user manual

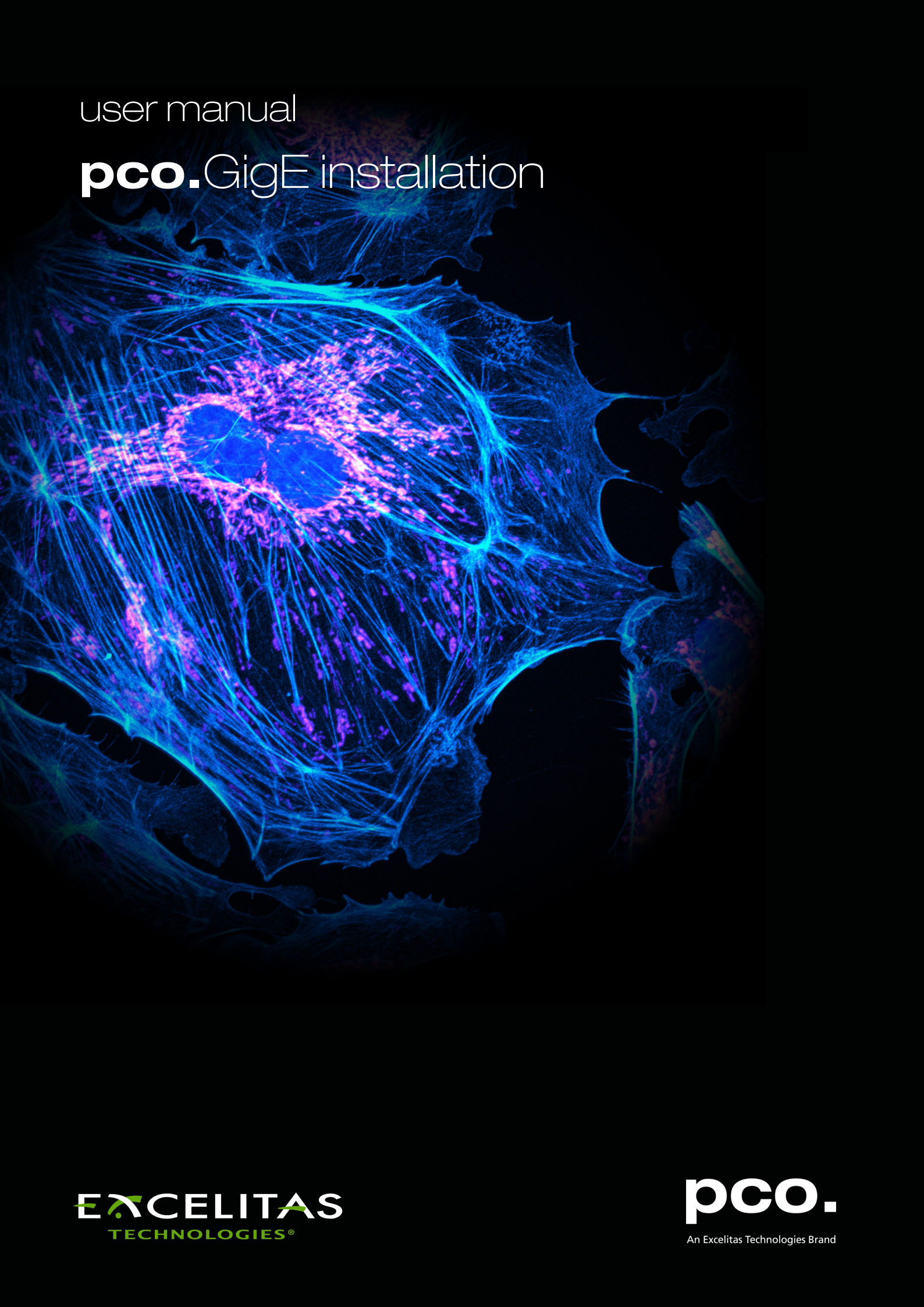# **pco.**GigE installation

Excelitas PCO GmbH asks you to carefully read and follow the instructions in this document.
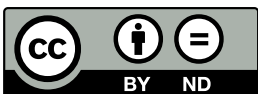**For any questions or comments, please feel free to contact us at any time.**

pco.

An Excelitas Technologies Brand

telephone:	+49 (0) 9441 2005 50
fax:	+49 (0) 9441 2005 20
postal address:	Excelitas PCO GmbH Donaupark 11 93309 Kelheim, Germany
email:	pco@excelitas.com
web:	www.pco.de

pco.GigE installation user manual 5.1.0

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Contents

1 Introduction

This manual describes the installation and configuration of a PCO camera with GigE interface.

For a better distinction:
The ***Gigabit Ethernet network technology*** in this manual is referred to as ***GbE***, however the Gigabit Ethernet camera interface is abbreviated as GigE in order to conform with technical nomenclature.

Gigabit Ethernet is not just the most commonly used network standard. Since 2006 GigE is an interface standard for high-performance scientific and industrial cameras. A group of more than 50 companies developed this standard. The GigE interface standard is based on the Gigabit Ethernet standard which uses standard Ethernet category cabling. The standard is trying to unify protocols currently used in machine vision industrial cameras and let 3rd party organizations develop compatible software and hardware (www.machinevisiononline.org).

System requirements:

- PCO camera with GigE interface
- pco.sdk greater 1.29.x.x includes latest GigE driver
- pco.gige_calib v5.x.x.x
- Uninstall GigE Driver v4.x.x.x
- Recommended Hardware see **2.2.2**
- Network patch cables and max. length see **2.2.3**
- Check PCO Website for latest versions
- Camware software package greater 4.14

1.1 What to use?

Which network standard should I use? 100BASE-T / GbE / 10GbE

It is possible to use 100BASE-T 100 Mbit/s network cards for a GigE connection (but only with PCO Gen2 driver and the max. data transfer rate is just 12 MB/s, that means data transfer is very slow), but recommended are Gigabit Ethernet network cards that provide the necessary transfer rates for PCO cameras. Such cards should be designated with a maximum data transfer rate of 1000 Megabits per second (120 MB/s).

