Appendix C: *Artifacts & Errors* Associated with Avalanche Photodetectors

Pulse widths and *dead time*

By varying the value of the resistor you place in series with the LED/SPAD, the *RC* time constant of the circuit can be tuned. This effectively **controls the *dead time* of the detector** (the time during which the detector cannot register the arrival of another photon).

After-pulsing

One crucial pathology seen in SPAD detectors is after-pulsing, which is a second pulse that occurs before the dead time has elapsed, as shown below. Such pulses do NOT correspond to the detection of a second photon (which we do not expect to occur until the unstable quiescent state is reestablished). Instead, after a photon initiates the first avalanche, it is possible for an electron inside the p-n junction to be left in an excited state, and if that electron gains enough energy (usually thermal energy) to reach the conduction band, a second avalanche will occur, *without a photon initiating it*. Thus, a *single* photon can cause not one, but a sequence of two or more pulses that are *not independent* and that occur over very short time intervals. After-pulsing can show up in the data as *non-Poisson* distributions (since some of the pulses are no longer random), and as a large spike at short times when examining the time between pulses. The "high-end" SPADs we use in your later coursework display after-pulsing (usually MUCH) less than 4% of the time, but the "cheap" SPADS you use for your initial investigations offer no such guarantees.