

Ultra fast ICCD cameras

STANFORD | **COMPUTER** | OPTICS

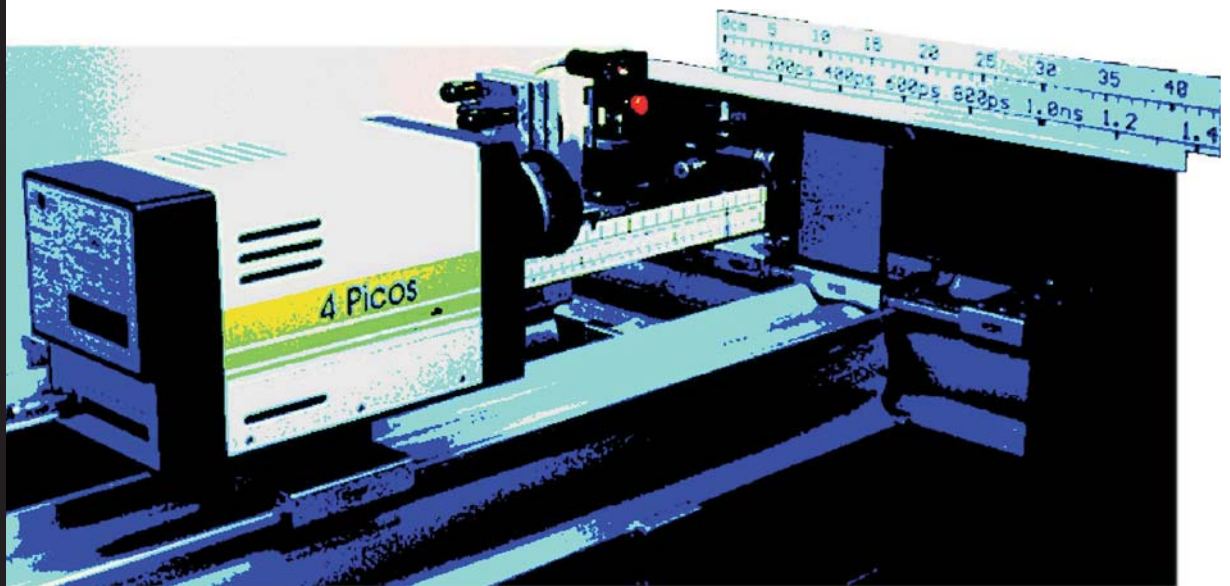


4 Picos

0.2ns gate time

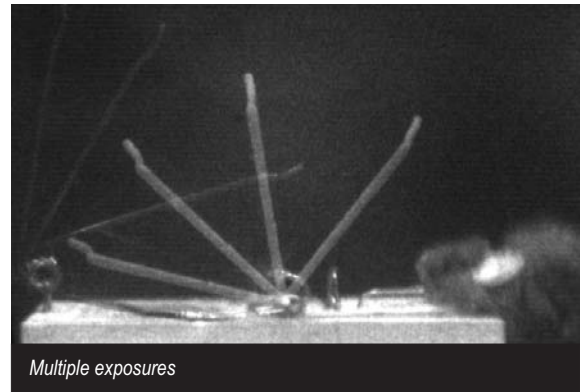
4 Quik E

1.2ns gate time



Top standard Features

- ◆ The very high system integration of **4 Picos/4 Quik E** permits small physical size of the total unit (all gate and delay electronics in one head) - even very difficult applications with space constraint are mastered easily by remote control.
- ◆ Programmable control parameter entry via RS 232 (digital set up CameraLink or USB 2.0), remote control software included
- ◆ The **4 Picos/4 Quik E** is a true digitally controlled camera making it ideal not only for laboratory use, but also for those applications where an operator does not have easy access, e.g., wind tunnels, combustion analysis, PIV, underwater imaging, airborne situations, astronomy, test cells or any environment hostile to personnel, etc.
- ◆ The **4 Picos/4 Quik E** functions in any possible trigger or synchronization mode. Standard outputs include signals to: Synchronize a frame grabber; synchronize external devices (F_{Sync}); and control an auto Iris. In addition, an input is provided for resetting the CCD detector (V_{Init}).
- ◆ The **4 Picos/4 Quik E** is totally self-contained. It contains its own RISC CPU and pulse generator module. Controls for setting the shutter speed, and delay, single or multiple exposure, MCP gain, video gain, video output live, video sync and integration input are remotely programmed through a RS 232 connection to any computer.
- ◆ A Single Trigger Discriminator (STD) is incorporated into the camera. This feature allows user to reject any number of unwanted, extraneous trigger signals per field or frame.
- ◆ The **4 Picos/4 Quik E** operates in the following exposure modes: Free run; independent triggered operation; single trigger or multiple exposure configuration; as a master clock or controller whereby it controls or triggers external events.
