



University of Wisconsin Department of Astronomy

**SOUTHERN AFRICAN LARGE TELESCOPE
ROBERT STOBIE SPECTROGRAPH
NEAR INFRARED INSTRUMENT**

STATUS REPORT

**SALT BOARD MEETING
JUNE 4-6, 2014**

**PROJECT YEAR 6
JANUARY - MAY 2014**

**PRINCIPAL INVESTIGATOR: MARSHA WOLF
PRINCIPAL INVESTIGATOR: ANDREW SHEINIS
PROJECT MANAGER: MARK MULLIGAN**



EXECUTIVE SUMMARY

Status of Key Tasks (additional information provided in the subsystem sections)

- *Dichroic:* We have safely received the dichroic and conducted a visual inspection of it. Pictures are provided in Figure 5. Infinite Optic has commenced work on a spare dichroic with an improved coating design.
- *Camera Testing:* “First light” has been beamed through the camera. Marsha Wolf and Mike Smith configured lenses L6 and L7 and the clear dewar filter into their respective mounts to properly space them. Jeff Percival has developed software to quantitatively analyze the spots focused on a CCD camera, see Figure 8.
- *Detector:* We have received the potted Teledyne cable and it has passed our room and operating temperature vacuum tests.

Greg Mosby has optimized 9 voltages and currents (and several more parameters) for the RSS-NIR detector system operating at a faster readout speed of 200 kHz. The present settings effectively bring 200 kHz operation performance in line with 100 kHz operation performance. With the current set of optimal parameters, the noise for a single CDS read is 17.5 e⁻ at 200 kHz operation and 18.5 e⁻ at 100 kHz operation. In 200 kHz mode, there are still hints of excess noise in several pixels that could be remedied by further optimization, but we are close to an optimal system. See details in Table 2 and Figure 9.

- *Skin Heaters:* Further testing of the skin heaters has been positive. With the enclosure interior cooled to ~-25°C, the heaters warmed the enclosure surface to ambient in ~10 min and held it there. The details of the test are shown in Figure 10. Further tests will be done with a cooler interior temperature and overnight outdoor testing with clear skies to maximize radiant cooling.
- *Integration & Testing:* Jeff Percival has functioning state machines for the eight mechanisms installed on the instrument assembly and has been exercising the mechanisms. He has discovered some issues with the absolute encoders that he has or is in the process of addressing. We continue to make progress on the punch list for each mechanism. Further details are provided in Section 14.

Budget & Schedule

The NIR financial status is summarized in Table 1. Spending through April 2014 is \$7.930M and we estimate that we will need \$775k to ready the instrument for delivery to South Africa. That sums to \$8.705M. The funding available to ready the instrument is \$8.548M leaving a deficit of \$156k, which is an increase of \$6k since the end of the last quarter and \$27k since the last Board Report. As we have previously detailed, the project continues to need electrical engineering (detector testing and control system implementation), engineering support of the cooling system design, and project management that was not included in an extremely lean budget. This accounts for the majority of the additional funds required. In addition, the project has required parts to be machined by the Physics Shop due to their familiarity with the parts, the complexity, and the backlog of work in the Astronomy machine shop. We are continuing to



closely monitor spending to take advantage of opportunities to save costs without compromising the instrument performance or operational reliability.

The project's critical path continues to be the instrument Dewar development and detector testing as presented in Figure 1, which has been expanded to two pages to improve the readability. Recently, the driving task has been the installation of the Teledyne flex cable into the Dewar flange. The cable was potted and vacuum tested in a lab configuration at operating temperature. The test verified that it did not leak more than a epoxy blank or an aluminum blank. The cable was recently mounted into the instrument Dewar and the preliminary tests have been positive. We are now performing longer term vacuum tests at operating temperatures. The next step will involve installing the bare mux to verify the thermal control of the Dewar and end-to-end electrical functionality before we install the science grade detector. We are continuing to work with the engineering grade detector to familiarize ourselves with which parameters to optimize to improve noise level. Details of the optimization are in the detector section. Table 4, at the end of the document, highlights completed tasks from the last three months and pending tasks. Appendix A has an updated schedule risk table.

Table 1. The table summarizes the financial state of the RSS-NIR. The left column presents the spending-to-date and budget estimate to get ready-to-ship, commission the instrument, add descoped items, and to add the Fabry-Perot mode (which never has been part of the funded scope). On the right, the source and amount of funding contributions are shown with the funds needed to reach development states or to add scope.

RSS-NIR SPENDING AND BUDGET SUMMARY		RSS-NIR FUNDING SUMMARY	
April 2014 (figures in thousands of dollars)		April 2014 (figures in thousands of dollars)	
Spending-to-date	\$7,930	Sources	
Budget to get ready to ship		Wisconsin Alumni Research Foundation	\$3,300
Apr '14 to Ready-to-Ship	\$664	National Science Foundation	\$1,997
Rescoped Items		UW-Astronomy	\$2,157
Dewar Cooling System	\$20	UW-Astronomy	\$1,400
Pre-dewar Enclosure Cooling System	\$90	Washburn Astronomy Laboratories: Ready-to-ship	\$546
Sum	\$775	Washburn Astronomy Laboratories: Commissioning	\$134
Commissioning		Washburn Astronomy Laboratories: De-scope Items	\$54
Estimate cost of commissioning	\$630	Washburn Astronomy Laboratories: F-P Etalon	\$23
Sum	\$630	SALT	\$932
Descoped Items		UW-Space Science & Engineering Center	\$373
Polarizing Beamsplitter	\$138	Sum of Funding to get Ready to Ship	\$8,548
Cooled Slit Hardware	\$54	Total Sum of Funding	\$8,759
Order Blocking Filters (12)	\$261		
Cryogenic Filters (2)	\$56	Funds Needed to be Ready-to-Ship	\$156
Gratings (4)	\$250	Funds needed through Commissioning (cumulative)	\$652
Sum	\$760	Funds needed to add descoped items (cumulative)	\$1,358
Fabry-Perot Etalon		Funds needed to include etalon (cumulative)	\$1,640
Fabry-Perot Etalon with controller	\$305	Balance of \$1.4M UW-Astronomy Funds	\$301
Sum	\$305		

Notes

1. These de-scope items should be installed before the NIR is installed on the telescope. The instrument will function with reduced capability without them, but it will require that the instrument be removed to install them.
2. Estimated figure based on assumed Astronomy support for project activities. The actual figure may be larger or smaller.
3. This figure includes the Dewar and instrument cooling systems as presented at the Nov '12 Board Meeting.
4. The etalon has never been officially added to the scope of work and therefore has not ever been included in previous budget estimates.



Our plan is to have the RSS-NIR ready to ship by mid-2015. This includes 2 months of schedule reserve. Our latest update on the tracker upgrade completion date is late 2015, so the RSS-NIR readiness is consistent with the tracker plan. The RSS-NIR de-scoped items would require about a year to implement into the instrument before delivery. This would be the most efficient path, since some items would require removal of RSS from the telescope to implement at a later time. Appendix B lists the de-scoped items and costs to re-scope them. ***It is time for consortium partners to seriously consider contributing to these items, as well as to RSS-NIR commissioning costs.*** UW will contribute salaries of the Astronomy Department team members through Washburn Astronomical Laboratories, which amounts to \$134k out of the total \$630k.



Figure 1: RSS-NIR Critical Path, chart 1/2, updated April 30, 2014.



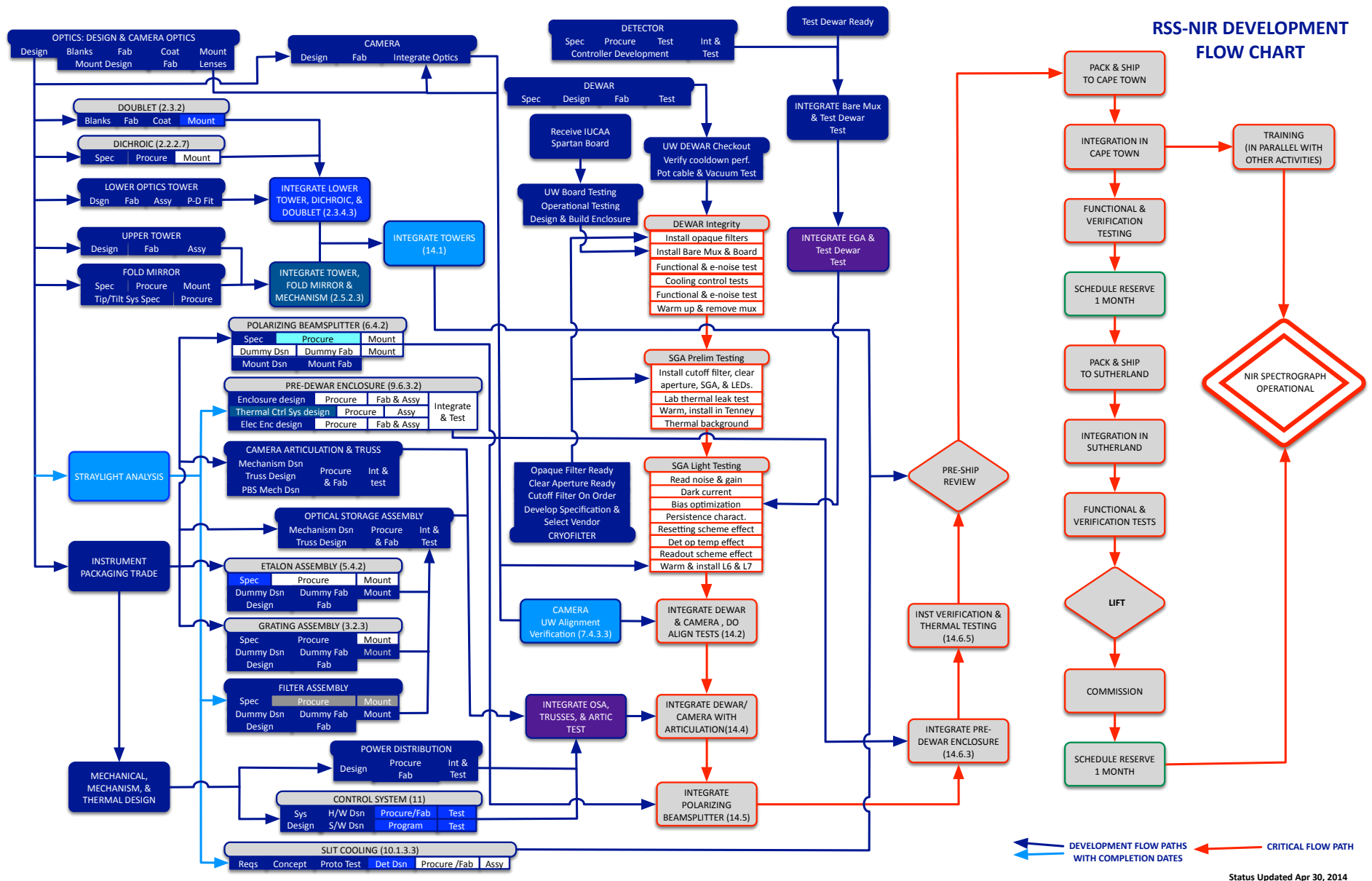
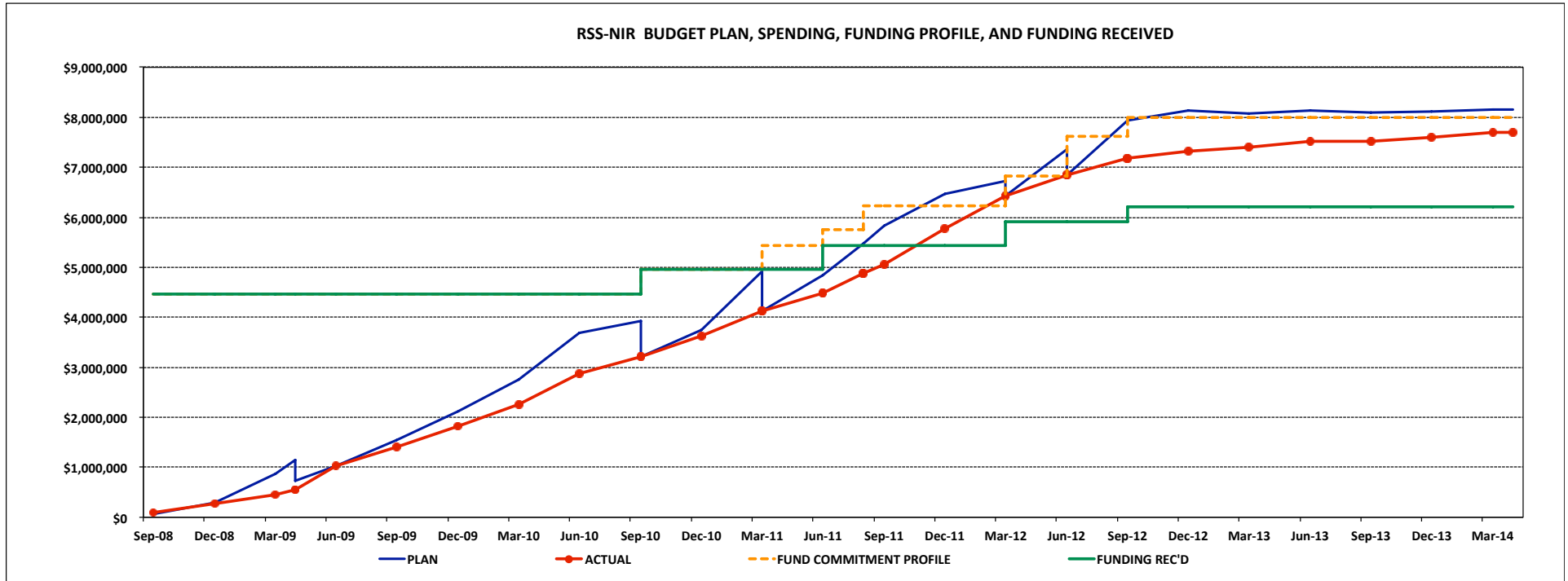


