

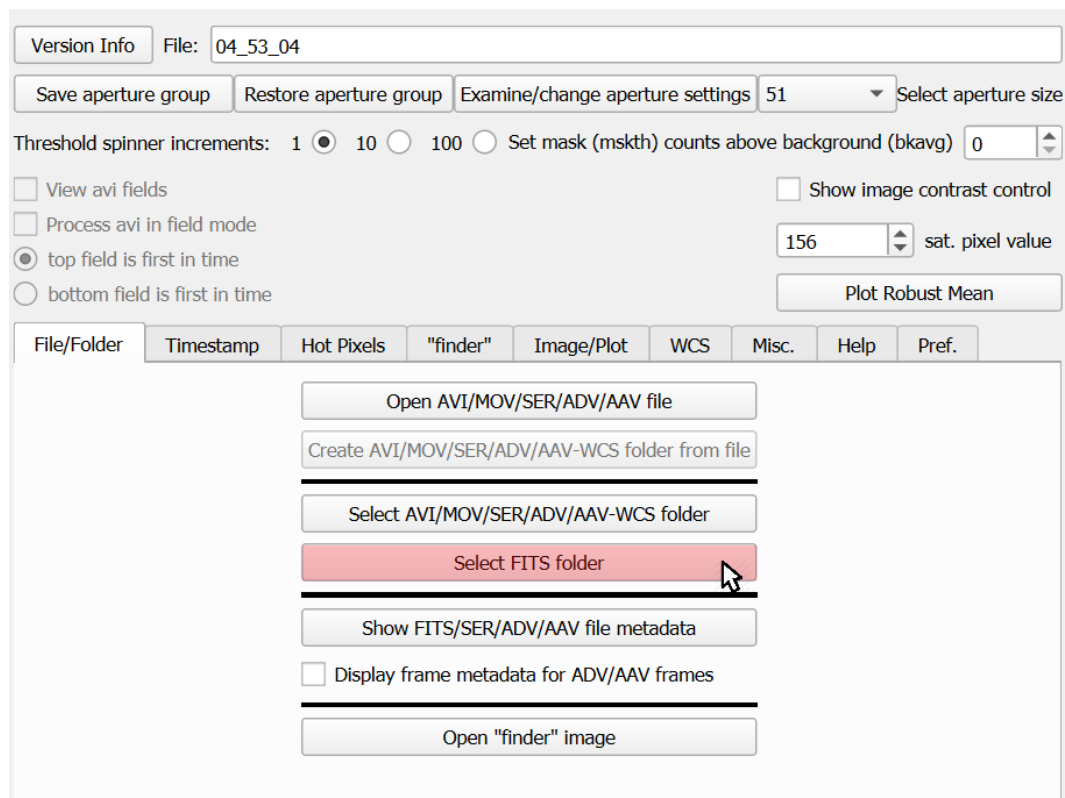
PyMovie Guide

Opening PyMovie

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

Opening your QHY Data

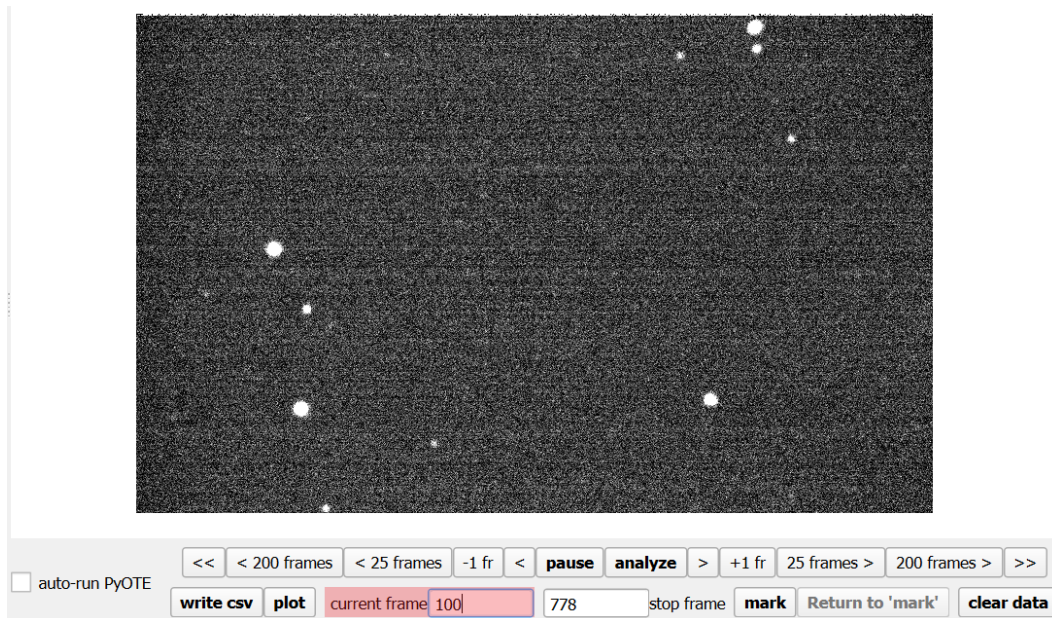
1. In the File/Folder tab, click **Select FITS folder** and navigate to your preferred directory that contains your FITS files.



