intensified
sCMOS

multi channel concept

the ultra-high-speed approach

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the groundbreaking **multi channel concept** for intensified cameras

4 channel intensified sCMOS

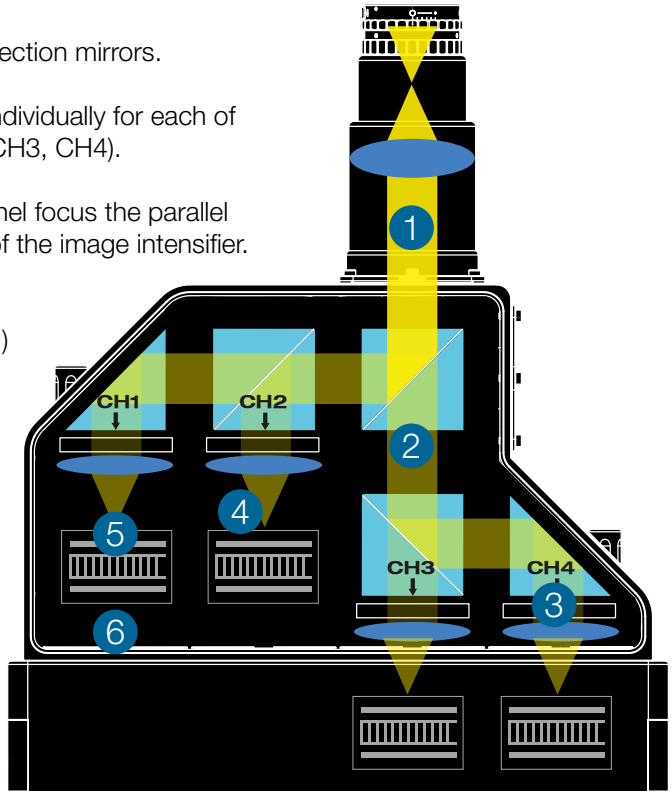
Using sophisticated beam splitter optics, multiple intensified pco.dicam C1 channels can be coupled in a compact housing to a single optical input, thus multiplying the speed, flexibility, and time resolution capabilities of a single pco.dicam C1. Doing so, completely new fields of application open up widely. Ultra-fast processes evolving on a time scale of a few ns out of reach even for the fastest CMOS high-speed cameras at smallest resolution can now be clearly resolved in space and time. The outstanding gating abilities, along with the precisely adjustable light amplification crucial to capture such ultra-fast processes, are unique features of intensified multiple channel camera systems.

The light of a single optical input is equally distributed to 4 image intensifiers with 25 mm diameter and 4 ns shortest gating. Each image intensifier is read out by a dedicated tandem lens coupled 4.2 MPixel sCMOS sensor with 16 bit dynamic.

multi channel concept

beamsplitter optics

1. A collimator lens generates bundles of parallel rays with focus set to infinity.
2. In between, 3 double prisms provide a 50:50 beam distribution under a 90° angle.
3. 2 single prisms act as 99.9 % reflection mirrors.
4. Spectral filters can be mounted individually for each of the 4 light channels (CH1, CH2, CH3, CH4).
5. The imaging lenses of each channel focus the parallel bundles onto the photocathode of the image intensifier.
6. Image intensifier
(See page 6 for more information.)



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4 channel intensified sCMOS

multi channel concept

pco.dicam C4 frame rates: ultra-speed

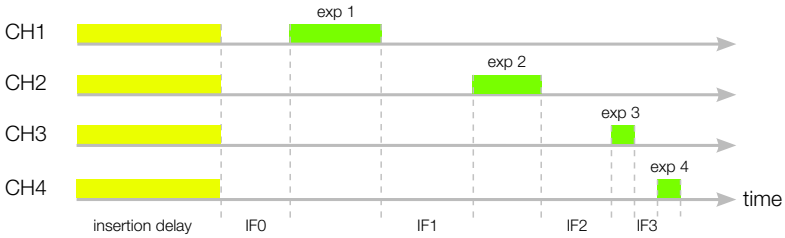
Due to the special 4 channel design of the pco.dicam C4 and the flexible timing possibilities, extremely high burst frame repetition rates for sequences of 4 images (single image mode) or sequences of 8 images (double image mode) can be achieved.

