filters listed in Table 7.

There is considerable fringing in the red narrow-band filters when they are illuminated at discrete wavelengths. Fringing has only been measured in the few filters mounted to date that are long-ward of 750 nm. In all filters tested, fringing is negligible for broadband illumination (sky and QTH lamps) with peak-to-trough variations of 2%. With arc lamp illumination (Ne or ThAr), the PI07500 filter shows no fringing while the PI08350, PI08535, and PI08730 filters have obvious fringing at levels of 10-20% peak-to-trough.

RSS imaging can be done in frame transfer and slot modes; however, the throughput of SALTICAM is higher, making it the preferred instrument for such observations. Timing tests carried out with an independent GPS demonstrate that the absolute and relative timing accuracy of RSS slot mode are good to a few tens of millisec.

7.4.2 Fabry-Perot

The SALT RSS Fabry-Perot system provides spectroscopic imaging over the whole RSS science field of view (8 arcmin diameter) in the wavelength range 430-860 nm with spectral resolutions ranging from 300-10000 depending on the mode used and wavelength observed.

The system consists of three etalons with gap spacings of ~0.6 nm, ~2.8 nm, and ~13.6 nm. The etalons are referred to as the low resolution (LR), medium resolution (MR), and high resolution (HR) etalons, respectively. The LR etalon can be used in its normal LR mode or configured as an even lower resolution tunable filter (TF). The MR and HR etalons are designed to be used in conjunction with the LR etalon in LR mode

The TF, LR, and single-etalon MR modes have been in normal operations thus far.

However, the coatings of the MR etalon have significantly degraded, and it had to be removed from the telescope in October 2015. Therefore, **MR is not available for 2017-1 proposals**.

Commissioning of the dual-etalon mode for HR has progressed. A serious reflection problem between the two inserted etalons was discovered during early commissioning of the dual-etalon modes. Multiple reflections between the etalons introduced a series of ghost images and significantly degraded throughput. Rectification of this problem was addressed with new mounts being installed and the alignment fixed and calibrated, and the dual-etalon HR mode has been shown to work technically. However, a temperature sensitivity was later discovered, limiting its practical operation. The current plan is to insert a polarising element into the Etalon to reduce ghosting arising from the mis-alignment. *This will, however, cut the flux to half,* which is taken into account in the Simulator. Nevertheless, both PIs and TACs should keep in mind, especially if large amounts of time are considered for FP/HR, that the mode is not yet officially commissioned and observations thus carry a risk of delays.

Table 7 shows the filters available for use with Fabry-Perot.

Table 7: RSS Narrow-band (Fabry-Perot) Filters

Name	Centre (Å)	FWHM (Å)
pi04340	4349.4	79.1
pi04400	4412.3	92.4
pi04465	4478.1	84.9
pi04530	4530	90
pi04600	4600	95
pi04670	4670	100
pi04740	4760.2	111.1
pi04820	4820	105
pi04895	4912.5	105
pi04975	4990.6	107.5
pi05060	5071.5	110.5
pi05145	5152.1	109.2
pi05235	5237	119.1
pi05325	5325	125
pi05420	5420	130
pi05520	5520	135
pi05620	5631.5	137
pi05725	5731.1	133.6
pi05830	5833.6	142.8
pi05945	5946.5	164.1
pi06055	6062.2	148.6
pi06170	6178.8	169
pi06290	6300.2	158.3
pi06410	6418.4	161.5
pi06530	6535.5	156
pi06645	6647.4	148.8
pi06765	6765	167.5

pi06885	6894.3	181.8
pi07005	7020.8	162.1
pi07130	7131.3	140.4
pi07260	7252.7	184.1
pi07390	7400	218
pi07535	7555.6	200.8
pi07685	7691.9	168.9
pi07840	7831.6	207.6
pi08005	7999	249.2
pi08175	8175.1	225.2
pi08350	8350	245
pi08535	8535	260
pi08730	8730	275

LR is calibrated for use in the H-α (650-700 nm) and H-β/[O III] (480-510 nm) regions, and dual-mode HR is also calibrated in a narrower H-α region. There are several other LR regions calibrated as well (e.g. 530-600 and 730-760 nm). In addition, we are also accepting proposals for wavelength regions that are not currently calibrated, though the PIs should be aware that uncalibrated wavelength region observations will be conducted as time and resources allow.

Flexure within RSS significantly impacts Fabry-Perot calibration so Fabry-Perot observations must be carried out as close as possible to a specific telescope rotation angle, which has been fixed to 90 degrees to the parallactic angle for all modes. Therefore, specific positions angles **cannot** be requested for Fabry-Perot observations. Because the position angle of the parallactic angle can vary significantly along a track or between east and west tracks it is very difficult to predict the location of the CCD gaps *a priori*.

To maintain maximum flexibility in scheduling we recommend that multiple dithered scans be obtained in cases where the object(s) of interest do not fall completely on the middle CCD.

All available Fabry-Perot modes need further work on flat-fielding. Flat-fielding is known to be problematic and work is actively ongoing to fully characterize this and how it might be calibrated properly.

Notwithstanding the previous comment, the LR, TF, single-etalon MR and dual-etalon HR modes have been used successfully for several science and/or commissioning programs. Observers should use the tables of etalon free spectral range given in the etalon technical reports and the blocking filter curves to estimate order effects on their particular program.

Further details and useful documentation can be found in the Appendix.

Tables containing the FWHM of the spectral resolution, the resolution and free spectral range of each etalon as a function of wavelength are included in that webpage. This information is helpful for proposal planning. A detailed description of the system is given in the paper by Naseem Rangwala, Ted Williams and their collaborators available at: http://iopscience.iop.org/1538-3881/135/5/1825

Additionally, Ted Williams has produced an Introduction to Fabry-Perot on SALT: An Introduction to Fabry.pdf

7.4.3 Long-slit Spectroscopy

Long-slit spectroscopy is the most commonly-used mode for RSS. The choice of slit widths is driven by considerations of resolution and throughput. A variety of slits is available to cover the range of atmospheric seeing conditions expected at the site. The RSS slitmask magazine has room for ten, tilted longslits. These allow for the SALT Imaging Camera (SALTICAM) to be used as a slit-viewing camera. Currently available slits are specified in Table 9.

#	Slit	Size
1	0.6	0.60”x8’
2	1.0	1.00”x8’
3	1.25	1.25”x8’
4	1.5	1.50”x8’
5	2.0	2.00”x8’
6	3.0	3.00”x8’
7	4.0	4.00”x8’

Table 9: Available long-slits for RSS

All available gratings are described in Section 7.2. All available order-blocking filters are described in Section 7.3.

Non-sidereal target spectra

Tracking at the object rates is not commissioned. However, observations of bright targets (that can be seen on the slit) whose motion is aligned along a wide slit (2” or greater) will be accepted. It is the responsibility of the PI to determine the correct PA to keep the target in the slit and to ensure that the target is bright enough to appear in the slit view images (so that the SA and SO can push it back into the slit if it moves out).

7.4.4 Multi-object Spectroscopy

RSS has multi-object spectroscopy (MOS) capability. Slits are laser-cut on carbon-fibre masks in Cape Town. The instrument can hold 30 MOS masks in a magazine at any given time, and the rest of the fabricated masks also reside at the telescope.

The masks are manufactured following user specifications through a java-based RSS Slit-Mask Tool (RSMT), as well as a Python-based tool especially useful for optimising slit selections from large catalogs. These tools are fully functional and are downloadable from the SALT proposal tools web pages:

http://astronomers.salt.ac.za/software/

No SALT pre-imaging is required for the mask preparation provided FITS files of the field containing astrometric solutions accurate enough for the PIs science goal are available. **We stress that high-quality astrometric solutions in the PIs images are absolutely crucial for successful MOS observations**. Pre-imaging can naturally be obtained with SALTICAM as well; however, these require their own Blocks which have to be observed well in advance of the MOS observations. Pre-existing astrometric files are strongly preferred and the reference stars for alignment and the science slits themselves must come from the same WCS source. MOS masks use 3-7 5"x5" holes for reference stars and alignment is done with feedback from through-slit images. Another important aspect to remember in the Phase 2 for MOS observations is the restricted Declination-dependent availability of field orientation; a document describing this can be found here.

One specific characteristic of VPH gratings used on RSS to keep in mind is that the wavelength dependence of the efficiency, as well as the simultaneous wavelength coverage for a given grating setup depends on the input angle to the grating. In MOS, the light entering through off-axis (in the dispersion direction) slits will hit the grating at different angles. Thus, the efficiency for the off-axis objects will be different than for the on-axis objects. This will in general not be symmetric either. Figure 9 illustrates this, and MOS users should consult the VPH grating simulator at http://www.sal.wisc.edu/PFIS/docs/rss-vis/ebb/pfis/observer/specsim.html for details.

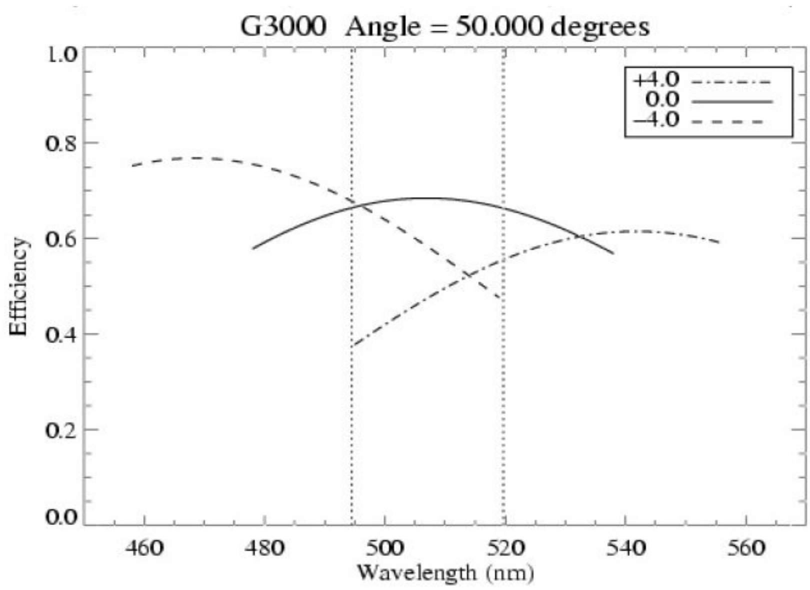


Figure 9. Example of the effect of blaze-angle on wavelength range and efficiency in MOS mode. Shown are the extreme cases of having an object at the edges of the RSS field-of-view, ±4' off-axis.

While MOS commissioning as a whole is completed and MOS projects are regularly observed, some telescope design features are placing restrictions on optimal MOS performance. An issue is that field rotation is open-loop on SALT by design (this is to be upgraded in 2017). There is typically a 0.03 degree drift in rotation during a 30 min track around the guide star, which would, at the edge of a field correspond to a spatial drift of 0.25". Experience has shown however that the rate is not constant, and can be more. **An exception are very Southerly tracks where the rotation is at its smallest, and re-alignment is not necessary for at least 1h.** For this reason we suggest the following:

- Slits narrower than 1.5" are not recommended.
- Programs which plan longer than 30 minute (sequences of) exposures should consider re-aligning the mask during the track (except in the South). Experience has shown that the re-alignment takes 5-7 minutes, and should be added to overheads if planned (in Phase 2 this can be explicitly taken into account).

Based on our first semesters of MOS observations the three most frequent issues we have seen when executing submitted programs are 1) the tendency of PIs to underestimate the required exposure times for faint targets, 2) insufficient accuracy in the WCS of the reference stars, and 3) some PIs specifying too short slits (<10") which will make sky subtraction very difficult. A set of instructions for preparation of MOS Phase 2 material, including e.g. proper selection of reference stars, can be found from the MOS specific Phase 2 FAQ page at
http://astronomers.salt.ac.za/proposals/mos/

7.4.5 Polarimetry Imaging/Spectropolarimetry

Polarimetry using RSS will *eventually* be possible in the following modes:

1) point-source long-slit linear spectropolarimetry with any grating and setting
2) point-source long-slit circular and all-stokes spectropolarimetry
3) diffuse long-slit spectropolarimetry (with spatial information)
4) multi-object (MOS) grating spectropolarimetry
5) imaging spectropolarimetry (using beamsplitter cross-dispersion in imaging mode)
6) Fabry-Perot spectropolarimetry

Polarimetry re-commissioning has been completed for mode 1) *point-source or compact object targets for linear long-slit spectropolarimetry* and is currently being commissioned for extended objects. We will prioritize the remaining grating polarimetric characterizations based on Phase 1 submissions. Therefore, **for the 2017-1, we offer long-slit *linear* spectropolarimetry**.

The priorities for the continued commissioning work will be set by the proposals being submitted for 2017-1. **We ask that those interested in any other modes *contact salthelp* with their wishes by the same Phase-1 deadline.**

Polarimetric Optics

The RSS polarimetric optics employs a “wide field'” design, in which a polarizing beamsplitter in the collimated beam takes the central half of the field and splits it into two separate orthogonally polarized fields, the “ordinary'” (O) and “extraordinary'” (E) beams. One (or two) waveplates can be inserted into the beam, right after the field lens in the collimator, to modulate the polarization state with time. The difference between the intensities of the O and E images as a function of time as the waveplates are rotated yields the polarization. For the polarimetric modes, only the central 4 arcminute portion of the focal plane is used (accomplished using a short slit for spectroscopy or a special mask blocking the upper and lower quarter of the field of view for imaging).

Waveplate Patterns

The waveplate modulators are used in five modes, *Linear, Linear-Hi, Circular,*

Circular-Hi, and *All Stokes.* For ease of operation, the waveplates are in the same order in all modes, half wave first. The table below gives the waveplate angle exposure progression pattern for each mode. The angle shown is that between the waveplate optic axis and the beam splitter polarization axis, which is perpendicular to the dispersion direction. A dash (-) means that the waveplate is not inserted.

