PULSE RHEED Oscillation Software User Manual

(Compatible with version 0.1.5.4)

BIZMUTH MBE LTD

Pulse

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Overview

PULSE is a simple and powerful RHEED oscillation software that can be used with any USB webcam. In addition to RHEED oscillations, PULSE can display various point and line scans/maps.

You can save and replay videos in avi format, track the brightest spot during capture and also simulate oscillations for training purposes.

Automatic fitting of raw data will give you the oscillation period, the dampening and the monolayer growth rate. Raw data can be smoothed to achieve a perfect fit.

Hardware requirements

PULSE is created exclusively to work on 64-bit Windows 10/11 operating systems. For best results a modern PC is recommended, in general the processor requirements are higher than the RAM requirements.

The specifications below are recommendations only. The final performance will depend on other factors, such as other software installed on the PC. It is recommended to use a single PC solely to operate the PULSE software to achieve the best possible results. It is typical to require >10% processor usage when operating the software.1

Any restriction in processor time can result in loss of frames from the camera and an inaccuracy in the calculated growth rate. In order to evaluate the overall software performance a resource monitoring tool is integrated into PULSE. It can be accessed following the instructions in the **Performance** section below.

Recommended specification

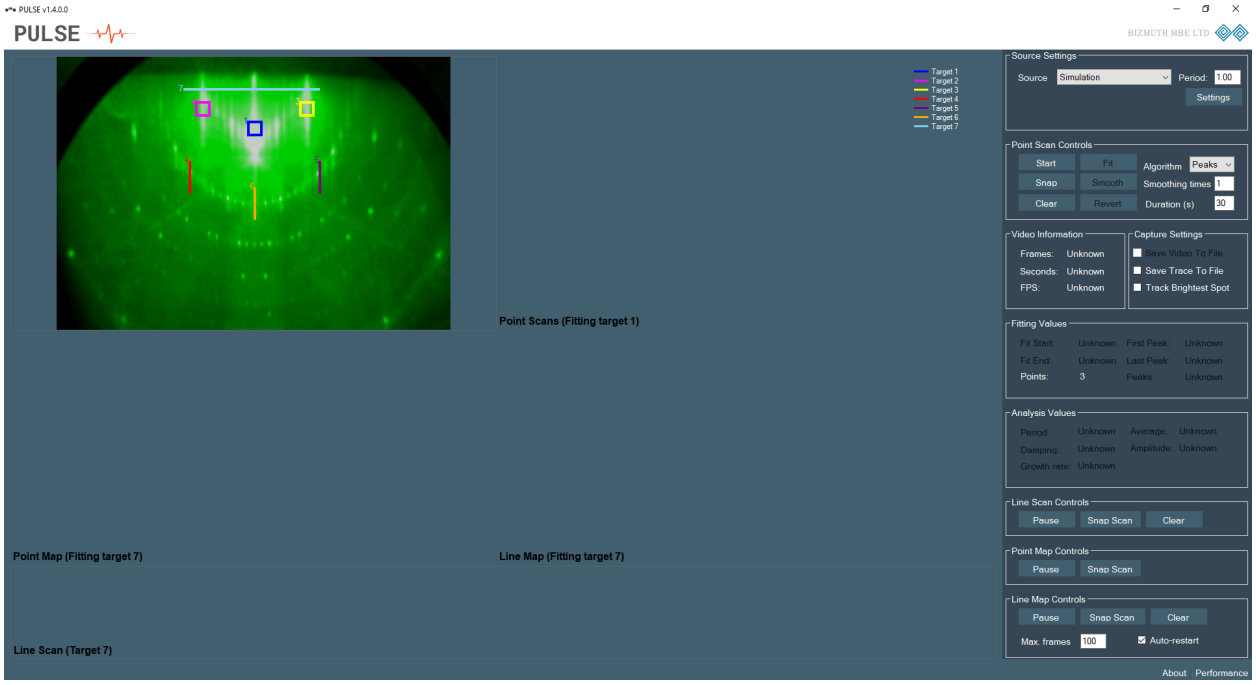
Processor: Raptor-Lake 14th generation Intel Core-i7 processor (or equivalent) circa 2023
RAM: 32GB DDR5

Minimum specification

Processor: Comet-Lake 10th generation Intel Core-i5 processor (or equivalent) circa 2019
RAM: 16GB DDR4

Start up

On software start the following screen will be displayed:



Safe Mode

Pulse has a “Safe Mode” to limit system resources. In safe mode the line scan, point map and line map features are disabled by default. The software name in the title bar will display “(Safe Mode)” when starting in safe mode. The line scan, point map and line map can be resumed by selecting the corresponding option. For more details, see the individual sections below: **Line Scan**, **Point Map** and **Line Map**.

