



Model TeraFAST-256

# USER MANUAL

revision 1.6

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## NOTATION:



left-click

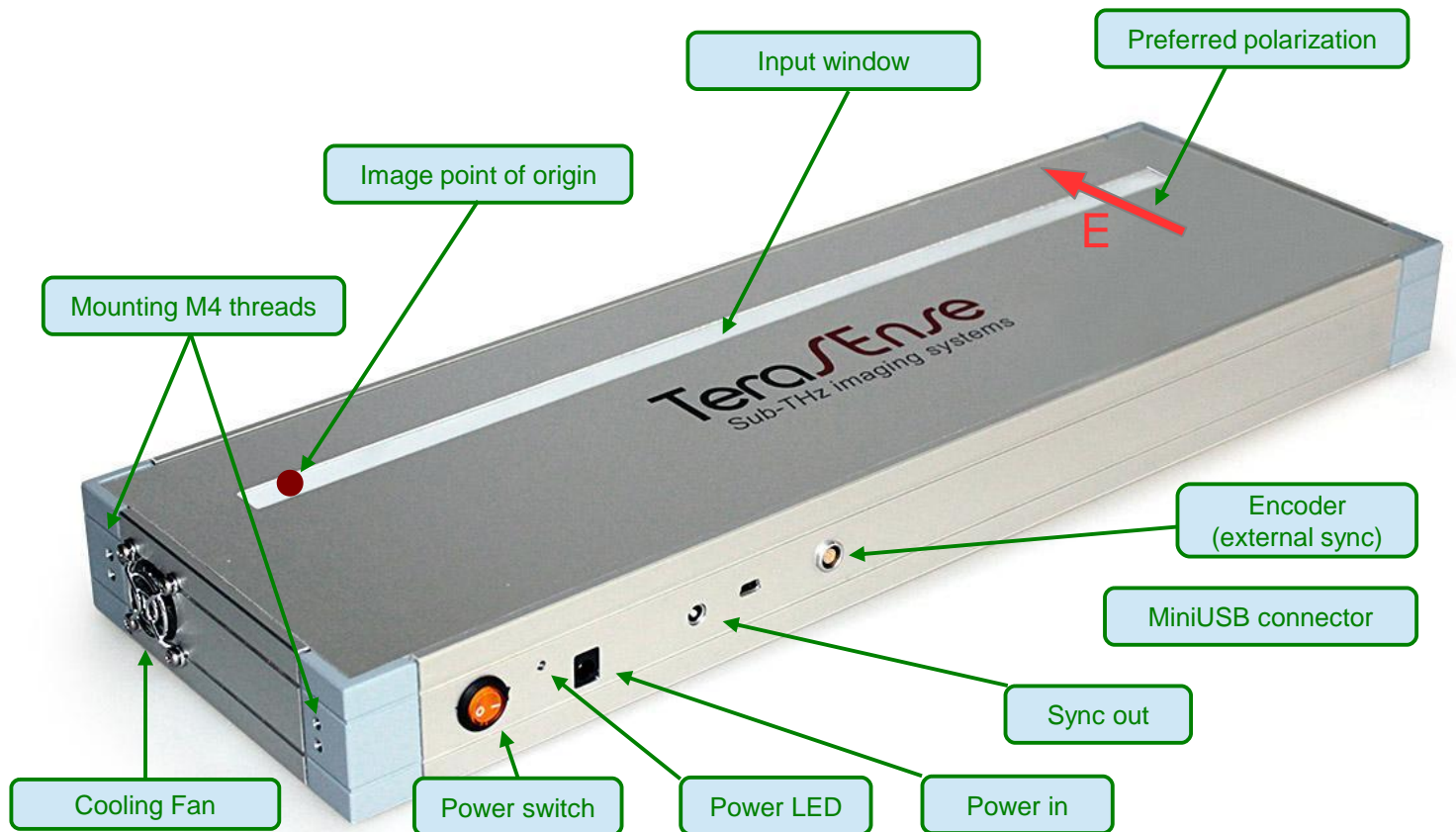


click-and-drag



right-click

# Overview\*



\* actual appearance may differ from the one shown

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# Functional overview

TeraSense™ camera, model TeraFAST-256, is a compact sub-THz linear imaging sensor that operates at room temperature. It is designed to be used primarily with conveyor belts or other similar close-range screening arrangements. Owing to its high acquisition rate of up to 5000 lines per second, it can accommodate scanning speeds of up to 15 m/s.

The sensor is tuned to a single narrow band of  $100\pm 10$ GHz though its operating frequency range can be adjusted according to customer specification. As it is sensitive to polarization of the incident radiation, its optimal performance is achieved provided the electric field direction is transverse to the 1D sensor array, as indicated in the pictorial diagram above.

The device is controlled by a PC via USB interface to enable data acquisition and processing. Only the Windows operating system is supported for the moment. Lest camera capabilities are undermined by the PC performance, it is strongly recommended to use the PC with CPU score in the Windows Experience Index of at least 5.

The camera is powered by an external AC/DC adapter rated for +24V, 2A output.

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# Specifications

Packaging dimensions: 467x144x43,6 mm

Sensor size: 384 x 3 mm, 256 x 1 pixels

Acquisition rate: 100 – 5000 lines per second

PC connection: mini-USB

Sync output: 5V TTL (LEMO 00.250 series socket)

Sync input: 5V TTL (LEMO EGG.0B.304 series socket)

DC Power adapter: 24V, 0.75A

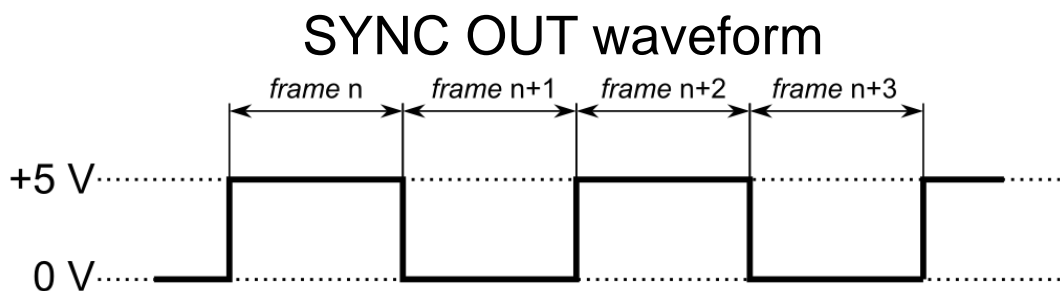
Operating conditions: +15 to +30 °C, humidity < 80%

Storage conditions: -30 to +45 °C, humidity < 90%

# Synchronization

## Internal synchronization

By default, the camera is synchronized internally with the line rate (lps) set by the camera software. In this mode, +5 V TTL signal is output at the SYNC OUT port. As illustrated below, it switches between the HIGH and the LOW (in any order) **each time the acquisition and the transfer of the line data is completed, which makes the SYNC OUT frequency (Hz) half the line rate (lps)**. The **SYNC OUT** signal is intended mainly for source modulation, in which case the camera can be operated in the difference mode where the software computes and displays the absolute value of the difference between the consecutive frames (see page 27). As the SYNC OUT port is fitted with the LEMO 00.250 series connector, an extra LEMO to BNC sync cable is supplied with the camera.



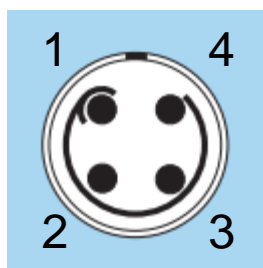
## External synchronization

The camera can also be synchronized externally with the line rate set by an external +5 V TTL signal supplied to the SYNC IN pin of the encoder connector shown below. In this case, the camera can be triggered by either falling or rising edge depending on the option selected through the TeraFast® Viewer Software.

In response to the trigger, the camera takes the measurement and starts the data transfer. However, when triggered externally, there is a delay,  $\Delta t = 3.5 \mu\text{s}$ , between the synchronization edge and the actual data acquisition. If the time period of external sync exceeds  $32768 \mu\text{s}$  (i.e. its frequency decreases below 30 Hz), the frames are terminated by timeout and filtered out from the data stream.

External synchronization can be applied through an independent rotary encoder to automatically adjust to the variations in conveyor belt speed or it can be used to integrate the camera with additional equipment in the line.

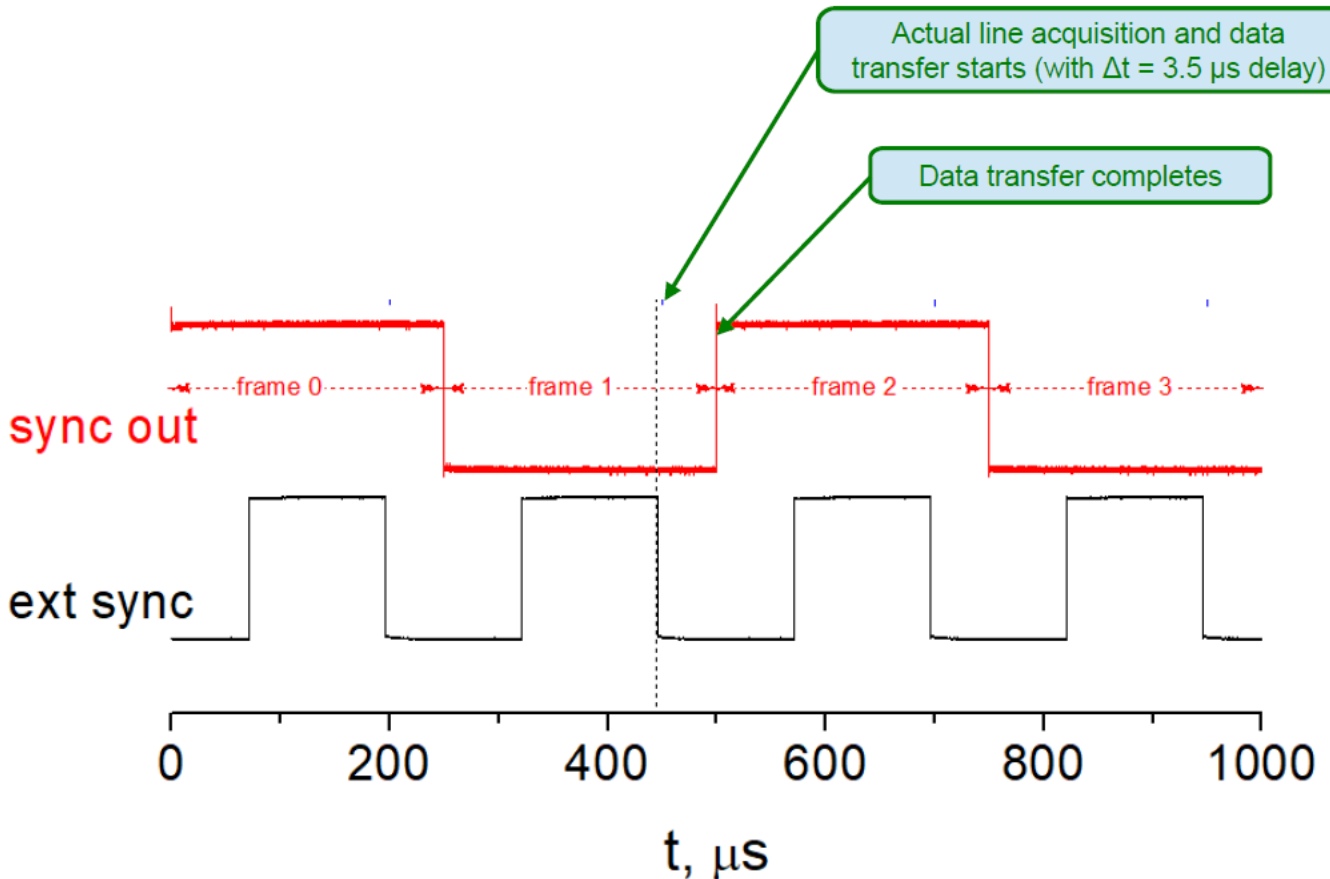
### Encoder connector pin out



1	power out (+5 V, 100mA)
2, 3	GND
4	sync in

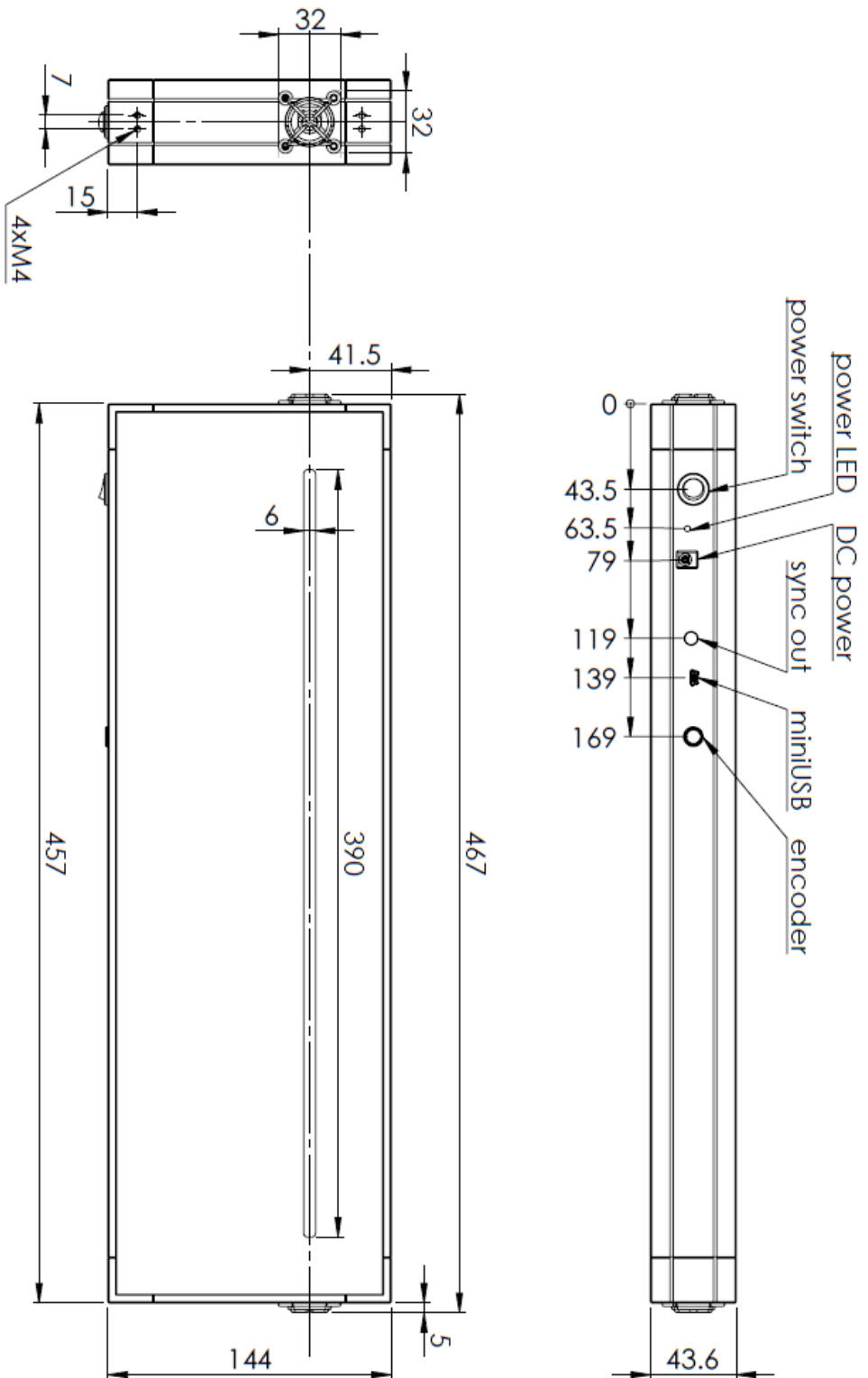


# Synchronization (advanced)



When camera operates in the external sync mode, the SYNC OUT signal is still generated. Hence, the external sync signal triggers the measurement while the internal sync waveform marks the end of the data acquisition and transfer. In this case, as illustrated above, the SYNC OUT is a TTL signal with half the frequency of the EXTERNAL SYNC signal. In addition, the former is shifted with respect to the latter by the time interval corresponding to the full duration of the line data acquisition and transfer.