Linear		Linear-Hi		Circular		Circular-Hi		All Stokes	
½ wave	¼ wave	½ wave	¼ wave	½ wave	¼ wave	½ wave	¼ wave	½ wave	¼ wave
0	-	0	-	0	45	0	45	0	0
45	-	45	-	0	-45	0	-45	45	0
22.5	-	22.5	-			22.5	-45	22.5	0
67.5	-	67.5	-			22.5	45	67.5	0
	-	11.25	-			45	45	0	45
	-	56.25	-			45	-45	0	-45
	-	33.75	-			67.5	-45		
		78.75	-			67.5	45		

Table 10: RSS Polarimetry waveplate patterns

PIs will need to select a waveplate pattern depending on the nature of the observation:

Linear: faint object linear polarization (minimizes exposures)
Linear-Hi: high-precision linear polarization. Redundant information gives systematic error estimate.
Circular: faint object with substantial ellipticity (circular/linear ratio)
Circular-Hi: object with low ellipticity. Redundant information to estimate linear-to-circular contamination.
All-stokes: linear and circular.

The full pattern must be completed to yield the stokes parameters.

<u>Advice for the current semester 2017-1:</u>
In the RSS Simulator and PIPT, when planning Phase 1 or defining Phase 2:

- Flag “use polarimetry”: this changes many of the following choices.

- Slit Type: only “Longslit” is currently available.
- Slit Width: use the PIPT, not the simulator selection, for the currently available longslits.
- Gratings: all stations and angles are available for gratings. Imaging polarimetry (slit/grating not set) is not yet fully commissioned.
- Always request guided observations (poor guiding can introduce spectropolarimetric features).

For estimation of expected S/N of linear spectropolarimetric features, use the simulator SN prediction (p = 1/SN). For baseline ('instrumental") linear polarization repeatability, assume 0.1-0.2%. This may improve during the semester as more calibration data is obtained, and the analysis software improves. It is very possible that, especially with the VPH gratings (those other than the 300 l/mm), there is a track position dependence of the linear polarization baseline at that level, and this is under investigation. If this is of concern, plan on doing everything twice to assess these sort of systematic errors.

Analysis software is available at https://github.com/saltastro/SALTsandbox.

7.4.6 High-speed Spectroscopy/Frame Transfer

This mode of operation ensures moderate time resolution (a few sec) and no dead time.

In Frame Transfer mode a mask covers the lower half the detector (all three chips). At the end of each exposure, the image in the top half of the chip is rapidly (0.2 sec) shifted to the lower half where it is readout while the next image in the top half accumulates during the next exposure, thereby ensuring no dead-time.

A list of the minimum exposure times for frame transfer in each binning can be seen in the third column of Table 11.

Frame Transfer spectroscopy is only currently available with the 1.5” slit, but please contact the SALT team should you require a different width.

Pre-binning	Slot Mode (sec)	Frame Transfer (sec)
1x1	0.70	20.0
2x2	0.30	8.4

3x3	0.20	4.7
4x4	0.15	2.0
5x5	N/A	2.6
6x6	0.08	2.2
7x7	N/A	1.9
8x8	0.07	1.7
9x9	0.05	1.6

Table 11: Minimum exposure times for Frame Transfer and Slot Mode for RSS.

7.5 Sensitivity

All RSS sensitivity calculations for planning observations should be done with the newest version of the RSS Simulator. PIs are warned that the RSS throughput below 400 nm is not nearly as good as expected originally. See Section 4.3 and Figure 7. for more information. **All current information on both the telescope and instrument throughput based on recent measurements is incorporated into the RSS Simulator.**

However, we have noticed through experience that *PIs often underestimate the required exposure times,* especially with fainter targets. Please be conservative when selecting the conditions for the simulation, and remember the IQ and seeing definitions (see Section 3.2.2) and that seeing and image quality has a large effect on the S/N of targets fainter than sky brightness. In addition, be sure you understand different definitions of S/N, per pixel or per resolution element, and what these mean for your science.

We note that in the past there was straylight reaching the RSS detectors decreasing the S/N of faint observations due to elevated background levels. This issue has now been fixed and during 2015 we have determined that straylight levels are far below the normal night sky levels on RSS. And the night sky levels were determined to be dark, similar to the Paranal night sky, the sky spectrum that the RSS Simulator is in fact based on. This is very encouraging, the improved throughput together with a well-baffled instrument mean that RSS is starting to be a competitive instrument in observations which do not require exceptionally good image quality.

As a guideline, approximate magnitude limits at a mid-range wavelength for each grating are tabulated in Table 12. *The limits have been calculated for 30-min exposures using the 1.5” slit, with 1.3” seeing at Zenith, in dark conditions, for an A0V type star (point-source).* The numbers are applicable to long-slit and MOS observations. The magnitude limit here corresponds to signal-to-noise ratio of 5 *per pixel* in 2x2 binning over a 2 x FWHM aperture spectral extraction at the tabulated wavelength.

As a rough rule of thumb for limiting magnitudes in good conditions, verified by actual observations, V=23 magnitude point sources can produce “measurable flux” in ~30 minute exposures with the PG900 grating and V=21 magnitude point sources with the PG3000 grating in blue settings. With the PG900 modes PIs have used RSS to successfully recover redshifts of 21 mag continuum sources and 22.5 mag emission lines sources.

We also draw to the attention of RSS users that the current RSS Simulator has inaccuracies up to ~2 nm in its wavelength range predictions to be noted when assessing the locations of the CCD gaps and edges.

Grating	**Central λ (nm)**	**Resolution (λ/δλ)**	**Mag Limit (*V*)**
PG0300	620	350	21.4
PG0900	605	1065	21.4
PG1300	665	1800	21.0
PG1800	677	2890	20.5
PG2300	566	3220	20.6
PG3000	434	3215	20.5

Table 12: Guideline RSS sensitivities in the middle of the ranges of the gratings, for S/N=5 in 30 min exposure. See Figure 8 for available wavelength ranges. The RSS Simulator tool should be used for more detailed calculations.

7.6 Guiding

The RSS auto-guider is routinely used for almost all RSS observations. Unfortunately, its sensitivity is limited to rather bright guide stars. The practical limit is *V* ~ 16 mag with 16.5 mag possible in good seeing. This is usually not a problem for long-slit work, but can be an issue for MOS and Fabry-Perot where the available field for selecting a guide star may be much more restricted.

The nominal closed-loop tracking performance with a bright guide star is about 0.2” RMS. With fainter guide stars and longer integrations this can degrade to 0.4” RMS. Work is ongoing to improve this and to improve the sensitivity of the guide camera. However, a major upgrade will be coming in 2017 with an altogether new system of guide cameras which will also not be plagued by rotational drift.

The auto-focus functionality of the RSS focus camera was not successful and is no longer available with the current guider.

In principle, it should also be possible to use SALTICAM as a guide camera in conjunction with the pellicle (software guiding). The pellicle degrades throughput to RSS by ~5-7%, but this mode provides the ability to correct for drifts in field rotation, making the throughput loss potentially worthwhile. However, since the current pellicle also degrades the SALTICAM image quality significantly, guiding this way has not been successful.

7.7 Blind Offsets/Dithering/Nodding

Objects fainter than approximately 21 mag in dark time, and 18 mag in bright time may not be visible in the several second long acquisition images to be put on the slit. The exact limit depends greatly on seeing at the time of observation as well as on the diffuseness of the target - the number above relates to point sources in typical 1.5” to 1.8” seeing. To put fainter targets on the slit, other methods are needed.

Our positional accuracy and repeatability is currently 0.3 to 0.5” RMS while guiding, measured by performing offsets of sizes varying from 0.5” to 30” and returning to the original position. This accuracy may or may not be sufficient for blind offsetting depending on the science application. If it is enough, e.g. for targeting more diffuse sources, and/or when using wide slits, blind offsetting is operationally feasible and may be requested in an *ad hoc* manner by discussing it with the liaison astronomer.

In most faint objects cases, however, we recommend providing a *brighter alignment object and a PA that will ensure placement of the fainter object in the slit*. The PA positioning accuracy is at least 0.5 deg, probably better, so finding a star of V=15-20 mag range at 60” distance would ensure the positioning of the slit with <0.5” accuracy. It is safer to use slit widths of 1.5” or more, and to *use alignment stars as close as possible to the target*.

All of the comments and caveats about SALTICAM dithering that are discussed in Section 6.5 apply to RSS as well. The accuracy of the dithering is, again, limited currently to 0.5” RMS. For some purposes (e.g. Fabry-Perot), this is perfectly fine. For others (e.g. dithering blindly between different slit positions), it may not be. However, since in most cases an object will be visible on the slit-viewer, the observer just would re-check alignment before re-starting exposures (60 sec overhead is defined for dithering along the slit, which includes the move and tweak of position if required).

Nod-and-shuffle mode is not offered during 2017-1 due to it not being commissioned yet.

7.8 Calibrations

7.8.1 Features of RSS Calibrations

The RSS calibration plan (see section 7.8.2) is based on the SALT telescope specifications and on current experience. We would like to point out the following items:

- SALT is a telescope with a variable pupil so that the illuminating beam changes continuously during the observations. This makes it impossible to perform absolute flux calibration even using spectrophotometric or photometric standards.
- Our current experience shows that biases are only useful for RSS Faint/Slow mode. Bias for this mode are now taken as part of the default calibration process (2x2 binning). A report discussing these biases is available at: https://sciencewiki.salt.ac.za/index.php/A._Schroeder_RSS_Bias_analysis
- **Imaging Mode:** Everything described in Section 6.7.2 about SALTICAM flat-fielding also applies to RSS imaging.
- **Long-slit Mode:**
    - Unless reference spectra (arcs) are obtained immediately before, after, or between science observations, wavelength calibration solutions may shift up to 10-14 unbinned pixels: 0.5-0.7 nm for grating PG0900 and 0.1-0.2 nm for PG3000: http://wiki.salt.ac.za/images_wiki.salt.ac.za/3/31/RSS_stability.pdf
    - For reference spectra we guarantee that the RMS uncertainty of 2D wavelength solutions will be **at most** ½ of an unbinned pixel for most of the spectral setups: 0.025 nm for PG0900 and 0.008 nm for PG3000.
    - Due to flexure within the spectrograph, spectra can have trends in their wavelength solutions of up to 1 unbinned pixel over the course of a track.
    - Each slit has some variations in throughput along the slit due to roughness in the slit edges. These variations are up to 10% row-to-row and can shift significantly due to spectrograph flexure and lack of mechanical repeatability. To correct for this effect, spectral flats must be obtained immediately before or (preferably) after science frames.
    - Spectral pixel-to-pixel variations are also corrected using spectral flats. These corrections can decrease the background RMS for data up to

5%. At the same time “lazy pixels” can be corrected for up to 95% of their difference in sensitivity.
    - The map of spectral pixel-to-pixel variations is roughly constant with maximum of 10-20% variation over a week’s time.
    - Fringing correction: Beyond approximately 7500 A there is significant **fringing** present on the spectral frames, and spectral flats (calibration screen flat fields) *taken together* with the science frames *are essential* **for all target types** in this case to reduce for this effect. In addition, for both sky and fringing removal for fainter and/or extended targets in these reddest settings it is also helpful to dither along the slit between the (two or more) science frames. The dither step must be larger than the extent of the target. A report on the findings and suggestions is available at https://sciencewiki.salt.ac.za/images_sciencewiki.salt.ac.za/1/12/SALT_RSS_fringing.pdf
- **MOS mode:** MOS calibrations **are equivalent** to long-slit calibrations. Arcs and flats will be taken through the PI-specified mask. However, the spectrophotometric standard will be taken with a 4” long-slit using otherwise the same RSS configuration, hence directly applicable only to those slitlets that happen to lie on-axis.
- **Fabry-Perot mode:** Ring calibration images using appropriate arc lamps are taken both before and after science data to define the wavelength calibration. The first ring calibration is used to calibrate the control software so that the etalon is accurately configured to the correct wavelengths. Subsequent ring images are used later to measure the wavelength calibration and its drift over time. *However, it has turned out that the resultant wavelength from the calibration system ring has unexplained offsets relative to the solution from sky emission lines, of the order of 1-2 A (though the relative wavelengths within the scans are fine)*. It is hence recommended that PIs, if at all possible, use sky lines to wavelength calibrate their data cubes. The calibration system rings will be taken by default nevertheless.

7.8.2 Current RSS Calibration Plan

All calibrations should be requested by the relevant check-boxes in the Phase 2 PIPT. For overhead estimations without using the PIPT Table 12 in Section 10. can be used as well.

The calibration plan (see Section 5.1 for definitions) for RSS for the upcoming semester is:

- No **DC** calibrations will be done
- No **LC** calibrations will be done

- **UCC** calibrations will be done by PI request and the PI will be charged accordingly. These include:
  - **Long-slit mode:**
    i. Observations of any reference arc spectra **before / in between / after** science observations. For each reference arc spectrum the PI will be charged at least 120 sec because of the time it takes to configure the calibration system and the integration time required to obtain a good arc spectrum (often 60 sec). For increased efficiency, we recommend the arc observation to occur **after** the science if only one set is needed. Arcs are highly recommended to be taken for every Block.
    ii. Observations of 5 spectral flats **before / in between / after** science observations. For each set of 5 spectral flats the PI will be charged approximately 120 sec, which includes the setup, integrations and readouts. We recommend spectral flats be taken **after** science for efficiency. For clarity, we ask that the PI clearly mentions in both Phase 1 and Phase 2 **whether or not** flats are needed.

