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

MECHANICAL OVERVIEW

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MECHANICAL ENGINEERING TEAM

- Mechanical Engineering
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- Designer
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- Thermal
  - Doug Adler
- Cryogenic Dewar
  - Stephen Smee

INTRODUCTION

- Lessons from the visible side
- Instrument layout
- Mass estimate
- Opto – Mechanics
  - Tolerances, Mounting
- Structure
  - Existing Structure, Additional Substructures, Modifications
- Mechanisms
  - Overview of mechanisms
- Enclosure
- Path Forward
  - Design activities and critical analysis

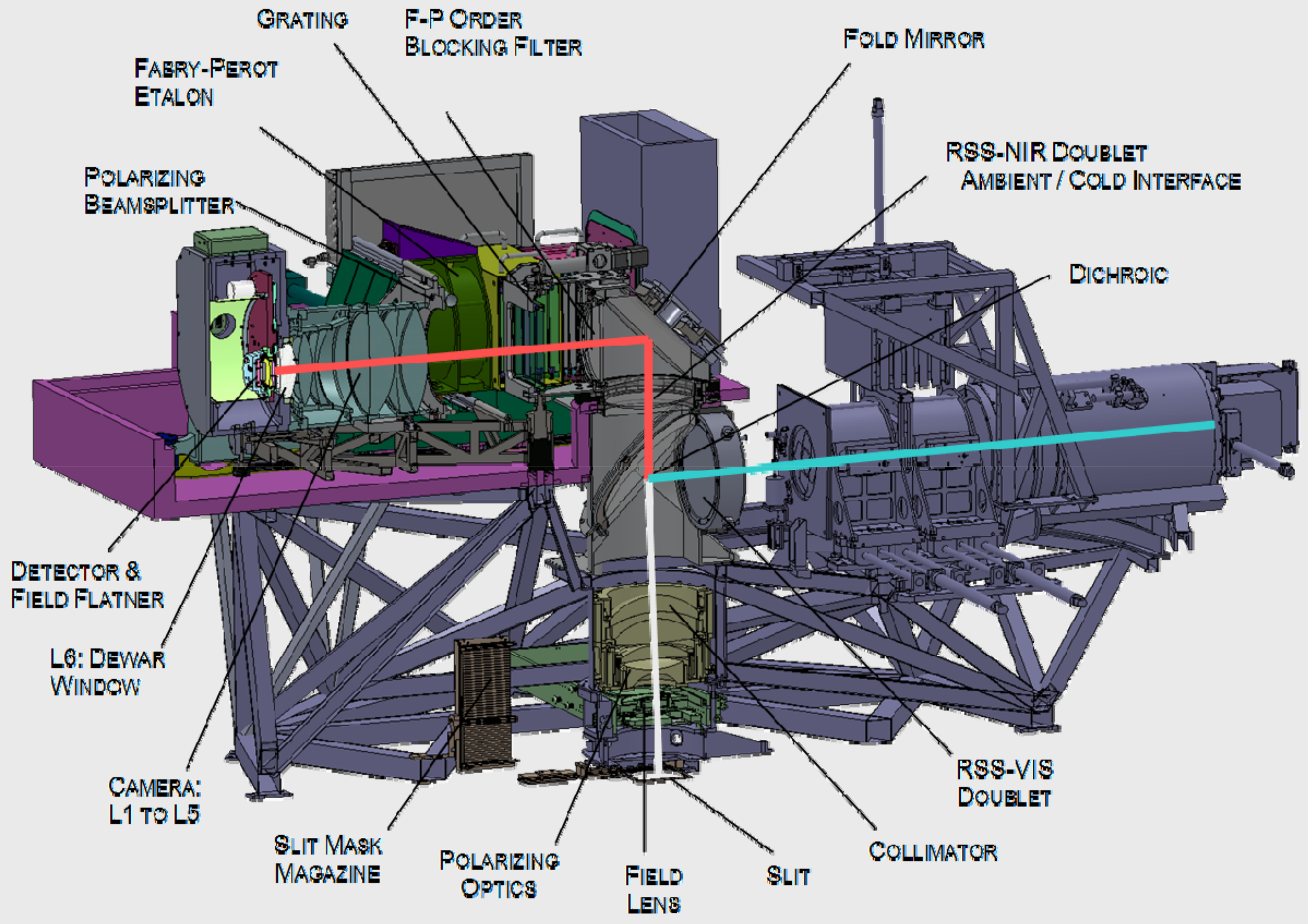
INTRODUCTION

- Major upgrade
- Built on existing structure
- Shared collimator, slitmask, waveplates
- New dichroic to replace Vis fold
- Nine major optics-moving mechanisms
- -40ºC Pre-Dewar
- Articulating Camera and Dewar
- Cryogenic detector Dewar

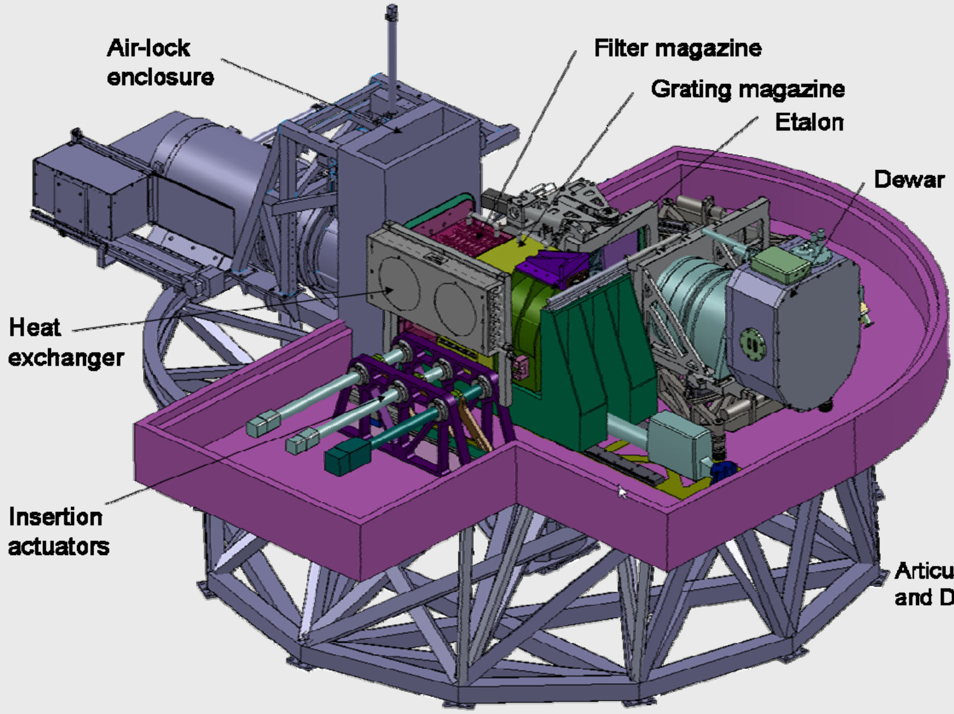
Lessons From RSS-VIS

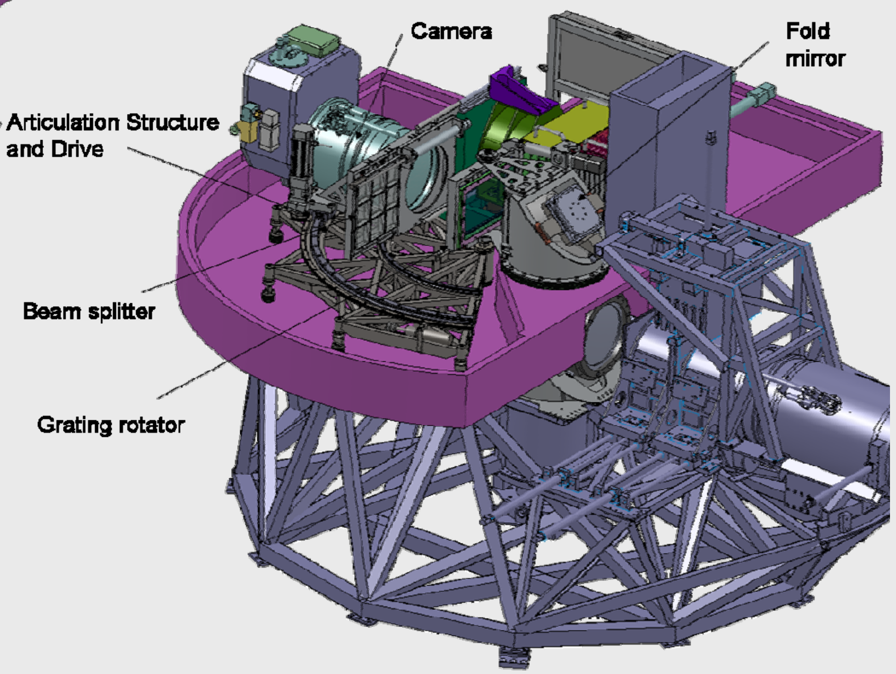
- Flexure
  - Improved camera cradle design
  - Reduced cantilevered mass on camera cradle (no grating magazine)
  - Better understanding of grating and etalon tolerances
- Serviceability
  - Access to alignment features, motors and sensors
- Rigidity of Magazine Mechanisms
  - Improved rigidity between stages in hand-off mechanisms will improve reliability
- Improve Baffling
  - Light tight, dust tight enclosures detailed in from beginning
  - Pre-Dewar is a natural enclosure
- Electronics Enclosures
  - Keep track of size, this is a complicated instrument with many components at prime focus
  - Keep space and mounting locations

