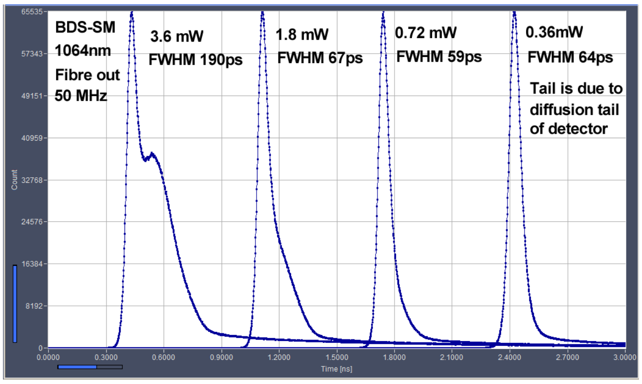
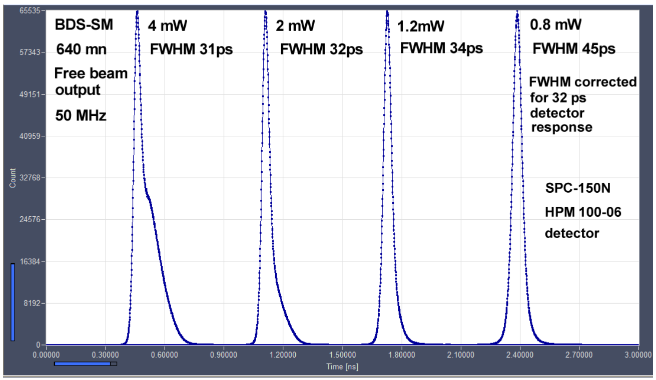
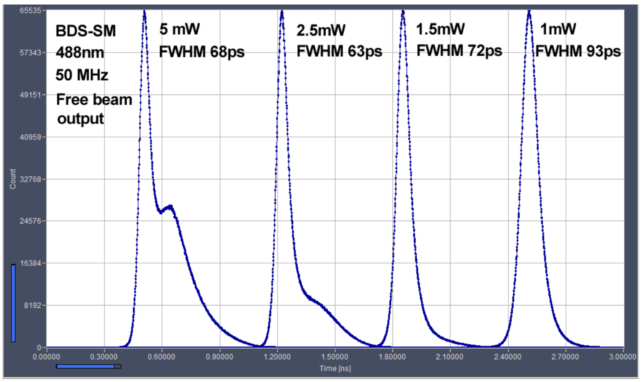
BDS-SM

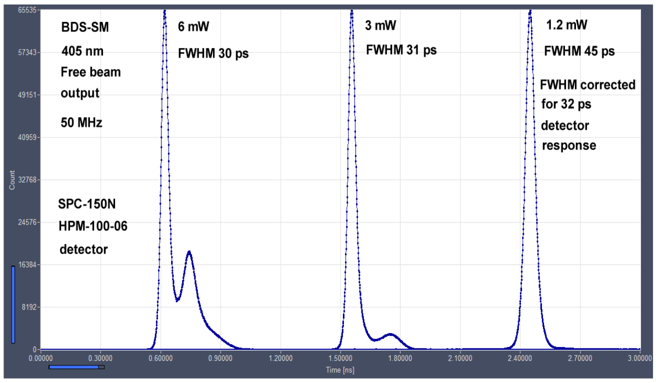
BDS-SM Family Picosecond Diode Lasers

Small-size OEM Module, 40 mm x 40 mm x 120 mm
Wavelengths 375 nm, 405 nm, 445 nm, 473 nm, 488 nm, 515 nm, 640 nm, 685 nm, 785 nm, 1064 nm
Free-beam or single-mode fibre output
Pulse width down to <40 ps
Pulse repetition rate 20 MHz, 50 MHz, and CW mode
Power in pulsed mode up to 5 mW
Power in CW mode up to 50 mW
Fast on / off / multiplexing capability
Internal power stabilisation loop
All electronics integrated
No external driver unit
Simple +12 V power supply
Compatible with all bh TCSPC devices









Pulse shapes and power levels may change due to development in laser diode technology. Coupling efficiency into single-mode fibres is 40 to 60%.