  - **UNC** calibrations can be done by PI request:
  - **Long-slit mode:**
    i. Observations of one spectrophotometric standard star (1 exposure) per detector and spectrograph setup. These observations will be taken with the widest available long-slit (normally 4”). The star will be placed in the middle of the slit. These data will be acquired during the *next available* twilight. Note that arcs and flats are not normally taken for spectrophotometric standards (the sets coming with the science exposures should be sufficient). For clarity, we ask that the PI clearly mentions in both Phase 1 and Phase 2 **whether or not** spectrophotometric standards are needed for the science. Finally, note that if a specific standard star needs to be observed, or the PI wants arcs/flats with the star, these are charged.
    ii. Observations of one Lick standard star (1 exposure) per detector and spectrograph setup. The star will be placed in the middle of the slit. These data will be acquired during the ***next available*** **twilight**. See comments above. If the PI requires a specific spectral type, this must be clearly indicated.
    iii. 5 spectral (lamp) flats per detector and spectrograph setup taken during the day or twilight. These can be requested **instead** of the charged UCC flats taken during the night time

after the science frames. However, we **do NOT recommend the use of these UNC flats except for pixel-to-pixel corrections.** Because the pixel-to-pixel variation is stable, we will take such flats only once per semester for a given setup**.**The illumination and, especially, the variations due to slit non-uniformity **ARE NOT** repeatable.

iv. 3-5 twilight spectral flats followed by an arc taken with the same slit width and setup as the science data will be taken upon request during the **next available twilight**. However, since these observations are very time-consuming the request needs a prior approval from the liaison astronomer.

- **Imaging mode:**
  i. 5 calibration screen flats per detector and camera setup taken during twilight or day.
  ii. 11 biases per detector setup.

  Again, we do not recommend these and have not found them to be effective for calibrations.

- Any additional calibrations can be done upon PI request and PIs will be charged accordingly.

8. HRS

The SALT HRS is a dual-beam (370-555 nm and 555-890 nm) fibre-fed, white-pupil, échelle spectrograph, employing VPH gratings as cross dispersers. The cameras are all-refractive. The concept is for SALT HRS to be an efficient single-object spectrograph using pairs of large (350 μm to 500 μm; 1.6-2.2 arcsec) diameter optical fibers, one for source (star) and one for background (sky). Some of these feed image slicers before injection into the spectrograph, which deliver resolving powers of R ~14000 (unsliced 500 μm fibres), ~40000 (sliced 500 μm fibres), and ~65000 (sliced 350 μm fibres). A single 2k x 4k CCD is sufficient to capture all the blue orders, while a 4k x 4k detector, using a fringe-suppressing deep-depletion CCD, is used for the red camera. Complete free spectral ranges are covered by both the blue and red arms.

8.1 Operational Modes

SALT HRS offers four different operational modes, which vary in spectral resolution at the expense of instrument throughput. Table 13 summarizes the four modes along with their options.

Parameter	Low Resolution Mode	Medium Resolution Mode	High Resolution Mode	High Stability Mode
Fibre Diameter (arcsec)	2.23	2.23	1.56	1.56
Slit width (arcsecs)	1.673	0.710	0.355	0.355
Image Slicers	No	3 slices	3 slices	3 slices
Blue arm resolution	15000	43000	67000	67000
Red arm resolution	14000	40000	74000	65000
Blue arm transmission (total %) at 460nm*	12	7	7	4
Red arm transmission (total %) at 625nm*	19	11	12	6
Fibre mode scrambling	No	No	No	Yes, permanent
Nod and shuffle	Optional	No	No	No
Iodine cell	No	No	No	Optional**
Simultaneous ThAr**	No	No	No	Optional**
Total photon count***	Yes	Yes	Yes	Yes

Table 13: Summary of HRS mode characteristics and efficiency predictions.

* These efficiency values represent the as-measured 'end-to-end' throughput for the spectrograph as a whole, including the optical fibre feed.
** Note that the Iodine cell and simultaneous ThAr feed cannot be used simultaneously.
*** From exposure meter (unless using the optional internal ThAr lamp in simultaneous use in the high stability mode).

8.1.1 Low Resolution Mode (LR)

This is lowest resolving-power *R* = 14000 configuration. The configuration offers the same fibre input diameter as the *R* = 40000 mode (500 μm) but with the benefit of a

1.4× higher throughput because the fibre output is not image-sliced (hence the coarser resolution).

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.

8.1.2 Medium Resolution Mode (MR)

The R = 40000 mode is 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 versus throughput trade-off available in this mode.

8.1.3. High Resolution Mode (HR)

The R = 65000 mode is likely to be selected only by those projects for which the lower throughput compared to the R = 40000 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 = 40000 because of the improved systematics compared to other spectrographs.

8.1.4 High Stability Mode (HS)

The high stability mode is optimised for precision radial velocity measurements and is 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 5 ms^{-1} corresponds to 10^{-3} of a resolution element). The light path includes a permanent ‘double scrambler’ to improve the radial scrambling of the optical 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 into 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 the iodine cell has yet not been fully characterised (i.e. no Fourier Transform Spectrometer spectra available, only the commonly available generic iodine atlases). It should also be noted that the simultaneous ThAr and iodine cells may not be used together.

8.2 Calibrations

We have chosen to standardise on unbinned, single-amplifier, slow readout for both the red and blue cameras for the coming semester. A set of 11 bias frames for this default mode (1x1, single-amplifier, 400kHz readout) is taken daily.

Wavelength calibration for the four modes is undertaken using the SALT Calibration System (CalSys) and consists of a set of ThAr hollow-cathode lamp spectra obtained through both object and sky fibres. These (uncharged) calibrations are taken during bad weather or in the daytime, weekly in the case of LR, MR and HR modes. Given the stability of the instrument, these daytime calibrations should suffice. The accuracy of radial velocities has been shown be to be *at least* in the 300-500 m/s range with this scheme.

In the case of the HS mode, the instrument's own internal ThAr arc lamp is additionally used for daily monitoring of the RV stability of HRS. Results of monitoring arcs indicate a total variation of +/- 0.4 pixels, and <1/10th of this over a timescales of days. For intra-night arc drifts, once the systematic trends are removed, the rms fluctuations are ~0.005 pixels (8 m/sec). For the other modes (LR, MR & HR), stability is expected to be <0.1 pixel.

RV standard stars are normally observed with the LR, MR and HR modes during twilight or during gaps in the observing queue (at no cost). These may be requested (as indeed can other standards or calibrators) at other times during the night, but these will be charged for. Note that due to availability or weather conditions, twilight standards may not be observed on the same night as science data. The request of the observation of specific Calibration Star should be done like any other science target.

8.2.1 Extra Calibrations

Uncharged flat fields (used mostly for order definition) are taken with the SALT Calibration System's quartz-tungsten-halogen (QTH) lamps for all four modes. Additional flat fields with the iodine cell in the beam for the HS mode may be requested. Given the stability of the instrument, these are not expected to change unless serious interventions require us to detach and re-attach the fibres, or open the vacuum tank.

SALT HRS is equipped with an exposure meter, which is available for use in all four operational modes (with the exception of the high stability mode when the simultaneous internal ThAr lamp is in use). Time-indexed photon counting data should therefore be available, as well as flux-weighted mid-points for the exposures.

8.3 Performance Prediction

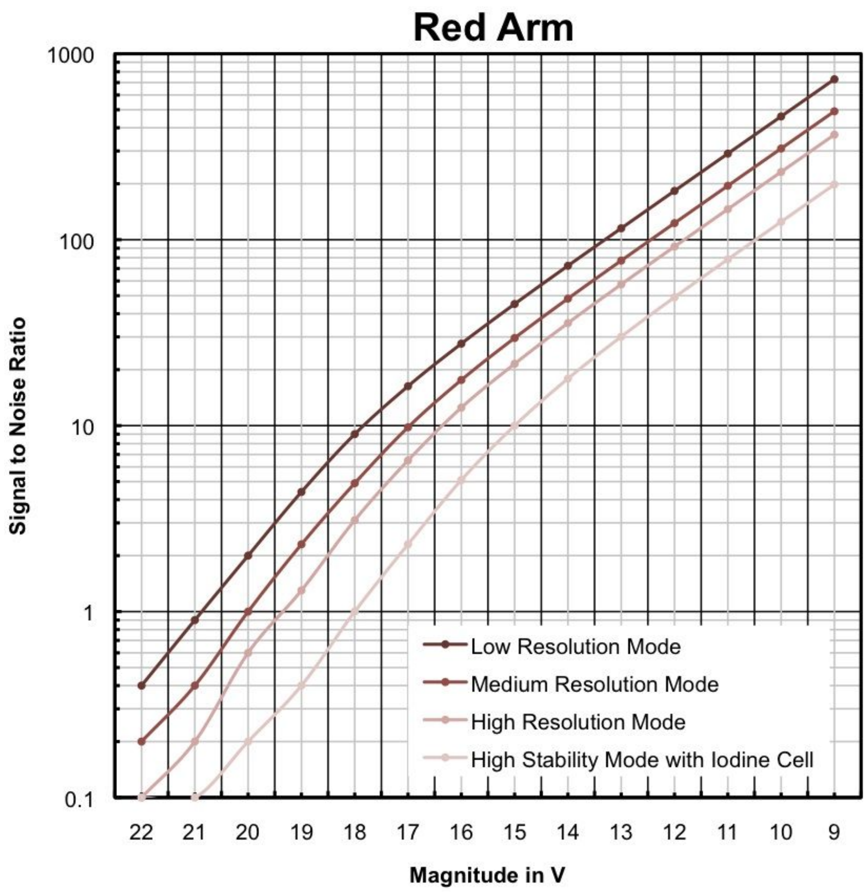


Figure 10. The expected signal to noise ratio (S/N) of SALT HRS as a function of stellar visual magnitude (m_V) using the red instrument arm and a variety of operational modes. The calculations are for a wavelength of 725 nm and the low (R~14000), medium (R~40000) and high (R~65000) spectral resolving 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.

Figures 10 and 11 show the anticipated SNR ratio of SALT HRS as a function of stellar visual magnitude (m_V). Note the difference in performance of the four instrument modes due to variance in throughput. These values are currently based on predicted instrument efficiencies (See section 8.3.1 for on-sky comparisons). Users may simulate HRS observations using the simulator tool available at http://astronomers.salt.ac.za/software/.

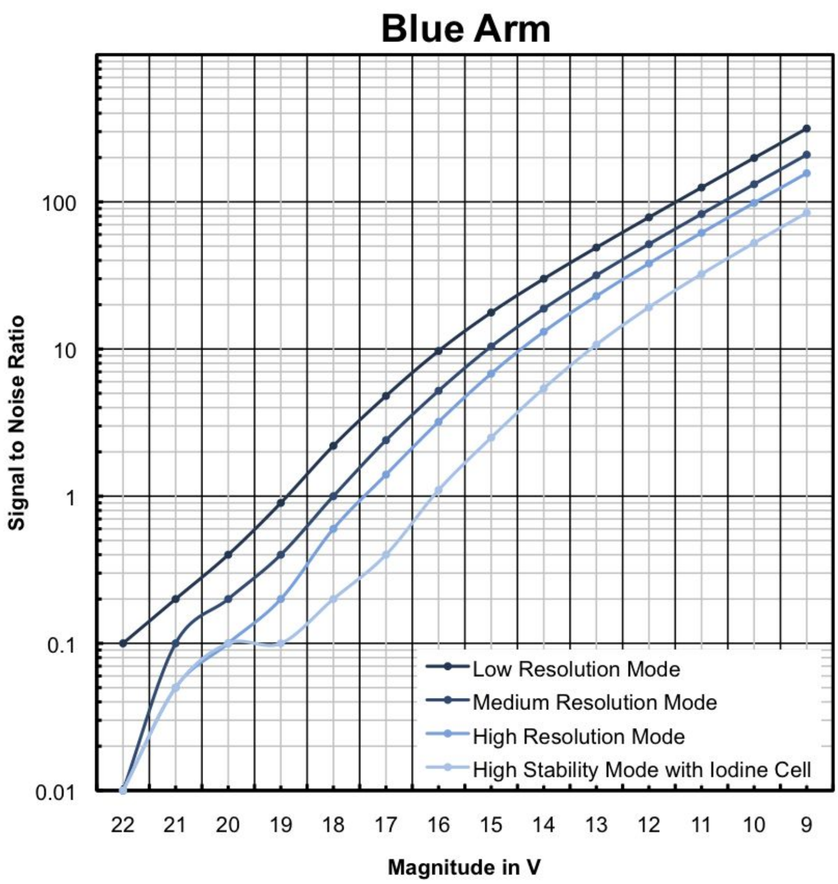


Figure 11. The expected signal to noise ratio (S/N) of SALT HRS as a function of stellar visual magnitude (m_V) using the blue instrument arm and a variety of operational modes. The calculations are for a wavelength of 460 nm and the low (R~14000), medium (R~40000) and high (R~65000) spectral resolving 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.

The radial velocity accuracy achievable using HRS depends on the mode used. The instrument is stable enough so that **radial velocities precision of better than 500m/s are routinely achievable**.

8.3.1 On-sky measurements.

We have verified that bright object (V = 6-10 mag) throughput is consistent with the simulator tool predictions. Due to the on-sky size of the fibres, it is possible to observe faint targets with HRS but there are several indications that for the faintest targets (V lower than 16), the simulator overestimates the signal to noise ratio. **Thus PIs are urged to be conservative in planning fainter target HRS observations, and should carefully consider observing targets fainter than V=18 even with the LR mode.**

8.4 Spectral Format

Figures 12 and 13 illustrate the echellogramme maps of the red and blue arm spectra as they appear on their 4k x 4k and 4k x 2k detectors respectively. The cross-over wavelength between the two arms is at 555 nm, with the blue arm covering 370-555 nm and the red detector covering 555-890 nm.

