SALT Instrumentation Report
To The SALT Board
For The 2014 May Meeting

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1. Scope

This reports on work carried out since the 2013 Nov Board meeting in Mafikeng. In the spirit of brevity in reporting, a short summary will be given, along with a zip file of BEC reports posted on the Board web site alongside this report.

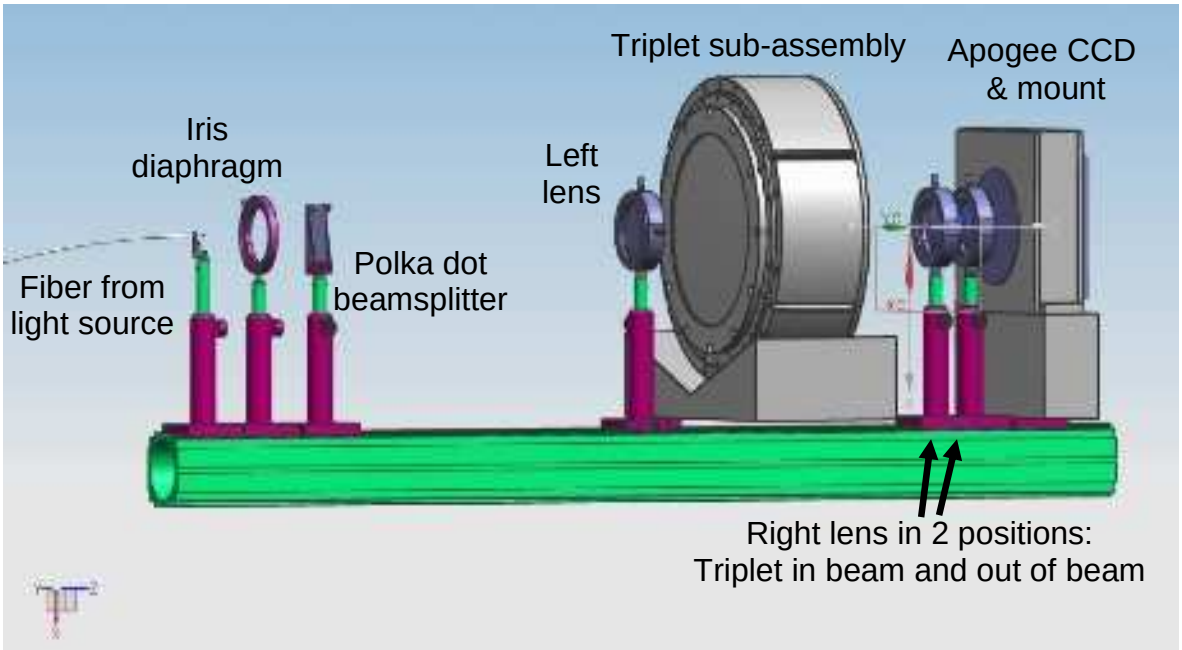

Fig. 1: Throughput Measurement System for RSS optics

2. RSS Collimator Triplet and Doublet Replacement

This project has taken up the majority of my time since the last Board meeting. Ockert has provided a written report on the status. I have participated in twice-weekly meetings with the project team, where all aspects of the project are reviewed on an ongoing basis. In between, I have specifically worked on:

- Developing optical tests for ensuring that the re-assembly of the new Triplet and Doublet are properly aligned.
- Producing an extensive tolerance analysis of the Triplet and Doublet to guide the re-assembly.
- Designing a throughput measurement system to check the throughput of the new optics as well as the old.

Fig. 1 shows a model of the new system measuring the throughput of the Triplet. Full details are in the BEC reports in the attached zip file.