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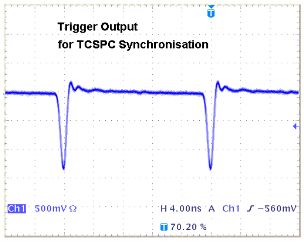
Optical

Repetition Rate, switchabel by TTL signal	20 MHz, 50 MHz and CW, other repetition rates on request
Wavelengths	375 nm, 405 nm, 445 nm, 470 nm, 485 nm, 515 nm, 640 nm, 685 nm, 785 nm, 1064 nm, other on request
Pulse width (FWHM, at medium power)	30 to 90 ps
Pulse width (FWHM, at maximum power)	60 to 300 ps
Power control range (power in free beam)	0 to 1 mW ..... 0 to 5 mW (depends on wavelength version)
Power control range (CW mode, power in free beam)	0 to 20 mW ..... 0 to 50 mW (depends on wavelength version)
Beam diameter, free beam	0.7 mm x 1.2 mm (depends on wavelength version)
Polarisation	horizontal
Coupling efficiency into single-mode fibre, typically	40% to 60 %

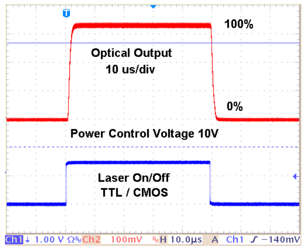


Trigger Output, to TCSPC Modules

Pulse Amplitude	-1.2 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

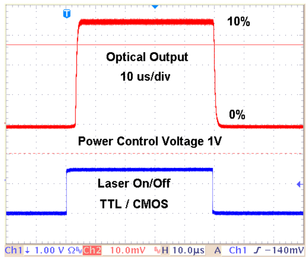
Synchronisation Input

Input amplitude	+3.3 to +5V into 50 Ω
Duty cycle	10 to 30 %. DC equivalent must be < 2.5V
Input frequency	20 to 60 MHz
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 + 10V
Response time of optical output to power control	<4 us for power 10 to 100%, see figure right
Frequency 50 MHz	active H, internal pull-up resistor
Frequency 20 MHz	active H, internal pull-down resistor
CW	active H, internal pull-down resistor
	Laser runs at 50 MHz when Frequency/CW inputs unconnected



Power Supply

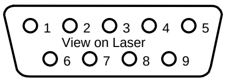
Power Supply Voltage	+ 9 V to +15 V
Power Supply Current at 12V	200 mA to 500 mA 1)

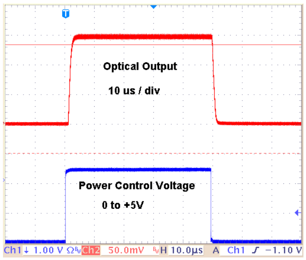
Mechanical Data

Dimensions	40 mm x 44 mm x 120 mm
Mounting holes	four holes for M3 screws
Heat sink requirements	< 2°C / W 2)

Connector Pin Assignment

Connector version	Mini Sub-D
Power supply +12V	1, 2
GND	4, 5, 9, and case
Power control voltage	8
Laser On/OFF (active H)	6
Frequency 50 MHz (active H, internal pull-up resistor)	7
Frequency 20 MHz (active H, internal pull-down resistor)	3
CW (active H, internal pull-down resistor)	9





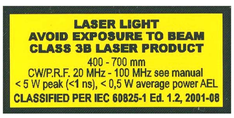
Maximum Values

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	0 °C to 40 °C 3)

1) Depends on case temperature due to laser diode cooling. Cooling current changes with case temperature
2) Laser must be mounted on heat sink. Case temperature must remain below 40°C

Related Products

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



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

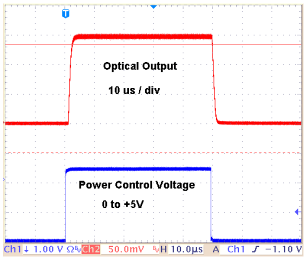
The BDS laser can be operated at two internal clock frequencies, normally 50 MHz and 20 MHz, and in the CW mode. The frequency and the mode are selected by three TTL input lines, F1, F2, and CW:

Signal	Pin at 9-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
CW	9	CW mode	active H, internal pull-down resistor

F1	F2	CW	Function
H	L	L	50 MHz
L	H	L	20 MHz
L	L	L	No output. Don't use to turn laser on/off. Use Laser ON/Off instead.
H	H	L	Both frequencies active. Don't use.
L	L	H	CW mode
not connected	not connected	not connected	50 MHz

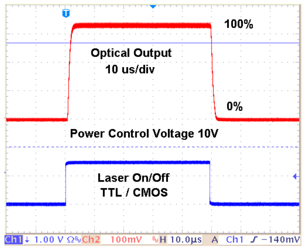
Power Control

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. 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.