10GBe: High performance 10 Gigabit Ethernet network interface cards with data transfer rates of up to 1200 MB/s work with PCO cameras. See chapter **1.2**.

1.2 Gigabit Ethernet

This network standard will enable you to connect multiple cameras using a 10GbE switch without causing transmission bottlenecks as known from GbE network technology.

These 10GbE components should be recommended, if you:

- use more than one camera connected to one PC via a switch and
- the PCO cameras' maximum data throughput of the GigE interface should be available and
- more than 4 PCO GigE camera should transfer their images in parallel (not synced) to a PC using a 10GbE switch
- Recommended hardware see chapter **2.2.2**

1.3 Some helpful explanations

Term	Explanation
NIC	Network Interface Card
UDP	User Datagram Protocol
Image Packet	UDP packets transmitting image content
Packet Delay	Delay between two image packets
Lost Packet	Image packet that got lost during transfer from camera to computer
DHCP-Server	The Dynamic Host Configuration Protocol (DHCP)-Server is used by networked devices (clients) to obtain the parameters necessary for operation in a network
Persistent IP	IP address used, if no DHCP server is available
OS	Operating System e.g. Windows 10
Camware	PCO's camera control software
100BASE-T	Network data transfer rate theoretical up to 12 MB/s
Gigabit Ethernet (GbE)	...up to 120 MB/s
10 Gigabit Ethernet (10GbE)	...up to 1200 MB/s

2 PCO GigE installation

This chapter explains all details of the PCO GigE installation.

2.1 Installation order

Please follow the steps in this order. Additional information can be found in the respective subchapters.

Steps	Description
First step **NIC**	**Install network interface card (NIC).** See chapter **2.2**
Second step **IP Address**	**Configure the IP address of your NIC.** See chapter **2.2.1**
Third step **Calib Tool**	**Install and apply pco.gige_calib for camera calibration.** See chapter **2.4**
Fourth step **Test**	**Test your calibration.** See chapter **2.4.3**
Fifth step **Install driver & Run**	**Install Camware or pco.sdk with GigE Driver.** Install and run Camware/pco.sdk. See chapter **2.5**

2.2 Network interface card

Your computer must have a network interface card (NIC) to connect the camera via GigE. This can be an onboard NIC (mainboard) or a plug-in card.

PCIe
Ideally it is a PCI Express NIC to bring out the best data transfer rates.
The PCI Express interface allows a faster and more stable data transfer rates than ordinary PCI interfaces. Finally, NIC's vary in the used chipset. Recommended are chipsets from Intel.

Driver
Please make sure that the **specific driver** of the NIC is installed to your Operating System (OS) - If not, your OS may use a standard plug & play driver not performing perfectly with the hardware.

Configuration
If you want to check your network connection or change parameters please open the ***properties dialog*** of your LAN connection. See chapter **2.2.1**.

Mainboard Slot for NIC
If you install a NIC in a ***PCIe*** slot of your computer, please check the data transfer rates of the preferred slot. Some mainboards do not provide the required data transfer rates on all ***PCIe*** slots. See chapter **2.4.2**.

2.2.1 IP address configuration

How to configure an IP address manually:

Exemplary for Windows 10.

1. Start -> Control Panel -> Network and Sharing Center

2. Select your GigE network connection

3. Properties

4. Internet protocol version 4 (TCP/IPv4)

5. Properties

6. Use the following IP address

Only use internet protocol **version 4** (TCP/IPv4), TCP/IPv6 is not supported by PCO cameras.

Recommended: configure your IP address **manually**.

7. The use of **Dynamic Host Configuration Protocol (DHCP)** is not recommended. DHCP is active if **obtain an IP address automatically is selected**.
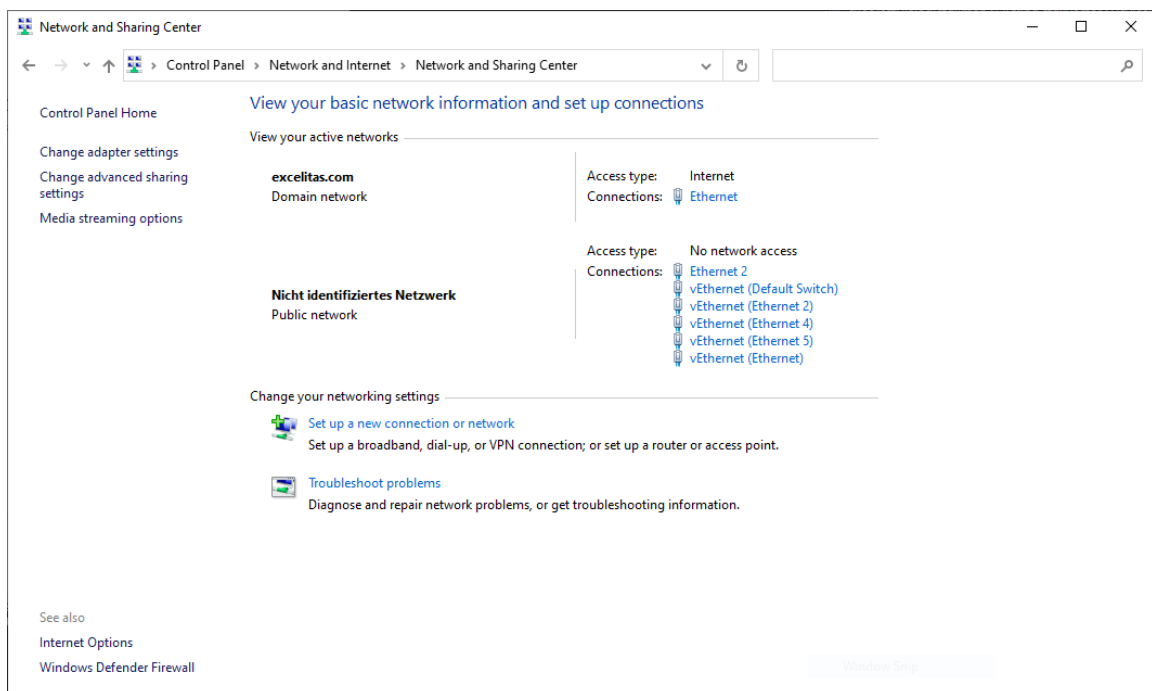

