It would be a good idea to read the [interferometric pointing procedure]() before going through this document.

The coefficients represent the following physical properties:

P1 The azimuth-angle offset, which includes the effects of encoder bias and tilt around (rotation of the azimuth ring around the vertical axis).

P2 The azimuth angle sag, the effect of gravity on the RF axis of the dish projected on the azimuth direction (positive if the RF axis is lower). Not relevant to az-el mounts.

P3 The left-right axis skew, which describes non-perpendicularity of the azimuth and elevation coordinate axes. Specifically, it is the angle by which the apparent elevation axis tilts over to the left relative to the azimuth ring, where left means along the meridian with azimuth value 90 degrees less than the desired azimuth. This parameter may also include contributions of elevation and azimuth bearing wobble.

P4 The azimuth box offset or left-right collimation error - a misalignment of the RF and pointing axes along the azimuth direction.

P5 The “tilt out” - tilt of the azimuth ring towards true North.

P6 The “tilt over”, tilt of the azimuth ring towards true East.

P7 The elevation offset, which includes the effects of encoder bias, forward axis skew and elevation box offset. These effects all appear as an elevation offset and cannot be distinguished from each other.

P8 The elevation angle sag - the maximum symmetric gravitational sag or vertical flexure, which is a downward deflection of the pointing axis experienced when the dish is pointing at the horizon. It models the effect of gravity on the dish structures under the assumption that the structures obey Hooke’s Law. This parameter also includes the cosine component of the elevation centering error, which is misalignment of the elevation encoder and the actual tilt axis and may be traced to eccentricity in the elevation tilt drive wheel or encoder disk, or encoder run-out.

P9 An ad hoc excess scale factor in the elevation angle, which occurs when the encoder readout changes faster or slower than the actual antenna position. It is a unitless number.

P10 An ad hoc DE cosE coefficient. Redundant for az-el mounts.

P11 An asymmetric gravity or flexure term that also includes the sine component of the elevation centering error, which is misalignment of the elevation encoder and the actual tilt axis and may be traced to eccentricity in the elevation tilt drive wheel or encoder disk, or encoder run-out.

P12 An ad hoc excess scale factor in the azimuth angle, which occurs when the encoder readout changes faster or slower than the actual antenna position. It is a unitless number.

P13 The cosine component of the azimuth centering error, a misalignment of the azimuth encoder and the actual azimuth axis that may be due to eccentricity of the azimuth drive wheel or encoder disk, or azimuth encoder run-out.

P14 The sine component of the azimuth centering error, a misalignment of the azimuth encoder and the actual azimuth axis that may be due to eccentricity of the azimuth drive wheel or encoder disk, or azimuth encoder run-out.
P15 The cosine component of an elevation nod twice per azimuth revolution.
P16 The sine component of an elevation nod twice per azimuth revolution.
P17 The cosine component of azimuth encoder tilt.
P18 The sine component of azimuth encoder tilt.
P19 models higher-order distortions in the elevation encoder scale that vary eight times per revolution.
P20 models higher-order distortions in the elevation encoder scale that vary eight times per revolution.
P21 The cosine component of an elevation nod once per azimuth revolution.
P22 The sine component of an elevation nod once per azimuth revolution.

Data Reduction for Interferometric Pointing

This is done in a jupyter notebook, link to the notebook can be found in the interferometric pointing procedure. The notebook is pretty self-explanatory, so there is no need to discuss this topic any further.

