



Pandora Spectrometer System Installation and Maintenance Manual

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SciGlob Instruments & Services

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Introduction

Safety

The Pandora sun photometer system utilizes 120/220VAC electrical power converted to 24VDC up to 14.5 Amp DC. The user is responsible for exercising all necessary precautions to ensure his/her safety and that of the product. Failure to do so could result in physical harm to the user and/or the product. The instrument uses one or two optical fibers to connect the head sensor to the spectrometer(s). **The fiber should not be stepped on, no objects should be placed on top of it and it should never be bent below the allowed minimum bend radius (10cm/4in).** The instrument should not be exposed to water or high humidity when open. Every effort is made by SciGlob to make the system as rugged and durable as possible. However, mechanical damage, extreme temperatures, rain, snow, and other natural wear can cause the system's safety features to degrade in an unanticipated way. Use proper caution when transporting or servicing the instrument.

About this manual

This manual is an official document of:

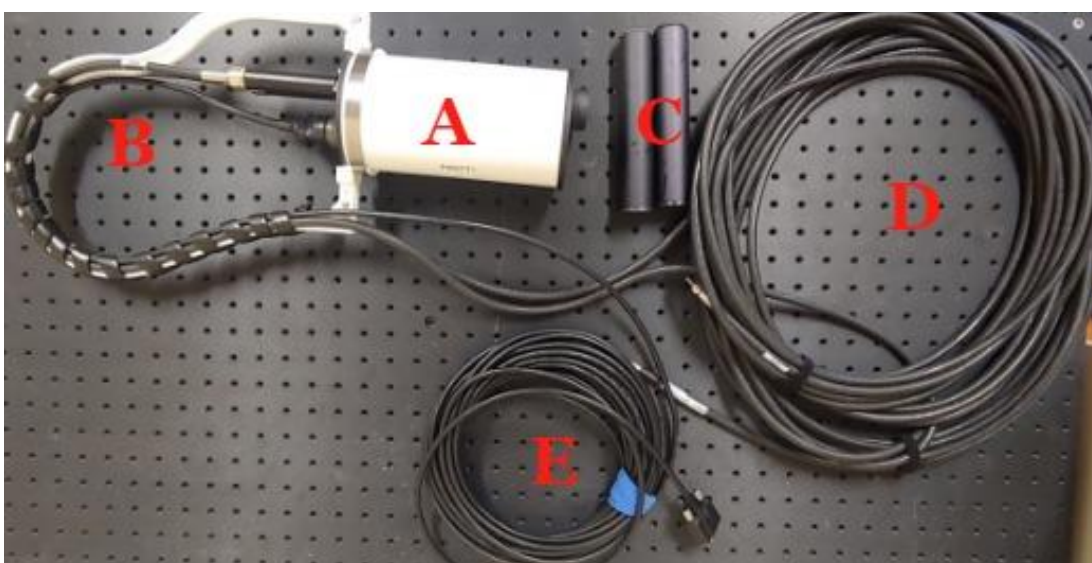
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This manual contains two sections; the first section, “Pandora Spectrometer System Installation and Maintenance Manual” describes the installation and maintenance for the Pandora spectrometer system (Pandora) instrument family; the second “General System Information and Troubleshooting Guide” provides general information that may be helpful when troubleshooting an issue with the Pandora. Additional information can be found on the company webpage www.sciglob.com, where you can also download this manual as PDF. For questions contact SciGlob Instruments & Services LLC (SciGlob) under <info@sciglob.com>.

System Overview

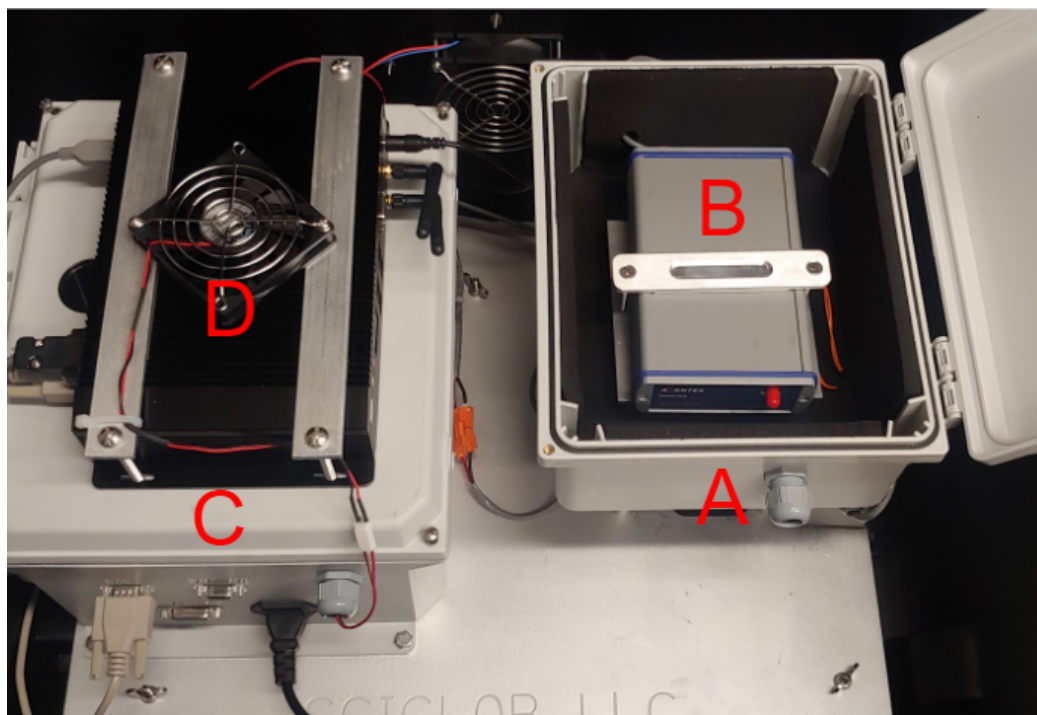
The Pandora consists of 3 major components: the head sensor, the sun tracker, and control box. An overview of these components is given below, more details can be found in the General System Information and Troubleshooting Guide section of this document

Head Sensor



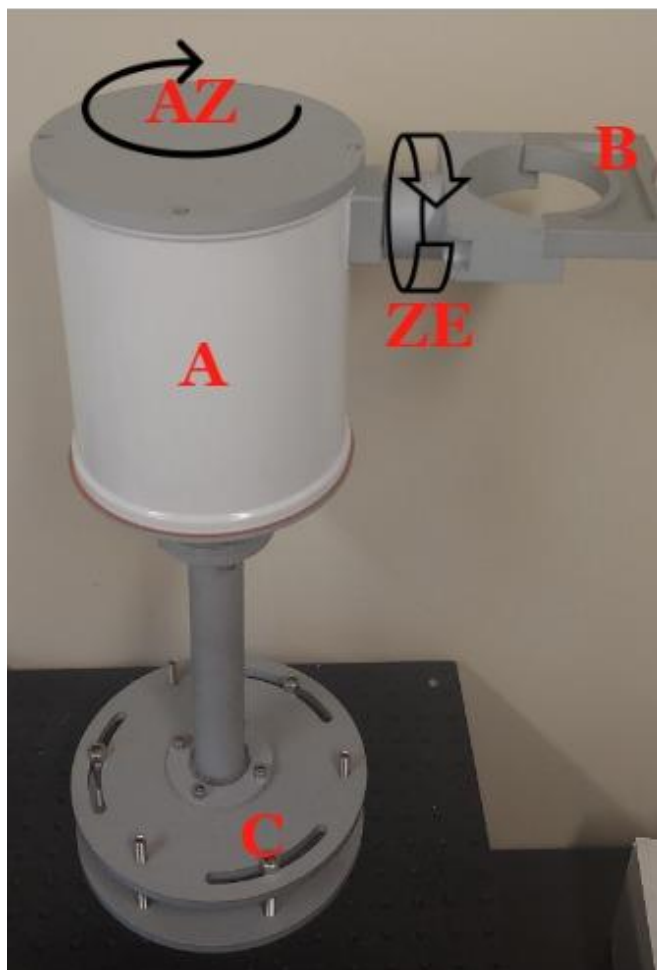
- The head sensor consists of the **main body (A)**, which contains the optical elements and a microcontroller, the **fiber guide (B)**, which maintains proper alignment between the optical fiber and head sensor main body, the **collimator(s) (C)**, which condition the light beams before entering the main body, the optical **fiber(s) (D)**, which carry the optical signal from the head sensor to the spectrometers in the control box, and the **head sensor cable (E)**, which carries electrical power and signal to and from the head sensor.
- The head sensor pictured above is a 2S model. If you have a 1S model, the head sensor will only have 1 collimator and 1 optical fiber.
- In general, unplugging fibers should be avoided, but if it is needed due to maintenance tasks, it should be unplugged always from the spectrometer side, never from the head sensor side. Otherwise the calibration of the instrument may be affected.

Main Control Box



The **main control box** (or **Pandora box**) is the large rugged container with two white entry ports on its front. It contains the 2 smaller boxes pictured above. The **spectrometer box (A)** is an insulated, temperature controlled enclosure that houses the **spectrometer(s) (B)**. The spectrometer box's temperature is controlled by a **thermo-electric cooler/TEC (not visible in picture)** mounted underneath the box. The main control box also contains the **relay box (C)**, which distributes power and coordinates the communication among the components of the Pandora system. A power supply and printed circuit board (the relay board) are mounted inside of the relay box. A **computer (D)** is mounted on top of the relay box.

Sun Tracker



The sun tracker holds the head sensor and moves it to any pointing position in the sky. The current model of the sun tracker is called the “LuftBlickTR1” sun tracker. It consists of 3 parts, the **main tracker body (A)**, the **head sensor clamp (B)**, which is used to secure the head sensor to the tracker, and the **baseplate assembly (C)**, which is used to secure the tracker to a tripod or platform as well as to level the tracker. The sun tracker has 2 axes of rotation: Azimuth (AZ) in the horizontal plane, and Zenith(ZE) in the vertical plane.

Note: For information on the older “FLIR” tracker model see appendix 2.

Site Requirements

Any Pandora measurement location should meet the power, connectivity and space requirements outlined in this section.

Power and connectivity

The power needs of Pandora are driven mainly by the thermo electric cooler (TEC) stabilizing the spectrometer temperature. The power consumption is typically 95 W for 1S models (180 W for 2S models) and maximum 125 W for 1S models (220 W for 2S models) for the Pandora 1S (2S). “Maximum” refers to the maximum draw of the TEC when the field enclosure box is deployed outside on a hot day. The power consumption on a cool day is significantly lower.

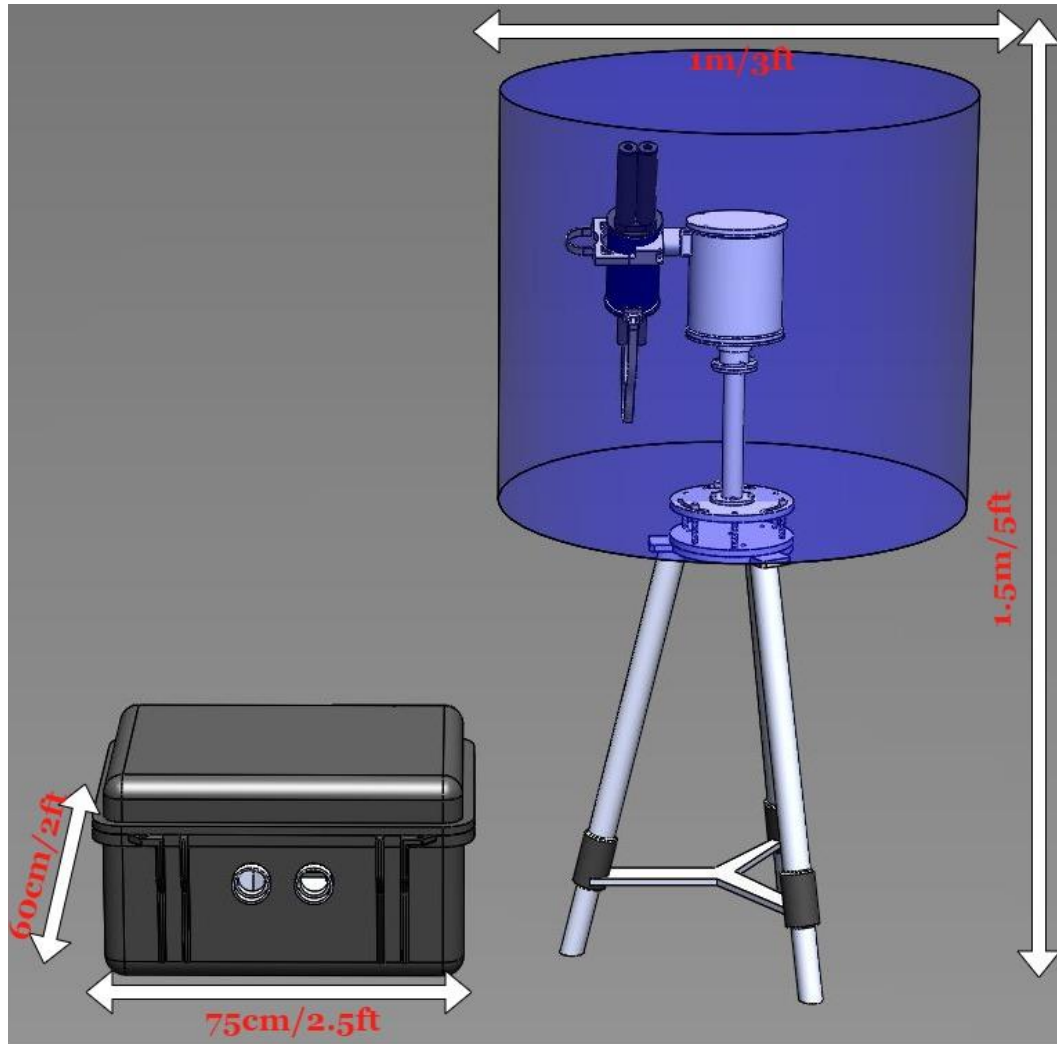
The computer inside the main control box must have a stable Internet connection if remote instrument control and data upload are required. Internet connectivity must be given through either a local ethernet port (preferred option) or WiFi. In the case of joining to the Pandonia Global Network, the local network firewall configuration must allow in/out traffic on SSH/SFTP (port 22, alternatively 115) in order to push data to lb3.pandonia.net, and outgoing HTTP (port 80). Note that the Pandora system will continue to operate normally without the presence of Internet connectivity, however data recorded will only be transferred to the server by the filepush software (BlickF) once a connection is established.

Space requirements

The pandora instrument requires enough ground space for the 75cm x 61cm (2.5ft x 2ft) footprint of the control box plus a roughly 1m (3ft) diameter circle for the base of the tripod. When operating the pandora it is important to remember the tracker with the head sensor will be constantly moving. It is best to give a sphere of roughly 1m (3ft) diameter safety bubble around the tracker and head sensor. The Pandora system, especially the tripod or tracker base plate must be mounted on a stable solid surface. Soft surfaces (e.g. grass) or surfaces that change with temperature (like some solid -all metal- roofs or tables) should be avoided because it may affect the pointing accuracy. It is highly recommended to strap or bolt the tripod/tracker base plate to a solid surface to avoid the instrument being blown over in the wind.

The head sensor further needs an unobstructed view of the sky and the sun's path.

Pandora Space Requirement



Hardware Setup

The steps to set up the instrument are divided in 3 subsections (initial hardware setup, software setup, and finishing hardware setup). It is done this way for two reasons:

- 1) If you run into any issue during the software setup procedure, it can often be easier to diagnose and troubleshoot before the system is totally set up and everything is mounted.
- 2) It is possible for the shafts of the tracker to rotate out of their home position during shipping. If this happens the tracker may spin multiple revolutions to get back to its home position once you connect it through the BlickO software for the first time. If this happens while the head sensor is already mounted it will likely damage the fiber optic cable. For this reason, unless you're absolutely sure that the tracker is in the proper home position, **it is always recommended that you connect the tracker through BlickO software before mounting the head sensor**. Note: All the communications that the BlickO software sends to the tracker pass through the head sensor first. So the head sensor must be plugged in in order to connect the tracker via software.

Initial Hardware Setup

If you are not already familiar with the Pandora system, it is recommended that you first set the instrument up indoors in an area large enough to spread the components out before setting it up outside in its final place of operation. Doing this can help get familiar with the instrument and possibly avoid any frustration that may arise from dealing with an unfamiliar instrument or unexpected issues caused by damage during shipping.

Install Tracker

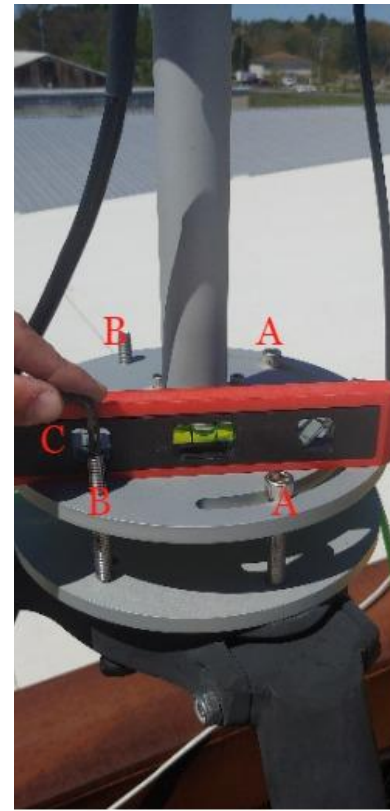
If your tracker is not already mounted on its baseplate assembly, you will have to do so utilizing the 4 1/4-20 screws. If your base plate assembly is not already assembled, see appendix 3.

Note: Some models of trackers use 1 large bolt to secure the tracker to the base plate instead of 4 smaller ones. In this case the tracker shaft must be spun down onto the bolt tightly.

If you are using a tripod, the 3 bolts around the perimeter of the top of the tripod must be screwed into the base plate of the tracker.

If you are using a tripod, it is recommended to strap it down to avoid damage from strong winds.

