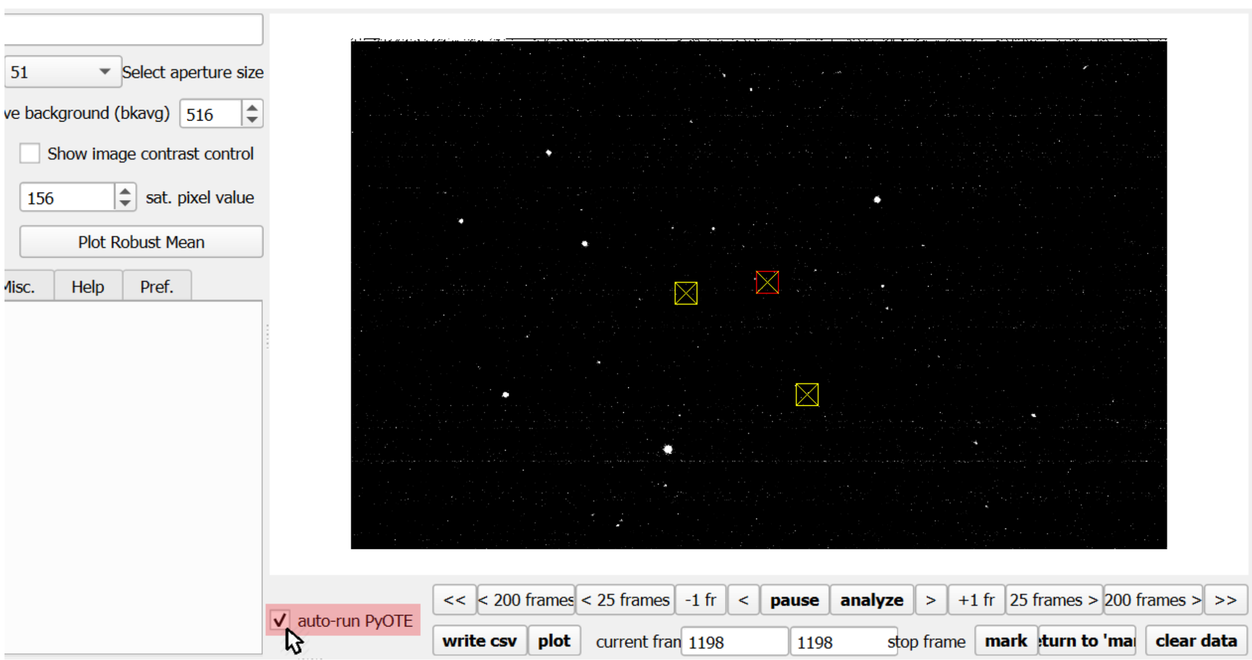
PyOTE Guide

Opening PyOTE

All RECON 2.0 laptops come with PyOTE installed. You should be able to click on the PyOTE icon on the desktop of your machine to initiate a PyOTE session. (See Alternate Possibilities for Opening PyOTE at the end of this guide if that is not the case.)

From Pymovie

1. When your analysis is complete, before saving the .csv file, make sure you have selected the checkbox for **auto-run PyOTE**. This will start PyOTE after creating the .csv file.



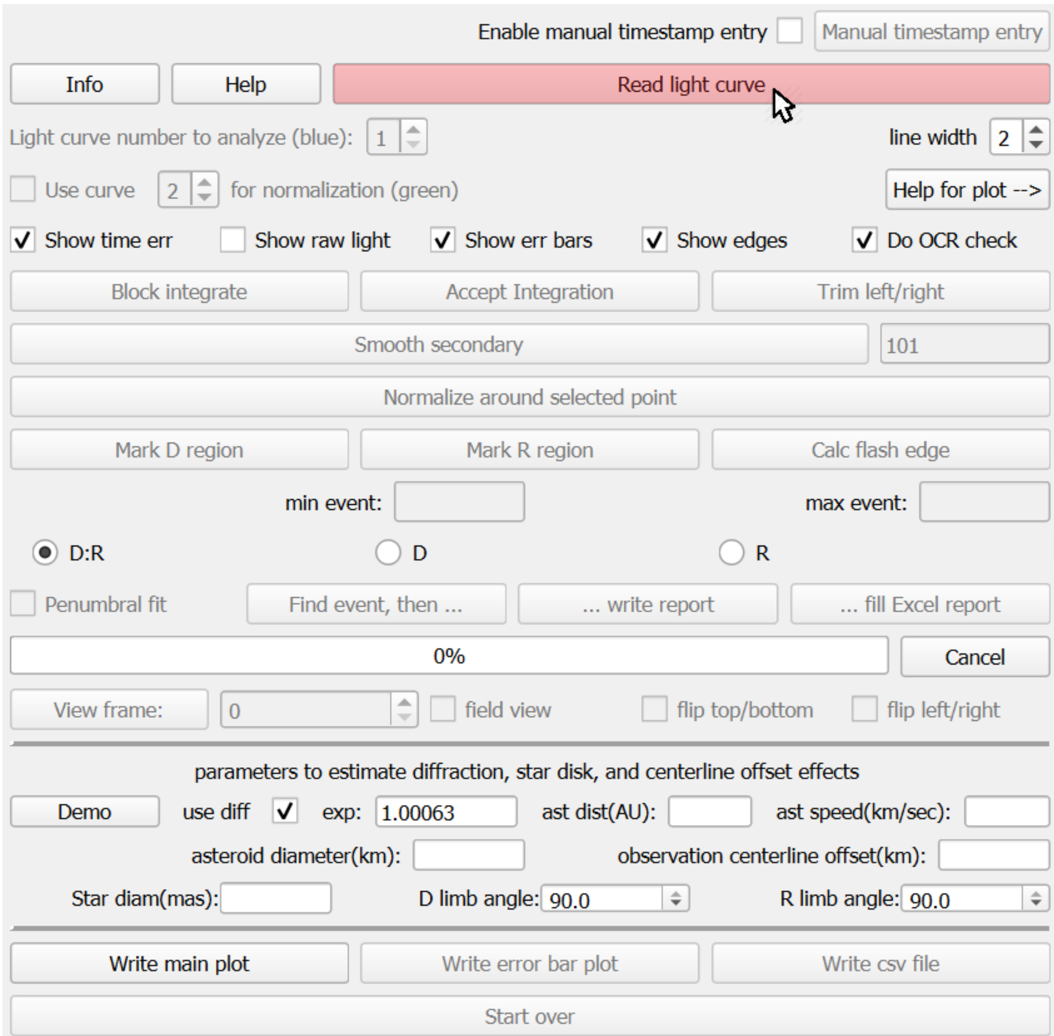
From Windows Desktop

1. In Windows operating systems, you can also run PyMovie and PyOTE by setting up shortcuts to the PyMovie and PyOTE windows batch files on your desktop and run them by clicking on them.
2. Locate the **PyMovie.bat** and **PyOTE.bat** files in the C:/Anaconda3 directory.
3. Create a shortcut of these files by right-clicking on each of them.
4. Drag the shortcuts to your desktop to easily access PyMovie and PyOTE in the future.

Please refer to the PyMovie installation guide for more information:
https://occultations.org/observing/software/pymovie/

Reading a light curve

1. In the top left panel, click on **Read light curve** to open up a previously generated light curve analysis. It is important to note that PyOTE is only able to read .csv files generated by PyMovie, Limovie, or Tangra.



2. If using MallinCam .avi files, check the Appendix for an additional step in analysis that involves scanning the light curve for video integration.

Smoothing the reference star (if needed)

1. Smoothing the reference star for normalizing the target star is useful if there were clouds or other atmospheric factors obscuring the view, and the light curves of both the target star and the reference star are not even and have the same features in their curves (i.e. ups and downs - increase and decrease of the flux).

