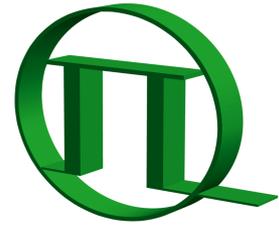


Dual Channel SPAD Detection Unit



External Detection Unit for Laser
Scanning Microscopes

PICOQUANT



User's Hardware Manual and Technical Data

Version 2.1

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Safety Instructions



LASER Warning!

Laser light of class 3B lasers may be delivered via the multimode fiber into the Dual Channel SPAD Detection Unit. Therefore, the multimode fiber must not be removed from the detection unit. Do not remove any items inside the unit. The installation room of the LSM Upgrade kit to be labeled as laser area. For class 3B lasers, a laser safety officer has to be announced to meet the laser safety regulations.



The LSM upgrade kit is fitted with one or more diode lasers. To avoid hazardous radiation exposure you should carefully obey the safety instructions that are provided with your PDL 800-B or PDL 808 „Sepia“ diode laser operation manual. If your instrument uses another excitation system, follow the safety instructions of the relevant manual.

The delivered instruments are pre-set by PicoQuant to operate on the power outlet line voltage for the country of delivery. Nevertheless, please check that the actual line voltage corresponds to the value set on these instruments!

Never connect or disconnect any cable while the data acquisition and control electronics are ON. Charged signal cables can destroy the devices!

Protect the photon detectors (SPAD or PMT) as much as possible, particularly from excessive light intensities, e.g. microscope illumination lamp, unattenuated backscattered excitation, etc. In case of operation with the DSN 102, the SPAD detector(s) must be switched off using the DSN 102 power supply unit before switching off the system by the main power button.

1. Introduction

This manual describes the basic components of the dual channel SPAD detection unit, as well as operation, maintenance and adjustment of the detectors .

The Dual Channel Detection Unit is an external detection unit for standard confocal laser scanning microscopes (LSMs). The detection unit is connected to the exit port of the LSM via a multi-mode fiber. Two single photon avalanche diodes (SPAD) as detectors allow time-resolved measurements on two different channels simultaneously. These features cannot only be used in FLIM applications, but also allow a broader range of FCS measurements. Possible applications are:

- FLIM measurements with single molecule sensitivity
- FLIM and FRET-FLIM measurements with 2 spectrally separated detectors
- FCS measurements, auto - and cross-correlation
- Single molecule FRET - measurements

Look at PicoQuant's website to download Technotes regarding different techniques and your LSM manual for instruction on how to perform different measurements on your confocal.

Depending on the application, the unit can be equipped with two types of detectors. PicoQuant's τ -SPAD has a high sensitivity, especially in the spectral region above 600 nm, while the PDM Series by MPD have a significantly better time resolution, making them superior in FLIM-applications.

The dual channel detection unit needs to be completed with two parts of controlling electronics:

- The DSN102 module, a stand-alone device, provides the power supply of the detectors, but also protects the SPADs against dangerous levels of illumination. Furthermore the device is equipped with a count rate meter.
- The detected photons from the detectors have to be fed into a router (PHR403 E), which allows correct assignment of the different photons to the detectors.

See the corresponding manuals for further information.



All abbreviations are explained at the end of the manual.

2. Physical Properties and Installation Requirements

Size [cm] (Width × Depth × Height)	25 × 51 × 26
Weight [kg]	23 kg
Operation Voltage	115V - 230 V AC
Fiber connector	FC-APC
room requirements	clean and dry
Temperature variation	should be kept within 1°C, otherwise deadadjustment of the microscope optics cannot be excluded

3. Detector Types

τ-SPAD Single Photon Avalanche Diode from PicoQuant

- Suitable for the **wavelength range** from **400 nm to 1100 nm**
- Provides high **detection efficiency** (typical 45% at 470 nm and 75% at 670 nm)
- Small **photosensitive area** with **0.15 mm** diameter
- **Dark count rate < 100 cps**
- **TTL and NIM signal** output
- **Instrument response function between 350 and 800 ps FWHM** dependent on module, wavelength and signal rate
- Built-in **thermoelectrical cooler** with controller, signal amplifier and discriminator
- Power supplied by the PicoQuant **DSN 102** module



Fig. 3.1: PicoQuant τ-SPAD SPAD module

PDM Series Single Photon Avalanche Diode (MPD SPAD)

- Highest **sensitivity** of **45 %** at 530 nm
- The **active area** in a module mounted into the two channel detection unit has **100 μm diameter**.
- The **dark count rate** of such a module in its cooled version is **<250 cps**.
- **Instrument response function** accounts to **50 ps FWHM**, so that an overall instrument response function below 150 ps can be obtained using a PicoHarp 300 TCSPC device together with a pulsed diode laser.
- **Instrument response function** does **not shift** with high count rates, so that lifetime measurements can be reliably performed with count rates up to 1 Mhz.
- The PDM series has a **TTL and a NIM output**. The NIM output has a better timing response and is used in conjunction with the PicoHarp 300 device, while the TTR output is used for feeding the DSN102 for count rate display