Whether the camera is operated in burst mode or in continuous mode, a maximum of 424 fps @ full 4.2 MPixel resolution is available. This equals 3.4 GByte/s of sustained image data rate.

To transmit this huge image data rate in real time to the control PC, the unique scalability of the CLHS FOL interface is exploited. Instead of a Single F2, 1X1, S10 port as with the pco.dicam C1, the pco.dicam C4 uses a QUAD F2, 1X1, S10 port (40G FOL) which runs on a single PCIExpress based CLHS interface board.

single image mode

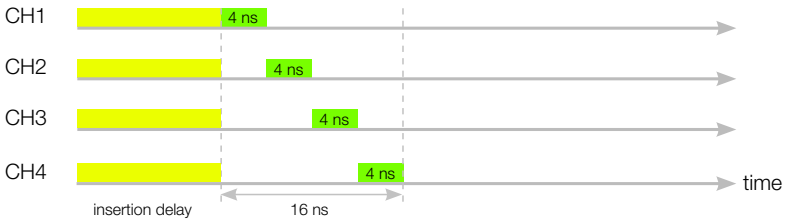
Example for a flexible 4 image timing scheme in single image mode



- Insertion delay: reaction time to external trigger (< 50 ns)
- IF0 to IF3: configurable interframing time, 0 ns - 1 s
- exp 1 to exp 4: exposure time of CH1 to CH4, 4 ns - 1 s

fastest timing

4 images of 4 ns exposure time with 0 ns interframing time correspond to a burst rate of **250,000,000 fps**. This 4 image sequence can be repeated every 9.6 ms.



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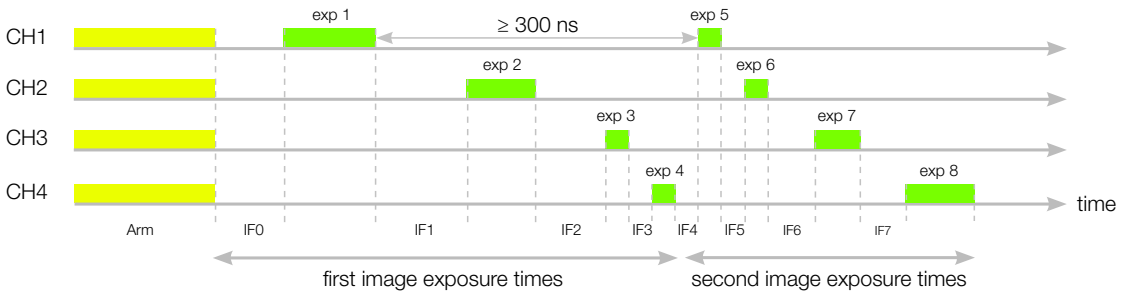
double image mode

Operating all 4 camera channels in double image mode allows for highly flexible positioning of 8 (different) exposure time windows with arbitrary interframing times on the recording time line.



- Arm: minimum 9.6 ms for full resolution frame
- Individually configurable exposure times for CH1 to CH4 (20 ns - 1 s)
- Two images on the same channel form one **double image**.
- Limiting condition: The interframing time for a double image has to be at least 300 ns.
- 8 images of 20 ns exposure time are possible with **12,500,000 fps.**
- This 8 image sequence can be repeated every 38.4 ms.

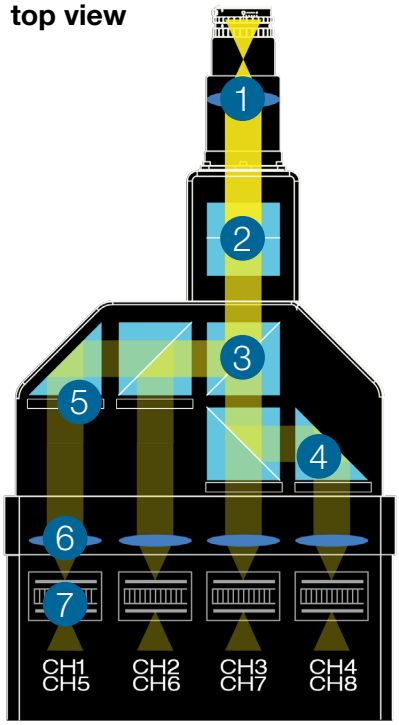
the new
pco.dicam C8

8 channel intensified sCMOS

The pco.dicam C8 has been developed as a consistent and logical next step to increase the image sequence length of the field proven pco.dicam C4 camera system. The light of a single optical input is equally distributed to 8 image intensifiers with 25 mm diameter and 4 ns shortest gating. Each image intensifier is read out by a dedicated tandem lens coupled 4.2 MPixel sCMOS sensor with 16 bit dynamic. All optical elements deployed for the beam splitting and guidance are adopted from the very successful pco.dicam C4 design.