INSTRUMENT LAYOUT



INSTRUMENT LAYOUT





Mass Estimate

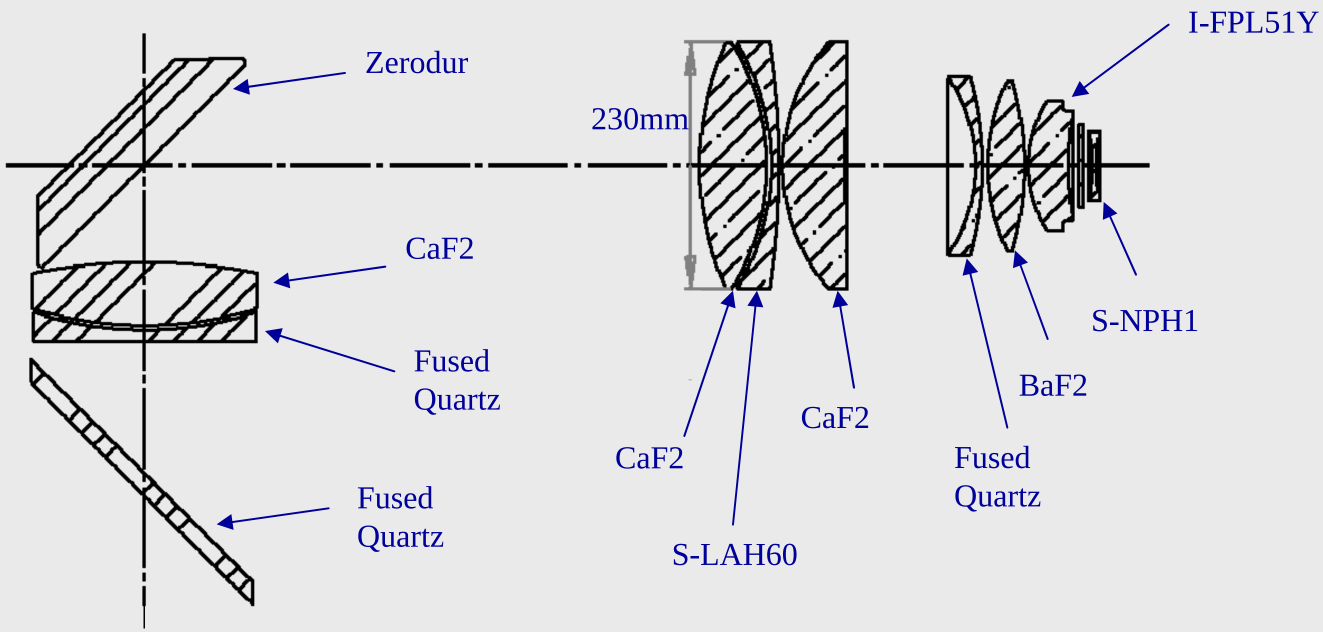
SUBSYSTEMS	kg
Optics Tower Assemlby	58
Fabry-Perot Etalon Assembly	20
Polarizing Beamsplitter Assembly	8
Camera Articulation Mount	37
Camera/Dewar Assembly	47
Strorage Optics	60
Predewar Assembly	45
Electronics Boxes	54
Wire Harness	12
Cooling Lines	10
Misc (5%)	18
SUBTOTAL	368
GROWTH (10%)	37
TOTAL	**405**

	kg	%
Glass	63	17%
Mechanical	161	44%
Enclosure	45	12%
Electrical	54	15%
Services	22	6%
Cryogenics	5	1%
Misc (5%)	18	5%
	368	
Growth (10%)	37	
Total	405	

OPTICS

- Dichroic
- Collimator doublet – pre-Dewar window
- Fold Mirror – Actuated for nodding and flexure compensation
- Collimator space optics: baffle, filter, grating, etalon, beam splitter
- 7 Element Articulating Camera with internal focus
- Cryogenic detector Dewar containing cold filters, field lens and detector.

Optics Layout

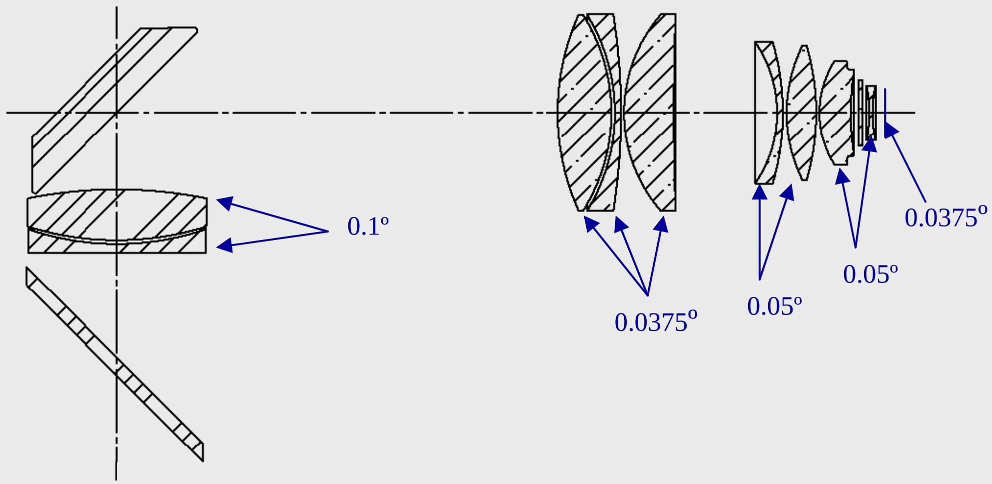


- Pre Dewar Window: Fused Quartz
- Dewar Window: I-FPL51Y
- 3 CaF2 and 1 BaF2 Lenses. One of which in close proximity to pre-Dewar Window
- Largest Optic ~ 230mm diameter

Alignment Tolerances

- Tight but achievable with standard practices
- Same specification as RSS-VIS which were met
- Analysis has enabled design of lens cell and groupings

Lens #	Decenter	tip/tilt	Axial Displacement
	mm	degrees	mm
D1	0.1	0.1	0.2
D2	0.1	0.1	0.2
L1	0.0375	0.0375	0.05
L2	0.0375	0.0375	0.05
L3	0.0375	0.0375	0.05
L4	0.05	0.05	0.1
L5	0.05	0.05	0.1
L6	0.05	0.05	0.1
L7	0.05	0.05	0.05
D	0.1	0.0375	0.0375



Flexure Tolerances for Powered and Non-Powered Optics

- For powered optics flexure induced motion should be < 25% of alignment tolerance
- Fold Mirror and Dichroic: 0.005º
- Gratings: Tip 0.02º, Tilt 0.04º, Roll 0.0025º
- Etalons: 0.01º
- Filters: Tip, Tilt 0.04º
- Grating roll, dichroic and fold mirror are the most sensitive to flexure and must be carefully addressed

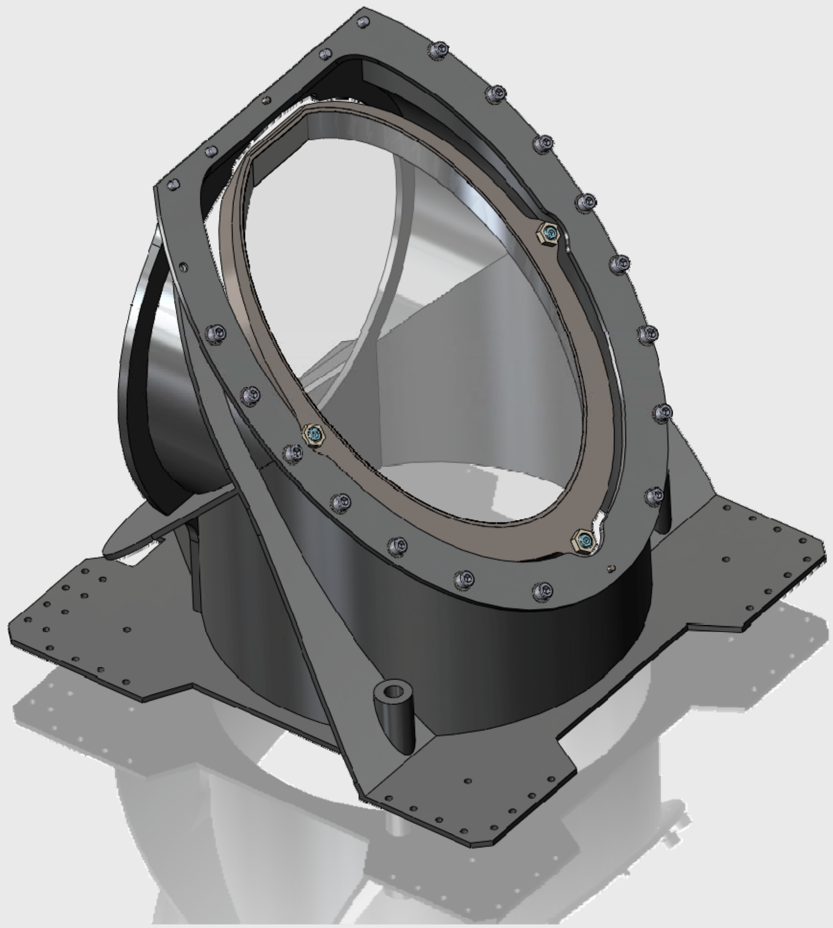
Optics Mounting Scheme

Elements bonded into precisely machined aluminum bezels, with tangential shoulder

