T3-mode

(derived from tttr-mode or Time-Tagged-Time-Resolved mode)

A special measurement mode of the PicoHarp 300, HydraHarp 400 and TimeHarp 260.

In T3 Mode input channel 0 is dedicated to a sync signal. As far as the experimental setup is concerned, this is similar to histogramming mode. The main objective is to allow high sync rates (up to 84 MHz) which could not be handled in T2 Mode. Accommodating the high sync rates in T3 Mode is achieved as follows:

- the sync divider is employed as in histogramming mode.
  This reduces the sync rate so that the channel dead time is no longer a problem.
- The remaining problem is now that even with a divider of 8, the sync rate is still too high for collecting all individual sync events like ordinary T2 Mode events. Considering that sync events are not of primary interest, the solution is to record them only if they arrive in the context of a photon event on channel 1.

The event record is then composed of two timing figures:

1. The start-stop timing difference between the photon event and the last sync event, and
2. the arrival time of the event pair on the overall experiment time scale (the time tag).

The latter was originally obtained from an independent asynchronous clock. This made it difficult to combine the start-stop timing with the time tag or to know the sync period the event belonged to. For the *Harp's T3 Mode a smarter approach was chosen:
The time tag is now obtained by simply counting sync pulses. From the T3 Mode event records it is therefore possible to precisely determine which sync period a photon event belongs to. Since the sync period is also known precisely, this furthermore allows to reconstruct the arrival time of the photon with respect to the overall experiment time.

T3 Mode measurements always implicitly provide routing information if a router is used. Routing information is represented by four bits in each TTTR record, that allow up to four routing channels to be distinguished. However, these bits are only meaningful if a router was actually used for the measurement.

Each T3 Mode event record consists of 32 bits:

- 4 bits for the channel number
- 12 bits for the start-stop time
- 16 bits for the sync counter.

If the counter overflows, a special overflow marker record is inserted in the data stream, so that upon processing of the data stream a theoretically infinite time span can be recovered. The 12 bits for the start-stop time difference cover a time span of 4096*R where R is the chosen resolution. At the highest possible resolution of 4 ps this results in a span of 16 ns. If the time difference between photon and the last sync event is larger, the photon event cannot be recorded. This is the same as in histogramming mode, where the number of bins is also finite. However, by choosing a suitable sync rate and a compatible resolution R, it should be possible to reasonably accommodate all relevant experiment scenarios. R can be chosen in doubling steps between 4 ps and 512 ps.

Dead time in T3 Mode is the same as in the other modes (eg. typ. 95 ns for PicoHarp) Since there is only one photon channel, only autocorrelations can be calculated (unless a router is used). This can be done at the resolution R but of course only starting from lag times larger than the dead time.

The 32 bit event records are queued in a FIFO (First In First Out) buffer capable of holding up to 256 k event records. The FIFO input is fast enough to accept records at the full speed of the time-to-digital converters (up to 10 Mcps each). This means, even during a fast burst no events will be dropped except those lost in the dead time anyhow. The FIFO output is continuously read by the host PC, thereby making room for fresh incoming events. Even if the average read rate of the host PC is limited, bursts with much higher rate can be recorded for some time. Only if the average count rate over a long period of time exceeds the readout speed of the PC, a FIFO overrun could occur. In case of a FIFO overrun the measurement must be aborted because data integrity cannot be maintained. However, on a modern and well configured PC with Windows 2000 or XP a sustained average count rate over 4 Mcps is possible. This total transfer rate is fully available for input channel 1. For all practically relevant fluorescence detection applications this is more than sufficient.

For maximum throughput, T3 Mode data streams are normally written directly to disk. The current *Harp software does not provide any immediate data visualization during a T3 Mode measurement, except count rate and progress display. However, using custom software it is also possible to analyze incoming data “on the fly”. Even on-line correlation can be implemented. Obviously this requires efficient processing and possible restrictions in average count rate. The *Harp software installation CD contains demo programs showing how T3 Mode files can be read by custom software. The implementation of custom measurement programs requires the *Harp programming library, which is available as a separate option.

see also t2-mode

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