user manual

pco.camware

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Excelitas PCO GmbH asks you to carefully read and follow the instructions in this document.
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pco.camware user manual 4.20.0

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Contents

1 Introduction

This manual describes the operation of the software pco.camware developed by PCO. With this software, all current and most older PCO cameras can be operated.

In the pco.camware manual all basic functions of the software are described, but all specific camera data, values and special functions can be found in the corresponding camera manual.

! Not all of the listed functions are supported by all cameras!

1.1 Conventions

The following typographic conventions are used in this manual:

Value	Description
bold italics	Terms that can be found in the pco.camware.
Features	Heading with a chapter.
3.9.2	Bold chapter: hyperlink to a chapter.
1 2	Numbers that help to find functions quickly.
Note	Notes that must be observed.

1.2 System requirements

Download the latest versions of our software and camera drivers from the PCO website. Contact us if you have any questions about your system configuration.

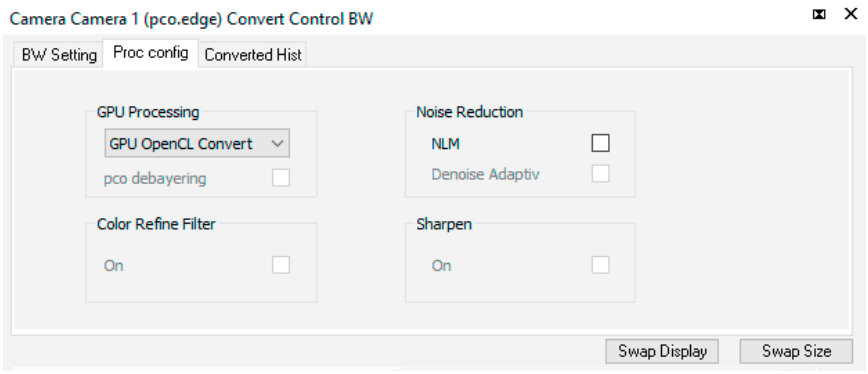
System requirements	
Intel®/ Xeon Core™ i7/ i9 at least 2.8 GHz	Full-HD resolution display
RAM > 8 GB DDR3	Windows 7 or higher
NVIDIA CUDA CC >= 5.0 (get current runtime version from NVIDIA)	

1.3 NVIDIA CUDA driver

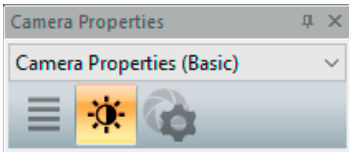
Our software relies on GPU processing, so the video drivers must be up to date. Update your NVIDIA driver before using pco.camware. If you have an older driver version ***GPU Processing*** will not work properly and therefore slow down image processing.

Check if ***GPU Processing*** is activated by having a look into the ***Proc config*** settings

1 in the ***Convert Control*** window



2 (see ***Convert Control*** chapter **3.3.8**).



If ***GPU Processing*** is disabled and shown grayed, update your NVIDIA driver or check the website of the computer manufacturer for graphic card driver updates.

1.4 Installation

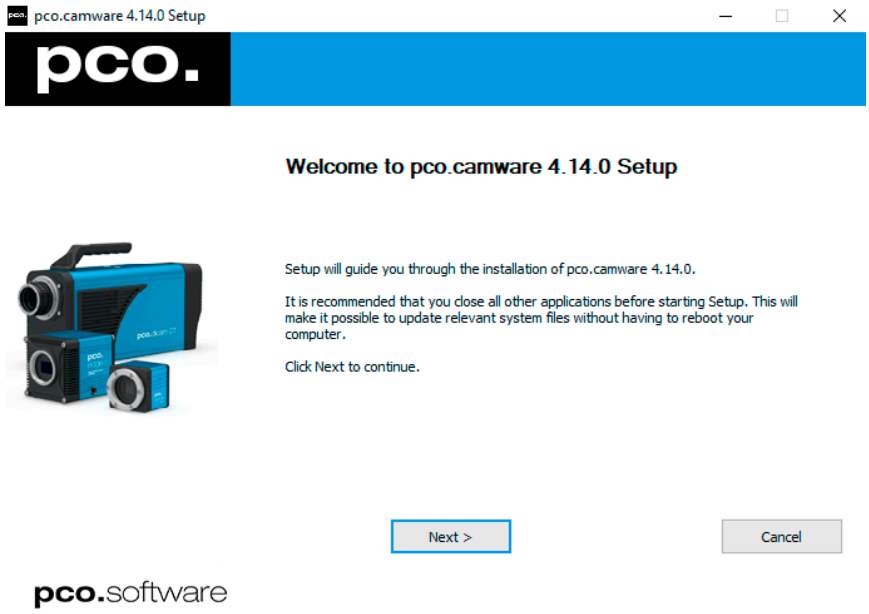
The pco.camware Microsoft Windows application software enables you to control every camera parameter or setting. Images can be displayed on a monitor and may be downloaded and stored. Installation files for latest 64-bit Windows operating systems are available.

After a successful installation, you will find the program folder PCO Digital Camera Toolbox in your program directory and a PCO button on your desktop.

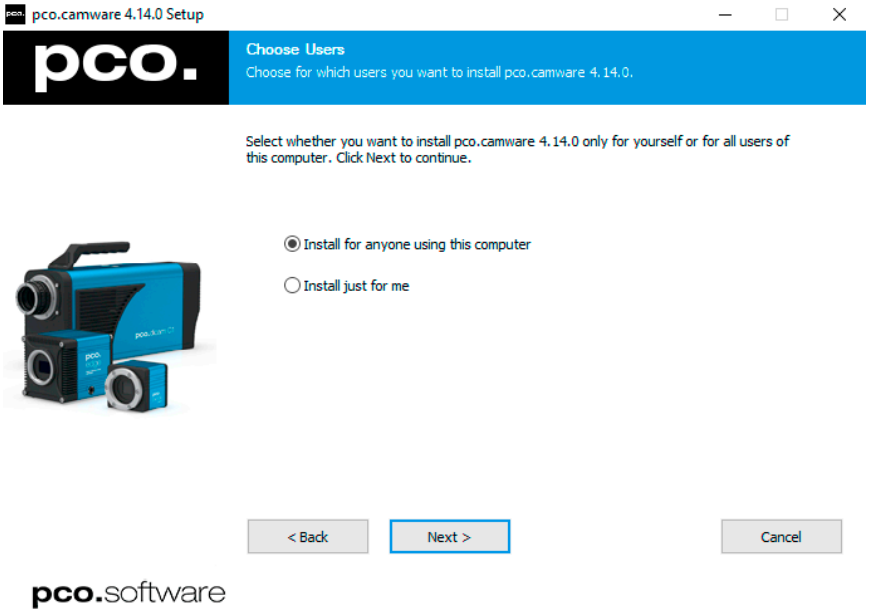
To uninstall the pco.camware program, use 'Apps and Features' under Windows' System Control.

Follow the installation Wizard:

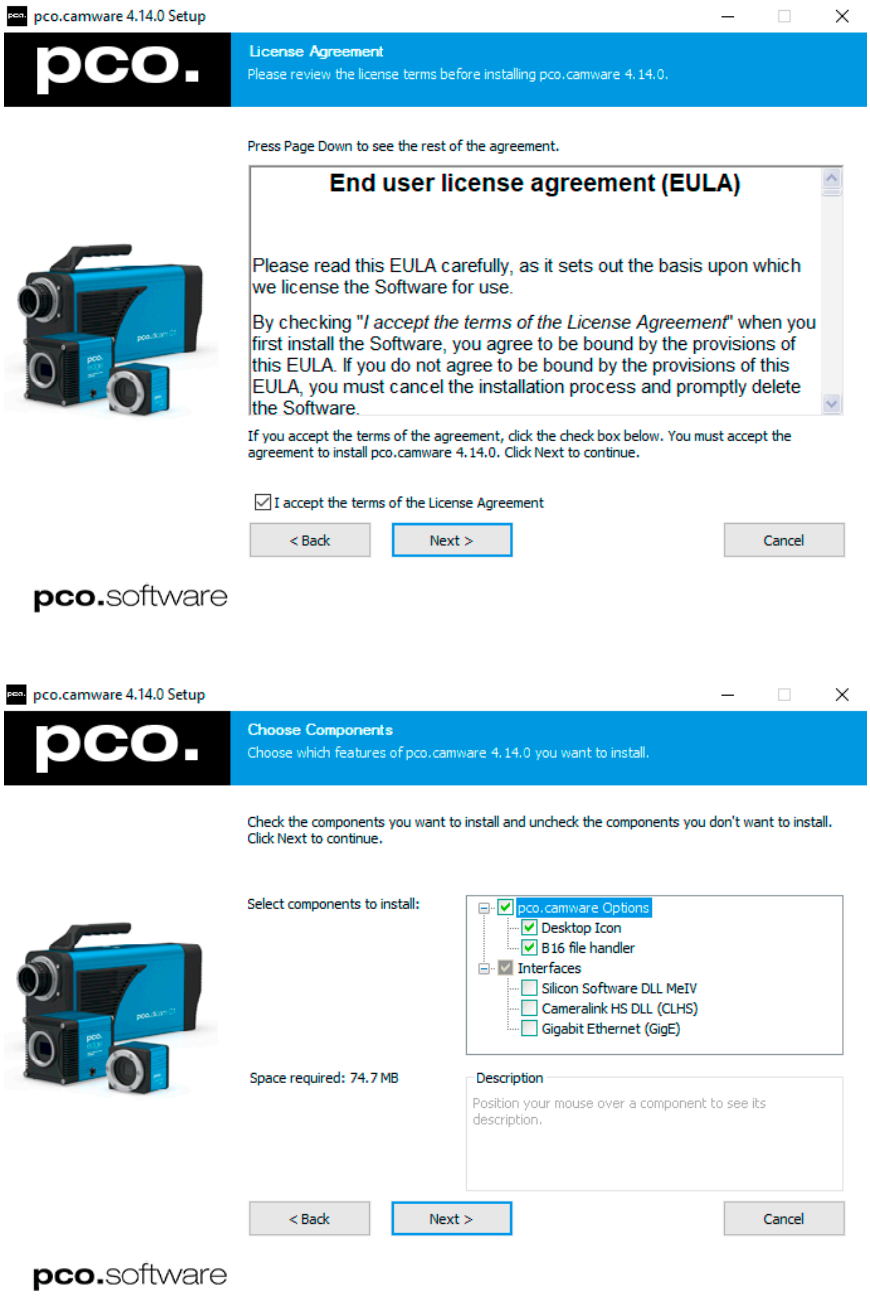
1 ***Install as admin*** to install to program folder, otherwise it will be installed only to user folder.



2 Then choose install directory.



3 Choose components; select additional drivers for Camera Link interface ***Silicon Software DLL MeIV*** or ***Camera Link HS DLL CLHS*** for Camera Link HS interface (for USB and USB3 the driver must be installed additionally).



4 After the next two screens installation is complete.


pco.camware 4.14.0 Setup
pco.
Choose Install Location
Choose the folder in which to install pco.camware 4.14.0.
Setup will install pco.camware 4.14.0 in the following folder. To install in a different folder, click Browse and select another folder. Click Install to start the installation.
Destination Folder
C:\Program Files\PCO Digital Camera Toolbox\pco.camware
Browse...
Space required: 74.7 MB
Space available: 75.1 GB
< Back
Install
Cancel
pco.software
pco.camware 4.14.0 Setup
pco.
Completing pco.camware 4.14.0 Setup
pco.camware 4.14.0 has been installed on your computer.
Click Finish to close Setup.
Start pco.camware
Show User Manual
Finish
Cancel
pco.software

2 Quick start

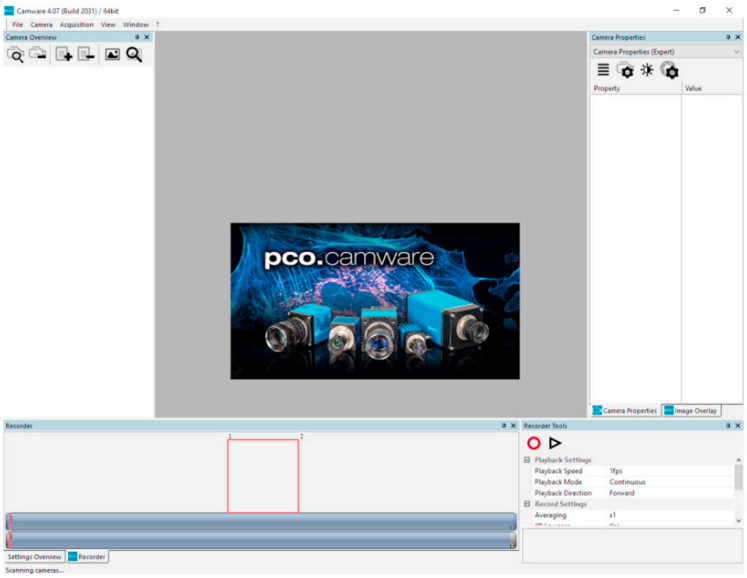
In order to get familiar with your new camera and software it will be helpful to first aim the camera at an object that is easy to focus on and visible under normal light conditions.

2.1 Preparation

1. Computer is turned on.
2. Installation of pco.camware and camera specific driver is finished.
3. An appropriate lens is attached (remove cap) or the camera is attached properly to the microscope, spectrograph or other scientific device.
4. Camera is connected to the computer.
5. Camera is connected to the power supply and powered up.

2.2 Start

Start pco.camware and the graphical user interface will start up:

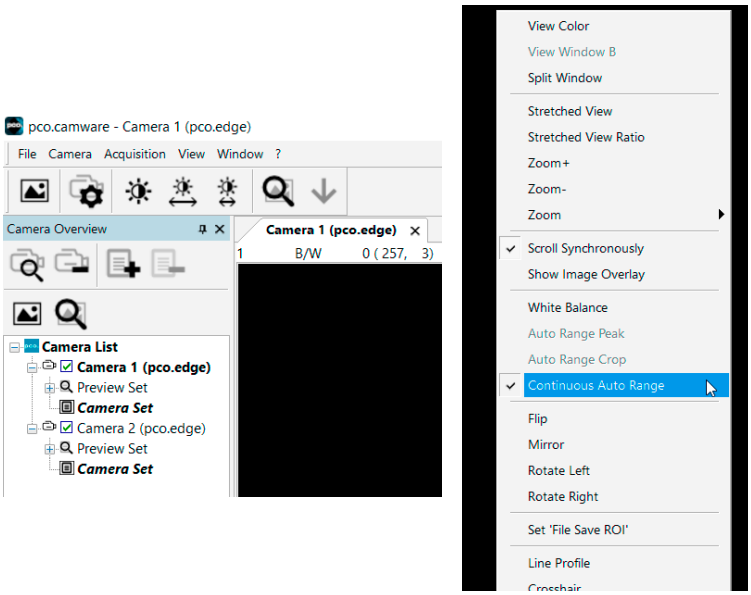


Note Always install latest pco.camware version from our website to use the full capabilities of your camera.

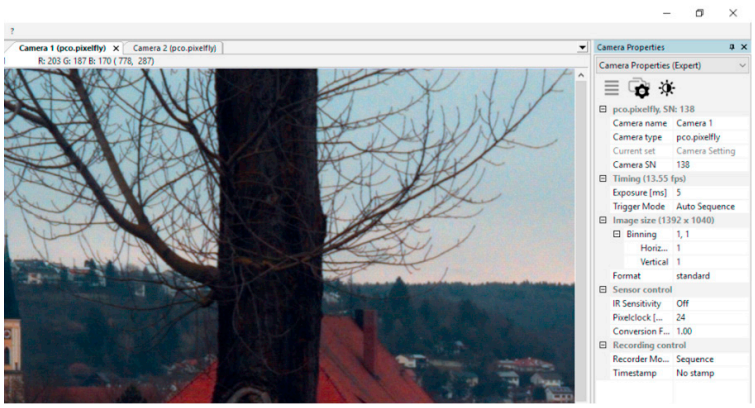
2.3 First image

Follow the Instructions:

1. pco.camware must be started.
2. A ***View Window***
3. is shown automatically or open a new one.
4. Start ***Live Preview***.



5. Right-click in the ***View Window*** & apply ***Continuous Auto Range***.



6. You may have to adjust ***Exposure*** time, and the aperture and focus of the mounted lens.
7. Now you should clearly see the object in the window.

To change Exposure time (e.g. the image is still either too dark or too bright), go to chapter **3.3.1**.

For recording and saving, see chapter **3.3.5**, **3.5** and **3.9.2** for detailed information.

Note Live preview is useful for fast and easy camera adjustment and focusing, but does not record or store images.

3 pco.camware software

3.1 Chapter overview

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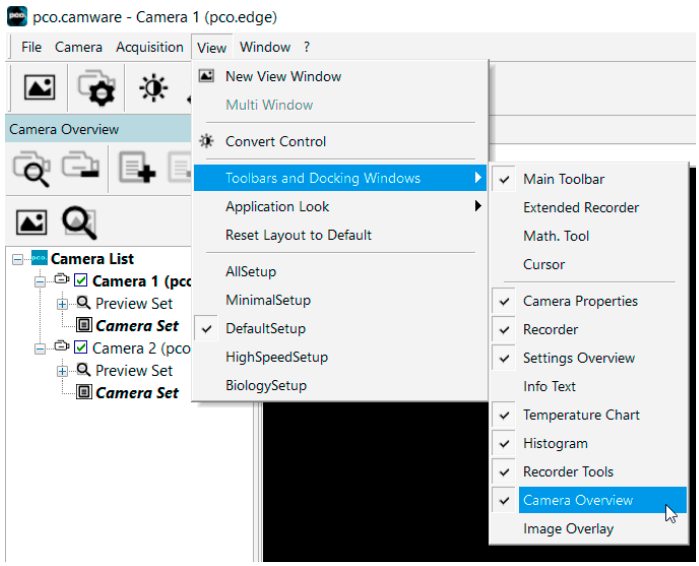
Value	Description	Page
3.9.4 acquisition menu	Live Preview, Acquire Single Image, Record Sequence, Memory Allocation Dialog, Auto Camera RAM Segment Switching	50
3.9.5 view menu	New View Window, Convert Control, Multi Window, Convert Control, Toolbars and Docking Windows, Application Look, Reset Layout to Default	51
3.9.6 window menu	Close Active Window, Arrange horz. view, Arrange vert. view, Split	53
3.9.7 help menu	Logging, Create Support File, Support Mail, About	54
3.9.8 view window menu	Right-click: Zoom / Flip / Mirror / Rotate...	55
3.9.9 additional features	White Balance, Fold-up window, Setting Contrast Area by Mouse, Setting a new ROI by Mouse, Short Cut List	57

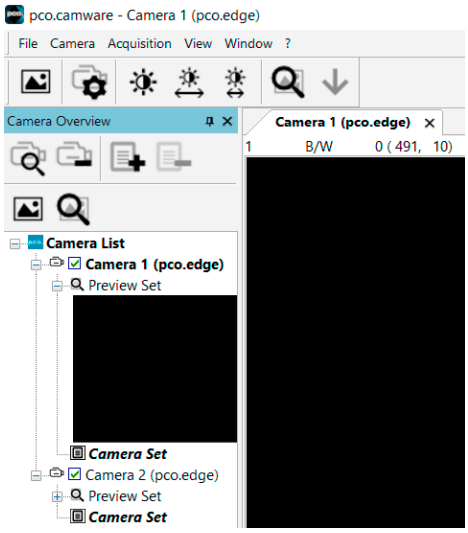
3.2 Camera overview/list

1 If closed, open the ***Camera Overview*** window by selecting the ***View*** tab and ***Toolbars*** and ***Docking Windows*** -> ***Camera Overview***.



Camera Overview

2. The ***Camera Overview*** window supports the management of more than one PCO cameras and displays a ***Camera List*** of the connected ones. You are able to ***Scan Cameras*** or close an active camera.
3. The user can define several different ***Camera Sets*** for each camera (max. 30 sets per camera -> ***Add set***).
4. ***New View Windows*** can be opened.
5. The ***Live Preview*** function can be started.



Live Preview

Live Preview facilitates the aperture and focus adjustment, allowing a first look at your object. During ***Live Preview***, ***Trigger Mode*** is set to ***Auto Sequence*** by default. This can be changed in ***Recorder Tools***. Preview can be set to use external trigger if needed.

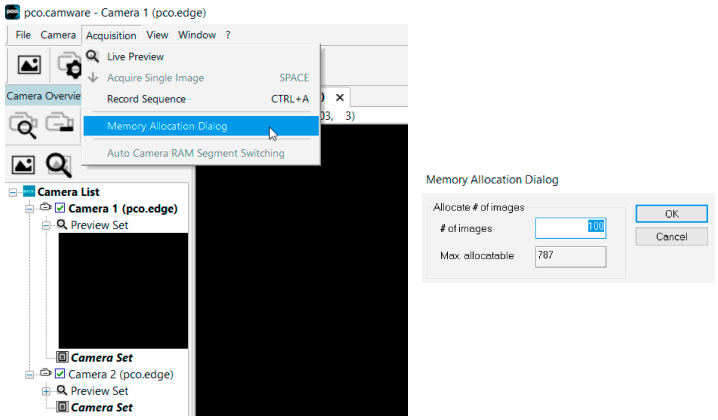
6. When opened up, the ***Live Preview*** shows a small ***Preview*** window (always monochrome) integrated in the ***Camera List***.
7. ***Camera Sets***

All settings, such as resolution and frame rate, in the ***Camera Properties*** (see 3.3.3) are saved to ***Camera Sets***. Define different ***Camera Sets*** with different preferences in ***Camera Properties*** for each of your experiments. ***Camera Sets*** can be switched at any time (not during record) and copied to other cameras.

Important Setting (for all cameras without internal memory)

Memory Allocation Dialog

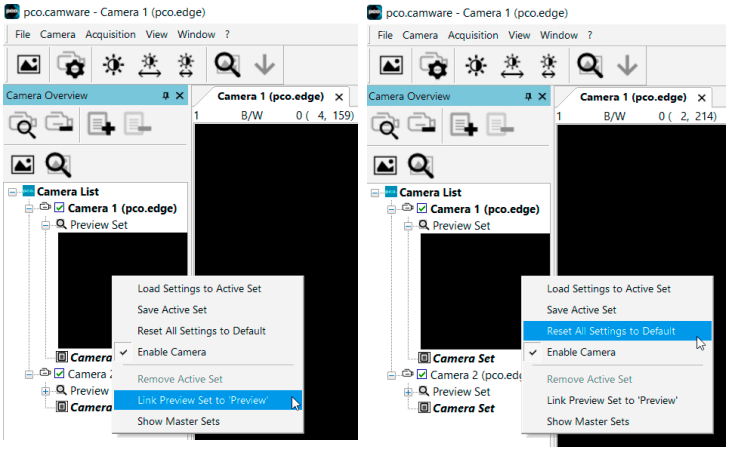
If you want to change the number of recorded images in pco.camware, you must open the ***Acquisition Tab*** (see 3.9.4) and select ***Memory Allocation Dialog***. This sets the number of images recorded in one sequence. The maximum is defined by the available PC RAM size.



Link Preview Set to 'Preview'

8 When ***Link Preview Set to 'Preview'*** is ticked the ***Preview*** will always be active with the set parameters when starting a ***Live Preview***.

If this function is deactivated, the ***Live Preview*** will always show live images with the parameters of your active ***Set***. Setting a higher exposure time for ***Preview Set*** and linking it to the ***Preview*** function is beneficial if ***Preview*** light conditions are different from those in recording situations.



Reset All Camera Settings to Default

Using ***Reset All Settings to Default*** in the Camera List context menu will reset all settings in the registry to default values.

Copy Settings to Current Set

To copy e.g. ***Camera Set 1*** to ***Camera Set 4***, just drag and drop e.g. ***Camera Set 1*** to ***Camera Set 4*** and pco.camware asks to confirm it. It is possible to copy each setting to every camera.

Master Sets

This function facilitates image acqusition with multiple cameras. Defining two or more ***Master Sets*** allows easy switching between different predefined settings for each camera during an experiment. Each image acquisition or experiment can be recorded with its own ***Master Set***.

To enable ***Master Sets***, right-click in the ***Camera Overview*** window and click ***Show Master Sets***.

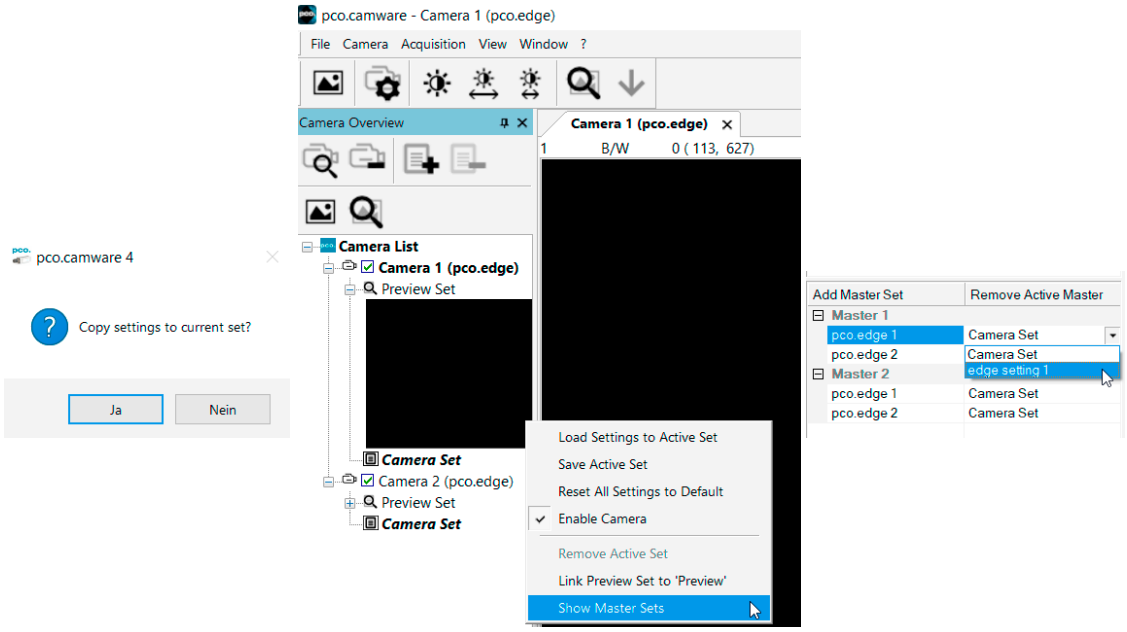
Define different ***Master Sets***. Select individual ***Camera Settings*** within each ***Master Set***.

