

# qutools – Time-Correlated Single Photon Counting

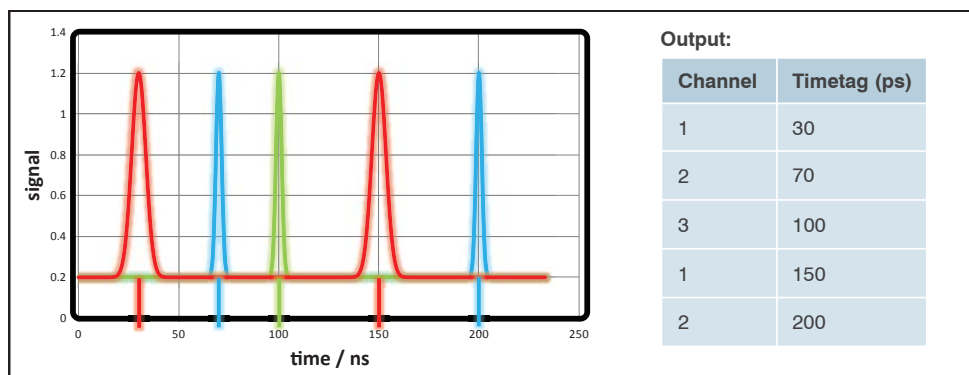
## Time-resolved measurements in the picosecond range

Based on the well-known time-correlated single photon counting (TCSPC) technique, quTAG and quTAU record electric signals with a temporal resolution in the picosecond range. Using photon detectors, such as Single Quantum's Eos X10 CS (SNSPD), it is possible to detect low light levels as used, for example, in fluorescence lifetime measurements.



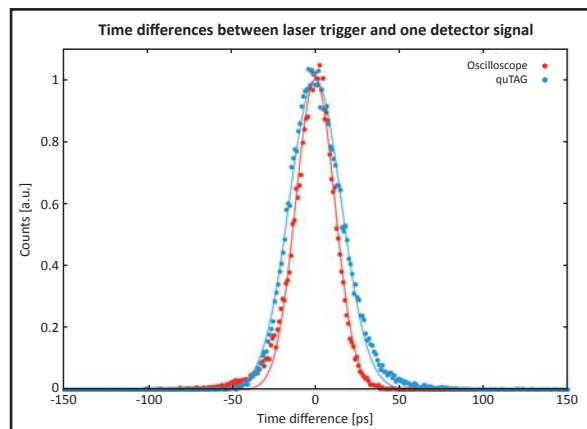
## One universal approach for all applications

Our time-to-digital converters measure electric signals and mark them with a time tag. This stream of time tags – from measurements in the picosecond range up to days – can be used in various applications. The universal time tagging method allows correlation measurements (cross-correlation, auto-correlation), lifetime measurements (start-(multi)stop) and many more possibilities within one measurement. You even can decide after the measurement what kind of analysis will be performed.



## Sample applications

- Single photon emitter characterization
- Coincidence measurements
- Fluorescence correlation spectroscopy
- Quantum state tomography
- Singlet oxygen luminescence decay
- Wavelength measurements



We measured a time difference histogram between the trigger pulse from the laser as start and the SQ detector signal as stop. This is basically the setup for a Fluorescence Lifetime Imaging Measurement (FLIM).

## quTAG – The next generation TDC (time to digital converter)

The quTAG is a high-speed Time-Correlated Single Photon Counting (TCSPC) system that features a bin width of 1 ps with a timing jitter of less than 10 ps (RMS). A divider for fast (periodic) signals is included for the start channel.

The standard model of the quTAG features 1 start and 4 stop channels and a versatile software and hardware package. The cost-sensitive basic model features 1 start and 2 stop channels with a limited software package. All available extensions can be upgraded in the field.



### Available extensions for the quTAG basic:

(in the standard version these extensions are all included)

- **Additional input channels**

The quTAG features up to two more flexible channels that can be enabled.

- **Clock input**

The quTAG can be synchronized to an external clock of 10 MHz, to allow more precise long-term accuracy.

- **Lifetime software extension**

This software add-on enables the user to analyze lifetime measurements on the fly (start-(multi)stop measurements). The software calculates the required histograms, fits exponential decays and takes response functions of the system into account.

- **Cross-correlation software extension (HBT)**

This software extension is intended for Hanbury Brown-Twiss experiments and fluorescence correlation spectroscopy. It calculates the  $g(2)(\tau)$  function from the detection times of two inputs. Standard functions can be fitted to assess the relevant parameters.

- **Synchronization between devices**

This extension allows you to synchronize up to 4 devices. By this, up to 16 equal stop channels are available – all sharing the same clock input and time base.

