Practicals summary: MICRO 429

27 March 2025

École polytechnique fédérale de Lausanne

Task 1

Dark count rate (DCR) and afterpulsing statistics in photon-counting devices

Objective:

- Understanding single-photon avalanche diodes (SPADs) & photon counting
- DCR vs. excess bias voltage
- Inter-arrival statistics, dead time, and afterpulsing
- (Temperature dependency)

Reading:

- Read reference [1] for general understanding of SPAD technology
- Read week 8 lecture notes – Introduction to single-photon detection

Setup:

- 1 Voltage supply
- 1 SPAD23™ detection unit
- (1 oscilloscope)

Task 1

Dark count rate (DCR) and afterpulsing statistics in photon-counting devices

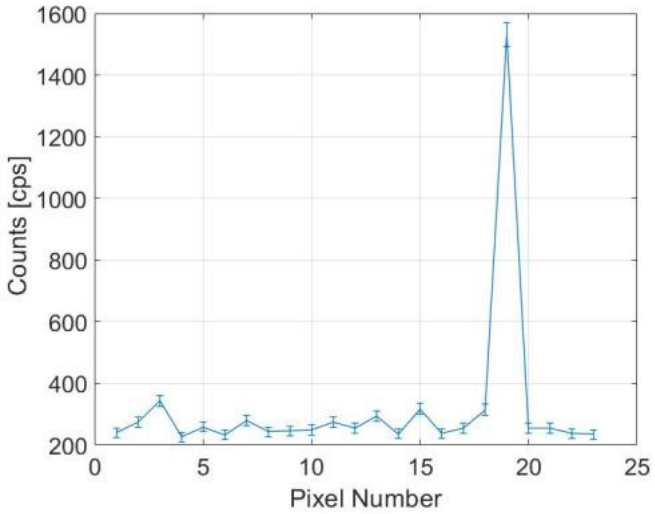
Methodology:

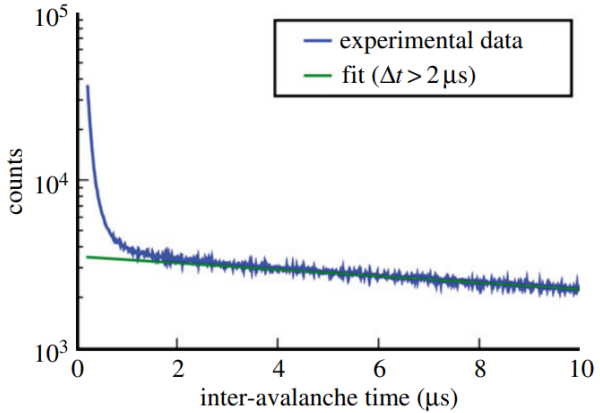
- Power up the SPAD23™ module, configure the UI, and test display/data acquisition in darkness and dim light for DCR and afterpulsing analysis, respectively.
- Use the counter option from the interface and measure DCR vs Excess bias.
- Modify the MATLAB code and run it to perform DCR measurements.
- Run the code with different integration times, operating voltages and repetition times.
- Compute std. deviation of the mean DCR for different measurement conditions.
- Set up the detection unit and modify the MATLAB code to extract inter-arrival times.
- Construct the histogram and compute dead time and afterpulsing with VEX=3V.
- Document your findings on the Lab Notebook along the way.

[1] E. Charbon, “Single-photon imaging in complementary metal oxide semiconductor processes”, Phil. Trans. Royal Society, 28 March 2014. DOI: 10.1098/rsta.2013.0100.

Task 1

Dark count rate (DCR) and afterpulsing statistics in photon-counting devices





Task 2

Sensitivity in photon-counting devices

Objective:

- Understanding the photon detection probability (PDP) and efficiency (PDE)
- Learn and observe Poisson nature of photons.
- Photo-response non-uniformity (PRNU)
- PDP improvement techniques.

