Flash Detection Software

Workshop Section

Capture your own Impact Flash

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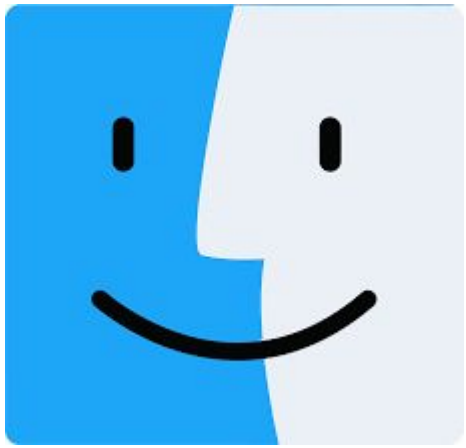
Installation

What Operating System do you have?

- Our Software works for all 3 major OS

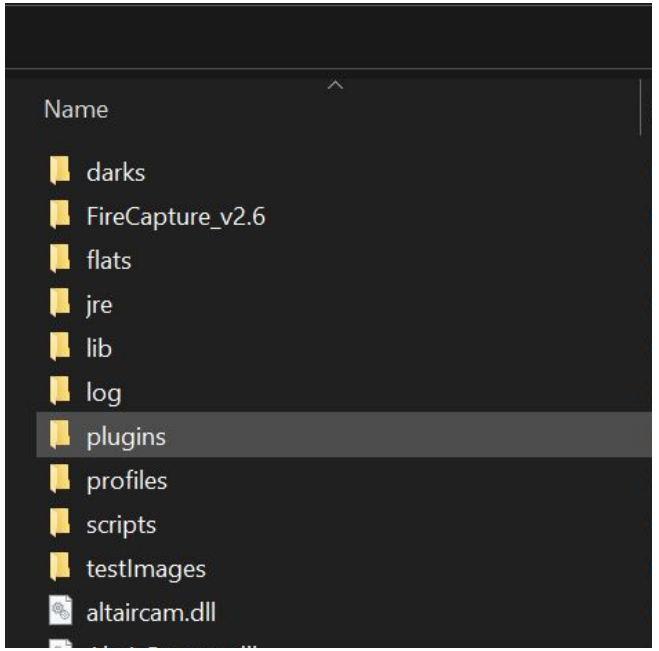


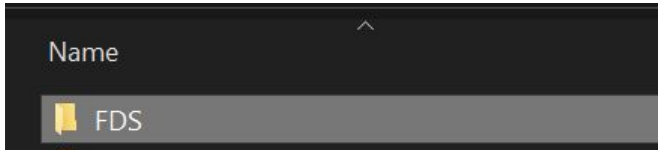
Online Detection Domain:

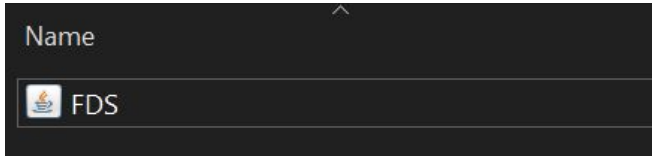
- Visit FireCapture Site:
  - http://www.firecapture.de/
- Scroll down and download FireCapture Version based on your OS
- Then install FireCapture

Online Detection Domain:

- Download our FDS Plugin
  - Download this jar
  - Name: FDS.jar
- Open FireCapture Folder
- Go to the “Plugins” folder (Fig. 1)
- Open **x64** or **x86** folder depending on your installation (Fig. 2)
- Create a folder (Fig. 3)
  - Name: FDS
- Inside this folder place our plugin “FDS.jar” (Fig.4)



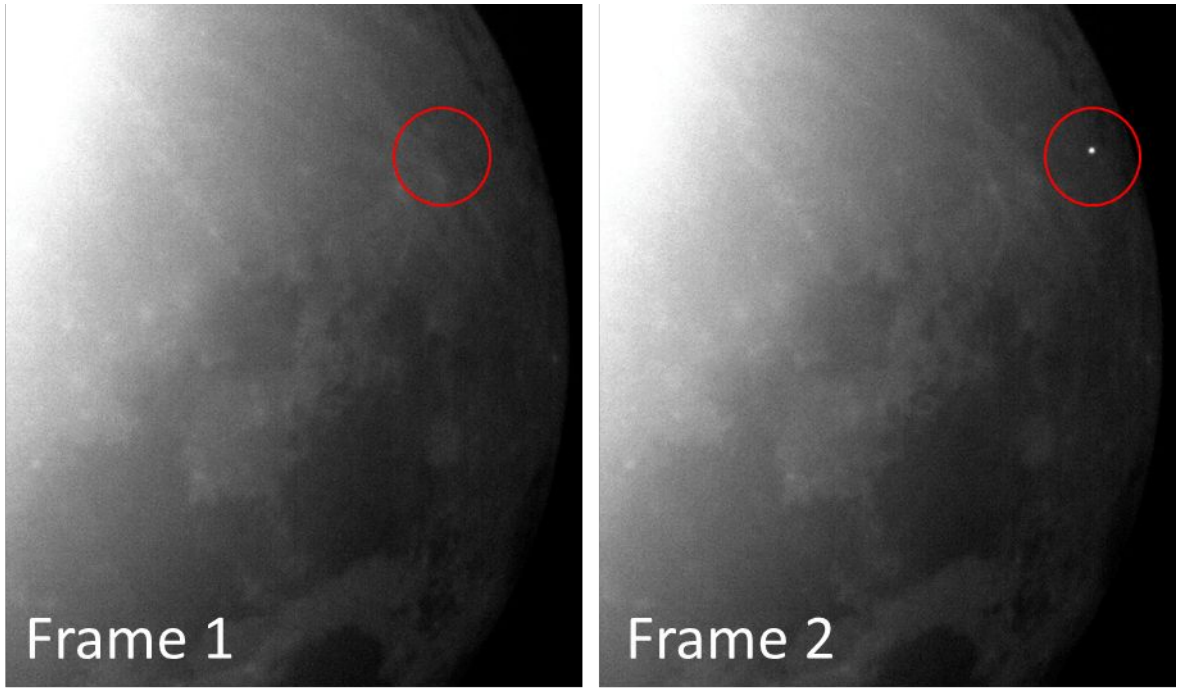




Simulations:

- For this workshop we create some **videos** with impact flashes or other events.
- Download these videos:
  - Here

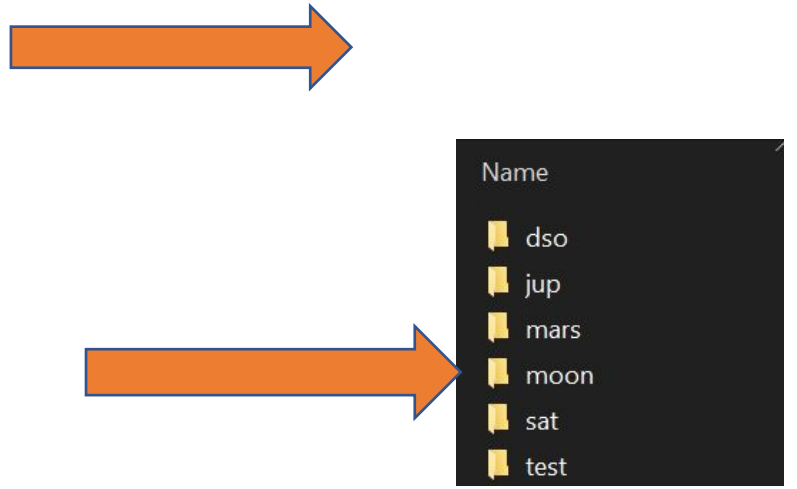
Example of such video

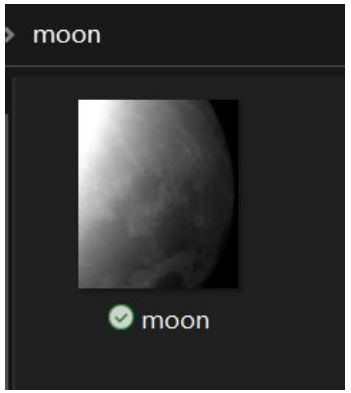


Simulations:

Now we will place the simulations in Firecapture

- Go to the FireCapture folder
- Go to the “testImages” folder (Fig. 1)
- Open the “moon” folder (Fig. 2)
- Delete the existed “moon.avi” video
- Take the first video
  - FDS_moon_1.avi
- Place it in this folder
- Rename the video (Fig. 3) :
  - Name: moon.avi



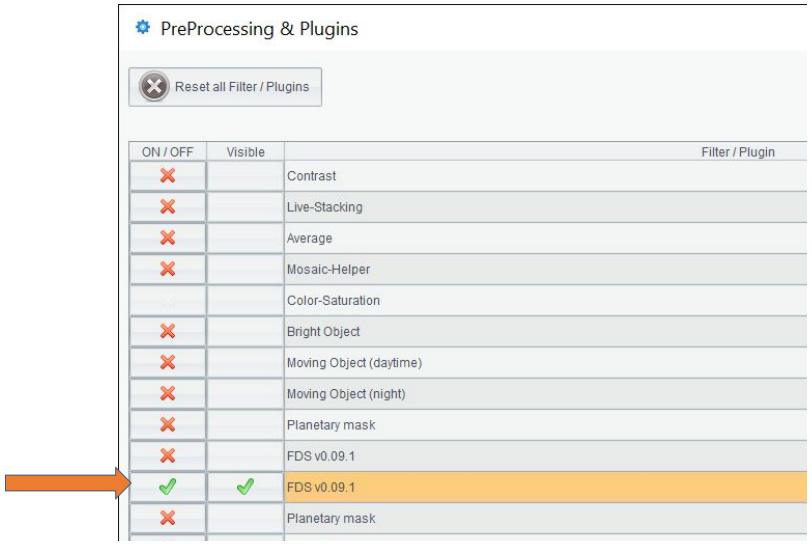


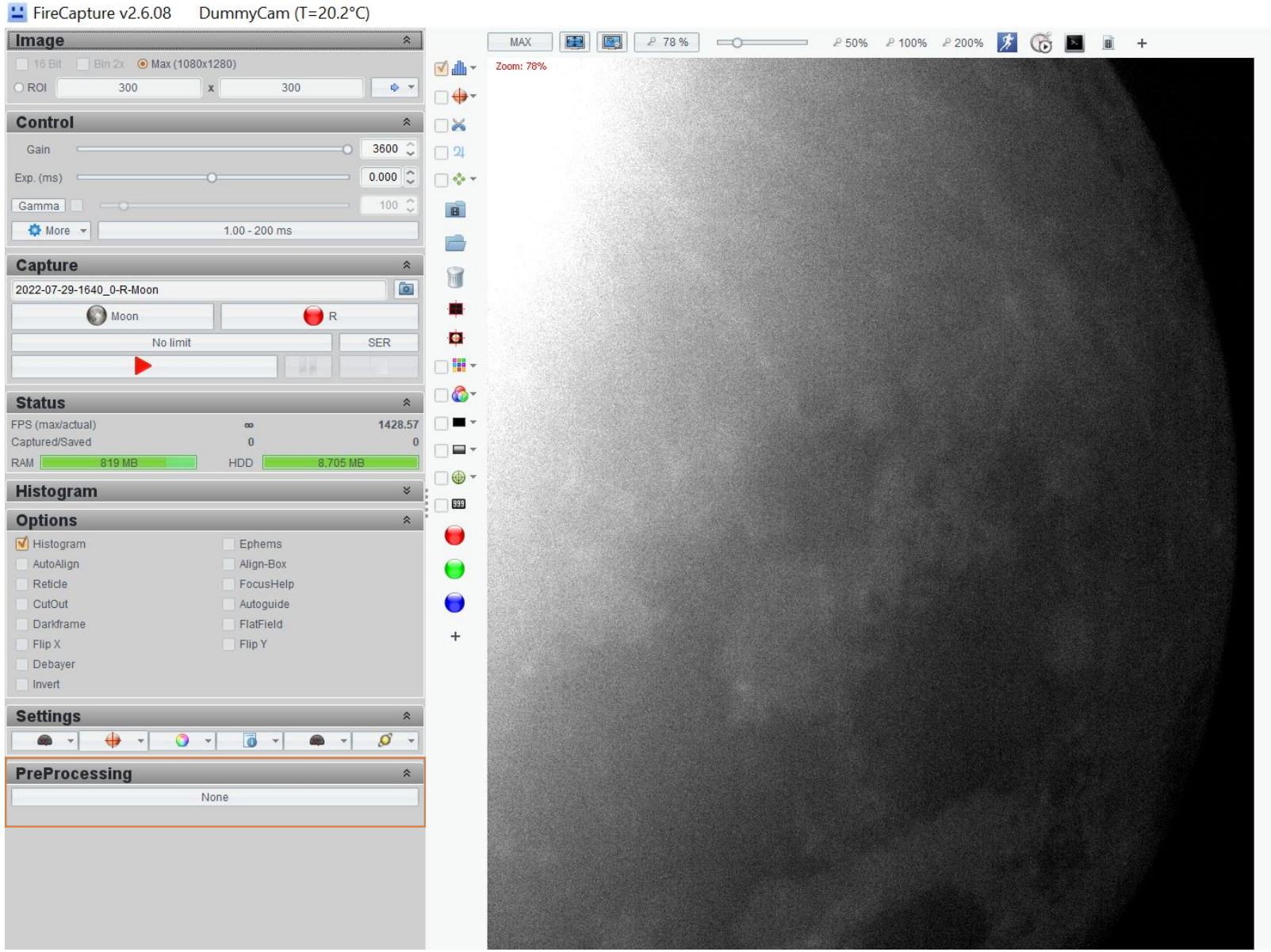
Let’s start

- Open FireCapture and select Dummy Mode
  - If you had a camera, you would choose your real camera

Let’s start

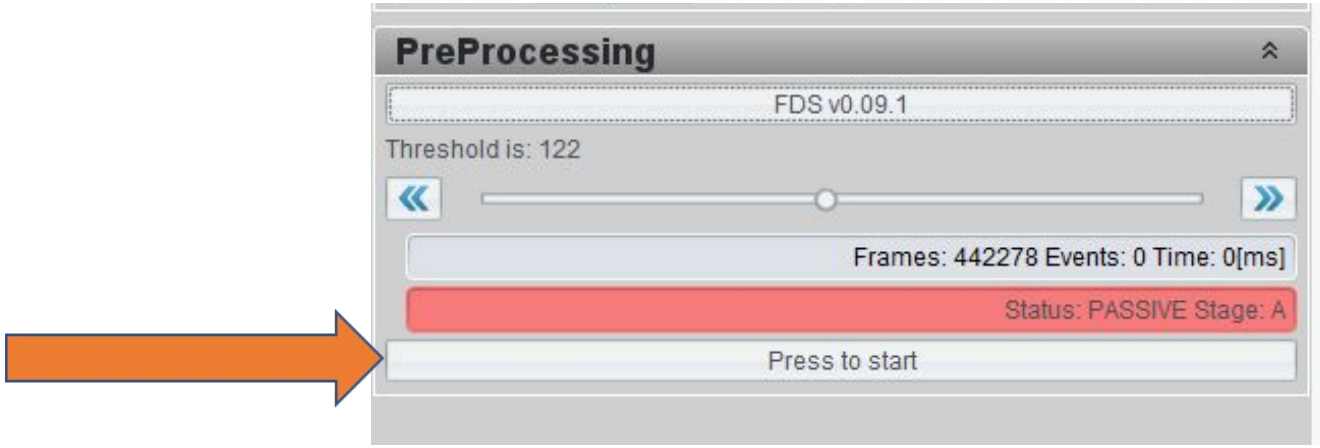
- Let’s set up our plugin
- In the “Preprocessing” area press the “None” button
- In the pop-up window select the FDS





Let’s start

- Select a Threshold value
- Then press the button “Press to start”



A proper threshold value is important. The program will capture the event only if at least one pixel of the frame has value greater than the threshold (in the difference image).

You can change this parameter, at any point during the observation.

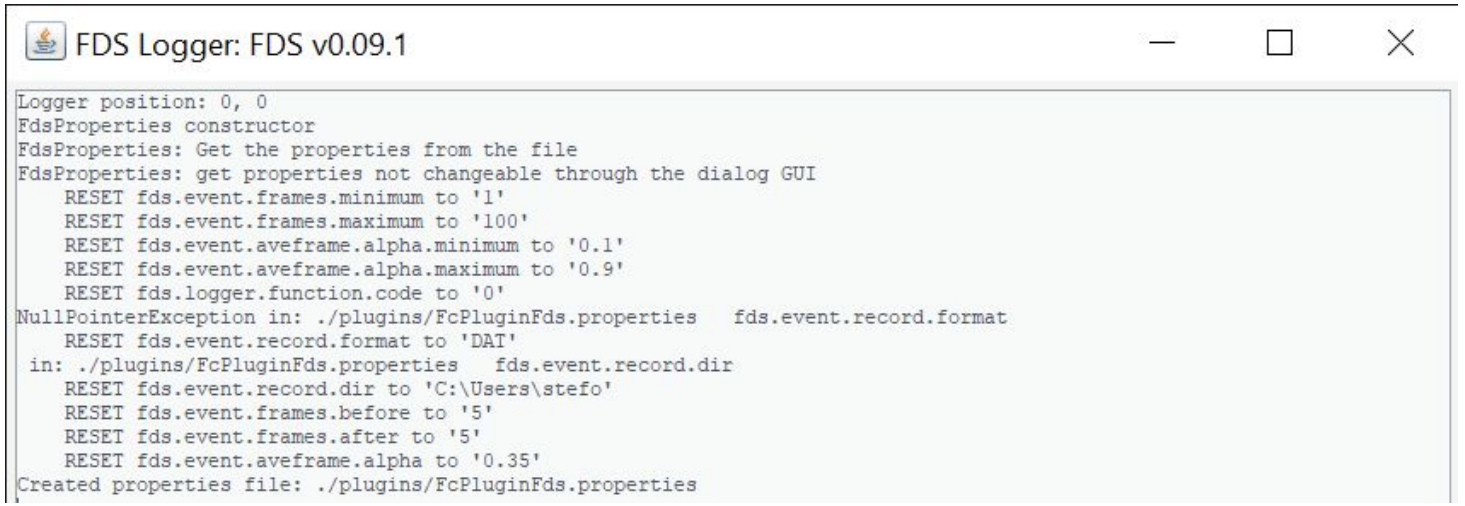
Setting a big threshold value will lead to “miss” some events.

On the other hand, setting a small threshold value will cause false positives.

Set the proper value, based on the weather conditions and the system.

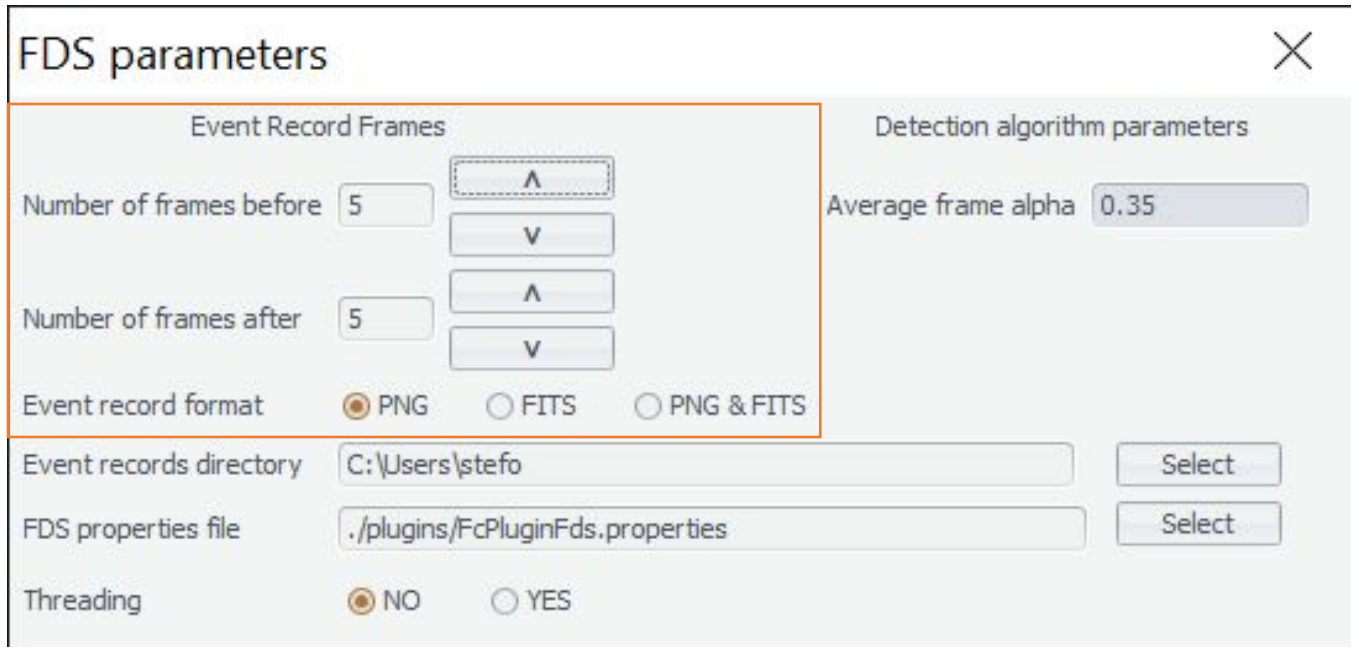
Logger

- During the whole process make sure to look the “Logger”
- Logger will print useful information about the process
  - Will inform you if you have captured any event
  - Will inform you about some stats of the event



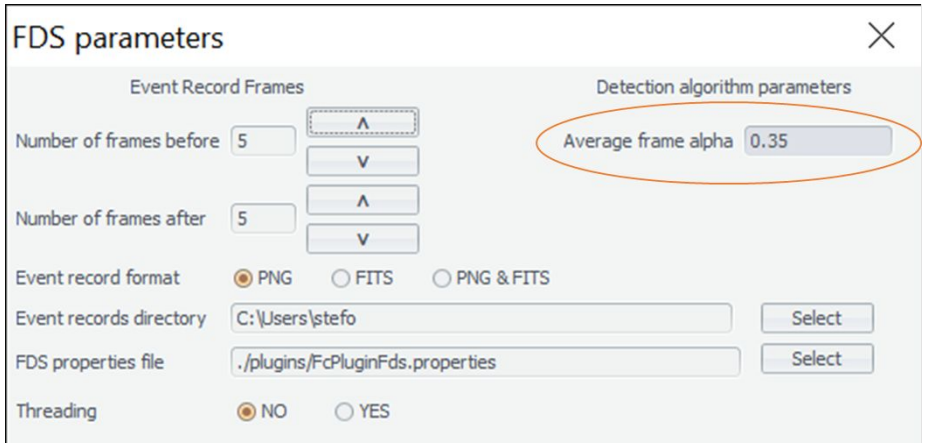
Parameters

- Select how many frames before and after the impact you would like to capture
- In which format you would like to capture the frames: png, fits, or both

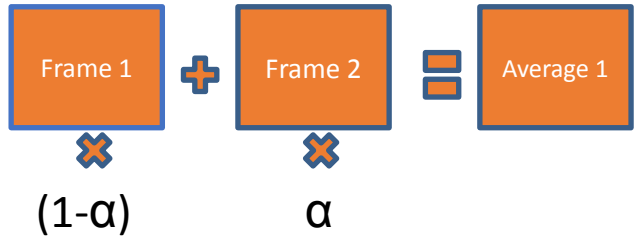


a-parameter

- Weighted average
- Same idea is used in NELIOTA software
- Default value a=0.35

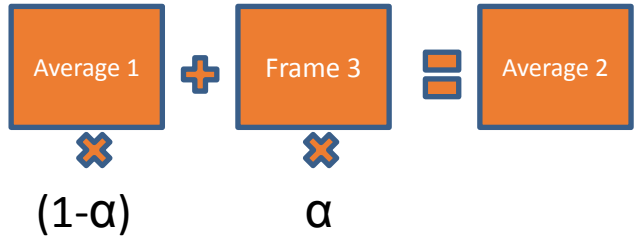


1-st average



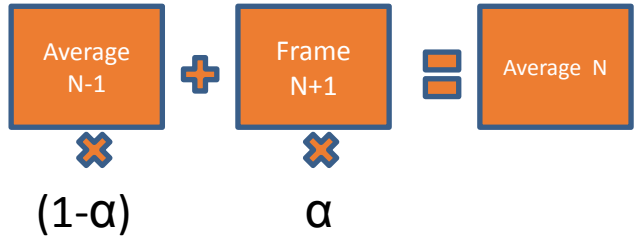
α < 1.0

2-nd average



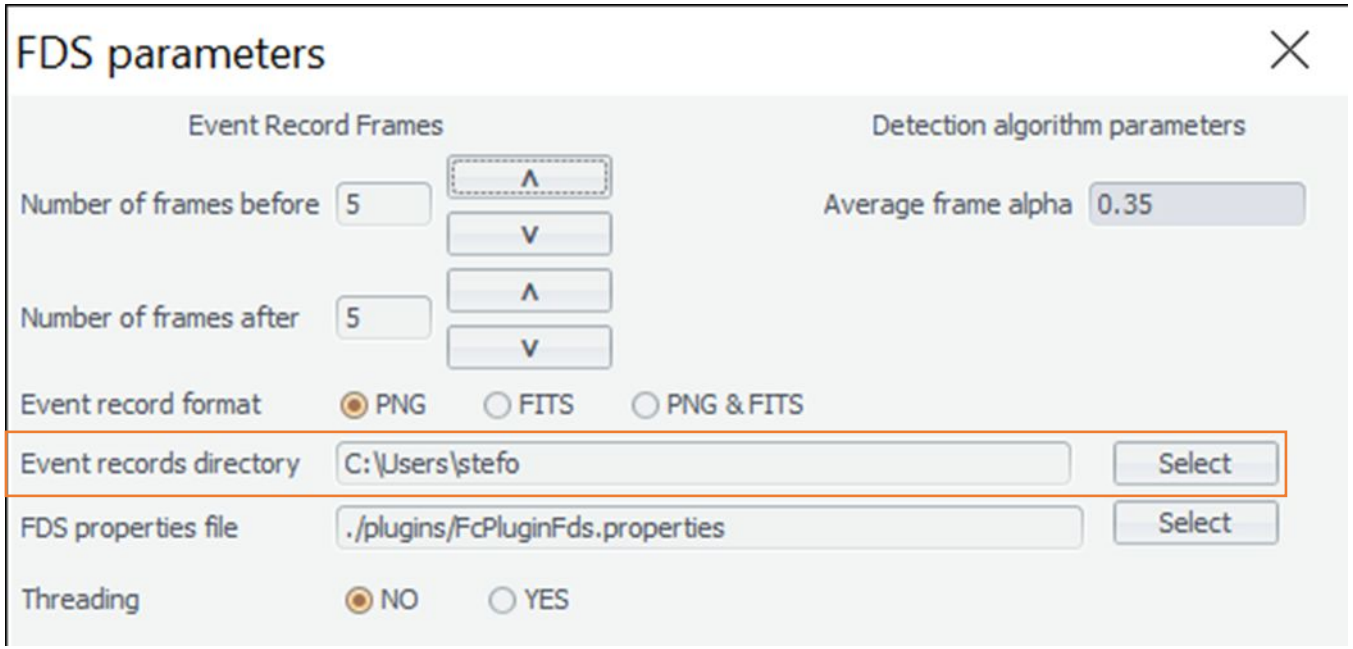
……

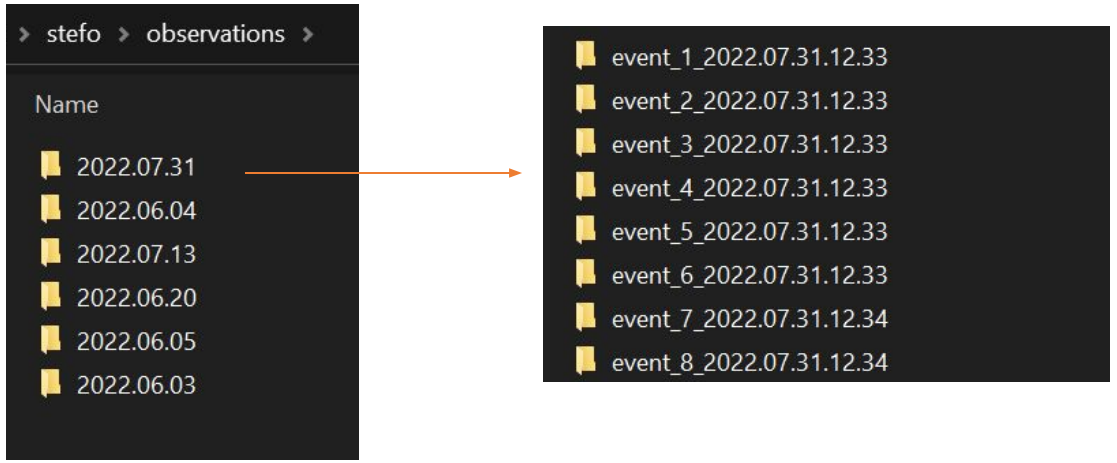
N-th average



Location of output files

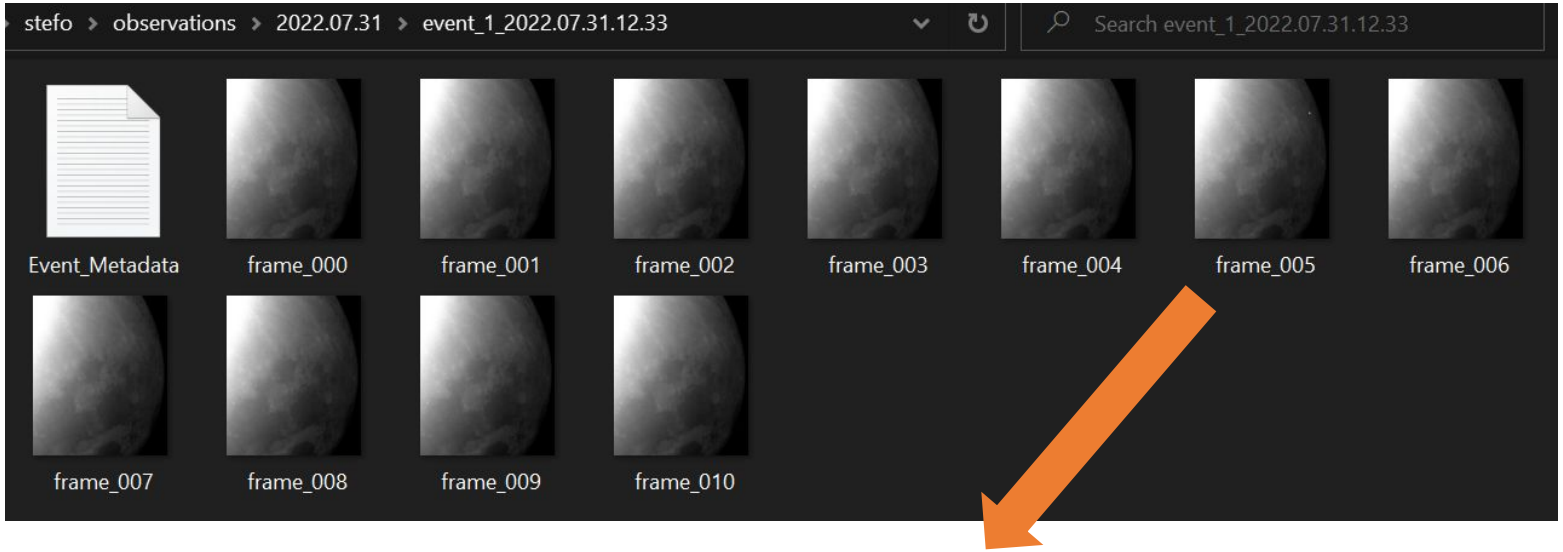
- After your first detection you will see a new folder in the location **C:\Users\stefo**
- The new folder is named “**observations**”
- There sub-directories of the day will be created
- In the directory of the day, you will find enumerated all the detected events

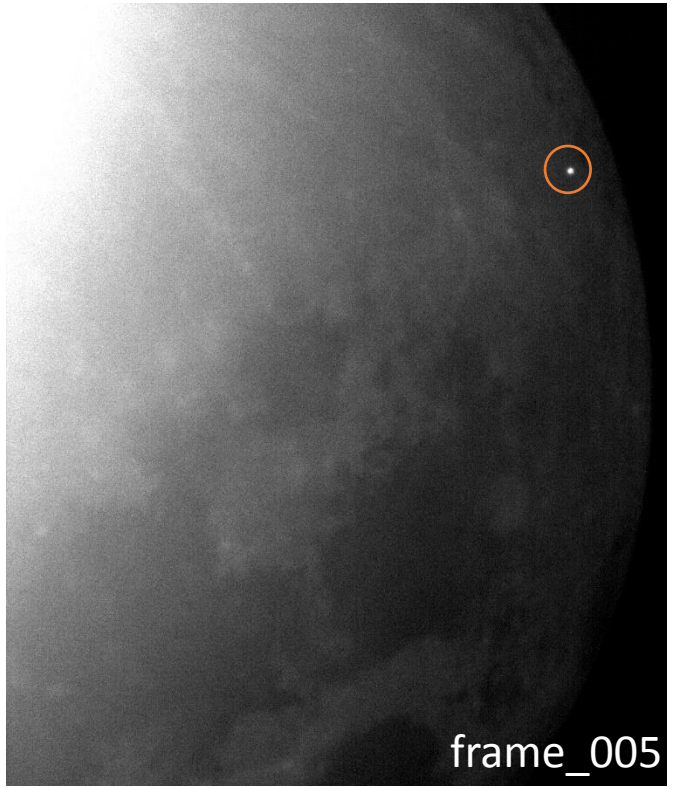




Output Files

- Metadata
- Sequence of frames:
  - 5 (configurable parameter) before the event
  - The frames of the event
  - 5 (configurable parameter) after the event





Metadata

- In the dummy mode, metadata are dummy too
  - Timestamp is dummy
  - FPS is dummy
- Include:
  - Timestamp
  - Number of pixels
  - Location (of pixels in the frame)
  - Camera Information
  - Capturing Information
  - FPS

