

# pco.dicam C8

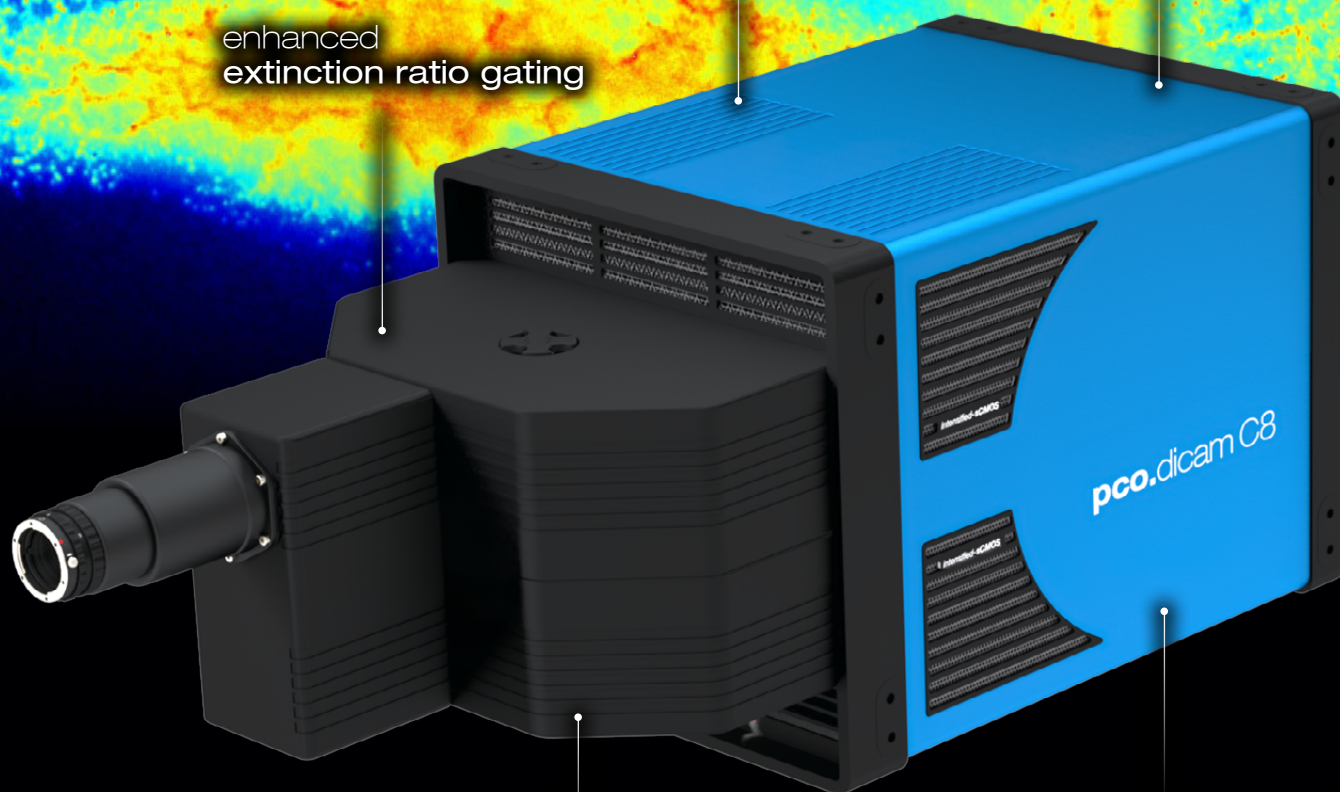
intensified 16 bit **sCMOS** camera

**intensified  
sCMOS**

8 images in 32 ns  
16 images in less than 1  $\mu$ s

80G fiber optic  
data interface

enhanced  
extinction ratio gating



exposure time 4 ns  
with 25 mm intensifier

intensified  
**sCMOS** technology  
2048 x 2048 pixel



## pco.dicam C8

After more than 30 years of experience with image intensified cameras, we are proud to introduce the new pco.dicam C8 to you. The pco.dicam C8 is the first multi-channel intensified camera system which exploits the full performance inherent to scientific **CMOS** sensor technology.

