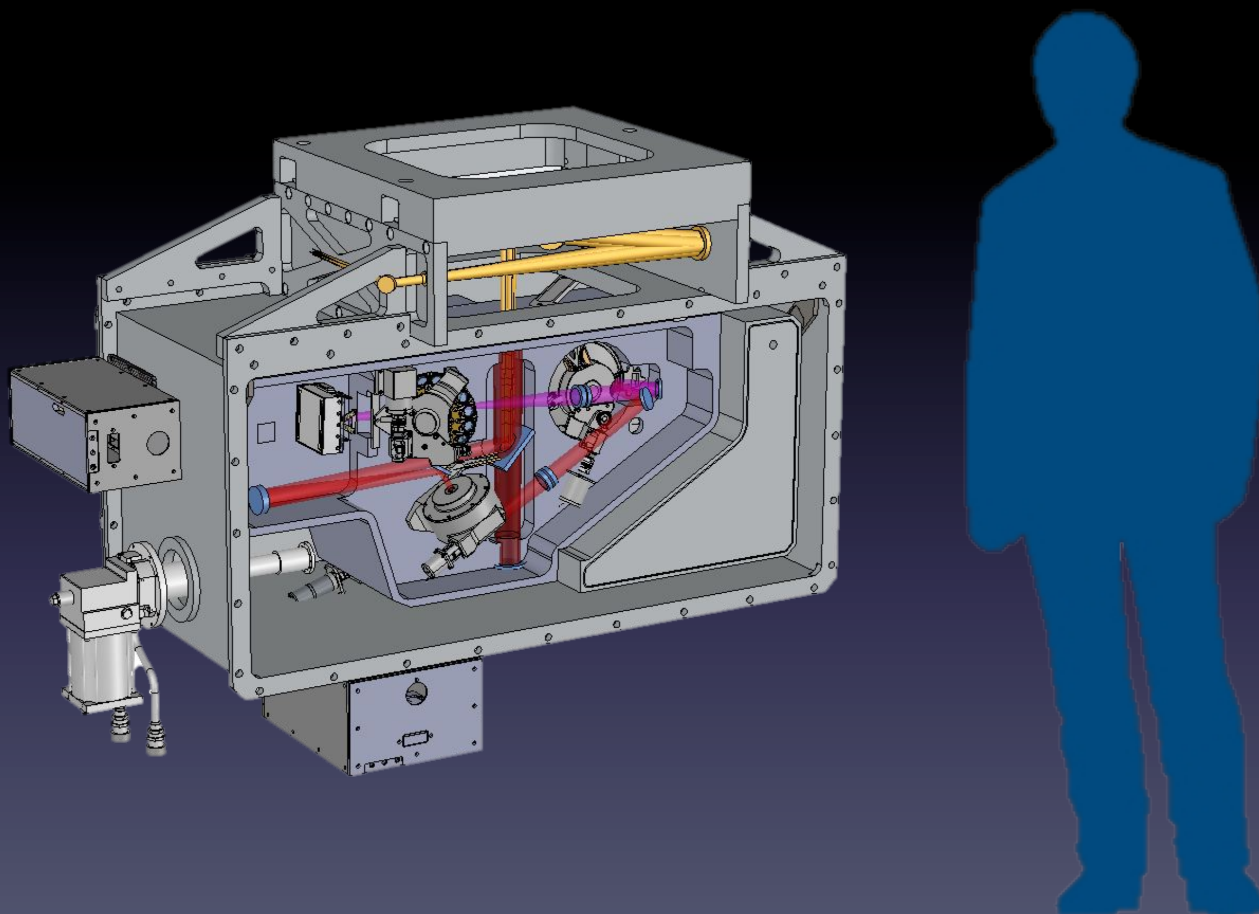
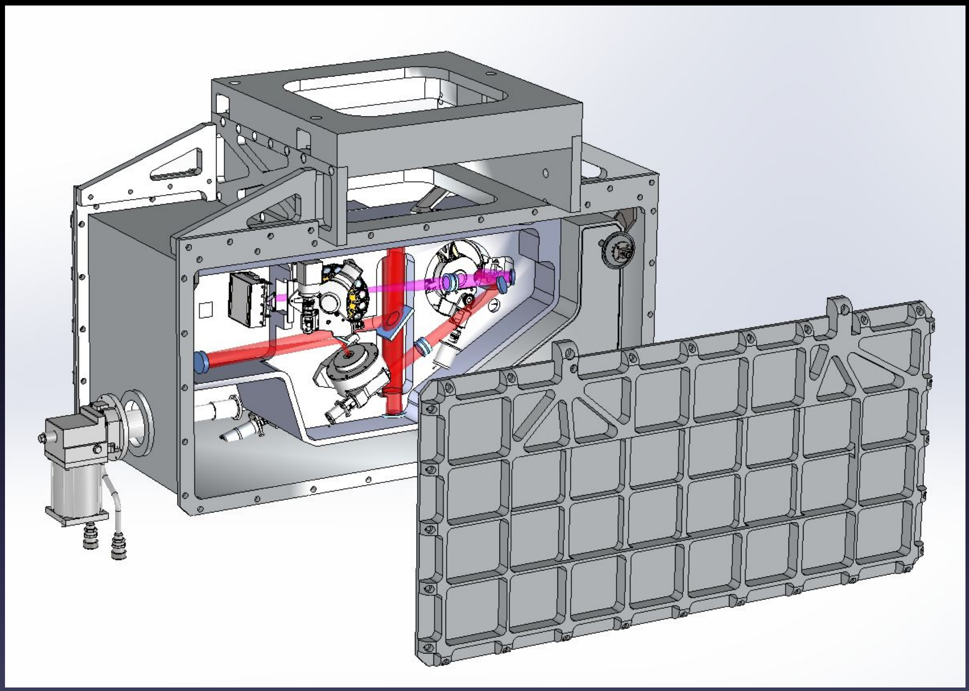
Opto-Mechanics and Cryostat



