Energy and time resolutions of Hamamatsu Photonics S10362-11-050P and S10362-33-050C Multi-Pixel Photon Counters

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The interest in Silicon photomultipliers (SiPM) or Multi-Pixel Photon Counters (MPPC) has been increasingly spreading because of several advantages with respect to ordinary photomultipliers, i.e. low-voltage operation, small sizes, single photon counting capabilities, magnetic field immunity. In the present work [1] we have investigated the time and energy resolution of two commercial SiPM with different number of cells, in order to evaluate their applicability as few photons detector in a Ring Imaging Cherenkov counter (RICH).

The two sensors are the Hamamatsu Photonics models S10362-11-050P and S10362-33-050C, with main features listed in Fig. 1, both having single cell size of $50 \times 50\ \mu m^2$.

Parameter	S10362-11-050P	S10362-33-050C
area [mm x mm]	1 x 1	3 x 3
number of pixel	400	3600
pixel size [µm x µm]	50 x 50	50 x 50
fill factor [%]	61.5	61.5
peak sensitivity wavelength [nm]	440	440
operating voltage [V]	70±10	70±10
terminal capacitance [pF]	35	320
gain	7.50E+05	7.50E+05

Figure 1. Specifications of the two Silicon photodetectors studied.

MPPCs are known to perform very well in timing measurements owing to their typical signal shape, having very short rise time. As a matter of fact, the timing performance is dominated by the front-end electronics bandwidth. For the present measurements a 63× pre-amplification/shaping board (Fig. 2) was designed based on the scheme suggested by Hamamatsu.

Amplification is mandatory for the detection of small pulses corresponding to a little average number of photons. Sample signals with no light excitation of the sensor are displayed in Fig. 3.

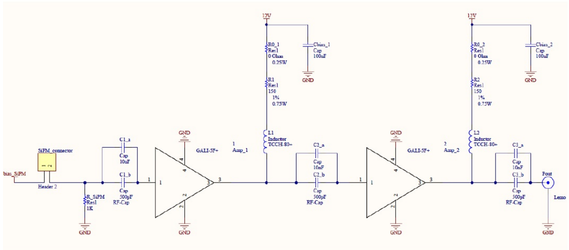

Figure 2. Layout of the front-end electronics.

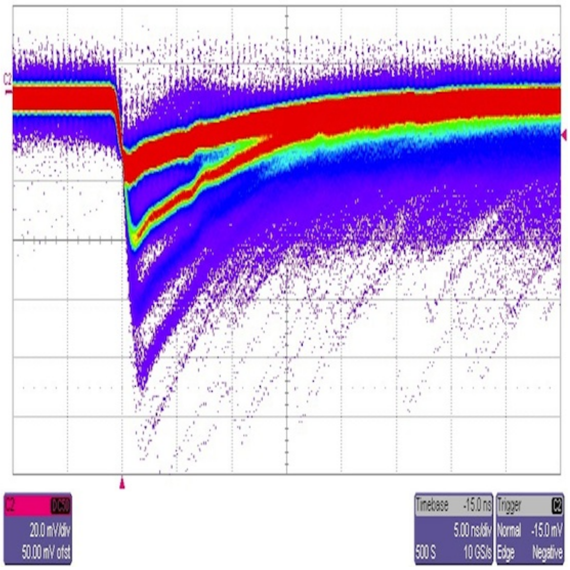

Figure 3. Dark-Count of the 400 cells SiPM. Horizontal Scale: 5 ns/div; Vertical Scale: 20 mV/div.

The measurement set-up is illustrated in Fig. 4. The light source was a solid state laser PIL040SM by Advanced Laser Diode Systems Berlin, Germany, emitting short (σ=20 ps) pulses at wavelength $\lambda = (409\pm1)$ nm, with externally triggered repetition rate, chosen to be 25 Hz.

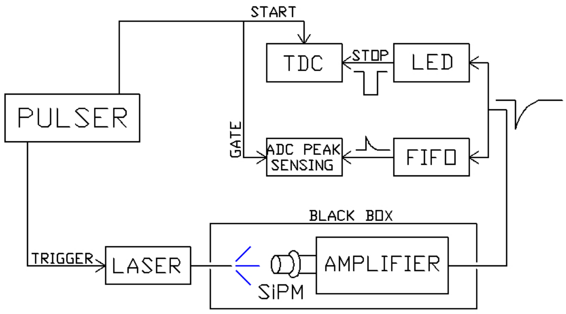

Figure 4. Sketch of the time resolution measurement setup.