- ◆ **4 Picos/4 Quik E** has an advanced programmable Multiple Exposure feature for high speed sequential video imaging, variable within a single video frame. On 'multiple exposure' the minimum time between exposures may be as short as $0.3\mu s$; i.e. 3.3MHz in burst mode; 200kHz in continuous operation. **New 10MHz model optional** (o.1 μs).
- ◆ Adaptation to in situ light level variations by internal digital programmable brightness control of the electronic shutter action, with exact reproducible digital setting of delay and exposure times.
- ◆ Double Frame mode with 500ns interframe time.

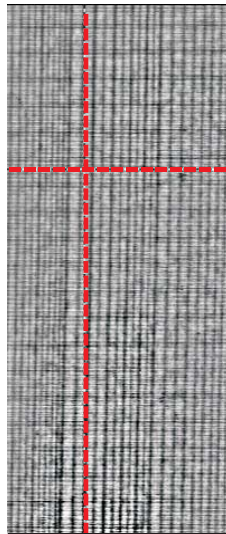


Standard Features	4 Picos	4 Quik E/01-18
Shortest gating time	0.2ns	1.2ns
Gate Pulse /Multiple Exposure with CPU	min steps 10ps	min steps 100ps
Multiple exposures, "dead" time between exposures	any sequence, min $0.3\mu s$, 0.1 μs optional	
Gate repetition rate	3.3MHz burst, 200kHz continuous; 10MHz optional	
Adaptation	C-Mount	
Optical input	C-Mount (standard); Nikon F-Mount adapters (optional)	
Power requirement	10W, with cooling 20W	
Voltage	12V +12%/-2%, 120 - 240V/50 - 60Hz	
Delay and Gate Electronics	All integrated in the Head (all in one)	
Dimensions	248(l) x 110(w) x 135(h) mm, without objective lens	
Weight	3kg, without objective lense	
CE	Yes	
RoHS compliant	Yes	

Top standard Features

Relay Lens Coupling Phosphor → CCD

- ◆ The special 6-element f/0.8 optical coupling lens provides absolutely distortion-free imaging with a 23% coupling efficiency.
- ◆ The highest resolution is 180lp/mm.
- ◆ Distortion free imaging due to advanced proximity focused MCP (Micro Channel Plate) image intensifier and use of highest quality CCD array for best sensitivity and resolution.
- ◆ This makes the 4 Picos/4 Quik E unique and ideal for pixel-by-pixel image analysis, spectroscopy, and other highly demanding applications.
- ◆ Any geometric distortions of the image such as those introduced by fiber optic coupling simply are not generated. Distortion free: no gross distortion, no shear distortion, no sudden dislocations in the alignment of adjacent fibers need to be corrected by any software.
- ◆ Detector cooling is thus made simple and more efficient by lens coupling due to reduced mass to be cooled (i.e., no fiber optic).

