The method at a glance

- Compared to the drift alignment method, this new method will allow you to easily achieve a perfect polar alignment in just one step. By "perfect polar alignment" we mean an offset error of only a few pixels from the true NCP

- The method is based on capturing two pictures at your CCD maximum resolution, binning 1 x 1
  - Image 1, named RA Mov. image: start and keep moving the RA from "Park" position towards East and launch a 2-3 min image capture. *Keep the mount RA moving towards East until the image capture ends.*
  - Image 2, named Sky Mov.: again from "Park" position, capture a 45-90 min image without moving the mount (keep the tracking off). *This long image is only captured the very first time you align the mount.*

    From then on, whenever you are in the same hemisphere and have the same optical train, only the short 2 - 3 min image capture will be required.

- Choose two star trails on both images (Sky Mov and RA Mov) and measure their starting and ending coordinates.
  These pairs will serve as reference stars. Select the same pair on both images.
  Then measure another 3 star trail coordinates on each image. *These extra star trails can be different for each image.*

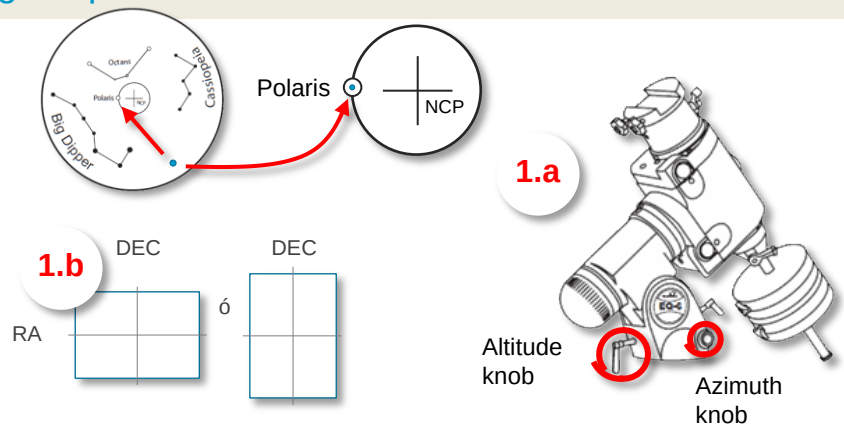
- Enter the stars' starting and ending coordinates *(x,y)* data into the RA Mov. and Sky Mov. worksheets.
  The "Calculated offset" worksheet will show the required amount of correction to apply to each mount axis.

- From "Park" position, turn the sidereal tracking on. Choose a star near the centre of the CCD field. Take note of the star's central pixel coordinates and add the required correction numbers as calculated. This will give you new x,y coordinates.

- Move the mouse pointer accurately pointing to the new coordinates and <u>leave it there</u>. Use the mount altitude / azimuth knobs to move the star from its current position to the mouse pointer position. The mount is now aligned.

Initial setup and RA Mov. image capture

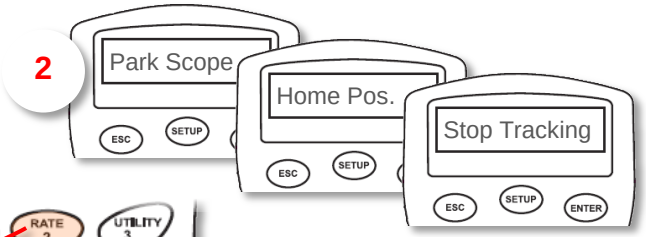
1. Initial setup:
   a. **Align your mount using the Polaris hour angle method** to achieve proper NCP (North Celestial Pole) alignment
      Or with Sigma Octantis if you are in the southern hemisphere
   b. **Align** the **CCD** axes with the mount **RA** and **DEC** axes



2. Go to ***"Park / Home"*** position

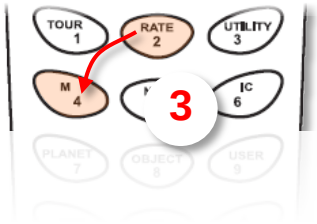
   A standard "Park / Home" position pointing at NCP is adopted.

