



PlaneWave Interface 4 (PWI4)

Software User Manual



For L-Series Mounts and the PW1000

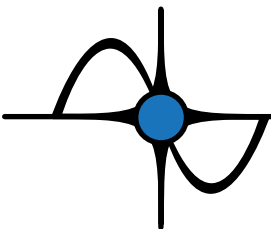
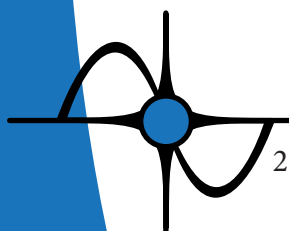


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SOFTWARE INSTALLATION

Before we can get up and running in the current version of PWI4, we need to install the following pieces of software.

1. PWI4
2. PWI3 for focusing, rotating, Delta-T dew prevention, and fan control if using a CDK12.5 through CDK24 systems. If using the PW1000 or CDK700 the focuser/rotator control is via PWI4.
3. PlateSolve Catalog for running plate solving in PWI4
4. Latest ASCOM Platform

Installing PWI4

PWI4 is the main control software for L-series mounts and the PW1000. The software operates the telescope mount and allows for the building of a pointing model, which yields high-precision pointing and tracking. Additionally, PWI4 serves as planetarium software for selecting targets. You are also able to monitor tracking performance amongst a variety of other parameters via PWI4. To install the latest version of PWI4 please visit our Software Downloads section of the website at: <http://planewave.com/downloads/software/>

Installing PWI3

PWI3 is the control software currently used to operate the focuser, rotator, Delta-T dew prevention, and fan control system for CDK12.5 through CDK24 telescopes. Importantly, PWI3 will be used for performing autofocusing routines. The latest version of PWI3 can be downloaded here: <http://planewave.com/downloads/software/>

Installing PlateSolve 3 Catalog Installer and Catalog Data

Both PlateSolve 3 Catalog Installer (Part 1 of 2) and Catalog Data (Part 2 of 2) must be installed for PWI4 to perform plate solving, which matches images captured through the telescope with a known catalog. Thusly, we can confirm exactly where the telescope is pointing! The most recent version of PlateSolve 3 Catalog can be found under the PWI4 section at: <http://planewave.com/downloads/software/>

Installing ASCOM Platform

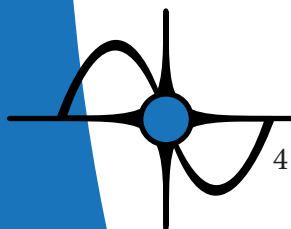
ASCOM Drivers allow you to control the mount, focusers, and rotators using ASCOM compatible third-party software such as TheSky, MaxIm DL, FocusMax, ACP, and CCDAutoPilot. The ASCOM Platform provides the framework and tools to allow various ASCOM compatible programs and devices to communicate. To install the latest ASCOM Platform please visit: <https://ascom-standards.org/>

SOFTWARE INSTALLATION (CONT.)

Installing MaxIm DL

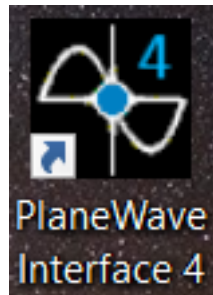
The primary third-party software we use for camera control is MaxIm DL. This software will be used to control our camera in conjunction with PWI4 during pointing model generation. If you do not currently own a full licensed version of MaxIm DL you can also download a 30 day trial. To download your 30 day free demo of MaxIm please visit: <http://diffractionlimited.com/product/maxim-dl/> and select the Demo tab

Now that we have the proper software installed, we are ready to jump into PWI4!

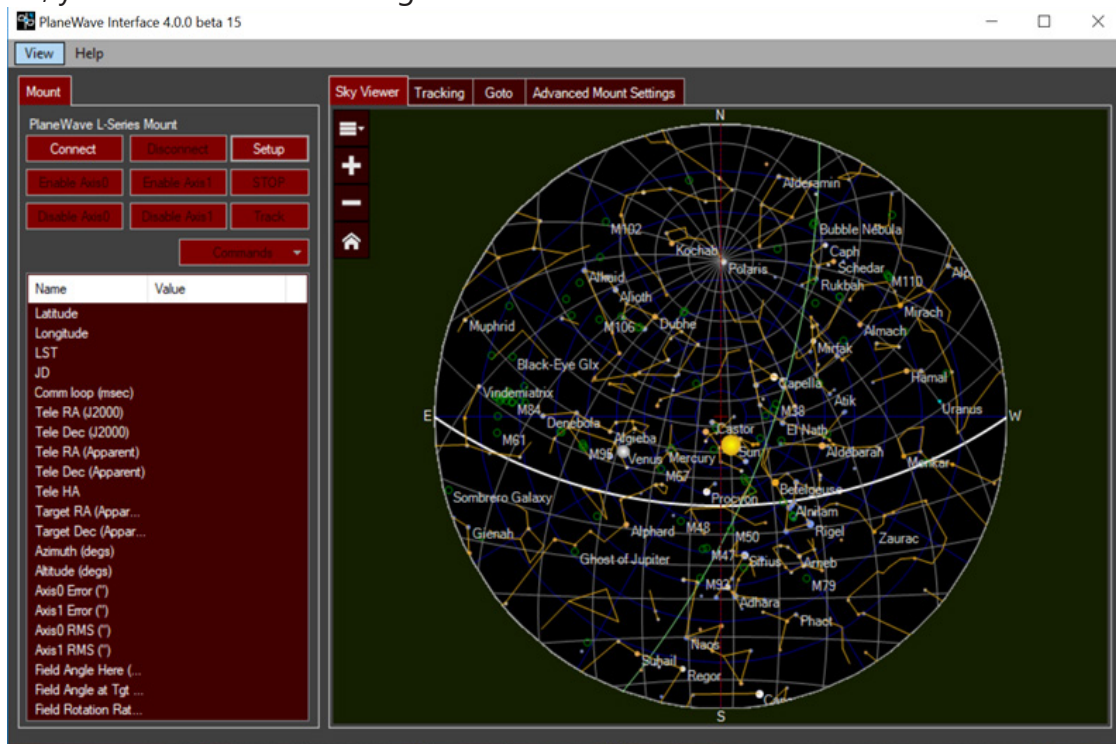


CONFIGURING PWI4

1. Open PWI4 by clicking the icon



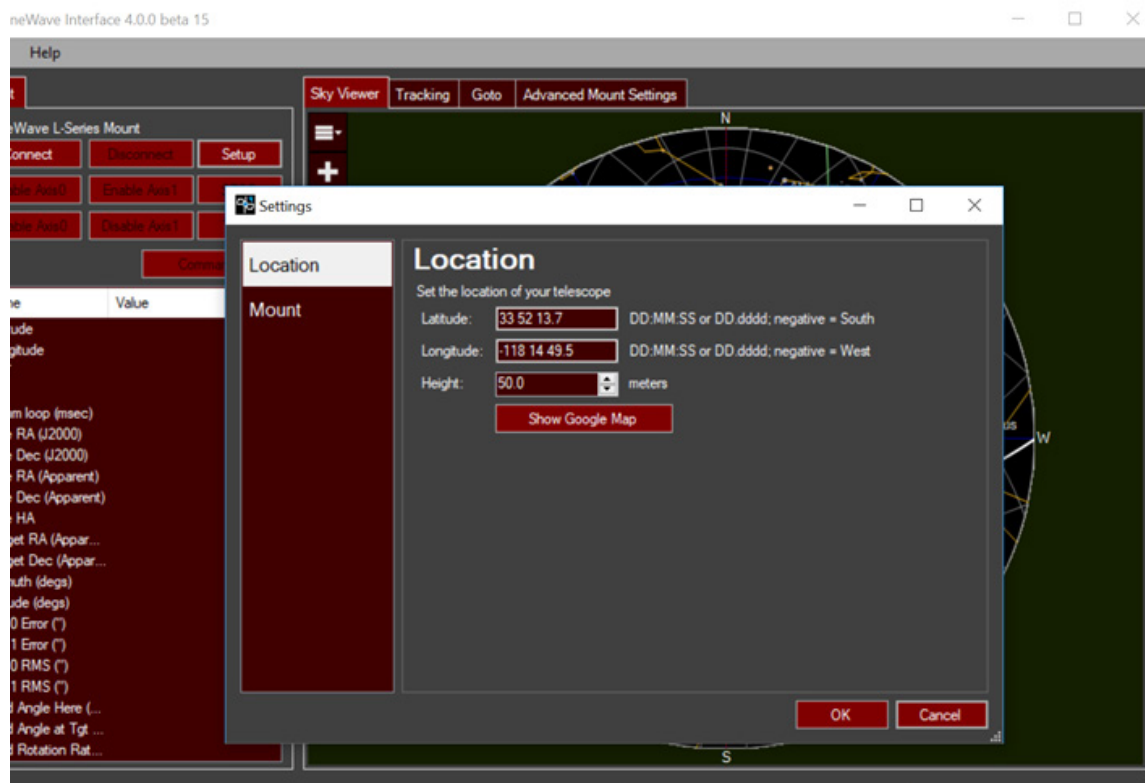
Once opened, you will see the following view:



Observatory Location

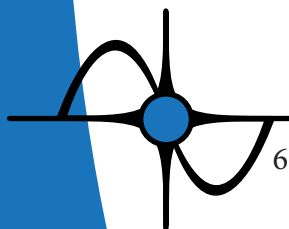
1. Navigate to **View > Settings > Location**
2. In the location panel, enter your Latitude and Longitude. Note: if you are in the western hemisphere (North or South America, and parts of western Europe and Africa) the longitude should be negative. If your computer is connected to the Internet, click **Show Google Map** to visually set, or confirm the coordinates.

CONFIGURING PWI4 (CONT.)



