IFR R&D status @ Padova

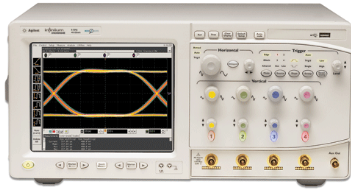
Flavio Dal Corso INFN-Padova

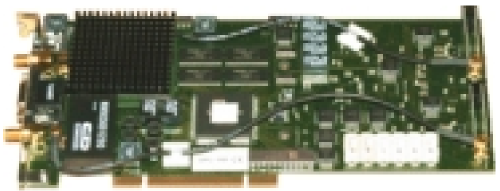
Objectives

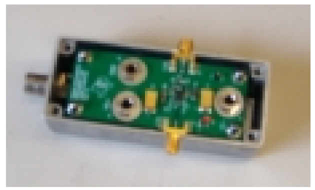
- Primary interest: front-end and read-out electronics of the IFR detectors.
- Immediate goal: to become familiar with fast light detectors (Si-PM) and device characterization and comparison.

Equipment & Setup

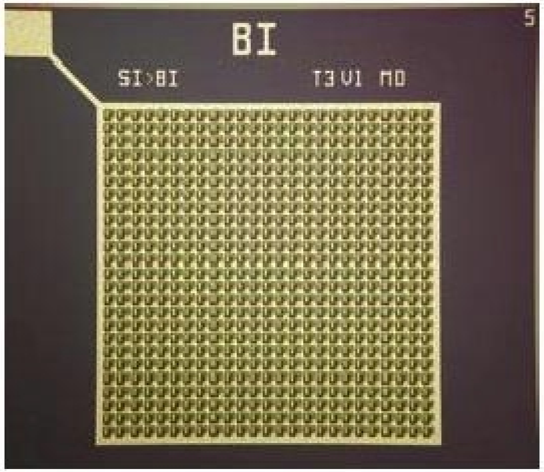
- Agilent DSO80604B scope (6 GHz - 40 GS/s).
- Picosecond Laser System (PiLas PIL040F: 400 nm, 40 ps)
- Kithley 6487 Picoammeter/Voltage Source
- Ortec 9327 Constant Fraction Discriminator
- Wideband amplifier THS4303 (1.5 GHz, x10 amp)
- Becker&Hickl SPC 130 TDC (σ=5 ps)
- SiPM by IRST and Hamamatsu



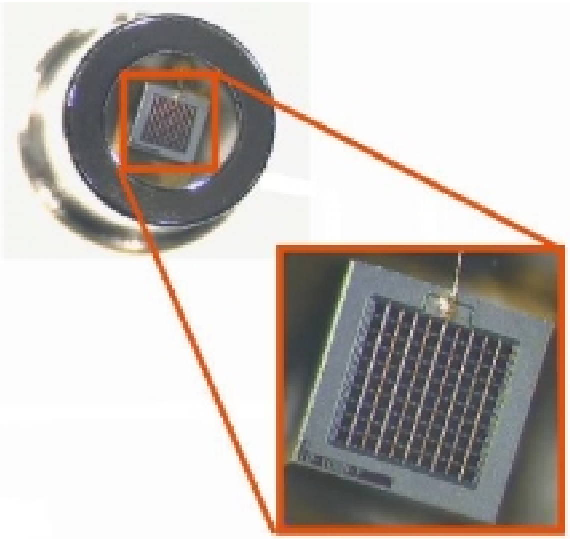




Devices under Test



- SiPM produced by IRST (Istituto di Ricerca Scientifica e Tecnologica Trentino).
  - 1x1 mm^2 active area
  - 25x25 pixels
  - 40x40 μm^2 pixel size
- MPPC (Multi Pixel Photon Counter) produced by Hamamtsu.
  - 1x1 mm^2 active area
  - 20x20 pixels
  - 50x50 μm^2 pixel size