### Other features available for both quTAG models:

- **Marker inputs**

In addition to the 4+1 channel input, the device features marker inputs that insert marker timestamps in your timeline. You can connect these inputs to your trigger signal (e.g. pixel clock or line clock). This helps you to sort and assign the timestamps in your setup.

- **Virtual channels / filters**

The device allows user-defined filters or virtual channels, e.g. coincidence filtering or artificial dead time. This filtering happens inside the device so that you save bandwidth on your USB connection.

- **User-defined clock input**

Use any frequency between 1 – 100 MHz as a clock input for long-term accuracy.

- **Start-channel as input**

The start channel can be converted to another stop channel, allowing the device to have 5 completely equal input channels.

## quTAU – Time tagging workhorse for quantum optics

The quTAU has 8 input channels that can be used either as start or stop channels and features a typical bin width of 81 ps.

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### Available extensions for the quTAU:

- **Variable signal input extension**

This extension widens the range of processable signals. It allows user-defined thresholds in the range of -2V to +3V. One channel features an additional divider allowing higher frequency periodic signals to be processed.

- **Lifetime software extension**

This software add-on enables the user to analyze lifetime measurements on the fly. Together with the input hardware extension, high frequency trigger signals can be used. The software calculates the required histograms, fits exponential decays and takes response functions of the system into account.

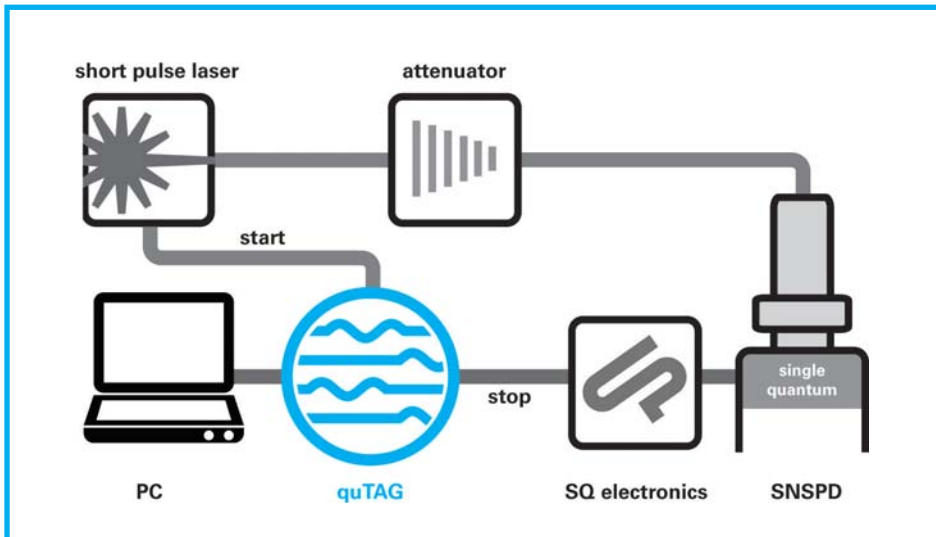
- **Cross-correlation software extension (HBT)**

This software extension is intended for Hanbury Brown-Twiss experiments. It calculates the  $g(2)(\tau)$  function from the detection times of two inputs. Standard functions can be fitted to assess the relevant parameters.



### Easy to use and integrate

All the included software can be used either in Windows or Linux with an easy-to-use graphical user interface. A powerful API is included together with examples in LabView, python, C/C++ and Matlab so that it can be easily integrated in your environment.



Together with our long-time collaborators at Single Quantum we have characterised their super-conducting nanowire single photon detector (SNSPD) "Eos" in combination with our quTAG. A short-pulse laser was attenuated and the resulting weak coherent pulses were sent to the detector.

## Available devices

Feature	quTAG	quTAG basic	quTAU(H+)	quTAU
Bin width	1 ps	1 ps	81 ps (typ.)	81 ps (typ.)
Timing jitter (RMS)	< 10 ps	< 10 ps	< 160 ps	< 160 ps
Input channels	1 start, 4 stop (up to 16)	1 start, 2 stop	8	8

Variable signal inputs	●	●	●	-
Lifetime software	●	○	●	○
HBT software	●	○	●	○
Input channels	●	○	-	-
Clock input	●	○	-	-
Synchronization	●	○	-	-
Marker input	○	○	-	-
Virtual channels	○	○	-	-
User defined clock frequency	○	○	-	-
Start channel as input	○	○	-	-
Divider for stop channels	○	○	-	-

- included
- optional feature
- not available

Detailed datasheets of each device can be found at: [www.qdusa.com/products/qutools.html](http://www.qdusa.com/products/qutools.html)

Do you need a feature or software extension not mentioned?  
Customized solutions in software and hardware are available from qutools.

Specifications subject to change.  
Distributed by:



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