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# The New HADES Trigger and Data Acquisition System

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The data transport and trigger system of the HADES di-electron spectrometer operating at GSI, Germany was upgraded recently. The main goal was to substantially increase the event rate capabilities to reach trigger rates of up to 100 kHz and data rates of 400 MByte/s.
The whole data communication system is based on FPGA-equipped platforms connected by optical links. Here, a custom network protocol, TrbNet, provides a framework to transport triggers, data and control information over the same physical network.
In collaboration with groups from experiments of the FAIR accelerator complex, further developments based on the versatile hardware and communication protocol are being pursued.

## Summary 500 words

The HADES experiment is a High Acceptance Di-Electron Spectrometer located at GSI in Darmstadt, Germany. Recently, its trigger and data acquisition system was upgraded. The main goal was to substantially increase the event rate capabilities by a factor of up to 20 to reach 100 kHz in light and 20 kHz in heavy ion reaction systems. The total data rate written to storage is about 400 MByte/s in peak.
In this context, the complete read-out system has been exchanged to FPGA-based platforms using optical communication. For data transport, a general-purpose real-time network protocol was developed to meet the strong requirements of the system. In particular, trigger information has to reach all front-end modules with latencies of less than 5 μs through up to 10 intermediate hubs in a star-like network setup.
Monitoring and slow control features as well as readout and trigger distribution were joined in a single network protocol. Hence, the network protocol features several logical channels with inherent arbitration by priority. Switching between channels takes less than 100 ns. For control and monitoring, a dedicated channel provides a data bus with a virtual address space spanning the whole network.
The full data acquisition system includes about 550 FPGAs distributed over the complete detector system. Data sent by front-ends are merged by the network hubs into data streams and passed on to a server farm using a standard Gigabit Ethernet network infrastructure. Due to the electromagnetic noise environment, several transmission error detection and correction features were included.
Based on the HADES data acquisition system, further work is in progress to develop a versatile read-out concept that can be used by other experiments. For example, in collaboration with groups of other experiments at the FAIR accelerator complex a common FPGA based platform with high I/O capabilities including Gigabit Ethernet and custom network protocols is being developed.
In particular, an FPGA based TDC with a time resolution of less than 10 ps RMS was designed. Being placed in programmable logic it features a high channel count and high rate capabilities of up to 50 MHz per channel.
In this contribution we present the new digital electronic modules that have been developed, and the structure of the data acquisition network will be described. In addition, future applications of both electronics and network infrastructure developed for HADES in other experiments will be presented.
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