The screenshot shows the PyMovie software interface. At the top, there is a 'Version Info' tab and a 'File:' field containing '04_53_04'. Below this are buttons for 'Save aperture group', 'Restore aperture group', and 'Examine/change aperture settings' followed by a dropdown menu set to '51' and the text 'Select aperture size'. A 'Threshold spinner increments:' section has radio buttons for '1' (selected), '10', and '100', followed by a checkbox for 'Set mask (mskth) counts above background (bkavg)' and a spinner set to '0'. There are checkboxes for 'View avi fields', 'Process avi in field mode', and 'top field is first in time' (selected), with a 'bottom field is first in time' option below. A 'Show image contrast control' checkbox is also present, with a spinner set to '156' and the text 'sat. pixel value'. A 'Plot Robust Mean' button is located to the right. Below these are tabs for 'File/Folder', 'Timestamp', 'Hot Pixels', '"finder"', 'Image/Plot', 'WCS', 'Misc.', 'Help', and 'Pref.'. The 'File/Folder' tab is active, showing a list of buttons: 'Open AVI/MOV/SER/ADV/AAV file', 'Create AVI/MOV/SER/ADV/AAV-WCS folder from file', 'Select AVI/MOV/SER/ADV/AAV-WCS folder', 'Select FITS folder' (highlighted in red with a mouse cursor), 'Show FITS/SER/ADV/AAV file metadata', 'Display frame metadata for ADV/AAV frames' (checkbox), and 'Open "finder" image'.

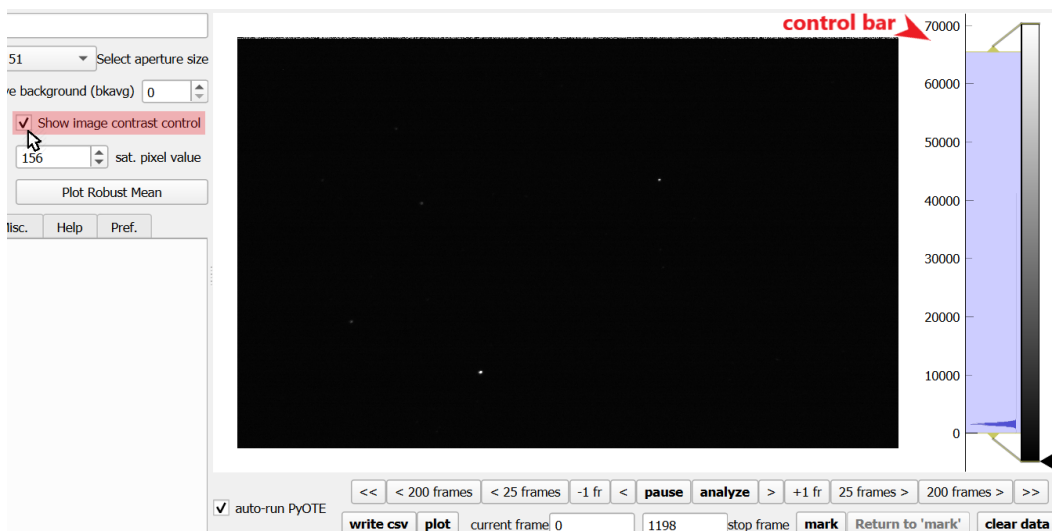
2. Select the folder your data is in and click **Select Folder**. The first frame of the FITS files will appear on the right.
3. You may view a different frame by typing the frame number in the **current frame** textbox. Please note when generating a light curve in the following steps, the analysis will start on this frame and end on the number indicated in the **stop frame** textbox so

make sure you have the correct frames. This tool is very helpful when we know what interval the occultation happens because it reduces the time of the analysis.

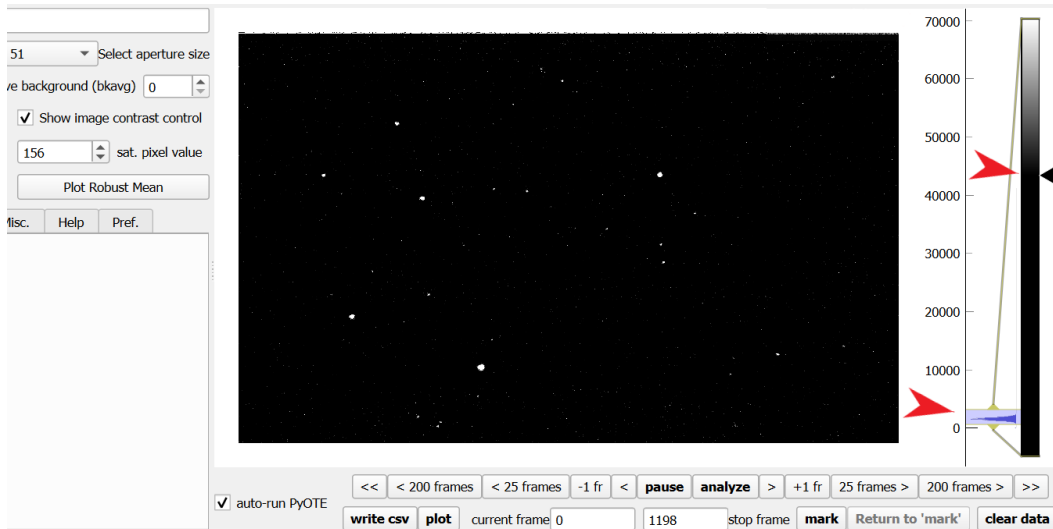


Changing image contrast

1. Check the **Show image contrast control** checkbox. This will bring up two adjustable control bars on the right side of the image.