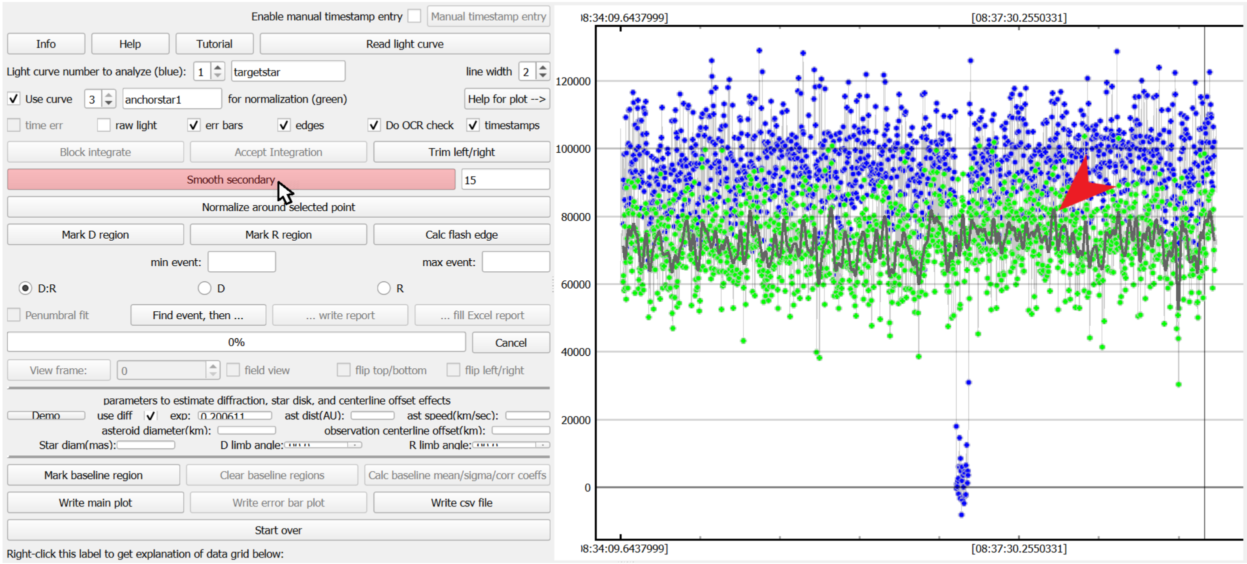
2. It is always a good idea to check the light curve of the reference stars even if you will not be smoothing/normalizing to see if there was definitely not a drop in the brightness of the reference stars where you suspect an occultation of the target star.
3. However, you may omit these steps of smoothing and normalization and skip to the **Trimming light curve** step if you think the sky was clear during the recording and the light curve of the target star is smooth.
4. Please note that smoothing is required for normalization.
5. As indicated in the left panel, the light curve to analyze is shown in blue, the reference star for normalization is shown in green.
6. Select the target star light curve in the **Light curve number to analyze (blue)** section using the up and down arrows. The text box will display the name of the light curve you labeled in PyMovie.

7. Select the light curve of the reference star you wish to use to normalize your target star in the **Use curve … for normalization (green)** section. It is preferable to choose a reference star as close as possible to the target star and the light curve that is most similar in brightness to the target star, but most importantly also follows the increase and decrease of flux (i.e. cloud movement). Furthermore, toggling between the light curve of the target star and the reference stars, compare where those dips occur and make sure they line up and are not time-shifted.

8. In the left panel next to the **Smooth secondary** button, you can change the smoothing factor before smoothing. It is 101 by default. A smoothing factor that is too large might dismiss important features in the light curve. Smaller smoothing factor will result in a more spiky curve than a larger smoothing factor. It is suggested that this number should be around 2-3 seconds divided by the timeDelta value that is shown in the panel below the curve.

In the example above, the timeDelta value is 0.200611. This number multiplied by 15 would give about 3 seconds. In this case, the smoothing will filter around 3 seconds.

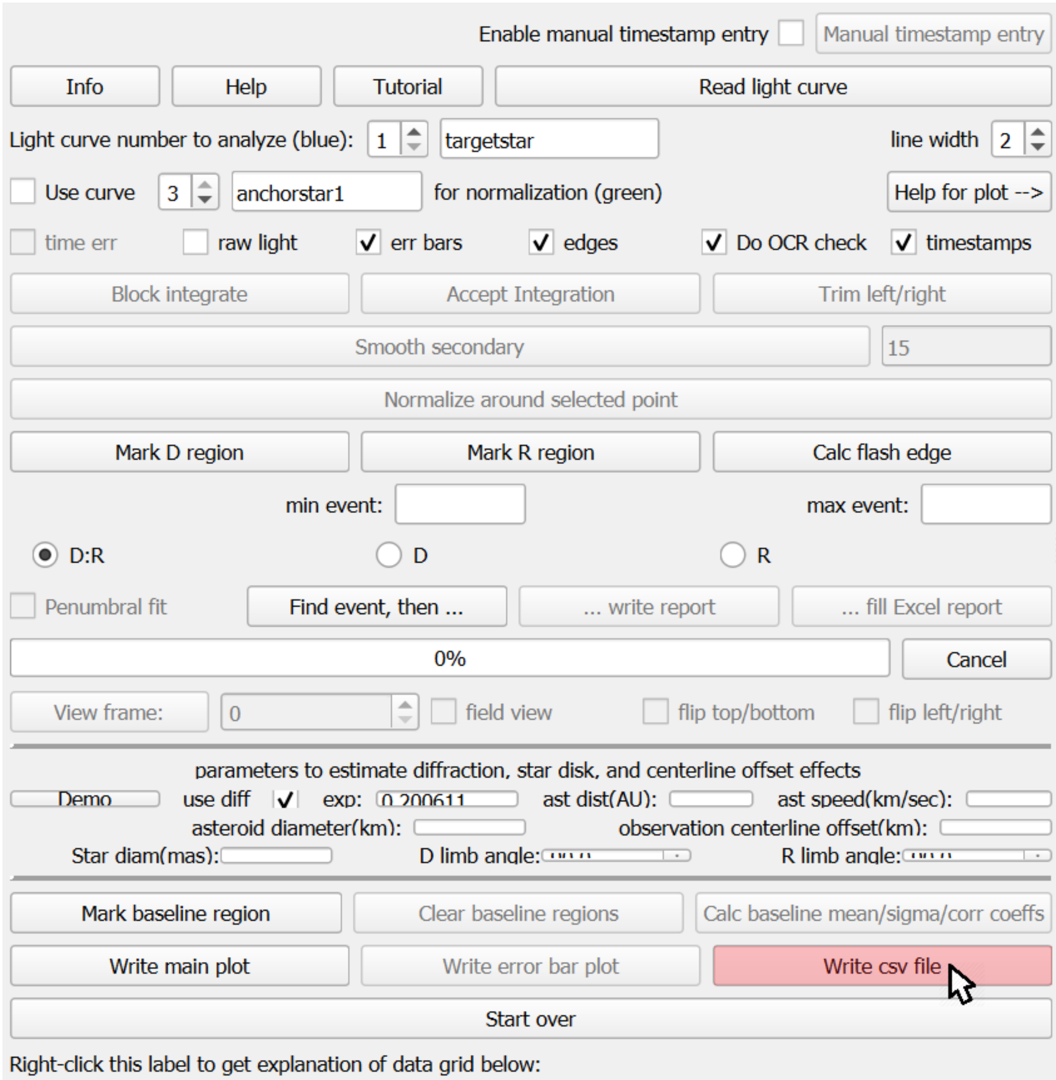
9. Click on the **Smooth secondary** button to smooth the selected reference star. A black smoothed curve will appear on top of the green data points.



Normalization (if needed)

1. Now, we are ready to normalize the light curve of the target star using the light curve of one of the reference stars. As mentioned earlier, this step is only necessary if the light curve of the target star is not even and there were clouds present during occultation. In the example above, the light curve of the target star is fairly smooth so it did not make much difference normalizing the curve.
2. Select any one point (preferably close to the event) on the graph and click on **Normalize around selected point**. The green curve of the reference star will disappear and the blue curve of the target star will be normalized.

