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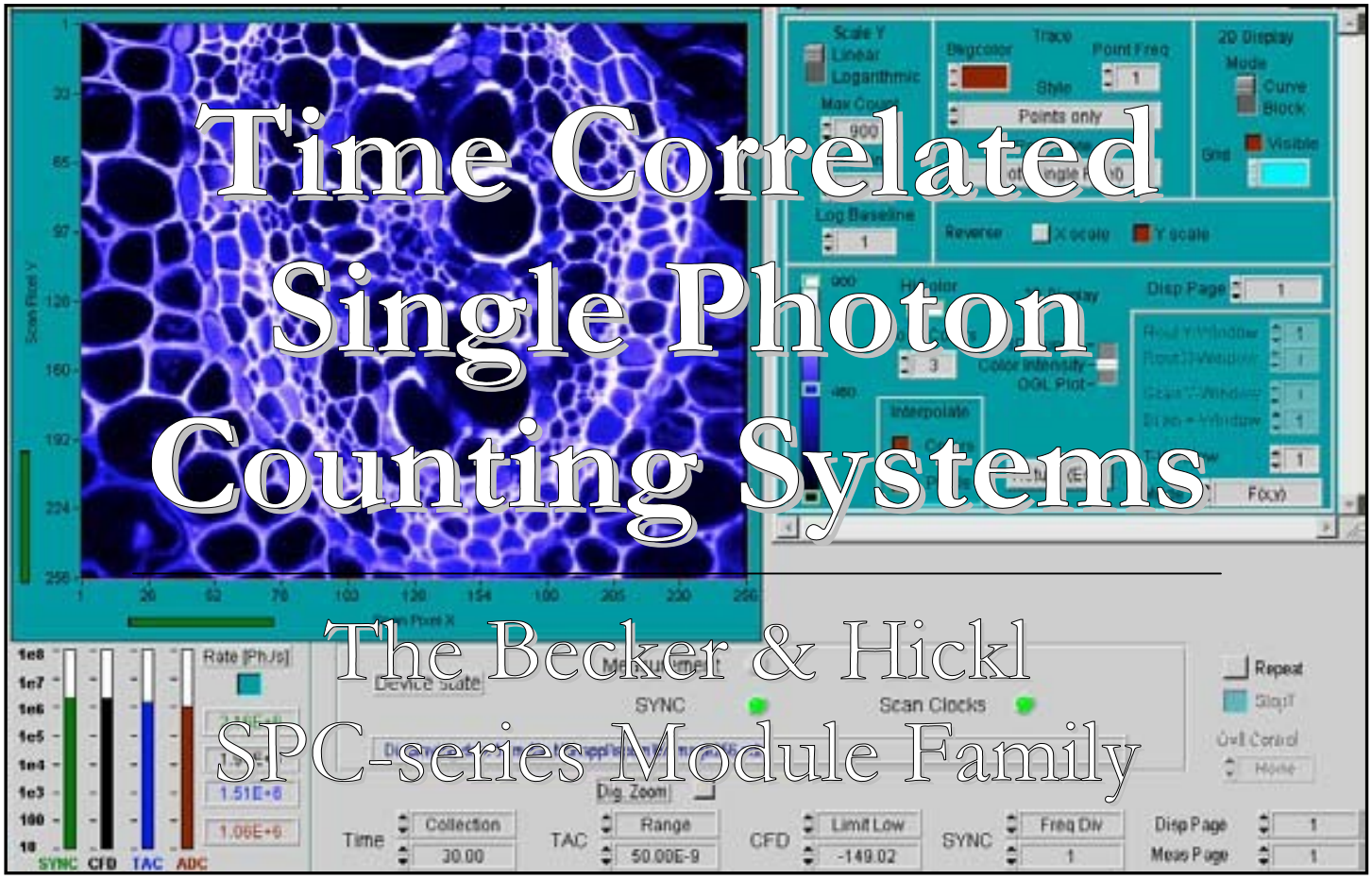

Time Correlated Single Photon Counting Systems

The Becker & Hickl SPC-series Module Family

PC Based Systems

intelligent measurement and control systems

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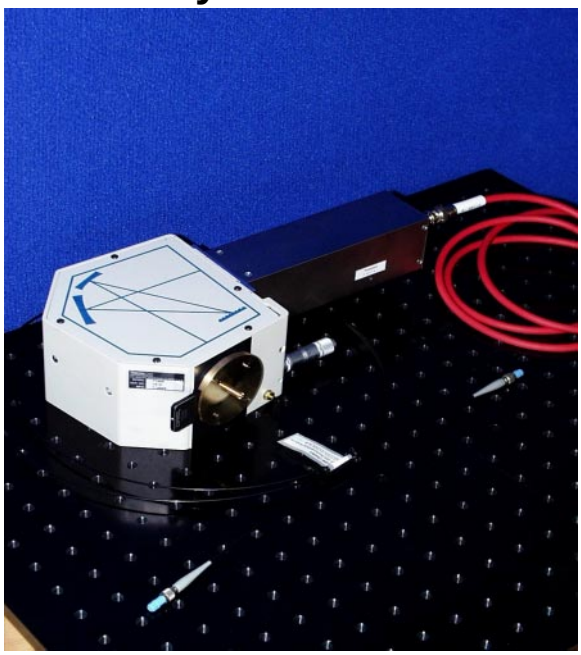
PML-Spec
Multi-Wavelength Lifetime Detection

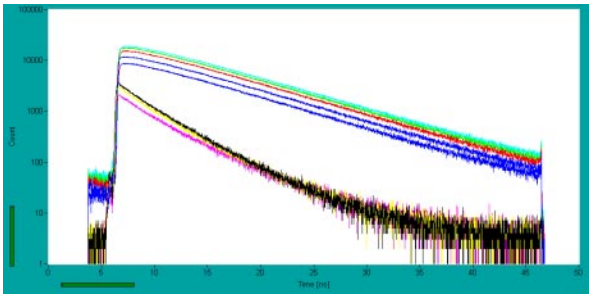
Multi-wavelength detection of fluorescence decay functions

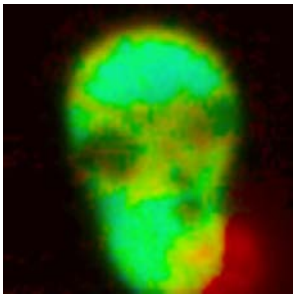


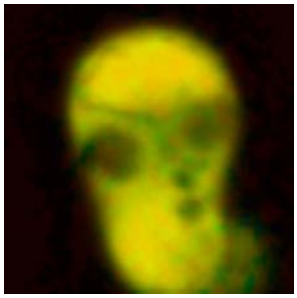
16 wavelength channels recording simultaneously
Spectral range 300-850 nm
High time resolution: 180 ps fwhm IRF width
Useful count rate > 2 MHz
Ultra-high sensitivity
Short acquisition times
Greatly reduced pile-up
Works with any bh TCSPC module

Biomedical fluorescence
Autofluorescence of tissue
Time-resolved laser scanning microscopy
Multi-spectral lifetime imaging
Recording of chlorophyll transients
Stopped flow fluorescence experiments

The PML-SPEC uses bh's proprietary multi-dimensional TCSPC technique. The light is split into its spectrum by a polychromator. The spectrum is detected by a 16-channel multi-anode PMT. The single photons detected in the PMT channels are recorded in a bh TCSPC module. The TCSPC module builds up a photon distribution over the time in the fluorescence decay and the wavelength. The technique does not use any time gating, detector channel multiplexing, or wavelength scanning and therefore reaches a near-ideal counting efficiency.







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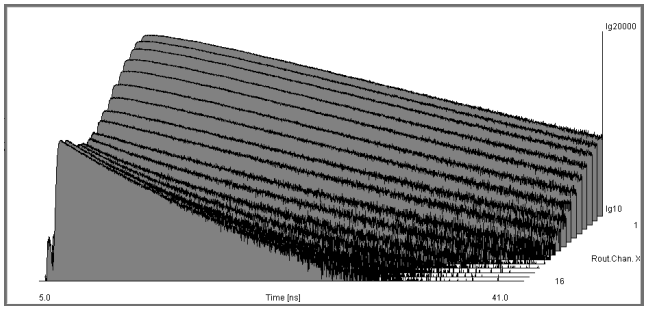
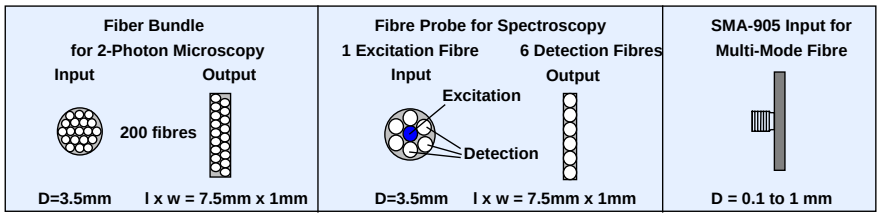


Covered by patent DE 43 39 787

PML-Spec Multi-Wavelength Lifetime Detection

Optical System

Type of grating, lines/mm	400	600	1200
Recorded interval[1], nm	320	208	106
Wavelength channel width, nm	20	13	6.65
Spectral range of grating[2], nm	300-600[2] 300-850[3]	300-600[2] 300-850[3]	300-600[2] 300-850[3]
F number		F / 3.7	
Input slit width, mm		0.6	
Input slit height, mm		7.5	
Optical Input Versions	Fibre bundle, fibre probe with 1 excitation fibre and 6 detection fibres, or SMA-905 connector		



[1] any interval within spectral range of grating
[2] Detector with bi-alkali cathode
[3] Detector with multi-alkali cathode

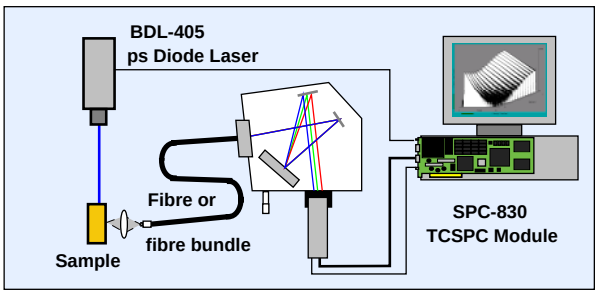
Detector[4]

Cathode spectral response	bi-alkali, 300 to 600 nm	multi-alkali, 300 to 850 nm
Typical dark count rate, s^{-1}	200	800
Number of spectral channels	16	
Timing output polarity of detector	negative	
Average timing pulse amplitude	40 mV	
Time resolution (FWHM)	150 to 200 ps	
Time skew between channels	< 40 ps	
Timing output connector	SMA, 50Ω	
Routing signal	4 bit + Count Disable Signal, TTL/CMOS	
Routing signal connector	15 pin Sub-D / HD	
Power supply (PML-16)	± 5V from SPC module, -800...-900V / 0.35 mA from external HV power supply	
Power supply (PML-16C)	± 5V, +12V from DCC-100 detector controller. Internal HV generator	

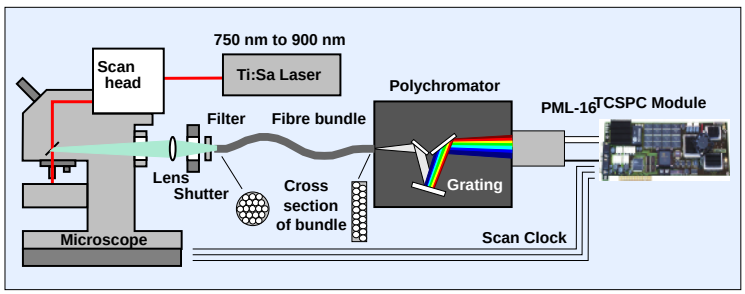
[4] please see data sheet and manual of PML-16 and PML-16C multichannel PMT heads

Applications

Multi-Wavelength Fluorescence Decay Measurement



Multi-Wavelength Picosecond Laser Scanning Microscope



Related Products and Accessories: SPC-134 through SPC-830 TCSPC boards, ps diode lasers, FLIM upgrade kits for scanning microscopes. Please see www.becker-hickl.com or call for individual data sheets.

Supplementary Literature: W. Becker, Advanced time-correlated single-photon counting techniques. Springer, Berlin, Heidelberg, New York, 2005
W. Becker, The bh TCSPC Handbook, Becker & Hickl GmbH, 2005

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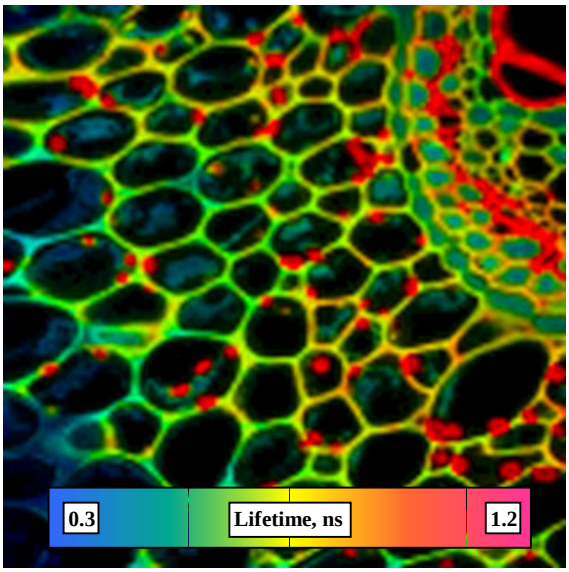
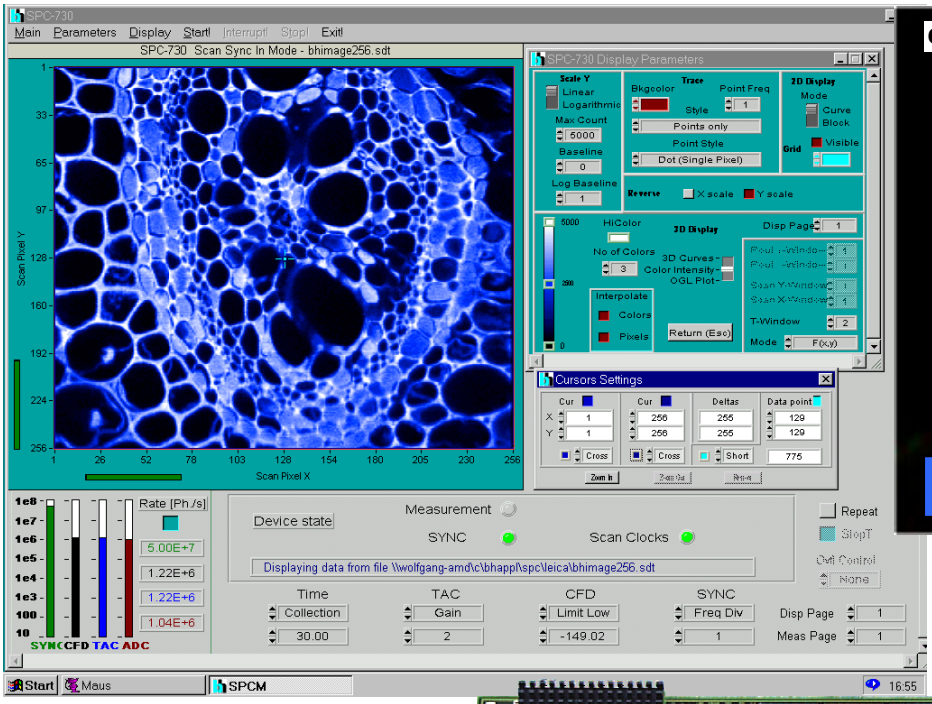
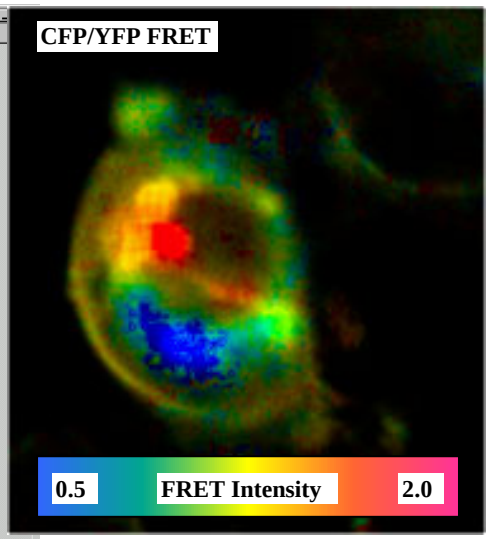
The TCSPC Microscopy Solution SPC-830

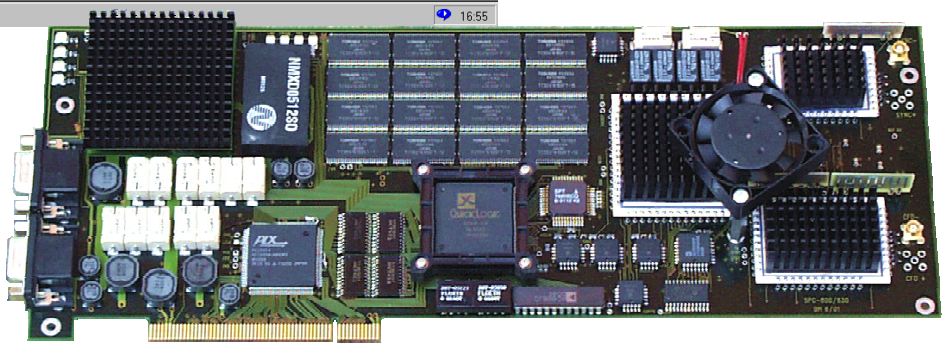
High Resolution Time-Correlated Single Photon Counting Imaging and FCS Module for Laser Scanning Microscopes

- Complete picosecond imaging system on single PC board
- Picosecond resolution
- Ultra-high sensitivity
- Multi detector capability
- High-speed on-board data acquisition
- Works at any scanning speed of microscope
- High resolution picosecond lifetime imaging
- FRET imaging
- High-resolution steady state imaging
- Single-point time-lapse lifetime analysis
- FCS, FIDA, FILDA, BIFL measurement
- Time channel width down to 813 fs
- Image size up to 4096 x 4096 pixels
- Electrical time resolution down to 8 ps fwhm / 4 ps rms
- Reversed start/stop: Laser repetition rates up to 200 MHz
- Useful detector count rate up to 8 MHz - dead time 125 ns
- Active and passive scanning control
- Software versions for windows 95 / 98 / 2000 / NT









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Covered by patents DE 43 39 784 and DE 43 39 787

The TCSPC Microscopy Solution SPC-830

Photon Channel

Principle	Constant Fraction Discriminator
Time Resolution (FWHM / RMS, electr.)	7 ps / 4 ps
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Lower Threshold	- 20 mV to - 500 mV
Zero Cross Adjust	- 100 mV to + 100 mV

Synchronisation Channel

Principle	Constant Fraction Discriminator
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Threshold	- 20 mV to -500 mV
Frequency Range	0 to 200 MHz
Frequency Divider	1-2-4-8-16
Zero Cross Adjust	-100 mV to + 100 mV

Time-to-Amplitude Converter / ADC

Principle	Ramp Generator / Biased Amplifier
TAC Range	50 ns to 2 us
Biased Amplifier Gain	1 to 15
Biased Amplifier Offset	0 to 100% of TAC Range
Time Range incl. Biased Amplifier	3.3 ns to 2 us
min. Time / Channel	813 fs
TAC Window Discriminator	Any Window inside TAC Range
ADC Principle	50 ns 12 bit Flash ADC with Error Correction
Diff. Nonlinearity (dith width 1/8, 90% of TAC range)	< 0.5% rms, typically <1% peak-peak

Data Acquisition, Histogram Modes

Method	on-board 4-dimensional histogramming process over t, x, y, and detector channel number						
Dead Time	125ns, independent of computer speed						
Saturated Count Rate / Useful Count Rate	8 MHz / 4 MHz						
Number of Time Channels / Pixel	1	4	16	64	256	1024	4096
IImage Resolution (pixels), 1 Detector Channel	4096 x 4096	2048 x 2048	1024 x 1024	512 x 512	256 x 256	128 x 128	64 x 64
IImage Resolution (pixels), 4 Detector Channels	2048 x 2048	1024 x 1024	512 x 512	256 x 256	128 x 128	64 x 64	32 x 32
IImage Resolution (pixels), 16 Detector Channels	1024 x 1024	512 x 512	256 x 256	128 x 128	64 x 64	32 x 32	16 x 16
Counts / Time Channel	2^{16}-1						
Counts / Time Channel ('Single' mode, repeat and acquire)	2^{32}-1						
Overflow Control	none / stop / repeat and acquire						
Collection Time (per curve or per pixel)	100 ns to 1000 s						
Display Interval Time	10ms to 1000 s						
Repeat Time	0.1 ms to 1000 s						
Curve Control (Internal Routing / Scan Sync In Mode)	up to 262,144 decay curves						
Routing Control / Detector Channels	14 bit TTL / 16384						
Count Enable Control	1 bit TTL						
Control Signal Latch Delay	0 to 255 ns						
Experiment Trigger	TTL						

Data Acquisition, FIFO/Time-Tag Modes

Method	Time-tagging of individual photons and continuous writing to disk
Macro Time Resolution	50 ns
ADC Resolution / No. of Time Channels	12 bit / 4096
Dead Time	150 ns
Output Data Format (ADC / Macrotime / Routing)	12 / 12 /4
FIFO buffer Capacity (photons)	8 million photons

Multi Module Systems

Number of modules operable parallel	4

Operation Environment

Computer System	PC Pentium
Bus Connector	PCI
Power Consumption	approx. 20 W at +5V, 0.7 W at +12V
Dimensions	312 mm x 122 mm x 28 mm

Related Products and Accessories

Detector Heads (MCPs, PMTs), Multichannel Detector Heads, Routing Devices for Multichannel Measurements, Preamplifiers, PIN and Avalanche Photodiode Modules, ps Diode Lasers, Adapter Cables for Scanning Microscopes. SPC-600/630 TCSPC modules for single molecule and correlation spectroscopy, SPC-700/730 and SPC-144 for imaging and SPC-134 for optical tomography. Please downlaod or call for individual data sheets. To control detectors and shutters please see DCC-100 detector controller.

