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Planet Finder Spectrograph

Installation instructions

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1 Introduction

Following are detailed instructions for moving PFS from its storage location and installing it on the nasmyth platform. An abbreviated version of these instructions is available on the last pages of this manual for those who simply need a reminder.

Execute the following steps deliberately and **slowly**.

If there are any problems or questions, contact a member of the instrument team, in the order listed below. Suggestions or comments concerning these instructions or the procedure described are welcome. Please send them to crane@carnegiescience.edu.

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2 Prior to Installation

PFS is normally stored on the first floor of the Auxiliary Building between the Magellan telescope enclosures. Prior to moving PFS to the telescope and installing it, the diffraction grating assembly must be pumped to refresh its vacuum and the CCD camera must be pumped and cooled. One person may execute all of the following steps. These procedures will take one day. The instrument team member charged with these tasks must arrive at the observatory at least one full day before the first day of observing if the arrival will be in the morning, or two days if the arrival will be in the afternoon.

Do not attempt to operate a vacuum pump without prior experience. Seek assistance and training from a qualified instrument specialist if needed.

Refer to Figure 1 and Figure 2 for the locations of several items mentioned in this manual.

1. Locate and acquire a vacuum pump, a KF40 centering ring, a KF40 clamp, a KF40 to KF25 adapter fitting, a KF25 centering ring, and a KF25 clamp. A set of these should be in the wooden drawer on the PFS cart. The hose attached to the vacuum pump has a KF40 flange, but the flanges on PFS are KF25. Attach the adapter to the vacuum pump hose using the KF40 centering ring and clamp. Take care not to scratch the surfaces of the flanges that contact the o-rings.

2. On the side of PFS that contains the Pre-Slit Assembly and faces the telescope when in use, there is a grating vacuum port and a grating vacuum valve access port. Remove the protective plastic cover from the vacuum port. Using the KF25 centering ring and clamp, attach the pump's KF40 to KF25 adapted vacuum hose to the PFS port, taking care not to scratch the flange surfaces that contact the o-ring. The position of the vacuum pump may need to be adjusted to avoid straining the hose or putting undue strain on the PFS vacuum port.

Figure 1: The side of PFS that faces the edge of the Nasmyth platform.

3. Open the main valve on the vacuum pump. If there was residual vacuum left in the pump from its last use, there may be the sound of air rushing from the hose into the pump as the valve is opened.
4. Turn the pump power on. If the high vacuum gauge controller is powered off, turn it on as well.
5. Start the pump in Low Speed mode and wait a few minutes to allow it to come to full speed. Then turn it to High Speed.
6. Open the PFS electronics enclosure after unlocking it using a flat head screwdriver. Locate the two vacuum gauge controllers and note their values. There is one controller for the grating vacuum and one controller for the CCD vacuum.
7. When the vacuum level in the pump's fore line (reported by the high vacuum gauge controller on the pump) is reliably lower than the vacuum level in the grating can as reported by the vacuum gauge controller in the PFS electronics box, it is safe to open the vacuum valve on the grating can.
8. Remove the cover from the grating vacuum valve port by first removing the socket head cap screws that secure it in place. A small hex wrench will be required. A set of wrenches can be found in the PFS cabinet on the first floor of the Auxiliary Building, but there should also be a set

in the wooden drawer on the instrument.