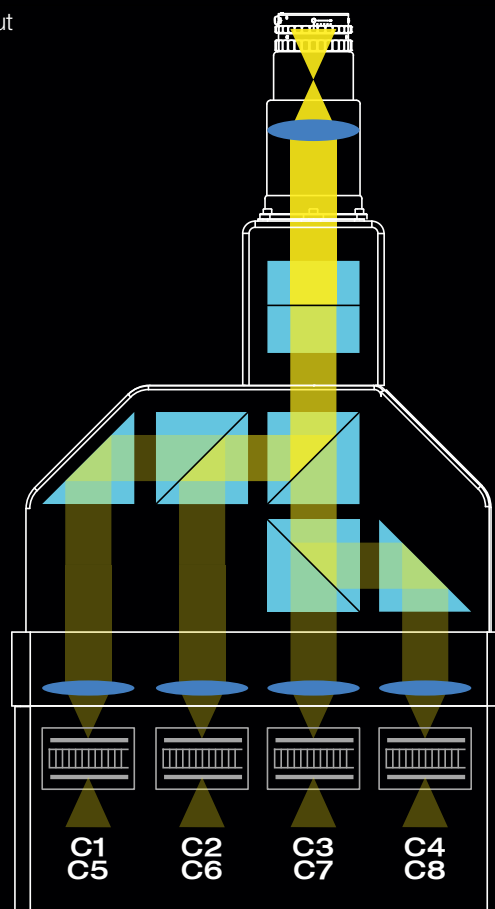
With its high-end optical beam splitters you are able to equally distribute the input light to the 8 image intensifiers. They are coupled with the pco.dicam C1 proven tandem lenses to the 16 bit 4.2 Mpixel sCMOS sensor. It's the most flexible configuration of 16 individual exposure times and their corresponding interframing times, which makes the camera so unique. The 80G fiber optic based data interface guarantees you uncompressed and robust 16 bit data transfer of 848 full frames per second via optical fiber over virtually any distance.

## feature & benefit

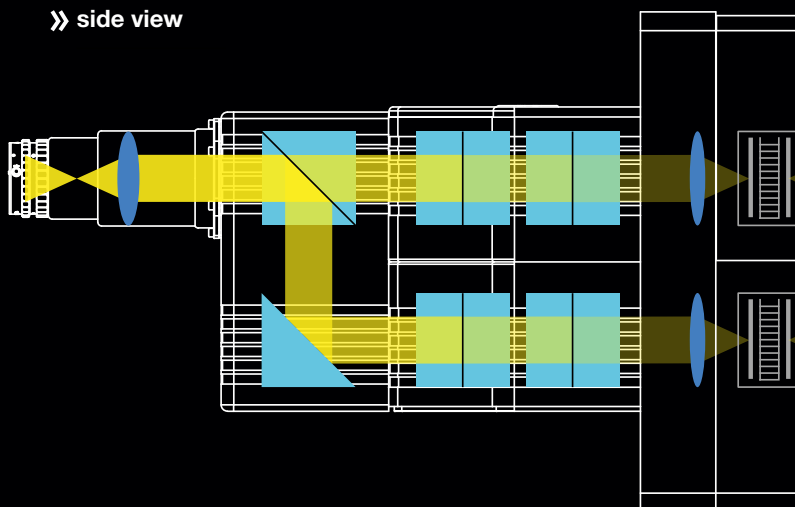
|  |   |
|--|---|
| <b>848 frames/s @ full 4.2 MPixel resolution</b>         | high frame rates at high resolution for imaging of dynamic processes  |
| <b>1.1 e<sup>-</sup> readout noise</b>                   | lowest readout noise of any gated intensified camera system   |
| <b>16 bit digitization</b>                               | taking advantage of the higher dynamic range possible from high end image intensifiers  |
| <b>eight 25 mm high resolution image intensifier</b>     | doubles the optical resolution of conventional 18 mm image intensifiers   |
| <b>optical coupling via ultra-speed tandem lens</b>      | outstanding image quality with high transmission efficiency and no artifacts  |
| <b>tandem lens with 0.53 : 1 image scaling</b>           | full 25 mm diameter of intensifier output is lossless imaged onto sCMOS sensor  |
| <b>80G fiber optic based data interface</b>              | fiber optical interface virtually covers any distance without deploying additional interface converters or signal amplifiers with immunity to EMI     |
| <b>8 x 880 MByte/s image data rate</b>                   | highest sustained image data rate of any intensified camera system on the market; no limitations for recording duration; valid for camera system only |
| <b>double shutter mode with 300 ns interframing time</b> | two consecutive full resolution images with a configurable minimum interframing time of 300 ns on each of the 8 channels                              |
| <b>4.2 MPix sCMOS sensor</b>                             | overcomes CCD limitations in terms of speed and sensitivity   |
| <b>enhanced extinction ratio gating</b>                  | fast MCP gating for improved extinction ratio for the blue and uv part of the spectrum  |
| <b>additional optical trigger input</b>                  | robust trigger transmission over long distance in EMC critical environments   |
| <b>EF lens control</b>                                   | convenient remote lens control for camera systems inaccessible during an experiment   |
| <b>selected highly homogeneous image intensifiers</b>    | uses best image intensifier quality available on the market   |
| <b>50 ns trigger to exposure start delay</b>             | ultra-fast camera reaction to trigger event   |
| <b>4 ns gating with 25 mm intensifier</b>                | captures fast transient phenomena   |
| <b>extensive and highly precise IN/OUT signaling</b>     | allows for perfect synchronization in any experimental set-up as timing master or slave   |
| <b>configurable delay in steps of 1 ns</b>               | flexible adaptation to synchronization needs  |

