SALT NEWS

(for distribution on public webpages)

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SUMMARY

Since completion of the construction phase of SALT and its successful inauguration in Nov 2005, the SALT Operations team at SAAO has been busy completing the commissioning of the telescope and its two first-light instruments, SALTICAM and the Robert Stobie Spectrograph (RSS). This has involved significant effort in both technical and scientific areas as we ramp up to full science operations. Already some significant scientific observations have been obtained for our SALT partners during the on-going "performance verification" phase, expected to extend until the end of 2006. Currently the telescope is used for science performance verification observations for ~70% of the useable hours.

SALT AN OPERATIONAL TELESCOPE

Already in 2005 we demonstrated SALT to be a "going concern" with the announcement of "first light" on 1 Sep 2005, followed later in the year with the submission of the first scientific paper featuring SALT results. The basic functionality of the telescope – pointing and tracking on objects – and its instruments was demonstrated and SALT began night-time work, with the aim of completing the commissioning and acceptance testing and beginning limited science observations.

SALT is an extremely sophisticated instrument with numerous subsystems that are all tied together by complex software residing in the Telescope Control System (TCS). This home-grown control system has already performed impressively, allowing the operators and astronomers to effortlessly point the telescope with no more than two mouse clicks! However, more complex operational requirements are still to be implemented and, as planned, the team of Software Engineers are still developing the final phase of the TCS, expected to be completed by the end of this year.

SOME SALT SCIENCE HIGHLIGHTS

For the first few months of 2006 the night time SALT operations were mainly devoted to solving various image quality issues and also supporting continuing engineering work. Of the available clear hours, the relevant statistics are summarized below. From May onwards, most effort has been to undertake scientific observations for the SALT partners, which is why the amounts of science time has increased dramatically since then. These observations were requested by the partners at the last SALT Board of Directors meeting, in early May, in order to showcase the potential of SALT. A set of proposals were submitted by the partners with the intention of completing them in a 3-month period, from June – August. Progress to date has been excellent, and we are currently running ahead of schedule, with ~75% of them completed.

Period	*Engineering Fraction*	*Science Fraction*
Since inauguration (end Nov 05) to end March 06:	85%	15%
April 06	75%	25%
May 06	40%	60%
June 06	27%	73%
July 06	34%	66%

Here are seven examples of science highlights from SALT:

1. Chemistry of Dwarf Galaxies

The first science observations with the Robert Stobie Spectrograph were longslit spectroscopy of the amorphous starbursting dwarf galaxy NGC 1140 obtained in November 2005 by the RSS Instrument Scientist, Eric Burgh. This was a 720 sec unguided observation using a 1.2 arcsec $\times$ 8 arcmin longlsit, giving a spatial resolution of ~3 arcsec and a spectral resolution of R ~ 5500. The data show emission features from H-alpha, [NII], [SII] and HeI. These lines are well-resolved with FWHM ~80-100 km/s in the inner galaxy, velocities that are typical of intensely star-forming regions, while FWHM ~100-140 km/s are seen in the outer galaxy, suggesting a possible galactic wind. The complex velocity field is consistent with the merger model for NGC1140. The intensity ratio of the [SII] doublet, 6717/6731 is 1.3, indicating a low electron density, and thus modest thermal pressure despite the galaxy's starburst status.

The H-alpha/[SII] ratio, which is an indicator of the presence of shocks, varies along the slit with a maximum of 8 at the peak of the gaseous emission and dropping to nearly 2 at the edges of the galaxy, with a value of 3 for the offset knot of gas. Thus shocks could play a role in the outer galaxy, while the knot is more likely a star forming region. These data were analyzed by members of the RSS instrument team and presented in a poster at the June 2006 meeting of the American Astronomical Society.

