

University of Wisconsin Department of Astronomy

SOUTHERN AFRICAN LARGE TELESCOPE
ROBERT STOBIE SPECTROGRAPH
NEAR INFRARED INSTRUMENT

STATUS REPORT

SUBMITTED
FEB 4, 2015

PROJECT YEAR 7
OCT 2014 – JAN 2015

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 accepted the second dichroic. Details of the optical performance is provided in the optics section.
- *Camera Testing:* The camera testing is complete. It will be integrated with the dewar once the dewar and science grade (SG) detector testing and optimization is complete.
- *Detector, Engineering Grade (EG) Characterization/Optimization*: While Greg Mosby is ready to proceed with testing the SG detector, he continues to work with the EG. He is optimizing the well depth for bright and faint objects while minimizing the impact to the read noise. He will start working with the SG detector as soon as it is installed and the dewar characterized.
- *Dewar Prep:* The dewar thermal control system and the electrical noise levels have been verified. There are a number of configuration tasks that need to be completed before the SG detector can be installed. During the course of completing these tasks, we discovered that the L7 holding ring was generating debris in the dewar. The source of the debris was the anodized surfaces. Johns Hopkins University is in the process of making a new part. We plan to have the dewar ready when the new part arrives in mid to late February.
- *CO_2 Cooling System:* The CO_2 cooling system bids were prohibitively expensive to implement (>$500,000), so we are in the process of exploring alternative options including working with an interested South African cooling system vendor.
- *Integration & Testing:* Jeff Percival is continuing to work with the startup and recovery initialization, state machine and interlocks, and the command and control of the mechanisms.

De-scoped Systems

Our plan is to have the RSS-NIR ready to ship in late 2015, which is consistent with the latest update on the tracker upgrade. 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. Delaying these may increase the cost of the components, will increase the operational costs to SALT and have a lost opportunity cost in downtime to the RSS.*** The estimated cost of commissioning the NIR, the de-scoped items, and the Fabry-Perot etalon are listed in Table 1. The Astronomy Department team member contributions through Washburn Astronomical Laboratories are listed as well. Appendix B summarizes the instrument performance gains through the addition of each de-scoped item.

Budget & Schedule

The NIR financial status is summarized in Table 1. Spending through December 2014 is $8.256M and we estimate the cost to ready the instrument for delivery to South Africa at $733k. The

sum of spending and what is required to ready the instrument is $8.988M. The funding available to ready the instrument is $8.757M leaving a deficit of $232k, which is an increase of $40k since the end of the last quarter. The reasons for the growth continue to be the same with one exception. The $40k growth includes a $15k payment to Infinite Optics for the second dichroic. While not in our budget, we chose to accept Infinite Optic's offer to coat the second substrate for $30k as it provided an opportunity for improved optical performance and an assurance of a spare dichroic. To order one later, would easily be three to four times more costly. The decision appears to have been good as the optical performance of the second dichroic is improved. We owe a balance of $15k which will be paid in January. As before, the project continues to require 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 to ready the instrument for shipping.

The schedule was updated with the status as of the end of December. The critical path has changed to the detail design, fabrication, skinning and final assembly of the pre-dewar enclosure. Previous reports have indicated that this effort was very near to the critical path. Mike Smith recently completed some rework of the model and transferred it to Jeff Wong for a review. However, moving forward with the enclosure is on hold while we work to find a solution to the enclosure cooling system. As indicated above, the CO_2 cooling system bids were too expensive to implement. We are working with a South African vendor to find another solution. Should that fail to converge, we may have to return to the fluorinert solution presented at the Mid-Term and Critical Design Reviews.

The dewar development and detector testing continues to make good progress but is still near the critical path, with the exception of the issue with the part from Johns Hopkins. We hope to soon install the SG detector into the dewar once we have the new part in February.

If either development path makes significant progress or is delayed, the critical path is likely to flip flop between them. We will continue to report on both paths in detail.

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

December 2014 (figures in thousands of dollars)

Spending-to-date	$8,256
Budget to get ready to ship	
Dec '14 to Ready-to-Ship	$622
Rescoped Items	
Dewar Cooling System	$20
Pre-dewar Enclosure Cooling System	$90
Sum	$733
Commissioning	
Estimate cost of commissioning	$630
Sum	$630
Descoped Items	
Polarizing Beamsplitter	$138
Cooled Slit Hardware	$54 [1]
Order Blocking Filters (12)	$261
Cryogenic Filters (2)	$56 [1]
Gratings (4)	$250
Sum	$760
Fabry-Perot Etalon	
Fabry-Perot Etalon with controller	$305
Sum	$305

RSS-NIR FUNDING SUMMARY

December 2014 (figures in thousands of dollars)

Sources			
Wisconsin Alumni Research Foundation		$3,300	
National Science Foundation		$1,997	
UW-Astronomy		$2,325	
UW-Astronomy	$1,400		
Washburn Astronomy Laboratories: Ready-to-ship	$715		[2]
Washburn Astronomy Laboratories: Commissioning	$134		[2]
Washburn Astronomy Laboratories: De-scope Items	$54		[2]
Washburn Astronomy Laboratories: F-P Etalon	$23		[2]
SALT		$932	
UW-Space Science & Engineering Center		$413	
Sum of Funding to get Ready to Ship		$8,757	
Total Sum of Funding		$8,967	

Funds Needed to be Ready-to-Ship	$232	[3]
Funds needed through Commissioning (cumulative)	$728	
Funds needed to add descoped items (cumulative)	$1,434	
Funds needed to include etalon (cumulative)	$1,716	[4]
Balance of $1.4M UW-Astronomy Funds	$192	

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.

WBS	Task Name	Duration	Start	Finish
1	Project administration	2164 d	Thu 7/17/08	Tue 11/1/16
1.1	Project management	2164 d	Thu 7/17/08	Tue 11/1/16
1.1.4	Reviews / Milestones / Meetings	2164 d	Thu 7/17/08	Tue 11/1/16
9	Predewar	1820 d	Mon 9/15/08	Fri 9/4/15
9.1	Enclosure design	1770 d	Mon 9/15/08	Fri 6/26/15
9.1.1	Housing / Structure	1770 d	Mon 9/15/08	Fri 6/26/15
9.1.1.5	*Detail Drawings*	*83 d*	*Wed 10/8/14*	*Fri 1/30/15*
9.1.1.6	*Order enclosure material*	*25 d*	*Mon 2/2/15*	*Fri 3/6/15*
9.1.1.7	*Prep and ship material to vendor*	*4 d*	*Mon 3/9/15*	*Thu 3/12/15*
9.1.1.9	*Machine Base*	*20 d*	*Wed 3/18/15*	*Tue 4/14/15*
9.1.1.10	*Machine Enclosure Top*	*20 d*	*Wed 3/18/15*	*Tue 4/14/15*
9.1.1.11	*Fit Checks*	*3 d*	*Wed 4/15/15*	*Fri 4/17/15*
9.1.1.12	*Ship to exterior skin vendor*	*5 d*	*Mon 4/20/15*	*Fri 4/24/15*
9.1.1.13	*Lay up enclosure base*	*40 d*	*Mon 4/27/15*	*Fri 6/19/15*
9.1.1.14	*Lay up enclosure top*	*40 d*	*Mon 4/27/15*	*Fri 6/19/15*
9.1.1.16	*Ship to UW*	*5 d*	*Mon 6/22/15*	*Fri 6/26/15*
9.6	Subsystem assembly and test	50 d	Mon 6/29/15	Fri 9/4/15
9.6.2	Assemble	35 d	Mon 6/29/15	Fri 8/14/15
9.6.2.1	*Apply any surface treatment to the enclosure & install internal H/W*	*15 d*	*Mon 6/29/15*	*Fri 7/17/15*
9.6.2.2	*Install skin heater system*	*20 d*	*Mon 7/20/15*	*Fri 8/14/15*
9.6.3	Subsytem Testing	15 d	Mon 8/17/15	Fri 9/4/15
9.6.3.1	*Test cooling and skin heater system, room temp environ*	*5 d*	*Mon 8/17/15*	*Fri 8/21/15*
9.6.3.2	*Test cooling and skin heater system, cold environ*	*10 d*	*Mon 8/24/15*	*Fri 9/4/15*
11	Control System	1935 d	Fri 8/1/08	Thu 12/31/15
11.7	Electronics Enclosure	1534 d	Mon 2/15/10	Thu 12/31/15
11.7.7	*Build up enclosure controls panel*	*20 d*	*Fri 11/13/15*	*Thu 12/10/15*
11.7.8	*Integrate cooling system*	*15 d*	*Fri 12/11/15*	*Thu 12/31/15*
14	Integration & Acceptance Testing - UW	1001 d	Thu 3/1/12	Thu 12/31/15
14.6	Pre-Dewar Enclosure Integration	49 d	Mon 9/7/15	Thu 11/12/15
14.6.1	*Integrate Enclosure, Airlock door, and baffling*	*15 d*	*Mon 9/7/15*	*Fri 9/25/15*
14.6.2	*Functional test mechanisms*	*5 d*	*Mon 9/28/15*	*Fri 10/2/15*
14.6.3	*Integrate pre-dewar cover*	*3 d*	*Mon 10/5/15*	*Wed 10/7/15*
14.6.4	*Configure cooling system*	*3 d*	*Thu 10/8/15*	*Mon 10/12/15*
14.6.5	*Cooling system verification testing*	*3 d*	*Tue 10/13/15*	*Thu 10/15/15*
14.6.6	Cold endurance testing	10 d	Fri 10/16/15	Thu 10/29/15
14.6.7	Cold operational testing	10 d	Fri 10/30/15	Thu 11/12/15
14.7	READY TO SHIP	0 d	Thu 12/31/15	Thu 12/31/15

