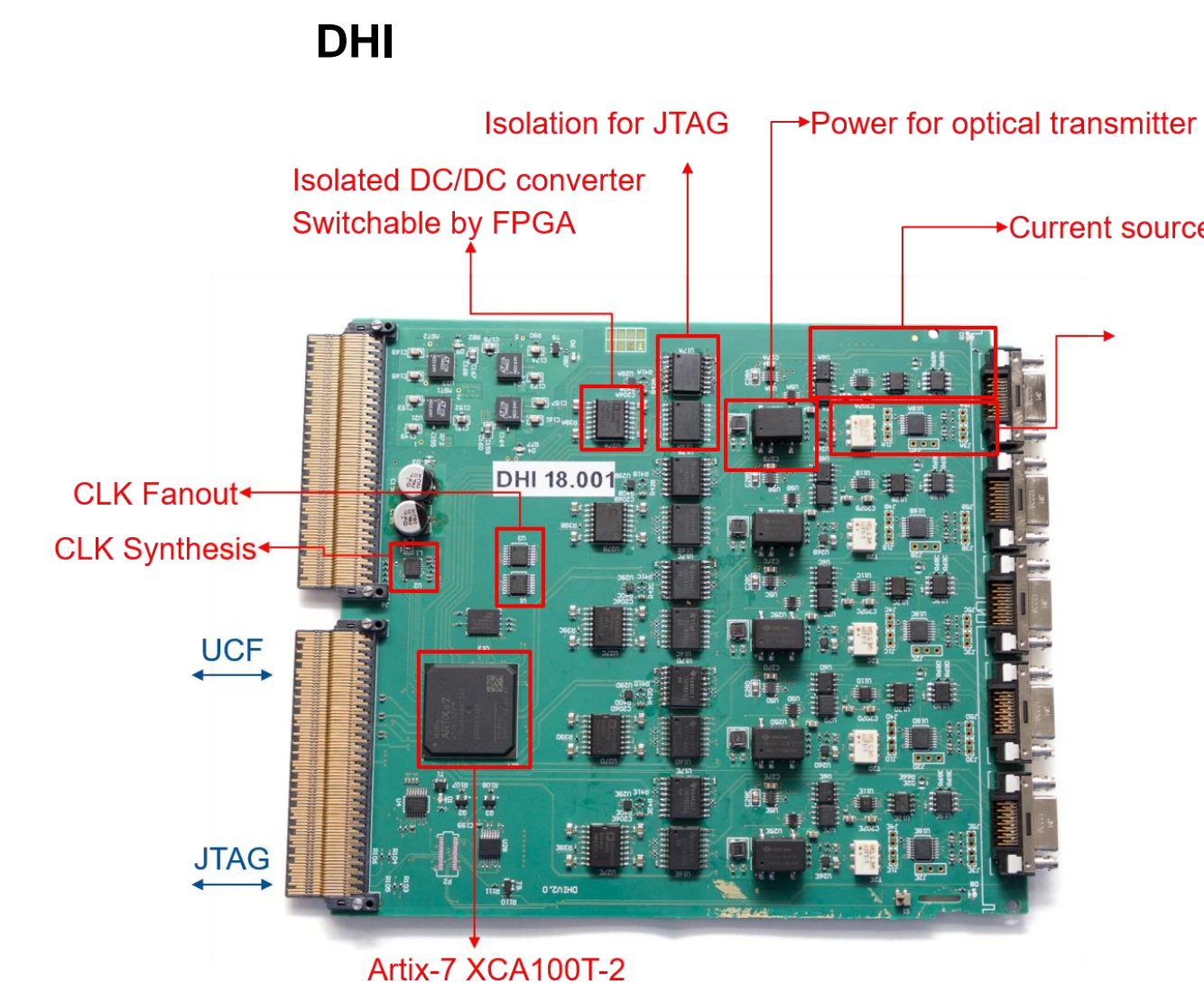
