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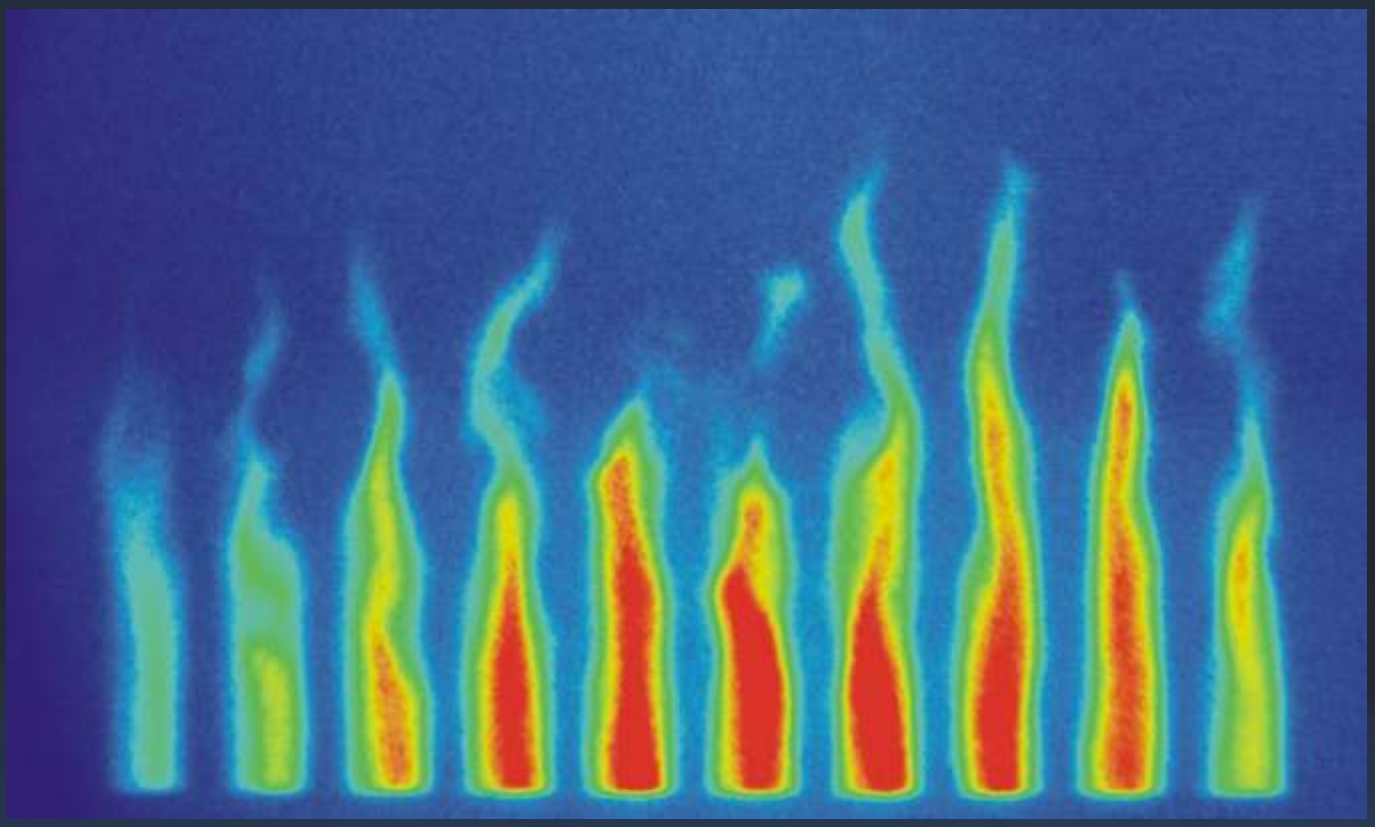
COMPUTER
OPTICS

Superior imaging intensified CCD cameras

Quantum Leap

The image intensifier module
for continuous or gated operation
providing high speed shutter.



- **High resolution image intensifier**
- **Shortest gating time down to 200ps**
- **Excellent for high-speed video cameras**
- **Time/Gain Module for remote control**

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Quantum Leap

The Quantum Leap is a stand alone image intensifier module, which upgrades your existing setup to a full-fledged intensified imaging system. It comprises the image intensifier, pulse amplifier, high-voltage power supply and a selectable output coupling lens.

