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Water Cooled Mirror Design

FY14 NNSA Mo-99 Program

FY14NorthStar Activity 3, Task 1 Report

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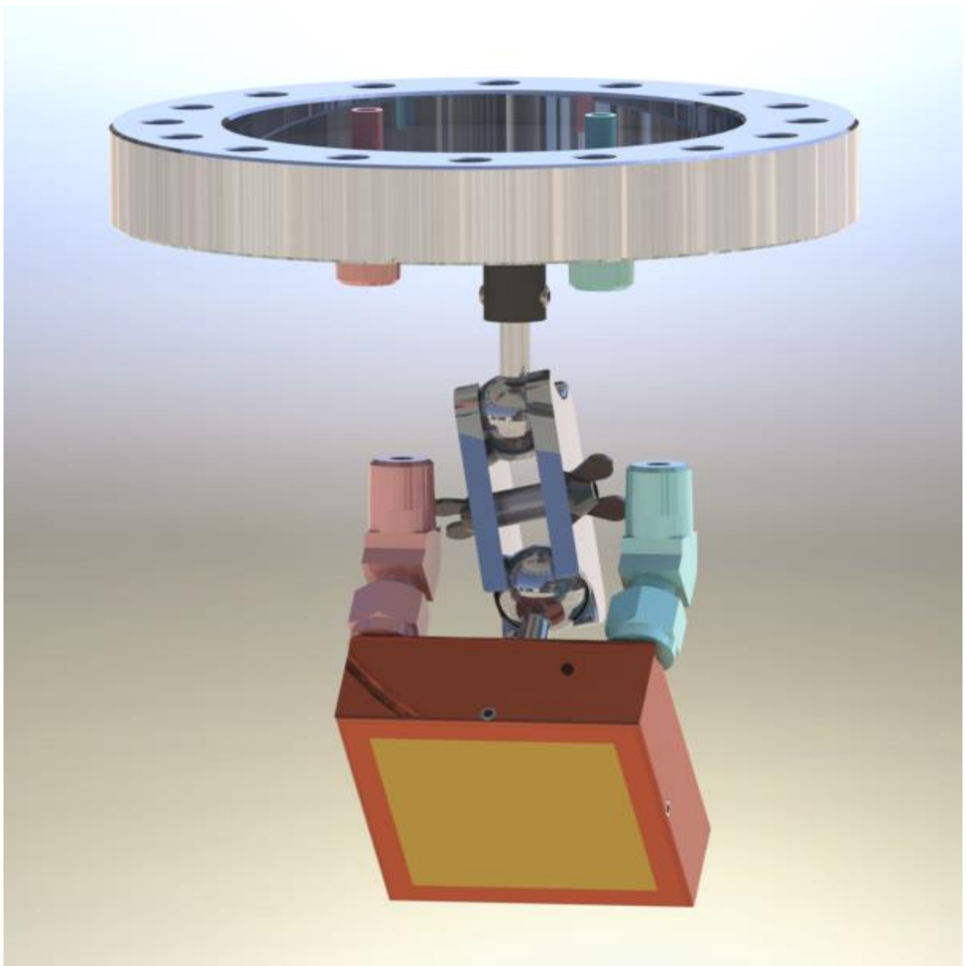


Abstract

This design is intended to replace the current mirror setup being used for the NorthStar Moly 99 project in order to monitor the target coupon. The existing setup has limited movement for camera alignment and is difficult to align properly. This proposed conceptual design for a water cooled mirror will allow for greater thermal transfer between the mirror and the water block. It will also improve positioning of the mirror by using flexible vacuum hosing and a ball head joint capable of a wide range of motion. Incorporating this design into the target monitoring system will provide more efficient cooling of the mirror which will improve

the amount of diffraction caused by the heating of the mirror.   The process of aligning the mirror for accurate position will be greatly improved by increasing the range of motion by offering six degrees of freedom.

