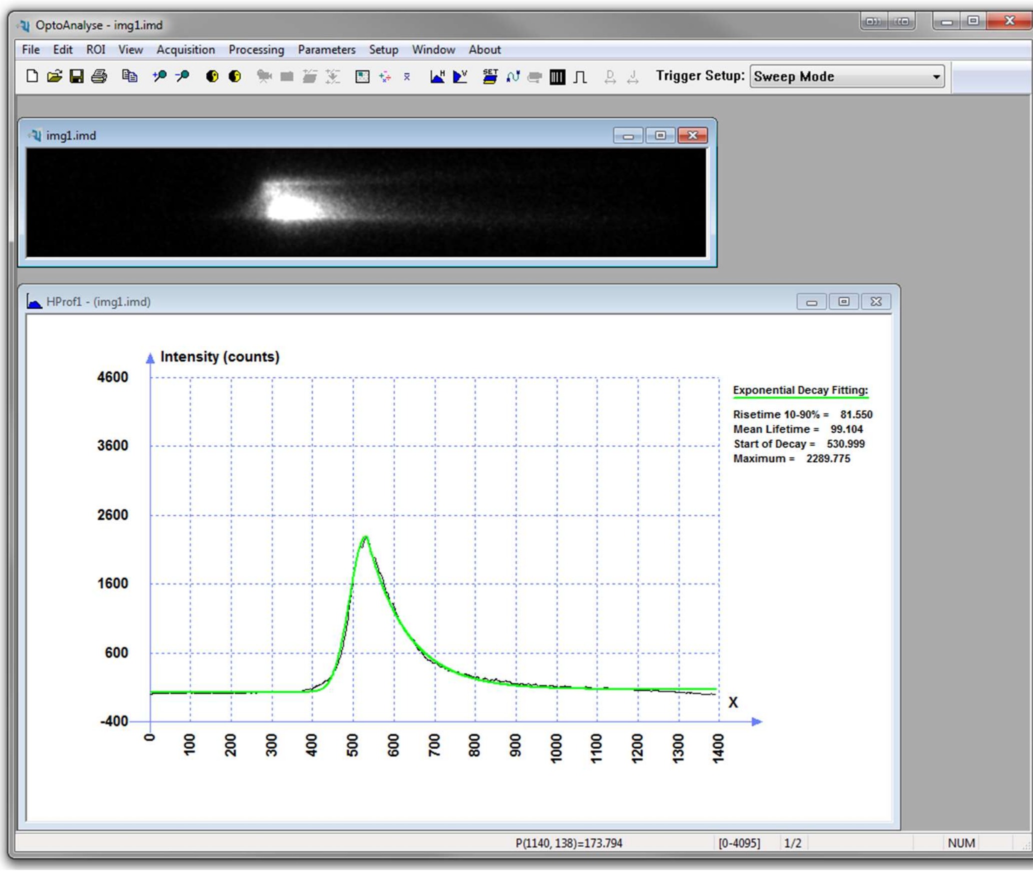
Optronis

OptoAnalyse

Ver. 3.95 and later



User Manual

Ref.: 3995-SU-01-X

Contents

Introduction

The OptoAnalyse program is used with the Optoscope or Optoscope-SC (SC-xx) streak camera for image acquisition and analysis. The program allows acquiring image data capture with different streak camera readout units. Various acquisition modes and image analysis functions needed to operate streak cameras are available. To control the streak camera functions the OptoControl box is integrated.

Compatibility

The OptoAnalyse software can be used in combination with the following components. Restriction might apply for particular configurations of readout camera and operating system due to hardware driver availability.

Streak Camera System: SC-10, SC-20

		Operating System					
		Windows XP		Windows 7		Windows 10	
Readout Camera	Version	32 bit	64 bit	32 bit	64 bit	32 bit	64 bit
ANIMA-PX	/PX, 32 bit	?	-	?	?	?	✓
SCRU-SE	/SE, 32 bit	?	-	✓	✓	?	✓
SCRU-SE-A	/SE, 32 bit	?	-	✓	✓	?	✓
SRU-BA SRU-BC SRU-BX	/B, 32 bit	?	–	✓	✓	?	✓
SI1000	/SI, 32 bit	?	-	✓	✓	?	?
SRU-ED SRU-EU SRU-EG	/E, 32 bit (on request)	?	-	✓ 1)	✓ 1)	?	–
	/E, 64 bit	?	-	-	✓ 2)	–	✓ 2)

✓ = Tested
? = Not tested
- = Not compatible
1) Full operation but reduced frame rate
2) No control of iHR320/iHR550 spectrometer with OptoAnalyse

Requirements

- Win XP, Win 7 or Win 10
- 2 GB RAM
- .NET Framework 3.5x SP1
- SynerJY® Software Development Kit (SDK) version 3.5.7 with USB-dongle needed to control of Horiba iHR320 or iHR550 spectrometers

Overview

The software captures frames from the readout camera and can control the OPTOSCOPE streak camera system via an Ethernet link.

Basic software functions are:

- Real-time video display and profile extraction dedicated to streak camera applications.
- Signal to noise improvement by analogue accumulation or photon counting mode.
- Photon counting mode by calculating the centre of gravity of each photon impact.
- Operation with 32 bit frame memory for fixed-point numbers ranging from $-2.147 \cdot 10^6$ to $+2.147 \cdot 10^6$ with 0.001 precision.
- Acquisition in continuous or single-shot mode
- Automatic sequential acquisitions at fixed time intervals. Records images and generates text report files
- Grey level / Gamma correction / Pseudo-colour palette display.
- Post-processing (arithmetic operations, digital filter, histogram, profiles, mean value).
- Export in uncompressed format (Bitmap or TIFF).
- Complete reporting of streak camera system setup.
- Multi camera control with ANIMA-PX readout.
- Automatic trigger delay adjustment with external timing controller (Version 3.40 for DG645-SRS and TDC-Optronis)
- Scaling features including time and wavelength linearization
- Distortion correction with graphical reference grid editor
- Drift correction
- Jitter correction

Three window classes referred to as windows are available. None, one or more windows can be used the same time.

FRAME window is used to display a frame. This typically shows the current captured frame or a frame loaded from the hard disk.

PROFILE windows are used to display horizontal or vertical profiles based on the entire frame or a region of interest (ROI). The horizontal profile is the pixels sum column by column in a rectangular area and divided by the number of lines. The vertical profile is the pixels sum line by line in a rectangular area and divided by the number of columns.

Network interface and Password protection

The OptoAnalyse software can control SC-xx streak cameras via Ethernet interface. The SC-xx cameras have a fixed IP address and might have a password definition to protect the device from unauthorized use. Without password defined any software can control the camera without prior verification. The IP address as well as the password of the SC-xx streak camera are saved inside the SC-xx streak camera and can be changed by using the OptoAnalyse software. The factory set IP is 192.254.128.254 and no password is defined. After installation of the OptoAnalyse software the IP address of the streak camera that needs to be controlled has to be programmed.

In case the IP address inside the streak camera and the IP saved on the PC are not identical, no communication is possible. As long as no password is defined inside the SC-xx streak camera, the access is not protected independent whether a password is saved on the PC or not. Only if a password is defined inside the streak camera, the password saved on the PC has to be identical to allow access after OptoAnalyse program start. If the access is denied, a dialog box asks the user to enter the correct password.

Attention

Never use the OptoAnalyse program if you are not familiar with the operation of the streak camera and the requirements necessary to avoid damages to the camera. Carefully read the operation manual of the streak camera and make sure never to over illuminate the optical input of the camera.

Installation

The OptoAnalyse software can be used with different readout cameras. For the installation of the readout camera on the rear of the streak camera, please refer to the corresponding section of the particular readout camera user manual.

Before installing the OptoAnalyse software the readout camera installation has to be completed. Part of the readout cameras are provided with their associated frame-grabber that has to be installed inside the PC prior to installing the software driver.

Driver and Frame Grabber Installation

This section provides a short description for the installation of frame-grabbers inside the PC as well as the installation of the driver. More details can be found on the documentation provided with the readout camera.

Attention:

The frame-grabber can be damaged by electrostatic discharge. The board is delivered in an anti-static bag and must be handled with care. Manipulate the board only when electrically connected to ground potential. Also connect PC to ground potential during manipulation.

SRU-ED

The SRU-ED camera uses components of the pco.edge camera from PCO and frame grabber from Silicon Software.

- Details for installation are provided with the manual for the SRU-ED

SRU-BA, SRU-BC and SRU-BX

The SRU-BA, SRU-BC and SRU-BX cameras have GigE interface and do not use a frame grabber. No hardware installation on the PC is strictly required. Nevertheless, for compatibility reasons, it is recommended to use the Ethernet interface board provided with the camera.

- For driver installation please refer to the SRU-BA, SRU-BC or SRU-BX user manual.

SI 1000 and SI 1000-4k

The SI 1000 and SI 1000-4K cameras have dedicated interface boards.

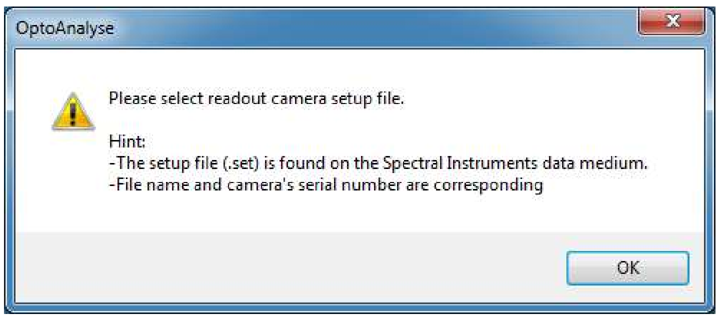
- For hardware installation of the camera as well as installation of interface board and driver please refer to the SI 1000 user manual. Attention: Please carefully follow the instructions there. Only particular driver version and OptoAnalyse version are compatible.

Camera Set-file installation

Each camera is provided with a particular setup file containing individual camera parameters needed for optimized performance of the readout camera. The setup file contains the camera serial number and has the extension .SET. Example: “1000-123.SET”

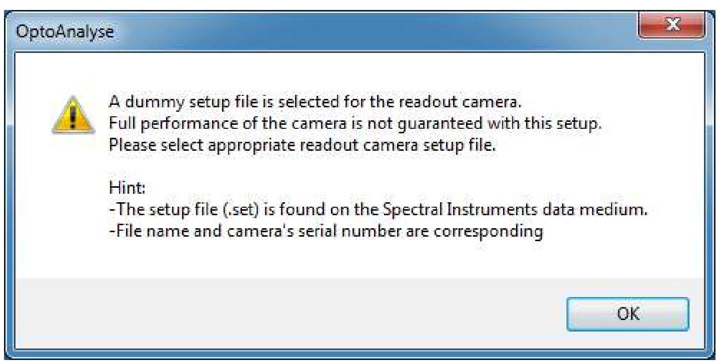
- Copy the setup file into the OptoAnalyse program folder normally “C:\Program Files\Optronis\OptoAnalyse-SI vX.XX\CFG”. The setup file (*.set) can be found on the Spectral Instruments data medium. Attention: Optronis might have optimized the original setup file. In this case the optimized file will be found on the OptoAnalyse installation CD.

During the first launch of OptoAnalyse no setup file is selected and the software asks to select a valid file. Once the OptoAnalyse software is operating, the Setup/Readout Camera menu allows defining the setup file at any time.



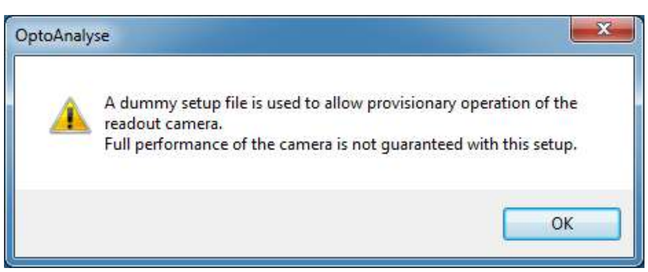
Click “OK” and select the file copied previously.

If no setup file is selected, a file with dummy parameters is used and the following message appears after each program start.

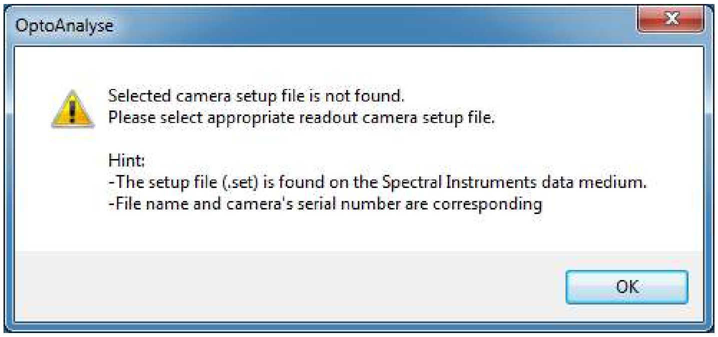


After clicking on “OK” the setup file can be selected again. No particular message appears after the successful selection.

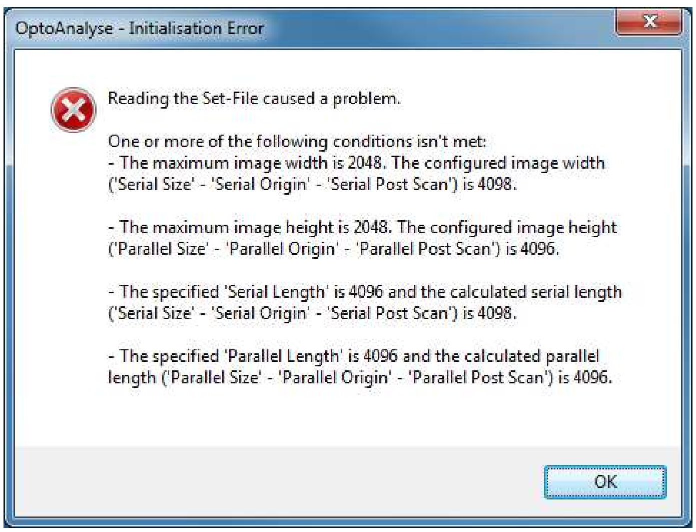
If the setup file selection is cancelled the message below appears.



Is the specified setup file is not found then OptoAnalyse request again the setup file selection.

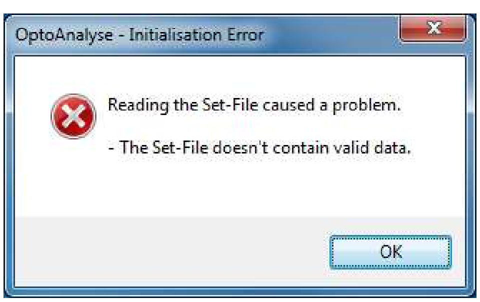


Once a setup file is read the parameters are verified whether they are consistent. In case they are not consistent, this message is displayed.



Numbers on the message box might be different from the image above. Please refer to the user manual of the SI1000 camera for more specific requirements. Mainly image position and image size will be affected if only dummy file parameters are used.

In case the setup file is specified but does not contain correct data at all the following message appears.



ANIMA-PX

Requirements:

- PCI interface slot
- Chipset Intel C600 or C602 (older chipsets might work also)

The ANIMA-PX camera uses components of the PixelFly camera from PCO.

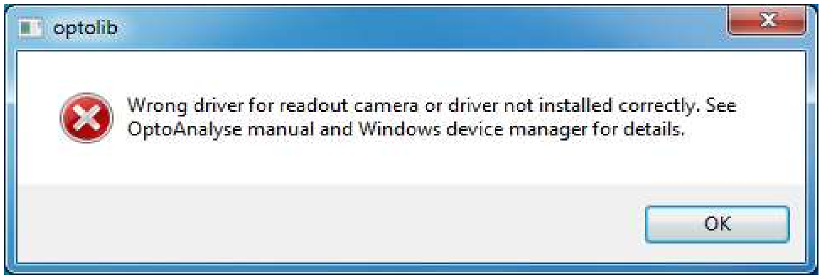
- The PC has to be switched off. Install the frame-grabber in the PC
- Connect the ANIMA-PX camera and the frame-grabber using the cable provided. Remark: Camera connector and cable are physically identical to standard network components but must not be connected to any network component.
- Switch on the PC.
- Windows should detect the new device automatically and prompt for the specific driver to be loaded
- Install the PixelFly driver following the instructions described in the PixelFly manual.
- PixelFly CamWare control application can be installed to verify the camera operation but is not required by the OptoAnalyse software.

SCRU-SE-A

The SCRU-SE-A camera uses components of the SensiCam camera from PCO.

- The PC has to be switched off. Install the frame-grabber in the PC
- Connect the SCRU-SE-A camera and the frame-grabber using the coaxial cable or the optical cable
- Connect the power supply of the SCRU-SE-A camera. Switch on the camera.
- Switch on the PC.
- Windows should detect the new device automatically and prompt for the specific driver to be loaded
- Install the SENSICAM driver following the instructions described in the PCO manual.

  Attention: OptoAnalyse/SE version 3.63 and higher can only be used with SENSICAM driver DD_525WIN_600_04.ZIP. OptoAnalyse/SE before version 3.63 needs the older driver DD_52XWIN9X00_521.ZIP. This error message will appear in case a wrong driver is installed.



This is valid for Win XP and Win 7 operating systems.

- SENSICAM control application can be installed to verify the camera operation but is not required by the OptoAnalyse software.

OptoAnalyse Installation

The installation of the OptoAnalyse has to be done after the setup of the readout camera driver and eventually the installation of the readout camera frame grabber is completed. Administrative rights are required during installation so make sure to logon accordingly. Depending on the readout camera to be used, the OptoAnalyse software is available with different options. Make sure to install the OptoAnalyse with the correct option.

Then follow the steps below:

- The software SETUP.EXE is automatically launched and starts the installation of the OptoAnalyse application.
- Follow the instruction given by this installation procedure

Reboot your system is recommended although not strictly need

For particular readout cameras, example SI 1000, the OptoAnalyse software is available in a 32 bit and a 64 bit version. The 32 bit version has to be used for 32 bit operating systems. For 64 bit operating systems the 64 bit version should be used although the 32 bit version is working. Driver compatibility needs to be considered separately. Details are provided with the readout camera menu.

Particularity for permission rights handling

The installation procedure will automatically change the permission for the access to the “OptoAnalyse” directory to “Full Control” on Windows 7 systems. Only in case this change needs to be done manually, follow the instructions below:

- Open the “Windows-Explorer” and navigate to the “Program Files” path:

  Windows 7 – 64 Bit: c:\Program Files (x86)

  Windows 7 – 32 Bit: c:\Program Files
- Right click the folder OptoAnalyse to open the context menu and click “Properties”.

- Select the tab “Security” and press the button “Advanced”.
- Select the tab “Permission” and press the button “Change permissions…”.
- Select the user “User” and press the button “Edit…”.
- Check the field “Allow” in the row “Full Control” and close all dialogs with “OK”.

OptoAnalyse Update Installation

New OptoAnalyse software can be installed on the same PC as additional version. Setup parameters like pixel size, exposure time and acquisition parameters remain unchanged after updates. Drivers for readout camera or spectrometer do not need to be installed again. Only the OptoAnalyse software has to be updated. On a first step this update installation is identical to a primary installation. On a second step the following files and directory need to be copied.

init.ini

correction.ini (if available)

BLC-Images_GS (directory only for OptoAnalyse/ED)

These files are found on ‘C:\Program Files\Optronis\OptoAnalyse-YY vX.XX’ if no different customer directory had been specified during installation. ’YY’ indicates readout camera version and ‘X.XX’ indicating the actual program version.

Example:

OptoAnalyse/ED had been updated from version 3.69 to version 3.70. Ini files and directors from ‘C:\Program Files\Optronis\OptoAnalyse-ED v3.69’ need to be copied to ‘C:\Program Files\Optronis\OptoAnalyse-ED v3.70’

Spectrometer installation

For hardware installation please refer to the manual of the spectrometer provider and the manual “Coupling Spectrometer User Manual” (Ref. 3818-SU-02). For software control of the spectrometer, the corresponding driver needs to be installed. This driver is provided by the spectrometer manufacturer and has to be installed before it can be used by OptoAnalyse. Spectrometer related commands of OptoAnalyse including grating selection, wavelength setup and wavelength calibration are described later on this manual.

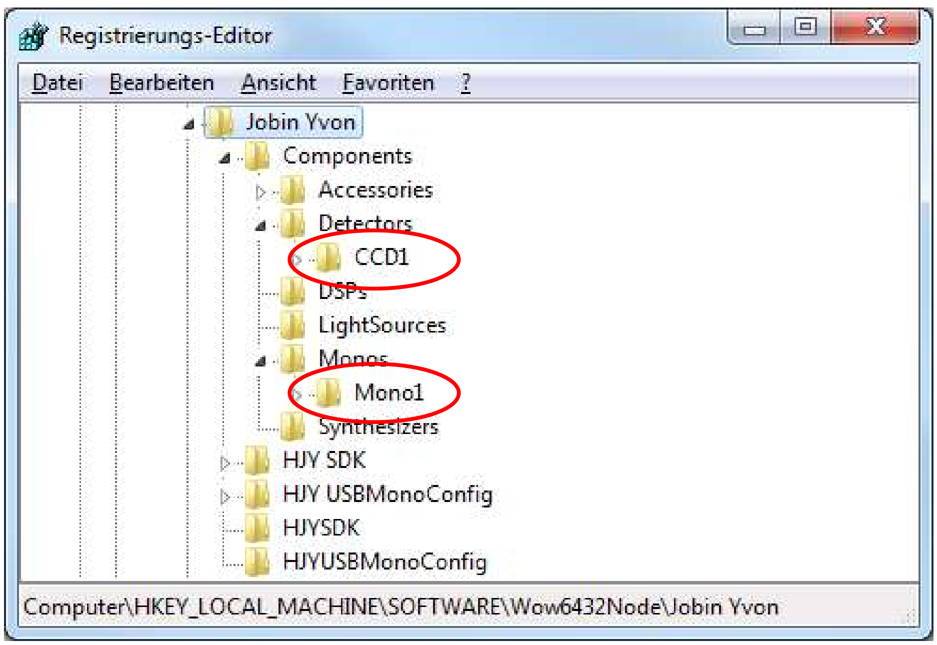
iHR320 and iHR550 particularities

- Install "USBSpectrometerControl" by starting "HJY USBMonoConfig.exe" available on the utilities directory of the spectrometer driver software
- Install SynerJY® Software Development Kit (SDK) version 3.5.7 by starting “Setup.exe” of the driver software

- Start "USBSpectrometerControl" to install (pos. 1) spectrometer with registry entries for gratings, shutter and slit configuration. Spectrometer should be installed with its “UniqueID = Mono1”.
- In case a so-called CCD shutter is installed in the spectrometer, a CCD camera needed to be configured by using HORIBA software. CCD camera has to be installed with the “UniqueID = CCD1”.
- Plug in USB-dongle
- Start OptoAnalyse version 3.73 or later
- Select HORIBA iHR 320 or iHR 550 on the Setup/Spectrometer control box
- After restart the spectrometer will be initialized

Remark: In case a HORIBA CCD camera is used with the spectrometer and a so-called CCD shutter is installed in the spectrometer, the shutter might be controlled by the CCD camera directly.

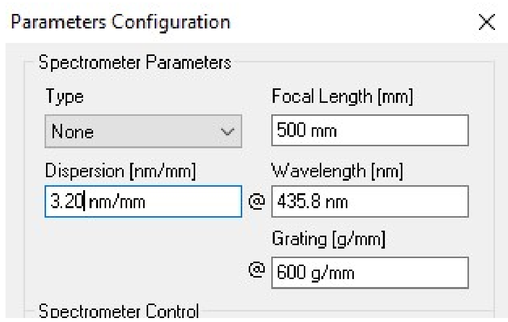
Remark: After configuring the spectrometer and eventually the CCD camera the registry should have these entries:



Spectrometer without control by OptoAnalyse

In case the streak camera is used on the output of a spectrometer which is NOT controlled by OptoAnalyse, it is nevertheless possible to get wavelength calibration by OptoAnalyse.

- Select type “none”.



- Do not keep parameters to zero (not shown above) but enter consistent parameters corresponding to the spectrometer used.

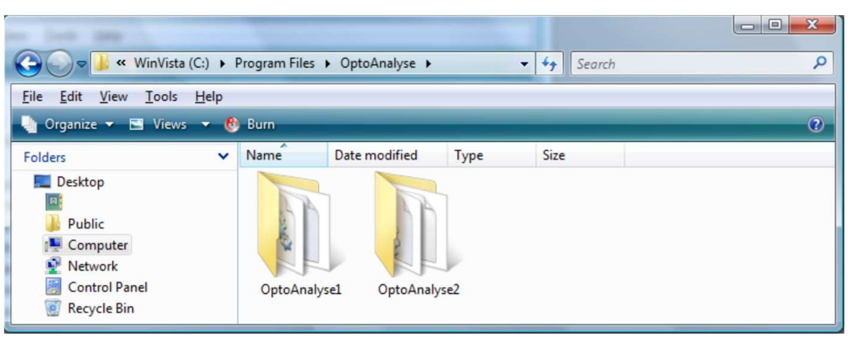
Multi camera control

The OptoAnalyse software version 3.10 and higher can be used to control more than one OPTOSCOPE-SC streak camera and more than one ANIMA-PX readout camera. If only one streak camera and one readout camera is used, this section can be skipped and installation continues with the “Setup readout camera” section.

To allow multi camera control the OptoAnalyse software needs to be installed multiple times at different locations. Additionally, minor adaptations on the corresponding INIT.INI files need to be made.

- Install OptoAnalyse software as described above. Make sure the driver for the readout camera is installed before.
- During installation the setup program requests the name of the directory where to save the software. Confirm or modify the proposed location and note this path. Example: *C:\Program Files\OptoAnalyse\OptoAnalyseV3.10*
- Rename the directory where the software had been installed. Example: *C: \Program Files \OptoAnalyse\OptoAnalyse1*
- Copy the directory or install the software as many times as streak systems need to be controlled. Rename these directories.

After installation the structure should appear similar to this:



Remark: Directory names where OptoAnalyse software is installed might be named according to the application or configuration of the different streak camera systems. For example *OptoAnalyse_Synchroscan* and *OptoAnalyse_Spectroscopy*.

A shortcut on the desktop might be created for each program installation and named accordingly.

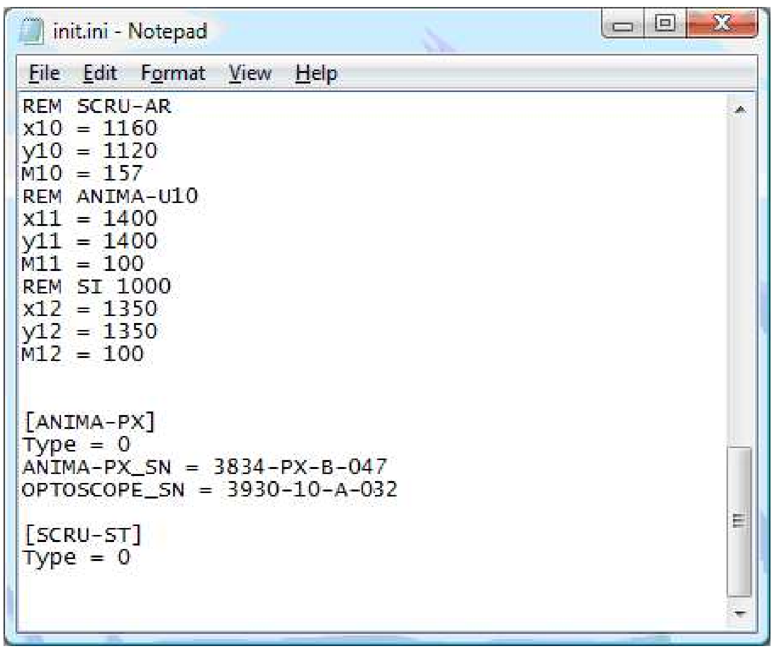
The INIT.INI file of each installation has to be modified in order to configure each OptoAnalyse software for a particular streak camera and readout camera.

- For each streak camera system note the serial number (SN) of the OPTOSCOPE streak camera and the ANIMA-PX readout camera. The SNs are printed on the device and they are written on the memory inside the camera.

  Remark: As the SN of the ANIMA-PX can be user modified it would be possible to use any other name to identify the ANIMA-PX. Nevertheless it is recommended to use the SN.

- Define which software installation (example *C:\...\OptoAnalyse1* or *C:\...\OptoAnalyse2*) should work with the streak camera system and edit the **corresponding** INIT.INI file. The file is found on the corresponding directory and can be edited for example by using Notepad. The parameters “ANIMA-PX_SN” and “OPTOSCOPE_SN” contain the corresponding SNs.

Example:



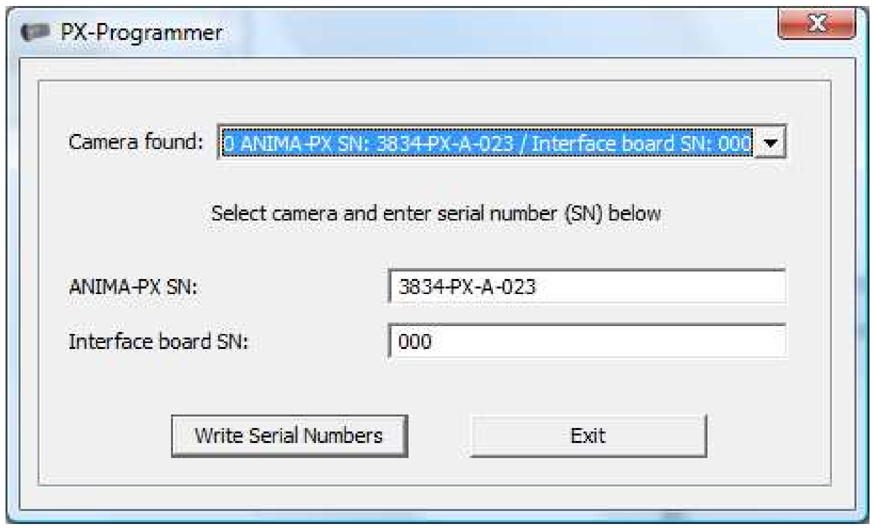

```
REM SCRU-AR
x10 = 1160
y10 = 1120
M10 = 157
REM ANIMA-U10
x11 = 1400
y11 = 1400
M11 = 100
REM SI 1000
x12 = 1350
y12 = 1350
M12 = 100


[ANIMA-PX]
Type = 0
ANIMA-PX_SN = 3834-PX-B-047
OPTOSCOPE_SN = 3930-10-A-032

[SCRU-ST]
Type = 0
```

Remark: If a particular serial number is defined in the INIT.INI file only this camera will be controlled by the software. No other camera can be used. In case the serial number of the streak camera or readout camera is not programmed (example “ANIMA-PX_SN = “ or “OPTOSCOPE_SN = “) any camera found would be used.

Configuring ANIMA-PX for multi camera applications

The ANIMA-PX readout camera needs to be configured if more than one camera is used on the same PC. The configuration consists in writing a unique identifier into the camera memory. We recommend using the camera’s serial number as unique identifier.

- Connect only **one** ANIMA-PX camera.
- Start the “PX-PROGRAMMER” found on the root directory of the installation disk.



- If more than one camera is connected select the camera that need to be configured.
- Enter the SN on the line named “ANIMA-PX SN:”
- The SN of the interface board might be specified optionally.
- “Write Serial Numbers” and exit.
- In case other readout cameras need to be configured, connect these cameras and repeat the procedure for all cameras.

Setup readout camera

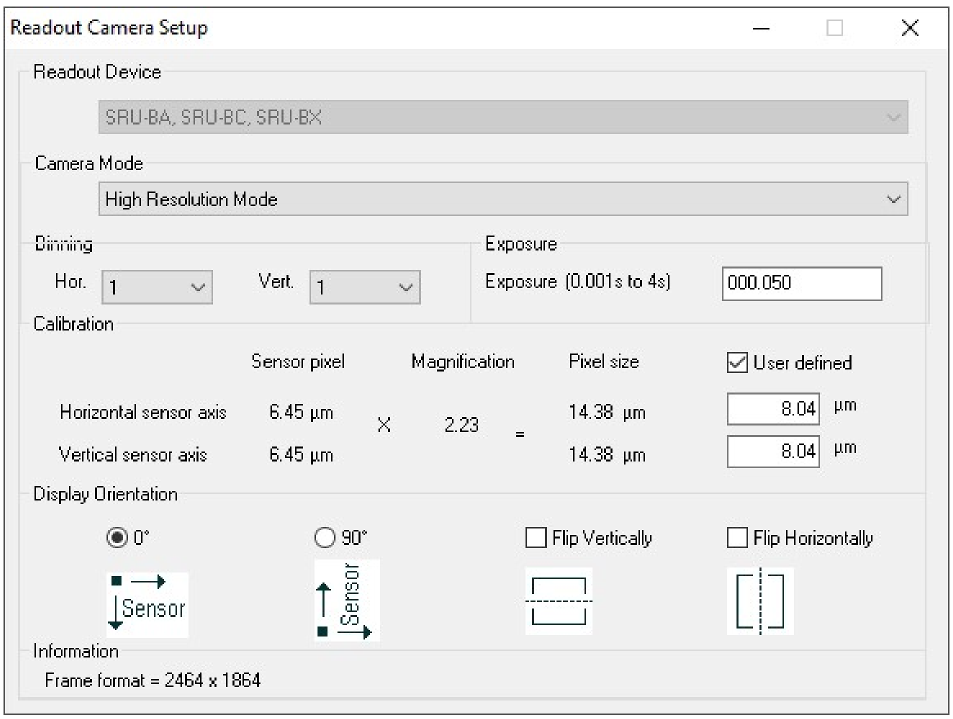
Prior to use the readout system parameters like pixel size, exposure time and others should be set. Particularly pixel size as shown on the tests sheet provided with each camera should be entered correctly. During first program start this parameter is requested but can be modified on the SETUP/READOUT CAMERA menu at any time. For each readout camera the corresponding setup screen is shown below.

For precise horizontal and vertical scale calibration the actual size of the pixel size should be copied from the final tests sheet to the *User defined* filed on the setup screen.

For most applications, exposure time can be set within the range of 10 ms to 100 ms.