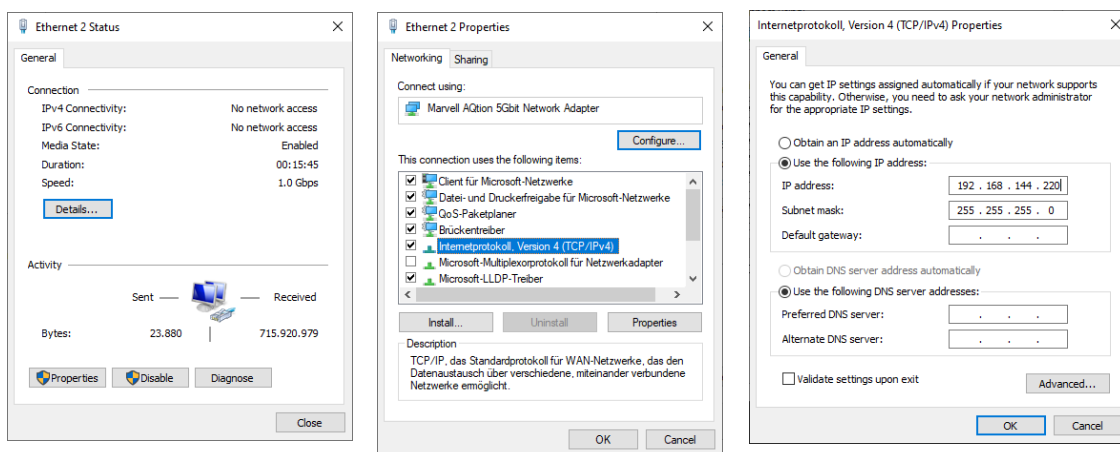*Figure 2.1: view your basic network information.*

Figure 2.2: view your basic network information.

2.2.2 Recommended hardware

The following hardware components are tested by PCO. The use guarantees stable data transfer rates.

Hardware	GbE	10GbE
NIC	Intel Ethernet Server Adapter I210 T1	Intel Ethernet Converged Network Adapter X550-T2
NIC	Intel Ethernet Server Adapter I350 T2 (2 port)	
NIC	Intel Ethernet Server Adapter I350 T4 (4 port)	
Switch	Standard 1 Gbit switch	Netgear ProSAFE XS716T

2.2.3 Network environment/patch cable

A correct configuration of the network is important for the transfer rates of the image data which could be achieved. It is mandatory that *any component* used for the network connection between camera and computer is compatible with a data transfer rate of 1000 MBit/s for Gigabit Ethernet or 10 Gigabit/s for 10 Gigabit Ethernet.

Some of these components are the NIC, router, hub, switch, etc., but also the patch cable.

The quality of patch cables is specified in categories. It is necessary to use *category 5e-, 6-, or 7- patch cables* for a network connection with a data transfer rate of *GbE*, for *10GbE* network only *Twisted Pair Cat 7e*.

	GbE	10GbE
Network cable	Cat 5e, 6, 7	TP Cat 7e
Max. cable length	100m	100m

2.2.4 Cable length

Available cable lengths:

	length
standard	10 m
optional	0.5 m; 2 m; 5 m; 12.5 m; 30 m; 50 m
maximum	100 m
included	10 m cable is included in the camera system

2.3 Single/Multiple camera operation

2.3.1 Single camera

Single camera operation means camera and computer are connected via *Point to Point* connection, i.e. direct connection via LAN cable between the GigE connector of the camera and the network interface card of your computer.

- Connect *NIC* and *camera* via *patch cable* directly
- Configure the IP address and Subnet mask of your NIC, see **2.2.1**

Configuration example:

Network Interface Card
IP: 192.168.144.10
Sub. mask: 255.255.255.0

Camera
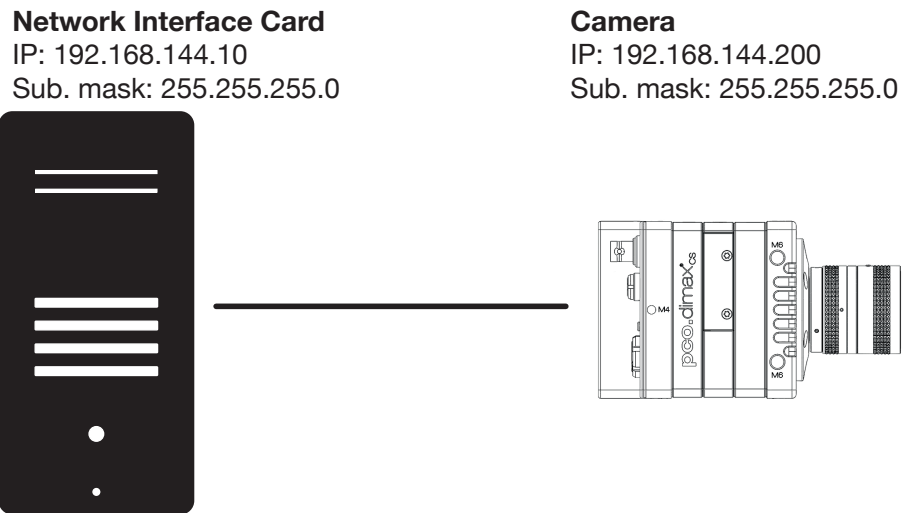IP: 192.168.144.200
Sub. mask: 255.255.255.0

Figure 2.3: single camera operation.