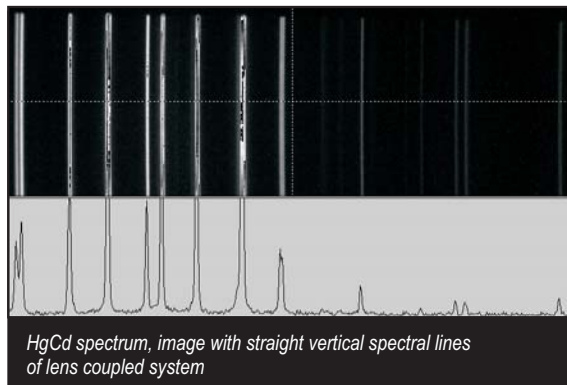


"Absorption spectrum" of fiber coupled system, deviation from straight vertical line more than 10 pixels

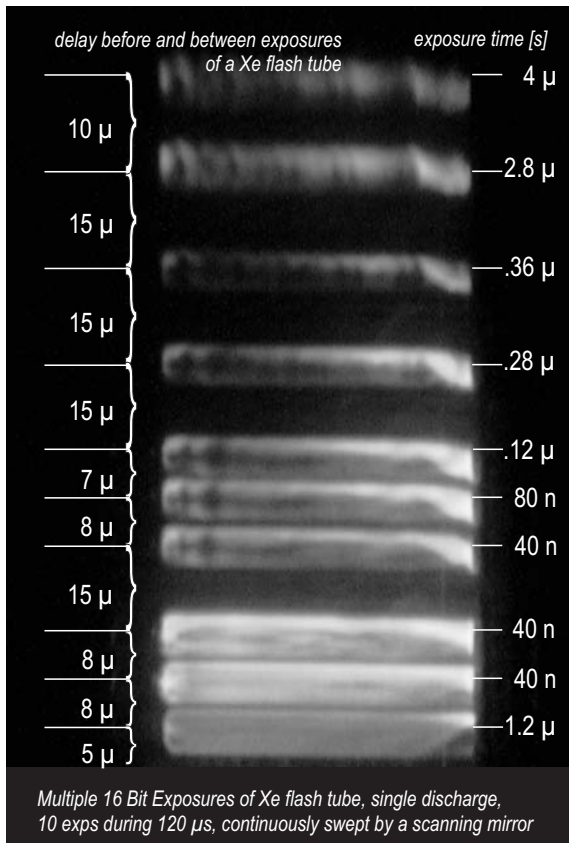
Adjustable exposure times during multiple exposure sequences provide an extension of the dynamic range by more than a factor of 1.000 (equivalent to 10 bit). Thus the total dynamic range in a single video frame can represent more than 24 bit.

Optional Features

- ◆ Effortless Image/Data storage and retrieve via system interface RS170 to an external VCR (standard), frame grabber or optical disk (optional).
- ◆ Regulated Peltier Cooling of CCD unit to 14°C to minimize dark current by a factor of 10 for exposure times above 100ms. Provides single photon sensitivity.
- ◆ Adaptations for Nikon F-Mount, Spectrographs, and Monochromator mounts. Special adaptations on request
- ◆ Automatic Exposure Control and Automatic Gain, for varying light conditions. The Auto Exposure operates from 1 μ Lx (overcast night sky) to 10⁵Lx (bright sunlight sky) without any mechanical interaction. Available for analog cameras only.



HgCd spectrum, image with straight vertical spectral lines of lens coupled system



Multiple 16 Bit Exposures of Xe flash tube, single discharge, 10 exps during 120 μ s, continuously swept by a scanning mirror

4 Picos / 4 Quik E



Ultra fast



Shutter control

A novel coupling network design transmits the ultra fast electrical pulses to the photo cathode.

The 200ps shortest gate time of the newly developed amplifier Pulse E can thus be applied with conventional circuitry.

The advanced, digitally controlled shutter delay feature is the perfect match for your laser, range gating, flow analysis, or many other ultra fast applications.

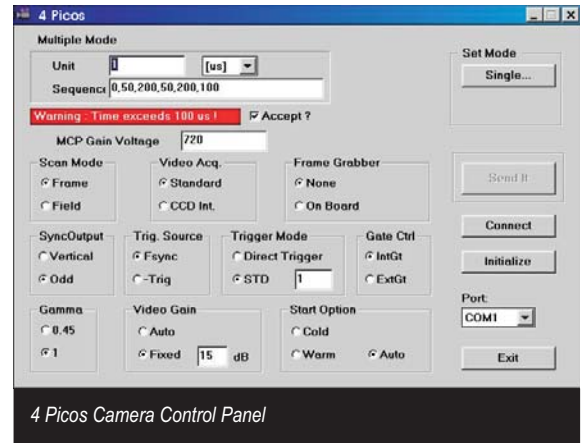
It is operational in 'scattered light environments, underwater or for highest speed multi-instrument sequential image acquisition. Multiple direct images with a repetition/delay time setting as short as 0.3µs can be synchronized with ease to any external TTL source.

