



Flash Detection Software

Workshop Section

Capture your own Impact Flash

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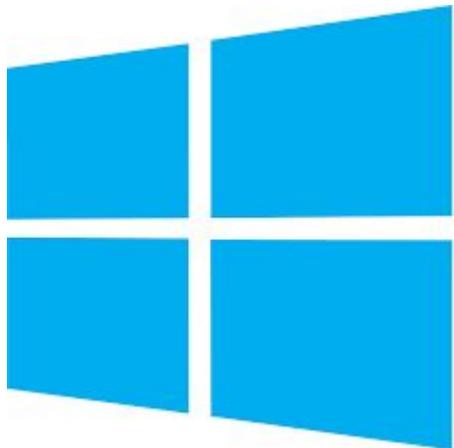
ESA Contract No.
4000135574/21/NL/IB/gg



Installation

What Operating System do you have?

- Our Software works for all 3 major OS

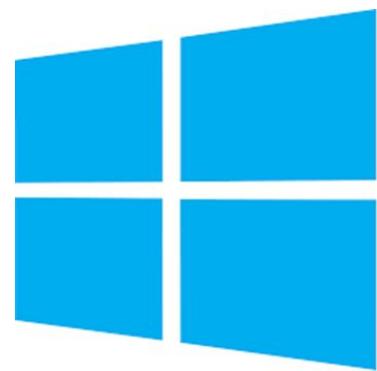




Online Detection Domain:

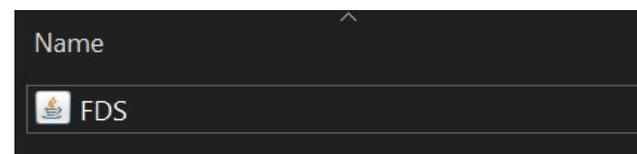
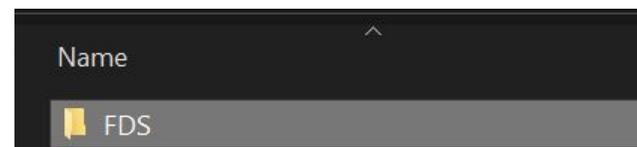
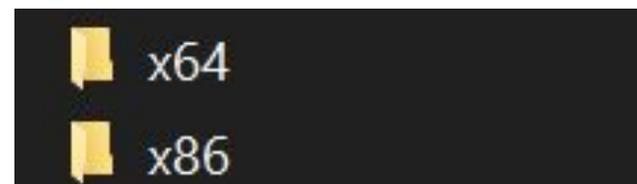
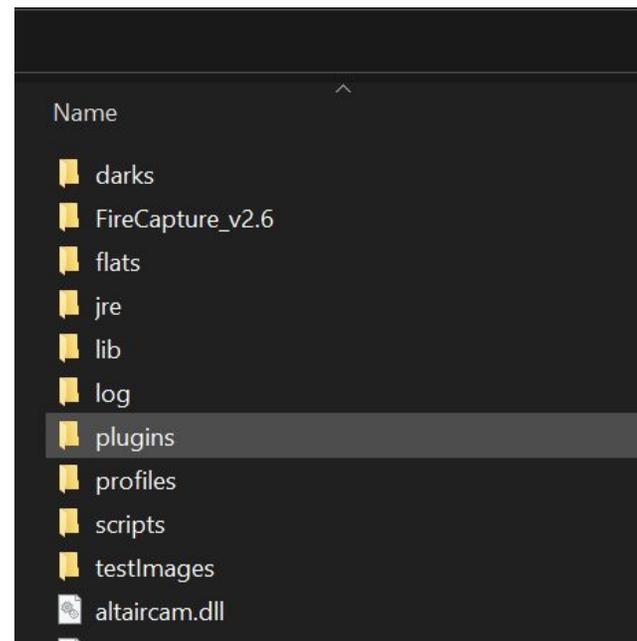
- Visit FireCapture Site:
 - <http://www.firecapture.de/>
- Scroll down and download FireCapture Version based on your OS
- Then install FireCapture





Online Detection Domain:

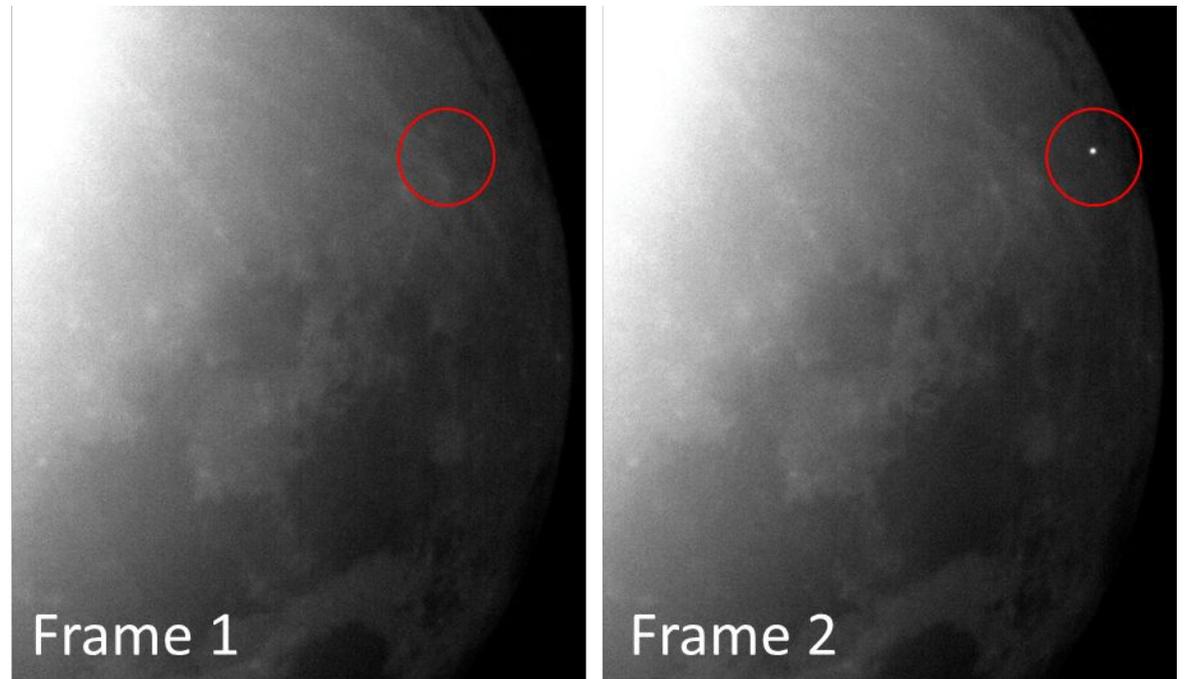
- Download our FDS Plugin
 - Download [this](#) jar
 - Name: FDS.jar
- Open FireCapture Folder
- Go to the “Plugins” folder (Fig. 1)
- Open **x64** or **x86** folder depending on your installation (Fig. 2)
- Create a folder (Fig. 3)
 - Name: FDS
- Inside this folder place our plugin “FDS.jar” (Fig.4)



Simulations:

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

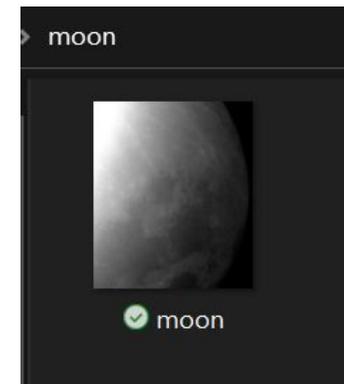
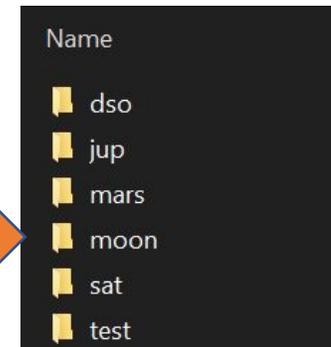
Example of such video



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

PreProcessing & Plugins

Reset all Filter / Plugins

ON / OFF	Visible	Filter / Plugin
<input checked="" type="checkbox"/>		Contrast
<input checked="" type="checkbox"/>		Live-Stacking
<input checked="" type="checkbox"/>		Average
<input checked="" type="checkbox"/>		Mosaic-Helper
<input type="checkbox"/>		Color-Saturation
<input checked="" type="checkbox"/>		Bright Object
<input checked="" type="checkbox"/>		Moving Object (daytime)
<input checked="" type="checkbox"/>		Moving Object (night)
<input checked="" type="checkbox"/>		Planetary mask
<input checked="" type="checkbox"/>		FDS v0.09.1
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	FDS v0.09.1
<input checked="" type="checkbox"/>		Planetary mask

FireCapture v2.6.08 DummyCam (T=20.2°C)

Image
16 Bit Bin 2x Max (1080x1280)
ROI 300 x 300

Control
Gain 3600
Exp. (ms) 0.000
Gamma 100
More 1.00 - 200 ms

Capture
2022-07-29-1640_0-R-Moon
Moon R
No limit SER

Status
FPS (max/actual) ∞ 1428.57
Captured/Saved 0 0
RAM 819 MB HDD 8.705 MB

Histogram

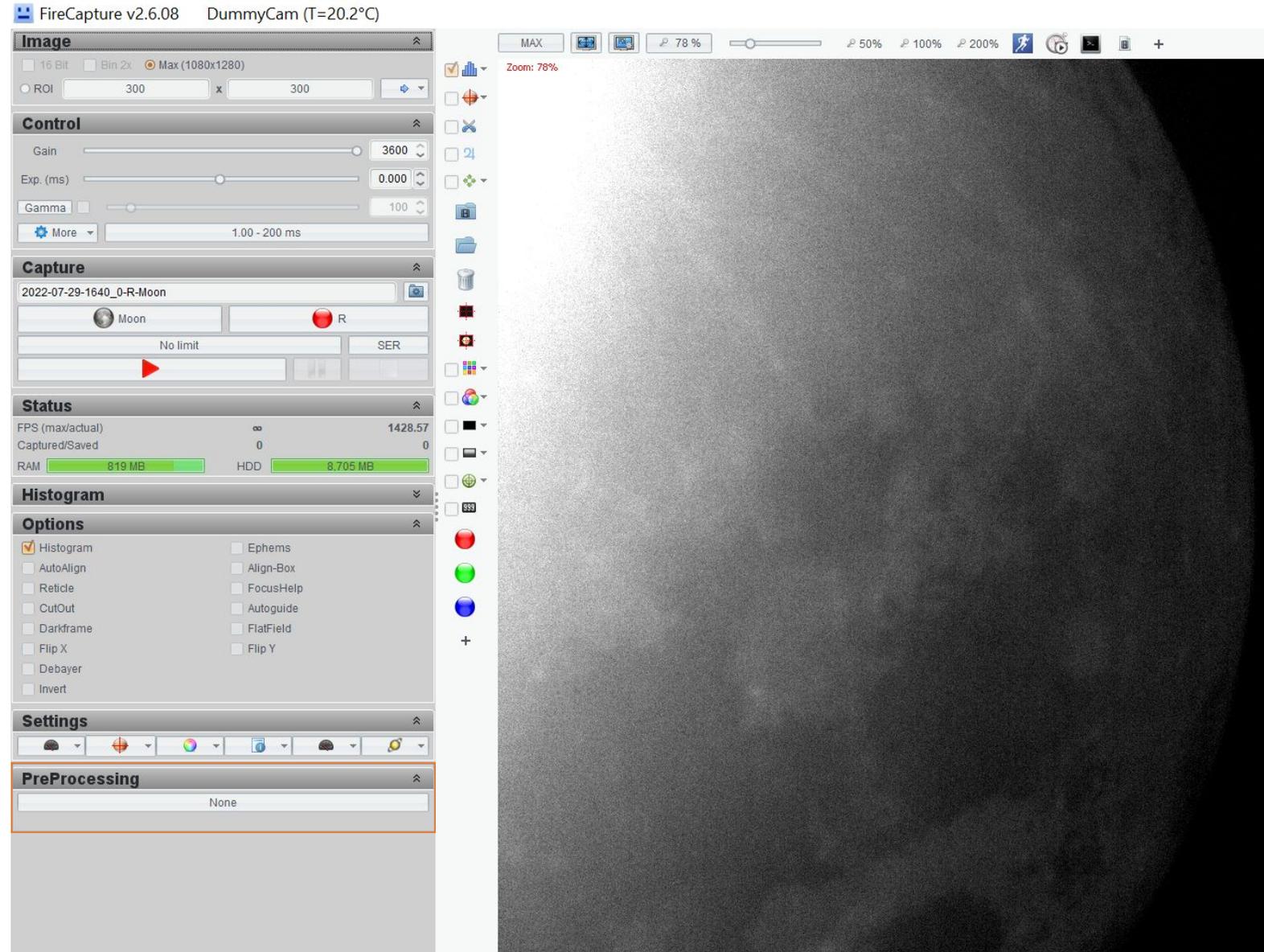
Options
 Histogram Ephems
 AutoAlign Align-Box
 Reticle FocusHelp
 CutOut Autoguide
 Darkframe FlatField
 Flip X Flip Y
 Debayer
 Invert

Settings

PreProcessing
None

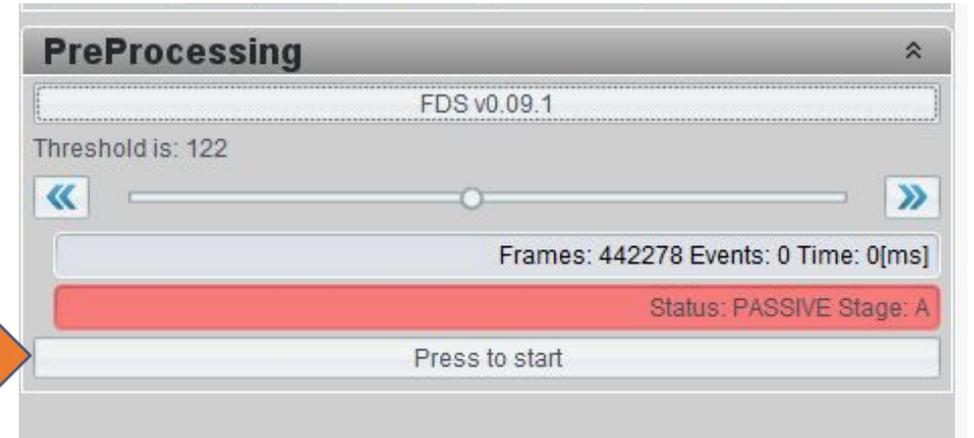
MAX 78% 50% 100% 200%

Zoom: 78%



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



```
FDS Logger: FDS v0.09.1
Logger position: 0, 0
FdsProperties constructor
FdsProperties: Get the properties from the file
FdsProperties: get properties not changeable through the dialog GUI
  RESET fds.event.frames.minimum to '1'
  RESET fds.event.frames.maximum to '100'
  RESET fds.event.aveframe.alpha.minimum to '0.1'
  RESET fds.event.aveframe.alpha.maximum to '0.9'
  RESET fds.logger.function.code to '0'
NullPointerException in: ./plugins/FcPluginFds.properties   fds.event.record.format
  RESET fds.event.record.format to 'DAT'
in: ./plugins/FcPluginFds.properties   fds.event.record.dir
  RESET fds.event.record.dir to 'C:\Users\stefo'
  RESET fds.event.frames.before to '5'
  RESET fds.event.frames.after to '5'
  RESET fds.event.aveframe.alpha to '0.35'
Created properties file: ./plugins/FcPluginFds.properties
```

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

FDS parameters

Event Record Frames

Number of frames before

Number of frames after

Event record format PNG FITS PNG & FITS

Detection algorithm parameters

Average frame alpha

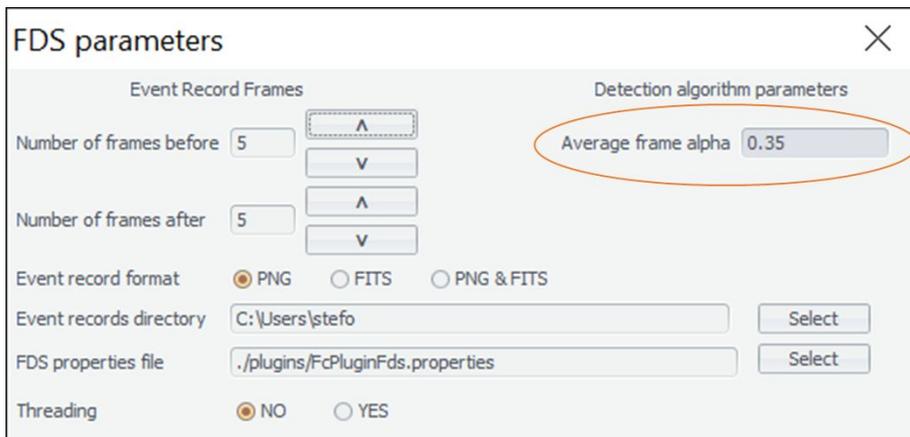
Event records directory

FDS properties file

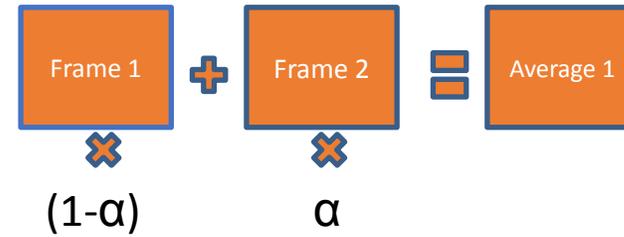
Threading NO YES

a-parameter

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

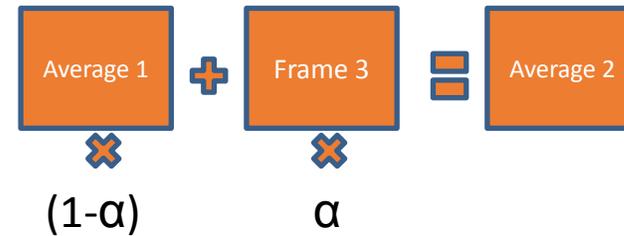


1-st average



$\alpha < 1.0$

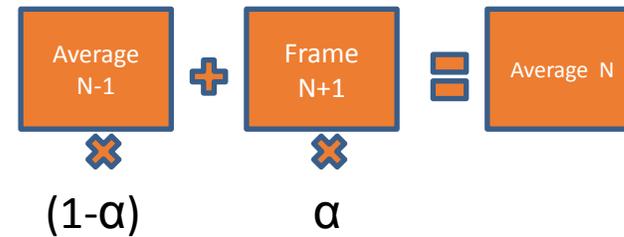
2-nd average



.....

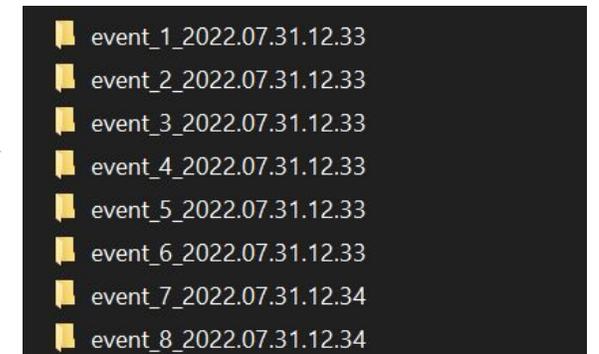
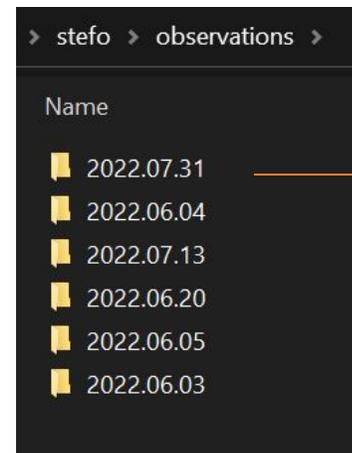
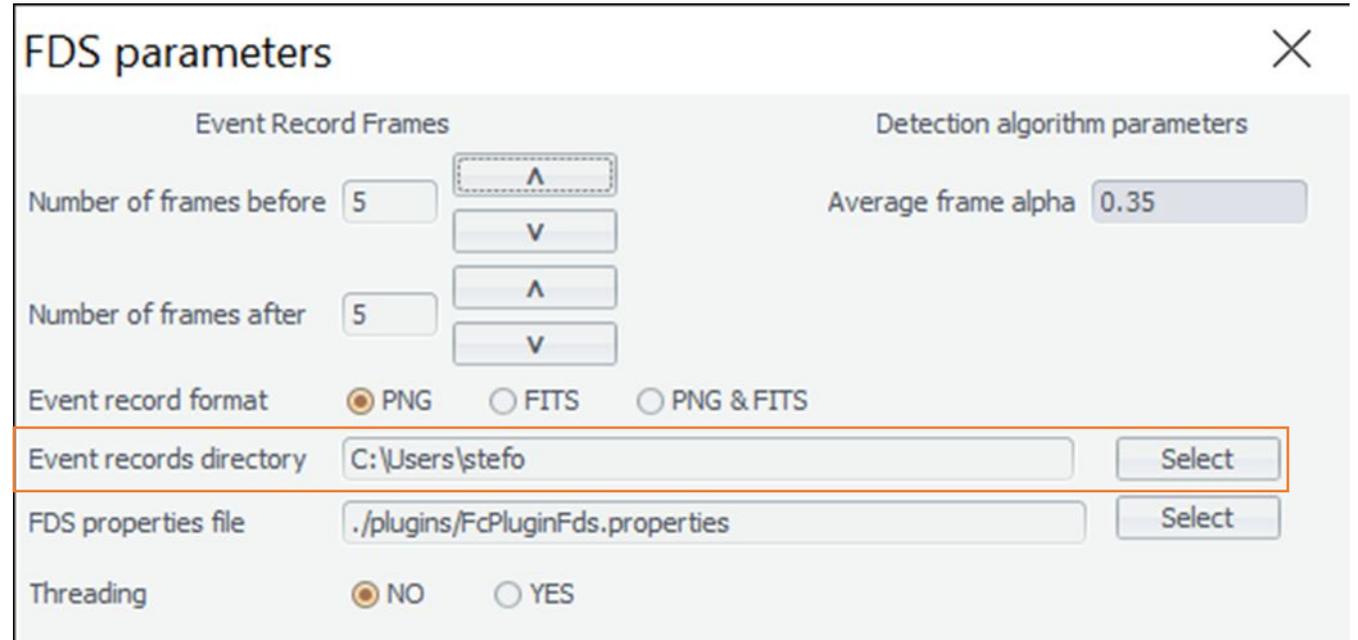


N-th average



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

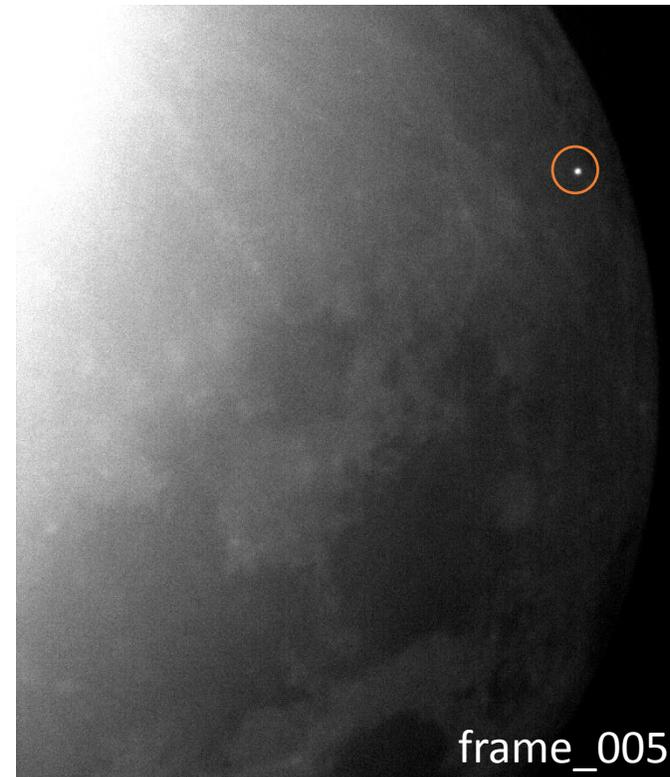
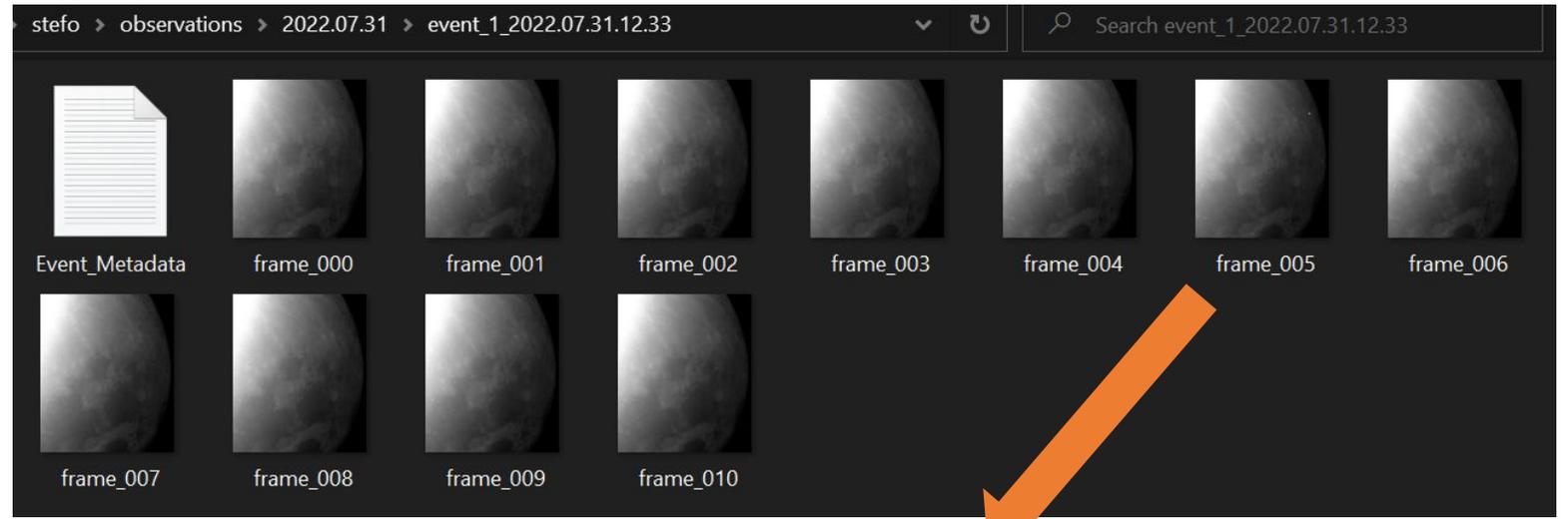


Output Files

- 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.

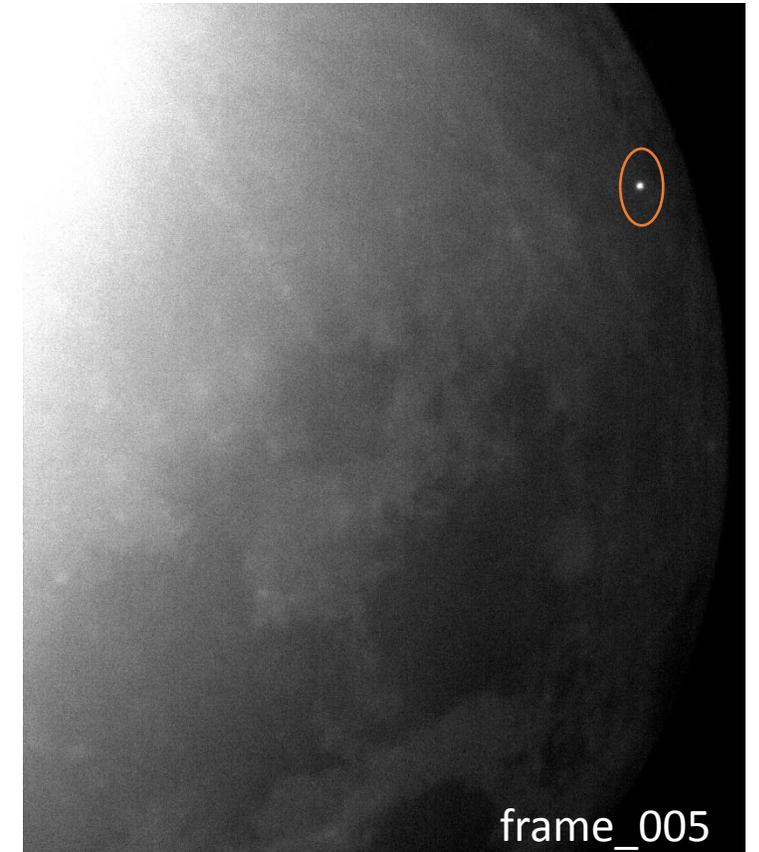
The coordinates of all the pixels that triggered capturing are:
x coordinate:161, y coordinate:336.