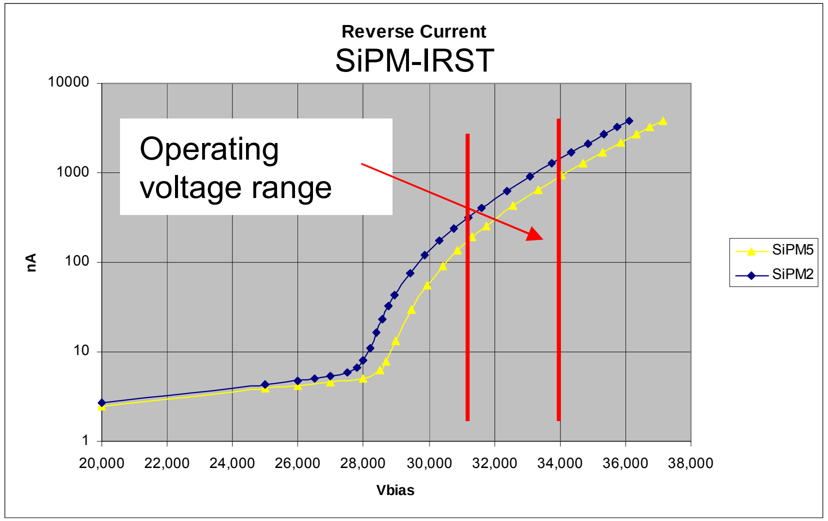
Different makers use different names: in both cases they are multi-pixel avalanche photodiode operated in geiger mode.

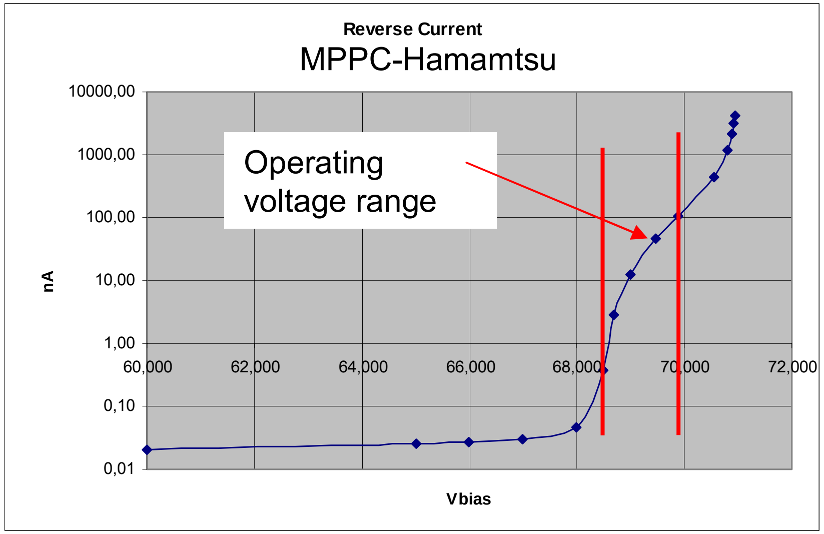
Devices Characterization

Few samples of SiPM by IRST and just one MPPC by Hamamtsu was characterized measuring:

- Reverse current,
- Signal shape,
- Gain,
- Dark rate,
- Time resolution.

Reverse Current



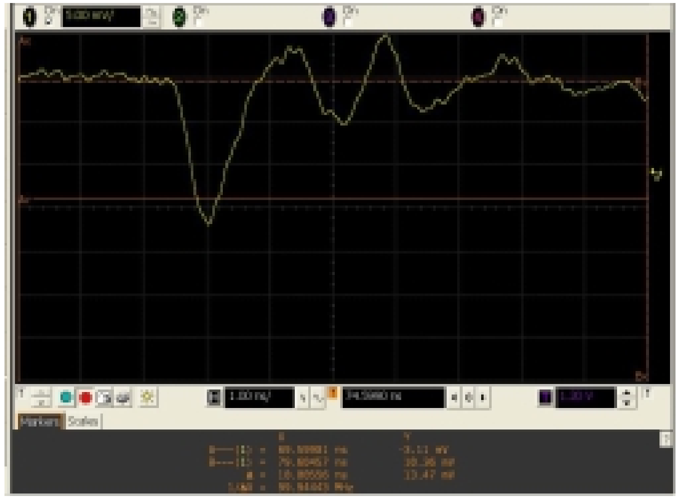


SiPM vs MPPC:

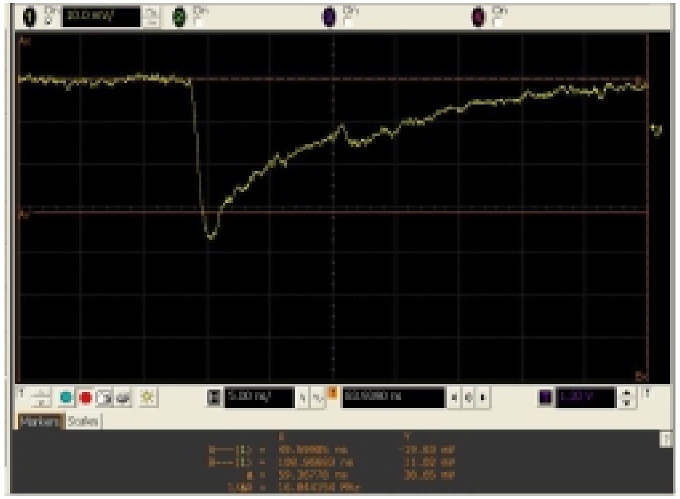
- Lower breakdown voltage
- Higher reverse current (⇒ higher noise)

Signal Shape

SiPM-IRST



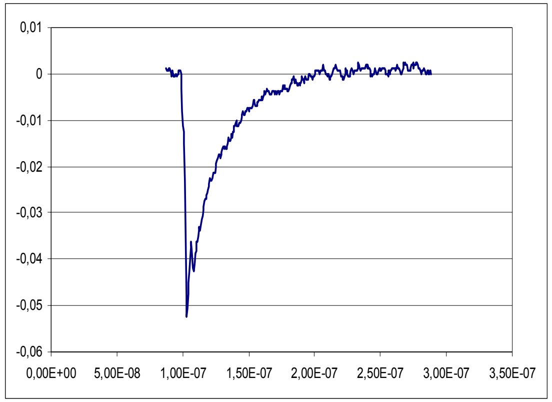
MPPC-Hamamtsu



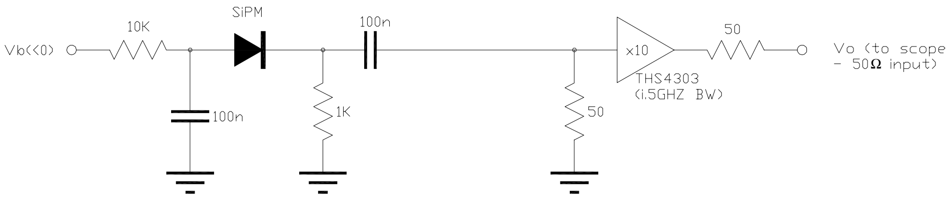
SiPM vs MPPC (marker at 5th γ):

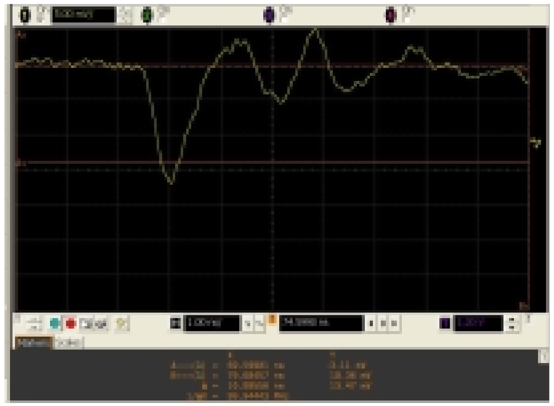
- Faster signal (r.t. ~0.2ns vs ~1ns)
- Lower gain
- No exponential tail