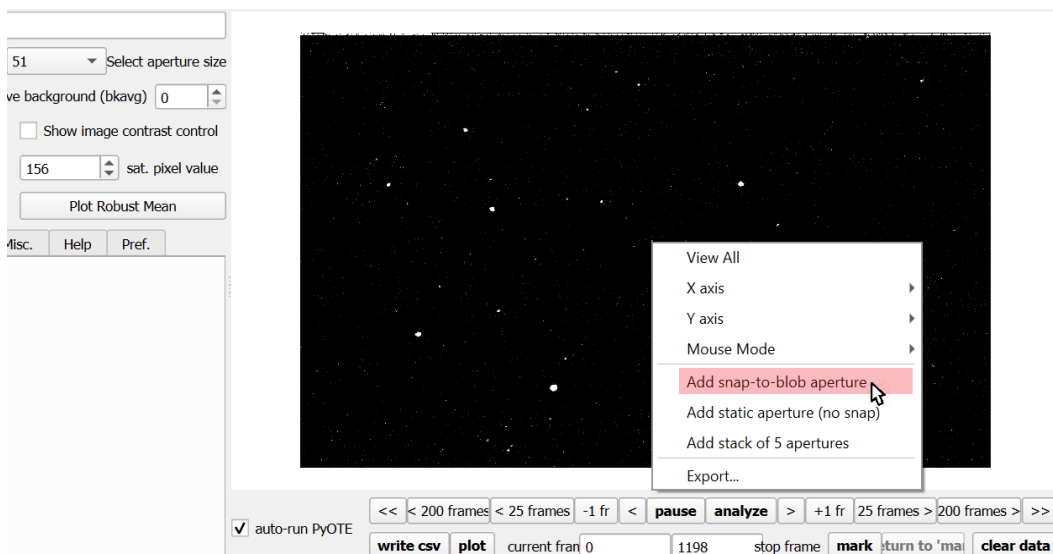
2. On the leftmost blue control bar, click and drag the upper and lower limit bars close to the data spike. You can zoom into this control bar using the scroll on the mouse or the touchpad. The black control bar on the right allows you to adjust the overall contrast. Using these two control bars, calibrate the image to get rid of the noise and reveal your target star.



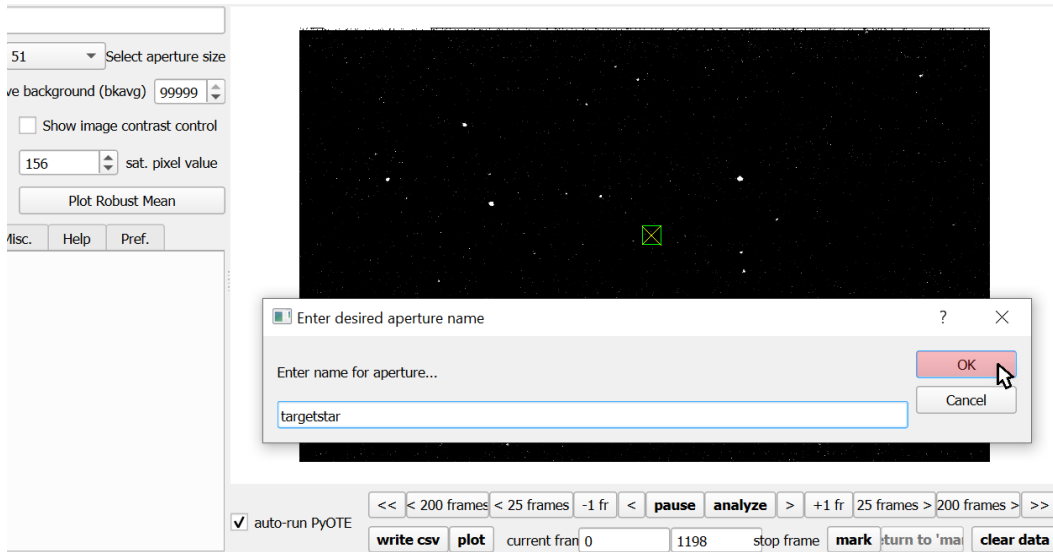
3. Make sure to uncheck the **Show image contrast control** checkbox after you have found the settings you like to lock the adjustments. The control bar will disappear.

