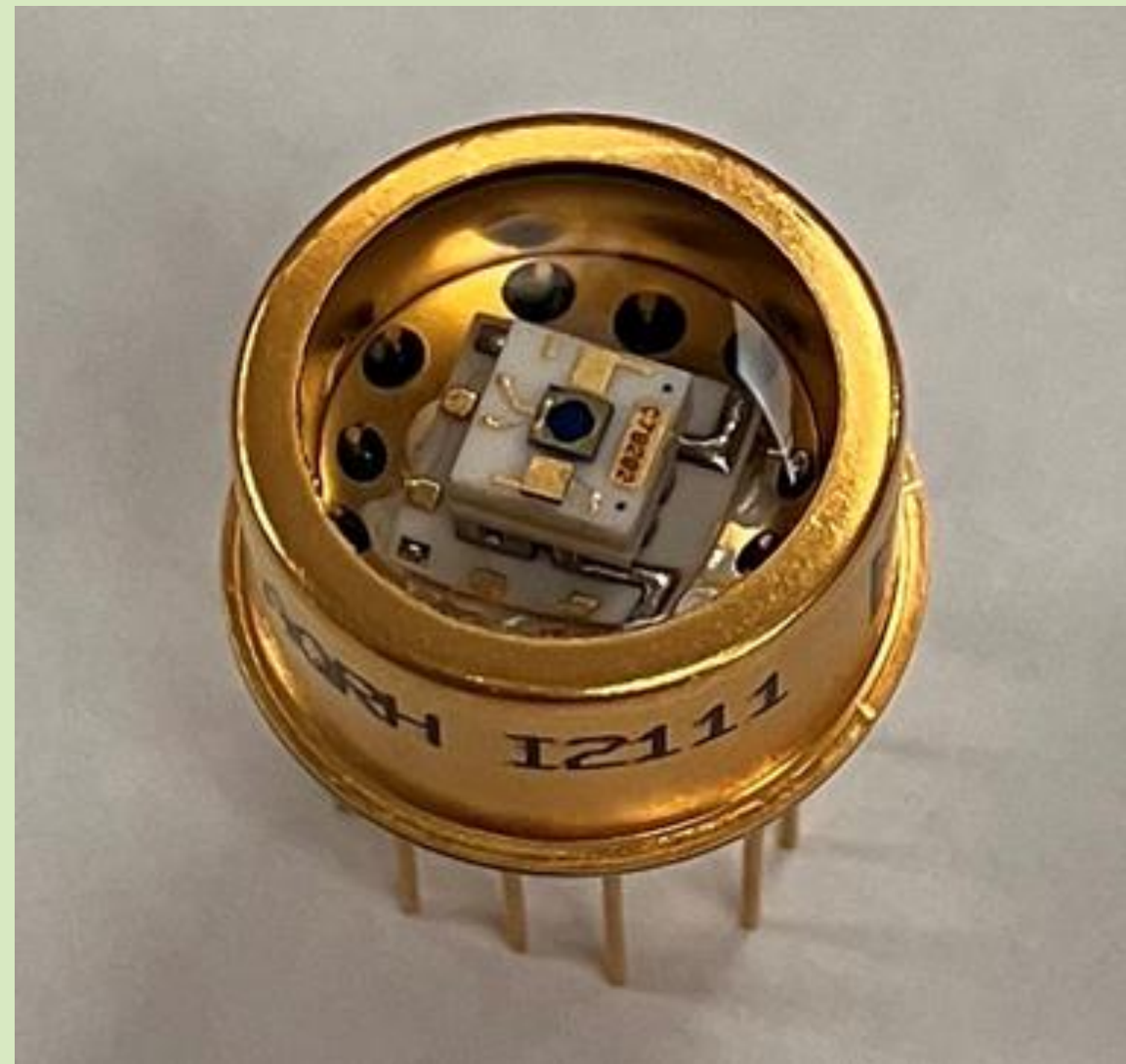


Abstract

Recent developments in silicon-based Single-Photon Counting Modules (SPCMs) demonstrate significant enhancements in Photon Detection Efficiency (PDE), temporal resolution, and wavelength coverage spanning the visible to near-infrared (NIR) spectral range. The SPCM-1064 extends high-performance photon counting into longer NIR wavelengths, delivering a typical PDE of approximately 10% at 1064 nm while maintaining PDE values exceeding 50% across the 750 – 950 nm range and greater than 60% at 830 nm and 905 nm. Its large 500 μm active area improves photon collection from divergent beams and reduces alignment sensitivity, while supporting high linearity at elevated count rates. Reported advances now extend practical silicon photon counting into the 1064 nm regime