   ***Important**: once at "Park / Home" position, set the mount tracking "off".*



3. **Select a x4 tracking rate** from your mount hand control.

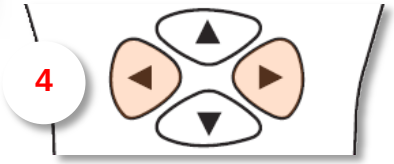
   The required speed will vary based on your mount model.



4. **Press and hold the R.A. directional key** that moves your mount **towards East.** Keep the key pressed during the 2 minute capture

   You should end up with the classic star trails image.

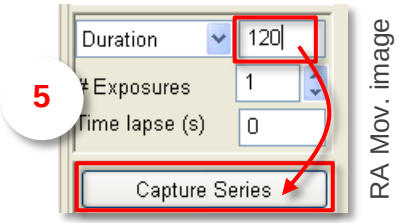
   The R.A. directional key to be pressed will depend on your hemisphere location.



5. Right after you press and hold the R.A. directional key, **launch a 2 minute image capture** from your imaging software

   *Save this image as **"RA Mov."***

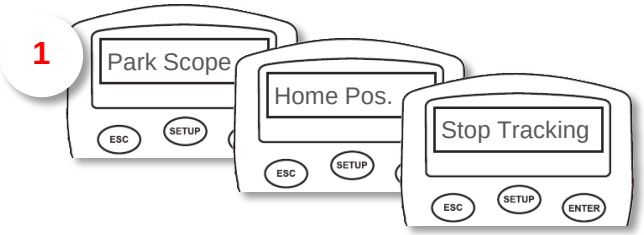
   keep the R.A. directional key pressed until the image capture ends.



1. Go to ***"Park / Home"*** position

   A standard "Park / Home" position pointing at NCP is adopted.

   ***Important**: once at "Park / Home" position, set the mount tracking "off".*

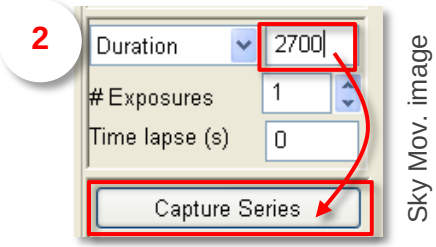


2. **Launch a minimum 45 minute** *(45-90 min)* **image capture** from your imaging software

   *Save this image as **"Sky Mov."***

   This time the rotation of the starry sky will create the star trails in the picture.

   The rotation centre of this image is the true NCP.



3. **Important:**

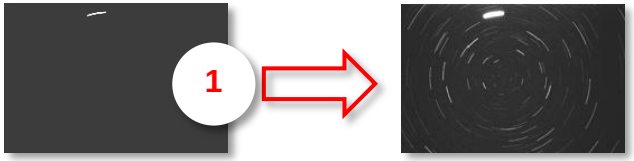
   - This long image is captured only the very first time you align the mount. From then on, whenever you are in the same hemisphere and have the same optical train (telescope, filter wheel, focal reducers/flatteners, camera, etc.), only the short 2–3 min "RA Mov." image capture will be required

   - If you save the Excel spreadsheet with the "Sky Mov." data, future alignments will only require an update of the "RA Mov." image data

   - Again, note that you capture the "Sky Mov." image just once, so we highly recommend extending its capture exposure time beyond the minimum 45 minute mentioned in step 2

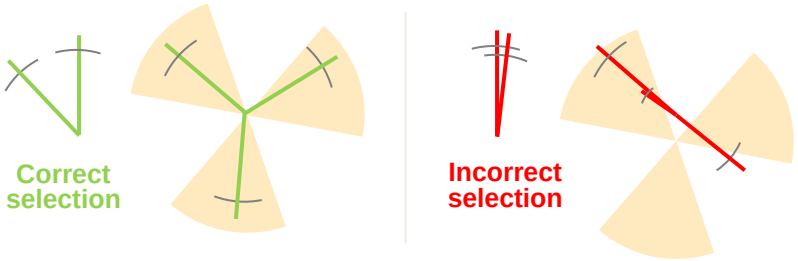
   The "Sky Mov." image shown in this quick guide is a 90 min image capture.

