1 Introduction

1.1 TrackMen lens calibrations

TrackMen camera tracking systems work with two differen lens calibration types that map the parameters of the lens' projection on the chip and compile them for the graphics engine.

Commonly used are zoom lens calibrations **ZLC**. These are complex files that capture thousands of zoom and focus combinations. They are generally being created in the **TrackMen** laboratory by our specialized staff.

As prime lenses with a fixed focal length require less measurements due to the lack of variation of their parameters, they can be calibrated more easily and potentially with a simple program on-site. These calibration files are called fixed lens calibrations **FLC**.

1.2 Fixed lens calibrations with variable focus

This document is a guide about how to create a fixed lens calibration for a prime lens for the use **as a VioTrack master lens** calibration file.

As these lenses are likely to have to change the focus during operation, the "lens breathe" has to be taken into account. This means the change of parameters, mainly **field of view and distortion**, during focus operation.

Furthermore, the varying **focus distances** may be measured if it is desired to apply defocus to the graphics.

1.3 Prerequisites

This guide will not cover the general use of either **VioTrack** or the *VioTrack R lens calibration* itself, but only the differences of calibrating variable focus for a FLC file. It is directed at experienced users who know the basics already.

The process requires a fully operational **VioTrack** system with a **lens encoder for the focus ring**.

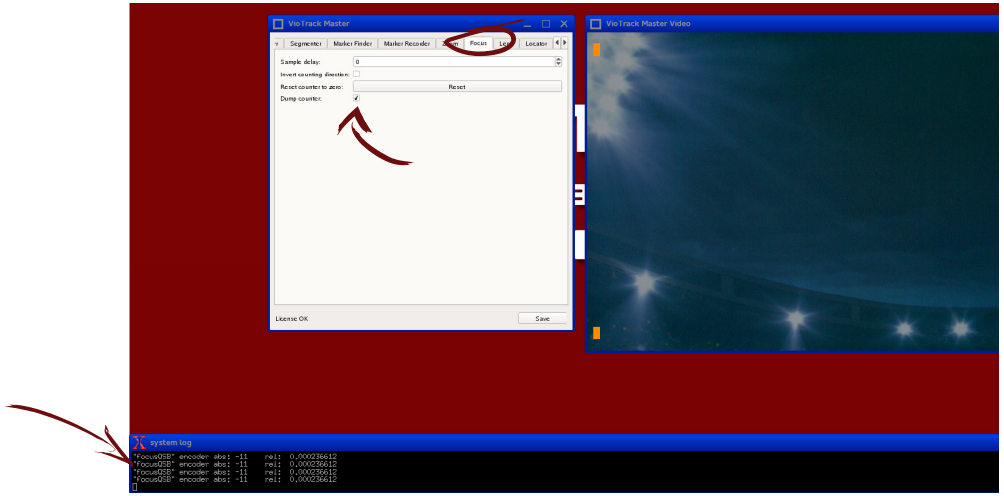
2 Variable focus calibration

2.1 Capturing multiple focus positions

In order to calibrate the varying parameters like field of view and distortion over the full focus range, take the following steps:

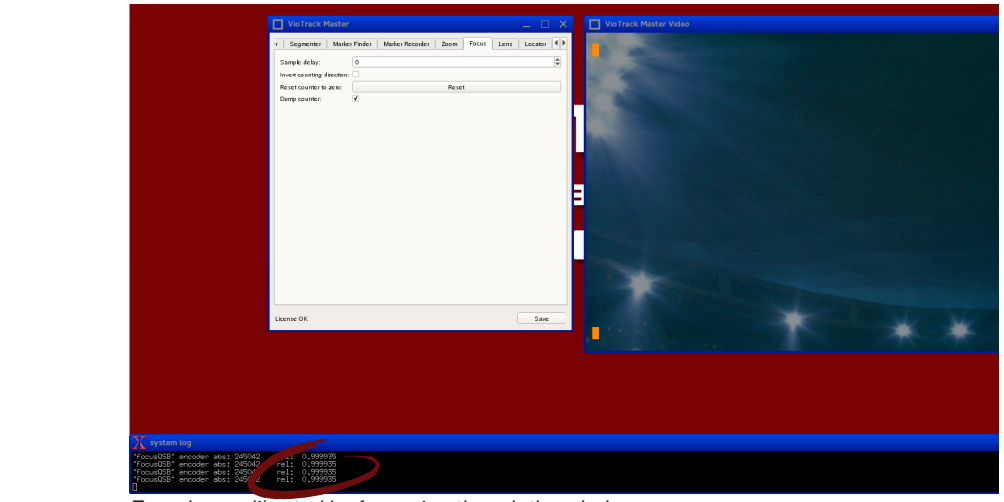
2.1.1 Preparations and determining focus sample positions

