HEQ5 Pro, the SA metal gear train versus Rowan belt modification

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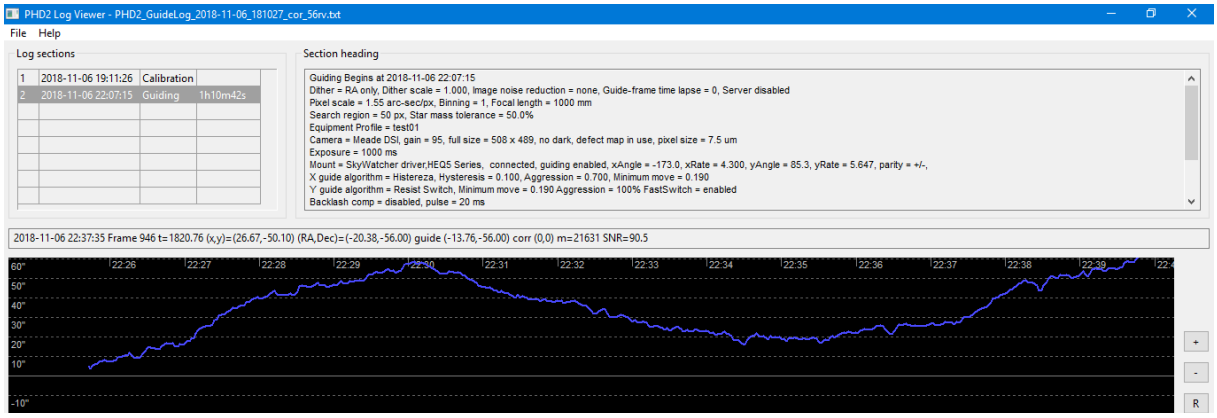
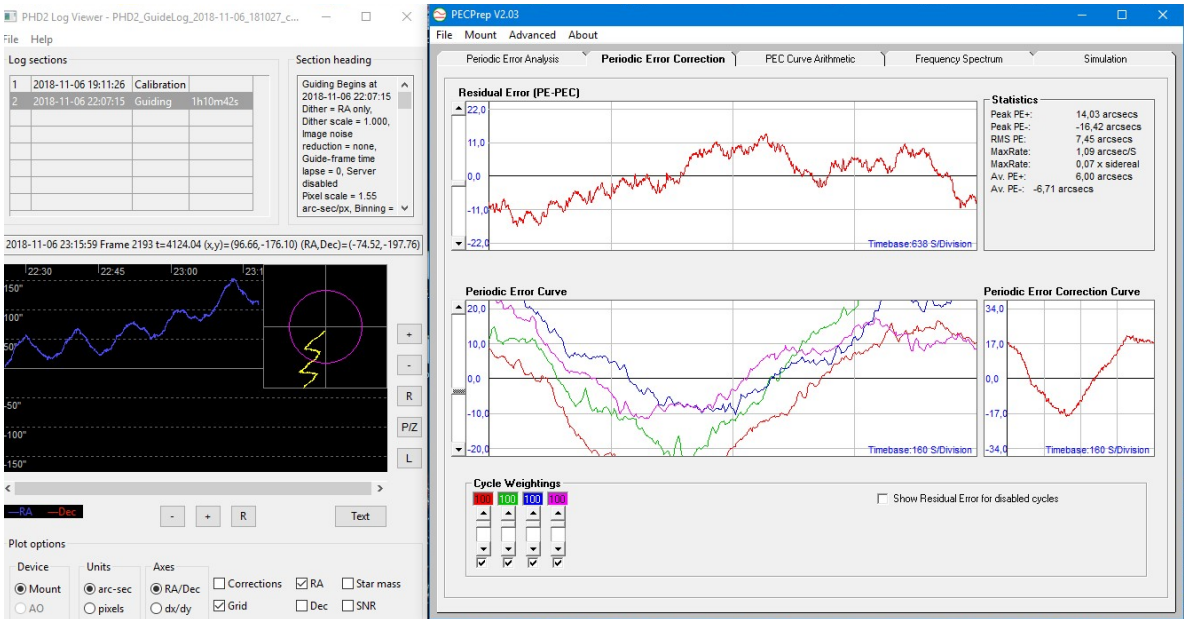
Test setup: HEQ5 Pro, WiFi module, laptop, PHD2 program, guiding scopes: f=1000mm (DSI Meade camera, pix=7.5 x 10^{-3} mm) and f=400mm (ZWO ASI 120mini camera, pix=3.8 x 10^{-3} mm)

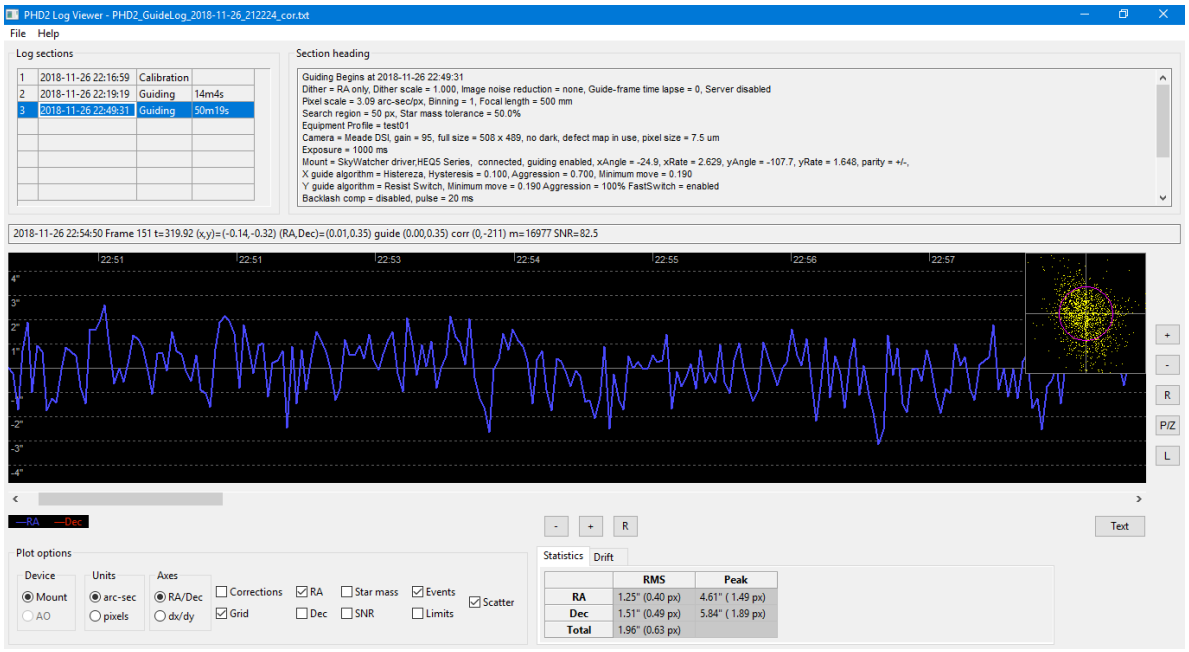
First the RA/DEC error tests with the original metal gear chain. Data collected on November 2018. **P**eriodic **E**rror measurements.



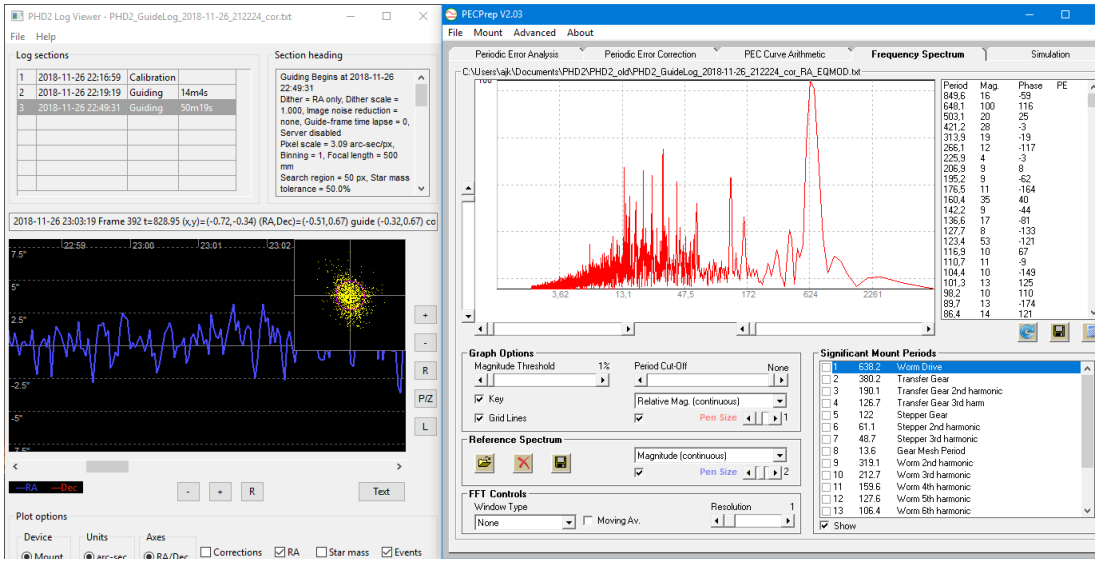
Below PECPrep screen shot, with four full period PE turns. Notice rather smooth, low amplitude (few arc sec) random modulations (in Periodic Error Curve window).



The next graph presents guiding quality and the measured RMS values for RA and DEC.
DEC curve line is not shown here for clarity, to avoid masking of the RA line.
DEC errors are of a comparable to the RA amplitude .



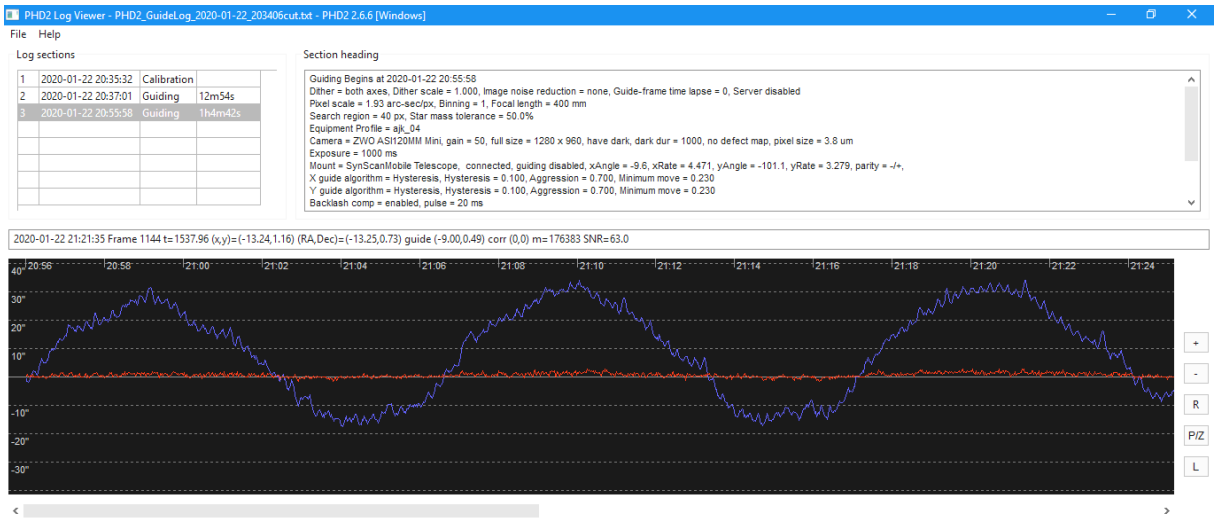
Finally, spectrum of guiding errors shown in PECPrep format. There are many short period components (<100sec) responsible for the noisy guiding curve line.

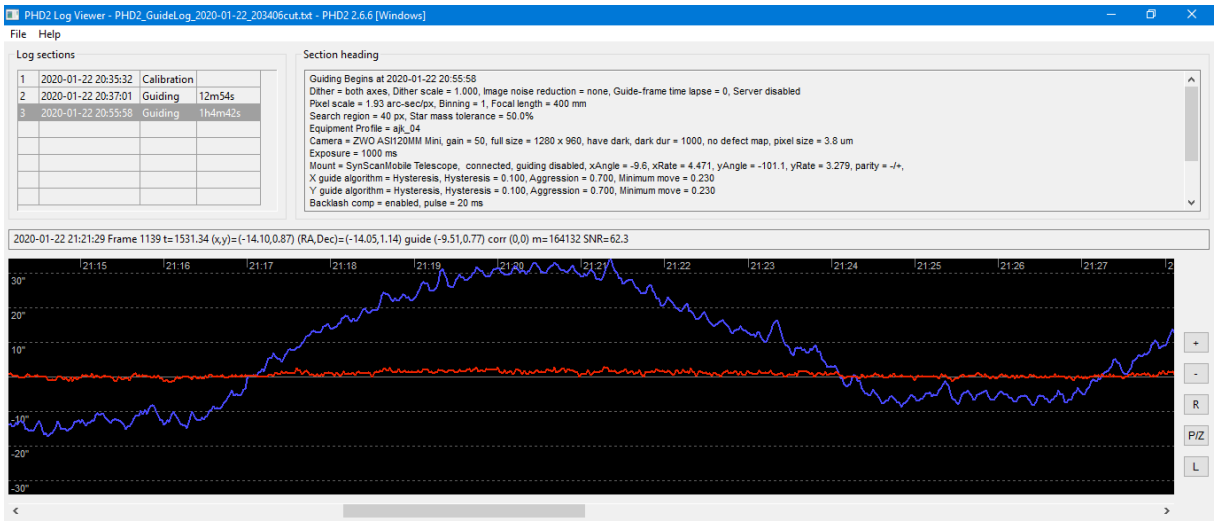


Rowan Astronomy belt system. The results presented here come from tests made on 22nd January 2020. The metal gear chains were replaced by Rowan Astronomy belt kit elements and on the first possible clear sky night the test observations were made.

Below, the **PE** error curves are shown. PHD2 Log Viewer and PECPrep programs were used to analyse and to present the data. Note unusually high modulation with period of 13.6 sec due to an error of the 9 tooth aluminium pulley (or belt quality ?). The pulley is mounted on motor axis and revolves with 122.4 sec period. From my measurements based on data from PHD2 log file (Feb. 2020), the periods are 121 +/- 2 sec and 13.4 +/- 0.2sec.

The ~13 sec period corresponds to path of one tooth. Modulation can also be caused by mismatch of tooth shape in belt and engaged slots in the pulley. There might also be other reasons i.e. belt quality.