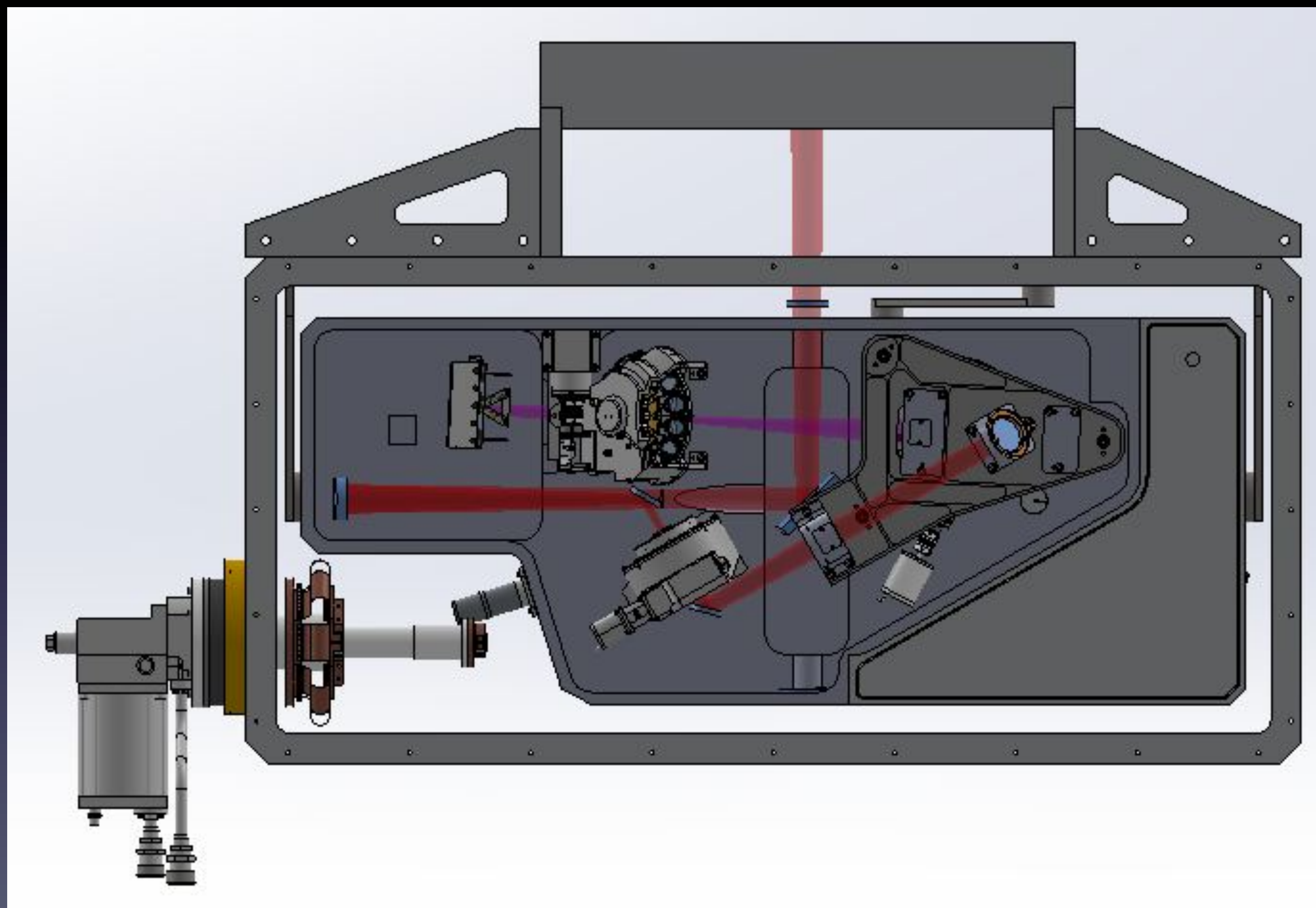
Instrument Overview



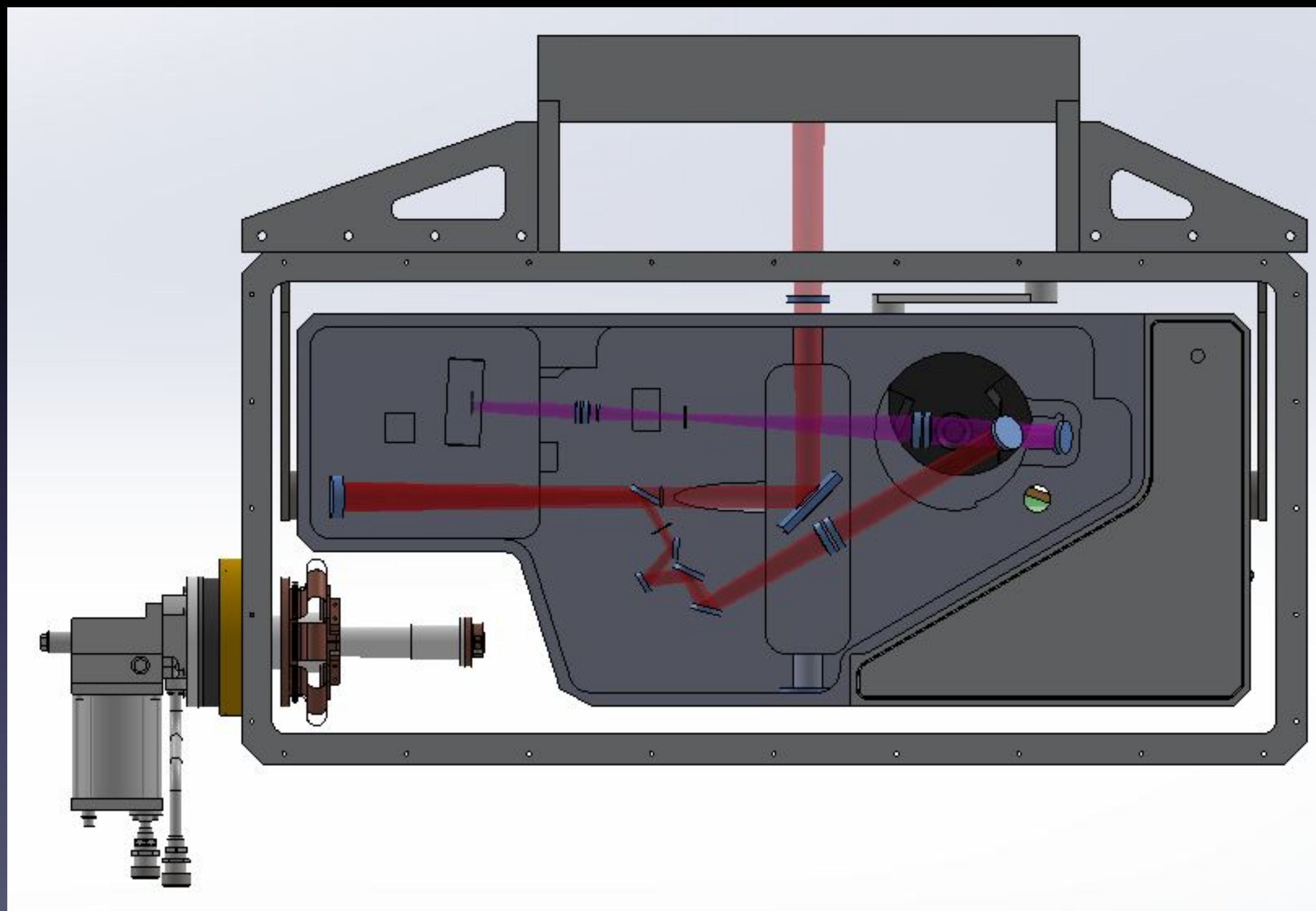
	item	mass (lb)	
Optical Bench Assembly	Optical Bench	193	
	Image Rotator Mechanism	4.7	
	Cross Disperser Mechanism	19.4	
	Radiation Shield	8.2	
	Slit Mechanism	5.2	
	Order Sorting Mechanism	5.2	
	Immersion Grating Mechanism	5.2	
	Filter Wheel Mechanism	5.6	
	Detector, H2RG	6.6	
	Detector, Alladin	1.2	
	LN Can w/12L LN	40	
	Optics + Mounts	20	
			314.3
Cryostat Assembly	Cryostat	230	
	Trusses	8.9	
	Cryo Cooler	30	
	He Lines	20	
	Copper Flanges	5	
	Aladdin Controller	13.6	
	H2RG Controller	21.4	
			328.9
	Telescope Interface	108	108
		Total Est	751.2

- Estimated weight: 751 lbs
- Estimated Hold time at zenith: 2.2 days

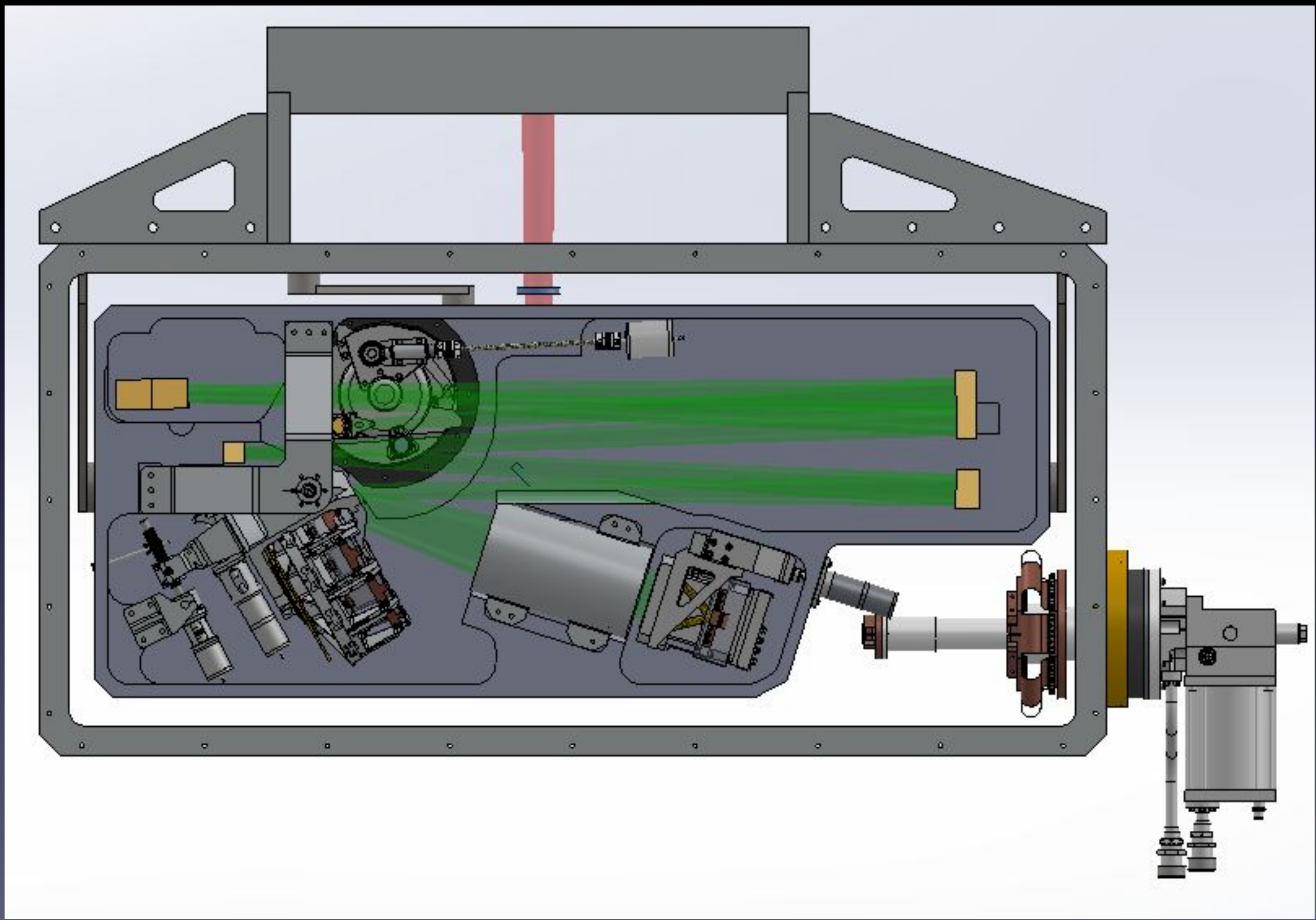
Instrument Layout – *Fore Optics*



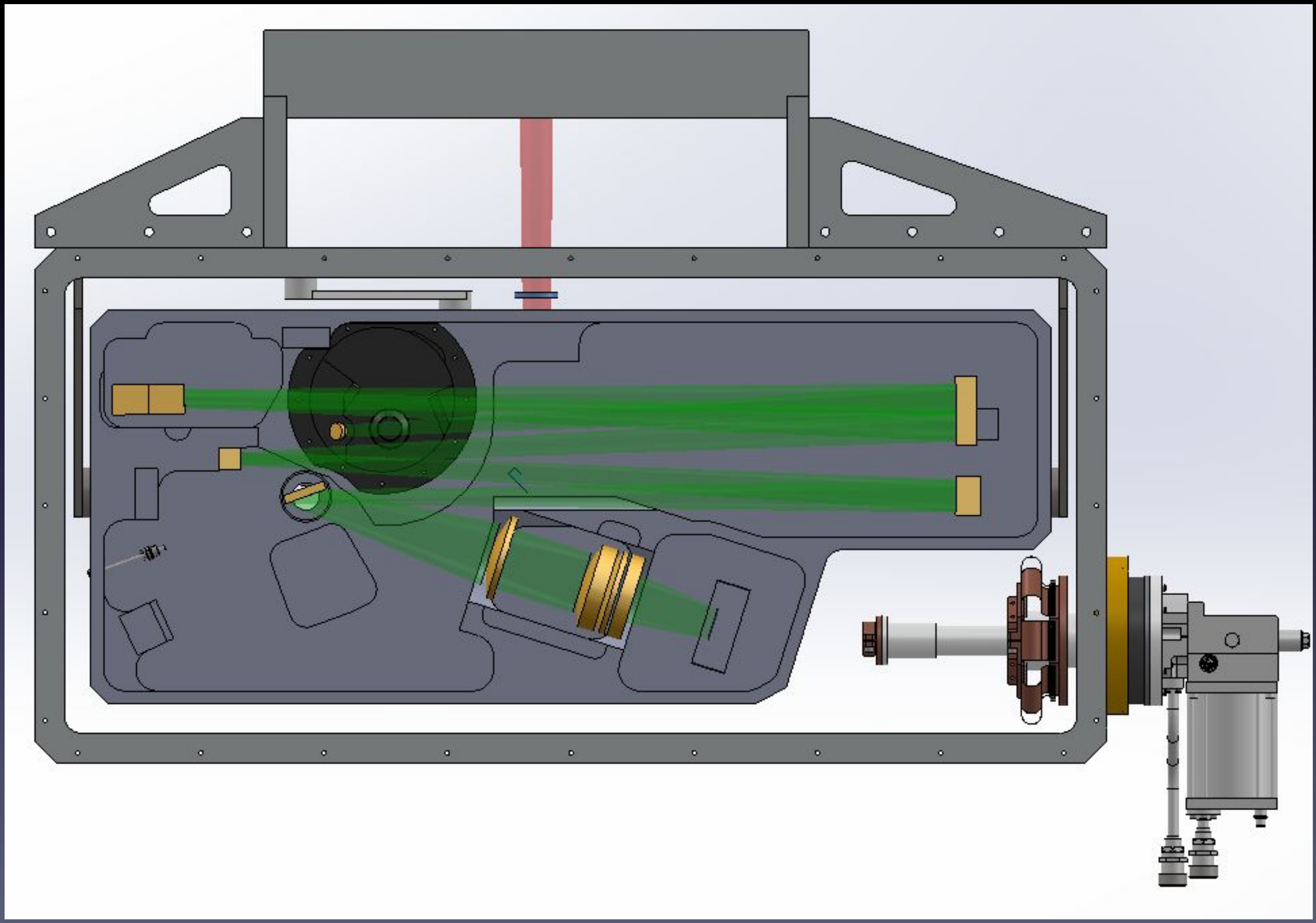
Fore Optics



Instrument Layout – *Spectrograph*

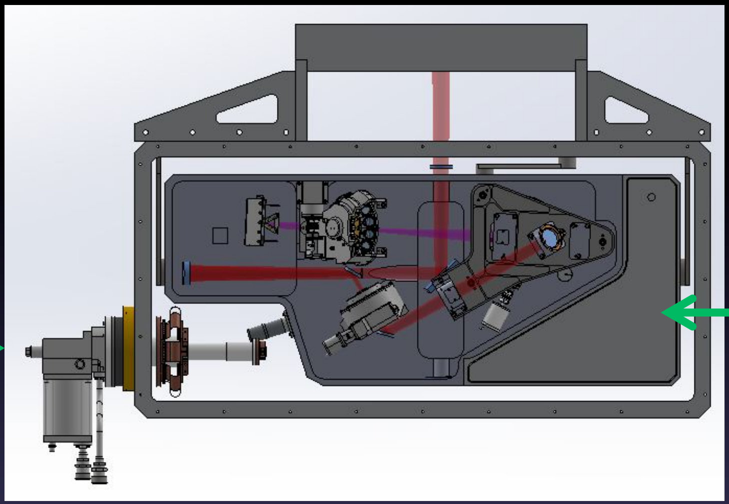


Spectrograph Optics



Cooling Approach

CTI 1050 CP



LN Dewar

- LN Dewar
  - Cools the bench
  - 12 L Capacity at zenith
  - 2.2 Days hold time
- Cryo Cooler
  - First stage cools the radiation shield
  - Second stage cools two imagers