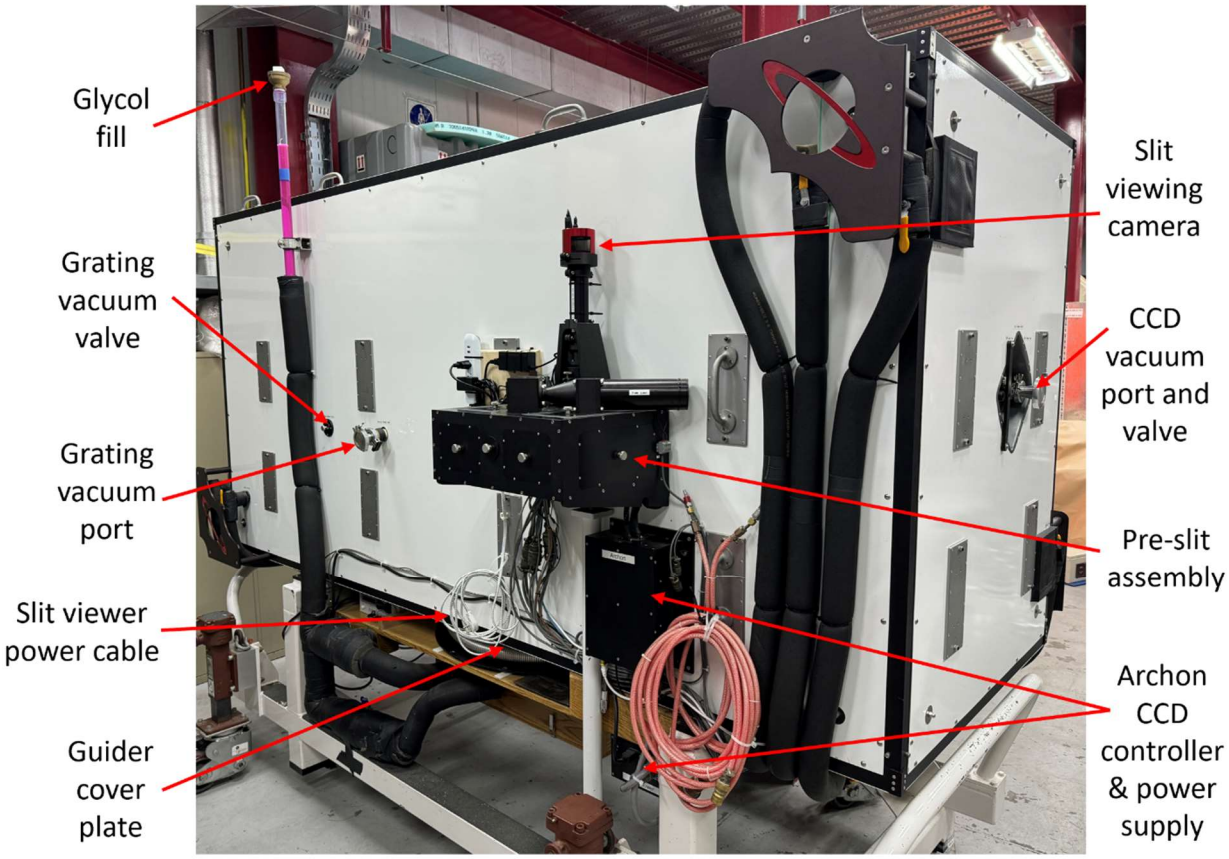

Figure 2: The side of PFS that faces the telescope.

9. Locate the large, T-handle hex wrench stored in the wooden drawer on the PFS cart. Insert this through the vacuum valve access port and engage it in the head of the socket head cap screw attached to the vacuum valve inside the thermal enclosure. It is easy to miss the socket when you insert the wrench. When the wrench is properly engaged in the socket, it will stick out about 4 1/4 inches (11 cm) past the black, circular mounting flange. Rotate fully counter-clockwise to open the valve.

10. Pump the grating assembly until the vacuum level is below 50 × 10−3 mbar. This may take a couple of hours. When that level is reached, close the vacuum valve on the PFS grating can using the T-handle hex wrench. Do not overtighten. Replace the cover and stop the vacuum pump. Wait for the pump to spin down or use the bleeder valve to very slowly introduce a small amount of air to increase the rate of spin-down.

11. Close the main valve on the vacuum pump. Remove the KF25 clamp holding the hose onto the PFS vacuum port and carefully remove the hose. Since the hose is under vacuum, it will be somewhat difficult to remove until the seal is broken and air rushes into it. Gently tilting the flanges apart works better than trying to pull them straight away.

12. Verify that the valve has been adequately closed by checking the vacuum level reported by the controller in the electronics box. There is a slow leak, so the number will rise at the rate of about 40 × 10−3 mbar/day, but should not rise very much faster than this. Sometimes the vacuum level rises more quickly immediately after the valve is closed, but should taper off to the daily leak rate fairly quickly.

13. Pump the CCD camera. The vacuum port and valve access ports are in the baking pan on the small end of the thermal enclosure. The procedure is the same as for the grating can except that the initial vacuum level of the dewar should be lower than it was for the grating. Pump the dewar to under a few × 10−3 mbar. This took a few hours with the original CCD camera, but as of 2018 usually goes faster.