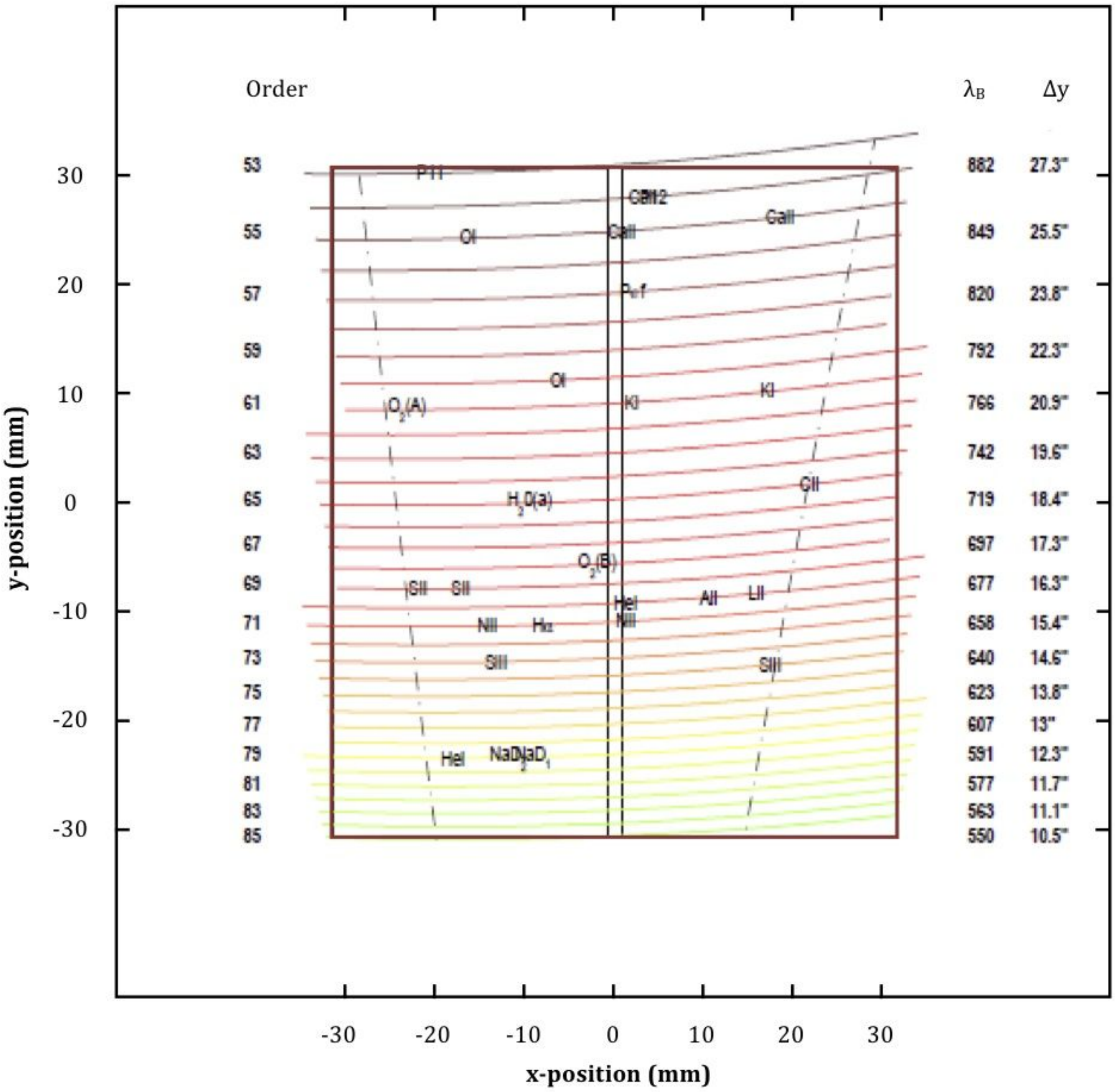


Figure 12. Wavelength coverage for the red arm of SALT HRS. Key spectral features are noted on each image, as are order numbers and the blaze wavelengths λ_B.

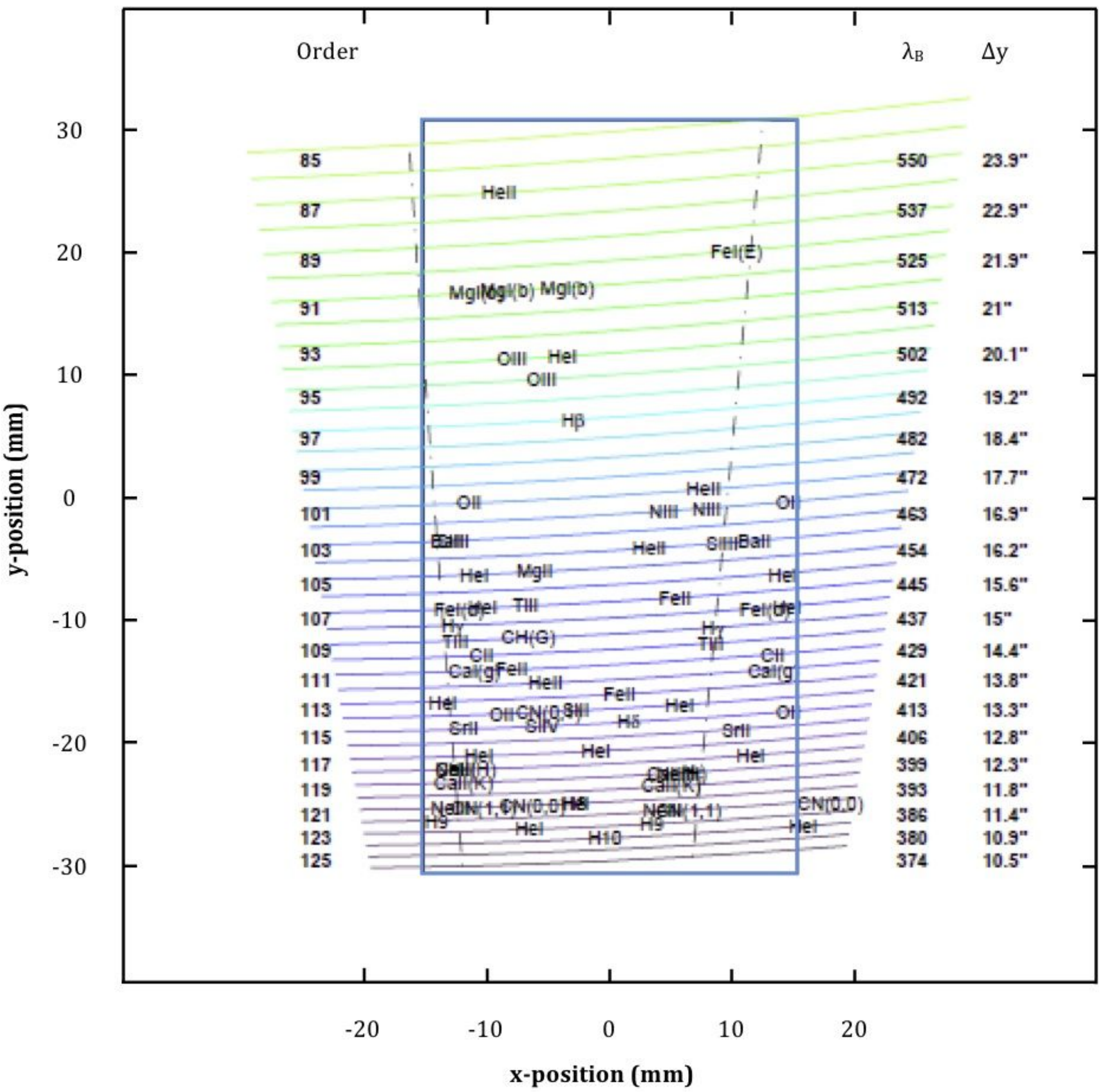


Figure 13. Wavelength coverage for the blue arm of SALT HRS. Key spectral features are noted on each image, as are order numbers and the blaze wavelengths λ_B.

8.5 Readout Modes:

HRS supports a variety of detector read-out modes, with users able to tailor read-out speed, binning and the number of read-out amplifiers to suit their needs. Modes and read-out speeds are summarized in Tables 15 and 16 below.

1000kHz and 400kHz read-out speeds are supported on both detectors. The former offers a shorter read-out time at the expense of marginally higher read-out noise. 1000kHz should offer acceptable read noise performance in many circumstances (see Table 14 for values - averaged over all two/four read-out amplifiers for blue/red CCDs respectively).

	1000kHz	400kHz
Red	4.7e- RMS	3.6e- RMS
Blue	5.8e- RMS	4.2e- RMS

Table 14: HRS red and blue detector read-out noise with different read-out speeds.

CCD binning options are 1x1, 2x2, 3x3, 8x8 and 3x1 (binning in the spatial direction only). 1x1 binning is the standard binning mode, since binning will degrade spectral resolution in all but the low resolution mode (where a resolution element is multiple pixels in width). Despite no binning in the spectral direction, the 3x1 binning mode will still cause some resolution loss in all but the low-resolution mode, since it will smear the effect of line tilt across the order. The advantages of binning are reduced read-out times and reduced read-out noise, since fewer 'pixels' are read-out.

It is possible to read-out the detectors using single or multiple read-out amplifiers. For the 2k x 4k blue CCD, the options are one or two amplifiers. In the case of the larger 4k x 4k red CCD, the options are one or four read-out ports. Read-out speed scales with the number of amplifiers (so four amplifier read-out is four times faster than a single amplifier at the same speed and binning). Note that when using multiple read-out amplifiers, each area of the chip will have a different bias level and overscan region, which must be dealt with in data reduction.

Red	400kHz		1000kHz	
Binning	**Single**	**Quadruple**	**Single**	**Quadruple**
1x1	**37s**	10s	19s	5s
2x2	11s	3s	6s	2s
3x3	6s	<2s	4s	<1s
3x1	13s	4s	7s	2s

Table 15: HRS red detector read-out times (seconds) with different binning and read-out amplifier configurations. The default (=standard) readout mode is highlighted.

Blue	400kHz		1000kHz	

Binning	Single	Double	Single	Double
1x1	**23s**	12s	10s	5s
2x2	8s	4s	5s	3s
3x3	5s	3s	3s	2s
3x1	8s	5s	4s	2s

Table 16: HRS blue detector read-out times (seconds) with different binning and read-out amplifier configurations. The default (=standard) readout mode is highlighted.

8.6 Caveats and Recommended Readout Modes:

A default read-out mode has been standardised as:

- **Red CCD: Single (1 of 4) amplifier, 400kHz read-out speed, 1x1 binning (37s readout-out time)**
- **Blue CCD: Single (1 of 2) amplifier, 400kHz read-out speed, 1x1 binning (23s read-out time)**

Users are strongly advised, in almost all cases, to use this recommended detector configuration for HRS proposals. Although it is the slowest option, the data quality will be of the highest achievable standard, with the simplest possible data reduction requirements. SALT will provide the calibration files (weekly CalSys arcs and flats for all modes; daily HR CalSys and HS internal ThAr mode arcs; daily bias frames, as mentioned in Section 8.2 above).

Alternatively, in extreme and specialist circumstances, users may request a configuration other than this default read-out option. In order to accommodate such a request, SALT will be required to create additional calibration frames in the requested new custom read-out mode, in addition to those made as standard. Clearly it is unfeasible to offer every possible read-out configuration (20 possible read-out mode combinations per detector), as the calibration requirements would be vast. In order to be granted the option for a customized readout-out mode, it will be the responsibility of the proposer to provide a detailed and valid technical motivation.

As an example, a hypothetical proposal with one target, one visit and 2x 1800s exposures on a bright star in low-resolution mode, might prefer to use multiple amplifiers, 1000kHz read-out speed and 3x3 binning. SALT would be unable to support such a request merely to save the proposer 117s of read-out time with 3600s of observing time.

On the other hand, a hypothetical proposal with 40 visits of 3x 2s exposures for an exoplanet monitoring program might make a reasonable argument to use a 1000kHz read-out configuration. Since overheads make up the bulk of the time in this case (a reduction from 7200s to 3480s overheads for 240s observing time), SALT may consider granting such a request, if possible, and at our discretion. Another example might be a scientific requirement for high time-resolution observations requiring low read-out overheads.

Although an 8x8 binning option is available for HRS, at the time of writing, the various gains in 8x8 mode for each CCD amplifier have not been empirically determined. For this reason, in addition to those mentioned above, 8x8 binning should be avoided until proper detector characterisation can be achieved.

It is also noteworthy that HRS CCDs are read-out in series rather than in parallel, as parallel read-out can cause a small cross-talk signal between the detectors. The blue CCD is therefore read-out before read-out of the red CCD commences. Read-out times reflect the sum of the two read-outs. As an example, running 3 back-to-back iterations of 10s exposures using the previously recommended (single amplifier, 1x1 binning , 400kHz read-out) detector settings would take:

$$3 \times (10s + 23s + 37s) = 210s$$

For additional details of HRS overheads please see section 10 of this document.

9. BVIT

The Berkeley Visible Image Tube camera (BVIT) is a visitor instrument built at the Space Science Laboratory of the University of California-Berkeley. It is a photon-counting camera with a ~1.3 arcmin diameter field of view, capable of very high time resolution (millisec or microsec) photometry with a *B*, *V*, *R* or *H*-alpha filter. It can be used for objects with magnitudes ranging from *V*~12-20. BVIT is available for general use. The most accurate and up-to-date information about the instrument, as well as a count-rate estimator, can be found at: http://bvit.ssl.berkeley.edu/.

BVIT does not provide high-precision absolute photometry; however, by observing nearby standard stars, a flux intensity relative precision of ~ 5% can typically be obtained. Every detected photon is assigned a time of arrival and a (x,y) position on the detector, which allows an observer a high degree of post-acquisition data analysis flexibility.

At this time, we are not allowing the BVIT iris size to be altered. The field of view is thus fixed at ~1.3 arcmin in diameter. Note that the two constraints when using BVIT are the *global* and *local* count rates. The global rate (sum of all counts on the detector) cannot exceed 1MHz. The local counts from any single source cannot exceed 100kHz. If proposing, please carefully check the field and consider counts from **all** sources that will be exposed and not solely the target of interest.