Please visit our web site to download the manual, the device software and application notes.

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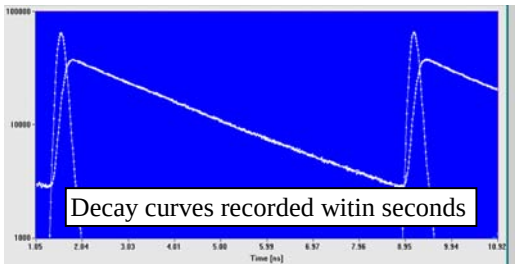
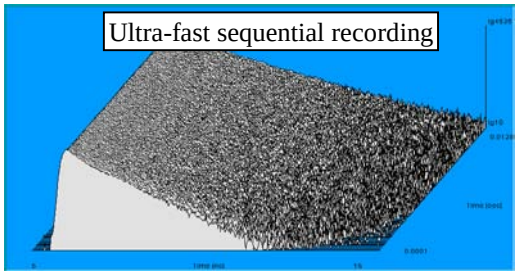
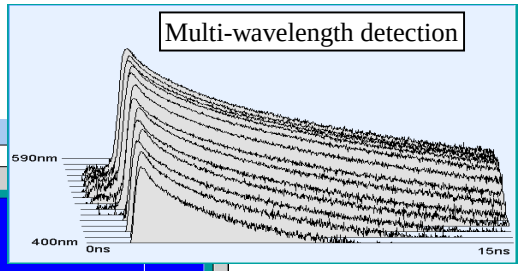
The TCSPC General Solution SPC-630

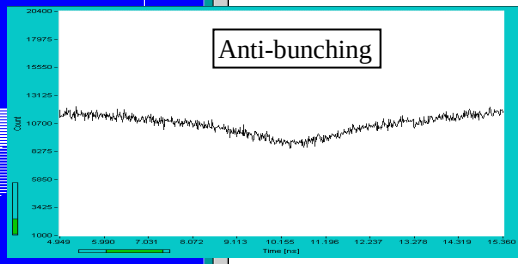
Time-Correlated Single Photon Counting Modules

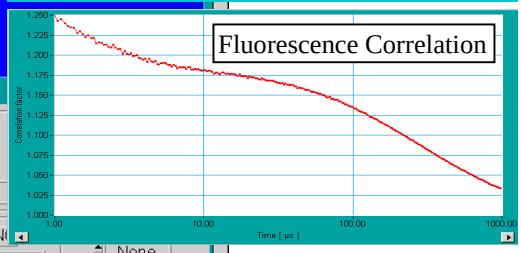
- Complete TCSPC Systems on single PC Boards
- Multi-Detector Capability
- Multiplexing Capability
- Histogram Mode: Recording of Decay Curves
- Dual-Memory Architecture: Unlimited Sequential Curve Recording
- Double-Kinetic Mode: Fast Triggered Accumulation of Sequences
- FIFO / Time-Tag Mode: FCS, FIDA, FILDA, or BIFL Experiments
- Reversed Start/Stop: Repetition Rates up to 200 MHz
- Electrical Time Resolution down to 8 ps FWHM / 5 ps rms
- Channel Resolution down to 813 fs
- Up to 4096 Time Channels / Curve
- Ultra-High Count Rate: Up to 8 MHz (125 ns Dead Time)
- Measurement Times down to 10 µs
- Operating Software for Windows 95 / 98 / 2000 / NT
- Parallel Operation of up to 4 Modules

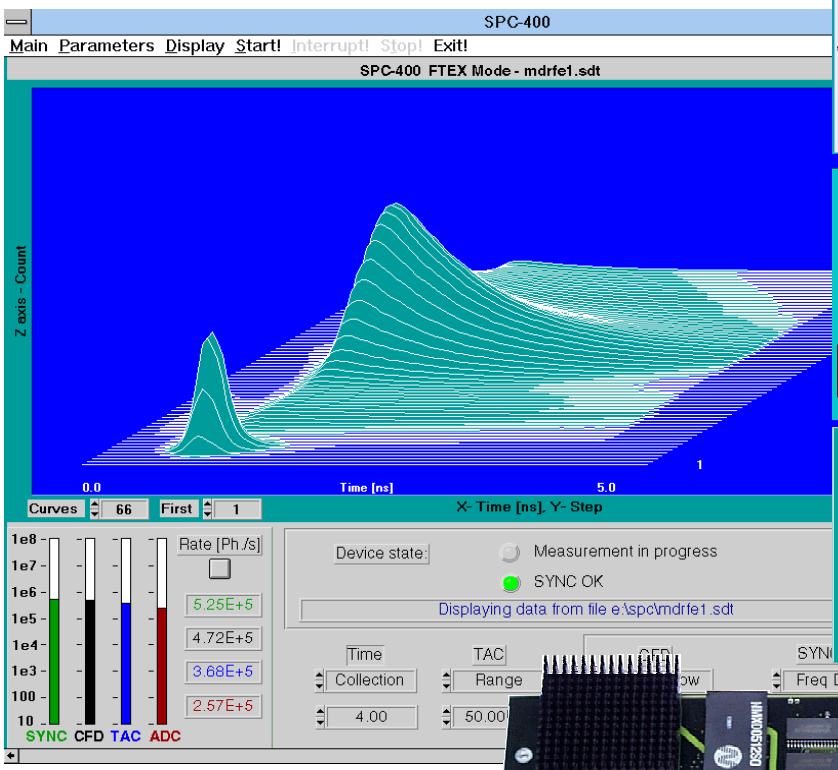


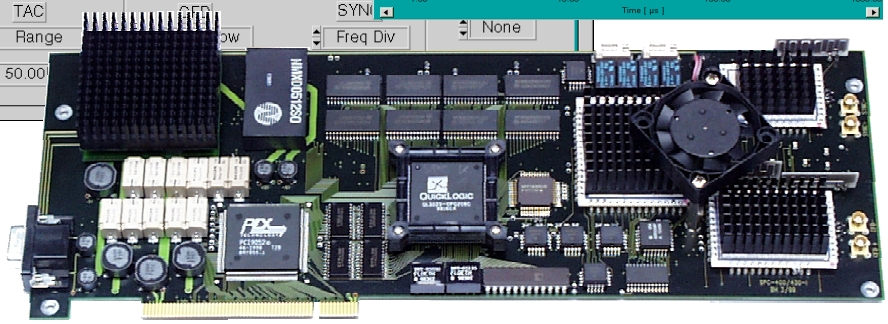












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Covered by patents DE 43 39 784 and DE 43 39 787

SPC-630

Photon Channel				
Principle	Constant Fraction Discriminator			
Time Resolution (FWHM / RMS, electr.)	8 ps / 5 ps			
Opt. Input Voltage Range	- 50 mV to - 1 V			
Threshold	- 20 mV to - 500 mV			
Zero Cross Adjust	- 100 mV to + 100 mV			
Synchronisation Channel				
Principle	Constant Fraction Discriminator			
Opt. Input Voltage Range	- 50 mV to - 1 V			
Threshold	20 mV to -500 mV			
Frequency Range	0 to 200 MHz			
Frequency Divider	1-2-4-8-16			
Zero Cross Adjust	-100 mV to + 100 mV			
Time-to-Amplitude Converter / ADC				
Principle	Ramp Generator / Biased Amplifier			
TAC Range	50 ns to 2 us			
Biased Amplifier Gain	1 to 15			
Biased Amplifier Offset	0 to 100% of TAC Range			
Time Range incl. Biased Amplifier	3.3 ns to 2 us			
min. Time / Channel	813 fs			
TAC Window Discriminator	Any Window inside TAC Range			
ADC Principle	50 ns Flash ADC with Error Correction			
Diff. Nonlinearity (dith. width 1/8)	< 0.5 % rms, typically 0.6 to 1% peak-peak			
Data Acquisition (Histogram Modes)				
Method	on-board 2-dimensional histogramming process			
Dead Time	125ns, independent of computer speed			
max. Number of Curves in Memory	4096	1024	256	64
max. Number of Detector Channels	128	128	128	32
Number of Time Channels / Curve	64	256	1024	4096
max. Counts / Channel	2^{16}-1			
Overflow Control	none / stop / repeat and correct			
Collection Time	0.1 us to 10000 s			
Display Interval Time	10ms to 1000 s			
Repeat Time	0.1 ms to 1000 s			
Curve Control (internal)	Programmable Hardware Sequencer			
Curve Control (external Routing)	7 bit TTL			
Add/Sub (Lock-in) Control	1 bit TTL			
Count Enable Control	1 bit TTL			
Control Signal Latch Delay	0 to 255 ns			
Data Acquisition (FIFO / BIFL Mode)				
Method	Time-tagging of individual photons and continuous writing to disk			
Dead Time	150 ns		125 ns	
Output Data Format (ADC / Macrotime / Routing)	12 / 24/ 8		8 / 17 / 3	
FIFO buffer Capacity (photons)	128 k		256 k	
Macro Timer Resolution	50ns, 24 bit		50ns, 17 bit	
Curve Control (external Routing)	8 bit TTL		3 bit TTL	
Count Enable Control	1 bit TTL			
Routing Signal Latch Delay	0 to 255 ns			
Operation Environment				
Computer System	PC Pentium or 486			
Bus Connector	PCI			
Power Consumption	approx. 20 W at +5V, 0.7 W at +12V			
Dimensions	312 mm x 122 mm x 28 mm			
Multi Module Systems				
Number of modules operable parallel	4			

Accessories and Associated Products

Detectors (MCPs, PMTs), multichannel detector heads, routing devices for multi-detector operation, detector controllers, preamplifiers, PIN and avalanche photodiode modules, ps diode lasers with multiplexing capability. Also available: SPC-134, SPC-144, SPC-730 and SPC-830 time-correlated single photon counting modules, gated photon counters and multiscalers. Please call for individual data sheets and manuals. For TCSPC imaging applications please see SPC-730/830 data sheets, for ultra-high count rate SPC-134 and SPC-144 data sheets.

Please visit our web site for free download of the manual, the device software and application literature.

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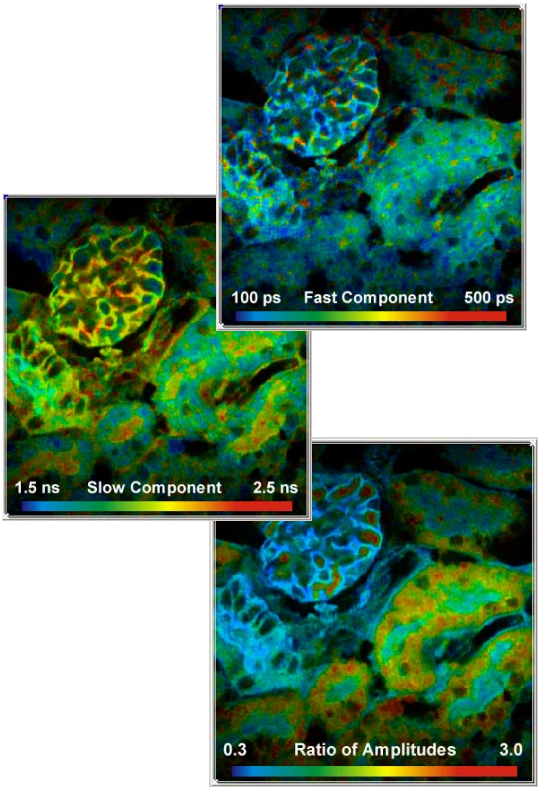
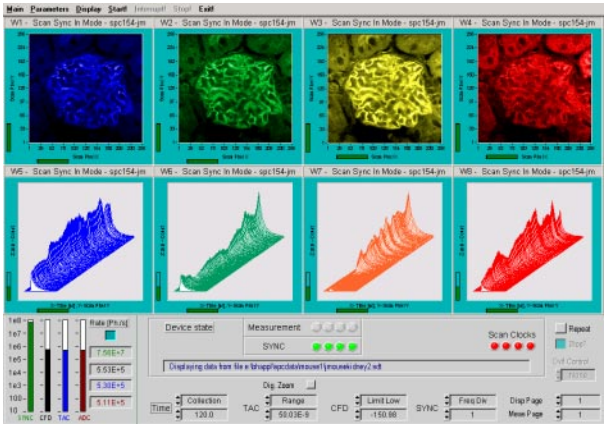
The TCSPC Imaging Package SPC-154

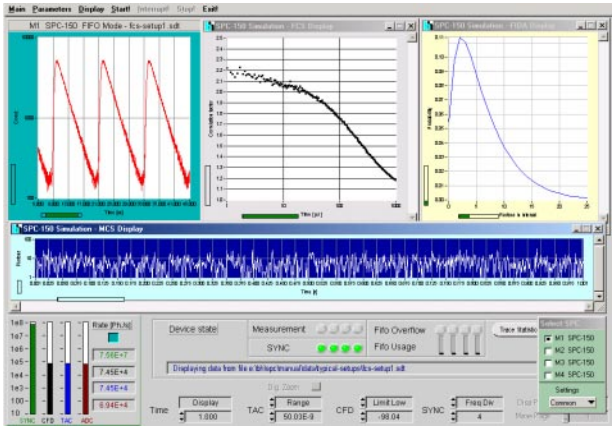
Four-Channel Time-Correlated Single Photon Counting Module

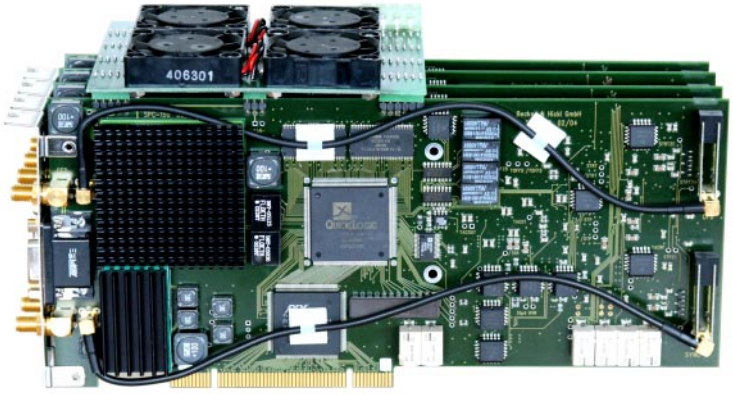
Four fully parallel TCSPC channels
Picosecond resolution
Ultra-high sensitivity
Multi-detector capability in all four channels
High-speed on-board data acquisition
Photon distribution and time-tag modes
Image acquisition by synchronisation with ext. scanner
Unlimited sequential recording of curves or images
Imaging in histogram mode and in time-tag mode
Works at any scan rate of CLSMs or MPLSMs
Time channel width down to 813 fs
Electrical time resolution down to 8 ps fwhm / 4 ps rms
Reversed start/stop: Laser repetition rates up to 150 MHz
Total saturated count rate 40 MHz
Total useful recorded count rate up to 20 MHz
Channel dead time 100 ns



Multi-wavelength FLIM
Double-exponential FLIM
Fast-Acquisition FLIM
Fast Sequential FLIM
Single and double-exponential FRET imaging
FCS, FCCS, FIDA, FILDA, BIFL
FCS Imaging
DOT, static and dynamic brain imaging
Transient fluorescence lifetime effects







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Covered by patents DE 43 39 784 and DE 43 39 787

SPC-154

Photon Channels

Principle	Constant Fraction Discriminator (CFD)
Time Resolution (FWHM / RMS, electr.)	8 ps / 5 ps
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Lower Threshold	- 20 mV to - 500 mV
Upper Threshold	-
Zero Cross Adjust	- 100 mV to + 100 mV

Synchronisation Channels

Principle	Constant Fraction Discriminator (CFD)
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Threshold	- 20 mV to -500 mV
Frequency Range	0 to 200 MHz
Frequency Divider	1-2-4
Zero Cross Adjust	-100 mV to + 100 mV

Time-to-Amplitude Converters / ADCs

Principle	Ramp Generator / Biased Amplifier
TAC Range	50 ns to 2 us
Biased Amplifier Gain	1 to 15
Biased Amplifier Offset	0 to 100% of TAC Range
Time Range incl. Biased Amplifier	3.3 ns to 2 us
min. Time / Channel	813 fs
ADC Principle	50 ns Flash ADC with Error Correction
Diff. Nonlinearity	< 0.5% rms, typ. <1% peak-peak

Data Acquisition (Histogram Mode)

Method	on-board multi-dimensional histogramming process						
Dead Time	100ns, independent of computer speed						
Saturated Count Rate, per TCSPC channel / total	10 MHz / 40 MHz						
Useful count rate, per TCSPC channel / total	5 MHz / 20 MHz						
Channels / Curve per TCSPC channel	4096	1024	256	64	16	4	1
max. Scanning Area per TCSPC channel	16x16	64x64	128 x 128	256x256	512x512	1024x1024	2048x2048
max. Counts / Time Channel	2^{16}-1						
Overflow Control	none / stop / repeat and correct						
Collection Time	0.1 us to 10000 s						
Display Interval Time	10ms to 1000 s						
Repeat Time	0.1 us to 1000 s						
Sequential Recording	Programmable Hardware Sequencer						
	Unlimited recording by memory swapping, in curve mode and scan mode						
Synchronisation with Scanning	pixel, line and frame clocks from scanning device						
Count Enable Control	1 bit TTL						
Experiment Trigger	TTL						

Data Acquisition (FIFO / Time-Tag Mode)

Method	Time-tagging of individual photons and continuous writing to disk
Dead Time	100 ns
Output Data Format (ADC / Macrotime / Routing)	12 bit ADC / 12 bit macro time / 4 bit routing
Output Data Format for Scan Clock Markers (pxl, line, frame)	12 bit macro time / pxl, line, frame
FIFO Buffer Capacity (photons and clock markers)	2 M
Macro Timer Resolution, internal clock	25 ns, 12 bit
Macro Timer Resolution, clock from SYNC input	10 ns to 100 ns, 12 bit
Curve Control (external Routing)	4 bit TTL
Count Enable Control	1 bit TTL

Operation Environment

Computer System	PC Pentium
Bus Connectors	PCI
Used PCI Slots	4
Total power Consumption	approx. 60 W from +5V, 0.7 W from +12V
Dimensions	240 mm x 130 mm x 85 mm

Product Literature

W. Becker, The bh TCSPC Handbook. Available on www.becker-hickl.com.

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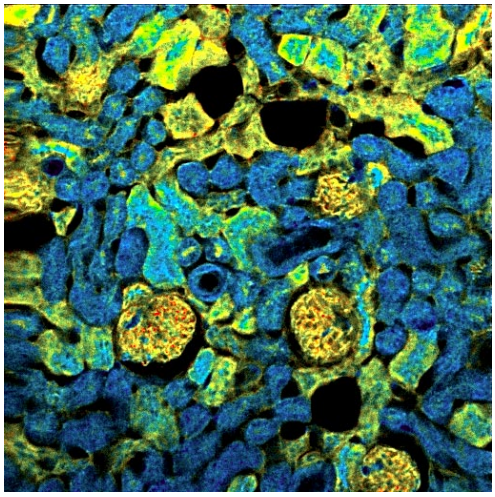
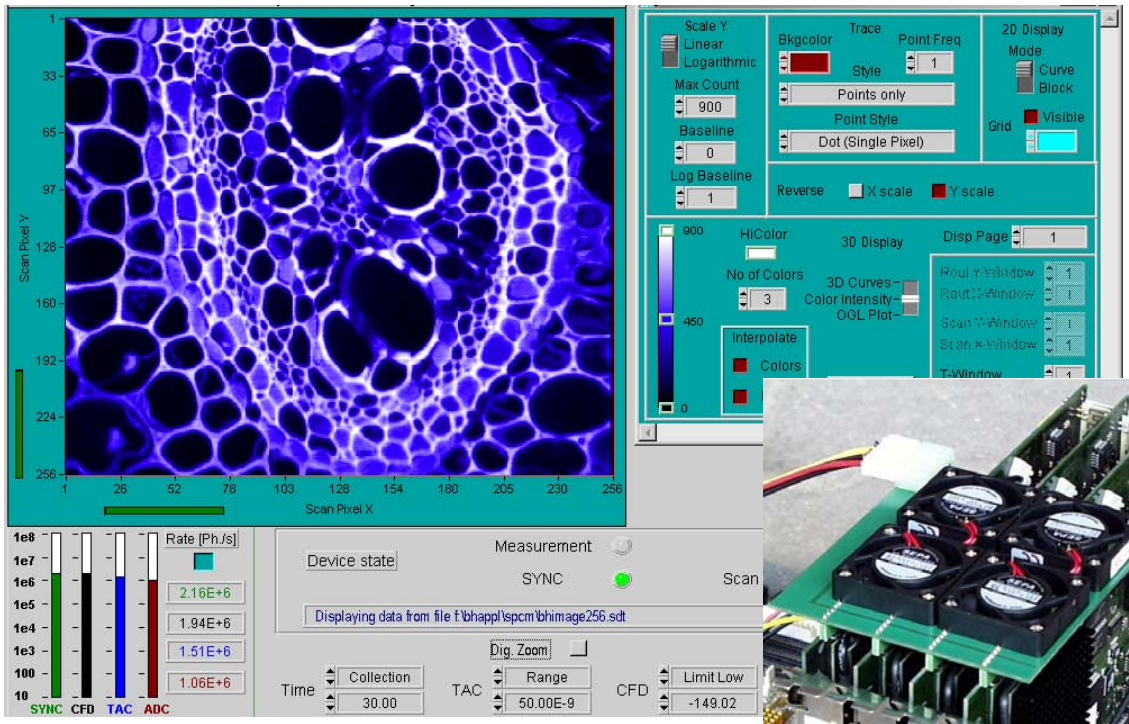
The TCSPC Imaging Package SPC-144