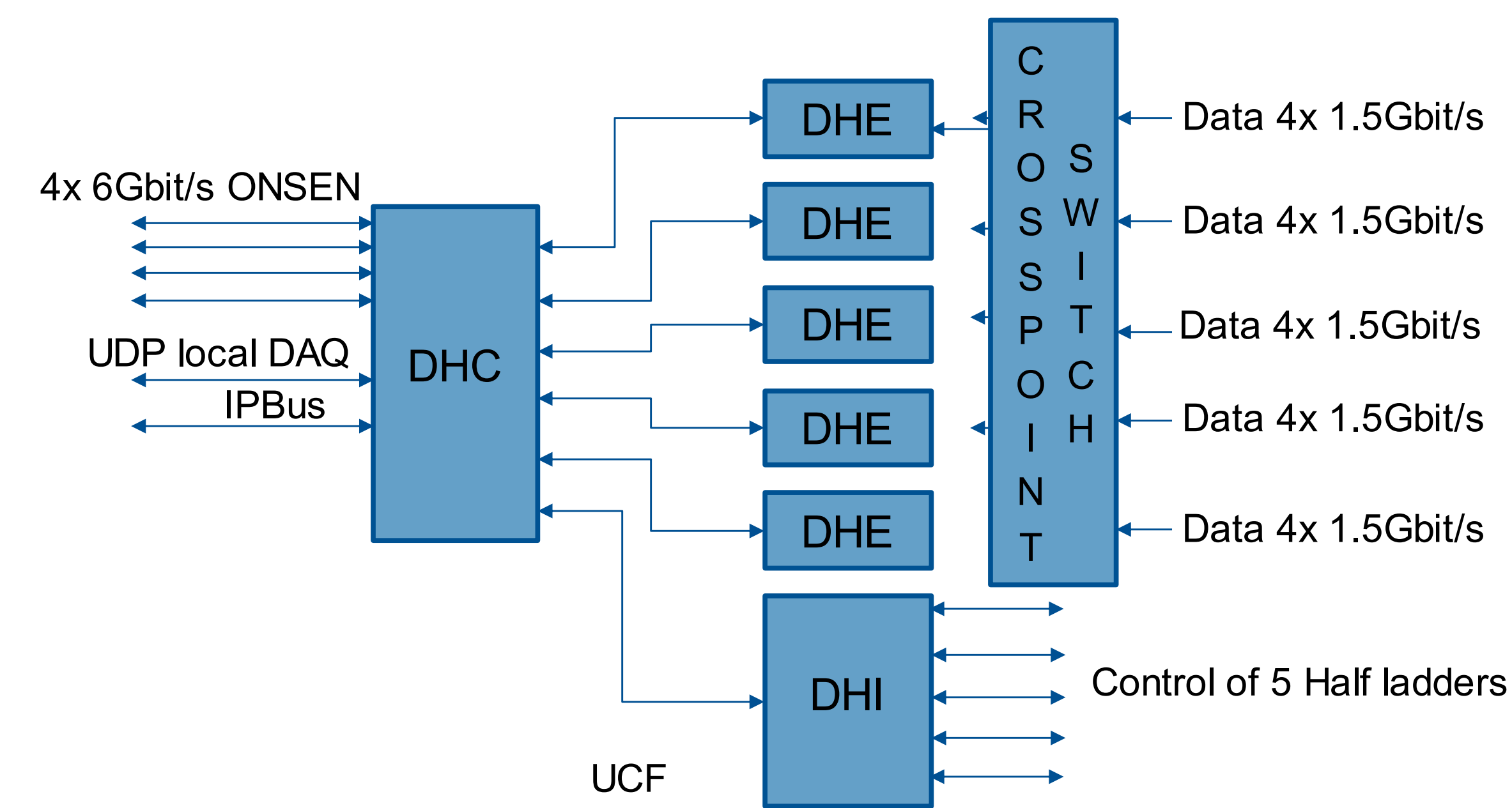
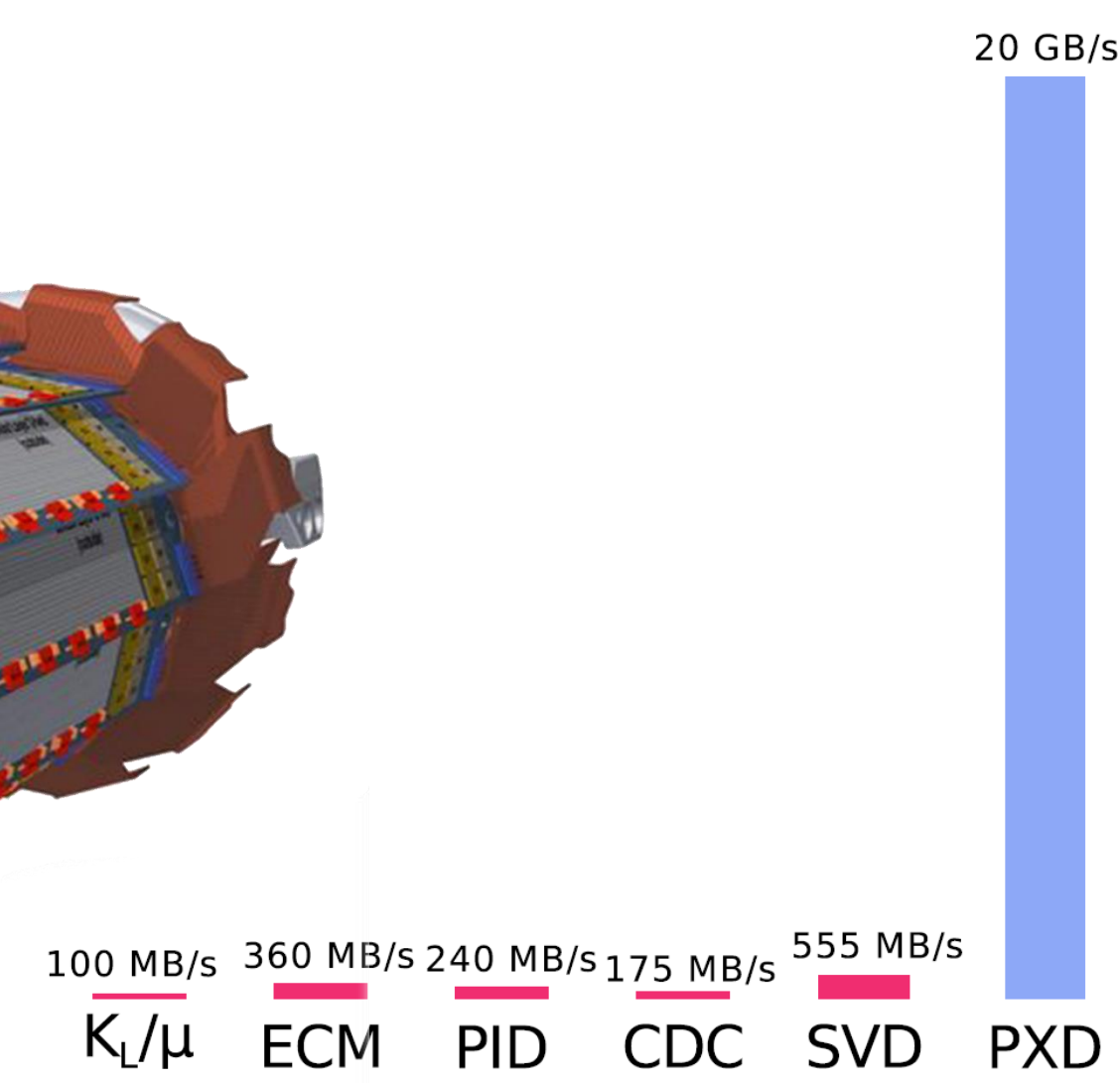