# Packaging drawings



# TeraFAST-256

revision 03.2019

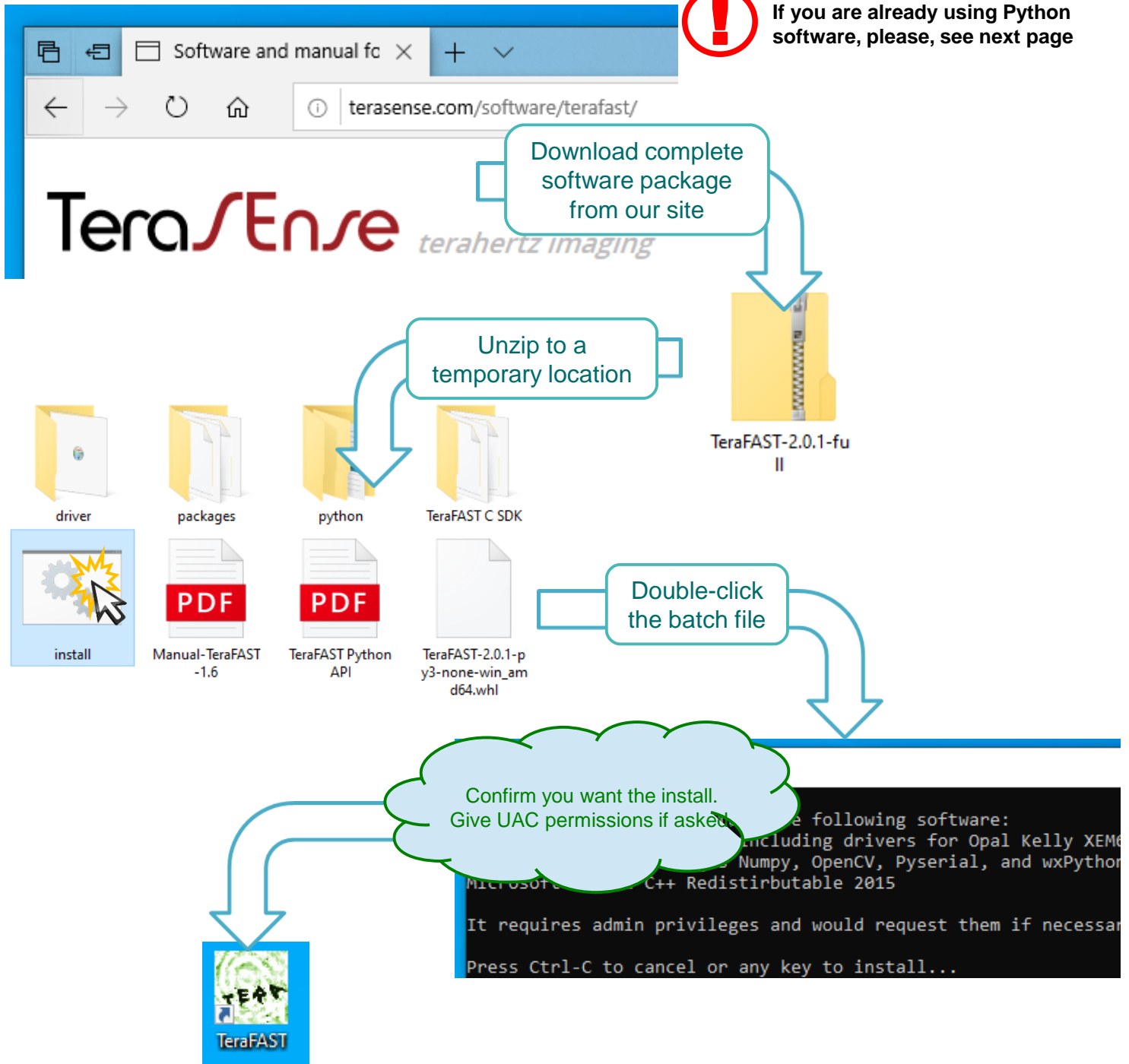


# Software Installation

## Basic



If you are already using Python software, please, see next page



Congratulations, you are done!

TeraFAST (TeraSense Viewer) icon is created on your desktop. You may also start it as "TeraFAST.pyw" from the command line.

# Software Installation

## Advanced

TeraFAST software by Terasense, Inc. (starting from version 2.0.1) works with Python 3.x, either 32 or 64 bit. It is packaged as a wheel and depends on the following packages:



If you have Python 3.x already installed you may download just a corresponding wheel package from our site (or use the one supplied on a thumb-drive) and install it from a command line as (substitute correct version of the wheel file):

```
>pip3 install TeraFAST-2.0.1-py3-none-win_amd64.whl
```

Missing dependency packages, if any, would be downloaded and installed by PIP automatically (you may also find them either on the thumb-drive or in the full package). Depending on your Python installation, you may need run the command line as administrator in order for PIP have enough rights to modify it.

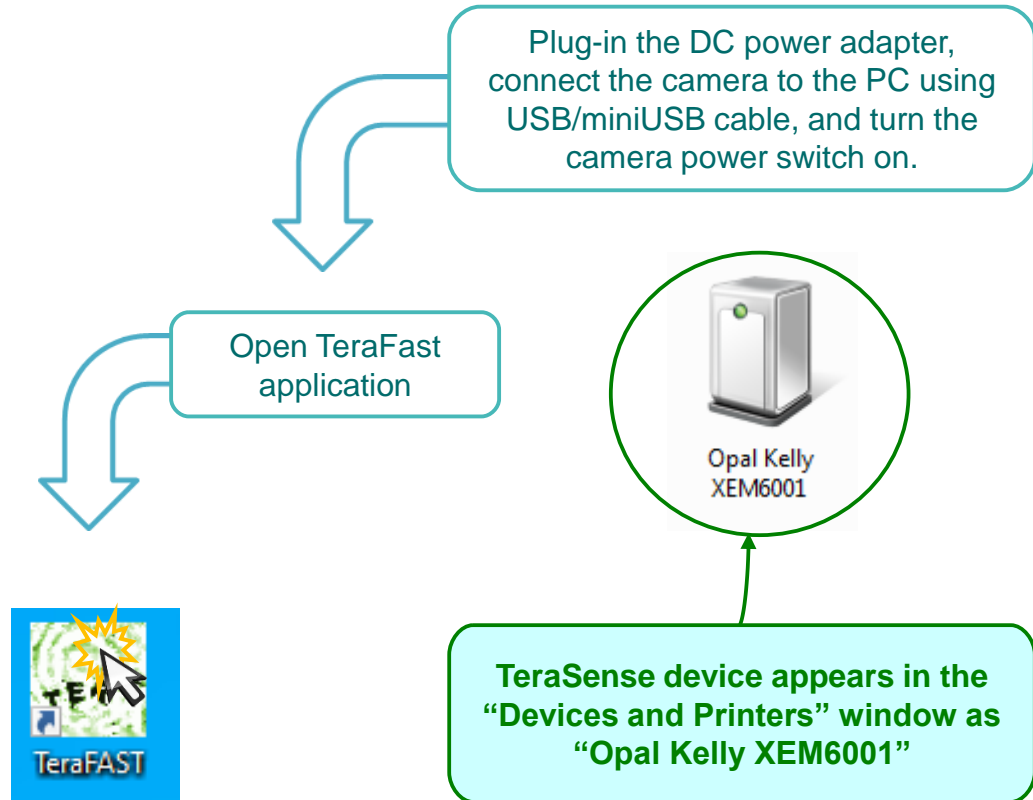
```
Administrator: Command Prompt - pip3 install TeraFAST-2.0.1-py3-none-win_amd64.whl
C:\Users\testt\Documents\TeraFAST-2.0.1-full>pip3 install TeraFAST-2.0.1-py3-none-win_amd64.whl
Processing c:\users\testt\documents\terafast-2.0.1-full\terafast-2.0.1-py3-none-win_amd64.whl
Collecting numpy
  Downloading numpy-1.18.2-cp38-cp38-win_amd64.whl (12.8 MB)
    | 5.6 MB 24 kB/s eta 0:04:57
```

When software installation finishes, connect your device to PC using USB-miniUSB cable and wait for Windows installing driver for the device controller (Opal Kelly XEM6001).

After the installation you may run the program as "TeraFAST.pyw" from a command line, however you won't get a shortcut on the desktop. Create it either by using "create shortcut.bat" or manually – the script is located at \Python3x\Scripts\TeraFAST.pyw and the icon is located at \Python3x\Lib\site-packages\teraFAST\gui\tera.ico

**TeraFAST software may or may not work with earlier versions of the prerequisite packages. Consult our support for more information.**

# Getting started

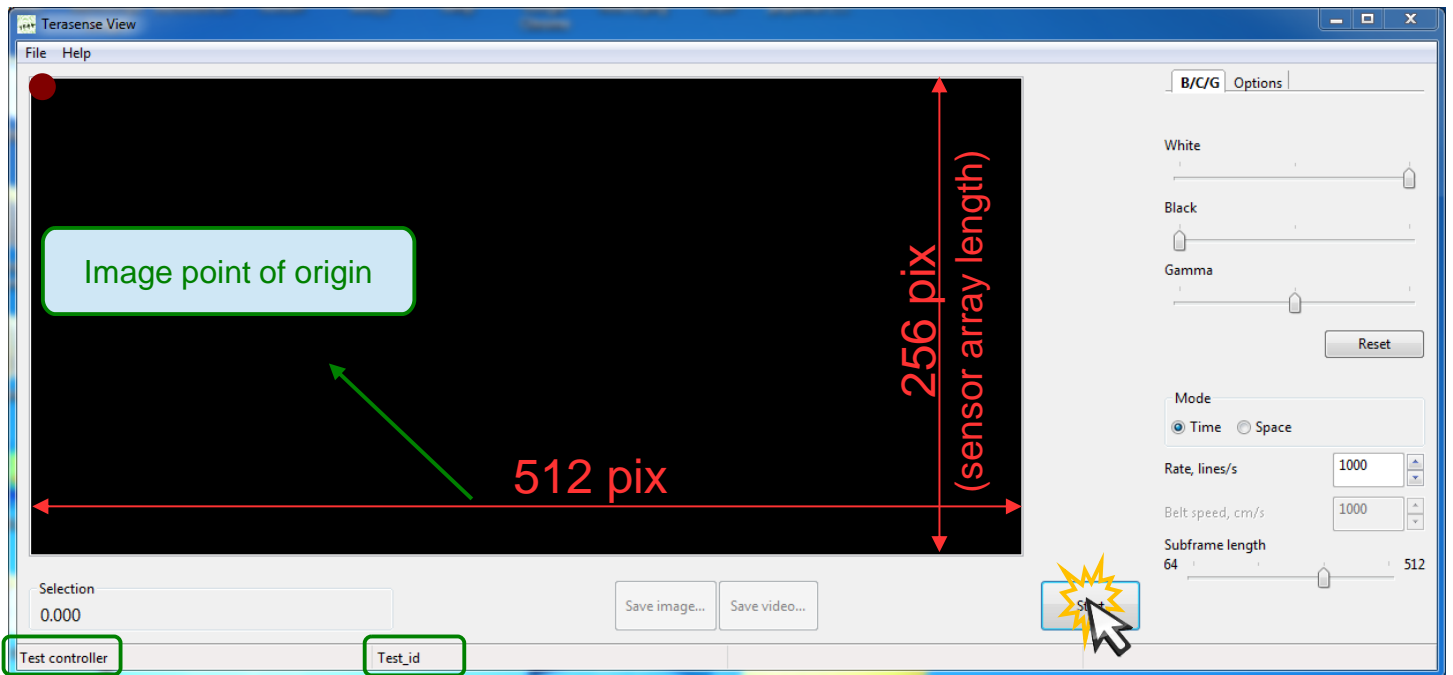


When connecting to a new PC for the first time, Windows should be allowed time first to instal the device drivers.