Four-Channel Time-Correlated Single Photon Counting FLIM Module for Laser Scanning Microscopes

Four fully parallel TCSPC imaging channels
Picosecond resolution
Ultra-high sensitivity
Multi-detector capability in all four channels
High-speed on-board data acquisition
Works at any scanning speed of CLSMs or MPLSMs
Time channel width down to 813 fs
Lifetime image size up to 1024 x 1024 pixels
Steady-state image size up to 2048 x 2048 pixels
Electrical time resolution down to 8 ps fwhm / 4 ps rms
Reversed start/stop: Laser repetition rates up to 150 MHz
Total useful recorded count rate up to 20 MHz
Dead time 100 ns

Multi-wavelength picosecond lifetime imaging
FRET imaging
FCS, FIDA, FILDA, BIFL
High-resolution steady state imaging
Single-point time-lapse lifetime analysis





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Covered by patents DE 43 39 784 and DE 43 39 787

SPC-144

Photon Channels

Principle	Constant Fraction Discriminator (CFD)
Time Resolution (FWHM / RMS, electr.)	8 ps / 5 ps
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Lower Threshold	- 20 mV to - 500 mV
Upper Threshold	-
Zero Cross Adjust	- 100 mV to + 100 mV

Synchronisation Channels

Principle	Constant Fraction Discriminator (CFD)
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Threshold	- 20 mV to -500 mV
Frequency Range	0 to 200 MHz
Frequency Divider	1-2-4
Zero Cross Adjust	-100 mV to + 100 mV

Time-to-Amplitude Converters / ADCs

Principle	Ramp Generator / Biased Amplifier
TAC Range	50 ns to 2 us
Biased Amplifier Gain	1 to 15
Biased Amplifier Offset	0 to 100% of TAC Range
Time Range incl. Biased Amplifier	3.3 ns to 2 us
min. Time / Channel	813 fs
ADC Principle	50 ns Flash ADC with Error Correction
Diff. Nonlinearity	< 0.5% rms, typ. <1% peak-peak

Data Acquisition (Histogram Mode)

Method	on-board multi-dimensional histogramming process						
Dead Time	100ns, independent of computer speed						
Saturated Count Rate, per TCSPC channel / total	10 MHz / 40 MHz						
Useful count rate, per TCSPC channel / total	5 MHz / 20 MHz						
Channels / Curve per TCSPC channel	4096	1024	256	64	16	4	1
max. Scanning Area per TCSPC channel	16x16	64x64	128 x 128	256x256	512x512	1024x1024	2048x2048
max. Counts / Time Channel	2^{16}-1						
Overflow Control	none / stop / repeat and correct						
Collection Time	0.1 us to 10000 s						
Display Interval Time	10ms to 1000 s						
Repeat Time	0.1 us to 1000 s						
Sequential recording	Programmable Hardware Sequencer						
Synchronisation with scanning	pixel, line and frame clocks from scanning microscope						
Count Enable Control	1 bit TTL						
Experiment Trigger	TTL						

Data Acquisition (FIFO / Time-Tag Mode)

Method	Time-tagging of individual photons and continuous writing to disk
Dead Time	100 ns
Output Data Format (ADC / Macrotime / Routing)	12 / 12 / 3
FIFO buffer Capacity (photons)	2 M
Macro Timer Resolution, internal clock	50ns, 12 bit
Macro Timer Resolution, clock from SYNC input	10ns to 100ns, 12 bit
Curve Control (external Routing)	3 bit TTL
Count Enable Control	1 bit TTL

Operation Environment

Computer System	PC Pentium
Bus Connectors	PCI
Used PCI Slots	4
Total power Consumption	approx. 60 W from +5V, 0.7 W from +12V
Dimensions	225 mm x 125 mm x 85 mm

Related Products and Accessories

Detectors and Detector Modules, Multichannel Detector Heads, Step Motor Controllers, Detector/Shutter Controllers, Preamplifiers, ps Diode Lasers. Also available: SPC-134, SPC-6, -7, -8 time-correlated single photon counting modules, gated photon counters and multiscalers. Please download or call for individual data sheets and manuals.

Please visit our web site to download the manual, the device software and application literature.

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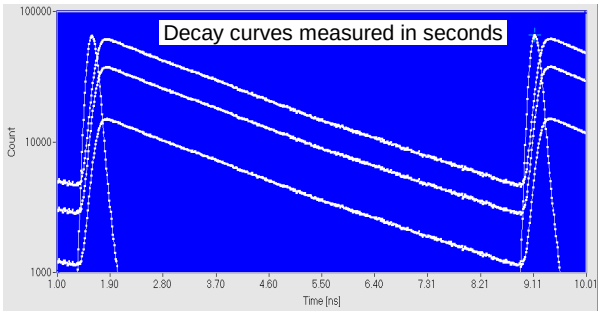
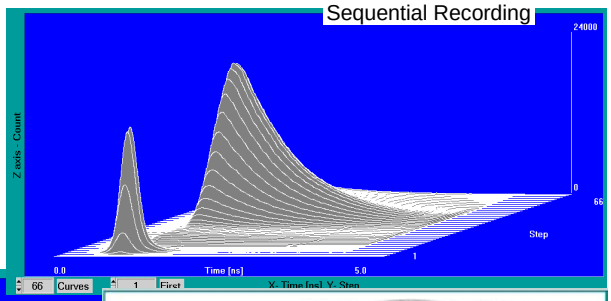
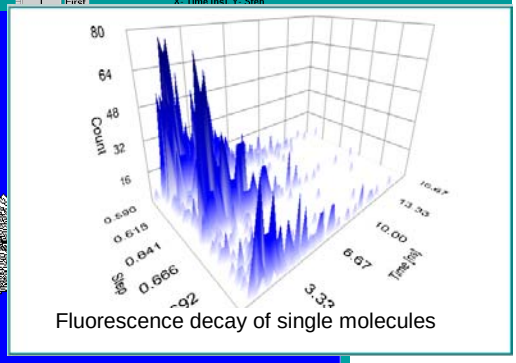
The TCSPC Power Package SPC-134

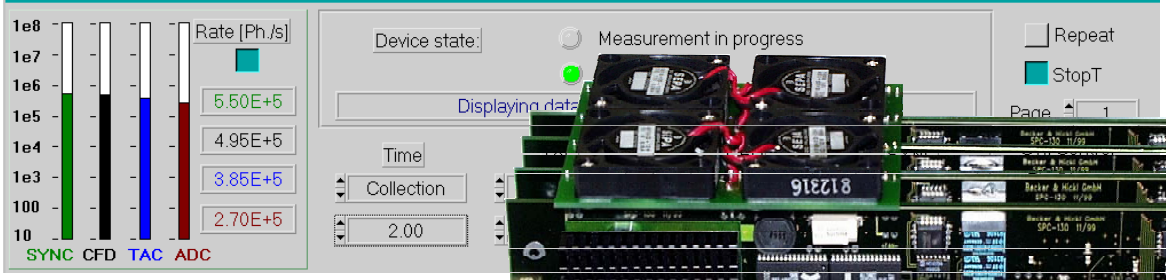
Four Channel Time-Correlated Single Photon Counting Module

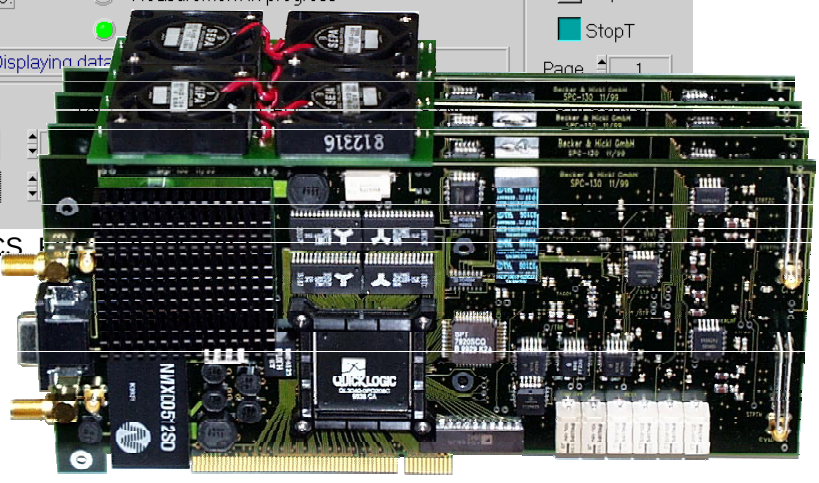
- Four Completely Parallel TCSPC Channels
- Ultra-High Data Throughput
- Overall Count Rate 32 MHz
- Channel Count Rate 10 MHz (Dead Time 100ns)
- Dual Memory Architecture: Readout during Measurement
- Reversed Start/Stop: Repetition Rates up to 200 MHz
- Electrical Time Resolution down to 8 ps FWHM / 5 ps rms
- Channel Resolution down to 813 fs
- Up to 4096 Time Channels / Curve
- Measurement Times down to 0.1 ms
- Software Versions for Windows 95 / 98 / NT
- Direct Interfacing to most Detector Types
- Single Decay Curve Mode
- Oscilloscope Mode
- Seqential Recording Mode
- Spectrum Scan Mode with 8 Independent Time Windows
- Continuous Flow Mode











▲ FIFO / Time Tag Mode for FCS

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Covered by patents DE 43 39 784 and DE 43 39 787

SPC-134

Photon Channels

Principle	Constant Fraction Discriminator (CFD)
Time Resolution (FWHM / RMS, electr.)	8 ps / 5 ps
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Lower Threshold	- 20 mV to - 500 mV
Upper Threshold	-
Zero Cross Adjust	- 100 mV to + 100 mV

Synchronisation Channels

Principle	Constant Fraction Discriminator (CFD)
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Threshold	- 20 mV to -500 mV
Frequency Range	0 to 200 MHz
Frequency Divider	1-2-4
Zero Cross Adjust	-100 mV to + 100 mV

Time-to-Amplitude Converters / ADCs

Principle	Ramp Generator / Biased Amplifier
TAC Range	50 ns to 2 us
Biased Amplifier Gain	1 to 15
Biased Amplifier Offset	0 to 100% of TAC Range
Time Range incl. Biased Amplifier	3.3 ns to 2 us
min. Time / Channel	813 fs
ADC Principle	40 ns Flash ADC with Error Correction
Diff. Nonlinearity	< 0.8% rms, typ. <2% peak-peak

Data Acquisition

Method	on-board 2-dimensional histogramming process			
Dead Time	100 ns, independent of computer speed			
max. Number of Curves in Memory	4096	1024	256	64
Number of Time Channels / Curve	64	256	1024	4096
max. Counts / Channel	2^{16}-1			
Overflow Control	none / stop / repeat and correct			
Collection Time	0.1 us to 10000 s			
Display Interval Time	10ms to 1000 s			
Repeat Time	0.1 us to 1000 s			
Curve Control (internal)	Programmable Hardware Sequencer			
Count Enable Control	1 bit TTL			
Experiment Trigger	TTL			

Data Acquisition (FIFO / Time-Tag Mode)

Method	Time-tagging of individual photons and continuous writing to disk
Dead Time	125 ns
Output Data Format (ADC / Macrotime / Routing)	12 / 12 / 3
FIFO buffer Capacity (photons)	128 k
Macro Timer Resolution, internal clock	50ns, 12 bit
Macro Timer Resolution, clock from SYNC input	10ns to 100ns, 12 bit
Curve Control (external Routing)	3 bit TTL
Count Enable Control	1 bit TTL

Operation Environment

Computer System	PC Pentium
Bus Connectors	PCI
Used PCI Slots	4
Power Consumption	approx. 18 W at +5V, 0.7 W at +12V
Dimensions	225 mm x 125 mm x 85 mm

Related Products and Accessories

Detectors (MCPs, PMTs), multichannel detector heads, routing devices for multi-detector operation, detector controllers, detector / shutter assemblies, preamplifiers, PIN and avalanche photodiode modules, ps diode lasers with multiplexing capability. Also available: SPC-134, SPC-144, SPC-630, SPC-730 and SPC-830 time-correlated single photon counting modules, gated photon counters and multiscalers. Please call for individual data sheets and manuals. For TCSPC imaging applications please see SPC-730, -830 and -144 data sheets.

Please visit our web site for free download of manuals, device software and application literature.

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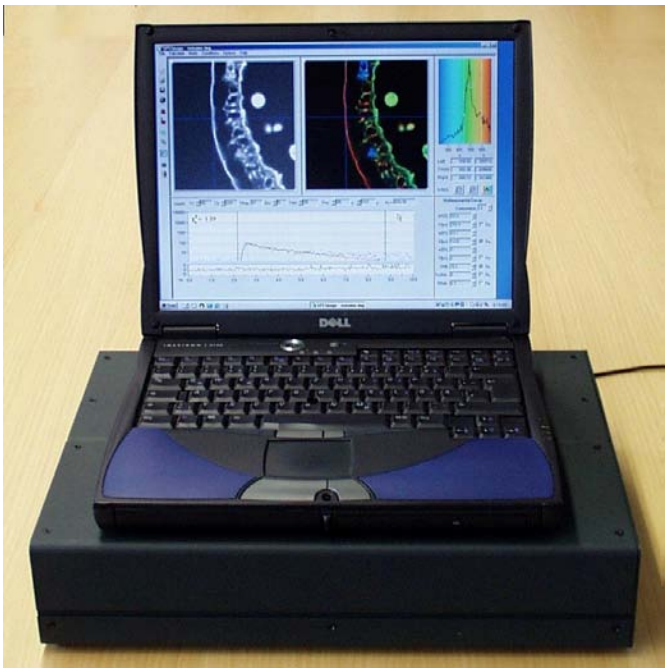
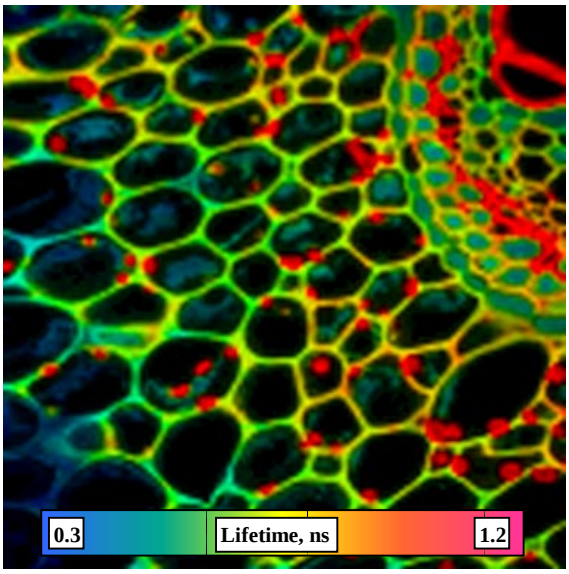
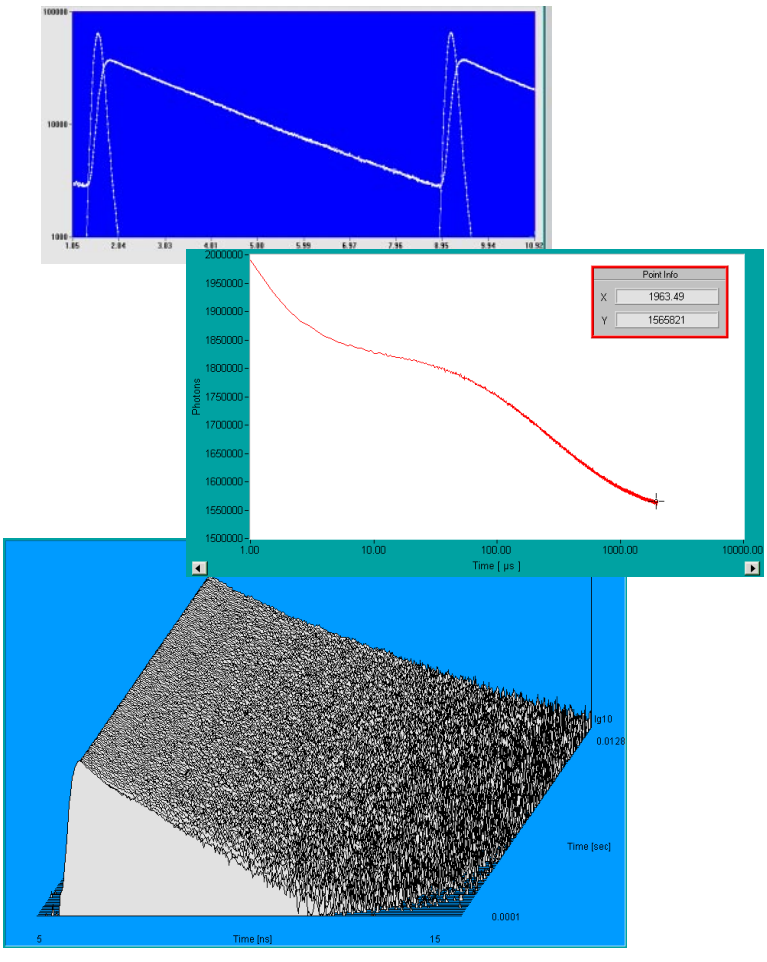
Simple-Tau 830 Table-Top TCSPC Systems

Ultra-fast time-correlated single photon counting systems in lap-top format

- Complete TCSPC system and detector control
- Cooled fast PMT module
- Picosecond resolution
- Unprecedented count rate
- Unprecedented timing stability
- Time channel width down to 813 fs
- Multi-dimensional on-board data acquisition
- Lifetime imaging capability
- Optional multi detector operation
- Optional multi-spectral operation
- Standard fluorescence lifetime applications
- On-line FCS recording
- Fast triggered sequential recording
- Lifetime imaging with scanning microscopes
- Works at any scan rate of microscope
- High-resolution steady-state imaging
- Diffuse optical tomography
- Single molecule spectroscopy
- Works under windows 2000, NT or XP







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Covered by patents DE 43 39 784 and DE 43 39 787

Simple-Tau 830 Table-Top TCSPC Systems

Photon Channel

Principle	Constant Fraction Discriminator (CFD)
Time Resolution (FWHM / RMS, electr.)	7 ps / 4 ps
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Threshold	- 20 mV to - 500 mV
Zero Cross Adjust	- 100 mV to + 100 mV

Synchronisation Channel

Principle	Constant Fraction Discriminator (CFD)
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Threshold	- 20 mV to -500 mV
Frequency Range	0 to 200 MHz
Frequency Divider	1-2-4-8
Zero Cross Adjust	-100 mV to + 100 mV

Time-to-Amplitude Converters / ADC

Principle	Ramp Generator / Biased Amplifier
TAC Range	50 ns to 2 us
Biased Amplifier Gain	1 to 15
Biased Amplifier Offset	0 to 100% of TAC Range
Time Range incl. Biased Amplifier	3.3 ns to 2 us
min. Time / Channel	813 fs
TAC Window Discriminator	Any window inside TAC range
ADC Principle	50 ns Flash ADC with Error Correction
Diff. Nonlinearity	< 0.5% rms, typ. <1% peak-peak

Data Acquisition (Histogram Mode)

Method	on-board multi-dimensional histogramming process						
Dead Time	125ns, independent of computer speed						
Saturated Count Rate, per TCSPC channel / total	8 MHz						
Useful count rate, per TCSPC channel / total	4 MHz						
Number of Time Channels / Pixel	1	4	16	64	256	1024	4096
IImage Resolution (pixels), 1 Detector Channel	4096 x 4096	2048 x 2048	1024 x 1024	512 x 512	256 x 256	128 x 128	64 x 64
IImage Resolution (pixels), 4 Detector Channels	2048 x 2048	1024 x 1024	512 x 512	256 x 256	128 x 128	64 x 64	32 x 32
IImage Resolution (pixels), 16 Detector Channels	1024 x 1024	512 x 512	256 x 256	128 x 128	64 x 64	32 x 32	16 x 16
max. Counts / Time Channel	2^{16}-1						
Overflow Control	none / stop / repeat and correct						
Collection Time	0.1 us to 10000 s						
Display Interval Time	100ms to 1000 s						
Repeat Time	0.1 us to 1000 s						
Sequential recording	Programmable Hardware Sequencer						
Synchronisation with scanning	pixel, line and frame clocks from scanning microscope						
Count Enable Control	1 bit TTL						
Experiment Trigger	TTL						

Data Acquisition (FIFO / Time-Tag Mode)

Method	Time-tagging of individual photons and continuous writing to disk
Dead Time	125 ns
Output Data Format (ADC / Macrotime / Routing)	12 / 12 / 3
FIFO buffer Capacity (photons)	8 M
Macro Timer Resolution, internal clock	50ns, 12 bit
Macro Timer Resolution, clock from SYNC input	10ns to 100ns, 12 bit
Curve Control (external Routing)	3 bit TTL
Count Enable Control	1 bit TTL

Detector control

Number of idependenly controlled detctors	one or two
Resolution of gain control	12 bit
Voltage Range Pin 12 of connector 1 and 3	0 to +10 V
Voltage Range Pin 13 of connector 1 and 3	0 to +0.9 V
Output Time Constant	100 ms
Detector overload shutdown	via TTL signal from PMC-100 detector module or preamplifier
Reset of overload shutdown	By Software and at Power-ON
Shutter control	8 independent high-current switches
Max. Switch Current, Single Switch	2 A
Max. Switch Current, Sum of all Switches	5 A
Max. turn-off Voltage at Switches	20 V
Control of thermoelectric coolers	for one or two detectors
Total output voltage	0 to 5 V
Output Current	0 to 2 A
Resolution of Output Voltage and Current	12 bit

Detectors, see individual data sheets

Standard detector	PMC-100-1 cooled PMT module
Optional	PMC-100-20 cooled NIR PMT module
Optional	R3809U MCP PMT with FuG HCN3500-14 power supply and HFA26-01 preamlifier
Optional	id100-20 and id100-50 single-photon APD modules
Optional	PMC-100, R3809U, or id100 multi-detector systems
Optional	PML-SPEC multi-wavelength detector

Related Products and Accessories

SPC-134 through SPC-830 TCSPC boards, Detector Heads (MCPs, PMTs), Multichannel Detector Heads, Routing Devices for Multichannel Measurements, Step Motor Controllers, Preamplifiers, PIN and Avalanche Photodiode Modules, ps Diode Lasers, Adapter Cables for Scanning Microscopes. Please downlaod or call for individual data sheets.

