An SCA ASIC-based Multi-channel Readout System for a Prototype Multi-purpose TPC at CSNS Back-n White Neutron Source

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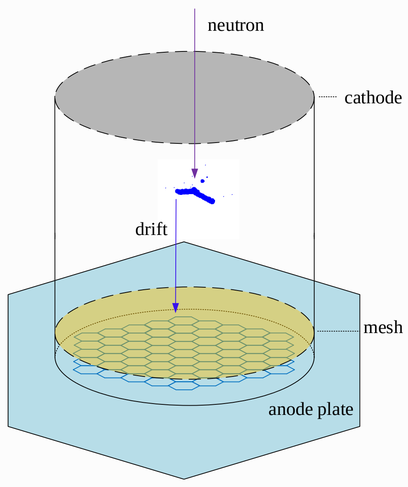
1. Introduction

The CSNS is the first spallation neutron source in China operating at a repetition rate of 25Hz with a stable 100kW beam power. Back-n neutron beam-line exploits high-flux back-streaming neutrons from the spallation target at CSNS with a wide energy spectrum, and good time resolution

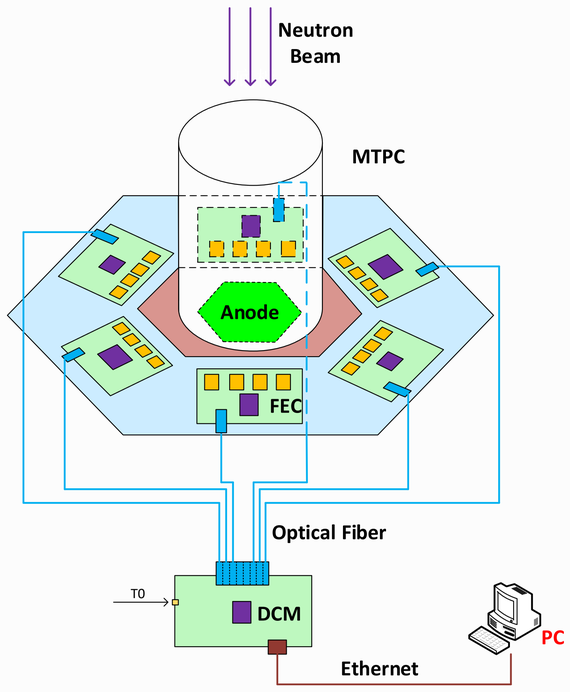
Back-n is working on Multi-purpose Time Projection Chambers (MTPC) and now finished a prototype one with 1519 channels, which is committed to measure the energy of incident neutron and emission particles, and more importantly, to reconstructed the 3D-track of emission particles.

2. The Structure of the Prototype MTPC



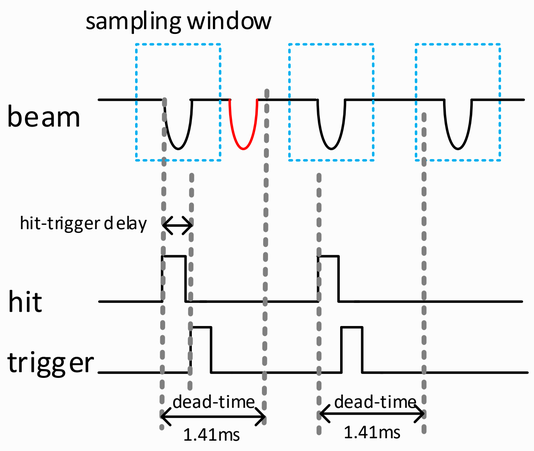
The prototype MTPC is a cylinder with a diameter of 140mm and an adjustable height of 70mm to 150mm with cathode at the top and anodes at the bottom. Hexagonal close-packed structure is applied to 1519 anode pad pixels with each side length of 1.63mm. Apart from energy measurement, it can record the 3D-track by its micro-pads anode plate for X-Y dimension and drift time of ionized electrons from track to the anode plate for Z dimension.

3. Readout Electronics System

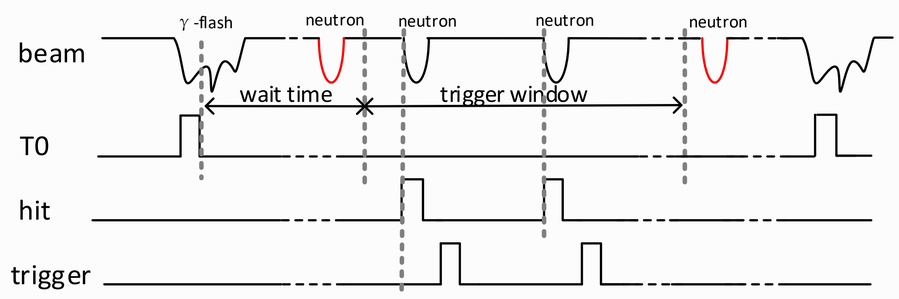


The SCA ASIC-based multi-channel readout system for MTPC

A multi-channel readout system composed of switched capacitor arrays (SCA) waveform sampling electronics is consists of 6 Front-end Cards (FEC) and 1 Data Collection Module (DCM). Each FEC uses four AGET chips to process and store the analog signal, then digitizes the signals by four single-channel 25MHz, 12bit ADCs and sends the compressed and packaged data to the DCM; the DCM is applied for interfacing the FEC via an optical fiber and collecting data. DCM can process data from FECs to a computer with associated FPGA, an external 4 Gbit DDR3 SDRAM, 24 SFP optical transceivers and a Gigabit Ethernet transceiver. The DCM sends control signals to the target FEC and collects data from the target FEC through the matched SFP optical transceiver.



