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Development of LBNE Photon Detector Front End Electronics

The LBNE (Long-Baseline Neutrino Experiment) is the next generation accelerator-based neutrino oscillation experiment planned in US. The experiment will use a new muon-neutrino beam sent from Fermi National Accelerator Laboratory and will detect electron-neutrino appearance and muon-neutrino disappearance using a Liquid Argon TPC located at a distance of 1300 km at Sanford Underground Research Facility in South Dakota. The primary physics goal of the LBNE is a definitive determination the neutrino mass hierarchy, determination the octant of the neutrino mixing angle theta-23, and precise measurement of CP violation in neutrino oscillation. Neutrino interaction in LAr result in charged particles producing ionization and scintillation light signals. Dedicated photon detection (PD) system is under design for use in the LBNE LArTPC far detectors. The PD is designed to capture ultraviolet scintillation light that occurs when excited atoms in the liquid argon decay back to the ground state. These photons have a wavelength of 128 nm. Two processes contribute to producing "prompt"(decay constant ˜ 6ns) and "late"(decay constant ˜1.6μs) light components. By measuring the time of arrival of the photons, as well as the pulse height, the PD system can provide a "time zero" reference for the reconstruction of the event, as well as help identify the spatial coordinates of the event by triangulating between different photon detector elements in the detector. In addition the detection of scintillation light may be used as a trigger for the TPC. Measurement of the "late"light that arises from triplet states, which can be useful as a particle identification tool.
The PD system must shift the wavelength of the scintillation light in order to use affordable photo-detectors. The baseline design couples wavelength-shifter coated ultraviolet transmitting acrylic to 3 mm2 silicon photomultipliers (SiPMs). By detecting scintillation light we aim to improve event reconstruction capabilities and efficiently separate neutrino events from background.
The signal out of the SiPMs is a charge or current pulse. The PD electronics must receive the SiPM signal, and digitize it to measure the time of arrival and also the pulse height. The SiPM response is quantized to measure integer number of photo-electrons, which is then used in the determination of the spatial location of the event. This presentation will describe requirements, implementation, and tested performance of the prototype front-end electronics to be used in PD system in LArTPC of LBNE.

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