14. Locate a liquid nitrogen dewar and the PFS ℓN_2 fill hose and attached stinger. The PFS stinger is longer than stingers for other instruments. The hose should be stored on the wooden shelf beneath the instrument but may have been left elsewhere, such as somewhere in the dome.

15. Immediately after closing the CCD camera vacuum valve, closing the main pump valve, and detaching the pump hose, move the pump out of the way to allow room for an ℓN_2 supply dewar.

16. Fill the CCD dewar with ℓN_2. Within a few minutes, the camera's vacuum level should drop to 0 × 10−3 mbar as the charcoal getter cools and adsorbs gas remaining in the camera. With a 13 psi supply dewar, it takes almost 20 minutes to fill the CCD dewar. The time might vary if the supply dewar is regulated to a different pressure. It will take close to six hours for the CCD to reach its operating temperature of -117˚C. The dewar cold plate temperature (visible in the PFS GUI) settles at about -190 ˚C.

17. While the dewar is filling, turn on the touch screen on the front of the electronics box. The switch is near the power switch on the back of the electronics box. To operate it, pull it outward and flip. Press the "Menu" button next to the touch screen. Using the arrows, highlight "Internal Thermal" and press "Enter". On this screen, there is a square labeled "Dewar Heat Off". Touch the square to toggle the dewar heater. The square should now say "Dewar Heat On".

18. After the dewar is full, turn on the power to the ion pump controller, which is located on the wooden shelf beneath the PFS thermal enclosure. Enable the pump using the "Vacuum" panel on the touch screen. If you turn the pump on too soon (while the vacuum level is still too high), it will automatically shut itself off. The power LED on the front of the controller will be illuminated, but the vacuum level LED sequence will be off. Wait a minute, and then try re-enabling the pump. When the pump is successfully running, the vacuum level LEDs will be fully illuminated and will gradually turn off in sequence, indicating lower vacuum levels.

    Note that while the ion pump used to begin working within a few minutes after the CCD dewar was filled, as of 2019 it is taking several hours for the pump to register the vacuum level in the 10^{-7} to 10^{-6} mbar range. This is currently a mystery, but so far it does consistently work.

19. Check the thermal control system glycol level. It should be visible in the clear PVC pipe extending upward near the top of the instrument. A target level is marked with tape, about one foot below the top of the pipe. If the level is low, add liquid. The proper mixture is 25%

Dowtherm SR-1 glycol combined with 75% deionized water. Pre-mixed solution can be found in labeled plastic bottles in the PFS storage cabinet in the Auxiliary Building.

20. After the initial ℓN_2 fill, refill the dewar once within a few hours, and then at least once every 17 hours thereafter.

3 Installation

Refer to Figure 1 and Figure 2**Error! Reference source not found.** for the locations of several items mentioned in this manual.

1. **Four people** are required for the instrument installation. The installation should ideally be performed as early in the day as possible (right after breakfast) in order to allow time to re-stabilize the temperature before the evening's observing begins. However, we sometimes do the installation immediately after lunch to allow for extra sleep in the morning.
2. A desk is typically stored on the Clay nasmyth platform. This desk must be removed from the platform and stored on the observing floor prior to installing PFS.
3. Turn off the power to PFS. The switch is located on the back of the electronics enclosure, near the bottom on the left side.
4. Unplug the instrument's power cable from the wall outlet. Collect the power cable, which is attached to a power strip on the instrument's wooden shelf beneath the thermal enclosure, and put the cable on the shelf. Do not unplug the power cable on the back of the electronics enclosure.
5. Unplug the ethernet cable from the network switch under the wooden shelf on the instrument.
6. If the brakes on the casters are engaged, disengage them.
7. Push PFS to the exterior elevator door on the ground floor of the Clay building. Four people should handle the instrument, one at each corner. Ensure that no part of the instrument hits anything en route. Pay particular attention to the black pre-slit assembly that extends from the side of the thermal enclosure. Also watch the glycol fill tube above the thermal enclosure. During any instrument move, ensure that the leveling mounts underneath the four corners of the instrument cart will not hit any low profile objects on the ground.
8. PFS will barely fit onto the elevator with all of the hand rails in place. However, the rails closest to the telescope must be completely removed in order to move the instrument onto the nasmyth platform.
9. Place steel plates (normally stored on the instrument's wooden shelf) on the threshold between the concrete and the elevator, separated by the same distance as that between the instrument casters.
10. Very carefully and SLOWLY, and with the combined effort of four people, roll the instrument halfway onto the elevator. Ensure that the casters roll across the steel plates on the threshold. The instrument should be oriented so that the pre-slit assembly faces right into the elevator. It will then be oriented correctly when it reaches the nasmyth platform.
11. If the elevator has sunk under the partial weight of PFS, readjust the elevator height as necessary to level it with the ground.