1. **Contrast** the "RA Mov." image until you clearly see the star trails

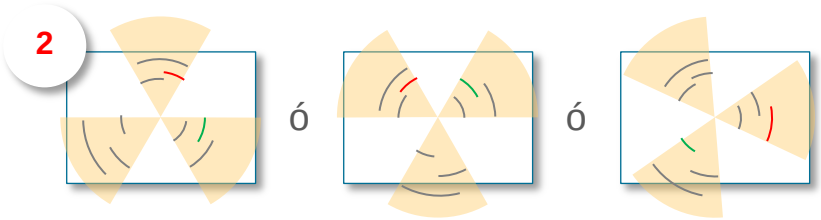


2. **Identify areas with bright and narrow star trails**

It is recommended that selected star trails roughly fall within areas within 60º one another. Do NOT select parallel or facing star trails.



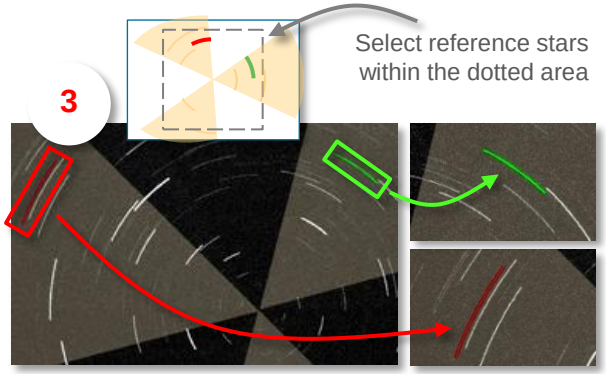
Three possible cases with star trail areas within 60º one another.



3. **Choose 2 bright and narrow star trails** This first pair will be used as a **reference** between the two images, "RA Mov." and "Sky Mov."

*From here on these two reference stars will be referred as **green** and **red**.*

Note: the next page will show you how to measure the star trail coordinates.



4. **Choose up to 14 star trails** within the areas mentioned in step (2)

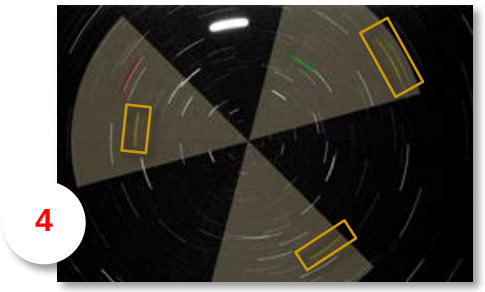
*The reference stars trails (**green** and **red**) mentioned at step (3) are mandatory.*

All others are optional. You do not need to fill in the 14 coordinates.

However, we highly recommend choosing at least 3 more in addition to the mandatory pair.

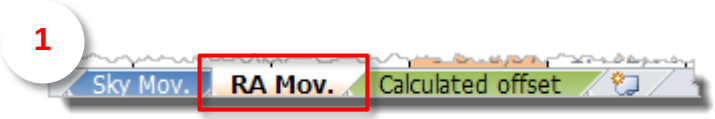
*With 5 star trails in total (**green** and **red**) + 3, the NCP offset estimation is highly accurate.*

The more star trails you add, and the more accurate you are when measuring their coordinates (see page 5), the lower the NCP offset estimation error.



RA Mov. image data input

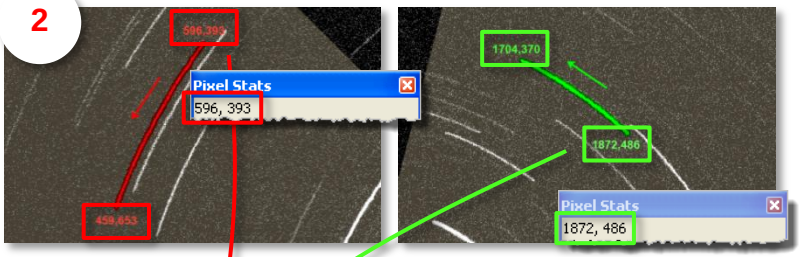
1. **Open the Excel tool** and select the **"RA Mov." worksheet**



2. **On the "RA Mov." image,** use your image capture software info tool to **measure the coordinates of both reference star trails** (**green** and **red**) **at their starting and ending points**

   When entering the (x,y) data into the cells, keep in mind the direction of the star trail. Counterclockwise in the northern hemisphere and clockwise in the southern hemisphere. Particularly for the reference stars (green and red) their starting points have to be measured very accurately.

