

Proposal of Readout Electronics for CASCA in XTP detector

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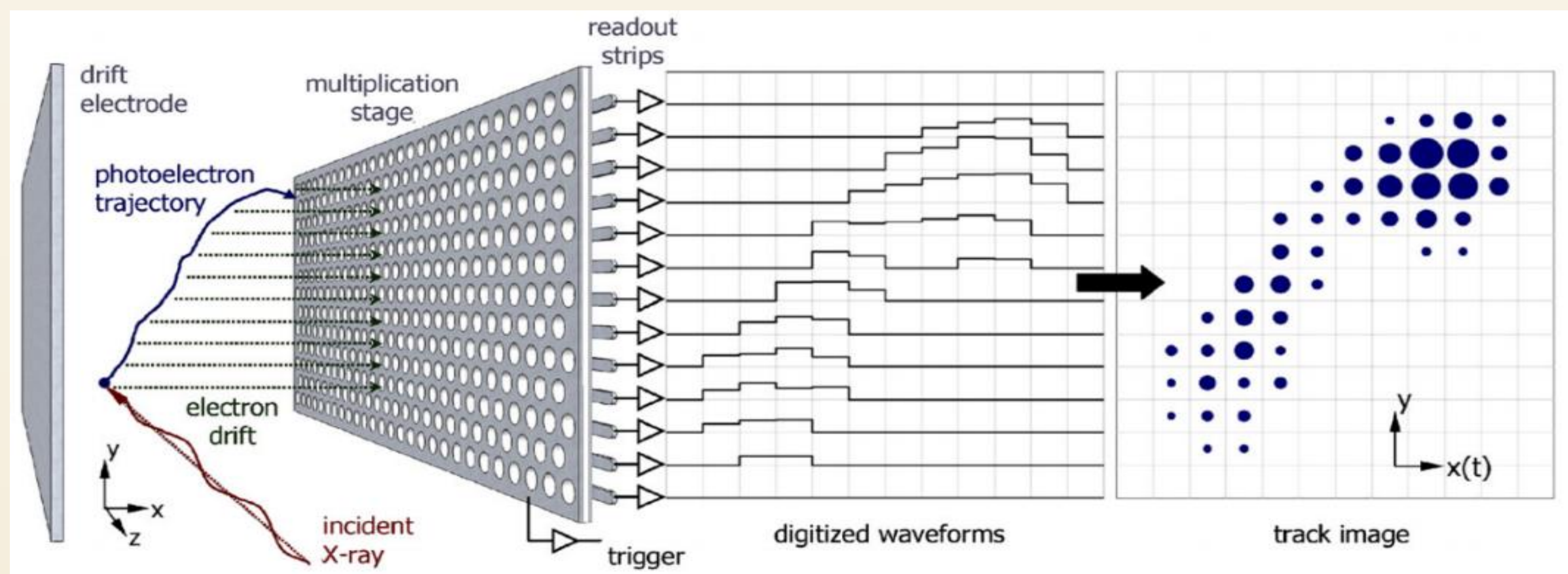
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Introduction

Mirco-pattern TPC (Time Project Chamber) based X-ray polarimeter (XTP) has been demonstrated in recent years for its main advantage of releasing the competition between absorption depth and drift distance. It measures two dimensional photoelectron tracks generated by the incident X-ray photons with one dimensional strip readout. The other dimension is calculated by the drift time from the signal waveform. The polarimeter focuses on the X-ray energy of 2-10 keV whose track length is only several millimeters, and 100 um track resolution, fast sampling rate (~20MSPS) is required. In order to satisfy all these characters, the CASCA (Charge amplifier and switched capacitor array) chip and the readout electronics have been designed.