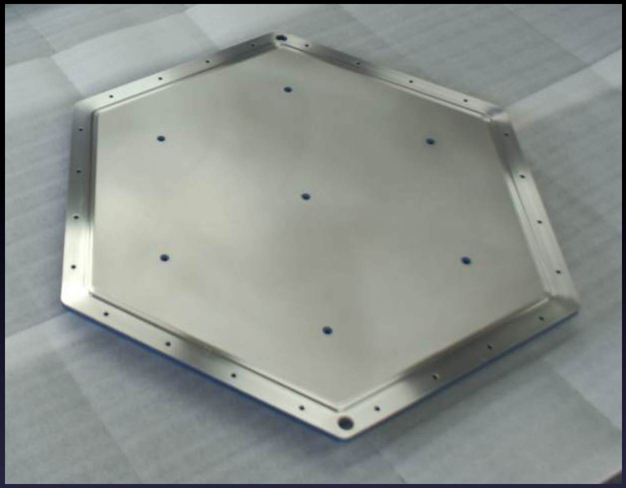
Cryostat – *Meyer Tool & Manufacturing*

- Meyer Tool & Manufacturing – *experienced in large cryostat fabrication*

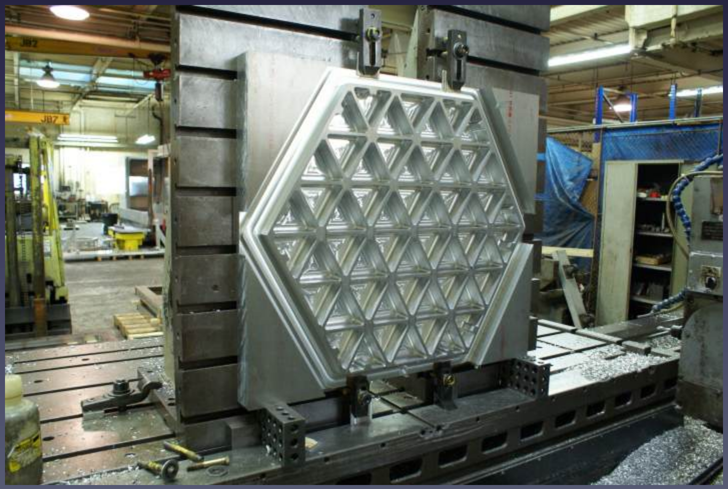
    - South Pole Telescope Cryostat
    - Pocketed Walls
    - Aluminum Welded Construction

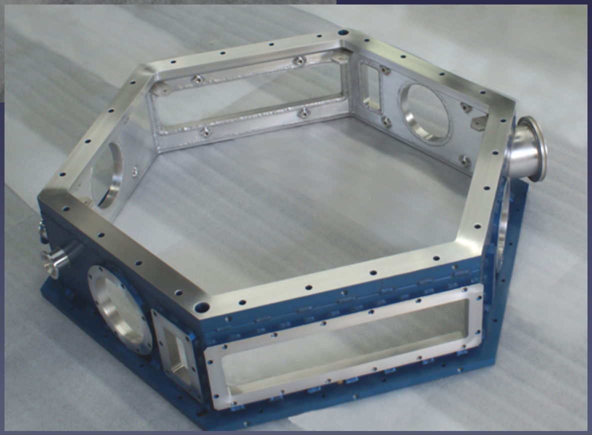
- NEWFIRM Dewar
- Aluminum Welded Construction
- Powder Coated

Cryostat – *Meyer Tool & Manufacturing*



- AURA One Degree Instrument (ODI)
- Vacuum rated welds
- O-ring grooves with dovetail
- Large Capacity Milling Machines
- Vacuum testing capability

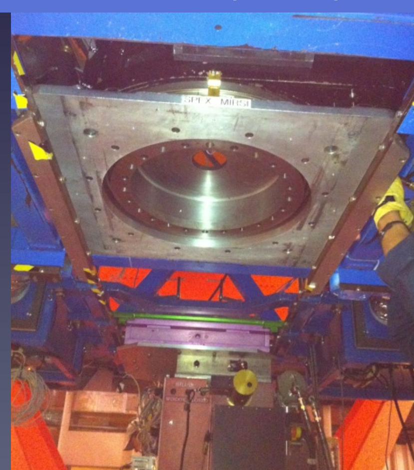


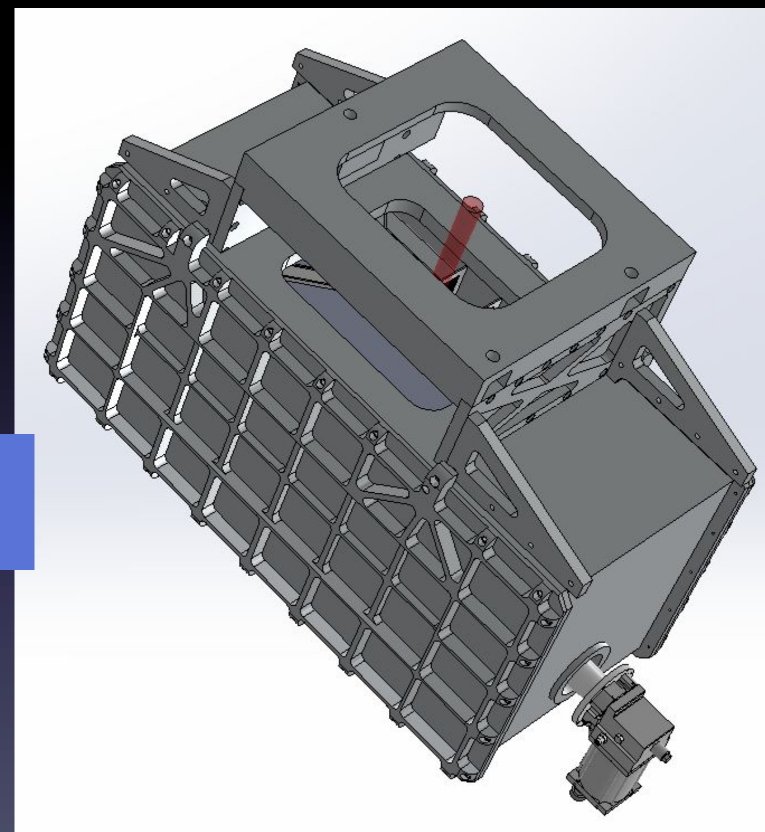


Telescope Interface

- Three point interface to the Multiple Instrument Mount (MIM Cart) to facilitate final alignment to the telescope
- Gussets provide open access to the calibration optics and cryostat window

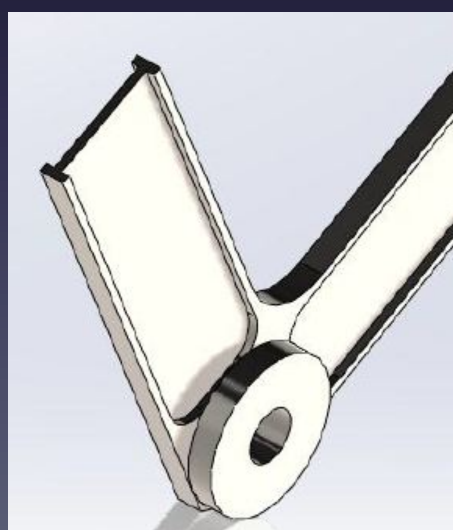
Multiple Instrument Mount (MIM)

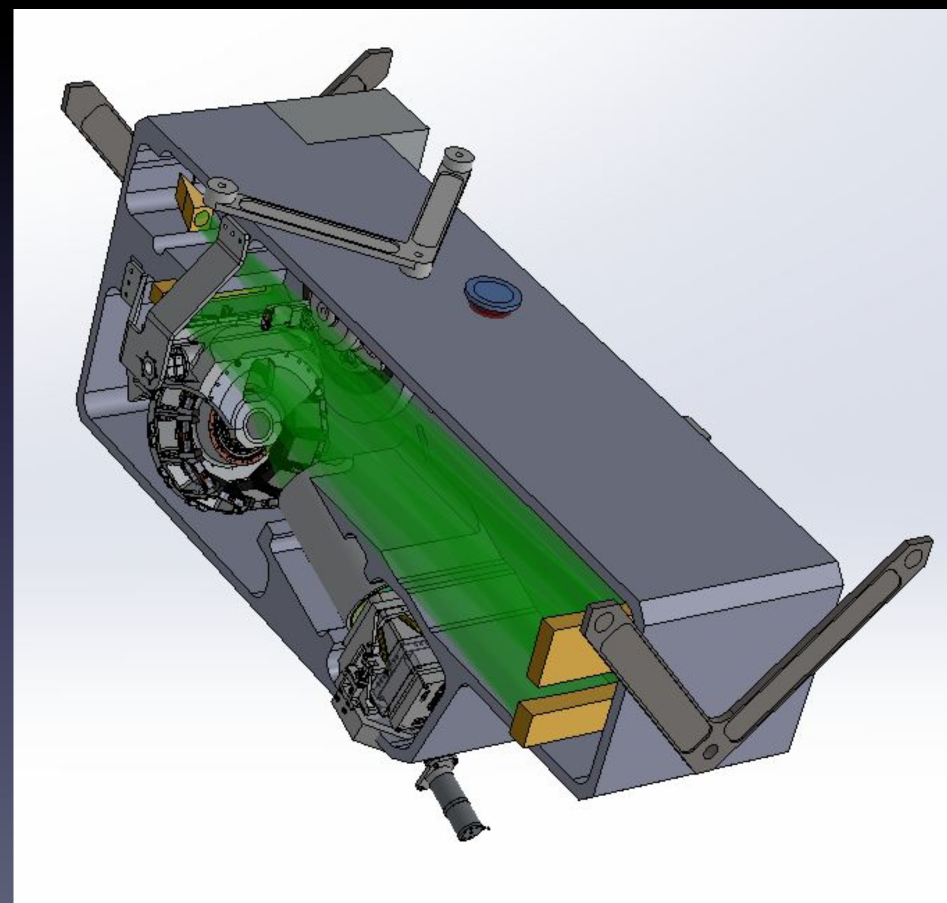




Trusses

- Three truss configuration (Titanium)
- Truss cross section optimized for maximum strength and thermal resistance
- Approximately 5W combined thermal load conducting through the trusses