Finally, the 4 Picos and the 4 Quik E represents the dramatically enhanced output of our continuously ongoing research and development efforts.

Highest Dynamic Range

Our special signal conditioning technique provides a dynamic range with a 16bit theoretical limit. The digitizing steps are corresponding to \sqrt{N} of the numbers of photons. They are the perfect match to the signal's inherent 'width of the error bar'.

In practice the chips' full well capacity limits the dynamic range to 14bits. With Stanford Computer Optics 4 Spec E spectroscopy software up to 21bit.



Internal Exposure Control	4 Picos	4 Quik E/01-18
Time (t_s) and delay (t_b) of the gate pulse, or multiple exposures with CPU internally digital programmable	$t_s = 0.2\text{ns} \dots 80\text{s}$ min steps 10ps $t_b = 0..80\text{s}$, min steps 10ps	$t_s = 1.2\text{ns} \dots 80\text{s}$ min steps 100ps $t_b = 0..80\text{s}$, min steps 100ps
Trigger propagation delay	60 - 65ns, less than 0.01ns jitter	
Initializing	-Trig, +Trig, or FSync	
Multiple Exposure	any sequence, 0.3µs "dead time" between exposure 0.1µs optional (10MHz model, optional)	

External Exposure Control	4 Picos	4 Quik E/01-18
Control of the camera internal Pulse E amplifier via ExtGtP (TTL Pulse) input: shutter continuous	$t_s = 0.2\text{ns} \dots \text{DC}$, $t_b = \text{DC}$ t_s, t_b determined by external device	$t_s = 1.2\text{ns} \dots \text{DC}$, $t_b = \text{DC}$
Trigger Propagation delay	30 - 35ns, no jitter	

Automatic Exposure Control	4 Picos	4 Quik E/01-18
Pixel by pixel exposure analysis providing automatic light level control by instantaneous adjustment of camera shutter speed and intensifier gain for very wide range of lighting conditions (up to 12 orders of magnitude)	0.2ns ... 15 (18)ms shutter time and MCP gain automatically adjusted in response to scene illumination	1.2ns ... 15 (18)ms

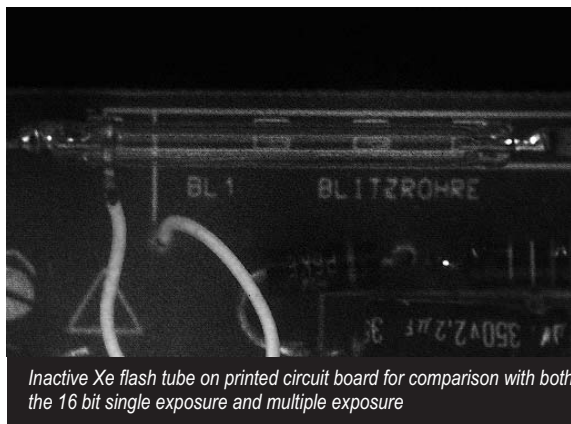
CCD video unit

4 Picos and 4 Quik E with interline transfer CCD module can be asynchronously reset in less than 1 μ s, it is triggered by external TTL level pulse.

