Photon-number and timing resolution of a near-IR continuous-wave source with a transition edge sensor
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Motivation

Measure 2nd-order correlation function with a single detector

- Avoids spatial multiplexing of Hanbury-Brown-Twiss
- Applicable to Satellites

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Outline

Transition-Edge Sensor & Setup

Photon-Number Resolution

Time-of-Arrival Estimation

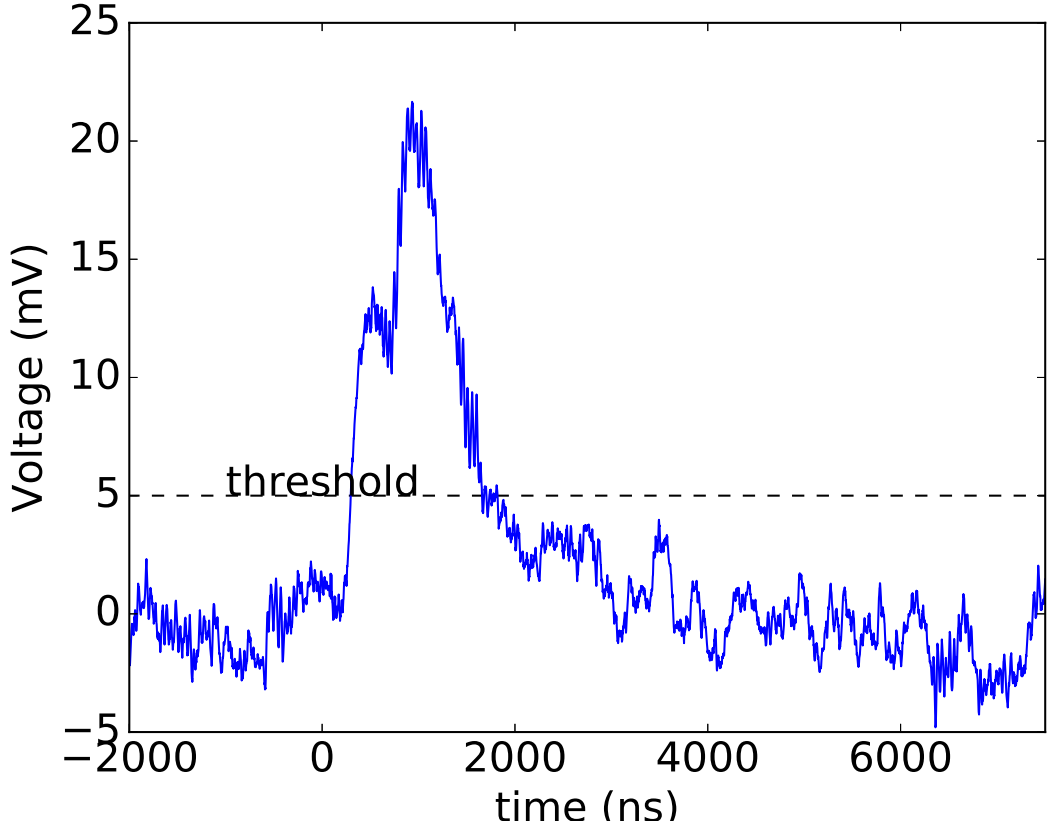
2nd-Order Correlation of Continuous Source