while preserving high count linearity, closing a long-standing gap between Si and InGaAs detectors. In parallel, performance-optimized timing modules from the SPCM-TR family achieve single-photon timing resolution below 200 ps full width at half maximum (FWHM), while maintaining peak PDE above 70% near 650 nm on a 180 μm active area.



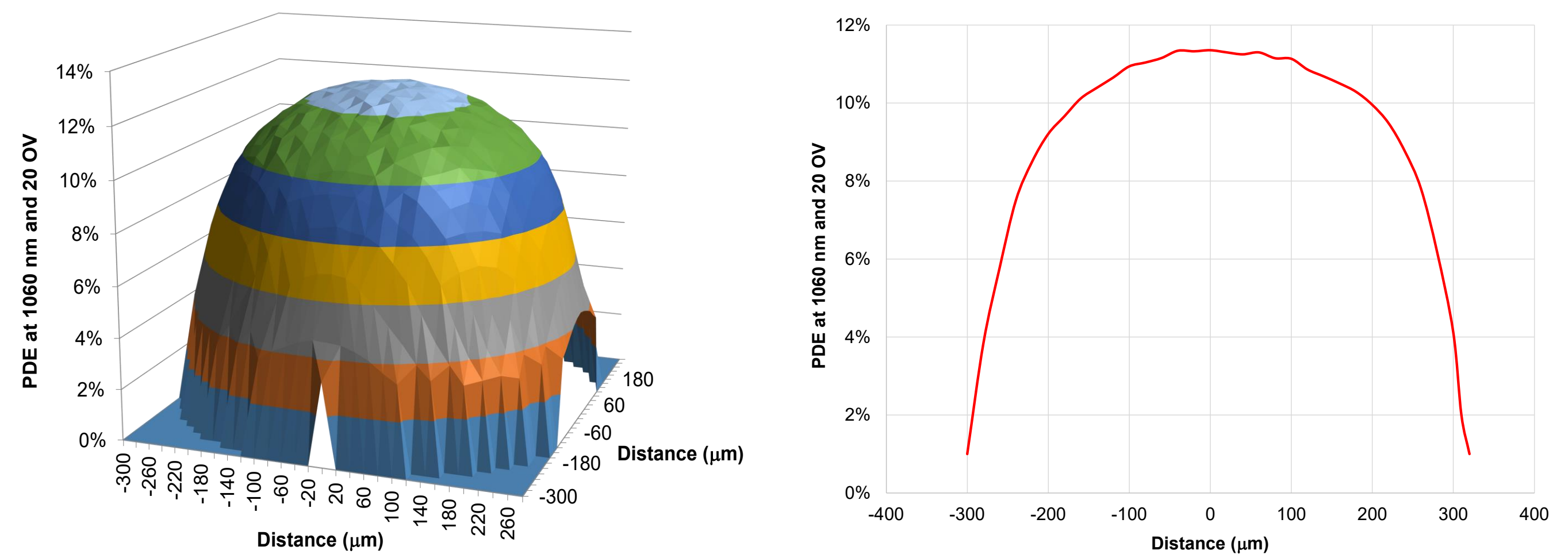
Material



- New 500 μm active area APD enhanced for 1064 nm (at least twice the active diameter of the APD in the SPCM-AQRH series)
- Chip mounted on a ceramic and thermo-electric cooler (temperature controlled)
- Detectors were built coming from two different silicon wafers. Wafer processing and assembly done in-house.
- Module deadtime set at 44 ns to limit afterpulsing
- All measurements presented were obtained with the SPCM module