Figure 2. RSS-NIR Development flow chart, updated April 30, 2014.



	PROJECT YEAR 1				PROJECT YEAR 2				PROJECT YEAR 3				PROJECT YEAR 4				PROJECT YEAR 5				PROJECT YEAR 6			
	Sep-08	Dec-08	Mar-09	Jun-09	Sep-09	Dec-09	Mar-10	Jun-10	Sep-10	Dec-10	Mar-11	Jun-11	Sep-11	Dec-11	Mar-12	Jun-12	Sep-12	Dec-12	Mar-13	Jun-13	Sep-13	Dec-13	Mar-14	Apr-14
PLAN	\$64,612	\$285,468	\$865,386	\$1,027,389	\$1,540,144	\$2,117,904	\$2,757,101	\$3,681,877	\$3,208,325	\$3,755,244	\$4,126,283	\$4,839,954	\$5,828,203	\$6,458,862	\$6,733,868	\$7,357,193	\$7,930,342	\$8,137,344	\$8,074,541	\$8,129,564	\$8,100,311	\$8,112,668	\$8,149,474	\$8,158,272
ACTUAL	\$91,360	\$266,537	\$446,216	\$1,030,224	\$1,401,832	\$1,827,211	\$2,268,551	\$2,873,635	\$3,208,325	\$3,622,470	\$4,126,283	\$4,491,212	\$5,067,153	\$5,765,223	\$6,423,320	\$6,855,314	\$7,175,203	\$7,321,634	\$7,399,173	\$7,520,030	\$7,518,774	\$7,594,779	\$7,691,425	\$7,700,715

Figure 3. RSS-NIR financial status since the Preliminary Design Review in July 2008. The adjustments in Sep'10, Mar'11, Mar'12, and Jun '12 are due to re-baselining cost projections. Project accounting is conducted monthly and the cost data updated quarterly. Please note that the cost data presented do not include the contributions made by the staff of the Washburn Observatory. Note: the current quarter is highlighted since it only includes data from one month.

**Risk Summary Table (updates are in blue)**

Risk	Type	Impact Assessment	Mitigation Plan	State
1. <i>Instrument Mass</i> : SALT facility currently cannot accommodate the instrument mass, estimated at 405 kg at MTR.	Technical Schedule	Medium High	The mass estimate remains at 448.1 kg.	Open
2. <i>ADC</i> : Must be corrected to allow simultaneous VIS and NIR observations.	Technical	Medium	Darragh O'Donoghue has been evaluating the effectiveness of the current ADC and options for the telescope looking forward.	Open
3. <i>Instrument Delivery</i> : Target delivery for the commissioned instrument is December 2012.	Schedule Cost	Low Significant	Ready to ship is currently projected as mid-2015.	Open
4. <i>Dichroic Thickness</i> : The dichroic must be sufficiently thick that the coatings do not distort the light beam, but the thickness is limited by the physical space.	Technical	Low	Ken and Marsha have reviewed the data on the dichroic. While it does not perfectly meet the specification, it will be accepted with a slight discount. Infinite Optics will coat the spare substrate and attempt to improve the optical performance. The flatness of the dichroic is acceptable.	Closed
5. <i>Dichroic Cost</i> : JDSU ROM estimate for a dichroic that meets our preliminary spec is \$500k. \$60k was budgeted based on scaling of costs for a dichroic on another instrument.	Cost	Medium	The dichroic final cost is \$98,040, which is well below the \$500k ROM.	Closed
6. <i>Pre-dewar Enclosure Cost</i> : ROM estimates from outside vendors to support the enclosure design and build the enclosure ranged from \$250-600k. The budget provided ~\$100k.	Cost	Medium	Mike Smith has resumed work to complete the detail design of the enclosure, as well as simplifying it for fabrication.	Open
7. <i>Pre-dewar Enclosure cooling system</i> : At CDR, The SALT Ops teams strongly requested that the RSS-NIR team research gas cooling alternatives to the high pressure fluorinert system proposed since PDR.	Schedule Cost	Medium Significant	We have held a meeting with SSEC purchasing and we are working on a detailed cooling system specification to include in the bid documentation.	Open
8. <i>Budget</i> : The project budget is not sufficient to fund the scope of work agreed to at the board meeting in Ireland.	Cost	Significant	An agreement has been reached between Astronomy and Space Science to continue to work on the project while Astronomy continues to identify sources of funds to ready the instrument for shipping.	Open



Status and Issues by Subsystems

1. Project Administration

- *Mass:* There have been no changes to the mass and the mass estimate in the last quarter. It remains at 448.1 kg.

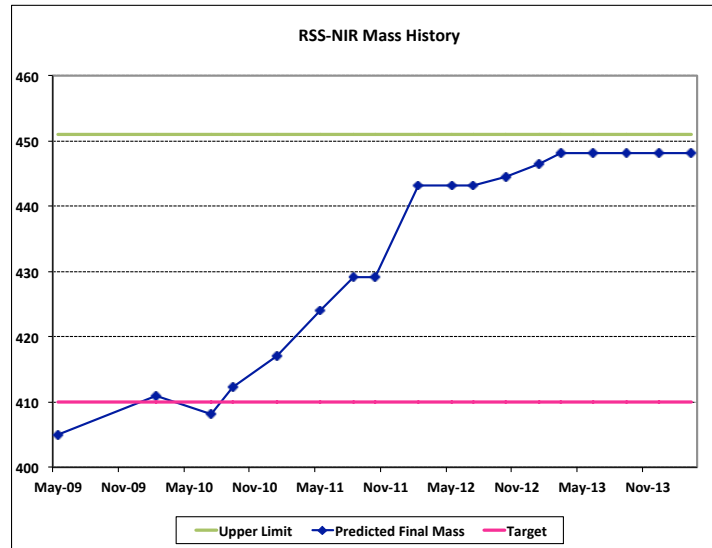


Figure 4. RSS-NIR mass history with the target and upper limit.

- *Interface Control Document:* The ICD has been submitted to Ockert Strydom with an updated cable and piping schedule. All of the schedule data that can be filled in by NIR staff has been. There are some TBDs due to systems that are currently out of scope. There are a number of items that require the knowledge of the SALT facility staff.

2. Optics (doublet, dichroic, and fold mirror)

- *Dichroic:* We safely received the dichroic and conducted a visual inspection. Pictures are shown in Figure 5. While the optical performance (Figure 6) did not exactly meet specifications, it is a usable dichroic.
- *Spare Dichroic:* Infinite Optics is proceeding with coating a spare dichroic with the goals of narrowing the crossover and improving the mean reflectivity at the UV and NIR ends of the bandwidth. Infinite Optics will use a new material, HfO_2 , that the model predicts will make these improvements. If improved, the spare will become the primary dichroic. The spare was coated in 5 stages with a number of layers in each stage. The 5th stage did not behave as predicted by the model. It is the only stage that has the new material. All aspects of the coatings looked better in stages 1-4 based on witness sample measurements taken after each stage. The thickness of the 5th stage looked to be off, so Geza will attempt to correct this in the next trial. Also, stage 4 added a hole in the reflectivity near the crossover, but stage 5 is supposed to fix this. The substrate deformation due to the coating is similar to the first dichroic. They have polished this curvature into the substrate for the next run. These results are very promising. If the 5th stage can be corrected in the next run, the dichroic will be very



near spec in the crossover width and the UV and NIR reflectivities.

3. Grating Assembly

- Ken Nordsieck prepared a summary report analyzing the data from Wasatch and Chris Clemens. He requested that Chris make one additional measurement of the S and P 0-order efficiency with the grating at an angle of 0° (measurement normal to the grating). He would like to determine if there are polarization effects. Kogelnik modeling suggests that there should not be, but he thinks the dichromated gelatin could polarize since it is non-isotropic. Chris has not yet had time to perform this measurement.