Setting apertures and centroids for stars

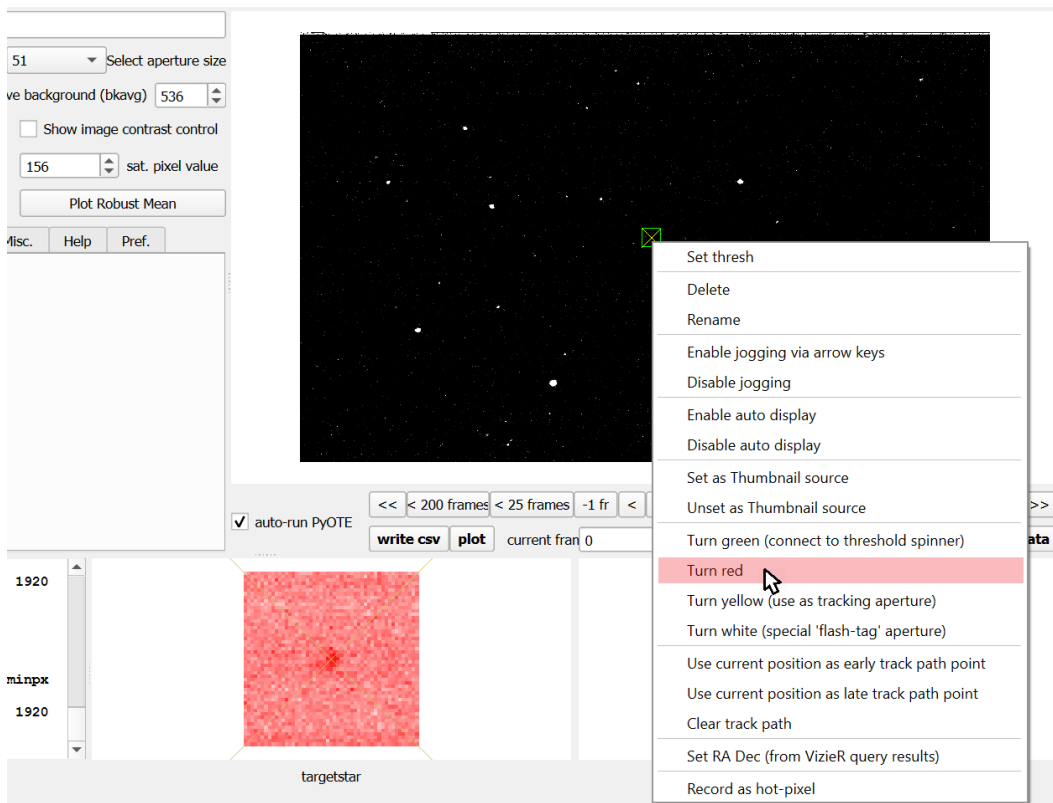
1. Upon comparing the given star field with the current frame, identify the target star. To apply an aperture, right-click on the target star to bring up a menu and select **Add snap-to-blob aperture**. (Note: you can zoom into the star using the scroll on the mouse or the touchpad.)



2. Enter an indicative aperture name (i.e. targetstar, anchor1, anchor2, etc.) and click **OK**.



3. Right-click on the target star one more time to bring up the menu and select **Turn red** (red refers to the target star) to change the color of the square selection.



4. Find at least one (but preferably two) reference stars near the target star with similar brightnesses and sizes for tracking and to calculate the rotation rate and repeat steps 1-3. However, for step 3, select **Turn yellow** instead for the anchor stars. Ideally, if you choose multiple anchor stars, they should be on different sides of the frame and not too