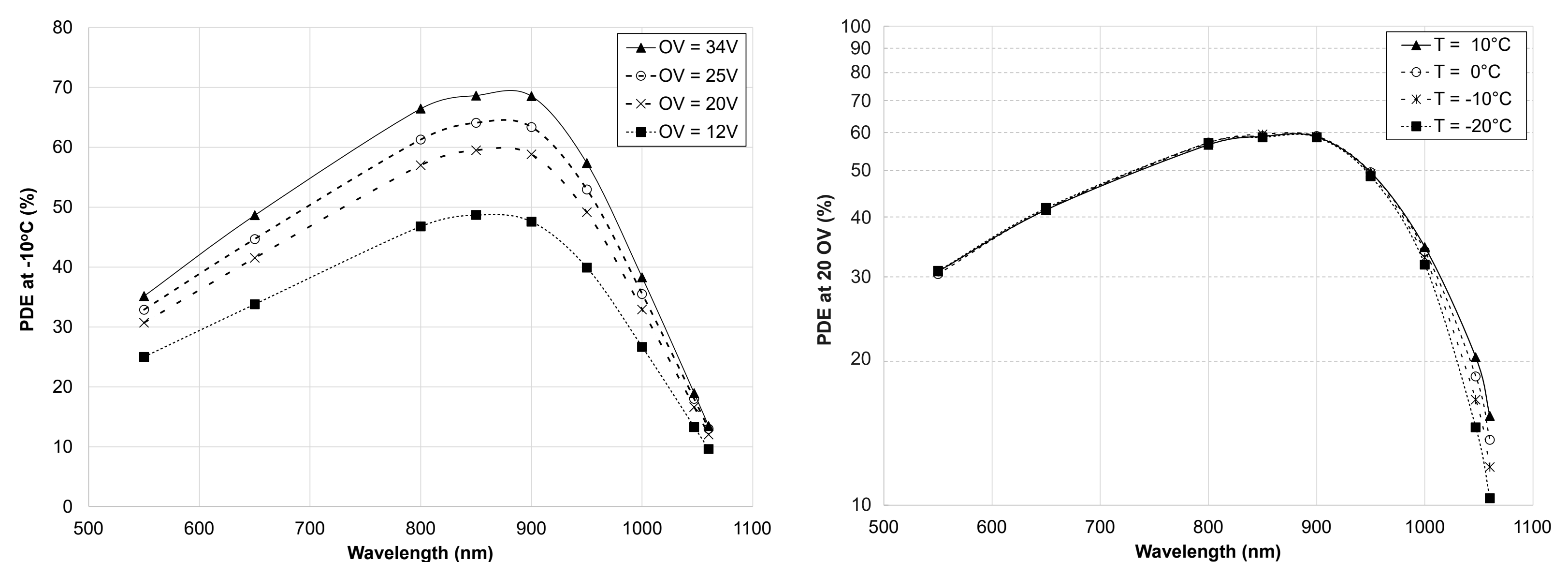
Photon Detection Efficiency (PDE)

PDE uniformity scan at 1060 nm and profile



- PDE uniformity scans at 1060 nm show consistent spatial response across the large active area.
- PDE reaches **~68% at 900 nm** and remains **>10% at 1060 nm**, confirming effective long-wavelength enhancement.
- PDE spectra under different operating conditions illustrate how **temperature tuning** improves long-wavelength PDE at the expense of increased dark counts but lower afterpulsing.