Calibration Tool:

Use the **Calibration Tool** to configure these settings, see chapter **2.4** (e.g. configuration of a pco.dimax camera connected to a NIC).
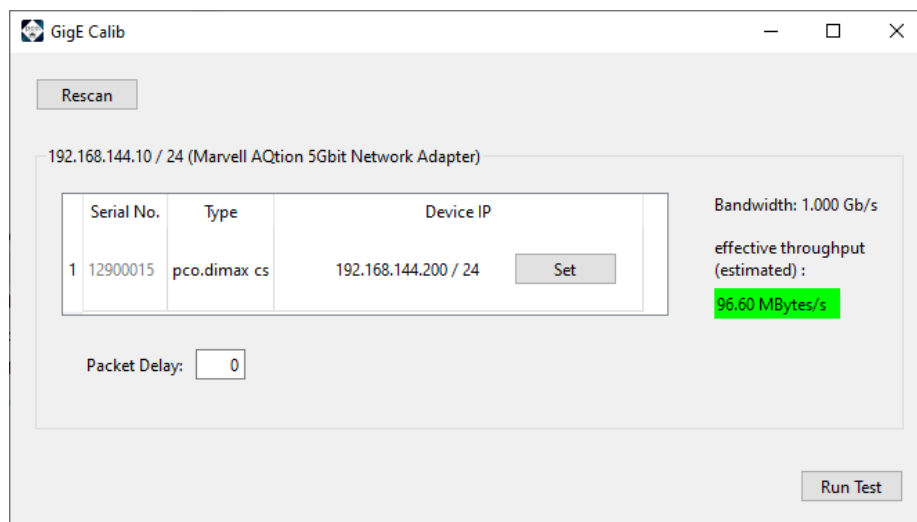

Figure 2.4: camera network settings.

2.3.2 Multiple cameras

There are two basic ways to connect **multiple cameras** to a computer: with a **switch** or with one network interface **port per camera**.

2.3.2.1 Switch

The network settings using a switch can be configured manually or with a DHCP server.

Note: Using a switch can cause network ***performance problems***: if the connected cameras require more bandwidth than can be provided by the switch and the associated network card. See also Network and Packet Delay **2.4.2**.

- Camera and NIC IP addresses have to be set manually.

- The subnet of camera and NIC must be identical, that means the first three sections of camera and NIC IP address must be identical (see configuration example).

- The next section of each camera and NIC IP can be any value between 1 and 254, but may not be the same for both devices.

- For example: NIC IP 192.168.144.10; a proper camera IP would be 192.168.144.100. The Subnet mask must be exactly the same, e.g 255.255.255.0.
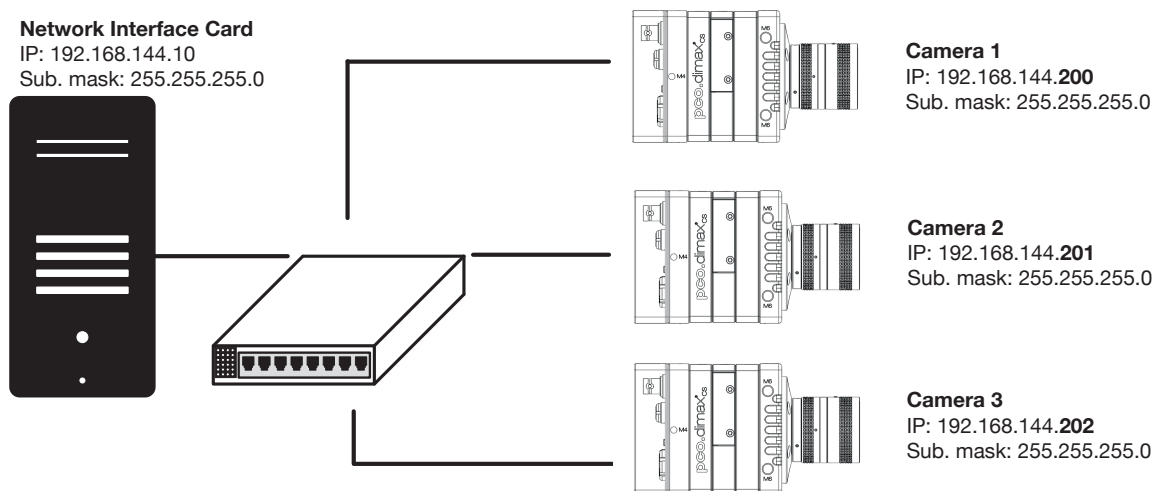
Configuration example:

Network Interface Card
IP: 192.168.144.10
Sub. mask: 255.255.255.0

Camera 1
IP: 192.168.144.**200**
Sub. mask: 255.255.255.0

Camera 2
IP: 192.168.144.**201**
Sub. mask: 255.255.255.0

Camera 3
IP: 192.168.144.**202**
Sub. mask: 255.255.255.0

Figure 2.5: multiple camera operation.

Calibration tool:

Use the ***Calibration tool*** to configure these settings, see chapter **2.4** (e.g. configuration of a switch with two pco.dimax cameras).
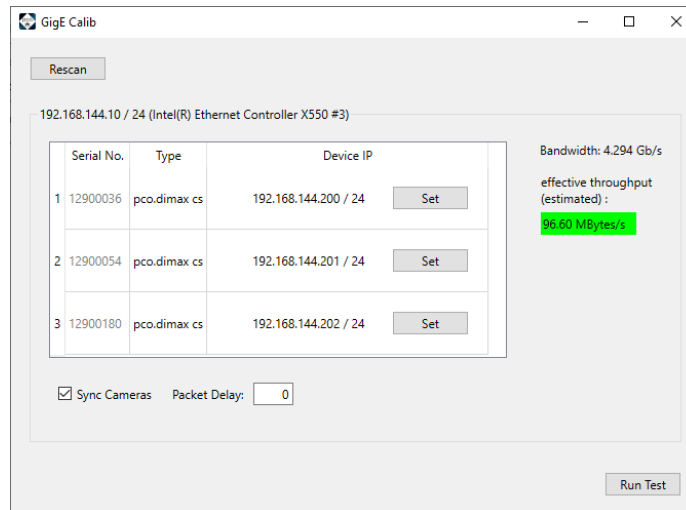
Figure 2.6: camera network settings.

