

user manual

**pc**o.panda



**pc**o.

**PCO asks you to carefully read this manual before using the pco.panda camera system and follow the instructions.**

**In case of any questions or comments, contact us at PCO.**



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The cover photo shows an exemplary PCO camera system.  
The lens is sold separately.

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# 1. INTRODUCTION



## Advantages of the pco.panda

### Features

The pco.panda joins the ranks as our newest member of PCO's state-of-the-art sCMOS sensor camera systems, which have revolutionized the scientific camera market since their introduction in 2010.

Despite small-size dimensions of roughly 65 x 65 x 65 mm<sup>3</sup>, the new pco.panda camera system provides high quantum efficiency with low readout noise making it suitable for countless applications.

The addition of the USB 3.1 interface has inherent advantages as it enables a new generation of cameras with ultra-speed data transfer and direct power via the USB cable, making external power supplies redundant.

### Main Features

- Ultra-compact size: 65 x 65 x 65 mm<sup>3</sup>
- Resolution: 2048 x 2048 pixels
- Superior quantum efficiency up to 80%
- 4000:1 dynamic range
- Superior low noise of 2.1 e<sup>-</sup> med
- USB 3.1 interface

## 1.1 INTENDED USE

This camera system is designed for use by technicians, engineers and scientists. It is a scientific measuring instrument, which provides images. The camera may only be used according to the instructions of this manual. The disclosures and operating conditions in these operating instructions installation must be respected. Unauthorized modifications and changes of the device are forbidden for safety reasons.

## 1.2 CONVENTIONS

The following typographic conventions are used in this manual:

<b><i>bold italics</i></b>	Terms that can be found in the software Camware.
<b>Features</b>	Heading within a chapter
<b>A1.4</b>	Bold chapter: hyperlink to a chapter
<b>1 1</b>	Numbers that help to find functions quickly
<b>NOTE</b>	Notes that must be observed

## 2. SAFETY INSTRUCTIONS



**DANGER**

Read the safety instructions completely and follow them strictly.

### **DAMAGED POWER CABLE OR POWER PLUG**

Danger to life due to electric shock.

- Each time the camera is used, check the power cable for damage.



**WARNING**

### **ELECTRIC SHOCK WARNING DUE TO VOLTAGE PARTS INSIDE**

Risk of injury due to electric shock.

- Never slide any items through slits or holes into the camera.



**CAUTION**

### **MOISTURE**

Risk of injury due to electric shock if moisture enters the camera.

- To avoid the risk of water condensation, protect the camera against extreme changes of ambient temperature.



**CAUTION**

### **TRIPPING HAZARD**

Risk of injury from tripping over loose cables.

- Never position the cable in a way that it could become a tripping hazard.

**NOTICE**

### **HUMIDITY, DUST OR RADIATION**

Humidity, dust or X-rays could damage the camera.

- Never operate the camera in humid or dusty environments or in places with high levels of x-ray radiation.

**NOTICE**

### **JOLT & VIBRATION**

To avoid damaging the camera it must be firmly mounted and protected against strong shocks or vibrations.

- Use the camera's mounting threads to secure it.

**NOTICE**

### **LENS MOUNTING**

Screw in the lens gently to avoid thread damage.

- To protect the lens connector thread from damage, use minimal force when attaching a lens to the camera.

**NOTICE**

### **LIQUIDS DAMAGE CAMERA**

If liquids have penetrated the device.

- Switch the camera off immediately, detach it from power and contact PCO's customer support.

**NOTICE**

### **DAMAGED CAMERA HOUSING**

If the camera has been dropped or the camera body is damaged.

- Switch the camera off immediately, detach it from power and contact PCO's customer support.

**NOTICE**

### **IF CAMERA IS NOT WORKING PROPERLY**

In case all actions following this manual to get the camera working properly were unsuccessful.

- Switch the camera off immediately, detach it from power and contact PCO's customer support.

## 3. SYSTEM COMPONENTS



The camera system includes the following parts.

### Camera

- C-mount optical connection
- F-mount adapter optional
- For standard C-mount / F-mount lenses and adapters

### Rear Panel

- USB 3.1 Type C connector
- LED indicates camera status (see **A1.4**)
- SMA connectors

### Serial Number Tag

### Mounting Thread

- 4x M4 (4)
- 1/4" - 20 UNC (7)

### USB 3.1 Cable

- USB Type A / USB Type C screwable cable
- Length 3 m

### USB 3.1 Interface Card

- 2x USB Type A socket
- PCI Express x1 V2.0

### Digital Camera Tools (USB flash drive content)

- Camware: software for camera control & image acquisition
- Camera driver & tools
- Software Development Kit (SDK) & demo programs in C and C++

## 4. INSTALLATION

You find all necessary files on the accompanying USB flash drive. You may also download the latest versions of our software, camera driver and third party software drivers from our Website ([www.pco.de](http://www.pco.de)).

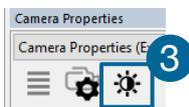
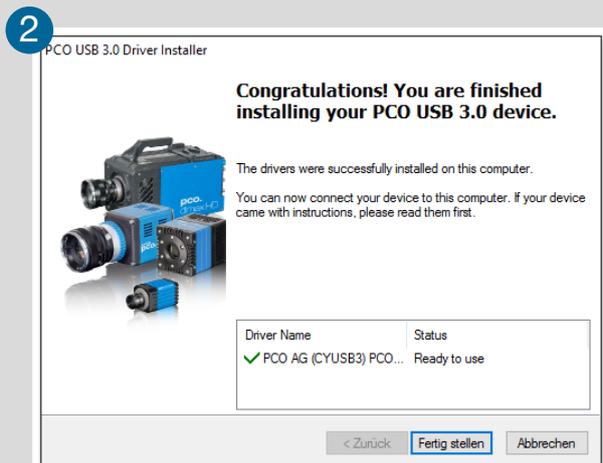
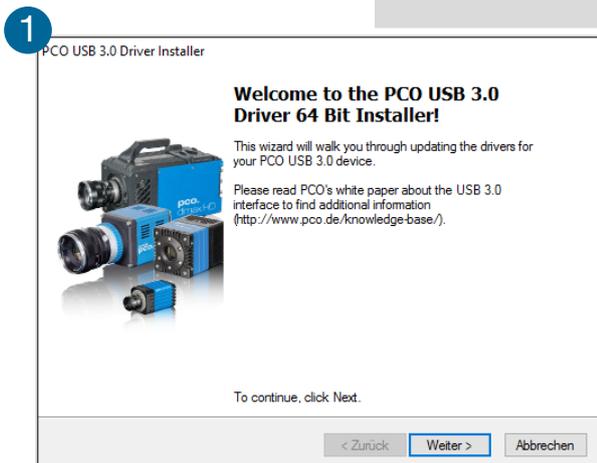
### Minimum system requirements:

- Intel® Core™ i7
- RAM > 8 GB DDR3
- Windows 7 or higher
- Full-HD resolution display
- USB 3.1 Gen1

### 4.1 DRIVER

#### Install PCO USB 3.0 Driver

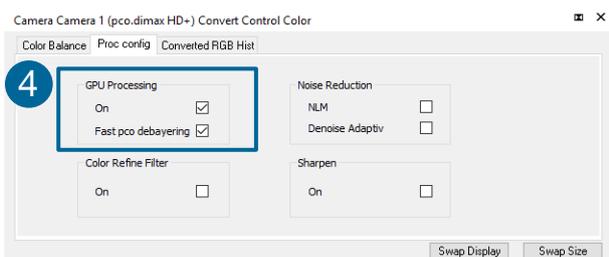
Always install the latest USB driver version. After these two screens the driver is completely installed. ① ②



#### NVIDIA Cuda Driver

Only relevant if an NVIDIA graphics card is used! **GPU Processing** is only working with NVIDIA graphics cards.

Update your NVIDIA driver for Camware 4. In case of an old driver version **GPU Processing** is not working. Therefore image processing is slow.



Check if **GPU Processing** is activated by having a look into the **Proc config** settings ④ in the **Convert Control** window ③ (see chapter 6.3.8).

If **GPU Processing** is disabled and greyed out, update your NVIDIA driver.

## 4.2 CAMWARE

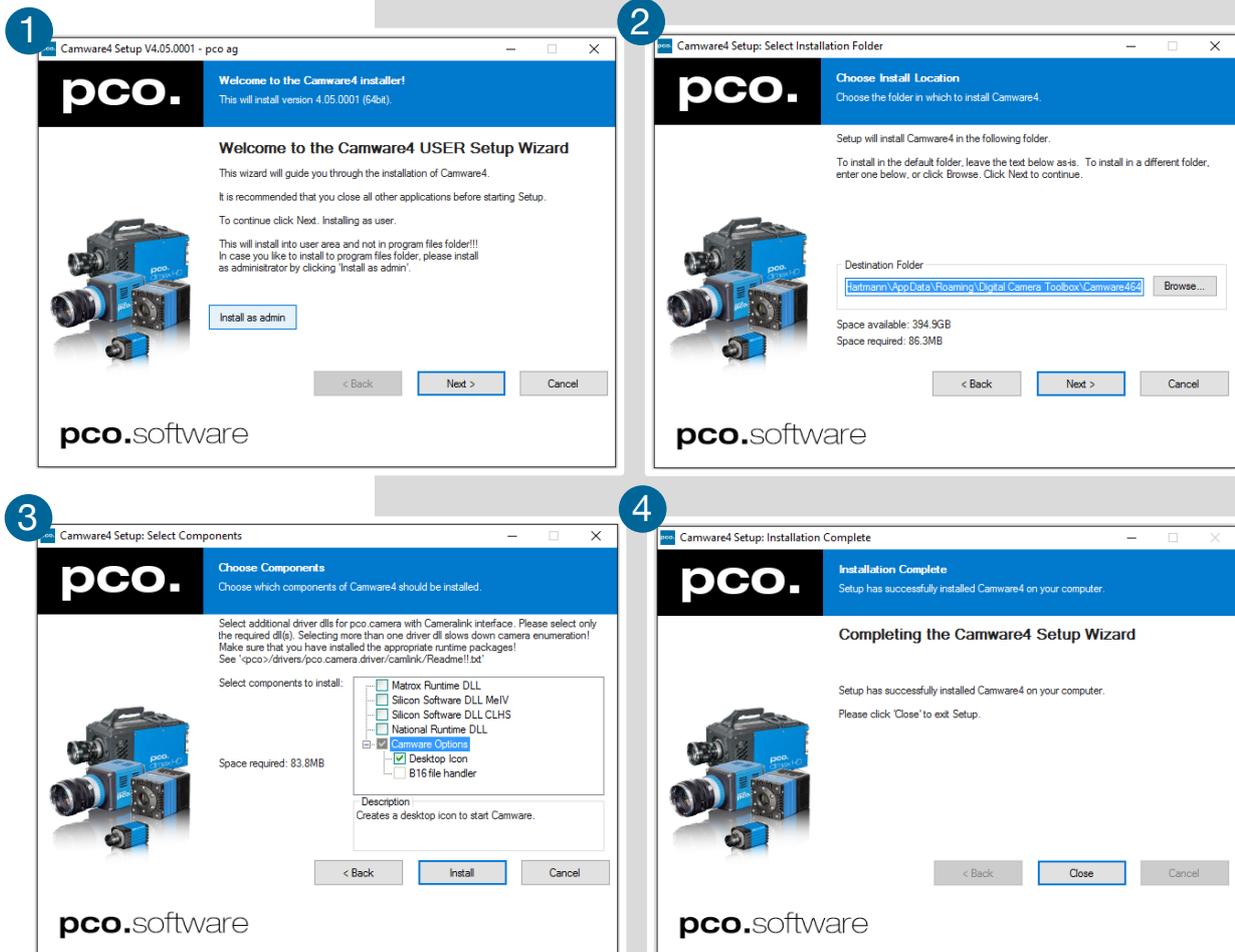
The Camware application software enables to control every camera parameter or setting. Images can be displayed on a monitor and may be downloaded and stored. The USB flash drive contains the installation files for the software for latest Windows operating systems in 32 & 64 bit.

After a successful installation, you find the program file Digital Camera Toolbox in your program directory and a Camware 32 / 64 button on your desktop.

To uninstall the Camware program, use the software feature under Windows' system control.

### Follow the Installation Wizard

- 1 **Install as admin** to install to program folder, otherwise it is installed only to user folder
- 2 Choose install directory
- 3 Choose components: select additional drivers (not recommended)
- 4 After the next two screens installation is complete



## 5. QUICK START

In order to get familiar with your new camera and software it might be helpful, if you first aim at an object that is easy to focus and that can be seen at standard light conditions.

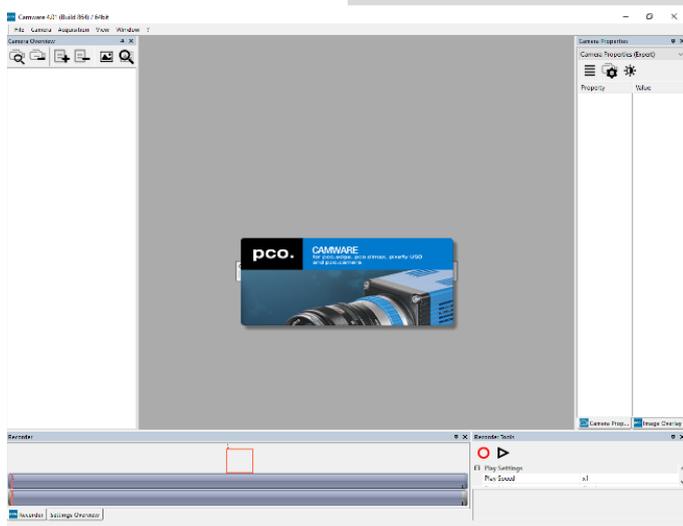
### 5.1 PREPARATION

- Computer is turned on
- Installation is finished (see chapter 4)
- An appropriate lens is attached (remove cap) or the camera is attached properly to the microscope, spectrograph or other scientific device
- Camera is connected to the PC

### 5.2 START



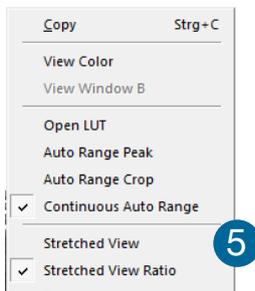
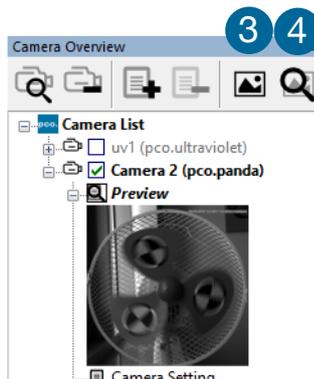
Start Camware and the graphical user interface starts up:



#### NOTE

Always install latest Camware version to be able to use full function of your pco camera ([www.pco.de/support](http://www.pco.de/support)).

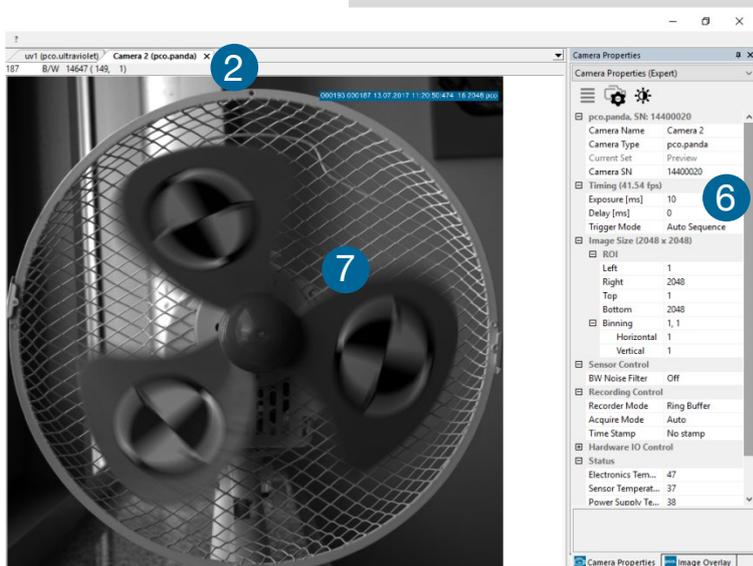
## 5.3 FIRST IMAGE



## Follow the Instructions



- Camware must be started **1**
- A **View Window** **2** is shown automatically or open a new one **3**
- Start **Live Preview** **4**
- Right-click in the view window & apply **Continuous Auto Range** **5**
- You may adjust **Exposure** time **6**, aperture and focus of the mounted lens
- Now you should clearly see the object in the window **7**



To change **Exposure** time (e.g. the image is still either too dark or too bright), see chapter **6.3.1**.