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



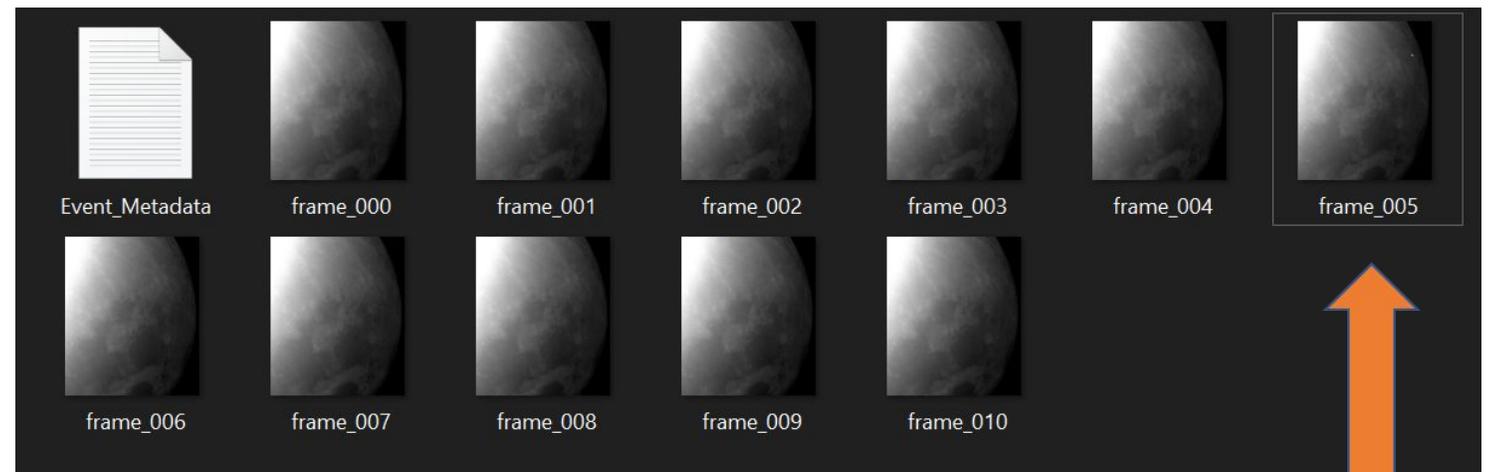
Results

- 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



FDS Logger: FDS v0.09.1

```
The number of pixels of the event is: 46.  
  
The writing process for the 5 captured event has ended.  
  
Detection occurred. The writing process starts. This is the 6 captured event.  
The event occurred at: 2022-08-09 08:13:14.967 (UTC).  
The number of pixels of the event is: 46.  
  
The writing process for the 6 captured event has ended.
```



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.

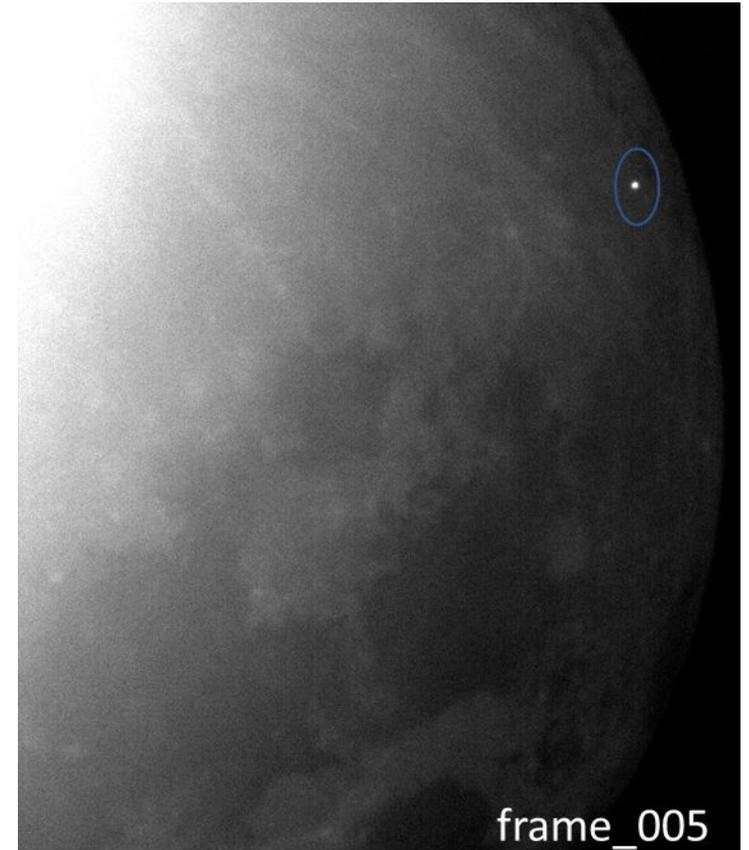
Camera Info:

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.
```



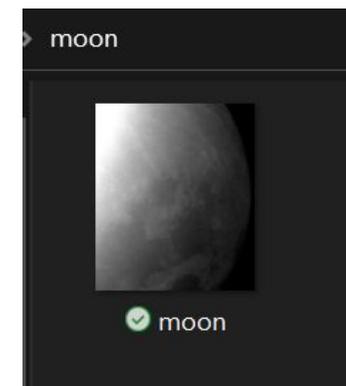
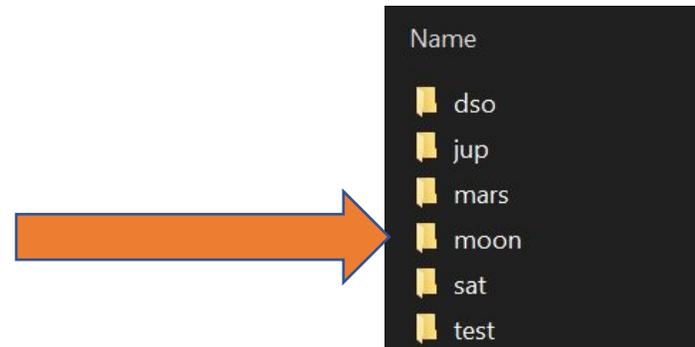
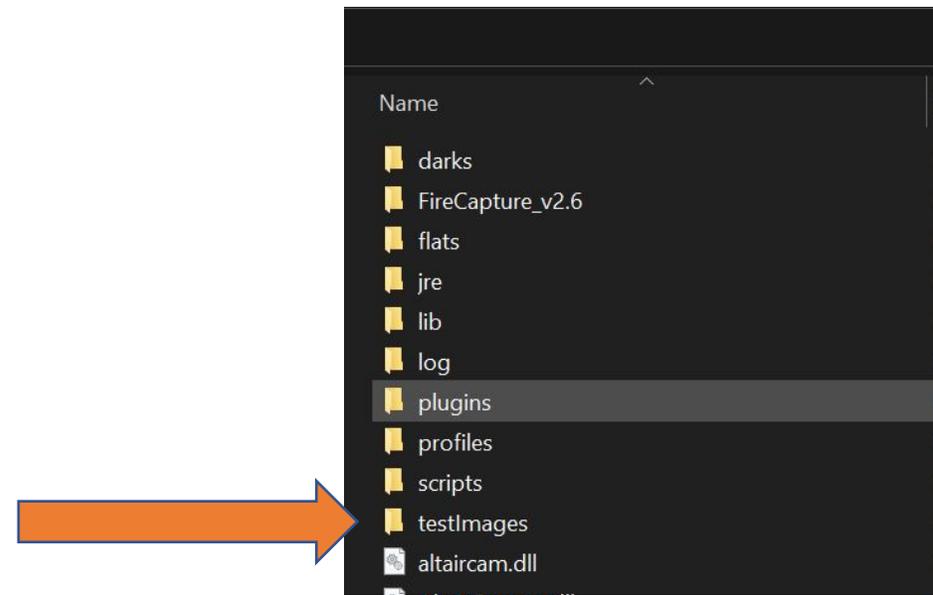
Second Event (provided by NELIOTA)

□ Multi-frame video

Set-up Second Simulation

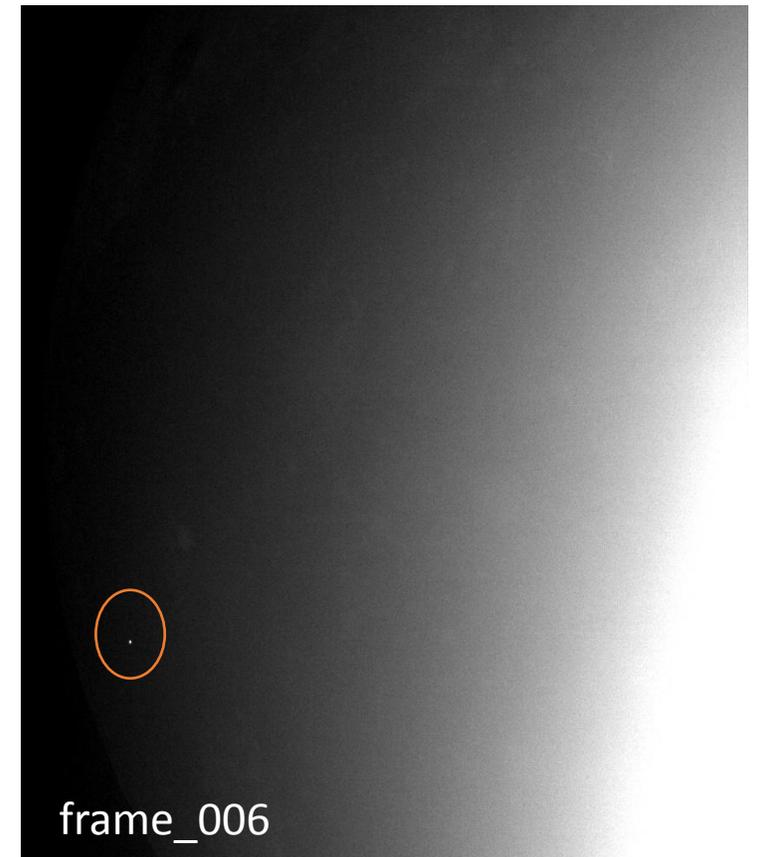
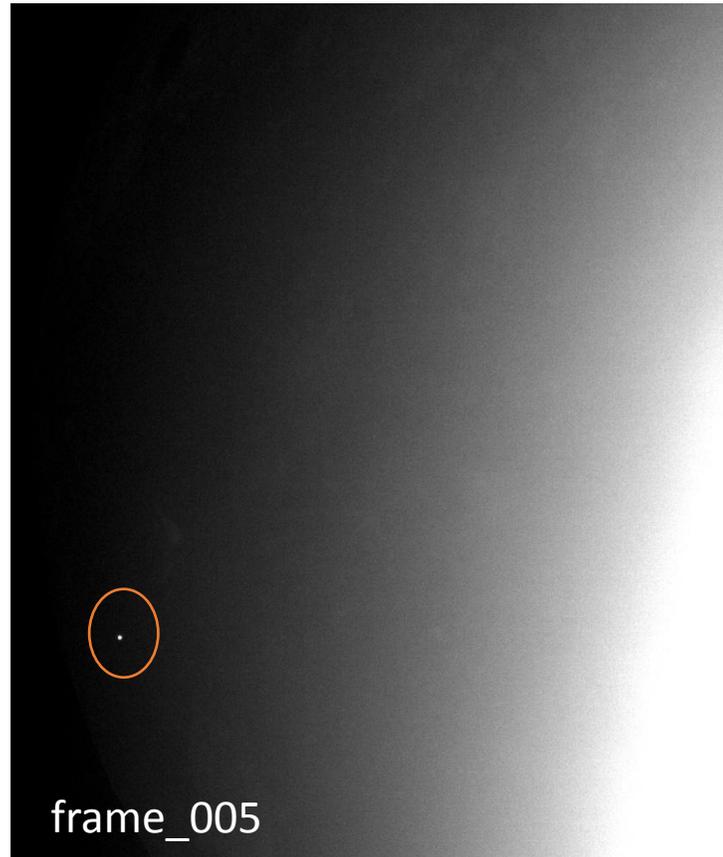
Now we will place the second event in FireCapture

- 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?



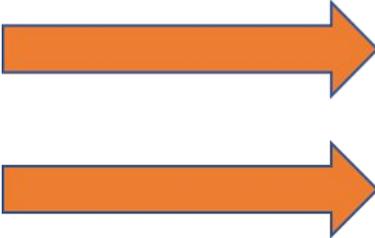
Discussion

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

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.
```

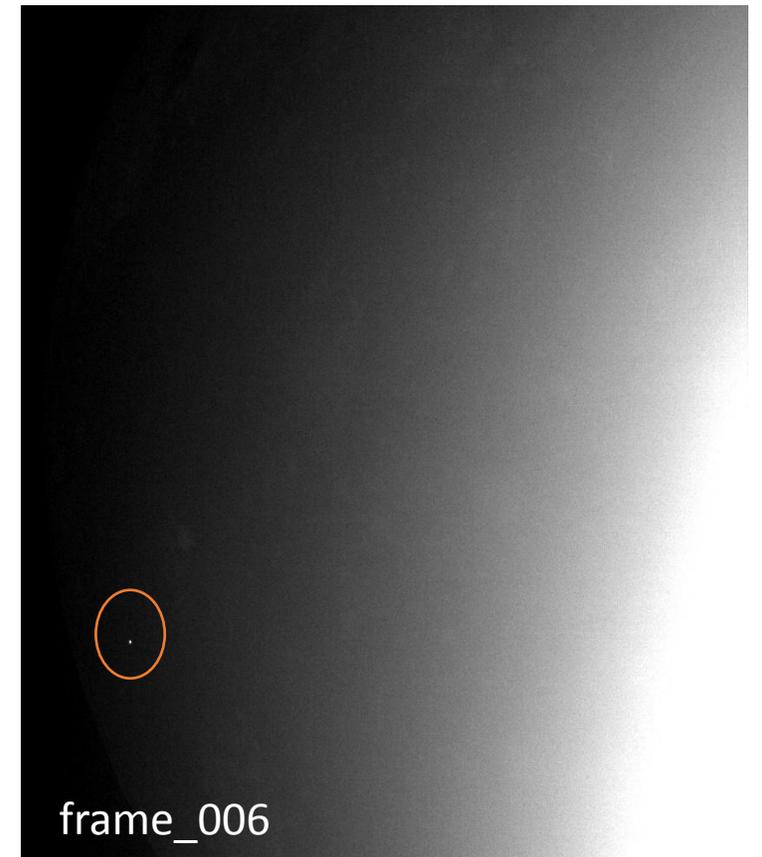
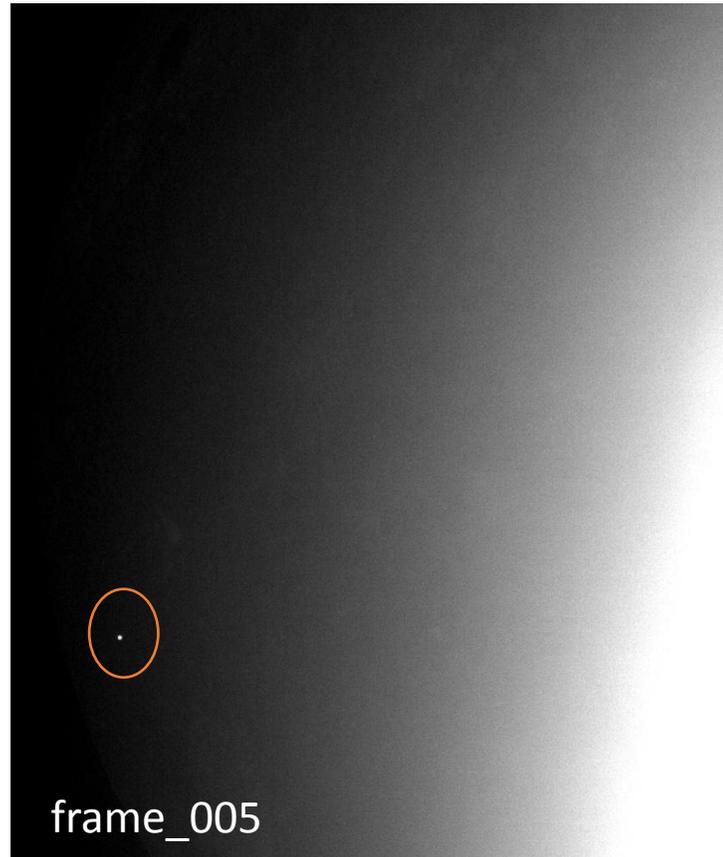


```
The duration of the event in frames is: 2.
```

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

Experiment:

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



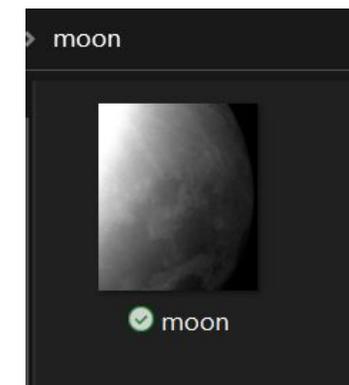
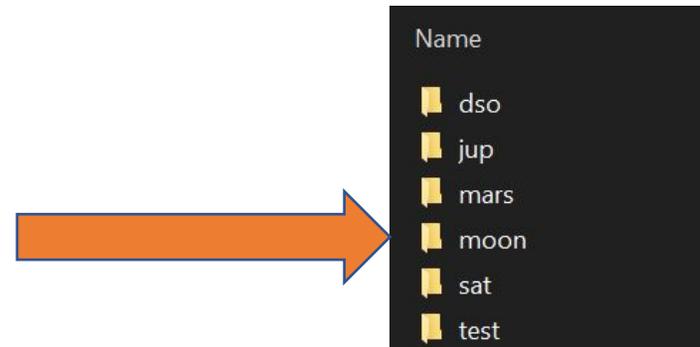
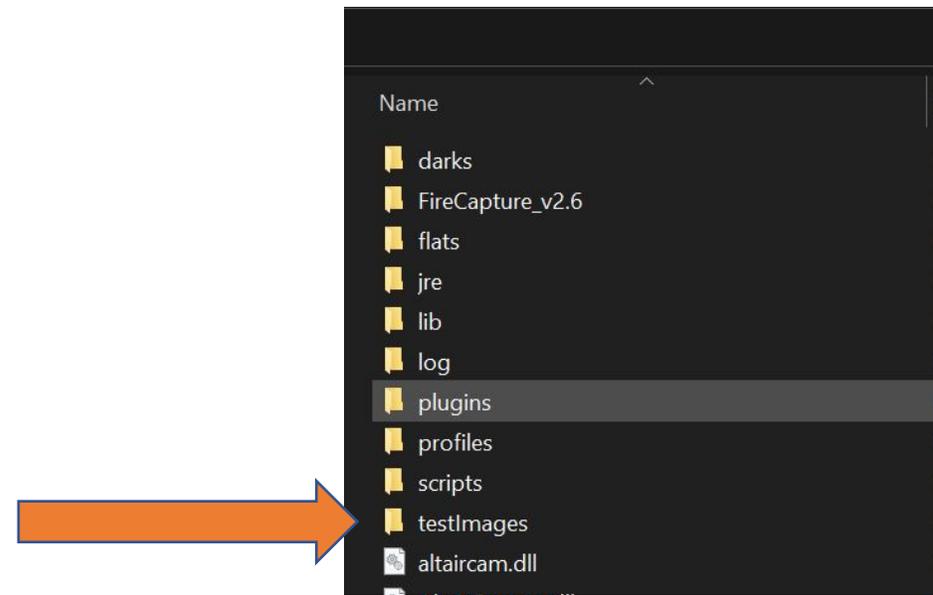
Third Event (provided by NELIOTA)

□ 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



FDS parameters

Event Record Frames

Number of frames before: 5

Number of frames after: 5

Event record format: PNG FITS PNG & FITS

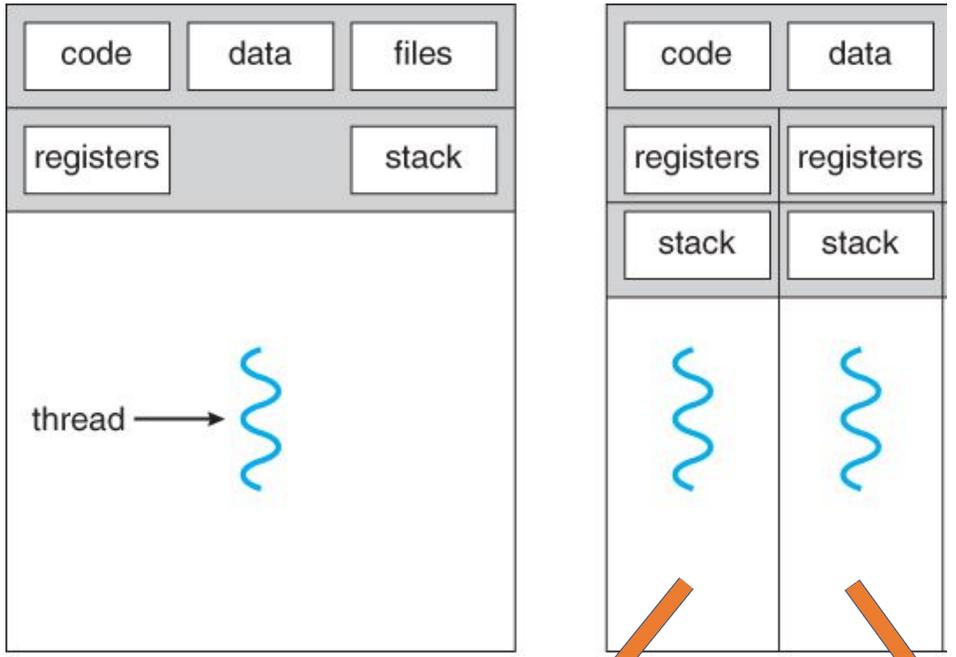
Event records directory: C:\Users\stefo

FDS properties file: ./plugins/FcPluginFds.properties

Detection algorithm parameters

Average frame alpha: 0.35

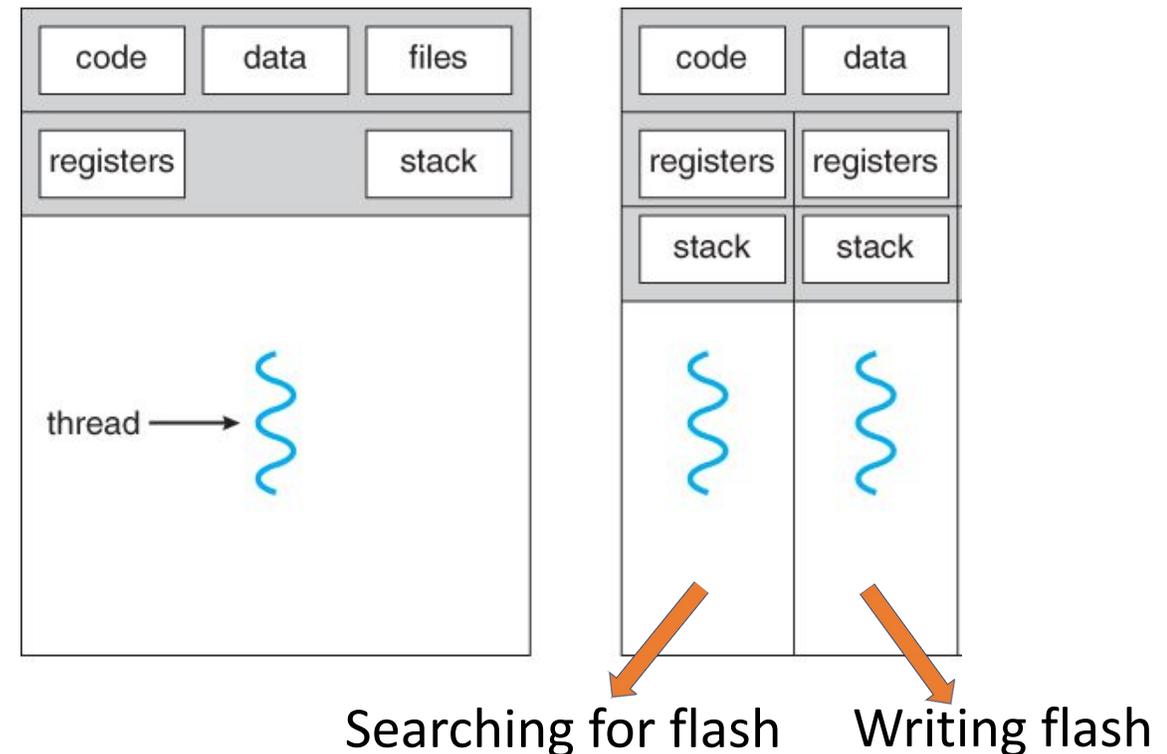
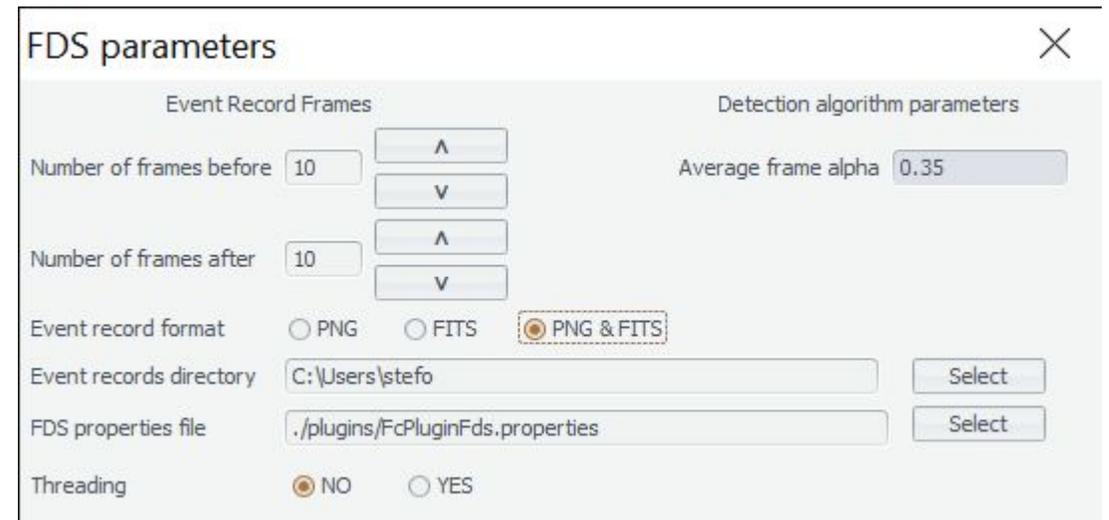
Threading: NO YES



Searching for flash Writing flash

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?

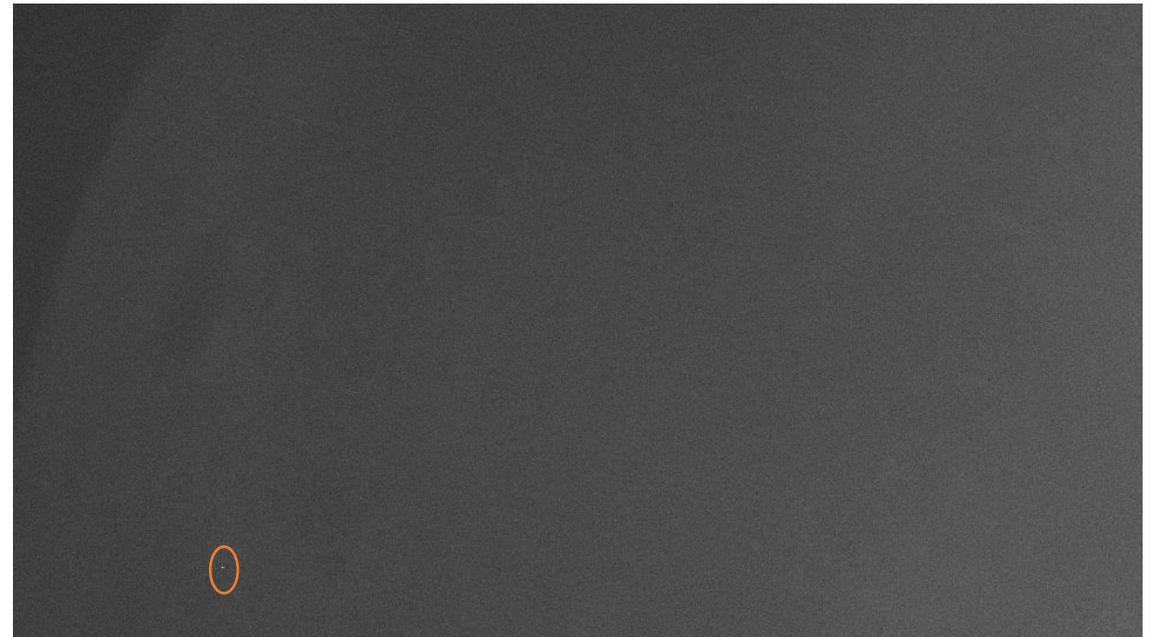


In which cases “threading” could be a problem?