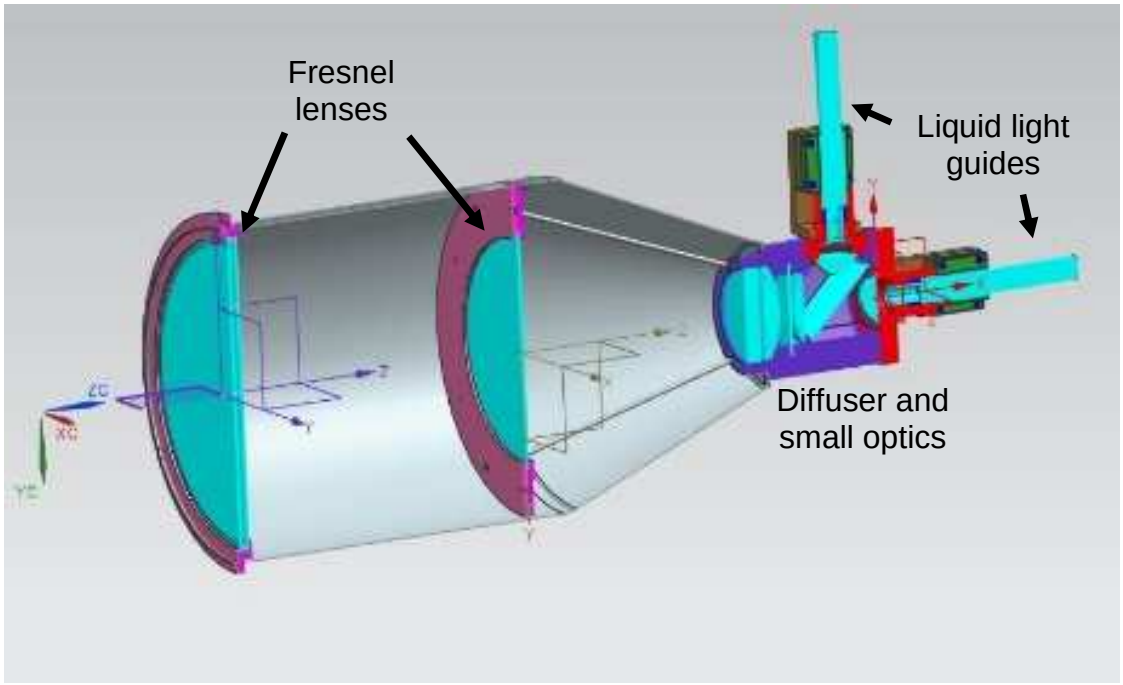

Fig. 2: Upgrade to the Optical Relay System of the SALT Calibration System

3. Replacement CALSYS Relay Optics

Replacement of the CALSYS relay optical system is in progress. The existing one does not conform to the original SALT optical design. Instead, it focuses light from a diffusing screen just under the SAC to a point just within the SAC. This is a reasonable quality image whereas the SAC is expecting the hugely spherically aberrated light from the primary mirror. Consequently, the reflections off the SAC mirrors then induce very large overcorrected spherical aberration at the exit hole of the M1-M2 system. The new baffles installed at the time of the SAC repair has been so successful that the CALSYS throughput is now much lower than prior to the SAC repair. Significant observing time is being used to obtain arc lamp exposures of sufficient S/N. For

example, some arc exposures for some configurations of RSS VIS require 5 min exposures, taking time away from science exposure during a track. For HRS, the situation is even more serious – 30 min exposures are required.

Because of the shortage of mechanical engineering effort, it was decided only to change the relay optics conveying light from the liquid light guides which are in turn fed by lamps in the lamp bay. Fig. 2 shows the design of the new system. Full technical details are in the BEC reports attached. R300k + 20 per cent contingency has been approved for this project and installation and testing on the telescope should take 15 weeks.