Event_Metadata - Notepad

File Edit Format View Help

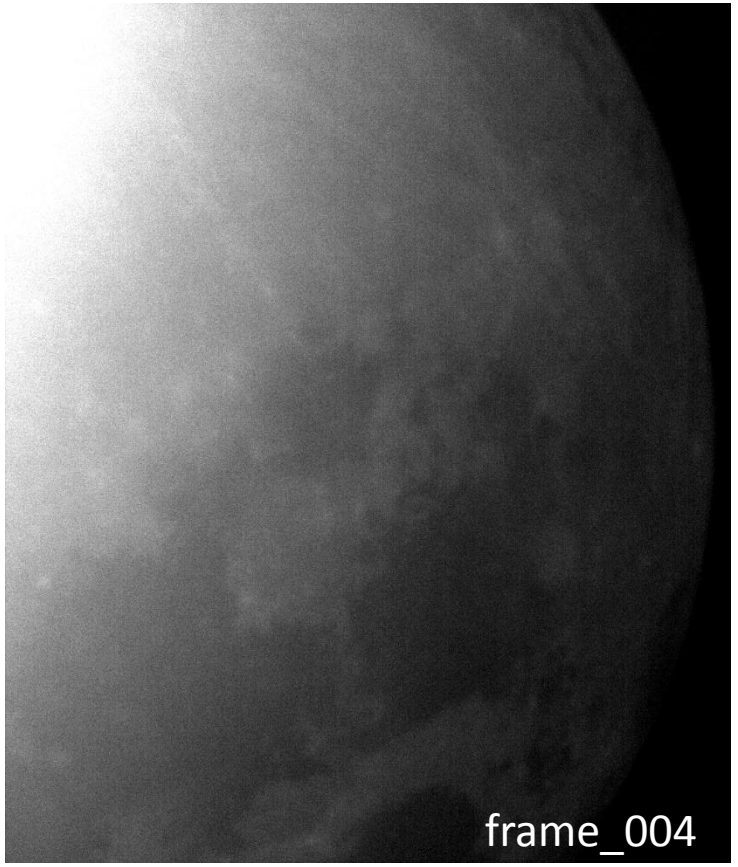
```
Event Info:

The event occurred at: 2022-08-09 08:25:26.636.
The recording consists of 12 frames.
The event can be found at the 6th frame (filename: frame_005).
The number of pixels of the event is: 8.
The coordinates of the brightest pixel of the frame are:
x coordinate:161, y coordinate:336.
The threshold that was set from the user for capturing is: 99.
The average FPS of all the recorded frames is: 6.

Camera Info:

Camera Name: DummyCam.
Pixel Size: 05.60(um).
Sensor Temperature in Celsius: 20.10.
Max Image Size: java.awt.Rectangle[x=0,y=0,width=1080,height=1280].
Region of Interest Offset: java.awt.Point[x=0,y=0].
Is 16 bit: false.
Is bin2: false.
Is colour: true.
Is threading enabled: false.

Time Information:

The timestamp of each frame is (UTC):
Frame 0: 2022-08-09 08:25:25.846.
Frame 1: 2022-08-09 08:25:25.998.
Frame 2: 2022-08-09 08:25:26.151.
Frame 3: 2022-08-09 08:25:26.304.
Frame 4: 2022-08-09 08:25:26.467.
Frame 5: 2022-08-09 08:25:26.636.
Frame 6: 2022-08-09 08:25:26.785.
Frame 7: 2022-08-09 08:25:27.100.
Frame 8: 2022-08-09 08:25:27.241.
Frame 9: 2022-08-09 08:25:27.379.
Frame 10: 2022-08-09 08:25:27.516.
Frame 11: 2022-08-09 08:25:27.662.
The duration of the event in frames is: 2.

-----------------------------------------------
The coordinates of all the pixels that triggered capturing are:
x coordinate:161, y coordinate:336.
```

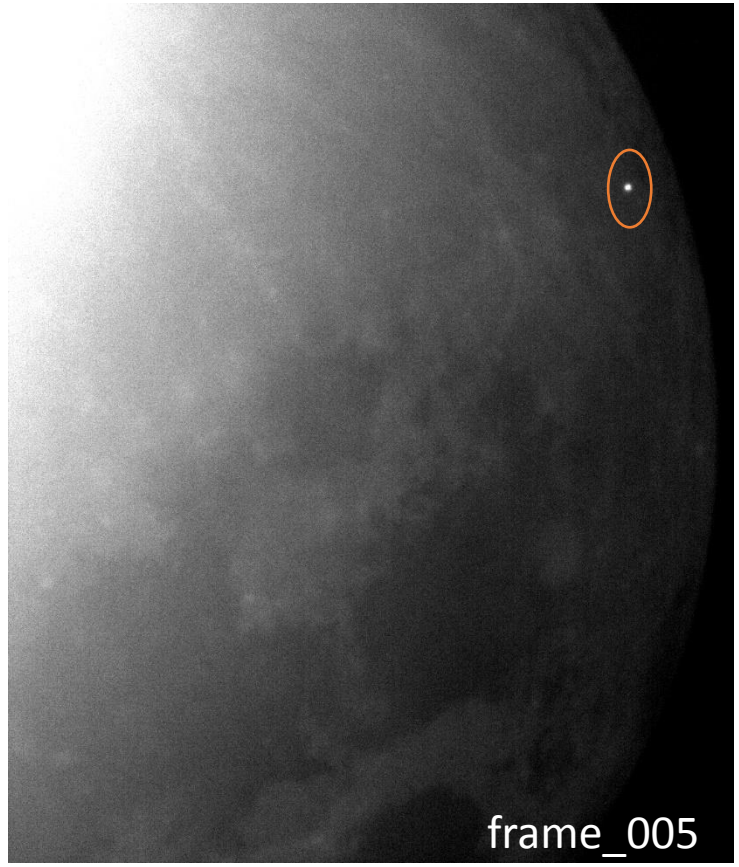
Now we are ready to capture our first Lunar Impact Flash (provided by NELIOTA)

- First easy example

First Video

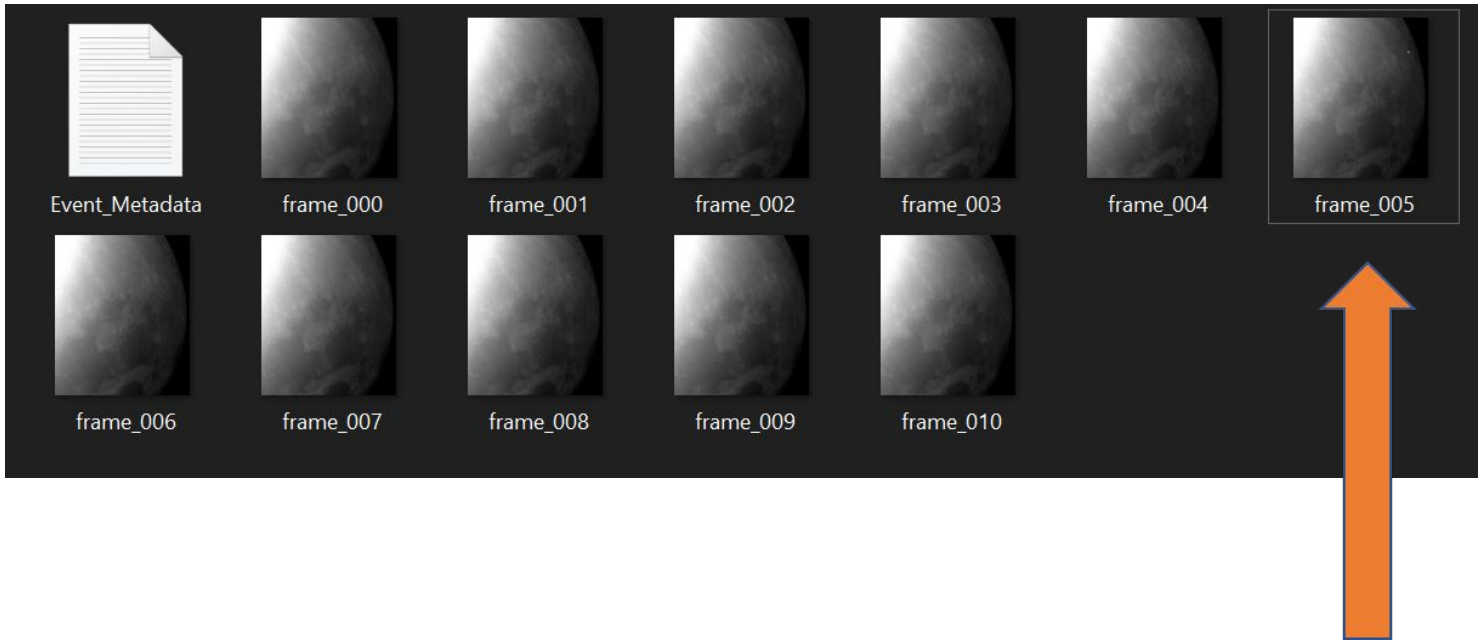
- Small duration video
- The video will play on repeat, so you will see again and again the same impact flash
- One frame impact flash (artificially set to be one frame)
- Set the proper threshold
  - Around 100





Results

- You will be notified by the logger that you have captured something
- Go to the “writing path” and check what is written
- Don’t let it run for much time, the video is small and will play on repeat thus you will capture many events



Discussion

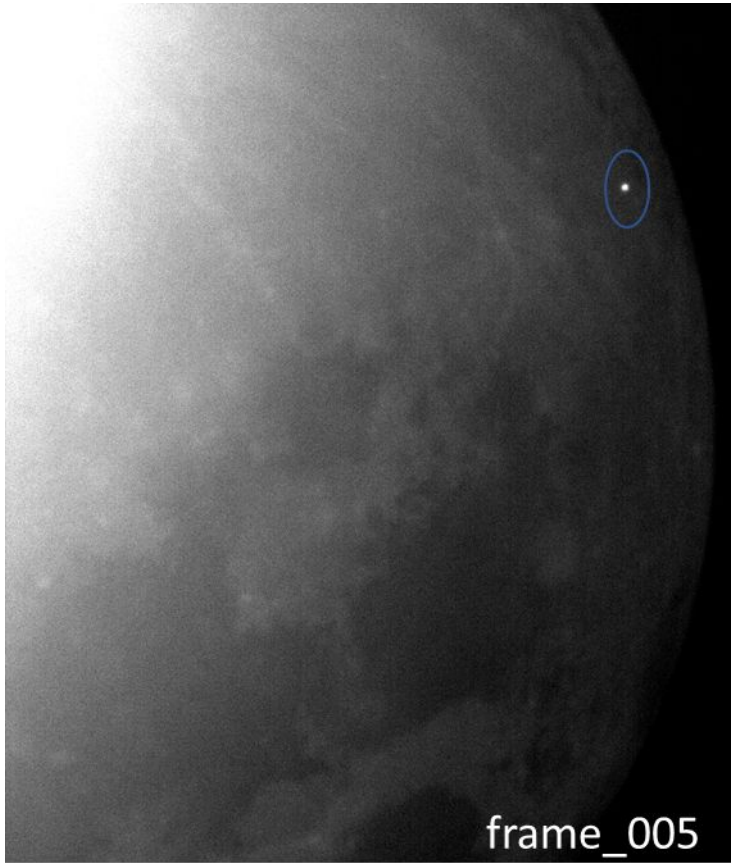
- Event Info
- Camera Info
- Time Info

- How many events did you captured?
- Was this flash multi-frame?

Event_Metadata - Notepad

File Edit Format View Help

```
Event Info:

The event occurred at: 2022-08-09 07:34:07.306.
The recording consists of 11 frames.
The event can be found at the 6th frame (filename: frame_005).
The number of pixels of the event is: 43.
The coordinates of the brightest pixel of the frame are:
x coordinate:919, y coordinate:1005.
The threshold that was set from the user for capturing is: 109.
The average FPS of all the recorded frames is: 8.

Camera Info:

Camera Name: DummyCam.
Pixel Size: 05.60(um).
Sensor Temperature in Celsius: 20.07.
Max Image Size: java.awt.Rectangle[x=0,y=0,width=1080,height=1280].
Region of Interest Offset: java.awt.Point[x=0,y=0].
Is 16 bit: false.
Is bin2: false.
Is colour: true.
Is threading enabled: false.

Time Information:

The timestamp of each frame is (UTC):
Frame 0: 2022-08-09 07:34:06.679.
Frame 1: 2022-08-09 07:34:06.806.
Frame 2: 2022-08-09 07:34:06.933.
Frame 3: 2022-08-09 07:34:07.064.
Frame 4: 2022-08-09 07:34:07.185.
Frame 5: 2022-08-09 07:34:07.306.
Frame 6: 2022-08-09 07:34:07.541.
Frame 7: 2022-08-09 07:34:07.643.
Frame 8: 2022-08-09 07:34:07.744.
Frame 9: 2022-08-09 07:34:07.863.
Frame 10: 2022-08-09 07:34:07.963.
The duration of the event in frames is: 1.

-------------------------------------------
The coordinates of all the pixels that triggered capturing are:
x coordinate:921, y coordinate:1009.
x coordinate:922, y coordinate:1009.
x coordinate:923, y coordinate:1009.
x coordinate:924, y coordinate:1009.
x coordinate:919, y coordinate:1008.
x coordinate:920, y coordinate:1008.
x coordinate:921, y coordinate:1008.
x coordinate:922, y coordinate:1008.
x coordinate:923, y coordinate:1008.
x coordinate:924, y coordinate:1008.
x coordinate:925, y coordinate:1008.
x coordinate:919, y coordinate:1007.
```



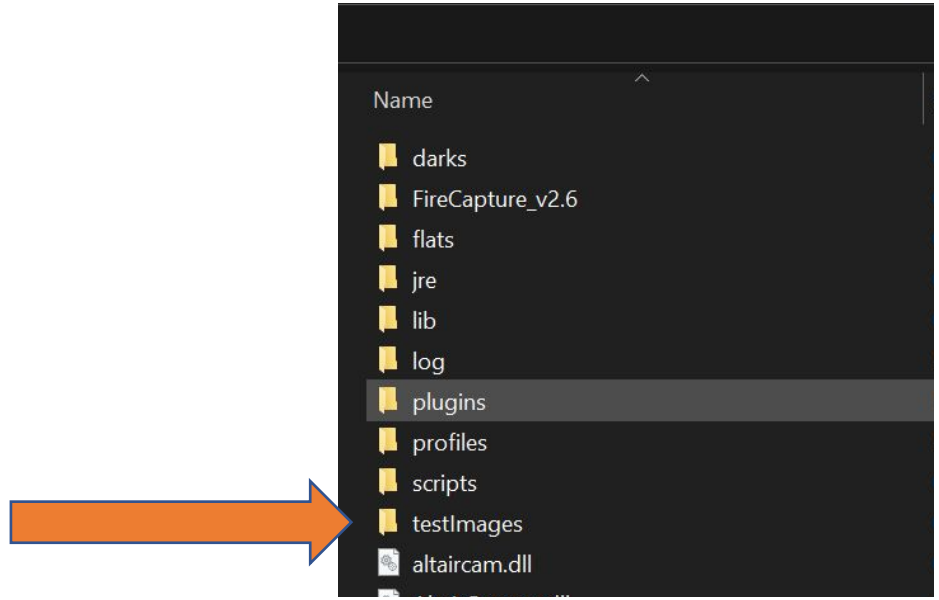
Second Event (provided by NELIOTA)

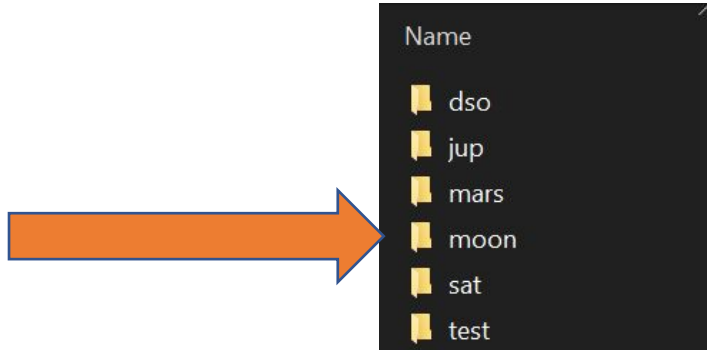
- Multi-frame video

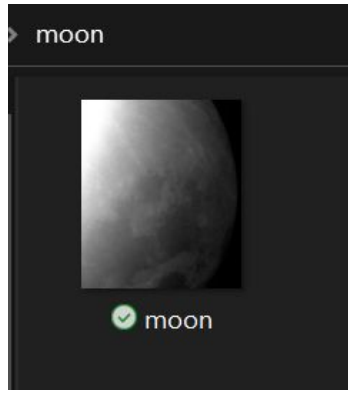
Set-up Second Simulation

Now we will place the second event in FireCapture

- Go to the FireCapture folder
- Go to the “testImages” folder (Fig. 1)
- Open the “moon” folder (Fig. 2)
- Hide the existed “moon.avi” video
- Take the second video
  - FDS_moon_2.avi
- Place it in this folder
- Rename the video (Fig. 3) :
  - Name: moon.avi

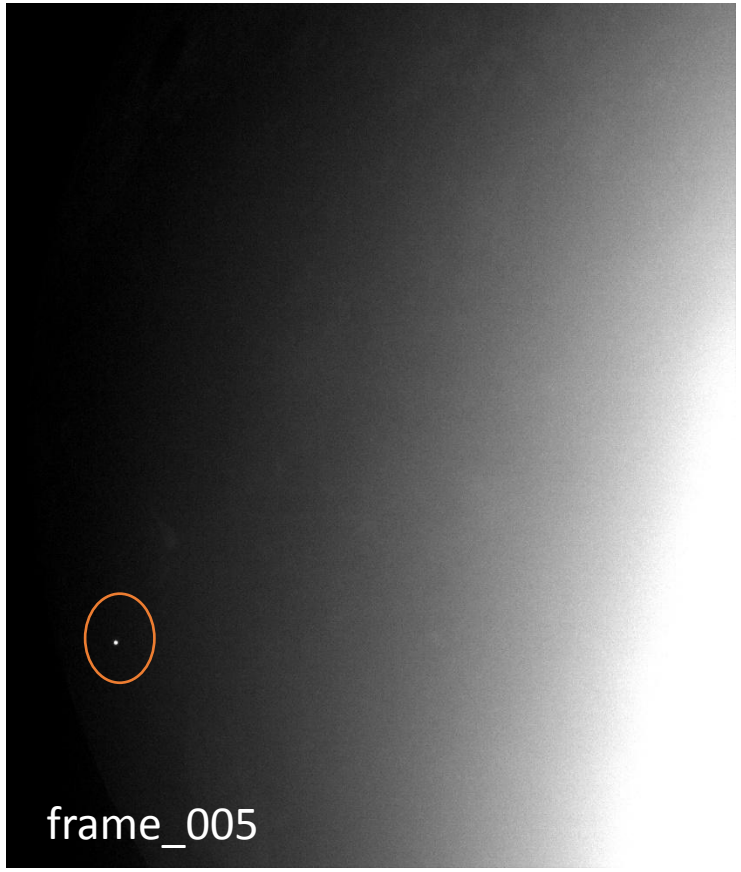


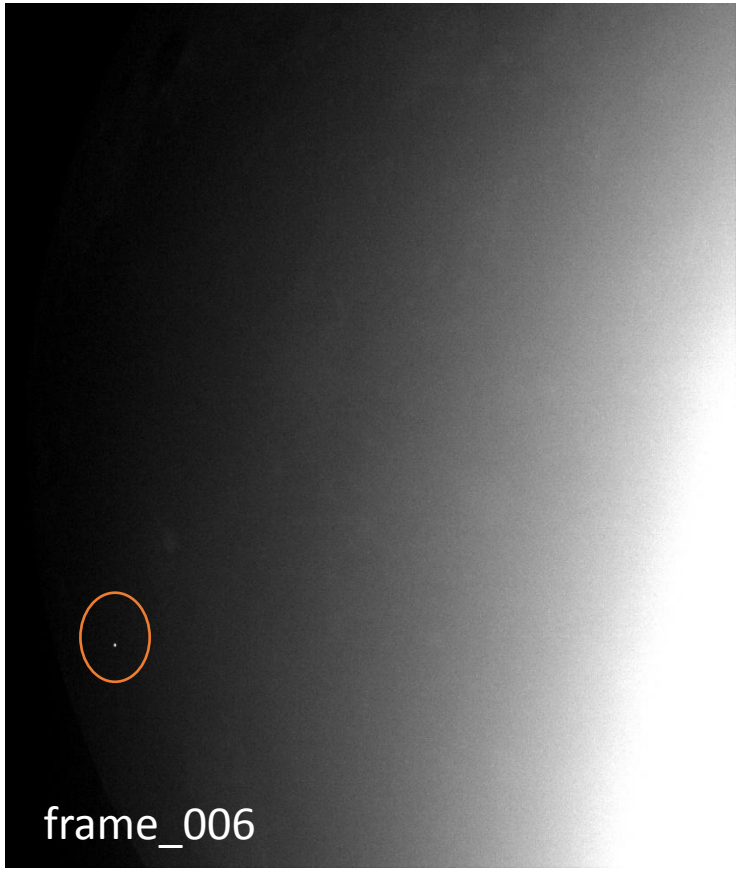




Second Video

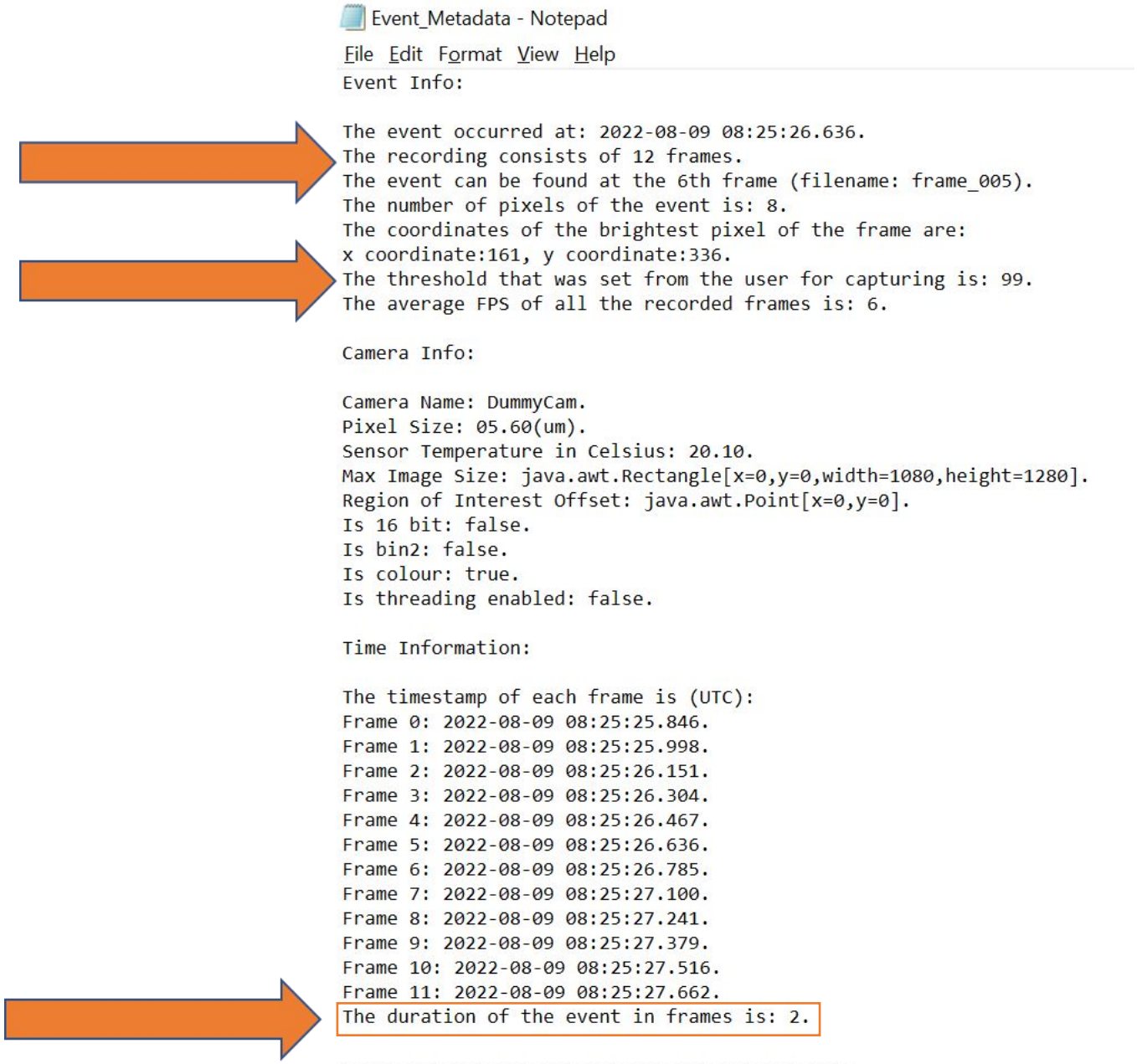
- Multi-Frame Video
- Now, experiment with different thresholds
- How the threshold interact with multi-frame events?





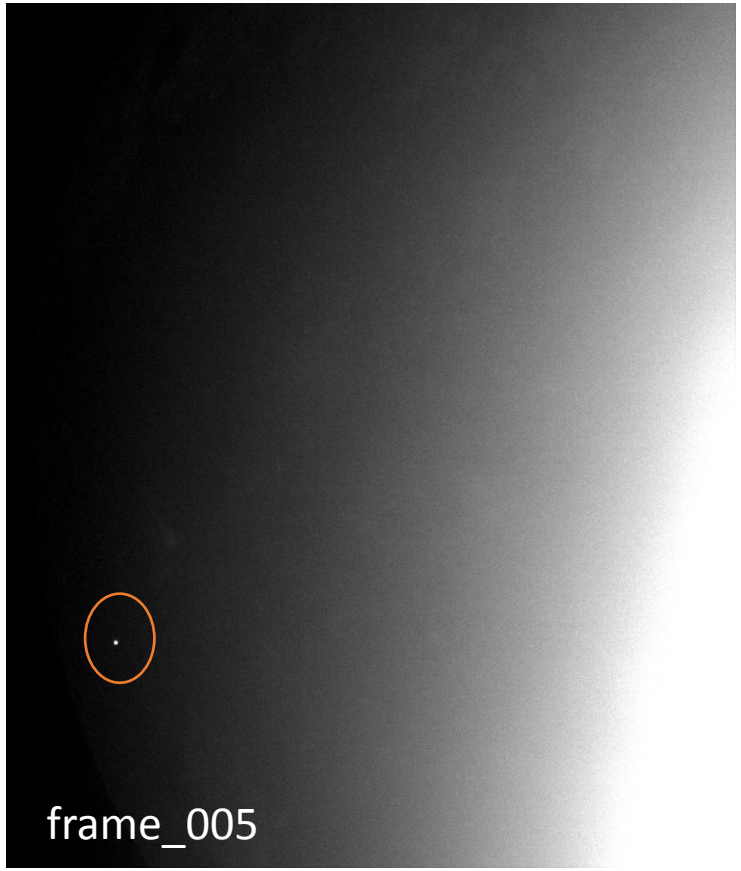
Discussion

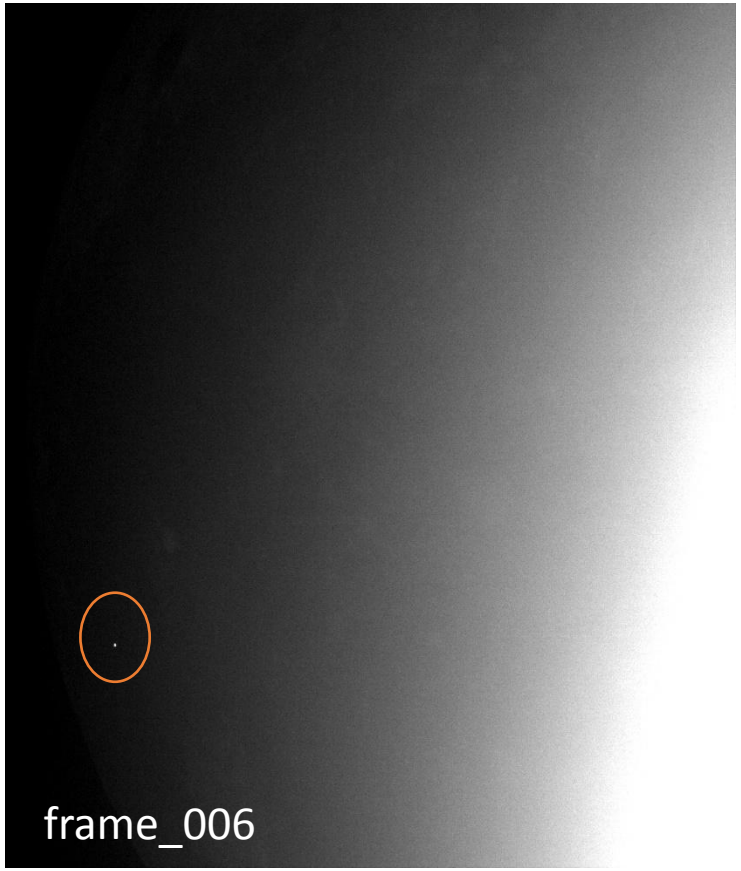
- The duration of the event was N?
- What threshold did you used?
- Note that you capture: 5+N+5 frames



Experiment:

- Now set even smaller threshold.
- What do we see?





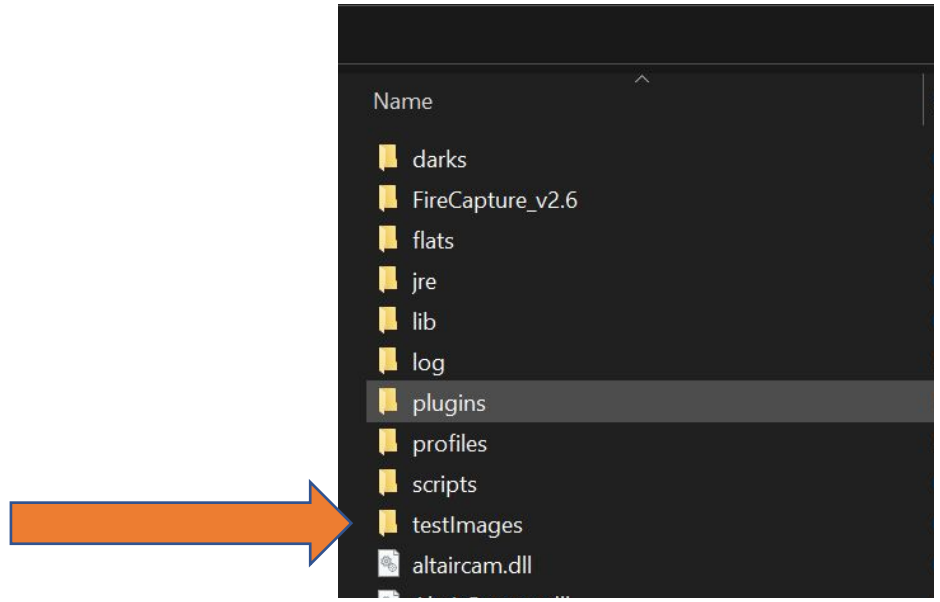
Third Event (provided by NELIOTA)

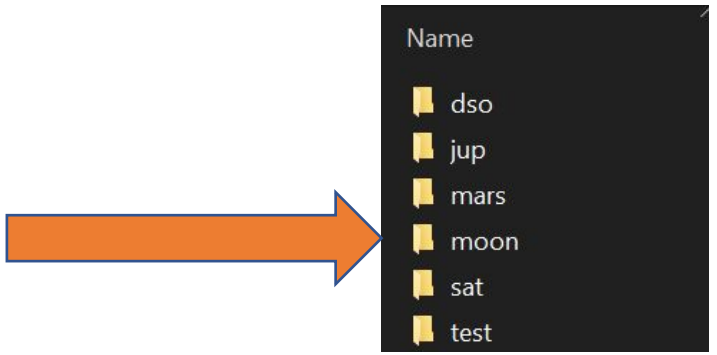
- Threading

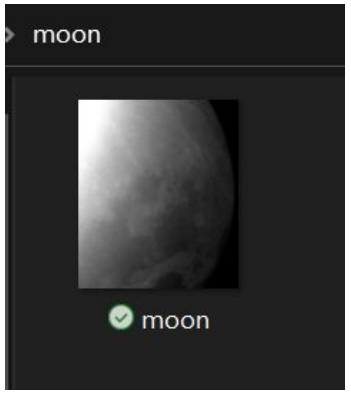
Set-up Third Simulation

Now we will place the third event in FireCapture

- Go to the FireCapture folder
- Go to the “testImages” folder (Fig. 1)
- Open the “moon” folder (Fig. 2)
- Hide the existed “moon.avi” video
- Take the third video
  - FDS_moon_3.avi
- Place it in this folder
- Rename the video (Fig. 3) :
  - Name: moon.avi