12. Move PFS fully onto the elevator. It must my positioned such that no part of the instrument — particularly the pre-slit assembly — will hit anything on the way up to the nasmyth platform, including the platform itself.
13. Apply the brakes for at least two of the casters.
14. Place the steel plates on the elevator.
15. Raise the elevator to the nasmyth platform. **Make sure that the pre-slit assembly does not clip anything — particularly the the nasmyth platform — on the way up.**
16. Remove the nasmyth platform hand rails nearest the elevator.
17. If the crew has decided to raise the elevator with the elevator hand rails in place, the rails must now be removed.
18. Set the elevator level with the platform. Place the steel plates across the threshold.
19. Release the caster brakes. Very, very carefully and SLOWLY, and with the combined effort of four people, roll the instrument halfway onto the platform, ensuring that the casters cross the steel plates.
20. If the elevator level changes when the instrument is half off of it, adjust the elevator height to level it with the platform.
21. Carefully push the instrument the rest of the way onto the platform. Move it close enough to the telescope that the power and ethernet cables may be plugged in, but far enough away so that the guider cover plate on the wooden shelf nearest the telescope can be accessed.
22. Plug the power cord for the power strip on the wooden shelf into an orange (UPS-supplied) outlet. Of the four orange outlets in the junction box nearest the platform steps, the lower right one seems to be preferable as we think that somehow other outlets affect the standard deviation of the bias. Ensure that the power is on. This step should be executed as soon as possible after reaching the nasmyth platform so that the thermal control system can have time to re-stabilize the instrument temperature before observing begins.
23. Temporarily place the steel plates on the platform. Replace the platform handrails.
24. Locate the telescope guider cover plate on the instrument's wooden shelf and a plastic bag containing bolts and washers in the wooden drawer. Attach the cover plate to the guider with at least three bolts and washers. The cover plate should be oriented with handles at 12 and 6 o'clock for maximum clearance. Return the plastic bag to the wooden drawer.
25. Place the steel plates on foam on the wooden shelf where the guider cover plate was stored.
26. Remove the small, round cover plate on the front aperture of the pre-slit assembly. Place it and its screws in a plastic bag in the wooden drawer.
27. Very carefully and slowly, position the instrument so that the three spherolinder blocks on the underside of the PFS cart are aligned with the spherolinder mount plates attached to the nasmyth platform. Take care to ensure that the pre-slit assembly does not crash into the telescope guider box.