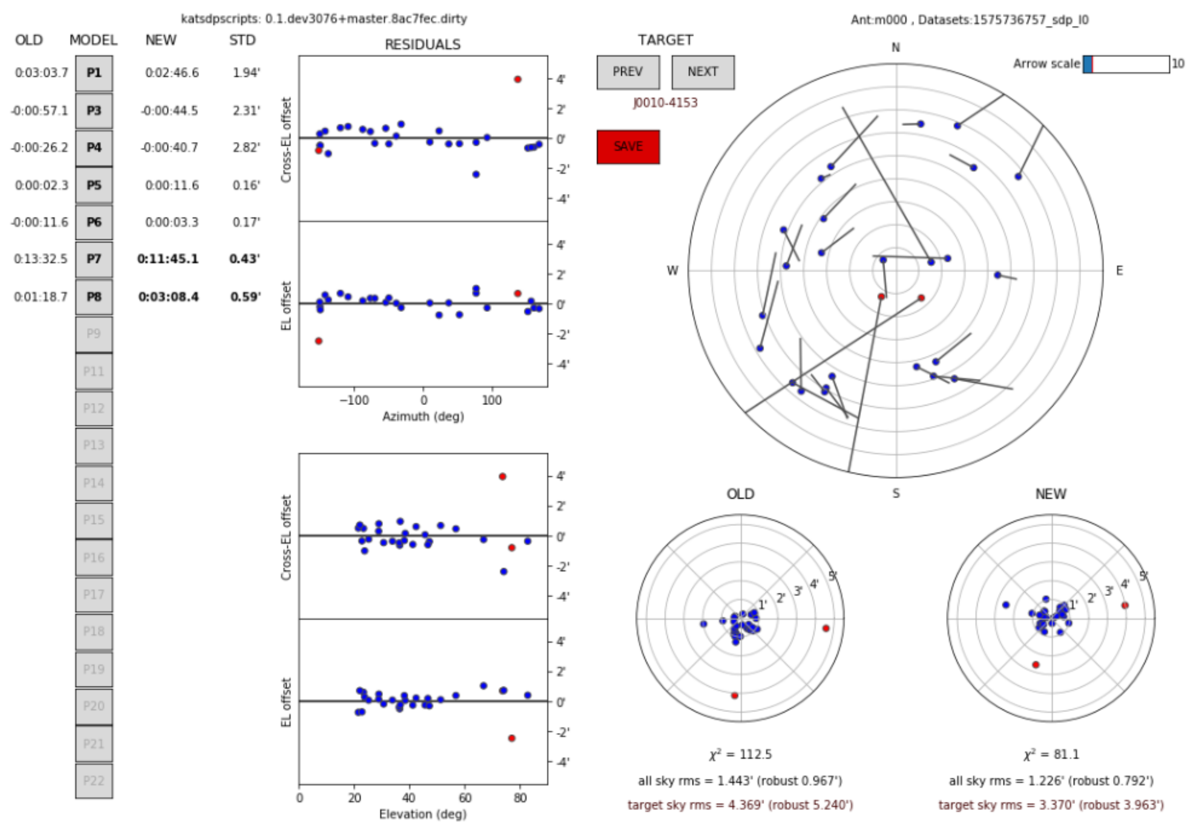
Analyzing Pointing Models

What to look out for?
The first thing to look at are the old and new circles on the bottom right corner of the plot.

χ^2 (measure of the goodness of fit)
All sky rms
EL offset and cross EL offset (tiltness): the smaller the range the better
Model parameters

Let us have a look at an example of a good pointing model and one of a bad pointing model.