The images below show a counterclockwise direction. As shown, the starting point coordinates of the star trails are entered in columns B (x) and C (y) n the Excel worksheet.



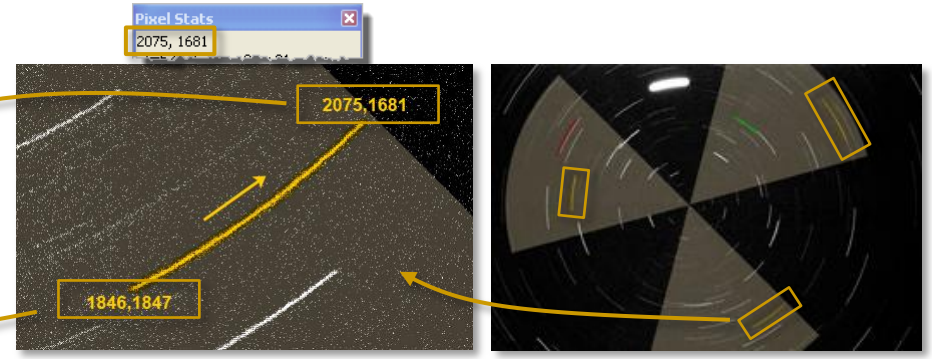
3. Enter data into the worksheet:
   a. **Enter the reference star trail** (*green* and *red*) **coordinates**
   b. **Enter at least 3 additional star trail coordinates**

3.a

	B	C	D	E	F	G	H	I
1	Star segment coordinates							
2	Starting point		Ending point		Centre		Perpendicular line	
3 Segment	x1	y1	x2	y2	xc	yc	m	1/m
4 1	1872	486	1704	370	1.788,00	428,00	-1,45	-0,69
5 2	596	393	459	653	527,50	523,00	0,53	1,90

	A	B	C	D	E
1		Star segment coordinates			
2		Starting point		Ending point	
3	Segment	x1	y1	x2	y2	xc
4	1	1872	486	1704	370	1
5	2	596	393	459	653	
6	3	595	784	571	1029	
7	4	1846	1847	2075	1681	
8	5	2508	542	2331	239	2.
9	6					

3.b

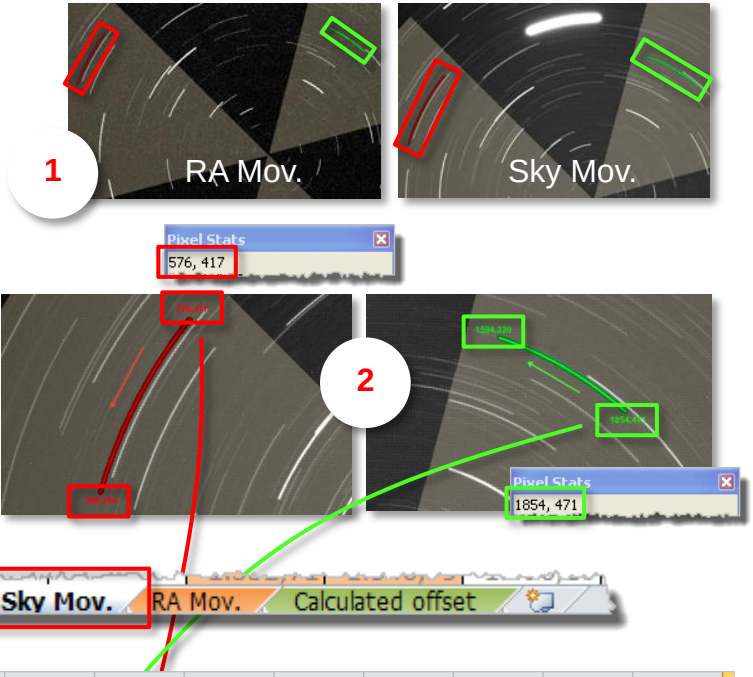


Reference star trails identification and Sky Mov. image data input

1. As you did earlier with the "RA Mov." image, **contrast** the "Sky Mov." image until you clearly see the star trails
   On the "Sky Mov." image, identify the two reference star trails (**green** and **red**) selected on the "RA Mov." image