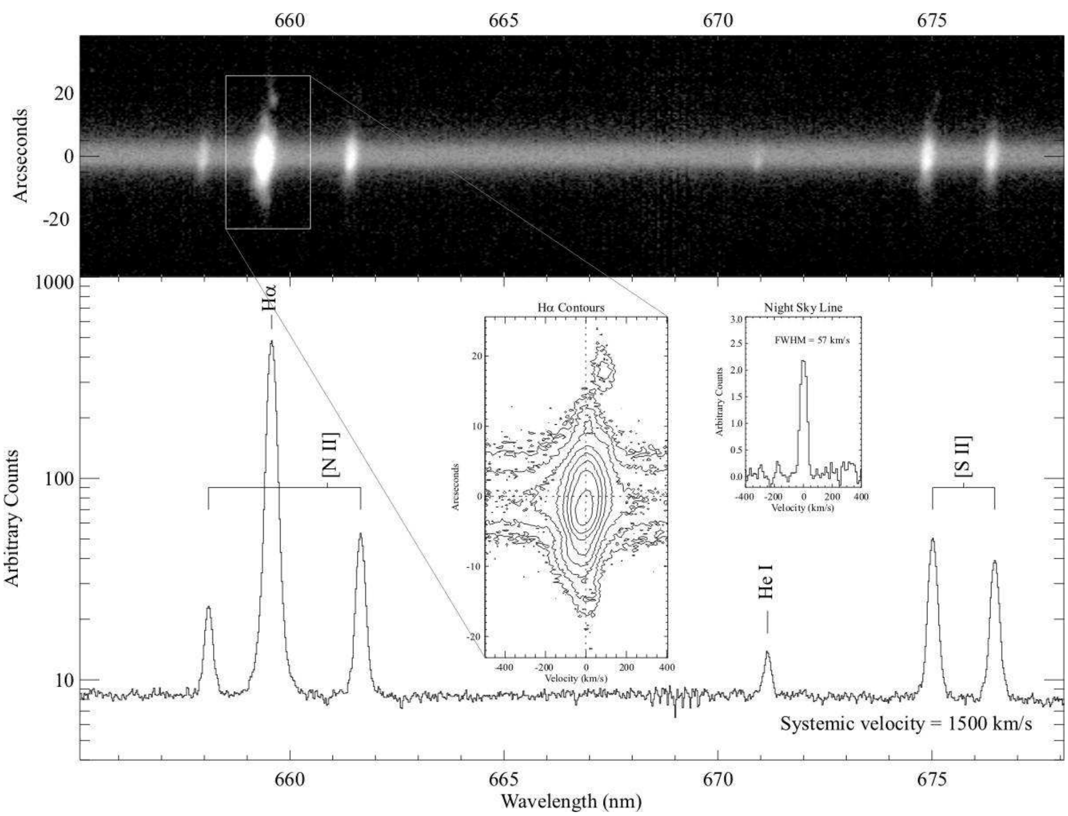

Figure 1: First RSS science observation: longslit spectroscopy of the amorphous dwarf galaxy, NGC1140. This R ~ 5500 spectrum was a result of a 720 sec unguided exposure.

2. Chemistry of Dwarf Galaxies

Spectra of several Planetary Nebulae (PNe) in some Local Group galaxies were observed with RSS during the last two months for the South African-led (Alexei Kniazev & Petri Vaisanen) performance verification program entitled "Probing chemical evolution and homogeneity of the nearest dwarf irregular galaxies". A fully reduced spectrum of one such PNe is shown in the figure below, which spans the spectral region 365 – 675 nm. This spectrum demonstrates the ability of SALT to observe faint PNe is the local group of galaxies. Chemical abundances of oxygen, nitrogen, neon, helium and sulfur were calculated using this spectrum. The spectrum at the bottom is scaled by 1/30 and shifted to show the relative intensities of the strong lines.