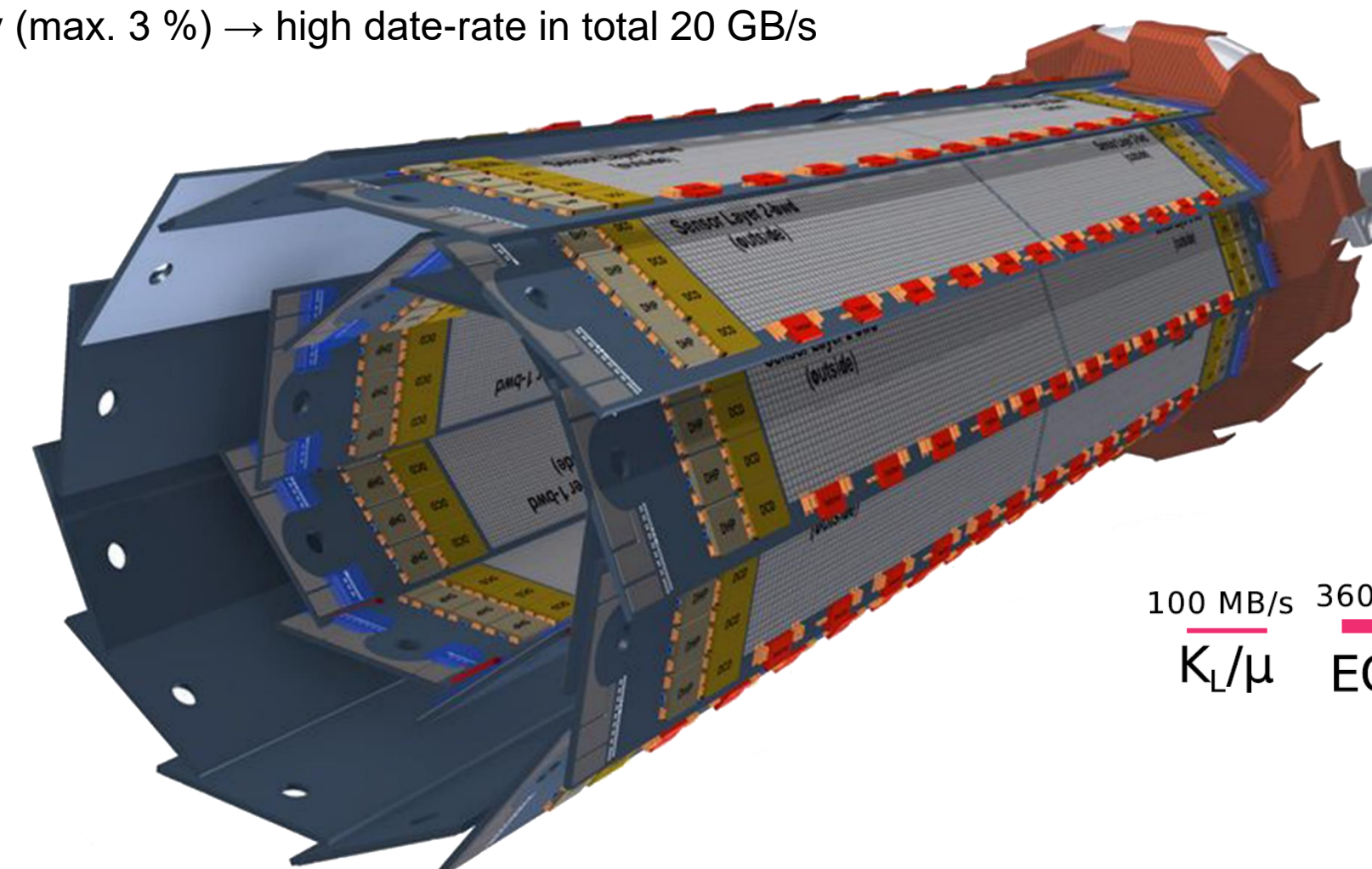


