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# Development of a FPGA-based Data Acquisition System (DAQ) for Muon Scattering Tomography

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An FPGA-based DAQ has been developed for collecting position information from several position-sensitive RPCs to reconstruct the tracks of cosmic muons in a muon scattering tomography setup. An 8-channel ultra-fast preamplifier discriminator NINO ASIC has been used in the front-end for the acquisition of current signals induced on readout channels of the RPCs. The DAQ has been designed for measuring the Time-Over-Threshold (TOT) property of the NINO ASIC by using a high-frequency clock. The performance of the scheme has been studied by measuring the efficiency of detecting cosmic muon events by a glass RPC in comparison to a plastic scintillator.

## Summary (500 words)

The FPGA-based Data Acquisition System (DAQ) can be found very useful in large-scale high-energy or low-energy nuclear physics experiments that deal with a huge amount of multi-parameter data-taking. This type of architecture can offer a simple low-cost system that can be configured as a scalable multi-parameter data acquisition system. In this work, the use of an FPGA-based DAQ has been introduced to serve a muon scattering tomography setup which is being built for material discrimination utilizing the multiple Coulomb scattering of cosmic muons in the matter. The tracking of the cosmic muons before and after their scattering due to their interaction with the target material has been planned to be done using several layers of position-sensitive Resistive Plate Chambers (RPCs). An 8-channel ultra-fast preamplifier discriminator chip NINO will be used in the front-end for the acquisition of current signals induced on readout channels of the RPCs. The DAQ has been designed for measuring the Time-Over-Threshold (TOT) output of each channel of the NINO ASICs by using a high-frequency clock. This information has been used to obtain the position information and accomplish the tracking.

This work will report the performance of the proposed DAQ scheme by measuring the muon detection efficiency using a glass-RPC. In our test setup, a glass-RPC of dimension 30cm x 30cm, filled with a gas mixture of 95% Freon and 5% Isobutane, equipped with two orthogonal planes of readout channels of width 3.0 cm and pitch 3.2 cm, has been operated. For each readout plane, one front-end board has been utilized to acquire signals from 8 channels in one orientation. Altogether two front-end boards have been used to acquire signals from 16 channels in an 8 × 8 configuration. The RPC has been placed in a horizontal plane to maximize cosmic muon interaction. Each NINO chip provides as outputs 8 pairs of LVDS (Low Voltage Differential Signalling) signals which are suitable for low-power, high-speed transmission with better noise-immunity. For parallel post-processing and to take advantage of this LVDS scheme, we have used an FPGA development board with ALTERA MAX 10, which has dedicated pins for the direct acquisition of LVDS analog signals. Moreover, using ALTERA MAX 10, which has a dedicated PLL (Phase Locked Loop)-controlled clock (500 MHz maximum frequency) for the sampling of LVDS analog signals, we have achieved 2 ns resolution for signal acquisition. Because of the direct LVDS signal handling capability, it is not necessary to use any LVDS to TLL conversion devices, and thereby, the purity of the LVDS signal is maintained. The FPGA has been programmed to transfer the acquired data to the computer using the UART protocol. The RPC data for muon events as collected by the present readout scheme have been analysed to estimate the position and time information. The data have been used for determining the efficiency of the RPC in muon detection in comparison to a plastic scintillator measured by the traditional method.

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