Application Note
Photon Number Resolving Detectors

SINGLE QUANTUM
Excellence in photon detection

Photon number resolving (PNR) detectors can recognize the number of arriving photons in one detection event. Until now, single-photon detectors based on superconducting nanowires (SNSPDs) could only resolve the photon number by making a multi-pixel array of SNSPDs connected to a read-out circuit that determine how many pixels click simultaneously. However, the need for more pixels increases the cost of the system and the probability that multiple photons are absorbed in the same pixel, reducing the photon number information.

Single Quantum has recently improved the timing jitter and recovery time of SNSPDs. This allows for a less complicated solution for PNR: with only one SNSPD, the PNR can be measured through a simple jitter measurement.

Measurement setup

The number of photons which are absorbed simultaneously influences the slope of the rising edge of the SNSPD electrical read-out pulse. This slope change can be extracted by time correlating the SNSPD read-out pulse to a pulsed laser source. For this measurement, a 1064 nm pulsed laser with a pulse width of 2.3 ps and a repetition rate slower than the recovery time of the SNSPD ($f_{rep} < 1/(5\tau)$) is used. The wavelength of the pulsed laser is not important, but the pulse width needs to be much shorter than the rise-time of the read-out pulse, which currently limits this scheme to picosecond laser-based experiments.

The laser output is split into two fibers. The first fiber is connected to a fast photo diode, generating the start event. The second fiber is connected to the SNSPD through an attenuator to lower the optical power such that an average of μ photons is absorbed by the SNSPD. The SNSPD is correlated to the photo diode with a time correlation device. We used a 40 GS/s oscilloscope with 4 GHz bandwidth to correlate the SNSPD and the photo diode. Our engineers can assist you with choosing the right correlation electronics for this type of measurement.

Results

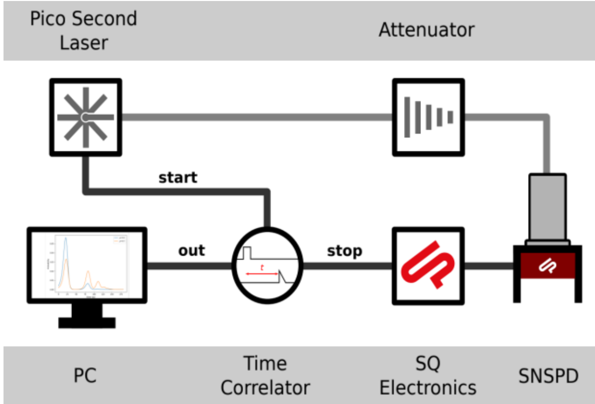

Fig. 1: Schematic overview of the measurement setup.

The results are depicted in Fig. 2. The blue curve shows the probability response function for an average photon absorbed per laser pulse of μ=0.2 and the orange curve for μ=0.7. Each peak in the curves is the probability function for an *n* amount photons to be simultaneously absorbed. Each curve shows a Poissonian trend as expected for a coherent light source. We demonstrate a very clean separation between one photon (*n*=1) and two photon (*n*=2) events. The ability to resolve one (*n*=1) or more than one (*n*>1) photon events is sufficient for most quantum applications like:

- Linear Optics Quantum Computing
- Quantum Cryptography, and
- Quantum Communication.

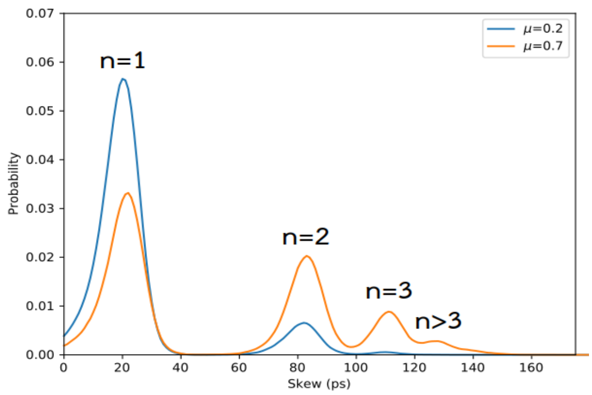

Fig. 2: Photon Number Resolved probability response functions for two laser intensities. The peaks are labeled with their corresponding photon number.

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