The Quantum Leap provides a minimal gate time of either 1.2ns, 0.2ns or 0.4ns. The compact design of all Quantum Leap models hosts everything needed for operation.

High speed with excellent signal amplification
Image intensifiers are providing an unique combination of intensifying low light images and a high speed shutter. This makes them the perfect tool in combination with high speed video cameras or multiple exposure applications like particle imaging velocimetry (PIV).

Easy integration and flexibility
With the integrated output coupling lens the image intensifier module can be easily connected with various cameras. Several output coupling lenses are available to ensure the best imaging quality with the particular used detector size.

Highest flexibility with Time & Gain Module
By default the photocathode gating of the image intensifier is activated using an external TTL signal and the signal gain is set manually. With the optional available Time & Gain Module the image intensifier gain, the gating and delay time can be controlled remotely via software.

More detailed information

Cover: Image sequence of the Triplex-plasma source taken with a corresponding frame rate of 1 million frames per second. Further details on page 11. Figure reprinted with permission of the Universität der Bundeswehr in Munich.

Highlights

Standard features and benefits

- Shortest gate time down to 1.2ns or 0.2ns with 100kHz continuous, 3.3MHz Burst
- Single stage 18mm image intensifier
- High resolution image intensifiers with optical system resolution of >60lp/mm
- Spectral sensitivity from UV to IR (depends on type of image intensifier)
- Brilliant sensitivity providing single photon detection
- Improves image contrast and S/N ratio
- Adjustable MCP-voltage for 50db dynamic range in signal amplification
- Customized f/0.8 distortion free coupling lense between image intensifier and CCD sensor
- Only 12V power supply necessary
- Compact and light system design
- Time & Gain Module providing:
  - Full remote control via RS232 of signal gain, gate and delay time
  - internal digital delay generator
  - Multiple trigger options: 3x input; 3x output
  - Multiple exposure operation with gate repetition rate up to 100kHz
  - control software

Optional features

- Shortest gate time down to 0.4ns with 2MHz continuous, 3.3MHz Burst
- Dual stage multi-channel plate (MCP) for highest signal gain and single photon detection
- Adapters for various spectrometer
- Vacuum flange for UHV connection

High resolution
image intensifier

Superior image qualitay by
customized lens coupong

8 mm output image diameter
Excellent for high-speed

video cameras
Long lasting elecetronics

(24 months warranty)

Time settings with Time&Gain module

High accuracy timing control of the high speed shutter

The Quantum Leap provides a minimal gate time of either 1.2ns, 0.2ns or 0.4ns. By default all Quantum Leap models provide manual adjustability of the signal amplification and the photocathode gating can be switched by an external TTL signal.

In combination with the Time&Gain Module the Quantum Leap is fully remotely controllable. The integrated digital delay generator provides highly accurate timing control with 100ps (Quantum Leap N), and 10ps (Quantum Leap E and Quantum Leap MHz) step sizes of the gating and delay time. Furthermore, the Time&Gain Module enables multiple exposure operation modes and external triggering.

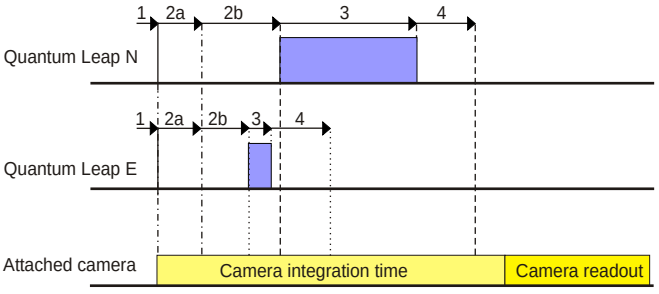
Time settings

Parameter	Quantum Leap N	Quantum Leap E	Quanturm Leap MHz
Gating time [step size]	1.2ns … 80s [100ps]	0.2ns … 80s [10ps]	0.4ns … 80s [10ps]
Delay time [step size]	100ps … 80s [100ps]	10ps … 80s [10ps]	10ps … 80s [10ps]
Jitter	<20ps	<10ps	<10ps
Gate repetition rate (burst mode)	3.3MHz	3.3MHz	3.3MHz
Gate repetition rate (continuous mode)	100kHz	100kHz	2MHz
Trigger propagation delay	standard with external gate pulse: 30-35ns optional with Time/Gain module: 60-65ns		
Gain control	standard: manual with potentiometer optional with Time/Gain module: digital via RS232		
Gate control	standard: manual with potentiometer optional with Time/Gain module: digital via RS232		

Operation showcase with a high frame rate video camera

The Time & Gain Module synchronizes the Quantum Leap with the connected camera using an adequate TTL signal as trigger. The trigger pulse follows an intrinsic delay time. Then the remotely adjustable delay time elapses before the shutter opens for an also remotely adjustable gating time. After the gating time the attached camera should further integrate during the luminous period of the phosphor screen.