Fig. 3.2: PDM series single photon counting avalanche diode

4. Set up of the Dual Channel Detection Unit

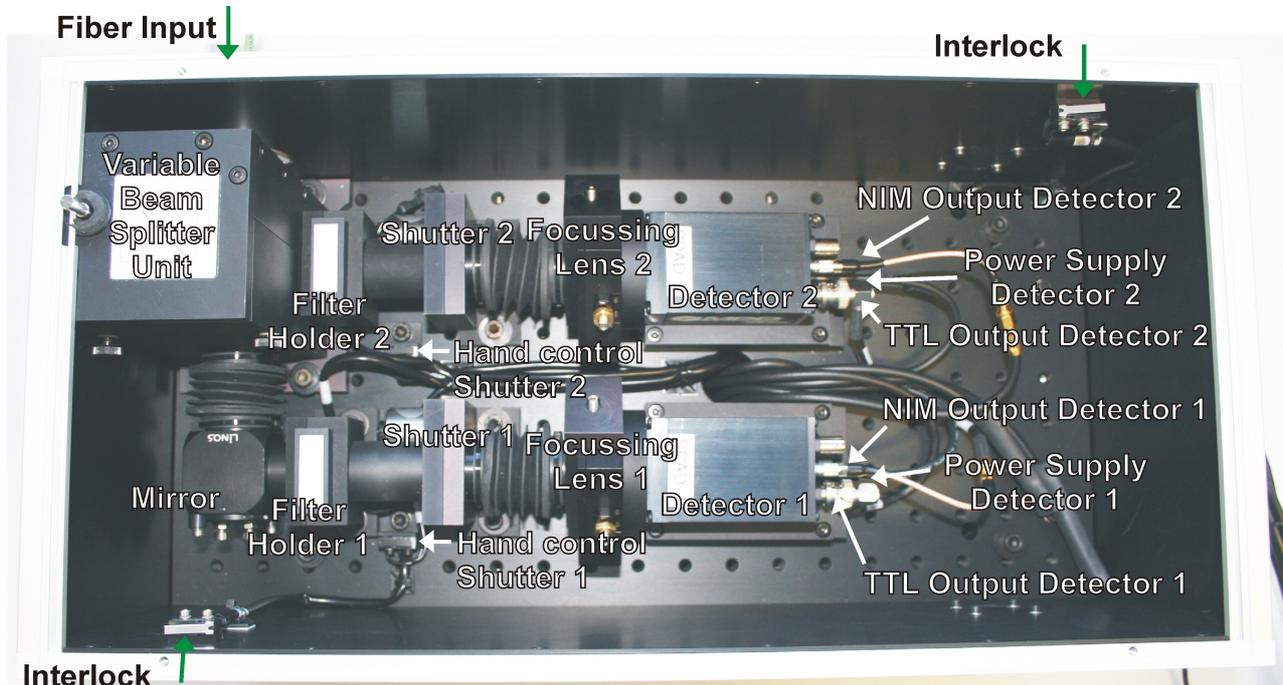


Fig. 4.1: Dual Channel SPAD detection unit

- Shutters **close automatically** when the cover is removed.
- Each **shutter** can be **manually opened** by pressing the respective hand control (see adjustment section).
- In front of each SPAD, a **filter** can be placed into the filter holder (25 mm diameter).
- The **beam splitter unit** has three positions as shown in Fig. 4.2:
 1. **Position 1** contains by default a **100 % mirror** and directs all light on detector 2.
 2. **Position 2** contains by default a **50 % beam splitter plate**, which distributes the light onto both detectors.
 3. **Position 3** is **empty**, and all light is directed onto detector 1.
- **Special configurations** of your system are described in the Appendix of your LSM upgrade manual.
- In position 1 and 2 of the variable beam splitter unit, **standard Olympus filter cubes** (U-MF2 or U-MBF3 type) fit. Replacement is easy, just open the cover and loose the screw indicated by a yellow arrow in Fig. 4.2 to slide a beam splitter cube out. After replacement, detector SPAD 2 may have to be adjusted again (See adjustment section of this manual).