To access safe mode, hold the CTRL key whilst double clicking on the desktop shortcut to start the Pulse application. If you are starting the application from the “Pulse.exe” file directly. Then select the “Pulse.exe” file with a single left mouse click, then hold CTRL and press the ENTER key to start the application. Safe mode can also be set on the “Settings” form, see the **Settings** section below.

License

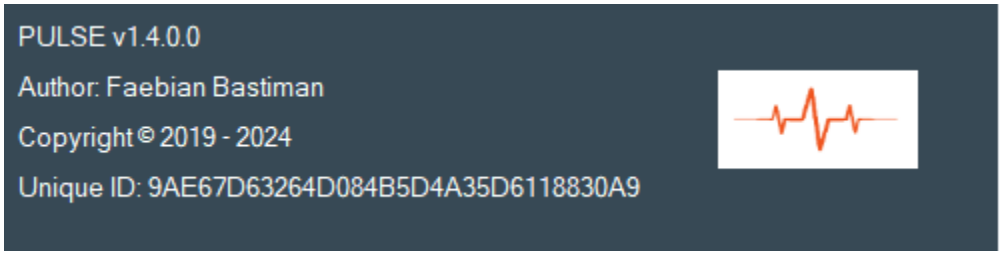
This is a licensed software. A license file containing a unique hexadecimal license code is required for live capture operation. To obtain a license, the hexadecimal uniqueID of the PC where the software is going to be operated needs to be sent to bastiman@bizmuthmbe.com. **Ensure that the UniqueID is obtained by running the software on the PC where it is intended to be used.** Once the UniqueID has been received, a license file will be returned containing the hexadecimal licence code.

Without a license the software can be used in simulation mode for evaluation purposes only. In this case, a uniqueID will be displayed on startup that should be sent to the author to obtain a license. The Unique ID can also be found on the About form, see **About** below.

Information

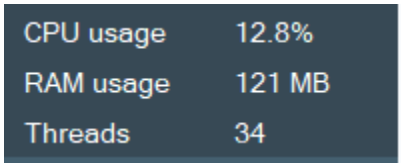
About

Click the About option on the bottom right status bar to view the software author information and the uniqueID used to obtain a license. For example:



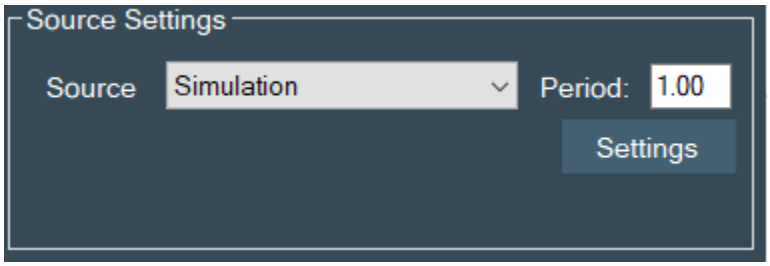
Performance

Click the **Performance** option on the bottom right status bar to view the software CPU, RAM and thread usage. For example:



Modes

The software has 3 main modes described below. These are accessed by using the Source Settings box:



Simulation

Simulation can be used to evaluate the software without a license, or for training purposes.

Select **Simulation** from the **Source** combobox directly below the left image. A pulsing image will appear showing a typical RHEED pattern.

You can change the period of the simulated “pulsing” oscillation by changing the value in the **Period** textbox to the right of the combobox to a value from 0.01 to 2.

Live camera capture

The **Source** combobox shown above will automatically list any USB cameras found at software start. Select the correct camera for the RHEED capture. The Camera will begin streaming automatically. The video streaming time will be indicated in HH:mm:ss format.