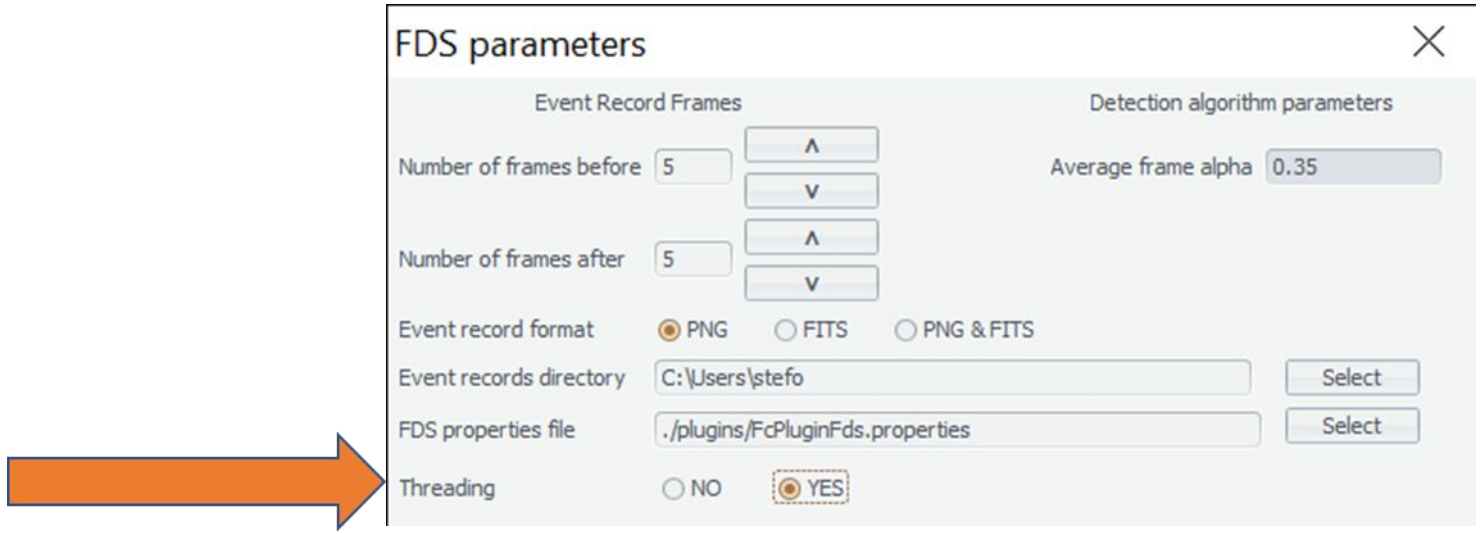


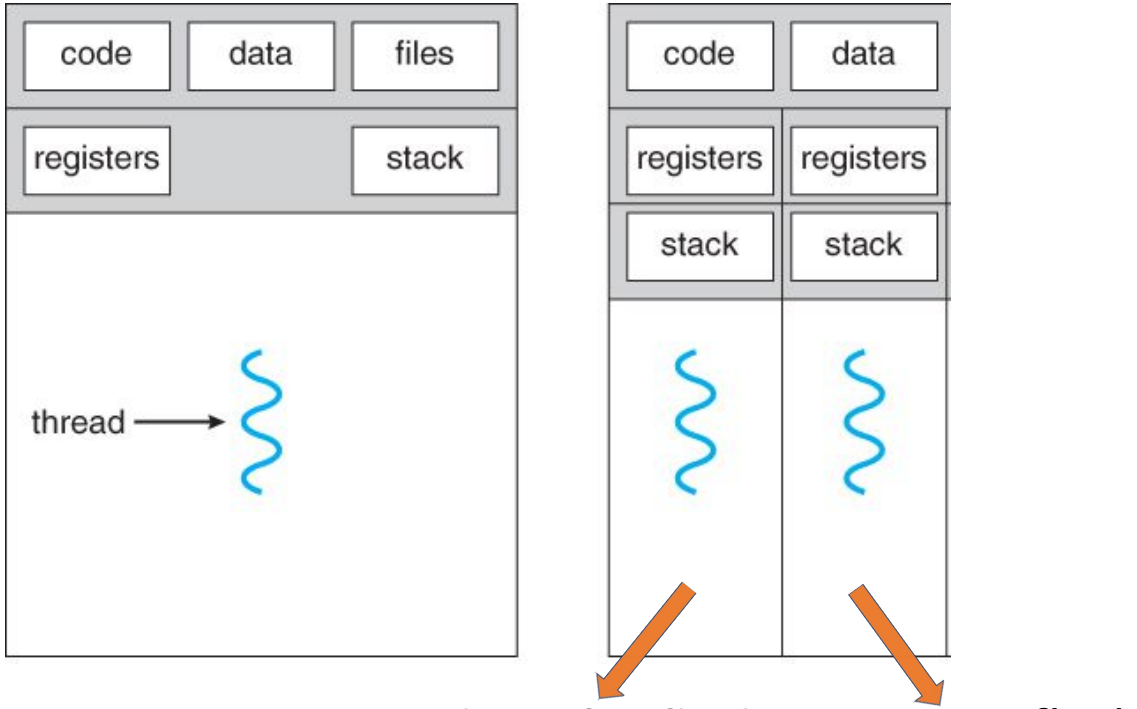




Third Video

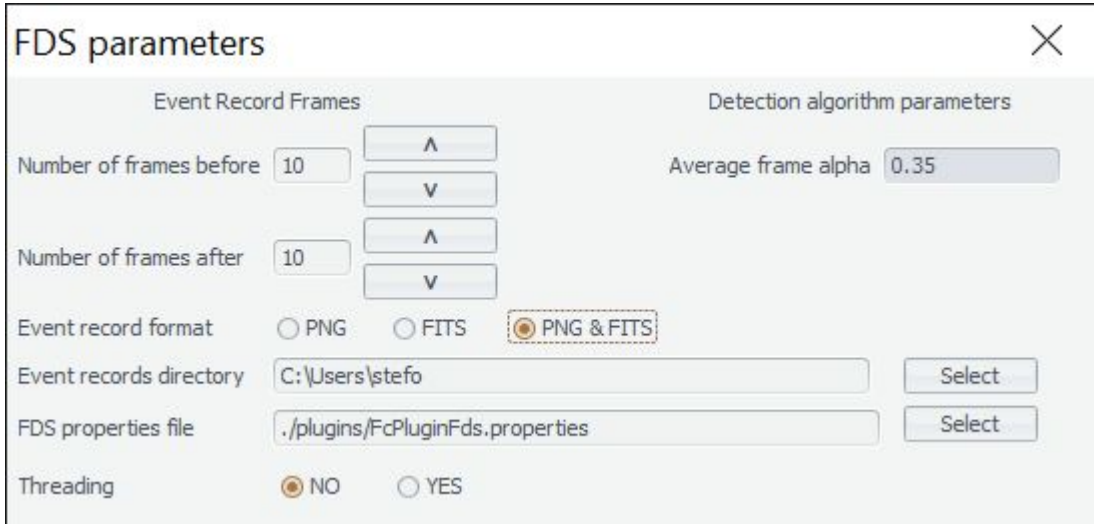
- This is a bigger video
- We will use “threading”
- Threading is enabled when a detection is occurred

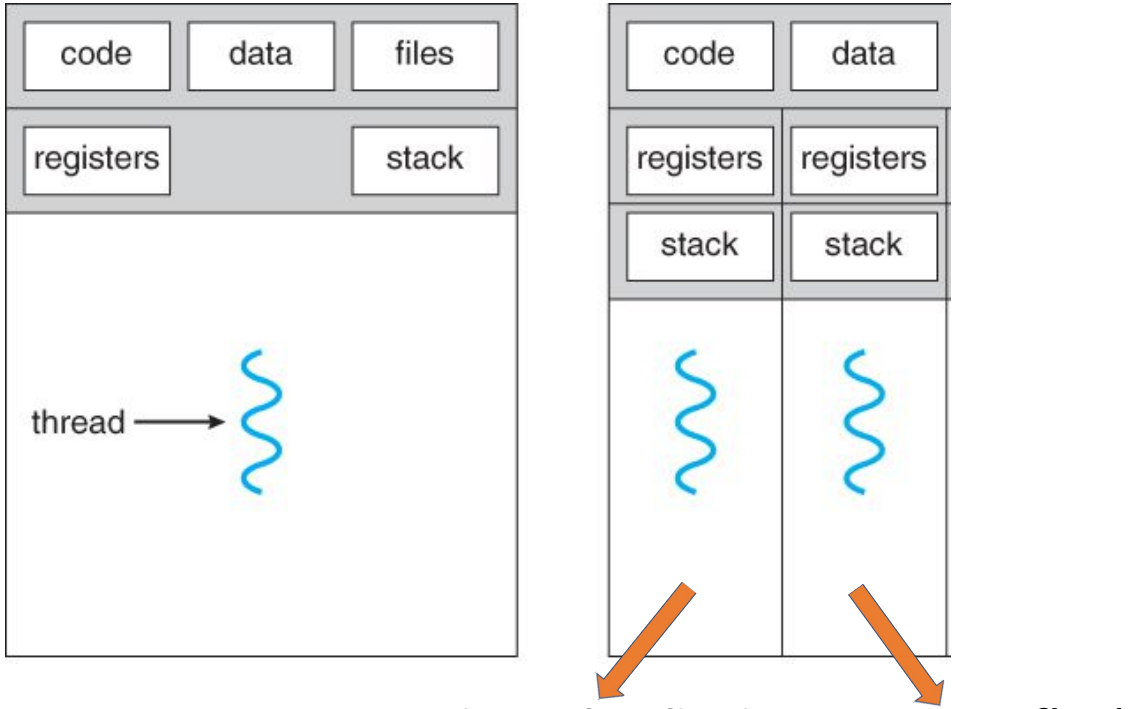




Experiment

- In order to see the effect of threading set the parameters as shown in the figure
- In this way we will make the writing process slightly slower, and you will see that the FireCapture will “lag” with the impact flash frame
- Why?



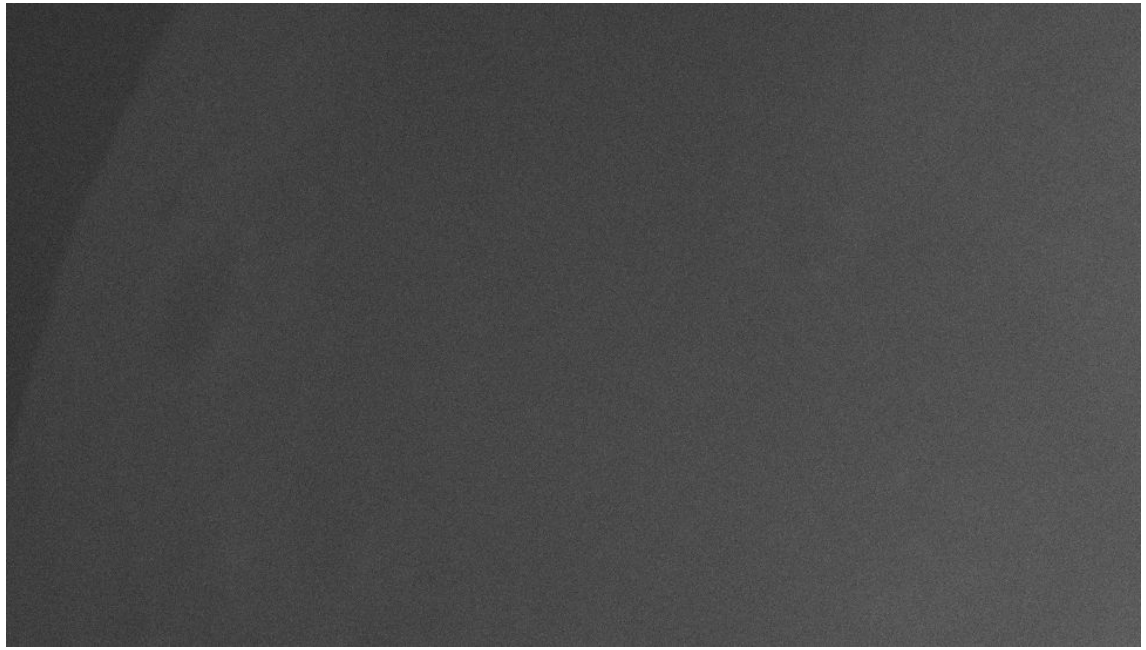


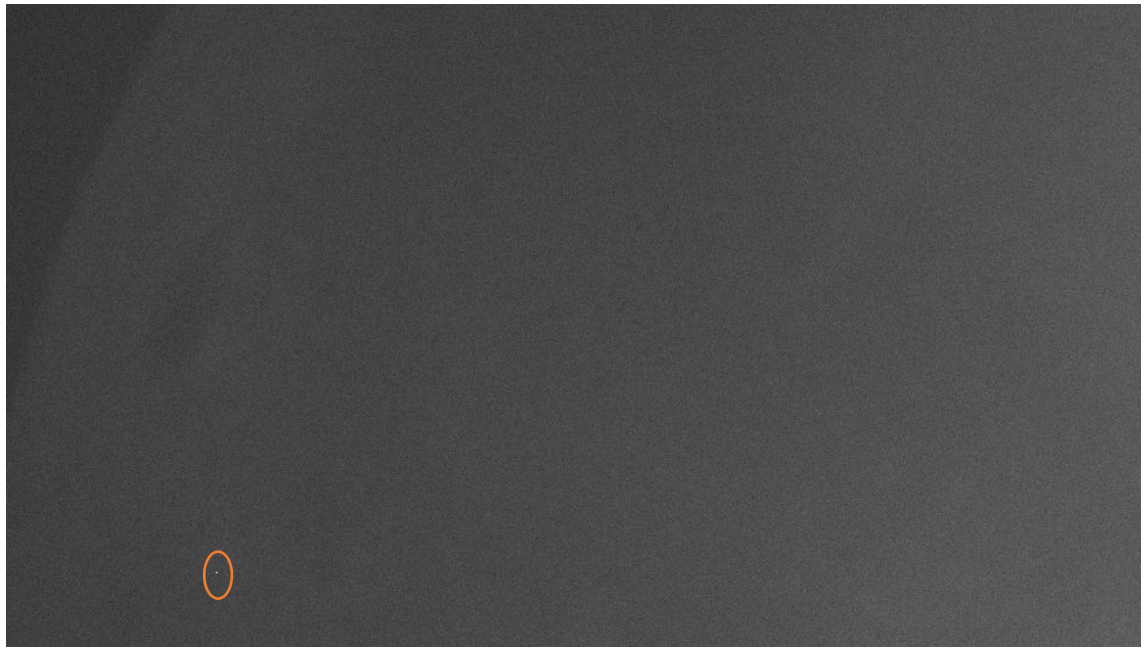
In which cases “threading” could be a problem?

Discussion

Discussion:

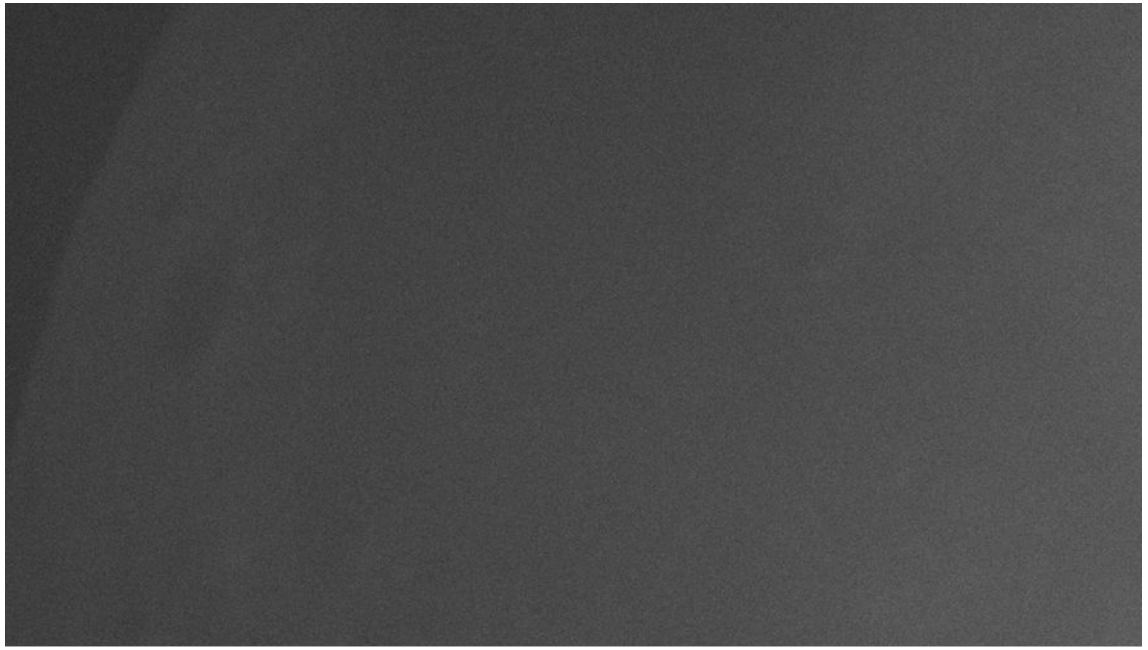
- Threading could be a problem in the following cases:
- When the moon is “shaking” due to bad weather or telescope movement if sunlit parts are included. This will lead to many fake detections.
- What about satellites?

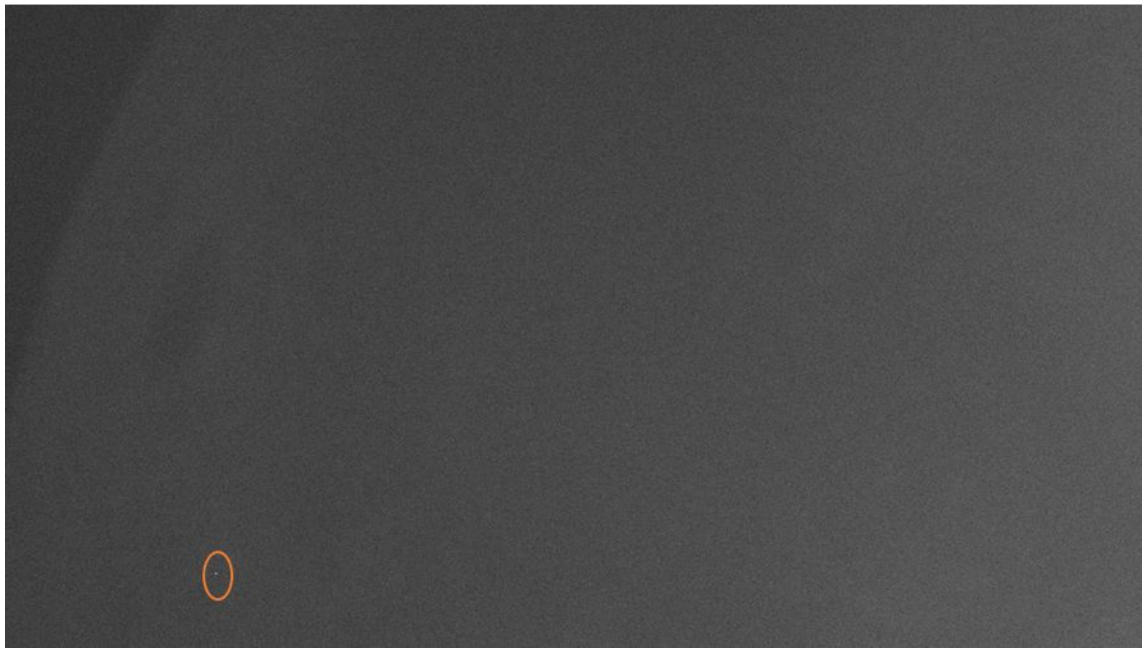




Question

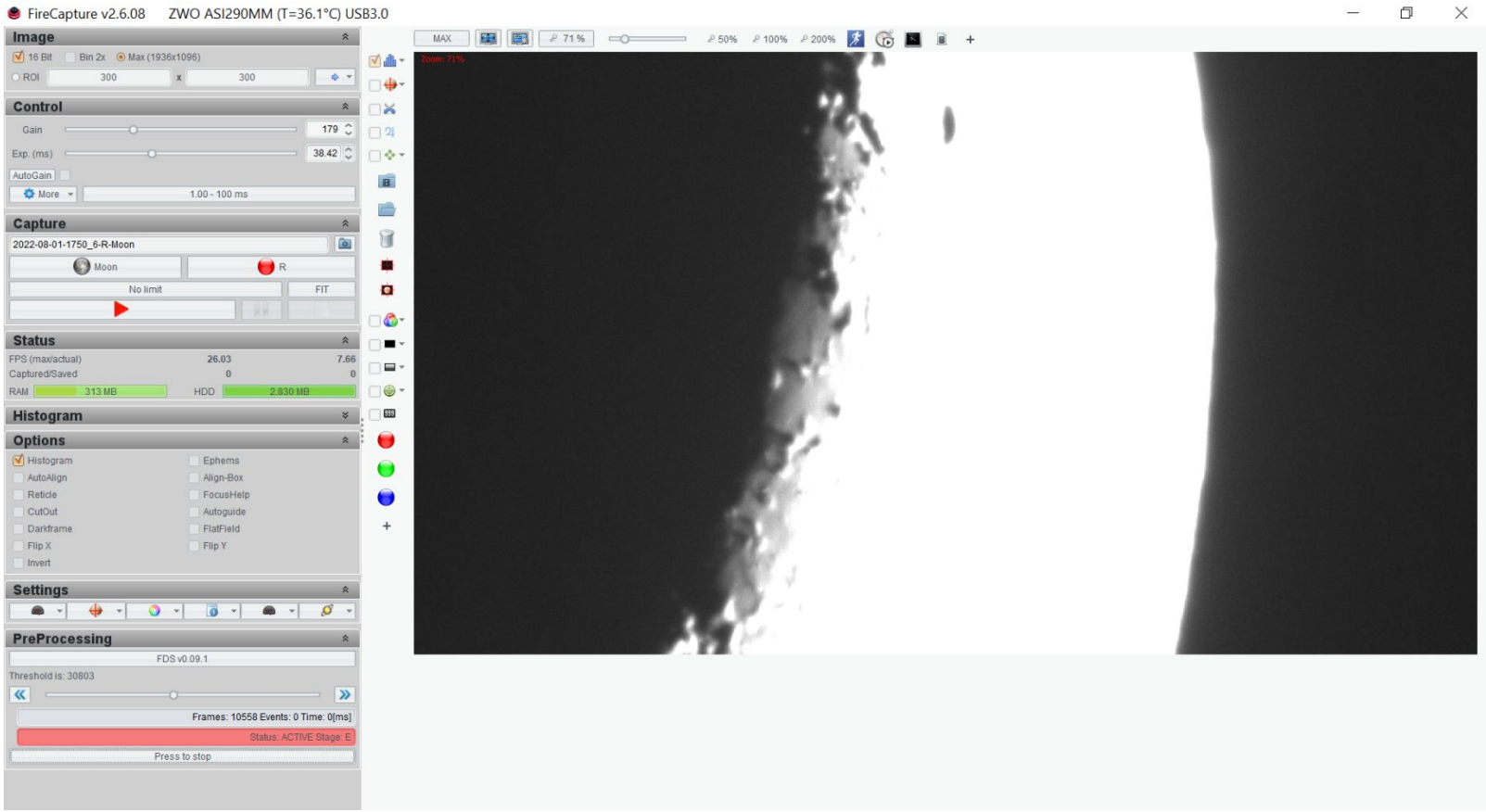
- If threading was enabled, will the movement of the lunar limb cause fake detection?





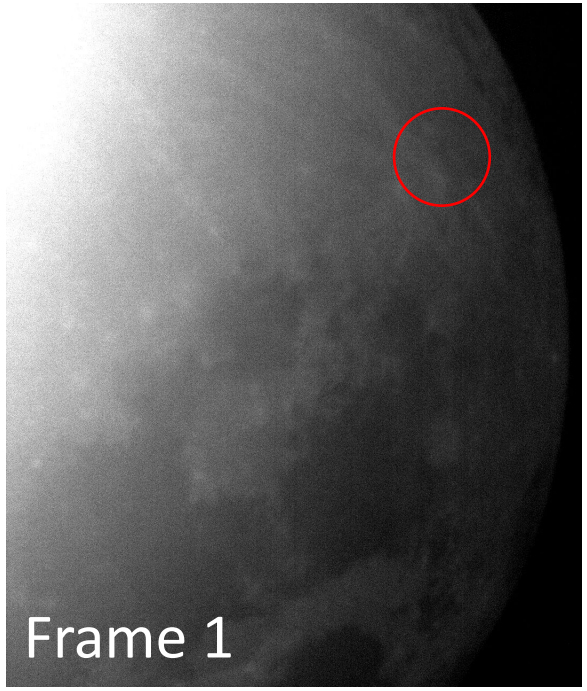
Question

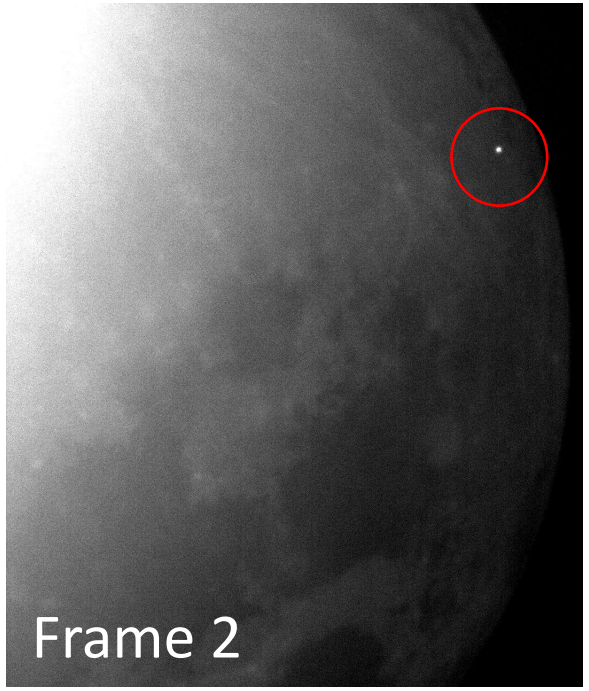
- If threading was enabled, will a fast movement of the telescope cause a fake detection? Why?
- If the threading was disabled, and no fast movement happened. Will we have a fake detection? Why?



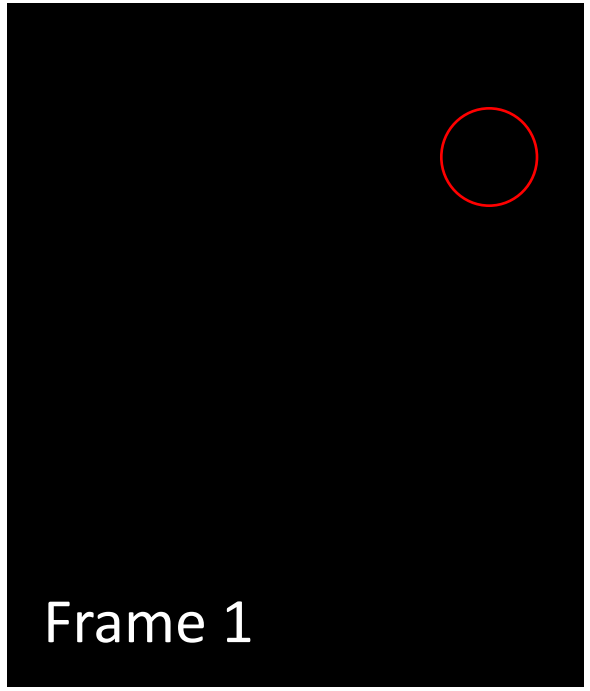
Why?

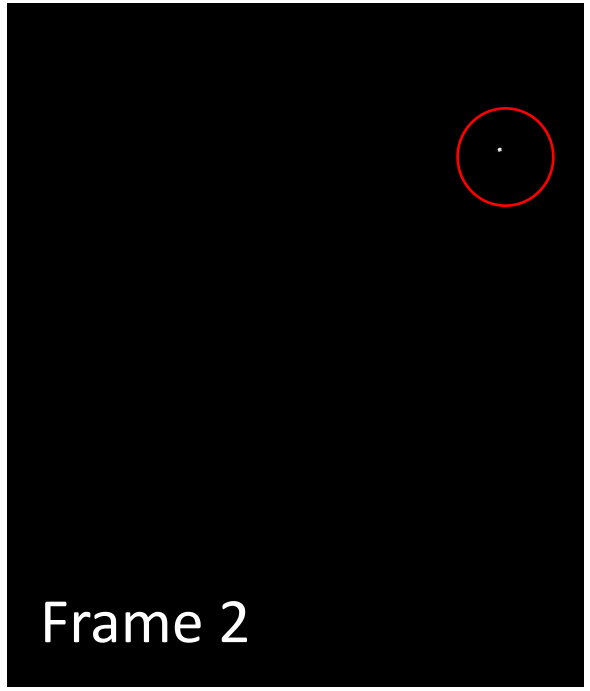
Before Processing



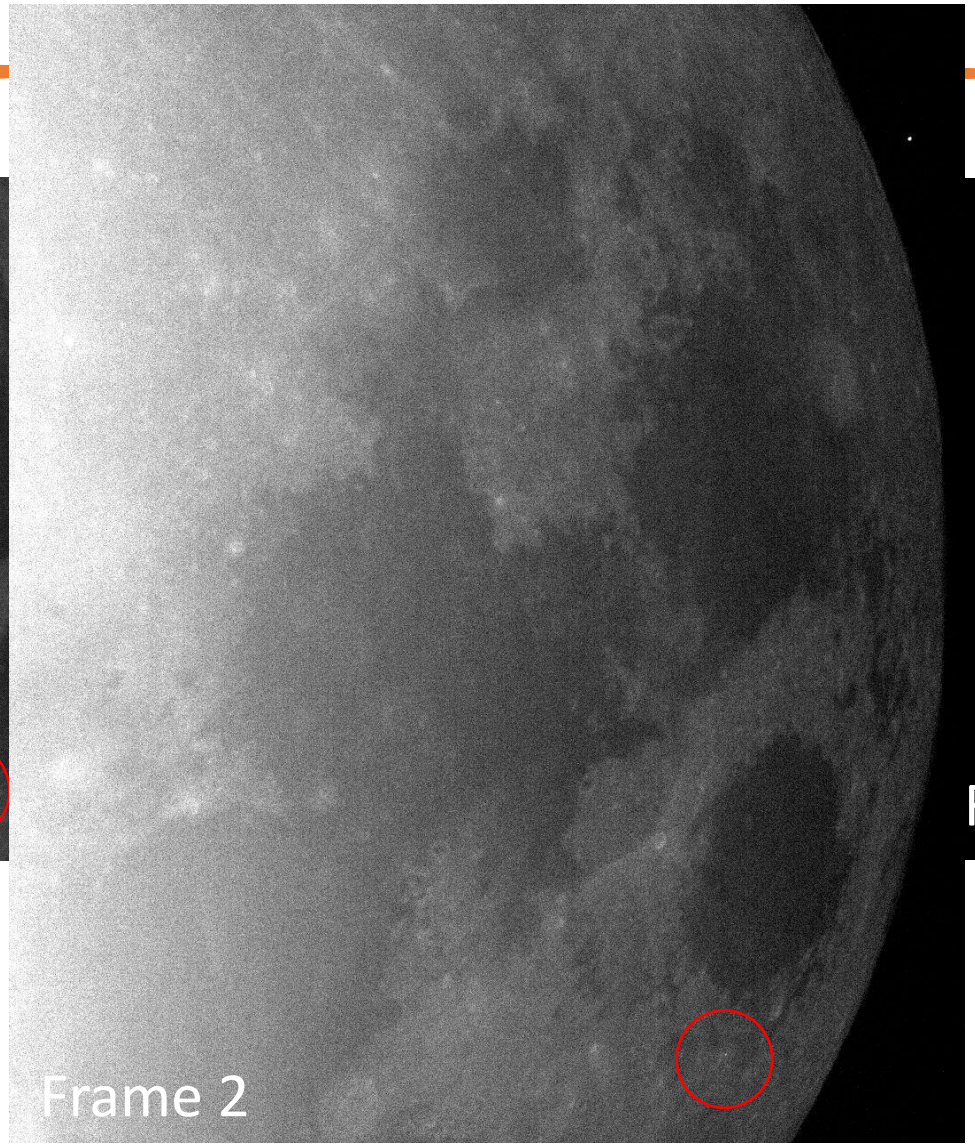


After Processing



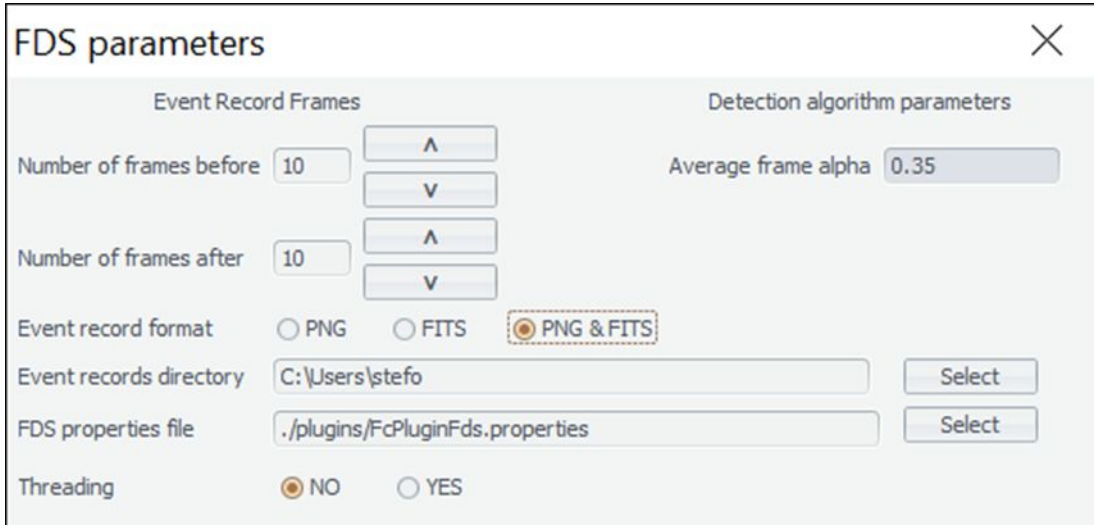


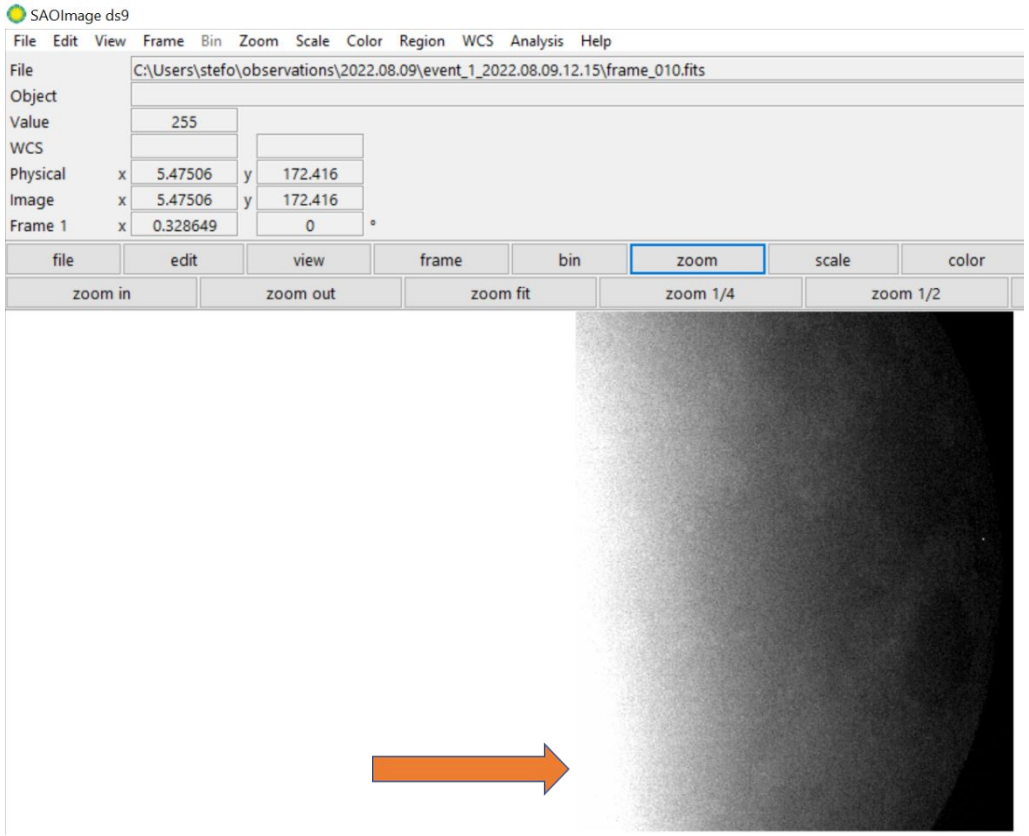
Why?