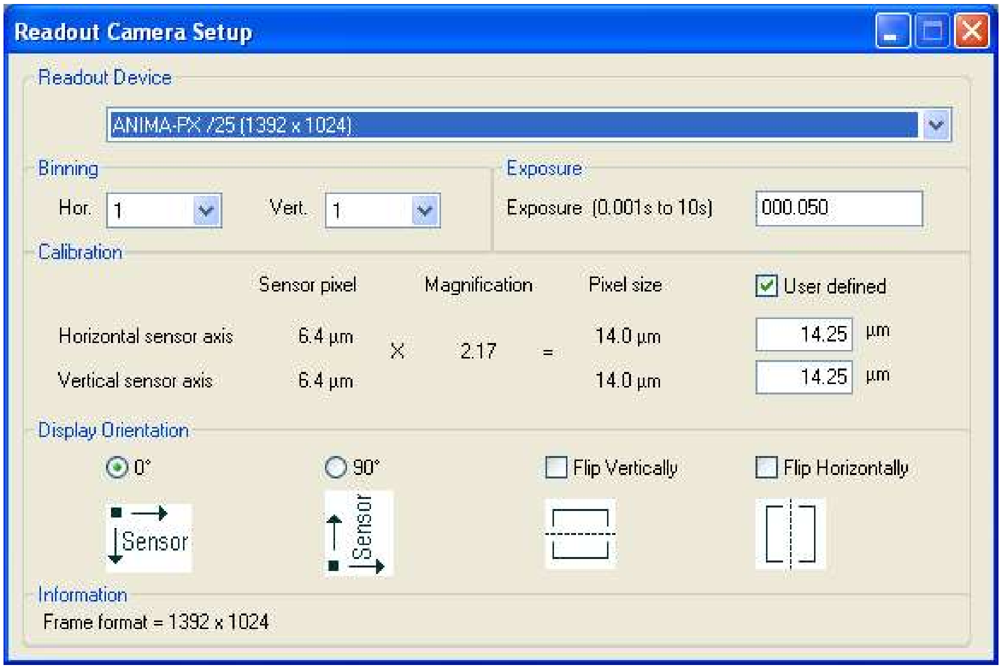
Below, typical example of setup screens are given.

Setup screen for SRU-BA, SRU-BC and SRU-BX camera.

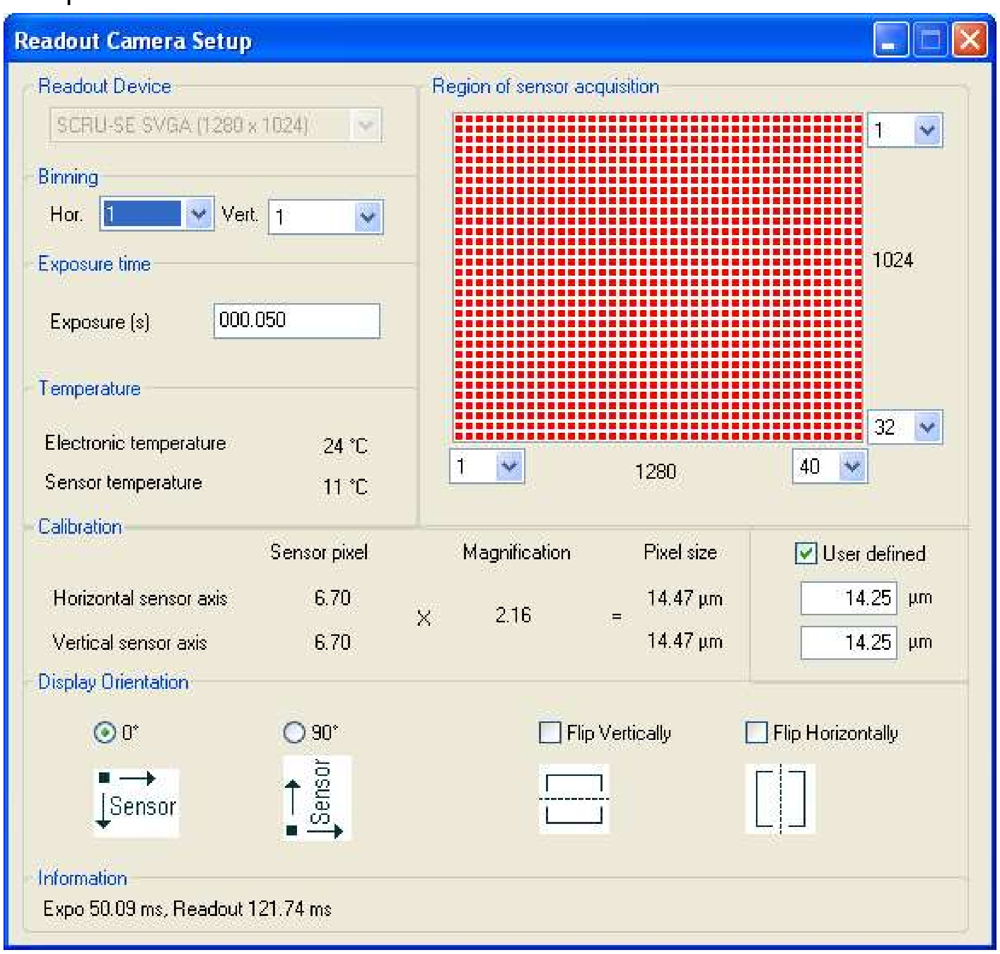


Remark: For SRU-BC readout cameras, pixel size corresponding to High-Resolution mode must be entered independent of camera mode selected. If camera mode is set to High-Sensitivity mode, effective pixel size is used automatically.

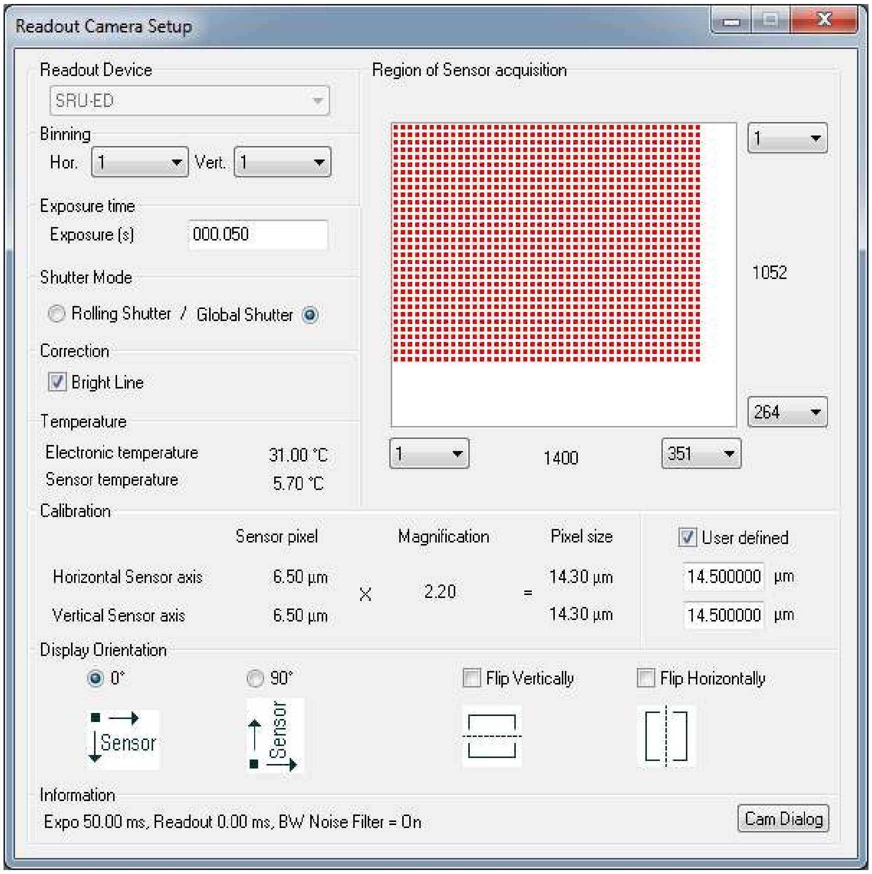
Setup screen for ANIMA-PX camera.



Make sure to select the correct version e.g. ANIMA-PX/11, …/25 or …/40.
Setup screen for SCRU-SE and SCRU-SE-A camera.



Setup screen for SRU-ED camera.



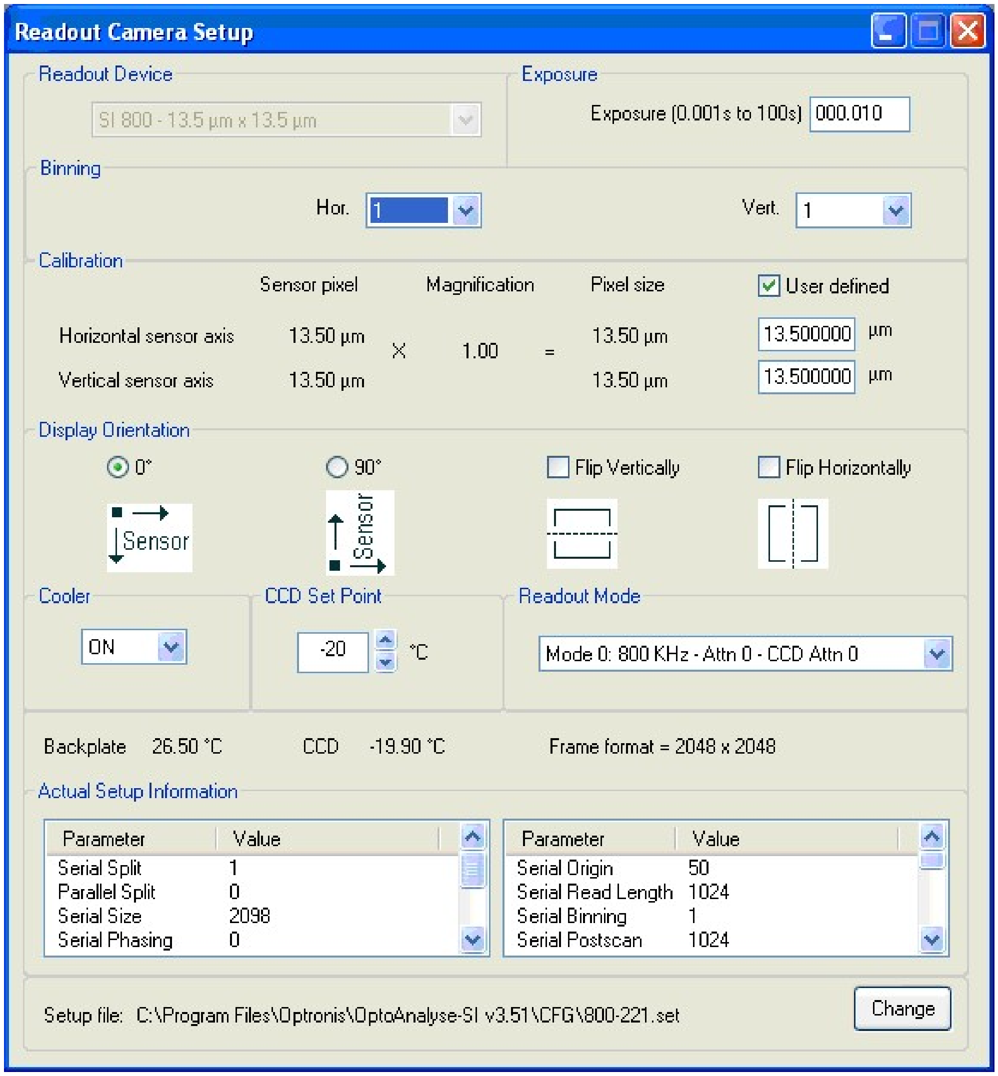
The setup menu above shows typical parameters. For details please refer to the SRU-ED user manual as well as to the 'Using the SRU-ED readout camera' section on the Setup menu later on this manual.

Factory setup on init.ini

Readout size and position of readout area of the SRU-ED camera can be configured to a certain extent. This configuration is factory set and saved on the *init.ini* file saved on the same directory as the OptoAnalyse executable *OptoAnalyse.exe*.

The line 'ED = 578 41c 64 4A' on this file defines the image size as hexadecimal number of horizontal pixels (578_h = 1400) and number of lines ($41C_h$ = 1052). The horizontal position (64_h = 100) and vertical position ($4A_h$ = 74) of the readout area is also defined. Modification of horizontal and vertical size should not be done. Modification of position should only be done after factory consultation. Both will have an impact on trigger delay and sweep speed linearity and.

Setup screen for SI 800/1000 camera.



For streak camera related applications of the SI 1000 camera the following parameter might be considered:

Exposure time: 0.2 s

Binning: 1 x 1

SENSOR Set Point: -20°C

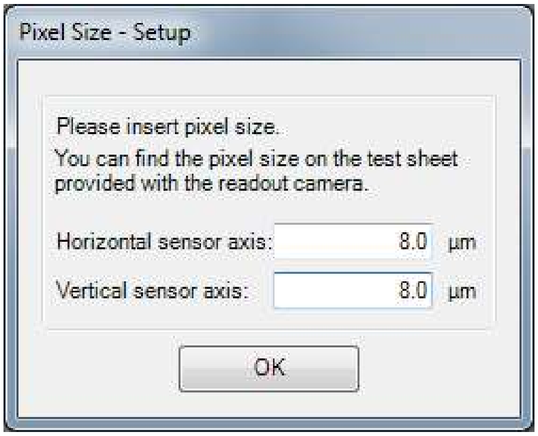
Make sure the correct setup file is selected.

Depending on actual applications, other setting might be necessary to optimize system performance. Further information can be found on the user manual provided by Optronis and describing the use of the camera within a streak system. Technical details about the camera operation are found on the SI 800/1000 user manual.

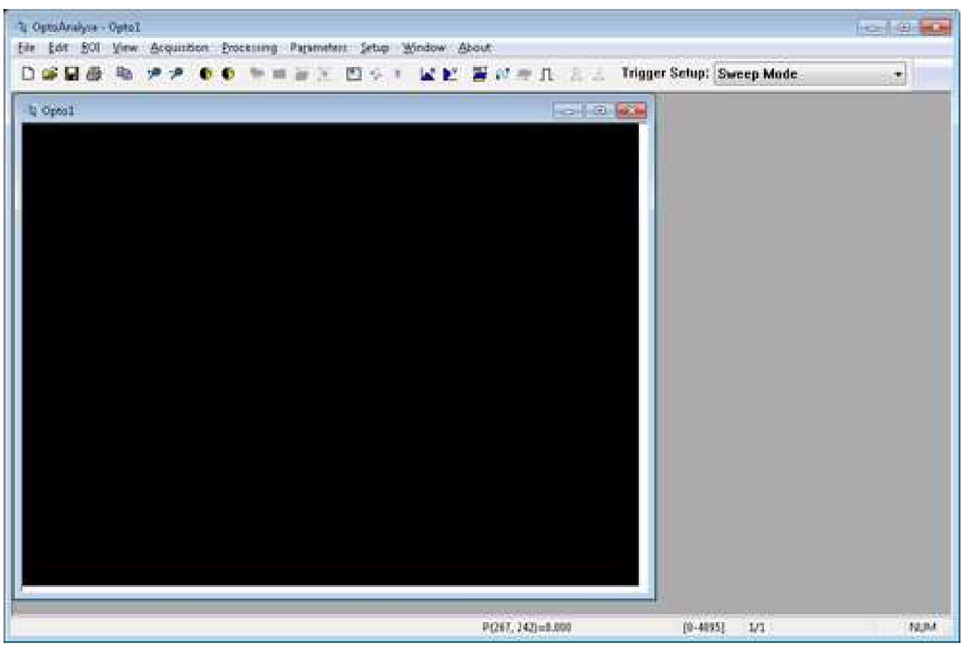
Start of OptoAnalyse

Prior to start the OptoAnalyse software the streak camera system needs to be installed and connected to the PC. The streak camera main unit as well as the readout camera (except ANIMA-PX) need to be switched on.

In case the OptoAnalyse software is started the first time after installation, the pixel size of the readout camera has to be entered. This value is found on the readout camera test sheet provided by Optronis.

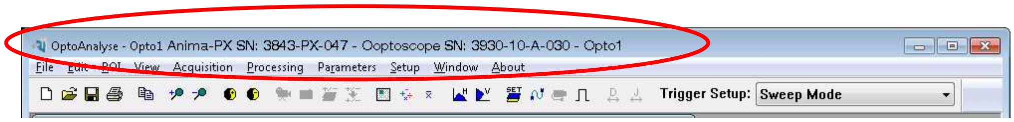


Later, the values can be modified on the Setup/Readout Camera menu.



See trouble shooting section for details if this display does not appear.

For multi camera installations where the OptoAnalyse software had been configured to operate with a particular ANIMA-PX readout camera or a particular OPTOSCOPE streak camera the display will appear differently as shown below.



The title bar shows the serial number programmed in the INIT.INI file but only if the device is connected to the PC and communicating with the software. This information allows to identify the different programs operating in parallel and to relate them to the corresponding streak systems.

Re-Start after modified Streak Camera Configuration

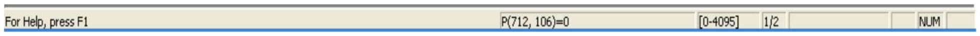
The OptoAnalyse software needs to be re-started after the streak camera system configuration had been changed. This concerns the exchange of sweep units and is required to make sure the correct calibration data are loaded from the camera. A restart is also required if the communication between PC and streak camera had not been possible before, or in case the communication had been interrupted.

Frame Window

A FRAME window displays a frame. A frame is either the real-time signal from the readout camera, the data after an image acquisition or an image from the disk. If an image file (.IMG or .IMD) is opened from the disk, a new FRAME will appear. Frame and Image are used as synonyms in this document.

After starting the application the first frame can display the real-time signal and therefore can be used for image acquisition. All other FRAMES only display images from the disk. In case the first frame is closed, use the **New** command during another FRAME is active to create a new FRAME allowing real-time display and image acquisition.

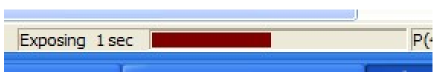
During a FRAME window is active, the menu contains all relevant commands available with this window type. The toolbar contains a part of the available commands.



The status bar contains several text fields. From left to right, you can see:

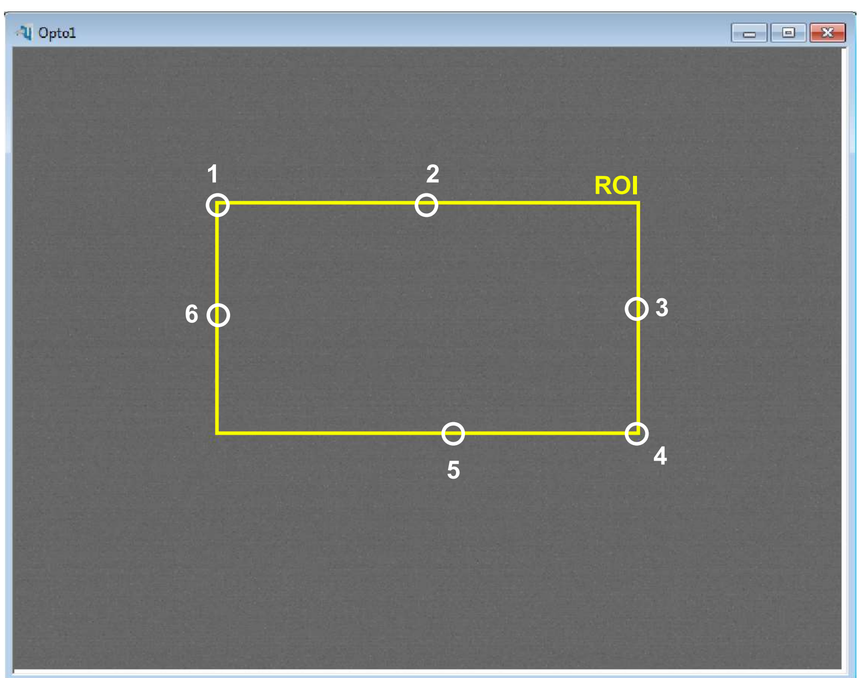
- Text field to show the command executed or status of the ongoing acquisition
- The cursor position with pixel intensity
- The intensity range displayed in the window
- The zoom factor
- Acquisition information
- The keyboard status

For readout cameras with long exposure time settings and long transfer time requirements, progress bars for exposure time and transfer time are displayed.



Region Of Interest ROI

A region of interest (ROI) can be defined in the FRAME window. The ROI appears as a yellow rectangle on the frame. This ROI is used to restrict the commands of the processing menu to the data inside the ROI. The minimum ROI size is 1 per 1 pixel.



To create a ROI select the upper left point (1) of the ROI by pressing the left mouse button and move the mouse cursor with left button always pressed to the bottom right point (4) of the ROI. Release the left button.

The left text field in the status bar then shows the ROI coordinates. Shape, size and position of the ROI can be changed with the mouse. Therefore the ROI has some action points.

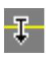
1 → Move the ROI

2 → Change ROI vertical coordinates.

3 → Change ROI right coordinates.

Pressing the Shift key when pointing with the mouse changes the symbol to  and allows to change the right and left coordinate of the ROI symmetrically.

4 → Change ROI size.



5 → Change ROI bottom coordinates.

Pressing the Shift key when pointing with the mouse changes the symbol to  and allows to change the right and left coordinate of the ROI symmetrically.

6 → Change ROI horizontal coordinates.

To change the ROI, move the mouse cursor to an action point. At the correct position the mouse pointer changes its shape. Press the left mouse button and move the mouse with its left button always pressed. Release the left button when you arrive on the new position.

During the mouse points to the ROI and the left mouse button is pressed, successive pressing the right button allows to set:

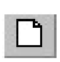
→ ROI width is equal to the frame width.

→ ROI height is equal to the frame height.

→ ROI width and height are equal to the initial rectangular area.

File Menu

New



This command creates an empty document and opens the corresponding FRAME window. The window name is Opto follow by a number. A FRAME allowing to display the real-time signal is created if the existing FRAMES only show documents from the disk.

Open

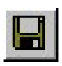
The command opens an existing document previously saved on disk. This command loads a frame file, a histogram file or a profile file. Selecting a file with the extension *.IMG will load a frame document previously saved under OptoAnalyse version 1.40 or before and containing pixel information with 16 bit format. This frame file contains the frame size, frame data in 16 bits per pixel and a comment text area. Selecting a file with the extension *.IMD will load a frame document previously saved under OptoAnalyse version 3.00 or later. This file contains pixel information with 32 bit format.

Shortcuts: Ctrl + O

Close

An open document is closed. If data contained in the document have been modified, the application asks you if you would like to save the current document.

Save



The command saves the current document as frame file on the disk. If the document hasn't been saved before, the application opens the common WINDOWS dialog box to input the filename. This frame file has the .IMD extension and can be read with the OptoAnalyse software. Details are given in the Annex B. The file contains the frame size and frame data in 32 bits per pixel format. Complementary data like calibration information, a comment text and all available setup information of the system during the acquisition are saved on a text file having the same name but the extension *.IMI.

Shortcuts: Ctrl + S

Save ROI as …

The content of the current ROI is saved as frame file on the disk with a new name. The ROI size has to be at least 10 x 10 pixel. The application opens the common WINDOWS dialog box to input the filename. It adds the .IMI extension. An additional text file with the extension *.IMD is saved and will contain complementary information.

Save As …

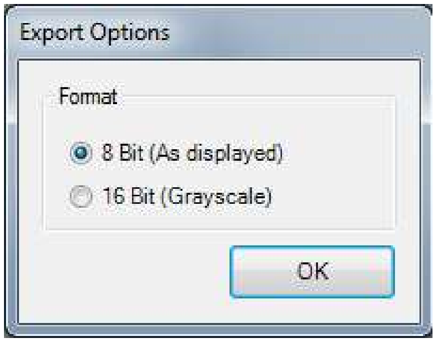
The current document is saved as frame file on the disk with a new name. The application opens the common WINDOWS dialog box to input the filename. It adds the .IMG extension.

Export

The command saves the current frame on the disk. Possible export formats are bitmap (.BMP), TIFF (.TIF), binary (.RAW) and ACSII (.ASC).

Selecting an export in bitmap format will result in saving the frame as it is displayed. So grey level adjustment and pseudo colour setup for the actual display have an impact on the data saved. The value of each pixel is converted into 8 bits. This format is useful for documentation purposes. Measurement data should not be saved in this format exclusively.

Selecting an export in TIFF format allows two options.



The 8 bit option will save the frame as it is displayed. So actual intensity and preudo color settings are considered. Measurement data should not be saved in this format exclusively. The 16 bit option will save integer values between 0 and 65535. Values below 1 will be set to 0 and values above 65535 are set 65535.

The binary format is a generic format and can be used with most third party image processing software. In this format, OptoAnalyse saves the frame without any header. Each pixel is coded in binary with a size of 16 bit in Intel format (LSB prior to MSB). The actual display setup does not have an impact on the data saved. Pixel values below 1 are set to 0 and values higher than 65535 are limited to this value.

In ASCII format, no header is saved. Intensity information of each pixel is coded in ASCII with decimal separator "." and 3 decimal digits. The tabulation character is used to separate values.

Example: pixel value = 102.1 → "1" "0" "2" "." "1" "0" "0" tab.

Import

The command allows reading of files in ASCII format. First intensity value is considered to correspond to the upper left pixel. Subsequent values have to be separated by the tabulator code (tab) and are considered to for the first horizontal image line ending with the LF CR sequence. Image size is therefore defined by the ASCII file structure. Each pixel value has to fit within the range of $-2.147 \cdot 10^6$ to $+2.147 \cdot 10^6$ with 0.001 precision. Decimal separator "." is used. The example below shows a 3 x 2 image.

"3" "5" "2" tab "3" "6" "9" "." "2" tab "3" "6" "4" "." "2" "8" "3" CR LF
"2" "8" "9" "." "3" "6" tab "3" "4" "0" "." "7" "7" "0" tab "3" "6" "4" "." "2" "8" CR LF

and the pixel intensities are converted to:

352	369.2	364.283
289.36	340.770	364.28

Print

The Print command opens the standard dialog box to print under WINDOWS. The grey levels of the printing frame are fitted to the displayed grey scale

Shortcuts: Ctrl + P

Print Preview

The command opens a window showing the screen preview of the printing page.

Print Setup

The opens the WINDOWS dialog box to setup the printer.

Recent Files

This list shows the last files opened or saved by the application.

Exit

The command closes the application.

Edit Menu

Copy Image

The command converts the entire image as it is displayed on the screen in Bitmap format and copies it to the clipboard.

Shortcuts: Ctrl + C

Copy ROI like a Bitmap

The view delimited by the ROI is converted to a Bitmap and is copied to the clipboard.

Copy ROI like an ASCII Text

The view delimited by the ROI is converted to an ASCII file and is copied to the clipboard.

ROI Menu

The ROI menu contains commands to manipulate the position and size of the ROI.

Copy

The command stores the coordinates of the current ROI temporally.

Paste

The Paste command reads the coordinates temporally stored with the Copy command and applies it to the current ROI.

Duplicate

This command reads the coordinates of the current ROI and applies them to all other open FRAME windows.

Shortcuts: Ctrl + D

Save as Default

The command stores the coordinates of the current ROI as default coordinates. The default coordinates are saved on the disk when the application is closed.

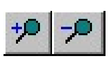
Apply Default ROI

Reads the default coordinates and applies them to the current ROI.

View Menu

These commands allow modifying the way how frames are displayed. Memory data remain unchanged.

Zoom



The command changes the frame magnification factor for display.

Zoom 4/1 Displays frame with zoom = 4

Zoom 2/1 Displays frame with zoom = 2

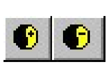
Zoom 1/1 Displays frame with zoom = 1 (one frame pixel -> one display pixel)

Zoom 1/2 Displays frame with zoom = 1/2

Zoom 1/4 Displays frame with zoom = 1/4

Shortcuts: Page Up → Zoom In
Page down → Zoom Out

Monochrome



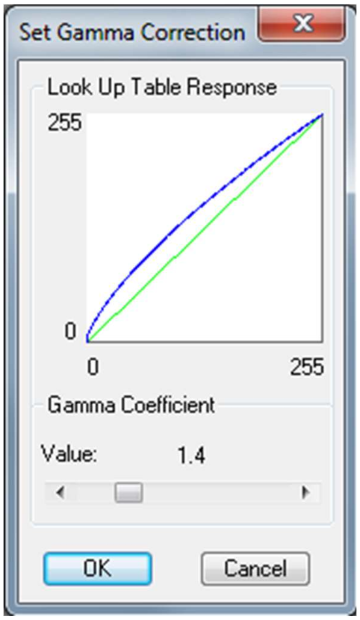
Loads a linear grey palette to display a monochrome frame with grey levels. The system displays 256 grey colours and uses a software barrel shifter to show 8 contiguous bits from the 16 bits intensity value of each pixel.

Shortcuts: activate → Alt + M

lower levels +
higher levels -

Gamma Correction

Opens a dialog box named Set Gamma Correction. This dialog box sets the grey palette using a gamma correction for the display.

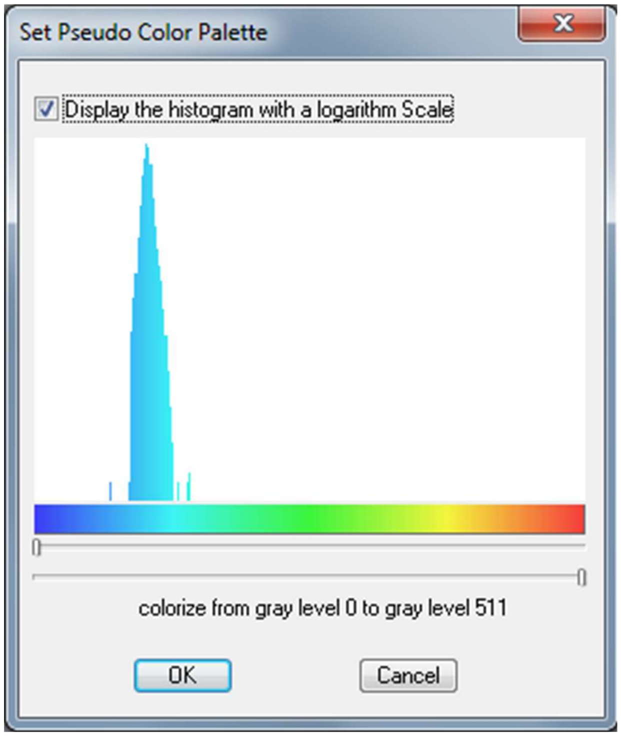


The dialog box shows the look-up table. The green line shows the linear law and the blue line shows the gamma corrected response. With a gamma coefficient greater than 1.0, the low levels are more amplified than the higher levels. A gamma coefficient of 1.0 corresponds to the linear response. With a gamma coefficient of less than 1.0, the higher levels are more amplified than the lower levels. The horizontal scrolling bar changes the value used for gamma correction. The gamma coefficient can be set between the values 0.5 to 5.0.

Shortcuts: Alt + G

Pseudo colors

Opens a dialog box named Set Pseudo Colour Palette. This allows setting the correspondence between the intensity values and the colour display. The dialog box shows the histogram of the active frame with coloured intensities values. The horizontal axis represents the intensity levels between the minimal and maximal intensities corresponding to the actual display setting. The vertical axis represents the occurrence of the corresponding intensity levels. Checking the box named **Display the histogram with a logarithm Scale** changes the vertical scale.



The colour palette is displayed on the bottom side of the histogram. Two horizontal scrolling bars select the first and the last levels affected by the coding.

Shortcuts: Alt + C

Toolbar

The Toolbar command shows or hides the toolbar

Status bar

The command shows or hides status bar.

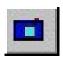
Acquisition Menu

Real Time

The command starts real-time display. If the real-time is stopped, the frame on the screen shows the last frame. The real time command is not available if a FRAME window showing the frame from the disk is active or if no readout camera is available. Use the File -> New command or connect the readout camera to allow real time display. Display update might be slower than frame rate provided by the camera. Real time display is not updated if the camera is operated in trigger mode and no trigger signal is detected.

Shortcuts: Alt + R

Snapshot



This command grabs one frame.

Shortcuts: Alt + S

Single Acquisition

The command executes the acquisition of one single frame using the parameters set in the Setup/Acquisition menu. Corrections as defined in this menu are applied.

Shortcuts: Ctrl + Alt + S

Acquisition

The command executes a frame acquisition using the parameters set in the *Setup -> Acquisition* menu. The maximum rate depends on the readout camera setup, the acquisition mode setup and the available performance of the PC. The more pixel need to be processed and the more correction features are activated the lower the frame rate. Increasing the integration time of the readout camera might be helpful to avoid the loss of image date. To get a frame rate measurement, the Sequence command can be used. Please refer to the sequence command for details.

When the accumulation starts, the system reduces the zoom factor to 1/1 if it was higher in order to optimize the frame rate. The frame display is always refreshed after 5 frames. During accumulation the + and – keys still allow to setup the display intensity.

Shortcuts: Start → Alt + A
Cancel → Esc

Sequence

The command executes multiple frame acquisitions using the timing and data parameters set in the *Setup -> Acquisition Sequence* menu. The same process as described with the Acquisition command is executed. The status bar indicates the progress of the sequence acquisition.

Shortcuts: Start → Alt + Q
Cancel → Esc

ROI Sampling

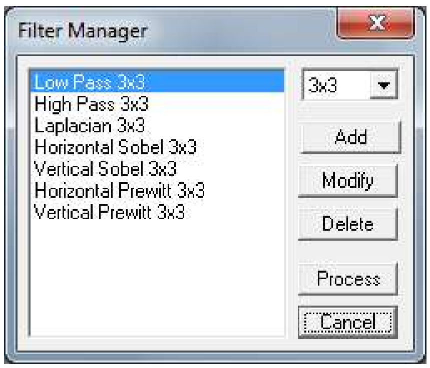
This command starts acquisition in ROI Sampling mode. Details for this mode of acquisition are given in the annex. Setup parameters of ROI Sampling mode are found on the *Setup → ROI Sampling* menu.

Shortcuts: none

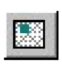
Processing Menu

Filter

The command opens a dialog box named Filter Manager used to select the a filter, to run a specific filter, to add filters with a size of 3x3 to 15x15, to delete a filter or to modify a filter. To select one of these filters, just click on it and select the filter dimensions.