2. **On the "Sky Mov." image,** use your image capture software info tool to **measure the coordinates of the starting and ending points of the reference star trails** (**green** and **red**)
   When entering the (x,y) data into the cells, bear in mind the direction of the star trail. Counterclockwise in the northern hemisphere and clockwise in the southern hemisphere. Particularly for the reference stars (green and red) their starting points have to be measured very accurately.

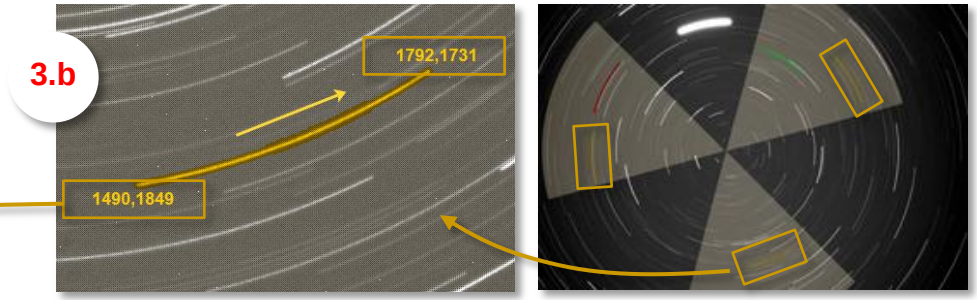
3. Enter data into the worksheet:
   a. **Enter the reference star trail** *(green and red)* **coordinates**
   b. **Enter at least 3 additional star trail coordinates**
      These additional stars trails do not need to be the same additional star trails selected in the "RA Mov." image.



	A	B	C	D	E	F	G	H	I
1		Star segment coordinates							
2		Starting point		Ending point		Centre		Perpendicular line	
3	Segment	x1	y1	x2	y2	xc	yc	m	1/m
4	1	1854	471	1594	320	1.	395,50	-1,72	-0,58
5	2	576	417	396	764		590,50	0,52	1,93

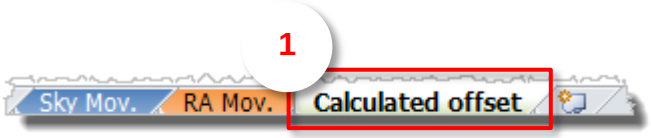
3.a

	A	B	C	D	E
1		Star segment coordinates			
2		Starting point		Ending point	
3	Segment	x1	y1	x2	y2
4	1	1854	471	1594	320
5	2	576	417	396	764
6	3	395	887	410	1268
7	4	1490	1849	1792	1731
8	5	2295	701	2090	361



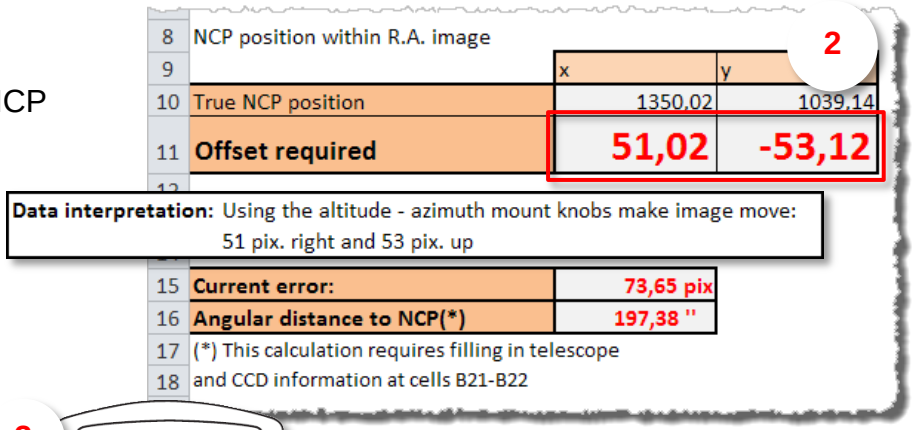
Offset required calculation and preparation for final correction steps