Please visit our web site to download the manuals, the device software and application notes.

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- Optional multi-spectral operation
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- On-line FCS recording
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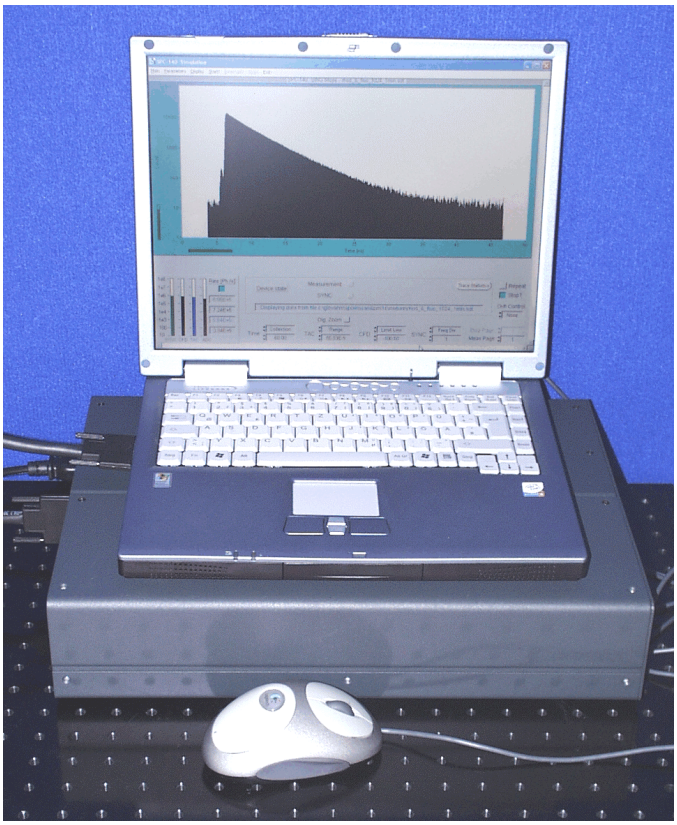
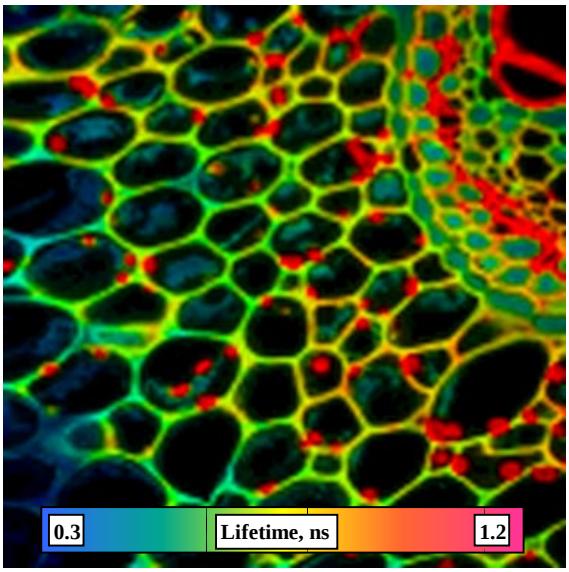
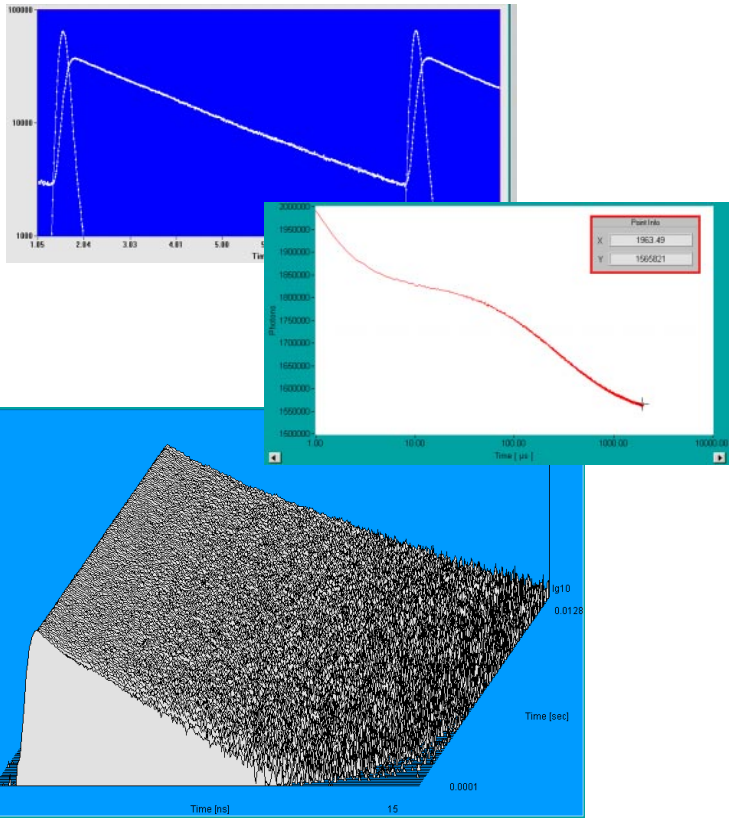
- Diffuse optical tomography
- Single molecule spectroscopy
- Works under windows 2000, NT or XP







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Covered by patents DE 43 39 784 and DE 43 39 787

Simple-Tau 140 Table-Top TCSPC Systems

Photon Channel

Principle	Constant Fraction Discriminator (CFD)
Time Resolution (FWHM / RMS, electr.)	8 ps / 5 ps
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Lower Threshold	- 20 mV to - 500 mV
Upper Threshold	-
Zero Cross Adjust	- 100 mV to + 100 mV

Synchronisation Channel

Principle	Constant Fraction Discriminator (CFD)
Opt. Input Voltage Range	- 50 mV to - 1 V
Min. Input Pulse Width	400 ps
Threshold	- 20 mV to -500 mV
Frequency Range	0 to 200 MHz
Frequency Divider	1-2-4
Zero Cross Adjust	-100 mV to + 100 mV

Time-to-Amplitude Converters / ADCs

Principle	Ramp Generator / Biased Amplifier
TAC Range	50 ns to 2 us
Biased Amplifier Gain	1 to 15
Biased Amplifier Offset	0 to 100% of TAC Range
Time Range incl. Biased Amplifier	3.3 ns to 2 us
min. Time / Channel	813 fs
ADC Principle	50 ns Flash ADC with Error Correction
Diff. Nonlinearity	< 0.5% rms, typ. <1% peak-peak

Data Acquisition (Histogram Mode)

Method	on-board multi-dimensional histogramming process						
Dead Time	100ns, independent of computer speed						
Saturated Count Rate, per TCSPC channel / total	10 MHz						
Useful count rate, per TCSPC channel / total	5 MHz						
Number of Time Channels / Pixel	1	4	16	64	256	1024	4096
Image Resolution (pixels), 1 Detector Channel	2048 x 2048	1024 x 1024	512 x 512	256 x 256	128 x 128	64 x 64	32 x 32
max. Counts / Time Channel	2^{16}-1						
Overflow Control	none / stop / repeat and correct						
Collection Time	0.1 us to 10000 s						
Display Interval Time	100ms to 1000 s						
Repeat Time	0.1 us to 1000 s						
Sequential recording	Programmable Hardware Sequencer						
Synchronisation with scanning	pixel, line and frame clocks from scanning microscope						
Count Enable Control	1 bit TTL						
Experiment Trigger	TTL						

Data Acquisition (FIFO / Time-Tag Mode)

Method	Time-tagging of individual photons and continuous writing to disk
Dead Time	125 ns
Output Data Format (ADC / Macrotime / Routing)	12 / 12 / 3
FIFO buffer Capacity (photons)	2 M
Macro Timer Resolution, internal clock	50ns, 12 bit
Macro Timer Resolution, clock from SYNC input	10ns to 100ns, 12 bit
Curve Control (external Routing)	3 bit TTL
Count Enable Control	1 bit TTL

Detector control

Number of idependenly controlled detctors	one or two
Resolution of gain control	12 bit
Voltage Range Pin 12 of connector 1 and 3	0 to +10 V
Voltage Range Pin 13 of connector 1 and 3	0 to +0.9 V
Output Time Constant	100 ms
Detector overload shutdown	via TTL signal from PMC-100 detector module or preamplifier
Reset of overload shutdown	By Software and at Power-ON
Shutter control	8 independent high-current switches
Max. Switch Current, Single Switch	2 A
Max. Switch Current, Sum of all Switches	5 A
Max. turn-off Voltage at Switches	20 V
Control of thermoelectric coolers	for one or two detectors
Total output voltage	0 to 5 V
Output Current	0 to 2 A
Resolution of Output Voltage and Current	12 bit

Detectors, see individual data sheets

Standard detector	PMC-100-1 cooled PMT module
Optional	PMC-100-20 cooled NIR PMT module
Optional	R3809U MCP PMT with FuG HCN3500-14 power supply and HFA26-01 preamlifier
Optional	id100-20 and id100-50 single-photon APD modules
Optional	PMC-100, R3809U, or id100 multi-detector systems
Optional	PML-SPEC multi-wavelength detector

Related Products and Accessories

SPC-134 through SPC-830 TCSPC boards, Detector Heads (MCPs, PMTs), Multichannel Detector Heads, Routing Devices for Multichannel Measurements, Step Motor Controllers, Preamplifiers, PIN and Avalanche Photodiode Modules, ps Diode Lasers, Adapter Cables for Scanning Microscopes. Please downlaod or call for individual data sheets.

Please visit our web site to download the manuals, the device software and application notes.

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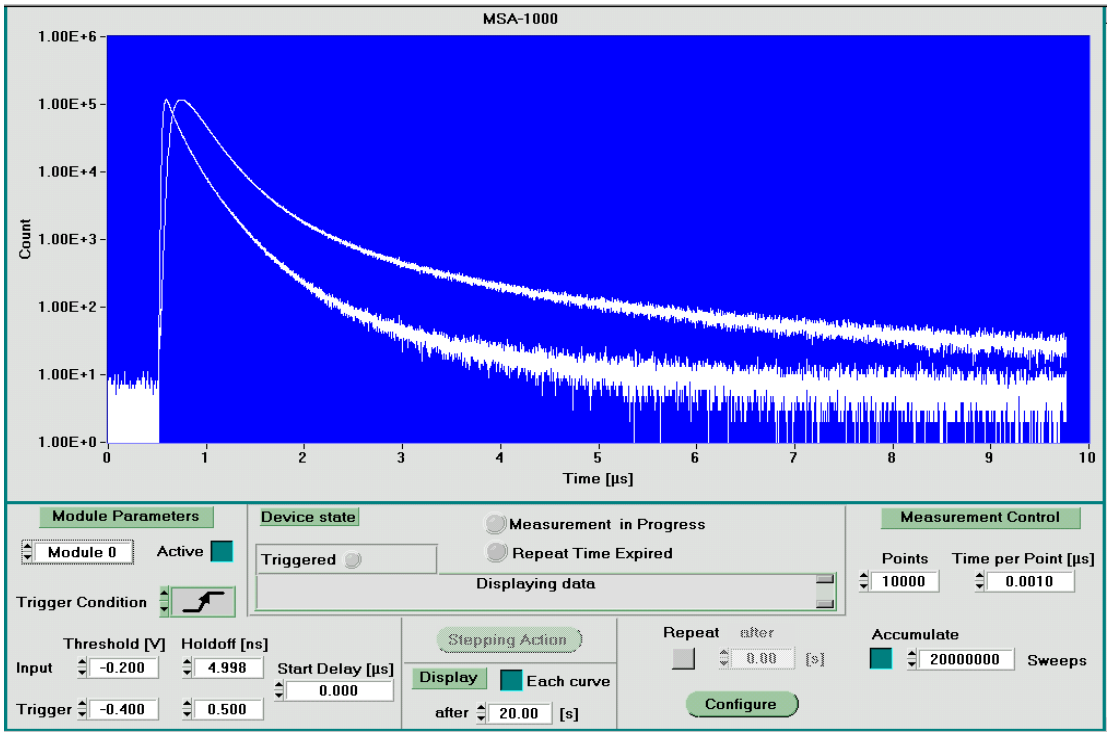
MSA-1000

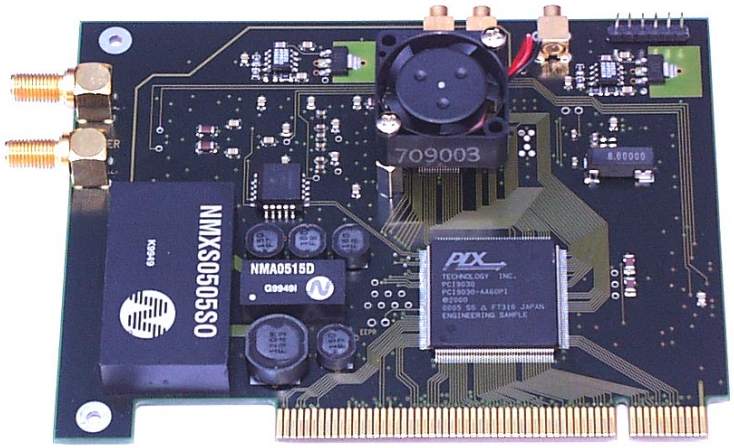
1ns Photon Counter / Multiscaler

Ultra-fast accumulation
High repetition rate
No dead time between sweeps
No dead time between channels
Fast on-board discriminators

Input pulse width down to 800 ps
Time / channel 1 ns
Count rate up to 1000 MHz
Up to 128 k points / curve
Software for Windows 95 / 98 / 2000 / NT

The MSA-1000 is an ultra-fast multiscaler for photon counting, Lidar measurements or other fast particle detection applications. By using a 128 bit memory structure a dead-time-free accumulation of subsequent sweeps is achieved. This makes the MSA-1000 exceptionally useful for a wide variety of high-repetition rate signal recording applications.





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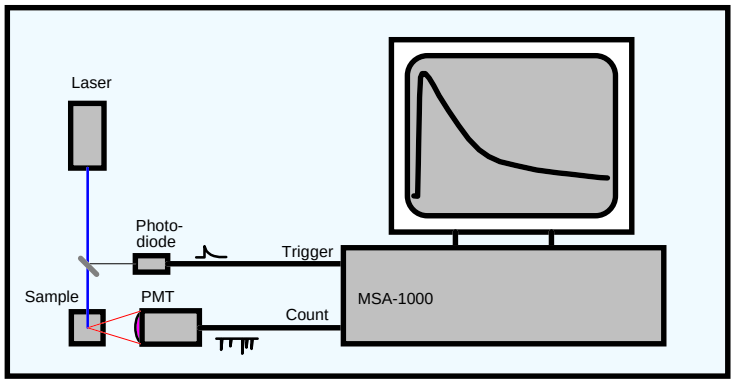
MSA-1000

Specification

Time per Channel	min. 1 ns
Count Rate	up to 1000 MHz
No of Points / Curve	up to 128 k
Overall Recording Length	up to 131 µs
Accumulation (up to 256 events/point)	Hardware, no dead time between recording cycles
Accumulation (> 256 events/point)	Software
Count Input Impedance	50 Ω
Count Input Amplitude	±20 mV to ±1 V
Count Input Threshold	0 to ± 200 mV, ± 8 bit resolution
Min.Count Input Pulse Width	800 ps
Trigger Input Impedance	50 Ω
Count and Trigger Input Connectors	SMA
Trigger Input Amplitude	±20 mV to ±1 V
Trigger Input Threshold	0 to ±1 V, ± 8 bit resolution
Min. Trigger Pulse Width	800 ps
Data Readout	subsequent data points are read by subsequent input instructions
Typical readout rate (Pentium 166 MHz)	1us/point (C^{++}, read 1 point and store into a data array)

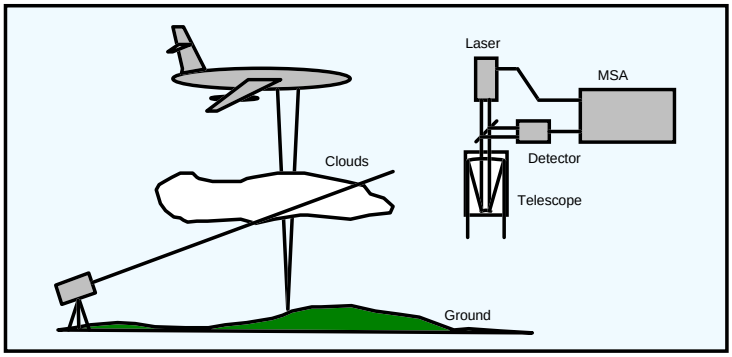
Luminescence Decay Measurements

The sample is excited by laser pulses and the luminescence signal is detected by a PMT in the photon counting mode. Due to the deep memory a time scale from ns to ms can be covered in one measurement.



Lidar Measurements

Laser pulses are sent through a telescope and backscattered light from distant objects is detected. Due to the high accumulation speed of the MSA-1000 very high repetion rates and short overall measurement times are achieved.



Accessories: PMTs, PMT detector heads with internal HV supply, preamplifiers, diode lasers, pulse generators for experiment control, step motor controllers. Please see individual data sheets.

Please visit our web site to download the manual, the device software and application notes.

