Optical to electrical detection delay in APD based detector

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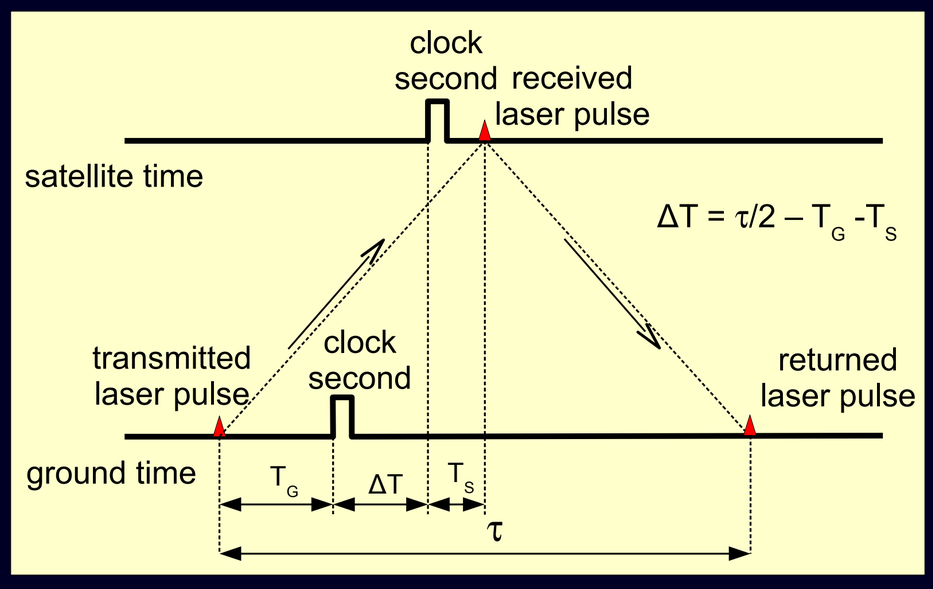
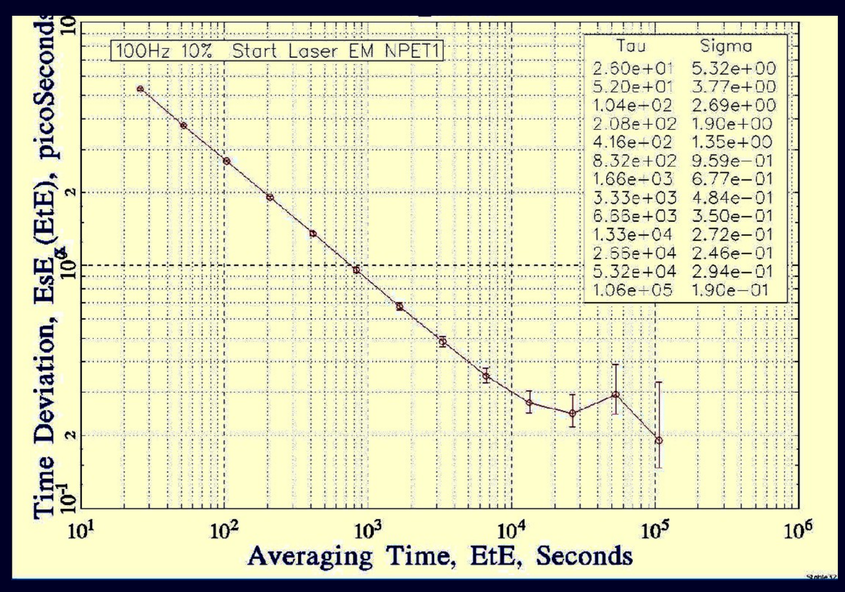
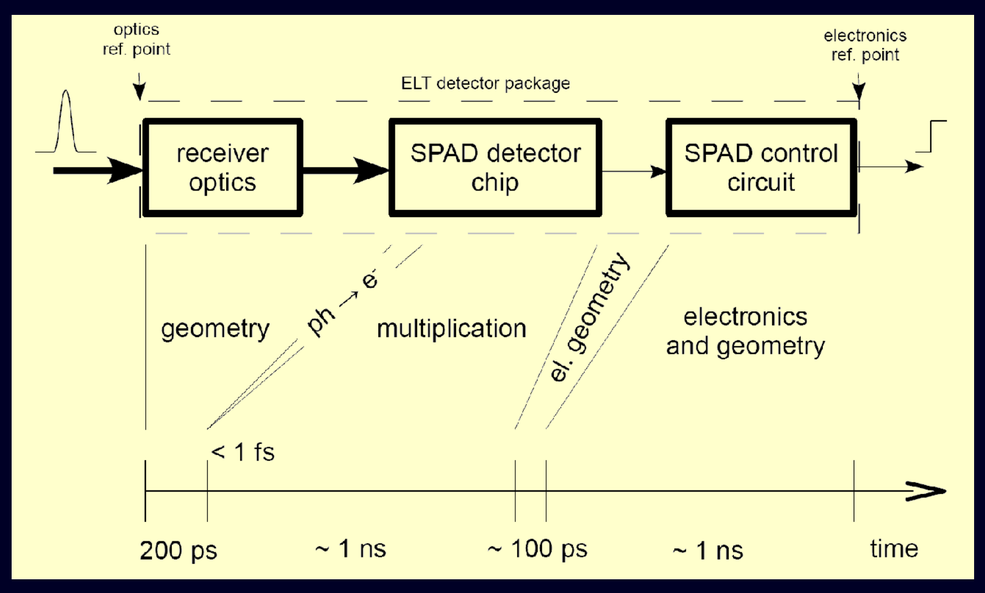
Motivation – ground-space time synchronization by picosecond laser pulses – laser time transfer



