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

**Jianwei Lee**[1], **Lijiong Shen**[1,2], **Alessandro Cerè**[1], **and Christian Kurtsiefer**[1,2]
*1. Centre for Quantum Technologies, National University of Singapore, 3 Science Drive 2, Singapore 117543*
*2. Department of Physics, National University of Singapore, 2 Science Drive 3, Singapore 117542*
*cqtac@nus.edu.sg*

**Abstract:** The slow recovery time of Transition-edge sensors limits their photon number resolution and timing accuracy in high photon-flux conditions. We present a solution to resolve overlapping events to the limit of the sensors jitter time. 

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## 1. Introduction

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].

## 2. Detection localization and fitting

We identify photodetection events using a two-level discriminator to coarsely locate both isolated and overlapping pulses, as in Fig. 1.

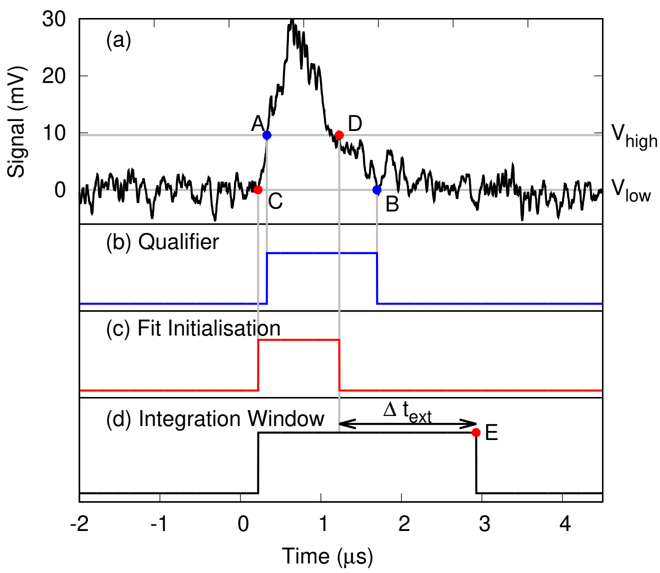


Fig. 1. Typical TES response with overlapping pulses (a), qualifying interval identified by the Schmitt trigger (b), fit initialization region (c), and integration window (d).

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, Fig. 2(Left).

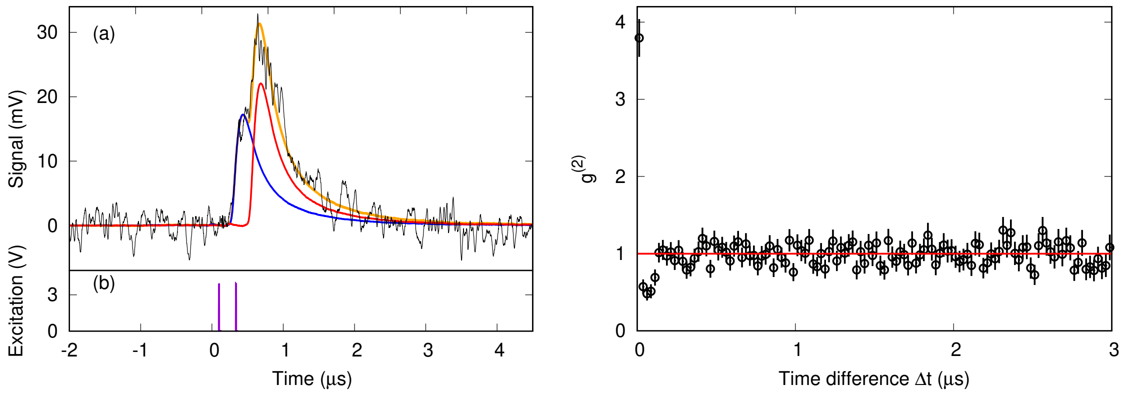


Fig. 2. (Left) Fit of a two-photon signal (black) and the heuristic fit model (orange) with its two single photon components (blue and red); electrical pulse pair driving the laser diode (purple). (Right) Normalized second order correlation function $g^{(2)}(\Delta t)$ for events recorded with a single TES from a coherent light field.

To examine the accuracy of the fitting technique over a continuous range of time differences $\Delta t$, 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. 2(Right).

For $\Delta t > 150\,\mathrm{ns}$ the events statistics is compatible with the expected value of 1, confirming the reliability of the met 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 ($\Delta t < 150\,\mathrm{ns}$) is comparable with the rise time of the average single-photon pulse.

## 3. Conclusion

The presented technique provides an alternative to photon counting using edge detection on the differentiated signal when signal-to-noise ratio is low. With the available TES, we can distinguish two photodetection events within $\approx 150\,\mathrm{ns}$, a value compatible with the detector time jitter, corresponding to an increase in the acceptable event detection rate from $\approx 4.0 \times 10^5\ \mathrm{s}^{-1}$, discarding overlapping pulses, to $\approx 6.7 \times 10^6\ \mathrm{s}^{-1}$.

## References

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