Figure 5. *Photos from the visual inspection of the RSS-NIR dichroic after receipt.*

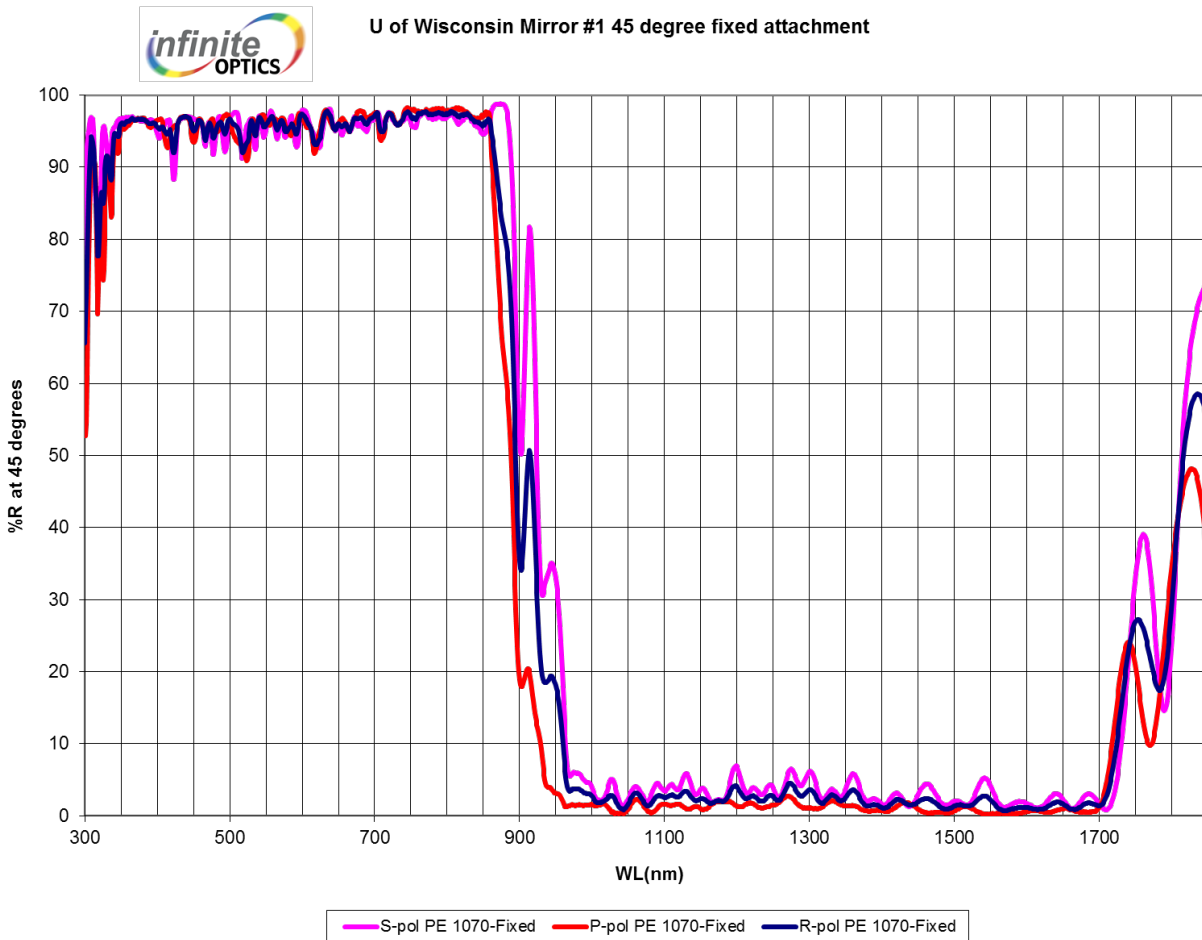


Figure 6. Measured performance of the first dichroic beamsplitter.

4. Fabry-Perot Assembly

- No issues or status update.

5. Polarizing Beamsplitter

- No change in status.

7. Camera Assembly

- **Camera Testing:** “First light” has been beamed through the camera. Marsha Wolf and Mike Smith configured lenses L6 and L7 and the clear dewar filter into their respective mounts. These were mounted into fixtures, some final and some temporary, onto the camera to position them in their instrument configuration spacing. The setup provides a means to conduct end-to-end camera testing, please see **Figure 7**

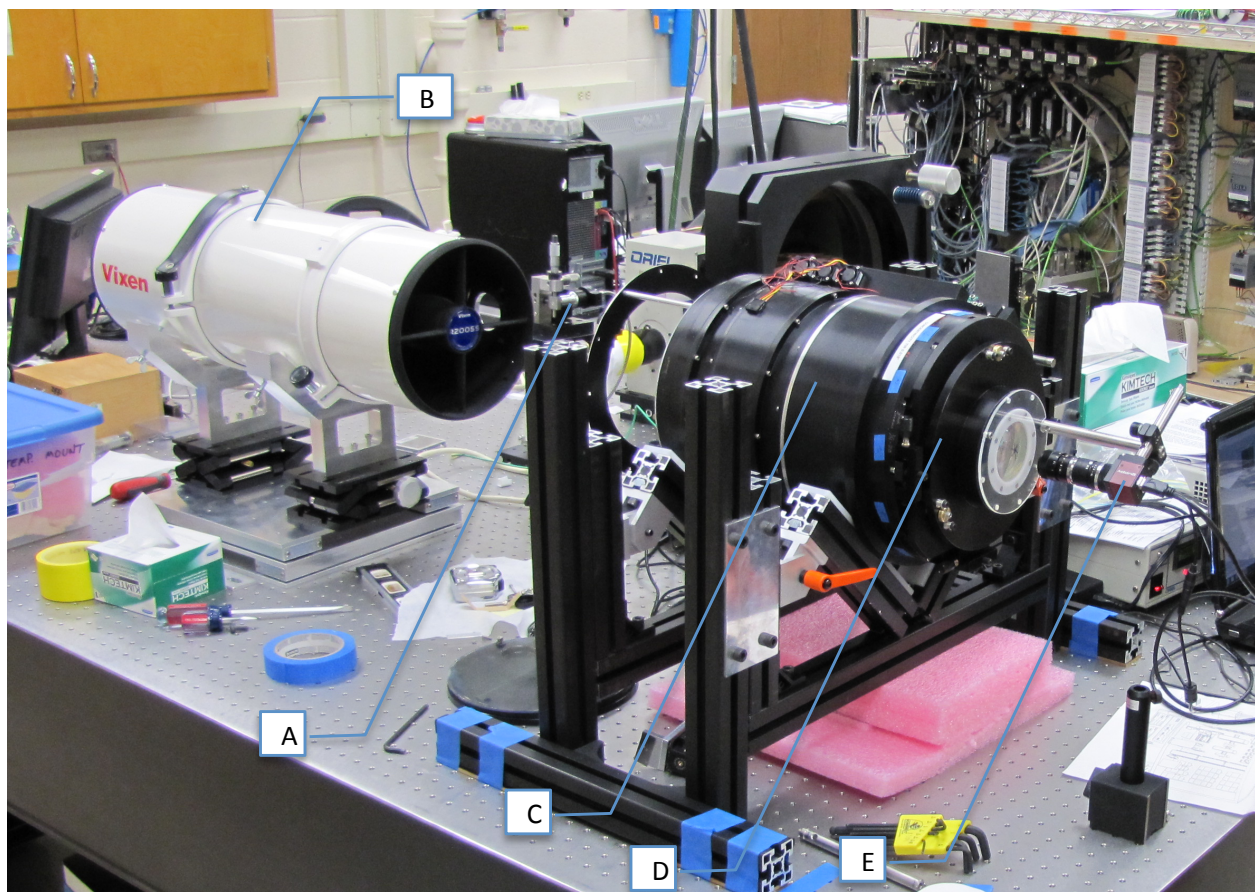


Figure 7. The picture shows the RSS-NIR camera test setup. The components are (A) the light light source, (B) the collimating telescope, (C) RSS-NIR Camera, (D) L6, L7, & clear aperture filter assembly mounted to the RSS-NIR camera, and (E) the CCD camera.

The first test will be a knife-edge test to determine the position of the back focal length. For analysis, Jeff Percival has further developed software that a former student started. The software allows a very quantitative analysis of the spot and provides a png image of it that may be imported into DS9 for further processing. See Figure 8 for a description of the user interface. The RSS-NIR camera focus mechanism is working. Knife-edge testing will begin after optics are configured to appropriately magnify the image of the focused spot onto the CCD camera for analysis.

We have received the NIR camera that will replace the CCD to test image quality through the entire operational wavelength range, and are awaiting lenses for it.

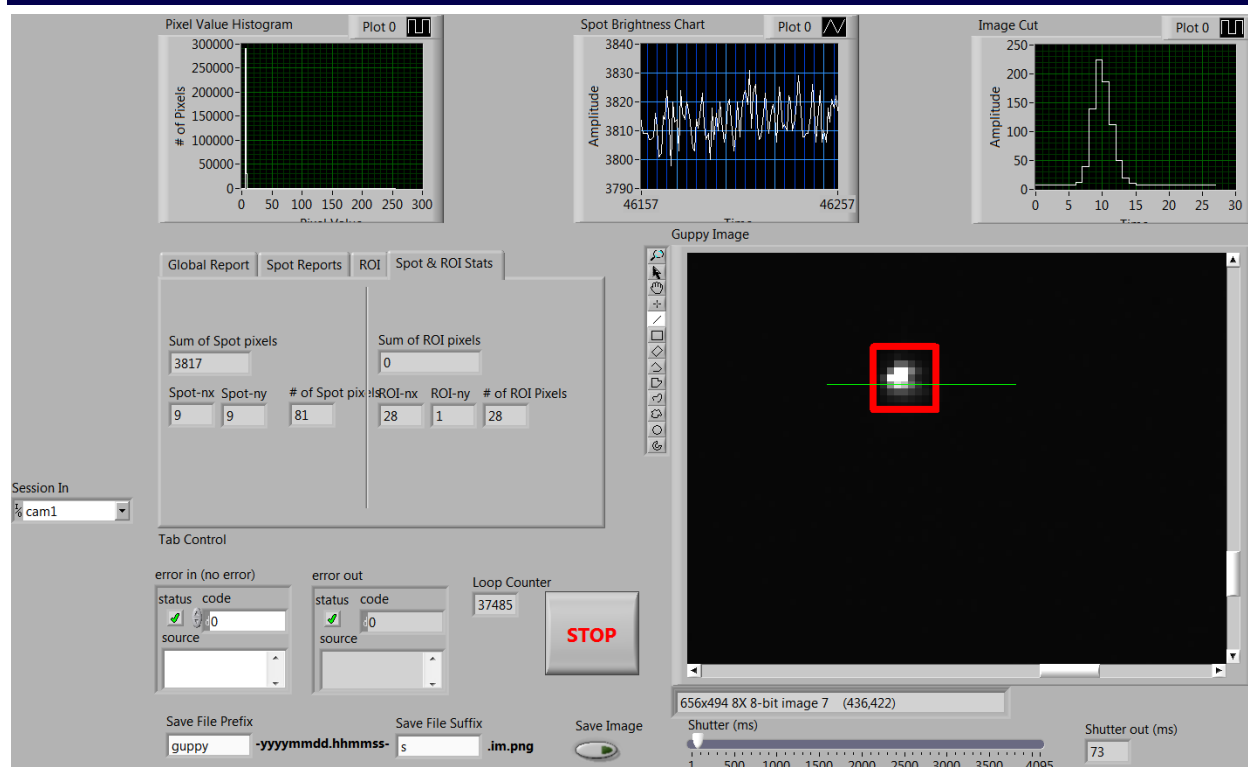


Figure 8. The figure is a screen capture of the RSS-NIR camera testing user interface. The bottom right *Guppy Image* frame presents the image from a CCD camera imaging the focused spot of the NIR camera. The scale beneath the image allows the user to adjust the CCD shutter speed. The intensity of the image along the horizontal line drawn through it is presented in the *Image Cut* frame to the right above the *Guppy Image*. The *Spot Brightness Chart* uses the user selected red box surrounding the spot to display the integrated image brightness over time. The *Pixel Value Histogram* produces a histogram of pixel brightness for the entire Guppy Image frame. We may modify this to be what is inside the red box. The lower left quadrant provides additional data from the image and allows the user to save the image to a .png file.