Superior imaging of fast moving objects
The described setup enables easy integration of the Quantum Leap in combination with an high frame rate video camera. This setup provides highly accurate delay and gating time adjustment. Therefore, the Quantum Leap ensures the best image quality and superior imaging at highest frame rates of e.g. ultra fast moving objects or hypervelocity impacts.



Legend:
1) external trigger signal (from attached camera)
2a) intrinsic delay 35ns or 65ns
2b) adjustable delay time: Quantum Leap N: 0 - 80s, step size 100ps
Quantum Leap E: 0 - 80s, step size 10ps
Quantum Leap Mhz: 0 - 80s, step size 10ps
3) adjustable gate time: Quantum Leap N: 1.2ns-80s, step size 100ps
Quantum Leap E: 0.2ns-80s, step size 10ps
Quantum Leap MHz: 0.4ns-80s, step size 10ps
4) luminous period of the phosphor screen

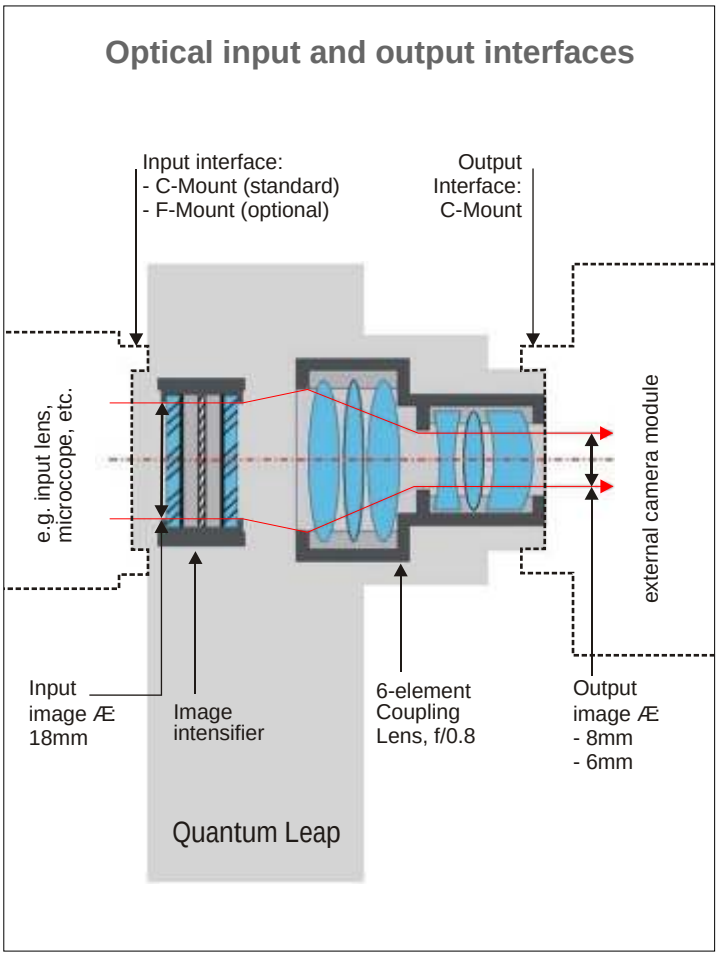
Optical input & output options

Various output image sizes by selectable coupling lens

Flexible intensified imaging extension
The Quantum Leap image intensifier module can be adapted between any optical device e.g. input lens or microscope and any detector. The input image is amplified by the image intensifier which also provides the high speed shutter functionality. The output is imaged on the sensor by the coupling lens.

Various input and output interfaces
The image intensifier module provides multiple input options to meet the requirements of the different optical devices on which the Quantum Leap can be connected. The input interface of the Quantum Leap provides by default a C-mount connector.
Adapter for Nikon F-mount is available.

Superior distortion free image quality
The output coupling lenses provide the flexibility of alternative sensor sizes in combination with high coupling efficiency and superior image quality. The output image is distortion- and vignetting-free and shows no honeycomb pattern. Depending on the detector size of the connected camera the suitable coupling lens in combination with the convenient diameter of the image intensifier can be chosen in the table below.