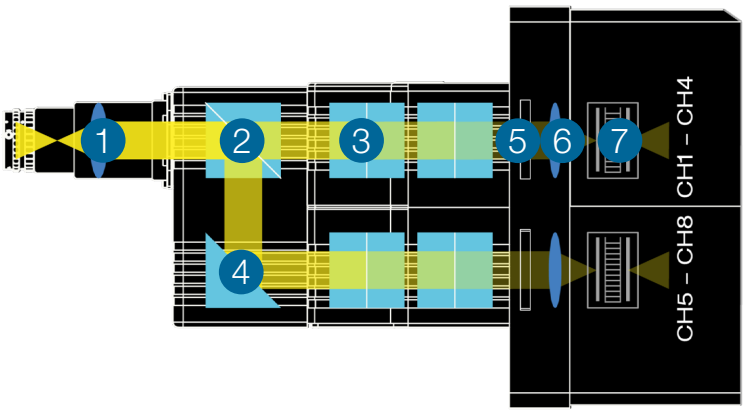
beamsplitter optics pco.dicam C8

top view



1. A collimator lens generates bundles of parallel rays with focus set to infinity.
2. A double prism redirects 50 % of the input light to the lower level of channels 5 - 8.
3. In both levels, 3 double prisms provide a 50:50 beam distribution under a 90° angle.
4. Single prisms act as 99.9 % reflection mirrors.
5. Spectral filters can be mounted individually for each of the 8 light channels (CH1, CH2, CH3, CH4, CH5, CH6, CH7, CH8).
6. The imaging lenses of each channel focus the parallel bundles onto the photocathode of the image intensifier.
7. Image intensifier
(See more information on the next page.)