1. Start **VioTrack**.
2. In the *VioTrack Master* window, switch to the *Focus* tab and check the *dump counter* option. The system log will write the encoder values, *abs* meaning the raw encoder counter while *rel* shows the normalized value between 0 and 1.



Encoder counter dump

3. Change focus all the way, from infinite to minimum object distance and back, to teach the system the minimum and maximum range.
4. Define a number of focus values. 4 should suffice for a lens with little parameter change during focus operation. Increase number for lenses with more severe changes in field of view and/or distortion.



Encoders calibrated by focussing though the whole range

Note that the relative value for Maximum and Minimum may not be exactly 0 and 1, but values very close to it, like 1.2875e-5 and 0.99997.

5. Find a respective number of focus ring positions, mark them on the lens and note the respective encoder *rel* value.
6. In this example, 4 focus settings will be used making these pairs of lens setting / encoder values:

   encoder *rel*: 0 — focus ring: infinite

   encoder *rel*: 0.316 — focus ring: 0.6

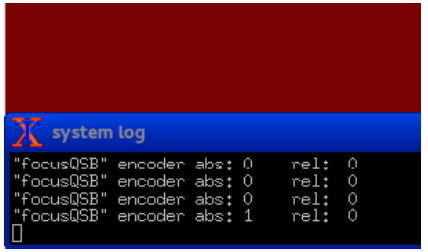
   encoder *rel*: 0.657 — focus ring: 0.35

   encoder *rel*: 1 — focus ring: 1
7. Set the focus ring to infinite for the first calibration run.
8. As the image may be heavily defocused in calibration pattern distance, it is recommended to close the iris as far as possible to have maximum depth of field.
9. Close VioTrack using the *STOP VioTrack* buttons in the *DIAG* menu.

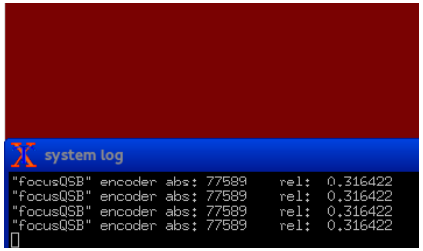
In this example, we use the original markings for distance on the lens to find 4 roughly equidistant positions. It is not necessary for the positions to have the same distance between them though. It may be advantageous to make more measurements around the actual filming distance. **The full range** has to be covered though.

It is important to **be able to reproduce the encoder values** to guarantee precision. Do not try to approximate the positions without detailed markings.

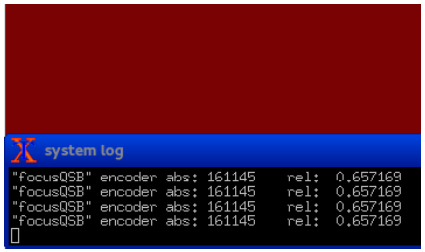
If this seems imprecise, the best way is to actually restart **VioTrack** between each calibration run, find a suitable next focus position using the *rel* encoder value, and then close **VioTrack** again to perform the respective focus sample calibration.



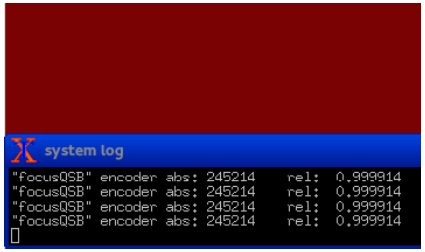
Examplary focus sample position for infinie