Output coupling lens

Output image diameter	Sensor size	Coupling lens magnification	Image intensifier Diameter	Output interface
8mm	1/2" CCD chip	2.2 : 1	18mm	C-mount only
6mm	1/3" CCD chip	3.1 : 1	18mm	C-mount only

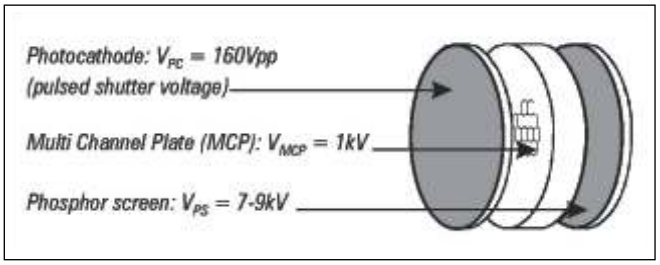
High performance image intensifier

Guidance to make the right choices in order to get the most suitable image intensifier.

The image intensifier is a key component of each ICCD camera. This section deals with the fundamental characteristics of image intensifiers and their options.
Different applications of ICCD cameras have different demands and requirements on the camera and thus on the image intensifier.

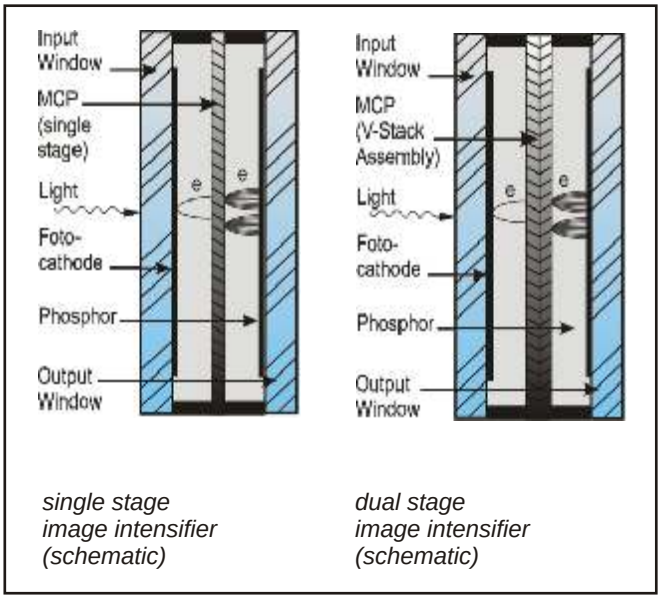
Following questions need to be addressed

- What are the spectral characteristics of the illumination?
  → Does determine the suitable photocathode.
- How fast need to be the shutter/shortest gating time?
  → Highest shutter speed does have some constrains to e.g. size of the image intensifier.
- How much light is there?
  → Dual stage MCP's have better performance at low light environments but 30% less image resolution compared to single stage.
- High speed or low light imaging?
  → Does determine the suitable phosphor screen.



GenII High QE photocathodes
Gen II high Quantum Efficiency photocathodes are providing the best spectral responsibility performance.

We do not use GenIII image intensifiers
because of the following disadvantages:
1. Service life is 50% less than for GenII image intensifier
2. GenIII are much more expensive than GenII
3. GenIII image intensifier have higher dark current
4. There may be more black spots in imaging



single stage image intensifier (schematic)

dual stage image intensifier (schematic)

First the incoming photon releases an electron in the photocathode, second the electron is accelerated and amplified to an electron avalanche within the multi-channel plate (MCP), third the accelerated electrons are converted into photons by the phosphor screen.

