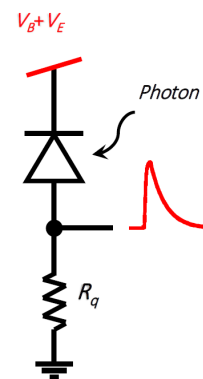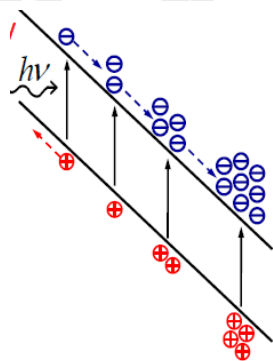# MICRO-523: Optical Detectors

Dr. C. Bruschini

January 16-17th, 2025

Question 11.1 *SPAD Fundamentals*: *Working principles & Metrics*

i.   [1 pt] SPAD operating principles:
   - ➤ How does a SPAD work?
   - ➤ Which are a SPAD's typical operation cycles and related time scales?
   - ➤ Which is the difference between a SPAD and an avalanche photodiode?

ii.   [1 pt] SPAD cross-section:
   - ➤ Draw at least one typical cross-section.
   - ➤ Identify anode/cathode, the p-n junction and the multiplication region.

iii.   [1 pt] SPAD as a digital device:
   - ➤ How can a SPAD be transformed into a digital photon detector?
   - ➤ How can such a device be typically used?

iv.   Bonus [0.25 pt]: Discuss two of the key SPAD metrics.

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Question 11.2 *SPAD Fundamentals*: *SPAD Metrics, device physics & metrology*

Discuss the key SPAD metrics (PDP, DCR, afterpulsing, …), the related Metrology and underlying physics.

i. [1 pt] SPAD metrics:
   - ➢ Select two of the most important SPAD metrics and discuss them.
   - ➢ For each draw a typical response graph, e.g. PDP vs. wavelength, DCR vs. temperature, timing jitter, etc.

ii. [1 pt] SPAD Metrology:
   - ➢ For the previously selected two metrics: discuss their metrology, i.e. how to measure them (one example provided below).

iii. [1 pt] Noise sources:
   - ➢ Which are the main noise sources in single SPADs and SPAD arrays?
   - ➢ Discuss correlated vs. uncorrelated noise sources.
   - ➢ Provide quantitative examples.

iv. Bonus [0.25 pt]: Briefly explain how an SiPM works and the main differences between analog and digital implementations.

PDP setup based on the continuous light technique
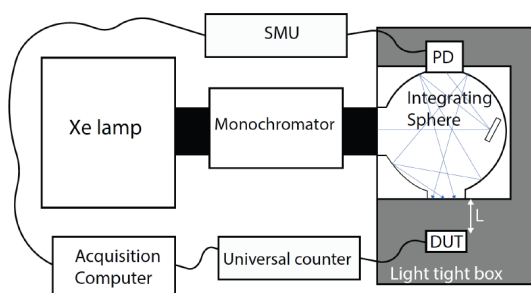
Laser scanning of the SPAD active area at several excess bias voltages

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