Technology Leaders in Photon Counting

About bh

Founded in 1993, Becker & Hickl have introduced a proprietary time-correlated single-photon counting principle that made TCSPC more than 100 times faster than the existing devices. Moreover, bh introduced a multi-dimensional TCSPC process that records the photons not only versus the time in the signal period, but also versus other parameters, such as experiment time, wavelength, or spatial coordinates. The bh devices are designed to record multi-dimensional photon distributions, time-resolved images, sequences of photon distributions, or multi-dimensional time-tag data. The bh TCSPC products are complemented by bh picosecond diode laser, detector modules, multi-spectral detector assemblies, and experiment control modules. Based on these components Becker & Hickl supply their own confocal fluorescence lifetime laser scanning microscope and FLIM upgrade kits for laser scanning microscopes of various manufacturers. Moreover, bh is supplier of TCSPC and lasers for clinical FLIM devices. bh market activities include currently five workshops around the world yearly and the distribution of more than 1500 pages of TCSPC literature.

1993  Introduction of multidimensional TCSPC. Introduction of fast TAC/ADC conversion. TCSPC becomes 100 times faster than it was before.


1997  SPC-535 modules. First implementation of TCSPC FLIM. First FLIM applications in laser scanning ophthalmology.


1999  SPC-730 modules. Introduction of TCSPC FLIM. Scan Sync In and Scan Sync out mode. First applications in FLIM microscopy.

2000  SPC-130 TCSPC board. SPC-134 four-channel packages for optical tomography. Saturated sustained count rate 32 MHz.

2001  FLIM upgrade kits for Zeiss LSM 510 NLO microscopes. SPImage FLIM data analysis software. BHL-600 red and NIR picosecond diode lasers.

2002  SPC-830 modules. For the first time, FLIM and single-molecule techniques were combined in one instrument.

2003  DCC-100 detector controller solves the problem of detector overload.


2006  Simple-Tau 140 and Simple-Tau 830 compact TCSPC systems. First multi-spectral NDD FLIM systems for multiphoton microscopes.

2007  Macro-time synchronisation of several TCSPC modules. First full correlation down to the picosecond region.

2008  New PML-16 sixteen channel detector. Internal high-voltage generator, overload shutdown, control via DCC-100.


2010  High-power CW mode for BDL-SMC picosecond diode lasers.


2012  SPC-154 package and SPC-150 modules.

2013  FLIM systems for Zeiss LSM 710 microscopes. NDD FLIM systems for Leica SP2 MP and SP5 MP microscopes. Simple-Tau 152 and -154 two and four channel TCSPC systems.

2014  HPM-100-40 GaAsP hybrid detectors. 8-channel parallel TCSPC and TCSPC FLIM systems


2016  Phosphorecence Lifetime imaging (PLIM) in DCS-120 and Zeiss LSM 710 FLIM systems. Fluorescence Lifetime-Transient Scanning (FLITS).

2017  DCS-120 Wideband, DCS-120 Multiphoton, and DCS-120 Macro FLIM systems


2021  Fast Online FLIM, FLIM with Abberior STED microscopes, SPC-160pcie, DCC-100pcie, GVD-120pcie PCI-Express TCSPC, Detector Control, and Scan Control modules. Single Tau II TCSPC systems with Thunderbolt interface. FLIM for Sutter Instrument MOM microscopes.

2022  Sub-20 ps (FWHM) IRF width with new PMH-100-06 and -07 hybrid detectors. Spatial Mosaic FLIM with with DCS-120 confocal and multiphoton FLIM systems. Phasor analysis integrated in SPImage. SPCM Software controls Ti:Sa laser, AOM, and motorised sample stage.


2024  FASTAC fast-acquisition FLIM system, 25 ps FWHM with fast HPM detectors.

2025  Metabolic FLIM with multiplexed diode lasers. Parallel detection of NADH and FAD fluorescence.
bh Modular TCSPC Systems - Unsurpassed in Time resolution

SPC-160: High performance in all TCSPC applications
- Internal histogramming modes and photon stream (parameter tag) modes
- Multi-detector / multi-wavelength / laser multiplexing operation
- Triggered multichannel scaler (phosphorescence) mode
- High-speed FLIM / PLIM / FLITS for laser scanning microscopes
- Megapixel Technology: Mosaic, Time Series, 2-stack, Multi-spectral FLIM
- High-speed parallel imaging channel
- FCS / FCCS in combination with fluorescence lifetime
- Single-molecule multi-parameter burst analysis
- Unlimited fast sequential recording for fNIRS / DOT systems
- Dead time 80 ns, saturated count rate 12.5 MHz
- Ultra-fast discriminators, 5 GHz input bandwidth
- Extra-low-low-frequency timing noise
- Part of bh modular FLIM systems

New: SPC-160 PCIe TCSPC module with PCI Express Interface
- Functions and parameters see SPC-160
- Part of Simple-Tau II system

SPC-150N: High-end performance at reasonable cost
- Internal histogramming modes and Photon stream (parameter tag) modes
- Multi-detector / multi-wavelength / laser multiplexing operation
- Triggered Multichannel Scaler (phosphorescence) mode
- High-speed FLIM / PLIM / FLITS for laser scanning microscopes
- Megapixel Technology: Mosaic, Time Series, 2-stack, Multi-spectral FLIM
- FCS / FCCS in combination with fluorescence lifetime
- Single-molecule multi-parameter burst analysis
- Unlimited fast sequential recording for DOT systems
- Electrical response 6.6 ps FWHM, electrical timing jitter 2.5 ps RMS
- Dead time 100 ns, saturated count rate 10 MHz
- Ultra-fast discriminators, 5 GHz input bandwidth
- Extra-low-low-frequency timing noise
- Minimum time channel width 813 fs
- Expandable with up to 8 detectors or 16-channel multispectral detection
- Part of bh modular FLIM systems

- Ultra-fast discriminators, 5 GHz input bandwidth
- Extra-low timing noise
- Electrical response 3.5 ps FWHM, electrical timing jitter 1.6 ps RMS
- Minimum time channel width 407 fs
- TAC Range from 12.5 ns to 100 ns
- World record in TCSPC time resolution: 17.8 ps FWHM / 7.9 ps RMS with superconducting detector

