Spectrograph characterization in Tucson: first discussion on data taking and analysis strategy

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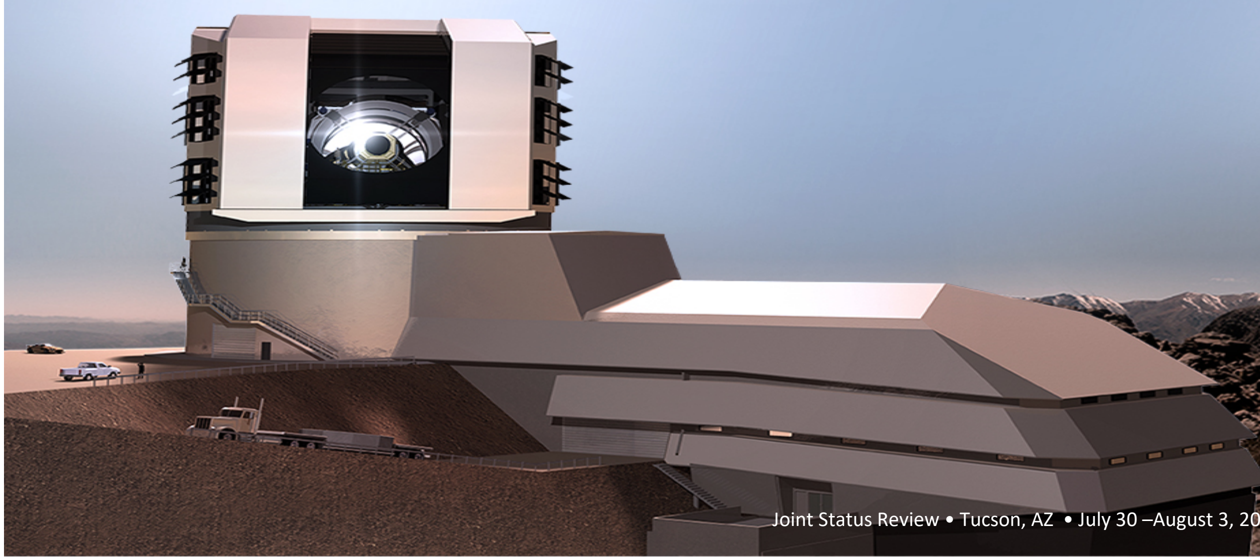
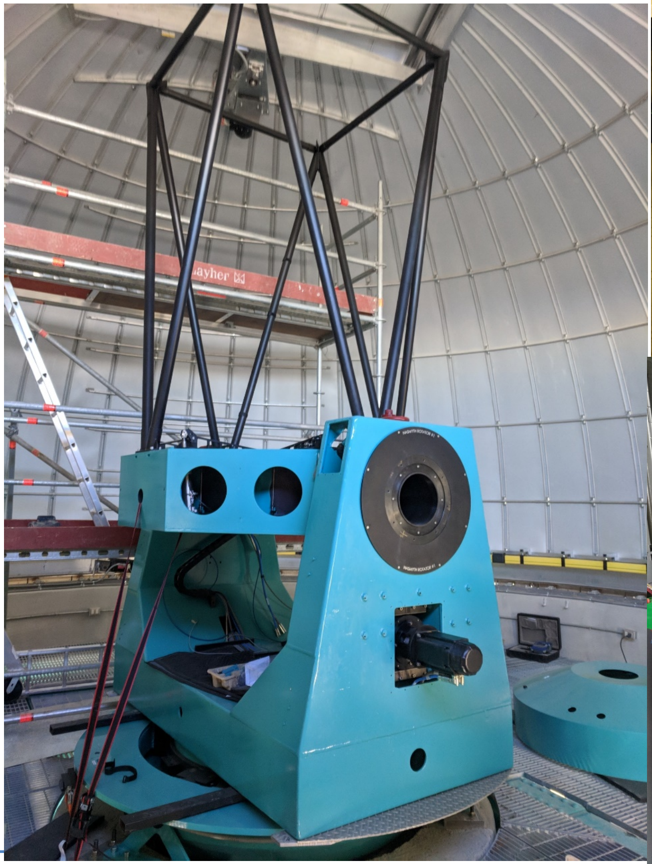
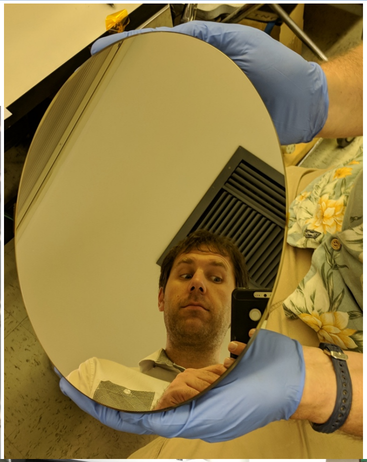


Auxiliary Telescope Status

- Telescope currently in the hands of the CTIO controls group now developing the mount control system (ATMCS)
- Dome functions but has slipring issues that have yet to be resolved
- Pointing component (T-point) being developed by Observatory Sciences
- Expecting first light in February
  - Development of Pointing model
  - Collimation of telescope
  - Verification of telescope image quality with Zwo "high speed" camera and filter wheel
  - Verification of telescope requirements
    - Slew & settle speeds, pointing accuracy etc

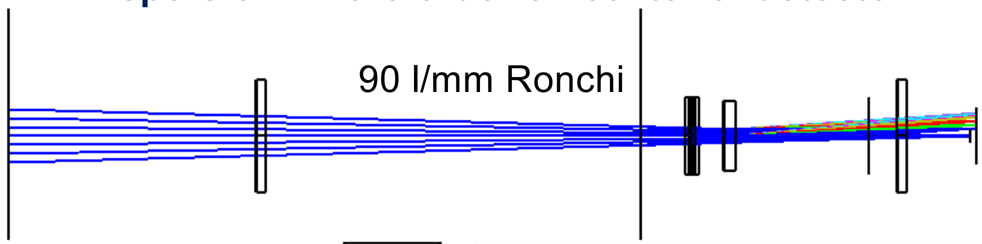


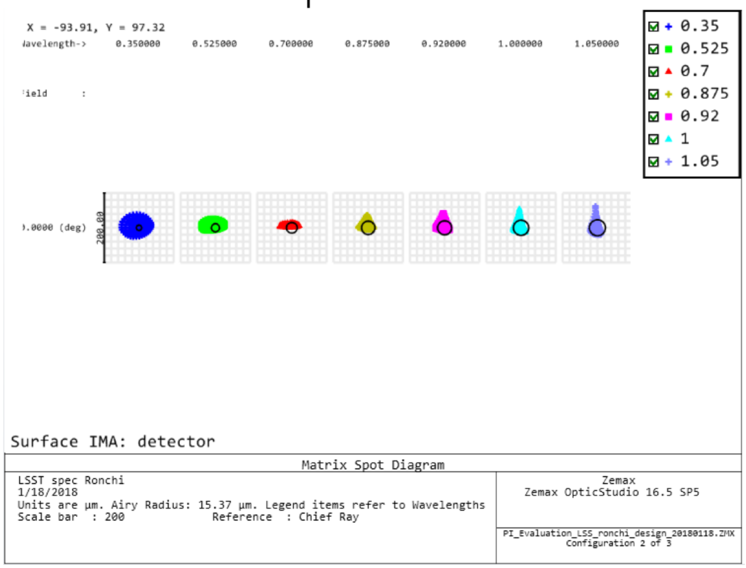


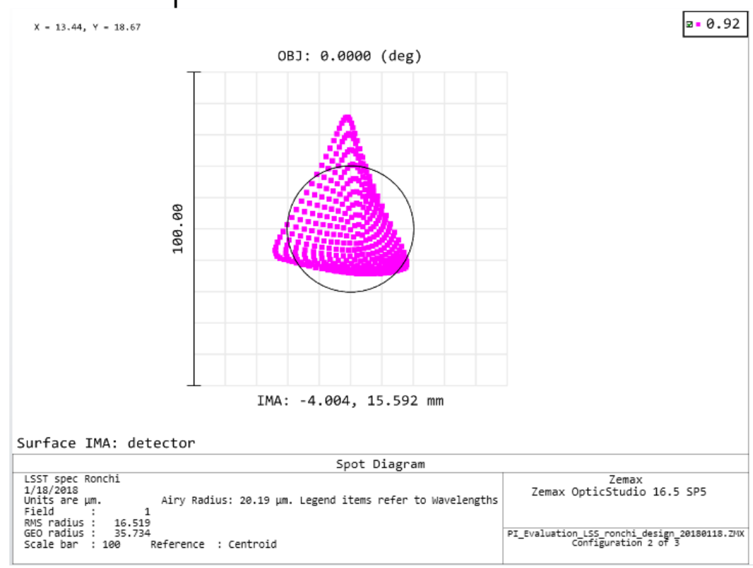
Work Remaining

- Lots of remaining work on-site including:
  - Installation of multiple E-stops
  - Installation of vent gate doors and (2) fans
  - Mirror installation procedure and handling equipment
  - Installation of Flat field Screen
  - Wiring of UPS
  - Dome lighting (and red night lights)
  - Installation of Control network (and spectrograph fiber)
  - Installation of light-tight rack for network and spectrograph hardware
  - Outfitting with environmental sensors
  - Paint the building white

Configuration 2, Flat Grating In median seeing and nominal Dispersion – Zero order on center of detector







The scale is 200 µm = 2”.

Numerical analysis of spectral resolution on the next page.

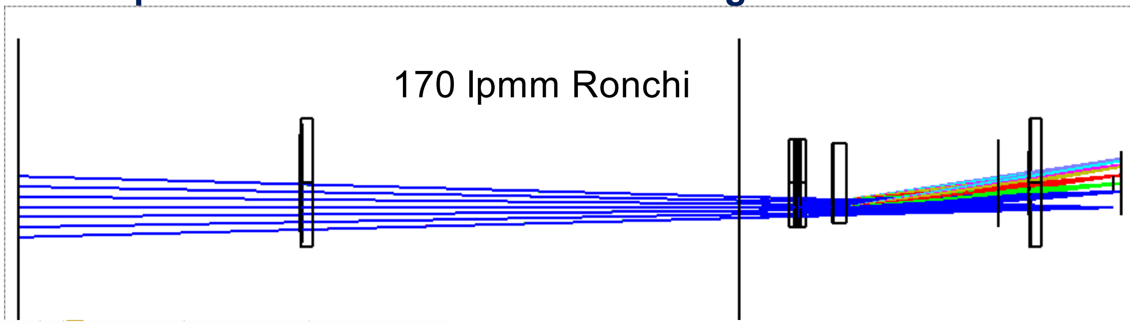
Significant astigmatism is present in the spatial (X) direction that will increase effect of readnoise and sky background contributions.

