WHERE DOES THE LIGHT GO?

The Goodman Spectrograph has a color-coded control panel that divides the instrument by major subassemblies. This document describes the layout and function of each part of the instrument, and is meant to help users build a mental picture of the light path through the spectrograph.

Figure 1 shows a graphic of the Goodman spectrograph that may be familiar from the front panel of the instrument control software. The colors of major assemblies in the model match the colors of corresponding control boxes in the user interface.

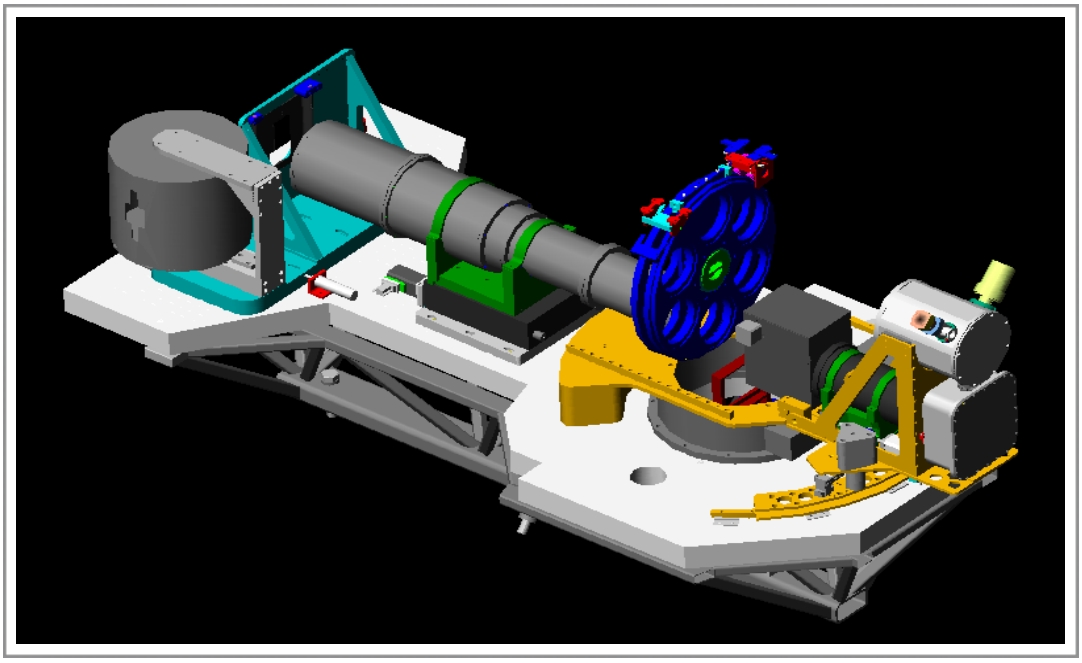

Figure 1: Color coded model of the Goodman Spectrograph

In this figure, light enters the instrument on the upper left and travels to the camera depicted at the lower right. Along the way, it passes through some or all of the following major assemblies:

1. Slit changer assembly with integral field mask (light blue)
2. Collimator (large gray tube riding on the leftmost green mounts)
3. Filter wheels (dark blue wheels)
4. Grating (red frame on moving stage, shown lowered in this image)
5. Shutter (gray box on front of the camera optics)
6. Camera optics (gray tube on rightmost green mounts)

The rotation stage that carries the camera though a 90 degree arc is colored yellow, and the flexure compensation assemblies are gray components on the near and far side of the camera optics. The remaining sections of this document describe the function and operation of each subassembly.