Note: if the camera was not connected at software start, simply connect the camera and then double click on the word “Source” to rescan for cameras once more.

Press the **Pause** button to pause the live capture stream at any moment. The button text will update to **Play**. Press the Play button to resume streaming.

Playback

Select **File** from the **Source** combobox directly below the left image and then click on the **Select File…** text that appears beneath the combobox. Select the file to play from the popup.

The video file will load and display the first image from the file. To begin the video file press the **Play** button, the text will update to “Pause”. Press the **Pause** button to stop the video file. Note: Video play will resume from the beginning of the file after a “pause”.

The current time and the total length of the video file will be displayed whilst playing. It is usual that the displayed total length will truncate to a fraction of a second once the video file recording is finished. This is due to slight variations in frame rate during playback.

Video files can be played and analysed in an identical manner to live camera capture streams.

Settings

The general settings of the software can be accessed by pressing the “Settings” button in the Source Settings box. A form will appear atop the Point Scan chart. The settings are:

- Mirror: to mirror the source feed or not.
- Contrast: to adjust the contrast from 0 to 255.
- Brightness: to adjust the brightness from 0 to 255.
- Filter: applies an available filter to the source including “False Palette Colours”.
- Target set: selects either the default or the custom/user saved target set at program start
- Video format: The output format of the saved video files: limited to .avi at present
- Trace format: The output format of the Trace data files: limited to .txt at present
- Safe mode: starts the software in safe mode by default. In safe mode the line scan, point map and point scan are disabled.
- Automatic binning: to attempt to increase or decrease the binning rate (the rate at which frames are ignored from the source) in order to attempt to limit total CPU and RAM usage.
- Line Scan Binning: this can only be modified if automatic binning is disabled. Modifies the binning rate of the line scan only.
- Point Map Binning: This can only be modified if automatic binning is disabled. Modifies the binning rate of the point map only.
- Line Map Binning: This can only be modified if automatic binning is disabled. Modifies the binning rate of the line map only.

To close the settings form, click on the “Close” button in the top right corner of the form.

Targets

Targets represent corresponding pixels that the software monitors and analyses. There are 7 targets by default:

- 3 rectangular targets
- 3 vertical line targets
- 1 horizontal line target

Each target has its own unique identifying colour. The targets appear on the video image.

Adding targets

In the current version the maximum number of targets is limited to 7. To add a target, right click on the video image and select “Add target” from the menu that appears. Targets are added in the default sequence listed above.

Deleting targets

The minimum number of targets is 1. To delete a target, right click on the video image and select “Delete target” from the menu that appears. Targets are deleted in the reverse of the default sequence listed above.

Selecting a target

To select a target, left click on the number that identifies the target. This will set the target as the active target for subsequence moving or editing.

Moving a target

To move a target, move the mouse to the number next to the target and then press and hold the left mouse button. With the left mouse button still held, move the mouse to the desired position. Once reached, release the left mouse button to update the target location.

Resizing a target

After selecting a target, use the mousewheel to increase or decrease the size of the target. Rectangular targets increase/decrease equally along all sides. Line targets increase/decrease in length only.

Edit a target

To edit a target, first select it as the active target by left mouse clicking near the target number. Then right mouse click and select “Edit target” from the menu that appears. The following form will appear atop the Point Scan chart:

The target name is displayed along with the type of target (i.e. Line or Rectangle). Five values can be altered:

1. The target X coordinate
2. The target Y coordinate
3. The target width (W)
4. The target height (H)
5. The target colour in hexadecimal ARGB

To update X, Y, W, or H, click or double click on the textbox and type a new value. The target location/dimension will update automatically. The X and Y values have a minimum of 0 and a maximum determined by the video resolution and the width and height of the target. The W and H values have a minimum of 0 and a maximum determined by the video resolution and the X and Y values.

To update the colour, click or double click in the textbox. Enter values from 0…F in hexadecimal to alter the colour. The color label to the left of the textbox will reflect the new target colour.

To close the “Edit target form” click the close button in the top right corner of the form.

Save targets

After adding, deleting, moving or otherwise editing targets, the target set can be saved by right clicking on the video image and selecting “Save targets” from the menu that appears. The targets are saved to a text file.

