Silicon PhotoMultipliers, introducing the Digital Age in Low Light Detection

The Department of Science and High Technology at Università dell'Insubria in Como hosts the activities of the team lead by Massimo Caccia, professor. The team develops instruments and methods based on the use of Silicon detectors of ionizing particles and light.

Since a decade, the core activities have been based on the use of Silicon Photomultipliers (SiPM), single photon sensitive devices with photon number resolving capability, low bias supply, robustness, low cost, magnetic field immunity, extreme time resolution and, last but not least, design flexibility.

The team ci collaborating with the major sensor producers and it has been involved in a number of projects, in collaboration with research teams and industry. Among them, it is worth mentioning:

- RAPSODI, a project supported by the European Commission within the VI Framework program. RAPSODI addressed the use of SiPM in homeland security, medical dosimetry and radon detection;
- MODES-SNM, a project supported by the European Commission within the VII Framework program. MODES targeted the development of a detector suite for homeland security, based on scintillation light by high pressure noble gases;
- The collaborative projects with AWE (the Atomic Weapons Establishment, https://www.awe.co.uk) and KROMEK (https://www.kromek.com), a British public company) on the characterization of novel scintillators for neutron detection and neutron/gamma discrimination;
- A series of developments with British and German companies in the medical domain;
- A joint development Laboratory established with CAEN s.p.a. (https://www.caen.it), a leading Italian company in the nuclear electronics market;
- An ongoing collaboration with Nuclear Instruments (http://www.nuclearinstruments.eu), focused on the commissioning and qualification of boards equipped with arrays of SiPM read-out by Application Specific Integrated Circuits (ASIC);
- The design and construction of Dual Readout Calorimeter (DRC) module, supported by Texas Tech, Iowa State University and INFN. The DRC is the core of a proposed experiment for the future circular accelerators being studied at CERN and in the Far-East (the CEPC, for Circular Electron-Positron Colliders).

Recently, the team addressed as well the use of Silicon Photomultipliers for the analysis of biological samples. Last but not least, it is collaborating with a team from University of Aveiro (Portugal) and CAEN s.p.a. on the development of a table top, low cost Positron Emission tomography scanner.

In curiosity-driven research, the team collaborates as well with prof. A. Allevi and dr.ssa Maria Bondani at Uni. Insubria on quantum optics issues where photon-number resolving detectors are a key issue.

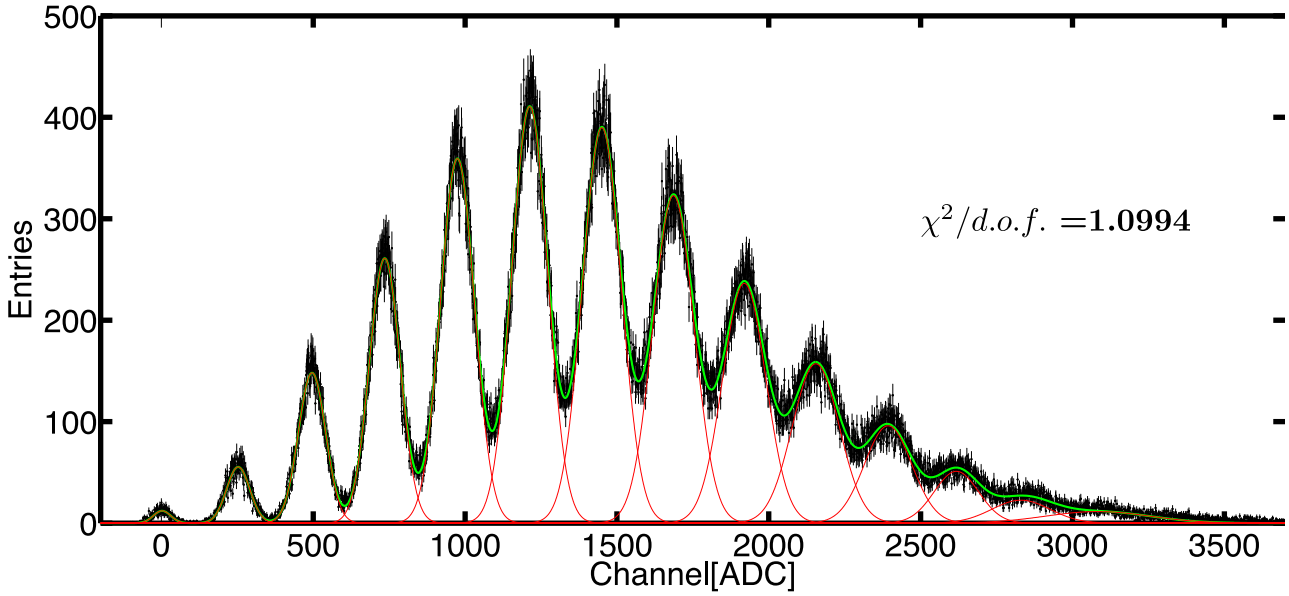

Figure 1.The picture is showing the response of a SiPM sensor to a high statistics of nanosecond long light bullets, illuminating the sensor at kHz rate. The peaks correspond to the number of illuminated pixels, proportional to the number of incoming photons. The different areas of the peaks are due to the statistical properties of the light source, notably following the Poisson distribution..

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References:

- V. Arosio et al., EasyPET: a novel concept for an affordable tomographic system – Nuclear Instruments and methods in Physics Research A, Volume 845, 11 February 2017, Pages 644-647, doi: 10-1016/j.nima.2016.05.004
- M. Caccia et al., A simple and robust method to study after-pulses in Silicon Photomultipliers, 2014 *JINST* 9 T10004 doi:10.1088/1748-0221/9/10/T10004
- V. Arosio et al., A robust and semi-automatic procedure for Silicon Photomultipliers characterisation, 2017 *JINST* 12 C03030
- M. Ramilli et al., Photon Number Statistics with Silicon Photomultipliers, J. Am. Opt. Soc. B, 27 (2010), 852-862
- G. Chesi et al., Measuring nonclassicality with silicon photomultipliers, Optics Letters, Vol. 44, No. 6 / 15 March 2019 / Optics Letters
- M. Antonello et al., Tests of a dual-readout fiber calorimeter with SiPM light sensors, Nuclear Inst. and Methods in Physics Research, A 899 (2018) 52–64