STANFORD COMPUTER OPTICS

2014

Product Catalog

ICCD cameras
(intensified CCD cameras)

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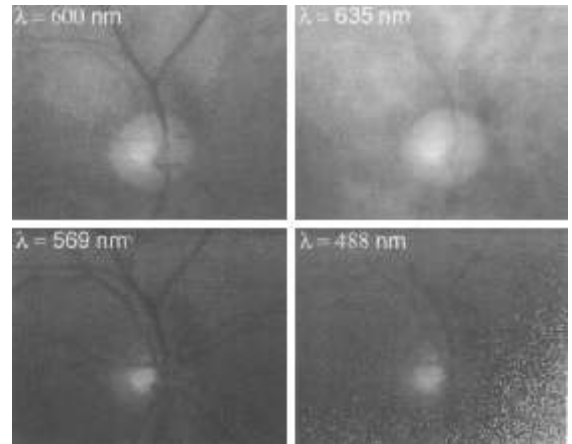
*A typical set of images taken with the retinal oximeter using ultra high speed ICCD cameras.
This technique enables measurements of oxygen saturation in retinal vessels of the human eye.*

Retinal oximeter with the ICCD camera 4 Picos at the top.

Both images with permission from M. Crittin et al, Klin Monatsbl Augenheilkd 2002; 219:289–91.

More information about applications

Stanford Computer Optics, Inc. and Paul Hoess KG

Based on more than 20 years of experience in the development and progression of world-class, ultra high speed Intensified CCD (ICCD) cameras, Stanford Computer Optics sets new standards with superior intensified imaging technology.

The products from Stanford Computer Optics cover the complete range of intensified imaging. All-in-one-head ICCD cameras with high speed shutter systems providing gating times down to the picosecond regime.

In 2003, the ultra high speed framing camera, XXRapidFrame, was introduced to our customers. This multi-channel camera is currently available with up to eight independent controllable channels based on the 4 Picos or 4 Quik E ICCD camera technology.

The image intensifier module, Quantum Leap, is designed to enhance any experimental setup with intensified imaging capabilities.

Additionally to the hardware, Stanford Computer Optics offers the 4 Spec E software providing camera control, imaging and spectroscopy solutions and an optional LabView API.

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4 Picos and 4 Quik E

Ultra high speed intensified CCD cameras providing gating times of 0.2ns and 1.2ns

The 4 Picos and 4 Quik E ICCD cameras contain the very best from CCD sensor and gated image intensifier technologies. They achieve a superior combination of rapid acquisition rates and ultra-high sensitivity down to single photons. Exceptional detection performances are accessed through high quantum-efficiency (QE) image intensifiers, up to 3.3MHz photocathode gating rates.

Extreme low jitter, low insertion delay gating electronics and picosecond-scale optical gating provide excellent timing accuracy, allowing ultra-precise synchronisation of complex experiments through 4 Picos and 4 Quik E ICCD camera series

ICCD camera technology

Standard features and benefits
  of 4 Picos ICCD camera
- 200 picosecond fastest gating time
- Gating time adjustable in 10ps steps
- Jitter <10ps

  of 4 Quik E ICCD camera
- 1.2 nanosecond fastest gating time
- Gating time adjustable in 100ps steps
- Jitter <20ps

General features and benefits
  of both ICCD cameras
- Compact, all-in-one-head design
- True optical flat top measurement
- High resolution image intensifier
  Image area 18mm: 14.4 x 10.8mm;
  Image area 25mm: 20 x 15mm
- Various photocathode options:
  (detailed information on pages 10 and 11)
- Customized 6-element f/0.8 relay coupling lens assures distortion free, vignetting free and honeycomb free imaging
- Digital output: USB 2.0 or
  CameraLink with frame grabber
- Highest gating repetition rate
  200kHz continuous, 3.3MHz burst
- Free programmable gating sequence
- Real-time remote control of all camera parameter
- Incorporated Single Trigger Discriminator (STD)
- Multiple gate repetition delay time 0.3μs
- 12V D/C power supply with cables
- Weight: 3kg (all in one head)
- Dimensions: 248 x 110 x 135mm (l x w x h)