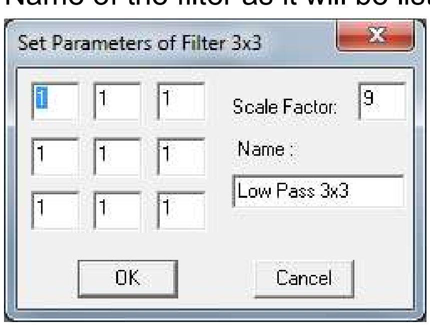
Shortcut: Shift + F



To apply a filter to the image or the ROI, the filter needs to be selected and the **Process** bottom has to be activated. The shortcut will apply the last filter selected again.

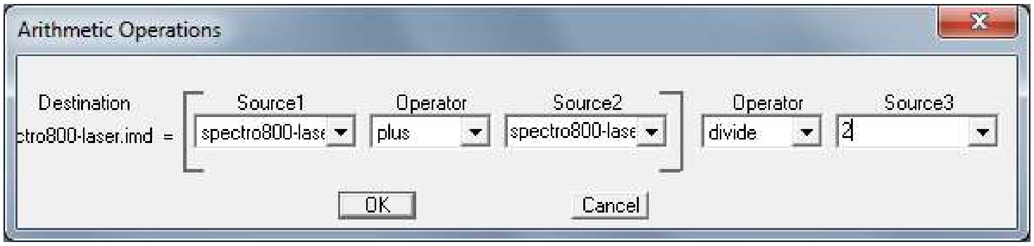
Shortcut: Alt + F

A new filter can be added or the selected filter can be modified by using the **Add** and **Modify** commands. If the 3x3 filter dimension is selected, the dialog box below appears. It allows to edit the filter parameters. After the filter operation the Scale Factor is used to divide the resulted value. The Name of the filter as it will be listed can be defined.



Arithmetic

This command opens the dialog box below. The current frame is called destination frame and will contain the resulting data. The software performs first the arithmetic operation between Source1 and Source2, and then the result is combined with Source3. The operations are executed pixel by pixel.



Operators used between two sources A and B are:

plus	Source1 **+** Source2
minus	Source1 **-** Source2
multiply	Source1 × by Source2
divide	Source1 **/** Source2
min is	**Minimum** of Source1 and Source2
max is	**Maximum** of Source1 and Source2

Source1 allows the selection of the first operand and **Source2** allows the selection of the second operand. The lists show the names of frames actually open within the OptoAnalyse software. A numerical constant can be entered as Source2.

Source3 allows the selection of the third operand. The same possibilities as described with Source2 are available. If only two operands are needed, the third operand can be set 0 and the operation plus should be activated.

Shortcut: Shift + O

Mean Value

The command processes pixels intensities to calculate the mean value and standard deviation of all pixels inside the ROI. If no ROI is defined the whole active frame is processed. The results are displayed on the left text field in the status bar.

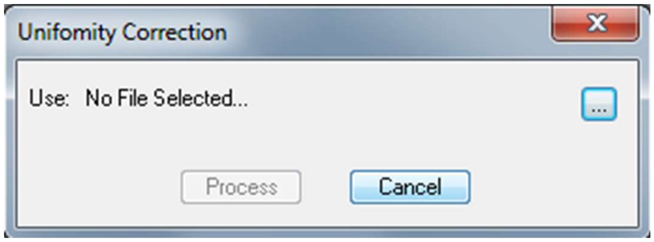
Shortcut: Shift + M

Uniformity Correction

The uniformity correction can be used to correct frames opened from the disk or after their acquisition. The correction is a pixel to pixel operation dividing the current frame by the uniformity correction frame and multiplying by the mean value of the uniformity frame. The total image brightness remains constant.

$$CorrecteFrame(x,y) = \frac{CurrentFrame(x,y)}{UniformityFrame(x,y)} \cdot \overline{UniformityFrame(x,y)}$$

The Uniformity Correction command opens a dialog box below.



Shortcuts: Shift + U

The text line **Use** shows the current file used for uniformity correction. The **Process** button executes the correction of the current frame. The **Select a File** button  allows selecting the name of the uniformity frame for the correction. The **Process** button executes the correction of the current frame.

Remark: The corresponding feature in the acquisition setup box can be used alternatively if the correction has to be done during or immediately after the acquisition.

Geometrical Correction

Different corrections explained and defined in the Setup/Geometrical Correction menu are executed.
This correction can be used to process images that had been acquired without the corresponding correction. This is the case when no geometrical correction had been defined at the time the acquisition took place. Once the correction is done, it will not be executed a second time.

Please note that only images where information about sweep unit and selected sweep speed are available in the .IMI file can be corrected. These information are saved automatically when the image is saved EXCEPT in case the steak camera had not been connected to the PC and controlled by the OptoAnalyse software to the during acquisition.

Shortcuts: Shift + Q

Drift Correction

The command activates the drift correction with the setup defined in the Setup/Correction/Drift dialog box. Drift correction is only available when the readout camera is coupled to the OPTOSCOPE streak camera and a synchroscan sweep unit (FSSUx, or SSUxx-xx) is installed. For more information see drift correction setup in the corresponding menu.

Shortcuts: Shift + D

Jitter Correction

The command activates the jitter correction with the setup defined in the Setup->Correction->Jitter dialog box. For more information see drift correction setup in the corresponding menu.

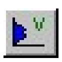
Shortcuts: Shift + J

Horizontal Profile

The command opens a PROFILE window. The profile along the horizontal axis is displayed. If a ROI is defined in the current frame, the histogram is limited to the ROI. For more information, see *Profile Window* chapter.

Shortcuts: Shift + H

Vertical Profile



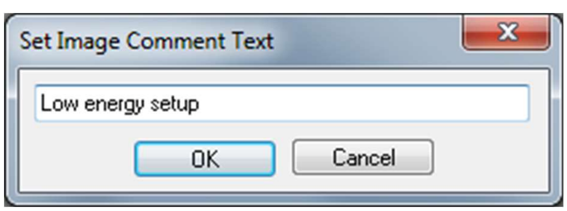
The command opens a PROFILE window. The profile along the vertical axis is displayed. If a ROI is defined in the current frame, the histogram is limited to the ROI. For more information, see *Profile Window* chapter.

Shortcuts: Shift + V

Parameter Menu

Image Comment

Frame Comment command opens a dialog box below and allows to enter a comment related to the current image. The comment is saved in the Optronis frame file (.IMI). This text appears when a frame or profile is printed.

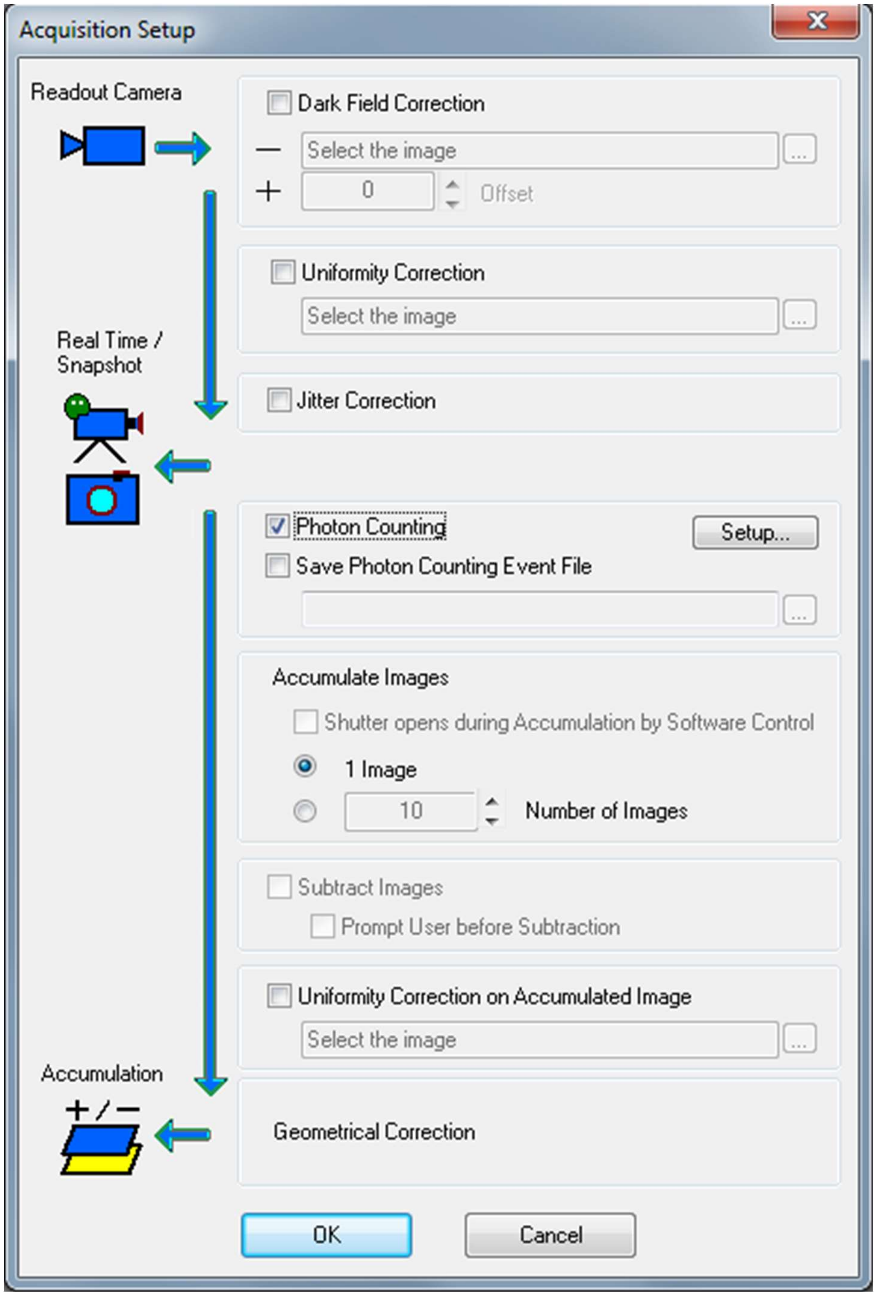


Shortcuts: Shift + I

Setup Menu

Acquisition

The command is used to set the acquisition parameters shown in the dialog box. This includes correction procedures, the photon counting mode and the number of frames to be accumulated. Together with the setup of the readout camera all parameters required to capture the readout of the streak camera are defined.



The data of the readout camera are processed in a specific order before the resulting frame is displayed and ready for storage. This order is represented in the dialog box.

Remark: The processing speed depends upon the number of selected processing steps. For a first evaluation of the maximum frame rate, the test feature in the Setup/Sequence box can be used.

For real Time and Snapshot acquisition mode, dark field correction, uniformity correction and jitter correction can be applied before an image is displayed.

The **Dark Filed Correction** button selects the dark filed correction of each frame acquired by the camera. The intensity value of each pixel of the selected file is subtracted from the acquired frame. For particular applications a constant value can be added but would typically not be needed.

The **Uniformity Correction** button activates a uniformity correction for each frame. The operation below is executed prior to any further processing of the frame. This option needs to be activated if a uniformity correction has to be performed prior to the Jitter Correction.

The **Jitter Correction** button activates the jitter correction and is identical to the activation as described in the Jitter Correction setup box.

The **Photon Counting** button selects the acquisition in the photon counting mode. In this mode, there is a processing of each frame before adding it to the accumulated frame. See the **Photon Detection** command to have a detailed description of the photon counting mode.

The **Save Photon Counting Event File** button is used to define the name of a file that will contain a list photon events. The file will show the positions of all single photon event detected. File format is given in the annex.

The **Accumulation** filed defines the number of frames to be added. Additionally, the reset of the frame memory and the activation of the internal electro-mechanical shutter can be controlled.

The **Reset Memory before Accumulation** sets the memory value for each pixel to 0 before any frame acquisition starts. This option should be active for all typical acquisitions. Only for special conditions it might be necessary to keep the previous memory content and to add the new frames without memory reset.

The **Shutter opens during Accumulation by Software Control** checkbox indicates that the internal shutter is activated under software control. The shutter is opened 20 ms before the accumulation or the photon counting acquisition. The shutter is closed at the end of the accumulation and at least 20 ms before the subtraction phase (if activated). If this box is not active, the OptoAnalyse software does not change the shutter status. To allow the shutter control, the PC has to be connected to the streak camera. If this connection is not available, the checkbox cannot be activated and the shutter is not controlled by software.

The Accumulation can be stopped in different ways:

- By selecting **1 Image** if only a single frame has to be acquired. This mode is identical to the Single Acquisition in the Acquisition menu.
- By defining a fixed **Number of Images**

The **Subtract Images** box allows subtracting the same number of frames. For photon counting acquisition modes, this option cannot be selected. In case the jitter correction had been activated during the accumulation, each dark frame is shifted accordingly to the corresponding frame during accumulation. Details about this processing are described in the jitter correction section.

If **Prompt User before Subtract** is activated, the application waits between the accumulation and the subtraction phase until the user acknowledges to continue. If it is not checked, the application does not ask for user confirmation between the accumulation and the subtraction phase.

The **Uniformity Correction on Accumulated Image** button activates a uniformity correction after the acquisition has been completed. The operation below is executed. This option can not be selected if already an individual uniformity correction is activated.

$$CorrecteFrame(x,y) = \frac{CurrentFrame(x,y)}{UniformityFrame(x,y)} \cdot \overline{UniformityFrame(x,y)}$$

Shortcuts: Shift + A

The **Geometrical Correction** is a set of different correction processes including distortion correction, sweep speed linearity correction and transit time distortion correction. Details of these corrections are described in the Setup/Geometrical Correction menu.

ROI Sampling

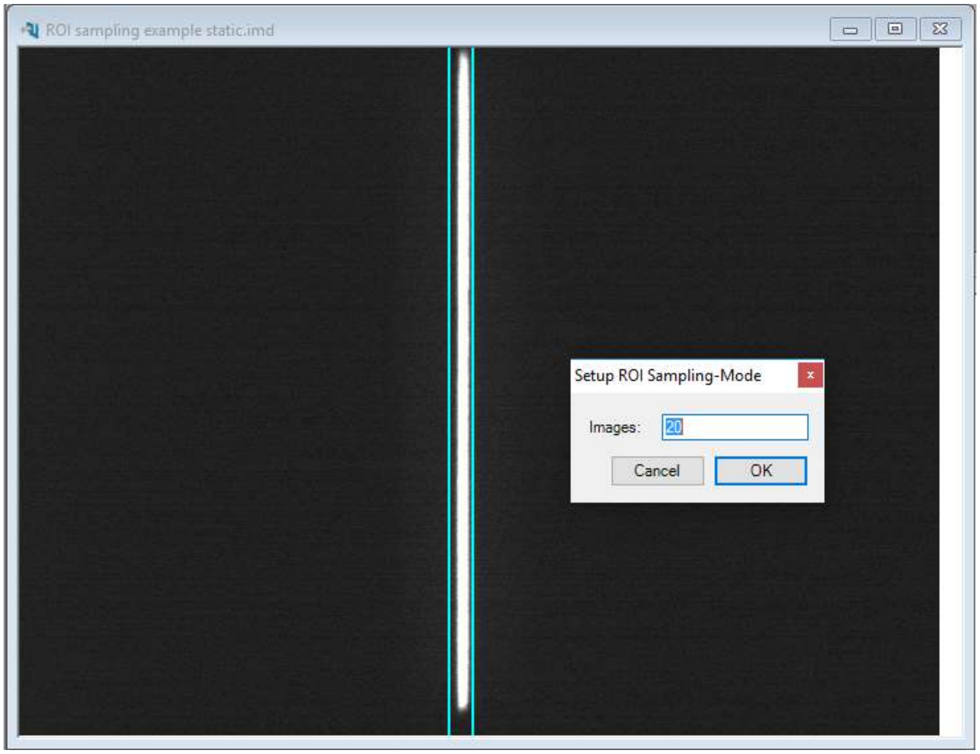
Parameters for ROI Sampling are set on this menu. Example below is given for *Display Orientation* set to *0°* on the *Setup → Readout Camera* menu.

On the image a blue ROI appears according to the figure below. Its height is equal to the image height. Horizontal width needs to be adjusted in order to include the complete signal. Handling for width adjustment of this sampling ROI is similar to the handling of any other ROI.

Additionally, the number of images to be acquired has to be adjusted. The minimum number is 2. Maximal number is equal to the total number of horizontal pixels on the image.

In ROI sampling mode time scale is based on total time from start of acquiring the first image until end of last image captured. As this measurement method is subject to some uncertainty, minor variations from one to the next measurement might be encountered. This can be avoided by using external readout camera triggering and setting the corresponding time per pixel manually.

$$Time\ per\ Pixel = \frac{1/(Trigger\ Frequency)}{Integer\left(\frac{Total\ Number\ of\ Pixel}{Number\ of Samples}\right)}$$



Correction

The **Correction** command opens a dialog box named Correction Setup used to set the drift and jitter correction parameters.

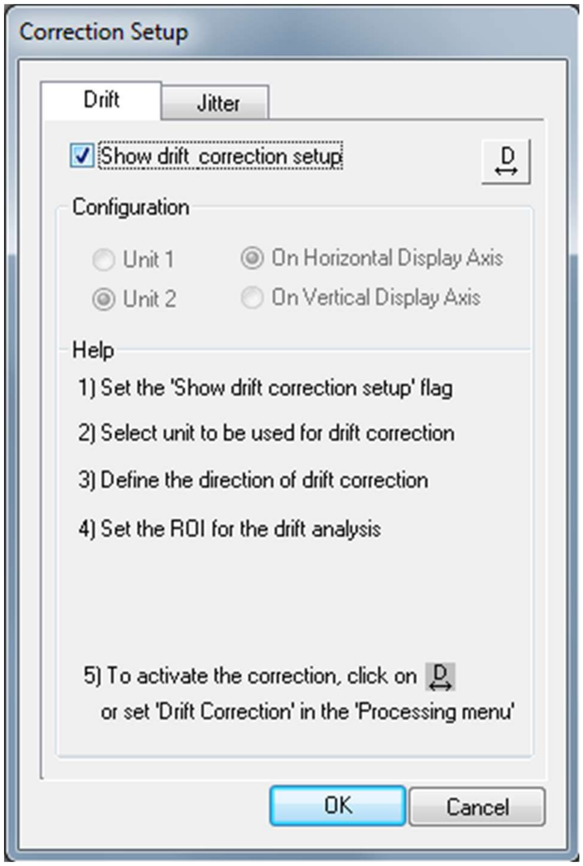
Shortcuts: Shift + E

Drift correction

Principe of Operation: The Drift Correction is a software regulation process that compensates for long term drift of the laser system and the streak camera when a synchroscan sweep unit (FSSUx or SSUxx-xx) is used. A RS-232 link and a mark (laser pulse, streak trace) giving a reference are required. For ease of use, Optronis provides a specific input optics with marker input.

When starting an acquisition (realtime or accumulation mode), the first captured frame is used to determine the center of gravity (COG) of the mark inside a predefined ROI. That COG is used as the reference COG. Every 500ms, the application calculates the new center of gravity (COG) of the mark inside that ROI and adjusts the synchroscan unit phase delay to stabilize the reference mark to the reference COG.

The first sub dialog box named 'Drift' allows to set the parameters for the Drift Correction. This menu is only available if the readout camera is coupled to the OPTOSCOPE streak camera and the RS-232 link is active.



First Step: Activate the ‘Show drift correction setup’ box. A green ROI will appear in the frame display (the drift and jitter correction use the same ROI).

Second Step: Select the unit (unit 1 or 2) and the direction (horizontal or vertical) for the drift correction. The software automatically detects the synchroscan unit(s) connected to the streak camera.

Third Step: Position the green ROI to the reference mark. All the mark analysis and COG calculation are made inside that ROI. To place the ROI, take care of the **reference mark validity criterion**.

Fourth Step: Activate the drift correction by pushing the ‘D’ button in the dialog box or in the OptoAnalyse toolbar.

Fifth Step: This step starts with the activation of the drift correction in real time mode or with the start of the acquisition. In a first phase the acquired frames are used to determine the center of gravity (COG) of the mark inside the green ROI. This COG is used as the reference COG. The application then achieves an analysis of the reference mark (width, signal to noise ratio measurement, distance to ROI borders, ...). If the reference mark complies with the **reference mark validity criterion** shown below, sixth phase begins. If not, drift correction is aborted.

Sixth Step: Acquisition starts. Every 500ms, the application analyzes the reference mark in the green ROI and calculates the new COG. If the mark complies with the **reference mark validity criterion**, the application adjusts the synchroscan unit phase delay to shift the reference mark at the reference COG. If not, drift correction is not stopped but paused until the reference mark complies again with the criterion.

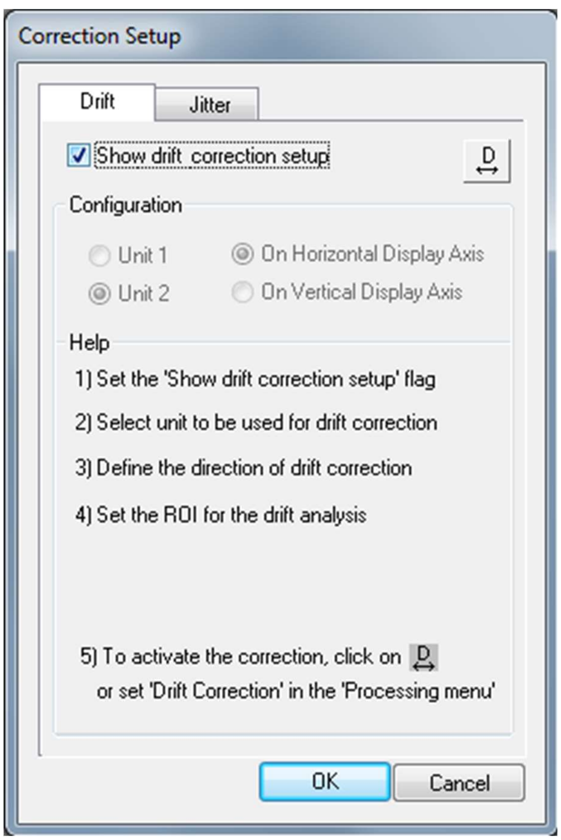
Jitter correction

Principe of Operation: The Jitter Correction is a software process that compensates for the jitter of the streak camera deflection from frame to frame. A mark (laser pulse, streak trace) giving a reference is required for that regulation.

When starting an acquisition (realtime or accumulation mode), the first captured frame is used to determine the center of gravity (COG) of the reference mark inside a predefined ROI. That COG is used as the reference COG. For new frames, the COG of the mark inside that ROI is calculated. Prior to each memory accumulation, each frame is shifted in order to obtain a frame with the same COG as the reference COG. The horizontal and vertical shift is written into a log file.

If the **subtraction option** is activated, the individual dark frames are shifted corresponding to the shift data in the log file before they are subtracted. If for example the first frame is shifted by 2 pixels to the right and the second frame is shifted 1 pixel to the left, then the first dark frame will be shifted 2 pixels to the right before its subtraction and the second frame will be shifted 1 pixel to the left before subtraction.

The second sub dialog box named ‘Jitter’ allows to set the parameters for the Jitter Correction.



First Step: Activate the ‘Show jitter correction setup’ box. A green ROI will appear in the frame display (the drift and jitter correction use the same ROI).

Second Step: Select the directions (horizontal and/or vertical) for the jitter correction. Jitter correction can be made in horizontal, vertical or both directions.

Third Step: Adjust the green ROI around the reference mark. All the mark analysis is made inside that ROI. To place the ROI, take care of the **reference mark validity criterion** shown below.

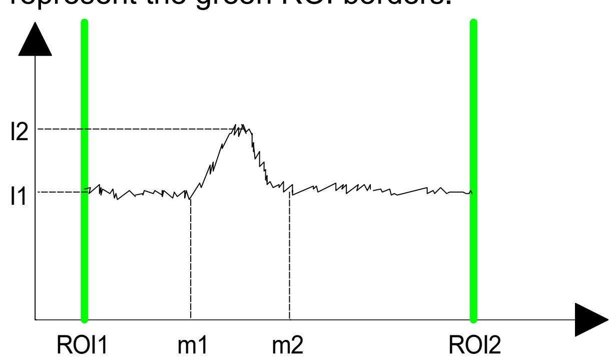
Fourth Step: Activate the jitter correction by pushing the ‘J’ button in the dialog box or in the OptoAnalyse toolbar.

Fifth Step: This step starts with the activation of the jitter correction in real time mode or with the start of the acquisition. First the captured frame is used to determine the center of gravity (COG) of the mark inside the green ROI. That COG is used as the reference COG. Then the application analyses the reference mark behaviour (width, signal to noise ratio measurement, distance to ROI borders, ...). If the reference mark complies with the **reference mark validity criterion** shown below, the sixth step can start.. If not, jitter correction is aborted.

Sixth Step: Acquisition starts. For each frame, the application analyzes the reference mark in the green ROI and calculates its COG. If the mark complies with the **reference mark validity criterion**, the application shifts the frame in order to shift the actual reference mark to the position of the reference COG. If not, jitter correction is not stopped but paused until the reference mark complies again with the criterion.

Reference mark validity criterion

The reference mark must present a good signal to noise ratio to allow a reliable drift and/or jitter correction. With pour signal quality, the correction process is disactivated. The validity criterion whether the correction is activ or not is described below. Inside the green ROI, a profile (horizontal or vertical, depending on the correction setup) is calculated. The green lines represent the green ROI borders.



The application calculates the values m1, m2, I1, I2 and the standard deviation s1 (from ROI1 to m1) and s2 (from m2 to ROI2). If (I2-I1) is less than 10 times (s1+s2)/2, the mark is not considered as a reference mark. The reference mark must not be too close to the ROI border. The conditions below should be met.

m1-ROI1 > m2-m1

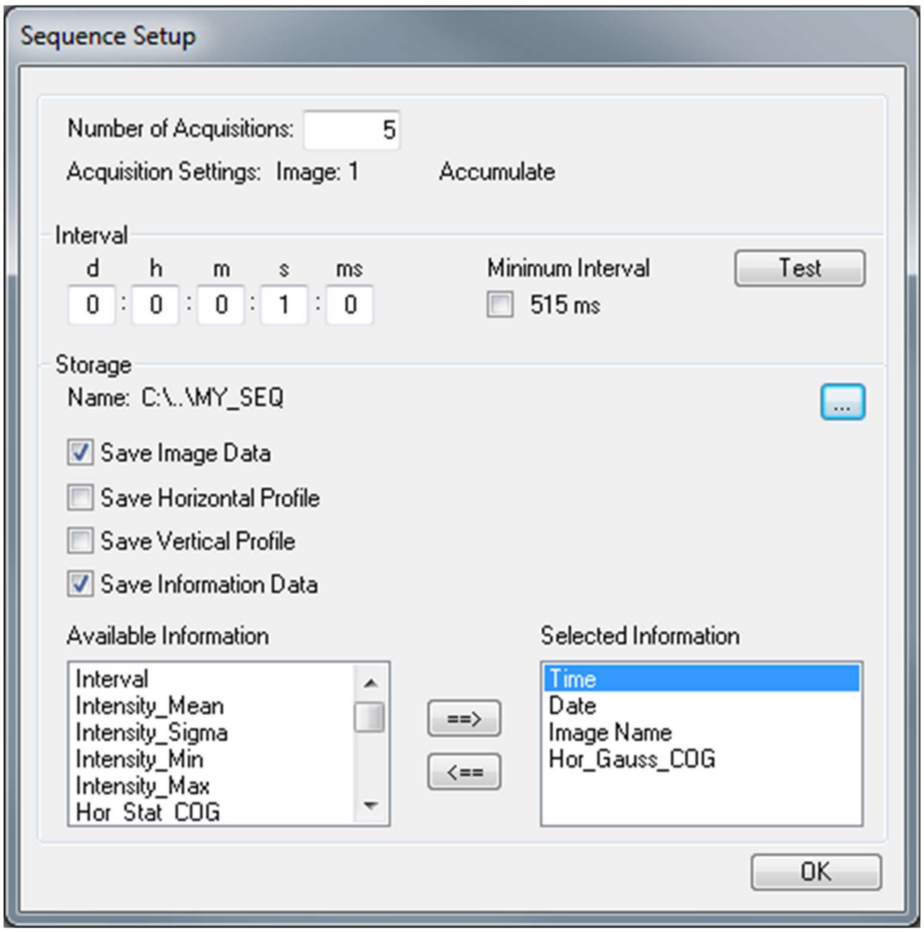
ROI2-m2 > m2-m1

For drift correction only, the synchroscan phase delay must stay between 1% and 99%. If all these points are verified, the reference mark is considered as complied.

Sequence

The command is used to repeat acquisitions at fixed time periods. Each acquisition starts with the initiation of the readout camera. This might require some time and therefore extend the minimum interval the acquisitions can be captured.

Shortcuts: Shift + S



The **Number of Acquisitions** defines the number of repeated acquisitions for each sequence. The system indicates the maximum number of frames that could be saved on the current disk.

The **Select a File** command is used to select the path and the base name of the sequence. The base name is limited to four characters. This command opens the common dialog box to select a file. The text below the **Path and File Name** shows the current path name of the sequence.

The **Day**, **Hour, Minute, Sec** and **ms values** define the delay for the start of the next acquisition. Selecting **Acquired with minimum interval** automatically starts the next acquisition at the end of the proceeding acquisition.

If the **Test** button is pressed, the software performs the acquisition as defined in the setup and saves the files temporally in order to determine the time needed for this process. The calculated value can be considered as a first evaluation but not as guaranteed value.

The **Save Image Data** needs to be activated if the acquired image has to be saved.

The **Save Information Data** can be activated if particular data calculated from the acquired image have to be written to a report file. The values are calculated based on the entire image. In case a ROI is defined only the partial image defined by the ROI is considered.

The list in the **Data Available** box shows the functions available. Pointing with the mouse allows selecting the function. The => button moves them to the **Data in file** box and the <= button removes them. The description below is based on an image with a number of *i* horizontal pixels and *j* vertical pixels. The intensity of each pixel is $I_{i,j}$.

Date — Date when the frame is acquired

Time — Time when the frame is acquired

Interval — Interval in ms since the last acquisition started.

Image Name — Name of the acquired image

Intensity_Mean — Calculates the mean of all intensity values.

$$Intensity\_Mean = \frac{\sum_{x=0..i-1,y=0..j-1} I_{x,y}}{i \cdot j}$$

Intensity_Sigma — Calculates the sigma (rms) of all intensity values.

$$Intensity\_Sigma = \left[\frac{1}{i \cdot j} \cdot \sum_{x=0..i-1,y=0..j-1} (I_{x,y} - Intensity\_Mean)^2\right]^{\frac{1}{2}}$$

Intensity_Min — Determines the minimum intensity value.

$$Intensity\_Min = Minimum\ (I_{x,y})$$

Intensity_Max — Determines the maximum intensity value

$$Intensity\_Max = Maximum\ (I_{x,y})$$

Hor_Stat_COG — Calculates the centre of gravity (COG) along the horizontal axis for a profile

$$PH_x = \sum_{y=0..j-1} I_{x,y}$$ (horizontal profile)

$$Hor\_Stat\_COG = \frac{\sum_{x=0..i-1} x \cdot PH_x}{\sum_{x=0..i-1} PH_x}$$

Hor_Stat_FWHM	Calculates the full width at half maximum (FWHM) of a horizontal profile. See 'Measure Menus' for details of FWHM algorithm.
Hor_Stat_Max	Calculates the maximum intensity value of a horizontal profile. $$Hor\_Stat\_Max = Maximum\left(\sum_{y=0..j-1} I_{x,y}\right)$$
Hor_Gauss_COG	The horizontal profile is fitted by a Gaussian function. The COG of this fitting function is calculated.
Hor_Gauss_FWHM	The horizontal profile is fitted by a Gaussian function. The FWHM of this fitting function is calculated.
Hor_Gauss_Max	The horizontal profile is fitted by a Gaussian function. The maximum value of the gauss function is calculated.
Hor_ExpD_Risetime	The horizontal profile is fitted by the first half of a Gaussian function and a decreasing exponential function. The rise time value represent the 10% to 90% rise time of the Gaussian rising edge.
Hor_ExpD_Lifetime	The horizontal profile is fitted by the first half of a Gaussian function and a decreasing exponential function. The lifetime value is the mean lifetime of the exponential part of the fitting.
Hor_ExpD_Decay_Start	The horizontal profile is fitted by the first half of a Gaussian function and a decreasing exponential function. The position of the maximum value of the fitting curve is calculated.
Hor_ExpD_Max	The horizontal profile is fitted by the first half of a Gaussian function and a decreasing exponential function. The maximum value of the fitting curve is calculated.
Ver_Stat_COG	Calculates the centre of gravity (COG) along the vertical axis for a portion

$$PV_y = \sum_{x=0..i-1} I_{x,y}$$ (vertical profile)

$$Ver\_Stat\_COG = \frac{\sum_{y=0..j-1} y \cdot PV_y}{\sum_{y=0..j-1} PV_y}$$

Ver_Stat_FWHM — Calculates the full width at half maximum (FWHM) of a vertical profile. See 'Measure Menus' for details of FWHM algorithm.

Ver_Stat_Max — Calculates the maximum intensity value of a vertical profile.

$$Ver\_Stat\_Max = Maximum\left(\sum_{x=0..i-1} I_{x,y}\right)$$

Ver_Gauss_COG — The vertical profile is fitted by a Gaussian function. The COG of this fitting function is calculated.

Ver_Gauss_FWHM — The vertical profile is fitted by a Gaussian function. The FWHM of this fitting function is calculated.

Ver_Gauss_Max — The vertical profile is fitted by a Gaussian function. The maximum value of the Gaussian function is calculated.

Ver_ExpD_Risetime — The vertical profile is fitted by the first half of a Gaussian function and a decreasing exponential function. The rise time value represent the 10% to 90% rise time of the Gaussian rising edge.

Ver _ExpD_Lifetime — The vertical profile is fitted by the first half of a Gaussian function and a decreasing exponential function. The lifetime value is the mean lifetime of the exponential part of the fitting.