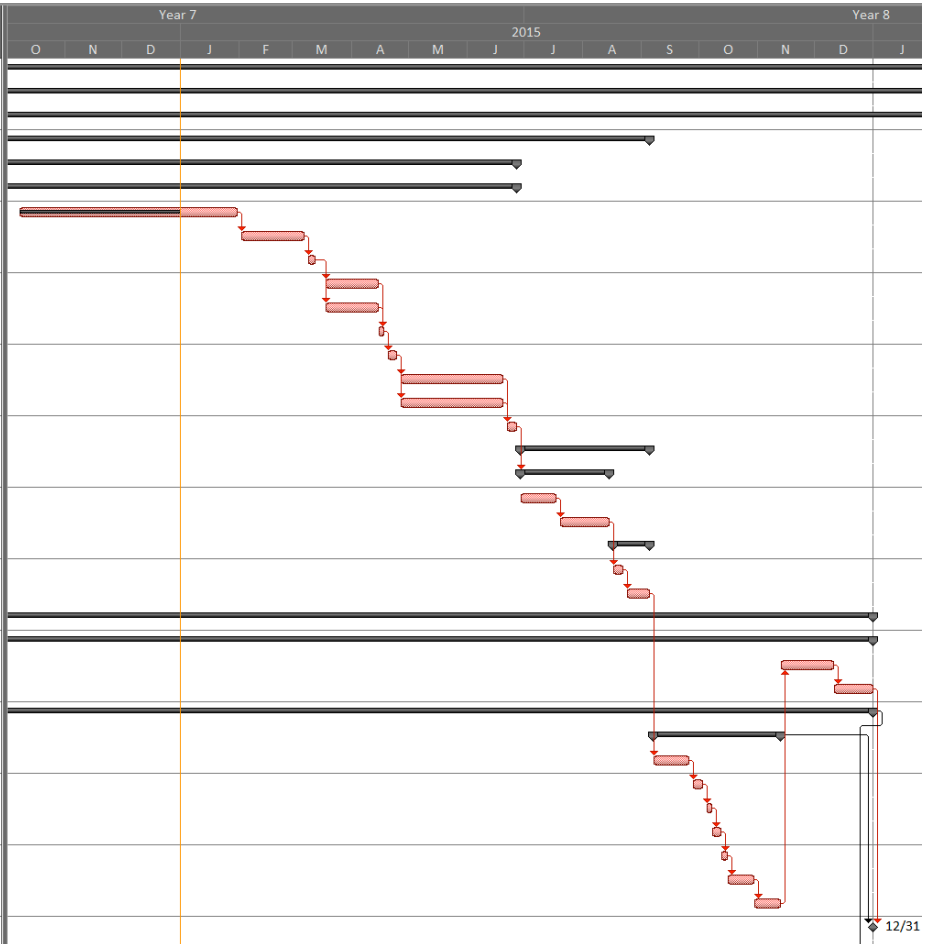


Figure 1. *RSS-NIR Critical Path updated December 31, 2014.*

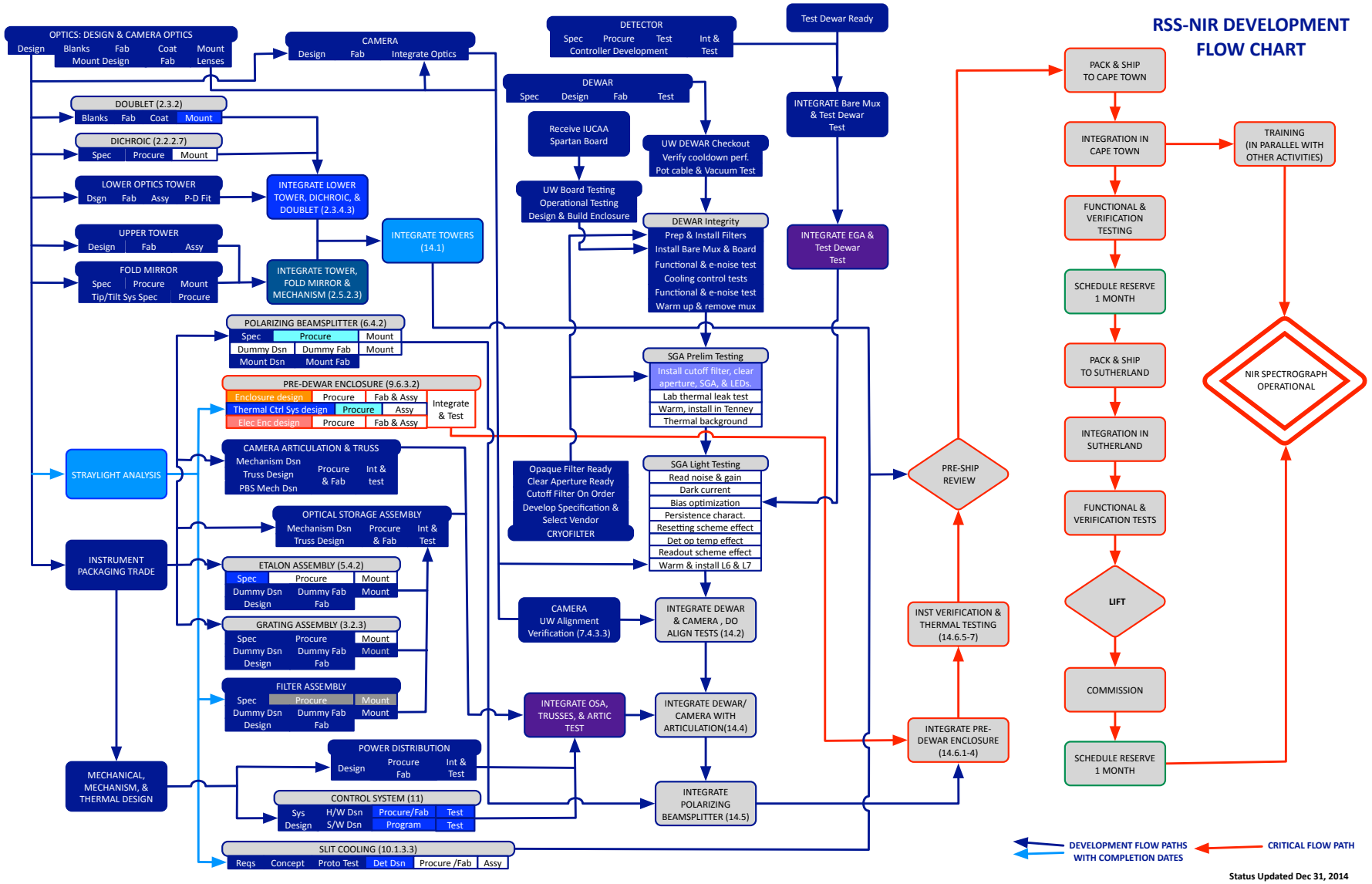
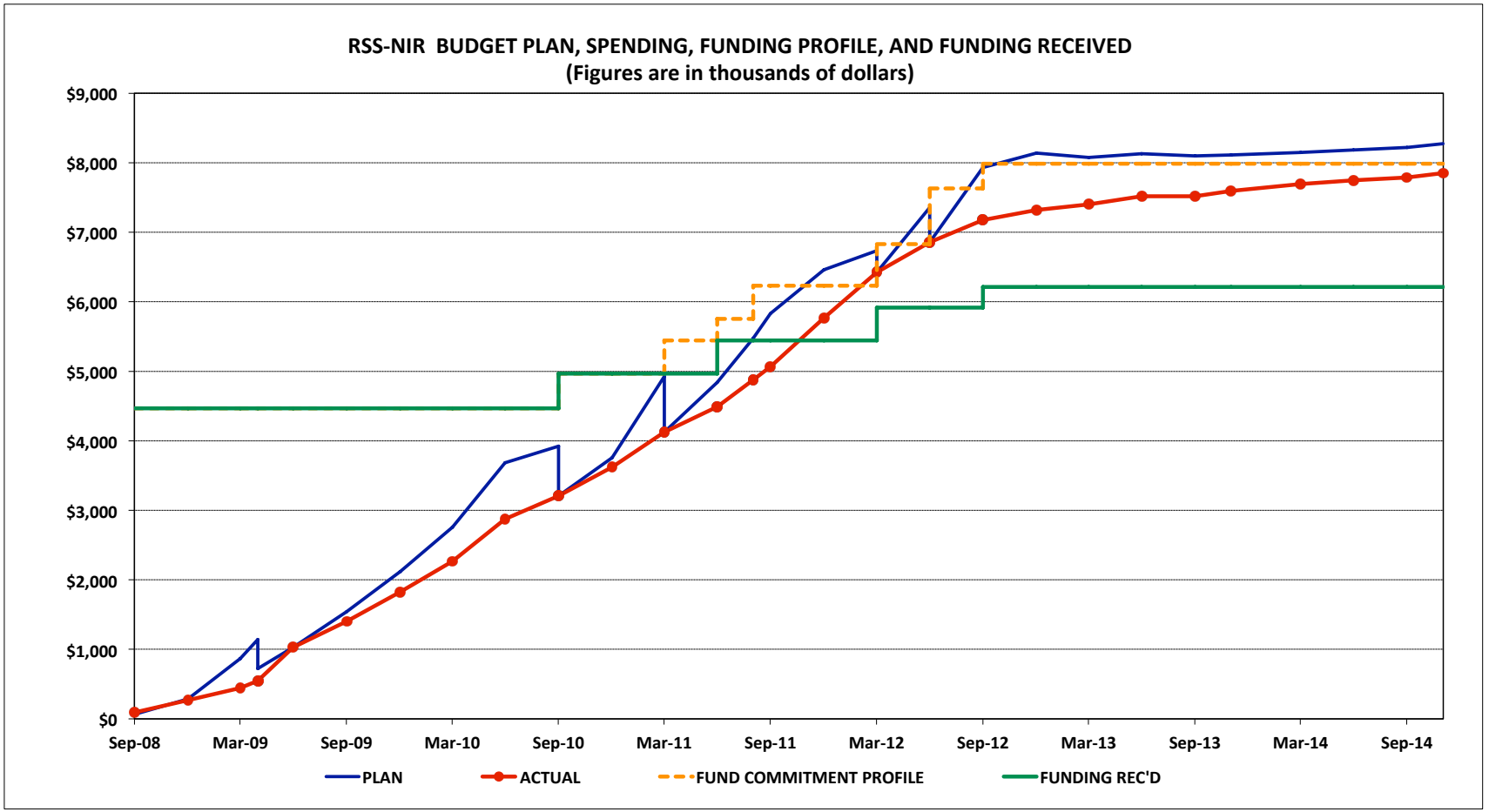