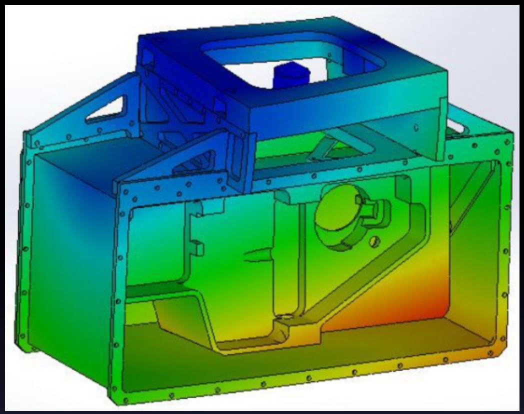




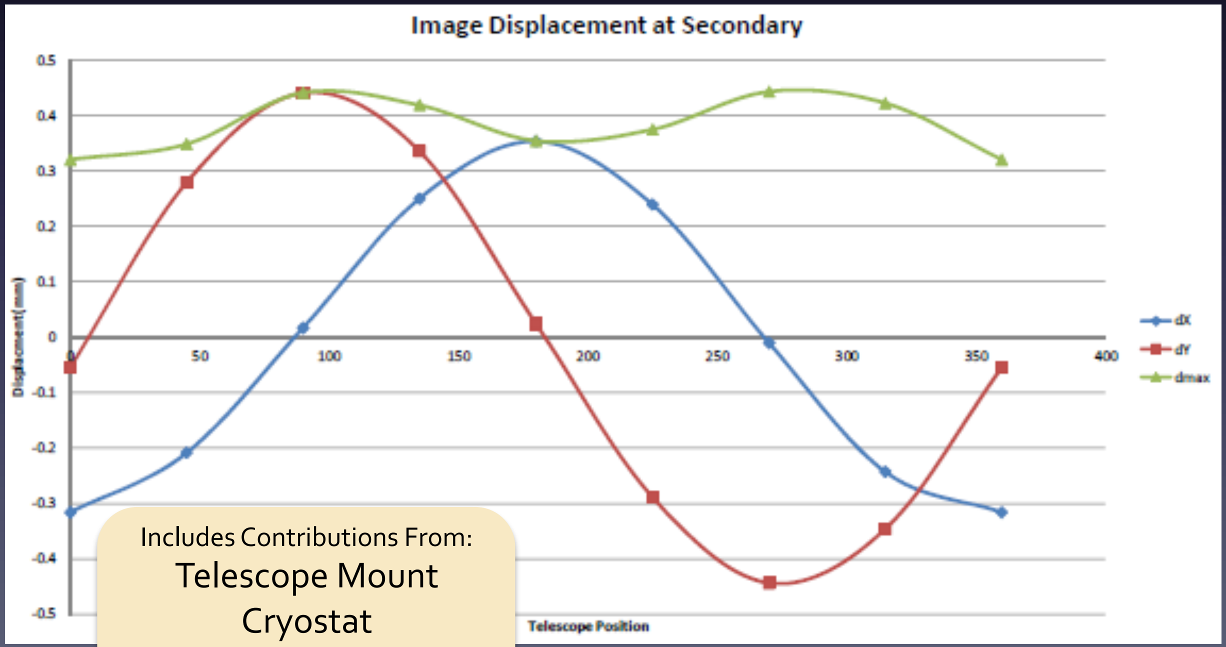
Flexure Study

Requirement: Co-alignment of the cold stop and telescope exit pupil to within 1% of their diameters...

This is equivalent to 2.4mm image displacement at the secondary



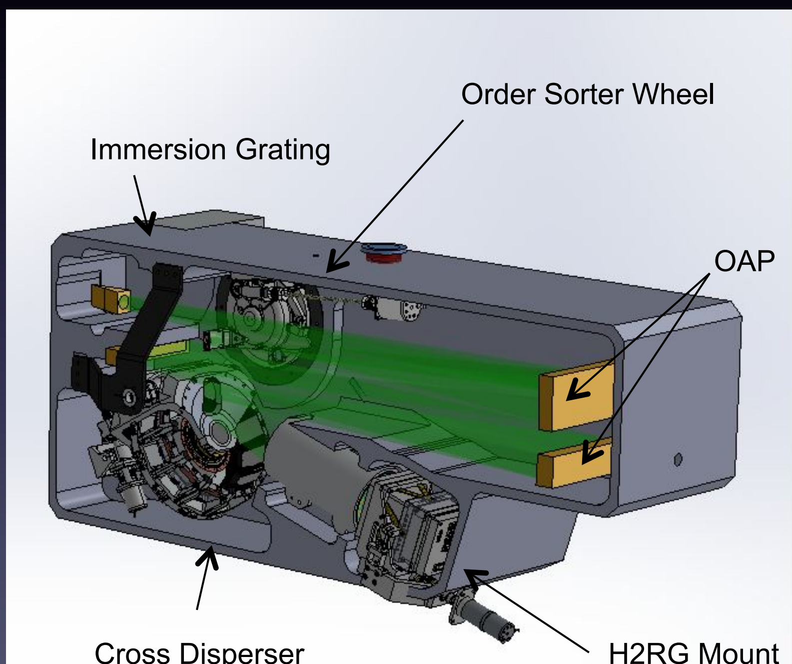
- Worst case gravity vectors used (60° from zenith)
- The resulting angular deflection of the optical axis is expressed as image displacement at the secondary
- Total contribution is 0.45 mm at the most - *20% of the allowable displacement*



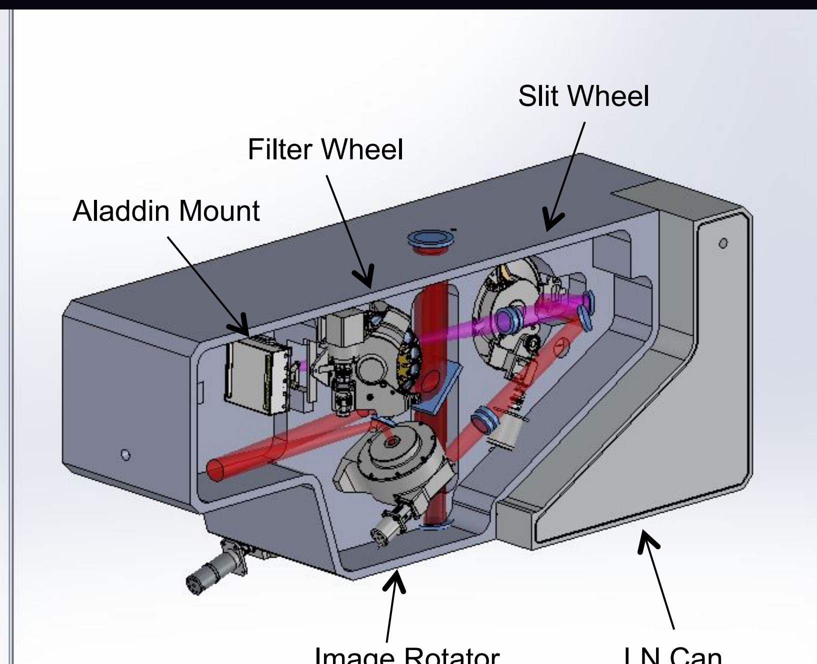
Includes Contributions From:
Telescope Mount
Cryostat
Trusses
Optical Bench