New: SPC-150NX: Ultra-High Time Resolution
- Ultra-fast discriminators, 5 GHz input bandwidth
- Extra-low timing noise
- Electrical response < 3 ps FWHM, electrical timing jitter 1.1 ps RMS
- Minimum time channel width 203 fs
- TAC Range from 12.5 ns to 100 ns
- New World record in TCSPC time resolution: 4.4 FWHM / 2 ps RMS with superconducting detector

SPC-130-EMN TCSPC Modules
- Improved SPC-130 with fast bus interface and larger memory
- Standard fluorescence and phosphorescence lifetime, diffuse optical tomography, single-molecule spectroscopy, FCS, photon correlation
- Rugged design
- Photon distribution, parameter tag, sequential-recording modes
- Also available as SPC-134-EMN four-channel package

More than 2000 TCSPC Systems Worldwide
Simple-Tau Compact TCSPC and TCSPC-FLIM Systems

**New: FASTAC Fast-Acquisition FLIM System**
- Photons distributed into four parallel SPC-150N TCSPC channels
- No compromise in time resolution and time channel width
- IRF width 25 ps FWHM with fast HPM detectors
- Time-channel width down to 407 fs
- Images up to 2048 x 1024 pixels, 1024 time channels
- Acquisition time down to 100 ms for 256 x 256 pixel images
- Fast acquisition FLIM or Precision FLIM
- Temporal and Lateral Mosaic FLIM
- Simultaneous FLIM / PLIM
- Works with DCS-120, DCS-120 MACRO and Zeiss LSM 880

**New: Simple-Tau II TCSPC/FLIM systems**
- Thunderbolt interface to system computer
- One or two SPC-160PcLe TCSPC/FLIM modules
- One DCC-100pcLe detector controller

**Simple-Tau 150N, and 160 compact TCSPC systems**
- One SPC-150N, or SPC-160 TCSPC channel
- One DCC-100 detector controller
- Portable DOT systems
- High-Speed FLIM systems
- Compatible with bh multispectral FLIM detectors
- Part of bh LCS-120 confocal scanning FLIM systems
- Part of bh FLIM systems for Zeiss LSM 510 and LSM 710 family
- Part of bh NDD FLIM systems for Leica SP2 and SP5 MP
- Can be upgraded with additional SPC-150N or measurement control cards

**Simple-Tau 152N, and 162 compact TCSPC systems**
- Two parallel SPC-152N, or SPC-162 TCSPC channels
- One DCC-100 detector controller
- Portable DOT systems
- High-Speed FLIM systems
- Part of bh LCS-120 confocal scanning FLIM systems
- Part of bh FLIM systems for Zeiss LSM 510 and LSM 710 family
- Can be upgraded with additional SPC-152N or measurement control cards

**Simple-Tau 154N, and 164 compact TCSPC systems**
- Four parallel SPC-154N, or SPC-164 TCSPC channels
- Portable DOT systems
- Ultra-High-Speed parallel multispectral FLIM systems

**Simple-Tau 130-EMN compact TCSPC systems**
- One SPC-130 EMN TCSPC channel
- One DCC-100 detector controller
- Standard fluorescence lifetime applications
- Anti-bunching measurements
- Can be upgraded with additional SPC-130 EMN or measurement control cards
More than 2000 TCSPC Systems Worldwide

**Simple-Tau ‘Big’ Versions**
- Up to seven TCSPC and measurement control cards
- User-specific hardware and software configuration
- High speed parallel FLIM systems
- Portable DOT systems

**Simple-Tau ‘Large Screen’ Versions**
- Combines large screen area with small size of TCSPC system
- FLIM and other TCSPC imaging applications
- High-resolution FLIM in combination with 64 bit SPCM software

**Multi-Tau 8-Channel TCSPC systems**
- Eight SPC-150N or SPC-130-EMN TCSPC modules controlled from a standard Pentium PC
- Portable DOT systems
- Ultra High-Speed FLIM systems

**Power-Tau TCSPC systems**
- Up to six TCSPC or measurement control cards in high performance PC
- Highly modular systems
- User-specific hardware and software configuration
- Large system memory for megapixel FLIM applications and DOT
- High data transfer rate
- High on-line computation power

---

**Picosecond Photon Correlators**

**DPC-230 - 16 Channel Picosecond Photon Correlator**
- Recording of absolute photon times in 16 channels
- Fluorescence correlation down to ps times
- FCS combined with fluorescence decay
- 3-channel reversed-start-stop TCSPC mode for PMT inputs
- 15-channel reversed start-stop mode for LVTTL SPAD inputs
- 15-channel multiscaler mode
- TCSPC FLIM Mode
- Multiscaler FLIM mode
- Autocorrelation / Cross correlation within 16 LVTTL or 4 CFD channels

**Simple-Tau DPC System**
- Lap-top based compact system
- DPC-230 - 16 Channel Picosecond Photon Correlator
- Optional:
  - DCC-100 detector controller card
  - GVD-120 scan controller card
Multichannel Scalers

PMS-400 Gated Photon Counter and Multichannel Scaler
- Dated detection of optical signals
- Luminescence decay in the µs and ms range
- Chemoluminescence
- Two parallel recording channels
- Gating down to 1 ns
- Multiscaler operation down to 300 ns per channel

SPC-130-EMN, SPC-150N, SPC-160 TCSPC Systems
- All SPC-130-EMN, SPC-150N, SPC-160, SPC-160PCIe and SPC-830 TCSPC systems have a multichannel-scaler function implemented. The MCS function works simultaneously with the TCSPC process.
- Applications:
  - Recording of photon bursts from single molecules
  - Single-molecule spectroscopy
  - FCS
  - Simultaneous phosphorescence and fluorescence decay recording
  - Simultaneous FLIM and PLIM
- Please see bh TCSPC Handbook, available on www.becker-hickl.com
Detectors and Detector Assemblies

bh guarantee that their TCSPC devices work with any photon counting detector.

