Robert Stobie  
Prime Focus Imaging Spectrograph  
Status  
K Nordsieck

- On-Sky Performance  
  - Throughput/ grating performance completed  
  - Total efficiency, comparison with Keck/LRIS  
  - Time dependence data  
  - Configuration, simulator update  
  - Still looking for commissioning proposal reports

- Calibration/ Reduction issues  
  - Imaging and spectral flats

- Acceptance Data Package  
  - Efficiency, FP numbers completed  
  - Still to complete: PSF, Polarimetry

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RSS Optics, Grating Efficiency

- 579 spec standard observations, 4/1/2011 – 8/1/2012
- all gratings, 21 stars, 118 configs
- saltclean, spec model wavelengths, python extraction
- from obs/ expect remove:  
  - Sutherland mean extinction  
  - P Vaisanen telescope throughput, pupil  
  - RSS QE from SAAO, 2008

- grating efficiency from RCWA, Kogelnik models (5x2 params)

- grey shift up to minimize optics efficiency rms, 10D downhill simplex

- 300 l/mm SR grating 20% low
- 900 l/mm blaze width low
- all others to spec

Optics Efficiency

Optics Efficiency

Grating Efficiency  
- dash: blaze;  
- solid: superblaze
This Analysis (2011-2012)  Predicted 2014 (after triplet and doublet repair)

- Compute RSS on-sky total spectral efficiency = Optics×Grat×Dtr
- Keck LRIS on-sky total efficiency from similar analysis
  (http://www2.keck.hawaii.edu/inst/lris/specEffOldRed.html)
- Now, we're ~20% below LRIS
- After fix, will be 20% above
- Favorable difference mainly due to RSS VPH gratings, articulated spectrograph

Time Dependence

- Analysis allows extraction of apparent transparency vs time
- Only use 4 arcsec slit observations
- No evidence of change in RSS × Telescope efficiency over first year of operation, at 10% level
**Configuration, Simulator Updates**

- New grating model allows reassessment of current spectroscopic configurations
  - Would improve mean efficiency over spectrum by 3-8% by correcting current grating angle offset from Littrow (1.4 deg)
  - Sensitivity of 900 l/mm due to narrow blaze
  - Would slightly move gaps. Implement for next semester?
- New optics, grating efficiency data allows revision of simulator
  - Replace current "reality factor" by actual RSS and telescope spectral efficiencies
  - Currently being checked out (by simulating actual standard star observations)
  - Overall change in predicted S/N not large => old simulator was reasonable, except 300 l/mm was optimistic and 3000 l/mm was pessimistic.

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**Commissioning Project Reports**

- Received some report on 16 of 30 commissioning proposals
- Especially interested in velocity, res, and uv tasks
- green: received since board papers
- Please?

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FlatField Calibration

• Original plan: use cal system + moving baffle to simulate uniformly illuminated field across track (daytime)
• Problems:
  – Cal system far from uniform
  – Significant vignetting (both cal system and telescope) occurs neither at pupil nor field stop. Moving baffle only simulates vignetting at pupil
• Possible remedies:
  – Use sky background to observe flat (can be done now)
  – Devise dome cal screen to simulate sky (future?)
  – Use model of vignetting to correct single flat (either daytime cal sys or sky) to actual track. Pursuing this one. Collect data to validate model, using sky background flats and a pupil map technique.

Pupil Mapping

• Flatfield (response over field of view \( h \)) is integral of telescope/instrument response over pupil \( p \) and track \( t \) to illumination \( I(h) \)

\[
F(h) = \int_{p} \int_{t} I(h) × R_{tel}(h,p,t) × R_{inst}(h,p)
\]

• Our problem is that, with telescope vignetting occurring neither at pupil nor field stops, \( R_{tel}(h,p) \neq R_{tel}(h) × R_{tel}(p) \), which would allow the pupil dependence to be separated
• So, model \( R_{tel} \) from imaging data where \( R_{inst} = \text{const} \)
  – Slitmask of small holes on Cartesian grid
  – RSS filter removed to take out of focus
  – shows \( R(p) \) at each FOV position \( h \)
  – model \( R(p) \) with Zernike polynomials \( Z_{j}(h) \)
  – (show: QTH lamp. \( Z(h) \) not flat \( \Rightarrow \) pupil is a function of FOV position \( h \), demonstrates cal system illumination problem)
• For non-imaging instrument modes, will also need \( R_{inst}(h,p) \), i.e. due to VPH nonuniformity
Acceptance Package, To Do