Examplary second focus sample position; note how a marking on the lens is used



Examplary third focus sample position

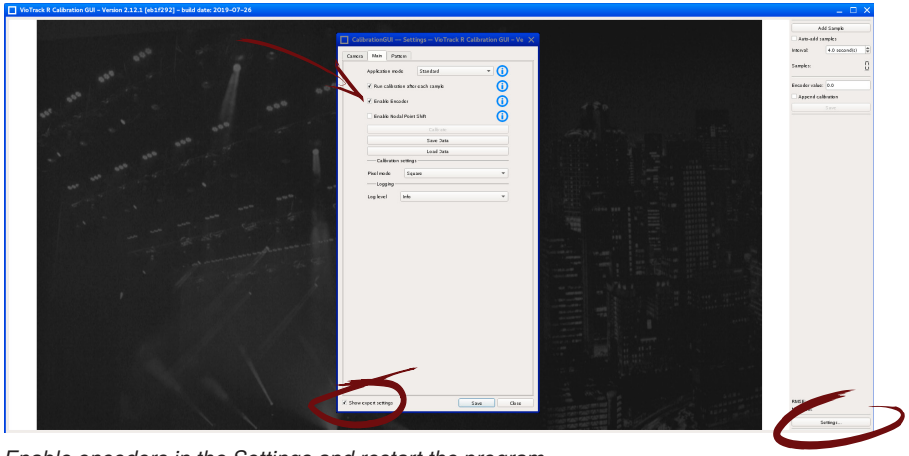


Examplary focus sample position for MOD

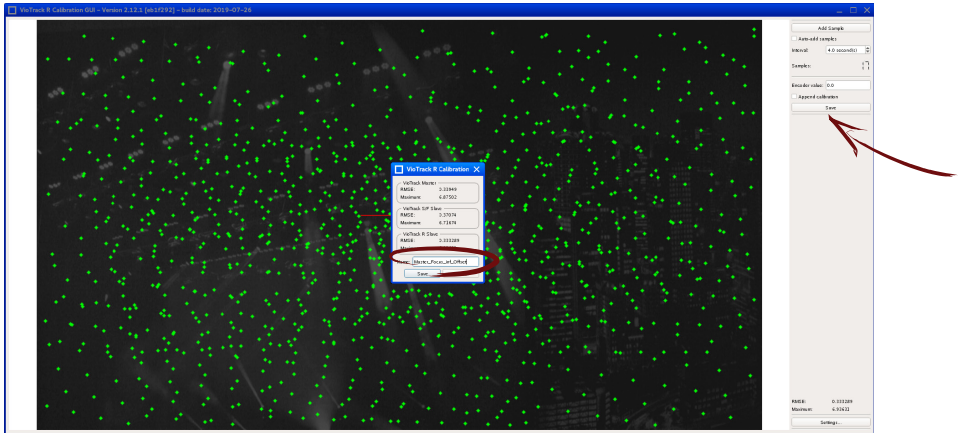
Make sure to have the **infinite** and the **MOD** measurement at the absolute end of the focus ring range, not at the marking on the lens. Most lenses exceed these markings by a bit, so rotate the ring until it meets its complete stop.

2.1.2 First focus setting calibration

10. Start the *VioTrack R Lens Calibration* from the *TOOLS* menu.
11. If not activated already, enable the ‘use encoders’ option: Open the *Settings...* and activate *Show expert settings*. Then switch to the *Main* tab and check the *Enable encoder* Optioin. Close and restart the *VioTrack R Lens Calibration* to apply.
12. For the first calibration run, with the focus set to infinite, leave the encoder value at 0.0 and perform a lens calibration as usual.
13. Save the first calibration for focus position infinite **twice**. One file will be used for the offset calibration between master and slave only. The other one will be used for the VioTrack Master.
14. Click *Save* and enter a filename recognizable for the offset calibration in the upcoming dialog box. Then click save in said box.