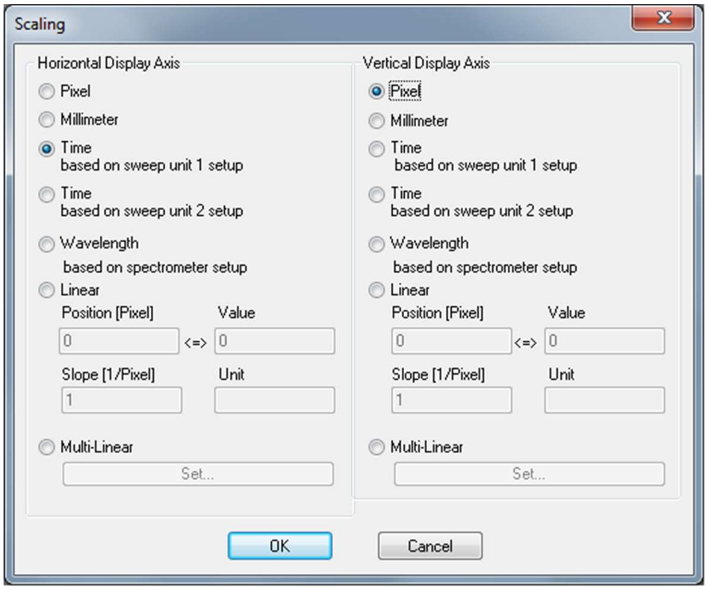
Ver_ExpD_Decay_Start — The vertical profile is fitted by the first half of a Gaussian function and a decreasing exponential function. The position of the maximum value of the fitting curve is calculated.

Ver_ExpD_Max — The vertical profile is fitted by the first half of a Gaussian function and a decreasing exponential function. The maximum value of the fitting curve is calculated.

Scaling

Scaling describes the conversion process from pixel coordinates to measurement values. So each pixel position in horizontal or vertical dimension can be related to a measurement value.

Shortcut: Alt + T



Pixel

In order to display pixel coordinates this option needs to be activated.

Millimeter

Dimensions referred to the readout camera object plane are shown. This plane is identical to the output of the streak camera. Dimensions are calculated by multiplying the pixel number by the pixel size adjusted on the readout camera setup box.

Time - based on sweep unit 1 setup

This feature is available if the PC is connected to the OPTOSCOPE streak camera and the software has access camera parameters. The actual sweep speed is read and combined with the pixel size of the readout camera to calculate the correct time scale.

Relation between display axis and sweep units can be selected individually. This depends upon physical readout camera orientation and software readout display setup (SETUP/READOUT CAMERA menu) for image rotation and image flip. Optronis generally proposes to install the readout camera with physical 90° rotation and 0° software rotation without image flips. The resulting correspondence is:

Horizontal Display Axis ⇔ Time - based on sweep unit 1 setup

The **Vertical Display Axis** might be used for timing information in case a second sweep unit (example TSU21-10 or TSU22-10) is used. Second sweep unit:

Vertical Display Axis ⬄ Time - based on sweep unit 2 setup

The Pixel Size value indicated with the setup of the readout camera is used to convert the pixel number to the dimension in mm.

Remark: The reading of the sweep speed is executed continuously during real-time display and at the start of an acquisition. Therefore, sweep speed should not be modified during an ongoing acquisition.

Wavelength based on spectrometer setup

If a spectrometer is installed in front of the streak camera it is possible to calculate wavelength. For typical configurations the vertical display axis is related to wavelength information.

Vertical Display Axis ⬄ Wavelength based on spectrometer setup

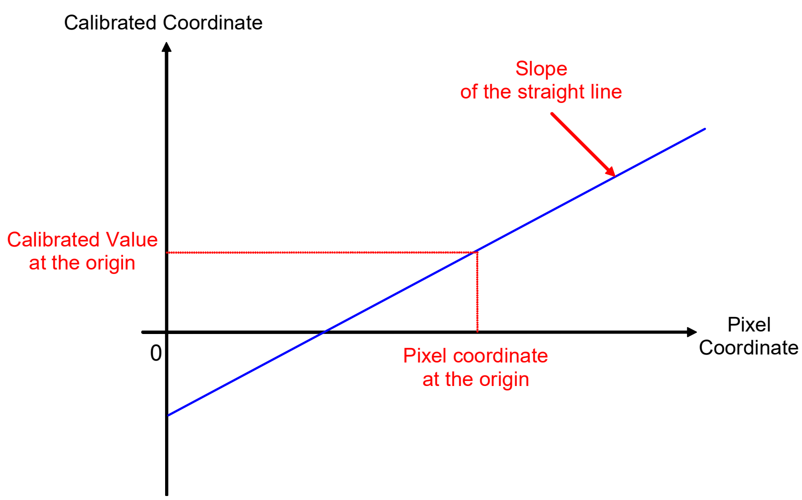
If the spectrometer is controlled by the PC the actual spectrometer setting is used. In case the spectrometer is not controlled by the PC for example because it is controlled by a particular software or it has no PC compatible interface, the parameters set on the *Setup/Spectrometer* box are used.

Remark:

Whether the *Horizontal Display Axis* or the *Vertical Display Axis* can be used for wavelength calibration depends on the *Wavelength Axis* definition on the *Parameters Configuration* box in the SETUP/SPECTROMETER menu.

Linear

Any linear relation between pixel position and calibrated value can be defined. First the position on the readout camera where a known value can be specified has to be entered. So the position [pixel] with its value has to be defined. The slope parameter allows entering the gradient of the calibrated value where the unit parameter defined the displayed unit.

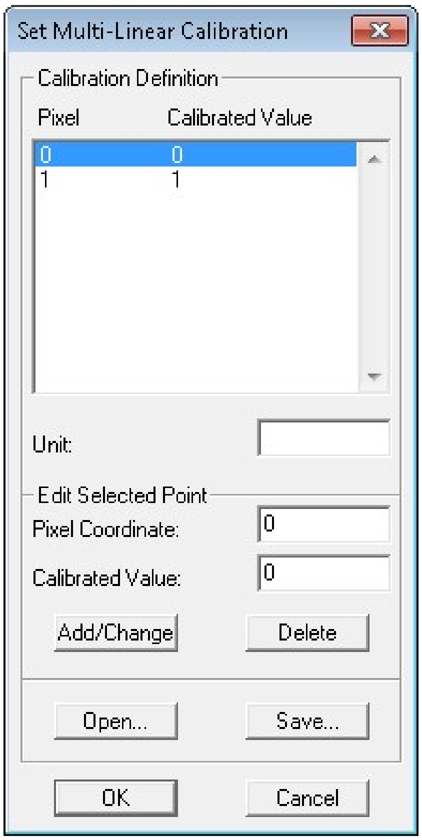


Example: At screen position 240 pixel the time should be zero and the total horizontal screen having 1392 pixel corresponds to a time base of 13.92ns. Consequently these parameters have to be entered:

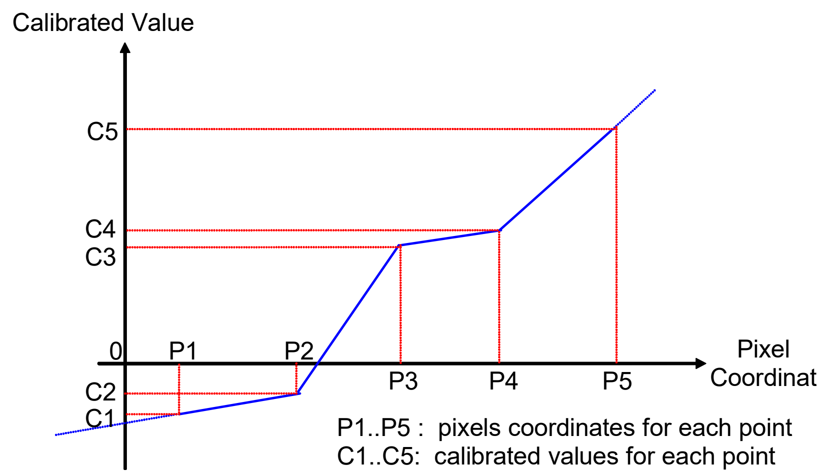
Position [Pixel]	=	240	Value	=	0
Slope [1/Pixel]	=	0.01	Unit	=	ns

Multi-Linear

The Multi-Linear feature allows separating the screen into different segments having different slopes. Each segment is defined by two pixel coordinates. To calculate a calibrated value, the system determines the segment containing the pixel value and calculates the calibrated value by linear interpolation. Linear extrapolation is applied for pixel values outside the defined segments. With *Set* the following dialog box opens.



The dialog box contains a list box where **Pixel** values and the corresponding **Calibrated** values are shown. To add a new pair of points or replace an older one, a **Pixel Coordinate** and a **Calibrated Value** has to be entered and the **Add/Change** button has to be activated. To delete a pair of points, the pair has to be selected and then the **Delete** button has to be activated. The edit box named **Unit** is used to enter a string of characters. This string is displayed after the value of the calibrated coordinate.



Open

The command loads an existing calibration. The calibration is available as disk file with the .SCL extension. This command opens the common windows dialog box to select a file.

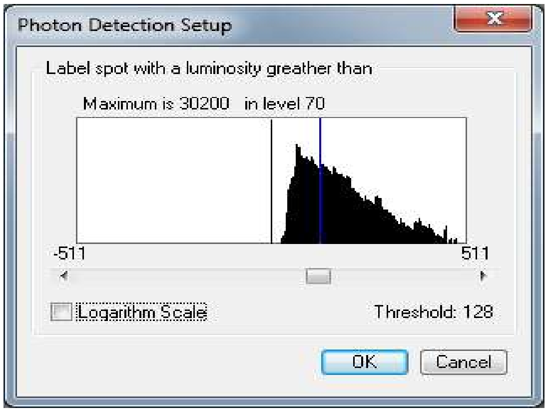
Save

The command saves the current calibration for the horizontal or vertical axis to the disk. If the document has not been saved before, the application opens the common windows dialog box to input the filename. The Calibration file has the .SCL extension.

Photon Detection

This mode is useful when working at low light level. In this mode, only a limited number of photons are detected at each frame. If the photons can be seen as single events, it is possible to count them individually instead of accumulating them in an analogue frame. Therefore only frame areas with intensities higher than a detection level fixed by the user are processed. The centre of gravity in this area represents the coordinates of a single photon impact. In the resulting frame, the pixel at the same coordinates is increased by one. This method allows the reduction of the readout noise of the readout camera and also the photo-cathode noise of the frame intensities if the system is used with the OPTOSCOPE streak camera.

Photon Counting Threshold command opens a dialog box named Photon Detection Setup to change the detection level used in photon counting mode.



The Graphic area in the dialog box displays the luminosity histogram of all pixels. The threshold level is displayed using a vertical blue line.

The check box named **Logarithm Scale** controls the display of the histogram with a logarithmic scale when checked or a linear scale otherwise.

The detection level setup has to consider the readout noise of the camera and the detection efficiency of the system. The detection level should be set at the readout camera offset level plus 3 to 5 times the rms readout noise. If for example a frame is analysed with the mean value command, the mean value might be 70 and the standard deviation 11. Then the detection level should be set to at least 103 to 125.

Hint: In case the dark image of the readout camera is not perfect flat, a dark image can be acquired as reference and subtracted from the actual image prior to proceed with photon counting. The detection level has to be modified accordingly.

Geometrical Correction

A set of different correction processes can be defined in order to correct the image for geometrical errors caused by image distortion, sweep speed non-linearity or transit time distortion. The geometrical correction is done by affecting the image content. The corrected image is saved with the information whether a correction had been done and thus effecting the same correction multiple times is prevented.

Each type of error has its own menu. The corrections are executed automatically after each acquisition or if the command Geometrical Correction is activated on the Processing menu. During real time operation or snap-shot acquisition, no correction is made.

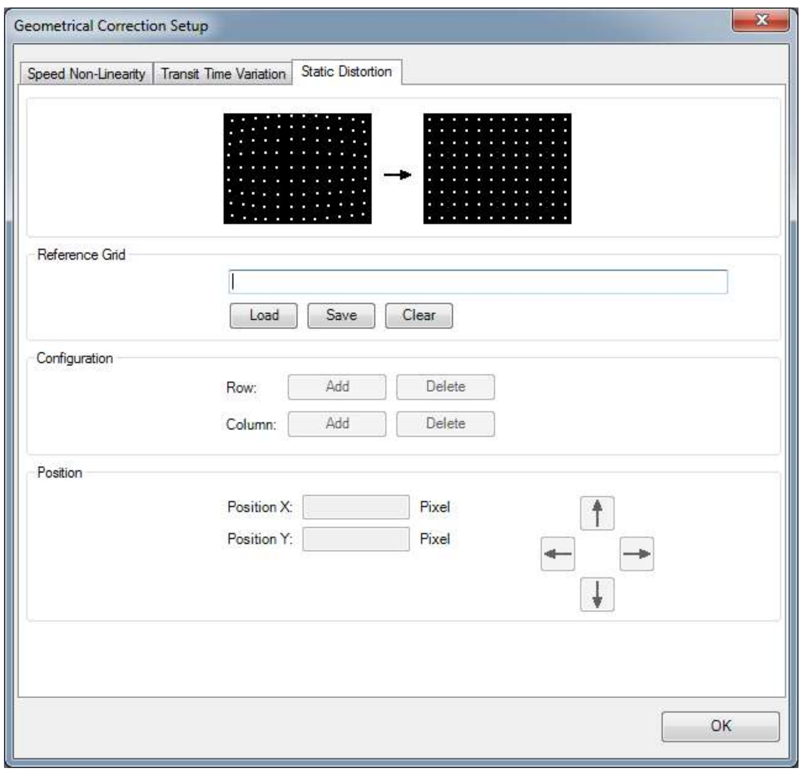
The order of corrections is:

1. Static Distortion Correction
2. Speed Non-Linearity Correction
3. Transit Time Variation

Remark:
Correction process is related to readout camera setup. Modification of the following parameters will require to adapt correction setup.
- Camera Mode (only SRU-BC)
- Binning (if available)
- Display Orientation

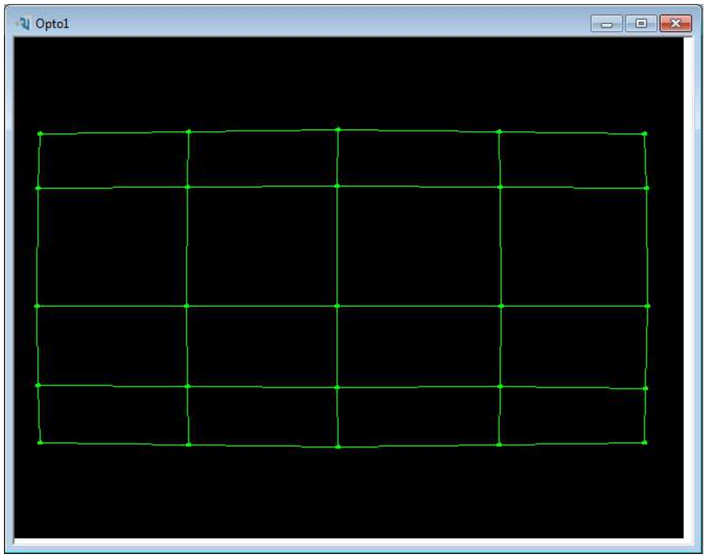
Static Distortion Correction

This correction can typically be used to correct barrel or cushion distortion caused by the streak tube or readout camera. System distortion characterization is required prior to their correction. Typically an image showing a grid of points that should ideally be aligned on strait lines needs to be captured. Realistically, the grid points are not aligned on straight lines but more likely on bended lines due to distortion. A distortion text file contains a set of points that are forming a grid. Details about principles of distortion correction with methods how to characterize the system and the distortion text file are given in the annex. The menu below will assist in creating the distortion text file.



The distortion correction setup provides a convenient possibility to generate the distortion text file by using the distortion gird editor. The text file might be edited also manually. Before the distortion grid editor is started, an image showing distortion should be loaded and the scaling should be removed, e.g. pixel coordinate should be shown.

Entering the menu will show a grid with minimum 5 horizontal and 5 vertical lines.



Click to one of the intersecting lines. The intersection point will become read and the pixel coordinates are shown on the **Position** box.

Position

Using the mouse pointer allows to move the point and to align it to the feature on the background image. Pressing the "Shift" key limits the movement to horizontal direction and pressing the "Crtl" key allows moving the point only in vertical direction. Alternatively, the arrow buttons or arrows keys (←, →, ↓, ↑) can be used. Non-integer point coordinates might also be entered directly. Those coordinates might be resulting from centre of gravity (COG) calculation by using horizontal or vertical profiles.

Once all points are defined use **Save** button to write the distortion text file to disk.

Row / Column

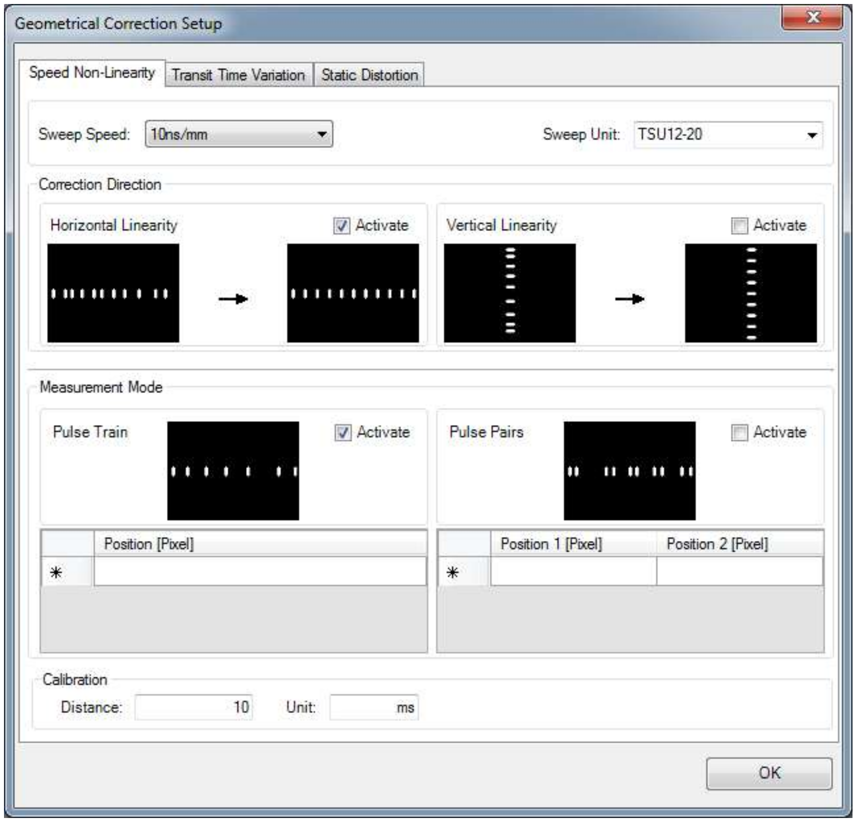
The number of lines should be increased by ROW/ADD if the image is showing more significant features with apparent distortion. COLUMN/ADD can be used if more vertical lines are needed. Removing lines is possible until the minimum of 5 horizontal or vertical lines is reached.

File

Distortion text file is saved on disk by using this file name. The load command allows reading of the point definition from the file.

Speed Non-Linearity Correction

Typically sweep speed linearity and absolute sweep speed value are both well within an error range of ±5% for the OptoScope streak system. In case measurements with higher precision are needed this correction process can be used.



Prior to correct sweep speed non-linearity, the speed needs to be characterized. This can be done by two different methods: Pulse Train and Pulse Pairs.

Sweep Speed and Sweep Unit

For each sweep unit and sweep speed a set of characterization data can be saved. The sweep unit is defined by its unique identifier whereas only the type of the sweep unit is shown. In case different sweep units of the same type are available, the type can be changed. The sweep speed can be characterized for all available sweep speeds but this is not a requirement. Only for sweep speeds that contain valid characterization date, the non-linearity correction will be done.

Correction Direction

The direction on which the correction will be executed needs to be defined. Make sure the display direction is also related to the sweep unit selected above.

Pulse Train

A train of temporally equidistant pulses is used. In case their distance is known, the value can be entered on the **Distance** box. The pulse train method needs to be activated on the corresponding check box.

For each pulse its centre of gravity should be entered. Similar to the distortion correction the active image will show green lines for assistance. Activating the line will high-light the corresponding position. The centre of gravity can either be entered by moving the lines with the mouse pointer or by directly entering the pixel coordinate.

Pulse Pairs

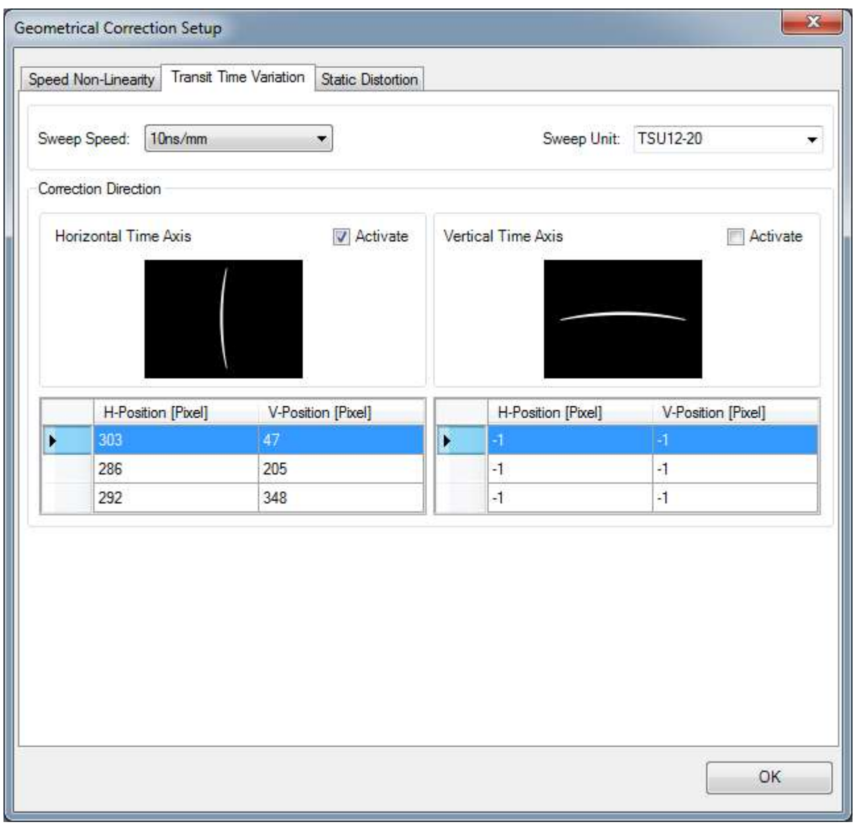
Contrary to the pulse train method only 2 pulses with constant temporal distance are needed. Typically the measurement is made by capturing different images while the absolute position of the pulse pair (not their temporal distance) is changed from image to image. In case the temporal distance of the pulses is known, the value can be entered on the **Distance** box. The pulse pairs method needs to be activated on the corresponding check box.

For each pair of pulse their centre of gravity has to be entered. Similar to the distortion correction the active image will show green lines for assistance. Activating the line will high-light the corresponding position. The centre of gravity can either be entered by moving the lines with the mouse pointer or by directly entering the pixel coordinate.

Please note that this correction can be used in an effective way only if the streak camera is controlled by the OptoAnalyse software. This allows relating an image to a particular sweep unit and sweep speed.

Transit Time Variation

Transit time variation is caused by the streak tube and becomes visible at very fast sweep speed typically above 100ps/mm. The effect is due to different transit times of photoelectrons when they are emitted on the tube axis or apart of it.



Prior to correct transit time variation, it has to be characterized.

As very short time differences are measured, the measurement setup has to be adequate. Any difference in path length from the light source to the centre of the slit and from the or light source to edge of the slit will be corrected also. This correction might not be intentional.

Please also make sure that sweep direction is the same for the image that characterises the transit time variation and the image to be corrected. This is a requirement to be respected for synchroscan sweep units (SSU11-10)

Sweep Speed and Sweep Unit

For each sweep unit and sweep speed a set of characterization data can be saved. The sweep unit is defined by its unique identifier whereas only the type of the sweep unit is shown. In case different sweep units of the same type are available, the type can be changed for example SSU11-10-A and SSU11-10-B. The transit time variation can be characterized for all available sweep speeds but typically only for the fastest ones this is needed. Only for sweep speeds that contain valid characterization date, the transit time variation correction will be done.

Correction Direction

The direction on which the correction will be executed needs to be defined. Make sure the display direction is also related to the sweep unit selected above.

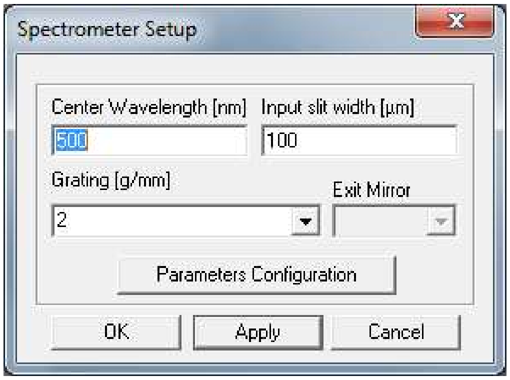
Please note that this correction can be used in an effective way only if the streak camera is controlled by the OptoAnalyse software. This allows relating an image to a particular sweep unit and sweep speed.

Method

The transit time variation is characterized by capturing a single pulse at high sweep speed. The pulse should appear as strait line but is bended due to the transit time variation. Now 3 points along the bend line have to be defined. The software will fit a 2^{nd} order function and show this function on the image as green line for assistance. The defined points are also shown. The green fitting line should be well aligned to the bended pulse.

Spectrometer

The box allows to control key parameters of the spectrometers like Center Wavelength, Input Slit Width, Grating and selection of the Exit Mirror (if available). The spectrometer will be set to the defined value if either the “OK” or “Apply” button is pressed and these values are then used for wavelength calibration.



Shortcut: Shift + P

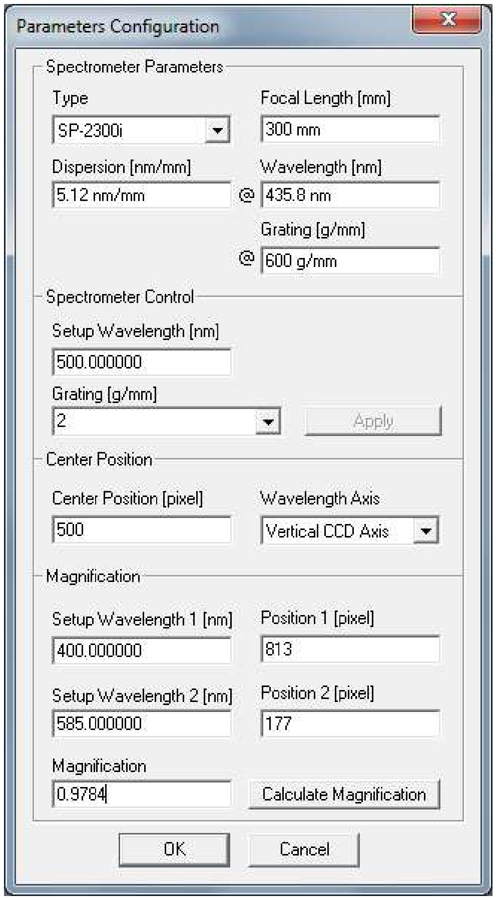
In case the spectrometer is not controlled by the PC, its center wavelength and grating must be controlled by other software. Nevertheless, for correct wavelength calibration center wavelength and grating must be entered manually. Press “OK” or “Apply” button to complete.

Input Slit Width can be controlled if a motorized input slit is available on the spectrometer. The Exit Mirror can also be controlled if two spectrometer outputs and a motorized mirror are available.

Other parameters of the spectrometer are not controlled by OptoAnalyse and might need to be set by other control software prior to start OptoAnalyse.

Parameters Configuration

For applications using a spectrometer installed in front of the streak camera the corresponding axis on the streak image can be wavelength calibrated. The calibration of the wavelength axis depends on spectrometer type, mechanical alignment to streak camera as well as on the spectrometer setup. The *Parameters Configurations* box needs to be entered prior to use the spectrometer setup the first time.

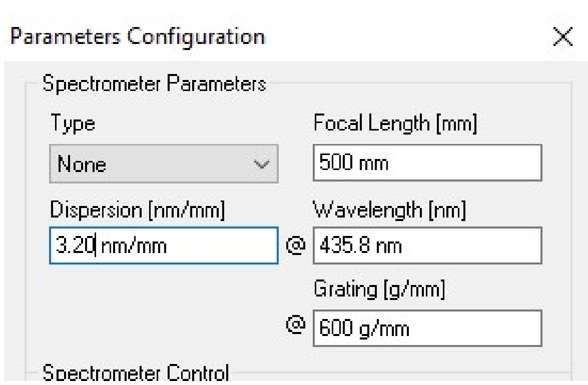


Spectrometer Parameters

Spectrometer parameters given by spectrometer manufacturer are used for wavelength axis calibration. It is important that they are consistent. Remark: Grating indication on spectrometer parameter section does not mean that this grating is actually available or selected.

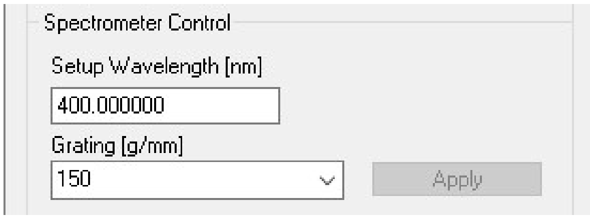
A number of spectrometers are pre-defined with their parameters in the `init.ini` file. The actual spectrometer should be selected. In this case the spectrometer can be controlled by OptoAnalyse.

In case actual spectrometer is not listed, `None` can be selected. Spectrometer needs to be controlled by its proprietary software and can't be controlled by OptoAnalyse. For correct wavelength calibration, the parameters need to be changed from zero to their correct values.



Spectrometer Control

The wavelength of the spectrometer and grating selection can be controlled directly as long as spectrometer type is not `None`. This simplifies setup for the magnification measurement later as the *Parameters Configuration* box can remain open.



Remark: Set *Pixel* on the *Scaling* box for the wavelength axis prior to continue the center position measurement and magnification measurement.

Center Position

This is the pixel position where the center wavelength as set on the spectrometer will appear on the image. Any change in optical alignment between spectrometer and streak camera should be followed by a verification of the center position.

Two alternative methods A or B are possible.

A. Setup by using a light source with precisely known wavelength: Set the spectrometer to the wavelength of the source used. Direct the light on the spectrometer input slit. The pixel position along the wavelength axis where the signal appears has to be entered. The measurement can be done with any grating available. In case a different grating is used for later measurements, any calibration error from the spectrometer has to be considered.

B. Setup by using zero wavelength setup: Set the spectrometer to zero wavelength and direct any light onto the input slit. The pixel position along the wavelength axis where the signal appears has to be entered.

The *Setup Wavelength* field of the *Spectrometer Control* section above can be used.

The definition of the wavelength axis has to be done here. Wavelength axis has to be along slit length. Depending on the selection of the wavelength axis, the corresponding pixel size given with the setup of the readout camera will be used. Any change of pixel size should be succeeded by recalibrating the magnification parameter.

Magnification

Defined *Spectrometer Parameters* together with the actual wavelength and grating selection allows calculating the wavelength calibration. Only the electro-optical magnification between spectrometer output and readout camera input has to be considered. Either a theoretical value (method A) or a measured value (method B) can be used.

A. The combined magnification of input optics and streak tube magnification can be used. For SC-10 systems there parameters are 0.5 for the input optics (IOV-10 or IOU-10) and 2 for the streak tube. Magnification = 1.

It might be necessary to change Magnification = **-1**. This depends on which spectrometer output is used and also whether the spectrometer is operated in order 1 or order -1. Just modify *Setup Wavelength* and check whether calibrated wavelength values are consistent. Do not press "Calculate Magnification" as this will overwrite magnification.

B. The magnification of input optics and streak tube can be determined by following the procedure below.

1. Illuminate the spectrometer input slit with light having a well-known wavelength.
2. Set spectrometer to wavelength 1 by entering this wavelength in field *Setup Wavelength* or by controlling the spectrometer by other means. This wavelength should result in a signal appearing out of the center position.
3. Enter the wavelength in field *Setup Wavelength 1* and enter also the corresponding pixel *Position 1*.
4. Set spectrometer to wavelength 2 similar to step 2 but with a signal appearing on the opposite of the center position compared to step 2.
5. Enter the wavelength in field *Setup Wavelength 2* and enter also the corresponding pixel *Position 2*. Pay attention that both positions are separated by about 50% of the wavelength axis length.
6. Press "Calculate Magnification"

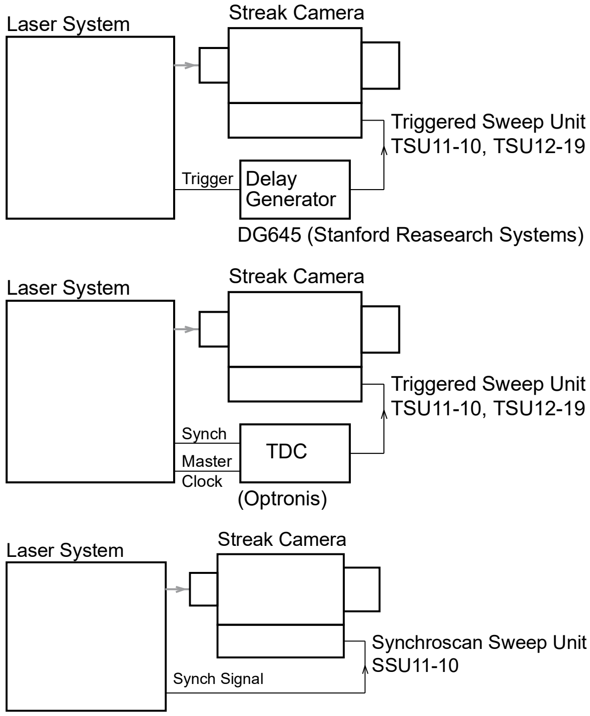
   Magnification values close to 1 or -1 should result. Values within 0.8 to 1.2 can be considered within the expected range. Lager deviations might still be possible but are likely related to some errors and should be accepted only after verification.

After the parameter setup, the wavelength calibration on the *Setup/Scaling* menu can be activated.