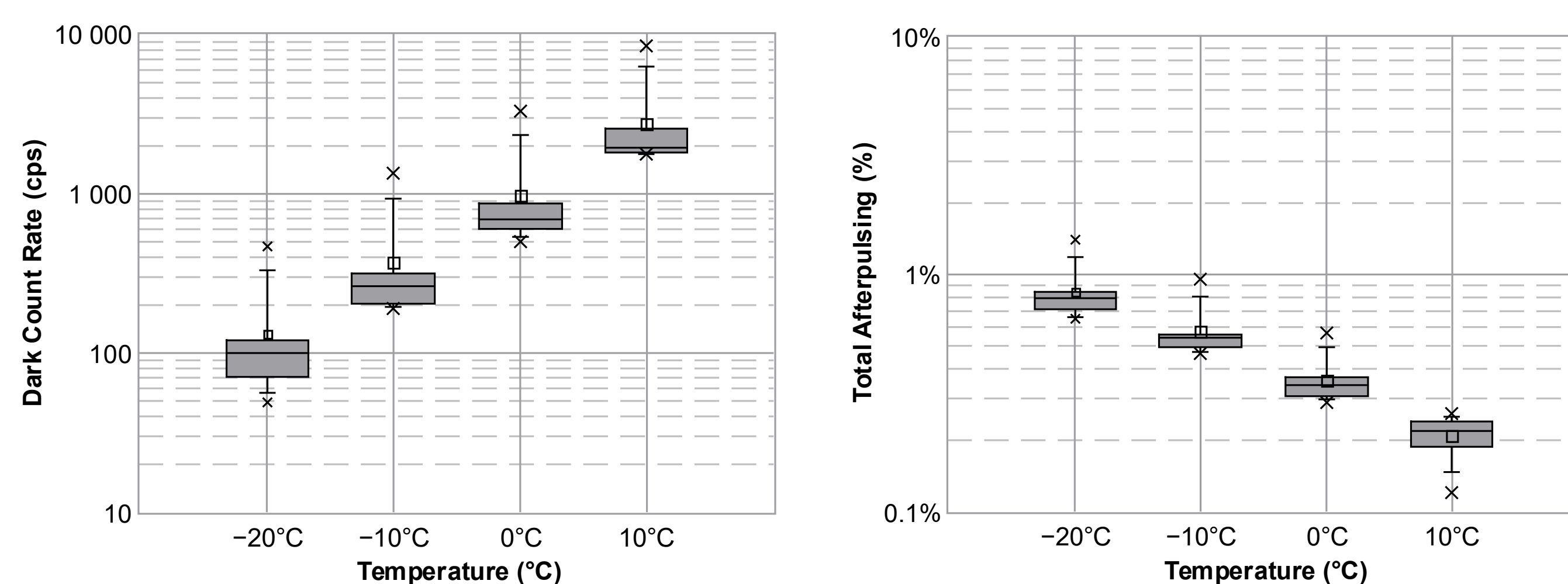
PDE spectrum for different operating conditions



