

# MANUAL

## Making Pointing Models with DDM60



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### What is a pointing model?

If you have an ideal telescope you would expect that by entering the real position of the object the telescope will hit the object without any error. However there is no ideal telescope and several errors can occur during slewing:

The main errors can be:

1. Polar alignment error in Azimuth
2. Polar alignment error in Altitude
3. Collimation error
4. Mount error (axes not perpendicular)
5. Tube flexure

And several gearing errors, mount flexure etc.

Autoslew can compensate all these errors as long as they are reproducible (same error every time telescope will point this position). To compensate these errors they first have to be measured. This is achieved by a pointing file.

A pointing file is a list of pointing observations specifying where the star really was and where the telescope readouts said the star was. Autoslew saves these files with the file extension .poi.

The simplest way to enhance the pointing would be make a table sorted by RA and Dec and put the error vectors there and if you point to the same area again correct the telescope coordinates by the error that has been measured. This method might work for really big pointing files with thousands of stars but if you want to have the maximum performance gain with as less as possible stars it is cleverer to make a model which models the telescope behavior with a set of error functions. This is also much more powerful in averaging out random noise in your pointing file.

Autoslew will work with a set of functions that describe the telescope pointing if the above listed errors (Polar alignment, Collimation, Mount error). All these functions have certain variables. These variables will be optimized so that the set of functions will optimally describe the telescopes pointing behavior that was measured with the pointing file. This set of variables that can be calculated from the pointing (\*.poi) files is called configuration. These files are saved with the extension cfg (\*.cfg).

It is important to understand that a pointing file is only a set of observations and a configuration file is a set of variables that are used to influence the telescope pointing.

### Why should you make pointing models?

The first reason of course is that you will achieve better pointing. However sometimes better pointing is not needed if you did a good polar alignment and your mount can hit the objects within your CCD field. But there is an even more important reason why you should use a pointing model in Autoslew and here comes the big difference to other pointing models that are not integrated into the mount control software but rather bought as external package.

Autoslew uses the pointing model configuration not only for correcting the pointing but also to change the tracking speeds in Right Ascension AND Declination in realtime during tracking. Please try to forget the old mount where a simple sidereal tracking rate was applied in RA and Dec was only moved in autoguiding by external commands.

If you start an exposure the telescope will move not in Right Ascension and Declination but in Hour Angle and Declination and thus move slowly through the Sky and also in areas where the pointing configuration indicate other pointing corrections compared to where the exposure started. Autoslew will update the drive rates several times per second in RA and Dec to keep the telescope on track. This can for example mean that the Dec speed is 0.1 arc seconds per Minute positive at the beginning of the exposure and turns negative 0.23 arc seconds per Minute at the end of the exposure.

It should be clear that old fashioned mounts with worm gears and a few arc seconds backlash will be without chance to correct these slight Dec speeds. If you tell these mounts to move 1.2 arc seconds in Declination it can be either 0 arc seconds or 2 arc seconds depending on which side of the backlash you currently are.

Only mounts with High Accuracy Encoders like the ASA DDM's and/or direct drive can convert these tiny speed commands in real sky movements and enable you to achieve pin point star images without autoguiding.

So the real gain if you try to make a good pointing model is not just in better pointing but especially in better tracking. You can easily expand your blind tracking time (without autoguiding) from 30secs without model to 10 minutes with a good pointing model.