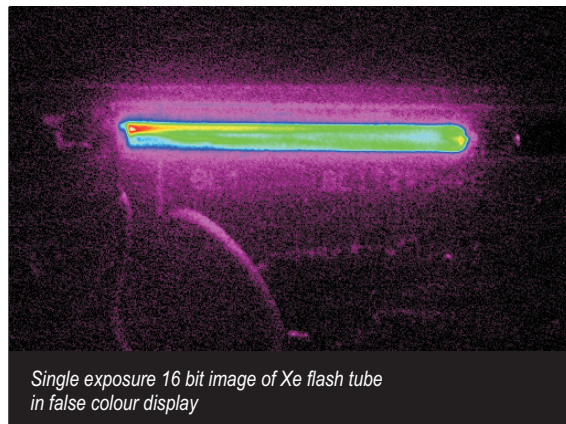
Thus, high repetition rate double frame exposures are possible. Fast double frame exposure mode is available with all digital models and progressive scan analog CCD chip.

Digital or Analog output

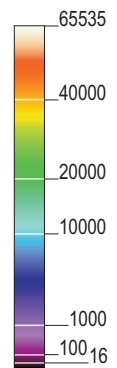
CCD Video Chip	Digital Output		Analog Output	
	Standard Res. CCD	High Res.CCD	Japan, USA	Elsewhere
Output	12bit / 14bit	12bit / 14bit	EIA	CCIR
Resolution H x V (pixel)	780 x 580	1360 x 1024	768 x 494	752 x 582
Pixel Size (μ m)	8.3 x 8.3	4.7 x 4.7	8.4 x 9.8	8.6 x 8.3
Frame Rate (fps) (digital)	12bit / 14bit 33.8/60.8/67.0fps	12bit / 14bit 10.6/17.9/20.9fps		
Image Frequency (analog)		30/60Hz	25/50Hz	
Video Gain	1x1, ROI: 0..20db, 2x2:0..25db		Automatic or manually adjustable via computer RS232	
On chip binning	1x1 (full frame), 2x2 (Binning), ROI			
Binning (horizontal/vertical)	software (spectrum with all lines integrated)			
Output	standard: CameraLink, optional: USB 2.0		1VPP (75 Ω), composite video, either EIA or CCIR	
Gamma			1 or .45, selectable through computer RS232 interface	
Image Sensor	ICX..AL			
Readout	Correlated double sampling, dark current corrected			
Scan Mode	Field/Frame, selectable through computer RS 232 interface ICCD camera 4 Picos or 4 Quik E may be Genlocked or supply Fsync pulse to operate as master clock			
Internal Synchronization	Free run mode			
Dynamic Range A/D	14bit, up to 21bit (with 4 Spec E spectroscopy software)			
External Synchronization	By negative or positive edge TTL pulse			
Cooling of CCD	Regulated Peltier cooling of CCD camera unit to 14°C to minimize dark current by a factor of 10 for exposure times above 100ms. Provides single photon sensitivity. No condensation, eliminates need for vacuum of special nitrogen atmosphere.			



Inactive Xe flash tube on printed circuit board for comparison with both the 16 bit single exposure and multiple exposure



Single exposure 16 bit image of Xe flash tube in false colour display



Both the arc's very bright cathode region and the printed text on the mounting board are visible within one exposure due to the ultra wide dynamic range of the 4 Picos/4 Quik E.



Image Intensifier

Highest sensitivity

The **4 Picos/4 Quik E** series, the most compact integrated cooled Intensified CCD Camera available, is a family of ultra high-speed, innovative Micro Channel Plate ICCD video cameras.

They may be ordered with any of a wide range of different 18mm and 25mm single-stage and 25mm dual-stage MCP Image Intensifiers which span the spectral range from VUV down to 110nm to Near IR, 1300nm.

