SAND2011-5855C

Optomechanical Design for Cost Effective DEMVAL Systems

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by

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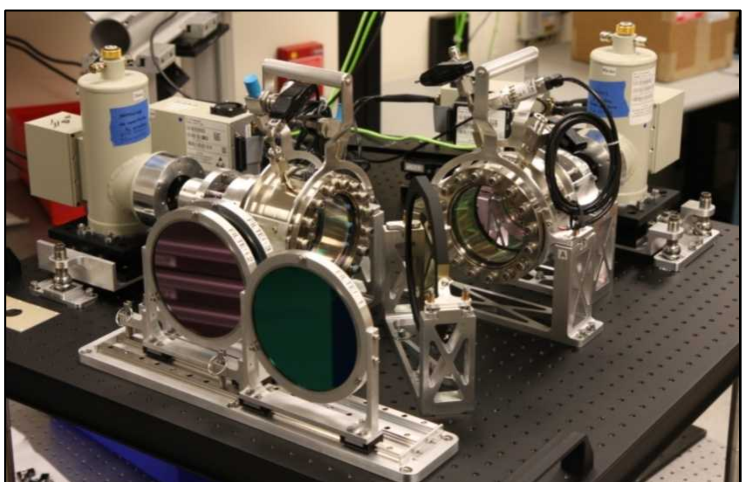
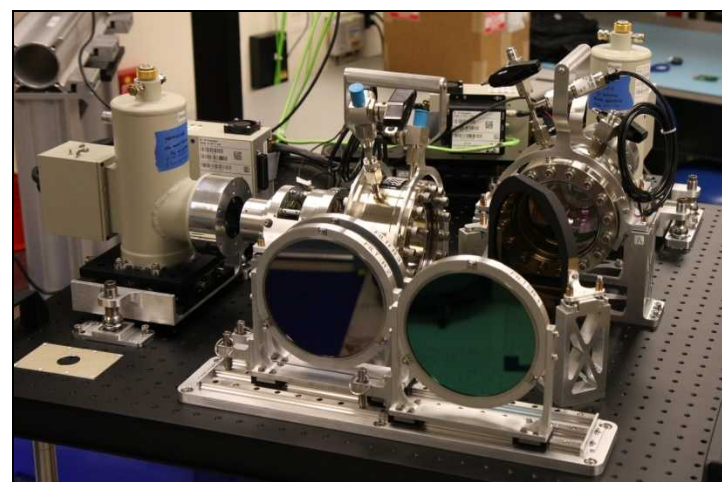
Optomechanical Design Engineer





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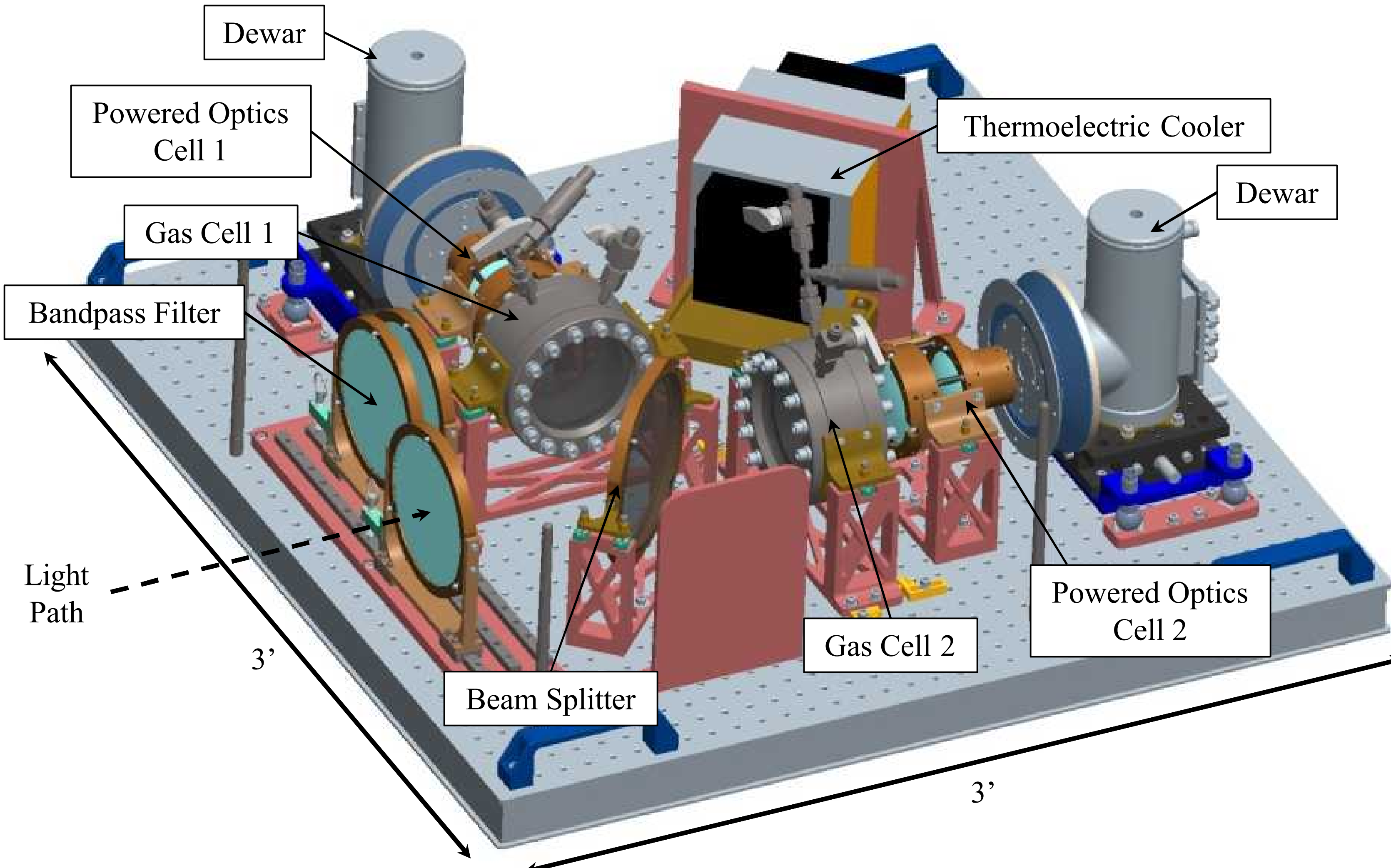
System Overview