Discussion

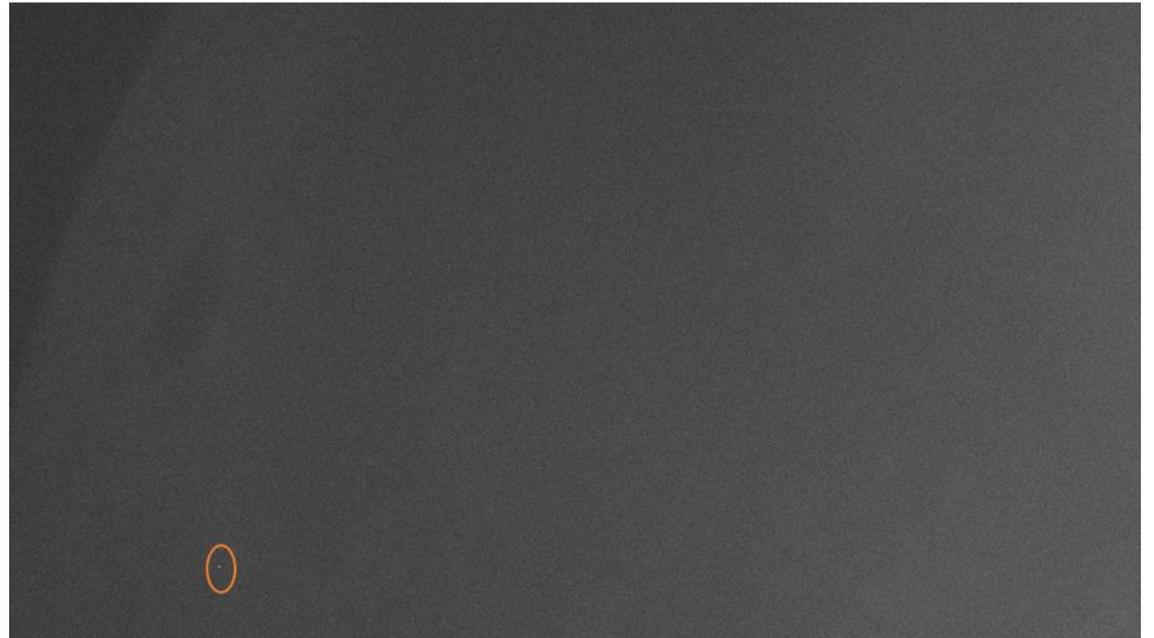
Discussion:

- 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?



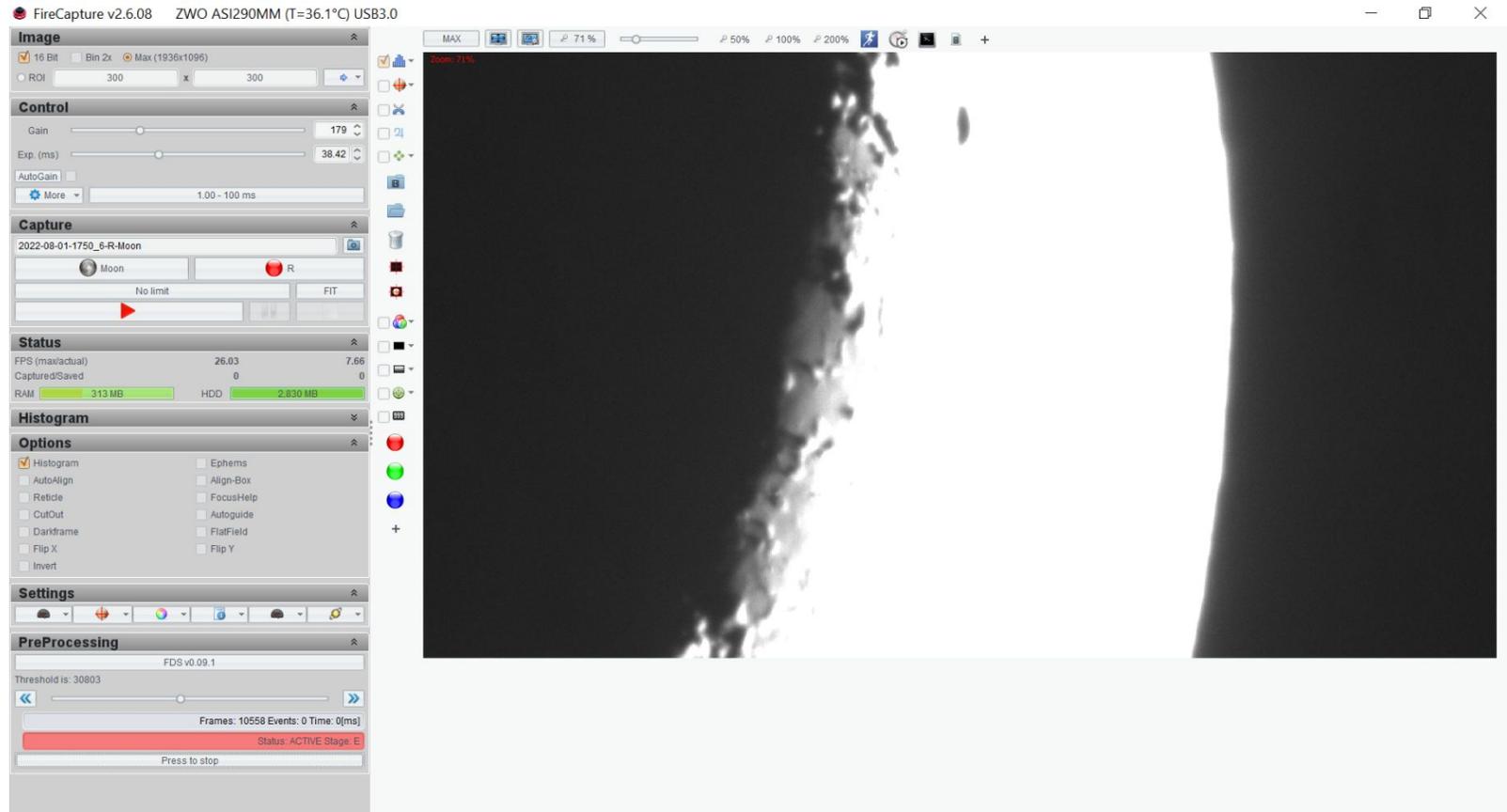
Question

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



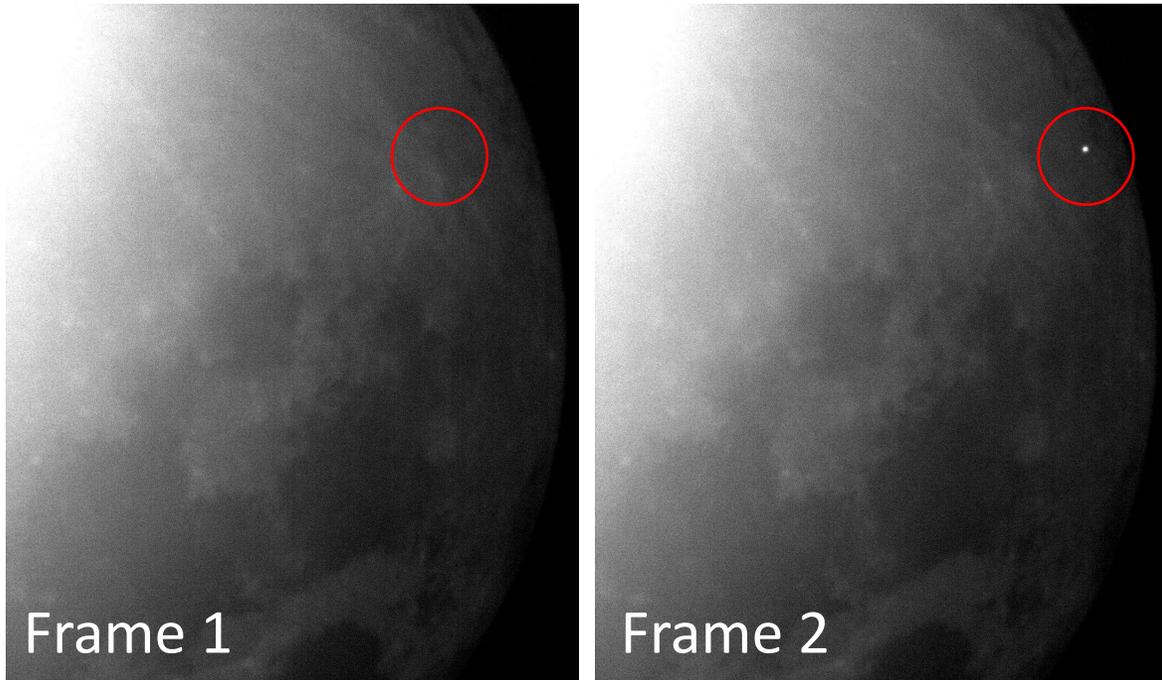
Question

- 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?

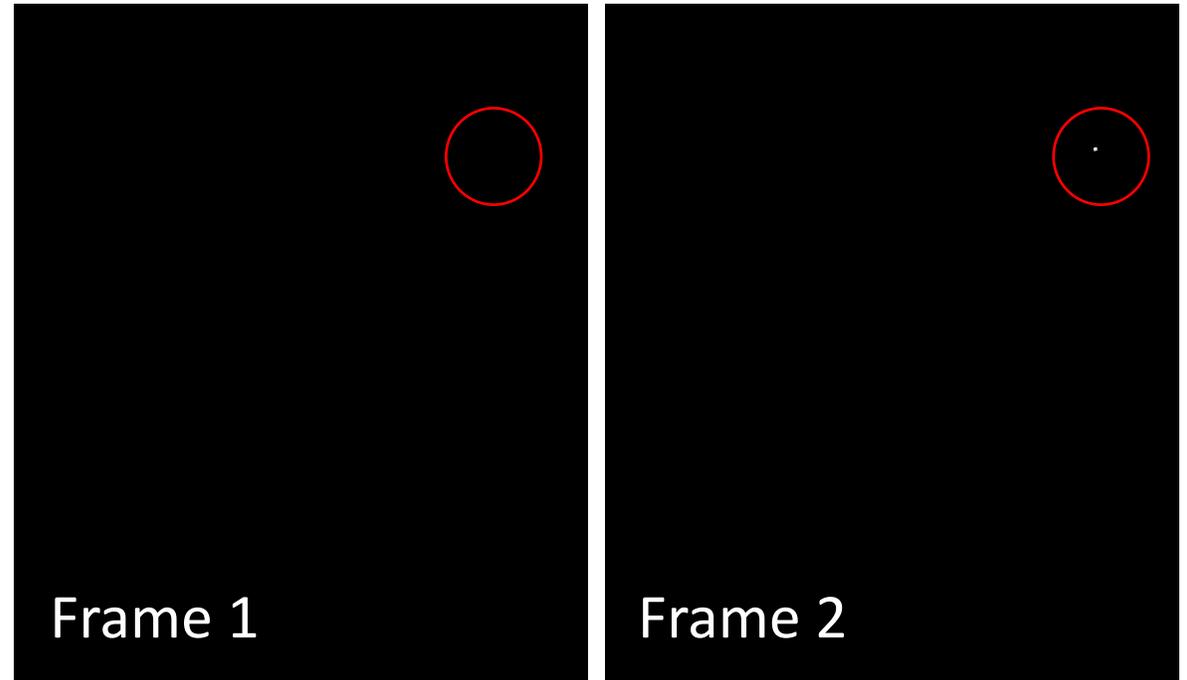


Why?

Before Processing



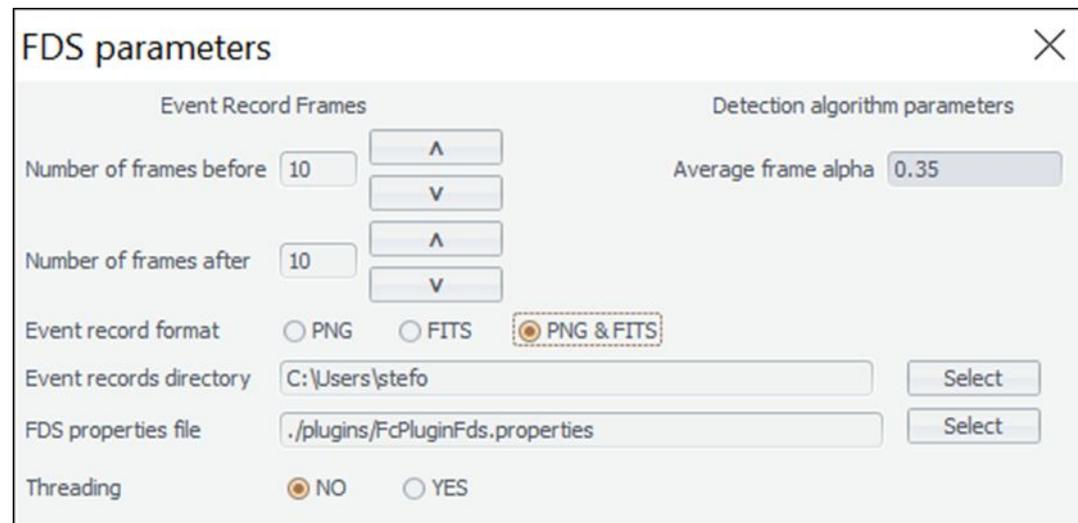
After Processing



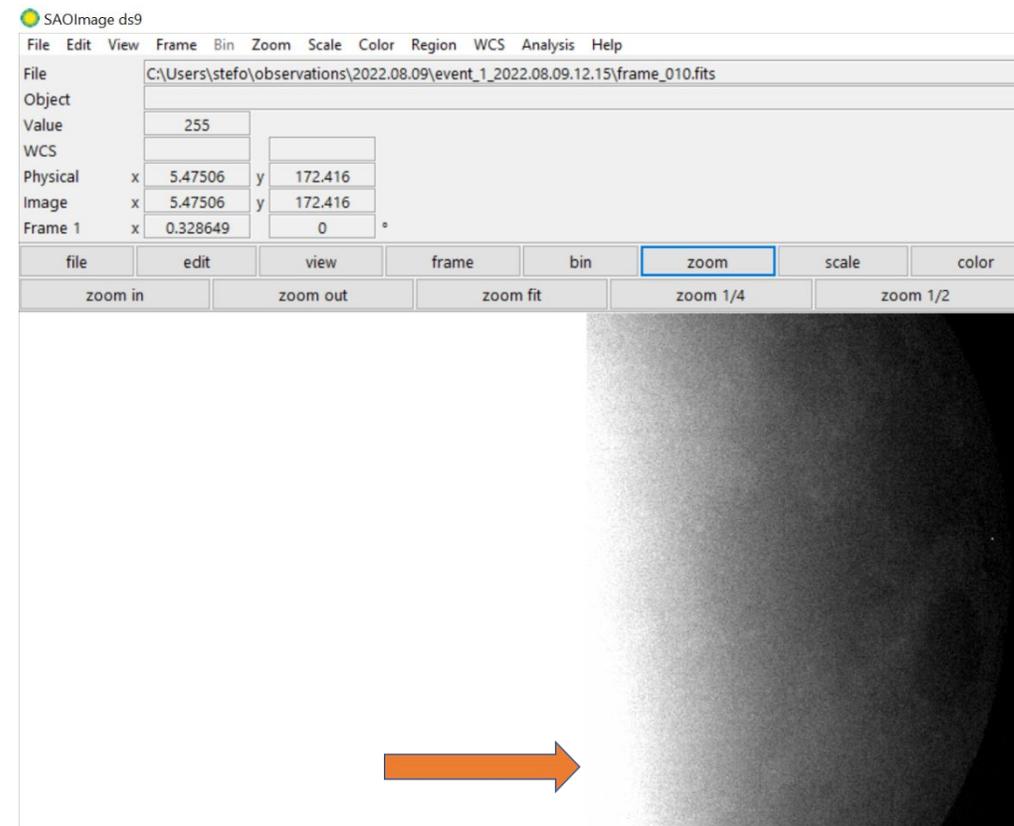
Why?



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.



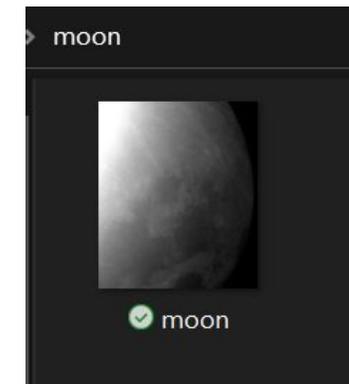
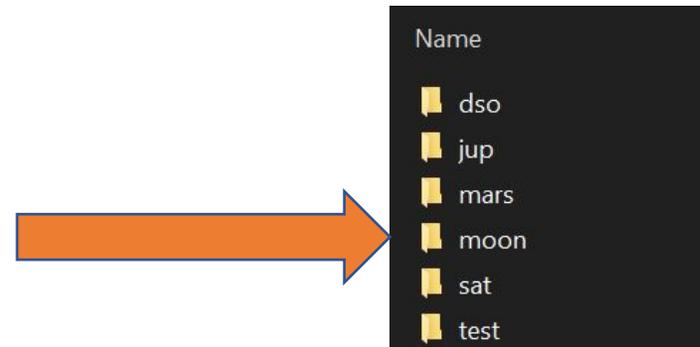
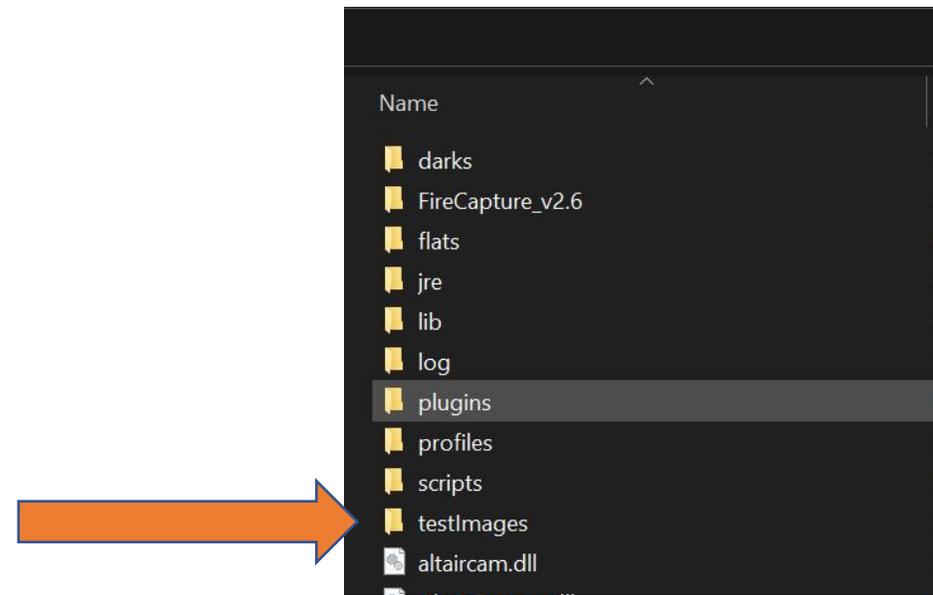
Fourth Event (provided by NELIOTA)

□ Impact Flash

Set-up Fourth Simulation

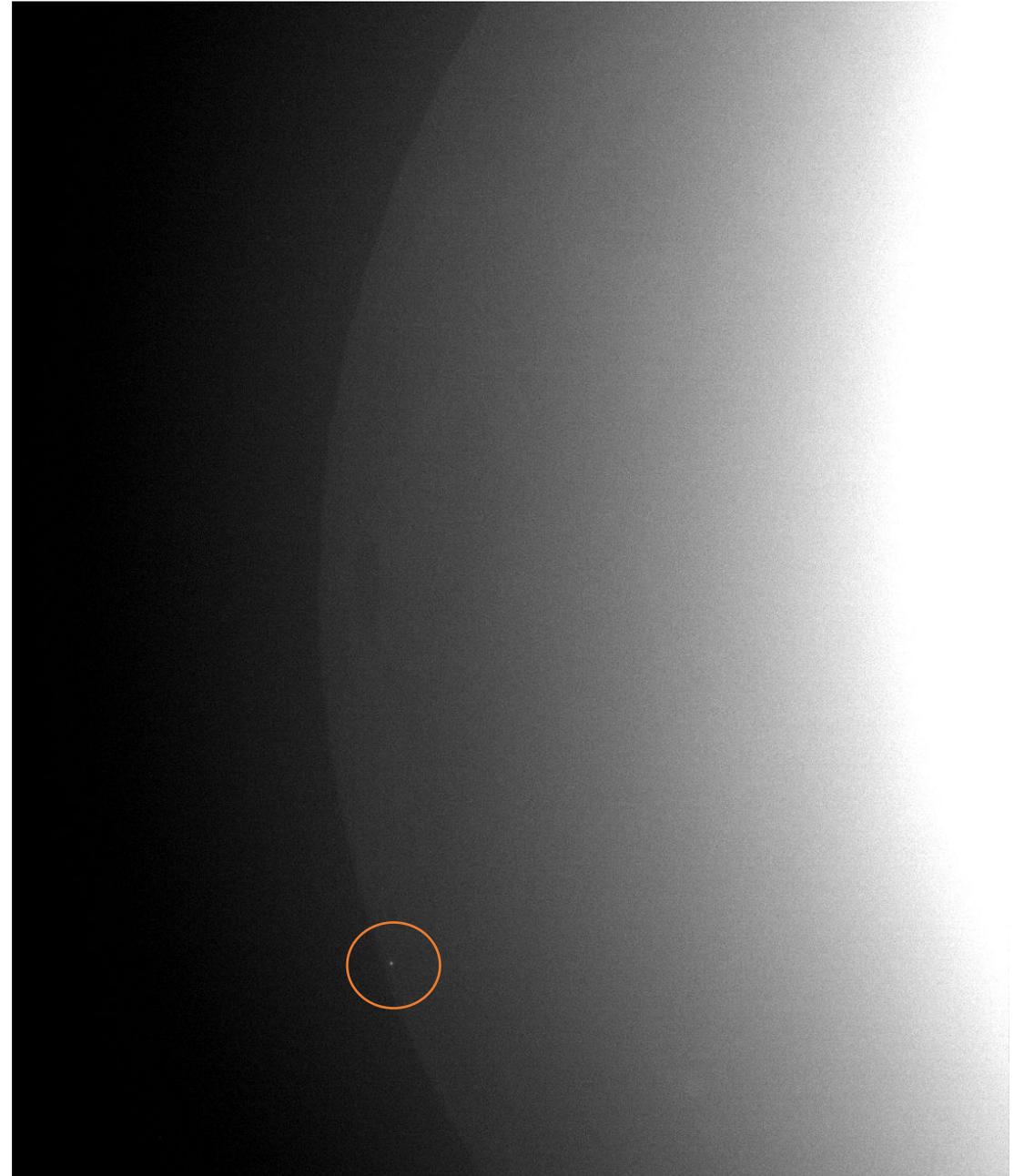
Now we will place the fourth event in FireCapture

- 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



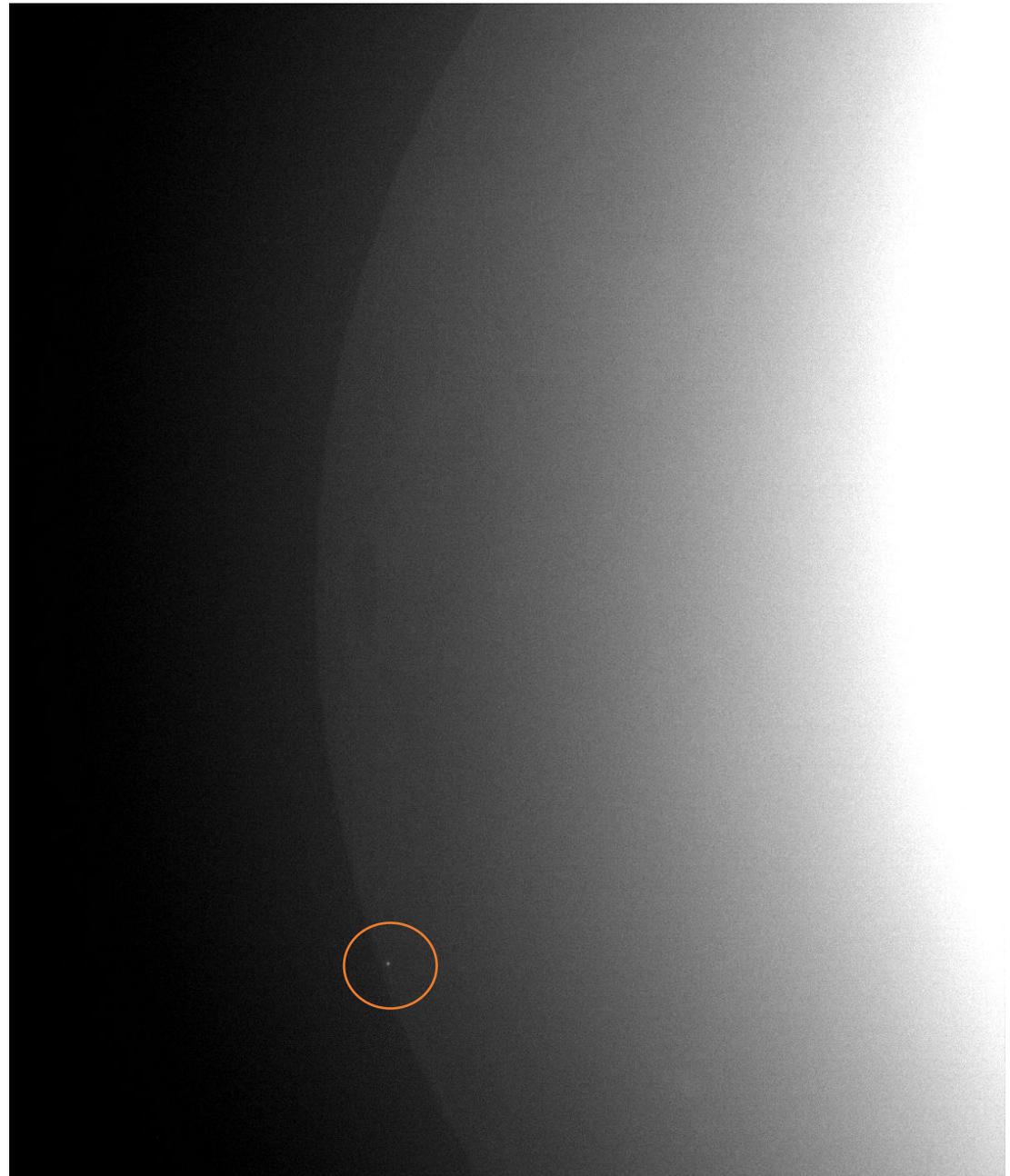
Fourth Video

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



Discussion

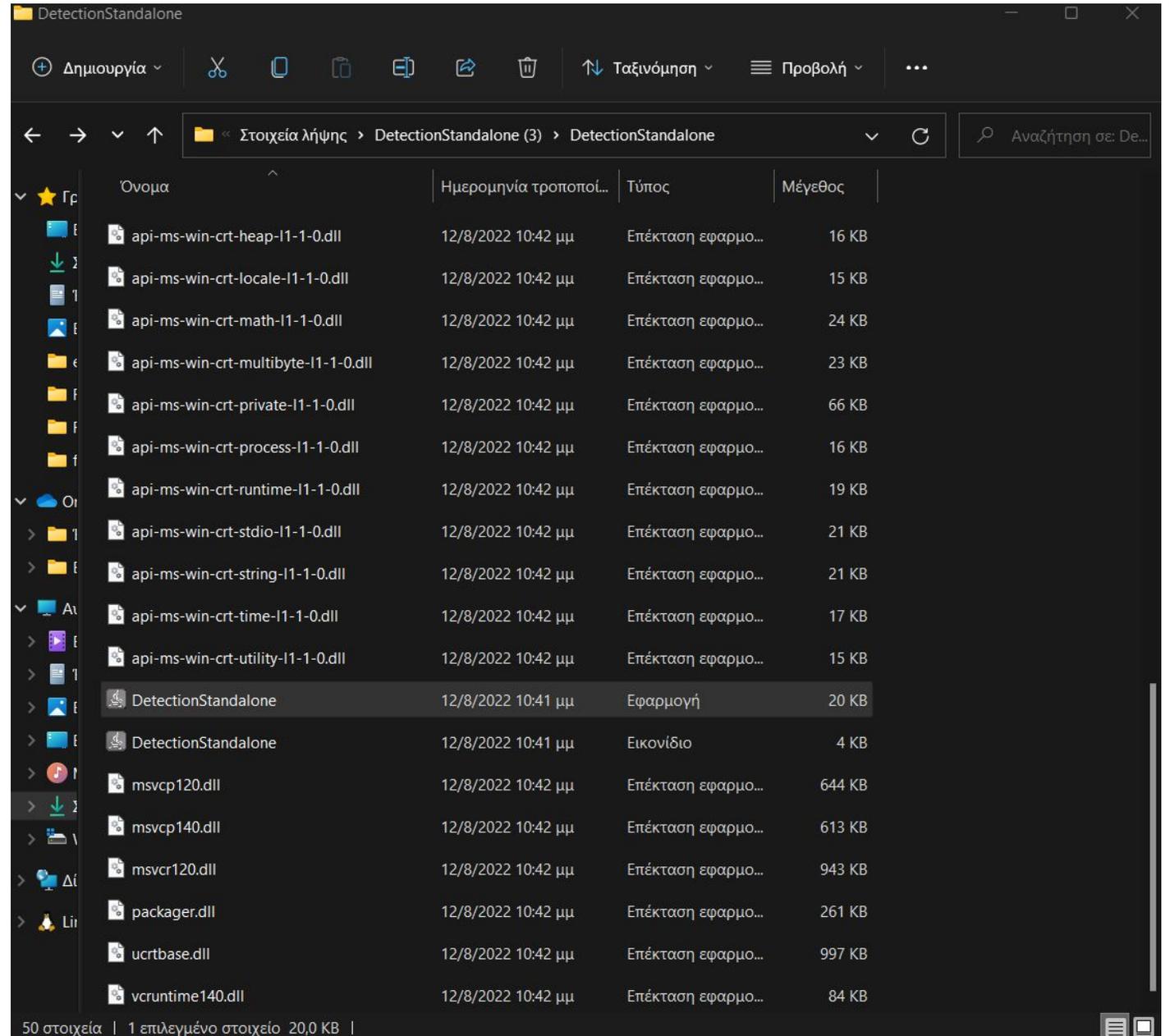
- What threading do you use?
- Is a multi-frame impact or single-frame?