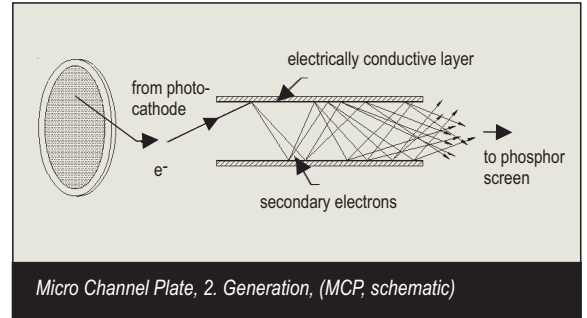
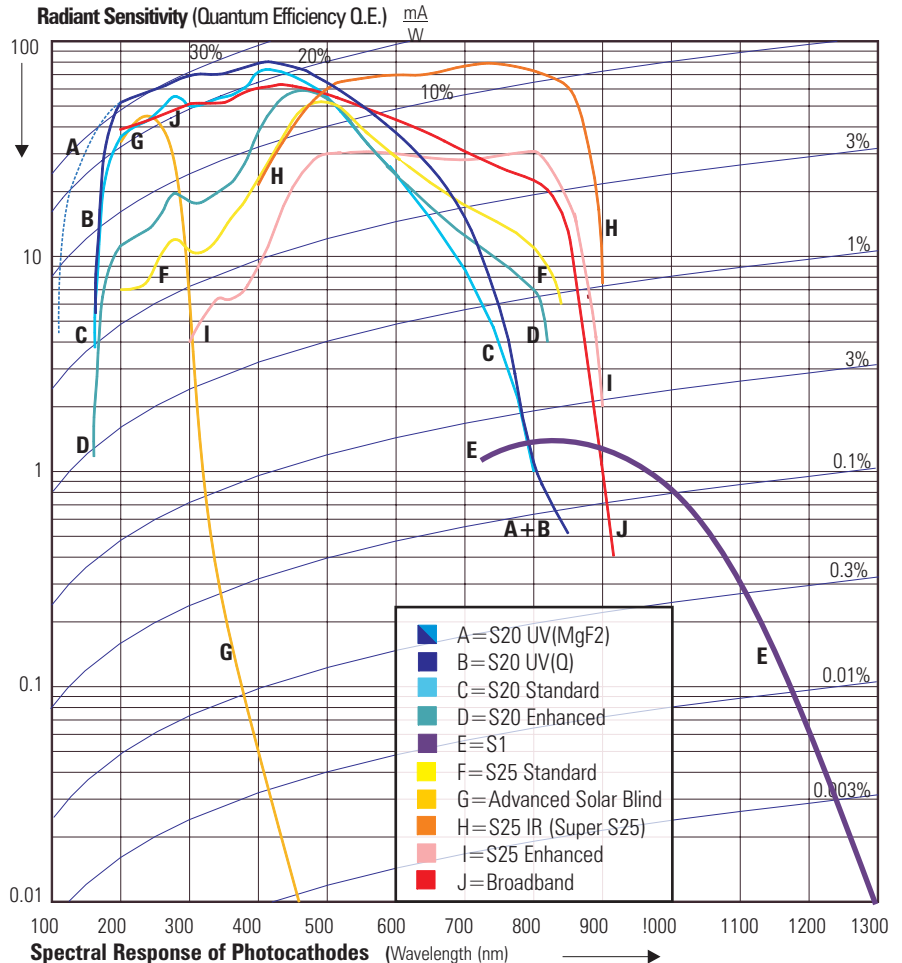
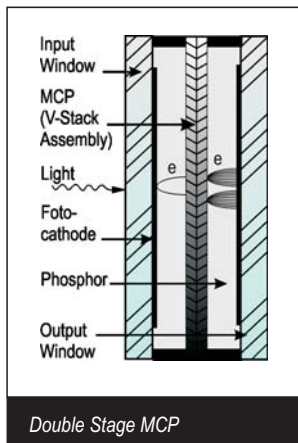
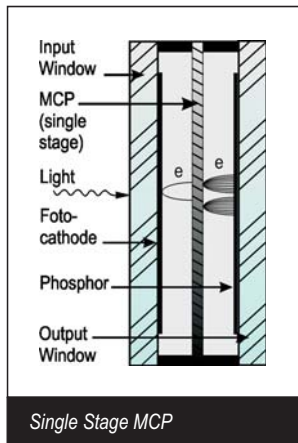