Figure 2. *RSS-NIR Development flow chart, updated December 31, 2014.*



	PROJECT YEAR 1				PROJECT YEAR 2				PROJECT YEAR 3				PROJECT YEAR 4				PROJECT YEAR 5				PROJECT YEAR 6				PROJECT YEAR 7	
	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	Jun-14	Sep-14	Dec-14
PLAN	$65	$285	$865	$1,027	$1,540	$2,118	$2,757	$3,682	$3,208	$3,755	$4,126	$4,840	$5,828	$6,459	$6,734	$7,357	$7,930	$8,137	$8,075	$8,130	$8,100	$8,113	$8,149	$8,185	$8,220	$8,274
ACTUAL	$91	$267	$446	$1,030	$1,402	$1,827	$2,269	$2,874	$3,208	$3,622	$4,126	$4,491	$5,067	$5,765	$6,423	$6,855	$7,175	$7,322	$7,399	$7,520	$7,519	$7,595	$7,691	$7,748	$7,788	$7,850

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: 1) the actual and planned spending presented does not include the contributions and spending made by the Washburn Astronomy Laboratories and 2) the planned spending does include the "Funds needed to be ready to ship" estimate from Table 1.*

Risk Summary Table (updates are in blue)

Risk	Type	Impact Assessment	Mitigation Plan	State
1. *Instrument Mass*: 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 as we have not machined new parts nor updated the design. Once the cooling system decision is finalized the enclosure design can be completed. The mass will be updated at that time.	Open
2. *ADC*: 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. *Instrument Delivery:* Target delivery for the commissioned instrument is December 2012.	Schedule Cost	Low Significant	Ready to ship is currently projected as Dec 2015.	Open
4. *Dichroic Thickness*: 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. Dichroic Cost: JDSU ROM estimate for a dichroic that meets our preliminary specification 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. *Pre-dewar Enclosure Cost*: 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 updated the model design and has Jeff Wong reviewing it. This is on hold while the cooling system decision is being made.	Open
7. *Pre-dewar Enclosure cooling system:* 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	Bids were received, but the cost of the CO_2 cooling system made it prohibitive. We are in the process of exploring other options.	Open
8. *Budget:* 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 as we have not machined new parts nor matured the design of the pre-dewar or electronics enclosures. It remains at 448.1 kg, but will be updated once we select a cooling system and complete the detailed design of the enclosure.

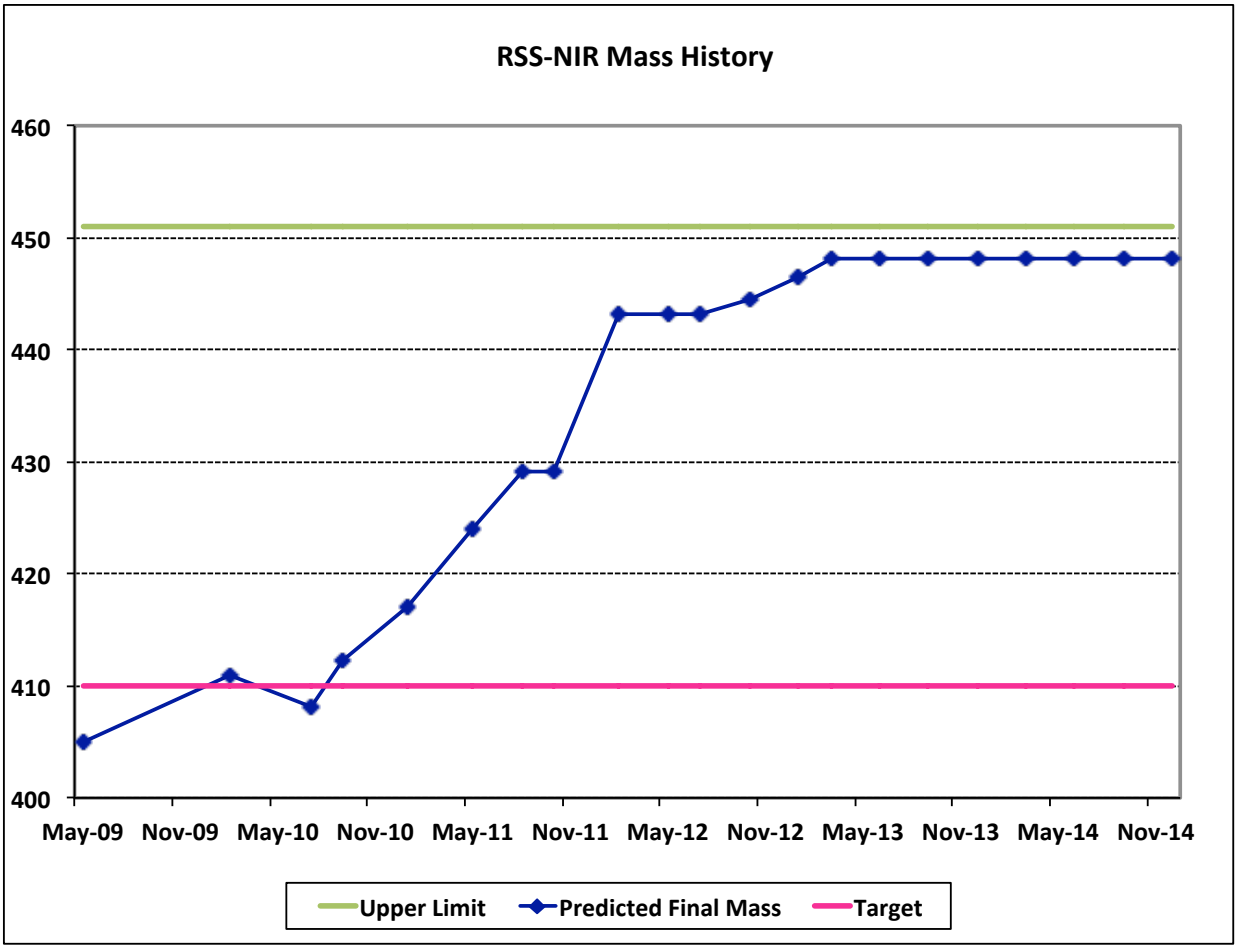


Figure 4. *RSS-NIR mass history with the target mass and upper limit.*

- *Interface Control Document:* There have been no further discussions between SALT staff and the NIR team concerning the ICD since the last quarterly report.

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

- *Second Dichroic*: Infinite Optics has completed and delivered the second dichroic. Ken Nordsieck and Marsha Wolf have reviewed the optical performance data and have accepted the dichroic. Below is a summary of the review of the data.
  - *The 40° incidence crossover width specification is 40 nm and the measured value is 83 nm*. The other angles are quite close to meeting the original tight specification of

40 nm from the 10% to the 90% point, and this mirror is certainly much better than the first one. The 40° incidence angle has a tail on the NIR side, which is not really a concern, since the uniformity on that side is quite good, so calibration near crossover should not be a problem. See the plots in Figure 5 and Figure 6.

- *The "max pol" specification is exceeded by more than 2x for the UV and VIS regions* (see Figure 7). This specification was somewhat arbitrary, since no one had listed such a specification before. It was difficult to know what was doable. To compare the data with the specification, the mean polarization was subtracted since the issue is really polarization spikes away from mean that might cause problems with instrumental polarization. After correcting the polarization data from the measured collimated beam to the RSS F/10 beam, the polarization deviations are reduced by ~2x. The deep UV (320-340 nm) is still ~3x above the specification and the VIS 50° run has a spike at 570 nm, otherwise the response is acceptable. The remaining deviations are not terrible. If the wavelength space, which has deviations, is summed, it becomes negligible if I double the specification from 3 to 6%, and even the UV has only 15% of its space with deviations. There are no issues in the NIR.
- The flatness is acceptable. It is less < 1 wave p-v over the center 100 mm and 4-5 waves p-v at the edges.

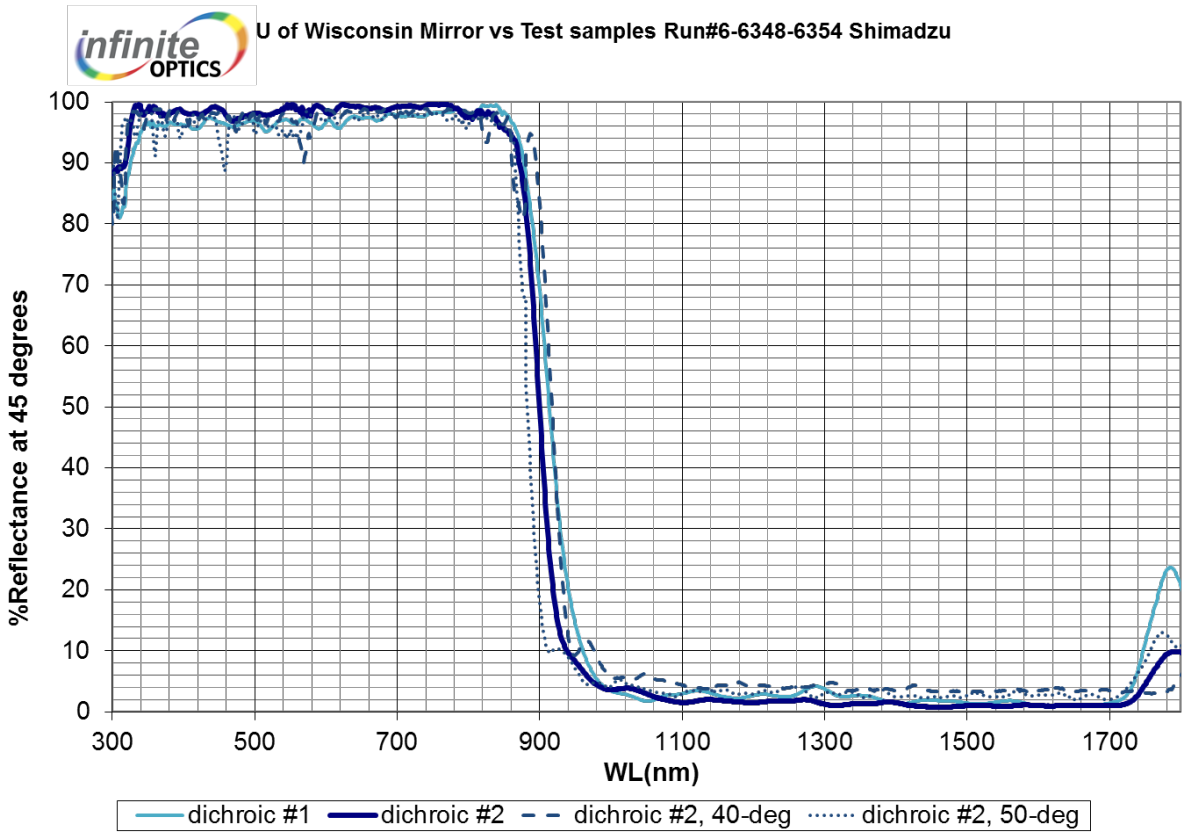


Figure 5. Dichroic beamsplitter performance (random polarization, 40 and 50 deg data from samples).