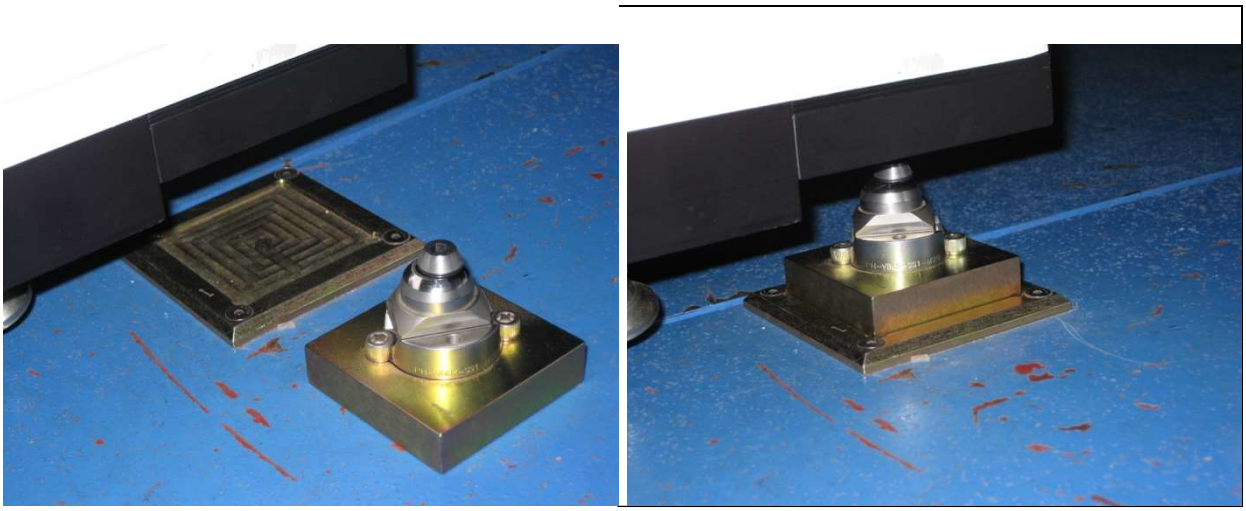

Figure 3: The spherolinder base plate and assembly are shown in the left photo. The assembly has been placed in the base plate in the right photo.

28. Plug an ethernet cable into the network switch under the wooden shelf. The instrument should be connected to a port on the 200.xx.xxx.xxx network (not the 138.xx.xxx.xxx network). The IP address of the PFS PLC is 200.28.147.102 (network alias pfsplc), and of the Archon CCD controller is 200.28.147.192 (network alias archon0125).
29. Turn on the dewar heater. If the touch screen on the electronics enclosure is off, turn it on. The switch is near the power switch on the back of the electronics box. To operate it, pull it outward and flip. Press the "Menu" button next to the touch screen. Using the arrows, highlight "Internal Thermal" and press "Enter". On this screen, there is a square labeled "Dewar Heat Off". Touch the square to toggle the dewar heater. The square should now say "Dewar Heat On".
30. Locate the loose spherolinder blocks (Figure 3**Error! Reference source not found.**) in the wooden drawer. Place these in their respective baseplates attached to the nasmyth platform. Each baseplate and each spherolinder assembly is stamped with a number at one corner. The numbers should be matched such that each stamped corner is appropriately aligned.
31. Lowering PFS onto its hard mount points can be accomplished by one person working alone. It can also be accomplished with four people, each operating one jack. However, if four people are to work together, one person must carefully coordinate the combined effort and enforce slow and deliberate care.

    Refer to Figure 4. The cross-sectional view shows the proper alignment of the base plate, spherolinder assembly, and spherolinder block attached to the underside of the instrument cart. It also shows the most common, dangerous misalignment. If the instrument is not properly aligned with the spherolinder assembly on the platform while lowering, a flat surface on the upper block can catch on the flat surface of the shoulder bolt in the lower assembly. The weight of the instrument will be supported unstably in this position. A small bump can cause the instrument to shift and fall to the aligned position, shocking and potentially misaligning or damaging instrument components. Worse, if this happens, fingers can become pinched or crushed. It is therefore very important to lower PFS very slowly and carefully while paying close attention to the alignment of the spherolinder parts.

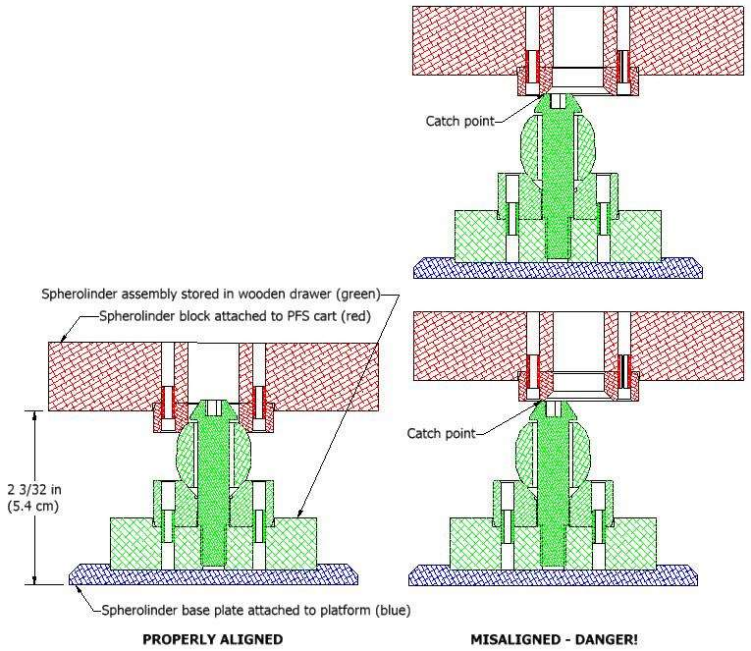

Figure 4: A cross-section of the spherolinder mount system, both properly aligned and misaligned. Great care is required to avoid the misalignments shown as it may result in the instrument slipping and slamming into the aligned position, potentially causing damage to hardware and/or personal injury.

