



from Firmware 1.20

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1. Methods supported

From Fw. 1.20 there is two methods for carrying out a precise polar alignment. One is an easy to use visual method for one who can see the pole on the sky and an other for the ones who can not see to the pole. These two can be found at the “Live View” menu’s “Polar align” item, which has this two alignment methods as a submenu.

When the pole is not visible, there is the Scheiner method that can help the user to determine the value of misalignments and the Firmware also helps how much to adjust the mount (in altitude or azimuth). The procedure takes time, the more time is spent, the more precise the measurement is (for good quality mounts). The theory of the method is in [this section](#), while using the Firmware for this method is described [here](#).

When the pole is visible, you can use the plate solving based visual method to align your mount to the pole. A very good precision is accessible in a few minutes. You can see the details and description [here](#).

2. Visual method

The Firmware ver. 1.20 contains embedded star data (no SD card required) for the two poles (northern and southern) up to 8 degrees away. MGen-3 is able to identify the star field within this area with plate solving. If you point a shorter focal length scope -possibly your guide scope- to the pole's area, you can easily find where your mount's RA rotation axis points on the sky and align it with the celestial pole's position. That's what this method offers.

2.1. Prerequisites

The plate solving without a big data structure for searching works fast only if a reasonably good focal length is set for the MGen-3. First you need to set the focal length of the used optics (guide scope or an objective) within ca. 10% precision. If you don't know the exact value, the Fw. offers to find the exact focal length for you. This may take up some seconds but should be run only for once and the precision is mostly much better than 1%.

The second thing that may be necessary to have a well running plate solving is a good focus to see not only some stars but all 'visible'. To help this you are advised to use an IR cut filter put before the MGen-3 Camera, that is also advised to have for guiding when you are using a guide scope that is not well corrected at the infra-red region. (Default and simple optics are not, all achromats needs that.)

Keep in mind that plate solving needs still frames. While moving / adjusting your mount the exposures are active and so the Camera sees blurred images, trailed stars etc. In this case plate solving may give no or "intermediate" result so always wait for the next still frame to get good feedback of your correction made etc.

The polar alignment always uses the highest gain (9) setting to take frames but this will not affect your setting for guiding, it is only active while the Visual alignment's screen is active. The exposure time is chosen to be just enough to do the alignment and plate solving well, it's 1 second. The system is designed to work with the following focal length and speed (f-ratio) of the optics:

focal length	f-ratio	(min. diameter)
50 mm	f/4	12.5 mm
100 mm	f/4.5	22.2 mm
180 mm	f/5	36 mm
300 mm	f/6	50 mm

Different values may also work well. Faster optics (lower f/ number) are welcome, while slower optics may need to be used with increased exposure time. (The Fw. offers this option.) The focal length interval (for determination) is set between 50 and 300 mm, though MGen-3 is able to find the focal length of a 28 to 430 mm optics too and would also probably work. (The closer to these absolute limits the less probably.)

Note that if you observe from near the equator, both poles' area may be at a too low altitude and the frames taken may not be good enough to serve plate solving.

2.2. The Visual alignment screen

When you select the screen (“Live View” / “Polar align” → “Visual”) you can see this screen on the right.

By the [Hemisphere](#) item you choose which pole you can see. This is the same variable as for the Scheiner screen and is preserved. Plate solving will apply the appropriate star data for the forthcoming frames, when changed.

To determine the focal length of your optics / guide scope first you should point it near the pole, where plate solving works. (Stars’ data is for 8 degrees away max.) Press **Find focal length** button and after some seconds the result should appear. If a good match is found, you’ll be asked if you want to store that value for the MGen-3.

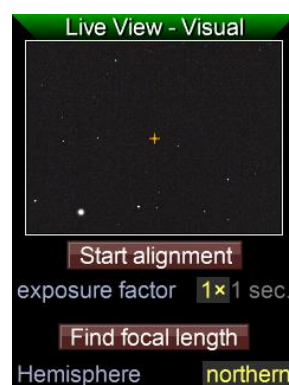
It is highly advised to determine the focal length of your optics by using plate solving before the alignment to minimize missed solves during it, though it’s critical only if the actual value is near the limits of the entered focal length (within ca. $\pm 10\%$).