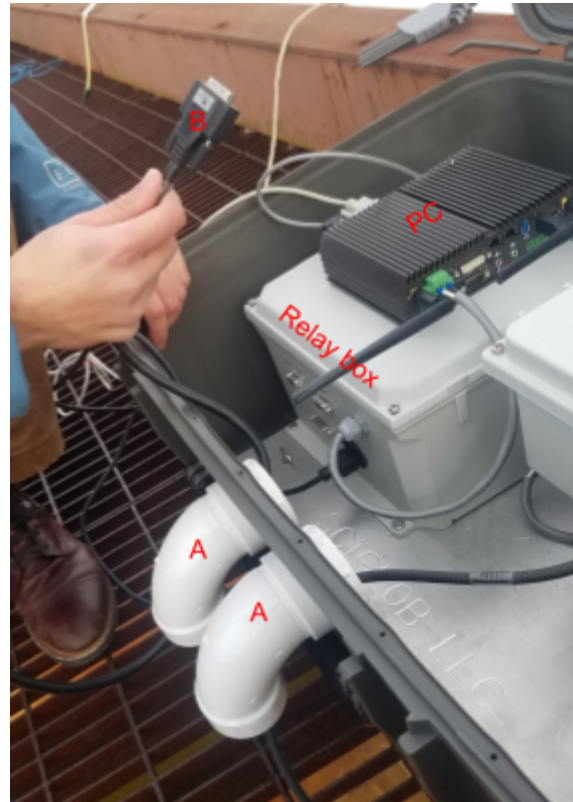
The tracker must be level in order to track the sun properly. In order to do this you must use a level placed on top of the tracker or baseplate and adjust the base plate by partially loosening the socket head bolts **(A)** (5/16" Allen wrench) and then adjusting the set screws **(B)** (3/16" Allen wrench), which will lower or raise each side of the upper base plate. Once the upper base plate is level you can tighten the socket head screws to lock the assembly.

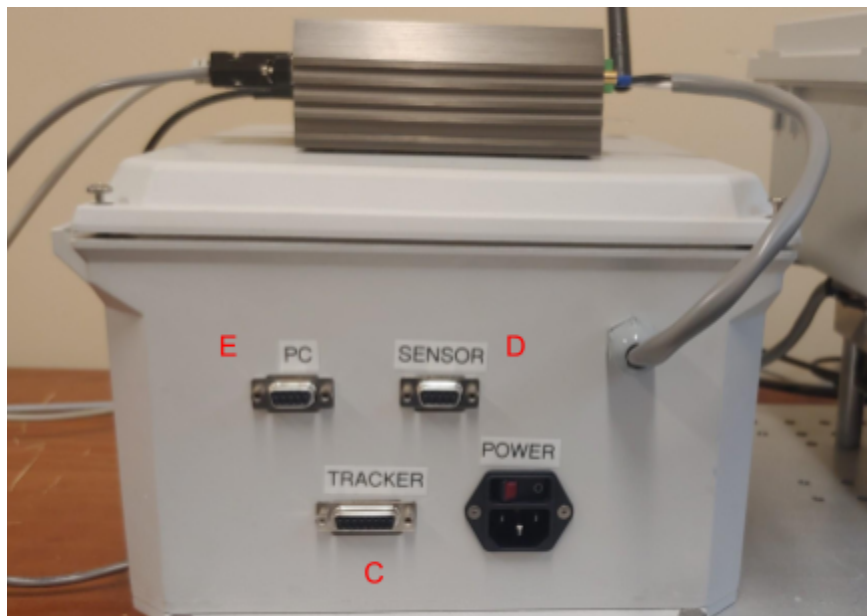


Before mounting the head sensor on the tracker, you must check the tracker functionality and it's home position. So for now, leave the head sensor unmounted but near the tracker, while all cables are connected and the operation software (BlickO) is started. The head sensor will be installed in a later step.

Connect Cables and Fiber

- Install the white cable passage elbows (A) into the front of the main box by pressing them in with moderate force.
- Pass the tracker cable (B) (thicker cable) through the left elbow leaving the flat connector inside the box. Connect the tracker cable to the 15 pin connector toward the bottom of the front face of the relay box (C) and connect the other end to the tracker.
- Repeat the previous step with the head sensor cable (thinner) plugging one end into the 9 pin connector label "SENSOR" on the relay box (D), and the other end into the head sensor.



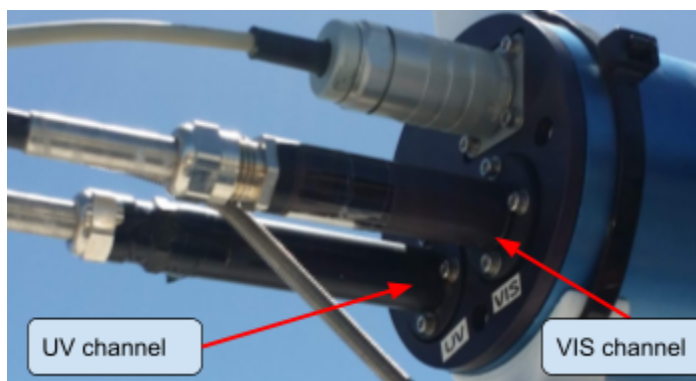
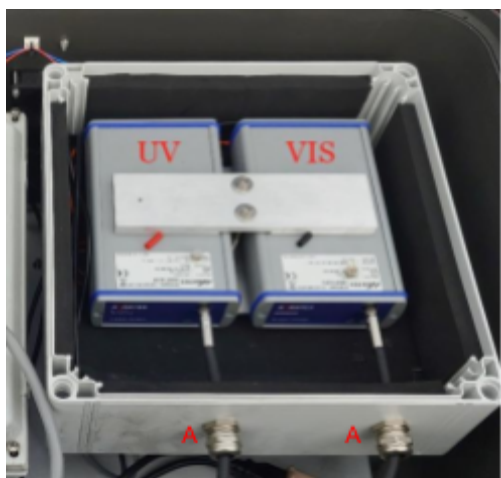


Here is a picture of the relay box. The labels indicate where they should be connected to every part of the hardware. The main power switch and power port are in the bottom right corner. The communications between the relay box and the PC are done by a rs232 (9pin) cable connected from the E connector of the relay box, to one of the com ports of the PC (usually the COM1).

- Unscrew the lid of the spectrometer box and remove the foam pad that is covering the spectrometer(s)
- Pass the fiber optic cable from the head sensor through the right cable passage of the main box and through the opening (cable pass) on the front of the spectrometer box.



NOTE: For a 2S model there will be 2 spectrometers in the box. Be sure that the VIS fiber is connected to the VIS spectrometer, and the UV fiber is connected to the UV spectrometer. Usually the UV fiber is the one connected at the left optical path of the head, and the VIS is the one connected to the right optical path, when looking at the head from its back side with the head sensor cable on top.



- With the tip of the fiber inside of the spectrometer box, remove the protective caps from the spectrometer and the fiber (never touch the front surface of the fiber!) and connect the fiber to the spectrometer. You may need to lightly push the fiber from the outside of the box while screwing it into the spectrometer. Place the protective caps in a safe place. **If the fiber is properly screwed into the spectrometer, you should not be able to spin it or move it in and out.** Before tightening the cable pass (A), ensure that the stiff part of the fiber is centered with respect to the cable pass, to avoid bending the tip of the fiber. Finally close the spectrometer box and tighten the screws on the lid to prevent humidity problems caused by condensation. For humid places, it is recommended to add a few small desiccant bags, in order to keep the enclosure dry. If you need to unplug the fiber from the spectrometer for maintenance, mark the fibers and spectrometers with a marker to ensure the fiber is reattached in the same position after maintenance. The latest Pandoras come with marks already on the fiber and spectrometer as seen below. If your instrument does not already have such a mark you will have to add it.



- Feed an extension cord through the right elbow, connect it to the power cord on the relay box and power on the system with the switch located at the power cord connection (see appendix 5, if you cannot find the power port and switch).

Initial Software Setup

1. Connect a monitor, keyboard, and mouse to the instrument's computer and log in.
2. Check that the Blick Software Suite is installed. The suite contains 3 apps:
 - BlickO -> Operational software.
 - BlickF -> File push and BlickO monitoring software.
 - BlickP -> Processing software.

It is usually installed by default in the folder C:/Blick/. If not, the software and the software manual can be found here

<https://www.pandonia-global-network.org/home/documents/manuals/>.

3. Check that the computer's time and time zone are set properly for its location.
4. Open BlickO, selecting the operation file that matches the instrument number, with the highest (most recent) validity date, and highest version number.
5. Check that the location in BlickO is correct (1, see screenshot below). If incorrect, enter the command 'cl' in the command window (2), and press enter. In the cl dialog, select the correct location (3). If the location is not available, send an email to the PGN Network Operators group email (pgn-ops@pandonia-global-network.org) requesting to add a new location, by sending them the following info:
 - Location name: Institution, building, or the place in which is mounted the instrument, city/town, and state or country.
 - Location Coordinates: Latitude, Longitude, Altitude
6. The Network Operators will create a new locations file, which you can download from <https://www.pandonia-global-network.org/home/documents/software/>. This file needs to be placed in C:/Blick/lib/oslib/ and then the proper location could be selected after restarting BlickO.
7. Once the location is correct in BlickO, the filepush software BlickF can be opened to start pushing the captured data to the PGN servers.

Note: one can check the hardware communications with whatever location set, but do not try to align nor leave the instrument running any schedule with an incorrect location. Otherwise BlickF will push wrong location data to the PGN server.

8. Using the “connect buttons” in BlickO (4), connect the spectrometer(s), head sensor, temperature controller, and tracker and verify all of the buttons turn green indicating successful connection.

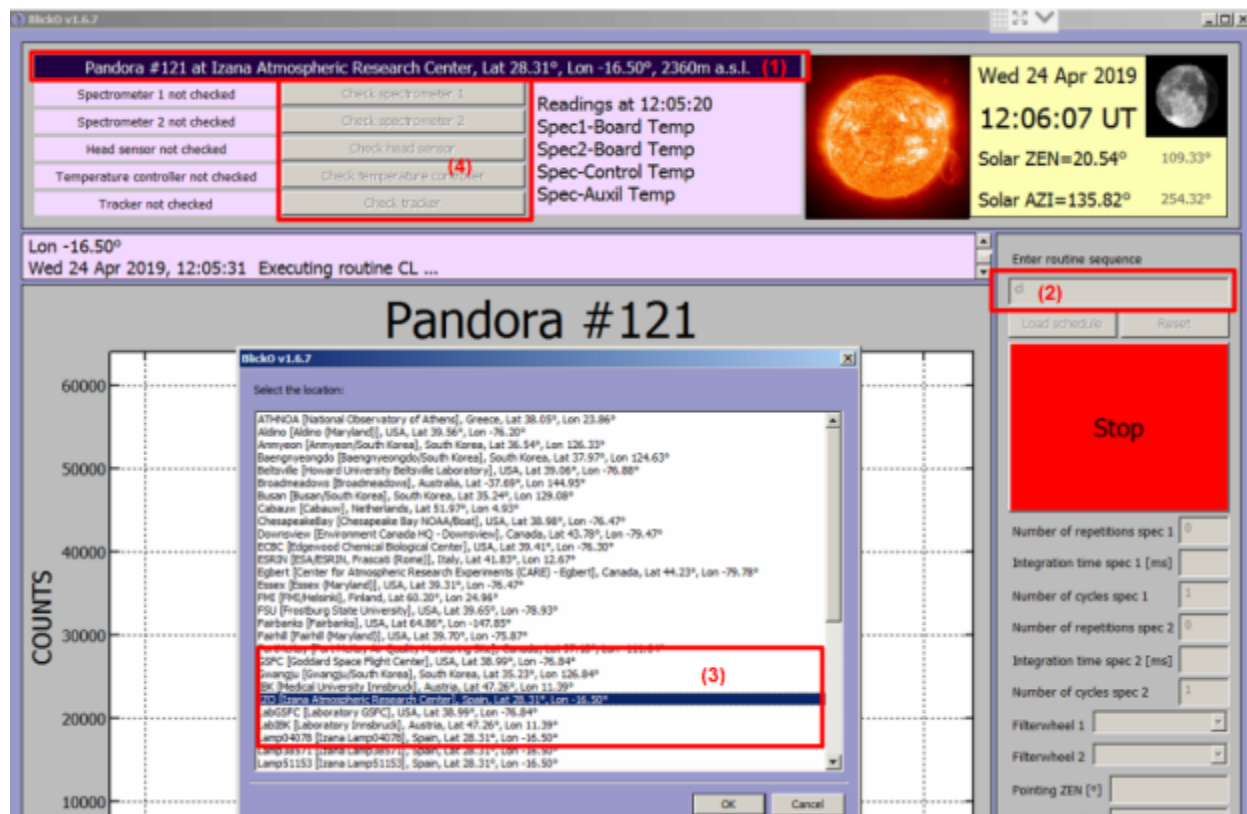


Figure 1

Tracker Home Position

Whenever the “Check Tracker” button is clicked, (or a tracker reset routine is executed, RT), the tracker will reset to its home position. In the case of the LuftBlickTR1 this home position is configurable. When the home position is set up correctly, the arm of the tracker will point East and the head sensor bracket will be parallel with the ground, which will make the head sensor point “UP” once mounted (see figure 2). Having the home position set correctly is important for the instrument's ability to track the sun properly. Minor corrections can be made through offsets in the software. If the home position is not correct, it must be corrected. This can be done through the software as detailed below.

Home position of new LuftBlickTR1 trackers:

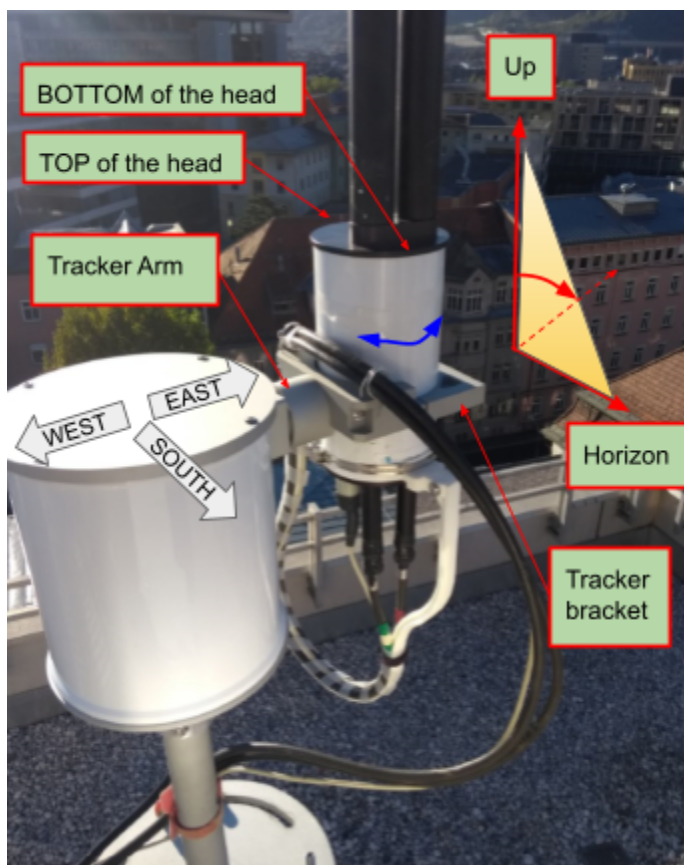


Figure 2.

Note: For old FLIR trackers, see appendix 2.

Tracker Home Position Correction

Only for new tracker models (not FLIR), the home position of the tracker after a tracker reset can be corrected following the next steps:

1. Open BlickO and connect all the hardware.
2. Enter routine “hs” in the command window (2, see figure 3) and press enter, to open the low level interface dialog.
3. **Correcting the Azimuth motor home position:** Choose Headsensor/Tracker serial connection and write the “TRpX” command in the serial port question field, then press enter to send the command, this will move the tracker in the azimuth direction. X represents an angle measured to 1/100 of a degree, ie “TRp9000” means move +90.00 degrees from the current home position or “TRp-18050” means -180.50 degrees from the current home position. One must find the proper X value in order to have the proper home position (see previous image). Once the arm is properly orientated send the command “MAh” to set this as the new azimuth home position.
4. **Correcting the Zenith motor home position:** Same as the previous step, but using “TRtX” and “MZh” commands instead.
5. Finally, close BlickO, restart the tracker power - you could unplug and replug the tracker cable -, reopen BlickO, and connect the tracker. The tracker will do a tracker reset and then it should end in the new Home position.

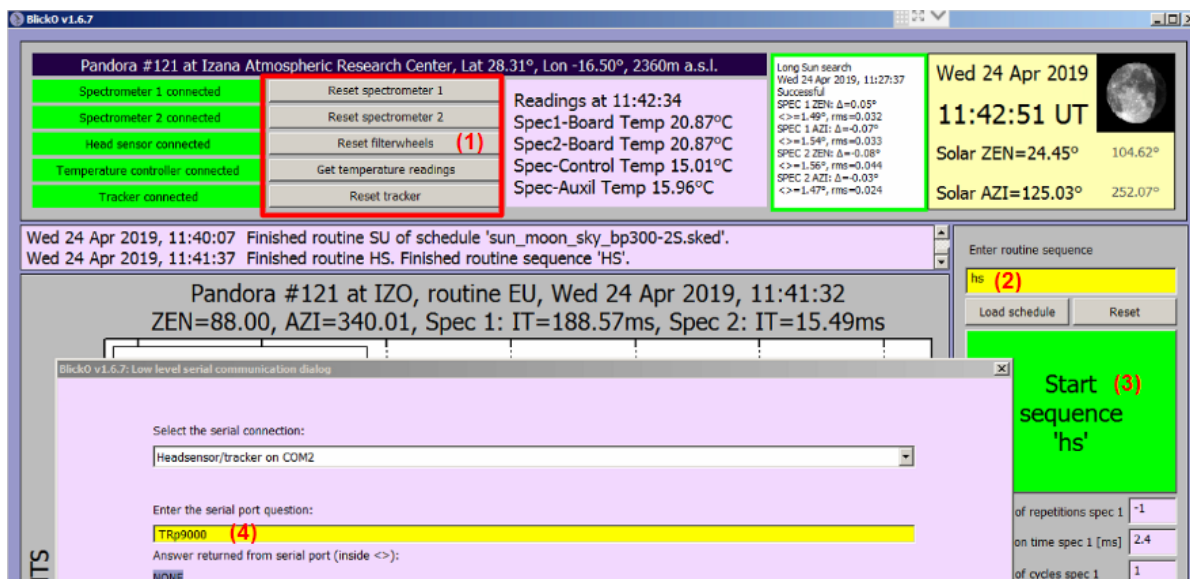
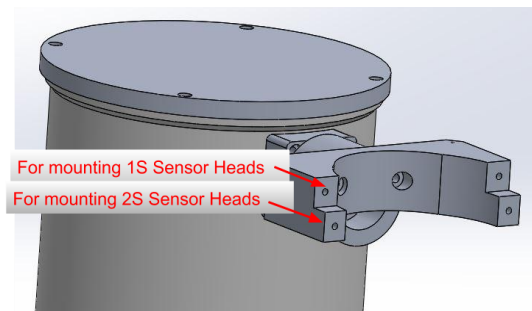
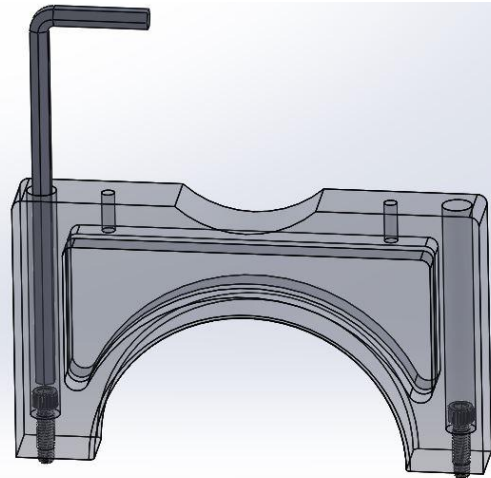


Figure 3

Install the Head Sensor

Once all the hardware pieces have been connected, and the tracker home position is correct, you can complete the hardware setup by installing the head sensor.