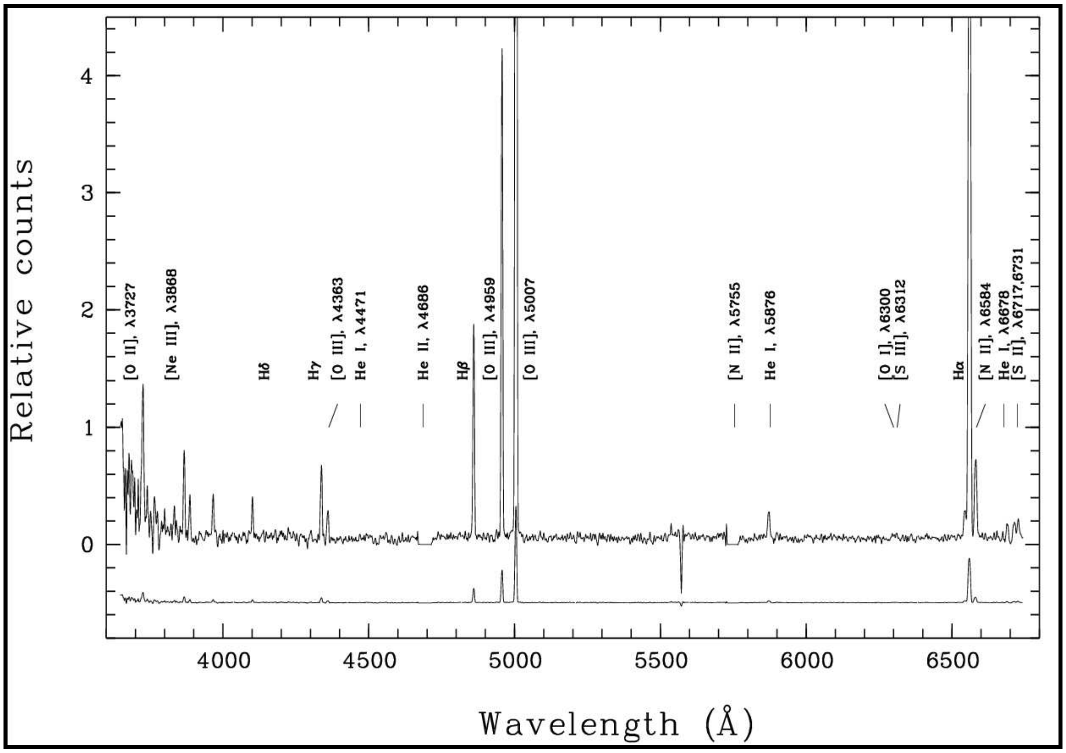

Figure 2: RSS spectrum of a V~20 Planetary Nebula

3. First SALT Gamma Ray Burst Afterglow Observed

The most energetic events in the Universe are known as Gamma Ray Bursters (GRBs), and result from either the collapse of massive stars into black holes or binary mergers. These often occur in distant galaxies at the extreme limit of detectability and are discovered by virtue of their prompt intense γ-ray emission, detected by orbiting satellites, likes the NASA *SWIFT* mission.

Optical observations from ground based telescopes are crucial in determining their distances, but is notoriously difficult, since the GRBs dim rapidly following their outbursts and the so-called “host galaxies” are typically very faint, requiring 10-m class telescope to see them.

One such GRB event, named GRB 060605, occurred on 5 June 2006. Six hours after the event was detected by the *SWIFT* satellite, SALT observed GRB 060605 at an approximate magnitude of R ~ 19. A combined exposure of 2.4 ksec was obtained using the RSS instrument. This spectrum (seen below) shows the featureless afterglow from the burst behind a forest of hydrogen Lyman-α absorption lines, from intervening absorbing clouds. While the broad, damped hydrogen Lyman-α line seen at 575 nm indicates a dense system at a huge redshift (i.e. distance) of z = 3.7, this may not in fact be the host galaxy. If we assume we’ve detected the Lyman edge unambiguously at 440 nm, the burst's redshift is actually z = 3.8. The Lyman α line from the host galaxy is blended with the red wing of the damped system at 483 nm.

The SALT observation of GRB 060605 represents a significant SALT scientific milestone and demonstrates how important SALT will be in unraveling the mysteries of these enigmatic objects. A SALT collaboration on GRB burst follow ups has been instigated which so far includes astronomers from South Africa (Martin Still, David Buckley), University of North Carolina (Dan Reichart) and Rutgers (Terry Matilsky).