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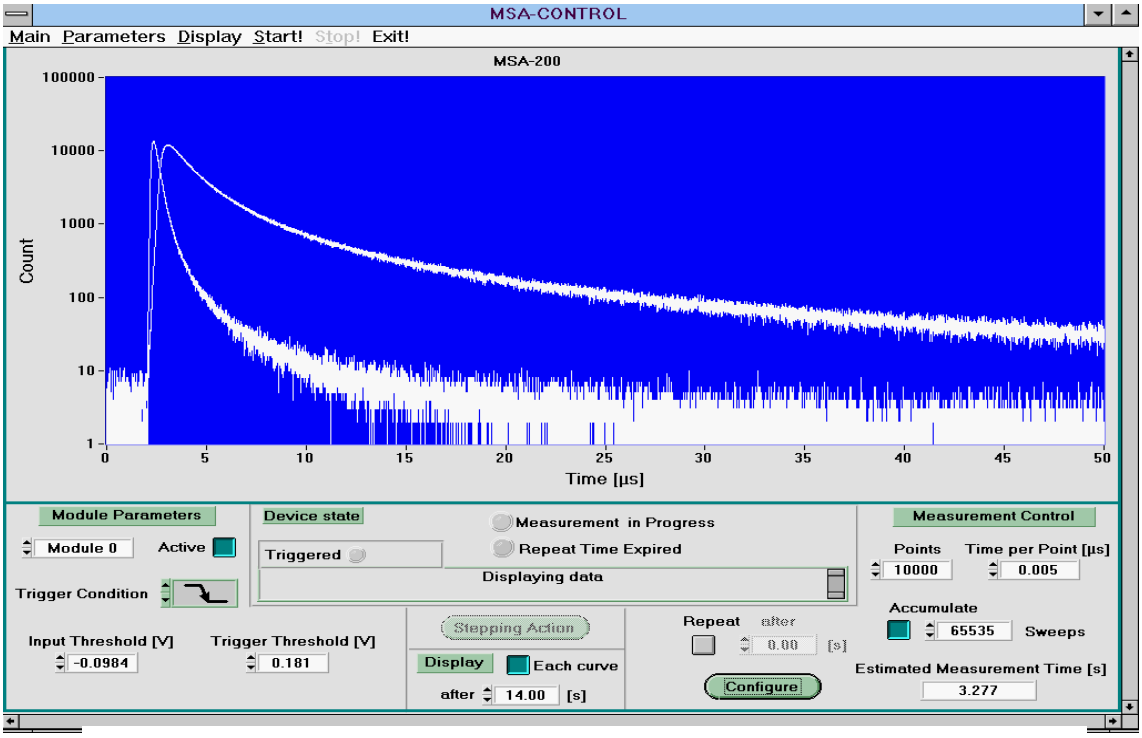
MSA-300

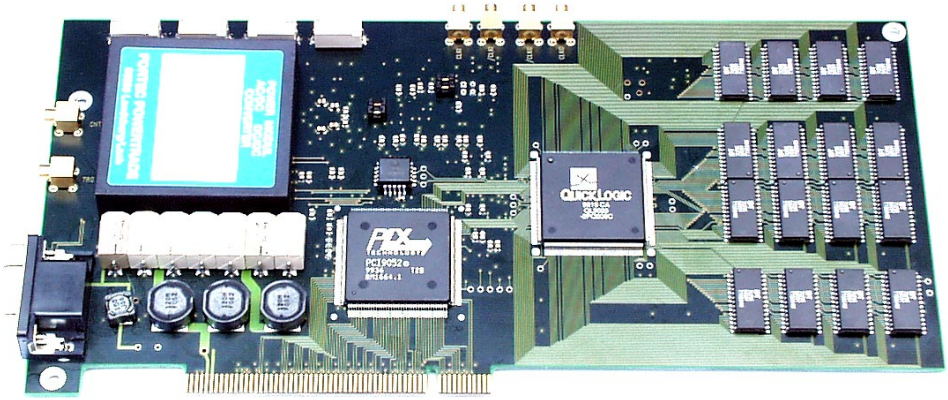
5ns Photon Counter / Multiscaler

Ultra-fast accumulation
High repetition rate
No dead time between sweeps
No dead time between channels
Fast on-board discriminators

Input pulse width down to 800 ps
Time / channel down to 5 ns
Count rate up to 100 MHz
Up to 512 k points / curve
Software for Windows 95 / 98 / 2000 / NT

The MSA-300 is a fast multiscaler for photon counting, time-of-flight measurements or other fast particle detection applications. By using a 128 bit memory structure a dead-time-free accumulation of subsequent sweeps is achieved. This makes the MSA-300 exceptionally useful for a wide variety of high-repetition rate signal recording applications.





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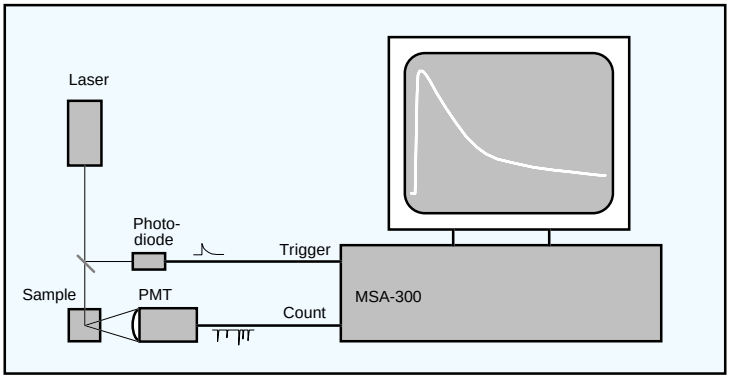
MSA-300

Specification

Time per Channel	min. 5 ns
Count Rate	up to 100 MHz
No of Points / Curve	up to 512 k
Overall Recording Length	up to 2.62 ms
Accumulation (up to 256 events/point)	Hardware, no dead time between recording cycles
Accumulation (> 256 events/point)	Software
Count Input Impedance	50 Ω
Count Input Amplitude	±20 mV to ±1 V
Count Input Threshold	0 to ± 200 mV, ± 8 bit resolution
Min.Count Input Pulse Width	800 ps
Trigger Input Impedance	50 Ω
Count and Trigger Input Connectors	MCX
Trigger Input Amplitude	±20 mV to ±1 V
Trigger Input Threshold	0 to ±1 V, ± 8 bit resolution
Min. Trigger Pulse Width	800 ps
Data Readout	subsequent data points are read by subsequent input instructions
Typical readout rate (Pentium 166 MHz)	1us/point (C^{++}, read 1 point and store into a data array)

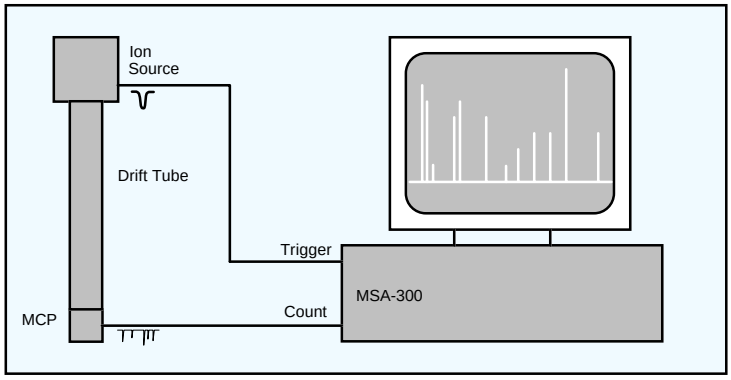
Luminescence Decay Measurements

The sample is excited by laser pulses and the luminescence signal is detected by a PMT in the photon counting mode. Due to the deep memory a time scale from ns to ms can be covered in one measurement.



Time-of-Flight Measurements

Packages of ions are released by a pulsed source, sent through a drift tube and detected by an MCP. Due to the high accumulation speed of the MSA-300 very high repetion rates and short overall measurement times are achieved.



Accessories: PMTs, PMT detector heads with internal HV supply, preamplifiers, diode lasers, pulse generators for experiment control, step motor controllers. Please see individual data sheets.

Please visit our web site to download the manual, the device software and application notes.

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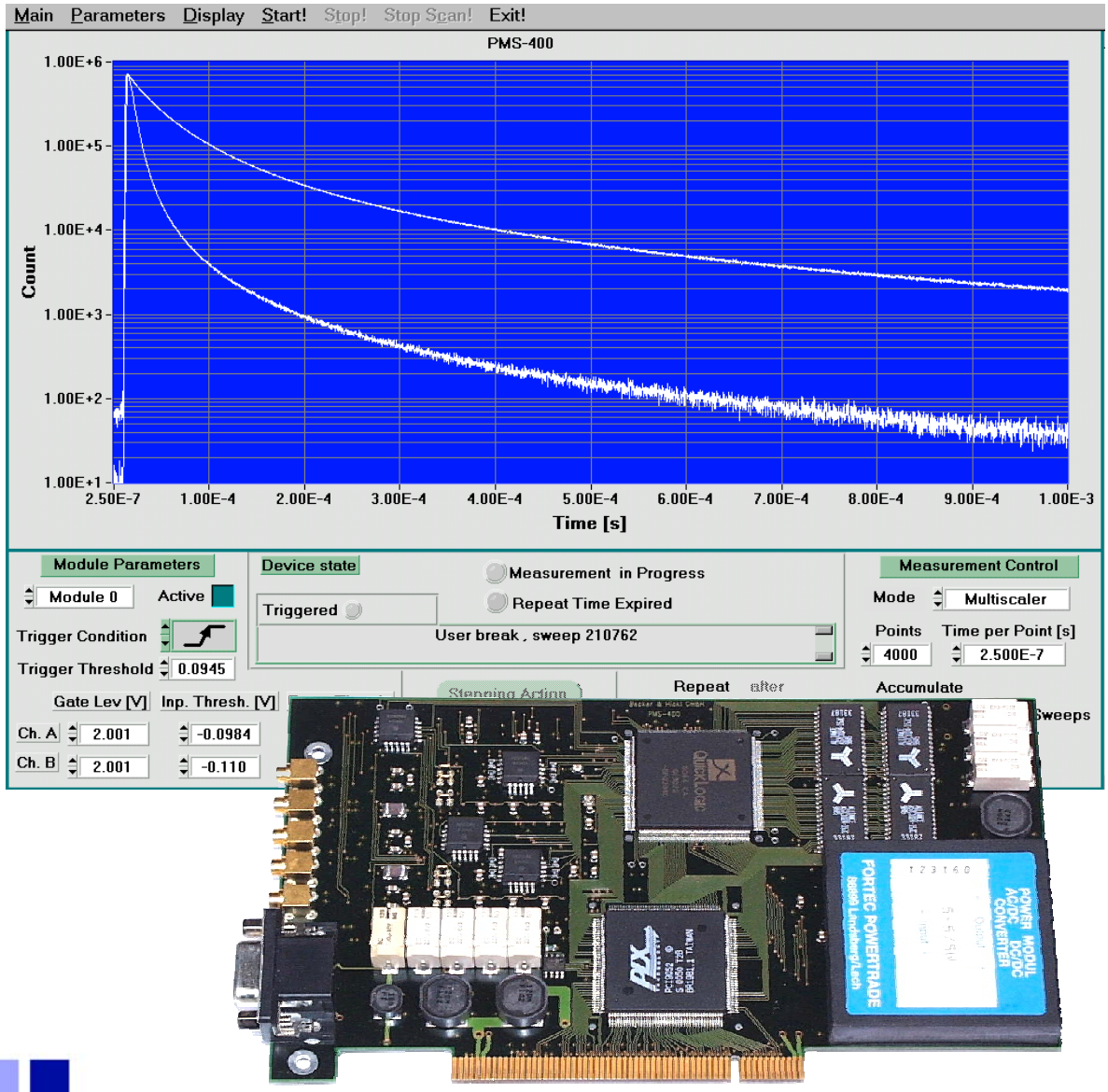
PMS-400A

800 MHz Gated Photon Counter / Multiscaler

- 2 Counter Channels
- 800 MHz Count Rate, 32 bit Resolution
- Direct Interfacing to most Detectors
- Multiscaler Mode: Up to 64k Time Channels, min. 250ns / Channel
- Gated Photon Counting: 1.5 ns min. Gate Pulse Width
- Event Recording Mode: Up to 32 k Events

new
- 32 bit Accumulation Counter for ultra-fast Accumulation
- On-Board Discriminators, Timing and Control Logics

new
- PCI Board with fast DMA (Bus Master),
- Software for Windows 98, NT, 2k and XP, Parallel Operation of Several Modules Supported



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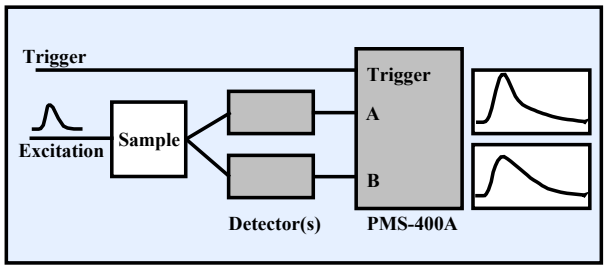
Optical Transient Waveform Recording

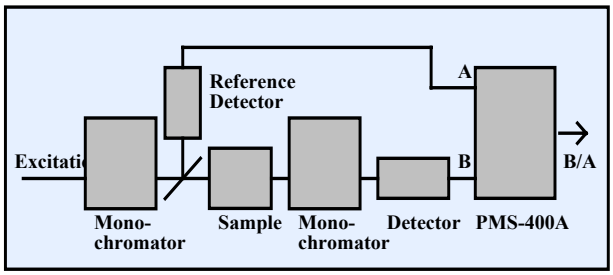
The waveform of the light is measured with a resolution down to 250ns. Two signals can be recorded simultaneously. Applicable to luminescence decay of inorganic samples, phosphorescence, delayed fluorescence, chemoluminescence, LIDAR.

New: The PMS-400A provides a 32 bit accumulation counter which enables accumulation with virtually no dead time between sweeps (< 100 ns).



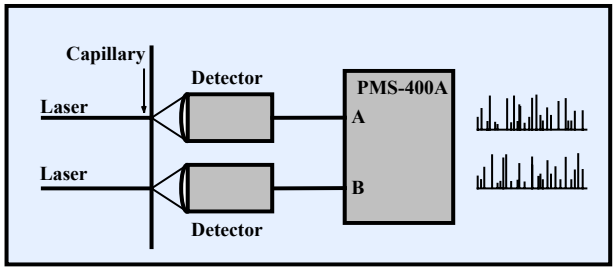
Recording of Luminescence Spectra

The luminescence and the excitation light are recorded simultaneously. Corrected excitation spectra are obtained by calculating B/A.



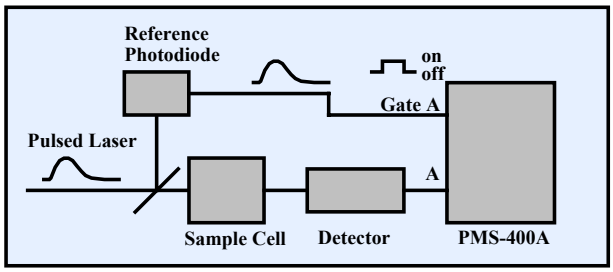
Single Molecule Detection

Recording of photon bursts. If the count rate inside a programmed time interval exceeds a programmed value, the number of photons and the time of the event ist stored.



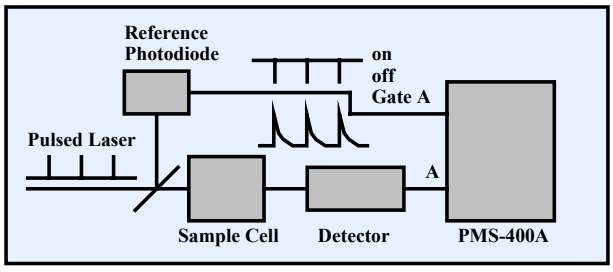
Gated Detection

The gate is opened during the laser pulse only.Events outside the laser pulses are suppressed. Exceptionally low background count rate.



Gating off Scattering Pulses

The gate is closed during the laser pulses. Scattered photons during the laser pulses are suppressed, the luminescence photons outside the laser pulses are recorded.



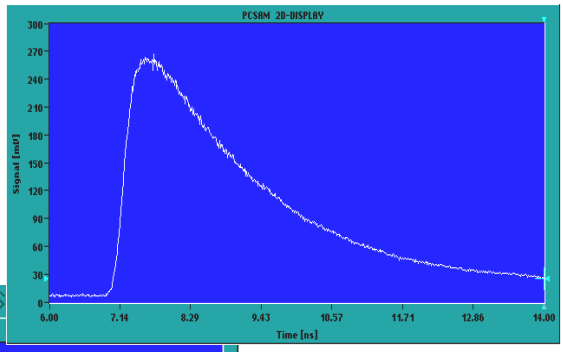
Specification (Typical Values)

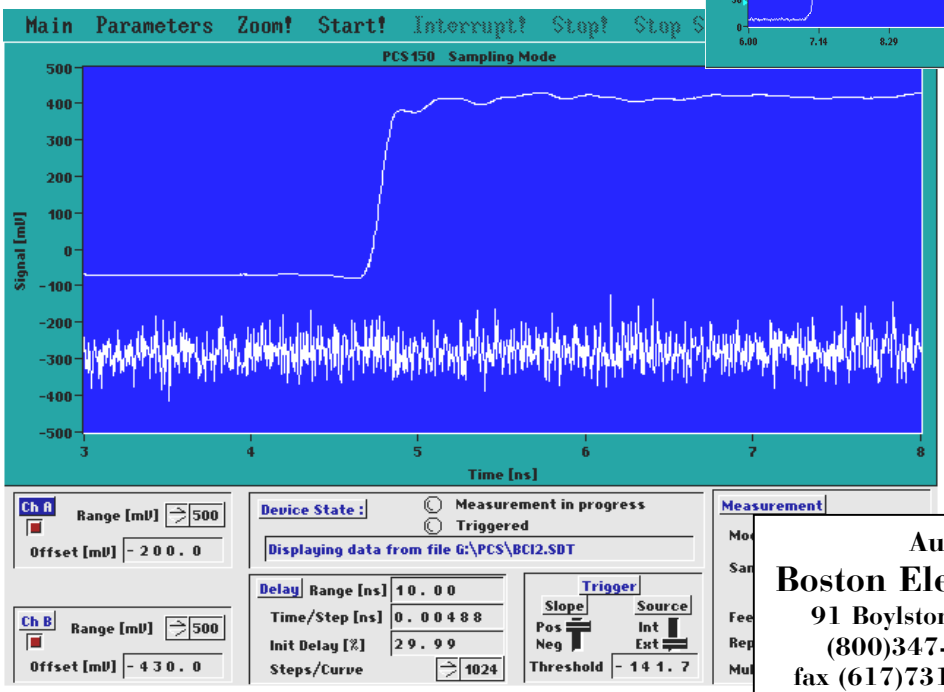
Counter Channels	2
Count Rate (Input Amplitude 50mV, peak-peak)	800 MHz
min. Count Pulse Width	800 ps
min. Gate Width (Input Amplitude 200mV, peak-peak)	1 ns
min Trigger Pulse Width	1 ns
Discriminator Threshold (Count Inputs)	-1 V to +1 V in steps of 4 mV
Discriminator Threshold (Gate Inputs)	-2 V to +2 V in steps of 16 mV
Discriminator Threshold (Trigger Input)	-2 V to +2 V in steps of 16 mV
Input Connectors	MCX, 50 Ω
Counter Width	32 bit
Accumululation Counter	32 bit
Dead time between sweeps	< 100ns
No. of Time Bins	64 k for each counter channel
Time / Bin	250 ns to 100 000 s
Hardware Environment	Pentium PC
Software Environment	Windows 95, 98, 2000 or NT
Dimensions	180 mm x 108 mm x 15 mm

PCS-150 PCI-200

High Speed Boxcar Modules

Gate Width 120 ps for PCS-150
Gate Width 2 ns to 50 ns for PCI-200
2 Synchronously Sampling Signal Channels
Internal Delay Generator
Delay Stepping down to 5 ps
Boxcar Measurements in the sub-ns Range
Recovery of Signals from Noise
Scanned Delay Mode: Recording of Waveforms
Fixed Delay Mode: Single Point Analysis





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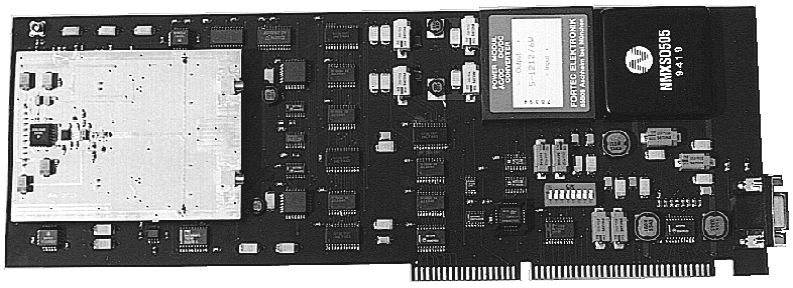

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intelligent measurement and control systems

PCS-150 PCI-200

	PCS-150	PCI-200
No. of Signal Channels	2	
Gate Width (PCS-150)	120 ps	2 ns to 50 ns
Input Impedance	50 Ω (SMA Connector)	
Input Voltage Ranges	50 100 200 500 mV	
Amplitude Resolution	9 10 11 12 bit (without averaging)	
Amplitude Resolution	12 bit (100 samples averaged)	
Internal Noise (rms)	1 mV	< 0.25 mV
Channel Arithmetics	A+B, A-B, A*B, A/B	
No of Samples Averaged	1 to 4096	
Averaging Modes	Repeated Sampling or Boxcar Mode	
Delay Range	10 ns to 20 us	
Delay Step Width	5 ps to 312 ns	
Virtual Sample Rate	up to 200 GS/s	
X-Axis Resolution	64 to 1024 points	
Scan Modes	Fixed Delay and Scanned Delay	
Trigger	external or internal on channel A	
Ext. Trigger Input	50 Ω (SMA Connector)	
Trigger Input Frequency	0 to 500 MHz	
min. Trigger Pulse Width	1 ns	
Trigger Threshold	-1V to + 1V	
Max. Internal Trigger Rate	up to 100 kHz dep. on mode and PC speed	
Dimensions	120 x 337 mm	
Power Consumption	typ. 12 W at + 5 V	

Accessories
AC coupled preamplifiers up to 2.2 GHz, DC coupled preamplifiers up to 250 MHz, high speed pin and avalanche photodiode modules, low noise integrating photodiode modules, PMT modules, optical trigger devices, step motor controllers, DLL and DOS library for user specific programming

Also Available:
Stand alone boxcar devices BCI-150 and BCI-200 with IEEE interface, gate width 120 ps or 2 ns to 50 ns.