» top view

front part with optical input  
and beam splitter optics



» side view

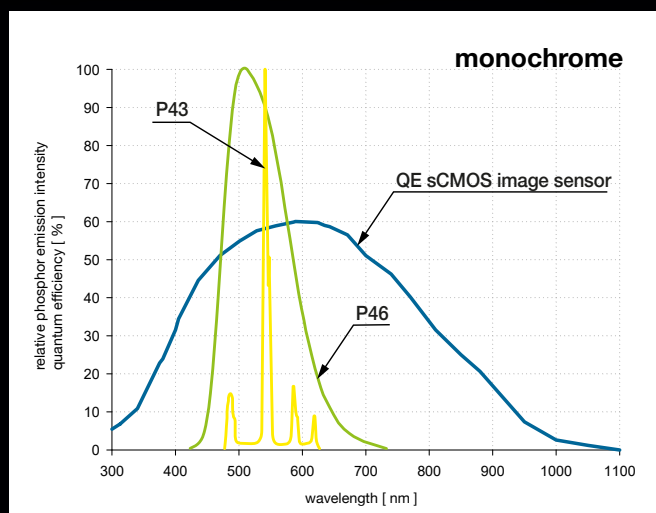


## » sCMOS image sensor

Each detector unit of this unique 8 channel design is equipped with a sCMOS image sensor.

|                                  |  |
|----------------------------------|--|
| <b>type of sensor</b>            | scientific CMOS (sCMOS)  |
| <b>resolution (h x v)</b>        | 2048 x 2048 active pixel   |
| <b>pixel size (h x v)</b>        | 6.5 $\mu\text{m}$ x 6.5 $\mu\text{m}$  |
| <b>sensor format / diagonal</b>  | 13.3 mm x 13.3 mm / 18.8 mm  |
| <b>shutter mode</b>              | single image<br>double image   |
| <b>MTF<sup>1</sup></b>           | 76.9 lp/mm (theoretical)   |
| <b>fullwell capacity</b>         | 15 000 e <sup>-</sup> for P46 phosphor<br>30 000 e <sup>-</sup> for P43 phosphor               |
| <b>readout noise<sup>2</sup></b> | 1.1 med / 1.5 rms e <sup>-</sup> single image<br>2.2 med / 2.5 rms e <sup>-</sup> double image |
| <b>dynamic range</b>             | 13 600 : 1 (82.7 dB) for P46 phosphor<br>27 200 : 1 (88.7 dB) for P43 phosphor                 |
| <b>quantum efficiency</b>        | 58 % for P43 peak emission @ 545 nm<br>57 % for P46 peak emission @ 530 nm                     |
| <b>spectral range</b>            | 300 nm ... 1000 nm   |
| <b>dark current<sup>3</sup></b>  | < 0.6 e <sup>-</sup> /pixel/s @ 7 °C   |
| <b>DSNU</b>                      | 1.0 e <sup>-</sup> rms   |
| <b>PRNU</b>                      | < 0.6 %  |
| <b>anti blooming factor</b>      | 1 : 10 000   |

## » perfect fit: phosphor emission vs. sCMOS quantum efficiency



This chart describes the spectral situation for the internal imaging of the image intensifier's phosphor output screen to the sCMOS sensor of the camera detector module. This imaging is done by the highly efficient tandem lens system.