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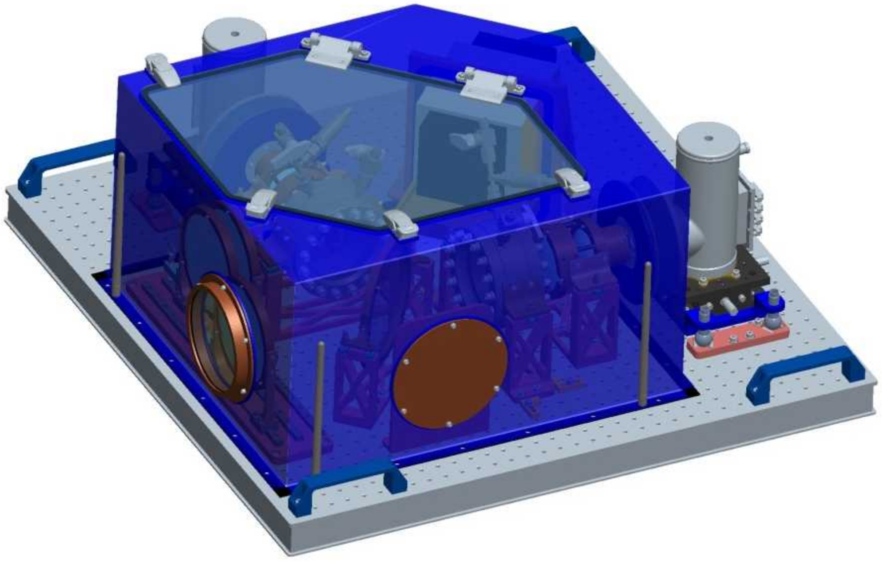
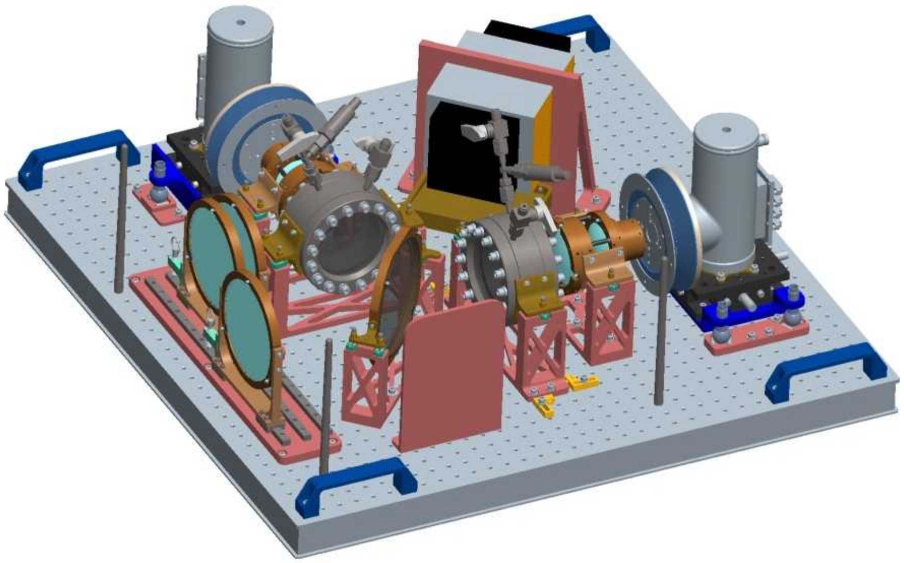
Optomechanical Requirements