Water Block Design

The water block was designed with the intention of increasing the cooling efficiency of the mirror, as well as decreasing the overall size of the mount. This is accomplished by using a channel system of direct water block cooling on a copper mirror mount. The mirror sits above the channels in the mount and is held in place on four sides by set screws. The two channel faces of the water block will be brazed together and will have an inlet and outlet of copper pipe. The back of the mirror mount attaches to the ball head assembly by the threaded ball head shaft and allows for full range of motion using the jointed system. The two Swagelock fittings will be attached to copper pipe stubs which are brazed to the backplate so that the seal will be capable of holding the pressure of the water system. The fittings will be attached to flexible stainless steel hosing (Figure 3) which is vacuum safe and capable of moving within the vacuum cross.

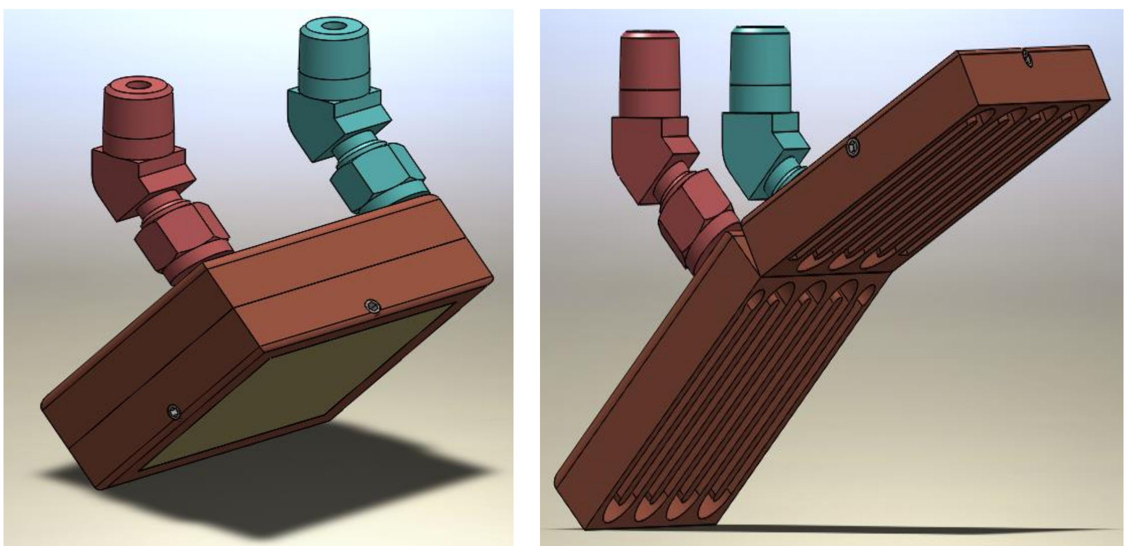


Figure 1: This shows the assembly of the water block as well as the inside of the water block with the channel for the input (blue) and output (red) of the cooling water.