A **1500s overhead on BVIT** data allows for acquisition from one of the larger field-of-view facility instruments (SALTICAM or RSS) as well as an acquisition and count rate check from BVIT.

Due to the complexity of the instrument setup, all BVIT observations will be carried out by our local BVIT expert, thus observations are also subject to expert availability.

10. Overheads

All SALT Phase 1 proposals *must* include the overhead times associated with the science observations in the proposed time. The most accurate way to estimate overheads is to use the PIPT tool to build actual Blocks to see how long their execution times are. While Block preparation is not required at Phase 1, the exercise is strongly encouraged to check how feasible the science observations are regarding track times and Block limitations (see Section 2.3) when overheads are included. The main sources of overheads are summarised in Table 17 as well for PIs to get an idea of the involved times. PIs must be especially aware that in addition to pointing and acquisition related overheads, there may be calibration related overheads. The latter may or may not be charged for (see Sections on Calibration Plans, 6.7.2, 7.8.2 and 8.5/8.6), and may or may not affect the available time for science during a track time (e.g. arcs taken after an observation vs. arcs in-between observations).

Please note especially that the basic acquisition time including pointing, focusing, object acquisition, and guidance configuration is ***1500s for BVIT, 900s for RSS-MOS, 600s in all other RSS modes as well as SALTICAM, and 500s for HRS.***

The overheads for arcs depend strongly on the setup, and for blue and/or high resolution setups can take several minutes. You should check the PIPT for the overhead estimates.

Item	Time (sec)	Comments

SALTICAM		
Acquisition (all modes)	600	point, acquire, (guide). Includes need for re-focusing in longer blocks.
Dither move	30	with ~0.5” accuracy
Filter change	11	
Readout, Full Frame, Slow	9.0, 21, 53	6x6, 2x2, 1x1
Readout, Full Frame, Fast	8, 14, 26	6x6, 2x2, 1x1
Readout: Frame Transfer	0	minimum exp.times apply
Readout: Slot Mode	0	minimum exp.times apply
RSS		
Imaging acquisition	600	point, acquire, guide, RSS config
Long-slit acquisition	600	point, acquire, guide, RSS config
FP acquisition	600	point, acquire, guide, RSS config
MOS acquisition	900	point, acquire, guide, RSS config
MOS realignment	360	re-acquisition, RSS config
Full RSS config change	240	
Grating angle change	15	
Filter change	45	
Slitmask change	40	
Articulation movement	71, 42, 142	100° → 0°, 50° → 0°, 100° ⇄ 0°
Nod along slit, blind offset	60 (spectroscopic dither), 30 (imaging dither)	with ~0.5” accuracy
Calibration screen in	30	
Calibration screen out	30	
Arc	check in PIPT	minimum 60 sec + readout time, cal.sys already inserted
Spectral flat	180	5 frames, lamp change, cal.sys already inserted

Readout Full Frame, Slow	7, 18, 28, 51	4x4, 2x2, 1x2, 1x1
Readout Full Frame, Fast	6, 11, 14, 24	4x4, 2x2, 1x2, 1x1
Readout: Frame Transfer	0	minimum exp.times apply
Readout: Slot Mode	0	minimum exp.times apply
HRS		
Acquisition (all modes)	500	point, acquire, guide, configure HRS
Configuration change	45	e.g. high stability mode with simultaneous ThAr to HS mode with iodine cell
Full readout and file saving overhead in Default HRS Mode	75	1x1
Readout Red Frame, Slow, Single Amplifier	6, 11, 13, 37	3x3, 2x2, 3x1, 1x1
Readout Red Frame, Fast, Single Amplifier	4, 6, 7, 19	3x3, 2x2, 3x1, 1x1
Readout Red Frame, Slow, Quadruple Amplifier	2, 3, 4, 10	3x3, 2x2, 3x1, 1x1
Readout Red Frame, Fast, Quadruple Amplifier	1, 2, 2, 5	3x3, 2x2, 3x1, 1x1
Readout Blue Frame, Slow, Single Amplifier	5, 8, 8, 23	3x3, 2x2, 3x1, 1x1
Readout Blue Frame, Fast, Single Amplifier	3, 4, 5, 10	3x3, 2x2, 3x1, 1x1
Readout Blue Frame, Slow, Double Amplifier	3, 4, 5, 12	3x3, 2x2, 3x1, 1x1
Readout Blue Frame, Fast, Double Amplifier	2, 2, 3, 5	3x3, 2x2, 3x1, 1x1
BVIT		
Acquisition (all modes)	1500	point, acquire, configure

Table 17: SALTICAM, RSS, HRS, BVIT overhead estimates.
*See section 8.6 for a fuller explanation of HRS read-out times

11. Policies

11.1 Proposal Types

There are five proposal types for this semester:

- Science (SCI)
    - Regular observing proposals. They follow regular Phase 1-Phase 2 deadlines and procedures. Only up to 150 hours may be requested.
- Science - Long Term (MLT)
    - Identical to regular science proposals but request (and obtain) observing time for more than one semester. See section 11.4 for more information.
- Large Science Proposal (LSP)
    - Large Science Proposals request > 150 hours from one or more Partners, which can be spread over a total of six semesters. See section 11.6 for more information.
- Director's Discretionary Time (DDT)
    - DDT proposals may be submitted at any point via the PIPT, but they must be agreed upon with SALT (sa@salt.ac.za) and ddt@saao.ac.za prior to submission. See section 11.5 for more details. A total of 10h of DDT time is potentially available for 2017-1.
- Commissioning (COM)
    - These are proposals intending to test new instruments, instrument modes or specific characteristics of the telescope/instrumentation. These must be agreed upon with SALT (sa@salt.ac.za) prior to submission, or be submitted in response to a Call for Commissioning proposals.

All proposal types, except the DDT, require a Phase 1 submission, but the details required depend on the type.

11.2 Proposal Priorities

An individual observing program will consist of a number of observations of different targets and will be assigned a set of priorities (though preferably only one priority per program) by the relevant TAC(s). Each partner TAC will have the same breakdown in terms of the percentages of different priorities, and all observations are charged in the same manner. The priorities just influence the likelihood of a given target being observed on a particular night and over a semester. See the Figure in the Quick Start section for historical completeness fractions per Priority.

For the upcoming semester, the available science time will be allocated to the different priorities such that 40% for P0+P1 time, 40% for P2 time, and 20% for P3 time with a factor 3 over-subscription rate for P3. These are applicable to the science and science long term programs.

Priority 0

Highest rated Targets of Opportunity (ToO) programs or time critical observations. Once scheduled, and weather permitting, Priority 0 observations will have the highest chance of being observed at the time requested. Examples of such observations might include supernovae and other transient events, and rare periodic phenomena.

Any proposal can consist of time critical observations, but only ones allocated a P0 priority will in general be observed in preference to other priority classes.

Note that P0 time is not permitted for non-time critical targets, P1 will be used for them.

Priority 1

Highest rated proposals, which, if scheduled, will have a high chance of being observed in a given night. Such targets will be the most scientifically compelling of all standard priority targets and completion of most P1 blocks in a given semester is expected. We hope to achieve at least 80% completion of P1 blocks, some cannot get done just due to conflicting target distributions.

Priority 2

P2 programs are not as highly rated as P1 by the TACs, but are still considered to be compelling and P2 blocks will have a good chance (60%) of being completed in a given semester.

Priority 3

P3 programs are lowest priority science as assigned by the TACs, but still worthy of consideration. P3 proposals are deliberately over-subscribed by a factor of 3 in order to always have a full queue. If P3 blocks and programs are intelligently designed, to be easy (short, loose constraints, wide RA-ranges with optional targets) dynamic scheduling will likely mean that a significantly larger fraction of them will get observed than the expectation of 20-30%.

Priority 4

This is a priority class consisting of “filler” targets, to be done in marginal observing conditions (i.e. poor transparency or bad seeing) or to fill gaps in the observing queue. They would not need to necessarily be strictly 10-m class science, but deemed to be useful science nevertheless. P4 programs *will not be charged*.

PIs should justify in the application (technical section) why their proposed programs should be considered P4 time (e.g. brightness, observing mode, allowable conditions, large pool of short observations). TACs will accept or reject the P4 proposals as they see fit. P4 programs will only be attempted if, at the duty SA's discretion, there are no other viable P0 - P3 programs that can be attempted.

Note that SALT Operations allows any TAC accepted program to add P4 blocks to their Phase 2 program free of charge, over and above their TAC time allocation - contact salthelp if interested to do so.

Please note that P4 programs should ideally consist of short observing blocks, so that they may be slotted in as needed. As mentioned with P3 programs, if designed well for the purpose, experience has shown that P4 programs can in fact get large completion fractions.

11.3 Time Allocation

SALT proposals can only be submitted by astronomers who are members of a SALT consortium institution, or are collaborating with such astronomers. Time can be requested from different SALT partner TACs according to the nature of the collaboration and it is entirely up to the PI and Co-Is to decide what fractions are requested from each TAC. It should be noted, however, that some TACs may look with disfavour on proposals from other partner institutions which request the majority of time from them if the respective Co-Is are minor players in the collaboration.

11.4 Long-term Programs

Programs that are foreseen to extend over multiple semesters will need to be specified as such in the Phase 1 PIPT submission, and may be allocated time over multiple semesters. The relevant TAC may, however, require a progress report for the following semester(s). A form for supplying this report will be made available on the proposal's page in the Web Manager (https://www.salt.ac.za/wm/).

11.5 Director's Discretionary Time (DDT) Proposals

Programs wishing to apply for DDT (currently 10 hours per semester) can be submitted at any time, but they must abide by the following rules:

1. DDT proposals should be targeted for compelling relatively short observations which have potential for an immediate high impact result, i.e. a paper.

2. DDT observations should ideally stand on their own, in terms of producing a

compelling science result, rather than just being part of the longer term program (active or planned), though short "proof-of-concept" pilot programs that inform larger regular proposals may be considered.

3. There should be good reasons for DDT observations to be done quickly, rather than being held over until the next proposal period (e.g. compelling ToO or opportunity of a quick high profile result).

4. A free format (text or PDF or both, but with sufficient motivation) DDT proposal should be submitted to ddt@salt.ac.za and, having received an approval, using the PIPT with “DDT” selected under “Proposal Type”. The latter is directly a Phase 2 submission. In urgent cases the a proposer may submit the Phase 2 using PIPT at the same time as emailing the justification to ddt@salt.ac.za. Questions regarding DDT proposals can be also sent to salthelp@salt.ac.za. DDT proposals will be assessed by the Head of SALT Astronomy Operations and the SAAO Director who may consult with others within the SALT consortium regarding acceptability.

5. All DDT observations with a SALT partner as PI or co-I become available to the entire SALT community **within 6 months** of them being taken. DDT observations from proposals with no SALT partner investigators become available to the entire SALT community **immediately**. In such a case, SALT will inform members of the SALT Board and SSC by email within 1 week of the observations being taken.

6. Any DDT observations undertaken must be expeditiously analyzed and the results of the program written up in a short report sent to SALT **within 3 months** of obtaining the observations. This report will be made available to the SSC and all partners. For positive science results, it is expected that the observations will lead to a quick scientific publication.

See the DDT page.

11.6 Large Science Proposals

Starting in 2016-2, PIs will be able to submit proposals for large science programs. These are programs that request >150 hours from one or more Partners, which can be spread over a total of six semesters. These programs have a new template that provides more space for the scientific justification as well as requests additional information for the proposal. These programs do not have any requirements on how the data are shared or how the time is distributed. PIs considering submitting to this program should send an email to the head of Astro Ops, Petri Vaisanen, at saltastrohead@salt.ac.za with their intention to submit *at least two weeks prior to the* *deadline* to discuss overall feasibility and strategy. Astro Ops will coordinate discussion with the relevant TACs during the review stage.

Large Science Proposals should only propose for commissioned modes of instruments, which are presented in the current Call for Proposals document. Proposals should request >150 hours from one or more partners, which can be spread over a maximum of 6 semesters. The proposal should include a strong justification for the total amount of time required. Science goals should be feasible. Programs with stringent conditions, poor target visibilities, or otherwise difficult observations will not be favored at this stage. However, proposals for any type of science will be considered as long as the proposal is of very high scientific merit.

Large Science Programs will be judged on the following criteria:

- Scientific merit, which is not limited to, but will include the overall importance of the science, the probability the observations will lead to rapid publications, the uniqueness of the project, and the overall impact of the project.
- Viability of the observations and efficient use of the telescope under a range of conditions.
- Probability of success of the proposals including sufficient resources for the program.
- Management plan for the program, including how it will contribute to the SALT community.

Time will be allocated to large projects by the individual Partners specified in the proposal submission. Each TAC will individually decide on the merits of the proposal. However, Astro Ops will coordinate communication and discussion between the TACs before final allocations are made. Prior to the final allocation, comments from the TACs will be distributed to the PIs of Large Science proposals and the PIs will have a chance to reply.

Large Science proposals will be required to submit a progress report to obtain support in future semesters. Time and allocations are not guaranteed for future semesters, but require satisfactory progress being made on the proposals. TACs may adjust their allocations according to how the proposal is progressing.

11.7 Time Charging

At the present time observing time is charged on the basis of completion of *requested* observing blocks as they appear in the PIPT and SALT Web Manager.

11.8 Phase 1 Policies

Details of the requirements for Phase 1 proposals are outlined in a separate document. Once TACs have approved proposals and allocated time according to priority class, the Phase 2 proposals have to be completed adhering to these allocations. Targets (mandatory or optional) cannot be changed between Phase 1 and Phase 2 unless agreed to by the relevant TACs.

11.9 Phase 1 late submission Policy

1. In general, no Phase 1 proposals will be accepted after the deadline specified in the Call for Proposals.

2. If submission is prevented by technical issues (eg, problems with PIPT, network, etc), the PI should email a zipped version (.zip) of the proposal to SALT Astro Ops before the deadline, in which case this will be counted as a valid submission. SALT Astro Ops may, at their discretion, accept late submissions caused by technical difficulties at the receiving end.