1. The Slit Changer

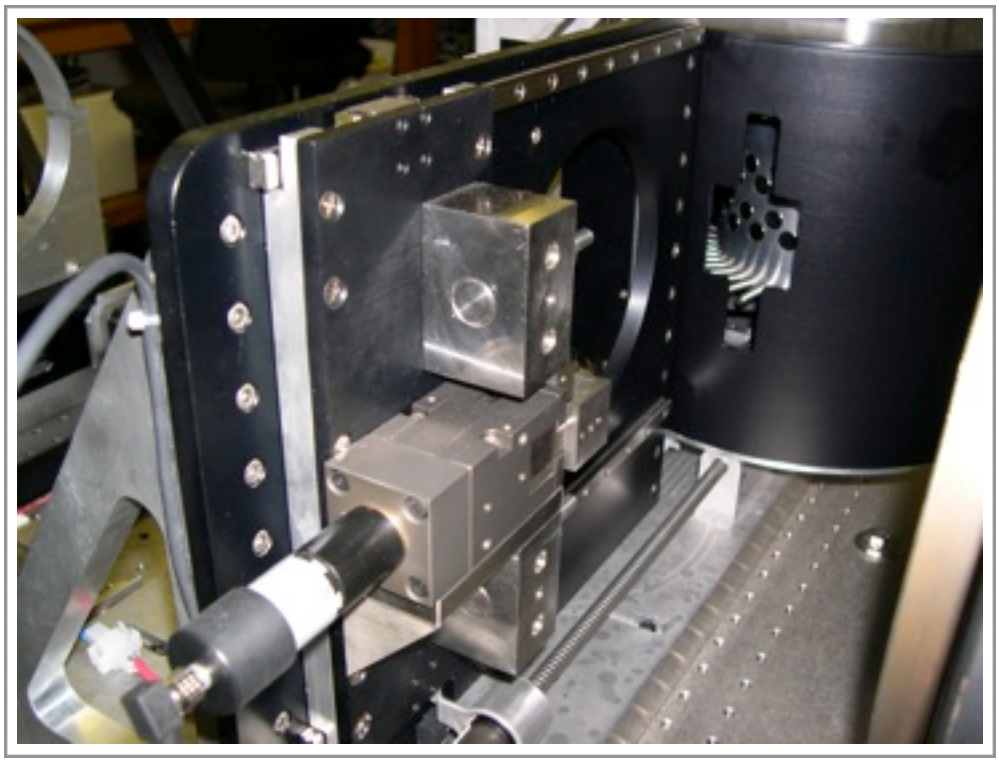

Figure 2: The slit changer assembly showing the side where light enters the instrument.

The slit changer assembly defines the entrance aperture to the instrument, and is mounted very close to the surface on the telescope where light exits the Nasmyth selector box. The autoguider probe in the selector box (not shown) moves around directly in front of this assembly, and, if placed too close to center field, can be seen as a shadow in the images. In imaging mode, the circular hole near the center of Figure 1 is the field stop, and defines the limit of the imaging field. It is not exactly in the focal plane because that spot is reserved for slit assemblies.

Slit holders (Figure 3) are mounted in the rotating carousel seen inside the black drum on the right side of Figure 1, and held in place by magnets. When a specific slit holder is requested, the carousel rotates until the requested holder is aligned to the hole in the drum. Then the translating "gripper" stage seen in the foreground of Figure 1 is driven by the worm screw at the bottom until it engages the requested slit holder. It closes jaws on the slit frame and draws it from the drum into the center of the imaging field. However, the slit holder does not cover the entire field stop, so light can leak past the edges, contaminating the spectra. To address this, there is a field mask on the rear side of the imaging field stop, as shown in Figure 4. The field mask closes automatically whenever a slit is positioned in the focal plane.