**HPM-100-40 and -50 hybrid detector modules**
- Based on Hamamatsu R10467 hybrid detector tubes
- GaAsP versions: 40% detection efficiency throughout visible spectrum
- GaAs versions: 15% detection efficiency up to 850 nm
- GaAsP versions: typ. 120 ps IRF width
- No afterpulsing
- Internal high-voltage generator, controlled via bh DCC-100
- Active area 3 mm diameter
- C-Mount adapter
- Adapter to bh DCS-120 confocal scanning FLIM system
- Adapter to NDD and BIG port of Zeiss LSM 710 NLO microscopes
- Adapter to RLD port of Leica SP2 MP and SPS MP microscopes
- SMA and FC multi-mode fiber adapters

**HPM-100-40C and -50C cooled hybrid detector modules**
- Based on Hamamatsu R10467 hybrid detector tubes
- GaAsP versions: 40% detection efficiency throughout visible spectrum
- GaAs versions: 15% detection efficiency up to 850 nm
- GaAsP versions: typ. 120 ps IRF width
- No afterpulsing
- Reduced dark count rate by cooling
- Internal high-voltage generator, power supply and control via bh DCC-100
- Active area 3 mm diameter
- C-Mount adapter
- Adapter to bh DCS-120 confocal scanning FLIM system
- Adapter to BIG port of Zeiss LSM 710 NLO microscopes
- Adapter to RLD port of Leica SP2 MP and SPS MP microscopes
- SMA and FC multi-mode fiber adapters

**HPM-100-06 and -06C ultra-fast hybrid detector modules**
- Based on Hamamatsu R10467-06 hybrid detector tubes
- Bi-alkali cathode, 290 to 600 nm
- Clean TCSPC response, no tails and bumps
- < 20 ps IRF width with SPC-150NX
- No afterpulsing
- Cooled version: HPM-100-06C

**HPM-100-07 and -07C ultra-fast hybrid detector modules**
- Based on Hamamatsu R10467-07 hybrid detector tubes
- Multi-alkali cathode, 250 to 850 nm
- Clean TCSPC response, no tails and bumps
- < 20 ps IRF width with SPC-150NX
- No afterpulsing
- Cooled version: HPM-100-07C

**PMC-150 cooled PMT modules**
- Cathode versions for UV to NIR region
- Internal PMT voltage generation
- IRF width typ. 130 ps
- Ultra-stable IRF up to recorded count rates of 5 MHz
- Internal preamplifier
- Overload shutdown
- Power supply and control via DCC-100 detector controller
- Adapters for Zeiss LSM NDD ports, Zeiss LSM confocal ports, Leica SP2 and SPS RLD Ports, bh DCS-120 confocal FLIM system
- Replaces older PMC-100 detector

**PMZ-100 PMT modules for FLIM Systems of Zeiss LSM 710 / 780 / 880 Family Microscopes**
- Adapter for Confocal (DC) port
- Adapter for non-descanned detection (NDD) port
- Adapter to Sutter MOM microscopes
- Internal PMT voltage generation
- IRF width 150 ps
- Ultra-stable IRF up to recorded count rates of 5 MHz
- Internal preamplifier
- Overload shutdown
- Power supply and control via DCC-100 detector controller
**PML-16 C - 16-Channel TCSPC detectors**

- 16-channel detector with routing electronics and internal HV power supply
- Based on Hamamatsu R5900-L16 multi-anode PMT
- Simultaneous detection in 16 channels
- Connects directly to all bh SPC modules
- Power supply and control via DCC-100 detector controller
- IRF width typ. value 180 to 200 ps
- Part of bh multispectral TCSPC FLIM detectors

**PML-16 GaAsP - 16-Channel TCSPC detectors**

- 16-channel detector with high-sensitivity GaAsP cathode
- Based on Hamamatsu GaAsP multi-anode PMT
- Simultaneous detection in 16 channels
- Internal routing electronics and HV power supply
- Connects directly to all bh SPC modules
- Power supply and control via DCC-100 detector controller
- IRF width typ. value 260 ps
- Part of bh multispectral TCSPC FLIM detectors

**Single-photon avalanche photodiode modules (SPADs)**

- Manufacturer: id Quantique
- Direct-coupled and fiber-coupled versions
- Active area d = 20 µm and d = 50 µm
- Ultra-high efficiency in visible region
- IRF width typ. 40 ps, max. 60 ps
- Active areas of 20 µm, 50 µm
- Stable IRF over count rate
- Dark count rates < 5 x /s (id100-20 ULN) and < 60 x /s (id100-50 ULN)
- Detector count rates up to 20 MHz (pulsed light)
- Direct-coupled and fiber-coupled versions
- Focusing and alignment adapters

**id-221 InGaAs IR SPAD Detectors**

- Manufacturer: id Quantique
- Detection from 900 nm to 1700 nm
- Quantum efficiency up to 20 %
- Continuous operation - no gating required
- Compatible with all bh TCSPC devices
- IRF width 150 ps FWHM
- Fiber coupling, FC/PC connector
- Fluorescence and phosphorescence decay recording
- Fluorescence correlation
- FLIM, PLIM

**id-230 InGaAs IR SPAD Detectors**

- Manufacturer: id Quantique
- Detection from 900 nm to 1700 nm
- Quantum efficiency up to 25 %
- Extremely low dark count rate - down to 50 – 80 counts / s
- Continuous operation - no gating required
- Compatible with all bh TCSPC devices
- IRF width typ. 150 ps, max. 200 ps FWHM
- Fiber coupling, SMA connector
- Fluorescence and phosphorescence decay recording
- Fluorescence correlation
- FLIM, PLIM

**SCONTEL Superconducting NbN Detectors**

- Manufacturer: SCONTEL, Moscow
- Detection from 400 nm to 1700 nm
- IRF width down to 17.8 ps FWHM with SPC-150NX
- Timing jitter with SPC-150NX 7.8 ps rms
Multi-Spectral TCSPC / FLIM Detectors

