SPTR of SiPMs as a function of the bias voltage, the wavelength and the temperature

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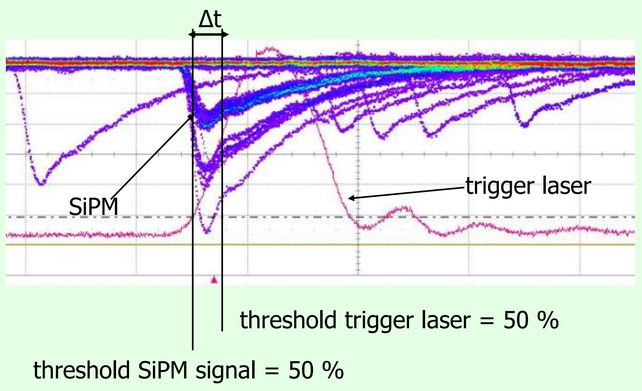
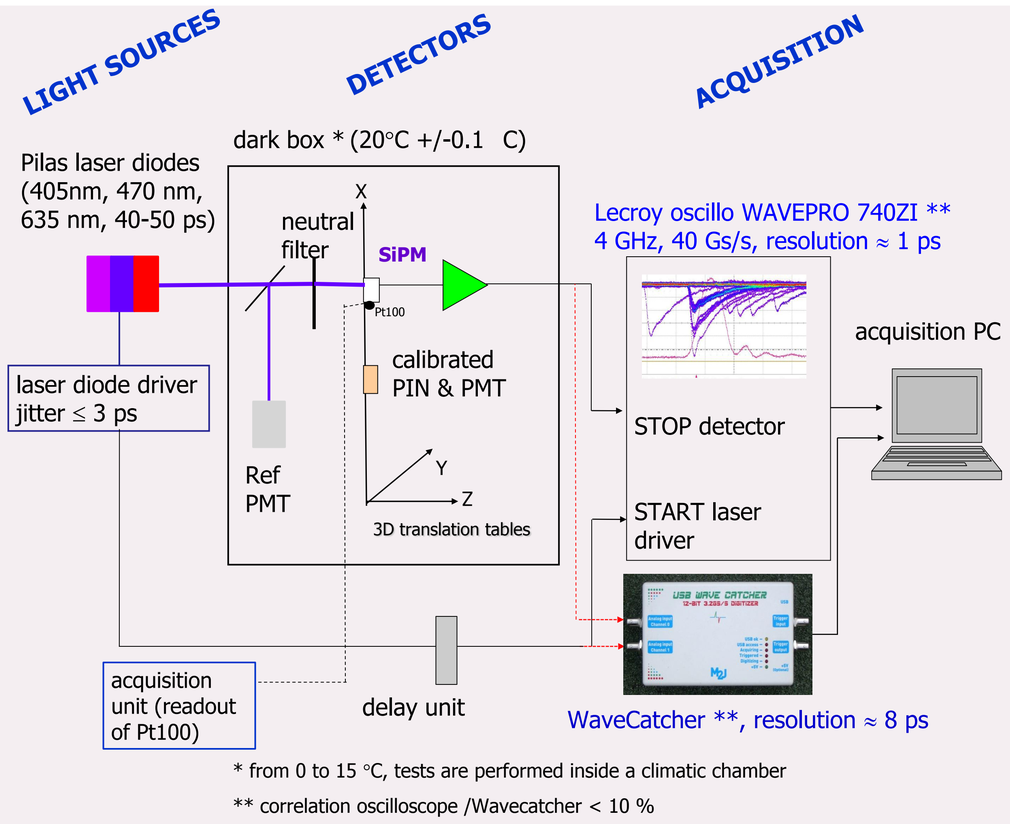
Study of the **SiPM Single Photoelectron Timing Resolution** (SPTR) variations with:

- ❖ the bias voltage
- ❖ the wavelength of the pulsed incident light : 405 – 467 - 635 nm
- ❖ the temperature : 0°C to 20 °C