1. Once you have entered the "RA Mov." and the "Sky Mov." data into their respective worksheets, **select the "Calculated offset" sheet**



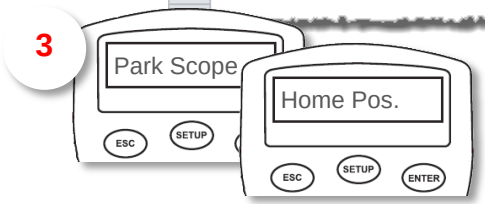
2. In the "Calculated offset" worksheet, you will find the True NCP position (x, y) within the "RA Mov." image and the mount **Offset required** for both axes

   The worksheet also provides a message with data interpretation in terms of up / down, left / right directions.



3. Go to ***"Park / Home"*** position

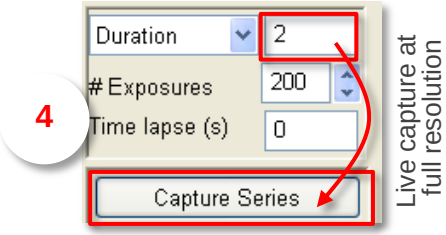
   A standard "Park / Home" position pointing at NCP is adopted.



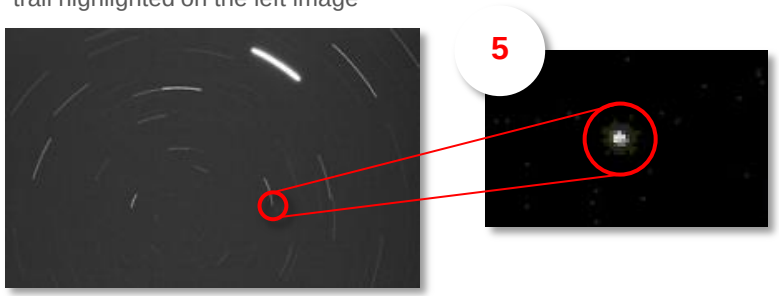
4. **Launch a live capture with 1–2 sec exposure time**

   If you cannot get small, bright stars within the 1–2 sec exposure time at full resolution, you might need to set a binning factor.

   If so, bear in mind that the required values for the offset, mentioned in step (2) will also have to be divided by the same binning factor.



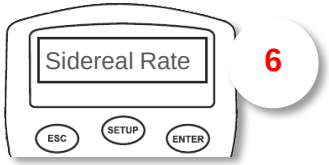
Any small, bright star is suitable for the final correction steps.
The star shown on the right image is the same star that drew the star trail highlighted on the left image



5. **Choose a star in the central area of your image**

   It is important to choose a small, bright star.

6. **Select the sidereal tracking rate**



Mount altitude and azimuth corrections

1. If your image capture software can tag image positions, **tag the position of the selected star and take note of the star position coordinates *(x,y)***

2. **Add the required offset values** shown in the "Calculated offset" sheet **to the position of the coordinates *(x,y)*** shown in step 1 ***Tag this as the calculated "final position" on the image.***

3. If your application does not have an image position tag feature, move the mouse pointer so that it is accurately pointing to the calculated "*final position*" coordinates and <u>leave it there.</u>
   The mouse pointer will be the position "tag" to reach.

4. **Use the mount altitude / azimuth knobs to move the star from its current position to the final "tag" position** (or to the mouse pointer position if you followed step 3 instead)

5. If your correction steps finished successfully, **your mount alignment should now have an error of only a few pixels from the true NCP**
   If you want to check your final error, you can repeat the 2–3-min "RA Mov." image capture, identify the two reference star trails and 3 additional ones, insert their coordinate data in the worksheet and check your current error again. However, this second step is generally not required.

   The true limitation to accuracy is a result of the mechanical output resolution of the mount altitude / azimuth knobs.