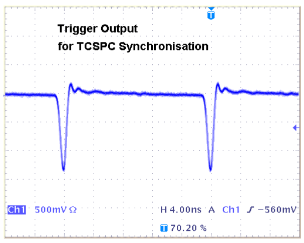
ON / OFF / Multiplexing Control

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

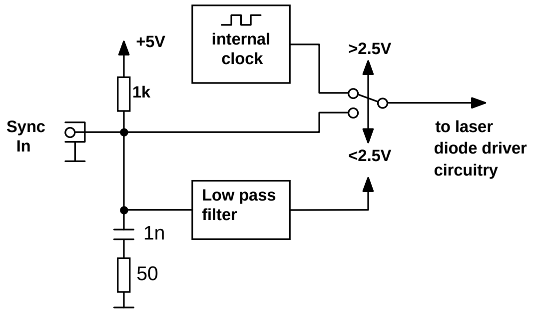
The laser delivers a synchronisation (SYNC) output for TCSPC modules. The pulse polarity is negative, the amplitude is about -1.2V. The pulse duration is about 1ns. The SYNC output is inactive when the laser is in the 'OFF' state (Laser On/Off = L). When lasers are multiplexed their SYNC Out signals 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 BDL-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.

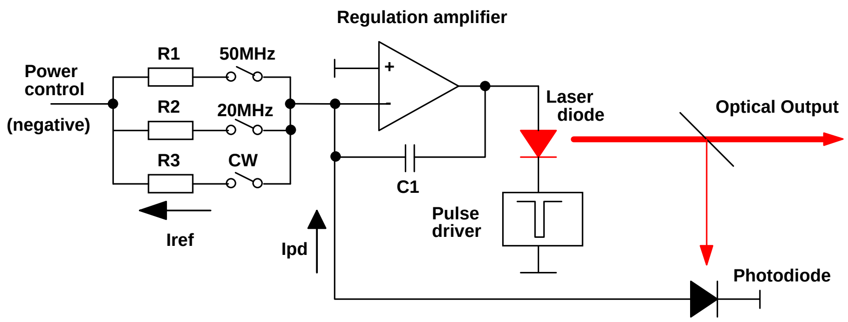


Fig. 2: Principle of power regulation loop

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 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.

Operation of the BDS Laser with the LSB Laser Switch Box

For stand-alone use the BDS laser modules come with the LSB Laser switch box and a AC/DC +12 V power adapter. The box contains the key switch and the emission indicator that it is mandatory for class 3b laser products, see Fig. 3, left.

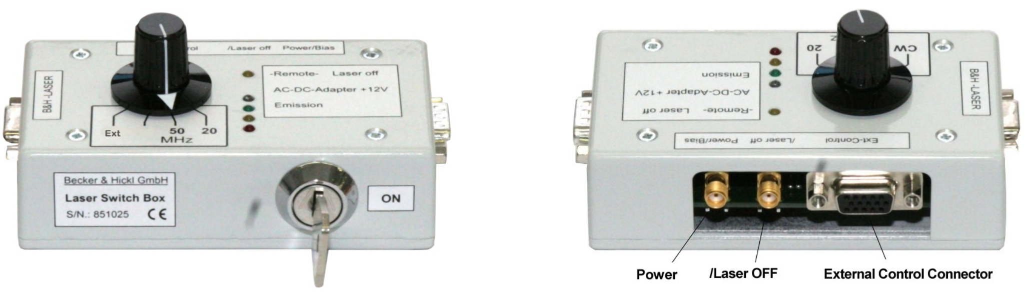


Fig. 3: LSB laser Switch box for operating the BDS lasers as a stand-alone device