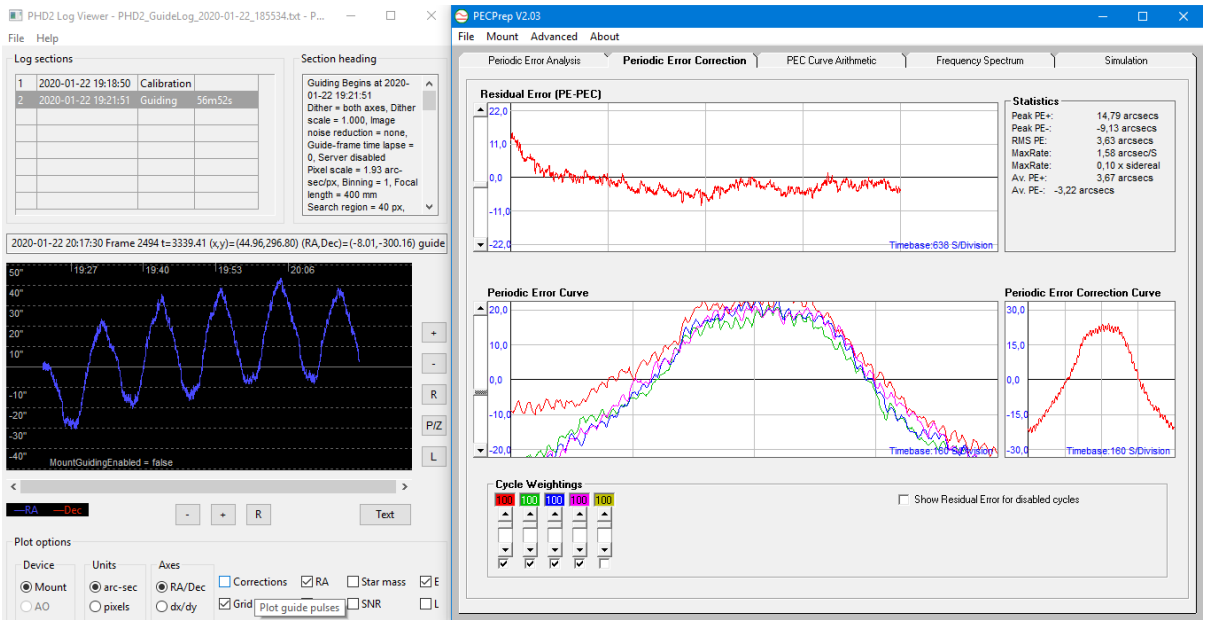


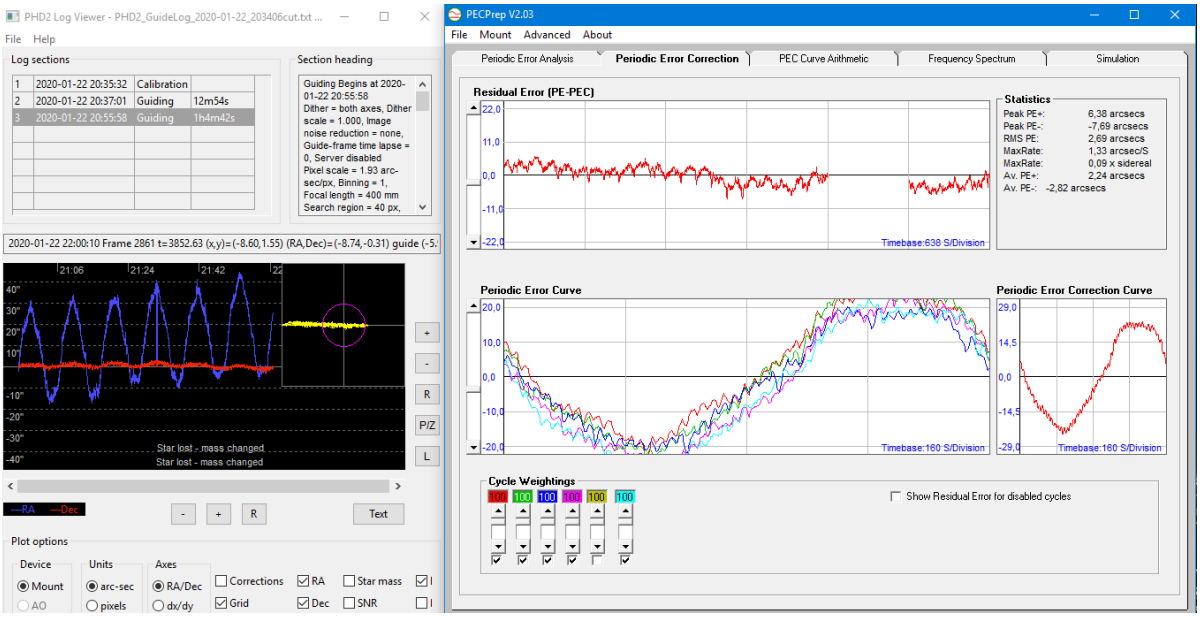


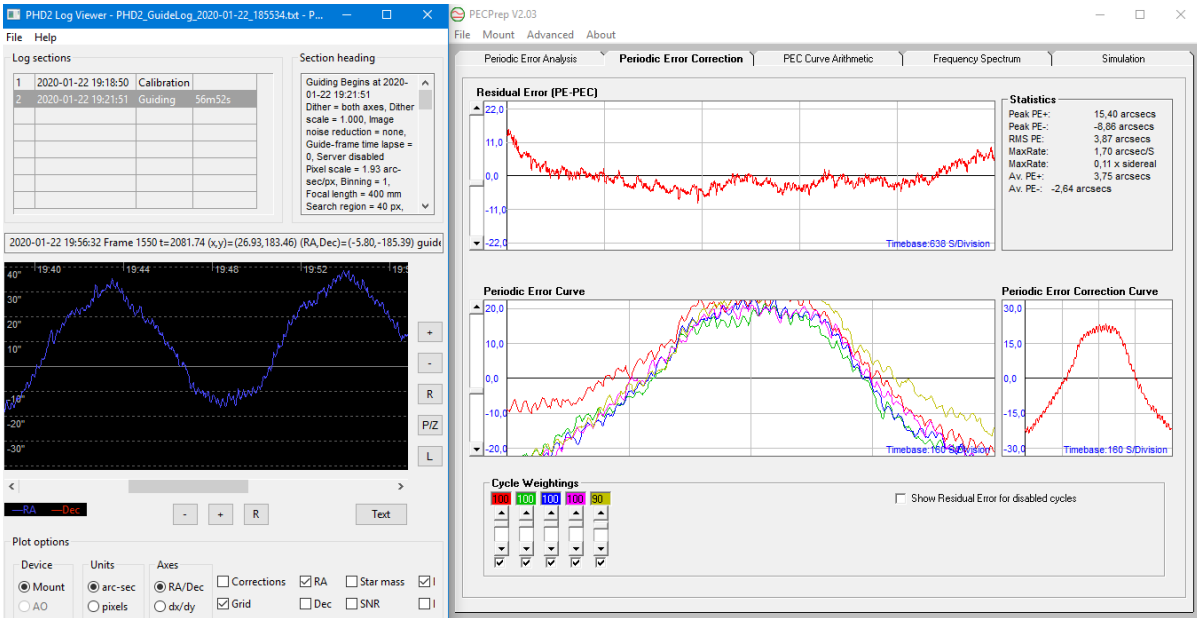
SFX belts used, as in the original components kit

upper belt - SFX #904 (sharp tooth edges)

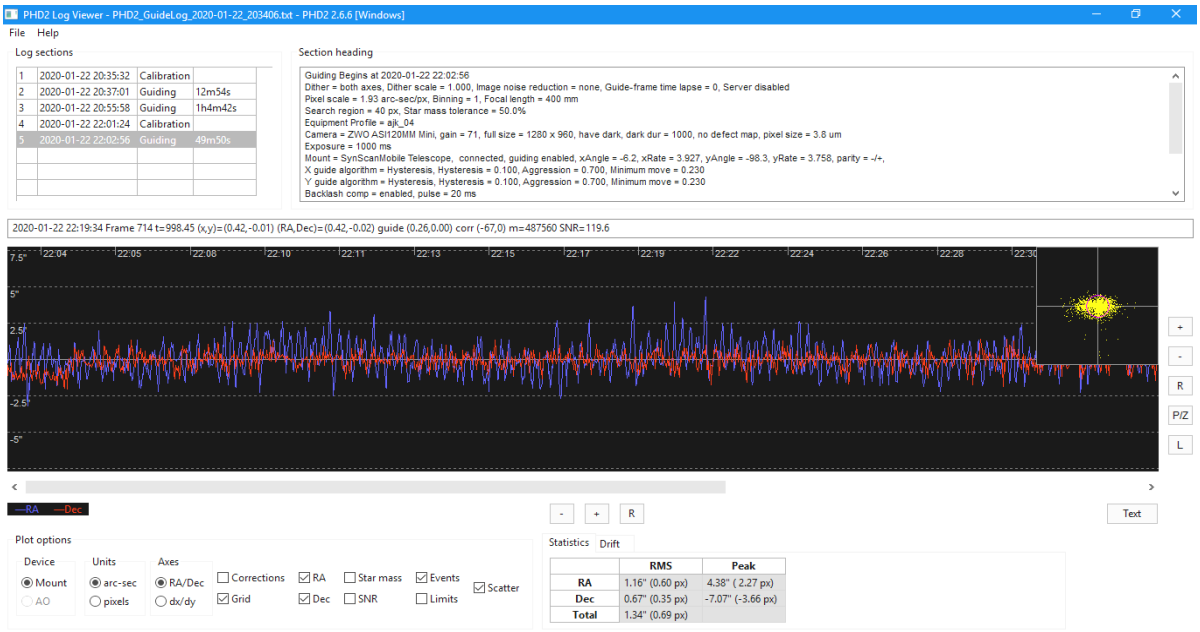
lower belt - SFX #905 (rounded edges)



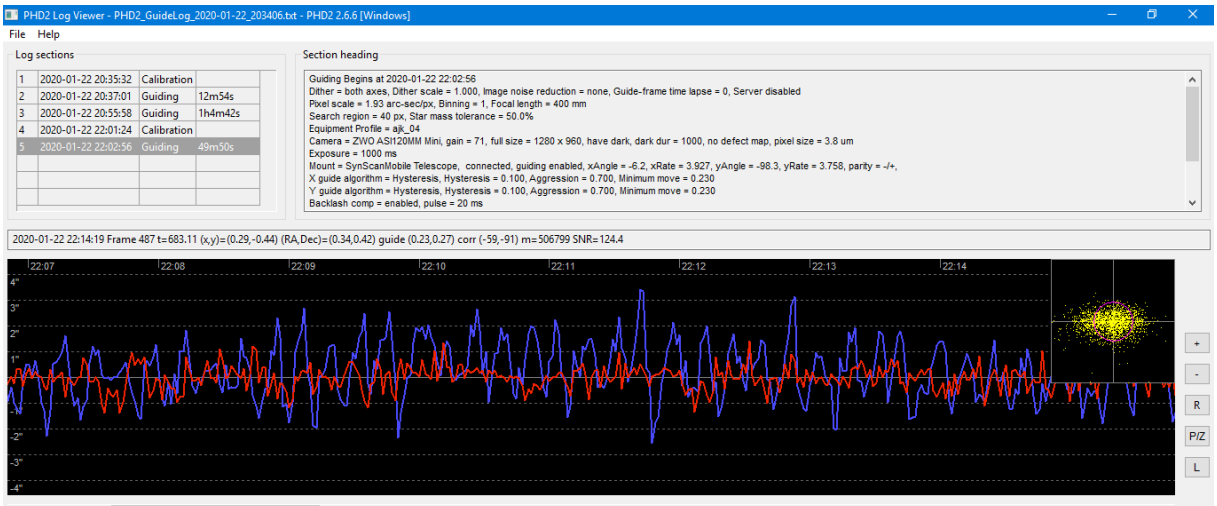




Guiding performance (14 min out of 49min 50sec)



Guiding curve with more high frequency details, the same data (8 minutes span).

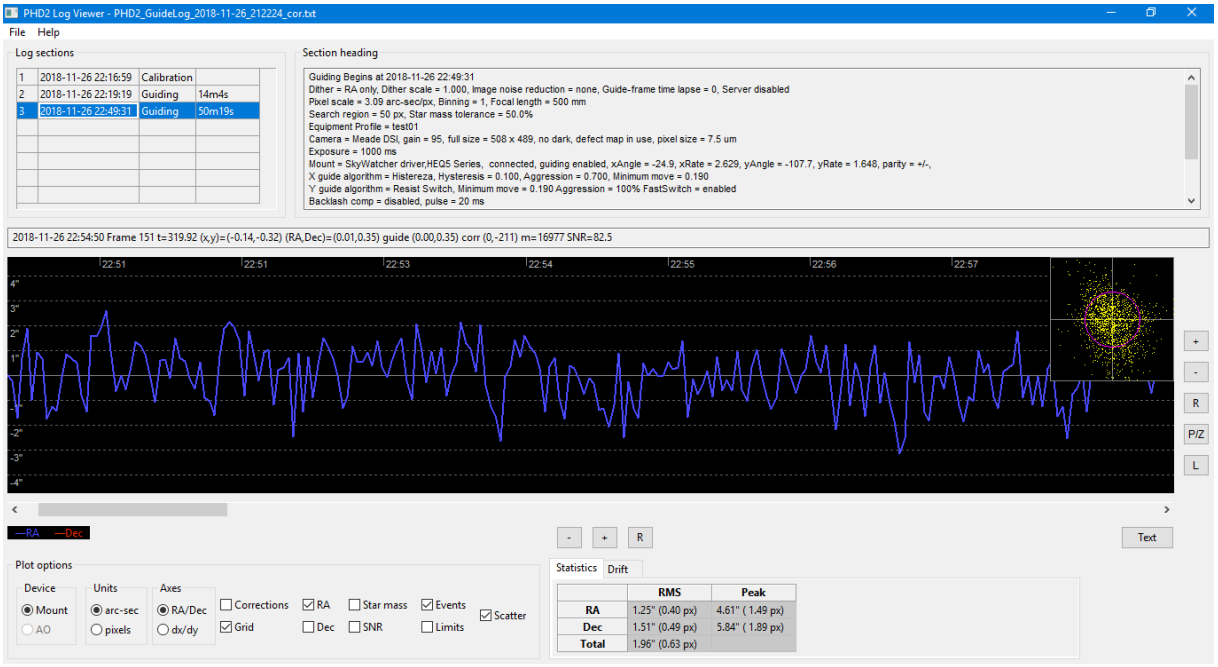


Generally, significant improvement (~2x) has been achieved in DEC performance, yet no improvement in RA tracking. The 13sec periodic modulations weaken the expectation to make better quality guiding system by modification of HEQ5 Pro mechanisms (the metal gear chains) with Rowan belt alternative.

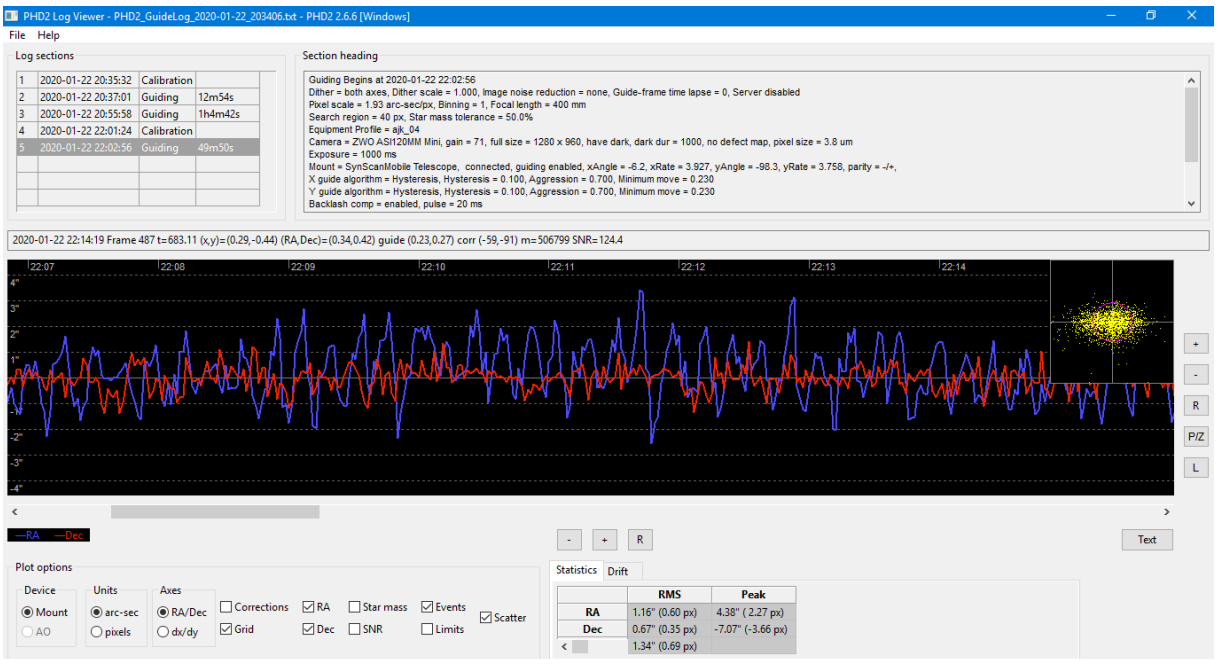
SUMMARY

Guiding.

Original Sky Watcher HEQ5 Pro gears.

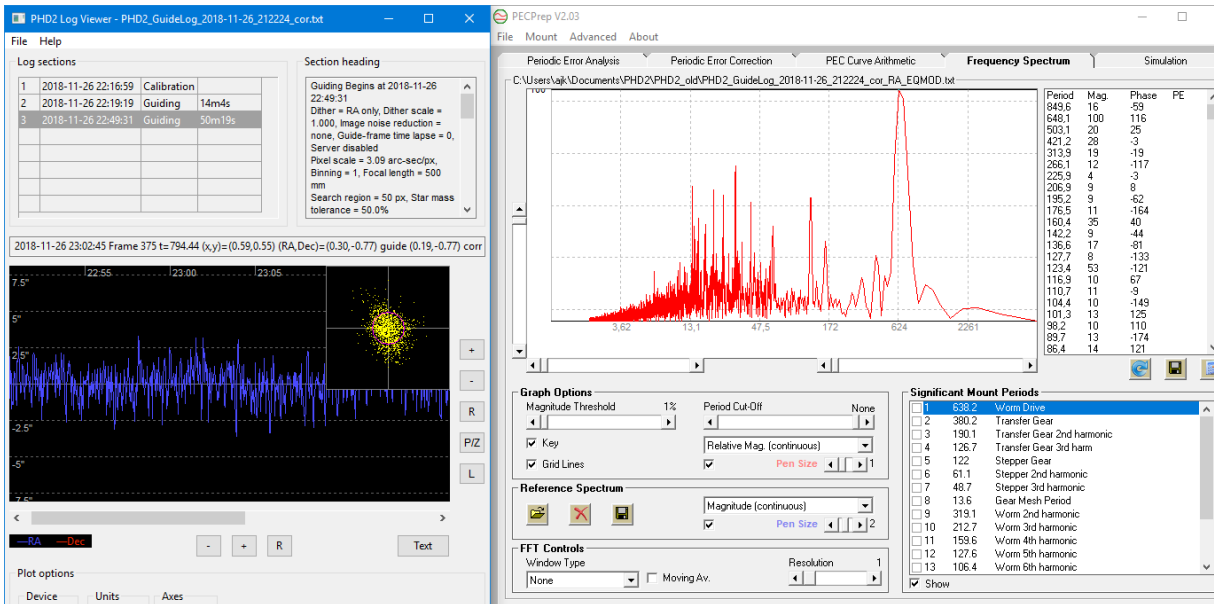


The Rowan belt kit mounted.

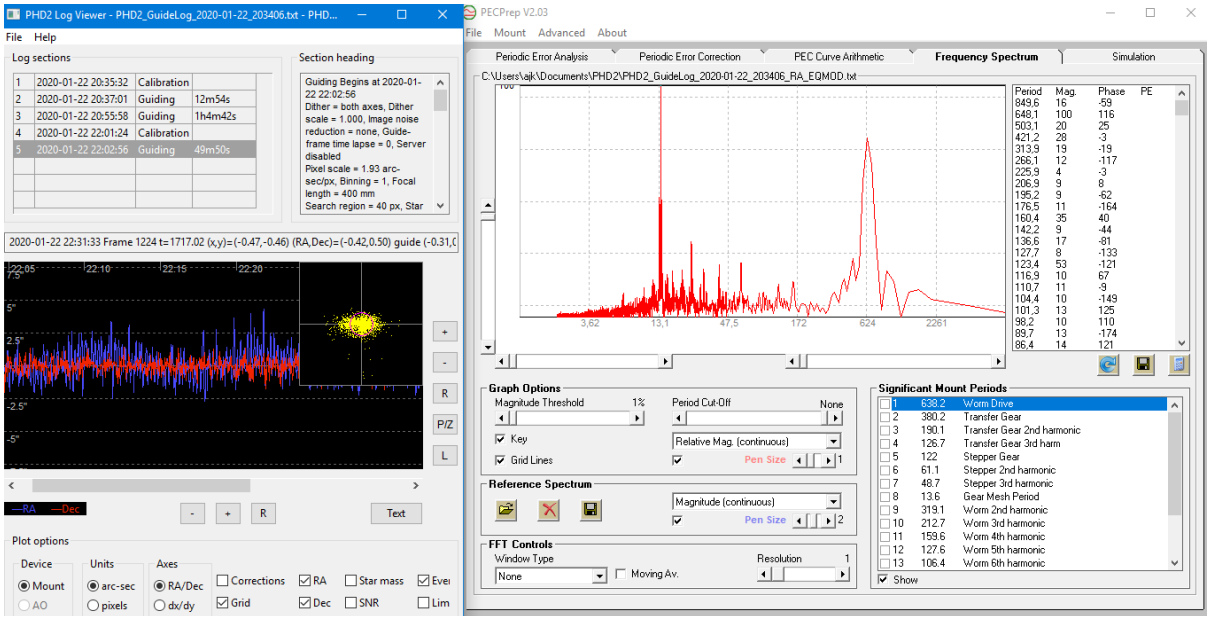


Comparison of the spectra

Original Sky Watcher HEQ5 Pro gears.



After modification with Rowan Astronomy belt kit very strong line is seen at period of 13sec. .