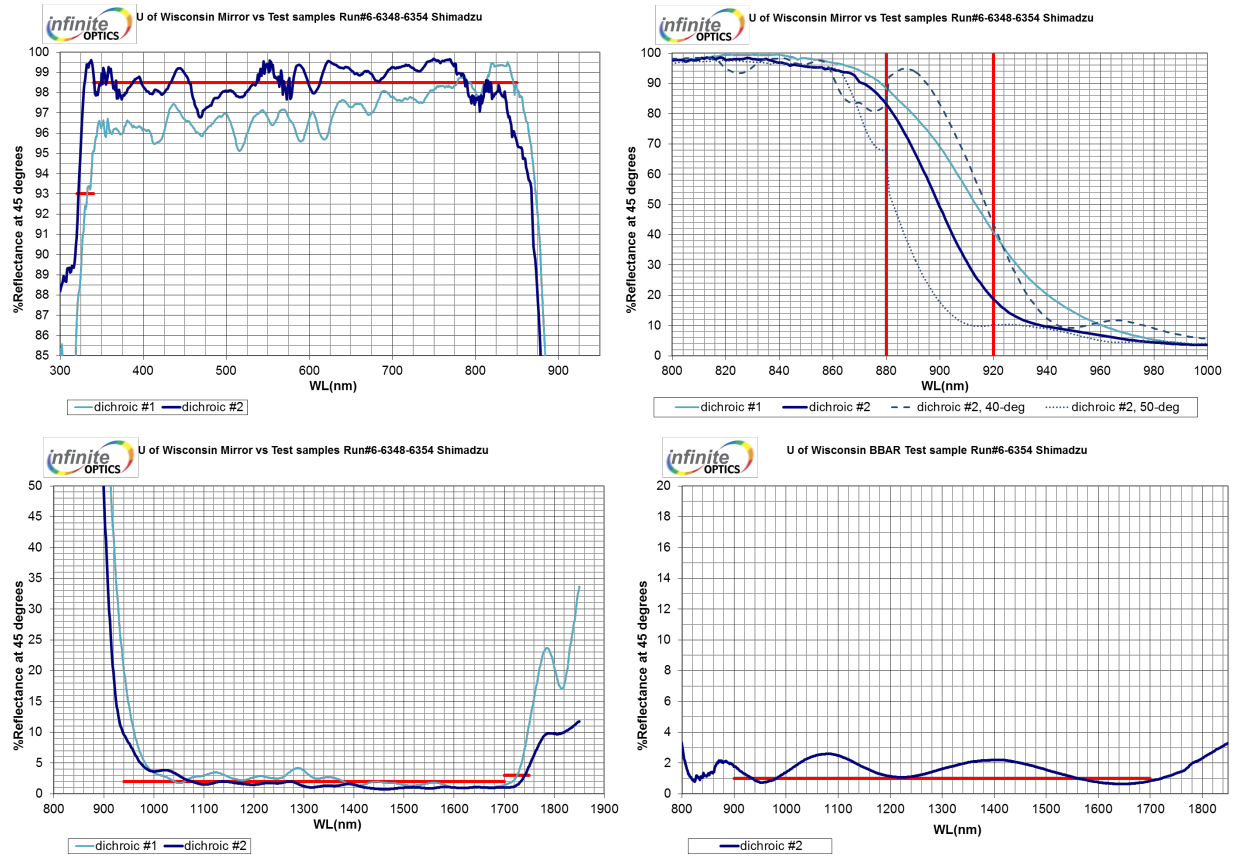


Figure 6. Dichroic performance (random polarization) compared to specifications. *Top left*: UV-VIS reflectivity, red lines mark the specified mean reflectance. *Top right*: Crossover region, red lines mark the specified crossover width around the 50% wavelength of 900 nm (40 and 50 deg data are from witness samples). *Bottom left*: NIR region, red lines mark the specified mean reflectance. *Bottom right*: AR coating on back side, red line marks the specified maximum reflectance.

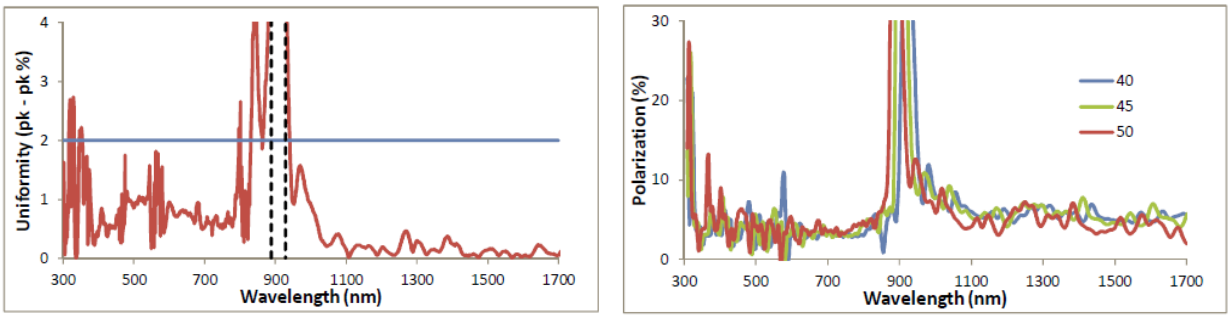


Figure 7. Uniformity and polarization plots for the RSS-NIR second dichroic.

Summary table of dichroic #2 specifications and measured performance.

		Spec		Mirror 2		
ID	Item	Lower	Upper	InfOptics	OK?	Comment
A-3 #1Collimated @ 45						
A-2 #1 Crossover	Width		40	44.58	N	almost
Crossover	Position	890	910	909.45	Y	
UV (320-340)	Ref	93		94.21	Y	
Vis (350-97ref)	Ref	98.5		97.36	N	almost
NIR (97Tran-1700)	Trans	96		96.41	Y	
NIR 4% wavl	Position	1750		1767	Y	
UV Uniformity	Ref		2	1.6	Y	
Vis Uniformity	Ref		2	3.4	N	almost
NIR Uniformity	Trans		2	0.7	Y	
A-3 #2 F/10 @ 40				collimated		
A-2 #1 Crossover	Width		40	83.09	N	NIR tail
Crossover	Position			926.04		
UV	Ref	93		92.63	N	almost
Vis	Ref	98.5		97.77	N	almost
NIR	Trans	96		95.92	N	almost
UV	Max %Pol		3	11.57	N	
Vis	Max %Pol		3	7.40	N	
NIR	Max %Pol		3	2.74	Y	
A-3 #2 F/10 @ 45				collimated		
A-2 #1 Crossover	Width		40	44.58	N	almost
Crossover	Position	890	910	909.45	Y	
UV	Ref	93		94.21	Y	
Vis	Ref	98.5		97.36	N	almost
NIR	Trans	96		96.41	Y	
UV	Max %Pol		3	15.41	N	
Vis	Max %Pol		3	4.24	N	almost
NIR	Max %Pol		3	3.53	N	almost
A-3 #2 F/10 @ 50				collimated		
A-2 #1 Crossover	Width		40	46.86	N	almost
Crossover	Position			891.50		
UV	Ref	93		96.21	Y	
Vis	Ref	98.5		96.82	N	almost
NIR	Trans	96		96.93	Y	
UV	Max %Pol		3	4.54	N	almost
Vis	Max %Pol		3	9.22	N	
NIR	Max %Pol		3	4.16	N	almost
Crossover Change			40	34.54	Y	

3. *Grating Assembly*

- Chris Clemens has not done the S and P 0-order efficiency measurements with the grating at an angle of 0° (measurements normal to the grating surface).

4. *Broadband Filters & Optical Storage Assembly*

- No issues or status update.

5. *Fabry-Perot Assembly*

- No issues or status update.

6. *Polarizing Beamsplitter*

- No change in status.

7. *Camera Assembly*

- No change in status. The camera will next be integrated with the dewar.

8. *Detector / Dewar Assembly*

- *EG Detector, Full Well Depth Optimization*: Greg Mosby, Astronomy graduate student, has continued his work to optimize the full well depth. He is optimizing the settings for faint object observations. For a given gain setting, he can set the detector bias (difference between Dsub and Vreset) for a desired well depth and adjust the voltages Vrefmain and Vbiasgate as needed.

  While optimizing, Greg determined that the Vrefmain has a limited range. He observed a nonlinear response when it was set much above or below 1-volt. With the Vrefmain set at approximately 1-volt, he explored finding an optimum detector bias. He also set the output common mode voltage, Vcm, at 1.2-volts to center the amplified detector output voltages on the midpoint of the range of input voltages acceptable to the ADC, at least for this testing. He feels this approach is working to find an optimal full-well depth as he was able to improve the well depth from 50,000 to 112,000 e-. Not surprisingly, the read noise increased, but Greg was able to reduce the RN (<20 DN) by re-optimizing a series of ASIC currents to operate at the new detector bias.

  He has not reviewed how the setting changes may be affecting persistence, specifically the induced persistence caused by detector bias changes. He has not been using the initial data collected after a bias change to avoid the persistence effects.

- *Dewar, Thermal Control Testing*: Previously, we were in the midst of ensuring that the detector (bare mux during testing) would never be the coldest point in the dewar during cool down, soak temperature or warm up. After consulting with Steve Smee, designer and builder of the dewar at Johns Hopkins University, we chose to trim the indium thermal strap, which had positive results. As shown in the table below, we were able to keep the “detector” temperature warmer than the cold plate in each test configuration.