side view



multi channel concept

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camera components overview

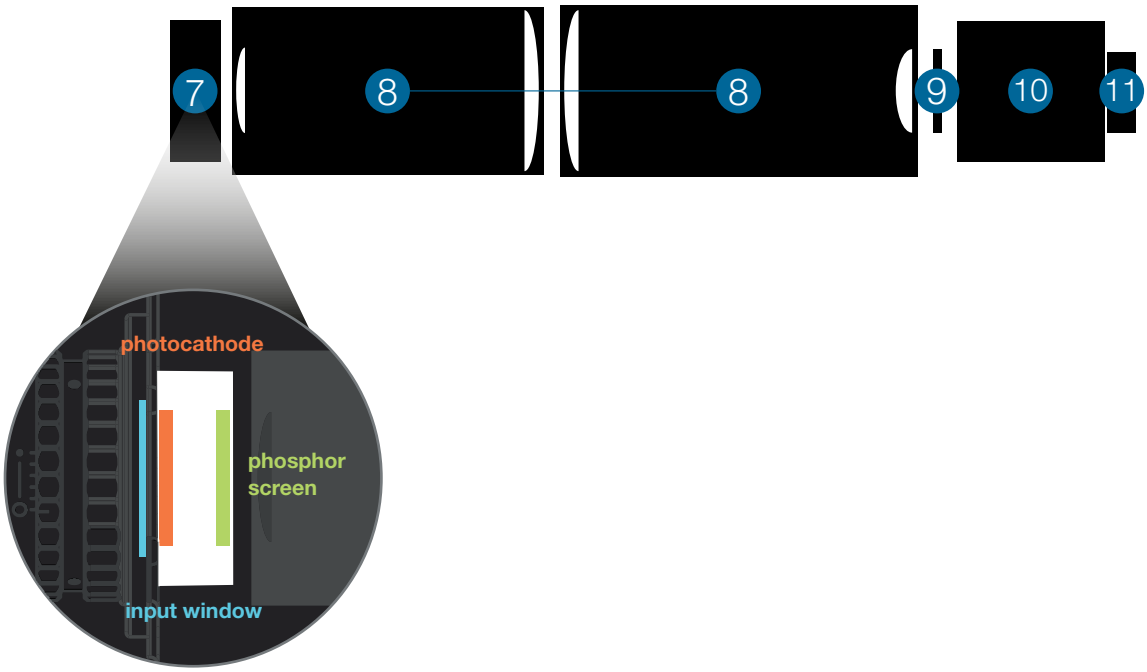
7 image intensifier

8 optical coupling lens system

9 sCMOS image sensor

10 camera system

11 10G fiber optic based interface

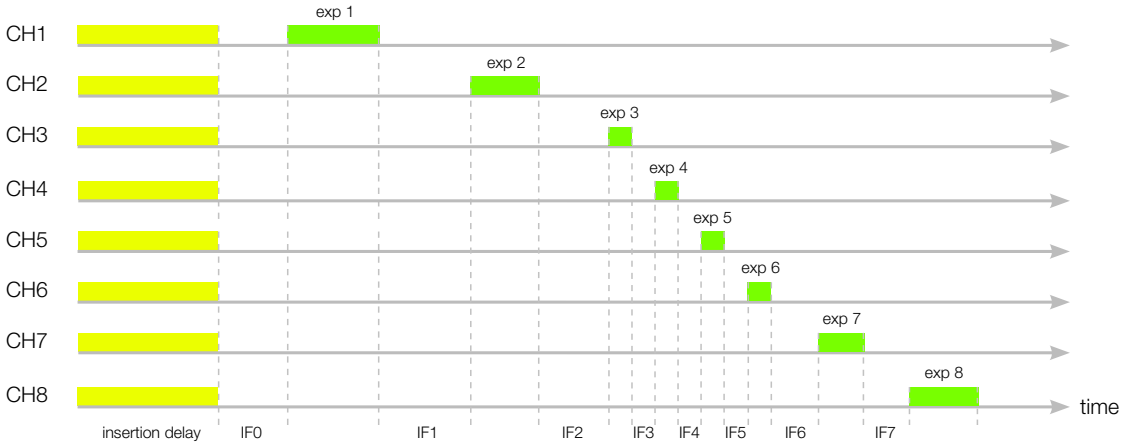


pco.dicam C8 frame rates: ultra-speed

single image mode

The same flexibillity of positioning 8 (different) exposure times on the time line as already described for the pco.dicam C4 applies for the pco.dicam C8.

Example for a flexible 8 image timing scheme in single image mode



- Insertion delay: reaction time to external trigger (< 50 ns)
- IF0 to IF7: configurable interframing time, 0 ns - 1 s
- exp 1 to exp 8: exposure time of CH1 to CH8, 4 ns - 1 s

A timing scheme like this could for instance be applied to analyze the evolution of an ultra-fast process with higher sensitivity but reduced time resolution in the beginning and end as well as lower sensitivity but highest time resolution in between.

fastest timing

8 images of 4 ns non-overlapping exposure time with zero ns interframing time correspond to a burst rate of **250,000,000 fps**. This 8 image sequence can be repeated every 9.6 ms.

double image mode

Operating all 8 camera channels in double image mode allows for highy flexible positioning of 16 (different) exposure time windows with arbitary interframing times on the recording time line.

16 images of 20 ns exposure time with 20 ns interframing time correspond to a burst rate of **25,000,000 fps.** This 16 image sequence can be repeated every 38.4 ms.

Whether the camera is operated in burst mode or in continuous mode - a maximum of 848 fps @ full 4.2 MPixel resolution is available. This equals 6.8 GByte/s of sustained image data rate.

To transmit this huge image data rate in real time to the control PC, the unique scalability of the CLHS FOL interface is exploited. Instead of a Single F2,1X1, S10 port as with the pco.dicam C1, the pco.dicam C8 uses an octal F2, 1X1, S10 port (80G FOL) which terminates on two PCIExpress based CLHS interface boards.