3. Click on the **write csv** button, then save it as a new file (do not overwrite the original file).

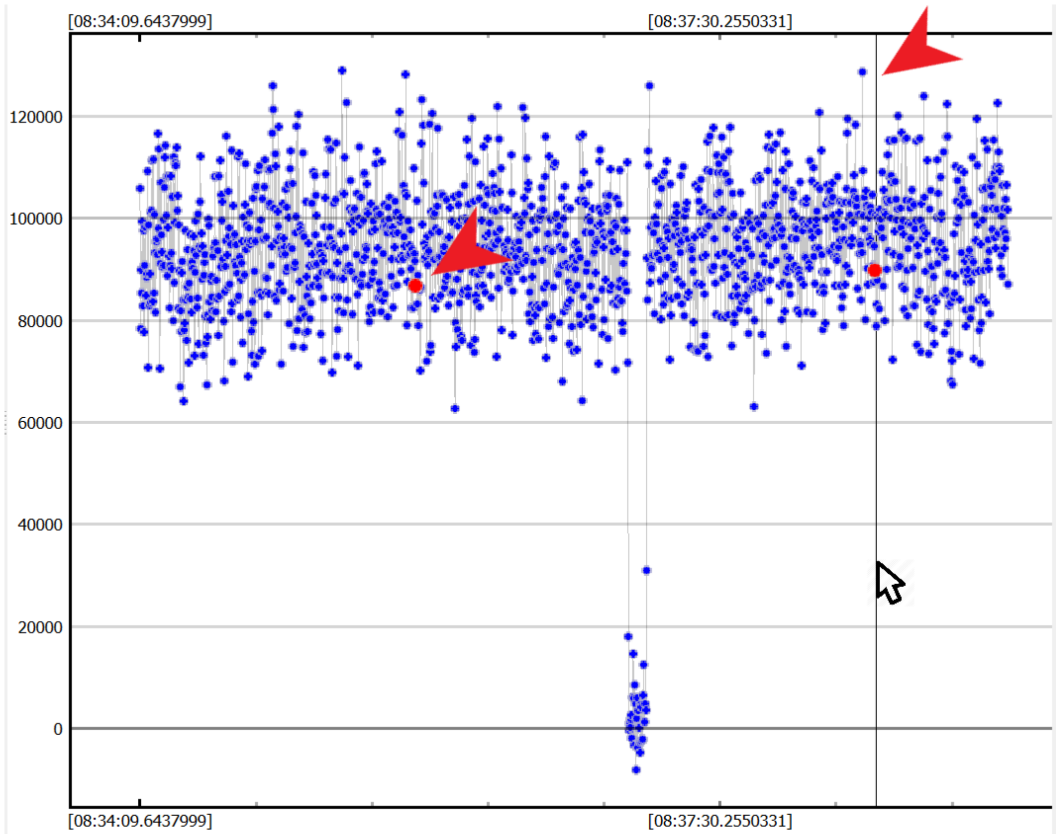


4. Read in the now normalized light curve for trimming following the steps in the “Reading a light curve” section.

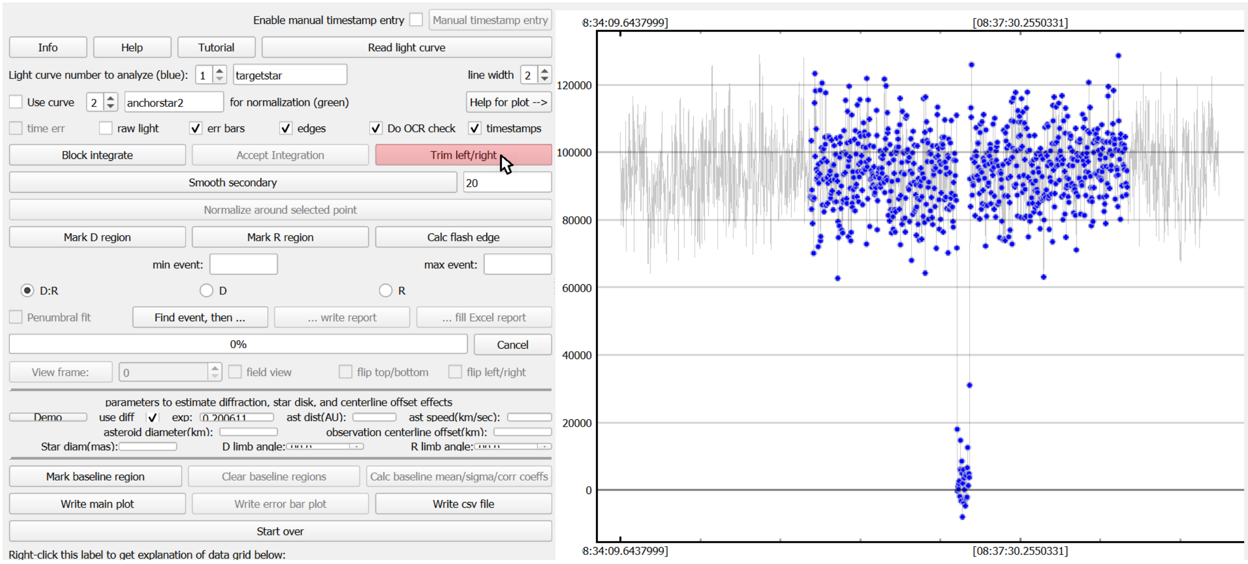
Trimming light curve

1. Trimming is only recommended if the recording was unnecessarily long, some outside interference occurred (flashlight or headlight), someone bumped into the camera, or you have recording of the GPS coordinates displayed on the screen. In these cases, trim the light curve around the occultation to reduce calculation time, decrease noise and the error bars.
2. Before trimming, normalization of the target star’s light curve will help determine if there was in fact a positive occultation, where it occurred, and also make sure we are not trimming that off. However, if you smooth/normalize first, the **Trim left/right** button becomes inaccessible (greyed out) so you will have to save the normalized light curve as a new .csv file and read that in.

3. After reading in the normalized light curve, you are now ready to trim. If you hover over the graph, a black vertical line will appear where the cursor is positioned. If you wish to turn on the cursor for easier navigation, press the **Shift** key on your keyboard.
4. Left-click on the two points (left and right of the occultation) where you want to trim the graph. This will change the selected points to red.

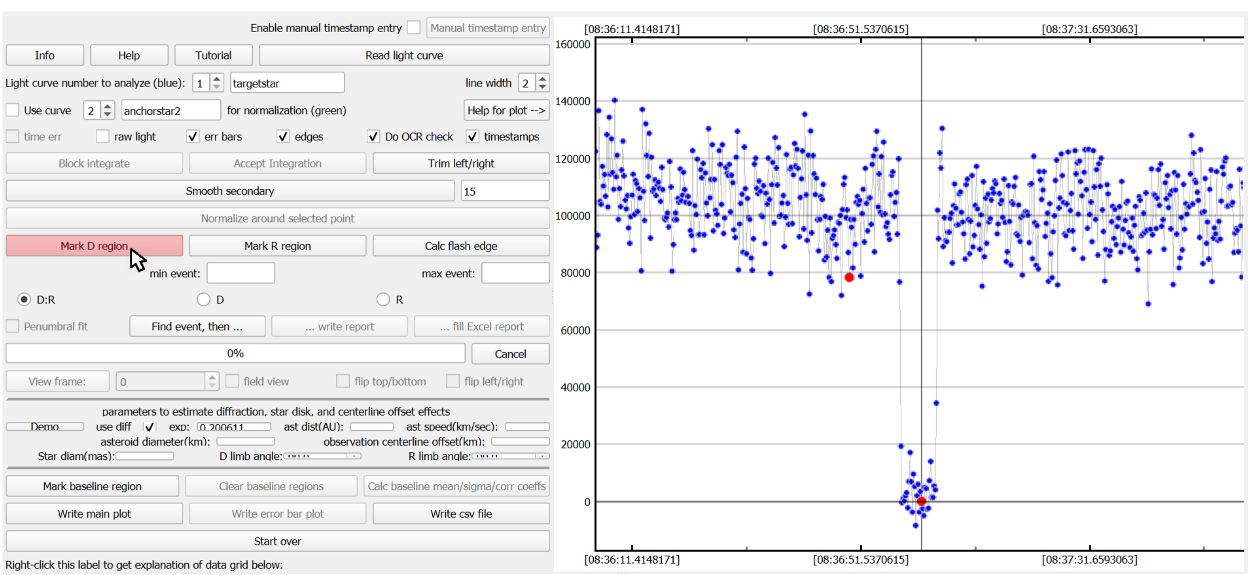


5. Click on the Trim left/right button on the left panel. This will turn all the data points that will be excluded in the calculation to grey.