**TeraFAST camera is sensitive to temperature fluctuations. Therefore, in case of a drastic change in ambient temperature, it is strongly recommended to allow it time to stabilize and then to make a new recording of the background data, as explained on page 13.**

# Software operation

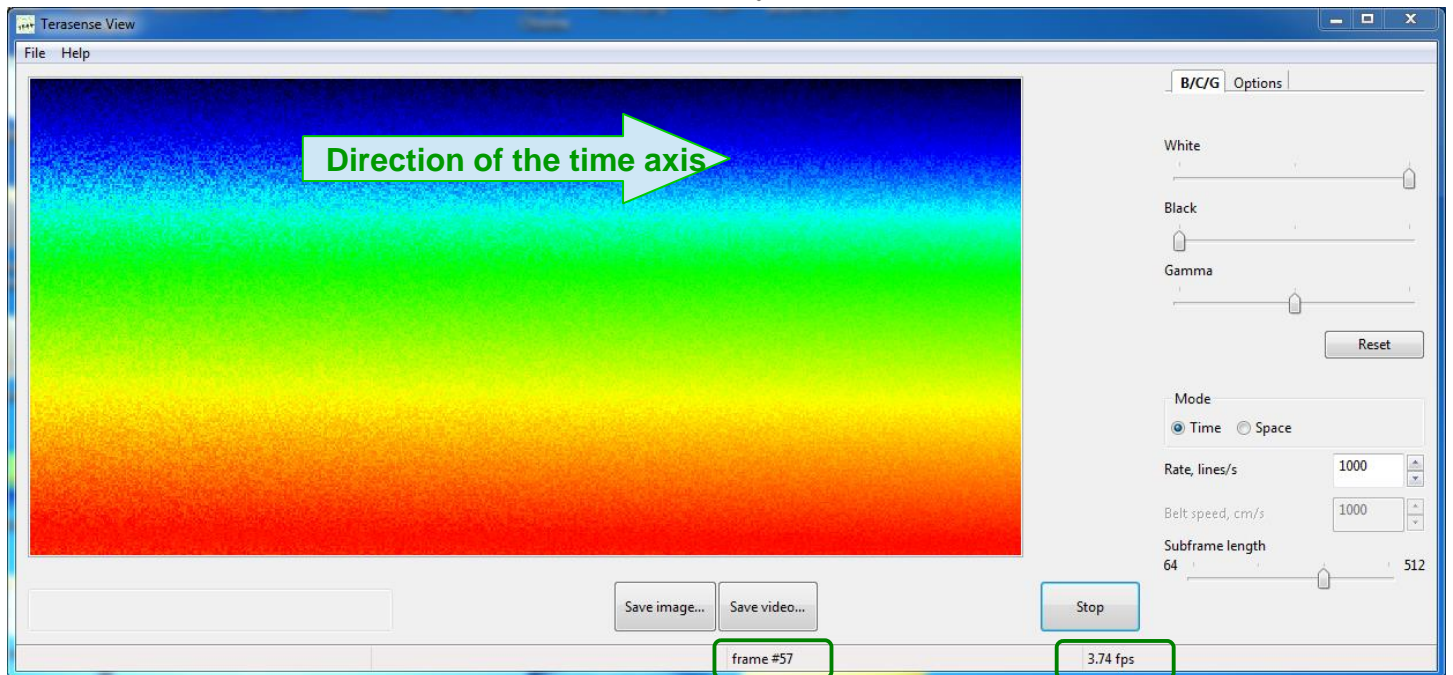
## The basics



Controller name

Device ID

Data acquisition begins



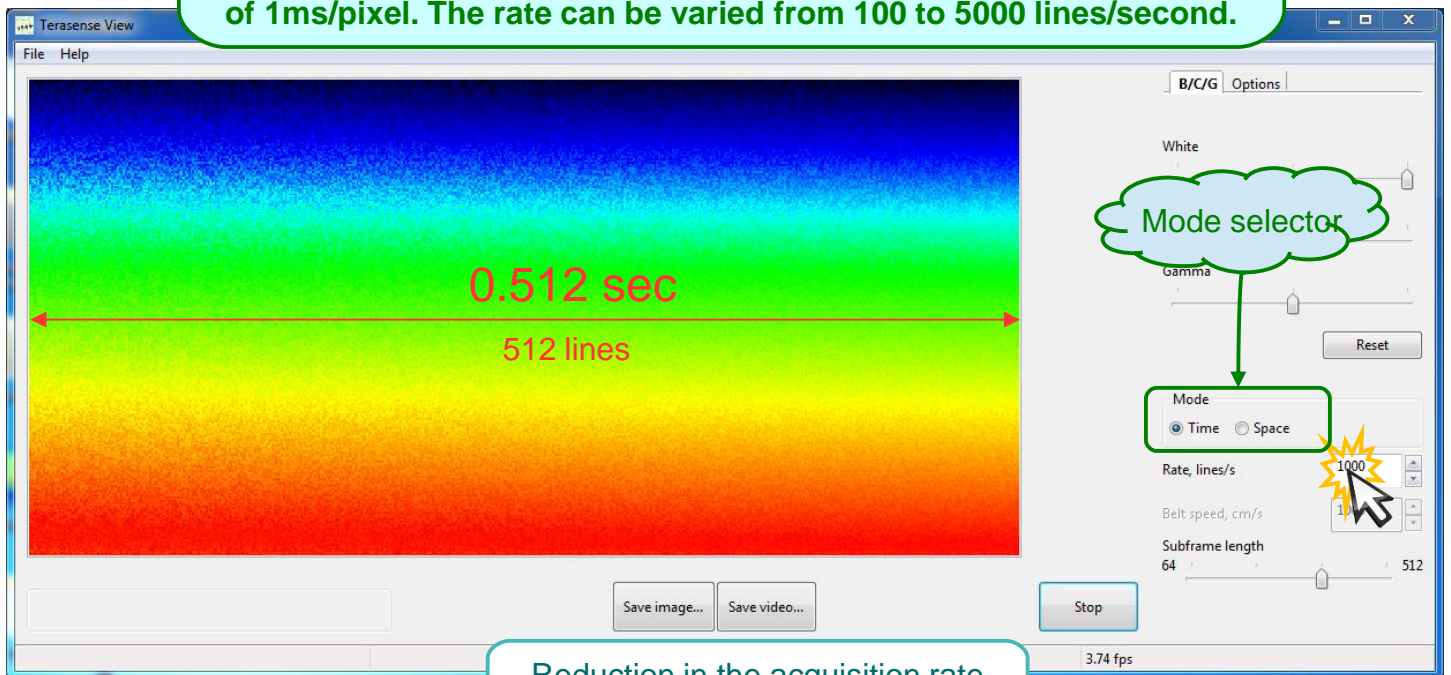
Current frame number

Current frame rate

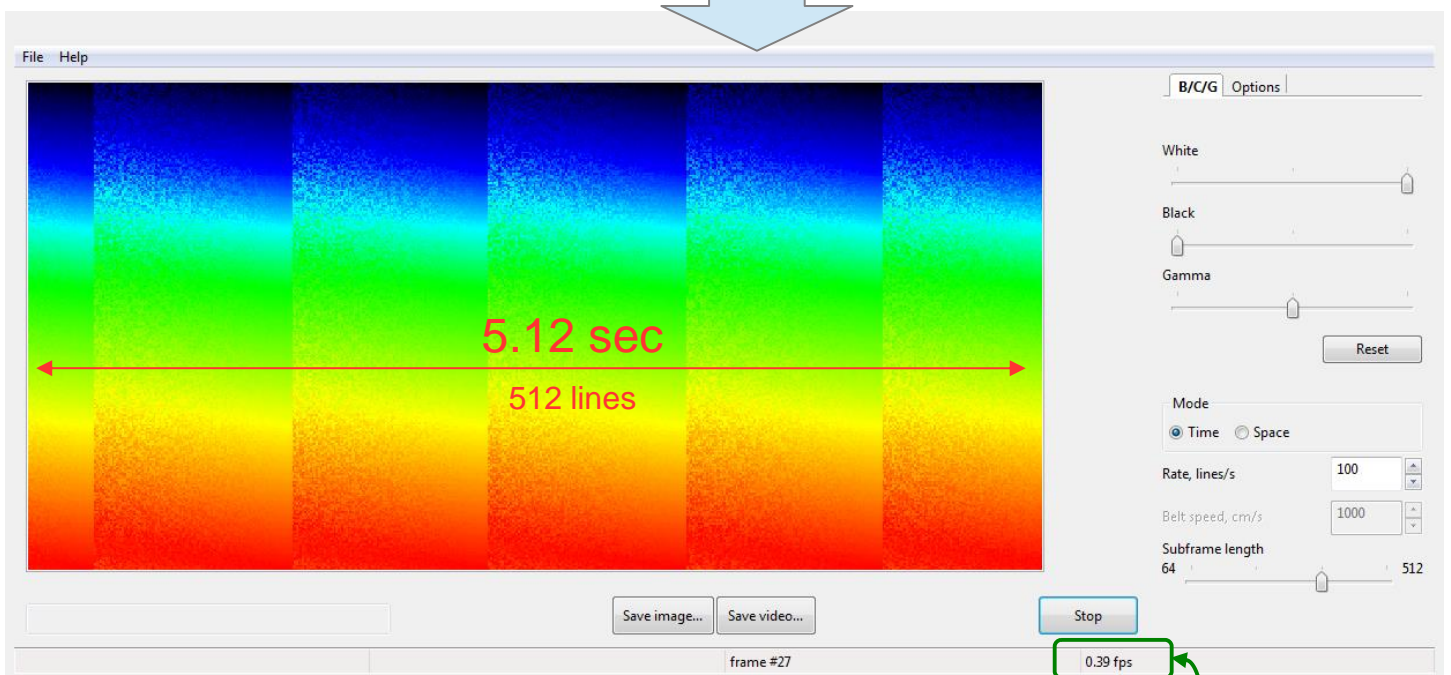
# Software operation

## Imaging in the time mode

In the time mode, the horizontal axis of the displayed image corresponds to the temporal scan. In this case, the temporal resolution is inversely proportional to the selected acquisition rate. Thus, for example, the rate of 1000 lines/second results in resolution of 1ms/pixel. The rate can be varied from 100 to 5000 lines/second.



Reduction in the acquisition rate from 1000 to 100 lines per second

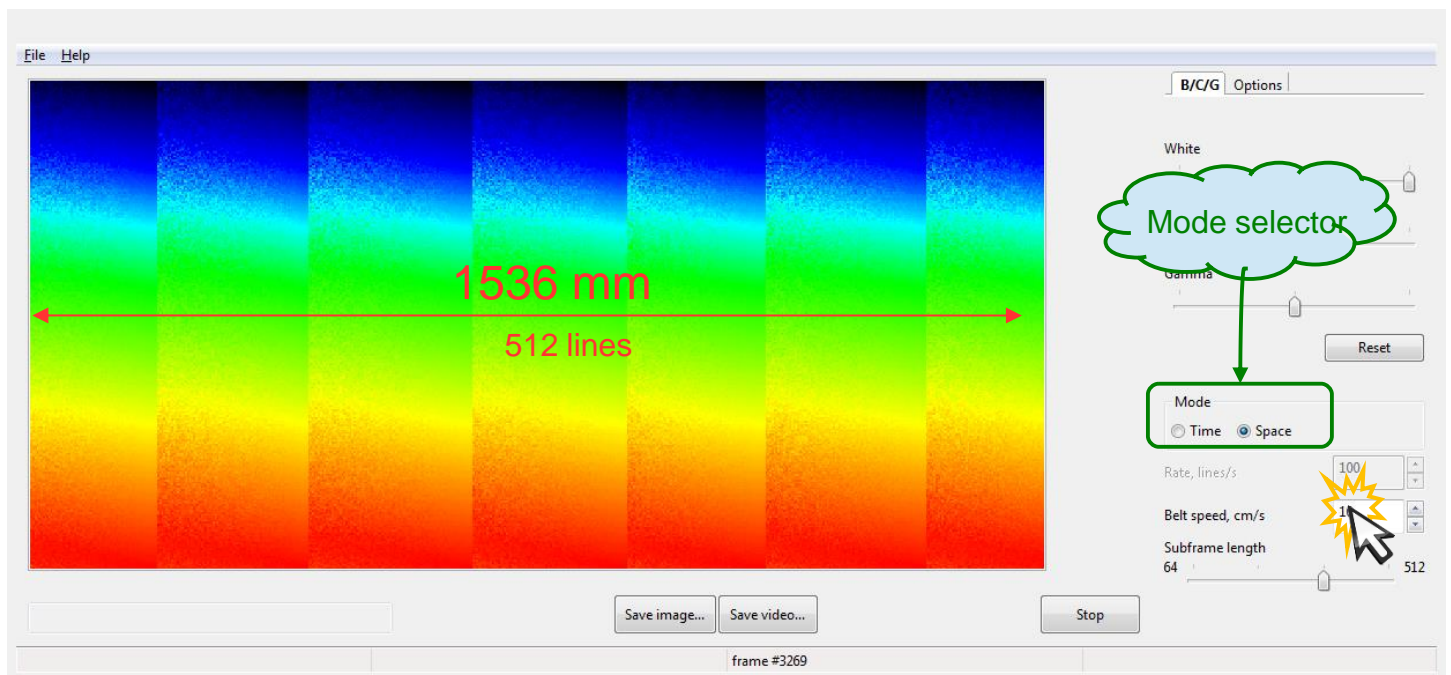


Frame rate is reduced proportionally

# Software operation

## Imaging in the space mode

In the space mode, the horizontal axis of the displayed image corresponds to the spatial scan, where the scanning span is calculated based on the speed of the conveyer belt. In this case, the spatial resolution of the image in the horizontal direction remains fixed at 3mm/pixel. The speed parameter can be varied from 10 to 1500 cm/s.

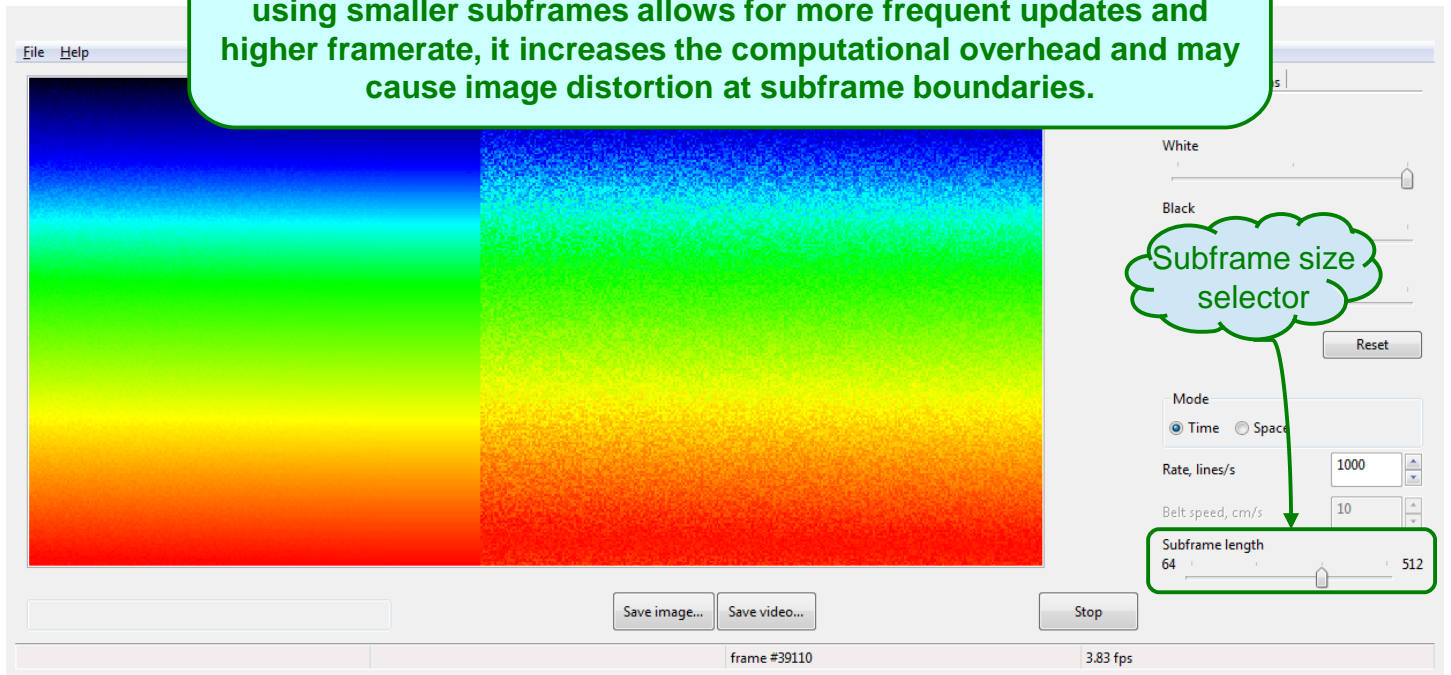


When the scanner is operated in this mode, the actual acquisition rate is set either to 3000 lines/s for speeds below 900 cm/s or to 5000 lines/s for speeds between 900 and 1500 cm/s. Then, the data is linearly rescaled to properly form the image.