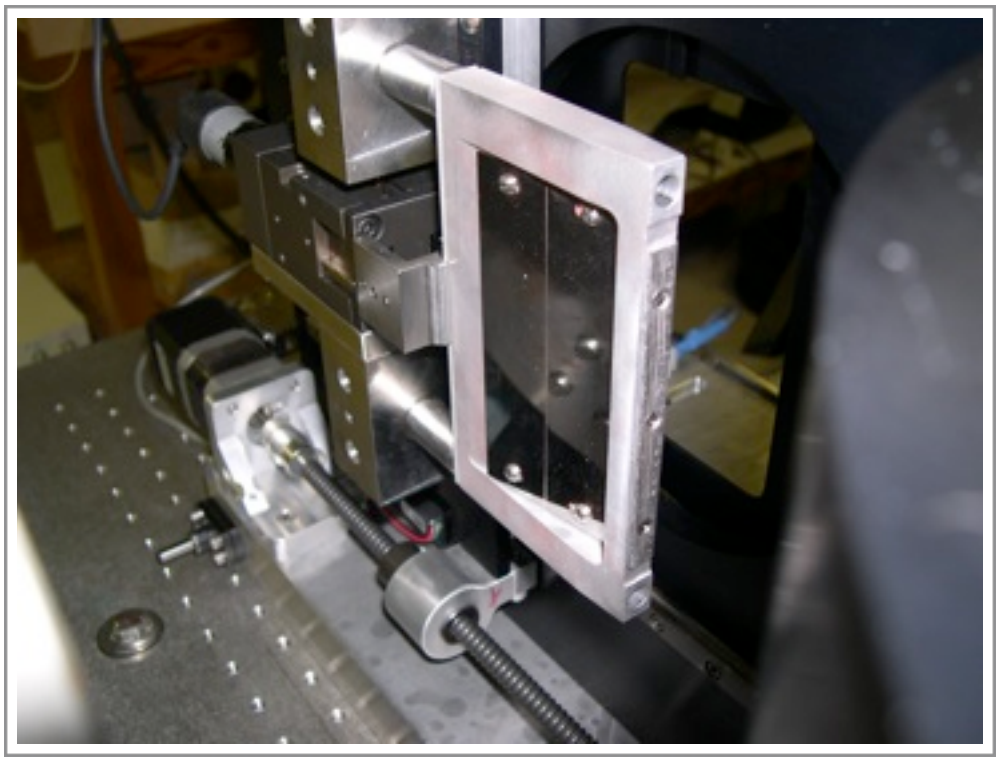

Figure 3: A slit holder is held at the focal surface by the translating gripper.

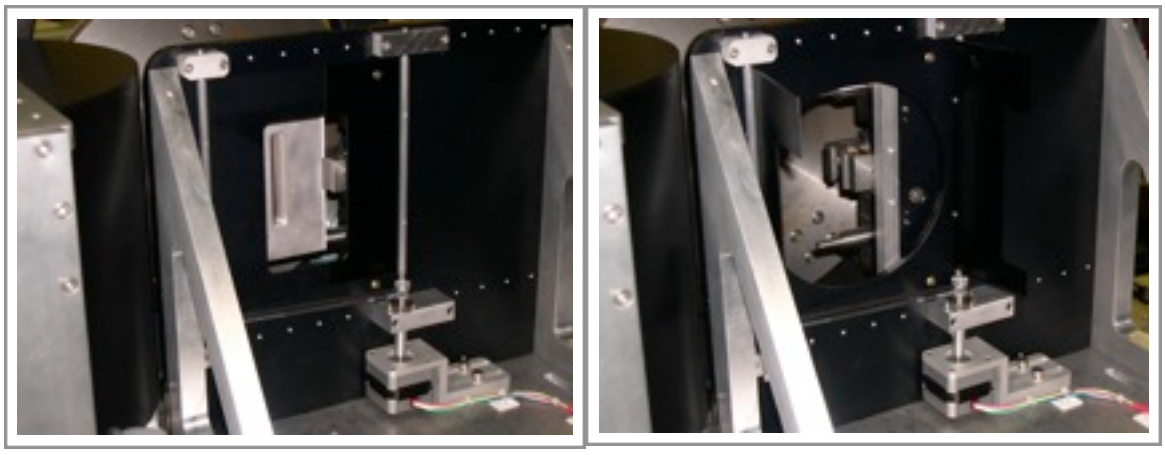

Figure 4: Rear side of slit changer assembly showing the field mask closed (left) and open (right). The open position is used for imaging mode and gives a 7.2' field of view.