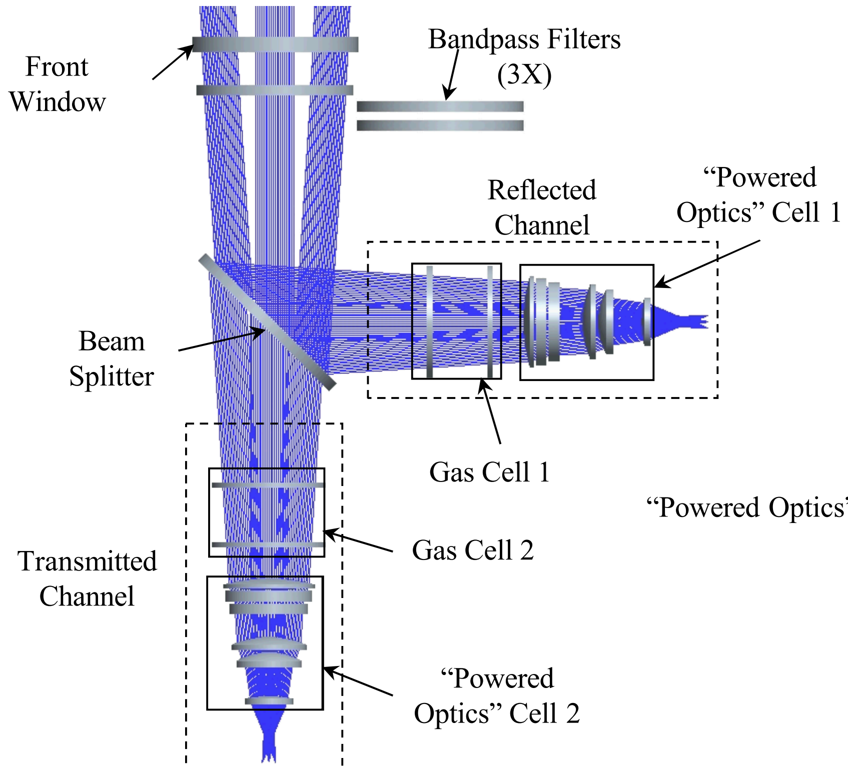
- All optomechanical mounts must hold optics within the allowable error budget range, while accommodating the necessary degrees of freedom for system alignment.
- Bandpass filters must be interchangeable in beam path.
- Cameras and gas cells must maintain alignment, yet be removable.





Error Budget Creation

- **Error Budget Design Criteria**
  - **Optics and Optomechanical team worked together to create an error budget that would accommodate an inexpensive and easily assembled system, yet still meet system performance.**



Optic	Tip/Tilt	Decenter (R)	Piston	Frame of Reference
	aMin	mil (mm)	mil (mm)	
Front Window	17.2	40 (1.02)		
Filter	17.2	40 (1.02)	19.7 (0.5)	S2[1] of Window to S1[2] of Filter
Beam Splitter	17.2	40 (1.02)	19.7 (0.5)	S2 of Filter to S1 of BS
Gas Cell (GC)	17.2	40 (1.02)	19.7 (0.5)	BS Surface[3] to S1 of GC
Lens 6	5	5.91 (0.15)	19.7 (0.5)	S2 of GC to S1 of Lens 6
Lens 7	3	5.91 (0.15)	3.9 (0.1)	S2 Lens 6 to S1 Lens 7:
Lens 8	3.1	5.91 (0.15)	15.7 (0.4)	S2 Lens 7 to S1 Lens 8:
Lens 9	4.6	5.91 (0.15)	11.8 (0.3)	S2 Lens 8 to S1 Lens 9:
Lens 10	3	5.91 (0.15)	3.9 (0.1)	S2 Lens 9 to S1 Lens 10:
Lens 11	1	5.91 (0.15)	3.9 (0.1)	S2 Lens 10 to S1 Lens 11:

"Powered Optics" (Lens 6 – Lens 11)

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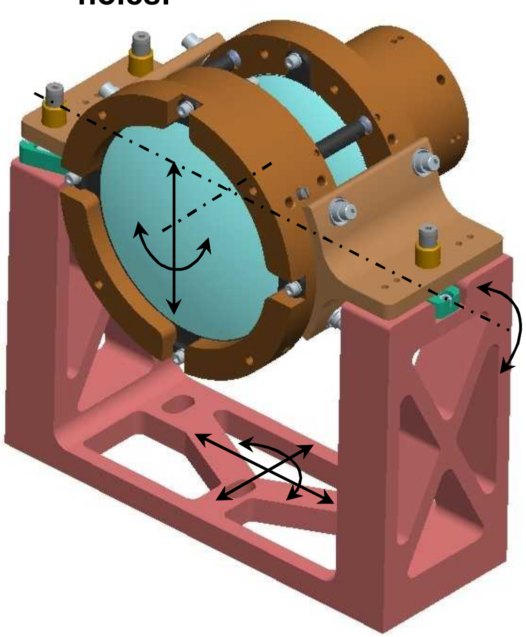
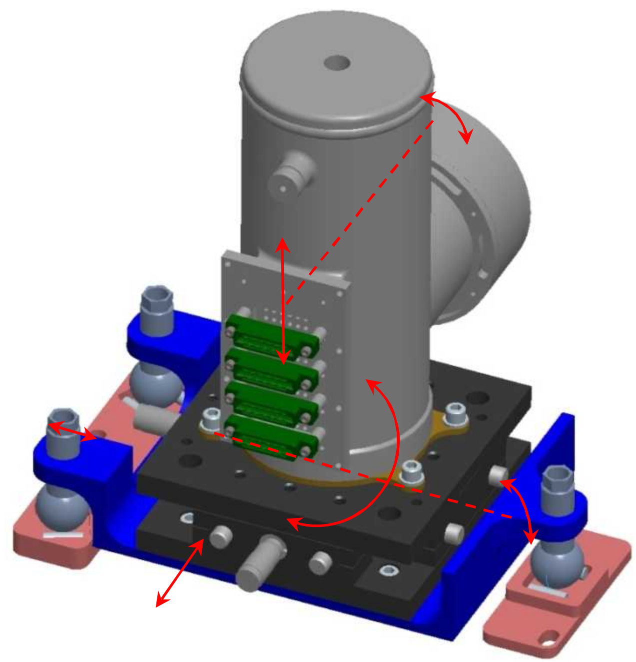
Alignment Tooling Degrees of Freedom