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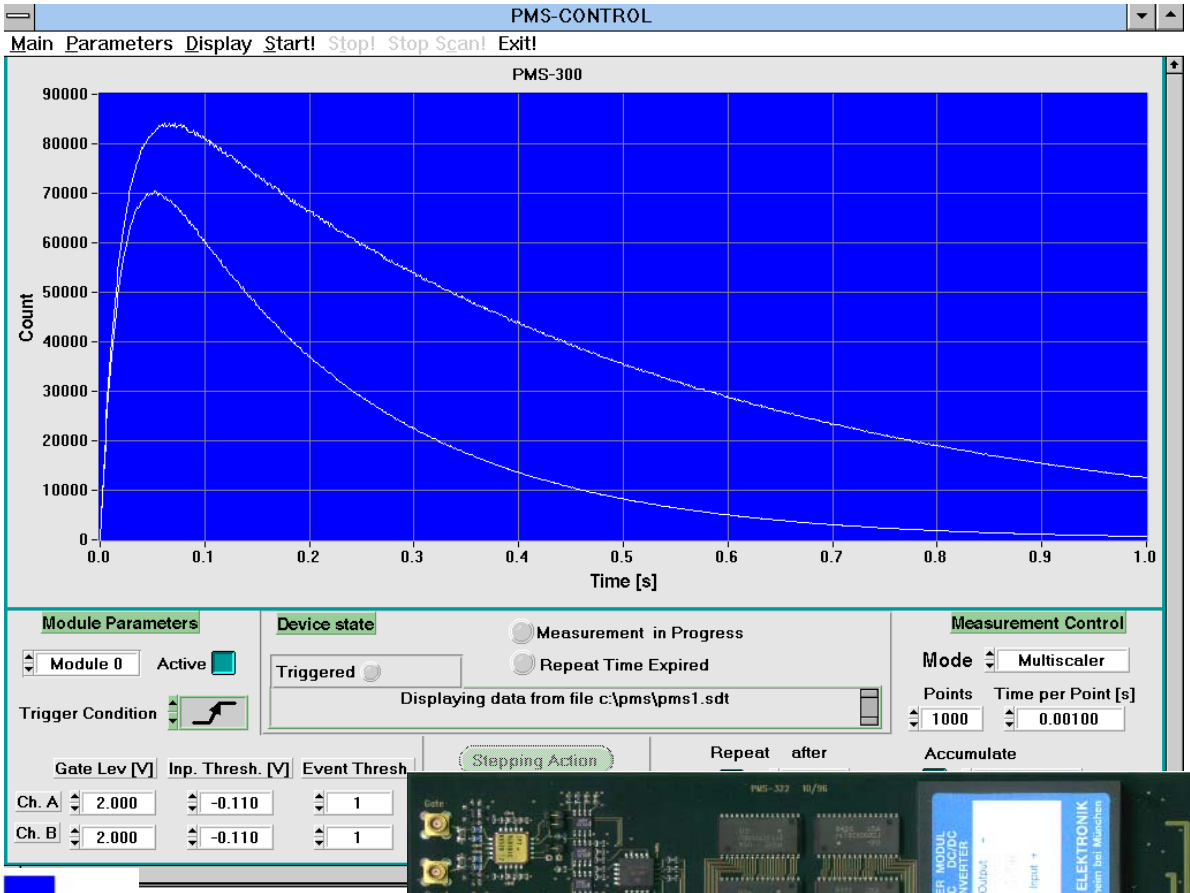
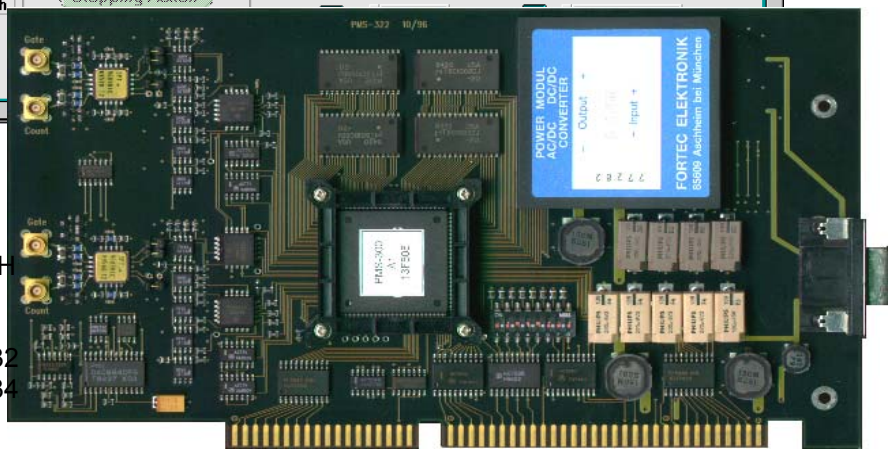
measurement
and
control systems

PMS-300

800 MHz Gated Photon Counter / Multiscaler

- 2 Counter Channels
- 800 MHz Count Rate, 32 bit Resolution
- Direct Interfacing to most Detectors
- Multiscaler: Up to 64k Time Channels, min. 250ns / Channel
- Gated Photon Counting: 1.5 ns min. Gate Pulse Width
- Event Storage Mode: Up to 32 k Events
- On-Board Timing and Control Circuitry
- PC-Plug-in-Board
- Parallel Operation of several Modules supported





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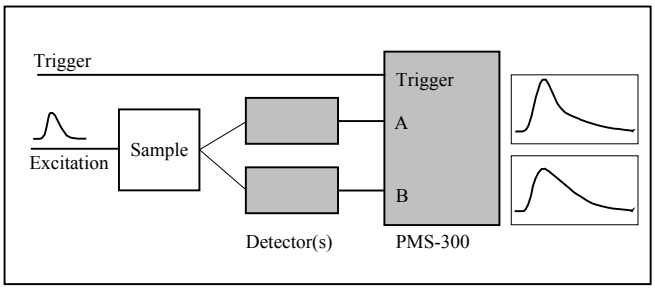
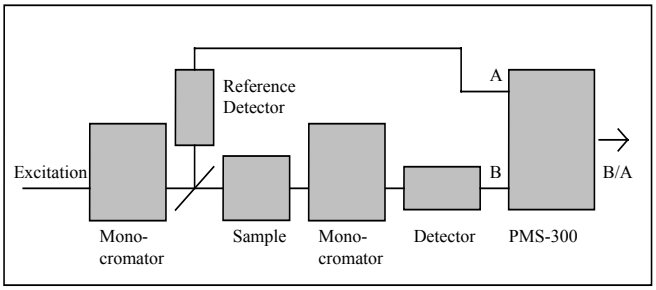
Optical Transient Waveform Recording

The waveform of the light is measured with a channel resolution down to 250ns. Two signals can be recorded simultaneously.



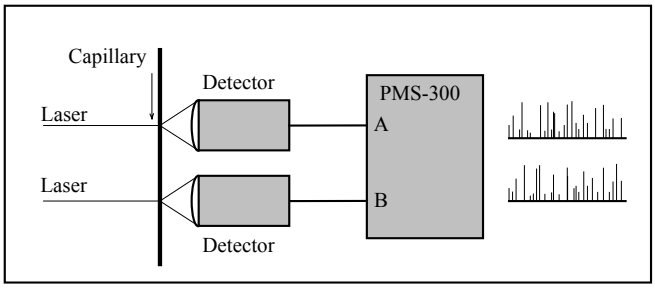
Recording of Luminescence Spectra

The luminescence and the excitation light are recorded simultaneously. Corrected excitation spectra are obtained by calculating B/A.



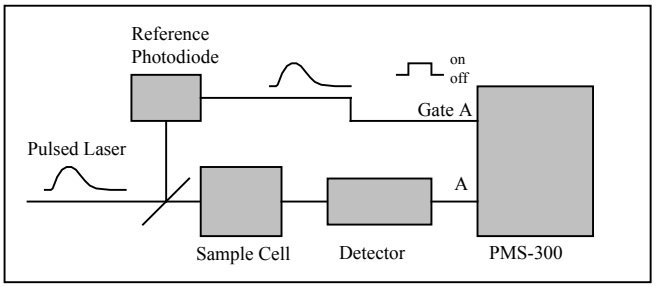
Single Molecule Detection

If the count rate inside a programmed time interval exceeds a programmed value, the number of photons and the actual time of the event ist stored.



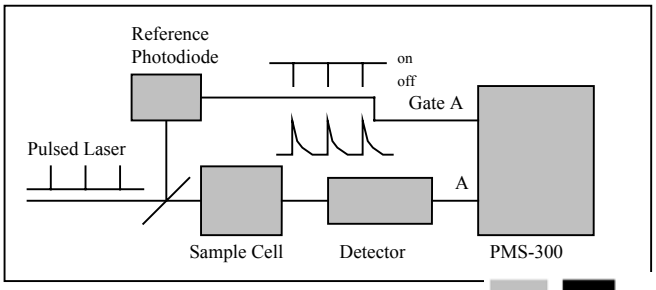
Gated Detection

The gate is opened during the laser pulse only. Background events outside the laser pulses are suppressed.



Gating off Straylight Pulses

The gate is closed during the laser pulses. The straylight during the laser pulses is suppressed, the fluorescence photons outside the laser pulses are recorded.



Specification (Typical Values)

Counter Channels	2
Count Rate (Input Amplitude 50mVss)	800 MHz
min. Count Pulse Width	800 ps
min . Gate Width (Input Amplitude 200mVss)	1 ns
Discriminator Threshold (Count Inputs)	0...-1024 mV in steps of 2mV
Discriminator Threshold (Gate Inputs)	-2048mV ... 2048 mV in steps of 8mV
Counter Width	32 bit
No. of Memory Channels	64 k for each counter channel
Time / Channel	250 ns to 100 000 s
Hardware Environment	PC 486 or Pentium with 1 available ISA slot
Software Environment	Windows 3.1, Windows 95, Windows NT

intelligent measurement and control systems

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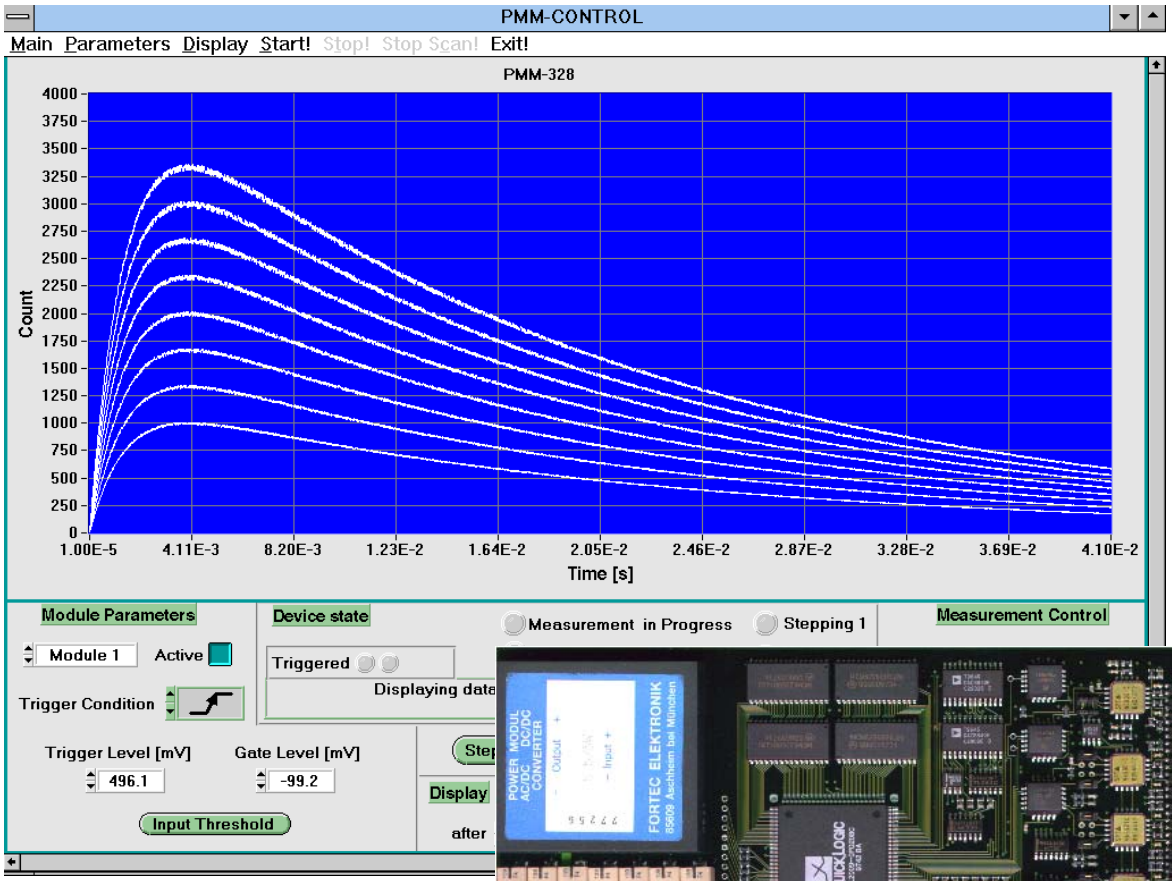
PMM-328

8 to 32 Channel 100 MHz Photon Counter / Multiscaler

8 Counter Channels per Module, 32 Counter Channels with 4 Modules
100 MHz Channel Count Rate
16 bit Counter Resolution
Up to 32 k Points / Channel
Multiscaler Operation down to 250 ns / Point
Gated Photon Counting down to 2 ns Gate Width
Optional Step Motor Controller for Experiment Control



intelligent measurement and control systems

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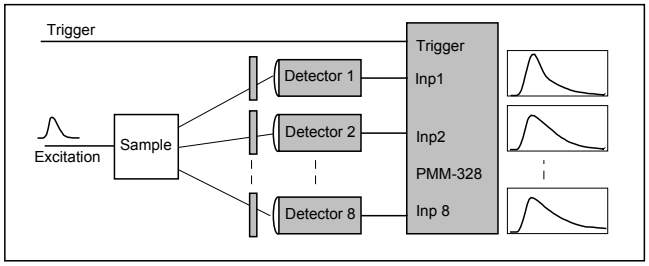
PMM-328

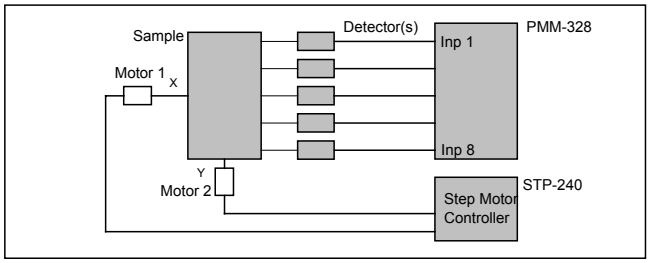
Multichannel Optical Waveform Recording

The waveform of the light is recorded with a channel resolution down to 250ns. Up to eight light signals can be recorded simultaneously in one module.



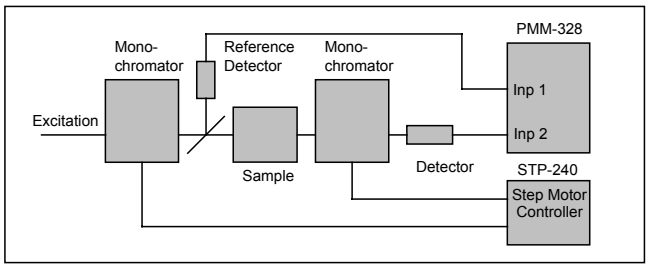
Sample Scanning

A sample is scanned in X-Y direction by two step motors controlled by the STP-240 step motor controller. Up to eight light signals can be recorded in one PMM module.



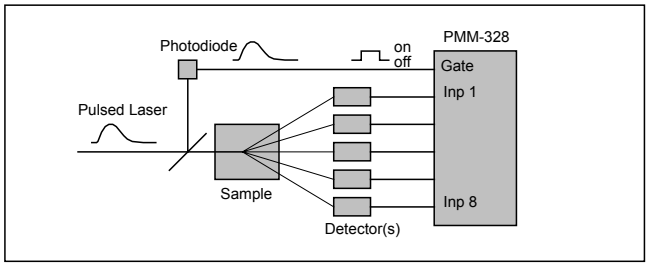
Measurement of Luminescence Spectra

The luminescence and the excitation light are recorded simultaneously. Corrected excitation spectra are obtained by calculating Inp1 / Inp2.



Gated Detection

The gate is opened during the laser pulse only. Background events outside the laser pulse are suppressed.



Specification

Counter Channels per Module	8
Input Pulse Polarity	positive or negative
Input Threshold	± 10 mV to ± 200 mV, Resolution 8 bit
Minimum Input Pulse Width	800 ps
Maximum Count Rate	> 100 MHz
Counter Resolution	16 bit
Memory Channels	32 k for each counter channel
Gate Input Pulse Polarity	positive or negative
Gate Threshold	± 10 mV to ± 200 mV, Resolution 8 bit
Minimum Gate Pulse Width	2 ns
Time / Point (Multiscaler)	250 ns to 100 000 s
Collection Time	200 ns to 100 000 s
Software	for Windows 3.1 / 95 / 98 / NT

For Detectors, Preamplifiers, Photodiode Modules, Optical Trigger Devices, Step Motor Controllers please see individual data sheets.

Authorized Agents:

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(800)347-5445 or (617)566-3821

fax (617)7310935 boselec@boselec.com

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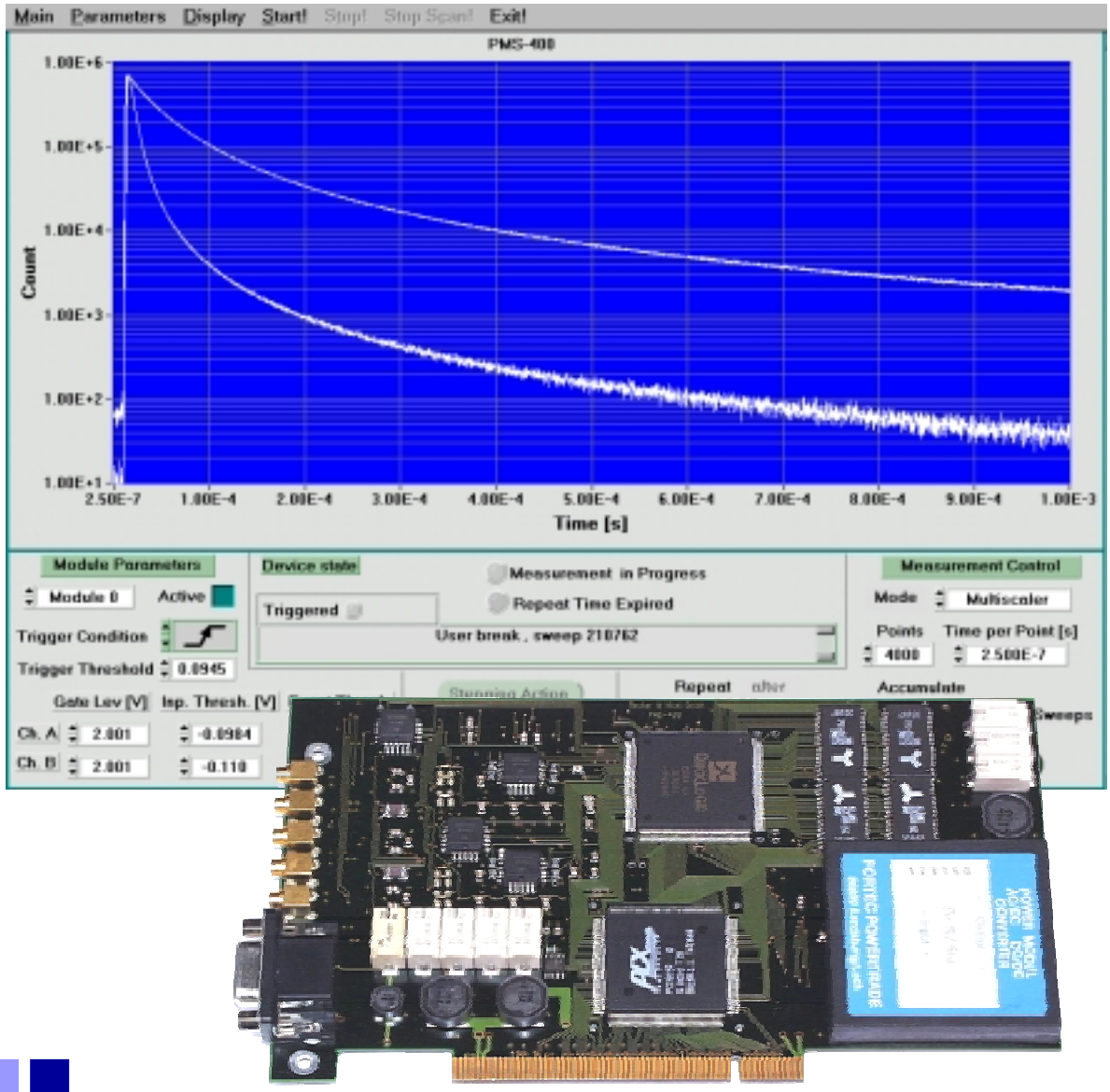
intelligent measurement and control systems

PMS-400

800 MHz Gated Photon Counter / Multiscaler

- 2 Counter Channels
- 800 MHz Count Rate, 32 bit Resolution
- Direct Interfacing to most Detectors
- Multiscaler Mode: Up to 64k Time Channels, min. 250ns / Channel
- Gated Photon Counting: 1.5 ns min. Gate Pulse Width
- Event Recording Mode: Up to 32 k Events
- On-Board Discriminators, Timing and Control Logics
- PCI Board, Software for Windows 95, 98, 2000 and NT
- Parallel Operation of Several Modules Supported



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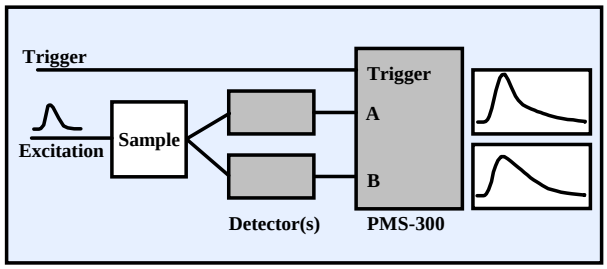
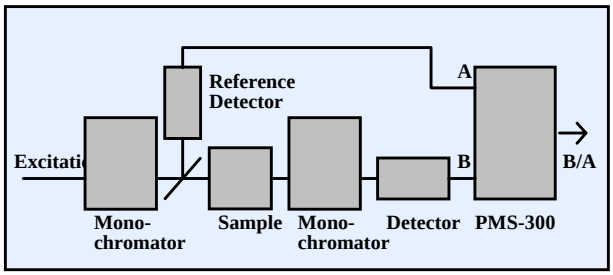
Optical Transient Waveform Recording

The waveform of the light is measured with a resolution down to 250ns. Two signals can be recorded simultaneously. Applicable to luminescence decay of inorganic samples, phosphorescence, delayed fluorescence, chemoluminescence, LIDAR.