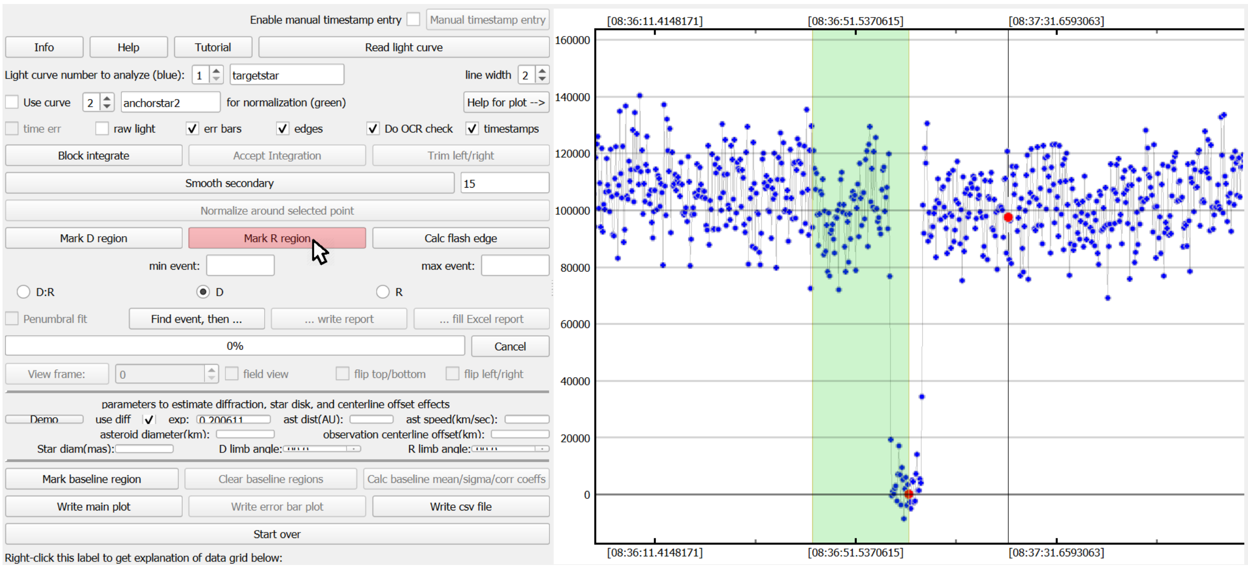


Mark D/R regions

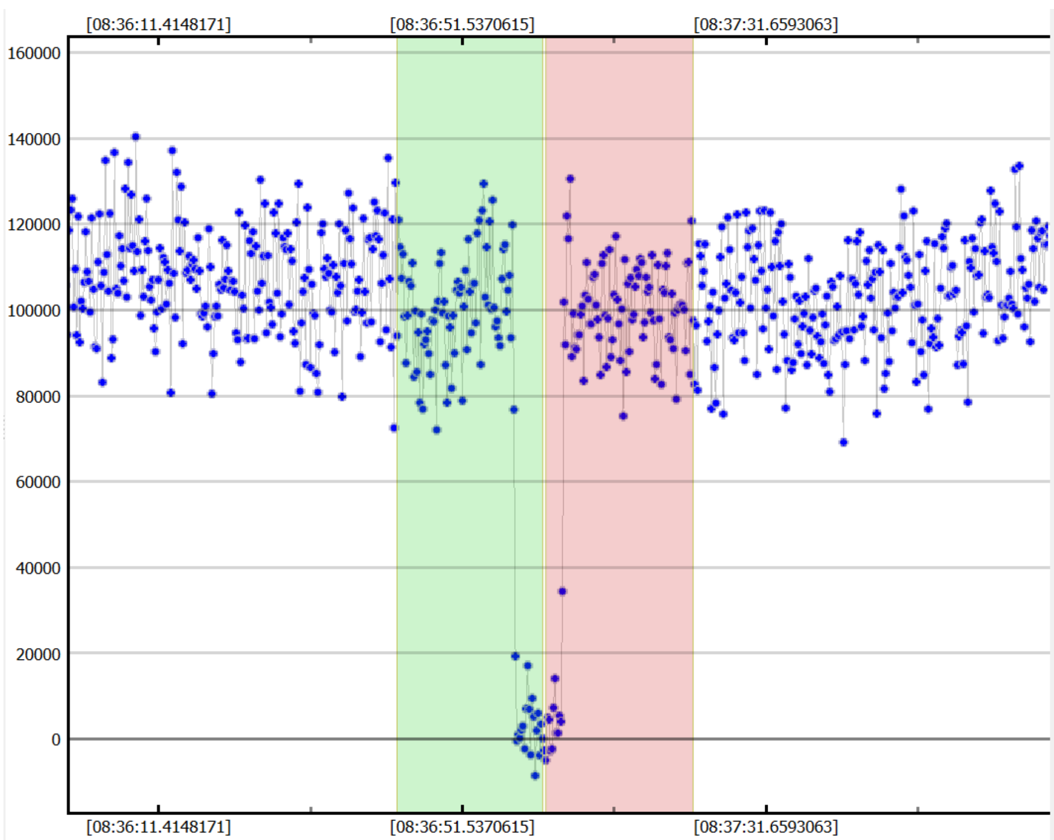
1. Once you are able to see that there is in fact an occultation, you can mark the D/R regions (Disappearance/Reappearance) and let PyOTE find the event.
2. If the D/R regions are hard to pinpoint, you can select a larger area and have PyOTE find it.
3. First, select two points by left-clicking on the graph: one that starts before the D region, and another one that is somewhere after the D region. This data point does not have to be during the occultation (if the time of the occultation is too short) but anywhere after the decrease in the target star's magnitude. Click on the **Mark D region** button in the left panel to highlight the D region in green.



4. Similarly, select two points again: one that starts anywhere before the R region, and another one that is after the R region. Click on the Mark R region button in the left panel to highlight the R region in red.