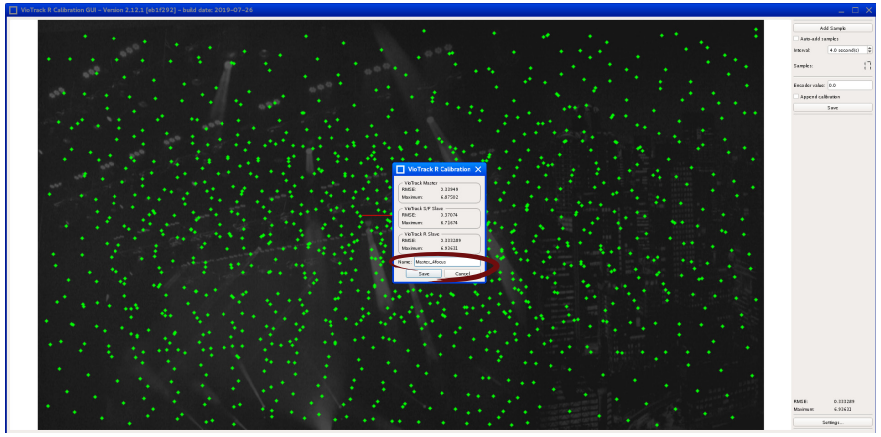


Enable encoders in the Settings and restart the program



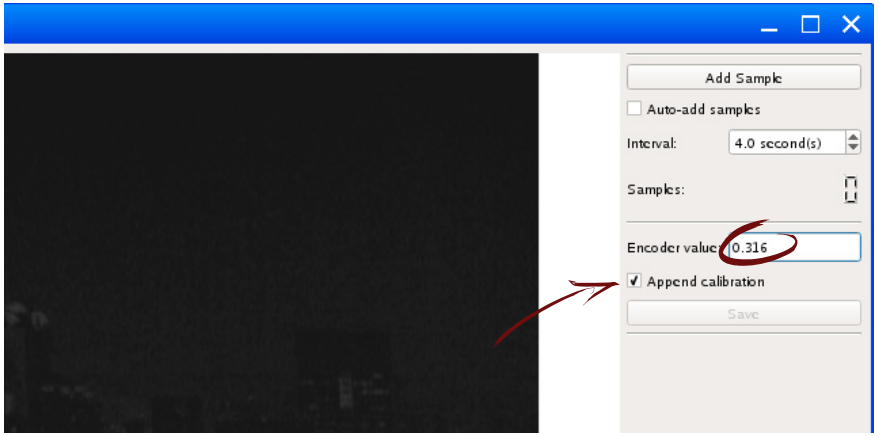
Save the first calibration in an individual file for the offset calculation

15. Click *Save* again, this time entering a file name that can be recognized as having multiple focus positions calibrated.



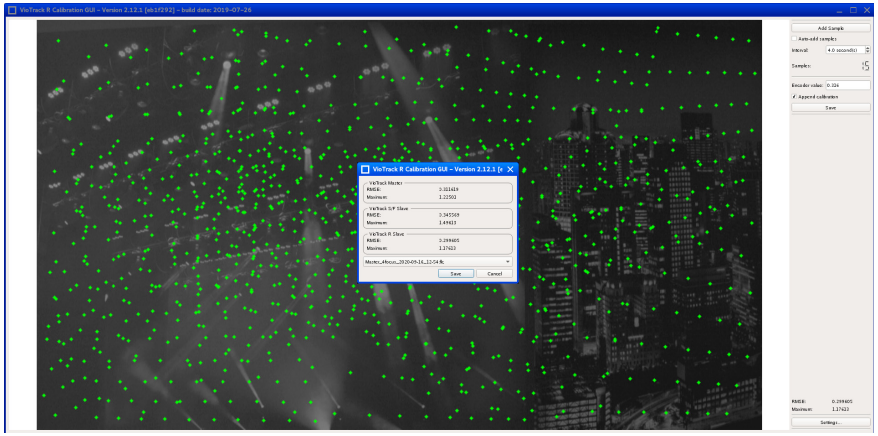
Save the first calibration in a second file which will be extended in the following steps

16. Close and restart the *VioTrack R Lens Calibration*.
17. Set the next focus sample position on the lens. In our example, this will be the 0.6 marking, with the associated encoder value 0.316.
18. On the left side of the calibration window, check the *append calibration* option.
19. Enter the current focus position encoder count in *Encoder value*.



Having restarted and set the next focus position, activate Append calibration and enter the corresponding encoder value

20. Perform another lens calibration as usual.
21. Click *Save*. This time, a dialog box will open, offering to choose a calibration file from existing lens calibrations.
22. Choose the file saved for multiple focus calibrations before and confirm with *Save*.
23. Repeat steps 16 to 22 until all focus positions have been calibrated and saved into the same calibration file.
24. Close the *VioTrack R Lens Calibration* and *(Re-)start VioTrack R*.
25. Choose the lens file with multiple focus positions in the *Lens* tab in the *VioTrack Master* window.