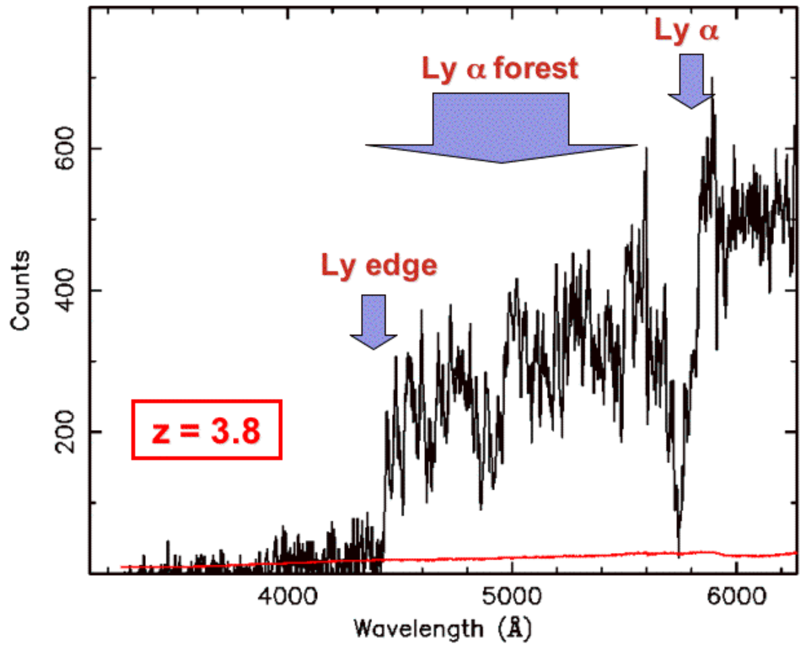

Figure 3: RSS spectrum of the afterglow of GRB060605

4. First Pulsations Detected in a sdO Star

A relatively new class of pulsating stars – discovered at SAAO – are the so-called EC stars, which are sdB stars. Recent time series photometry on the SAAO 1.9-m by Patrick Woudt and Brian Warner (UCT), has led to the discovery of similar non-radial oscillations in a sdO star, the first of its type. Confirming spectroscopy of this relatively faint object required a SALT observation. Below is a combined SALT spectrum of SDSS J160043.6+074802.9, the first confirmed sdO pulsator. This spectrum is an average of three 600-s exposures taken with SALT+RSS and the G1300 grating, obtained on April 4 and June 5 2006, respectively. It reveals a spectroscopic binary (sdO + late-type main-sequence companion) and confirms that the previously identified suite of pulsation periods in the range of 59 - 120 s originate from the sdO star (reference: Woudt et al. MNRAS, accepted, astro-ph/0607171)

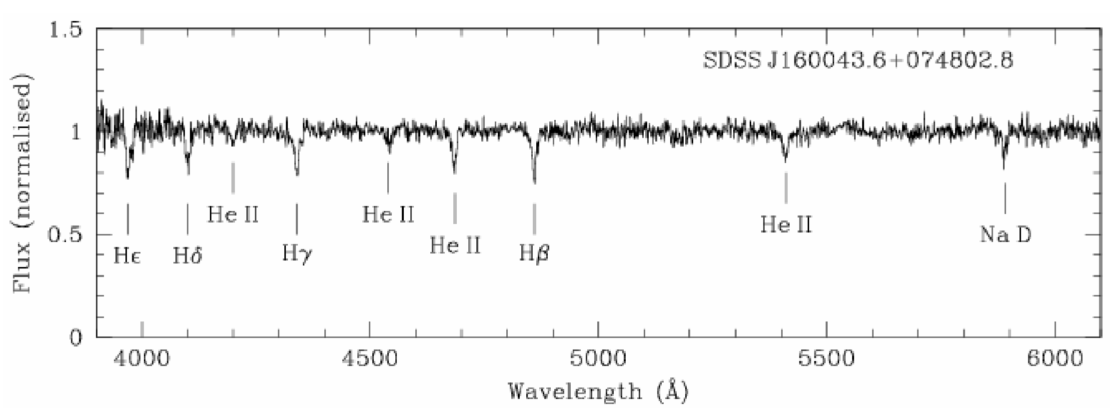

Figure 4: RSS spectrum of the sdO pulsator SDSS J160043.6+074802.8

5. Observations of Diffuse Interstellar Bands

Recently some very high S/N (1200-1500) spectra (R~6000) of the binary system κ Cra A & B were obtained by Martin Cordiner (Nottingham) using RSS in order to study Diffuse Interstellar Bands (DIBs). The 578, 585 and 620.3nm diffuse interstellar bands were detected and measured, along with the interstellar Na D lines, as seen in the following figure.

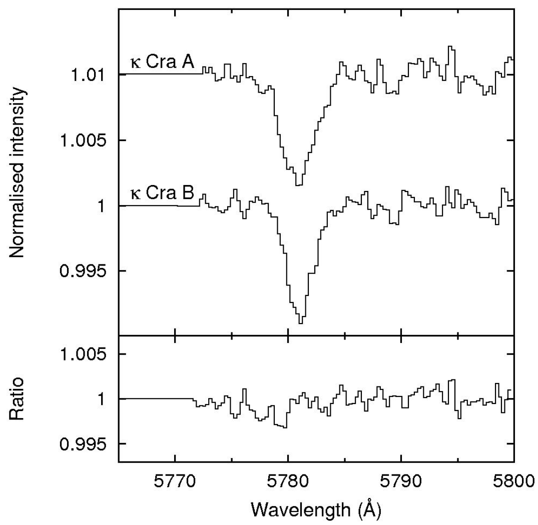

Figure 5: Upper panel: Continuum-normalised SALT RSS spectra of the 5780nm DIB observed towards κ Cra A and B. Lower panel: Ratio of the spectra A/B.