The motivation is realization of laser time transfer – an advanced satellite laser ranging (SLR) application. Two time scales synchronization by pulse laser in visible range, its principle is described above. In compare with classical microwave communication it allows decrease the systematic error in signal delay down to 10^{-11} s, i.e. about 1000 times better. We are principal investigator of detector packages in several realizations (China, France, ESA). Typical question of investors is ”What is the absolute delay between optical and electrical signal in detector?”

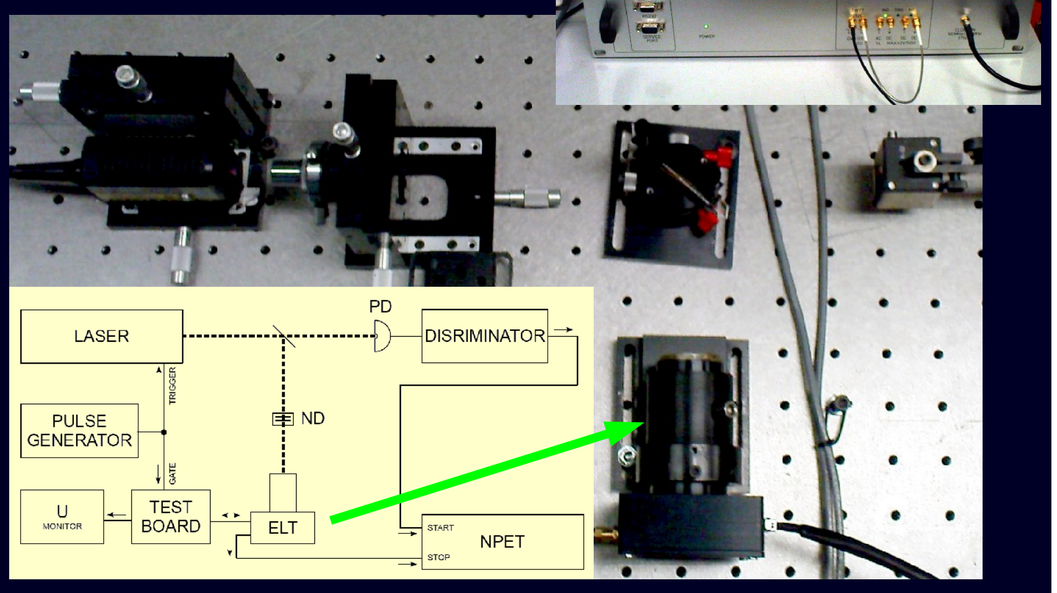


T_{DEV} of bread board model of European Laser Timing (ELT) experiment. Even the single shot temporal resolution of single photon avalanche detector is in order of tens of ps and overall stability allows averaging down sub-picosecond level, the absolute delay cannot determined from standard TCPC experiment.

