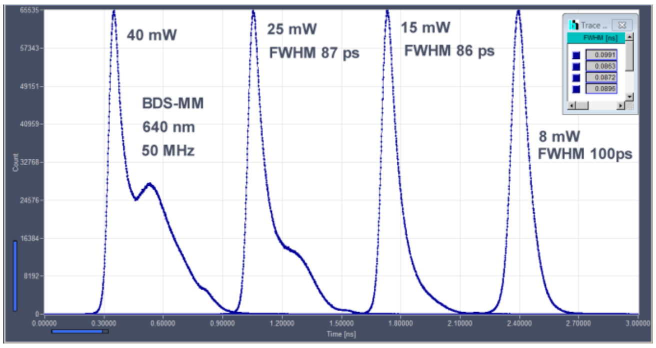
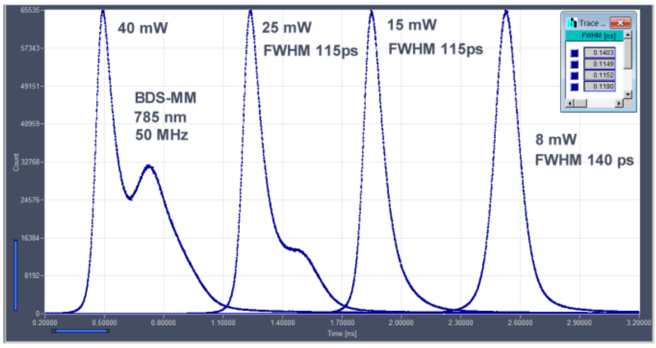
BDS-MM

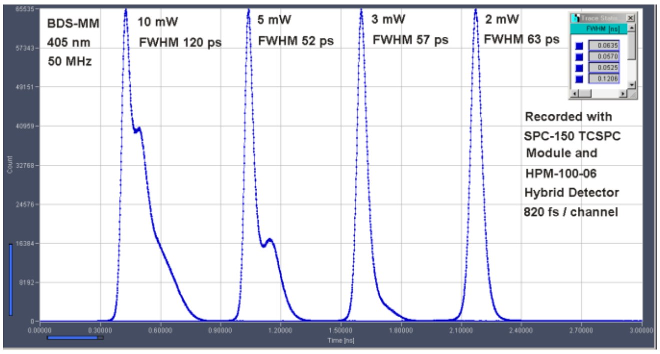
BDS-MM Family Picosecond Diode Lasers

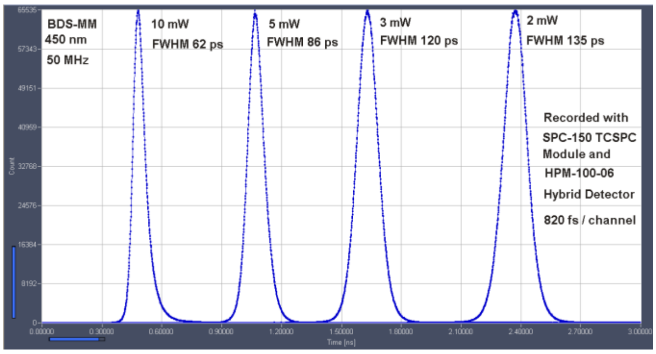
Optical power up to 60 mW @ 50 MHz

Small-size module, 40 x 40 x 120 mm³ or 40 x 70 x 120 mm³
Wavelengths 405, 445, 525, 640, 685, 785, 915 nm
Power up to 60 mW, multi-mode @ 50 MHz
Free-beam or multi-mode fibre output
Pulse repetition rate 20 MHz and 50 MHz, others on request
Ext. trigger via sync. input: 20 to 50 MHz, others on request
Fast ON/OFF and multiplexing capability
High power stability
All electronics integrated, no external driver unit required
Simple +12 V power supply
Compatible with all bh TCSPC devices









Pulse shapes may change due to development in laser diode performance. Power measured in free beam. Coupling efficiency into optical fibres is 60 to 90%, depending on fibre diameter