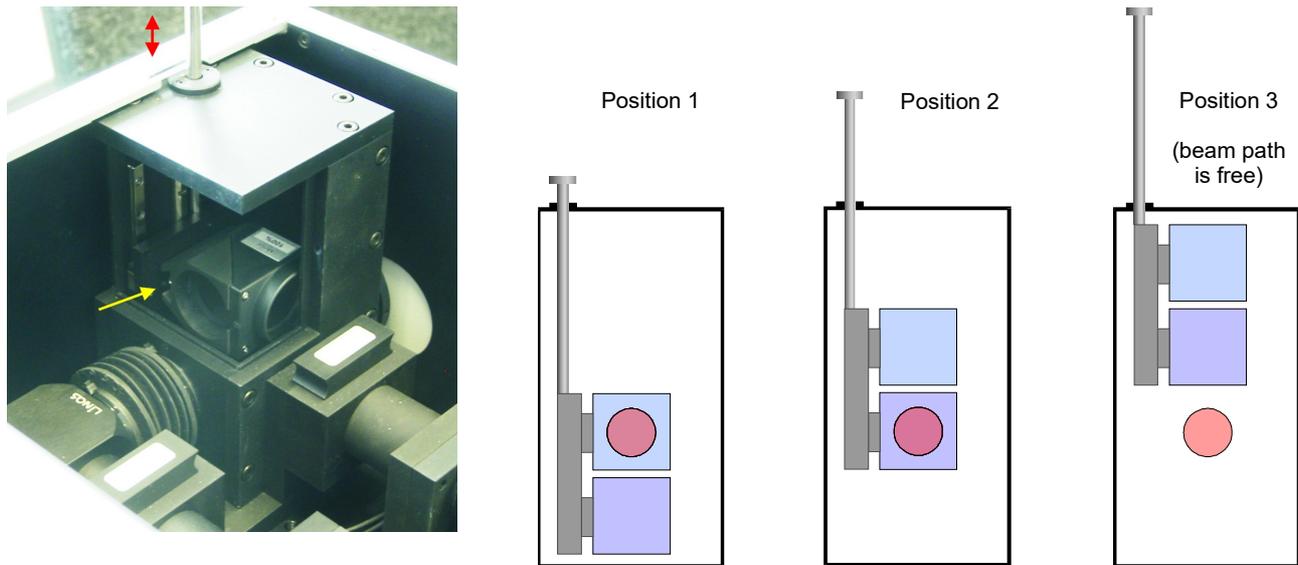


Fig. 4.2: Sketch of the variable beam splitter unit. Left: Removal of a beam splitter cube is performed by removing the cover, lifting the lever indicated by the red arrow, untighten the screw indicated by the yellow arrow and sliding the cube out. Right: The three positions that can be adapted by the variable beam splitter cube. The illumination height is indicated by the red circle.

- The **Power Supply** of the detectors is provided by a **DSN 102** module (Fig. 4.3). The **TTL output** of the detectors has to be connected with the DSN 102. The complete cable scheme of your setup is part of the Appendix to your system.
- - ➔ The DSN can control and monitor **two SPAD detectors** at the same time, displaying the count rate of one selected module.
 - ➔ Power connectors are provided for τ -SPAD and MPD module types. Contact PicoQuant, if you want to change the detector type in your system.
 - ➔ Because excessive light exposure will damage the SPAD module, we have equipped the DSN with an **automatic protection circuitry**. The built-in logic protects the SPAD modules by shutting down the supply voltage when the signal count rate exceeds 8 000 000 cps. Shutting down a SPAD module will be signalled with a warning beep and a message *Err* will appear on the display. The affected detector must then be powered up again manually.
- ⚠ This protection has an approximately 1 second latency and is meant as a last rescue only. Protect the detector against over-illumination as much as possible.
- ⚠ Do not turn off the main power before switching off the SPADs via the DSN.
- ⚠ The SPAD modules must be connected **before** you switch on the system.
- At the DSN 102 (optional) select the appropriate input **resistance** (impedance) for the signal input with the input termination switch. Choose **1 MOhm** if the **signal is fed through** this device to another device with an appropriate 50 Ohm termination. **Choose 50 Ohm** termination only if there is **no termination** in the subsequent signal chain, for example when no cables are connected to *TTL OUT* sockets as shown(Fig. 4.3).



Fig. 4.3: DSN 102 dual SPAD power supply (optional)

- The detector signals are guided to a **router module (e.g. PHR 800)** or to a **HydraHarp TCSPC** unit.
- The **router unit** permits up to **four SPAD detectors** to operate quasi in parallel on the PicoHarp 300 unit. Its role is to feed the detectors' signals into the single start input of the TCSPC device, simultaneously generating routing information (i.e. detector number) for each photon event
- In order to perform fluorescence lifetime imaging, the **spatial origin** of the photons must be recovered as well. The TTTR file generated by the PicoHarp or HydraHarp contain **markers**, e.g. synchronization information derived from the scan-controller. This makes it possible to reconstruct the 2D image from the stream of TTTR records, since the relevant XY-position of the scanner can be determined during the data analysis
- Since **all three markers are already used** for the scanner synchronization, no additional markers are free to be used for customs purposes

5. Operation

5.1. Switching Your Dual Channel Detection Unit On

1. Make sure that all **cables** are **connected correctly** according to the label scheme in the appendix.
2. Make sure that the **correct filters** are in the corresponding filter holders.
3. Make sure that the **correct dichroic** is placed into the variable beam splitter unit.
4. **Close** the **top** of the dual channel detection unit.
5. Set the **variable dichroic holder** into the correct position.
6. **switch all components** of the system **on** (we recommend powering all devices by one central power switch).
7. **switch the detectors on**, make sure that the count rate of both detectors is sufficiently low.
8. Using your LSM, **place** your **sample** into the focus and **take an image** with correct filter settings using internal LSM detectors.