In addition to the location and size of the targets, saving also saves the selected target for each of the point scan, line scan, point map and line map sections.

Loading targets

Saved targets can be reloaded by right clicking on the video image and selecting “Load targets” from the menu that appears. The targets are reloaded from a text file.

Resetting targets to default

To restore the default target set, right clicking on the video image and select “Reset targets”.

Capture mode

Taking a Snapshot

To take a snapshot of the current video frame, click the **Snap** button at any time. The snapshot will be saved in BMP (bitmap) format. Files are saved with a filename encoded with a date and time stamp of the type: “YYYY-MM-DD HH-mm-ss Snaphot.bmp” where:

- YYYY is the year in 4 digits
- MM is the month in 2 digits
- DD is the date in 2 digits
- HH is the hour in 24 hour time
- mm is the minutes in 2 digits
- ss is the seconds in 2 digits

BMP files can be found in: C:\RHEED Capture\Output

Saving video to file

Check the **Save Video to File** checkbox to save the video as AVI file during capture. **The video can only be recorded and saved if the checkbox is ticked before starting capture**, not once capture is running nor complete. The video file is only finalized and saved once the **Stop** button is clicked. To start the capture, use the **Start** button to start a RHEED oscillation trace,

the text will change to Stop. Once complete, click the **Stop** button to end the trace. The video file will be saved automatically as the trace ends.

AVI files can be found in: C:\RHEED Capture\Output

Save trace to CSV file

Check **Save Trace to File** checkbox to save the trace data as a CSV file for later use. To start the capture, use the **Start** button to start a RHEED oscillation trace, the text will change to Stop. Once complete, click the **Stop** button to end the trace. The CSV file will be saved automatically as the trace ends.

Note: in the current version only the trace of the selected target for the point scan is saved.

CSV files can be found in: C:\RHEED Capture\Output

Tracking the brightest spot

Select “track brightest spot” from the capture setting menu to attempt to find and follow the brightest spot in the source video stream. This option will automatically move the target and can attempt to compensate for instability in the RHEED spot.

Capturing RHEED oscillation trace

Move the active target to the correct position on the screen by pressing and holding with the left mouse button and then dragging to the correct position.

Press the **Start** button to start the live capture, the text will change to Stop. The variation of the intensity in all targets with time will be plotted on the chart to the right. Once done, press the **Stop** button to stop the live capture.

Select the **Track Brightest Spot** checkbox to follow the brightest spot during capture.

Showing or hiding traces

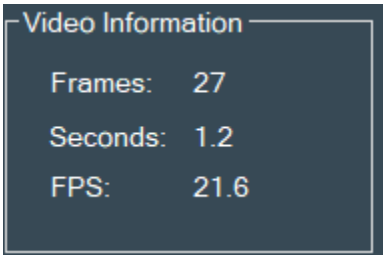
All traces for all targets are shown by default. To show or hide an individual trace, left click on the target name in the legend in the upper right corner of the point scan chart. To hide all but one target, hold the CTRL key on the keyboard and then left click on the target name in the legend. To restore all target traces double click anywhere on the chart.

Clearing the RHEED oscillation trace

To clear the RHEED oscillation trace press the Clear button at any time. Clear can also be used during a trace to clear earlier data from the chart.

Video Information

The video information is used to monitor the number of frames, the number of seconds and the frames per second (FPS) during a point scan. Until the first point scan is started all the values will read “unknown”. For example:



Fitting and Smoothing

Once the capture is complete you can automatically determine the growth rate using the built in curve analyser function. In principle, any value of growth rate can be determined, though in practical terms the growth rate is only reliable in the 0.01 to 2 ML/s range.

Selecting a target

To change the target used by the point scan, right click on **an empty area** on the point scan chart, highlight “Select target” in the menu that appears and then select the desired target from the dropdown menu.

Note: an empty area must be selected to view the menu. The area below the legend is recommended.

Selecting start and end points

Once the capture is complete two vertical lines will appear on the chart. The green line marks the start point for fitting and the blue line marks the end point for fitting.

To move the green line, left click on any data series on the chart. Similarly, to move the blue line, on any data series on the chart. The **Fit Start** and **Fit End** data labels below the chart will update to reflect the new values.