To record and save images, see chapter **6.3.5** and chapter **6.9.2** for detailed information.

**NOTE**

Live preview: useful for fast and easy camera adjustment and focusing.

## 6. CAMWARE 4 SOFTWARE



PCO's Camware is excellent software for camera control, image acquisition and archiving of images in various file formats. This chapter provides a detailed description of all Camware functions.

Camware works with any kind of PCO camera. See **PCO website** for the latest version of this software.

### 6.1 CHAPTER OVERVIEW

#### Chapter 6.2: cameras detected in Camware

**6.2 Camera Overview/List**      Preview / Connected cameras / Recording profiles

#### Chapter 6.3: camera settings

**6.3.1 Timing**      Exposure Time / Trigger Modes

**6.3.2 Rolling Shutter**      Explanation / Timing

**6.3.3 Image Size**      ROI / Binning

**6.3.4 Sensor Control**      Offset Control / BW Noise Filter

**6.3.5 Recording Control**      Recorder Mode / Acquire Mode / Timestamp

**6.3.6 Status**      Temperature

**6.3.7 Hardware IO Control**      Exposure Trigger / Acquire Enable / Status Busy / Status Expos

**6.3.8 Convert Control**      Contrast / Saturation / Gamma...

#### Chapter 6.4 / 6.5 / 6.6 / 6.7 / 6.8 recording

**6.4 Image Overlay**      Overlay for recorded images

**6.5 Recorder Tools**      Record / Play / Settings

**6.6 View Window**      View Window Functions

**6.7 Recorder (Images)**      Preview Recorded Images

**6.8 Settings Overview**      Overview of all Parameter Settings / Auto Save

#### Chapter 6.9 software menus

**6.9.1 Demo Mode**      No camera connected

**6.9.2 File Menu**      Open / Save Raw / Export / Options

**6.9.3 Camera Menu**      Setup / Close / Rescan  
Live Preview / Acquire Sequence

**6.9.4 Acquisition Menu**      Rec. Memory Settings

**6.9.5 View Menu**      New Window / Convert Control / Multi Window / Toolbar / Application Look

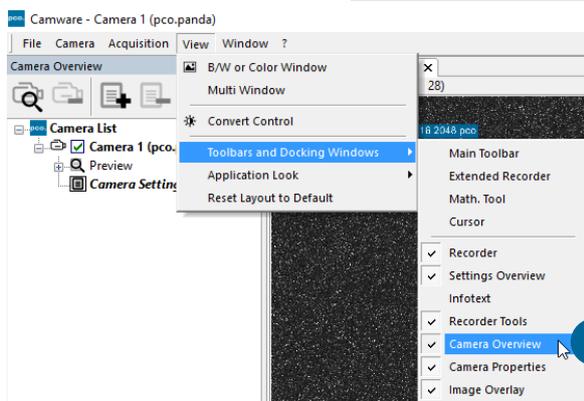
**6.9.6 Window Menu**      New / Close / Split window

**6.9.7 Help Menu**      Logfiles / Support file / About

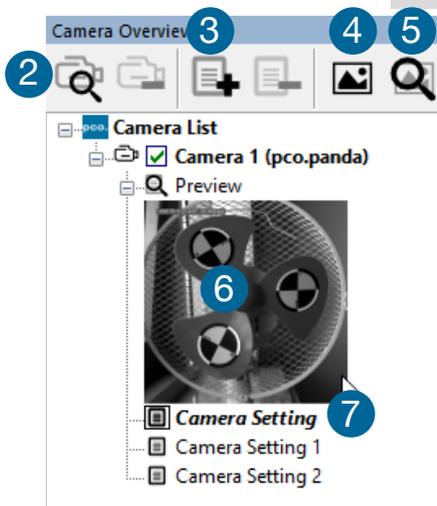
**6.9.8 View window menu**      Right-click: Zoom / Flip / Mirror / Rotate / Line Profile / Properties

**6.9.8 Additional features**      Contrast / Short cut list

## 6.2 CAMERA OVERVIEW / LIST



If closed, the **Camera Overview** window can be opened by selecting the **View** tab and **Toolbars and Docking Windows** → **Camera Overview** 1.



### Camera Overview

The **Camera Overview** window supports management of more than one PCO cameras and displays a **Camera List** of the connected ones. Camware is able to **Scan Cameras** 2 or close a connected camera. It allows to define several different **Camera Settings** for each camera (max. 30 sets per camera → **Add Set** 3).

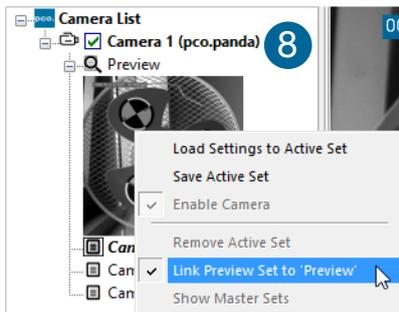
New **View Windows** 4 can be opened and the **Live Preview** 5 function started. When opened up, the **Live Preview** shows a small **Preview** window 6 (always monochrome) integrated in the **Camera List**.

### Live Preview 5

**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**.

### Camera Setting 7

All presets, such as resolution and frame rate, in the **Camera Properties** (see 6.3) are saved to **Camera Settings**. Define different **Camera Settings** with different **Preferences** in **Camera Properties** for each of your experiments. **Camera Settings** can be switched at any time (not during record) and copied to other cameras.



### Link Preview Set to 'Preview'

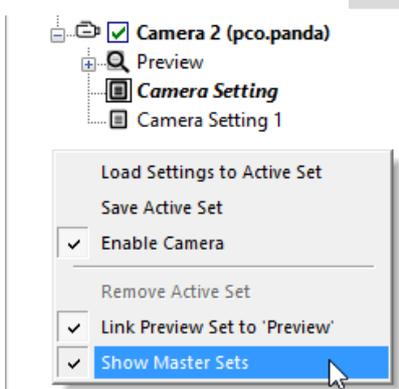
When **Link Preview Set to 'Preview'** is ticked the **Preview** is always active with the set parameters when starting a **Live Preview** 8.

In case this function is deactivated, the **Live Preview** always shows live images with the parameters of your active setting. 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.



### Copy Settings to Current Set

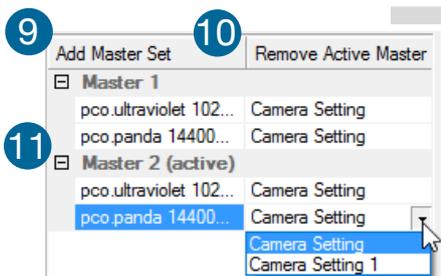
To copy e.g. **Camera Setting 1** to **Camera Setting 4**, just drag and drop **Camera Setting 1** to **Camera Setting 4** and Camware asks to confirm it. It is possible to copy each setting to every camera.



### Master Sets

This function facilitates the image acquisition 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 display **Master Sets**, right-click in the **Camera Overview** window and click **Show Master Sets**.

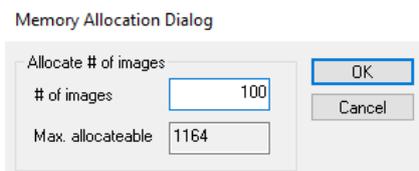


Define different **Master Sets**. Select individual **Camera Settings** within each **Master Set**.

Functions:

**Add Master Set** 9 or **Remove Active Master** 10.

Put it to **active** status by clicking on one of your sets 11.



### Important Setting (for cameras without internal memory)

#### Memory Allocation Dialog

If you want to change the number of recorded images in Camware, you have to open the **Acquisition** menu (see 6.9.4) and choose **Rec. Memory Settings**.

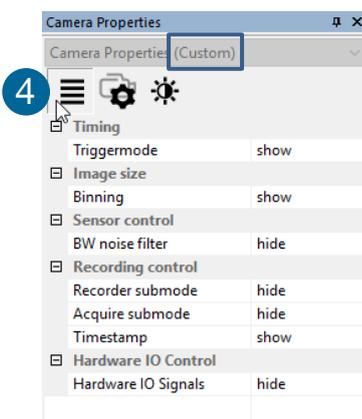
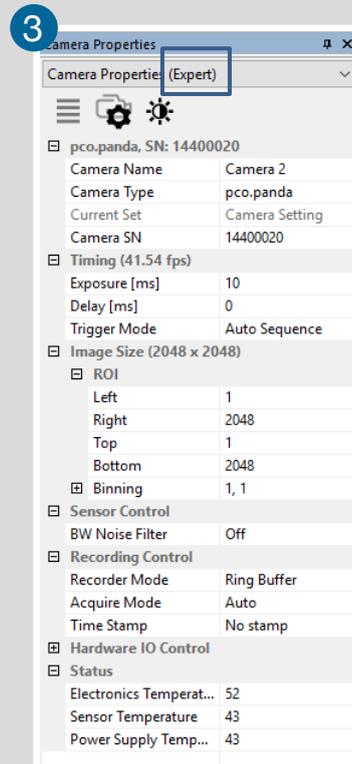
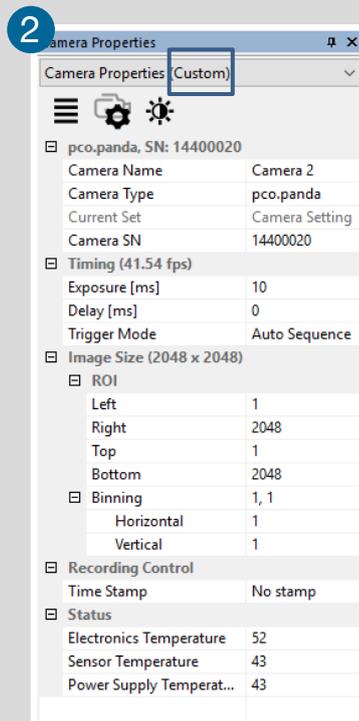
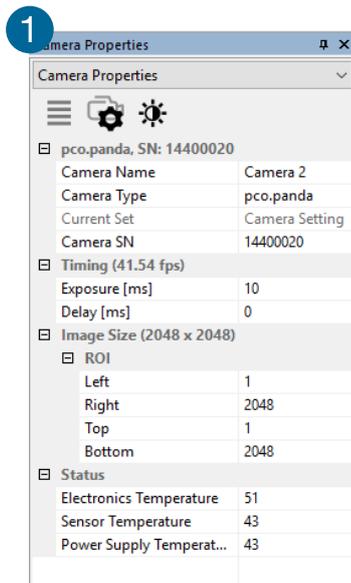
This sets the number of images recorded in one sequence. The maximum is defined by approved RAM size.

## 6.3 CAMERA PROPERTIES

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

The former main instance **Camera Control** (known from Camware 3.x) and the **Convert Control** (see 6.3.8) can be opened additionally.

Three view options with various functions can be selected: **Basic**, **Custom** and **Expert**.



**Exposure [ms]**  
Specifies the exposure time

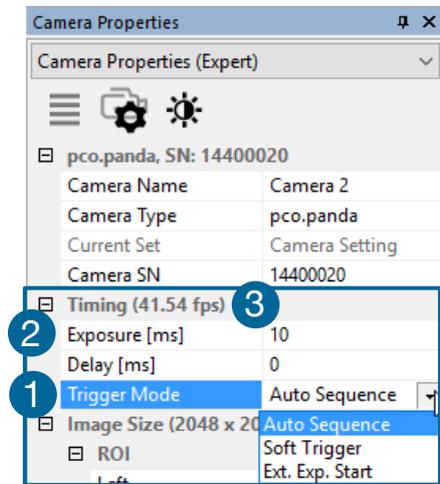
**Basic** mode ① only shows camera name, type, set, serial number and exposure time. In **Basic** mode the frame rate is always calculated automatically based on the selected exposure time, i.e. if exposure time is increased, frame rate decreases. It is recommended for Camware beginners.

**Custom** mode ② shows several more setting possibilities and functions are hidden or shown by the **Custom Properties** button. ④ Additional to the **Basic** mode, Trigger Mode, Image Size and Recording control options are selectable.

**Expert** mode ③ (for advanced users) shows all possible camera feature settings.

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

## 6.3.1 TIMING



This chapter explains the timing of the pco.panda in Camware. To basically understand the timing of the camera, read the chapter **6.3.2 ROLLING SHUTTER**.

### Trigger Mode ①

In this context trigger means exposure trigger, i.e. the trigger signal controls the exposure of a single image (light integration time).

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

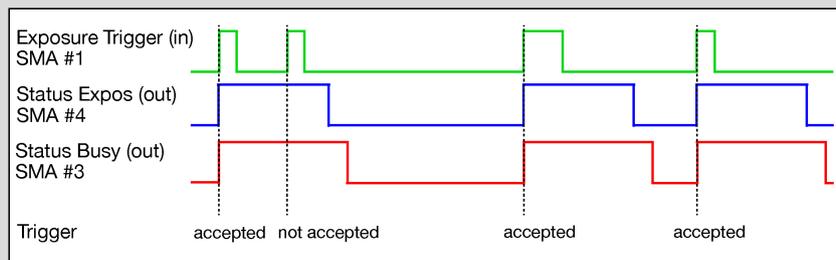
In the **Auto Sequence** mode, camera determines the highest possible frame rate against set exposure time and the time required for a frame readout.

Upon a start command the sequential recording starts and lasts until a stop command.

**Soft Trigger:** single images are recorded with this Camware command. A single image is acquired by pressing the **Software Trigger** button, which appears after pressing the **Record** button (see 6.4). Other signals have no influence on this operating mode.

**Ext. Exp. Start:** in the External Exposure Start exposure control mode, single image recording is started by the falling or rising edge of the voltage signal at the SMA input #1(see 6.3.7). 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 SMA #3 (see 6.3.7) indicates whether a new trigger is accepted.

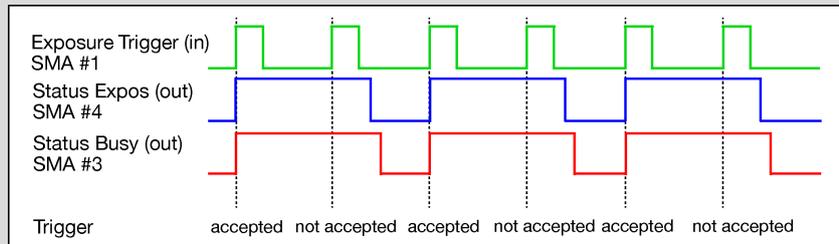


The maximum achievable frame rate in external trigger mode is lower than in **Auto Sequence** mode, since the camera only starts exposing after the readout of the previous image is completed.

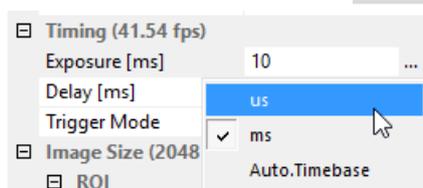
Example calculation for exposure time 10 ms:

- Line time: 12.136  $\mu$ s
- Readout time full resolution (readout time depends on vertical resolution):
  - Image size: 2048 x 2048 pixels
  - Readout time: 2048 x 12.136  $\mu$ s = 24.85 ms
- Calculation:  $1 / (24.85 \text{ ms} + 10 \text{ ms}) = 28.69 \text{ fps}$

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.



### Exposure Time and Time-base ②



It is possible to change time-base from automatic to  $\mu\text{s}$  or  $\text{ms}$ . If your input is out of the range of the camera, it is automatically changed to the next possible setting. The exposure time and delay time can be adjusted in steps of  $10 \mu\text{s}$ . The jitter of the actual exposure start edge is about  $12 \mu\text{s}$ .

### Maximum Frame Rate ③

Camware automatically calculates and displays the maximum achievable frame rate based on the timing and ROI settings.

## 6.3.2 ROLLING SHUTTER

The pco.panda uses the rolling shutter mode. In this mode the pixel reset and exposure start is carried out line by line. Each line has the same exposure time, but a different start and end of exposure. Within one line, the exposure starts simultaneously for all pixels.