Please note: The spectral sensitivity relevant for your experiment is solely determined by the QE curve of the photocathode material of the image intensifier (page 8).

<sup>1</sup> Modulation transfer function

<sup>2</sup> The readout noise values are given as median (med) and root mean square (rms) values due to the different noise models, which can be used for evaluation. All values are raw data without any filtering.

<sup>3</sup> Measurements with dark current compensation



» detector unit (8x)

|                                |  |
|--------------------------------|--|
| frame rate                     | 106 fps @ 2048 x 2048 pixel<br>> 7000 fps @ 2048 x 16 pixel  |
| dynamic range A/D <sup>4</sup> | 16 bit   |
| pixel scan rate                | 286.0 MHz  |
| binning horizontal             | x1, x2, x4   |
| binning vertical               | x1, x2, x4   |
| region of interest (ROI)       | horizontal: steps of 4 pixels<br>vertical: steps of 1 pixel  |
| non linearity                  | < 1 %  |
| cooling method                 | + 7 °C stabilized, 1 stage peltier with forced air (fan)   |
| input signals                  | electrical trigger, arm input (TTL level, BNC connectors), gate disable (high-speed TTL input, BNC connectors) |
| output signals                 | gate/expos out monitor, user monitor output (TTL level, BNC connectors)  |
| time stamp                     | in image (1 µs resolution)   |

» general camera system

|                           |  |
|---------------------------|--|
| power supply              | 110 - 230 V                            |
| power consumption         | 360 W                                  |
| weight                    | 90 kg                                  |
| operating temperature     | + 10 °C ... + 40 °C                    |
| operating humidity range  | 10 % ... 80 % (non-condensing)         |
| storage temperature range | - 10 °C ... + 60 °C                    |
| optical interface         | F-mount<br>optional: Canon mount       |
| lens remote controller    | electronic control for Canon EF lenses |
| input signals             | master trigger electrical and optical  |
| CE / FCC certified        | yes                                    |

<sup>4</sup> The high dynamic signal is simultaneously converted at high and low gain by two 11 bit A/D converters and the two 11 bit values are sophisticatedly merged into one 16 bit value.

» exposure modes

single image mode

|                               |   |
|-------------------------------|---|
| exposure times                | 4, 10 ns fixed,<br>20 ns ... 250 ns (1 ns steps),<br>250 ns ... 1 s (10 ns steps) |
| delay times                   | 0 ns ... 250 ns (1 ns steps),<br>250 ns ... 1 s (10 ns steps)                     |
| maximum repetition frequency  | 200 kHz sustained, 3.3 MHz burst  |
| insertion delay               |   |
| trigger input to exposure out | 19 ns   |
| trigger input to optical open | 49 ns   |
| jitter                        |   |
| trigger input to exposure out | 35 ps rms   |
| trigger input to optical open | 150 ps rms  |

double image mode

|                                       |                                   |
|---------------------------------------|-----------------------------------|
| exposure times                        | 20 ns ... 1 ms (in 10 ns steps)   |
| delay settings                        | 0 ns ... 10 ms (in 10 ns steps)   |
| interframing time<br>on every channel | 300 ns ... 10 ms (in 10 ns steps) |

» continuous imaging

|             |                |
|-------------|----------------|
| 2048 x 2048 | 848 fps        |
| 2048 x 256  | up to 6400 fps |
| 2048 x 16   | > 54 000 fps   |

» frame rates

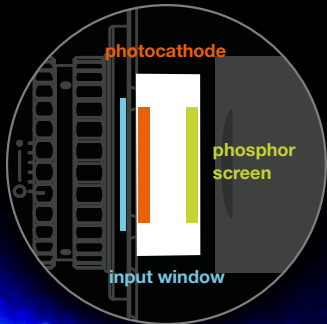
Due to the special 8 channel design of the pco.dicam C8 and the flexible timing possibilities, extremely high burst frame repetition rates are feasible. In single image mode you can record sequences of 8 ultra fast images and in double image mode sequences of 16 ultra fast images. Examples for such extreme frame repetition rates are given below.