The repetition rate can be changed by a switch. The 'Power' control signal and a Laser 'On/Off' signal can be connected to the box via SMA connectors. The control signals can also be fed into a 15-pin sub-D connector, see Fig. 3, right. The pin assignment of this connector is

1	not connected	9	not connected
2	Frequency 20 MHz*	10	not connected
3	Frequency 50 MHz*	11	not connected
4	not connected	12	Power, 0 to +10 V, parallel to SMA connector
5	GND	13	not connected
6	not connected	14	not connected
7	On/Off, parallel to SMA connector	15	GND
8	not connected		

* Put frequency switch in 'EXT' position to use the F1 and F2 inputs

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. 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.

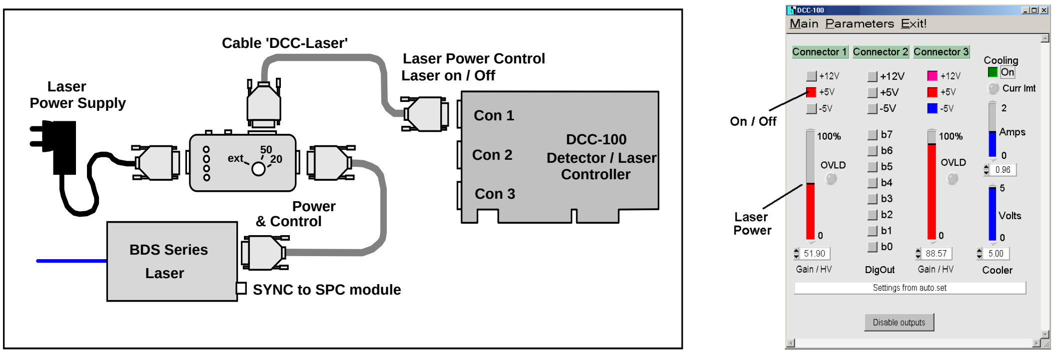


Fig. 4: Controlling the BDL-SMN from a DCC Detector / Laser Controller card

Simple Fluorescence-Decay Experiment

The setup shown in Fig. 5 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. 5, right.

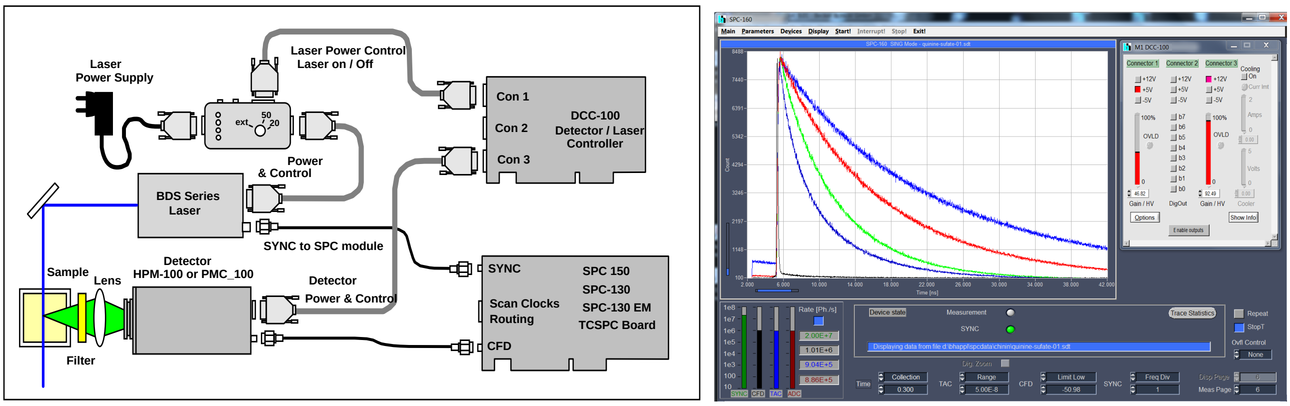


Fig. 5: Simple fluorescence-lifetime experiment. Left: System setup. Right: SPCM panel.

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. 6. 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.

