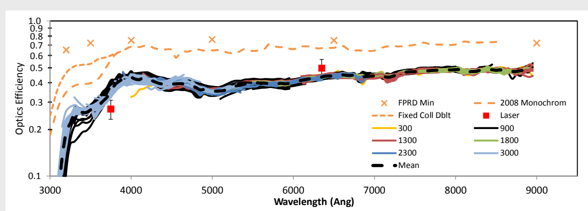
Robert Stobie
Prime Focus Imaging Spectrograph
Status

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

RSS Optics, Grating Efficiency

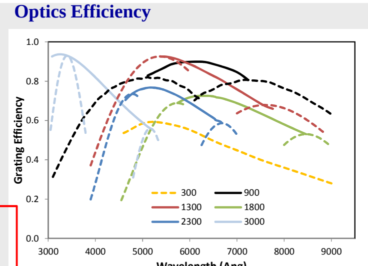
- 579 spec standard observations , 4/1/2011 – 8/1/2012
- all gratings, 21 stars, 118 configs
- saltclean, spec model wavelengths, python extraction
- from obs/ expect remove:
  - Sutherland mean extinction
  - P Vaisanen telescope throughput, pupil
  - RSS QE from SAAO, 2008
- grating efficiency from RCWA, Kogelnik models (5x2 params)
- grey shift up to minimize optics efficiency rms, 10D downhill simplex



Optics Efficiency

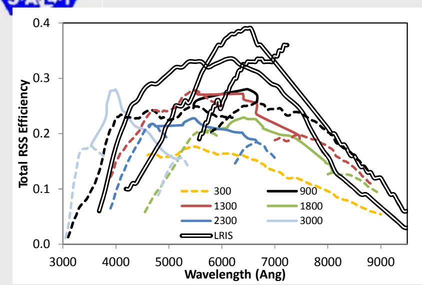
Grating	dn	thick	Trans
PG0300	-	-	0.801
PG0900	0.075	3.976	0.979
PG1300	0.102	2.761	0.939
PG1800	0.165	2.238	0.843
PG2300	0.157	2.017	0.944
PG3000	0.073	2.473	1

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

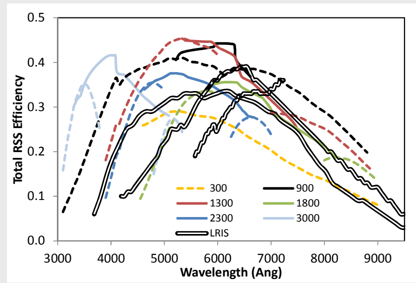


Grating Efficiency. dash: blaze; **solid**: superblaze

RSS Total Efficiency vs LRIS



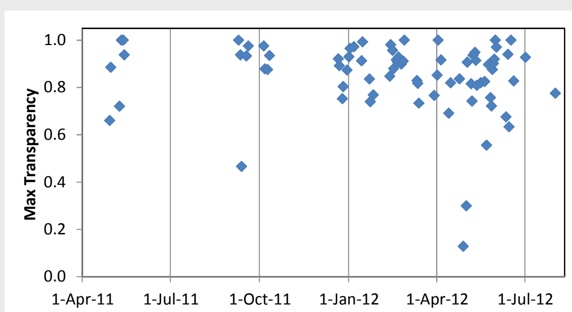
This Analysis (2011-2012)



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

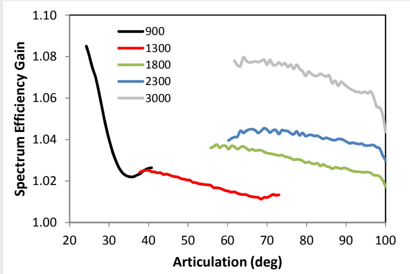
Time Dependence

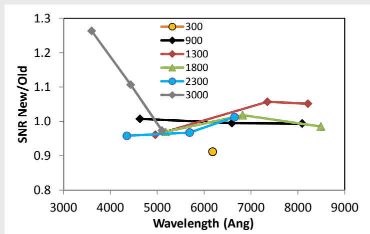


- Analysis allows extraction of apparent transparency vs time
- Only use 4 arcsec slit observations
- No evidence of change in RSS × Telescope efficiency over first year of operation, at 10% level

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.