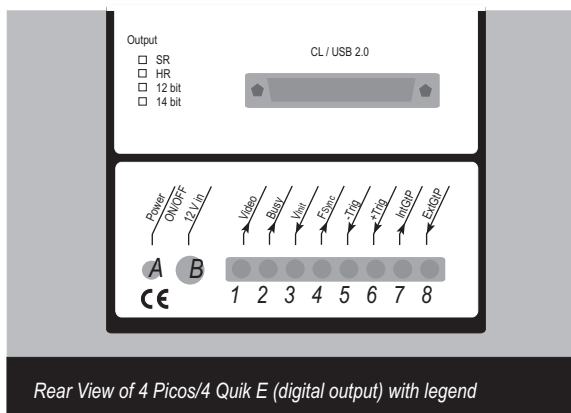
Image Intensifier Specifications	25mm	18mm
Image area of the relay lens	20 x 15mm	14.4 x 10.8mm
Image intensifier type (proximity focused MCP)	Single stage (standard), dual stage (optional)	
Phosphor material	P43 or P46	
Quantum Efficiency (Q.E., see curves below)	Depends on the type of the MCP	
Coupling phosphor (image intensifier -> CCD)	Customized 6-element f/0.8 relay coupling lens	
Gain: 4k steps ($V_{MCP} = \dots 1000V$)	Single stage MCP: 4×10^4 , dual stage MCP: 4×10^6	
Spectral Sensitivity of MCP (wavelength) subject to window design (see below)	165 - ... - 920nm quartz window (S20 or S25 standard) 110 - ... - 1300nm (e.g.: Mg F2-window, optional)	



All in one head

Spectral Sensitivity (wavelength in nm)			
18mm MCP		25mm MCP	
Standard			
S20UV	B	165 - 820	S20 C 165 - 820
S25IR	H	350 - 920	S25 F 220 - 840
Broadband	J	190 - 920	
Optional			
S20 (MgF2)	A	110 - 820	Enhanced S20 D 165 - 820
S1	E	700 - 1300	Enhanced S25 I 270 - 900
			Solar Blind G 165 - 340

Deviations of up to $\pm 25\%$ from the above typical spectral sensitivity curves are possible. The position of the curves can vary $\pm 20\text{nm}$. The input window material limits the spectral response of the photocathode in the shorter wavelengths. The window materials and their transmission limits are: quartz (165nm), MgF2 (110nm).



Rear View of 4 Picos/4 Quik E (digital output) with legend

Delay & gate electronics

Very high system integration permits small physical size of the total unit - all delay and gate electronics in one head, since the very beginning. Even very difficult applications with space constraint are mastered easily by remote control.

Switches and Connections

A	Power Switch ON/OFF
B	Power Supply Socket (12V)
1	Video Analog camera output signal (EIA or CCIR)
2	Busy Synchronization Signal (TTL), e.g. Frame grabber
3	V _{init} Asynchronous reset of CCD camera
4	F _{sync} TTL output for synchronization purposes
5	- Trig Trigger input, negative edge TTL
6	+Trig Trigger input, positive edge TTL
7	IntGtP Output of internal time delay gate pulse generator
8	ExtGtP Input for control of HV MCP Pulse (TTL)

Note:

For control by internal time/delay generator, "7" and "8" are shorted internally.

Camera will free run when "4" to "5", and "7" to "8" are internally connected. These settings are both under remote RS 232, CameraLink, or USB 2.0 control.

Camera may be externally driven through "8" by external pulse delay generator when "7" and "8" are disconnected. Pulse monitoring is provided by "7" and camera master sync output is available at "4".

Mechanical & Environmental data

Camera Dimensions (all in one head, without lens)	248 x 110 x 135 mm, 9 3/4 x 4 3/8 x 5 4/16" (l x w x h)
Camera Weight (all in one head, without lens)	3 kg
Camera mount (at the bottom of the camera)	1/4" x 20 and M8 mounting hole
Operating Humidity (%)	25 ..95%, non condensing
Operating Temperature (°C, °F)	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 Vibration	60g accel. shock, 7g Vibration (11 - 200Hz)
Voltage	12V +5%/-2%

Ultra fast ICCD cameras



Application

Biological Sciences

Cancer research
Fundus imaging spectroscopy
X-ray detection
Luminescence
Time resolved fluorescence
FLIM
FRET