Transition-Edge Sensor

Photon-Number Resolving

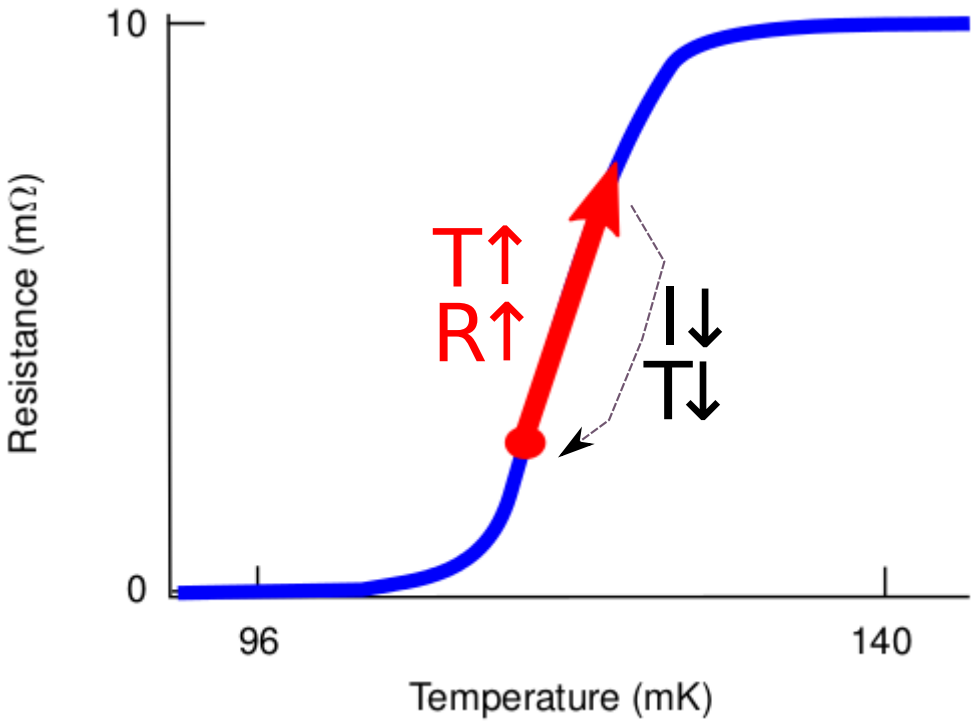
Near unit Efficiency

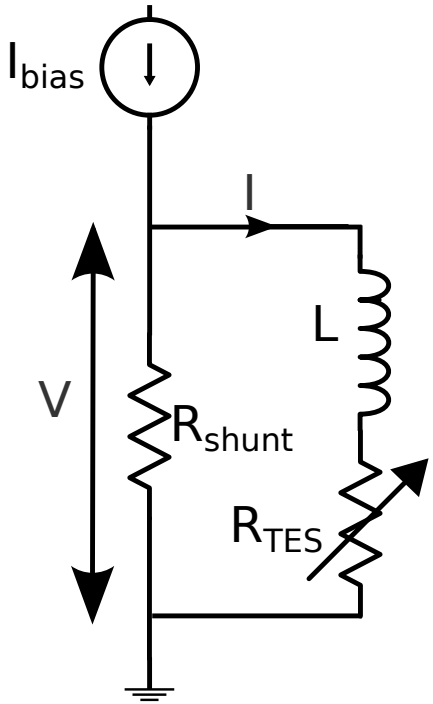
Long Recovery Time ($\approx 2\mu s$) limits flux detection rates