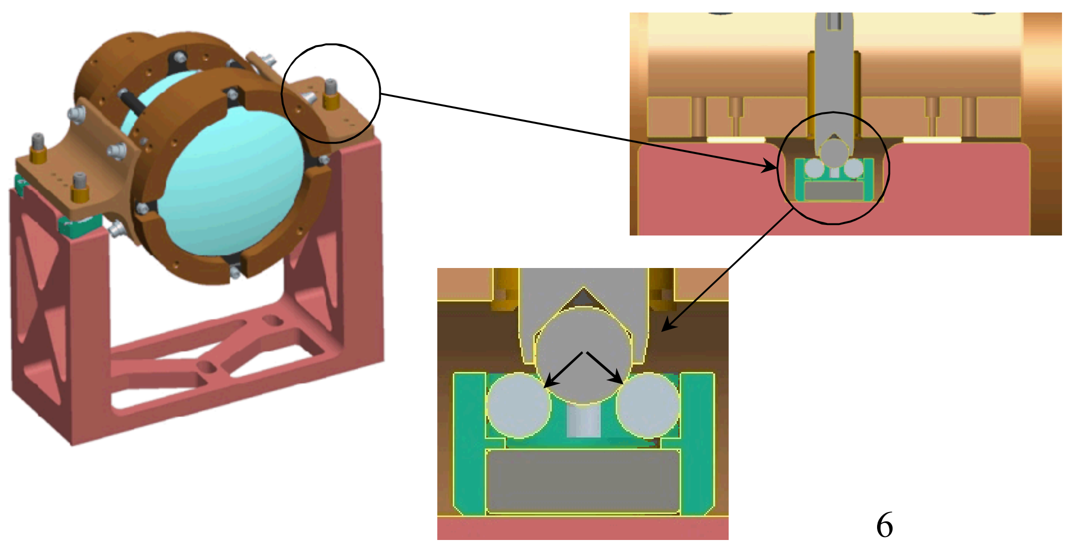
- **The camera, beam splitter, gas cell, and powered optic subcell mounts accommodate the necessary degrees of freedom for alignment activities.**
- **The same design strategy was used for all optomechanical hardware that requires alignment**
  - **Tooling ball or ThorLabs adjusters accommodate vertical decenter, tip, and rotation. Horizontal decenter, piston, and tilt are accommodated through oversized base mounting holes.**





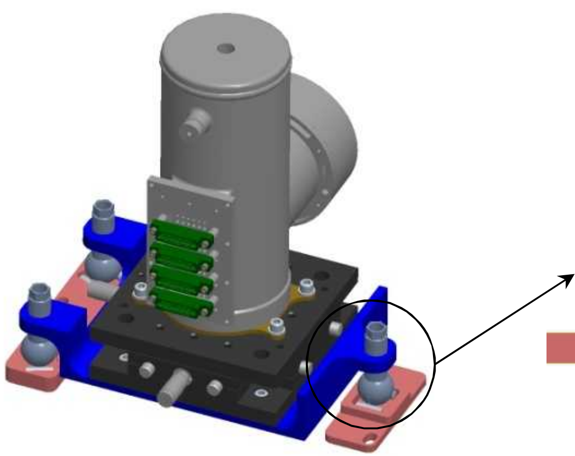
Adjustable Kinematic Mounts

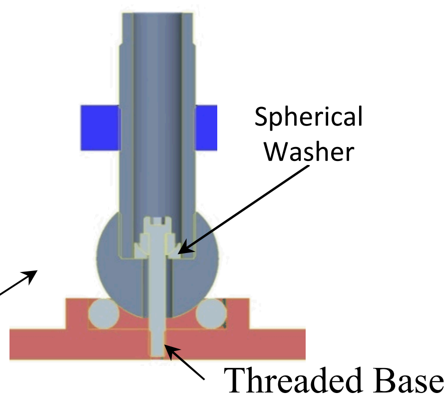
- **The beam splitter, gas cells, and powered optics subcells were all designed to utilize simplistic magnetic kinematic mounts.**
- **Each mount consists of a ThorLabs ¼-80 adjuster and bushing coupled with a magnetic pin base.**
  - **Off the shelf hardened steel pins are bonded into place.**
  - **The pin location is designed such that tangent contact on the ThorLabs adjuster is achieved.**
  - **The magnet is used to apply a "seating" force to the adjuster.**
    - The ThorLabs adjusters have a ferrous ball tip.

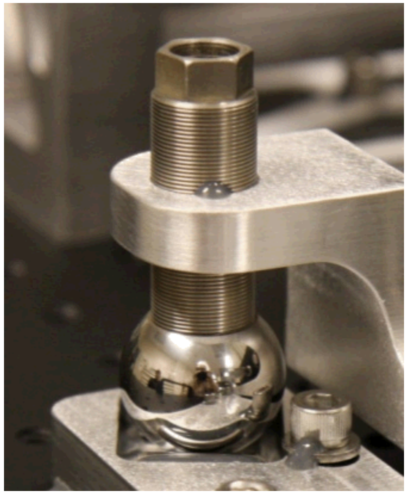


Camera Adjustable Kinematic Mounts

- **The camera kinematic mounts required features to allow the cameras to be removable.**
  - **Each kinematic mount contains a counter bore sized to accommodate a spherical washer and fastener through its center.**
  - **These fasteners can be engaged into the threaded base to lock it in place or removed to accommodate the removability requirement.**
- **Kinematic interface utilizes the same ball and pin concept that has been shown previously.**
  - **Pins are bonded in position such that a tangent interface with the ball is achieved.**







