SALT RSS-NIR
MID-TERM REVIEW
MAY 20 & 21, 2009

INTRODUCTION

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• History
• Telescope/Instrument Introduction
• Optical layout/components
• Definitions
• Risks
• Concerns from PDR
Overview

- semi-warm, near infrared spectrograph
- complement the RSS-Visible on SALT
- major upgrade anticipated since Day 1
- 2K x 2K Hawaii 2RG focal plane
- wavelength range from 0.85 to 1.7 µm
- resolution of up to 14,000 (0.5 arcsec slit)
- 5 Volume Phase Holographic gratings,
- 12 filters (FP order blocking filters and imaging filters)
- 3 cryogenic long wavelength blocking filters
- high-throughput, medium resolution multi-object spectroscopy
- Spectropolarimetry
- Fabry-Perot imaging
HISTORY

- Passed CoDR, May 2006, Capetown SA
  - SALT granted $145K to proceed to PDR
- Granted $3.3M from UW WARF Foundation, May 2008
  - Ramp up resources, partner with SSEC
- Officially Passed PDR July 2008
- Granted $2.0M, NSF MRI program 9/2008
  - Hire 2 ME, 1 postdoc
  - Major engineering effort
- Several concerns raised during PDR, panel requested an MTR before major purchases
The SALT Telescope

- 10m-class Optical Telescope
- Fixed Elevation
- 91 segments make up the spherical primary mirror
- Tracker performs all precision motions
SALT Payload Details:

Prime Focus Payload mounts via hexapod to tracker bridge and comprises:

- Prime Focus Imaging Spectrograph (PFIS/RSS)
- Acquisition camera
- Guidance & focus System
- Optical fiber feed
- Pupil baffle
- Atmospheric dispersion corrector (ADC)
- Spherical aberration corrector
- Calibration system
- 4 instrument foci fed by 45 deg “fold” mirrors
Payload structure (rotating & non-rotating components) made of carbon composite

- Dummy PFIS/RSS mass
- Instrument rotator ring
- Hexapod legs
- SAC
- Tracker beam
Optical layout/Components

Dewar 120 K

Pre-dewar -40 °C

RSS-NIR beam

RSS-VIS beam

Ambient T

Grating

F-P Order Blocking Filter

Fold Mirror

RSS-NIR Doublet

Dichroic

RSS-VIS Doublet

Detector & Field Flatner

L6: Dewar Window

Camera: L1 to L5

Collimator

Slit

RSS-NIR beam

RSS-VIS beam

Polarizing Optics

Field Lens
Definitions

• **RSS-Vis**: Robert Stobie Spectrograph (visible side) for SALT formerly Prime Focus Imaging Spectrograph (PFIS)
• **RSS-NIR**: Robert Stobie Spectrograph for SALT (NIR side)
• **Pre-Dewar**: -40C cooled enclosure for RSS-NIR
• **Cryogenic Dewar**: 120K cooled enclosure for detector, 3 blocking filters and field flattener
• **Camera**: focussing optics and housing not located in Dewar
Definitions

• **Doublet**: last two collimator optics before collimated space, one each for visible and NIR
• **F-P**: Fabry-Perot etalon
• **Filters**: J,H, line and order blocking filters at -40°C
• **Dichroic**: dichroic beamsplitter, reflecting visible < 0.85, transmitting NIR > 0.85
• **Polarizing beamsplitter**: Wollaston prism array for polarization studies
## System Specs

<table>
<thead>
<tr>
<th>Optical</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Telescope Aperture</td>
<td>11 meters</td>
</tr>
<tr>
<td>Telescope focal ratio</td>
<td>f/4.18</td>
</tr>
<tr>
<td>Collimator Focal Length</td>
<td>302 mm</td>
</tr>
<tr>
<td>Camera Focal Length</td>
<td>220 mm</td>
</tr>
<tr>
<td>Image space F/#</td>
<td>1.4289</td>
</tr>
<tr>
<td>Efl</td>
<td>15718.39 mm</td>
</tr>
<tr>
<td>Plate scale</td>
<td>76.205 µm/arcsec</td>
</tr>
<tr>
<td>Plate scale</td>
<td>4.233 pixels per arcsec (18 µm pixels)</td>
</tr>
<tr>
<td>Image Quality</td>
<td>Pixel limited in all modes, 2 pixels = 0.5 arcsec</td>
</tr>
<tr>
<td>Field of View</td>
<td>8 arcmin dia (imaging), 8 x 8 arcmin (spectroscopic)</td>
</tr>
</tbody>
</table>
## System Specs