This study has shown that the RSS spectrograph is capable of producing spectra with very high signal-to-noise (>1500), with Poisson noise statistics. It should be possible to observe small-scale interstellar structure using spectrographs of this (low) resolution, which have the advantage of long slits allowing both stars to be observed at once.

6. Velocity Profile Observations of NGC59

Bonita de Swardt (University of Cape Town graduate student) has obtained some SALT Performance Verification data on NGC59, a dwarf lenticular whose spectrum (seen below) shows both prominent absorption and emission line features. For this project, she is particularly interested in measuring the velocity profile of the galaxy using the Ca II K (3933A) and H (3968A) absorption lines. The surface brightness profile in the blue part of the spectrum indicates that this galaxy has a star-formation region close to the galaxy center, which is the reason we see these unexpected emission features. These emission features include Hδ, Hγ and OIII (4364A).

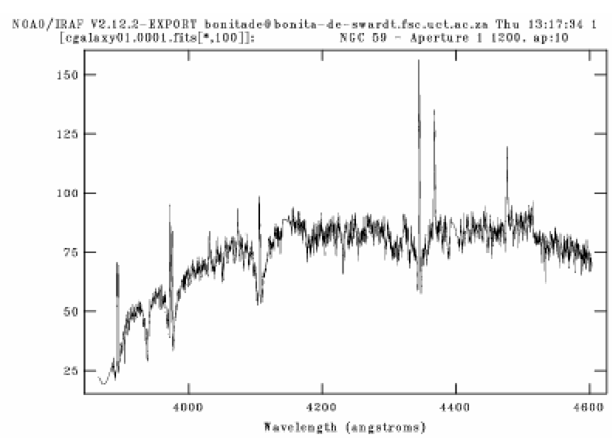

Figure 6: RSS spectrum of NGC59

7. SALTICAM imaging of the spiral merger galaxy NGC1457

A SALTICAM Performance Verification program begun in 2005 involved imaging of the spiral merger galaxy NGC147 for Uta Fritz-van Alvensleben, Polis Papederos and Peter Anders from the University of Göttingen. SALT's large field of view coupled with its UV-sensitivity is ideal for multi-band photometric analyses of Star Cluster systems, where ages, metallicities, extinctions and masses can be obtained to $\pm 1\sigma$ accuracy. This can be done for a variety of galaxy types, redshifts, star formation histories, masses and metallicities with accuracies comparable to spectroscopic studies. These are key to understanding galaxy formation histories.

This observation showed the excellent potential for studies of star forming stellar populations in nearby galaxies, and the importance of the U band photometry to assist in discriminating metallicity effects. These results have demonstrated SALTICAM's high performance already during the Performance Verification phase.

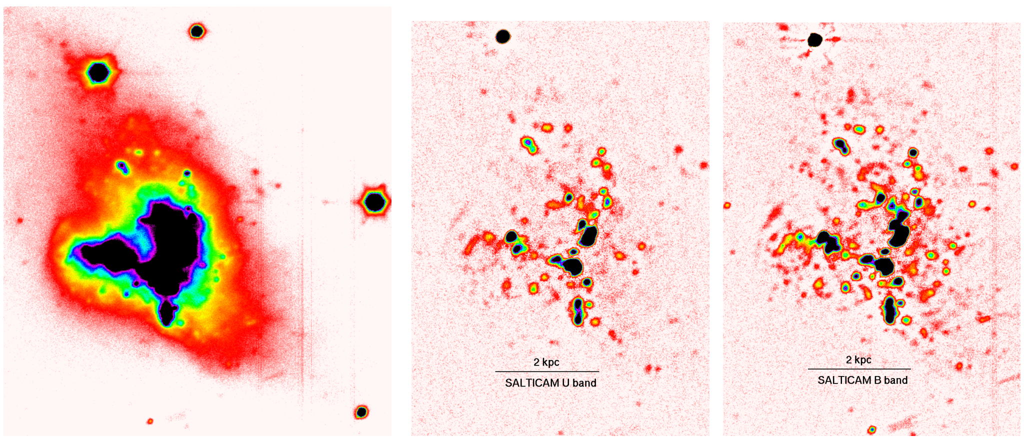

Figure 7: SALTICAM B image of NGC1457 (left) and unsharp-mask images in U & B filters.