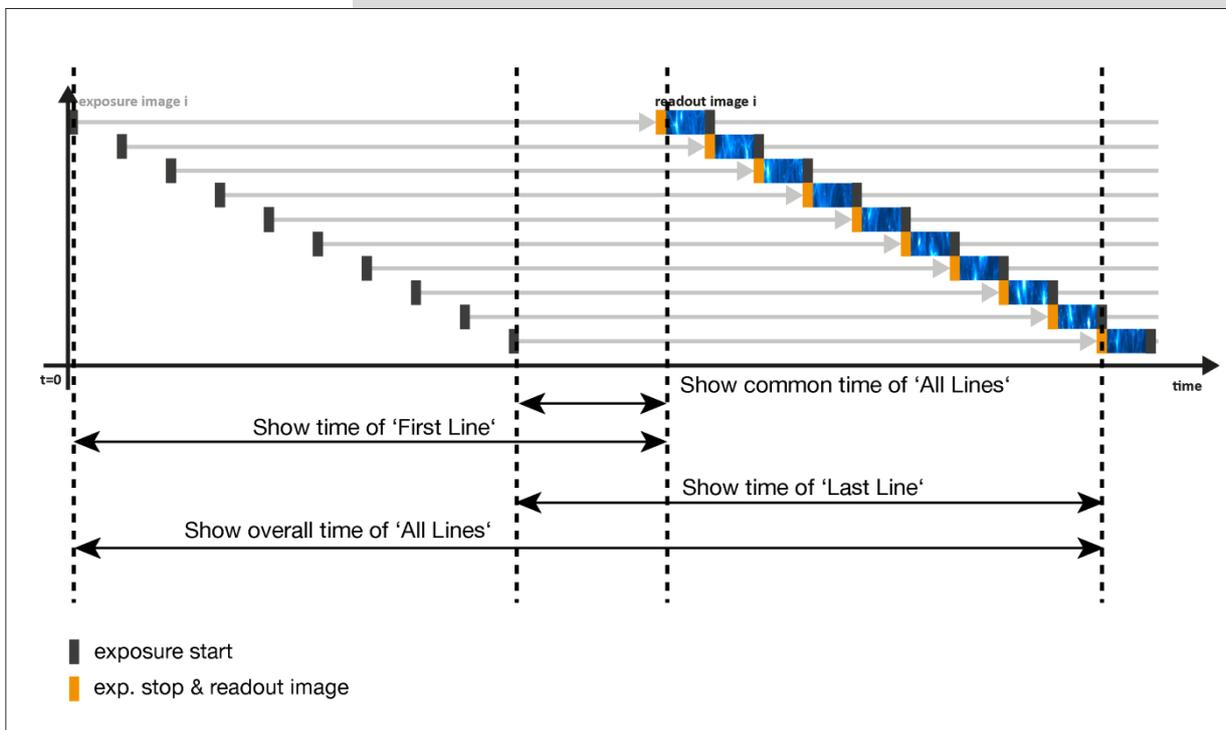
The exposure time of each line starts with the corresponding reset of the line. Then after a predefined time (exposure time), the exposure is stopped. The light induced accumulated charge carriers of the pixels in a line are recorded into memory in a low noise (readout) mode. This way the content of the pixels is assembled in the memory to form the complete image.

The diagram shows different signal timing settings (see chapter 6.3.7). During **Show common time of 'All Lines'** the image sensor is completely exposed to light. The labels **Show time of 'First Line'** and **'Last Line'** are the setting for the first / last exposed line and **Show overall time of 'All Lines'** for the entire exposure period.

There are two different timing cases for rolling shutter mode, which are explained on the following pages:

- exposure time > sensor readout time
- exposure time < sensor readout time

### Rolling Shutter General Timing Diagram



#### NOTE

The exposure and delay time can be adjusted in steps of one line time.

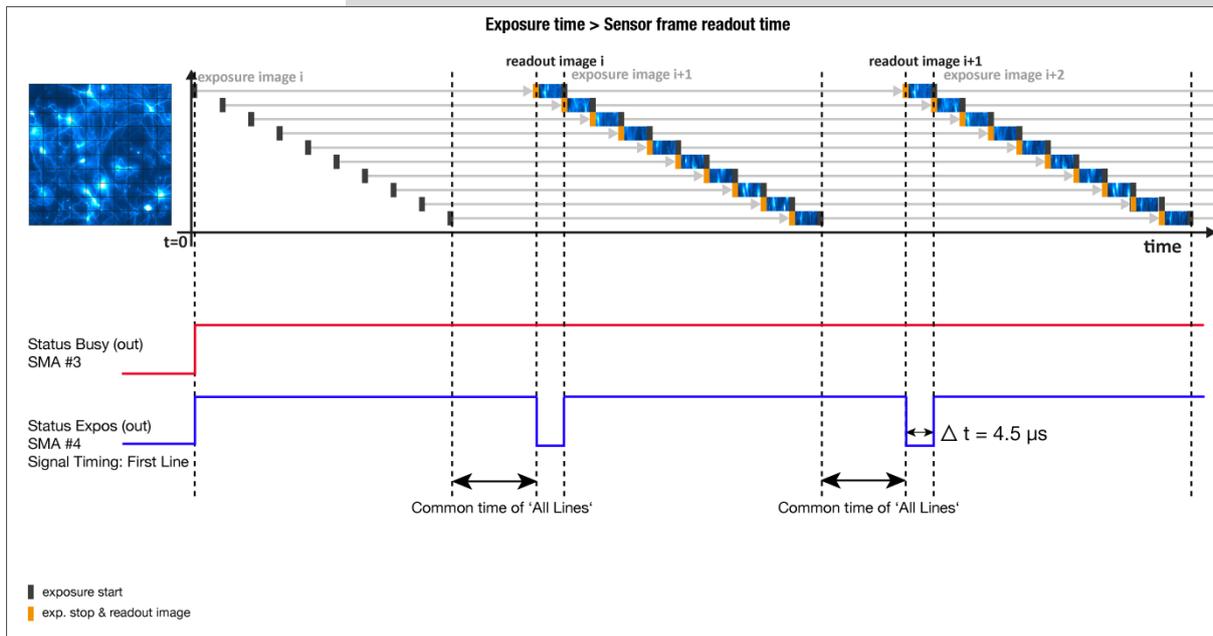
#### Timing

Camera	Exposure time	Delay time	Line time
pco.panda 4.2 USB 3.1	10 $\mu$ s ... 5 s	0 ... 5 s	12.136 $\mu$ s

### Exposure time > Sensor frame readout time

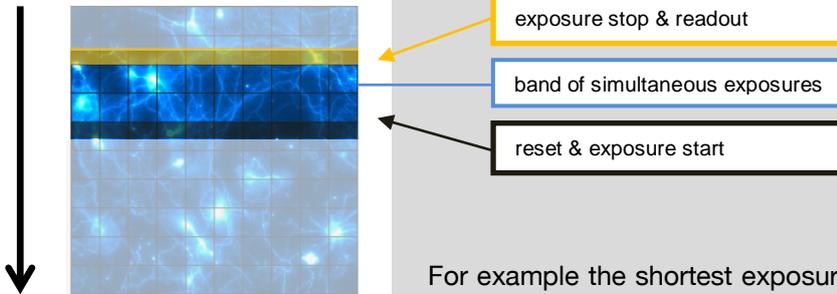
In case the required exposure time is longer than the frame readout time, the image sensor is completely exposed to light for some time (**Show common time of 'All Lines'** also see General Timing Diagram). In case of a triggered flash illumination, this would be the best moment to illuminate the image sensor. The hardware signal for the time **Show common time of 'All Lines'** is available on connector #4 (see 6.3.7).

This is an example timing diagram for **Trigger Mode Auto Sequence**, SMA explanation see 6.3.7



### Exposure time < Sensor frame readout time

In case the required exposure time is shorter than the frame readout time, the image is readout through an exposure band moving from the top to the bottom of the sensor.

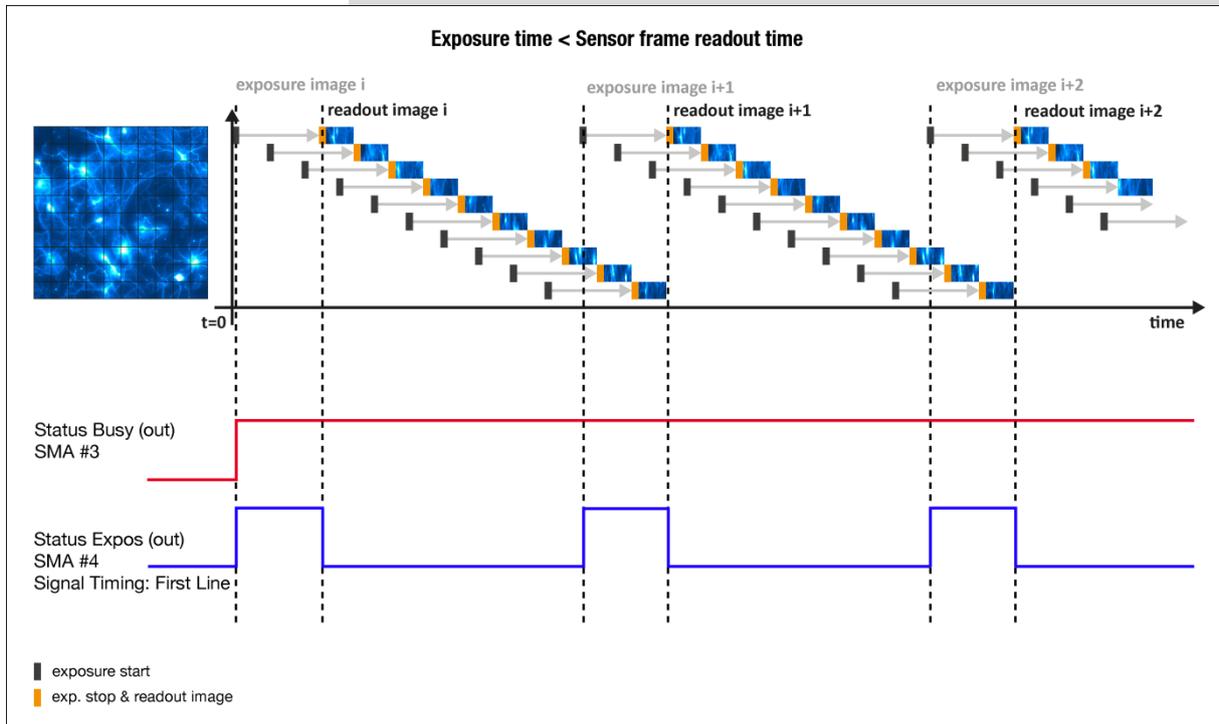


For example the shortest exposure time in rolling shutter is 10  $\mu$ s for the pco.panda 4.2.

The band of simultaneous exposure is in this case (smallest possible height) at full resolution:

For example: pco.panda 4.2: 10  $\mu$ s / 12.136  $\mu$ s (line time) = 1  $\rightarrow$  number of simultaneous lines.

This is an example timing diagram for **Trigger Mode Auto Sequence**, SMA explanation see 6.3.7

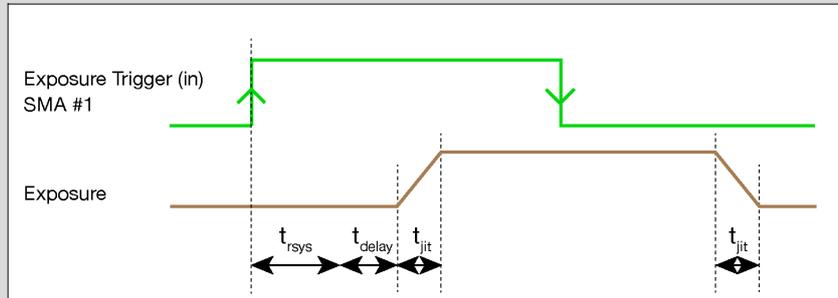


**NOTE**

The jitter  $t_{jit}$  can be a maximum of one line time.

**Details for External Exposure Start**

The detailed timing for external trigger includes system delay times, an adjustable additional delay time, and the jitter.



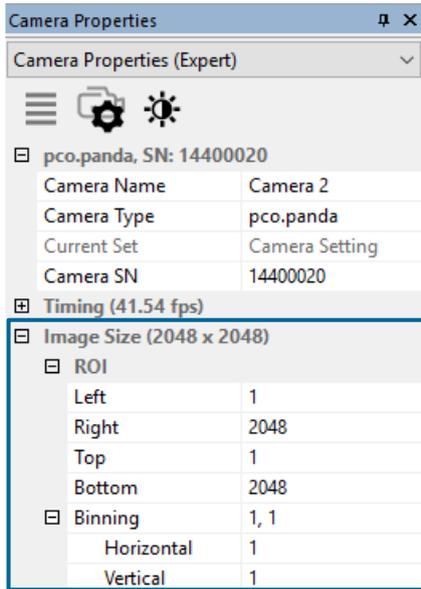
Name	Explanation	Value
$t_{jit}$	jitter	$\leq 1$ line time <sup>1</sup>
$t_{rsys}$	fixed system delay of rising edge	$2x$ line time <sup>1</sup>
$t_{delay}$	programmable delay time	$0 \mu s \dots 5 s$

<sup>1</sup>line time =  $12.136 \mu s$

For optimized synchronization (minimized jitter time) use the falling edge of the line signal at the **Status Expos** output SMA #4 (see **6.3.7**).

System time  $t_{rsys}$  is depending on your camera settings and can be read out from your camera, for further information see SDK manual function `PCO_GetImageTiming`.

### 6.3.3 IMAGE SIZE



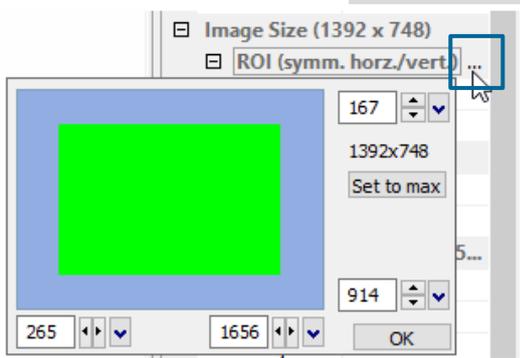
#### ROI

The ROI (Region of Interest) selects only a part of the sensor to be read out, to speed up the frame-rate and to reduce the amount of image data. The decreased image size you see within Camware is a combination of reduced sensor resolution and software downsizing.

The frame-rate only increases, if the vertical resolution is decreased.

ROI by mouse see **6.9.9**.

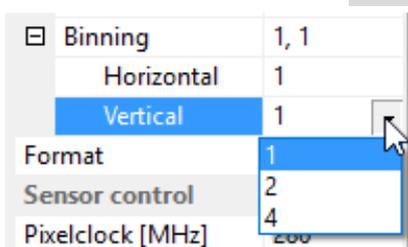
ROI step sizes	
Horizontal steps	32 pixel steps
Vertical steps	8 pixel steps
Minimum ROI	64 x 16 pixels



#### ROI window

Select the **ROI** menu and activate **ROI window** by clicking on ... or use the ... right to the **Left / Right / Top / Bottom** and click on **ROI window**.

The **ROI window** opens and new region of interest might be set by dragging a window with the mouse or by typing in the values.



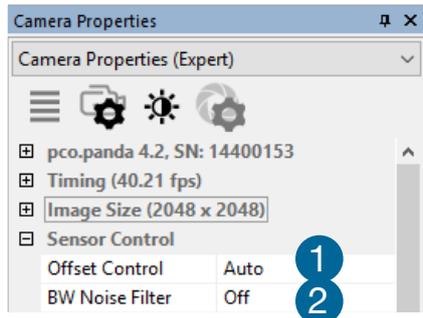
#### Binning

**Binning** combines neighboring pixels (in either the horizontal or vertical direction) to form super pixels. It increases the signal to noise ratio (SNR), reduces the readout noise of the resulting pixels and decreases the spatial resolution of the total image, which is recorded.