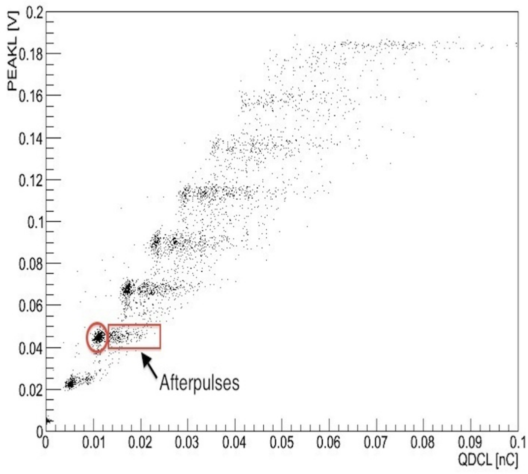

Figure 5. Charge-amplitude correlation.

The light pulse was directed to the MPPC, enclosed in a lightproof box, through fiber optics. The signal from the MPPC front-end board was subsequently split in order to get time and energy simultaneous measurements. Energy was obtained by a Peak Sensing ADC Ortec AD811 (1 mV/channel), while time was measured with respect to the laser pulse trigger time by means of a TDC CAEN C414 (25 ps/channel).

Time resolution is then measured by the width of the time distribution between the start time of the trigger and the time tag of the signal generated by the MPPC. Peak sensing rather than charge digitizer was chosen because of its immunity to afterpulses, which spoil the photoelectron resolution, as illustrated by the charge-amplitude scatter plot (Fig. 5).

The event-by-event analysis, owing to the time-energy correlation, allowed to tag the individual photoelectron contribution to time resolution, by means of event selection on the energy value (individual peaks in sample Fig. 6).

The measurements were performed for several

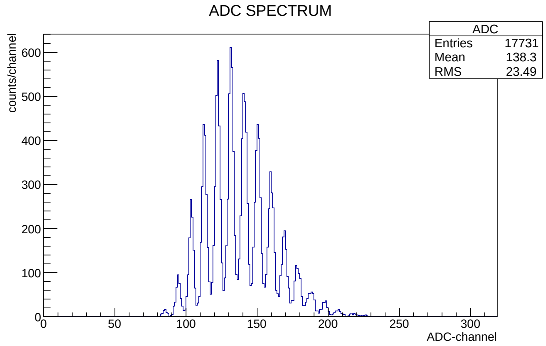

Figure 6. Energy response (photoelectron peaks) of the 400 cells SiPM at a voltage of 70.3 V and 10% laser power.

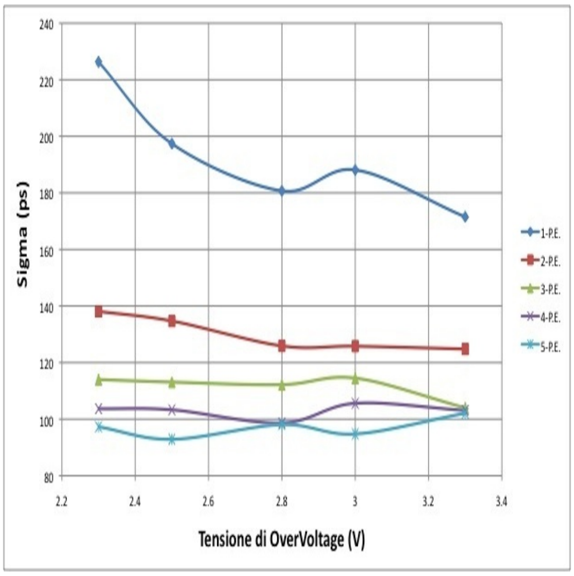

Figure 7. Time resolution (sigma) as a function of overvoltage V_{OV} of individual photoelectrons levels for the SiPM of 400 cells.

values of the over-voltage, which allows for gain adjustment. Time spectra acquired from the TDC in each run and photoelectron-selected were analyzed by gaussian fit and the σ values were extracted (Fig. 7). Present results show that the major contribution to resolution comes from the detection of the first photoelectron and that it decreases with increasing over-voltage. Energy resolution was extracted through a peak fitting procedure. For a given n-th photoelectron, the corresponding resolving power was quoted as the maximum number k of photons which can be counted in the spectrum (Fig. 8) such that $n \times \sigma_k = d$, where d is the distance between two subsequent peaks, $\sigma_k^2 = \sigma_{noise}^2 + k\sigma_1^2$, σ_1^2 is the standard deviation of the first photoelectron peak.