3. All other late submissions will be flagged and forwarded to the relevant TAC(s). The PI will be requested to submit an appeal to the TAC(s) outlining the reasons for late submission. Acceptance of such proposals will be at the sole discretion of the relevant TAC(s).

Guidelines for the TAC regarding late submissions:

Late submissions that show no evidence of an attempt to submit or to make contact with Astro Ops before the deadline should be rejected, though the TAC may decide to accept the proposal following consideration of an appeal from the PI.

In any case, acceptance or rejection should be decided by the TAC(s) and communicated to SALT Astro Ops within 3 working days following the original deadline, after which no further proposals will be added to the database.

11.10 Phase 2 Policies

For a Phase 2 proposal, the PIPT will ensure that:

- It does not require more observing time than allocated by the TAC
- It does not contain any observation blocks with sky conditions *tighter* than those requested during Phase 1 and approved by the TACs. Conditions may be relaxed, however.

When an imported proposal exists on the user's computer already, the version on the computer will be replaced with the imported one. Naturally, the user shall be warned beforehand.

Submission of Phase 2 proposals should be done at the earliest opportunity following confirmation of proposal acceptance by the TAC, and ***must be done by the stipulated deadline.*** This is crucial for planning of semester observations. ToO programs that do not yet have targets available should submit dummy block(s) so their configurations can be reviewed. For normal proposals, all targets must be submitted at the deadline, but updates may be supplied throughout the semester if required. Any target changes during Phase 2 need the approval of the Head of Astronomy Operations who may refer the request to the relevant TACs.

All accepted SALT proposals will be assigned a Liaison SALT Astronomer (LSA) who will be the main point of contact between the PI and SALT Ast Ops. Communications regarding the completion of the Phase 2 proposal, the status of the proposal and and issues regarding the observations and data should be communicated with the LSA in the first instance (please refer to Section 11.7).

11.11 Communications with SALT Astronomy Operations

All communications with SALT Ast Ops should be via email (or telephonically in urgent cases, like ToO alerts) primarily to the SALT Help email address (*sa@salt.ac.za*). ***In all cases relating to existing proposals it is imperative that the assigned proposal code is included in the subject of the email***. This will ensure that all Ast Ops staff are aware of a request or query even if the particular Liaison SA is unavailable.

11.12 ToO Alerts

For activation of ToO programs, PIs should communicate their request to *salthelp@salt.ac.za*. For short notice or urgent real-time alerts, the SALT control room telephone number (+27 23 5711356) can be used to contact the duty SA directly.

11.13 Data Distribution

The PI has two options for data distributions: Normal and Fast. All data will be made available at *ftp://saltdata.salt.ac.za/* and are accessible by the contact-PI logging onto that site with their Web Manager username and password.

For “Normal” data distribution, the PI will receive an email when the data has passed through the pipeline in Cape Town. This will typically be within 24 hours of the observations, but may be up to one week later. The PI will receive the raw data, processed data, and documentation including the night log. Information about the current status of the processed data can be found at:

https://wiki.salt.ac.za/index.php/SALT Data Quality

The data will only be guaranteed to be on the ftp site for two weeks. All data should have been downloaded by that time, but if necessary, the PC can have their data posted to their ftp site via their proposal page on the webmanager.

For “Fast” data distribution, the raw data will be made immediately available along with any quicklook product. Once the first observation has been taken for the proposal during a night, the contact-PI will be notified that observations are being made for their proposal. Due to limits on bandwidth and data processing, we ask that only proposals that would truly benefit from this high response time select this option.

Data Proprietary Period

The proprietary period of the data will be decided by each individual partner. At this time, none of the partners have yet specified a proprietary period. The PI may specify any proprietary period for their data - we suggest an 18 month proprietary period.

11.14 Publication Policy

Publications

Please notify *sa@salt.ac.za* of any publication made using SALT data including reviewed papers and conference proceedings.

Science Paper Acknowledgements

All science papers that include SALT data which are submitted for publication in refereed science journals must include the following words of acknowledgment:

> *“All/some [choose which is appropriate] of the observations reported in this paper were obtained with the Southern African Large Telescope (SALT).”*

In addition, a footnote symbol should appear after the paper title*, and the following text should be written as a footnote:

> **based on observations made with the Southern African Large Telescope (SALT)*

If possible, please include the Proposal Code and Principle Investigator for the observations in the paper.

If you use data reduced by the SALT science pipeline or use the PySALT software, please provide a link to *http://pysalt.salt.ac.za/* and cite the following paper:

Crawford, S.M., Still, M., Schellart, P., Balona, L., Buckley, D.A.H., Gulbis, A.A.S., Kniazev, A., Kotze, M., Loaring, N., Nordsieck, K.H., Pickering, T.E., Potter, S., Romero Colmenero, E., Vaisanen, P., Wiliams, T., Zietsman, E., 2010. PySALT: the SALT Science Pipeline. SPIE Astronomical Instrumentation, 7737-82

In addition, the following papers provide a description of the telescope and instruments:

SALT:

Buckley, D.A.H., Swart, G.P., & Meiring, J.G. 2006, SPIE, 6267, 32

RSS:

Burgh, E. B., Nordsieck, K. H., Kobulnicky, H. A., et al. 2003, SPIE, 4841, 1463

Kobulnicky, H. A., Nordsieck, K. H., Burgh, E. B., et al. 2003, SPIE, 4841, 1634

RSS FP:

Rangwala, N., Williams, T. B., Pietraszewski, C., & Joseph, C.L. 2008, AJ, 135, 1825

SALTICAM:

O'Donoghue, D. et al. 2006, MNRAS, 372, 151

SALT-HRS:

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

BVIT:

Welsh, B., D. Anderson, J. McPhate, J. Vallerga, O. Siegmund, D. Buckley, A. Gulbis, M. Kotze, and S. Potter, *High Time-Resolution Astronomy on the 10-m SALT, New Horizons in Time-Domain Astronomy*, Proceedings of the International Astronomical Union, IAU Symposium, Volume 285, p. 99-102, 2012.

McPhate, J., O. Siegmund, B. Welsh, J. Vallerga, D. Buckley, A.A.S. Gulbis, J. Brink, and D. Rogers, *BVIT: A visible imaging, photon counting instrument on the Southern African Large Telescope for high time resolution astronomy*, Proceedings of the 2nd International conference of Technology and Instrumentation in Particle Physics, Chicago, 9-14 June 2011.

12. Appendices

12.1 SALTICAM technical information

Basic Properties

Image Quality	See the SALTICAM optical design, Figure A1. 0.3 arcsec (EE50), combined with SALT 0.6 arcsec (EE50), to give 0.67 arcsec image quality, independent of seeing. EE80 shall be no more than 0.5 arcsec. Distortion shall be less than 1 per cent. The mean plate scale shall be 107 micron/arcsec or 9.35 arcsec/mm within 1 per cent.
Science Field of View	8 arcmin in diameter
Guide Star Field of View	10 arcmin in diameter
Wavelength range	320 – 950 nm
Filters	8 position filter unit. Available filters include U, B, V, R, I, clear; Sloan u', g', r', i', and z'; Strömgren u, v, b, y, H-beta wide, H-beta narrow, and red extensions SRE1, SRE2, SRE3, and SRE 4; H-alpha; neutral density; and short wavelength interference filters at 340 nm (FWHM 35 nm) and 380 nm (FWHM 40 nm). (see the PIPT for filter curves)
CCD chips	E2V Technologies 44-82
Format	2048 x 4102 x 15 micron square pixels per chip
Imaging area per chip	30.7 x 61.5 mm^2 imaging area per chip
Readout capabilities	2 readout amplifiers per chip
Mosaicing	2 x 1 mini-mosaic
CTE	better than 99.99%
Full well	164 and 172 k e-/pix (for CCDs SALT-01 and SALT-02 respectively)
Dark current	less than 1e-/pix/hr at 160 K
Readout noise	less than 3.0 e-/pix at 100 kHz (10.0 usec/pix) (slow readout)
CCD Controller	SDSU II (Leach) from Astronomical Research Camera Inc.
Sensitivity	Thinned, back-illuminated. Deep depletion

	silicon. Astro Broad Band anti-reflection coating.

Observer specifics

NOTE: CCD-01 (aka CCD-B) is on the *right* side of the default SCAM display view and written SALTICAM files and CCD-02 (aka CCD-A) is on the *left*.

Cosmetics:

Delivered quantum efficiency for each chip is shown below:

NOTE: CCD-01 (aka CCD-B) is on the *right* side of the scam view and written SCAM files and CCD-02 (aka CCD-A) is on the *left*.

Wavelength (nm)	Spectral Response (QE)	
	CCD SALT-01	CCD SALT-02
350	41	49
400	80	71
500	81	76
650	78	73
900	48	45

Cosmetics:

Delivered cosmetics for each chip are shown below:

Defects	CCD SALT-01	CCD SALT-02
Column defects (black & white)	5	0
White	25	0
Total spots (black & white)	51	11
Traps	2	1

Gain:

Gain is user selectable and dependent on selected readout speed:

For this readout speed	Observer-specified gain	Actual e-/ADU

<table>
<tr><td></td><td>
<table>
<tr><td>Fast</td><td>Faint</td><td>1.55</td></tr>
<tr><td>Fast</td><td>Bright</td><td>4.50</td></tr>
<tr><td>Slow</td><td>Faint</td><td>1.0</td></tr>
<tr><td>Slow</td><td>Bright</td><td>2.5</td></tr>
</table>
</td></tr>
<tr><td>Prebinning:</td><td>1 x 1 to 9 x 9, independently in each direction</td></tr>
<tr><td>Readout speed:</td><td>Frame transfer architecture: 0.10 sec frame transfer time 100-333 kHz (10-3.0 usec/pix). Observer specifies readout speed as "FAST" or "SLOW".</td></tr>
<tr><td>Readout times:</td><td>
<table>
<tr><th>Mode</th><th>Prebin</th><th>Observer-specified gain</th><th>Readout speed (usec/pix)</th><th>Readout noise (e-/pix)</th><th>Readout time (sec)</th></tr>
<tr><td>full frame</td><td>2x2</td><td>slow</td><td>10.0</td><td>3.3</td><td>11.2</td></tr>
<tr><td>full frame</td><td>2x2</td><td>fast</td><td>4.0</td><td>5.</td><td>4.6</td></tr>
<tr><td>frame transfer</td><td>2x2</td><td>fast</td><td>4.0</td><td>5.</td><td>2.4</td></tr>
</table>
</td></tr>
<tr><td>Minimum exposure times:</td><td>The table shows the minimum exposure times for slot mode and frame transfer mode for all the valid binning parameters:
<table>
<tr><th>Prebin</th><th>Slot mode (sec)</th><th>Frame transfer (sec)</th></tr>
<tr><td>1x1</td><td>0.7</td><td>15.90</td></tr>
<tr><td>2x2</td><td>0.3</td><td>4.70</td></tr>
<tr><td>3x3</td><td>0.2</td><td>2.80</td></tr>
<tr><td>4x4</td><td>0.15</td><td>2.0</td></tr>
<tr><td>5x5</td><td>-</td><td>1.70</td></tr>
<tr><td>6x6</td><td>0.08</td><td>1.40</td></tr>
<tr><td>7x7</td><td>-</td><td>1.30</td></tr>
<tr><td>8x8</td><td>0.07</td><td>1.10</td></tr>
<tr><td>9x9</td><td>0.05</td><td>1.10</td></tr>
</table>
</td></tr>
</table>

Windowing:	Up to 10 windows (prefer not to specify for P-V phase)
Fastest windowed photometry:	0.1 sec/sample with no dead time
Count Rates:	Please use the most recent version of the SALTICAM simulator (http://astronomers.salt.ac.za/software/) for the most accurate exposure times and corresponding signal-to-noise ratios.

Optical path and detectors

The lens system reduces the SALT f/4.2 prime focal ratio to f/2, thereby enabling the full 8-arcmin diameter science field of view, as well as almost all of the guide star field of view, to be captured on the 2x1 CCD mosaic. The lenses are made from UV-transmitting crystals, and the CCDs have excellent UV performance, so the instrument is expected to be very efficient at short wavelengths. The optical design is illustrated in Figure A1.

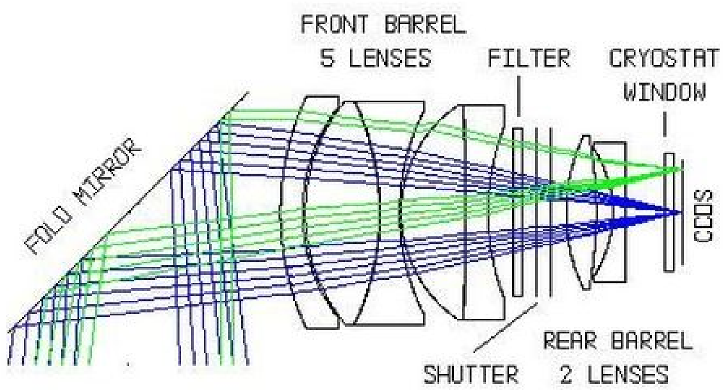


Figure A1. SALTICAM optical path.