Optical Bench

- Two sided bench
- Milled from a single billet
- Pocketed for weight reduction

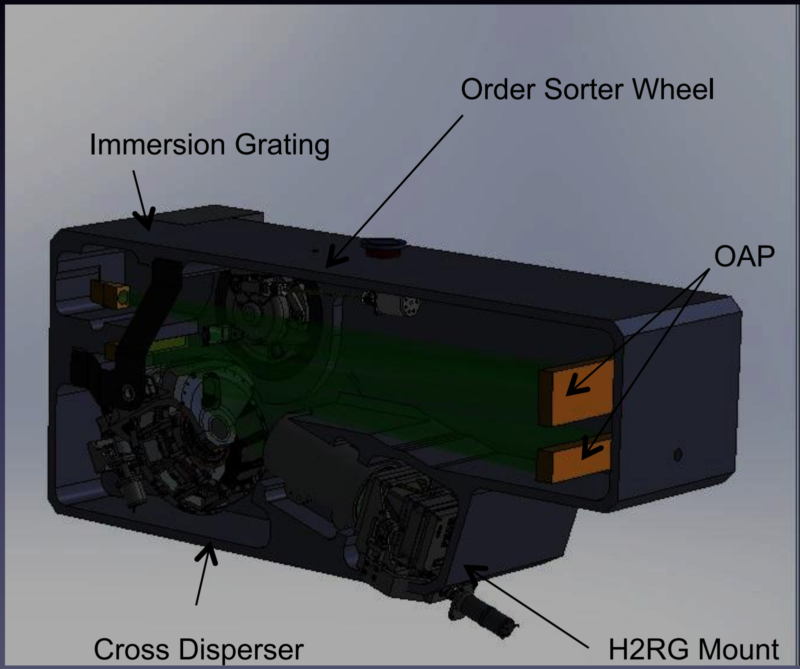


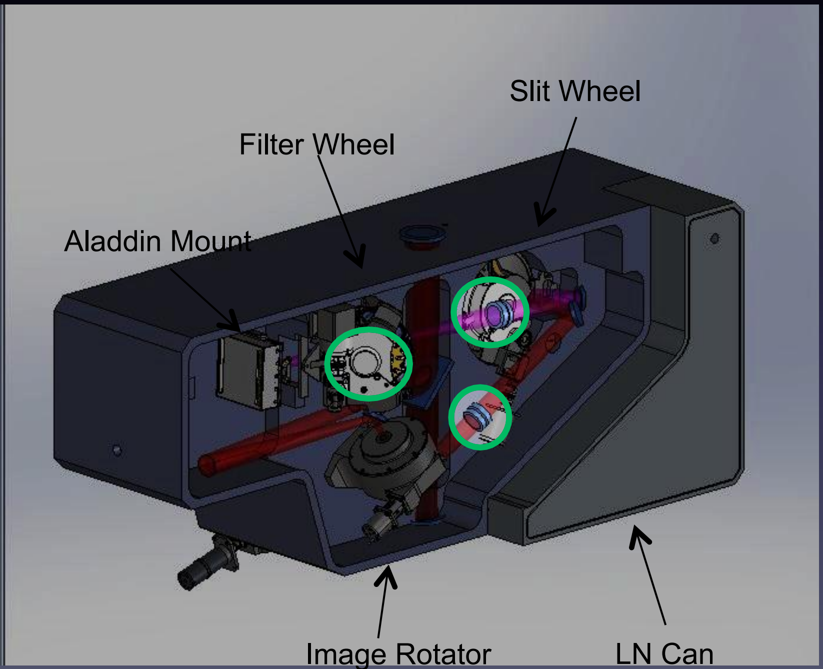
Spectrograph Side



Fore Optics Side

Optic Mounts - *Doublets*



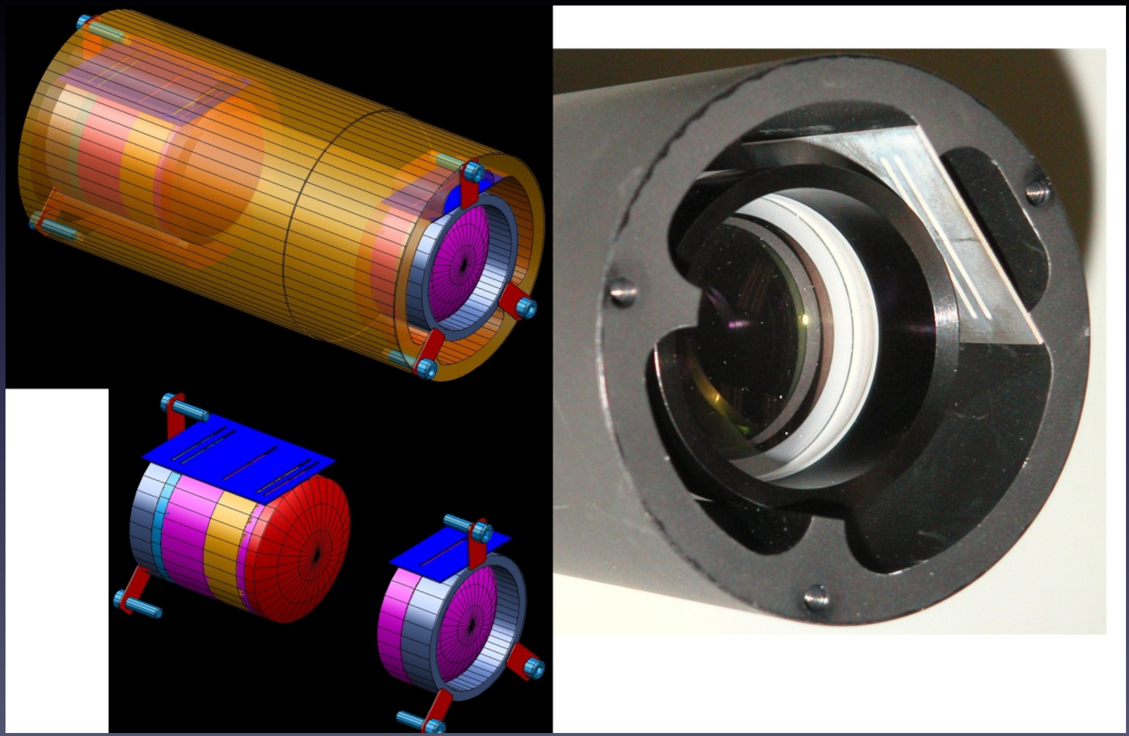


Spectrograph Side

Fore Optics Side

SpeX Lens Barrel Design

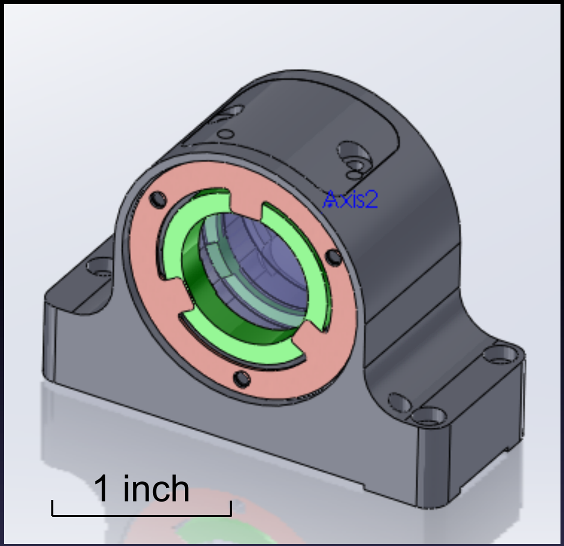
Used on SpeX with good results



Doublet Lens Barrel Concept

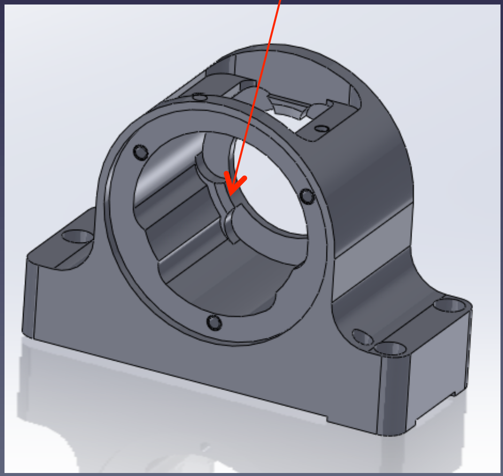
Proven design approach

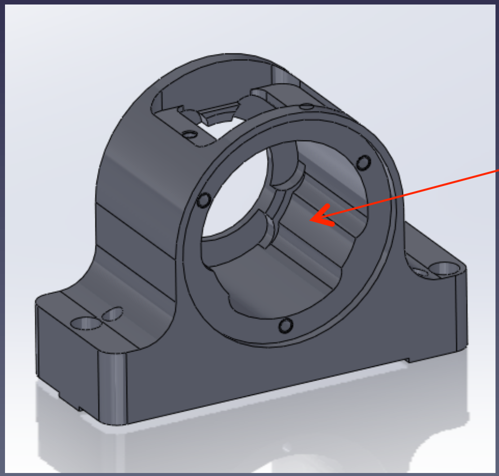
Used on SpeX instrument



Three Axial Support Pads

- *Cone geometry provides tangent-line contact with convex lenses*
- *Spring preloaded*





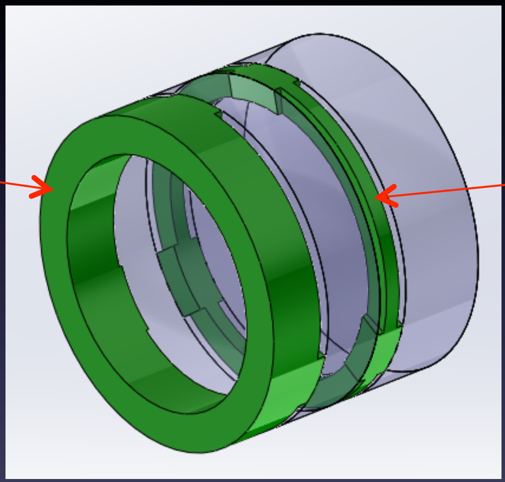
Two Radial Support Pads

- *Same diameter for all lenses and spacers*
- *Cylindrical geometry*
- *Spring preloaded*

Doublet Lens Barrel Concept
Lens and Spacer Stack

Axial Preload Spacer

- Protects lens from rubbing contact with spring clips
- Same pad geometry as lens spacers

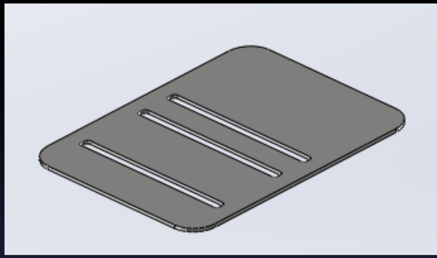


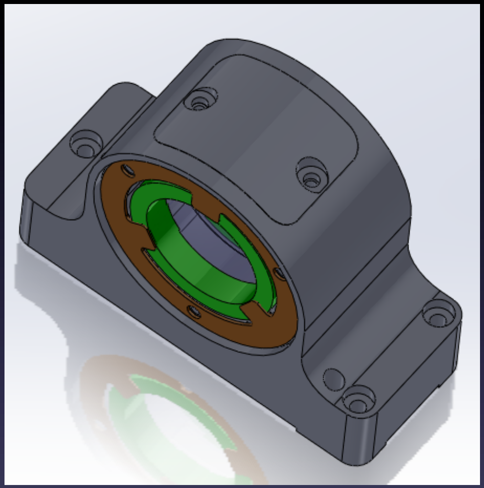
Lens Spacer

- Three pad contact on front and back
- Cone geometry on pads for tangential-line contact
- Flat geometry when contacting bevels
- Small gaps allow evacuation

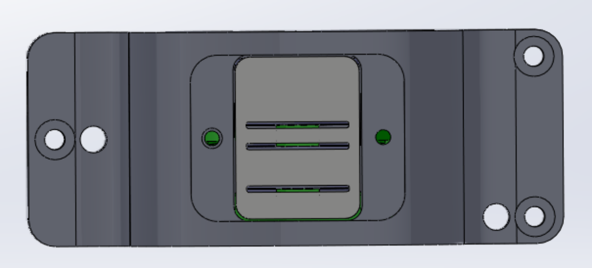
Doublet Lens Barrel Concept
Radial Spring Preload

Radial Spring
- *Ladder Rung Design*
- *6Al4V Titanium (grade 5)*
- *One rung per lens/spacer*

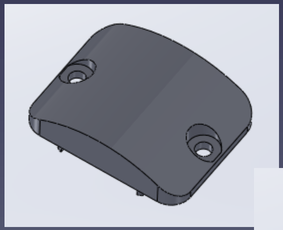


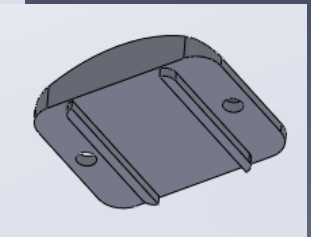


Externally Installed
- *Captured in the "spring well"*
- *Preload generated by the spring cap*
- *Avoids chipping lens edges*



Flush External Surface

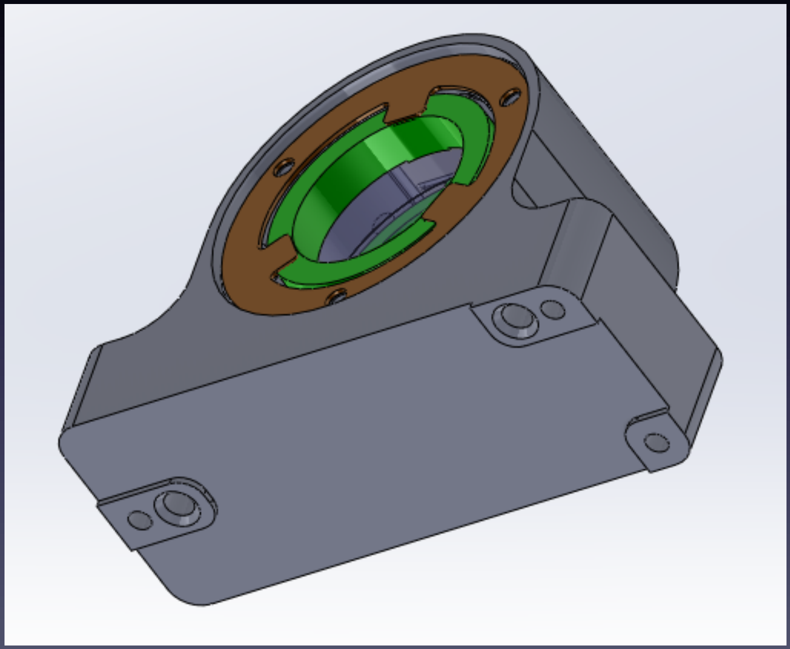




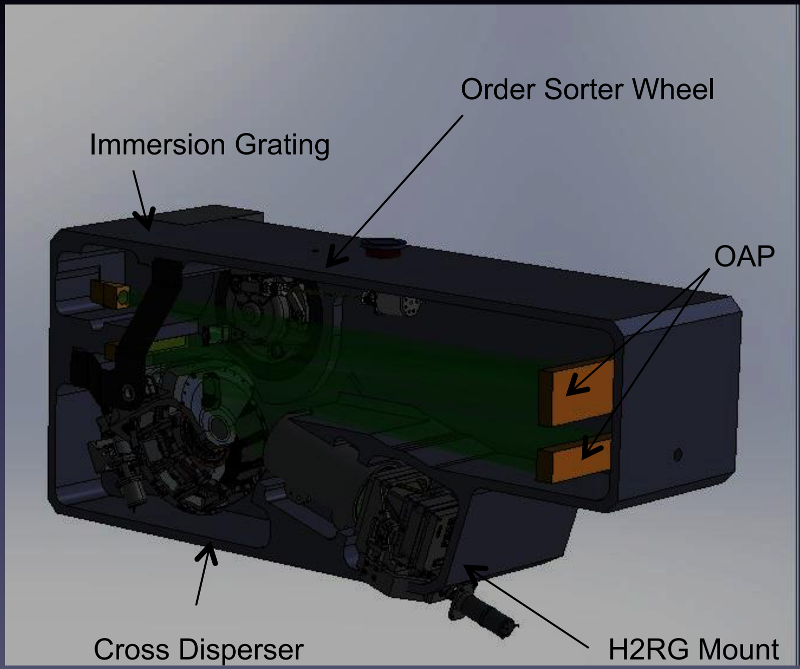
Spring Cap
- *Light Tight*
- *Preload bosses determine the amount of spring deflection*

