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Studies on the Readout of the ATLAS Inner Tracker Using Commercial Networking Hardware

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In the context of the ATLAS Phase-II upgrade, new front-end electronics is developed, which reads out the detector at higher bandwidth due to finer granularity and higher occupancy.
Because of the high bandwidth requirements, new concepts are needed for the ATLAS ITk readout system. A new scalable approach based on many rather simple nodes is proposed to support lab setups, testing sites as well as the readout of large detector parts. This study is focused on the use of COTS networking components to reduce the costs and increase the flexibility of such a system. Results from first studies are presented.

Summary

For the ATLAS Phase-II upgrade, a complete new all-silicon inner tracker is planned, the ITk. ITk will consist of an outer strip-detector and an inner pixel-detector. The pixel detector on its own will consist of around 10 000 detector modules. In combination with a reduced pixel size and at least 10 times higher trigger rate, the needed readout bandwidth is increasing a lot to the order of 100Tbps. Therefore, a new readout system has to be established for ITk.
Also, in preparation for the construction of the new subdetector, smaller systems are needed being able to handle only a handful of modules. To meet all these requirements in a single solution, a new more flexible approach is proposed being based of rather simple nodes in some crate architecture.
Our group is working on a concept using ATCA carrier boards equipped with mezzanine cards. These mezzanine cards are planned to be the fundamental building blocks of the system. The detector links are connected to these cards and all the signals to and from the detector are dealt with by a powerful FPGA. Also, the trigger information will be fed through these mezzanine boards.
The connection to further off-detector electronics or computers will be realized by network connections. One of the main topics to study will be the throughput of the system from many detector links to the network. There are some fixed latency paths or signals needed in order to trigger and calibrate the detector, these paths need to be implemented and studies as well.
To provide a scalable system, small units should be operational stand-alone. This shall be realized by table top setup solutions which do not need any crate infrastructure. The very modular way of construction offers the possibility of very small and rather large system by simply adding mezzanine boards and carrier boards.
As this concept uses commercial network components, development and purchase costs can be reduced and the integration into the readout chain is simplified,
Finally, the system follows the ATLAS TDAQ approach using interface cards between the detector and the network (FELIX). Therefore, the system can provide a beneficial input for developing the final ITk readout system. As the strategy of detector connection is the same, critical topics can be studied and development of firmware and software which is needed for the detector specific operation tasks, as they are calibration and data taking, can be started.

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