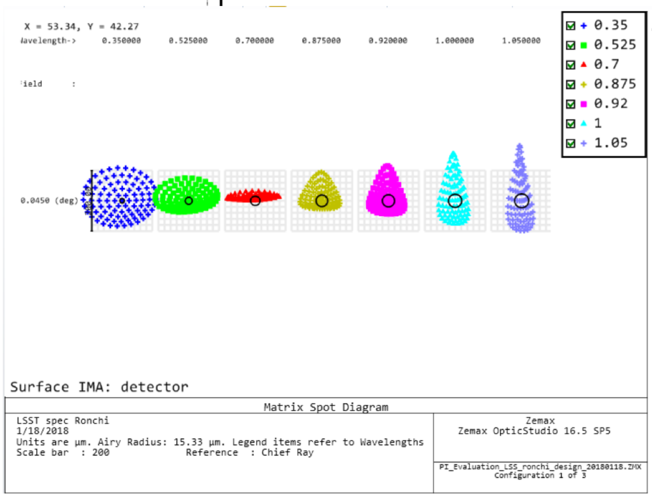
Median Seeing Setup Summary

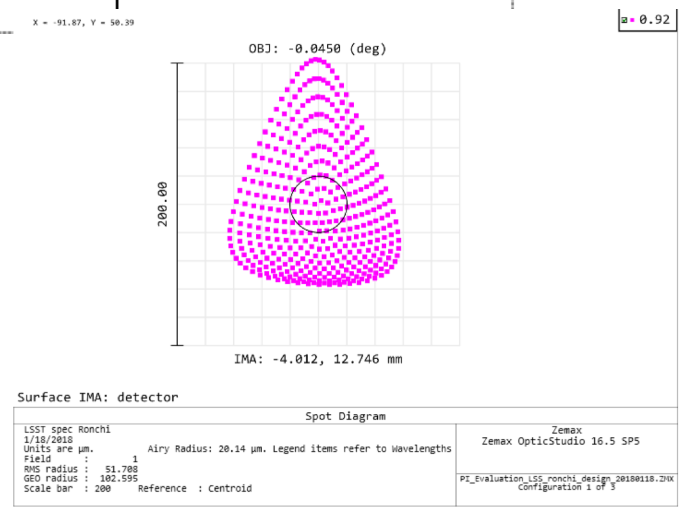
Assumes zenith seeing of 0.69" which is our median seeing													
Zenith Distance=45													
Wavelengths [um]	0.35	0.525	0.7	0.875	0.92	1	1.05		Note				
Instrument spectral PSF FWHM [um]	38.9	20.5	8.9	25.0	31.3	43.4	51.6		RMS Spot Y size in Zemax * 2.355				
Seeing+System ZD PSF width [um]	111.0	102.4	96.7	92.5	91.5	90.0	89.1		Corrected for wavelength dependence of seeing				
Total PSF width [um]	117.7	104.4	97.1	95.8	96.7	99.9	103.0						
Total PSF width [nm]	6.9	6.1	5.7	5.6	5.7	5.9	6.1						
Spectral Resolution	50.5	85.4	122.5	155.2	161.5	170.0	173.2		R=150 for 900nm and above is goal over the sky				
Zenith Distance=60													
Wavelengths [um]	0.35	0.525	0.7	0.875	0.92	1	1.05		Note				
Instrument spectral PSF FWHM [um]	38.9	20.5	8.9	25.0	31.3	43.4	51.6		RMS Spot Y size in Zemax * 2.355				
Seeing+System ZD PSF width [um]	158.1	145.8	137.6	131.6	130.3	128.1	126.9		Corrected for wavelength dependence of seeing				
Total PSF width [um]	162.8	147.2	137.9	133.9	134.0	135.3	137.0						
Total PSF width [nm]	9.6	8.7	8.1	7.9	7.9	8.0	8.1						
Spectral Resolution	36.5	60.6	86.2	111.0	116.6	125.5	130.2		R=150 for 900nm and above is goal over the sky				
Constants													
Spectral Dispersion [nm/um]	0.058873												
Spectral Dispersion [nm/pixel]	0.58873003												
Plate Scale [um/arcsec]	105												
Size of zeroth order star FWHM [um	4.36146		From largest of X and Y RMS spot size in Zemax (spot is circular) when diffraction order set to zero. Wavelength is for 902nm.										
Size of zeroth order star [pixels]	0.436146												
Size of zeroth order star [arcseconds	0.04153771												

Spectral Resolution requirements met at 45 degrees elevation, but not at 30 degrees.
Low elevation angles require switching to the “poor seeing” setup to meet requirements.

Configuration 1, Flat Grating In Poor seeing and High Dispersion – Zero order offset to edge of detector







The scale is 200 µm = 2”.

Numerical analysis of spectral resolution on the next page.

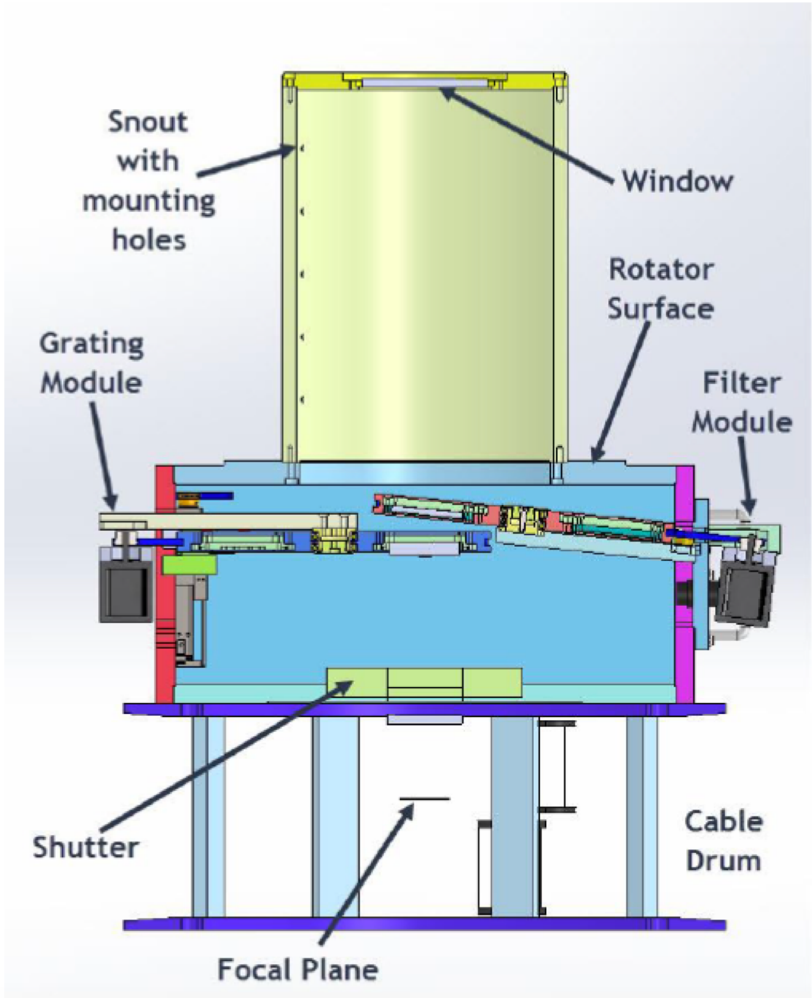
Aberrations worse than good seeing mode. Increased dispersion to get spectral resolution results in +1 order falling off the detector, thus the signal decreases by a factor 2. Readnoise and sky contributions will go up by ~100%.

Poor Seeing Setup Summary

Assumes zenith seeing of 0.84" which is our 3rd quartile seeing								
Zenith Distance=45								
Wavelengths [um]	0.35	0.525	0.7	0.875	0.92	1	1.05	Note
Instrument spectral PSF FWHM [um]	118.5	69.7	17.6	76.9	100.1	144.8	175.2	RMS Spot Y size in Zemax * 2.355
Seeing+System ZD PSF width [um]	129.4	119.4	112.7	107.8	106.7	104.9	103.9	
Total PSF width [um]	175.5	138.2	114.0	132.4	146.3	178.8	203.7	
Total PSF width [nm]	5.4	4.2	3.5	4.1	4.5	5.5	6.2	
Spectral Resolution	65.0	123.9	200.2	215.6	205.1	182.4	168.1	R=150 for 900nm and above is goal over the sky
Zenith Distance=60								
Wavelengths [um]	0.35	0.525	0.7	0.875	0.92	1	1.05	Note
Instrument spectral PSF FWHM [um]	227.7	180.6	121.9	53.5	40.1	46.2	68.1	RMS Spot Y size in Zemax * 2.355
Seeing+System ZD PSF width [um]	158.1	145.8	137.6	131.6	130.3	128.1	126.9	
Total PSF width [um]	277.2	232.1	183.8	142.1	136.3	136.2	144.0	
Total PSF width [nm]	8.5	7.1	5.6	4.4	4.2	4.2	4.4	
Spectral Resolution	41.2	73.8	124.2	200.9	220.1	239.5	237.8	R=150 for 900nm and above is goal over the sky
Zenith Distance=70								
Wavelengths [um]	0.35	0.525	0.7	0.875	0.92	1	1.05	Note
Instrument spectral PSF FWHM [um]	227.7	180.6	121.9	53.5	40.1	46.2	68.1	RMS Spot Y size in Zemax * 2.355
Seeing+System ZD PSF width [um]	197.4	182.0	171.8	164.3	162.7	160.0	158.4	
Total PSF width [um]	301.3	256.4	210.7	172.8	167.6	166.5	172.4	
Total PSF width [nm]	9.2	7.9	6.5	5.3	5.1	5.1	5.3	
Spectral Resolution	37.9	66.8	108.4	165.1	179.1	195.9	198.6	R=150 for 900nm and above is goal over the sky
Constants								
Spectral Dispersion [nm/um]	0.03066141							
Spectral Dispersion [nm/pixel]	0.3066141							
Plate Scale [um/arcsec]	105							
Size of zeroth order star FWHM [um	145.7745		From largest of X and Y RMS spot size in Zemax (spot is circular) when diffraction order set to zero. Wavelength is for 902nm.					
Size of zeroth order star [pixels]	14.57745							
Size of zeroth order star [arcseconds	1.38832857							