Functions:

9 ***Add Master Set*** or

10 ***Remove Active Master***.

11 Activate it by clicking on, for example, ***Master 1***.

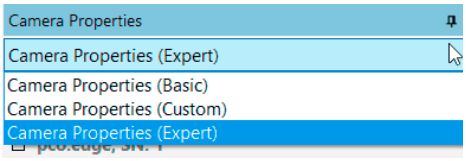


3.3 Camera properties

The ***Camera Properties*** window is the main interface for all camera settings. The active set selected within ***Camera List*** is adjusted here.

The former main topic ***Camera Control*** dialog (known from pco.camware 3.x) and the ***Convert Control*** (see 3.3.8) dialog can also be opened, but these dialogs will be removed in future versions of pco.camware.

Four view options with various functions can be selected: ***Basic***, ***Custom***, ***Expert***, and the adjustable ***MyCustomSetup*** (see instructions below).

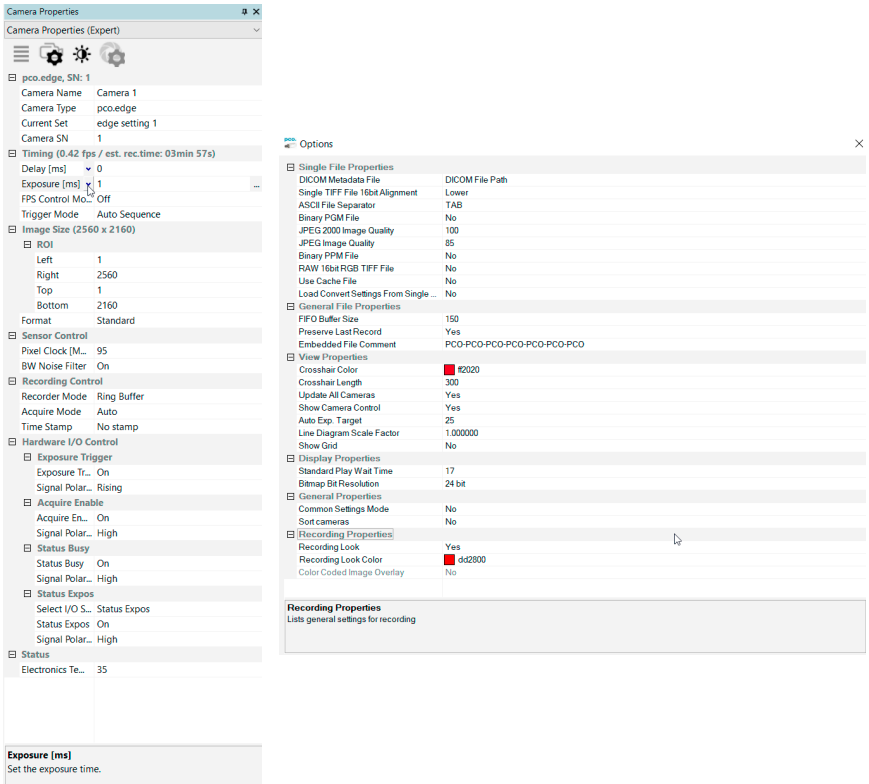


1. ***Basic*** mode only shows camera name, type, set, serial number and exposure time. In Basic mode the frame rate is always calculated automatically based on the selected exposure time: if exposure time increases, frame rate decreases, etc. this mode is recommended for beginners.
2. ***Custom*** mode shows several more setting possibilities and functions are hidden or shown by the Custom Properties button. In addition to the Basic mode options, all other options are selectable.
3. ***Expert*** mode (for advanced users) shows all possible camera feature settings.
4. ***MyCustomSetup*** mode can be used to create custom settings with a .reg file. This option can only be selected once the setup has been created.

Open `C:\ProgramData\pco`.

- `CustomSettingMode.reg` can be edited with a regular text editor.
- `CustomSettingMode.txt` contains instructions on how to use the .reg file.

An explanation for every setting is displayed below the ***Camera Properties*** dialog.



Common Settings Mode / Common Properties

If you work with two or more identical PCO cameras, the ***Common Properties*** help simplify the recording setup by determining which settings are common to all cameras and which are set individually for each camera.

This setting is available only when multiple cameras of the same type are active in pco.camware.

In order to be able to use the ***Common Properties***, ***the Common Setting Mode*** must be activated. To do this, open the ***File*** menu and click ***Options***. Under ***General Properties*** set the ***Common Settings Mode*** to ***Yes***, (see **3.9.2**).

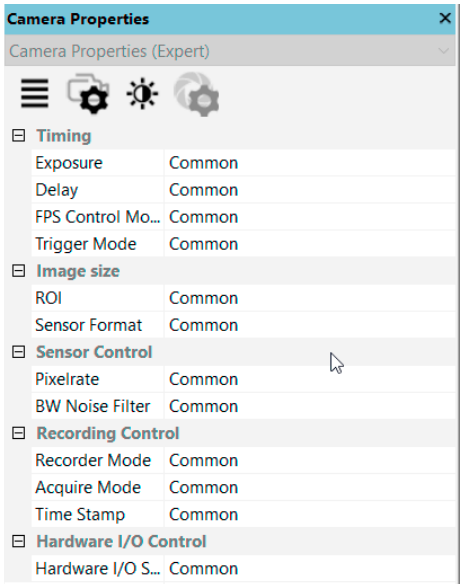
Now you can switch the menu in ***Camera Properties***. Click on the four horizontal lines. Immediately ***Camera Properties*** switches to the ***Common Properties***. If ***Camera Properties Custom mode*** is selected you can choose between ***Common*** and ***Custom***.

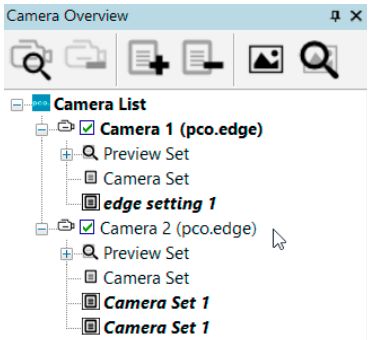
All settings for which ***Common*** is selected must be set for ***Camera 1*** and then automatically apply to all cameras.

The camera properties of camera 2, 3, 4, etc. only show the options set to ***Individual***, all others are hidden.

All other setting options can be set to ***Common***, so that an easy operation via channel 1 is possible, but ***Exposure*** and ***Delay*** can be set independently for each camera.

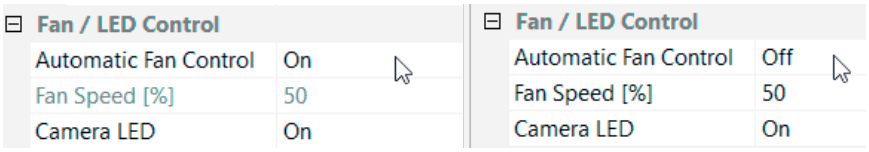
Significantly, ***Common Settings Mode*** affects the ***Camera Sets***. If you create a new set or edit an existing one and click on it to activate it, it will be duplicated on all other cameras.





Set Fan and LED

Set LEDs on the rear panel to ***On*** or ***Off***.



Set fan via dropdown menu to ***Manual*** or ***Auto***. If set to ***Manual***, you will be able to set the speed of the camera fan from 0 % to 100 %.

Note It is the users' responsibility to monitor the camera condition. PCO is not responsible for damage to the camera from overheating due to the fan being switched off during operation. Take care and do not overheat your camera!

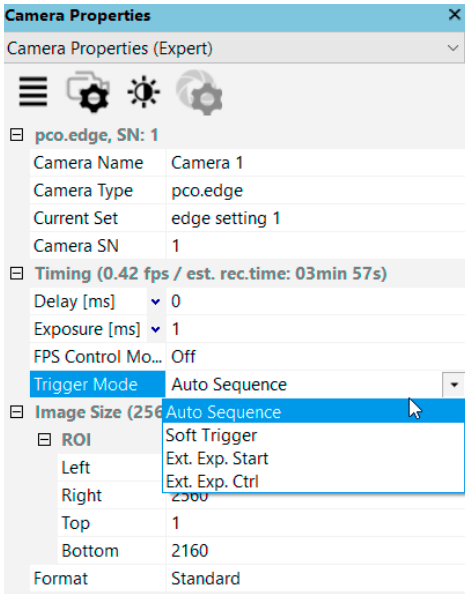
3.3.1 Timing

Introduction to Timing

An important parameter for a camera is the frame rate. The upper limit of the frame rate is defined by exposure and readout time.

The figure below shows the timing scheme. Exposure and readout are done simultaneously. This means while image ***n*** is read out from the sensor, image ***n+1*** is already integrated within the sensor's pixel elements.

Figure 1 shows that for short exposure times, the readout is the limiting factor. The second figure shows that for long exposure times the exposure time plus delay (t_{delay}) is the limiting factor.



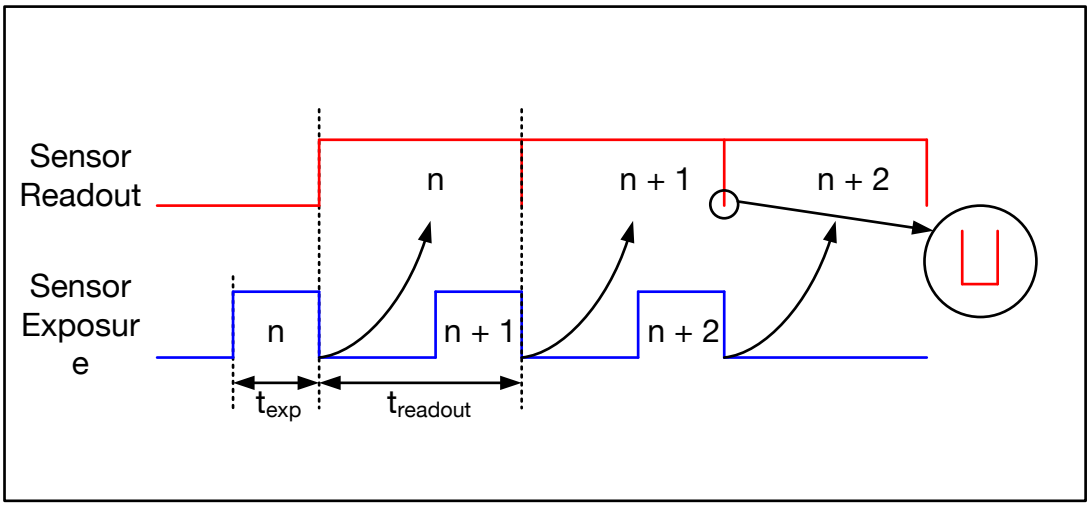


Figure 3.1: Image timing for short exposure times - readout time is the limiting factor.

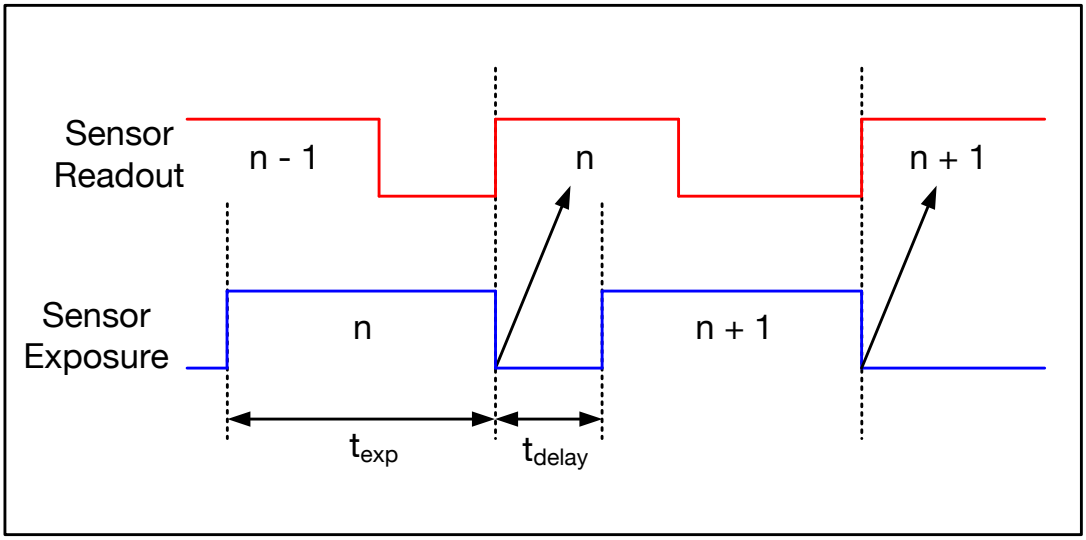


Figure 3.2: Image timing for long exposure times - exposure time is the limiting factor.

Lower frame rates can be achieved by inserting additional delay times before each exposure. This is valid also for external triggering as it defines when a next trigger can be set and is recognized.

Maximum Frame Rate

3 The maximum achievable frame rate based on the timing and ROI settings is calculated and displayed automatically.

Trigger Mode

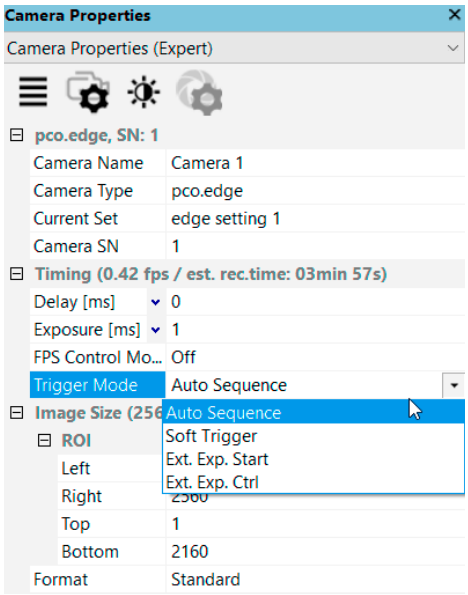
4 In this context trigger means exposure trigger, i.e. the trigger signal controls the exposure time of a single image (light integration time). Input and output connectors are camera specific – see the manual for your specific camera.

Auto Sequence: the camera optimizes the image recording to achieve the best possible frame rate.

In ***Auto Sequence*** mode, the camera determines the highest possible frame rate for the set exposure time and the time required for a frame readout.

After a start command is given, the sequential recording begins and continues until a stop command is given.

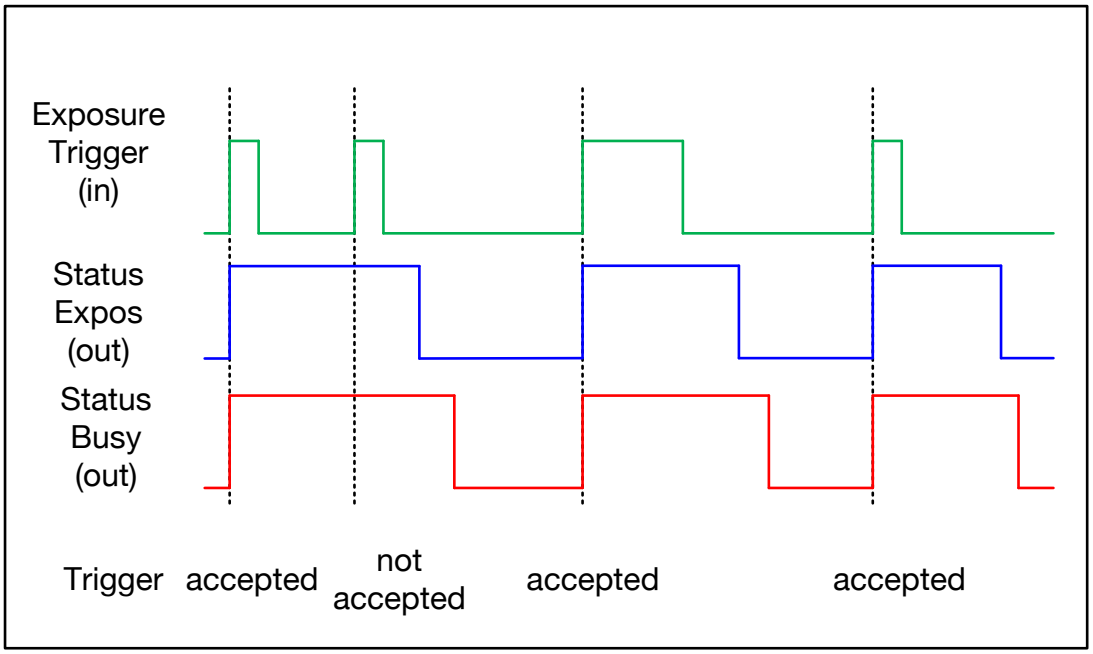
Soft Trigger: single images are recorded with this command. A single image is acquired by clicking the ***Software Trigger*** button, which appears after pressing the ***Record*** button (see **3.5**). Other signals have no influence on this operating mode.



Ext. Exp. Start: in External Exposure Start mode, single image recording is started by the falling or rising edge of the voltage signal at the input connector. The frame rate cannot be set, as the frame rate is defined by the frequency of the external signal. However the predefined exposure time and ROI settings affect the maximum possible frame rate.

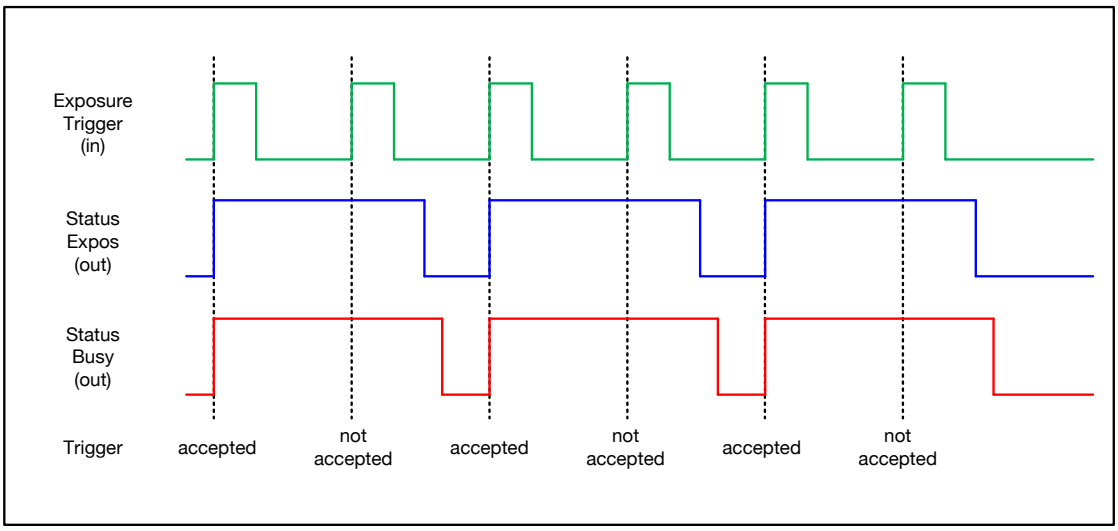
The ***Status Busy*** signal at output connector indicates whether a new trigger can be accepted.

Note If the trigger rate of the external signal is very close to the maximum possible frame rate (difference < 1/1000), it will be random whether a trigger is accepted or not.



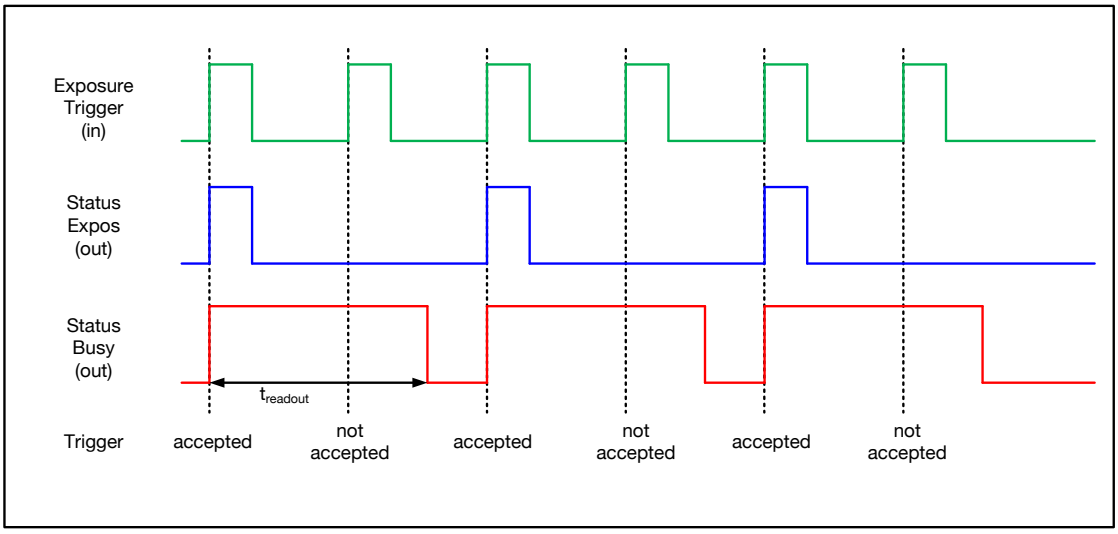
The maximum achievable frame rate in external trigger mode might be lower than in Auto Sequence mode depending on your camera model, since some cameras start exposing after the readout of the previous image is completed. Refer to the camera specific manual for details.

If the trigger rate of the external signal is higher than the maximum possible frame rate, every second trigger pulse is ignored. Therefore the actual frame rate drops to half of the external trigger rate. If the trigger rate is increased further, then only every third, every fourth etc. trigger edge is accepted.



Ext. Exp. Ctrl: in 'External Exposure Control' an external signal applied at the input connector controls the start and the duration of the exposure.

A new exposure is started by the falling or rising edge of the voltage signal at the input connector. The exposure is finished when the opposite edge is detected. In this mode, the start as well as the length of the exposure time can be controlled. No further settings can be made, as the image timing is completely controlled by the external trigger signal.

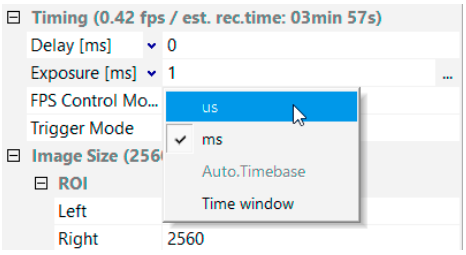


Note that the externally controlled exposure time is limited. The integration will be stopped automatically if the maximum exposure time of your camera is achieved.

The ***Status Busy*** signal at output connector indicates if a new trigger is accepted.

Exposure Time and Timebase

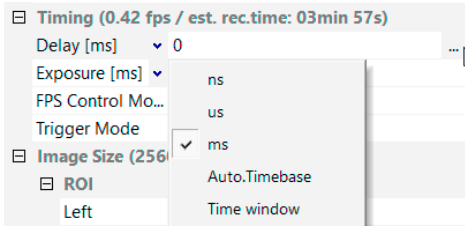
2 It is possible to change time-base from automatic to µs or ms. If your input is out of the range of the camera, it is automatically changed to the next possible setting. The adjustment steps of exposure time and delay time depend on the specific camera model.



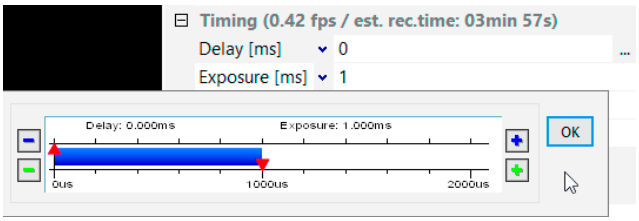
Timing

The ***Exposure*** and ***Delay*** time can be precisely set in camera specific steps. The effective step size depends on minimum internal camera restrictions (usually in ns) or the time base set. The slider and the up/down control refer to the blue highlighted unit. The resulting frame rate is derived from this setting. Delay time setting is not recommended for high-speed applications.

Change time base by clicking on ... and the respective window opens.

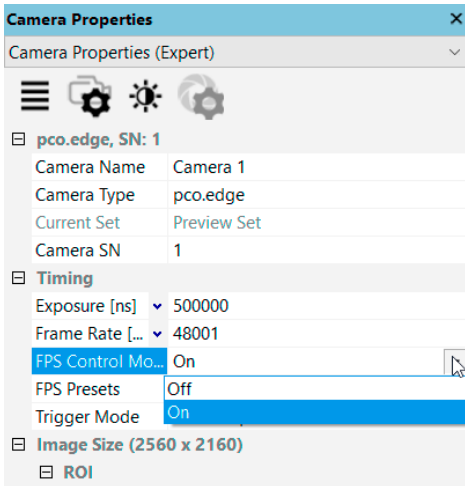


In this context menu, you can also choose ***Time window***, which will open a high dynamic dialog to control the exposure and delay times (single shutter mode). Click ***OK*** to validate the changes and hit ESC on your keyboard to close the window.



FPS Control Mode

The camera optimizes the image recording to achieve the selected frame rate. The exposure time is limited to 1/fps, lower values can be selected.



