SALT NEWSLETTER

ISSUE APRIL 2020

Southern African Large Telescope,
Sutherland, South Africa
Cover image: Jackie Boshoff

TOPICS

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Contributors to this issue:

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LETTER FROM THE HEAD OF ASTRO OPS

Dear SALT Community,

I am writing this from my "home office", which we've set up in my spare room, with the dogs lying around my feet, and hearing the children playing on the PS4 in the living room. This is now the reality for most of us, working from home during the COVID-19 pandemic. We are certainly living a historic moment!

South Africa, as you may have heard, went on lockdown on the 26th March for a period of (at least) 5 weeks, much earlier in the curve than most countries. For SALT, this meant that SALT is closed, together with the rest of the SAAO telescopes and most of the guest facilities on the plateau in Sutherland. In case you are wondering - yes, we can operate SALT remotely, but the day team are not available to repair anything that may go wrong with the telescope. And that's just way too risky...

Despite being stuck at home, for most us, work continues nearly as usual. We continue to manage the SALT helpdesk to answer your questions. We are also working on all of our projects to improve our efficiency, our throughput and our data quality, focusing on things we can work on remotely: finalizing designs, defining specs, coding, documentation and, of course, research!

And we continue to have regular meetings using Zoom, which my dog Maxi likes to videobomb. Yep, the Zoombie apocalypse is here! ;)

The lockdown came on the heels of a very successful shutdown period. We are very happy to report that the new controllers for the primary mirror actuators are working beautifully and the entire project was a resounding success. RSS and SALTICAM both got their optics cleaned, the polarimetry process was streamlined and one of our SAC mirrors, M3, is now looking sparkling clean! Unfortunately, we didn't manage to get throughput measurements between the shutdown and the lockdown to verify the improvement on sky, but we'll share those numbers as soon as we have them. More details on the shutdown below.

The SALT Data Archive is nearing completion and we will soon be contacting PIs regarding making their data available in the archive - stay tuned!

And to finish off, we would like to introduce you to our newest SALT Astronomer, Dr Lee Townsend. He started with us at the end of February 2020 and, with the shutdown and the lockdown, he has not yet had a chance to go observing with SALT! He has, however, started to look into our block scoring system, which helps the SAs at the telescope to choose observations. Welcome! :)

Stay at home, stay safe and let's flatten the curve!
- Encarni

Image: aerial shot of SALT courtesy of Jackie Boshoff.

SCIENCE HIGHLIGHTS:

ENERGETIC TRANSIENTS OBSERVED BY SALT: GRB191221B

SALT has recently made some significant contributions and discoveries relating to highly energetic phenomena as part of the Large Science Programme on transient followup, led by Principal Investigator, David Buckley. Some of the most energetic examples are Gamma Ray Bursts (GRBs), fast transients which, over the sub-second to few hundred timescale of the event, are the most luminous sources of γ-rays in the Universe. Because of their rapid evolution it is often very difficult to observe their so-called optical "afterglows", since they typically fade to oblivion in less than a few hours. This is why so few GRB afterglows have been successfully observed by SALT, whose restricted sky visibility usually means that by the time SALT could observe one, they have dimmed beyond detection.

However, on 21 Dec 2019 fortune smiled and SALT was able to observe a bright, long GRB afterglow, namely GRB 191221B. It was detected as a γ-ray burst by the Neil Gehrels Swift Observatory – a γ-ray/X-ray/UV satellite – and detected optically with the MASTER-SAAO observatory in Sutherland, a mere 28 seconds after the automated alert. At this stage it had reached a brightness of magnitude ~10, typically more than 500 times brighter than most observed GRBs. The news of this bright GRB was conveyed to David about 20 min after the alert by one of the Swift team, Paul Kuin at Mullard Space Science Lab in the UK. This allowed for a P0 block to be submitted in time to observe it, when it became visible to SALT about 2.9 hours after the alert, at which point it had faded to a magnitude of 16.5.

Because it was still so bright, spectropolarimetric observations were undertaken using the linear polarimetry mode of RSS and the observations were successfully completed by Encarni (SA) and Veronica (SO). One of the members of the transients team, Richard Britto (University of the Free State), ably reduced the data, which proved to be of excellent quality, with rarely achieved signal to noise for a GRB on any telescope, never mind SALT. The results indicate GRB 191221B has relatively low, but significant polarization at the ~1.5% level (Figure 1), compared to the ~0.3% value for the interstellar medium, obtained from a simultaneous observation of a field star. GRBs exhibiting polarization are thought to have ordered magnetic fields and reverse shocks, giving rise to polarized afterglow emission. Observations of GRB 191211B were also obtained ~10 h after the burst by the ESO Very Large Telescope (VLT), using both the X-shooter and FORS2 instruments, the latter also in spectropolarimetry mode. The results from the latter indicate a slight decrease in the polarization. The SALT and VLT spectra also showed weak absorption lines (Figure 1), particularly MgII 2800Å, seen at two different redshifts attributed to the GRB host galaxy (*z* = 1.15) and an intervening galaxy (*z* = 0.96).