# Performance of the DHH readout system for the Belle-II pixel detector

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

## Belle-II pixel detector

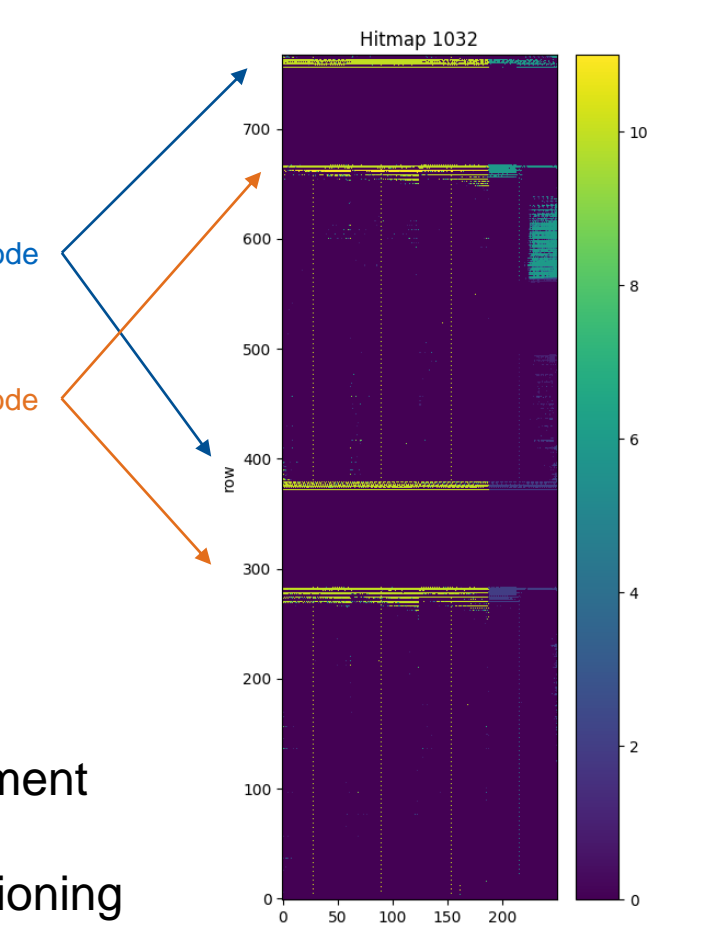
- thickness: 75 mm
- rolling shutter read-out integration time: 20 ms
- 2 layers consisting of in total 40 half-ladders
- 4 digital data processors per half-ladder
  - zero suppression
  - pedestal and common mode correction
  - 4 x 1.2 Gb/s optical links
- High occupancy (max. 3 %) → high data-rate in total 20 GB/s



- Galvanically isolated control signals
- JTAG for detector configuration
- Manchester encoding for real-time signal
  - Sync, trigger, synchronization and veto
- Power for optical transmitters