Available **Binning** modes:

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

## 6.3.4 SENSOR CONTROL



### Offset Control ①

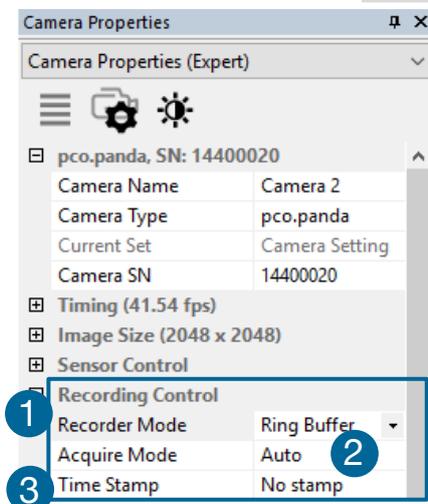
Select **Auto** to automatically compensate dark current and signal drift of the offset. Select **Off** to deactivate **Offset Control**.

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 only recording is stopped and restarted.

### BW Noise Filter ②

In addition to the processing of the embedded unchangeable defect pixel list, 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.

## 6.3.5 RECORDING CONTROL



### Recorder Mode ①

Camware uses free RAM space on your computer. The recorded images are temporarily saved as 16 bit multi TIFF. In **Sequence** mode the recording stops when RAM space is full. In **Ring Buffer** mode the camera stops only by a stop command, hence overwriting previous images. For longer recording periods an appropriate RAID system is necessary, see also the **Direct Record to File** option (see 6.9.2).

### Acquire Mode ②

The **Acquire Mode** enables or disables the recording by an external signal. If set to **Auto** all images are accepted and all images taken are saved. A signal at the **Acquire Enable** input SMA #2 (see chapter 6.3.7) is ignored for this function. Operation of the **Acquire Mode** depends on the selected **Trigger Mode** (see 6.3.1).

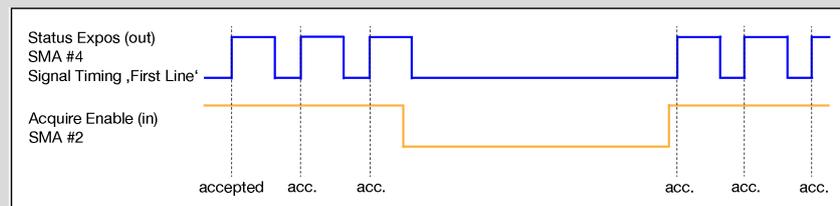
Explanation of how the **Acquire Mode External** works in the different **Trigger Modes** (see 6.3.1):

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

The **Acquire Mode** is level controlled. That means at the level "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 SMA #2. The **Acquire Enable** input is sampled at the beginning of the image generation, shown by the rising edge of the **Status Expos** output SMA #4.

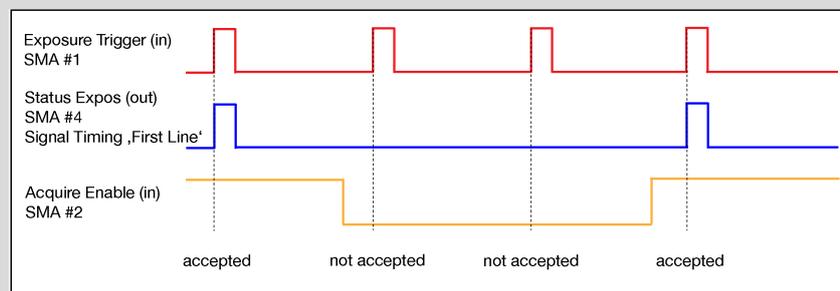
Image acquisition is on an idle state if the **Acquire Enable** input is on low level (high, when inverted); it pauses image acquisition until the **Acquire Enable** input is on high level again (high, when inverted).

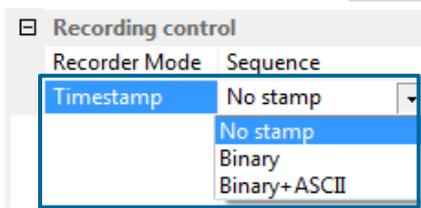


In **Trigger Mode External Exposure Start**, the **Acquire Enable** input SMA #2 works like a gate for the trigger signal.

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).

**Status Expos** signal see chapter 6.3.7 for **Signal Timing First Line**.





### Timestamp <sup>3</sup>

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

The time resolution is 1  $\mu$ s. In binary mode the first 16 pixels are 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  $\hat{=}$  4 bits; 2 numbers  $\hat{=}$  2 BCD  $\hat{=}$  8 bits = 1 byte; every pixel contains 2 digits)

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

Three different information is stamped onto the image: number of the image <sup>3</sup>, date <sup>4</sup> and time <sup>5</sup>.



Additionally to **Timestamp** the **Image Overlay** function is available, see chapter 6.4.

## 6.3.6 STATUS

Status	
Electronics Temperature	53
Sensor Temperature	44
Power Supply Temperature	44

Shows the current temperature level of the pco.panda camera.

**Electronics Temperature:** shows the actual temperature of the FPGA

**Sensor Temperature:** shows the actual sensor temperature.

**Power Supply Temperature:** shows the actual temperature of the voltage supply inside the camera

### NOTICE

If the temperature rises above a certain level, Camware gives a warning.

Always ensure adequate cooling of the camera.

Do not expose it to direct sunlight or other sources of heat.

## 6.3.7 HARDWARE IO CONTROL

Hardware IO Control	
Exposure Trigger	
1	Exposure Trigger On
	Signal Polarity Rising
Acquire Enable	
2	Acquire Enable On
	Signal Polarity High
Status Busy	
3	Status Busy On
	Signal Polarity High
Status Expos	
4	Select IO Signal Status Expos
	Signal Timing Show time of 'Last Line'
	Status Expos On
	Signal Polarity High

Change setting via drop-down menu.



### Exposure Trigger 1

If checked, a signal for **External Exposure Start Trigger Mode** (see chapter 6.3.1) is accepted at the **Exposure Trigger** SMA input #1.

**Exposure Trigger:** On; Off  
**Signal Polarity:** Rising; Falling

### Acquire Enable 2

If checked, a signal for **Acquire Mode** (see chapter 6.3.5) is accepted at the **Acquire Enable** SMA input #2.

**Acquire Enable:** On; Off  
**Signal Polarity:** High; Low

### Status Busy 3

If checked on, a signal indicating busy status is provided at the **Status Busy** output. Once an acceptable trigger edge is received, 'busy' goes to status high. As soon as 'busy' goes low again, a new trigger edge is accepted.

**Status Busy:** On; Off  
**Signal Polarity:** High; Low

### Status Expos / Status Line 4

If checked, a signal indicating exposure or line status is given at the status output. **Status Expos** indicates the actual exposure window for one frame. Use the falling edge of the **Status Line** signal for optimized synchronization (minimized jitter time; see page 21). Detailed explanation for **Signal timing** see next page!

**Select IO Signal:** Status Expos; Status Line  
**Signal timing:** Show time of 'First Line'; Show common time of 'All lines'; Show time of 'Last line'; Show overall time of 'All lines'  
**Status Expos:** On; Off  
**Signal Polarity:** High; Low

### Enabling and Polarity of I/O Signals

The polarity of the I/O 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).



### Detailed Explanation for Status Expos SMA #4 Signal Timing

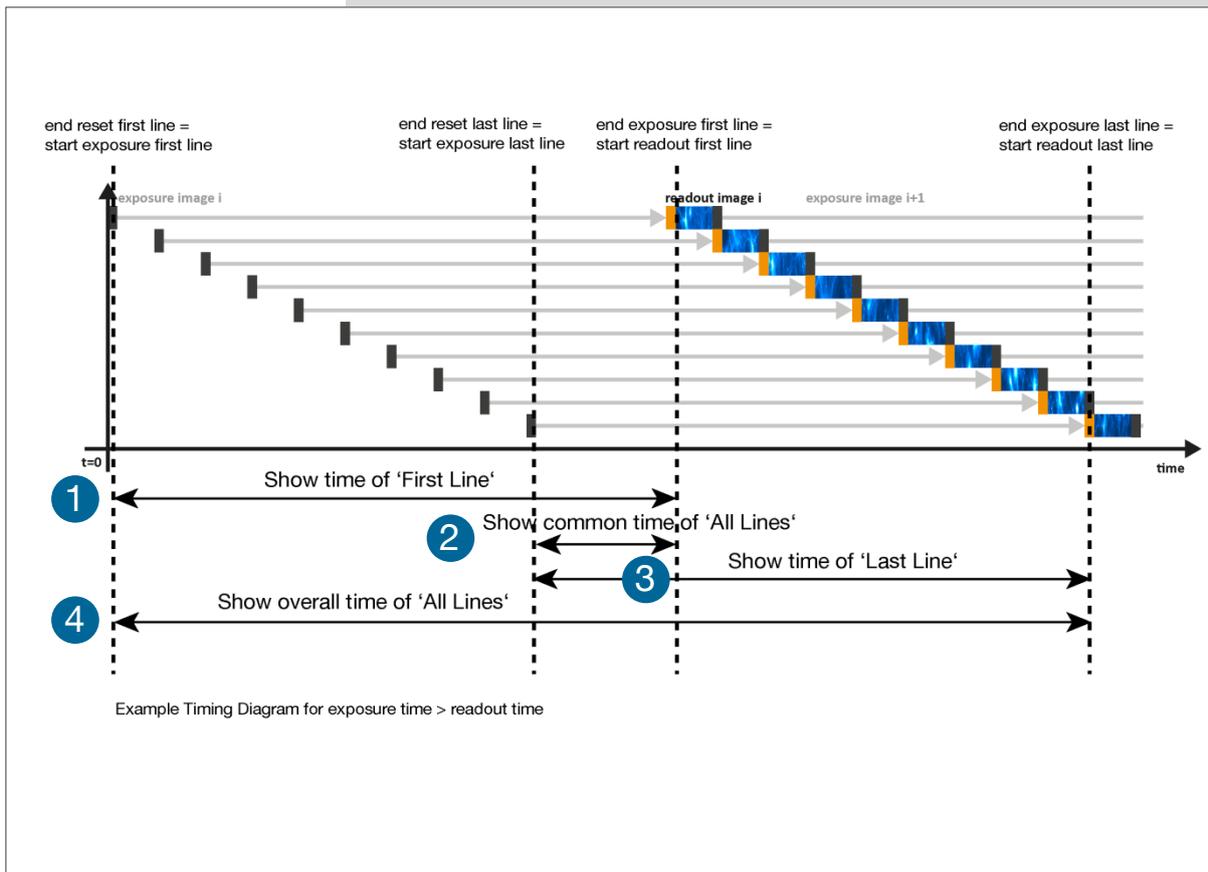
Setting in Camware:

Status Expos	
Select IO Signal	Status Expos
Signal Timing	Show time of 'Last Line'
Status Expos	On
Signal Polarity	High

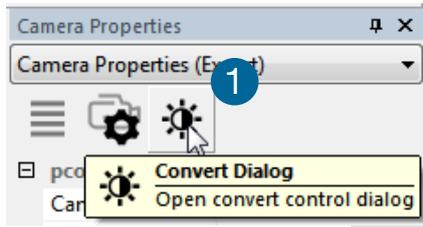
- 1 Show time of 'Last Line'
- 2 Show time of 'First Line'
- 3 Show common time of 'All Lines'
- 4 Show time of 'Last Line'
- 5 Show overall time of 'All Lines'

There are four different signal types selectable. The example timing diagram shows all four different possibilities:

- 1 Shows the exposure time of the first line
- 2 Shows when all sensor lines are exposed
- 3 Shows the exposure time of the last line
- 4 Shows if any sensor line is integrating

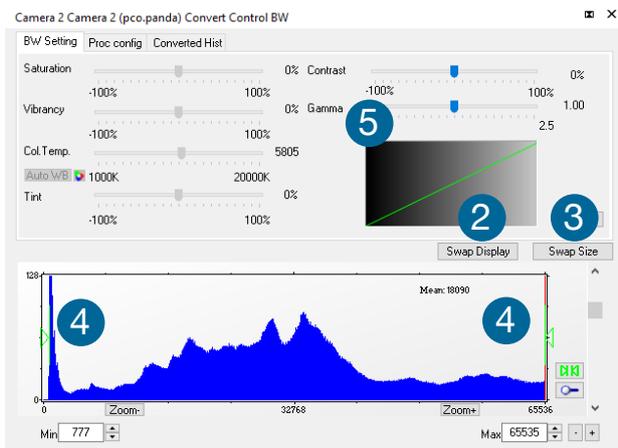


## 6.3.8 CONVERT CONTROL DIALOG



Start the **Convert Dialog** with the black / white button 1.

The user can influence how the 16 bit intensity values (x-axis) of the original image are displayed in 8 bit values (y-axis) in different ways.



### BW Settings

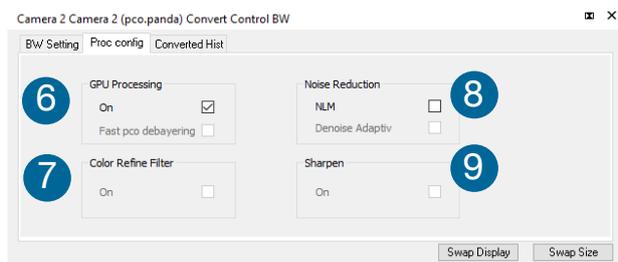
It is possible to hide the histogram of original data 2 and to switch tab / histogram 3.

#### Green sliders in histogram 4

**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 into a value between 0 and 255 according to **Contrast** and **Gamma** settings. See the small graph 5, which reflects the calculation.



### Proc. Config (Process configuration)

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

#### GPU Processing 6

**On:** Switch on in order to significantly reduce processing time (increases refresh rate of the live image). Only for NVIDIA graphic cards.

**Fast pco debayering:** n/a (only color cameras)

#### Color Refine Filter 7

**On:** n/a (only color cameras)

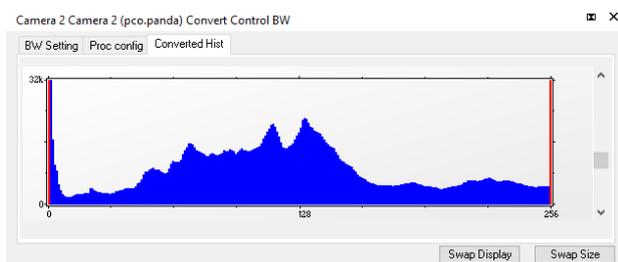
#### Noise Reduction 8

**NLM:** Non local means algorithm

**Denoise Adaptive:** not available

#### Sharpen 9

**On:** not available



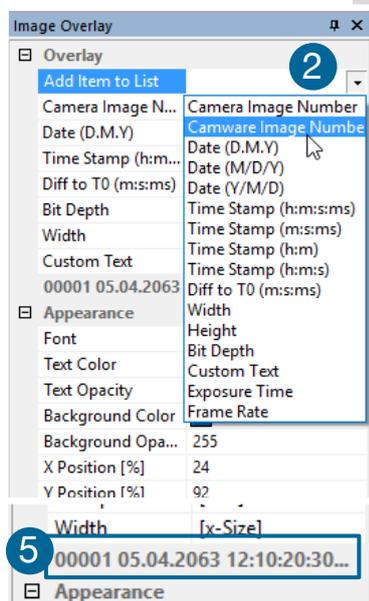
### Converted Hist

This tab shows the histogram of converted data.

## 6.4 IMAGE OVERLAY



Open **Image Overlay**: these buttons allow easy switching between **Camera Properties** and **Image Overlay** windows. **1**  
If not available, see **6.9.5 View Menu** to activate this menu.



This function enables an individually configurable image overlay, to display information within the images.

Many options are available by clicking **Add Item to List** **2**

Also the **Appearance** is configurable:

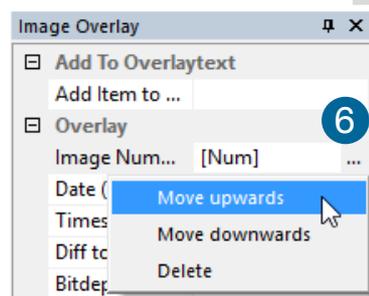
**Font, Text Color, Text Opacity, Background Color, Background Opacity** and **X Position** or **Y Position**.