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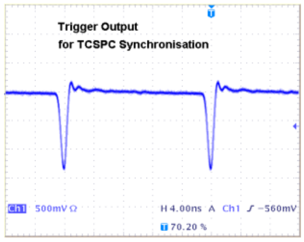
Optical

Repetition Rate, switchabel by TTL signal	20 MHz and 50 MHz, other combinations on request
Wavelengths	405, 450, 525, 640, 685, 785, 915 nm, others on request
Max. optical power	10 to 60 mW at 50 MHz, depends on wavelength version
Coupling efficiency into fibres (multi-mode, typical values)	100 µm: 60% 200 µm: 80 % 500 µm: 90 %
Pulse width (FWHM, at medium power)	65 to 120 ps
Pulse width (FWHM, at maximum power)	120 to 300 ps
Warm-up time for power and pulse shape stabilisation after power on	1 min [1)]

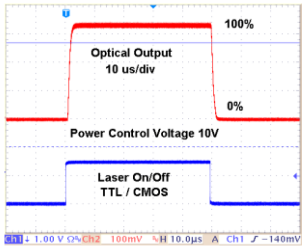
Trigger Output, to TCSPC Modules

Pulse Amplitude	-1 V (peak) into 50 Ω
Pulse Width	1 ns, see figure right
Output Impedance	50 Ω
Connector	SMA
Jitter between Trigger and Optical Pulse	< 10 ps



Synchronisation Input

Input amplitude	+3.3 to +5 V into 50 Ω
Duty cycle	10 to 30 %. DC equivalent must be < 2.5V
Input frequency	20 to 50 MHz, others on request
Connector	SMA
Switch between internal clock and sync input	automatic, by average voltage at trigger connector

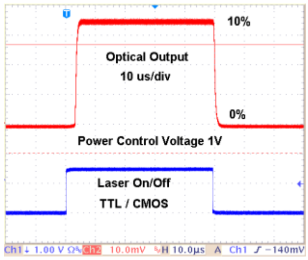


Control Inputs

Laser ON/OFF	TTL / CMOS, 'low' means 'OFF', internal pull-up
Response of optical output to ON/OFF signal	< 4 us for power 10 to 100 %, see figures right
External Power Control	analog input, 0 to + 10 V
Response time of optical output to power control	< 4 us for power 10 to 100 %, see figure right
F1: 50 MHz	active H, internal pull-up resistor
F2: 20 MHz	active H, internal pull-down resistor
	Laser runs at 50 MHz with Frequency inputs unconnected

Power Supply

Power Supply Voltage	+ 9 V to +15 V
Power Supply Current at 12V	200 mA to 500 mA [2)]

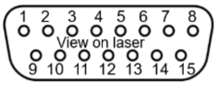


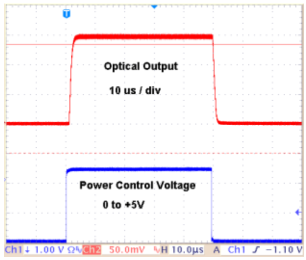
Mechanical Data

Dimensions (OEM)	40 mm x 40 mm x 120 mm
Dimensions (w/ cooling)	40 mm x 70 mm x 120 mm
Mounting holes	four holes for M3 screws
Heat sink requirements	< 2°C / W [3)]

Connector Pin Assignment

Connector version	Micro Sub-D
Power supply +12V	1, 2
GND	4, 5, 9, and case
Power control voltage	8
Laser ON/OFF (active H)	6
F1: 50 MHz (active H, internal pull-up resistor)	7
F2: 20 MHz (active H, internal pull-down resistor)	3
Do not connect:	9 to 15





Maximum Values

Power Supply Voltage	0 V to +15 V
Voltage at 'Laser ON/OFF' and 'Frequency' inputs	-2 V to +7 V
Voltage at 'Laser Power' input	-12 V to + 12 V
Ambient Temperature	15 °C to +35 °C [3)]

1) Operation below 15 °C ambient temperature may result in extended warm-up time.
2) Depends on case temperature due to laser diode cooling. Cooling current changes with case temperature.
3) OEM version without active cooling must be mounted on heat sink. Case temperature must remain below 40 °C.