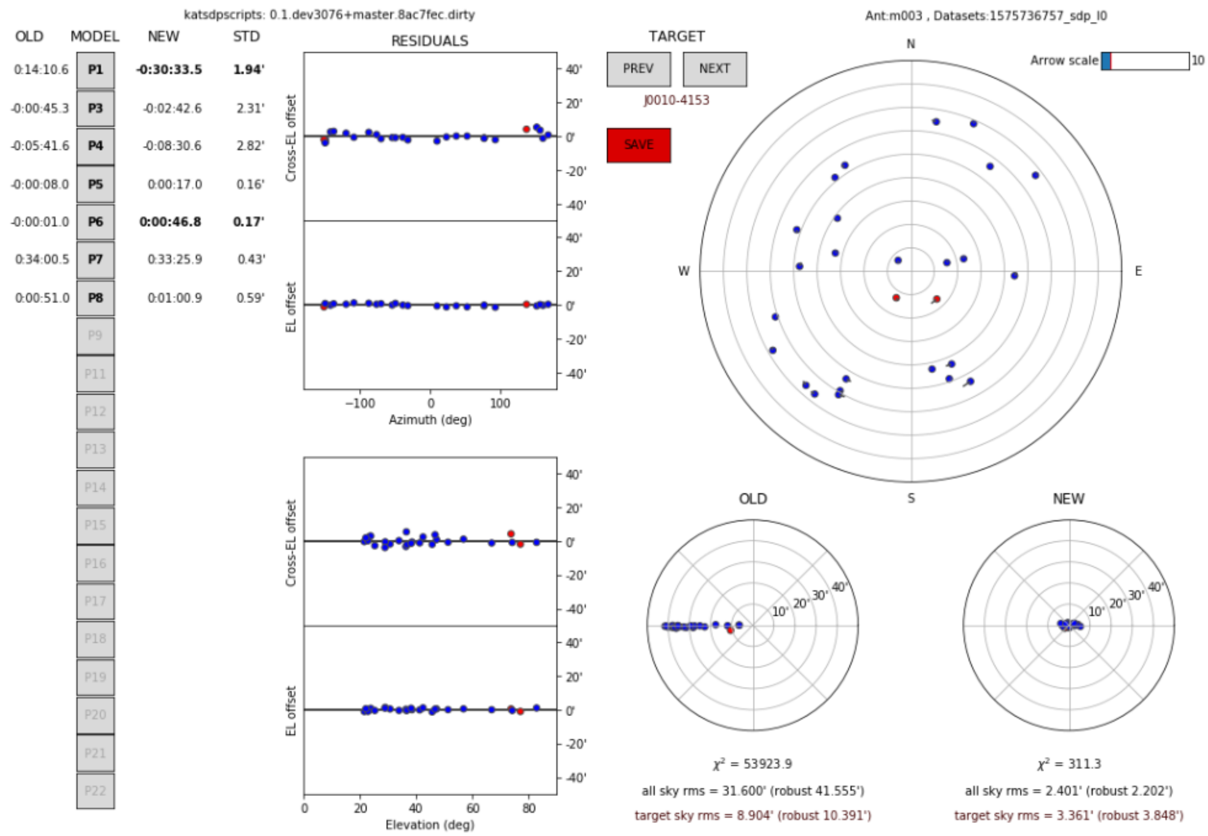
Example of a good pointing model



The values of χ^2 between the old and new plots are not very far off from each other. The all sky rms is below 2 and the robust is below 1. The smaller the robust and all sky rms the better. The lines in the plot showing the amount of sky coverage indicates offset differences.

Comparison between the old and new plots show small jumps to the centre of the new plot in arcminutes after corrections are made.

Example of a bad pointing model



Huge difference in the values for $\chi 2$ between the old and new pointing models. The value of all sky rms for the old plot is too high and the robust is above 2'. Much larger jumps between old and new models. Parameters P1 and P6 are highlighted in bold, they can be used to indicate what the issue could be.

Normally, there will be values for parameters P1 to P8 (except for P2). Sometimes there will be another parameter added to the list, which will be highlighted in bold . This happens so that we can get a reasonable fit to the plot.

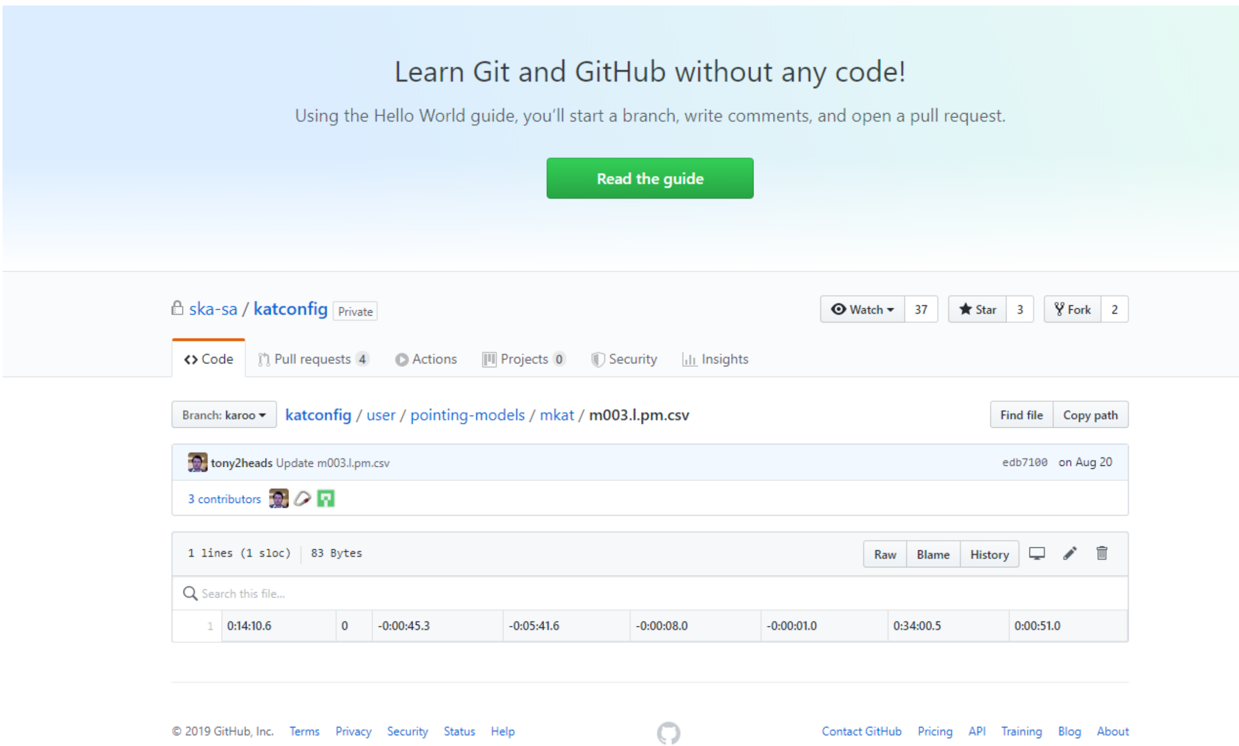
To get a perfect fit, you could run a pointing for about 6 hrs for 2s. For an 8s pointing, it would have to be longer than that. By running a 2s pointing for about 2-3 hrs, data is good enough to get a reasonable fit.

