A New Home For RSS-NIR?

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1. Scope

This discussion document considers the possibility, and pros and cons, of placing RSS-NIR in the spectrometer room rather than on the Tracker.

2. Background

At the RSS-NIR Critical Design Review in 2010, the SALT Tech Ops team requested a change in the instrument cooling system design from the baseline fluorinert coolant to CO2. To accommodate this request the RSS-NIR team initiated a completely new custom design effort. Very few vendors with CO2 capability were found, however a design contract was begun with Gartner Refrigeration who specializes in factory CO2 cooling systems for the food industry. Very slow progress was made for years due to their other much larger ongoing projects. Finally, a preliminary design was completed and bids for construction were solicited in 2014 October. Only one quote for a CO2 cooling system was received, from Gartner, which was prohibitively expensive at nearly 5 times the budgeted cost of a fluorinert system. At this point Marsha Wolf, in collaboration with Matt Bershady, began exploring options for putting RSS-NIR in the spectrometer room with a simplified cooling system, and feeding it with optical fibers. This would, of course, require it to be supplied with a new collimator, as well as optical fibers which would be deployed in an Integral Field Unit (IFU) either in the FIF port or the AUX port in the payload. Eric Wilcots had informal discussions about this potentially new RSS-NIR configuration in the Pune Board meeting in 2014 November.

2. RSS-NIR

2.1 The Outlook for RSS-NIR

For some years, RSS-NIR has had a precarious future because of the lack of funding to complete the instrument in Madison as the project extended beyond its budgeted duration, and the lack of funds to commission the instrument on the telescope. Shortage of money is the single biggest risk to putting the instrument into scientific operation.

Additional funds required to complete the instrument in Madison, ready to ship, continue to grow at a slow rate and are up to $273k as of March 2015. Commissioning the instrument on SALT requires $505k (recently updated from the previous $630k rough estimate). The current situation has not really changed in a couple of years: the SALT Board appears to have no appetite (and probably insufficient funding) to contribute to these shortfalls; the University of Wisconsin has not succeeded in raising the required money.

The future of the instrument is then one of two outcomes: (i) the UW Astronomy Department comes up with the funds to finish the instrument in Madison, but there is insufficient commissioning money; (ii) another source of commissioning money is found and RSS-NIR is installed and commissioned on the telescope.

2.2 Other Risks

There are additional risks, mainly faced by the SALT Board, if RSS-NIR goes on the Tracker:

- The technical complexity of getting RSS-NIR married to RSS-VIS, installed on the telescope, commissioned and scientifically operational. It is inevitable that a large number of SALT staff will have to be assigned to supporting this effort, thereby distracting them from other work they could otherwise have undertaken.
- The HUGE loss of observing efficiency in RSS-VIS at least, and possibly the telescope as a whole, resulting from such a major change in the hardware configuration on the Tracker.
    - For perspective, after re-commissioning of the telescope in 2011, it was about 6 months before the telescope settled down into routine operation. After the RSS-VIS optical service in October last year, the disturbance to the system took about 3 months to settle down. During these periods, scientific productivity was far lower than at present or in the first half of 2015. Integration of RSS-NIR is expected to take 4 months, science commissioning another 6 weeks, and possibly another 3 months of telescope settling down time as previously experienced with RSS-VIS. During this time, the availability of the telescope for science operations will be severely compromised for the reasons just mentioned.
- Additional risks (compared to at present) to the maintainability of RSS, since the NIR arm will be fully integrated with the VIS as one instrument, requiring both to be removed for service on either instrument.
- The much greater challenge of maintaining RSS-NIR and ensuring reliability on the Tracker, compared to maintaining it in the spectrometer room.

2.3 An Alternative Home For RSS-NIR

Matt Bershady and Darragh O'Donoghue, who were already working together on a potential IFU feed for a STGS instrument on SALT, began serious exploratory discussions of mounting RSS-NIR in the spectrometer room and feeding it with optical fibers. The telescope end of the optical fibers would be arranged in an IFU mounted in either the FIF or Aux ports in the payload. If the Aux port is developed as a "smart focal plane" with movable fibers / IFUs, multi-object spectroscopy (fiber-fed) with RSS-NIR would eventually be possible.

The rest of this document therefore considers the pros and cons of the baseline option (on the Tracker) and the possibility of the spectrometer room home. The assumption is that the instrument is completed in Madison and is delivered to the telescope.