Optional features
- 3MHz continuous photocathode gating
- Dual stage multi-channel plate (MCP) for highest S/N ratio and single photon detection
- Double frame with 500ns interframing delay
- Analog CCD sensor providing 50/60Hz frame rate
- Choice of adapters for different lens mount systems
- Choice of adapters for all major spectrograph manufacturers

Applications
- Non scanning 3D laser scanner
- Ultra high speed lightning dynamics
- Fluoreszenz lifetime measurements
- Exponential decay measurements
- Combustion dynamics
- Time resolved spectroscopy

> **Note**
> The intensified CCD cameras do not need active cooling.
> Only measurements with very long exposure times need active cooling to increase S/R.

On request for very long integration times
- Regulated Peltier cooling of CCD sensor to 14°C for integration times above 100ms.
  Total encapsulated cooling system with no condensation and no need for vacuum or special

High speed ICCD camera specifications

Description	4 Picos	4 Quik E
Shortest gating time	0.2ns	1.2ns
Minimum delay steps	0.01ns steps	0.1ns steps
Image intensifier size	standard 18mm, optional 25mm	
Gate repetition rate	3.3MHz burst, 200kHz continuous; optional: 3MHz continuous	
Multiple exposures	free programmable sequence, min step 0.3µs	
Photocathode spectral range	110 - 1300nm (not all in one, please see page 11 for more information)	
Frame rate frames/sec	up to 60fps	
Optical coupling	customized, distortion free, shading free, and vignetting free F/0.8 lens	
Active pixels	high resolution (HR): 1360 x 1024 pixel standard resolution (SR): 782 x 582 pixel	
Digitization	standard: 12bit, optional: 14bit	
Delay and gate electronics	all integrated in the head (all in one)	
Weight / Dimensions	3kg; 6.6lb / 248 x 110 x 135mm	

Delay generator specifications

Description	4 Picos	4 Quik E
Gate pulse adjustable Software controlled	from 200ps to 80s in 10ps steps	from 1.2ns to 80s in 100ps steps
Gate delay adjustable Software controlled	from 0 to 80s in 10ps steps	from 0 to 80s in 100ps steps
Jitter	<10ps	<20ps
Trigger input	camera trigger neg/pos slope TTL pulse (-Trig/+Trig)	
External gate pulse	TTL input signal for direct control of photocathode gating (ExtGtP)	
Trigger output	multiple TTL output signals for synchronisation (Fsync, CCD-Busy) TTL output signal of photocathode gating pulse (IntGtP)	
Multiple exposures modes	double frame mode (two frames in 500ns interframing delay) multiple gating on single trigger multiple gating on multiple trigger free programmable gating sequence	
Trigger propagation delay	internal gate pulse: 60-65ns external gate pulse: 30-35ns	

Camera options

Description	digital HR	digital SR	analog EIA	analog CCIR
Active pixel	1360 x 1024	782 x 582	768 x 494	752 x 582
Pixel size	4.7 x x4.7µm	8.3 x 8.3µm	8.4 x 9.8µm	8.6 x 8.3µm
Digitization	12bit / 14bit	12bit / 14bit	8bit / 10bit	8bit / 10bit
Binning	Full / 2x2 / ROI	Full / 2x2 / ROI	-	-
Scan mode	field/frame, selectable through remote control			

4 Picos and 4 Quik E

Customize the optimum 4 Picos or 4 Quik E for your application

The 4 Picos ICCD camera enables the customization to the requirement and needs of your experiment. This guarantees best performance in combination with superior intensified imaging. Please follow the indicated four step process to get the best and most suiting ICCD camera for your application.

Customize the 4 Picos camera in 4 steps:

1. Select the minimum gating time
2. Select the optimum image intensifier
3. Choose the ideal CCD sensor
4. Pick the required accessories

1. Minimum gate time

200ps

the 4 Picos is the "ICCD camera of your choice".

