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Cryogenic digital data links for a liquid argon time projection chamber

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In this paper we present the R&D towards cryogenic digital data links for a Liquid Argon Time Projection Chamber (LArTPC). An electrical data link with a commercial LVDS driver and a 20-meter CAT5E twisted pair can work up to 1 Gbps at liquid nitrogen temperature or 77 K. Components of a cryogenic optical data link, including a serializer ASIC, laser diodes, optical fibers, and optical connectors, have been test operating properly. Commercial Field Programmable Gate Arrays (FPGAs) continue to function properly at 77 K. A variety of commercial resistors and capacitors suitable to cryogenic operation have been identified.

Summary 500 words

A Liquid Argon Time Projection Chamber (LArTPC) has been proposed as a potential far site detector of the long baseline neutrino experiment (LBNE). Operating front-end electronics inside the liquid argon cryostat has the advantages of low thermal load, high data bandwidth, low noise, and low power consumption. The cold front-end electronics, including preamplifiers, shapers, analog to digital converters, digital memories, data multiplexers, and cable drivers is under development. In this paper we present the requirements of a LArTPC on the data links and the R&D towards cryogenic digital data links.

The maximum length of each data link is estimated to be about 20 meters. The data rate depends highly on where the LArTPC is located. When a LArTPC is located at 800 feet underground, the data rate of an anode plane assembly (APA) is estimated to be less than 10 Mbit/s (Mbps), low enough to be handled electrically with copper wires and LVDS signals. If the LArTPC is located on the earth surface, the data rate of an APA is estimated to be near 1 Gbps. Data links using optical fibers as the transmission media may be a natural choice.

For an electrical data link, we have tested an LVDS driver with 20-meter CAT5E twisted-pair cables. The electrical link works up to 1 gigabit per second at liquid nitrogen temperature (77 K), exceeding the data rate requirement. For an optical data link, a 16:1 serializer Application Specific Integrated Circuit (ASIC) fabricated in a commercial 0.25-micrometer Silicon-on-Sapphire CMOS technology, three types of laser diodes, and multimode and single mode optical fibers and optical connectors have been tested. All components continue to function at 77 K.

A Field Programmable Gate Array (FPGA) can be used in both electrical data link and an optical data link to implement multiplexing and the cable driving. Two commercial FPGAs have been tested and both function properly at 77 K.

A variety of commercial resistors and capacitors, which are necessary component in printed circuit boards, have been tested at 77 K. Resistance of almost all types resistors except carbon composition and capacitance of tantalum electrolytic capacitors, C0G/NP0 ceramic capacitors, specific types of film capacitors, and mica capacitors changes little.

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