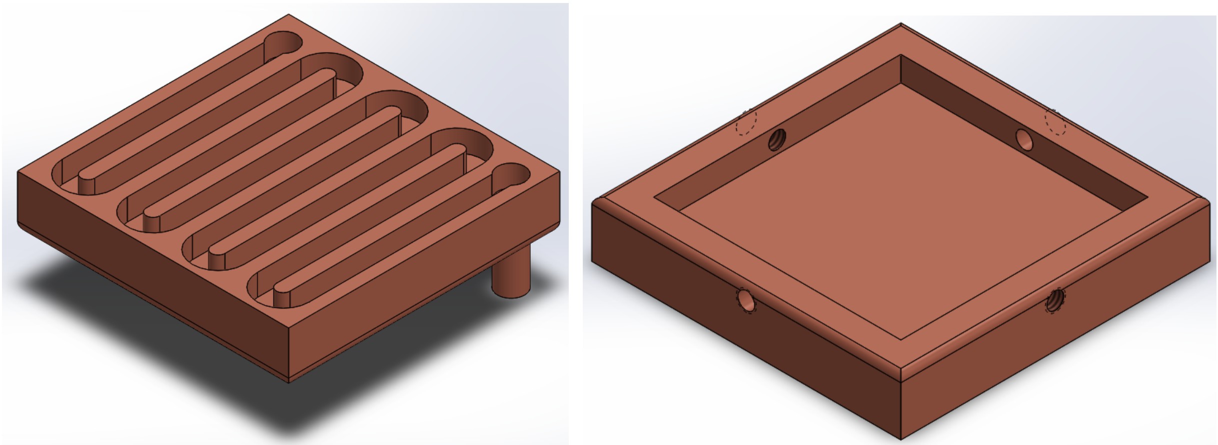
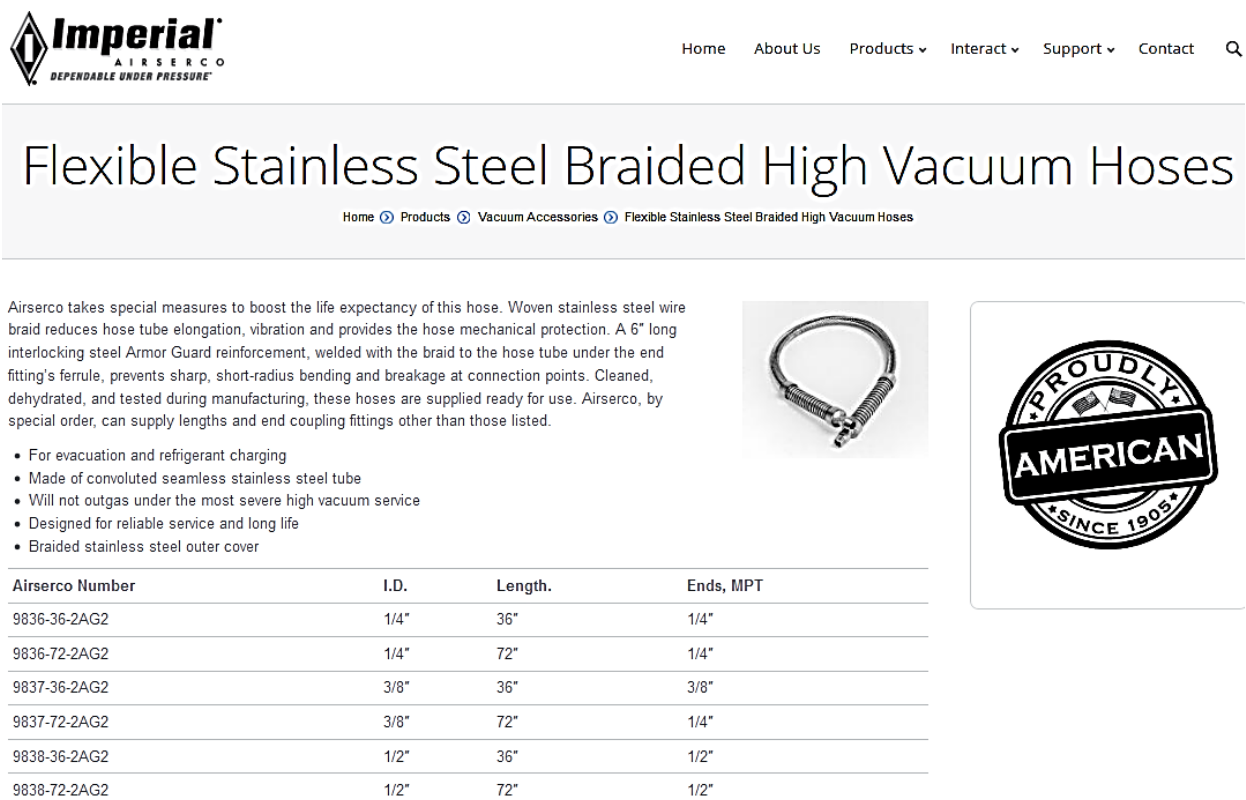


Figure 2: The bottom (left) and top (right) of the waterblock are shown above.