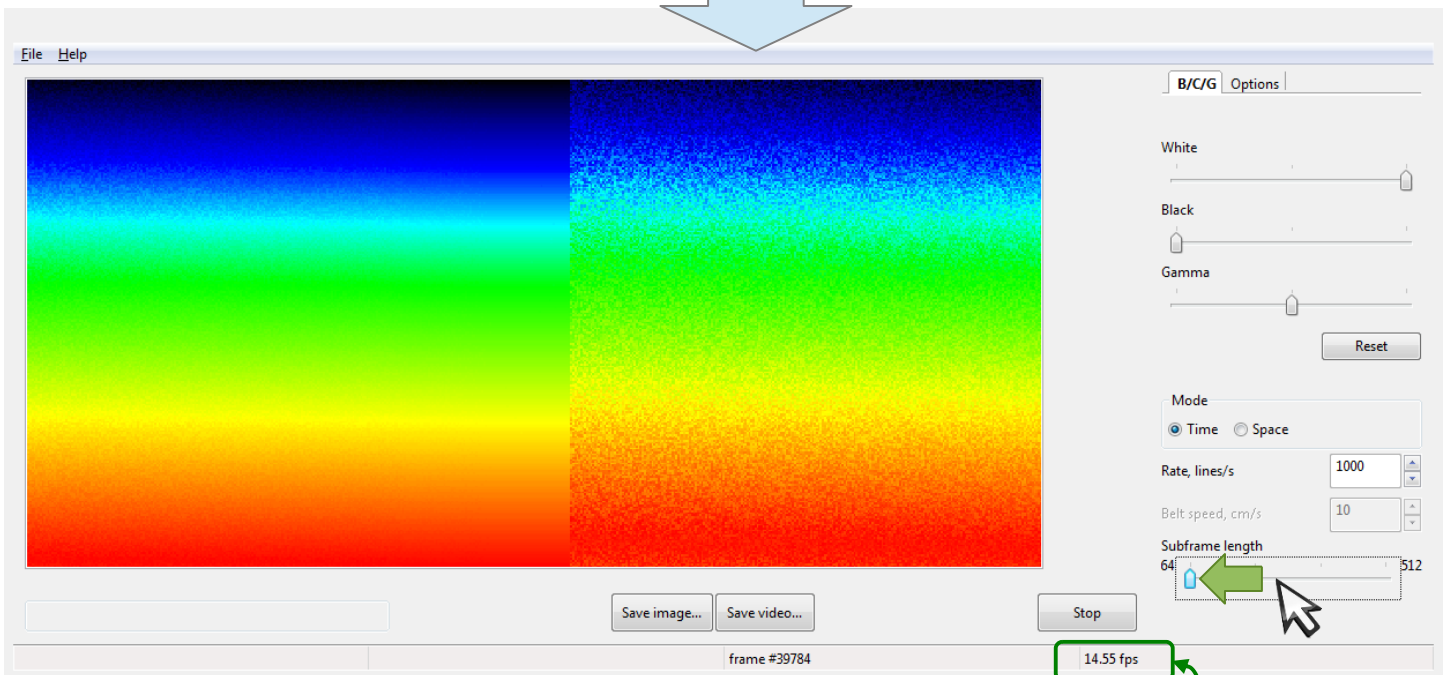
# Software operation

## Changing subframe length

The measurement data are read from the camera in batches called subframes. Their size can be set to 64, 128, 256, or 512. Although using smaller subframes allows for more frequent updates and higher framerate, it increases the computational overhead and may cause image distortion at subframe boundaries.

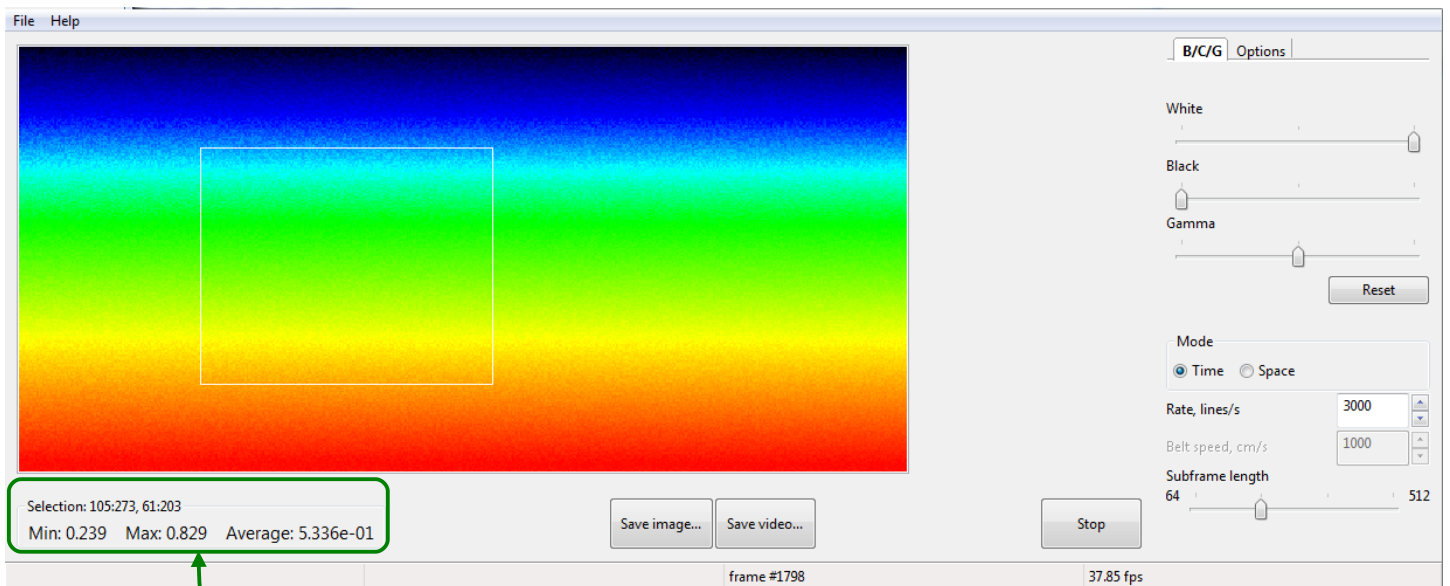
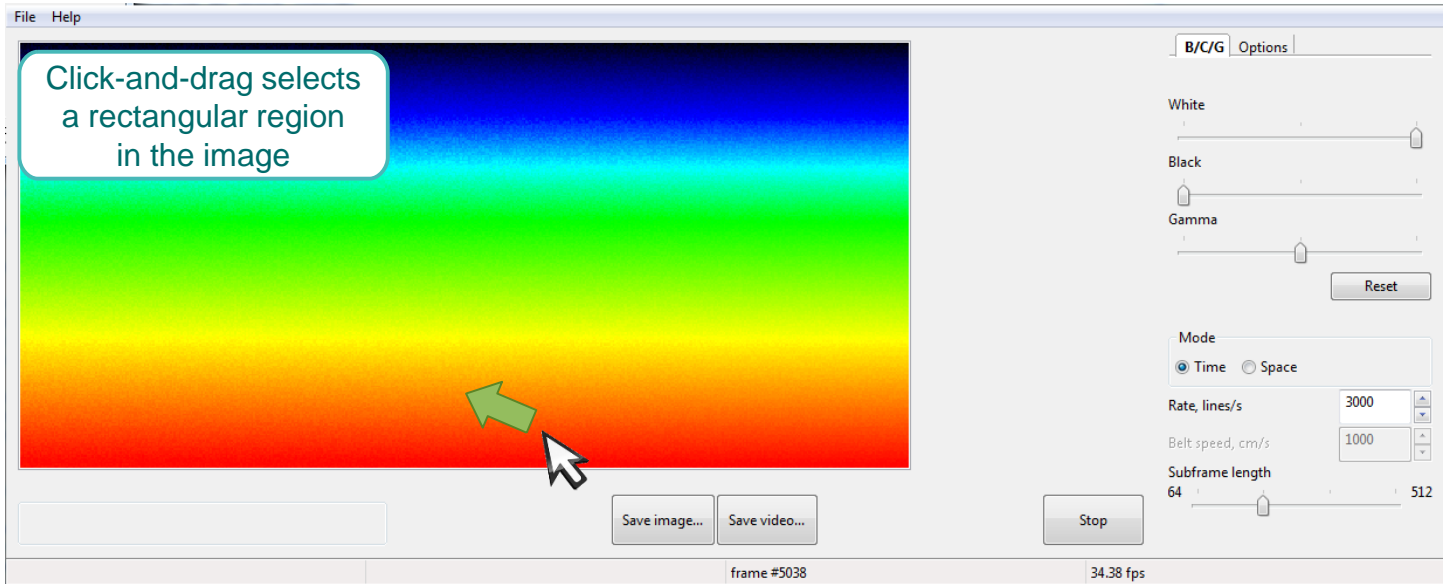