- Aligned on rotary table axial run-out measured optically
- Lens bonded into bezel using elastomer such as Dow-Corning Sylgard 184
- Elastomer gap is matched to the lens material / aluminum to athermalize
- Stresses held below 100psi, below 70psi for CaF2
- Sag ~1µm radially and >20µm axially
- Bezels bolted together with spacers to ensure correct spacing. Spacer double as baffles.

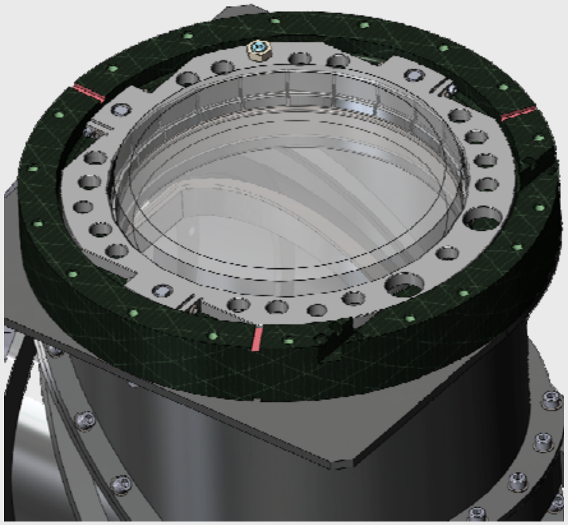
Dichroic

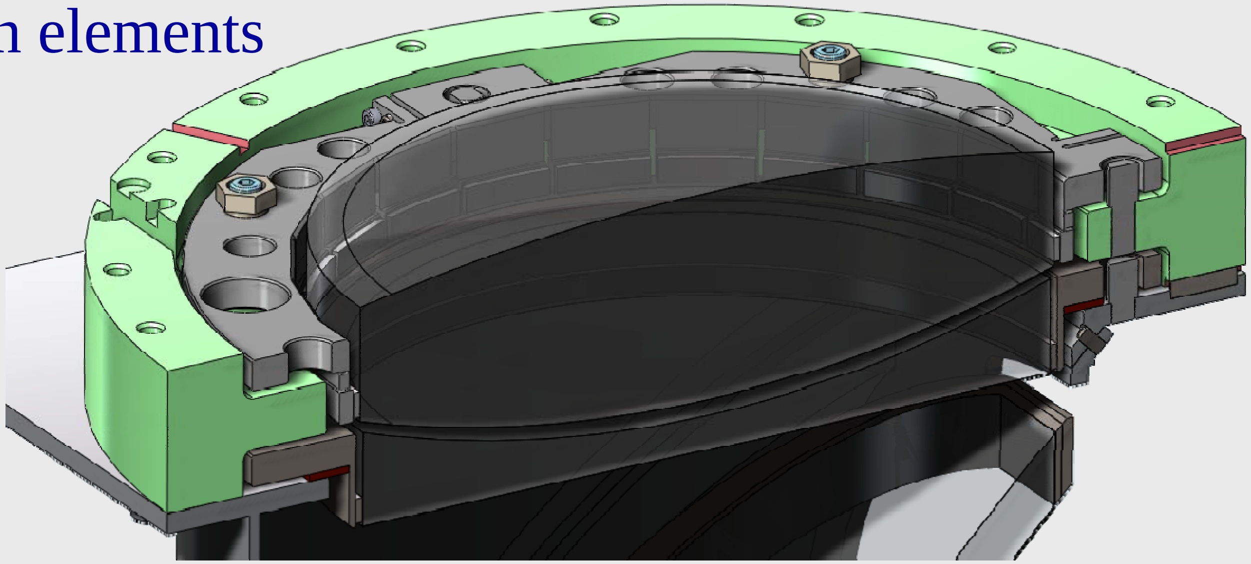
- 15mm thick, fused quartz
- Elastomer mounted into bezel
- Tip/tilt Z adjustment
- Very tight clearances with both visible and NIR doublets



NIR Collimator Doublet

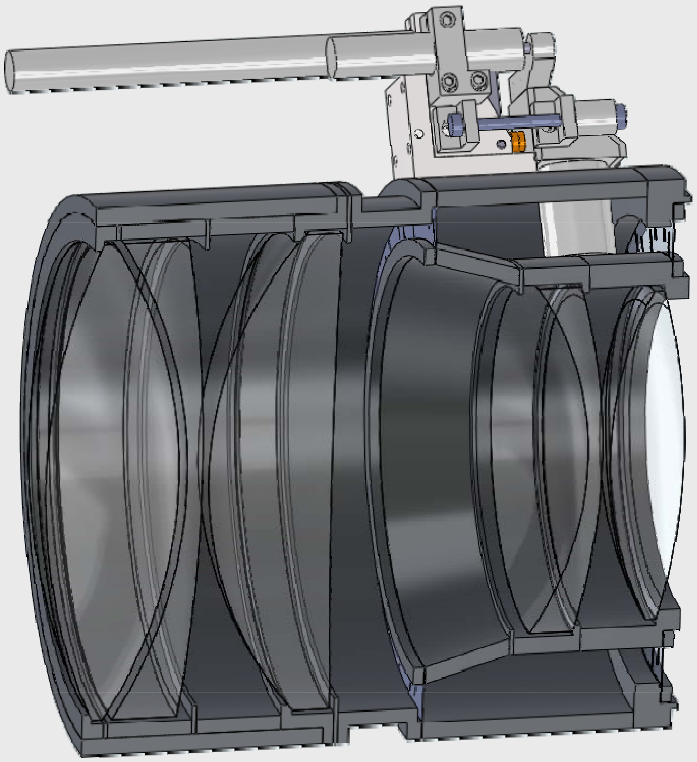
- Element 1 is the sealed pre-Dewar Window
- Elements are elastomer bonded into lens cells.
- Independently adjusted in tip/tilt and piston
- 4mm gap between elements
- G10 outer cell
- Incorporated into enclosure





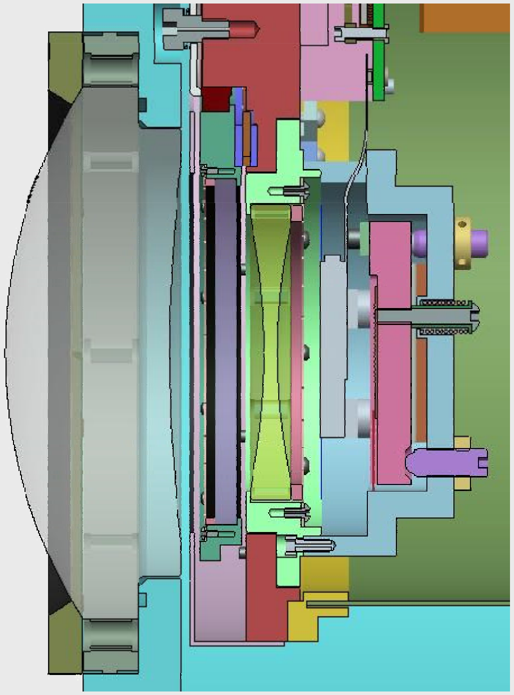
Camera Barrel Assembly

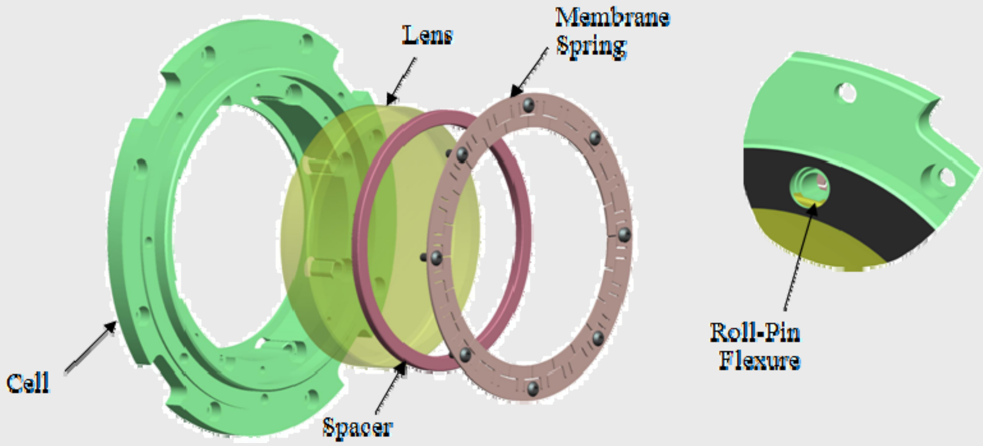
- Aluminum barrel, ~280mm diameter
- First 3 elements tightest tolerance
- Mounted together in grouping
- Elements 4,5 focus in diaphragm flexure
- Flexure mounted to Camera cradle
- Carries Dewar at back flange which allows for rotation of Dewar for detector alignment with spectra