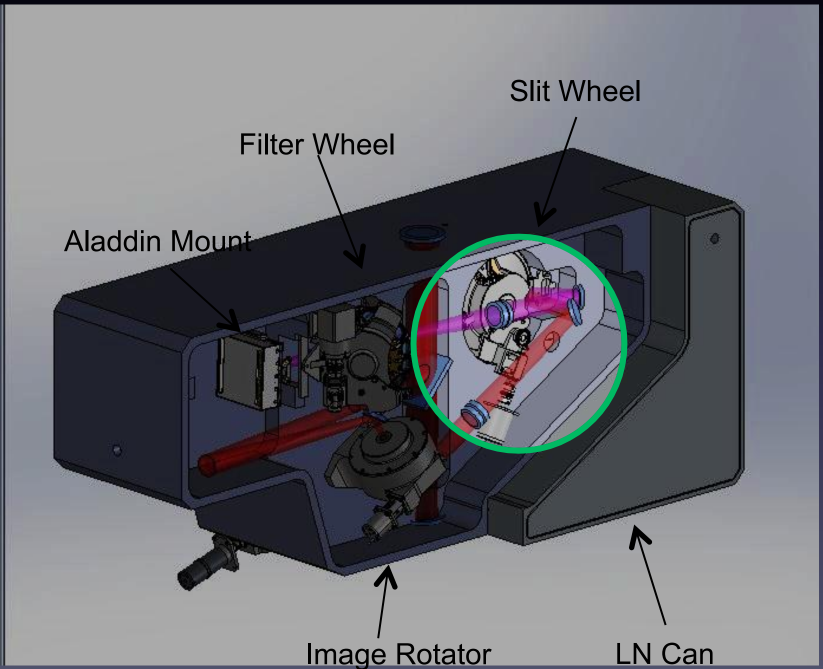
Doublet Lens Barrel Concept
Interface to Optical Bench

- Mount Pads (3x)
- Located with pins (2x)
- Pin holes are chamfered to allow for mushroom effect around the pin base
- Can be shimmed if necessary
- Same approach used in SpeX



Optic Mounts – *Slit Wheel Optics Group*



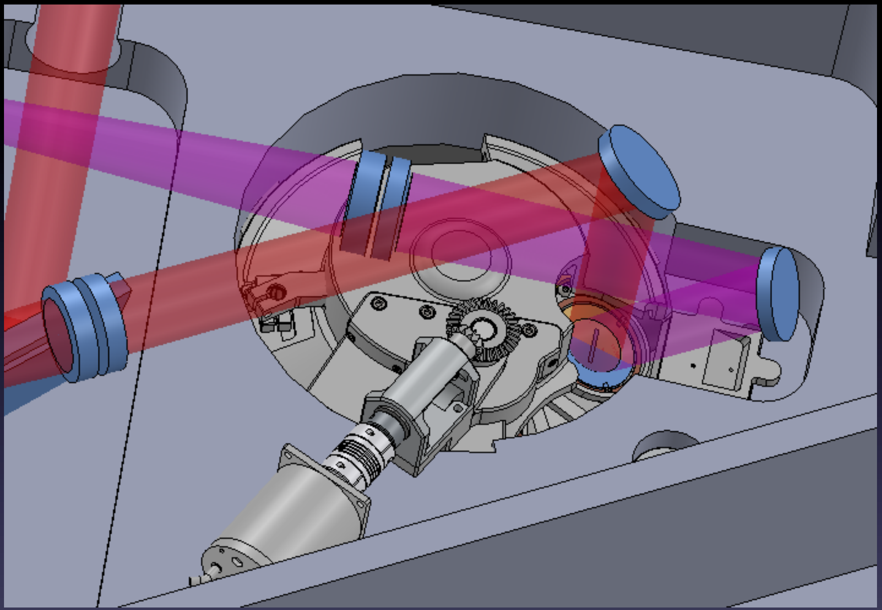


Spectrograph Side

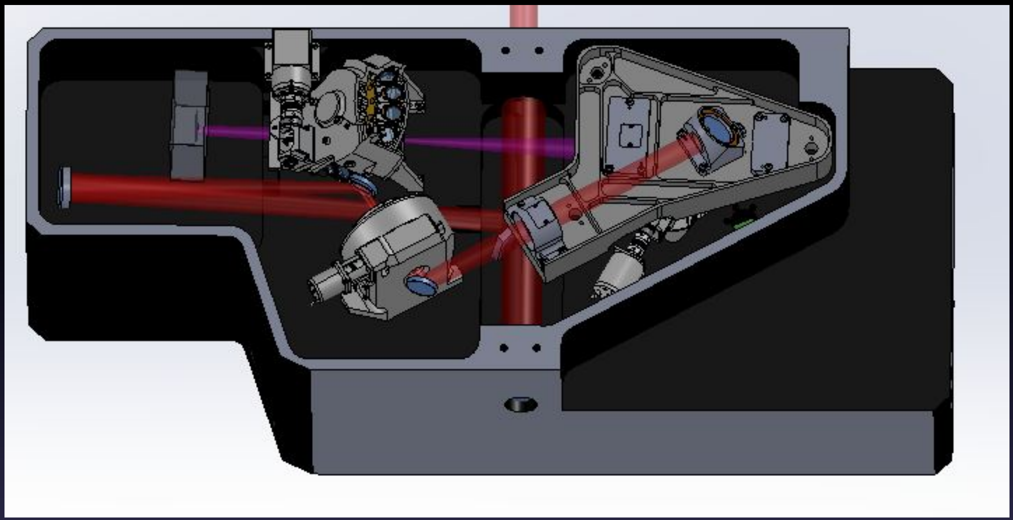
Fore Optics Side

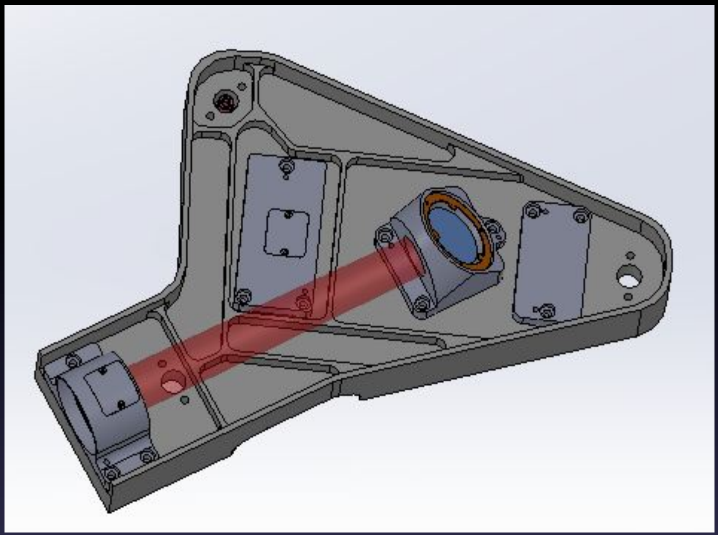
Slit Viewer Optics

- Group of optics above the slit wheel
- Need access to the Slit Wheel
- Need access to the Dekker Mechanism
- Need to be able to remove and install the optics group without requiring realignment

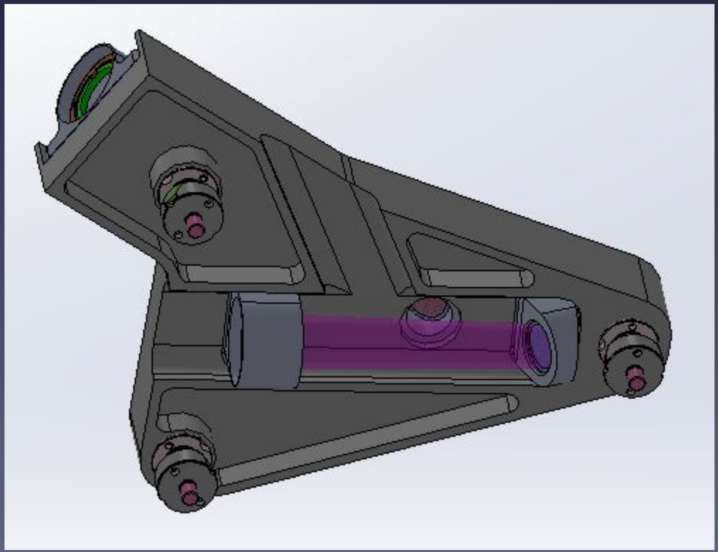


Slit Viewer Optics - *Subplate*



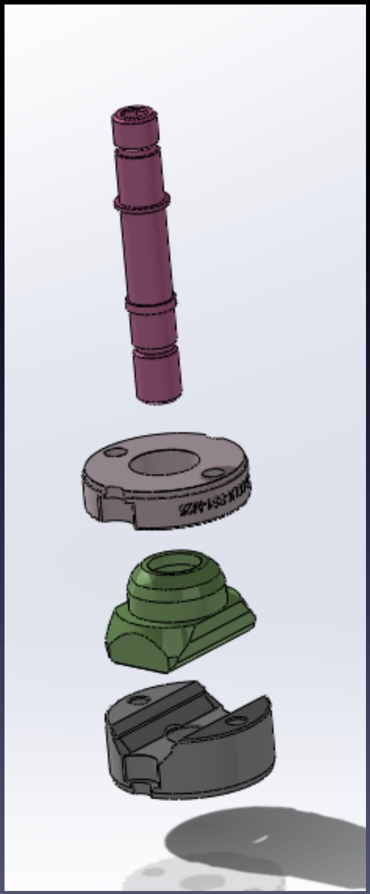


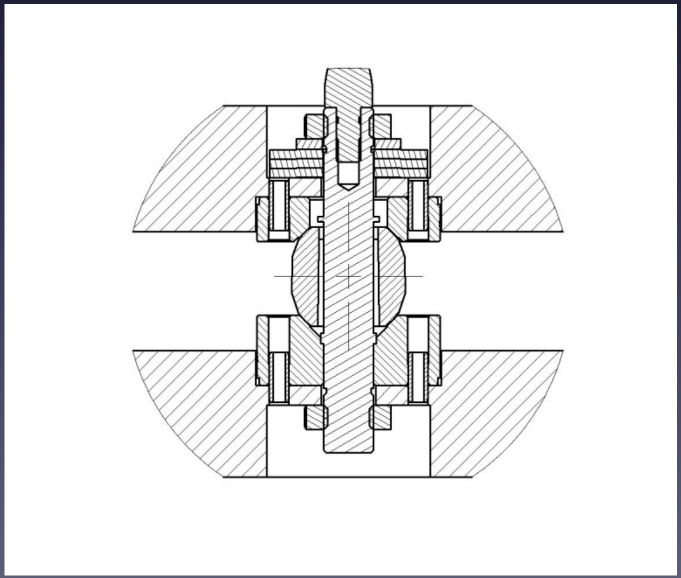
- Four optic mounts
  - Two mirrors
  - Two doublets
  - Individually shimmable
- The optics group can be removed as an assembly
- Realignment not required
- Spherolinder Kinematic Mounts (3x)