Reduction in subframe size from 256 to 64



# Software operation

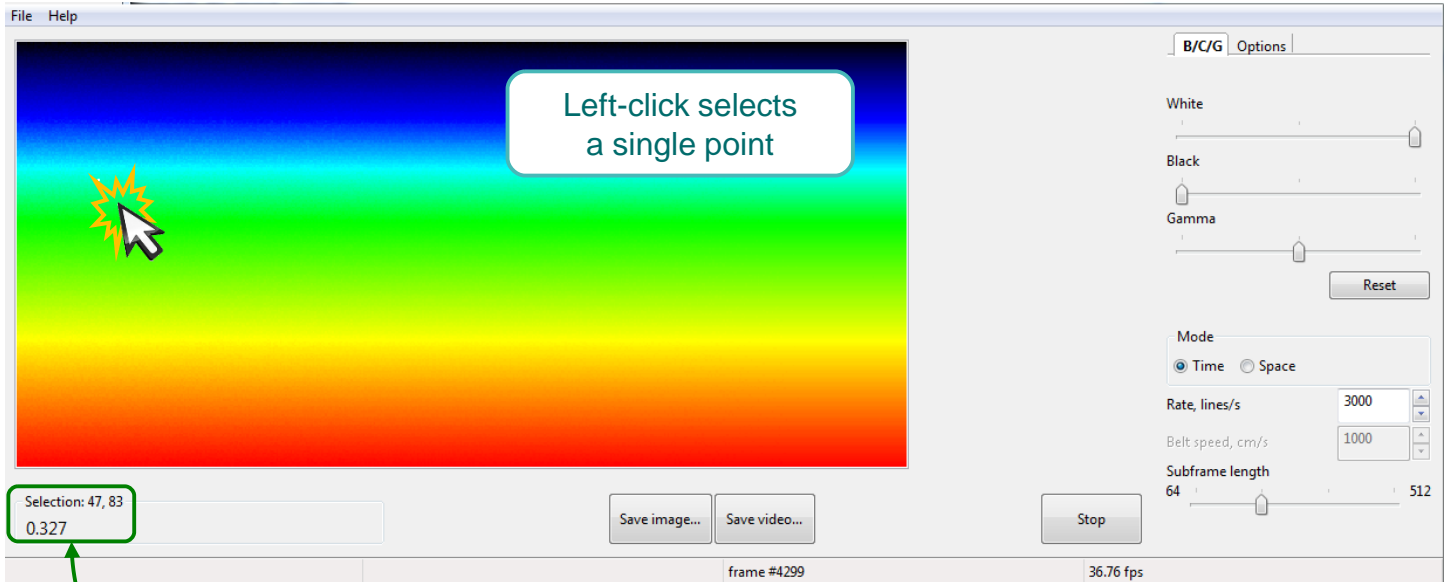
## Examining region of interest



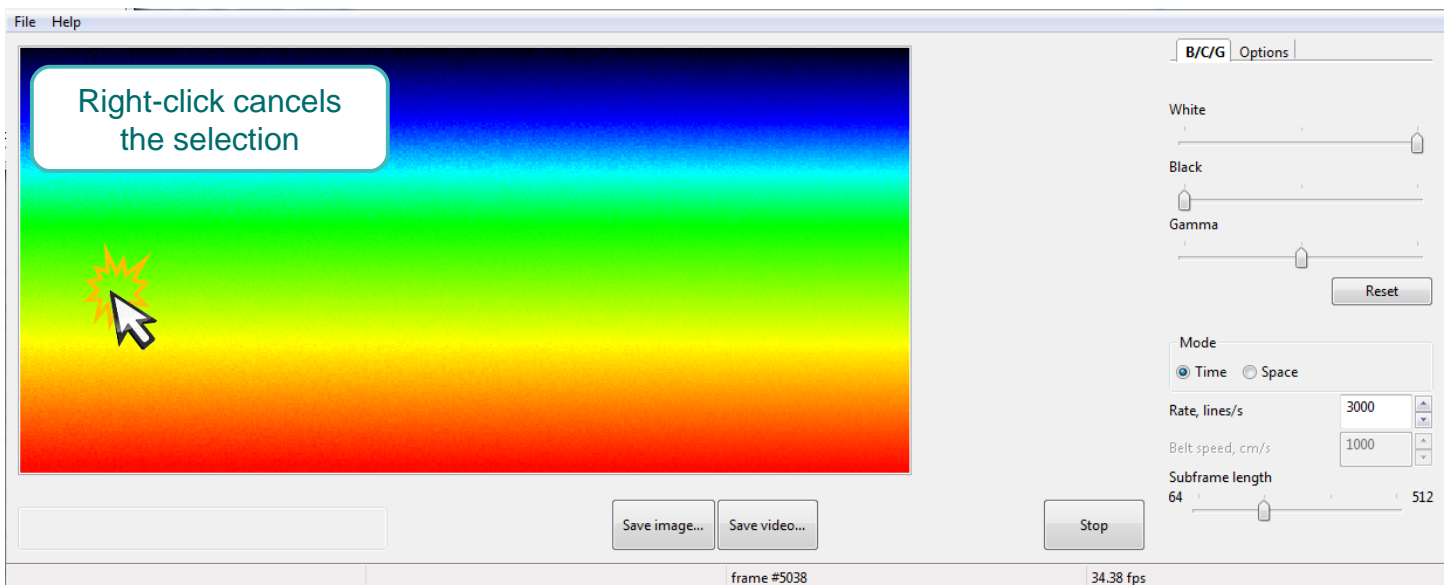


# Software operation

## Examining region of interest

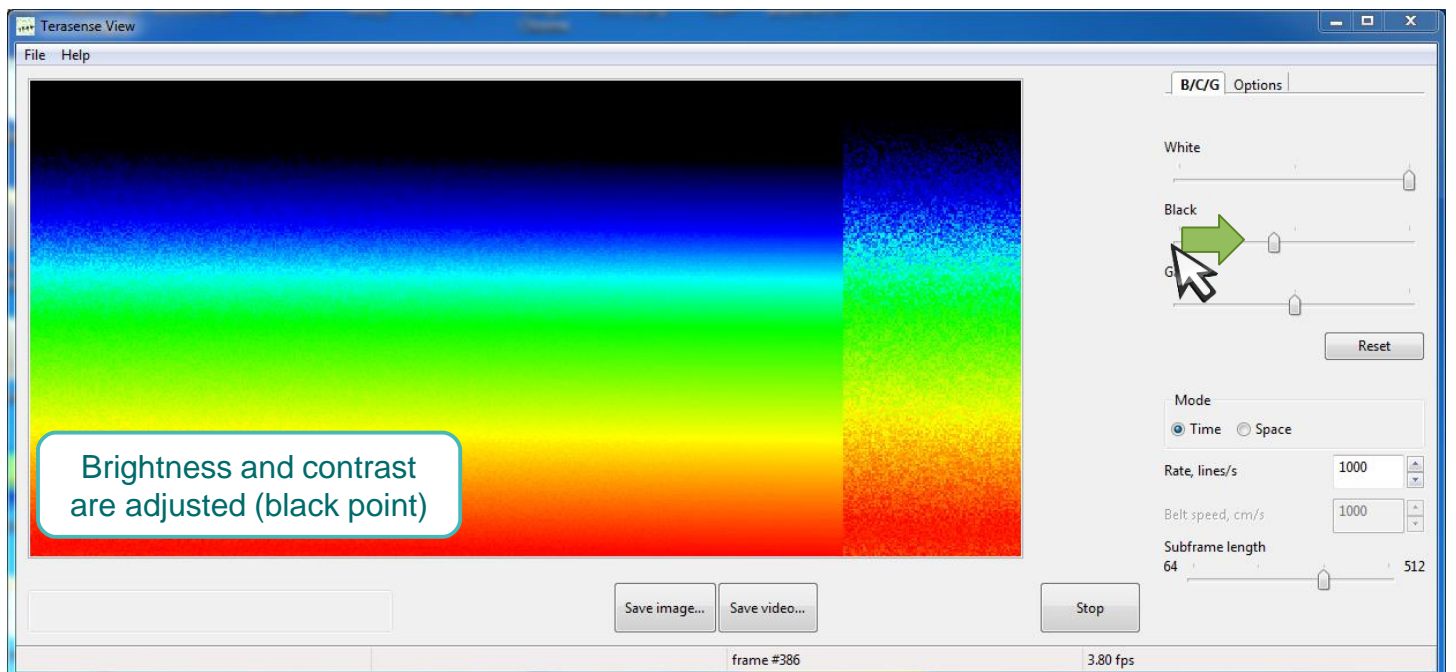
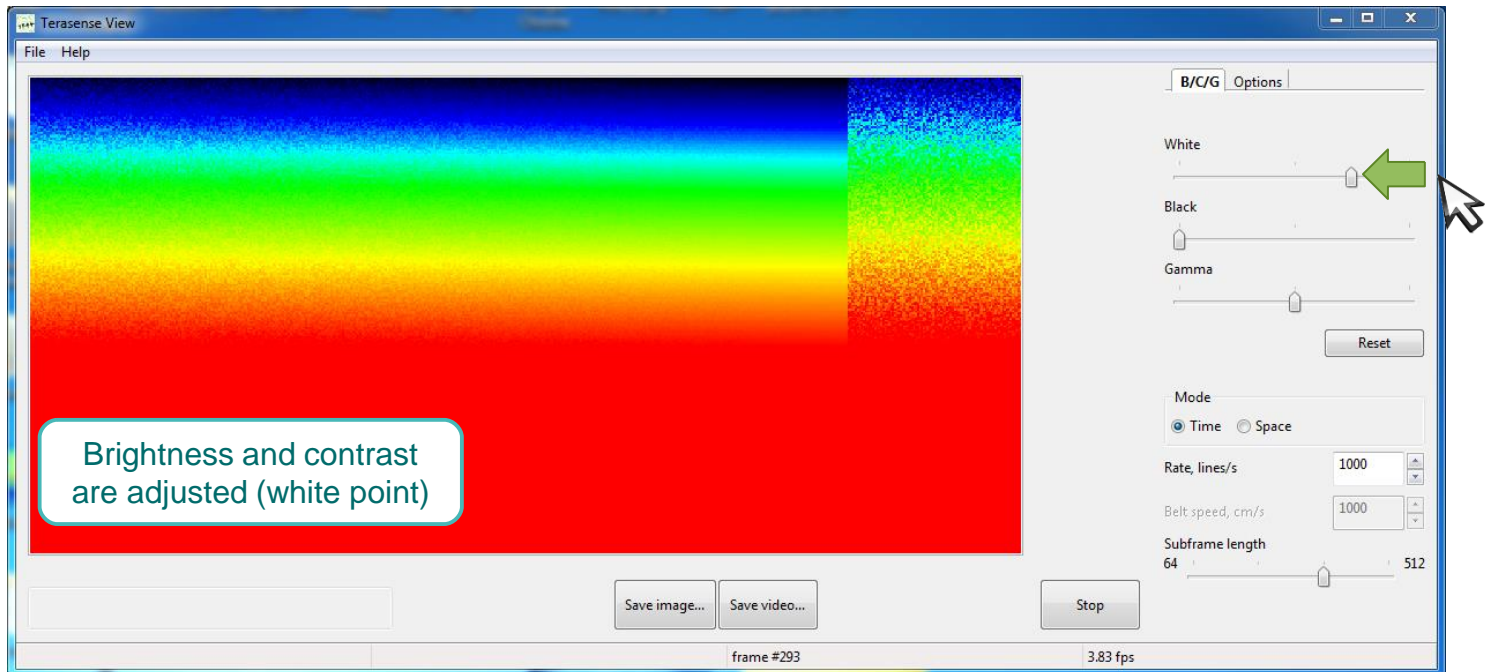


Point coordinates and value are displayed automatically



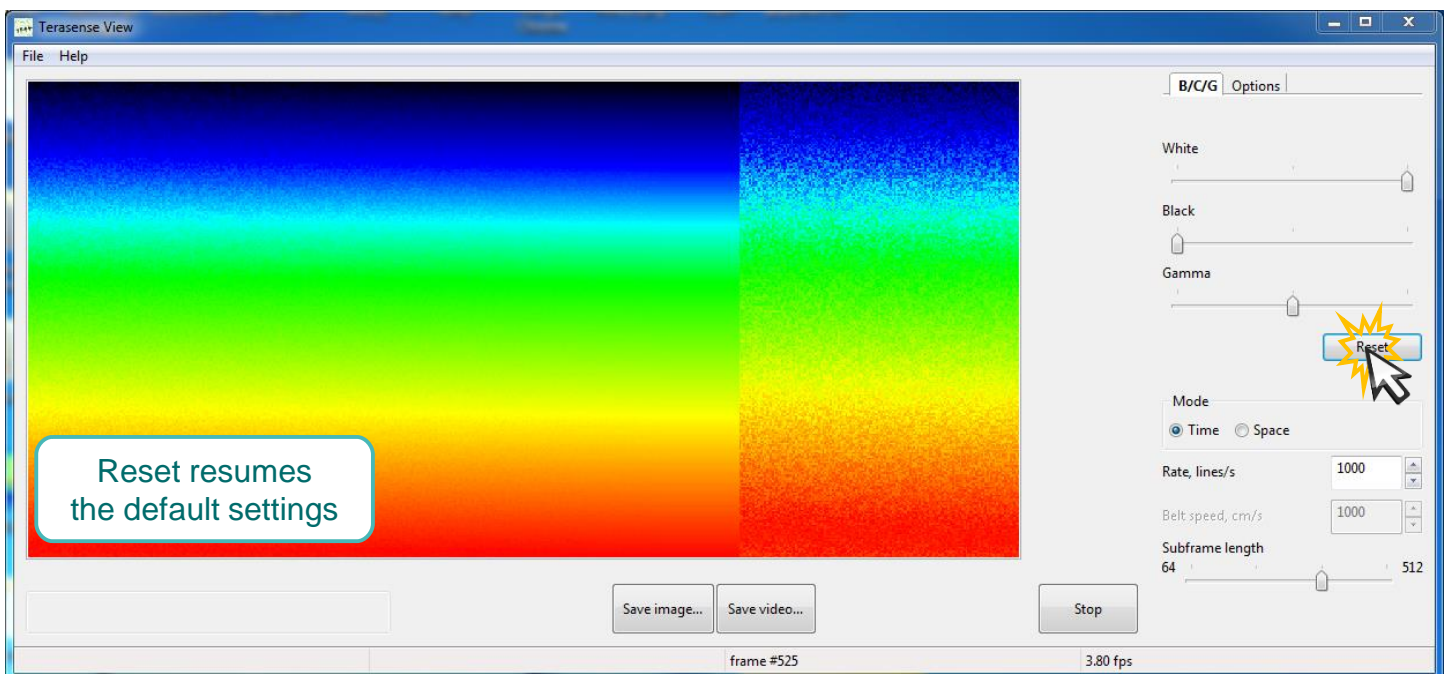
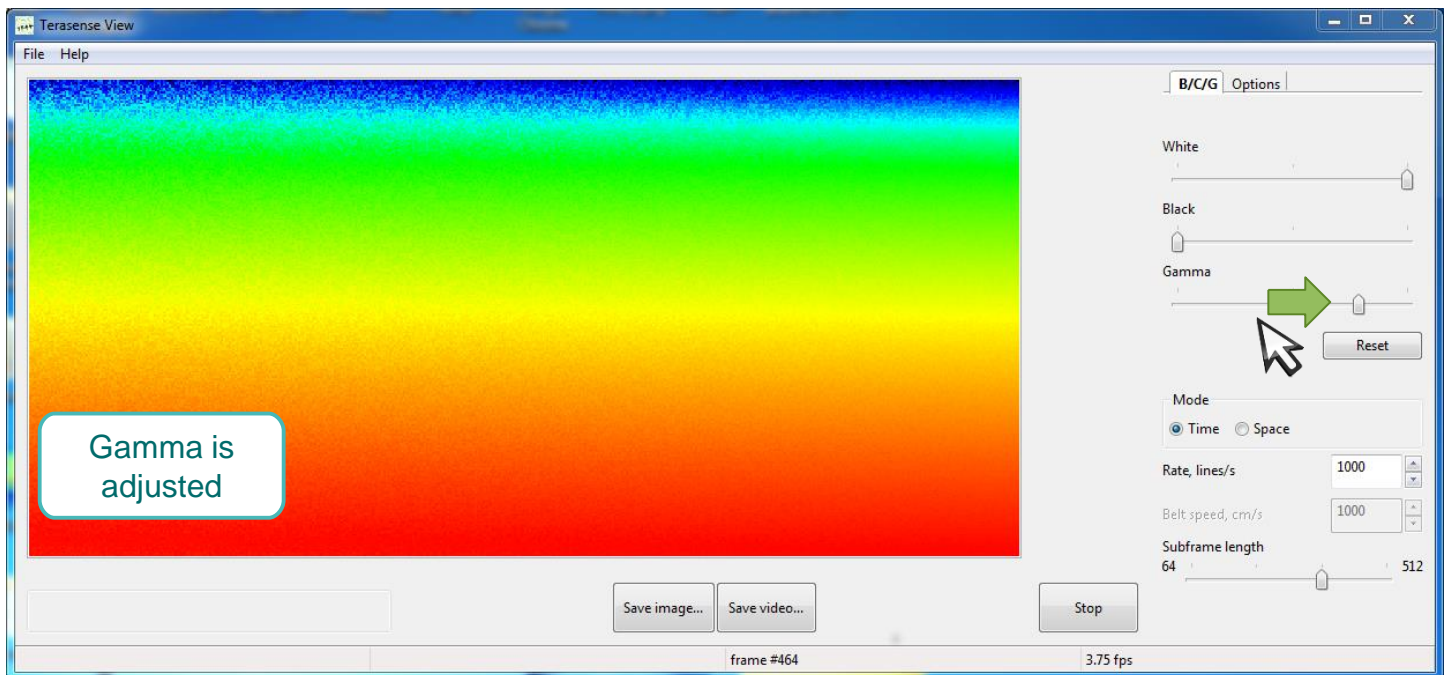
# Software operation

