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FPGA Based Time Measurement for the MRPC Detector

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A FPGA based time measurement electronics is developed for MRPC (multigap resistive plate chamber) detector in TOF (time of flight) applications. The basic structure is composed of an ultra-fast amplifier/discriminator (NINO) connected to MRPC and a dedicated FPGA based time-to-digital converter to measure TOT (Time-Over-Threshold), instead of charge. Preliminary tests show that the RMS of leading edge measurement of electronics is better than 15 ps, and that of TOT measurement by a single channel is better than 25 ps. By the cosmic-ray test with MRPC detector, the typical time resolutions is better than 50 ps, with an efficiency of 98%.

Summary

MRPC is a new kind of gas detector with good time resolution (30~50ps) and high detection efficiency (95%~99%) with the counting rate up to hundreds of Hz/cm^2 under the avalanche mode. At present, the readout electronics for MRPC mainly relies on the solution based on the NINO and HPTDC chip from CERN, but its time resolution is limited to 25 ps. Recent literatures show that FPGA based TDC has achieved the time resolution below 5 ps. We propose a 32-channel readout electronics measuring TOT with FPGA based TDC techniques for MRPC. We use the NINO chip to get TOT as usual, but make Xilinx Kintex-7 series FPGA to capture the timestamp of leading and trailing edges. The coarse counter records the arrival time with a time resolution equal to the clock period, and the carry chain is utilized for fine time interpolation. In order to improve the TDC sensitivity to the operating temperature and supply voltage, we adopt multiple carry chains to be integrated in a single TDC channel, analyze the temperature-dependent delay variation, and average the timestamps to ensure stable performance over a wide temperature range. The tests demonstrate that an excellent time performance is achieved, the RMS of single channel is better than 25 ps. In addition, considering the power consumption, high multi-channel capacity, measurement dead time, radiation tolerant and budget, FPGA based TDC is also very suitable for practical applications of large-scale high performance detectors in particle physics spectrometer.

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