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Flexible Stainless Steel Braided High Vacuum Hoses

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Airserco takes special measures to boost the life expectancy of this hose. Woven stainless steel wire braid reduces hose tube elongation, vibration and provides the hose mechanical protection. A 6" long interlocking steel Armor Guard reinforcement, welded with the braid to the hose tube under the end fitting's ferrule, prevents sharp, short-radius bending and breakage at connection points. Cleaned, dehydrated, and tested during manufacturing, these hoses are supplied ready for use. Airserco, by special order, can supply lengths and end coupling fittings other than those listed.

- For evacuation and refrigerant charging
- Made of convoluted seamless stainless steel tube
- Will not outgas under the most severe high vacuum service
- Designed for reliable service and long life
- Braided stainless steel outer cover

Airserco Number	I.D.	Length.	Ends, MPT
9836-36-2AG2	1/4"	36"	1/4"
9836-72-2AG2	1/4"	72"	1/4"
9837-36-2AG2	3/8"	36"	3/8"
9837-72-2AG2	3/8"	72"	1/4"
9838-36-2AG2	1/2"	36"	1/2"
9838-72-2AG2	1/2"	72"	1/2"

Figure 3: This is the manufacturer's description of the stainless steel vacuum hoses choosen for this design. The hoses will be customed ordered with the appropriate length and fittings.

Part No.: SS-400-5-4

Description: SS Swagelok Tube Fitting, 45° Male Elbow, 1/4 in. Tube OD x 1/4 in. Male NPT

Price: Log in to see pricing

Availability: Log in to see availability

Quantity: Buy Quote

SPECIFICATION SUMMARY	
Body Material	Stainless Steel
Body Type	45° Male elbow
Series	Swagelok tube and adapter fittings
End Connection 1 Size	1/4 in
End Connection 1 Type	Swagelok® tube fitting
End Connection 2 Size	1/4 in
End Connection 2 Type	Male NPT
Cleaning	Swagelok SC-10

Part No.: SS-4-TA-1-4

Description: SS Swagelok Tube Fitting, Male Tube Adapter, 1/4 in. Tube OD x 1/4 in. Male NPT

Price: Log in to see pricing

Availability: Log in to see availability

Quantity: Buy Quote

SPECIFICATION SUMMARY	
Body Material	Stainless Steel
Body Type	Male connector
Series	Swagelok tube and adapter fittings
End Connection 1 Size	1/4 in
End Connection 1 Type	Frational Swagelok® tube adapter
End Connection 2 Size	1/4 in
End Connection 2 Type	Male NPT
Cleaning	Swagelok SC-10

Figure 4: These are the current connectors incorporated into the design with the manufacturer's description.

Ball Head Joint Design

The connection between the top vacuum flange and the water block will be made by using a multi jointed ball head system (Figure 5). This will allow the mirror to have 6 degrees of freedom for alignment and will accurately hold the system in place for extended periods of time. The black mount at the top has a through hole that will allow a screw to be threaded into the top of the flange to hold it securely in place. The top flange will be machined with a linear pattern of screw mounts in order for a wider range of mounting options (Figure 7). The top ball head will be held, by the black mount, using two set screws which allow vertical linear movement inside the mount. Both ball heads will be attached using spherical surface mounts that will be held in compression using an all thread bar connected by two wing nuts (Figure 6). This mount will be loosened when the mirror needs to be moved and can then easily be secured by tightening the wing nuts. The cut out at the top and bottom of these mounts allows clearance for the shaft of the ball head to move in various positions. This ball head design allows much greater range of motion than the current mirror setup and will ease the alignment of the target monitoring system.