## Adjusting brightness / contrast / gamma



# Software operation

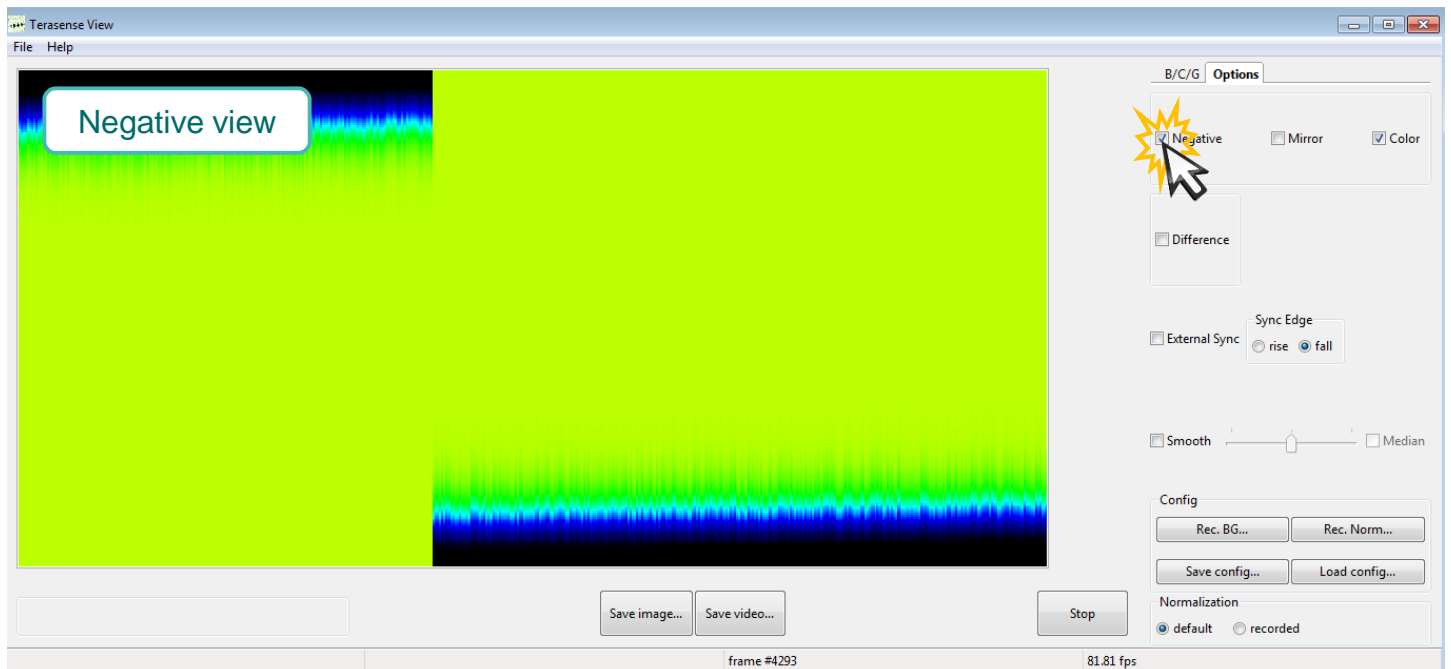
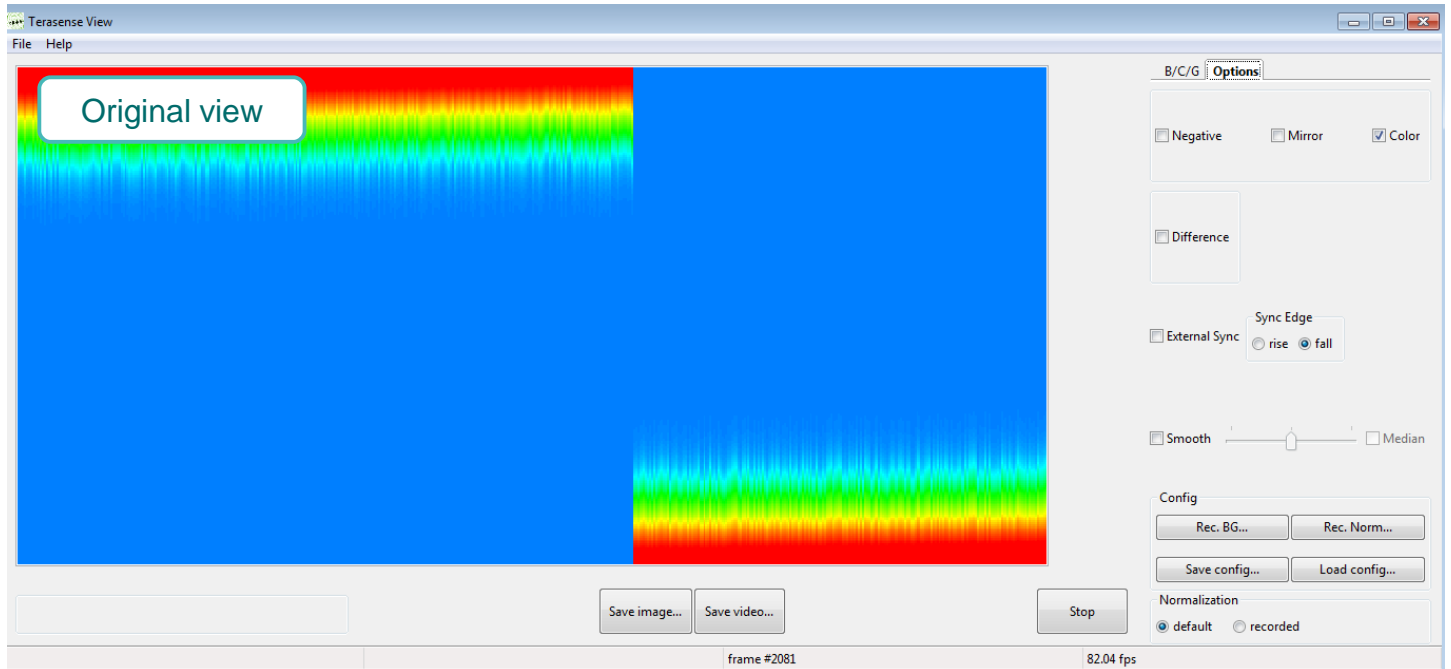
## Adjusting brightness / contrast / gamma



Adjustments in white point, black point and gamma are applied as part of digital image postprocessing.

# Software operation

## Additional data display options



Values are inverted within [0, 1] range.

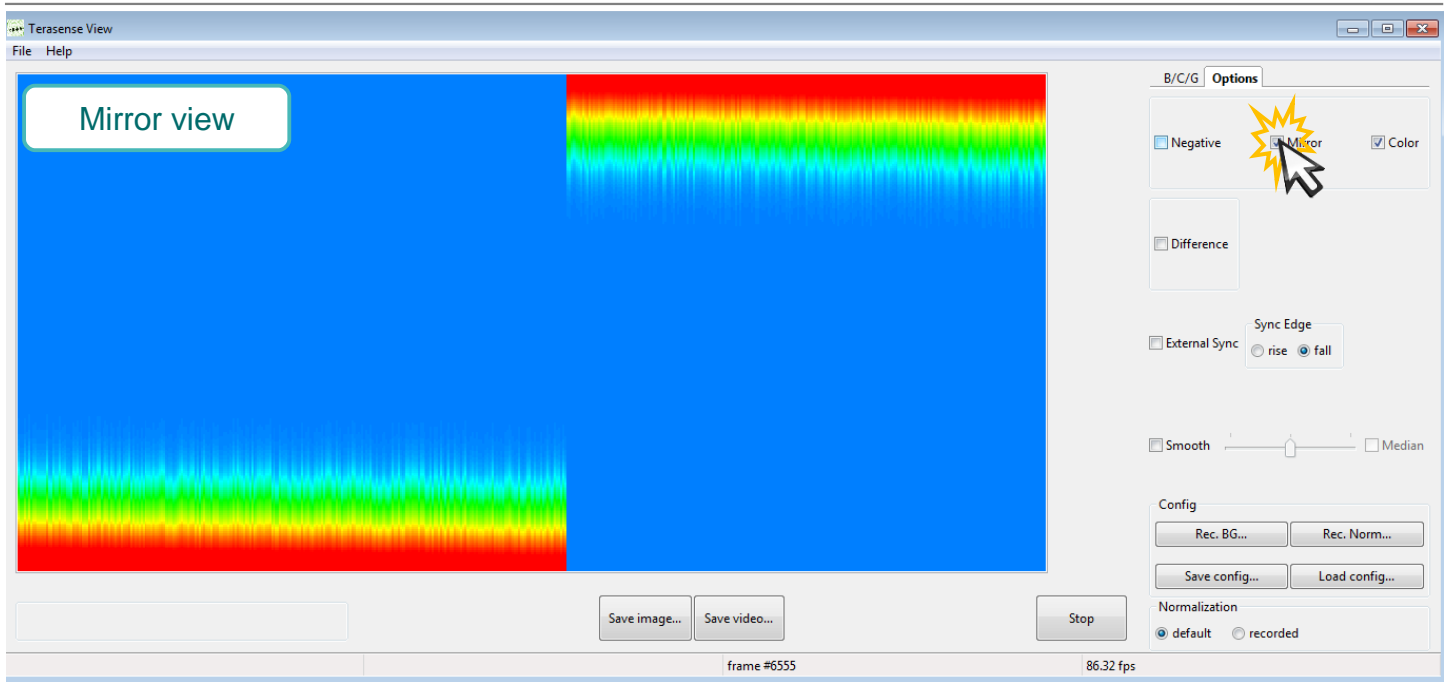
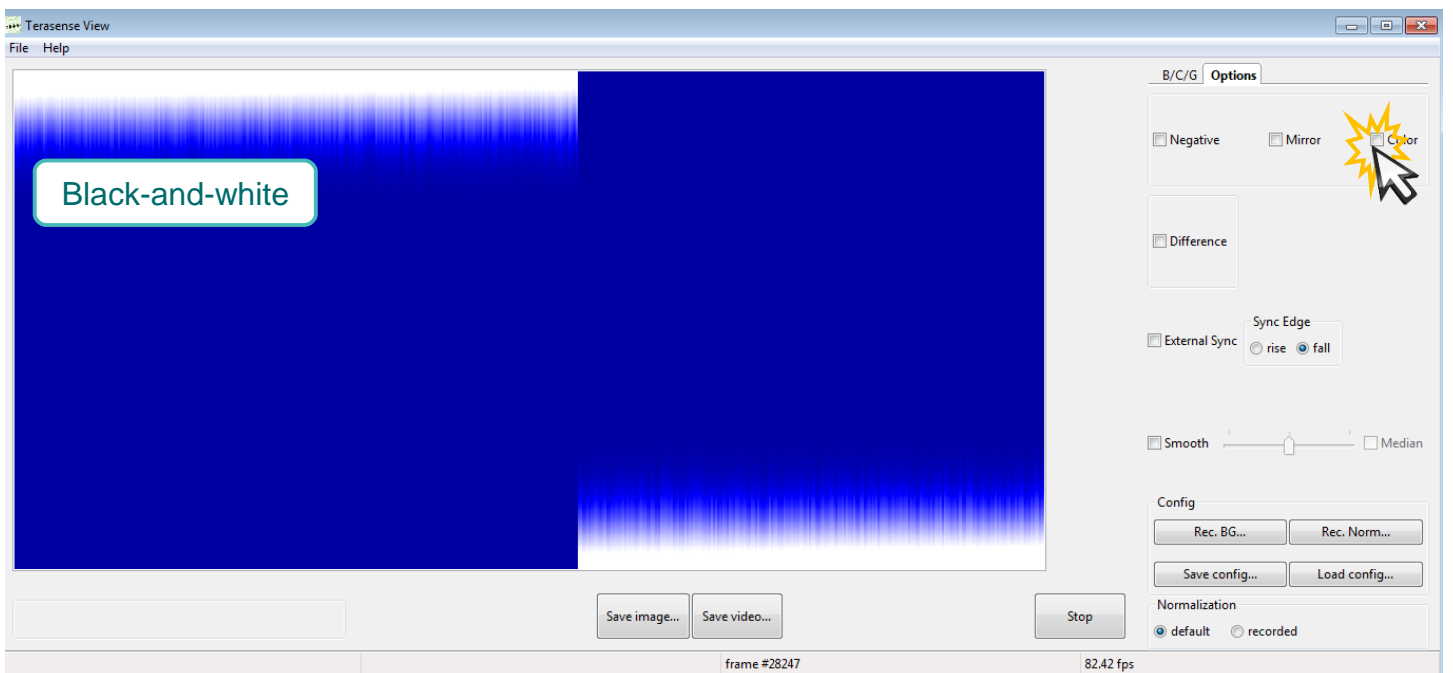


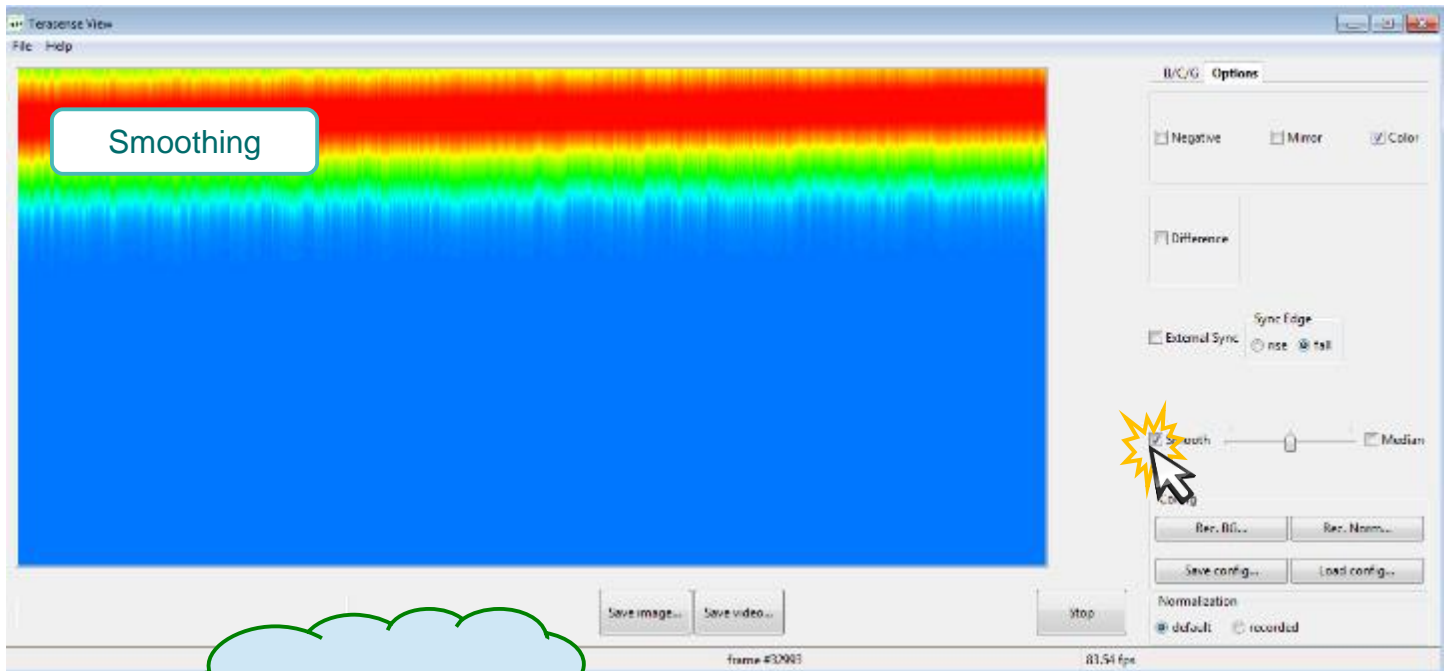
Image is reflected about the horizontal axis



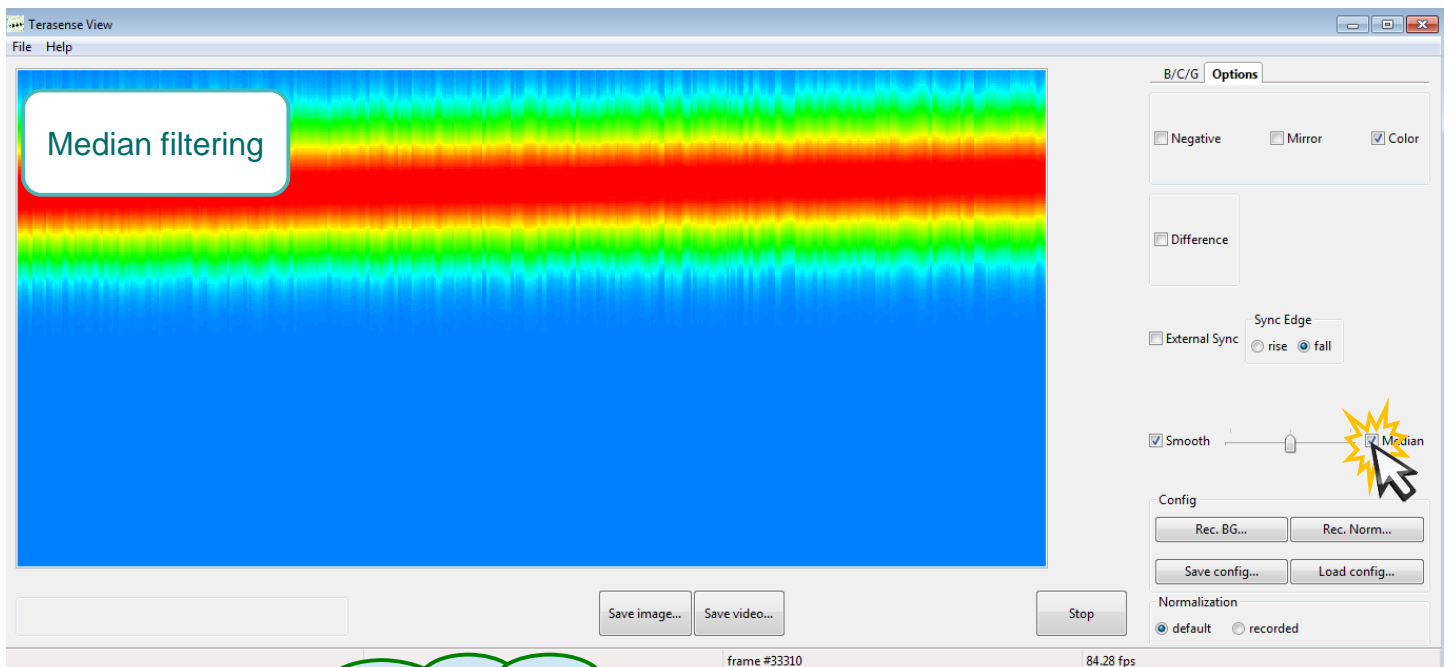
Palette is changed to monochrome.