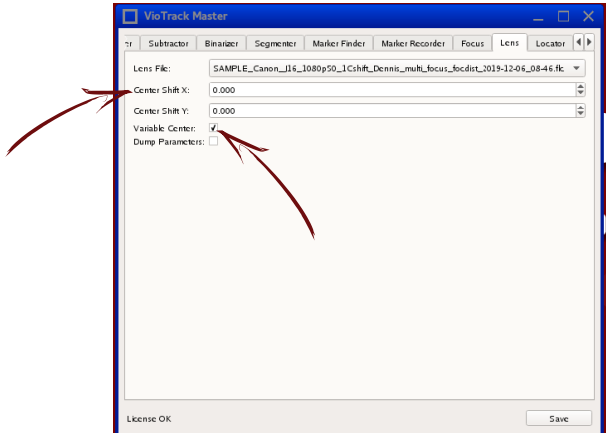
When saving, choose the calibration file created before for multiple focus positions

2.2 Troubleshooting

In some cases, a lens may show irregular behavior in the center shift. In order to avoid repeating the whole process to exclude errors in calibration, the following steps may help.

If, after a very good offset calculation and reconstruction, the graphics are shown displaced in the image **and** the displacement remains in the same 2D image direction when moving the camera around the object, try changing the *Center Shift X* and *Y*.

If a graphic object in the middle of the camera image moves (differently than the real video content), while the camera itself is static and only the focus is operated, try unchecking the *Variable Center* option.



Lens center shift options for troubleshooting

3 Focus distances

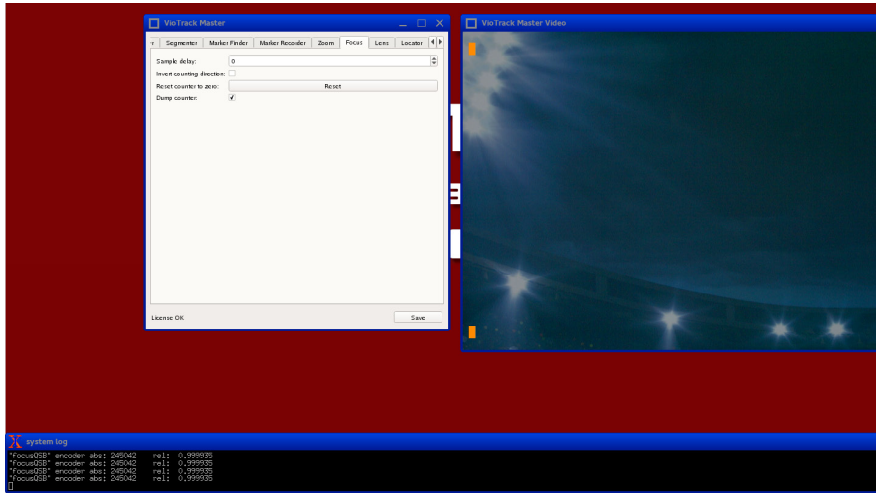
In order to use the focus encoder to calculate a focal plane and forward it to the graphics engine, to apply defocus, separate measurements must be taken and added to the lens calibration file manually.