If the optics is too slow and it sees too few stars only, the default exposure time of 1 second can be multiplied up to 4 seconds by the [exposure factor](#) item.

The main alignment procedure is started by pressing the **Start alignment** button. The Fw. guides you through it, but it is described more detailed in the [next section](#).

When this screen is active, it runs the plate solving for each new frame taken and shows the result if there is any. If no match is found you can see only the latest frame with some stars on it.

If it has found a good match, the celestial pole’s position on the shown frame is marked with a cross and circle, if it’s within the field of view of the Camera and you can also zoom into it:



In the case if the pole was outside the view, the direction and distance of it from the view's center is displayed:

The celestial pole's sky position is corrected for the Earth's precession, the slow drift of the pole from year to year. The date set in MGen-3 is used for this, so be ensure that the date is set correctly. The celestial pole shifts its location on the sky by ca. 20" each year.



(This special screen owns the Camera's control interface so it's not allowed to switch to this screen when AutoGuiding is active or other function is running in the background (star search, one-push etc.) issued from the API by a PC. Similarly such API functions can't run while this screen is active.)

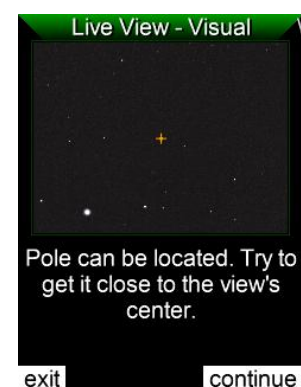
2.3. The procedure

We assume that all conditions listed in [Prerequisites](#) are satisfied. Your mount's RA axis should already point close to the pole, at least within the search area, what is 8 degrees. This can be done by naked eye on the northern hemisphere where Polaris is clearly visible or roughly done by your mount's polar scope.

After pressing **Start alignment** button a message box informs you that by continuing you are meant to point your guide scope so that the pole's 8 degree area can be seen. The view goes back to fully zoomed out.

- 1) If the pole can be located, you can see it displayed as normally and have the "continue" option at the SET button. The Camera view's sky orientation is stored internally. Press SET to go to the next step.

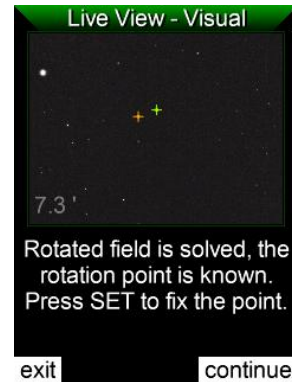
The best is that the pole is visible within the field of view (very best is at the center), though it's not that important if your mount may be quite well misaligned yet. (It will be important later, we'll refer back to this.)



- 2) At this step you need to rotate the RA axis by at least 15 degrees to have a reasonably good new Camera view position, from which (along with the previously stored one) the RA axis' rotation point on the sky can be determined. This is essential as you'll need to align this point with the celestial pole at the adjusting step. Precision of this point gets better as the rotation angle increases (up to 180 °). Quite good is above 45, very good is over ~70. The direction of rotation doesn't matter. (Note that if the alignment is too bad yet, you may rotate the Camera out of the 8-degree area of the pole, so in this case a lower amount of rotation is enough.)

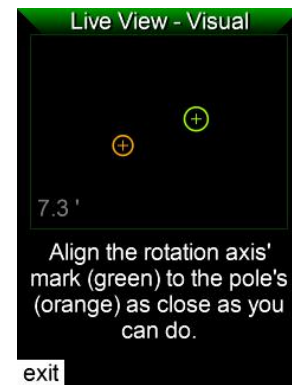
Unless you have rotated below 15 °, you can see "Rotation is too low yet..." on the screen and you can't continue to the next step.

As soon as the angle is acceptable you can see the screen as on the right. A green cross shows the calculated rotation point of your mount's RA axis on the sky. (The distance (misalignment) between this and the celestial pole is displayed as grey at the left bottom of the view.) By pressing SET ("continue") this point will be fixed at the Camera's coordinate system as your mount turns around this point by the Camera's point of view. You'll need get the celestial pole to this point as the next step to have a good polar alignment.