SiPM Signal Shape



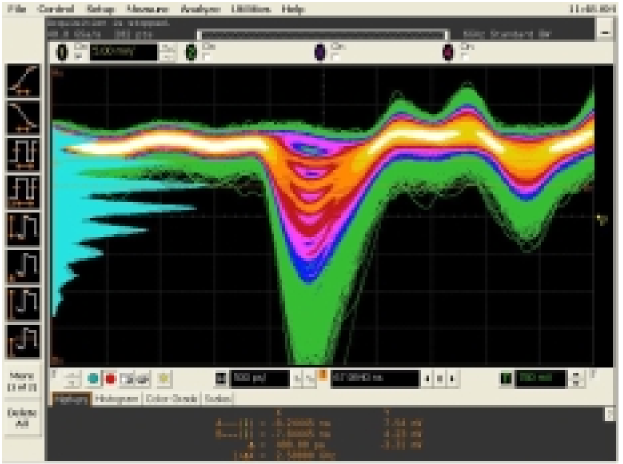
SiPM waveform shows an unexpected shape w.r.t the shape reported by IRST, (upper picture) in spite of a very simple polarization end amplification circuit.
Problem under investigation.



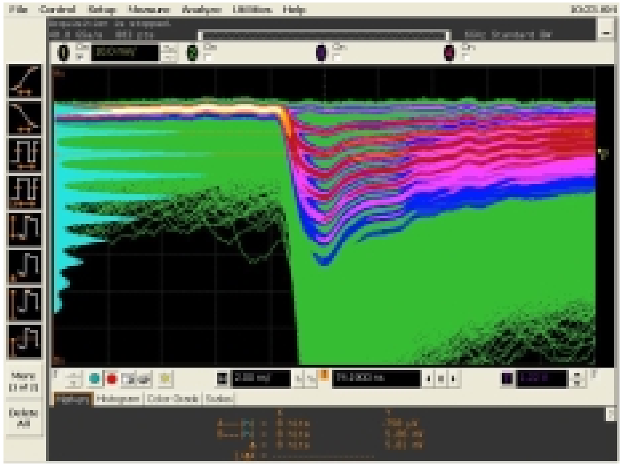


Gain

SiPM-IRST



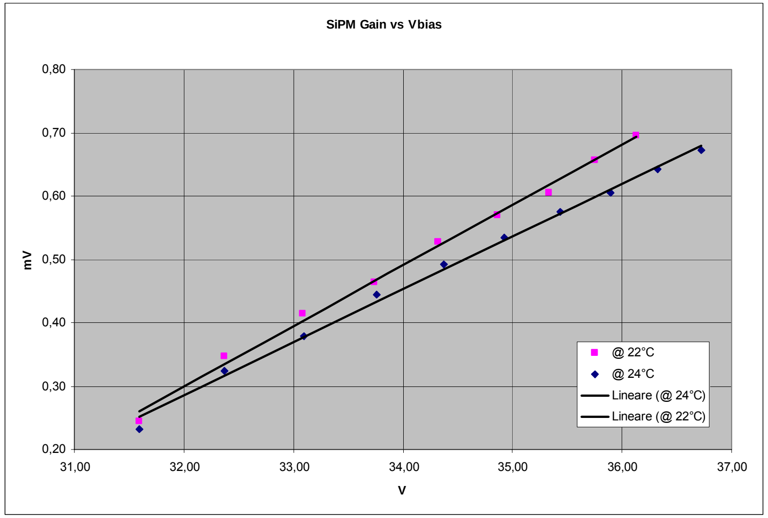
MPPC-Hamamtsu

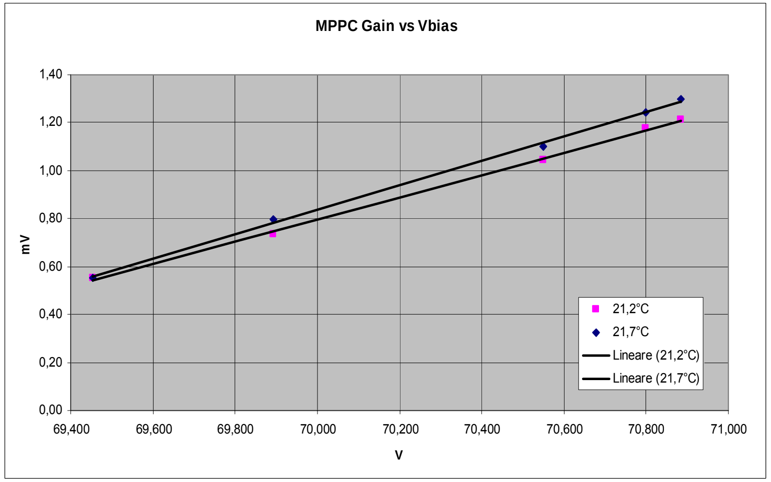


SiPM vs MPPC:

- Lower gain (~ a factor 2)
- Higher noise (Gaussian width)

Gain vs Vbias