Transition-Edge Sensor

Photon absorbed → Temperature increases → Resistance increases

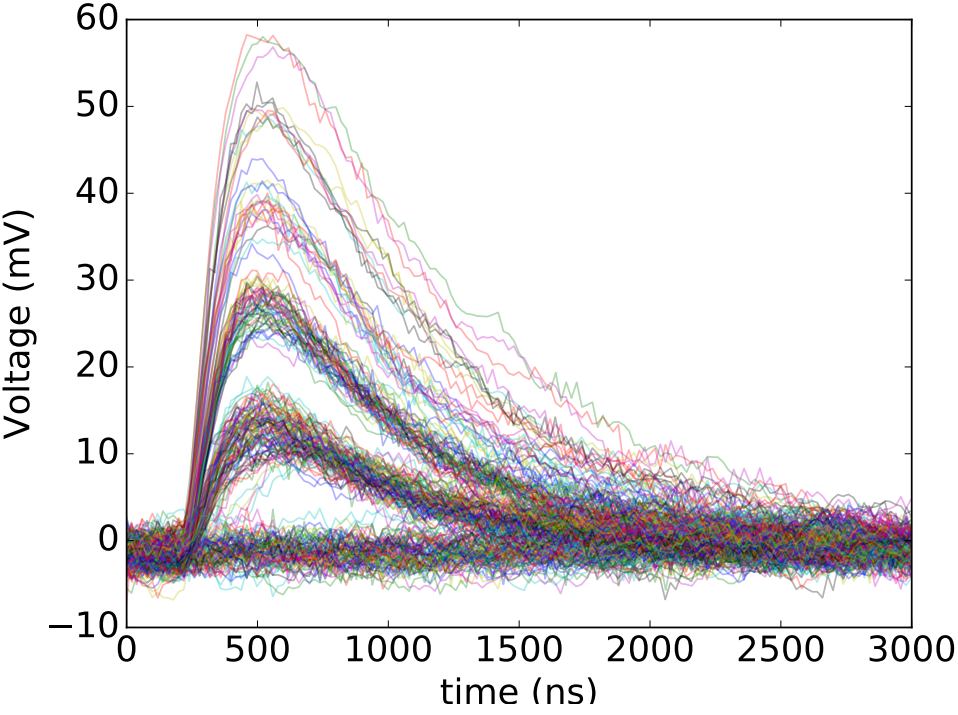


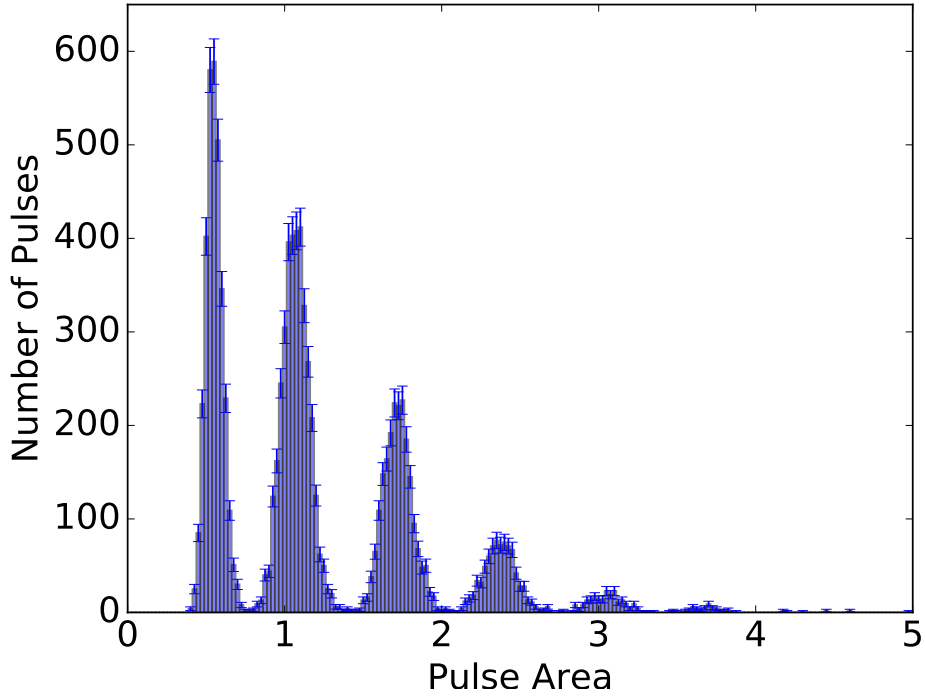


A.E.Lita, Proc. SPIE 7681, Adv Photon Counting Techniques IV, 76810D (2010)