Note that the rotation point (green cross) may not be visible but the text indicates that plate solving ran ok and the point is known by the MGen-3, somewhere outside the view.

- 3) The last step is doing the alignment in altitude and azimuth. The Camera frames disappear and a virtual image is shown, where the two point -the celestial pole and the rotation point- can be seen together. Zooming is automatic, the closer the points are to each other, the higher zoom is used to display them. At higher zoom the size of the circles are larger. The center crosses have a fixed display size. The actual distance of the two points are always shown so you can monitor if the adjustment was done in good direction or the opposite. The virtual image is not rotated during the alignment so you can track which direction the pole moves by aligning the alt. or azi. of the mount.

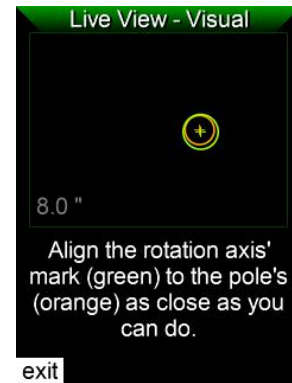


When the two circles intersect, it's a quite good alignment for any allowed focal length but you can align them as low as you can do.

Once done, you can quit the procedure by ESC.

If you had a poor alignment before starting the procedure and any of the points were out of the Camera's view and need a very precise alignment, you are advised to start a new procedure but this time you should align the guide scope (only that, not the mount!) so that the pole is near the center of the view, at the 1st step. By this the measurements at this second alignment offer an even more precise result.

A quite satisfactory alignment out in the field may look like this. The misalignment here is only 8", which is achievable and is way too good for photography and can be carried out in some minutes. The mount mostly mechanically limits the possible precision.



3. Scheiner method

Also known as “declination drift method” as it uses the drift observed on the direction of the declination axis due to a polar misalignment. MGen-3 Firmware offers the method for accurate polar alignment.

From Fw. ver. 1.05 there is the possibility of executing the required corrections precisely with visual feedback.

There are two parts of the method, each one is used to measure the polar misalignment’s direction and value: for altitude and for azimuth. The method is the same for the northern or southern hemisphere, depending on which pole is visible (above the horizon) but there are small differences in the interpretation of the directions.

The method’s parts must be used alternately, here’s a brief example of execution of this method:

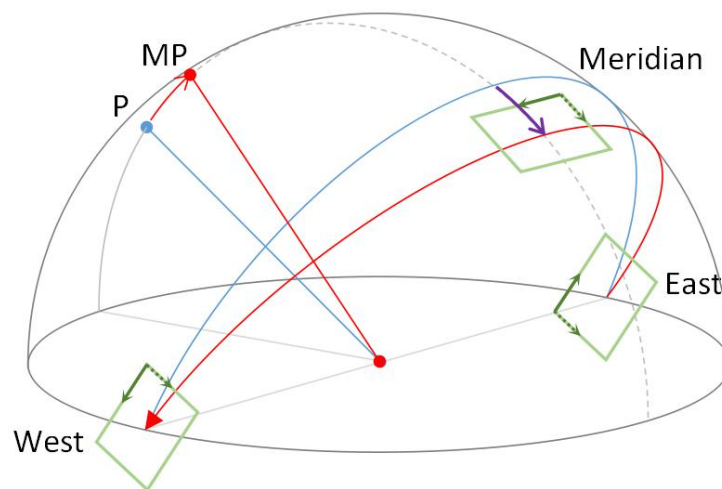
1. Measure at East/West.
2. Point to the Meridian and correct for the altitude of the mount.
3. Measure at the Meridian.
4. Point to East/West and correct for the azimuth of the mount.
5. Iterate from point 1.

The number of iterations required depends on the precision of the adjustment (the other direction (Alt/Az.) should not be altered when adjusting), on the precision of the measurements (mount’s mechanical quality) and the distance to the optimal point of the measurements. In practice one or two iteration gives an acceptable accuracy for guided photography, more iterations can give almost perfect polar alignment.