2. The Collimator

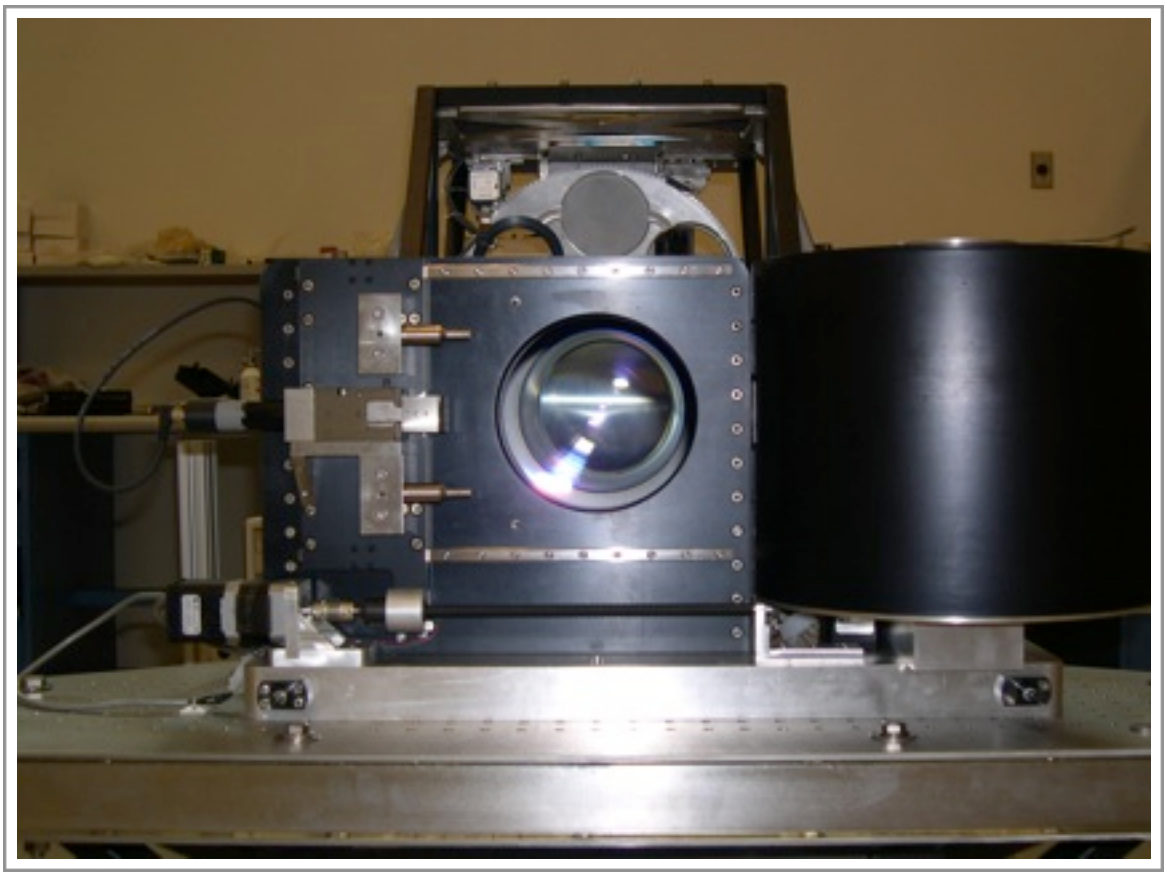

Figure 5: The entrance to the collimator as seen through the imaging field stop.

After passing through the field stop or slit, light enters the 1200.15 mm focal length, 5 element collimator. The collimator elements are mounted in a closed tube that rides on the focus stage shown in Figure 6. Figure 6 also shows the focus assembly with collimator tube installed.

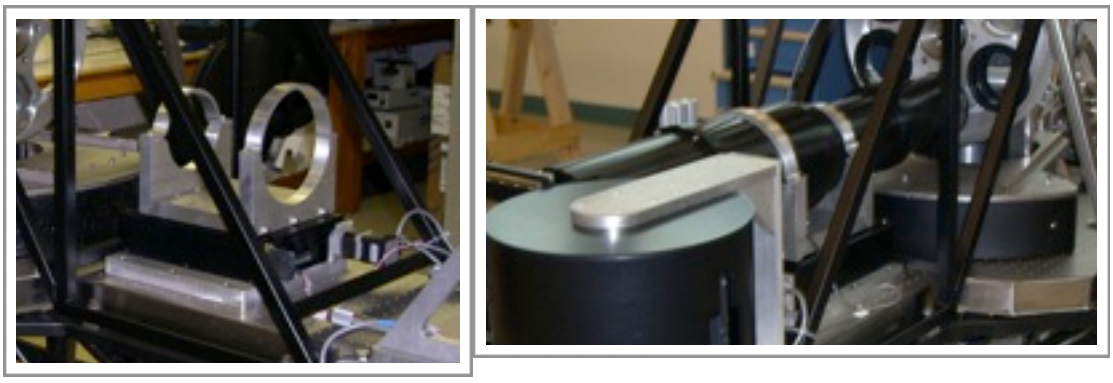

Figure 6: The collimator ring mounts on the motorized focus stage (left). The right hand image shows the spectrograph with collimator installed.