Measurement principle: measurement of the difference of time (Δt) between the laser trigger signal and the SiPM signal (at the amplifier outpout) → histogram of Δt → SPTR = FWHM



measurement accuracy=± 5 %



* from 0 to 15 °C, tests are performed inside a climatic chamber

** correlation oscilloscope /Wavecatcher < 10 %

List of the studied SiPMs (1 and 9 mm²)

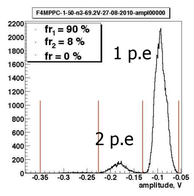
Producer	Ref SiPM	pixel size (µm)	V_{BD} (V)	
AdvanSiD	ASD-1S-M-50	50x50	29	1 mm²
HAMAMATSU	S10362-11-25	25x25	69,2	1 mm²
HAMAMATSU	S10362-11-50	50x50	68,3	1 mm²
HAMAMATSU	S10362-11-100	100x100	68,7	1 mm²
HAMAMATSU	MPPC-10-50S	50x50	69,1	1 mm²
HAMAMATSU	MPPC-10-100S	100x100	69,1	1 mm²
Sensl	SPM1020X13	20x20	27	1 mm²
Sensl	SPM1035X13	35x35	27,5	1 mm²
AdvanSiD	ASD-3S-M-50	50x50	31	9 mm²
HAMAMATSU	S10362-33-25	25x25	69,5	9 mm²
HAMAMATSU	S10362-33-50	50x50	69,5	9 mm²
HAMAMATSU	S10362-33-100	100x100	69,2	9 mm²
Sensl	SPM3035X13	35x35	27	9 mm²

Full characterization of the SiPMs:

Before measuring the SPTR, each SiPM is characterized : breakdown voltage (V_{BD}), gain, dark count rate (DCR) as a function of the temperature → adaptation of bias voltage with the temperature in order to keep V_{BD} constant

Illumination conditions:

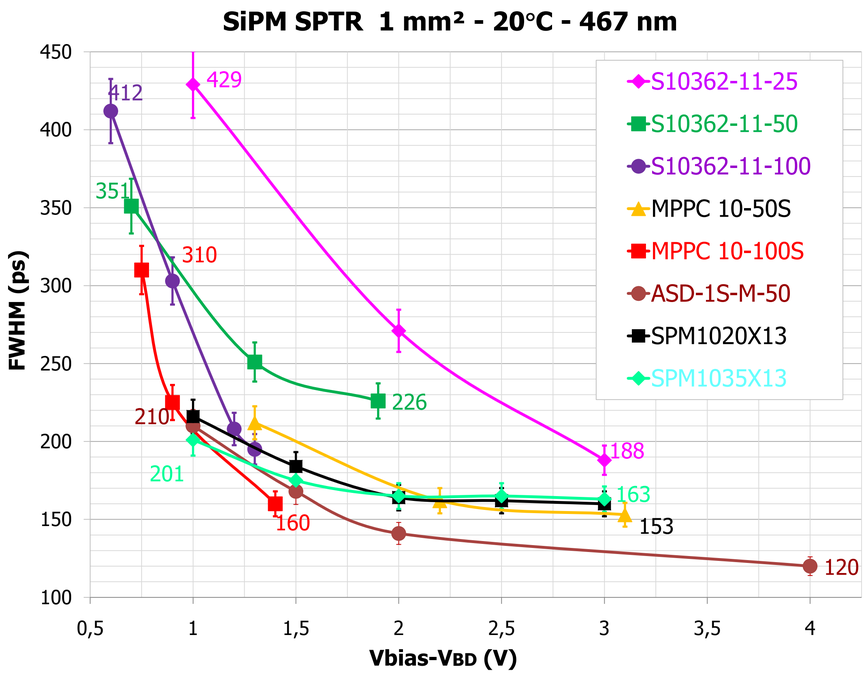
Very low light flux ≈ 1-2 photons/pulse →at the SiPM output: majority of 0, few pulses α 1 p.e, very few signal α 2 p.e (SiPM cross-talk)