Handles for the caster jacks are located in the wooden drawer. The black handle is for the caster jack nearest the telescope guider. Using the handles, lower the instrument toward its hard mounts. Only one rotation of the jack handles should be made. Then the alignment of the spherolinder assemblies should be checked and the instrument position adjusted as necessary. Then another single rotation of the jack handles can be made, followed by a spherolinder alignment check and instrument position adjustment. Then another single jack handle rotation may be made. Repeat this sequence until the instrument is sitting with its full weight on the spherolinder hard mounts in the properly aligned orientation. If more than one person is operating the jack handles, all operators must work in tandem. No person should operate independently since operating a jack on one corner of the instrument could potentially cause the dangerous misalignment to occur at another corner where someone else might have their fingers in a dangerous spot. Throughout the lowering process, check that the instrument is not tilted so much that the pre-slit assembly pushes into the guider cover plate.

Align the casters longitudinally along the length of the instrument cart to minimize tripping hazards. The jacks should be positioned so that the weight of the instrument is taken up by the three hard mounts, but the casters are still touching the platform and the caster springs are slightly compressed. This allows the casters to act as stabilization points in the event of a large earthquake.

32. Place the jack handles back in the wooden drawer. If left on the instrument, it is very easy to run into them and hurt one’s shins.

33. In the wooden drawer, there are two baffles. One baffle attaches magnetically to the telescope guider box cover plate. The other, smaller baffle attaches magnetically to the front of the pre-slit assembly. The second baffle contains an AR-coated filter. Take care not to touch it. The baffles must be attached simultaneously. This is an awkward procedure. It is most easily accomplished by lowering the baffles, one inside the other, into the space between the pre-slit assembly and guider cover plate from the top using both hands at first, and then moving one hand underneath the gap to help with final positioning and to catch the baffles if they fall. Note that the pre-slit assembly baffle has an alignment pin that must be mated with a corresponding hole. The fit is somewhat loose.
34. Plug the slit viewing camera cord into an outlet. Ensure that the Rasberry Pi is powered on by the inline switch on its power cable. A LED should be illuminated inside the case.

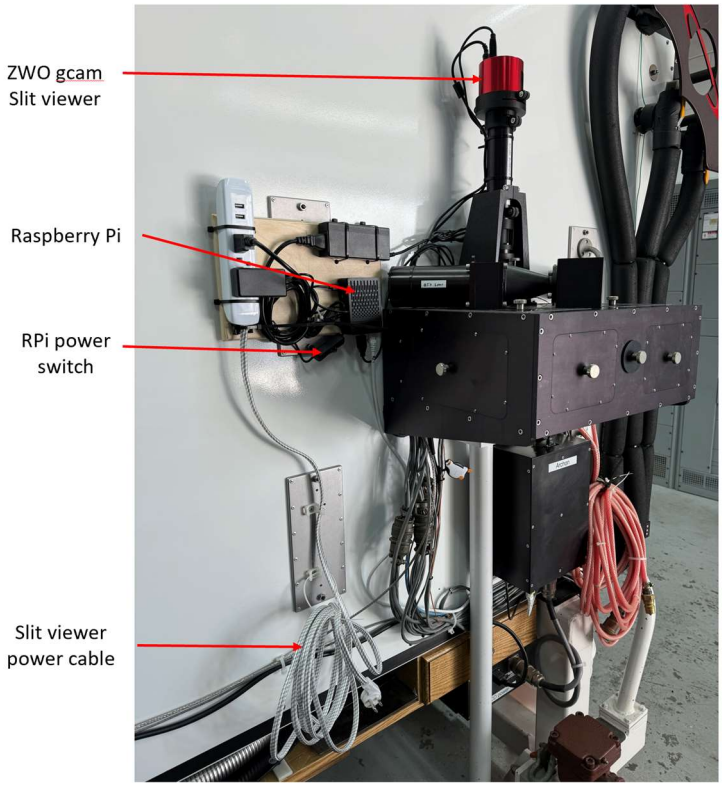

Figure 5: Slit viewer components.