### Limitations of pointing models

You can only fit pointing errors if they are reproducible. This means that the pointing error must be the same at a certain location in the sky no matter if the telescope slews to this point coming from deep East or far West. You can test the repeatability of your scope by synching on a star and then slew again to the same star coming from different positions in the sky. If you are more than one arc minute off in this test, try to optimize your telescope (mirror cell, focuser etc.). Your final pointing will always be as good as your telescope. In 99% of all cases where people complain about bad pointing the problem is in the telescope and not the mount. We can build mounts with 5arc sec RMS pointing but with a Schmidt Cassegrain put on this mount with 1arcmin mirror shift you will never reach the mount performance! However, please accept that there is NO telescope in this world that has zero hysteresis. Especially reflectors will always have a little mirror shift and if you try to fix your mirrors until nothing moves you might have the mirror bent in its cell and have good pointing but bad image quality. Try to be realistic with your targets. If you can reach 5m unguided then it's often easier to stack more CCD frames than to try hard to get up to 20m unguided. I remember one 1m telescope from an Australian company where the mirror was GLUED to the mirror cell. This telescope reached 2arcsec RMS pointing but at the same time the image quality was a disaster. Since the telescope was only used photometric, there was no problem.

## Instructions for the DDM60 mount

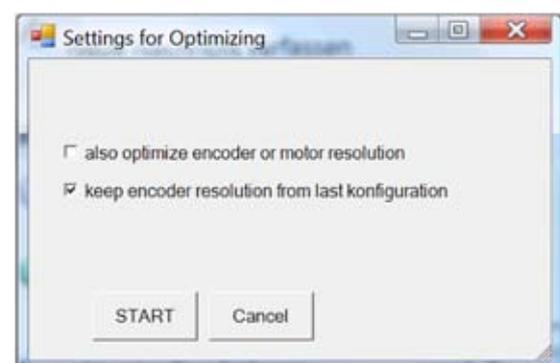
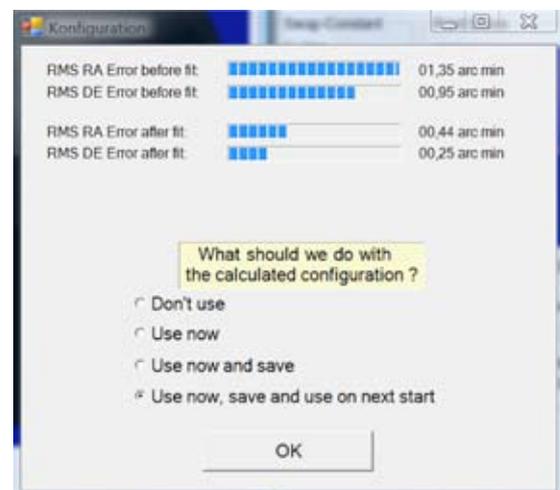
The DDM60 is a little trickier in the beginning and first pointing files compared to the DDM85. The reason for that is that other encoders are used where the resolution (number of encoder lines per revolution) is only specified within a certain tolerance. This would lead to problems if you would make a polar alignment pointing file described above since the pointing model could try to put errors on encoder resolution in the alignment error and causing wrong results.

The following steps need to be taken with the DDM60:

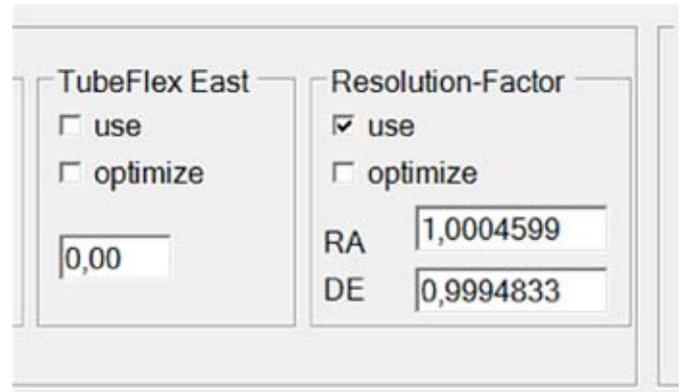
1. Use 6 stars for your first pointing file and when you are calculating the configuration check the box like shown below
2. Move your polar axis and repeat the pointing file and polar adjustment until you are below 5-10 arc minutes polar error.
3. Make one 10-15 star pointing file on East OR West side and calculate the configuration
4. Select the "Use now, save and use on next start" option because this will save also the encoder resolution which you have found out now with great accuracy.
5. When you take out your DDM60 mount next time and make a new setup it will be sufficient to make 4 stars for your first polar pointing file because now the encoder resolution is known.