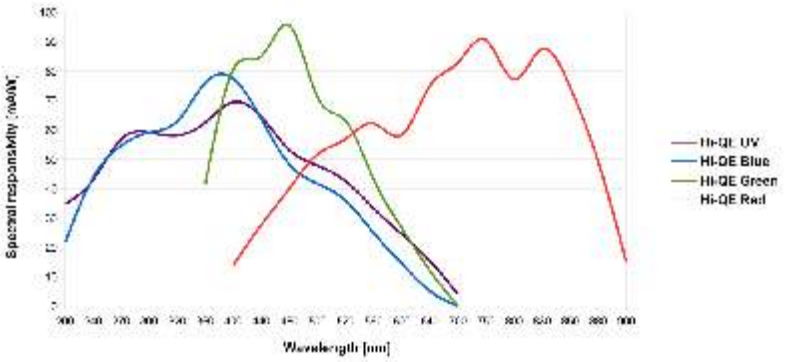
Photocathodes

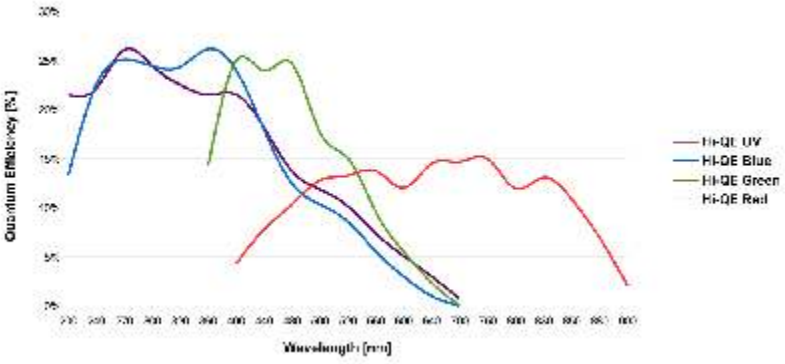
	Type	Spectral range
Standard	High QE UV	approx. 180 - 700nm
Optional	High QE UV, MgF2	approx. 110 - 700nm
	High QE blue	approx. 200 - 700nm
	High QE red	approx. 400 - 900nm
	(*High QE green cancelled in 2021)*	*approx. 360 - 700nm*

Image intensifier specifications

Shutter speed
The shutter speed is limited by the speed of light since any electromagnetic signal does not travel faster.

Input window
The standard input window is made of quartz. This limits the UV spectral range below 200nm. The optional Magnesium Fluoride (MgF2) window enables measurements down to 110nm.





Photocathode
Photocathodes define the sensitivity and the spectral response of the image intensifier.

Phosphor screen
There are three important considerations in choosing a luminous (phosphor) output screen.

1. spectral emission range
2. efficiency
3. phosphor decay time

The P43 phosphor screen has a higher efficiency, however, a longer decay time. For fast applications e.g. double frame mode with interframing time of 500ns the P46 phosphor screen is neccessary to avoid gost images from the previous exposure.

Multi-channel-plate (MCP)
Image intensifiers can be equipped with single or double stage MCP's. The single stage MCP features excellent signal gain and fits most applications of the ultra high speed ICCD cameras.

The V-stacked double MCP's are especially used for extreme low light environments. The increased electron multiplication provide single photon detection with increased signal to noise ratio and reduced ion feedback noise. Therefore, the double MCP is mainly used for long exposure measurements and extreme low light applications

Upper graph: Spectral responsitivity [mAW]
Lower graph: Quantum Efficiency [%]

Phosphor screen

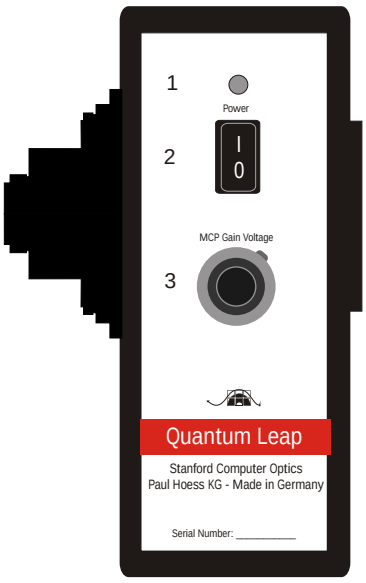
Type	Composition	Efficiency	Decay time		Emission spectral range
			90% to 10%	10% to 1%	
P43	Gd_2O_2S:Tb	185 ph/e @6kV	1.5ms	3.3ms	360 - 680nm
P46	$Y_3Al_5O_{12}$:Ce	90 ph/e @6kV	0.2µs	10µs	490 - 620nm

Micro-channel-plate (MCP)

Type	Electron multiplication	S/N ratio	Notice
Single stage	up to 10^3	very good	best image quality
Double stage	up to 10^6	excellent	highest sensitivity