<table>
<thead>
<tr>
<th>Spectroscopy</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength Coverage</td>
<td>0.9 – 1.7 μm, Δλ = 0.8 μm</td>
</tr>
<tr>
<td>Gratings</td>
<td>4 articulated VPHGs, 1 conventional low R grating</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>800, 2000-7000 (1 arcsec slit)</td>
</tr>
</tbody>
</table>
| Free Spectral Range (FSR) in one grating setting | FSR ~ 0.13 μm @ R ~ 2000  
FSR ~ 0.11 μm @ R ~ 4000  
FSR ~ 0.09 μm @ R ~ 7000  
R~800 conventional grating to cover entire range, FSR = 0.8 μm |
| Pixel Scale                               | 0.24  |
| Field of View                             | 8 x 8 arcmin |
| Multiplex                                 | Laser-cut MOS masks, up to 40 slits per mask |
| Throughput                                | 45%, not including telescope |
| Detector                                  | 2048 x 2048 Teledyne Hawaii 2RG and ASIC, 18 μm pixels, long-wavelength cutoff @1.7 μm |
## System Specs

<table>
<thead>
<tr>
<th>Fabry-Perot Imaging</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Resolution</td>
<td>2500</td>
</tr>
<tr>
<td>Field of View</td>
<td>8 arcmin dia</td>
</tr>
<tr>
<td>Etalon Finesse</td>
<td>50</td>
</tr>
<tr>
<td>Order Blocking Filters</td>
<td>R ~ 50, 12 filters covering discrete atmospheric windows in J and H bands</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spectropolarimetry</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Polarization Measurements</td>
<td>linear, circular, all stokes</td>
</tr>
<tr>
<td>Instrument Modes</td>
<td>imaging, spectroscopy</td>
</tr>
<tr>
<td>Field of View</td>
<td>4 x 8 arcmin</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Imaging</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Field of View</td>
<td>8 arcmin dia</td>
</tr>
<tr>
<td>Broadband Filters</td>
<td>Y, J, H</td>
</tr>
</tbody>
</table>
Major Risks

- Thermal background
- Flexure
- Thermal enclosure
  - Cool down
  - Access
- Test and integration
  - Limited access to real system
- Detector
- Reliability
- Polarizing Beamsplitter
Minor Risks

- Optical Fabrication
- Focusing mechanism
- Can’t test the Collimator until Cape Town
- Astigmatism introduced by the Dichroic
- Will Tracker mods meet the RSS-NIR Weight
- Sealing the pre-Dewar
- Condensation issues
- Index matching fluid in Doublet at 40C
- Slit mask reliability
PDR Concerns

• Re-consider the moving seal
• Investigate allowing space for more filters
• Re-visit beam-size as part re-evaluation of optical design
• Investigate re-engineering the slit-mask and initial collimator elements to allow cooling to -20°C to enable full H-band performance
• Concern at the understanding of FP implementation issues
• Mechanical design not fully developed to appropriate level for PDR
• SALT should provide a better ICD protocol for weight
• 3-element ADC design:
• ASAP modeling should be performed at warmer ambient temperatures and include possible long wavelength tail on detector QE response
PDR Concerns continued

- Flexure control via articulation of the folding flat mirror
- Filter/grating exchange mechanism design not mature
- Number of cryogenic blocking filters, not fully determined
- Delivered finesse of cooled FP
- SALT deliverables: 3 element ADC and AR coating and Calibration Unit
- Optical/NIR simultaneity not well justified
- Slit and collimator emissivity mitigation not fully analyzed
- No exchangeable dichroic
- FP design optimization in context of OH lines
PDR Concerns continued

• No tilting of Interference Filters
• Filter Exchange Box design very conceptual:
• Justification of nodding fold mirror required
• IQ specs for optics
• Faster f-ratios to give a better matching of the pixel-size
• Incomplete Collimator design
• Grating mount flexure
• Mechanical tolerancing incomplete.