|                   |  |
|-------------------|--|
| single image mode | 8 images of 4 ns exposure time<br>with 0 ns interframing time:<br>250.000.000 fps<br>This 8 image sequence can be<br>repeated every 9.6 ms     |
| double image mode | 16 images of 20 ns exposure time<br>with 20 ns interframing time:<br>25.000.000 fps<br>This 16 image sequence can be<br>repeated every 38.4 ms |

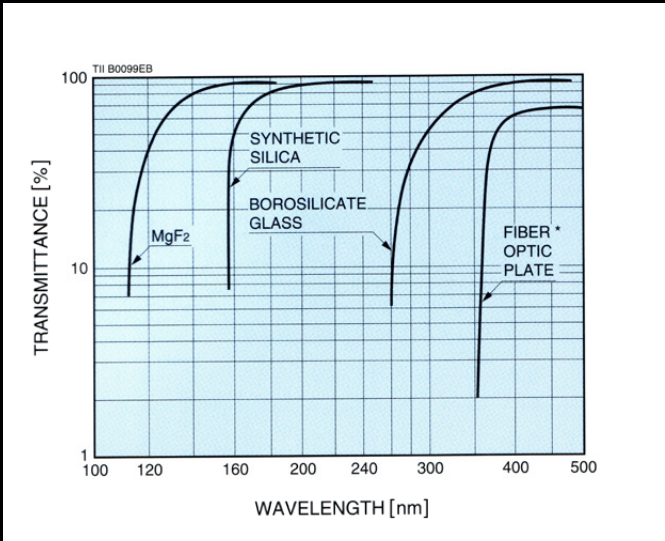
» image intensifier

8x

|                                     |  |
|-------------------------------------|--|
| type                                | HighRes micro channel plate (MCP)<br>6 µm channel      |
| input window                        | synthetic silica, borosilicate                         |
| photocathode material               | S20, GaAs, GaAsP (others on request)                   |
| image intensifier pitch distance    | 6 µm   |
| image intensifier MCP type          | single stage low resistance MCP for high strip current |
| MCP operational modes               | continuous<br>gated for enhanced extinction ratio      |
| image intensifier diameter          | 25 mm (18 mm optional on request)                      |
| phosphor screen material            | P43, P46   |
| output window                       | glass  |
| image intensifier system resolution | > 50 lp/mm @ 5 % MTF typical<br>(depends on phosphor)  |
| shortest gating time                | 4 ns   |



» image intensifier input window

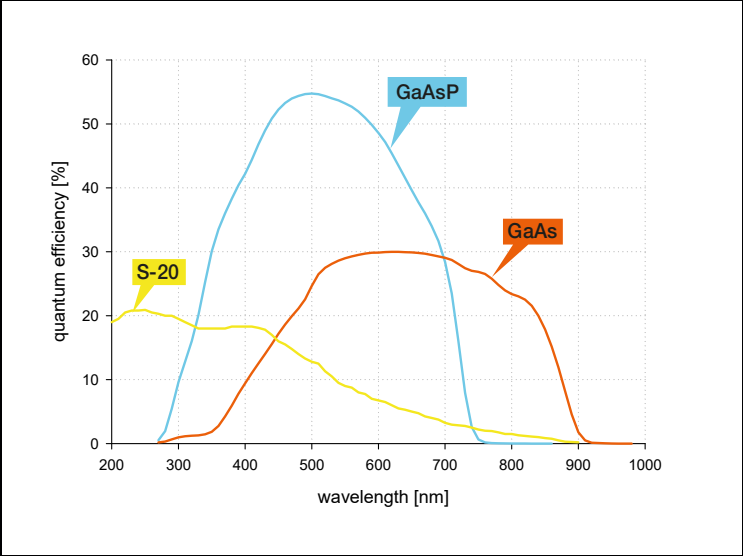


Typical transmittance  
of image intensifier  
input window  
materials

Due to the optical properties of the beam-splitter optics, there is no uv transmission below 380 nm. Intensifiers with MgF<sub>2</sub> input window are not available. Standard input window for S20 photocathodes is synthetic silica.

GaAs and GaAsP photocathodes are deposited on borosilicate glass.