1.2ns
4 Quik E is the "ICCD camera of your choice".

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

2. Image intensifier

2.1. Diameter
- 18mm or
- 25mm

2.2. Photocathode
- S20 (I) or S25 (II)
- others on request
- input window: quartz or MgF2 on request

2.3. Multi-channel plate (MCP)
- single or
- dual stage (optional)

2.4. Phosphor screen
- P43 standard
- P46 optional (for dual frame mode)

3. CCD sensor and camera connection

3.1. Digital
- with USB 2.0 or
- CameraLink (with frame grabber)

3.1.1. Resolution of CCD sensor
- standard resolution: 780 x 580 pixel
- high resolution: 1360 x 1024 pixel

3.1.2. Dynamic range of CCD sensor
- 12bit or
- 14bit

3.2. Analog
with frame grabber
- 25/50Hz (EIA) or
- 30/60Hz (CCIR)

4. Selection of optional accessories and adapters

Item-No.	Name of product	Description
LA-LMA-...	lens mount adapter	selection of adapter for various lens mount systems (e.g. F-mount, EOS) providing full aperture and reduced stray light by black anodized aluminum
LA-SGA-...	spectrograph adapter	selection of adapter for all common spectrograph manufacturer e.g. Acton, Horiba and Jobin Yvon, others on request
LA-VF	vacuum flange	customized flange to connect the ICCD camera to any vacuum tube
LA-SMB-BNC	SMB-BNC	SMB - BNC adapter cables in any length
LA-IOL-...	input objective lens	various input objective lenses e.g. Pentax UV lens 25mm, F2.8-16; Pentax UV lens 78mm, F3.8-16F3.8-1, others on request

XXRapid Frame

The ultra high speed framing camera is a multi-channel system based on 4 Picos or 4 Quik E ICCD cameras

The **XXRapidFrame** is a framing camera with up to eight ICCD channels.
The all-in-one-head design enables out of the box measurements and includes a single optical input, an image splitter unit and up to eight individually controllable channels.
It is available based on the 4 Picos or on the 4 Quik E ICCD camera technology with the shortest gating time down to 0.2ns and 1.2ns, respectively. The framing camera can take up to 8 images with an interframing delay as short as 10ps and 100ps, respectively.
This enables successive image sequences taken with a corresponding frame rate of up to 100 billion frames per second.
The custom optical design provides superior imaging without compromising resolution, shading, distortion or parallax. The mirror image splitter design ensures a constant intensity division over the entire spectral range. The optional UV enhanced splitting optics enables measurements from 200nm to 1300nm (limited by the photocathode).

Standard Features and Benefits
- Multi-channel ICCD camera with 2, 3, 4, 6, or 8 individual intensified CCD channels
- Based either on 4 Picos or 4 Quik E camera technology
- Total of 2, 3, 4, 6, or 8 frames from one trigger
- Image sequences with up to 100 billion fps
- Trigger options: TTL, 100V or optical fiber
- Perfectly spectral flat image splitter
- Compact design: 625 x 325 x 375mm (body only)

Optional Features
- UV enhanced splitting optics from 200nm - 1300nm
- Total of 4, 6, 8, 12, or 16 frames from one trigger using double fra...

Specifications of XXRapidFrame

Parameter	based on 4 Picos technology	based on 4 Quik E technology
Shortest gating time	200ps	1.2ns
Minimum delay steps	10ps steps	100ps steps
Image intensifier size	standard: 18mm, optional: 25mm	
Spectral sensitivity	standard: 380 - 1300nm (limited by splitting optic) optional: 200 - 1300nm (UV enhanced splitting optic) **Note:** the system sensitivity is limited by the photocathode (see page 11)	
Delay and gate electronics	all integrated in the body (all in one)	
Dimensions (without objective lens)	3-channels: 625 x 325 x 325mm (body only) 2, 4, 6, 8 channels: 625 x 325 x 375mm (body only)	
Weight	2, 3, 4, 6, 8-channel system (kg/lb): 29/63.9, 32/70.5, 35/77.2, 39/86.0, 43/94.8	