Related Products

BDS-SM picosecond diode lasers, BDS-SMN picosecond and CW diode lasers, 375, 405, 445, 473, 488, 515, 640, 685, 785, 1064 nm

Caution: Class 3B laser product. Avoid direct eye exposure. Light emitted by the device may be harmful to the human eye. Please obey laser safety rules when operating the devices. Complies with US federal laser product performance standards.

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Application Information

Frequency Selection

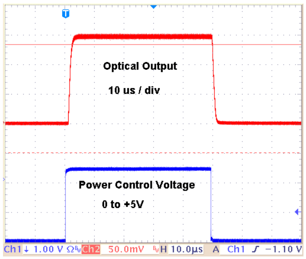
The BDS-MM laser can be operated at two internal clock frequencies, normally 50 MHz and 20 MHz. The frequency is selected by two TTL input lines, F1, and F2:

Signal	Pin at 15-pin laser connector	Frequency	Logic Level
F1	7	50 MHz	active H, internal pull-up resistor
F2	3	20 MHz	active H, internal pull-down resistor

F1	F2	Function
H	L	50 MHz
L	H	20 MHz
L	L	No laser operation. Don’t use. Use Laser ON/OFF to turn off emission
H	H	Both frequencies active. Don't use.
not connected	not connected	50 MHz

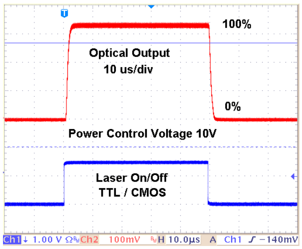
Power Control

The optical power is controlled via a 0 to 10 V analog signal. The signal is connected to pin 8 of the 15-pin connector of the laser or pin 12 at the LSB-C control box. The source of the signal should have less to 100 Ω source impedance. If the input is left open the laser runs at approximately 20 % of its maximum power. The reaction to a change in the power control voltage occurs within a time of about 2 µs, see diagram on the right.



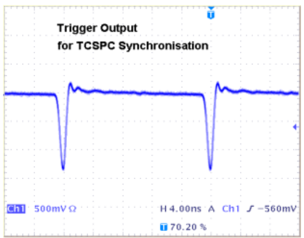
ON / OFF / Multiplexing Control

The optical output of the laser can be switched on and off by a 'Laser ON/OFF' signal at pin 7 of the 15-pin connector of the laser. The logic level is TTL /CMOS, H means 'Laser ON', L means 'Laser OFF'. The laser is 'ON' if the input is left open. The reaction time to the Laser ON/OFF signal is in the range of 1 to 5 µs, see figure on the right. The SYNC output of the laser becomes inactive when the Laser is in the 'OFF' state. When several lasers are multiplexed their SYNC signals can be combined into a single SYNC line to a TCSPC module by a simple resistive power combiner.



Synchronisation Output

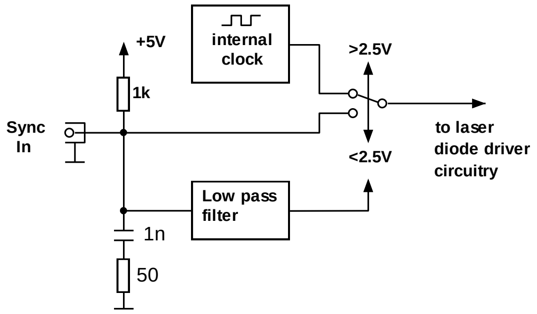
The laser delivers a synchronisation (SYNC) output for TCSPC modules. The pulse polarity is negative, the amplitude is about -1.2 V. The pulse duration is about 1ns. The SYNC output is inactive when the laser is in the 'OFF' state (Laser ON/OFF = L). When lasers are multiplexed their SYNC Out signals can be combined by a simple resistive power combiner.