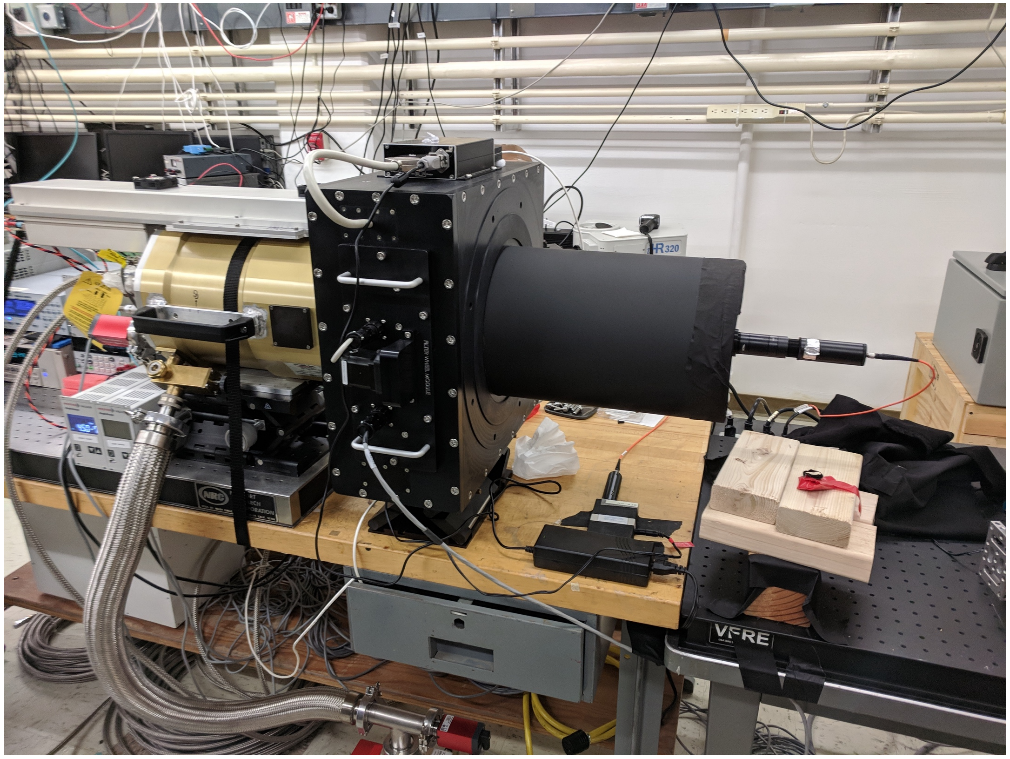
Meets spectral resolution requirement even in poor seeing at high airmass.
Cadence (or star selection options) will be reduced to get adequate SNR.

Spectrograph Solid Model (without detector)



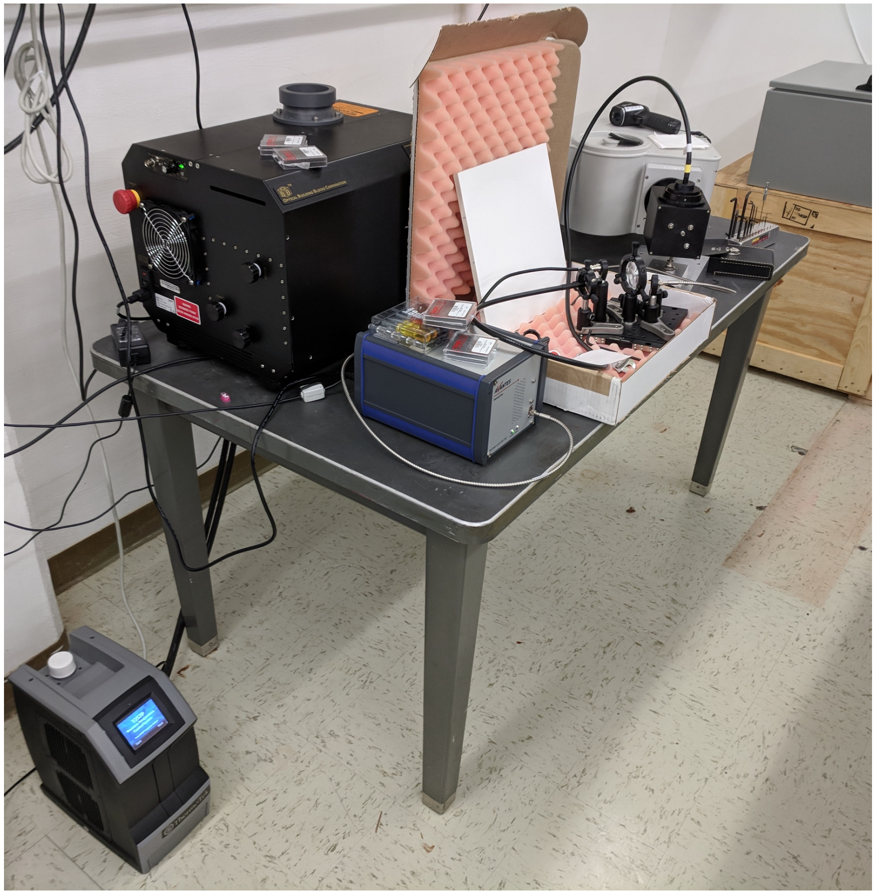
LATISS Status

- LSST Atmospheric Transmission Imager and Slitless Spectrograph
  - Grating + filter wheels each have 4 positions
  - Ronchi gratings were delivered, but were rejected because they were not wedged
    - Should be finished this week
  - Kirk to discuss detector characterization
- Have a few vendor software issues to resolve but not halting progress
- Telescope simulator allows (semi-realistic) spectra to be obtained
  - Optimized for 400-700 nm
  - Re-images fiber therefore creating odd “PSF”
  - Cannot tip/tilt/translate beam



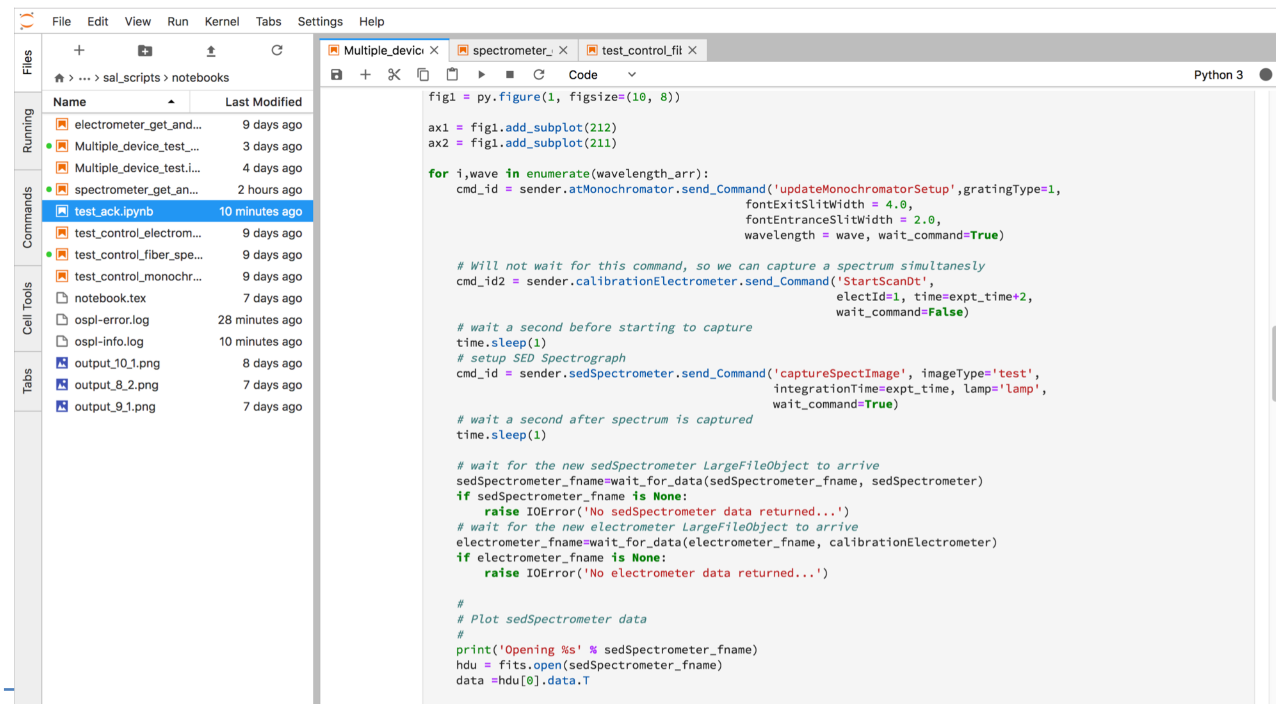
AuxTel Calibration Illumination System (LATCIS) Status