Discussion

- Let's see the results of the **experiment**. Open the frame_010.fits with a FITS viewer.
- Point at the bright side, see that the value of the pixels in this region is 255.





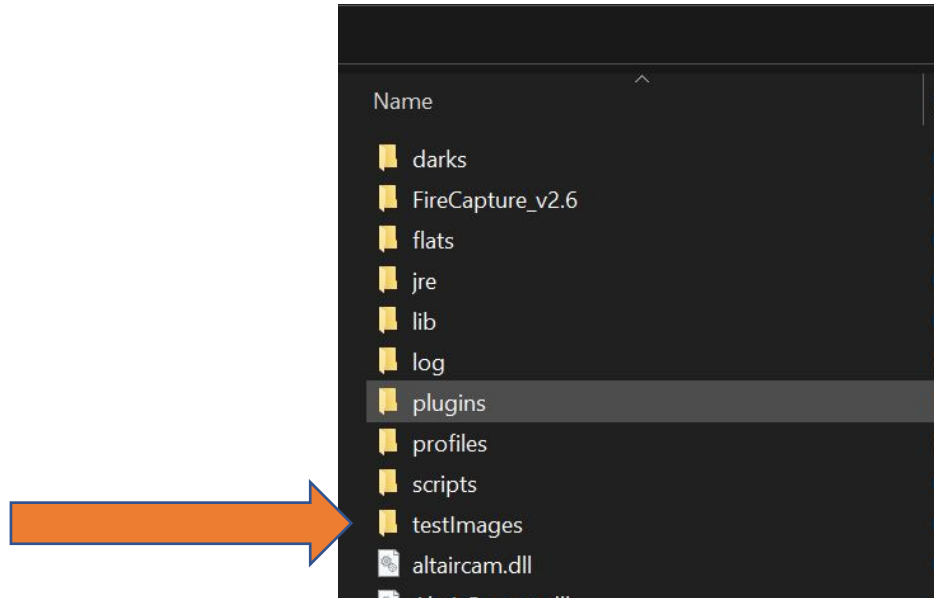
Fourth Event (provided by NELIOTA)

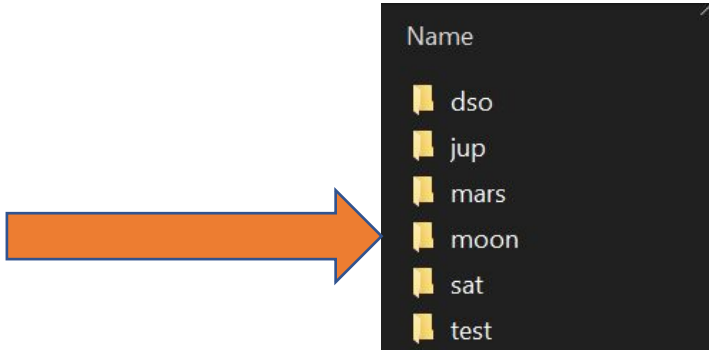
- Impact Flash

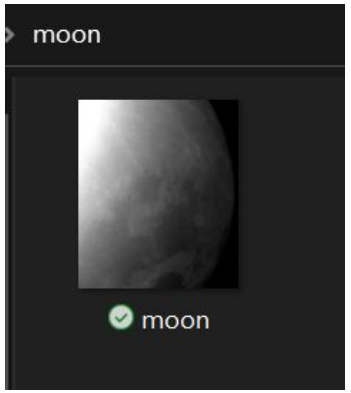
Set-up Fourth Simulation

Now we will place the fourth event in FireCapture

- Go to the FireCapture folder
- Go to the “testImages” folder (Fig. 1)
- Open the “moon” folder (Fig. 2)
- Hide the existed “moon.avi” video
- Take the fourth video
  - FDS_moon_4.avi
- Place it in this folder
- Rename the video (Fig. 3) :
  - Name: moon.avi

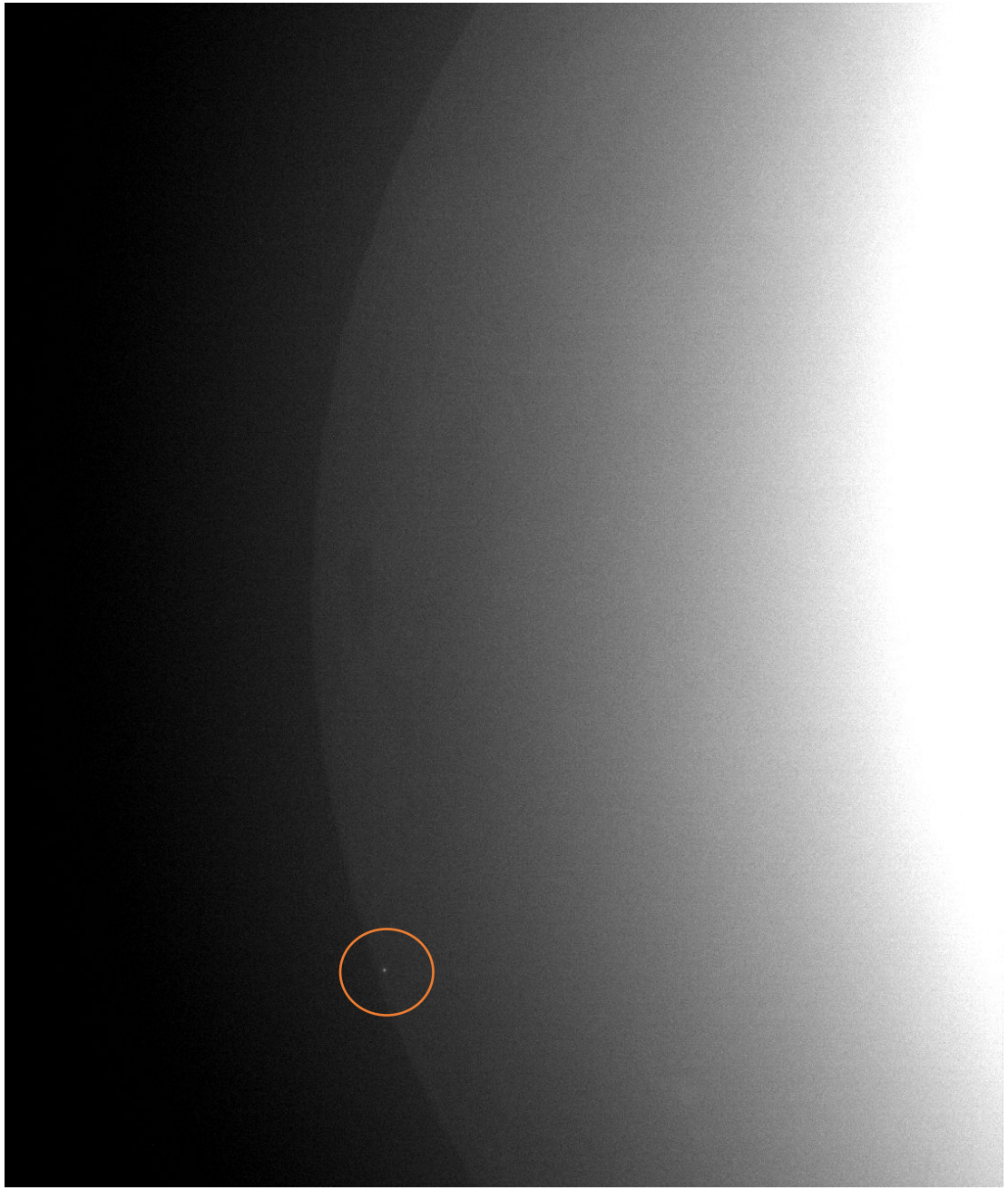






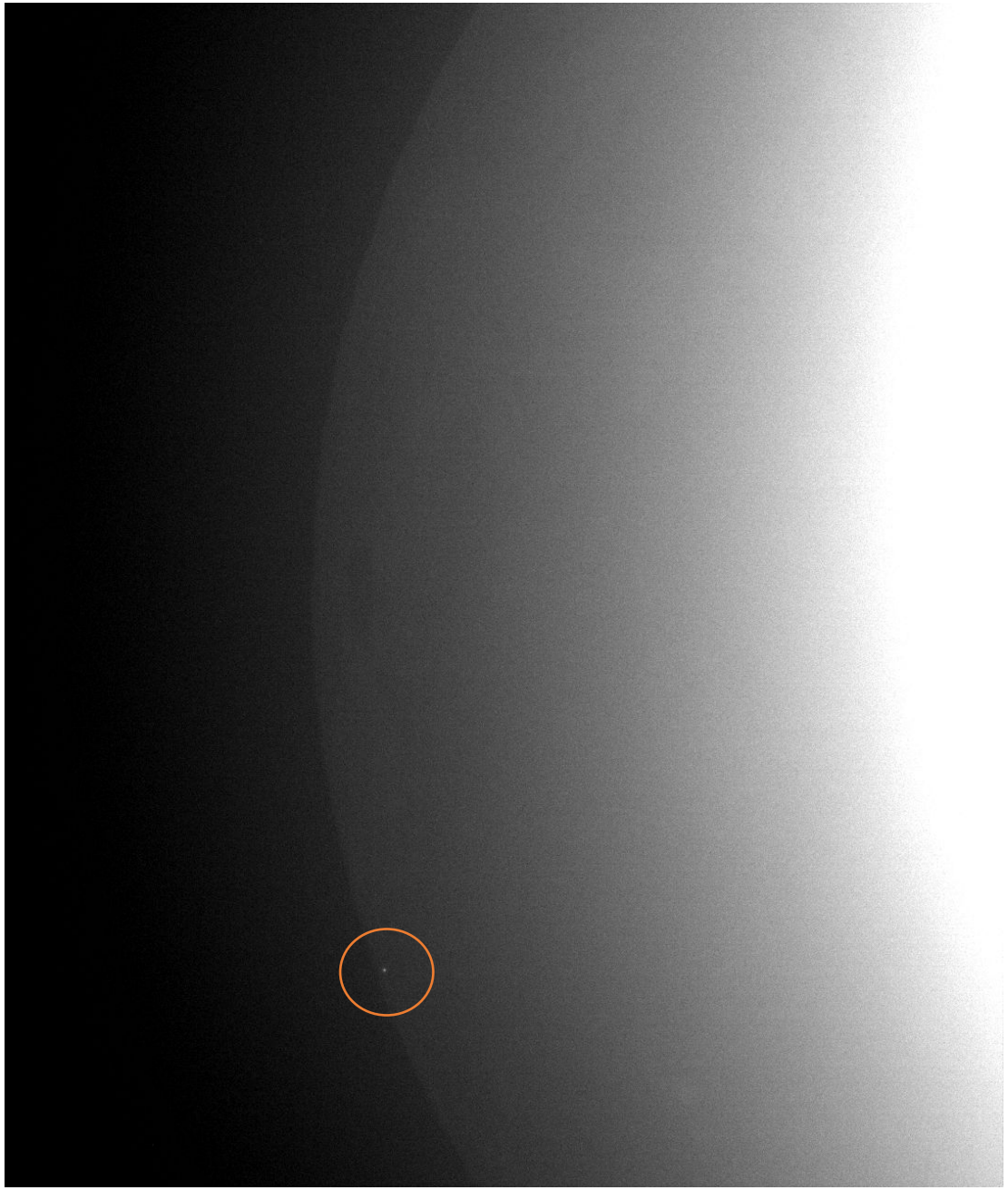
Fourth Video

- This is a video with an impact flash with small duration
- Set the proper threading and parameters



Discussion

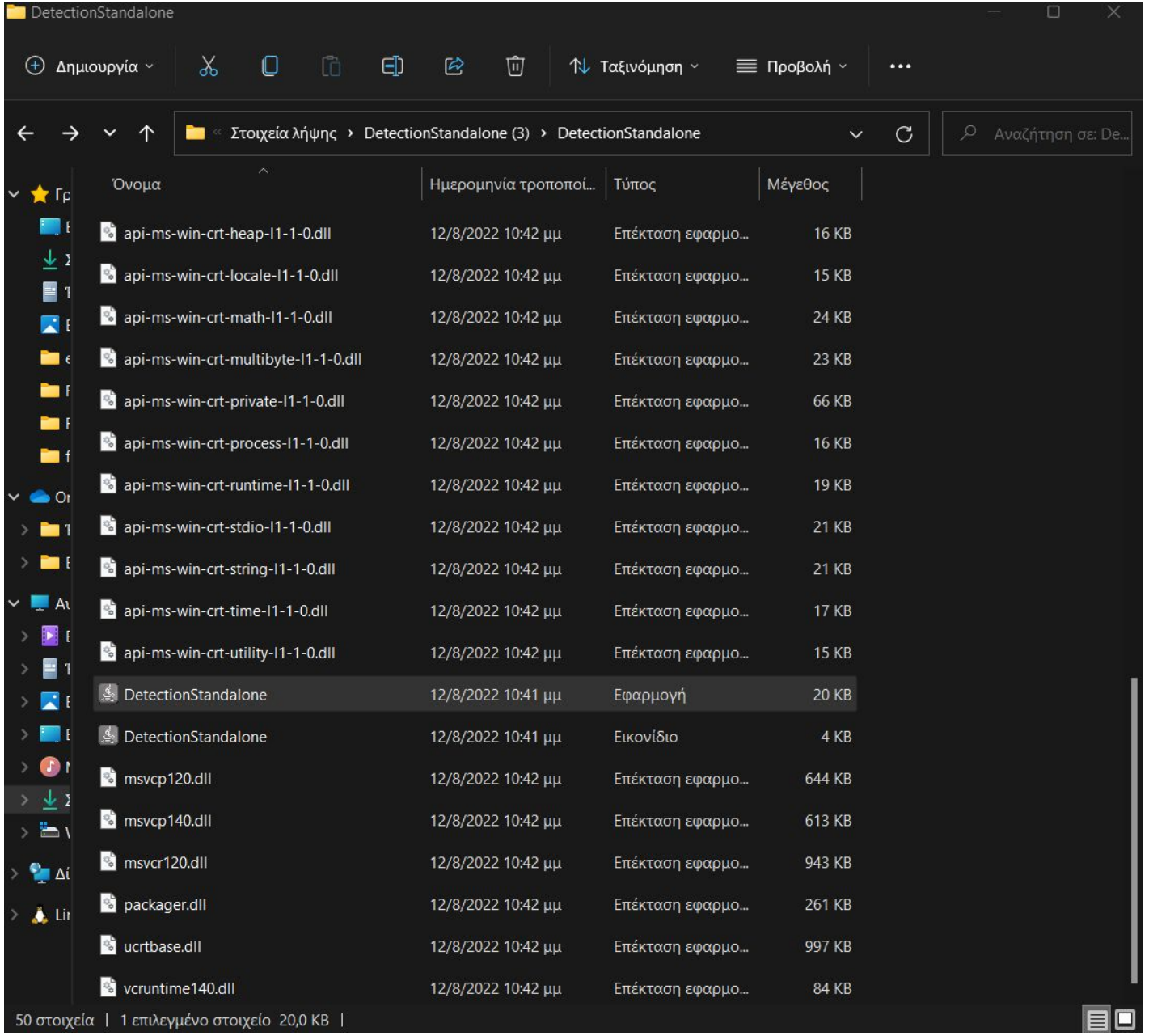
- What threading do you use?
- Is a multi-frame impact or single-frame?



Offline Detection

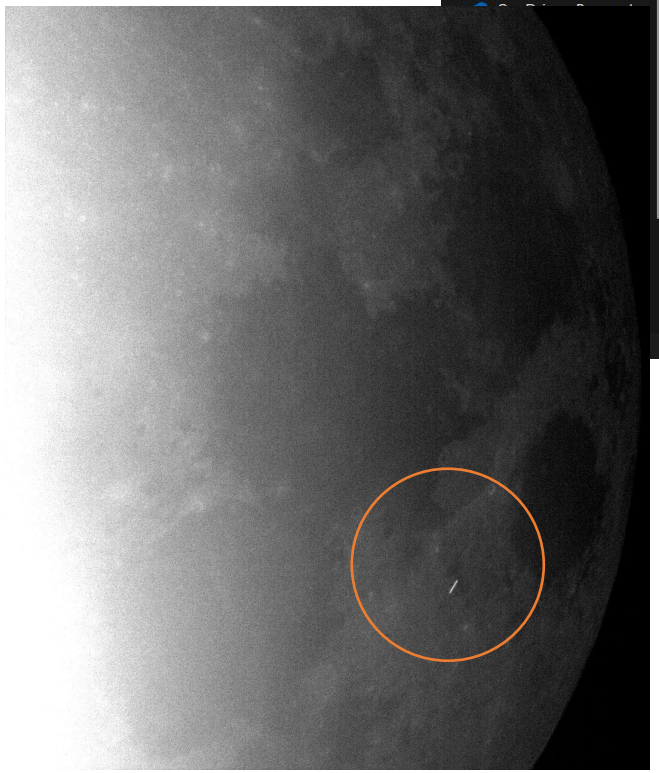
Set-up

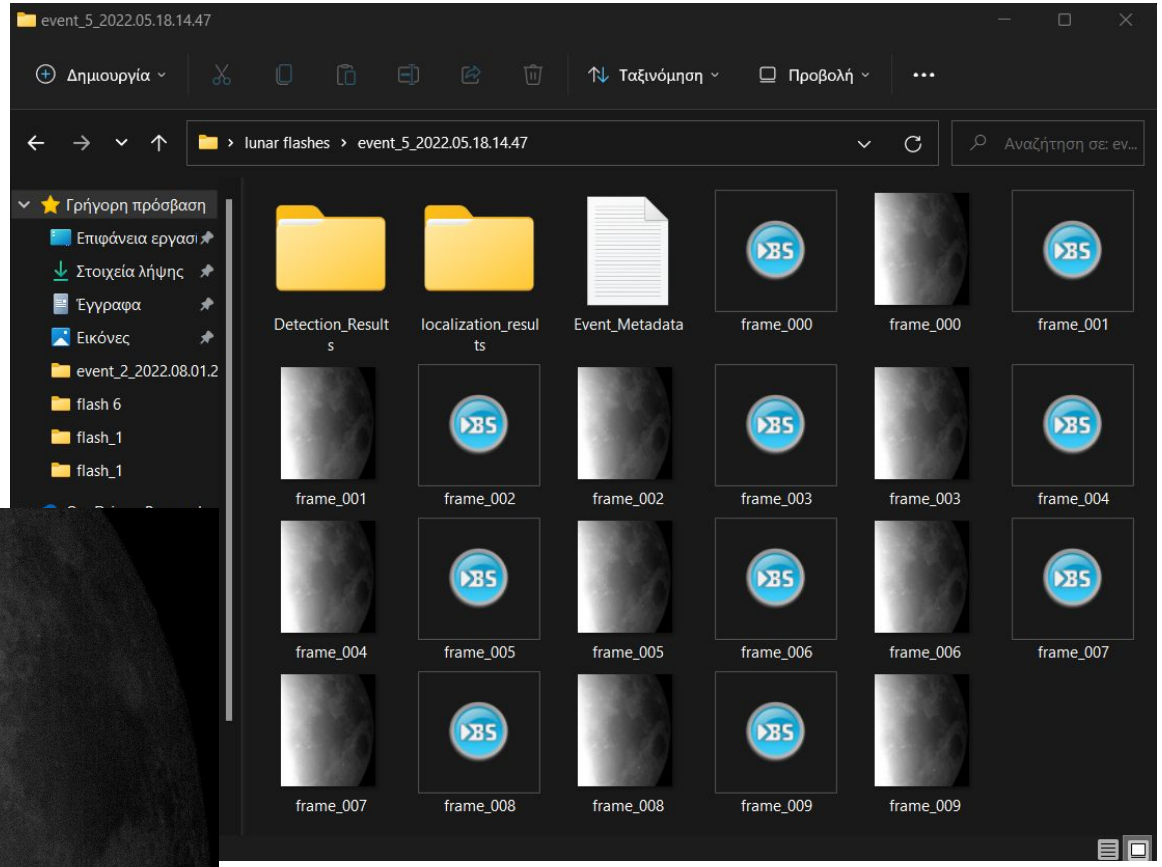
- Firstly, unzip the folder DetectionStandalone.zip
- Open the Detection Standalone app



Set-up

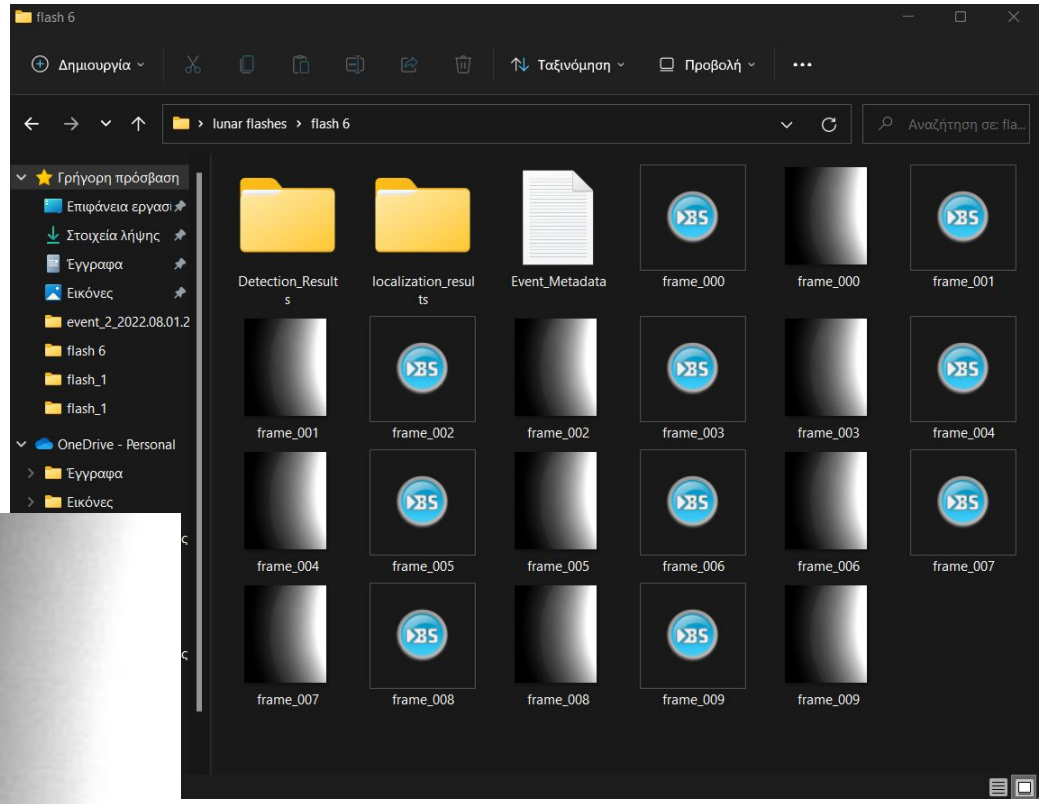
- We will perform the task of offline detection in a satellite that was captured by NELIOTA
- Name of the folder “FDS_offline_1”





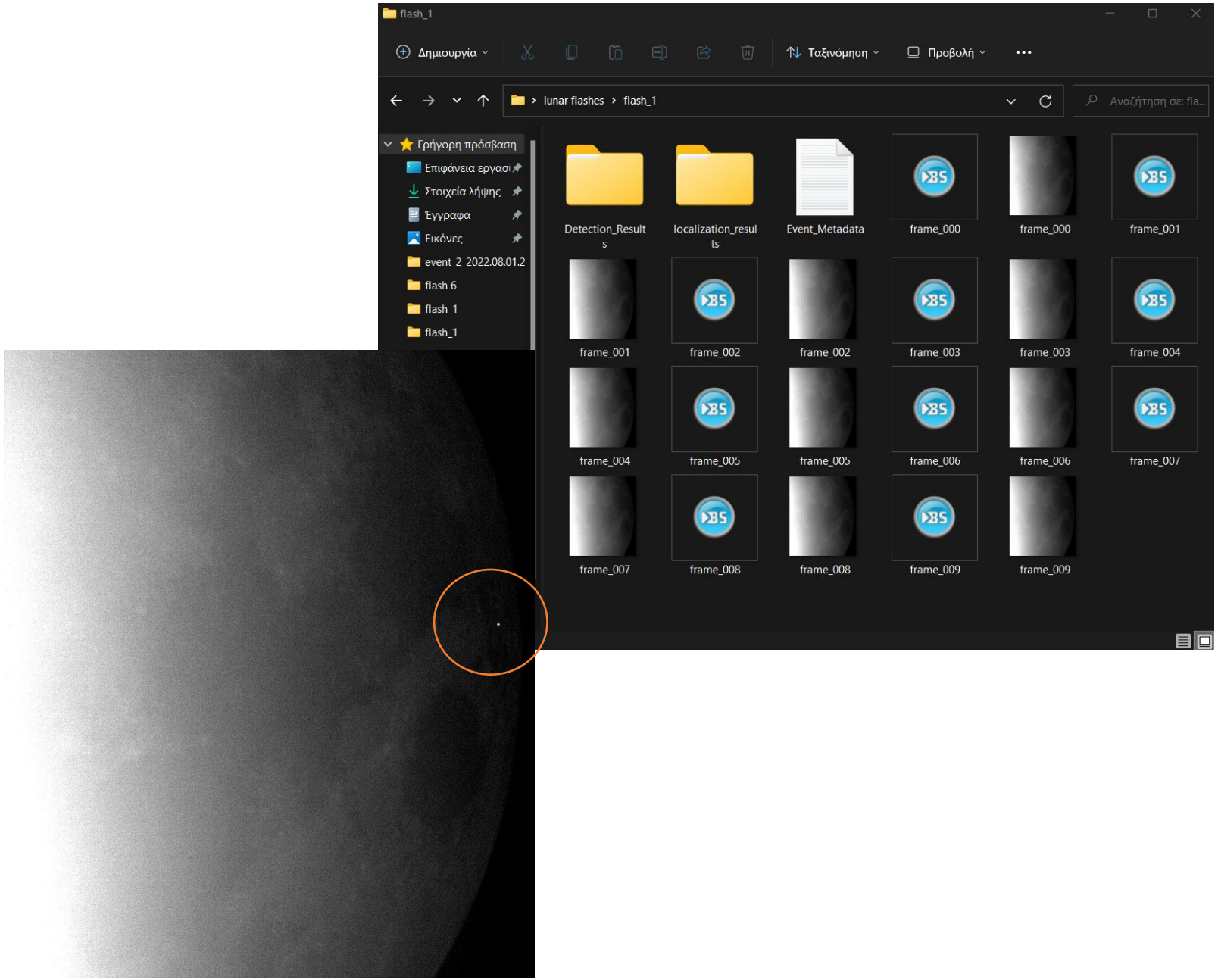
Set-up

- We will perform the task of offline detection in an impact flash that was captured by NELIOTA
- Name of the folder “FDS_offline_2”



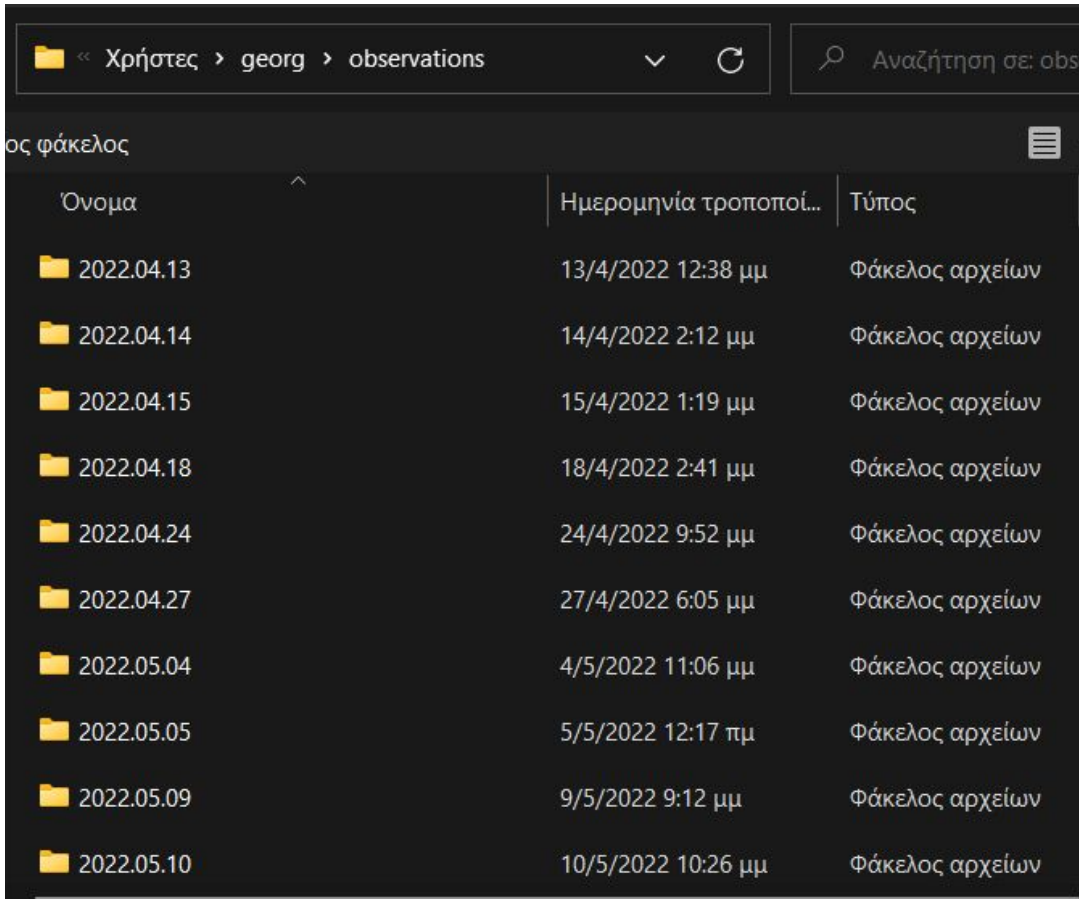
Set-up

- We will perform the task of offline detection in an impact flash that was captured by NELIOTA
- Name of the folder “FDS_offline_3”



Set-up

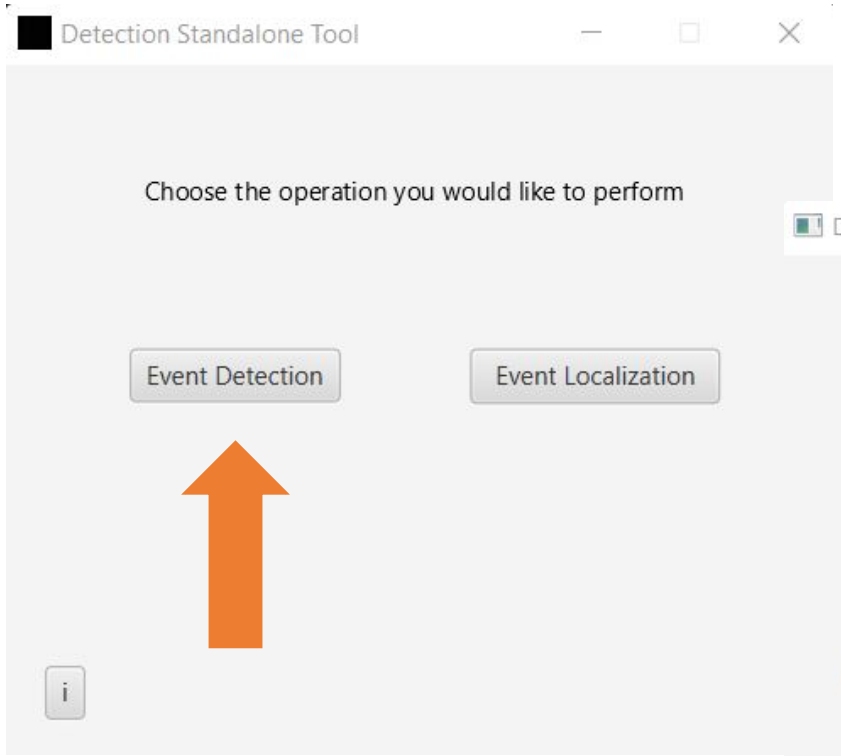
- Offline Detection could take the entire directory of the observations of the day, and not each event separately
- Thus create a new folder and name it "FDS_Offline" and place all the above three events

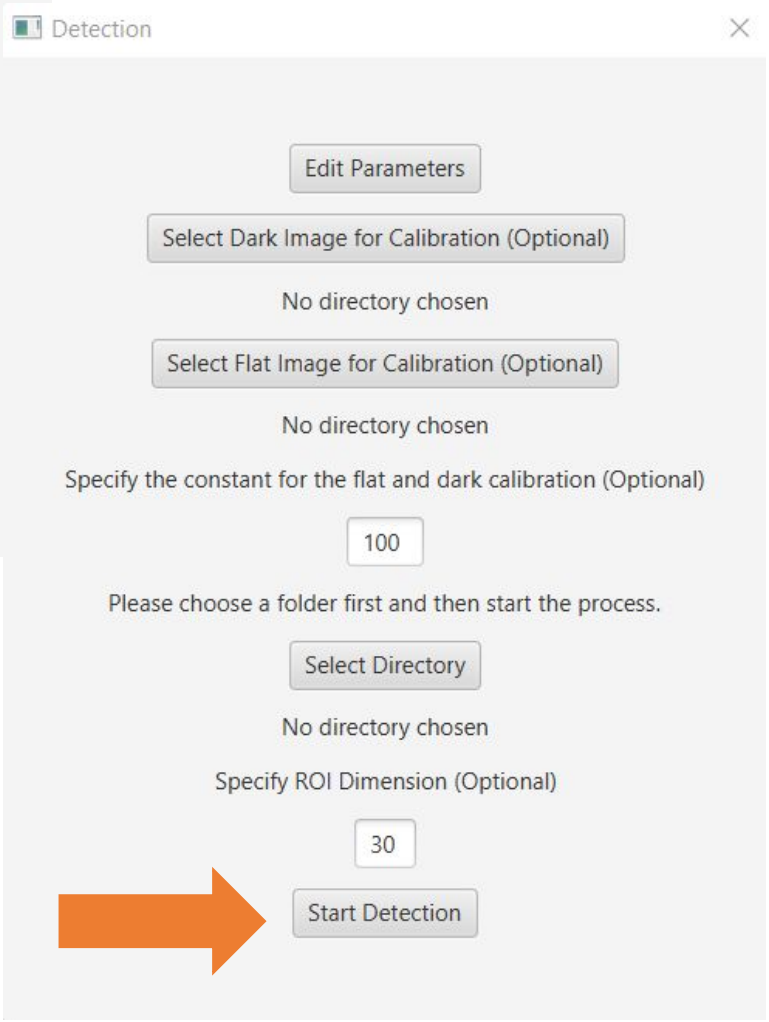


- Each of these folders contains up to 50-200 events
- Offline detection will inform us quickly which of them could be impact flashes, and which of them are satellite, cosmic rays

First Step

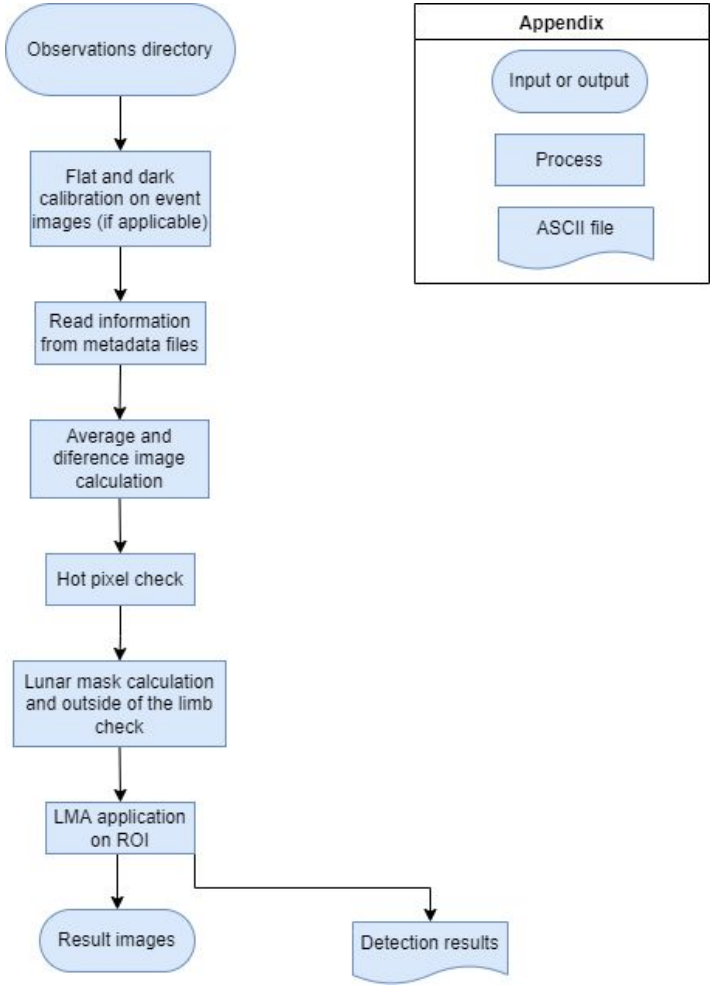
- Offline Detection could take the entire directory of the observations of the day, and not each event separately
- Thus create a new folder and name it "FDS_Offline" and place all the above three events
- Select this directory and press "Start Detection"
- Wait a bit...