# Software operation

## Additional data display options



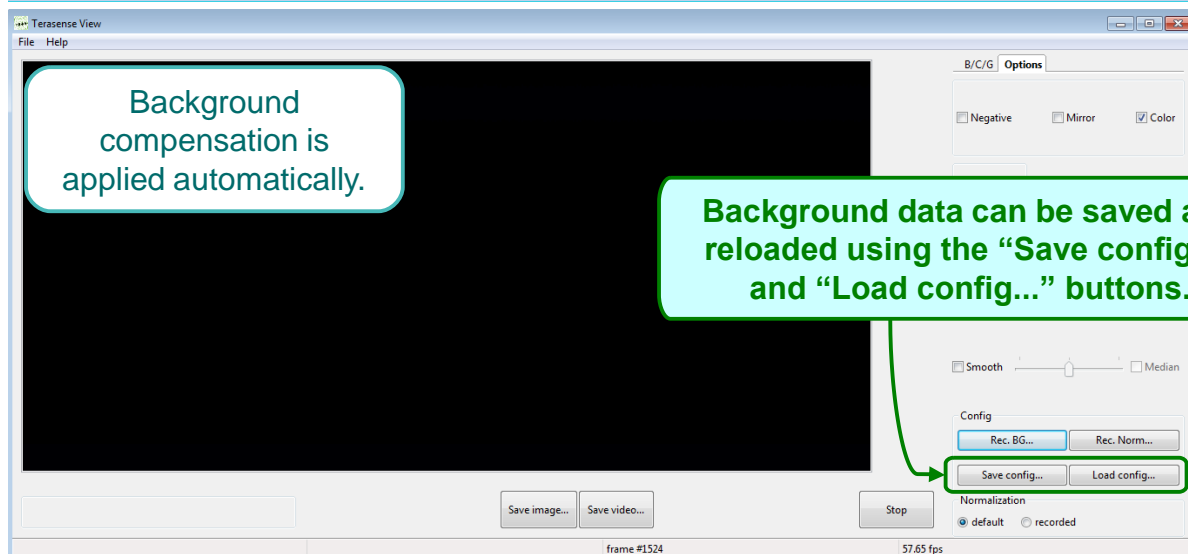
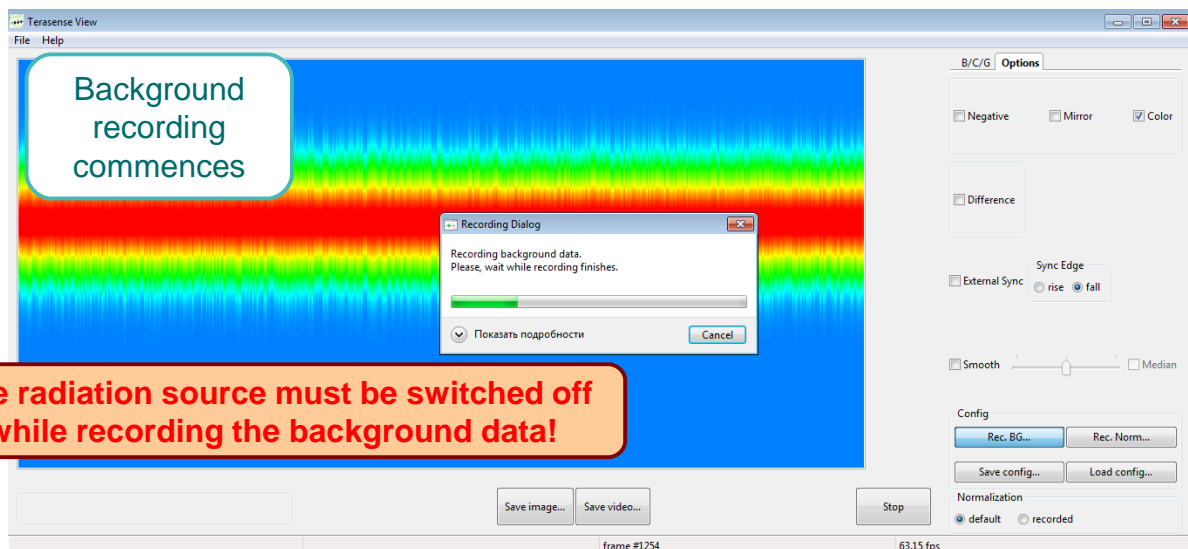
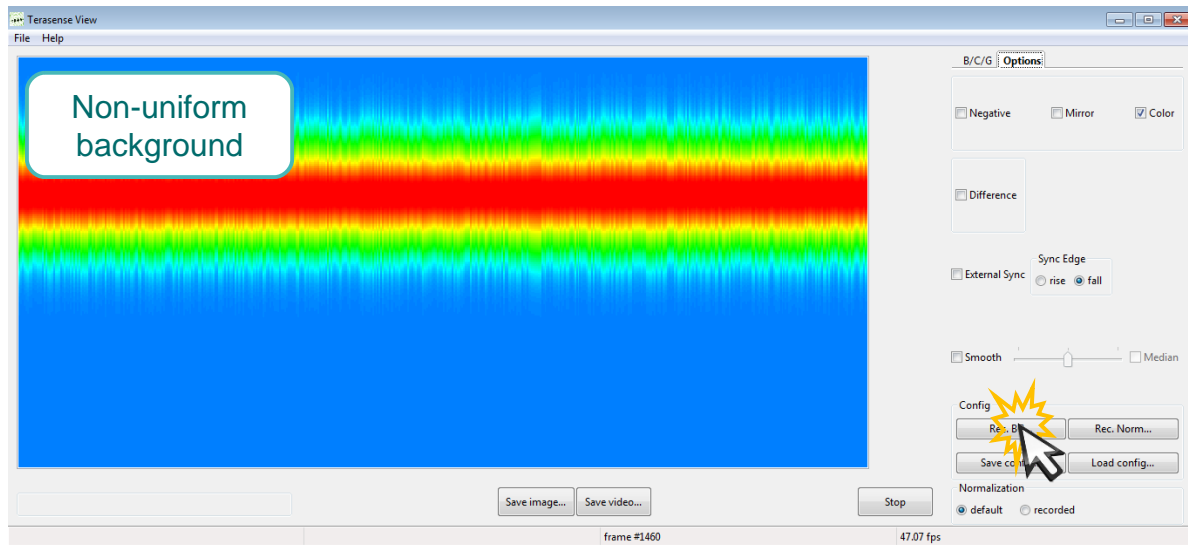
Default filter - averaging with 3x3 kernel



Median filter uses either 3x3 or 5x5 kernel

# Software operation

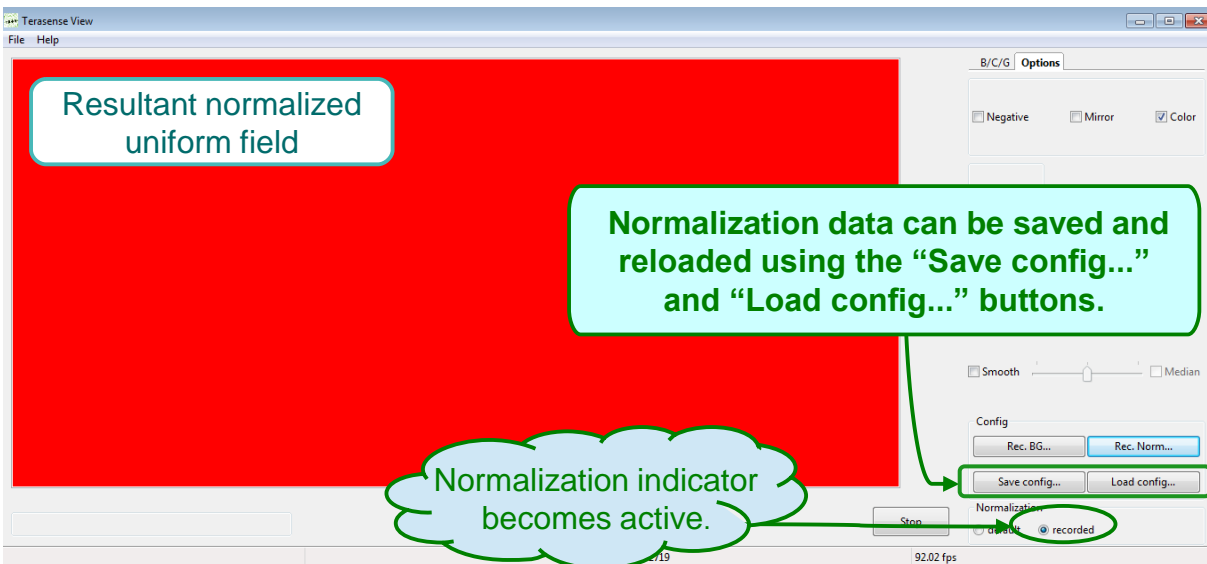
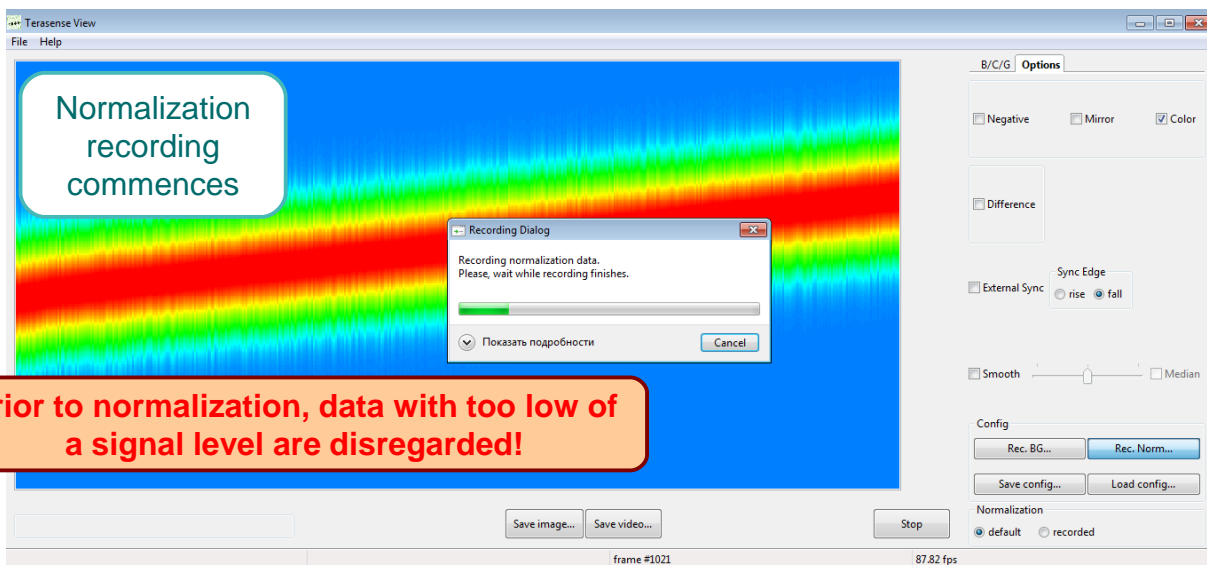
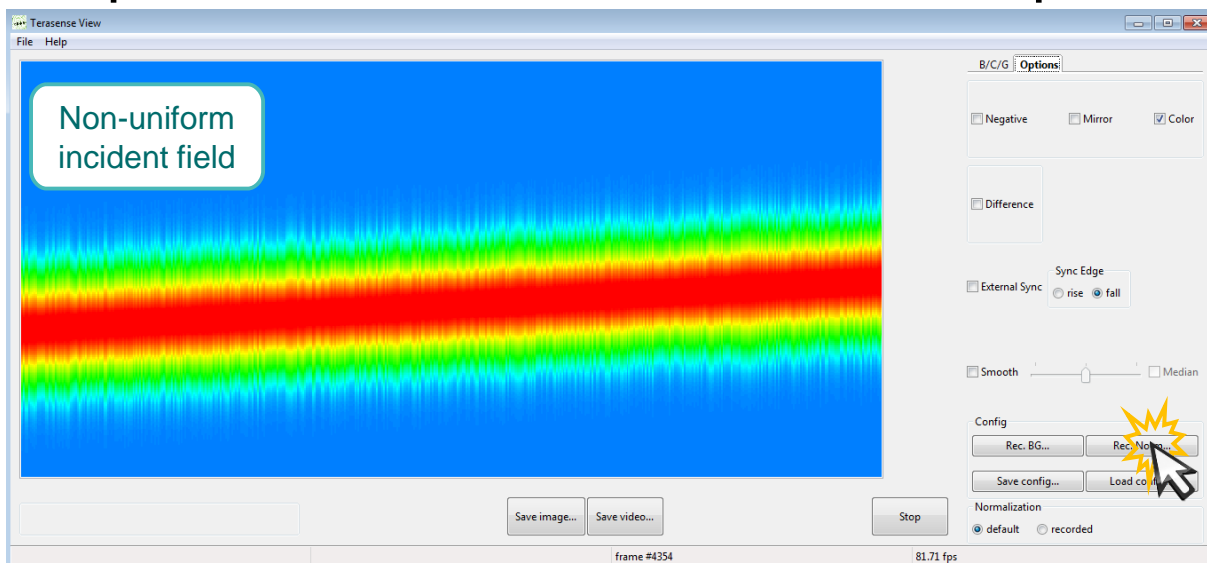
## Background compensation



# Software operation

## Data normalization

(compensation for non-uniform beam profile)





# Software operation

## Saving image

File browsing dialog window is opened

Enter the file name and press OK

File format options:

- “PNG Image”: a copy of what is displayed on the screen is saved in a common image format;
- “Image data”: pixel values of the displayed image are saved as comma-delimited floating point numbers in 0 to 1 range;
- “Original data”: the same format as “Image data” but without any brightness / contrast / gamma modifications applied;

# Software operation

## Recording video

File browsing dialog window is opened

Enter the file name and press OK

Format options:

- “MPEG4 P2 Video”: a common video format accepted by most videoplayers;
- “Uncompressed AVI”: uncompressed videostream, preferable for further data processing.