Figure A2 shows the fields of view superimposed on the detector and includes:

- The edge of the science field of view (inner circle)
- The edge of the guide star field of view (outer circle)
- The two rectangular CCD chips separated by a 1.5 mm gap
- The (horizontal) frame transfer boundary
- The (vertical) boundary between the two halves on each chip read out by different readout amplifiers

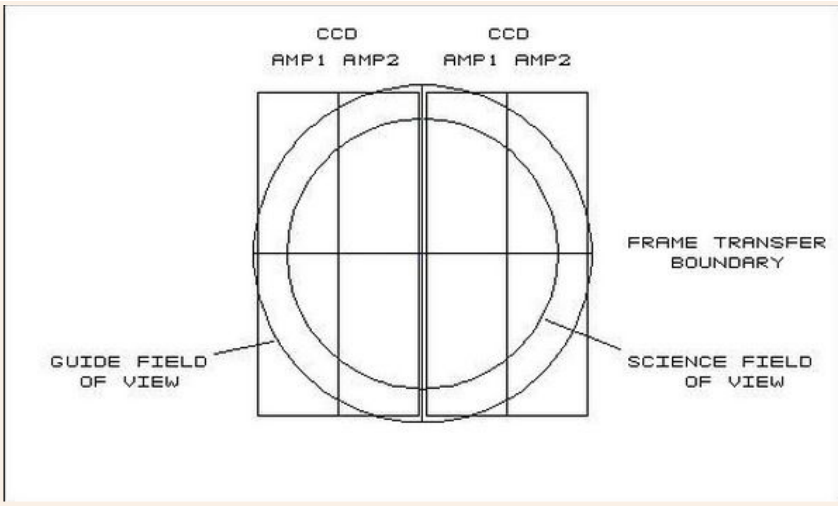


Figure A2. SALTICAM full layout.

The detector is a 2x2 mosaic of 2kx4kx15 micron pixel CCD 44-82 chips from E2V Technologies. These devices are thinned, back-illuminated and coated with the E2V Astro Broad Band coating. They are also deep-depletion devices for better near-infrared sensitivity and lower fringing. A schematic of one of the chips is shown in Figure A3.

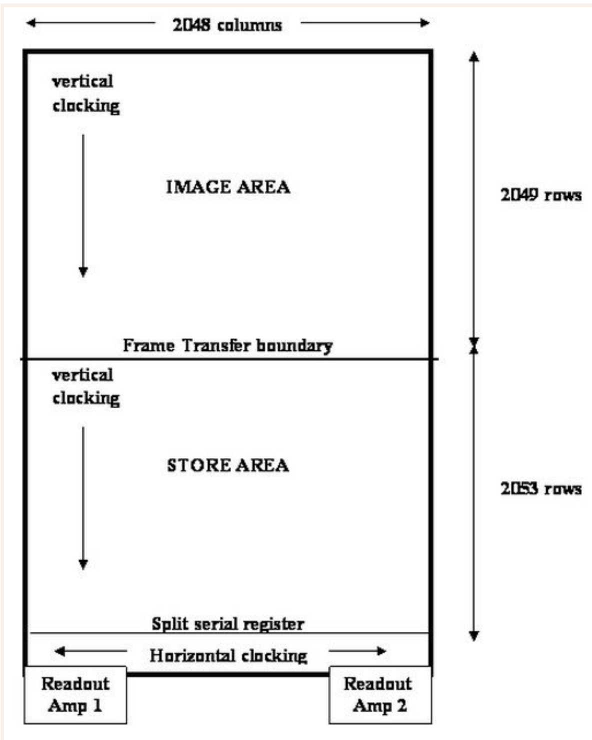


Figure A3. SALTICAM schematic for one of the two CCDs.

High-time resolution modes: FT and slot mode

For moderate time resolution on the order of a few sec, frame transfer (FT) operation is used. This is explained by the left hand diagram in Figure A4: a mask (shown in grey) covers the lower half of each chip. At the end of each exposure, the image in the top half of the chip is rapidly (200 millisec) shifted to the lower half where it is readout while the next image in the top half accumulates during the next exposure.

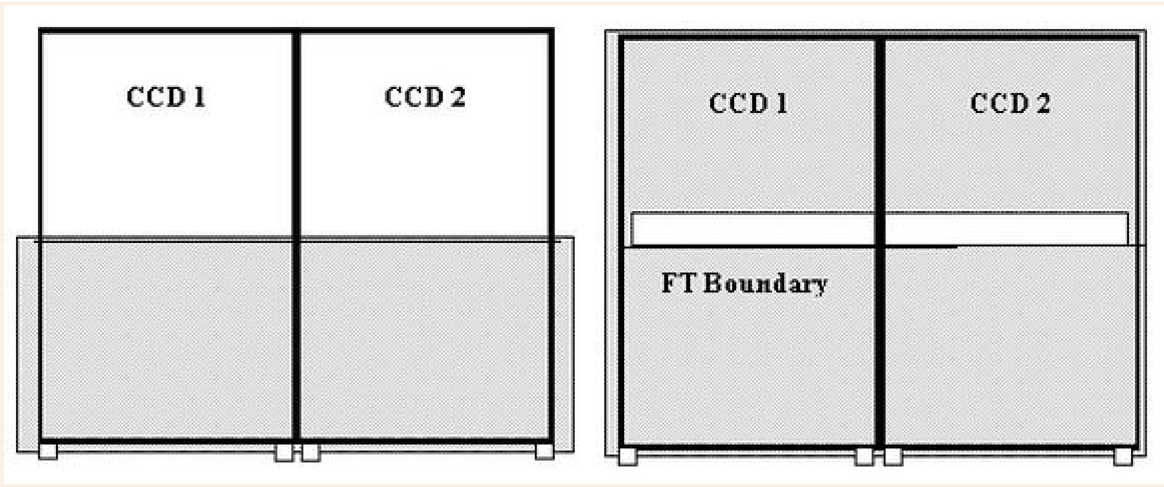


Figure A4. SALTICAM schematic for frame transfer (left) and slot mode (right). The gray regions are masked.

Even faster sampling can be obtained with so-called slot mode: in this mode a mask is advanced over the entire chips except for a slot just above the frame transfer boundary. Instead of half frame transfers at the end of each exposure, 144 rows are moved and this allows exposure times as short as 100 millisec. The slot position is illustrated in the right hand diagram in Figure A4. Figure A5 shows a schematic of the slot mode readout:

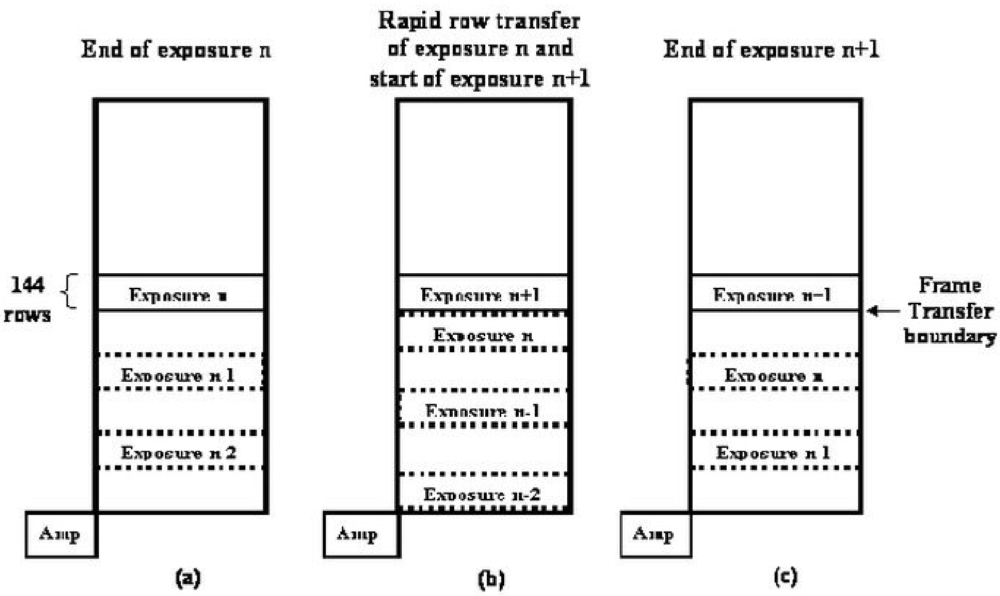


Figure A5. SALTICAM schematic for slot mode readout.

Figure A5, panel (a) shows the situation at the end of exposure *n* in one of the 4 amplifiers of the SALTICAM CCDs. The 144 rows indicated are transferred in about 15 millisec over the frame transfer boundary which is supposed to be aligned with the lower edge of the slot. At the end of this operation (panel (b)), exposure *n* lies in the 144 rows below the FT boundary, and exposure *n*+1 begins. During exposure *n*+1, the 144 rows next to the readout register (indicated by exposure *n*-2 but in reality *n*-6) are read out, and the other data sections slowly scroll down by 144 rows. At the end of exposure *n*+1, the situation is then as in panel (c) which is the same layout as in panel (a) except that *n* is now replaced by *n*+1.

Of course both FT mode and slot mode techniques require field of view to be sacrificed for time resolution: in FT mode, half the field of view is lost; in slot mode, only the slot is available for imaging. The intended use of slot mode is to position a rapidly varying target star and a brighter nearby companion star in the slot to perform differential photometry of the variable with respect to the comparison star. The telescope rho stage can be rotated to locate comparison stars at arbitrary position angles within the slot.

Optical efficiency

"Typical" instrument and system efficiencies are shown in Fig. A1 and were calculated for the on-axis field position using:

- **Optics:**
- **(i)** No absorption in any of the lens material or cryostat window (CaF_2, BaF_2, fused Si); Absorption by Sylgard 184 at two doublet interfaces;
- **(ii)** Reflection at 10 air-glass interfaces using the Spectrum Thin Films BBAR coating;
- **(iii)** Reflection at 2 air-glass interfaces using a single layer of MgF2 coating (see the 3310AE0001 Optical Design Issue 2.7.doc for details).
- The reflection or absorption in any filter is not included.
- **CCDs:** Quantum efficiency as delivered.

Fig. A6 shows SALTICAM efficiency as the product of the optics and the CCD curves. For reference, RSS performance taken from Fig. 5 of the PFIS PDR Instrument Description Document is also shown.

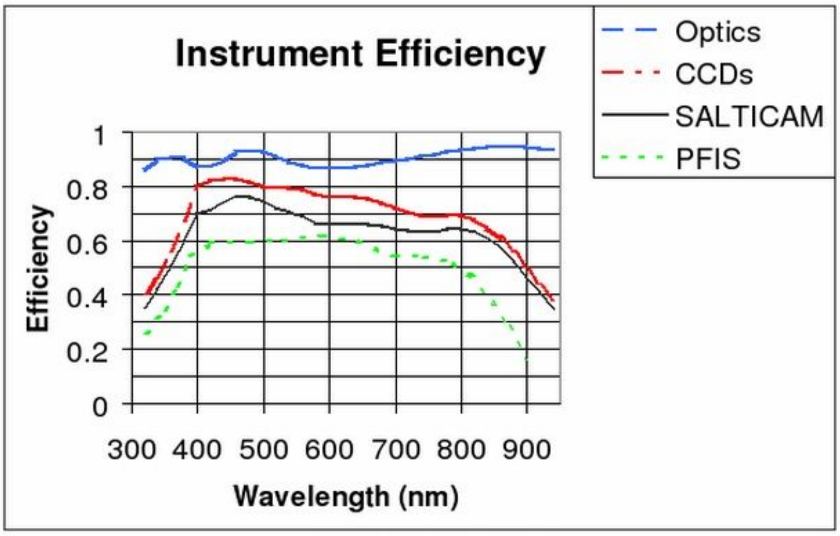


Figure 1. Instrument Efficiencies

Figure A6. SALTICAM instrument efficiency with PFIS (now RSS) for comparison.

Below, Fig. A7 shows overall efficiency based on:

- **Atmosphere:** The standard atmospheric extinction curve for Sutherland at a zenith distance of 37 degrees.
- **SALT + Fold:** This is the minimum throughput taken from the system specification and includes reflectivity of the SALT Primary Mirror and the spherical aberration corrector (SAC), the SAC central obscuration, four per cent light losses at the four surfaces of the ADC, and the reflectivity of the fold mirror using the Livermore coating performance as supplied by David Buckley.
- **Total:** At the bottom of Fig. A2 is the product of the SALTICAM, Atmosphere and SALT+Fold curves.

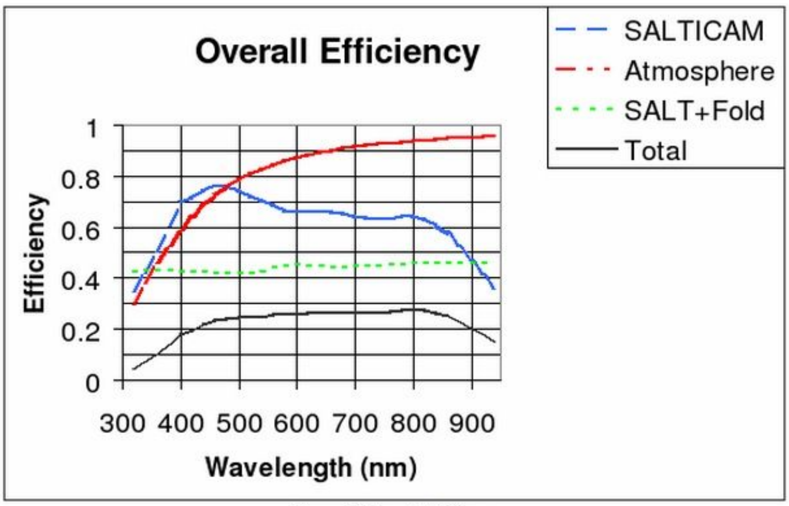


Figure 2. Overall Efficiency

Figure A7. SALTICAM overall efficiency (including telescope optics and atmosphere).

Implications of doing photometry with SALTICAM

NOTE: the text below presents the ideal, expected situation. Flat-fielding in particular remains an unsolved issue as of 2014, and even relative photometry within the SALTICAM fov has not been achieved to much better than 5% accuracy.

The moving pupil inherent to the basic operation of SALT presents special problems for doing photometry with SALTICAM. While it is true that if the tracker position is known at all times, the fraction of the primary mirror within the pupil can be calculated (including gaps between mirrors) and the photometric "response" function of the telescope can be worked out. However, this assumes equal reflectivity for all mirrors; clearly this will not be true and furthermore it will be variable as the cycle of mirror recoating runs. (Typically, at least one and possibly two segments per week will be recoated).