What will happen while waiting:

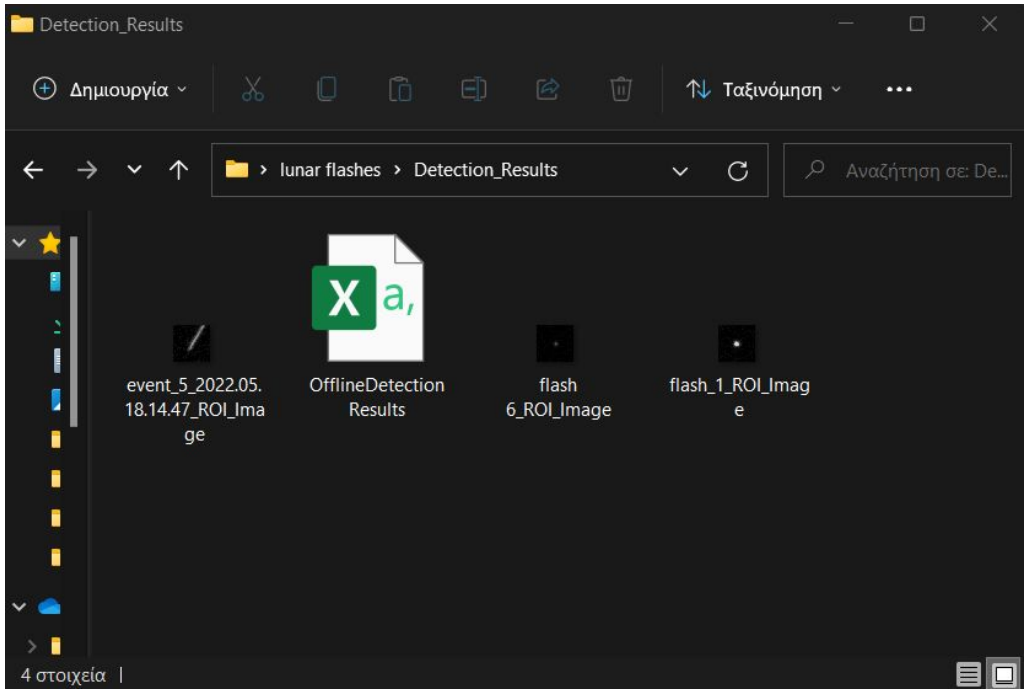
- For each event, the program will read some essential information from the metadata file
- Select a Region of Interest around the event
- Perform **Levenberg–Marquardt algorithm** and fit a 2D Gaussian in the event
- Depending on the characteristics of the Gaussian the program classify the event



Results

A	B	C	D	E	F	G	H	I	J	K	L	M
Event Directory Name	FWHM x	FWHM y	Impact Flash	Satellite	Hot Pixel	Cosmic Ray	Event outside of the limb	Result:				
flash_1	3,571	3,198	TRUE	FALSE	FALSE	FALSE	FALSE	Impact flash detected. (Coordinates: 1006, 721).				
flash 6	2,255	2,453	TRUE	FALSE	FALSE	FALSE	FALSE	Impact flash detected. (Coordinates: 410, 235).				
event_5_2022.05.18.14.4	2,399	22,761	FALSE	TRUE	FALSE	FALSE	FALSE	Satellite detected. (Coordinates: 747, 302).				

- In the directory "FDS_Offline" you will find a .csv file with the results
- Moreover, a folder named "Detection_Results" will be created
- There you can find more information about each event detection results



Localization

First Event (provided by FDS team)

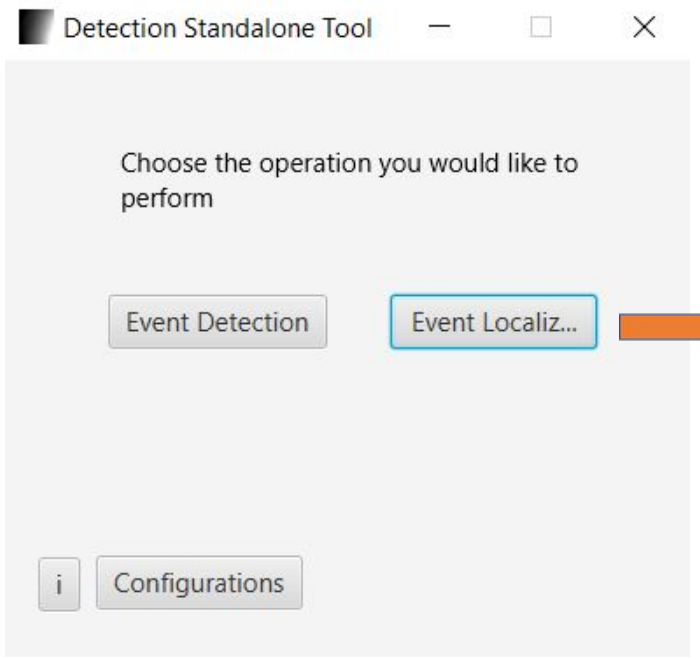
Set-up

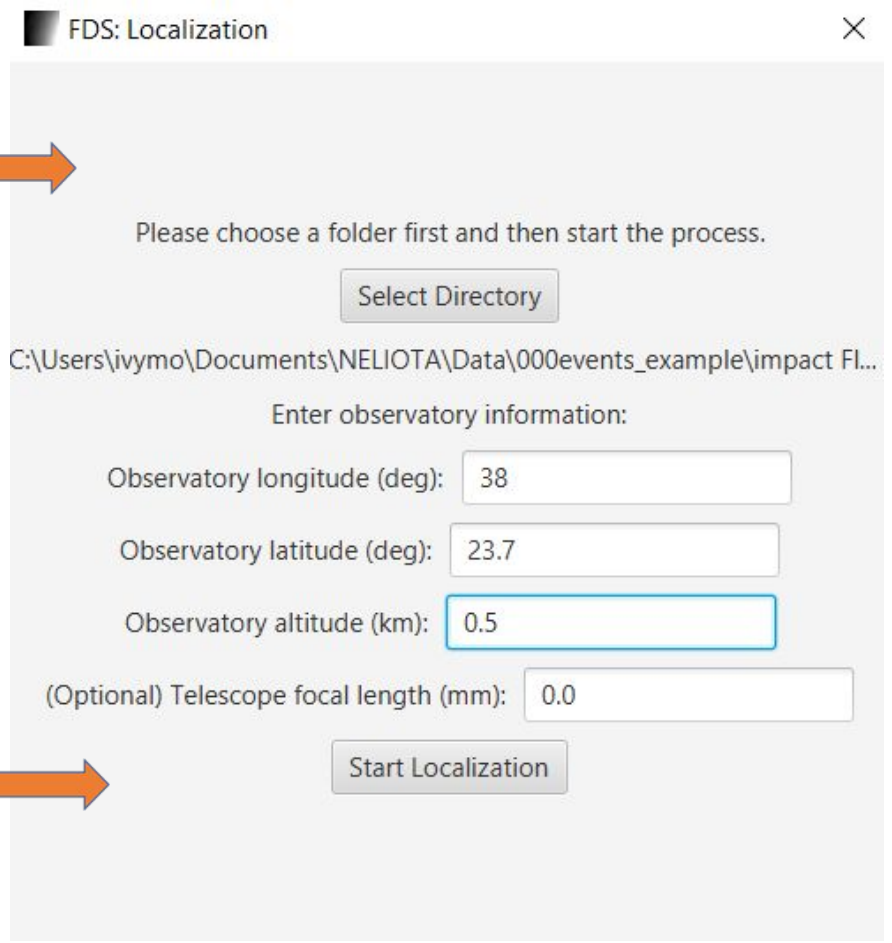
- We will perform the task of localization in an impact flash that we captured using this software on 03/06/22
- Choose the folder “FDS_localization_1”

Name	Date modified	Type	Size
Event_Metadata	8/9/2022 12:15 PM	Text Document	3 KB
frame_000	8/9/2022 12:15 PM	FITS File	5,403 KB
frame_000	8/9/2022 12:15 PM	PNG File	1,181 KB
frame_001	8/9/2022 12:15 PM	FITS File	5,403 KB
frame_001	8/9/2022 12:15 PM	PNG File	1,181 KB
frame_002	8/9/2022 12:15 PM	FITS File	5,403 KB
frame_002	8/9/2022 12:15 PM	PNG File	1,181 KB
frame_003	8/9/2022 12:15 PM	FITS File	5,403 KB
frame_003	8/9/2022 12:15 PM	PNG File	1,181 KB
frame_004	8/9/2022 12:15 PM	FITS File	5,403 KB
frame_004	8/9/2022 12:15 PM	PNG File	1,181 KB
frame_005	8/9/2022 12:15 PM	FITS File	5,403 KB
frame_005	8/9/2022 12:15 PM	PNG File	1,181 KB
frame_006	8/9/2022 12:15 PM	FITS File	5,403 KB

Set-up

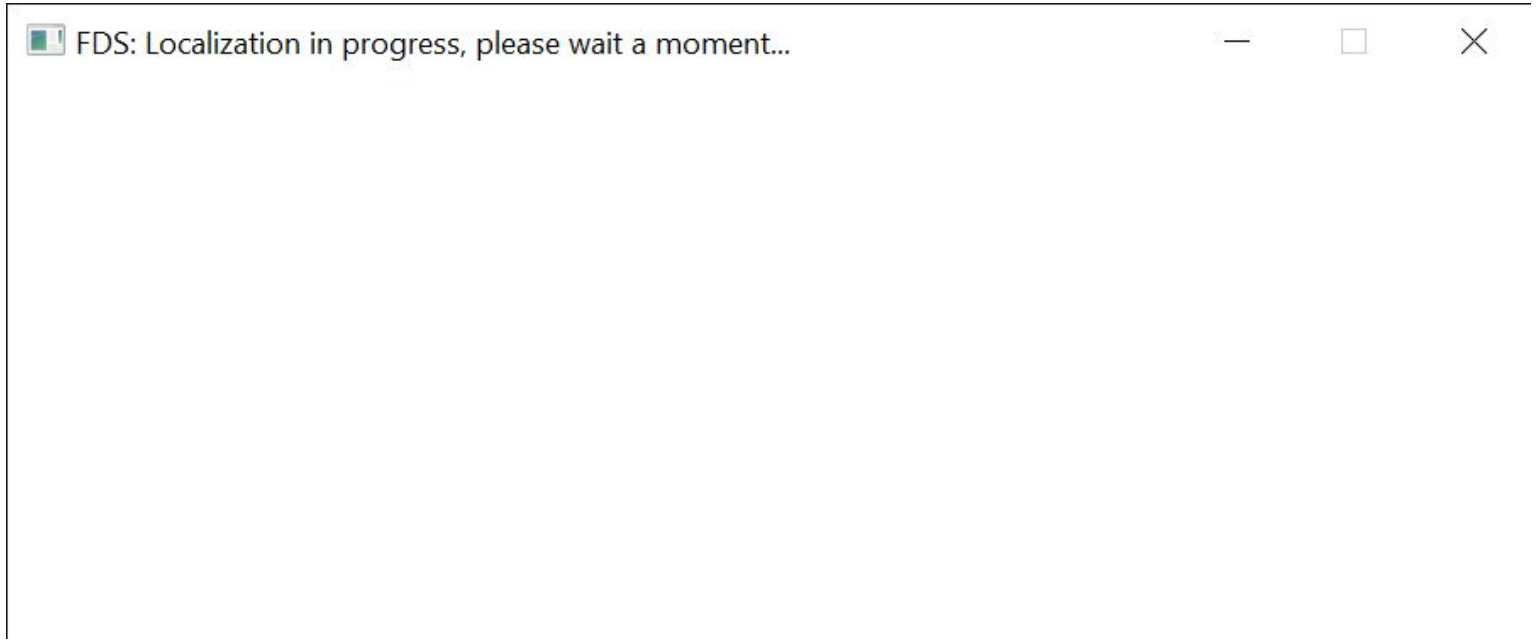
- Click “Event Localization”
- Select the Directory of the event
- Input observatory information as shown in the figure
- Press “Start Localization”



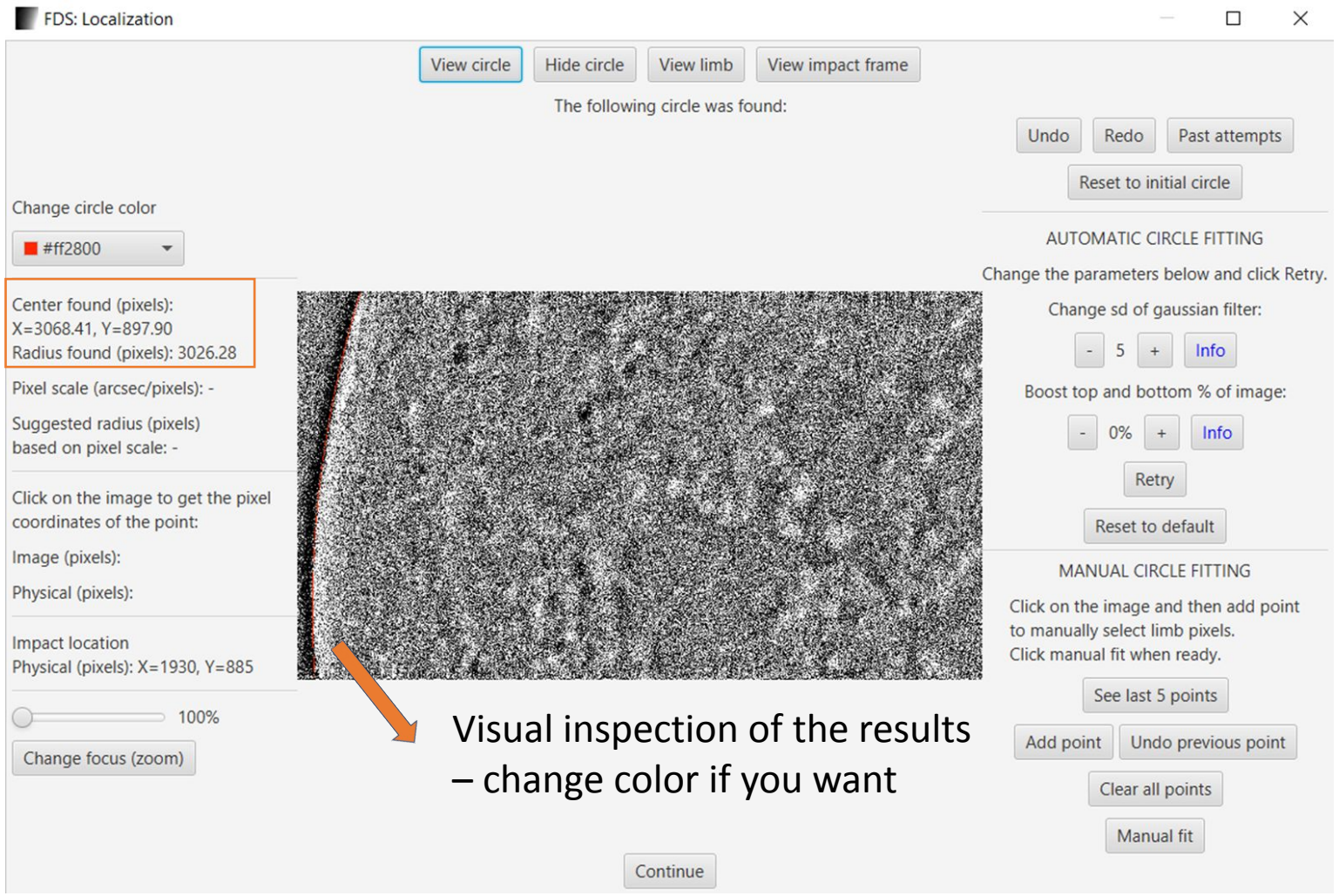


Set-up

- After pressing “Start Localization” you will wait a bit for the program to automatically find the lunar limb.
- Accurately finding the lunar limb is important for the localization



Results of automatically circle fitting



The results

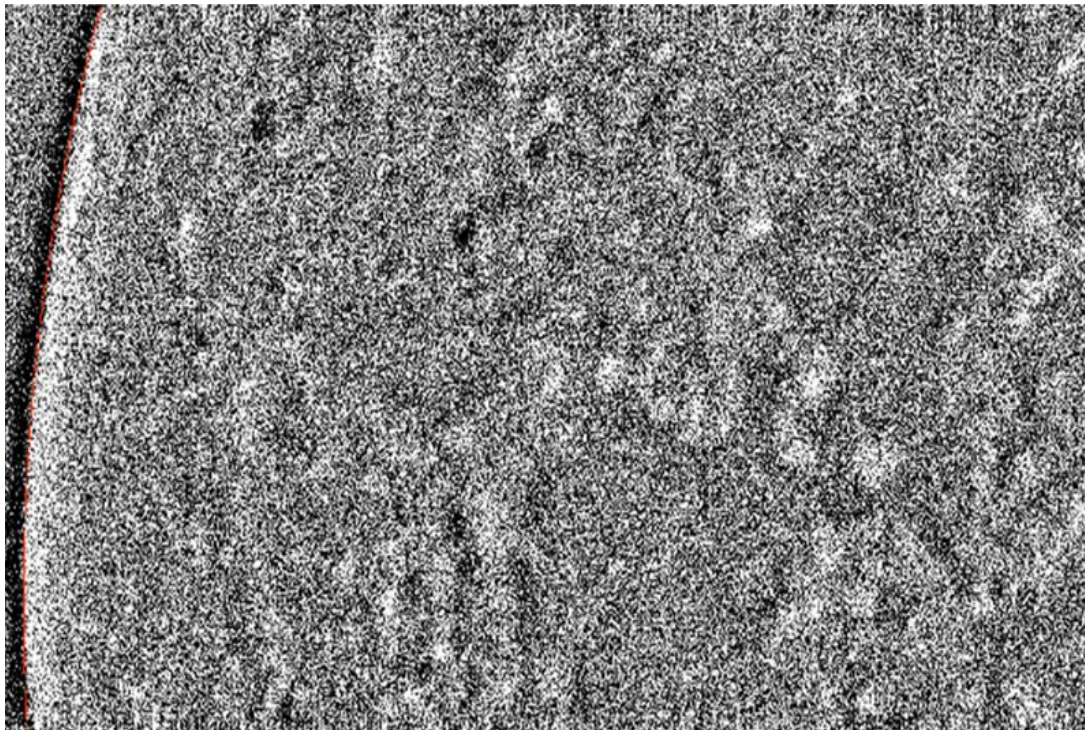
These results are empty because no focal length was given

Location of the event

Visual inspection of the results – change color if you want

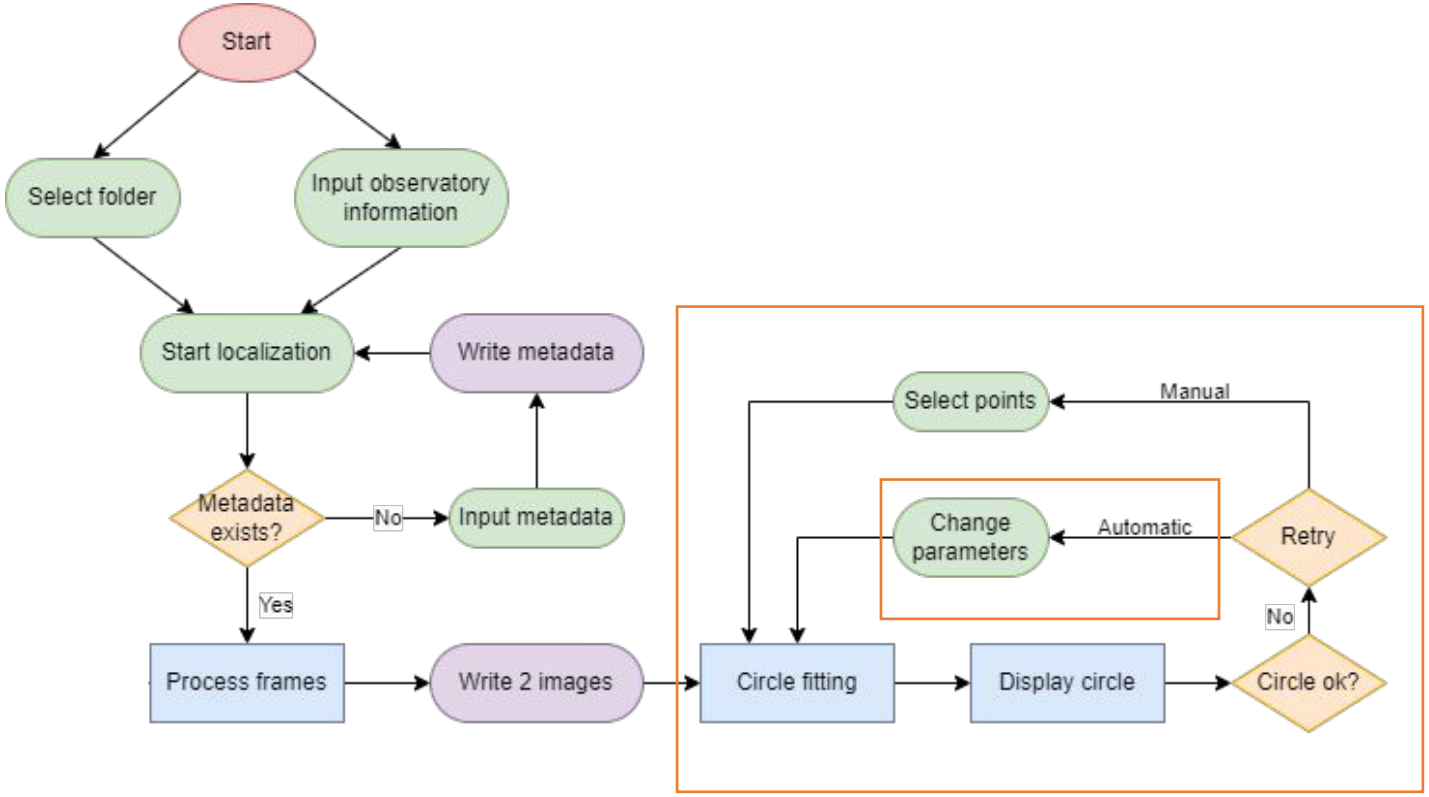
Are we satisfied with the suggested lunar limb?

View Circle

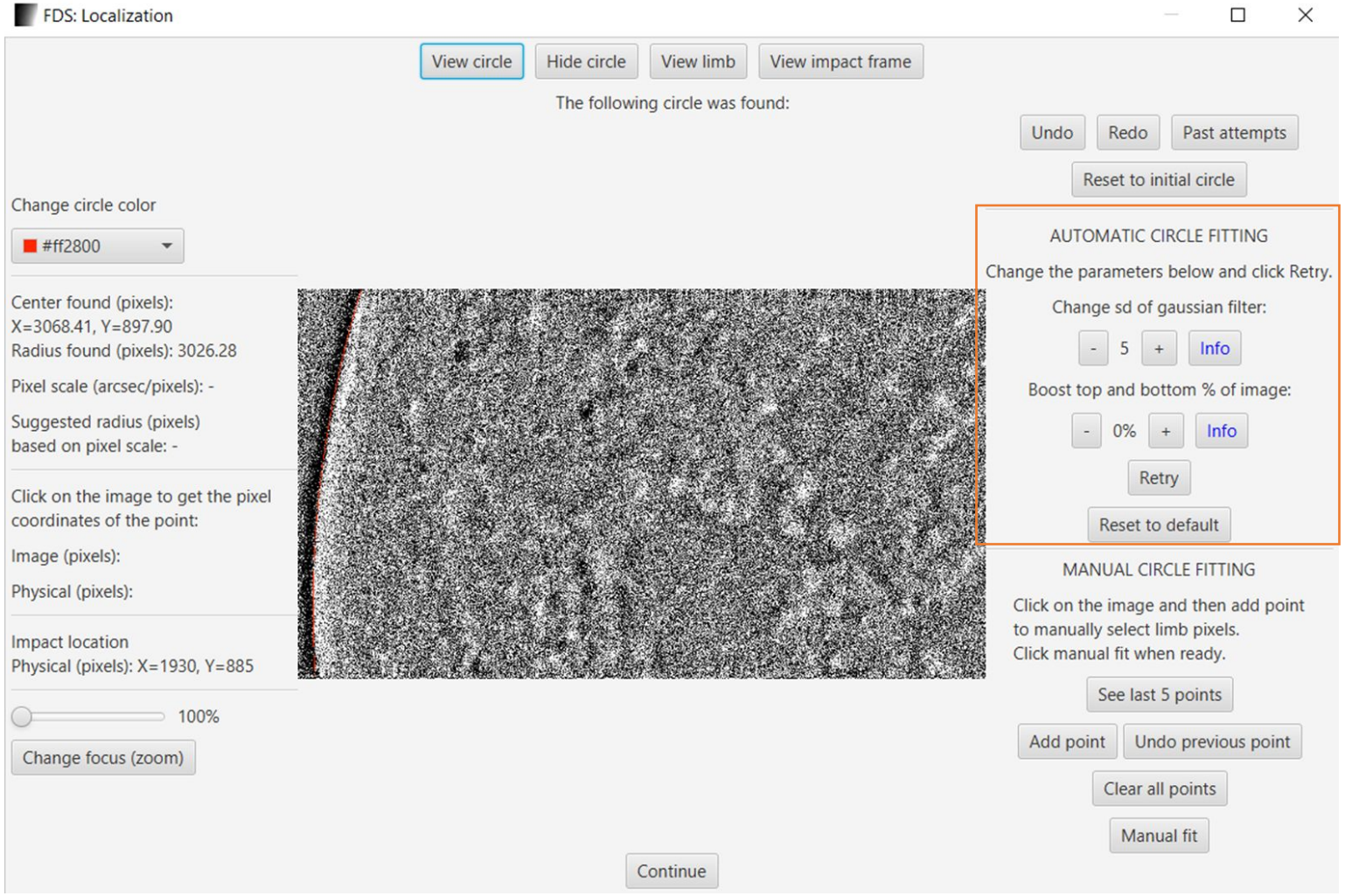


View Limb

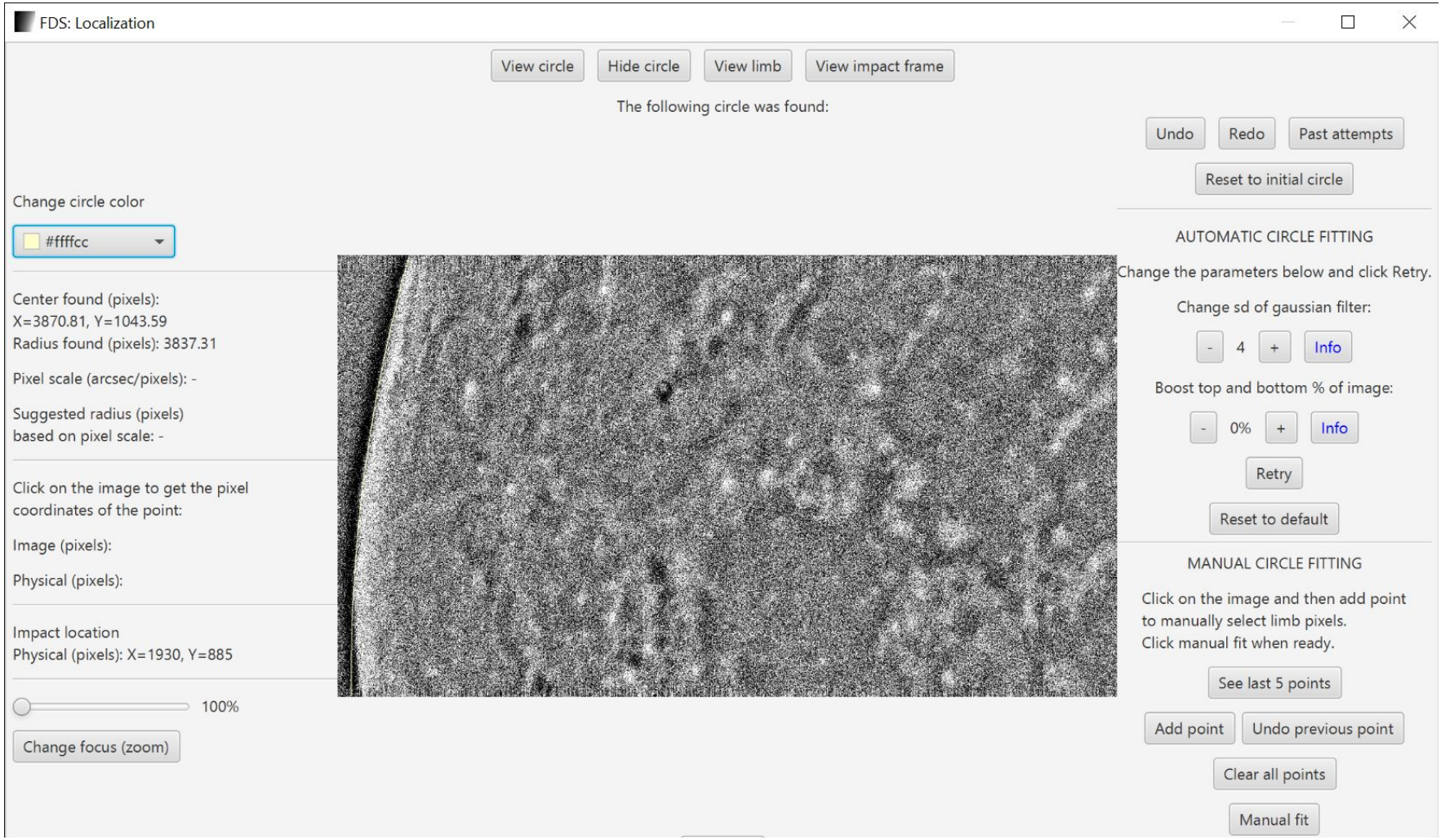
If no, change parameters of the algorithm