Offline Detection

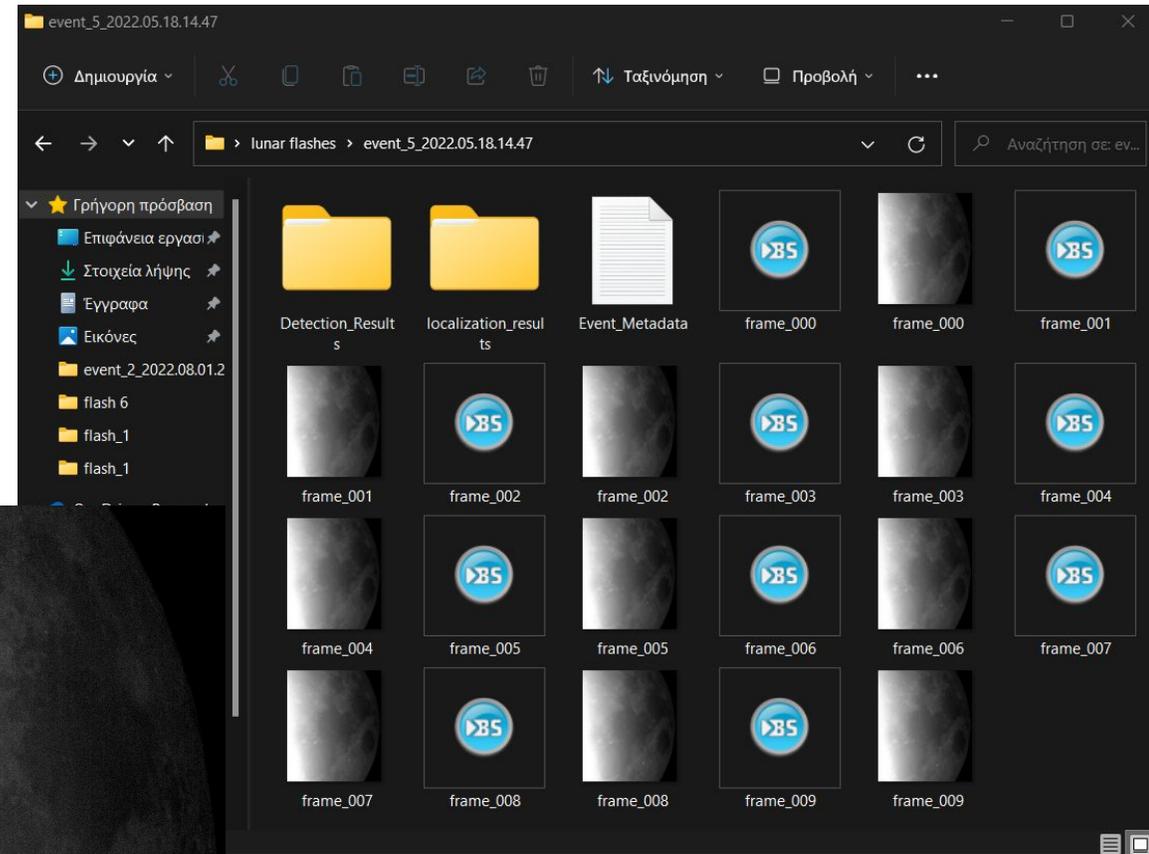
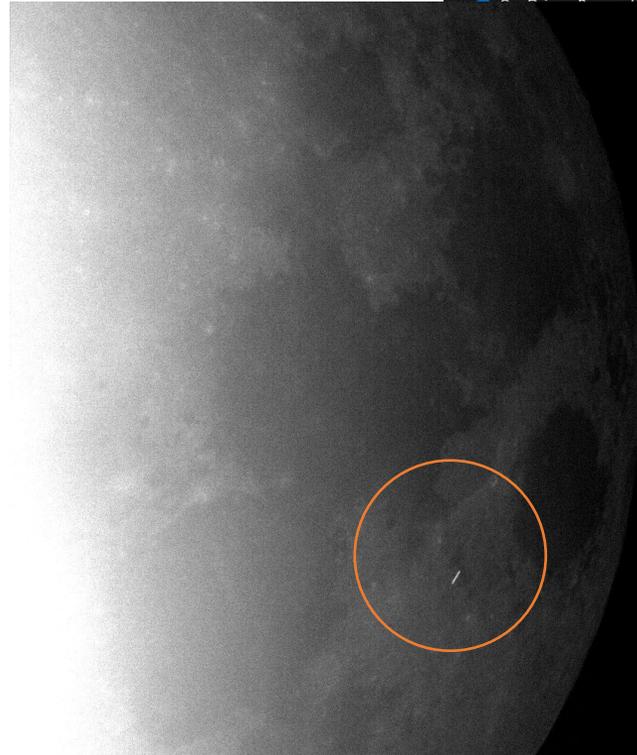
Set-up

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



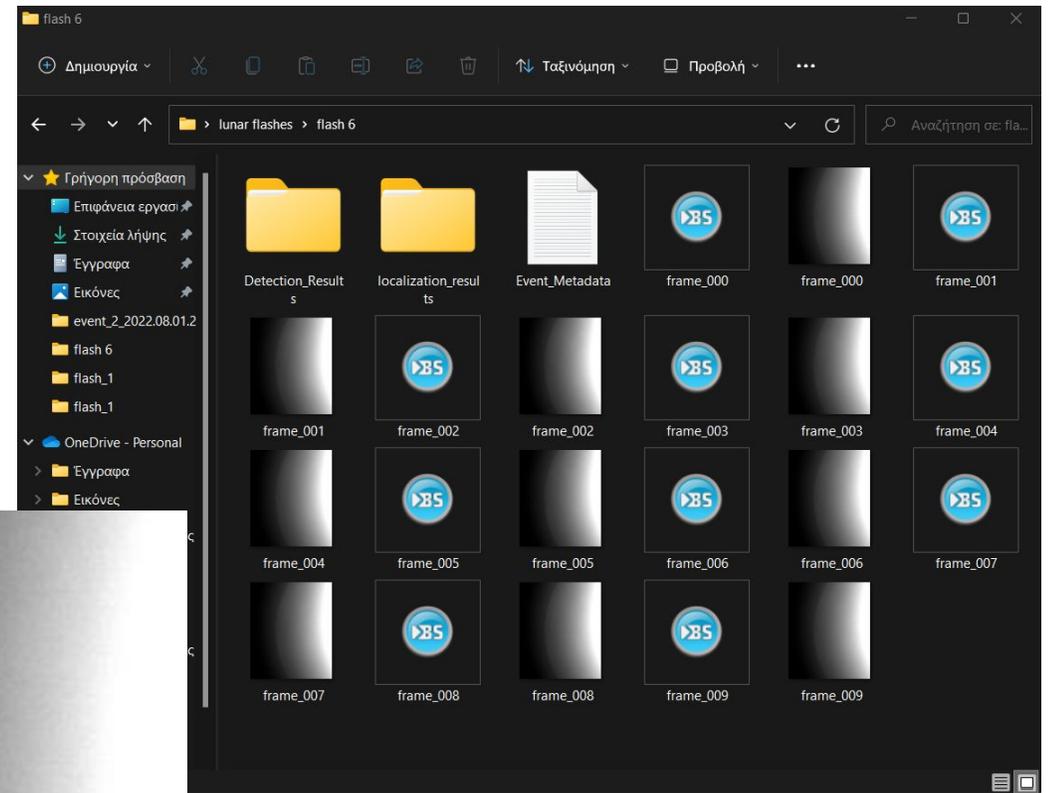
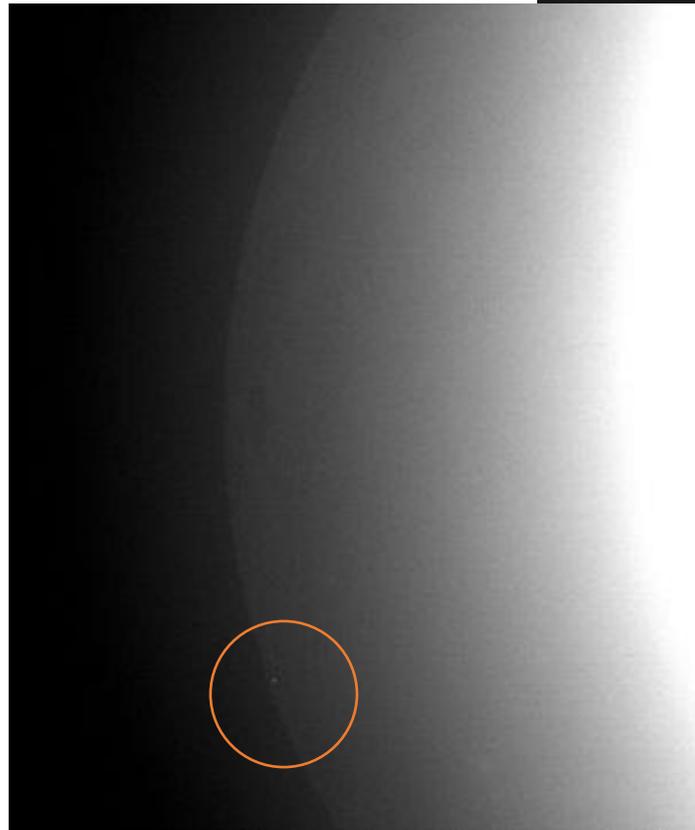
Set-up

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



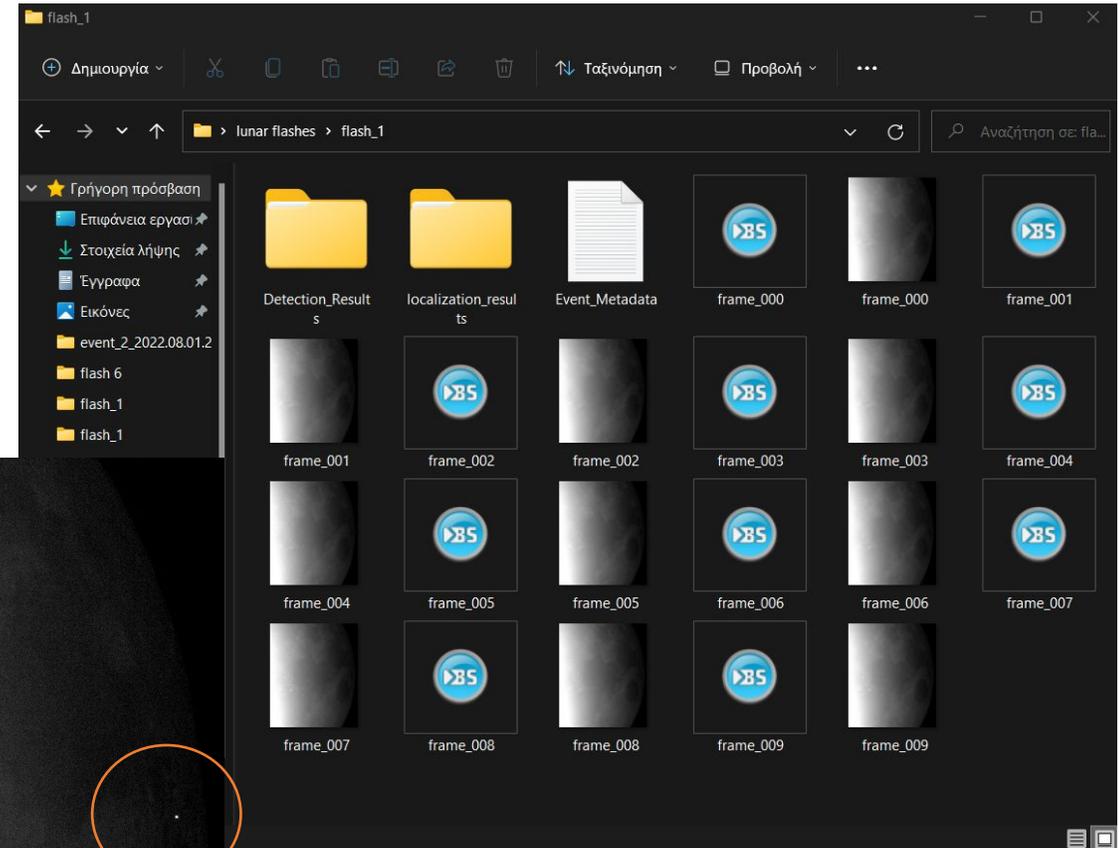
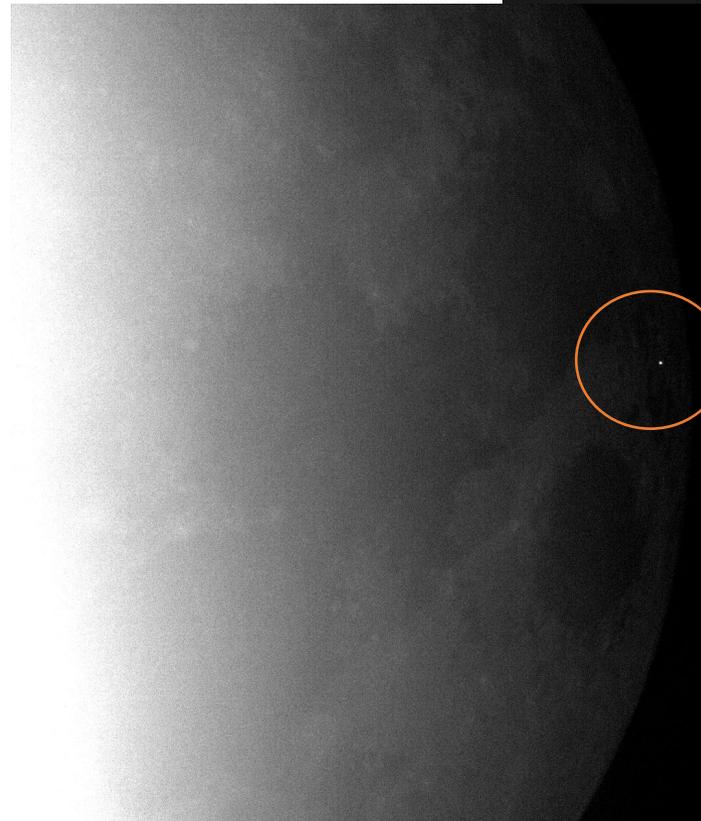
Set-up

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



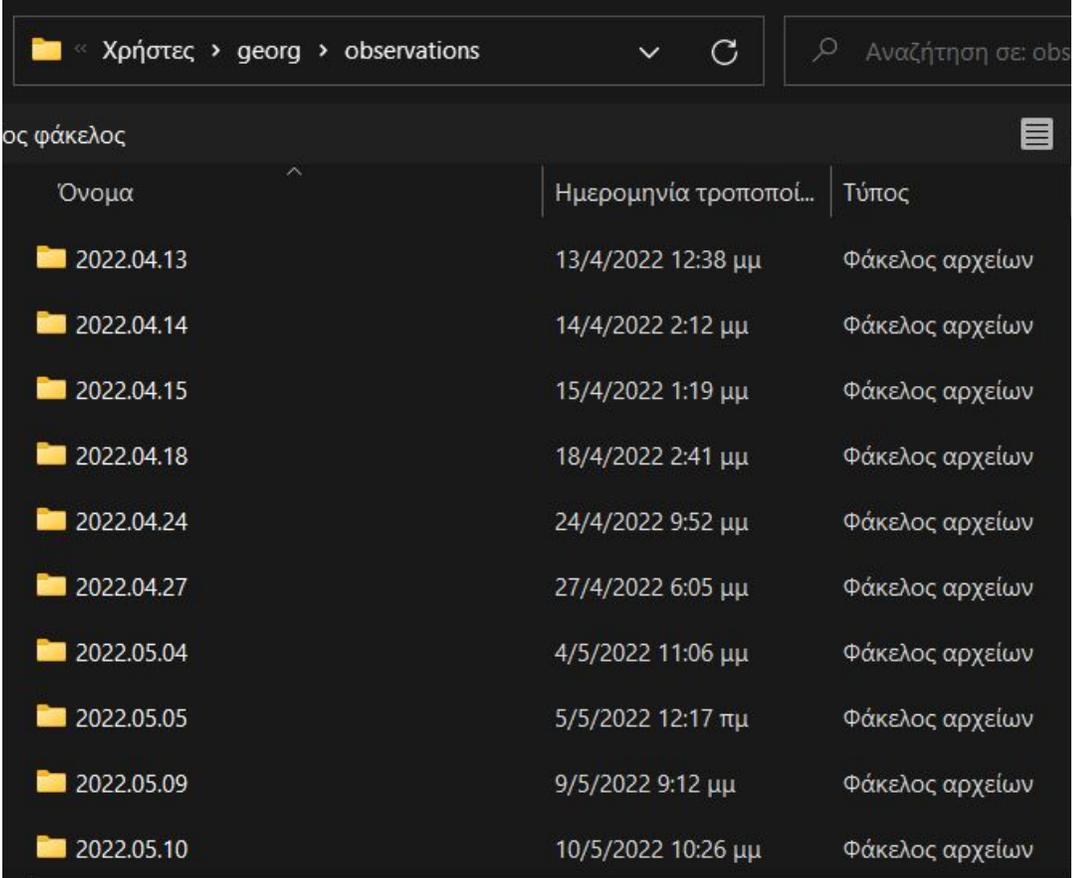
Set-up

- 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



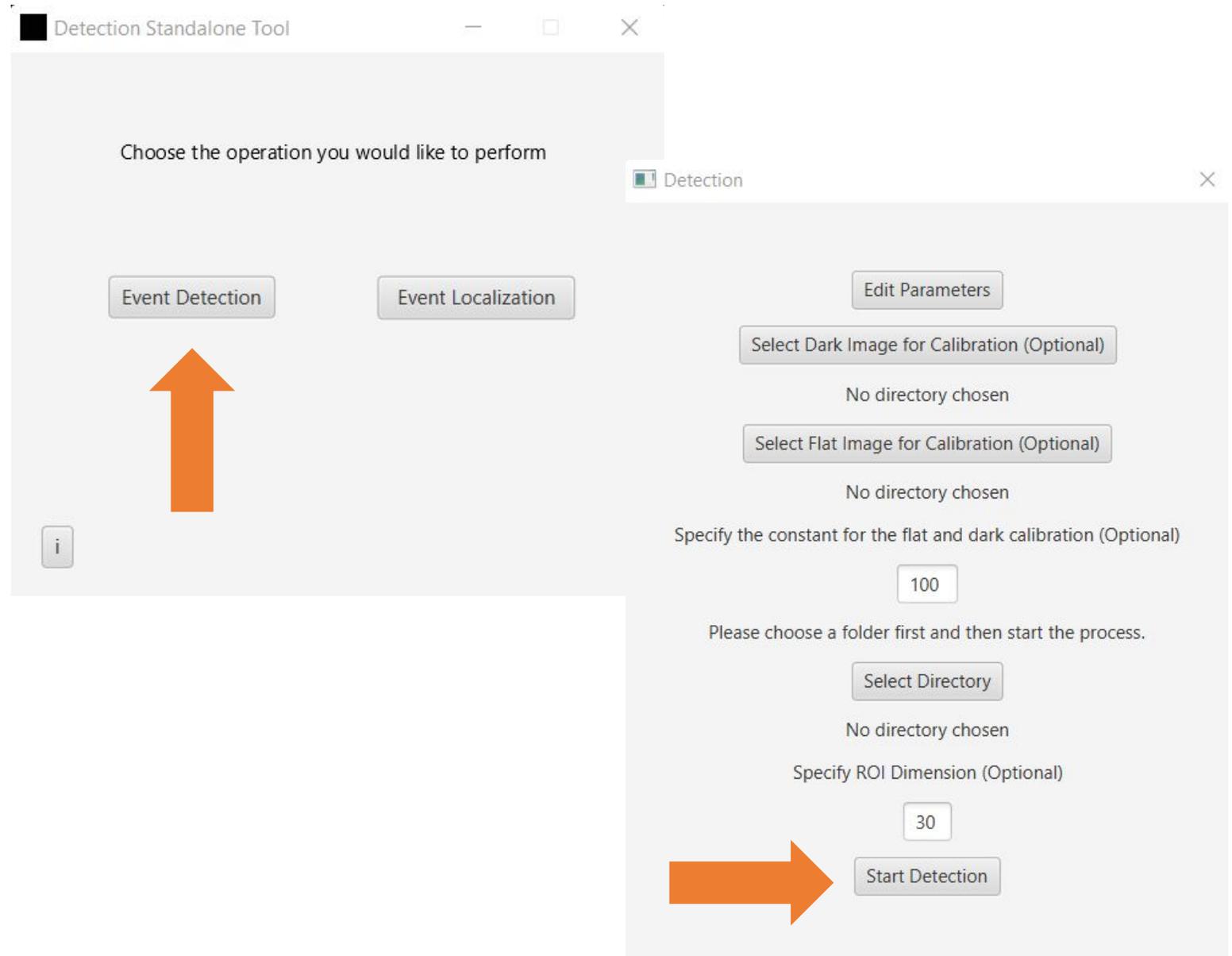
The screenshot shows a Windows File Explorer window with the address bar set to "Χρήστες > georg > observations". The search bar contains "Αναζήτηση σε: obs". The main area displays a list of folders in a table format. The columns are "Όνομα", "Ημερομηνία τροποποι...", and "Τύπος". The folders listed are:

Όνομα	Ημερομηνία τροποποι...	Τύπος
2022.04.13	13/4/2022 12:38 μμ	Φάκελος αρχείων
2022.04.14	14/4/2022 2:12 μμ	Φάκελος αρχείων
2022.04.15	15/4/2022 1:19 μμ	Φάκελος αρχείων
2022.04.18	18/4/2022 2:41 μμ	Φάκελος αρχείων
2022.04.24	24/4/2022 9:52 μμ	Φάκελος αρχείων
2022.04.27	27/4/2022 6:05 μμ	Φάκελος αρχείων
2022.05.04	4/5/2022 11:06 μμ	Φάκελος αρχείων
2022.05.05	5/5/2022 12:17 πμ	Φάκελος αρχείων
2022.05.09	9/5/2022 9:12 μμ	Φάκελος αρχείων
2022.05.10	10/5/2022 10:26 μμ	Φάκελος αρχείων

- ❖ 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

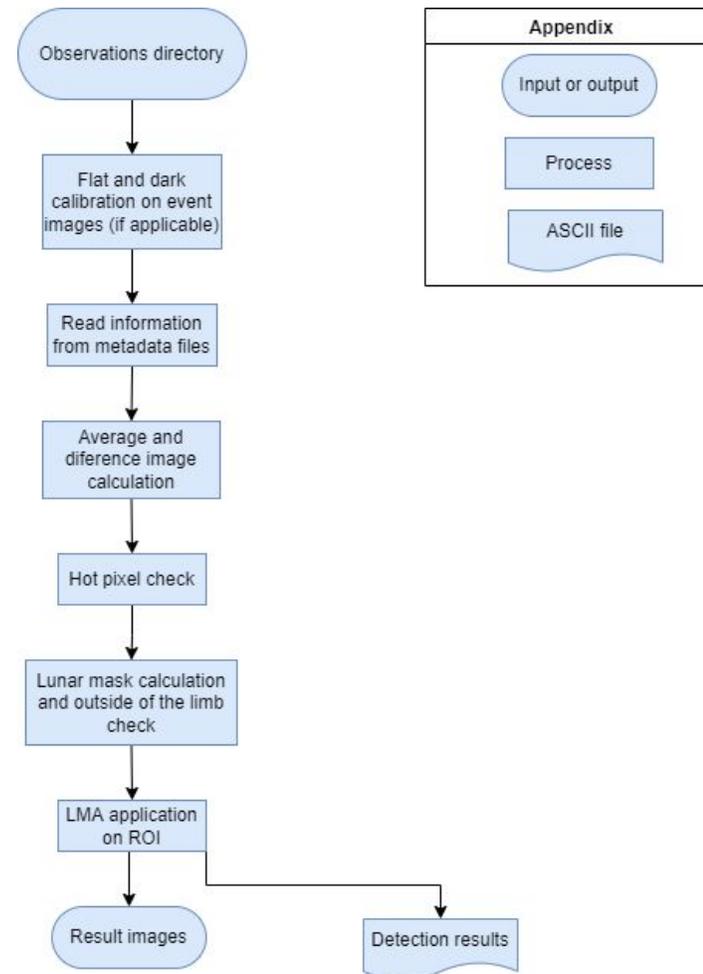
First Step

- 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:

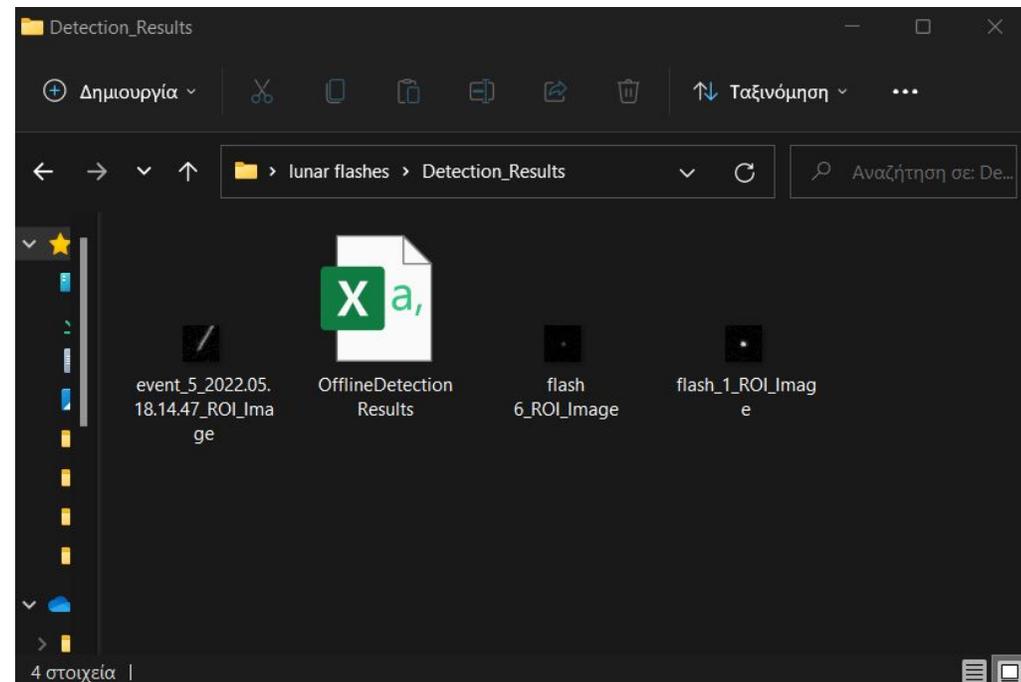
- For each event, the program will read some essential information from the metadata file
- Select a Region of Interest around the event
- Perform **Levenberg–Marquardt algorithm** and fit a 2D Gaussian in the event
- Depending on the characteristics of the Gaussian the program classify the event