Note: whilst right clicking on the chart, the options menu will not appear. To view the menu right click on some empty space, for example below the legend.

Algorithm

There are two algorithms:

1. Peaks
2. Sine

Peaks attempts to identify and count the number of peaks in a given trace. This is advantageous if there is a shift in the average intensity value of the trace over time, but it is prone to errors when the trace is significantly noisy. Peaks may also encounter difficulties identifying peaks at the start and the end of the trace.

Sine attempts to fit the data to a three parameter sine function. This is advantageous when the trace is noisy, but may encounter difficulties when the average value varies significantly.

Duration

The total duration of the trace is configurable from 1 to 600 seconds. Once the duration has been reached the trace will automatically stop. The trace can also be manually stopped at any time by pressing the **Stop** button.

Smoothing

Real raw captured RHEED data is often noisy. The **Smooth** feature can be used to smooth and average the data to assist with fitting. Click the **Smooth** button to smooth the data. For highly noisy data and to decrease frantic clicking, set the Smoothing times value to a higher value. Values from 1 to 10 are permitted.

Note: only the currently selected target trace will be smoothed. After a scan is complete the target can be changed to use the data already recorded without the need to start a new trace.

After smoothing, **Revert** can be selected to restore the original trace.

Fitting values

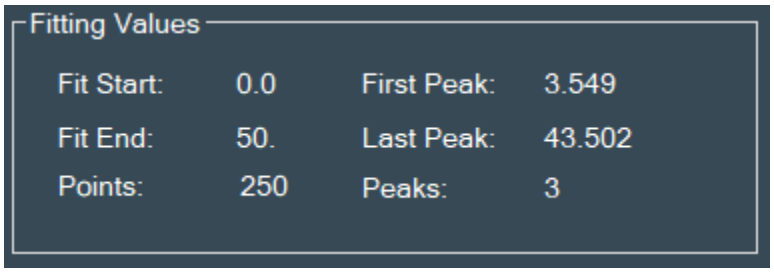
Click **Fit** to automatically analyse the trace. An orange trendline will appear on the chart showing the fitting data.

Note: if there is insufficient data to perform a fit. A message box will appear with a warning that at least two peaks are required.

The fitting data below the chart will also update. These are:

- First Peak - indicating the X value of the first detected peak
- Last Peak - indicating the X value of the last detected peak
- Points: An internal evaluator proportional to the period of oscillation used by the algorithm to determine initial conditions for fitting
- Peaks: Giving the number of peaks identified by the algorithm (not this may be less than the total visible peaks)

The fitting data appears in the Fitting Values box:

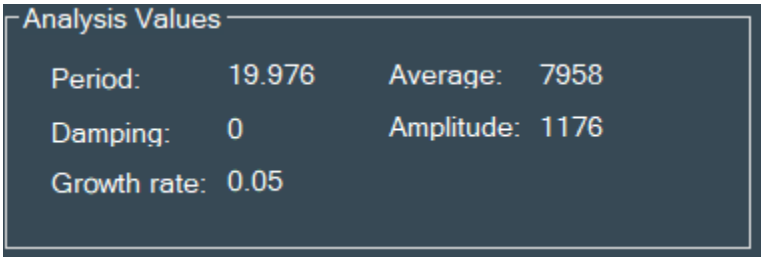


Analysis values

In addition to the fitting values, the software provides the following analysis values:

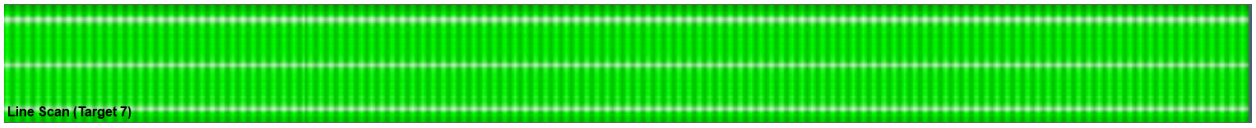
- Period - giving the average period of the oscillations
- Damping - giving the approximate damping factor (if any) of the sinusoidal oscillation trace
- Average - giving the average intensity
- Amplitude - half the peak to peak distance of the first full oscillation
- Growth rate - giving the calculated growth rate in monolayers per second

The analysis data appears in the Analysis Values box:

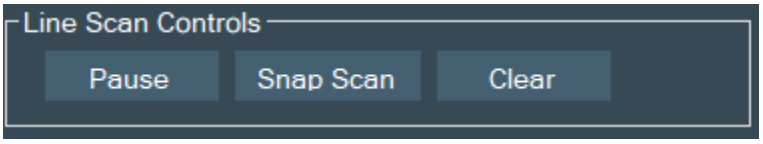


Line Scan

The line scan features creates a pixel/bitmap scan image. The output is displayed across the bottom of the screen in the “Line Scan” section. For example:



The line scan progresses until the maximum number of frames have been reached (currently 500) and then overwrites the previous image. The line scan is controlled with the buttons in the Line Scan Control box:



Changing the target

By default, the line scan uses the 7th target. In order to change the target, right click on the line scan section, highlight “Select Target” in the menu that appears and then select the desired target from the drop down menu.

The line scan image will clear and then the scan will continue using the new target. The line scan is designed to work with “line” type targets. Regardless of whether the line target is horizontal or vertical in orientation, the line scan image will always progress from left to right displaying the pixels along the length of the line target. If a rectangular target is chosen, the line scan will utilise only the left hand most vertical section of the rectangular target - and thus create a line target from the rectangular target.

Pause/Resume

The line scan can be paused at any time by clicking the “Pause” button. Once paused, the text will update to “Resume”. To resume the line scan, click the button once more.

The line scan can also be paused by right clicking on the Line Scan section and then selecting “Active” from the menu that appears. To resume the line scan select “Active” once more.

Taking a snapshot

To take a snapshot of the existing line scan click the “Snap Scan” button. The corresponding snapshot will be saved as a bitmap file in the “Output” folder in the Pulse root directory. A

message box will appear to indicate the path and the name of the file. Files are saved with a filename encoded with a date and time stamp of the type: “YYYY-MM-DD HH-mm-ss Line Scan.bmp” where:

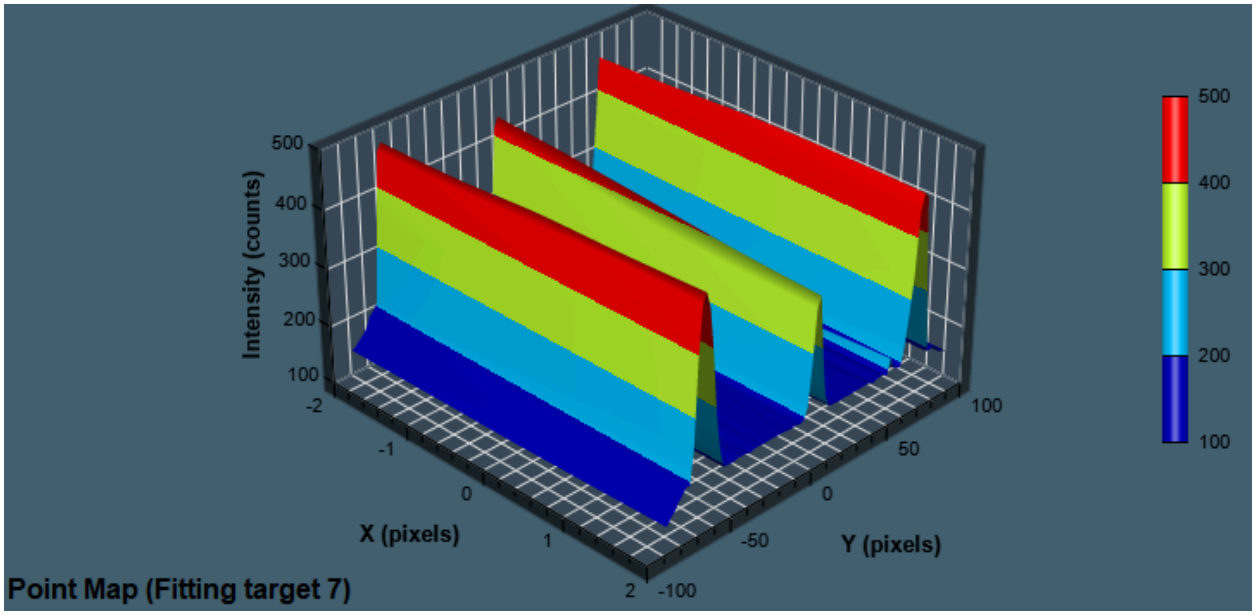
- YYYY is the year in 4 digits
- MM is the month in 2 digits
- DD is the date in 2 digits
- HH is the hour in 24 hour time
- mm is the minutes in 2 digits
- ss is the seconds in 2 digits