Timing Controller

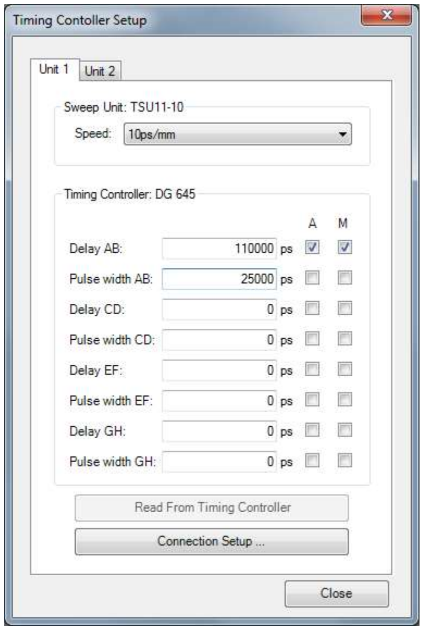
Timing controller means a device controlling the timing of the trigger or synchronization signal used by a sweep unit. Examples below show systems where sweep unit 1 is used with different timing controllers.

Example three shows the synchroscan sweep unit SSU11-10 with an internal phase shifter as timing control device.



Key feature is to control the sweep unit timing in order to compensate trigger delay changes when sweep speed is modified. So the optical signal still appears within the visible time base window. This simplifies system operation as the setup of the timing controller does not need to be changed manually for each sweep speed change.

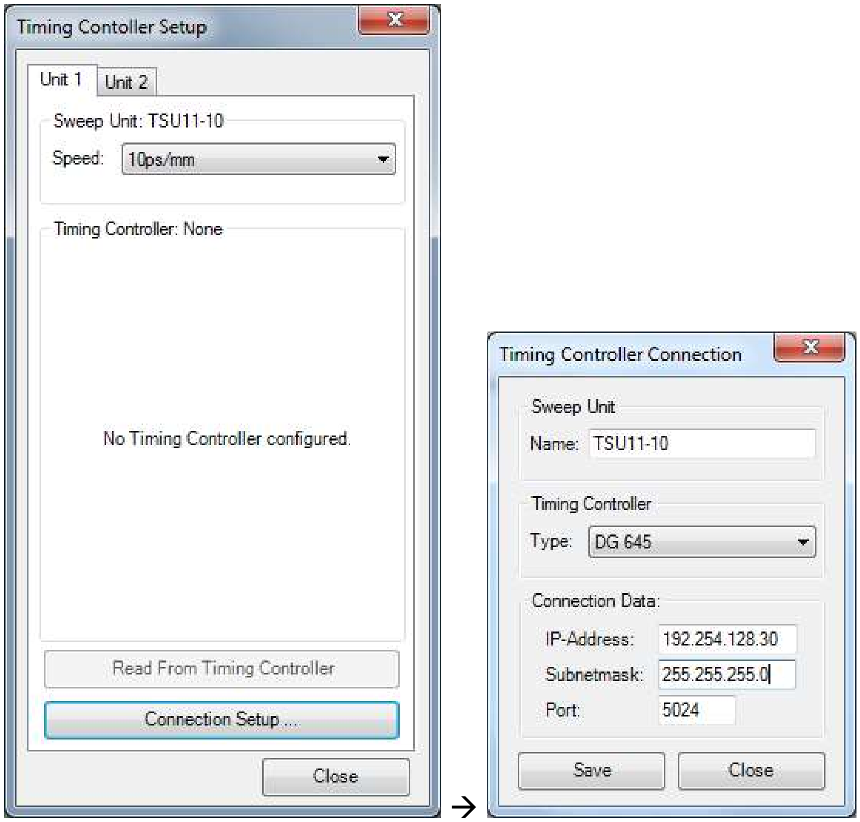
Using the timing control requires a connection between the timing controller and the PC as well as a connection between the streak camera and the PC. Timing controller setup is saved for each sweep speed and together with sweep unit information. Each sweep unit will thus have its own set of timing parameters. If the streak camera is connected to the PC, the timing controller menu can be opened and might appear as follows. The example shows

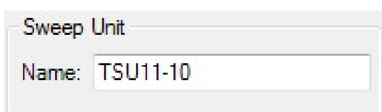


Prior to delay time settings, the type of timing controller providing a trigger signal for unit 1 or eventually unit 2 has to be defined. Additionally, connection parameters need to be set.

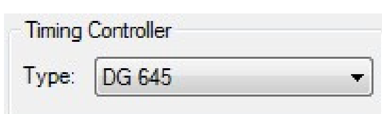
Connection Setup

The connection setup menu has to be opened from the timing controller setup.





The name of sweep unit might be completed or modified in order to relate it to customer specific requirements.

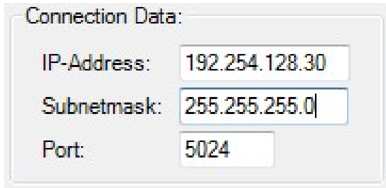


The type of timing controller has to be defined. This relates a particular sweep unit to the timing controller settings. Actually 3 controller types are possible:

TDC	- Time and Delay Controller, Optronis GmbH
DG645	- Digital Delay Generator, Stanford Research Systems Inc.
Internal	- This defines the phase shifting device integrated in the synchroscan sweep unit SSU11-10.

Triggered sweep units like TSU11-10 or TSU12-10 are used with DG645 or TDC whereas synchroscan sweep units like SSU11-10 only use „Internal“ as timing controller.

Connection Data for DG645



The DG645 has to be connected by using the Ethernet interface. The connection to the PC can be made directly or via network. For simple system setup a direct connection between PC and DG645 with fixed IP addresses is proposed. The PC is also configured with fixed IP address (example 192.254.128.1). For other configurations, please refer to the DG645 user manual for further details.

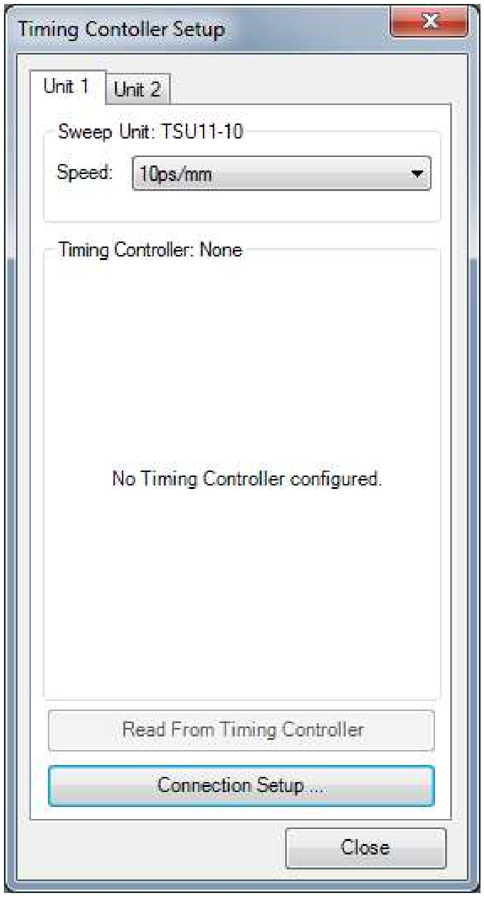
To make sure the DG645 is configured as follows.

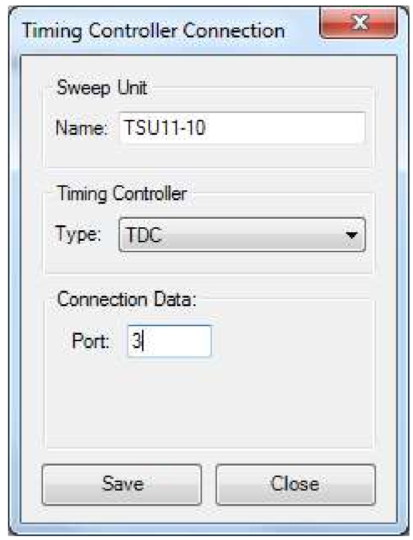
Activate “NET” by pressing “Shift” + “STO” and set these parameters:

tcPiP	EnAblEd
dhcp	disabled
AutoiP	disabled
StAtic iP	EnAblEd
iP	192.254.128.30
Sub nEt	255.255.255.0
dEFgty	0.0.0.0
bArE	EnAblEd
tElnEt	EnAblEd
nEt inStr	EnAblEd
SPEEd	100 bASEt
rESEt	no

Press “Shift” again to setup timing parameters.

Connection Data for TDC

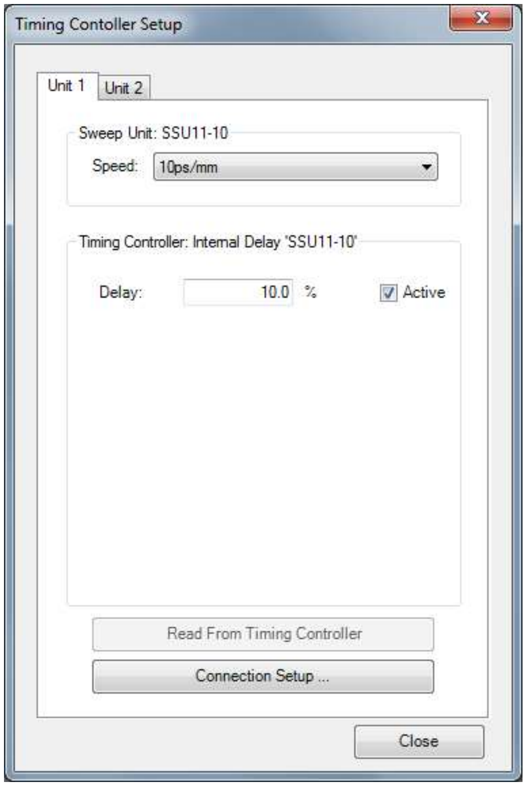




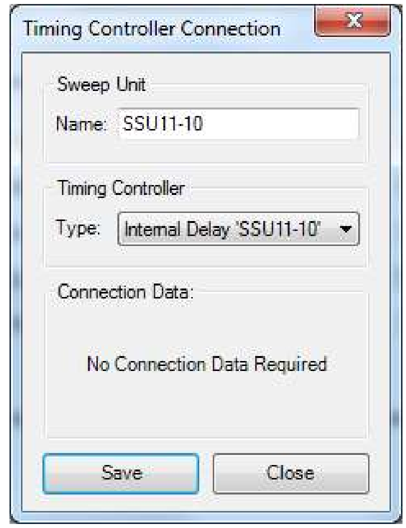
The TDC is connected via USB interface. Details about driver installation are provided with the user TDC user manual. The operating system handles this connection as a virtual serial port (COM). The connection setup allows fixing the COM port number. If no number is defined or if no communication is possible OptoAnalyse will try to find the TDC on the first 20 COM ports.

Remark: Each new device might cause the operating system to attribute a new COM port with typically incremented number. Therefore, it can't be excluded that TDC is attributed to a port number higher than 20. This will cause the TDC not to be detected automatically by OptoAnalyse and requires to explicitly define the COM port number. Using the device manager of the operating system allows to determine the actual COM port number of the TDC. The easiest way to find this COM port is to disconnect/connect the TDC and see which COM port disappears and reappears on the device list.

Connection Data for “Internal”



→

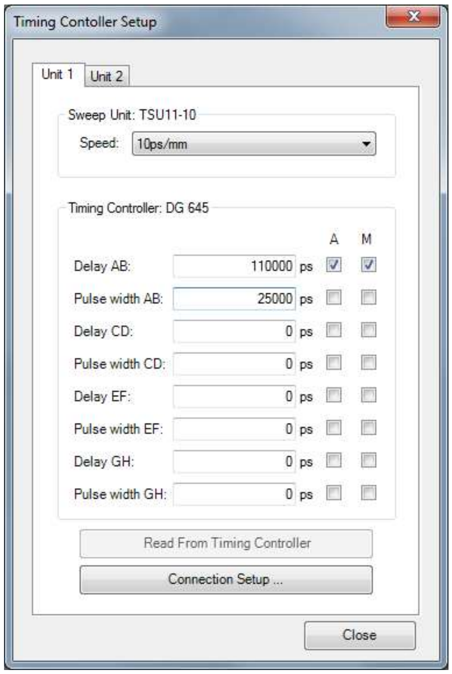


For this setup the selected sweep unit 1 or unit 2 needs to be a synchroscan sweep SSU11-10 or a synchronous blanking unit SBU21-10. No particular connection setting is needed.

How to use the Timing Controller setup menu

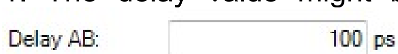
The menu shows the delay time adjustments for sweep speed 10 ps/mm and a DG6454 timing controller. OptoAnalyse will only control timing parameters. Other parameters like pulse amplitude or operation mode need to be set manually.

Typically delay values for the output used to trigger the streak camera sweep unit need be modified. Other outputs to trigger laser or other devices might remain with unchanged delay times. Reading from the DG645 will update all delay values. Only if the “A” box is activated, the corresponding time on the DG645 is controlled by OptoAnalyse software.



The examples below for the delay of AB output will show how the timing parameters can be modified.

1. The delay value might be entered directly by typing the number.



The “A” box need to be marked and the “Return” button has to be pressed to send the number to the timing controller.

2. A particular digit might be selected and using the arrow up and arrow down key will increment or decrement this digit.

arrow up ↑


The “A” box need to be marked to obtain a simultaneous update of the timing controller setup.

3. The parameter might also be modified on the DG645 directly. This might require configuring the DG645 for local control by pressing “Shift” key followed by “3” key.

Using the “Read From Timing Controller” will update all parameters on the OptoAnalyse software.

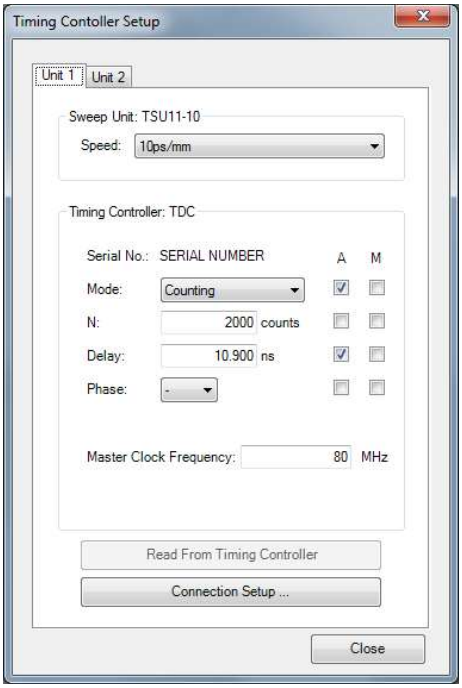
Individual delay time need to be programmed for each sweep speed. Selecting a sweep speed on the timing controller box will switch the streak camera to this speed and display the corresponding set up delay values. The values where “A” box is checked are updated simultaneously.

For each parameter the update on the timing controller can be set to “Active”. So with the “A” box activated, the timing controller will be updated from the OptoAnalyse software. Typically, the parameter related to the output of the DG645 that triggers the sweep unit will be set to “Active”. This can be done for each sweep speed individually. The activation is saved.

The box named “Modify” can be activated for each parameter but will be active or inactive for all sweep speeds simultaneously. With the “M” box activated, incrementing or decrementing is done simultaneously for ALL other sweep speeds.

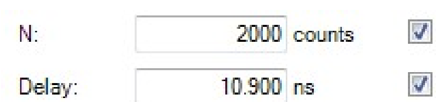
Once the timing controller is set correctly for all sweep speeds, any change in cable length or other laser settings might require recalibration delay time for each sweep speed. This task can be simplified with the “M” box. Activating the “M” box is not saved.

Similar to the modification of timing parameters with the DG645 controller, the TDC controller is used. There is one particularity when using the TDC.

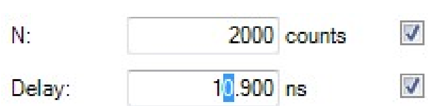


In case the delay value is incremented or decremented beyond the possible delay range, the count value N is incremented and the new delay value is corrected accordingly. This requires precise information of the master clock frequency. For example 80 MHz is entered.

Assuming the minimum delay value is 10.9 ns.



The ns digit is marked.



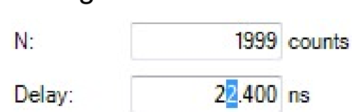
If the delay value is decremented by pressing the down key ↓ the counts number N is decremented

2000 counts – 1 = 1999 counts

and a new delay is calculated by:

10.9 ns – 1 ns + 1/80 MHz = 22.4 ns

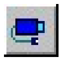
resulting in:



In case the “M” box is activated, the same rule is applied for the delay value and counts number for all other sweep speeds. With the “A” box activated the parameter modifications will be send to the TDC.

All timing control parameters are saved on the .INI file located in the same directory as the OptoAnalyse software.

Readout Camera



The **Readout Camera** command opens a dialog box named Readout Camera Setup to select the acquisition parameters of the readout camera. The content of that dialog box depends on the readout camera (ANIMA-PX, SCRU-SE-A, SRU-BA, SRU-BC, SRU-ED, SI1000). The different dialog boxes are described below.

Shortcut: Shift + G

Remark: The readout camera can be installed with different orientations on the streak camera. Additionally, the image captured by the readout camera can be rotated before it is displayed. Therefore 3 different orientations need to be separated.

Streak Orientation: This refers to the physical orientation of the slit and sweep direction seen on the screen of the streak camera. Typically the slit is oriented horizontally and appears horizontal on the screen. The first (fast) sweep direction is perpendicular and therefore vertical from bottom to top.

Sensor Orientation: This refers to the sensor chip. The pixels of one line of the sensor are oriented horizontally. This is typically the long side of the chip and corresponds to the sweep of the first (fast) sweep unit. In most cases the camera is installed with 90° rotation so the horizontal sensor direction is fixed vertically on the streak camera.

Display Orientation: This refers to the orientation on the display. The setup dialog box allows rotating the image before it is displayed. As the sensor is already installed with 90° rotation on the streak camera, 0° display orientation needs to be selected to obtain a horizontal (fast) time axis on the display although the sweep direction on the streak camera is vertical.

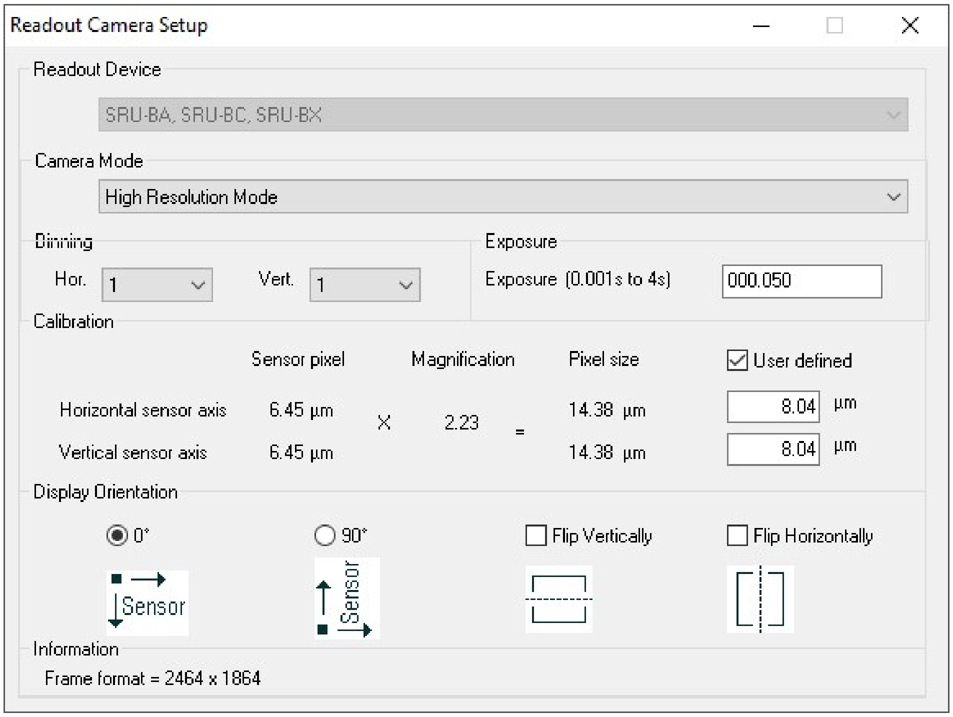
External Trigger: All readout cameras can be operated in a free running mode also called continuous mode. The image acquisition is not synchronized and the camera provides them at their own speed. If image acquisition needs to be synchronized, the camera has to be set to **Ext** trigger mode. This is done on the *Trigger* menu. In trigger mode, a trigger signal has to be provided.

Exposure Time: Exposure time, also called integration time, defines the period during which the sensor is sensitive. Typical times of 20ms to 50ms are recommended but have to be adapted for particular applications. The impact of exposure time on the measurement depends on the operation mode of the streak camera.

In single-shot mode, the exposure time must not end unless sweep is completed and the complete phosphor decay time has elapsed. At fast sweep speeds this can be as short as 5ms for standard P43 screens or even 1ms for fast decay screens. For slow sweep speeds >100µs/mm the trigger delay and half of the time base need to be considered.

Exposure time settings outside the possible range are corrected and the actually adjusted value is displayed.

Using the SRU-BA, SRU-BC or SRU-BX readout camera



Camera Mode is available for SRU-BC readout cameras only.

The **Binning** frame sets the binning along the horizontal axis or the vertical axis. A binning is a hardware operation to accumulate intensity charge of contiguous pixels. Just select the number of contiguous pixels along the horizontal axis and the vertical axis. This operation creates a super pixel with more sensibility but it decreases the spatial resolution of the sensor. The horizontal and vertical orientation refers to the sensor chip and not to the display orientation.

The **Exposure Time** edit box is used to adjust the exposure time from 1 ms to 4s by step of 1 ms. After typing a modified exposure time, the value has to be confirmed by pressing the ☑ key. The actual time is then read from the camera and displayed. Due to camera restrictions the actual time might differ slightly from the number entered.

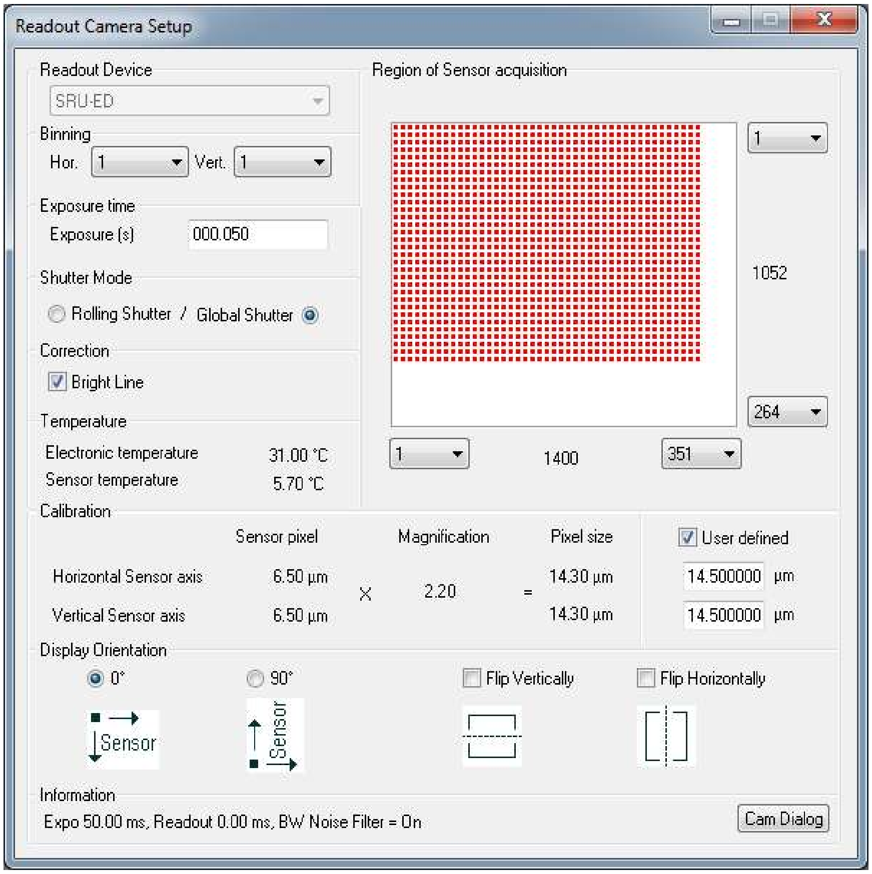
The **Calibration** frame displays the pixel size in µm referred to the streak camera screen. This size is given on the test sheet of the each individual readout camera. Typical values are shown but it is recommended to use individual values for higher precision.

Please note that this value is used to calculate scaling of the image. Any change in value will have a linear impact on temporal or special axis calibration.

The **Orientation** allows selecting the orientation of the readout image on the display. As the physical installation of the sensor on the streak camera can be changed this parameter allows rotating the image in order to obtain a positive time axis in horizontal direction on the display.

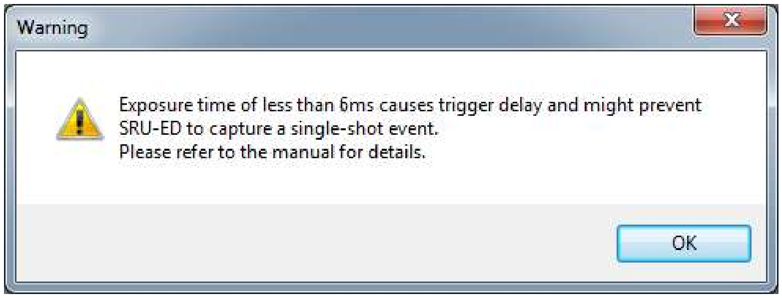
The **Information frame** shows the current frame format.

Using the SRU-ED readout camera



The **Binning** frame sets the binning along the horizontal axis or the vertical axis. A binning is a software operation to accumulate signal of contiguous pixels. Just select the number of contiguous pixels along the horizontal axis and the vertical axis. This operation creates a super pixel with more sensibility but it decreases the spatial resolution of the sensor. The horizontal and vertical orientation refers to the sensor chip and not to the display orientation.

The **Exposure Time** edit box is used to adjust the exposure time by step of 1 ms. After typing a modified exposure time, the value has to be confirmed by pressing the key. The actual time is then read from the camera and displayed. Due to camera restrictions the actual time might differ slightly from the number entered.



Attention: For exposure times below 6 ms please pay attention to the particularity of the SRU-ED camera. Additional trigger delay has to be considered and the readout camera might need to be pre-triggered. Details are given on the SRU-ED manual.

The **Shutter Mode** edit box is used to switch from Rolling Shutter to Global Shutter. Please refer to the camera manual for details. Shutter mode and trigger mode of the camera are independent.

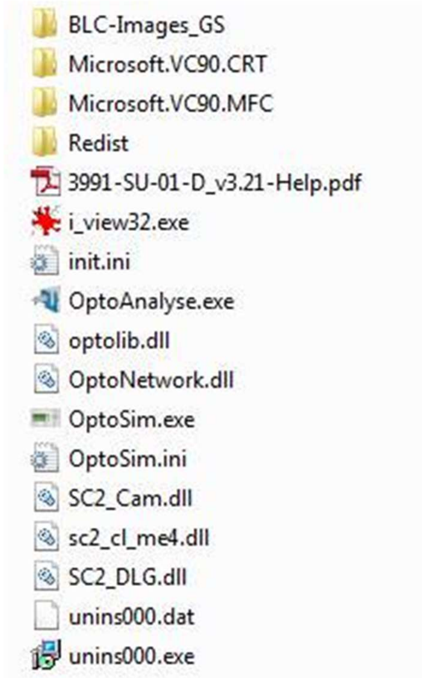
Bright Line

Bright line correction can be activated to correct an artefact of the SRU-ED camera. This artefact is a faint horizontal line near the centre. Details are described on the SRU-ED user manual.

This correction is done prior to any other image processing.

Reference Images for Bright Line Correction

Reference images are needed to use the bright line correction. They have to be saved on the directory 'BLC-Images_GS' located on the same directory where the OptoAnalyse software is saved. This is typically 'C:\Program Files\Optronis\OptoAnalyse-ED vX.XX'. With 'X.XX' indicating the actual program version. Figure below shows a typical directory.



The reference images have to be captured under the same operation conditions the SRU-ED will be operated later. Particularly, setup for binning and region of sensor acquisition has to be identical. At least one reference image has to be captured with the OptoAnalyse software and saved with the dedicated time information. The reference image name has to follow this pattern:

BLC-XXsec.imd or
BLC-XXmin.imd

With X representing numbers 0..9 indicating either seconds or minutes. Examples of valid names for bright line reference images: *BLC-90sec.img*, *BLC-30SEC.img*, *BLC-2.5min.img* and *BLC-20MIN.img*.

Examples of wrong names:
BC-90sec.img, *BLC-40SEC_.img*, *BLC-2000ms.img* and *BLC-20m.img*.

OptoAnaylse scans reference images and generates correction images after each program start and after activating the bright line correction. The correction images are saved on the same directory. Their names are identical to the reference images except ‘BLC’ is replaced by ‘IC’. Only reference images having valid names and useful image content are converted to correction images. One additional correction image ‘*IC-last.imd*’ is saved. This image had been used to correct the latest image provided by the SRU-ED camera.

The **Region of Sensor Acquisition** allows selecting the part of the sensor to be read. The size is selected by steps of 32 pixels along the horizontal axis and the vertical axis. The area is defined by the mouse or by four numerical values to select the left, the right, the top and the bottom coordinates of the area. The orientation refers to the sensor chip. If the orientation is selected not to be 0°, it does not correspond to the display orientation.

When using the mouse, the pointer has to be placed on the upper left corner of the area to be selected. Moving the cursor and keeping the left mouse button pressed when moving to the lower left corner defined the region of sensor acquisition. If the mouse cursor quits the sensor area, the current selection is aborted. Reducing the acquisition region allows to increases the readout rate.

Attention: Only reduce the acquisition region if needed and make sure not to over-illuminate the region that is not captured.

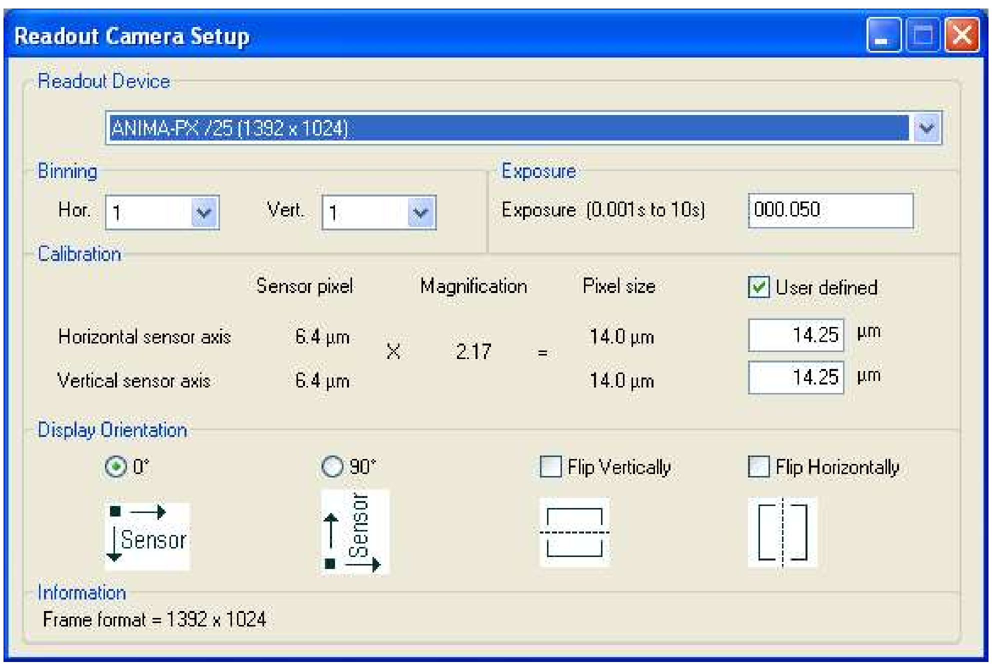
The **Calibration** frame displays the pixel size in µm referred to the streak camera screen. This size is given on the test sheet of the readout camera. Typically these values can be used:

Please note that this value is used to calculate scaling of the image. Any change in value will have a linear impact on temporal or special axis calibration.

The **Orientation** allows selecting the orientation of the readout image on the display. As the physical installation of the sensor on the streak camera can be changed this parameter allows rotating the image in order to obtain a positive time axis in horizontal direction on the display.

The **Information frame** shows the current frame format.

Using the ANIMA-PX readout camera



The **Readout Device** text shows the type of ANIMA-PX camera connected to the frame-grabber.

The **Binning** frame sets the binning along the horizontal axis or the vertical axis. A binning is a hardware operation to accumulate intensity charge of contiguous pixels. Just select the number of contiguous pixels along the horizontal axis and the vertical axis. This operation creates a super pixel with more sensibility but it decreases the resolution of the sensor. The horizontal and vertical orientation refers to the sensor chip and not to the display orientation.