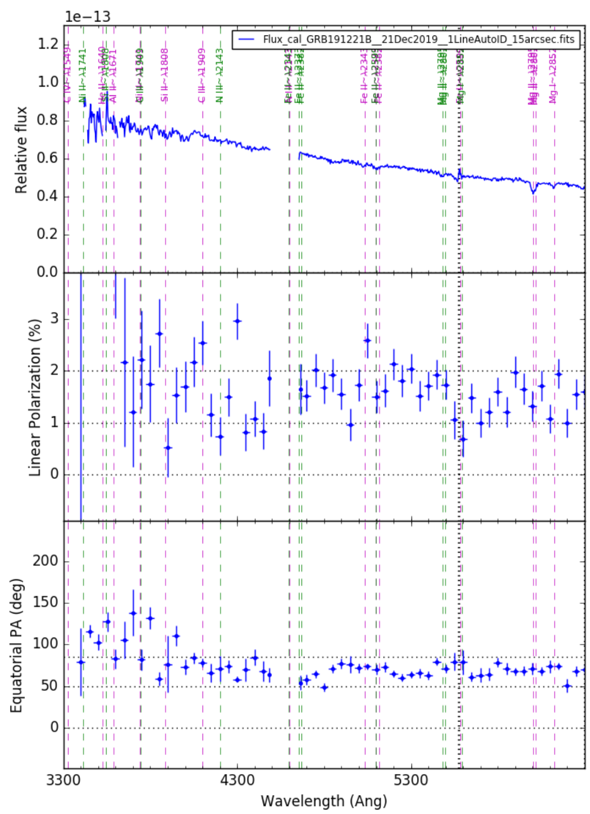


Figure 1: SALT RSS linear spectropolarimetry of GRB 191221B. Absorption features from the host galaxy and an intervening galaxy are indicated by dashed lines.

The decay optical light curve of GRB 191221B was determined by two of the southern hemisphere MASTER facilities, with observations from MASTER-SAAO continuing to ~5.6 h after the burst alert (Figure 2). After this the MASTER-OAFA facility, in Argentina, took over and observed it until ~12 h after the burst, when it had dimmed to magnitude ~17. The decline is characterised by a broken power law, with an overall slowing in the decline rate and even a period lasting ~2 h when the brightness was almost constant, which is when SALT observed it.

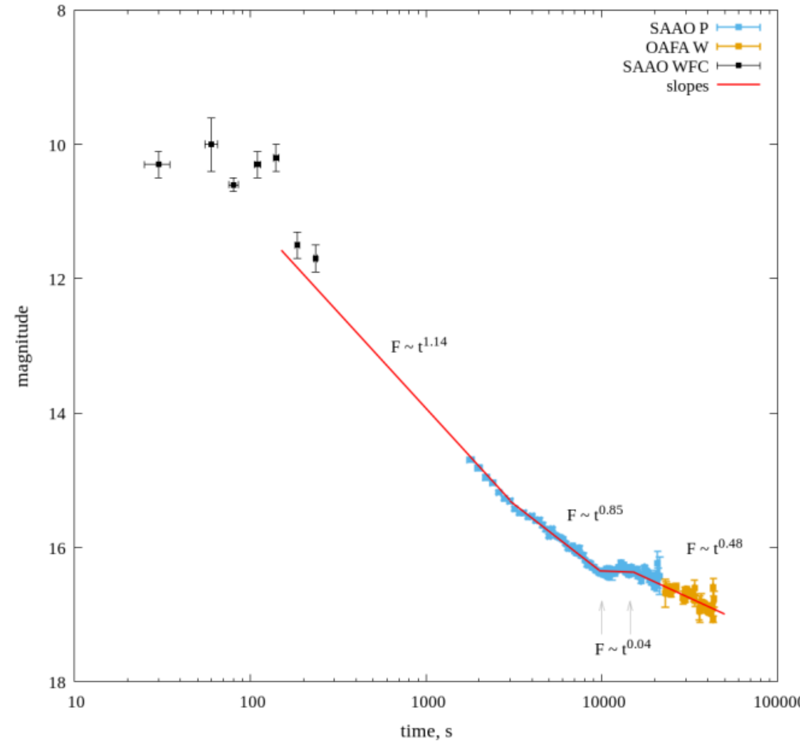


Figure 2: Light curve evolution of GRB191221B, determined by the MASTER-SAAO and MASTER-OAFA facilities, which is characterised by a broken power law. Time is measured in seconds after the γ-ray burst detection.

GRB afterglows are observed across the electromagnetic spectrum, usually associated with emission in a relativistic jet, and in the case of radio emission, this typically peaks 2 – 4 weeks after the burst. This motivated an attempt to observe GRB191221B with the MeerKAT radio telescope array, using DDT time, which was attempted on 21 Jan. These observations were reduced by Itu Monageng and Danté Hewitt, a UCT Masters student, with the result that the GRB afterglow was detected at 3 sigma flux level of 69µJy per beam.

The SALT, VLT/FORS2, MASTER and MeerKAT results are now being written up in a paper, led by the South African investigators. This is proving to be the most successful observation yet undertaken by SALT. For MASTER, this continues an impressive record of important GRB observations, including two recent publications on GRB 191114A (Jordana-Mitjans *et al.* 2020, ApJ, 892, 97) and GRB 181220A (Laskar *et al*. 2019, ApJ, 884, 121).

SHUTDOWN

The shutdown started on the 10th of February and continued to the 17th of March. There were a couple of major tasks planned for the shutdown: the M3 cleaning and the installation of the new SPS controllers were among these (see more on this later in the newsletter). This was the fourth shutdown SALT has had since the shutdowns started. It shows. The teams are well versed in their tasks to remove the RSS, SALTICAM and the Payload Rotating Structure from the telescope. With each shutdown these procedures are updated and the next shutdown runs smoother and faster. During the flurry of activity, a delegation of people from Astro-ops arrived to take a good look at all the things that go bump in the night. I think the visit gave great insight into the inner workings of the machine.

