

## TRiCAM

### Time-Resolved Intensified CMOS Camera

The TRiCAM is an intensified CMOS camera for scientific and industrial applications that require 1) low-light level imaging, 2) ultra-short exposures through fast gating, and/or 3) frequency domain imaging using lock-in detection. The TRiCAM features a fast CMOS sensor that is fiber-optically coupled to an image intensifier for optimal transmission efficiency. The high sensitivity of the TRiCAM, down to the single photon level, is supplemented with an acquisition speed up to 162 fps.

The TRiCAM (Time-Resolved intensified CAMera) is the best choice for ultra-fast imaging in the time domain and/or frequency domain.

For time-domain imaging the ICMOS is equipped with an integrated timing pulse generator and gate-unit (TRiCAM G). The TRiCAM G includes the LI-Capture software for control of gate width, gate frequency, delay, gain and binning. Two synchronised TTL output signals (output A and B) are provided for driving pulsed lasers or LEDs.

For frequency domain imaging the ICMOS supports gain modulation of 120 MHz (standard) and higher (external signal generator). This is the TRiCAM M model. Modulation is provided by a single-chip digital synthesizer to ensure a very low phase noise. The TRiCAM is the key component of the Lambert Instruments LIFA system for FLIM.

The TRiCAM is highly customizable and can be equipped with the image intensifier that best matches your application. Different camera models covering a range in spectral sensitivity, phosphor, spatial resolution, gain, linearity, minimum gate width and gating frequency are available.



## KEY FEATURES

### High-resolution image intensifiers

Image intensifiers offering the world's highest resolution and sensitivity in the UV, Visible or Near Infrared

### Small gate widths

Down to less than 3 ns (FWHM) with minimal jitter

### Single-chip digital synthesizer for frequency-domain acquisition

For high dynamic range fluorescence lifetime imaging at the lowest possible phase noise

### Compact camera design

For an easy fit to a microscope body or imaging spectroscopy

### LI-Capture software

For complete camera control; the SDK enables integration with third-party software

## APPLICATIONS

Time-resolved imaging and spectroscopy

Particle Image Velocimetry (PIV)

Laser Induced Fluorescence (LIF)

Time-gated luminescence

Fluorescence Lifetime Imaging Microscopy (FLIM)

Förster Resonance Energy Transfer (FRET)

Oxygen imaging

Viscosity imaging

Single molecule imaging

Bio- and Chemiluminescence Imaging

Solar PV and LED characterization

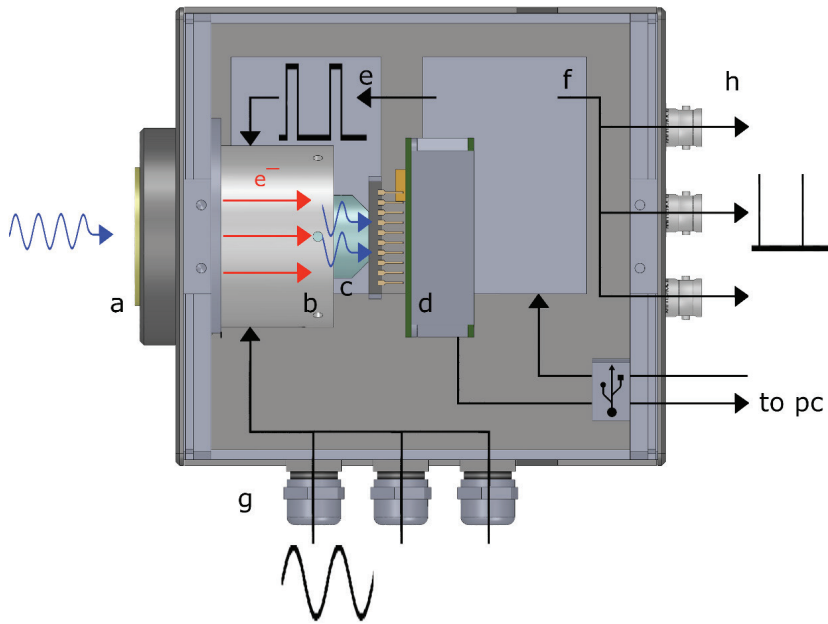
Combustion

Time-gated Raman

Plasma physics

X-ray Imaging

## Intensified CMOS camera layout



When the TRiCAM is mounted to a microscope or lens, the incoming light (a) is focused onto the entrance window of the image intensifier (b). The image intensifier converts the optical image to electrons, amplifies this electron image, and re-converts the electrons into photons. A fiber-optic taper (c) guides the amplified optical image to the CMOS module for registration and read-out (d).