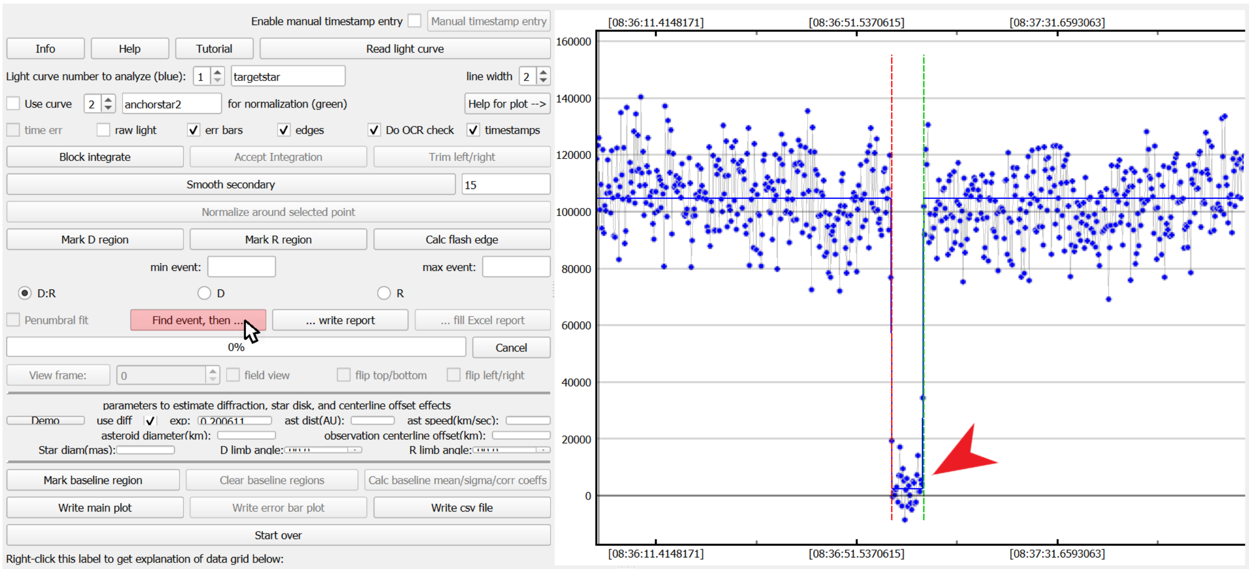


5. After marking both the D/R regions, your graph should look something like this:

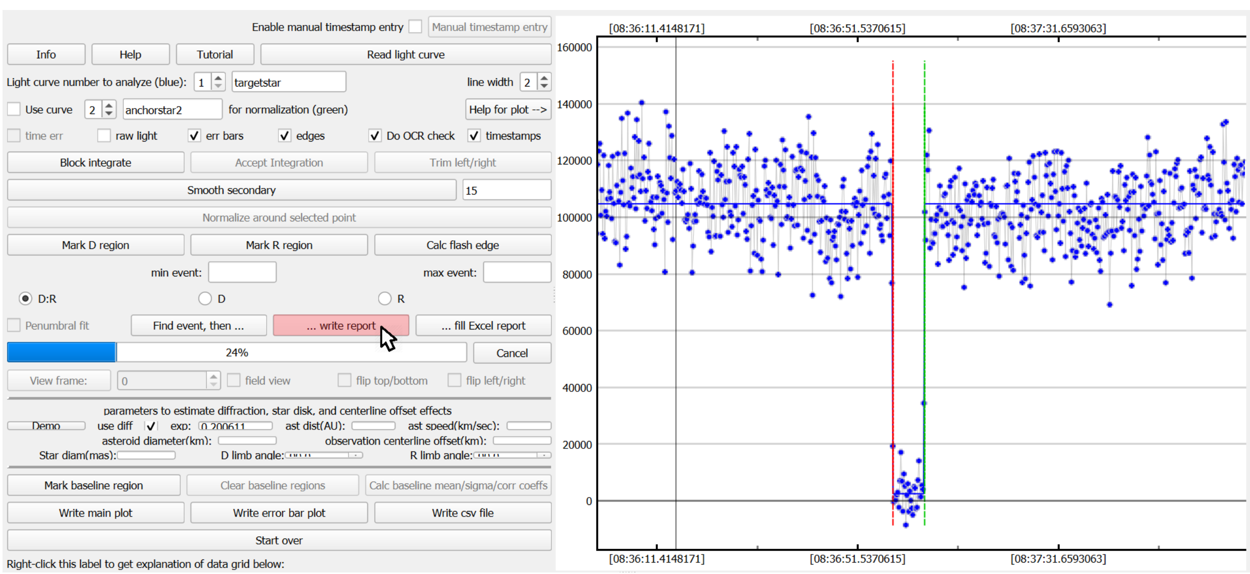


Find event, then write report

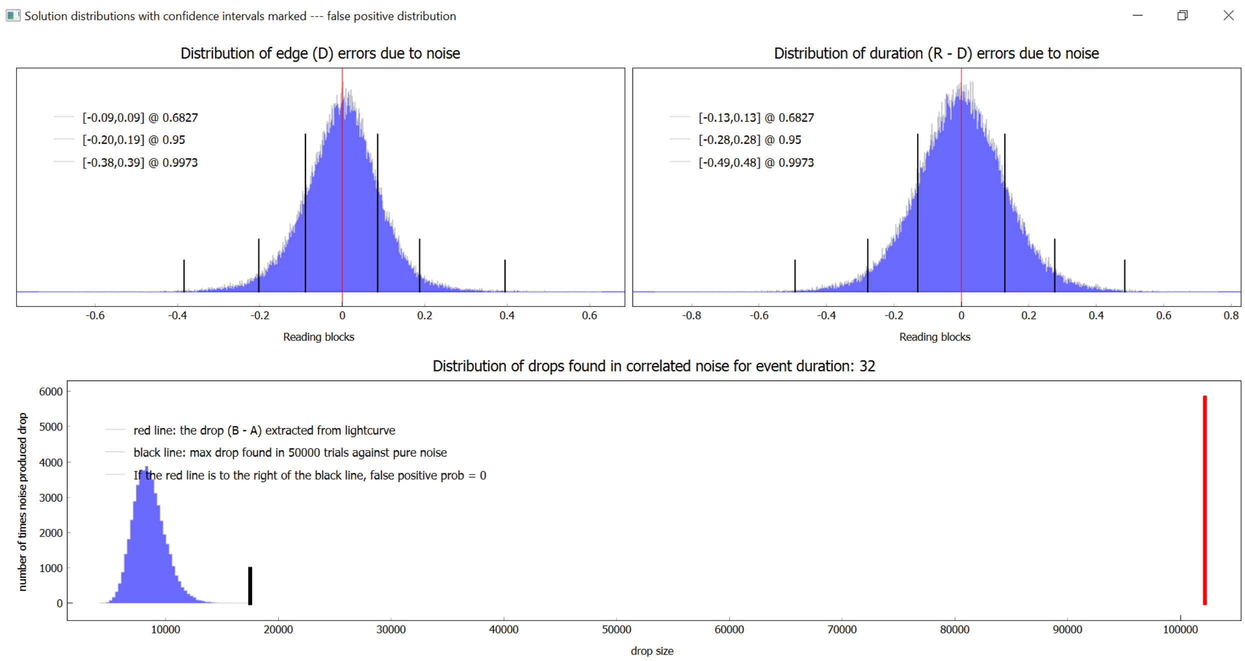
1. Upon clicking on the **Find event, then…** button, PyOTE will give a square wave solution to the light curve.



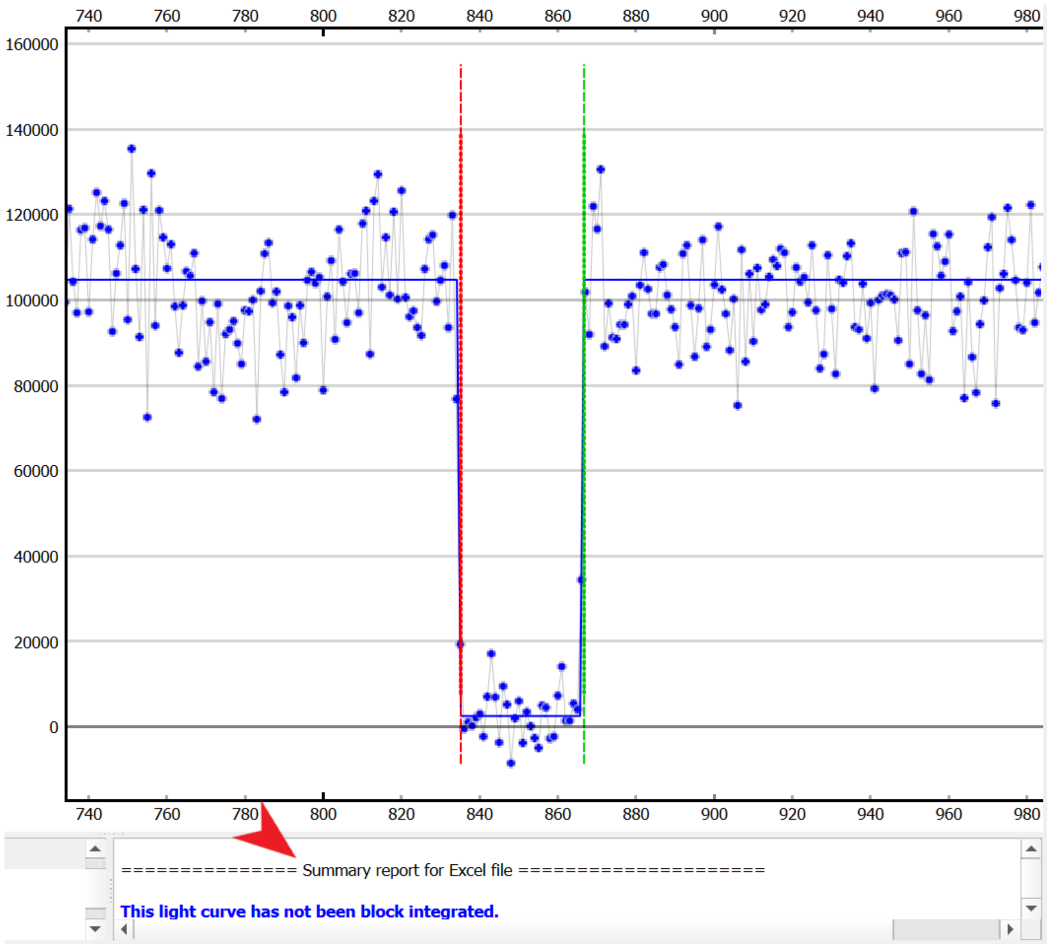
2. Click on the **… write report** button to get a final report on the analysis.