PML-SPEC and PML-SPEC GaAsP multi-wavelength detection modules
- Simultaneous fluorescence decay detection in 16 wavelength channels
- SMA 905 or FC fiber adapter
- Fiber diameter up to 1 mm
- Multi-spectral FLIM for confocal laser scanning microscopes
- IRF width 200 ps
- Works with all bh TCSPC modules
- Internal high-voltage power supply
- Internal routing electronics
- Overload shutdown
- Full control via DCC-100 card
- Part of the bh multi-wavelength FLIM systems for laser scanning microscopes
- Adapter for DCS-120 confocal scanning FLIM system

MW FLIM multi-spectral FLIM detection modules for multiphoton microscopes
- Multi-spectral FLIM in 16 wavelength channels
- Fiber bundle for large area detection and area transformation
- Non-descanned (NDD) detection or confocal detection
- Adapters for Zeiss, Leica, Olympus, Nikon, bh DCS-120
- IRF width 200 ps FWHM
- Works with all bh TCSPC modules
- Internal high-voltage power supply
- Internal routing electronics
- Protected by overload shutdown
- Shutter for input protection available
- Full control via DCC-100 card
- Part of the bh multi-wavelength FLIM systems for laser scanning microscopes

New! MW FLIM GaAsP multi-spectral NDD FLIM detection systems for multiphoton microscopes
- Multi-spectral FLIM in 16 wavelength channels
- High-efficiency GaAsP cathode
- Fiber bundle for large area detection and area transformation
- Non-descanned (direct) detection or confocal detection
- Adapters for Zeiss, Leica, Olympus, bh DCS-120
- IRF width 200 ps FWHM
- Works with all bh TCSPC modules
- Internal high-voltage power supply
- Internal routing electronics
- Protected by overload shutdown
- Shutter for input protection available
- Full control via DCC-100 card
- Part of the bh multi-wavelength FLIM systems for laser scanning microscopes

Opto-Mechanical Detector Components

Detector / Shutter Assemblies for Various PMTs
- For NDD ports of multiphoton laser scanning microscopes
- Shutter operation via DCC-100 detector controller
- Overload shutdown of PMT
- Input field lens
- For bh PMC-150 and HPM-100 modules, Hamamatsu R3809U, Hamamatsu H7422
- Part of bh modular FLIM systems

Beamsplitter / detector assemblies
- For HPM-100, PMC-150, R3809U and H7422 detectors
- Dichroic beamsplitters, polarising beamsplitters
- Input filter, bandpass filters in front of detectors
- Compatible with NDD ports of multiphoton laser scanning microscopes
- Part of bh modular FLIM systems

Detectors and Detector Assemblies with Fiber Adapters
- For HPM-100, PMC-150, R3809U and H7422 detectors
- Input filter, bandpass filters in front of detectors
Detector Electronics

**DCC-100 detector controller**
*Now:* DCC-100 PCIe detector controller with PCI express interface
- Power supply for two detectors
- Power supply of thermoelectric coolers of detectors
- Power supply of preamplifiers
- Detector gain control
- Detector overload shutdown
- Control of shutters or actuators
- Control of bh detector / shutter assemblies
- Intensity control of bh BDL and BIDS ps diode lasers
- Integrated in SPCM TCSPC software package
- Part of the bh modular FLIM, modular DOT systems
- Part of bh Simple-Tau TCSPC systems

**HVP High-Voltage Power Supply for PMTs and MCP-PMTs**
- Small size, attaches directly to PMT or MCP
- SHV connector, connects to Hamamatsu R3809U MCP PMTs and Photek FGN 392:1000 wide-field TCSPC detector
- +12 V power supply via bh DCC-100 detector controller
- Output voltage -400 to -3000 V, controlled via DCC-100 detector controller

**HRT-41 four-channel router**
- Connects up to four PMC-150, H7422 or R3809U detectors to one TCSPC channel
- All detectors are detecting simultaneously.

**HRT-81 eight-channel router**
- Connects up to eight PMC-150, H7422 or R3809U detectors to one TCSPC channel
- All detectors are detecting simultaneously.

**HRT-82 eight-channel router**
- Connects up to eight SPAD modules to one TCSPC channel
- All detectors are detecting simultaneously.

**HFAC-26 Preamplifiers**
- For R3809U MCP PMT, H7422 modules, and other PMTs
- Power supply from SPC or DCC module
- Overload shutdown in conjunction with DCC-100 controller
- Overload thresholds 0.1 µA, 0.3 µA, 1 µA, 2 µA, 3 µA, 10 µA, 100 µA

**HFAH-26 Preamplifiers**
- Low-noise
- For R3809U MCP PMT, H7422 modules, and other PMTs
- Power supply from SPC or DCC module
- Overload shutdown in conjunction with DCC-100 controller

**HPM-CON-02 Frequency-to-Analog Converter for PMT Pulses**
- Converts single-photon-pulse signals of photon-counting detectors into an intensity-proportional analog signal
- Analog output independent of single-photon pulse amplitude
- Inserts directly in detector output pulse line
- Provides photon pulses to TCSPC modules and intensity signal to analog electronics
- Input pulse amplitude -30 mV to -200 mV, input pulse width down to 500 ps
- Input pulse rate up to 10^7 pulses per second
- Output voltage range 0 to +4.9 V
- Power supply ±5 V from bh SPC or DCC module

**New! APS-100 TCSPC Synchronisation Module**
- For synchronisation of TCSPC experiments with Ti:Sapphire lasers
- Output amplitude widely independent of laser intensity and laser wavelength
- Intensity range 1:100
- Power supply from SPC or DCC module

**PHD-400 PIN Photodiode Modules**
- For synchronisation of TCSPC experiments with lasers
- Power supply from SPC or DCC module
- Detector area 0.25 mm²
- Current indicator for easy alignment
Picosecond Diode Lasers

**BDS-SM series picosecond diode lasers**
Small-size Module, single-mode output
Dimensions 40 mm x 70 mm x 120 mm (40 mm x 40 mm x 120 mm OEM version)
Wavelengths 375, 405, 445, 473, 488, 515, 640, 685, 785, 1064 nm
Single-Mode free-beam or single-mode fiber output
Pulse width down to 40 ps
Pulse repetition rate 20 MHz / 50 MHz / 80 MHz and CW
CW equivalent power up to 1.3 / 3 / 5 mW @ 20 / 50 / 80 MHz
Fast ON / OFF / multiplexing capability
Ext. Trigger input (single pulse to 80 MHz). Trigger output
Internal power stabilisation
All electronics integrated, no external driver unit required
Operation from simple +12 V power supply
Part of the bh modular FLIM systems for laser scanning microscopes