The **Exposure Time** edit box is used to adjust the exposure time from 1 ms to 10s by step of 1 ms. After typing a modified exposure time, the value has to be confirmed by pressing the ☑ key

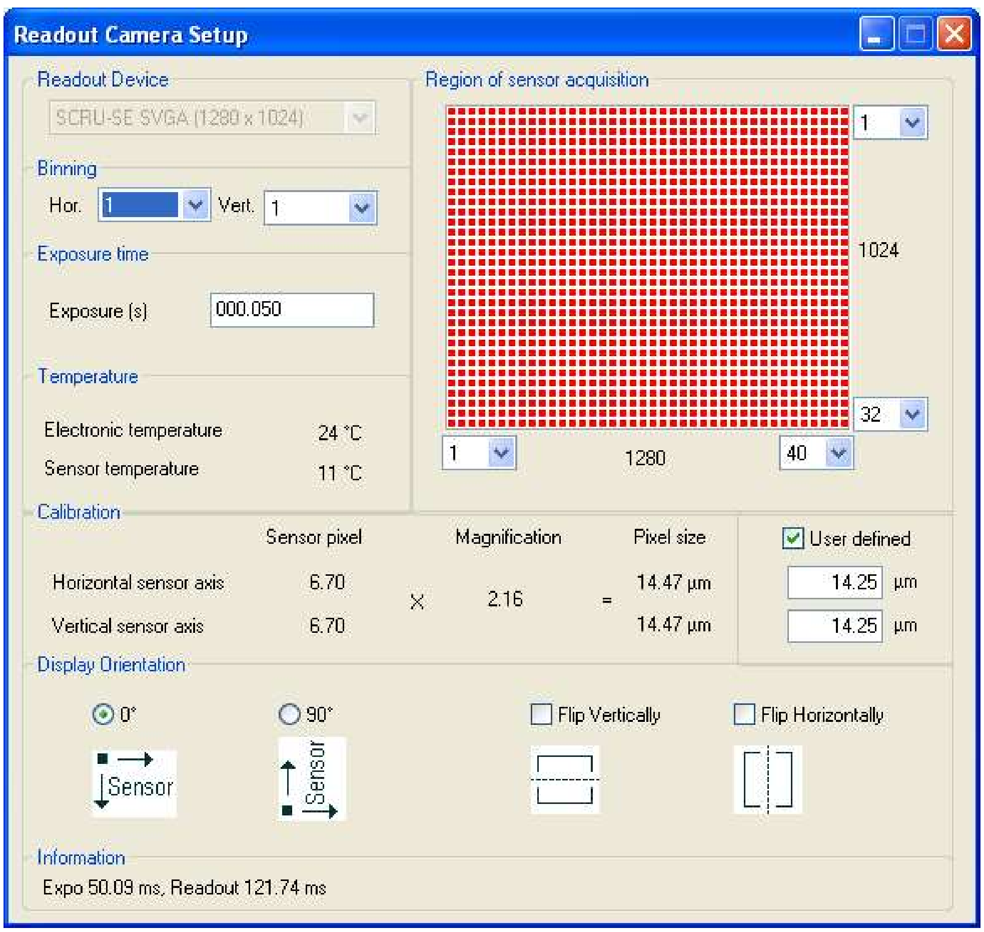
The **Calibration** frame displays the pixel size in µm referred to the streak camera screen. This size is given on the test sheet of the readout camera. Typically these values can be used:

Please note that this value is used to calculate scaling of the image. Any change in value will have a linear impact on temporal or special axis calibration.

The **Orientation** allows selecting the orientation of the readout image on the display. As the physical installation of the sensor on the streak camera can be changed this parameter allows to rotate the image in order to obtain a positive time axis in horizontal direction on the display.

The **Information frame** shows the current frame format.

Using the SCRU-SE-A Readout Camera



The **Readout Device** text shows the type of SCRU-SE-A camera connected to the frame-grabber. Commonly the cameras are SCRU-SE-A

VGA (640x480), SCRU-SE-A SVGA (1280 x 1024) or SCRU-SE-A QE (1376 x 1040).

The **Binning** frame sets the binning along the horizontal axis or the vertical axis. A binning is a hardware operation to accumulate intensity charge of contiguous pixels. Just select the number of contiguous pixels along the horizontal axis and the vertical axis. This operation creates a super pixel with more sensibility but it decreases the resolution of the sensor. The horizontal and vertical orientation refers to the sensor chip and not to the display orientation.

The **Exposure Time** edit box is used to adjust the exposure time from 1 ms to 1000 s by steps of 1 ms. Shorter times than 5 ms are not recommended as the decay of standard P43 phosphor screens are in this order of magnitude. Typically 40 ms or more are recommended. After typing a modified exposure time, the value has to be confirmed by pressing the ☑ key

The **Temperature** frame displays the temperature in °C of the SCRU-SE-A electronics and the sensor chip. Typically the sensor has a temperature of –11°C.

The **Calibration** frame displays the pixel size in µm referred to the streak camera screen. This size is given on the test sheet of the readout camera. Typically these values can be used:

Please note that this value is used to calculate scaling of the image. Any change in value will have a linear impact on temporal or special axis calibration.

The **Region of Sensor Acquisition** allows to select the part of the sensor to be read. The size is selected by steps of 32 pixels along the horizontal axis and the vertical axis. The area is defined by the mouse or by four numerical values to select the left, the right, the top and the bottom coordinates of the area. The orientation refers to the sensor chip. If the orientation is selected not to be 0°, it does not correspond to the display orientation.

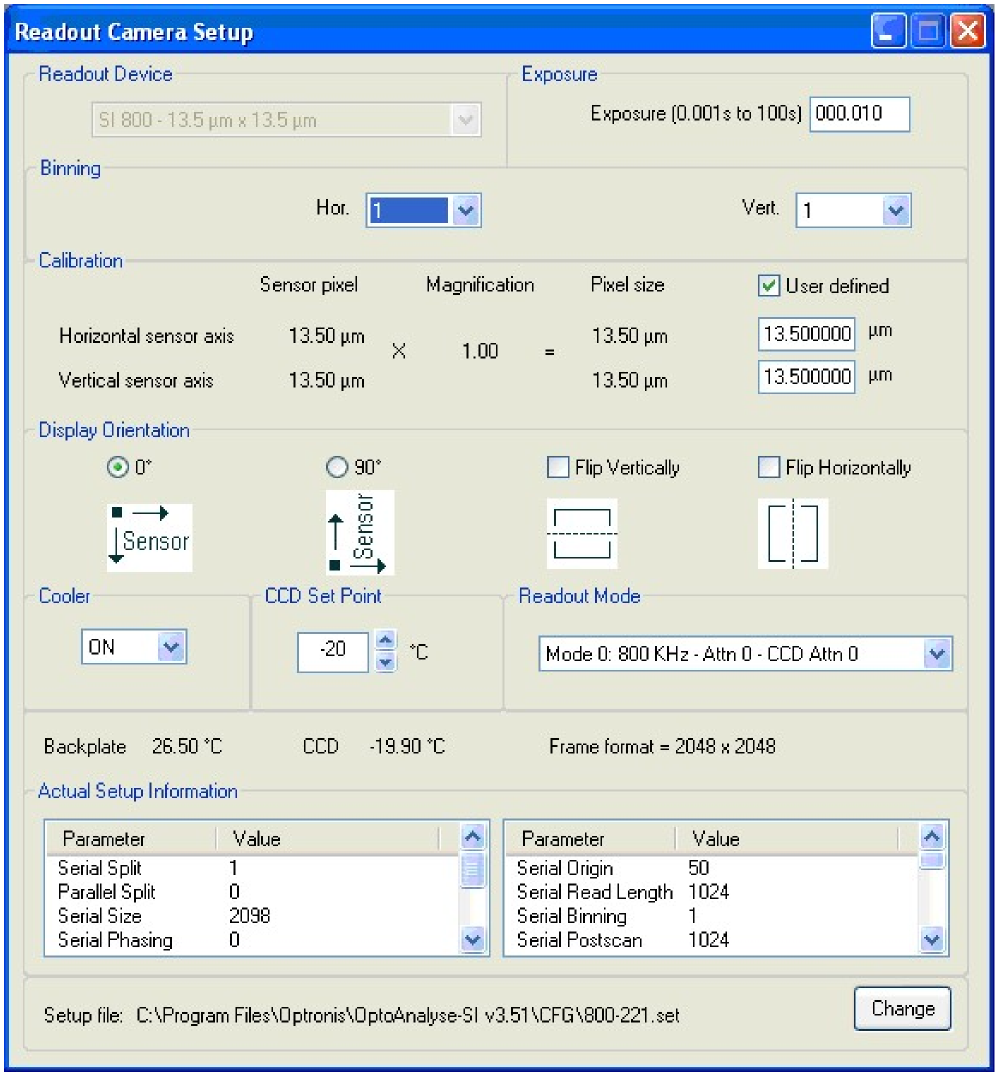
When using the mouse, the pointer has to be placed on the upper left corner of the area to be selected. Moving the cursor and keeping the left mouse button pressed when moving to the lower left corner defined the region of sensor acquisition. If the mouse cursor quits the sensor area, the current selection is aborted. Reducing the acquisition region allows to increases the readout rate.

Attention: Only reduce the acquisition region if needed and make sure not to over-illuminate the region that is not captured.

The **Orientation** allows to select the orientation of the readout image on the display. As the physical installation of the sensor on the streak camera can be changed this parameter allows image rotation to specific requirements. Typically orientation is selected to obtain a positive time axis in horizontal direction on the display.

The **Information frame** shows the current exposure time, readout time and the rate.

Using the SI 1000 and SI 1000-4k readout camera



The **Readout Device** text shows the type of readout camera.

The **Binning** frame sets the binning along the horizontal axis or the vertical axis. A binning is a hardware operation to accumulate intensity charge of contiguous pixels. Just select the number of contiguous pixels along the horizontal axis and the vertical axis. This operation creates a super pixel with more sensibility but it decreases the resolution of the sensor. The horizontal and vertical orientation refers to the sensor chip and not to the display orientation.

The **Calibration** frame displays the pixel size in µm referred to the streak camera screen. This size is given on the test sheet of the readout camera. Typically these values can be used:

SI 1000:	Horizontal Sensor Axis =	13.5 µm
	Vertical Sensor Axis =	13.5 µm
SI 1000-4k:	Horizontal Sensor Axis =	9.0 µm
	Vertical Sensor Axis =	9.0 µm

Please note that this value is used to calculate scaling of the image. Any change in value will have a linear impact on temporal or special axis calibration.

The **Exposure Time** edit box is used to adjust the exposure time from 1 ms to 1000 s by steps of 1 ms. Shorter times than 5 ms are not recommended as the decay of most phosphor screens are in this order of magnitude. Typically 200 ms or more are recommended.

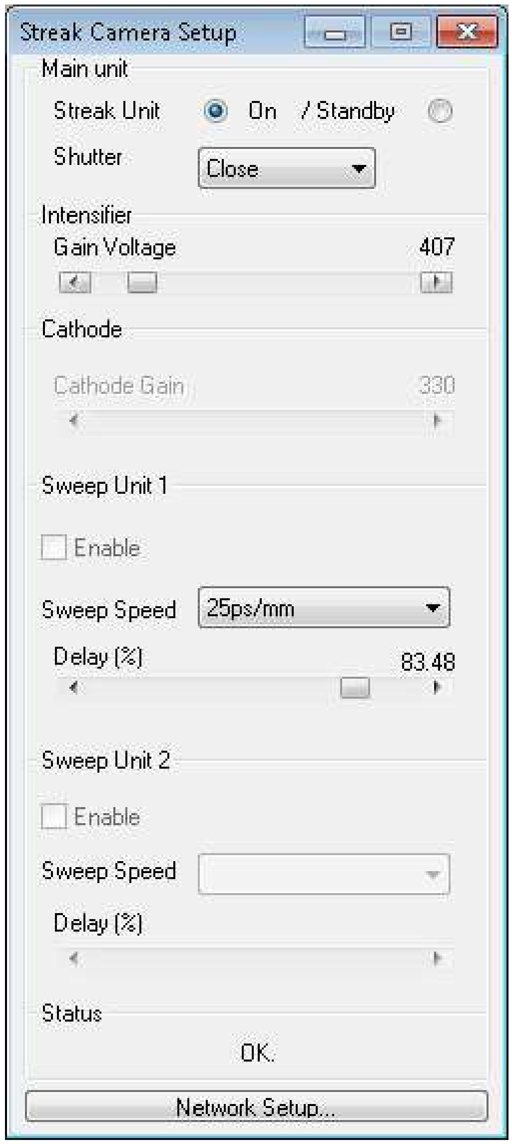
The **Orientation** allows selecting the orientation of the readout image on the display. As the physical installation of the readout camera on the streak camera can be changed this parameter allows image rotation to specific requirements. Typically orientation is selected to obtain a positive time axis in horizontal direction on the display.

The **Cooling** frame displays the cooler control status with Sensor Set Point and sensor temperature both in °C. Typical values are shown. Please refer to the user manual of the SI 1000 for more information and detailed recommendations.

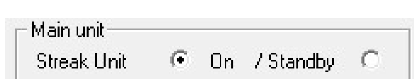
Streak Camera

The appearance of the box depends on the actual camera configuration and therefore might be different to the figure below. Example: If no second sweep unit is installed, the control elements of *Sweep Unit 2* are disabled. If there is no communication with the streak camera only the *Network Setup* can be accessed.

Shortcut: Shift + C

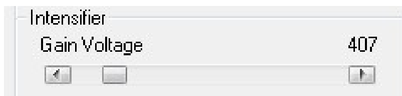


Control Elements

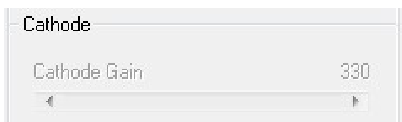


The buttons **Run** and **Standby** set the operating mode of the camera. If **Run** is selected, the camera is switched on and can be used for measurements. If **Standby** is selected, all high voltages are switched off and the camera is not available for measurements.

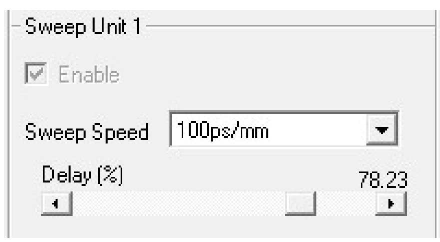
The **Shutter** box is used to open or close the shutter when it is set to internal mode. If **External** mode is selected on the Trigger menu, an external pulse applied on the shutter input opens the shutter.



The intensifier box allows to control the intensifier gain. Operation modes are controlled on the Trigger menu.

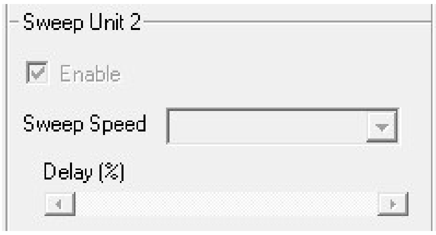


The **Cathode** voltage adjustment is only available for the X-Ray type streak camera. The voltage setup controls the gain of the X-ray detection.



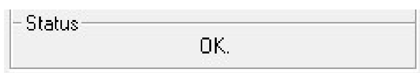
The **Sweep Unit 1** box is used to control the sweep speed and the delay for the temporal sweep. The list of sweep speeds is loaded from the camera. A click on the specific line selects the corresponding sweep speed. The delay can be set with the scrollbar if the sweep unit provides an adjustable delay setting. The 'Enable' flag permits to enable or disable the sweep unit 1. This control is available if two sweep units are installed. Otherwise the "Enable" flag only informs about the operation according to the focus mode setting. If the streak camera is set to Focus mode the sweep units do not need to be disabled individually.

The 'Delayed Backtrace' button activates this feature on the sweep unit. In case the unit does not provide a delayed backtrace feature this control box is not available.



The **Sweep Unit 2** elements are used to control the sweep speed and the delay of the sweep perpendicular to the temporal sweep. The elements are active if a second sweep unit is installed. The list of sweep speeds is loaded from the camera. A click on the specific line selects the corresponding sweep speed. The delay can be set with the scrollbar if the sweep unit provides an adjustable delay setting. The 'Enable' flag permits to enable or disable the sweep unit 2. If the streak camera is set to Focus mode the sweep units do not need to be disabled individually.

The 'Delayed Backtrace' button (not shown above) allows activating this feature on the sweep unit. In case the unit does not provide a delayed backtrace feature this control box is not available.



The **Status** text shows the current state of the camera. In particular, this status text informs whether any unexpected states had been detected on the intensifier, the unit 1 or the unit 2. The status information also informs whether the communication with the camera had been established.

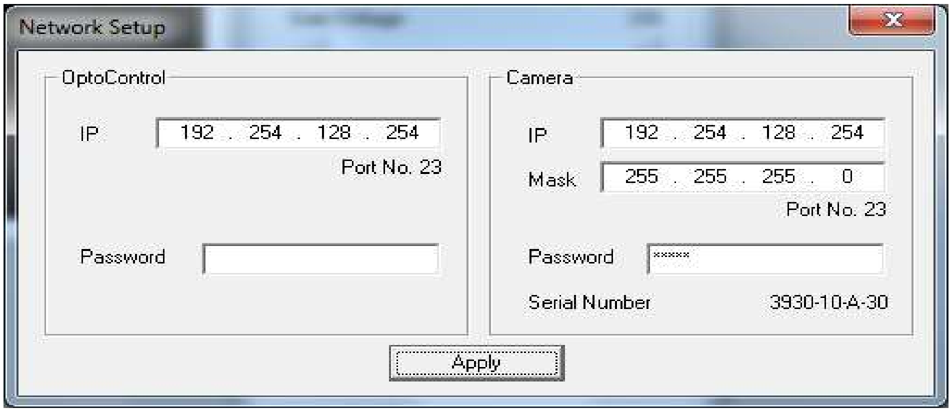
Network Setup

The software controls the Optoscope SCMU streak camera by using an RS-232 connection and it controls the Optoscope-SC camera family by Ethernet connection between the control PC and the streak camera. The RS-232 connection type does not require any network setup.

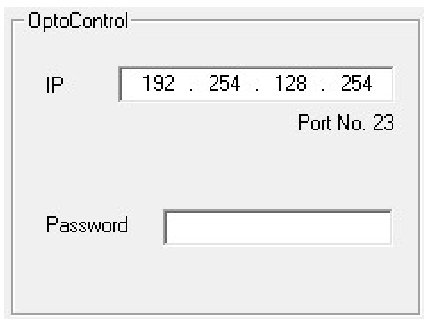
The following description is based on an Ethernet interface on the PC that is already installed correctly. Please refer to the installation manual of the hardware or the help tools of the operating system for more details related to the Ethernet interface on the PC. The settings related to the program are available by pressing *Network Setup*.

Attention: Modifications of network settings might stop communication between PC and streak camera. Save all data prior to enter the Network Setup.

The following control box opens. The *OptoControl* settings on the left hand side are related to the control software of the PC. The *Camera* settings on the right hand side are parameters of the streak camera.

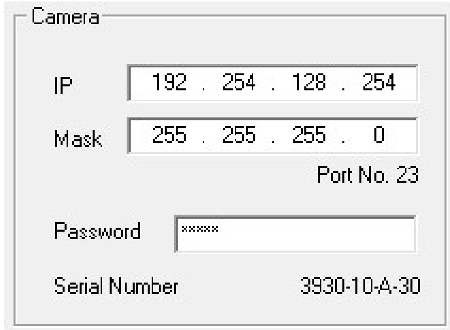


The **Port No. 23** is a fixed parameter that cannot be changed. **Serial Number** is read from the streak camera. After modifying the settings, press **Apply** to make them active. Attention: The program needs to be restarted after any change of the settings.



The **IP** address displayed is used by the OptoControl program to communicate with streak camera. This IP can be modified. To modify just the new number has to be entered.

The **Password** can be used to prevent unauthorized users from operating the streak camera. Before the streak camera can be controlled the password is verified. In case no valid password is sent to the streak camera, no control by Ethernet is possible. If the streak camera is configured with a password, the same password can be entered in the OptoControl section of the control box to simplify program start. If no password is entered in the OptoControl section, the correct password has to be typed after each program start.



The **IP** and **Mask** of the camera related to the Ethernet communication are saved in the streak camera and can be modified by the control box. Before any modification of IP or Mask consult the network administrator to make sure not to create any conflicts on the network. Note the modified IP and Mask on the label of the streak camera main unit.

The **Password** is verified prior the streak camera can be controlled. To enter a new password it has to be typed and activated by **Apply**. The password should be noted on a save place but not on the camera itself. The password is case sensitive and must not be longer than 15 characters. Independent of its length always 5 “*” are displayed. To enter no password just delete the old password and press **Apply**. If no password is set only the IP of the camera needs to be known for system control.

Factory Settings

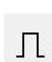
IP 192.254.128.254

Mask 255.255.255.0

Password -none-

The IP address and mask can be reset to its factory settings. Details are given with the user manual of the main unit. In case the password had been lost, please contact Optronis GmbH.

Trigger



The Trigger menu summarizes the trigger configuration of the streak system. This includes trigger configurations of shutter, photocathode gating, sweep unit 1, sweep unit 2, MCP gating and readout camera. Each configuration can be saved under a customer defined name. Figure below shows an example. Units not installed are greyed.

Sweep Mode and Focus Mode

The system separates between sweep mode and focus mode configurations. All sweep modes have the Focus button NOT activated. For all sweep modes the Focus button is always activated. Any new customer mode will either be a focus mode or sweep mode independent how it is named by the user. Switching from focus mode to sweep mode or vice versa can be done by selecting the corresponding mode from the box or by pressing the Focus button on the control pad. Using the control pad will activate the focus mode or sweep mode that had been used previously.

Remark 1: Switching operation modes by the control pad might modify trigger configuration of all units even if the trigger menu is not open. This might cause some confusion on the behaviour of the system. Therefore, user should be well aware of the latest focus mode and sweep mode setups. Both modes should be well defined according to the system configuration and measurement requirements.

Remark 2: Once OptoAnalyse is stopped, the selection of the mode is saved on disk and will be used after a restart of the software. So streak camera operation mode might be changed after start of OptoAnalyse.

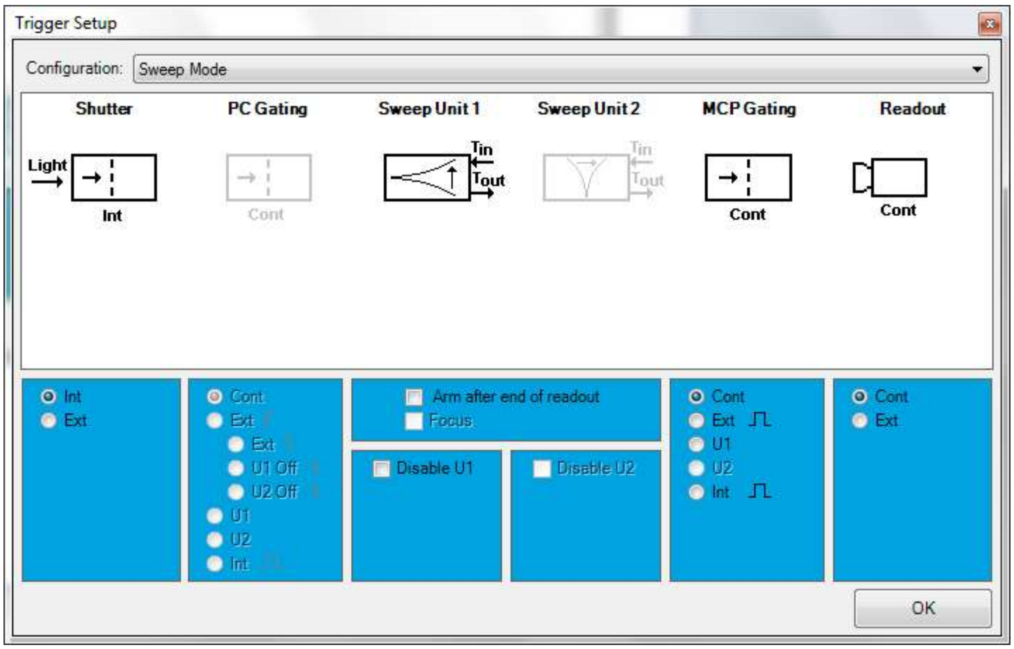
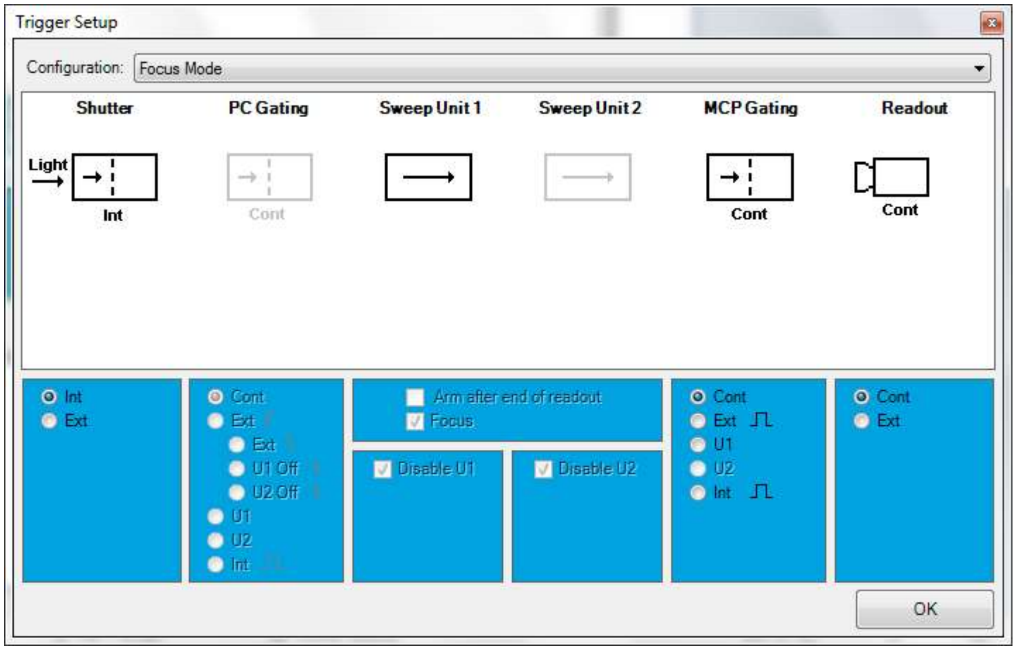
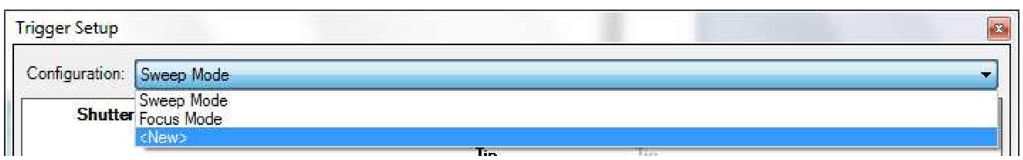


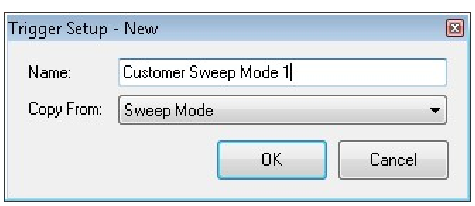
Figure above shows a typical sweep mode. Figure below shows a typical focus mode.



The **Configuration** line shows the name of the active configuration setup. New configuration can be created by activating the line and selecting <New>.



Activate *Copy From: Sweep Mode* if a new sweep mode needs to be created. Alternatively *Copy From: Focus Mode* can be selected to create a new focus mode.



The graphical presentation below the *Configuration* line provides a visual information about the setup and trigger modes of all units. Modifications are only possible on the unit boxes below.

The **Shutter** box defines whether the shutter is externally controlled **(Ext)** or whether it is controlled manually **(Int)** by the shutter button on the control pad. The manual trigger configuration needs to be activated if the OptoAnalyse software should control the shutter. If the external mode is selected, an external pulse applied on the shutter input opens the shutter.

The **PC Gating** box allows opening the photocathode continuously (**Cont**). If photocathode has to be gated it can be triggered from an external signal on the *Cath. IN* input by activating **Ext**. For triggering synchronously with a sweep **U1** or **U2** have to be selected. If Ext is selected, the rising edge on the *Cath. IN* input will open the photocathode. The closing of the photocathode might be defined by the falling edge of the Cath IN if Ext is selected. Activating U1 off or U2 off will cause the closing of the photocathode at the end of the corresponding sweep. Selecting **Int** will set the photocathode to be triggered by software each time the readout camera is starting its exposure. This mode is mainly needed for systems using full frame CCD readout cameras that do not have any shutter function.

The **Sweep Unit 1** and **Sweep Unit 2** boxes define whether the units are operating or disabled (**Disable U1** and **Disable U2**). Particular sweep units can be armed prior to their triggering. This can be done by activating **Arm after end of readout**. Please refer to the individual unit manual for details about available feature of the unit. The trigger menu will not provide any information whether the selected arm button will have an impact on the unit operation.

Selecting the trigger mode of the intensifier is done on the **MCP Gating** box.

Cont The intensifier is continuously open.

Ext The external trigger input of the streak camera main unit is used to trigger the image intensifier. External pulse width above the minimum duration will control the open time.

Unit 1 The sweep unit 1 triggers the image intensifier. The intensifier is closed after the sweep ended.

Unit 2 The sweep unit 2 triggers the image intensifier. The intensifier is closed after the sweep ended.

The **Readout** camera can be configured to capture frames continuously (**Cont**) or to be triggered (**Ext**). In continuous mode, also called free running mode, the camera will capture images at is own speed. In triggered mode the start of the exposure time can be synchronized to the sweep or any other external event. This is needed for **Single-Shot** mode where one sweep needs to be captured on one image.

Remark: If the readout camera is set to Ext a trigger signal has to be provided to the camera. Without trigger signal no image will be captured and displayed. The streak camera might be damaged if high levels are directed to the camera without noticing this.

Attention: Internal propagation delay times of PC Gating, MCP Gating or Readout Camera trigger delay might inhibit using all possible configurations.

Window Menu

Cascade

Cascade command arranges all windows in a progression from upper left to lower right of working area.

Tile

Tile command re-sizes all windows to fit within the working area.

Arrange Icons

Arrange Icons command aligns icons on the working area.

Window list 1, 2, 3...

List of opened windows on the working area. Selection of a window in the list focuses this window.

About Optoscope

About Optoscope command displays the version of the application.

Profile Window

A profile window shows the mean value of the intensity distribution of an image along the horizontal or vertical direction. It is based on the selected ROI. If no ROI is defined, the entire image is used to calculate the profile. Assuming a ROI with horizontal size of *j* pixel and vertical size of *i* pixel the profile PH_x in horizontal direction is calculated by:

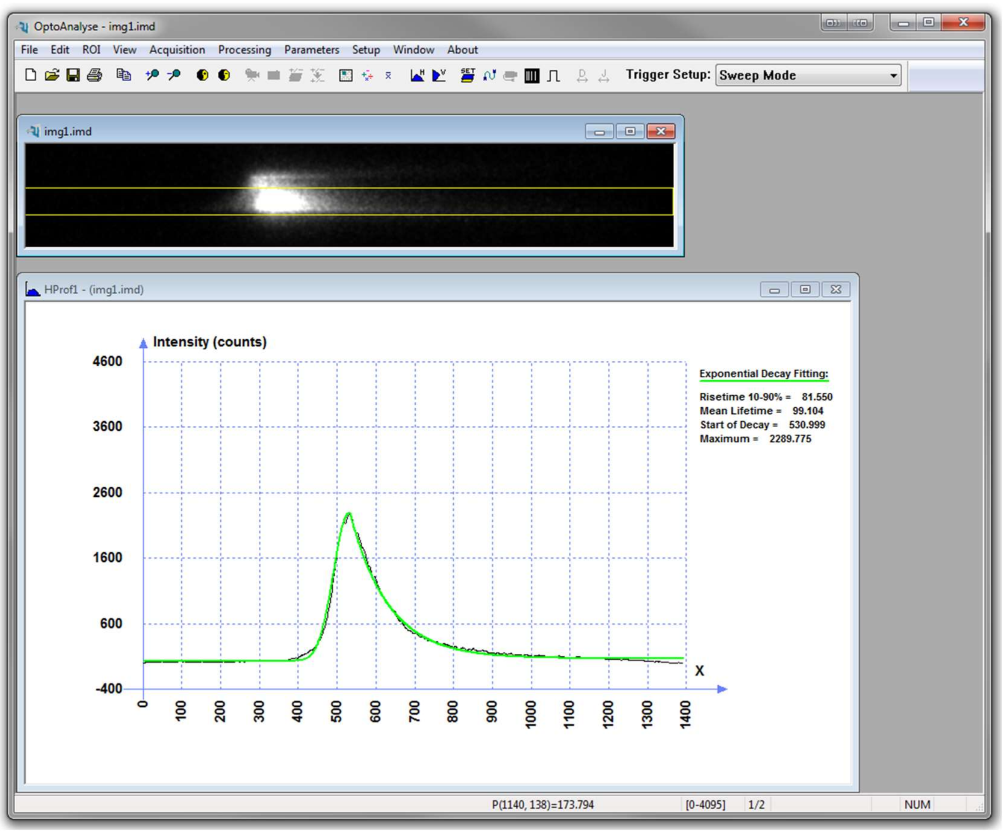
$$PH_x = \frac{1}{j} \cdot \sum_{y=0}^{j-1} I_{x,y}$$

A profile in vertical direction PV_y is calculated correspondingly by:

$$PV_y = \frac{1}{i} \cdot \sum_{x=0}^{i-1} I_{x,y}$$

Pixel intensity *I* at position *x, y* is referred as $I_{x,y}$. Each profile value is within -2.147•10^6 to +2.147•10^6 with 0.001 precision. The horizontal profile function is selected with *Processing* / Profile */ Horizontal* when a frame window is active. To select a vertical profile *Processing / Profile / Vertical*. is used.

The profile is **automatically refreshed** when the ROI on the frame window is modified or in case the frame window displays a real time image.



When the mouse cursor is moved on the profile surface, the status bar second field displays the intensity value of the profile at the cursor position. A range of interest can be defined.

Range of Interest

To create a range of interest:

- Position the mouse cursor on the left of the area to be selected.
- Press left button.
- Move the mouse cursor to the right, with left button always pressed.
- Release left button.

The range of interest is displayed by two blue cursors. Size and position could be changed using the mouse.

To change the position of the range of interest:

- Position the mouse cursor on the left blue line. The cursor shape changes when correctly positioned.
- Press left button and move the cursor.

To change the size of the range of interest:

- Position the mouse cursor on the right blue line. The cursor shape changes when correctly positioned.
- Press left button and move the cursor. To change the size symmetrically, press Shift at the same time.

Vertical Scaling

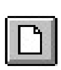
Vertical scale is modified using the **+** and **-** keys. The vertical offset is modified using the ↓ and ↑ keys.

Horizontal Scaling

The horizontal scale is shifted by pressing the → or ← keys. The **Page Down** keys zooms in and the **Page Up** key allows to zoom out.

File Menu

New



The **New** command creates a frame document and opens the corresponding Frame window. The window name is HProf (for a horizontal profile) or Vprof (for a vertical profile) follow by a number. This command doesn't create a histogram view.

Shortcut: Ctrl + N

Open

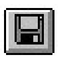
The **Open** command opens an existing document saved on the disk. This command enables to load frame, histogram or profile files. Files with the extension .PRH need to be selected if a horizontal profile has to be opened.

Shortcut: Ctrl + O

Close

The **Close** command closes the existing view.