Dewar Optics

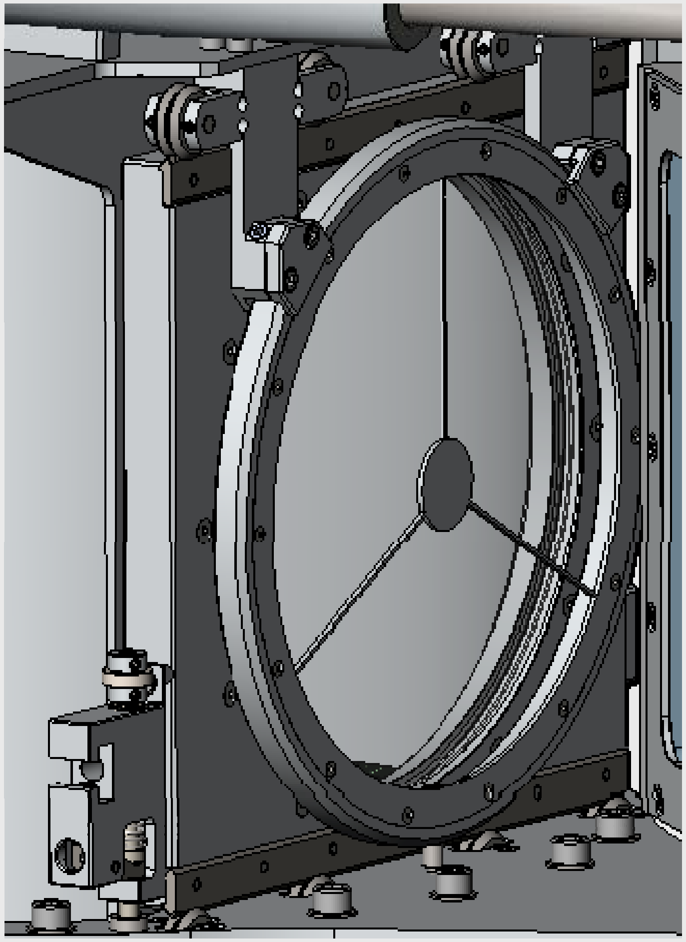
- Element 6 is Dewar vacuum window
- Filters in 5 position wheel
- Field lens roll-pin flexure mounted in cell
- Detector tip/tilt Z adjustable
- Detector, field lens and filter at 120K





Baffles

- Pupil Mask immediately after filter
- Adjustable in x-y
- Camera barrel baffles at spacer locations in camera



STRUCTURE

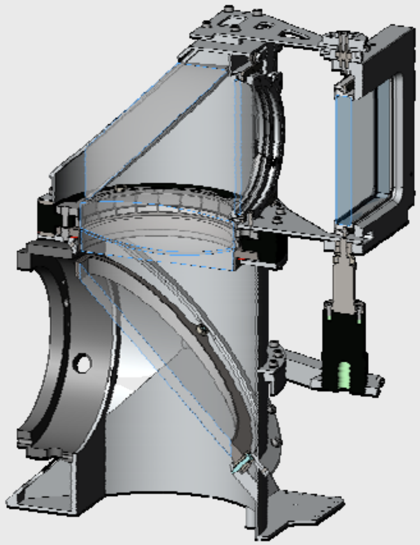
- Existing RSS Structure
- New invar fold mirror tower which will replace VIS fold structure and VIS Dichroic mount structure
- RSS-NIR has steel articulation substructure inside of pre-Dewar
- Discrete substructures facilitates NIR integration in Wisconsin

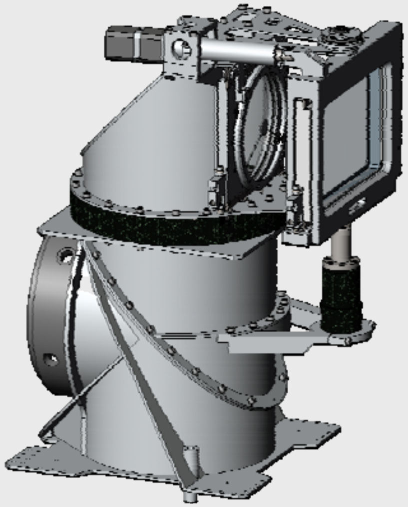
RSS Structure

- Welded thin-walled (1mm) invar tube truss structure
- 12 Mounting pads attach to SALT rho-stage. 1 pad pinned, opposite pad slotted, remaining pads z-support
- Built by Rutgers University
- Limited number of integral mount points

Fold Mirror Tower

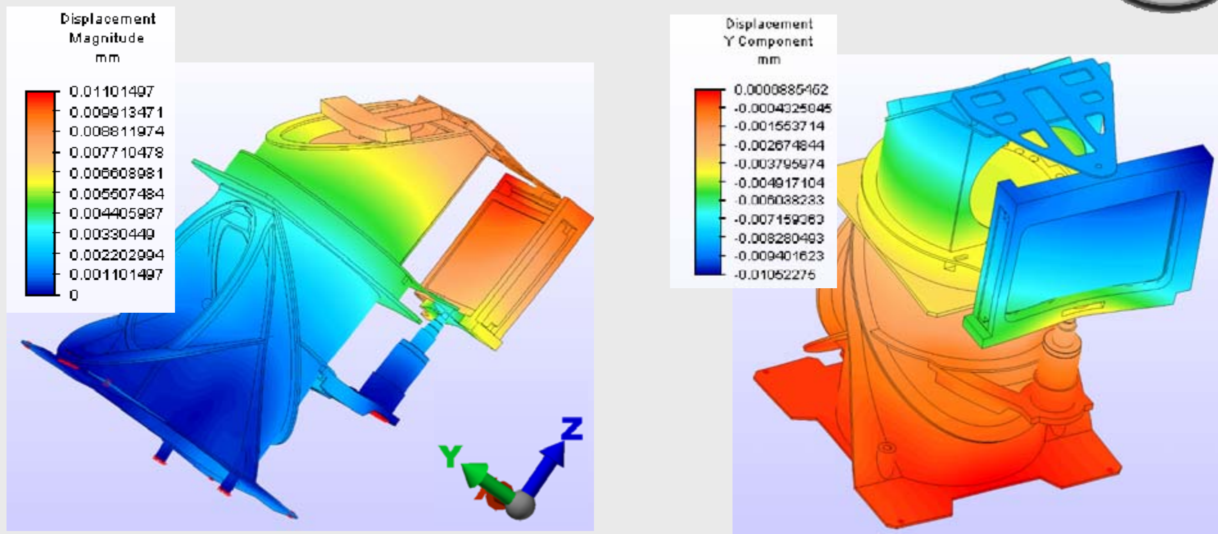
- Two welded invar structures separated by G10 spacer
- Structural support for VIS doublet, dichroic, NIR doublet, fold mirror, filter, pupil mask and grating rotator
- Needs to be very stiff as it supports the most sensitive optics
- Lower structure is sealed and purged to prevent condensation on pre-Dewar window
- Attached to top of collimator tube and NIR hub



