Colloidal quantum dots (QDs) exhibit unique optical properties such as a tunable emission color, sharp emission peaks, high luminescence efficiency with a high photostability. The unique properties of these nano-sized semiconductor particles are determined by quantum size effects ­— the particles are so small that the quantum mechanical states of the material’s charge carriers are determined by the particle size. Due to these quantum size effects, quantum dots have bound and discrete electronic states comparable to those of naturally occurring atoms.[1] Absorption of a photon from an excitation laser creates an exciton in a quantum dot, i.e. an electron in the conduction band and a hole in the valence band. Recombination of the electron and hole generates a fluorescence photon. A strong excitation laser can create multiple electron–hole pairs. Emission of photons from multiply excited state, such as the bi-exciton or tri-exciton state, is relevant for high-power applications of quantum dots.

In my research, I perform time-correlated single-photon counting (TCSPC) measurements using a pulsed excitation laser to study photon triplets emitted by individual quantum dots. More specifically, I study the characteristic time delays between combinations of three photons. Three photons can be emitted following three consecutive laser pulses (three excitons in separate laser pulses, Figure 1), two laser pulses (a combination of a bi-exciton and an exciton during a separate laser pulse, Figure 2), or a single laser pulse (a tri-exciton event, Figure 3). The results of the measurement can be visualized with a histogram of the delay times of two photons with regards to the third, Figure 5, with each peak representing a different three-photon scenario, Figure 4.[2]