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spectrally resolved intensified imaging

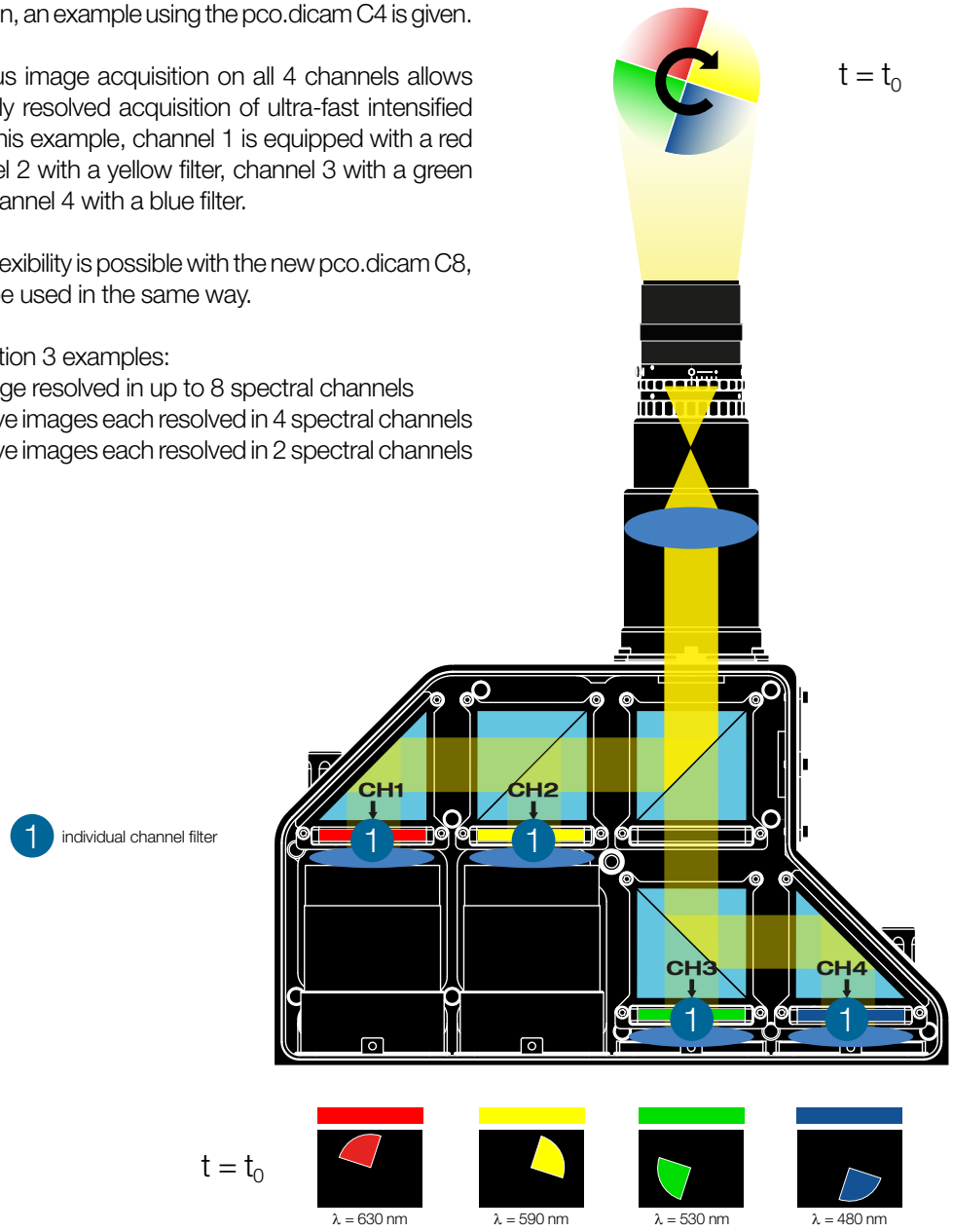
The option of mounting different spectral filters to each individual channel and the completely independent relative timing of the channels can be exploited to achieve spectrally resolved intensified imaging.

For illustration, an example using the pco.dicam C4 is given.

Simultaneous image acquisition on all 4 channels allows the spectrally resolved acquisition of ultra-fast intensified images. In this example, channel 1 is equipped with a red filter, channel 2 with a yellow filter, channel 3 with a green filter, and channel 4 with a blue filter.

Even more flexibility is possible with the new pco.dicam C8, which can be used in the same way.

Just to mention 3 examples:
A single image resolved in up to 8 spectral channels
2 consecutive images each resolved in 4 spectral channels
4 consecutive images each resolved in 2 spectral channels



Overlay of all 4 channels results in a **spectrally resolved intensified image** which gives the situation at $t = t_0$