35. Turn on the CCD power supply, which is attached to the underside of the wooden shelf beneath the pre-slit assembly. This must be done only after the instrument's network cable is plugged in.
36. Turn on the power to the iodine cell temperature controller. The controller is on the wooden shelf underneath the large white thermal enclosure. The switch is on the back, left side of the controller and can be accessed (with some difficulty) by reaching between the temperature controller and the ion pump controller. Push the "Run" button on the iodine cell temperature controller. Verify that the controller is running. If it is, the display will not say "STOP".
37. Attach the PFS ℓN2 fill hose and stinger to a small dewar and bring it to the nasmyth platform. Fill the CCD dewar.

38. In the control room, open the PFS GUI, which is installed on *guanaco* in /Applications/LCO/. Verify instrument functionality.
39. If the outside temperature has changed significantly since the last observing run, the slit viewing camera may need to focused. Two people are required to do this.

    Turn on the quartz lamp and adjust the scaling of the slit viewer image in the control room until the slit plate can be clearly seen. There are a number of scratches on the slit plate. One person should stay in the control room and observe the sharpness of the focus on the slit edges and scratches. The other person will adjust the camera position on the nasmyth platform. The cordless phones in the control room can be used in intercom mode to allow communication.

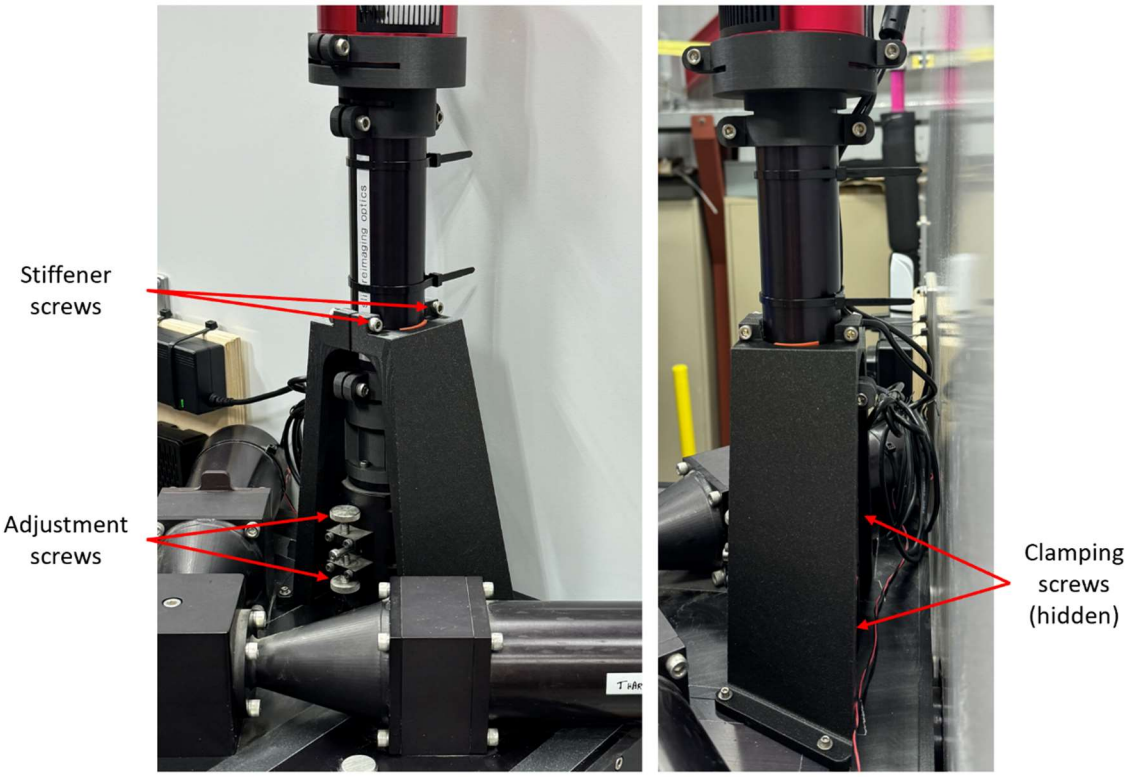

Figure 6: Slit viewer focus adjustment elements. The clamping screws should be accessible with a ball end hex wrench behind the twisted stiffener.