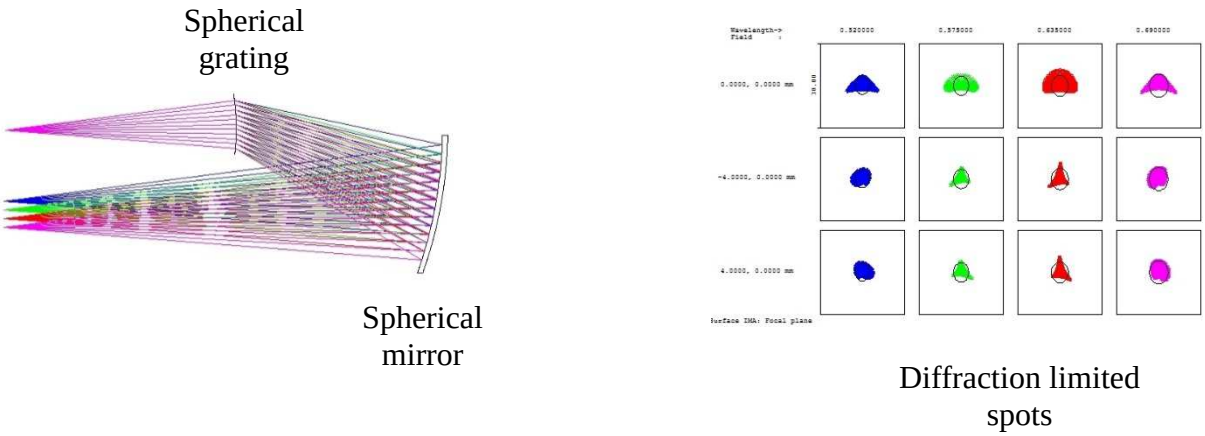

Fig. 3: Spherical Transmission Grating Spectrometer (STGS)

The next section of this report is largely a repeat of the November report which I did not have a chance to speak to, owing to my absence due to illness.

4. Spherical Grating Spectrometers

In collaboration with Chris Clemens, a spectrometer concept based on spherical VPH gratings is being developed. A report on this initiative was given at the 2012 Nov Board Meeting in Cape Town and since then there has been much progress.

The first design developed was called a Half Offner and used 2 reflections off a single spherical mirror, as well as 2 passages through a VPH grating with a reflecting exit surface. This design has excellent image quality. Since then, we have realized that the aberrations of a spherical grating are compensated for, essentially perfectly, by reflection off a single spherical mirror used off axis. This gives rise to the simplest possible spectrometer, shown in Fig. 3, a grating and a spherical mirror. We call this the STGS: Spherical Transmission Grating Spectrometer.

We believe this design is superior to many (most?) traditional astronomical spectrographs which rely on feeding a *plane* wavefront (collimated beam) on to a *planar* disperser (grating or prism) and followed by conversion back to a spherical wavefront (by the camera) to form focused images. The STGS requires no collimator and the single spherical mirror acts as the camera. Of course a spherical VPH grating is needed; Chris has learned how to make such gratings (albeit a small prototype so far).

Is this relevant to SALT? Yes. One can list some limitations on spectroscopic performance with SALT:

- Poorer seeing (~1.5 arcsec) than anticipated (~0.9 arcsec) at the inception of the project. Typically 330 micron slits are used.
- Inefficiency in RSS. Even if there were no lens fluid problems, there are still 19 air-glass surfaces which is a 20 per cent loss assuming 1 per cent efficient AR coatings.