Save



The **Save** command saves vertical profile in an ASCII file with an extension .PRV and horizontal profile in an ASCII file with an extension .PRH. These files could be read with EXCEL, MATHCAD or other software accepting ASCII file input.

A profile file is a succession of ASCII lines. A carriage return character terminates always a line. In each line, the coordinates of the point and the profile value is printed. A comma separates these values.

Shortcuts: Ctrl + S

Save As

The **Save As** saves the current document on the disk with a new name. The application opens the common WINDOWS dialog box to input the filename.

Print

The **Print** command opens the standard dialog box to print under WINDOWS.

Shortcuts: Ctrl + P

Print Preview

The **Print Preview** command opens a window which shows you the screen preview of the printing page.

Print Setup

The **Print Setup** opens the WINDOWS dialog box to setup the printer.

Exit

The **Exit** command closes the application.

Edit Menu

Copy like a Bitmap to the Clipboard

This copy command copies the view of the profile into the clipboard

Shortcuts: Ctrl + C

Copy like a Bitmap to the Clipboard

This copy command copies the view of the profile as ASCII file into the clipboard

Shortcuts: Ctrl + Shift + C

View Menu

Zoom In

This command allows to change the X-axis scale to enlarge the display. If a range of interest is defined the command scales the X-axis to display the entire range of interest. When the profile frame is zoomed, horizontal position of the view could be changed using the ← and → keys.

Shortcuts: Page Up

Zoom Out

This command allows to change the X-axis scale to zoom out. If no range of interest is defined, the entire profile is shown.

Shortcuts: Page Down

Linear Scale on Axis Y

The **Linear Scale on Axis Y** command displays the view of the profile with a linear scale.

Shortcuts: Ctrl + Shift + A

Logarithm Scale on Axis Y

The **Logarithm Scale on Axis Y** command displays the view of the profile with a logarithm scale.

Shortcuts: Ctrl + Shift +L

Drawing with Dots

The **Drawing with Dots** command displays the profile with a point for each value of the profile. This command deselects the Line command.

Shortcuts: Alt + D

Drawing with Lines

The **Drawing with Lines** command displays the profile with a line between two points of the profile. This command deselects the Dot command.

Shortcuts: Alt + L

White Background

The **White Background** command displays the profile with a white background. The profile is displayed with a black colour.

Shortcuts: Alt + W

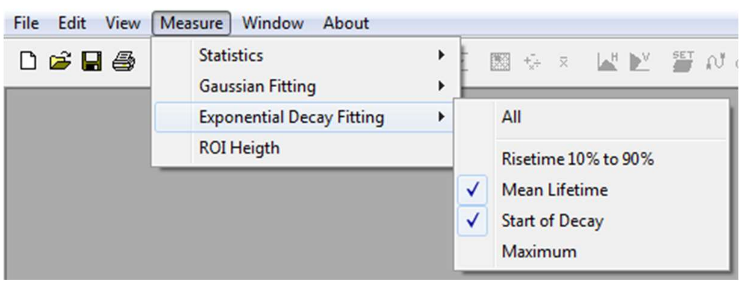
Black Background

The **Black Background** command displays the profile with a black background. The profile is displayed with a white colour.

Shortcuts: Alt + B

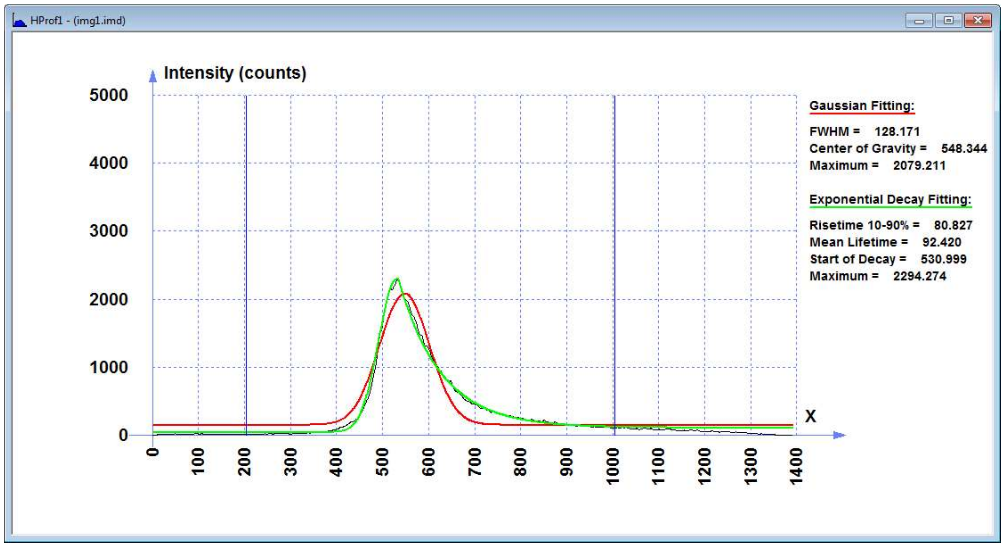
Measure Menu

The measure menus allow to define different measurements applied to the profile. To obtain a measurement it has to be marked with a ✓.



The results are displayed on the top right corner of the profile diagram. The results are also available and can be saved if a sequence is acquired. The processing time to calculate the measurements might be considered for measurements where frame rate is an important parameter. To increase frame rate measurements can be activated and removed individually.

The measurements are applied to the entire profile if no range of interest is defined. To limit the measurement to a particular part of the profile a range of interest can be defined. This can be done by left clicking and dragging the cursor to the right side of the profile.



Statistics

Full Width at Half Maximum (FWHM)

The FWHM measurement enables the calculation of the full width at half maximum value. To find the full width at half maximum, the system assumes a positive pulse on the profile. The maximum (MAX) on the profile as well as the left and right minima (MINl, MINr) are determined.

$$Height = MAX - \frac{1}{2}(MINl + MINr)$$

Center of Gravity

With P_x as profile descriptor the following function is applied.

$$COG = \frac{\sum_{x=0..i-1} x \cdot P_x}{\sum_{x=0..i-1} P_x}$$

Maximum

This command calculates the maximum of the profile.

$$MAX = Maximum(P_x)$$

Gaussian Fitting

The profile is fitted with a Gaussian function using the following formula:

$$F_{Gaussian}(x) = \frac{A}{\sigma\sqrt{2\pi}} e^{(x-\mu)^2 / 2\sigma^2} + offset$$

The resulting fitting function is displayed as a red line on the profile. In case the fitting was not possible, no result is displayed

Full Width at Half Maximum (FWHM)

The FWHM of the Gaussian function is calculated.

Center of Gravity

The center of gravity of the Gaussian function is calculated.

Maximum

The maximum intensity value of the Gaussian function is calculated. The measurement adds also the offset, if any, related to the dark counts or dark value.

Coefficient of determination (r^2)

The coefficient of determination of the Gaussian fitting is calculated. This coefficient is a statistical quantity between 0 and 1 describing the accuracy of the fitting curve in regards to the data set. A good fitting results in a value close to 1.

Exponential Decay Fitting

Two fittings are made. The first consists in a Gaussian fitting of the pulse's rising edge. The function used for this part is the same as for the previous Gaussian fitting but only the rising edge is fitted. The second fitting is using the following exponential decay expression:

$$F_{Exp\ decay}(x) = Ae^{(x-\mu)/\tau} + offset$$

The combined fitting function is displayed as a green line on the profile. In case the fitting was not possible, no result is displayed

Risetime 10% to 90%

The risetime of the rising edge part of the fitting curve is calculated. The risetime is computed between a 10% and a 90% amplitude level.

Mean Lifetime

The mean lifetime of the fitting curve is calculated. This value corresponds to τ in the $F_{Exp\ decay}$ expression.

Start of Decay

The start of decay is calculated. This corresponds to the intersection between the Gaussian portion of the curve and the exponential decay.

Maximum

The maximum intensity value of the fitting curve is calculated. The measurement adds also the offset, if any, related to the dark counts or dark value.

Coefficient of determination (r^2)

The coefficient of determination of the exponential decay fitting is calculated. This coefficient is a statistical quantity between 0 and 1 describing the accuracy of the fitting curve in regards to the data set. A good fitting results in a value close to 1.

Window Menu

Cascade

The command arranges all windows in a progression from upper left to lower right of working area.

Tile

This command resizes all windows to fit within the working area.

Arrange Icons

The command aligns icons on the working area.

Window list 1, 2, 3...

List of opened windows on the working area. Selection of a window in the list focuses this window.

About Menu

About Optoscope

The command displays the version of the application.

Annex A: Structure of Optoscope files

Frame file with extension .IMD (OptoAnalyse 3.0 and higher)

OptoAnalyse version 3.0 and higher is using the IMage Data (IMD) format to save the radiometric image information on a binary file with the following format.

- A header composed of three 16-bits values [IMD File Version] [W] [H]
- The header is immediately followed with W x H (lines x columns) values. Each value is a 32-bit signed integer representing the pixel intensity and multiplied by 1000. So the real intensity value is a floating point number Pfloat calculated from the 32-bit signed integer value Psi32 with the following formula:

Pfloat = Psi32 / 1000

Example:

```
    01 01 60 05 10 04
    68 42 00 00 F0 55 00 00 5C E4 00 00 30 F8 FF FF …
```

Version: 257
Image width W: 1376
Image heigth H: 1040
Intensities: 17, 22, 58.46, -2, …

To open an .IMD file, a standard C++ source code would be:

```
  FILE *file;
  file = fopen("test.imd","rb");
  if (file)
  {
    unsigned short int VER,W,H;
    // read file version
    // read image width
    // read image height
    fread(&VER,sizeof(unsigned short int),1,file);
    fread(&W,sizeof(unsigned short int),1,file);
    fread(&H,sizeof(unsigned short int),1,file);
    m_s32data = new signed int[W*H];
    // retrieve the 32-bits signed int buffer
    fread(m_s32data,sizeof(signed int),W*H,file);
    fclose(file);
    // If you want to create and use a floating buffer
    with the floating pixel value,
    // proceed like this
    float *fdata = new float[W*H];
    …
    for (int k=0;k<H*W;k++)
    fdata[k] = m_s32data[k]/1000;
    …
    delete fdata;
    …
    delete m_s32data;
  }
```

Image Information file with extension .IMI (from OptoAnalyse 3.0)

OptoAnalyse version 3.0 and higher saves an Image Information (.IMI) file to the same location as the .IMD file. The .IMI file is a standard text file that can be easily opened with any text editor. It contains all relevant setup parameters that had been used during the acquisition of the frame.

Frame file with extension IMG (up to OptoAnalyse 1.4)

This information could be used by programmers to read Optronis frame files. The programmer needs to have knowledge in C/C++ programming and Microsoft Foundation Classes. The IMG format is used to save 16 bits data of a frame.

First data in the file is the header containing the .IMG format version, the size of the offset pointer array and the offset pointer array itself.

The header contains:

C/C++ WINDOWS type	Data name	Comment
WORD	WfmtVer	.IMG format version
WORD	WAOffSz	size of offset pointer array
LONG	AlOff[]	data array of offset pointers

The offset is the number of bytes between the beginning of the file and the data. The offset pointer array AlOff[] is used to indicate the starting position of the data as follows:

Offset	Frame comment
AlOff [0]	Horizontal and vertical image size
AlOff [1]	comment
AlOff [2]	reserved
AlOff [3]	reserved
AlOff [4]	reserved
AlOff [5]	image intensity values in 16 bit integer format
AlOff [6]	reserved

The first pointer indicates the position of the horizontal and vertical size information of the image. Data pointed by AlOff[0] is:

C/C++ WINDOWS type	Data name	Comment
WORD	wImgWidth	frame width in pixel
WORD	wImgHeight	frame height in pixel

The second pointer indicates the position of the comment of the frame as entered with the *Frame Comment* command in the *Parameters* menu. Data pointed by AlOff[1] is:

C/C++ WINDOWS type	Data name	Comment
Cstring	strComment	comments of the frame

The pointer indicates the position of the beginning of binary image data. Data pointed by AlOff[5] is:

C/C++ WINDOWS type	Data name	Comment
WORD	wBinary[]	pixel array

Each pixel in the frame is a 16 bits data so the C/C++ WINDOWS type used is a WORD (unsigned 16 bits data). The software saves data line per line.

The pointers AlOff[2..4] and AlOff[6] are used for internal information storage. As the sizes of the corresponding data fields are not fix. Therefore the pointers should be used to find the required data instead of using fixed values that might be correct only for particular files.

Profile files with PRH and PRV extension

The profile file is an ASCII file used to save the data along a horizontal or vertical profile. The extension is PRH for a horizontal profile and PRV for a vertical profile. The array below shows the structure of the ASCII file.

Calibrated Coordinate	Value	Coordinates of the ROI				Terminator
⇓	⇓	⇓				⇓
Position1,	Value1,	Left,	Top,	Right,	Bottom	CR/LF
Position2,	Value2					CR/LF
Position3,	Value3					CR/LF
.	.					.
.	.					.
PositionN,	ValueN					CR/LF

Each line contains the horizontal (PRH) or vertical (PRV) position and the corresponding value. The numbers are separated by a comma followed by a blank and the lines are terminated by a sequence of characters CR/LF (equivalent in C/C++ to the string « \r\n »). The first line additionally contains the pixel coordinates of the ROI used to calculate the profile.

The column named **Calibrated Coordinate** is the position on the horizontal axis (PRH files) or the position on the vertical axis (PRV files). If no axis calibration is used each number is an integer value of the pixel position. If the calibration is activated, floating point numbers with a point separating the integer and the decimal part are used.

The column named **Value** is the intensity value of the profile. Up to version 1.46 of the software, a 16 bit integer value is calculated by adding the pixel intensity values. From version 3.00 a floating number is used. This number is also calculated by adding the pixel intensity values but additionally the result is divided by the vertical or horizontal size of the ROI respectively.

The **Coordinates of the ROI** added to the first line are integer values of the upper/left and lower/right pixel positions of the ROI used to create the profile.

Histogram file with HIS extension

The histogram file is ASCII file used to save the histogram information. The extension of the file is HIS. The array below shows the structure of the file

Luminosity Range		**Value**	**Coordinates of the ROI**				**Terminator**
⇓		⇓	⇓				⇓
Start1,	End1,	Value1,	Left,	Top,	Right,	Bottom	CR/LF
Start2,	End2,	Value2					CR/LF
Start3,	End3,	Value3					CR/LF
.	.						.
.	.						.
.	.						.
Start256,	End256,	Value256					CR/LF

Each line contains the luminosity range and the corresponding value. The numbers are separated by a comma followed by a blank and the lines are terminated by a sequence of characters CR/LF (equivalent in C/C++ to the string « \r\n »). The first line additionally contains the pixel coordinates of the ROI used to calculate the profile.

When a histogram is calculated, always 256 luminosity groups are used. If for example the intensity range 0..16383 is displayed during the histogram calculation, Start1=0, End1=63 and Value1 is the number of pixels with intensities between 0 and 63.

The two columns named **Luminosity range** is the range of luminosity used to obtain the value. The Start is the first luminosity level and the End is the last luminosity level used. Each Start and End is an integer number.

The column named **Value** is the number of pixel. Each Value is a long integer (OptoAnalyse version 1.46) or a signed integer (OptoAnalyse version 3.0 and higher). For example, if the displayed intensity range is 0 .. 255, the Value1 is the number of pixel with the value 0. The Value256 is the number of pixel with the value 255.

The **Coordinates of the ROI** added to the first line are integer values of the upper/left and lower/right pixel positions of the ROI used to create the profile.

Photon Counting Event File

The text file contains a list of positions where a single photon had been detected.

Example:

```
Photon counting event file

X = Pixel
Y = mm

[0]
94
207
154   0.0129
475   0.04515
…
221   6.5661
[1]
62
179
596   0
913   0.03225
264   0.0387
…
```

Headline: The first line shows the headline.

X, Y The measurement units in “X” and “Y” direction are indicated on line 3 and 4.

Remark: X and Y refer to the sensor orientation and not strictly to the horizontal and vertical direction of the displayed image. X would correspond to the horizontal display axis and Y to the vertical one, only in case rotation is set to 0° and neither horizontal nor vertical flip is activated on the *Setup/Readout Camera* menu.

[0], [1] Image number

Interval Time in Milliseconds (showing 94 ms and 62 ms in this example) between successive images. Details: With each start of the image analysis for photon counting, the time since the last start is indicated. The first interval for image [0] indicates the time since the image acquisition had been started. Accumulating all intervals for image [1] till the last image corresponds to the time needed for the complete acquisition.

Events Indicates the number of events detected on this image. (showing 207 and 179 events in this example). One event is interpreted as one detected photon.

Coordinates For each detected photon the X and Y coordinate is given in one line. The relation between pixel coordinate and indicated value in X is defined by the horizontal scaling definition *(Setup/Scaling)*. The relation between pixel coordinate and indicated value in Y is defined by the vertical scaling definition *(Setup/Scaling)*.
Remark: Calibrated coordinates might be wrong in case image

rotation is set to 90° or in case either horizontal or vertical flip is activated on the *Setup/Readout Camera* menu.

Annex B: List of shortcuts used with the keyboard

Shortcuts for all sections

Ctrl + N	Creates a new document of frame type
Ctrl + O	Opens a document from disk for all types of document supported
Ctrl + S	Saves the current document on disk
Ctrl + P	Prints the current document
Ctrl + C	Copy the current document to the clipboard

Shortcuts for the frame section

Ctrl + D	Applies the current ROI to all other frame windows
Page Up	Zooms in
Page Down	Zooms out
Alt + M	Displays the frame with a linear gray palette
Alt + G	Displays the frame with a gamma corrected gray palette
Alt + C	Sets the pseudo color palette and displays the frame with it
+	Modifies the barrel shifter to see the lower levels of luminosity
-	Modifies the barrel shifter to see the higher levels of luminosity
Alt + R	Starts / stops the real-time display
Alt + S	Acquires one frame in memory
Alt + A	Acquires frame in accumulation or photon counting mode
Shift + F	Opens the digital filter manager dialog box
Shift + O	Processes arithmetic operation
Shift + M	Processes mean value and standard deviation in the frame ROI
Shift + U	Executes a uniformity correction using a previously saved frame
Shift + Q	Executes a distortion correction using the pre-defined distortion correction file
Ctrl + H	Builds a histogram frame
Shift + H	Builds a profile frame doing a projection along the horizontal axis
Shift + V	Builds a profile frame doing a projection along the vertical axis

Shift + I	Sets current frame comment
Alt + O	Loads the current calibration from the disk
Alt + T	Opens the X and Y scaling setup
Alt + N	Flag to apply the default calibration to new frame
Shift + A	Sets acquire parameters used in accumulation or photon counting
Shift + S	Sets sequence name and slice time between each acquisitions
Shift + T	Sets the threshold used in photon counting mode
Shift + N	Opens the timing controller setup
Alt + Shift + G	Opens the geometrical correction setup box
Shift + R	Selects the device used to readout the streak information
Shift + C	Remote controls of the camera
Shift + D	Activates drift correction
Shift + J	Activates jitter correction
Shift + E	Opens correction dialog box for drift/jitter parameter setup

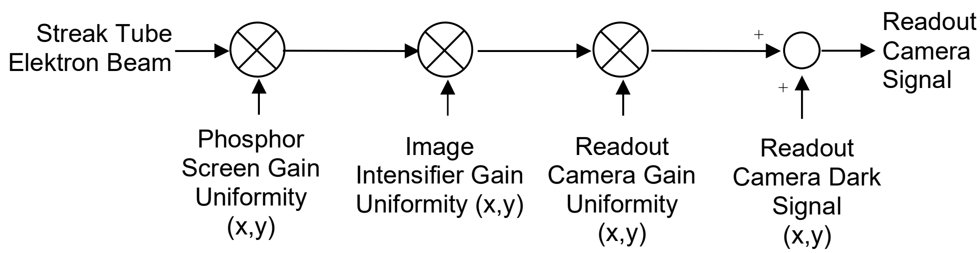
Shortcuts for the profile section

Page Up	Displays the profile part delimited by the two cursors
Page Down	Displays all the profile
Ctrl + Shift + A	Displays the profile with a linear scale
Ctrl + Shift + L	Displays the profile with a logarithm scale
Alt + D	Displays the profile with separated points
Alt + L	Displays the profile with lines between each points
Alt + W	Sets the background color to white
Alt + B	Sets the background color to black

Annex C: Correction Techniques

Principal Considerations

The acquisition and processing algorithms used with this software allows to correct a certain number of streak camera and readout camera imperfections. The following description is based on this system model.



The conversion efficiency of the streak tube phosphor screen, the gain of the image intensifier (if installed) and also the sensitivity of the readout camera including the coupling between screen and sensor chip is ideally constant all over the active readout area. Practically it is a function of position and to a minor extent also of the gain adjustment of the image intensifier. The conversion efficiency of the streak tube phosphor screen and the image intensifier gain might be modified by small area defects like blemishes (small dark spots). Larger area defects are typically caused by MCP gain non-uniformity or coupling optics vignetting. The uniformity of streak tube phosphor screen, image intensifier and readout camera can be combined to one single uniformity process. The dark signal of the readout camera is added to the image from the streak camera. All defects typically have a fixed pattern character. Therefore the components should not be moved with respect to each other after the dark signal frames and uniformity frames are acquired. The display orientation as defined in the readout camera setup box must not be changed after the acquisition of dark signal frames or uniformity frames.

In order to use the correction algorithms effectively and to obtain best results, the correction frames need to be acquired in a specific way. To optimize the correction algorithm it might be necessary to adapt the acquisition procedure to specific operation conditions.

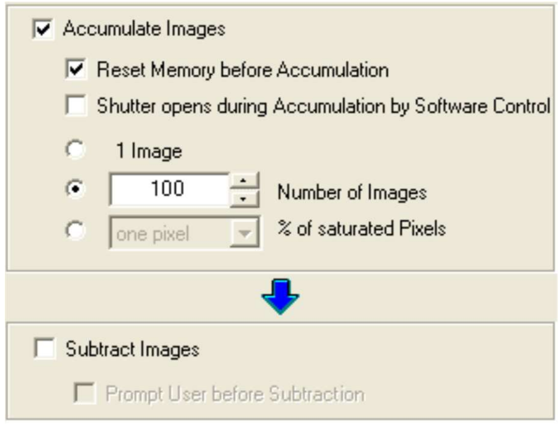
Acquisition of Dark Signal Frame

In order to allow a dark signal correction, the darks signal has to be acquired separately. For most systems, the dark signal should be acquired the following way:

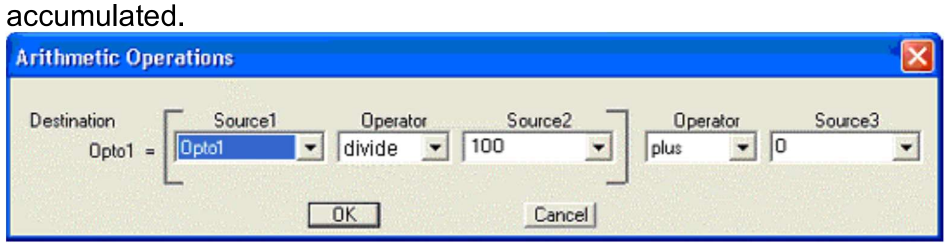
1. Reduce the streak camera gain to minimum and switch of the image intensifier (if installed) by selecting a non-active trigger source. Alternatively, the streak camera might be completely switched off.
2. Select the readout camera setup box and adjust the parameters similar to those to be used during image acquisition later. Typically no binning,

full sensor readout region, 40ms integration time and continuous readout mode should be selected.

3. Select the acquisition setup box and deactivate all corrections. Set accumulation to 100.



4. Start acquisition after the readout camera has been operated for at least 30 minutes.
5. The acquired frame needs to be divided by the number of frames accumulated.



6. Save the frame on disk. If different setup parameters for the readout camera will be used during the system operation later, it is possible to repeat this procedure for different setups and to save different dark frames on disk.

Acquisition of Uniformity Frames

The acquisition of uniformity frames allows to correct the non-uniformity of the system. The way how the uniformity frames need to be acquired depends upon the parameters (intensifier gain, accumulation mode, correction algorithm) set for the system operation later. Mainly the accumulation mode used later on needs to be known for correct uniformity frame acquisition. Typically the following description will give a useful help:

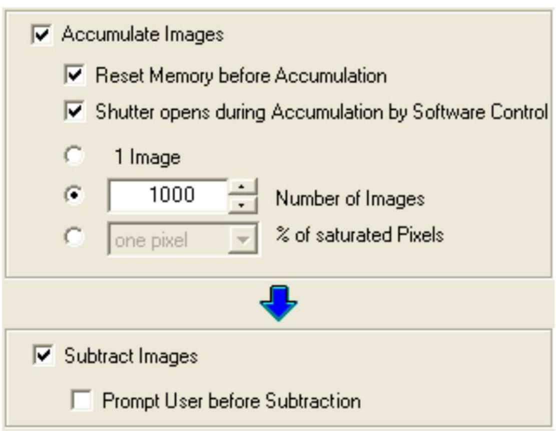
1. Operate the streak camera with one sweep unit. FSSU1 or STSU1 are best suited but also FTSU1 can be used. For FSSU1 select the fastest speed and provide the synchronization signal with the nominal frequency. For STSU1 10 µs/mm and for FTSU1 500 ps/mm should be selected. This units need to be triggered at about 1 kHz.
2. A variable and continuous light source is needed to illuminate the input slit homogeneously. The slit should be set to about 100 µm.

3. The image intensifier should operate in continuous mode. Intensifier gain should be set to about 50% to 75% its max. voltage. Other gain setting can be used if the streak camera is typically operated at this gain.

4. Select the readout camera setup box and adjust the parameters similar to those to be used during image acquisition later. Typically no binning, full sensor readout region and continuous readout mode should be selected. Integration time can be set to larger values in order to get a good signal to noise ratio during uniformity frame acquisition.

5. Close the fish-tail slide, activate the real-time mode of the readout camera and open the electro-magnetic shutter (if available). Now slowly open the fish-tail slide and adjust slit width and illumination in order to get a uniform image on the screen. The intensity should be significantly higher than the noise level but still far from readout camera saturation. Close the shutter during the following setup.

6. Set the acquisition mode without any uniformity correction activated but with the option to subtract images.



7. Start acquisition after the readout camera has been operated for at least 30 minutes. Verify during the accumulation that no saturation of the memory occurs. Reduce number of images is necessary.

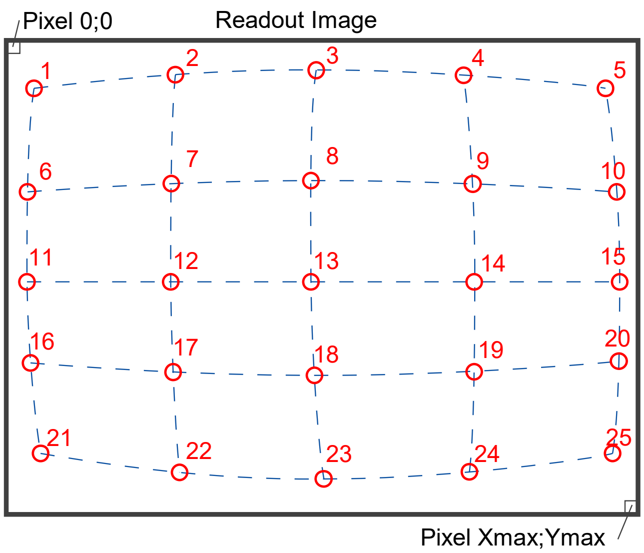
8. Save the frame on disk. If different image intensifier gains will be used during the system operation later, it is possible to repeat this procedure for different setups and to save uniformity correction frames on disk.

Distortion Correction

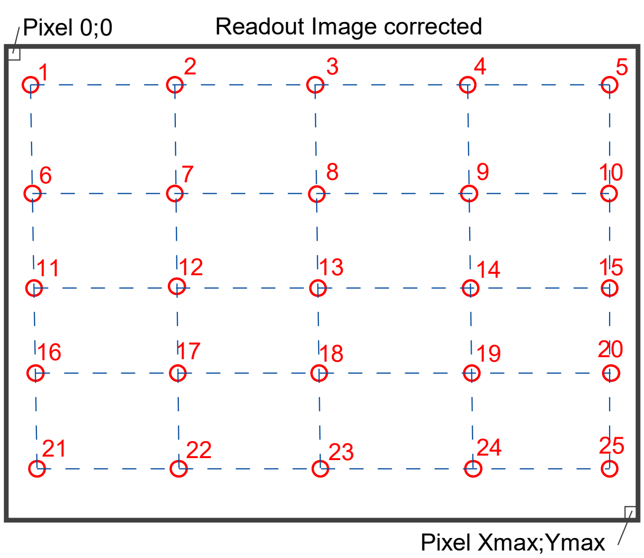
Principle

Non perfect imagine characteristics of optical or electro-optical components may be present causing objects to appear deformed on the image. The OptoAnalyse software allows to correct typical defects like barrel and cushion distortions introduced by input optics, streak tube or readout camera.

Figure below shows the readout image of a system with barrel distortion. Points 1 to 25 should appear aligned on straight lines instead on bended lines.



For each bended line a straight line is calculated to pass as close as possible the all relevant points. The image is deformed to move each point to its position on this straight line. The resulting image is shown below.



The distorted frame might be capture by the readout camera alone. In this case the defects of only the readout camera will be corrected. If the distorted frame is captured by using the streak tube, also the associated distortion effects of the streak tube are corrected.

In case distortion correction is used in combination with jitter correction the results will in principle not be correct. For practical work it will depend on the amount of jitter expressed in pixels compared to the total pixel count whether the distortion correction might still improve measurement quality.

To enable distortion correction, the distorted image is used and points on horizontal and vertical lines are defined. The more points are used the better the result. Typically 25 to 200 points should allow a precise correction. The points are defined and a matrix of points has to be available as distortion text file (.txt). The correction is not aligning the points on strictly parallel lines nor is the algorithm aligning the points on equally spaced lines. The image used for point definition has to be acquired with the same spatial resolution and image orientation as the images that need to be corrected.

The distortion correction can be initiated for each image individually by using the **Distortion Correction** command on the **Processing** menu. The distortion correction can be done automatically at the end of each acquisition by activating the corresponding correction on the **Acquisition Setup** menu.

Distortion Correction with different Display Orientation

The display orientation of the image acquired by the readout camera can be defined according to the Setup/Readout Camera. The image format used for image saving corresponds to the display format. In order to obtain the required distortion correction, the distorted image has to be acquired with the same display orientation as the images that need to be corrected later. So after the acquisition of the distorted image and the generation of the distortion text file, the display orientation must not be modified. In case where the distortion correction is correcting also the streak tube distortion also the mechanical installation of the readout camera on the streak unit must not be modified.

Distortion Text File

To allow the distortion correction a matrix of points need to be defined and saved on the distortion text file. This file might be generated manually by using a text editor. Pixel coordinates can be calculated with OptoAnalyse or any another method. An alternative and somewhat easier way is to use the graphical distortion grid editor available at SETUP/DISTORTION CORRECTION menu.

For both ways to generate the distortion text file, general guidelines should be considered. The point definition is based on an image showing the distortions that need to be corrected. The horizontal and vertical pixel positions of each point need to be determined. As shown above the points have to be aligned on lines. The line orientation should be horizontal or vertical. The lines do not need to be parallel nor equally spaced. The matrix of points should cover to whole image to avoid artefacts caused by extrapolation.

For manual distortion text file generation the list below shows the requirements of the distortion text file:

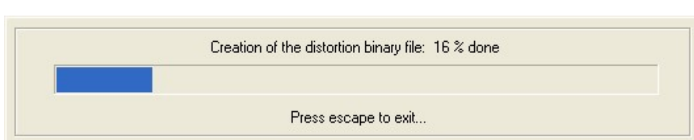
- The first line of the text file defines the total number of pixels (maximum pixel number Xmax + 1 and Ymax + 1) in horizontal and vertical direction. Both numbers are separated by a semicolon (;). Images that will be corrected have to have the same number of pixels.
- Each point is defined by its pixel coordinate. The coordinate can be integer or real. The first number defines the horizontal position, the second number defines the vertical position. The numbers are separated by a semicolon (;).
- The number of points has to be identical for every horizontal line.
- The number of points has to be identical for every vertical line.
- The number of horizontal lines has to be min. 5 and the number of vertical lines has to be at least 5.
- All points on a horizontal line are typed on one text line. The points are separated by a slash (/). The line ends with carriage return.
- The order as shown above has to be respected. The first point on the first line on the distortion image has to be defined first on the distortion text file.
- Additional space characters can be used.

The Text file below shows an example with an image with 1392 x 1024 pixel size having 5 horizontal lines and 5 points for each line.

```
1392;1024
50;27 / 393;10.5 / 804;5 / 1172.5;14 / 1348;23
44;338 / 394;328 / 813;325 / 1186;327 / 1364;330
45;565 / 397;564 / 818;562 / 1191;558 / 1369;556
53;840 / 403;845 / 820;844 / 1191;833 / 1368;826
55;990 / 405;997 / 820;998 / 1189;981 / 1367;973
```

Distortion Binary File

For the execution of the distortion correction the distortion binary file is needed. This file is calculated by the OptoAnalyse software.

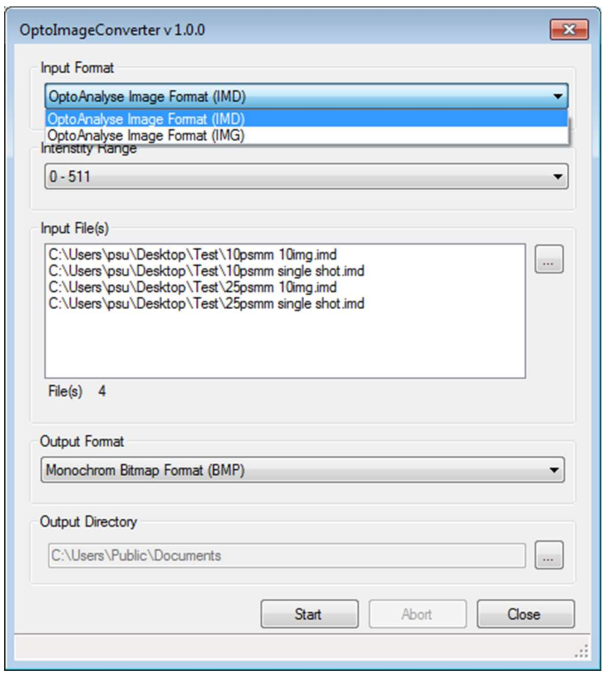


The distortion binary file is created when distortion correction is activated on the **Processing Menu** or when distortion correction is defined in the **Acquisition Setup**. The file is saved with the same file name as the distortion text file but with the extension .bin. Both files have to be saved in the same directory. In case no distortion binary file is available or in case the date and time code of the binary file is older than the text file, a new binary file is calculated.