9. Guide the **detection light** into the **fiber exit port** of the LSM.
10. Now the system is ready to take FLIM images or to make point measurements. For detailed description about how to perform individual measurements, follow the instructions in the LSM manual.

5.2. Switching Off Your System

1. Turn off **both detectors** on the DSN102 **first**
2. Turn off all other equipment, which is not further needed

5.3. Checking Instrument Performance

1. To check the general performance, **acquire images** with the **normal LSM detectors** and afterwards with the **PicoQuant detectors**. Thus a drop in performance can be easily recognized. In the following description we assume that LSM images using the standard LSM can be obtained without problems, using reasonable settings
2. A good way to check the performance of the detection unit is the **acquisition of FCS-traces** of a nano-Molar dye solution with a dye that can be effectively excited (see LSM manual). Acquire such traces with a standard solution from time to time using always the same settings (laser intensity, filters, pinhole size, objective, and the distance from the focus and the cover slide). If you are using a water objective, make sure the the cover slide correction ring is always at the same position. The count rate should not exceed 500 kHz, as the detector response becomes non linear at higher count rates. For FCS measurements, also cw lasers from your LSM can be used. If the laser power needs to be increased significantly in order to reach the same intensity values on the objective, the fiber coupling unit (FCU) must be optimized (see FCU manual).
3. Calculate the **molecular brightness** of your dye by dividing the count rate of your detector by the number of molecules in the focus provided by FCS fitting (see SymPhoTime manual). Suited dyes for different wavelengths are: ATTO655 for 635 nm, Rhodamine 6G for 532 nm or Fluorescein (in a solution with high pH) for 470 nm excitation. The molecular brightness is not too sensitive to concentration changes. In general, a nM solution should be used. A more detailed description for acquiring FCS measurements is given in the LSM manual. If the molecular brightness has dropped significantly, the detector needs to be adjusted.
4. If a performance drop is noticed, first the **origin** of the **performance drop** needs so be found. To make sure that the sensitivity drop is due to detector misalignment, measure the **laser intensity** on top of the objective with a power meter. If the laser power is comparable to earlier measurements, place a test solution onto the objective and monitor the **count rate** in the time trace tab of the oscilloscope of the SymPhoTime software. **Switch** the **light** between two detectors using the variable beam splitter unit (Position 1, equipped with a 100% mirror and position 3, free). If both detectors exhibit very different intensities, the detector showing the lower intensity needs to be adjusted (see following section for detector adjustment)
5. If **both detectors** show a significant **intensity drop**, adjust 1 detector to see whether the count rate increases. If the performance of the detectors cannot be increased, misalignment is already in the LSM. Make sure that all filters and beam splitters are build in and set correctly, and contact your LSM representative or PicoQuant

5.4. Detector Unit Adjustment

5.4.1. Standard Alignment Procedure

1. Place an **empty cover slide** on the microscope stage
2. Place a **OD3 light attenuator** at the filter holder in front of the misaligned SPAD detector. The filter is placed into the filter holder 1 or 2 for the respective detectors as shown in Fig. 4.1.
3. **Switch** the corresponding **pulsed laser on and lift the lever at the FCU to direct pulsed laser light through the objective** (see FCU manual).
4. Select the settings in the LSM in a way, that the **back reflection** of the cover slide can be **monitored** by the LSM detectors (e.g. if a 470 nm laser diode is used for the adjustment, select the appropriate beamsplitter and an emission filter that is transmitting at 470 nm). Find the right axial position of the objective which gives the maximum intensity of the scanned image. Now guide the reflected light to the fiber exit port where the detection unit is attached.
5. Activate the **oscilloscope window** in the SymPhoTime software () and select the Time Trace - tab with settings shown in Fig. 5.1. Important is the setting of a **linear count axis**.

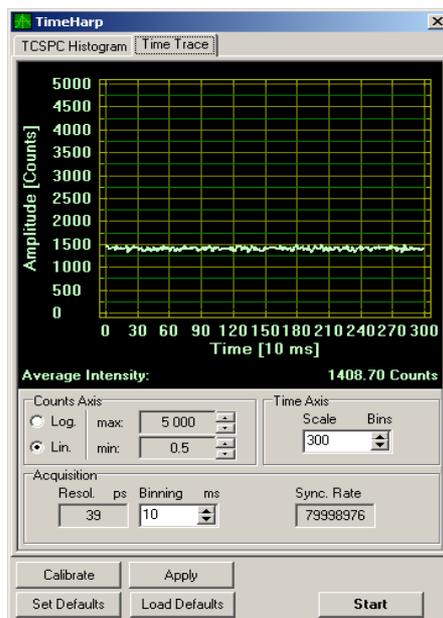


Fig. 5.1: The Time Trace tab from the Oscilloscope window

6. Start the Oscilloscope measurement by clicking the Start - icon. The Amplitude axis can be adapted by scrolling with the mouse wheel button while the arrow is placed over the window.
7. **Remove** the **lid** from the Dual Channel SPAD Detection Unit. There's an automatic interlock that closes the shutters in front of the detectors upon removing the lid. For adjustment, the lid has to be open, but the shutter in front of the detector to be adjusted must be opened as well. The **shutter** of this detector can be **opened** by pushing the **manual shutter control** levers indicated in Fig. 5.2. Every shutter control switch controls the shutter of just the detector next to it, the shutter in front of the other detector remains closed. During the alignment procedure the switch has to be pressed the whole time

- ⚠ Make sure that a pulsed laser is switched on and the corresponding repetition rate (sync rate) can be observed in the sync rate window
- ⚠ Do not remove any filter from a dual channel detection unit while the manual shutter control is pressed.