SALT TECHNICAL OPERATIONS REPORT

At the time of the handover from the SALT construction team to the operations team, much of the telescope commissioning work was still outstanding. The operations team consisting of engineers and technicians and a team of astronomers was faced with the challenging task to take the telescope through commissioning to full science operations. With the project team no longer around to help, although still available on consultation basis, the ops team had to solve many problems on their own and learned many lessons the hard way. They were nevertheless enthusiastic and took many of the problems head on.

Apart from the science instruments, the tracker is by far one of the most complex subsystems on the telescope but through sheer hard work and dedication the technical team can now maintain the system and solve most problems without assistance from the original contractor, *Reutech Radar Systems*.

Figure 8: Staff training to remove Hexapod Gearbox

The operations team is currently busy with the final commissioning of a mirror cleaning system which is needed to preserve the reflectivity of the primary mirror. Each mirror segment will be recoated (aluminized) on site at least once a year but between coatings the mirror must be kept free from dust and other contaminants. A CO2 cleaning process will be used whereby the mirror surface is bombarded with CO2 "snow flakes" to remove any particles from the mirror surface. To clean aluminized optics, ultra pure bone dry CO2 is required with a CO2 purity level is 99.9999%. CO2 of this grade is very expensive and suppliers generally keep only low volumes of this grade in stock. SALT will use a CO2 purifier which can convert inexpensive industrial grade CO2 at 99.0%, into ultra pure CO2 at 99.9999%.

Figure 9: Mirror Cleaning System being lowered over the mirror

Figure 10: Mirror Cleaning System in position over the mirror

Upgrades and performance improvements play a significant role during the operational life of a telescope. In a sense the design and construction of a telescope is never complete since the telescope has to keep up with the progress in science which leads to new requirements that will in many cases push the operational requirement beyond the limits of the original design. Telescope reliability improvement also plays a significant role in the ongoing development of the system. This process starts almost immediately after construction when design flaws are being identified in the commissioning phase. This is also true for SALT and one particular source of unreliability was identified in the “Slit Mask Mechanism” which is an integral part of the Robert Stobie Spectrograph (RSS). This mechanism inserts different masks in the optical path which blanks off the light from all objects except the object/s being studied. After numerous attempts to improve the reliability of the mechanism the conclusion was that a redesign was necessary. The technical operations team joined forces with the original design team from the University of Wisconsin, Madison, USA, to do the redesign. The final design was reviewed recently and approval was obtained to continue with the manufacturing. The mechanism is expected to be fully operational by mid October.