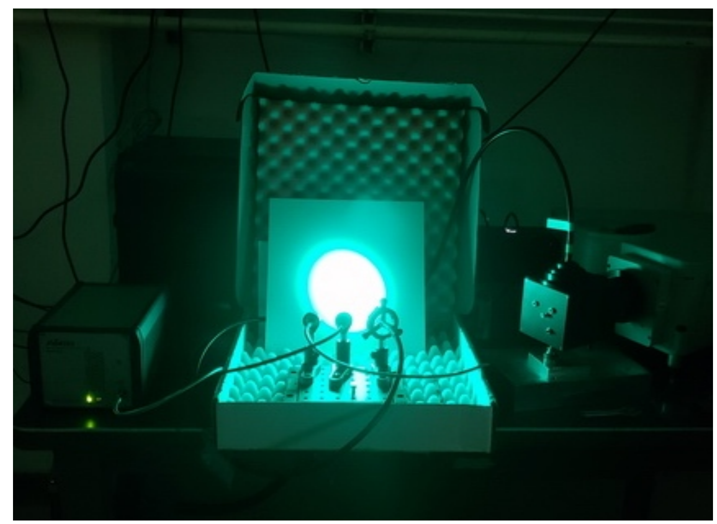
- Horiba KiloArc white light source (1 kW)
- Coupled to a monochromator with 2 gratings (red, blue) and 1 mirror (white)
  - Controllable entry/exit slits + grating controls spectral profile
- Light will be projected onto a calibration screen mounted on the dome
  - Currently gets put into a liquid light pipe in the lab for ease of use + UV blocking
- S2281 photodiode plus Keithley 6517b electrometer to monitor flux variations
- Fiber spectrograph 320-1050 nm spectral range with ~1nm resolution to measure spectral profile



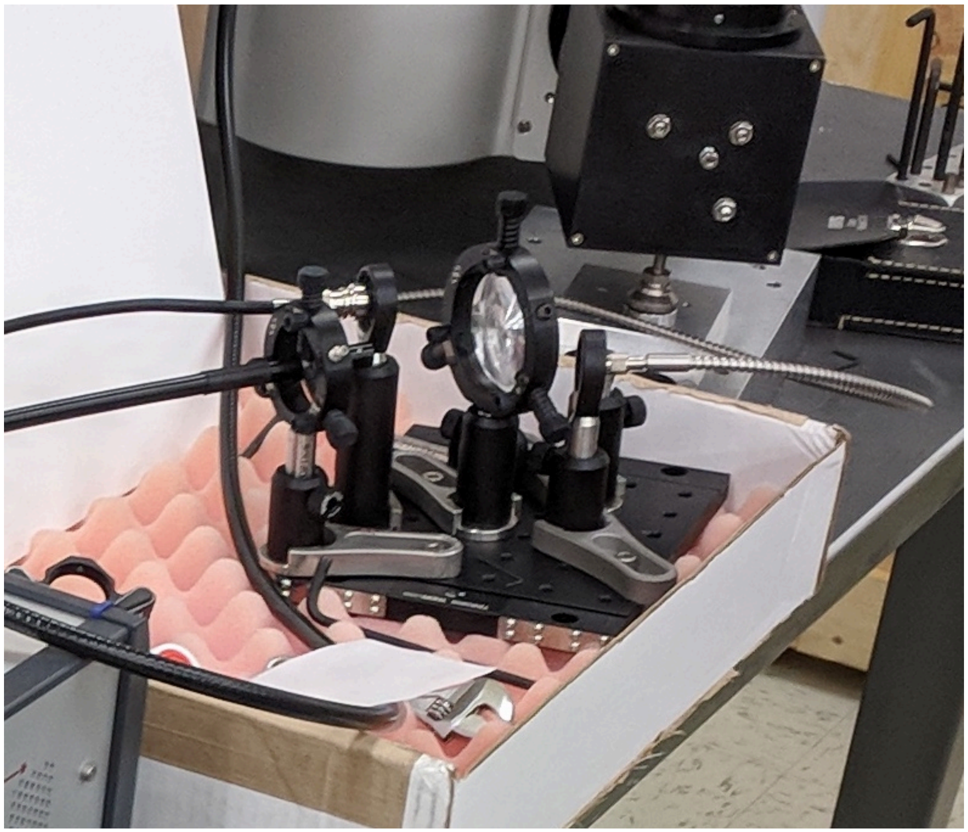
AuxTel Use in On-going Integration Activities

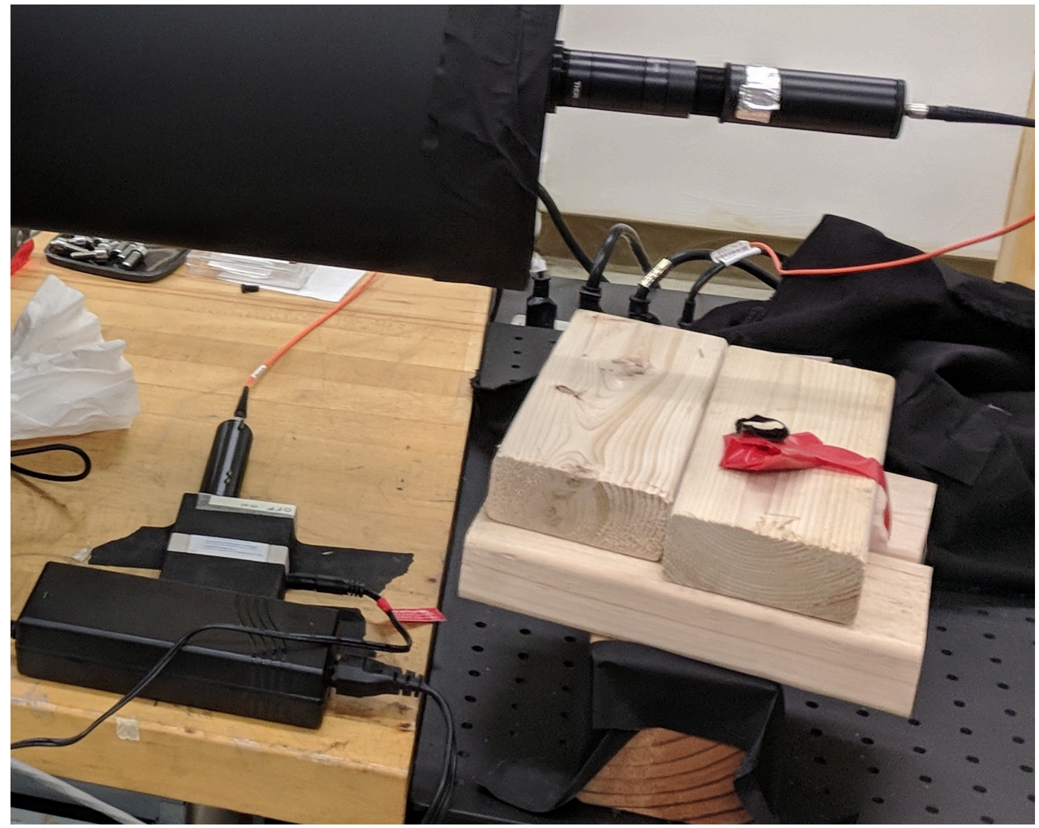
- Using AT spectrograph system for system-wide software “Early” integration activities (EIAs)
- Preliminary Scripting interface (Jupyter Notebook) now allows coordinated control of devices via SAL → Real scripting interface now being developed by Russell Owen!





Coupling LATCIS to LATISS

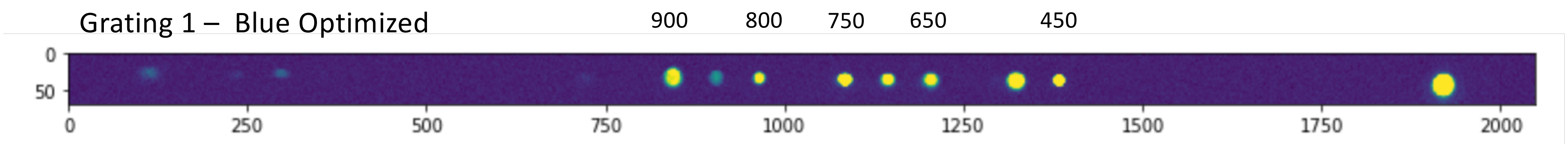




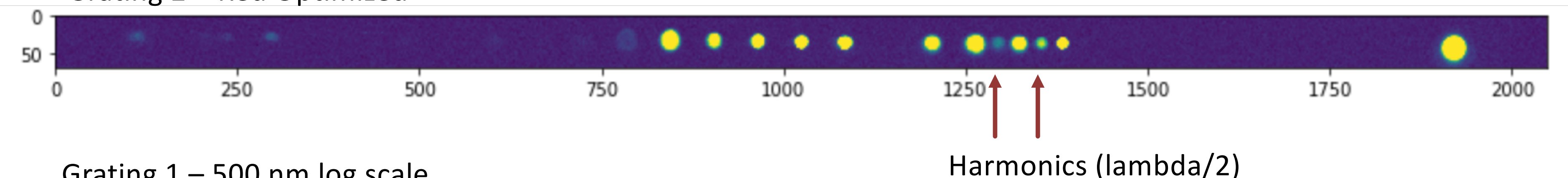
Coupling LATCIS to LATISS

- PRELIMINARY - Uses vendor supplied grating with lower spectral resolution.
  - Uses 1um entry/exit slits
  - ***Superposition of multiple narrowband images!***