**Camera Image Number** **3** and **Camware Image Number** **4** are two different count methods:

**Camera Image Number**: the image numbers are being incremented continuously. When recording in **Ring Buffer** mode, the image numbers are exceeding the number of images being stored in the RAM memory of the camera since images are being overwritten when the memory is full.

**Camware Image Number**: the software displays the image numbers according to the number of images being recorded (starting with image 1).

006964 000001 26.06.2017 10:54:48:521 12 1584 pco

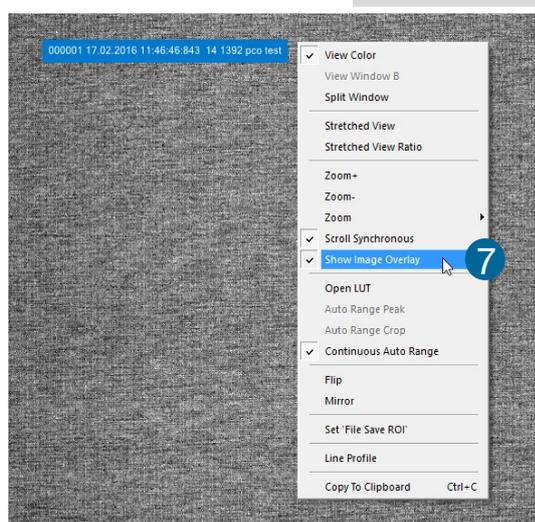


Preview of the **Image Overlay**. **5**

Each item can be moved or deleted: **Move Upwards, Move Downwards** or **Delete** by clicking on ... **6**



Move the **Image Overlay** to your favorite position by drag & drop.



Right-click in the image window to activate **Show Image Overlay**. **7**

### NOTE

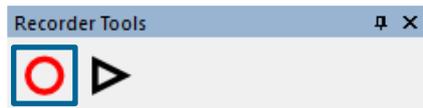
In contrast to Timestamp, this function does not overwrite image data.

## 6.5 RECORDER TOOLS

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

It can be found on the right lower side of Camware or, if closed, activated by **View** menu (see chapter 6.9.5)

### Record



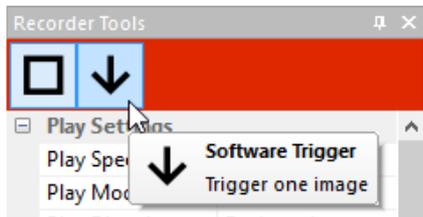
**Start/Stop record:** with **Record** button

Second option: press enter or STRG+A to Start / Stop recording.

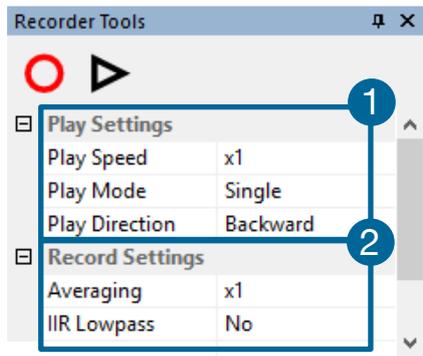


**Record:** in record state Camware software is highlighted in red.

**Exposure** time may be changed during recording. See 6.3 **Camera Properties**.



**Software Trigger:** after record is started an arrow pointing downwards appears. Clicking on it triggers a single image (see 6.3.1).



### Play Settings 1

**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 with 25fps. 1 fps means that only one frame per second is played.

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

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

### Record Settings 2

**Averaging:** averaging images in the buffer reduces statistically independent (image) noise. Set a value higher than x1 in the drop-down list and this number of images is averaged.

**IIR Lowpass:** another option to reduce the noise is the activation of the infinite impulse response **IIR Lowpass** filter. This filter takes 90% of the previous image and 10% of the new image to create images with clearly reduced noise.

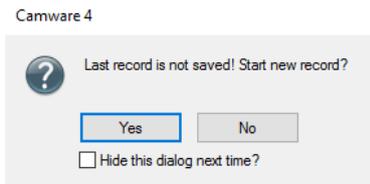
Image (actual) = Image (act - 1) \* 0.9 + Image (new) \* 0.1



### Preview Settings

If **Preview with ext. signals** is set to **Yes: Trigger Mode Ext. Exp. Start** or **Acquire Mode External** are active during **Live Preview** in case 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 not save it yet, Camware reminds to save the record before starting a new one.

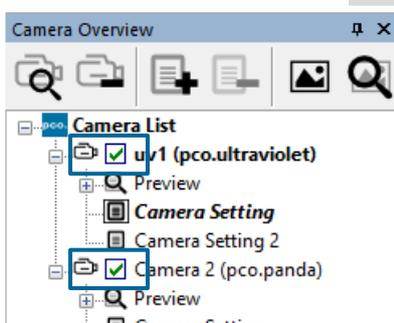
### Extended Recorder



**Extended Recorder** can be activated (see 6.9.5).

- ③ **Record / Stop** record / **Play**
- ④ **First Image** (jump to first image) / **Back Fast** (jump backward) / **Back** (jump one image backward)
- ⑤ **Forward** (jump one image forward) / **Forward Fast** (jump forward) / **Last Image** (jump to last image in record)

### Recording with Multiple Cameras



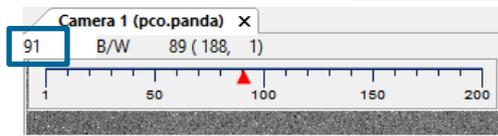
With all cameras activated recording starts simultaneously on all of them.

Recorder uses **Recorder Mode** settings (**Sequence** or **Ring Buffer**) of the active camera for all cameras (see 6.3.5)

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

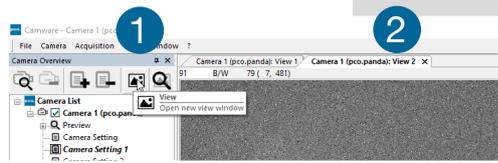
## 6.6 VIEW WINDOW

### Quick Scrolling



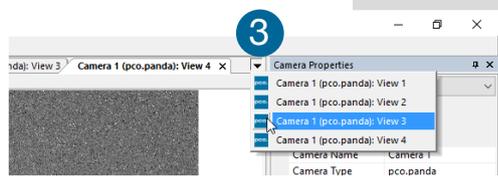
Having recorded at least 50 images, you may scroll through the images quickly by holding down the left mouse button on the image number. Or enter the desired image number directly into the number field.

### More View Windows



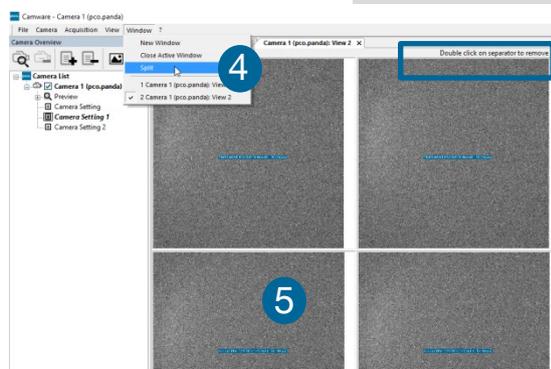
To open more **View Windows** from one camera: click **View Window** button ① and Camware creates a new **View Window** ②.

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



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

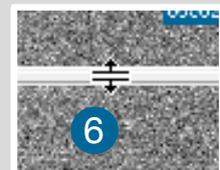
### Split View Window



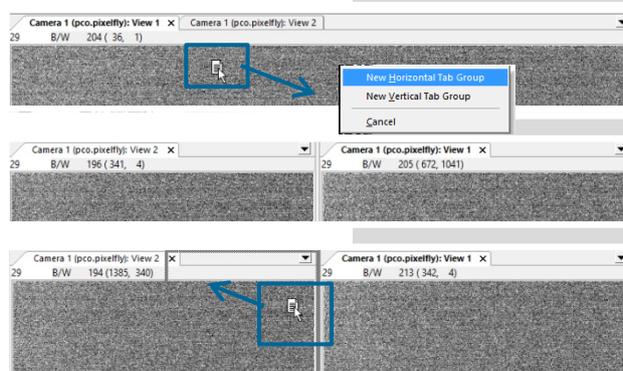
The **View Window** can be **Split**. Click **Window** → **Split** ④ and a split cross is shown. You can easily adjust the size of the splitted window elements by grabbing and dragging the dividing lines ⑤.

The main reason for this function is to view four sections of your image in one view. Choose the **Zoom±** function to zoom in the image (first turn off **Stretched View**, see 6.9.8)

If you want to undo the **Split**, double click on the dividing line (after symbol ⑥ is visible).



### New Horizontal / Vertical Tab Group

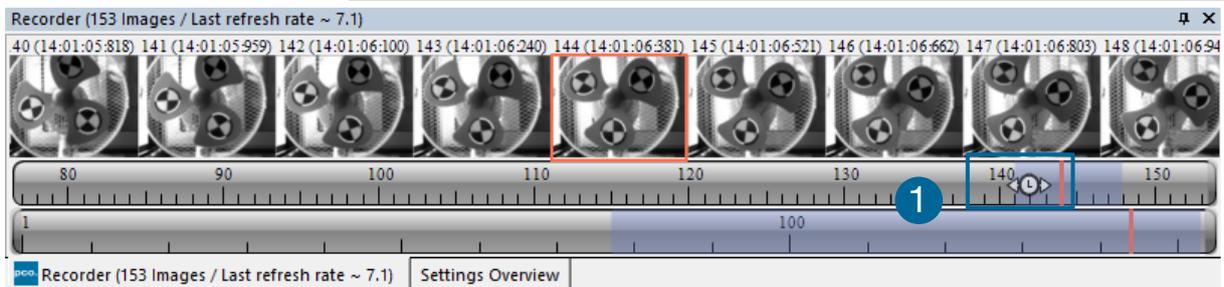


To view two tabs side by side or arranged one above the other just drag a tab and Camware asks you whether you want to create a **New Horizontal / Vertical Tab Group**. Undo this very easily by dragging the tab back to its former position.

This also applies for **View Windows** of several cameras.

## 6.7 RECORDER (IMAGES)

Once recording is done, small preview images (thumbnails) are built and displayed automatically in the **Recorder (Images)** docking window. It takes some time depending on the performance of your computer system and of the interface used.

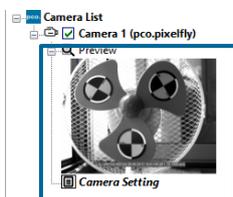


Clicking (left mouse button) within the upper scale bar **1**, adjusts the number of images shown by moving the mouse left or right. In this scale minimum is 20 and the maximum is half of the recorded images.

### 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.

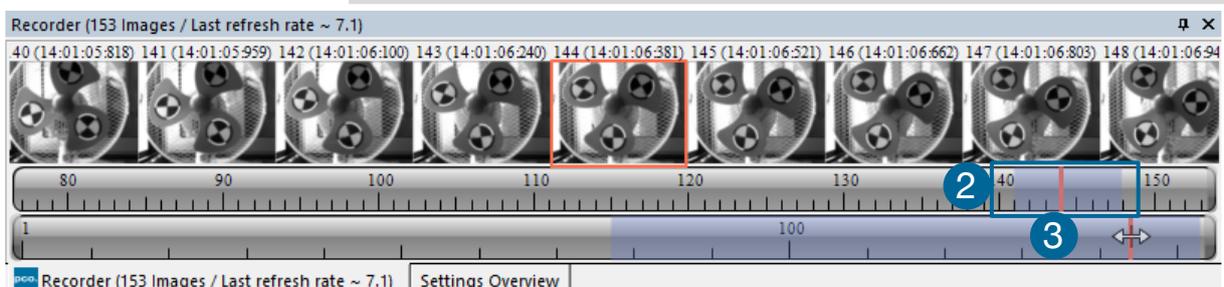


While quick scrolling, the **Preview Window** displays the active image sequence, allowing to scroll through the image sequence and showing the images in the **Preview Window** forwards or backwards. The **View Window** does not actively show live images during quick scrolling (only in normal scrolling speed by mouse-wheel).

### Thumbnail Image

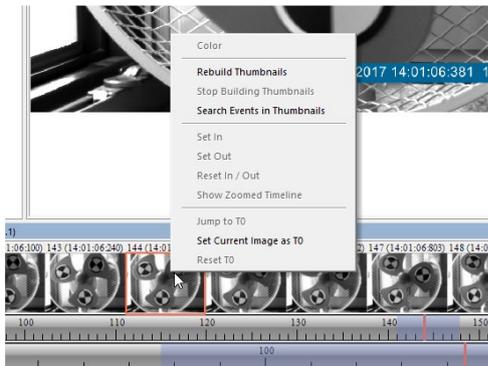
Click on a thumbnail image and the **View Window** displays it. Scroll via mouse wheel through the thumbnails.

The upper blue bar **2** matches with the number of displayed thumbnails. The lower blue bar shows the range of the upper scale in relation to the whole record.



The second scale shows the total number of recorded images. It allows to scroll quick through the recorded images **3**.

## Right-Click Menu



Right-click on thumbnails.  
Allows to rebuild all thumbnails and to search for events.

Furthermore, the **Set In / Out** gives you the possibility to set values for a sequence, which can be played via play button. **Reset In / Out** discards these settings.

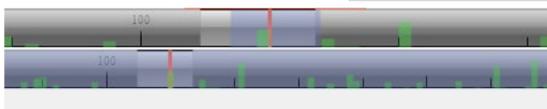
**Set In / Out** is active: if you save / export your images, only the selected images are saved / exported (see 6.9.2).



The light gray area in the upper scale shows an **In-Out** example area. To define a new area: just right-click on the start and end frame in one of the scales.

The **In** image must be left to 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.



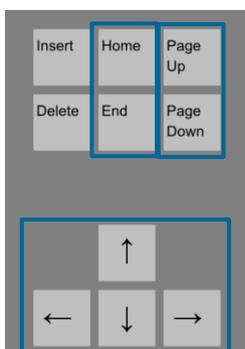
**Search Events in Thumbnails:** detected events are displayed as green bars.

## Too Dark or Bright Thumbnails



If thumbnails are too dark or too bright, right-click in **View Window** (see 6.9.8) 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

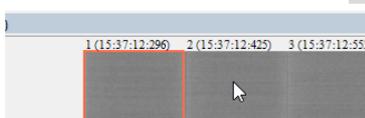
Page up / down keys: 10 images up or down.

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.



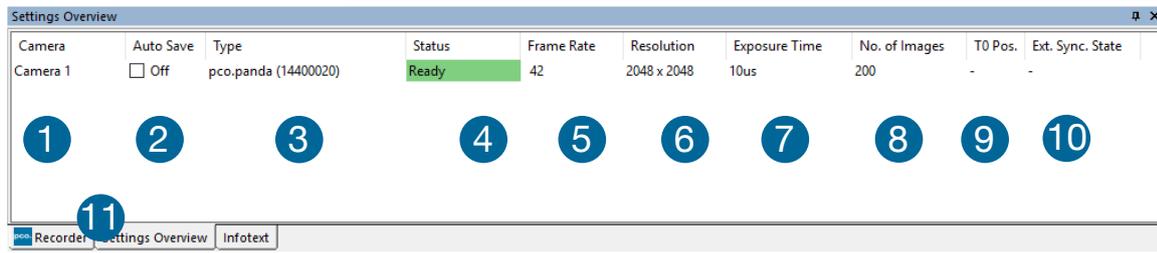
## Additional Short-Cuts

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

Press CTRL + left mouse button to jump to the first image

Press CTRL + right mouse button to jump to the last image

## 6.8 SETTINGS OVERVIEW



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

The parameters can only be changed using **6.3 Camera Properties**.

It is possible to easily switch between the **Recorder (Images)** section and the **Settings Overview**. **11**

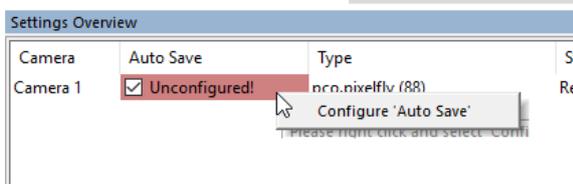
No.	Function	Description
1	Camera	Name
2	Auto Save	Off , Unconfigured (red), OK (green)
3	Type	Camera type and serial number
4	Status	Ready or Recording Green background: Images are in memory
5	Frame Rate	Currently selected frame rate
6	Resolution	Resolution in pixels
7	Exposure Time	Selected exposure time
8	No. of Images	Number of images to be recorded
9	T0 Pos.	Not available
10	Ext. Sync. State	Not available

## 6.8.1 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. Therefore this function is very useful if you use more than one camera. Once configured **Auto Save** allows acquiring and saving 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.