Synchronisation Input

The synchronisation input is used to synchronise a BDS laser to an external clock source. The input signal must be TTL/CMOS compatible, and DC coupled into the synchronisation input from a 50 Ω source. The pulses must be positive, with a duty cycle of no more than 30 %. With a signal like that, the laser automatically recognises that a synchronisation signal is connected, and switches its clock path from the internal clock generator to the synchronisation input.

The principle of clock source switching is shown in Fig. 1. The average voltage at the Sync input connector is sensed via a low-pass filter. The output voltage from the filter sets a switch. If the average voltage is > 3 V the clock comes from the internal clock generator, if the voltage is < 3 V it comes from the Sync input connector. The active edge of the input signal is the rising edge.



Sync Input:	open	TTL High	TTL Low		
Average voltage:	>3V	>3V	<3V	<3V	>3V
Clock source:	internal	internal	external, but no clock. Don't use	external	internal Don't use

Fig. 1: Principle of switching between the internal clock generator and an external clock source

Power Regulation Loop

Light generation in a laser diode is a highly nonlinear process. The slightest changes in the driving conditions or junction temperature, or mode fluctuations and back-reflection of light into the laser diode can result in large changes in the optical power. Therefore, the BDS-SMN lasers have an internal power regulation loop, see Fig. 2. The laser power is monitored by a photodiode, and the photodiode current, Ipd, compared with a reference current, Iref. The difference of both is amplified, and used to control the electrical driving power to the laser diode. Thus, the difference between the photodiode current and the power control signal is regulated down to zero. That means the optical power is linearly related to the power control signal. Changes in the optical power due to temperature variation, variation in the supply voltages, or mode fluctuations in the laser diode are largely suppressed.

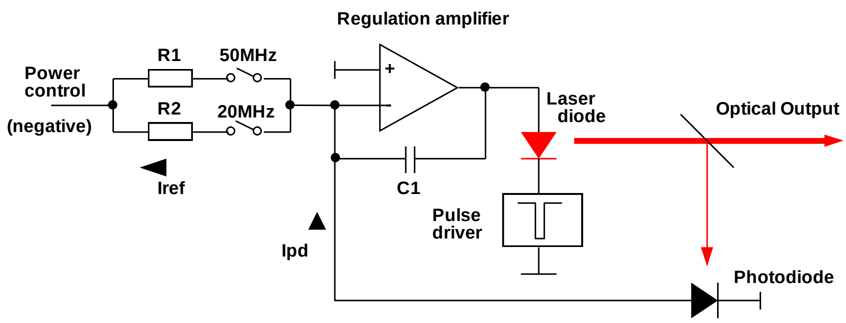


Fig. 2: Principle of power regulation loop

The regulation loop reacts to the average intensity of the optical output, not to the peak intensity of the laser pulses. For constant average power the peak power changes with the pulse repetition rate. When the lasers are running with the internal clock oscillators the variation with the repetition rate is taken into account by switching the resistors, R1 and R2, in proportion to repetition rate selected. For operation with external clock frequencies the peak power changes with the pulse period. To obtain a reasonable power regulation range with an external clock we recommend to chose the F1 an F2 signals for an internal clock frequency closest to the external clock frequency.

Dependence of Pulse Shape on Laser Power

When a laser diode is sharply driven from the off state into the on state is emits a short pulse of light before it settles into its steady-state intensity. In a picosecond diode laser, driving conditions are chosen which result in short duration and high peak intensity of the initial pulse. The pulse shape depends on the amplitude of the current pulse that drives the diode. At low pulse current light pulses of near Gaussian shape are emitted. The pulses get narrower with increasing pulse current. If the pulse current through the diode is increased further emission by the normal light generation mechanism occurs. It more or less follows the current flowing through the diode junction, and forms a bump or tail following the initial peak. At very high power, the amplitude of the bump can reach or exceed the amplitude of the initial peak, and, eventually, become the dominating part of the pulse profile. Please see pulse shapes at Page 1 of this data sheet. The change of the pulse profile versus the laser power makes it recommendable to keep the laser power at a constant level within one series of experiments.