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



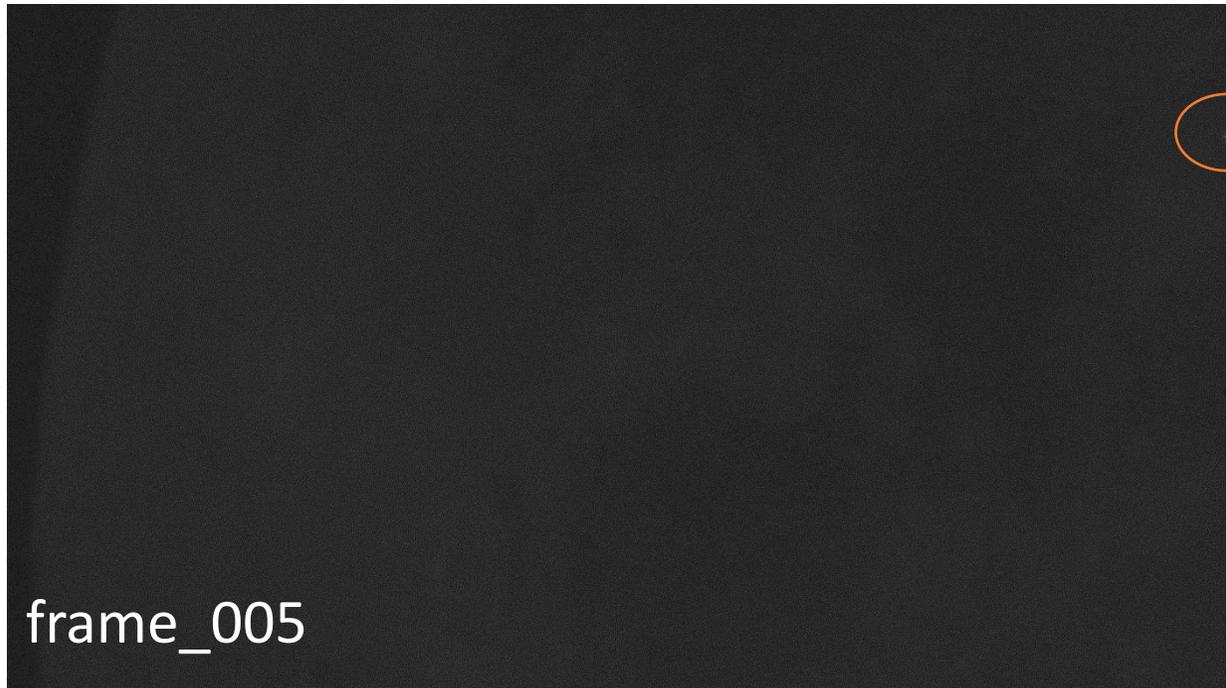
Localization

First Event (provided by FDS team)

Set-up

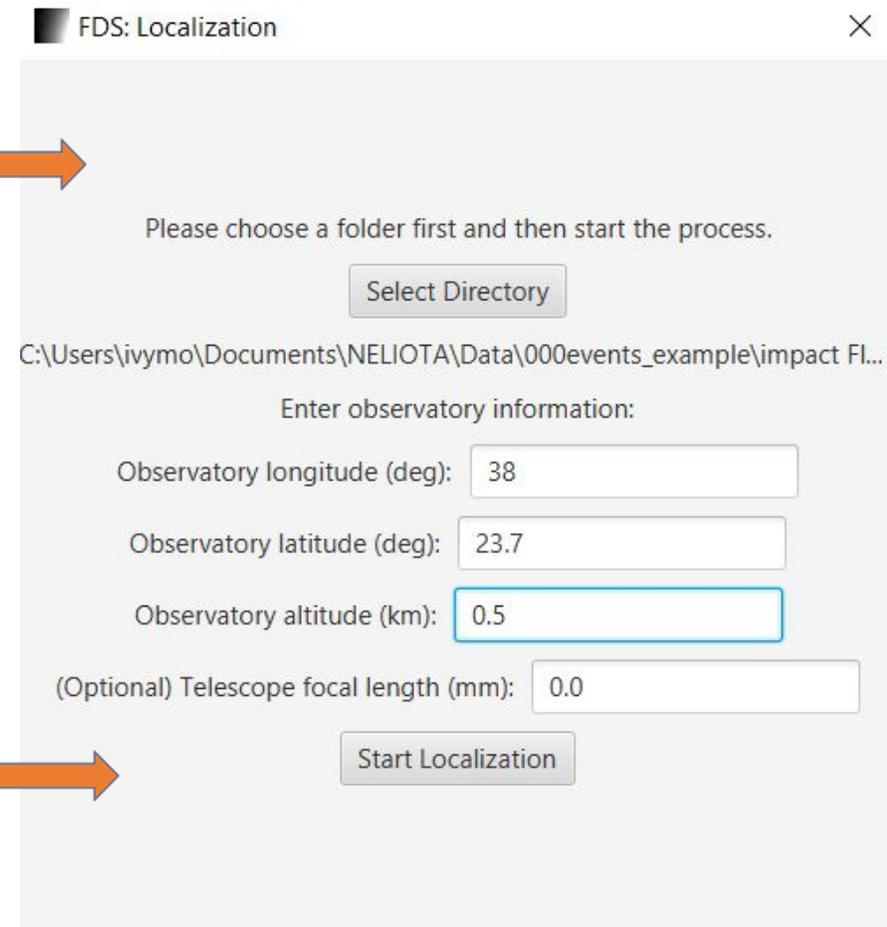
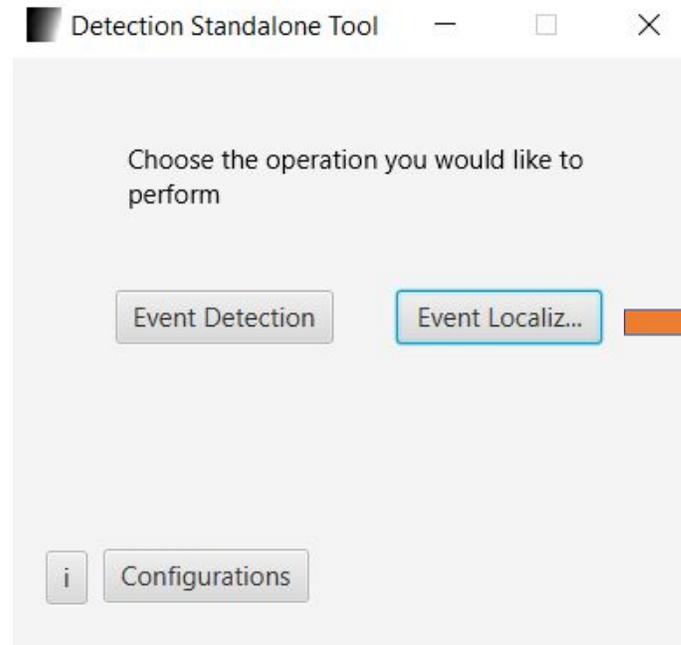
- We will perform the task of localization in an impact flash that we captured using this software on 03/06/22
- Choose the folder “FDS_localization_1”

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

FDS: Localization

View circle | Hide circle | View limb | View impact frame

The following circle was found:

Change circle color: #ff2800

Center found (pixels): X=3068.41, Y=897.90
Radius found (pixels): 3026.28

Pixel scale (arcsec/pixels): -
Suggested radius (pixels) based on pixel scale: -

Click on the image to get the pixel coordinates of the point:

Image (pixels):
Physical (pixels):

Impact location
Physical (pixels): X=1930, Y=885

100%
Change focus (zoom)

Continue

Undo | Redo | Past attempts
Reset to initial circle

AUTOMATIC CIRCLE FITTING
Change the parameters below and click Retry.

Change sd of gaussian filter: - 5 + Info

Boost top and bottom % of image: - 0% + Info

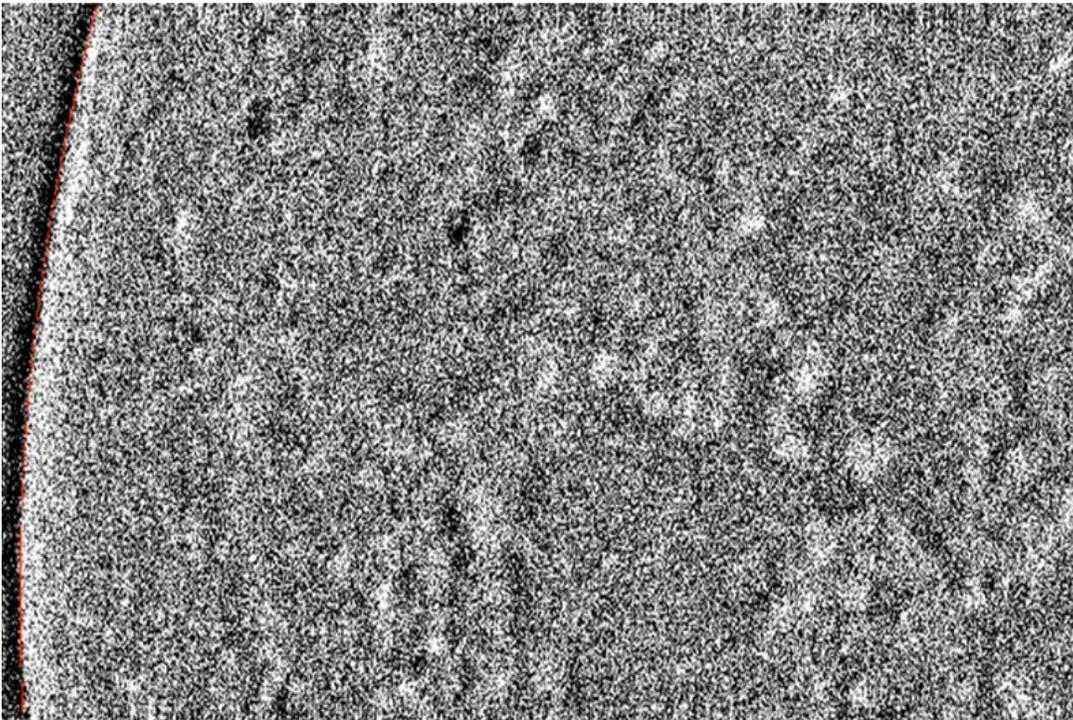
Retry
Reset to default

MANUAL CIRCLE FITTING
Click on the image and then add point to manually select limb pixels. Click manual fit when ready.

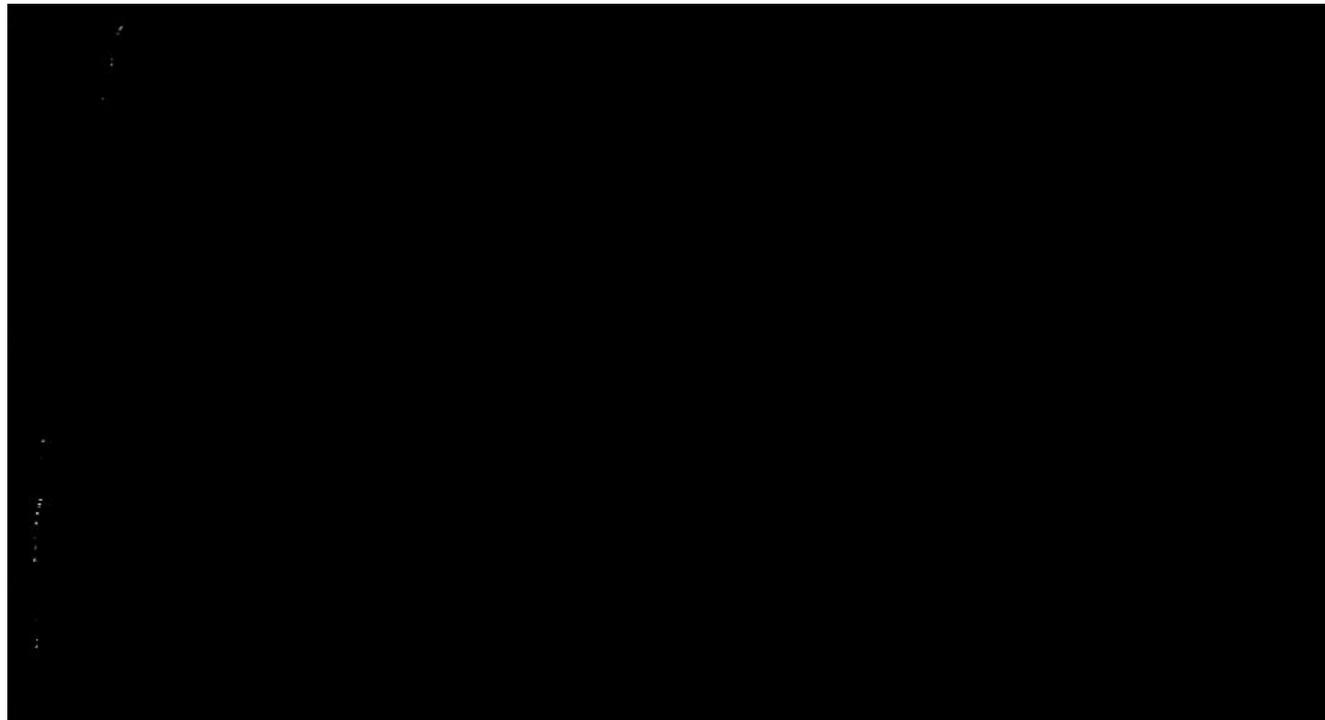
See last 5 points
Add point | Undo previous point
Clear all points
Manual fit

Are we satisfied with the suggested lunar limb?

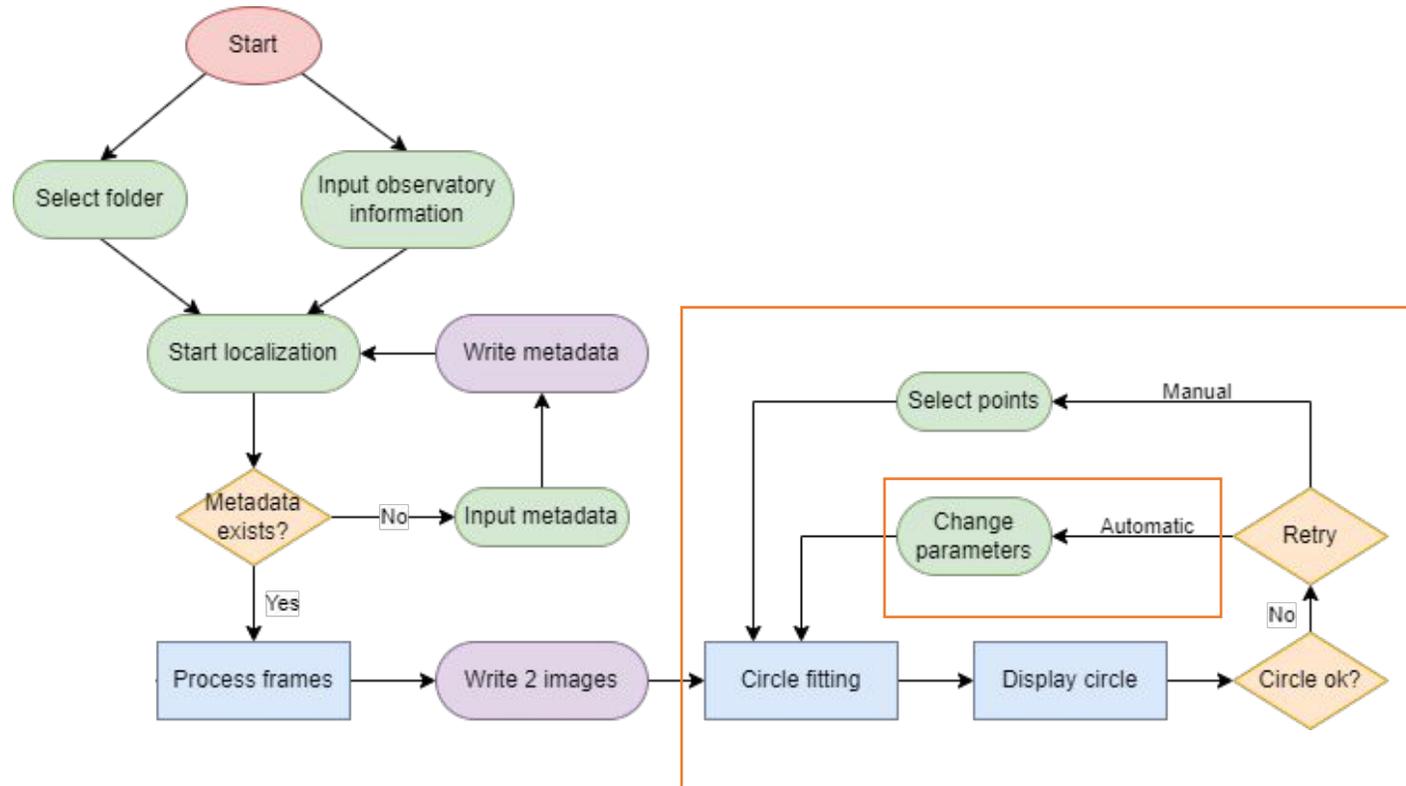
View Circle



View Limb



If no, change parameters of the algorithm



If no, change parameters of the algorithm

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

#ff2800

Center found (pixels):
X=3068.41, Y=897.90
Radius found (pixels): 3026.28

Pixel scale (arcsec/pixels): -
Suggested radius (pixels)
based on pixel scale: -

Click on the image to get the pixel
coordinates of the point:

Image (pixels):
Physical (pixels):

Impact location
Physical (pixels): X=1930, Y=885

100%
Change focus (zoom)

AUTOMATIC CIRCLE FITTING

Change the parameters below and click Retry.

Change sd of gaussian filter:
- 5 + Info

Boost top and bottom % of image:
- 0% + Info

Retry

Reset to default

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

Add point Undo previous point

Clear all points

Manual fit

Continue

Set sd=4 and press Retry

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

#ffffcc

Center found (pixels):
X=3870.81, Y=1043.59
Radius found (pixels): 3837.31

Pixel scale (arcsec/pixels): -

Suggested radius (pixels)
based on pixel scale: -

Click on the image to get the pixel
coordinates of the point:

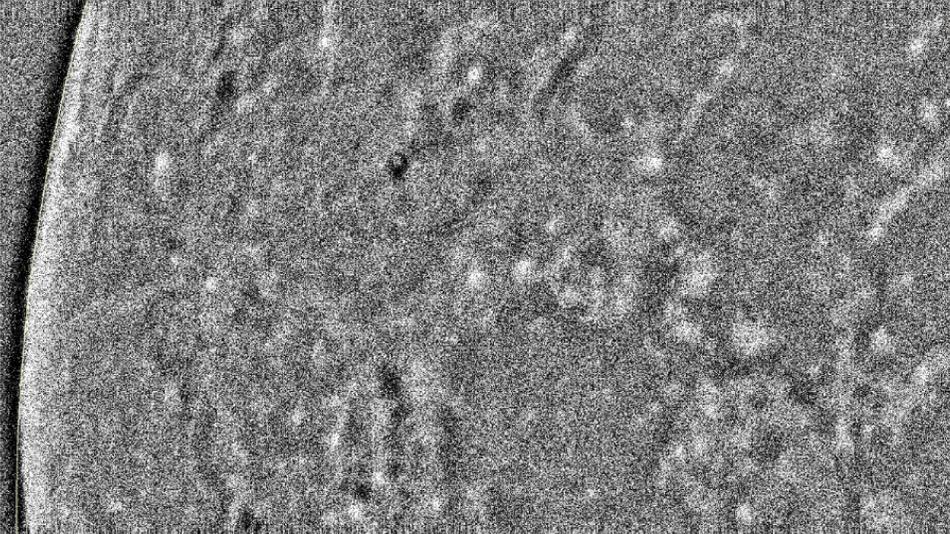
Image (pixels):

Physical (pixels):

Impact location
Physical (pixels): X=1930, Y=885

100%

Change focus (zoom)



AUTOMATIC CIRCLE FITTING

Change the parameters below and click Retry.

Change sd of gaussian filter:

- 4 + Info

Boost top and bottom % of image:

- 0% + Info

Retry

Reset to default

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

Add point Undo previous point

Clear all points

Manual fit

Set sd=6 and press Retry

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
#ff8080

Center found (pixels):
X=3677.02, Y=997.32
Radius found (pixels): 3639.54

Pixel scale (arcsec/pixels): -

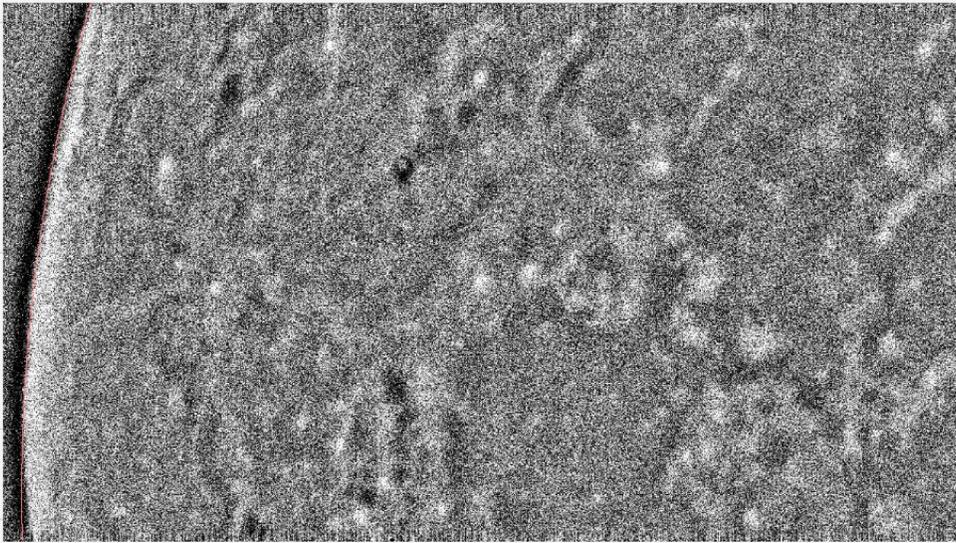
Suggested radius (pixels)
based on pixel scale: -

Click on the image to get the pixel
coordinates of the point:

Image (pixels):
Physical (pixels):

Impact location
Physical (pixels): X=1930, Y=885

100%
Change focus (zoom)



AUTOMATIC CIRCLE FITTING

Change the parameters below and click Retry.

Change sd of gaussian filter:
- 6 + Info

Boost top and bottom % of image:
- 0% + Info

Retry

Reset to default

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

Add point Undo previous point

Clear all points

Manual fit

Set Boost = 1%

FDS: Localization

View circle Hide circle View limb View impact frame

The following circle was found:

Change circle color
#b3b31a

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: -

Click on the image to get the pixel
coordinates of the point:

Image (pixels):
Physical (pixels):

Impact location
Physical (pixels): X=1930, Y=885

100%

Change focus (zoom)

Undo Redo Past attempts
Reset to initial circle

AUTOMATIC CIRCLE FITTING
Change the parameters below and click Retry.

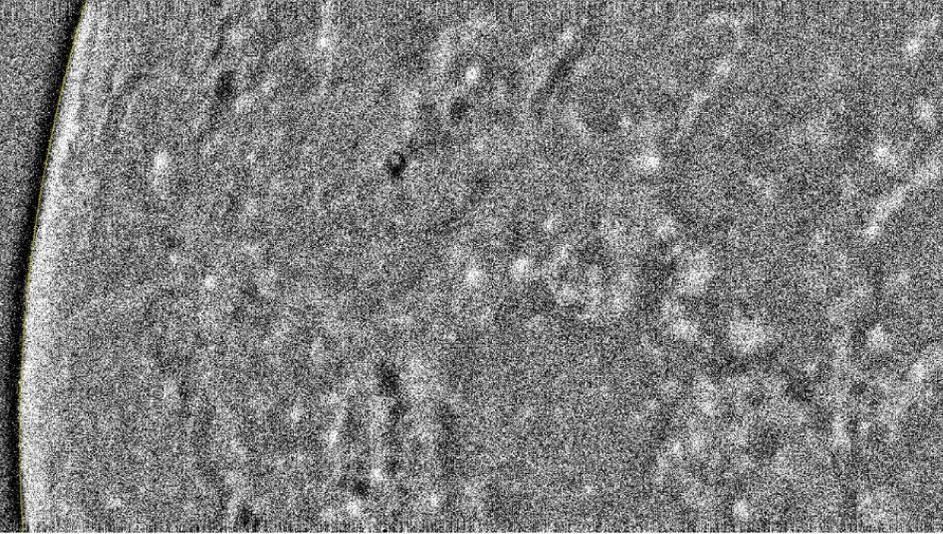
Change sd of gaussian filter:
- 5 + Info

Boost top and bottom % of image:
- 1% + Info

Retry
Reset to default

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
Add point Undo previous point
Clear all points
Manual fit



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

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

#ffcce6

Center found (pixels):
X=2931.24, Y=878.51
Radius found (pixels): 2886.93

Pixel scale (arcsec/pixels): -

Suggested radius (pixels)
based on pixel scale: -

Click on the image to get the pixel coordinates of the point:

Image (pixels):

Physical (pixels):

Impact location
Physical (pixels): X=1930, Y=885

100%

Change focus (zoom)

AUTOMATIC CIRCLE FITTING

Change the parameters below and click Retry.