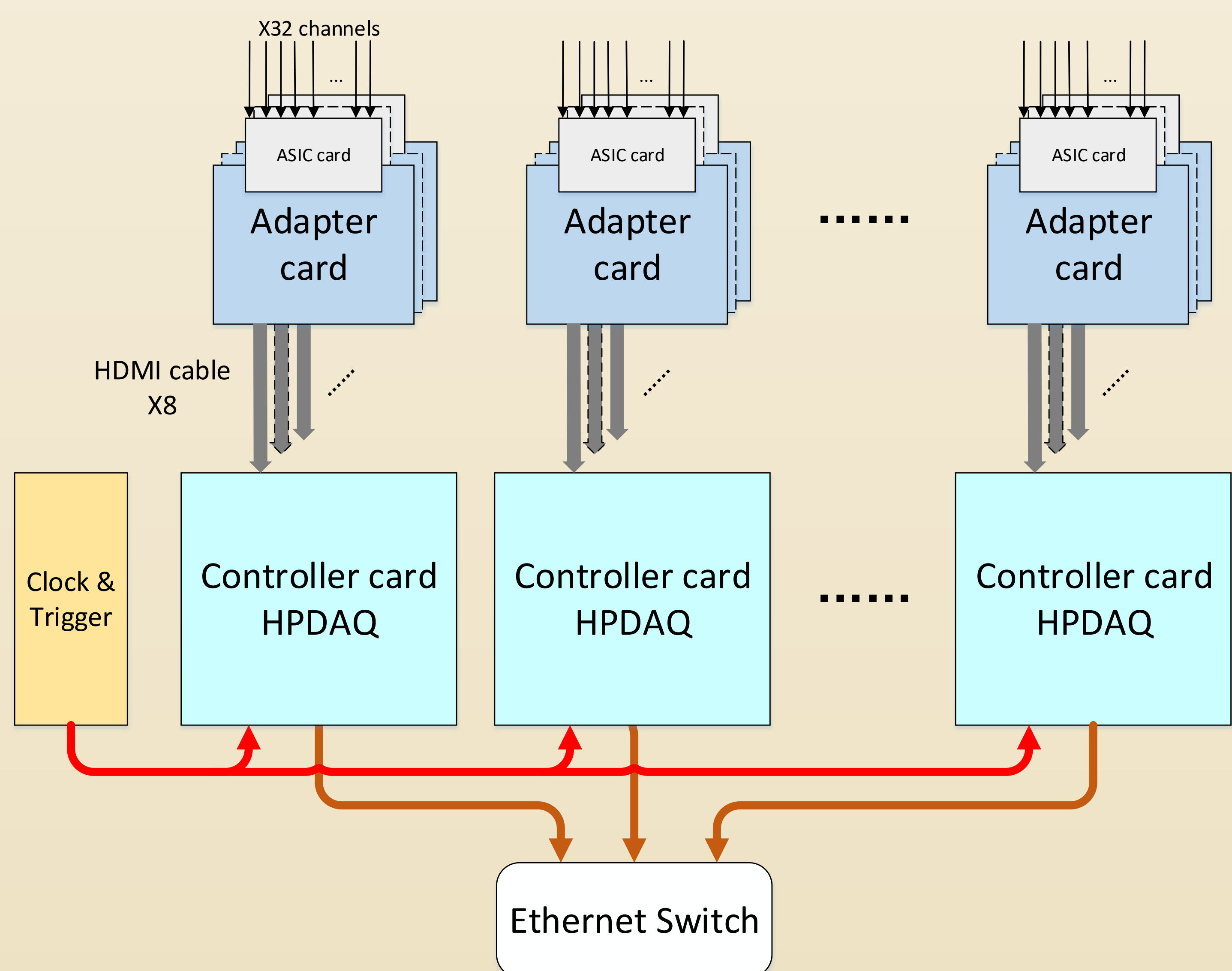
Specifications

The CASCA chip is a 32-channel readout front-end ASIC integrated with the front-end part and the SCA (Switched Capacitor Array), the former for amplifying and shaping and the latter for sampling. The sampling rate of the ASIC is designed for 40MSPS and the valid readout frequency is 5MHz.



The Adapter card named CASCA_AD card, edged-mounted with the CASCA card, is in charge of digitizing the output from the CASCA card and driving the ASIC. A low-power FPGA chip, a 12-bit ADC and a multi-output clock generating chip are mounted on the CASCA_AD card.