Indicator of recording in progress

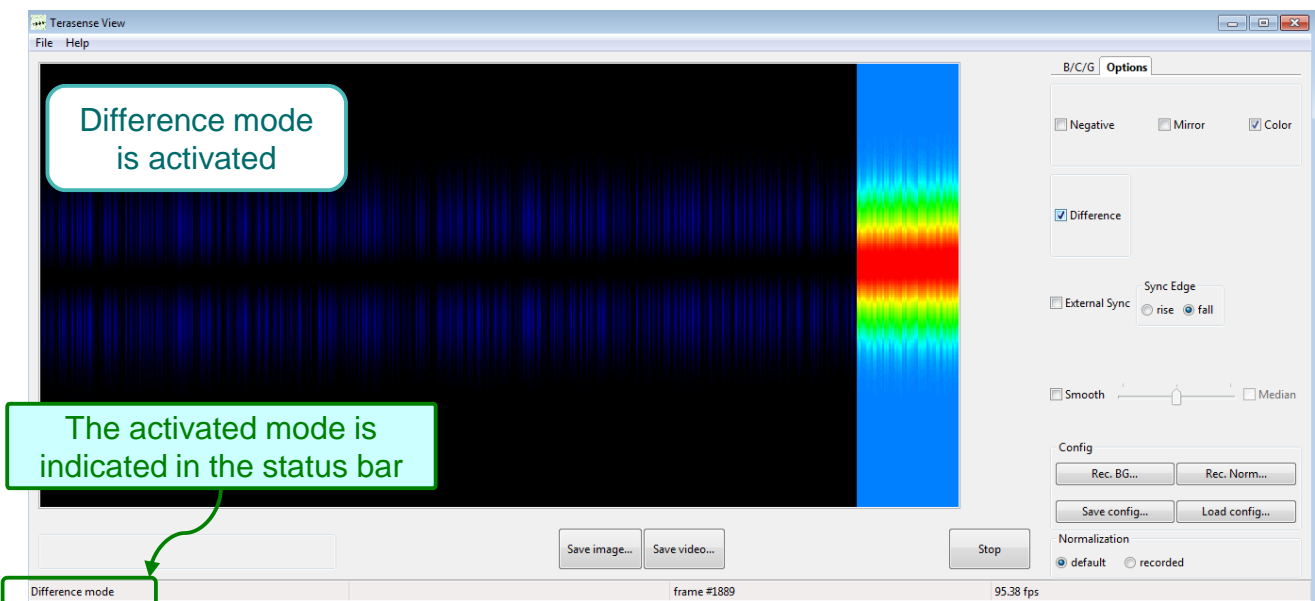
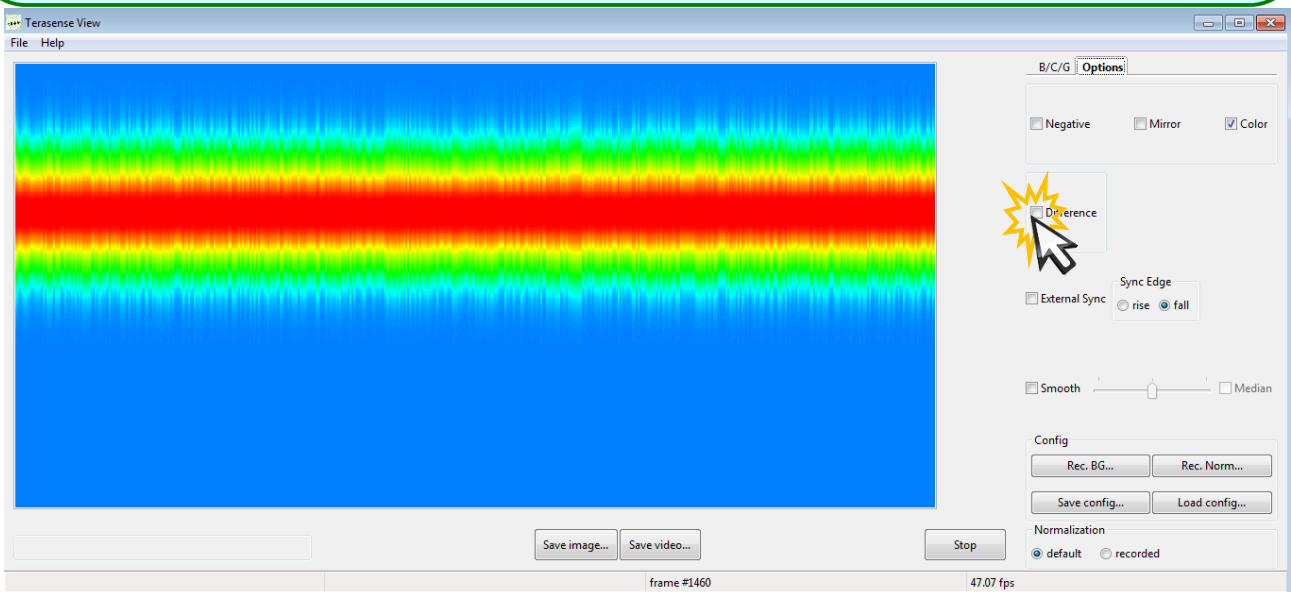
Click to stop the recording.

The video is recorded at the actual frame rate, as long as it exceeds 1 fps. Otherwise, the frame rate is set to 1 fps.

# Software operation

## Imaging in the difference mode

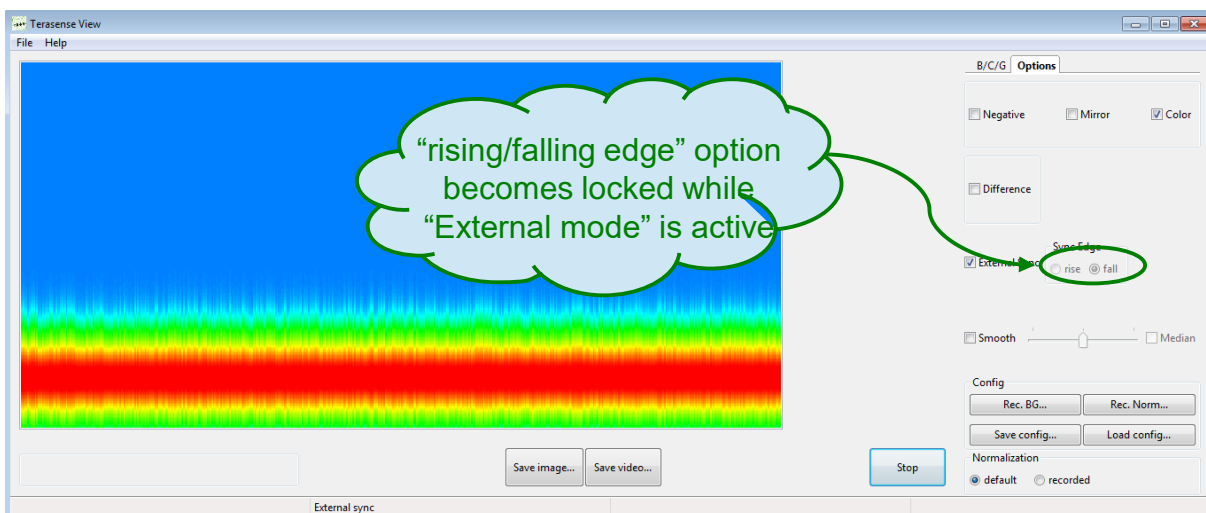
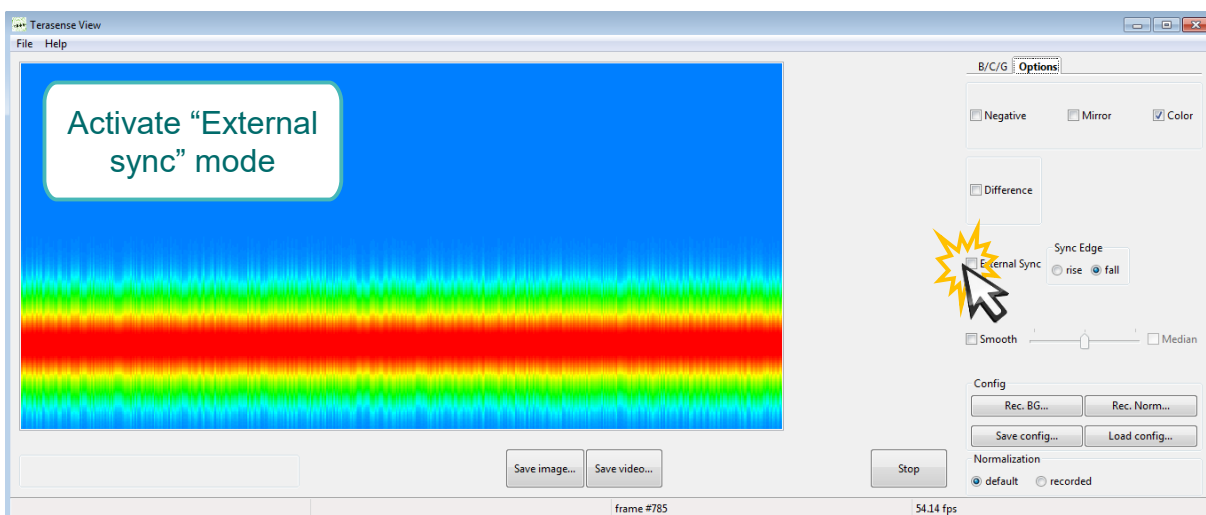
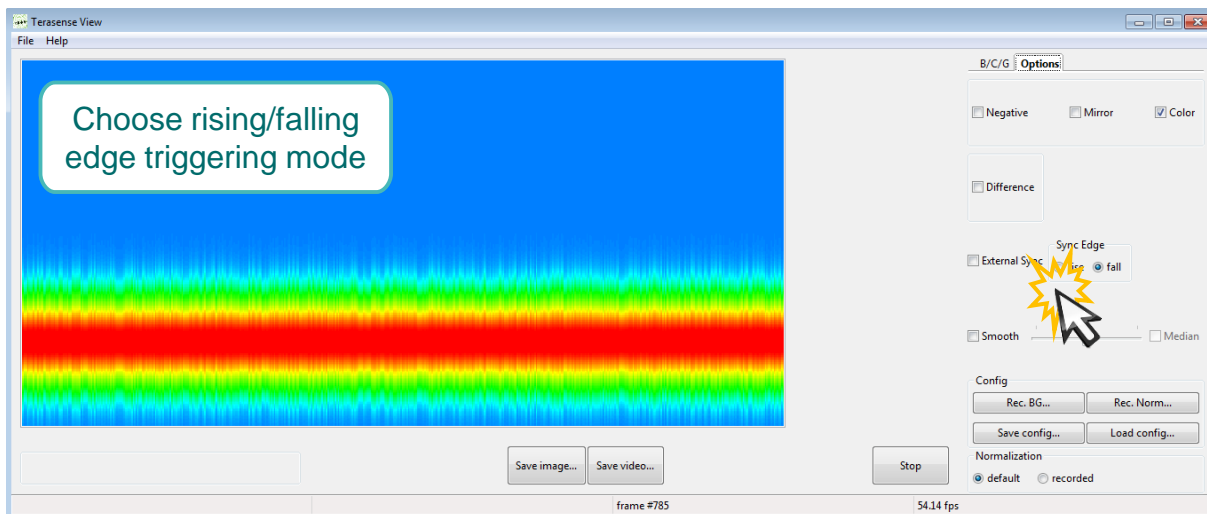
- In this mode the software displays the absolute value of the difference between the two consecutive frames. In order to use this mode, the radiation source has to be modulated by the sync out signal supplied by the camera. The sync out signal is a standard +5V TTL waveform with high/low level transitions designating the frame boundaries, as described on page 6.
- In the difference mode the background and its long-term drift variations are automatically removed.



When using one of TeraSense(TM) IMPATT-diode sub-THz sources, the "SYNC OUT" output port of the camera has to be connected to the "MOD IN" input port of the generator.

# Software operation

## Applying external synchronization



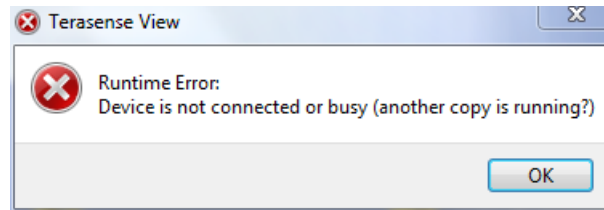
---

# Maintenance

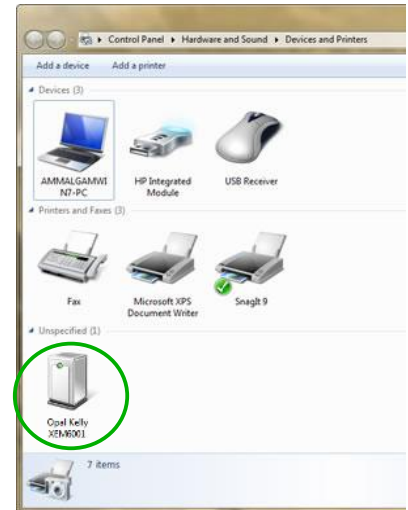
- The device should not be exposed to excessive heat or prolonged direct sunlight.
- On drastic change in ambient temperature, it must be allowed to stabilize before the device can be used.
- As it is not airtight, the device should not be operated in excessively humid or dusty environment.
- PTFE window should not be subject to any pressure as it can be damaged easily.
- The device can be cleaned with soft cloth. If necessary, the cloth can be dampened slightly with mild detergent, in which case the device should be dried thoroughly afterwards.
- The device must never be submerged in water as it will cause permanent damage!

# Troubleshooting

Problem:



Solution:



Check whether Opal Kelly XEM6001 is present in "Devices and Printers" window.

Yes

No

Use "Alt-Tab" to look for another active copy of the TeraSense Viewer software (only one copy can be running at a time)

Use "Ctrl-Shift-Esc" to start the Windows Task Manager. Terminate all pythonw.exe processes, then restart TeraSense Viewer software.

If the software crashed (for example, due to the device being disconnected during the operation), it may have left a zombie process, which would prevent the new copy from running.

Check that the camera is plugged in (Power LED should be on) and connected to the PC.

If you are using a USB hub (especially, unpowered USB hub), try to connect the camera directly to the PC.

Try to connect the camera to another USB port on the PC.

Disconnect any other USB devices and reconnect the camera.