3.1 Preparations

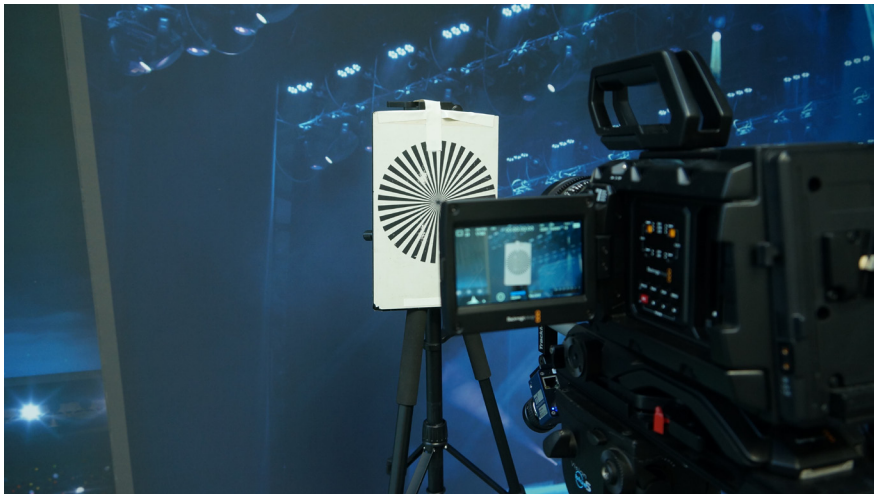
The measurements will be done focusing an object in various distances and noting down the corresponding encoder value. As an object, a Simens star is recommended to optimally judge focussing. Either the object or the camera must be able to be moved so various distances can easily be created. Depending on the focal length of the lens, a large area may be necessary to provide enough samples.

3.2 Measuring the focus distances

1. Start **VioTrack** from the TOOLS menu. Focus all the way from infinite to MOD and back to teach the system the minimum and maximum encoder values.
2. In the *VioTrack Master* window, switch to the *Focus* tab and check the *Dump counter* option to see the current encoder values in the *System Log*.
3. Place the object in front of the camera.



Encoders min and max calibrated by focussing though the whole range



Siemens star placed in front of the camera

Fixed lenses with variable focus

4. Set the focus to minimum object distance MOD. The encoder value should be 1.
5. Move the object close to the camera, so that is is in perfect focus.
6. Measure the distance between flange of the camera and the object. Then note down the first measurement pair of encoder value (1) and that distance.
7. Move the object away a bit. For example to 1m. Measure that distance to the camera flange
8. Focus the object and note the second pair of distance and encoder value.
9. Repeat with multiple distances. The number of distances vary with the type of lens. Around 10 will surely suffice for a prime lens.

Quick and dirty: If there is no time to take the measurements or the precision is not of importance, you may choose to trust the markings on the lens that give the focus distances. Just position the focus ring on a distance mark and read the corresponding encoder value and note a number of these pairs down.

Focus the object and measure the distance while reading the encoder value from the System log.

Move either the camera or the object to create an appropriate amount of measurements

3.3 Implementing into the calibration file

10. Open a *Text editor* from the TOOLS menu.
11. Click *File* and *Open* and find the lens calibration file in the folder */mnt/arch/lenses*
12. Find the position to enter the measurements:

```
“encoder_value”: 1.0
}],
“VioTrack S/F Slave”: [{
```

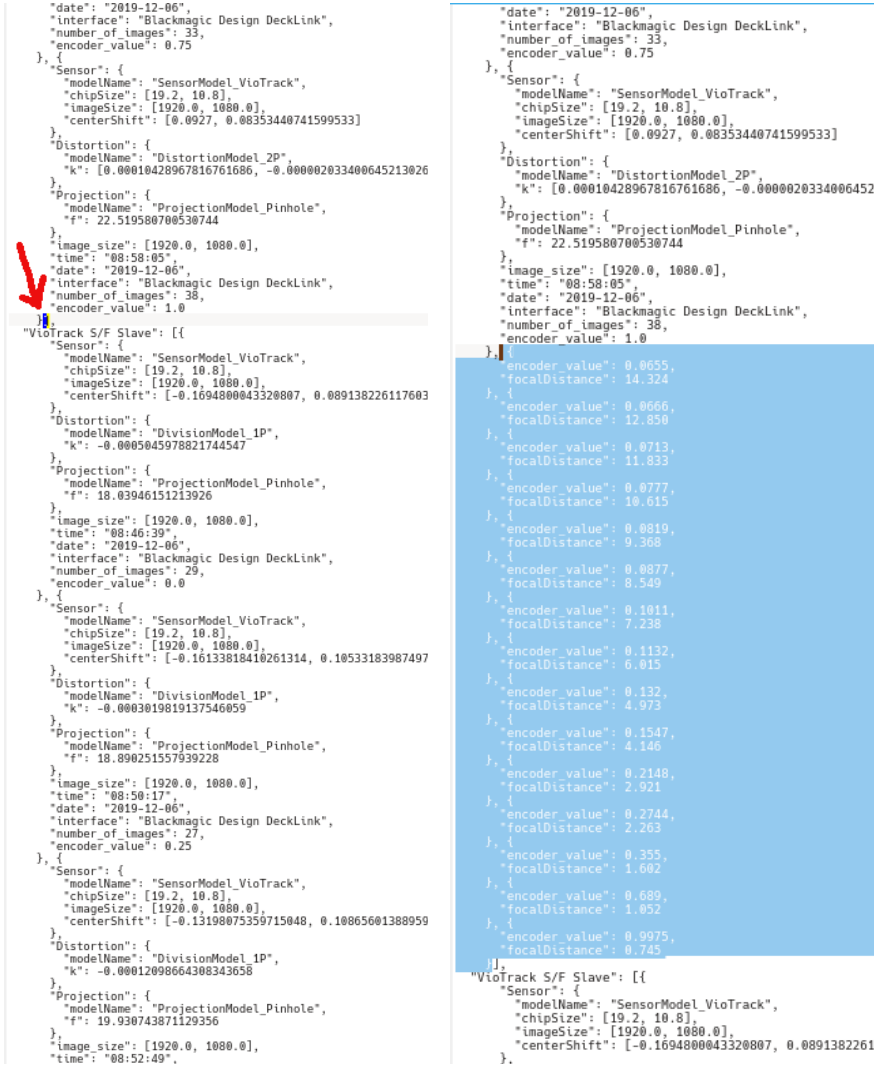
The next lines will be added **between** the } and the],