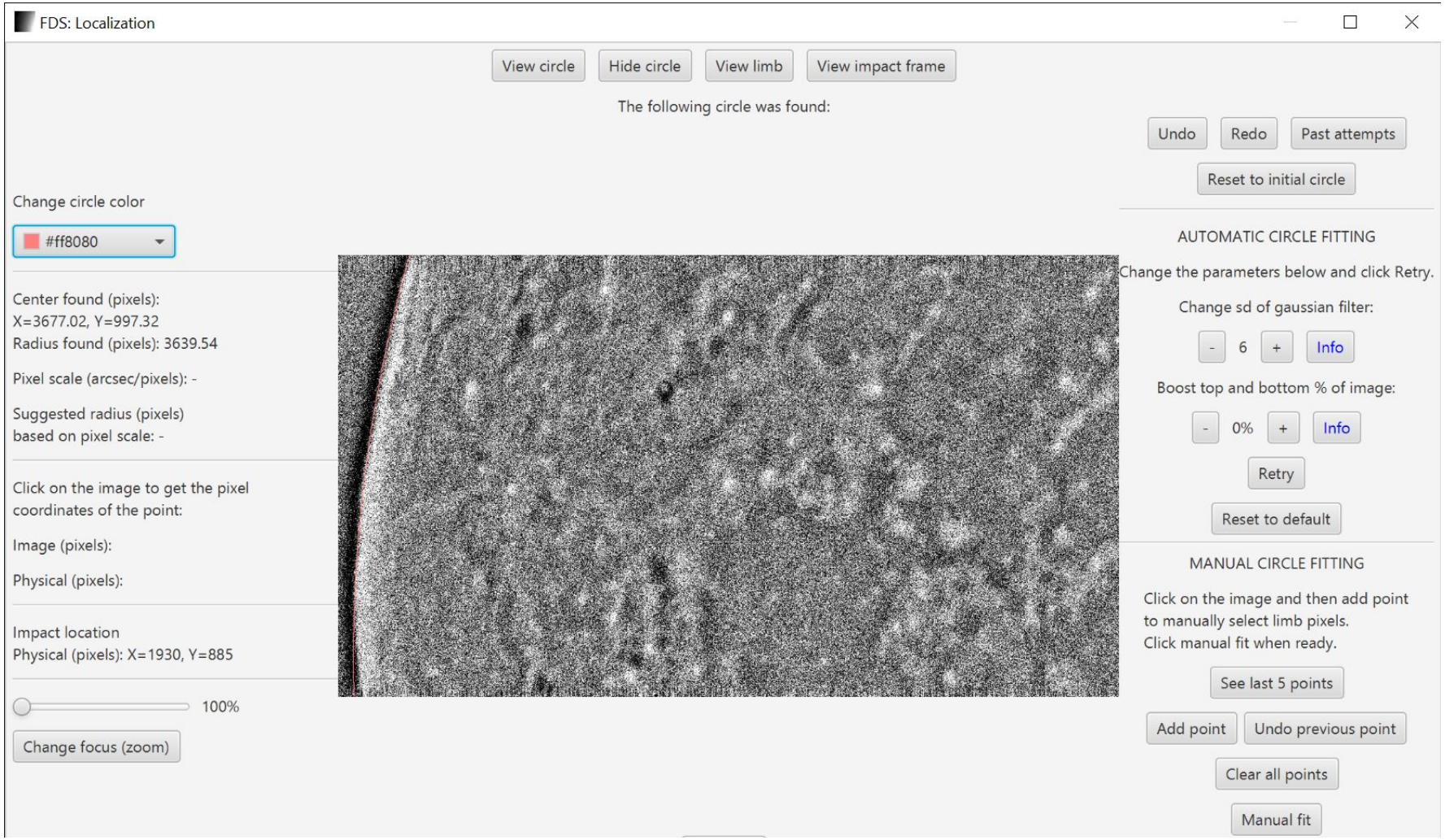
If no, change parameters of the algorithm



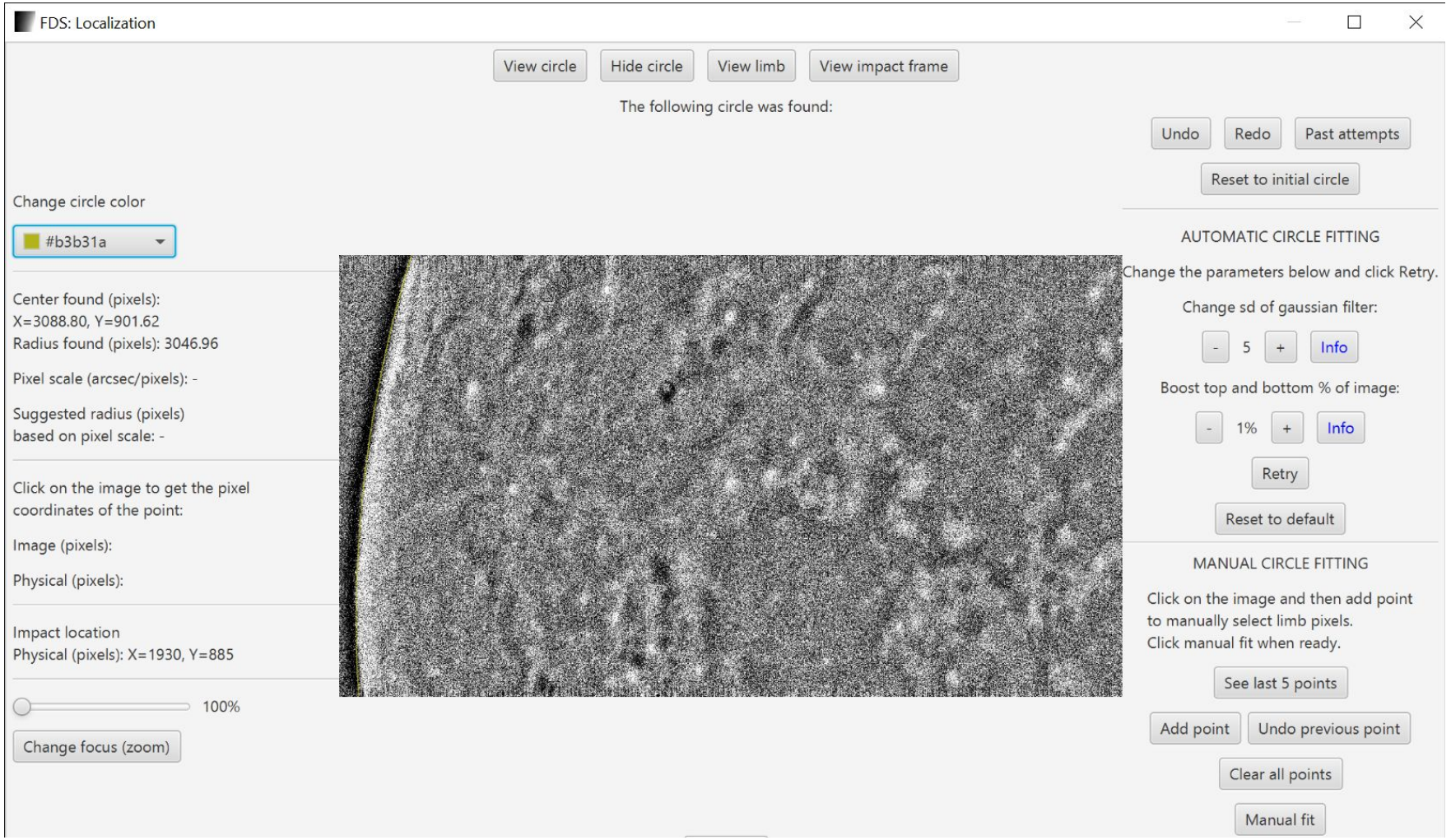
Set sd=4 and press Retry



Set sd=6 and press Retry

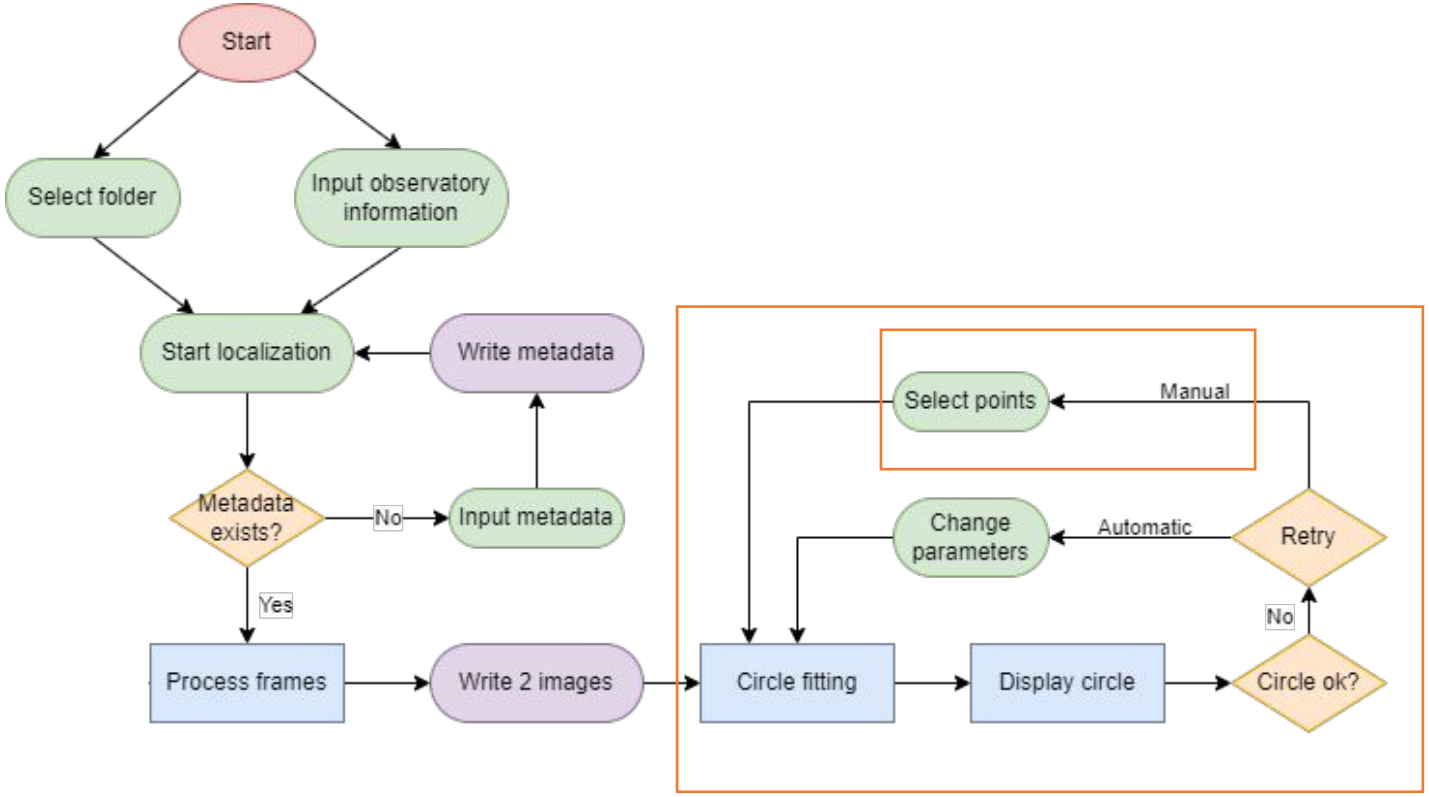


Set Boost = 1%

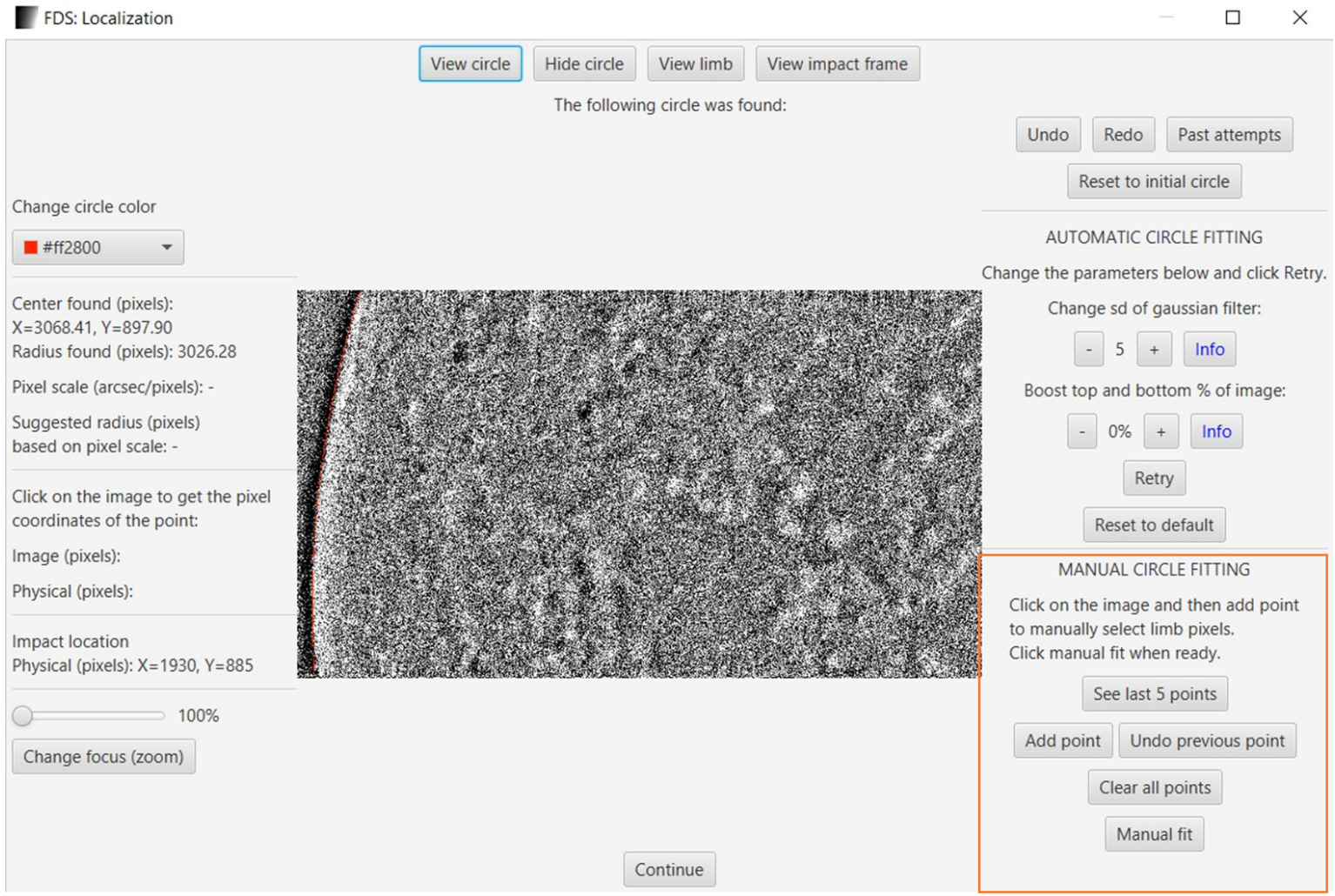

FDS: Localization
View circle
Hide circle
View limb
View impact frame
The following circle was found:
Undo
Redo
Past attempts
Reset to initial circle
Change circle color
#b3b31a
AUTOMATIC CIRCLE FITTING
Change the parameters below and click Retry.
Change sd of gaussian filter:
- 5 + Info
Center found (pixels):
X=3088.80, Y=901.62
Radius found (pixels): 3046.96
Pixel scale (arcsec/pixels): -
Suggested radius (pixels)
based on pixel scale: -
Boost top and bottom % of image:
- 1% + Info
Retry
Reset to default
Click on the image to get the pixel coordinates of the point:
Image (pixels):
Physical (pixels):
MANUAL CIRCLE FITTING
Click on the image and then add point to manually select limb pixels.
Click manual fit when ready.
See last 5 points
Impact location
Physical (pixels): X=1930, Y=885
100%
Add point
Undo previous point
Change focus (zoom)
Clear all points
Manual fit

Set Boost = 5% -> This is the best result

If you are still not satisfied with the result use Manual Fit

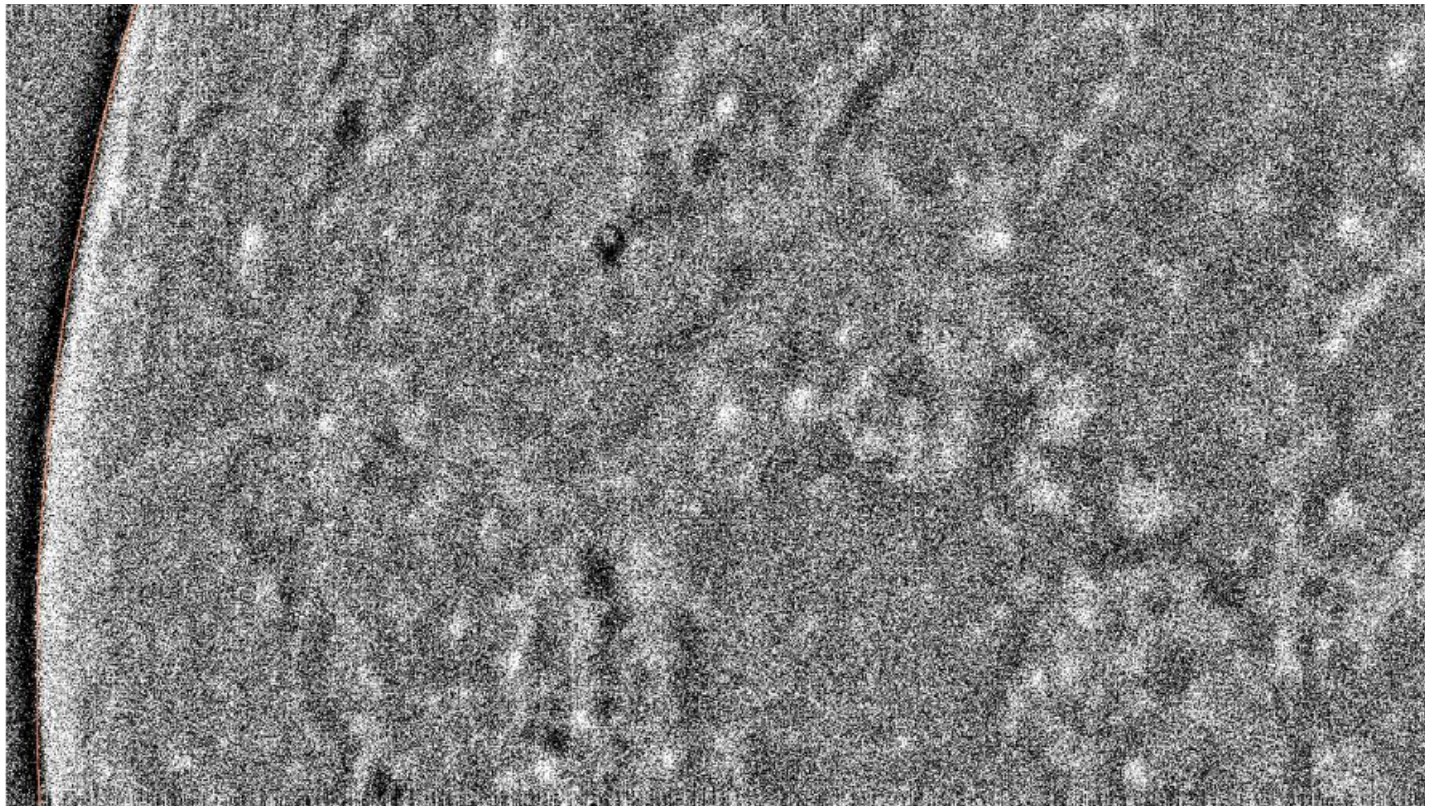


Manual Circle Fitting



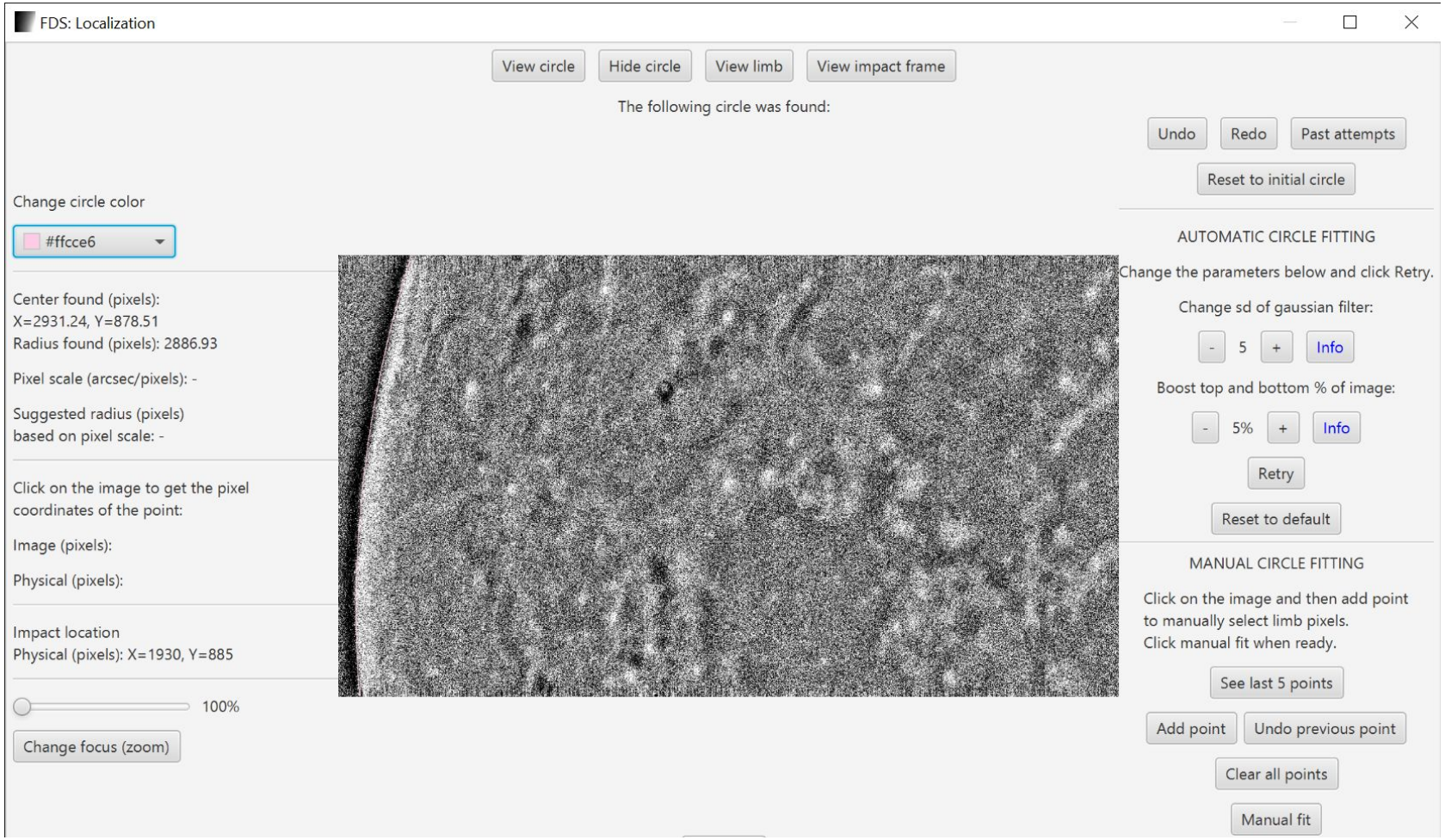
Manual Circle Fitting

- Select Point on the Image
- Press "Add point"
- Continue until you have selected enough points
- Press "Manual Fit"



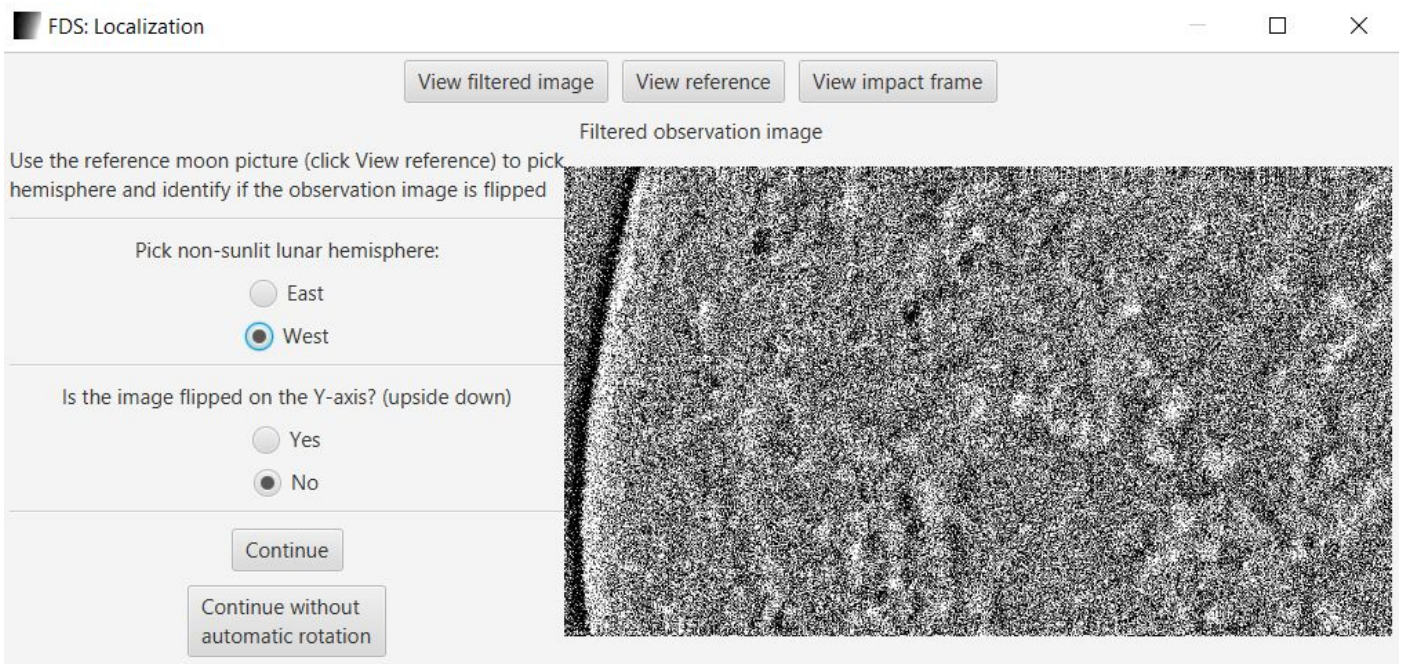
The best result: Set Boost = 5%

- See "Past attempts"
- Choose the best fitting circle
- Press continue
- Wait a bit



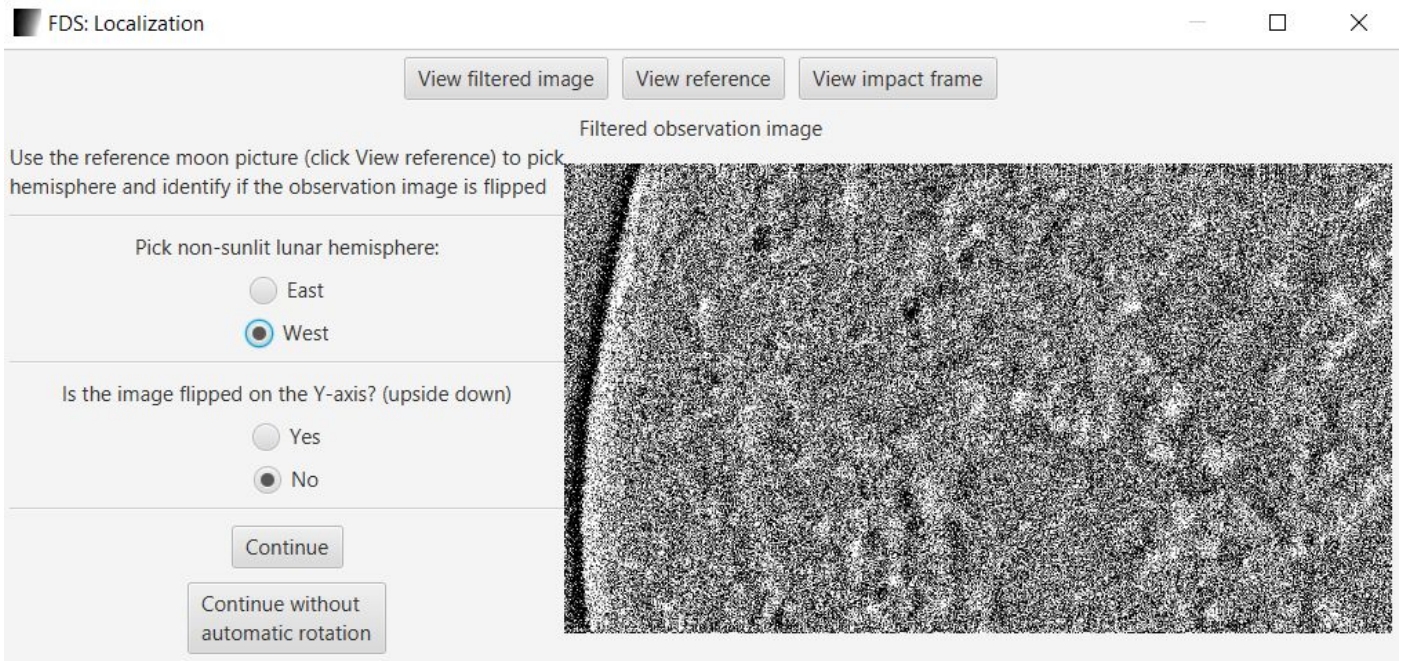
Next Step

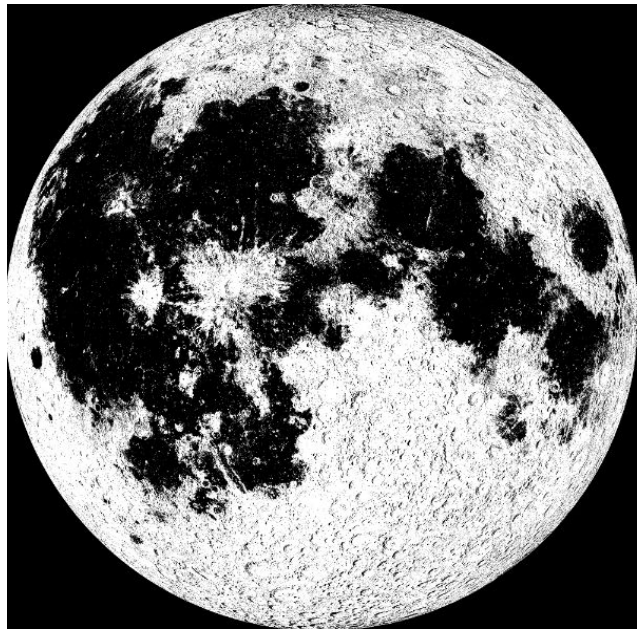
- In this step you must answer two questions:
  - Ø Is the non-sunlit lunar hemisphere the east or the west?
  - Ø Is the image flipped?
- Use the reference Image to answer these questions



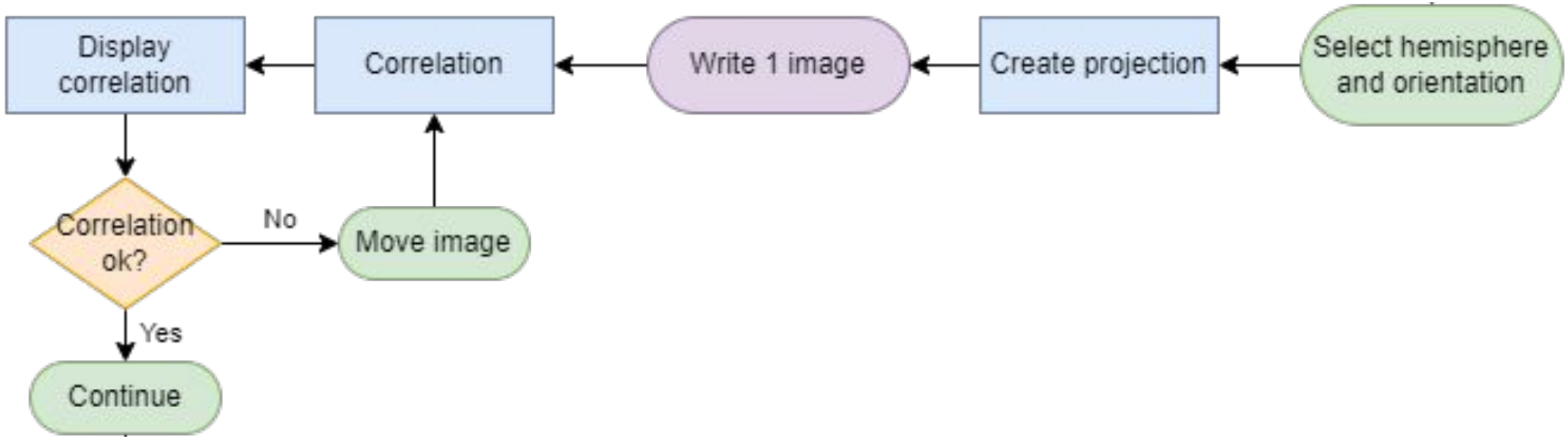
Next Step

- Is the non-sunlit lunar hemisphere the east or the west?
  - Ø West
- Is the image flipped?
  - Ø No
- Then press "Continue without automatic rotation"
- Wait… It will take a while