LSB-C Laser Switch Box

Starting from May 2018, the BDS lasers are operated via the new LSB-C switch box. Note, the BDS-MM lasers in standard configuration are optimized for 20 MHz and 50 MHz, only. 80 MHz and CW are not available. The LSB-C is shown in Fig. 3:

Fig. 4: LSB-C Laser Switch Box

At the front panel, the LSB-C box has the mandatory key switch, a switch for the pulse frequency, a potentiometer for the laser power, and SMA connectors for an external power control signal and the laser ON/OFF signal. At the rear panel the box has a 9-pin connector for a +12 V power supply, a 15-pin connector to the laser, and a 15-pin connector for external control signals. The pin assignment for the conrol signals is shown in Table 2.

Pin number **15 pin control connector of LSB-C**	**Function of Signal**
1	do not connect
2	F2: 20 MHz [1,2]
3	F1: 50 MHz [1,2]
4	do not connect
5	GND
6	reseved, do not connect
7	Laser ON/OFF, TTL/CMOS, parallel to SMA connector
8	do not connect
9	not connected
10	not connected
11	reserved, do not connect
12	Power control signal, 0 to +10 V, parallel to SMA connector
13	not connected
14	not connected
15	GND

1) Put frequency switch in 'EXT' position
2) Only one of the inputs must be in H state, the other two inputs must be pulled to Low (GND).

Table 2: Control signals at 15-pin external-control connector of LSB-C laser switch box

The lasers are, however, fully operable without the switch box, e.g., for integration into other instruments. These must then have their own laser safety provisions incorporated.

Safety Interlock Connector

The ‘Interlock’ connector of the LSB-C box is used to build up a laser-safety loop when the BDS laser is integrated in larger systems. To enable laser operation the safety cable delivered with the LSB-C box must be connected to the interlock connector, and the blue wire connected to the black wire or to ground either directly or via the laser safety loop.

Application Examples

Controlling the BDS Lasers from a DCC-100 Card

The BDS series lasers can be controlled via the bh DCC-100 detector / laser controller card (Fig. 4). One of the outputs, Con1, is connected to the control input connector of the laser switch box. The laser power can then be controlled via the ‘Gain’ slider, and the laser output be turned on and off via the +5V button. The other output, Con3, can be used to control a detector or a second laser. Con2 is reserved for controlling shutters.

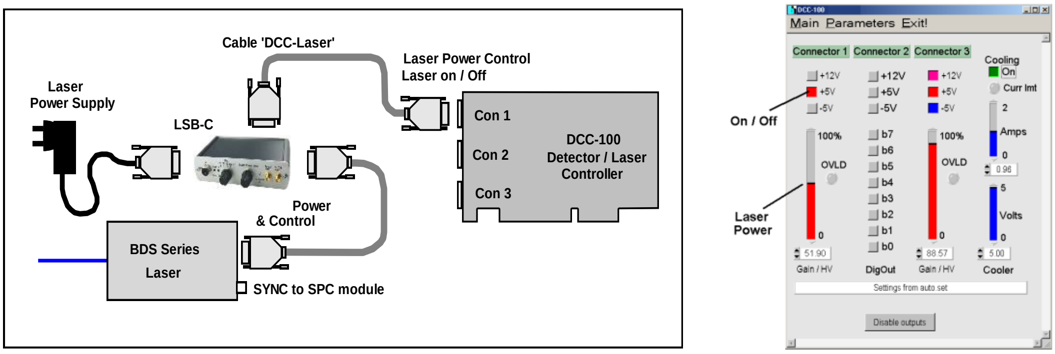


Fig. 5: Controlling the BDS-SMN from a DCC Detector / Laser Controller card

Simple Fluorescence-Decay Experiment

The setup shown in Fig. 6 uses a BDS-MM or BDS-SM laser for a simple fluorescence lifetime experiment. The sample is excited by the picosecond pulses from the laser. The fluorescence photons are detected by a bh HPM-100 or PMC-100 detector, and recorded by an SPC-150, SPC-130, or SPC-130EM TCSPC module (any bh TCSPC module will work). The timing synchronisation signal for the TCSPC module comes from the Sync output of the laser. Both the laser and the detector are controlled by a DCC-100 detector / laser controller card. The entire setup is operated via the bh SPCM TCSPC operating software, see Fig. 6, right.