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Quantum Leap

Stand alone intensifier module, upgrade your setup to an intensified imaging system

The Quantum Leap is available as non-gateable or gateable version, where the gateable Quantum Leap provides a minimal gating time of either 200ps or 1.2ns. All gateable Quantum Leap models can be remotely controlled with a Time & Gain module. The compact design of all Quantum Leap models hosts all necessary parts for operation. All Quantum Leap models need only a 12V DC power supply and a RS232 connection for remote parameter control.

Standard Features and Benefits

- Stand alone intensifier module
- Standard 18mm, optional 25mm image intensifier
- Available as non-gateable or gateable version with various shutter speeds
- C-mount input lens connector
- C-mount output camera connector
- Output lens for 1/2" and 2/3" CCD sensors
- Gain control: analog controlled with precision-step potentiometer
- Voltage: 12V ±5% Power requirement: 400mA
- Compact design: 70 x 120 x 140mm (l x w x h)

Optional Features

- 3MHz continuous photocathode gating
- Nikon makro output lens for sensor size up to 25mm

Accessories

- Time & Gain Module (TG)
  Programmable control parameter entry via RS 232 (digital set up) remote control software
  TGE: gate times 200ps - DC
  TGN: gate times 1.2ns - DC
- Various lens mount adapters or adapters to join devices like spectrographs or microscopes on request

❑ Specifications

Description	Quantum Leap	Quantum Leap E	Quantum Leap N
Shortest gate time	non gateable	down to 200ps	down to 1.2ns
Gating control	not applicable	TTL pulse (standard) remote with Time & Gain Module (optional)	
Optical input	C-mount (standard); F-mount or others (optional)		
Image intensifier diameter	18mm (standard); 25mm (optional)		
Coupling lens	customized coupling lens, image size 1/2" (standard) Nikon makro lens, image size up to 18 or 25mm (optional)		
Optical output	C-mount (standard), F-mount (optional in combination with Nikon output lens)		
Weight / dimensions QL	1.8kg, 4lb / 60 x 236 x 150mm		
Weight / dimensions TG	0.3kg, 1.8lb / 240 x 140 x 40mm		

4 Spec E software

4 Spec E provides the perfect tools for ICCD camera operation: camera control, image editor, spectroscopy analysis and data handling

Standard Features and Benefits
- Camera control, image editor, spectroscopic analysis and data handling
- Fastest acquisition of spectra
- Dynamic range up to 32bit
- Real time sequence to hard disk
- Data import/export curves as text, raw data, TIFF file, BMP file

Optional Features
- LabVIEW API

Camera control
The camera control interface of the 4 Spec E software provides a comfortable and intuitive interface for the remote control of all ICCD cameras from Stanford Computer Optics.
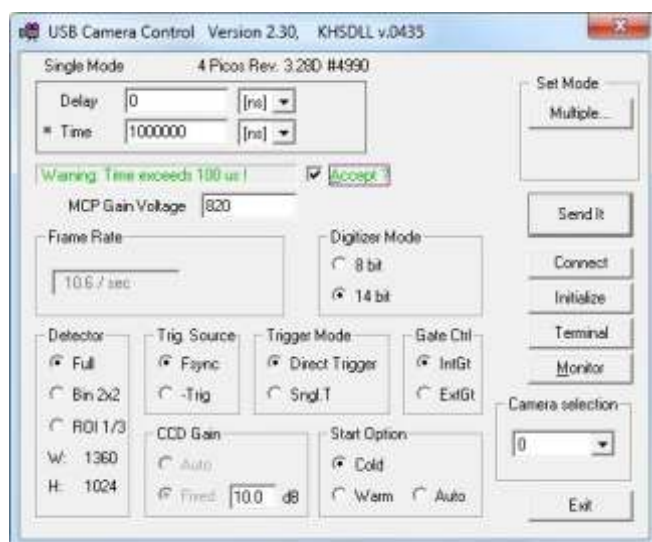

Image editor
The image editor gives direct access to the acquired images and allows basic image correction like background subtraction and flat field correction.