**BDS-SMY series green / yellow picosecond diode lasers**
Small-size Module, single mode output
Dimensions 40 mm x 70 mm x 120 mm (40 mm x 40 mm x 120 mm OEM version)
Wavelength 532 nm, 561 nm and 594 nm
Pulse width down to 50 ps
Pulse repetition rate 50 MHz (20 MHz on request)
CW equivalent power up to 0.5 mW @ 50 MHz
Operation from simple +12 V power supply

**BDS-MM series picosecond diode lasers**
Small-size Module, multi-mode output
Dimensions 40 mm x 70 mm x 120 mm (40 mm x 40 mm x 120 mm OEM version)
Wavelengths 405, 445, 522, 640, 685, 785, 915 nm
Multi-Mode free-beam or multi-mode fiber output
Pulse width down to 65 ps
Pulse repetition rate 20 MHz and 50 MHz
CW equivalent power up to 50 mW
Fast ON / OFF / multiplexing capability
Ext. Trigger input (single pulse to 50 MHz). Trigger output
Internal power stabilisation
All electronics integrated, no external driver unit required
Operation from simple +12 V power supply

**BDL-SMN Series Picosecond / CW diode lasers**
Wavelengths 375, 405, 445, 473, 488, 515, 640, 685, 785 nm
Driver and control electronics integrated laser head
Power regulation in ps mode and in CW mode
Beam corrector removes astigmatism and makes beam circular
Interfaces with all commonly used fiber couplers
Repetition rate 20 MHz / 50 MHz / 80 MHz and CW
Pulse width typically 40 to 80 ps for up to 2 mW @ 80 MHz
Pulse width at high power typ. 200 ps at 8 mW / 80 MHz
Fast ON / OFF / multiplexing capability
Ext. Sync input (single pulse to 80 MHz). Trigger output
Internal power stabilisation
The BDL-SMN lasers were designed in cooperation with Lasos GmbH, Jena

All lasers are available as:

- **Free-beam versions**
  Highly corrected beam
  Circular cross-section and low astigmatism

- **Fiber-coupled versions**
  Fiber coupling with up to 70% coupling efficiency
  Fibers with FC output or with collimated output
  Part of DCS-120 Confocal Scanning FLIM Systems

- **Fiber-pigtial versions**
  Single-mode fiber pigtial
  Single-mode fiber permanently attached to laser
  No fiber alignment required
  Part of DCS-120 Confocal Scanning FLIM Systems
  Designed and manufactured in cooperation with Lasos GmbH, Jena, Germany

All lasers operate from single +12V power supply
All bh laser have the electronics integrated in the laser head
No external controller unit
Operation from single +12V power supply
All Lasers interface directly with DCC-100 detector controller, GVD-120 scan controller, or DC8-120 controller box.
Experiment Control and Connecting Electronics

DDG-210 Digital Delay Generator
Multiplexing of lasers and routing to TCSPC Modules
Multiplexing rate up to 1 MHz
Laser on/off modulation for PLIM
Non-overlapping laser multiplexing
On-times programmable individually
Part of bh modular DOT systems
Part of bh FLIM / PLIM systems for Zeiss LSM 710 / 780 / 880 family
Integrated in bh SPCM TCSPC instrument control software

GVD-120 Scan Controller Card
New: GVD-120 PCIe Scan Controller Card
Generation of scan signals for galvanometer scanners and piezo stages
Dual-axis control
Frame scan, line scan, high-stability point operation
Laser ON / OFF modulation for PLIM
Linear x scan with cycloid flyback
New: Sinusoidal x scan option
Extremely high scan rates
Controls also two bh BDL-SMN, or BDL ps diode lasers
Laser beam blanking
Laser multiplexing, Laser on/off modulation for PLIM
Fully digital signal generation
Independent of software response times
Pixel times down to 0.5 µs
Pixel numbers up to 4096 x 4096
Fully integrated in bh SPCM TCSPC software
Part of bh DCS-120 confocal scanning systems

DCC-100 and DCC-100 PCIe detector controllers
Control of two bh TCSPC detectors
Intensity control of bh picosecond diode lasers
For details please see ‘Detector Electronics’

Delay-Box-32N
32 step passive delay line
Delay from 0 to 31.5 ns in 0.5 ns steps
New! Selection of one of two signal sources
Transmits any signal waveform
Signal bandwidth 1 GHz
No noise, no jitter
No external power supply needed
Settings persist when box is disconnected from USB
Easy adjustment of TCSPC SYNC path length
Control integrated in bh SPCM TCSPC operating software

BOB-104 Signal Distribution Box
Distributes scan clock signals to four SPC modules
Combines routing signals and other control signals into 15-pin control inputs of four SPC-130 EMN, -150N, and -160 modules
Auxiliary +12 V input for power supply of amplifiers, routers, detectors

BOB-101 Signal Distribution Box
Combines routing signals and other control signals into 15-pin control inputs of one SPC-130 EMN, -150N, and -160 modules
Auxiliary +12 V input for power supply of amplifiers, routers, detectors

DCS Connection Box
Power supply and control of two bh BDS or BDL-SMN ps diode lasers
Connects scan clocks and laser multiplexing signals of GVD-120 scan controller into two SPC-150N or SPC-160 modules and two BDS or BDL-SMN diode lasers
Connects routing signals of two bh multi-spectral FLIM detectors into SPC modules
Configurable by SPCM software

Cables and Adapters
A-PPI-D passive pulse inverters
1:3, 1:4 power splitters and combiners
Attenuators
SMA cables
SMA to SMA adapters
SMA to BNC adapters
Power supply cables for detectors
Interface cables for bh FLIM systems for various laser scanning microscopes

A reasonable set of cables and adapters is delivered with each bh SPC module or Simple-Tau system
Fluorescence Lifetime Microscopy