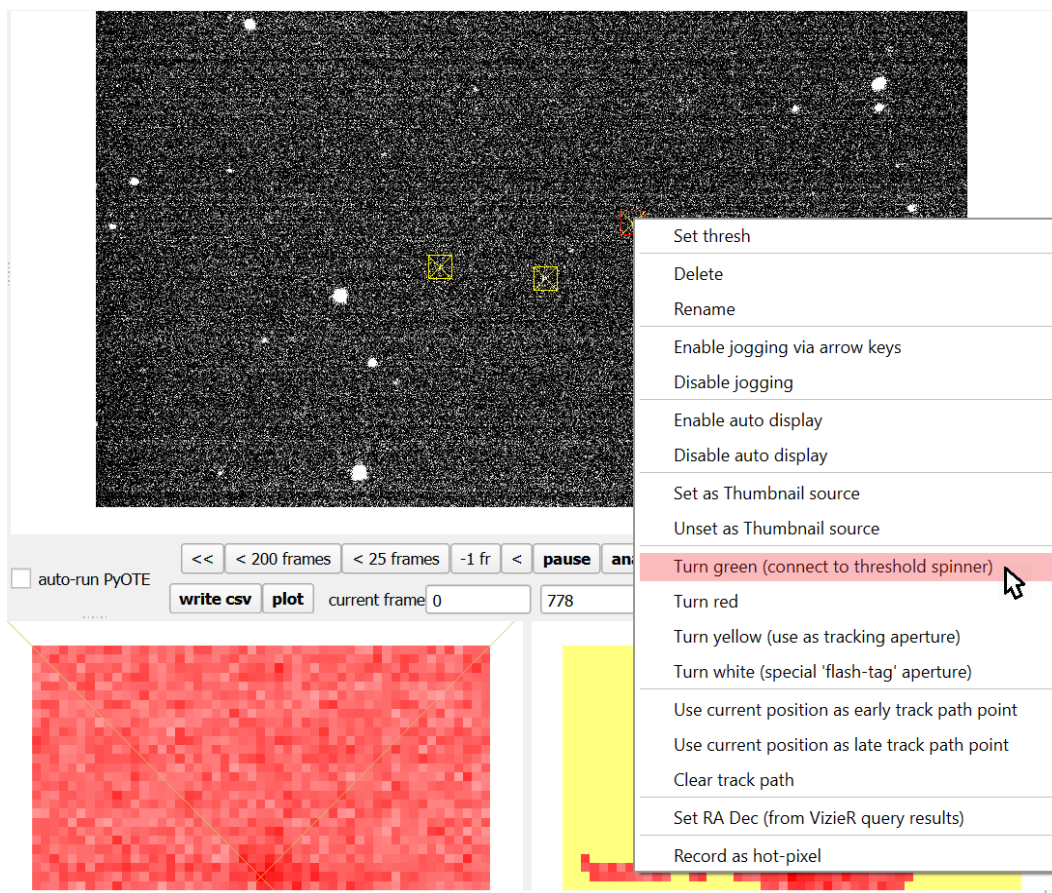
close to the edge of the frame, i.e. try to select stars that will definitely stay in the field frame. Note: In the PyOTE light curve analysis you will only be able to use one reference star, but having multiple options available might help selecting the best light curve for the normalization. Also, it is better to use at least two reference stars for PyMovie for more accurate tracking and to deal with field rotation.

WCS (World Coordinate System) calibration to find faint stars

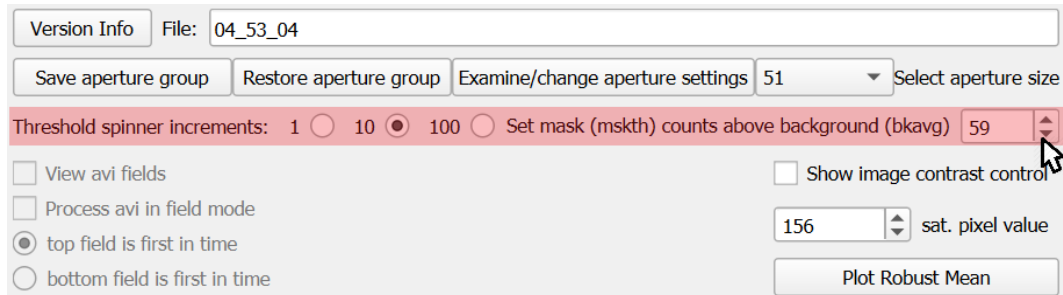
1. In some cases when the target star is too faint to find, you can use WCS calibration for your image by converting its axes to RA (right ascension) and DEC (declination) coordinates.
2. Here is a video guide about the WCS calibration provided by Robert Anderson:
<https://www.youtube.com/watch?v=YDbwEL3BhGI>

Setting mask threshold

1. In order to set the mask threshold manually for the selected star, right-click on the star and select **Turn green (connect to threshold spinner)**. The mask is used for creating a selection around the star and ignores the rest of the frame to reduce time of the calculation.



- In the top right panel, set the mask threshold to an acceptable value that would align to the shape of the star to get rid of background noise. You can either type the desired number in the space to the right of **Set mask (mskth) counts above background (bkavg)** or increment by 1, 10 or 100 using the **Threshold spinner increments** and the up and down arrows.



Version Info File: 04_53_04

Save aperture group Restore aperture group Examine/change aperture settings 51 Select aperture size

Threshold spinner increments: 1 10 100 1000 Set mask (mskth) counts above background (bkavg) 59

