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Front-end Electronics for a Novel Boron-coated MWPC Thermal Neutron Detector

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Traditionally, 3He proportional counter tube is widely used for thermal neutron detecting. However, because of the lack of 3He, the research and development of new thermal neutron detector has become an international hotspot. As a new type of thermal neutron detector, boron-coated Multi-wire Proportional Chamber (MWPC) thermal neutron detector has the advantages of good time and position resolution, two-dimensional readout, etc. Furthermore, the high detection efficiency can be achieved through the MWPC multilayer thin film structure. In this paper, the front-end electronics (FEE) for boron-coated thermal neutron detector is studied. It is suitable for delay line time difference measurement. The principle of readout electronics for MWPC based on time difference methodology is to measure the relative delay of the signal at both ends of the delay line. To achieve good resolution for locating neutron hit, the precision of time discrimination and measurement should be achieved as good as enough. Time discrimination is to accurately determine the start and end time of the signal, which directly determines the accuracy of time difference measurement. However, the leading edge of the discriminated signal varies with the input amplitude or rise time, which leads to timing error. In this paper, the characteristic of the output signal from detector is studies, according to which, the timing method satisfying the requirement of timing accuracy is further studied. At last, optimal design parameters of the front-end amplification and timing circuit are given through the analysis. To receive the weak signal from detector and to guarantee the timing precision, pre-amplifier with two-stage cascade structure is proposed in this paper. It can meet the requirements about amplitude and bandwidth for analog signal conditioning. For this novel Boron-coated MWPC thermal neutron detector, timing signal is transmitted to backend readout electronics through twisted-pair cable with several meters. To guarantee the timing precision, the amplified signal is fed into a comparator in FEE to generate a timing signal with fast leading edge. This timing signal is signaled with LVDS for the purpose of being transmitted to backend readout electronics over long distance cable. To accurately generate the threshold voltage for the comparator, a DAC controlled by CPLD is also provided in FEE. Time difference of signals at both ends of delay line is measured precisely by high precision Time-to-Digital converter (TDC) at FPGA on the backend electronics. Simulation analysis and preliminary tests shows that this front-end electronics can meet the requirement for signal amplifying and timing with good accuracy. It can be used for Boron-coated MWPC thermal neutron detector signal conditioning.

Author: Mr ZHENG, Manyu (State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei 230026, China;School of Nuclear Science and Technology, University of Science and Technology of China, Hefei 230026, China)

Co-authors: DI, Jiang (G); Prof. CAO, Ping (State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei 230026, China;School of Nuclear Science and Technology, University of Science and Technology of China, Hefei 230026, China); Prof. AN, Qi (State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei 230026, China;School of Nuclear Science and Technology, University of Science and Technology of China, Hefei 230026, China); Ms SUN, Weijia (State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei 230026, China;Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China); Mr ZHANG, Ying (State Key Laboratory of Particle Detection and Electronics, University of Science and

Technology of China, Hefei 230026, China;School of Nuclear Science and Technology, University of Science and Technology of China, Hefei 230026, China)

Presenter: DI, Jiang (G)

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