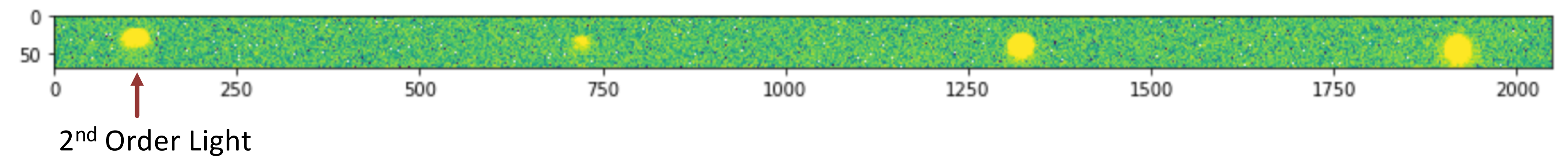
Grating 1 – Blue Optimized



Grating 2 – Red Optimized

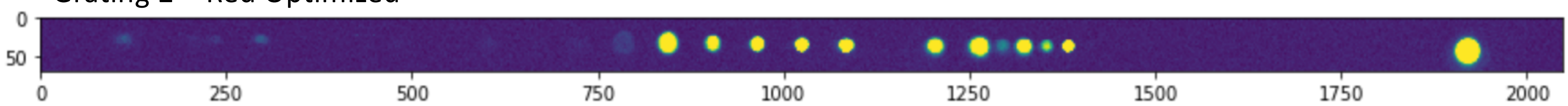


Grating 1 – 500 nm log scale

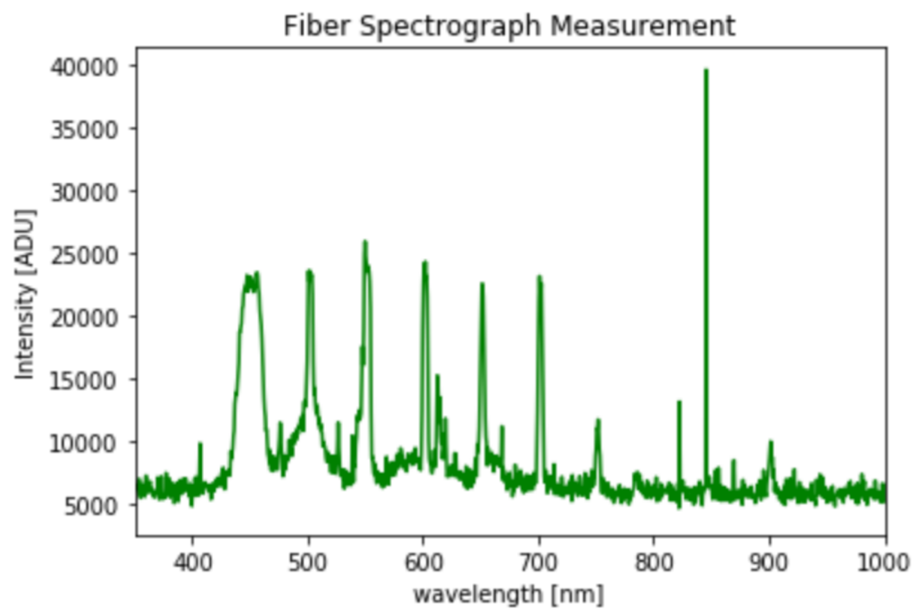


Coupling LATCIS to LATISS

Grating 2 – Red Optimized



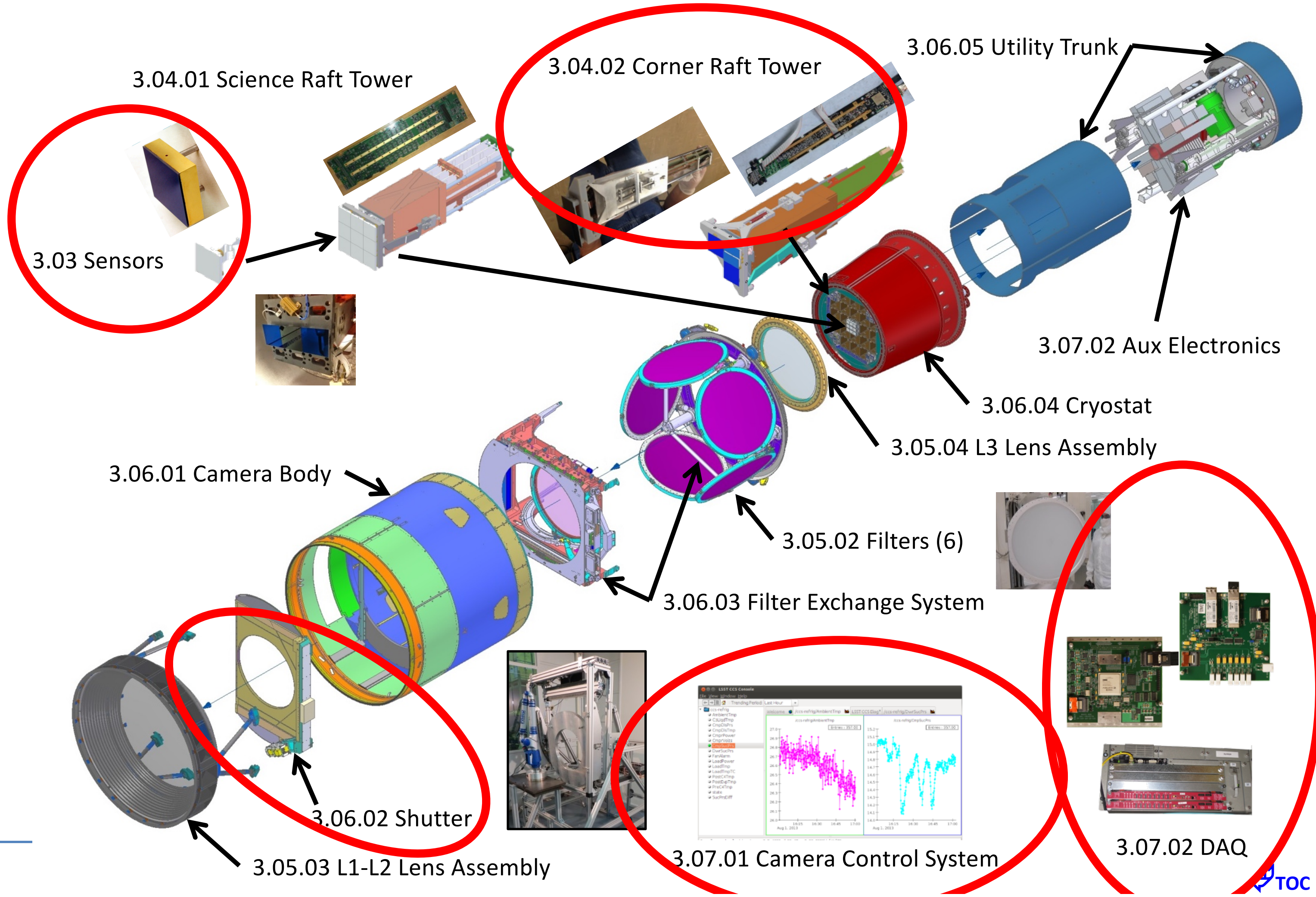
- Fiber Spectrograph Data
  - Data taken from scattered light going towards TelSim input fiber
    - No knowledge of fiber, TelSim nor spectrograph throughput function
    - FiberSpectrograph also not intrinsically calibrated for its own sensitivity
- Normally electrometer data
  - was non-functional for this dataset



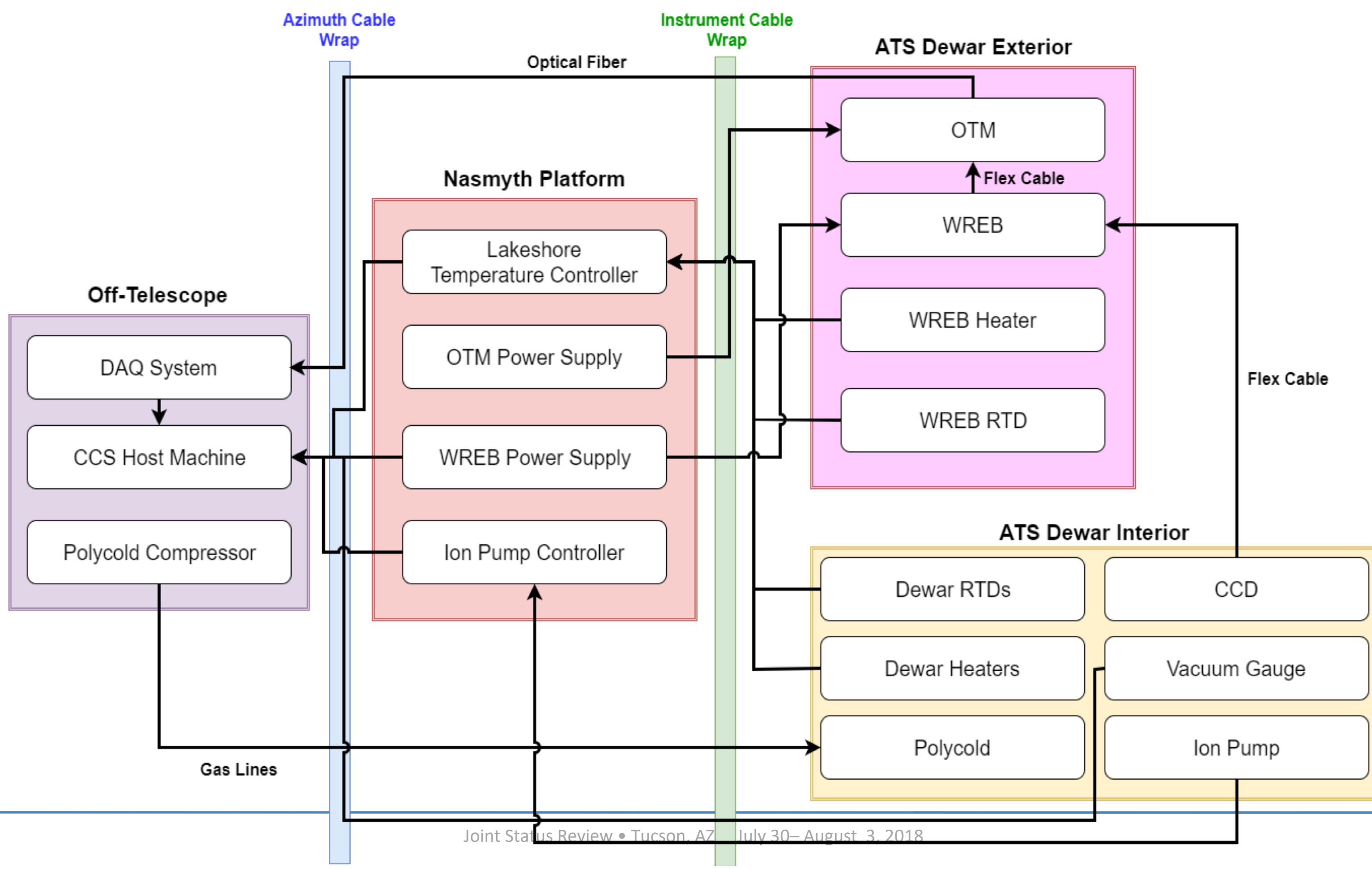
Data Sets to be Acquired and Analysed:

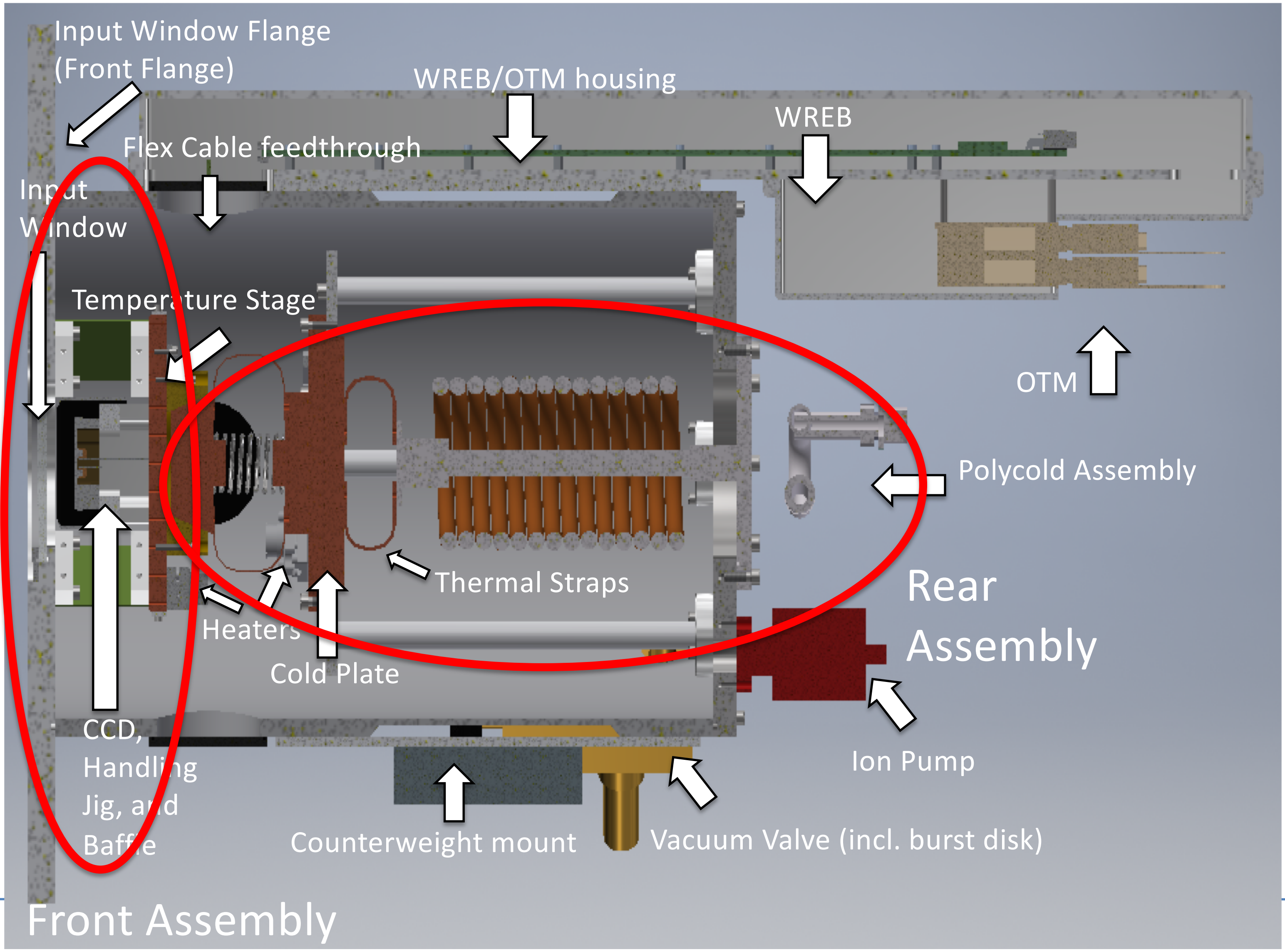
- "Monochromatic" PSF scans at varying depth:
  - Verification of optical model (resolution as a function of wavelength)
  - wavelength dependent ghosting
  - 2^{nd} order contamination
- Series of monochromatic and polychromatic flats
  - Cross-talk, CTE etc
  - Disperser location?
- Bias, darks etc.
- Generic tasks associated with datasets
  - Need verification of all metadata from all components
  - Strongly suggest using the same code to relate detector to photodiode data for flat construction as the main telescope
  - Need scaling relationships between photodiode signal and accumulated detector signal for each spectrograph setup!
- Need set of data quality metrics for all acquired data
  - What do we want to run on-site, versus post-facto
- *Can simulate stellar spectra using narrowband images to practice reduction/model fitting*