☐ View avi fields ☐ Show image contrast control

☐ Process avi in field mode

☒ top field is first in time 156 sat. pixel value

☐ bottom field is first in time

Plot Robust Mean

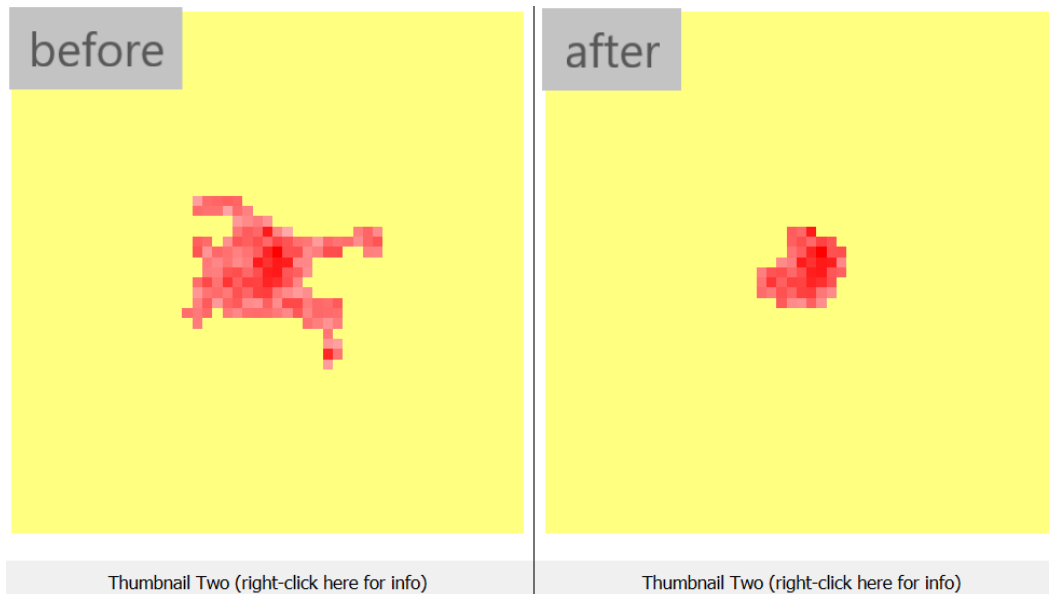
- A good starting point is setting it equal to the background noise (**bkstd**) that is shown in the bottom left textbox. This is a 1 sigma mask. You may change it between 1 and 2 sigma (1x or 2x bkstd).

```
targetstar: frame:0.0
  signal  appsum  bkavg  bkstd  mskth  mskpx  xpos  ypos  minpx  maxpx
    43160   229408 1565.11 270.21  1665    119  3128   573  1184  3104

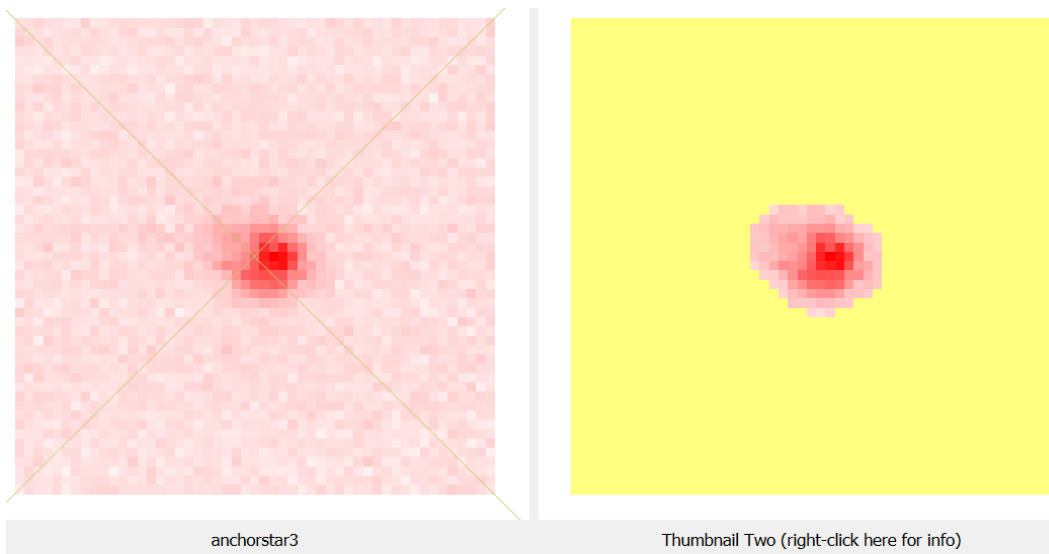
mean_top: 1573.011 mean_bot: 1555.124

targetstar: frame:0.0
  signal  appsum  bkavg  bkstd  mskth  mskpx  xpos  ypos  minpx  maxpx
    43160   229408 1565.11 270.21  1665    119  3128   573  1184  3104
```

- The effect of the change is shown in the bottom right **Thumbnail Two**. The threshold when generating the left image was set to 100, and was set to 540 (that is equal to about two sigma) when generating the right image



5. In the bottom right, **Thumbnail One** (displays the name given to the selected star) shows the zoomed image of the selected star. **Thumbnail Two** shows the mask that will be applied to the image.



6. You can also edit/view the mask threshold settings of each star by clicking on **Examine/change aperture settings** in the upper left panel. A new window will pop up.

Version Info File: 04_53_04

Save aperture group Restore aperture group **Examine/change aperture settings** 51 Select aperture size

Threshold spinner increments: 1 ☒ 10 ☐ 100 ☐ Set mask (mskth) counts above background (bkavg) 540

☐ View avi fields ☒ Show image contrast control

☐ Process avi in field mode 436 sat. pixel value

☒ top field is first in time ☐ bottom field is first in time

Plot Robust Mean

- You can change the radius of the default mask for a star by clicking on the cell in the **def mask radius** column and typing in the desired value. When done, simply close the popup window. The default mask radius is used when the star is too dim to adapt to the mask threshold value.