2.3.2.2 Several NICs

Via several NIC's (or NIC ports) at one computer:

- Camera and NIC IP addresses have to be set ***manually***.

- Each ***camera and NIC*** pair needs its own subnet (see configuration example).

- If you use NICs with multiple ports: check the bandwidth of the PCIe slot.

The following example shows how to calibrate IP addresses when connecting cameras to individual NIC's. Most ***important*** is that ***each camera & NIC combination needs its own subnet*** and the camera IP address and subnet and NIC IP address and subnet have to match.
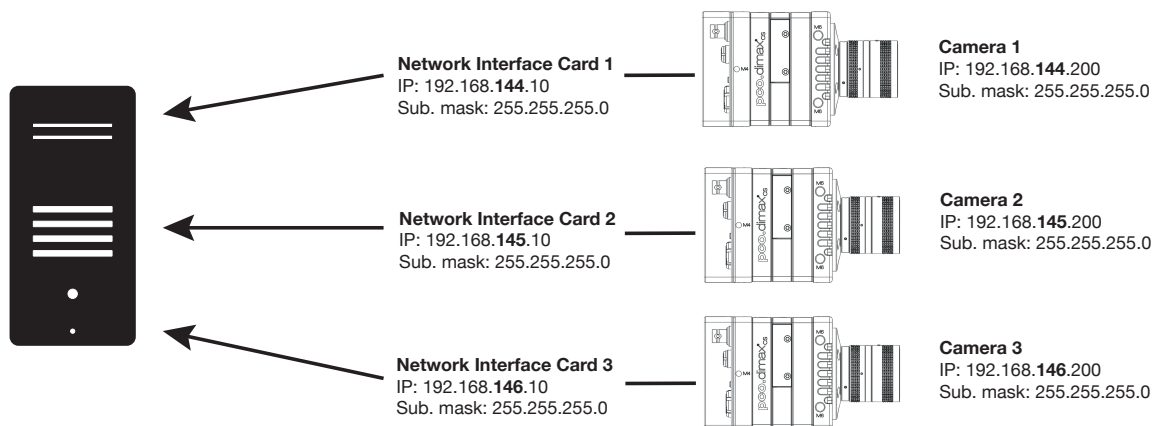
Configuration example:

Network Interface Card 1
IP: 192.168.**144**.10
Sub. mask: 255.255.255.0

Camera 1
IP: 192.168.**144**.200
Sub. mask: 255.255.255.0

Network Interface Card 2
IP: 192.168.**145**.10
Sub. mask: 255.255.255.0

Camera 2
IP: 192.168.**145**.200
Sub. mask: 255.255.255.0

Network Interface Card 3
IP: 192.168.**146**.10
Sub. mask: 255.255.255.0

Camera 3
IP: 192.168.**146**.200
Sub. mask: 255.255.255.0

Figure 2.7: several NICs.

Calibration Tool:

Use the ***Calibration Tool*** to configure these settings, see chapter **2.4** (e.g. configuration of two NIC's with two pco.dimax cameras).
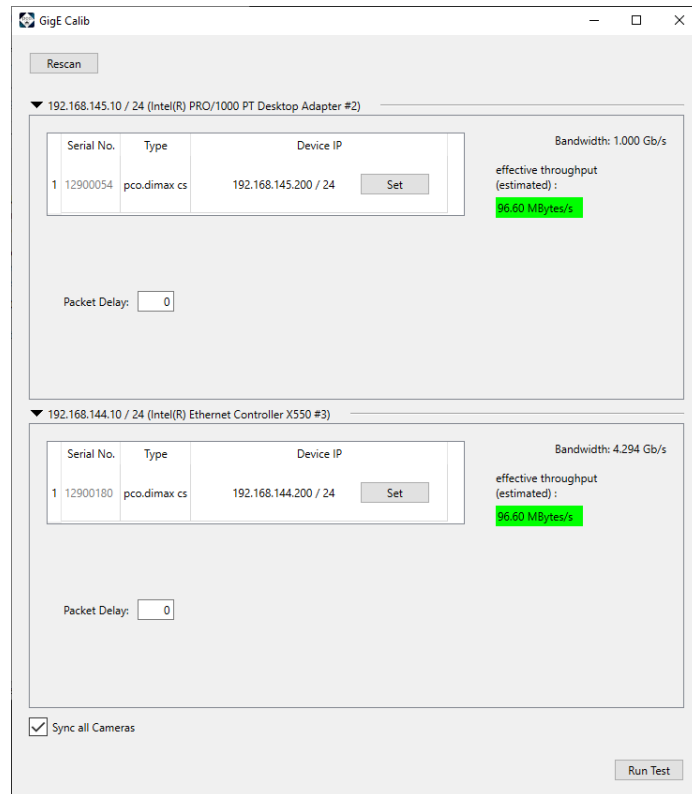
Figure 2.8: several NICs.

2.4 Calibration tool

The pco.gige_calib Tool is part of the PCO software package and is started automatically after its installation and is automatically linked to your desktop.