High Speed Imaging

Dynamic Schlieren Phenomena
Shock tubes
Range gating

Engineering Research

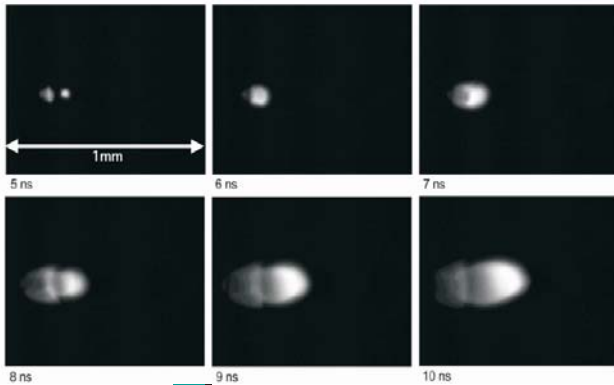
Particle Tracking Velocimetry (PTV)
Particle Image Velocimetry (PIV)
Automotive Fuel Injection
Spray analysis
Wind tunnel studies
Stress analysis of ceramics materials

Low Light Level Imaging

Thomson Scattering
Raman Spectroscopy
Glow Discharge Spectroscopy
Semiconductor failure analysis

Physical Sciences

Plasma temperature analysis
Plasma density analysis
Plasma flow analysis
Combustion analysis
Synchrotron radiation
Ballistics, explosions
Laser induced fluorescence
Single Photon Detection

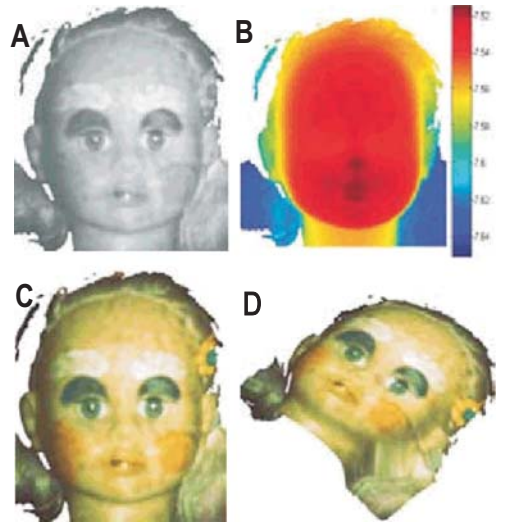


< Plasma images of water droplets, shutter time 200ps, Fraunhofer ILT, Germany,
© with courtesy of Ch. Janzen, 2003

> A doll's head is imaged at a range of 7 to 8 m using a laser radar for distance calculations and a multispectral source for color information.

A black-and-white intensity image (A) is merged with a range image (B) to produce a 3-dimensional color image (C), rotated view (D).

© Laser Focus World, Nov 2006



Data acquisition

Pulsed and Time resolved Spectroscopy

In addition to high-speed and low light imaging applications, the **4 Picos / 4 Quik E** is the #1 choice for many spectroscopy applications. It is the only intensified sensor system that is equipped with a proprietary f/0.8 relay coupling lens.

In terms of geometrical size, vignetting and image resolution (180 lp/mm), this is clearly superior to any so called "tandem lens" or fiber optic tapered solutions. This leads to the lowest distortion (less than 0.1 pixel) available anywhere on the market. We offer a specially developed software package for spectroscopy data acquisition application: **4 Spec E**, designed for PC Pentium® - Windows® (98, ME, NT, 2000, XP, Vista) (Windows is a registered Trademark of Microsoft Crop. All other product and brand names are trademarks of their respective owners.)

Specifications

Sensitivity	more than 1 count/photoelectron pixel. Up to 80 seconds integration time on CCD detector
Image configuration	1 line scan to 1024 lines horizontal and vertical binning
Dynamic Range	More than 21 Bit (2 Mio:1), with all lines integrated (binned), dynamic expansion active.
Display options	Stores up to 30,000 curve memories in RAM, 32 Bit/pixel curve memories; 256 level gray scale or 256 level pseudo color; 2-D and 3-D overlays; peak finder; wave length, wave number, and photon energy calibration image function for laser profile displays.

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