Table 2. RSS-NIR dewar cold plate and detector temperatures in lab and operational environments at different heater power levels, listed in parenthesis.

Sensor	Lab Environment			-40°C Chamber
Cold Plate	111 K (0%)	111 K (10%)	112 K (100%)	106.5 K (90%)
Detector	119 K (0%)	120 K (20%)	137 K (100%)	120 K (60%)

The tests verified that we can maintain the detector warmer than the cold plate and that we can control the detector to 120 K while in a -40°C enclosure. A final test confirmed that the detector temperature was warmer than the cold plate during a warm up of the dewar in the -40°C environment. The dewar thermal control system is verified in both steady state and transient conditions.

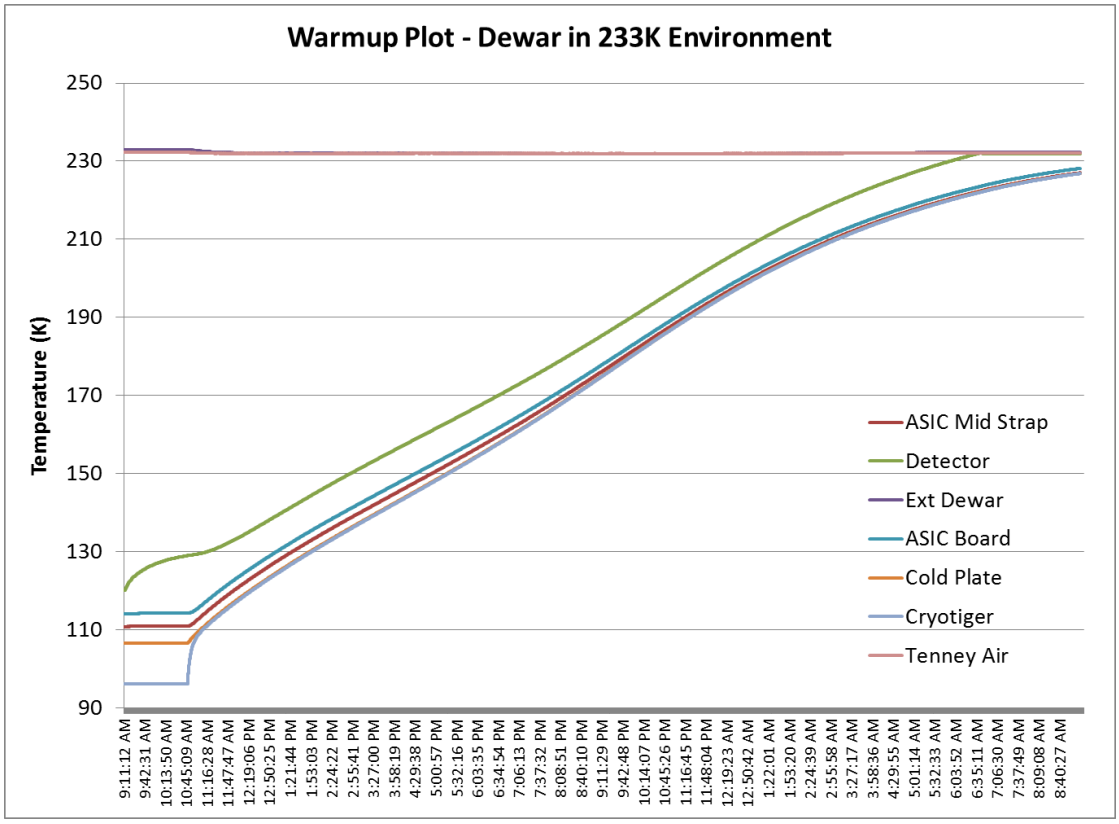


Figure 8. Instrument dewar warmup inside the Tenney environmental chamber. The external dewar temperature is at its operating temperature of -40°C (233K). Note that the detector (green curve) stays warmer than all other internal dewar components during the warmup cycle.

- *Dewar Noise Verification*: As of the last report, Greg Mosby had verified that the dewar noise levels measured with the bare mux installed were consistent with previous measurements. From an electronic noise perspective, we were ready to install the SG detector. A number of issues were identified that needed to be addressed before we could install the SG detector.
  - *Review and update the SG installation procedure.* ***Done***.
  - *Prep the clean room*. ***Done***.
  - *Install the diffuser, long wavelength cutoff filter, and the glass blank in the filter wheel*. ***Done***.
  - *Prepare new indium straps*. Needs to be done.
  - *Install the field flattener*. Will be done during SG detector install.

- *Install the detector cup position adjusters*. Will be done during SG detector install.
- *Inspect the long cable*. Needs to be done.
- *Install LEDs*. The LEDS need to be mounted to the front-end flange. A cable has been made and assembled to feed them with power.
- *Additional Temperature Sensors*. We decided to add two additional temperatures, one on the dewar external surface and one in the air near it, into the Lakeshore. Ron Koch is reconfiguring the cable to accommodate these sensors.
- *Power cabling to the ISDEC Card*. Ron is completing the configuration to power the ISDEC card so that it is in its final configuration.
- *Interlocks*. Kurt Jaehnig developed a series of interlocks to safe the system in the event of different failures. Work on this was started in late September. The system includes an over/under temperature monitoring of the Tenney Chamber, a power relay box between the Tenney and the single phase 208-volt power, and an "uber" interlock box that monitors the state of the system and cuts off power if needed. This system is nearly assembled and ready for a checkout and test.
- *Bare Mux Removal / SG Install*. The bare mux has been removed from the dewar. While removing it, some black debris was noticed in the detector cup. By eye examination, it had the appearance of black talc. This was the second time we have noticed it. Initially, we thought it might be some loose debris that would cease to appear. Since it reappeared, we needed to determine the source. A microscopic inspection of the debris was inconclusive. Kurt ultrasonically cleaned three parts from the detector installation. The first two (mask in front of the detector and the diffuser mounting ring for the filter wheel) did not generate any debris in the bath. The L7 retaining ring generated particles, which by microscope inspection, were consistent with the earlier particles. Kurt continued the ultrasonic cleaning hoping the part would cease to generate debris. It did not, but Kurt was able to identify a source – the anodized surfaces on the inside of the through holes. If you look closely above the holes in Figure 9, the debris can be seen floating away from the part. Eventually, the paint peeled off the part to expose anodized surfaces.

  Steve Smee was consulted. We determined that the painted surfaces had been incorrectly anodized underneath and that the applied anodize was infused with PTFE molecules or Teflon. Steve offered to make a new part, properly anodize it and paint it. He felt the part would take until the end of January to machine. Surface treating will likely take another 2-4 weeks. The part machining is wrapping up. In the meantime, we will continue to ready the dewar for the SG detector.

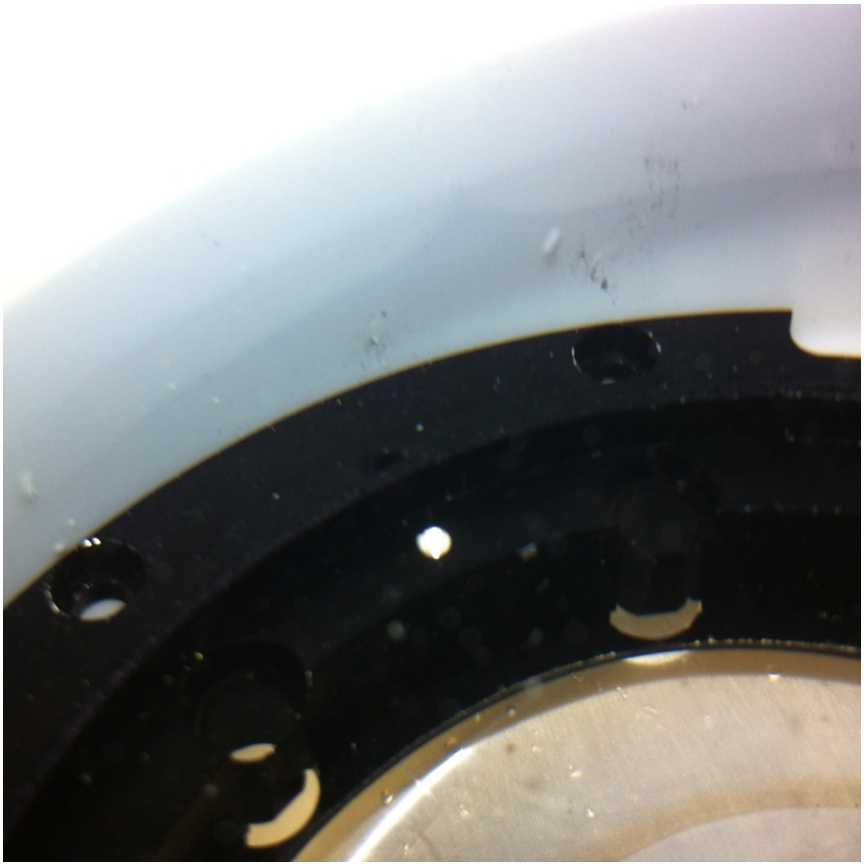


Figure 9. RSS-NIR L7 holding ring in an ultrasonic isopropyl bath. Small bits of anodizing can be seen be lifting for the inner surfaces of the outer ring of holes.

9. Pre-dewar Enclosure

- *Enclosure cooling system:* The bids for the CO_2 cooling system were prohibitively expensive (>$500k), so we are exploring other options for providing cooling. We have been working with Bryone Billings at Concept Cooling, a South African vendor. He has been to SALT to review the facilities and is working to come up with a design that meets the instrument and facility needs. Depending on how this proceeds, we may have to reconsider a fluorinert system if Concept Cooling's standard refrigerant option is not viable.
- *Enclosure Design*: This is again on hold while we finalize the cooling system.
- *Skin Heater System Design:* No significant progress to report.

10. RSS Common Optics Environmental Control

- *Slit Cooling Test:* No significant progress.

11. Control System

- *Documentation:* Ron Koch has updated and organized the documentation for the all of the custom board designs in the NIR. Tom Demke has added them to the NIR documentation server.