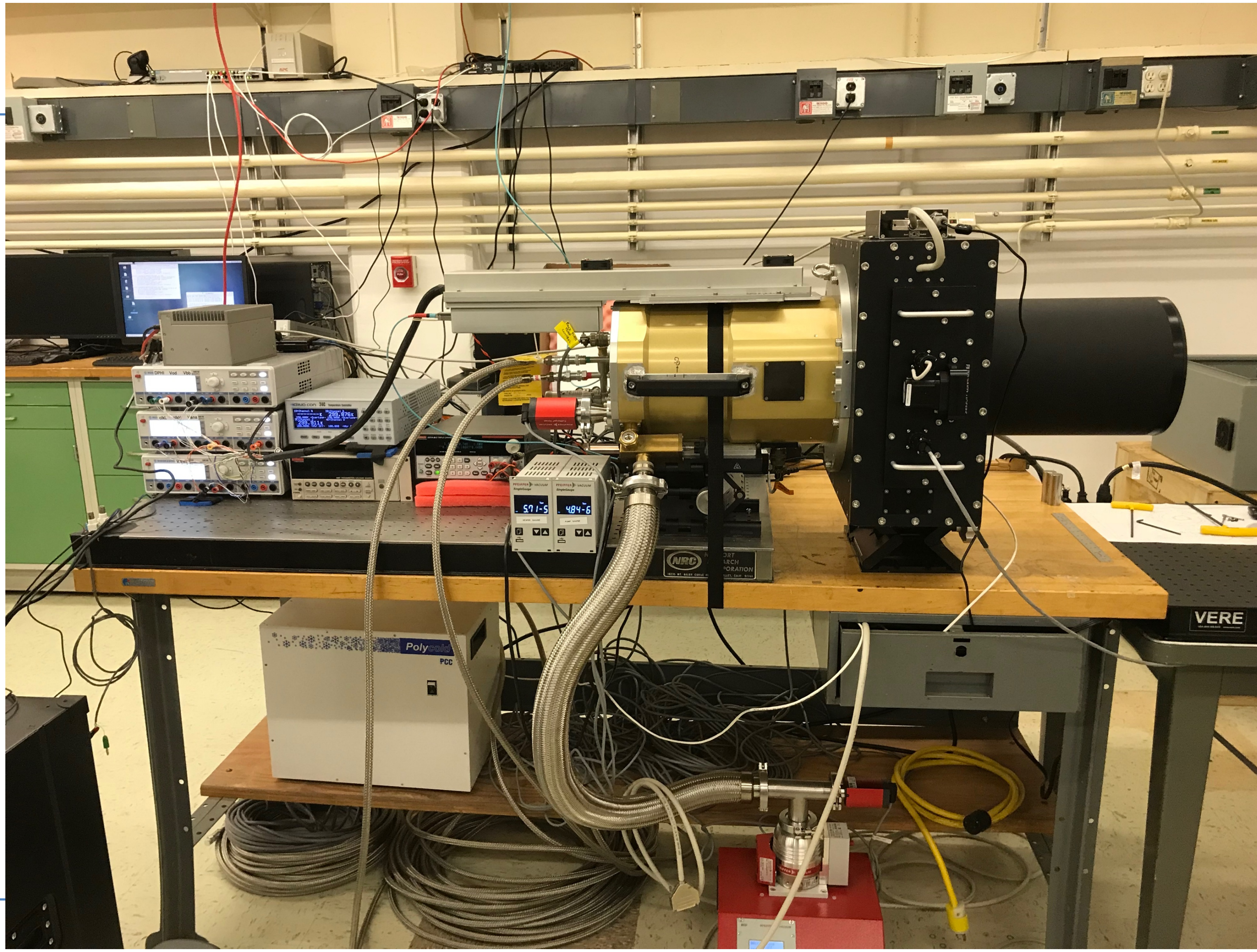
LSST Camera systems used by the ATS

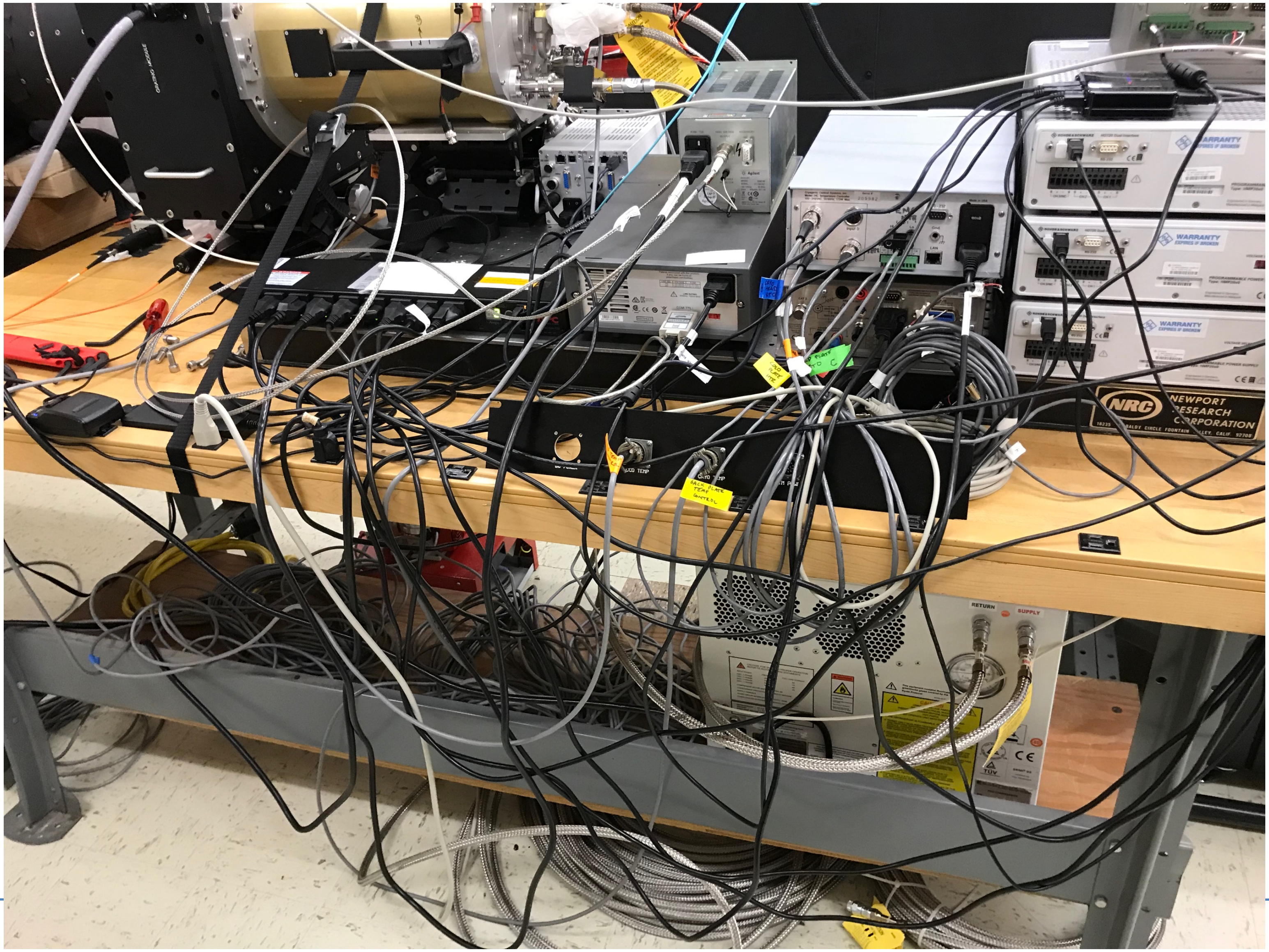


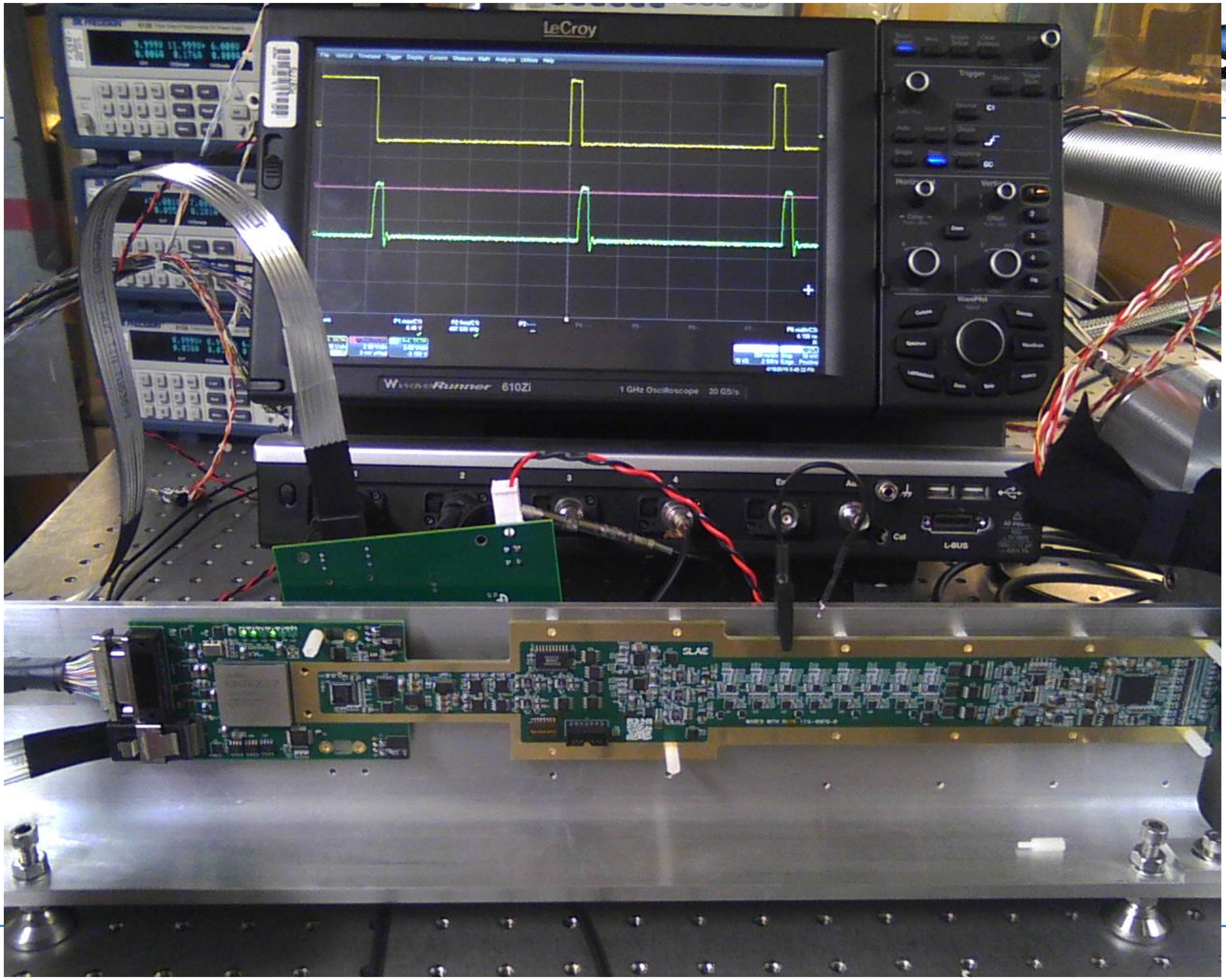
ATS System Block Diagram




Input Window Flange
(Front Flange)
WREB/OTM housing
WREB
Flex Cable feedthrough
Input
Window
Temperature Stage
OTM
Polycold Assembly
Thermal Straps
Rear
Assembly
Heaters
Cold Plate
CCD,
Handling
Jig, and
Baffle
Ion Pump
Counterweight mount
Vacuum Valve (incl. burst disk)
Front Assembly


Polycold
PCC
VERE


NRC
NEWPORT
RESEARCH
CORPORATION
WARRANTY


LeCroy
WaveRunner 610Zi
1 GHz Oscilloscope 20 GS/s
SLAC
L-BUS

WREB Temperature regulation

Temperature Regulation

From the SoW (LTS-520 v1.0):

2.1.3 Raft Electronics Board Temperature Control

The Contractor shall provide all equipment and control software necessary to control the temperature of the Raft electronics board.

Discussion:

This requires that the contractor provide a thermal control system for the electronics.

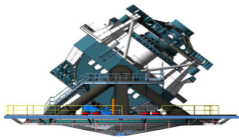
2.5 Readout Electronics Thermal Control and Monitoring

The electronics board temperatures will be monitored and controlled to a user-defined setpoint using sensors that have an accuracy of no worse than

+/- 1degree C. Requirements on this system are defined in LTS-521.

This system will consist of a fan for removing air, an electrical heating element and the associated electronics and controls.

Proposal: The REB will be housed between a pair of copper plates identical in design to those used in the LSSTcam Corner Raft Tower Module. An RTD temperature sensor (Lakeshore Model PT-103-AM) and heating element (Lakeshore Model HTR-50) will be added to those copper plates. A programmable temperature controller (Lakeshore Model 336) will be used to regulate the temperature of those copper plates and therefore the REB. Additionally, the REB includes temperature sensors which may be read through the CCS system to measure temperature of the PCB itself. A small mechanical fan will be used to circulate air through the REB housing



WREB Temperature Regulation

From LTS-521 v.1.1

5.9 Electronics Enclosure Internal Temperature Condition

ID: LTS-521-050

Specification: The temperature of the electronics boards shall be controlled to within +/- 3 degrees Celsius of the temperature setpoint. The setpoint shall be defined by the LSST PO with input from the Contractor based on sensor performance and seeing degradation inside the telescope enclosure. The temperature shall be monitored to better than or equal to 1 degree Celsius increments. The temperature setpoint shall be commanded by the CCS. Heat removal shall be accomplished by a fan discharging to the ambient environment. Heating shall be provided by an electronic heating element.

Proposal: The temperature of the sensor Readout Electronics Board will be controlled by CCS programming of the Lakeshore Model 336 temperature controller described on the previous slide. As this system provides only a heating functionality, a fan (as specified in LTS-521-050) will be used to move ambient air across the copper bars that enclose the REB.