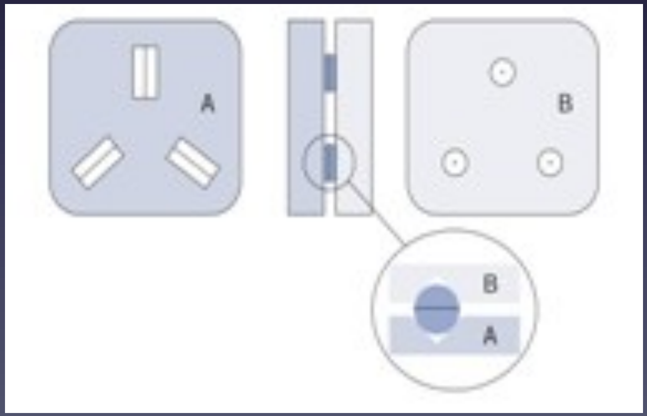


Slit Viewer Optics - *Spherolinders*

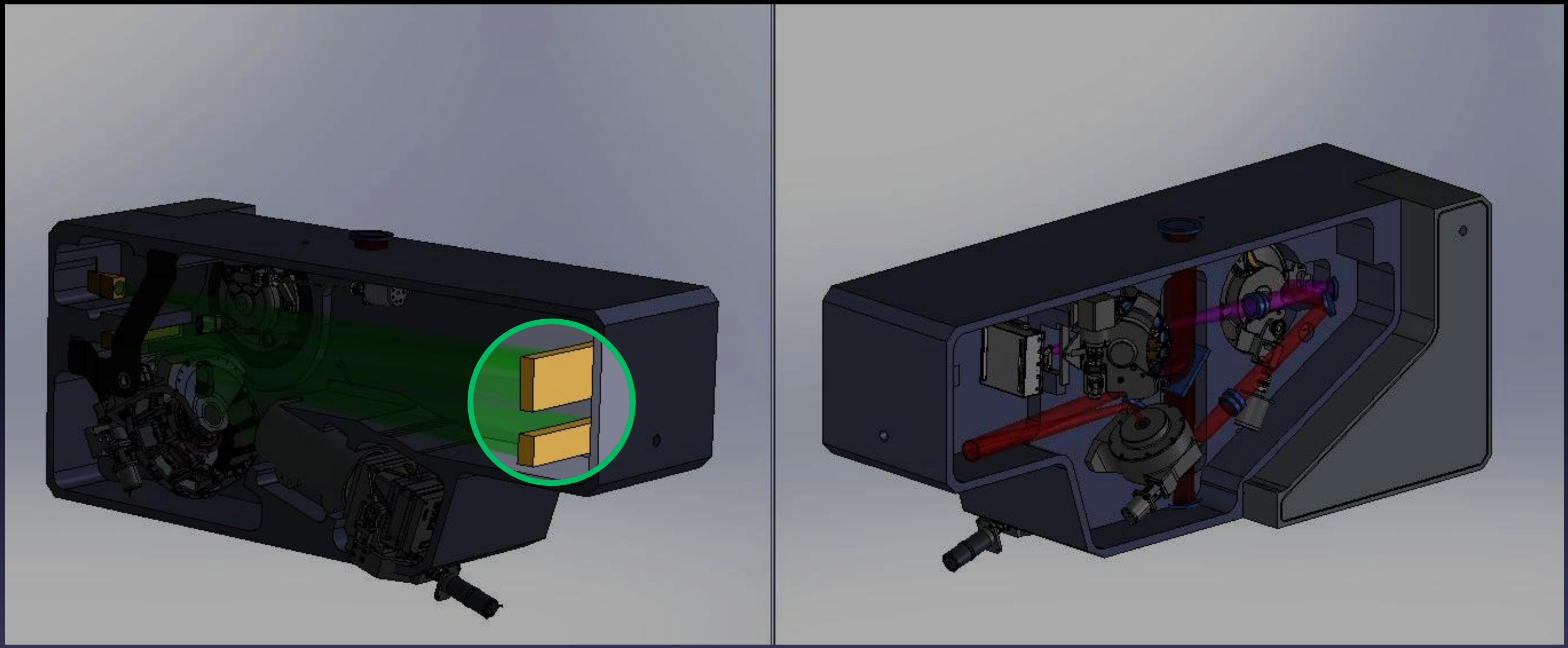
- Sphere on top, Cylinder on bottom
- 25mm sphere capable of 2 tons per spherolinder
- Hardened 440C Steel
- COTS assembly with mating cone block, V block, and preloading connector.







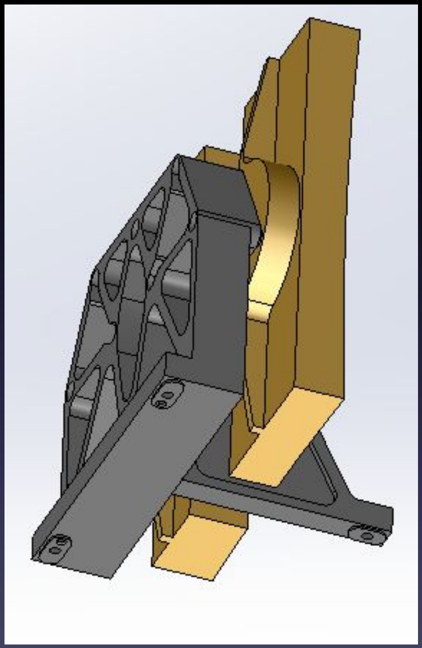
OAP Mirrors

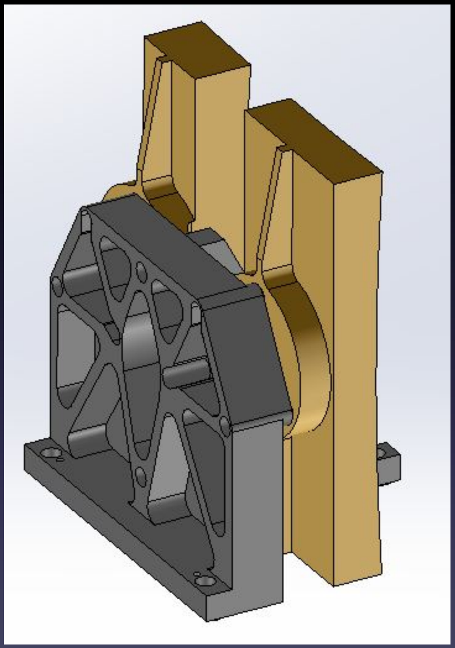


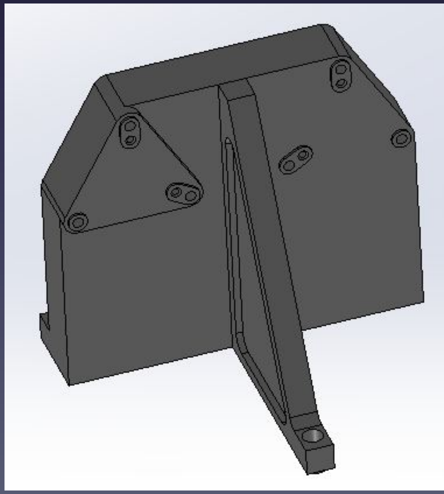
- Two OAP mirrors
- Mirrors and Mount to be fabricated by the optics vendor
- Mirrors will be aligned to the mount at the vendor's facility

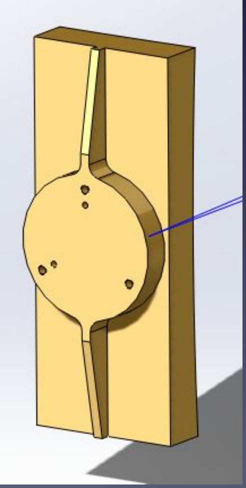
OAP Mount Concept

- Mirror/Mount interface uses three pads and two pins
- Mount/Bench interface uses three pads and two pins
- Wide footprint for stability and shimming resolution

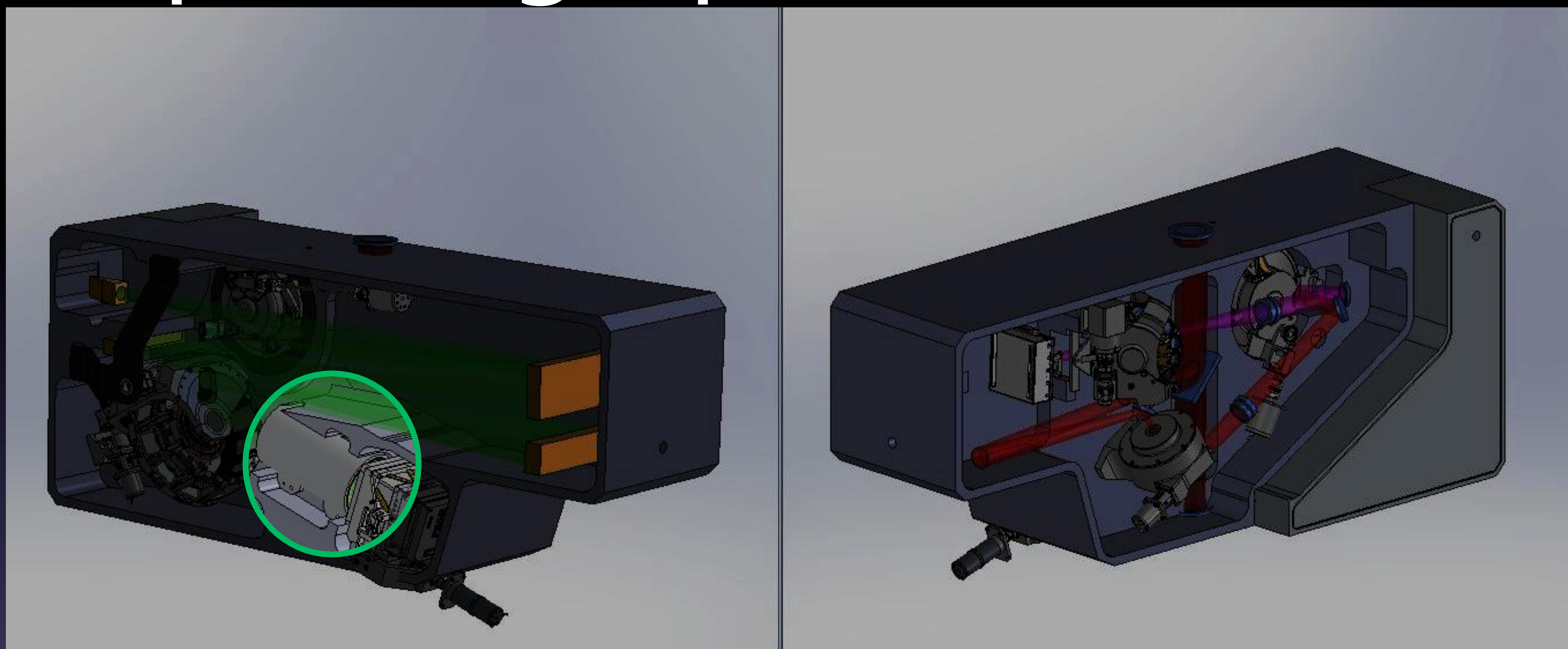








Spectrograph Camera Lens



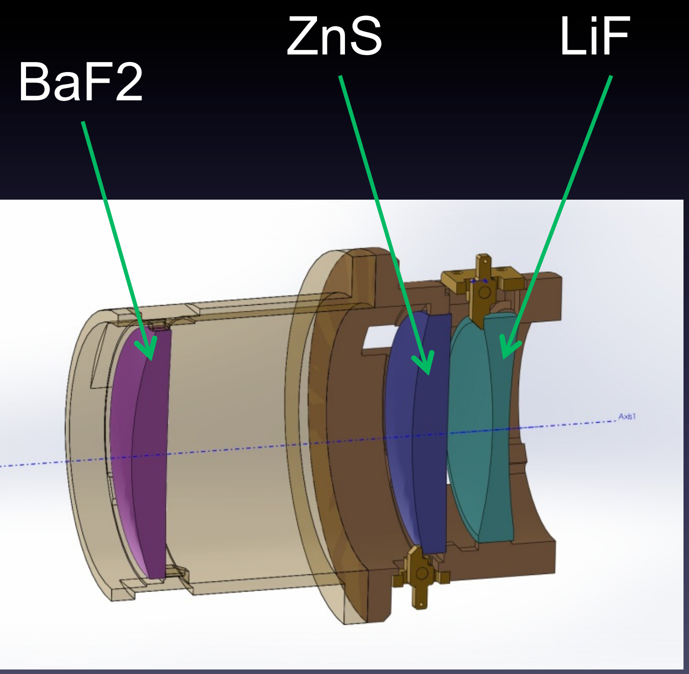
- ISHELL has three large lenses in the Spectrograph Camera Lens
    - Ø ~ 100mm each
    - V ~ 96 mm^3 each
    - m ~ 250 g each