If any channel of AGET input exceeds configured threshold of this chip, this AGET chip will generate a hit signal and FPGA receives hit signal and send it to DCM. DCM collects and analyzes all hit signals to generate trigger signals. The trigger is distributed to 6 FECS to achieve event synchronization. After a configurable delay, SCA in AGET chips stops sampling waveforms and sends them to ADC.

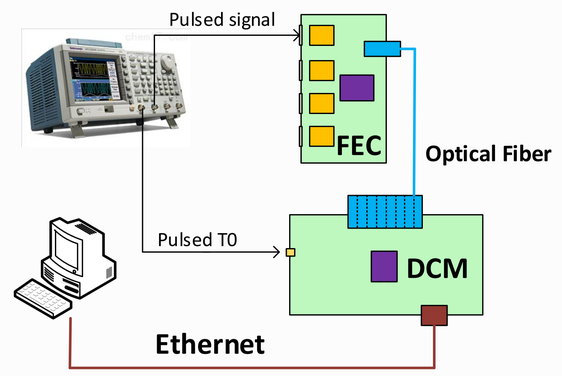


Trigger enable window after T0 signal

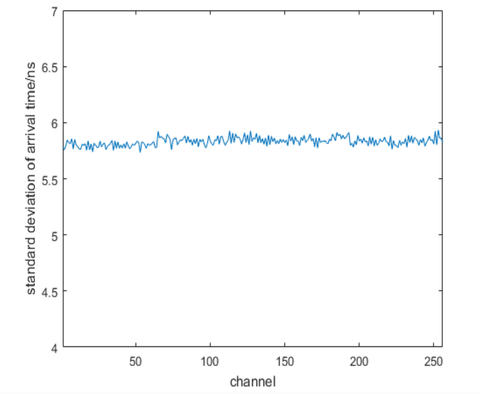
Time-of-fight (TOF) spectrum is used to determine the energy of incident neutrons. It is obtained by measuring the interval time of T0 signal provided by Back-n and cathode signal of MTPC. The former signal represents the emission time of neutron from the collision target and the signal and the latter one represents the arrival time of neutrons.

The intense flux of γ rays produced with the white neutron beam is the dominant background to neutron events. To avoid the impact of γ rays in the neutron beam, FECs are configured to generate hit signal in a configurable time window after receiving T0 signal.

4. Test of TOF Method



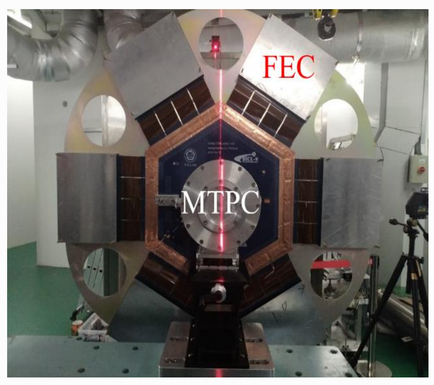
Test Platform of Time of Flight



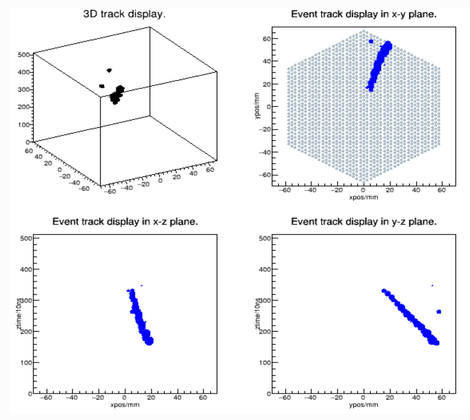
Standard deviation of arrival time of 256 channels

The calculated standard deviation of arrival time of every channel of one board is around 6ns and has a little difference between chips. The time resolution of the entire system would be less than 10ns.

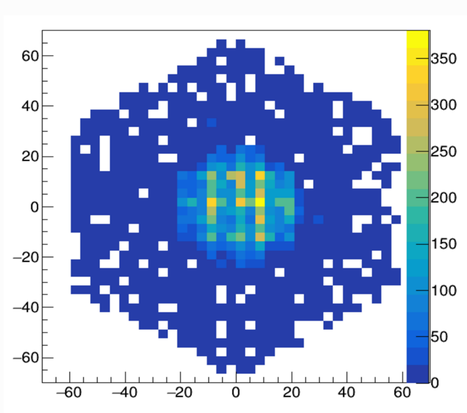
5. Experiment Result



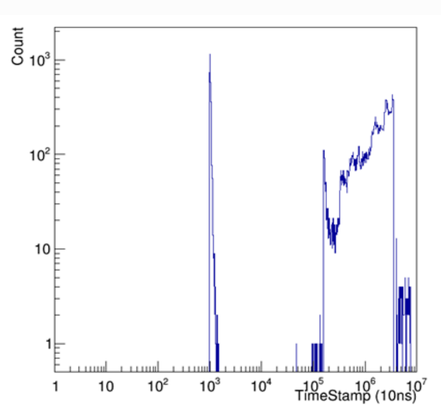
Prototype MTPC with 6 FECs installed



The reconstructed 3D-track of emission triton



Hit-map of neutron beam



TOF spectrum from 1μs to 35ms time window

6. Conclusion

This poster presents an SCA ASIC-based multi-channel readout system the prototype MTPC for measurements of neutron induced light charged particles. The performance test has been carried out and the results show the performance meets the requirements. During the joint test with the prototype MTPC, the electronics system works well. After analyzing the data collected by this system, the 3D-track of emission particles and TOF spectrum have been reconstructed successfully. The ability of particle identification of MTPC is proved.

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