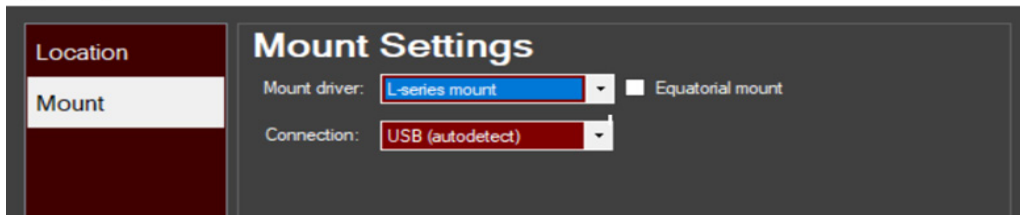
3. Once Google Maps opens, search for your address, or a nearby business/landmark.

4. The most reliable way to set your location is as follows. Click on the map to refine your location. You can switch to satellite view to precisely locate your building or site. Confirm the coordinates in PWI4.



MOUNT SETTINGS AND POWERING UP

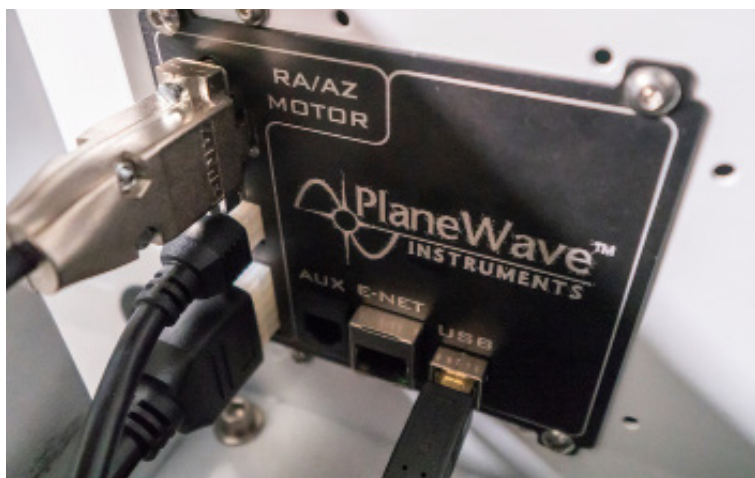
1. In PWI4, select the correct mount type via **View > Settings > Mount**. In this example we are connecting to a L-series mount.
2. Check the equatorial mount box if yours is set up on a wedge. Leave this box unchecked if you have the telescope set up in Alt/Az orientation.



3. For L-series mounts, connect the 120v AC power cable to your mount by routing the cable through the inner opening of the azimuth base to prevent cord wrap.



4. Connect the USB or Ethernet cable from the mount to your computer.

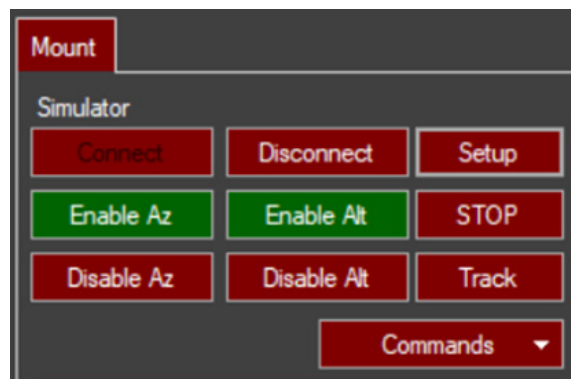


5. Flip the power switch on the side of the mount to On.

CONNECTING TO THE MOUNT

Enabling the Motors

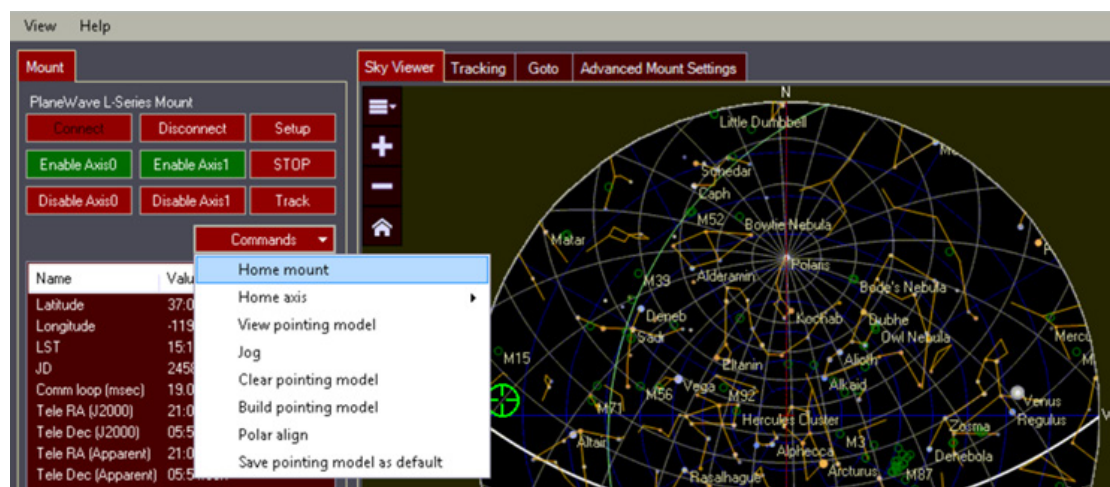
1. Go back to the PWI4 main window and click **Connect**



2. Once connected to the mount in PWI4, the azimuth and altitude axes can be enabled. Once enabled, power is being set to each axis and you will feel resistance when pushing against each axis. To disable either axis at any time, simply click disable.

Homing the Mount

1. Homing is a procedure where the mount locates encoder reference points in relation to mechanical stops inside both axes. Homing takes approximately 10 seconds and is finished once each axis stops slewing. Homing should be performed each time the mount is power cycled, or reconnected via PWI4.
2. To home the mount click **Command > Home Mount**

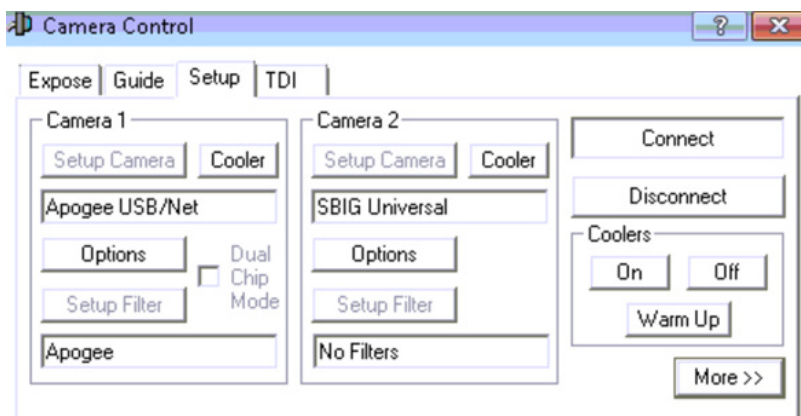


PRE-POINTING MODEL CHECKLIST

Before creating your first pointing model, please connect your camera and then focus the telescope. If your camera is not in rough focus before performing an automatic focusing run, then the focusing run and subsequent pointing model may fail.

Connecting Your Camera

1. Open MaxIm DL and connect your camera. In MaxIm go to **View > Camera Control Window**, or use the keyboard shortcut **Ctrl+W**. Click **Connect**.



Focusing in PWI3

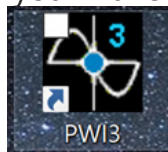
The current version of PWI4 requires the use of PWI3 for controlling the focuser on CDK12.5 thru CDK24 telescopes. A future update to PWI4 will integrate focuser and rotator control directly.

Approximately focus the telescope manually or automatically with PWI3 before running an autofocusing v-curve routine. If you are using a PlaneWave focuser such as the IRF90 or Hedrick Focuser please see below for autofocusing steps in PWI3.

Focusing Tip:

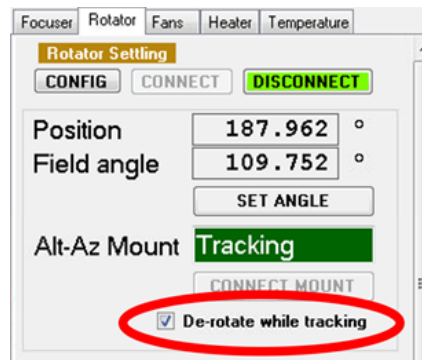
- Aim the telescope towards the Celestial Pole where any trailing will be minimal.

1. Open PWI3 and connect to your PlaneWave Focuser.



POINTING MODEL CHECKLIST (CONT.)

2. Before starting the autofocusing run in PWI3, click on the **Rotator** tab and enable **de-rotate while tracking** if you have an IRF90 rotating focuser from PlaneWave installed.