First the frame rate is set. If the time required for readout of the image is longer than 1 / frame rate, then the frame rate will be reduced to 1 / $t_{readout}$.

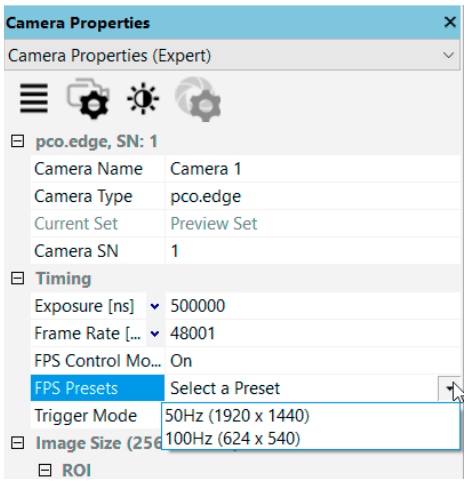
If ***FPS Control Mode*** is selected and the selected exposure time requires a lower frame rate, the exposure time will be reduced to the maximum possible time at that frame rate.

FPS Presets

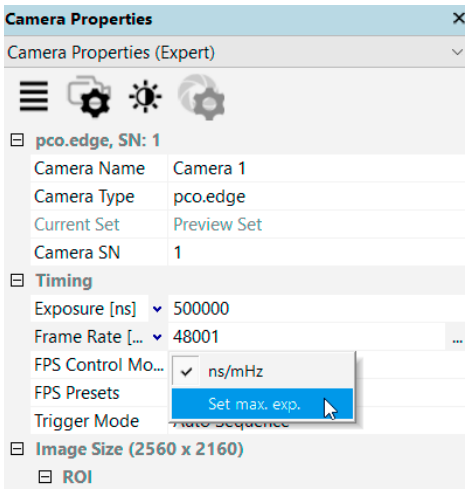
If ***FPS Control Mode*** is set to on, a predefined combination of frame rate and resolution may be selected.

These presets may vary and depend on your PCO camera model:

For example pco.edge 5.5: 50 Hz @ 1920x1440 (full resolution).



Clicking on ***Set max. exp.*** pco.camware sets the maximum possible exposure time according to the selected frame rate.

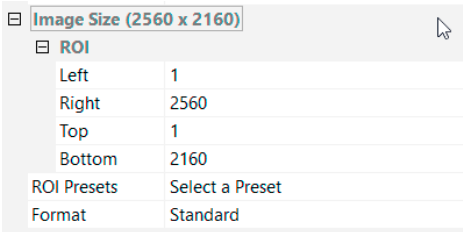


3.3.2 Image size

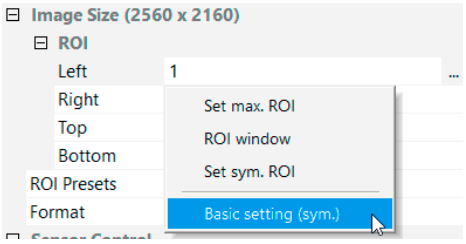
1 Region of Interest

ROI (Region of Interest) selects a part of the sensor to be read out, thus reducing the amount of image data and potentially increasing the frame rate.

Based on your camera model, the ROI might need to be set symmetrically, especially to affect the frame rate.



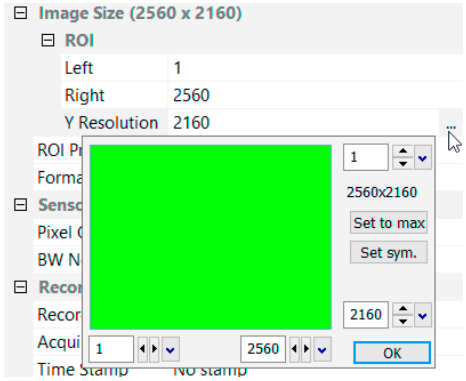
Click ... and tick ***Basic setting (sym.)*** to establish a ROI by typing in the horizontal and vertical resolution in pixels.



ROI window

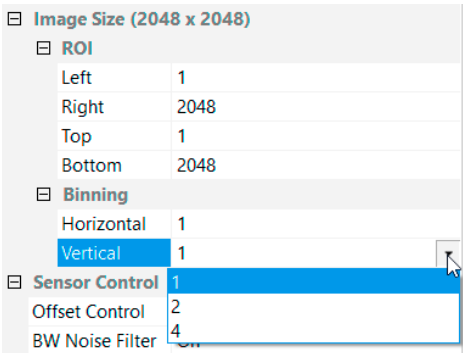
Use the **...** right of the size edit boxes and click on ***ROI window***.

The ***ROI window*** opens and a new 'Region of Interest' may be defined using a mouse or by typing in specific numbers.



2 Binning

Binning combines adjacent pixels (in either the horizontal or vertical direction) to form super pixels. This increases the signal to noise ratio (SNR) and but decreases the spatial resolution of the image.



Examples for available binning modes:

H1xV1, H1xV2, H1xV4, H2xV1, H2xV2, H2xV4, H4xV1, H4xV2, H4xV4.

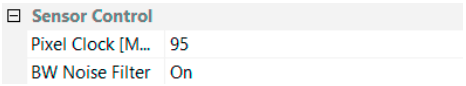
3 Format

In some of the cameras, it is possible to change the standard resolution (sensor format).

3.3.3 Sensor control

1 Pixel Clock

The pixel clock sets the clock frequency and therefore the image sensor readout speed. A higher Pixel Clock leads to higher achievable frame rates but influences image quality.

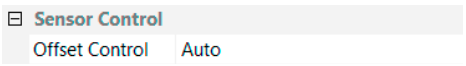


2 B/W Noise Filter

In addition to the processing of the calibration of the camera, a dynamic noise filter can be activated to remove so-called blinkers and high noise pixels. If you encounter unexpected aliasing effects, turn this filter off.

3 Offset Control

Select ***Auto*** to automatically compensate dark current and signal drift of the offset. Select ***Off*** to deactivate ***Offset Control***.

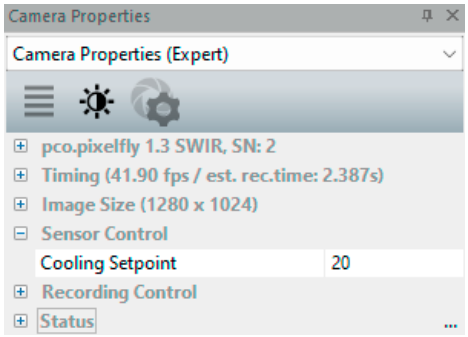


The offset is recalculated if the exposure time is changed during a ***Record*** session. This applies also if any setting in ***Camera Properties*** is changed. The offset is not recalculated if recording

only stops and restarts and no other properties are changed.

4 Cooling Setpoint

Set the cooling temperature of your camera. The set temperature has an effect on the noise performance of the camera. Depending on the cooling system, it takes a few minutes after starting the camera to reach the set temperature.



5 Double Image

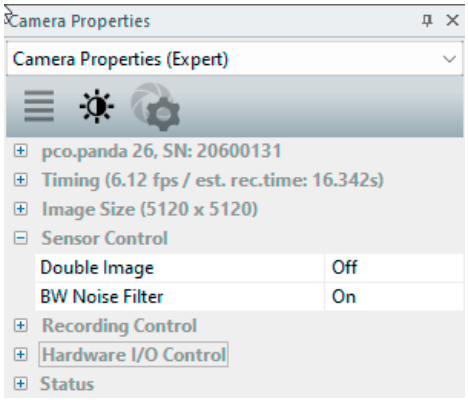
This feature is used to turn on alternative modes, such as particle image velocimetry (PIV) measurements or double shutter.

The first exposure time t_{e1} may be any exposure time of the available range of the PCO camera. The second exposure time t_{e2} cannot be directly adjusted. The length of the second exposure is the readout time of the first image. The interframing time t_{itf} denotes the transition time between end of exposure #1 and start of exposure #2.

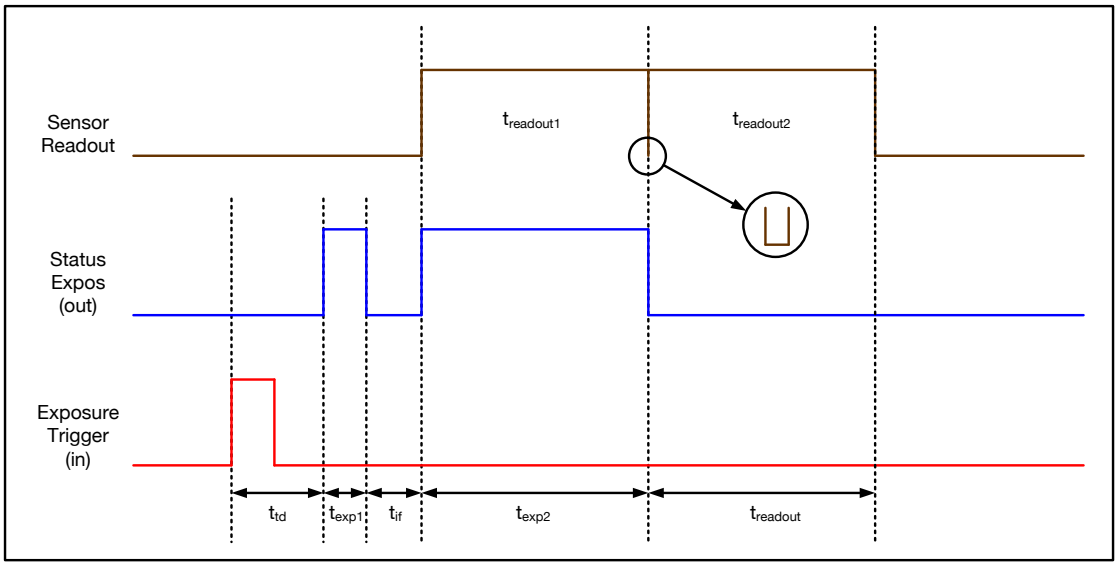
As can be seen the maximum frame rate of the double image mode (where frame rate is defined as the frequency of the double images) will drop to just half the value compared to the standard mode.

The double image mode will work only in the trigger modes ***Auto Sequence*** and ***Ext. Exp. Start***.

Note To achieve a blur free second image the environment should be kept dark and the exposure duration of the second image determined by a flash light.



Example timing diagram for ***Trigger Mode Auto Sequence***:



t_{exp1}: exposure 1	t_{exp2}: exposure 2
t_{td}: delay time	t_{id}: intrinsic delay
t_{if}: interframing time	$t_{readout}$: readout time

6 CDI mode

The correlated double image (CDI) mode records images with increased dynamic range and a 30% better performance on low signal side images (at the expense of half of the usual frame rate, because double images are acquired).

The min. exposure time is calculated as follows: $t_{exp} = \frac{1}{2 * f_{CDI}}$

t_{exp}: min. exposure time	f_{CDI}: max. frame rate

Example:

resolution = 1920 x 1080 pixel; f_{CDI} = 1067 fps -> t_{exp} = 467 µs

In this case t_{exp} is both, minimum and maximum exposure time.

To increase t_{exp} decrease frame rate or resolution.

7 Conversion Factor

The conversion factor defines how many charges (electrons), generated by light striking a pixel, are necessary to generate one count (one intensity level) in the digital image. Therefore, the conversion factor describes the gain when converting electrons into a digital value.

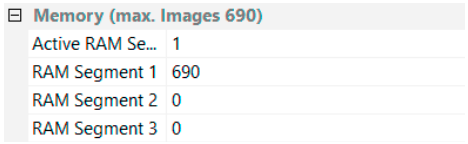
Example:

The pco.pixelfly usb has two conversion factors: 1.0 e^-/count and 1.5 e^-/count, both of which can be used in 1x1 (full resolution) and higher binning modes. Binning is available for the pco.pixelfly usb / pco.ultraviolet. The usable extended fullwell-capacity rises in binning mode from 16000 to 24000e^-. For 1x1 binning (full resolution) it makes sense to keep 1.0 e^-/count, as changing the conversion factor to 1.5 e^- the full dynamic range of 16384 grey steps is not accessible. In ***binning mode*** you can use both conversion factors: for low light conditions, the 1.0 e^-/count mode helps to spread the low image information content over the full 14 bits. For brighter images it makes sense to use 1.5 e^-/count to access the full dynamic.

3.3.4 Memory

For cameras with internal memory (RAM).

The RAM has four different segments. In pco.camware only three can be used to save images. The fourth is used by pco.camware itself for internal processes.



You may record into three different segments and to set the exact number of images in each segment. The software always shows the maximum number of images (depending on RAM size and chosen ROI).

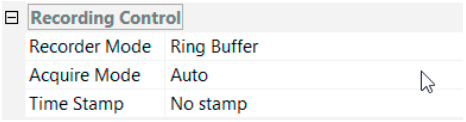
Active RAM Segment: choose the active segment: e.g. 1, 2 or 3.

3.3.5 Recording control

1 Recorder Mode

For cameras without internal RAM:

Our software uses free RAM space on your computer. In ***Sequence mode*** the recording stops when RAM space is full. In ***Ring Buffer*** mode the camera only stops by a stop command, hence overwriting previous images continuously, starting at the first image. For longer recording periods an appropriate RAID system is necessary, see also the ***Direct Record to File*** option, see **3.9.2**.



For cameras with internal memory:

The recorded images are temporarily saved as 16 bit multi TIFF if thumbnails are generated after recording is done. In ***Sequence mode*** the camera stops after the memory (i.e. the active RAM segment) is completely filled. In ***Ring Buffer*** mode the camera records until it is stopped – overwriting the previous images continuously. Also see ***Memory Allocation Dialog*** **3.9.4**.

2 Acquire Mode

The ***Acquire Mode*** is an additional instance to control image acquisition by an external signal. Like a gate signal it opens or closes the time window during which images according to the selected ***Trigger Mode*** (see **3.3.1**) are recorded.

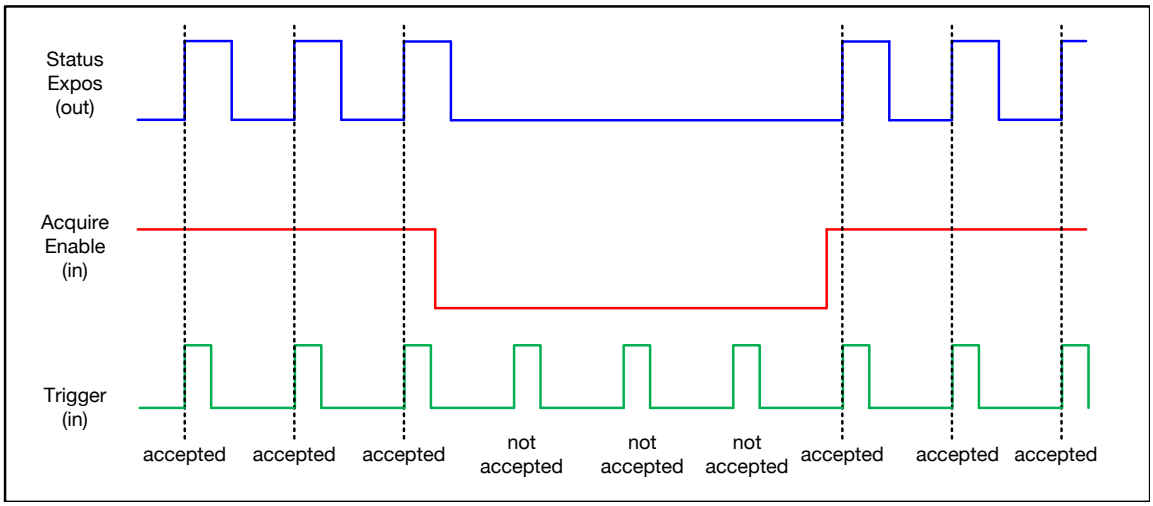
If set to ***Auto*** any signal at the ***Acquire Enable*** input connector is ignored.

If set to ***External***, the camera only records images if the external signal enables it.

The ***Acquire Mode*** is level controlled. This means when the signal level is ”high” image acquisition is possible, at the level ”low” not (or inverted). A practical example would be an illumination of the experiment which generates a signal and is coupled to the ***Acquire Enable*** input: light on means level ”high” and thus image acquisition, light off level ”low” and no image acquisition.

In ***Trigger Mode Auto Sequence*** the sensor timing scheme (image acquisition of the sensor) is paused by the signal at the ***Acquire Enable*** input connector. The ***Acquire Enable*** input is sampled at the beginning of the image generation, shown by at the rising edge of the ***Status Expos*** output connector.

Image acquisition is in an idle state if the ***Acquire Enable*** input is on low level (high, when inverted); it pauses image acquisition until the ***Acquire Enable*** input is on high level again (low, when inverted).

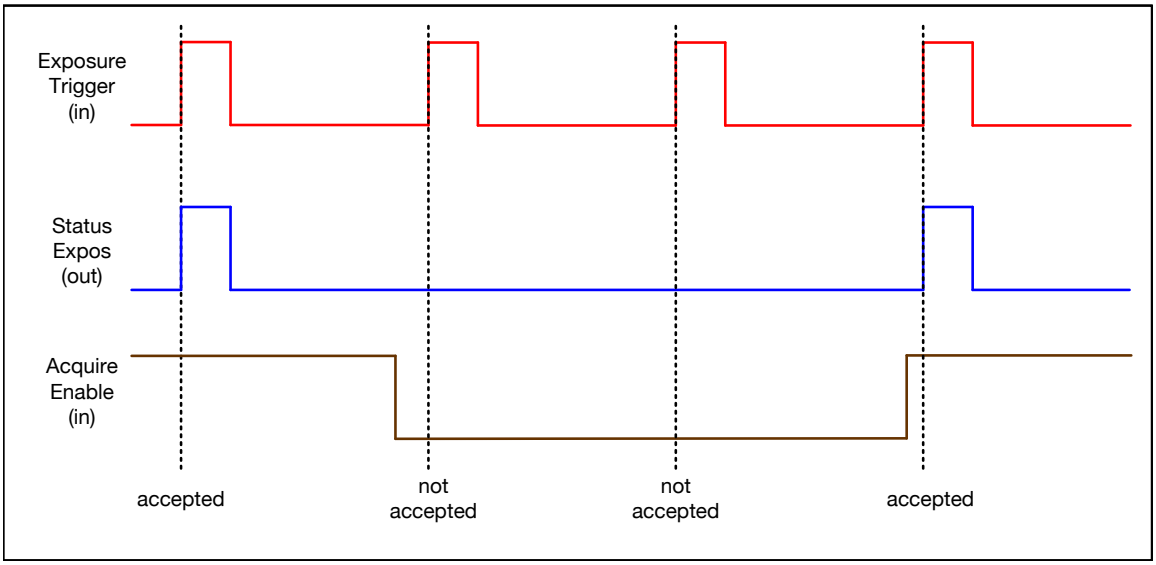


In ***Trigger Mode External Exposure Start***, the ***Acquire Enable*** input connector works like a gate for the trigger signal.

The rising edge of the trigger (falling when ***Exposure Trigger*** is inverted) is accepted only when the ***Acquire Enable*** signal is high level (low, when inverted).

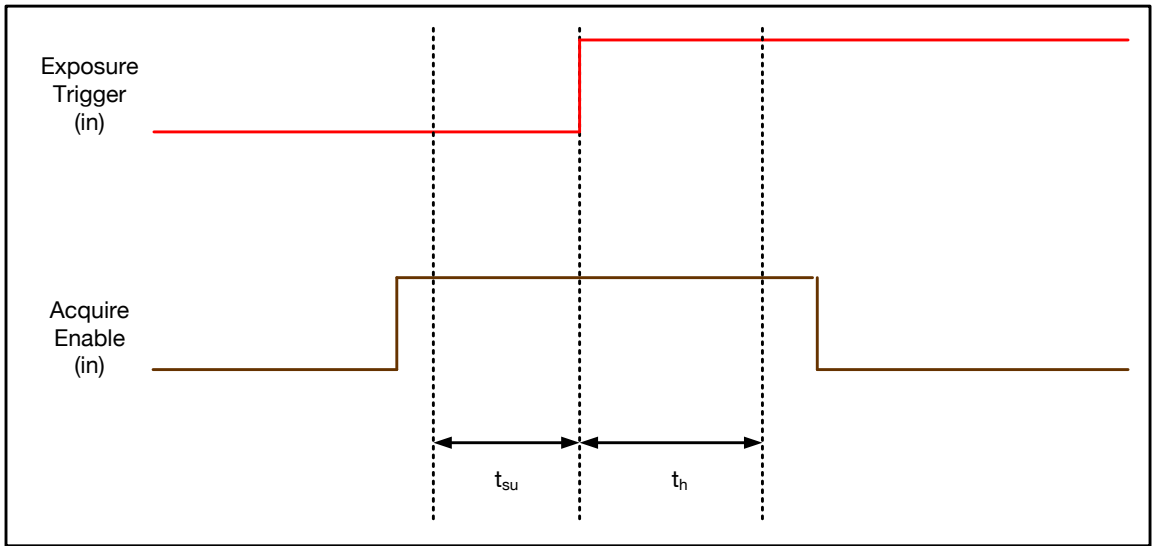
Example:

Status Expos signal for ***Signal Timing First Line*** (for Rolling Shutter pco.panda and pco.edge).



In ***Trigger Mode External Exposure Control*** the ***Acquire Enable*** input works very similar to the mode ***External Exposure Start***. However, the ***Acquire Enable*** input is ignored for the rising/falling edge which is closing the exposure time (an already started exposure will be finished).

Using ***Acquire Enable*** in ***External Trigger Modes***, following timing specification should be met:



If the ***Acquire Enable*** signal changes during the time window of t_{su} (set up) to t_h (hold), the behavior is random. The trigger may be accepted or ignored. Specific values for your camera can be found in the camera manual.

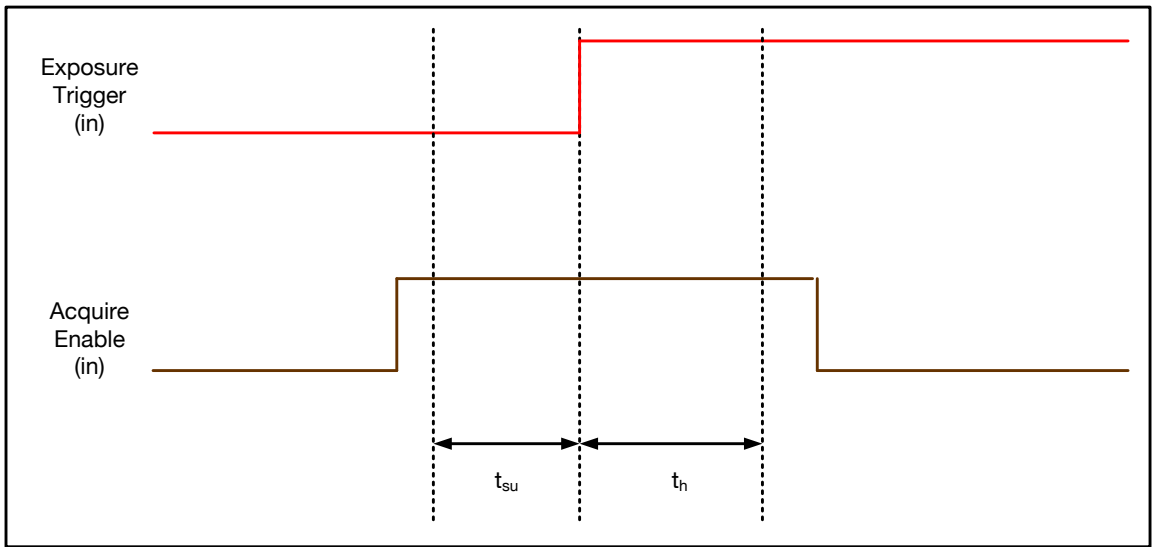
Sequence Trigger

Once a falling or rising edge at the ***Acquire Enable*** trigger input (see chapter **3.3.7**) is recognized, an internal image counter starts. It counts all acquired images and stops the recording when the predefined number of images is reached.

Recording Control	
Recorder Mode	Ring Buffer
Acquire Mode	Sequence Trigger
Number of Images	0
Time Stamp	Binary+ASCII

Example Timing Diagram:

Trigger Mode is set to ***Ext. Exposure Start*** and ***Acquire Mode*** is set to ***Sequence Trigger*** mode; Image counter: 3.



Note Do not confuse the function with the ***Sequence Trigger Mode*** (see camera specific manual).

3 Time Stamp

A time stamp can be placed into the upper left corner of the image. It can be either ***No Stamp***, ***Binary***, ***Binary + ASCII*** (text) or ***ASCII***.

The time resolution is 1 µs. In binary mode the first 16 pixels will be filled with the time stamp information (binary code). The numbers are coded in BCD with one byte per pixel, which means that every pixel contains 2 digits. If the pixels have more resolution than 8 bits, then the BCD digits are right bound placed and the upper bits are zero.

(1 BCD digit 4 bits; 2 numbers 2 BCD 8 bits = 1 byte; every pixel contains 2 digits)

For further information refer to our SDK manual. In binary and ASCII mode text will be placed into the image replacing the content of the image (271x 8 pixels). Time stamp shows the end of exposure time.

Three values are stamped onto the image:

1. **Image number**
2. **date**
3. **time**

3.3.6 Status

Shows the temperature of various camera elements.

1 Electronics Temperature

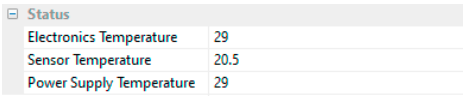
Shows the actual temperature of the FPGA.

2 Power Supply Temperature

Shows the actual temperature of the voltage supply inside the camera.

3 Sensor Temperature

Shows the actual sensor temperature.