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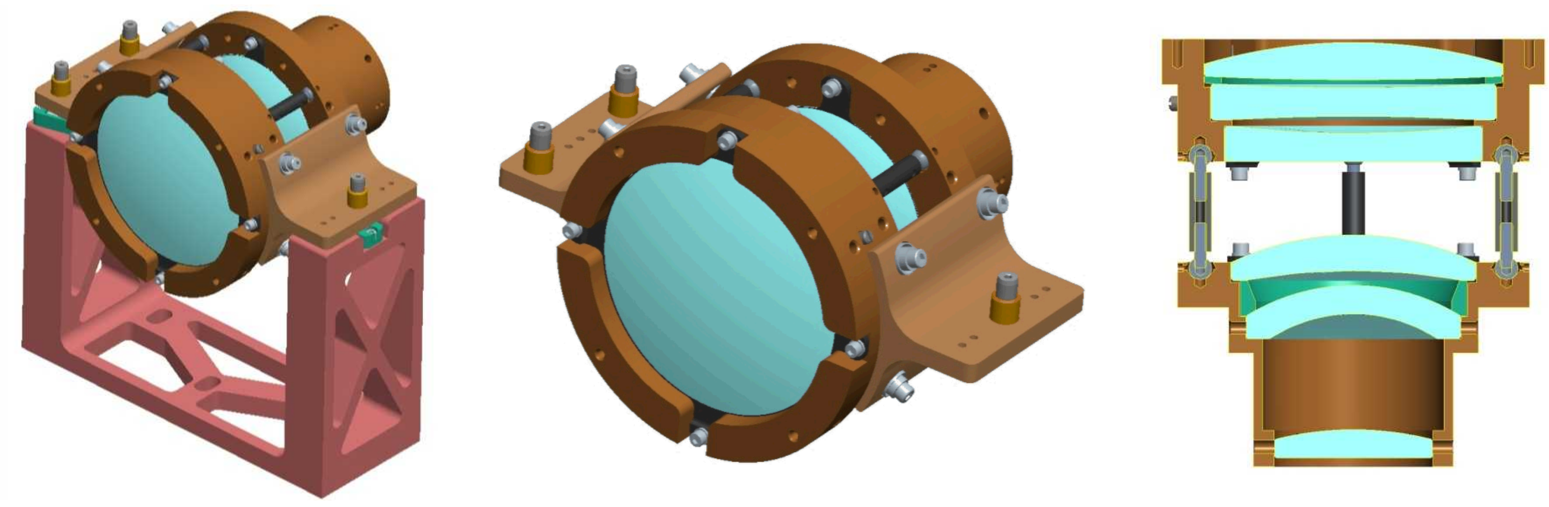
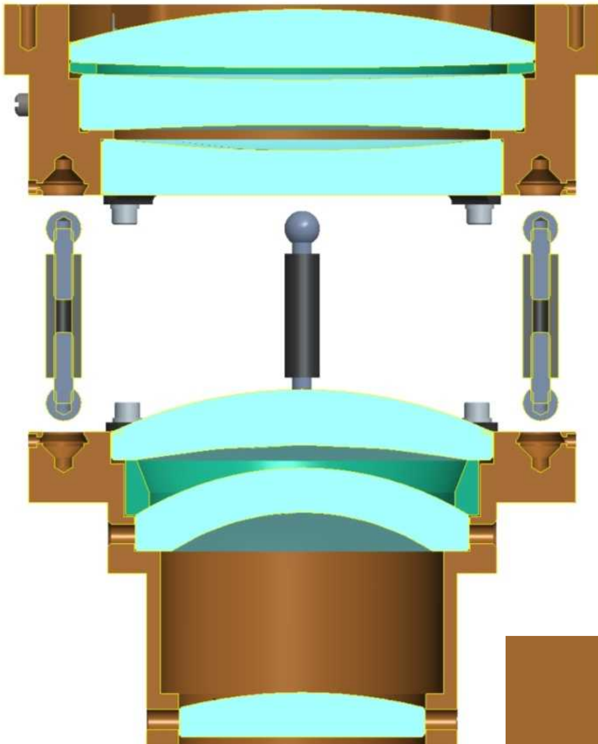
Powered Optic Subcells (Focusing Elements)

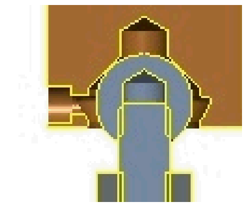
- **All optics in collimated space have relatively loose alignment tolerances.**
- **Powered optics alignment tolerances are tighter, since beam focusing occurs. Tighter tolerances tend to mean higher cost parts.**
- **Subcells are designed for "drop-in" optics.**
  - **Error budget was worked between Optical & Optomechanical groups to ensure worst case fabrication tolerance stackup, would meet system performance requirements.**