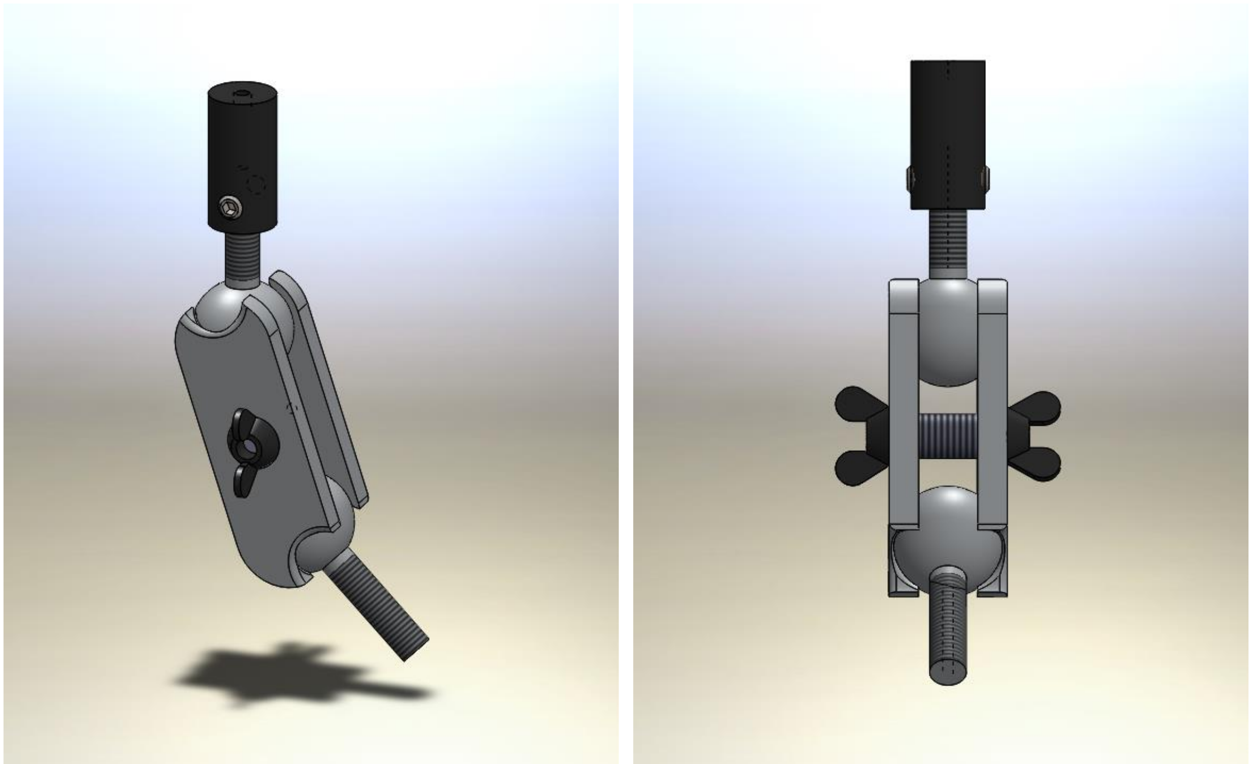

Figure 5: The ball head assembly is shown above with the top part attaching to the top flange, and the bottom is threaded into the bottom of the water block.