8. Detector / Dewar Assembly

- *EG Detector, CDS Noise Testing, ASIC optimization:* Marsha Wolf, Don Thielman, and Greg Mosby have had regular videoconferences with Mahesh Burse from IUCAA in the past quarter. IUCAA is currently optimizing a detector system for operation at 150 kHz for a TMT AO instrument, so the collaboration has been fruitful and Mahesh has made several suggestions for improving our detector optimization.

Greg Mosby has developed a script to automate the process of varying detector parameters, collecting sets of images, measuring the noise, and plotting the results. The script allows for multiple parameters to be changed for each test. The program is proving to be a significant time saver for collecting and analyzing the detector data. See an example output plot in **Figure 9**.

We have been able to optimize 9 voltages and currents (and several more parameters) for the RSS-NIR detector system operating at a faster readout speed of 200 kHz. The present settings effectively bring 200 kHz operation performance in line with 100 kHz operation performance. Before optimization at 200 kHz, the read noise (80.3 e-) was more than four times the best read noise previously attained with 100 kHz operation



(19.3 e-) with the same parameter values. To lower the read noise, we systematically tested the system's settings for the SIDECAR ASIC and ADC using newly developed software to automatically run tests over a grid of the SIDECAR's parameters and their values. Using this software, we have not only found optimal values for 9 ASIC and ADC parameters, but we have also found an optimal reset scheme (by LINE) and optimal use of low noise resistor options. With the current set of optimal parameters (given in **Table 2**), the noise for a single CDS read (calculated on individual pixels across multiple images, then averaged over all pixels in the array) is **17.5 e-** at 200 kHz operation and **18.5 e-** at 100 kHz operation. In 200 kHz mode, there are still hints of excess noise in several pixels that could be remedied by further optimization, but we are close to an optimal system.

As part of his next steps, Greg plans to map out the bad pixels on the detector and mask them out of the noise calculations.

Table 2. *Table of the previous and optimized values for several SIDECAR ASIC and ADC voltages and currents.*

Parameter	Previous Value	Optimized Value
IPreampBias	5.4 μ A	7.5 μ A
IPreampCasc	5.3 μ A	7.4 μ A
I_Nbias1	5.0 μ A	10.0 μ A
Filterpole	947 kHz	1895 kHz
I_Nfb1	1.5 μ A	7.5 μ A
I_Nfb2	1.4 μ A	7.4 μ A
Vrp	2100 mV	2100 mV
Vrn	200 mV	0 mV
Vrefmain	930 mV	1017 mV

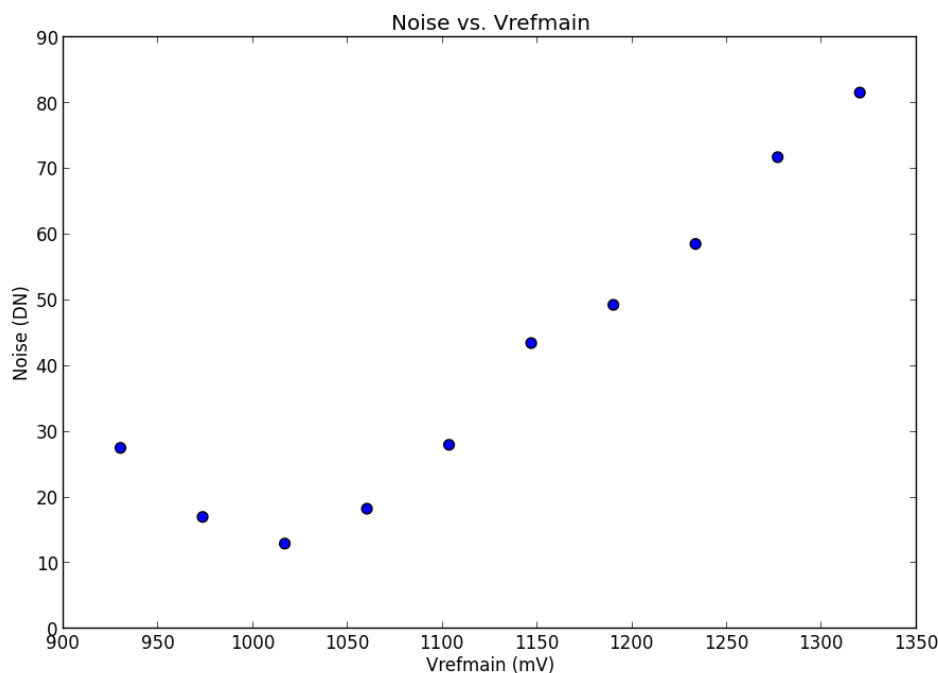


Figure 9. A plot of the estimated read noise in DN after running the new automated software to find the optimal value for the ADC voltage Vrefmain. There's a clear minimum at ~1017 mV.

- **Dewar:** A test plug and potted cable plug were ordered from Pave Technology. We requested the test plug to verify the suitability of the epoxy before approving Pave Technology to pot the cable. Our Dewar was tested with an aluminum plug to set a baseline and then with the Pave plug. Vacuum pressure rate of rise was essentially the same for both (~2.5 mTorr/hr) so Pave Technology was instructed to pot the cable.

We have received the potted cable and started testing it. Its measured pressure rate of rise is about 9-10 mTorr/hr or about 4 times worse than the epoxy or aluminum plugs. Kurt Jaehnig measured the same rate pre and post cold cycling the potted cable, which is encouraging. He observed no degradation in performance. The epoxy plug and potted cable both passed testing at Pave Technology where they were certified as having a leak rate of less than 1×10^{-8} atm-cc/sec.

To swap the epoxy plug and the potted cable, the sealing o-rings are exposed and a system sealing connection must be broken. It is possible that the potted cable is fine, but one of these seals is leaking. To test that theory, we replaced the potted cable with the epoxy and aluminum plugs. The pressure rate of rise remained in the 9-10 mTorr/hr range. This indicates that the leak issue is somewhere else in the system. We believe the potted cable is okay for use. We cannot be certain until we use it in the instrument Dewar and determine if the getters can maintain the vacuum in an operating range over a 16 hour period and the ion pump returns the vacuum to its pre-operational level.

Before installing the cable in the instrument Dewar, Kurt pumped on it for a long



period of time to see if there was any outgassing. He did observe a drop in the vacuum level indicating some outgassing from the cable. All of the materials have low outgassing properties, so we believe this to be trapped water.

The potted cable has been installed in the instrument Dewar and the vacuum level is holding well. We hope to install the bare mux in the next couple of weeks, perhaps by the time of the board meeting.

9. Pre-dewar Enclosure

- *Enclosure cooling system:* We held a meeting for releasing a request for bid for a fully detailed CO₂ cooling system based on our preliminary design from Gartner Refrigeration. Doug Adler is developing a more detail specification based on the Gartner design to define the requirements and constraints of the system. We plan to release a bid document in the next 6-8 weeks.
- *Skin Heater System Design:* We have not conducted further skin heater tests since the update in the February status report, which is reprinted here.

We conducted a test with the skin heater prototype enclosure panel. The prototype panel is used as a lid on an insulated box. Previously, we had filled the box with ice chilled to sub-freezing temperatures (it was left outside overnight in -15°C weather). For this test, the enclosure was filled with dry ice (-78.5°C). This created a temperature differential of 45°C between the lab and the enclosure air measured just inside surface of the prototype panel (the air directly in contact with the backside of the panel). The system was allowed to reach equilibrium before the skin heater system was turned on. Within 10 minutes of turning on the system, the panel temperature was within facility specifications (+/-2°C of ambient). The results are shown Figure 10.

The test was repeated with a fan blowing across the board (left to right, right to left, and bottom to top) on low (1.12-1.79 m/s) and high (1.61-2.68 m/s) speed setting. As expected, the temperature on the panel was more uniform due to the forced convection from the moving air. The wind better coupled the board temperature to the air temperature.

Our plan is to repeat the dry ice tests with a small fan inside the enclosure. This should cool the internal air temperature even further to create a larger gradient between it and the outside. We'll also turn the fans on and off or vary the speed more to simulate wind gusts.

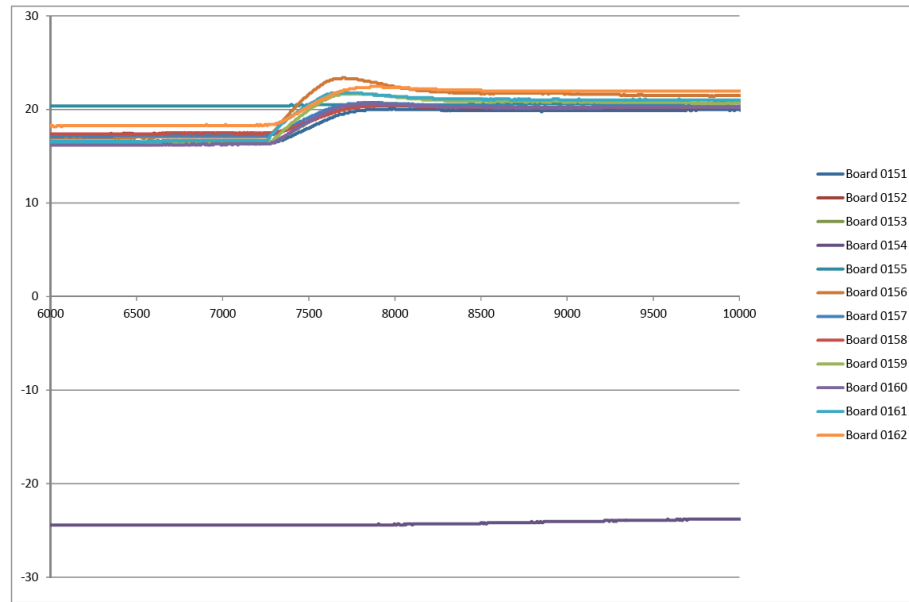


Figure 10. A plot of RSS-NIR prototype enclosure panel skin heater testing is presented. The enclosure was filled with dry ice and allowed to come to equilibrium before the skin heaters were turned on. In the above plot, the vertical axis is °C and the horizontal axis is seconds. Once the heaters were turned on at approximately the 7300 sec (a little over 2 hours), the system reached a new equilibrium about ambient in about 10 min. Sensor 155 is measuring the ambient temperature and sensor 154 is the air temperature just below the inside surface of the prototype panel.

We are also planning an outside overnight test to observe the effects of the cool night sky. We are planning to conduct this on a clear night with an overnight low temperature of 5°C or higher.