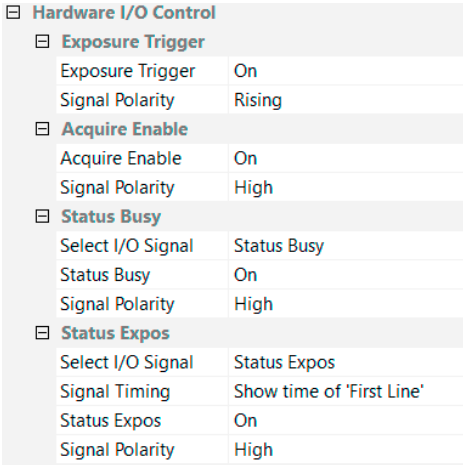
For cooled cameras:

A Peltier cooling unit keeps the sensor's dark current to an acceptable minimum to achieve a continuous image acquisition free of any drift phenomena. Either an internal fan or an external water cooling system assures proper heat transfer from the Peltier element to stabilize the temperature of the camera.

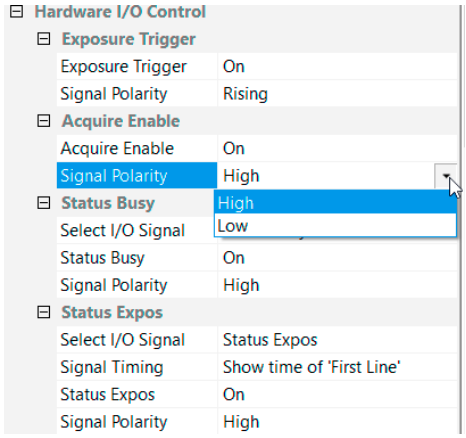
Note If the temperature rises above a certain level, pco.camware will give you a warning. Please always ensure adequate cooling of the cameras. Do not expose it to direct sunlight or other sources of heat.

3.3.7 Hardware IO control

Hardware IO control options differ depending on the camera model. Refer to the camera specific manual to see which options are available for your camera.



Change settings using the drop-down menu.



Enabling and Polarity of IO Signals

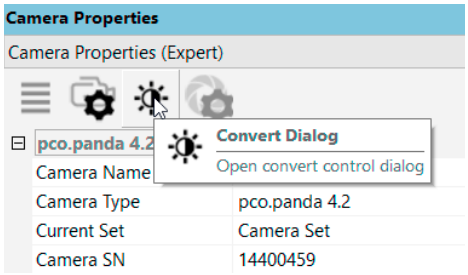
Signals can be enable or disabled from this menu. The polarity of the input and output signals indicating their active states is selectable (positive or negative logic).

The polarity of level-sensitive signals can be set to ***High*** (positive logic) or ***Low*** (negative logic).

The polarity of edge-sensitive signals can be set to ***Rising*** (positive logic) or ***Falling*** (negative logic).

3.3.8 Convert control

Start the ***Convert Dialog*** with the black/white button in ***Camera Properties***.



Convert Control BW

The conversion of the original 12/14/16 bit image intensity values (x-axis) to the corresponding 8 bit values of your computer can be arranged.

BW Setting (includes histogram of original data)

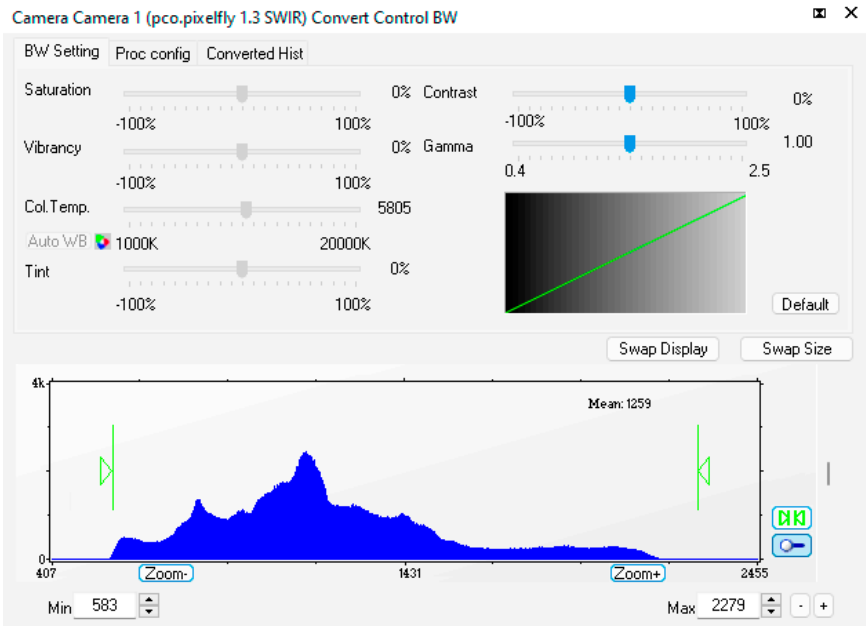
1. **Swap Display** shows either gamma setting graph or histogram of the converted image (8 bit).

2 **Swap Size** shows both in the same window.

3 **Green sliders in historam**

Left slider: minimum controller (corresponds to value 0 of the 8 bit display). Values below that mark are set to 0, i.e. displayed as black.

Right slider: maximum controller (corresponds to value 255). Values above that mark are set to 255, i.e. displayed as white.



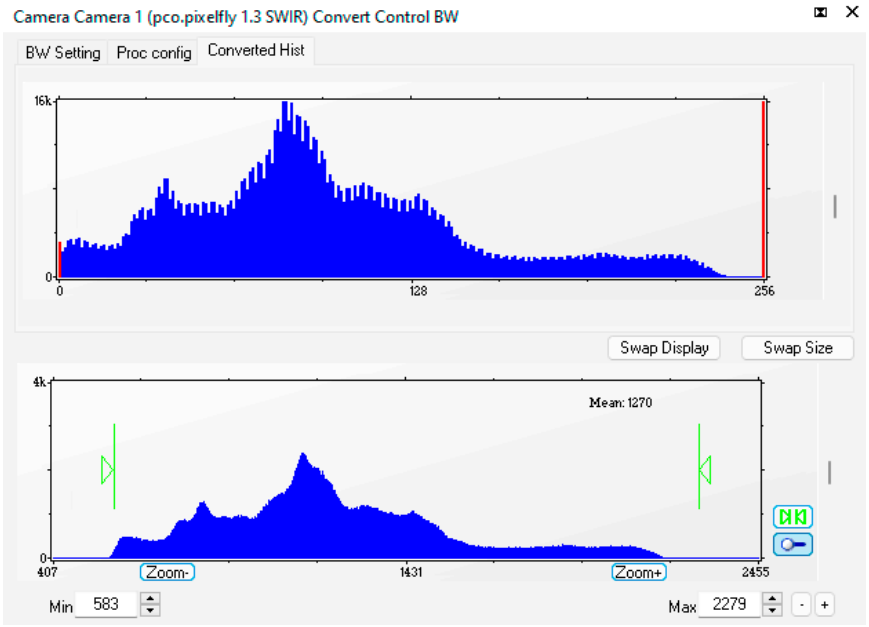
The values in-between are converted to a value between 0 and 255 depending on ***Contrast*** and ***Gamma*** settings.

4 See the small graph, which reflects the calculation.

Proc config tab: see ***Convert Control Color*** on next page.

Converted Hist

This tab shows you the histogram of converted data.



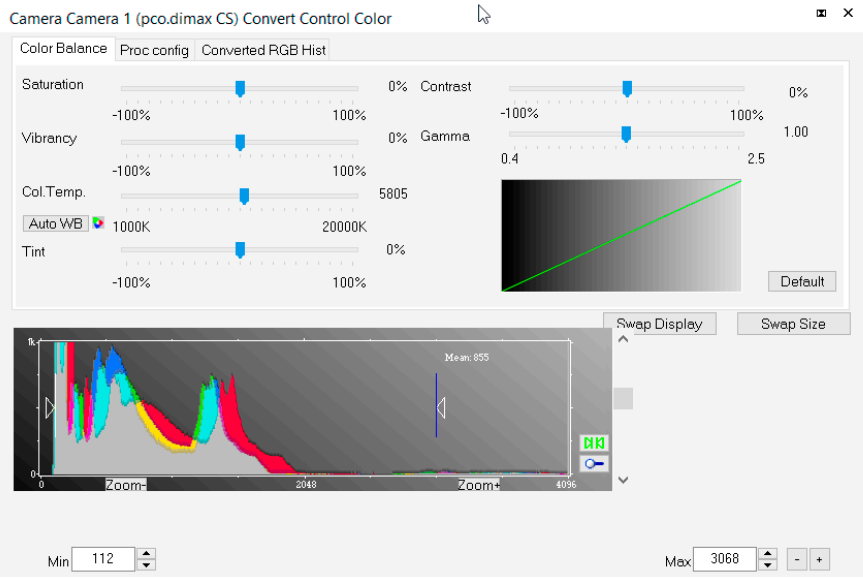
Other functions (Saturation, Vibrancy, Col.Temp, Tint) are inactive for monochrome cameras.

Convert Control Color (only color cameras)

The displayed color images are RGB images, calculated with the help of the three different color channels (red, green, blue). As a result, there are three different histograms for an RGB image: one for each color channel. The available user controls are the same as those for grayscale histogram.

Color Balance (Histogram of original data)

1. Intensity of a single color is controlled by ***Saturation*** and ***Vibrancy***.
2. Press the ***Auto WB*** button to set the ***white balance***.
3. The balancing of RGB is controlled by ***Col.Temp.*** and ***Tint***.
4. ***Swap Display*** shows either gamma setting graph or histogram.
5. ***Swap Size*** shows both in the same window.
6. ***White sliders in histogram***



Left slider:

Minimum controller (corresponds to value 0 of the 8 bit display). Values below that mark are set to 0, i.e. displayed as no color.

Right slider:

Maximum controller (corresponds to value 255). Values above that mark are set to 255, i.e. displayed as full color. The values in-between are converted to a value between 0 and 255 depending on ***Contrast*** and ***Gamma*** settings.

7 The small graph reflects the lookup table calculation, includin gamma, contrast, brightness, etc.

Proc. Config (Process configuration)

Due to proprietary high-end algorithms used for these image processing features, no detailed description is given here.

8 *GPU Processing*

Choose between ***Opencl*** and ***Nvidia GPU*** in order to significantly reduce processing time (increases refresh rate of the live image). If this option is not available use an Nvidia graphics device or update to the most recent driver for Nvidia GPU.

Fast pco debayering: only for color cameras. An alternative method for removing the Bayer pattern.

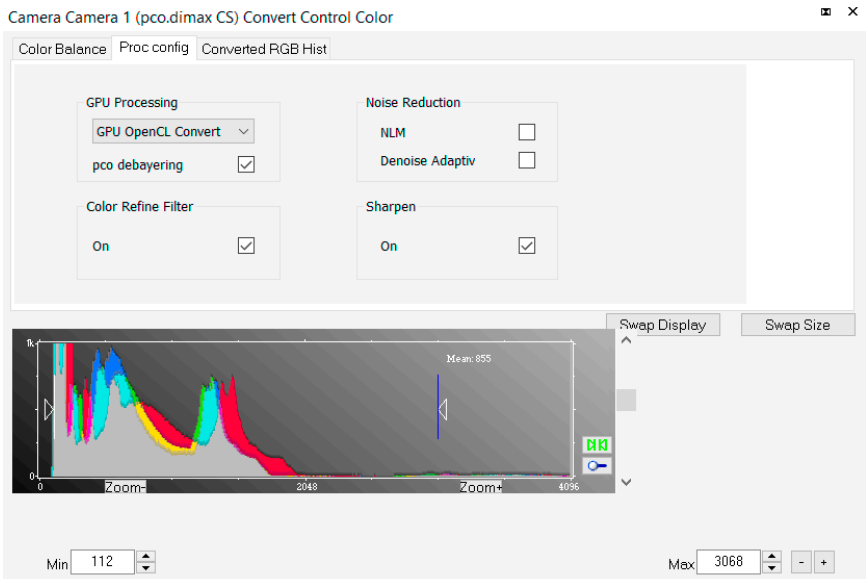
9 ***Color define Filter***: only for color cameras

10 *Noise reduction*

NLM: non-local means algorithm

Denoise Adaptive: only for color cameras

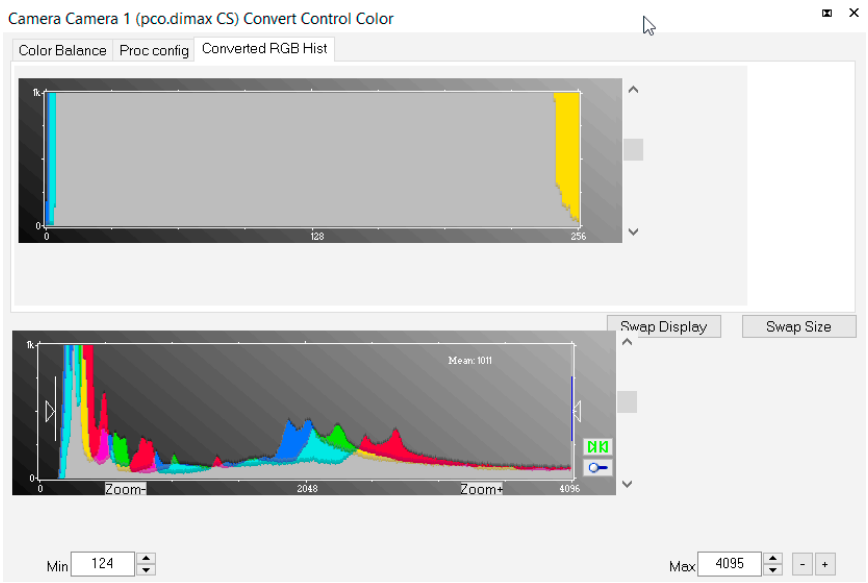
11 *Sharpen*



On: only for color cameras (first activate ***Fast pco debayering***)

Converted RGB Hist

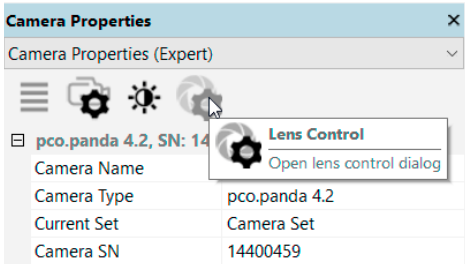
This tab shows you the histogram of converted data.



3.3.9 Lens control dialog

Open ***Lens Control Dialog*** with this button. Button is only active if a camera with EF lens is detected.

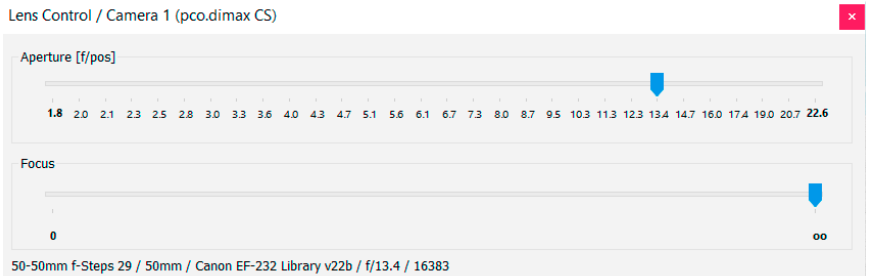
Lens Control is only available for pco.edge with Camera Link HS interface, pco.dimax cs and pco.dicam C1.



Settings

Aperture (f/pos): select the aperture. All possible apertures of your lens are listed.

Focus: select focus from 0 to infinity.

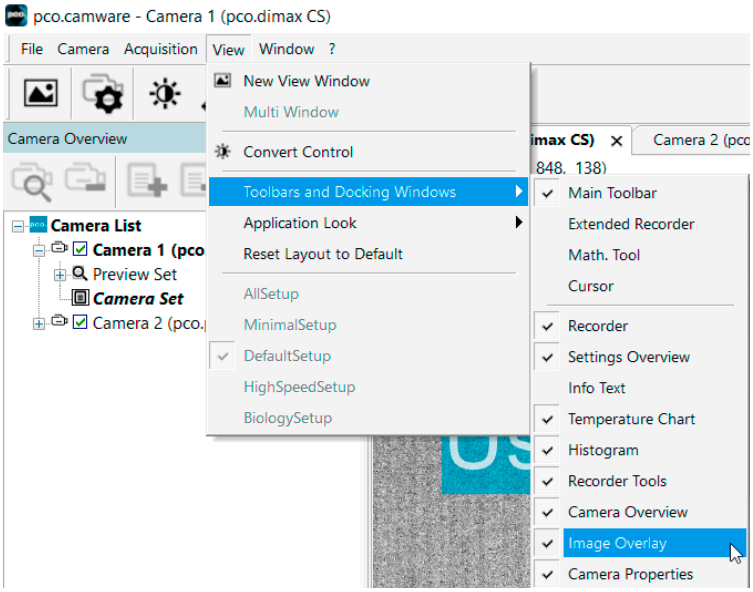


1 ***Lens Control Dialog*** shows detailed information about the mounted lens and the current position of aperture and focus.

3.4 Image overlay

1 Open ***Image Overlay***: toggle between ***Camera Properties*** and ***Image Overlay*** with these tab controls.

If not available, see **3.9.5** to activate it.



This function enables a configurable image overlay allowing to display information within the images.

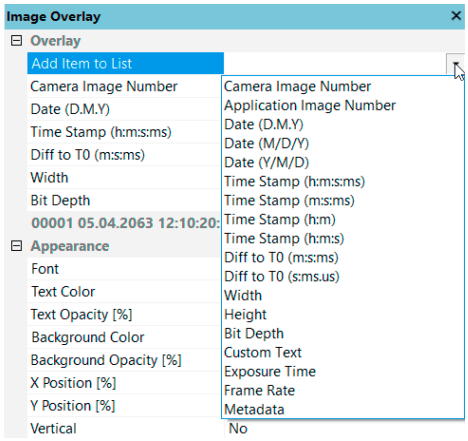
2 Many options are available by clicking ***Add item to List***.

The ***Appearance*** is of the overlay is configurable:

Font, ***Text Color***, ***Text Opacity***, ***Background Color***, ***Background Opacity*** and ***X Position*** or ***Y Position***.

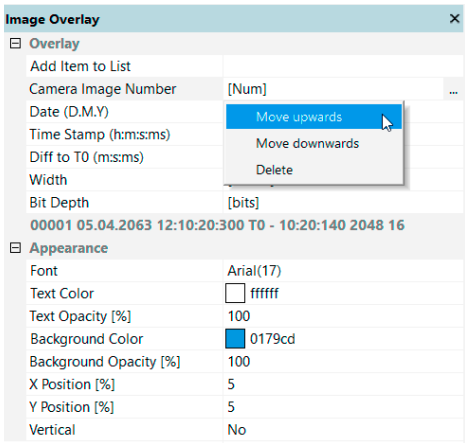
3 ***Camera Image Number*** The image numbers are incremented continuously. Recording in ***Ring Buffer*** mode, once the camera's RAM is full, results in overwriting the images, starting with the first image in the loop. However the camera continues to increment the image number.

4 ***Application Image Number*** The software displays the image numbers according to the quantity of images being recorded (starting with image 1). After ***Ring Buffer*** is full the number is always reset to 1.

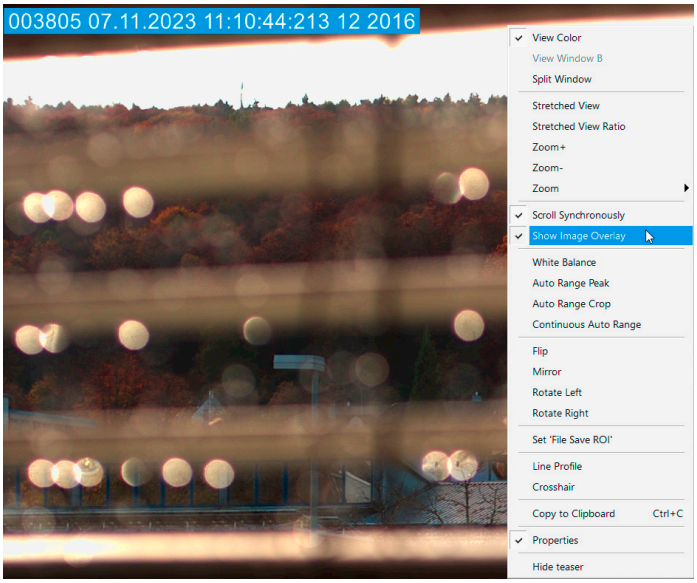


5 A preview of the ***Image Overlay*** is shown.

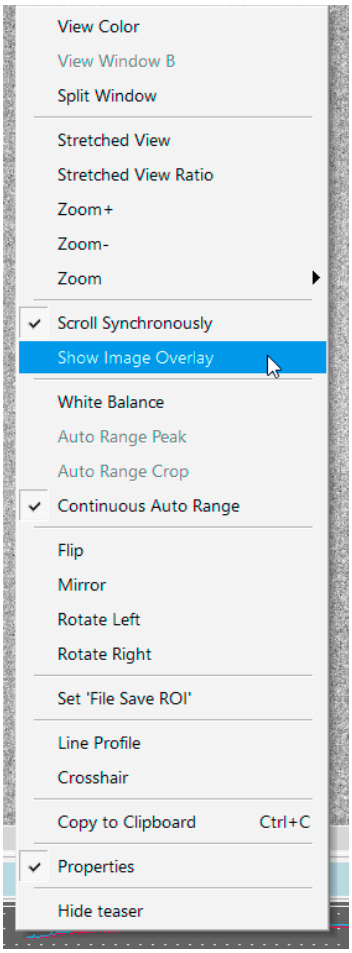
6 Each item can be moved or deleted: ***Move Upwards***, ***Move Downwards*** or ***Delete*** by clicking on ... or move freely by clicking on ... and dragging an item.



Drag & drop the ***Image Overlay*** to the desired position within an image.



7 Right click in the image to start ***Show Image Overlay***.



Note This function does not overwrite raw recorded image data. Only the converted 8 bit image will be covered depending on the opacity.

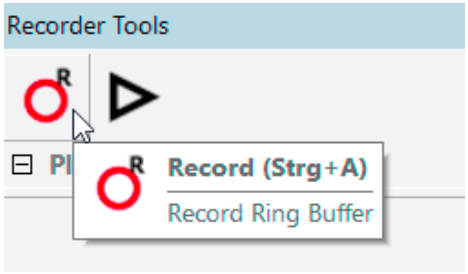
3.5 Recorder tools

Recorder Tools provides ***Record*** and ***Play*** function, ***Play Settings*** and ***Record Settings***.

Located on the right lower side of pco.camware or, if closed, activated by View Menu (see chapter **3.9.5**).

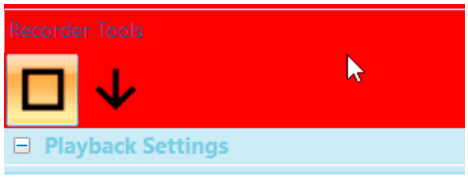
Record

Start/Stop record: with ***Record*** Button or press ***enter*** in the ***View window*** to Start / Stop a record session.

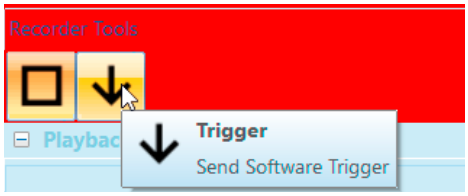


Record: in record state pco.camware software is highlighted in red.

Exposure time can be changed during recording. See **3.3** ***Camera Properties***.



Software Trigger: after record is started an arrow pointing downward appears. Clicking on it triggers a single image. (see **3.3.1**).



1 *Play Settings*

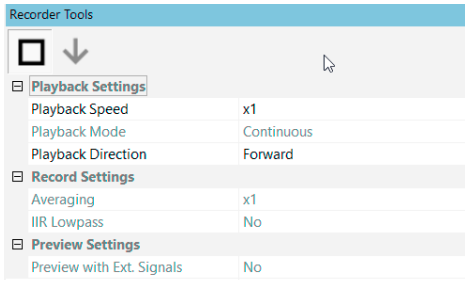
Play Speed: selectable ***Play Speed*** from ***x1*** to ***x256*** or from ***1 fps*** to ***16 fps***.

E.g. in mode x1 a recording with 1000 fps is played as fast as possible.

1 fps means that only one frame per second is played. X2 displays only each second image.

Play Mode: selectable play mode of the recorder (***Single*** or ***Continuous*** (re)play).

Play Direction: selects direction of record play (***Forward*** or ***Backward***).



2 *Record Settings*

Averaging: averaging images in the buffer reduces random image noise. Set a value higher than x1 in the drop-down list and this number of images will be averaged.

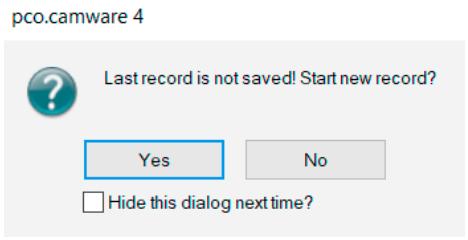
IIR Lowpass: another option to reduce the noise is the activation of the Infinite impulse response ***IIR Lowpass*** filter. This filter takes 50% of the previous image and 50% of the new image to create images with reduced noise.

Image (actual) = {Image (act - 1) + Image (new) } / 2

Preview Settings

If ***Preview with ext. signals*** is set to ***Yes***: ***Trigger Mode Ext. Exp.*** / ***Ext. Exp. Ctrl. Start*** or ***Acquire Mode External*** are active during Live Preview, if the ***Trigger Mode*** or ***Acquire Mode*** is enabled in the ***Preview*** set.

Use this during ***Live Preview*** e.g. for external synchronization of a camera and an external light source.



Reminder Dialog

If you made a recording but did save it yet, pco.camware will remind you to do it before starting a new one. If the dialog is deactivated, it can be reactivated via the file options menu **3.9.2**.