- Using a **9/64 Allen wrench** to remove the head sensor clamp from the tracker.
- Pick up the head sensor and install it on the tracker.
 - The easiest way to install the head sensor is to place one screw and the Allen wrench into a hole in the sensor clamp and set it aside (on top of the tracker).
 - Pick up the head sensor and give yourself enough slack on the optical fiber to work with the head sensor, while leaving most of the fiber on the ground.
 - Place the head sensor into the head sensor bracket of the tracker arm, hold it with one hand while using the other hand to pick up the clamp, screw and allen wrench and tighten the first screw
 - For 1S models the clamp will fasten to the top (recessed) set of holes, 2S models will fasten to the lower set



- The correct axial position of the head with respect to the tracker bracket is the one that makes the collimator be at the lowest part of the head, when the head is pointing to the horizon (Zenith=90deg). The collimator should be in the 9 O'clock position when looking at the system like in the following image. For a 2S model, both collimators should be at the lowest part of the head and parallel to the horizon line, when pointing to the horizon.
- While still supporting the head sensor, install and fasten the second screw.
- In the case the head came with an unmounted fiber guide, please follow the Appendix 1 instructions "Fiber guide installation".



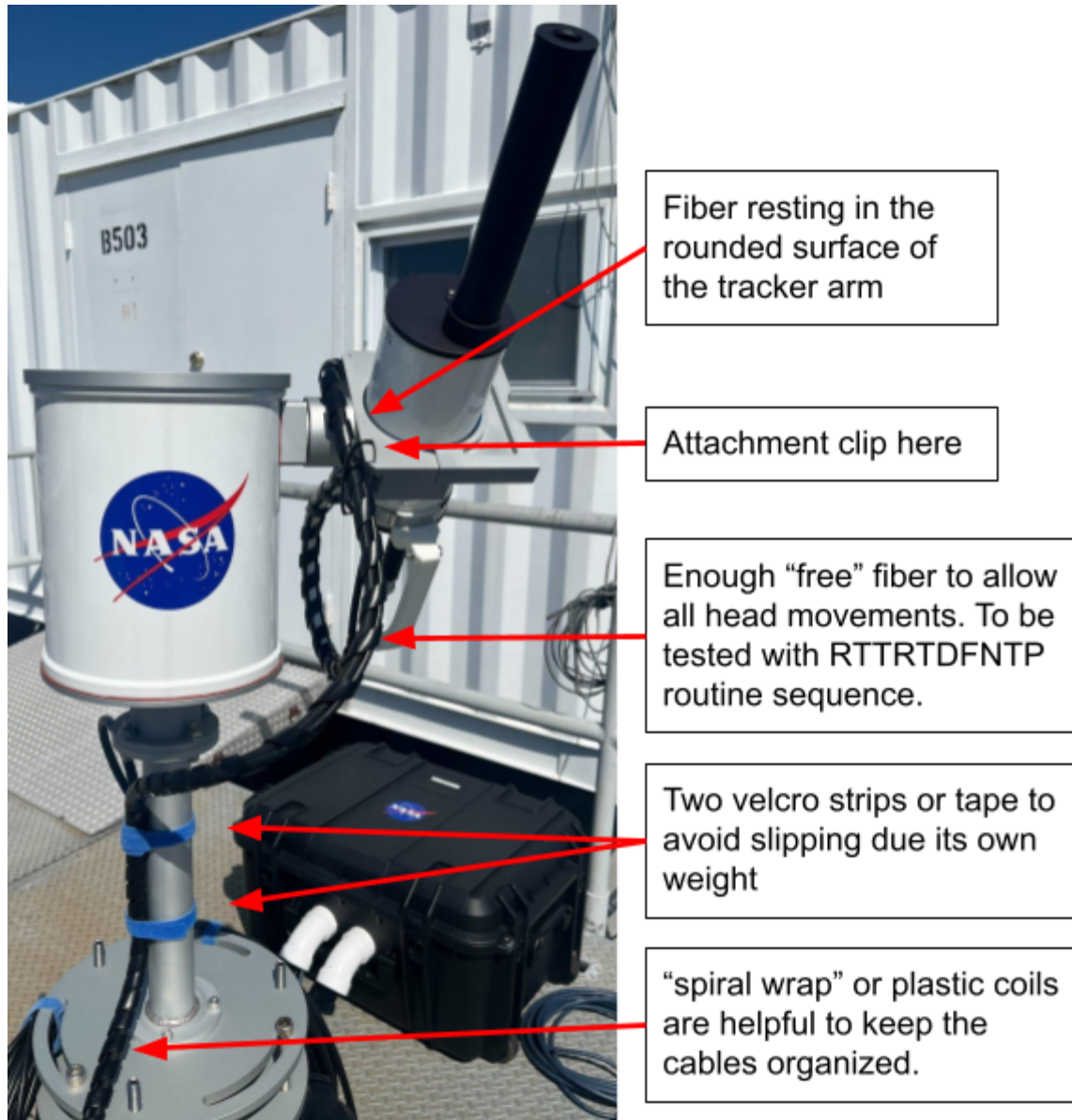
Recommend Tracker Cable Layout

The tracker cable connector should not carry the weight of the entire tracker cable. To avoid that it is recommended to fix the tracker cable to the main vertical shaft, leaving enough free cable to allow 360deg azimuth rotations as shown below. The cable should be fixed approximately 18in (45cm) from the end of the cable. An optional “cone” accessory is available which helps to avoid cable jamming in the screws of the base plates. UV resistant velcro straps are also available for fiber management.



Recommended Fiber Layout

To prevent binding of the fiber with the base plate screws, or with any sharp edge nearby, it is recommended to have all the possible movements of the fiber controlled, by applying the recommended fiber layout.







For this tracker model, the fiber can be attached to the head bracket with the included attachment clip, and to the main shaft with two velcro strips. Is important to attach the fiber to the main shaft with two velcro strips to prevent the fiber slip due to its own weight, in the long term. For information on the old FLIR tracker see Appendix 2.

Testing the cables layout

After applying the recommended tracker cable layout, and the recommended fiber layout, you can test the set up to ensure there is no binding or snagging of any cable, by executing the following sequence of routines in BlickO “RTTRTDFNTP”, while seeing the instrument moving.

RT: Do a tracker reset

TR: Point to the 4 cardinal points and to the zenith in the middle.

TD: Point down (as down as it is set in the instrument operation file) and then point to horizon.

FN: Do a sun search.

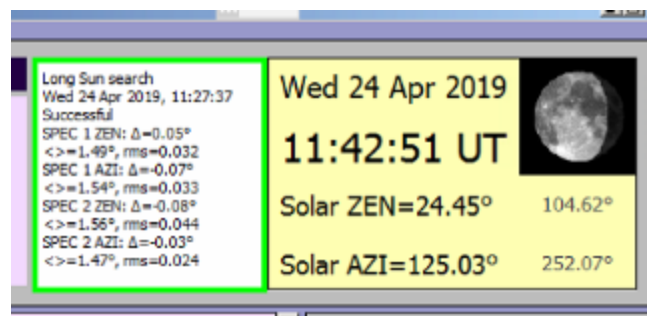
TP: Tracker parking position. It will rest in this position when there is nothing to measure. (No moon visible at night for example).

Initial Alignment

The initial alignment is done manually to help the Pandora find the sun after being set up.

1. It is recommended to do the initial alignment being at the instrument location, preferably at hours in which the solar zenith angle is higher than 40deg, on a clear sky day. Do not ever look directly into the sun without eye protection, similarly one should never look into the output of the fiber (spectrometer side) once the instrument is tracking the sun. In the instrument PC, the hour and time zone should be correct so that BlickO can display the correct UTC hour. Also the BlickO selected location must be correct, in order to find the sun near where it is supposed to be.
2. Click on the button “Reset” [2] just below the command window, to clear the routine sequence command window.
3. Select an appropriate configuration of filters to look for the sun [3]. It is recommended to start with the highest ND config available, for example select ND4 in the filterwheel 1 + OPEN in the filter wheel 2 in the case of a 1S instrument, or ND3/ND4 + OPEN/OPEN in a 2S instrument. This will prevent saturation in the spectrometer/s, when pointing to the sun.
4. In BlickO, enter the routine sequence ‘FI’ to perform a manual alignment [1] (figure 4). When the ‘Sight Alignment’ window appears, click on the button “Reset” [2] just below of the command window, to reset the routine sequence and set the default spectrometer parameters.

5. Click 'measure continuously and display' [5] to display the observed signal while adjusting the tracker position.
6. With the buttons of the FI dialog, move the azimuth motor (CW vs CCW) [6], then the zenith motor (up vs down) [7] looking for the maximum signal point in the signal panel behind the FI dialog. If the maximum signal point cannot be distinguished, then a lower ND filter configuration could be used to get more signal. If while doing that, the signal reaches a signal level above 25% of the maximum of the plot then one must select a higher ND in order to reduce the amount of light.
7. Once the maximum signal point is found, the manual alignment can be finished by clicking on the "save" [8] button of the FI dialog, and then one has to choose between creating a new alignments file, or adding the current offsets to an already existing alignments file:
 - The first time the instrument is mounted in a new location, or after any change in the tracker hardware that could affect the leveling, or after a change in the tracker home position, or when the tripod has moved, it is needed to create a new alignment file by selecting "new".
 - If a previous initial alignment has been already done (for example in the morning) and the instrument was able to get successful sun searches for the morning but not for the afternoon, then "add" can be used.
8. To check that the initial alignment done with FI is correct, one must run the FN routine 4 or 5 times. If the initial alignment is correct, most of the FN routines will get a successful sun search. You will know because a new line is added into the alignments file
 C:/Blick/data/alignments/PandoraXXX_Location_alignments.txt, and also the border of the alignments section of BlickO will become green. If the FN routine cannot get successful sun searches, then you will need to repeat the initial alignment again.



9. Once it is confirmed that the initial alignment is correct, one must leave the instrument running with the “align.sked” schedule for at least one full clear day. This schedule will perform iterative sun search routines along the day, in order to fine tune the leveling angles automatically, which will allow it to find the sun at whatever hour of the day with high accuracy.
10. Once there are enough successful sun searches in the alignment file (At least 50, for different moments of the day), the align schedule can be changed to the operative schedule, usually **uv_sun_moon_sky_hsm.sked** for 1s models, or **uvvis_sun_moon_sky_hsm.sked** for 2s models.
11. Note that any spectra taken with the instrument before a good alignment is established, cannot be converted into meaningful final data products. Therefore good alignment must be assured before switching to an operational schedule!

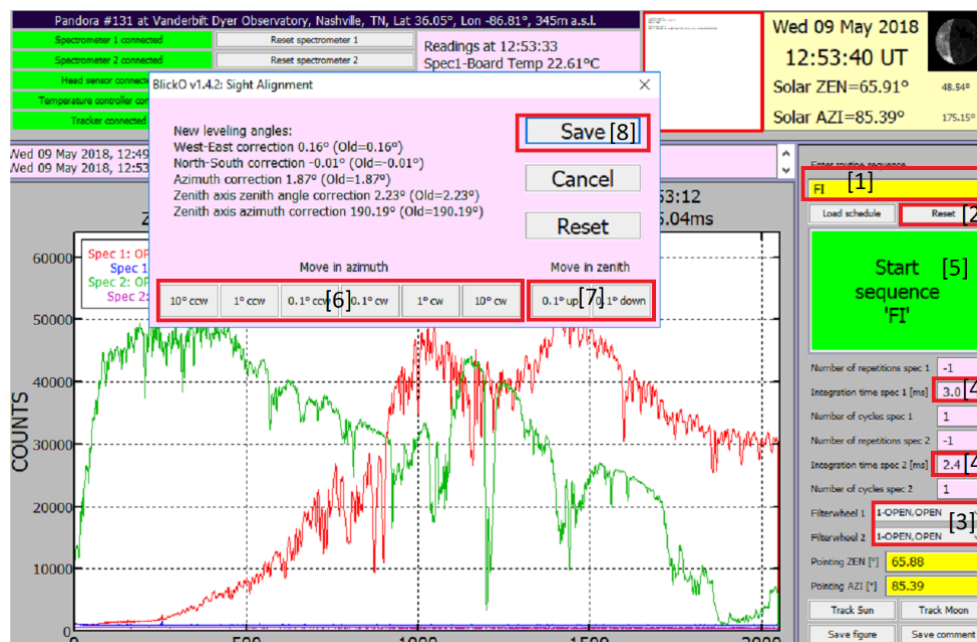


Figure 4

Configuration of the preferred azimuth for sky scans

Some schedules contain sky scan measurements (measurements that are done at a fixed azimuth angle, but at several different zenith angles). In BlickO, this fixed azimuth angle is called the “Standard azimuth for elevation scans”. In order to have a good quality sky measurements, it is needed to configure it in the following way:

- Close BlickO
- In the instrument config file, C:/Blick/config/PandoraNNN_config.txt, set in the entry “Standard azimuth for elevation scans [deg] -> 0.00” to the proper azimuth angle for doing the sky scans measurements (where 0=North, 90=East). It should be an azimuth angle in which there are no obstacles in the field of view of the instrument from the horizon to noon.
- Open BlickO, run one sky scan routine (for example EO), and check that the head is pointing to the desired azimuth direction, while doing the different zenith angle measurements.

Information for Local Operators

Local Operator Checks

This section lists checks that the instrument's local operator should carry out on a regular basis to ensure the instrument is in good working order.

Software Checks

1. **Maintain updated Local Log:** The PGN Network Operator will create a document in the instrument PC to be used as a Local Log file. It is usually located in C:\Blick\data\PandoraXXX_Local_Log.rtf, and is used as a primary log of the instrument. Anybody that performs any action to the instrument or its software **MUST** add the date, their initials, a short descriptions of the actions performed, and the state in which is left the instrument after the actions, for example:

“20200306, 15:05h utc, DS:
Cleaned entrance window. Left it running with uv_sun_moon_sky_hsm.sked
schedule”

In this way all the involved people (The Local operators, the Principal Investigators, the Network Operators, and the persons in charge of maintaining the Calibration files) will know what happened to the instrument and when. One of the responsibilities of the Local Operators is to keep this log up to date as well as checking for any recommendation given by the Network Operators regularly.

2. **Check that BlickF and BlickO programs are open.**
3. **In BlickO, check that all hardware pieces are connected.**
 - a. If any part of the hardware is not connected, restart BlickO and reconnect everything. If the problem continues, restart the PC and reconnect. Check the hardware connections on the instrument and consult the troubleshooting section of this document if needed.
4. **Check that the instrument temperatures are within their ranges.** The current temperatures can be seen in the BlickO main screen, while historical records can be seen in the diagnosis plots (C:\Blick\data\diagnostic).

Spec-Control Temp	Set temperature of the temperature controller	Must be 15 °C or 20 °C
Spec-Board Temp	Measured temperature of the spectrometer electronics board	Spec-control temp + 7-8 °C
Spec-Auxil Temp	Measured temperature of the spectrometer detector	Spec-control temp -5deg/+10deg
Head sensor Hum	Measured relative humidity inside the head sensor.	It depends on where the head was closed. But it should remain low, below 40%. If the humidity grows suddenly, it may be an indicator of water sealing problems.

5. **Check that the correct operative schedule is running**, which matches the one stated in the header of the local log file.
6. **Check that the BlickO time is in sync with the UTC Time**. Usually extra software is used for automatic time synchronization. An icon of this application can be found in the tray area of the windows taskbar. If the automatic time synchronization is not working, contact the Network Operator, or the local IT staff.
7. **Check the instrument's alignment**.
 - a. Once the initial alignment has been done, the sun searches done during the day by the operative schedule can be diagnosed by analyzing the plots in the folder C:\Blick\data\alignments\figures\, and comparing them with the example plots listed in the Diagrams section of this document.
 - b. If the alignment is bad on a clear day, reset the tracker and enter the command 'FN2', to run the find sun routine twice. If alignment is still bad, then the tracker must be checked locally.
 - c. At the instrument location, reset the tracker. During the reset, check that the tracker is not slipping (or losing steps), and that it ends in the correct reference position:
 - LuftBlickTR1 tracker: zenith pointing up, and tracker bracket pointing to East.
 - Old FLIR tracker: zenith pointing up and both motor shafts aligned.

Check that the final tracker position on BlickO is close to the reference position (pointing zen $\approx$ 0°, pointing azi $\approx$ 180°).