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?**

Code (2010-1-)	PI	Vis	Task1	Task2	Report
DC-002	fesen	14	UV		
POL-002	czerny	1	sigma		**UW Help offered**
POL-003	konacki	3	res	vel_stability	Cal Issues (new data)
POL-004	pietrukowicz	1			
POL-005	koziel-wierzbowska	2	z		
POL-006	szczerba	3	line_ratios		Poor S/N (new data)
RSA-003	menzies	1	hiSN		
RSA-004	kniazev	1	res	hiSN	Not useful; conditions
RSA-007	kniazev	1			Standards only
RSA-009	odendaal	1	vel		
RSA-013	menzies	1			
RSA_OTH-001	kniazev	26	line_ratios		Line ratios 5-10%
RSA_OTH-002	kniazev	15	stellar_pops		
RSA_OTH-005	vaisanen	8	vel	stellar_pops	**Working**
RSA_OTH-012	kniazev	18	sigma	stellar_pops	Efficiency
RSA_OTH-013	kniazev	12	uv		Red Fringing
RSA_OTH-014	loaring	1			
RSA_OTH_IUCAA-001	barway	20	vel	stellar_pops	
RSA_POL_OTH-001	charles	2	vel		
RSA_RU-001	hilton	2			Not useful (was MOS)
RSA_UKSC-003	rajoelimanana	7			
RSA_UKSC_GU-001	jeffery	6	res	vel_stability	Narrow slit: poor S/N
RSA_UKSC_OTH-002	charles	5	vel		
RSA_UW-001	holwerda	1			**MOS (2012 SALT mtg)**
UC-001	albrow	14	uv	res	
UKSC-002	sarre	2	uv	faint_limit	Blue spectrum excellent, exceptionall high S/N
UKSC-004	sarre	2	hiSN	res	Good, working on S/N
UKSC-005	smith	26	hiSN	res	Mixed, working
UKSC_OTH-001	mcbride	3			
UNC-002	stark	3	uv		

FlatField Calibration

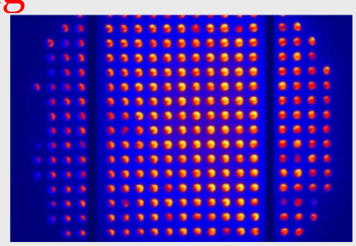
- Original plan: use cal system + moving baffle to simulate uniformly illuminated field across track (daytime)
- Problems:
  - Cal system far from uniform
  - Significant vignetting (both cal system and telescope) occurs neither at pupil nor field stop. Moving baffle only simulates vignetting at pupil
- Possible remedies:
  - Use sky background to observe flat (can be done now)
  - Devise dome cal screen to simulate sky (future?)
- Problems:
  - simulating whole track requires very lengthy on-sky observations, greatly lowering efficiency
  - screen very close to payload; difficult to simulate payload vignetting
- 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

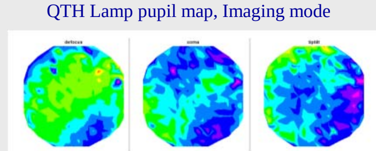
- Flatfield (response over field of view *h*) is integral of telescope/instrument response over pupil *p* and track *t* to illumination *I(h)*

$$F(h) = \int_p \int_t I(h) \times R_{tel}(h,p,t) \times R_{inst}(h,p)$$

- Our problem is that, with telescope vignetting occurring neither at pupil nor field stops, $R_{tel}(h,p) \neq R_{tel\ h}(h) \times R_{tel\ p}(p)$, which would allow the pupil dependence to be separated
- So, model R_{tel} from imaging data where R_{inst} = 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 $Z_p(h)$
  - (show: QTH lamp. *Z(h)* not flat => 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