13. *Enter each pair of measurements like this:*

```
{
“encoder_value”: 0.0655,
“focalDistance”: 14.324
    },
```

Each pair is followed by a comma, **except** for the last one.
See the screenshots on the left, as well as a sample .flc file for reference.

14. Open a *Terminal window* from the TOOLS menu, enter
`prewrite`
and confirm with <Enter>.
15. In the text editor, save the changes in the file.

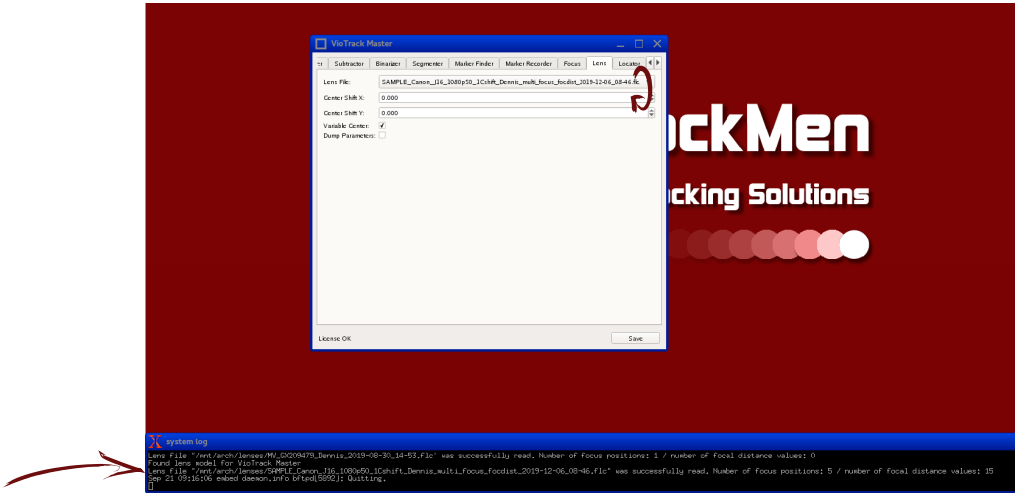


Enter the focus distance values as shown above, mind the placement and commas

Fixed lenses with variable focus

If it feels easier or more comfortable to work on an office PC, the lens file can be copied via FTP and opened in any text editor in a different operating system.

16. Check the result by reloading the lens file in the *VioTrack Master Lens* tab. Either restart **VioTrack** or change to a different lens file and then back to the one with the focus distances. Stop the encoder counter dump in order to read the *System log*.
17. The *System log* will print a line when the lens file is loaded. If it says that the lens file can not be read, there is a typo in the text editor changes. Otherwise, it will give the number of focus positions and focal distance values.



Reload the lens file to check results