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Prototype design of the readout electronics for NvDEx-100 experiment

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NvDEx-100 is the phase I of NvDEx, which is a proposed 0νββ detection experiment based on the high pressure gaseous TPC filled with SeF6. Thousands of sensors will be placed on the readout plane located in one end-cap of the TPC. The sensors collect ions, measure the charge and output analog waveforms with the integrated CSA. The outputs are then digitized, aggregated, and transmitted to the back-end DAQ system. This presentation introduces the prototype design of the 19-sensor front-end module and the integration with DAQ system. The design and integration with Am-241 radiation source in a TPC will be presented.

Summary (500 words)

Double beta decay has been observed with a few nuclides. However, the neutrinoless double beta decay (0νββ) is still unobserved though the lower limit of half-life period has been pushed to magnitude of 1026 years for some nuclides. 82Se is a nuclide candidate for 0νββ experiment, with the decay energy of about 3 MeV. NvDEx is an experiment for 0νββ detection with a high pressure gaseous TPC. As the Phase-I, the NvDEx-100 TPC will be filled with around 100 kg SeF6 under 10 atm pressure.

The readout electronics are placed on the readout plane in one end-cap. There are about 10,000 nodes, each consists of the Topmetal-S sensor, and the circuit for waveform digitization and data transmission. In current stage, a commercial multi-channel ADC is used for the digitization. A commercial SerDes chip is used for the data aggregation. A 19-sensor prototype is designed to evaluate this tree-style architecture. In the system, two ADC AD4695 chips support digitization of pulses from all sensors, with temperature measurement in the same time. The SPI interface of the ADC, and the conversion trigger signal are connected to the slow ports of the TLK1501. The high speed serial port of TLK1501 connect this module with the back-end system.

In the back-end, an SMA-SFP adapter card is put between the 19-sensor module in the TPC and the PCIe based DAQ system. It converts the electric signal to the optical signal. Fibers connect the SFP+ module on it and the optical module on the PCIe card in the server. Firmware is developed for the FPGA on the PCIe card. Together with the software, it supports configuration of the front-end system, data decoding, and data saving. Finally, the waveform data from the 19-sensors are obtained continuously in a trigger-less way. The sampling rate for each sensor is about 15 kHz.

With this system, the ENC of each sensor is measured. Then the integration with the TPC, and the Am-241 radiation source is carried out. The pressure of the air is about 0.3 bar, and the electric field is about 18,000 V/m. The ion tracks are captured, and the track reconstruction ability is proved.
This presentation will show the design details of the prototype electronics and the integration with the DAQ system. Then the electronic performance test and the track measurement will be introduced.

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