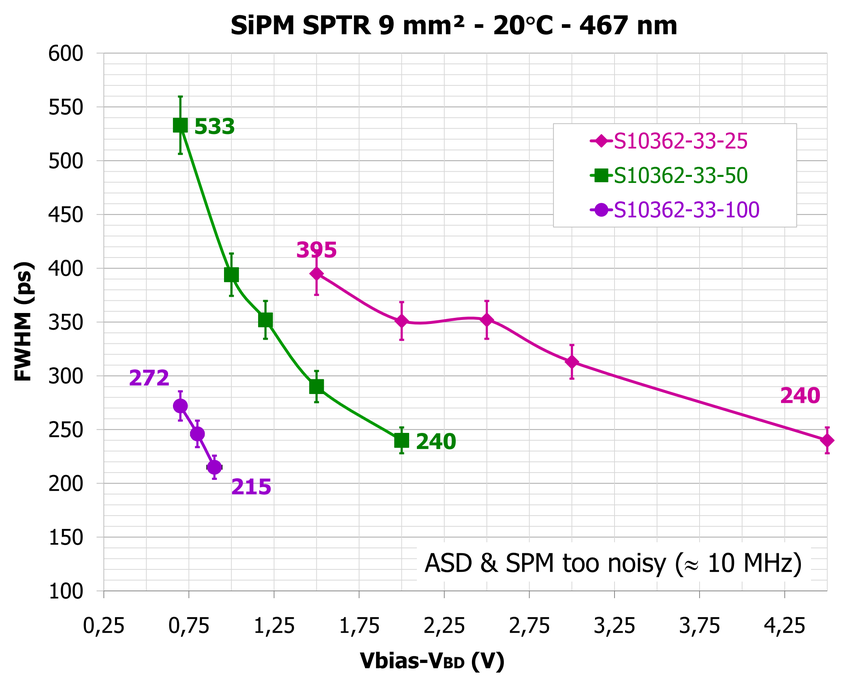


Contribution to the timing resolution:

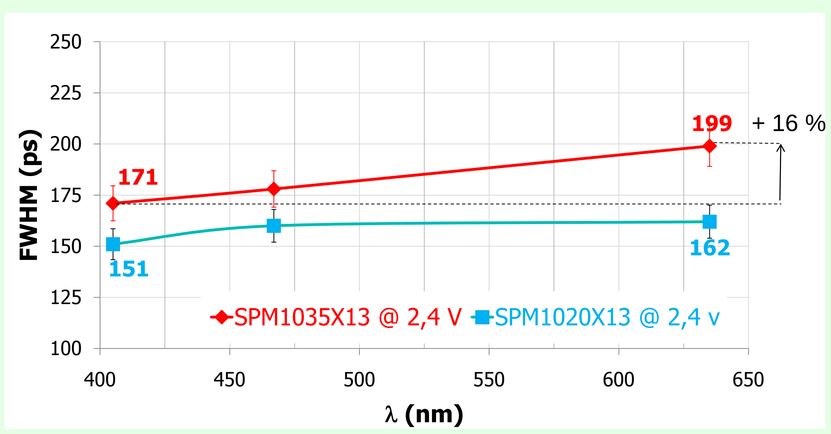
- laser jitter ≤ 3 ps
- 40 ps <laser pulse width < 50 ps
- timing resolution of the Wavecatcher ≈ 8 ps
- timing resolution of the oscilloscope ≈ 1 ps

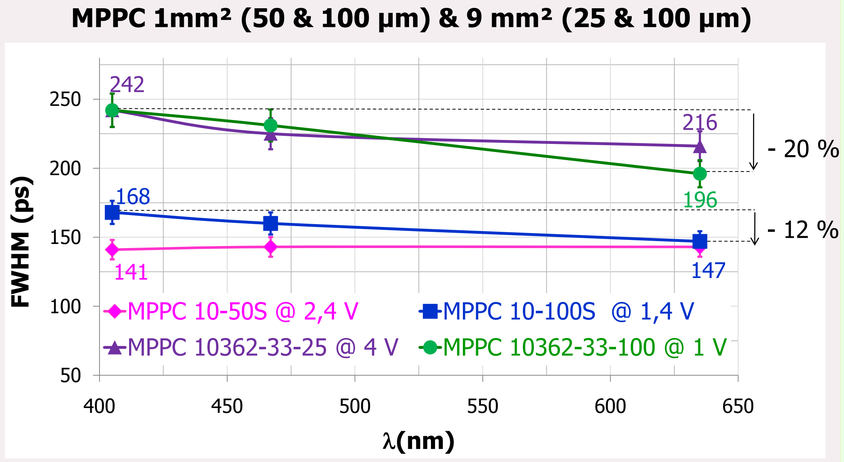
Study of the SPTR variation as a function of the bias voltage