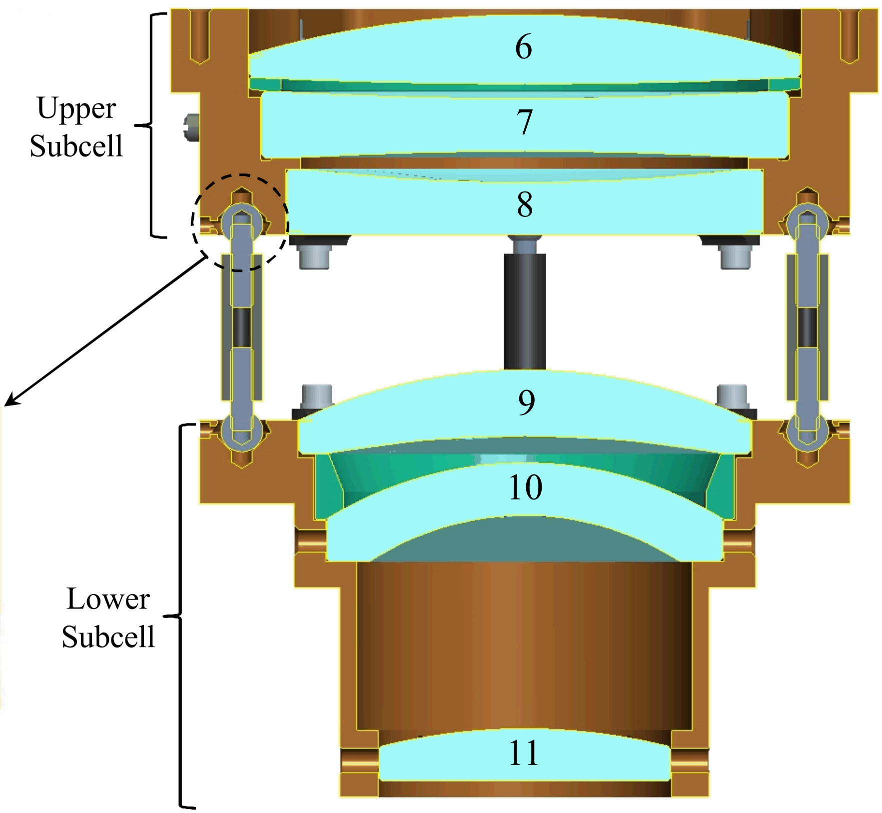


Powered Optic Subcells Assembly

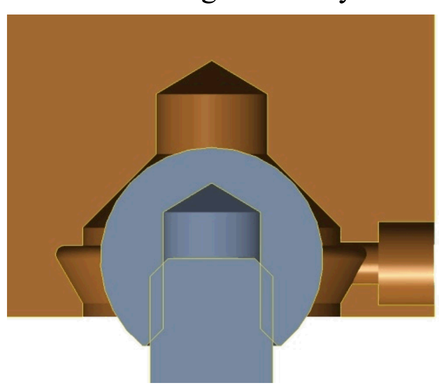


Adjustable tooling ball rod





Tooling Ball Bonding Geometry



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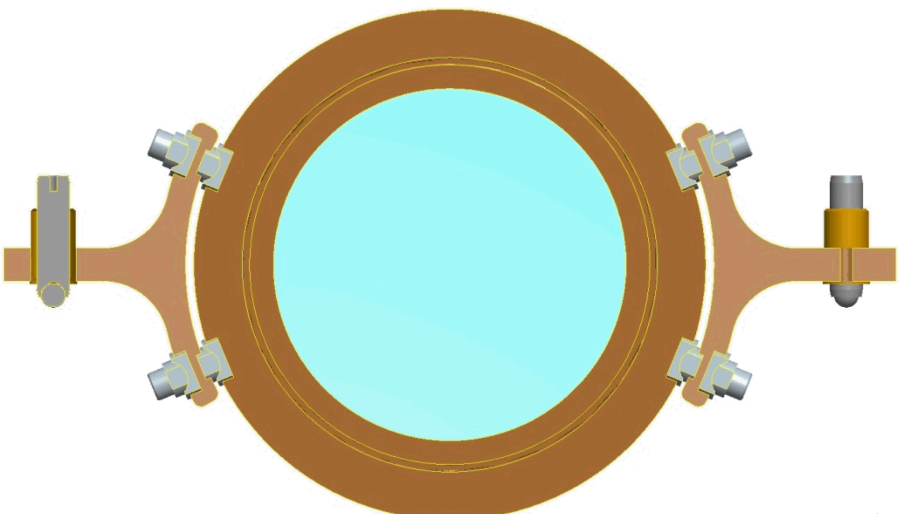
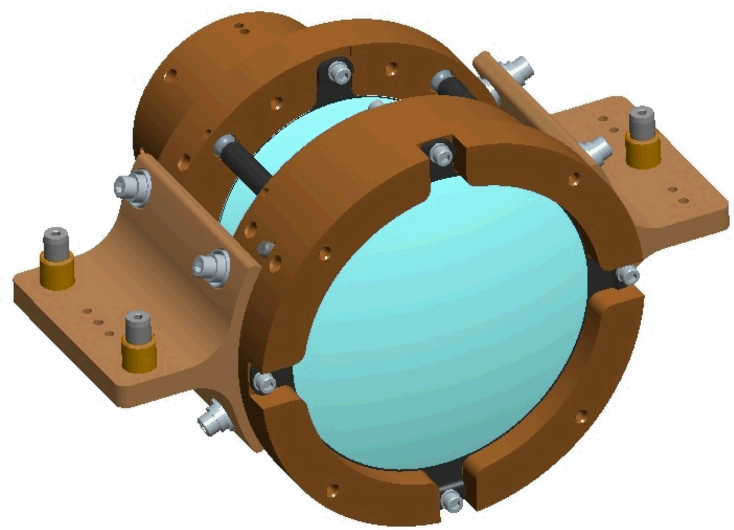
Powered Optic Subcells Assembly

- **Once the two subcells are aligned to each other, bonded and cured, the system alignment flanges are installed.**
  - **Alignment flanges are installed with spherical washer contacts to the housing, to accommodate any misalignment between the two.**
  - **Thorlabs adjusters are mounted/bonded into the flanges.**