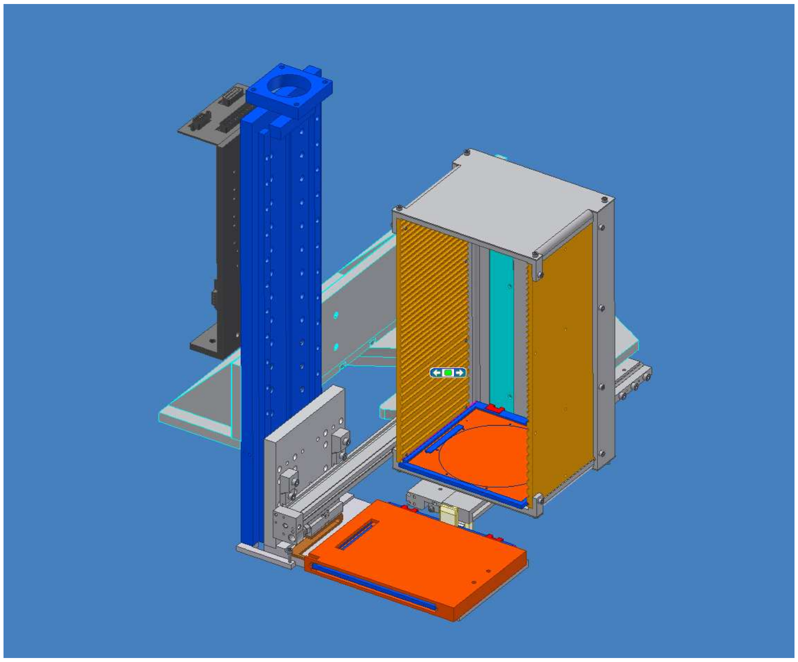

Figure 11: CAD Model of the new RSS Slit Mask Mechanism

SALT OBSERVATORY CONTROL SYSTEM

SALT is essentially a software telescope, or at least software plays a crucial role in how it is operated. A number of different software "modules" interact to transfer information needed to conduct observations. The source of all observations eventually will come via the PI Planning Tools (PIPT), which generates the SALT Phase I & II proposals that then populates the Science Database (SDB) with all of the required information (i.e. target information, instrumentation configuration, observing block sequence definitions, times, etc). A whole article could be written on this, and will be in a subsequent issue of SALTeNEWS.

When SALT is ready to observe, the SDB can be queried by the Observation Planning Tool (OPT, aka the scheduler) to select viable target visible at the time. When the observation is scheduled by the Observation Planning Tool (OPT), the OCS extracts the relevant information from the database, points the telescope to the target and configures the instrument(s) for the science run. Once data have been collected, the Observatory Control System (OCS) populates the database with the actual observed parameters such as links to the data-products, actual exposure times, actual telescope pointing and environmental parameters. The OCS also communicates to the Telescope Control System pertinent telescope commands required during an observation (e.g. nodding of the telescope).

The OCS therefore forms the core functionality that allows SALT to perform queue-scheduled observations and forms the last major component of the telescope software that needs to be completed. This work by the SALT software team will run in parallel with the completion of the higher level functions of the TCS.

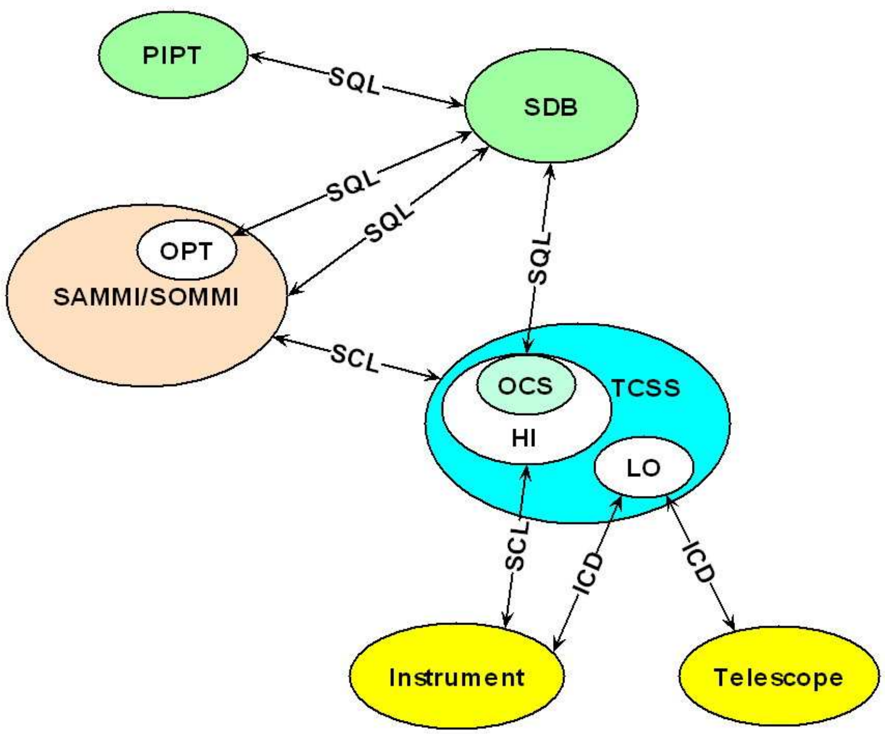

Figure 12. This diagram shows the planned context of the Observation Control System (OCS), which forms part of the Telescope Control System (TCS) software. SOMMI and SAMMI are the SALT Operator and Astronomer control GUIs, which communicates with the TCS Server (TCSS) using a set of customized SALT Control Language (SCL) commands. This is the same also for some communications with the instruments.

THE "BACK PAGE"

This time we feature a group photograph of the SALT Astronomers taken during one of the weekly planning meeting in the author's office.

Figure 13: The SA-Team! From left: Yasuhiro Hashimoto, Petri Vaisanen, Nicola Loaring, Encarni Romero Colmenero, Martin Still (with his knee) and David Buckley. Alexei Kniazev was absent – observing on SALT!