Previous designs used lenses no larger than 80mm

Spectrograph Camera Lens

Barrel Mount Concept

- 3 axial and 2 radial mount pads per lens
- External coil springs hold the lens in place.
    - One per axial pad (3x)
    - One for radial loading
    - Precise holding force (10 G's or 2.5 kg)
    - Easier assembly
- Two piece lens barrel used for manufacturability
    - Precision locating features at the split
    - All lens reference surfaces are cut on a single lathe setup



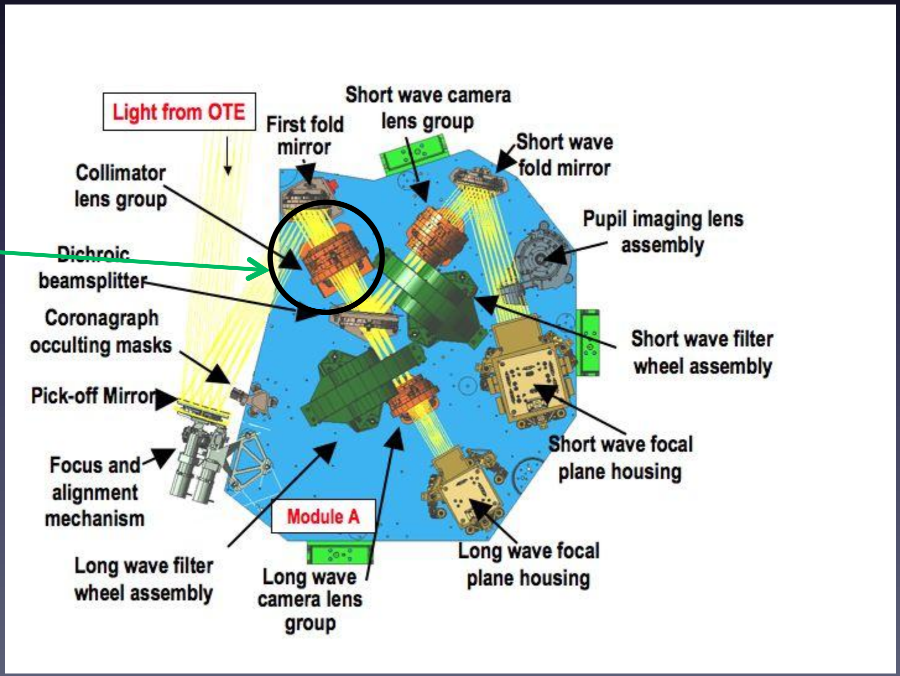
LiF Lens – *Thermal Stress Analysis*

NIRCam-JWST

LiF Lens is the most susceptible to fracture – selected for analysis

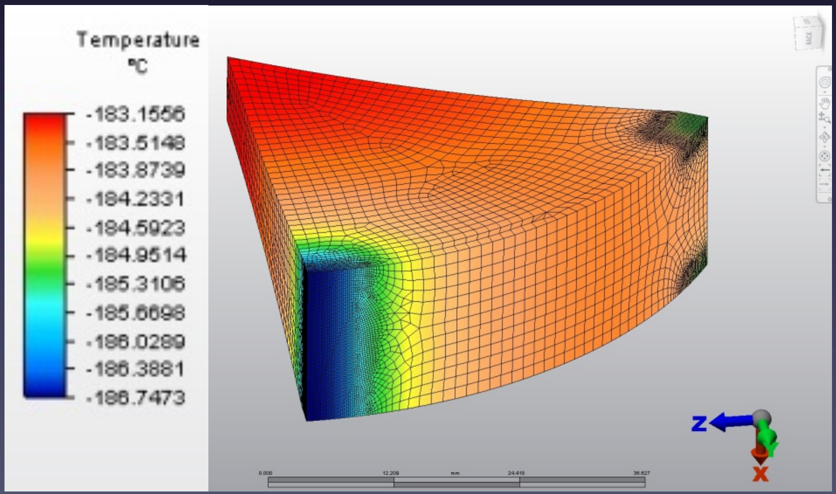
- FEA transient thermal analysis
- FEA internal stress analysis
- NIRCam analysis used for reference

NIRCam same sized LiF element (94 mm)



LiF Lens – *Thermal Analysis*

- Symmetry used to simplify the analysis
- Contact resistance modeled at mount points (400 $W/m^2 \cdot K$)
- Lens cell cooled at a rate of 0.5 ° K/min from 298 ºK down to 73 ºK.
- Includes radiative and conductive effects

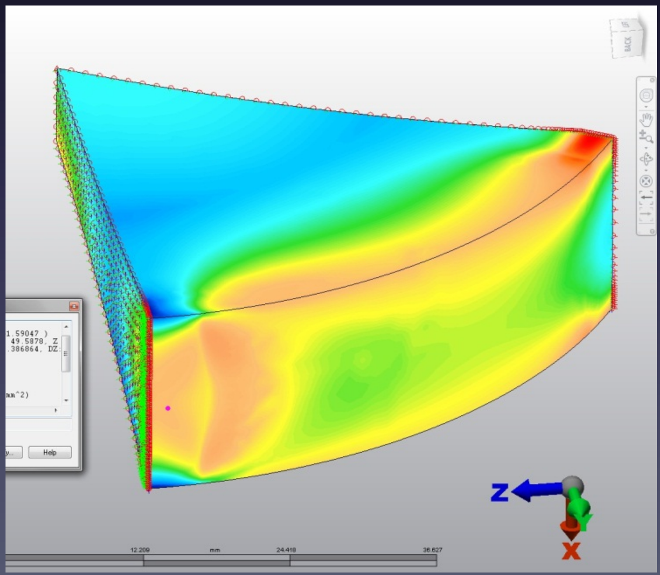


- Max temp gradient ~ 3.6 ° K across the lens.
- Dominated by conductive heat transfer
- Total cooling time of 500 min (8.3 hrs).
  - Similar to SpeX

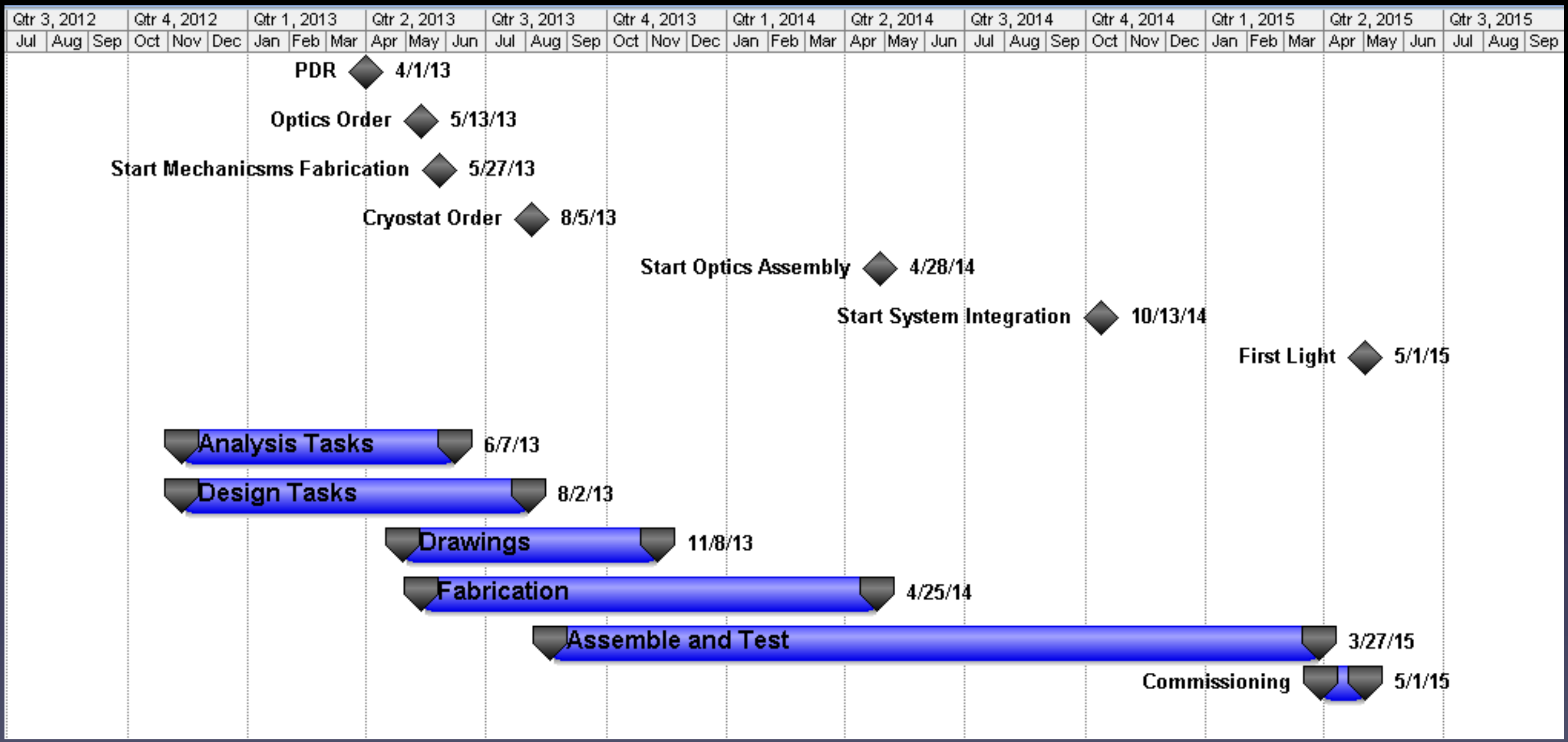
LiF Lens – *Stress Analysis*

- Stress analysis based on output from thermal analysis
- NIRCam used a criteria of “maximum resolved shear stress” < 2.0 MPa.

- Largest stresses occur at 7.5 hrs
- Calculated shear stresses are ~1.25 MPa
- Mount pads need to be sized to reduce the additional contribution from contact stress.
- Risk Reduction: Plan to use a LiF blank for verification



Schedule



Qtr 3, 2012
Qtr 4, 2012
Qtr 1, 2013
Qtr 2, 2013
Qtr 3, 2013
Qtr 4, 2013
Qtr 1, 2014
Qtr 2, 2014
Qtr 3, 2014
Qtr 4, 2014
Qtr 1, 2015
Qtr 2, 2015
Qtr 3, 2015
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
PDR 4/1/13
Optics Order 5/13/13
Start Mechanicsms Fabrication 5/27/13
Cryostat Order 8/5/13
Start Optics Assembly 4/28/14
Start System Integration 10/13/14
First Light 5/1/15
Analysis Tasks 6/7/13
Design Tasks 8/2/13
Drawings 11/8/13
Fabrication 4/25/14
Assemble and Test 3/27/15
Commissioning 5/1/15