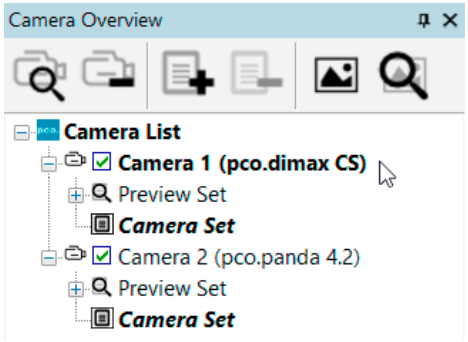
Extended Recorder

Extended Recorder can be activated (see **3.9.5**).

1 ***Record*** / ***Stop*** record / ***Play***.

2 ***First image*** (jump to first image) / ***Back fast*** (jump backward) / ***Back*** (jump one image backward).

3 ***Forward*** (jump one image forward) / ***Forward fast*** (jump forward) / ***Last image*** (jump to last image in record).

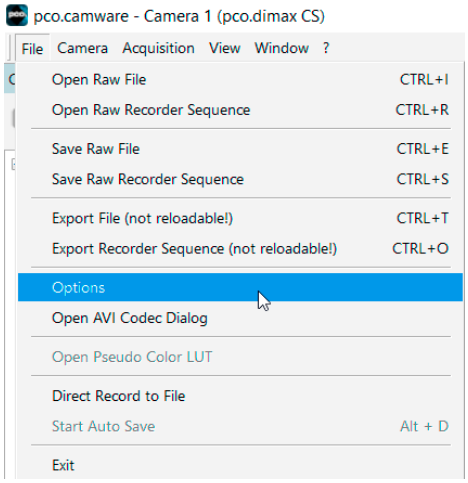


Recording with Multiple Cameras

With all cameras activated recording starts simultaneously on all of them.

Recorder will use ***Recorder Mode*** settings (Sequence or Ring Buffer) of the selected camera for all cameras (see **3.3.5**).

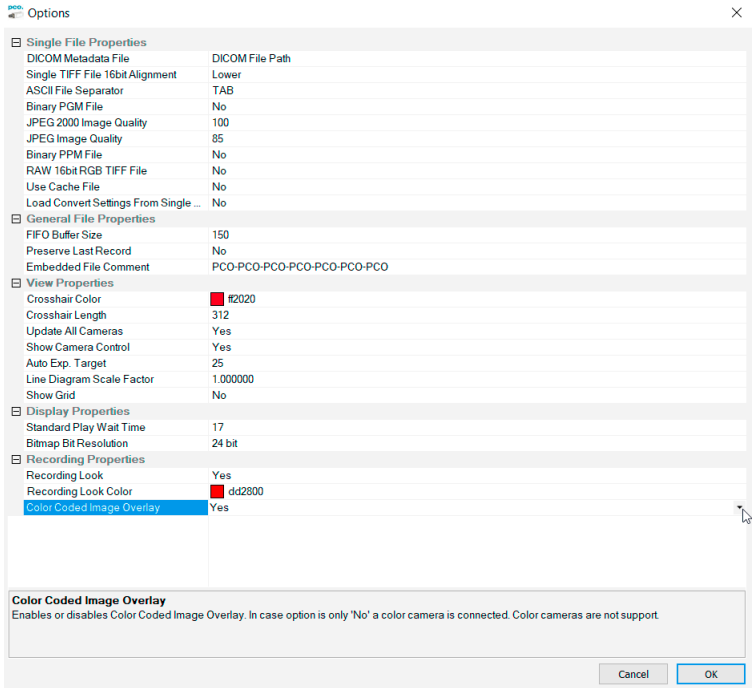
1. For single camera recording, deactivate cameras by removing the check mark from the box.

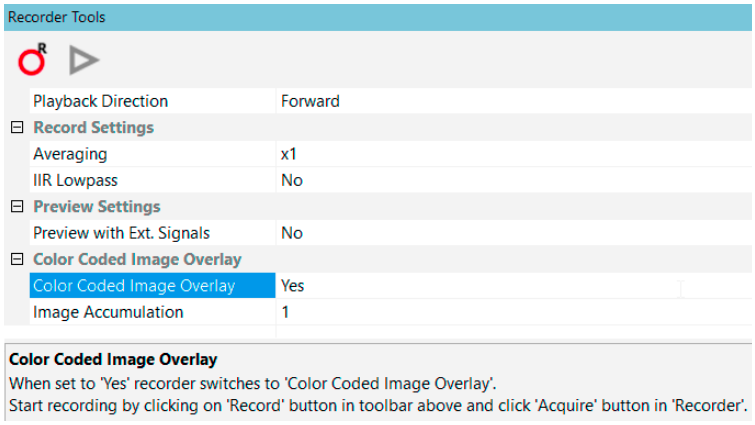


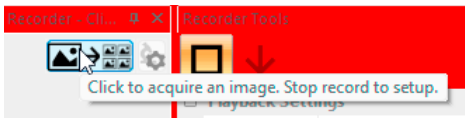
Coolor Coded Image Overlay

Set up and acquire a sequence of images that are overlayed to form a color composite. To open Color Coded Image Overlay, open:

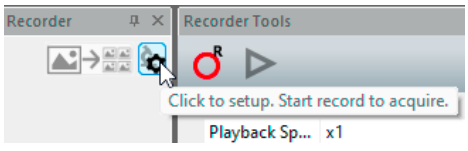
1. ***File***
2. ***Options***
3. ***Recording Properties***
4. If enabled, it can be activated in the ***Recorder Tools*** window.







5 The Recorder window will now have 2 additional buttons. Click on the setup button.



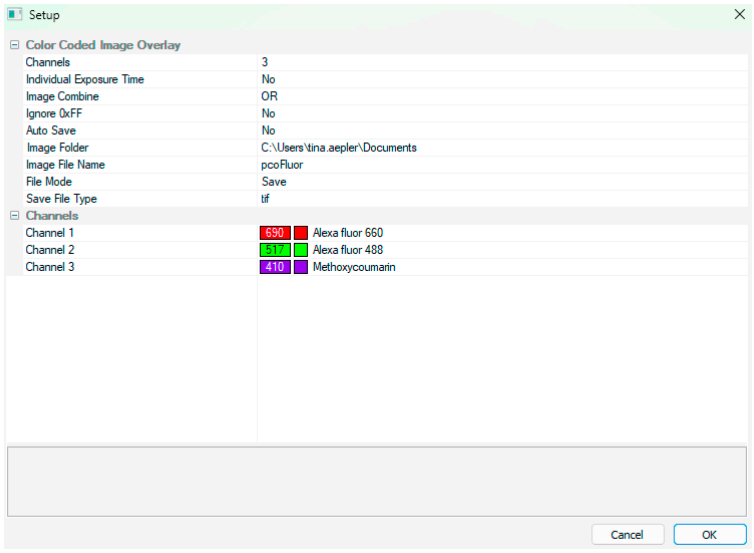
This opens the ***Setup*** dialog.

Channels sets the number of images per sequence.

The **+** adds a fluorophore to the end of the list, the **-** deletes it.

Individual Exposure Time sets an individual exposure time for each image of the sequence (LUT min/max are always individual).

Image Combine sets the calculation method for the combining images.



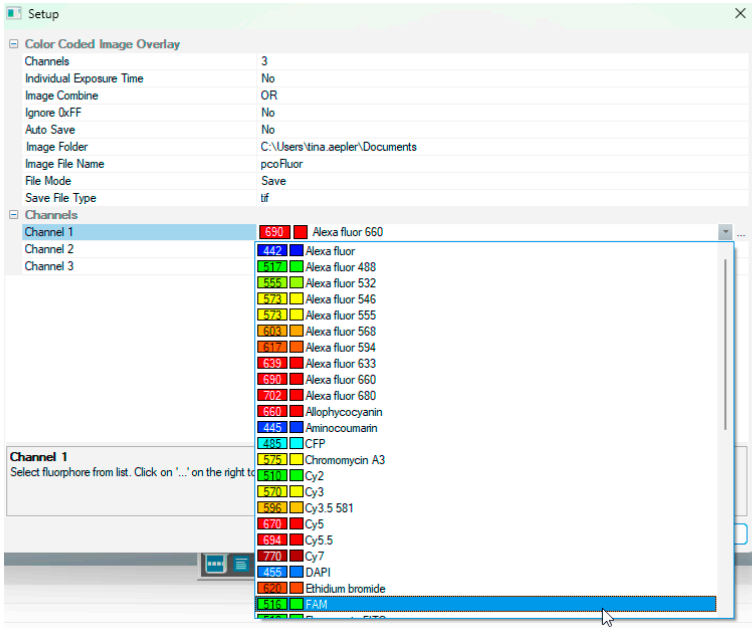
Auto Save enables the saving of images during the recording of the sequence.

Image Folder sets the file location, ***Image File Name*** sets the file name.

File Mode sets whether Save and/or Export should be used.

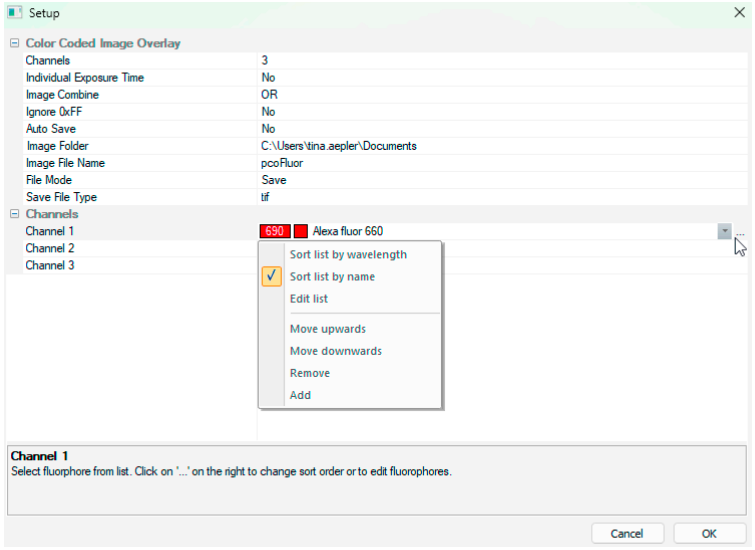
Save File Type and ***Export File Type*** set the respective file types.

You can select individual fluorophores for each channel from a predefined list by clicking on them in the ***Channels*** section.



You can change the order of channels: Click on the three dots at the end of the channel line and select ***Move upwards*** or ***Move downwards***. You can also rearrange the channels via drag and drop.

Remove or add fluorophores in the sequence with ***Remove*** and ***Add***.

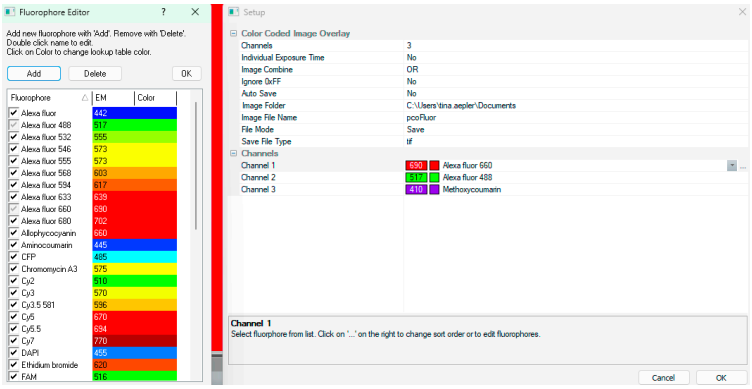


You can also edit the Fluorophore List with ***Edit list***. This will open the ***Fluorophore Editor***.

Use the header bar in the ***Fluorophore Editor*** to arrange the fluorophores either by name (***Fluorophore***) or wavelength (***EM***). You can edit the names of both the fluorophores and the wavelength EMs by double-clicking on the entry.

The arrow next to the column shows the sorting order.

Clicking on ***Color*** opens a color selection dialog.

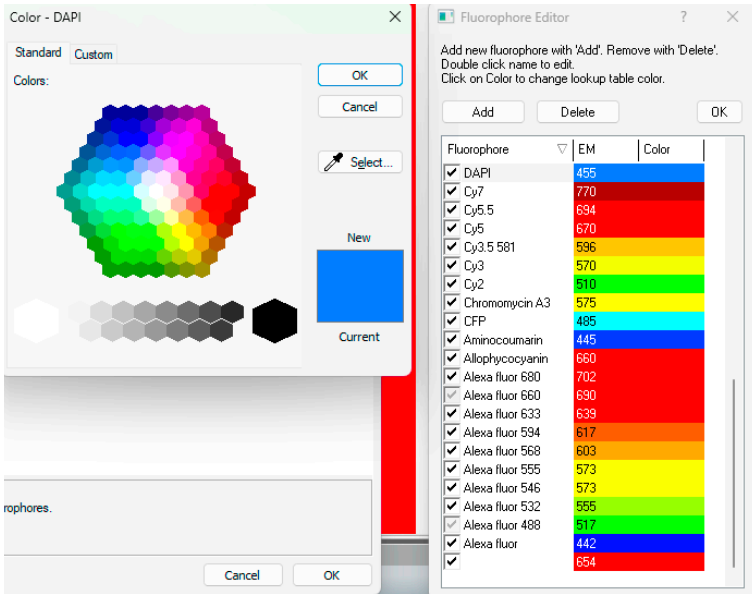


Click on ***Add*** to add fluorophores to the list and click on ***Delete*** to remove them.

The checkmark column at the far-left of the ***Fluorophore Editor*** sets whether the individual fluorophores can be selected in the drop-down list for the channel.

If a fluorophore has already been selected, it cannot be unchecked and will be grayed out.

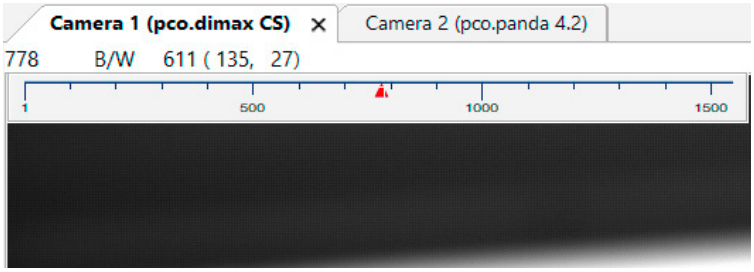
Multiple fluorophores can be selected at once by holding Shift while checking in the column.



3.6 View window

Quick Scrolling

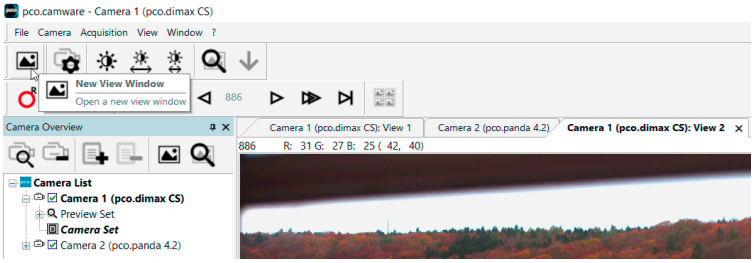
If at least 50 images have been recorded, you can scroll through them quickly by holding down the left mouse button on the image number. Alternatively, you can enter the desired image number directly into the number field or use the mouse wheel to scroll up or down.



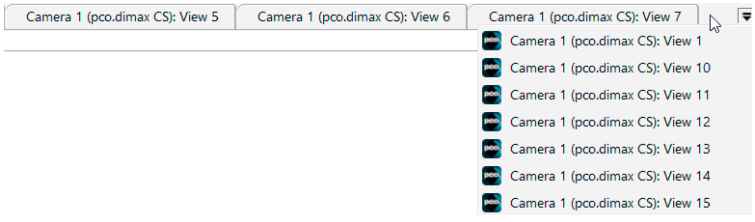
More View Windows

1. You may open more than one window for one camera: click View Window button
2. and pco.camware will create a new one.

Even when multiple ***View Windows*** (or from multiple cameras) are open, the same image number is always shown in all of the ***View Windows***.



3. A dropdown menu helps to select a ***View Window***. If there are more ***View Windows*** than can be displayed on the desktop, you may select individual ***View Windows***.

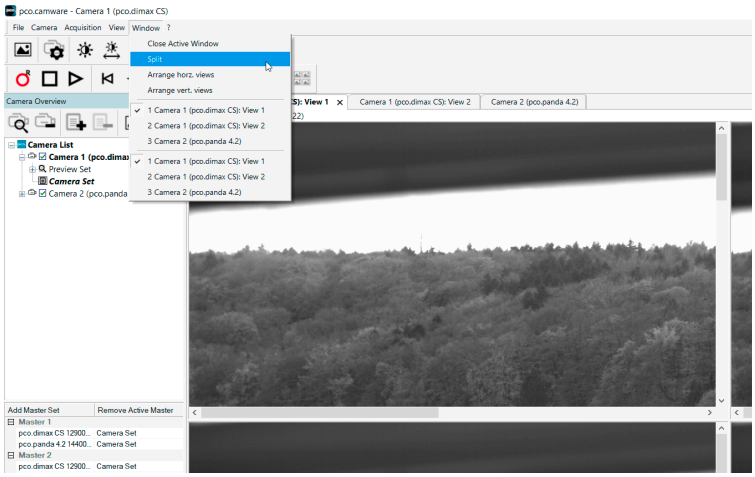


Split View Window

4. The View Window can be split. Click Window -> Split and a split cross is shown.

5 The size of split window elements is easily adjusted by grabbing and dragging the dividing lines.

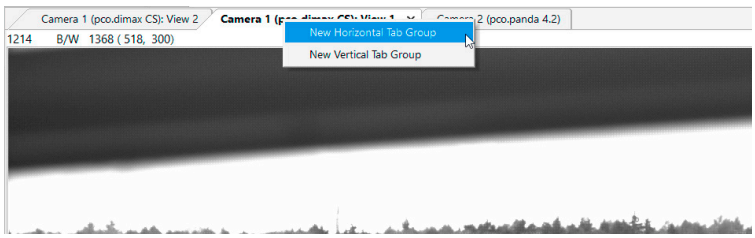
The main reason for this function is to view four sections of the image in one view. Choose the ***Zoom±*** function to zoom in the image (first turn off ***Stretched View*** see **3.9.8**).



6 To undo the split, double click on the dividing line (after symbol is visible).

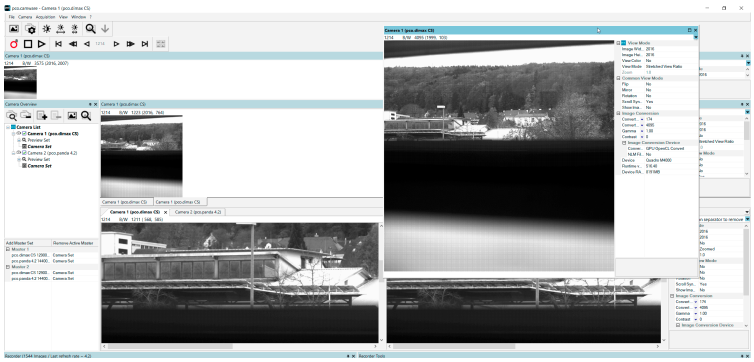
New Horizontal / Vertical Tab Group

To view two tabs side by side or arranged one above the other just drag a tab and pco.camware will prompt to create a ***New Horizontal / Vertical Tab Group***. Undo this by dragging the tab back to its former position. This also applies for ***View Windows*** of several cameras.



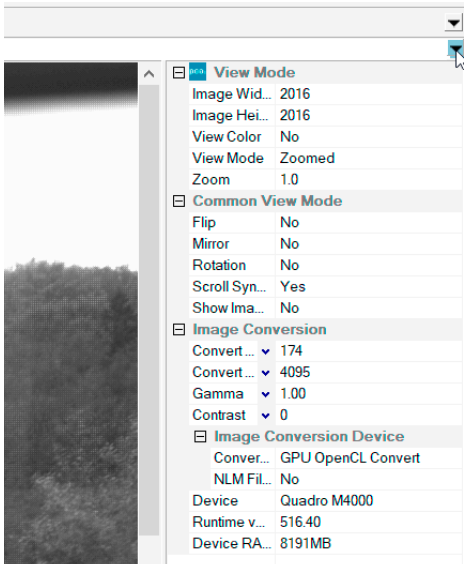
Place View Window

This function provides free positioning of one or more ***View Windows***. Just drag the ***View Window*** by mouse and move it upwards to undock from the ***View Window*** tab bar. Now place it to a second monitor or dock it to the desired toolbar. Some example screen shots show the variety of options.



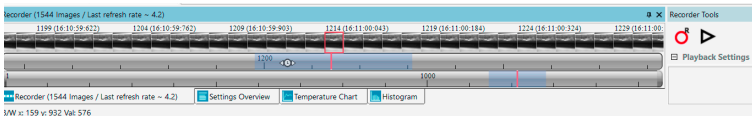
View Mode Properties

Click on the triangle button on the right-hand side of the view window to open or close the view mode properties.



3.7 Recorder (Images)

When recording is done, small preview images (thumbnails) are built and displayed automatically in the ***Recorder (Images)*** docking window.



This may take some time depending on the performance of your computer system and the interface used.

1. A green bar indicates the thumbnail download is in progress, and pco.camware is frozen during this download. The build process can be stopped by selecting ***Stop Build Thumbnail*** in the ***Right-click Menu*** (next page).
2. Clicking (left mouse button) within the upper scale bar, you can adjust the number of images shown by moving the mouse left or right. Minimum is 20 and maximum is half of the total recorded images.

Quick Scrolling

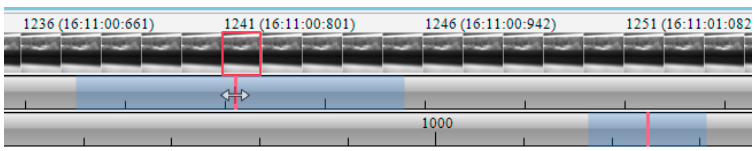
Scroll through the thumbnails by dragging the orange bar with the mouse or by mouse wheel while the cursor is over the image number bar.

While quick scrolling, the ***Preview Window*** displays the active image sequence. This allows you to quickly scroll through the image sequence displaying the images in the ***Preview Window*** forwards or backwards. The ***View Window*** will not actively show live images during quick scrolling (only in normal scrolling speed by mouse-wheel).

Thumbnail Image

Clicking on a thumbnail image it will make it appear in the ***View Window***. Scroll via mouse wheel through the thumbnails.

3. The upper blue bar refers to the number of displayed thumbnails. The lower blue bar shows the range of the upper scale in relation to the whole record.
4. The second scale shows the total number of recorded images. It allows fast scrolling through the images.



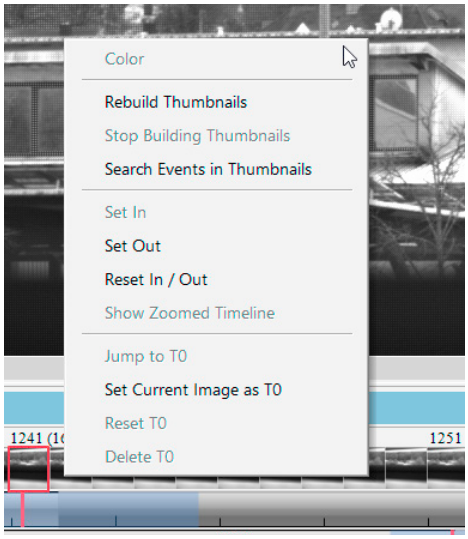
Right-Click Menu

Right-click on thumbnails to open the menu. From this menu, you can rebuild all thumbnails and search for events.

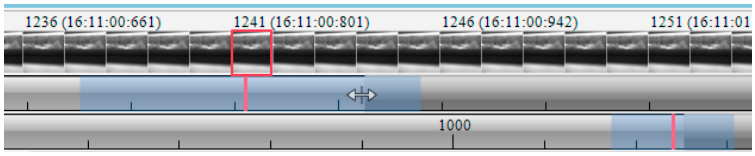
5 Use ***Set In / Out*** to set values for a sequence that can be played via play button.

6 ***Reset In / Out*** discards these settings.

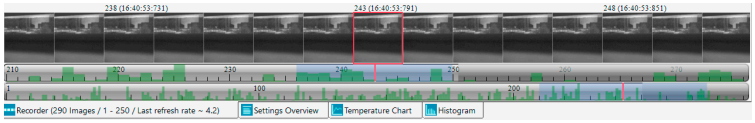
Set In / Out is active: if you save/export your images, only the selected ones are saved/exported (see **3.9.2**).



The light gray area in the upper scale shows an ***In-Out*** example area. To define a new area, right-click on the start and end frame in one of the scales. The ***In*** image must be left of the red bar, the ***Out*** image to the right of the red bar. Adjust the ***In / Out*** area by holding down the left mouse button and slide the borders to increase / decrease the range.

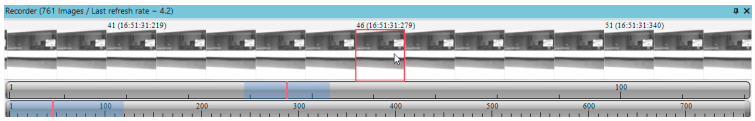


7 ***Search Events in Thumbnails:*** detected events are shown as green bars.



Too Dark or Bright Thumbnails

If thumbnails are too dark or too bright, right-click in ***View Window*** (see **3.9.8**) and select ***Auto Range Peak*** or ***Auto Range Crop***. Then right-click on a thumbnail image and select ***Rebuild Thumbnails***. Now the thumbnail images should conform to the ***View Window***.