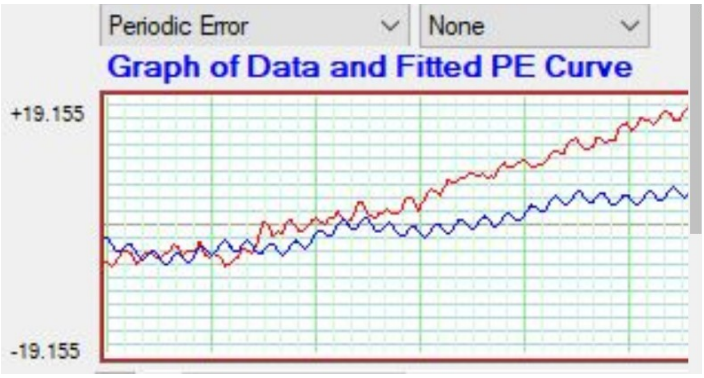


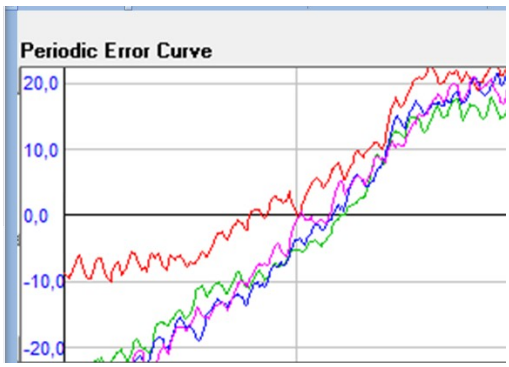
Comments, conclusions:

1. Much smaller errors in DEC, significant improvement gained over the original gear.
2. Large error in RA makes ~3" extensions of stars images in E-W direction. No improvements compared to the original metal gear. The 9 tooth aluminium pulley seems to be outside quality standard, or maybe there is another reasonable explanation like imperfect tooth shape of the pulley and of the belt (mismatch). The possible cure ? – Read the last section of this report.
3. It should be considered to request possible replacement of the RA 9 tooth pulley within the manufacturers guarantee scheme however, all these elements seem to be produced with the same precision.

References to the similar issues, reported on web **forum discussion,** *find here :*

https://stargazerslounge.com/topic/304113-heq5-pro-rowan-mod-problem/





13 sec periodic errors are on avarage ~ 2 x larger in amplitude in my measurements (on the right side ^)

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Other most recent discussions on Rowan HEQ5 modification and the 9T pulley:

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https://groups.google.com/forum/#!topic/open-phd-guiding/ewNtq0c_Duc

https://docs.google.com/viewer?a=v&pid=forums&srcid=MDcxMDI2NDk2Mzk3MDAyNTAyNzgBMTU2OTQ5MTg0MjQ4MjU4NDk5N

Fm : Michael 2019.12.27

Hi, I have a HEQ5 with Belt mod and I really struggle with an annoying peak in the frequency spectrum at 13.6 seconds. It is of amplitude of 2" and destroys my observing results. It is very good reproducible and not removable by any guide setting. As I already found out this is already known issue of the belt meshing.
The gear with the belt has a period of 86.164,091s / 135 teeth / 47 teeth = 13.58s which is an exact match.

It tried to change the tension and the moved the motor so that the teeth of the gear and the belt smoothly mesh. But the problem remains. Does anybody had the same problem and can tell me how it was fixed?
Thank you Michael Hedenus

Reply from Rowan Engineering https://docs.google.com/viewer?a=v&pid=forums&srcid=MDcxMDI2NDk2Mzk3MDAyNTAyNzgBMTU2OTQ5MTg0MjQ4MjU4NDk5NjkBVkItYmpnZjlCUUFKATAuMQEBdjI

We have had a couple of customers who have also seen a small ripple from the belt meshing with the 9tooth pulley and they have had fully tuned mounts too where the ripple becomes measureable.
We think this is due to a small variation in the belts we buy in. I have made a small number of 9 tooth pulleys for testing which should give a smoother meshing with the belts you have.
The belt could be lubricated but I would hold off from doing that until you've had to opportunity to test the new 9T pulley.

I'll send one to you in the post today and I would appreciate your feedback if it has improved the ripple you are seeing.

Kind regards,
Dave Rose.

Rowan Engineering Ltd.

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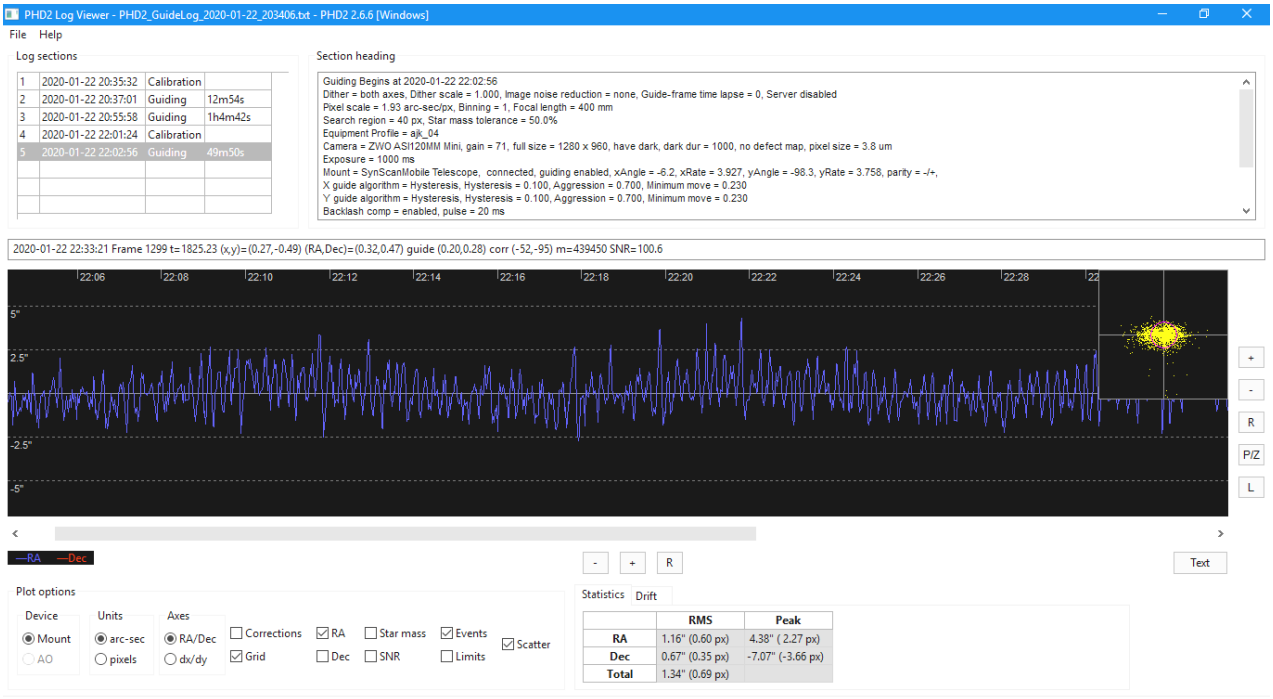
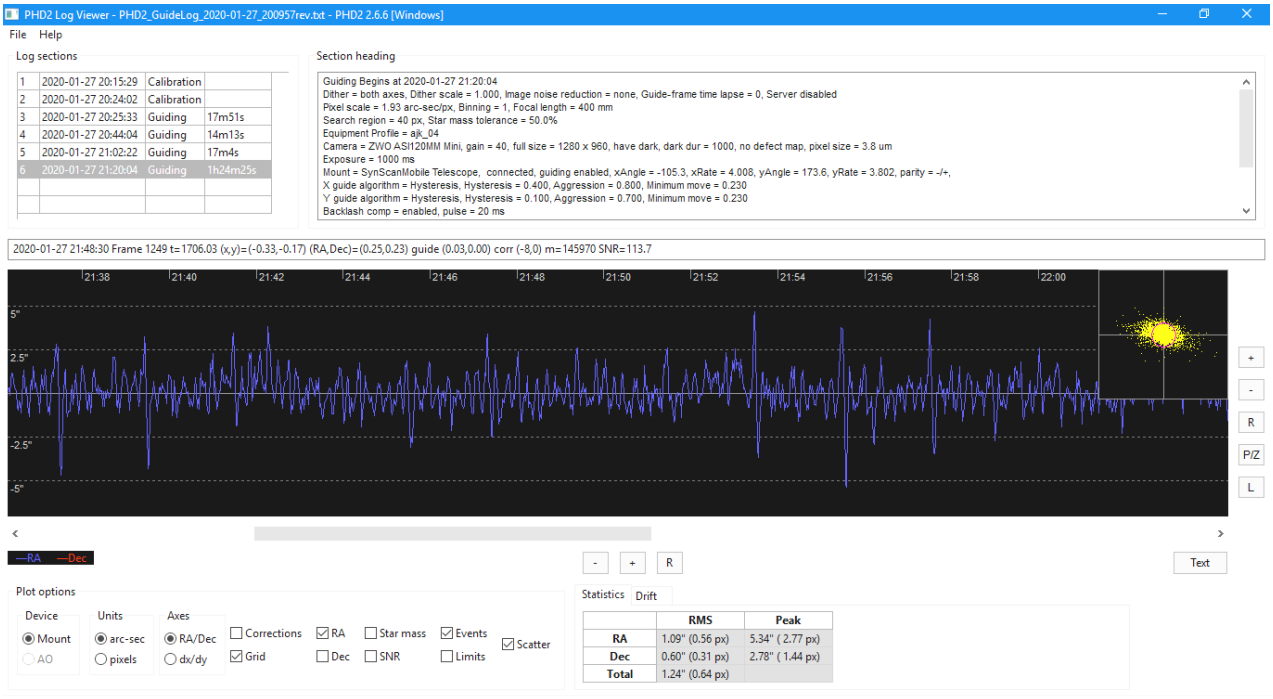
22 January 2020, Dear All,
I got a replacement tooth wheel from Rowan and there it solved the problem. The 13.6s peak has vanished. The stars have now an eccentricity of 0.5!!
Michael

Comparison of two my guiding records with different belt's tension (no significant change in amplitude of 13 sec modulation)

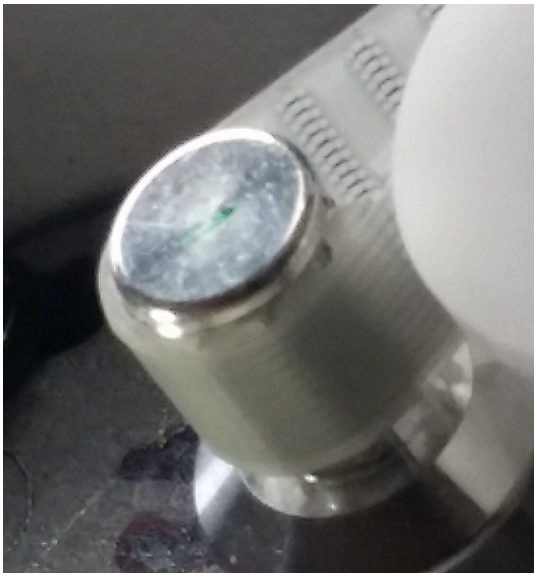
Medium tension



Strong tension (tight)



Possible problem with SFX belts ?

Flexible SFX belts tend to fit closely to T9 pulley shape (nanogon) making flat surfaces where the tooth is stiff (above tooth), and the major bent occurs between teeth, where the belt is thin and thus most flexi.
This shape of the belt around T9 pulley and odd number of T9 teeth add small variation (up to 2%) into the assumed constant linear velocity of the belt. More on the following photos.




The solution of this problem is to use stiffer and thicker belts, which then can wind up, wrap up, smoothly circular, as show on the next two photos.

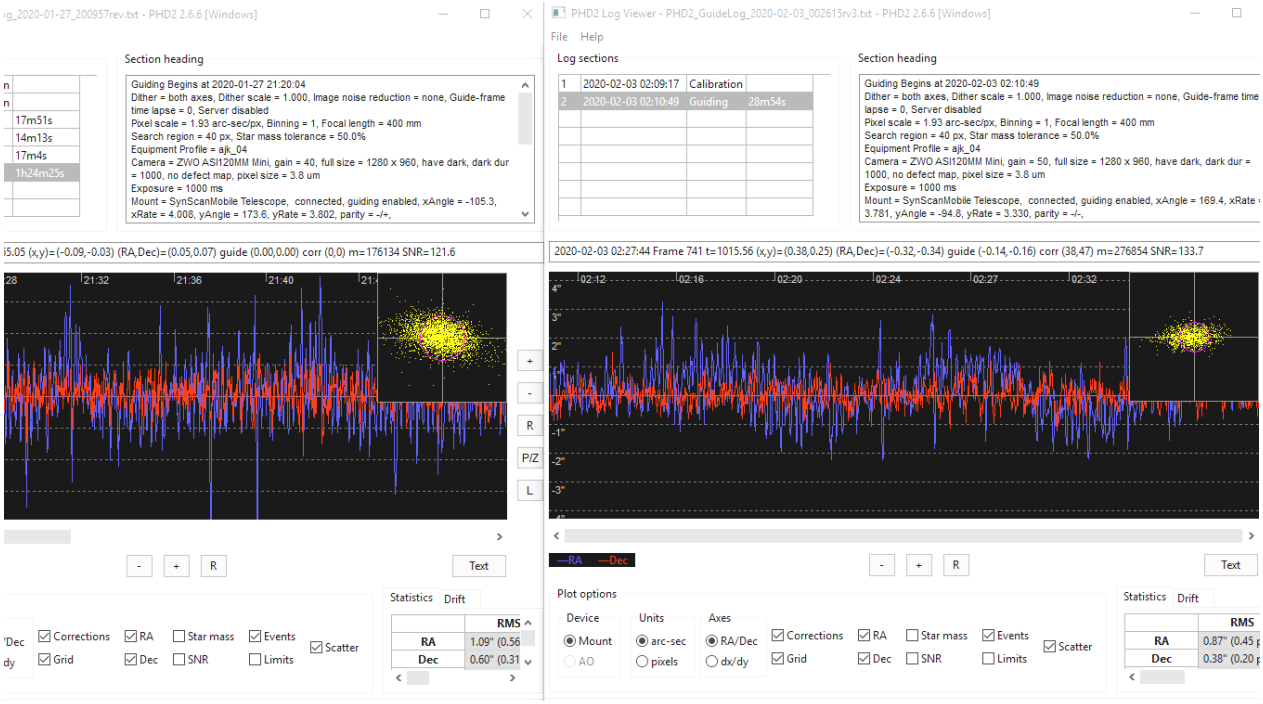
The used belt made by MEGADYNE in Italy, is thicker and stiffer, with rounded tooth shape, may however cause other problems (belt's durability, wear of T9 pulley, or motor bearings wear ? probably insignificant).

This result in smoothness of RA guiding is remarkable.

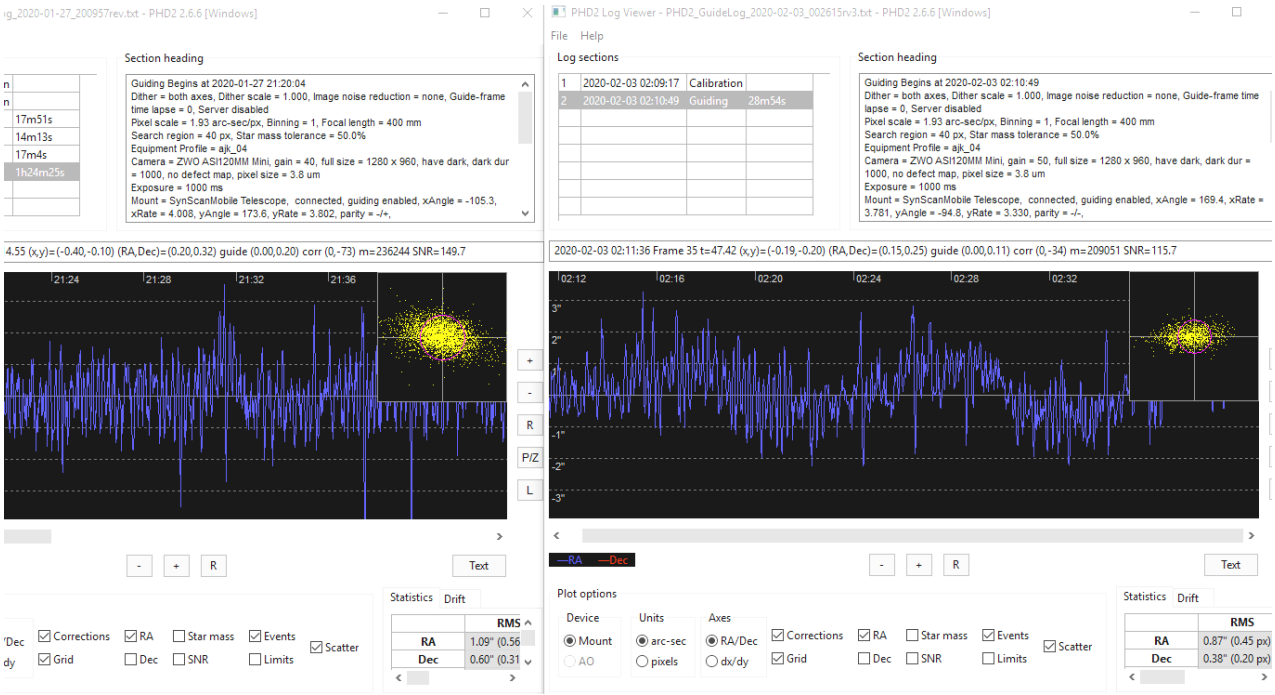
Results on guiding are shown on following graphs from PHD2 and PECPrep

Tests with SFX original belt (Jan. 27th) on **the left side** compared with **a stiffer belt** (***MEGADYNE 2212***) **on the right side** (Feb. 3rd))

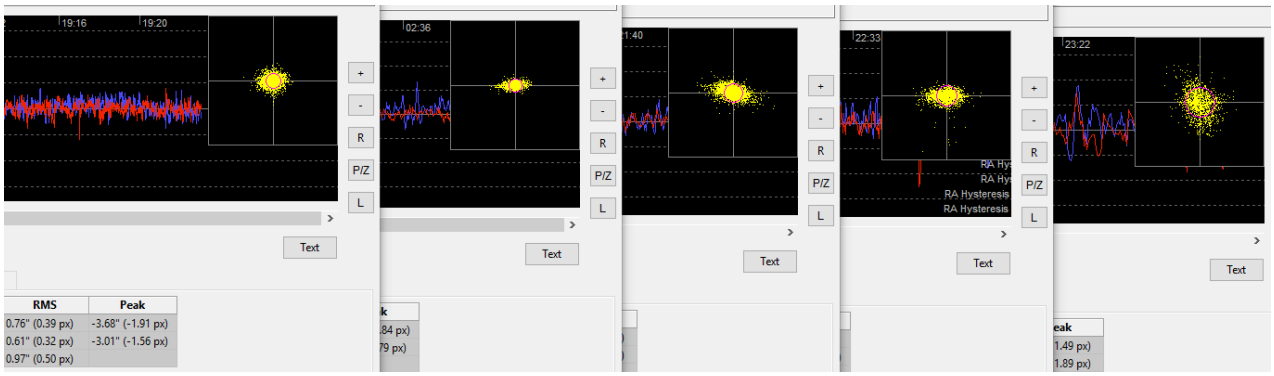
Generally the 13.6 sec modulation is reduced from +/- 1.5" to ~ +/- 0.5. This is clearly presented on inserted scatter graphs, shown here at the same scale. With the MEGADYNE belts the RA guiding performance has been improved by ~3x . There is also better, improved guiding in DEC, 0.6/0.38=1.6 x.