- Previously Done
- Grating, Fabry Perot (since last Board)
- Optics imaging performance, PSF (KN, July)
- Polarimetry: Use 2011 commissioning data (KN, July)

Acceptance Package I

<table>
<thead>
<tr>
<th>Param</th>
<th>Description</th>
<th>Specification</th>
<th>Pre-Delivery Measurement</th>
<th>Post-Delivery Measurement</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1.1</td>
<td>Imaging Field Size</td>
<td>8 arcminute diameter</td>
<td>PASS</td>
<td>8.12 arcminutes</td>
<td>1 Set by machined aperture in slitmask</td>
</tr>
<tr>
<td>2.1.2</td>
<td>Slit Mask Capability</td>
<td>Arbitrary features down to 0.45 arcsec</td>
<td>PASS</td>
<td>2 detector</td>
<td>CONCEDE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Collimation measured with Fabry-Perot ghosts</td>
<td>3</td>
</tr>
<tr>
<td>2.1.3</td>
<td>Image Quality</td>
<td>See FPRD Table 1</td>
<td>PASS</td>
<td>Imaging mode tested at 629 nm</td>
<td>4</td>
</tr>
<tr>
<td>2.1.4</td>
<td>Focus Range</td>
<td>+/- 400 microns</td>
<td>PASS</td>
<td>+/- 500 microns</td>
<td>Range extended to accommodate actual filter thickness</td>
</tr>
<tr>
<td>2.1.5</td>
<td>Detector Pixel Scale</td>
<td>0.128 arcsec/pixel</td>
<td>PASS</td>
<td>0.118 arcsec/pixel</td>
<td>After SALT ADC remount</td>
</tr>
<tr>
<td>2.1.6</td>
<td>Flexure</td>
<td>Dispersion direction: &lt;0.1 arcsec/track Perp. to dispersion: &lt;0.15 arcsec</td>
<td>FAIL</td>
<td>CONCEDE: Dispersion direction: —0.2 arcsec/track Perp. To dispersion: —0.3 arcsec/track</td>
<td>Detailed Imaging mode flexure data at rho +/- 100 deg</td>
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<tr>
<td>2.1.7</td>
<td>Transmission</td>
<td>See FPRD Table 2</td>
<td>PASS</td>
<td>~70% of expected (grey)</td>
<td>~65% of FPRD Min</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Collimator/Camera ghost</td>
<td>&lt; 10^4</td>
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<tr>
<td>2.2.1</td>
<td>Spectroscopy FOV</td>
<td>8 arcmin diameter</td>
<td>PASS</td>
<td>(PASS)</td>
<td>(PASS, except 900 l/mm) red: (Low)</td>
</tr>
<tr>
<td>2.2.2</td>
<td>Max Resolution</td>
<td>1.25 arcsec slit R=5300</td>
<td>PASS</td>
<td>0.6 arcsec slit R=10000</td>
<td>11</td>
</tr>
<tr>
<td>2.2.3</td>
<td>Grating Efficiency</td>
<td>&gt;</td>
<td>PASS</td>
<td>12</td>
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<tr>
<td>2.2.4</td>
<td>Central Wavelength</td>
<td>Precision</td>
<td>AA, &lt;1 nm x (300/ )</td>
<td>PASS</td>
<td>PASS</td>
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<tr>
<td>2.3.1</td>
<td>Etalon Resolution</td>
<td>&lt;0.135 (900 l/mm) nm R<del>1200 R</del>3000</td>
<td>320 66% 80%</td>
<td>350 66% 72%</td>
<td>400 69% 75%</td>
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</table>