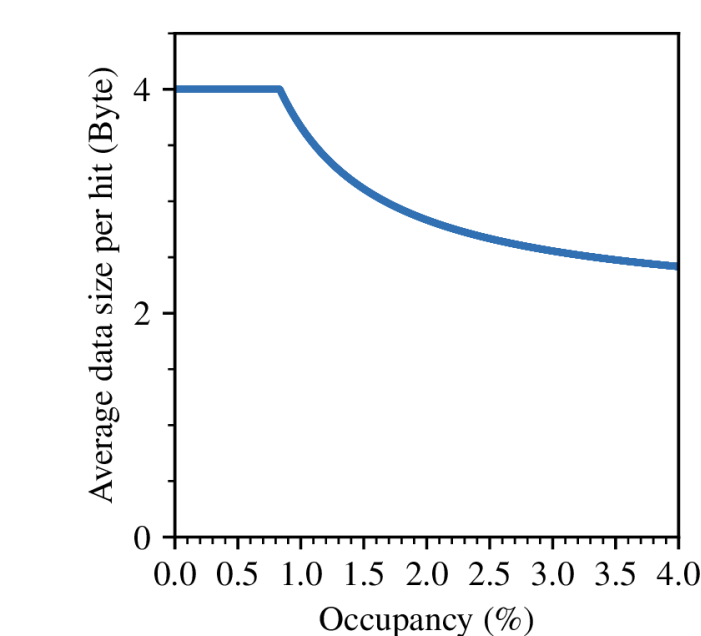
## Gated mode

- High background after freshly injected bunch
  - Sensor stores currently accumulated charge
  - Sensor does not collect new charge
- Veto signal from DHI
  - Inhibit trigger signal during that time
- Baseline oscillations while switching on and off gated mode
  - Inhibit trigger signal during that time
- Functionality proven and noise reduction seen in the experiment
- Baseline fluctuations to be understood before final commissioning

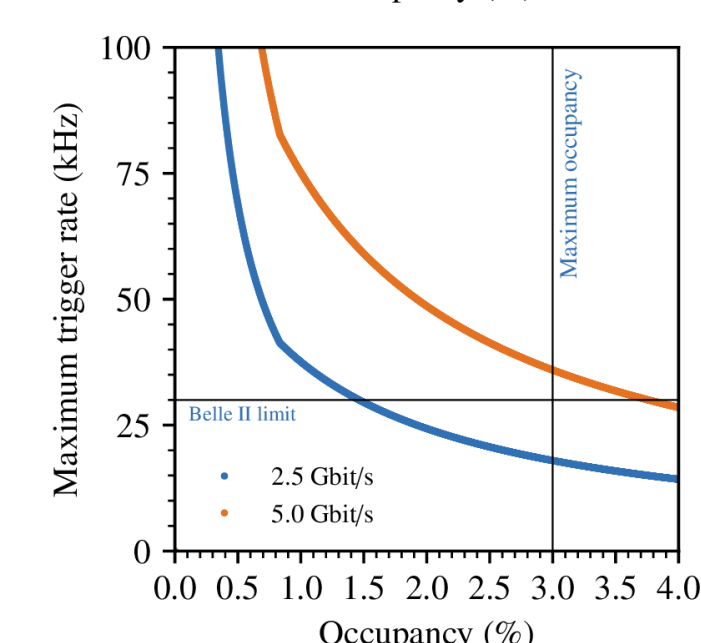


## Performance

- DHH running stably with 20 sensors attached
- Currently operation at low trigger rates (<5 kHz)
- Maximum trigger rate limited by UCF link speed
  - ~20 kHz @ 3% occupancy