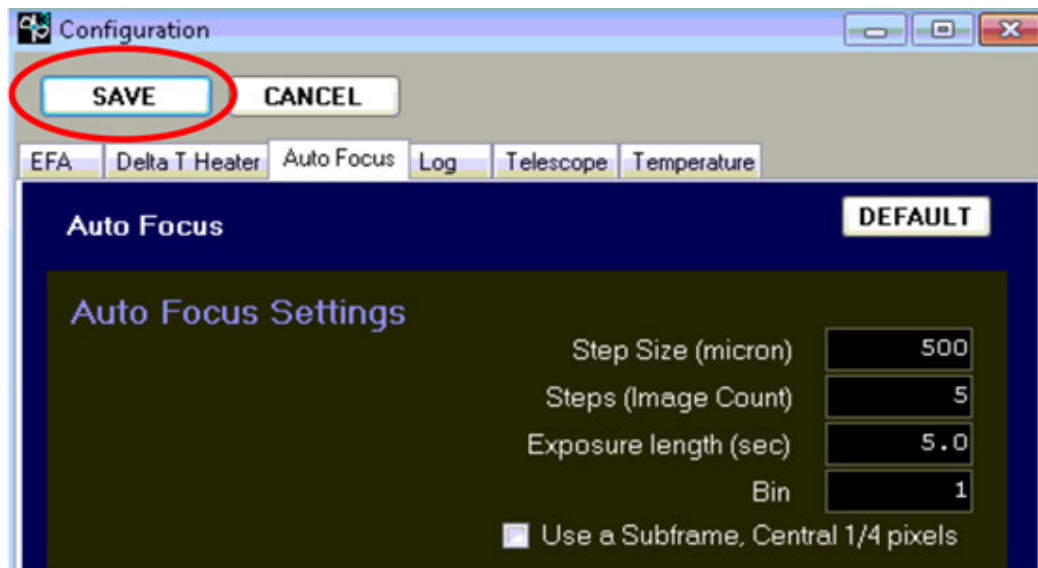


3. Click on the **Focuser** tab and click **AF Config** under Auto Focus

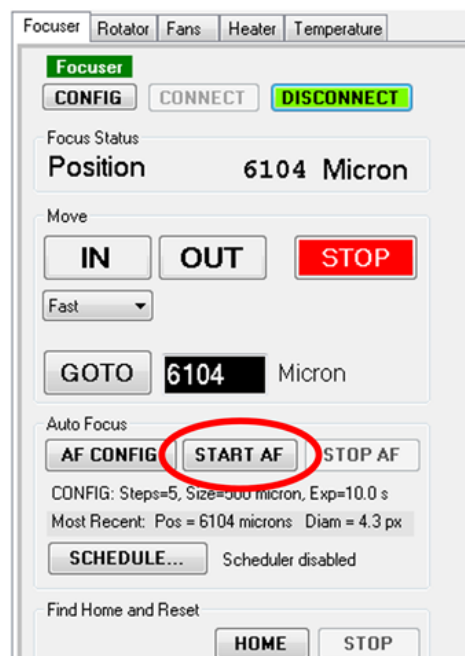


POINTING MODEL CHECKLIST (CONT.)

4. In the **AF Config** box, recommended starting settings for autofocusing use a step size of 500 microns, 5 steps, and 5 second exposures. Feel free to adjust the exposure length depending on your application i.e. 1-2 seconds. Once finished adjusting parameters, confirm the settings and click **Save**.

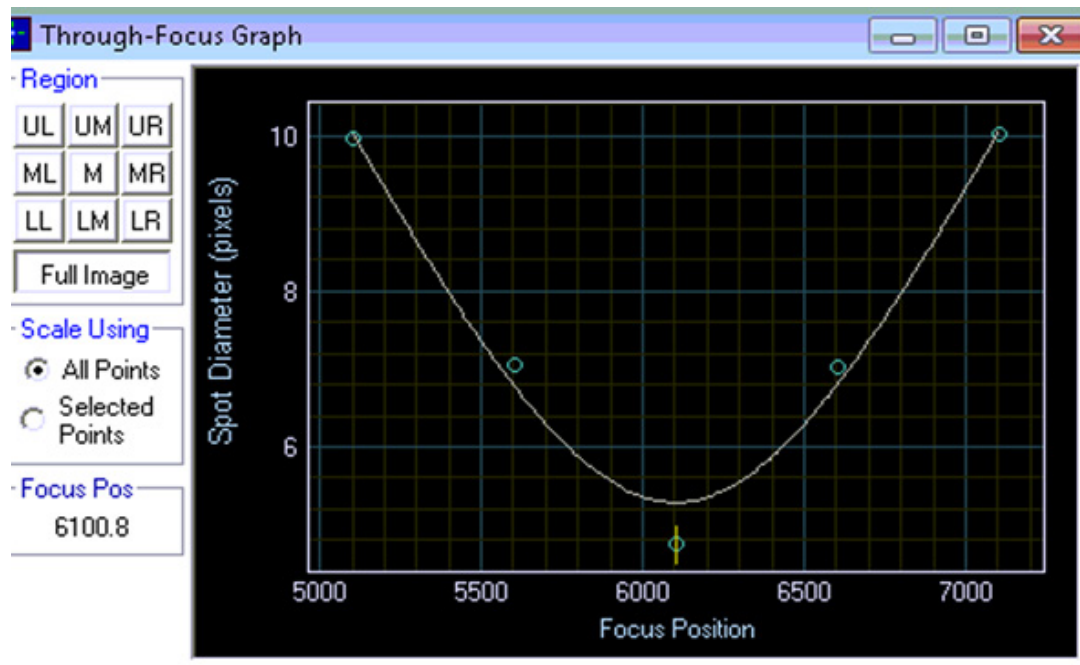


5. Click **Start AF** to begin the autofocusing routine. Allow the software to perform the auto-focusing routine, which should complete within a few minutes. Once finished, we can create a pointing model.



POINTING MODEL CHECKLIST (CONT.)

6. When the autofocusing completes you can click the **graph button** to see the final focusing position. You want to see a similar "V curve" which signifies the best focus position has been calculated and selected by the focuser.



7. You are now ready to create your pointing model since the telescope is in focus and the camera is connected.

Setting Plate-Scale

Each camera and telescope combination has a particular plate-scale, which is important to enter in PWI4 before starting a pointing model. This scale will be used to help calculate the model.

Use the following formula to calculate plate-scale:

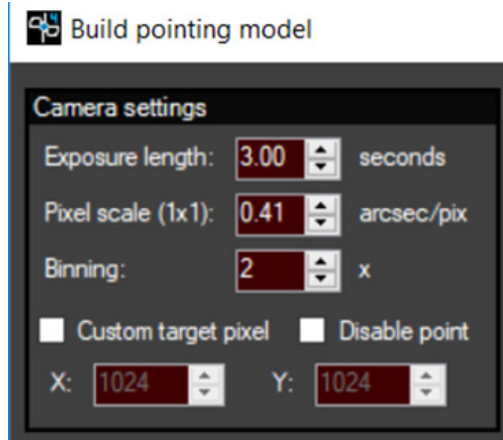
$$\text{Arcseconds per pixel} = \text{Pixel size (microns)} * 206.265 / \text{Focal Length (millimeters)}$$

For instance, the focal length of the CDK700 is 4540mm and the KAF-16803 CCD has 9 micron pixels. The unbinned pixel scale will be:

$$9 * 206.265 / 4540 = 0.41 \text{ arcseconds per pixel}$$

POINTING MODEL CHECKLIST (CONT.)

1. In PWI4 select **Commands > Build Pointing Model**
2. Enter your calculated pixel scale under the Camera Settings
3. In our example with the CDK700 and KAF-16803 this would be 0.41 arcsec/pixel



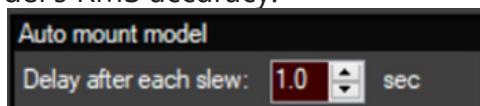
CREATING A POINTING MODEL

Now that we are connected to the mount, are in focus with the camera, and both axes are enabled, we need to tell the mount where it is pointing in the sky. This is done by creating a pointing model, which takes numerous photos of the night sky and compares them to known catalogs of star positions.

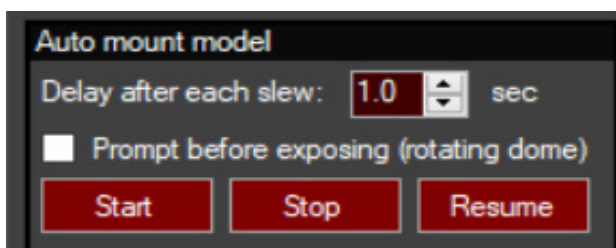
NOTE: *If using a PlaneWave IRF-90 rotator, make sure the rotator is fully disabled in PWI3 before starting your pointing model run and also home the mount. If a previous model was built, make sure to clear the old model via Commands > Clear pointing model before creating a new model.*

Tips for Creating Pointing Models

- Increase the binning of your CCD sensor to 2x2 in order to reduce the time it takes to read each image from the camera.
- Make sure the mount is first homed via **Commands > Home mount** before creating a model
- Depending on your skies, try using shorter exposures of 1-2 seconds.
- Capturing your first plate solve image near the galactic plane (seen as the green line on the Sky Viewer) will increase chances of success due to dense star fields.
- Increase **Delay after each slew** to allow the mount to settle between exposures. This will improve the pointing model's RMS accuracy.



- Adding additional points near zenith for Alt/Az setups, or near the celestial pole for equatorial setups, is beneficial for tracking objects through these regions of "singularity".
- If using a rotating dome, PWI4 has the ability to delay between exposures to assist when dome slaving is not as fast as the mount. To enable this feature, click **Prompt before exposing** under the **Build pointing model** menu.

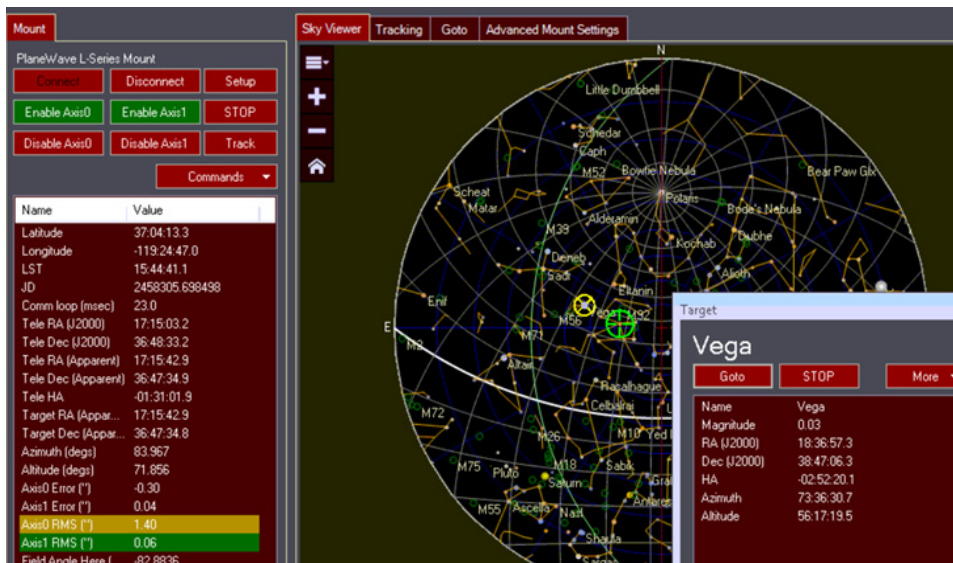


- If using a monochrome CCD select the red filter when creating a pointing model as this filter will increase contrast.