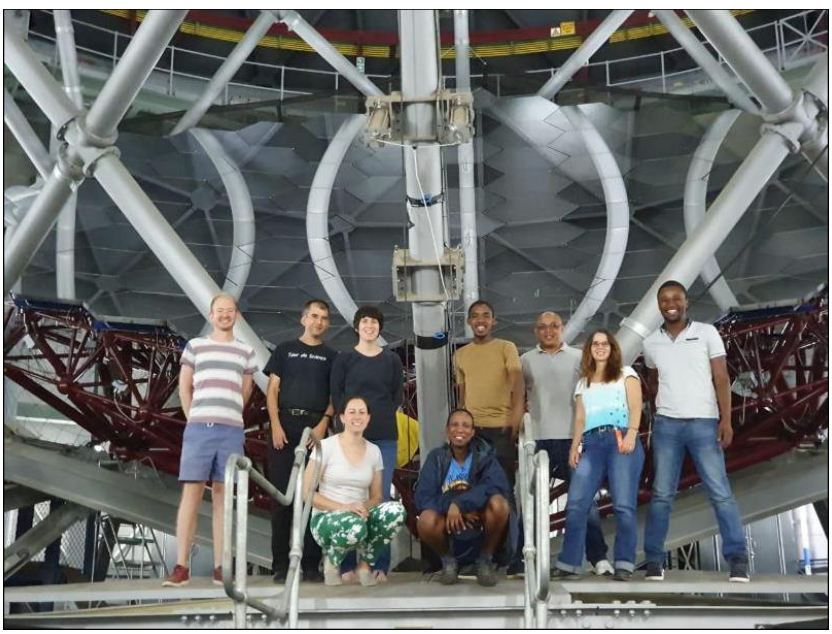
Apart from the major tasks, RSS was the focus of the shutdown. The routine cleaning of the optics was done without a hitch. The collimation of the optics was checked with a shearing interferometer at a wavelength of 632.8nm and was found to be within design optimisation for polychromatic light. The position of the detector package was tweaked for focus. A significant portion of the time spent on RSS was to collect information for the RSS Red Arm design, to this end a laser tracker was used to measure up the critical mounting surfaces on the RSS frame and the locations of the optical surfaces.

Another important task on RSS was to service the waveplate mechanism and to try and figure out what caused the shift in waveplate rotation. In the end no mechanical reason could be found. What was discovered though, was that many of the bolts for the pneumatics had come loose from the shocks of coming to a hard stop. Some of the pistons were also found to be too small for the load they needed to shift. Luckily the supplier could provide uprated pneumatic cylinders within a few days. The rework on the pneumatics included adding shock absorbers to prevent the hard stops that rattled the bolts loose. The waveplate mechanism was thoroughly tested and with a couple of software tweaks the encoders were made more stable and the mechanism has never been as smooth or stable as it is now.

Some fettling was done to the Grating magazine to make its operation smoother and alignment tabs were added to the Grating Rotation stage to make the alignment easier after installation. This worked perfectly and saved a lot of time. The slitmask mechanism also got a once over with some alignment adjustments to make operations smoother. The shutter was due for its annual replacement and this was taken care of during the shutdown.

SALTICAM got a puff clean to remove the black dust on its lenses that comes from the shutter. The routine maintenance of SALTICAM's mechanisms was also carried out. The Payload Rotating Structure also got the clean and check treatment as well as having the redundant components from the old prime focus guider removed to make life easier when working on other systems in the confined spaces. The ADC fell into the same boat. The spare time from the laser tracker contractor after he was finished with RSS was not wasted, but put to good use by measuring up the surface of the pier relative to the gravity vector. That data still needs to be analysed.

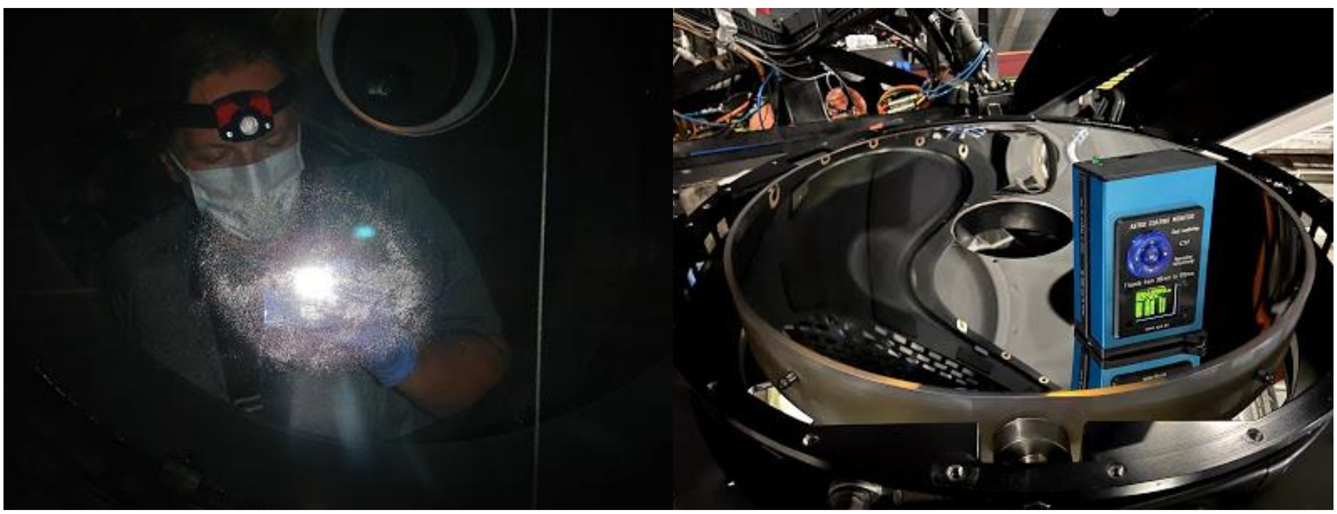
With all the jobs done the telescope was reassembled and brought on sky. Much to the delight of the technical crew the post shutdown engineering tests show that everything ended up back in the right place! As far as shutdowns go this was the smoothest transition back into operations with the least amount of niggles that needed to be taken care of just after going on sky.