Photon Number Discrimination

Light source: Pulsed Laser Diode
Pulse Area $\propto$ Photon Number

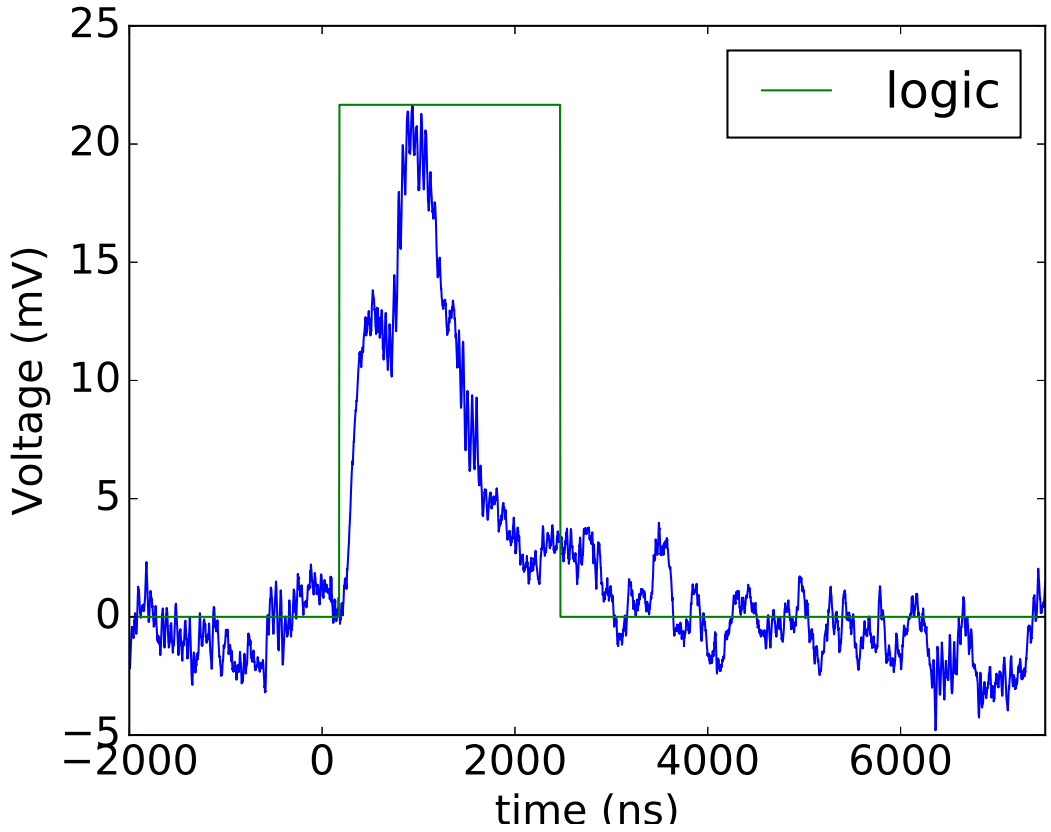




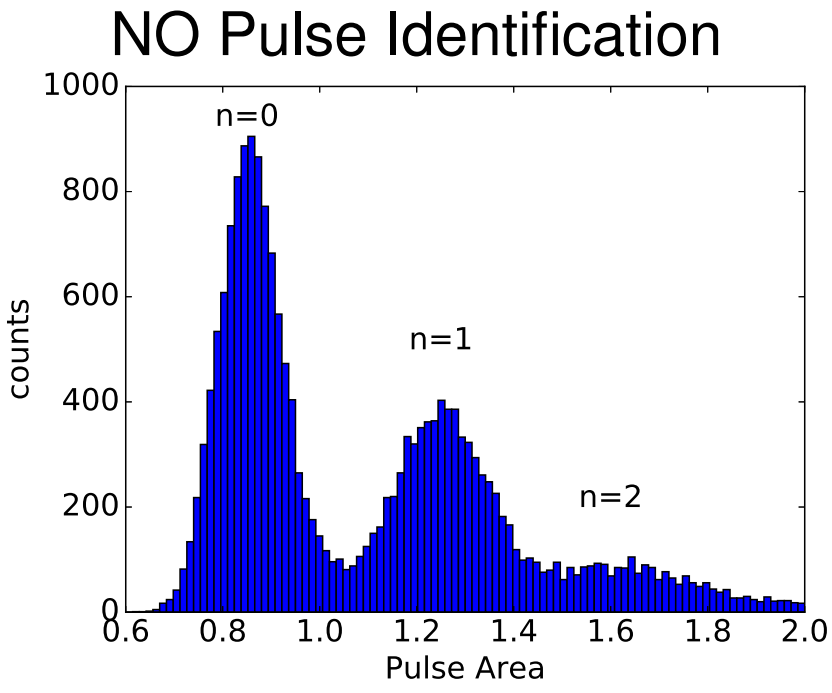
Pulse Identification for Continuous Source

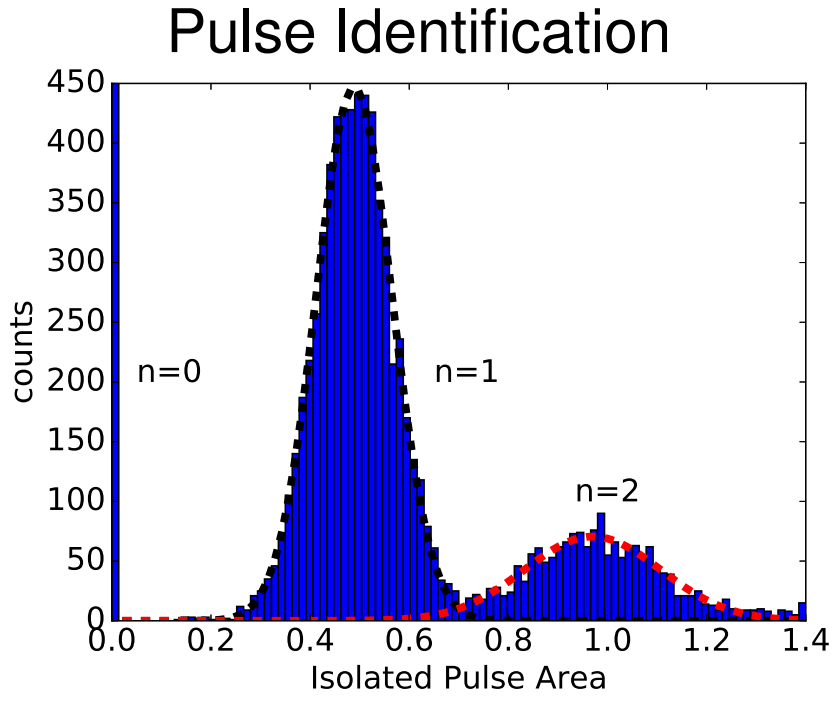
Discard Incomplete Pulses at Edges

Limit Background Noise



Photon Number Resolution (Continuous Source)