- *Enclosure Design:* Mike Smith has resumed working with Jeff Wong to complete the detail design of the enclosure. Jeff worked through the design to ensure that it is up-to-date with any changes that have been discussed or developed but have not been implemented. Mike is now finalizing the detail design and making some simplifications to ease fabrication. Once that is complete Jeff Wong will see it through fabrication with the vendors. It will likely take another month to complete the detail design.

10. RSS Common Optics Environmental Control

- *Slit Cooling Test:* No significant progress.

11. Control System

- *Documentation:* Ron Koch's efforts to update the cable database are ongoing. He has been working with Sam Gabelt to update and review the bill of materials for all of the custom boards. We believe, with a couple of exceptions, we have this data organized.
- *Maintenance Computer:* Paul Sendelbach has added software to communicate with and program the skin heater controllers.
- *Spare Boards:* Sam Gabelt has completed the build of spare boards.



12. Power Distribution

- No issues or status update.

13. Support and Test Equipment

- The machining of the dummy Etalon is complete and it has been installed on the instrument.

14. Integration, Verification and Testing (@ UW)

- *Control System Software:* Jeff's primary focus the last three months has been the development of the state machines. He has created software to read in the real-time data from the mechanisms on the instrument, which has allowed him to establish the state machines for each. The mechanisms currently on the instrument are:
 - Filter inserter
 - Etalon inserter
 - OSA translation
 - Camera articulation
 - Grating inserter
 - Rotation latch
 - Grating rotator
 - Camera articulation lock

In the course of exercising the mechanisms and testing the control software, Jeff observed that absolute encoder readings at the start and end of strokes can be off by 0.1% which is significant enough for the reading to be outside of the acceptable range defining its state. Jeff recalibrated the absolute encoder values at the start and finish stroke positions. This information was compiled in a lookup table and mechanism testing using the values was all positive.

During further tests, Jeff would move an inserter mechanism, read the absolute encoder value, move the rotation latch, and the reread the absolute encoder value again. The pre and post rotation latch movement values did not agree. It seems the moving of metal parts near the encoder is slightly affecting its magnet and thus its reading. We suspect we may be able to simply shield the encoders to address the issue, but that has not been tested. This is an open issue.

Jeff, with support from Mike Smith and Ron Koch, has started working with the camera focus mechanism. It's functionally similar to our other mechanisms as it uses a motor to drive a Tempsonic actuator. The mechanism is equipped with limit switches and hard stops and Mike Smith is having Jeff add software limit switches as well.

Open Punch List Items:

- *OSA Mechanism Readiness*
 - *Light-tight enclosure for the relative encoder:* This is an issue for a number of the mechanisms. Mike Smith has a solution, which requires a machining a new light-tight enclosure for the encoders. He plans to have the part made when the backlog is reduced in the Astronomy Department Machine Shop.
- *Grating & Filter Insertion Mechanism:*
 - *Cable tie-down bracket:* To safely position the cables away from the mechanism, a cable tie-down will be required on the base of the pre-dewar enclosure. We need to simulate that on the test setup until the instrument is installed in the enclosure.



- *Adjust limit switches:* Not yet done.
- *Calibrate the home switch on the absolute encoder:* Not yet done.
- *Light tight enclosure for the relative encoder:* See the OSA mechanism.
- *RFID*
 - *Protect antennas:* We need to implement a scheme to protect the RFID antennas from damage.
- *Grating Rotator*
 - *Motor Initialization:* We need to ensure that the grating rotator motor can be initialized with the instrument in a non-horizontal position.
- *Control System, General*
 - *Connector Tool:* We need to design a tool to safely disconnect the Molex connectors. It is a difficult connector to de-mate manually.



Budget and Spending Detail

Table 3: RSS-NIR planned versus actual spending since the Preliminary Design Review in July 2008. Only the last four years of spending is presented. The adjustments in Sep'10, Mar'11, Mar'12, and Jun '12 are due to re-baselining cost projections. Project accounting is conducted monthly and the cost data updated quarterly.

RSS-NIR SUMMARY	2009	2010				2011				2012				2013				2014				PROJECT TOTAL
	PROJECT YEAR 2			PROJECT YEAR 3				PROJECT YEAR 4				PROJECT YEAR 5				PROJECT YEAR 6						
QUARTERLY SPENDING	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4			
LABOR	\$165,972	\$205,640	\$197,933	\$249,718	\$183,081	\$223,806	\$196,636	\$210,544	\$232,976	\$231,359	\$209,190	\$77,307	\$30,663	\$21,459	\$17,900	(\$3,899)	\$16,147	\$9,377	\$3,295	\$3,192,806		
MATERIAL	\$27,932	\$36,216	\$59,491	\$14,857	\$16,431	\$16,642	\$46,680	\$27,277	\$27,127	\$32,330	\$20,137	\$11,535	(\$2,755)	\$9,742	\$2,850	\$11,734	\$4,422	\$8,402	\$975	\$449,732		
CAPITAL EQUIPMENT	\$166,131	\$85,302	\$228,920	\$4,373	(\$14)	\$19,395	\$23,069	\$140,304	\$144,011	\$111,847	\$33,948	\$6,457	\$3,403	\$0	\$49,878	\$0	\$24,255	\$42,419	\$0	\$1,347,155		
TRAVEL	\$6,882	\$9,300	\$9,830	\$13,344	\$12,257	\$2,454	\$5,210	\$8,407	\$13	\$870	\$6,144	\$6,746	\$0	\$0	\$0	\$0	\$3,243	\$0	\$0	\$112,959		
SUBCONTRACTS	\$47,504	\$93,011	\$87,941	\$59,375	\$161,997	\$97,027	\$71,763	\$124,229	\$121,029	\$110,393	\$156,407	\$92,600	\$46,874	\$25,081	\$25,744	\$45,623	\$14,138	\$19,657	\$2,138	\$1,671,489		
TUITION REMISSION	\$4,325	\$7,376	\$5,333	\$1,778	\$2,667	\$4,889	\$0	\$0	\$889	\$2,889	\$1,778	\$6,408	\$0	\$0	\$0	(\$4,000)	\$0	\$0	\$0	\$42,331		
OVERHEAD	\$6,634	\$4,494	\$15,636	(\$8,753)	\$37,726	\$139,600	\$21,570	\$65,181	\$172,027	\$168,409	\$4,391	\$118,837	\$68,247	\$21,257	\$24,484	(\$50,714)	\$13,800	\$16,789	\$2,883	\$884,243		
QUARTERLY TOTAL	\$425,380	\$441,339	\$605,084	\$334,690	\$414,145	\$503,813	\$364,928	\$575,941	\$698,071	\$658,096	\$431,994	\$319,889	\$146,431	\$77,539	\$120,857	(\$1,256)	\$76,005	\$96,645	\$9,290	\$7,700,715		
QUARTERLY BUDGET																						
LABOR	\$222,423	\$230,217	\$326,558	\$116,405	\$230,177	\$279,723	\$293,234	\$346,776	\$242,188	\$185,906	\$216,498	\$82,664	\$197,888	\$182,180	\$172,018	\$0	\$0	\$0	\$0	\$3,649,949		
MATERIAL	\$4,600	\$43,330	\$142,790	\$12,150	\$47,150	\$78,487	\$28,112	\$86,883	\$41,812	\$18,850	\$70,889	\$5,542	\$7,542	\$24,542	\$21,875	\$0	\$0	\$0	\$0	\$468,320		
CAPITAL EQUIPMENT	\$197,196	\$220,400	\$333,006	\$85,450	\$51,659	\$614,529	\$129,124	\$270,131	\$151,290	\$20,000	\$251,440	\$10,000	\$165,100	\$97,750	\$68,750	\$0	\$0	\$0	\$0	\$1,558,800		
TRAVEL	\$980	\$8,184	\$0	\$0	\$9,254	\$13,606	\$4,350	\$32,282	\$3,397	\$0	\$12,764	\$0	\$31,000	\$1,500	\$1,500	\$0	\$0	\$0	\$0	\$143,715		
SUBCONTRACTS	\$134,585	\$102,918	\$59,048	\$19,933	\$187,385	\$157,335	\$257,051	\$193,980	\$79,050	\$50,250	\$189,918	\$12,500	\$32,500	\$0	\$20,000	\$0	\$0	\$0	\$0	\$1,544,734		
TUITION REMISSION	\$5,340	\$20,340	\$31,560	\$0	\$2,670	\$2,670	\$1,800	\$900	\$2,700	\$0	\$1,600	\$1,000	\$3,000	\$0	\$0	\$0	\$0	\$0	\$0	\$49,331		
OVERHEAD	\$12,635	\$13,808	\$31,815	\$7,505	\$18,624	\$23,915	\$0	\$57,297	\$110,223	\$0	\$190,765	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$787,497		
QUARTERLY TOTAL	\$577,760	\$639,197	\$924,776	\$241,443	\$546,919	\$1,170,266	\$713,670	\$988,249	\$630,659	\$275,006	\$933,873	\$111,706	\$437,029	\$305,972	\$284,143	\$0	\$0	\$0	\$0	\$8,202,347		
NET (BUDGET - SPEND)																						
LABOR	\$56,451	\$24,577	\$128,625	(\$133,313)	\$47,095	\$55,917	\$96,598	\$136,232	\$9,212	(\$45,453)	\$7,308	\$5,358	\$167,225	\$160,721	\$154,118	\$3,899	(\$16,147)	(\$9,377)	(\$3,295)	\$457,143		
MATERIAL	(\$23,332)	\$7,114	\$83,299	(\$2,707)	\$30,719	\$61,845	(\$18,568)	\$59,607	\$14,685	(\$13,480)	\$50,752	(\$5,993)	\$10,297	\$14,799	\$19,025	(\$11,734)	(\$4,422)	(\$8,402)	(\$975)	\$18,588		
CAPITAL EQUIPMENT	\$31,065	\$135,098	\$104,086	\$81,077	\$51,673	\$595,134	\$106,055	\$129,827	\$7,279	(\$91,847)	\$217,492	\$3,543	\$161,697	\$97,750	\$18,872	\$0	(\$24,255)	(\$42,419)	\$0	\$211,645		
TRAVEL	(\$5,902)	(\$1,116)	(\$9,830)	(\$13,344)	(\$3,003)	\$11,152	(\$860)	\$23,875	\$3,384	(\$870)	\$6,620	(\$6,746)	\$31,000	\$1,500	\$1,500	\$0	(\$3,243)	\$0	\$0	\$30,757		
SUBCONTRACTS	\$87,081	\$9,906	(\$28,893)	(\$39,443)	\$25,388	\$60,308	\$185,288	\$69,751	(\$41,979)	(\$60,143)	\$33,511	(\$80,100)	(\$14,374)	(\$25,081)	(\$5,744)	(\$45,623)	(\$14,138)	(\$19,657)	(\$2,138)	(\$126,755)		
TUITION REMISSION	\$1,015	\$12,964	\$26,227	(\$1,778)	\$3	(\$2,219)	\$1,800	\$900	\$1,811	(\$2,889)	(\$178)	(\$5,408)	\$3,000	\$0	\$0	\$4,000	\$0	\$0	\$0	\$7,000		
OVERHEAD	\$6,002	\$9,315	\$16,178	\$16,258	(\$19,101)	(\$115,685)	(\$21,570)	(\$7,884)	(\$61,804)	(\$168,409)	\$186,374	(\$118,837)	(\$68,247)	(\$21,257)	(\$24,484)	\$50,714	(\$13,800)	(\$16,789)	(\$2,883)	(\$96,746)		
QUARTERLY NET	\$152,380	\$197,858	\$319,692	(\$93,248)	\$132,774	\$666,453	\$348,742	\$412,308	(\$67,411)	(\$383,090)	\$501,880	(\$208,183)	\$290,598	\$228,432	\$163,286	\$1,256	(\$76,005)	(\$96,645)	(\$9,290)	\$501,632		



Table 4. RSS-NIR key schedule milestones by WBS.