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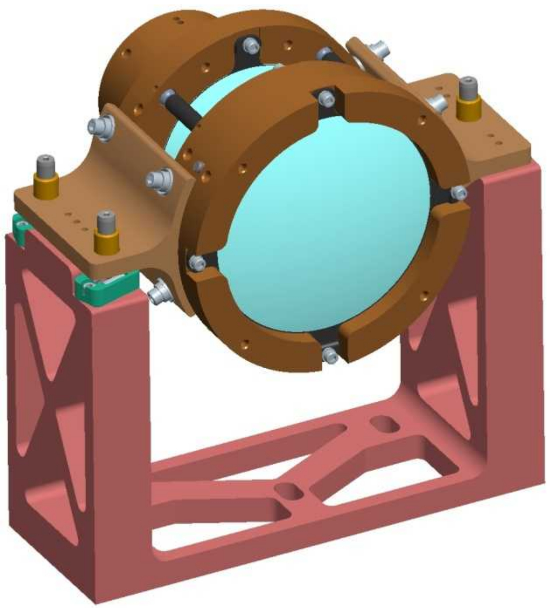
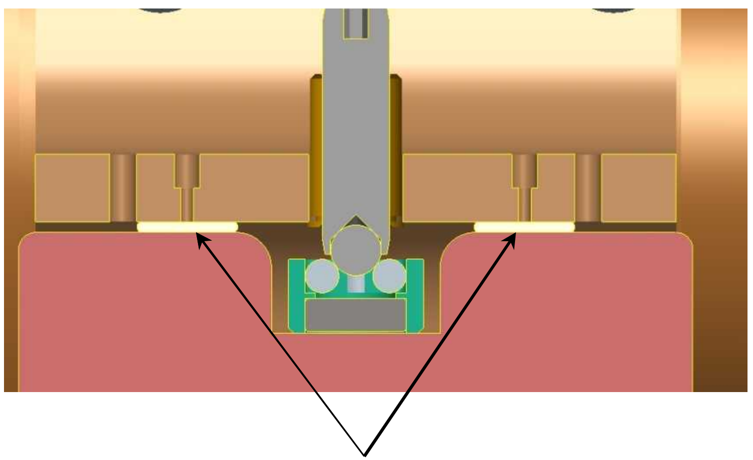
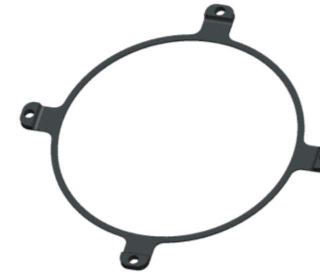
Powered Optic Subcells

- **The powered optic alignment flanges are installed onto the magnetic kinematic mounts on the base.**
- **Alignment is achieved by manipulating all the DOF's necessary.**
- **Once aligned, subcell is bonded in place to the base mount.**



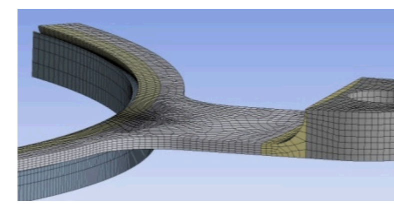


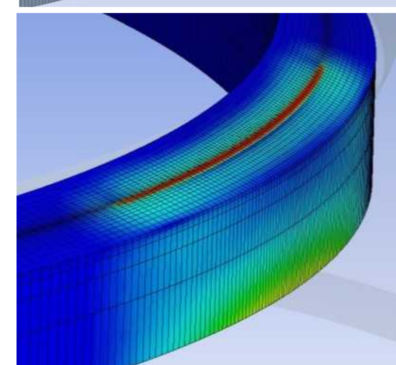
Bond pad geometry
(nominal gap of 0.040" and diameter of 0.375")

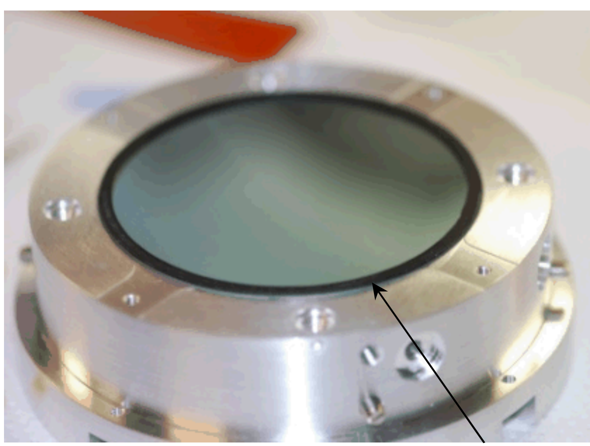


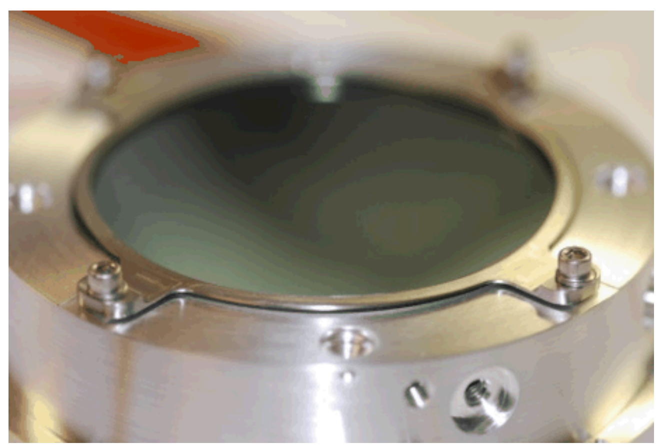
Lens Retainment

- **Aside from the gas cell, all optics in the system were retained using a flexure ring.**
  - **A simple four tabbed, 0.020" thick titanium ring was used to apply axial load onto their respective optics.**
- **Contact stress analysis of flexure-on-optic was determined to be within fracture stress of the various optical elements.**
  - **To increase contact area (and reduce contact stress) an EPDM gasket was applied between the optic and flexure ring.**