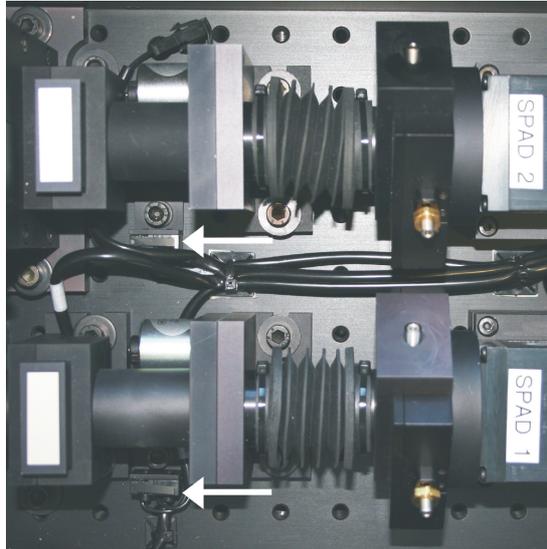


Fig. 5.2: Manual shutter control in the Dual SPAD Channel Detection unit

8. Adjust the laser settings and the axial position of the objective on the microscope until you detect a reasonable count rate (e.g. 50000 cps)
9. **Shift the focussing lens** in front of the detector by turning the **adjustment screws** indicated by the white arrows in Fig. 5.3. Turning one screw moves the lens in one single direction. In the oscilloscope window, the count rate should directly react to the lens movement.

If you shift the lens back and forth around the optimal position with one screw, the time trace should show a distinct **maximum**.

In the case of the τ -SPAD adjustment, this is a relative flat, high intensity plateau with steep edges, where the intensity drops to the background count rate (Fig. 5.4), whereas the plateau is less pronounced for a MPD detector.

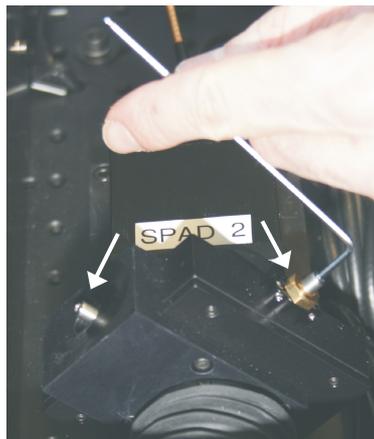


Fig. 5.3: Adjustment Screws for the focussing lens in front of the SPAD detector. Use the allen key size 2 mm (part of the toolbox) for detector lens adjustment.

10. The adjustment for a MPD SPAD is finished, when the lens is directed to the **center** of the **plateau**, indicating maximum count rate

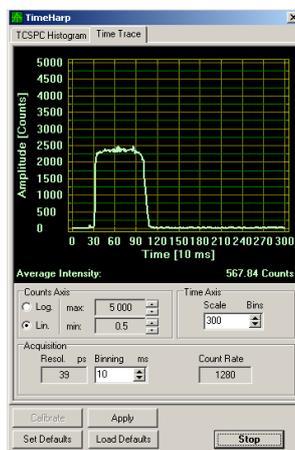


Fig. 5.4: Response of a τ -SPAD detector upon scanning a fluorescence beam over the detection area by moving the focussing lens.

11. For an τ -SPAD SPAD detector from PicoQuant however, the maximum signal rate is only one of the criteria to optimize the lens position. In a second step you have to position the focus close to the center of the active area of the SPAD to ensure the narrowest IRF (i.e. the best time resolution) of the detector. Switch to TCSPC histogramming mode (by selecting the *TCSPC Histogram* tab) to constantly monitor the width and the time-position of the detector's IRF, next to the average signal count rate. Fine tune now the position of the focus on the active area by moving the focussing lens again, and watch the width of IRF. As a rule of thumb, try to move the IRF to its leftmost position.

For PicoQuant τ -SPAD modules, this position corresponds directly to the shortest IRF (Fig. 5.5). For MPD modules, this alignment step is not necessary.



In case of multiple detection channels, the time trace in the *TimeHarp (PicoHarp)* window shows the summed count rate of all open detector channels. Similarly, the on-line TCSPC histogram is built from the summed photon events. Selective monitoring of a detection channel of interest is possible by opening or closing the appropriate shutters.