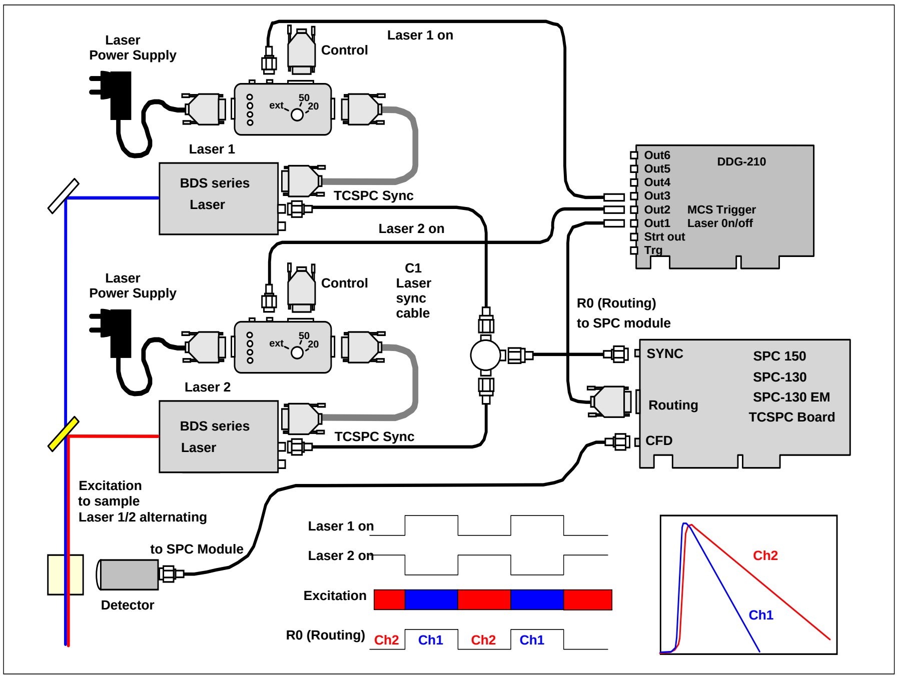


Fig. 6: Laser multiplexing. The lasers are switched on/off alternatingly, the photons excited by different lasers are stored in separate TCSPC memory channels

Combined Fluorescence / Phosphorescence Lifetime Detection System

The system shown in Fig. 6 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. 7, 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, $T\text{-}T_0$. A result is shown in Fig. 7, right. The method can be combined with confocal or two-photon laser scanning. Details are described in [2, 3, 4].

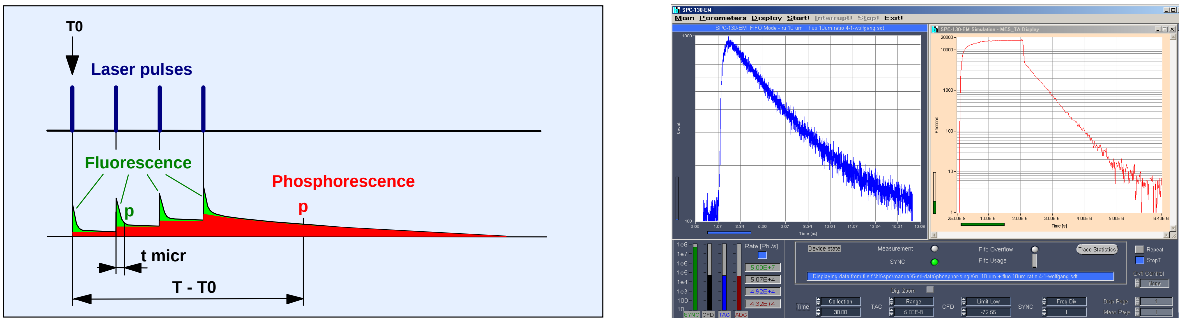


Fig. 7: Simultaneous recording of fluorescence and phosphorescence decay curves. Left: Principle. Right: Display of fluorescence (left) and phosphorescence decay (right) in SPCM software