Dark Count Rate and Afterpulsing

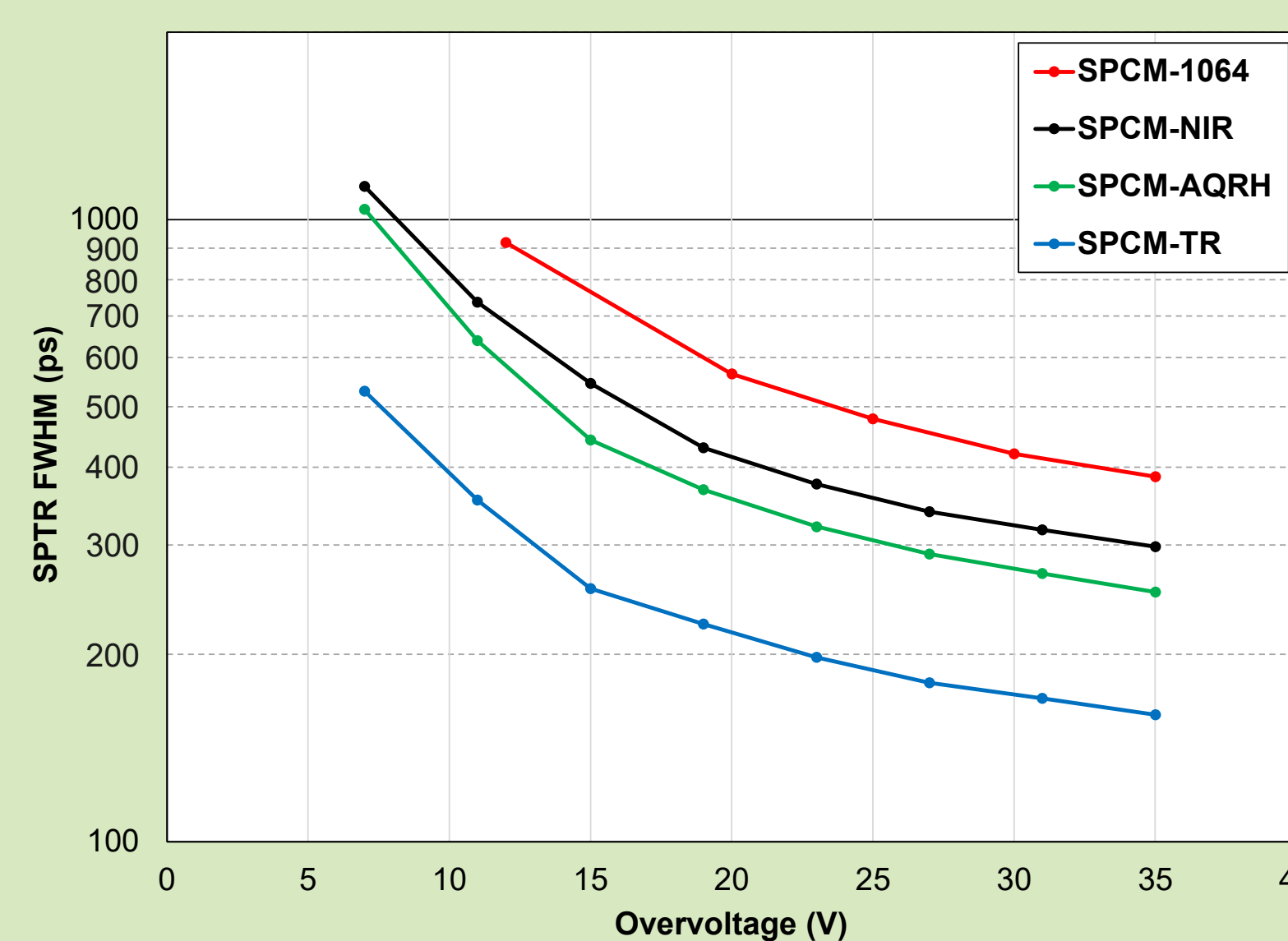
Afterpulsing (44 ns – 1 μs) remains below 1% with the module deadtime set to 44 ns, demonstrating effective suppression of trapped-carrier release even with the large 500 μm active area.

Dark count rate and afterpulsing relation as temperature is increased



Timing Performance

Single photon timing resolution is shown for all SPCM families with emphasis on later SPCM-TR reaching SPTR values as low as 160 ps on specifically selected APDs. Typical 200 ps FWHM can now be offered on SPCM-TR.



SPTR measured with 1064 nm light for SPCM-1064 and 826 nm for all other modules.



Summary

SPCM-1064 is the latest SPCM product offering to extend PDE further toward 1064 nm and silicon's detection limit while maintaining good DCR and Afterpulsing. SPCM-TR can now reach lower SPTR levels.

Enhanced long-wavelength sensitivity: >10% PDE achievable at 1064 nm and up to 68% at 900 nm.

Large 500 μm active area: Improved optical coupling, reduced alignment sensitivity, and strong count-rate linearity.

Low noise performance: Afterpulsing (44 ns – 1 μs) <1% with a 44 ns deadtime; dark-count rate optimized through temperature control.

Application-ready: Ideal for Nd:YAG systems, fiber-based sensing, quantum technologies, and NIR photon-counting instrumentation.