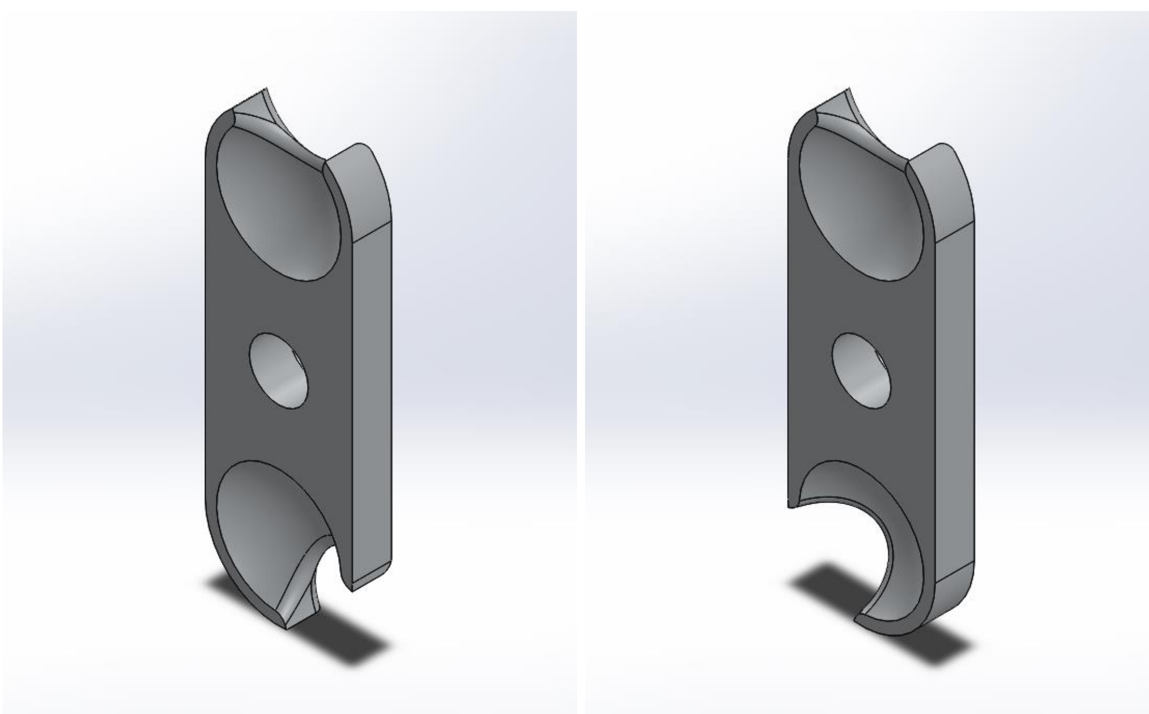

Figure 6: These two mounts will be used to connect the two ball heads and will allow a large range of motion for the alignment of the mirror.

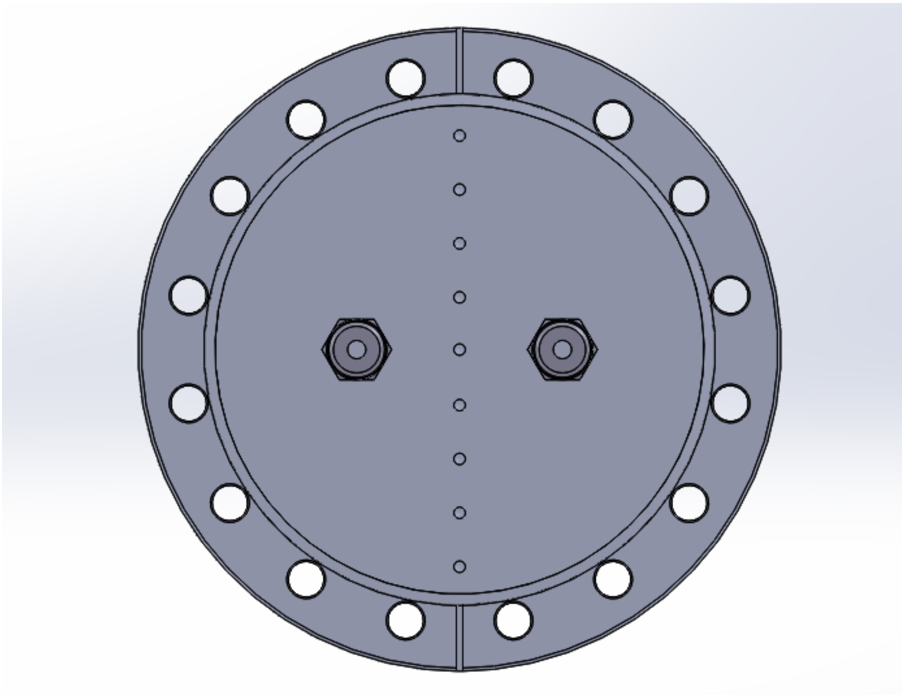

Figure 7: This bottom view of the rotatable 6 inch flange shows the linear screw pattern which will be used to mount the ball head system to the flange, and the Swagelok fittings welded through the flange.

Summary

This conceptual design for a water cooled mirror improves the efficiency of cooling as well as the overall size. It also is easier to move within the cross and will allow the camera alignment to be achieved with less hassle. The ball head system will securely hold the mirror in place while allowing for a large range of movement within the cross. The flexible vacuum hose makes movement more possible and will supply adequate water cooling to the water block. This conceptual design will refined throughout the design process and shows promise for an improved mirror mount system for the Moly 99 Project.