3. The Filter Wheels

Figure 7: View from the collimator (removed) looking through the filter wheels into the grating.

Immediately following the collimator are two 6-position filter wheels. The wheels hold 4" round filters in mounting rings (visible in Figure 6) that can be inserted and removed with no tools. The entire wheel can be removed by turning the hub at the center. The filters are in the collimated beam, which means no refocus is required when changing between them. To avoid contamination by ghost reflections from the filters, they are tilted by 3 degrees. The wheels are driven independently by rim mounted motors (see Figure 8).

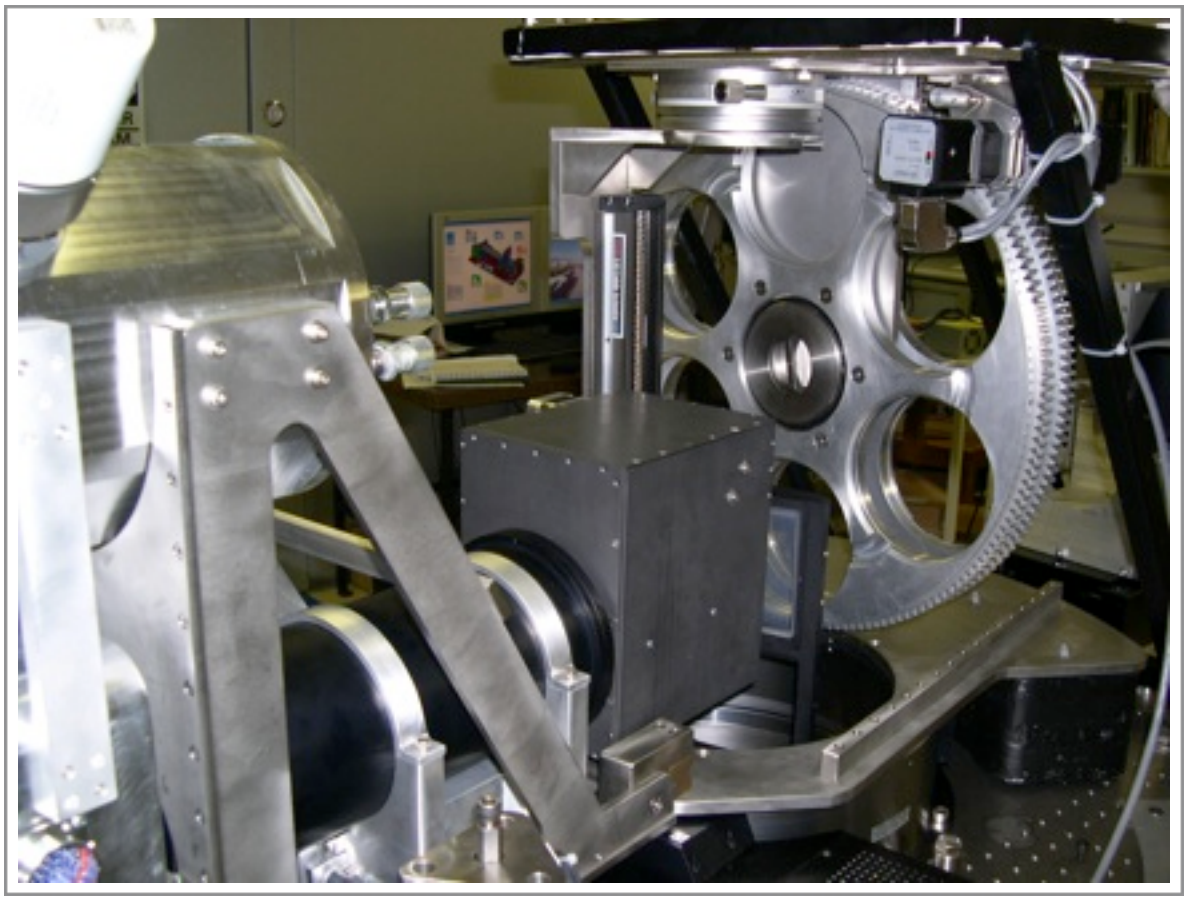

Figure 8: Filter wheel seen from the opposite side, showing drive motors in the upper right.