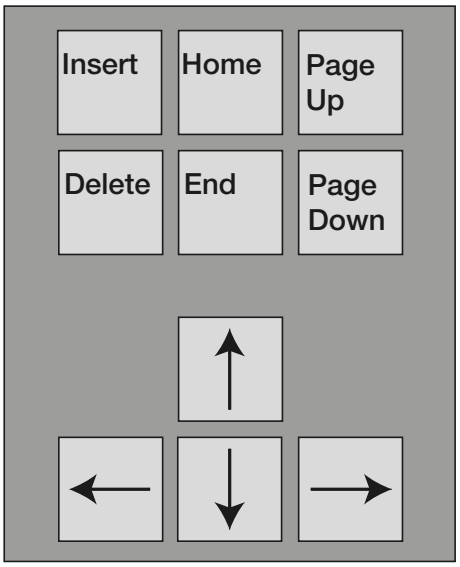


Keyboard Scrolling

Use your keyboard to scroll through the Images. Page up / down keys: 10 Images up or down. Arrow keys: quick scrolling through the images.

Advantage: fluent video playback in the View Window (forwards or backwards).

Home/Pos1 key: first image. End key: last image.



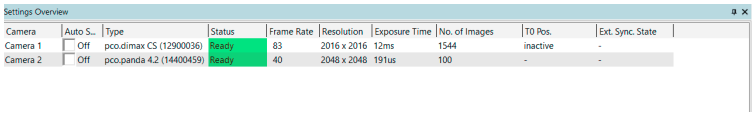
Additional Short-Cuts

While mouse is in the thumbnail area in ***Recorder (Images):***

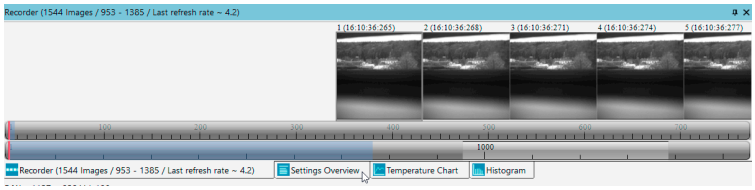
Press CTRL + click jumps in that direction to the end. Left of the current image to jump to the first image. Right of the current image to jump to the last image.

3.8 Settings overview

Open ***Settings Overview*** in the lower toolbar right next to the recorder. If it is not visible see chapter **3.6** ***Toolbars and Docking Windows*** to open it.



Settings Overview shows the most important parameters of your camera(s) at a glance. If more than one camera is connected, each camera and its parameters are listed.



The parameters can only be changed under **3.3**.

11 Switch easily between the ***Recorder (Images)*** section and the ***Settings Overview***.

Number	Function	Description
1	Camera name	Name
2	Auto Save	Off, Unconfigured (red), OK (green)
3	Type	Camera type and serial number
4	Status	Ready or Recording; Green background: Images are in memory.
5	Frame rate	Currently selected frame rate
6	Resolution	Resolution in pixels
7	Exposure time	Selected exposure time
8	Number of images	Number of images to be recorded

Continued on next page

Continued from previous page

Number	Function	Description
9	T0 Position	See camera specific manual
10	Ext. Sync. State	See camera specific manual

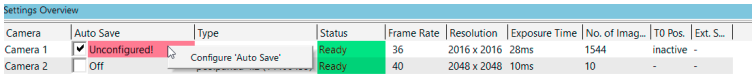
3.8.1 Auto save

Auto Save helps to save recorded images or sequences in an easy way. There is no need to save each image/sequence separately from each connected camera. This function is very useful if you use more than one camera. Once configured ***Auto Save*** can acquireand save as many images / sequences as needed during your experiment. This function stores ***RAW*** (e.g. b16, TIFF) and ***Export*** (compressed e.g. AVI, JPG) files.

For standard file save and export see ***File menu*** 3.9.2. Explanations are shown in the info text window at the bottom of the menu.

Enable ***Auto Save*** by clicking on the check box. The text changes to ***Unconfigured!*** (red background).

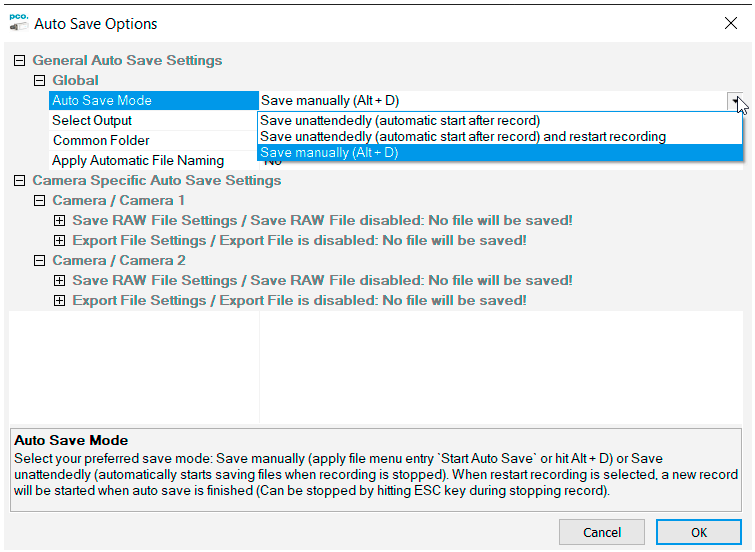
Right-click on the ***Unconfigured!*** field and click on ***Configure 'Auto Save'***.The ***Auto Save Options*** dialog is displayed.



General Auto Save Settings

Global

Auto Save Mode: three different modes are available, ***Save manually*** and two variants of ***Save unattendedly***.



The ***Save manually*** mode stores RAW images and export images after a recording session, when ***ALT*** and ***D*** keys are pressed. This can be useful for selcting a subset of the image sequence in the ***Recorder Toolbar*** before saving.

The ***Save unattendedly*** mode downloads all RAW images and exports the complete image sequences of all cameras immediately after an active recording is stopped.

Save unattendely (automatic start after record): saves all image data after recording, without any further user interaction.

Save unattendely (automatic start after record) and restart recording: after a recording has been saved, ***Auto Save*** restarts the recording, and then saves again – endlessly (stopped by stopping the recording).

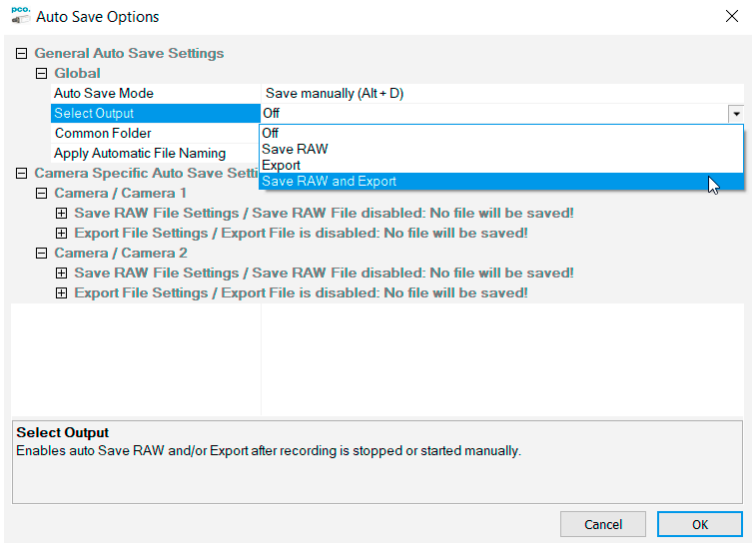
Select Output:

Off: Auto Save is deactivated

Save RAW: only 16 bit RAW files are stored (b16, PCO Raw-File, MultiTif-File, tiff)

Export: only converted files (8 bit) are stored (bmp, jpg, tiff, avi, mpeg, wmv)

Save RAW and Export: RAW and converted files are stored simultaneously.

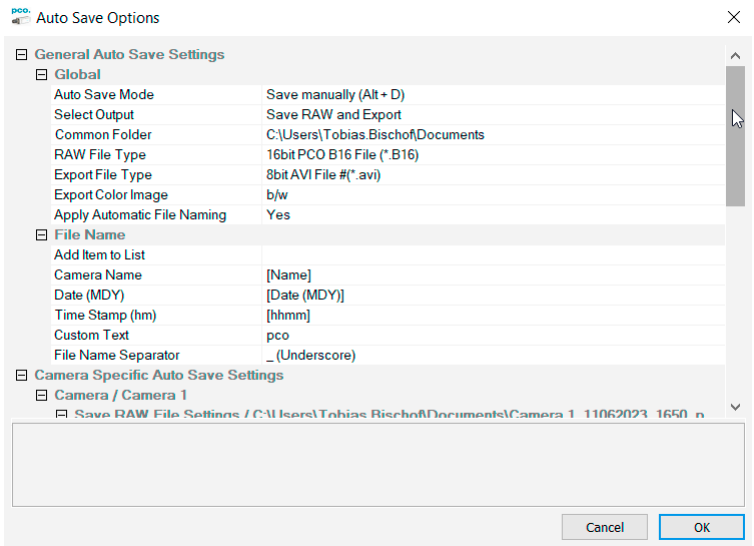


Common Folder: select main folder for stored files

Raw and Export File Type: select the type of RAW and converted file

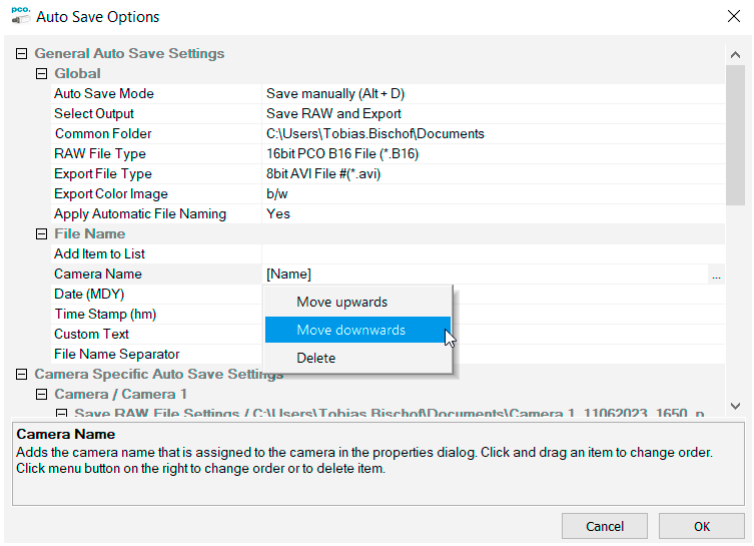
Export Color Image: select to export color images (only for color cameras)

Apply Automatic File Naming: if set to ***Yes***, stored files are automatically named by pco.camware according to your automatic file name settings.



File Name

Set file name individually by adding or deleting items. Position these elements as needed.

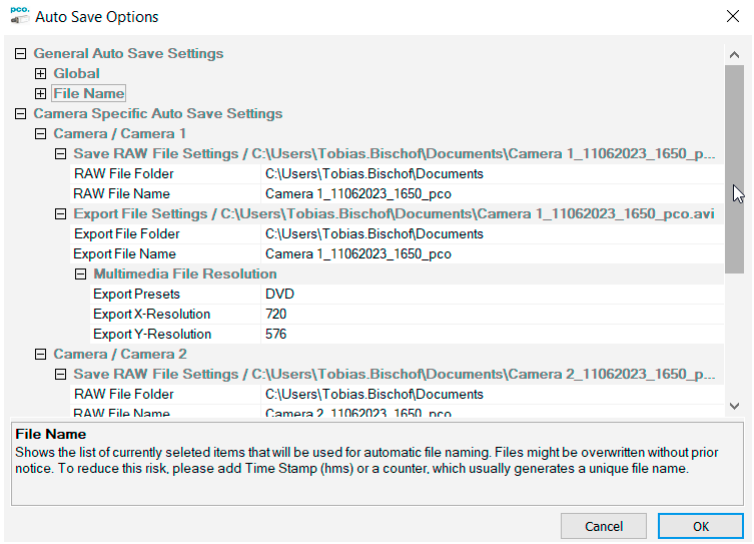


Camera Specific Auto Save Settings

Configure camera specific settings for each connected camera.

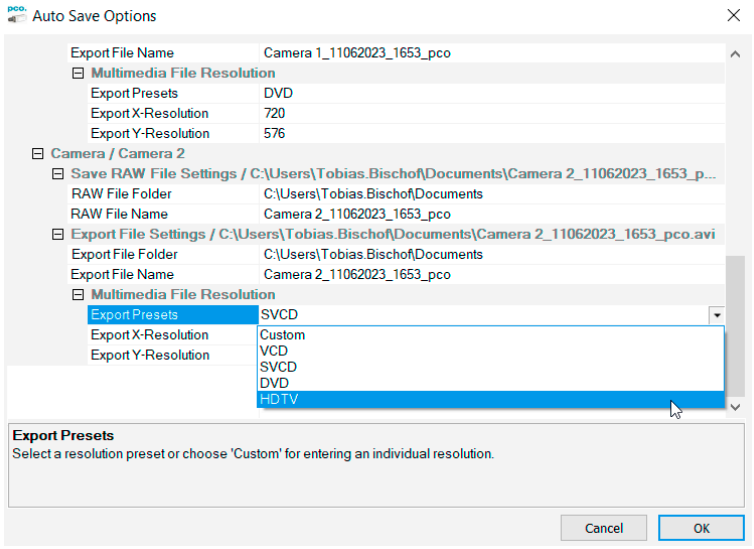
Save RAW File Settings: set ***RAW File Folder*** and ***RAW File Name*** (if not set to automatic file naming).

Export File Settings: set ***Export File Folder*** and ***Export File Name*** (if not set to automatic file naming).

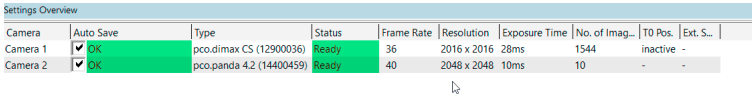


Multimedia File Resolution: set predefined video export resolution or enter a ***Custom*** x- and y-resolution.

You may have to set the resolution to match the configured resolution of your camera here.



Finish the configuration by clicking ***OK***.



After configuration is finished, ***Auto Save*** status turns ***OK*** (green background).

3.9 Tabs and features

This chapter describes in detail the pco.camware ***Demo Mode*** and the pco.camware tabs: ***File, Camera, Acquisition, View*** and ***Window***. The right-click menu and some additional features are also described.

3.9.1 Demo mode

Upon startup pco.camware automatically recognizes the camera type of all connected and running cameras.

It starts in ***Demo Mode*** if your camera is off or no camera is connected.

If you want to force pco.camware into ***Demo Mode***, hold down the D key and press ***Scan Cameras*** button.

In this mode all image processing features are available, but all camera settings and options are deactivated. An image type can be selected to simulate the output of a particular camera model so images can be laoded and processed when the camera is not connected. The ***Demo Mode Setup*** window opens, requesting the corresponding input.

Need Help? Having troubles to run the camera this window will pop up. Follow instructions of chapter **B**.

Resolution

The drop down list displays the existing image sensor spatial resolutions of all PCO camera systems. Select the specific resolution and bit depth of the images to be opened. To open Double Image (shutter) images tick ***Double Shutter*** if such images have been recorded.

Color

With the radio buttons, the user can specify whether the image type is monochrome (b/w) or color.

Alignment

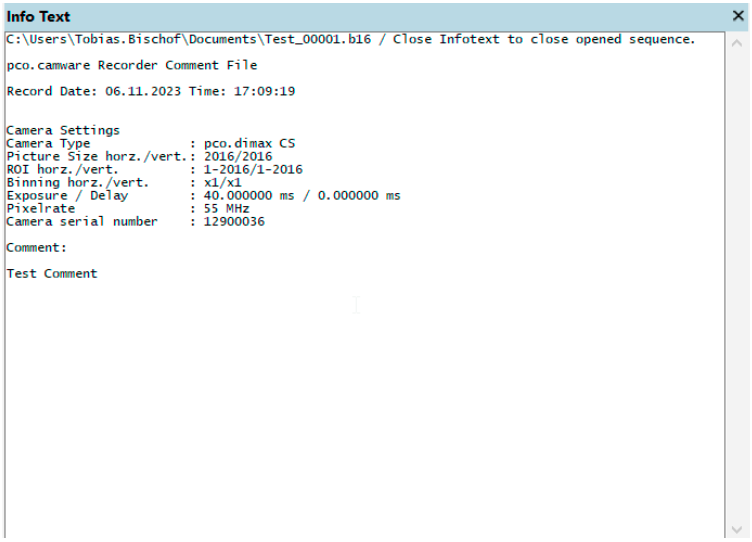
These two radio buttons adjust whether MSB (most significant bit) aligned (upper) or LSB (least significant bit) aligned (lower) images have been stored.

Infotext

The ***Infotext*** is automatically shown in pco.camware if you open a stored image sequence.

The ***Camera Properties*** settings, storing location and Record date are listed in this file.

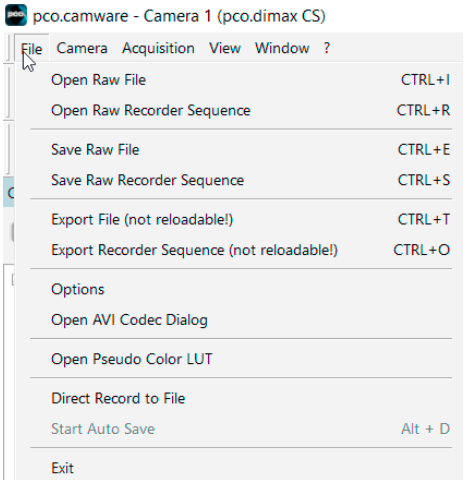
Infotext can be activated in the View Menu **3.9.5** at any time.



3.9.2 File menu

Open Raw File

Imports a single image into the active image window. Only files with the extension and format of *.b16 (PCO proprietary binary image format) and *.tif (16 bit TIFF image format) can be imported. If the recorder is enabled, each imported image is transferred to the buffer shown in the picture number. The imported image is adjusted to the current image size.



Open Raw Recorder Sequence

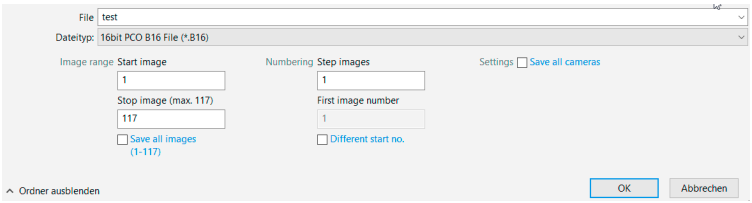
Imports a sequence of images. If more than one camera is connected and an image window is open, the sequence is loaded to the active window. If no image window is open, the images are loaded to camera #1. This command opens the Open file dialog box. Only files with the extension and the format of ***.b16, *.pcoraw, *.tif*** and ***multi tif*** can be imported.

Save Raw File

Saves the image displayed in the active window and opens the Save file dialog. The image file can be saved in ***16bit *.b16, dcm*** or ****.tif*** format. If more than one camera is connected, it is possible to save all current images by selecting Export all images in the Save file dialog box. This feature saves one image of each active camera within one process step (it is not necessary to repeat the procedure for each camera). The save command is not available if no image window is open. For ***Auto File Save*** see **3.8.1**.

Save Raw Recorder Sequence

Saves or exports image sequences. If more than one camera is connected and an image window is currently open, the record of the active window is saved. The command opens the Save recorder file dialog box. It is possible to select the number of saved images, to step images and to choose the first image number. For ***Auto File Save*** see **3.8.1**.

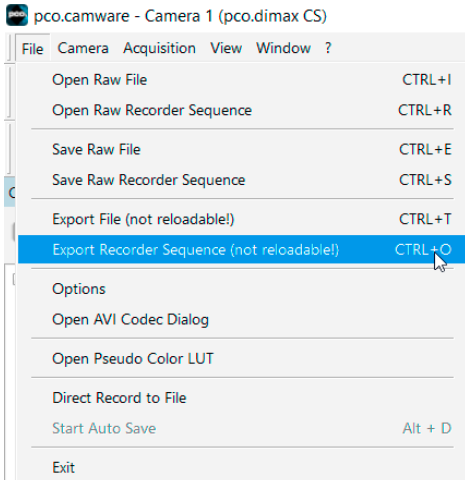


Export File (not reloadable!)

Exports the image of the active image window. This command opens the ***Export File*** dialog box. Files with the extensions asc, bmp, fts, jp2, jpg, pgm, png, tif can be exported. This item will not be available if no image window is open. For ***Auto File Save*** see **3.8.1**.

Export Recorder Sequence (not reloadable!)

Exports a sequence of images. If more than one camera is connected the image record of the currently open window will be saved. If no image window is open the Export Recorder Sequence menu does not appear. This command opens the Export recorder box. Files with the extensions asc, avi, bmp, fts, jp2, jpg, mpg, pgm, png, tif and wmv can be exported (see Appendix **A**). ***Auto File Save*** see **3.8.1**.



Options

Single File Properties

Single TIFF File 16bit Alignment: upper/lower

ASCII File Seperator: select a separator for the values in the ASCII file. Select: TAB, SPACE, SEMICOLON, COLON, COMMA, HYPHEN, SLASH, BACKSLASH.

Binary PGM File: set the format of the pgm (portable gray map) file. Select: Yes, No.

JPEG 2000 Image Quality: set compression from 20 to 100 %.

JPEG Image Quality: set compression from 20 to 100 %.

Binary PPM File: set format of the ppm (portable pixmap) file. Select: Yes, No.

RAW 16bit RGB TIFF File: save raw tif without color balance. Select: Yes, No.

Use Cache File: caches image data on disc for a camera with camera internal memory and thumbnail readout. Select: Yes, No.

General File Properties

FIFO Buffer Size: set the FIFO buffer size in number of images for ***Direct Record To File***. This avoids gaps during file write delays. Usually it is set to 150.

Preserve Last Record: preserves current recorded images. The user is prompted whether to really start a new record or to close.

Embedded File Comment: add a comment.

View Properties:

Crosshair Color: set crosshair color (color for save ROI & line tool).

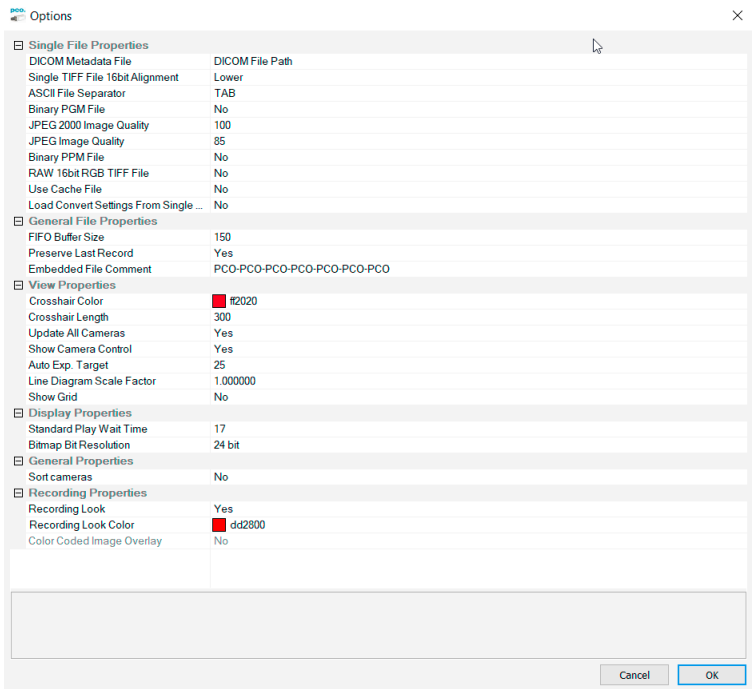
Crosshair Length: set crosshair length in pixels (see chapter **3.9.8**).

Update All Cameras: update all non-streaming cameras during recording or preview. Set to ***No*** to update only the active camera.

Display Properties:

Standard Play Wait Time: set wait time in ms to get reduce tearing and stuttering display during ***Multi Window***.

Bitmap Bit Resolution: 24 bit: sets the bit resolution of the bitmaps created for display and export.



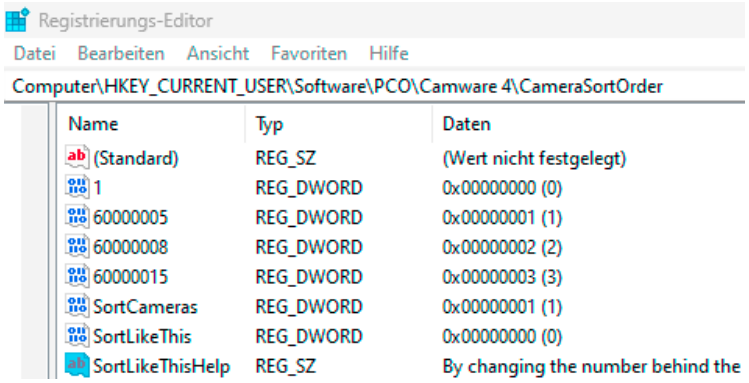
General Properties:

Common Settings Mode: activate this mode to use the common settings during multi camera operation. Select: Yes, No.

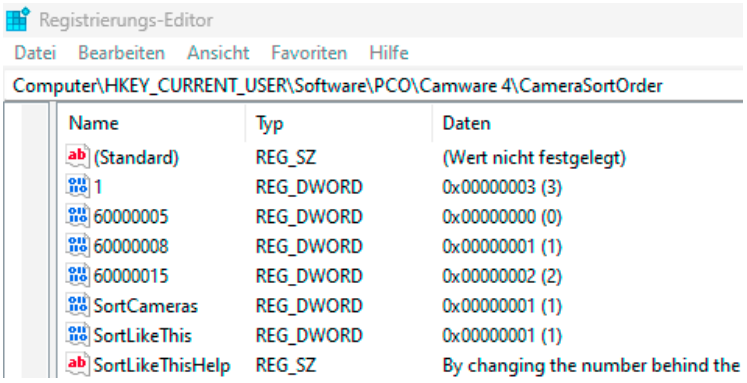
Sort cameras: activate this option in order to sort the cameras ascending related to their camera serial number.