DCS-120 Confocal Scanning FLIM Systems
Based on bh’s 64-bit megapixel FLIM technology
FLIM with up to 2048 x 2048 pixels
Complete Confocal Laser Scanning FLIM microscopes
FLIM upgrade for existing conventional microscopes
Scanning by fast galvanometer mirrors
Two fully confocal detection channels
One or two BDS or BDL-5MN picosecond diode lasers
Laser wavelengths 375, 405, 445, 473, 488, 515, 640, 685, 785 nm
Tuneable excitation by super-continuum laser with AOTF
One or two confocal detection channels, parallel acquisition
Channel separation by dichroic or polarising beam-splitters
Individually selectable pinholes, individually selectable filters
GaAsP hybrid detectors for visible range, GaAs hybrid detectors for NIR range
16-channel multi-wavelength GaAsP detector module
Z-stack FLIM acquisition with Zeiss Axio Observer Z1
Spatial Mosaic FLIM via motorised sample stage (optional)
Simultaneous fluorescence and phosphorescence lifetime imaging (PLIM)
Fluorescence lifetime transient scanning (FLITS)
Ultrastable time-series recording by temporal mosaic FLIM function
Wideband (WB) version, compatible with tuneable lasers
Electronic pinhole alignment

DCS-120 MP Multiphoton FLIM System
Multiphoton version of DCS-120 scanning system
Excitation by Ti:Sa laser
IRF width 20 ps FWHM with HPM-100-06 detectors
Laser control integrated in SPCDM data acquisition software
Laser intensity control and PLIM laser modulation by AOM
One or two non-descanned detection channels
Clear Images from deep tissue layers
Excellent spatial and temporal resolution
Images up to 2048 x 2048 pixels, 256 time channels
Full field of view of microscope lens scanned
Optional 16-channel multi-wavelength GaAsP detector module
Z-stack FLIM acquisition with Zeiss Axio Observer Z1
Spatial Mosaic FLIM via motorised sample stage (optional)
Simultaneous fluorescence and phosphorescence lifetime imaging (PLIM)
Fluorescence lifetime transient scanning (FLITS)
Ultrastable time-series recording by temporal mosaic FLIM function

DCS-120 Macro System
FLIM of macroscopic objects
Scan field up to 15 mm diameter
FLIM with up to 2048 x 2048 pixels
Scanning by fast galvano mirrors
Two fully confocal detection channels
One or two BDS or BDL-5MN picosecond diode lasers
Laser wavelengths 375, 405, 445, 473, 488, 515, 640, 685, 785 nm
Tuneable excitation by super-continuum laser with AOTF
One or two confocal detection channels, parallel acquisition
Channel separation by dichroic or polarising beam-splitters
Individually selectable pinholes, individually selectable filters
GaAsP hybrid detectors for visible range, GaAs hybrid detectors for NIR range
Optional 16-channel multi-wavelength GaAsP detector module
Spatial Mosaic FLIM via motorised sample stage (optional)
Simultaneous fluorescence and phosphorescence lifetime imaging (PLIM)
Fluorescence lifetime transient scanning (FLITS)
Ultrastable time-series recording by temporal mosaic FLIM function
Wideband (WB) version, compatible with tuneable lasers
Electronic pinhole alignment

Please see handbook:
Overview brochure DCS-120 Confocal Scanning FLIM Systems

FLIM Systems for Zeiss LSM 710 / 780 / 880 Microscopes
LSM 710 / 780 / 880 NLO, LSM 7MP Multiphoton Microscopes
LSM 710, LSM 780, LSM 880 Confocal Microscopes
LSM 710, LSM 780, LSM 880 In Tune systems
Based on bh’s 64-bit megapixel FLIM technology
FLIM with up to 2048 x 2048 pixels
Multiphoton FLIM, PLIM, multispectral FLIM, FCS
Confocal FLIM, PLIM, multispectral FLIM, FCS
FLIM with bh HPM hybrid detectors or Zeiss BIG-2 detectors
Fast preview mode, both for intensity and lifetime
Mosaic FLIM
Z Stack FLIM
Fast Time-series FLIM
Acquisition by 1, 2, 3 or 4 parallel TCSPC FLIM channels
Simultaneous fluorescence and phosphorescence lifetime imaging (PLIM)
Fluorescence lifetime transient scanning (FLITS) fully integrated
Ultrastable time-series recording by temporal mosaic FLIM function
Confocal NIR FLIM up to 900 nm detection wavelength
Two-Photon OPD FLIM up to 900 nm detection wavelength

Please see handbook
Modular FLIM Systems for Zeiss LSM 710 / 780 / 880 Family Laser Scanning Microscopes and Overview brochure
Still available: FLIM Systems for Zeiss LSM 510 NLO
Multiphoton Microscopes
FLIM with up to 2048 x 2048 pixels
Multiphoton excitation with non-descanned detection
Detectors connected to Zeiss NDD switch box
Single-wavelength NDD FLIM
Dual-wavelength NDD FLIM
Multi-spectral NDD FLIM
Fast preview mode
Mosaic FLIM
Z Stack FLIM
Fast time series FLIM
HPM-100-40 hybrid detectors
One or two parallel SPG-150N TCSPC channels
PC-based systems or Simple-Tau TCSPC systems

Non-Descanned FLIM Systems for Leica SP2 MP, SP5 MP, SP8 MP Microscopes
64-bit megapixel FLIM technology
Non-descanned detection via Leica RLD port
1 detector coupled directly to RLD port
2 detectors via external beamsplitter
Simple-Tau 150N or 152N TCSPC systems
Acquisition in 1 or 2 parallel TCSPC FLIM channels
bh-HPM-100-40 hybrid detectors or Leica HYD detectors
Multi-spectral FLIM with 16-channel GaAsP detector
Works at any scan rate of SP2 and SP5
Fast acquisition, fast preview mode
Megapixel FLIM, 2048 x 2048 pixels
Fluorescence lifetime transient scanning (FLITS)
Ultra-fast time series by temporal mosaic FLIM
Simultaneous FLIM / FLIM