Annex D: OptoImageConverter

OptoImageConverter is a separate tool. It is used to convert images saved with OptoAnalyse in the original .IMG or .IMD format into other formats like BMP, TIFF or RAW. A number of images can be converted in a single process instead of opening the images with OptoAnalyse and converting them individually. All images need to be located in a common directory. The same intensity conversion is applied to all images.

After program start the *Input Format* of the source image has to be selected.

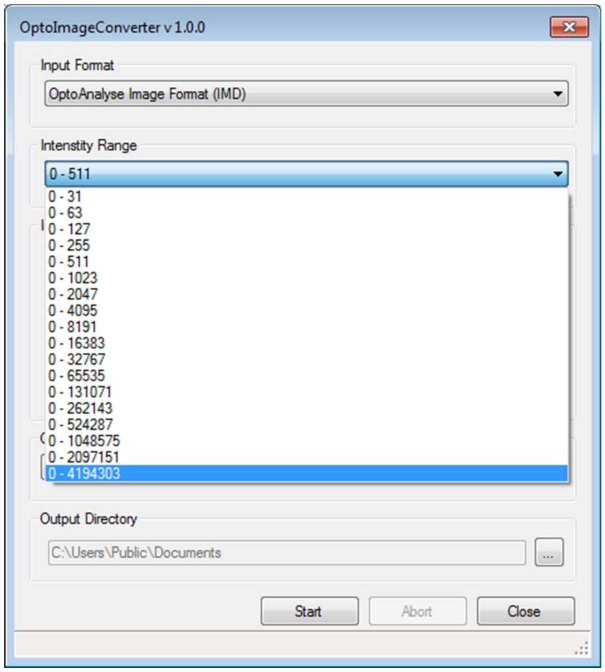


The *Intensity Range* defines how the intensity of the source image will be converted to the intensity of the output image.

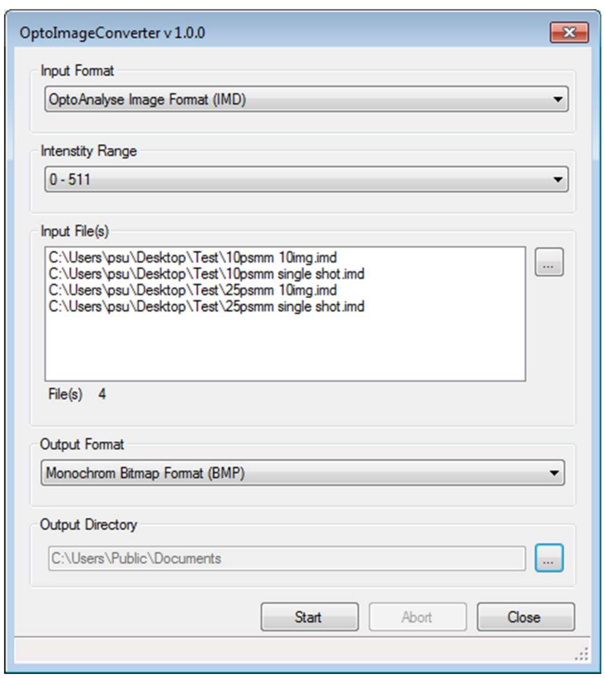
Example: Selection of intensity range 0 - 511 will result in a BMP image where 511 on the source image is converted to 255 on the BMP image.

Selection of intensity range is needed for BMP and TIFF output formats. For this formats, all negative intensity values on the source image are converted to 0. All intensities on the source image that are above the max. range are converted to the max. for BMP and TIFF outputs.

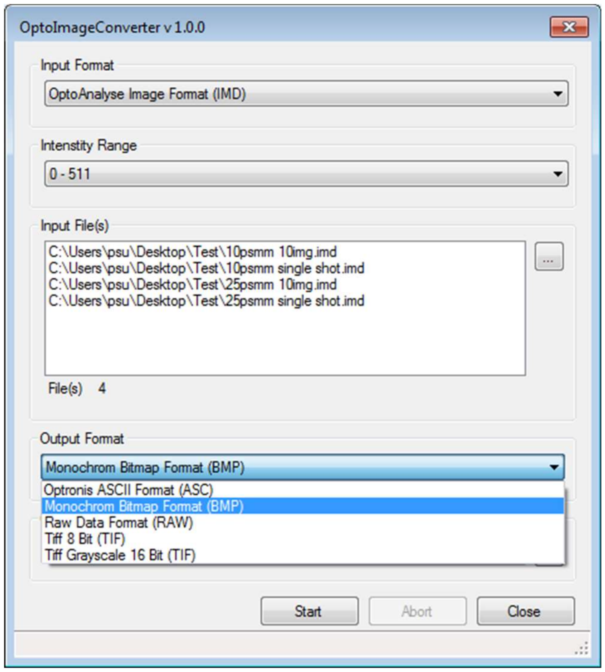
For ASCII and RAW formats this selection is not taken into account.



The source images are defined on the *Input File(s)* box. Just open the directory and click on the file or select multiple files by using the CRST or SHIFT keys while clicking.



Select the *Output Format*.



The *Output Directory* can be selected. It might be the same as the directory where the source images are located.

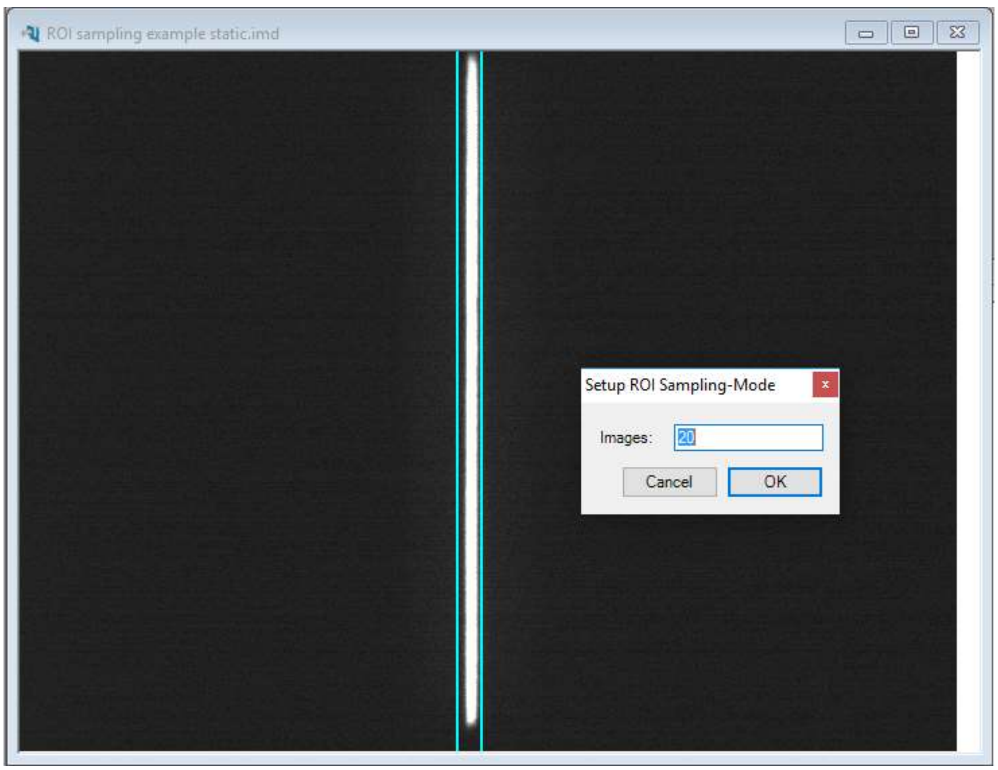
After Start all input files are processed and saved on the output directory. File name remains but extension is changed. Existing files with the same name are replaced without prior warning.

Annex E: ROI Sampling Mode

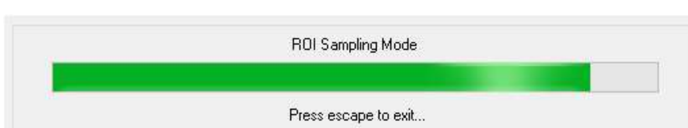
This mode is used to capture very slow processes where sweep speed is too fast. ROI Sampling mode is based on a static image of the slit and can be used with the SRU-BA camera only. Temporal variations of intensity along the slit are captured by the readout camera. Frame rate of readout camera is defining sample rate of this mode.

ROI Sampling is assuming a static image with orientation of the input slit to appear vertically for *Display Orientation* set to 0° (see *Setup → Readout Camera* menu). If *Display Orientation* set to 90°, image of static slit has to appear in horizontal direction. Physical orientation of readout camera needs to be set accordingly.

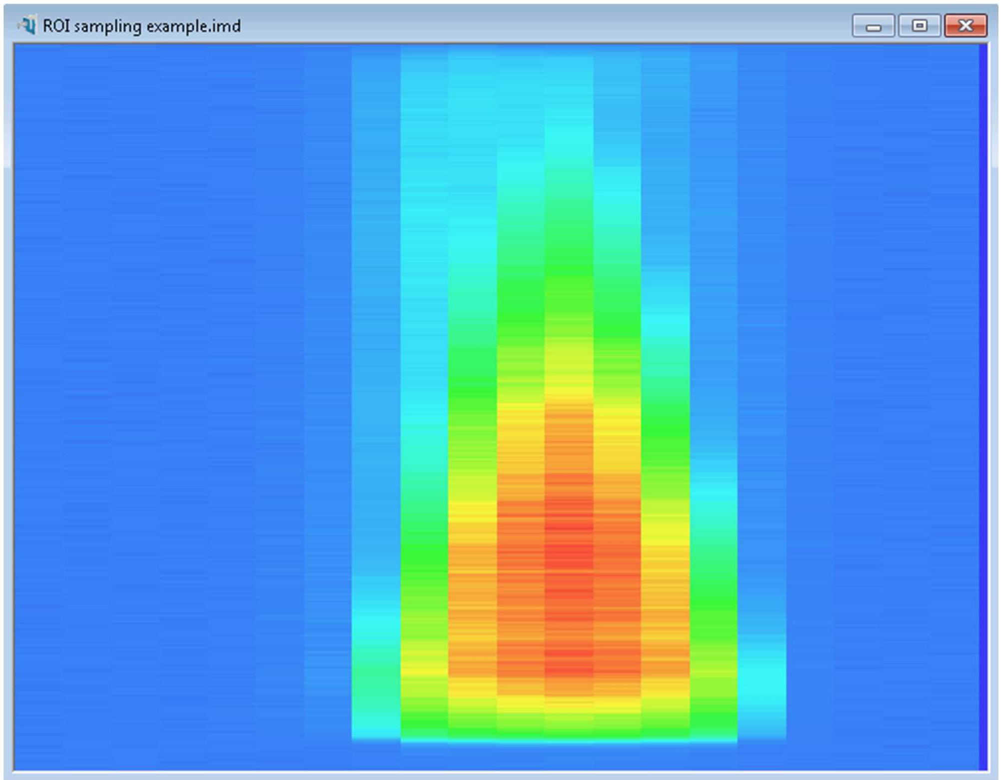
First, the ROI used to capture the static signal needs to be defined. This is done by activating the *Setup → ROI Sampling* menu. Example below is showing slit orientation with *Display Orientation* set to 0°.



Mean intensity is calculated within the blue ROI for each line in horizontal direction. So horizontal intensity variation within the ROI is not processed further. Vertical intensity variations are maintained. After setting up the ROI Sampling mode, ROI sampling can be started on the *Acquisition → ROI Sampling* menu. During sampling a progress bar is shown.



The resulting image after ROI Sampling might be similar to this. Remark: For *Display Orientation* set to 90° resulting image appears rotated 90 °.



Each sample is a vertical rectangle having the same vertical height as the resulting image. Intensity in horizontal direction is constant and corresponds to the mean intensity on the blue sampling ROI. Width of the rectangular is defined by using the integer part of the quotient of the total image width in pixel and the number of samples defined on the *Setup→ ROI Sampling* menu. All rectangles are placed on the resulting image side by side beginning from left. Due to truncation, some pixel on the right of the image might remain zero.

Readout camera can be operated in continuous mode (Cont) or external trigger mode (Ext.). For both modes, time interval is measured by software to determine time scaling of the resulting image. In case of external triggering of the readout camera, time scale can be set manually to the precise number.

Remark:

For external trigger mode, maximum frame rate of readout camera is a limiting parameter. This parameter is given on the datasheet of the readout camera. Additionally, operation mode and integration time of the readout camera as well as PC performance and active image processing (profile calculation, fitting algorithms, …) needs to be taken into account

If external trigger frequency is higher than maximum frame rate, images might be missing. It is therefore recommended to pay attention to this point and not to operate the system close to its maximum frame rate.

Trouble Shooting

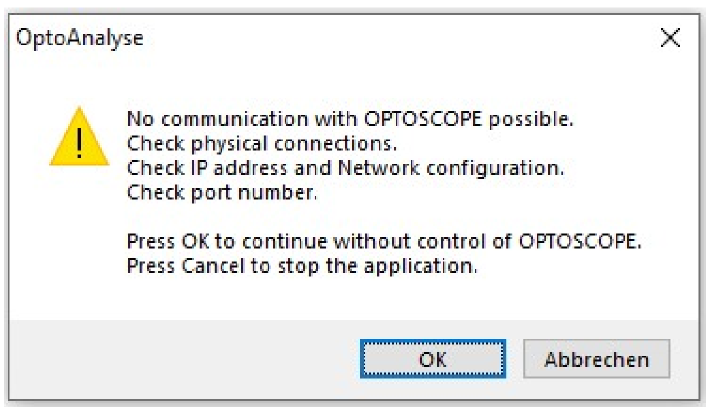
Nothing happens after program start

It is likely that .NET framework is not installed on the PC. Follow windows instructions to install .NET framework 3.5x. On Win 10 system the framework is a feature to be activated.

Program Start

After starting OptoControl the program tries to communicate with the streak camera.

In case the communication is not possible the box below appears.



Make sure the streak camera is in Standby mode or On mode. Verify the network cable is used and plugged correctly.

Also verify whether the OptoAnalyse software had been installed in a multi camera configuration. In this case the INIT.INI file contains the serial number of the streak camera. INIT.INI file configuration and physically connected device have to fit.

IP and Mask of Streak Camera unknown

If no communication with the camera is possible verify the correct IP setting of the OptoControl Program. Set the IP and Mask according to the indications on the rear of the streak camera main unit.

IP Conflict

An IP conflict might appear in case the static IP of the streak camera is used by another device in the same network. Consult the network administrator to prevent other devices to use the static IP of the streak camera. Alternatively a peer-to-peer connection can be used to avoid any conflicts.

Password Unknown

If no communication with the camera is possible verify the correct IP setting of the OptoControl program. Set the IP and Mask according to the indications on the rear of the streak camera main unit.

Two Ethernet Interfaces on the PC

If more than one Ethernet interface is installed in the PC make sure to use different sub-networks as underlined below. Example:

IP1: 192.254.127.254

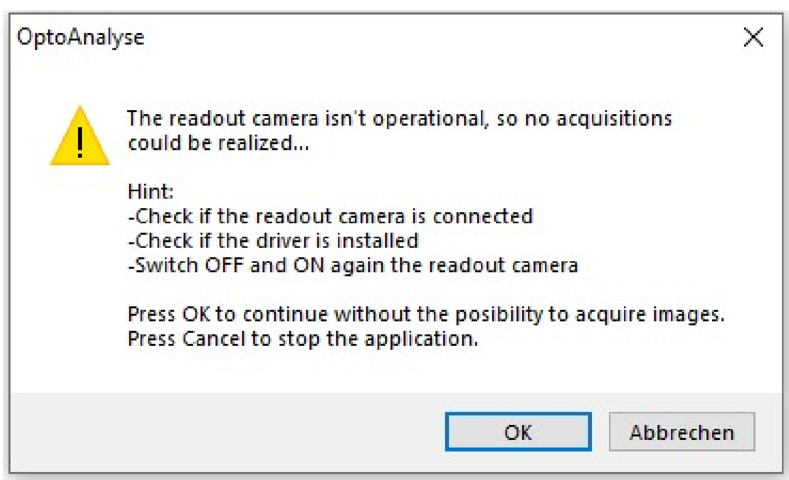
IP2: 192.254.128.12

Network Settings Reset

In case none of the hints above allowed to establish a communication with the SC-xx streak camera, the network parameters of the camera can be set to the factory settings. Please refer to the streak camera user manual for details.

Readout Camera not found

After program start the OptoAnalyse software tries to communicate with the readout camera. In case communication fails an error message is displayed.



Please verify:

1. Is there a physical link between the PC and the readout camera?
2. Is the readout camera powered up (except ANIMA-PX)?
3. Is the OptoAnalyse compilation consistent with the readout camera connected? See below for details.
4. Switch OFF and ON again the readout camera prior to start OptoAnalyse

5. Readout camera IP address for the SRU-BA model
6. If SRU-ED readout camera is used with camera firmware 5.16 or later, OptoAnalyse version 3.74 or higher is needed.

Press *Ignore* if the OptoAnalyse software should be operated in stand-alone mode for example for post measurement analysis.

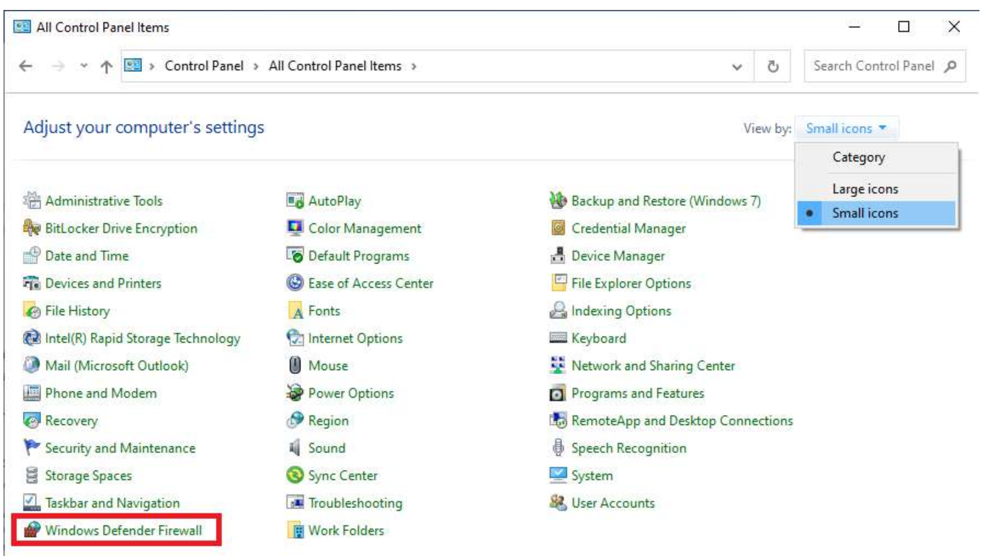
Press *Abandon* if the software will be used for measurements. Connect the readout camera and make sure the camera is operating before the OptoAnalyse program is started again.

SRU-BA or SRU-BC Readout Camera does not send any image

If the camera is in external trigger mode, please make sure that a trigger signal is applied.

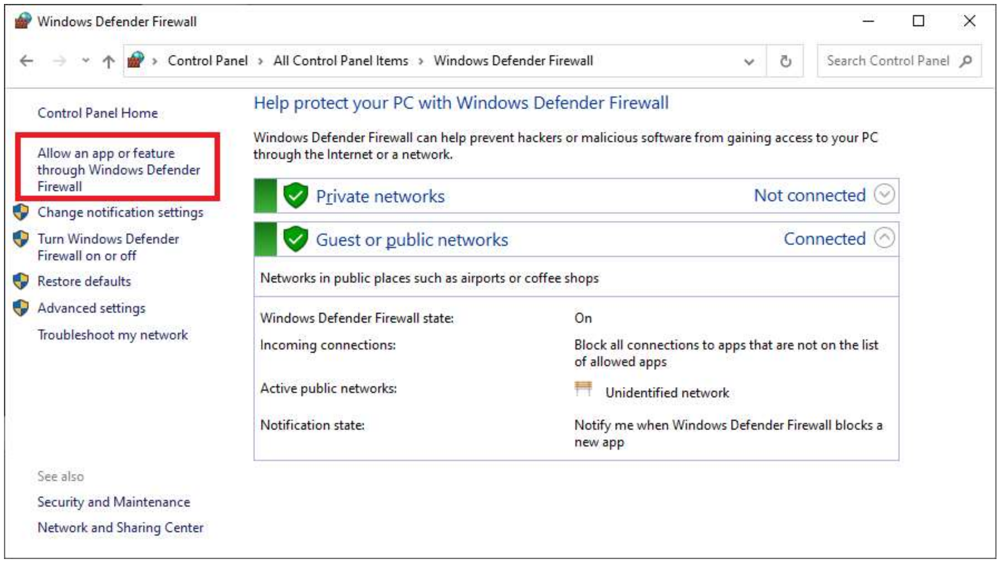
Windows 10 firewall default settings prevent the SRU-BA or SRU-BC camera to communicate with OptoAnalyse. To solve this problem, you might need to manually set a firewall exception. Please understand that the following description is an example only. Evolution of Windows operation software might require some adaptations.

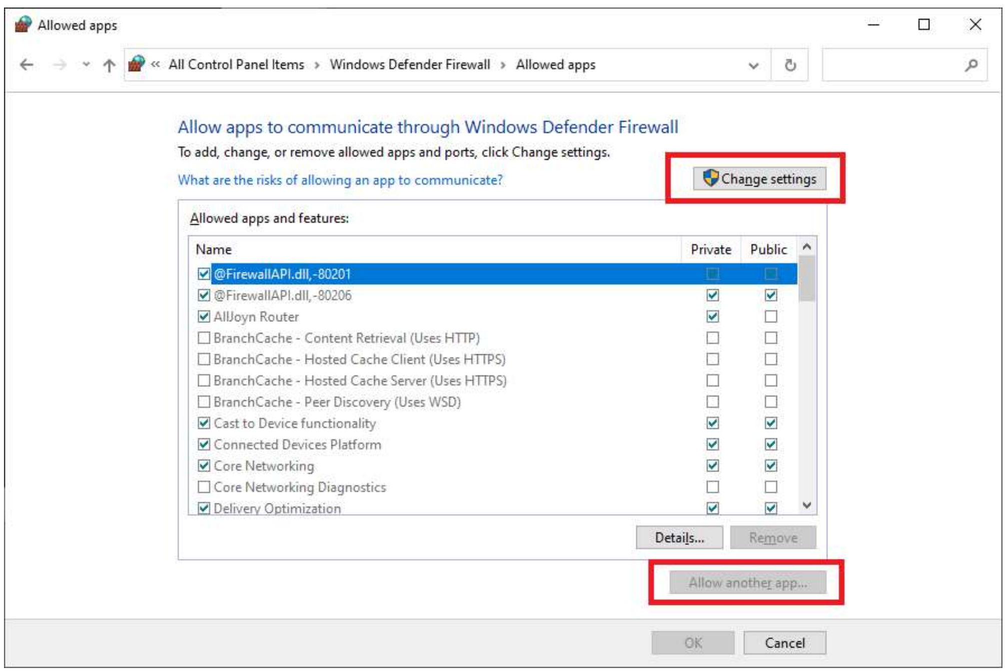
Type *firewall* in your windows start menu or open Control Panel

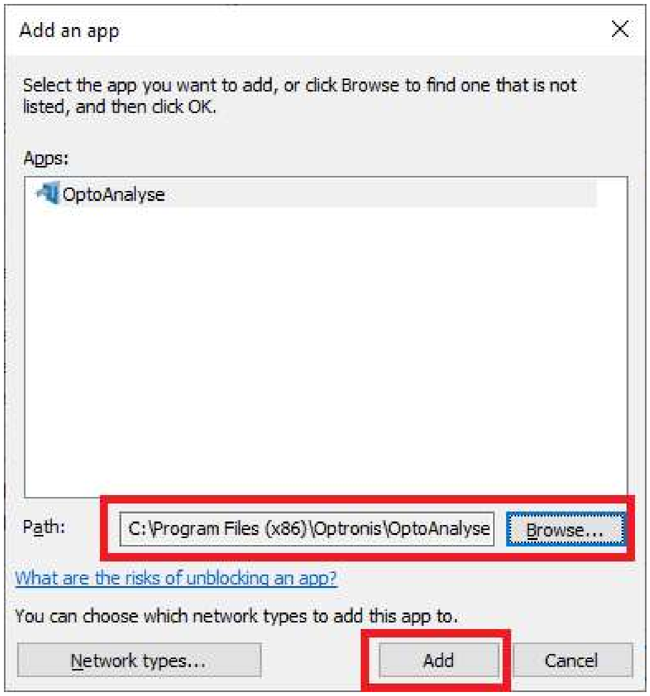


Use Windows Firewall with Advanced Security. In the opened window click on *Inbound Rules* on the left panel and look for two OptoAnalyse or OptoAnalyseNet lines. Double click on each line to open the rule properties. Inside the property dialog box go to the General tab and authorize the communication by checking the *Allow the connection* checkbox.

Similar procedure is shown here:


Windows Defender Firewall
Control Panel > All Control Panel Items > Windows Defender Firewall
Search Control Panel
Control Panel Home
Allow an app or feature through Windows Defender Firewall
Change notification settings
Turn Windows Defender Firewall on or off
Restore defaults
Advanced settings
Troubleshoot my network
See also
Security and Maintenance
Network and Sharing Center
Help protect your PC with Windows Defender Firewall
Windows Defender Firewall can help prevent hackers or malicious software from gaining access to your PC through the Internet or a network.
Private networks
Not connected
Guest or public networks
Connected
Networks in public places such as airports or coffee shops
Windows Defender Firewall state:
On
Incoming connections:
Block all connections to apps that are not on the list of allowed apps
Active public networks:
Unidentified network
Notification state:
Notify me when Windows Defender Firewall blocks a new app


Allowed apps
« All Control Panel Items > Windows Defender Firewall > Allowed apps
Allow apps to communicate through Windows Defender Firewall
To add, change, or remove allowed apps and ports, click Change settings.
What are the risks of allowing an app to communicate?
Change settings
Allowed apps and features:
Name
Private
Public
@FirewallAPI.dll,-80201
@FirewallAPI.dll,-80206
AllJoyn Router
BranchCache - Content Retrieval (Uses HTTP)
BranchCache - Hosted Cache Client (Uses HTTPS)
BranchCache - Hosted Cache Server (Uses HTTPS)
BranchCache - Peer Discovery (Uses WSD)
Cast to Device functionality
Connected Devices Platform
Core Networking
Core Networking Diagnostics
Delivery Optimization
Details...
Remove
Allow another app...
OK
Cancel



OptoAnalyse does not show readout images

The OptoAnalyse software is compiled according to a specific readout camera. Optronis makes sure to provide the right program compilation according to the actual customer configuration. To verify whether the program compilation is consistent with the readout camera, please use the *About OptoAnalyse* command in the *About* menu. Contact your distributor or Optronis for assistance.

SCRU-SE-A Readout Camera is not working

Hints when the LED on the camera is not green:

- LED is off: Camera is off. Verify power supply connections and switch on the camera.
- LED is red: No communication between frame-grabber and camera. Verify cable between camera and frame-grabber. The coaxial cables might be inverted or the PC might be switched off.
- LED is blinking red/green: SENSOR temperature is still too high. Wait until SENSOR operating temperature is reached.
- LED is blinking red: SENSOR temperature is still too high and coaxial cables are inverted.

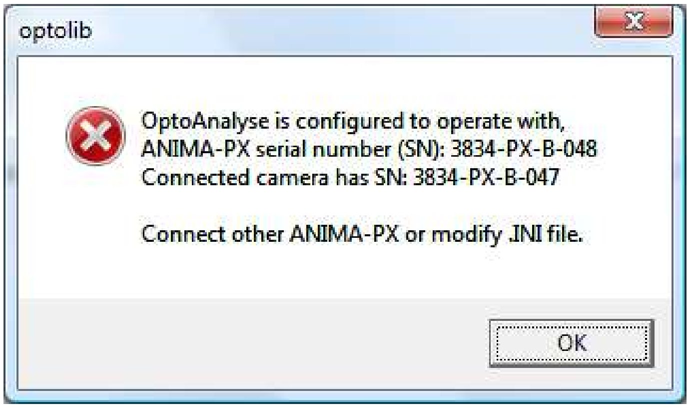
No Real-time display and no Acquisition possible

In case the OptoAnalyse software had been started with the readout camera not connected or not switched on, the software needs to be closed and re-started after the readout camera is connected and operating.

In case the real-time display had been possible before, very probably the frame window used for the real-time display had been closed. Use *New* command of the *File* menu to get a new frame window allowing real-time display and image acquisition.

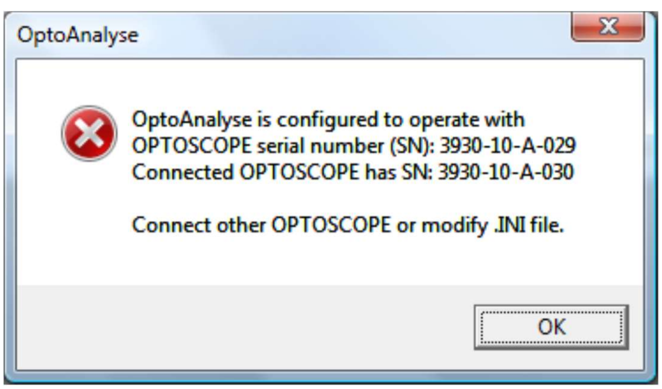
Configuration mismatch in multi camera configurations

If the OptoAnalyse software had been installed different times in order to control different streak camera systems error messages on program start might appear.



Serial number inside the camera memory and serial number written in the INIT.INI file are not identical. It is likely that the correct ANIMA-PX readout camera is not connected.

Alternatively the configuration of the camera or software has to be modified. Use PX-Programmer to verify whether the correct number is programmed inside the camera memory. Eventually modify this number and make sure the same number is written on the INIT.INI file of this software installation.



Streak camera serial number inside the main unit and serial number written in the INIT.INI file are not identical. Possibly, the wrong streak camera main unit is connected. Connect the right streak camera. Verify IP address of the camera and compare with the *Setup/Streak Camera Setup/Network Setup.*

Alternatively the configuration of the software has to be modified.

- Delete the serial number of the "OPTOSCOPE_SN" parameter on the INIT.INI file and start OptoAnaylse again. If only "OPTOSCOPE_SN = " appears on the INIT.INI file the OptoAnalyse software will control any streak camera found. Make sure only one main unit is connected when starting the software.

- Verify the serial number displayed on the “Network Setup” box of the “Streak Camera Setup” menu. It has to be identical to the SN printed on the camera.
- Write the SN of the streak camera main unit in the INIT.INI file.

Remark: Not specifying the serial number of the streak camera or readout camera might simplify setup but might cause problems during system operation as correspondence between software and hardware is lost.

No Geometrical Correction is processed

The geometrical corrections are not executed although they are defined in the Setup/Geometrical Correction menu. Different reasons are possible.

- The correction already had been done.
- Missing information of sweep unit and selected sweep speed for the image to be corrected. This information is saved in the .IMI file except the steak camera had not been controlled by the OptoAnaylse software during the acquisition.
- Image format mismatch. The geometrical data are related to a particular image size in horizontal and vertical pixels. This changes if binning is activated or if the display orientation is changed in the Setup/Readout Camera menu.

No linearity correction after program update

The information needed for linearity correction and transit time correction has to be availabel on the ‘correction.ini’ file located on the same directory as the actual OptoAnalyse executable. Therefore this file might need to be copied.

Example: OptoAnalyse/ED had been updated from version 3.69 to version 3.70. ‘Correction.ini’ file has to be copied from the old location ‘C:\Program Files\Optronis\OptoAnalyse-ED v3.69’ to the new one ‘C:\Program Files\Optronis\OptoAnalyse-ED v3.70’.

No calibration of wavelength axis after program update

Spectrometer calibration data needed for wavelength calibration have to be available on the ‘init.ini’ file located on the same directory as the actual OptoAnalyse executable. Therefore this file might need to be copied.

Example: OptoAnalyse/ED had been updated from version 3.69 to version 3.70. ‘Init.ini’ file has to be copied from the old location ‘C:\Program Files\Optronis\OptoAnalyse-ED v3.69’ to the new one ‘C:\Program Files\Optronis\OptoAnalyse-ED v3.70’

No BLC working after program update

Reference images for BLC have to be available on the 'BLC-Correction_GS' directory located on the same directory as the actual OptoAnalyse executable. Therefore this directory might need to be copied.

Example: OptoAnalyse/ED had been updated from version 3.69 to version 3.70. 'BLC-Correction_GS' directory has to be copied from the old location 'C:\Program Files\Optronis\OptoAnalyse-ED v3.69' to the new one 'C:\Program Files\Optronis\OptoAnalyse-ED v3.70'

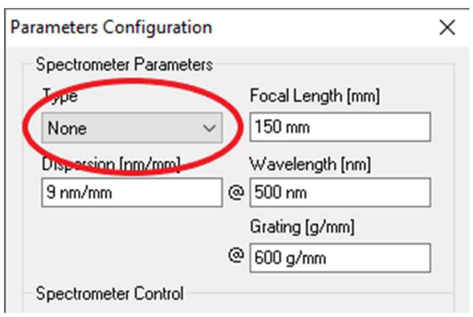
No spectrometer control possible

OptoAnalyse till version 3.77 search for spectrometer after program start. The init.ini file in the same directory as the program file might have parameter

```
spectro_comm = 1
```

and this parameter might be set to `spectro_comm = 0`. In this case no spectrometer will be connected. Change to `1` and start OptoAnalyse again.

OptoAnalyse version 3.78 and later require to select the actual spectrometer. If `None` or the wrong type is selected no spectrometer control is possible.



Horiba spectrometer require the installation of SDK. Make sure the correct version is installed.