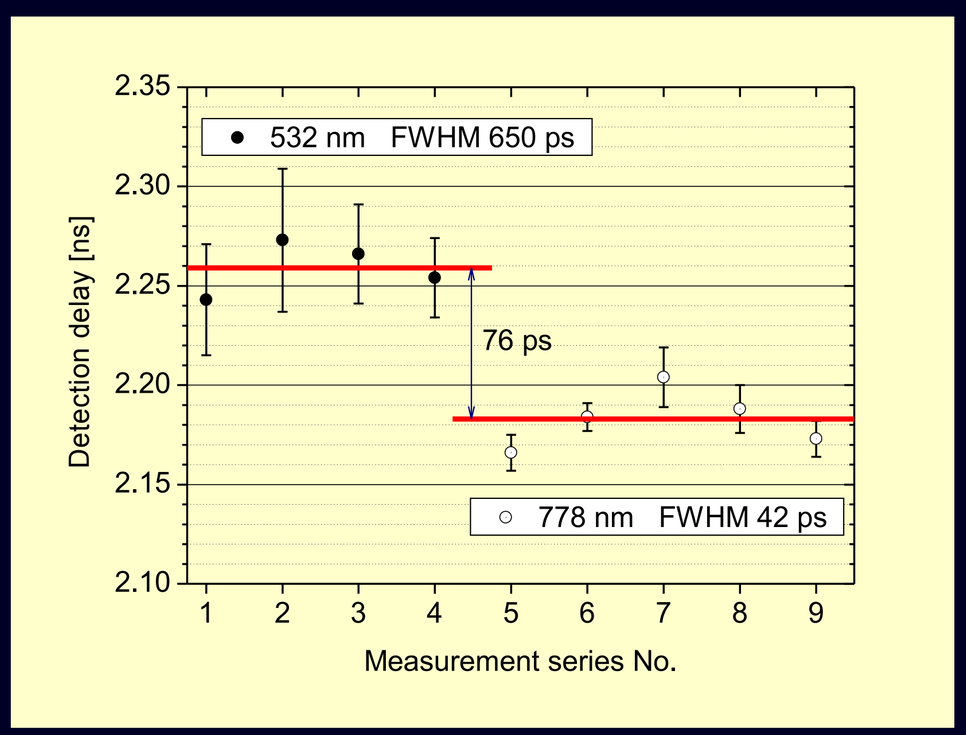


The diagram of individual contributors of the photon detection delays in single photon avalanche detector package with the rough estimate of the typical values. Two lasers (diode 42 ps @ 778 nm and solid state 650 ps @ 532 nm) was used to determine the multiplication one and demonstrate the stability of all.

NPET – the femtosecond event timer

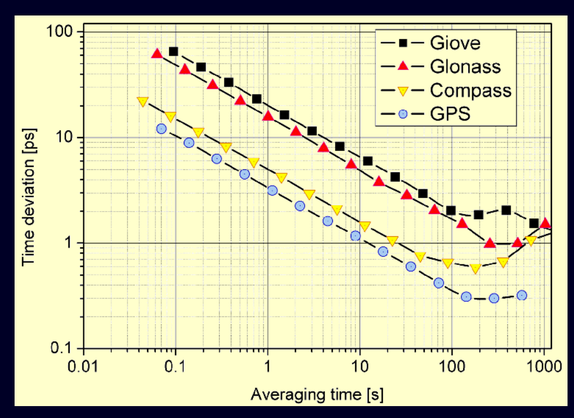


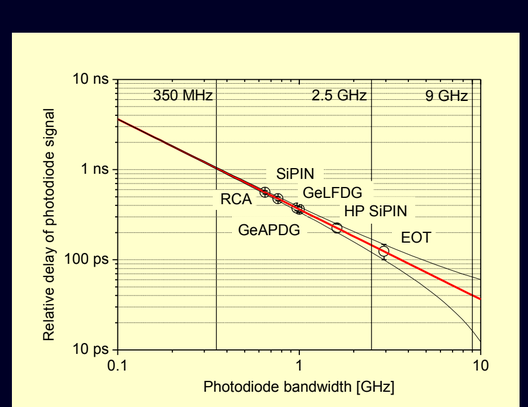
The photo and block scheme of one part of experiment – comparison of photon counting detector delay and delay in linear photodiode. The reproducibility is conditioned by extreme stability of used detectors and event timer.



The absolute value of the time interval between the time of arrival of the signal photon onto detector input aperture and the time when the electrical output signal is exceeding the predefined level was determined with the precision of 10 to 12 picoseconds. The acceptable mean values reproducibility and entire experiment stability within each series was achieved, however, the unexplained difference of 76 ps peak to peak exists between the two groups corresponding to two different experimental setups and employing two different laser sources. The origin of this discrepancy will be further investigated. One has to take into account the fact, that the measurements at the wavelength of 532 nm were completed employing rather long pulses 650 ps. We do expect to repeat the same experiment employing the 8 ps long laser pulses at 532 nm wavelength in a near future.

The demonstration of current stability of satellite laser ranging (SLR) measurements. T_{DEV} of ranging data of selected satellites completed at SLR station Graz, Austria (2 KHz, 532 nm).





One of crucial factors in this type of experiments is the effective bandwidth used for signal measure/observation. The left graph summarized relative changes of absolute delay for different types of photodiodes as a function of photodiode bandwidth (not as a function of material)

in electronic version several hyperlinks are available

This research has been supported by grant provided by the Ministry of Education of the Czech Republic and the international grant agencies, as well. The recent publication has been supported by grant RVO68407700.
Presented at 3rd International Workshop on New Photon-Detectors, Orsay, France, June 13 – 15, 2012.