Above: SALT Astro-ops learning the finer details of RSS during shutdown.

SPHERICAL ABERRATION CORRECTOR WORK

The main SAC intervention during the shutdown was to detach, wash and re-install the upward-facing mirror at the bottom of the corrector (M3), while working on a small platform suspended from the tracker bridge. This entirely new procedure proceeded remarkably smoothly and yielded a 10-15% increase in reflectivity and a dramatic (~50%) reduction in scattering, as measured with our new 7-wavelength hand-held reflectometer. We were relieved to find that the M3 coating is still in extremely good condition and we're eager to quantify the improvement in SALT's on-sky performance, both in terms of throughput and signal-to-noise. Unfortunately, photometric conditions proved elusive during the time between the telescope going back online and operations being suspended for South Africa's COVID-19 national lockdown, so those tests remain on our to-do list.



Above: Lisa Crause illuminating the M2 mirror (left). The CT-7 reflectometer measuring a clean M3 (right).

The other SAC mirrors were also inspected during the course of the shutdown and it was possible to make reflectometer measurements on the large, downward facing M2. M4 and M5 are both highly curved and thus not amenable to such measurements. We were alarmed to find that M2's multi-layer coating has degraded significantly since it was last seen 10 years ago. It seems that the deeper layers have deteriorated, such that illuminating the mirror produces a halo of bright (white) scattered light, regardless of where/how the light is directed at any part of the mirror. Access was extremely awkward so the results may be questionable, but the reflectivity appears to be >90% and though the scattering is higher than it should be, it's not as bad as that of a dusty mirror. M4's still in excellent condition, but the top upward-facing mirror (M5) is significantly worse off than when it was cleaned (in situ) in mid-2016. M5's quite dusty again and the old glycol spots from a major payload leak in 2012 are now showing signs of the coating failing in those areas.

The M5 surface is now considered too vulnerable to clean, so recoating the mirror is our only option. The SALT Ops team therefore needs to develop a plan to safely bring the SAC down and to extract M5 (and perhaps M2 as well) for recoating - ideally in time for the next major telescope shutdown. Once recoated, the mirrors will have to be re-installed and the SAC optically aligned before being returned to the tracker payload. As daunting as this exercise will be, restoring the SAC mirrors to optimal condition would significantly enhance SALT's performance.

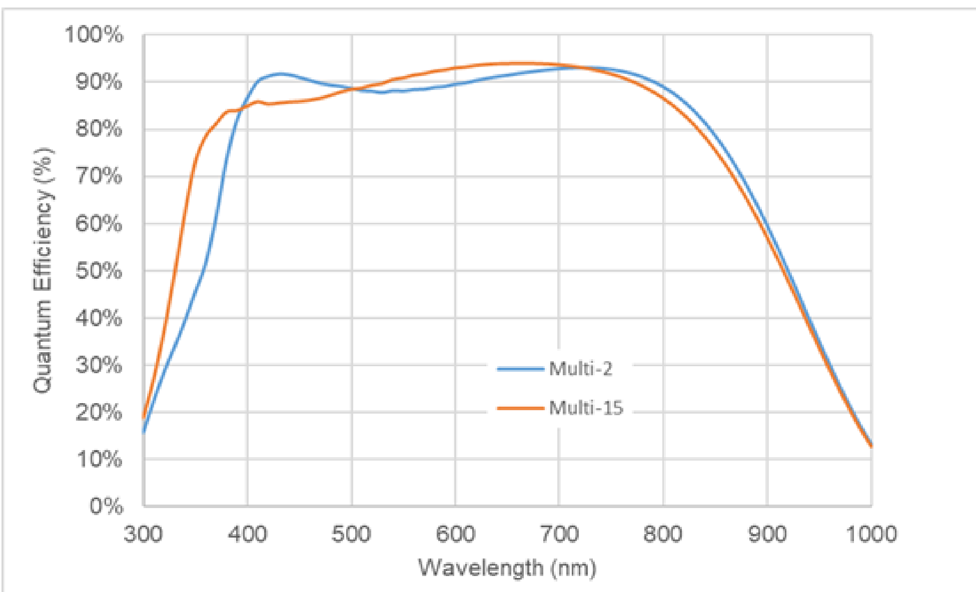
See https://saltastro.blogspot.com/2020/02/cleaning-m3-way-up-high.html for a detailed description of the M3 clean and M2 inspection.

Above: Nicolaas Jacobs and Timothy Fransman removing the lower section of the SAC baffle.

RSS DETECTOR UPGRADE

The SAAO instrumentation group and SALT Operations are working on an upgrade to the detector package on the Robert Stobie Spectrograph. We would like to replace the current CCD, a mosaic of 3 chips, with a new monolithic chip and use a new CCD controller developed by IUCAA. The reasons for the upgrade are to mitigate risks from aging hardware, particularly the now obsolete SDSU Gen II CCD controller, to remove the gaps between chips and take advantage of developments in fringe suppression techniques to optimise the throughput of RSS. This project is being done in parallel with the development of the RSS-Red arm, which will use a very similar detector.