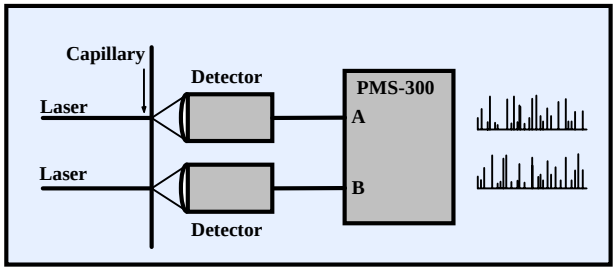
Recording of Luminescence Spectra

The luminescence and the excitation light are recorded simultaneously. Corrected excitation spectra are obtained by calculating B/A.



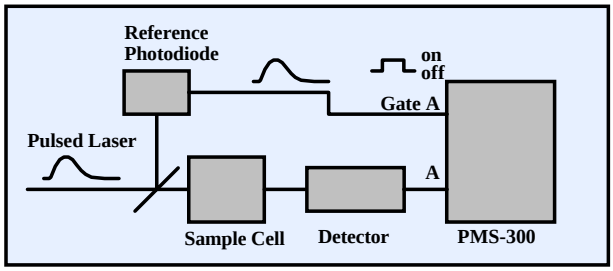
Single Molecule Detection

Recording of photon bursts. If the count rate inside a programmed time interval exceeds a programmed value, the number of photons and the time of the event ist stored.



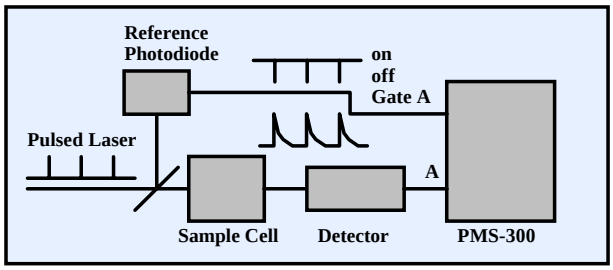
Gated Detection

The gate is opened during the laser pulse only.Events outside the laser pulses are suppressed. Exceptionally low background count rate.



Gating off Scattering Pulses

The gate is closed during the laser pulses. Scattered photons during the laser pulses are suppressed, the luminescence photons outside the laser pulses are recorded.



Specification (Typical Values)

Counter Channels	2
Count Rate (Input Amplitude 50mV, peak-peak)	800 MHz
min. Count Pulse Width	800 ps
min. Gate Width (Input Amplitude 200mV, peak-peak)	1 ns
min Trigger Pulse Width	1 ns
Discriminator Threshold (Count Inputs)	-1 V to +1 V in steps of 4 mV
Discriminator Threshold (Gate Inputs)	-2 V to +2 V in steps of 16 mV
Discriminator Threshold (Trigger Input)	-2 V to +2 V in steps of 16 mV
Input Connectors	MCX, 50 Ω
Counter Width	32 bit
No. of Time Bins	64 k for each counter channel
Time / Bin	250 ns to 100 000 s
Hardware Environment	Pentium PC
Software Environment	Windows 95, 98, 2000 or NT
Dimensions	180 mm x 108 mm x 15 mm

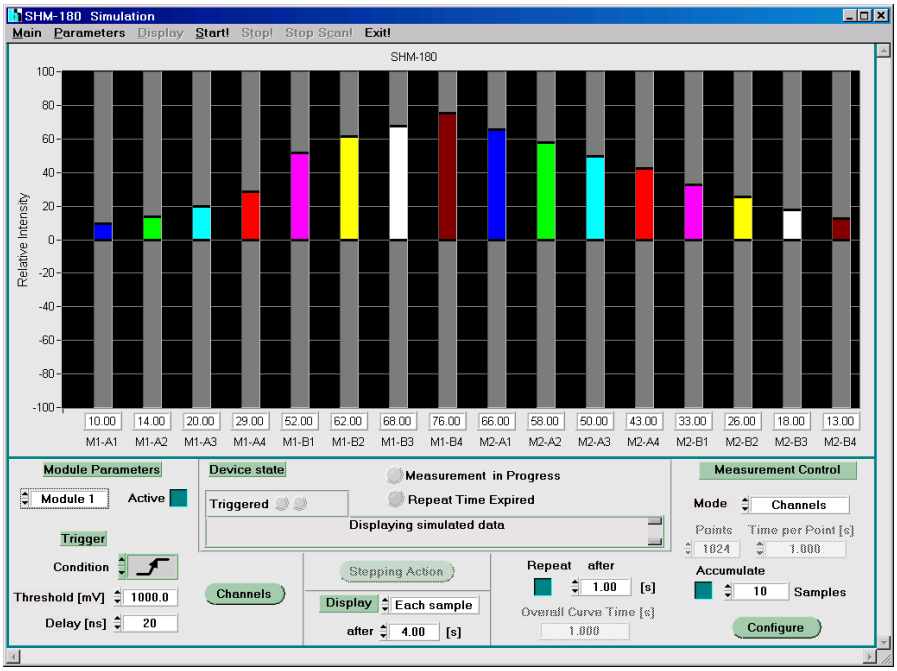
For manual, application notes and software please see www.becker-hickl.de

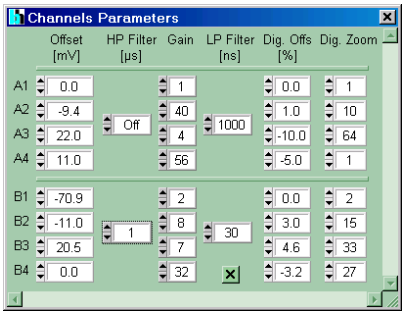
8 Channel Sample & Hold Module SHM-180

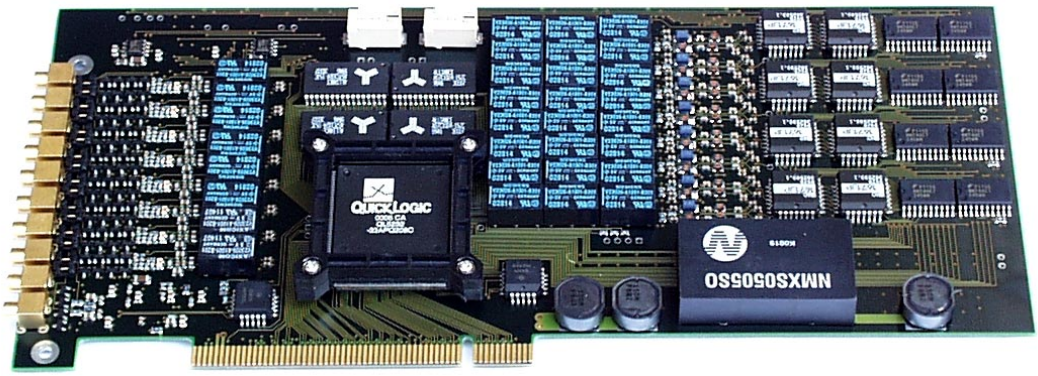
Parallel sampling of signals from PMT arrays, multi-anode PMTs, or photodiode arrays

- 8 parallel sampling channels in one SHM-180 module
- Up to 32 channels in four parallel SHM-180 modules
- On-board sample delay generator
- Low noise due to selectable input filtering
- Wide, adjustable input voltage range
- 12 bit single-shot conversion accuracy
- Accumulation of up to 65.535 samples
- Accumulation rate up to 1 MS / s
- Operation software for Windows 95, 98, NT4 and 2000

New Product







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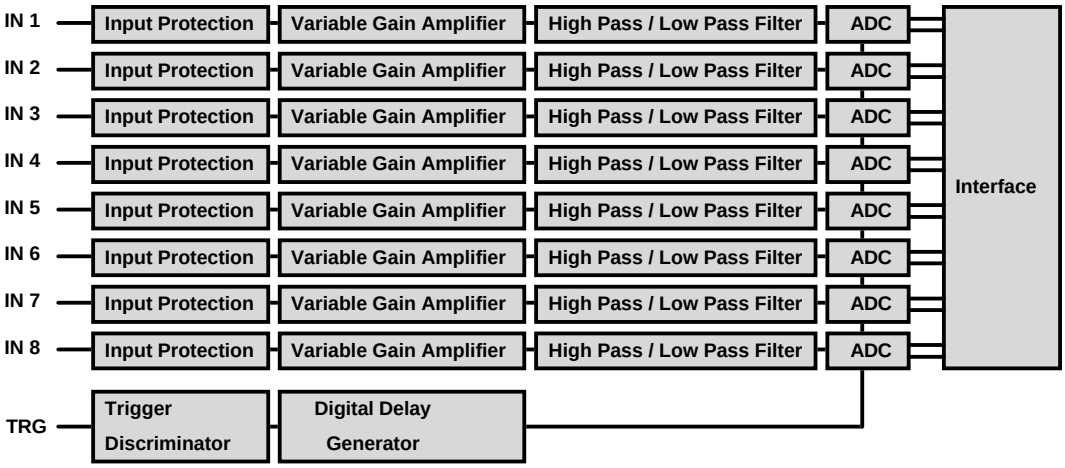
8 Channel Sample & Hold Module SHM-180

System Architecture



Signal Channels

Input Impedance	1 kΩ or 50 Ω, jumper selectable
Input Coupling	DC or AC, jumper selectable
Input Connectors	MCX
Low Pass Filter	30 ns - 100 ns - 300 ns - 1 µs
High Pass Filter	1 µs - 10 µs - 100 µs - 'off'
Channel Gain	1 to 56
Full scale input voltage	± 45 mV to ± 2.5V
Max. Sample Rate	1 MS/s
ADC Resolution	12 bit

Trigger Input

Input Impedance	50 Ω
Input Coupling	DC
Input Connector	MCX
Trigger Threshold	-1 V to +1 V
Min. Trigger Pulse Width	1 ns
Max. Trigger Input Frequency	100 MHz
Max. Trigger Rate	1 MHz

Sample Delay Generator

Delay Range	0 to 655 µs
Delay Step Width	10 ns
Delay Jitter	2.5 ns
Delay Stability	< 50 ppm

Multi Module Systems

Number of modules operable parallel	4

Operation Environment

Computer System	PC Pentium
Bus Connector	PCI
Power Consumption	approx. 10 W at +5V
Dimensions	PCI card, 235 x 110 mm

Related Products and Accessories

PMT modules, pin and avalanche photodiode modules, integrating photodiode modules, preamplifiers, step motor controllers, delay generators, programmable pulse generators, ps Diode Lasers, gated and time-correlated photon counters, photon-multiscalers. To control detectors and shutters please see DCC-100 detector controller. Please download or call for individual data sheets and manuals.

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TCSPC1.DOC July. 2002 Printer HP 4500 PS

intelligent measurement and control systems

Time-Correlated Single Photon Counting

Time-Correlated Single Photon Counting (TCSPC) is a technique to record low level light signals with ps time resolution. Typical applications are

Ultra-Fast Recording of Optical Waveforms
Fluorescence Lifetime Measurements
Detection and Identification of Single Molecules
Fluorescence Correlation Spectroscopy (FCS)
DNA Sequencing
Optical Tomography
Photon Correlation Experiments
Fluorescence Lifetime Imaging (FLIM)
Fluorescence Resonance Energy Transfer (FRET)

The method has some striking benefits:

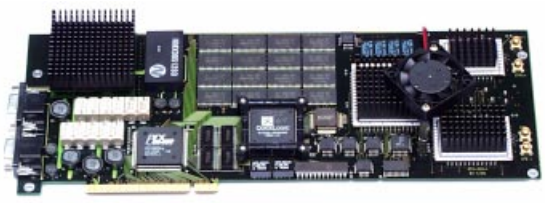
Ultra-High Time Resolution - 25 ps fwhm with the best detectors
Ultra-High Sensitivity - down to the Single Photon Level
Short Measurement Times
High Dynamic Range - Limited by Photon Statistics only
High Linearity
Excellent Signal-to-Noise Ratio
High Gain Stability

TCSPC works best for

High Repetition Rate Signals
Wavelength from 160 nm to 1000 nm

Principle of TCSPC Technique

Time-Correlated Single Photon Counting (TCSPC) is based on the detection of single photons of a periodical light signal, the measurement of the detection times of the individual photons and the reconstruction of the waveform from the individual time measurements.



Complete electronics on board - a TCSPC Module of Becker & Hickl

The method makes use of the fact that for low level, high repetition rate signals the light intensity is usually so low that the probability to detect one photon in one signal period is much less than one. Therefore, the detection of several photons can be neglected and the principle shown in the figure below be used:

The detector signal consists of a train of randomly distributed pulses due to the detection of the individual photons. There are many signal periods without photons, other signal periods contain one photon pulse. Periods with more than one photons are very rare.

When a photon is detected, the time of the corresponding detector pulse is measured. The events are collected in a memory by adding a '1' in a memory location with an address proportional to the detection time. After many photons, in the memory the histogram of the detection times, i.e. the waveform of the optical pulse builds up.

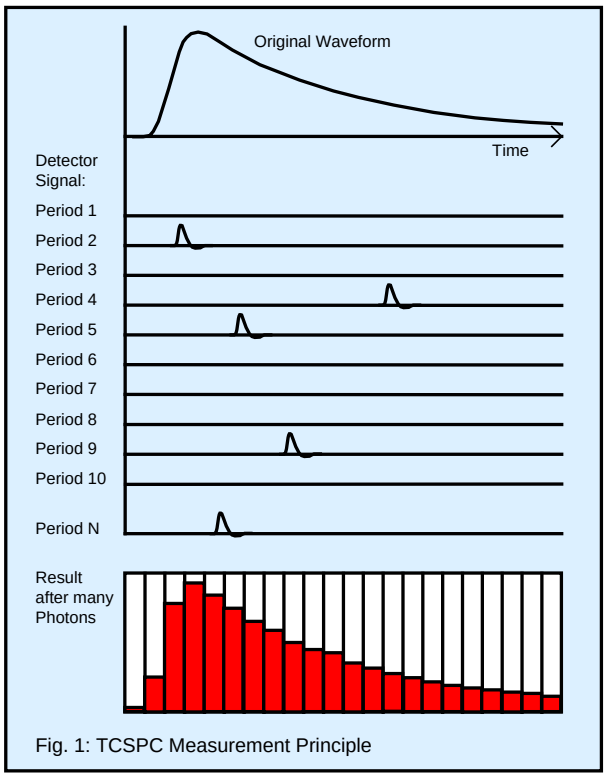


Fig. 1: TCSPC Measurement Principle

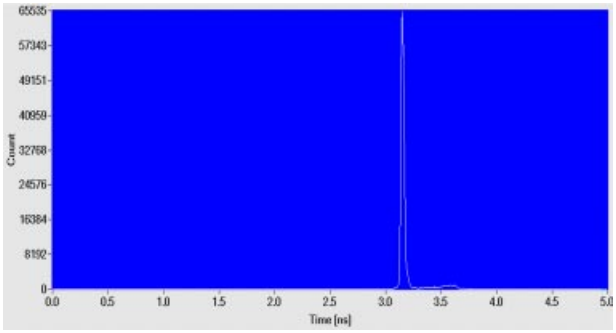
Although this principle looks complicated at first glance, it has a number of striking benefits:

- The time resolution of TCSPC is limited by the transit time spread, not by the width of the output pulse of the detector
- TCSPC has a near-perfect counting efficiency and therefore achieves optimum signal-to-noise ratio for a given number of detected photons
- TCSPC is able to record the signals from several detectors simultaneously
- TCSPC can be combined with a fast scanning technique and therefore be used as a high resolution high efficiency lifetime imaging (FLIM) technique in confocal and two-photon laser scanning microscopes
- TCSPC is able to acquire fluorescence lifetime and fluorescence correlation data simultaneously
- State-of-the-art TCSPC devices achieve count rates in the MHz range and acquisition times down to a few milliseconds

Time resolution

The TCSPC technique differs from methods with analog signal processing in that the time resolution is not limited by the width of the detector impulse response. Instead, for TSPC the timing jitter in the detection channel is essential. This accuracy is determined by the transit time spread of the single photon pulses in the detector and the timing jitter in the electronic system. When photomultipliers are used as detectors the half-width of the instrument response function (IRF) is usually 10 times shorter than the half width of the detector impulse response. Some typical values for different detector types are given below.

conventional photomultipliers	
standard types	0.6 ... 1 ns
high speed (XP2020)	0.35 ns
Hamamatsu TO8 photomultipliers	
R5600, H5783	140 ... 220 ps
micro channel plate photomultipliers	
Hamamatsu R3809	25 ... 30 ps
single photon avalanche photodiodes	60 ... 500 ps



A laser pulse recorded with 30 ps fwhm

Efficiency

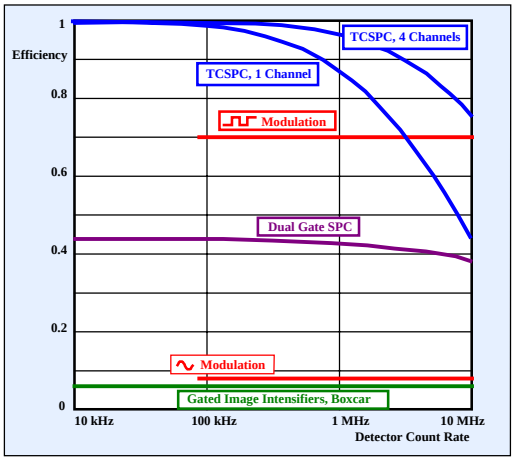
Different time-resolved optical signal recording techniques differ considerably in terms of recording efficiency, i.e. in the exploitation of the detected photons. Taking into regard that the available number of photons is limited by the photostability of the sample or by the acceptable acquisition time, recording efficiency is the most important parameter next to time resolution. The efficiency is defined by the ratio of the number of photons actually recorded, $N_{recorded}$, and the number of photons seen by the detector, $N_{detected}$:

$$E = N_{detected} / N_{recorded}$$

Since the SNR is proportional to the square root of the number of detected photons the efficiency is also

$$E = (SNR_{real} / SNR_{ideal})^2$$

A comparison of the efficiency for TCSPC with one channel and four parallel channels, for single channel modulation techniques with sine wave and square wave modulation, modulated and gated image intensifiers, boxcar, and dual-gate photon counting is given in the figure right. TCSPC features a near-perfect counting efficiency up to a detector count rate of 1 MHz. The reason is that TCSPC does not involve any gating process or gain modulation. Surprisingly, TCSPC beats the other methods in efficiency even for detector count rates of the order of 5 to 10 MHz.



Efficiency of different time-resolved signal recording techniques

Sensitivity

The sensitivity of the SPC method is limited mainly by the dark count rate of the detector. Defining the sensitivity as the intensity at which the signal is equal to the noise of the dark signal the following equation applies:

$$S = \frac{(Rd * N/T)^{1/2}}{Q}$$

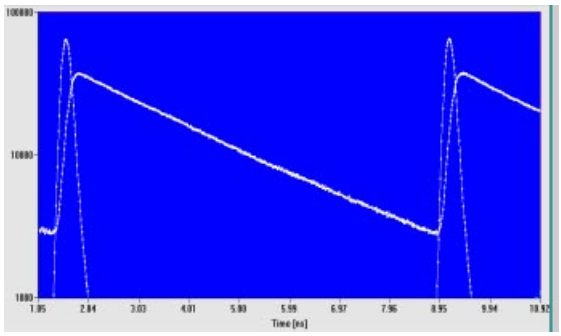
(Rd = dark count rate, N = number of time channels, Q = quantum efficiency of the detector, T = overall measurement time)

Typical values (PMT with multialkali cathode without cooling) are $Rd=300s^{-1}$, N=256, Q=0.1 and T=100s. This yields a sensitivity of S=280 photons/second. This value is by a factor of 10^{15} smaller than the intensity of a typical laser (10^{18} photons/second). Thus, when a sample is excited by the

laser and the emitted light is measured, the emission is still detectable for a conversion efficiency of 10^{-15}.