Win10: Start -> All Apps -> PCO Digital Camera Toolbox -> pco.gige_calib

The purpose of this software:

- To set camera network parameter (Packet Delay, and Sync image stream **2.4.2**).
- To change the network settings (IP address & subnet mask **2.4.1**) of the camera.
- Display connected PCO GigE cameras.
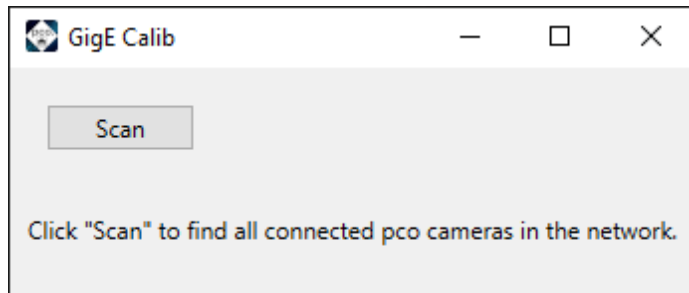- To check if the network is configured correctly.
- To test the data transfer rate.

Figure 2.9: Start scan.

How does it work?

Click **"Scan"** to find all connected pco cameras in the network.

2.4.1 Set camera IP address

Make sure that the Camera IP Address (Cam IP) and the Camera Network Mask (Cam Subnet) fit to the Network Interface Card (NIC IP & NIC Subnet) connected to. Everything is correct if all values are highlighted in **green**.

If Camera IP or Subnet is **not correct**, it will be highlighted in red (1). The first three sections of Camera and NIC IP must be identical. The fourth section between 1 and 254.

For example: NIC IP **192.168.144**.49; a proper camera IP would be **192.168.144**.100. The Subnet mask must be exactly the same, e.g **255.255.255.0**.

Set **Packet Delay**, standard is **40**. Please read **2.4.2** before you set the **Packet Delay**.

You can only change **Camera** IP & Subnet with this tool, but **not** NIC IP & Subnet (for NIC configurtation see **2.2.1**).

Please double-click onto the table to manipulate the value. Press the **Set** button to validate the changings. After configuration is finished click **Done**.

The next step is to check if IP and Subnet configuration is correct: click **Set** again to check if all values are highlighted in **green**.
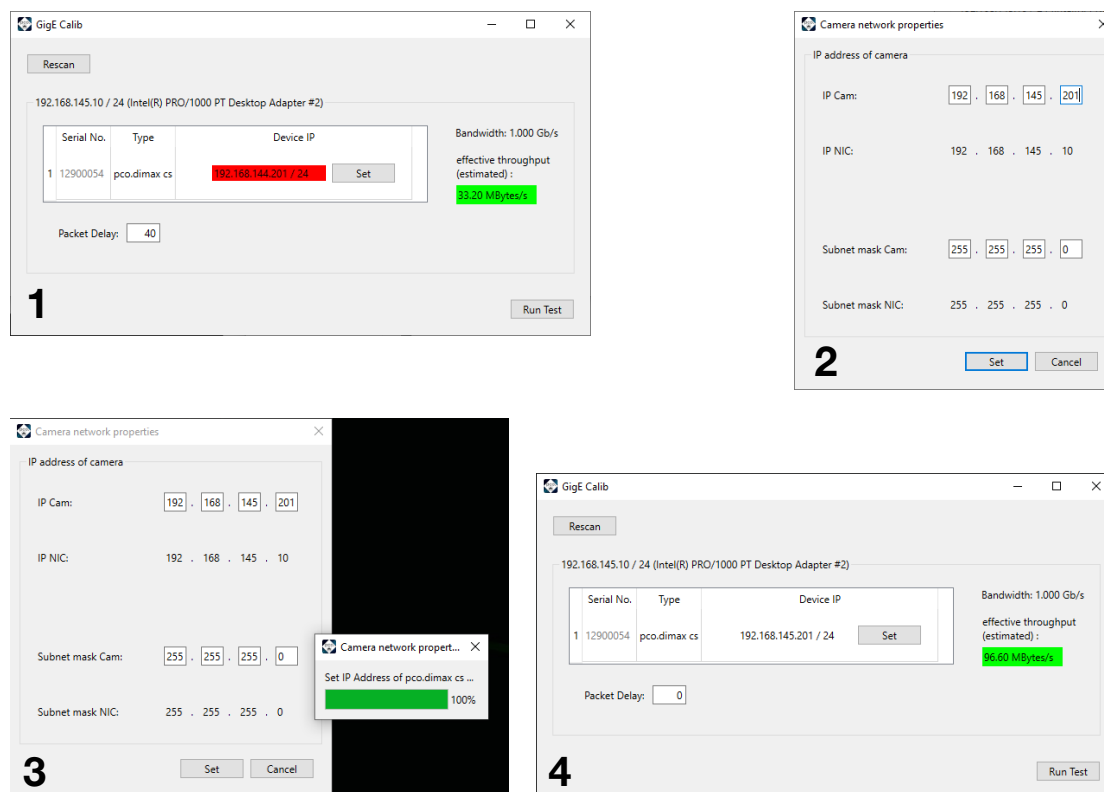
Finally always **Test** your settings. See chapter **2.4.3**.

Figure 2.10: set camera IP.

2.4.2 Driver tuning

The main dialog of **pco.gige_calib** allows to set tuning parameter for cameras to regulate the data throughput in the network. Incorrect configuration of transfer parameters may lead to image loss during streaming from camera to the PC.

If tuning parameters are set, the estimated throughput in the upper right corner is updated. According to the detected bandwidth of the network, the expected throughput is validated by its color overlay which indicates whether parallel image requests will succeed without image loss.