Connection options

Quantum Leap non gateable and gateable



1 LED signal; green: power on
red: shutter (gate) open
(Quantum Leap busy)

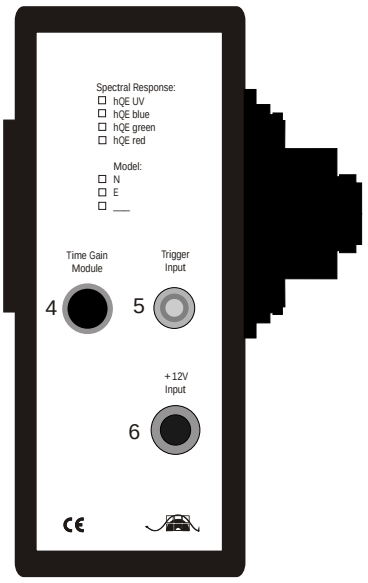
2 Power ON/OFF switch

3 Manual adjustable signal gain;
Manual adjustable resistance to set the the signal gain of the image intensifier by varying the high-voltage MCP gain.

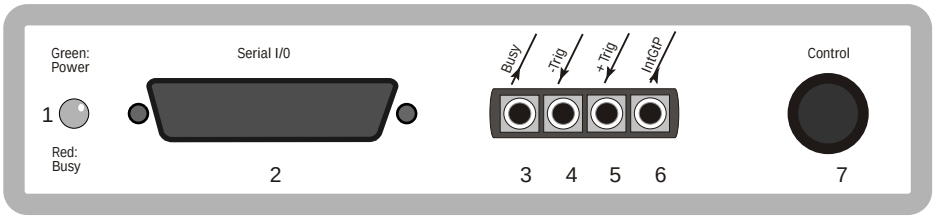
4 Connector of the Time/Gain Module; The link with the Time/Gain Module enables the remote control of the signal gain, gating and delay time

5 TTL input signal;
External TTL signal to control the photocathode gating.

6 Power supply socket;
Supply voltage 12V
approx. 1A without cooling
with cooling approx. 2.5A max.



I/0 Connectors: Time & Gain Module



1 LED
green: Power on
red: shutter (gate) open
(Quantum Leap busy)

2 RS232 interface
RS232 output socket for connection with a PC or Laptop

3 Busy
TTL output signal; this timing circuitry busy signal can be used as an external trigger for a camera or any external instrument.
It is an active low signal.

4 -Trig
TTL input trigger; Input for external trigger on negative edge ±5V, transition at 1.3V.

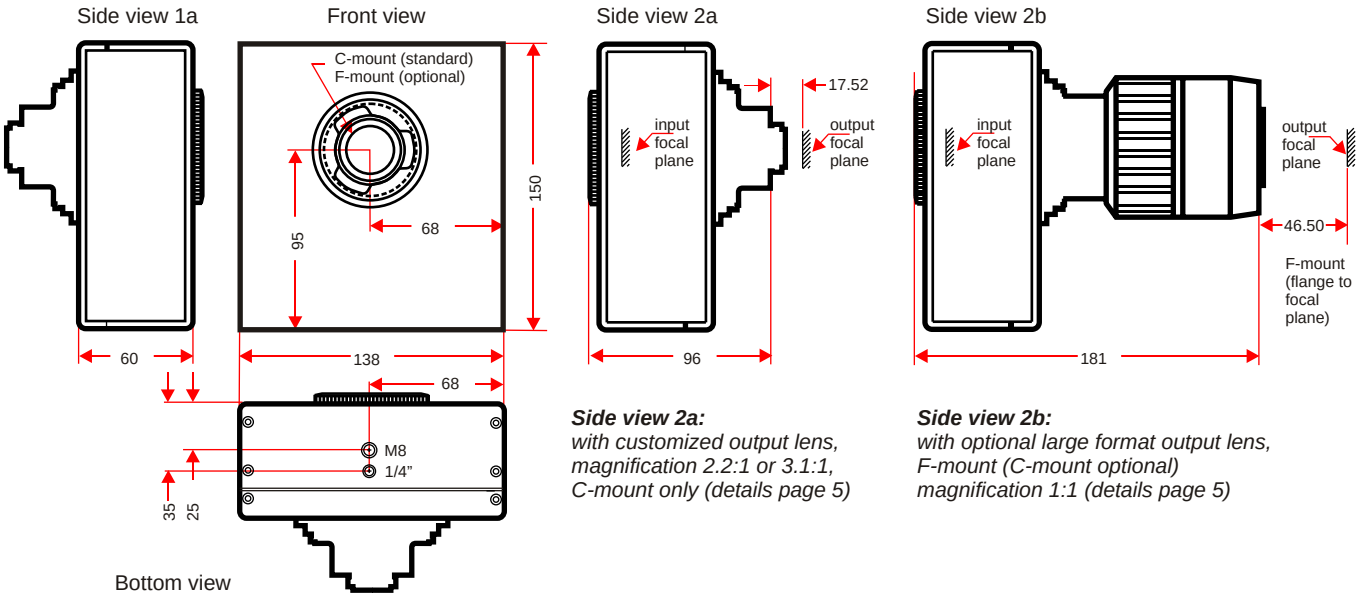
5 +Trig
TTL input trigger; Input for external trigger on positive edge ±5V, transition at 1.3V.

