Time-gated Raman spectroscopy with 775nm 100ps pulsed laser and CMOS-SPAD detector

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Infrared excitation in Raman spectroscopy has been routinely used to lower fluorescence, a dominant noise factor in continuous wave Raman instruments. Time-gating is a technology that rejects slow fluorescence and is selective to scattered wavelength shifted photons. Our product series PicoRaman® incorporates our Timegated® technology using 532nm excitation. Here, for the first time, we demonstrate time gating using near IR excitation. We also demonstrate how this opens an application area that has been previously inaccessible to both commercial Raman systems and Timegated 532nm.

The PicoRaman 775nm Raman spectrometer is based on a modified version of our 532nm spectrograph platform, consisting of a transmission grating polychromator and custom CMOS SPAD detector array. The modified spectrometer has the range 775nm-895nm and resolution 0.3nm. An ultrafast picosecond laser with 775nm output is used to excite the sample. The laser oscillator is a gain switched laser diode operating at 1550nm. The weak pulses are amplified through a two stage Erbium doped fiber amplifier and are converted to second harmonic at 775nm. A sampled 1550nm beam is used to trigger the detector with adjustable relative timing, called gate delay. A Raman probe with a 200µm spot diameter and 150µm working distance is connected to the spectrometer with optical fibers and can be directly integrated to bioreactors. The FWHM of the temporal instrument response function of the complete system is approximately 160ps. A simplified free space equivalent schematic is shown in Fig. 1(Left).

To put the designed system to test, we chose extremely fluorescent pigment dyes as our test sample, provided to Timegate by a museum. Some of these samples exhibit too intense and fast fluorescence to be effectively measured using the regular 532nm PicoRaman. With the newly developed 775nm system, the fluorescence naturally reduces and time gating yielded good quality spectrum (Fig. 1 middle and right) that has previously been inaccessible. Raman signatures of the pigments were more easily seen under 775nm illumination than 532nm.

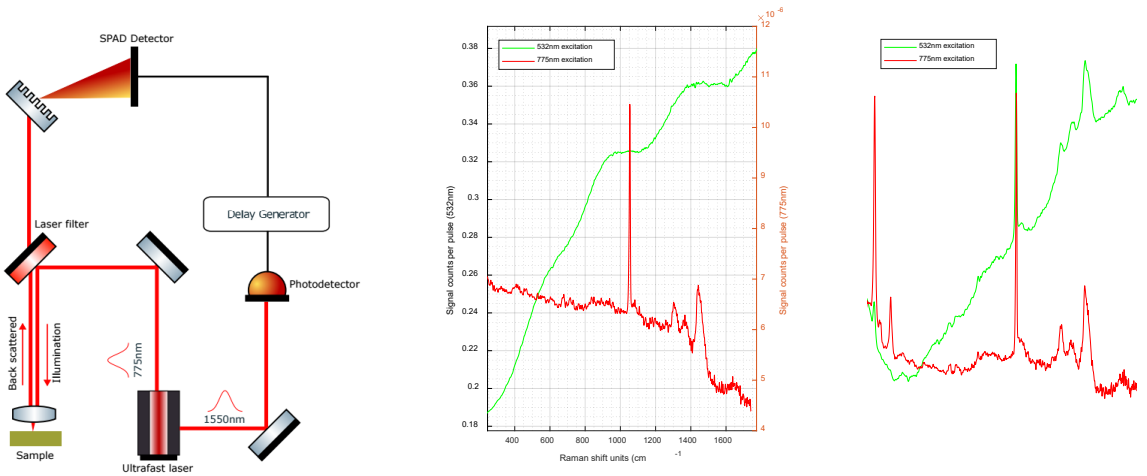

Fig. 1 (Left): Free space equivalent measurement setup. (Middle and right): Raman spectra comparison between 532nm and 775nm timegated systems.

At the time of writing, PicoRaman 775nm was successfully used at a bioreactor trial run as a part of the EU-BioIndustry 4.0 project[2]. The data analysis will be carried out and results discussed. In the near future, several of the project partners will use our device and evaluate application specific performance parameters. We are continuing to find various new application areas to bring Timegated systems to even more markets around the world.

1. J. Kostamovaara, et.al., "Fluorescence suppression in Raman spectroscopy using a time-gated CMOS SPAD," *Optics Express* **21**, pp. 31632-31645, 2013
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