- *General*: Ron continues to address other minor hardware issues as they arise.

12. Power Distribution

- No issues or status update.

13. Support and Test Equipment

- No issues or status update.

14. Integration, Verification and Testing (@ UW)

- *Control System Software*: Jeff Percival has made the following progress with the software control system:
  - Developing the instrument state machines and interlocks.
  - Communicating with Janus and Anthony to coordinate the integration of the NIR into the SALT facility.
  - Improved the mechanism initialization, which included ensuring that it worked with the instrument in a non-horizontal position.

- *Fold Mirror Tip/Tilt Mechanism*: Greg Mosby and undergraduate student Dustin Mason have continued their work to understand the operation and control of the piezo driven tip/tilt mechanism. They are working to understand the hysteresis in the system but are having trouble measuring it above the noise in the system. They are exploring tools within LabView to help them with this. Jeff Percival is supporting their efforts as well.

Open Punch List Items:

- *OSA Mechanism Readiness*
  - *Light-tight enclosure for the relative encoder*: Prototype encoder enclosure has been machined and anodized. Curtis Bartocz, a lab technician (former undergraduate), is setting up a test to verify the light tightness of the new enclosures.
- *Grating & Filter Insertion Mechanism:*
  - *Cable tie-down bracket*: Mike Smith is planning to have a student simulate the cable tie down that will be used once the instrument is in the enclosure.
  - *Adjust limit switches:* Not yet done.
  - *Calibrate the home switch on the absolute encoder:* Ron has developed a scheme to calibrate the home switch. He has provided this to Jeff.
  - *Light tight enclosure for the relative encoder:* See the OSA mechanism.
- *RFID*
  - *Protect antennas*: We are planning to coat the antennas in a thin layer of RTV. Kurt Jaehnig will be evaluating the best approach to apply the RTV without damaging the antennas.
- *Grating Rotator*
  - *Motor Initialization*: We need to ensure that the grating rotator motor can be

initialized with the instrument in a non-horizontal position. DONE.

- *Camera Focus*
  - Set the hardware limit switches
  - Add software limit switches
  - Swap out the hall sensor
- *Control System, General:* Jeff is continuing to work on system initialization, mechanism control and changing between states.

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	2010		2011		2012				2013				2014						PROJECT TOTAL
	PROJECT YEAR 3				PROJECT YEAR 4				PROJECT YEAR 5				PROJECT YEAR 6				PROJECT YEAR 7		
QUARTERLY SPENDING	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	
LABOR	$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	$15,206	$10,524	$13,025	$3,228,266
MATERIAL	$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	$2,161	$6,081	$2,610	$459,610
CAPITAL EQUIPMENT	$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	$6,195	$0	$15,000	$1,368,350
TRAVEL	$13,344	$12,257	$2,454	$5,210	$8,407	$13	$870	$6,144	$6,746	$0	$0	$0	$0	$3,243	$0	$0	$0	$0	$112,959
SUBCONTRACTS	$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	$17,266	$11,345	$16,690	$1,714,653
TUITION REMISSION	$1,778	$2,667	$4,889	$0	$0	$889	$2,889	$1,778	$6,408	$0	$0	$0	($4,000)	$0	$0	$0	$0	$0	$42,331
OVERHEAD	($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	$15,585	$12,577	$14,547	$924,069
QUARTERLY TOTAL	$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	$56,414	$40,527	$61,872	$7,850,238
QUARTERLY BUDGET																			
LABOR	$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	$0	$0	$3,649,949
MATERIAL	$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	$0	$0	$468,320
CAPITAL EQUIPMENT	$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	$0	$0	$1,558,800
TRAVEL	$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	$0	$0	$143,715
SUBCONTRACTS	$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	$0	$0	$1,544,734
TUITION REMISSION	$0	$2,670	$2,670	$1,800	$900	$2,700	$0	$1,600	$1,000	$3,000	$0	$0	$0	$0	$0	$0	$0	$0	$49,331
OVERHEAD	$7,505	$18,624	$23,915	$0	$57,297	$110,223	$0	$190,765	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$787,497
QUARTERLY TOTAL	$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	$0	$0	$8,202,347
NET (BUDGET - SPEND)																			
LABOR	($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)	($15,206)	($10,524)	($13,025)	$421,683
MATERIAL	($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)	($2,161)	($6,081)	($2,610)	$8,710
CAPITAL EQUIPMENT	$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)	($6,195)	$0	($15,000)	$190,450
TRAVEL	($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	$0	$0	$30,757
SUBCONTRACTS	($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)	($17,266)	($11,345)	($16,690)	($169,918)
TUITION REMISSION	($1,778)	$3	($2,219)	$1,800	$900	$1,811	($2,889)	($178)	($5,408)	$3,000	$0	$0	$4,000	$0	$0	$0	$0	$0	$7,000
OVERHEAD	$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)	($15,585)	($12,577)	($14,547)	($136,572)
QUARTERLY NET	($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)	($56,414)	($40,527)	($61,872)	$352,109

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

RSS-NIR KEY MILESTONES

CRITCAL PATH | TASKS COMPLTED IN THE LAST QUARTER

WBS	DESCRIPTION	TARGET DATE	SLACK (WORKDAYS) FREE	SLACK (WORKDAYS) TOTAL	MUST HAVE BY DATE	RESPONSIBLE TEAM MEMBER
1.3.2	**Documentation**					
1.3.2.2	FPRD	2/6/15			-	Wolf
1.3.2.5	OCDD	6/4/15			-	Wolf
1.3.2.4	ICD	3/3/15			-	Mulligan
1.3.2.6	Verification & Test Plan	6/16/15			-	Wolf
1.3.2.7	Commissioning Plan	8/21/15			-	Wolf
2.2	**Dichroic**					
2.2.1.6	Receive Spare Dichroic	1/30/15	0	81		Nordsieck
2.2.2.7	Dichroic Mounted in holder	2/19/15	21	21	3/20/15	Smith
2.3	**Doublet**					
2.3.2.9	Doublet lens mounted in holder, delivered to UW	3/20/15	*0*	0	3/20/15	Smith
2.2.4	**Lower Tower**					
2.3.4	Assemble dichroic, doublet, & lower tower	4/17/15	0	0	4/17/15	Smith
2.4.4	**Upper Tower**					
2.5.2.2	Assemble fold mirror & mechanism, pupil baffle, grating rotation stage mechanism and upper tower	3/13/15	25	25	4/17/15	Smith
3.1	**Gratings**					
3.2.1.6.1	Grating mounted in holder	4/14/15	73	83	8/8/15	Smith
6.2	**Polarizing Beamsplitter Mechanism**					
6.2.8	Dummy Polarizing Beamsplitter assembled in housing	5/20/15	62	72	8/28/15	Smith
7	**Camera**					
7.4.3.3	Camera alignment testing at UW	11/26/14			11/26/14	Wolf
8.3	**Bare Mux Testing**					
8.3.11.5	Dewar cooldown and temperature stability verified	10/31/14			10/31/14	Wolf
8.3.11.6	Cold temperature functional test	11/7/14			11/7/14	Wolf
8.3.11.7	FFT testing complete at cold temperature	11/14/14			11/14/14	Wolf
8.3.11.8	Warm Dewar	11/19/14			11/19/14	Wolf
8.3.11.9	Bare mux removed	11/26/14			11/26/14	Wolf
8.4	**Engineering Grade Array**					
8.4.6.3	Test Dewar: Cold temperature testing of engineering grade array complete	1/30/15	0	457	10/30/16	Wolf
8.5	**Science Grade Array**					
8.5.2.1	Cutoff and Clear Aperture installed in filter wheel	12/19/14			12/19/14	Wolf
8.5.2.2	LEDs installed in Dewar	1/16/15	10	37	3/8/15	Wolf
8.5.2.6	SGA integrated in Dewar. Thermal light leak testing complete @ room temp	3/19/15	0	10	4/2/15	Wolf
8.5.2.8	Dewar installed in Tenney Chamber and the chamber is cooled down	3/31/15	0	10	4/14/15	Wolf
8.5.2.9	Thermal background characterized at cold temperature	4/8/15	0	10	4/22/15	Wolf
8.5.3	SGA Dark Dewar characterization complete (bias opt., read noise, dark current)	5/7/15	10	10	5/21/15	Wolf
8.5.4.4	SGA Persistence Characterization and Testing Complete	6/4/15	10	10	6/18/15	Wolf/Smith
8.5.4.6	Dewar configured with L6 & L7	6/12/15	0	10	6/26/15	Wolf/Smith
8.5.5	Data reduction sofware complete	6/12/15	30	40	8/7/15	Babler
9.1	**Pre-dewar Enclosure**					
9.1.1.5	**Pre-dewar enclosure detail design complete**	**1/30/15**	**0**	**0**	**1/30/15**	**Wong**
9.1.1.6	**Order remaining enclosure material**	**3/6/15**	**0**	**0**	**3/6/15**	**Wong/Mulligan**
9.1.1.7	**Prep material for machining vendor**	**3/12/15**	**0**	**0**	**3/12/15**	**Smith/Wong**
9.1.1.8	Award pre-dewar enclosure machining and skin layup RFP	3/13/15	2	2	3/15/15	Wong
9.1.1.12	**Machining Complete, delivered to skin layup Vendor**	**4/24/15**	**0**	**0**	**4/24/15**	**Wong**
9.1.1.16	**Layup complete, enclosure delivered to UW**	**6/26/15**	**0**	**0**	**6/26/15**	**Wong**
9.6.2.1	**Inspect and surface treat enclosure**	**7/17/15**	**0**	**0**	**7/17/15**	**Smith**
9.6.2.2	**Skin heaters installed**	**8/14/15**	**0**	**0**	**8/14/15**	**Werner**
9.6.3.2	**Enclosure functionally tested (TBD)**	**9/4/15**	**0**	**0**	**9/4/15**	**Smith**
9.5	**Pre-Dewar & Electronic Enclosures Cooling System Design**					
9.5.2.2	Place order for components	3/2/15	0	12	3/18/15	Adler/Smith
9.5.2.3	Receive components	6/19/15	0	12	7/5/15	Adler/Smith
10	**Slit Cooling**					
10.1.2.1	Detail design complete (shop ready drawings & all components specified)	7/10/15	0	342	-	Smith
11	**Control System**					
11.4.4	Detailed design of cables complete	3/20/15	53	53	6/2/15	Koch
11.3	RFID system assembled and tested	11/10/14			11/10/14	Koch
11.4.5	**Wire Harnesses and cables**					
11.4.5.6	PBS mechanism (power, hall)	3/13/15	0	120	8/28/15	Koch
11.4.5.11	Pre-dewar enclosure cooling system wire harness	4/10/15	40	90	8/14/15	Koch
11.4.5.12	Pre-dewar skin heater wire harness	3/27/15	0	60	6/19/15	Koch
11.4.5.13	Airlock cooling system/interlocks	4/3/15	45	95	8/14/15	Koch
11.4.5.15	Housekeeping wire harness	3/27/15	68	68	6/30/15	Koch