Refer to Figure 6. The camera is mounted on a tube that slides up and down inside a larger tube attached to the pre-slit assembly. The inner tube is clamped with two screws on the instrument side of the assembly and are behind the twisted stiffener for the column. Loosen these screws. Also loosen the screws that hold the two stiffener halves together. Now the inner tube and camera can be slide freely, confined by the adjustment screws. A shoulder bolt attached to the inner tube sits on an adjustment screw. The camera may be lowered by rotating the adjustment screw by hand counter-clockwise. Some gentle downward force on the tube may be required. To raise the camera, lift it away from the adjustment screw with one hand and rotate the screw clockwise with the other hand. Then lower the camera and tube back onto the screw to check the focus. Remove

your hands from the camera and tube after each adjustment so that the image will settle adequately for examination by the person in the control room. When the desired focus position is found, clamp the inner tube and stiffeners into place. This may move the camera slightly, taking it away from the optimal focus. Iteration may be necessary.

40. At the commencement of the first night of observing, work with the telescope operator to make sure that the following are set:

    a. ~~Slit viewer pixel size (0.037"/pixel) - enter "px .037"~~ **TBD December 18, 2023**

    b. ~~Slit viewer orientation - T.O. should run "pfscaloop.csh"~~ **TBD December 18, 2023**

    c. Guider and Shack-Hartmann probes - T.O. sets these. As of October 2019, the best values were F1= -19.5 and F2= -8.5. These numbers occasionally change for some reason. The T.O. should check the appropriate log to see which numbers were used during the last run. Ask whether anything has changed since the last run that might have caused these values to change. If so, then a focus run in good seeing conditions will be necessary to re-determine the best values. **TBD or updated December 18, 2023**

4 PFS Installation Checklist

4.1 Day before installation — One person required

1. Pump the grating vacuum chamber to below 50 × 10−3 mbar.
2. Pump the CCD camera to a few × 10−3 mbar.
3. Fill the CCD dewar with liquid nitrogen.
4. Turn “Dewar Heat On” using the touch screen on the electronics enclosure.
5. Turn on power to the ion pump controller. Enable it using the touch screen.
6. Refill the glycol in the clear pipe on the side of the instrument.

4.2 Day of installation — Four people required

1. Remove the desk from the nasmyth platform.
2. Turn off power to PFS using the switch on the back of the electronics box.
3. Unplug the instrument power cable from the wall outlet.
4. Unplug the ethernet cable from the network switch.
5. Disengage caster brakes.
6. Remove elevator hand rails nearest telescope and nearest elevator door.
7. Roll PFS onto the elevator with steel plates laid across the threshold.
8. Verify safe positioning of the instrument. Apply at least two caster brakes.
9. Raise the elevator to the nasmyth platform.
10. Remove the platform hand rails nearest the elevator.
11. Roll PFS onto the platform with steel plates laid across the threshold.
12. Plug the power cord into the lower right UPS-supplied outlet.
13. Turn on power to the Hoffman box and enable the dewar heater.
14. Replace the platform hand rails.
15. Attach the guider cover plate to the guider. Handles at 12 and 6 o’clock.
16. Place the steel plates on the wooden instrument shelf.
17. Remove the cover plate from the instrument entrance aperture.
18. Position the instrument over its mount plates on the platform.
19. Place the spherolinder blocks in their respective mount plates.
20. Lower PFS onto the spherolinder blocks.
21. Place the jack handles back in the drawer.
22. Install the small baffles on the guider cover plate and instrument entrance aperture.

23. Plug in power for the slit viewing camera.
24. Turn on the guider power supply.
25. Plug an ethernet cable into the network switch.
26. Turn on the CCD power supply.
27. Turn on the power to the iodine cell temperature controller and push the “Run” button.
28. Fill the CCD dewar.
29. Run the PFS application. Test mechanisms and take test exposures.
30. Check the guide camera focus and adjust if necessary.
31. Verify that telescope operator has set guider parameters and probe positions correctly.