Aperture properties (view and edit) ? X

	name	x,y	thresh	def mask radius	color	joggable	auto textOut	thumbnail source	csv output
1	target	(978,572)	500	3.2	red (standard)	False	False	False	9
2	anchor_1	(1351, 792)	534	3.2	yellow (tracking aperture)	False	False	False	10
3	anchor_2	(1071, 575)	540	3.2	yellow (tracking aperture)	False	False	False	11
4	anchor_3	(460,267)	582	3.2	green (connect to ...)	True	True	True	2

- Once satisfied with the mask, right-click on the star and select **Turn red** for the target star and **Turn yellow (use as tracking aperture)** for the anchor stars.

Saving/Restoring selected aperture group

- Click on **Save aperture group** to save the selected apertures for the target and anchor stars. This will allow you to be able to come back to these aperture settings if return to this event for future analysis.

Version Info File: 05_07_03

Save aperture group Restore aperture group Examine/change aperture settings 51 Select aperture size

Threshold spinner increments: 1 ☒ 10 ☐ 100 ☐ Set mask (mskth) counts above background (bkavg) 668

☐ View avi fields ☐ Show image contrast control

☐ Process avi in field mode 156 sat. pixel value

☒ top field is first in time Plot Robust Mean

☐ bottom field is first in time

File/Folder Timestamp Hot Pixels "finder" Image/Plot WCS Misc. Help Pref.

Open AVI/MOV/SER/ADV/AAV file

Create AVI/MOV/SER/ADV/AAV-WCS folder from file

Select AVI/MOV/SER/ADV/AAV-WCS folder

Select FITS folder

Show FITS/SER/ADV/AAV file metadata

☐ Display frame metadata for ADV/AAV frames

Open "finder" image

- In the pop-up window, enter an indicative name for the ID, then click **OK**. (Note: the program saves the file as "savedApertures-<ID>.p".)

Enter id to append to aperture group files ? X

ids already in use:

new id to append (creates savedApertures-id.p, etc)
(Dots and dashes are converted to spaces to maintain proper format)

ellensburg01

OK Cancel

- Any time you would like to restore the saved apertures, click on **Restore aperture group**. Select the previously saved aperture group and click **Open**.

Version Info File: 05_07_03

Save aperture group **Restore aperture group** Examine/change aperture settings 51 Select aperture size

Threshold spinner increments: 1 ☒ 10 ☐ 100 ☐ Set mask (mskth) counts above background (bkavg) 668

☐ View avi fields ☐ Show image contrast control

☐ Process avi in field mode 156 sat. pixel value

☒ top field is first in time ☐ bottom field is first in time

Plot Robust Mean

File/Folder Timestamp Hot Pixels "finder" Image/Plot WCS Misc. Help Pref.

Open AVI/MOV/SER/ADV/AAV file

Create AVI/MOV/SER/ADV/AAV-WCS folder from file

Select AVI/MOV/SER/ADV/AAV-WCS folder

Select FITS folder

Show FITS/SER/ADV/AAV file metadata

☐ Display frame metadata for ADV/AAV frames

Open "finder" image

Generating light curves

- Once you have selected the target and anchor stars (completed the above steps), click on the **analyze** button below the image to generate your light curves. This analysis will take a few minutes so be patient. You will be able to monitor every frame and how your selected stars shift during this process.

51 Select aperture size

ve background (bkavg) 516

☐ Show image contrast control

156 sat. pixel value

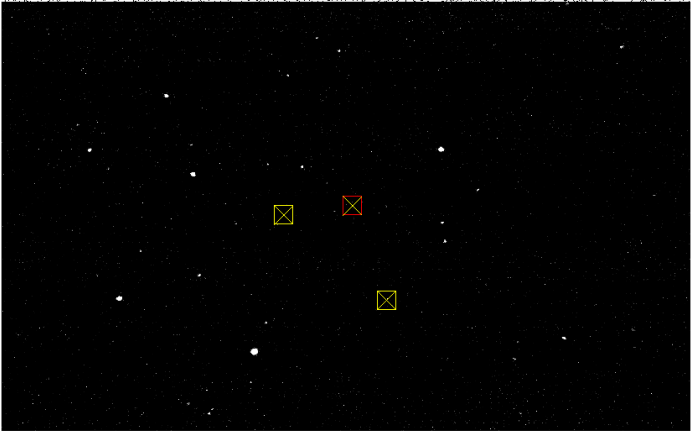
Plot Robust Mean

Misc. Help Pref.