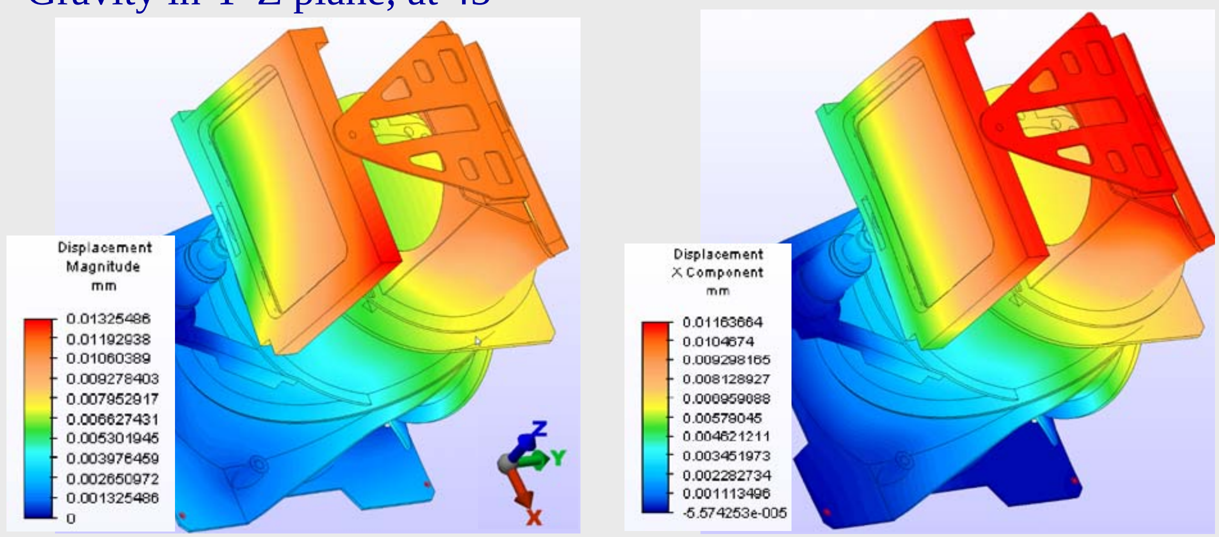


Fold Mirror Tower FEA

- Maximum flexure ~13µm
- Maximum tip of fold mirror ~ 0.003º
- Maximum roll of grating ~ 0.0017º



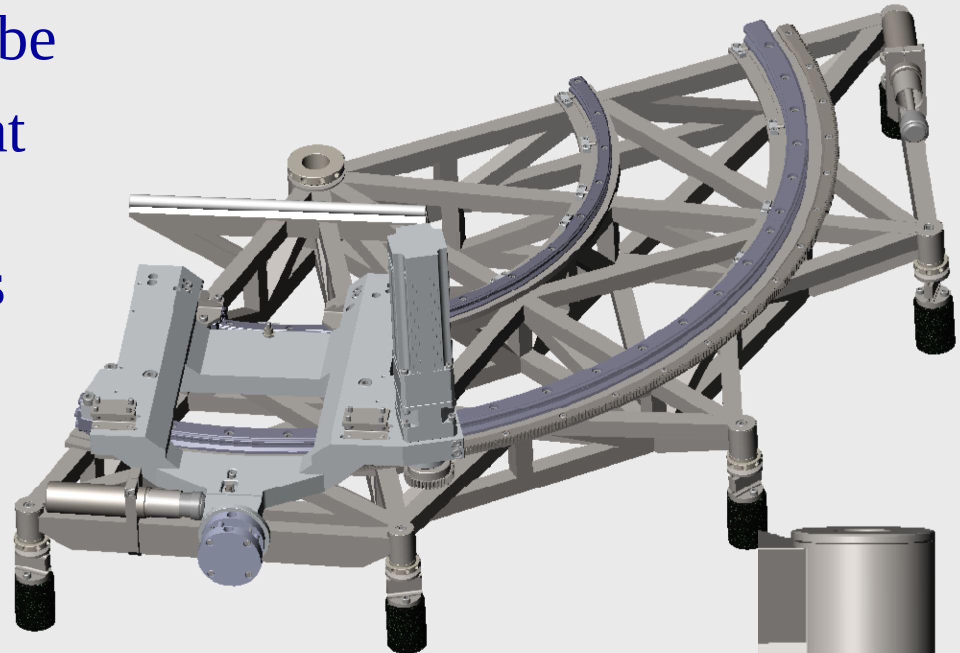
Gravity in Y-Z plane, at 45º

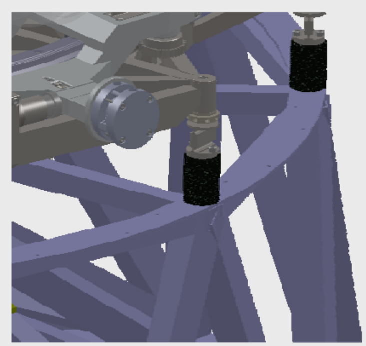


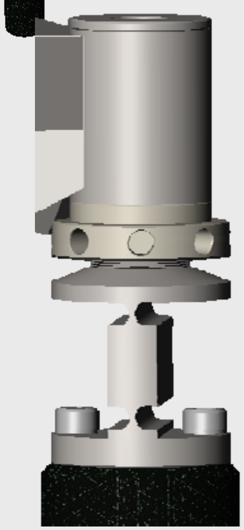
Gravity in X-Z plane, at 45º

Articulation Structure

- Welded thin walled steel tube
- Attached to RSS structure at node points with G10 feed throughs and blade flexures
- Mounting plate for THK bearing rails and gear
- Why was steel chosen?
  - Superior elastic modulus
  - Matched to bearing rails and gears
  - In isothermal pre-Dewar



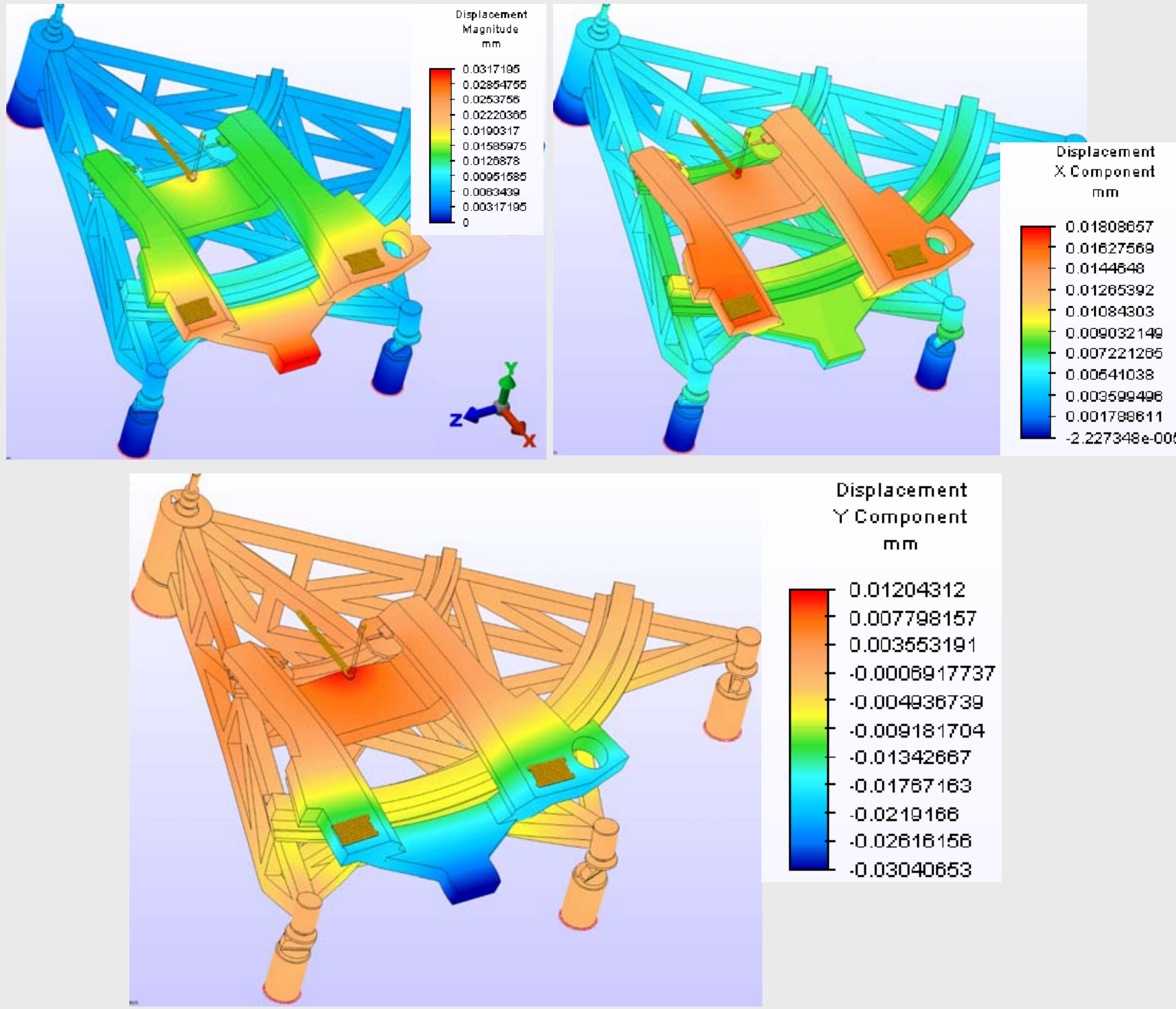




Articulation Structure FEA

- First cut FEA
- Camera pointing down the tracker
- Maximum deflections of ~32µm
- Axial motion ~ 18µm insensitive to this
- Tip of ~ 0.005º this is at the edge of the spec and needs to be further optimized
- Improve strain path by mounting camera directly above bearing