Without DEC track

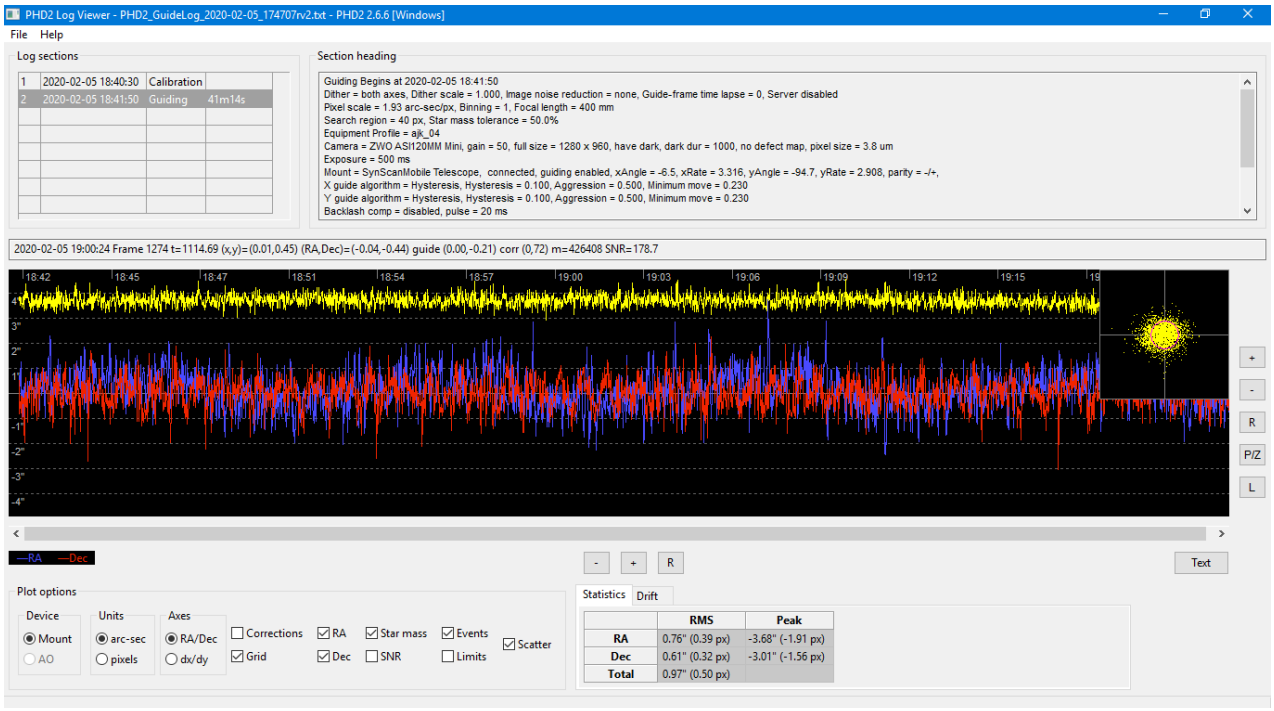


The residual 10 min modulation (with amplitude about +/- 0.8") is most probably caused by an <u>insufficiently fast correction of **PE** by PHD2 control software</u>. Sampling rate was here 1 sec. Maxima in this modulation curve are in moments, where |dPE/dt| has max values, i.e. at the fastest rate of RA drift.

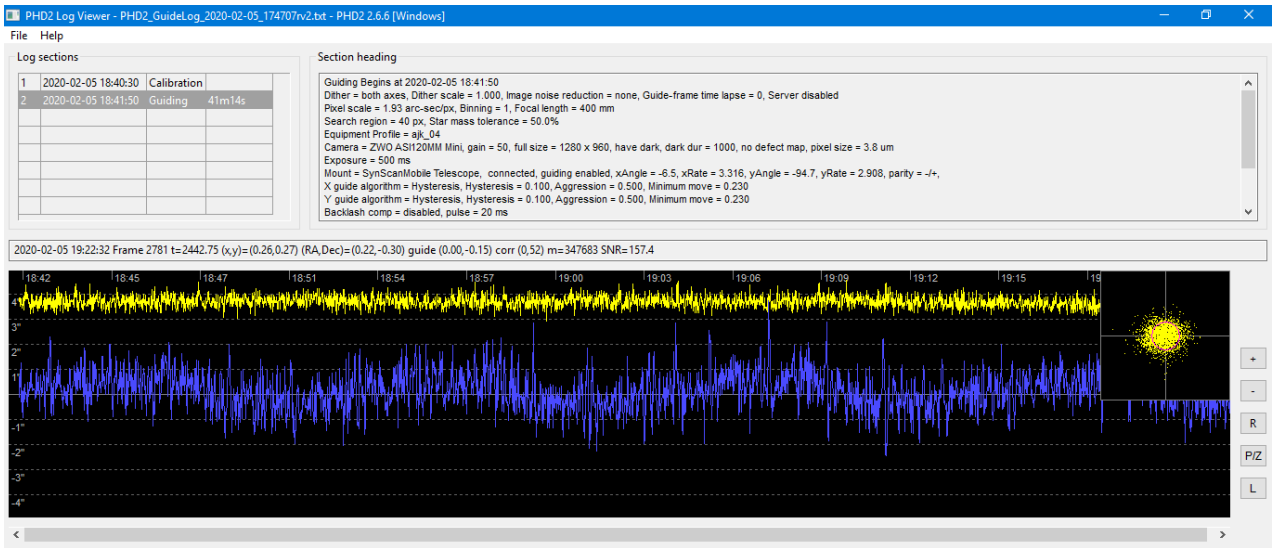


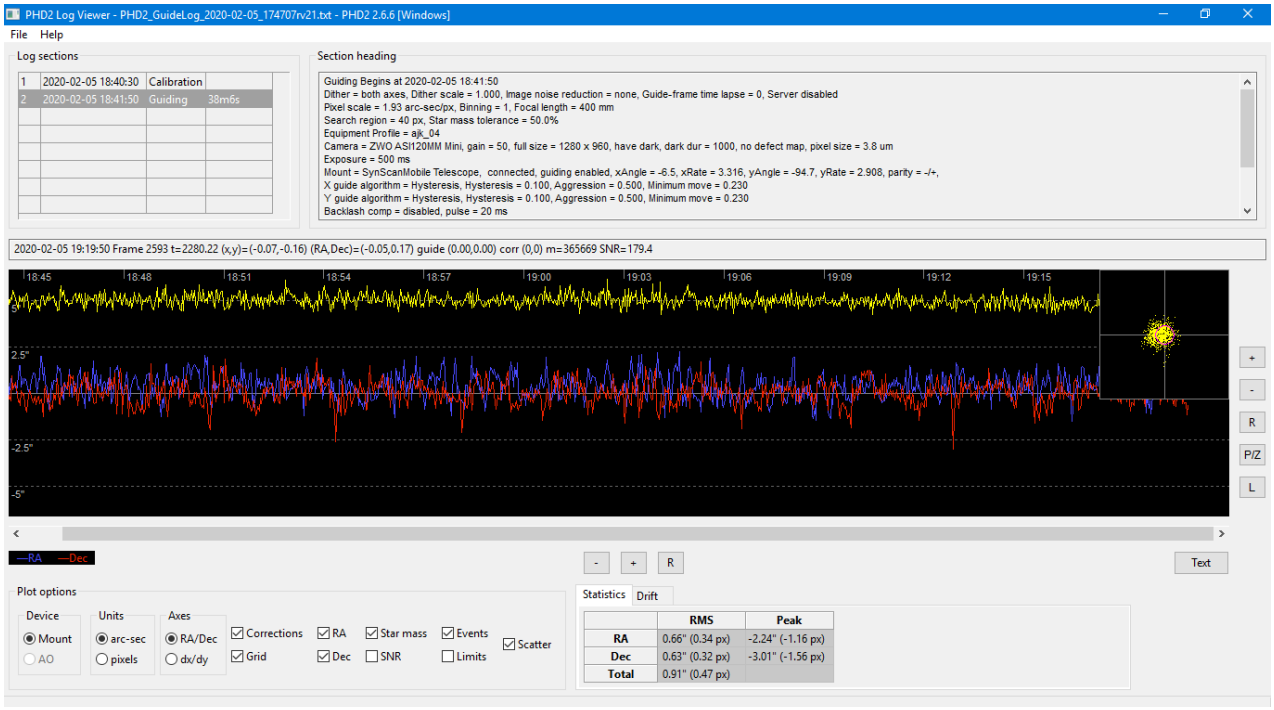
Observing tests, from the left: Feb. 5th, Feb. 3rd, Jan. 22nd, Jan. 22nd 2020, Nov. 6th 2018.