CREATING A POINTING MODEL (CONT.)

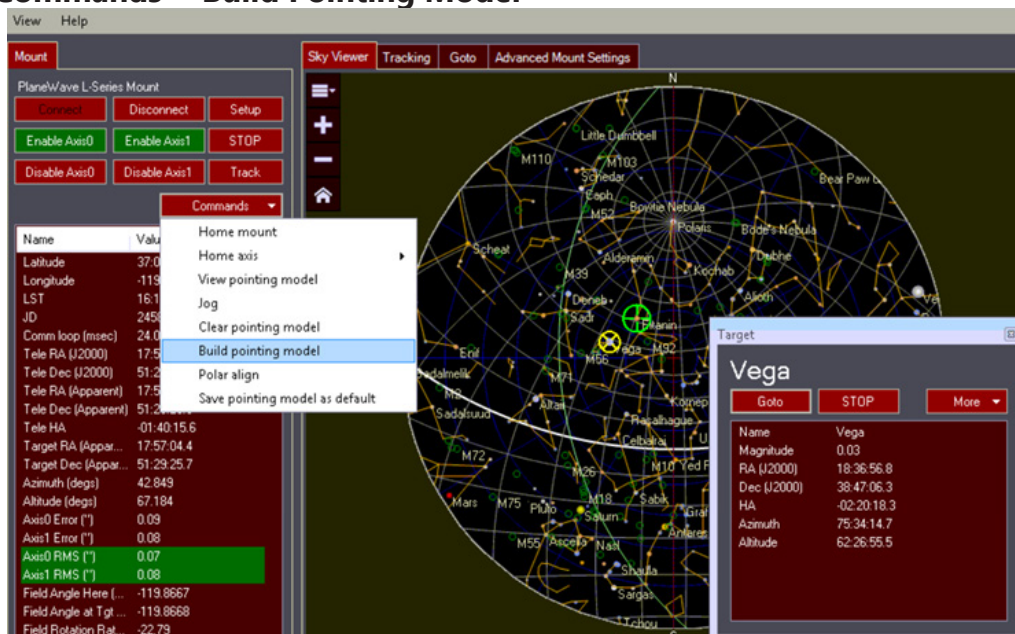
Building a Pointing Model

1. In PWI4, **first home the mount** then click a target in the Sky Viewer and click **Goto**.



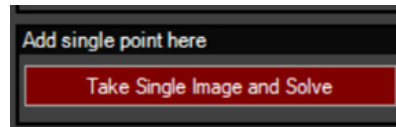
Note: The telescope is not likely to slew directly to this target you selected because we have not created the pointing model yet.

2. Select **Commands > Build Pointing Model**



CREATING A POINTING MODEL (CONT.)

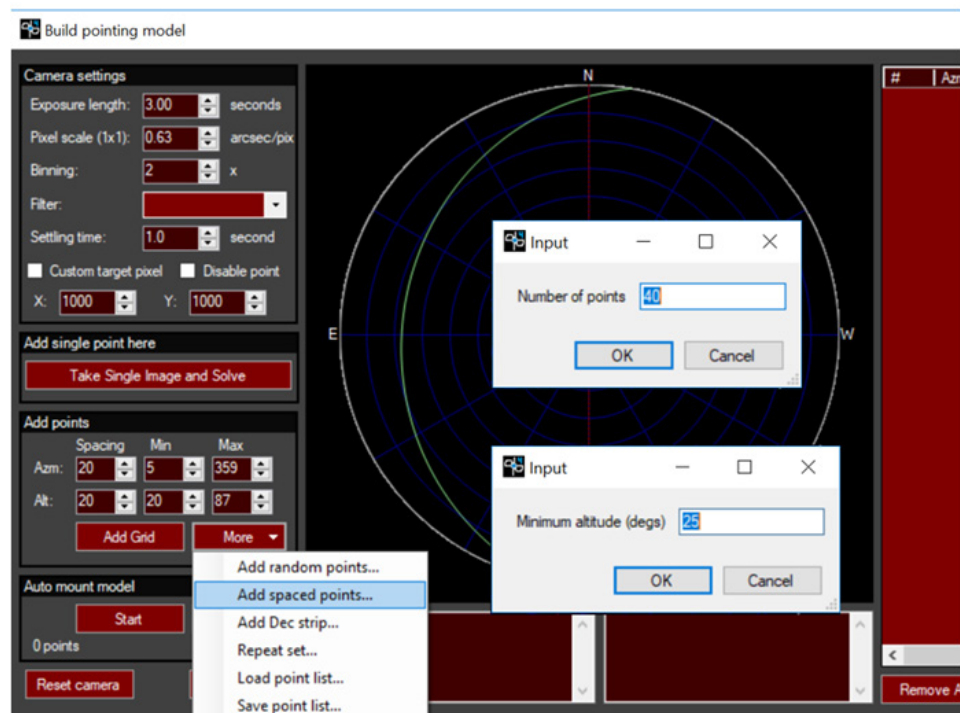
3. After the telescope has stopped slewing, we need to plate solve one image before building the larger pointing model. Click **Add Single Image and Solve**



a. Keep your exposure length short (e.g. 1 to 3 seconds) to prevent star trailing of the first images. ***Plate solving this first point is crucial for the next step of building the entire pointing model.***

4. Now you can automatically build a model. Between 20 – 30 points will make a good first model. We recommend building your model automatically via **More > Add Spaced Points**.

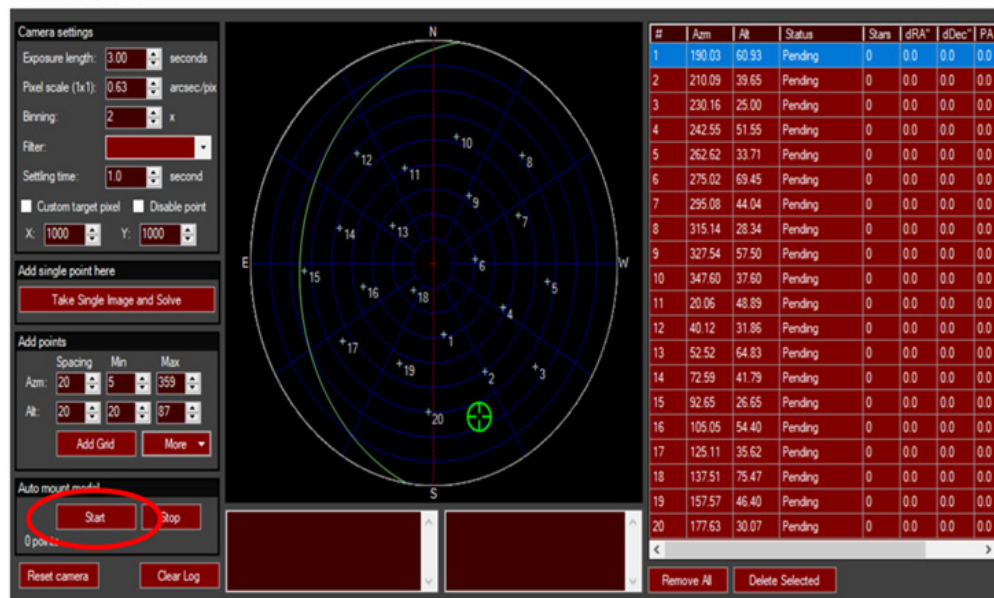
a. **Add Spaced Points** is the recommended sampling procedure for building a pointing model. This is due to the fact that it gives the best distribution of points across the sky. In short, the distribution of points helps the model determine as many mechanical variations for your specific setup as possible.



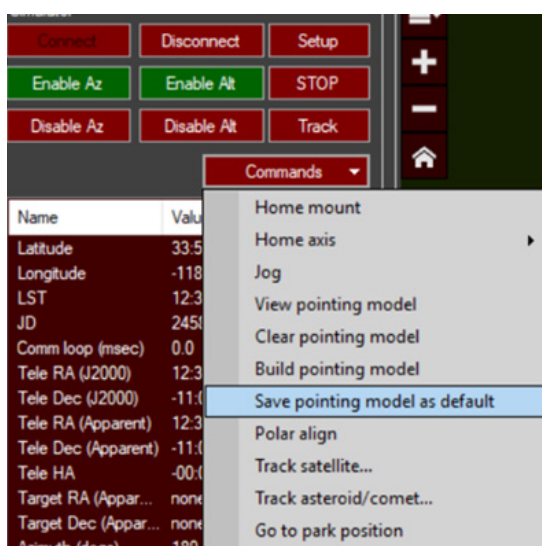
*The remaining model sample generation methods should primarily be used if advised by a PlaneWave employee for specific reasons.

CREATING A POINTING MODEL (CONT.)

5. Enter the number of points to use and click **OK**. Next, set the minimum altitude of points depending on your observing location (i.e. trees, buildings, or dome interference), click **OK**.
6. **Increase Settling Time** under **Camera Settings** if you are using a dome that moves slower than the mount.
7. Click **Start** to begin creating the pointing model. The telescope will slew point to point, capturing an image and checking that against a known star catalog to verify it's position. If the plate solving succeed in matching the status will change to **Added to Model**.