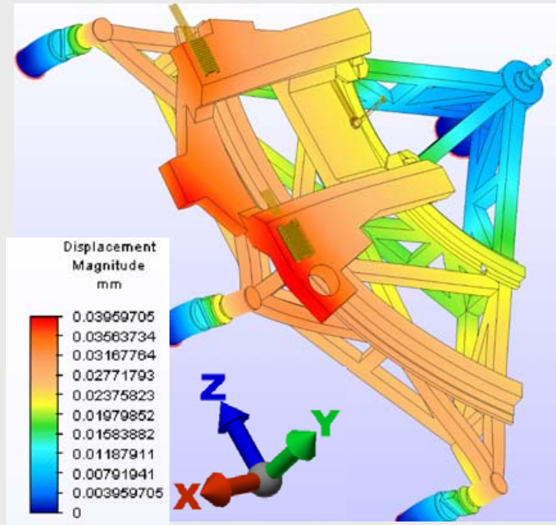
Gravity in X-Y plane, at 45º

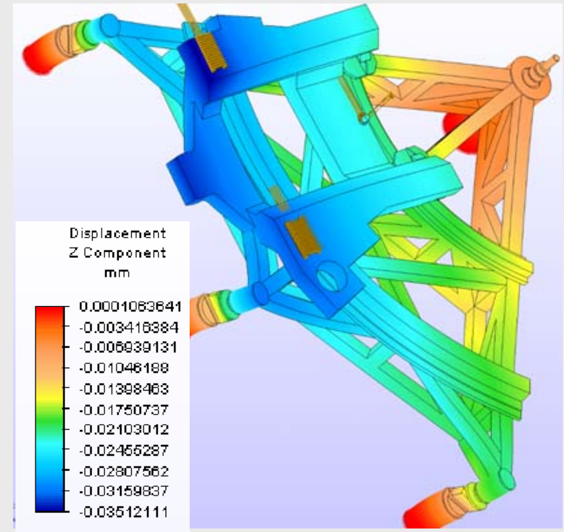


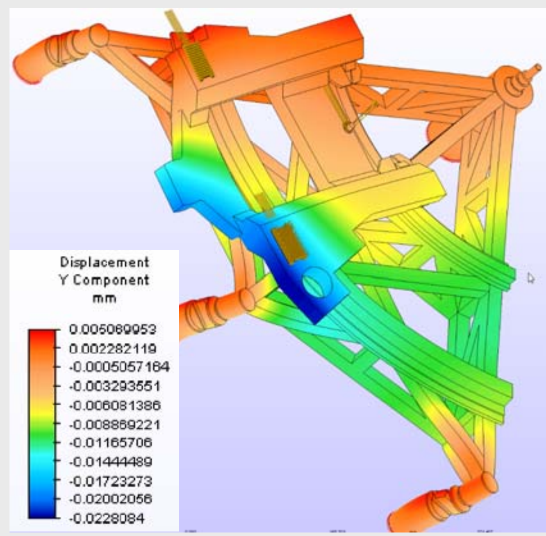
Articulation Structure FEA

- Camera pointing perpendicular to tracker
- Maximum deflections of ~40µm
- Tilt of ~ 0.004º this is at the edge of the spec and needs to be further optimized
- Camera Roll of ~ 0.005º which is well within spec

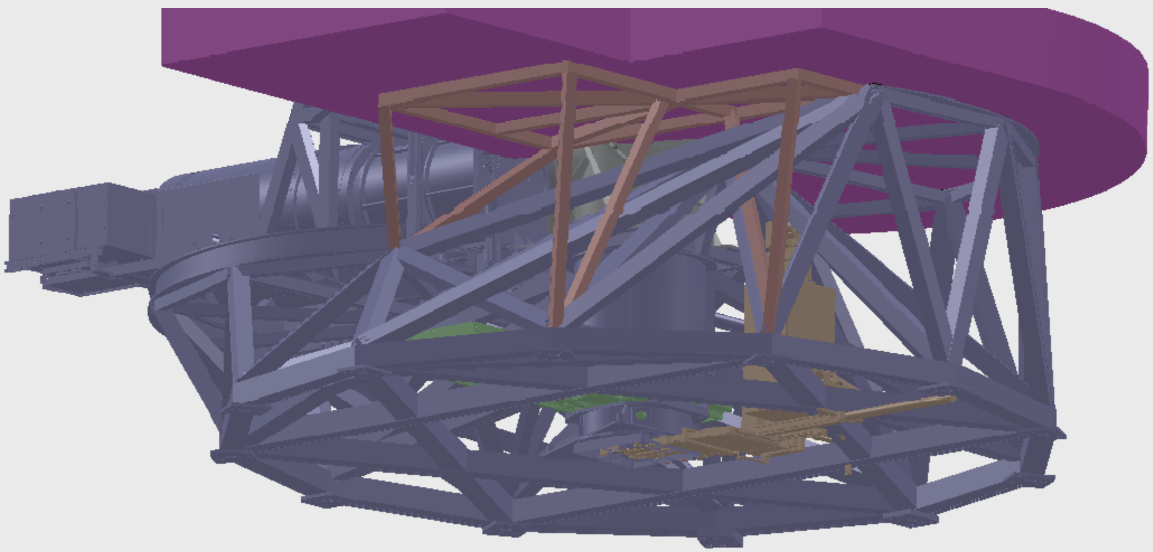
Gravity in Z-Y plane, at 45º







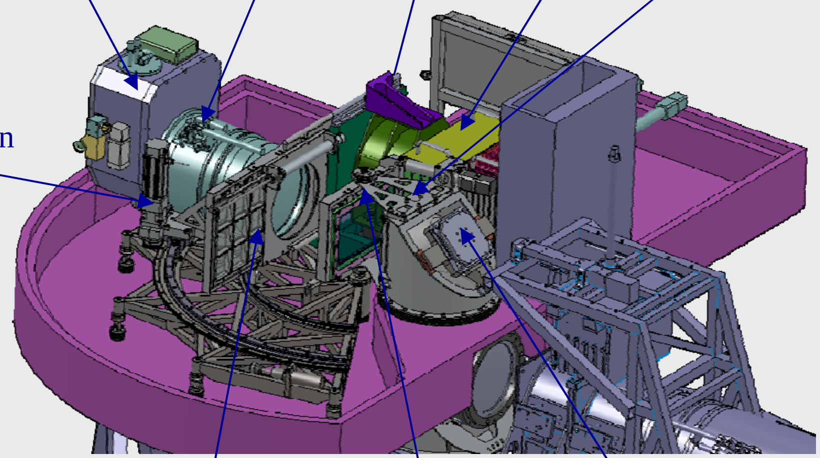
Structural Modifications



- The RSS Structure was fabricated with a mounting structure for etalons which interferes with the pre-Dewar. It has been agreed with SALT that this structure will be removed when the NIR instrument is integrated.
- A new structure will be added to support the optics storage assembly. We will further analyze whether this will be a weld-on or clamp-on modification.

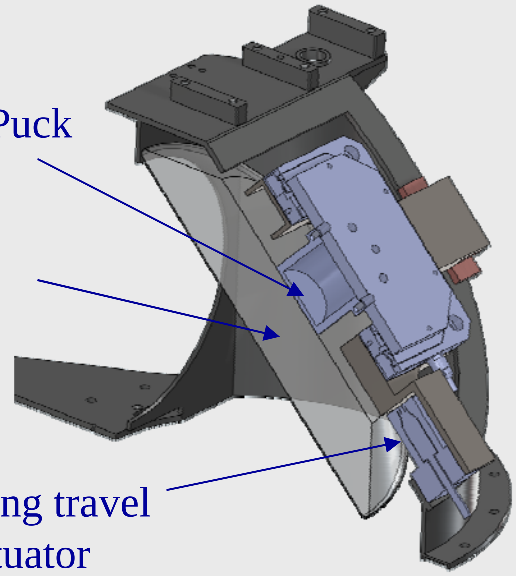
MECHANISMS

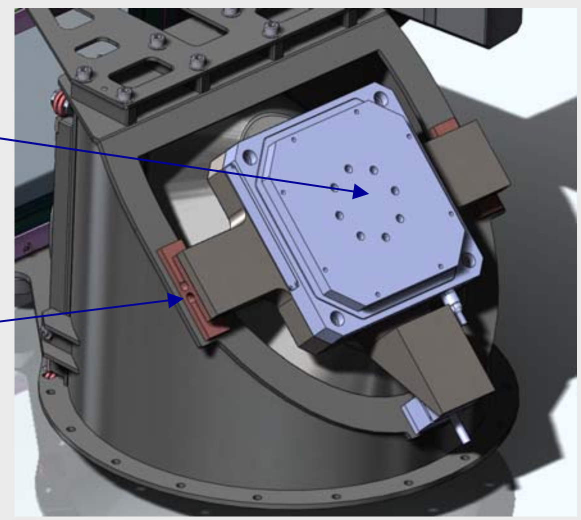
- 9 Mechanisms
- Multiple Controlled Axes
  - 9 Motors
  - 3 Pneumatic Actuators
  - 4 Piezo Actuators
  - 13 Encoders
  - ~60 Position sensors
  - 7 Brakes