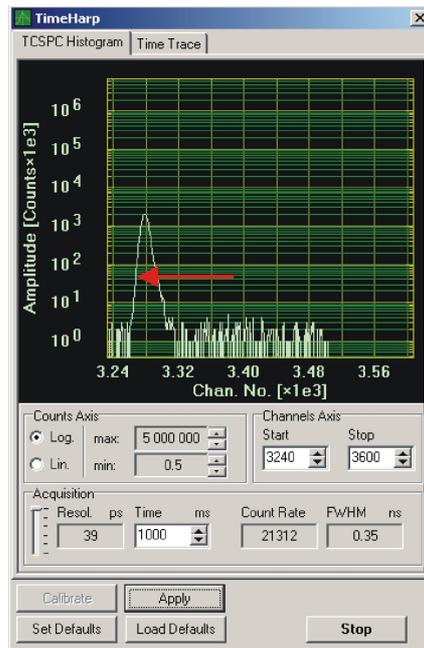


Fig. 5.5: IRF of a PicoQuant τ -SPAD module in the oscilloscope window. The shortest IRF is obtained when the pulse peak is shifted maximally to the left. The width of the IRF is given by the FWHM value

10. When finished, lower the objective, remove the test sample. The system is now **ready** to perform measurements.

5.4.2. Fundamental Alignment of the Dual Channel SPAD Detection Unit

If adjustment of the focussing lens does not lead to a satisfactory result, a fundamental alignment is necessary.

Switch all SPAD detectors off before performing the alignment steps!



LASER Warning!

Laser light of class 3B lasers may be delivered via the multimode fiber into the Dual Channel SPAD Detection Unit. Therefore, the multimode fiber must not be removed from the detection unit. As during the alignment, items within the Dual Channel Detection Unit will have to be removed, follow the laser safety rules for treating open laser beams. Do not look into the beam. Do not insert reflecting items (e.g. mirrors, rings) into the beam.



Generally, this alignment procedure should be a rare event. During the installation of the system by PicoQuant, the optics is aligned and then remains stable for a long time. Re-alignment is necessary when the LSM Upgrade Kit detector unit is disassembled, or when its optical design is changed. Carrying out such a procedure requires considerable experience. Before proceeding with the alignment, make sure that the problem is not in the excitation path and that the alignment cannot be done with the ordinary procedure.

Proceed the following steps:

1. Prepare the **alignment tool** (Fig. 5.6) delivered with the instrument.



Fig. 5.6: Alignment tool for detector unit alignment

2. Detach the four screws at the corners of the **cover** and **remove** it. Make sure that the **detectors** are **switched off**. Still, the power supply for the shutters should be present.
3. Use a **back reflection** of a **mirror** or the lower side of the sample holder plate. Increase the **laser power** of all lasers to the **maximum**.
4. **Remove** the **tubing** between the focussing lens and the shutter of detector 2 (Fig. 5.7). The tubing is screwed into the focussing lens holder, the direction to unscrew the tubing is indicated by the green arrow. Also, remove any filter from the filter holder, put an empty filter holder in and put the variable beam splitter unit to position 1 (lowest, Fig. 4.2). In this position, all the light should be directed to detector 2. Make sure that in position 1 of the variable beam splitter unit a 100 % mirror is placed (compare Fig. 4.2).