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

RSS-NIR KEY MILESTONES

WBS	DESCRIPTION	TARGET DATE	SLACK (WORKDAYS) FREE	SLACK (WORKDAYS) TOTAL	MUST HAVE BY DATE	RESPONSIBLE TEAM MEMBER
					CRITCAL PATH	TASKS COMPLTED IN THE LAST QUARTER
11.5	**Thermal control systems**					
11.5.3	Pre-dewar enclosure skin heater system ready to be installed on the enclosure	4/24/15	60	60	7/17/15	Werner
11.5.4	Airlock control system ready to be configured to support enclosure thermal testing	6/5/15	50	50	8/14/15	Koch
11.5.5	Pre-dewar enclosure thermal control system configured to support enclosure thermal testing	6/5/15	50	50	8/14/15	Koch
11.5.6	Electronics enclosure thermal control system ready to cool enclosure	5/13/15	166	166	12/31/15	Koch
11.7	**Electronics Enclosure**					
11.7.3	Detail design complete (enclosure and panel layout)	2/13/15	0	117	7/26/15	Koch/Smith
11.7.6	Enclosure Ready	5/1/15	159	159	12/9/15	Smith
11.7.7	**Panel built up**	**12/10/15**	**0**	**0**	**12/10/15**	**Koch**
11.7.8	**Enclosure, with cooling system, assembled**	**12/31/15**	**0**	**0**	**12/31/15**	**Koch**
11.8	**Additional PC Boards (includes mounting bracket fabrication if required)**					
11.8.8	One-wire: Airlock Bulkhead & Exhange Filter Boards	7/31/15	10	10	8/14/15	Koch
11.9.3 Real-time instrument control software (cRIO)						
11.9.3.1	Fold Mirror Tip/Tilt & Nodding	2/27/15	60	60	5/22/15	Percival
11.9.3.7	Polarzing beamsplitter insertion and removal	8/26/15	22	22	9/25/15	Percival
11.9.3.12	Airlock door lock	6/19/15	55	55	9/4/15	Percival
11.9.3.13	Dewar thermal control system	10/5/14	0	20	11/2/14	Percival
11.9.3.14	Pre-dewar thermal control system	7/29/15	12	12	8/14/15	Percival
11.9.3.15	Airlock thermal control system	7/29/15	12	12	8/14/15	Percival
11.9.3.16	Skin heater control system	3/10/15	73	73	6/20/15	Percival
13	**Support Equipment**					
13.3.2.6	Dummy polarizing beamsplitter fabricated	5/6/15	0	72	8/14/15	Smith
14	**Integration, Verification, & Testing at UW**					
14.1	**Towers**					
14.1.1	Commence integration of the upper and lower towers	5/1/15	0	0	5/1/15	Smith
14.1.3	Upper and lower towers integrated and tested. Ready to ship	6/12/15	0	0	6/12/15	Wolf
14.2	**Detector/Dewar/Camera**					
14.2.1	Commence integration of the Detector/Dewar with the Camera	6/15/15	0	10	6/29/15	Smith
14.2.3	Detector/Dewar/Camera integration and testing complete	7/24/15	0	10	8/7/15	Wolf
14.3	**Trusses and Mechanisms**					
14.3.3	Electronic integration and testing complete	3/13/15	38	38	5/5/15	Koch
14.3.4	Alignment and functional testing complete	4/3/15	23	23	5/5/15	Smith/Koch
14.3.5	Verification and endurance testing complete - Room Temperature	7/1/15	0	0	7/1/15	Smith/Koch
14.4	**Dewar/Camera & Articulation Mechanism**					
14.4.1	Completed integration of the Dewar/Camera into the articulation truss	7/31/15	0	10	8/14/15	Smith
14.4.2	Functional testing complete	8/7/15	0	10	8/21/15	Wolf / Smith
14.4.3	Detector / Grating testing	8/14/15	0	10	8/28/15	Wolf / Smith
14.5	**Polarizing Beamsplitter Mechanism**					
14.5.1	PBS integrated and tested	8/21/15	0	10	9/4/15	Smith
14.5	**Pre-Dewar Enclosure Integration**					
14.6.1	**Integrate enclosure, air-lock door, and baffling**	**9/25/15**	**0**	**0**	**9/25/15**	**Smith**
14.6.2	**Functional test mechansims complete**	**10/2/15**	**0**	**0**	**10/2/15**	**Smith**
14.6.3	**Integrate pre-dewar cover complete**	**10/7/15**	**0**	**0**	**10/7/15**	**Smith**
14.6.4	**Configure cooling system complete**	**10/12/15**	**0**	**0**	**10/12/15**	**Smith**
14.6.5	**Verify functionality of the cooling system**	**10/15/15**	**0**	**0**	**10/15/15**	**Smith**
14.6.6	**Cold endurance testing**	**10/29/15**	**0**	**0**	**10/29/15**	**Smith**
14.6.7	**Cold operational testing**	**11/12/15**	**0**	**0**	**11/12/15**	**Smith**

APPENDIX A.

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

SUBSYSTEM	RESPONSIBLE ORG.	SCHEDULED COMPLETE	CURRENT SCHEDULE	ISSUS/CONCERNS/DETAILS	R_P	R_S	Score	Risk	ESTIMATED SCHEDULE SLIP
1. Pre-Dewar Enclosure	UW, Gartner Refrigration, Paradigm Design, and TBD vendors	May 27, 2013	**Sep 4, 2015**	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.	**5.3**	**11.1**	**59.0**	**MAJOR**	Possibly as much as 3-4 months late.
2. Skin Heaters	UW	Mar 23, 2013	**Apr 24, 2015**	1. Testing and verification of the skin heaters may be time consuming.	**5.3**	**1.0**	**5.3**	**MINOR**	3-4 weeks, but no effect on the overall schedule.
3. Slit Cooling	UW	Feb 11, 2013	**Jul 10, 2015**	1. Installation on the telescope is the primary concern.	1	1	1	**MINOR**	-
4. Electronics Enclosure	UW and TBD Vendor	Aug 31, 2013	**Dec 31, 2015**	1. Fitting all of the electronics into the enclosure in a servicable manner.	3.6	7.6	27.4	**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	Nov 10, 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.	-	-	-	-	1-2 weeks, but these tasks are well off the critical path.
5B. Control System - Software	UW	Jun 30, 2013	**Aug 26, 2015**	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.	**5.5**	**1.7**	**9.1**	**MINOR**	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	**Mar 20, 2015**	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	Nov 26, 2015	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.	-	-	-	-	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	**Feb 19, 2015**	1. Infinite Optics has consistently made very slwo progress.	6.0	1.0	6.0	**MINOR**	1 month - would not impact overall schedule
9. Grating	UW	Dec 21, 2012	**Apr 14, 2015**	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	**Dec 19, 2015**	1. No significent issues. Simply need to mount the filters at the appropriate opportunity.	-	-	-	-	4-5 weeks. This would have a direct impact on the overall schedule.
11. Dewar	UW	Nov 16, 2012	**Nov 26, 2015**	1. Conducting the light leak testing may be time consuming due to cooling-testing-warming-modifying-cooling-retesting cycles.	-	-	-	-	4-6 months
12. Detector	UW	Mar 12, 2013	**Jun 12, 2015**	1. The learning curve on the detector has been very challenging and issues seem to come up fequently. 2. Schedule is likely optimistic.	5.4	4.9	26.2	**MODERATE**	2 months. We are very likely to run into issues with the detector.
13. Integration & Instrument Testing	UW	Aug 5, 2013	**Nov 12, 2015**	1. Final testing always takes longer than you plan. 2. Expected unknown problems.	5.3	9.2	48.8	**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, resouces under project control, schedule is good
2	Remote	4 of 5 are true: Task is understood, experienced staff, resources available, resouces under project control, schedule is good
3	Possible	3 of 5 are true: Task is understood, experienced staff, resources available, resouces under project control, schedule is good
4	Likely	2 of 5 are true: Task is understood, experienced staff, resources available, resouces under project control, schedule is good
5	Very Likely	1 of 5 are true: Task is understood, experienced staff, resources available, resouces under project control, schedule is good
6	Extremely Likely	0 of 5 are true: Task is understood, experienced staff, resources available, resouces under project control, schedule is good

SCHEDULE IMPACT, R_S

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

SCHEUDLE 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 ~ 3000 at 0.9 microns to R ~ 7000 at 1.7 microns for a 1 arcsec slit.