QTH Lamp pupil map, Imaging mode



3 largest Zernike amplitudes: variation over FOV

- Pupil map Commissioning Projects:
  Imaging: 2012-2-UW-006
  Longslit: 2013-1-UW-006

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

FPRD Req #	Description	Specification	Pre-Delivery Measurement	Post-Delivery Measurement	On-telescope Measurement	#	Comments
2.1.1	Imaging Field Size	*8 arcminute diameter*	**PASS; 8.12 arcminutes**			1	Set by machined aperture in slitmask frame.
2.1.2	Slit Mask Capability	*Arbitrary features down to 0.45 arcsec*	**PASS**			2	
2.1.3	Collimation	*< 60 micron defocus at detector*	**CONCEDE**		Collimation measured with Fabry-Perot ghosts	3	
2.1.4	Image Quality	*See FPRD Table 1*	**PASS**		Imaging mode tested at 629 nm	4	
2.1.5	Focus Range	*+/- 400 microns*	**PASS; +/- 500 microns**	**PASS: 1.5 mm full range**	**+/- 600 microns**	5	Extended to accomodate actual filter thicknesses
2.1.6	Detector Pixel Scale	*0.128 arcsec/pixel*	**PASS**		**0.118 arcsec/pixel**	6	After SALT ADC remount
2.1.7	Flexure	*Dispersion direction: <0.1 arcsec/track Perp. to dispersion: <0.15 arcsec/track*	***FAIL***	***CONCEDE: Dispersion direction: —0.2 arcsechrack Perp. To dispersion: —0.3 arcsechrack***	Detailed Imaging mode flexure data at rho +/- 100 deg	7	
2.1.8	Transmission	*See FPRD Table 2*	**PASS**		**~70% of expected (grey) ~65% of FPRD Min**	8	(Low)
2.1.9	Stray Light	*Collimator/Camera ghost brightness < 10^4*	**PASS: 434 nm: $1.6x10^5$ 629 nm: $2.9x10^5$**		**problem found at filter stations 1 and 20**	9	
		Disperser (focused) ghost brightness <$1 0^{-3}$	**CONCEDE**				
2.2.1	Spectroscopy FOV	*8 arcmin diameter*	**PASS**			10	
2.2.2	Max Resolution	*1.25 arcsec slit R=5300 0.6 arcsec slit R= 10000*	**PASS**			11	
2.2.3	Grating efficiency>	*nm R~1200 R~3000 320 62% 70% 350 66% 80% 400 66% 72% 500 69% 75% 650 75% 75% 900 55% 55%*	***PASS***		**nm R~1200 R~3000 320 42% 79% 350 55% 90% 400 70% 81% 500 79% 80% 650 76% 86% 900 63% 55%**	12	(PASS, except **red:** 900 l/mm)
2.2.4	Central Wavelength Precision	*AA, <1 nm x (300/σ)*	**PASS**	**PASS**	**<0.135 (900 l/mm)**	13	(PASS)
2.3.1	Etalon Resolution	*Low Res: R=500-1000*	**CONCEDE: TF: 250-370 LR: 600-780**		**LR: 378-549**	14	(Low)
		Mid Res: R=2500	**CONCEDE: 1300-1750**		**MR: 1609**		