8. **Check that BlickF is pushing the data files.** If there are too many files in the queue waiting to be pushed, and the queue is not decreasing, perhaps the filepush is stuck due to an Internet interruption. In this case one can press “q” to exit BlickF, and then restart it to make it work again. If the non working behavior continues, notify the network operator.
9. **Check if the software is creating “warning log files”** too often, usually in C:\Blick\log\oslog, and C:\Blick\log\fslog. The info of these files can give a clue of what could be going wrong in the software.

Hardware Checks

- 1) **Once a week the instrument should be checked for dirt, water or insects in the collimator and entrance windows.** If something is not clean, stop the operative schedule and run the ‘TP’ routine to park the tracker. Unscrew the collimator, clean the entrance window and the interior of the collimator using a chemwipe and a 90% distilled water and 10% isopropyl alcohol solution. **Do not use a material that will leave lint or fibers on the window.** Once cleaned, attach the collimator and start the instrument’s schedule.
- 2) Check the desiccant in the spectrometer box. For a good desiccant you will feel many small beads inside the bag. A bad desiccant will feel squishy like peanut butter or it will feel like one large brittle chunk. If the desiccant is bad it should be replaced in order to avoid accumulation of moisture in the spectrometer box. The desiccant should be checked at least once a month.

Update the local log file with observations and procedures performed during the instrument check.

Maintenance Checks

Maintenance	
Weekly	• Clean entrance window • Check that the fiber, head sensor cable, and tracker cable are not caught or binding
Monthly	• Check for condensations in the spectrometer box. Replace the desiccant inside this box if necessary. • Check general cleanliness of instrument main case i.e. no bugs, dust etc
Yearly	• Replace the vulcanized tape, if it is broken or cracked, and renew the silicone sealant of the grooves in the back plate to maintain a proper water sealing(see appendix 5) • Replace aged plastic coils that are used to attach the fibers to the fiber guide, and aged velcro strips.
As needed	• If you need to unplug fibers, add a mark in order to plug it again at the same position afterwards. • An additional enclosure is helpful to store only the head sensor without unplugging any fiber, when the weather conditions are very harsh. (gusty winds >100km/h, or strong ice accumulation, that may damage the the fibers)

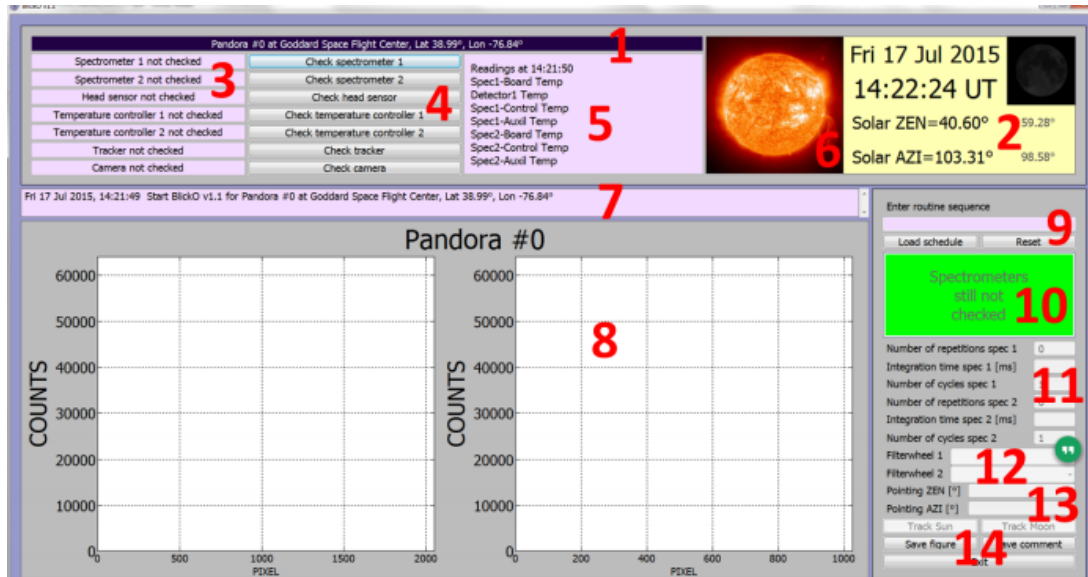
Example of recommended additional enclosure:



BlickO routines used for instrument alignment and troubleshooting

RT	Do a tracker reset (Same effect as clicking in the connect/reset tracker button)
RF	Do a filterwheels reset.
FN	Finds the Sun, and resets the tracker if the offset angle is too large
FA	Finds the Sun without resetting the tracker.
FD	Finds the Sun with Diffuser filters in.
FU	Finds the Sun with U340 filter in.
FI	Manually align the zenith and azimuth
TD	Moves the tracker to point down to maximum zenith angle, and waits 5 secs.
TR	Moves the head to the four cardinal positions along the horizon and the zenith from 0° to 90°. (Useful to test the fiber/cables layout)
TP	Parks the tracker in the tracker parking position (By default is zenith=90° and azimuth=90°). Zenith=90° is the recommended zenith for the parking position to make the head rest in an horizontal position when there is nothing to measure for a long time. Both angles can be configured in the instrument config file.
T0	Moves the head to point to the zenith.
?	Provides a list of the routines used in BlickO.

BlickO Interface

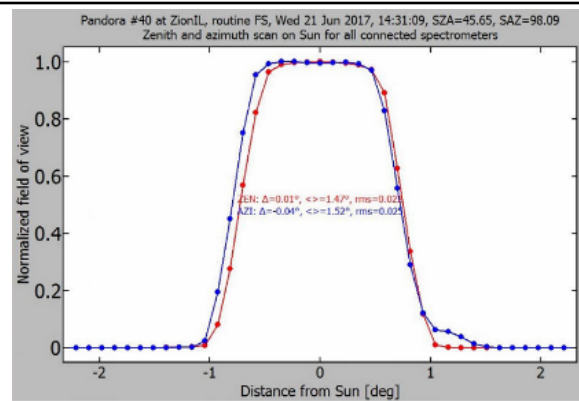


1	Instrument + location label
2	Date, time, and solar/lunar angles
3	Connection status labels
4	Connection buttons for all interfaces.
5	Auxiliary data display (Temperatures)
6	Display of sun-search results (contains an image of the sun upon startup)
7	Action logger
8	Figure showing current measurements for all spectrometers
9	Routine control, load schedule button, and reset button
10	Start-stop button
11	Spectrometer settings: control of # of repetition, integration time, and # of cycles
12	Filter wheel settings: filter wheel 1 selection and filter wheel 2 selection
13	Tracker settings: control of zenith and azimuth angles, track-sun, and track-moon buttons
14	Save figure button, save comment button, and exit button

Instrument Alignment Plot Examples

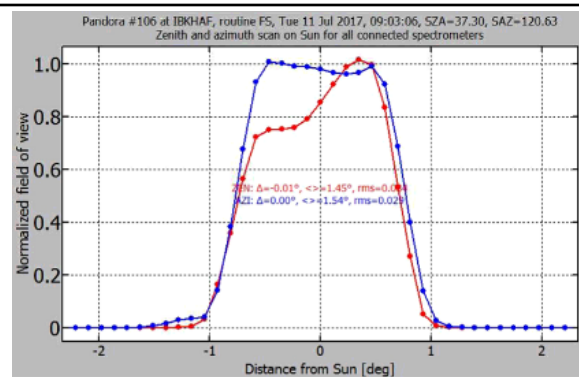
Good alignment on a clear day

- Trapezoidal shape
- FWHM of open hole sun search (FS or FN) near 1.55°
- Centered at 0°



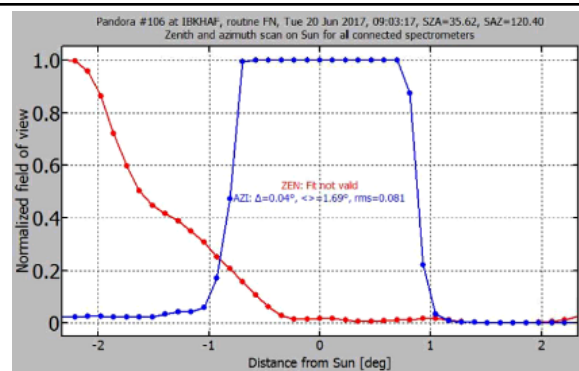
Good alignment on a clear day, but poor FOV (check for water/dust/insects in the entrance window or collimator)

- Slight dip in shape
- FWHM near 1.55° Centered at 0°



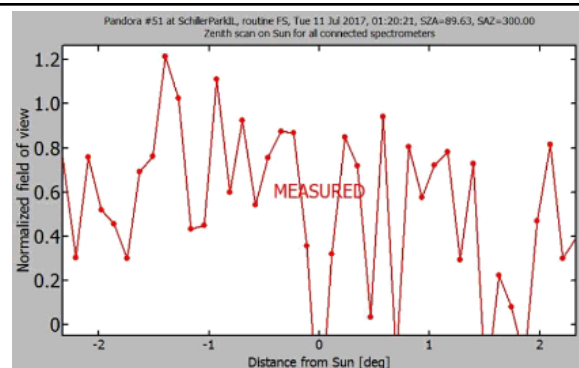
Bad alignment on a clear day

- One or both shapes not centered at 0°
- It might be a few steps lost in one of the motors, or the home position of the tracker could have changed (slipped).



Bad/unsuccessful scan

- Skewed shape, or no shape at all.
- FWHM not near 1.55°
- Not centered at 0°



General System Information and Troubleshooting Guide

Overview

The BlickO software operates the instrument. In order to collect the data, the PC uses serial communication to communicate with the head sensor in order to position the internal filter wheels as well as the sun tracker. The PC also communicates with the temperature controller directly through serial communication in order to keep the spectrometer at the ideal temperature.

Head Sensor

In addition to the optical components, the head sensor contains a microcontroller that serves as a slave to the PC.

Functions

Microcontroller Functions

- Drive motors to position optics in filter wheel
- Relays position commands from PC to tracker
- Triggers relays to reset the power to the tracker and spectrometers

Optics Function

- Condition the light in a way that allows for easy and accurate analysis by the spectrometer

Troubleshooting

If you cannot connect to the head sensor through BlickO software the first step is to ensure that the head sensor is receiving power. The easiest way to do this is to listen to the head sensor when it is first powered on. You can do this by switching the main power button on the relay box or by unplugging the main power input to the relay board. When the head sensor first receives power it will move the filter-wheels. You should be able to hear them move for 1-2 seconds. If you cannot hear it then the head sensor is most likely not receiving power and may have a damaged head sensor cable. Note: do not unplug the head sensor while the instrument is operating.

If you determine the head sensor has power the next step is to check if you can communicate with it through the PC. Open BlickO and try to connect the head sensor with the “Check head sensor” button. Independently if it is able to connect or not, this will make BlickO open the head sensor-tracker COM port (the one indicated in the instrument operation file). Then run the HS routine to open the low level serial interface of BlickO, and send the low level command “?” a few times (without quotes). Have your eyes on the green and red LEDs on the relay board. The LED labeled PC-TX should flash. If it does not flash you are most likely not connected to the proper COM port, or the PC is not connected to the relay board. Open the operation file you used to start blick, it is in C:\Blick\data\operationfiles. Check that the parameter “Head sensor port number” matches the physical label on the PC for the serial cable connecting the PC to the relay box. Ensure that all cables connecting the PC to the relay board are fully plugged in.

If these steps do not provide you with a clue as to how to resolve the issue, relay the information to your Network Operator for further assistance.

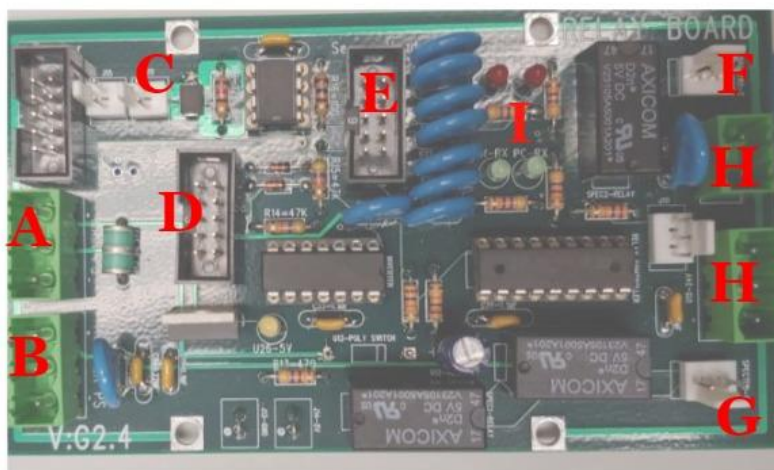
Relay Board

Functions

- Opens and closes relays in response to head sensor triggers to reset power to the spectrometers and tracker
- Converts RS232 communication from head sensor to RS-485 communication for tracker
- Drives LEDs to indicate communication from Sensors Head and PC

Relay Board 2.4

A	Voltage In
B	Tracker Supply Voltage
C	Tracker Communication
D	PC Connection
E	Sensor Head Connection
F	Spectrometer 2 Reset
G	Spectrometer 1 Reset
H	Auxiliary 24V
I	Communication Indicating LEDs



Thermoelectric Cooler

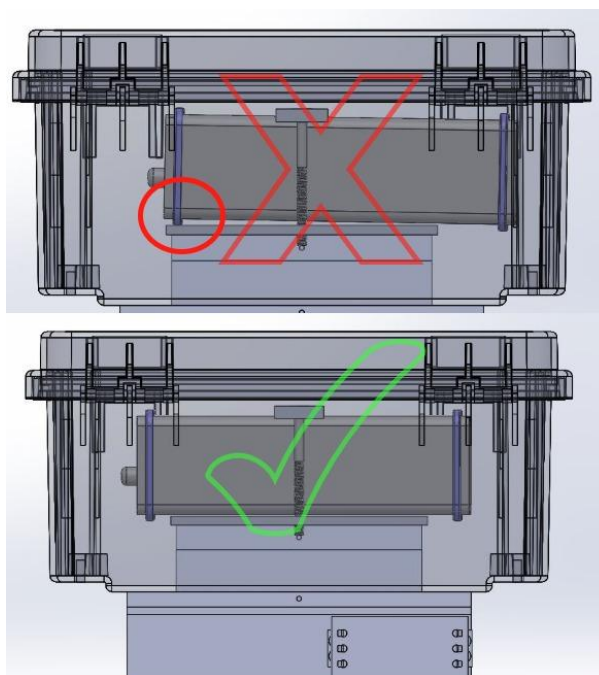
Functions

- The thermoelectric cooler (Peltier) is controlled by the temperature controller circuit board (housed in the black box on the side of the cooler).
- The temperature controller receives a set temperature from the PC and varies the voltage input to the thermoelectric cooler to achieve the set temperature. The temp controller will reverse the polarity of the input voltage depending on if the spectrometers need to be heated or cooled

Troubleshooting

If the spectrometer temperature is unstable, ensure that:

- the bottom of the spectrometer is making complete contact with the cold plate (see next figure)
- the spectrometer is securely fastened to the cold plate
- the spectrometer box insulation is in good condition
- the spectrometer box is closed tightly



If all of the temp controller wiring is intact and the above conditions are met the temperature controller **gain** and **bandwidth** parameters within the instruments operations file may need to be adjusted. This is especially likely if the instrument has been moved from one climate to another. **Please in the case of PGN instruments remember to contact the Network Operator before modifying anything in the instrument operation file.**

Bandwidth

The bandwidth parameter represents a range outside of which the temperature controller will supply full power to the thermoelectric cooler. For example, a bandwidth of 4 means that the temp controller will be at full power when it is 4 degrees above or below the set temp while trying to achieve the set temp. A bandwidth that is too wide/high will result in the thermo electric cooler being slow to respond to temperature changes. A bandwidth that is too narrow will result in the temp controller constantly “over shooting” above and below the set temperature and failing to settle at the set temperature.

Integral Gain

The Integral Gain controls how much of the control output is generated due to the accumulated error between the current temperature, and the set temperature.

The integral gain helps compensate for changing thermal dynamics, such as varying loads, and often aids the temperature in rapidly reaching the setting temp. A low gain slows the response of the temperature controller to changes and may avoid the temperature from reaching the setting temp. A gain that is too high may create temperature overshoots.

Spectrometer

Functions

- Analyze spectral data from head sensor and convert to a digital signal to be sent to the PC, through USB 2.0 ports.

Troubleshooting

If the spectrometer is not connecting to BlickO first ensure that the spectrometer has power (the green LED on the front of the spectrometer should be lit when powered on).

If the spectrometer does not have power:

- Use the command “S1s” or “S2s” in the low level interface dialog (HS routine) depending on the affected spectrometer, this will use the relay board to reset the power to each spectrometer.
- If the previous commands do not work, you can rule out malfunctions in the relay board or head sensor by unplugging the spectrometer cable from the relay board and jumping the 2 pins at the cable connector.

If there is still no power try:

- restarting the PC
- connecting the spectrometer directly to the PC with a new USB cable (a printer cable could work)

If the spectrometer still does not have power, the spectrometer or PC USB port might be damaged.

If the spectrometer has power but will not connect to Blick:

- Ensure you are using the latest version of Blick, and the proper Avantes development driver package (you can ask the Network Operator).
- Ensure the spectrometer serial number matches the serial number in the instruments operation file.
- Try connecting the spec to an USB 2.0 port of the PC (not to a USB 3.0 port).