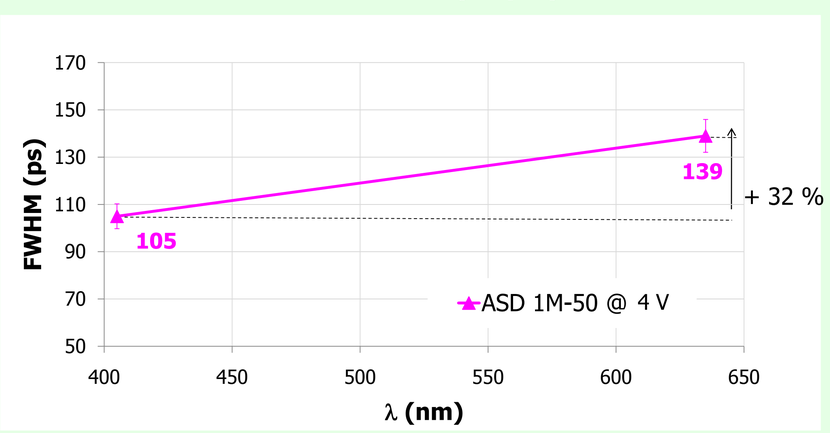




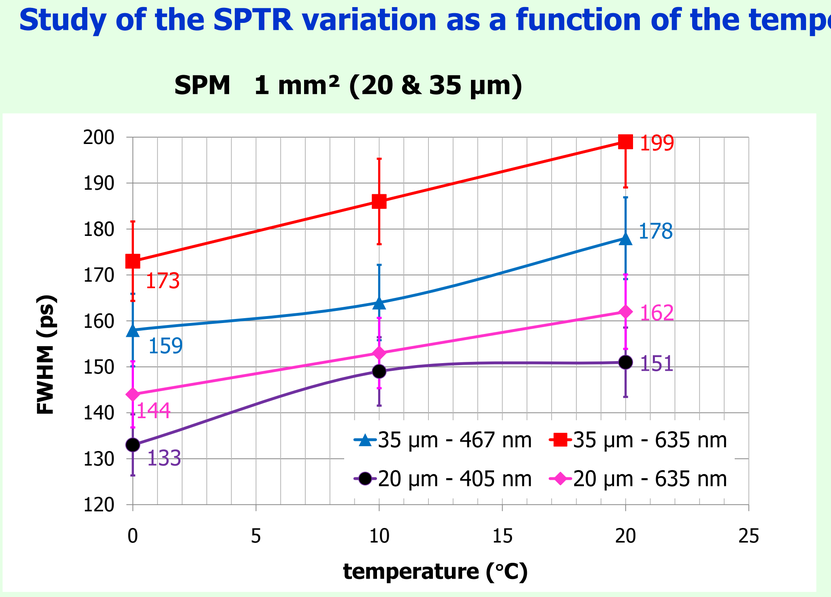
Study of the SPTR variation as a function of the wavelength at 20 °C and with Vbias max (above this value the timing resolution is difficult to measure due to the high DCR)