In this case, if you calculate your configuration, check the box "keep encoder resolution from last configuration".

This makes it necessary to use MORE stars for your first pointing files to be able to also calculate the encoder resolution. It is clear, that the encoder resolution is something that never changes in your mount so as soon as you have determined the exact encoder resolution you can save that for further use and have no further disadvantage compared to the DDM85. But in the beginning, you should spend a few hours to find out your encoder resolution.



You can also find your encoder correction factor in the advanced pointing control menu:

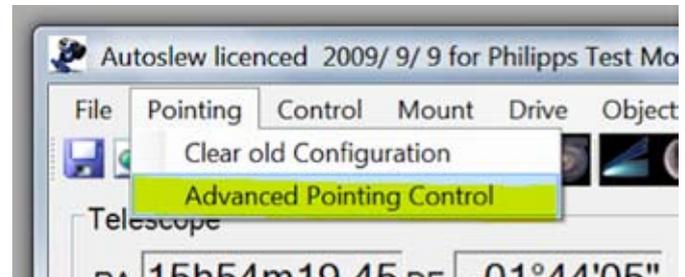


### Advanced manual optimization

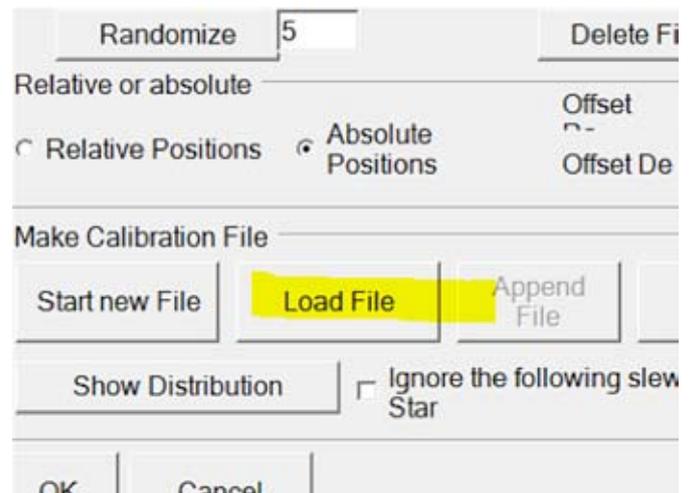
Please only read this if you want to have more influence on what Autoslew is using or optimizing. If you have already reached your limit with above explanations ignore the next chapter.