Clearing the line scan image

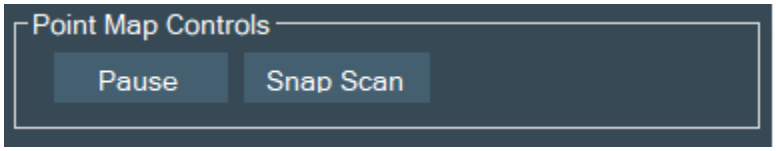
The line scan can be cleared at any time by pressing the “Clear” button. The image generated by the scan will be removed from the section and scanning will continue to create a new image.

Point Map

The point map creates a 3D surface intensity profile of any of the targets with a pixel level precision. For example:



The X and Y axis show the pixel position of the point scan, with the (0, 0) coordinate representing the centre of the target. The Z axis gives the overall pixel intensity from 0 to the maximum value of 765.
The corresponding options are shown here:



Viewing values

To view the values at various locations on the map, hover the mouse over the surface. A notification box appears displaying the X, Y and Z.

Changing the target

By default, the point map uses the 7th target. In order to change the target, right click on the line scan section, highlight “Select Target” in the menu that appears and then select the desired target from the drop down menu.

The point map image will automatically update to the new target. The point map is designed to work with “rectangular” type targets. If a “line” target is selected, the target will be extended by 2 pixels along each side of the line - and hence a thin rectangular target will be created from the “line”.

Pause/Resume

The point map can be paused at any time by clicking the “Pause” button. Once paused, the text will update to “Resume”. To resume the point map, click the button once more.

The point map can also be paused by right clicking on the Point Map section and then selecting “Active” from the menu that appears. To resume the point map select “Active” once more.