FLIM Systems for Olympus FV1000 and FV300 Confocals
64-bit megapixel FLIM technology
Excitation by bh BDL-405 SMN or BDL-473 SMN picosecond diode laser
High efficiency by direct coupling of detectors
Single-wavelength detection: PMT, MCP-PMT, or Hybrid PMT
Multi-wavelength detection: bh PML-SPEC detector
Full overload protection of detectors
ROI and Zoom functions of FV1000 or FV300 available
Works at any scan rate
FCS capability
Megapixel FLIM
Fluorescence lifetime transient scanning (FLITS)

Non-descanned FLIM Systems for Olympus FV1000 and FV300 Multiphoton Microscopes
64-bit megapixel FLIM technology
Multiphoton FV1000 and FV300 systems with inverted microscopes
High efficiency by non-descanned FLIM detection
Deep-tissue imaging capability
Single-wavelength detection: PMT, MCP-PMT, or Hybrid PMT
Multi-spectral FLIM with 16-channel GaAsP detector
Full overload protection of FLIM detectors
ROI and Zoom functions of FV1000 or FV300 available
Works at any scan rate
New! Megapixel FLIM
New! Fluorescence lifetime transient scanning (FLITS)

FLIM Systems for Nikon A1+ Microscopes
64-bit megapixel FLIM technology
New! Nikon integrated version available
One FLIM channel or two parallel FLIM channels
High-efficiency HPM-100 hybrid detectors
Non-descanned detection for multiphoton microscopes
Confocal detection for one-photon microscopes
Multi-spectral FLIM with 16-channel GaAsP detector
Works at any scan rate
Megapixel FLIM
Fluorescence lifetime transient scanning (FLITS)
Ultra-fast time series by temporal mosaic FLIM
Simultaneous FLIM / FLIM
FLIM Systems for Sutter Instrument MOM Microscopes
Up to four parallel FLIM channels
Multiphoton excitation by Ti:Sa laser
Non-descanned detection for deep-tissue imaging
Overload protection of FLIM detectors
Up to 1024 x 1024 pixels, 1024 time channels
High efficiency
Fast acquisition
SPCM Online FLIM function available
Simultaneous FLIM / PLIM

PZ-FLIM-110 Stage-Scanning FLIM System
Sample scanning by piezo scan stage
Excitation by BDL or BDS series ps diode lasers
Confocal detection
HPM-100 hybrid detector
Optional PML SPEC GaAsP multi-spectral detector
Excellent contrast and resolution
Fully controlled by bh SPCM TCSPC/FLIM data acquisition software
Compact electronics, integrated in bh Simple-Tau system
Megapixel FLIM technology - images up to 2048 x 2048 pixels
Lateral (x-y) and vertical (z) scanning
Simultaneous FLIM / PLIM

FLIM for NSOM Systems
For NSOM systems of Nanonics and NT-MDT
Combines atomic-force and fluorescence lifetime information
High sensitivity by HPM-100 hybrid detectors
Fluorescence and phosphorescence lifetime imaging
Single-point transient lifetime recording
Please see bh TCSPC Handbook or contact bh.

FLIM Systems for Clinical Imaging
64-bit megapixel FLIM technology
FLIM systems for ophthalmology
FLIM systems for dermatology
FLIM systems for tissue imaging
FLIM through endoscopes
Time-resolved NIRS and fNIRS Imaging
Online FLIM at rates of up to 10 images per second
Please see bh TCSPC Handbook or contact bh

FLIM for other Scanning Systems
bh FLIM systems can be configured for almost any conceivable laser scanning system. They work with galvanometer scanners, polygon scanners, resonance scanners, and motor-driven and piezo-driven scan stages.

Left: FLIM recorded with Lucid Vivascope, ultra-fast polygon scanner
Right: STED FLIM recorded with STED microscope of Abberior Systems, Goettingen

Please see bh TCSPC Handbook or contact bh.
TCSPC Systems for Time-Domain Diffuse Optical Tomography

**Modular DOT systems**
- Up to 8 parallel TCSPC channels
- Up to 32 detector channels
- Up to 8 BDS-MM lasers with wavelength multiplexing
- Up to 8 wavelengths multiplexed with supercontinuum laser
- Recording with multiplexed source position
- Time-of-flight distributions for all combinations of wavelength, source, and detection channels
- Diffuse correlation in 16 channels
- Recording by SPS-PG-134-EMN, SPC-154N, or SPC-164 TCSPC packages
- Laser control by DDG-210 digital delay generator
- Detector control via DCC-100 cards
- Saturated count rates up to 40 MHz
- Multiplexing periods of lasers individually programmable
- Unlimited sequential recording by continuous flow mode
- Acquisition rate up to 20 time-of-flight distributions per second

**New:** Non-contact scanning by galvanometer scanner controlled by GVD-120 card

---

Fiber-Based Fluorescence-Lifetime Systems for *in-vivo* Applications

**Fiber-based TCSPC system for in-vivo application**
- Implantable fiber tip, removable from fiber system
- Single mode excitation, multi-mode detection
- Excitation by BDL or BDS ps diode lasers
- Detection by hybrid detectors or SPAD detectors
- Multi-wavelength detector option
- Excellent sensitivity
- Excellent time resolution
- Low background fluorescence
- Detection of NADH, FAD, or exogenous fluorophores
- Ca**2+** detection in neuronal tissue
- pO2 measurement in live tissue

---

Systems for Recording Optical Emission from Barrier Discharges

**Recording of full spatio-temporal pulse profiles**
- Multi-dimensional TCSPC process
- Sinusoidal discharge voltage, 5 to 15 kHz
- Fast galvanometer scanning along discharge gap
- Control by GVD-120 scan controller
- Fully integrated in SPCM software
- Detection of optical signals by one or two detectors
- Optional 16-wavelength detector
- Recording by one or two parallel SPC-150N TCSPC modules
- Online display of data

Please see bh TCSPC Handbook, 7th edition
More than 2000 TCSPC Systems Worldwide

TCSPC Instrument Software

SPCM Data Acquisition Software for all bh TCSPC Modules and DPC-230 Photon Correlator