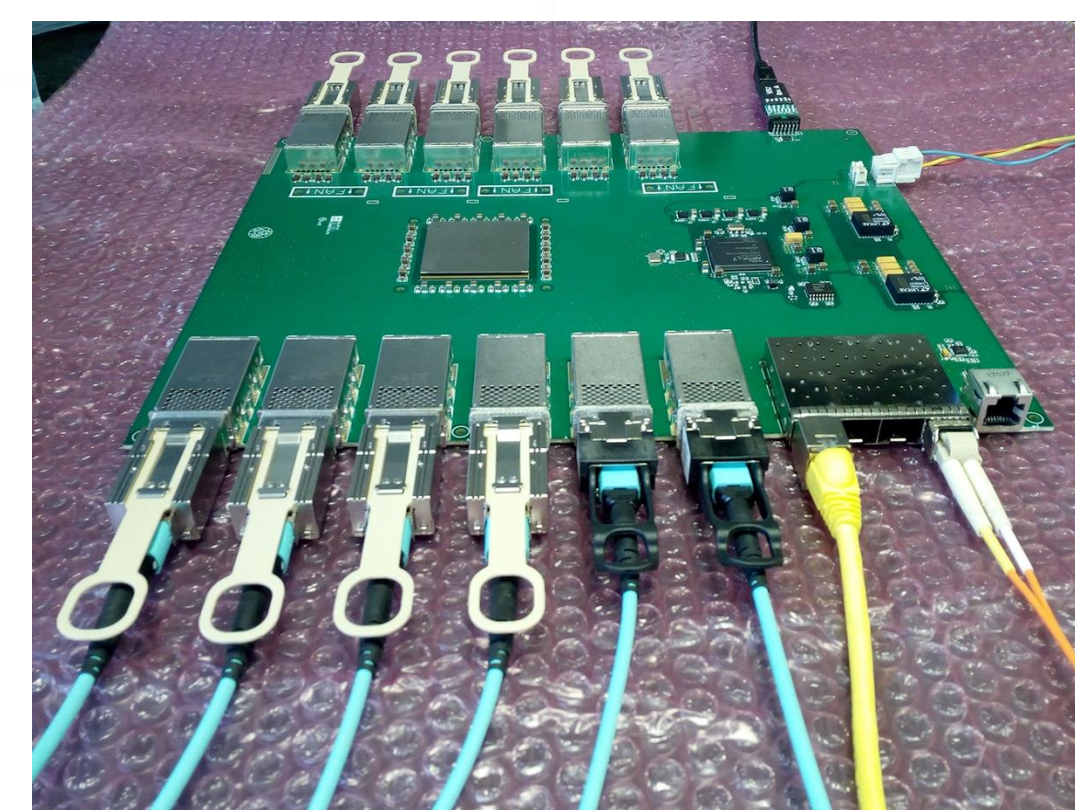


## System capable of handling 20 GB/s



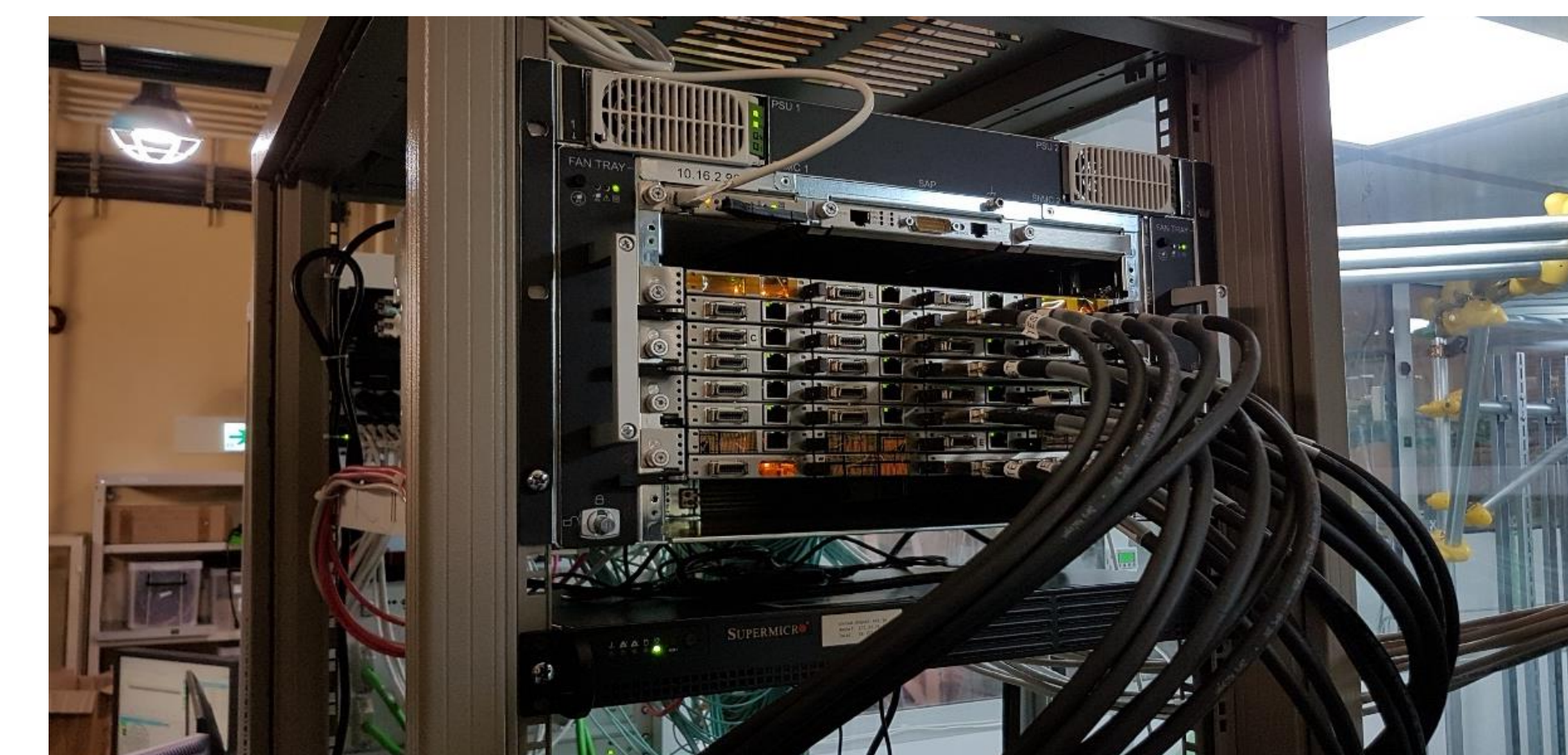
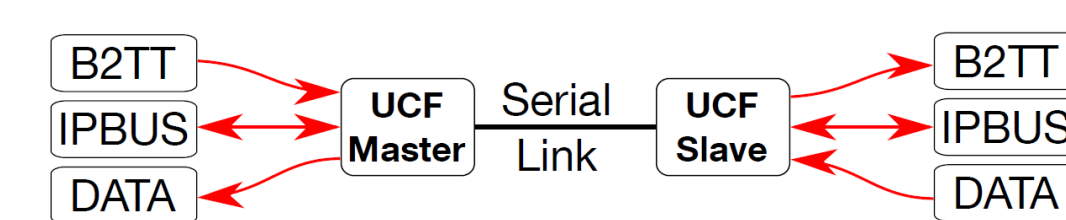
## Crosspoint switch