Spectroscopy analysis
4 Spec E software provides extended functions for spectroscopy applications. It enables the spectrum extraction from the 2D raw images, the spectrum handling and calibration. Moreover it provides multiple tools for data presentation and storage.
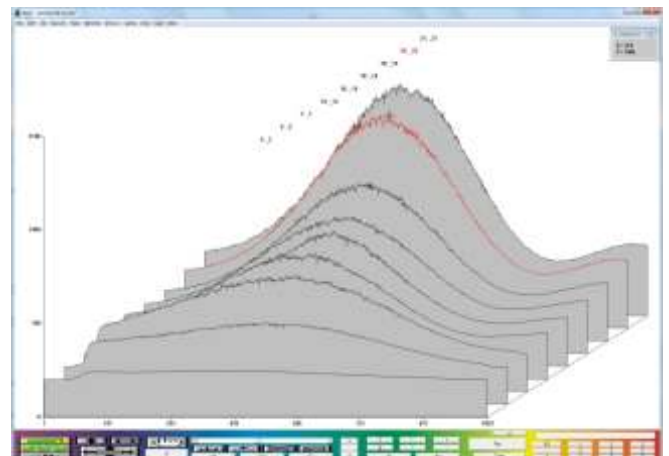
LabVIEW API for 4 Spec E
A LabVIEW API is available optionally to the 4 Spec E software. It is not a stand alone solution and uses the 4 Spec E basis. With this API the user gain full control of the ICCD camera within the LabVIEW environment.

4 Spec E software

Item-No.	Name of product	Description
LA-4SpecE	4 Spec E, Version 2.2	camera control, image-data acquisition and video spectroscopy software for the PC. Intel Pentium® or subsequent, Microsoft® Windows XP, Vista, Windows 7 (x32, x64 Version)
LA-LV	LabVIEW API	the LabVIEW API is no stand alone solution and uses the 4 Spec E basis for full control of the ICCD camera.

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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 illumination?
  → Does determine the suitable photocathode.

- What spatial resolution is neccessary?
  → Does determine the size of the image intensifier.

- 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.

- High speed or low light imaging?
  → Does determine the suitable phosphor screen.

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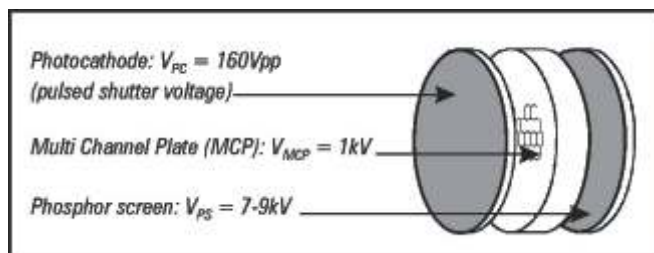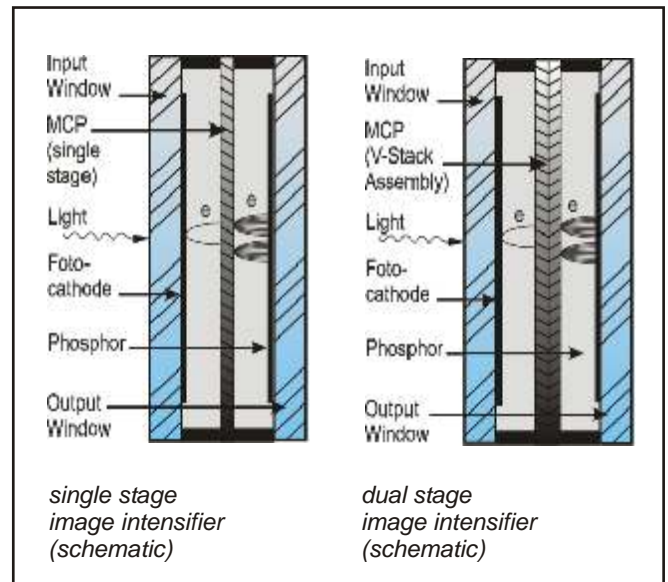
First the incoming photon releases an electron in the photocathode, second the electron is accelerated and amplified to an electron avalanche within the multi-channel plate (MCP), third the accelerated electrons are converted into photons by the phosphor screen.