This estimation serves only as a hint. However, additional load on the network may lead also to image loss during streaming. The image stream should always be tested after setup and configuration. See **2.4.3**.
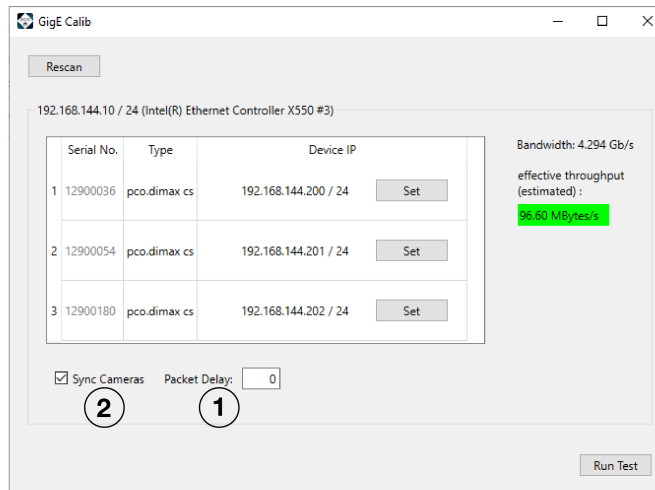
Figure 2.11: tuning transfer parameters: packet delay (1) and synchronize image stream (2).

2.4.2.1 Packet Delay

The **Packet Delay** value indicates the **delay (in μs)** inserted between each ethernet packet of the image payload data.

This can be used as a crude flow-control mechanism, if the application or the network infrastructure cannot keep up with the ethernet packets coming from the device. A packet delay **always slows down** transfer data rate.
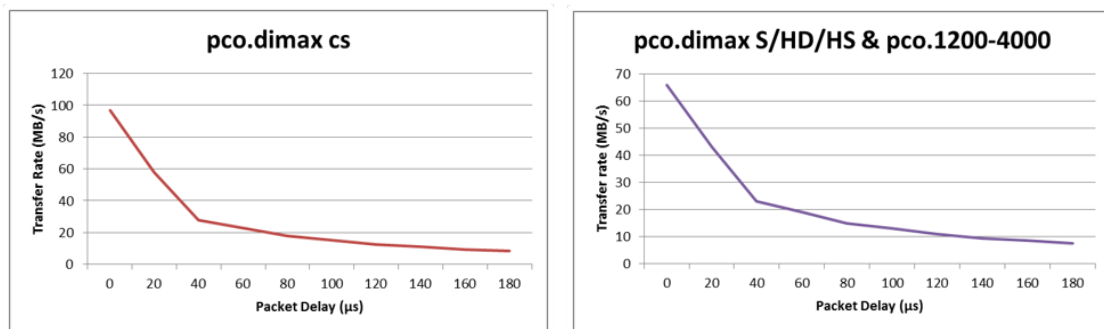

Figure 2.12: packet delay diagrams.

Example: if two PCO GigE cameras are connected to a single Gigabit Ethernet Port (for example via a network switch) the sum of the bandwidths has to be smaller than the maximum possible transfer data rate that can be transferred by GigE (about 100 MB/s).

Note: If **Packet Delay** is increased, the data transfer rate is decreased.

Table Delay Time and transfer rate pco.dimax cs

Delay/ µs	0	20	40	60	80	100	120	140	160	180
MB/s	97	58	28	23	18	15	12.5	11	9.5	8.8

Table Delay Time and transfer rate pco.dimax HD/S/HS and pco.1600-4000

Delay/ µs	0	20	40	60	80	100	120	140	160	180
MB/s	66	43	23	19	15	13	11	9.5	8.5	7.5

2.4.2.2 Synchronize Image Stream

For synchronizing the image stream, there is a check box **Sync**, if more than one camera are connected and found by the pco.gige_calib tool.

In activated sync mode, cameras (opened by a single process) do not send images to the computer in parallel. The GigE Driver ensures that concurrent requested images by an application (i.e. Camware or other apps based on pco.sdk) are queued and processed sequentially. So, the transfer rate between cameras and PC is the arithmetic mean of the transfer rates of the individual cameras.

2.4.3 Camera test

The **pco.gige_calib** tool provides a test routine which requests images in parallel for each installed network adapter with connected PCO cameras.

Please click the *Run Test* button to begin the *Camera Transfer Test*. The test grabs images from *each* camera and transfers images *in parallel*!

The whole *Camera Transfer Test* succeeds only if no image was lost during streaming.

If the *Camera Transfer Test* fails, the first thing to do is to check the tuning parameters (see **2.4.2**). *Packet Delay* indicates the delay (in µs) inserted between each ethernet packet of the image payload data. *Sync* ensures that requested images are processed sequentially.

Note: The Gen2 GigE (e.g. pco.dimax cs) maximum transfer data rate is about 100 MB/s, if you have a pco.dimax camera with the Gen1 GigE interface card, the maximum data rate is up to 68 MB/s.
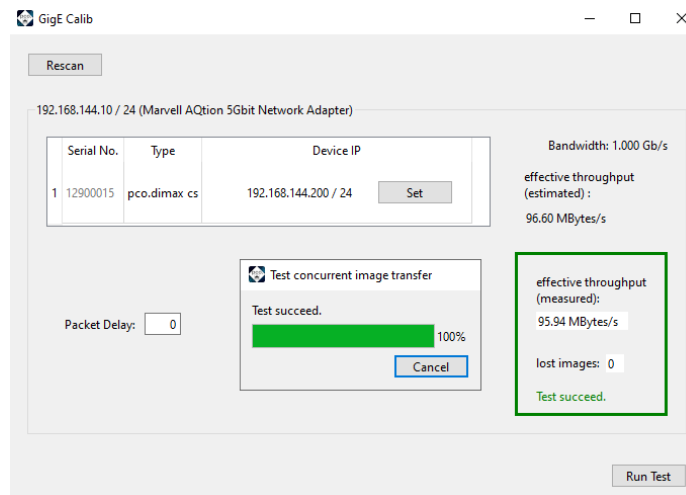
Figure 2.13: camera test.

2.4.4 Performance

The following table gives example configurations: minimum and recommended. The specified values are only valid for these configurations and should act as an orientation.