Tracker

Functions

- Precisely orients the head sensor in relation to the sun to facilitate accurate measurements
- Internal motor drivers are commanded by head sensor through RS-485 communication
- Electro magnetic brake applied when the tracker is powered off (only models with brake)

Troubleshooting

If Tracker will not connect to Blick:

Replug the tracker cable, tracker side connector. If the problem persists, then ensure that the tracker has power by moving either shaft by hand. When powered the tracker will have a spring-like effect and return the shaft to its correct position. If you cannot feel this spring effect, then unplug the tracker cable in the tracker side and check:

1. There should be 24 Volts between pins M and K at the Traker end of the tracker cable (see diagram section for circuit diagram). → If the voltage is present then the malfunction is likely inside the tracker.
2. There should be 24 Volts at pins 1 and 2 of the DB15 connector on the relay box. If the voltage is present then the malfunction is likely inside the tracker.
3. There should be 24 Volts between the 2 outside pins of the tracker power connector on the relay board. → If the voltage is present then the malfunction is likely an open circuit between the relay board and the DB15 connector of the relay box.
4. If there is no power AND the relay board itself does have power
 - a. Disconnect the power from the relay board, unplug the head sensor , and reconnect the power to the relay board. → If power is now present at the tracker connector, there is likely an internal malfunction in the head sensor.
 - b. If there is still no power to the tracker connector, then there is likely an internal malfunction in the relay board

If the tracker has power but will not connect:

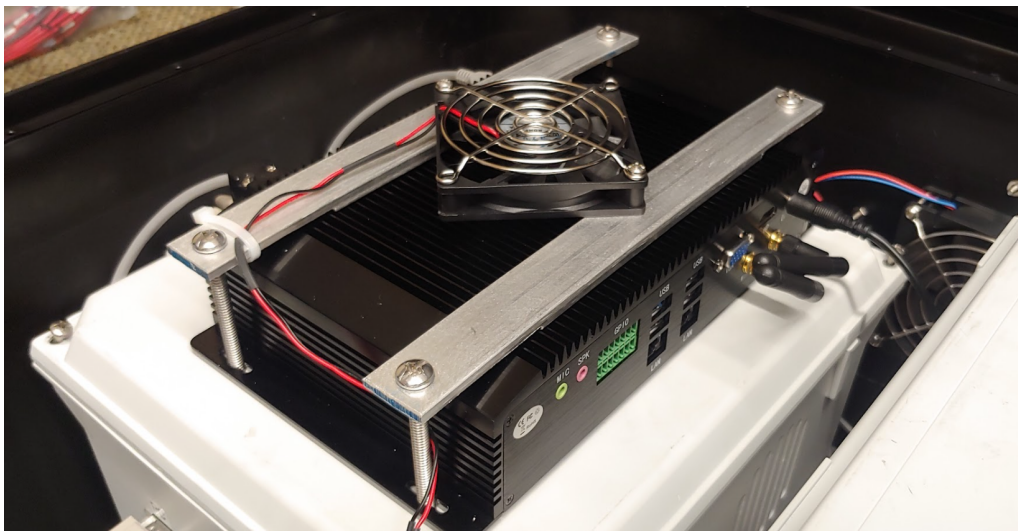
Check for an open circuit in the data communication line from the relay board to the tracker end of the tracker cable.(see the Tracker Control Diagram in the wiring Diagrams section).

Checking alarms

The drivers inside of the tracker can set alarms or error codes that may be helpful when troubleshooting some issues. To check the alarm codes you can send the low level commands “MZa?” or “MAa?” from the low level serial interface (routine HS). These commands are to check the alarm codes in the zenith and azimuth motor drivers respectively. “Alarm code = 0” means all is ok. “Alarm code = 30” means overload, so for example when a fiber is jammed and the tracker motor cannot reach the requested position. Commands “MZa” and “MAa” can be used to reset/erase some alarm codes, but not all. A power reset might be needed to reset all alarms.

Control Computer

Control computer, with external fan, controls instrument through operative software and uploads data to the server.



Control Files

Operation File Key Parameters

(C:\Blick\data\operationfiles\PandoraNNN_OF_vVdDDDDDDDD.txt)	
Spec Serial Number	This number must match the serial number of the spectrometer
Tracker Type	LuftBlickTR1 or Directed Perceptions (FLIR)
Head Sensor port Number:	Denotes which COM Port head sensor is connected to, value of 0 will scan all ports
Temperature Controller port Number	Denotes which COM Port temperature is connected to, value of 0 will scan all ports
Tracker Motion Limits	Zenith and Azimuth Tracker motion limits to protect the hardware and avoid cable pinching.

Config File Key Parameters

(C:\Blick\config\PandoraNNN_config.txt)	
Tracker parking zenith angle and azimuth	Determines in what position the instrument will park once finished measuring. (TP routine) zenith=90, azimuth=90 by default.
Maximum allowed azimuth correction [deg] -> 70.00 Maximum allowed zenith angle correction [deg] -> 5.00	Are the maximum allowed software offsets while looking for the maximum signal point in the FI routine.
Standard azimuth for elevation scans [deg] -> 0.00	Is the azimuth angle that will be used for the sky scan routines (E* routines). It must be one with no obstacles in the field of view from the horizon to the zenith.

Low Level Interface

The low level interface allows you to communicate directly with the head sensor or temperature controller. To access the low level interface type “HS” into the routine box on the right side of the BlickO interface then click “Start sequence”.

Once the interface is open you can use the following commands to control and troubleshoot the pandora system:

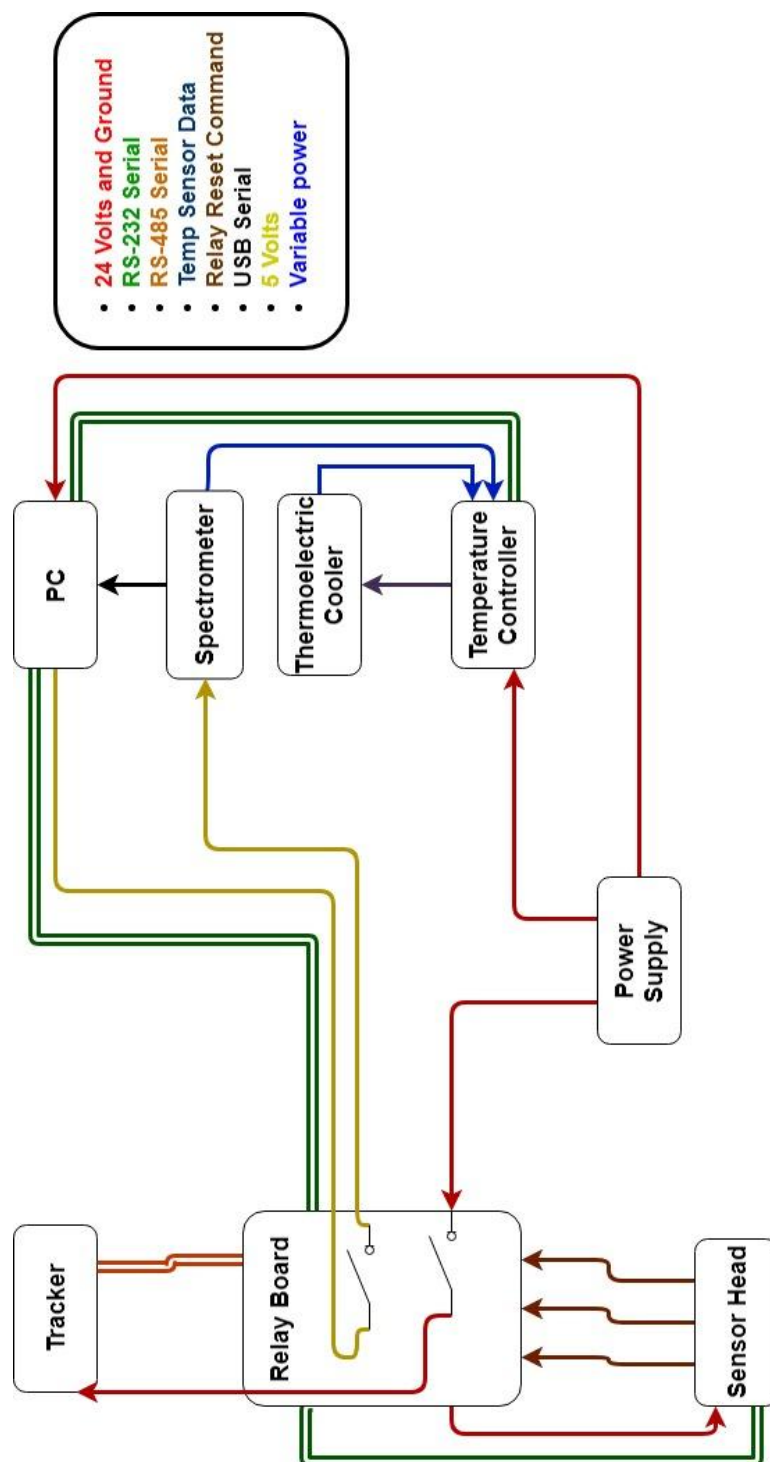
Firmware Version 4 and 7

Command (V7)	Command (V4)	Description
?	?	Get the head sensor number. EX: Pan100HST
HTv?	V	Get the software version. EX: V7
HTp?		Read head sensor pressure
HTh?		Read head sensor humidity
F1m	n	Move FW1 in both directions.
F2m	m	Move FW2 in both directions.
F1r	F1r	Reset FW1 (ends at the OPEN position)
F1*	F1*	Move FW1 to position *=1 to 9
	F2r, F2*, F2R	Same commands for FW2
TRb*,* (TRb Az, Ze)	TRb*,* (TRb Az, Ze)	Move tracker to position to position Az,Ze, EX: TRb50000,50000

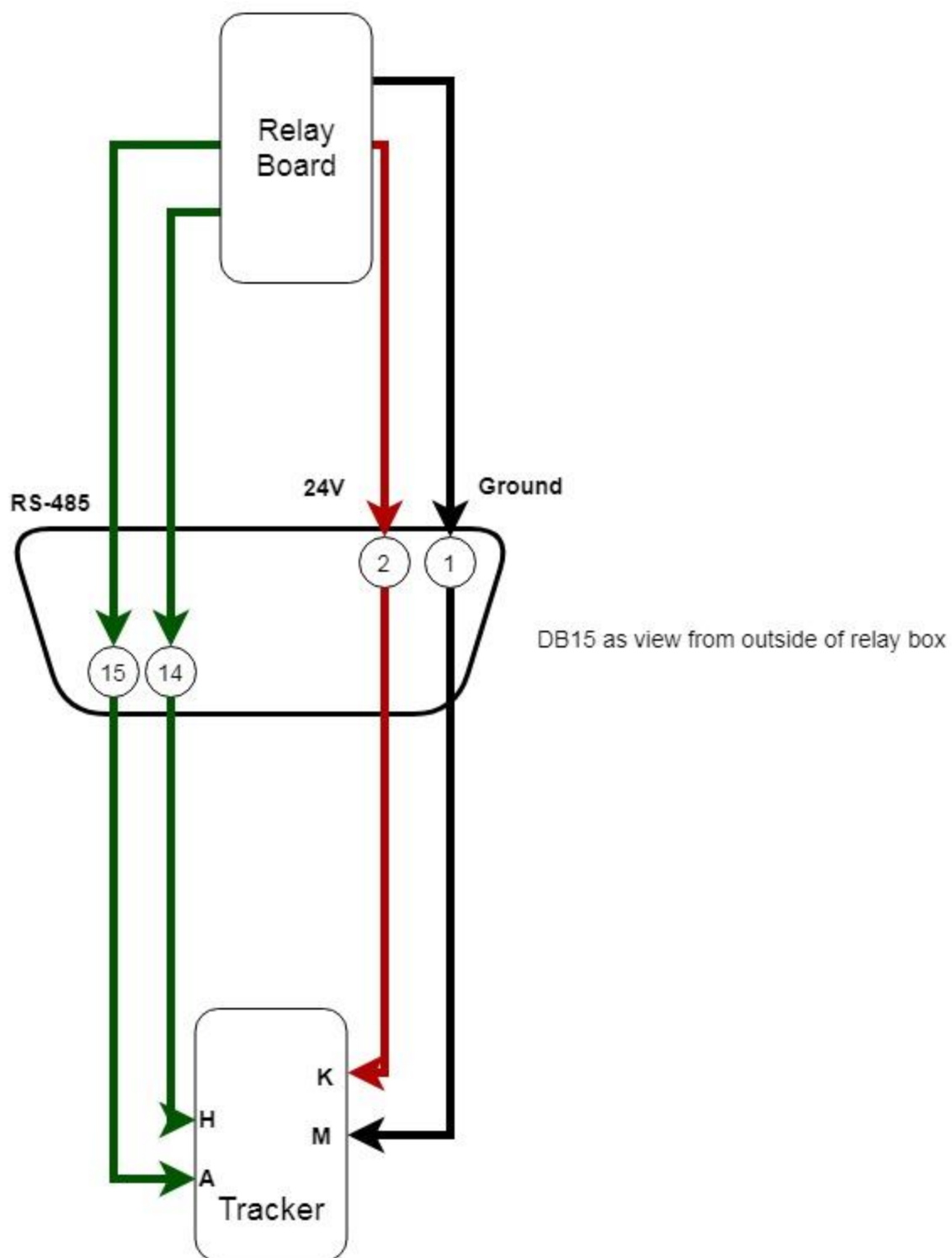
TRw	TRw	Read the tracker current position AZ, ZE
TRs	TRs	Tracker power cycle
S1s	S1s	Spectrometer 1 power cycle
S2s	S2s	Spectrometer 2 power cycle
MAa?		Check Azimuth motor driver alarm
MZa?		Check Zenith motor driver alarm

Wiring Diagrams

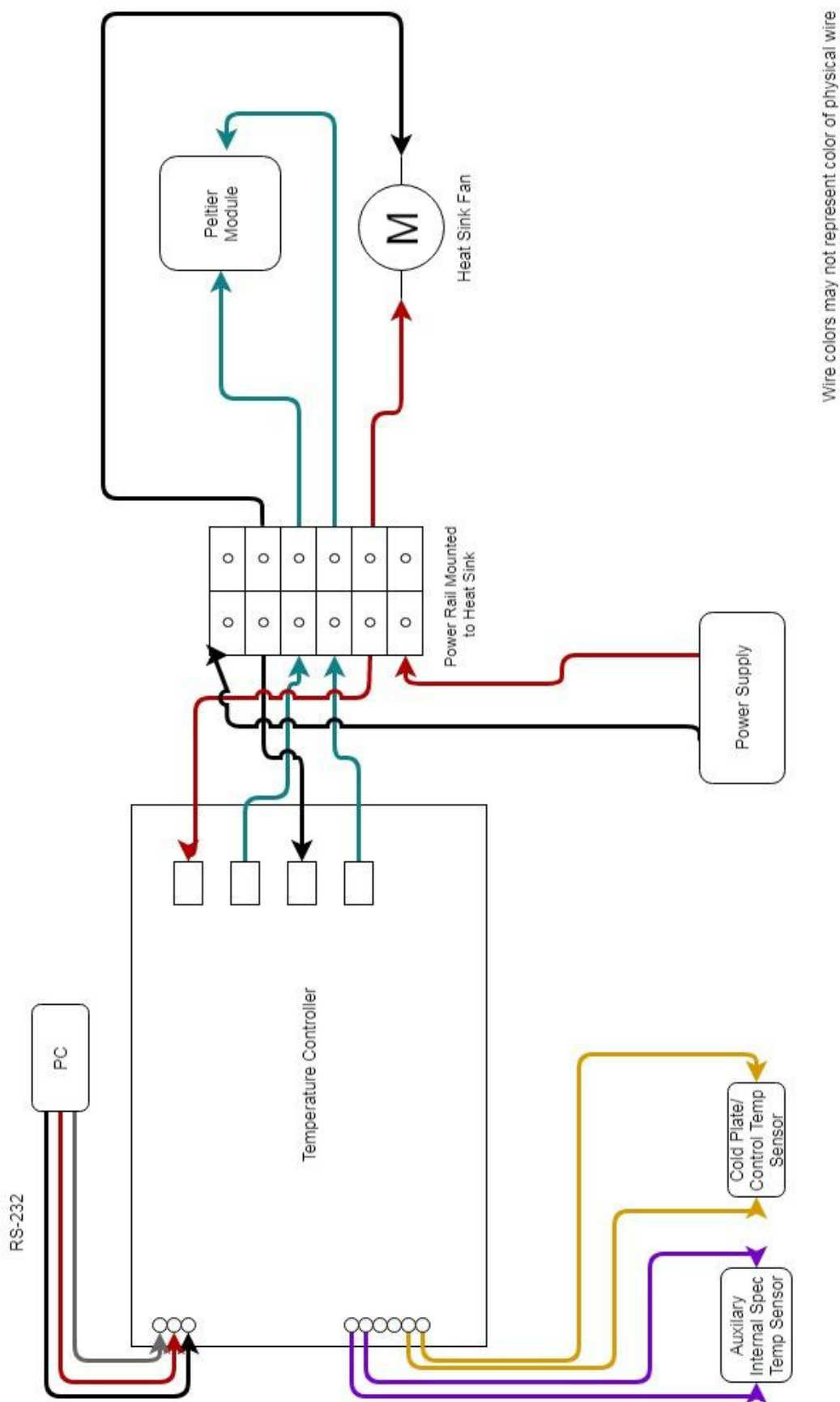
Main wiring diagram



Tracker control diagram

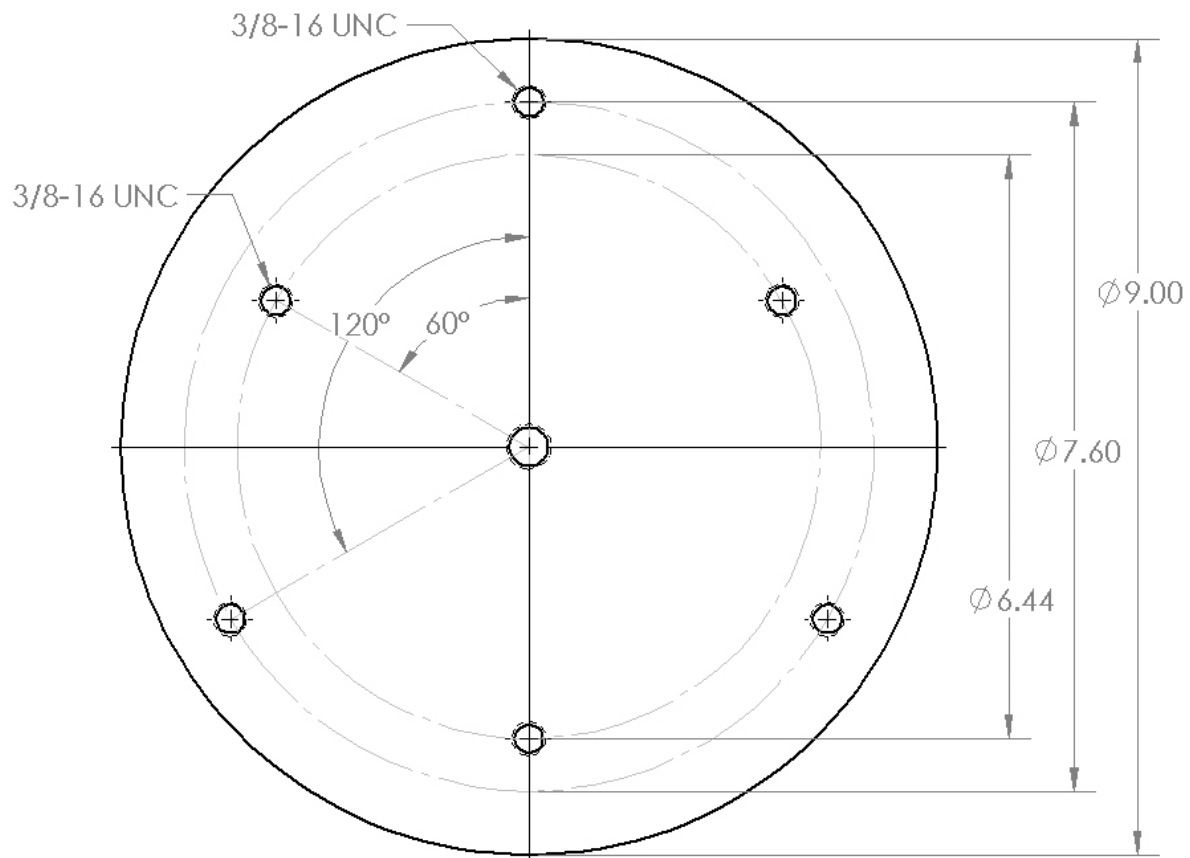


Temperature control diagram



Sensor Head Cable Pinout (Green/ Black 12 pin Connector)