» image intensifier photocathode characteristics



Spectral sensitivities of different photocathode materials: S20 (multialkali), GaAs, GaAsP

data courtesy of Hamamatsu Photonics

| photocathode material | peak wavelength [nm] | typical quantum efficiency at peak wavelength [%] | dark counts [s <sup>-1</sup> /cm <sup>2</sup> ] |
|-----------------------|----------------------|---|---|
| S20 (multialkali)     | 250                  | 20  | 1500  |
| GaAs                  | 650                  | 30  | 30 000  |
| GaAsP                 | 500                  | 55  | 10 000  |

data courtesy of Hamamatsu Photonics

» image intensifier phosphor

| phosphor | phosphor decay (typ.) to.. |        | peak emission | typical efficiency |
|----------|----------------------------|--------|---------------|--------------------|
|          | .. 10%                     | .. 1 % |               |                    |
| P43      | 1 ms                       | 4 ms   | 545 nm        | 100 %              |
| P46      | 0.2 - 0.4 µs               | 2 µs   | 530 nm        | 30 %               |

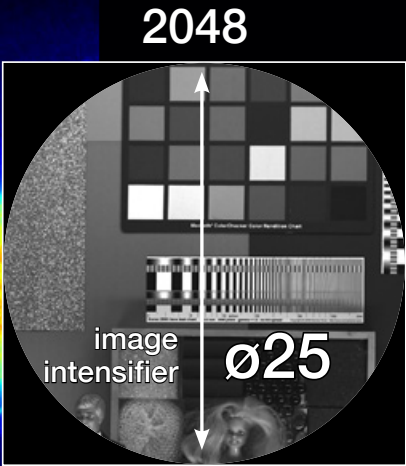
You can combine all photocathode materials with P43 or P46 phosphor. Whereas the P43 phosphor has a much brighter emission than the P46 phosphor, it has a rather long decay time, i.e. the time required till the phosphor emission fades out after the excitation by electron bombardement has been stopped. This decay time is therefore critical for fast image repetition rates primarily in double image application or when operating the camera in spectroscopic mode with line rates in the kHz range.



» optical coupling lens system of the detector units

ultra-speed tandem lens between image intensifier & sCMOS

|                         |                                    |
|-------------------------|------------------------------------|
| transmission efficiency | > 30 %                             |
| vignetting              | < 3 %                              |
| resolution              | > 60 lp/mm                         |
| scaling rates           | $\beta=0.53$ for 25 mm intensifier |



The projected image circle is completely covered by 2048 x 2048 6.5  $\mu\text{m}$  pixels of the sCMOS detector – cf. image left. There is no “waste” of valuable intensifier area. As a consequence the four corners of the sCMOS sensor remain black. For a fast scan of just a few vertically centered lines - the camera module allows you to achieve more than 54.000 fps for such a ROI - the full line length of 2048 pixels is available.



» camera interface

8x

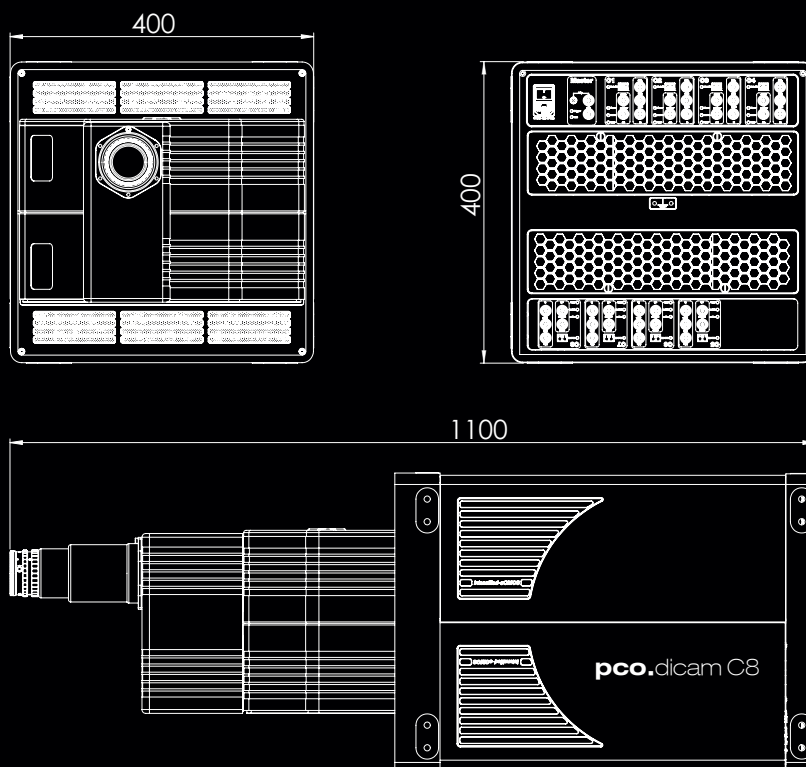
|                                       |   |
|---------------------------------------|---|
| data transfer                         | Camera Link HS, FOL (Single F2, 1X1, S10)<br>two 4 port frame grabber for PCI Express                             |
| master input signals                  | optical trigger (FOL),<br>electrical trigger, arm input (TTL level, BNC connectors)                               |
| additional input signals per channel  | electrical trigger, arm input (TTL level, BNC connectors),<br>gate disable (high-speed TTL input, BNC connectors) |
| additional output signals per channel | gate/expos out monitor,<br>user monitor output (TTL level, BNC connectors)  |