The proposed CCD replacement is a 6k x 6k 231-C6 chip from Teledyne e2v. The 231-C6 CCD has the same size pixels as the current chip and low readout noise. We are aiming to maintain or improve on the quantum efficiency (QE) over the full wavelength range, however given the unusually high QE of the current blue CCD on RSS (~77% at 355nm), matching the response at the blue end with a new chip may be challenging. The plot below shows the QE for two anti-reflection coating options. The “multi-15” coating is the preferred choice for the RSS replacement due to its better blue performance.



Fgure 1. Typical quantum efficiency as a function of wavelength modelled by Teledyne e2v for two types of CCD coating (Lawrie, 2020, private communication).

Deep depletion silicon and fringing suppression will be used to improve the red throughput and reduce the impact of fringing at wavelengths larger than 650nm in both detectors, as shown in the figure below.

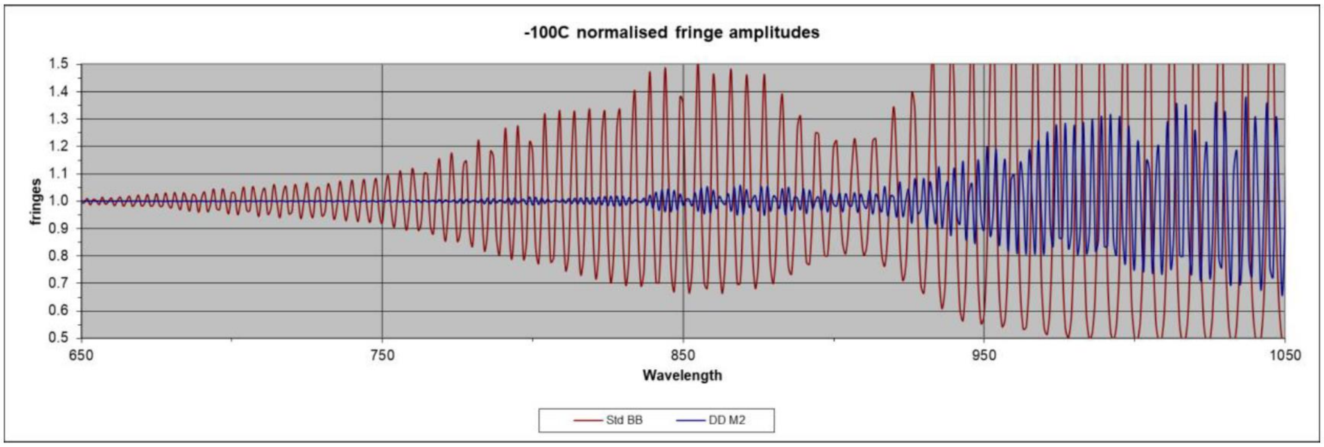
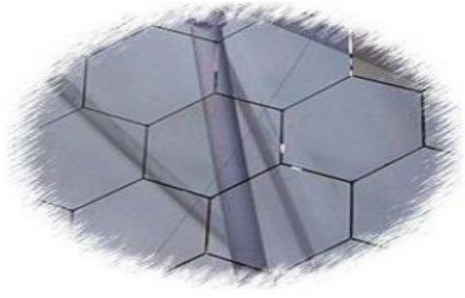


Figure 2. Model calculations of the difference in fringing between the standard silicon with the astro broadband coating (red lines) and deep depletion silicon with multi-2 coating (blue lines) from Teledyne e2v (Lawrie 2020, private communication).

The Sibonise imager currently being commissioned on the SAAO's Lesedi 1-m telescope in Sutherland also makes use of an IUCAA controller and 231-C6 CCD. This provides an opportunity to test and learn about the setup. Based on Sibonise, the readout speeds expected for SALT RSS frame transfer are 2-4s and 1s for the slot region with 4x4 binning. Faster readout times (potentially down to 0.1s, tbc) are possible for slot mode using in-frame stacking and 6x6 binning.

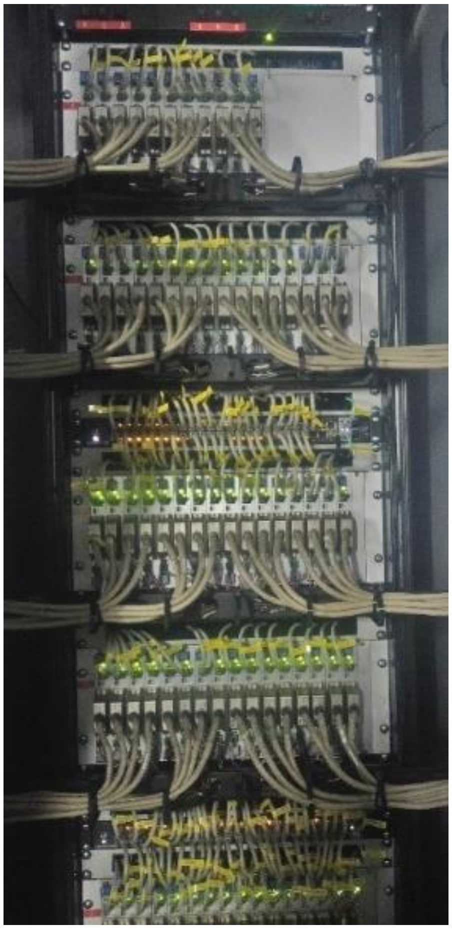
We would love to hear any feedback on the proposed upgrade from the community. Please let us know if high blue throughput or fast read out speeds in particular are important for your science interests. If you have any comments or questions, please contact me at ros@saao.ac.za or through sa@salt.ac.za.