For time-resolved imaging the image intensifier is used as an electro-optical shutter during the process of image acquisition. This uses either a signal generated by the gate unit and timing unit (e & f - the TRiCAM G model) or a high-frequency modulation signal (g - the TRiCAM M model) provided by a direct digital synthesizer. The camera provides multiple output signals (h) for accurate synchronization of external equipment such as a pulsed light source.

Figure caption: a) lens mount, b) image intensifier, c) fiber-optic taper, d) CMOS camera module, e) gate unit, f) timing unit, g) intensifier modulation input, h) output synchr. gate pulses.

# CAMERA SPECIFICATIONS

Image sensor	1920 x 1200 pixels ; 5.86 $\mu\text{m}$ square pixels
Dynamic range	72 dB
Max. frame rate at full resolution	162 fps
Readout noise	14 $e^-$
Integration time control	0.005 ms – 3.2 s
Selectable Region of Interest	1920 x 1200 @ 128 fps (12 bit) or 162 fps (10 bit)
Digitization	10 or 12 bit (selectable)
Triggering	External trigger input LVTTTL ; Trigger output LVTTTL
Lens mount	C-mount (F-mount upon request)
Intensifier models	Single-stage MCP Gen II or Gen III (filmless)
Input diameter	18 mm
Sensitivity and spectral range	TRiCAM G: see graph on page 5
Phosphors	TRiCAM M: S20, S25, GaAs, GaAsP (blue curves graph p.5) TRiCAM G: P20,P24,P43,P46; TRiCAM M: P43
Sensor coupling	Tapered fiber optics 1.33:1
Photon gain (max)	S20: 40000, S25: 30000, GaAs: 30000, GaAsP: 50000
Equivalent Background Input	S20: 0.006 photo $e^-/\text{pix}/\text{s}$ , S25: 0.008 photo $e^-/\text{pix}/\text{s}$ , GaAs: 0.024 photo $e^-/\text{pix}/\text{s}$ , GaAsP: 0.006 photo $e^-/\text{pix}/\text{s}$
Spatial resolution bare intensifier	Gen II: up to 69 lp/mm, Gen III: up to 64 lp/mm

## Gating

The TRiCAM G can be used as an ultra-fast electro-optical shutter by gating the image intensifier and thereby reducing the effective exposure time. Time domain gating eliminates motion blur and significantly widens the range of light levels at which the camera can be used.

The user has full control of the camera gate pulse width, delay and gain through either the dedicated LI-Capture software or the software SDK. The software supports an array of gating modes, including synchronization of the internal oscillator to an external source. The standard camera has two additional output channels (output A and B) synchronised with the gate frequency. For both channels the user has control of the delay time as well as the pulse width and polarity.

For the TRiCAM M model the camera modulation signal at frequencies below 100 kHz can be produced using the optional gate unit and timing pulse generator. The pulse generator also generates the synchronisation signal for a modulated light source or acousto-optic modulator.



# GATING SPECIFICATION

Models	TRiCAM G 40n	TRiCAM G 2n
Min. gate width (FWHM)	40 ns	Gen II: < 3 ns Gen III: 5 ns
Max. repetition frequency	100 kHz	300 kHz
Gate pulse width control	40 ns – 5 s, 20 ns resolution	< 3 ns – 10 s, 10 ps resolution
Gate delay time control	0 – 5 s, 20 ns resolution	0 – 10 s, 10 ps resolution
Dead time after trailing edge	200 ns	100 ns
Pulse generator resolution; jitter	20 ns; 10 ns	10 ps; < 35 ps
Insertion delay	100 ns	65 ns
Trigger input	TTL	TTL
Output A/B pulse width control	0	5 ns – 10 s, 10 ps resolution
Output A/B delay control	n.a.	0 – 10 s, 10 ps resolution
Interface	USB 3.0	USB 3.0
Programmable gate trains	n.a.	Available

## Modulation control unit specification

The TRiCAM M provides highly accurate frequency-domain imaging with high-resolution gain modulated Gen II and Gen III image intensifiers.