True 64 bit software for Windows 7, 8, 10
Megapixel FLIM Technology

- Same software for all bh TCSPC modules and DPC-230 card
- One software for all operation modes
- Full access to all functions of the boards
- Configurable for different instrument configurations
- Parallel operation of up to four SPC or DPC modules
- Online display of images and curves
- Online calculation of FCS, PCH, and MCS traces
- Online fit of FCS curves
- Cycle function
- Page stepping
- Autosave functions
- Oscilloscope mode
- Multi-wavelength fluorescence decay recording
- Single and repeat mode
- Sequential modes
- Imaging modes
- Single photon parameter-tag mode
- Hardware-accumulation FLIM mode
- Software-accumulation (parameter tag) FLIM mode
- Multi-wavelength FLIM
- Spatial Mosaic FLIM
  - Temporal mosaic FLIM for accumulation of ultrafast time series
  - Fluorescence lifetime transient scanning (FLITS)
- Simultaneous recording of FLIM and PLIM
- Integrated scanner control
- Integrated detector control
- Integrated laser control for FLIM
- Integrated control of Ti:Sapphire laser and AOM
- Integrated control of motorised sample stage
- Integrated control of Zeiss Axio Observer Z1 microscope
- 2D and 3D display modes
- Online display of lifetime images
- Image display with software gating
- Display of multi-wavelength FLIM images
- 3D Curve mode, colour-intensity display of multi-dimensional data
- Saving, loading, and conversion of photon distributions, images, and time-tag data
- Loading of instrument configuration via predefined setups
- Automatic interaction with SPCImage FLIM data analysis
- Runs under Windows 7, Windows 8, Windows 10

Technology Leaders in Photon Counting

SPCM Data Acquisition Software for bh TCSPC Modules and DPC-230 Photon Correlator

One Software - Multiple Applications
TCSPC Data FLIM Analysis Software

SPCImage FLIM Data Analysis Software

- Analysis of FLIM data
- Analysis of PLIM data
- Analysis of single FLIM or PLIM channels
- Analysis of multiple FLIM or PLIM channels
- Analysis of single-curve fluorescence data
- Analysis of single-curve phosphorescence data
- Analysis by iterative convolution and fit procedure
- Analysis by first moment of photon distribution
- Multi-traced calculation procedure
- Single, double, and triple-exponential decay models
- Incomplete decay models
- Baseline correction
- Free or fixed lifetimes of decay components
- Pseudo-global analysis
- Synthetic, measured or manually defined IRF
- Extraction of IRF from SHG components in FLIM image
- Region-of-interest selection
- Single and double-exponential FRET
- Display of lifetime images
- Display of FRET images
- Display of lifetimes, amplitudes, intensities or ratios of parameters
- Calculation of FRET efficiencies
- Histograms of lifetimes, amplitudes, intensities or ratios of these parameters
- Export of lifetime data
- Export of images
- Direct interaction with SPCM software
- Automatic transfer of SPCM data to SPCImage
- Transfer of data of selected channels or of all channels
- Processing of Megapixel FLIM data
- Processing of Mosaic FLIM data
- Batch processing of multiple FLIM files
- Batch processing of multi-wavelength FLIM data
- Batch export of FLIM images and decay data

New! Multiple region of interest definition

New! Two-dimensional histograms of decay parameters
- Histograms of pixel frequency over two selected parameters of the fluorescence decay
- Colored annotation of pixels in 2D histograms
- Back-annotation of 2D parameter ranges in FLIM images

New! Phasor plot
- Fourier transform of decay data
- Histograms of amplitude and phase of decay data in frequency space
- Coloured annotation of pixels in phasor plot
- Back-annotation of parameter ranges in FLIM images
TCSPC Single-Molecule Burst-Analysis Software

**Single-Molecule Burst-Analysis Software**
- Identification of single-molecule photon bursts in parameter tag data
- Analysis of fluorescence intensity within photon bursts
- Analysis of fluorescence lifetime within photon bursts
- One- and two-dimensional histograms of burst parameters
- Discrimination of different fluorescent species
- Determination of FRET efficiencies
- Discrimination of different FRET states
- Calculation of FCS and cross-FCS
- FCS fit with user-defined model functions
- Exclusion of artefacts in intensity traces
- Time-gating
- Selection of excitation channels in PIE data

**DLL Libraries for TCSPC and Multiscaler Modules**
- DLL libraries are available for most bh data acquisition and experiment control modules.
- Please contact bh for details.

**Lab View Library for TCSPC / FLIM Modules**
- Lab View modules for basic functions of bh TCSPC / FLIM modules
- Measurement and measurement control functions
- Parameter setup functions
- Display functions
- Load and save functions
- Example programs
Technology Leaders in Photon Counting

Design, Manufacturing and Quality Management

A Strong Partnership
bh and Dorazil form an alliance since 1993. Located in the same building, our companies closely cooperate at all stages through schematics design, hybrid circuit design, board layout, and computer-aided manufacturing and testing. Continuous quality management through the complete design and manufacturing flow results in high reliability and short delivery time both for prototypes and large order quantities.

Continuous flow from design into manufacturing
Hybrid-circuit, FPGA, and PCB design

Electronics running off the mill
High-density automatic SMD placement
Automatic soldering
ROHS lead-free

Thin film and thick film hybrid circuits
In-house manufacturing
Automatic placement of components
Automatic chip bonding

ISO 9001 and ISO 14001 certified
Quality management though entire manufacturing process
Uncompromised quality at any number of pieces
More than 2000 TCSPC Systems Worldwide

International Sales Representatives

USA, Canada
Boston Electronics Corp
tcspc@boselec.com
www.boselec.com

UK:
Photonic Solutions PLC
sales@psplc.com
www.psplc.com

Japan:
Tokyo Instruments Inc.
sales@tokyoinst.co.jp
www.tokyoinst.co.jp

China and Hongkong:
DynaSense Photonics Co. Ltd.
info@dyna-sense.com
www.dyna-sense.com

India:
Carl Zeiss India
info.microscopy.in@zeiss.com
http://www.zeiss.co.in

Russian Federation:
BioVitrum
http://www.biovitrum.ru

Russian Federation:
Azimuth Photonics
info@azimp.ru
http://www.azimp.ru

Korea:
UniNanoTech Co.Ltd.
nano@uninanotech.com
https://www.unithink.co.kr

Other Regions:
Please feel free to contact bh directly