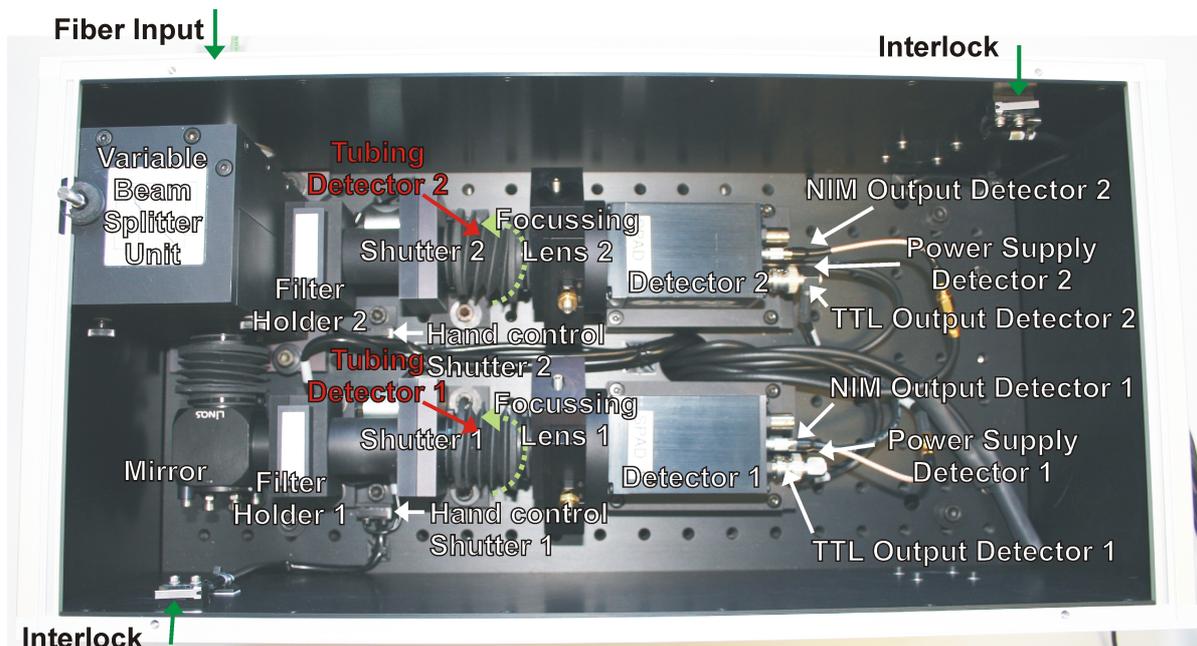


Fig. 5.7: Dual Channel SPAD detection unit with relevant parts for alignment

5. Place the adjustment plate (Fig. 5.6) before the detector as shown in Fig. 5.8. In case of correct adjustment, the beam is placed at the center of the adjustment plate, when shutter 2 is opened by pressing the “Hand Control Shutter 2” (Fig. 5.7, Fig. 5.8). Otherwise the beam needs to be directed to the center of the adjustment plate by adjusting the screws at the fiber coupler (Fig. 5.9). Therefore, adjust the beam with the screws indicated in red in Fig. 5.9; if necessary, loose the counter screws indicated in yellow in Fig. 5.9. The counter screws must be tightened after alignment.

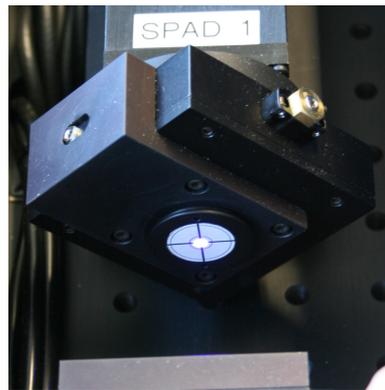


Fig. 5.8: SPAD with removed tubing and attached beam alignment tool



Fig. 5.9: Fiber Outcoupling Unit at the dual detector unit. the adjustment screws are marked in red, the counter screws are marked in yellow.

6. When the beam is correctly aligned, check detector one in an analogous way: Check that the SPADs are powered off. Remove the filter in front of detector 1 and replace it with an empty one, set the "Variable Beam Splitter Unit" to the upmost position 3 (Fig. 4.2). Remove the tubing from detector 1, place the beam alignment tool in front of detector 1 and open the shutter by pressing the corresponding hand switch. The light is then completely directed to detector 1.
7. For adjustment of detector 1, the mirror at the left bottom of Fig. 5.7 is adjusted with the screws shown in Fig. 5.10. Adjust the screws to hit the center of the alignment cap with the laser beam. After alignment fasten the counter screws on the mirror mount.

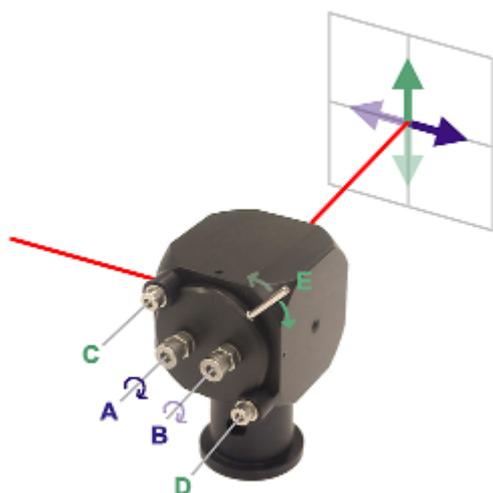


Fig. 5.10: Handling of the light-tight mirror holders

Note that directions left, right, up and down, used in the following text, correspond only to the depicted situation.

Unlock the nuts of screws A and B for horizontal tilting. To tilt the beam to the right side, first loosen B, then screw in A until you reach the desired angle, then tighten screw B. To tilt the beam to the left side, first loosen A, then screw in B until you reach the desired angle, then tighten screw A. Finally, lock both A and B screws with their nuts.

For vertical tilting, loosen screws C and D until you can rotate the mirror holder with the lever E. Clockwise rotation tilts the beam up, counter-clockwise tilts down. Finally tighten screws C and D to lock the position.

8. When both beams are aligned, insert the tubing again and set the relevant filters. Finally, the lens position needs to be optimized using a scattering or reflecting test sample as described in the standard alignment procedure.