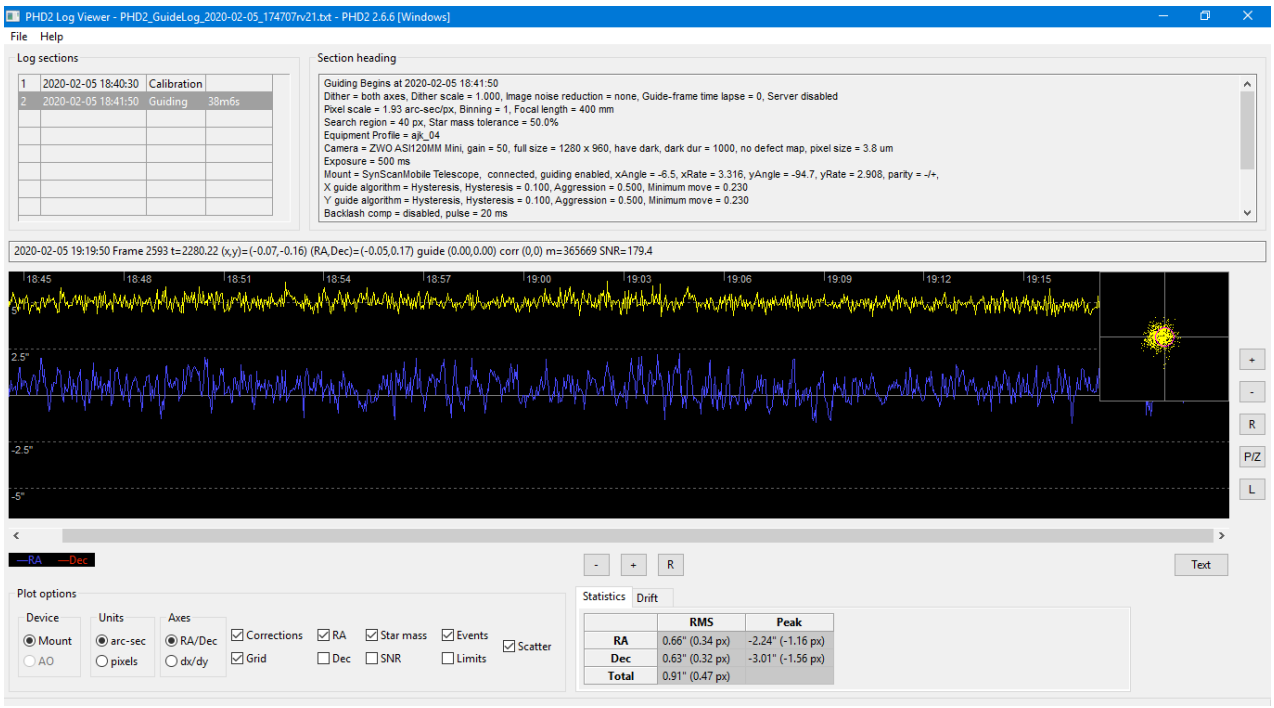
More from Feb. 5th tests



DEC track record removed

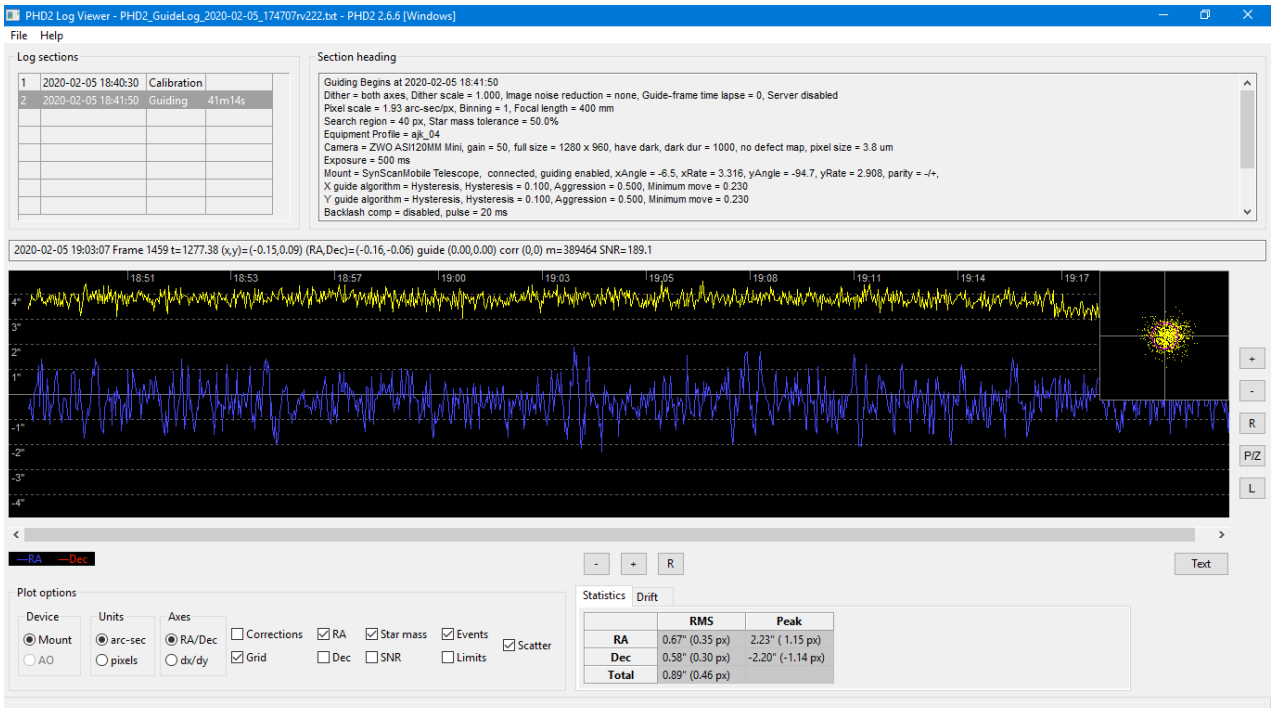


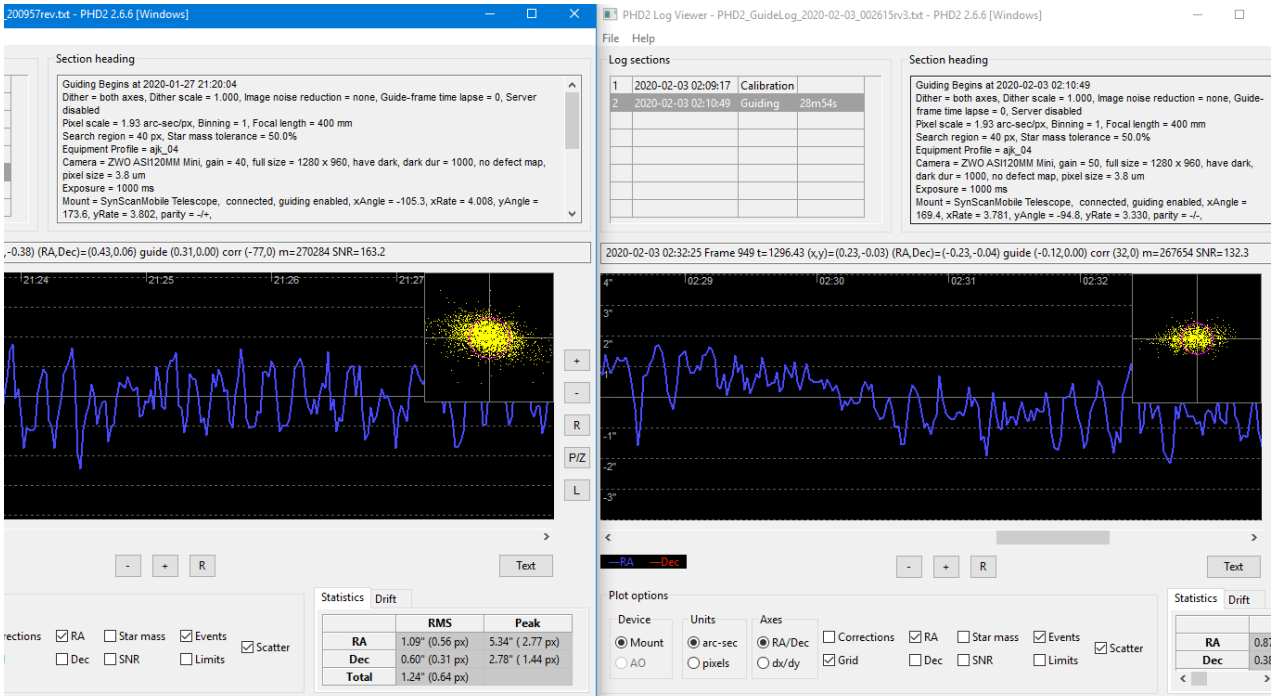


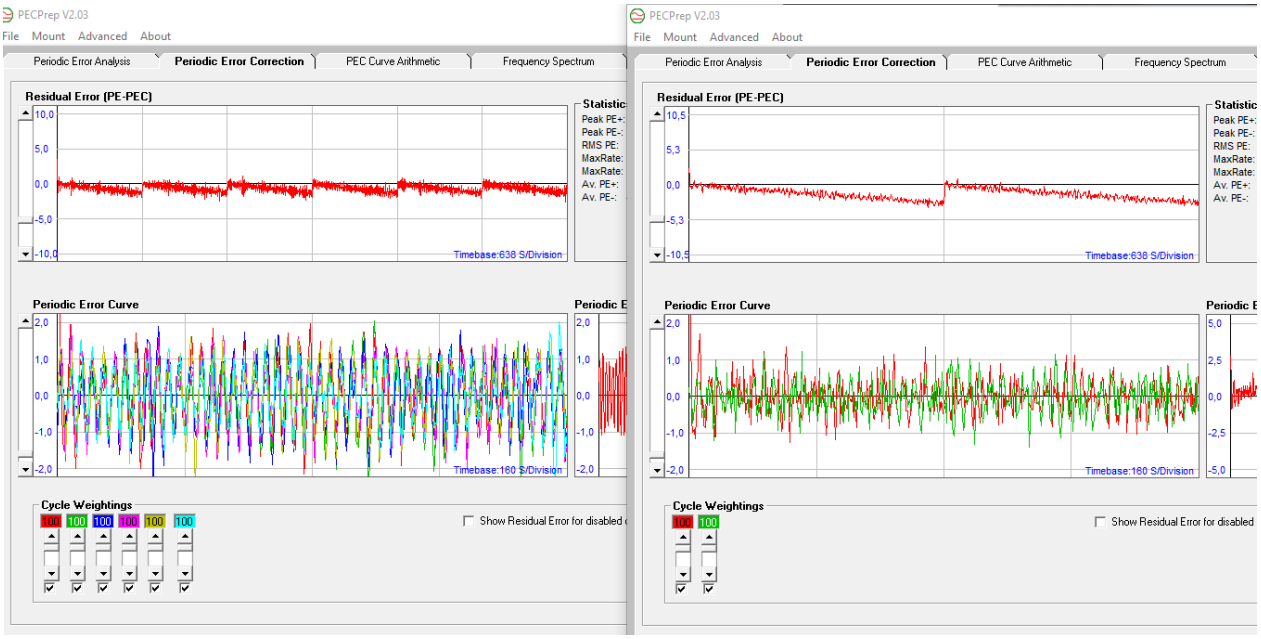


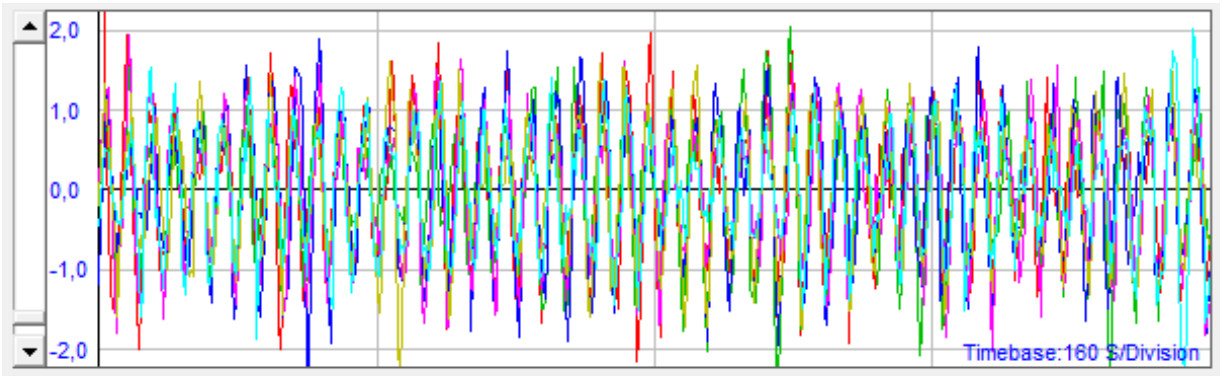
Current results on guiding are shown on following graphs taken from PHD2 and PECPrep (screen shots).

and with some spikes removed

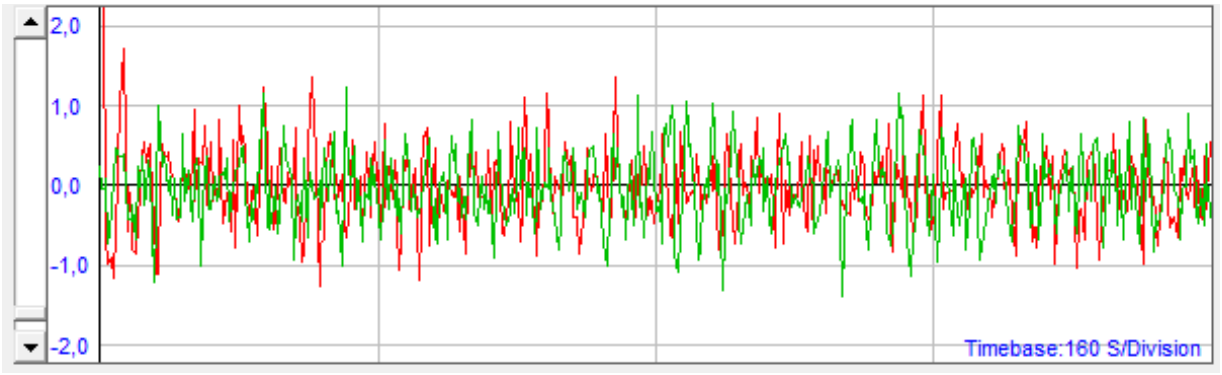






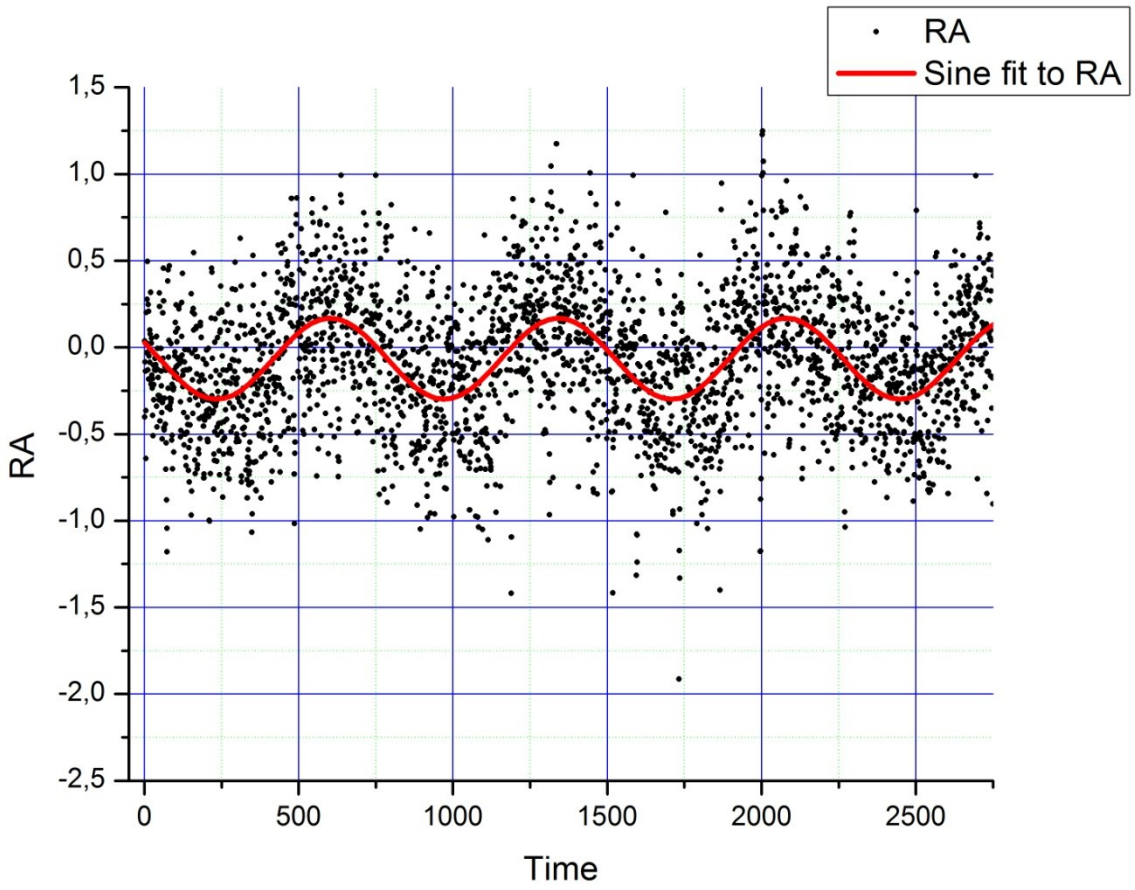


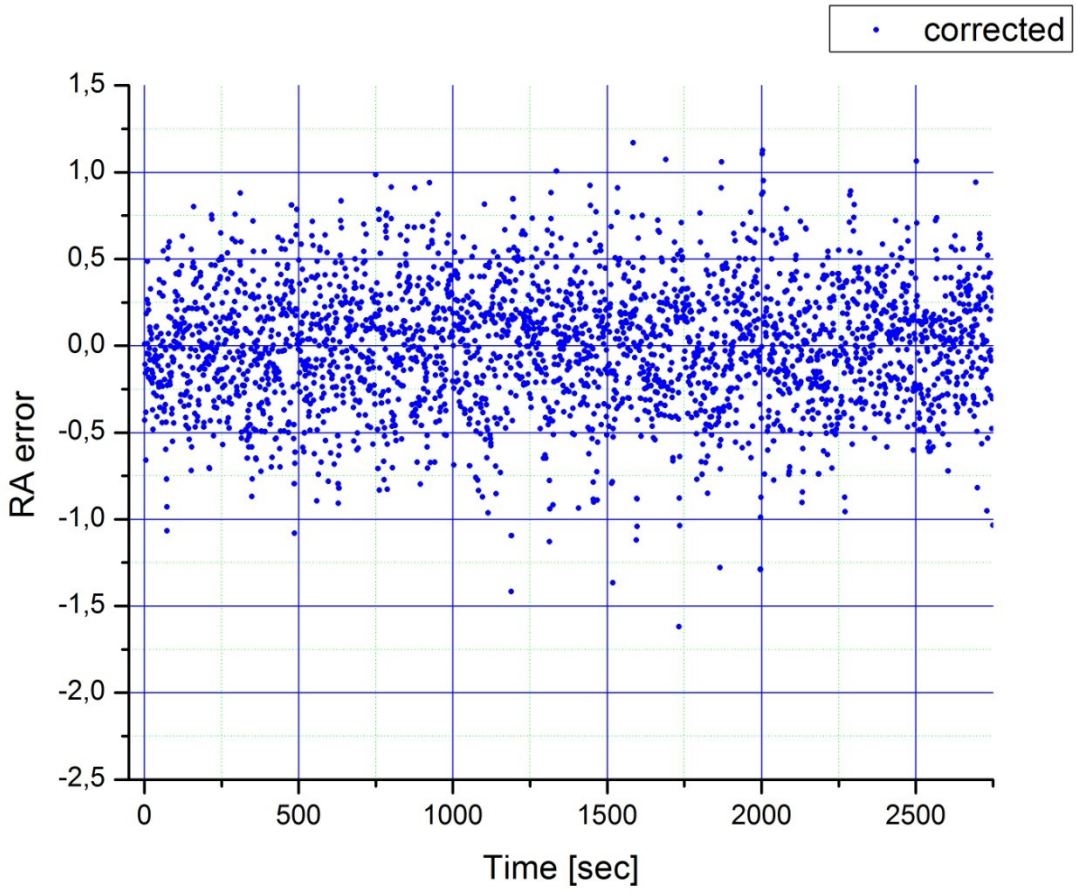
RA guiding error over six 10.64min cycles. Vertical scale in arcsec. The remarkable coherence of the 13.6 s. oscillations over long time. The period of these oscillations is related to the pass of one tooth of nine of the pulley, and is locked to one turns of worm gear 86,164.09054s / 135 teeth = 638.25s, and thus the one tooth pass takes 638.25s/47teeth = 13.58s.



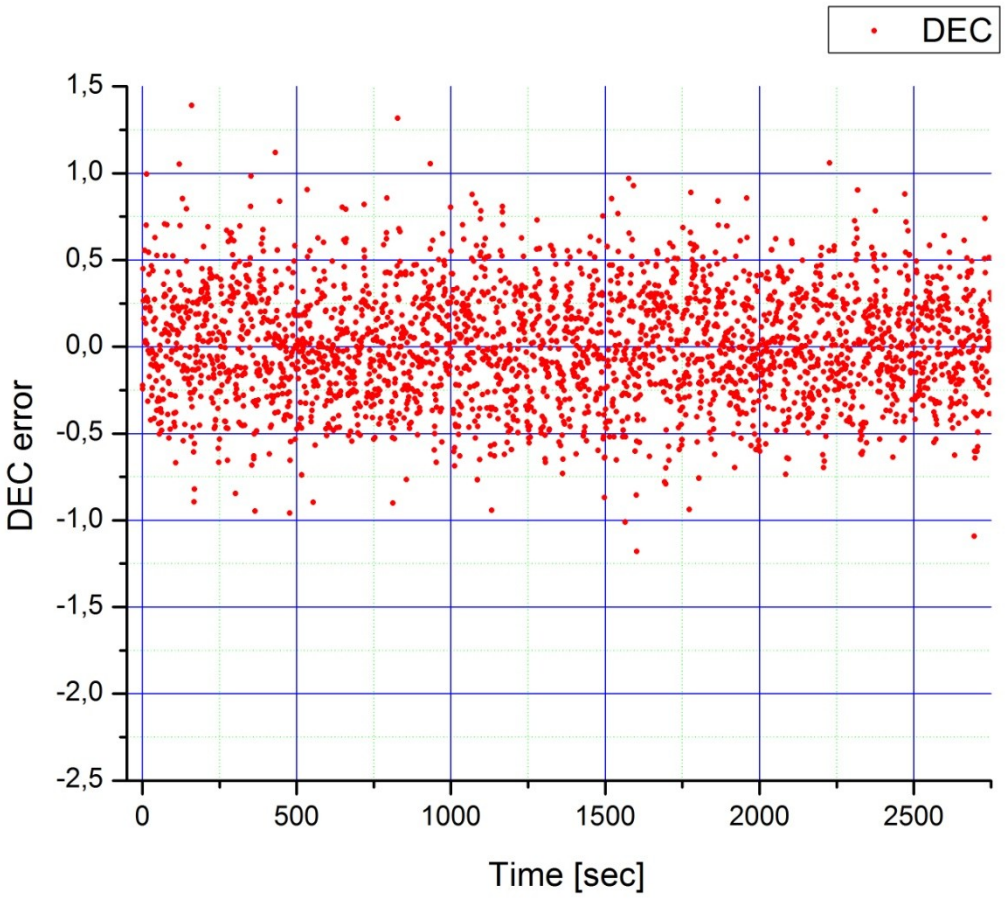
The guiding error in RA after replacement of belts.

The above results come from my tests, the graphs clearly represent guiding problem with original belts supplied by Rowan, and for comparison the improvement obtained with use of Megadyne belts.

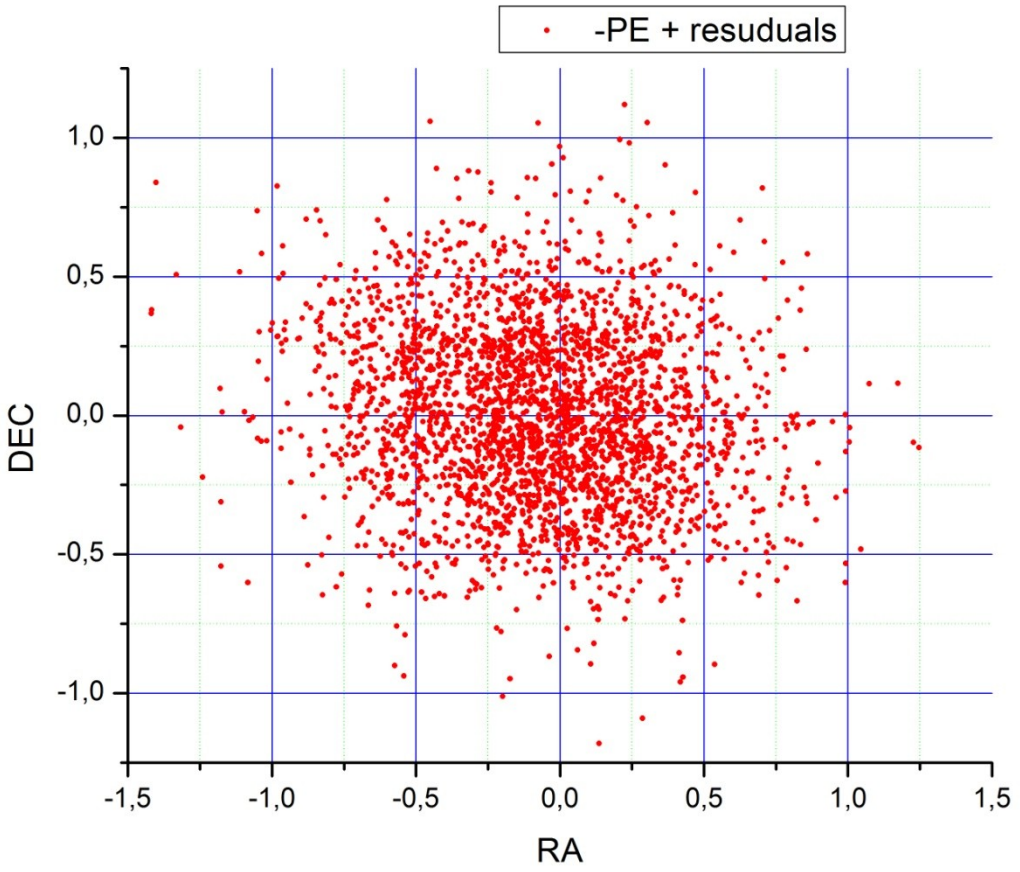


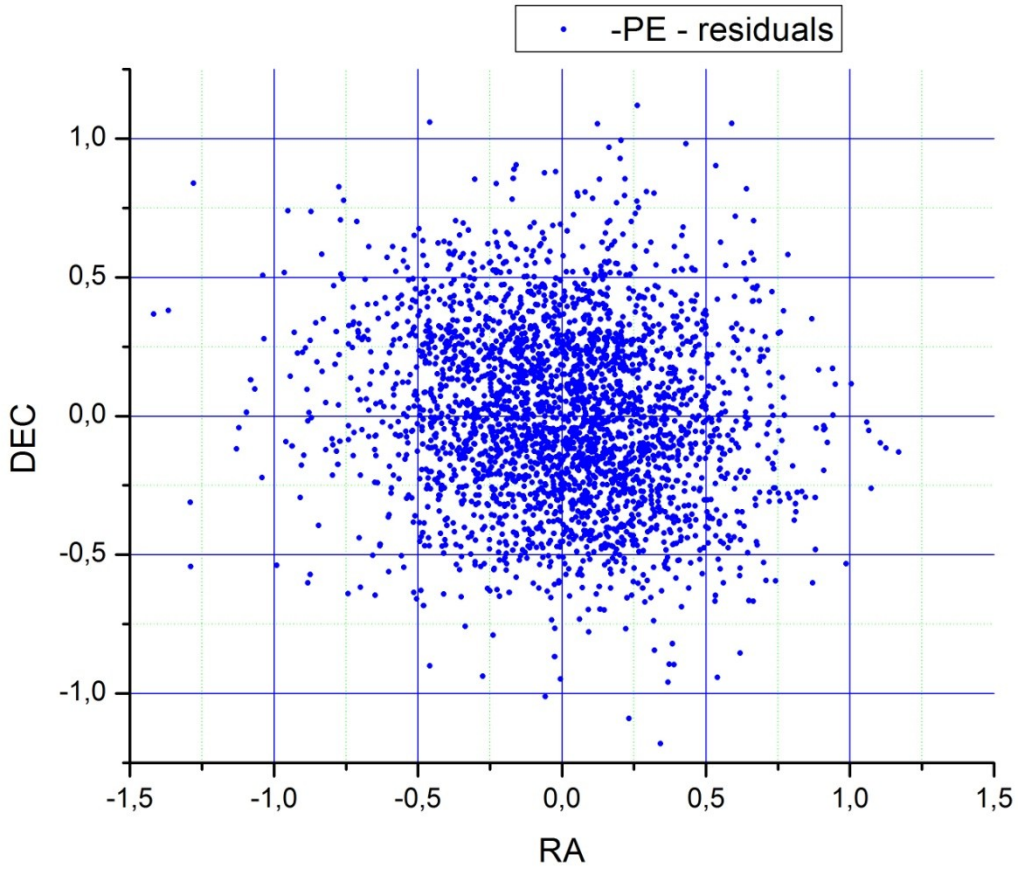


Vertical scale in pixels (1 pix = 1.93")