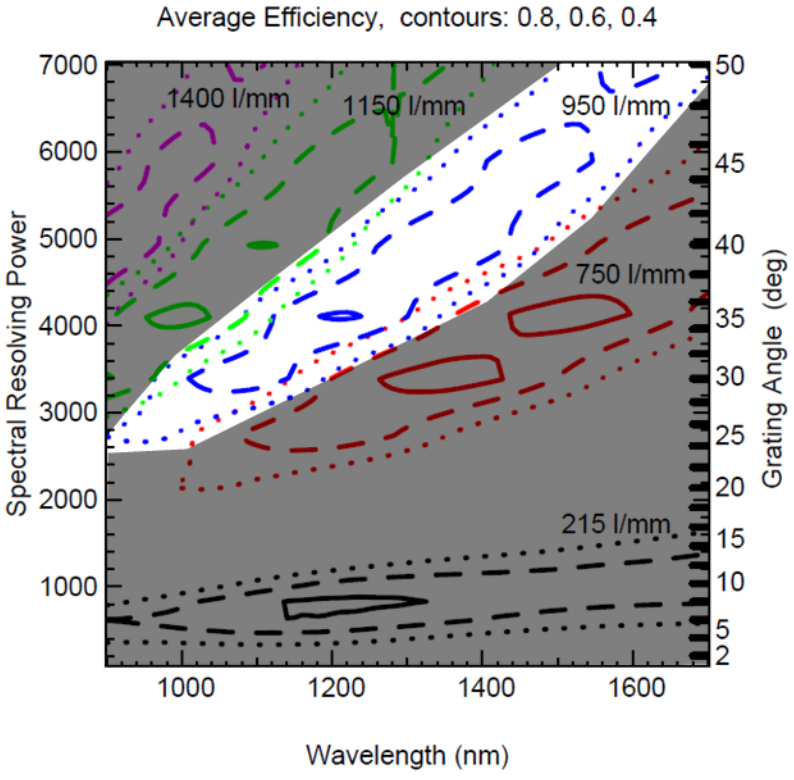


Figure B1. *Predicted performance of the full RSS-NIR grating suite. The spectral resolving power is for a 1 arcsec slit. Initially, only the 950 l/mm grating will be installed. The gray areas mark parameter space that will not be accessible without more gratings.*

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)	$250
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

Without slit cooling, sky-limited spectroscopy will only be possible out to a maximum wavelength of 1.55 microns. This is the only long wavelength cutoff filter that has been purchased.

The design includes long wavelength cutoff filters at 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. Performance statistics of the amount of time sky-limited spectroscopy would be possible, based on SALT weather archives, at different cutoff wavelengths are shown in Figure B2.

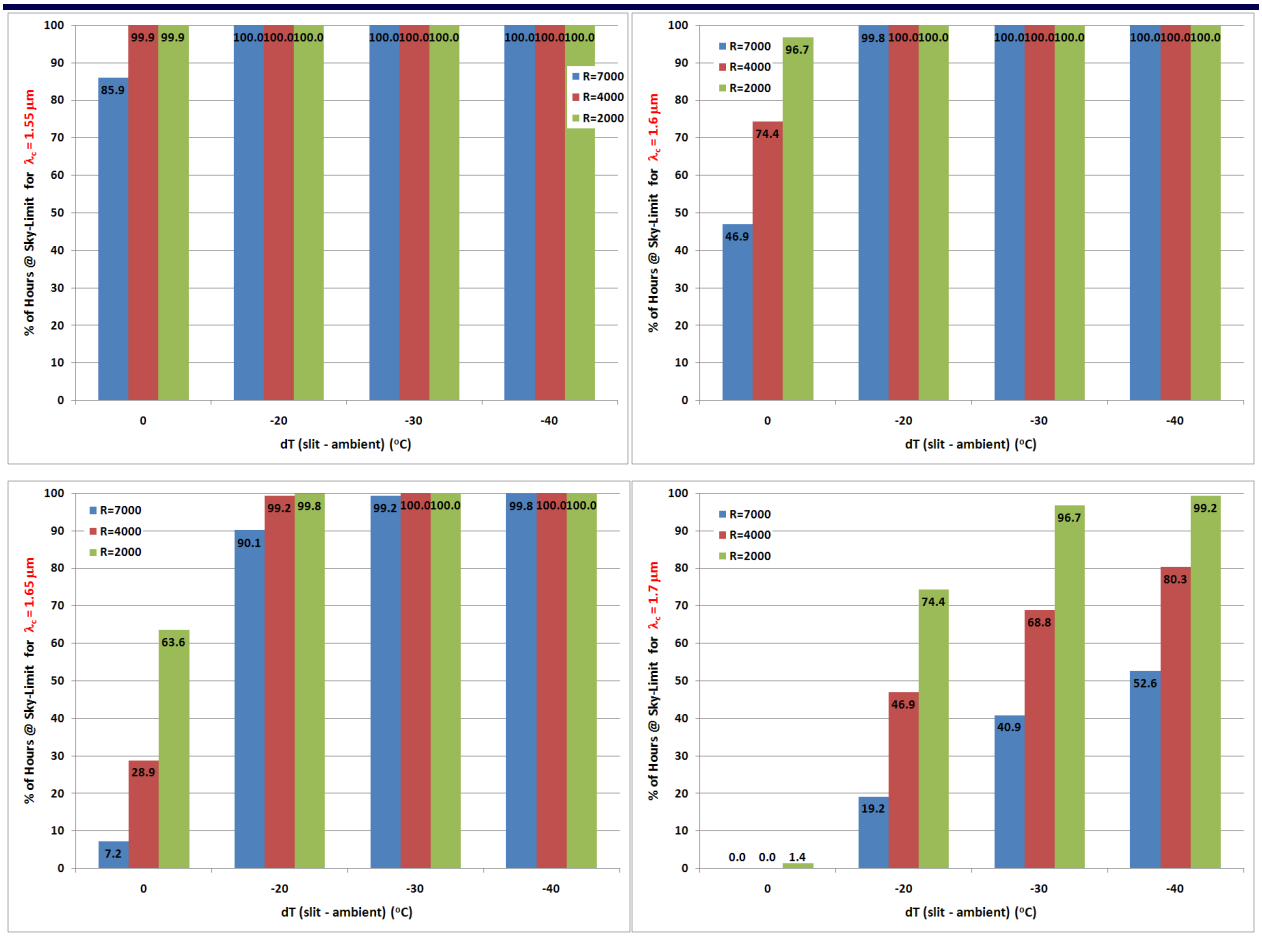


Figure B2. *Based on past SALT temperature statistics, this shows the predicted percentage of dark hours per year during which observations with a cooled slit would be possible at different cutoff wavelengths. We expect to be able to cool the slit to 20 °C below ambient temperature. This would mean, for example, at R = 7000 sky-limited observations out to 1.7 microns would only be possible 19% 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.*

The addition of slit cooling or extra cutoff filters (for the cryogenic dewar filter wheel) would require removal of RSS-NIR from the telescope.

B5. Broadband imaging

We plan to utilize the Maunea 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 ~ 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.

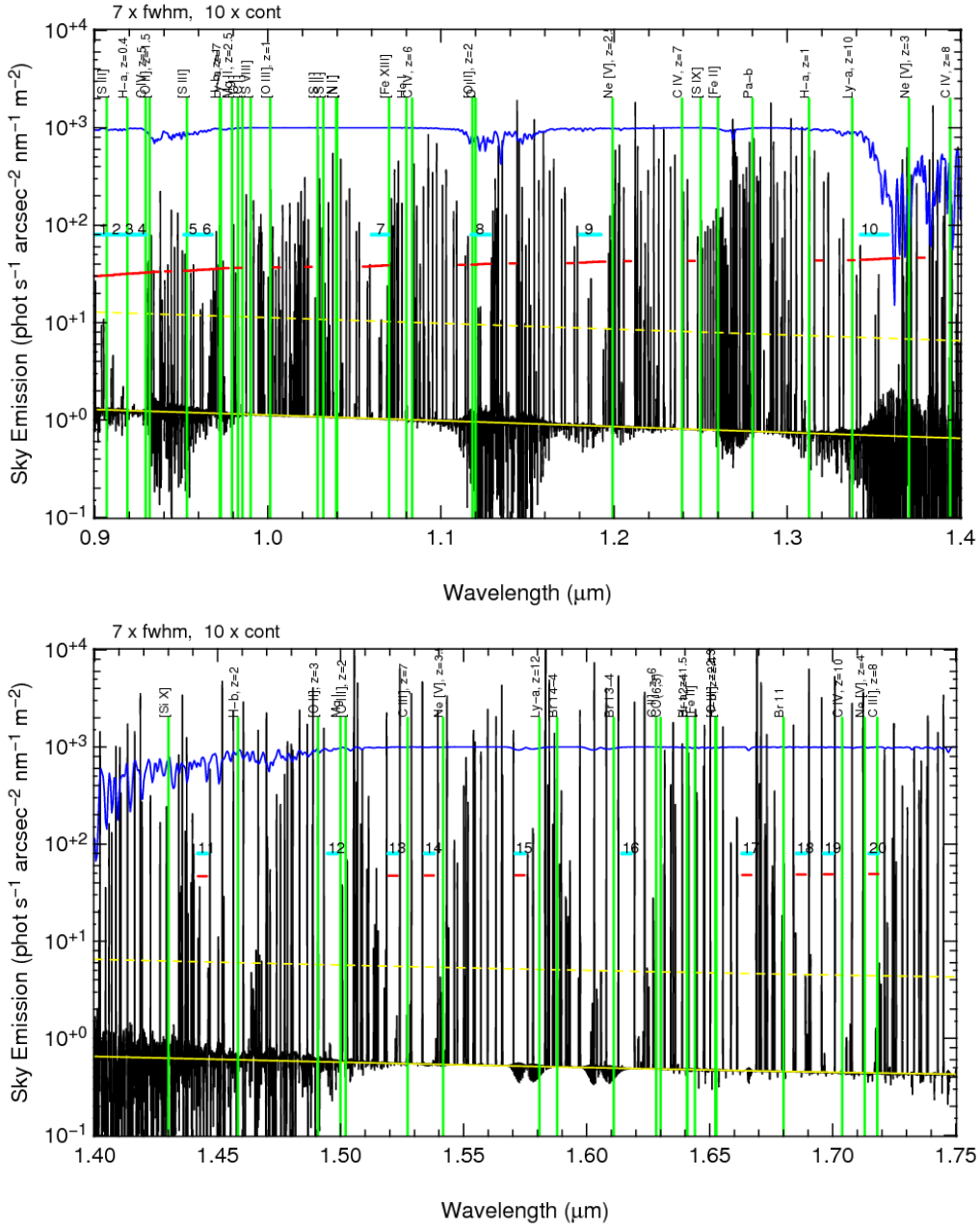


Figure B3. *In black is a night sky spectrum from Maunea Kea in Hawaii. Atmospheric transmission is shown in blue (with arbitrary scaling). The solid yellow line is a fit to the sky continuum and the dashed yellow line marks 10 times the continuum level. Possible Fabry-Perot filter locations are marked 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.