Measuring reflectivities of mirrors is an uncertain process so it seems very difficult to provide calibrations sufficient to estimate the response function to at least 1 per cent (preferably better) for all tracker positions.

So those carrying out photometry with SALTICAM should bear in mind:

- Relative photometry within the 8 arcmin science field should be unaffected by the pupil/primary mirror mismatch: all field angles will be equally affected by the mismatch. There is variable vignetting due to the SAC over the science field but this will be calibrated by the instrument team and provided for the data reduction. This vignetting should be constant in time. Thus programs requiring relative surface photometry of extended objects or relative photometry of point sources will be unaffected. Variability monitoring will require referencing the variable to one or more constant comparison stars within the field.
- Absolute photometry will, of course, not work because of the varying amount of pupil/primary mirror mismatch. Thus, absolute photometry will require referencing SALTICAM data to a measurement of at least one and preferably several point sources in the field on another telescope using the same filter system. SAAO is building a CCD camera for the Newtonian focus of its 1.9-m telescope to facilitate these supporting observations. Of course, if the magnitudes are known from other sources, this will suffice.
- Most accurate absolute photometry, especially at U, will require knowing the colour transformation equations for the SALTICAM filter system. Determining these is not a trivial task and will require observations of a cluster of stars with known and reliable photometry.

RSS Fabry-Perot System

The SALT RSS Fabry-Perot system provides spectroscopic imaging over the whole RSS science field of view (8 arcmin diameter) in the wavelength range 430-860 nm with spectral resolutions ranging from 300-10,000.
The system employs a set of three etalons with gap spacings of ~6, ~28 and ~136 μm respectively. The etalons are referred to as the small gap (SG), medium gap (MG) and large gap (LG) etalons respectively. The SG etalon may be selected on its own for use in tunable filter (TF) and low resolution (LR) modes. The MG or LG etalon are selected for use in medium resolution (MR) and high resolution (HR) mode respectively. Both these etalons are always used in conjunction with the SG etalon which effectively acts as a transmission filter in this case. *PLEASE SEE THE UPDATE BELOW.*

A set of 40 blocking filters are employed to select the transmission order. Filter transmission curves are here.

The table below summarises the key characteristics of the system in the various modes.

	TF mode	LR mode	MR mode	HR mode
Bandpass	430 - 860 nm	430 - 860 nm	430 - 860 nm	430 - 860 nm
Free Spectral Range at 650 nm	364 A	182 A	75 A	15 A
Resolution at 650 nm	323	779	1494	8777
Finesse at 650 nm	16.7	21.9	17.3	21.0
Effective plate gap	5.8 μm	11.5 μm	28.2 μm	135.9 μm
Wavelength drift	< 1 A per hour	< 1 A per hour	< 1 A per hour	TBD

A detailed description of the system is given in the paper by Naseem Rangwala, Ted Williams and their collaborators:

An Imaging Fabry-Perot system for the Robert Stobie Spectrograph on the Southern African Large Telescope.

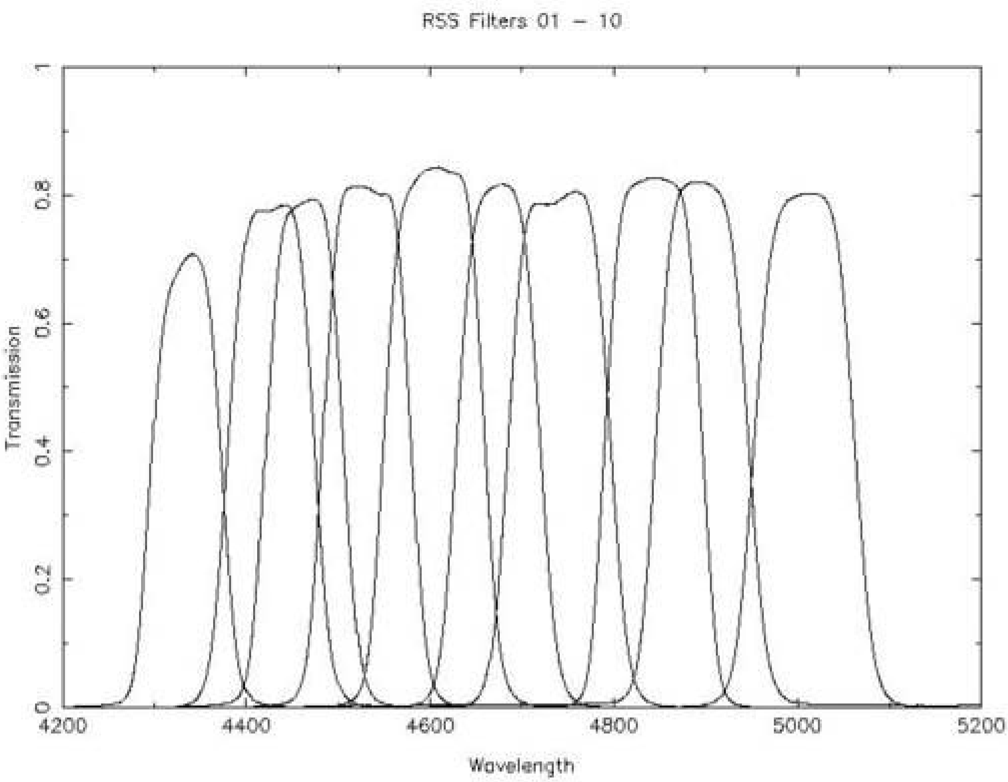
Additionally, Ted Williams has produced an introduction to Fabry-Perot on SALT.

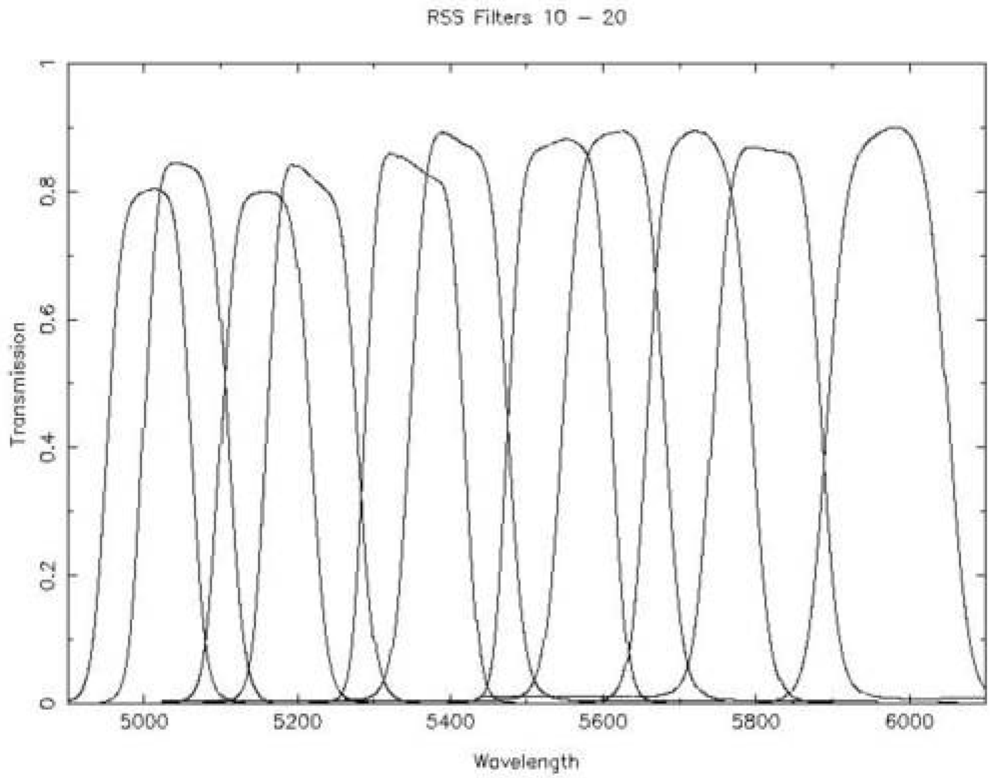
The following 3 etalon reports detail the technical details of each etalon.

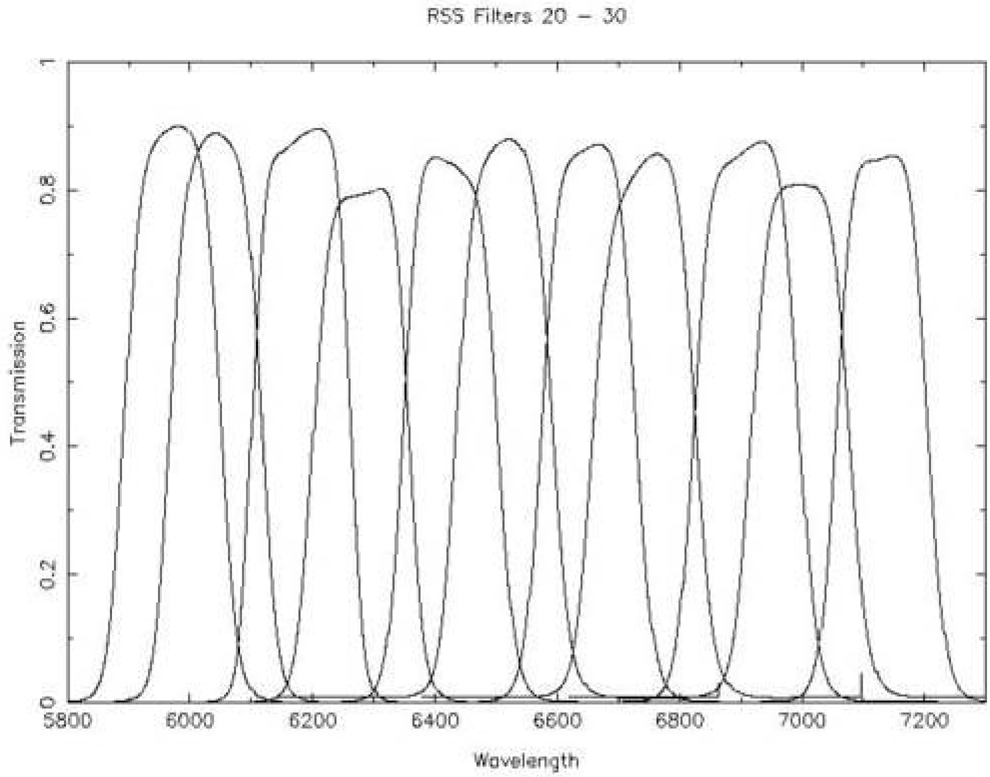
[TF/LR Mode report](#)
[MR Mode report](#)
[HR Mode report](#)

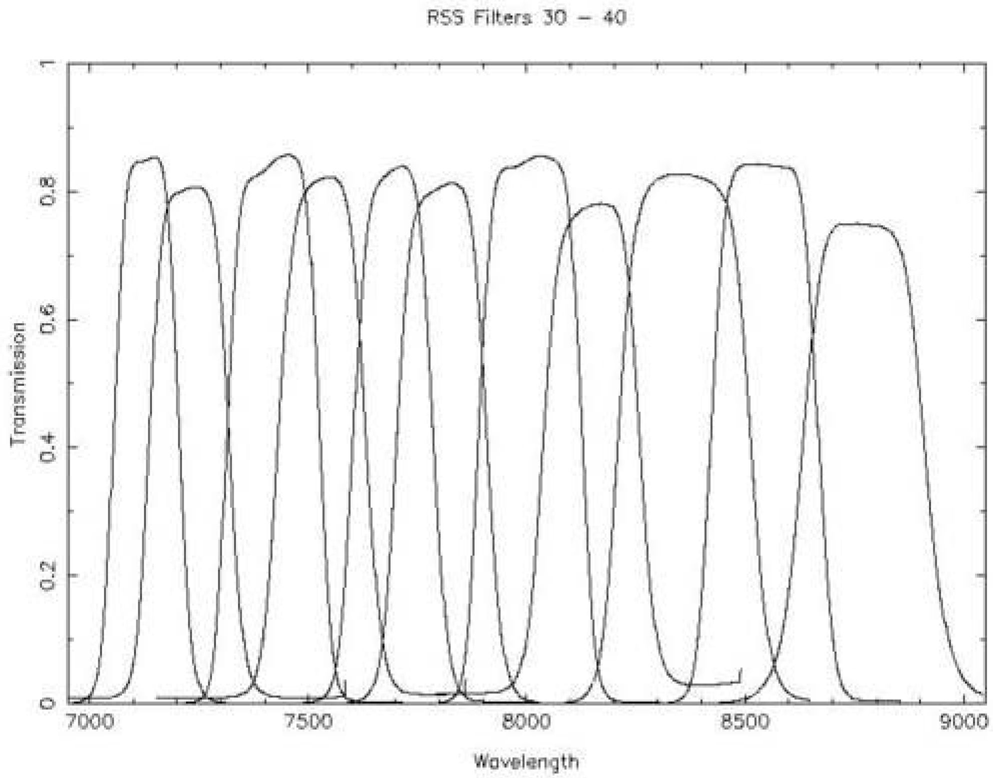
Tables containing the FWHM of the spectral resolution, the resolution and free spectral range of each etalon as a function of wavelength are included in each report. This information is helpful for proposal planning.

Fabry-Perot Filter Transmission Curves




RSS Filters 10 – 20
Transmission
0
0.2
0.4
0.6
0.8
1
5000
5200
5400
5600
5800
6000
Wavelength


RSS Filters 20 – 30
Transmission
0
0.2
0.4
0.6
0.8
1
5800
6000
6200
6400
6600
6800
7000
7200
Wavelength


RSS Filters 30 − 40
Transmission
0
0.2
0.4
0.6
0.8
1
7000
7500
8000
8500
9000
Wavelength