Standard file save see **File** menu **6.9.2**.

Explanations are shown in the info text window at the bottom of the menu.

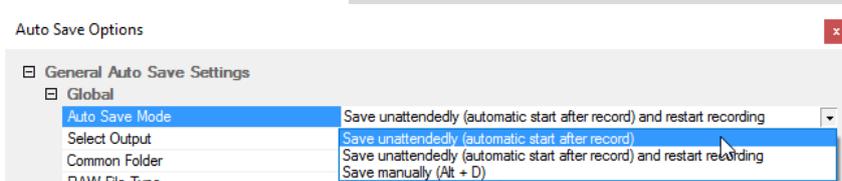


Enable **Auto Save** by clicking on the check box. The text changes to **Unconfigured!** (red background).

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

### General Auto Save Settings

#### Global



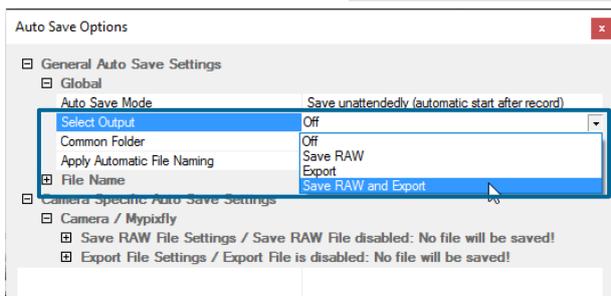
**Auto Save Mode:** three different modes are available, **Save manually** and two variants of **Save unattended**.

The **Save manually** mode allows to store RAW images and export images after a recording session, when hitting the **ALT** and **D** keys. This allows to cut the image sequence in the **Recorder Toolbar** before saving.

The **Save unattended** mode enables to download all RAW images and to export the complete image sequences of all cameras immediately after an active recording is stopped.

**Save unattended (automatic start after record):** saves all image data after recording is stopped.

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



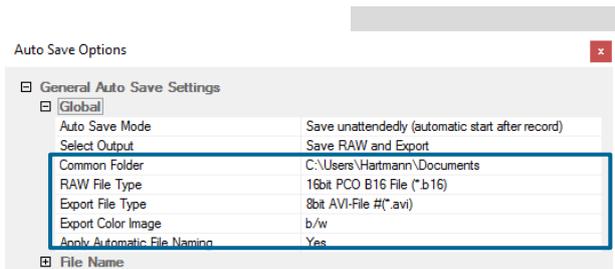
#### Select Output:

**Off:** **Auto Save** is deactivated

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

**Export:** only compressed files are stored (bmp, jpg, tiff, avi, mpeg, wmv)

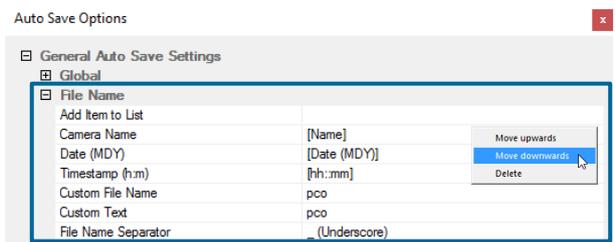
**Save RAW and Export:** RAW and compressed files are stored simultaneously



**Common Folder:** select main folder for stored files  
**RAW** and **Export File Type:** select the type of RAW and compressed 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

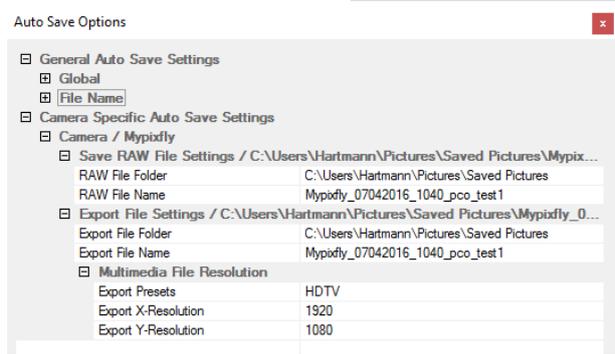
Camware according to your automatic file name settings.

### 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).

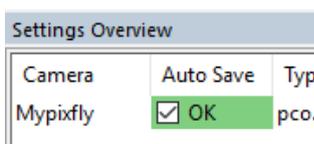
**Export File Settings:** set **Export File Folder** and **Export File Name** (if not set to automatic file naming).



**Multimedia File Resolution:** set predefined video export resolution or enter a **Custom** x- and y-resolution. Most likely you may have to set the configured resolution of your camera here.



Finish the configuration by clicking **OK**.

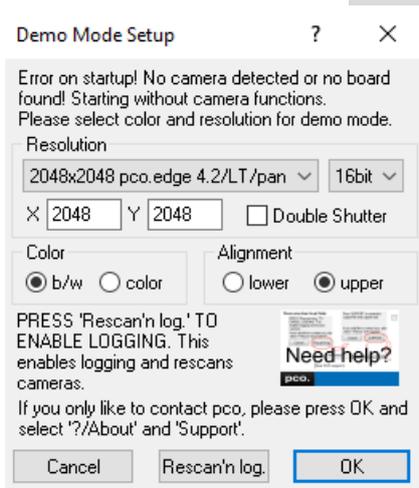


After configuration is finished, **Auto Save** status turns **OK** (green background).

## 6.9 CAMWARE MENU TABS & FEATURES

This chapter describes in detail the Camware Demo Mode and the Camware Tabs: File, Camera, Acquisition, View and Window. Furthermore the right-click menu and some additional features are listed.

### 6.9.1 DEMO MODE



When Camware is started, it automatically recognizes the camera type of the connected and running cameras. Camware starts in **Demo Mode**, if your camera is off or no camera is connected.

If you want to force 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. State in Camware the image type and the **Demo Mode Setup** window opens, requesting the corresponding input.

**Need Help?** Having troubles to run the camera this window pops up. Follow instructions of chapter **A5**.

Settings to view the b16 files of the pco.panda

Resolution	Bit	Double Shutter	Color	Alignment
2048 x 2048	16	yes / no	b/w	upper

#### Resolution

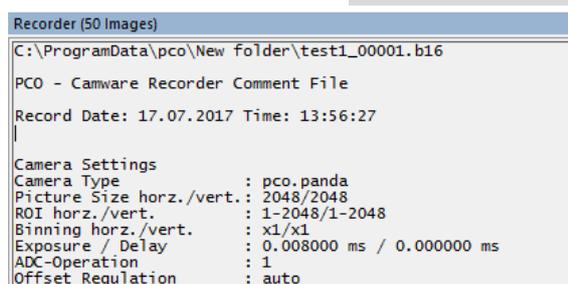
The drop down list shows the PCO camera image sensor resolutions. Select the specific resolution and bit depth of the images to be opened.

#### Color

Select color mode (not available for pco.panda).

#### Alignment

Adjust whether MSB (most significant bit) aligned (upper) or LSB (least significant bit) aligned (lower) images have been stored.



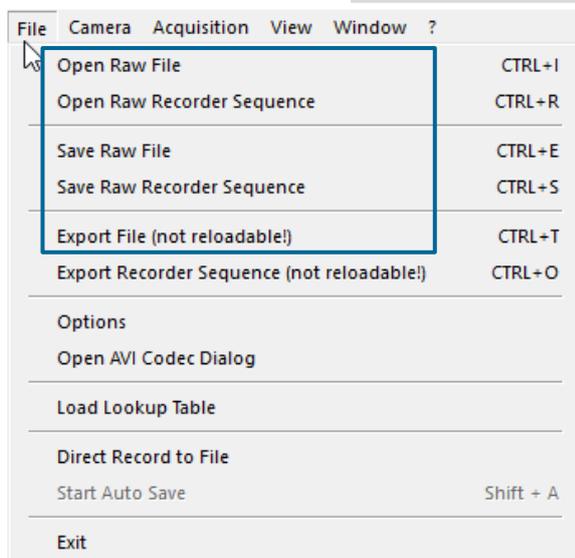
#### Infotext

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

The **Camera Settings**, storing location and **Record Date** are listed in this file.

**Infotext** can be activated in the **View** menu **6.9.5** at any time.

## 6.9.2 FILE MENU



### NOTE

Be aware of the different storage characteristics of the formats, for example \*.bmp - the bitmap format stores 8 bit values only and therefore the image content of a 16 bit image is reduced, if stored as bitmap.

### Open Raw File

This command imports a single image into the active image window. Only files with the extension and format \*.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 image itself is fitted to the current image size. If the recorder is disabled, the current image size is set to the parameters of the imported image.

### 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 RAW File Recorder** dialog box. Only files with the extension and the format \*.b16, \*.pcoraw, \*.tif and multi tif can be imported.

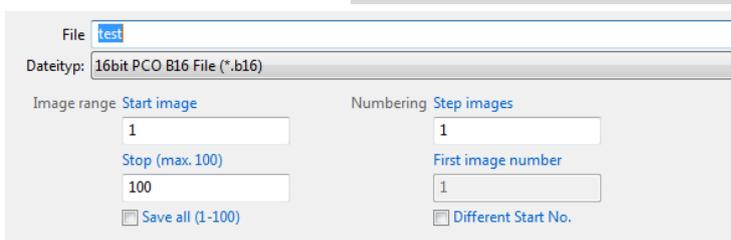
### Save Raw File

Saves the image displayed in the active window and opens the **Save RAW File** dialog. The image file can be saved in 16bit \*.b16 and \*.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 RAW File** dialog box. This feature saves one image of each active camera within one step (it is not necessary to repeat the save process for each camera). The save command is not available, if no image window is open. For **Auto File Save** see 6.8.1

### Save Raw Recorder Sequence

This command should be used to save or export image sequences. If more than one camera is connected and an image window is 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 6.8.1



### Export File

This is not reloadable! Exports the image of the active image window. This command opens the **Export Image** dialog box. Files with the extensions fts, tif, bmp, asc, jpg, and jp2 can be exported. This topic is not visible, if no image window is open. For **Auto File Save** see 6.8.1

## Export Recorder Sequence

Export Recorder Sequence (not reloadable!)	CTRL+O
Options	
Open AVI Codec Dialog	
Load Lookup Table	
Direct Record to File	
Start Auto Save	Shift + A
Exit	

This is not reloadable! Exports a sequence of images. If more than one camera is connected the image record of the currently open window is 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 fts, tif, bmp, asc, avi, mpg, jpg, jp2, and wmv can be exported (see Appendix A4). For **Auto File Save** see 6.8.1

## Options

Options

Single File Properties	
Single Tif File 16bit Alignment	Lower
ASCII File Separator	TAB
Binary PGM File	No
JPEG 2000 Image Quality	20
JPEG Image Quality	85
Binary PPM File	No
RAW 16bit RGB TIF File	No
Use Cache File	Yes
General File Properties	
FIFO Buffer Size	150
Preserve Last Record	Yes
View Properties	
Crosshair Color	<span style="color: red;">■</span> #f2020
Crosshair Length	210

Cancel OK

### Single File Properties

#### Single Tif file 16 bit Alignment:

Upper / Lower

#### ASCII File Separator:

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 TIF File:

Save RAW TIF without color balance. Select: Yes, No.

*Use Cache File:* (n/a for pco.panda)

### General File Properties

#### FIFO Buffer Size:

Set the FIFO buffer size in number of images. This avoids gaps during file write delays. Usually it is set to 150.

#### Preserve Last Record:

Preserves current recorded images. When set, the user is asked whether to really start a new record or to close.

### View Properties

#### Crosshair Color:

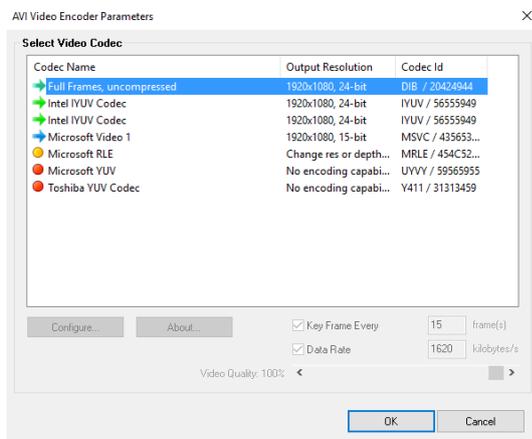
Set the crosshairs color for Save ROI and Line Profile.

#### Crosshair Length:

Set the crosshairs length in pixel.

Activate crosshairs: see chapter 6.9.8

### Open AVI Codec Dialog



Using Auto File Save and selecting AVI for video output affects stored video sequences.

You only need to set this option, if you use **Auto File Save** see **6.8.1**

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

### Load Lookup Table

This feature assigns pseudo colors (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

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

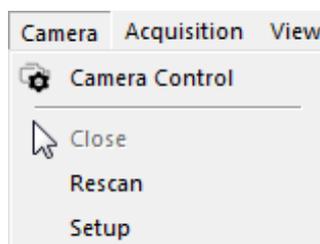
### Start Auto Save

Only available if **Auto Save** is activated (see **6.8.1**)

### Exit

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

## 6.9.3 CAMERA MENU



### Camera Control

Opens the camera control window.

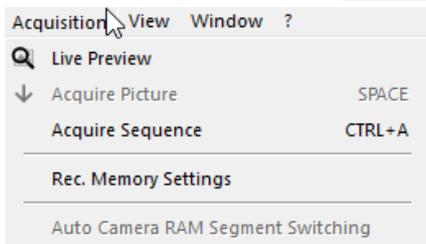
### Close

Disconnects camera and switches Camware to Demo Mode. In case of multiple cameras, all cameras must be closed for Camware to switch to Demo Mode.

### Rescan

Disconnects and reconnects all cameras.

## 6.9.4 ACQUISITION MENU



### Live Preview

**Live Preview** for quick and easy adjusting and focusing of the camera. The active window is refreshed. To see another window, simply click on the window.

### Acquire Picture

Only available if **Trigger Mode** is set to **Soft Trigger**, see 6.3.1

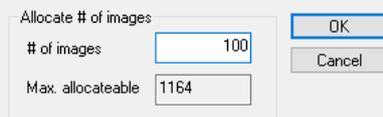
### Acquire Sequence

Starts recording images into the system memory according to Trigger Mode selection (see 6.3.1). During recording, all camera controls are locked.

### Rec. Memory Settings

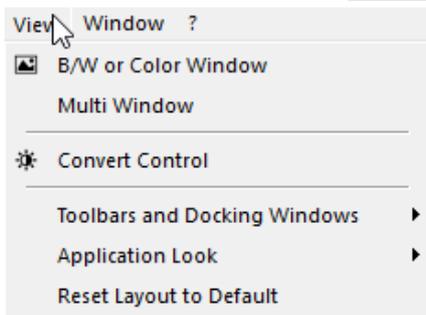
This sets the number of images recorded in one sequence. The maximum is defined by approved RAM size.

Memory Allocation Dialog



Auto Camera RAM Segment Switching (not available)

## 6.9.5 VIEW MENU



### B/W or Color Window

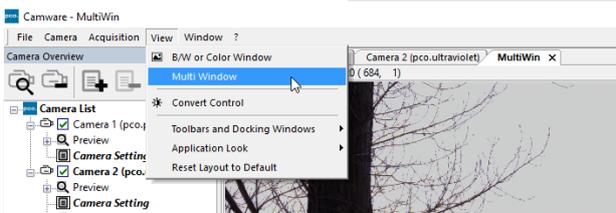
Opens a new **View window**.

### 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.

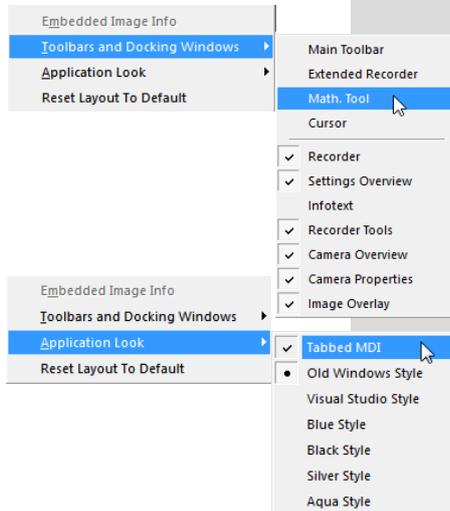
Use the same ROI and timing settings for all cameras.

