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Silicon Photonics Based Optical Communication System for Large Scale Physics Experiments

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Particle physics and dark matter experiments using large time projection chambers (TPC) with several square meters of light detectors produce tremendous amounts of data. To retrieve such a high volume of data, traditional copper or kapton-based solutions require significant trade-offs to meet the performances and constraints needed by the physics goals. A novel communication system based on silicon photonics and using optical fibers is proposed. The goal of this system is to link the acquisition system to the inside of the TPC while addressing the unique challenges of each experiment, whether it be power consumption, high data rates, cryogenic environments, radiation-sensitive or radiation-heavy environments or long-range communication. The system operates by using external lasers as optical sources for both the transmit and receive communication channels. Doing so removes a power-consuming component from the constrained environment but forbids using commercial solutions. In addition, external laser diodes solve the problem of their high sensitivity to radiation damage when this is relevant. Data is modulated upon this continuous laser source with silicon photonics micro-ring resonators (MRR). The signal is received on embedded germanium photodiodes. An application-specific CMOS chip is used to control and drive the silicon photonics MRR, receive the photodiode signals as well as doing all the required data link control. This two-chip assembly, called an optical engine transceiver, sits at both ends of the communication channel between detectors in harsh environments and the data acquisition servers (DAQ) outside of the experiments. To deploy those transceivers and integrate with the rest of the DAQ, we also designed and demonstrated an FPGA-based system capable of concentrating up to 32 optical engines onto a 100 Gb/s Ethernet link. We will present the structure and the operation of the system and how it can help data collection in physics experiments.

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