Gains are reported as voltage at the amplifier input ($\Rightarrow$ mV over 50Ω)

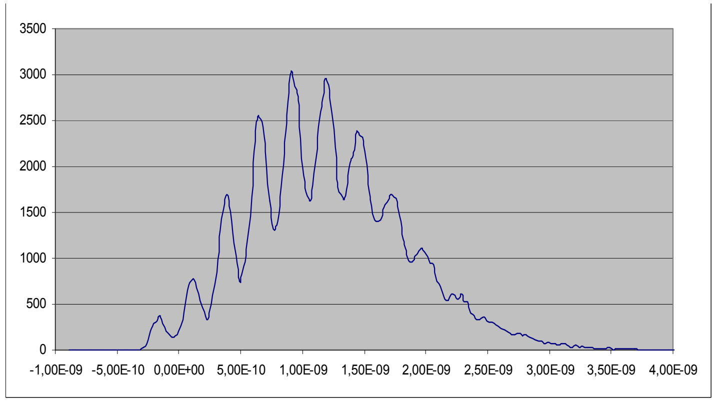
- To get a reasonable gain SiPM must be operated at ΔV ≈ 4 - 8V, against 1.5 – 2.5 V for the MPPC.
- Good linearity vs Vbias and weak T dependence, as expected.

SiPM Gain Problems

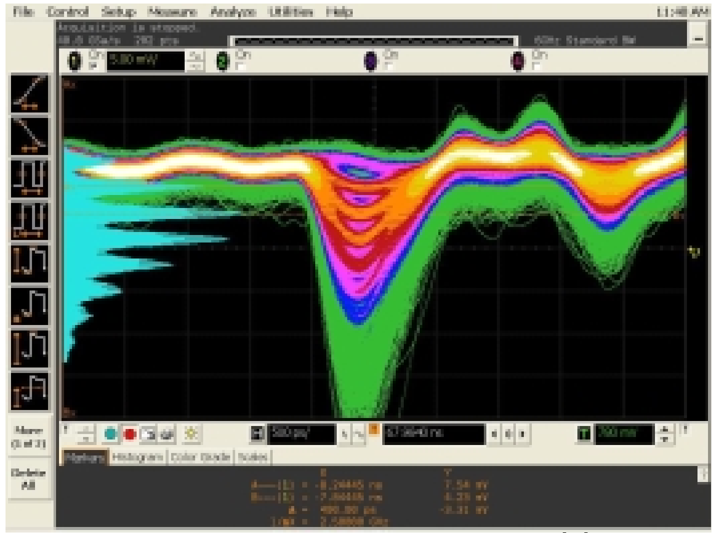
IRST reports a SiPM spectrum with a clear discrete structure even at low working voltage. This is due (probably) to the different acquisition system:

- IRST uses charge integrating ADC
- We use peak sensing ADC

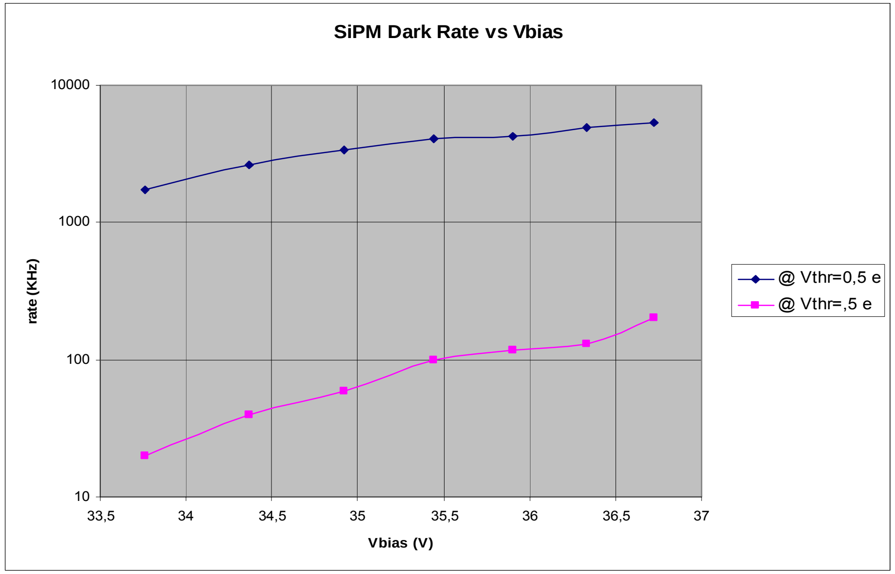
This mean that for best performances some signal conditioning is required (noise filtering). To be investigated.