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## Acceptance Package II

<table>
<thead>
<tr>
<th>Req #</th>
<th>Description</th>
<th>Specification</th>
<th>Pre-Delivery Measurement</th>
<th>Post-Delivery Measurement</th>
<th>On-telescope Measurement</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3.2</td>
<td>FP Spectral Range</td>
<td>430 — 860 nm</td>
<td>PASS</td>
<td>15</td>
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<tr>
<td>2.3.3</td>
<td>FP Field of View</td>
<td>8 arcminute diameter</td>
<td>PASS</td>
<td>16</td>
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<tr>
<td>2.3.4</td>
<td>FP Wavelength Gradient</td>
<td>(2r = 1.0c \cos(4.877° x r/4))</td>
<td>PASS</td>
<td>17</td>
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<tr>
<td>2.3.5</td>
<td>FP Wavelength Precision</td>
<td>FWHM/50 LR: /120, MR: /170, HR: /220, MR: /48, HR: /56</td>
<td>PASS</td>
<td>18</td>
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<tr>
<td>2.3.6</td>
<td>FP Wavelength Stability</td>
<td>FWHM/3 per hour (MR: 1.35 Ang per hour)</td>
<td>PASS</td>
<td>19</td>
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<tr>
<td>2.3.7</td>
<td>FP Wavelength Set Time</td>
<td>2 msec, 100 msec</td>
<td>CONCEDE</td>
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<tr>
<td>2.3.8</td>
<td>FP Efficiency</td>
<td>75% minimum (approximately achromatic); 80% expected (approximately achromatic)</td>
<td>CONCEDE</td>
<td>60% Blue</td>
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<tr>
<td>2.4.2</td>
<td>Polarimetric Efficiency</td>
<td>Linear: &gt;95%, calibrated to better than ±0.5%. Circular: &gt;92%, calibrated to better than ±0.5%.</td>
<td>NO TEST</td>
<td>(PASS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4.3</td>
<td>Instrumental Polarization</td>
<td>Linear: &lt;0.4%, calibrated to &lt;0.04%. Linear to circular&lt;3x10^{-3}, calibrated to &lt;3x10^{-4}</td>
<td>NO TEST</td>
<td>(PASS)</td>
<td></td>
<td></td>
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<tr>
<td>2.4.4</td>
<td>Position Angle Repeatability</td>
<td>Repeatability &lt;6 arcminutes</td>
<td>NO TEST</td>
<td>&lt;1.8 arcminutes</td>
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<tr>
<td>2.4.5</td>
<td>Transmission</td>
<td>70% of spectroscopic/imaging modes at 650 nm</td>
<td>NO TEST</td>
<td>&gt;70%</td>
<td>Have Data</td>
<td></td>
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<tr>
<td>2.5.1</td>
<td>CTE</td>
<td>CTE=99.9995% (typical), 99.999% (guaranteed).</td>
<td>NO TEST</td>
<td>&gt;99.9995%</td>
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<td></td>
</tr>
<tr>
<td>2.5.2</td>
<td>Full Well</td>
<td>200 k e^7pix (typical) 150 k e^7pix (guaranteed).</td>
<td>NO TEST</td>
<td>&gt;153 ke^7pix</td>
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<tr>
<td>2.5.3</td>
<td>Sensitivity</td>
<td>See FPRD Table 5.</td>
<td>PASS</td>
<td>See Table below</td>
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<tr>
<td>2.5.4</td>
<td>Dark Current</td>
<td>Dark current of 1 e^7pix/hr (typical) at 163 K</td>
<td>NO TEST</td>
<td>LATER: &lt;1.5e^7pix/hr</td>
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<tr>
<td>2.5.5</td>
<td>Readout Noise</td>
<td>3.0 e^7pix at 100kHz (10.0 psec/pix) TBC; 5.0 e^7pix at 345 kHz (2.9 psec/pix) TBC</td>
<td>See table below</td>
<td>See table below</td>
<td></td>
<td></td>
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<tr>
<td>2.5.6</td>
<td>Gain</td>
<td>Software selectable from : x1; x2; x4.75; x9.5</td>
<td>PASS: see table below</td>
<td>See Table</td>
<td></td>
<td></td>
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<tr>
<td>2.5.7</td>
<td>Prebinning</td>
<td>/x/ to 9x9, independently in each direction</td>
<td>PASS</td>
<td></td>
<td></td>
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<tr>
<td>2.5.8</td>
<td>Readout Speed</td>
<td>Frame transfer architecture: 0.103 sec frame transfer time 100—345 kHz (10-2.9 psec/pix) FAST; 4.102微秒/pix SLOW</td>
<td>See FPRD Table 6 for detector readout times.</td>
<td>See FPRD Table 6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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