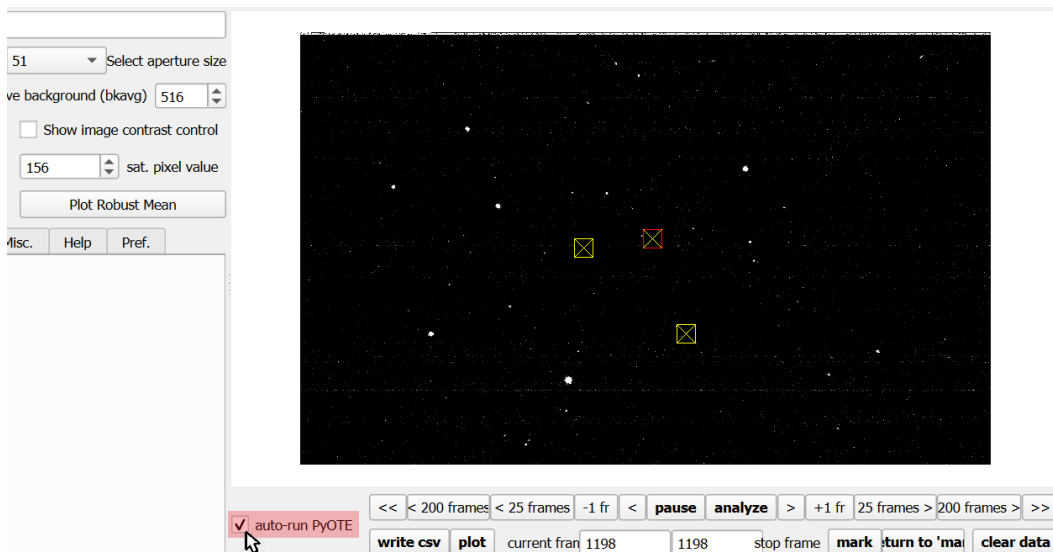
auto-run PyOTE

<< < 200 frames < 25 frames -1 fr < **pause** **analyze** > +1 fr 25 frames > 200 frames >>

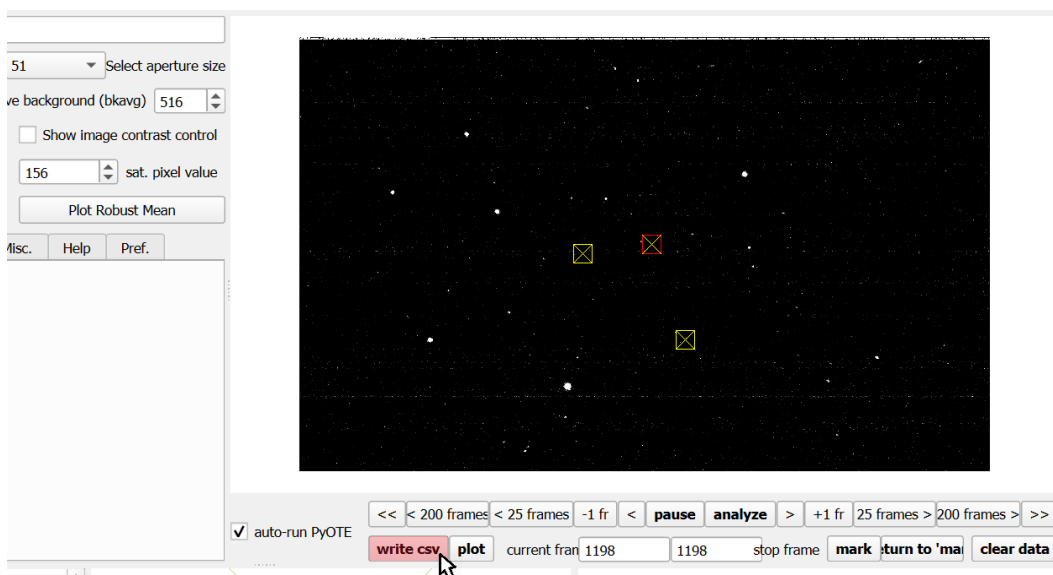
write csv plot current frame 0 1198 stop frame mark turn to 'mai' clear data



2. While the analysis is in progress, you can click on the **plot** button to see the plots as the analysis proceeds. This might be valuable to check to make sure nothing weird has happened (e.g. a jump in the tracking, or clouds), or to look for an occultation. It should be noted that the occultation will only happen on the plot of the target star. However, a decrease in flux (e.g. cloud or poor seeing) should be seen on the plot of both target and anchor stars.
3. 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 in the next steps.



4. When your analysis is complete, click on the **write csv** button below the image to save your light curve as a .csv in a folder that does not contain your FITS files.



Useful tips

- Right-clicking on a button will bring up a 'Help' window with an explanation of the purpose of that button.
- You can zoom into the star field using the scroll on the mouse or the touchpad. To revert back to the full view, right-click on the field and select **View All**.

More information

- For a video guide made by Terry Bridges on how to use PyMovie, please visit: <https://www.youtube.com/watch?v=c3trK92BKfQ>
- For more detailed manual, please visit: <https://occultations.org/observing/software/pymovie/>

Alternate Possibilities for Opening PyMovie

From Anaconda Prompt

1. Type the following: `python`
2. Hit **Enter**. The symbols: `>>>` will appear once it is finished.
3. Type the following: `from pymovie import main`
4. Hit **Enter**. The symbols: `>>>` will appear once it is finished.
5. Type the following: `from pyoteapp import pyote`
6. Hit **Enter**. The symbols: `>>>` will appear once it is finished.
7. Type the following: `main.main()`
8. Hit **Enter**. The program will load.

From Windows Desktop

9. 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.
10. Locate the **PyMovie.bat** and **PyOTE.bat** files in the C:/Anaconda3 directory.
11. Create a shortcut of these files by right-clicking on each of them.
12. 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/>