TWEPP 2019 Topical Workshop on Electronics for Particle Physics

Contribution ID: **22** Type: **Poster**

A Fault-tolerance Readout Network for High-Density Electrode Array Targeting Neutrinoless Double-Beta Decay Search in TPC

Thursday 5 September 2019 16:55 (20 minutes)

A high-density electrode array is being developed for Neutrinoless Double-Beta Decay search in high-pressure gaseous TPC. A sensor, Topmetal-S, is designed to have mm-sized electrode, followed by an amplifier and an ADC based on a 0.35um CMOS process. The Topmetal-S array can collect charge directly without gas avalanche gain to achieve high energy and spatial resolution simultaneously. To realize a ton-scale TPC, approximately one hundred thousand Topmetal-S need to be laid on a meter-sized plane. The greatest challenge is a reliable high-density channels readout. A distributed, self-organizing and fault-tolerance readout network is implemented and will be integrated into the Topmetal-S.

Summary

Among the current and planned experiments of neutrinoless double-beta decay ($0\nu\beta\beta$), the high-pressure gaseous TPC stands out for its excellent energy resolution, very low radioactive background level and good scalability. Moreover, high position resolution can be maintained with an appropriate charge readout scheme for gaseous TPC to further suppress the background through ionization imaging. A pixelated charge readout plane without gas-electron avalanche is desirable. Based on a 0.35um CMOS process, a low noise sensor, Topmetal-S, is being developed which, even without gas gain, the energy resolution requirement could be met. Since $0\nu\beta\beta$ tracks are extended to tens of cm in length in high-pressure gas, Topmetal-S is designed to have mm-sized charge collection electrode, followed by a charge sensitive amplifier and an ADC in the first prototype. However, to realize a ton-scale high-pressure gaseous TPC, approximately one hundred thousand Topmetal-S sensors need to be laid on a meter-sized plane. The greatest challenge is a reliable high-density sensor readout and sensor control. It is practically impossible to route data channels and control channels directly from each sensor to the edge of the plane. It is also difficult to guarantee air tightness by draw high density channels out of the TPC.

This paper proposed a distributed, self-organizing and fault-tolerance readout network. As a node of the network, each Topmetal-S integrates a router. The scheme establishes local connection between nearby sensors to form a sensor network. Each sensor not only generates and transmits their own data, but also forwards data from nearby sensors, and data packet is finally received by a computer that is connected at the edge of the network. In order to simplify the complexity of router, 2D-Mesh is chosen as the topology of the network. A distributed routing algorithm, Fault-Tolerance-XY (FT-XY), is implemented. The distributed routing algorithm relies only on local information, which makes it possible to integrate the router into the sensor, thus no additional radioactive material will be introduced into TPC. The routing algorithm is also fault-tolerant, so that failed sensors will not disable a large section of the network. Faulty node detection is implemented by sending test packets by the computer. After fault detection, through configuration the computer will form a set of rectangular region called faulty blocks to contain detected faults. The FT-XY routing follows the regular XY routing until the packet reaches a boundary node of a faulty block. At that point, the packet is routed around the block clockwise to pass through. We first completed the logic design of the router using verilog. The simulation shows that the throughput of the readout network reaches 11641 Mbit/s and the latency of the network is less than 120 us. Then we verified and tested the design on the FPGA. We are now implementing the router on a 130 nm CMOS process and expected to be submit it in June 2019. The details of the routing algorithm, the fault detection scheme, the micro-architecture of the router,will be presented.

Authors: Mr YOU, Bihui; XIAO, Le (Central China Normal University); SUN, Xiangming; MEI, Yuan; HUANG, Guangming

Presenter: XIAO, Le (Central China Normal University)

Session Classification: Posters

Track Classification: ASIC