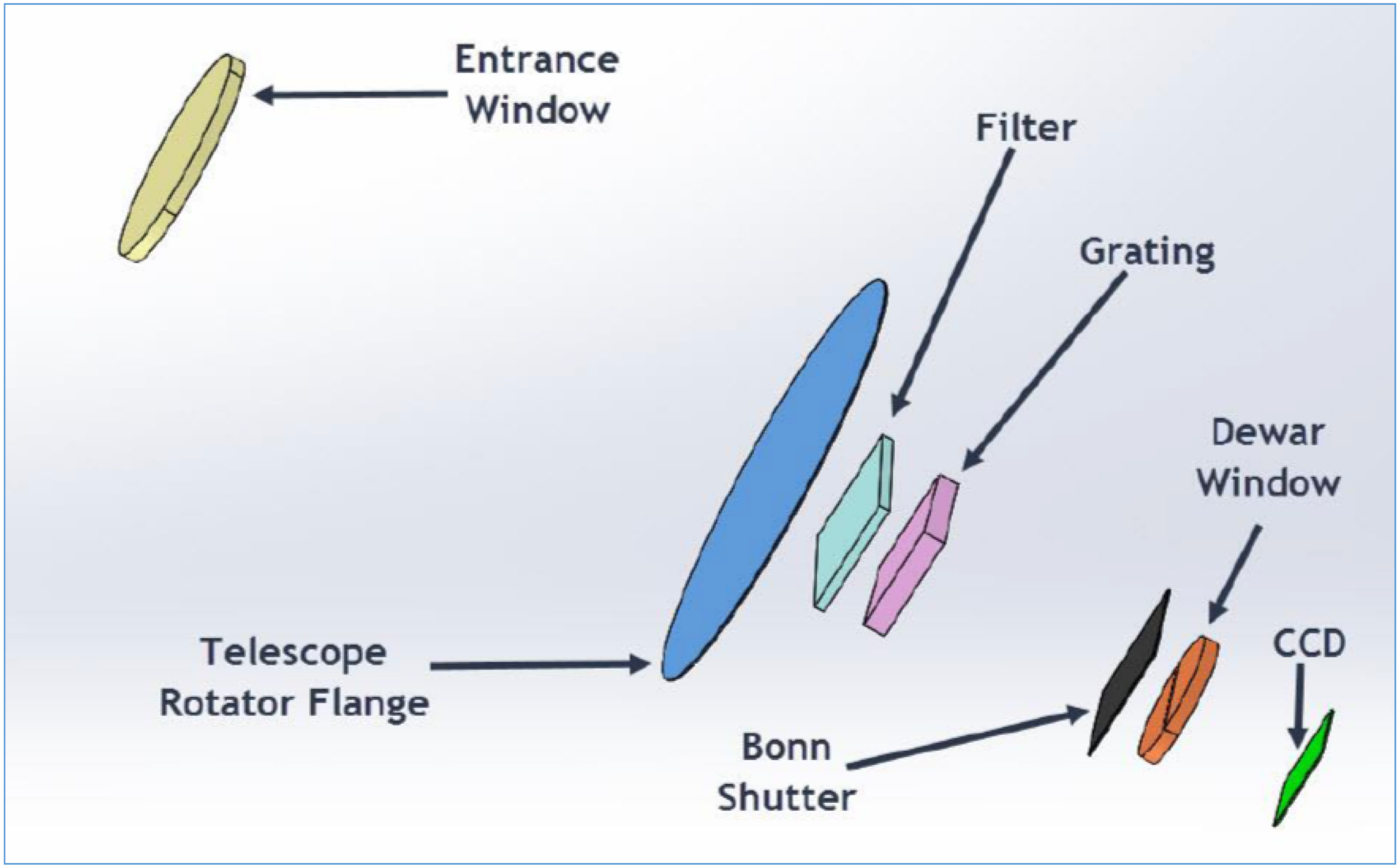
The system will measure/regulate the temperature of the copper plates to 0.01 C precision.

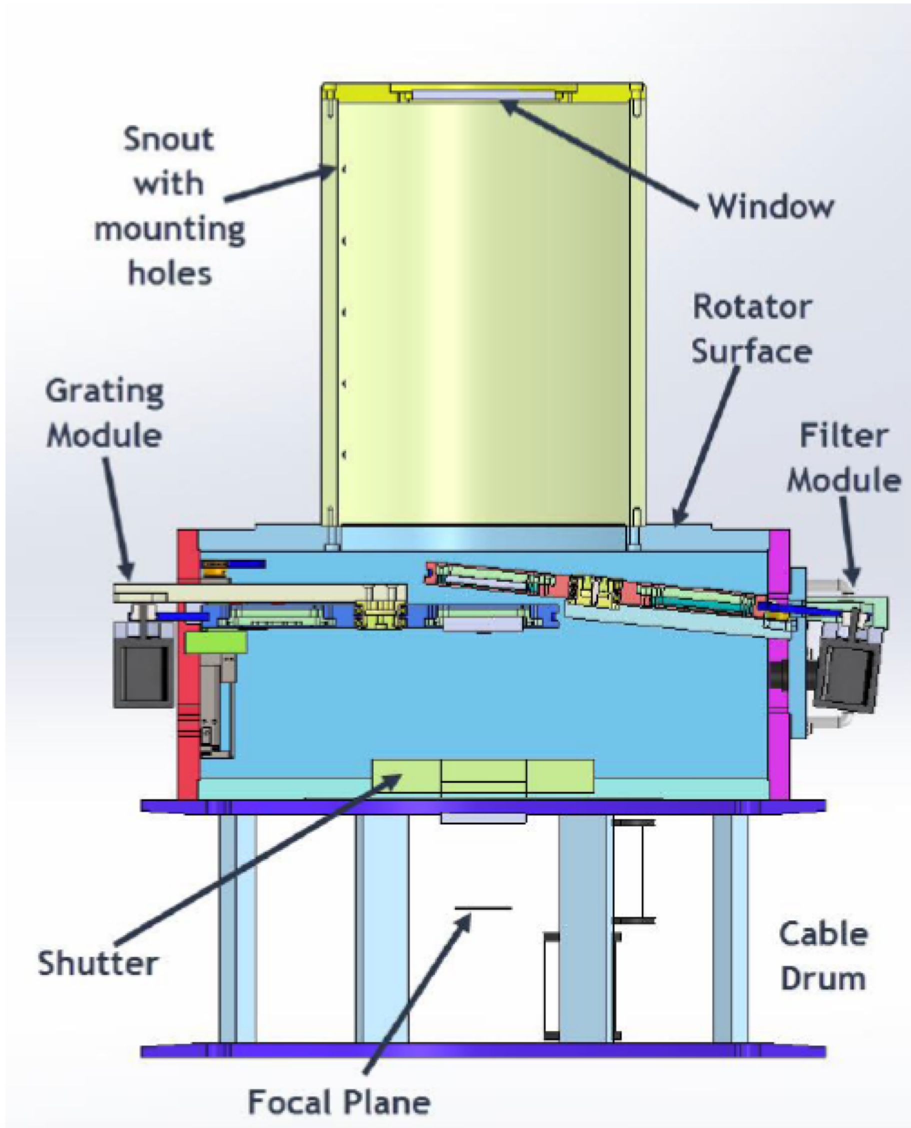
The full range of available set points will be from a few (TBD) degrees above ambient to TBD degrees above ambient. Thermal testing will take place during construction of the SRS prior to delivery.

REB POWER SUPPLY
REB POWER SUPPLY
REB POWER SUPPLY
KEITHLEY INSTRUMENTS, INC.
A Tektronix Company
FRAGILE
120/208 V
4-WIRE
1&3 PHASE

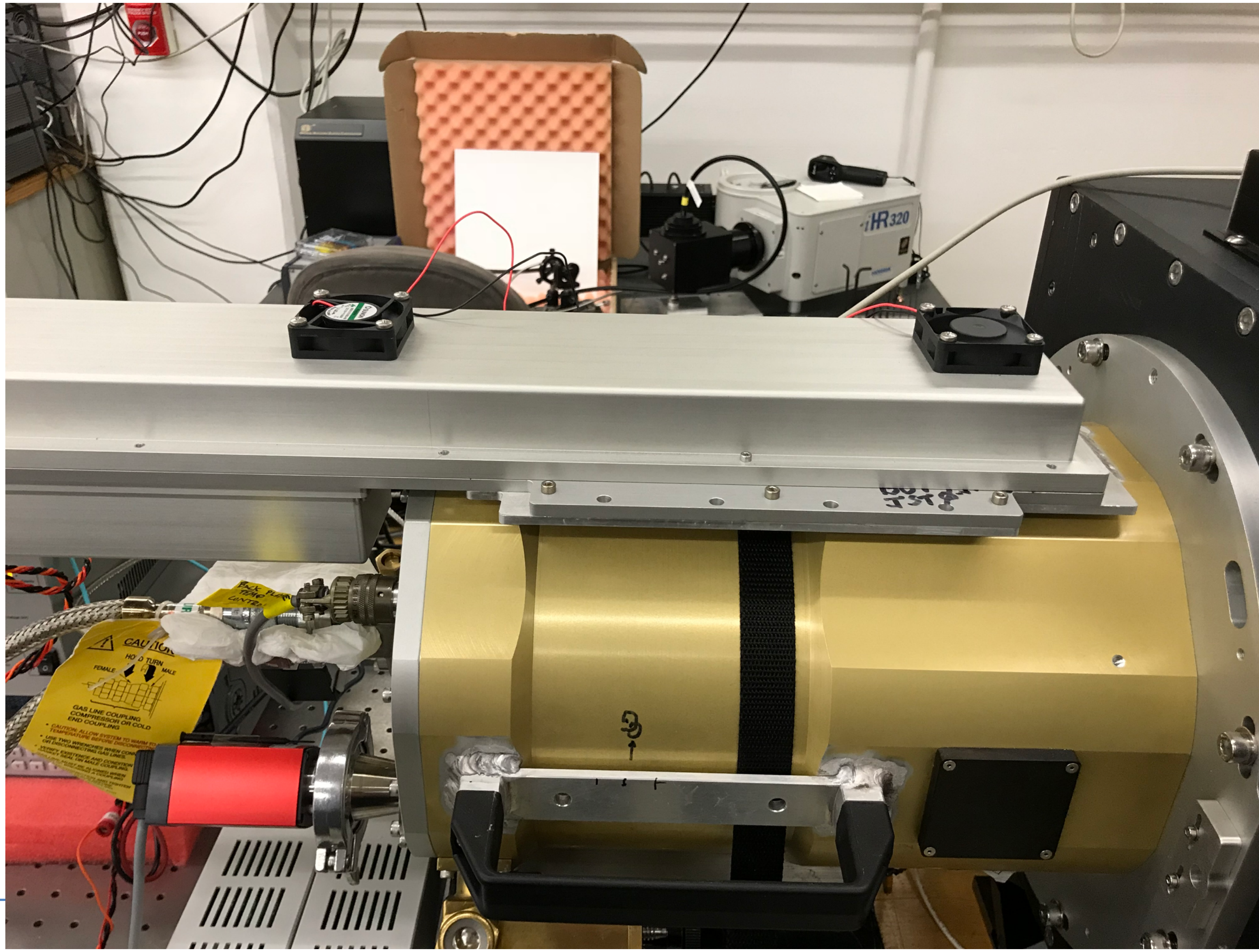

StarTech.com

Spectrograph Optics





Snout with mounting holes
Window
Rotator Surface
Grating Module
Filter Module
Shutter
Cable Drum
Focal Plane


iHR320
CAUTION
GAS LINE COUPLING
COMPRESSOR OR COLD
END COUPLING

In-Dome Calibration: Status