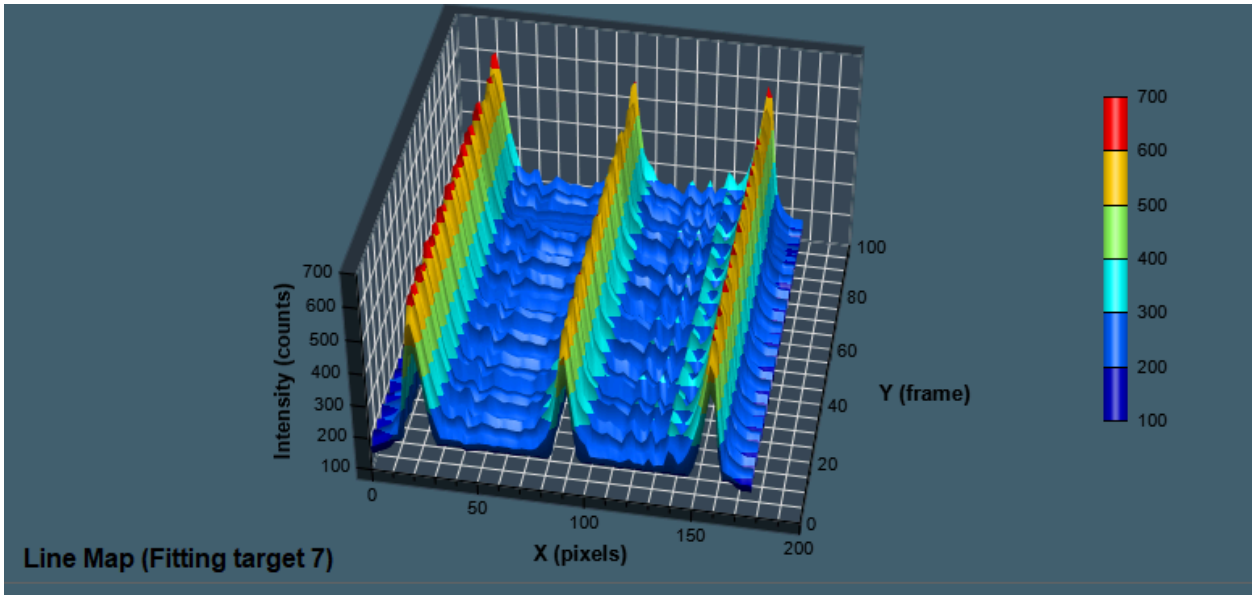
Taking a snapshot

To take a snapshot of the existing point map. Click the “Snap Scan” button. The corresponding snapshot will be saved as a bitmap file in the “Output” folder in the Pulse root directory. A message box will appear to indicate the path and the name of the file. Files are saved with a filename encoded with a date and time stamp of the type: “YYYY-MM-DD HH-mm-ss Point Map.bmp” where:

- YYYY is the year in 4 digits
- MM is the month in 2 digits
- DD is the date in 2 digits
- HH is the hour in 24 hour time
- mm is the minutes in 2 digits
- ss is the seconds in 2 digits

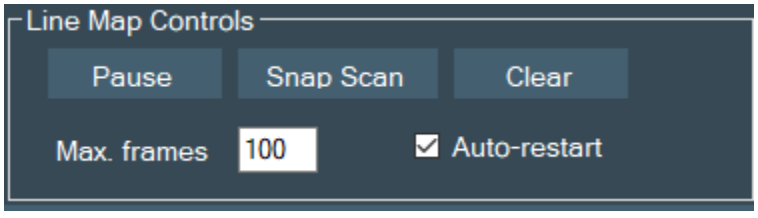
Line Map

The line map creates a 4D surface intensity profile of any of the targets with a pixel level precision. For example:



The X axis gives the pixel coordinate along the length of the target and the Y axis gives the frame number and hence the pixel variation with time. The Z axis gives the overall pixel intensity from 0 to the maximum value of 765.

The corresponding options are shown here:



Viewing values

To view the values at various locations on the map, hover the mouse over the surface. A notification box appears displaying the X, Y and Z.

Changing the target

By default, the line map uses the 7th target. In order to change the target, right click on the line scan section, highlight “Select Target” in the menu that appears and then select the desired target from the drop down menu.

The line map will clear and automatically update to the new target. Like the line scan, the line map is designed to work with “line” type targets. Regardless of whether the line target is horizontal or vertical in orientation, the line scan image will always progress from left to right displaying the pixels along the length of the line target. If a rectangular target is chosen, the line scan will utilise only the left hand most vertical section of the rectangular target - and thus create a line target from the rectangular target.

Pause/Resume

The point map can be paused at any time by clicking the “Pause” button. Once paused, the text will update to “Resume”. To resume the point map, click the button once more.

The point map can also be paused by right clicking on the Point Map section and then selecting “Active” from the menu that appears. To resume the point map select “Active” once more.

Clearing the line map

The line scan can be cleared at any time by pressing the “Clear” button. The image generated by the scan will be removed from the section and scanning will continue to create a new image.

Taking a snapshot

To take a snapshot of the existing line map. Click the “Snap Scan” button. The corresponding snapshot will be saved as a bitmap file in the “Output” folder in the Pulse root directory. A message box will appear to indicate the path and the name of the file. Files are saved with a filename encoded with a date and time stamp of the type: “YYYY-MM-DD HH-mm-ss Line Map.bmp” where:

- YYYY is the year in 4 digits
- MM is the month in 2 digits
- DD is the date in 2 digits
- HH is the hour in 24 hour time
- mm is the minutes in 2 digits
- ss is the seconds in 2 digits

Maximum frames

The default maximum frames of the line map is set to 100. This number represents the maximum value on the Y axis of the line map. To update the value simply double click in the text box and type a new value. The maximum frames will update automatically. The Minimum value is 1 and the maximum value is 1000, though values less than 10 will cause the line map to reset frequently if auto restart is active.

Auto restart

By default, the line map will automatically restart when the maximum number of frames has been reached. The line map will then clear and resume from the first frame. To deactivate auto restart, clear the auto-restart check box. The line map will then automatically pause at the last frame. The line map can be resumed by following the “Pause/Resume” instructions above. Upon resuming, the line map will clear and restart from the first frame once more.