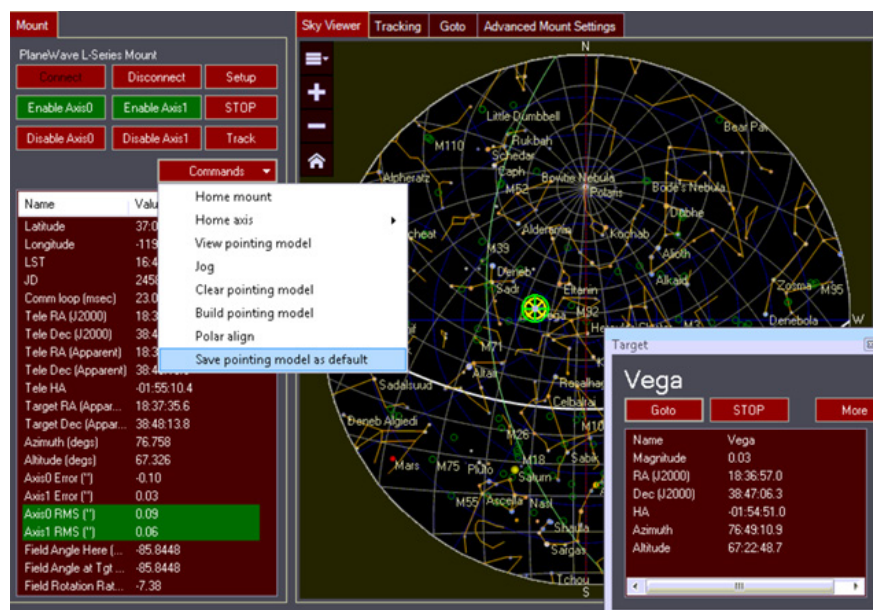


8. Save your new model once the automatic pointing run has finished by clicking **Commands** > **Save pointing model as default**. PWI4 will now recall this pointing model when closing and opening the software.

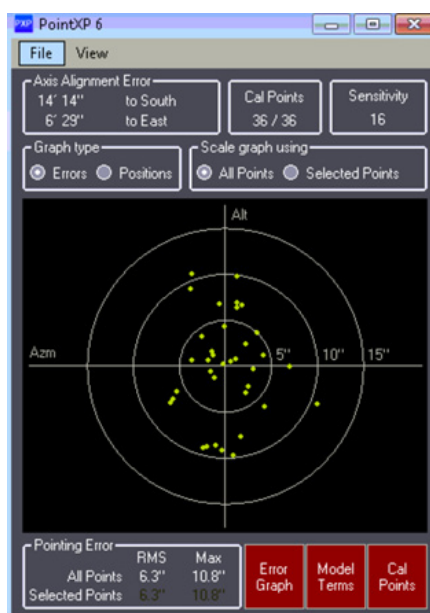


CREATING A POINTING MODEL (CONT.)

9. Once the pointing model has finished you can save the pointing model as default if your equipment is permanently mounted via **Commands > Save Pointing Model as Default**. PWI4 will now recall this pointing model each time you reopen the software, ideal for permanently mounted observatory equipment.



10. Let's pull up a graph of our pointing model. Access this via **Commands > View Pointing Model**. Here you will see the RMS error in arcseconds of your pointing model, ours has an error of 6.3 arcseconds, which is very good.

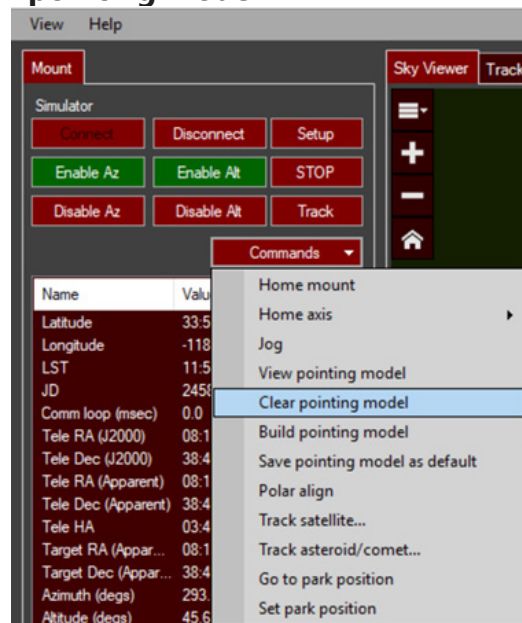


CLEARING A PREVIOUS POINTING MODEL

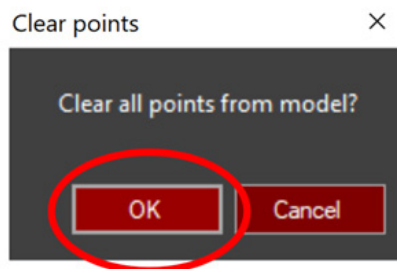
Clearing a Previous Pointing Model

In the event that you wish to clear your old pointing model to rebuild a new one, follow the steps below. Clearing your previous model is important to prevent errors with the new model.

1. Click **Commands** > **Clear pointing model**

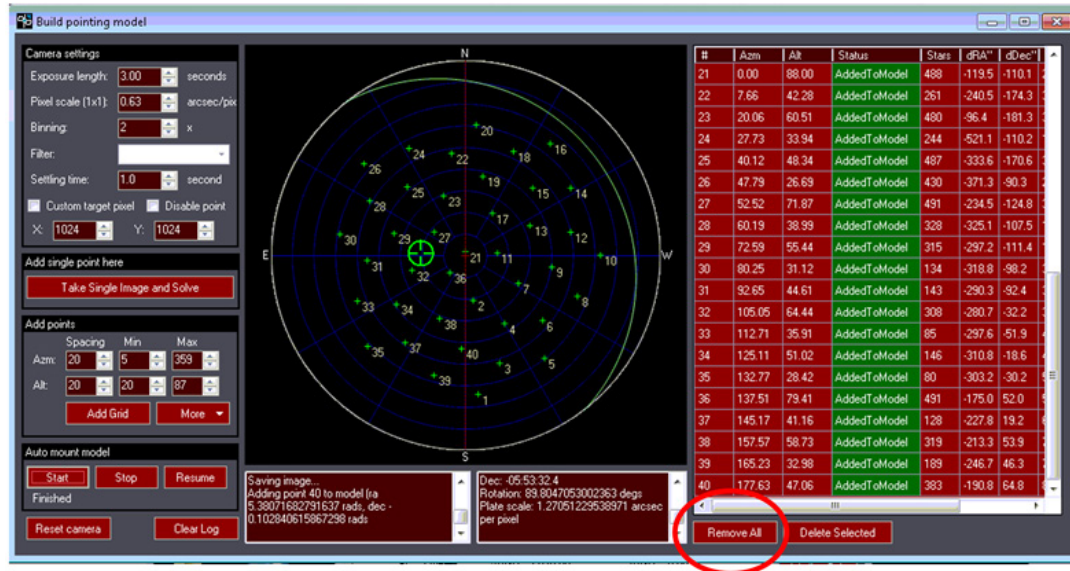


2. Click **Ok**

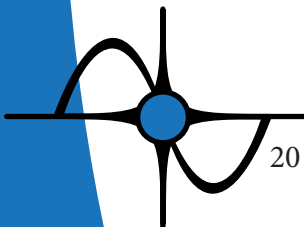


CLEARING A PREVIOUS POINTING MODEL

3. Click **Commands > Build pointing model > Remove all points**



After performing the above steps PWI4 software is now cleared of the previous pointing model. From here, you can home the mount and rebuild a new pointing model.

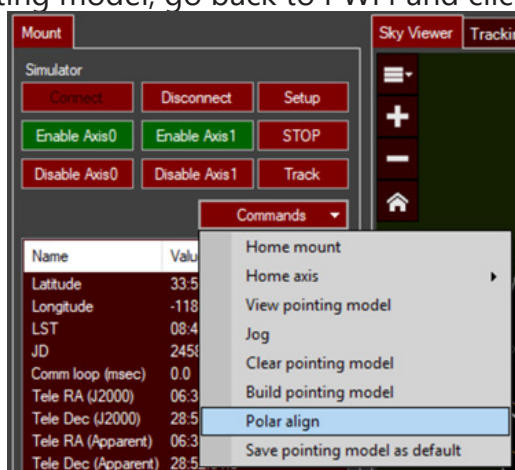


WEDGE POLAR ALIGNMENT

After your first pointing model has been created, and if you have an optional equatorial wedge installed, PWI4 can be used to help refine polar alignment. Error of less than 10 arc-minutes in each axis is recommended and realistically 1 arcminute will be a practical limit. PWI4 software will account for residual polar alignment error in the model.

Before adjusting the wedge via the supplied wrench tool please loosen the 6 bolts holding the wedge-top to the wedge-base plate by 1/4 to 1/2 of a turn in order to allow for the wedge to freely move during wedge polar refinement.

1. After building your pointing model, go back to PWI4 and click **Commands > Polar Align**.



2. After clicking **Polar Align**, the first box to appear is a polar alignment software prompt. This shows you how much adjustment of the azimuth and altitude in deg./min./sec is required. For the example prompt below, the azimuth bolt needs turned 3.5 turns counter-clockwise (note: one full turn of the azimuth bolt is 0.33 degrees, so $1.158 \div 0.33 = 3.5$ turns). The altitude adjustment required is about 8.5 turns up ($3.984 \div 0.47 = 8.47$). If your polar alignment was pretty close then these refinement values will be small (i.e. a few degrees or less).

Polar alignment



Move in azimuth 1.158 degs counter-clockwise viewed from above / left viewed from behind.

Move in altitude 3.984 degs up (for northern hemisphere).