Acceptance Package II

FPRD Req #	Description	Specification	Pre-Delivery Measurement	Post-Delivery Measurement	On-telescope Measurement	#	Comments
		High Res: R=12500	**CONCEDE: 5500-9500**		**HR: 10206**		(Low)
2.3.2	FP Spectral Range	*430 — 860 nm*	**PASS**		**430 - >900 nm**	15	(PASS)
2.3.3	FP Field of View	*8 arcminute diameter*	**PASS**		**8.03 arcmin dia**	16	(PASS)
2.3.4	FP Wavelength Gradient	2r=i1c *cos(4.877° x r/4) (?(4') = 0.9964 ?(0))*	**PASS**		**λ(4') = 0.9964 λ(0)**	17	(PASS)
2.3.5	FP Wavelength Precision	*FWHM/50*	***PASS*** **TF: /120 LR: /220 MR: /170 HR: /48**		**LR: /100 MR: / 56 HR: / 50**	18	(PASS)
2.3.6	FP Wavelength Stability	*FWHM/3 per hour (MR: 1.35 Ang per hour)*	**LR: PASS MR: PASS HR:** ***NO TEST***	**HR: PASS**	**MR: 1.0 Ang/hour**	19	(PASS)
2.3.7	FP Wavelength Set *Time*	*2 msec*	**CONCEDE 2 msec in controller, 100 msec practical in Labview**		**100 msec**	20	Not a problem.
2.3.8	FP Efficiency	*75% minimum (approximately achromatic); 80% expected (approximately achromatic).*	**CONCEDE 60% Blue 85% Red**		**LR: 57 - 83% MR: 55 - 89% HR: 49 - 78%**	21	(Low)
2.3.9	Parasitic Light	*Low Res: <1.5%*	***NO TEST***	***PASS***		22	
		Mid Res: <1.0%	***NO TEST***	***NO TEST***			
		High Res: <6.0%	***NO TEST***	***NO TEST***			
2.4.1	Polarimetric FOV	Linear: 4x7.2 arcmin	***NO TEST***	**PASS: Unvignetted to 7.3 arcmin diam**		23	
		Circular: 3 arcmin diam	***NO TEST***	**CONCEDE: Unvignetted to 2.8 arcmin diam**			
2.4.2	Polarimetric Efficiency	Linear: >95%, calibrated to better than ±0.5%. Circular: >92%, calibrated to better than ±0.5%.	***NO TEST***	***PASS:*** **Linear: >95% Circular: >94%**	Have data 320 - 850 nm	24	

Acceptance Package III

FPRD Req #	Description	Specification	Pre-Delivery Measurement	Post-Delivery Measurement	On-telescope Measurement	#	Comments
2.4.3	Instrumental Polarization	Linear: <0.4%, calibrated to <0.04%. Linear to circular<3x10-3, calibrated to $<3x10^{-4}$			**Linear: ~ 0.2%**	25	
2.4.4	Position Angle Repeatability	Repeatability <6 arcminutes	***NO TEST***	**PASS: <1.8 arcminutes**	**Have Data**	26	
2.4.5	Transmission	70% of spectroscopic/imaging modes at 650 nm	***NO TEST***	***PASS:*** **>70%**	**Have Data**	27	
2.5.1	CTE	*CTE=99.9995% (typical), 99.999% (guaranteed).*	***NO TEST***	***PASS:*** **>99.9995%**		28	
2.5.2	Full Well	*200 k e7pix (typical) 150 k e7pix (guaranteed).*	***NO TEST***	**PASS: >153 ke"**		29	
2.5.3	Sensitivity	*see FPRD Table 5.*	**PASS. See Table below**			30	
2.5.4	Dark Current	*Dark current of 1 e7pix/hr (typical) at 163 K*	***NO TEST***	**LATER: <1.5e"/pix/hr**		31	
2.5.5	Readout Noise	*3.0 e7pix at 100kHz (10.0 psec/pix) TBC4; 5.0 e7pix at 345 kHz (2.9 psec/pix) TBC4*	***See table below***	***See table below***	**See Table**	32	
2.5.6	Gain	*Software selectable from : xl; x2; x4.75; x9.5*	**See table below**	**PASS: see table below**	**See Table**	32	BRIGHT/ FAST changed to high dynamic range
2.5.7	Prebinning	*/x/ to 9x9, independently in each direction*	**PASS**			33	
2.5.8	Readout Speed	*Frame transfer architecture: 0.103 sec frame transfer time 100— 345 kHz (10-2.9 psec/pix) See FPRD Table 6 for detector readout times.*	**4microsec/pix FAST; 10microsec/pix SLOW**				