RSS-NIR KEY MILESTONES						CRITICAL PATH	TASKS COMPLETED IN THE LAST QUARTER
WBS	DESCRIPTION	TARGET DATE	SLACK (WORKDAYS) FREE	TOTAL	MUST HAVE BY DATE	RESPONSIBLE TEAM MEMBER	
1.3.2	Documentation						
1.3.2.2	FPRD	11/28/14			-	Wolf	
1.3.2.5	OCDD	6/4/14			-	Wolf	
1.3.2.4	ICD	5/27/14			-	Mulligan	
1.3.2.6	Verification & Test Plan	6/16/15			-	Wolf	
1.3.2.7	Commissioning Plan	8/22/15			-	Wolf	
2.2	Dichroic						
2.2.1.6	Receive Spare Dichroic	7/22/14	22	55		Nordsieck	
2.2.2.7	Dichroic Mounted in holder	6/27/14	23	23	7/29/14	Smith	
2.3	Doublet						
2.3.2.9	Doublet lens mounted in holder, delivered to UW	4/21/14	0	0	4/21/14	Smith	
2.2.4	Lower Tower						
2.3.4	Assemble dichroic, doublet, & lower tower	6/18/14	0	0	6/18/14	Smith	
2.4.4	Upper Tower						
2.5.2.2	Assemble fold mirror & mechanism, pupil baffle, grating rotation stage mechanism and upper tower	4/14/14	113	113	9/19/14	Smith	
3.1	Gratings						
3.2.1.6.1	Grating mounted in holder	7/14/14	101	101	12/2/14	Smith	
6.2	Polarizing Beamsplitter Mechanism						
6.2.8	Dummy Polarizing Beamsplitter assembled in housing	8/18/14	91	91	12/23/14	Smith	
7	Camera						
7.4.3.3	Camera alignment testing at UW	6/13/14	92	92	10/19/14	Wolf	
8.3	Bare Mux Testing						
8.3.11.1	Opaque filter installed in filter wheel	6/2/14	0	0	6/2/14	Wolf	
8.3.11.2	Install bare mux and sparten board	6/4/14	0	0	6/4/14	Wolf	
8.3.11.3	Room Temperature functional test	6/9/14	0	0	6/9/14	Wolf	
8.3.11.4	FFT testing complete at room temperature	6/12/14	0	0	6/12/14	Wolf	
8.3.11.5	Dewar cooldown and temperature stability verified	6/19/14	0	0	6/19/14	Wolf	
8.3.11.6	Cold temperature functional test	6/23/14	0	0	6/23/14	Wolf	
8.3.11.7	FFT testing complete at cold temperature	6/26/14	0	0	6/26/14	Wolf	
8.3.11.8	Warm Dewar	6/27/14	0	0	6/27/14	Wolf	
8.3.11.9	Bare mux removed	6/30/14	0	0	6/30/14	Wolf	
8.4	Engineering Grade Array						
8.4.9	Test Dewar: Cold temperature testing of engineering grade array complete	5/21/14	28	28	6/29/14	Wolf	
8.5	Science Grade Array						
8.5.2.1	Cutoff and Clear Aperture installed in filter wheel	7/2/14	0	0	7/2/14	Wolf	
8.5.2.2	LEDs installed in Dewar	7/3/14	0	0	7/3/14	Wolf	
8.5.2.6	SGA integrated in Dewar. Thermal light leak testing complete @ room temp	7/28/14	0	0	7/28/14	Wolf	
8.5.2.8	Dewar installed in Tenney Chamber and the chamber is cooled down	8/7/14	0	0	8/7/14	Wolf	
8.5.2.9	Thermal background characterized at cold temperature	8/15/14	0	0	8/15/14	Wolf	
8.5.3	SGA Dark Dewar characterization complete (bias opt., read noise, dark current)	9/15/14	0	0	9/15/14	Wolf	
8.5.4.4	SGA Persistence Characterization and Testing Complete	10/13/14	0	0	10/13/14	Wolf/Smith	
8.5.4.6	Dewar configured with L6 & L7	10/21/14	0	0	10/21/14	Wolf/Smith	
8.5.5	Data reduction software complete	10/13/14	41	41	12/9/14	Babler	
8.7	Dewar						
8.7.11.7	Pot 15-inch cable in flange	4/30/14	-	-		Smith/Jeahnig	
9.1	Pre-dewar Enclosure						
9.1.1.5	Pre-dewar enclosure detail design complete	5/23/14	0	24	6/25/14	Wong	
9.1.1.6	Order remaining enclosure material	6/16/14	0	1	6/17/14	Wong/Mulligan	
9.1.1.7	Prep material for machining vendor	7/11/14	0	1	7/12/14	Smith/Wong	
9.1.1.8	Award pre-dewar enclosure machining and skin layup RFP	6/13/14	23	24	7/16/14	Wong	
9.1.1.12	Machining Complete, delivered to skin layup Vendor	8/25/14	0	1	8/26/14	Wong	
9.1.1.16	Layup complete, enclosure delivered to UW	10/27/14	0	1	10/28/14	Wong	
9.6.2.1	Inspect and surface treat enclosure	11/10/14	0	1	11/11/14	Smith	
9.6.2.2	Skin heaters installed	11/24/14	0	1	11/25/14	Werner	
9.6.3.2	Enclosure functionally tested (TBD)	12/29/14	1	1	12/30/14	Smith	
9.5	Pre-Dewar & Electronic Enclosures Cooling System Design						
9.5.2.2	Place order for components	7/11/14	0	27	8/17/14	Adler/Smith	
9.5.2.3	Receive components	10/31/14	26	27	12/7/14	Adler/Smith	



Table 4 (continued). RSS-NIR key schedule milestones by WBS.

RSS-NIR KEY MILESTONES					CRITICAL PATH	TASKS COMPLETED IN THE LAST QUARTER
WBS	DESCRIPTION	TARGET DATE	SLACK (WORKDAYS) FREE	TOTAL	MUST HAVE BY DATE	RESPONSIBLE TEAM MEMBER
10	Slit Cooling					
10.1.2.1	Detail design complete (shop ready drawings & all components specified)	8/11/14	0	478	-	Smith
11	Control System					
11.4.4	Detailed design of cables complete	7/14/14	59	59	10/4/14	Koch
11.3	RFID system assembled and tested	5/19/14	139	139	11/29/14	Koch
11.4.5	Wire Harnesses and cables					
11.4.5.6	PBS mechanism (power, hall)	9/12/14	72	72	12/21/14	Koch
11.4.5.11	Pre-dewar enclosure cooling system wire harness	8/8/14	40	87	12/7/14	Koch
11.4.5.12	Pre-dewar skin heater wire harness	7/21/14	0	61	10/14/14	Koch
11.4.5.13	Airlock cooling system/interlocks	7/28/14	59	96	12/9/14	Koch
11.4.5.15	Housekeeping wire harness	7/14/14	79	79	11/1/14	Koch
11.5	Thermal control systems					
11.5.3	Pre-dewar enclosure skin heater system ready to be installed on the enclosure	8/29/14	52	52	11/9/14	Werner
11.5.4	Airlock control system ready to be configured to support enclosure thermal testing	10/17/14	37	37	12/7/14	Koch
11.5.5	Pre-dewar enclosure thermal control system configured to support enclosure thermal testing	10/3/14	47	47	12/7/14	Koch
11.5.6	Electronics enclosure thermal control system ready to cool enclosure	10/15/14	213	213	8/9/15	Koch
11.7	Electronics Enclosure					
11.7.3	Detail design complete (enclosure and panel layout)	5/9/14	0	144	11/26/14	Koch/Smith
11.7.6	Enclosure Ready	7/25/14	181	181	4/4/15	Smith
11.7.7	Panel built up	4/6/15	0	0	4/6/15	Koch
11.7.8	Enclosure, with cooling system, assembled	5/4/15	0	0	5/4/15	Koch
11.8	Additional PC Boards (includes mounting bracket fabrication if required)					
11.8.8	One-wire: Airlock Bulkhead & Exchange Filter Boards	12/8/14	0	1	12/9/14	Koch
11.9.3	Real-time instrument control software (cRIO)					
11.9.3.1	Fold Mirror Tip/Tilt & Nodding	6/27/14	84	84	10/22/14	Percival
11.9.3.7	Polarizing beamsplitter insertion and removal	7/21/14	111	111	12/23/14	Percival
11.9.3.8	Camera focus	7/14/14	81	81	11/4/14	Percival
11.9.3.12	Airlock door lock	9/29/14	92	92	2/4/15	Percival
11.9.3.13	Dewar thermal control system	5/23/14	32	32	7/6/14	Percival
11.9.3.14	Pre-dewar thermal control system	9/22/14	56	56	12/9/14	Percival
11.9.3.15	Airlock thermal control system	10/13/14	41	41	12/9/14	Percival
11.9.3.16	Skin heater control system	6/3/14	95	95	10/14/14	Percival
13	Support Equipment					
13.3.2.6	Dummy polarizing beamsplitter fabricated	8/4/14	0	91	12/9/14	Smith
14	Integration, Verification, & Testing at UW					
14.1	Towers					
14.1.1	Commence integration of the upper and lower towers	9/19/14	0	0	9/19/14	Smith
14.1.3	Upper and lower towers integrated and tested. Ready to ship	11/13/14	0	0	11/13/14	Wolf
14.2	Detector/Dewar/Camera					
14.2.1	Commence integration of the Detector/Dewar with the Camera	10/22/14	0	0	10/22/14	Smith
14.2.3	Detector/Dewar/Camera integration and testing complete	12/2/14	0	0	12/2/14	Wolf
14.3	Trusses and Mechanisms					
14.3.3	Electronic integration and testing complete	8/15/14	15	15	9/5/14	Koch
14.3.4	Alignment and functional testing complete	9/5/14	0	0	9/5/14	Smith/Koch
14.3.5	Verification and endurance testing complete - Room Temperature	10/31/14	0	0	10/31/14	Smith/Koch
14.4	Dewar/Camera & Articulation Mechanism					
14.4.1	Completed integration of the Dewar/Camera into the articulation truss	12/3/14	0	0	12/3/14	Smith
14.4.2	Functional testing complete	12/16/14	0	0	12/16/14	Wolf / Smith
14.4.3	Detector / Grating testing	12/23/14	0	0	12/23/14	Wolf / Smith
14.5	Polarizing Beamsplitter Mechanism					
14.5.1	PBS integrated and tested	12/30/14	0	0	12/30/14	Smith
14.5	Pre-Dewar Enclosure Integration					
14.6.1	Integrate enclosure, air-lock door, and baffling	1/20/15	0	0	1/20/15	Smith
14.6.2	Functional test mechanisms complete	1/27/15	0	0	1/27/15	Smith
14.6.3	Integrate pre-dewar cover complete	1/30/15	0	0	1/30/15	Smith
14.6.4	Configure cooling system complete	2/4/15	0	0	2/4/15	Smith
14.6.5	Verify functionality of the cooling system	2/9/15	0	0	2/9/15	Smith
14.6.6	Cold endurance testing	2/23/15	0	0	2/23/15	Smith
14.6.7	Cold operational testing	3/9/15	0	0	3/9/15	Smith



APPENDIX A.