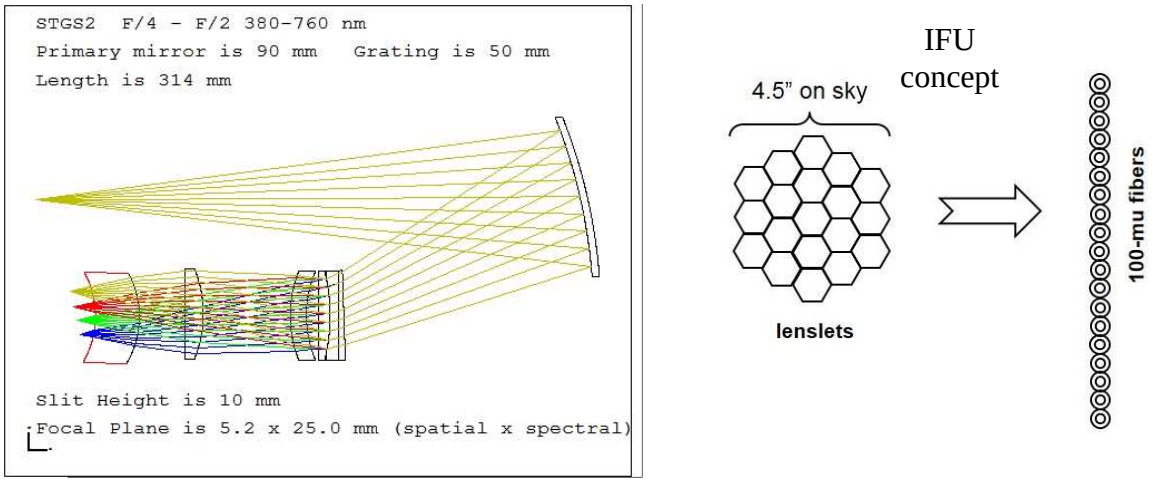

Fig. 4: Real world prototype STGS. Almost all optics are COTS from major optics vendors. All optics are made of BK7 or fused silica. The IFU concept is shown at the right.

We have developed a concept for a spectrometer fed by an IFU comprising 19 x 100 micro fibers arranged in a close-packed hexagonal (experience with the Gemini IFU shows 80 per cent throughput for such lenslets). The IFU will gather up 80 per cent of the light from faint point sources over a 2.5 arcsec diameter patch on the sky. Reformatted to a 100 micron pseudo slit, it is then possible to assemble an instrument delivering resolution of ~800 over the wavelength range 380-760 nm. The volume occupied will be about the size of shoebox (total length of the optics is 320 mm), not counting the detector package (add half a shoebox). The cost will be $100k. The payoff will be the fastest possible low resolution, point source spectrograph on SALT, suitable for redshifts and classification spectroscopy (targets could, for example, be SNe, other transients etc.).

Funding for development work has kindly been made available by Ted, from DST/NRF infrastructure funds, to build a laboratory prototype to measure efficiency and image quality over the next few months. After that, the funding will continue to build a prototype instrument to be tried out on the SAAO 1.9 m. Thereafter, if it pleases the SALT Board, it could replace BVIT in the Aux Port to test on SALT. A real world instrument concept is illustrated in Fig. 4. It uses almost all off-the-shelf 50 mm lenses from Melles-Griot and Edmunds Optics: there are no aspheric surfaces, no CaF2, no lens fluid coupling, only fused silica or BK7, the most common of all optical glass.

The above developments in spherical grating spectrographs were reported at the Scientific Detector Workshop (2013) in Florence during 7-11 October. The presentation at the conference

was listed with the Mafikeng Board papers and shows the context of the new development in the history of spectrometers.

Since the last Board meeting, Chris Clemens has succeeded in making a spherical VPH grating with excellent transmission. This was received a week or two ago; the spherical mirror and test lens for the lab characterization are awaited. Measurements of image quality and throughput will then be carried out. Should these conform to expectations, a small spectrograph, fed by an IFU, covering 380-760 nm with a resolution of ~800, will be constructed as a prototype instrument.

5. Other Activities

I simply list some of my other activities and will be happy to take comments or questions during the Board meeting:

- SALT meetings and committees: attendance at almost all internal SALT management meetings, as well as BEC meetings. I chaired the HRS Acceptance Test Committee. I attended the DST-run risk management workshop to develop a risk management plan for SALT.

- Science: a week's observing on the SAAO 1-m at Sutherland to follow up interesting stars found in the Edinburgh-Cape blue object survey.

- Advice and support to Ted Williams as requested.

- South African/SAAO Committees:
    - I am on Panel 1 and Panel 4 of the Astronomy Desk's initiative to develop a Decadal Plan for South African Astronomy. This has involved attending meetings and contributing to and reviewing documentation.
    - I am a member of the South African SALT Task Committee.
    - I sat on the selection committee for a new optomechanical engineer for SAAO.
    - I sat on the bid evaluation committee for the new SAAO 1-m telescope.