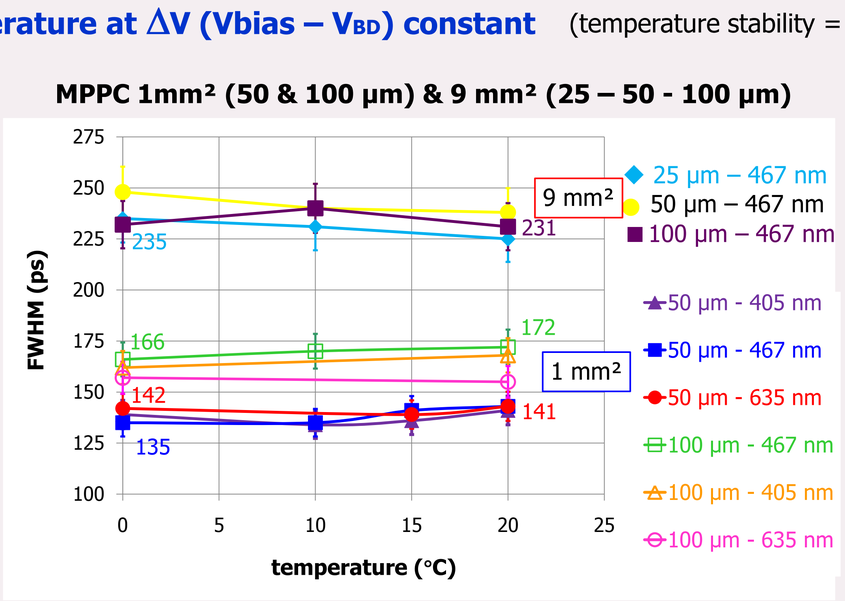


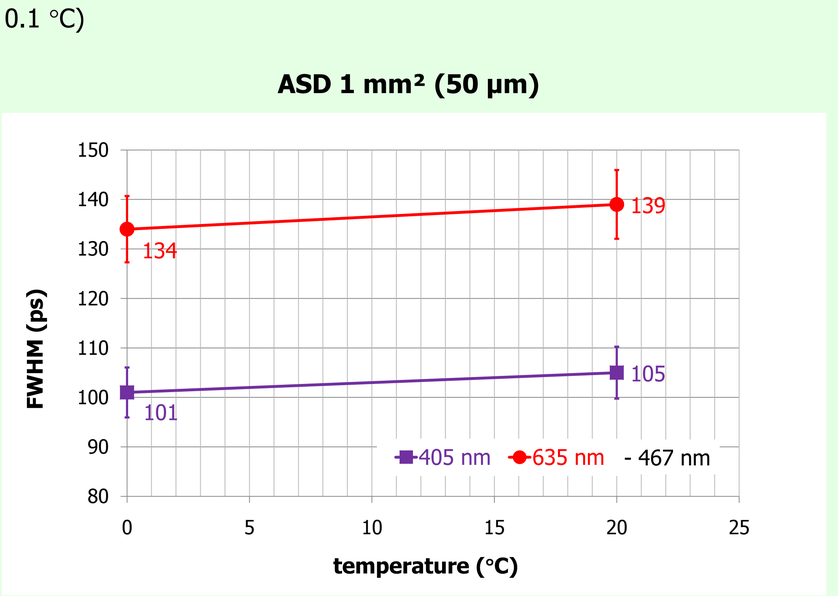




Study of the SPTR variation as a function of the temperature at ΔV (Vbias – V_{BD}) constant (temperature stability = ± 0.1 °C)







Summary

SPTR variation with the bias voltage

Improvement of the SPTR with the increasing of the bias voltage

Best SPTR @ 467 nm & 20°C

1 mm² : 120 ps (FWHM)
9 mm² : 215 ps (FWHM)

SPTR variation with the wavelength

405 nm — λ — 635 nm

- SPM: small degradation (5 %-15 %)
- MPPC: small improvement:
  5- 10 % for 1 mm²
  10 – 20 % for 9 mm²
- ASD: degradation (30 %)

SPTR variation with the temperature

0°C — temperature — 20°C

- ❖ SPM: small degradation (5-15 %)
- ❖ MPPC: stable for 1 and 9 mm²
- ❖ ASD: stable

Work still under study

Explanation of :

- ➢ the timing distribution shape
- ➢ the SPTR differences between 2 SiPMs of the same kind but with different pixel size
- ➢ the SPTR variation with the temperature