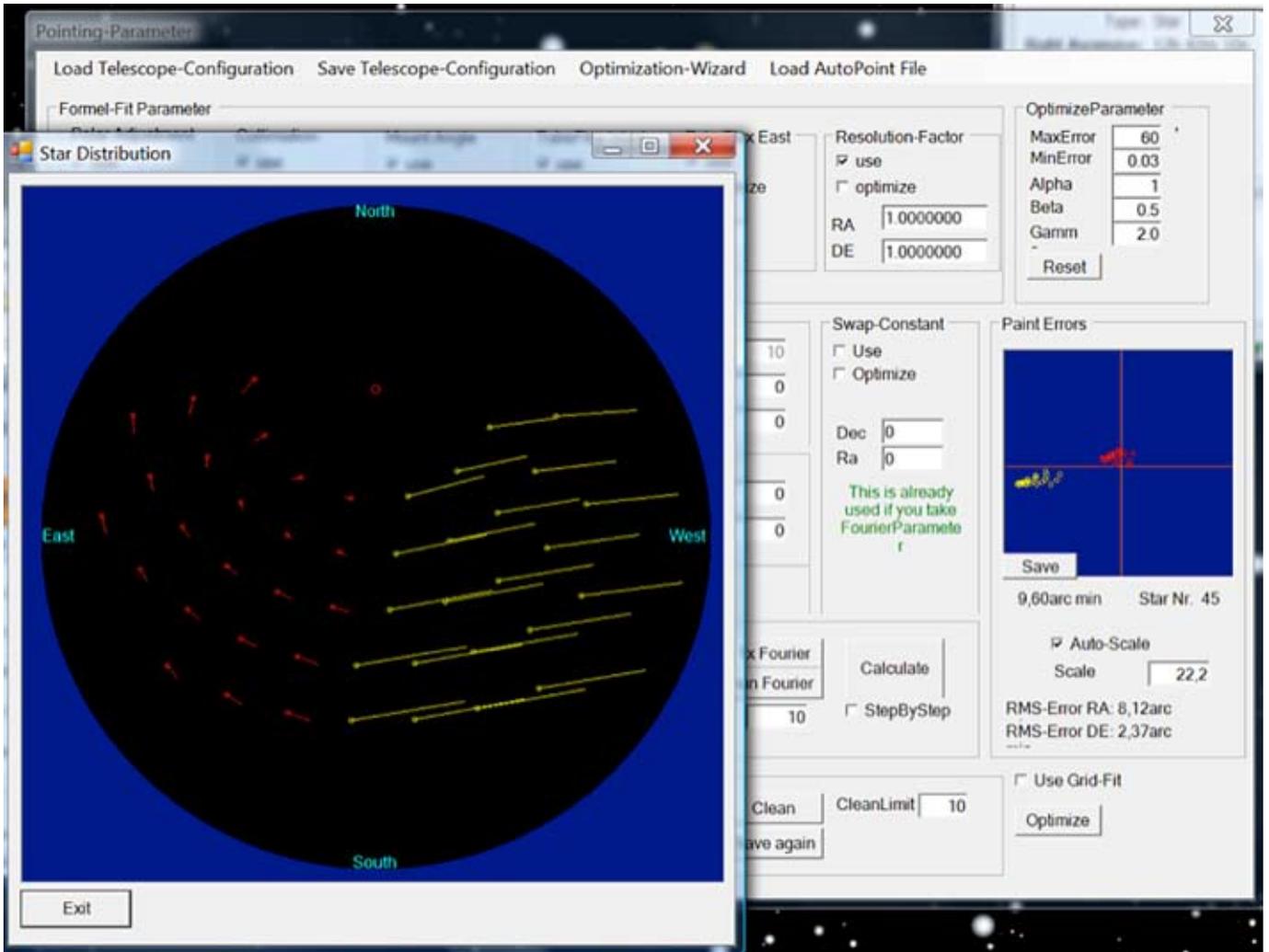
I am discussing the advanced optimization here with a pointing model that was made with a DDM85 mount.

Get into the advanced pointing control.



Load a pointing file you have saved:

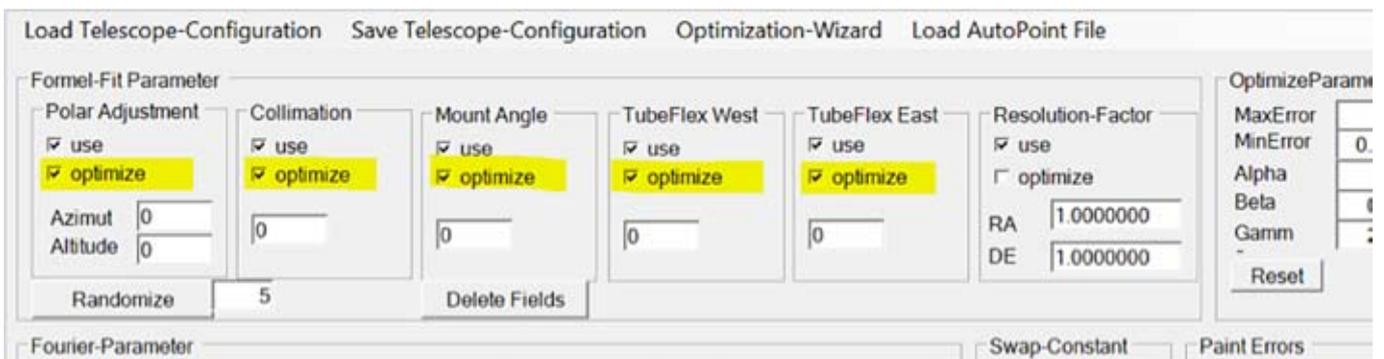




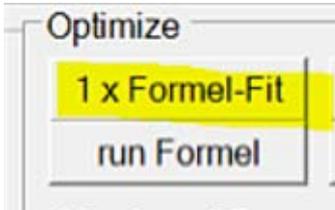
You will have one frame open that shows the points where you selected your stars. The red color indicates that the star was slewed on the East side whereas the yellow color indicates a star on the west side. The error vectors indicate the direction and size of the error. The length of the error vector is always scaled to the error of the worst star so even if the pointing gets much better you will have the same length of these vectors.

On the right side of the screen you can see the pointing error presented as star cloud and below that field you find the RMS Ra and De pointing error calculated.

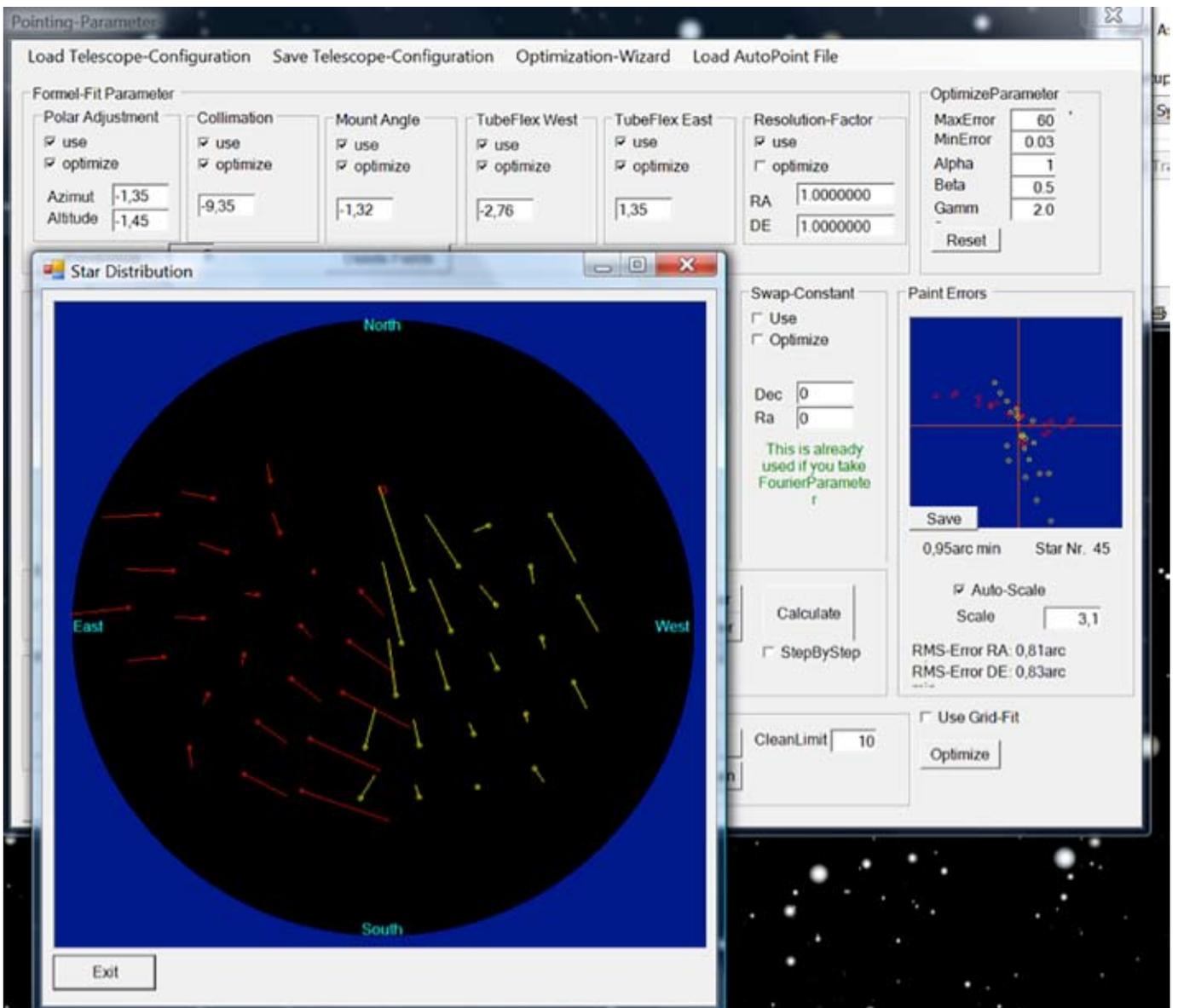
Now let's try to do a manual optimization.