Applying corrections to pointing models/updating pointing models

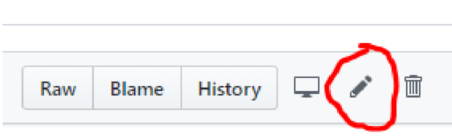
Click on the URL below:
https://github.com/ska-sa/katconfig/tree/karoo/user/pointing-models/mkat

or log into your GITHUB, go to katconfig and choose the karoo branch

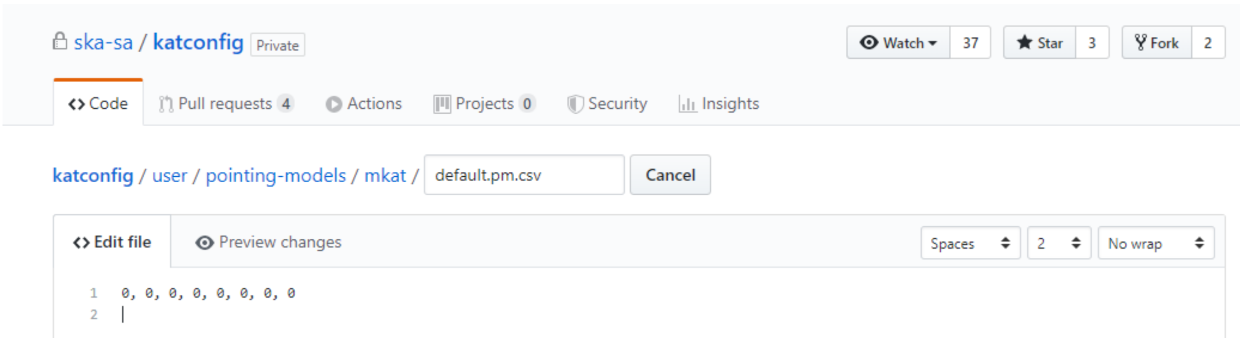
Select user □ pointing models □mkat and the antenna whose models that you would like to update. Always ensure that you choose the correct band for the antenna. For example, if you would like to update the pointing model for M003 in L-band, choose m003.l.pm.csv. A page similar to the one below should pop up on the screen