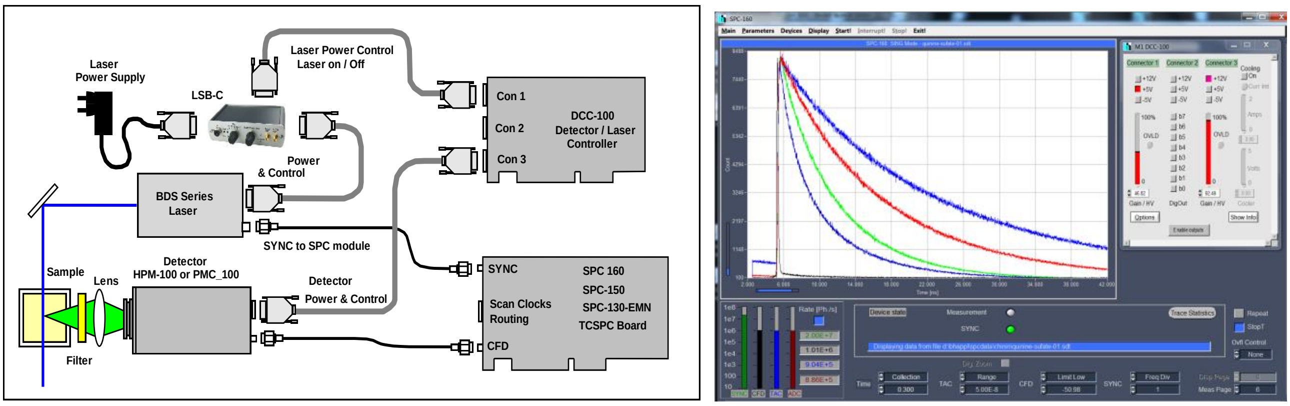


Fig. 6: Simple fluorescence-lifetime experiment. Left: System setup. Right: SPCM panel.

Laser Multiplexing

Two or more lasers are switched ON/OFF alternatingly at a period in the microsecond or millisecond range. Simultaneously with the switching of the lasers, the memory block address in the SPC module is switched. Thus, photons excited by each laser are stored in separate memory blocks in the SPC module [1, 2].

A connection diagram is shown in Fig. 7. The laser ON/OFF signals are generated in a DDG-210 pulse generator card. Switching of the lasers is achieved via the 'Laser ON/OFF' inputs of the lasers. The DDG-210 card also generates the routing signal for the SPC module. It is applied to the lowest routing bit, R0, via the 15-pin control connector of the SPC module. Please see [2] for details.