3.1. Measuring for the Altitude component

You must point your telescope (or guider scope) to the **East** or **West** location of the horizon, on the celestial equator (zero declination), or a near sky position to them. At this location you do a measurement for some minutes while the mount's tracking is on and observe the drift of the star field in declination direction. The result will approximately tell you how much is your mount's axis **above** or **below** the real polar axis. Then you can adjust your mount in Altitude to have a better polar alignment at this direction.

MGen-3 Firmware from ver. 1.05 offers visual assistance to make the correction precisely. For this you should point your scope perpendicular to the measuring point so to the **Meridian**, still close to zero declination. When correcting your mount in altitude, the movement of the star field can be observed and MGen-3 will show you a goal line where the star should be moved on to correct the measured misalignment.

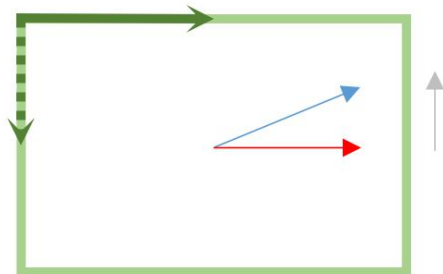


The example drawing of the northern sky hemisphere above shows the effect of the polar misalignment in **altitude**. The observer's point (O) is in the center, the Earth's polar axis point or northern **celestial pole** (P) and the **celestial equator** is given. Zero-declination stars move on this half circle from East to West. The **mount's polar axis** point (MP) is some above the **celestial pole** or is towards the zenith and so the **mount path** where the telescope is moved along on the sky is a bit tilted. This path and the celestial equator intersect at East and West points.

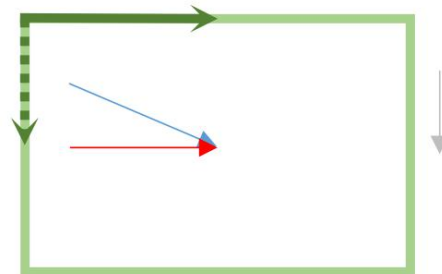
A **Camera's field of view** are also shown for demonstration. (It's X coordinate equals RA direction and is shown with a **solid line arrow**, while the Y coordinate equals DEC direction and shown with **dashed line arrow**.)

We take the measurements at East or West because the drift speed of a star on the Camera's view is the highest at these points as the mount follows the **mount path** but the **stars** move on the **celestial equator**. This maximal drift speed depends on the amount of polar misalignment in altitude and so one is able to calculate misalignment's angle.

At East the Camera's view:

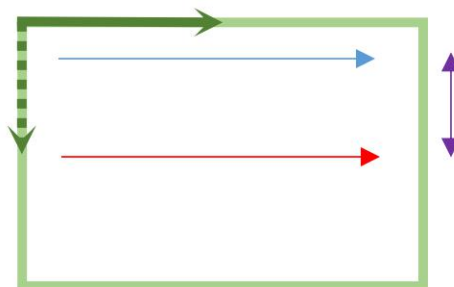


At West the Camera's view:



The **highest amount of distance** (declination) between them can be measured on the Meridian line. The **star** is maximally drifted towards the pole and so we can do the correction here visually as the altitude error (tilt angle) is equal to the **drift observed here**.

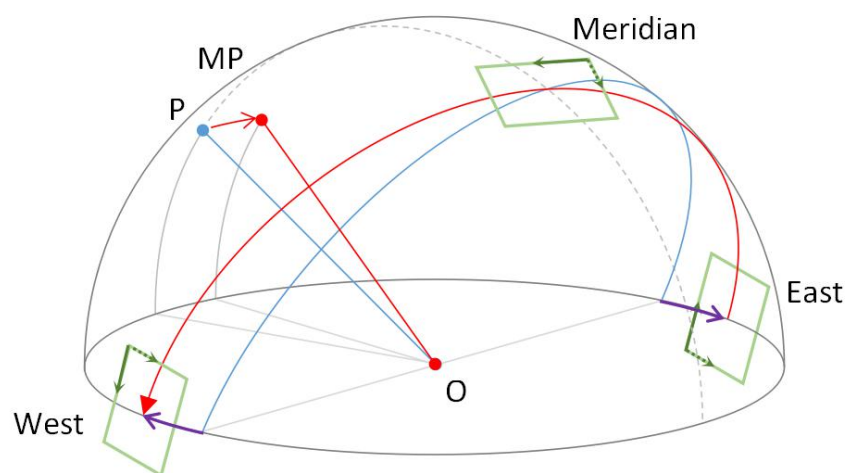
On the Meridian the Camera's view:



3.2. Measuring for the Azimuth component

The method is very similar, only the used sky locations differ from the previous one: you must point your scope to the **Meridian** near to zero declination and take the measurement at this sky location. The result will approximately tell you how much is your mount's axis to the **right** or **left** of the real polar axis. (When facing to the pole's direction (north or south).) Then you can adjust your mount in Azimuth.

For the visual assistance you should then point your scope to the **East** or **West** and while you are adjusting your mount in azimuth the star field will move in declination. The goal line is shown the same way by the Firmware.

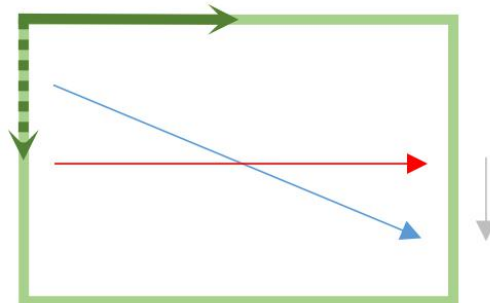


The example drawing of the northern sky hemisphere above shows the effect of the polar misalignment in **azimuth**. The observer's point (O) is in the center, the Earth's polar axis point or northern **celestial pole** (P) and the **celestial equator** is given. Zero-declination stars move on this half circle from East to West. The **mount's polar axis** point (MP) is somewhat right to the **celestial pole** or is towards East and so the **mount path** where the telescope is moved along on the sky is a bit rotated. This path and the celestial equator intersect right at the Meridian line.

A **Camera's field of view** are shown here too.

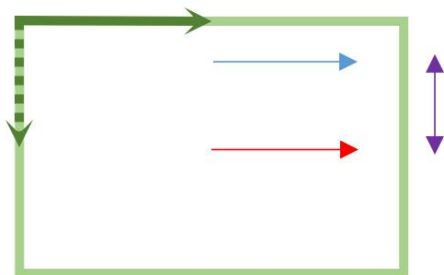
We take the measurements at the Meridian because the drift speed of a star on the Camera's view is the highest at these points as the mount follows the **mount path** but the **stars** move on the **celestial equator**:

On the Meridian the Camera's view:

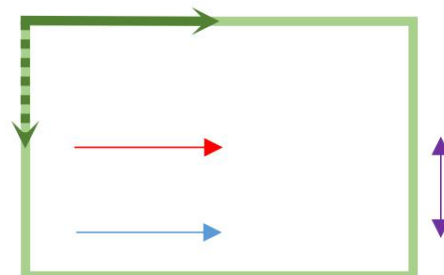


The **highest amount of distance** (declination) between them can be measured on the East or West points. The **star** is maximally drifted towards or off from the pole and so we can do the correction here visually as the azimuth error (rotation angle) is equal to the **drift** observed here.

At East the Camera's view:



At West the Camera's view:



4. How to use the Firmware for Scheiner

The controls for the method can be found at “Live View (menu) / Polar align (page)”.



Prerequisites for the Scheiner method:

- your mount is nearly aligned to the celestial pole (within some degrees);
- tracking is turned on;
- the guider Camera is focused optimally.

4.1. Enter main data

First you should set some main data of your guiding system and location.

Choose the hemisphere (northern / southern) of the Earth where you are observing from. (With other words: which celestial pole you can see.)

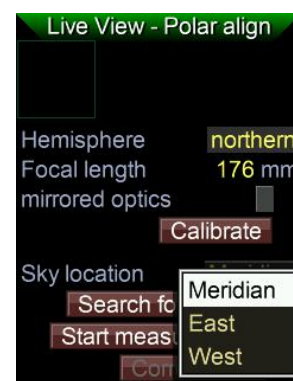
Then check or specify the **effective focal length** of the guiding scope used, including a Barlow lens or reducer. If you are not sure, just guess for it and keep in mind that the measured and displayed angle values may be invalid. Though if you will use only the visual assistance feature for correction, the focal length value is not necessary to be given accurately.