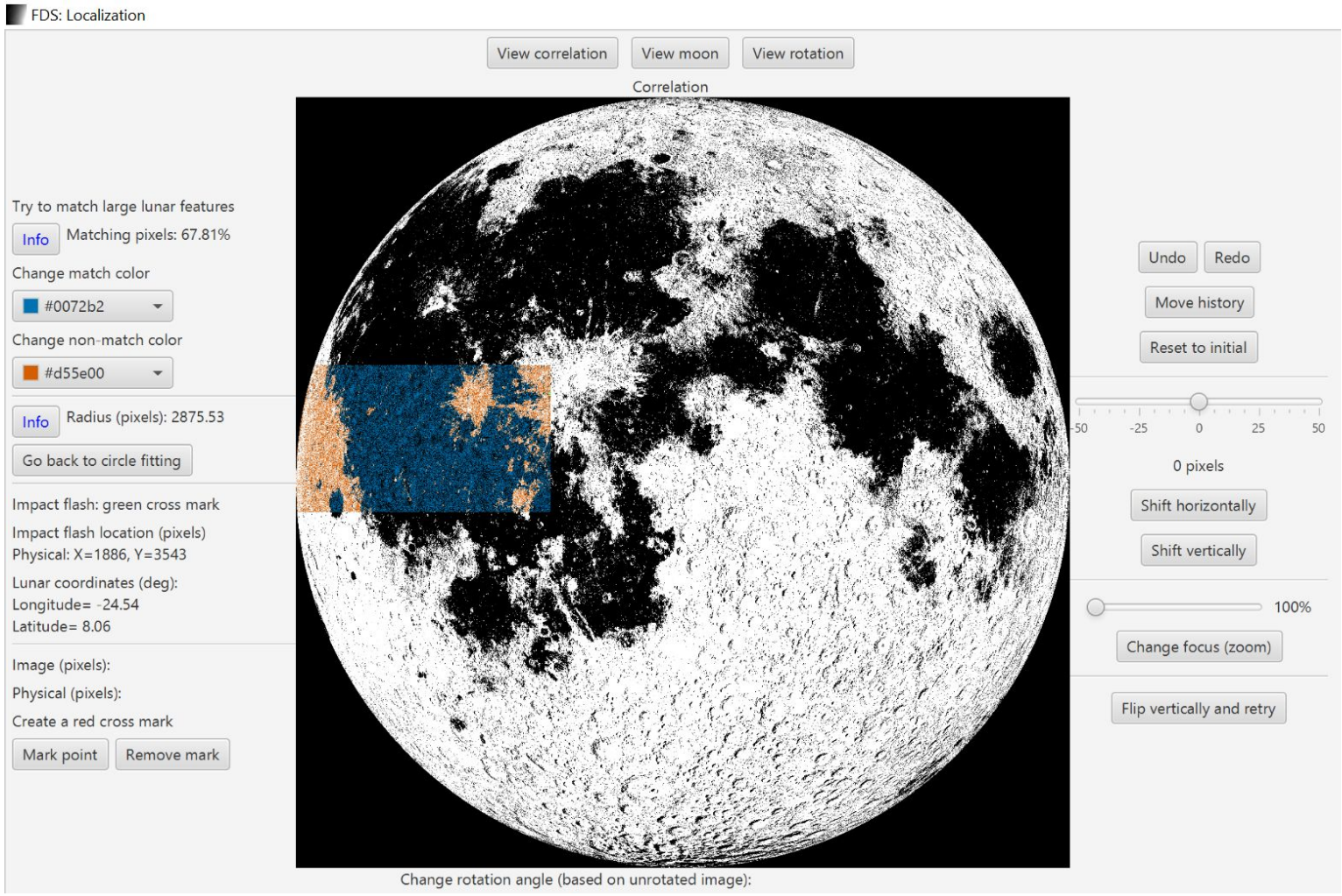


Next Step:
Automatic Correlation



Automatic Correlation

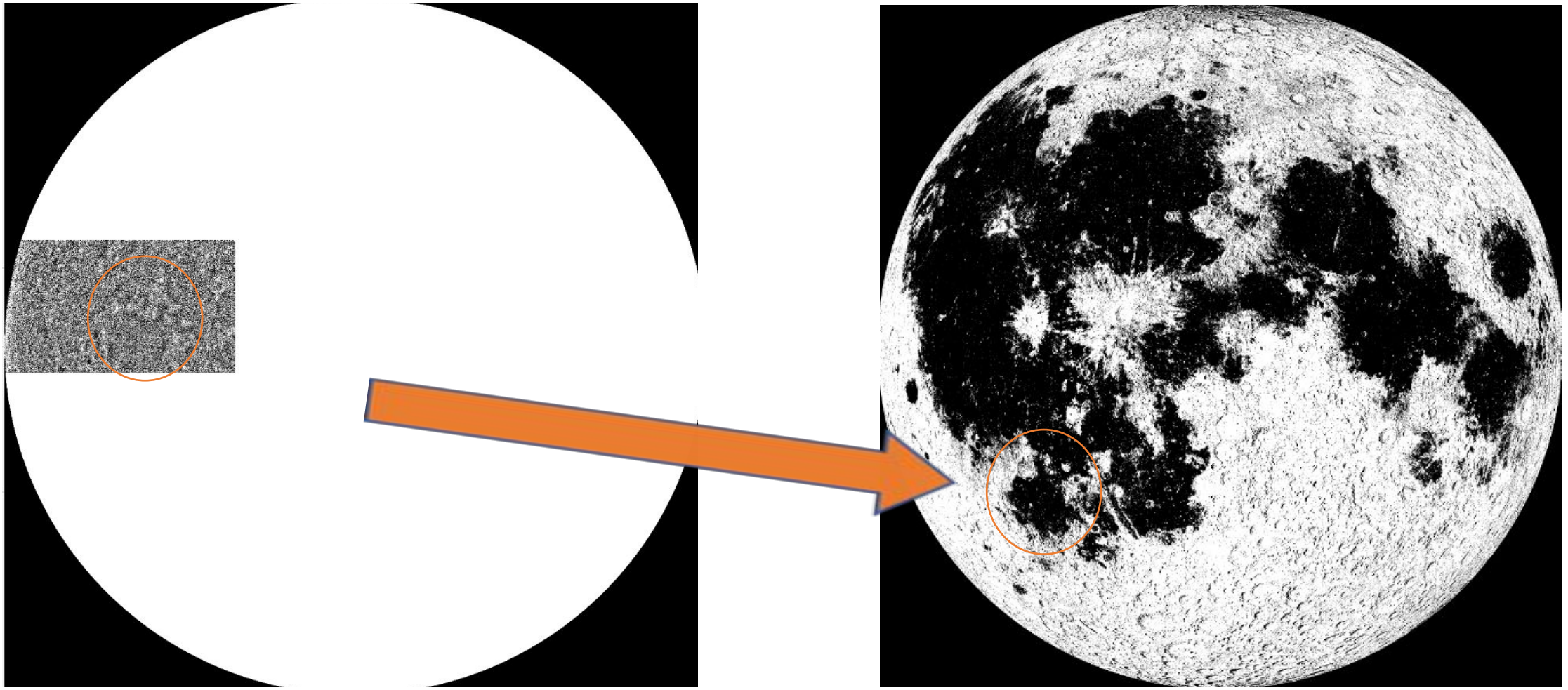
- The image must be rotated so that Mare Humorum is in the correct spot



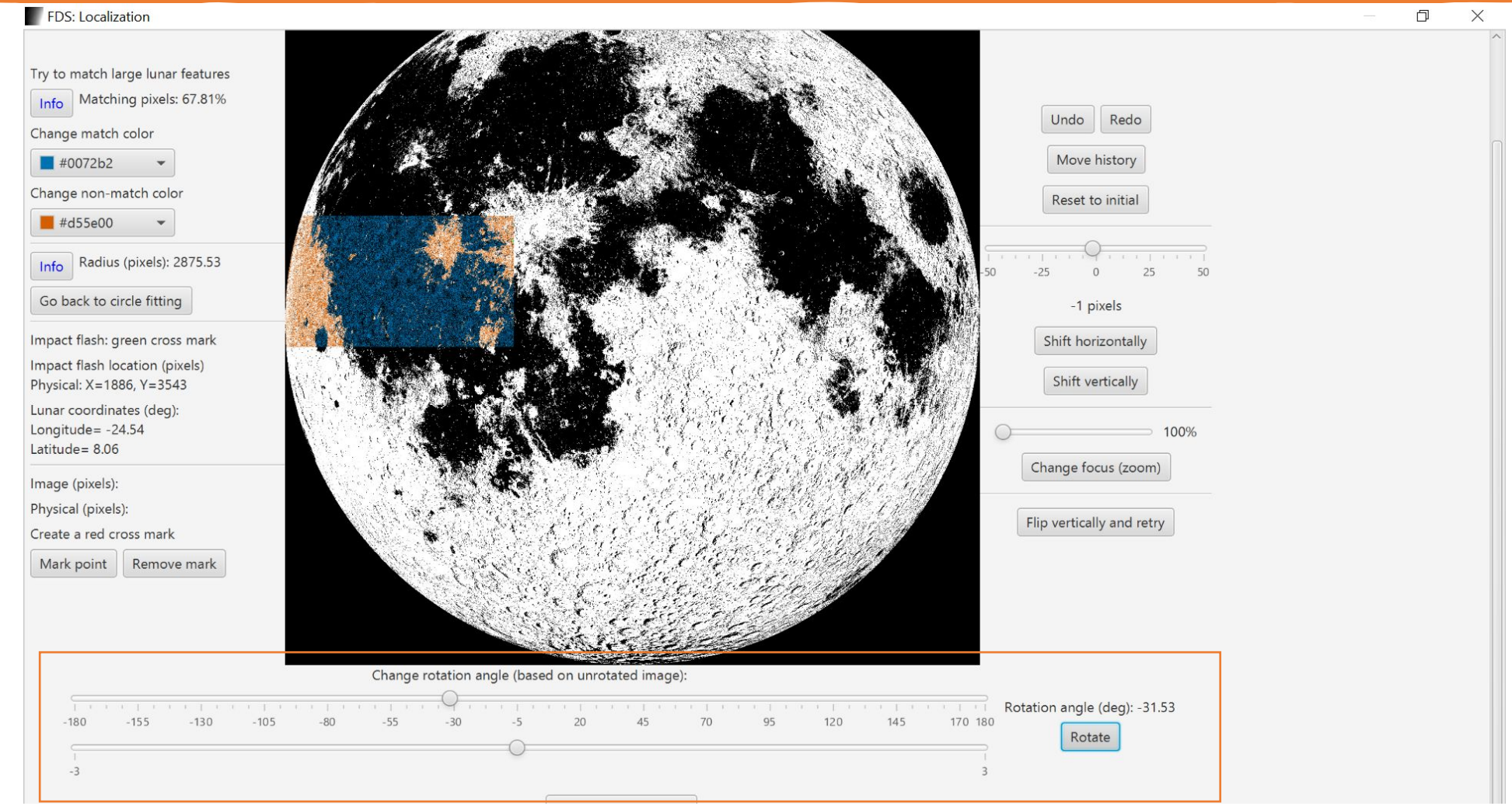
Suggested rotation

View rotation

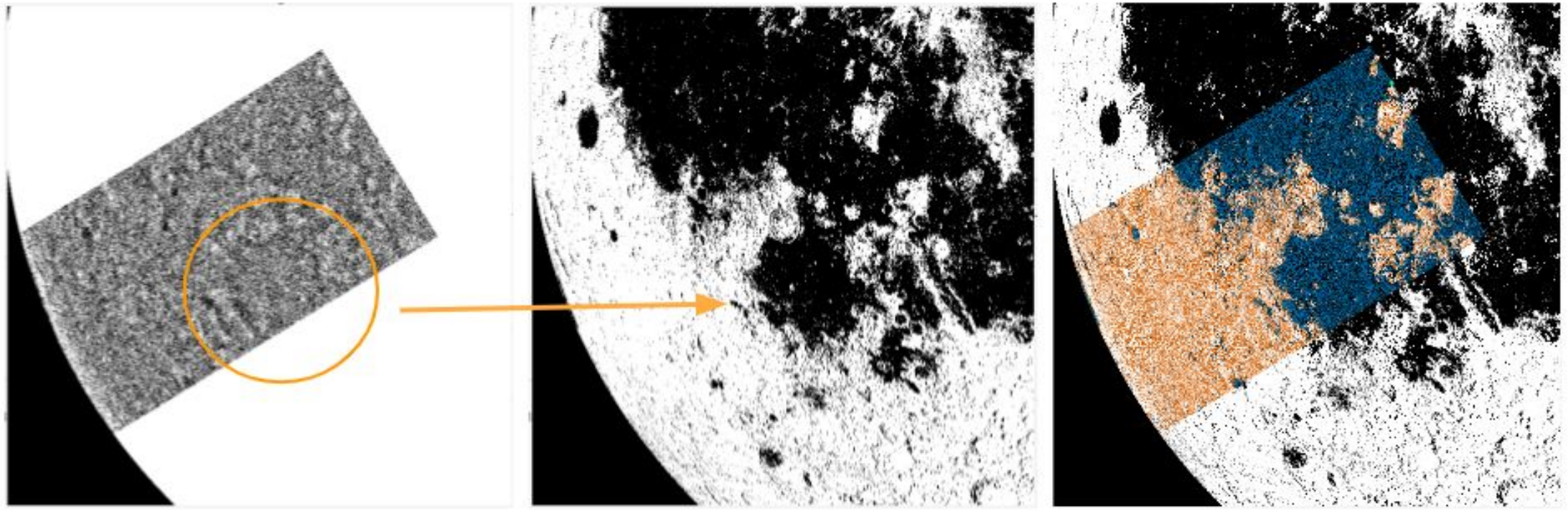
View moon



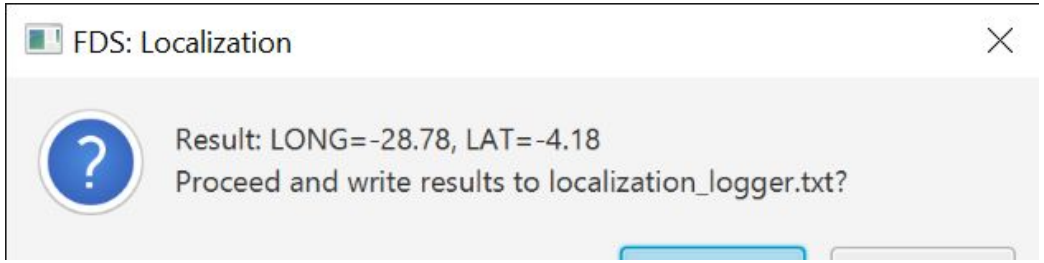
Rotation: -31.53 deg



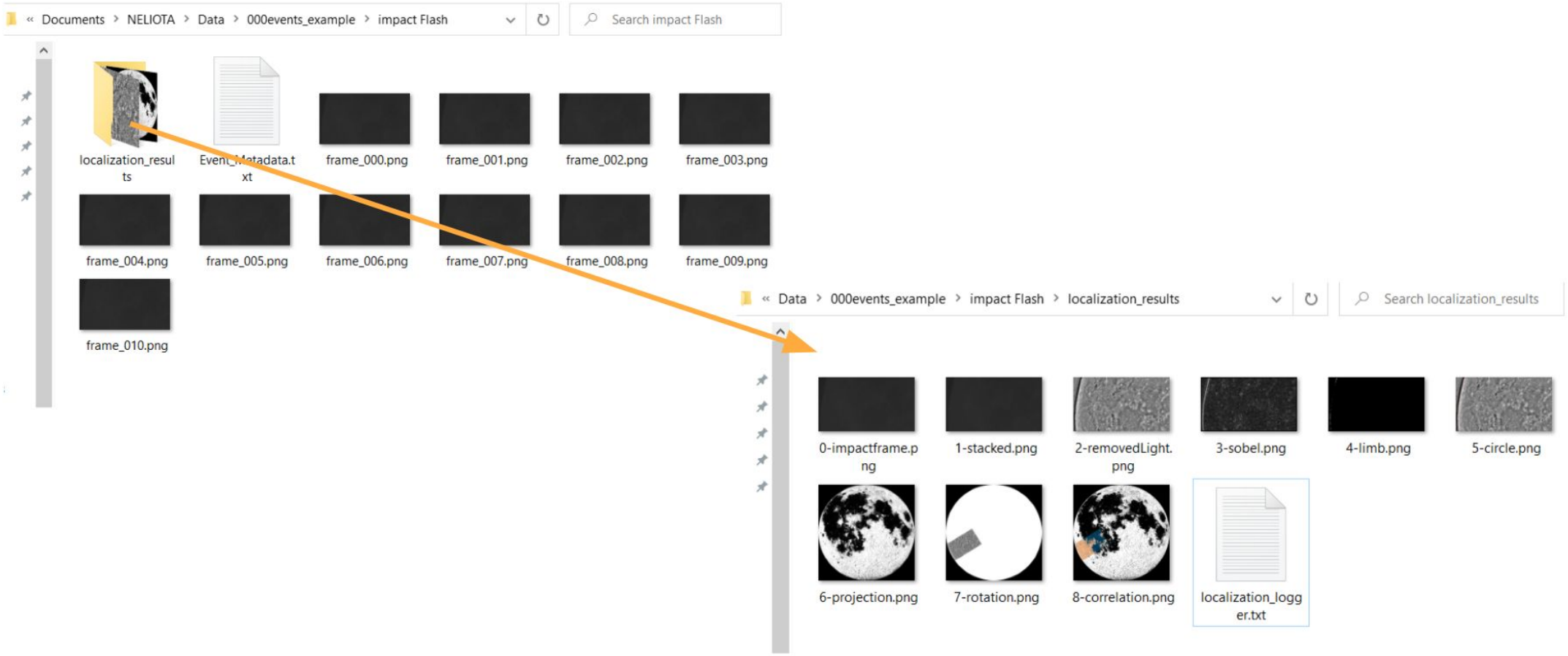
Mare Humorum is now correctly placed



- If you are satisfied with the correlation press "Complete Localization"



Results on the event directory:



Results on the event directory:

- This event was also captured by NELIOTA and we can compare our localization results

localization_logger.txt - Notepad

File Edit Format View Help

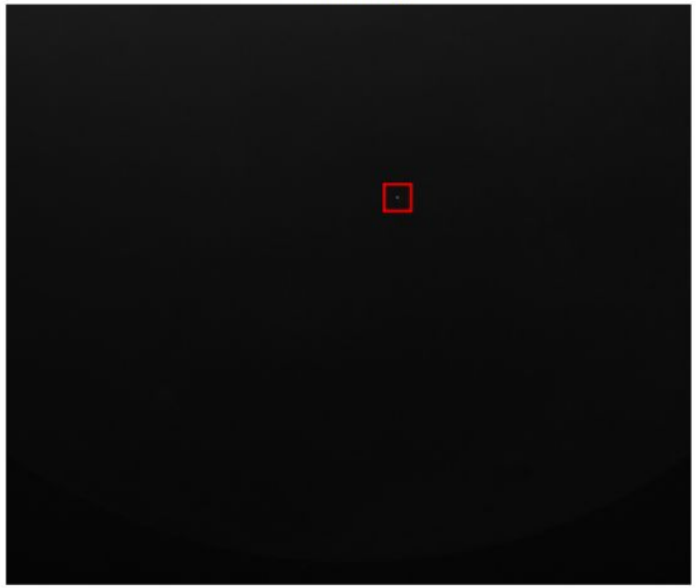
```
Localization Process Started for folder C:\Users\ivymo\D
Lunar coordinates (deg): LONG=-28.86, LAT=-4.25

Other info:
Center coordinates (deg): LONG=355.79, LAT=-5.70
Angular diameter (arcmin): 29.36
Pixel scale (arcsec/pixel): -
Radius calculated based on pixel scale (pixels): -
Radius (pixels): 2883.14
Center of circle (pixels): X=2927.77, Y=877.40
Rotation angle (deg): -31.53
Offset (pixels): X=0, Y=0
Impact location on rotated image (pixels): 1684, 2930
Localization stopped at 2022-07-17 11:01:56.913.
```

Detected NEO Lunar Impact Event

ID: 20220603_182131

Moon Position (Topocentric)	
Airmass:	1.86
Altitude (deg):	32.5
Azimuth (deg):	277.3
Event Data	
UT Date (DD/MM/YYYY):	03/06/2022
UT Time:	18:21:31.377
R (mag):	8.0 ± 0.1
I (mag):	6.6 ± 0.0
Lunar Long (deg):	-28.8
Lunar Lat (deg):	-4.0
Duration (sec):	0.132
Additional Information	
Number of Cameras:	2

Finderchart (I)

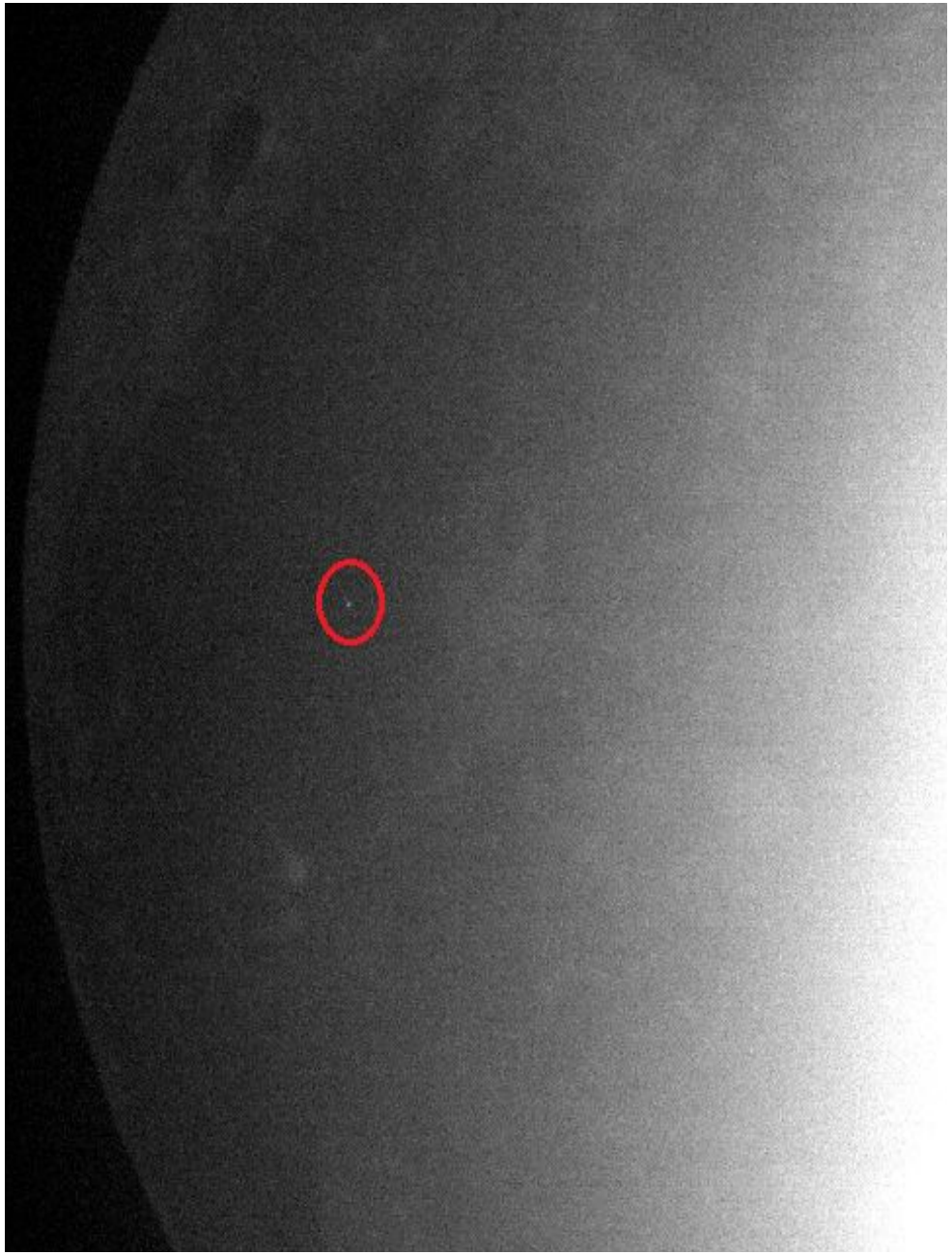


Second Event (provided by NELIOTA)

Event from Kryoneri telescope at 2020-06-25 18:28:18

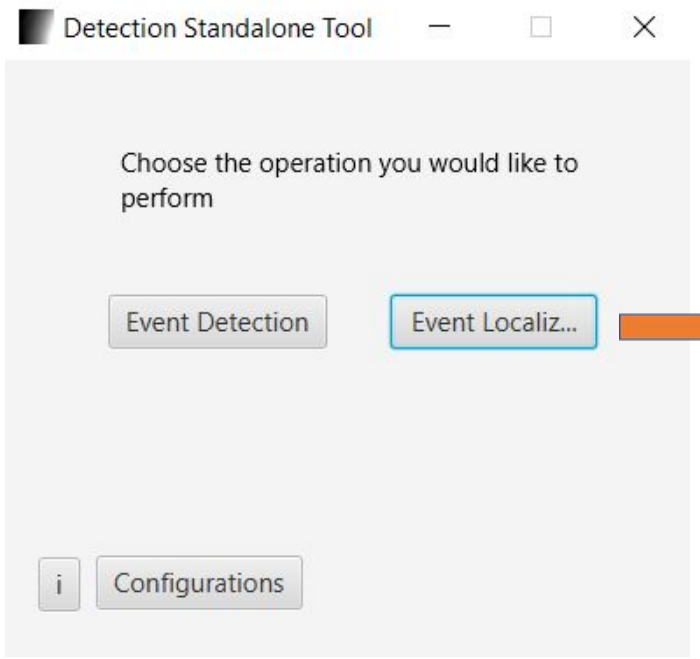
Set-up

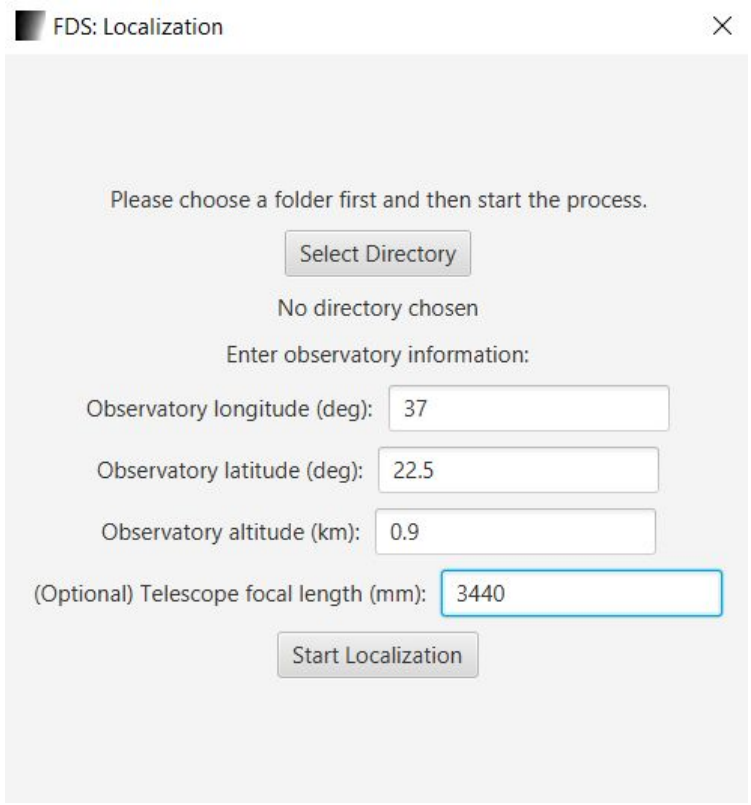
- We will perform the task of localization in an impact flash from Kryoneri telescope at 2020-06-25 18:28:18
- Choose the folder “FDS_localization_2”



Set-up

- Click “Event Localization”
- Select the Directory of the event
- Input observatory information as shown in the figure
- This time, give the focal length of the telescope to calculate the pixel scale
- Press “Start Localization”

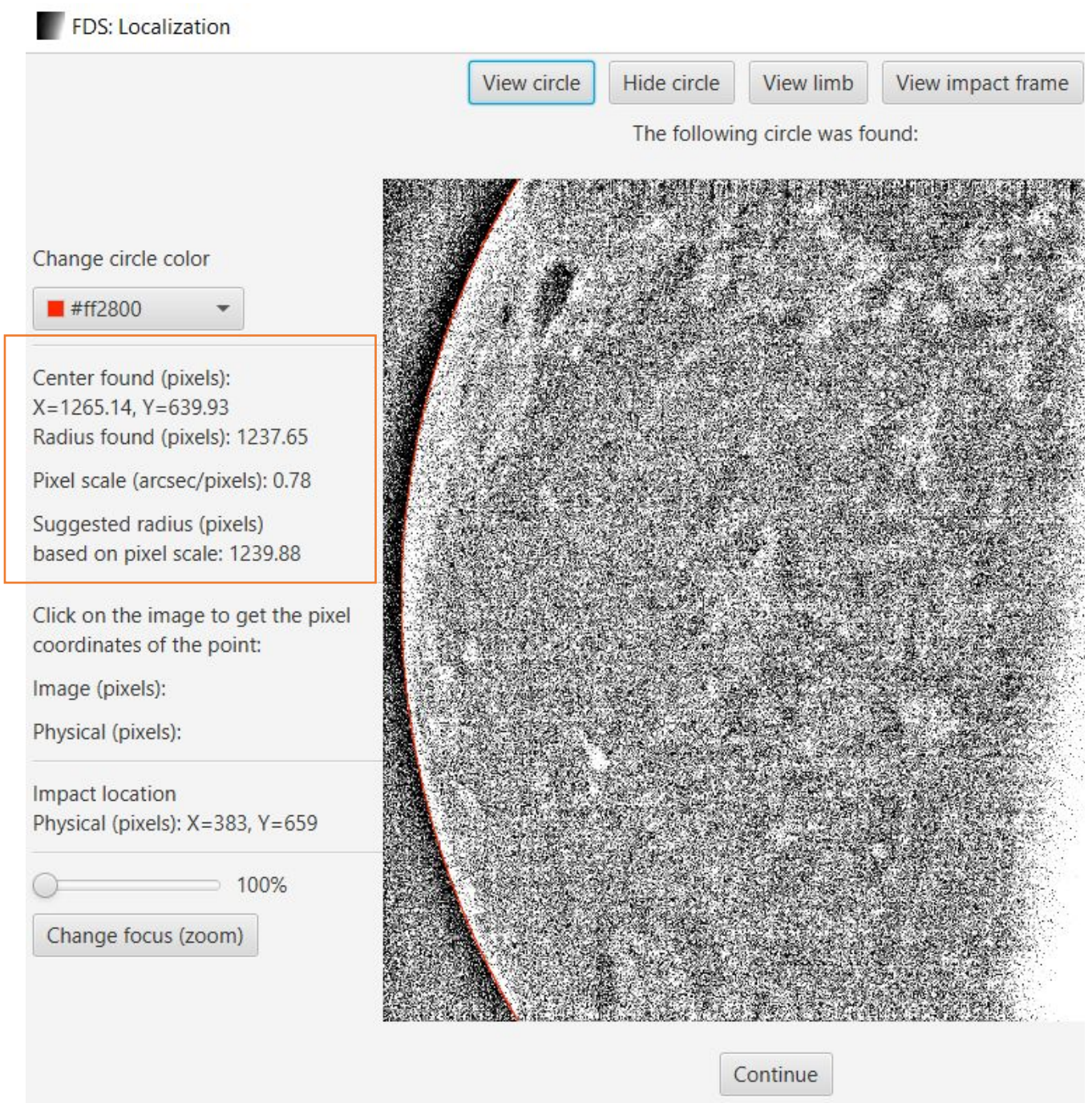




Fitting Circle

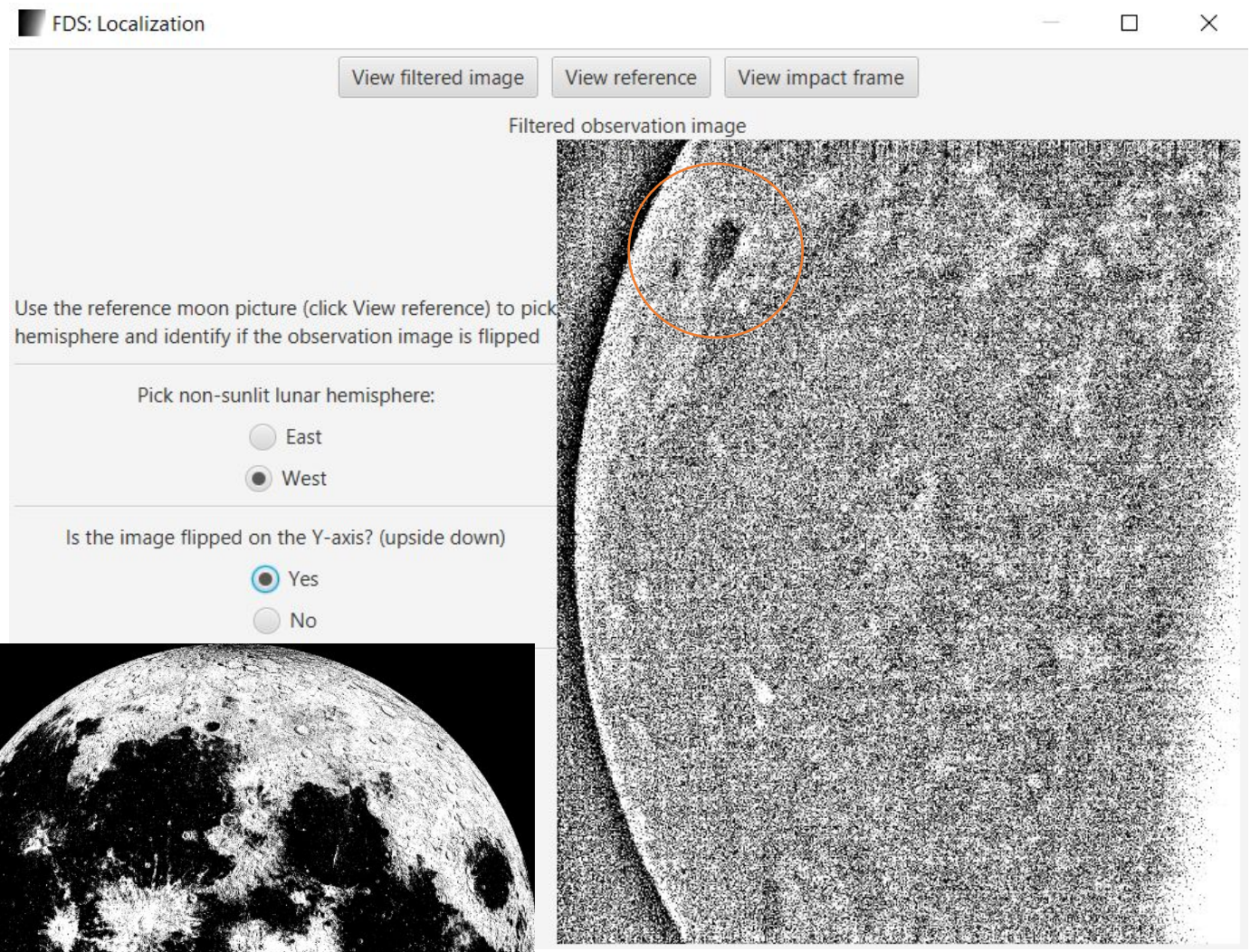
- With the pixel scale, a suggested radius is calculated
- Compare with radius found by circle fitting

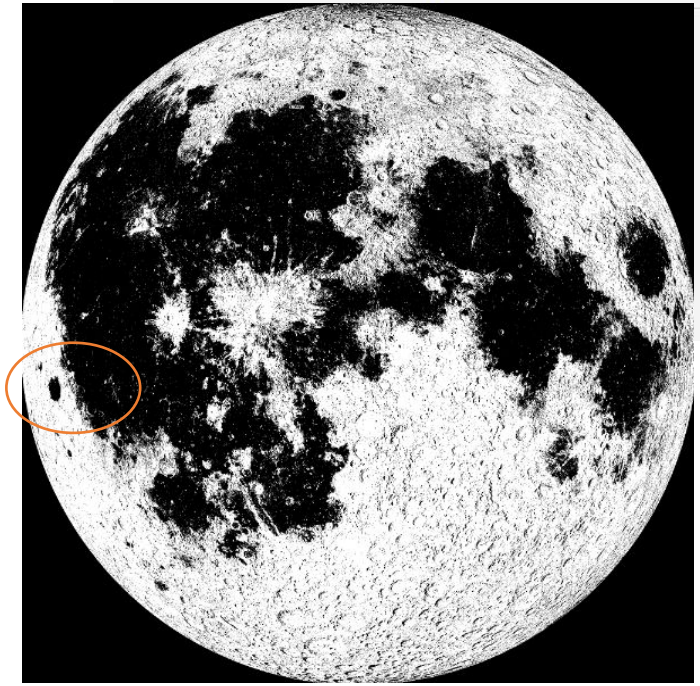
$$206.265 \frac{pixel\ size\ (\mu m)}{focal\ length\ (mm)} = \frac{arcsec}{pixel}$$