Table A1. RSS-NIR Schedule Risk Assessment (see next page for explanation)

SUBSYSTEM	RESPONSIBLE ORG.	SCHEDULED COMPLETE	CURRENT SCHEDULE	ISSUES/CONCERNS/DETAILS	R _p	R _s	Score	Risk	ESTIMATED SCHEDULE SLIP
1. Pre-Dewar Enclosure	UW, Gartner Refrigeration, Paradigm Design, and TBD vendors	May 27, 2013	Dec 29, 2014	1. Need to find a vendor to complete detail design. 2. Completing the detail design. 3. Lead-times to machine the structure and apply the skin. 4. Installation of skin heaters may be tedious and slow. 5. Relies heavily on Mike Smith.	5.2	8.0	41.5	MAJOR	Possibly as much as 3-4 months late.
2. Skin Heaters	UW	Mar 23, 2013	Aug 29, 2014	1. Testing and verification of the skin heaters may be time consuming.	3.8	3.2	12.2	MINOR	3-4 weeks, but no effect on the overall schedule.
3. Slit Cooling	UW	Feb 11, 2013	Aug 11, 2014	1. Installation on the telescope is the primary concern.	1	1	1	MINOR	-
4. Electronics Enclosure	UW and TBD Vendor	Aug 31, 2013	Jul 25, 2014	1. Fitting all of the electronics into the enclosure in a servicable manner.	2.9	9.3	26.6	MODERATE	- Enclosure could be up to a month late, but that would not delay the schedule. - The electrical migration could take an extra 2 weeks, but that seems unlikely. That would slip the ship readiness of the instrument.
5A. Control System - Hardware	UW	Apr 10, 2013	May 19, 2014	1. Just need to address some minor issues with the RFID system. 2. Continue to follow up on control system issues as they arise.	1.0	1.0	1.0	MINOR	1-2 weeks, but these tasks are well off the critical path.
5B. Control System - Software	UW	Jun 30, 2013	Dec 31, 2014	1. The software development itself should be straightforward. No significant design concerns. 2. Development is all done my Jeff Percival at ~half-time. May slip some if troubleshooting becomes extensive. 3. Cold burn in tests will likely result in some mechanical troubleshooting. Schedule is very success orientated.	5.4	3.9	20.8	MODERATE	4-6 weeks. Many tasks may slip with no impact on the schedule. The concern is the functional state system and the burn-in tests.
6. Mechanical Assemblies (Doublet)	UW, Physics Machine Shop, & The Pilot Group	Nov 30, 2012	Apr 21, 2014	1. Amount of time required by The Pilot Group to mount the lenses	6.0	1.0	6.0	MINOR	2 months to allow more time for the doublet to be mounted. Would still not impact schedule.
7. Camera	The Pilot Group & UW	Jan 4, 2013	Jun 16, 2014	1. While the schedule is comfortable for the UW test of the camera, this was a task that Andy was to lead. Marsha and Mike have experience, but have not been the lead for camera testing. 2. Marsha and Mike have many project responsibilities.	5.0	5.0	25.0	MODERATE	4- 6 weeks. Testing at Pilot Group is currently slow and we may need a little more time for interferometer tests at UW.
8. Dichroic	Infinite Optics & UW	Jan 18, 2013	Jul 21, 2014	1. Infinite Optics has consistently made very slow progress.	6.0	3.0	18.0	MODERATE	1 month - would not impact overall schedule
9. Grating	UW	Dec 21, 2012	Jul 14, 2014	1. Grating received. UW needs to mount the grating.	2.0	1.0	2.0	MINOR	1 month. Unlikely to effect schedule.
10. Cryofilter	UW & TBD Vendor	Jan 11, 2013	Jul 2, 2014	1. No significant issues. Simply need to mount the filters at the appropriate opportunity.	1.0	12.0	12.0	MINOR	4-5 weeks. This would have a direct impact on the overall schedule.
11. Dewar	UW	Nov 16, 2012	Jun 30, 2014	1. Conducting the light leak testing may be time consuming due to cooling-testing-warming-modifying-cooling-retesting cycles.	4.8	12.0	57.0	MAJOR	4-6 months
12. Detector	UW	Mar 12, 2013	Oct 21, 2014	1. The learning curve on the detector has been very challenging and issues seem to come up frequently. 2. Schedule is likely optimistic.	5.3	11.8	62.0	MAJOR	2 months. We are very likely to run into issues with the detector.
13. Integration & Instrument Testing	UW	Aug 5, 2013	Mar 9, 2015	1. Final testing always takes longer than you plan. 2. Expected unknown problems.	5.1	12.0	60.8	MAJOR	2-3 months

The schedule was reviewed to assess the level of risk associated with each subsystem being completed on time and its risk to delaying the overall schedule. The table presents the scheduled completion date and a list of issues, concerns or additional information for each subsystem. The tasks (not shown) for each subsystem were scored for the probability it will be



late (Risk Probability, R_p) and its risk to the overall schedule (R_s). A weighted average of the task scores were multiplied together to arrive at an overall risk score that were scaled to assign a minor, moderate, or major level of risk to the subsystem.

The two risk factors balance one another. For example, a subsystem may have a high probability of slipping, but is not a risk to the overall schedule (9. Grating), or it may be unlikely to slip, but if it does it will delay the schedule (4. Electronics Enclosure - migration of the electronics). The tasks were weighted 1, 2, or 3 to keep the subsystem score from being skewed by a series of simple tasks which diluted the risk associated with one significantly difficult task.

The last column presents an estimated schedule slip assessment. This is an educated guess at an amount of time, if added to the schedule would, presumably, reduce the schedule risk to zero. Under ideal circumstances (infinite amount of time and money) the project would add this time to the schedule to increase the probability of meeting the ship readiness date to 100%.

PROBABILITY TO DELAY, R_p

1	Negligible	5 of 5 are true: Task is understood, experienced staff, resources available, resources under project control, schedule is good
2	Remote	4 of 5 are true: Task is understood, experienced staff, resources available, resources under project control, schedule is good
3	Possible	3 of 5 are true: Task is understood, experienced staff, resources available, resources under project control, schedule is good
4	Likely	2 of 5 are true: Task is understood, experienced staff, resources available, resources under project control, schedule is good
5	Very Likely	1 of 5 are true: Task is understood, experienced staff, resources available, resources under project control, schedule is good
6	Extremely Likely	0 of 5 are true: Task is understood, experienced staff, resources available, resources under project control, schedule is good

SCHEDULE IMPACT, R_s

1	Remote	Has less than 10 weeks slack before the tasks becomes the critical path
2	Possible	Has less than 8 weeks slack before the tasks becomes the critical path
3	Likely	Has less than 6 weeks slack before the tasks becomes the critical path
5	Very Likely	Has less than 4 weeks slack before the tasks becomes the critical path
8	Sub-critical	Has less than 2 week slack before the tasks becomes the critical path
12	Critical	Task is on the critical path and any delay will delay the schedule

SCHEDULE RISK ASSESSMENT

≤ 12	MINOR	Unlikely to be a schedule risk
13 - 35	MODERATE	May end up impacting schedule
≥ 36	MAJOR	Very likely to impact schedule and should be monitored closely.



APPENDIX B.

RSS-NIR Capabilities and De-Scoped Options

This appendix serves as a reminder of the capabilities of RSS-NIR at different levels of re-scope. Our hope is that this will make it clearer for SALT partners to consider how additional funding contributions would increase the capabilities of the instrument.

B1. As delivered with current budget

Although the envisioned RSS-NIR would provide all the operating modes of RSS-VIS, the delivered RSS-NIR will be a de-scoped version of its original concept, due to the current level of funding. The delivered RSS-NIR will be an articulated imaging spectrograph with one volume phase holographic grating that operates over 0.9 – 1.55 microns for faint sky-limited objects and 0.9 – 1.7 microns for bright objects. None of the other instrument modes have been precluded by the RSS-NIR design. All mechanisms are in place to support the full suite of gratings for spectroscopy, filters for broadband imaging, Fabry-Perot tunable narrow band imaging, and polarimetry in imaging and spectroscopy modes.

Spectroscopy will initially be limited by the single grating. The predicted performance of the full grating suite is shown in Figure B1. Initially, only the 950 l/mm grating will be installed. It will allow spectroscopy over the full range of 0.9 – 1.7 microns with spectral resolution that varies with wavelength from $R \sim 3000$ at 0.9 microns to $R \sim 7000$ at 1.7 microns for a 1 arcsec slit.

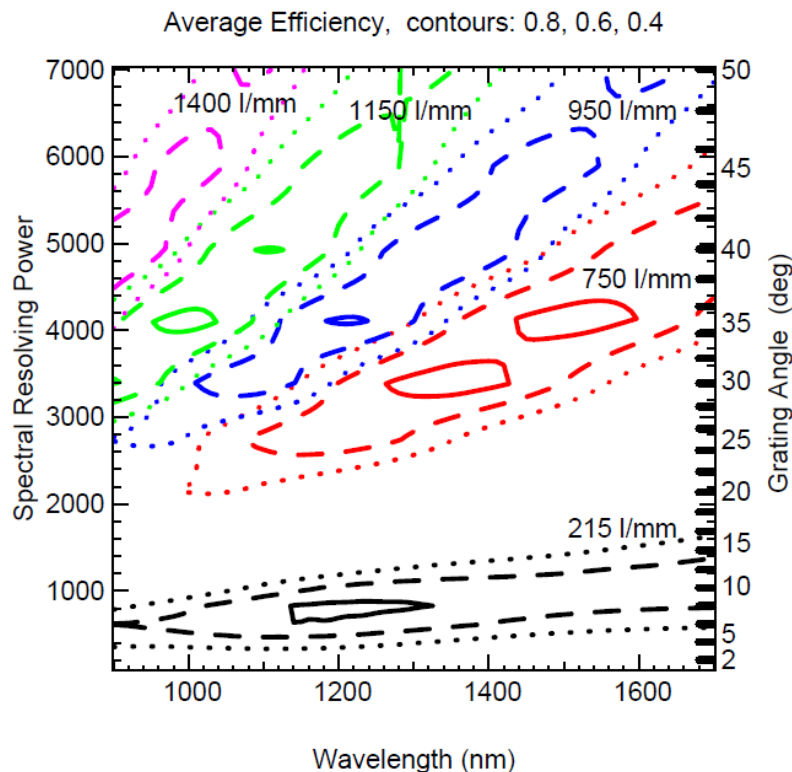


Figure B1. Predicted performance of the full RSS-NIR grating suite. The spectral resolving power is for a 1 arcsec slit. Initially, only the 950 l/mm grating will be installed.