The TRiCAM M combines the IC MOS camera with a separate modulation control unit. The modulation control unit contains a single-chip dual channel DDS for generation and amplification of the RF modulation signals for the modulated lightsource and the image intensifier (100 kHz – 120 MHz standard). The control unit further supplies the required high-voltages to the

image intensifier. A software SDK is provided for digital control of the gain, modulation and cathode bias voltages via an USB interface, emulating a standard RS232 serial communications port.

Modulation frequencies below 100 kHz are supported by the optional gate unit and time pulse generator. The pulse generator generates the synchronisation signal for an external modulated light source or acousto-optic modulator.

# MODULATION SPECIFICATION

## TRiCAM M

Frequency range	100 kHz – 120 MHz (standard), up to at least 250 MHz with an external signal generator
Frequency adjustment resolution	1 kHz
Frequency deviation	100 ppm max.
Phase adjustment range	0 – 360° in 1° steps, phase deviation < 0.01°
Harmonics suppression	Better than 25 dB
High light level protection	Integrated intensifier protection, switches off all DC and AC power

## Output 1. TRiCAM

AC signal level	Adjustable from –30 to 0 dBm
AC signal after amplification	50 Vpp max.

## Output 2. Lightsource

Programmable options:

### a) Multi-LED

AC signal level (DC current adjust)	Adjustable in 250 steps (0 – 1000 mA, 12 bit)
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### b) Modulated laser diode

AC signal level (DC level adjust)	0.00 – 1.00 V peak-peak (0.00 – 1.00 V)
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### c) AOM for CW laser

AC signal level	0.00 – 1.00 V peak-peak
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Frequency	Half the frequency of output 2
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Modulation input	Input for external modulation signal, 250mV (peak-peak), 50Ω
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External trigger input	LVTTL (high frequency mode only), 50Ω
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Trigger input	Available upon request
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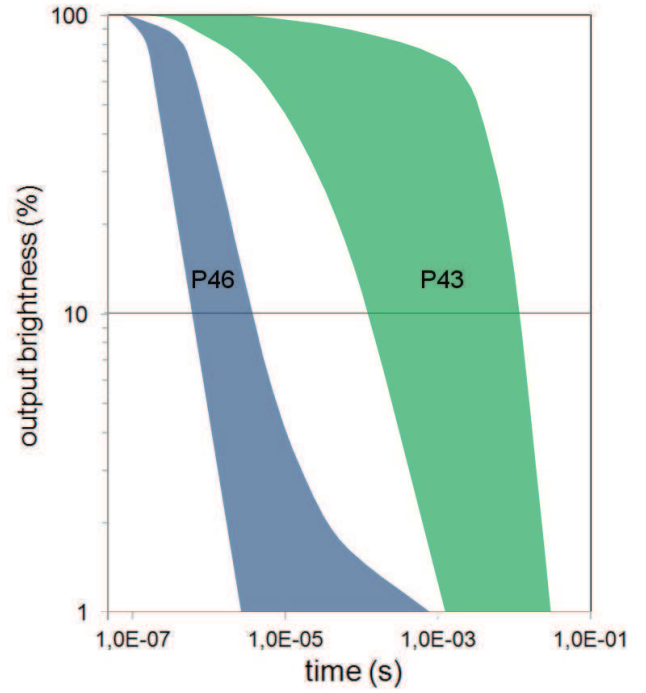
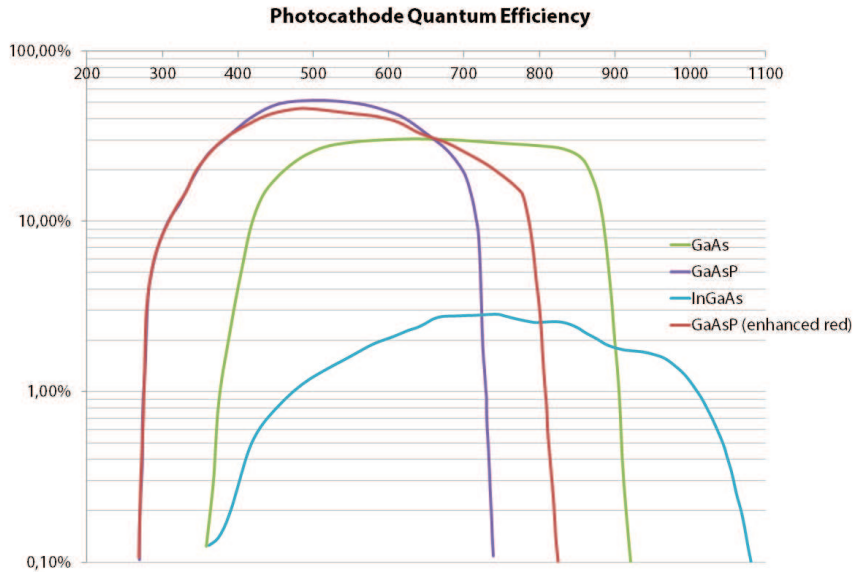
Monitor Output	Output modulation signal monitor
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Interface	USB 3
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## TRiCAM GM, as TRiCAM M plus:

Frequency Range	0 – 100 kHz
Min. gate width (FWHM)	40 ns
Gate pulse width control	40 ns – 10 s, 10 ps resolution
Gate delay time control	0 – 10 s, 10 ps resolution
Dead time after trailing edge	100 ns
Pulse generator resolution (jitter)	10 ps (< 35 ps)
Insertion delay	45 ns
Trigger input	3.5 V – 5.0 V 50 Ω
Output A/B pulse width/delay control	Fully programmable, 50 Ω source imped.

## Spectral response and phosphor decay time



Phosphor	Efficiency	Decay time to 10%	Decay time to 1%
P43 (standard)	20 photons/e-/kV	1.5 ms	3 ms
P46 (optional)	6 photons/e-/kV	500 ns	2000 ns

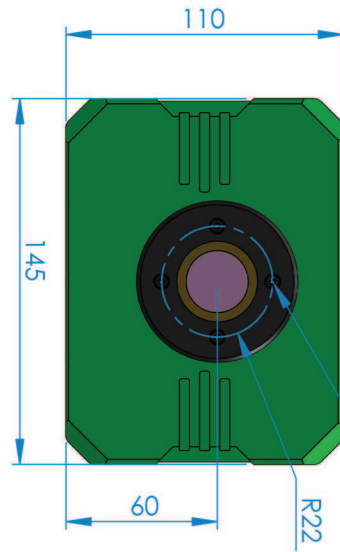
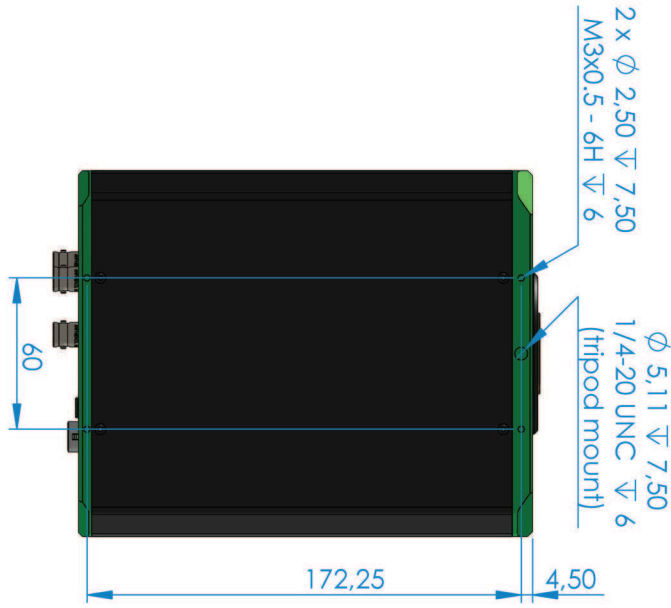
P20 and P24 available on request

## Operating conditions

	Minimum	Typical	Maximum
Supply voltage	12 Vdc		15 Vdc
Power		1 W	
Operating temperature	5 °C		40 °C
Operating humidity (non-condensing)	20%		80%
Input lens mount		C-mount, F-mount*	

\* Other lens mounts available upon request





can be used to attach a custom lens mount  
4 x  $\phi$  2,50  $\nabla$  6  
M3x0,5 - 6H  $\nabla$  5