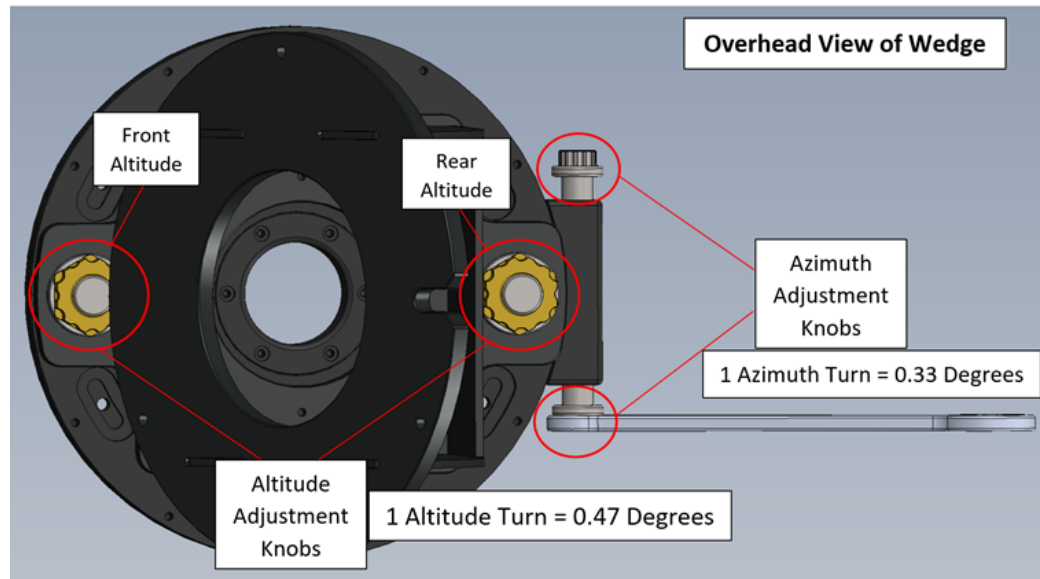
Do you want to offset the model? This will allow you to use a bright star to refine your polar alignment adjustment.

Yes

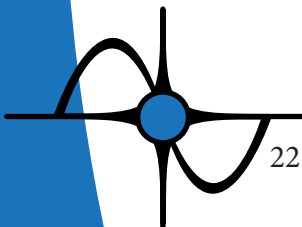
No

WEDGE POLAR ALIGNMENT

3. The image below shows the altitude and azimuth bolts located on the wedge to be used when making adjustments. 1 azimuth turn = 0.33 degrees and 1 altitude turn = 0.47 degrees.



4. If prompted to move down in altitude, loosen the back altitude screw and tighten the front altitude screw using the approximate turns per degree seen in the image above.
5. Follow the same procedure used in Step 5 to adjust the azimuth knobs to the recommended value.
6. Following adjusting altitude and azimuth, Click **Yes** to offset the model. Doing so will apply the polar axis correction to the current pointing model.
7. Once you have performed the manual adjustments in altitude and azimuth the next step is to slew to a star that's in the range of the next prompt.
8. Center the star in the middle of your camera's field of view by making fine adjustments to the altitude and azimuth knobs used in steps 4 and 5.



WEDGE POLAR ALIGNMENT

9. Finally, for permanent setups, use multiple iterations of creating pointing models and mechanically moving the mount axes to achieve polar alignment.

a. For the follow-up polar alignment model use a denser model with around 30 points.

10. Once polar alignment has been completed please make sure to retighten the 6 bolts on the PlaneWave equatorial wedge accessory, which hold the wedge-top plate to the wedge-base.

TELESCOPE USE

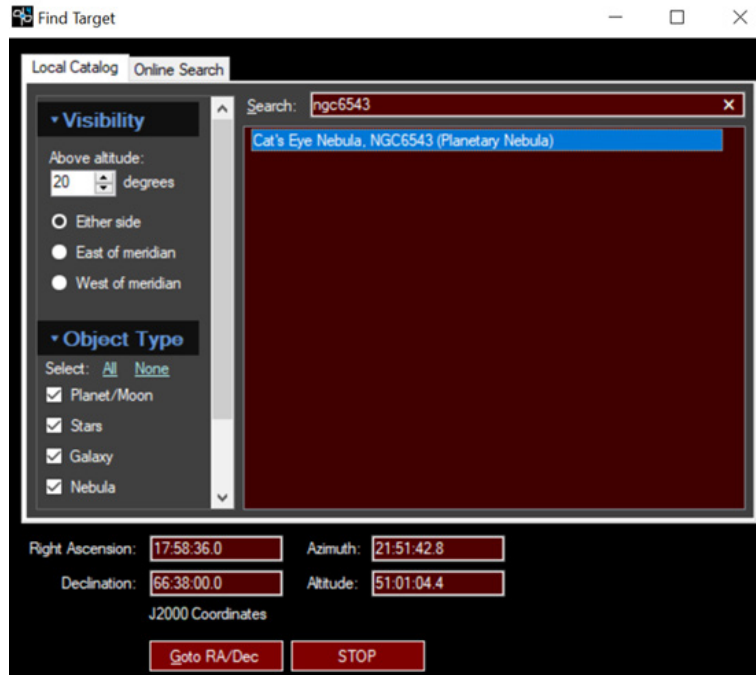
Slewing to Targets

1. Now starts the exciting part! Go ahead and slew to your first target to confirm success of the model! Do this via **View > Find Target (Ctrl+F)** or simply click on a target in the star chart and hit **GoTo**.



TELESCOPE USE - SLEWING (CONT.)

3. Try searching for objects with our integrated database. Simply type in a known object to find it's RA and Dec position, click on the object and then hit **Goto RA/Dec** to slew the telescope to the target.



TELESCOPE USE - TRACKING

Tracking Targets

1. After slewing to an object the tracking will automatically engage. If you wish to disengage tracking to stop the mount at a certain position, simply click the Track button.



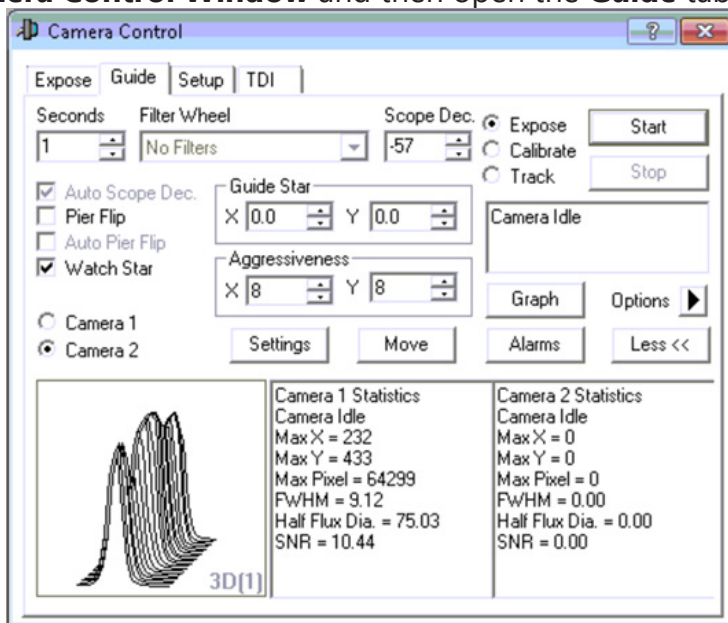
2. When tracking is enabled the Axis0 (Azimuth/RA) and Axis1 (Altitude/Dec) RMS numbers should turn green after slewing has completed. Ideally you should see RMS in both axes between 0.07 to 0.25 depending on how well balanced and vibration-free your setup is. Even small vibrations and the wind can affect tracking, which will raise the RMS in each axis. Re-balance your system if you find that your tracking is above 0.20 RMS or contact PlaneWave Support for adjusting the motor tuning. **Remember:** the lower your RMS is in each axis, the better your track will be.

Target RA (Appar...	20:00:24.6
Target Dec (Appar...	22:46:05.2
Azimuth (degs)	95.226
Altitude (degs)	51.221
Axis0 Error (")	0.07
Axis1 Error (")	0.10
Axis0 RMS (")	0.18
Axis1 RMS (")	0.09
Field Angle Here (...)	-63.2801
Field Angle at Tgt ...	-63.2801
Field Rotation Rat...	1.51

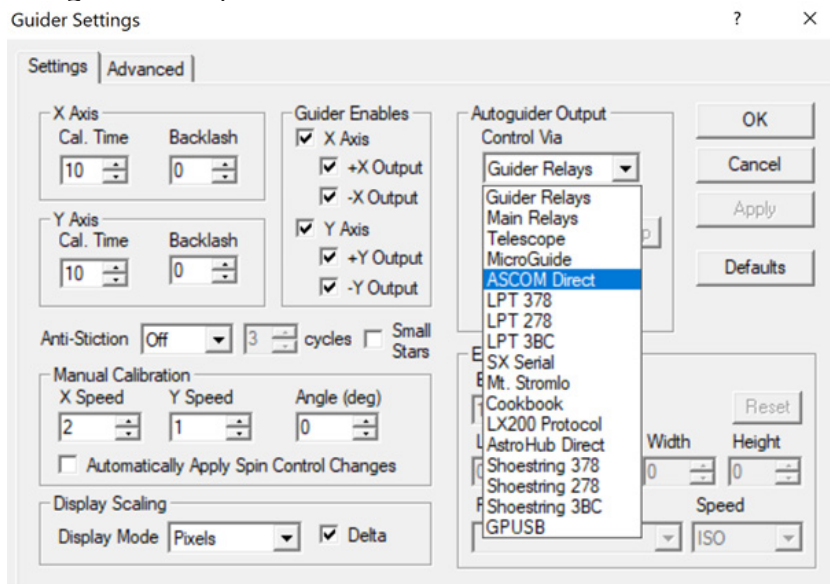
TELESCOPE USE - AUTOGUIDING

Autoguiding

1. To autoguide with your PlaneWave mount simply select the ASCOM compliant camera control software of your choice. In this example below, MaxIm DL is used.
2. Click **View > Camera Control Window** and then open the **Guide** tab.

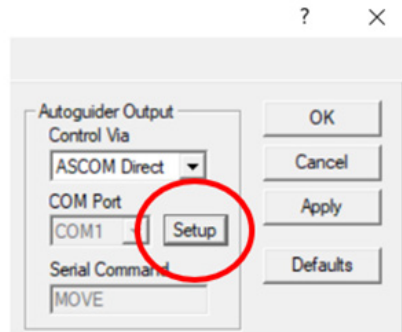


3. Under the Guide tab, click **Settings** and use the dropdown menu to select the **ASCOM Direct** option for Autoguider Output.