Change sd of gaussian filter:

- 5 + Info

Boost top and bottom % of image:

- 5% + Info

Retry

Reset to default

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

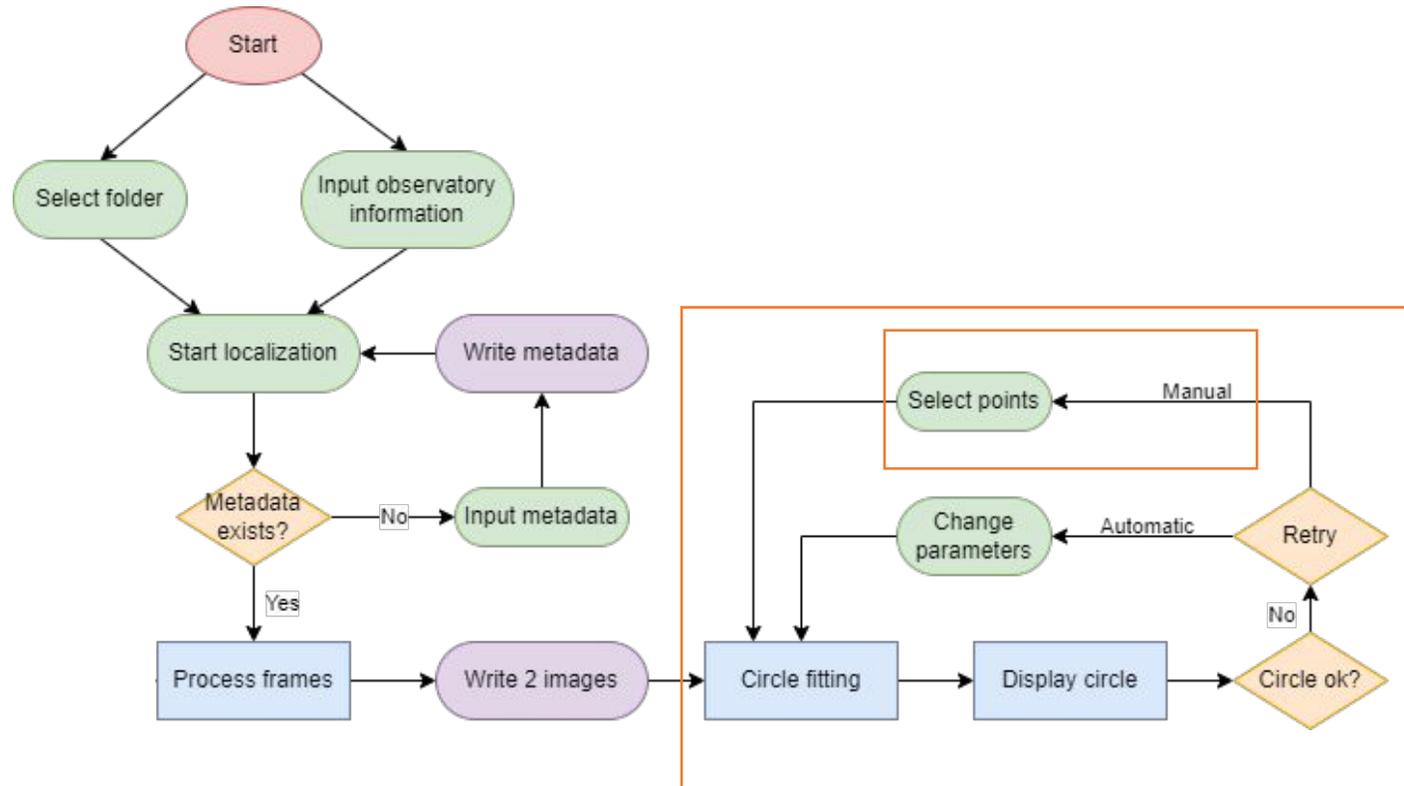
Add point Undo previous point

Clear all points

Manual fit



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



Manual Circle Fitting

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
#ff2800

Center found (pixels):
X=3068.41, Y=897.90
Radius found (pixels): 3026.28

Pixel scale (arcsec/pixels): -
Suggested radius (pixels)
based on pixel scale: -

Click on the image to get the pixel
coordinates of the point:

Image (pixels):
Physical (pixels):

Impact location
Physical (pixels): X=1930, Y=885

100%
Change focus (zoom)

Change sd of gaussian filter:
- 5 + Info

Boost top and bottom % of image:
- 0% + Info

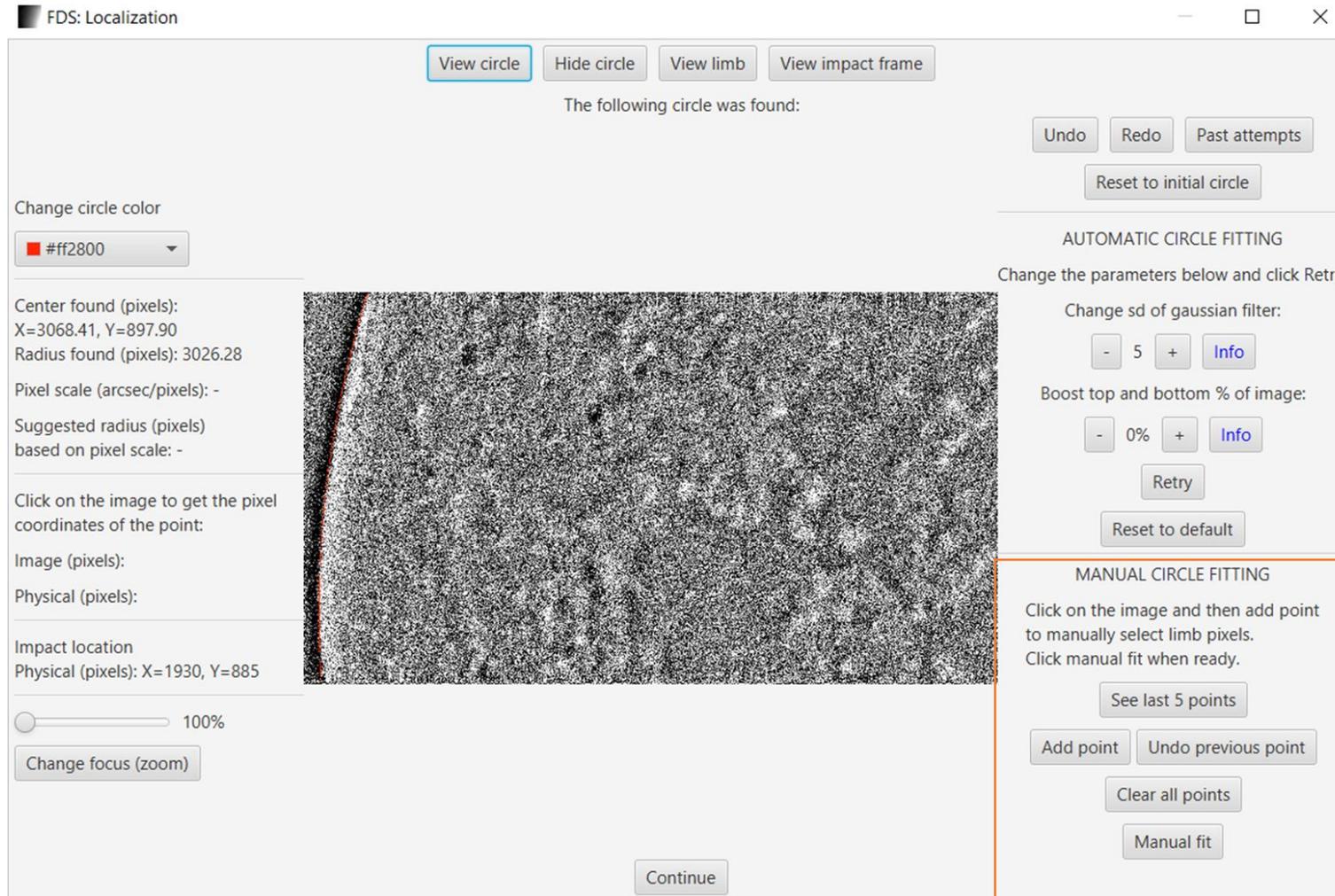
Retry
Reset to default

MANUAL CIRCLE FITTING

Click on the image and then add point
to manually select limb pixels.
Click manual fit when ready.

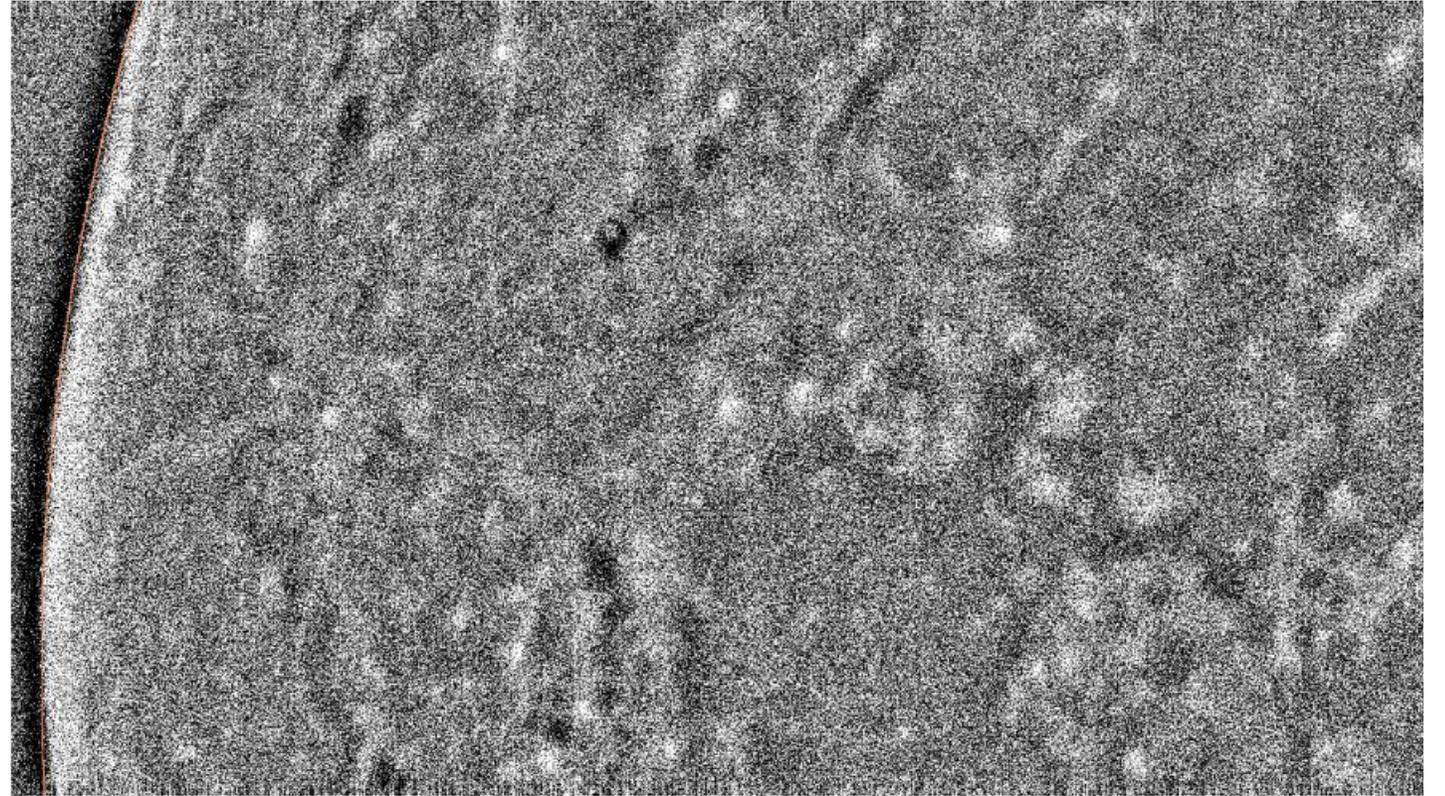
See last 5 points
Add point Undo previous point
Clear all points
Manual fit

Continue

The image shows a software window titled "FDS: Localization" with a central grayscale image of a limb. A red circle is fitted to the limb's edge. The interface includes several control panels. On the left, there are buttons for "View circle", "Hide circle", "View limb", and "View impact frame". Below these are fields for "Change circle color" (set to #ff2800), "Center found (pixels)" (X=3068.41, Y=897.90), "Radius found (pixels)" (3026.28), "Pixel scale (arcsec/pixels)", "Suggested radius (pixels) based on pixel scale", "Click on the image to get the pixel coordinates of the point", "Image (pixels)", "Physical (pixels)", "Impact location", and "Physical (pixels): X=1930, Y=885". At the bottom left is a zoom slider at 100% and a "Change focus (zoom)" button. On the right, there are buttons for "Undo", "Redo", "Past attempts", and "Reset to initial circle". Below that is the "AUTOMATIC CIRCLE FITTING" section with "Change sd of gaussian filter" (set to 5) and "Boost top and bottom % of image" (set to 0%), both with minus, plus, and info buttons, and "Retry" and "Reset to default" buttons. The "MANUAL CIRCLE FITTING" section, highlighted with an orange border, contains instructions: "Click on the image and then add point to manually select limb pixels. Click manual fit when ready." and buttons for "See last 5 points", "Add point", "Undo previous point", "Clear all points", and "Manual fit". A "Continue" button is at the bottom center.

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

FDS: Localization

View circle Hide circle View limb View impact frame

The following circle was found:

Change circle color: #ffcce6

Center found (pixels): X=2931.24, Y=878.51
Radius found (pixels): 2886.93

Pixel scale (arcsec/pixels): -
Suggested radius (pixels) based on pixel scale: -

Click on the image to get the pixel coordinates of the point:

Image (pixels):
Physical (pixels):

Impact location
Physical (pixels): X=1930, Y=885

100%
Change focus (zoom)

Undo Redo Past attempts
Reset to initial circle

AUTOMATIC CIRCLE FITTING
Change the parameters below and click Retry.

Change sd of gaussian filter:
- 5 + Info

Boost top and bottom % of image:
- 5% + Info

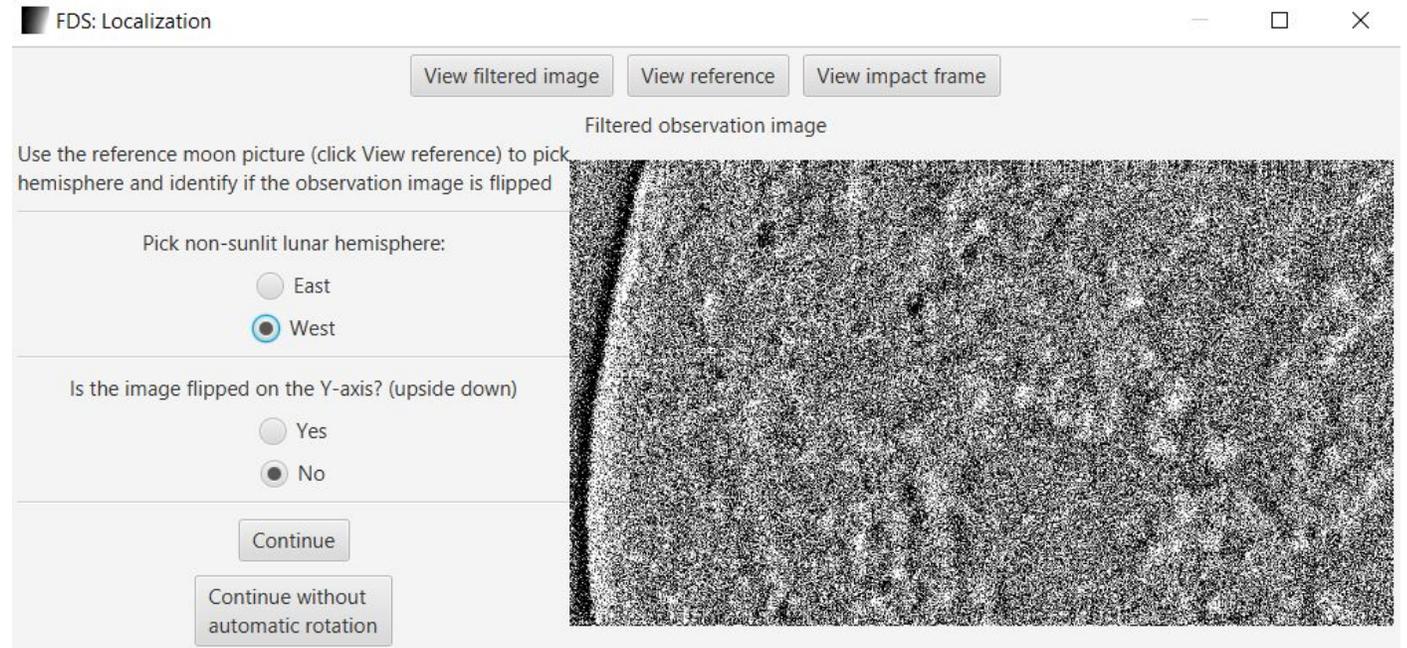
Retry
Reset to default

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
Add point Undo previous point
Clear all points
Manual fit

Next Step

- In this step you must answer two questions:
 - ∅ Is the non-sunlit lunar hemisphere the east or the west?
 - ∅ 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

FDS: Localization

View filtered image View reference View impact frame

Filtered observation image

Use the reference moon picture (click View reference) to pick hemisphere and identify if the observation image is flipped

Pick non-sunlit lunar hemisphere:

East

West

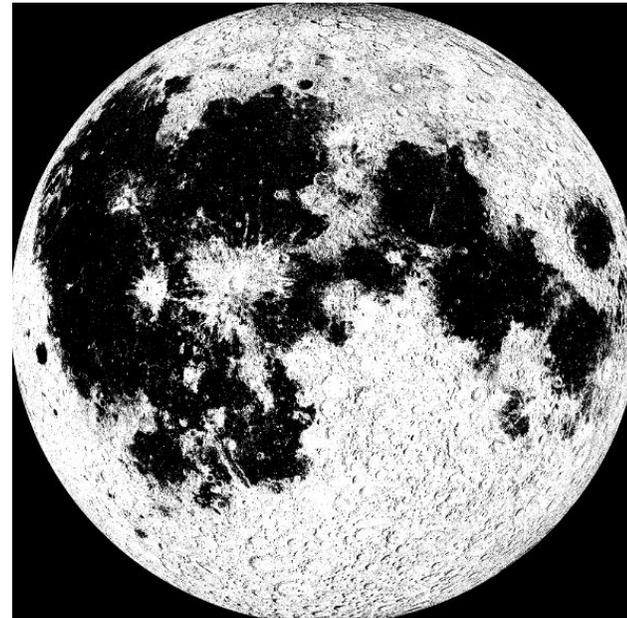
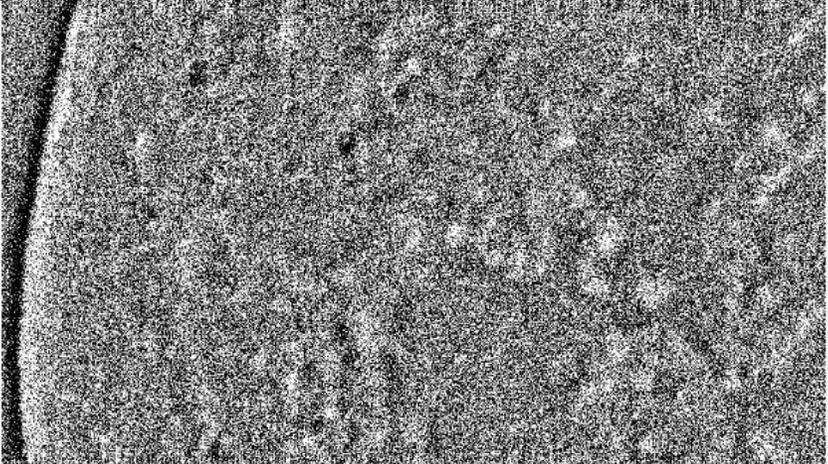
Is the image flipped on the Y-axis? (upside down)

Yes

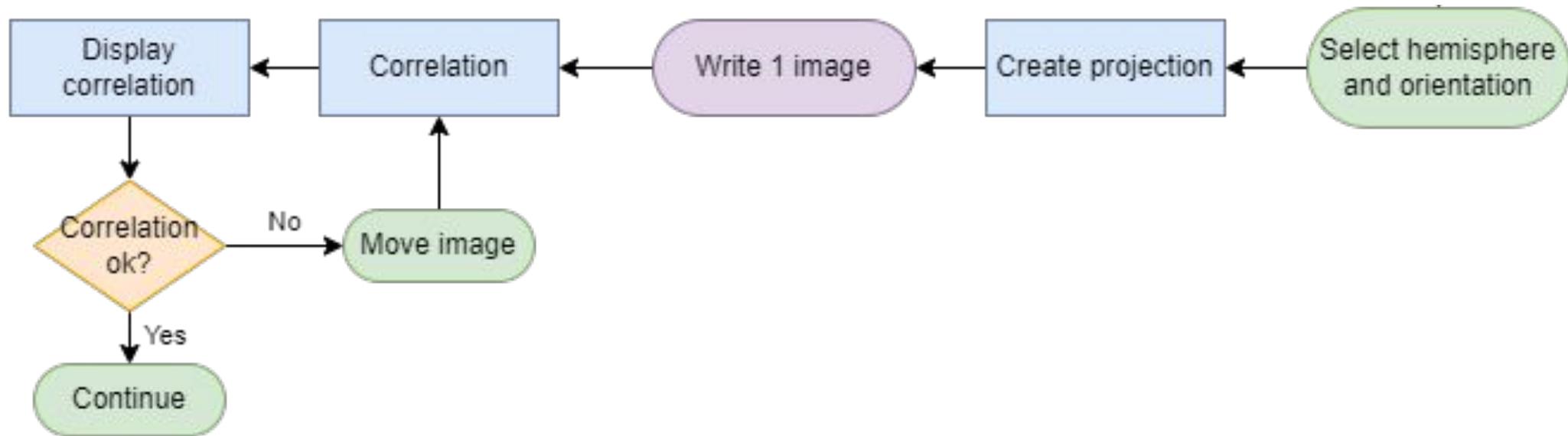
No

Continue

Continue without automatic rotation



Next Step: Automatic Correlation



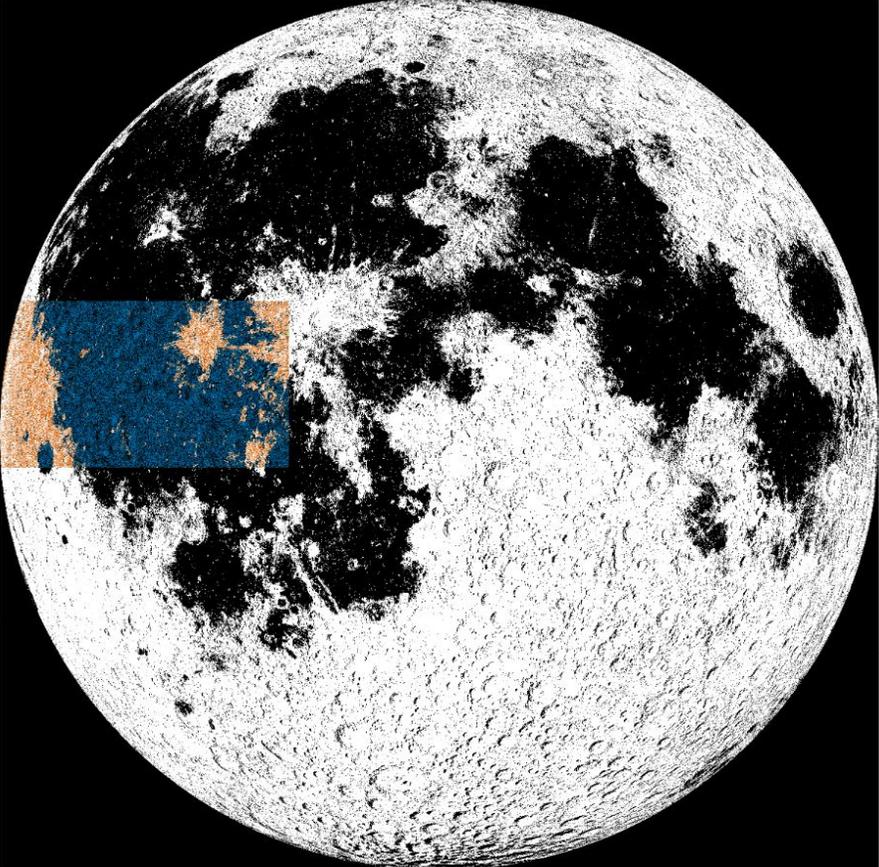
Automatic Correlation

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

FDS: Localization

View correlation View moon View rotation

Correlation



Try to match large lunar features
Info Matching pixels: 67.81%

Change match color
#0072b2

Change non-match color
#d55e00

Info Radius (pixels): 2875.53
Go back to circle fitting

Impact flash: green cross mark
Impact flash location (pixels)
Physical: X=1886, Y=3543
Lunar coordinates (deg):
Longitude= -24.54
Latitude= 8.06

Image (pixels):
Physical (pixels):
Create a red cross mark
Mark point Remove mark

Undo Redo
Move history
Reset to initial

50 -25 0 25 50
0 pixels
Shift horizontally
Shift vertically

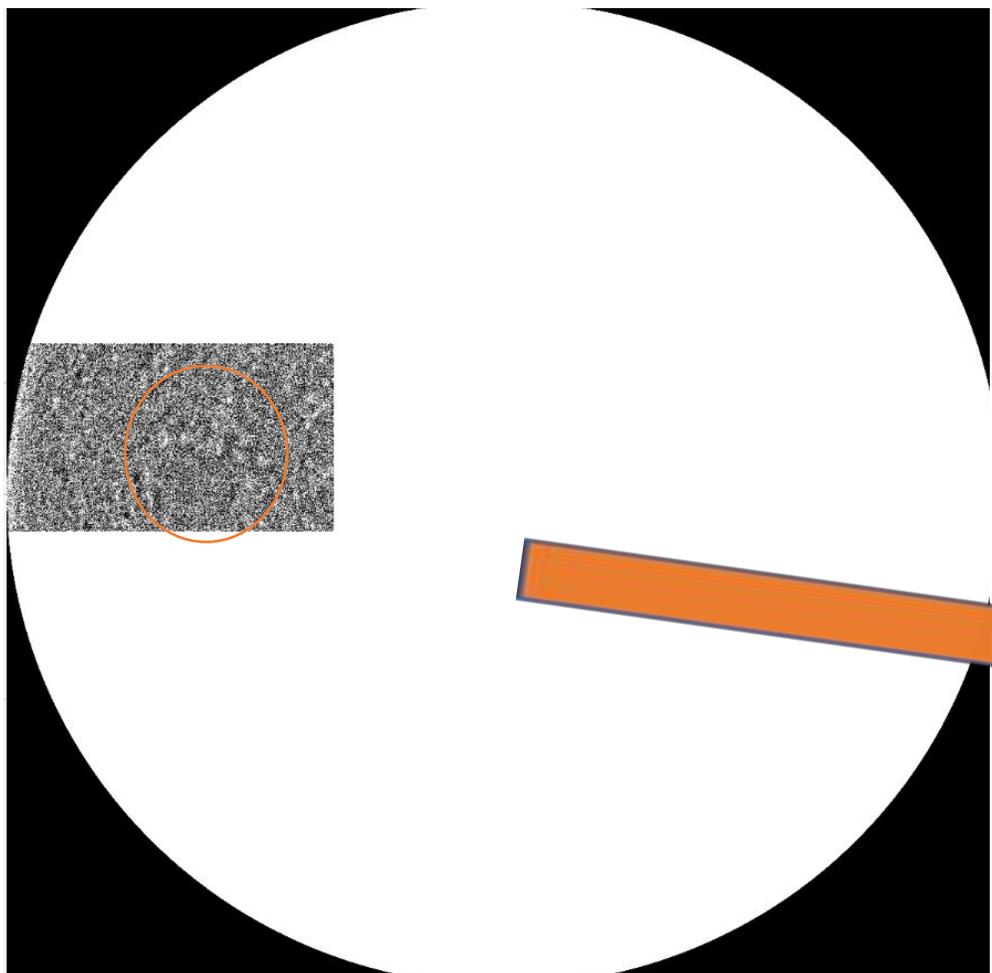
100%
Change focus (zoom)

Flip vertically and retry

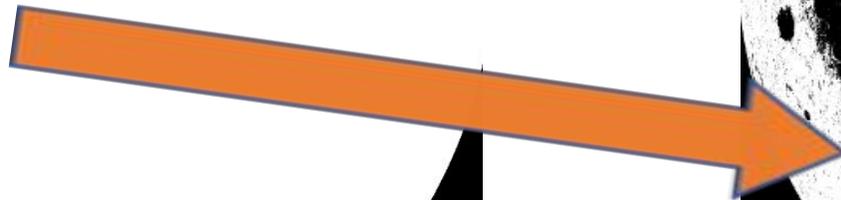
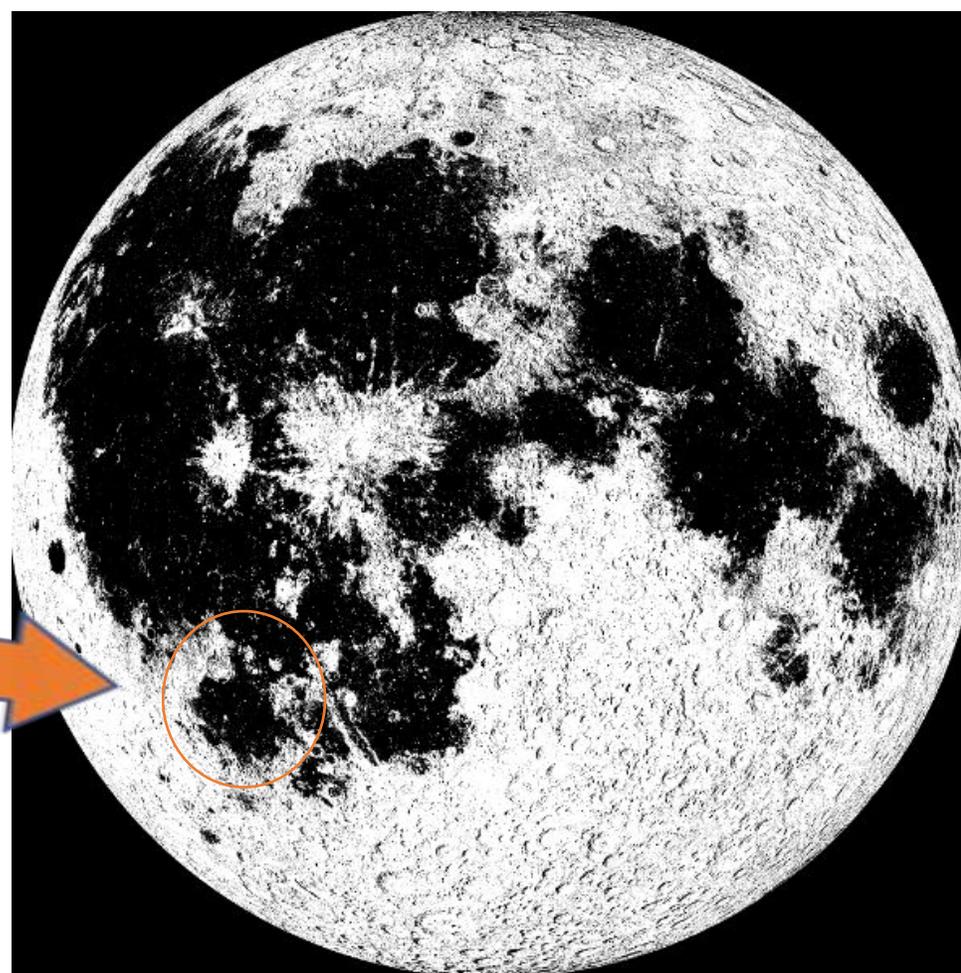
Change rotation angle (based on unrotated image):