Once sorted the order will be visible in the registry under 'CameraSortOrder'. If it is necessary to change the order by SN, this can be done by setting 'SortLikeThis' and adapting the number

associated with the serial number of the camera. 'SortCameras' must be kept on.



In this sample camera SN 1 is at position 0. If you want to place this camera as last camera, change SN1 'Value Data' from 0 to 3 and the other cameras to 0,1,2. SortLikeThis must be set to 1. Then the cameras will be sorted 'like this' enumeration here in registry under Value Data.

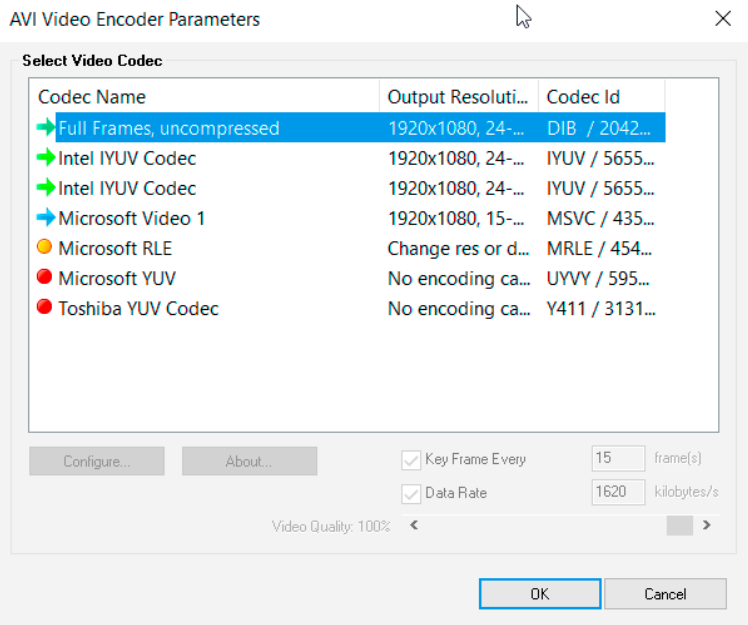


Open AVI Codec Dialog

Set these options only if you use ***Auto File Save*** see **3.8.1**.

Select the (compression) codec that you want to use for your stored sequences. All installed codecs are listed here.

If you use ***Auto File Save***, this setting takes an effect on your stored video sequences.



Load Lookup Table (for monochrome cameras)

This feature assigns pseudo colors (Lookup-Table LUT) to a monochrome image. Either select one of the four predefined or create your own. The result is shown in the color ***View Window***.

Direct Record to File

Preset a certain number of images to be stored. If the camera captures images faster than the computer can save to disk, you will lose images. Images display doesn't interfere with the record process.

Start Auto Save

Only available if ***Auto Save*** is activated (see **3.8.1**).

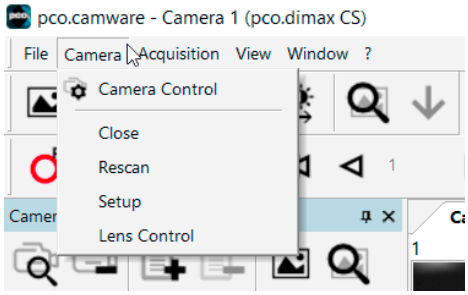
Exit

Exits the program and closes all channel dialog windows. Window positions, settings and sizes are stored in the windows registry and will be loaded again at next start-up.

3.9.3 Camera menu

Camera Control

Opens the camera control window.



Close

Disconnects camera when more than one camera is connected.

Rescan

Disconnects and reconnects all cameras.

Setup

This function lists former options e.g. switch shutter mode depending on your camera model, see camera specific manual.

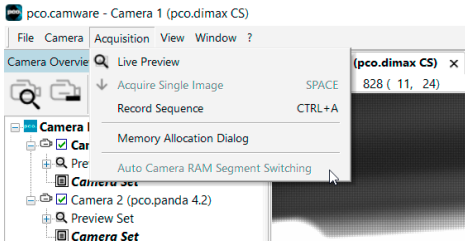
Lens Control

See chapter **3.3.9**.

3.9.4 Acquisition menu

Live Preview

Live Preview is useful for fast and easy adjusting and focusing of the camera. The active window will be updated. To see another window, simply click on the window. This option is not available in Double Shutter mode.



Acquire Single Image

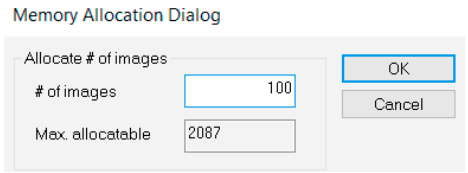
Active if ***Trigger Mode*** is set to ***Soft Trigger***, see **3.3.1**.

Record Sequence

Starts recording images into the computer system memory according to ***Trigger Mode*** selection (see **3.3.1**). During recording, all camera controls except for ***Exposure*** and ***Delay*** time are locked.

Memory Allocation Dialog

Only available for cameras without internal memory. This sets the number of images recorded in one sequence. The maximum is defined by available computer RAM size.



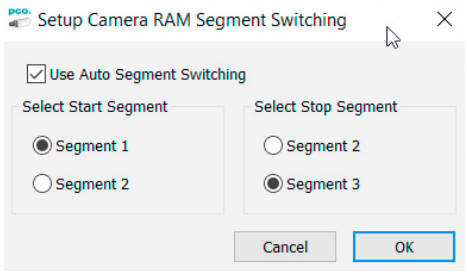
Auto Camera RAM Segment Switching

Only for cameras with internal memory (Cam RAM).

Records automatically in two or three different camera RAM segments one after another resulting in two or three separate image sequences.

If ***Recorder Mode*** is set to ***Sequence*** and the set number of images is achieved the RAM segment switches automatically to the next segment and stops after the last segment is full.

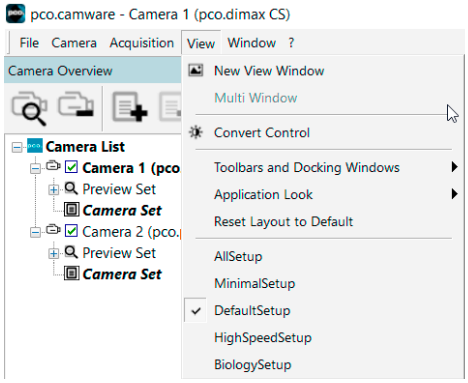
If ***Recorder Mode*** is set to ***Ring Buffer*** a stop trigger must stop the active record into the dedicated segment. A new record starts automatically into the next segment.



3.9.5 View menu

New View Window

Use this command to open a ***New View Window***.

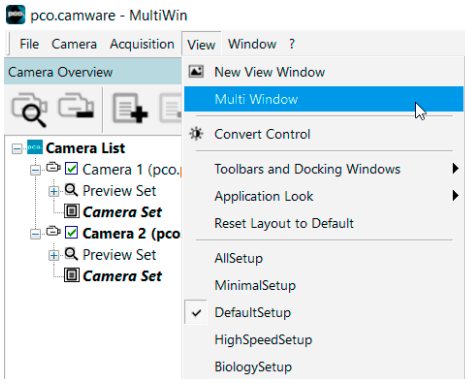


Multi Window

View the images of all active cameras in consecutive order in one window. It provides an easy comparison of the views of different cameras.

Use the same ROI and timing settings for all cameras.

Only available when using more than one camera and only after a complete sequence is recorded (sequence mode) or after buffer is full for the first time (Ring Buffer).



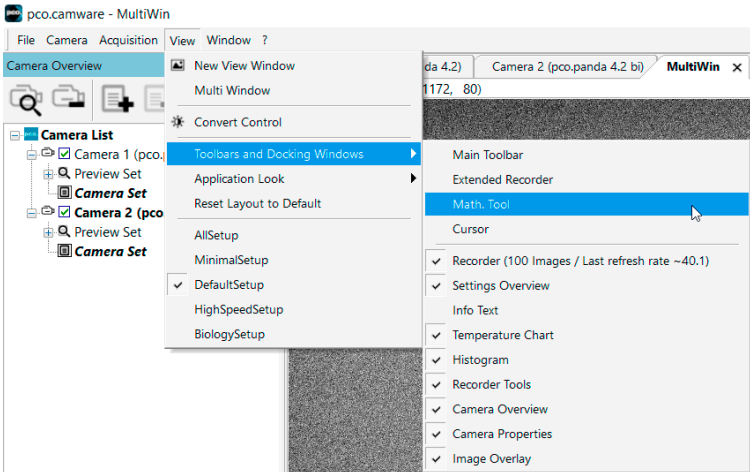
Convert Control

See chapter **3.3.8**.

Toolbars and Docking Windows

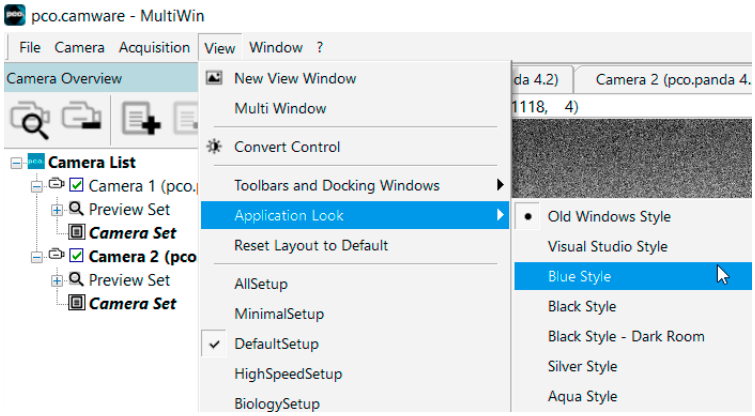
Standard toolbars of pco.camware are Recorder/ Recorder Tools / Camera Overview / Camera Properties and Image Overlay.

Additional Toolbars are available, but not essential: ***Main Toolbar / Extended Recorder / Math. Tool / Cursor***. See below. For function ***Infotext*** see **3.9.1**.



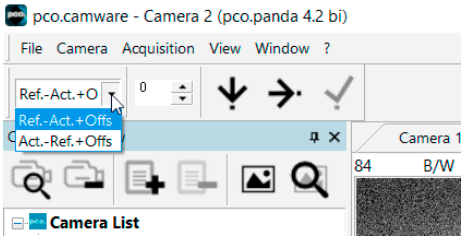
Application Look

Style and look of pco.camware can be customized; many different style sheets are selectable. The ***Tabbed MDI*** function docks or undocks the view windows.

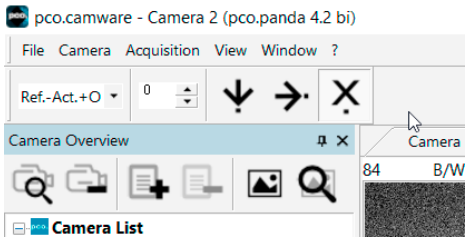


Math. Tool

Calculate the difference between a reference image and the actual image. Activating ***Math. Tool*** every new acquired image is subtracted from the reference image or vice versa:



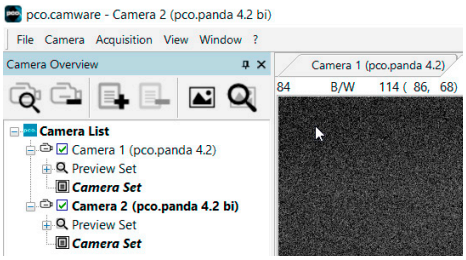
1. Reference (image) – Actual (image) + Offset or Actual (image) – Reference (image) + Offset
2. A reference picture is acquired and copied to reference buffer
3. Last acquired image is copied to reference buffer
4. Add offset to avoid negative values, which would not be visible
5. Enable math function
6. Disable math function



Cursor

Shows position of mouse cursor and the corresponding pixel value.

Example: B/W (black/white camera) x-axis: 639; y-axis: 508; Value: 16383 counts.



Reset Layout to Default

Resets all customized changes and restores the default layout.

Selectable Layouts

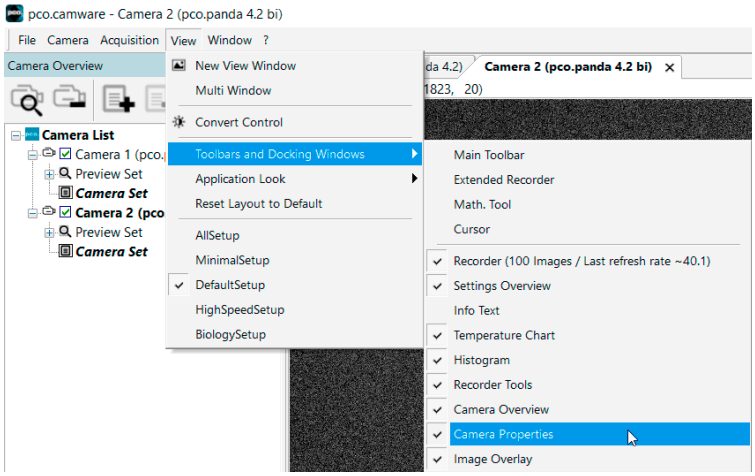
If a ***camware_setup.ini*** file is available either via a local path or `C:\ProgramData\pco`, new configurable layouts will be available in the view menu.

The ini file can be set with a main chapter and several setup chapter.

Main chapter (example):

```
[Camware Setup]
Setup=DefaultSetup
SetupLoaded=DefaultSetup
Setup1=AllSetup
Setup2=MinimalSetup
Setup3=DefaultSetup
Setup4=HighSpeedSetup
Setup5=BiologySetup
```

The setup chapter stores which setup is selected for loading and which one is active currently. Available setups are listed according to their own name, which appears in the view menu if the setup is valid.



53 A setup may contain a selection from the following entries:

```
[DefaultSetup]
MainToolbar=0
ExtendedRecorder=0
MathTool=0
Cursor=0
Recorder=1
SettingsOverview=0
TemperatureChart=0
Histogram=0
RecorderTools=1
CameraOverview=1
CameraProperties=1
ImageOverlay=0
CommonTimeProperties=0
CameraSetMode=2
```

A ”1” beside the entry name marks the entry as active and ”0” as inactive. ***CameraSetMode*** controls how Camera Properties are displayed: 0=Basic, 1=Custom, 2=Expert

The ini-file can be configured and extended. There is no limit in number of setups. Currently 5 Setups are pre-configured.

3.9.6 Window menu

Close Active Window

Active window closes.

Split

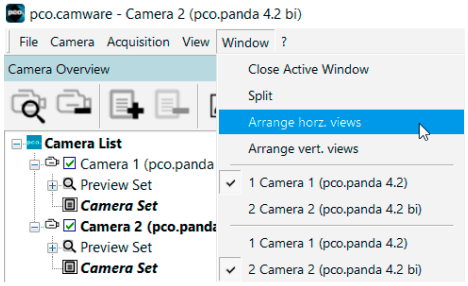
The view window splits in four quarters.

Arrange horz. views

Arranges the windows in horizontal direction.

Arrange vert. views

Arranges the windows in vertical direction.



Open Windows

Shows all connected cameras, e.g. ***1 camera (pco.ultraviolet)***.

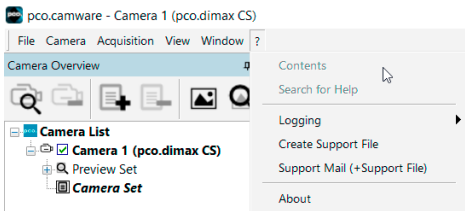
3.9.7 Help menu

Contents

Not available.

Search for Help on

Not available.



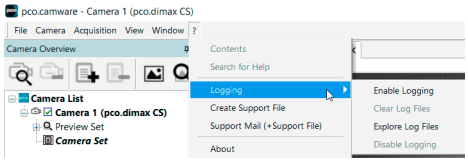
Logging

Enable Logging: Activates pco.camware log files (this cuts down performance).

Clear Logfiles: (only visible if logging is enabled) this command erases all actual log files.

Explore Logfiles: opens windows explorer.

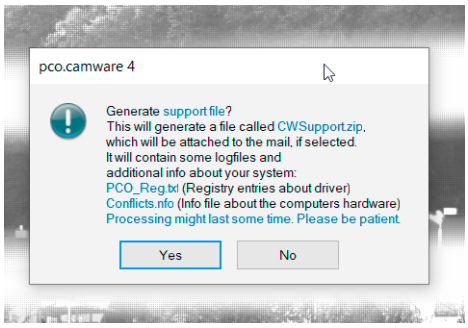
Disablle Logging: (only visible if logging is enabled) disables logging.



Create Support File

Press ***YES*** to activate log files. Reboot pco.camware and your PCO camera.

After log files are activated it is possible to create a support file. Send this file to PCO support (see **B**).

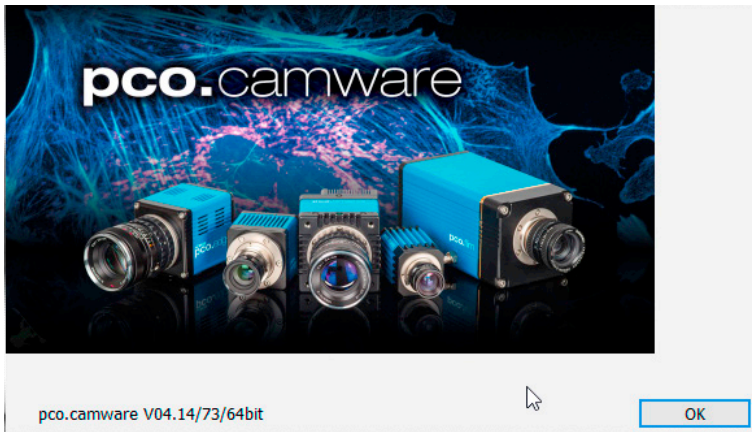


Support Mail

This command opens your email-program and the created support file is added automatically as attachment.

About Camware

This window shows program information.



3.9.8 View window menu

Right-click in the ***View Window*** to open this menu.

View Color

Switch to color window. Required for LUT if monochrome camera is attached.

View Window B

Available when ***Double Image*** is active see **3.3.3**.

1 Split Window

Splits the ***View Window*** in four quadrants. Double-click on separator to undo.

Stretched View

Image is resized to fit the ***View Window***.

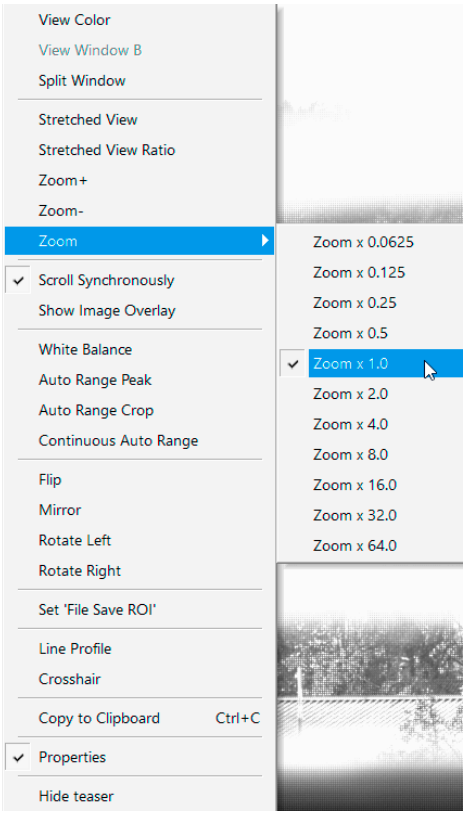
Stretched View Ratio

Aspect ratio is maintained in ”stretched” view.

2 Zoom +/-: Image zoom (only available if Stretched View is deactivated).

Zoom

Sets the factor of the zoom (from 0.0625 to 32).



Scroll Synchronously

If more than one ***View Window*** is open, you may scroll through all images synchronously (available if ***Stretched View*** is deactivated).

Show Image Overlay

Activates the ***Image Overlay*** see **3.4**.

Open LUT

Opens look-up table file for false-color representation.

Auto Range Peak

Searches for the minimum and maximum 12/14/16 bit intensity values of the image. Based on these limits, the converter scales the 8 bit display (256) within these two values.

Auto Range Crop

Sets the converter to ignore the extreme intensity values of the image and scales the display in a smaller range. Thus dark or bright light spots, reflections, etc. are cut off.

Continuous Auto Range

(Crop) Enables the automatic min / max function (Auto Range Crop) during record and replay.

Flip / Mirror

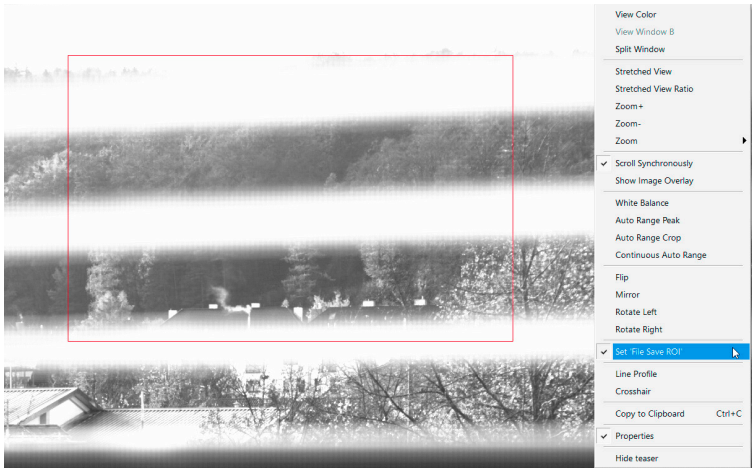
Image will be flipped or mirrored.

Rotate Left / Right

Rotates the image in steps of 90°.

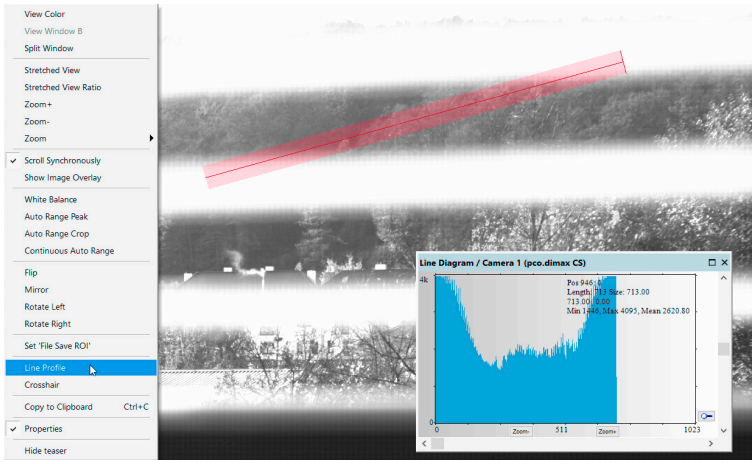
Set 'File Save ROI'

To save just a part of the recorded image (region of interest), draw a rectangle with the mouse. This rectangle is valid for all recorded images and can be dragged at its edges.



Line Profile

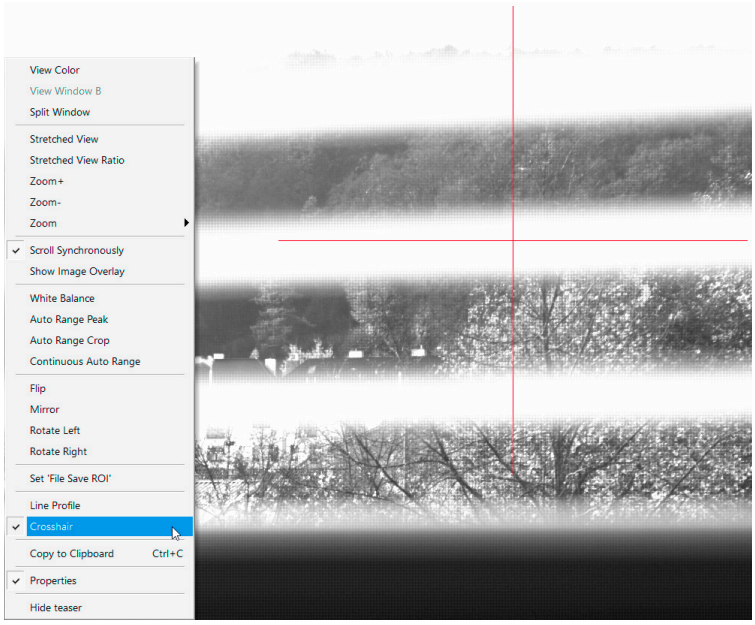
Left-click on ***Line Profile*** and the line starts automatically at the point where the View Window menu is opened. Move the mouse to the desired line end and left-click again. The line may be stretched, shrunk or moved by grasping its end point. A ***Line Diagram*** opens. The graph in the length of the line (units: pixel) is displayed showing the intensity values of the pixels along the red line.



Crosshairs

Activates centered crosshairs. Size and color are selectable see chapter **3.9.2** -> ***Options***.

To move the crosshairs drag it with the mouse. Reset it to center position by double-clicking into center of the crosshairs.

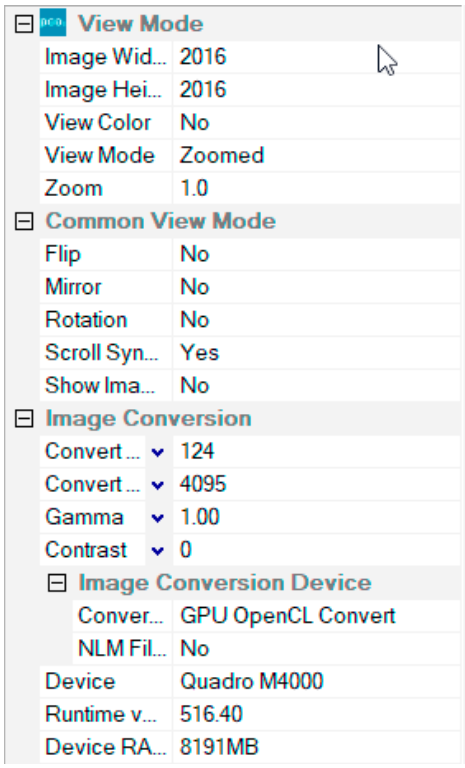


Copy to Clipboard

Copies the actual image to clipboard.