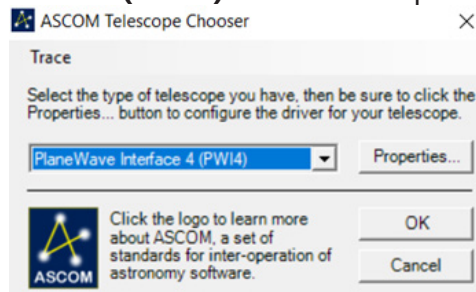


TELESCOPE USE - AUTOGUIDING (CONT.)

4. Click **Setup**



5. Select **PlaneWave Interface 4 (PWI4)** from the dropdown menu and click **OK**

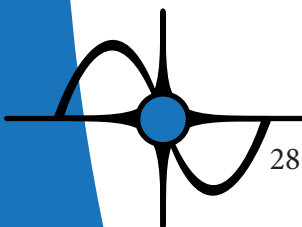


6. Now your autoguider camera is setup to send commands via to the mount. The final step is to perform the guiding setup procedures outlined in the camera control software you are working with.

Note: Since PlaneWave mounts contain encoders on both axes, tracking accuracy is already very high. Therefore, reducing how often your autoguider sends adjustment commands to the mount should be considered.

In MaxIm, this is done under via the following:

1. Open the Camera Control Window (Ctrl + W) > **Click Guide** > **Settings** > **Advanced Settings**
2. Increase the **Delay After Correction** to 15 – 20 seconds
3. Also, try lowering the **Maximum X/Y** moves from 2 seconds to 1 or 0.5 seconds

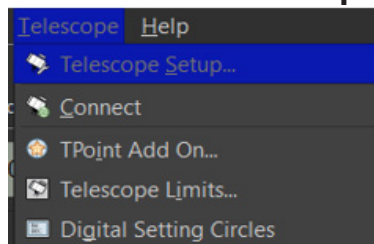


TELESCOPE USE - PLANETARIUM SOFTWARE

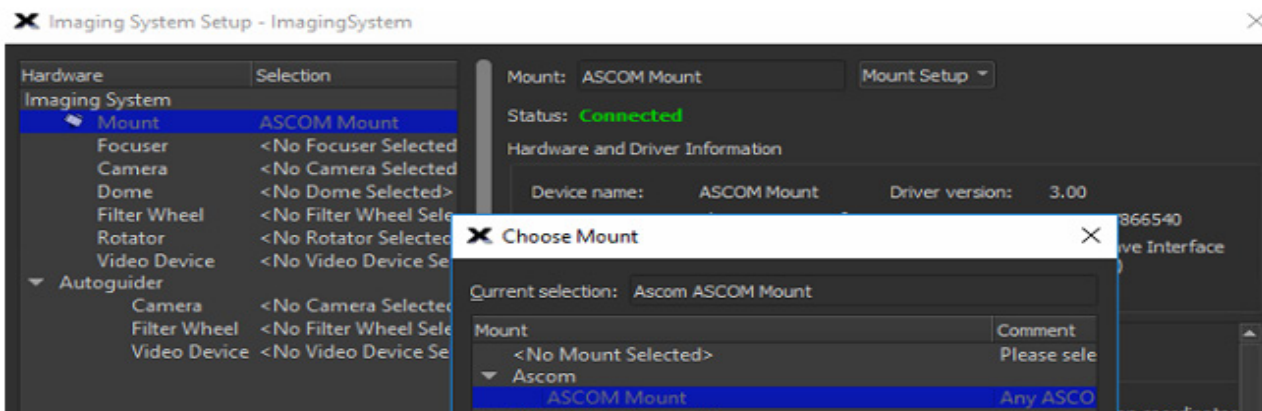
Connecting with TheSkyX

Once you are connected to the mount and the first pointing model has been created, some users of PWI4 may wish to use another planetarium software for telescope control. Below are steps on how to connect via TheSkyX. Make sure to download the most recent "daily build" from Software Bisque's website if you would like to connect via TheSkyX and also have the ASCOM Platform installed.

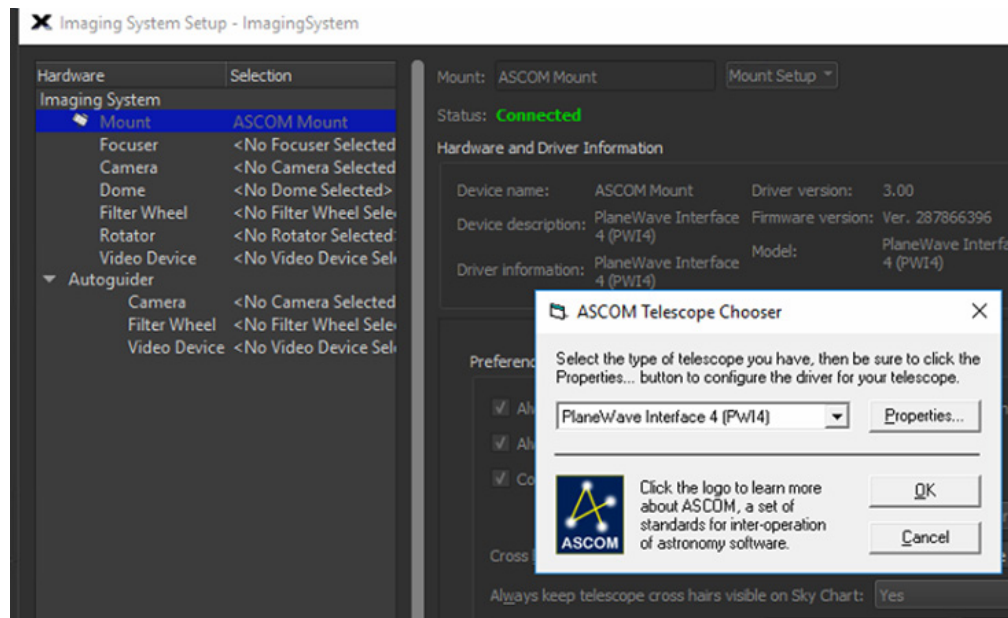
1. Open TheSkyX
2. Select **Telescope** in the top menu bar and click **Telescope Setup**



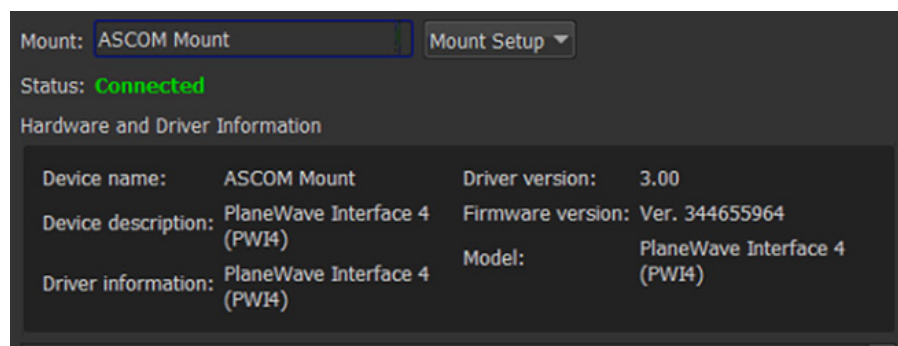
- 3 Click **Mount** in the Imaging System menu, then select **ASCOM Mount** from the dropdown menu. Then click **Mount Setup** > **Settings**. When the ASCOM Telescope Chooser dialogue box opens, use the dropdown menu to select PWI4 and click **OK**.



PLANETARIUM SOFTWARE (CONT.)



4. Make sure your telescope is powered on and connected in PW14 with both axis motors enabled, or TheSkyX will not connect. Now go back to the **Telescope** menu in TheSkyX and click **Connect**. You are now connected and ready to send slew commands via TheSkyX.