Accuracy

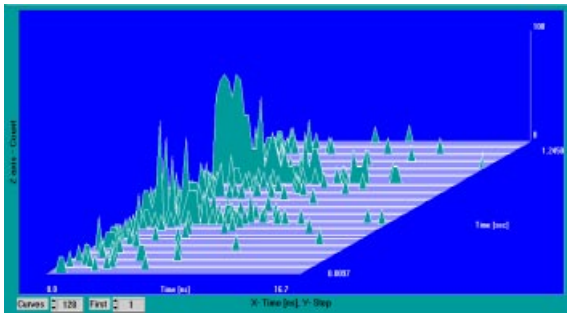
The accuracy of the measurement is given by the standard deviation of the number of collected photons in a particular time channel. For a given number of photons N the signal-to-noise ratio is $SNR = N^{-1/2}$. If the light intensity is not too high, all detected photons contribute to the result. Therefore, TCSPC yields an ideal signal-to-noise ratio for a given intensity and measurement time. Furthermore, in the TCSPC technique noise due leakage currents, gain instabilities, and the random gain mechanism of the detector does not appear in the result. This yields an additional SNR improvement compared to analog signal processing methods.



Fluorescence decay curves, excitation with Ar+ laser

Acquisition Time

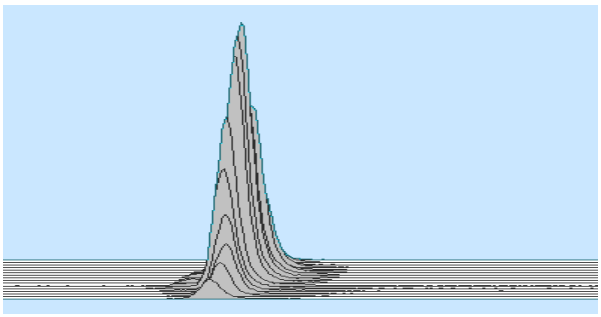
The TCSPC method is often thought to suffer from slow recording speed and long measurement times. This ill reputation comes from traditional TCSPC devices built up from nuclear instrumentation modules which had a maximum count rate of some 10^4 photons per second. Due to a proprietary AD conversion principle the TCSPC devices from Becker & Hickl achieve count rates of several 10^6 photons per seconds. Thus, 1000 photons can be collected in less than 1 ms, and the devices can be used for high speed applications as the detection of single molecules flowing through a capillary, fast image scanning, for the investigation of unstable samples or simply as optical oscilloscopes.



Fluorescence decay signals from single molecules running through a capillary. Collection time 1 ms per curve.

Multidetector Capability

Becker & Hickl have introduced a proprietary TCSPC multidetector technique. Multidetector operation makes use of the fact that at the low light intensities typical for TCSPC the detection of several photons in the same laser period is unlikely.



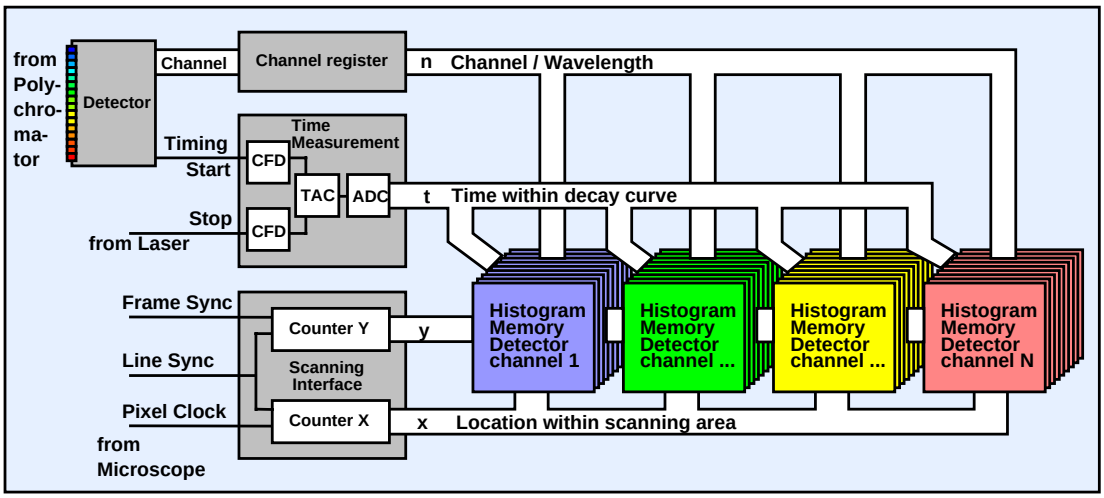
16 signals measured simultaneously with a 16 channel PMT

Thus, the output pulses of several detectors can be combined into one common timing pulse line and sent through the timing and histogramming circuitry of one TCSPC channel. An external 'Routing' device determines in which detector a particular photon was detected. This information is used to route the photons from different detectors into different memory blocks of the TCSPC module. As a result, separate histograms build up containing the waveforms for the individual detectors.

Multidetector operation can increase the efficiency of a TCSPC measurement considerably since photons from different wavelength intervals or from different spots of the sample are recorded simultaneously. Moreover, multidetector operation reduces classic pile-up-effects because multi-photon events are recognised and rejected by the routing electronics. Typical applications are optical tomography, multi-wavelength lifetime imaging and single molecule experiments.

Fluorescence Lifetime Imaging with Laser Scanning Microscopes

The SPC-730 and SPC-830 modules can be connected directly to a confocal or two-photon laser scanning microscope. The modules employ an advanced three-dimensional TCSPC technique and build up the photon density over the time, t, within the fluorescence decay, the image coordinates, x,y, and the detector number or wavelength, n or λ. The principle is shown in the figure below.



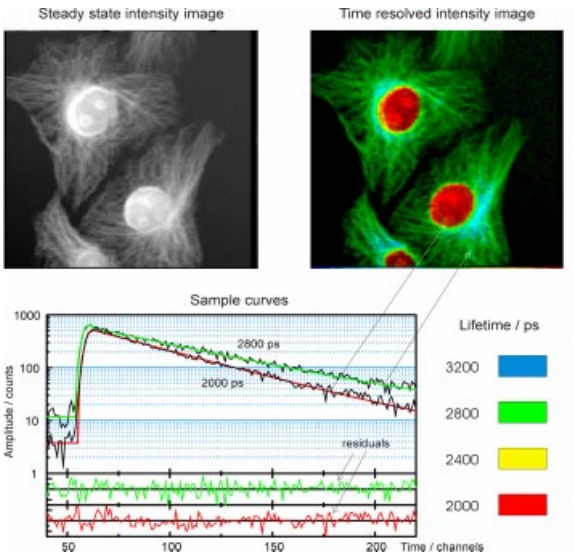
TCSPC imaging technique used in the SPC-730 and SPC-830

The TCSPC module receives the single photon pulses from the photomultiplier (PMT) of the microscope, the reference pulses from the laser and the Frame Sync, Line Sync and Pixel Clock signals from the scanning unit of the microscope. For each PMT pulse, i.e. for each photon, the TCSPC module determines the time of the photon within the laser pulse sequence and the location within the scanning area. These values are used to address the histogram memory in which the events are accumulated. Thus, in the memory the distribution of the photon density over the scan coordinates, x, y, and the time, t, within the fluorescence decay function builds up. The result can be interpreted as a two-dimensional (x, y) array of fluorescence decay curves or as a sequence of fluorescence images for different times (t) after the excitation pulse. Several such arrays exist depending on the number of detector or wavelength channels.

As for the basic TCSPC technique, there is virtually no loss of photons in the TCSPC imaging process. As long as the photon detection rate is not too high all detected photons are processed and accumulated in the histogram, thus providing near-ideal signal-to-noise ratio and maximum sensitivity. This is a key advantage of TCSPC imaging compared to gated photon counting, gated image intensifiers and modulation techniques.

The figure right shows a TCSPC image of a single cell layer (double staining with Hoechst for DNA and Alexa 488) obtained by two-photon excitation at 800 nm in a Zeiss LSM-510 microscope. The intensity image (containing the photons of all time channels) is shown left. Deconvolution analysis delivers the fluorescence lifetime τ in the individual pixels of the image. This allows to generate intensity-τ images that display the fluorescence intensity and the fluorescence time as brightness and colour (figure right). The quality of the fit is shown for two selected pixels (right, bottom).

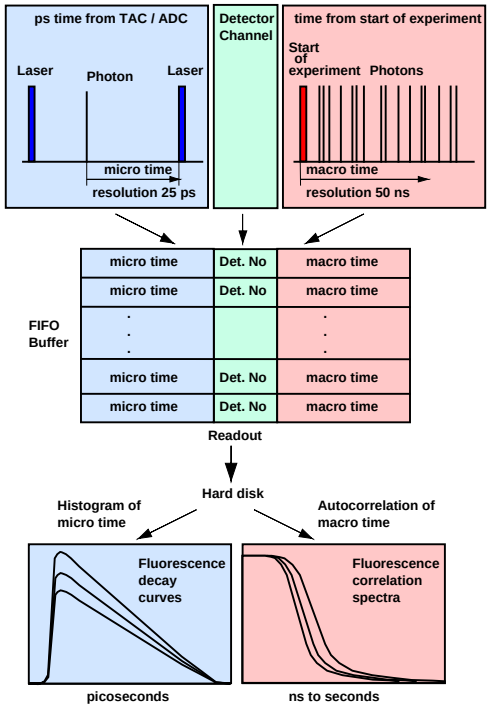
Main applications of TCSPC lifetime imaging are fluorescence quenching, fluorescence resonance transfer (FRET) and the separation of autofluorescence components in cells.



Lifetime imaging of cells. Intensity Image (top left), Intensity / τ Image (top right) and decay curves of selected pixels (bottom)

Simultaneous Lifetime and FCS data acquisition

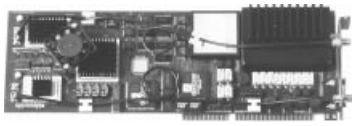
Fluorescence Correlation Spectroscopy (FCS) exploits intensity fluctuations in the emission of a small number of chromophore molecules in a femtoliter sample volume. The fluorescence correlation spectrum is the autocorrelation function of the intensity fluctuation. FCS yields information about diffusion processes, conformational changes of chromophore - protein complexes and intramolecular dynamics. These effects can be accompanied by lifetime fluctuations which, of course, should be recorded simultaneously from the same sample volume. The 'FIFO' mode of the SPC-630, SPC-134, and SPC-830 modules can be used for such measurements. This mode does not build up a histogram as the TCSPC imaging techniques do. Instead, it records the full information about each photon. Each entry contains the time of the photon in the laser pulse sequence, the time from the start of the experiment, and the detector channel. The data structure is shown in the figure right. For each detector an individual correlation spectrum and a fluorescence decay curve can be calculated. If several detectors are used to record the photons from different chromophores, the signals of these chromophores can be cross-correlated. The fluorescence cross-correlation spectrum shows whether the molecules of both chromophores and the associated protein structures are linked or diffuse independently.



Simultaneous FCS / lifetime data acquisition

BH TCSPC Modules

BH has developed and manufactures a wide variety of TCSPC modules for different applications. The most common modules are listed below.

Module	Count Rate MHz		Memory		Application	
	Saturated	Useful 50% loss	Histogram curves * channels	FIFO Buffer photons		
SPC-300 SPC-330	5 5	2.5 2.5	131,072	- -	traditional fluorescence lifetime measurement	
SPC-400 SPC-430	8 8	4 4	262,144 262,144	- -	fluorescence lifetime, single molecule detection	
SPC-500 SPC-530	3 3	1.5 1.5	4,194,304 4,194,304	- -	fluorescence lifetime, multi-parameter measurements FLIM	
SPC-630	8	4	262,144	131,072	fluorescence lifetime, single molecule detection, FCS, correlation experiments optical tomography stopped flow	
SPC-730	5.5	2.25	4,194,304	-	fluorescence lifetime, TCSPC imaging, laser scanning microscopy, FLIM, FRET, multi-parameter measurements, correlation experiments, stopped flow	
SPC-134	32	16	1,485,576	262,144	4 fully parallel TCSPC channels. optical tomography, photon migration single molecule detection, FCS correlation experiments, stopped flow	
SPC-830	8	4	16,777,216	8,388,608	fluorescence lifetime, TCSPC imaging, laser scanning microscopy, FLIM / FRET, single molecule detection, FCS correlation experiments, multi-parameter measurements, stopped flow	

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Boston Electronics Corporation, 91 Boylston St, Brookline MA 02445 USA * (800)3477-5445 or (617)566-3821 * fax (617731-0935 * tcspc@boselec.com

	SPC-630	SPC-730	SPC-830	SPC-134	Time Harp 200
Target Application	Standard lifetime experiments Single Molecule Detection Stopped Flow Correlation Experiments FCS Experiments	Standard lifetime experiments, Lifetime imaging, Confocal and two-photon scanning Microscopy Multi parameter experiments Stopped Flow	Standard lifetime experiments, Lifetime imaging, Confocal and two-photon scanning Microscopy Multi parameter experiments Stopped Flow Single Molecule Detection Correlation Experiments FCS Experiments	Optical tomography Single Molecule Stopped Flow Correlation Experiments FCS Experiments	Standard lifetime Single Molecule Microscope with scan stage Correlation Experiments FCS Experiments
No. of TCSPC Channels	1	1	1	4	1
Modules operable in parallel	4 x SPC-630	4 x SPC-730	4 x SPC-830	1 x SPC-134	
Conversion Principle	TAC - ADC with error reduction Patent DE 43 39 784 A1	TAC - ADC with error reduction Patent DE 43 39 784 A1	TAC - ADC with error reduction Patent DE 43 39 784 A1	TAC - ADC with error reduction Patent DE 43 39 784 A1	Time-to-Digital Converter
Detector Channel Sync Channel	Constant Fraction Constant Fraction	Constant Fraction Constant Fraction	Constant Fraction Constant Fraction	Constant Fraction Constant Fraction	Constant Fraction Level Trigger
Time Resolution	820 fs per time channel	820 fs per time channel	820 fs per time channel	820 fs per time channel	40 ps per time channel
Diff. nonlinearity	0.6% to 1% pp, <0.5% rms	0.6% to 1% pp, <0.5% rms	0.6% to 1% pp, <0.5% rms	0.6% to 1% pp, <0.5% rms	<6%pp, <0.5% rms
Detectable Lifetimes	2 ps to 2µs	2 ps to 2µs	2 ps to 2µs	2 ps to 2µs	<100ps to 4.5µs
Histogramming Process	Hardware, on board histogram memory	Hardware, 4-dimensional, on board histogram memory	Hardware, 4-dimensional, on board histogram memory	Hardware, on board histogram memory	Hardware, on board histogram memory
Image size for fast scan modes		max. 256 x 256 pixels	max 4096 x 4096 pixels		
Dead Time	125 ns	180 ns	125 ns	125 ns	<350 ns
Useful continuous count rate, Histogram Modes, 50% loss, per module	4 MHz	2.8 MHz	4 MHz	16 MHz (overall for 4 channels)	1.4 MHz
Peak Count Rate, histogram modes, 50% loss, per moduel	4 MHZ	2.8 MHz	4 MHz	16 MHz (overall for 4 channels)	1.4 MHz
Continuous count rate, time-tag modes	0.4...0.8 MHz, depends on computer speed and background activity		3...4 MHz, depends on computer speed and background activity	0.4...0.8 MHz, depends on computer speed and background activity	Depends on computer speed and background activity
Peak count rate, time-tag modes, 50% loss	4 MHz independent of computer speed		4 MHz independent of computer speed	16 MHz independent of computer speed	Depends on computer speed and background activity
on-board FIFO buffer size, time tag modes	128,000 photons or 256,000 photons		8 Million photons	512,000 photons	128,000 photons
Macro time resolution in time tag (FIFO) modes	50 ns		50 ns from internal clock or 12ns to 100 ns from sync (laser)	50 ns from internal clock or 12ns to 100 ns from sync (laser)	100ns
Scan rate, Scan syn in mode		down to 100ns per pixel independent of computer speed	down to 100ns per pixel independent of computer speed		
Multi-Detector Operation	yes Patent DE 43 39 787 A1	yes Patent DE 43 39 787 A1	yes Patent DE 43 39 787 A1	yes Patent DE 43 39 787 A1	yes
No of curves in memory	2 x 64 to 4096	1024 to 65,536	4096 to 2,000,0000	2 x 32 to 2 x 2048 per TCSPC channel	2 x 32
Min. time per histogram	1µs in continuous flow mode	100ns in scan sync in/out mode	100ns in scan sync in/out mode	1µs in continuous flow mode	1µs in ext sync mode

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	SPC-630	**SPC-730**	**SPC-830**	**SPC-134**	**Time Harp 200**
Available multi-detector extension devices for	4 MCPs, 4 PMTs 8 MCPs, 8 PMTs 8 APDs 16 channel pmt head	4 MCPs, 4 PMTs 8 MCPs, 8 PMTs 8 APDs 16 channel pmt head	4 MCPs, 4 PMTs 8 MCPs, 8 PMTs 8 APDs 16 channel pmt head	4 MCPs, 4 PMTs 8 MCPs, 8 PMTs 8 APDs	4 APDs
Operating Modes	Single Oscilloscope 2 dimensional f(xyt) Sequence f(t,T), fi(t,ext) Spectrum fi(T), fi(ext) Continuous Flow (unlimited seq.) Time Tag (FIFO)	Single Oscilloscope 2 dimensional f(xyt) Sequence f(t,T), fi(t,ext) Spectrum fi(T), fi(ext) Imaging (Sync In, Sync Out, XY in, XY out)	Single Oscilloscope 2 dimensional f(xyt) Sequence f(t,T), fi(t,ext) Spectrum fi(T), fi(ext) Imaging (Sync In, Sync Out, XY in) Time Tag (FIFO)	Single Oscilloscope 2 dimensional f(xyt) Sequence f(t,T), fi(t,ext) Spectrum fi(T), fi(ext) Continuous Flow (unlimited seq.) Time Tag (FIFO)	Integration Oscilloscope Sequence f(t,T) Contiuous Time-tag (Option)
Experiment Trigger	Start of measurement Start of sequence Each step of sequence	Start of measurement Start of sequence Each step of sequence Frame Clock, Line Clock, Pxl Clock	Start of measurement Start of sequence Each step of sequence Frame Clock, Line Clock, Pxl Clock	Start of measurement Start of sequence Each step of sequence	Start of measurement Start of sequence
Triggered accumulation of sequences	yes	yes	yes	yes	yes
Detector / Experiment control (Own products only)	Preamplifiers with detector overload protection, PMH-100 Detector modules, PML-16 multichannel detector head, DCC-100 Detector Controller , STP-340 Step Motor Controller, Routers for MCPs, PMTs, APDs, Dual ADC module for XY In operation	Preamplifiers with detector overload protection, PMH-100 Detector modules, PML-16 multichannel detector head, DCC-100 Detector Controller , STP-340 Step Motor Controller, Routers for MCPs, PMTs, APDs, Dual ADC module for XY In operation, Adapters for Zeiss, Leica, Olympus and Biorad laser scanning microscopes	Preamplifiers with detector overload protection, PMH-100 Detector modules, PML-16 multichannel detector head, DCC-100 Detector Controller , STP-340 Step Motor Controller, Routers for MCPs, PMTs, APDs, Dual ADC module for XY In operation, Adapters for Zeiss, Leica, Olympus and Biorad laser scanning microscopes	Preamplifiers with detector overload protection, PMH-100 Detector modules, PML-16 multichannel detector head, DCC-100 Detector Controller , STP-340 Step Motor Controller, Routers for MCPs, PMTs, APDs	Preamplifiers with detector overload protection, Routers for APDs
Free Documentaion available on web site	SPC Manual, 165 pages; TCSPC Introduction, 5 pages; Upgrading laser scanning microscopes for lifetime imaging; Controlling SPC modules; Protecting Photomultipliers; FRET measurements by TCSPC lifetime microscopy; Multi-wavelengthe TCSPC lifetime imaging; High count rate multichannel TCSPC for optical tomography; Optical Tomography: TCSPC Imaging of Female Breast; Setting up High Gain Detector Electronics for TCSPC Applications; Testing SPC Modules; 16 Channel Detector Head for TCSPC Modules; Routing Modules for Time-Correlated Single Photon Counting; Detector Control Module DCC100 Manual; **TCSPC Software is available and FREE**; Manual: Multi - SPC 32 bit Dynamic Link Library				Measurement examples
Related Products (Own products only)	SPC-300, SPC-330 TCSPC; SPC-400, SPC-430 TCSPC; SPC-500, SPC-530 TCSPC; MSA-100 1ns multiscaler; MSA-300 5ns multisclaer; PMS-400 and PMM-328 Gated photon counters / multiscalers; Picosecond Diode Lasers				Time Harp 100 Picosecond Diode Lasers