Properties

Displays the current settings for ***View Mode / Common View Mode*** and ***Image Conversion***. They can be opened and closed via the triangle button in the View window (see chapter **3.6**).



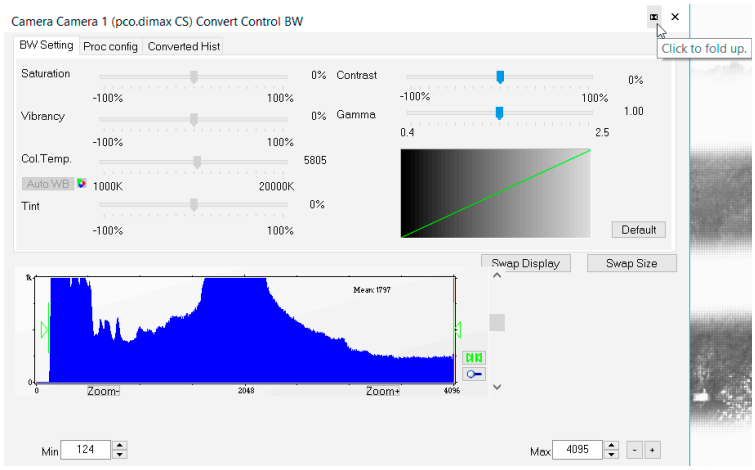
3.9.9 Additional features

White Balance by Mouse

Change white balance with a mouse by pressing the CTRL and Shift keys at the same time, then selecting a white or gray area within the image by dragging a rectangle while holding the left mouse button. The pixel values within the coordinates of the selection rectangle are used for calculating a new white balance. For best results we recommend to use the white balance button in the ***Convert Control Color*** (see **3.3.8**).

Fold Up Window

1. The ***Convert Control*** window can be minimized / folded.
2. Move the pointer over the bar and the window will unfold again.



Setting Contrast Area by Mouse

Control the minimum and maximum values used for the conversion from 16 bit to 8 bit with the mouse. Move the mouse cursor into a region which should be shown with maximum contrast. Press the SHIFT and the left mouse button. Hold down the mouse button while changing the selected rectangle's size by moving the mouse. After releasing the mouse button the coordinates of the selected rectangle act as a border for calculating the minimum and maximum values.

Setting a new ROI by Mouse

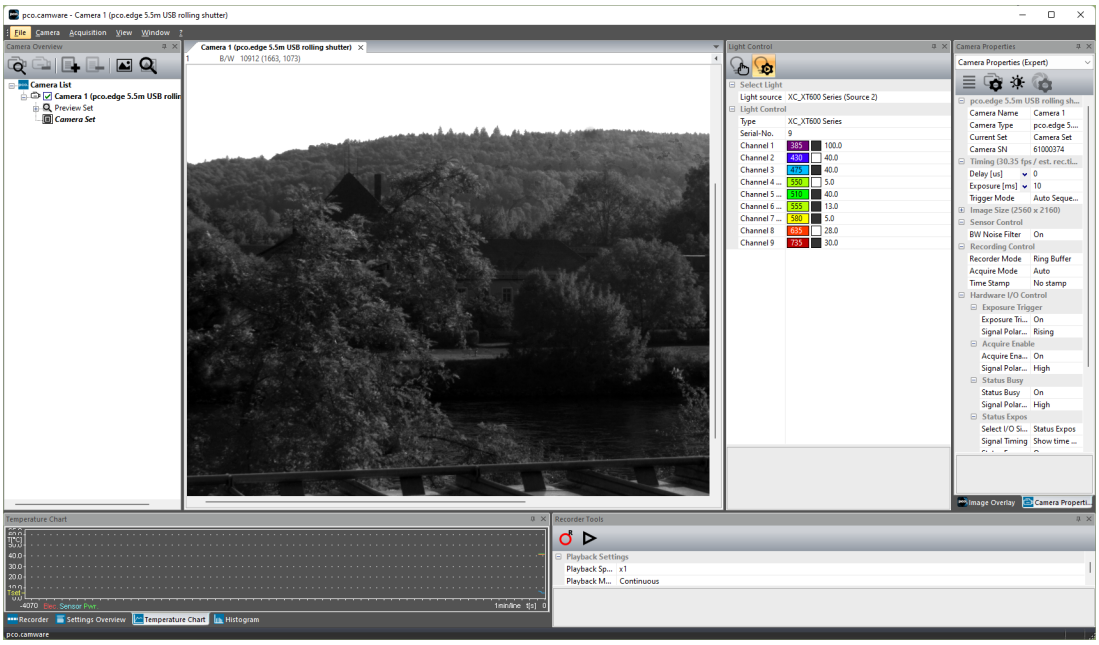
In the same manner you can setup a new region of interest (see **3.3.2 *ROI***) for the camera. Press the CTRL key and drag an area with the left mouse button. The coordinates of the selection rectangle are used for calculating a new region of interest, which will be adapted to the camera capabilities automatically. You can reset the ROI to maximum by pressing the CTRL key and the right mouse button.

Short Cut List

- Start / Stop record: ENTER
- Acquire Picture: SPACE (Soft Trigger mode)
- Acquire Sequence: CTRL + A
- Auto Save: ALT + D
- Export File: CTRL + T
- Export Recorder Sequence: CTRL + O
- INSERT: saves an image during recording, an easy way to save an image e.g. when working on a microscope.
- Open Raw Image File: CTRL + I
- Open Raw Recorder Sequence: CTRL + R
- Save Raw Image File: CTRL + E
- Save Raw Recorder Sequence: CTRL + S

3.10 Camware X-Cite integration

You are able to also control Excelitas X-Cite® light sources within pco.camware. This makes it very intuitive to use X-Cite light sources together with PCO cameras without the need of using and maintaining multiple applications.



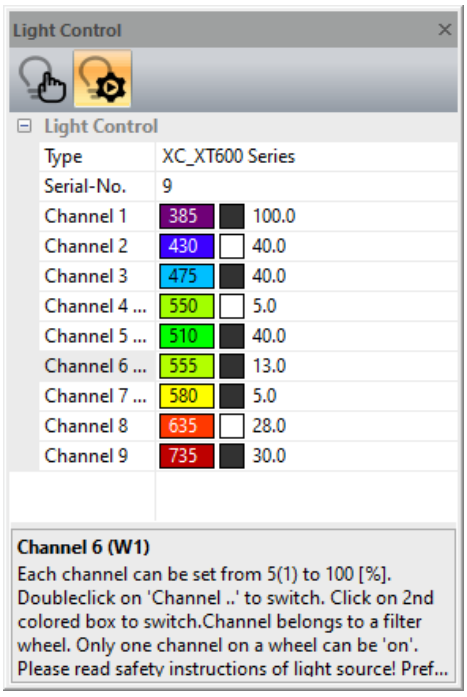
This chapter is a quick start guide on how to enable and use the X-Cite control feature inside pco.camware. Therefore you do not need to install **any** additional driver or software for X-Cite, just installing pco.camware as usual is enough.

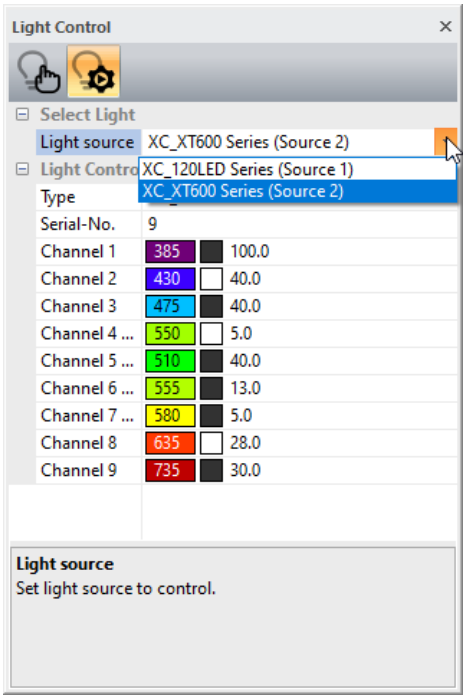
If you encounter any problems with your X-Cite light source, please visit the X-Cite homepage (https://www.excelitas.com/de/product-category/x-cite-illuminators) for further information.

3.10.1 Usage

In order to use the X-Cite light control in pco.camware, you have to make sure that your light source is switched on and is connected to your PC **before you start pco.camware**

On startup, pco.camware automatically searches for all connected cameras and also for all connected X-Cite light sources. If at least one light source is found, the associated light control dialog will appear. This dialog is shown below. See left for one connected light source, or right for multiple connected light sources.





Tip Make sure to activate the histogram in the GUI and deactivate auto range to easily track the brightness changes in the images when changing the light intensity.

Per default, the light is only switched on when recording is active! This behavior can be changed in the settings, see chapter 3.10.3.

3.10.2 Light control dialog

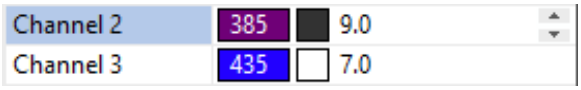
The usage of the light control dialog is very intuitive.

- **Light source** controls which light source is currently active (This is only visible if multiple light sources are connected)
- **Type** displays the windows driver name of the X-Cite light source
- **Serial-No** displays the serial number of the X-Cite light source
- **Channel X** controls the channel with number X of the light source. Depending on the light source you can either have multiple channels or only one (e.g. for a white light source)
- The gray box below the list will always display additional information for the currently selected element

Note In the screenshots you will see a **(W1)** on some of the channels. This indicates that for activating this channel, a movement of the filter wheel might be necessary, which will take approximately 2 seconds. Additionally, only one of the channels on the filter wheel can be activated at a time (this is automatically handled by pco.camware), while all other channels can be controlled independently.

Channel Settings

The control of each channel consists of 3 elements



which are (from left to right):

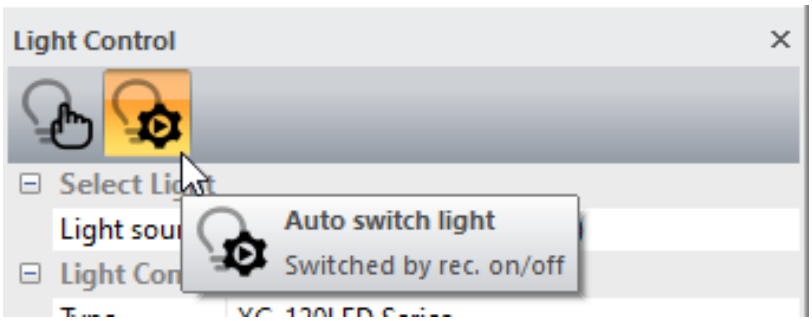
- a display of the wavelength of the channel, colored in approximately the color that corresponds to the wavelength
- a checkable box for activating and deactivating the channel. In default each channel is off (= black, like *Channel 2* in the screenshot above), when clicking on this box the channel will be activated (= white, like *Channel 3* in the screenshot above)
- a numerical input to control the intensity of the channel. You can change the intensity value with either the mouse wheel or the keyboard. The intensity can be set in a range from 5.0 to 100.0 with a stepping of 1.0

3.10.3 Sync Light with Acquisition

The software is able to control the sync of the light source with the recording state of the camera. This means that the light is only **ON** when the camera is actually recording (i.e when pco.camware GUI is red). In this mode, activating the channels (setting associated boxes to white) will not directly activate the light. Only during active recording the light is activated according to the current selections in the light control dialog.

This feature prevents your sample from over-exposition. Thus, permanent damage of the imaged cells and/or bleaching of your fluorophore can be minimized.

Per default, this feature is **enabled** as it is the typical use case. You can switch between *auto* and permanent illumination by using the two buttons on the top of the light control dialog, like shown in the following screenshot.



Note The synchronization that is described here refers to the recording state of the camera, i.e will be switched on when recording starts and switched off when the recording ends. For some applications you may want to have the light source only active during the actual exposure time of an image and it should be switched off during delay and readout. For this you need to synchronize the exposure output signal with the TTL of your light source. Please reade the manuals of your PCO camera and your X-Cite light source for further information on this.

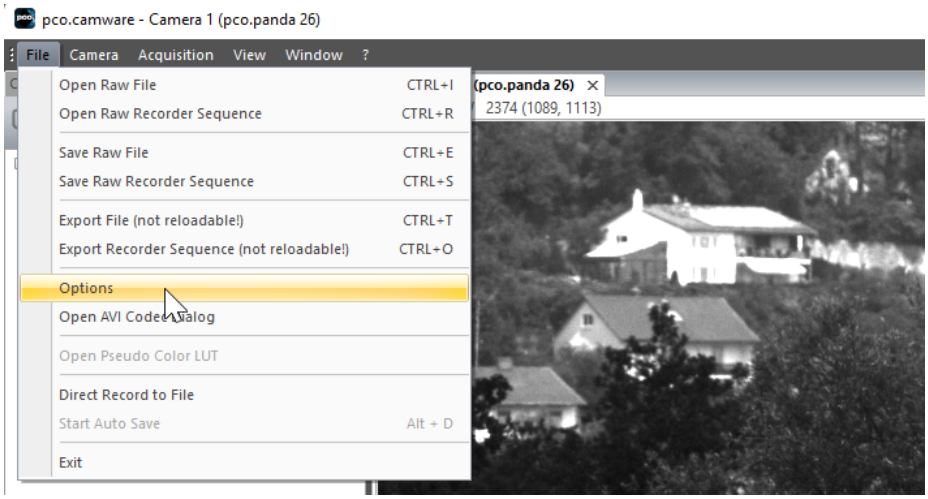
3.10.4 Auto-Link Light Source

When you are working with at least 2 cameras and at least 2 light sources, pco.camware has an additional feature to automatically link a light source to a camera. **This is done automatically on startup of pco.camware**. For successful auto-link, please ensure an open beam path, so that light from the source can be detected by the camera. When an assigned camera is selected in the *Camera List*, the linked light source automatically becomes also selected in the light control dialog. Thus, you always configure the correct light source for the camera.

To enable this feature:

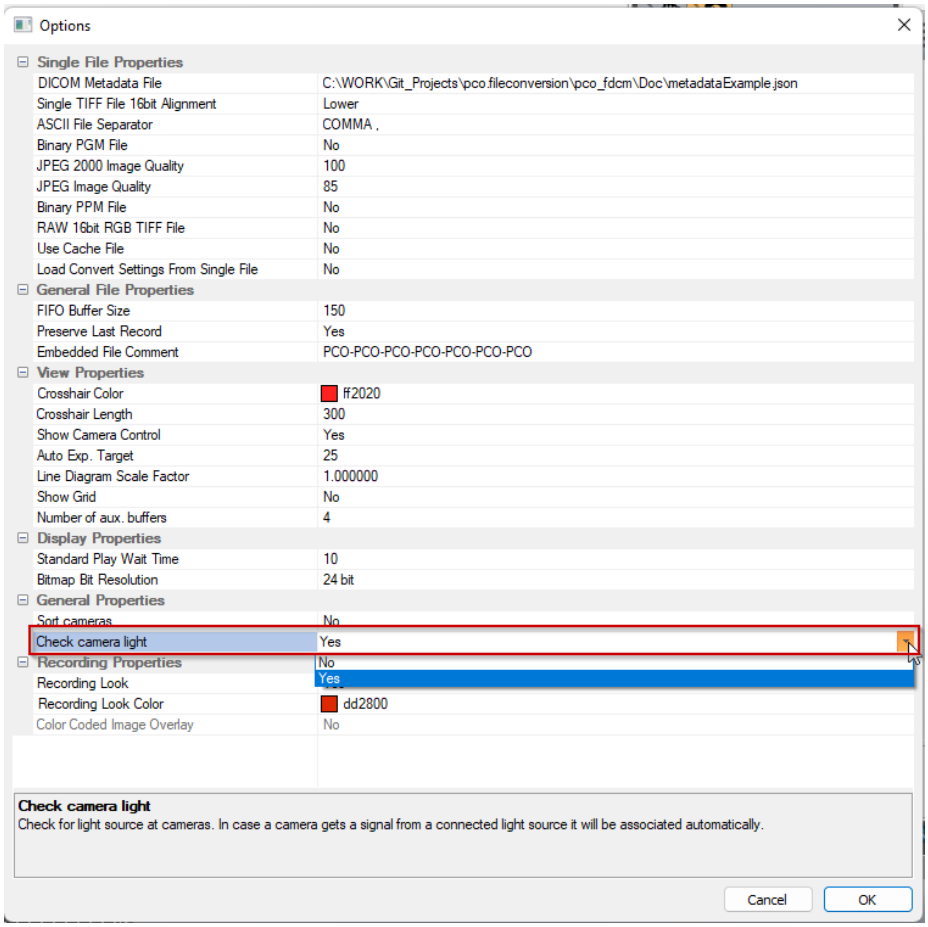
- at least 2 cameras must be connected
- at least 2 light sources must be connected
- *Auto switch light* must be switched off (see chapter 3.10.3)

Then open the pco.camware options menu, which can be found under *File -> Options*



To enable the feature, the *Check camera light* option must be set to **Yes** (default is **Yes**, see figure below) [1]

[1] This option is only visible when at least 2 cameras are detected



Always be sure to follow the X-Cite safety instructions. Never look into the beam or hold the light guide in your hands when the light source is on.
Be especially careful when this feature is activated.

Appendix

A Image File Formats

There are several file formats available for saving camera images with pco.camware:
PCO Formats
b16

The b16 format is similar to the bmp format. However, 16 bit pixel values are used instead of 8 bit pixel values.

The file format consists either of a Basic Header (6 Long-parameter) or an Extended Header (32 Long-parameter), the latter is optional for additional information. It might follow a variable comment field (ASCII code). Finally, there is the actual data set that is saved linearly (as in the case of BMP files).

With the exception of the first value, all parameters are Long Integers (4 Byte). The first 6 parameters must always exist. The rest of the parameters, as well as the comment field, are optional.

Address	Parameter	Denotation
0x00	pco-	B16 file identificator ”PCO-”
0x04	file size	file size in byte
0x08	header length	headersize in byte (older versions: 128, 256, 512; act.: 1024)
0x0C	image width	image width in pixel (e.g. 4 …1280)
0x10	image height	image height in pixel (e.g. 1 …2048)
0x14	extended header	-1 (true), extended header
0x18	color mode	0 = b/w camera, 1 = color camera
0x1C	b/w min	black / white LUT-setup, minimum value (0 …b/w max)
0x20	b/w max	black / white LUT-setup, max. value (b/w min …bit-resolution^2-1; 12 bit -> 4095)
0x24	b/w linlog	black / white LUT-linear or log; 0 = linear, 1 = logarithmic
0x28	red min	red LUT-setup, minimum value (0 …red max)
0x2C	red max	red LUT-setup, maximum value (red min. …bit-resolution^2-1; 12 bit -> 4095)
0x30	green min	green LUT-setup
0x34	green max	green LUT-setup
0x38	blue min	blue LUT-setup
0x3C	blue max	blue LUT-setup
0x40	color linlog	color LUT-linear or log., 0 = lin, 1 = log
0x44	doubleshutter	0 = single image, ’DS’ = doubleshutter (0x5344)
0x48 …0x7F	gap	filled with 0
0x80 …Headersize -1	Embedded structure	see structure `Bild` definition below. Gap will be filled with 0.
		16 Bit Pixel Values

Continued on next page

Continued from previous page

Address	Parameter	Denotation
Headersize	Line 1, pixel 1	value of first pixel
Headersize + 2	Line 1, pixel 2	value of second pixel
…	…	

A pixel value is a hexadecimal value, e.g. 0x1234 (4660), which is listed in the file as 0x34 0x12. Typical scan line: 0x34 0x12 0x29 0x12 …(4660 4649 …). The order of pixels starts with top left and scans down to bottom right of the image.

Most of the table values are still valid, but it is recommended to use the structure data for reading parameters. This is by design and due to the historical evolution of the b16 parameters.

PCO recommends that all images should be saved first in one of the following formats. The advantage is to have the b16 or tiff images available all the time, having the maximum 16 bit information. Note that not all image analysis programs can accommodate 16 bit data. The 8 bit format saves only the information displayed on the monitor screen. The 16 bit information will be lost and cannot be recovered.

pcoraw

This 16 bit pco file format is based on the new BigTIFF format, thus allowing for file size > 4GB. A new pco proprietary compression scheme is added if it is necessary.

Standard File Formats

TIFF

Tag Image File Format, version 6.0 and lower. Both 16bit monochrome and color image formats are available. For the 48bit RGB export format, the resulting image has only demosaicking and optional white-balancing. The dynamic of the camera will not be changed.

BMP

Windows Bitmap Format, b/w or color 8 bit format-images, which have been saved in BMP format can be loaded later only as 8 bit images, i.e. part of the original information (16 bit) is lost.

FTS

Flexible Image Transport System, Version 3.1, is a 16 bit image format defined by the NASA/Science Office of Standards and Technology (NOST) has defined this format. Some programs use the FIT extension for this format.

ASCII

16 bit format for mathematical programs that process ASCII data.

JPG

JPEG (named after the Joint Photographic Experts Group who created the standard) is a commonly used method of lossy compression for photographic images. The degree of compression can be adjusted, allowing a selectable tradeoff between storage size and image quality.

JP2

JPEG 2000 is a wavelet-based image compression standard and coding system. It was created by the Joint Photographic Experts Group committee in the year 2000 with the intention of superseding their original discrete cosine transform-based JPEG standard (created 1992).

AVI

Audio Video Interleave is a multimedia container format introduced by Microsoft in November 1992 as part of its Video for Windows technology.

MPG

MPEG-1, similar to JPEG, is a standard for lossy compression of video and audio developed by the Moving Picture Experts Group (MPEG).

WMV

Windows Media Video (WMV) is a compressed video format for several proprietary codecs developed by Microsoft. The original video format, known as WMV, was originally designed for Internet streaming applications, as a competitor to RealVideo.

B Trouble Shooting

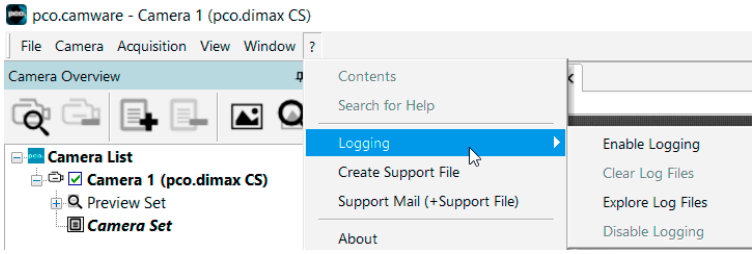
If you have a question that is not adequately addressed in this manual, contact PCO or your local dealer.

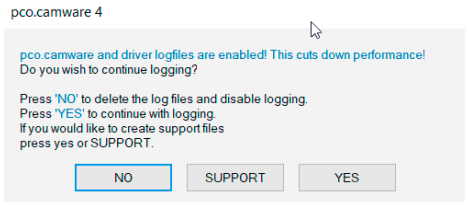
How to create Logfiles

1 ***Enable Logging***

Open ***? Help*** menu, select ***Logging*** and then ***Enable Logging***.

2 The pco.camware will ask you to press ***YES*** to activate ***Logfiles*** after a restart of the software.

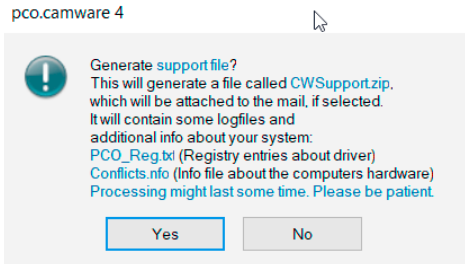




Repeat Workflow

The workflow that produces the errors must be repeated while logging is enabled.

The pco.camware opens a new email addressed to pco@excelitas.com, attach the ***Support File*** manually to this email and send the mail to PCO support.



Alternatively use the support form on our website and upload the support file.

To speed up your Request

Give us the following information:

- Describe the problem!
- Your application?
- Your camera: Type and Version, Serial number
- Your setup: Software version, operating system, processor and memory, graphics card

Firmware, Software and Driver Updates

All necessary software and drivers can be downloaded from our website:
https://www.excelitas.com/product-category/pco-camera-software

C Index

Note The mentioned page is always the starting page of a chapter!

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D About Excelitas PCO

Pioneering in Cameras and Optoelectronics (PCO) has been our shared philosophy since our establishment in 1987. Starting with image-intensified cameras, followed by the co-invention of the groundbreaking sCMOS sensor technology, PCO greatly surpassed the imaging performance standards of the day. Acquired by Excelitas in 2021, our PCO camera portfolio continues to forge ahead as a leader in digital imaging innovation across diverse applications such as scientific and industrial research, automotive testing, quality control, and metrology.

With sophisticated mechanical design, extensive software support, and a broad range of accessories, we deliver adaptable solutions for all demands. This adaptability extends to tailor-made firmware and custom image sensors, which allow us to develop highly specialized solutions for all our customers. PCO represents a world-renowned brand of high-performance camera systems that complement Excelitas' expansive range of illumination, optical, and sensor technologies and extend the bounds of our end-to-end photonic solutions capabilities.

Our comprehensive camera portfolio covers the entire spectrum - from deep ultraviolet (DUV) to shortwave infrared (SWIR), from long exposure to high-speed, from line scan to high-resolution area scan. Our camera systems are controlled and processed through an intuitive and powerful software suite addressing an extensive range of platforms and architectures.

pco.®

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