Suggested rotation

View rotation



View moon



Rotation: -31.53 deg

FDS: Localization

Try to match large lunar features
Info Matching pixels: 67.81%

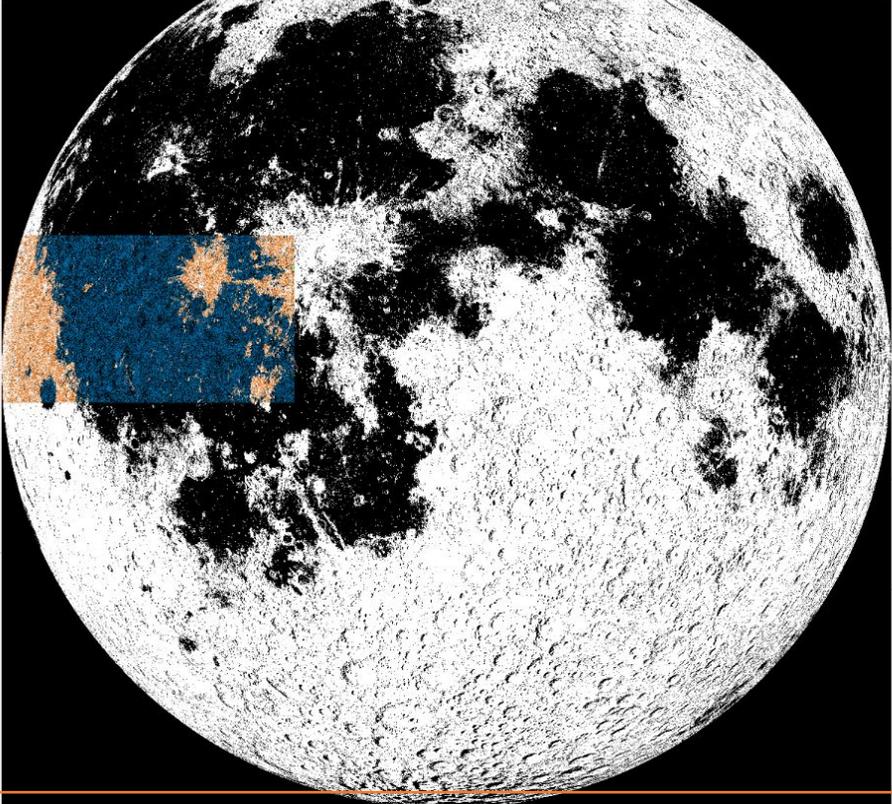
Change match color
#0072b2

Change non-match color
#d55e00

Info Radius (pixels): 2875.53
Go back to circle fitting

Impact flash: green cross mark
Impact flash location (pixels)
Physical: X=1886, Y=3543
Lunar coordinates (deg):
Longitude= -24.54
Latitude= 8.06

Image (pixels):
Physical (pixels):
Create a red cross mark
Mark point Remove mark



Undo Redo
Move history
Reset to initial

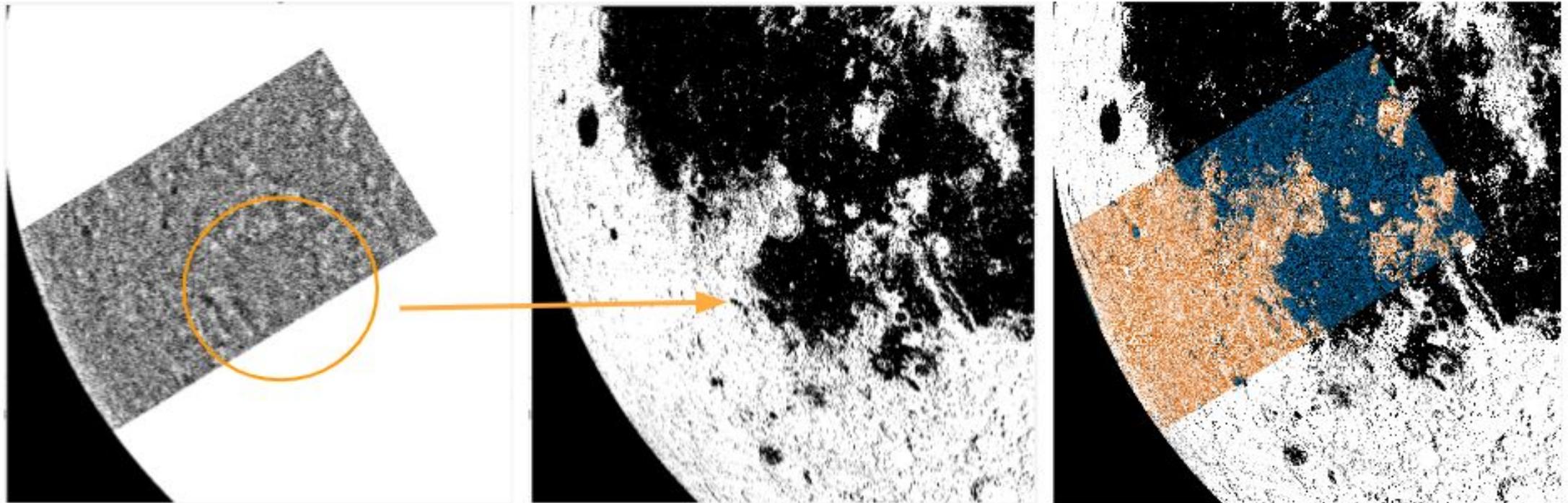
50 -25 0 25 50
-1 pixels
Shift horizontally
Shift vertically

100%
Change focus (zoom)
Flip vertically and retry

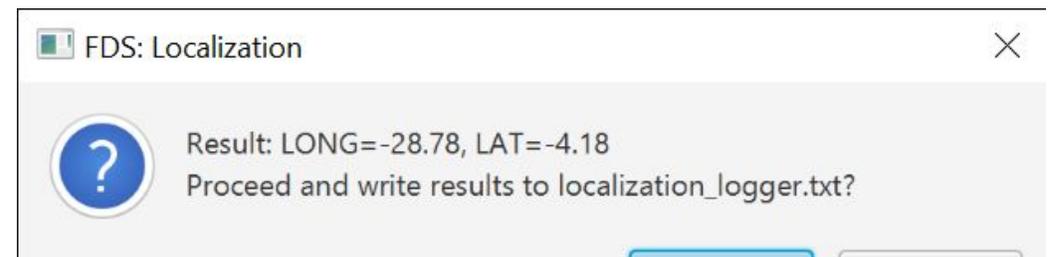
Change rotation angle (based on unrotated image):
-180 -155 -130 -105 -80 -55 -30 -5 20 45 70 95 120 145 170 180
Rotation angle (deg): -31.53
Rotate

-3 3

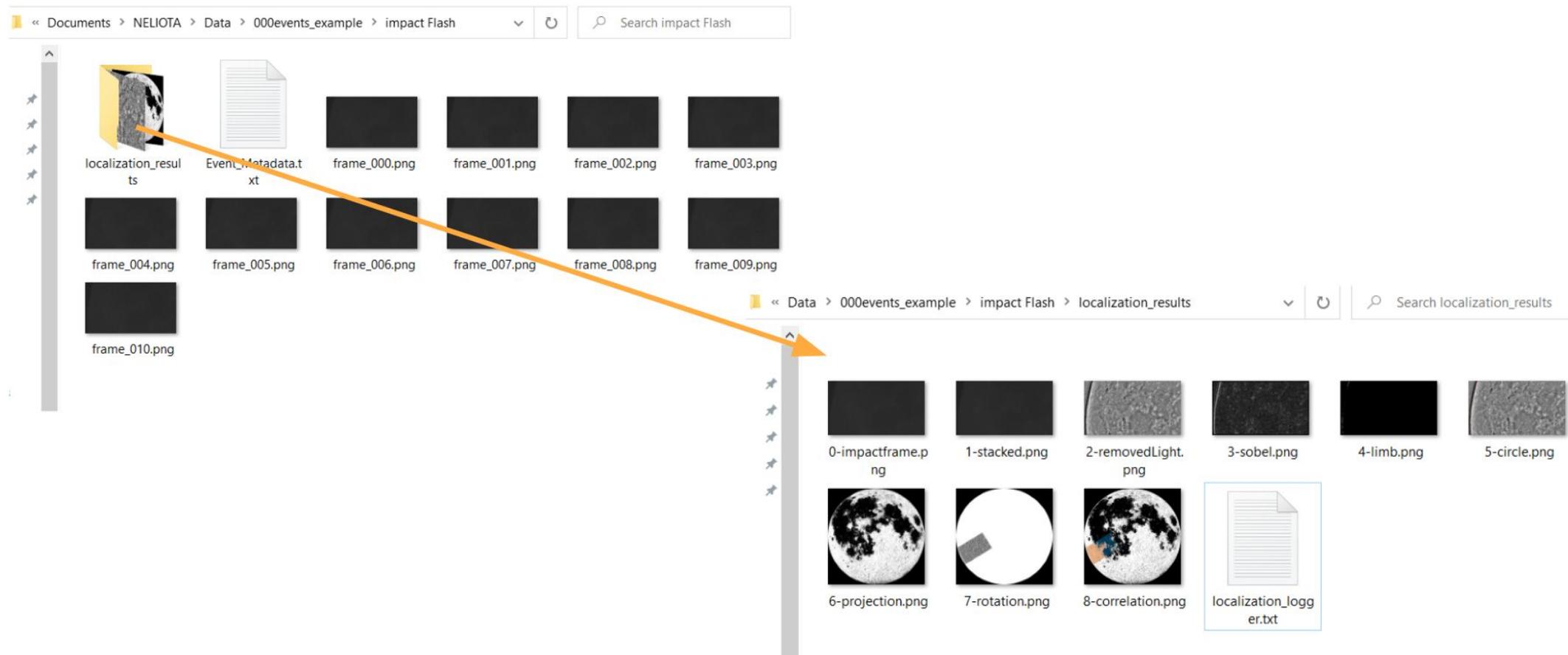
Mare Humorum is now correctly placed



- 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\I  
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

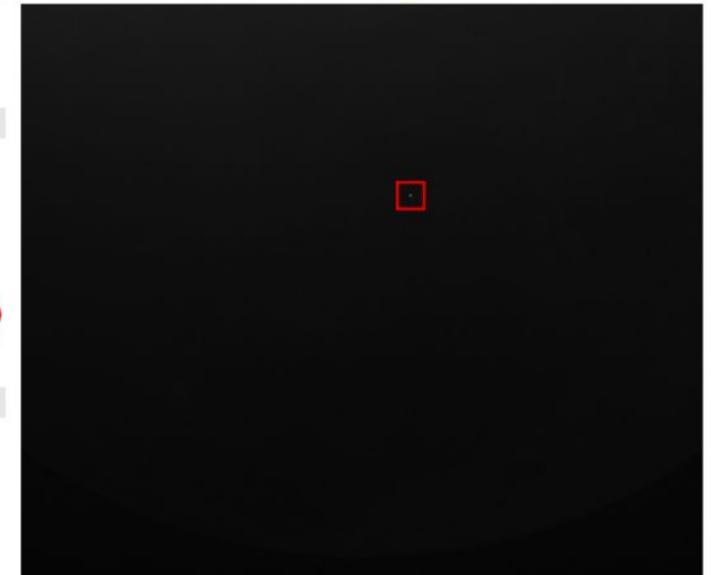
Event Data

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)

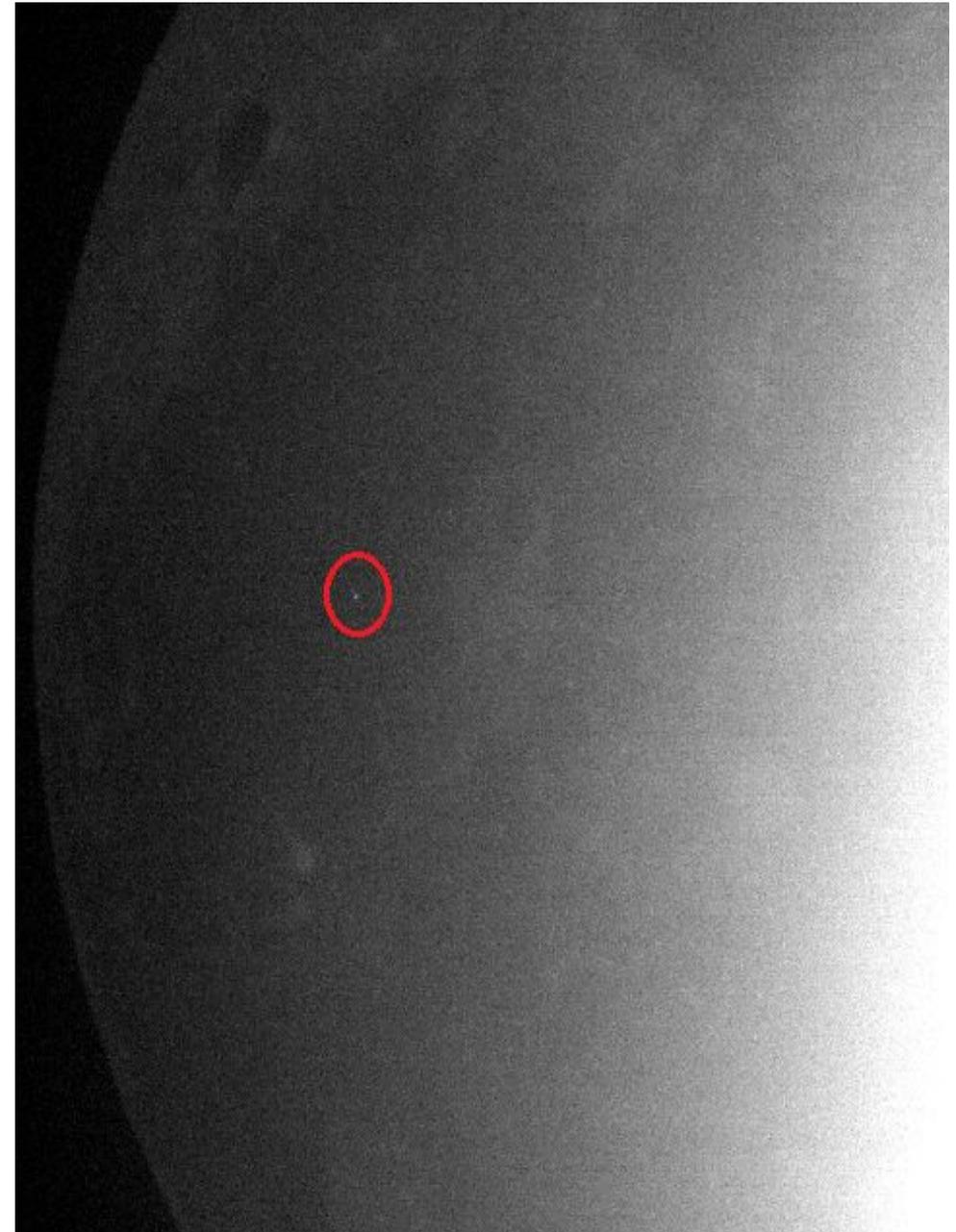


Second Event (provided by NELIOTA)

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

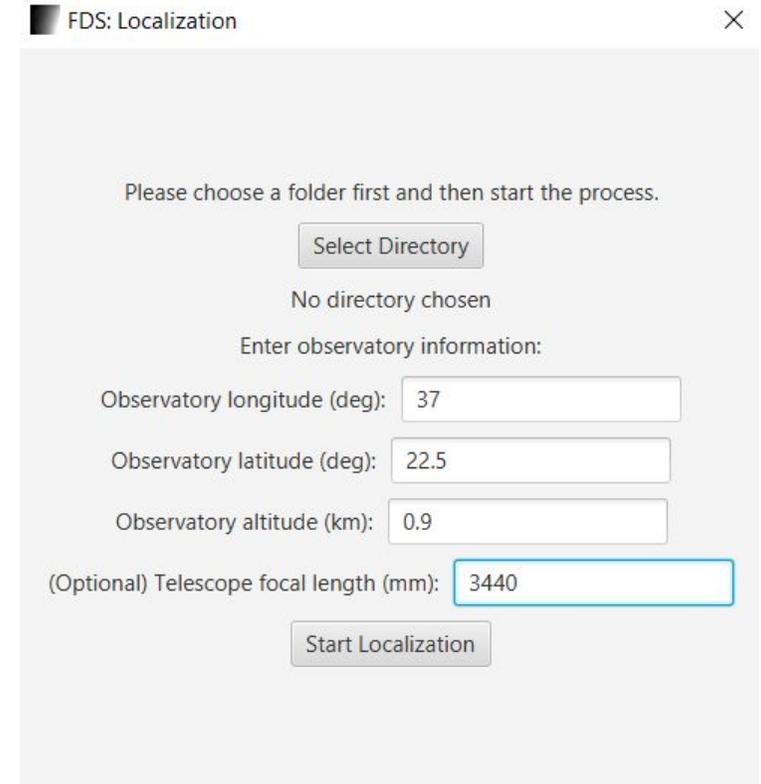
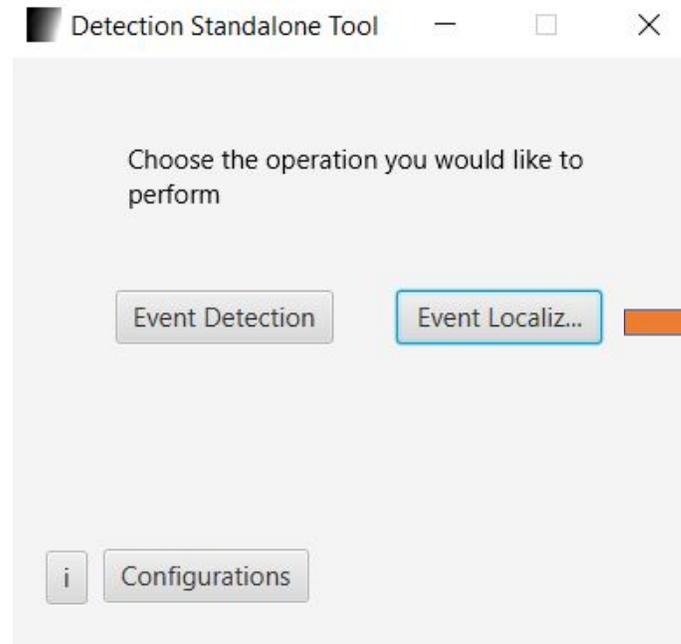
Set-up

- 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

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

FDS: Localization

[View circle](#) [Hide circle](#) [View limb](#) [View impact frame](#)

The following circle was found:

Change circle color
#ff2800

Center found (pixels):
X=1265.14, Y=639.93
Radius found (pixels): 1237.65

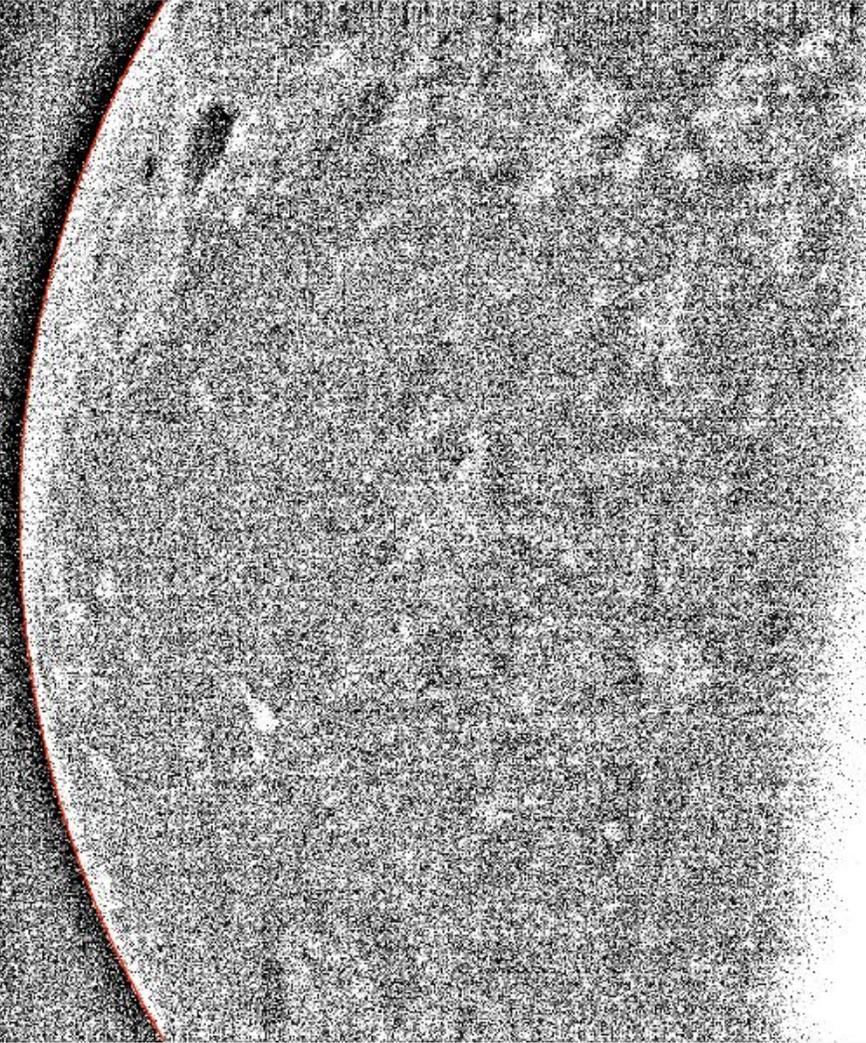
Pixel scale (arcsec/pixels): 0.78
Suggested radius (pixels)
based on pixel scale: 1239.88

Click on the image to get the pixel coordinates of the point:

Image (pixels):
Physical (pixels):

Impact location
Physical (pixels): X=383, Y=659

100%
[Change focus \(zoom\)](#)



[Continue](#)

Next Step

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

FDS: Localization

View filtered image View reference View impact frame

Filtered observation image

Use the reference moon picture (click View reference) to pick hemisphere and identify if the observation image is flipped

Pick non-sunlit lunar hemisphere:

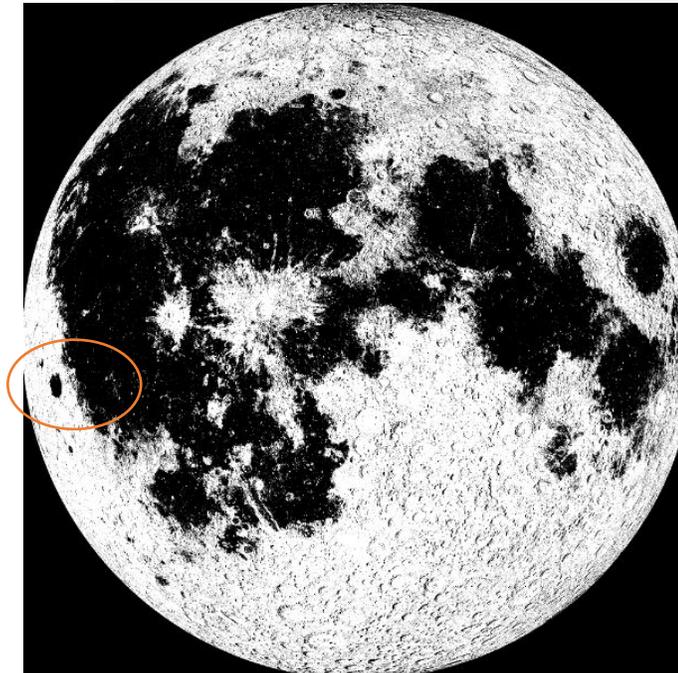
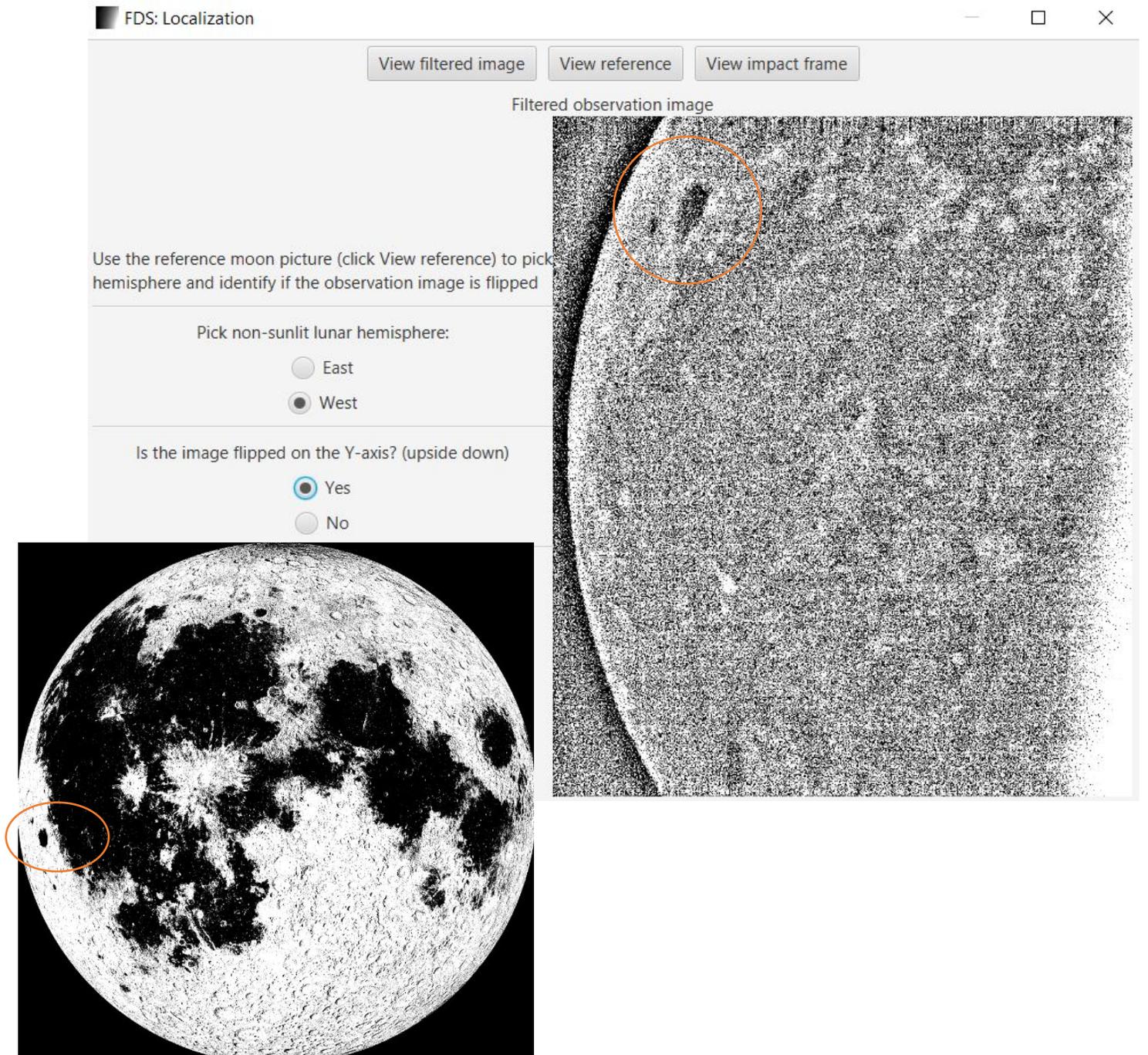
East

West

Is the image flipped on the Y-axis? (upside down)

Yes

No



Automatic rotation

- Automatic rotation found a rotation angle of 21.7 degrees

FDS: Localization

View correlation View moon View rotation

Correlation

Try to match large lunar features

Info Matching pixels: 61.82%

Change match color

#0072b2

Change non-match color

#d55e00

Info Radius (pixels): 1237.65

Go back to circle fitting

Impact flash: green cross mark

Impact flash location (pixels)

Physical: X=412, Y=1547

Lunar coordinates (deg):

Longitude= -47.18

Latitude= 10.52

Image (pixels):

Physical (pixels):

Create a red cross mark

Mark point Remove mark

Undo Redo

Move history

Reset to initial

-50 -25 0 25 50

0 pixels

Shift horizontally

Shift vertically

63%

Change focus (zoom)

Flip vertically and retry

Change rotation angle (based on unrotated image):