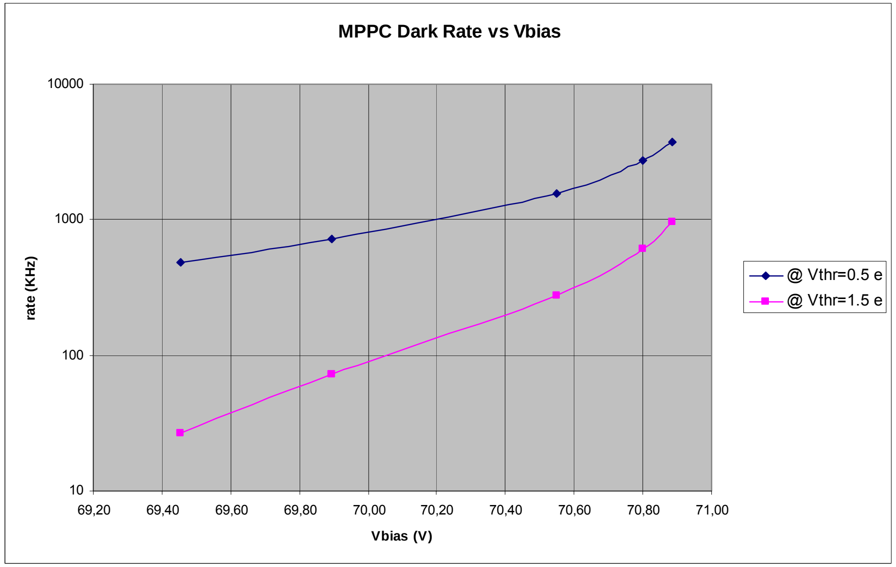


ΔV=2V and charge integration ADC (↑)
ΔV=7V and peak sensing ADC (↓),



Dark Rates



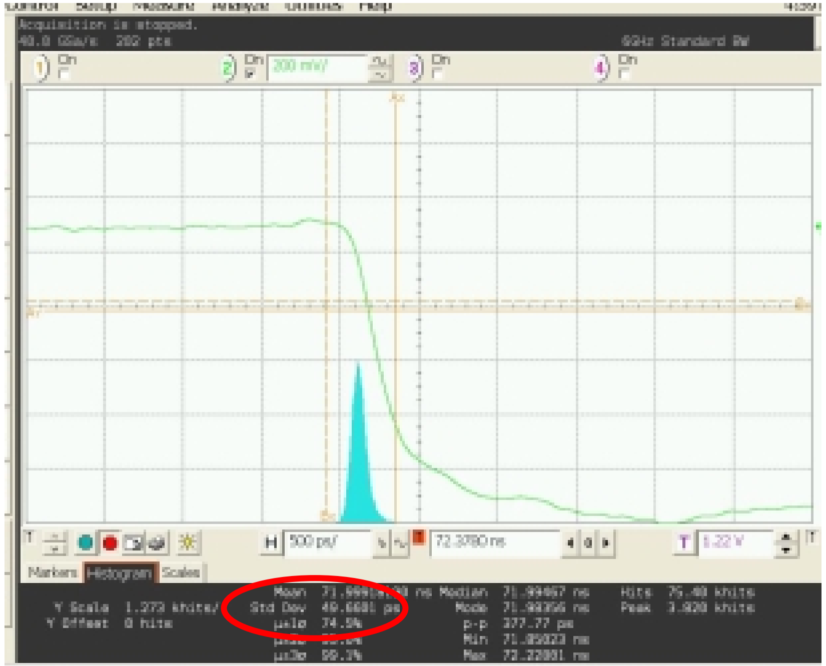


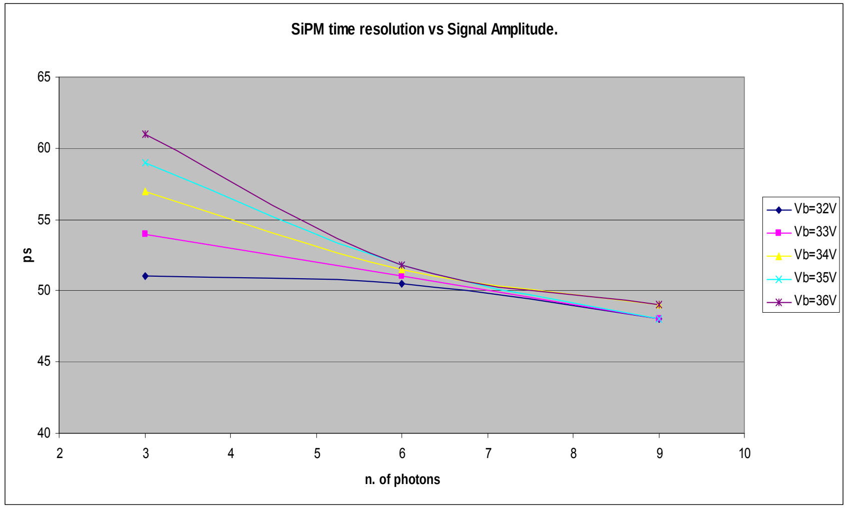
- At low threshold (< 1 γ), SiPM more noisy than MPPC.
- At higher thresholds SiPM becomes more silent.

It should be noted that SiPM is operated at $\Delta V \approx 5 - 8V$,
while MPPC at 1.5 – 3 V.

SiPM - IRST time resolution

- Jitter of the CFD output w.r.t. PiLas trigger (measured with the "histogram function" of the scope).

