Contribution ID: **350** Type: **Poster**

Smart Fast-Digitizer system for astro-particle physics detectors

Thursday, 28 May 2015 17:38 (0 minutes)

We developed a Fast-Digitizer based zero-suppression algorithm which supports single channel self-triggering, TDC and ADC functionalities, and detector triggering capabilities.
We implemented and successfully tested the system in the veto of the DarkSide experiment for the search of dark matter, composed by a liquid scintillator detector equipped with 110 PMTs and a water Cherenkov detector equipped with 80 PMTs.
The system can be used as it is for any next generation dark matter or neutrino experiments which use photo-detectors and is scalable up to tens of thousands of channels.

Summary

Many experiments in astroparticle physics require the acquisition of high-speed signals coming from a large number of photo-multipliers tubes (PMT).
Usually, the signal of interest of a single PMT is limited to relatively short pulses (10 to 20 ns) generated by specific events.
The detector requires continuous acquisition, but only the data (sampled data and time of the pulse) associated with these pulses is of scientific interest.

This contribution presents the implementation and performances of a novel system for data reduction and software group trigger to satisfy these needs.
The system is based on NI PXIe-5162 waveform digitizers (4 channels, 1.25 GSample/s/ch)
and has been tested on the outer detectors of the DarkSide-50 experiment, composed by a liquid scintillator equipped with 110 PMTs and a water Cherenkov detector equipped with 80 PMTs.

Each channel of the waveform digitizer is able to identify pulses and perform zero suppression.
When a pulse is identified, a 64 bit time-stamp, that encodes the time of the pulse and his geographical id, is generated.
Time-stamps can be read independently from the sampled data of the pulses.

The trigger of the system is entirely generated by software, that continously reads the time-stamps and evaluate group trigger conditions.
The sampled data (waveforms) of the pulses are only requested by the DAQ when the software group trigger is issued.

The description of the system, implementation of the DAQ, results, and scalability to next generation experiments are discussed in this contribution.

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Session Classification: Front end, Trigger, DAQ and Data Management - Poster Session

Track Classification: S5 - Front End, Trigger, DAQ and Data Management