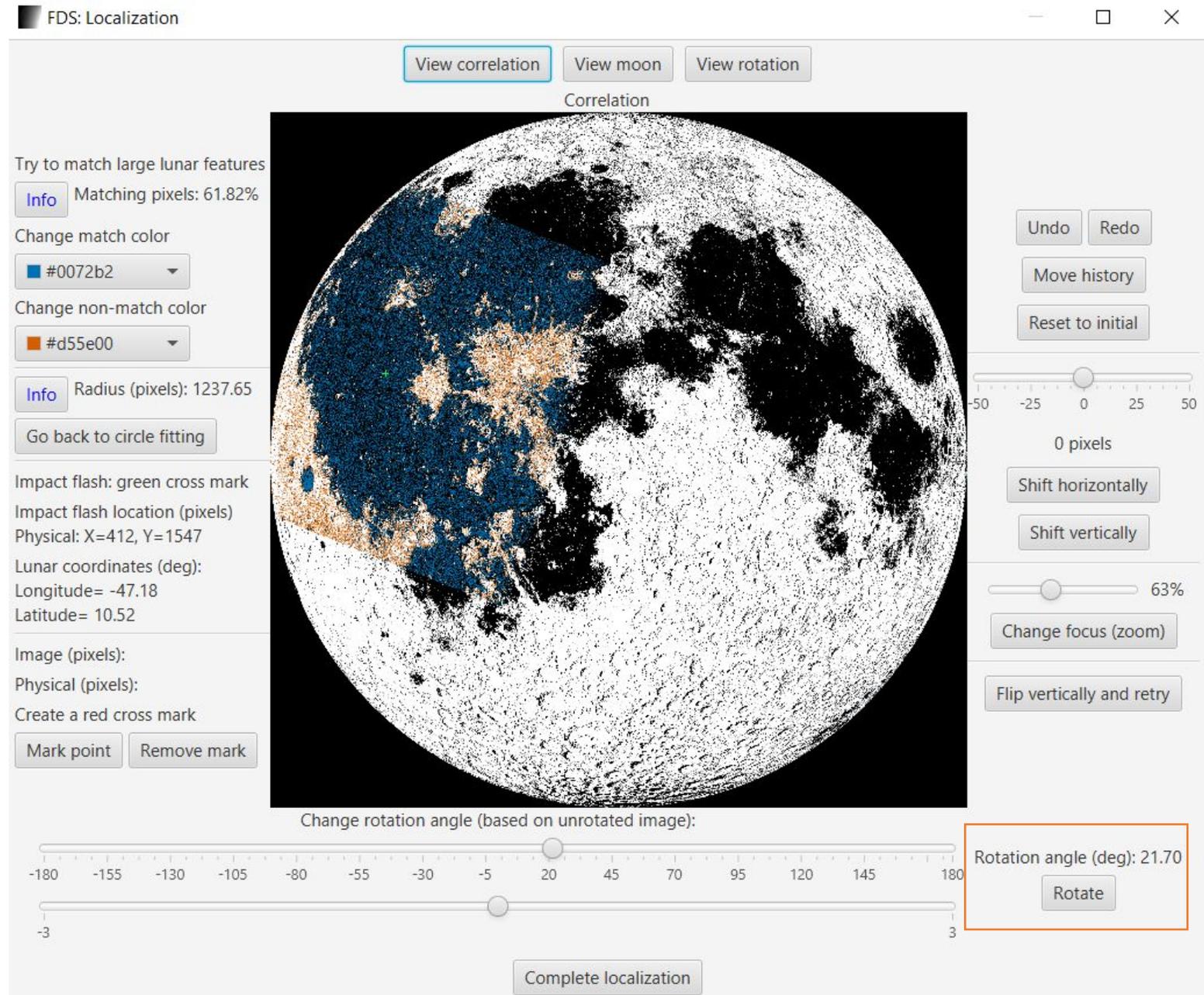
-180 -155 -130 -105 -80 -55 -30 -5 20 45 70 95 120 145 180

-3 3

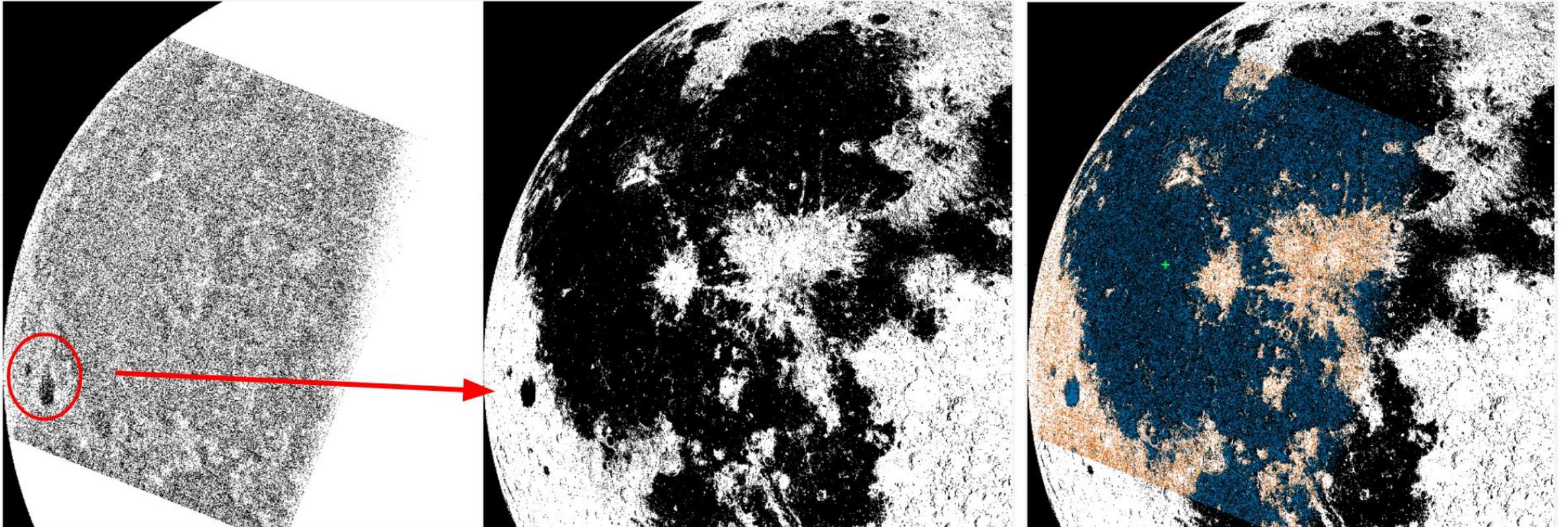
Rotation angle (deg): 21.70

Rotate

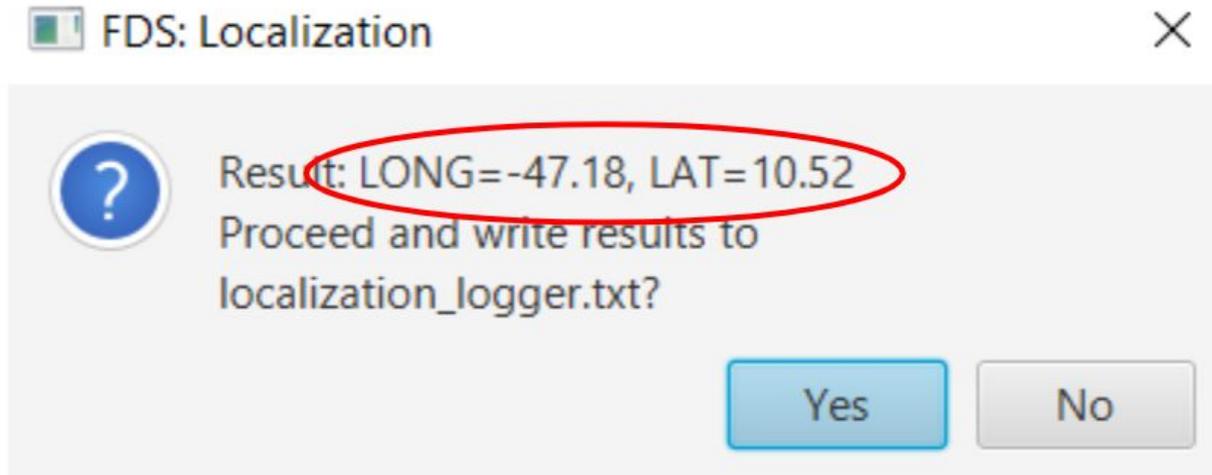
Complete localization



Grimaldi crater is correctly matched



Comparing results with NELIOTA



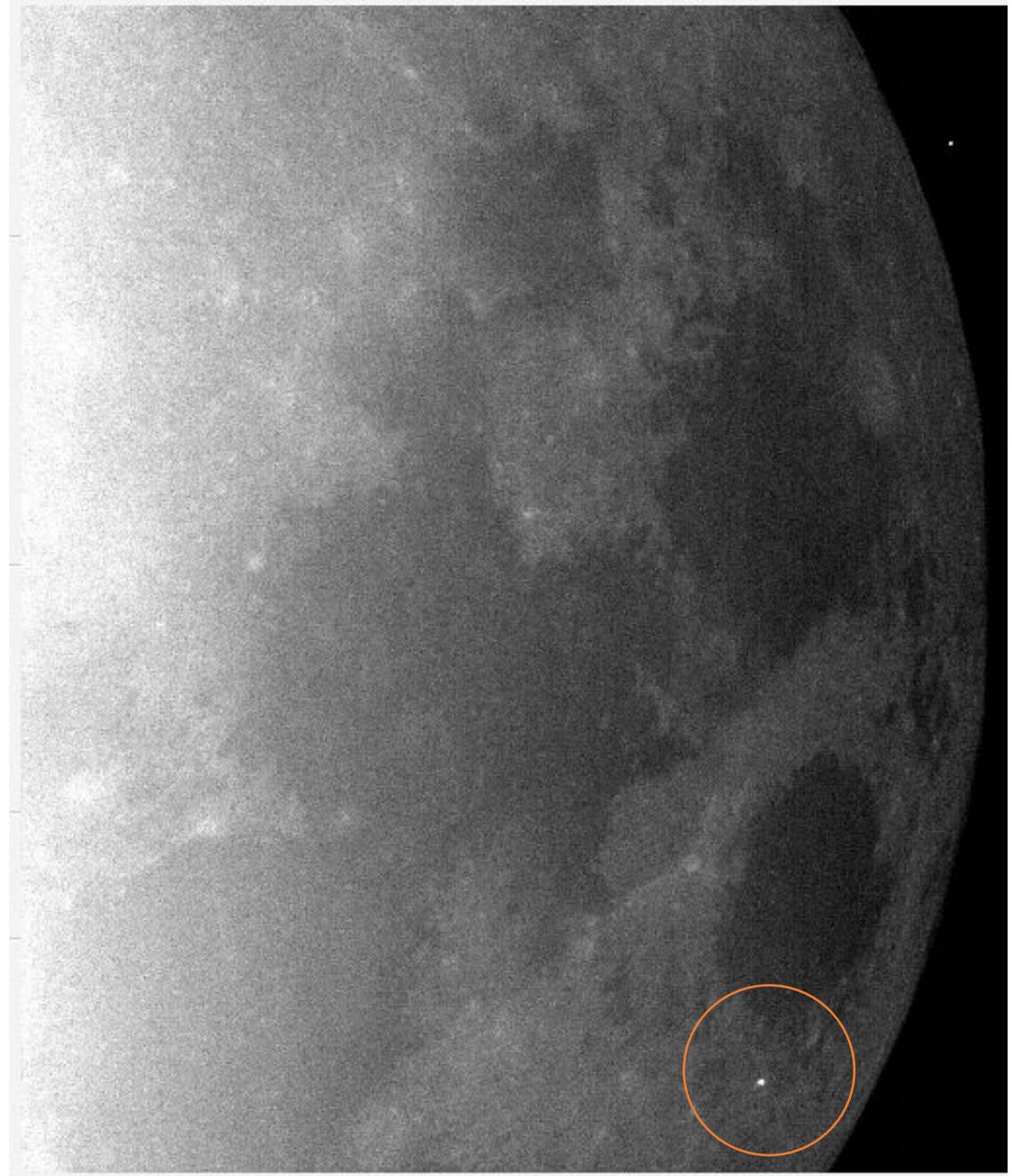
Event Data	
UT Date (DD/MM/YYYY):	25/06/2020
UT Time:	18:28:18.340
R (mag):	7.9 ± 0.1
I (mag):	6.7 ± 0.0
Lunar Long (deg):	-46.5
Lunar Lat (deg):	10.8
Duration (sec):	0.132

Third Event (provided by NELIOTA)

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

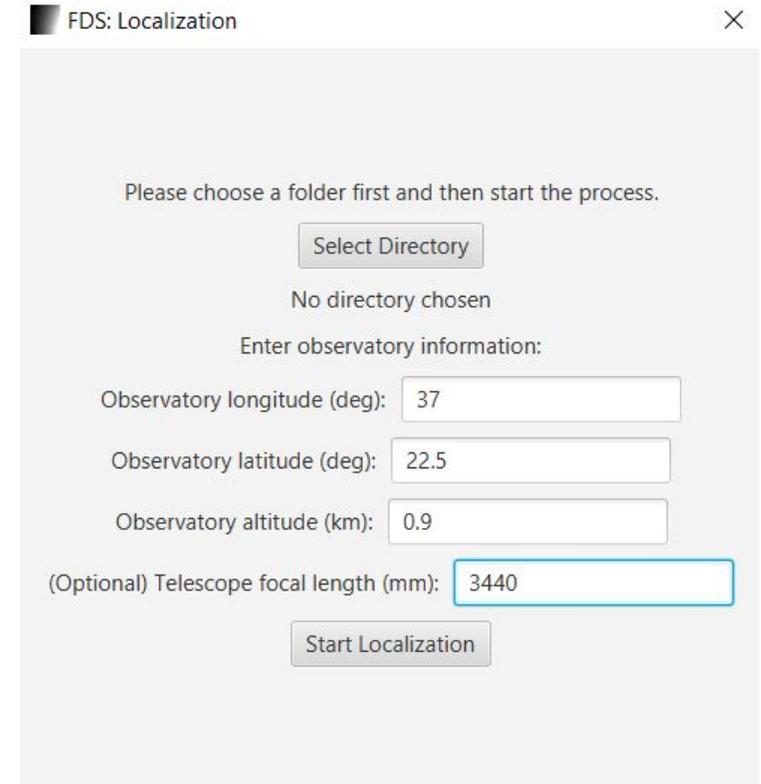
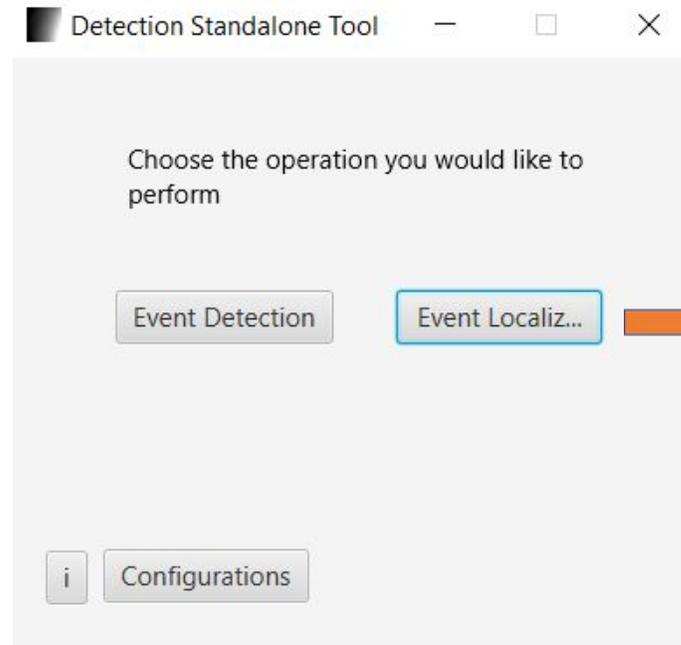
Set-up

- 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

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

FDS: Localization

View circle Hide circle View limb View impact frame

The following circle was found:

Change circle color
#ff2800

Center found (pixels):
X=-220.59, Y=630.01
Radius found (pixels): 1279.69

Pixel scale (arcsec/pixels): 0.78

Suggested radius (pixels)
based on pixel scale: 1279.60

Click on the image to get the pixel coordinates of the point:

Image (pixels):
Physical (pixels):

Impact location
Physical (pixels): X=809, Y=99

100%
Change focus (zoom)

Undo Redo Past attempts
Reset to initial circle

AUTOMATIC CIRCLE FITTING
Change the parameters below and click Retry.
Change sd of gaussian filter:
- 5 + Info
Boost top and bottom % of image:
- 0% + Info
Retry
Reset to default

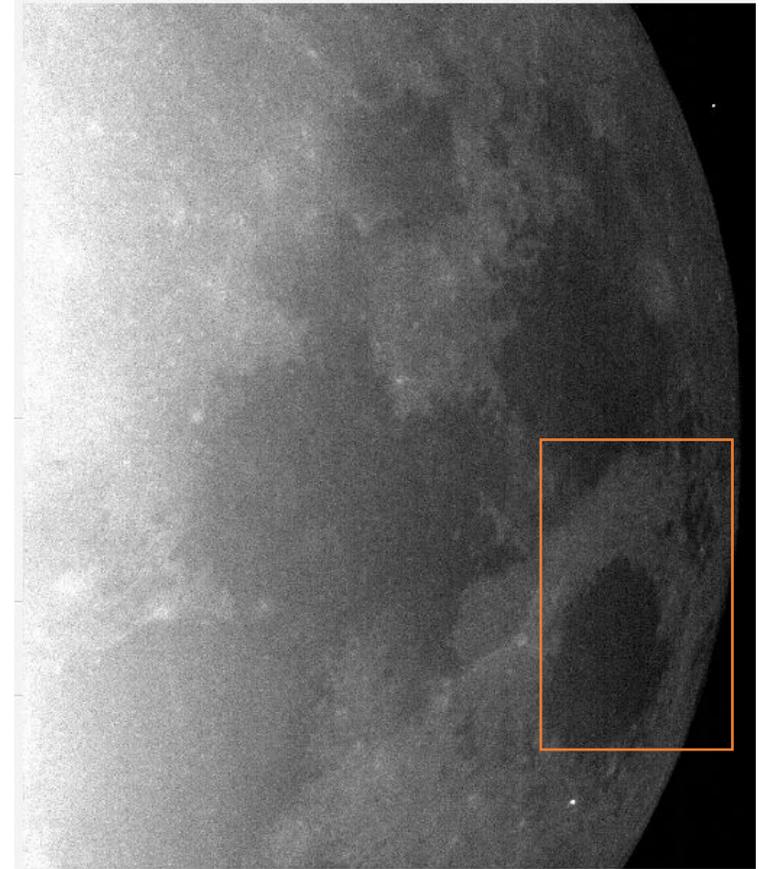
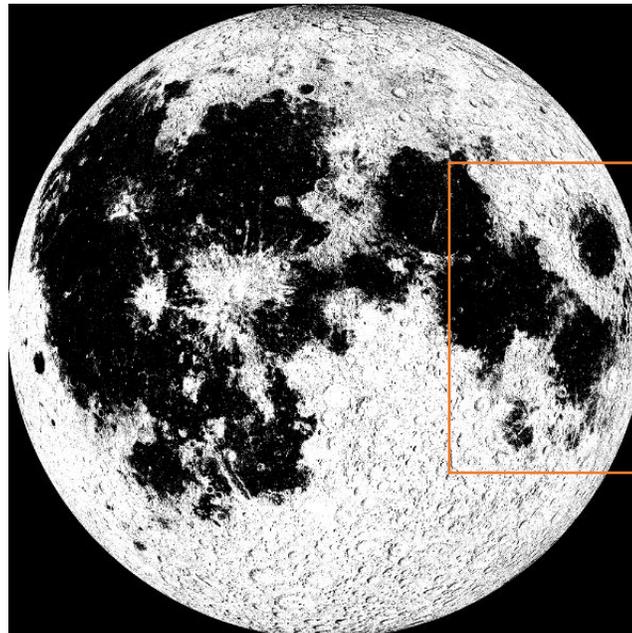
MANUAL CIRCLE FITTING
Click on the image and then add point to manually select limb pixels. Click manual fit when ready.
See last 5 points
Add point Undo previous point
Clear all points
Manual fit

Continue



Next Step

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



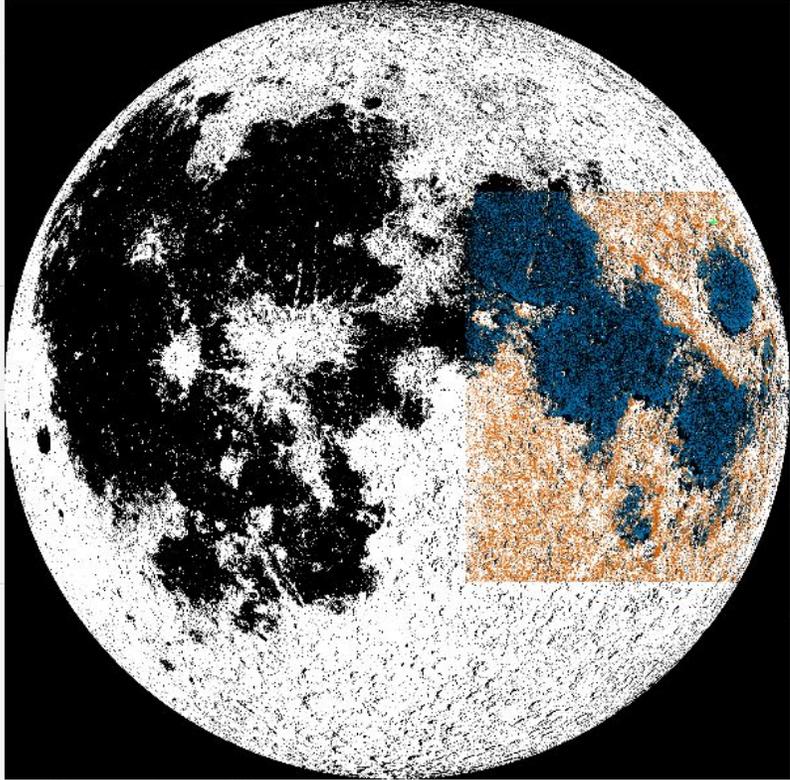
Find the right rotation

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

FDS: Localization

View correlation View moon View rotation

Correlation



Try to match large lunar features

Info Matching pixels: 42.03%

Change match color

#0072b2

Change non-match color

#d55e00

Info Radius (pixels): 1279.69

Go back to circle fitting

Impact flash: green cross mark

Impact flash location (pixels)
Physical: X=2310, Y=1830

Lunar coordinates (deg):
Longitude= 61.35
Latitude= 27.30

Image (pixels):
Physical (pixels):

Create a red cross mark

Mark point Remove mark

Undo Redo

Move history

Reset to initial

0 pixels

Shift horizontally

Shift vertically

100%

Change focus (zoom)

Flip vertically and retry

Change rotation angle (based on unrotated image):

Rotation angle (deg): 0.00

Rotate

Complete localization

Shift Horizontal and Vertical

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

FDS: Localization

View correlation View moon View rotation

Correlation

Try to match large lunar features
Info Matching pixels: 42.03%

Change match color
#0072b2

Change non-match color
#d55e00

Info Radius (pixels): 1279.69
Go back to circle fitting

Impact flash: green cross mark
Impact flash location (pixels)
Physical: X=2310, Y=1830
Lunar coordinates (deg):
Longitude= 61.35
Latitude= 27.30

Image (pixels):
Physical (pixels):
Create a red cross mark
Mark point Remove mark

Change rotation angle (based on unrotated image):
-180 -155 -130 -105 -80 -55 -30 -5 20 45 70 95 120 145 180
-3 3
Rotation angle (deg): 0.00
Rotate

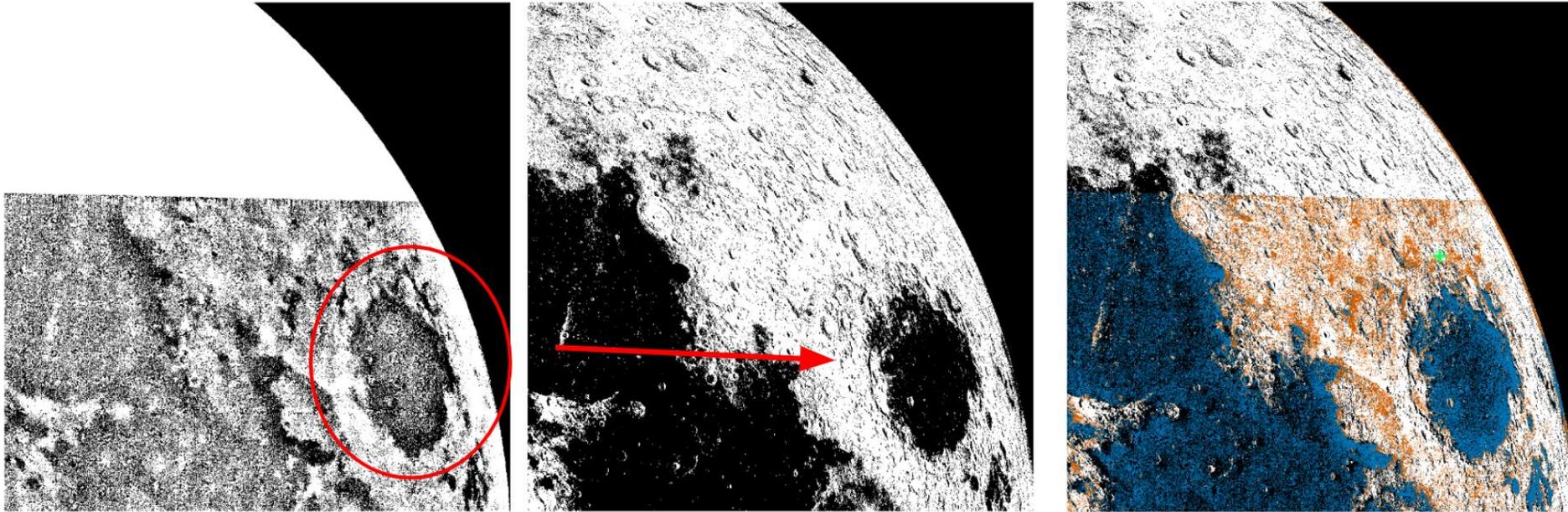
Undo Redo
Move history
Reset to initial

0 pixels
Shift horizontally
Shift vertically

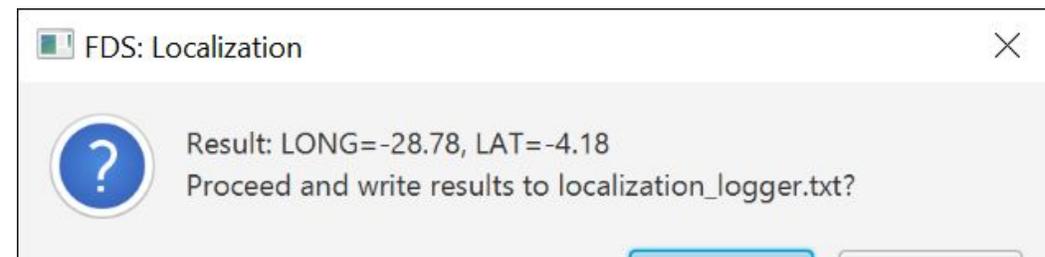
100%
Change focus (zoom)
Flip vertically and retry

Complete localization

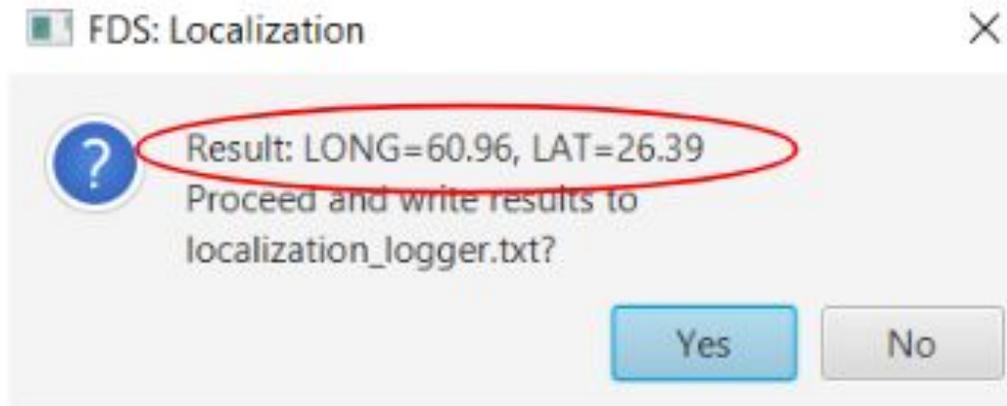
Mare Crisium is now correctly placed



- 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