Photocathodes

	Type	Nb		Spectra range
Standard	S20	■ I	UV - VIS	approx. 165 - 820nm
	S25	■ II	VIS - IR	approx. 350 - 920nm
Optional	S20 (MgF2)	■ III	UV - VIS	approx. 110 - 820nm
	Broadband	■ IV	UV - IR	approx. 190 - 920nm
	Solar Blind	■ V	UV	approx. 180 - 340nm
	S1	■ VI	IR	approx. 700 - 1300nm

Image intensifier specifications

Diameter

The diameter of the image intensifier is one key parameter. The 18mm image intensifier provides high shutter speed and a higher specific resolution than the 25mm image intensifier. This makes the 18mm image intensifier to the standard and most suitable to many applications of ICCD cameras. If you are looking for the best spatial resolution with the drawback of slower shutter speeds the 25mm image intensifier is the preferred choice.

Shutter speed

The shutter speed is limited by the speed of light since any electromagnetic signal does not travel faster. Due to this physical constraint the shutter of the 25mm image intensifier is slower.

Input window

The standard input window is made of quartz. This limits the UV spectral range below 165nm. The optional Magnesium Fluoride (MgF2) window enables measurements down to 110nm.
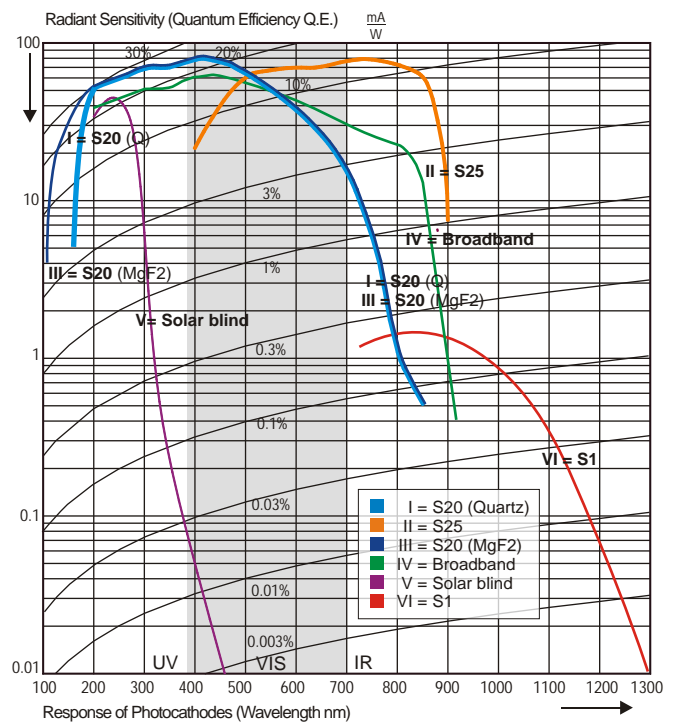
Photocathode

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.

Radiant Sensitivity (Quantum Efficiency Q.E.) $\frac{mA}{W}$
Response of Photocathodes (Wavelength nm)

I = S20 (Quartz)
II = S25
III = S20 (MgF2)
IV = Broadband
V = Solar blind
VI = S1

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

Phosphor screen

Type	Composition	Efficiency	Decay time 90% to 10%	10% to 1%	Emission spectral range
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

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