Performance of the DHH readout system for the Belle-II pixel detector

Stefan Huber*, Igor Konorov, Dmytro Levit, Stephan Paul

Belle-II pixel detector
- thickness: 15 mm
- rolling shutter read-out integration time: 28 ms
- 2 layers consisting of in total 40 half-ladders
- 4 digital data processors per half-ladder
- zero suppression, spectral and common mode correction
- 4 x 1.5 Gbit optical links
- high occupancy (max. 3%) - high data rates in total 20 GB/s

Crosspoint switch
- Allows to map any sensor to any DHE
- Clock optical power from the detector
- Change over to spare module without access to radiation area
- Flexcast feature - independent verification of data flow
- Configurable load-balancing between different DHHs

DHE
- Receiver for detector data
- Accepts data which correspond to triggers
- Long integration time = high trigger rates
- Several triggers per detector frame
- Formatted data sent further to DHC

Unified Communication Framework
- Single high-speed serial link for data, slow control, trigger, and timing information
- Three different communication channels used (Trigger, Data, Ethernet)
- Fixed latency for one channel
- Priority handling for all channels
- Self recoverable after connection losses
- Independent from physical layer

DHC
- Master module in one ATCA carrier
- Interface to the Belle-II trigger and timing system
- Distribution of control signals to 5 DHEs and one DHI
- Ethernet hub
- UCF speed currently 2.5 Gbit/s
- UDP interface for monitoring data
- Event-building of data from 5 DHEs via DDR3 memory
- Round robin event distribution via 4 6 Gbit/s Aurora links

Outlook
- Install full system (40 sensors / 8 DHHs)
- Change UCF to 5Gbit/s links
- Commission gated mode
- Replace UDP for local DAQ by PCIe readout
- Online clustering

System capable of handling 20 GB/s

Gated mode
- High background after freshly injected bunch
- Veto signal from DHC
- Detector stores currently accumulated charge
- Baseline oscillations while waiting on end of gated mode
- Inhibit trigger signal during that time
- Functionally proven and tested readout even in the experiment
- Baseline fluctuations to be understood before final commissioning

Belle-II pixel detector
- thickness: 75 mm
- rolling shutter read-out integration time: 20 ms
- 2 layers consisting of in total 40 half-ladders
- 4 digital data processors per half-ladder
- zero suppression, spectral and common mode correction
- 4 x 1.5 Gbit optical links
- high occupancy (max. 3%) - high data rates in total 20 GB/s