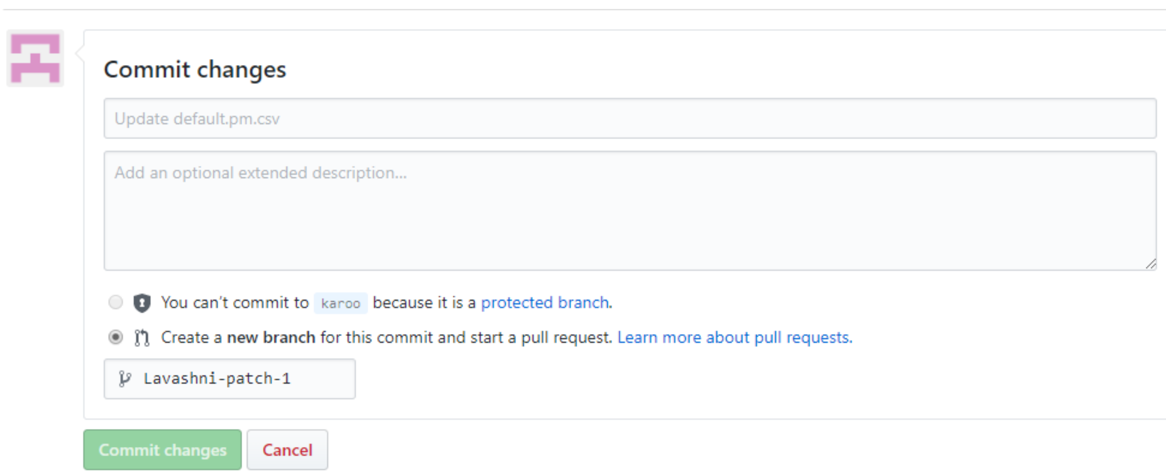
Click on the edit button to update the pointing model

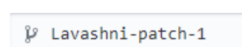


Fill in the new parameters for the pointing model on line 2 (P2 will always be 0 as it is not used). Remove line one by pressing the delete button once you are done filling in line 2.



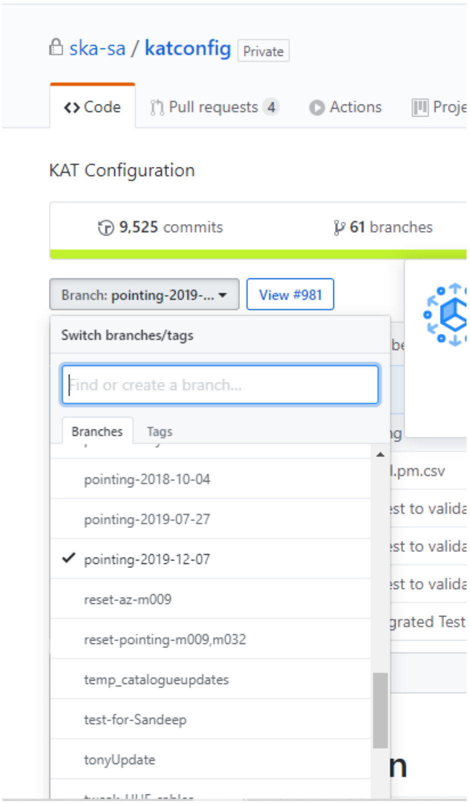
Scroll down further and you will find the commit changes section.



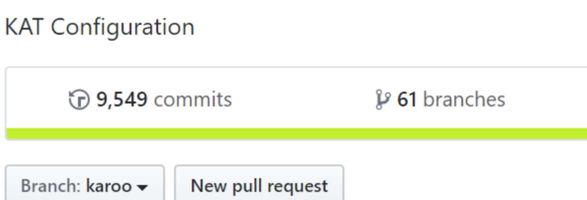
In this section, you could add extra information about the model for that antenna where it says ‘add an optional extended description…’.Edit the branch name 

to ‘pointing-yyyy-mm-dd’ (should be date on which pointing ran). Once that has been done, click on commit changes.

If models need to be updated for more than one antenna, it is not necessary to repeat the process above, you can access the branch that you have created without having to click on the karoo branch again.



Pull requests are created to propose and collaborate on the changes to pointing models. To issue a pull request, choose the 'Karoo' branch and click on 'pull request'.



Use the base branch dropdown menu to select the branch you'd like to merge your changes into which in this case would be the Karoo branch, then use the compare branch drop-down menu to choose the topic branch you made your changes in.

Add a title and description to your pull request. Choose reviewers (Sean, Tony, Sharmila, AOD) and add attachments. To create a pull request that is ready for review, click 'Create Pull Request'. To create a draft pull request, use the drop-down and select 'Create Draft Pull Request', then click 'Draft Pull Request'. Example of a pull request I submitted is below.
https://github.com/ska-sa/katconfig/pull/981

To view status of pull request, go to katconfig □ pull requests □ click on branch created.