3. Once the blue progress bar in the left panel is completed, a new window will appear with the solution distribution. The graphs on this image will automatically be saved as three separate .png files in the same folder as where the .csv file is located, along with the final fitting on the light curve.



4. A **Summary report** will also appear in the bottom right panel of the main window displaying the results of the calculations such as:
    - magDrop: magnitude drop
    - SNR: signal-to-noise ratio
    - D/R time and their error bars at 0.6800, 0.9500, 0.9973 confidence levels (equivalent to 1,2,3 sigma)
    - Duration R - D: duration of the event and their error bars at the three confidence levels.



Locating log files of all activities

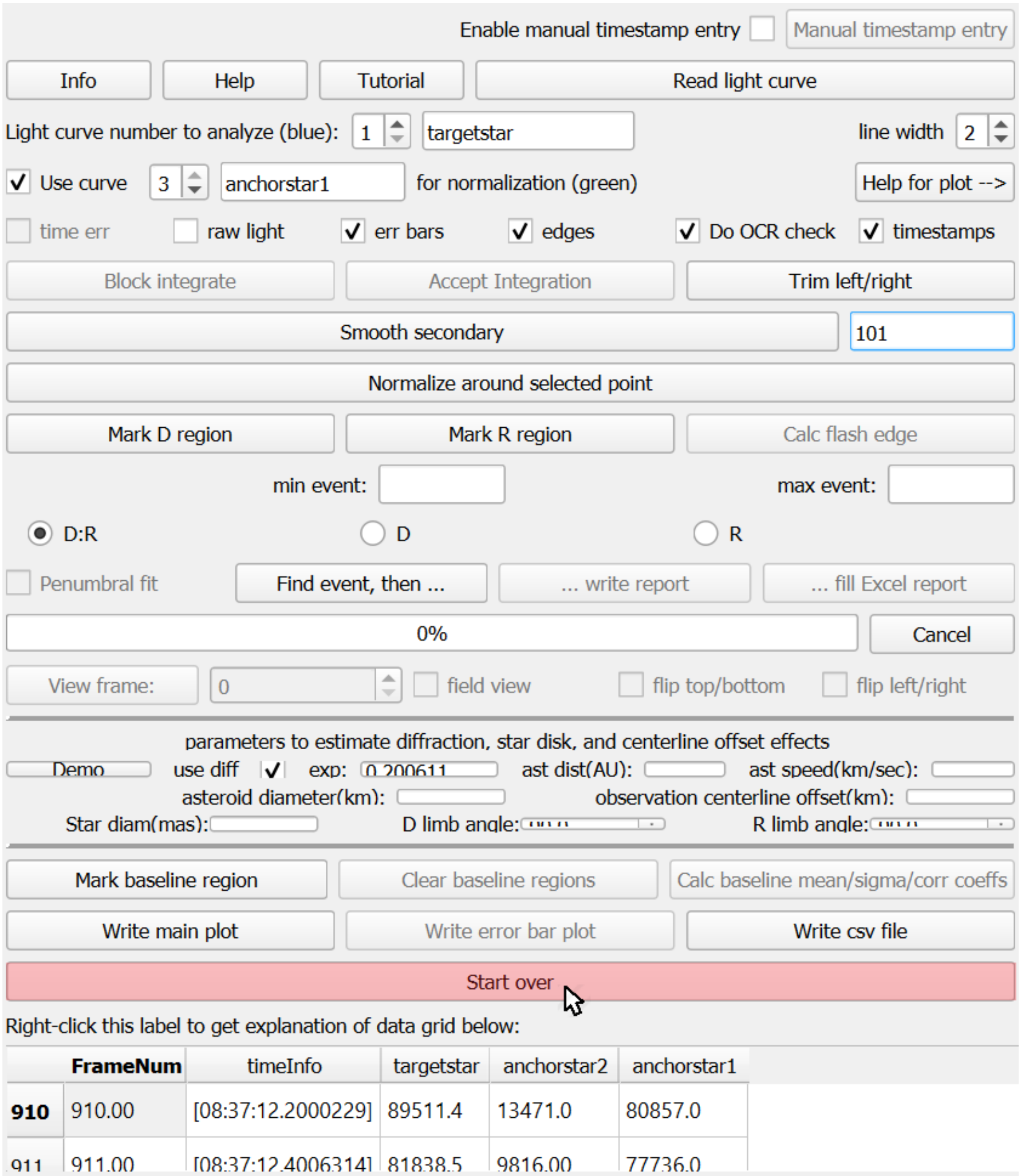
1. PyOTE automatically logs all activities of all sessions that were done after reading the light curve the first time, even after using the **Start over** button. The log file is named as **<light curve filename>.PYOTE** and saved as a text file in the same directory as the light curve.

JB_Patroclus2	7/29/2021 3:42 PM	Microsoft Excel Com...	286 KB
JB_Patroclus2.D.PYOTE	8/12/2021 7:58 PM	PNG File	23 KB
JB_Patroclus2.false-positive.PYOTE	8/12/2021 7:58 PM	PNG File	21 KB
JB_Patroclus2.PYOTE	8/12/2021 8:03 PM	Text Document	48 KB
JB_Patroclus2.PYOTE	8/12/2021 7:58 PM	PNG File	75 KB
JB_Patroclus2.R-D.PYOTE	8/12/2021 7:58 PM	PNG File	25 KB

