3d International Summer School on:
INtelligent Signal Processing for FrontIEr Research and Industry

Statistical Analysis Framework in Application to the Silicon Photomultiplier Data Analysis

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Introduction

Statistical Analysis is one of the most important Tool for the Physicists in understanding of the physical phenomena and performance of the detectors.

SiPMs are Statistical Detection Systems concerning Physics and Detection Method

And only the Statistical Analysis gives the Correct Performance Representation.

The Lab gives the experience to study the unique characteristics of the Silicon Photomultipliers through Modern Statistical Analysis Tool: RooFit – Library provides a toolkit for modeling the expected distribution of events in a physics analysis (CERN)

Analysis

Basic:

- Study of Gaussian Distributed Data, provided in an histogram.

- Study of the Response of a Silicon Photomultiplier illuminated by a low photon source (Single Photon Spectra Statistics)

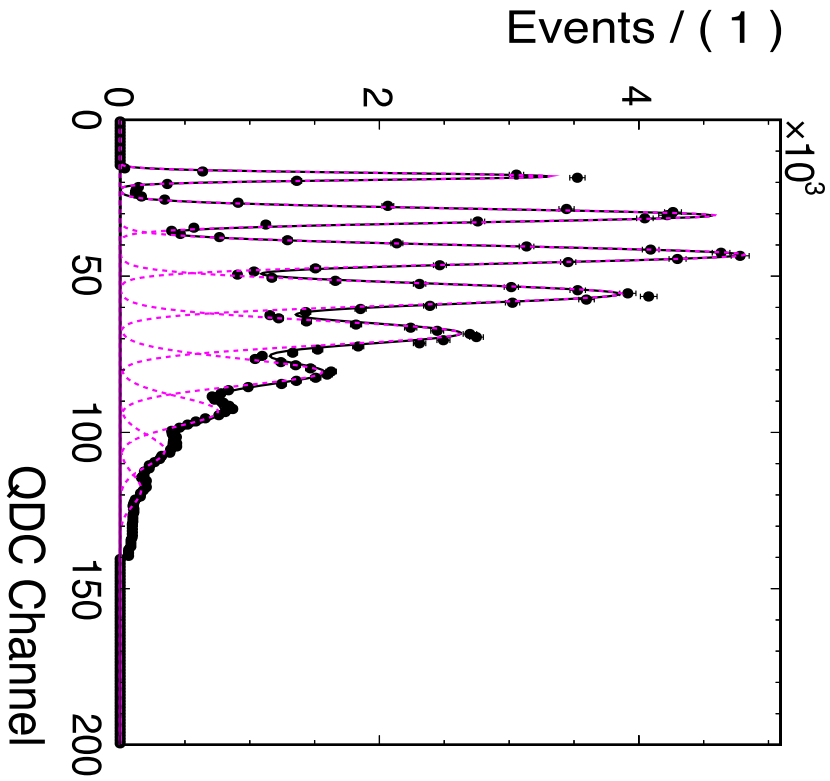
- Study of the Theoretical Expectation of the response of the SiPM to light as a Poisson Distribution (Photon Statistics)

Advanced:

- Statistical Analysis of Experimental Data of the new detections system on the basis of LySO/SiPM for applications in the Medical Imaging Systems (Positron Emission Tomography).
- Energy Resolution, Time Resolution

Analysis 1

The response of a Silicon Photomultiplier illuminated by a low flux photon source is provided in the histogram “spectrum2” in the file “SiPM_spectrum.root”.



In the spectrum each peak corresponds incrementally to the number of detected photons (0,1,2…)

Verify that the width of the n^{th} peak is described by the sum of gaussians low:

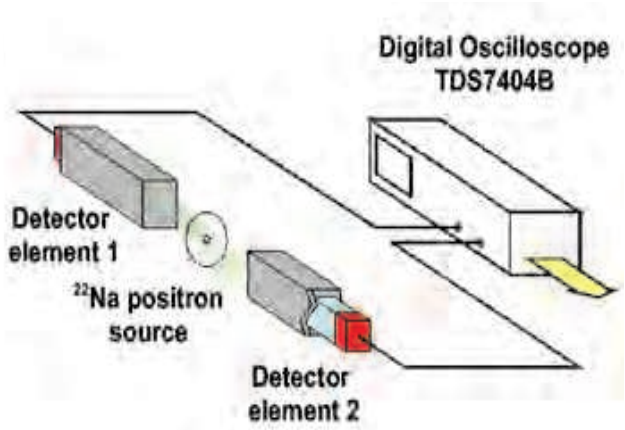
$$\sigma_n = \sqrt{\sigma_0^2 + n\sigma_1^2}$$

where σ_0 is the pedestal width and σ_1 is the intrinsic response of the SiPM to the single photon.

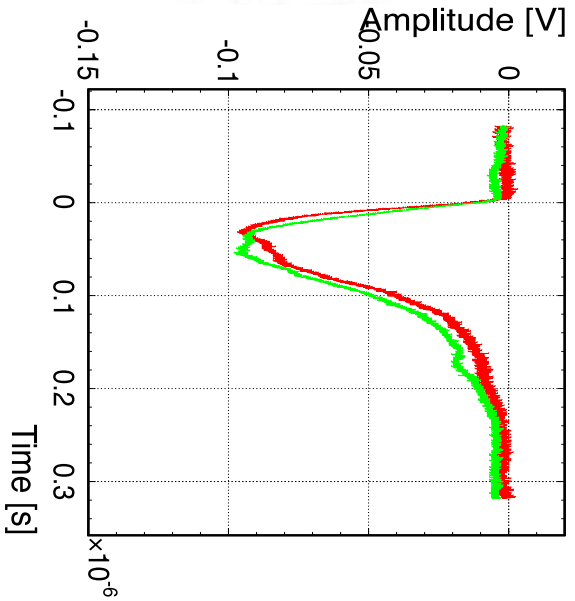
Measure σ_1 and estimate its statistical error.

Analysis 2

The data proposed in this exercise were collected in the context of an experimental study of the new detections system on the basis of LySO/SiPM photo-detectors for applications in medical imaging. The corresponding setup is shown in the figure.



An e^+ source is placed between two LySO crystals. The annihilation back-to-back 511 keV photons are detected in the scintillators. The scintillation light is read-out by SiPM and the SiPM signal waveforms are digitized and stored using a 4 GHz, 20Gs/s oscilloscope. Only events corresponding to detection in coincidence in the two crystals are stored.



The waveforms are provided in the ROOT Tree *"data"* contained in the ROOT file data