Green/Black Amphenol Connector (12 Pin)	Silver Amphenol Connector (9 pin)	DB9	Function
A	A	1	24V
B	B	2	Tracker relay
C	C	3	PC-Tx
D	D	4	PC-Rx
E	E	5	Ground
F	F	6	Spec 1 Relay
H	H	7	Spec 2 Relay
J	J	8	TR-Rx
K	K	9	TR-Tx

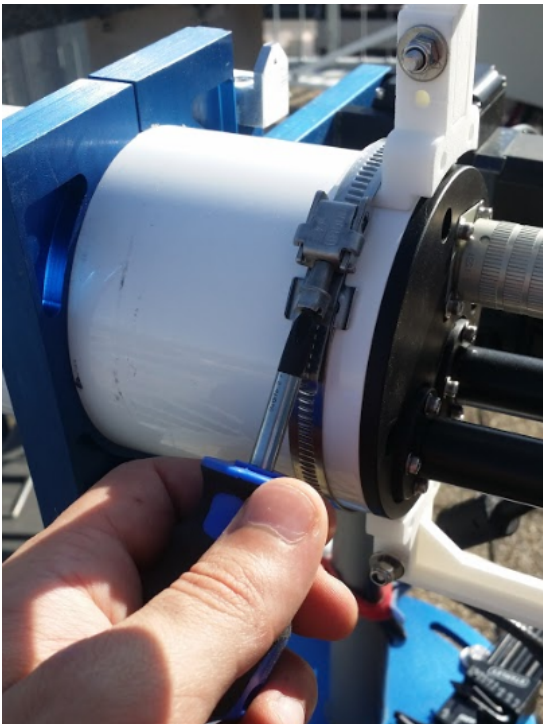


Appendix 1: Fiber guide installation

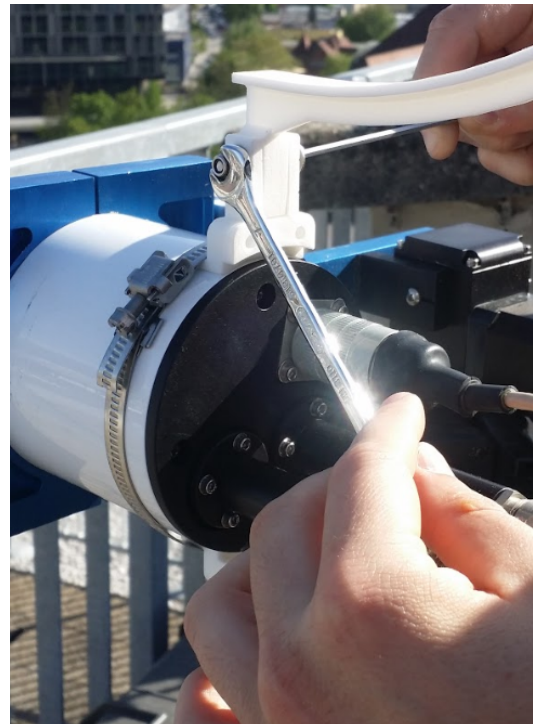
Fiber Guide Installation

For ease of installation it is recommended to point the head in a way it is parallel to the ground (pointing to horizon, zenith=90deg). You may use the TP routine (Tracker Parking), which is usually configured to point there.

The fiber guide is made up of 4 pieces: two holders, one band clamp, and the main guide.

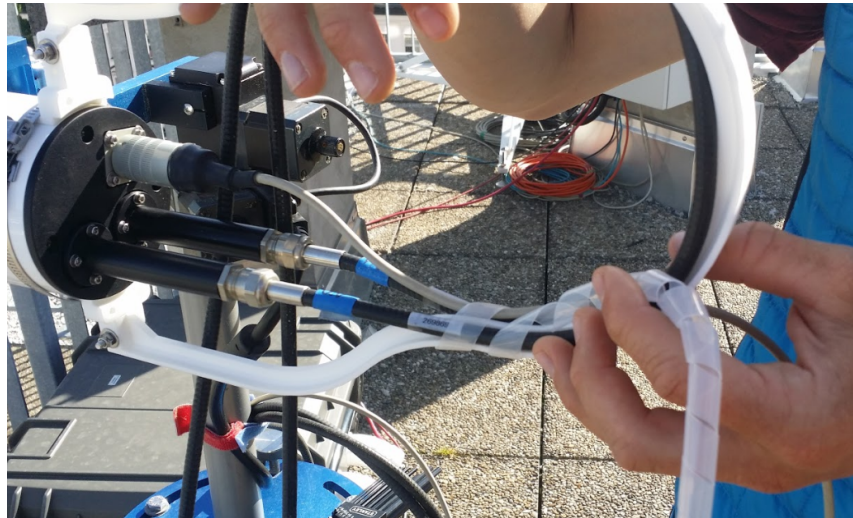


1- The guide holders are attached to the head sensor with the stainless steel band clamp with the longer guide holder on top.



2- Once the holders are attached to the head sensor, the screws that secure the main guide to the holders can be tightened.

3- The plastic coil is used to secure the fiber(s) and head sensor cable to the fiber guide.



4- Installation complete.



Appendix 2: FLIR Tracker information

Earlier models of the Pandora were equipped with the FLIR sun tracker. This section includes information on the operation of these trackers.



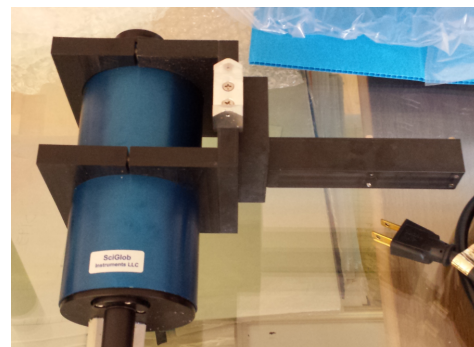
FLIR Tracker



FLIR tracker with head sensor mounted



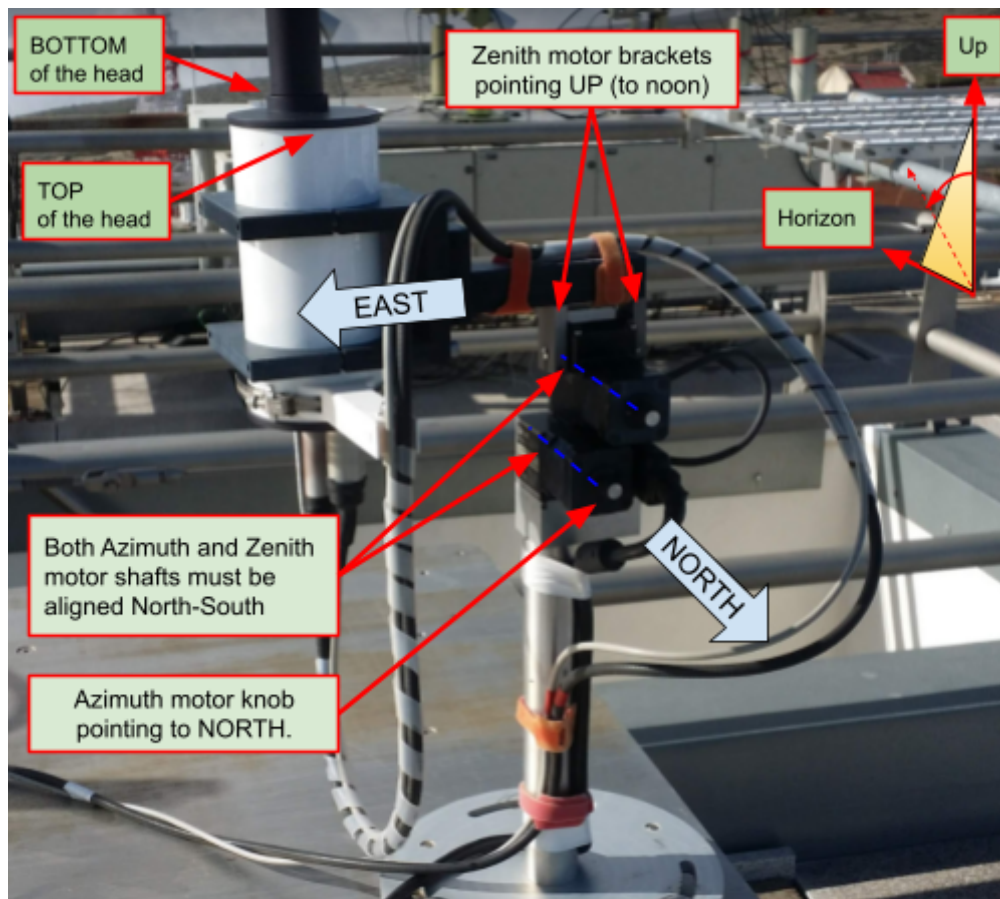
(FLIR tracker single bracket)



(FLIR tracker double bracket)

Home position of old FLIR trackers:

At home position, the azimuth motor knob should be pointing to North, the tracker arm should be pointing to East, and the zenith motor brackets must be pointing up (to the zenith). This model of tracker does not allow a change of the home position by software, so if the azimuth motor shaft is not pointing to North, one needs to unscrew the base plate screws and rotate the full system accordingly. This model of tracker can have a known hardware issue, in which the inner pinions can slip from their shafts. So it is important to check that at home position, both motor shafts are parallel and aligned to North-South direction, and that the zenith motor brackets are pointing up. If it is not happening, one could apply a bit of force to move it to the proper position. If after doing a few tracker resets, the tracker is still losing constantly this reference position, please contact Sciglob or to the PGN Network operator to get instructions to fix it.



Recommended fiber layout for old FLIR trackers:

For old trackers (FLIR), the fiber should be attached with two Velcro strips to the tracker arm, and then with two other Velcro strips to the main shaft.

Installation Recommendations - Fiber Layout

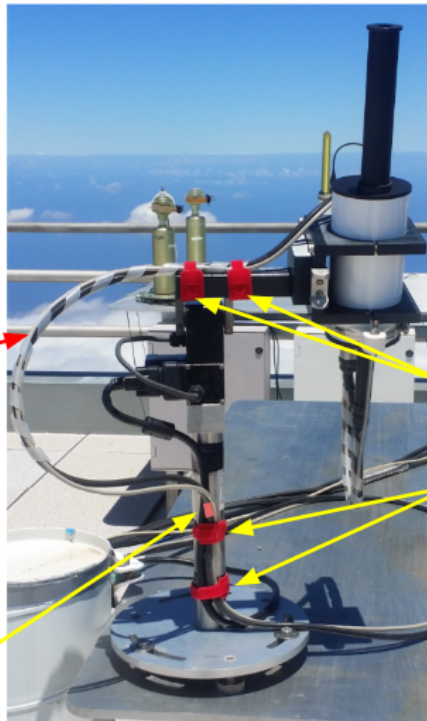
The 95% of the misalignment problems are due to fiber or head sensor cable jams!

Recommended fiber layout (with fiber guide)

Enough slack in the fiber, to allow 360 deg rotations.

Important: Run TR routine while seeing the head moving to check there is enough slack.

A piece of tape can be added, to have marked the proper position of the fiber.



Fiber & HS cable attachment:
2x velcro strips.

Fiber & Main shaft attachment:
2x velcro strips.

Appendix 3: Tracker Base plate assembly

Assemble Base Plate Assembly

- Install the $\frac{5}{8}$ inch bolt and threaded rod into the upper (slotted) base plate. It is recommended to use thread locking compound (such as loctite) on the $\frac{5}{8}$ inch bolt. The rounded ends of the rods should be on the same side of the plate as the head of the center bolt. Leave about 1.5 inches of threaded rod extending from this side of the plate.



- Place the upper (slotted) base plate on top of the lower base plate (without slots), pass one the socket head bolt through each slot and screw them into the three holes closest to the edge of the bottom plate. Do not tighten them all the way.



- Use a **3/16" Allen wrench** to adjust the threaded rods and get the top plate approximately level. You will fine tune this adjustment in a future step.

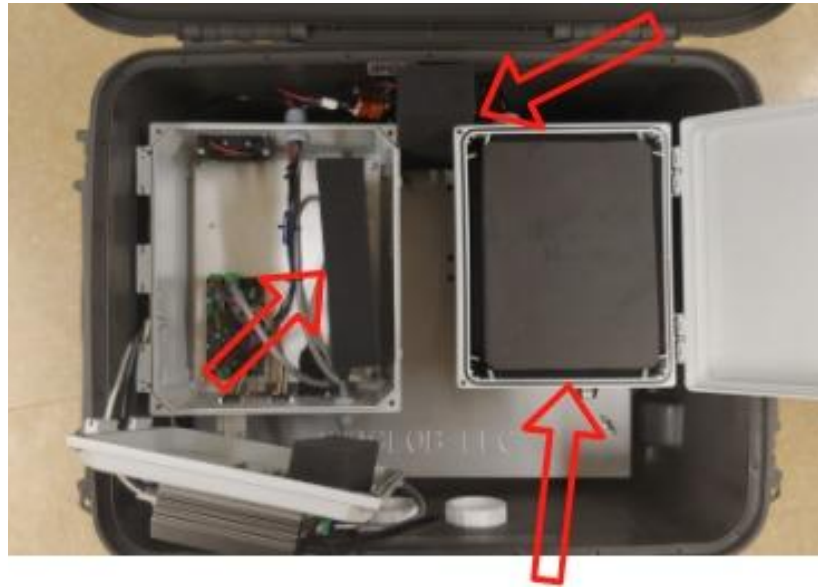
Appendix 4: Packing

Pandoras operate in many different environments, but one of the roughest scenarios for the instrument is being shipped. Improper care during shipping can result in unexpected damage, for this reason it is important to take all of the following precautions when packing an instrument.

- Before disconnecting the fiber from the spectrometer be sure to place a mark on the spectrometer and fiber to ensure that you can put the fiber back in the same position.
- The head sensor should be fully seated in its foam inside of its case to avoid shifting during transport.
- Be extremely careful with the back part of the head, to avoid misaligning the fiber entrance subassembly, with respect to the focusing lens. Be sure that this part is not under pressure, by any other element in the box.
- The fiber optic cable (grey in below picture) should be coiled neatly, and without sharp bending radius.
- Avoid pinching the fiber when closing the lid.



- Place foam over the power supply to help protect against harsh vibration and rattling during shipping.
- Avoid placing loose items in the Pandora enclosure if possible. If there are loose items in the enclosure, place a piece of foam in front of the fan to avoid damage from being hit by loose items during shipping.



- Place foam over the computer to help protect against harsh vibration and rattling during shipping. The foam should be thick enough that it requires slight pressure to close the lid of the large grey enclosure.



- The tracker can be shipped in an appropriately sized cardboard box allowing for enough room for the tracker to be protected on all sides with foam.
- Note: top and front foam are removed in this picture for visibility.

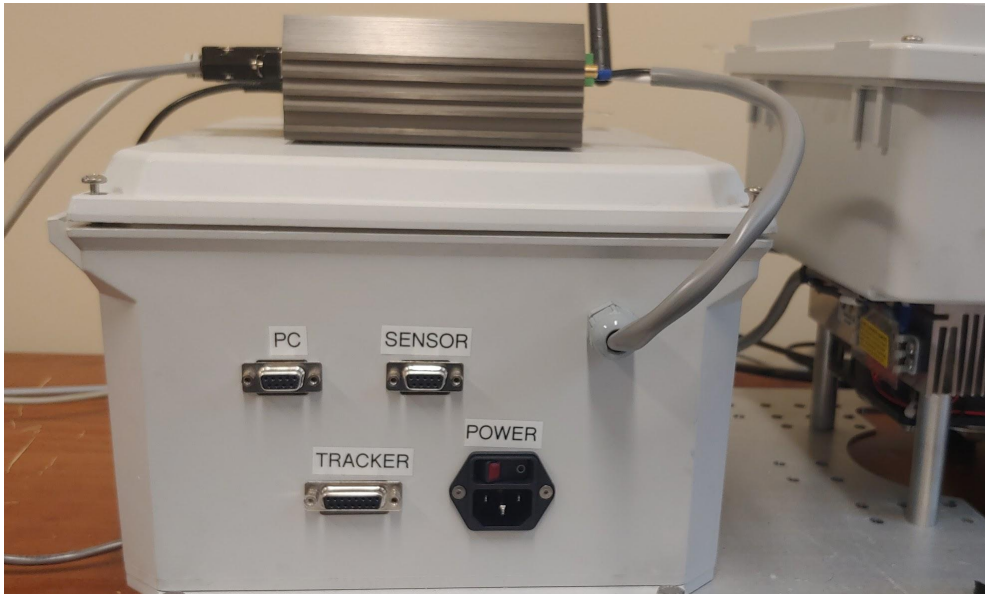


- The Pandora box should be shipped in the same large cardboard box it was delivered in. Place foam between the rear of the Pandora box and the wall of the cardboard box to prevent damage to the fan shroud. The head sensor case can be shipped in the same box with adequate foam to prevent shifting during shipping.