Setup

	minimum	**recommended**	**10GbE**
Network interface card (NIC)	100 Mbps NIC with standard PCI interface (only working with GigE Gen**2** driver)	GbE NIC with **PCI Express** interface recommended NIC	10GbE NIC
NIC configuration	Receive / transmit buffer is set to maximum	Receive / transmit buffer is set to maximum	Receive / transmit buffer is set to maximum
Network connection	P2P or via switch	P2P	P2P / Cameras directly to 10GbE switch
Patch cable	Cat5e	Cat5e or higher	TP Cat7e
Additional network components	switch, hub, router are compatible to 1 Gbps	no additional components	no additional components
Network environment	-	virus protection/ firewall inactive	virus protection/ firewall inactive
Packet delay /max speed mode	20 µs	0 µs	0 µs
Computer	INTEL® Core™ i5 CPU; 2.4GHz; 4GB RAM	INTEL® Core™ i7 CPU; >2.8GHz; 8GB RAM	INTEL® Core™ i7 CPU; >2.8GHz; 8GB RAM

	minimum	recommended	10GbE
Operating system	Win 10 – x64/x86	Win 10/ 11 – x64	Win 10/ 11 – x64

Note: Data transfer rate performance depends on sensor resolution.

2.5 Driver installation

The latest PCO GigE driver is included to the pco.sdk package and all pco software products e.g. PCO Camware.

To install the PCO GigE driver you have to set a check mark at **Gigabit Ethernet (GigE)** in the respective installer setup of a PCO software package
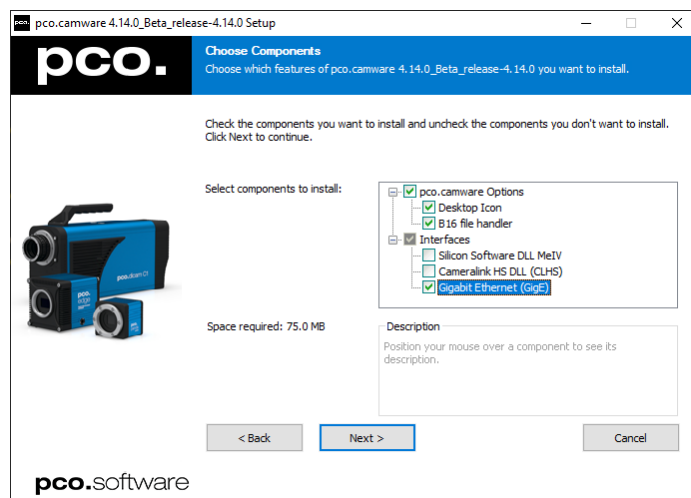

Figure 2.14: Check the GigE driver on installation.

You must remove an older GigE driver version, before starting the installation. Otherwise, the installer will ask you to do this for you.

If you use proprietary image acquisition software make sure that the **sc2_gige.dll** and the directory **genicam**, including GenICam dependencies, are placed next to the **sc2_cam.dll** which is included by the corresponding software.

Appendix

A Windows firewall configuration

In order to ensure proper functioning of the GigE driver and the pco.camware software, it is necessary to configure the Windows Firewall under Windows 10.

If the firewall is not configured, it may happen that in the pco.gige_calib tool, the camera is not recognized or in pco.camware no pictures can be retrieved from the camera.

Therefore, go to *Start* -> *Windows System / Contorl Panel* -> *System and Security* -> *Windows Defender Firewall* -> *Allow an App or feature through Windows Defender Firewall*.

First click *Change settings*, otherwise you cannot set any checkmarks. Then search for the entries of *pco.gige_calib*, *pco.camware* and respectively for each application which is based on pco.sdk.

All checkmarks must be set for all *pco.gige_calib* entries and also for all available *Excelitas PCO GmbH* entries. When your done, click "Ok" to apply the new firewall configuration.

B Help guide

Name	Description
Firewall	If your camera is not recognized or the image stream is blocked, please deactivate Firewall and Antivirus programs.
Driver (NIC)	Install original driver of your network interface card (e.g. intel driver) guaranteeing full performance.
Latest driver	Always install the latest pco.sdk with the GigE Driver (see https://www.pco.de/support).
Buffer	Pay attention to the network interface card buffer settings.
Slow data transfer rate (NIC)	If your computer has a network card installed (PCI / PCI express slot) and the data transfer rate is slow or data transfer is only working with a high packet delay (see chapter **2.4.2**): please remove the NIC and select a different slot of your mainboard. It is quite possible, that some slots do not reach the specified data transfer rate. Please also check the wiring diagram of your mainboard to be able to select the fastest slot. If you have a mainboard with e.g. two network ports, the same problem can occur.
Windows update	Install the latest windows updates. This can prevent problems with the GigE driver installation

C About Excelitas PCO

PCO, an Excelitas Technologies® Corp. brand, is a leading specialist and Pioneer in Cameras and Optoelectronics with more than 30 years of expert knowledge and experience of developing and manufacturing high-end imaging systems. The company's cutting edge sCMOS and high-speed cameras are used in scientific and industrial research, automotive testing, quality control, metrology and a large variety of other applications all over the world.

The PCO® advanced imaging concept was conceived in the early 1980s by imaging pioneer, Dr. Emil Ott, who was conducting research at the Technical University of Munich for the Chair of Technical Electrophysics. His work there led to the establishment of PCO AG in 1987 with the introduction of the first image-intensified camera followed by the development of its proprietary Advanced Core technologies which greatly surpassed the imaging performance standards of the day.

Today, PCO continues to innovate, offering a wide range of high-performance camera technologies covering scientific, high-speed, intensified and FLIM imaging applications across the scientific research, industrial and automotive sectors.

Acquired by Excelitas Technologies in 2021, PCO represents a world renowned brand of high-performance scientific CMOS, sCMOS, CCD and high-speed cameras that complement Excelitas' expansive range of illumination, optical and sensor technologies and extend the bounds of our end-to-end photonic solutions capabilities.

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Appendix Figures

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