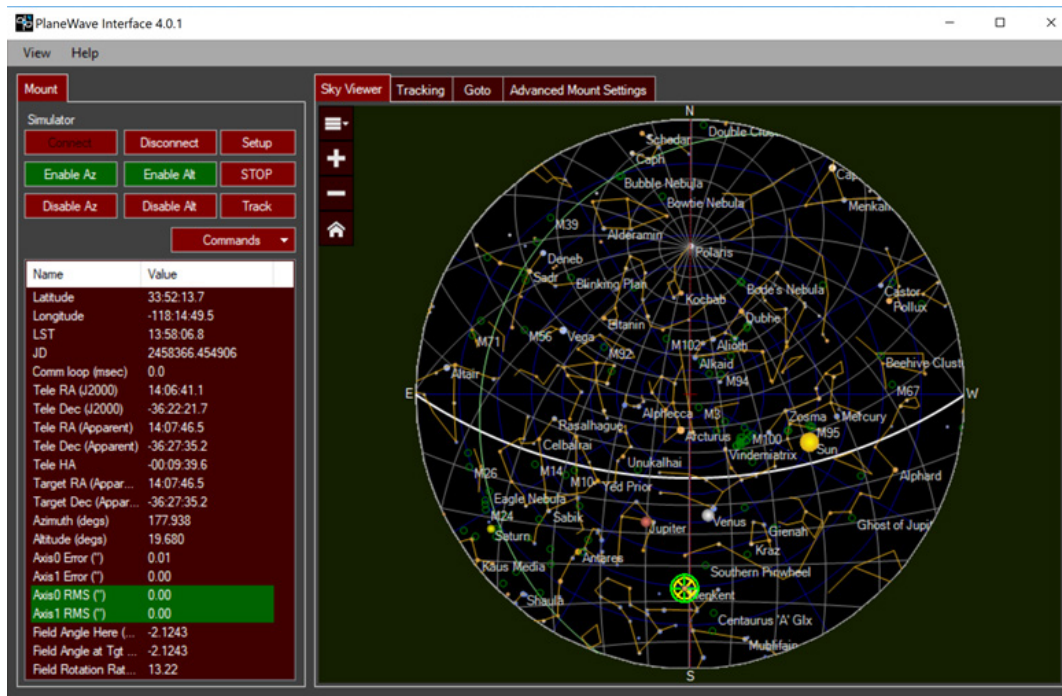


SETTING A MOUNT PARK POSITION

Setting a Mount Park Position

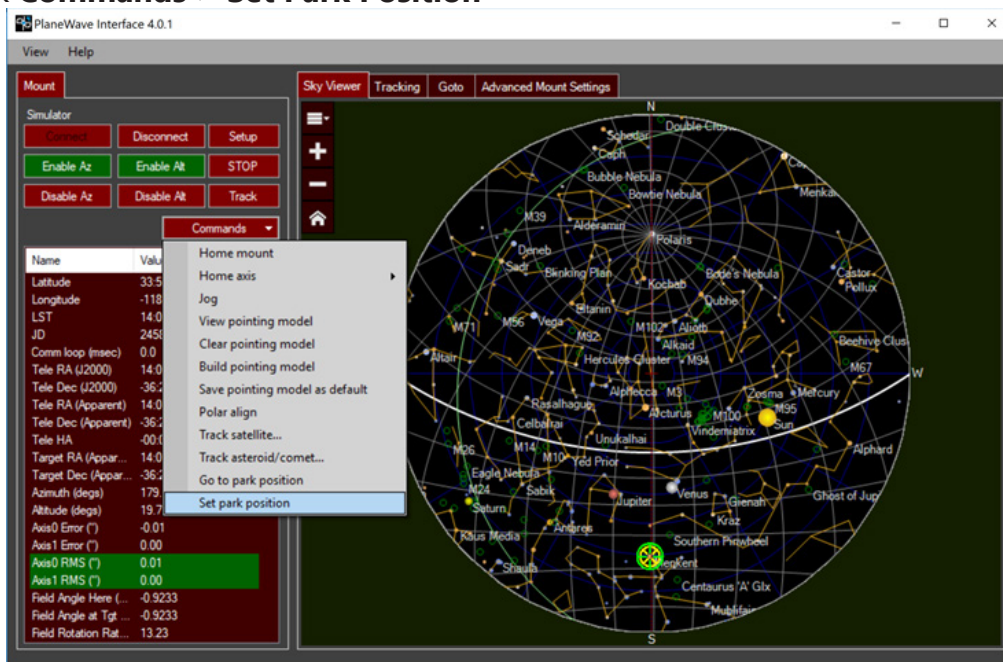
In PWI4 you can set a park position of the mount. This is a beneficial feature for users who want set the telescope to a certain position following use, such as in a roll off observatory with low ceiling clearance. Additionally, some users may operate remotely and want the park position to aim at a flat panel following their imaging session. To set the park position of your mount please follow the simple steps below.

1. In PWI4, connect to your mount and click a point on the Sky Viewer and slew the telescope to that point where you want the telescope to park. The green crosshair shows where the telescope is pointing, which is the location where park location will be set. For this example, I will set park to aim south.



SETTING A MOUNT PARK POSITION

2. Click **Commands > Set Park Position**

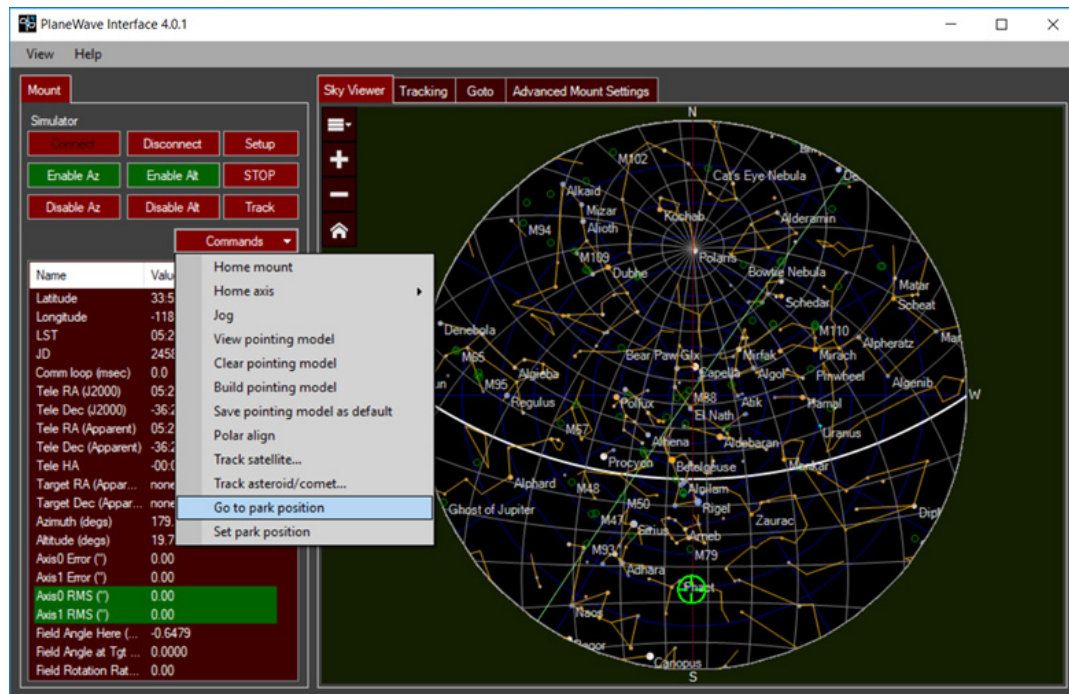


3. Confirm the park position by clicking **Set Park**



SETTING A MOUNT PARK POSITION

4. Confirm the park position was properly set back sending the mount to the Home position and then click **Commands > Go to park position**



CONNECTING THE JOYSTICK

Included with L-Series mounts and the PW1000 is a Logitech gamepad joystick that can be used for slewing the mount.

To set up the Logitech F710 joystick:

1. Plug the Logitech Nano Receiver into a USB port. Windows should recognize the device and install the correct drivers after a few moments.

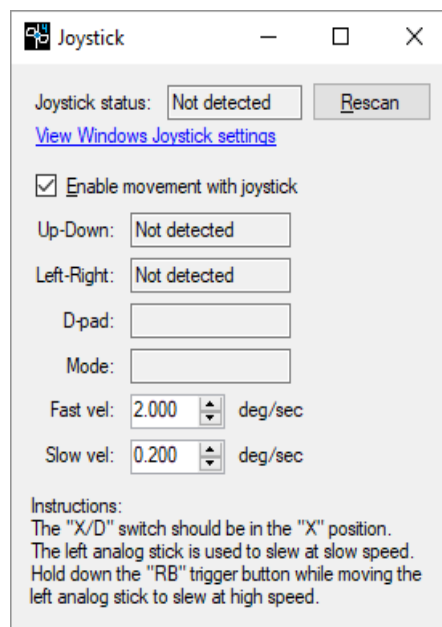


2. On the forward surface of the joystick, there is a switch that can be in either the X position or the D position. This switch rearranges some of the functions on the joystick. For standard usage, make sure the switch is in the X position.

3. Turn on the joystick by pressing the center "Logitech" button.

4. Launch PWI4 and connect to the mount

5. Go to the "View" menu and select the "Joystick Control" item. This will launch the following window.



CONNECTING THE JOYSTICK

6. If the joystick is not initially detected, click rescan.
7. Be sure to check the "Enable movement with joystick" checkbox.
8. Adjust speeds as desired.
9. Note the control instructions at the bottom of the window.



TROUBLESHOOTING NOTES

Unlevel Azimuth Base with Non-PlaneWave Derotators Introducing Pointing Errors:

Leveling the azimuth base when using third-party derotators (Optec, Moonlite, etc) is important to prevent errors from being introduced into the pointing model. Many of these after-market (non-PlaneWave rotators) do not provide the same degree of compensation when communicating with PWI4 if the azimuth base is unlevel. PlaneWave derotators are able to provide compensation and account for the azimuth base being slightly unlevel in PWI4, so you will not have to follow the same degree of precision if using the PlaneWave IRF90 rotator. To make sure your azimuth base is level when setting up your mount, we recommend following the procedure below.

1. Use a digital level to get the azimuth base level when setting up the base.
2. We recommend using a digital level to achieve 0.50 degrees off from level.

If “Take single image and solve” does not work and gives a Maxim labeled error in the PWI4 window:

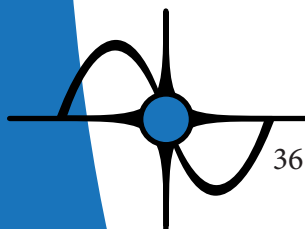
Run PWI4 as an administrator and this should solve the problem by right clicking on the PWI4 icon and selecting “run as administrator”. Also try clicking the Reset Camera button in the Build Pointing Model window.

Trailed stars at the corner of your images when imaging a target near Zenith in Alt/Az mode:

If you are experiencing trailing on the corner of your images when using an alt/az setup and IRF90 derotator when imaging near Zenith, then the likely solution is to add more points to your model around Zenith. Imaging near the Zenith is difficult if your current pointing model is under-sampled around the zenith. Try adding 40 to 50 more points between 60 and 88 degrees latitude to your current model.

Adding Custom Target Pixel in PWI4 for increasing precision of the IRF90 rotating focuser when setup in Alt/Az mode.

1. Point at a star field.
2. Take a long exposure (i.e. 5 min) while moving the IRF90 rotator in PWI3 manually 180 degrees during the exposure. During that exposure you will see star trails in the resulting image because the rotator is moving.
3. Open that 5 minute image in Maxim DL and locate the center of where the star trails appear smallest, that’s where the center of rotation is for the imaging train.



4. Take that image into MaxIm DL and look at the X Y coordinates of that pixel where the rotation appears to be centered.
5. Go back to PWI4 and enter the X Y coordinates you identified in Step 4 under **Commands > Build pointing model > Camera settings > Custom Target Pixel**. Make sure to check "Custom Target Pixel" box as well.