Appendix 5: Port labels

Relay Box



Computer (DC1100) Ports



COM1 COM2



Power Monitor

COM4 COM3

Appendix 6: Temporary Humidity Fixes

Check for water

Do not attempt these procedures without first contacting your assigned Network Operator.

We must first check to see if there is water inside the head sensor as opposed to just humid air. If there is water in the head sensor it will have to be shipped to SciGlob/LuftBlick/GSFC to be cleaned, resealed and re-calibrated.

Remove the collimator(s) and look through the window(s) in the front of the head sensor. Use a flashlight and check if you can see any drops of water on the filter-wheel or anywhere else in the head sensor. Use BlickO to move the filter-wheel through its different positions and recheck for water.

If there is no visible water in the head sensor then you most likely only have humid air in the head sensor. For this you have two options:

Option A: Dehumidifying the head sensor indoors with a dehumidifier

1. Remove the head sensor from the tracker and unplug the fiber from the spectrometer. If there is not already an alignment mark on the fiber and spectrometer, make marks on the fiber and spectrometer to be sure you can install the fiber in the same orientation after completing the repair. Bring the head sensor inside to a closed room.
2. Follow steps for removing the head sensor electrical connector in the “Remove electrical connector” section of this appendix.
3. Leave the head sensor in a closed room, near the dehumidifier for a few days. Rotate it from time to time. If you connect the head sensor to BlickO, and the head sensor has a humidity sensor, you can monitor the humidity inside the head sensor, in the sensor readings section.



Spectrometer 1 connected	Reset spectrometer 1	Readings at 09:24:27
Spectrometer 2 connected	Reset spectrometer 2	Spec1-Board Temp 22.50°C
Head sensor connected	Reset filterwheels	Spec2-Board Temp 21.27°C
Temperature controller connected	Get sensor readings	Spec-Control Temp 15.02°C
Tracker connected	Reset tracker	Spec-Auxil Temp 14.40°C
		Head-Sensor Temp 43.06°C
		Head-Sensor Hum 29.3%
		Head-Sensor Pres 1064.44hPa

- Reinstall the electrical connector.
- Follow the steps to reseal the head sensor in the “Resealing head sensor” section at the end of this appendix.
- Set the instrument back up outside and return it to operation.

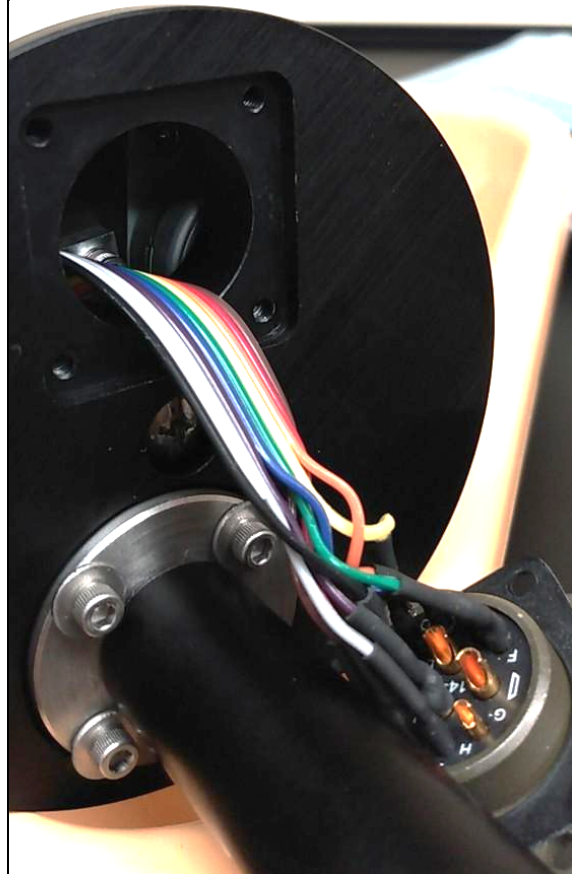
Option B: Dehumidifying with desiccant

- On a day with clear skies and low humidity, use a tissue to dry all the external grooves of the head sensor.
- Follow the steps to reseal the head sensor in the “Resealing head sensor” section at the end of this appendix.
- Follow the steps for removing the head sensor electrical connector in the “Remove electrical connector” section of this appendix.
- Slide 1-3 small bags of desiccant through the connector hole. (recommended: Part # 2189K14 from mcmaster.com)
- To be able to extract it afterwards, a good idea is to tie the silica gel bag with a fine cord, leaving part of this cord out of the head sensor. Reinstall the connector with the 4 screws and leave the instrument running for a few days. Repeat the process until the humidity problem is solved. You can monitor the humidity inside the head sensor in the sensor readings section of BlickO. With desiccants, a good goal humidity is around 20-30%.

Remove electrical connector

Remove the 4 screws securing the electrical connector to the back of the head sensor (be sure to keep track of any washers used with these screws), and pull the connector a few centimeters from the opening. The idea is that this opening will act as an exit for the humidity inside the head sensor. Make sure the gasket is not cracked or ripped.

If water quits through this hole when pointing the head up, then contact SciGlob directly for a hardware repair and recalibration.

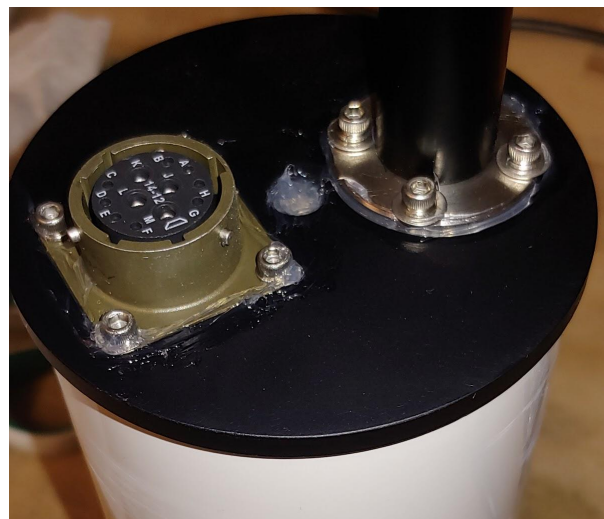


Resealing head sensor

Add vulcanized tape to cover the grooves on the front and back of the head sensor. We recommend “3M Scotch 23” for its sealing properties and resistance to UV radiation.

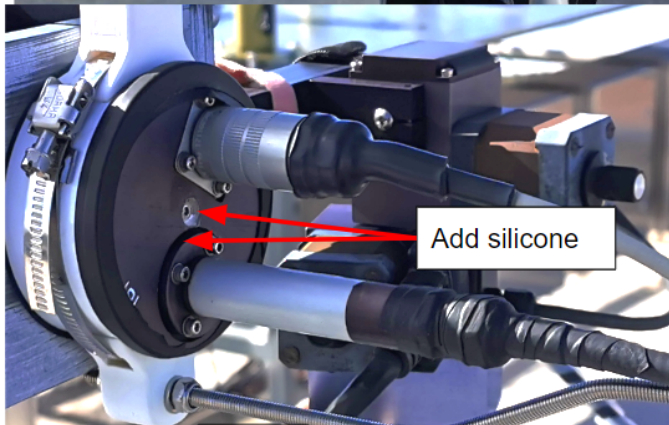


Add silicone sealant in all external grooves or holes of the back plate of the head sensor (the central screw and the grooves of the fiber connector). We recommend “3M 4000UV” silicone brand.



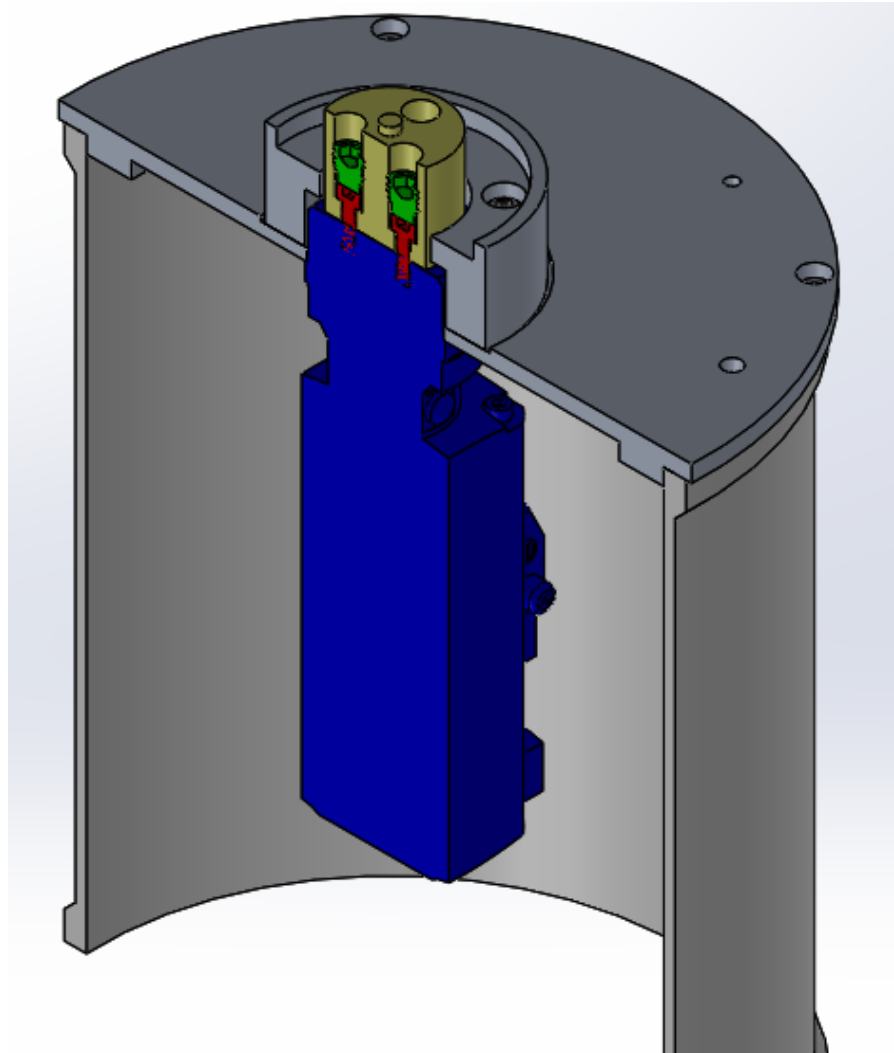


Good brand of uv resistant
 vulcanized tape:
 "3M Scotch 23"
 Good brand of uv resistant
 silicone:
 "3M 4000UV"

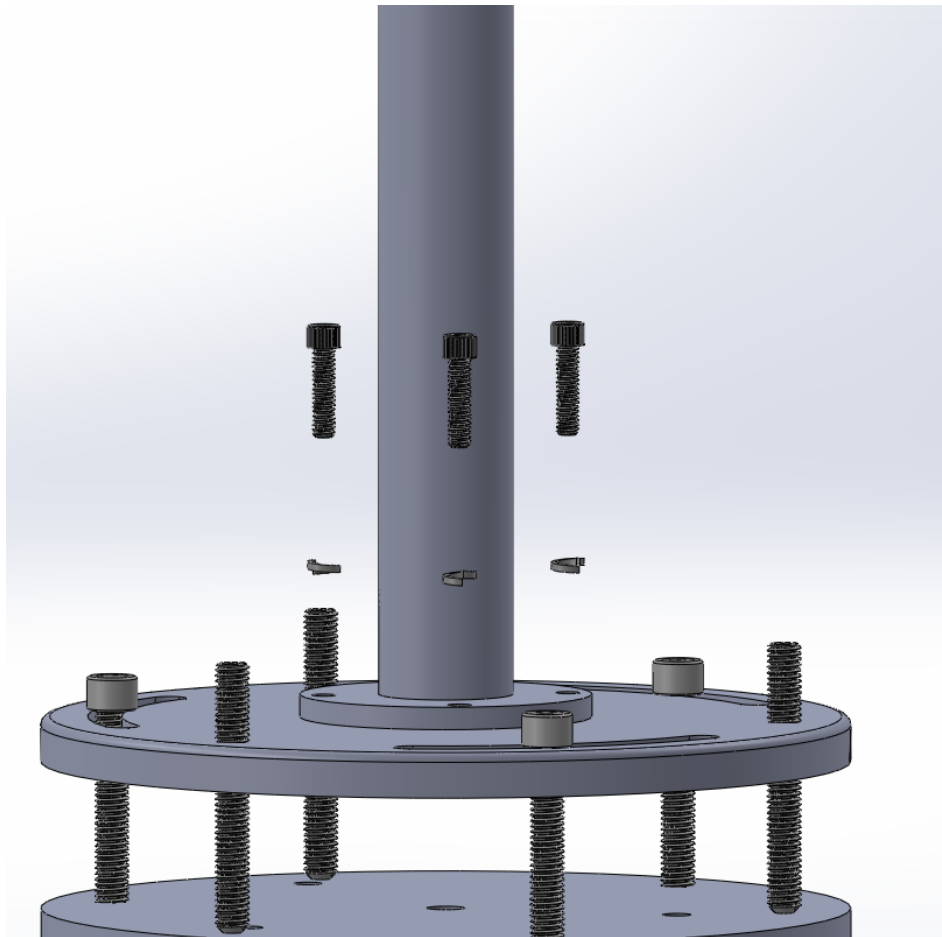


Appendix 7: Loose Tracker Shaft Repair

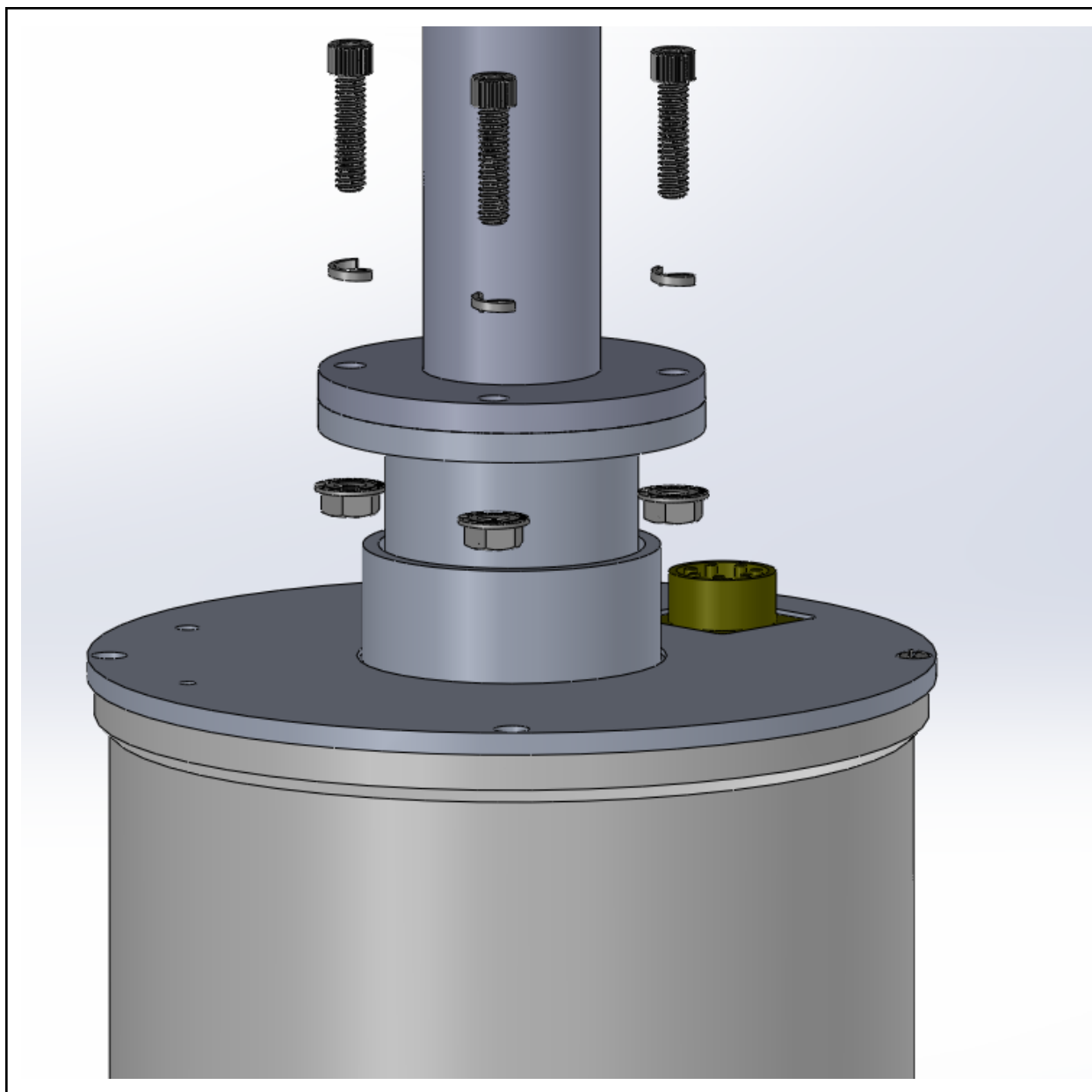
It is possible for the shaft of the tracker to come loose from the motor in extreme operating conditions or if mishandled during shipping. The following procedure describes how to repair a loose tracker shaft.