4. The Grating

The gratings are mounted in a 3 position linear slide that has a rotation stage at its top and bottom. The bottom stage is driven, and sets the angle of the grating in the collimated beam. As seen in Figure 9, the entire assembly passes through the central hole of a larger annular rotation stage. The larger stage moves the camera through an arc that is concentric with the center of the grating. Most efficient operation normally occurs at the Bragg Condition, and the grating diverts the collimated beam by 2 times the input angle. Thus the camera rotation is often set to 2 times the grating rotation. The grating stage is capable of dropping entirely below the collimated beam for imaging mode. IN that case the camera is aligned to point directly through the filter wheels into the back of the collimator.

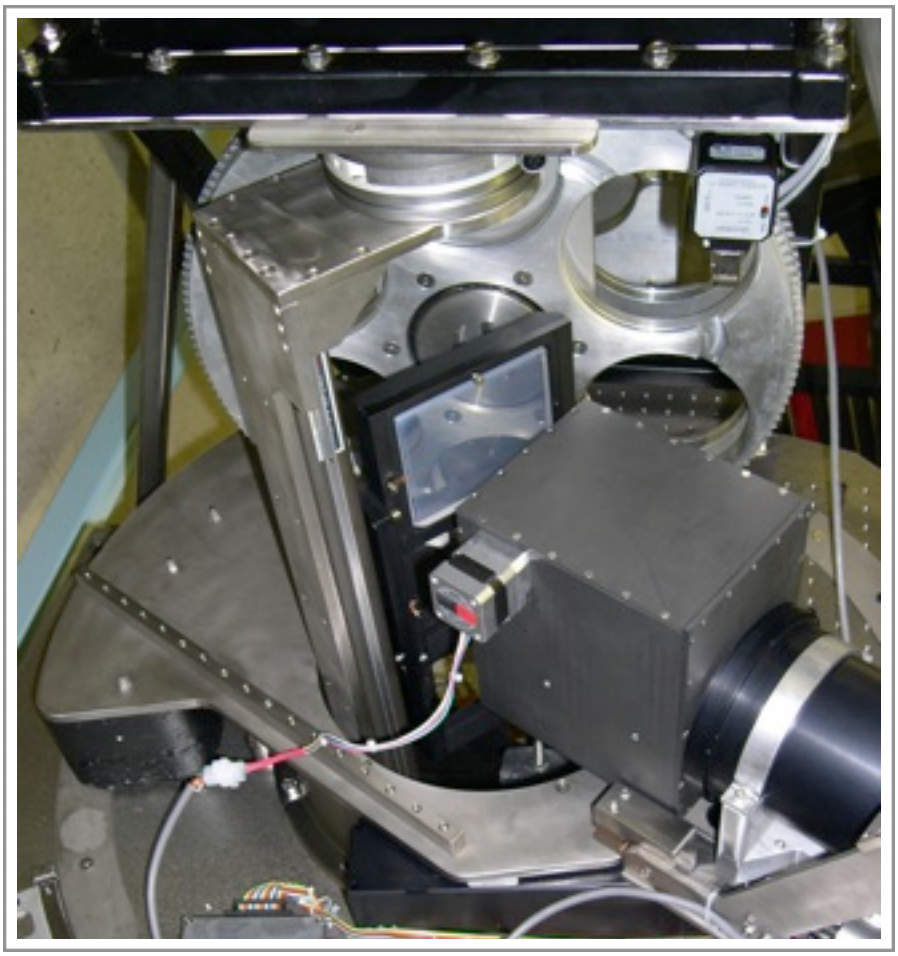

Figure 9: The grating holder (black rectangular frame) on its translation stage, which also rotates. The grating diffracts light through approximately twice the grating angle. The larger annular stage moves the camera (black tube with gray box on front) to the correct angle to intercept the diffracted beam.