6. Recommended Literature

Publications related to the LSM Upgrade Kit hardware, software, and underlying key technologies:

Wahl M., Koberling F., Patting M., Rahn H., Erdmann R.: *Time-resolved confocal fluorescence imaging and spectroscopy system with single molecule sensitivity and sub-micrometer resolution*. Current Pharmaceutical Biotechnology, Vol.05, p.299-308 (2004)

Koberling F., Wahl M., Patting M., Rahn H.-J., Kapusta P., Erdmann R.: *Two-channel fluorescence lifetime microscope with two colour laser excitation, single-molecule sensitivity, and submicrometer resolution*. Proceedings of SPIE, Vol.5143, p.181-192 (2003)

Ortmann U., Dertinger T., Wahl M., Rahn H., Patting M., Erdmann R.: *Compact TCSPC upgrade package for laser scanning microscopes based on 375 to 470 nm picosecond diode lasers* Proceedings of SPIE, Vol.5325, p.179 (2004)

Benda A., Hof. M., Wahl M., Patting M., Erdmann R., Kapusta P.: *TCSPC upgrade of a confocal FCS microscope*. Review of Scientific Instruments, Vol.76, 033106 (2005)

The following application and technical notes are available from PicoQuant upon request:

Koberling F., Schuler B.: *FRET analysis of freely diffusing molecules using the MicroTime 200*

Krämer B., Koberling F.: *Lifetime based hydrophobicity analysis of hepatocytes using the MicroTime 200*

Krämer B., Koberling F., Tannert A., Korte T., Hermann A.: *Lifetime based analysis of lipid organization in hepatocytes using the MicroTime 200*

Ortmann U., Dertinger T., Wahl M., Bülter A., Erdmann R., Kahl H.: *Compact FLIM and FCS upgrade kit for Olympus FV 300 and FV 1000 laser scanning microscopes*

Wahl M.: *Time-correlated single photon counting in fluorescence lifetime analysis*

Wahl M.: *Time tagged time resolved fluorescence data collection*

Numerous measurement examples are published on the PicoQuant website. Please visit the LSM Upgrade Kit section of http://www.picoquant.com/_systems.htm.

This manual frequently refers to information in additional PicoQuant manuals, which also belong to the LSM Upgrade Kit documentation:

- LSM Upgrade Kit Manual
- FCU Manual
- PDL 800-B – User's Manual
- PDL 808 "Sepia" – User's Manual
- TimeHarp 200 – User's Manual and Technical Data (this manual also contains an introduction into Time Correlated Single Photon Counting)
- PicoHarp 300 – User's Manual and Technical Data (this manual also contains an introduction into Time Correlated Single Photon Counting)
- SymPhoTime – User's Manual and Technical Data

7. Useful WWW Resources

Optical filter manufacturers:

- <http://www.chroma.com>
- <http://www.omegafilters.com>
- <http://www.semrock.com>
- <http://www.lambda.cc>

Fluorescence dyes, probes and labels:

- <http://www.probes.com> (Alexa dyes)
- <http://www.amershambiosciences.com> (Cy dyes)
- <http://www.exciton.com>
- <http://www.eurogentec.com>
- <http://www.sigmaaldrich.com>
- <http://www.atto-tec.com> (Atto-dyes)
- <http://www.dyomics.com> (DY-dyes)

8. Abbreviations

BNC	British Naval Connector or Bayonet Nut Connector or Bayonet Neill Concelman
CCD	Charge-Coupled Device
CFD	Constant Fraction Discriminator
cps	Counts per Second
cw	Continuous wave (not pulsed)
FCS	Fluorescence Correlation Spectroscopy
FCU	Fiber Coupling Unit
FIFO	First In, First Out (buffer type)
FLIM	Fluorescence Lifetime Imaging
FRET	Förster Resonance Energy Transfer
FWHM	Full-Width at Half-Maximum
IO	Input-Output
IRF	Instrument Response Function
LED	Light Emitting Diode
LSM	Laser Scanning Microscope
MCS	Multichannel Scaling
OD	Optical Density
PC	Personal Computer
PCI	Peripheral Component Interface
PIE	Pulsed Interleaved Excitation
PMT	Photomultiplier Tube
RGB	Red-Green-Blue (colour scheme)
ROI	Region of Interest
SMA	SubMiniature version A (connector type)
SMD	Single Molecule Detection
SPAD	Single Photon Avalanche Diode
SYNC	Synchronization (signal)
TCSPC	Time-Correlated Single Photon Counting
TTL	Transistor-Transistor Logic
TTTR	Time-Tagged Time-Resolved

9. Support

If you observe any errors or bugs, please try to find a reproducible error situation. E-mail a detailed description of the problem and relevant circumstances to info@picoquant.com. Your feedback will help us to improve the product and documentation.

In any case, we would like to offer you our complete support. Please do not hesitate to contact PicoQuant if you would like to have assistance with your system.

Of course, we also appreciate good news: If you have obtained exciting results with the LSM Upgrade Kit or published scientific papers, we would also like to know! Please send us an e-mail to info@picoquant.com containing the appropriate citation. Gain additional publicity! PicoQuant maintains a database of publications mentioning PicoQuant devices and/or written by us. It can be found at our website at http://www.picoquant.com/_scientific.htm. It is a valuable source if you want to know which laboratories are using PicoQuant products or how broad the field of various applications is.

Thank you very much in advance for your kind cooperation!

All information given here is reliable to the best of our knowledge. However, no responsibility is assumed for possible inaccuracies or omissions. Specifications and external appearance are subject to change without notice.

<p>Retraction of old devices</p> <p>Waste electrical products must not be disposed of with household waste. This equipment should be taken to your local recycling centre for safe treatment.</p> <p>WEEE-Reg.-Nr. DE 96457402</p>	
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