



Contribution ID: 42

Type: Oral

The Development of Front-End Readout Electronics for ProtoDUNE-SP LAr TPC

Tuesday 12 September 2017 08:30 (25 minutes)

As a prototype of DUNE far detector, ProtoDUNE-SP single phase LAr TPC will sit in H4 beam line at CERN to study detector response to particles. It consists of 6 full-size APAs plus 2 CPAs, with total 15,360 TPC readout channels. The front-end readout electronics is comprised of cold electronics and warm interface electronics. The integral design concept of APA, cold electronics, feed-through, plus warm interface electronics with local diagnostic and strict isolation and grounding rules has been followed and studied at BNL. The production front-end readout electronics are being fabricated and will be installed in ProtoDUNE-SP in fall 2017.

Summary

ProtoDUNE-SP is a 700 ton single phase LAr TPC using full scale components of DUNE far detector module, will sit in H4 beam line at CERN and plans for operation in 2018. Its goals include measuring detector response to known particles, confirming modeling and simulation, and validating mechanical and electrical design and interface. It consists of 6 full-size APAs (Anode Plane Assembly) plus 2 CPAs (Cathode Plane Assembly), which get 2 x 3.6m drift regions and 15,360 TPC readout channels in total. In the DUNE experiment, the total equivalent noise charge (ENC) should be less than 1/9 of the expected worst case instantaneous charge arriving at the APA from a MIP, which requires the ENC for induction wires to be less than 650 electrons. This is enabled by the CMOS cold electronics installed in the cryostat and operating in LAr to achieve the optimal noise performance.

The ProtoDUNE-SP front-end readout electronics is comprised of cold electronics and warm interface electronics. Cold electronics is placed close to the wire electrodes inside the cryostat, which makes the noise independent of fiducial volume (signal cable lengths). It mainly consists of 960 FE ASICs, 960 ADC ASICs and 120 cold FPGAs to form 120 Front End Mother Board (FEMB) assemblies. Each FEMB assembly is made up of an analog mother board (AM) and a FPGA mezzanine (FM). An AM has 128 channels with 8 FE (front-end) ASICs and 8 ADC ASICs designed by BNL for 77K-300K operation and long lifetime with low power consumption. An FE ASIC has 16 channels of charge amplifier with programmable gain and filter time constant. An ADC ASIC has 16 channels of 12-bit ADC at 2MHz sampling rate. FM multiplexes and transmits 128 channels of data through four 1 Gb/s serial links to warm interface electronics. Warm interface electronics with local diagnostic is installed in the crate on the flange, which aggregates all the data with up to 10 Gb/s optical links to DAQ system.

Noise performance of FEMB with 150pF input capacitance has been characterized. ENC is about 1100 electrons at room temperature and about 550 electrons in liquid nitrogen. However, to have a chance to achieve a good performance with ProtoDUNE-SP detector, the integral design concept of APA, cold electronics, feed-through, warm interface electronics, plus strict isolation and grounding rules should be followed. An integration test stand with 40% APA has been built at BNL, which is used to test the full readout chain from APA to WIB at both room and liquid nitrogen temperatures. With proper ground scheme, ENC measurement at room temperature achieves 770 electrons with collection wires (2.8m) and 830 electrons with induction wires (4m), which is consistent with what we expected. We are performing the cold test from April through May, the detailed test results will be presented in the meeting. The production front-end readout electronics are being fabricated and will be installed in ProtoDUNE-SP in fall 2017. The experience of the production test of

front-end electronics will be presented as well.

Authors: BERNIS, Hans-Gerd (University of California Davis); CHEN, Hucheng (Brookhaven National Laboratory); D'ANDRAGORA, Alessio (Brookhaven National Laboratory); FRIED, Jack (Brookhaven National Laboratory); GASTLER, Daniel (Brookhaven National Laboratory); GAO, Shanshan (Brookhaven National Laboratory); HAZEN, Eric (Boston University); HOU, Wenbin (Brookhaven National Laboratory); LI, Shaorui (Brookhaven National Laboratory); LIU, Feng (Brookhaven National Laboratory); RADEKA, Veljko (Brookhaven National Laboratory); VERNON, Emerson (Brookhaven National Laboratory); WORCESTER, Elizabeth (Brookhaven National Laboratory); WORCESTER, Matthew (Brookhaven National Laboratory); YETHIRAJ, Krithika (Brookhaven National Laboratory); YU, Bo (Brookhaven National Laboratory)

Presenter: GAO, Shanshan (Brookhaven National Laboratory)

Session Classification: Production, Testing and Reliability

Track Classification: Production, Testing and Reliability