Fold Mirror

- Two nested actuations
- Large travel nodding actuation on single rotation axis – Tip
- Small travel Tip/Tilt Z stage for image motion correction



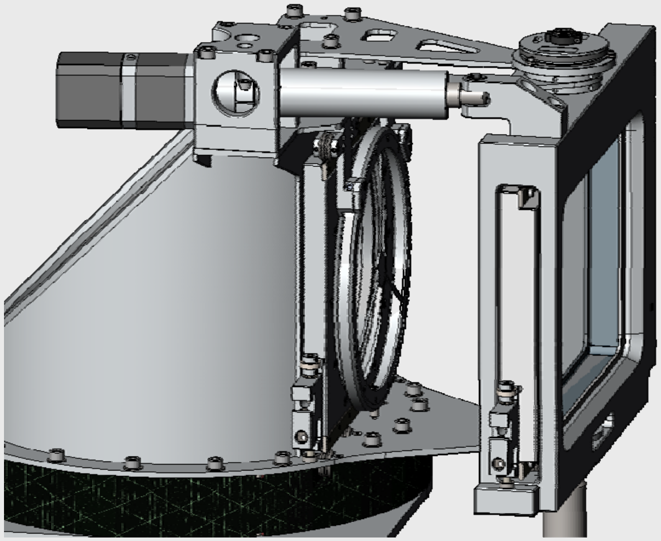


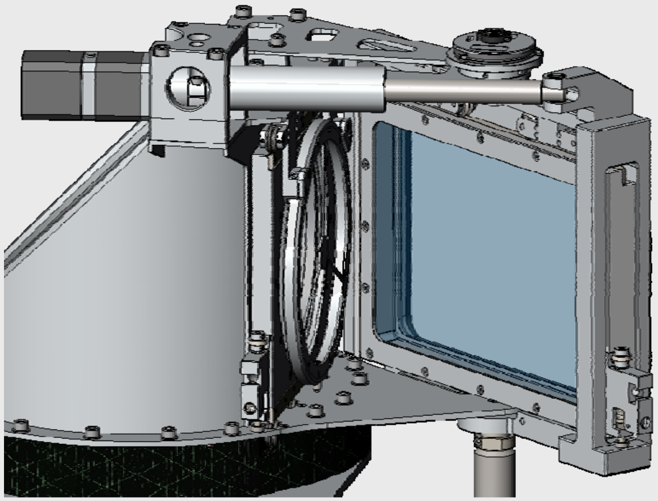
Filter

- Filter inserted from 12 slot magazine
- Held determinately in position by V-rollers.
- 8 rollers, 2 outer lower rollers are fixed, 2 middle are set 0.1mm lower. Upper 4 rollers are flexure mounted
- Filters mounted in holder at 2º tilt
- Latch mechanism for safe transfer between magazine, inserter and beam position

Grating

- Grating inserted from 5 position magazine
- Same roller and latch configuration as filters
- Supported from mirror tower with bearings, z supported from hub
- Rotated with linear actuator at edge of grating holder



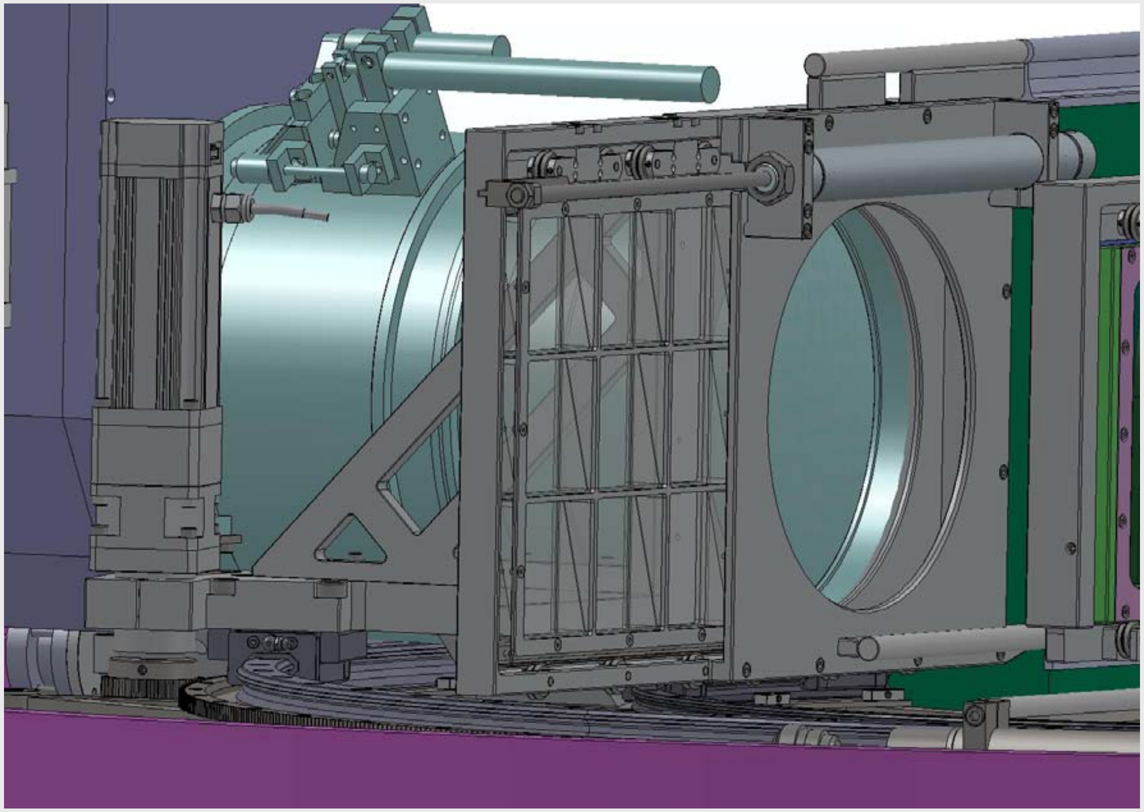


Etalon

- The Etalon is inserted on three linear rails, rollers position it on two and preload roller runs on the third
- Same latch mechanism as filter and grating
- Addition pneumatic safety latch in both in and out positions

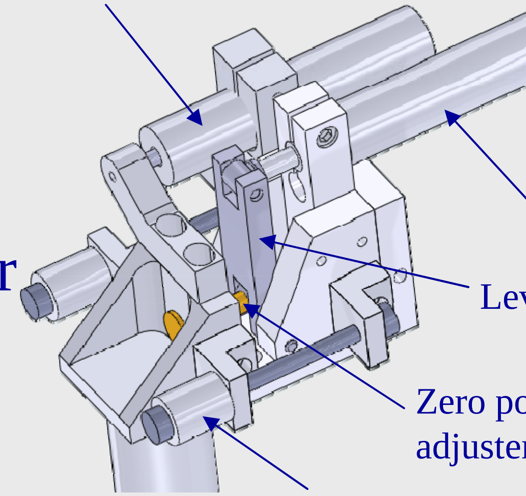
Beam Splitter

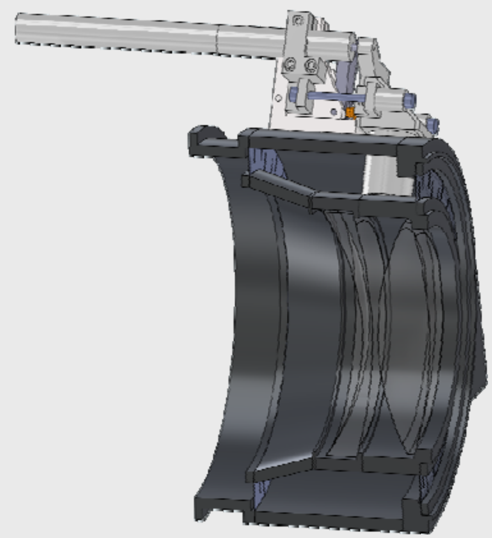
- Inserted/removed using pneumatic actuator and v- rollers
- Travels with the articulating camera