SPS REPORT

SALT continuously strives to ensure that our technology stays up to date and this is accomplished through our asset renewal plan. The most recent project was to replace the obsolete Segment Positioning System (SPS) controllers with new efficient controllers. This would also help to minimise the downtime experienced with the old system.

The SPS controls the primary mirror segments' tip, tilt and z position and is commanded by the Mirror Alignment Control System (MACS) to retain the Primary Mirror's spherical shape either through CCAS tower mirror alignment, or the SAMS edge sensor measurements. This meant purchasing new customised controllers that would be controlled via the network compared to the previous serial interface control which was problematic. A new custom igloo was built to house these controllers with optimal cooling control. Additionally, the software was rewritten from scratch to command the controllers, and a new Human Machine Interface (HMI) was designed that is more user friendly, and with a backend capable of better analysis of the performance of the system.



During the SALT Shutdown in February/March, a huge task was undertaken to install the new igloo with cooling, install all the controllers, and to move 271 cables from the old controllers to the new controllers in the new igloo. Testing continued between the SALT Operator, Mirror Team, and SPS Project Team and was a huge success. The new system also allows for better fault finding and logging should any problems be experienced. More than a year went into the planning and design with a dedicated SALT team, some working in their spare time, to make this happen.

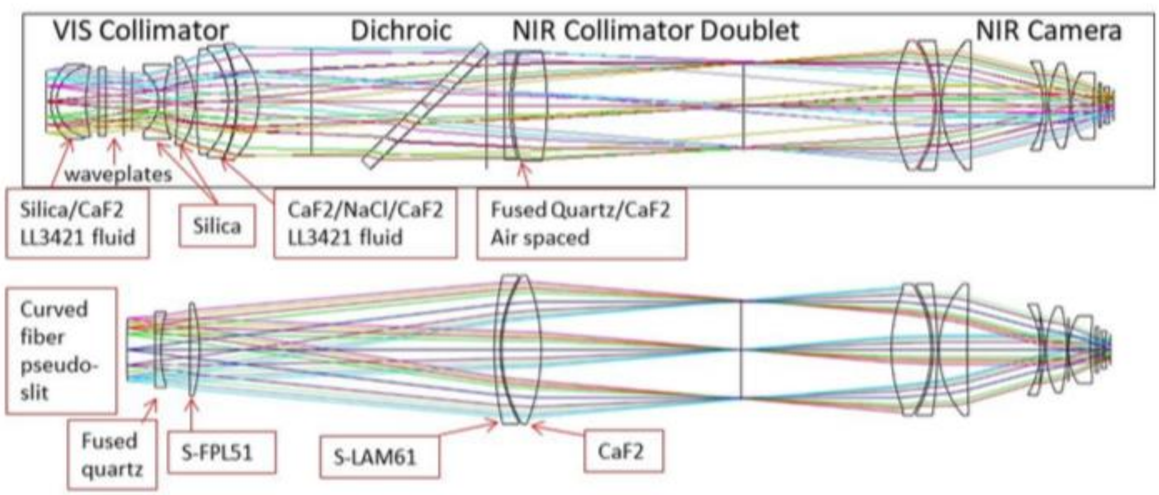
Right: New SPS Contollers Rack.

SALT NIR SPECTROGRAPH UPDATE

PI Dr. Marsha Wolf (University of Wisconsin) reports successful completion and delivery of the gigantic collimator optics for the near-infrared spectrograph for SALT. The collimator barrel and last lens surface are shown in the two images on the right. Note the PI can be seen in the v*isible-light* reflection!

Above: NIR collimator barrel (left) and last optical surface (right).

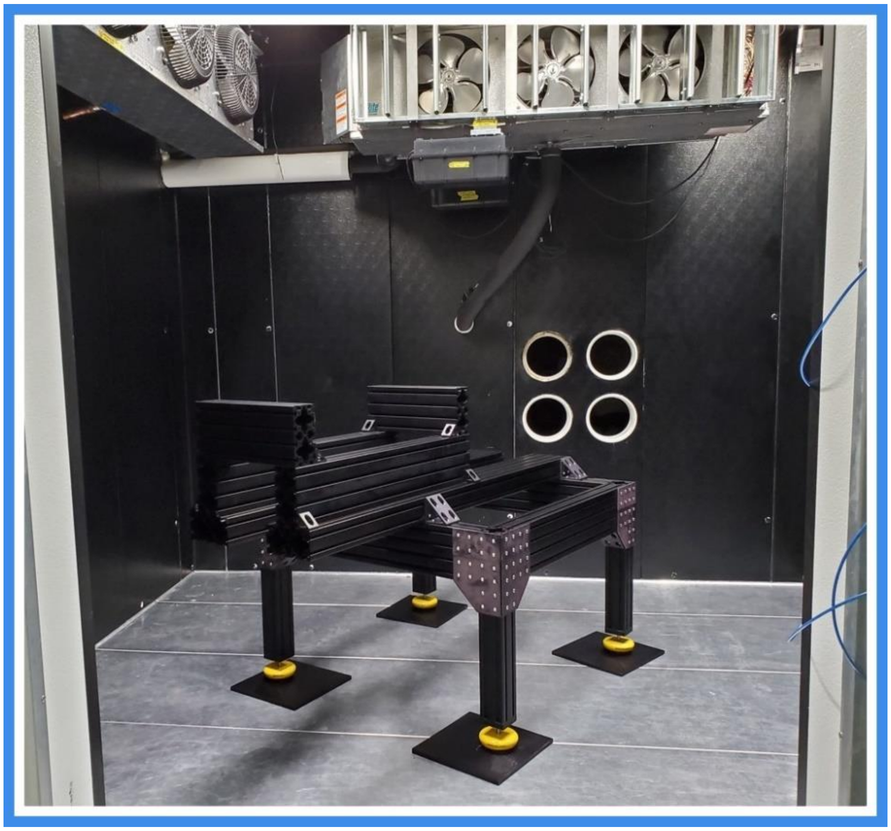
The collimator design is far simpler and has higher throughput than the RSS counterpart. A diagram of the two designs is shown below, taken from Wolf et al. (2018).