## » lens remote controller

The optional Canon lens controller enables you to connect electronic EF - and EF-S Canon lenses allowing to remote control focus and aperture of those lenses.

## » dimensions

Camera equipped with F-mount lens adapter. All dimensions are given in millimeter.



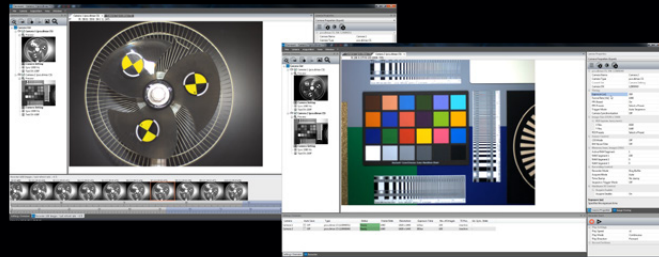
## » camera view



## » applications

laser induced incandescence (LII) | shock wave physics | laser induced breakdown spectroscopy (LIBS) | particle image velocimetry (PIV) | time resolved spectroscopy | plasmaphysics | laser induced fluorescence (LIF) | ballistics | combustion

## » software



With pco.camware you control all camera settings, the image acquisition and the storage of your image data. The pco.sdk is the complementary software development kit. It includes dynamic link libraries for user customization and integration on Windows-PC platforms. Drivers for popular third party software packages are also available for you.

All this items like pco.camware, pco.sdk and third party drivers, are free-to-download at [www.pco.de](http://www.pco.de).

## » third party integrations



## » possible combinations

| photocathode   | input window     | phosphor |
|--|------------------|----------|
| S20 selected   | synthetic silica | P46      |
|  |                  | P43      |
|  |                  |          |
| GaAs standard  | borosilicate     | P46      |
|  |                  | P43      |
| GaAs selected  | borosilicate     | P46      |
|  |                  | P43      |
|  |                  |          |
| GaAsP standard   | borosilicate     | P46      |
|  |                  | P43      |
| GaAsP selected   | borosilicate     | P46      |
|  |                  | P43      |
|  |                  |          |
| Please note that P43 phosphor can't be used, if 16 fast images with interframing times << 1 ms are required. |                  |          |

Image intensifiers with GaAs and GaAsP photocathode are available in two quality grades:

|           |  |
|-----------|--|
| Standard: | quality specified for central 16 mm x 16 mm square region corresponding to 1300 x 1300 pixel sCMOS sensor resolution   |
| Selected: | quality specified for 24.9 mm diameter area corresponding to full 2048 x 2048 pixel sCMOS sensor resolution, extinction ratio 10 times higher than standard grade, image intensifiers with S20 photocathode exclusively come in selected grade quality, contact our technical sales team for further details on the two quality grades |

## » select optical interface

|                 |
|-----------------|
| F-mount         |
| EF lens control |

## » select FOL

type of data interface FOL module in camera and frame grabber

|                     |
|---------------------|
| SM SFP+ up to 10 km |
| MM SFP+ up to 300 m |

FOL cable length default: 10 m

## Need more help?

Get in touch with our experts, tell us what you want to achieve and let us help you find the best customization for your application!



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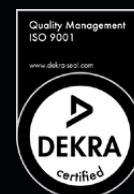


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subject to changes without prior notice | objective lens is sold separately  
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