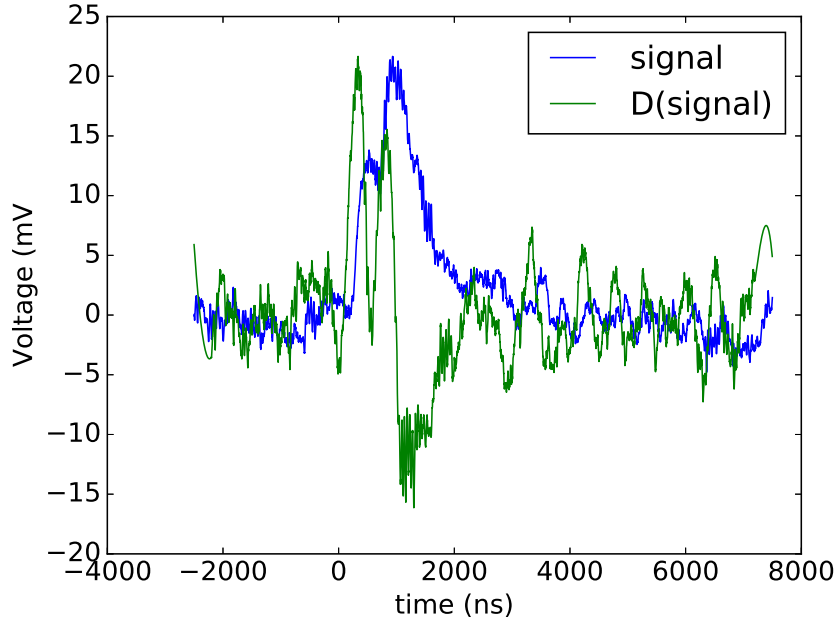




Time-of-Arrival Estimation

Model: $A_1 S(t - t_1) + A_2 S(t - t_2)$

1. Select 2-photon signals (pulse area)
2. Detect Pulse edges (filter + differentiate)
3. 2 Edges
   - Initialise using Pulse Edges Timings
   - Least Squares Fit
4. 1 Edge
   - Initialise using Pulse Region
   - Monte-Carlo Markov Chain Fit