Above: Comparison of the original RSS collimator, λ = 320 – 1700 nm, (top) and the new NIR collimator, λ = 800-1700 nm, (bottom). The RSS-VIS collimator contains 7 refractive elements before the dichroic split with 2 fluid-coupled multiplets, the triplet includes a NaCl element. The final air-spaced NIR doublet after the split used an aspherical element to remove the astigmatism introduced by the 45° dichroic beamsplitter. The new NIR collimator is much simpler, consisting of only 4 air-spaced spherical lenses. The NIR camera has not changed from the original design.

The team is busy readying the new home for the spectograph – a walk-in refrigerator that will operate at -40 C (colder than most winter days in Madison) – seen in the image below. *Because the entire NIR spectrograph will now be operating at cold temperatures it will be able to extend farther into the near-infrared H-band with higher sensitivity.* This entire structure will be shipped and assembled in the spectrograph room at SALT. The black space-frame made of extruded aluminum replaces the space-frame of RSS at prime focus, and was assembled last week in Madison. The four large holes behind the frame are the feed-throughs for electronics cables and dewar cooling lines.

Next steps include installation of the spectrograph onto this frame, and collimator and camera optics integration for preliminary image quality testing on the lab bench before the BaF_2 camera element (with a defective coating) is replaced. Work continues on the fiber-optic feed cryogenic testing and final cable design. Stay tuned for updates in the near future.



.Above: SALT NIR spectrograph cold-room with spectrograph support structure assembled

THE DATA ARCHIVE TO BE RELEASED

(AND WHAT IT MEANS FOR YOUR DATA!)

The SALT Data Archive is ready to be released! While we are still battling with a few last-minute issues, beta testing is expected to start at the end of April. The public release will happen a few weeks later.

The data archive will allow you to search within all of SALT's data by a variety of criteria such as target coordinates (including a cone search), detector properties or Principal Investigator. Search results can be stored in a "shopping cart" and subsequently downloaded as a zip file.

While you can create an account for the archive, you can also login with your existing Web Manager account. The latter is actually preferable, as it will give you access to your own data.

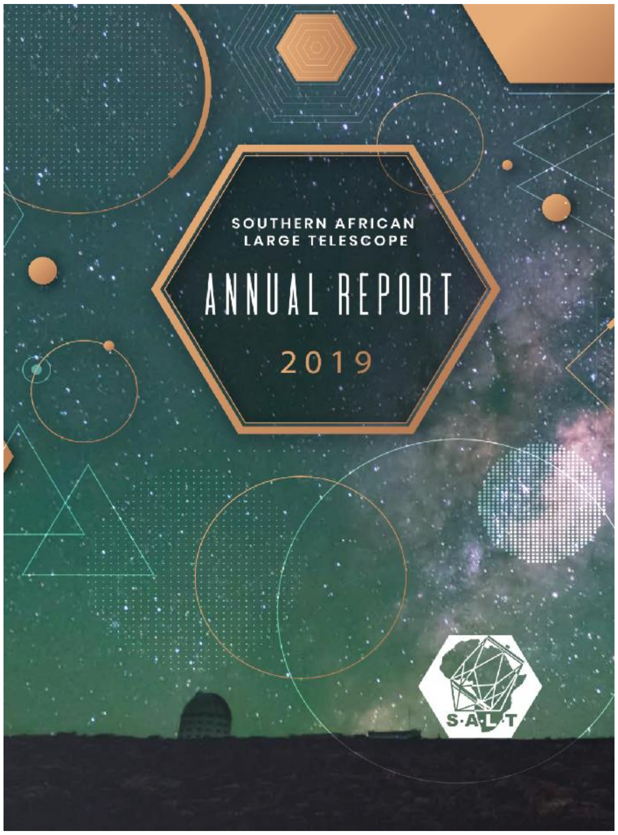
The archive will include both public and proprietary data in its search results, but won't include target coordinates of proprietary observations. Of course data download is restricted to public and your own files.

With the public release of the data archive the proprietary period of existing observations will be updated. Generally, science data will become available after 36 months (or 24 months if South Africa has allocated time). This proprietary period starts at the end of the semester when the last data was taken.

If a proposal does not include any time from South Africa, the Principal Investigator will be able to increase the proprietary period for that proposal in the Web Manager. Otherwise they need to request this by sending an email with their motivation to salthelp@salt.ac.za. Of course all PIs are welcome to decrease the proprietary period in the Web Manager.

All Principal Investigators will be notified with more details a few weeks before the data would become publicly available, so that, if necessary they can change the proprietary period (or request the change).

SALT ANNUAL REPORT 2019



The new annual report is now available on SALT's 'News' website. There's plenty of new exciting science done with SALT data, leading to a record of over 50 refereed publications in 2019. Transient science takes up an increasing fraction of these publications, with eleven refereed papers based on the Large Science Proposal on transients alone.

The report also highlights what is going on at the instrument front, from increasing the operations efficiency to improving the existing instruments (equipping the HRS for exoplanet science, refurbishment of the Fabry-Pérot mode of the RSS)) to new instruments (MaxE) and new ideas (mini-trackers). In addition, the SALT data archive will be coming online soon.