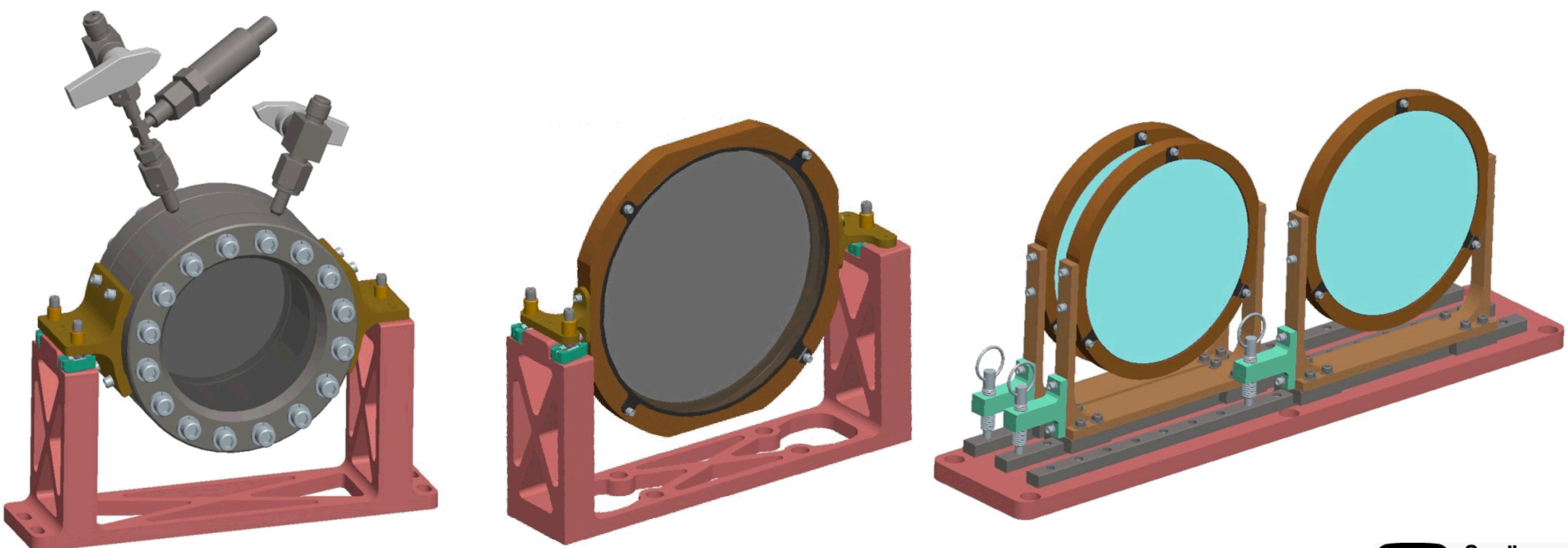




EPDM Gasket

Gas Cell, Beam Splitter, and Filter Slide

- **Common design concepts were applied throughout the system to reduce design time and complexity**
  - **Beam splitter mount utilizes the flexure ring and ThorLabs kinematic adjuster designs.**
  - **Filters utilize the flexure ring design.**
  - **Gas cells utilize the ThorLabs kinematic adjuster design.**



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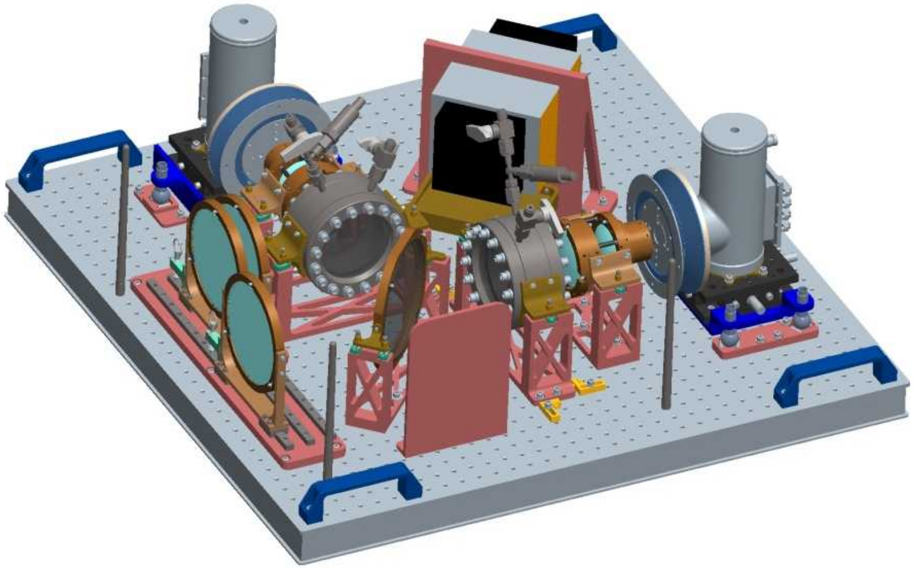
Conclusions

- All optomechanical hardware (including one spare set) was ~ $50k.
- Working closely with the optical engineer to evaluate tweaks in the design for ease of manufacturability was critical to the cost savings.
- System alignment was completed in ~ 2 weeks.
- Many of the mount design concepts can be modified and applied to different configurations with minimal change.



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