Multi-Pulse Fitting of Transition Edge Sensor Signals from a Near-Infrared Continuous-Wave Source

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Transition-edge sensors (TES) are photon-number resolving calorimetric spectrometers with near unit efficiency [1]. Their recovery time, which is on the order of microseconds, limits the number resolving ability and timing accuracy in high photon-flux conditions because of the finite probability of overlap between detection events. When detecting near-infrared radiation, the low signal-to-noise precludes the use of established techniques based on signal differentiation for high energy radiation [2]. We approach the problem by separating it into two distinct phases: an initial event identification, followed by a more accurate timing discrimination [3].

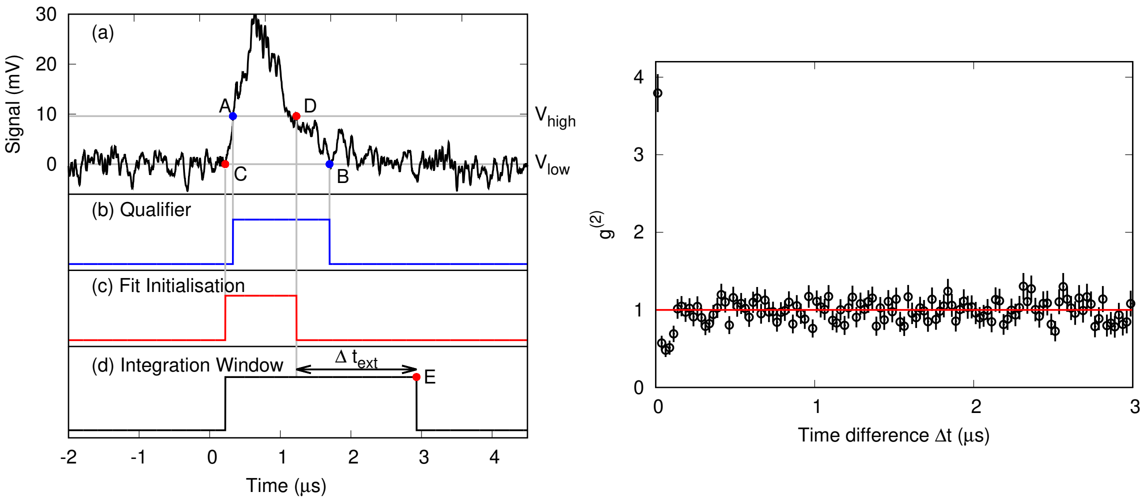

Fig. 1 Left: Typical TES response with overlapping pulses (a), qualifying interval identified by a two-level discriminator (b), fit initialization region (c), and integration window (d). Right: Normalized second order correlation function $g^{(2)}(\Delta t)$ for events recorded with a single TES from a coherent light field.

We identify photodetection events using a two-level discriminator to coarsely locate both isolated and overlapping pulses, as in Fig. 1(Left). For monochromatic sources we can then estimate the number of photons for every detection region from the total pulse area, identifying the cases of overlapping events. From the number of photons, we calculate a heuristic model function and fit it to the signal to recover the detection-times.

To examine the accuracy of the fitting technique over a continuous range of time differences Δt, we extract the normalized second order correlation function $g^{(2)}(\Delta t)$ for detection events recorded with a single TES from a coherent light field, Fig. 1(Right).

For $\Delta t > 150\,\text{ns}$ the events statistics is compatible with the expected value of 1, confirming the reliability of the method. For shorter time differences, the measured correlation deviates from the expected behavior, including the unphysical value $g^{(2)}(\Delta t = 0) > 2$. This instability region ($\Delta t < 150\,\text{ns}$) is comparable with the rise time of the average single-photon pulse.

References

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