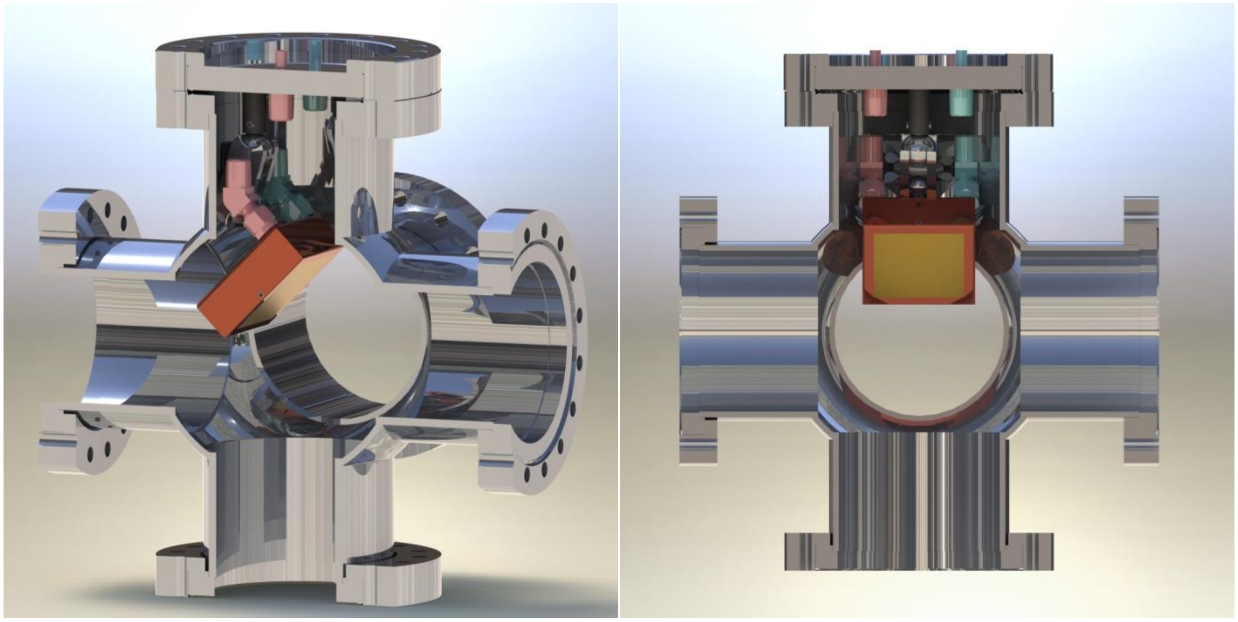

Figure 8: These cutaway renderings of the entire system mounted in a 6 inch vacuum cross show the tolerance there will be for movement of the mirror.

Recomendations and Future Work

This design is still very preliminary, but did provide a baseline for improving the design and highlighting future improvements.

We would have preferred to use a commercial mirror mount onto which we adapted the cooling block. However, the 6” flange used as a baseline for this design precluded the use of any commercial mirror mounts due to size constraints. This is why we used the ball-head assembly design. This design is able to fit within the 6” flange, and provides all the necessary range of motion, but may be susceptible to drift and vibration. We therefore recommend increasing the flange size and using a more robust commercial mirror mount onto which the mirror cooling block is mounted. An 8” CF flange would possibly work.

Now that we have a preliminary design of the cooling block, we can run MCNP calculations of mirror heating for different beam misalignments. This will provide us with a heat load from which we can better specify the cooling requirements. These heating calculations can be coupled with an upstream aperture to lower the mirror heating from the upstream beam. We will also need to calculate the mirror heating from the beam hitting the target from the other side in a two sided irradiation. Other important calculations will be radiation hitting the camera from the collimator and mirror, and the possible inclusion of a shielding aperture between the camera and mirror. Using an aluminum cooling block instead of copper may lower the heat load and should also be considered.

The cooling channel sizes are just a bit of an educated guess right now. Once we know the heat loading on the camera, we can optimize the cooling channel size, flow rate, and pressure drop.