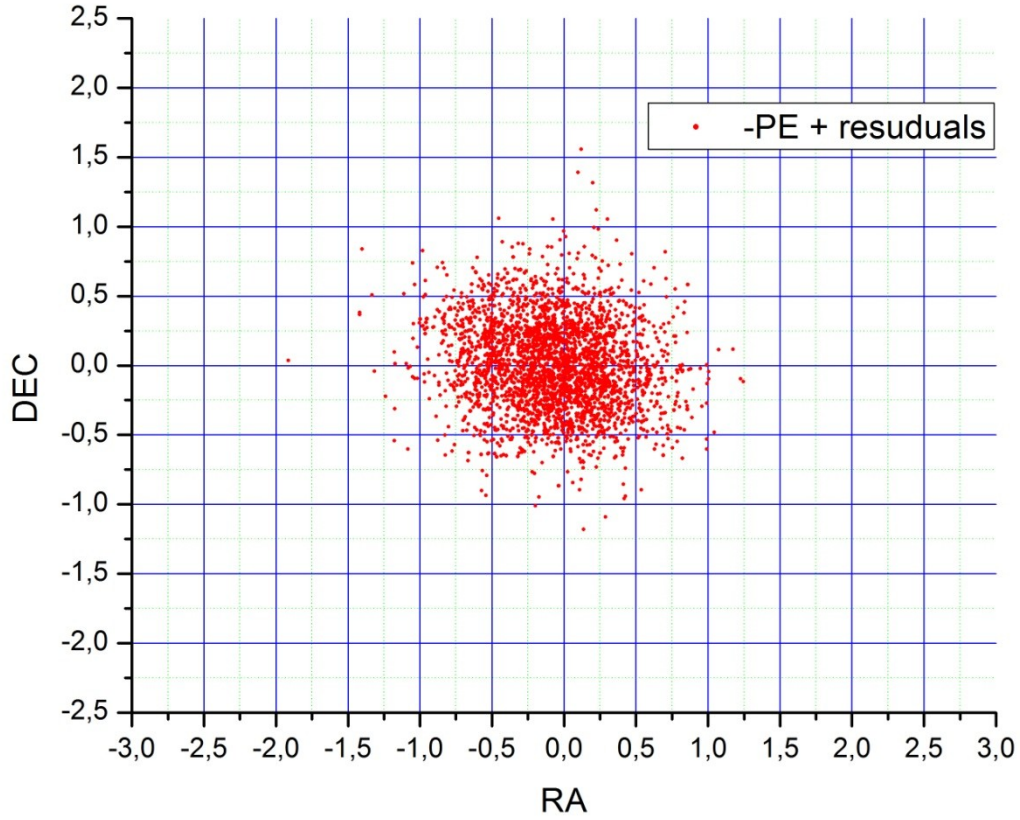


Vertical scale in pixels (1 pix = 1.93”)

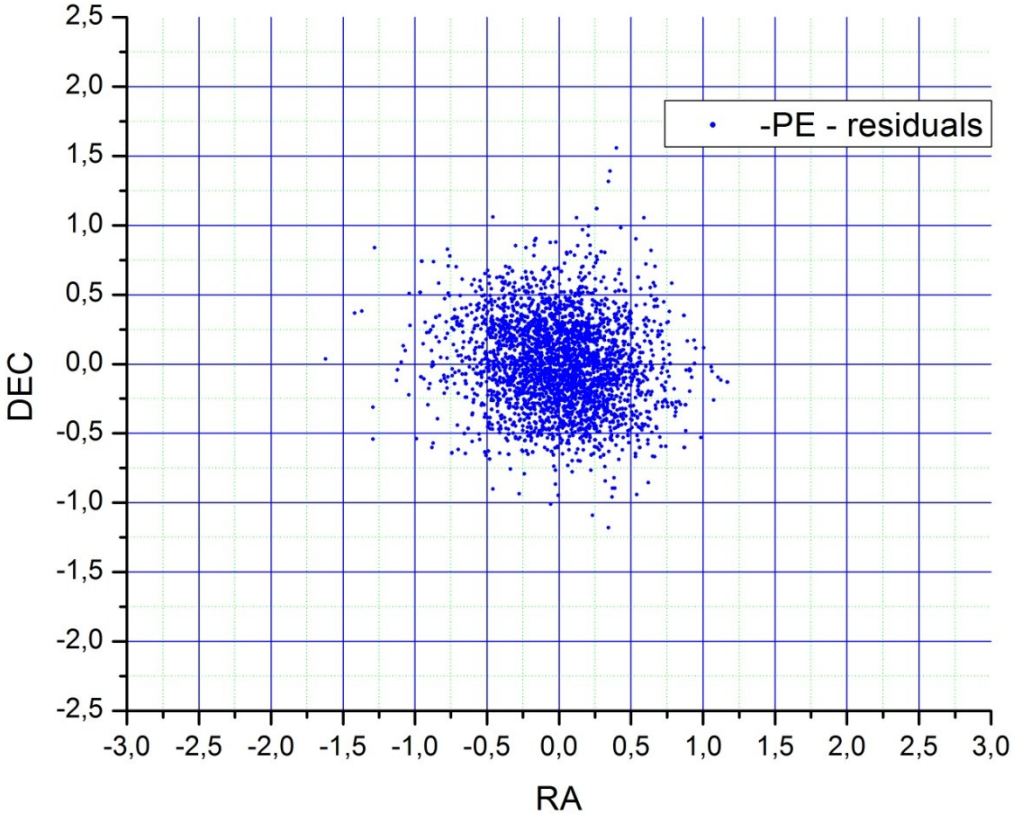




RA and DEC errors [pixels] (1 pix = 1.93")



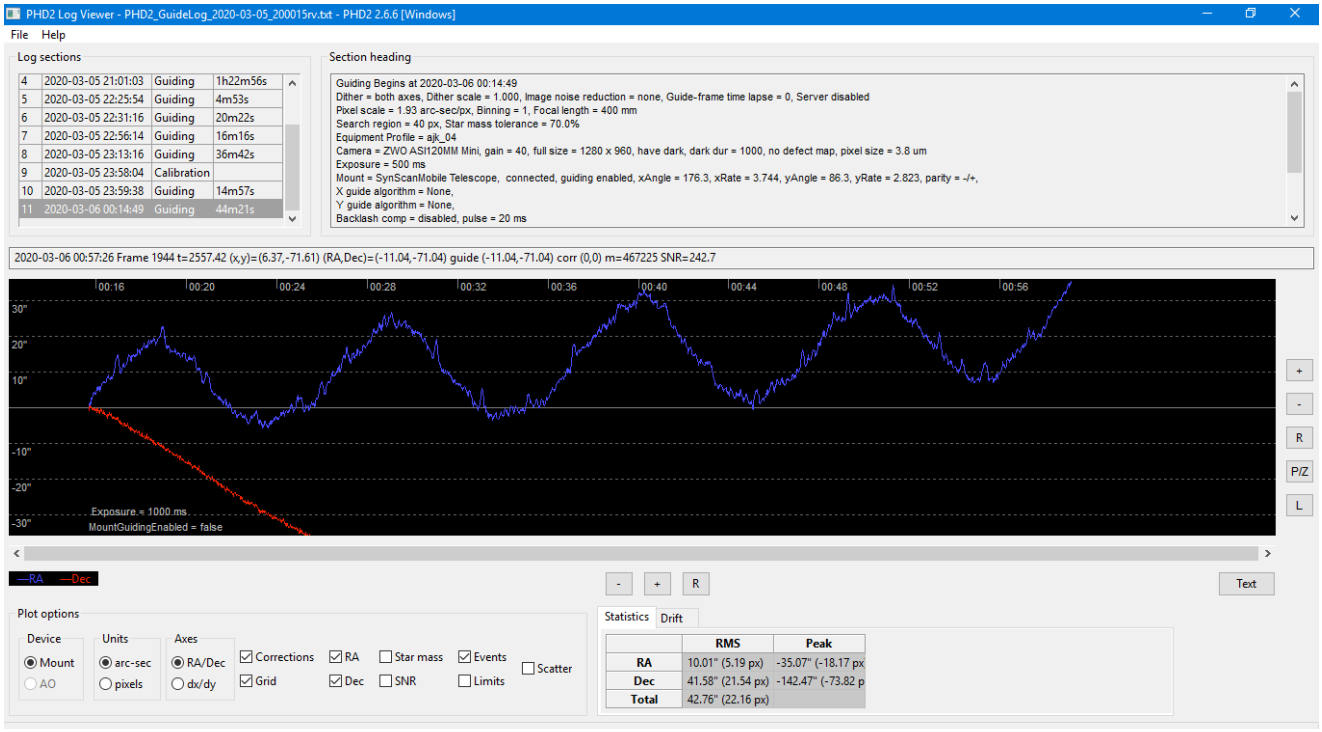
RA and DEC errors in pixels

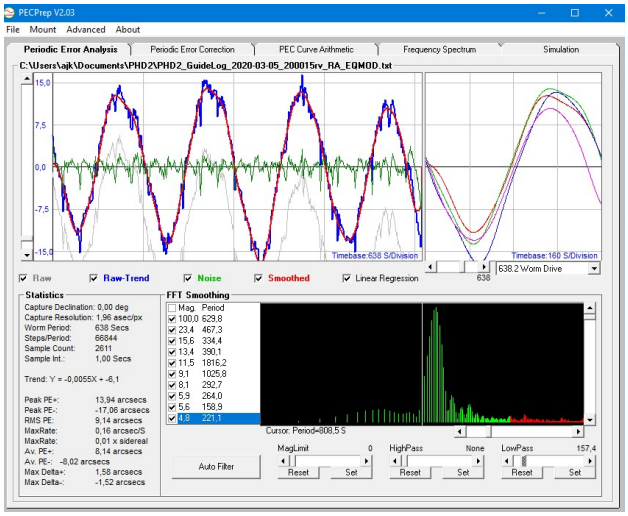


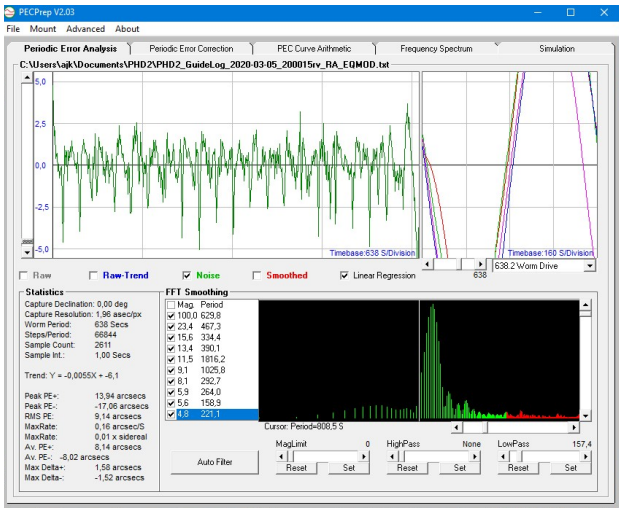
RA and DEC errors in pixels

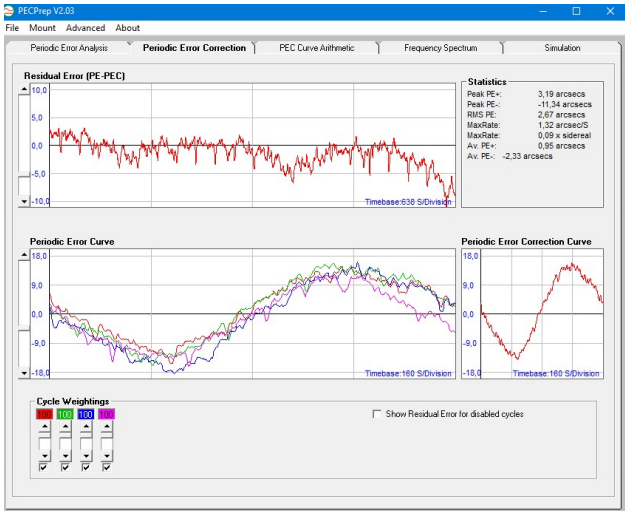
PE measurements for SW HEQ5 Pro with WiFi and Rowan belts system NEW