You must also specify whether the guiding Camera is attached on a “mirrored optics” or not. A “mirrored optics” means that the optical system gives a mirrored image. This is the case if there is an **odd number of reflecting surfaces** present in the optical system in front of the guiding Camera. This includes mirrors and prisms too. (An off-axis guider adapter is also probable to have a mirroring element in it.) Lenses do not cause the image being mirrored.

4.2. Define a sky location for measurement

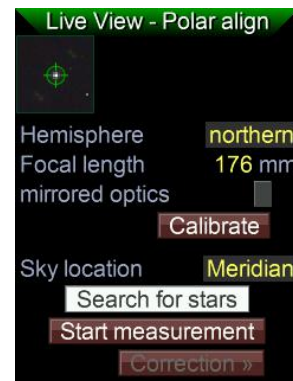
For the first step of the method you should choose a sky location to take the first measurement at. You should **point your guiding scope** near to zero declination and choose one of the following RA locations: near the Meridian line, near East or West point.

Define this location into the “Sky location” field on the screen. →



4.3. Search for stars

Click on the [Search stars] button. MGen-3 will try to locate as many stars as possible, within the given gain and exposure time intervals (that can be found at the “Live View / Star search” page). After success you should see a star with a green cross-hair on it in the left top small guiding window.

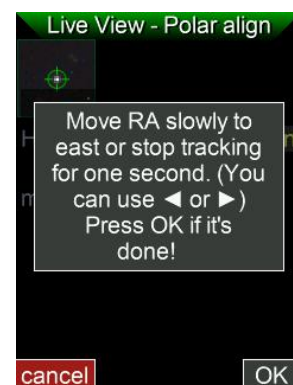


4.4. Calibrate for the declination

This step must be done only for once, you can skip this step in later iterations.

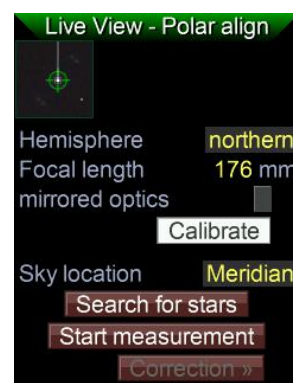
Calibration is needed because **guider should know about the direction in which the visible pole is** on the Camera's coordinate system, that is the direction of the declination axis. Click on the [Calibrate] button, wait some and the shown message appears. →

Now you need to slow down or stop the tracking for a short time (a few seconds, one might be enough). You can do it with your mount's controller or through the autoguider port using the left or right buttons of MGen-3 HandController. In this later case you must be ensured that the proper direction is signaled and the tracking will be slowed down. Then press [OK] (SET button).



After the new position is measured, a line starting from the star appears in the small guiding window. →
This line points nearly towards your mount's pole.

Now MGen-3 is prepared to return valid polar misalignment directions during the method's process.



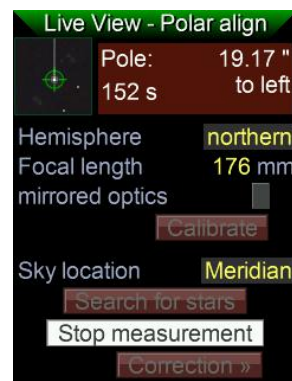
4.5. Do a measurement

By clicking [Start measurement] MGen-3 starts to **collect position data** and will display the currently approximated polar misalignment value and direction continuously on a dark red background. →

The time spent with the current measurement is also shown.

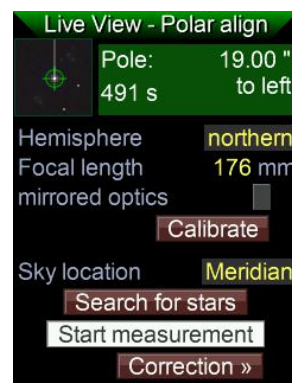
The star field's drift in declination is very slow. This step needs time to converge to an acceptable value, probably for few or many minutes. This depends on the actual seeing factor, on your mount's mechanical precision etc.