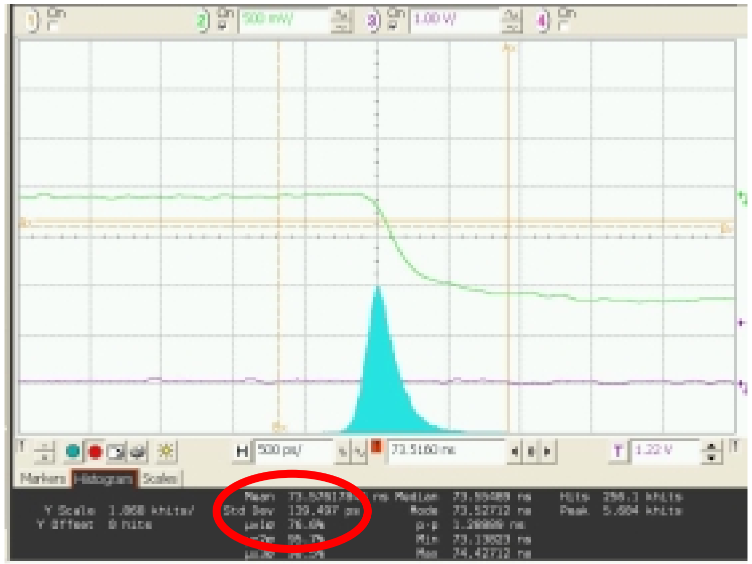




- Strong dependence on Vbias al low amplitude.
- Almost constant at low Vb or high enough signal (≥6 photons)

MPPC - Hamamatsu time resolution

Hamamatsu device, in spite of the higher gain exhibits a worse time resolution; ~140 ps (due to slower rise time).



Consideration on SiPM-IRST time resolution

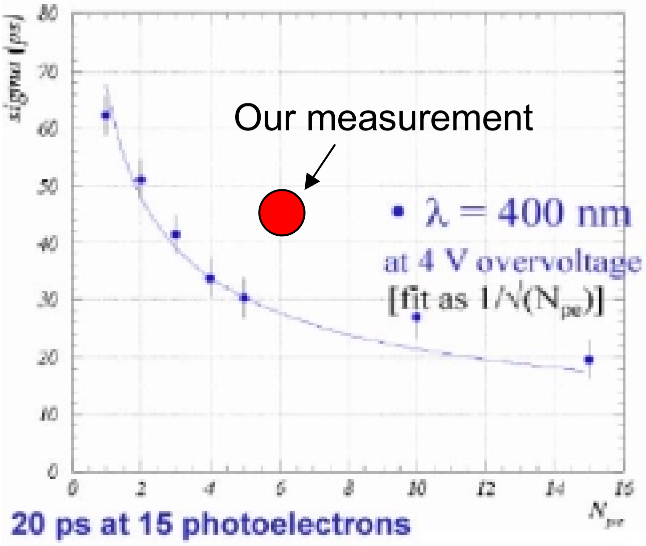
Time resolution is due to many terms; trying to de-convolve them, and assuming a total time resolution of 50 ps:

$$\sigma_{mis} = \sqrt{\sigma^2_{SiPM} + \sigma^2_{CFD} + \sigma^2_{Pilas} + \sigma^2_{scope}}$$

$$\sigma_{CFD} \approx 20\,ps \qquad \sigma_{Pilas} \approx 3\,ps \qquad \sigma_{scope} \approx 5\,ps$$

$$\Rightarrow \sigma_{SiPM} \approx 45\,ps$$

This is a very good result; even a better result was reported, with high enough signals.



[G. Collazuol et al., VCI 2007, to be published in NIM A.]

Conclusions

Simple measurements was performed over too few devices.
The work must continue trying to improve/complete the measurements and increase our understanding of the device.

However these preliminary results confirm that SiPM is an excellent candidate for the readout of fiber based detectors, with some very well recognized point of force:

- Compactness
- Simple to readout
- Simple to polarize
- Excellent time resolution