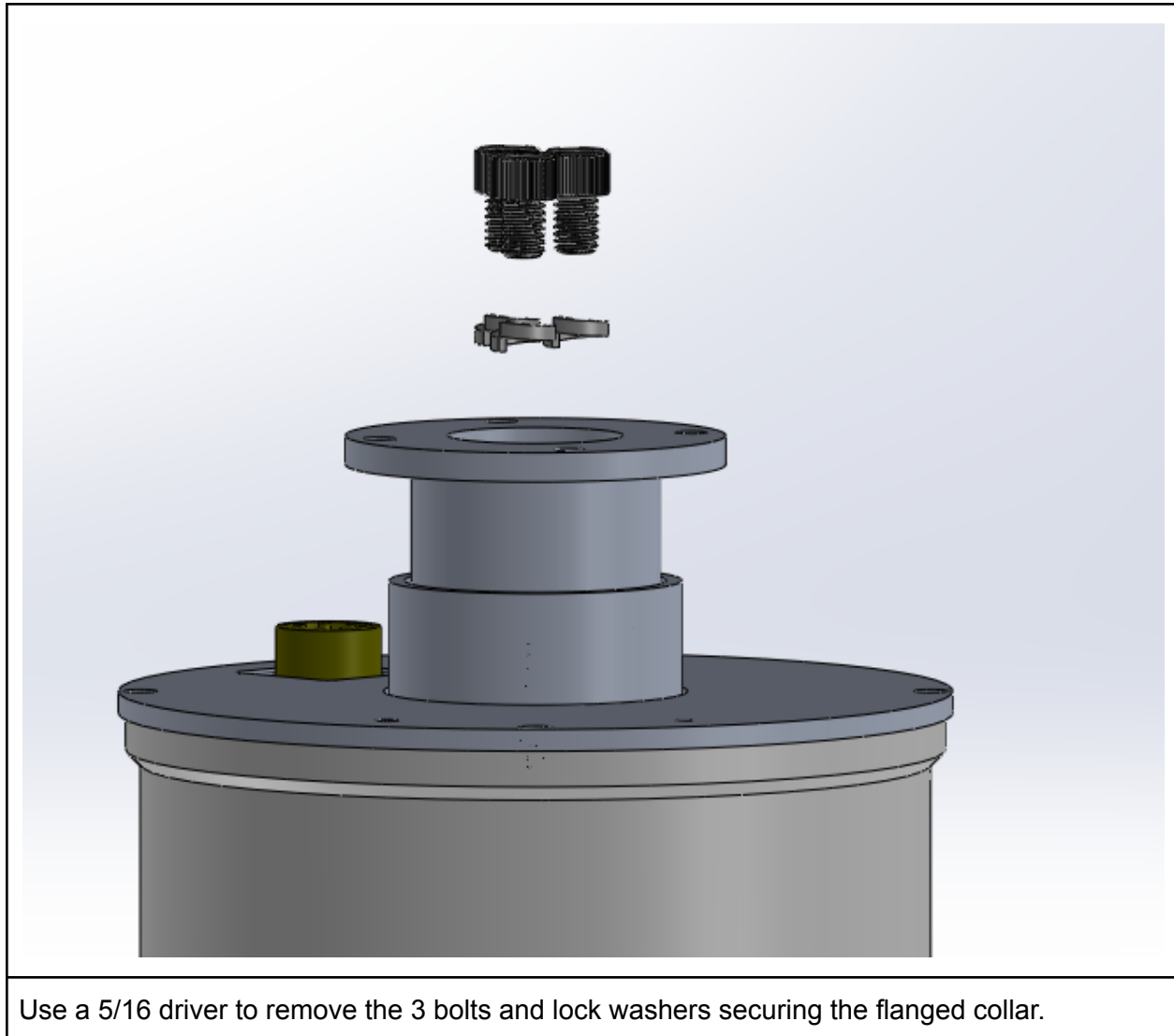
The socket head screws (red) hold the motor shaft adapter (yellow) to the motor (blue). The set screws (green) keep the socket head screws from coming loose. In certain conditions the set screws can fail to keep the socket head screw tight. This procedure details how to tighten the socket head screws and replace the set screws with an alternative design.

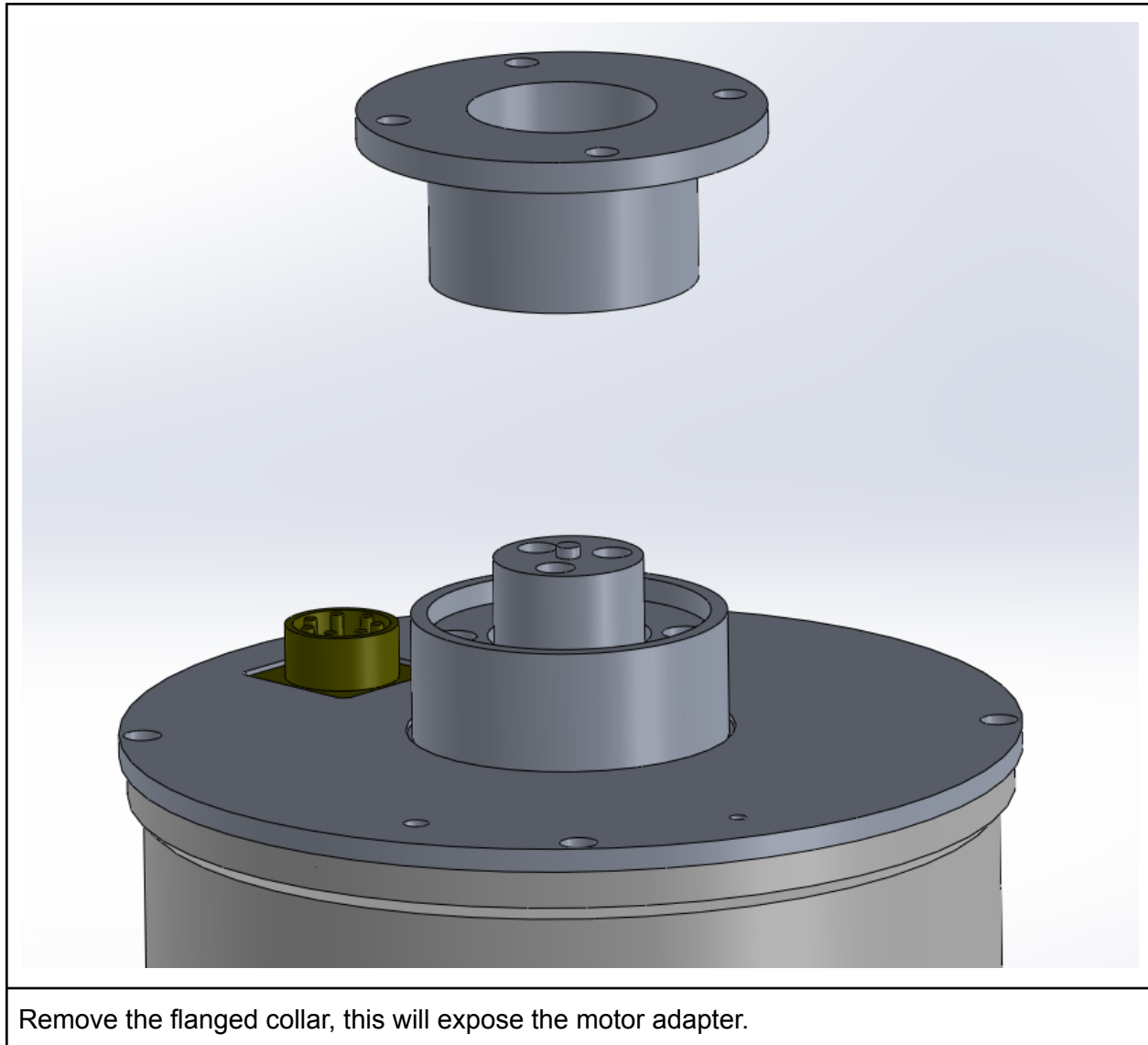


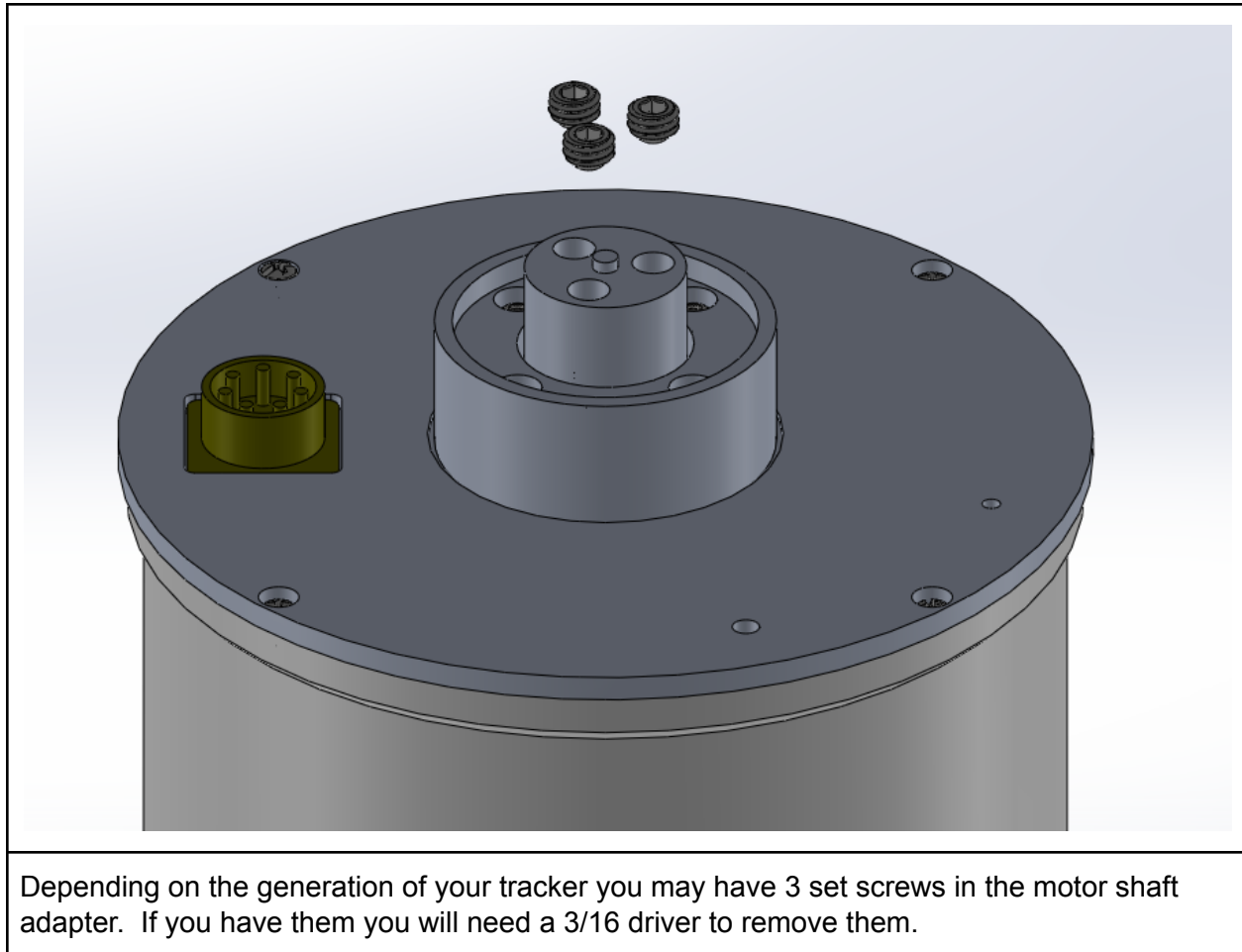
Use a 3/16 driver to remove the screws holding the tracker shaft to the base plate. Make note of the 4 lock washers.



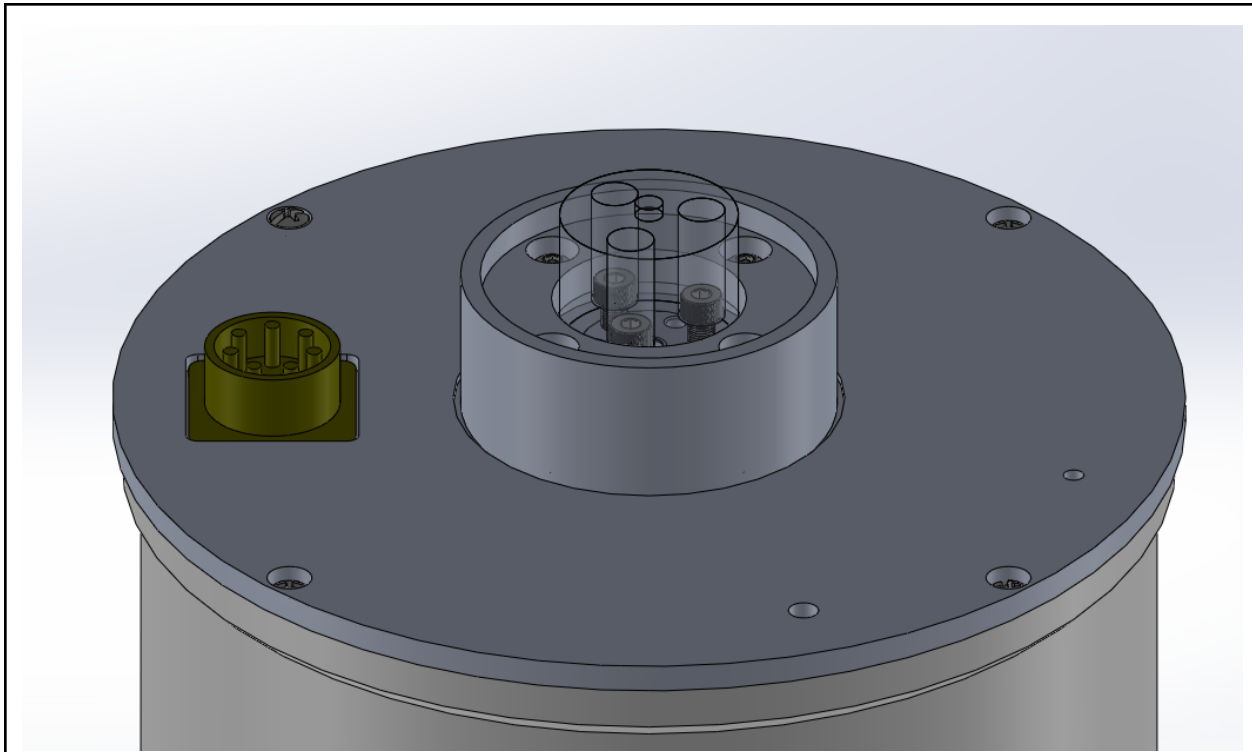
Place the tracker upside down on a bench. Use a 3/16 driver and a 7/16 wrench to remove the screws and nuts holding the tracker shaft to the flanged collar.







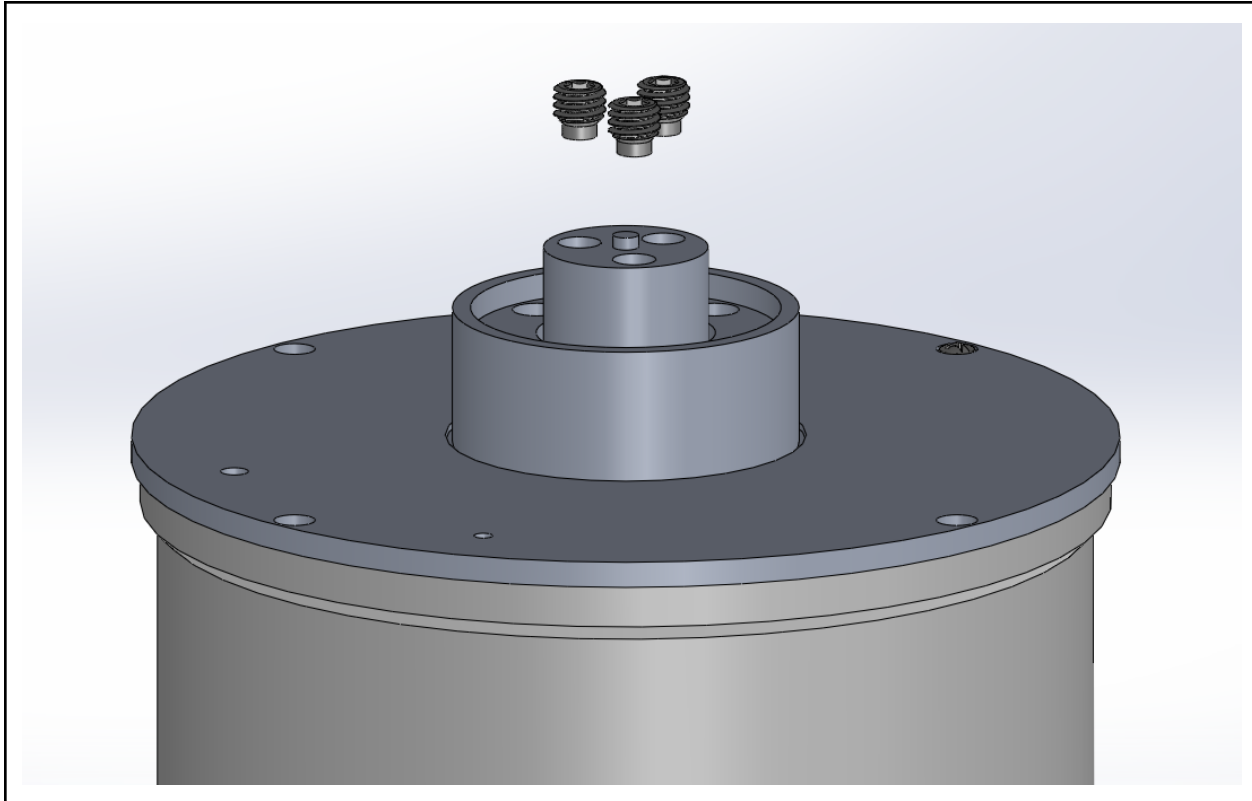
Depending on the generation of your tracker you may have 3 set screws in the motor shaft adapter. If you have them you will need a 3/16 driver to remove them.



The motor adapter is made transparent in the above image for clarity.

You can see 3 screws, these may have come loose which would cause the tracker to be loose on the shaft when mounted. If the screws are loose tighten them, they are metric and will require either a 3mm or 2.5mm driver

If these screws are not loose contact you Network Operator to assist in further diagnosis.



When reassembling the tracker it is recommended to use alternative set screws. Take note of the extended short shaft extending out of the bottom of the set screw. These alternative screws can be acquired from <https://www.mcmaster.com/92845A645/> or through SciGlob LLC(support@sciglob.com).

The assembly procedure would involve just repeating these steps in reverse. **When reassembling, take care to ensure that the motor adapter and shaft collar are reinstalled in the center of the openings they sit in and all lock washers are put back in place/.**