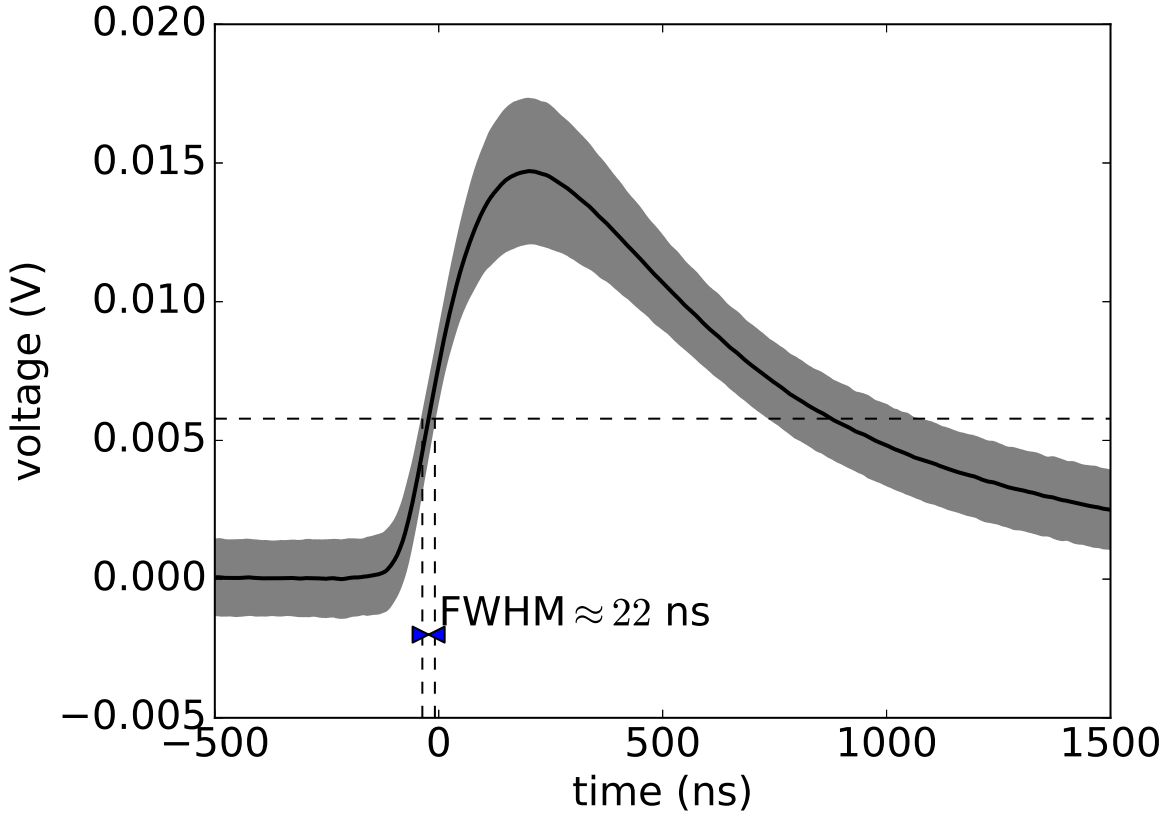


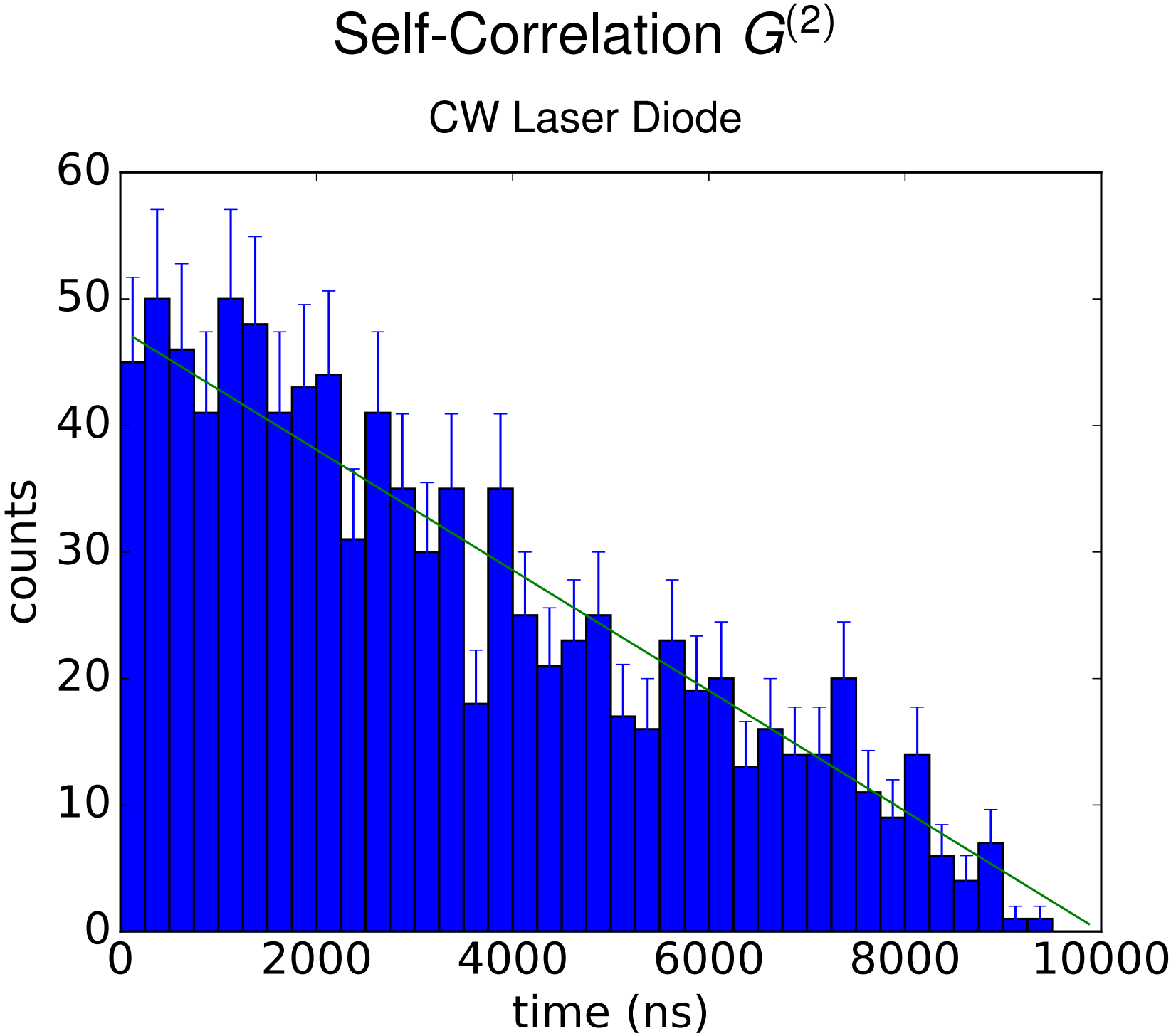
Single-Photon Detection Model

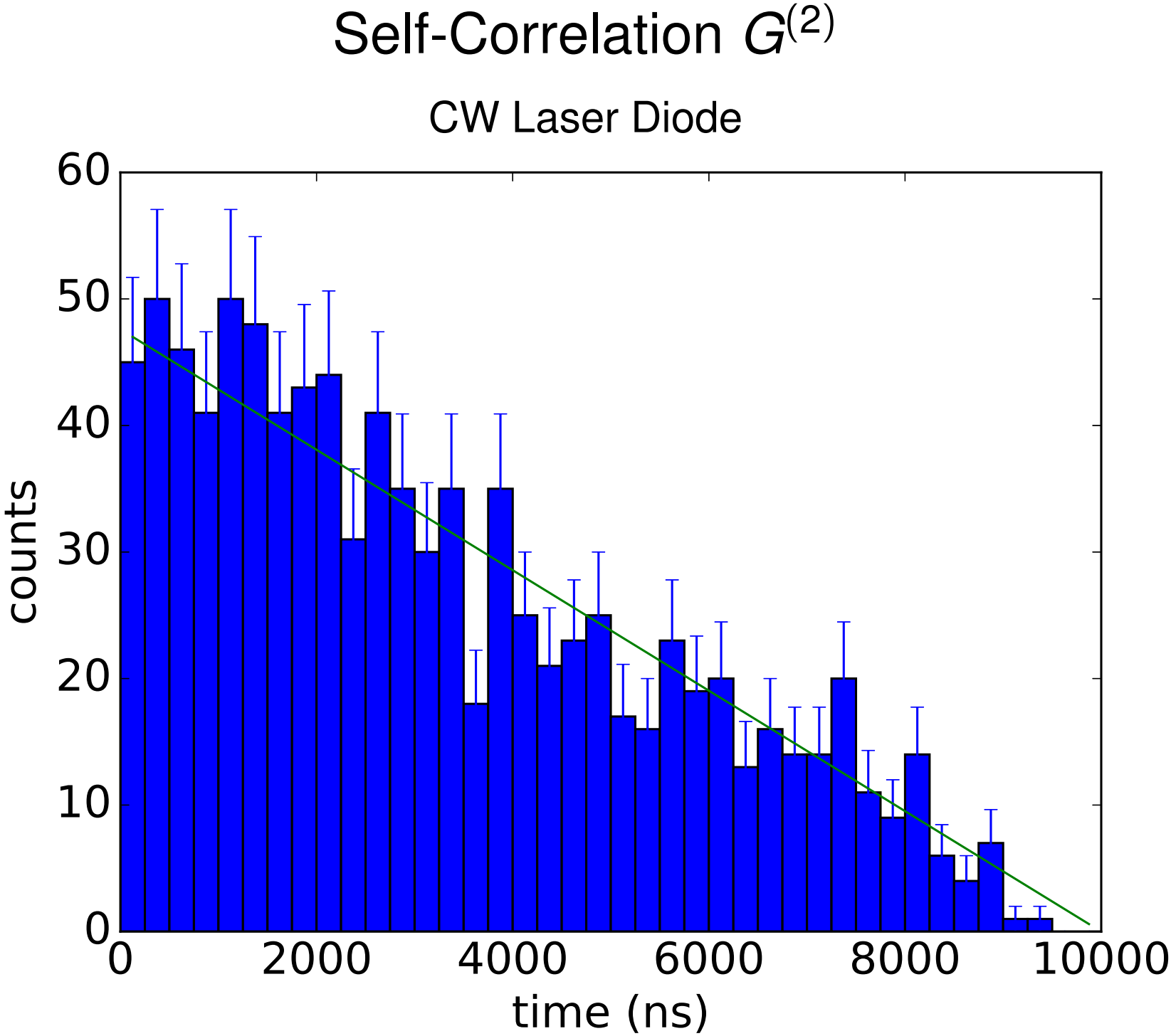
Select 5000 single-photon pulses

Correct for Vertical & Horizontal Offset

Average




Self-Correlation $G^{(2)}$
CW Laser Diode
counts
time (ns)
0
10
20
30
40
50
60
0
2000
4000