Since we have a lot of stars we can try to optimize all errors that are typical telescope pointing errors and can easily be modeled.



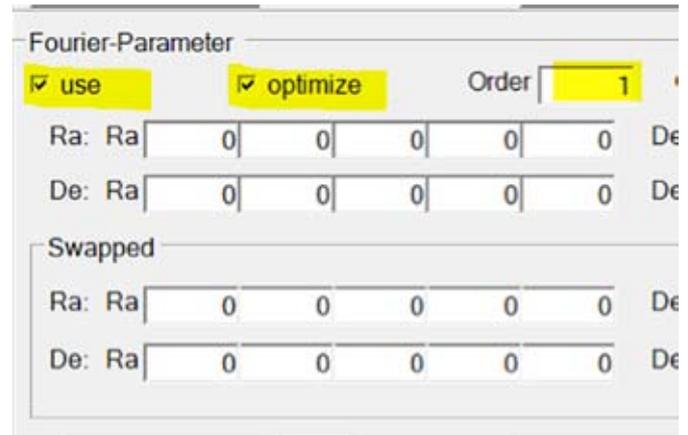
Clicking the 1x Formel Fit button will start the optimization process.



As you can see, the errors have been reduced by a factor of nearly 10 now and you can find information about the size of the errors in the text boxes below the checkboxes.

You can further improve the pointing if you allow Autoslew to apply a fourier transform model of spherical harmonics) on your pointing model.

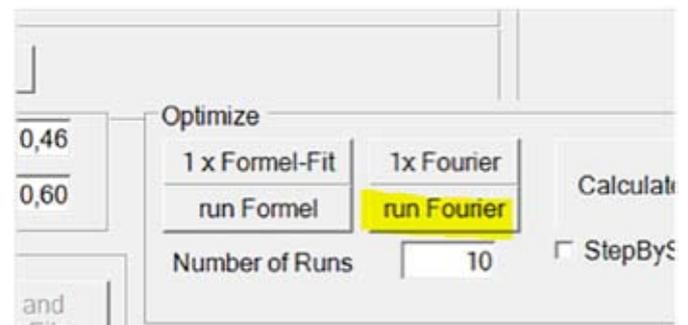
You can start this by selecting the following options:

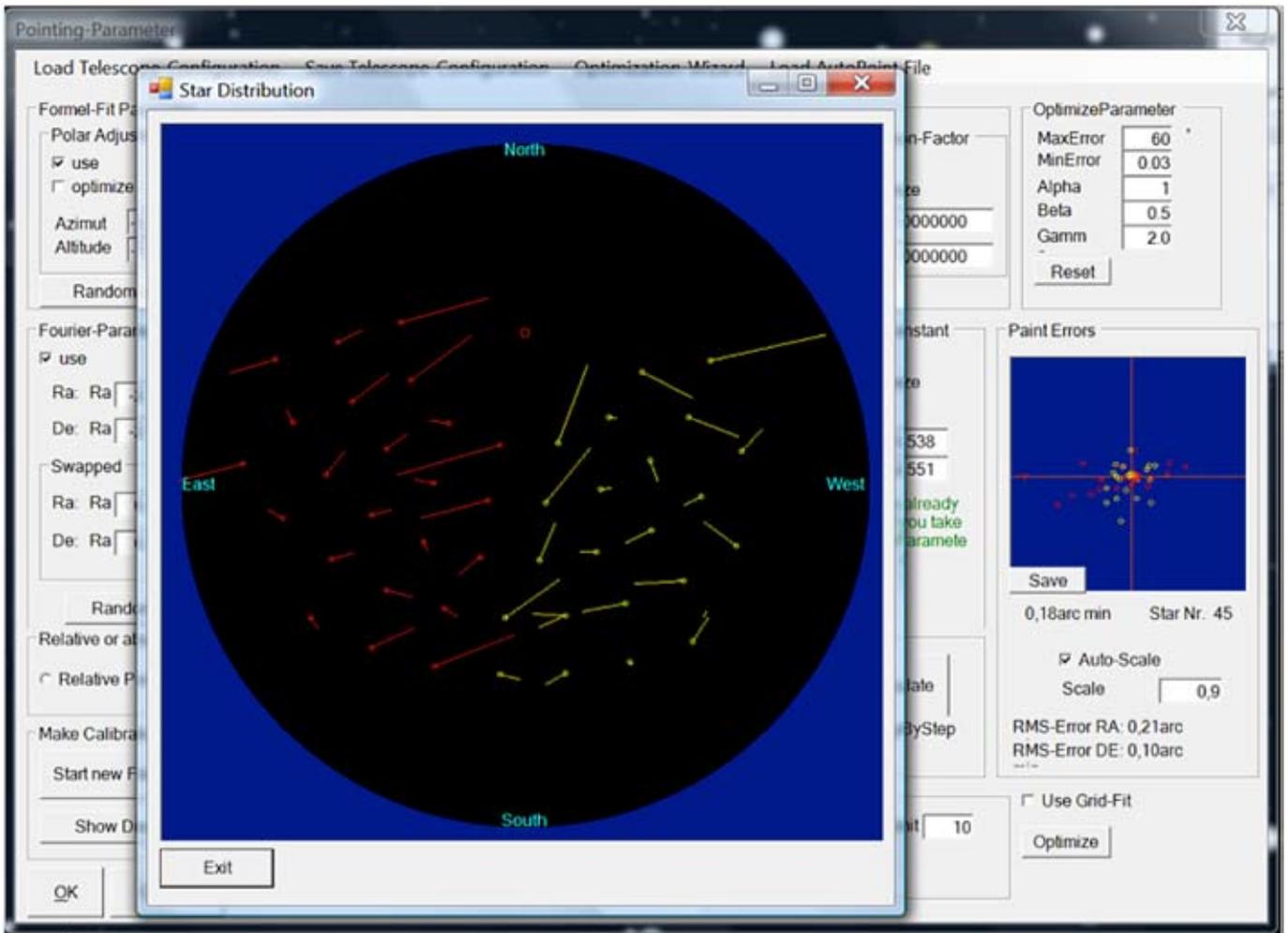


**Remark:**

If you have even more stars, you can also use Order 2 instead of 1 here.

Start the modeling by clicking on "run Fourier". This is a little more time consuming and you need to wait a few seconds or even up to a minute if you have big pointing files.





The result is impressive with around 12 arc sec. RMS pointing in Ra and 6 arc sec. RMS pointing in Dec. Such a mount / telescope combination will also track very well.

In this menu, you can save the configuration by



You can also try the Optimization Wizard which will explain the optimum steps for your pointing file!

**Support:**

In case you encounter a problem that you cannot solve on your own, ASA's technical staff can assist you through remotely accessing your Autoslew software. Should you encounter a problem, send us an email describing the nature of your problem (support@astrossysteme.at). We will then get in touch to arrange a remote session with you.