6 IntGtP - TTL output signal
Gate monitor output provides reliable timing information on actual gating occurrence with internal time generator or external gating pulse.

7 Time & Gain output
Output socket for the link with the Quantum Leap

Dimensions

Quantum Leap - compact and light design



Side view 2a:
with customized output lens, magnification 2.2:1 or 3.1:1, C-mount only (details page 5)

Side view 2b:
with optional large format output lens, F-mount (C-mount optional) magnification 1:1 (details page 5)

Mechanical and environmental data

Parameter	Quantum Leap Module (all types)	Time & Gain Module (all types)
Weight (all in one)	1.8kg / 4lb	0.3kg / 1.8lb
Dimensions (camera without lens)	60 x 136 x 150mm (l x w x h)	240 x 140 x 40mm (l x w x h)
Camera mount	1/2" and M8 mounting holes	
Operating humidity	25..95%, non condensing	
Operating temperature	0°C - 50°C / 32°F - 122°F	
Performance specification	10°C - 40°C / 50°F - 104°F	
Operating limits	-10°C - 50°C / 14°F - 122°F	
Shock and vibration	60g accel. shock, 7g Vibration (11 - 200Hz), excludes MCP in direct frontal impact	
Voltage	90..260VAC	

Extended warranty on all products from Stanford Computer Optics

2 years
on mechanics and electronics
Stanford Computer Optics Inc. warrants all new products to be free from defects in materials and workmanship for 24 months from the date of dispatch.

1 year on image intensifier
Image intensifiers are subject to the original manufacturer's warranty conditions. It comprises a warranty of 12 months. In case of any defect the Paul Hoess KG or Stanford Computer Optics Inc. will assist for repair or replacement.

Warranty restriction
Warranties do not cover normal wear, misuse, negligence or accident. They do not apply to goods which have been misused, altered, inadequately maintained, stored incorrectly, or negligently installed or serviced.

Quantum Leap Serie

Customize the optimum Quantum Leap image intensifier module for you application

The Quantum Leap enables the customization to the requirement and needs of your experiment and many detector systems. Please follow the indicated four step process to get the most suiting stand-alone image intensifier module for your application.

Customize your Quantum Leap in 4 steps:
1. Select the required gate operation
2. Select the optimum image intensifier
3. Choose the ideal output coupling lens
4. Pick the required accessories

1. Gate operation

Choose the required gate operation for your experiment.

Gateable down to 1.2ns:
This gating time provides superior images in combination with high speed video cameras.

Gateable down to 0.2ns:
The fastest shutter is available for research on ultra high speed physical phenomena.

Gateable down to 0.4ns:
With 2MHz continuous optical shutter repetition rate.

2. Image intensifier

2.1. Photocathode
- standard: high QE UV
- optional: high QE blue
  high QE red
  (more details page 7)
  (high QE green cancelled)
- input window: quartz
  or MgF2 on request

2.2. Multi-channel plate (MCP)
- standard: single stage
- optional: dual stage

2.3. Phosphor screen
- standard: P43
- optional: P46
  (requested for 500ns fast dual frame mode)

3. Coupling lens

The output coupling lens is the optical link between the image intensifier and the detector system.
Choose the optimal coupling lens for best imaging quality and optimal sensor coverage.
See details on page 5.

Please contact our sales team to get assistance and further details to these options.