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** mode).



## Convert Control

See 6.3.8



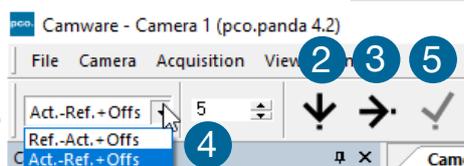
## Toolbars and Docking Windows

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

**Additional Toolbars** are displayable, but not essential: Main Toolbar / Extended Recorder / Math. Tool / Cursor. See below. For function **Infotext** see 6.9.1.

## Application Look

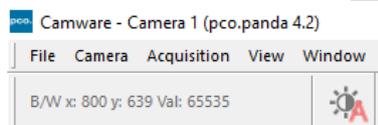
Style and look of Camware can be customized; many different style sheets are selectable. The Tabbed MDI function (un)docks the view windows.



## 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

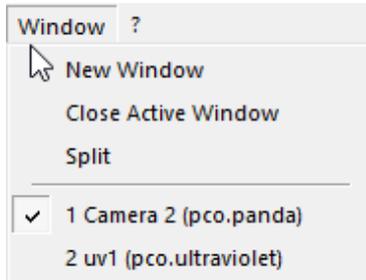
Shows position of mouse cursor.

B/W (black/white camera) x-axis: 456; y-axis: 1; Value: 16383 counts

## Reset Layout to Default

This resets all your customized changes and restores the default layout.

## 6.9.6 WINDOW MENU



### New Window

A new view window appears.

### Close Active Window

Active window closes.

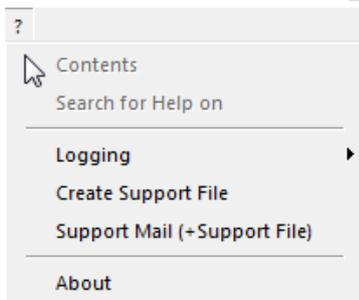
### Split

The view window is split in four quadrants.

### Camera Overview

Shows all connected cameras, e.g. **1 Camera 2 (pco.panda)**

## 6.9.7 HELP MENU



### Contents (not available)

### Search for Help on (not available)

### Logging

#### Enable Logging:

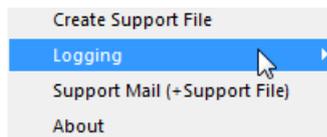
Activates Camware log files (this cuts down performance)

**Clear Logfiles** (only visible if logging is enabled): Erases all actual log files

#### Explore Logfiles:

Opens windows explorer. Log files are formatted as e.g. SC2\_Cam.log

**Disable Logging** (only visible if logging is enabled): disables logging



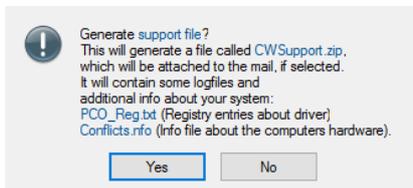
Enable Logging

Clear Logfiles

Explore Logfiles

Disable Logging

Camware 4



### Create Support File

This activates Camware log files. Click **Yes** to activate log files. Reboot Camware and your pco.flim.

After log files are activated it is possible to create a support file. Send this file to the PCO support (see **A5.4**).



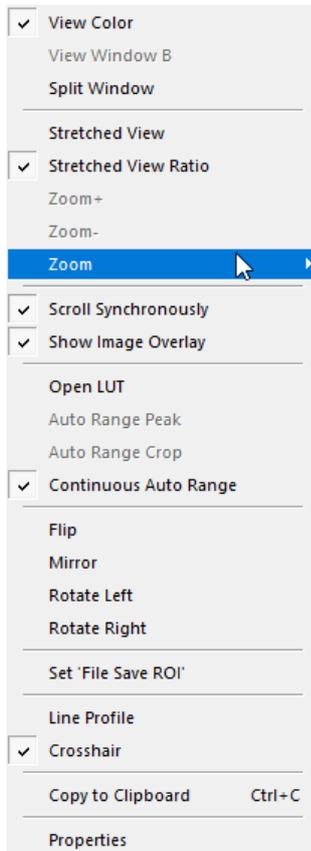
### Support Mail

Opens your email-program and the created support file is added automatically as attachment.

### About

Shows program version information.

## 6.9.8 VIEW WINDOW MENU



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

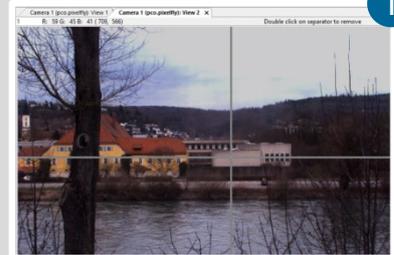
### View Color

Color window.

### View Window B (not available)

### Split Window 1

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



### Stretched View

Image is fitted into the **View Window**.

### Stretched View Ratio

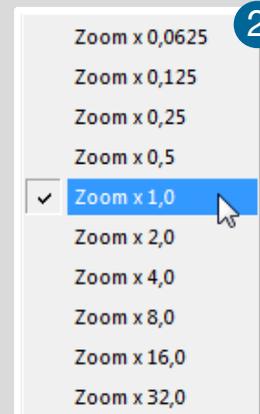
Aspect ratio is maintained.

### Zoom +/- 2

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 (only available if **Stretched View** is deactivated on all images).

### Show Image Overlay

Activates the overlay see [6.4](#)

### Open LUT

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

### Auto Range Peak

Searches for the minimum and maximum 14 bit intensity values of the image. Given these numbers 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

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

### Flip / Mirror

Image is flipped or mirrored.

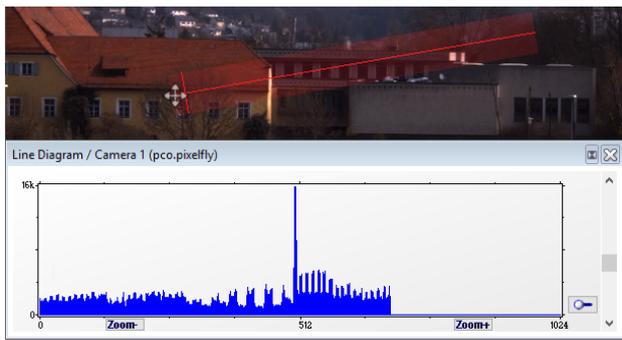
### Rotate Left / Right

Rotates the image in steps of 90°.



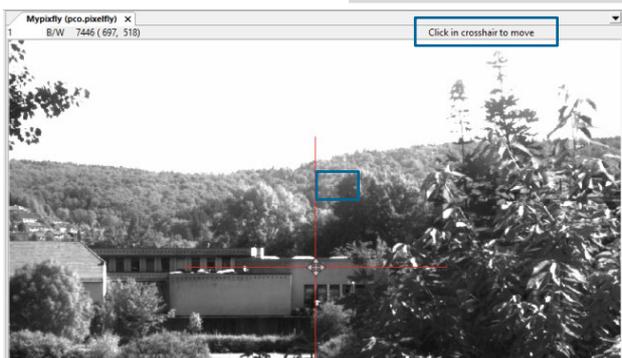
### Set 'File Save ROI'

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

Point the mouse where the line should start and left-click. 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 6.9.2 → **Options**. To move the crosshairs drag it by mouse. Reset it to center position by double-click into center of the crosshairs.

View Mode	
View Color	no
View Mode	Stretched View ...
Zoom	0.5

Common View Mode	
Flip	no
Mirror	no
Rotation	no
Scroll Synchron...	yes
Show Image...	no

Image Conversion	
Convert Min	183
Convert Max	220

### Copy to Clipboard

Copies the actual image to clipboard.

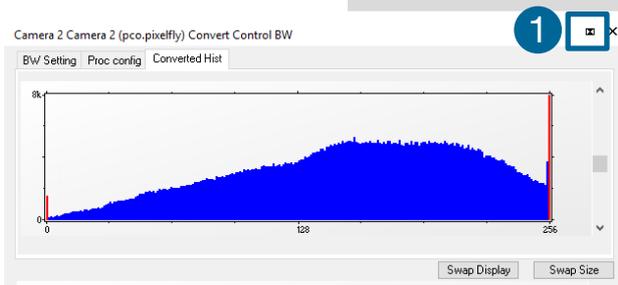
### Properties

Displays the current settings for **View Mode / Common View Mode** and **Image Conversion**.

## 6.9.9 ADDITIONAL FEATURES

### White Balance by Mouse

Change white balance by mouse: You only have to press the CTRL (STRG) and the shift button at the same time and select 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.



1

### Fold Up Window

The Convert Control windows can be minimized / folded up **1**. Just move the pointer over the bar and the window is unfolded again **2**.

2

### Setting a new ROI by Mouse

In the same manner you can setup a new region of interest (see **6.3.5 ROI**) for the camera. Press the CTRL (STRG) button 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 is adapted to the camera capabilities automatically. You can reset the ROI to maximum by pressing the CTRL (STRG) button and the right mouse button.

### Setting Contrast Area by Mouse

You can 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 increasing the size of the selection rectangle with mouse moves. After releasing the mouse button the coordinates of the selection rectangle act as a border for calculating the minimum and maximum values.

### Short Cut List

- Start / Stop record: ENTER
- Acquire Picture (Soft Trigger mode): SPACE
- Acquire Sequence: STRG + A
- Auto Save: ALT + D
- Export File: STRG + T
- Export Recorder Sequence: STRG + O
- Open Raw Image File: STRG + I
- Open Raw Recorder Sequence: STRG + R
- Save Raw Image File: STRG + E
- Save Raw Recorder Sequence: STRG + S

# APPENDIX

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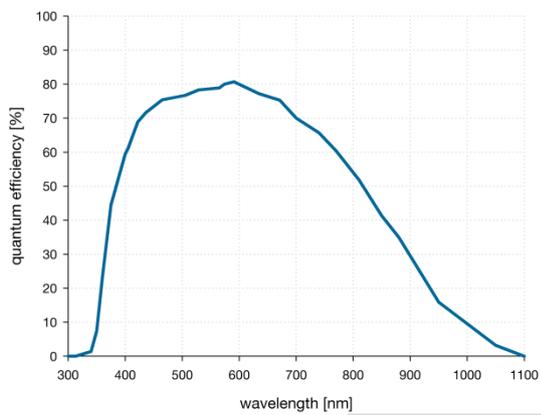
# A1 TECHNICAL DATA

## A1.1 DATA SHEET

image sensor	
type of sensor	customized sCMOS
resolution (h x v)	2048 x 2048 pixel
pixel size (h x v)	6.5 $\mu\text{m}$ x 6.5 $\mu\text{m}$
sensor format / diagonal	13.3 x 13.3 mm / 18 mm
shutter mode	Rolling Shutter
fullwell capacity (typ.)	45000 e <sup>-</sup>
readout noise (typ.)	2.1 e <sup>-</sup> med / 2.3 e <sup>-</sup> rms
dynamic range	87 dB
quantum efficiency	up to 80%
spectral range	370 nm ... 1100 nm
dark current (typ.)	15 e <sup>-</sup> /pixel/s @ 21 °C
DSNU	0.5 e <sup>-</sup> rms @ 21 °C
PRNU	0,60 %
camera	
frame rate	40 fps @ full resolution
exposure / shutter time	10 $\mu\text{s}$ ... 5 s
dynamic range A/D	16 bit
A/D conversion factor	0.65 e <sup>-</sup> /count
region of interest	64x16 minimum ROI
binning (h x v)	1x1 ... 4x4
non linearity	< 0.6 %
colling method	passive cooling
trigger input signals	frame trigger, acquire (SMA connectors)
trigger output signals	exposure, busy (SMA connectors)
data interface	USB 3.1 Gen1
timestamp	in image (1 $\mu\text{s}$ resolution)
general	
power delivery	via USB Type-C
power consumption	< 4.5 W
weight	420 g
operating temperature	+10°C ... +40°C
operating humidity range	10% ... 90% (non-condensing)
storing temperature range	-10°C ... +60°C
optical interface	C-mount, F-mount (optional)
CE / FCC certified	yes

Subject to change, refer to current data sheet available on our website.

## A1.2 QUANTUM EFFICIENCY CURVE

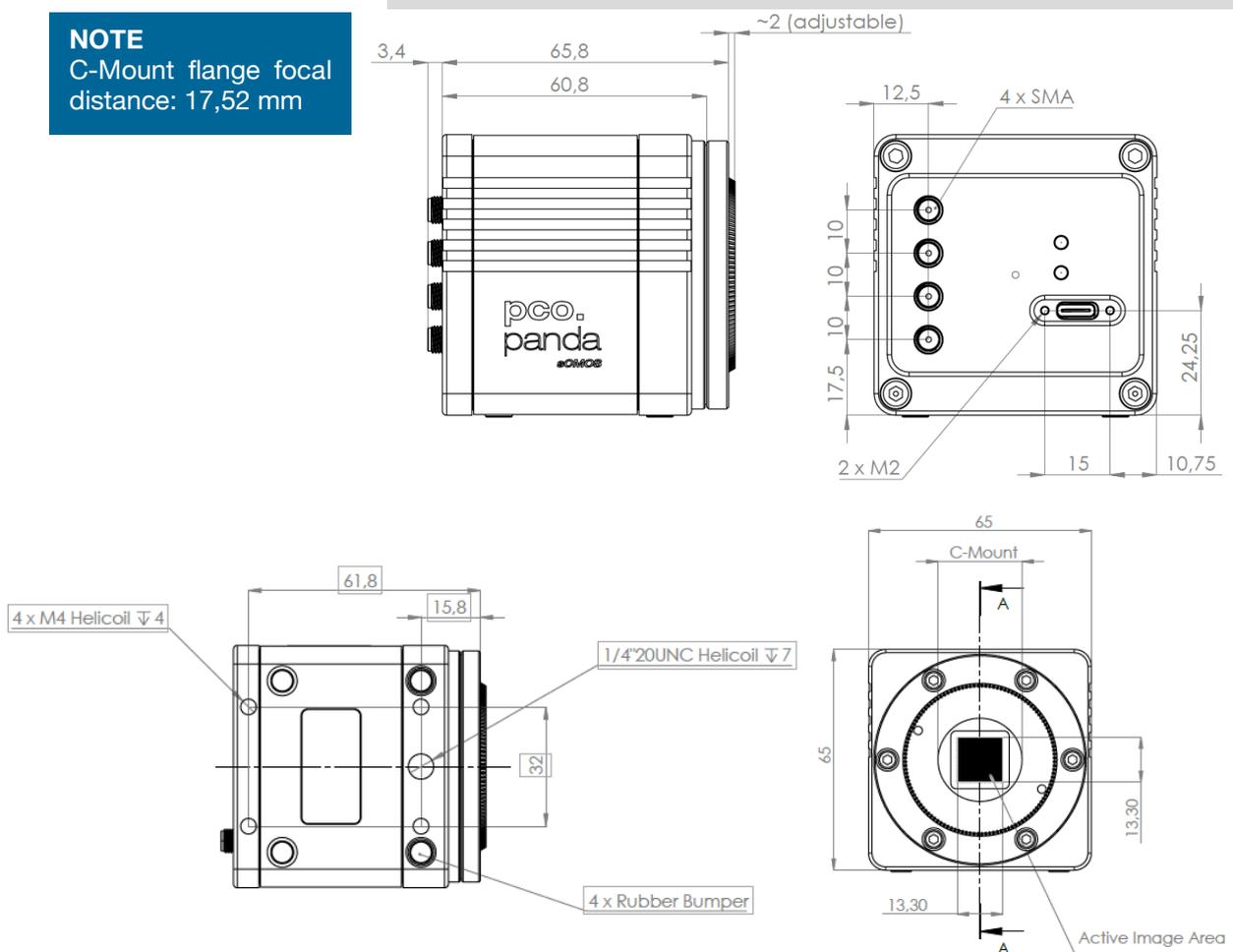


Quantum efficiency curve for the pco.panda 4.2.

## A1.3 MECHANICAL DIMENSIONS

### NOTE

C-Mount flange focal distance: 17,52 mm



All dimensions given in millimeter.