Next Step

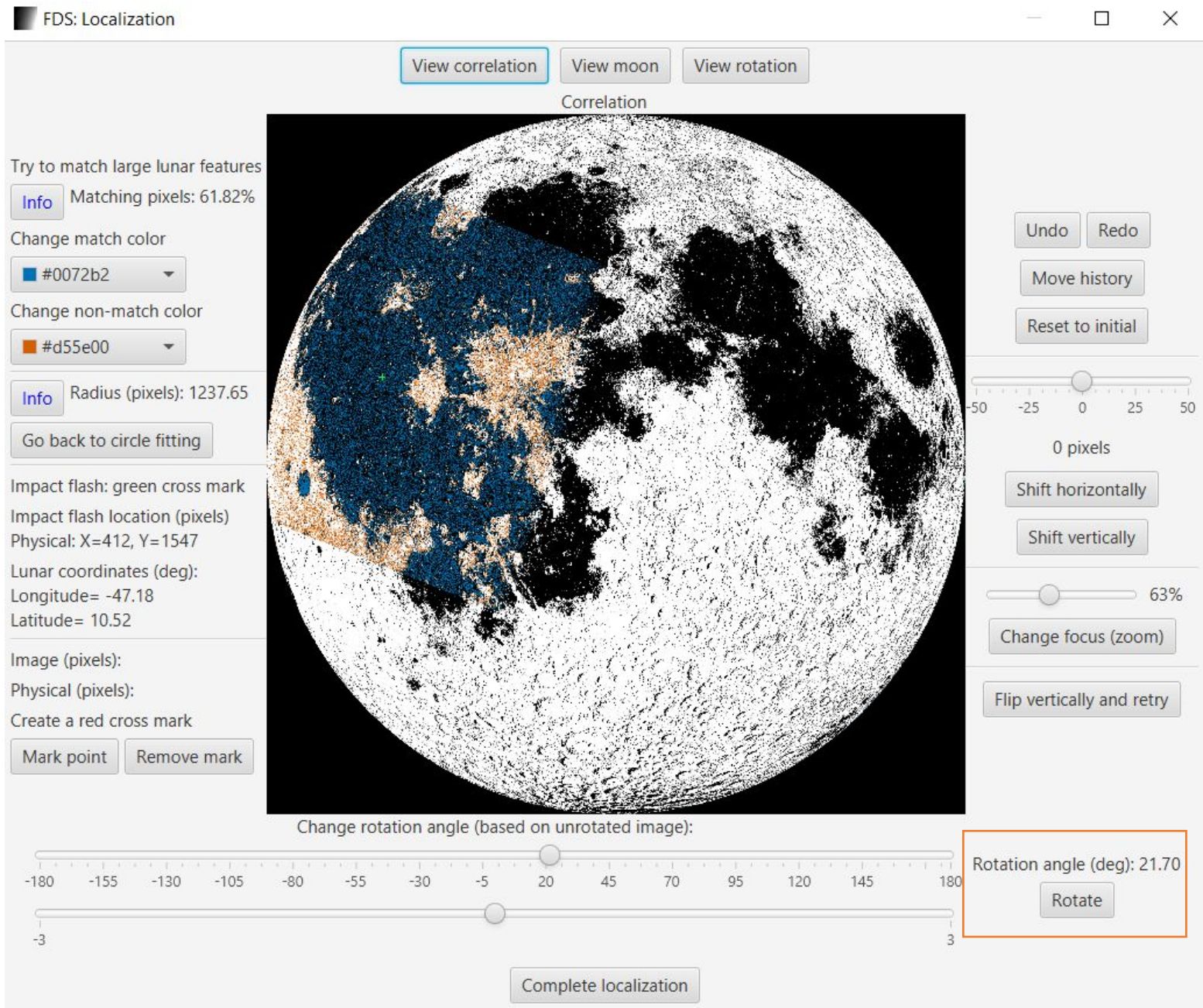
- Is the non-sunlit lunar hemisphere the east or the west?
  - Ø West
- Is the image flipped?
  - Ø Yes
- Let's do **automatic rotation**





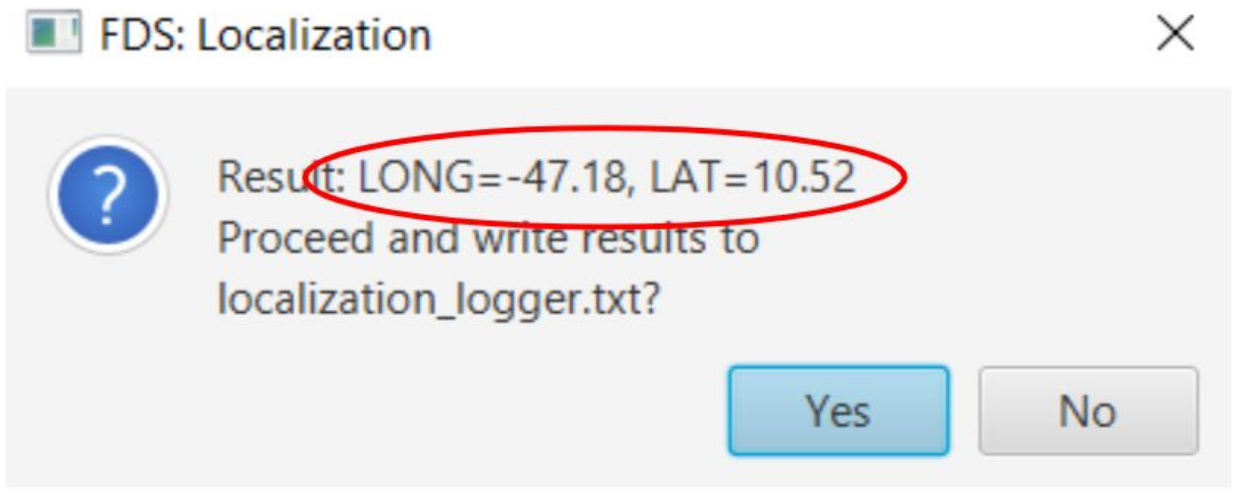
Automatic rotation

- Automatic rotation found a rotation angle of 21.7 degrees



Grimaldi crater is correctly matched

Comparing results with NELIOTA



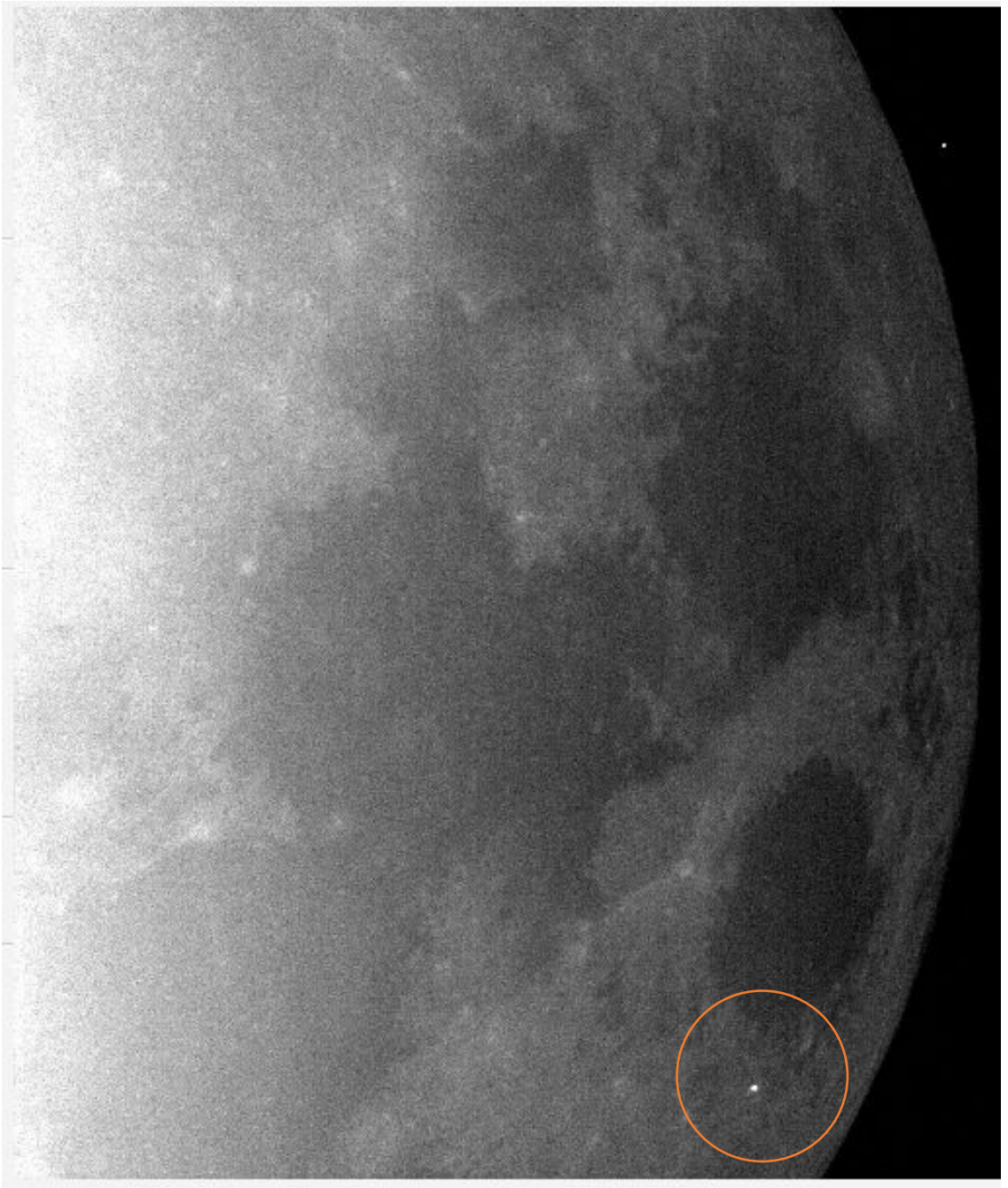
Event Data	
UT Date (DD/MM/YYYY):	25/06/2020
UT Time:	18:28:18.340
R (mag):	7.9 ± 0.1
I (mag):	6.7 ± 0.0
Lunar Long (deg):	-46.5
Lunar Lat (deg):	10.8
Duration (sec):	0.132

Third Event (provided by NELIOTA)

Event from Kryoneri telescope at 2018-08-08 02:29:44

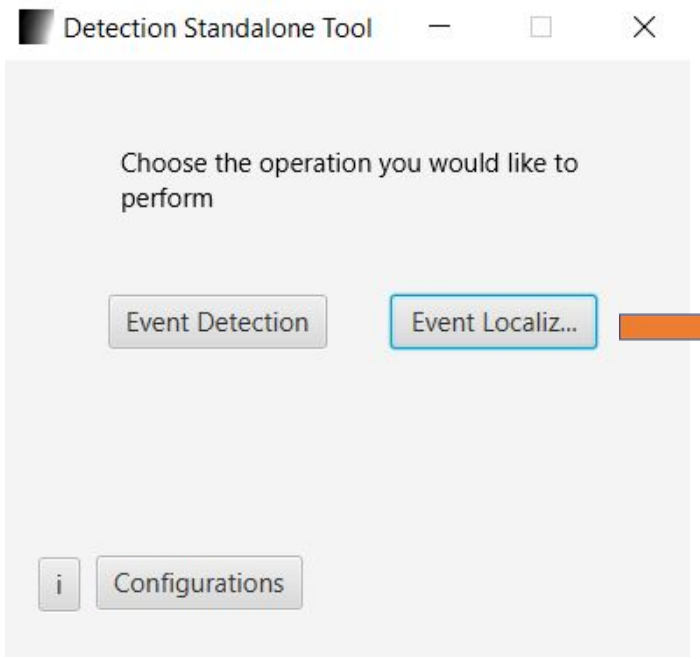
Set-up

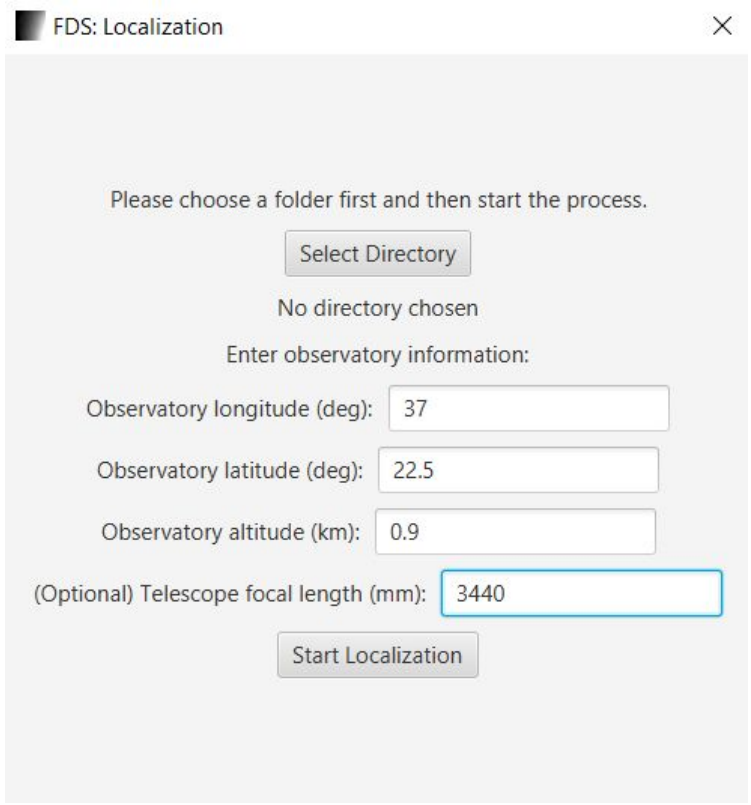
- We will perform the task of localization in an impact flash from Kryoneri telescope at 2018-08-08 02:29:44
- Choose the folder “FDS_localization_3”



Set-up

- Click “Event Localization”
- Select the Directory of the event
- Input observatory information as shown in the figure
- This time, give the focal length of the telescope to calculate the pixel scale
- Press “Start Localization”

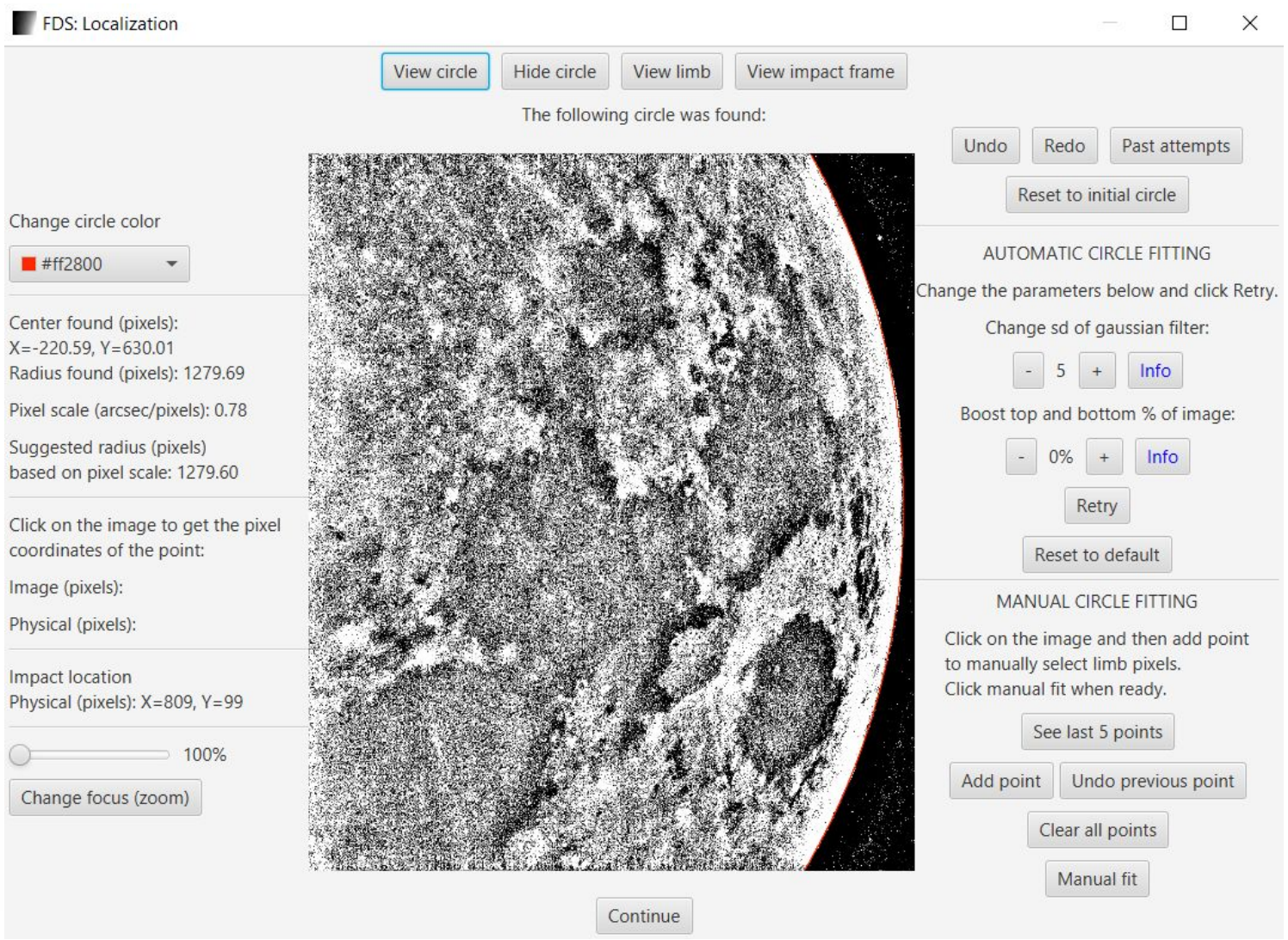




Fitting Circle

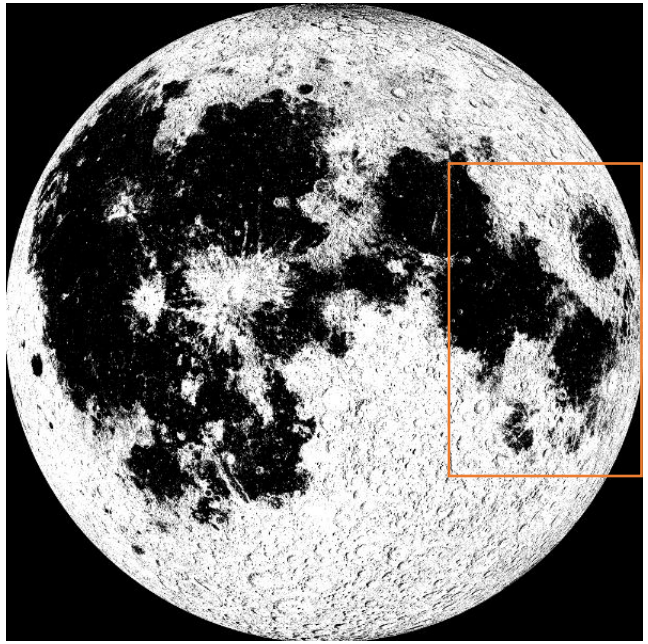
- With the pixel scale, a suggested radius is calculated
- Compare with radius found by circle fitting
- Clear image, better results

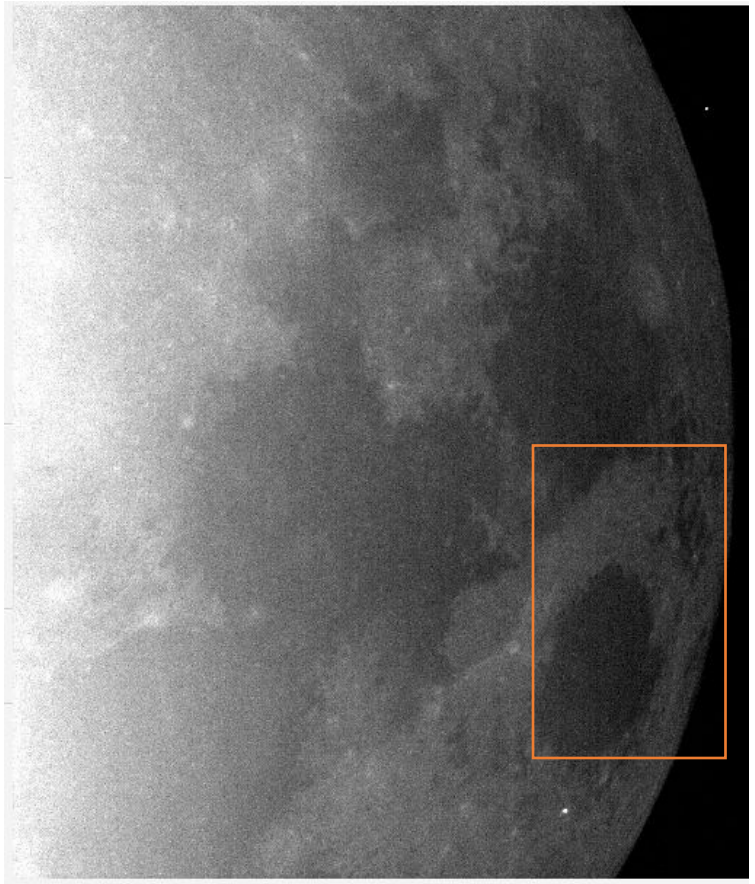
$$206.265 \frac{pixel\ size\ (\mu m)}{focal\ length\ (mm)} = \frac{arcsec}{pixel}$$



Next Step

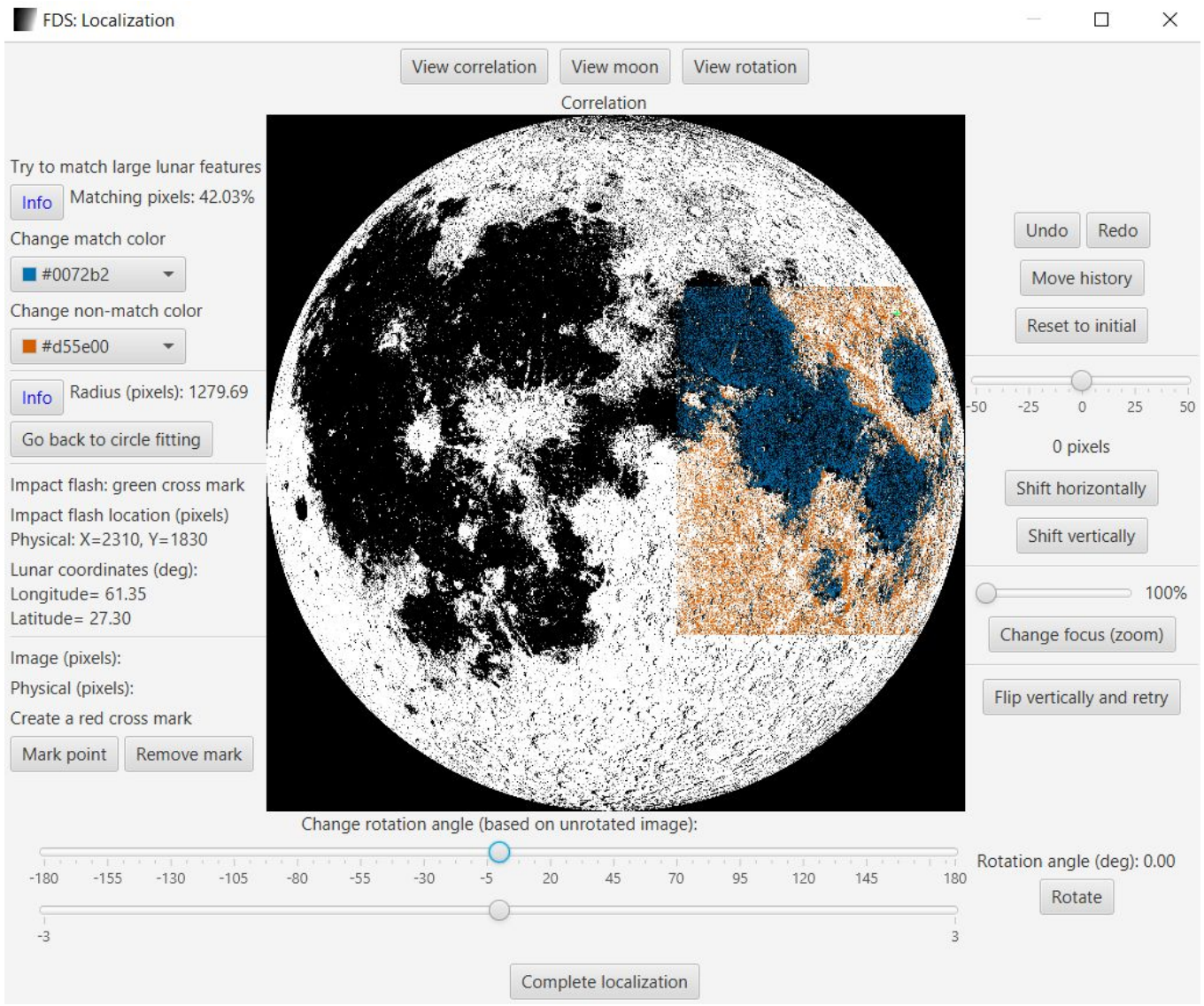
- Is the non-sunlit lunar hemisphere the east or the west?
  - Ø West
- Is the image flipped?
  - Ø Yes
- This time we will not do **automatic rotation**





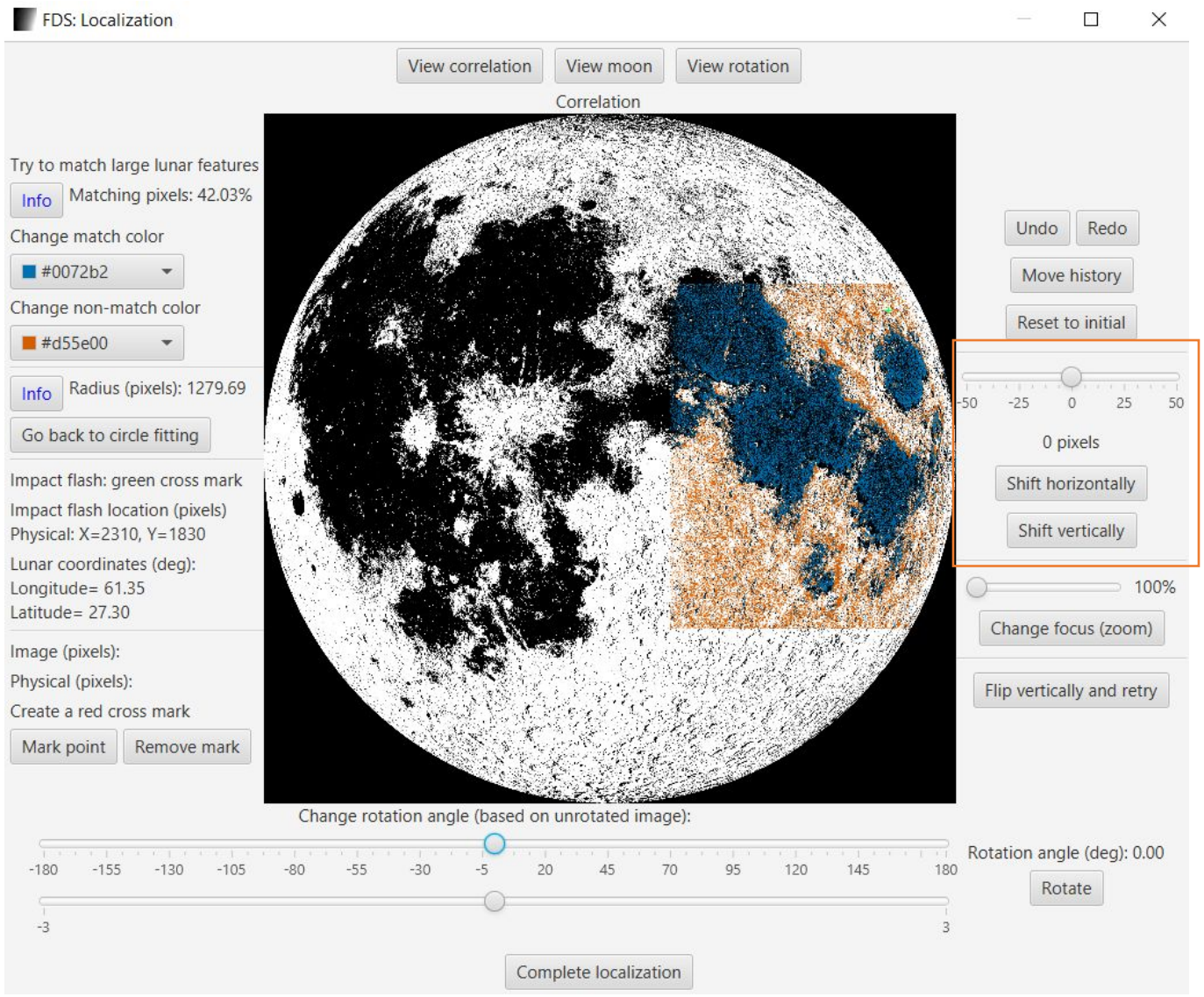
Find the right rotation

- This time try to find the right rotation
- Use rotation of 1.2 degrees

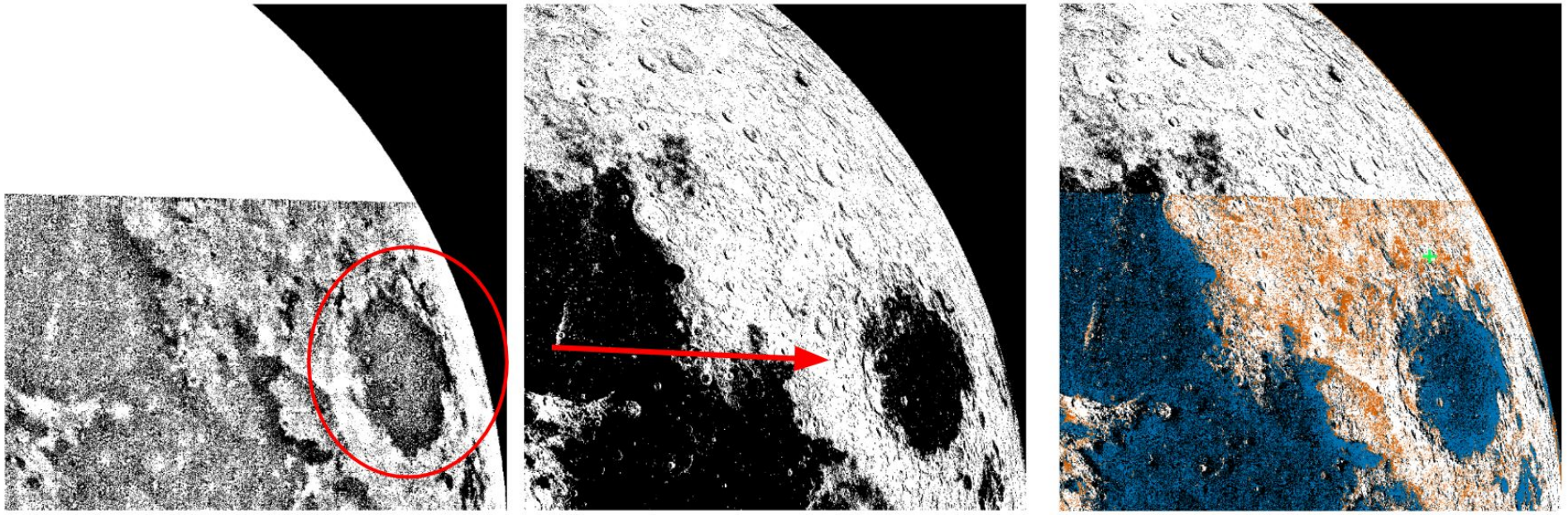


Shift Horizontal and Vertical

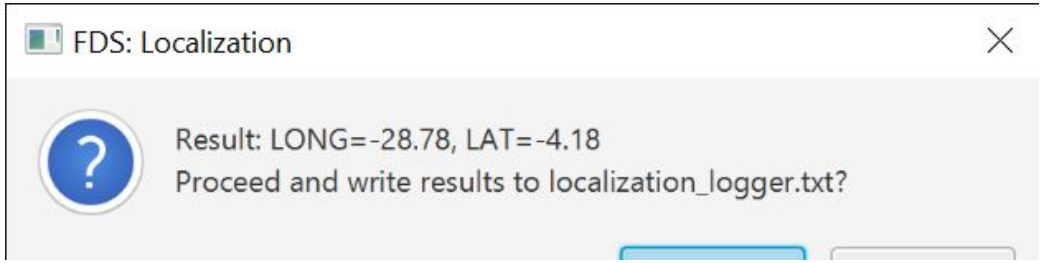
- Horizontal shift by 6 pixels
- Vertical shift by 3 pixels



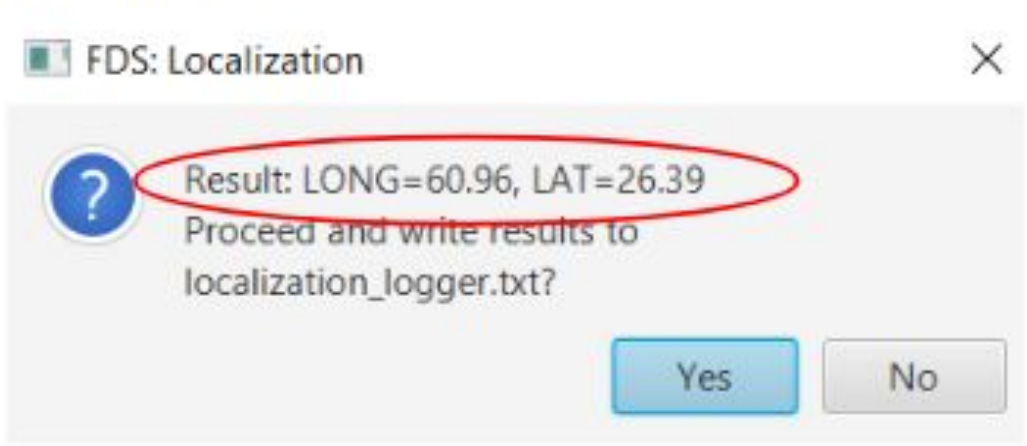
Mare Crisium is now correctly placed



- If you are satisfied with the correlation press "Complete Localization"



Comparing results with NELIOTA



Event Data	
UT Date (DD/MM/YYYY):	08/08/2018
UT Time:	02:29:44.573
R (mag):	8.4 ± 0.0
I (mag):	7.3 ± 0.0
Lunar Long (deg):	60.2
Lunar Lat (deg):	26.6
Duration (sec):	0.165

Thanks for your attention