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Cryogenic Electronics for Very Large Liquid Argon Neutrino and Nucleon Decay Detectors

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The Liquid Argon Time Projection Chamber (LAr TPC) technology offers extraordinarily precise event reconstruction and particle identification, as well as scalability to very-large detectors. To go beyond the sensitivities of current experiments for neutrino physics and proton decay, the next generation of liquid argon TPCs are envisioned to be in the range of 20-100 kton. Detectors of this size pose many engineering challenges. The number of sense wires, i.e., input signal channels is expected to be in the range of 3-7 hundred thousand for a 20 kton scale TPC. The location of the signal processing electronics (on the electrodes in LAr vs outside of the cryostat) has a far reaching effect on the cryostat design, on the TPC electrode design (sense wire spacing, wire length and drift distance), and on the electronic noise. All these factors make cryogenic ("cold") electronics with multiplexed readout essential. In this presentation we summarize the basics of TPC signal formation and electronic noise, present an outline of the readout chain and the measurement results of the front end CMOS ASIC(s) designed and fabricated for this purpose. The results of the R&D on the CMOS electronics show significantly improved transistor properties at LAr temperature (˜89K), such as greatly increased transconductance/current ratio gm/I (beneficial for low power design), higher speed and lower noise. We discuss the design guidelines to ensure a long life of MOS transistors. Application of cryogenic electronics to other types of detectors will be summarized.

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