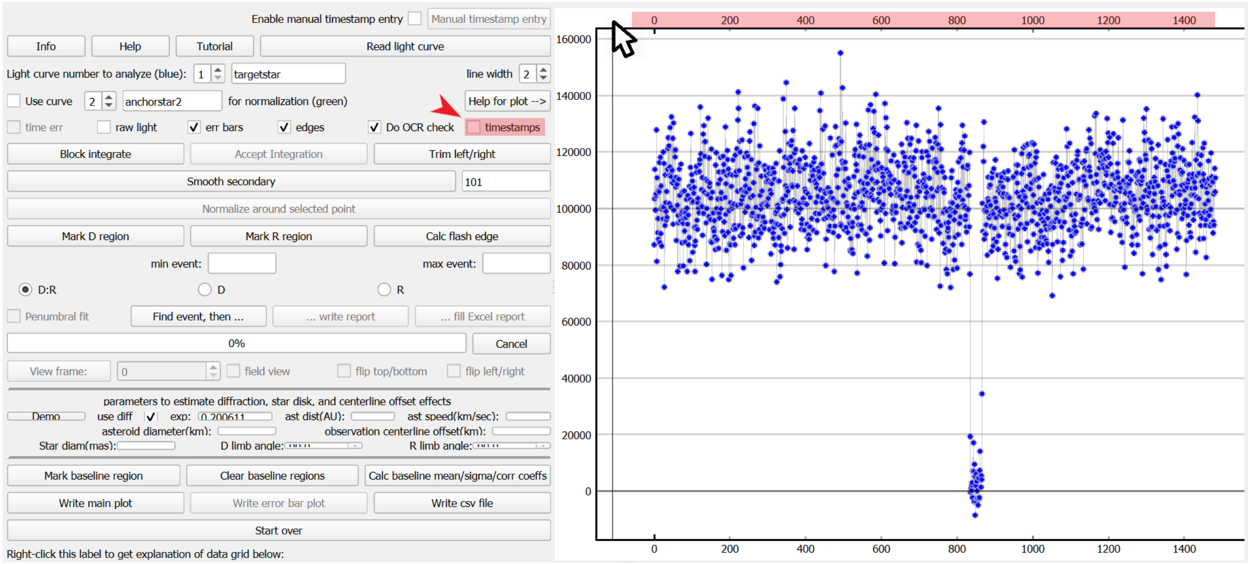
Useful tips

- Right-clicking on a button will bring up a window with an explanation of the purpose of that button.
- Zoom in the light curve using the scroll on the mouse or the touchpad on your laptop. Right-click on the graph to revert back to view the whole light curve.

- Any time you would like to reset the changes you made in PyOTE (except after clicking on the **Block integrate**, click on the **Start over** button in the bottom of the left panel.

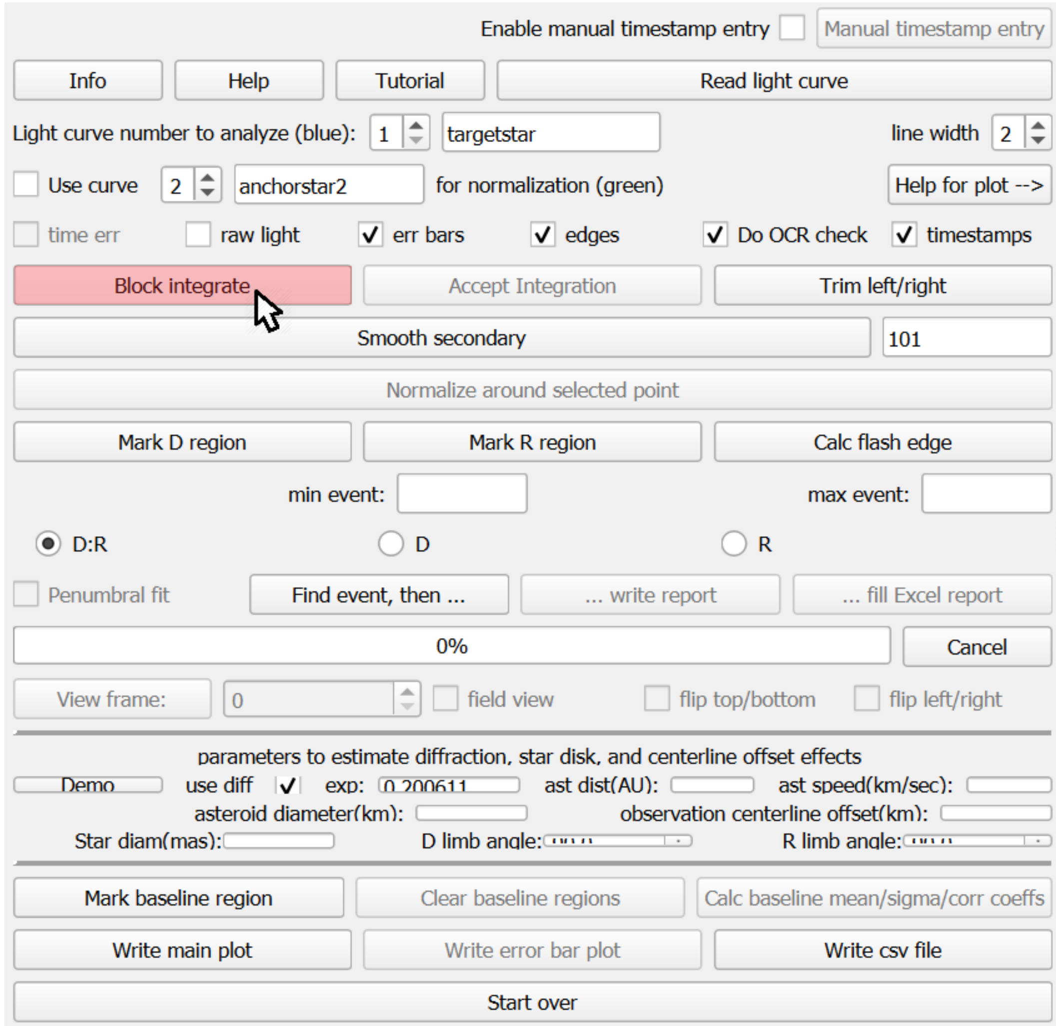


- You are able to change the labels on the x-axis from timestamps to frame numbers by unchecking the **timestamps** checkbox, hovering over the graph, pressing the **Shift** key on your keyboard to turn on the cursor, then right-clicking on the top left corner of the graph.

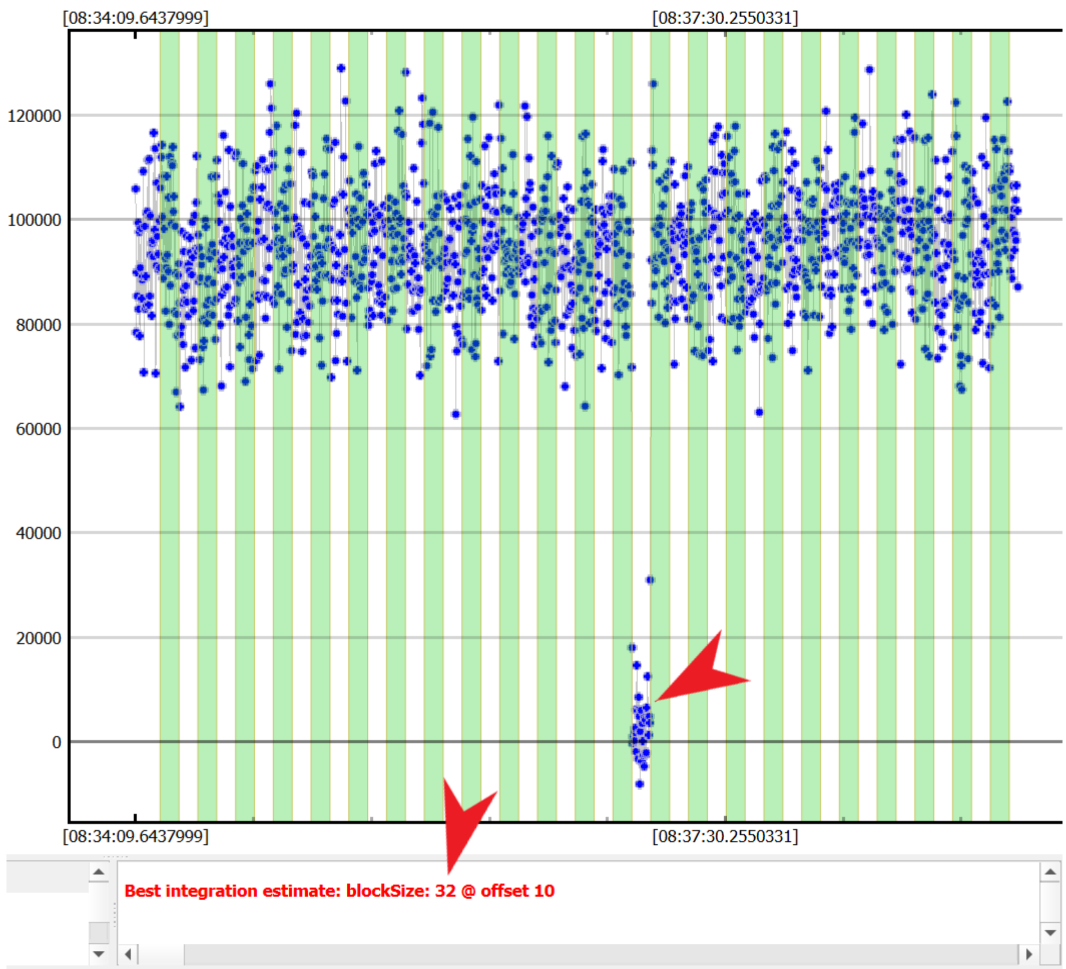


Appendix: Check integration (only for MallinCam .avi files)

1. To get an accurate time for your event, first you need to check if the light curve is from an integrated video. An integrated video refers to frame integration which is how many data points are collected per frame. This step is only necessary if you are using MallinCam .avi files but it is not for QHY fits files.
2. There are two scenarios:
   i. If you are unsure whether the video is integrated, click on **Block Integrate** to run an automatic analysis of the entire light curve without selecting any points.