## A1.4 REAR PANEL

**Status LEDs 1**

(LED1: green / red; LED 2: orange)

Color		Description
Red / green continuous		Camera is booting
Green		Camera is ready for operation
Orange continuous		Arm camera / rec state off
Orange blinking		Recording on
Red continuous		Error

**Interface Connector 2**

USB 3.1 plug Type-C screwable;  
Power delivery for the camera over USB cable

**SMA Inputs 3**

(see chapter 6.3.7)

Input (1=Exposure Trigger; 2=Acquire Enable)	
Type	Digital
Level	3.3 V LVTTTL (5 V tolerant)
Coupling	DC
Impedance	1 k $\Omega$
Slew rate	> 1 V/ms

**SMA Outputs 4**

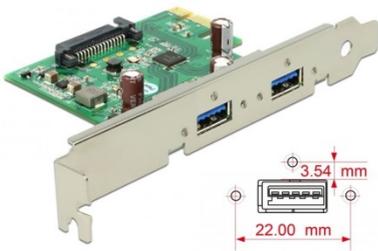
(see chapter 6.3.7)

Output (3=Status Busy; 4=Status Expos)	
Type	Digital
Level	3.3 V LVTTTL
Coupling	DC
Load current	Max. 100 mA

# A2 HARDWARE MOUNTING

Instructions how to mount the pco.panda camera system.

## A2.1 USB CARD INSTALLATION



**WARNING**

### NOTE

In multi-camera operation, each pco.panda camera needs its own USB 3.0 card.

An external USB 3.0 host controller card comes along with to each pco.panda camera.

### Hardware Installation

First shut down your computer and install the USB 3.0 Host Controller. Hardware Installation must be performed by a technician, because high voltages can occur on the device.

### ELECTRIC SHOCK WARNING DUE TO VOLTAGE PARTS INSIDE

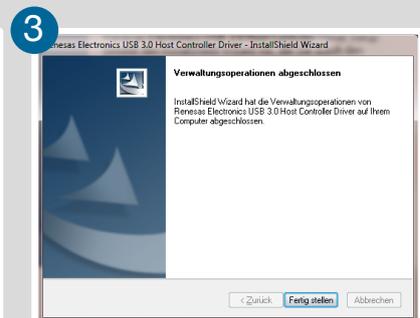
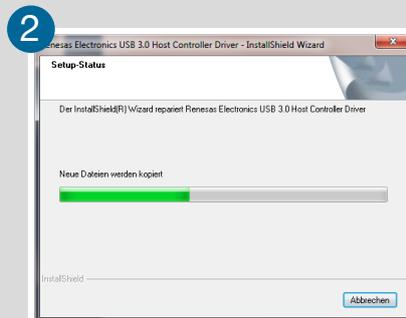
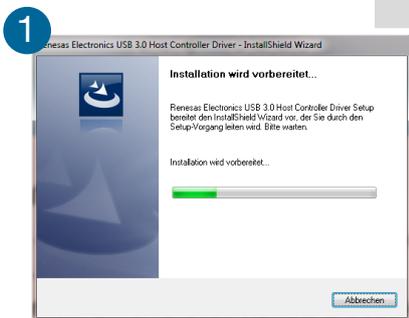
Risk of injury due to electrical shock.

→ Always pull the main plug before opening the computer.

### Driver Installation Instructions

- Within the provided installation files USB\_HBA, open the folder U3X4-PCIE4XE101, U3X4-PCIE1XE101, U3-PCIE1XG202.
- Open the subfolder Driver and run RENESAS-USB3-Host-Driver-30230-setup.exe.
- If your current OS is Win7/8 and the User Account Control is enabled, a dialog prompts whether you wish to start the setup: accept with Yes.

- 1 At first the installation is prepared.
- 2 Secondly the software components are copied automatically.
- 3 Finally the installation is completed and the Delock USB 3.0 extension card can be used.



## A2.2 MOUNTING OF THE PCO.PANDA



In order to ensure a proper function of the pco.panda, it is necessary to secure the USB cable by the fixing screws.

The accompanying USB cable is screwable on both ends of the cable.

### Screw Connection to the Camera (recommended)

- The screw threads of the camera are very sensitive due to the small size.
- Plug the USB cable into the camera.
- Then attach the fittings to the threads by hand.
- Use a small screwdriver to gently tighten the fittings.

### Screw Connection to the Computer (optional)

- Attach the cable to the USB card in the same way.

## A3 F-MOUNT ADAPTER (OPTIONAL)

### A3.1 PCO F-MOUNT ADAPTER



PCO's proprietary F-mount adapter for lenses with automatic diaphragm. Sets manually the lens aperture by turning the ring on the adapter.

F-mount lenses without automatic diaphragm can be fastened to the camera's mount but the aperture not changed.



#### Adjust Back Focal Length

To adjust the back focal length (e.g. you cannot focus to infinity or to the minimum object distance of your lens), proceed as follows:

Set the focus of your lens to infinity. Look at an object in infinity and generate a sharp image by turning the adapter. Use the rearmost ring to fix the setting.

#### Matching Lenses with Automatic Diaphragm

Nikon: all Nikkor lenses of type D and type G (not for type E, this one is only electronic).

Zeiss: all ZEISS ZF.2 lenses (Otus, Milvus, Interlock, Distagon, Planar).

Sigma: only lenses, which already have a manual diaphragm ring; all other lenses have an aperture control lever, which does not spring back, if you turn the aperture ring at the adapter.

Tamron: only some lenses provide automatic diaphragm (no particular lens family):

#### Type 35mm F-Mount

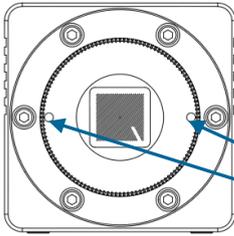
- A012: SP 15-30mm F/2.8 Di VC USD
- A007: SP 24-70mm F/2.8 Di VC USD
- A009: SP 70-200mm F/2.8 Di VC USD
- A011: SP 150-600mm F/5-6.3 Di VC USD
- F012: SP 35mm F/1.8 Di VC USD
- F013: SP 45mm F/1.8 Di VC USD
- F017: SP 90mm F/2.8 Di MACRO 1:1 VC USD

#### Type APS-C(H) F-Mount

- B001: SP AF 10-24mm F/3.5-4.5 Di II LD Aspherical [IF]
- B005: SP AF 17-50mm F/2.8 XR Di II VC LD Aspherical [IF]
- G005: SP AF 60mm F/2.0 Di II LD [IF] Macro 1:1

## A3.2 CHANGE FROM C-MOUNT TO F-MOUNT

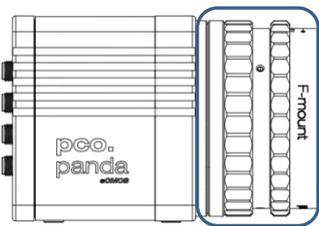
Instructions on how to change the optical input from C-mount to optional F-mount:



### Step 1: Remove C-mount Adapter

Loosen the hexagon socket screws and unscrew the C-mount adapter counterclockwise.

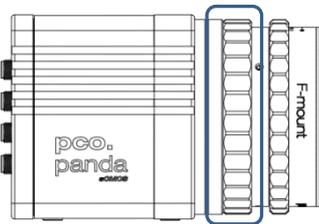
hexagon socket screws



### Step 2: Insert F-mount Adapter

Screw the F-mount adapter ring in gently, but not completely, because back focal length still has to be adjusted.

F-mount adapter



### Step 3: Adjust Back Focal Length

First of all, attach a lens to your F-mount adapter. Then set the focus of your lens to infinity. After that, look for an object in infinity\* and generate a sharp image by turning the adapter. Then fix this position by turning the black ring clockwise. Finally, check again if the sharpness is perfect.

\*rule of thumb: object should be away about 2000 times the focal length in mm

### Limitations of C-mount Lenses

Keep in mind that C-mount lenses could cause shadings at the edges of big sized sensors. Most C-mount lenses are able to illuminate a maximum image circle of 11 mm (2/3"), 16 mm (1") or 22 mm (4/3") diameter only. The pco.panda has a sensor diagonal of 18 mm, it follows that you have to use the ROI function for a shade less image while using the C-mount adapter with the two smaller C-mount diameters.

## A4 IMAGE FILE FORMATS

There are different file formats available for saving camera images with Camware.

### b16

The b16 16 bit 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 of an Extended Header (32 Long-parameter), the latter of which is optional for additional information. It may 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.

	Parameter	Function
1	PCO-	The first 4 byte are the characters PCO-
2	File size	File size in byte
3	Header length	Header size + comment field in byte
4	Image width	Image width in pixel
5	Image height	Image height in pixel
6	Extended header	-1 (true), extended header follows
7	Color mode	0 = black/with camera, 1 = color camera
8	B/w min	Black/white LUT-setting, minimum value
9	B/w max	Black/white LUT-setting, maximum value
10	B/w linlog	Black/white LUT-setting, 0 = linear, 1 = logarithmic
11	Red min	Red LUT-setting, minimum value
12	Red max	Red LUT-setting, maximum value
13	Green min	Green LUT-setting, minimum value
14	Green max	Green LUT-setting, maximum value
15	Blue min	Blue LUT-setting, minimum value
16	Blue max	Blue LUT-setting, maximum value
17	Color linlog	Color LUT-setting, 0 = linear, 1 = logarithmic
18 ... 266	Internal use	

Comment file in ASCII characters with variable length of 0..XX.  
The length of the comment field must be documented in the header length field.

	16 bit pixel data	
Line 1, pixel 1	value of the first pixel	
Line 1, pixel 2	value of the second pixel	
...	...	

PCO recommends that all images should be saved first in the b16 or TIFF format. 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 is 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 necessary.

## Standard File Formats

### TIFF

Tag Image File Format, version 6.0 and lower. There is a 16bit monochrome and color image format.

### 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. It is a 16 bit image format defined by NASA / Science Office of Standards and Technology (NOST). Some programs use the FIT extension for this format.

### ASCII

16 bit format, some mathematical programs prefer 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.

## A5 CUSTOMER SERVICE

### A5.1 SERVICE

The camera is designed to operate with no need of special adjustments or periodic inspections.

### A5.2 MAINTENANCE



#### CAUTION

#### UNPLUG CAMERA BEFORE CLEANING

Risk of injury due to electric shock!

- Unplug the camera from any power supply before cleaning it.

#### NOTICE

#### CLEANING

- Use a soft, dry cloth for cleaning the camera.
- Do not clean the input window unless it is absolutely necessary (clean it with pressurized air).
- Be careful and avoid scratches and damage to the input window surface.
- Do not use liquid cleaners or sprays.

#### NOTICE

#### LENS CLEANING

- The lens is best cleaned with pressurized air or with liquid cleaners such as pure alcohol or with special optical cleaners that are available at high quality photo stores.
- Use a cotton swab dipped in pure alcohol or optical cleaning liquid and wipe only on the glass surface.
- Do not get any cleaning liquid on the metallic parts such as the lens thread, because tiny detached particles may scratch the surface.

#### NOTICE

#### CLEANING LIQUIDS

Aggressive cleaning liquids can damage your camera.

- Never use aggressive cleaning liquids such as gasoline, acetone, spirits or nitro cleanser.
- Every time the input window is cleaned, there is the possibility of surface damage.

#### NOTICE

#### PROTECTIVE CAP

Always store the camera with the protective cap or with a lens mounted to avoid dust and dirt on the input window.

### A5.3 RECYCLING



If you want to dispose your camera, send it to PCO or take it to a local recycling center.

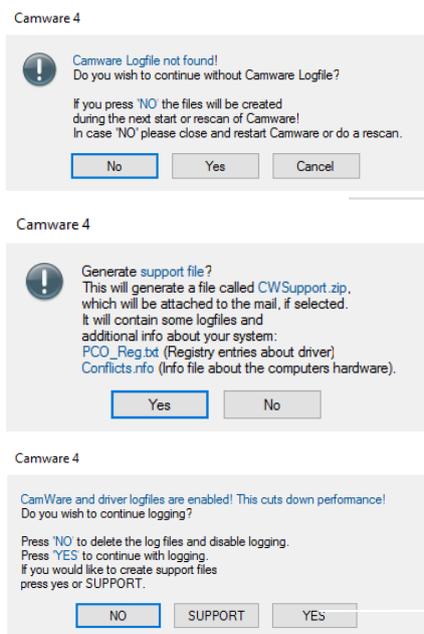
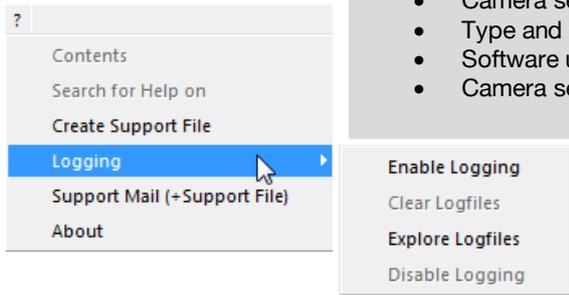
The camera includes electronic devices, which can contain materials harmful to the environment. These electronic devices must be recycled.

## A5.4 TROUBLE SHOOTING

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

### To Speed up Your Request

- Short description of the problem
- Description of your application
- Camera settings
- Type and version of camera
- Software used
- Camera serial number
- Operating system (PC)
- Processor type (PC)
- Memory
- Graphic card
- Graphic card setup



### How to Create Logfiles

Steps	Explanation
Enable <b>Logfiles</b>	Open <b>? Help</b> menu → Logging → Enable log file → Camware asks you to press <b>NO</b> to activate <b>Logfiles</b> after restart of Camware
Repeat	The workflow which produces the faults
Open <b>? Help</b> menu	Click Support Mail (+ Support File) → Camware asks you: <b>Generate support file?</b>
Save this file	(CWSupport.zip – don't rename it) and send it to PCO Support (support@pco.de)
Or visit website:	<a href="http://www.pco.de/support/">http://www.pco.de/support/</a> and upload the support file with our support form

### Repair

Before sending the camera for repair, first contact your local dealer or PCO respectively.

When shipping the camera for repair, be certain to carefully pack the camera with proper shipping materials. If possible use the original packaging. Use the protection cap to protect the camera on the lens thread.

### Firmware, Software and Driver Update

You find all necessary software and drivers on the accompanying USB flash drive.

For the latest versions check our [Website](#).

## A6 INDEX

**NOTE:**

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

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## ABOUT PCO



pcoco.

### ***pcoco.history***

“PCO” stands for what we are: a Pioneer in Cameras and Optoelectronics. With 30 years of expert knowledge and experience PCO has forged ahead to becoming a leading specialist and innovator in digital imaging used in scientific and industrial applications such as life and physical science, high-speed imaging and machine vision. However, the beginning of PCO’s story of success dates back to the 1980s and a research project of the founder, Dr. Emil Ott, who was working at the Technical University Munich for the Chair of Technical Electrophysics. While performing measurements with intensified slow scan cameras, Dr. Ott realized that the existing standard did not meet the sophisticated requirements of scientific applications – and so PCO came to life in 1987. With a small team of engineers Dr. Ott began to develop his first image intensified camera followed by several variations on the original model, geared to overcoming all the existing flaws and surpassing standards of the day. During these early years PCO developed a now well established core of advance technologies used as the foundation to develop cutting edge products.

In the early 1990s PCO expanded its business activities to the global market by successfully establishing an international network of highly trained sales partners and customers. We entered additional fields beyond traditional scientific research expanding the potential for our cameras’ applications in life science, automotive testing and even broadcasting. This step paved the way for a wide range of innovative highlights:

As of 2017, PCO has three decades of technical know-how and expert knowledge in the development and manufacturing of high-performing camera systems. In-house competence of all significant technical disciplines and partnering with leading image sensors manufactures ensures cutting edge sCMOS, CMOS and CCD technology for all PCO cameras.

### ***pcoco.prospect***

“If you want to do something special, particularly in the high end fields, you have to develop your own image sensors. So we work with partner companies who develop tailored sensors made especially for us. This is something we are doing continuously, so we’re already working on the next generation of cameras that we will introduce in the coming years” – Dr. Emil Ott.

In PCO’s first 30 years, Dr. Emil Ott took a company that he started right after finishing university and has built it into a major player in scientific and industrial cameras – and there’s plenty more to come.

**pcó.**