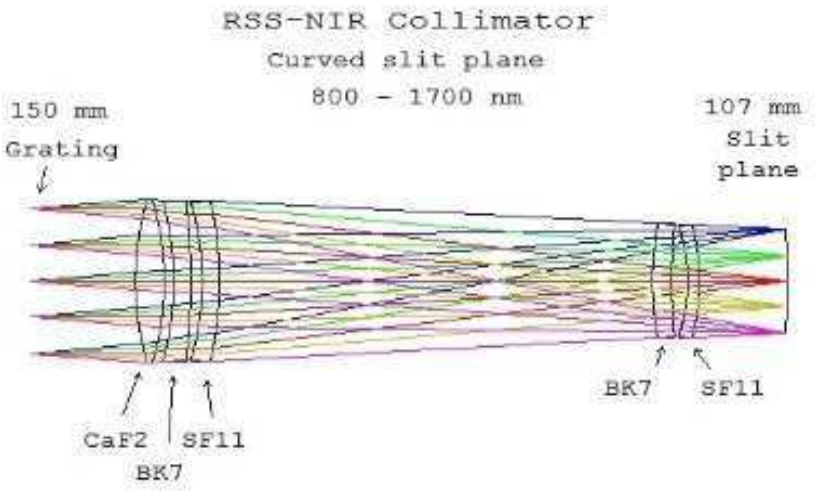


Fig. 1: New collimator for RSS-NIR

Additional hardware would have to be supplied, over and above that envisaged in the current scope of work. Furthermore, this major change at such a late stage in the project means that resources already devoted to components that would not be used in the spectrometer room option (e.g. dichroic beamsplitter, NIR collimator doublet, fold mirror flexure compensation mechanism) reduces the potential savings that one might initially expect to gain. A new collimator would have to be supplied as well as an IFU. DOD has already designed a new collimator (see Fig. 1); Matt Bershady has indicated willingness to lead the effort to supply the IFU. Both collimator and IFU will cost money.

Fig. 2 shows a comparison of the hardware components in the system depending on where RSS-NIR is located. The coloured boxes indicate the changes to the system to bring RSS-NIR into operation in each case.

Colour code

Blue – No Modification or development required.

Green – Low risk modification required.

Yellow – Medium risk modification required.

Red – High risk modification required.