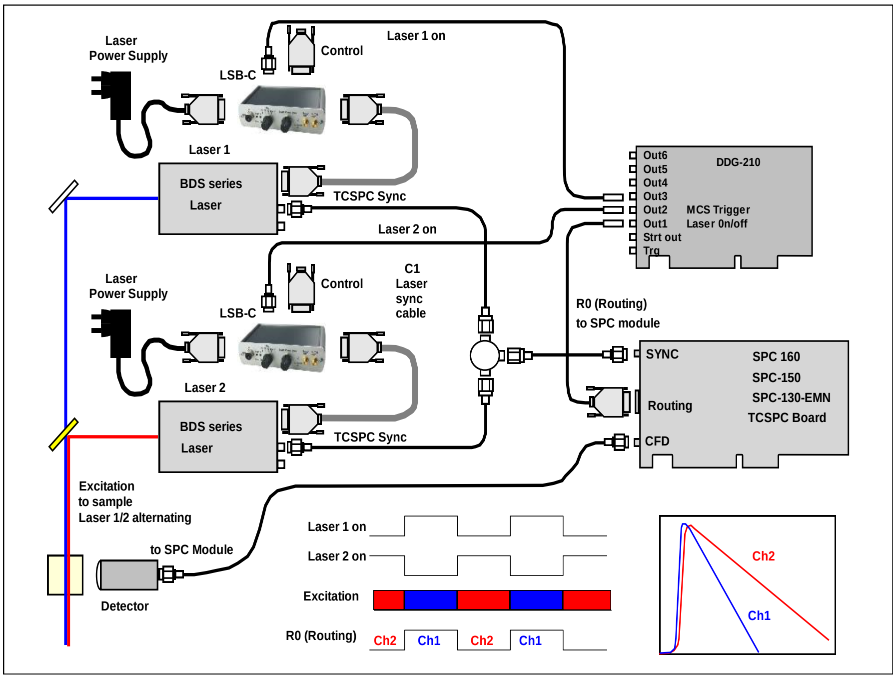


Fig. 7: Laser multiplexing. The lasers are switched ON/OFF alternatingly, the photons excited by different lasers are stored in separate TCSPC memory channels

Combined Fluorescence / Phosphorescence Lifetime Detection System

The system shown in Fig. 7 can be used to simultaneously record fluorescence and phosphorescence decay curves. Only one laser is used, the other one is blocked optically or replaced with a SYG-1 sync generator [2]. The laser is ON/OFF modulated at a period in the microsecond or millisecond range. In the 'on' phase fluorescence is excited and phosphorescence is build up. In the 'off' phase pure phosphorescence is observed, see Fig. 8, left. Fluorescence decay curves are built up from the photon times in the laser pulse period, t_{micr}, phosphorescence decay curve from the times in the modulation period, $T-T_0$. A result is shown in Fig. 8, right. The method can be combined with confocal or two-photon laser scanning. Details are described in [2, 3, 4].

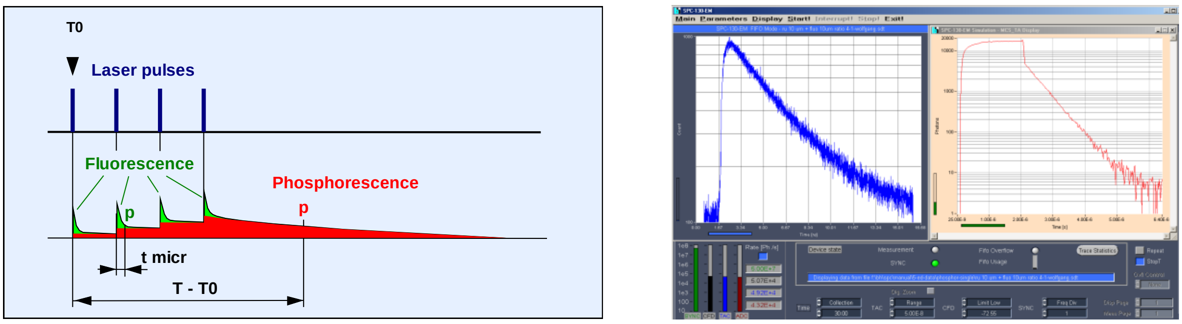


Fig. 8: Simultaneous recording of fluorescence and phosphorescence decay curves. Left: Principle. Right: Display of fluorescence (left) and phosphorescence decay (right) in SPCM software

References

1. W. Becker, Advanced time-correlated single-photon counting techniques. Springer, Berlin, Heidelberg, New York, 2005
2. W. Becker, The bh TCSPC handbook. 6th edition. Becker & Hickl GmbH (2015), www.becker-hickl.com
3. Becker, W., Su, B., Bergmann, A., Weisshart, K. & Holub, O. Simultaneous Fluorescence and Phosphorescence Lifetime Imaging. Proc. SPIE 7903, 790320 (2011)
4. Simultaneous phosphorescence and fluorescence lifetime imaging by multi-dimensional TCSPC and multi-pulse excitation. Application note, www.becker-hickl.com