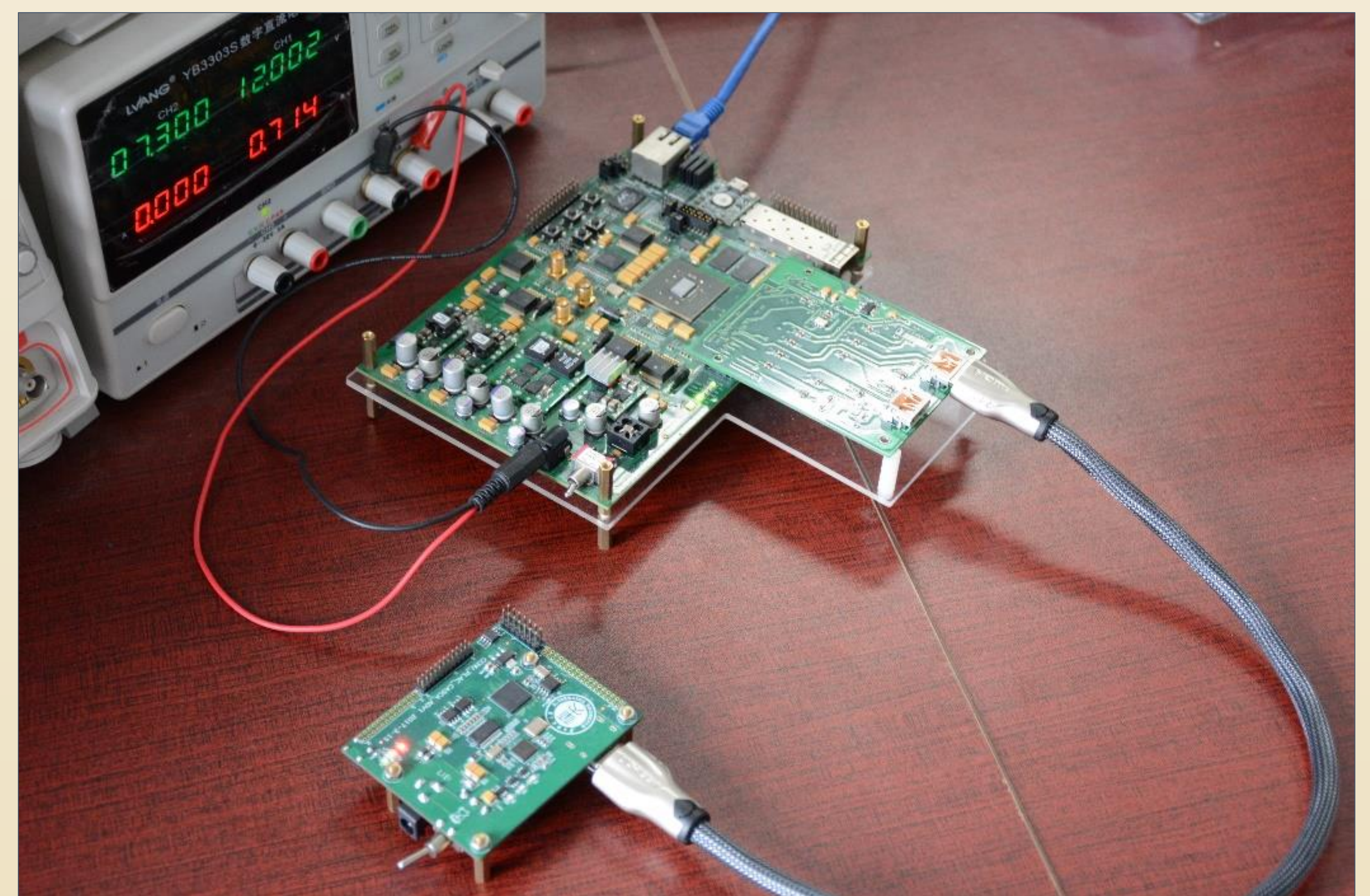
System Architecture



The system mainly consists of three kinds of modules: the ASIC card (CASCA), the Adapter card (CASCA_AD) and the Master controller card (FMC-Based HPDAQ card). The ASIC cards, mounted with dedicated CASCA chips, are designed for receiving XTP signals. The Adapter card, edged-mounted with the ASIC card, is in charge of digitizing the output signals from ASIC card by a 12-bit ADC and driving the ASIC card based on a field-programmable gate arrays (FPGA). The dataflow between the Adapter card and the Master card is based on the Serial RapidIO protocol. The Master card, is designed as a FMC carrier card, providing 8 or more high-speed interfaces connected with the Adapter card. The Master card transfers data through 10Gigabit Ethernet protocol realized by a FPGA.

A synchronous clock and trigger network is designed to ensure the whole readout electronics system operating synchronously. The clock signal is generated with a local oscillator on Clock & Trigger module and fanned out to all the Controller cards.

The Master Controller card named HPDAQ card as a FMC-Based card with two FMC connectors, which is responsible for digital data acquiring and data processing, connects to the CASCA_AD card through a Mezzanine card. In a way of "Several-in-One", several CASCA_AD card are connected to one Master card with 8 or more HDMI cables. After processing the digitized, the Master card transmits data to Server or PC over 10Gigabit Ethernet.



Conclusion

A prototype of XTP detector readout system using a CASCA asic has been designed. And this readout electronics system is flexible to apply in the XTP. A Master card is able to support 256 or more detector channels, and a large number of the Master card could be assembled in parallel to meet the requirement of the large XTP.

References: H. Y. Zhang, Z. Deng, L. He, H. Li, H. Feng and Y. N. Liu.: CASCA: A readout ASIC for a TPC based X-ray polarimeter. IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC), San Diego, CA. 1-4 (2015).