Reading:

- Read reference [2] to learn about typical characteristics – breakdown voltage, DCR, photon detection probability (PDP), timing jitter, afterpulsing probability – of a SPAD23™ pixel

Setup:

- 1 SPAD23™ detection unit
- 1 x Pulsed laser source
- 1 Laser controller
- 1 NIM to TTL converter
- Reflective neutral density filters
- 1 x Mirror
- 1x Diffuser
- 1 laptop

Task 2

Sensitivity in photon-counting devices

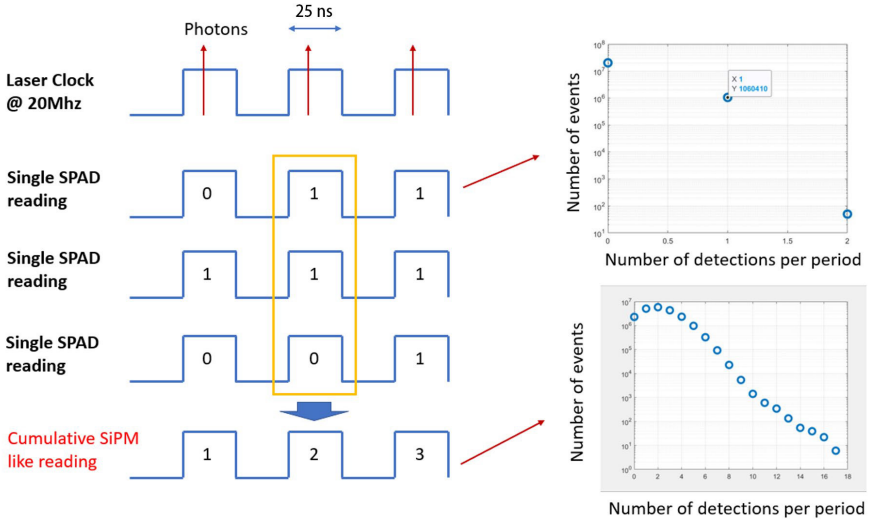
Methodology:

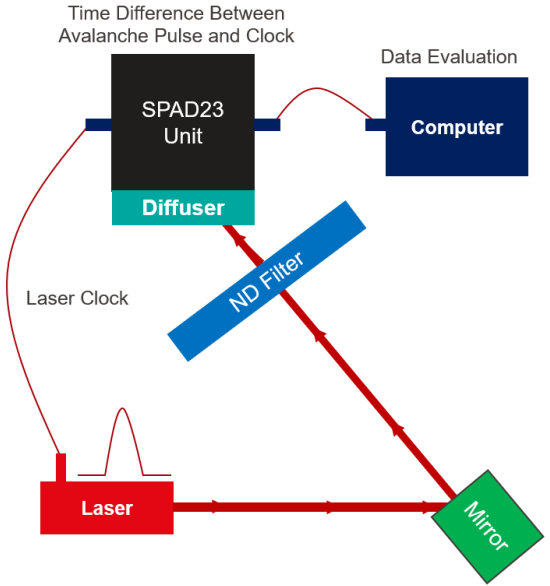
- Preparation before the practical will involve evaluating the raw histogram of detected events.
- Power up the SPAD23™ module, set up the user interface, and explore the SPAD/photon behavior under different illumination conditions.
- Use the timestamping option from the interface and collect the timing data of the incident photons.
- Write a MATLAB code to investigate the effect of the incident light power on SPAD pixels and the nature of the photons.
- Estimate the spatial photo-response uniformity.
- Document your findings in the Lab Notebook along the way.

[2] I. M. Antolovic, C. Bruschini, and E. Charbon, "Dynamic range extension for photon counting arrays." Optics Express 26.17 (2018): 22234-22248.

Task 2

Sensitivity in photon-counting devices





Task 3

Timing jitter measurements in single-photon detectors

Objective:

- Understanding and performing time-correlated single photon counting (TCSPC)
- Single-photon timing resolution (SPTR)
- Pile-up effect

Reading:

- Read reference [2] to learn about typical characteristics – breakdown voltage, DCR, photon detection probability (PDP), timing jitter, afterpulsing probability – of a SPAD23™ pixel

Setup:

- 1 SPAD23™ detection unit
- 2 x Pulsed laser source
- 1 Laser controller
- 1 NIM to TTL converter
- Reflective neutral density filters
- Mirrors
- 1 laptop

Task 3

Timing jitter measurements in single-photon detectors

Methodology:

- Power up the SPAD23^{TM} module, set up the user interface, and explore the different display and data acquisition options in the dark and when exposed to (dim) light.
- Use the timestamping option from the interface and collect the timing histogram of the arrival photons.
- Write a MATLAB code to calculate the single-photon timing resolution (SPTR).
- Compare the effect of two different light sources on the jitter parameters.
- Document your findings in the Lab Notebook along the way.

Thank you

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