6000
8000
10000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4000
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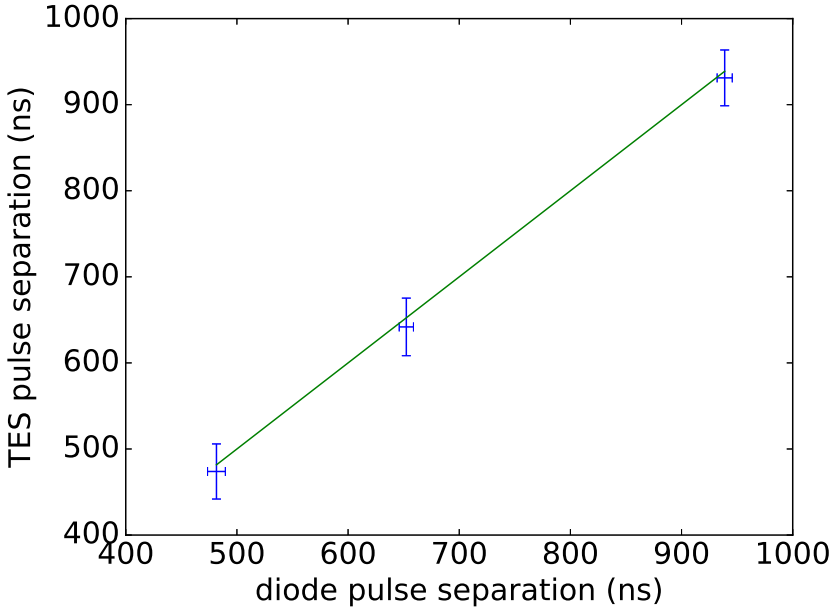
8000
10000

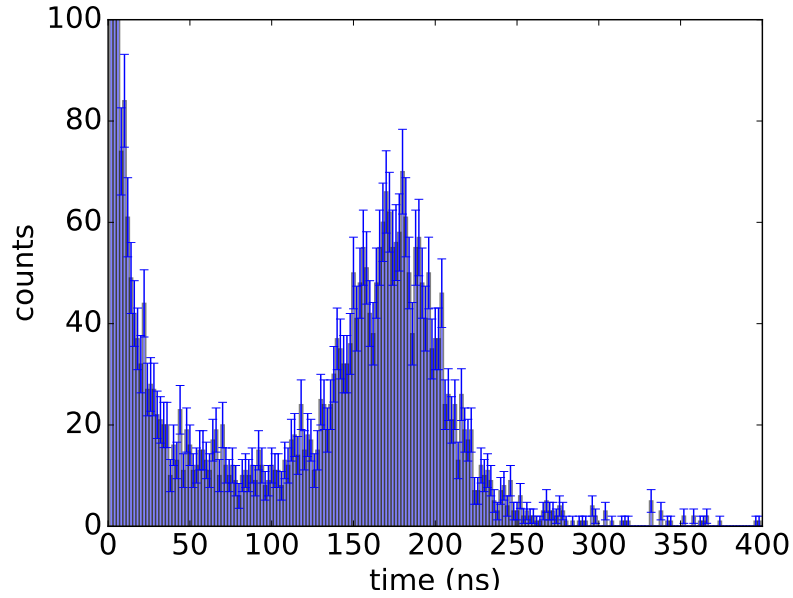
Self-Correlation $G^{(2)}$ Fit Accuracy

Light Source: Laser Diode Pulse Pairs

Seperation > 200ns



Seperation = 200ns



Conclusion

Timing Resolution $\approx$ 250 *ns*

Photon Number Resolution

- n = 0, 1 misidentification negigible
- 1-photon event misidentified as 2-photon event: 0.8%

Applications

- Correlation measurements without spatial-mode multiplexing
- Increased Photon Flux

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