4. Selection of optional accessories and adapters

Item-No.	Name of product	Description
TG-...	Time & Gain Module	TGN (min. gate time 1.2ns) TGE (min. gate time 0.2ns) TGMHz (min. Gate time 0.4ns)
LMA-...	lens mount adapter	selection of adapter for various lens mount systems (e.g. F-mount) providing full aperture and reduced stray light by black anodized aluminum
SGA-...	spectrograph adapter	selection of adapter for some spectrograph manufacturer standard Zolix, optional: e.g. Acton, Horiba and Jobin Yvon, on request
VF	vacuum flange	customized flange to connect the ICCD camera to any vacuum tube
SMB-BNC	SMB-BNC	SMB - BNC adapter (12cm standard), other length on request

Applications

Quantum Leap intensifier module provides user-friendly intensified imaging for applications in many different fields of research

Velocity map imaging
e.g. by H. S. Chung, et al., from the Seoul National University, Korea: J. Chem. Phys., Vol. 114, 2001

Raman line imaging
e.g. by C. R. Howle, et al., from the Defence Science and Technology Lab, United Kingdom: Proc. SPIE 7116, Optically Based Biological and Chemical Detection for Defence IV, 2008

Photodissociation dynamics
e.g. by K. S. Lee, from the Advanced Institute of Science and Technology, Korea: The Journal of Chemical Physics, Vol. 122, 2005

Adaptive optics
e.g. D. L. McKenna, et al. from the Steward Observatory, United States: Proc. SPIE 4839, Adaptive Optical System Technologies II, 2003

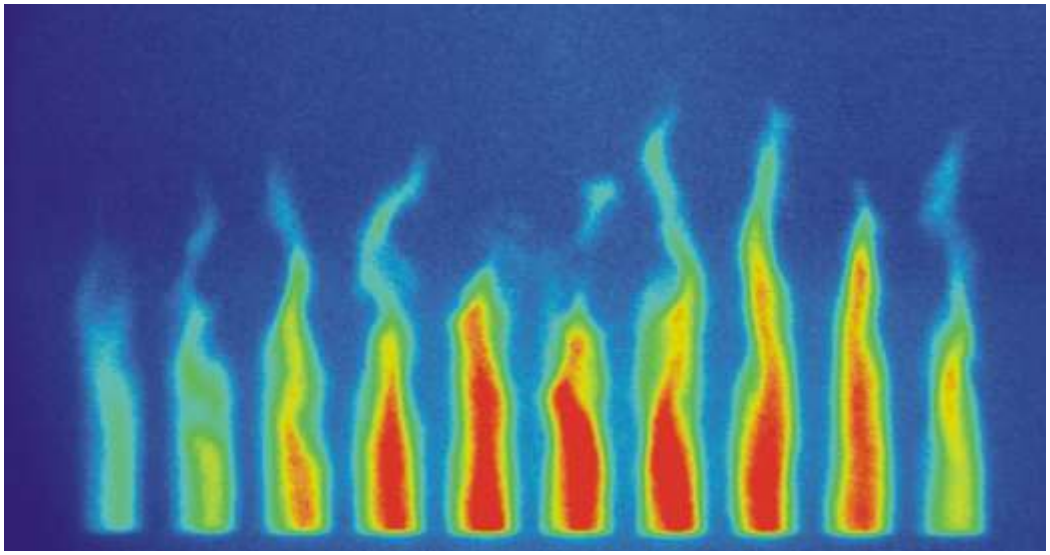


Image sequence with 1 million frames per second (fps) using a rotating mirror high speed camera.

S. Kirner from the Universität der Bundeswehr in Munich used the stand-alone image intensifier module, Quantum Leap, to construct a rotating mirror ultra-high speed camera which enables image sequences of up to 1 million fps.

Image sequence of the Triplex-plasma source taken with a corresponding frame rate of 1 million frames per second. The image of the plasma source was moved along the image intensifier using a rotating mirror. The Quantum Leap provides 10 shutter openings with 1MHz repetition rate. The triplex-plasma source is a multi cathode plasma source which ensures the independent formation of multiple electric arcs and a steady plasma. Figure reprinted with permission of the Universität der Bundeswehr in Munich.

Designed for high speed video cameras

The Quantum Leap image intensifier module is specially designed for the usage in combination with a high speed video cameras. This combination ensures sharp and clear images of ultra fast processes like hyper-velocity impacts.
Outstanding imaging quality can be achieved with the stand-alone image intensifier, Quantum Leap. It amplifies the incoming light signal so that the shutter (gate) time can be reduced to overcome any image smear or blur. Furthermore, the highly accurate timing control of the Quantum Leap allows the precise synchronization of the high speed shutter with external devices like Lasers.

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Superior imaging intensified CCD cameras

Quantum Leap

The modular high speed image intensifier module for continuous or gated operation

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