Stage-Scanning FLIM System with the BDS-SM Laser

The optical principle of a simple FLIM system with a BDS-SM laser and a piezo scan stage is shown in Fig. 8, left. A BDS series ps diode laser is coupled into the system via a single-mode fibre. A Qioptics fibre collimator is used to obtain a collimated beam out of the fibre. The beam is reflected down into the microscope beam path by a dichroic mirror. A lens focuses the laser into the upper image plane of the microscope. The laser thus forms a focused spot in the sample. The fluorescence light from the sample is collected back through the microscope lens, collimated by the lens, and separated from the laser beam by the dichroic mirror. A bandpass or longpass filter in the collimated beam selects the detection wavelength range. The light passing the filter is focused into a multi-mode fibre by a second lens, and transferred to an id-100-50 SPAD detector. The electrical connections are shown in Fig. 8, right. The scanner is controlled via a bh GVD-120 scanner control card, the FLIM data are recorded by an SPC-150, SPC-160, or SPC-830 TCSPC / FLIM module. Please see [5, 6] for details.

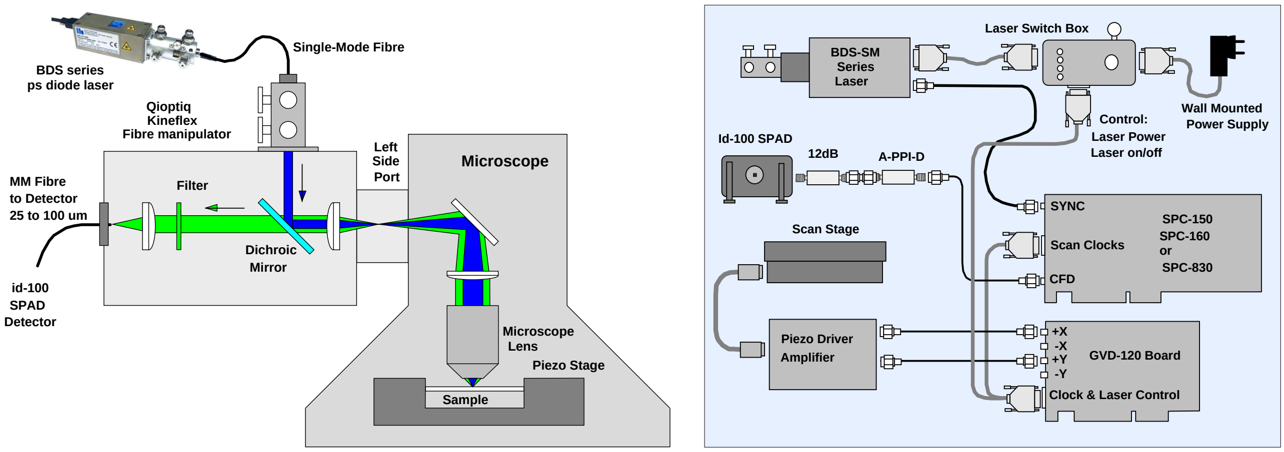


Fig. 8: Stage-scanning FLIM System with BDS-MM laser. Left: Optical principle. Right: System connections

Fig. 9, left, shows a FLIM image recorded by this setup. Decay curves in selected pixels are shown in Fig. 9, right.

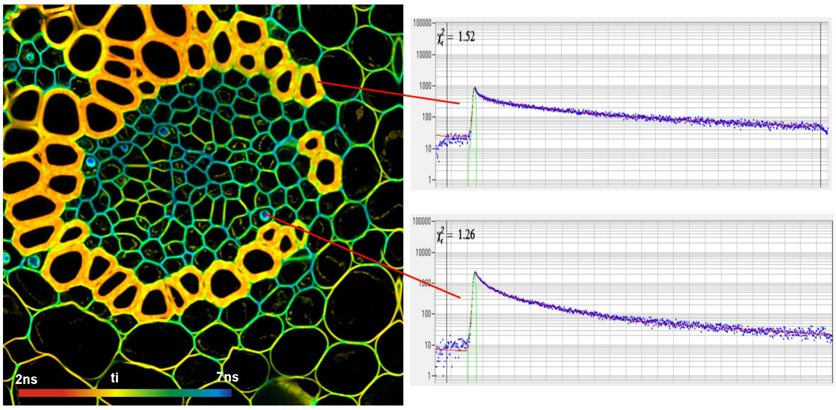


Fig. 9: FLIM of a Convallaria smple. 512x512 pixels, 1024 time channels per pixel. Decay curves in selected pixels shown right.

References

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