One of SALTs strategic objectives is outreach and education. A whole section shows the activities and progress made, not only by the SALT Collateral Benefits Programme, but also by individual SALT partners.

You can grab the report from our website at www.salt.ac.za/news/salt-annual-report-2019/, or send us an email and we'll send you a hardcopy.

LOCKDOWN SNIPPETS

In a new spin on "the dog ate my homework", SALT operator Thea Koen had monkeys break into her house, eat all her quarantine snacks and then pee on her laptop. Fortunately no work was harmed in the making of this newsletter.

PODCAST: COSMIC SAVANNAH

The Cosmic Savannah is a podcast about astronomy in Africa. It is produced and hosted by Dr Jacinta Delhaize from the University of Cape Town and Dr Daniel Cunnama who is the Science Engagement Astronomer at the South African Astronomical Observatory. Astronomy on the African continent is thriving, thanks to giant telescopes like SALT and MeerKAT. This podcast aims to share the joy of astronomical research and discovery with the general public. Each fortnight, we pick a different Astro-topic and interview a special guest or two about their work in the area. Our very first episode featured SALT Astronomer Dr Moses Mogotsi, who described what it's like to do an observing run in Sutherland. Episode 13 is one of our most popular, and features SAAO director Prof Petri Vaisanen who dazzles us with plans for SALT 2.0 and the Intelligent Observatory!

We usually record our podcast in a little make-shift studio on the SAAO site in Observatory, where we have stuck foam to the walls for soundproofing. During the lockdown, we are of course unable to get to the studio to record. So instead, Jacinta built a blanket fort studio at home to create a space that blocks out most outside sound and absorbs echos. It's even lit by fairy lights! Dan joins via Skype and together they keep the podcast running. After all, lots of people are looking for online learning and entertainment at the moment!

If you'd like to listen, you can go to www.thecosmicsavannah.com or search for "The Cosmic Savannah" on Apple Podcasts, Spotify, Google Podcasts, or any other podcast app. You can also find us on Facebook, Twitter and Instagram @cosmicsavannah.

Join us for a virtual safari through the skies!

MEET THE TEAM: LEE TOWNSEND

Hello everyone, my name is Lee. I was born in the medieval town of Salisbury in the south-west of the U.K., just a few kilometres from Stonehenge. I lived there until I was 12 before moving to a small town close to the beautiful Roman city of Bath. I did my undergrad in physics and Ph.D. in astrophysics at the University of Southampton in the U.K. before moving to Cape Town in 2013 for a post-doc at UCT - and have been here ever since. The weather, wine and night skies are much better here! I'm a keen squash player and also enjoy hiking or running around the mountain.

I specialise in optical and X-ray observational astronomy; focusing on X-ray binaries, accreting neutron stars, massive stellar and binary evolution and, more generally, most types of X-ray or optical transient events. After finishing my second post-doc at UCT at the end of 2018, I took on the role of operations manager for the MeerLICHT telescope during the final stages of commissioning and early science operations. I am now thrilled and excited to be joining the SAAO as a SALT astronomer and look forward to working with everyone in Cape Town and in Sutherland.

SCIENCE PAPERS (JAN-APRIL 2020)

Below is the list of SALT publications since our last newsletter (for our full list of publications, please visit http://astronomers.salt.ac.za/data/publications/).

- Andreoni, I.; Goldstein, D.A.; Kasliwal, M.M.; et al. 2020/2. GROWTH on S190814bv: Deep Synoptic Limits on the Optical/Near-infrared Counterpart to a Neutron Star–Black Hole Merger. *AJ*, 890/131.
  https://ui.adsabs.harvard.edu/abs/2020ApJ...890..131A/abstract

- Blue Bird, J.; Davis, J.; Luber, N.; et al. 2020/2. CHILES VI: H I and H α observations for z < 0.1 galaxies; probing H I spin alignment with filaments in the cosmic web. *MNRAS*, 492/153.
  https://ui.adsabs.harvard.edu/abs/2020MNRAS.492..153B/abstract

- Driessen, L.N.; McDonald, I.; Buckley, D.A.H.; et al. 2020/1. MKT J170456.2-482100: the first transient discovered by MeerKAT. *MNRAS*, 491:560.
  https://ui.adsabs.harvard.edu/abs/2020MNRAS.491..560D/abstract

- Gvaramadze, V.V.; Kniazev, A.Y.; Gräfener, G.; and Langer, N. 2020/3. WR 72: a born-again planetary nebula with hydrogen-poor knots. *MNRAS*, 492:3316.
  https://ui.adsabs.harvard.edu/#abs/2020MNRAS.492.3316G/abstract

- Gvaramadze, V.V.; Kniazev, A.Y.; Castro, N.; and Katkov, I.Y. 2020/3. HD 93795: a late-B supergiant star with a square circumstellar nebula. *MNRAS*, 492/2383.
  https://ui.adsabs.harvard.edu/abs/2020MNRAS.492.2383G/abstract

- Handler, G.; Kurtz, D.W.; Rappaport, S.A.; et al. 2020/3. Tidally trapped pulsations in a close binary star system discovered by TESS. *Nature Astronomy*, 45.
  https://ui.adsabs.harvard.edu/#abs/2020NatAs.tmp...45H/abstract

- Jeffery, C.S.; Kameswara Rao, N.; Lambert, D.L. 2020/4. SALT revisits DY Cen: a rapidly evolving strontium-rich single helium star. *MNRAS*, 493:3565.
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