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Designing a first Mexican SiPM Data Acquisition System - MexSiC

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Silicon Photomultipliers (SiPMs) [1] are currently an excellent option to replace the traditional photomultiplier tubes (PMTs) in several fields ranging from astrophysics to medical applications. Having photon detection efficiencies (PDE) higher than 40% at peak wavelengths (in the blue-green visible part of the spectra), much lower operational voltages (ranging between 27 and 70 volts, depending on the manufacturer) than the PMTs (with biasing voltages between 1 and 2 kV), and high immunity to magnetic fields, SiPMs are reliable photodetectors enabling near single-photon counting capability alongside nanosecond time resolutions. One disadvantage of SiPMs, if used in applications where huge detection areas are required, is their respectively small photoactive area (of few square millimeters). Arrays of SiPMs are normally used in such cases.

In order to use SiPM arrays, data acquisition (DAQ) systems capable of reading multiple channels in parallel synchronizing their time of arrival, processing the input electric signals, discriminate between events, and generate resulting digital output signals that can be stored on an external memory unit are required. This work describes a DAQ system currently being developed for an array of nine SensL J-Series 30035 SiPMs [2]. The aim of the system is to be as flexible as possible so it could be applied in the Cherenkov light detection or together with any array of scintillation based detectors using SiPMs. An application specific integrated circuit (MexSIC) to be fabricated in the 180 nm CMOS technology has been designed as a core unit of this DAQ system. It contains a transimpedance amplifier (TIA) as its input stage, used to amplify and convert the SiPM output current pulses into voltage signals, a triggering logic unit (TLU) used to discriminate the input signals and generate a master readout triggering signal in case a desirable event has been detected, a phase locked loop (PLL) used to generate a clock reference for the time-to-digital converter (TDC), and an additional charge-to-digital converter (QDC) to be able to determine the amount of charge generated within each individual SiPM. An additional field-programmable gate array (FPGA) -the Xilinx Kintex 7- is used for signal processing and system controlling. With this approach, the end-user will obtain the information regarding the charge generated in each SiPM, the exact time in which a valid event has been identified accompanied by the exact single SiPM that triggered it first, as well as the time duration of the event (using the time-over-threshold TOT approach) for all the individual SiPM channels, additionally considering all the time delays present in the signals of all the SiPMs triggered for coincidence analysis.

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