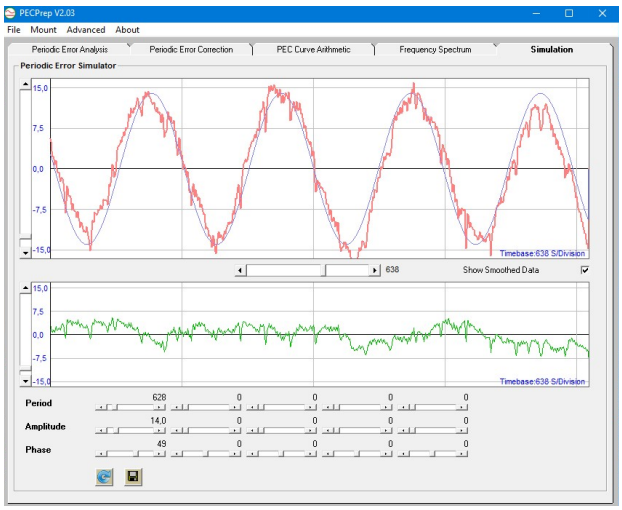
2020-03-05

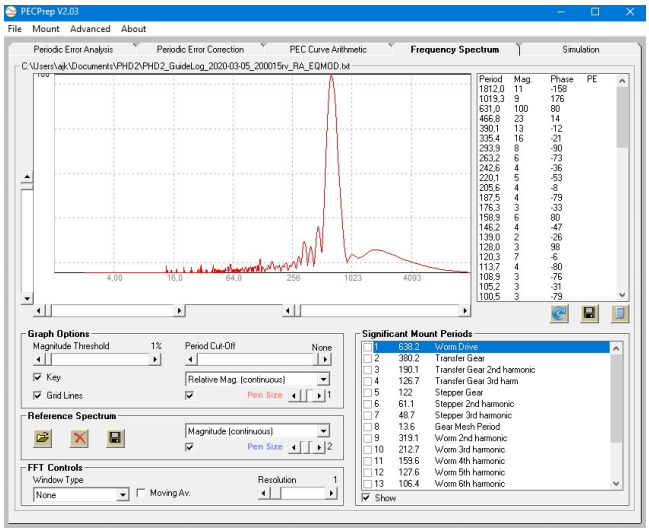


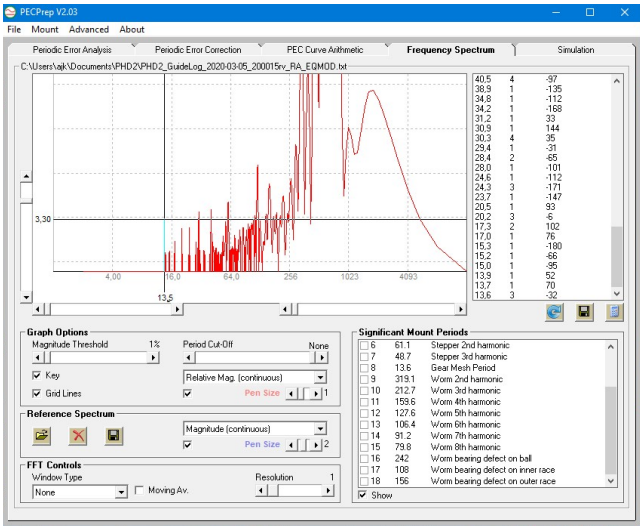


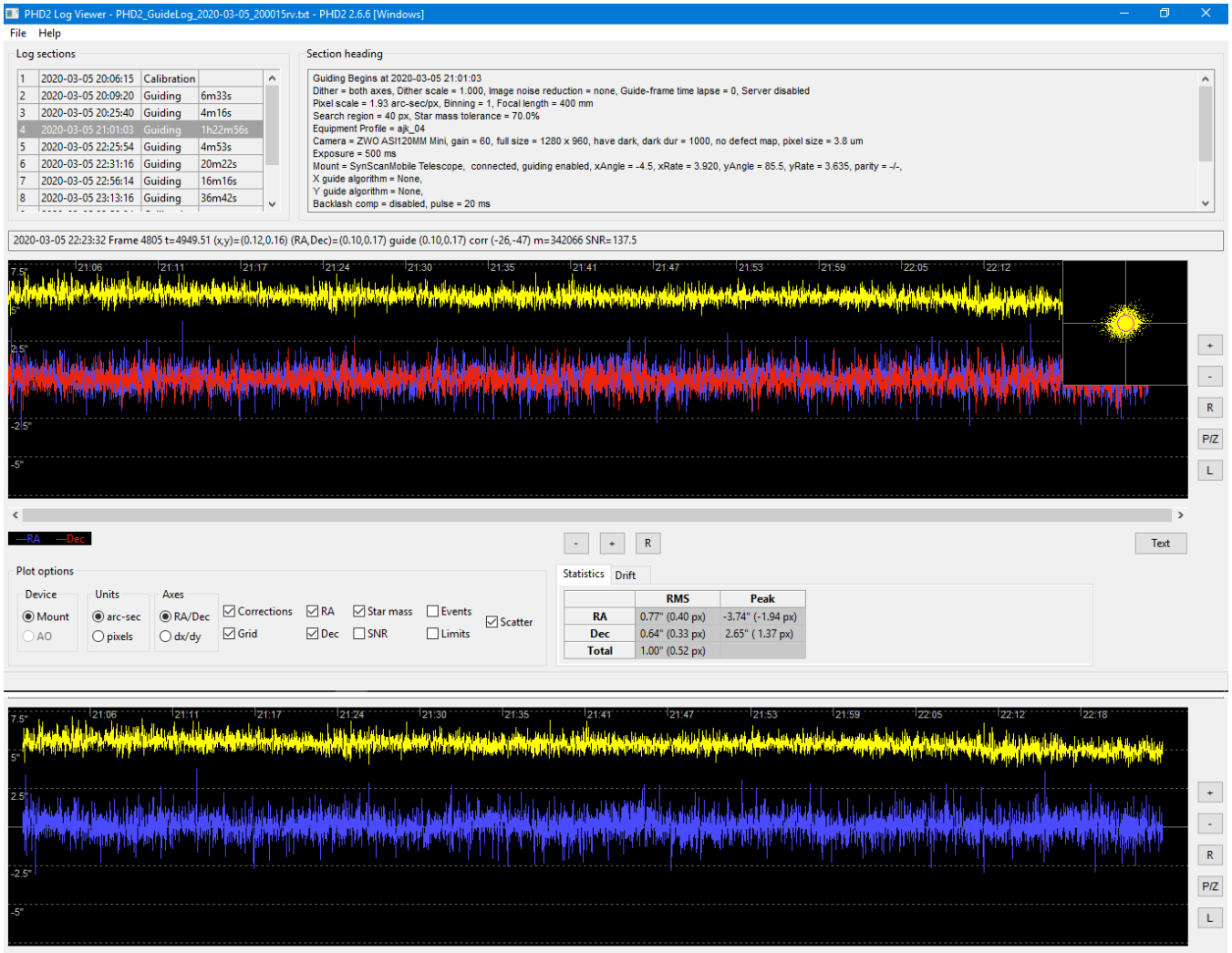


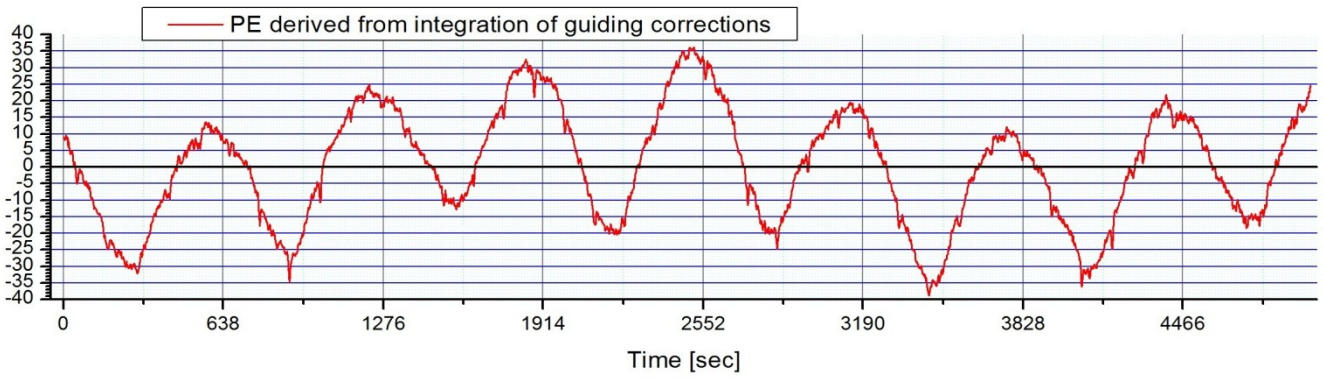


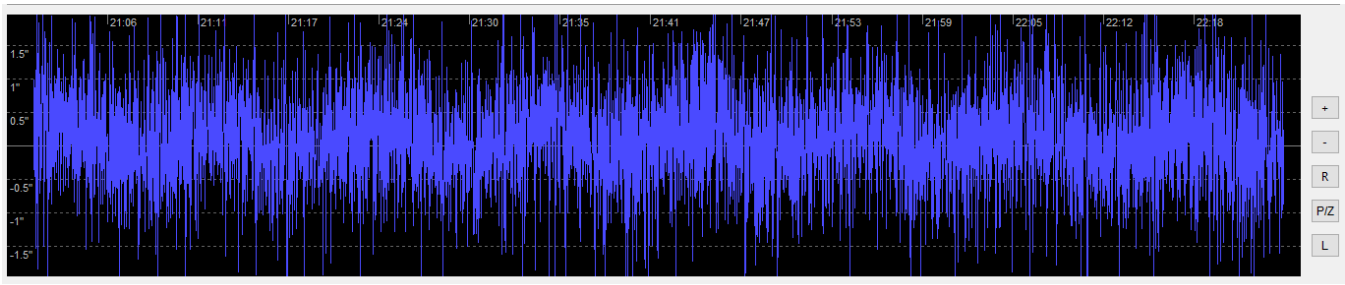



PECPrep V2.03
File Mount Advanced About
Periodic Error Analysis
Periodic Error Correction
PEC Curve Arithmetic
Frequency Spectrum
Simulation
Graph Options
Reference Spectrum
FFT Controls
Significant Mount Periods

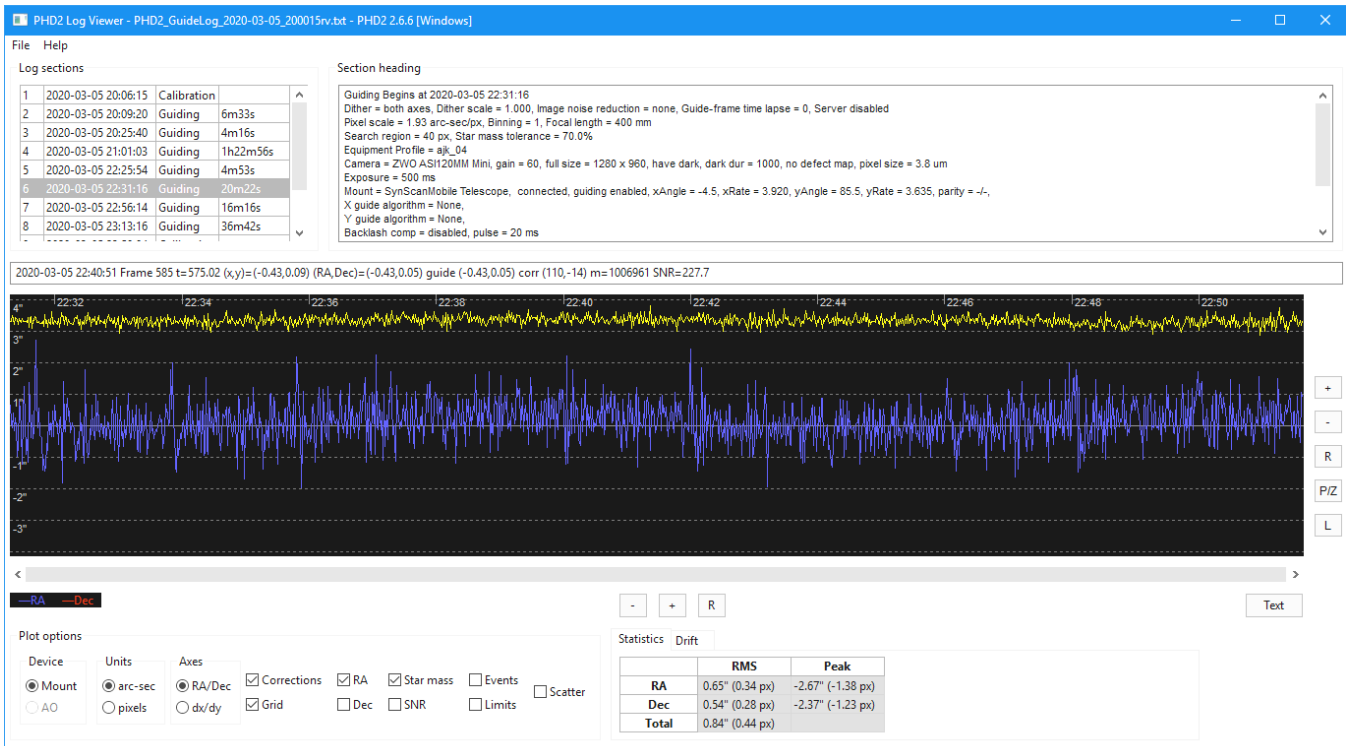

PECPrep V2.03
File Mount Advanced About
Periodic Error Analysis
Periodic Error Correction
PEC Curve Arithmetic
Frequency Spectrum
Simulation
Graph Options
Reference Spectrum
FFT Controls
Significant Mount Periods

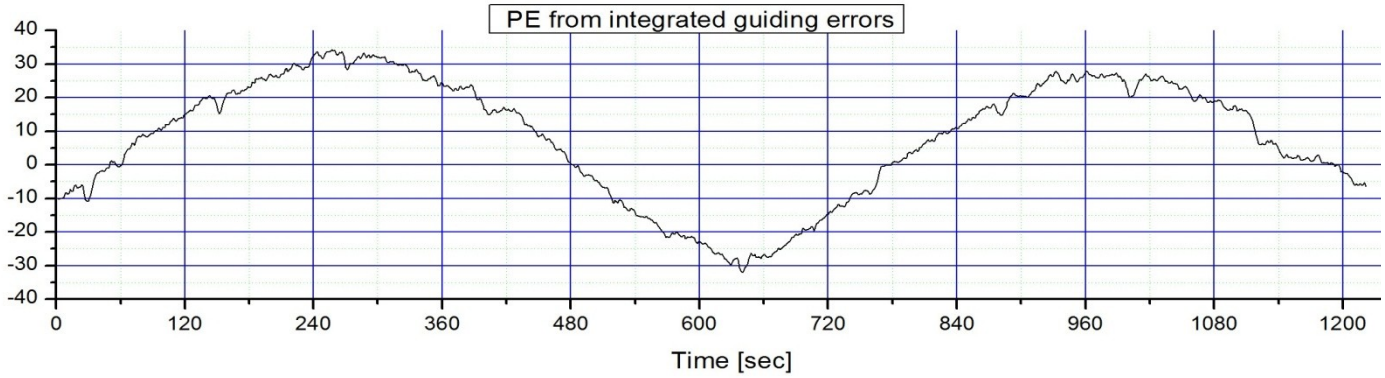

PHD2 Log Viewer - PHD2_GuideLog_2020-03-05_200015rv.txt - PHD2 2.6.6 [Windows]
File Help
Log sections
Section heading
Guiding Begins at 2020-03-05 21:01:03
Dither = both axes, Dither scale = 1.000, Image noise reduction = none, Guide-frame time lapse = 0, Server disabled
Pixel scale = 1.93 arc-sec/px, Binning = 1, Focal length = 400 mm
Search region = 40 px, Star mass tolerance = 70.0%
Equipment Profile = ajk_04
Camera = ZWO ASI120MM Mini, gain = 60, full size = 1280 x 960, have dark, dark dur = 1000, no defect map, pixel size = 3.8 um
Exposure = 500 ms
Mount = SynScanMobile Telescope, connected, guiding enabled, xAngle = -4.5, xRate = 3.920, yAngle = 85.5, yRate = 3.635, parity = -/-,
X guide algorithm = None,
Y guide algorithm = None,
Backlash comp = disabled, pulse = 20 ms
2020-03-05 22:23:32 Frame 4805 t=4949.51 (x,y)=(0.12,0.16) (RA,Dec)=(0.10,0.17) guide (0.10,0.17) corr (-26,-47) m=342066 SNR=137.5
Plot options
Device
Units
Axes
Statistics
Drift
RMS
Peak
RA
Dec
Total
Text



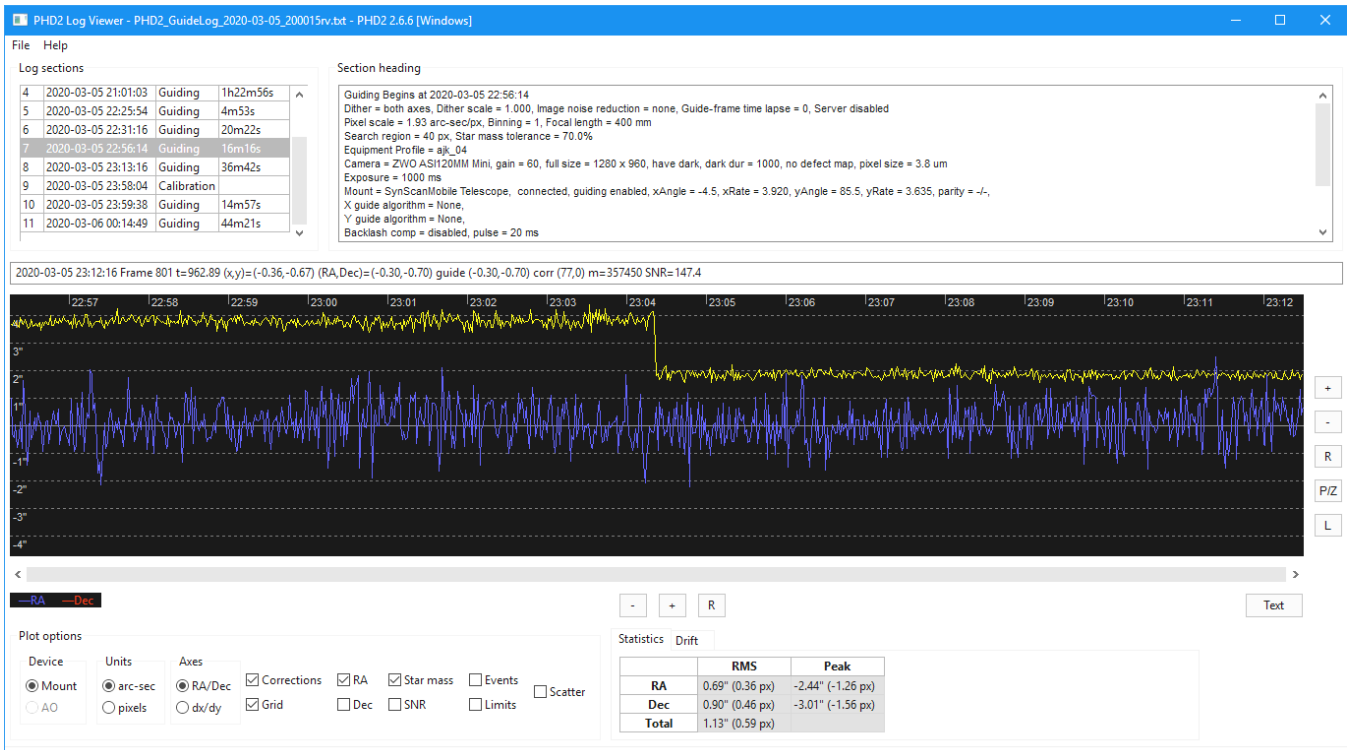


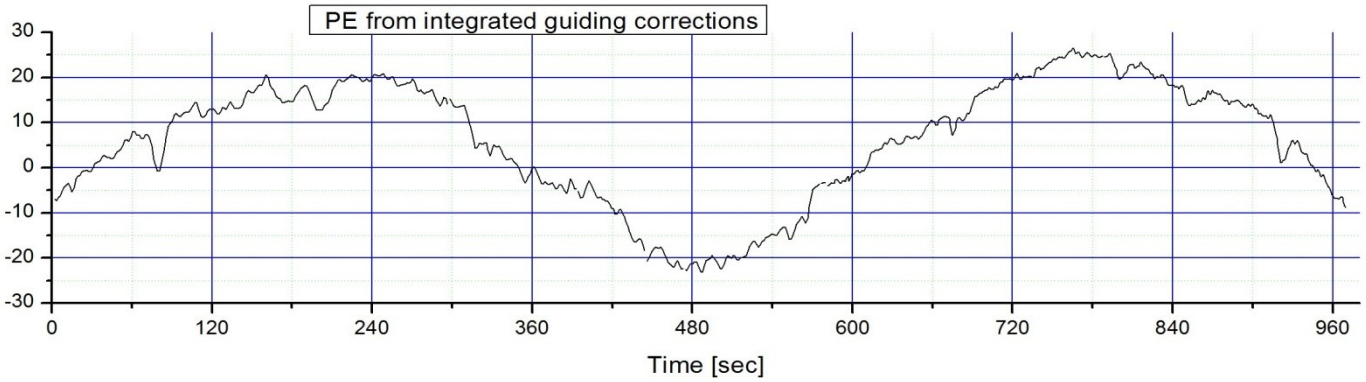
Guiding 1h22m56s, sampling / exposure 0.5sec, timing in phase with the above graph Zero correction at abs{PE}=max, large corrections at large values of dPE/dt.