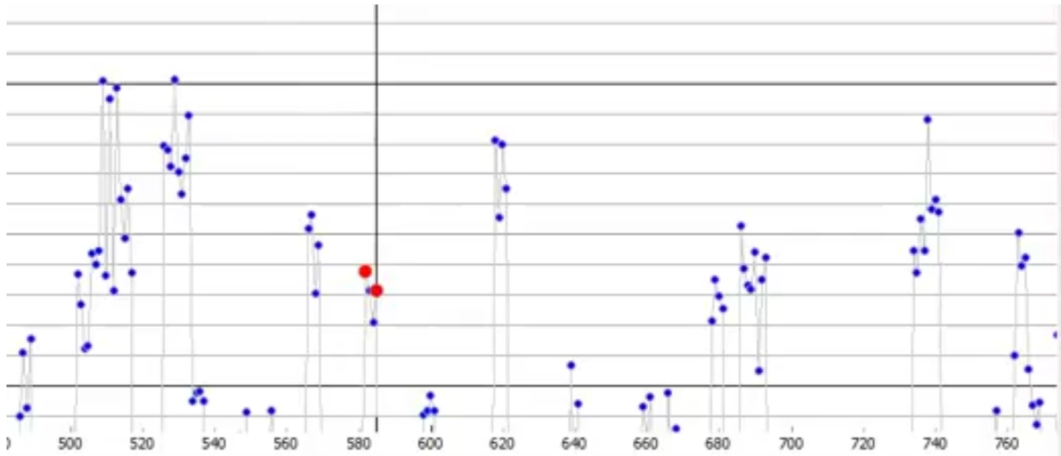
If the light curve is not from an integrated video, PyOTE will most likely offer an integration that is the same size as the occultation (if there is any) with a large block size, similarly as shown here:



Do not accept this as integration! Unfortunately, you will have to reload the light curve to start over. The **Start over** button on the bottom of the left panel will not work in this case.

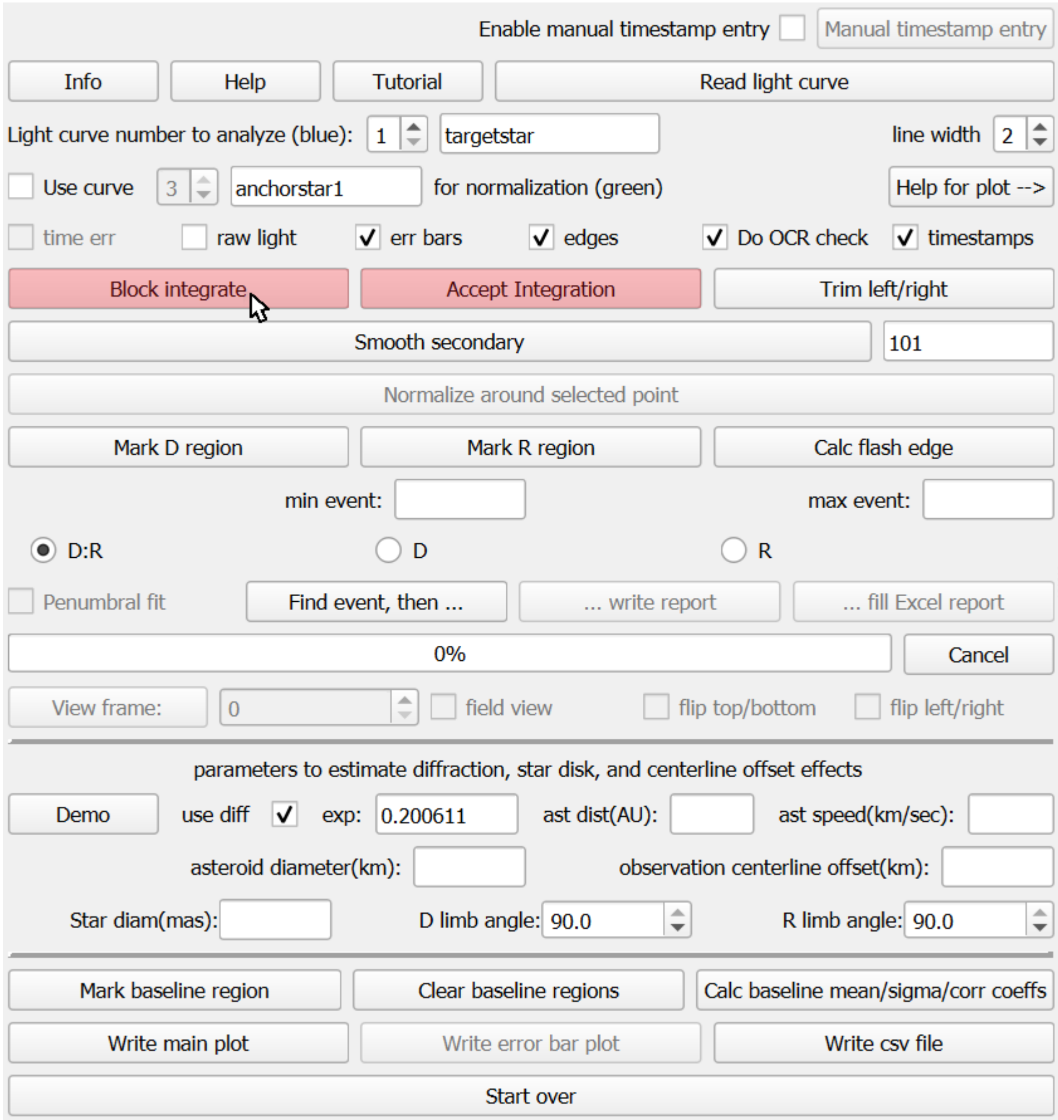
ii. If by zooming in the light curve (using the scroll on the mouse or on the touchpad of your laptop) you notice groups (blocks) of the same number of datapoints, the light curve is from an integrated video.

Select the first and last frame integration points by clicking on them when the black vertical line aligns with the point. This will change the selected points to red.



This is a screenshot from the video: https://www.youtube.com/watch?v=tdEfAJ2hOW0

Click on **Block integrate** and **Accept Integration** if the light curve is definitely from an integrated video. Otherwise, reload the light curve to start over, i.e. decline the integration recommendation.



More information

- For a video of a PyOTE work session on normalization made by Robert Anderson and Tony George, please visit: https://vimeo.com/511862694

Alternate Possibilities for Opening PyOTE

From Anaconda Prompt

1. Open **Anaconda Prompt**.
2. Type the following: `python`
3. Hit **Enter**. The symbols: >>> will appear once it is finished.
4. Type the following: `from pymovie import main`
5. Hit **Enter**. The symbols: >>> will appear once it is finished.

6. Type the following: `from pyoteapp import pyote`
7. Hit **Enter**. The symbols: `>>>` will appear once it is finished.
8. Type the following: `pyote.main()`
9. Hit **Enter**. The program will load.