5. The Shutter

The shutter consists of a curved plate that travels in two tracks inside a gray box that surrounds the front end of the camera optics. The curved plate is moved by friction wheels on a shaft that is rotated by a stepper motor (see Figure 9). Because the shutter is in the collimated beam, there is no spatial variation in exposure time over the camera image plane, even though the shutter closes in the opposite direction from which it opens.

6. The Camera

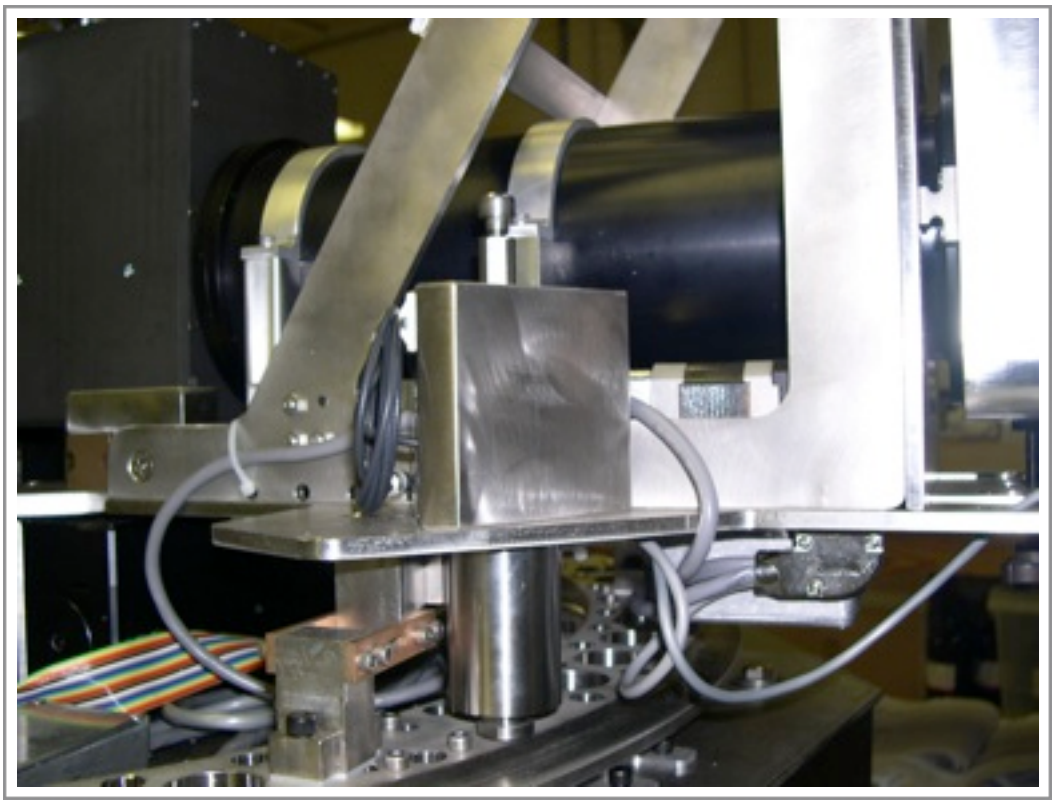

Figure 10: The camera optics (black tube) with mounting rings on a focus stage. The shutter box is on the left, and CCD dewar on the right.

Five of the eight elements in the 377.3 mm focal length camera are housed in a closed tube (Figure 10) that rides on a translation stage used for focusing. The remaining elements are mounted to the dewar; the last acting as an optic and a vacuum window. The dewar elements are fixed to the Dewar, so the translating tube with five elements slides over an o-ring seal between the camera tube and the Dewar lens mounts, and this motion changes the camera focus.

The entire stage upon which the camera tube and its focus stage are mounted is capable of rotation through 90 degrees around the centerline of the grating. The stage also incorporates a smaller (100 micron) internal motion to compensate for flexure. The motion is driven by two piezoelectric actuators acting against tuned flexures (seen in Figure 10).

After light passes through the last camera element, it is inside the vacuum Dewar, and ends its journey at the cooled CCD inside.