Focus Mechanism

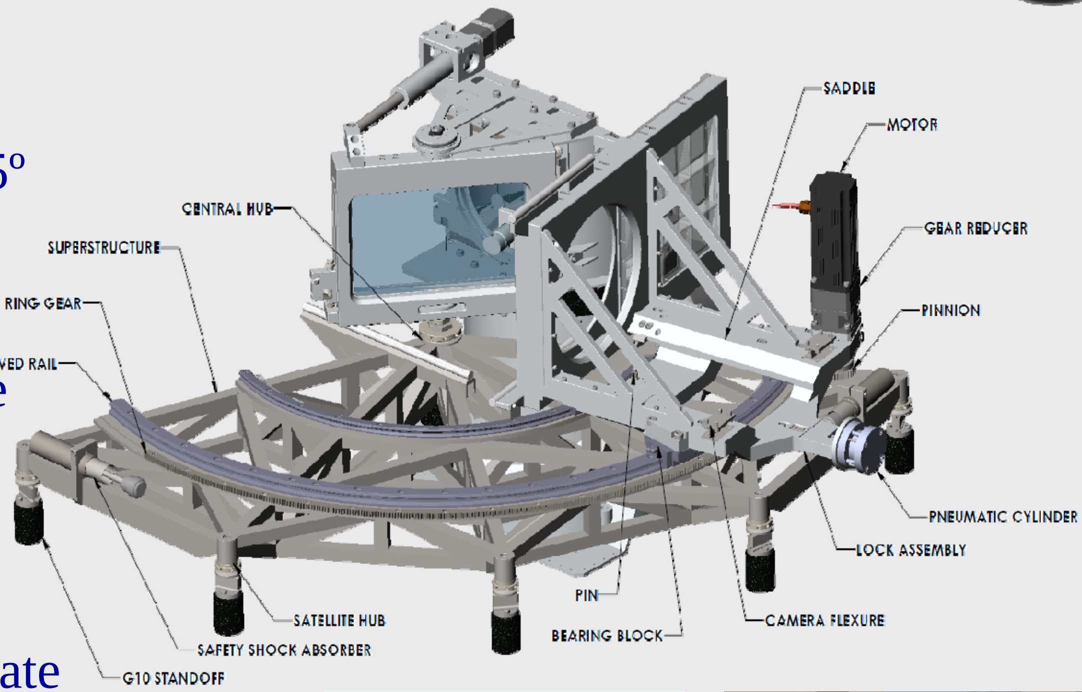
- Elements 4 & 5 move ±1.5mm axially
- Lens cell mounted in diaphragm flexure
- Levered drive with stepper micrometer
- Adjustable zero-point
- Copy of system used on RSS-VIS
- Cells diaphragm flexure mounted
- Actuated from outside the barrel using a levered stepper micrometer
- Very little parasitic tilt due to long baseline between flexures
- *Alternate design based on MOSFIRE flexure stage internal to Dewar which focuses using Detector and field lens*

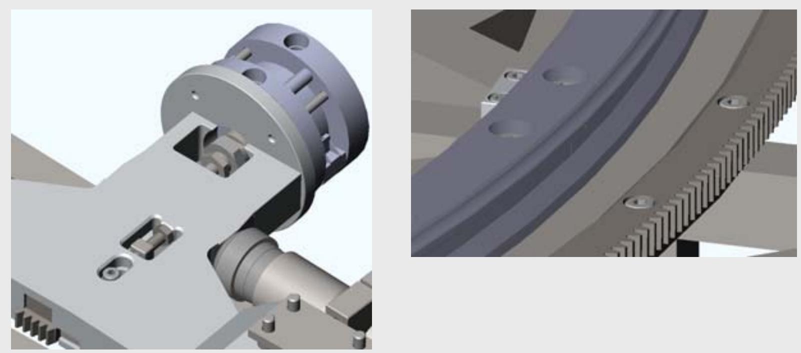




Articulation

- Camera articulates 100º
- Detent positions every ~ 0.5º
- Two parallel THK curved bearing rails
- Ring gear driven with inline motor, gearbox
- Pneumatic detent locks into ring gear
- Beam splitter, dewar articulate with camera

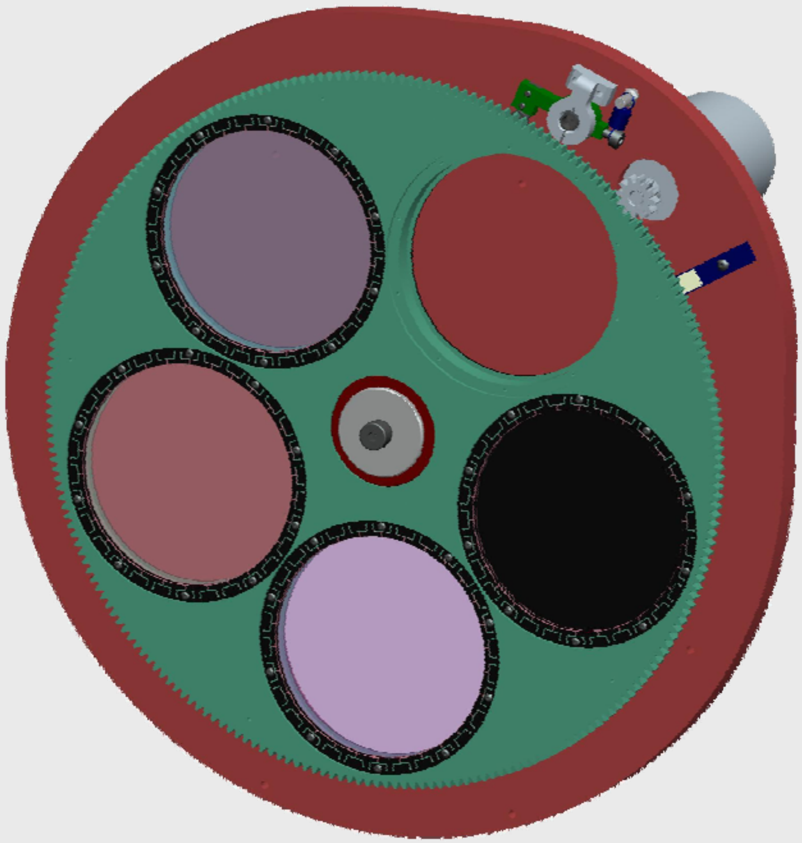




Detent assembly

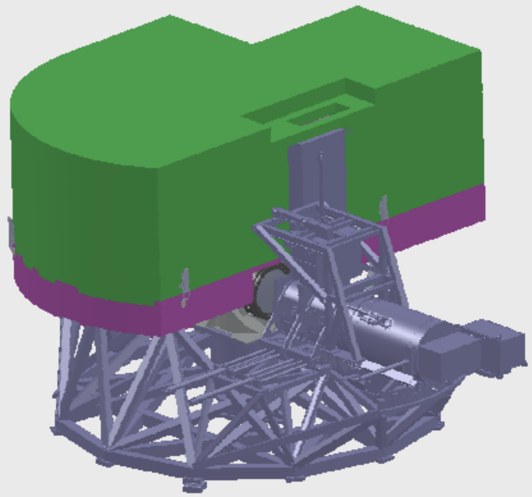
Cold Filter

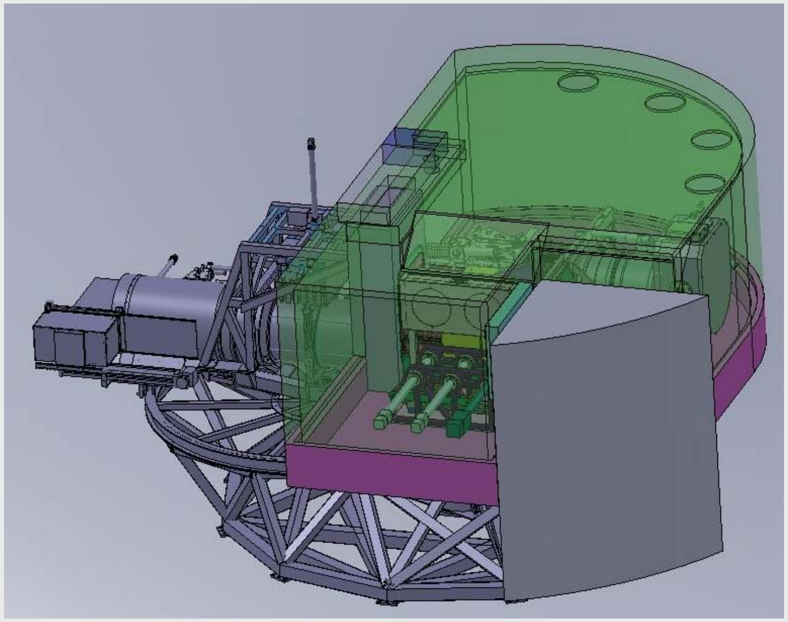
- Filter wheel inside Dewar
- 5 positions
- Gear driven
- Detent at each position



Thermal Pre-Dewar Enclosure

- Maintains NIR arm at -40ºC
- Maintains Outside wall temp at ambient ±2ºC
- Multilayer construction with the bulk constructed from Divinycel H60 thermoplastic material
- Good mechanical and thermal properties
- False ceiling for return air flow
- Integral filter airlock chamber
- Enclosure also provides light dust and moisture sealed environment





The Path Forward

- Three major analytical design iterations
  - Flexure
    - Further optimize substructures
    - Perform FEA on integrated model as far as is possible
    - Develop tolerance budget for each substructure (including bearing compliance) to ensure we meet overall flexure tolerances
  - Opto-Mechanics
    - Further develop lens mounting design
    - Iterate with optical design on lens group tolerances
    - Fully develop mounting and alignment plan
  - Thermal
    - Further investigate thermal transients in pre-Dewar and its affect on the thermally induced stresses on the optics
    - Develop a system for the thermal enclosure and lens mounts that maintains safe thermal loads on the optics at all times
- *Following this analysis the detailed design will proceed to producing manufacturing drawings and final component selection*