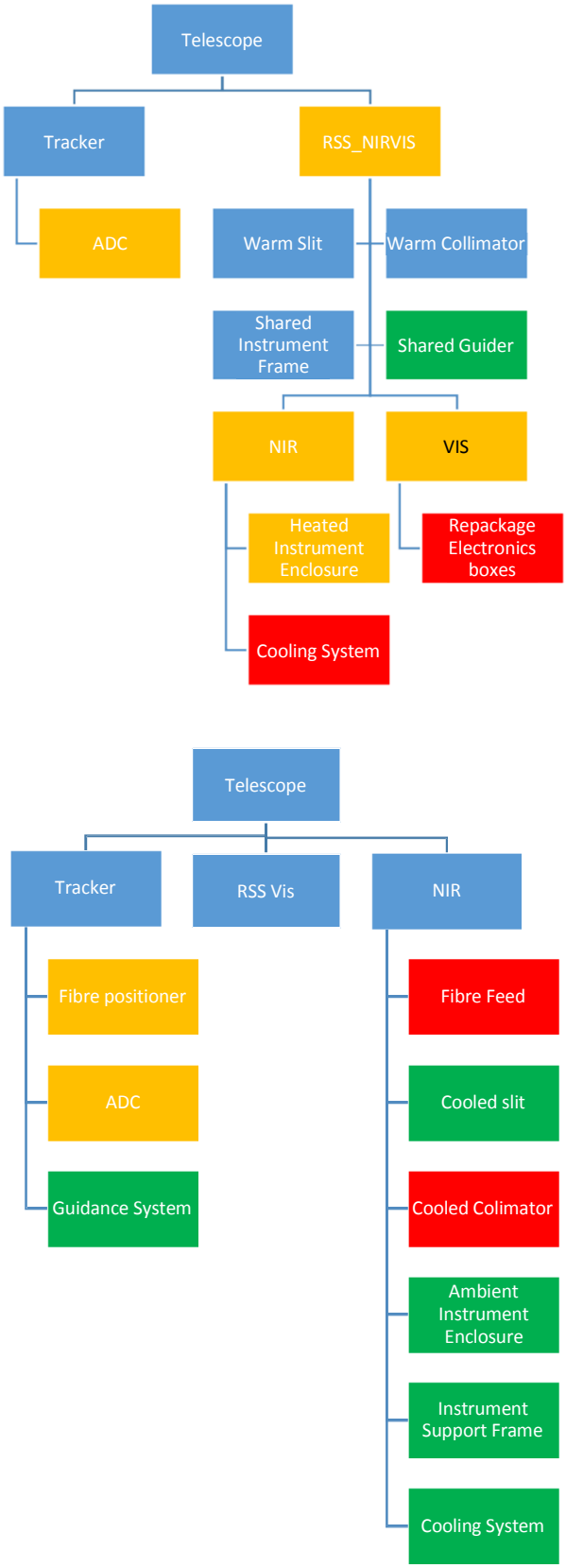


Fig. 2: (Top): RSS-NIR on Tracker. (Bottom): RSS-NIR in the spectrometer room.

2.4 Advantages of a New Home

In considering these advantages, it is further assumed that commissioning in the spectrometer room implies that the instrument remains in the spectrometer room for science operations (at least for quite some time).

- Integral field spectroscopy would be a new science capability on SALT.
- A fiber-fed RSS-NIR should improve the calibration of its spectroscopic data. Fibers azimuthally scramble the input light, which in essence would provide a more stable pupil illumination on the diffraction grating. Because RSS-NIR (and VIS) uses volume phase holographic gratings that have intrinsic non-uniformities in wavelength-dependent diffraction efficiency across the clear aperture, SALT's varying pupil illumination during tracks and between multiple exposures in different parts of a track, causes problems in flat fielding and sky subtraction. This has been an issue in RSS-VIS data.
- Integration and commissioning of RSS-NIR would proceed almost entirely independently of the telescope whose operations would not be affected, except possibly during installation of the fiber feed at prime focus. Commissioning can therefore proceed at whatever pace resources are available. If the instrument is mounted on the telescope, commissioning has to be completed as fast as possible to put the telescope back at full productivity.
- Integration and commissioning is HUGELY simplified. It takes place in the spectrometer room and not on the telescope.
- A cooled slit and collimator become possible. This would result in a significant improvement to the sensitivity of the instrument.
- The unfunded commissioning cost ($505k) would be met, in part, by SALT assigning its personnel to support commissioning. Other partners may also contribute to science commissioning.
- HUGELY simplified operational technical complexity, and repairs and maintenance.
- An advantage of separating the two arms is better optimized coatings over a shorter wavelength range for the new RSS-NIR collimator, and for future coatings on the RSS-VIS collimator optics.

An additional possible advantage is that if RSS-NIR does not go on the Tracker, the final part of the Tracker upgrade project, the hexapod upgrade, might then be able to proceed with the new ball joint option. This might free up manpower from that project to assist with the RSS-NIR new home.

2.5 Dis-advantages of a New Home

- If RSS-NIR is mounted in the spectrometer room, nothing would be changed on the instrument that would preclude installing it on the Tracker at a later time. However, the later tracker installation would require addition of the custom-designed pre-dewar enclosure with a skin heater system on the outside surfaces, a cooling system that can supply coolant up to SALT's prime focus, opto-mechanical mounting of the NIR collimator doublet as the window into the pre-dewar, the final implementation of flexure compensation via the fold mirror tip/tilt actuators, and the custom-designed electronics enclosure (total ~$400k). The fiber fed option would mean a loss of near-term realization of the following capabilities:
    - no simultaneous RSS-VIS + RSS-NIR observations

- no multi-object NIR spectroscopy (at least initially)
- no NIR (spectro-)polarimetry
- no NIR imaging
- upgrade potential to NIR Fabry-Perot

- Effort would be required from SALT staff to contribute to developing the new arrangement
- Money would be required for a new collimator and an IFU, as well as a revamped cooling scheme for a larger enclosure that would include the new collimator.
- The RSS-NIR Collimator Doublet and Dichroic would be wasteful expenditure

2.6 Costs

The central point of the alternative scheme from a resources point of view is solving the commissioning cash flow problem by SALT contributing its resources to execute the commissioning, using people funded out of operations. The alternative home for RSS-NIR makes sense only if the commissioning cash cost is substantially smaller than $505k. The cost estimates gathered to date comprise:

- The cash cost of a new collimator: the new collimator (see Fig. 1) comprises 4 singlets made of inexpensive glasses, and a CaF2 singlet. UW have a spare CaF2 blank (the main cost of fabricating CaF2 lenses). Marsha and her team have estimated budget and schedule, drawing from their experience with producing the RSS-NIR camera. Drawing from his experience in producing the new RSS-VIS collimator doublet and triplet, Ockert has also derived an estimate. These are set out below:

	UW Estimate	SALT Estimate
Budget:	$ 182 000 (= R2.2M)	R1.9 million + R0.56M contingency
Schedule:	84 wks (1.6. yr)	15 months (1.25 yr)

  Money-wise, the two estimates are similar. The schedule for Ockert's estimate is quite a bit smaller.

- The cash cost of an IFU: Matt Bershady has made a tentative estimate of this on the assumption that machining of the ferrules as well as the mounting interface in the payload would be supplied as in-house contributions by SAAO and/or UW. On this basis, he arrives at a figure of $145k.

- The delta in cost from commissioning on the Tracker or in the spectrometer room. Marsha Wolf has estimated this as follows (with the estimate for commissioning the fiber fed option less well developed at this point):

	RSS-NIR on Tracker	RSS-NIR Fiber Fed
Budget:	$ 505k (= R?M)	$ 336k (= R? M)
Exclude UW: labor	$ 256k (= R?M)	$ 202k (= R$ M)

- Some savings in the cost of completing RSS-NIR could be realized in immediately switching

from the Tracker location to the fiber fed option (see following tables). However, most of these savings come from the construction of the custom pre-dewar enclosure and cooling system, which are both imminently about to begin. The decision must be made now.

Overall Cost Summary:

BUDGET TO COMPLETE RSS-NIR			
Budgets	**Baseline Instrument**	**Fiber Fed**	**Fiber Fed - Baseline**
Ready to Ship			
SSEC Labor	$189,437	$196,060	
Astro Labor	$593,354	$638,889	
Materials	$73,000	$59,000	
Equipment	$347,500	$335,975	
Services	$0	$126,125	
Travel	$3,500	$7,000	
Sum	**$1,206,791**	**$1,363,049**	**$156,258**
Sum without Washburn Labs Labor	**$613,437**	**$724,160**	**$110,722**
Commissioning			
SSEC Labor	$97,932	$74,799	
Astro Labor	$248,715	$133,923	
Materials	$54,000	$60,000	
Equipment	$15,000	$10,000	
Services	$0	$0	
Travel	$88,445	$56,522	
Sum	**$504,092**	**$335,244**	**-$168,848**
Sum without Washburn Labs Labor	**$255,377**	**$201,321**	**-$54,056**
TOTAL	**$1,710,883**	**$1,698,293**	**-$12,590**
TOTAL without Washburn Labs Labor	**$868,814**	**$925,480**	**$56,666**

Notes:

- UW's cheaper estimate of the collimator cost was preferred to Ockert's to avoid including the unknown R/$ exchange rate at the time of the expenditures.
- Commissioning costs are much smaller (~$135k-250k) if Washburn Labs labor during the commissioning can be excluded.
- However, costs to SALT for the personnel required in all cases is not known at the time of writing this bullet.

Cost Breakdown by Subsystem:

BUDGET TO COMPLETE RSS-NIR	Baseline Instrument				Fiber Fed				Baseline	Fiber Fed	Baseline	Fiber Fed
SUBSYSTEM	Astro Labor	SSEC Labor	Matrl, Equip, Serv	Travel	Astro Labor	SSEC Labor	Matrl, Equip, Serv	Travel	Sum with WL Labor		Sum w/out WL Labor	
1.0 Project Admininstration / System Design	$39,241	$42,416	$3,500	$0	$47,374	$63,108	$7,500	$0	$85,157	$117,982	$45,916	$70,608
2.0 & 14.1 Optical Tower	$10,995	$0	$18,000	$0	$0	$0	$0	$0	$28,995	$0	$18,000	$0
2.4 Tip/Tilt Mechanism	$12,803	$1,900	$1,500	$0	$0	$0	$0	$0	$16,203	$0	$3,400	$0
8.0 Detector & Dewar	$54,471	$13,798	$0	$0	$54,471	$13,798	$0	$0	$68,270	$68,270	$13,798	$13,798
8.7 Dewar	$23,552	$1,900	$57,500	$0	$23,604	$1,900	$44,000	$0	$82,952	$69,504	$59,400	$45,900
9.1 Pre-Dewar Enclosure*	$6,971	$7,650	$133,500	$3,500	$43,949	$20,651	$70,625	$0	$151,621	$135,224	$144,650	$91,276
9.5 Enclosure Cooling System*	$4,880	$15,653	$110,000	$0	$0	$0	$0	$0	$130,533	$0	$125,653	$0
9.6 Enclosure Assembly & Testing	$47,938	$3,459	$32,500	$0	$0	$0	$0	$0	$83,897	$0	$35,959	$0
10.0 Slit Cooling	$10,457	$4,543	$0	$0	$0	$0	$0	$0	$15,000	$0	$4,543	$0
11.5 Skin-Heaters	$14,705	$13,267	$24,000	$0	$0	$0	$0	$0	$51,972	$0	$37,267	$0
11.7 Instrument Electronics Enclosure	$37,103	$22,800	$21,000	$0	$19,363	$41,800	$5,500	$0	$80,903	$66,663	$43,800	$47,300
14.3 IV&T Mechanisms	$97,245	$49,875	$4,500	$0	$74,333	$28,500	$5,500	$0	$151,620	$108,333	$54,375	$34,000
14.2 & 14.4 Dewar & Camera	$84,345	$3,750	$4,500	$0	$84,445	$3,750	$4,500	$0	$92,595	$92,695	$8,250	$8,250
14.6 Instrument Testing	$148,649	$8,426	$10,000	$0	$97,630	$9,334	$4,500	$0	$167,075	$111,464	$18,426	$13,834
16.0 Fiber Feed IFU Cable	$0	$0	$0	$0	$50,424	$0	$145,500	$3,500	$0	$199,424	$0	$149,000
17.0 Fiber Feed Collimator	$0	$0	$0	$0	$77,301	$6,093	$200,350	$3,500	$0	$287,244	$0	$209,943
19.0 Support Structure	$0	$0	$0	$0	$65,996	$7,125	$33,125	$0	$0	$106,246	$0	$40,250
SUM	**$593,354**	**$189,437**	**$420,500**	**$3,500**	**$638,889**	**$196,060**	**$521,100**	**$7,000**	**$1,206,791**	**$1,363,049**	**$613,437**	**$724,160**
Fiber Fed - Baseline					**$45,536**	**$6,622**	**$100,600**	**$3,500**		**$156,258**		**$110,722**
20.0 Commissioning	**$248,715**	**$97,932**	**$69,000**	**$88,445**	**$133,923**	**$74,799**	**$70,000**	**$56,522**	**$504,092**	**$335,244**	**$255,377**	**$201,321**
Fiber Fed - Baseline					**-$114,792**	**-$23,133**	**$1,000**	**-$31,923**		**-$168,848**		**-$54,056**
TOTAL	**$842,069**	**$287,369**	**$489,500**	**$91,945**	**$772,813**	**$270,858**	**$591,100**	**$63,522**	**$1,710,883**	**$1,698,293**	**$868,814**	**$925,480**
Fiber Fed - Baseline					**-$69,256**	**-$16,511**	**$101,600**	**-$28,423**		**-$12,590**		**$56,666**

* Enclosure & cooling sytem combined for fiber fed option

Gray = N/A for that configuration

3. Conclusions

1. On the basis of the costs calculated so far, the RSS-NIR in the spectrometer room is slightly more expensive than placing it on the Tracker at this late stage in the project.
2. On the other hand, if RSS-NIR goes in the spectrometer room the reduced risk, the improved thermal control, and the addition of the IFU respectively add more likely achievable spectroscopic modes, better sensitivity in those modes, and new capabilities. This configuration would hugely reduce technical risk and complexity, commissioning support effort by SALT personnel, and the risk of loss of science time to SALT. The latter also has a large financial consequence in that operations costs would continue to be paid even if the productivity of the telescope was much reduced. If it were halved or cut by 1/3, then R10-15M would be wasted.
3. On the original hand, RSS-NIR on the Tracker is, in principle, a more capable instrument in terms of possible operational modes.

4. Postscript

The un-posed question is: “why should SALT take a major and hitherto uncontemplated role in the commissioning of RSS-NIR?”. This only makes sense if SALT is compensated for this in some way. Exactly how this is to occur is not in the scope of this report.