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



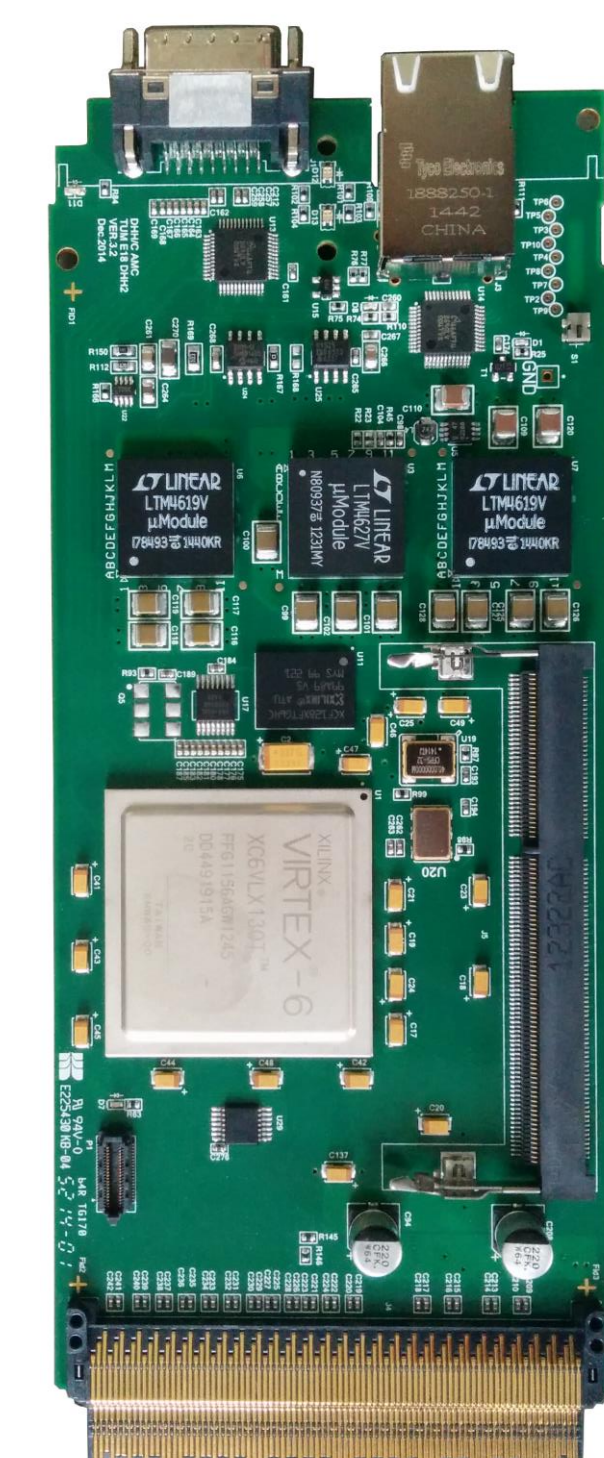
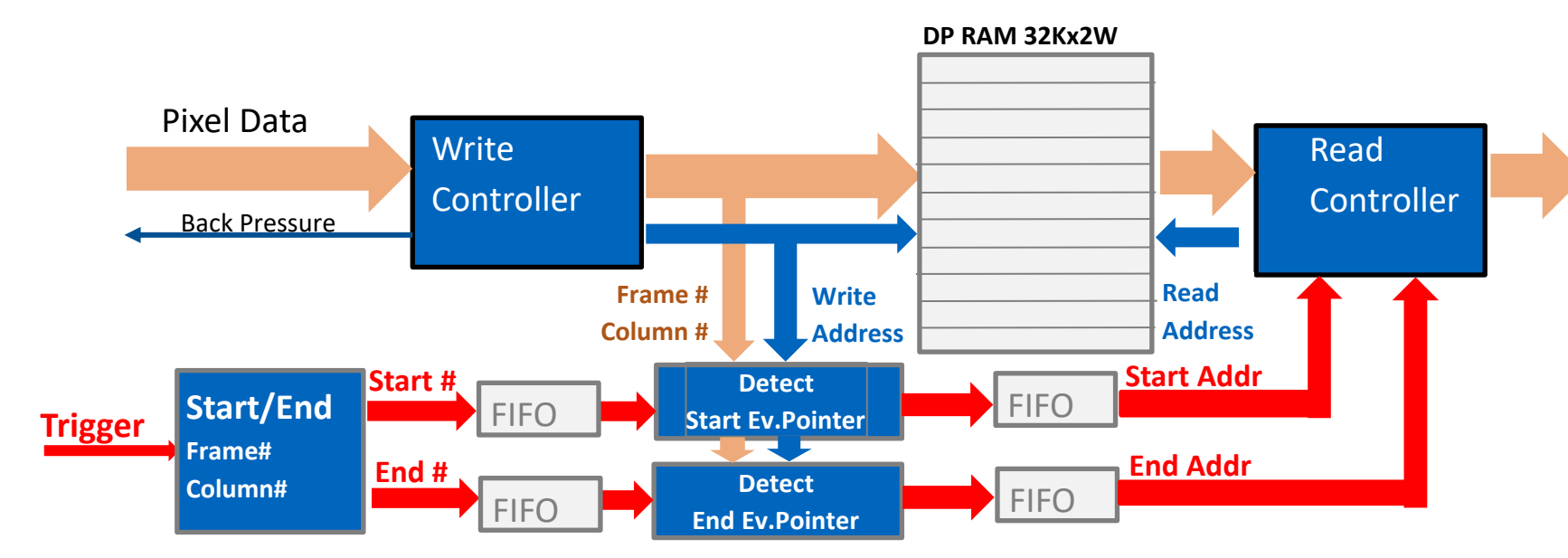
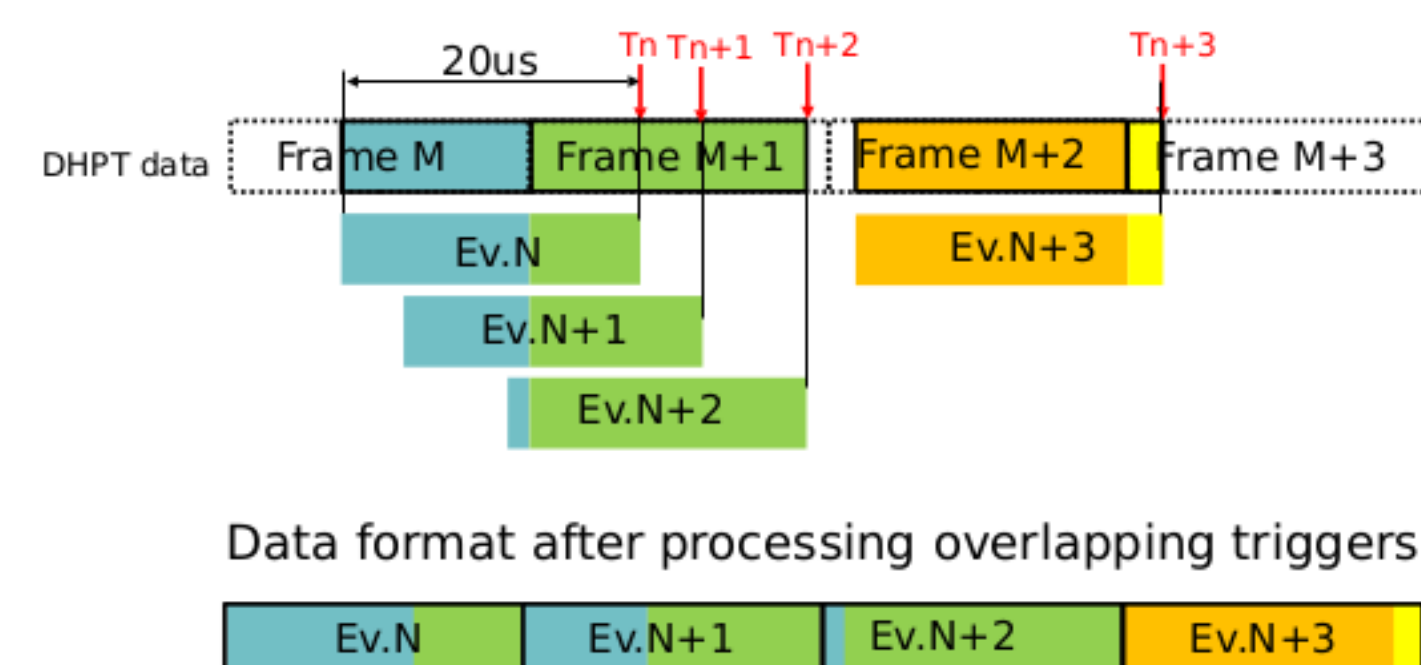
## Unified Communication Framework

- 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



## DHE

- Receiver for detector data
- Accepts data which corresponds to triggers
- Long integration time + high trigger rate
  - Several trigger per detector frame
- DHE splits and copies data in order to have full frames for every trigger
- Formatted data sent further to DHC



## 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