Note that leaving this screen will stop the measurement automatically as you must be allowed then to do any other thing with MGen-3.



When you see the value on the top right is converged and changes only a very little by time you can **stop the measurement** by clicking the [Stop measurement] button. The background changes to green, indicating that the measurement is finished now. →

The visual assistance option for carrying out the correction is now available.

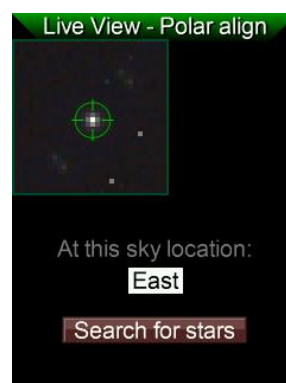


4.6. Switch to a new sky location for correction

Click on the [Correction >>] button and the correction screen appears. →

Choose a new sky location from the offered ones. (As we measured on the Meridian in this example, we have the option for East or West.) **Point your telescope** near to that RA location, still near to zero declination.

Next click on [Search for stars] button to **locate a new star field** at this new sky location.

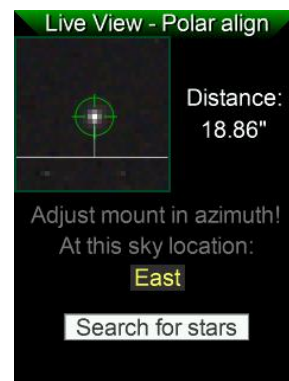


4.7. Carry out the correction on your mount

After a successful search the info are shown: →

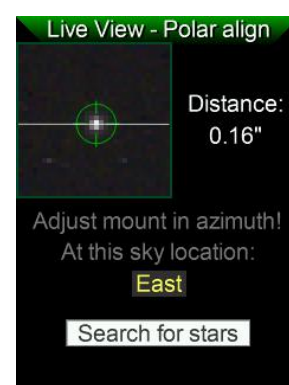
- in which direction you need to **adjust your mount** (altitude or azimuth);
- where (onto an assistance line) the shown star should be moved **by the adjustment screws** of your mount.

The actual distance (from the assistance line) is displayed on the right to the guiding window. You can see the “overcorrection” because a negative value is shown in this case.



After the adjustment is treated to be done so the shown **assistance line crosses the star** (→) and the distance is zero in long-time average, you can step to a new iteration (from “Define a measuring location:”).

Press ESC to go back to the Scheiner method’s page and start a new iteration for the orthogonal component of the misalignment. (Go to section 2.2 here.). Don’t forget to **change the sky location field** to the one used for correction (where your telescope points to) as most probably this location would be used as the next measurement location.



NOTE: Issuing a star search from the Scheiner’s correction screen uses special parameters to get a higher frame rate, not to lose the star so easy by trimming the mount’s screws. For the same reason if the star can’t be located on a frame, the Firmware automatically searches for it in the near environment and moves the guiding windows onto the brightest spot. But to be sure, try to trim the screws as smooth as possible to avoid sudden jumps of the guiding star. The distance value displayed is only valid for one star search result (therefore you can’t start it twice from here) and that’s why it’s important to avoid losing the star.

After both the altitude and azimuth distances measured last time converged near zero, you may be satisfied that your mount is precisely aligned with the celestial pole.

WARNING: the main info and sky locations must be set correctly, otherwise MGen-3 may show you the opposite direction and the correction carried out would nearly double the polar misalignment!

4.8. Interpretation of the displayed directions

MGen-3 displays the actually measured polar misalignment as the following: (valid for both hemispheres)

For altitude:

- Upward: the celestial pole is towards the zenith from the actual pole (RA axis) of your mount; altitude of RA axis must be increased.
- Downward: the celestial pole is towards the horizon from the actual pole (RA axis) of your mount; altitude of RA axis must be decreased.

For azimuth:

- To left: the celestial pole is to the left from the actual pole (RA axis) of your mount; the mount must be turned to the left direction (counter-clockwise) when viewed from top.
- To right: the celestial pole is to the right from the actual pole (RA axis) of your mount; the mount must be turned to the right direction (clockwise) when viewed from top.