No slit cooling will be provided, so the resulting instrument thermal background of an ambient temperature slit limits the longest observed wavelength for faint sky-limited objects to 1.55 microns. This will be achieved with a selectable cryogenic long wavelength cutoff filter in the dewar filter wheel. A clear filter will also be provided to allow observations out to 1.73 microns, the detector cutoff, for bright objects.

RSS-NIR can also be used for imaging, but no broadband or narrowband filters will initially be provided.

B2. De-scoped items

Table B1. *De-scoped items and their estimated costs. The cost estimates include the associated labor to develop specifications, review specifications with vendors, produce purchasing documentation, and, ultimately, the integration and testing. The component prices have been based on actual orders on hold, similar purchases, or discussions with vendors. Please note the descoped grating cost assumes a fused silica substrate. The low OH infrasil adds about \$20k/grating or \$80k.*

De-Scoped Item	Cost (thousands of US dollars)
Gratings (4)	\$170
Cooled slit hardware	\$54
Cryogenic long wavelength cutoff filters (2)	\$56
Broadband filters (3)	\$66
Fabry-Perot order blocking filters (9)	\$196
Fabry-Perot etalon system	\$305
Polarizing beamsplitter	\$138

B3. Full grating suite

The additional 4 gratings in Figure B1 would provide the full range of spectral resolution at each wavelength. However, the long wavelength limitation of 1.55 microns would still apply to faint sky-limited observations without slit cooling.

These gratings could be added with RSS-NIR on the telescope. The instrument would have to be warmed and the pre-dewar enclosure top would have to be removed.

B4. Slit cooling and cryogenic long wavelength cutoff filters

Wavelengths of the long wavelength cutoff filters will be 1.55, 1.6, 1.67, and 1.73 microns (the latter is a clear filter that relies on the detector cutoff). Using past SALT temperature statistics, we predict that slit cooling to 20 °C below the ambient temperature would allow faint sky-limited observations out to 1.67 microns at R = 4000 for 85% of the time and at R = 7000 for 70% of the time. Predicted performance at other cutoff wavelengths are given in Figure B2.

The addition of slit cooling would require removal of RSS-NIR from the telescope.

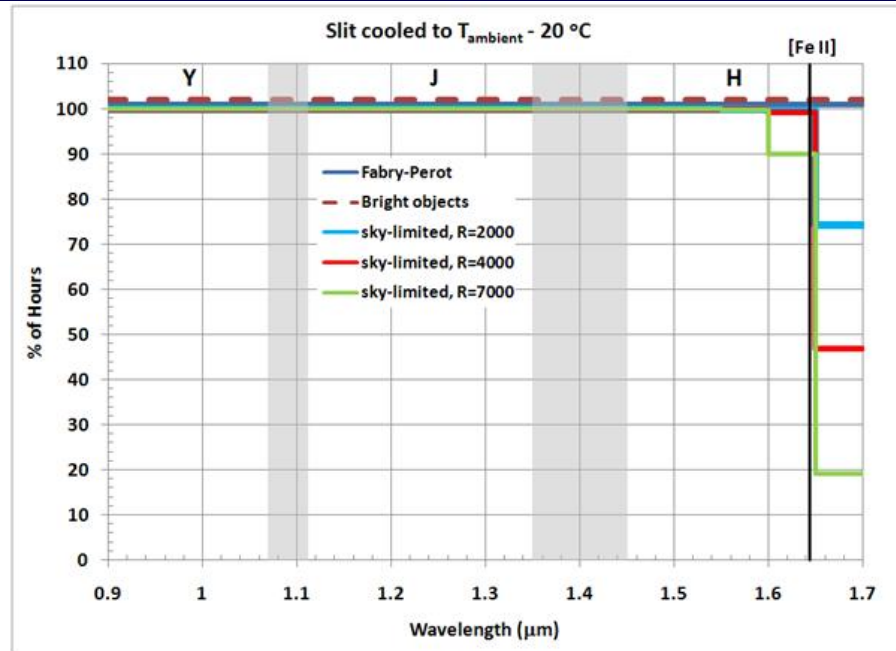


Figure B2. Based on past SALT temperature statistics, this shows the predicted percentage of dark hours per year during which observations with a cooled slit would be possible at different cutoff wavelengths. The analysis was only done at discrete wavelengths, so the step function values refer to the longer wavelengths. For example, at $R = 7000$ sky-limited observations out to 1.7 microns would only be possible 20% of the time (during winter nights when the slit is coolest). At 1.65 microns this jumps up to 90% of the time. The longest cutoff wavelength filter at 1.67 microns was chosen by extrapolating between 1.65 and 1.7 microns.

B5. Broadband imaging

We plan to utilize the Mauna Kea set of Y, J, and H filters. Note that H will be an H_{short} filter, defined by the detector cutoff of 1.73 microns.

These filters could be added with RSS-NIR on the telescope. The instrument would have to be warmed and the pre-dewar enclosure top would have to be removed.

B6. Fabry-Perot tunable narrowband imaging

The addition of the Fabry-Perot mode would require both the etalon system (includes controller) and the set of order blocking filters. The Fabry-Perot system for RSS-NIR will consist of a single etalon operating at $R \sim 2500$. A series of narrow order blocking filters will be designed to operate with the etalon in specific atmospheric windows between bright OH emission lines in the night sky. Approximately 20 such windows have been identified (Figure B3). However, only 9 filters (the number that would fit in the instrument at once, along with 3 broadband filters) were included in the original RSS-NIR budget and subsequently de-scoped. A filter exchange airlock is part of the baseline instrument. If more than 9 filters are procured, this mechanism would allow the exchange of 3 filters during the day. This mechanism will be checked out as part of the overall integration and testing in Madison.

As long as the cabling (not currently in the budget) for the Fabry-Perot system is installed before RSS-NIR is initially put on the telescope, the etalon and filters could be added with RSS-NIR on the telescope. The instrument would have to be warmed and the pre-dewar enclosure top would have to be removed.

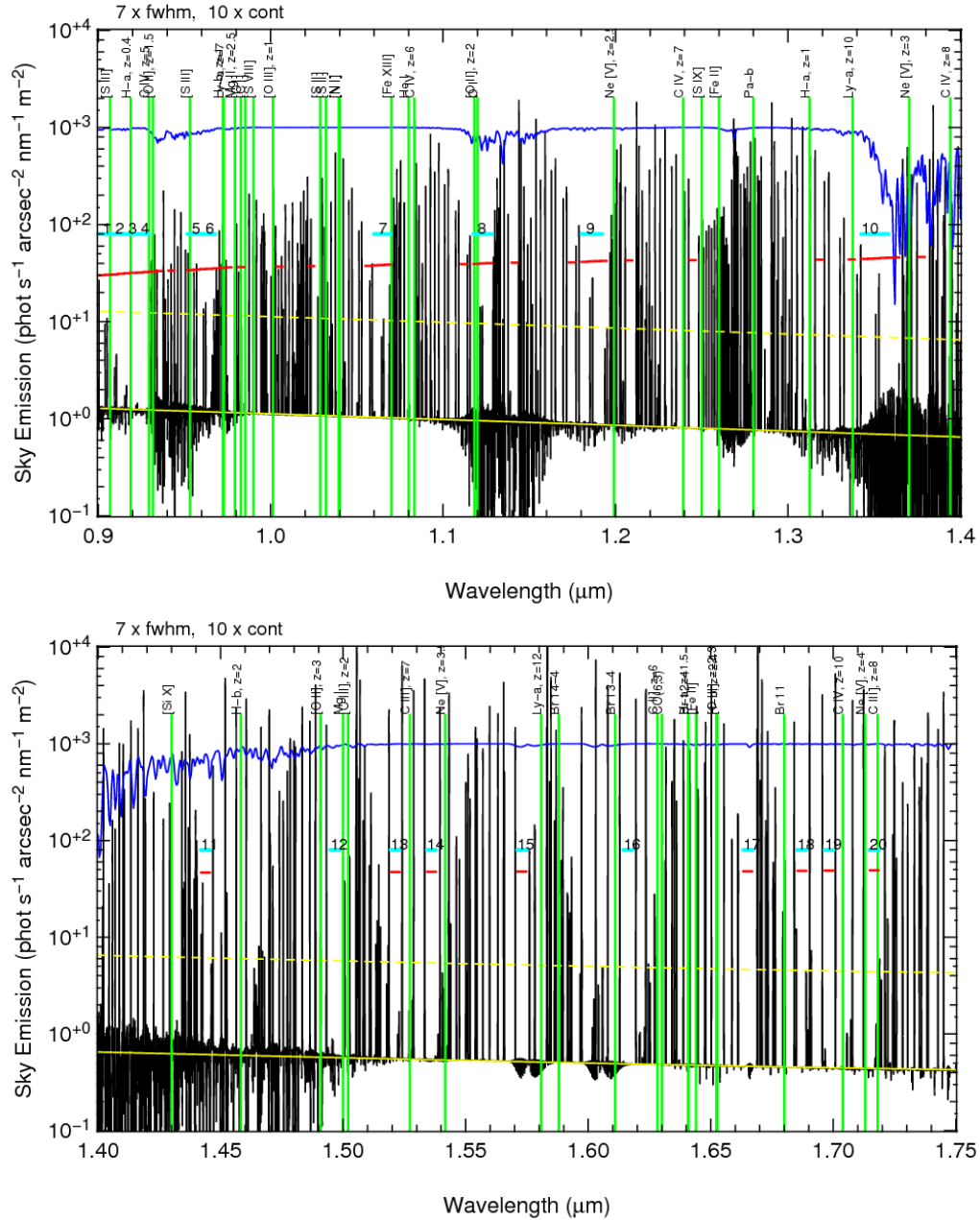


Figure B3. In black is a night sky spectrum from Mauna Kea in Hawaii. Atmospheric transmission is shown in blue (with arbitrary scaling). The solid yellow line is a fit to the sky continuum and the dashed yellow line marks 10 times the continuum level. Possible Fabry-Perot filter locations are marked by the thick cyan dashes. Their width in the J band is matched to the etalon free spectral range, while the H band is approximately 7x the etalon FWHM. Wavelengths of astronomical lines of interest are marked by the vertical green lines.

B7. Polarimetry

Polarimetry could be added with the purchase of the polarizing beamsplitter. Its holder and insertion mechanism are part of the baseline instrument.

This beamsplitter could be added with RSS-NIR on the telescope. The instrument would have to be warmed and the pre-dewar enclosure top would have to be removed.

**B8. Requirements of SALT**

There are a few requirements of SALT for RSS-NIR to operate on the telescope.

- The tracker must be upgraded to take the extra weight of RSS-NIR.
- The atmospheric dispersion corrector must be redesigned to operate through 1.73 microns.
- The upgraded calibration system must operate through 1.73 microns. We will work with the calibration system upgrade team to specify and meet these requirements.
- The tracker focus interferometer uses a laser that falls within the RSS-NIR wavelength range and will interfere with astronomical observations. If the interferometer will be used again in the future, this needs to be replaced with a laser that operates at > 1.8 microns.