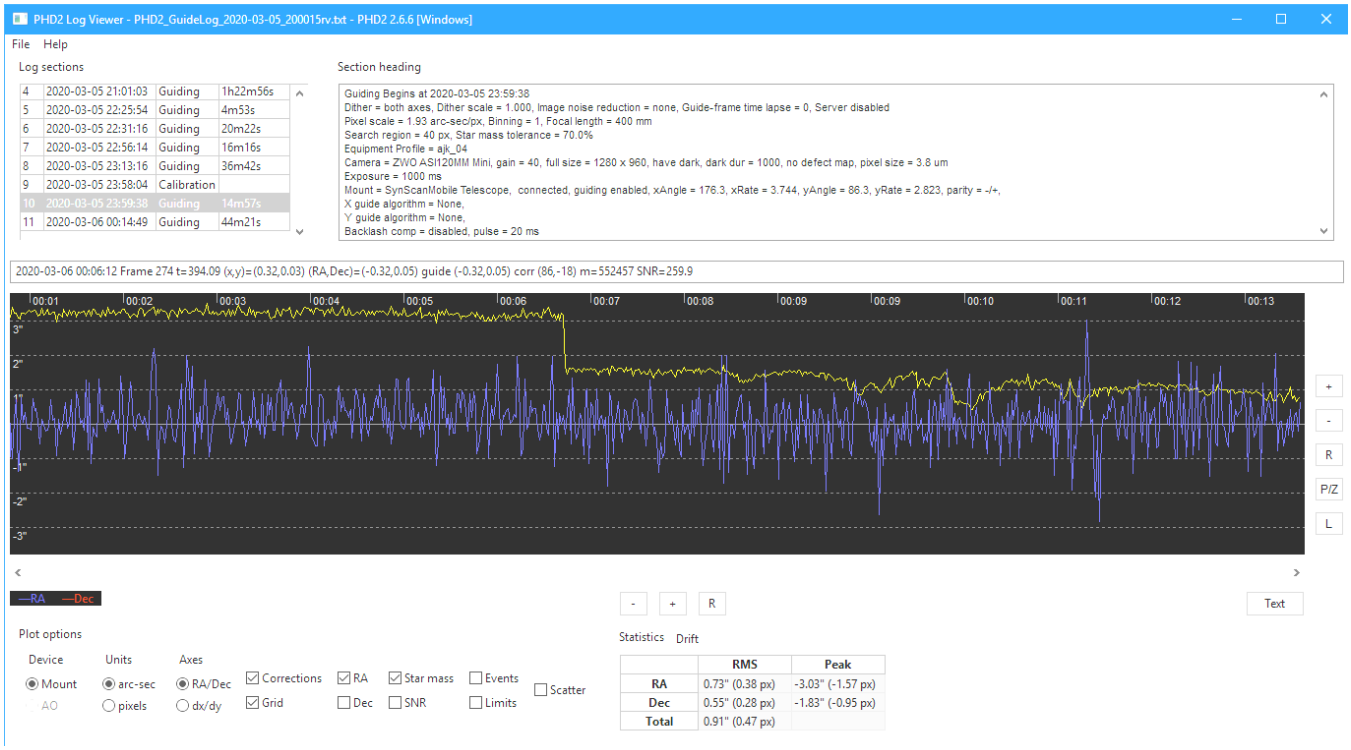


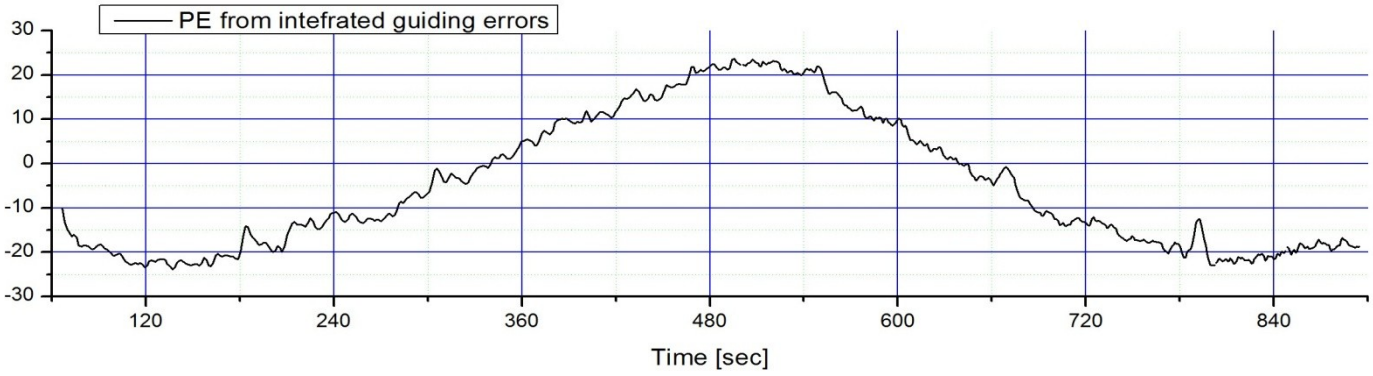
Exposure time 0.5 sec





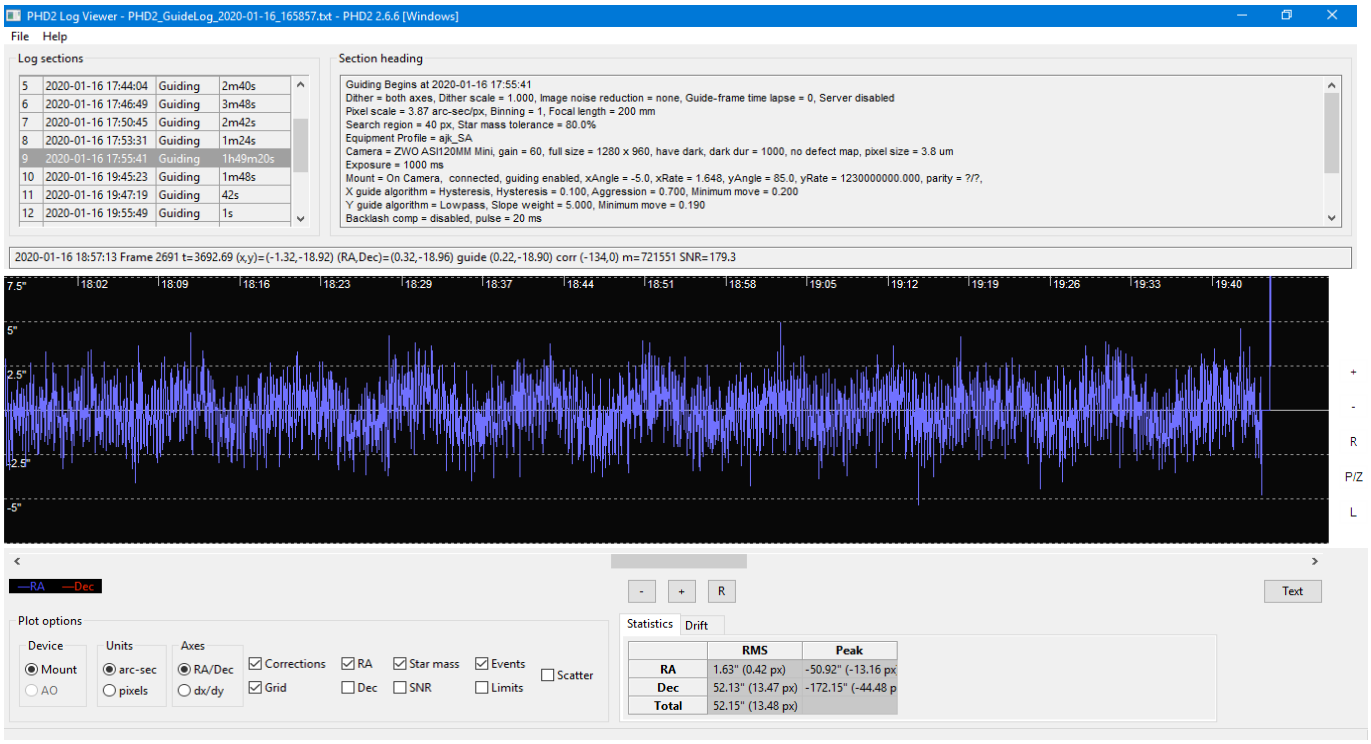
Exposure time ========== 1 sec ========== | ========== 0.5 sec ==========

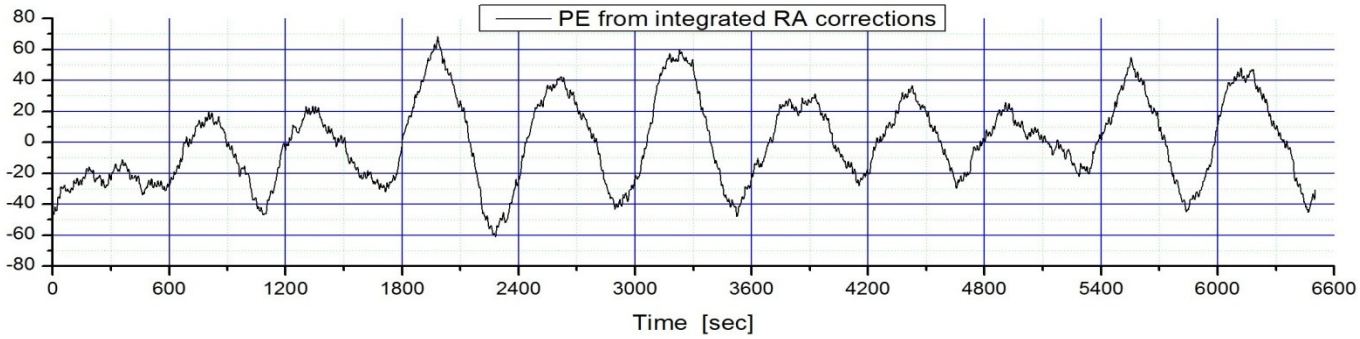




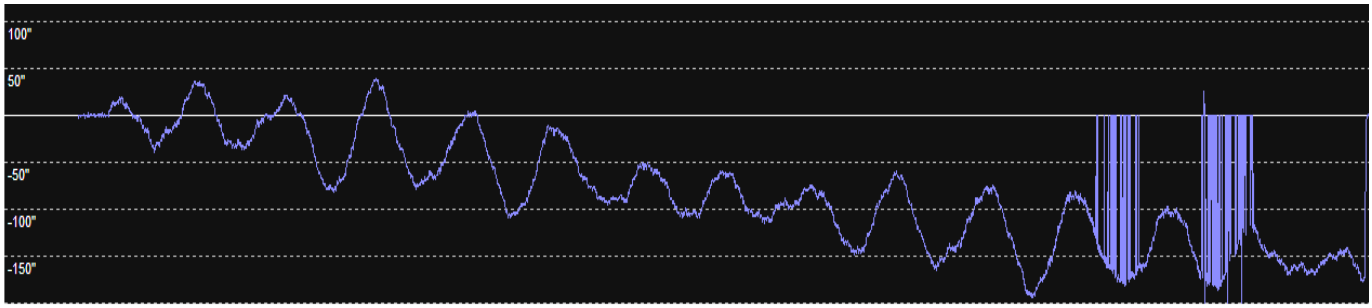
Exposure time ========== 1 sec ======= | ========== 0.5 sec ==========

Dane dla mojego egzemplarza ***Star Adventurer*** guiding errors, recorded 1h49m20s

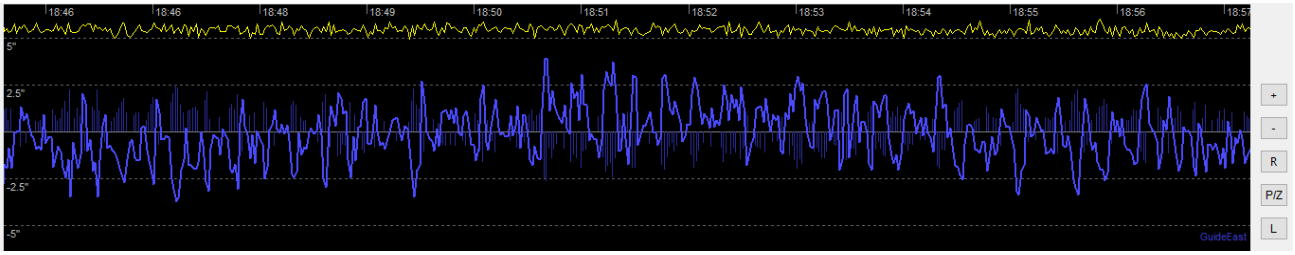




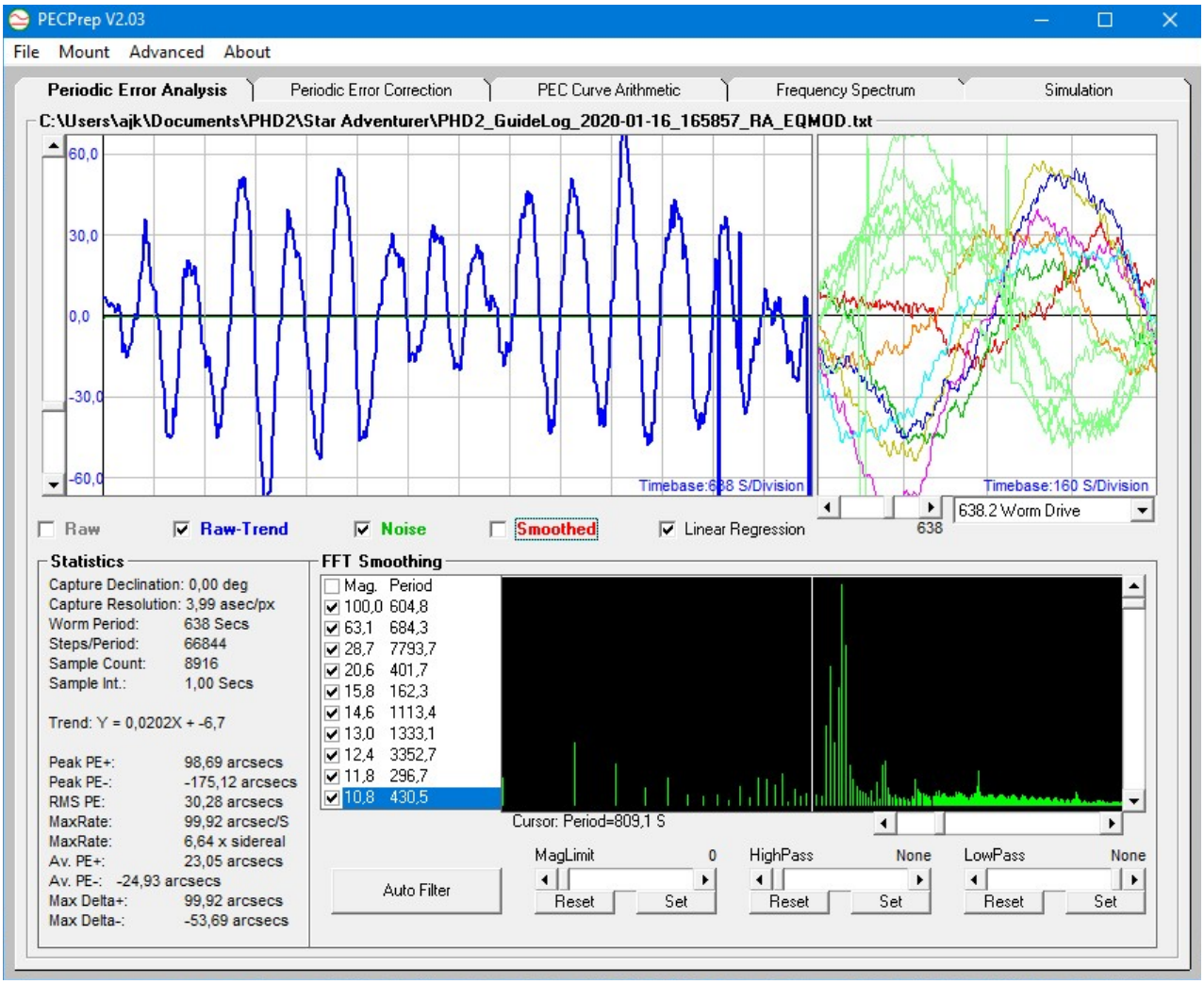
Maximum PE +/-60”, average ~ +/- 25”, time scale phased up to the above pgaph.

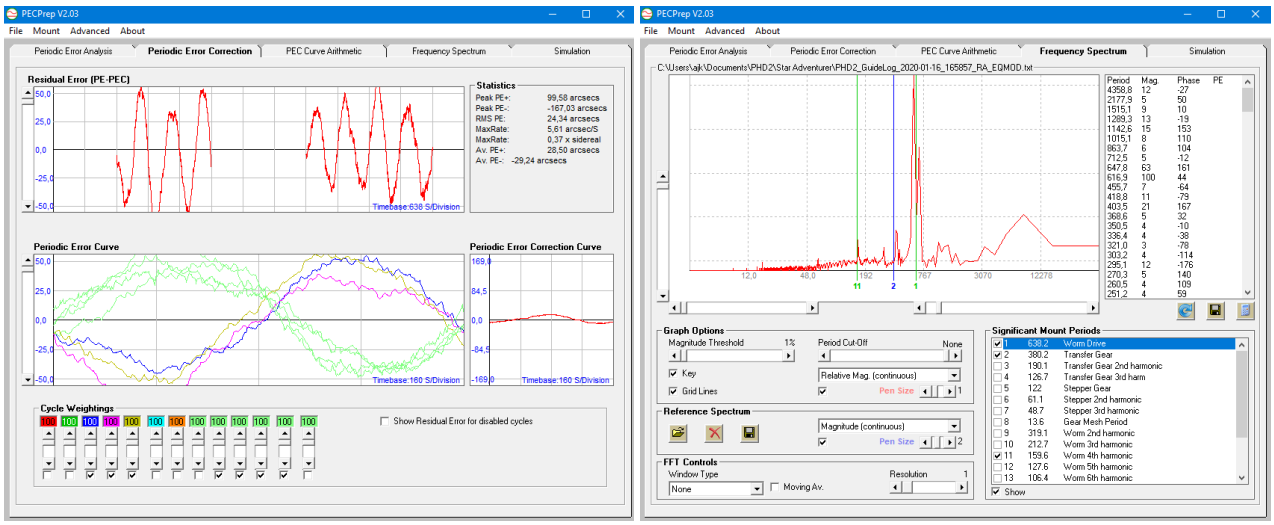


Direct PE measurements record (guiding with RA corrections disabled), nearly two hours, and below ~10min guiding record



PECPrep analyses





Characteristic amplitude modulation and a phase shift in by 180 deg every hour (!!!).
Spectrum shows two different amplitude peaks separated by ~30Hz.

Looks to me as beating of two basic frequencies or a modulation of one with 30 Hz. **Firmware problem ?**
This issue needs consultation with the manufacturer of the Star Adventurer. Not done yet.