Results of this analysis for the 400 pixel detec-

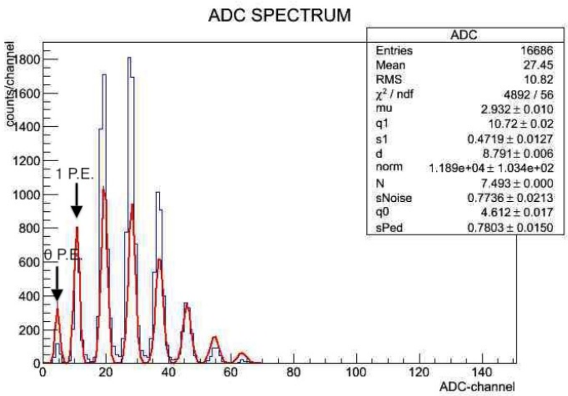

Figure 8. Energy resolution analysis for the 400 cells SiPM.

tor are summarized in Fig. 9. Results for the 3600 pixel detector are similar, however affected by a larger dark counts and cross-talk which spoils (Fig. 10) the resolution significantly.

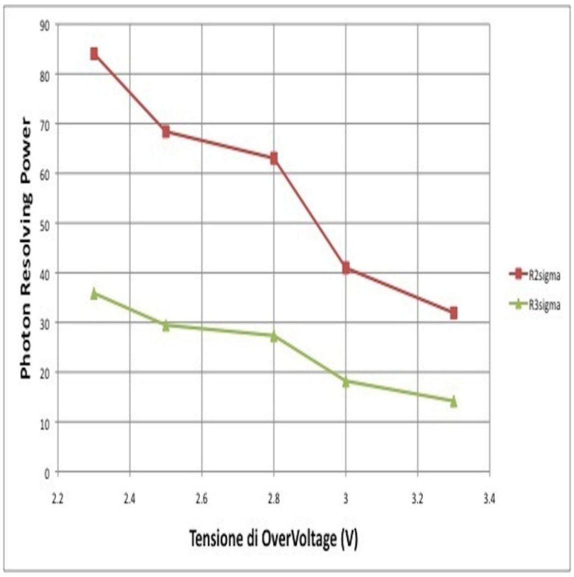

Figure 9. Energy resolution as a function of overvoltage V_{OV} for the 400 cells SiPM.

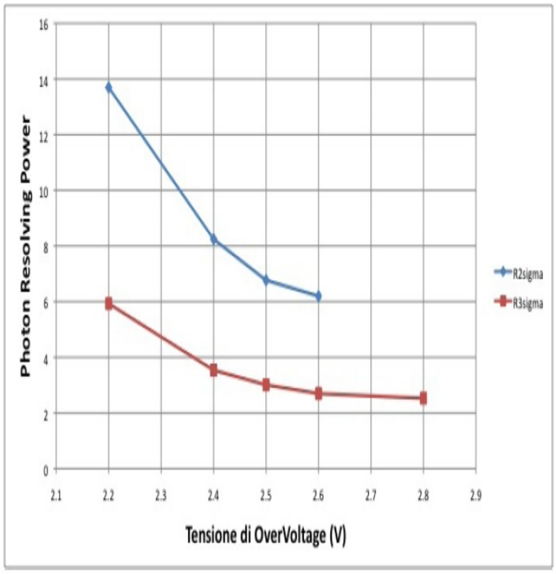

Figure 10. Energy resolution as a function of overvoltage V_{OV} for the 3600 pixels device.

REFERENCES

1. G. Galetta, "Risoluzioni energetiche e temporali di rivelatori SiPM", Tesi di Laurea Magistrale in Fisica, Curriculum di Tecnologie Fisiche Innovative, Bari, 2012 and references therein