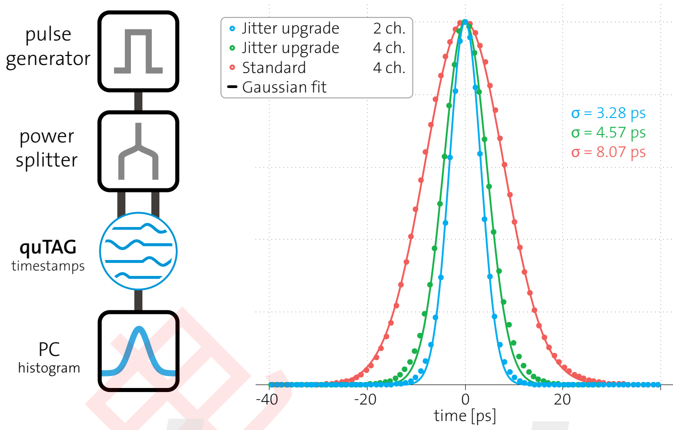
# quTAG

The time tagger that grows with your needs.


## Key Features

- 1 ps digital resolution
- Timing jitter down to 3.0 ps RMS / 7.0 ps FWHM
- Sustained event rate 100 Mcps
- 2 to 16 stop channels
- USB 3.0 interface
- Cost-sensitive, modular version available




## quTAG Specifications

### Time to Digital Converters

| | | | |
|---|---|---|---|
| Digital resolution | | 1 ps | |
| Timing jitter*1 | | RMS/√2 | RMS [ps] |
| Jitter upgrade | 2 channels: | < 3.0 | < 4.2 |
| | 4 channels: | < 4.5 | < 6.4 |
| Standard | 4 channels: | < 7.1 | < 10.0 |
| Max. event rate per channel | | 25 Mcps<br>200 MHz periodic*2 | |
| Sustained throughput rate | | 100 Mcps (USB3.0) | |
| Delay range | | -100 ... +100 ns | |
| Delay resolution | | 1 ps | |
| Min. pulse to pulse separation | | 40 ns | |
| Differential non-linearity | | <1 % | |
| Max. acquisition time | | 13 days | |

### Input channels

| | | |
|---|---|---|
| Number of channels | standard:<br>basic: | 4 stop and 1 start<br>2 stop and 1 start |
| Input connectors | | SMA |
| Signal levels (threshold comparator) | | -3 ... +3 V<br>e.g. LVTTL, NIM |
| Threshold level resolution | | 1.46 mV |
| Max. input level | | ±3.3V |
| Edge | | rising, falling |
| Min. input pulse width | | 300 ps |
| Termination | | 50 Ohms |
| Divider | | on start input*3 |

### Clock Input (standard only)

| | |
|---|---|
| Frequency | 10 MHz*4 |
| Signal levels (threshold) | -5 ... +5 V |
| Signal form | sinusoidal<br>square wave |
| Termination | 50 Ohms |
| Input connector | SMA |

### Synchronisation (standard only)*5

| | |
|---|---|
| Number of synchronisable quTAGs | 4 |
| Number of synchronised channels | 16 |

### Operation

| | |
|---|---|
| Interface | USB 3.0 |
| Operating systems | Windows, Linux |
| Supplied software | GUI / DLL / LabView / Python / Command line |
| Dimensions (in mm) | 440 x 330 x 50 |
| Weight | 4 kg |
| Power consumption | < 50 W<br>at 100 to 230 VAC |

*1: see jitter measurement method in the graph and on next page *2: with divider enabled
*3: for stop channels optional *4: other frequencies optional
*5: an external Clock may be required, jitter between synchronized devices may increase by up to 10%

## Applications

- Time-correlated Single Photon Counting (TCSPC)
- Quantum Optics / Information / Communication
- Quantum Key Distribution (QKD) / Quantum Cryptography
- Fluorescence / Phosphorescence Lifetime Imaging (FLIM)
- Fluorescence Correlation Spectroscopy (FCS)
- Foerster Resonance Energy Transfer (FLIM-FRET)
- Single Photon Emitter Characterization
- Light Detection and Ranging (LIDAR)

## How we measure the jitter

In order to measure the jitter, we generate an electrical pulse with steep edges. This pulse gets split into two by a power splitter and sent into two different inputs of the quTAG (i.e. start and stop-X or stop-X and stop-Y).
Then we use the quTAG software to generate a start-stop-histogram. We fit a Gaussian function to this histogram and determine RMS and FWHM. The single channel jitter corresponds to $\sigma/\sqrt{2}$ from this two channel measurement, assuming equal Gaussian contributions from both signals. The FWHM can be obtained by the standard deviation with the relation $\mathrm{FWHM} = 2\sqrt{2\ln 2}\,\sigma \approx 2.35\sigma$.

## Available Extensions

**Lifetime software extension**
This software addon enables the user to analyze lifetime measurements on the fly. The software calculates the required histograms, fits exponential decreases and takes response functions of the system into account.

**Cross-correlation software extension**
This software extension is intended for calculating the correlation function, as needed for example in Hanbury Brown-Twiss experiments or fluorescence correlation spectroscopy. Standard functions can be fitted to assess the relevant parameters.

**Stop channel extension**
The quTAG basic features up to two more flexible stop channels. In the standard model, all 4 stop channels are enabled by default.

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

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

**Divider for stop channels**
This option allows you to enable the divider on all stop channels. This allows higher frequency periodic signals to be recorded.

**Jitter upgrade**
This feature allows lower jitter at < 4.5 ps (RMS) on all four input channels. For lowest jitter of < 3.0 ps, two channels can be combined, leaving two stop-channels of one device for measurements. For optimal jitter results, recalibration with external signals might be necessary.

**Marker inputs**
In addition to the stop channel inputs, the device features marker inputs that insert marker timestamps in your timeline. You can connect these inputs e.g. to your pixel clock or line clock in your FLIM setup.

**Virtual channels**
The device allows to enable user-defined filters or virtual channels. This filtering happens inside the device so that you save bandwidth on your USB connection.

**User-defined clock frequency**
Any frequency between 1 – 100 MHz can be used 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.