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Overview of the *(Phase II)* DAQ Architectures of ATLAS and CMS

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+ DAQ System Overview

- Provide an overall framework for configuration, control and monitoring of the experiment (online software)
- Distribute timing, trigger and fast commands to detector front-end
- Readout detector data after hardware trigger
- Build events from fragments based on unique event identifier
- Store data for further selection
- Serve data to the High Level Trigger (HLT)
- Forward accepted events to permanent storage
  - Build data files

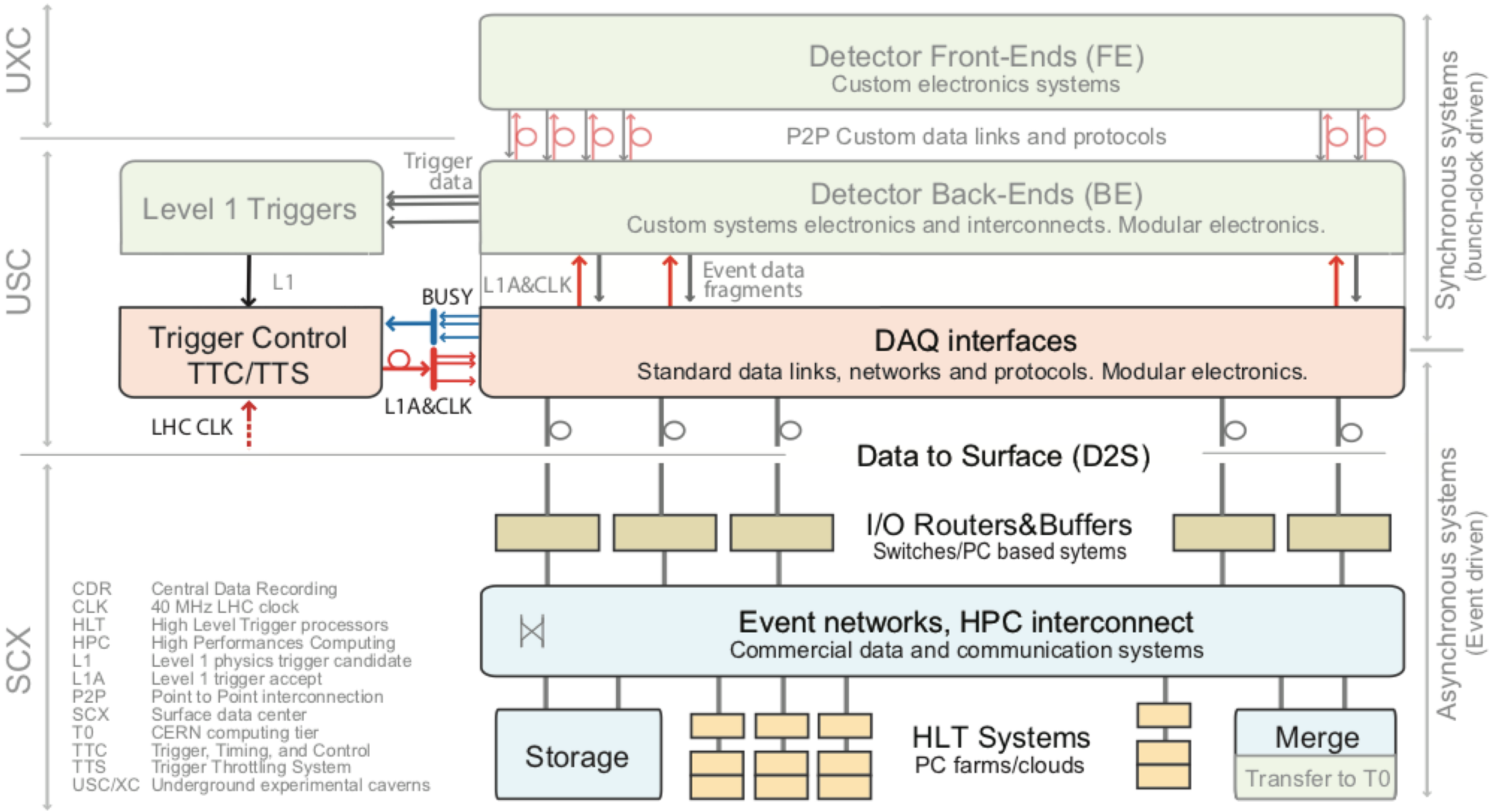
ATLAS and CMS in Phase II

- High luminosity LHC increases the number of interactions per bunch crossing to ~200
- Hardware based, fast triggers loose part of their selectivity
  - Increased rate of accepted events
- New/upgraded detectors
  - More readout channels
  - Harsher radiation environment
  - Larger event size

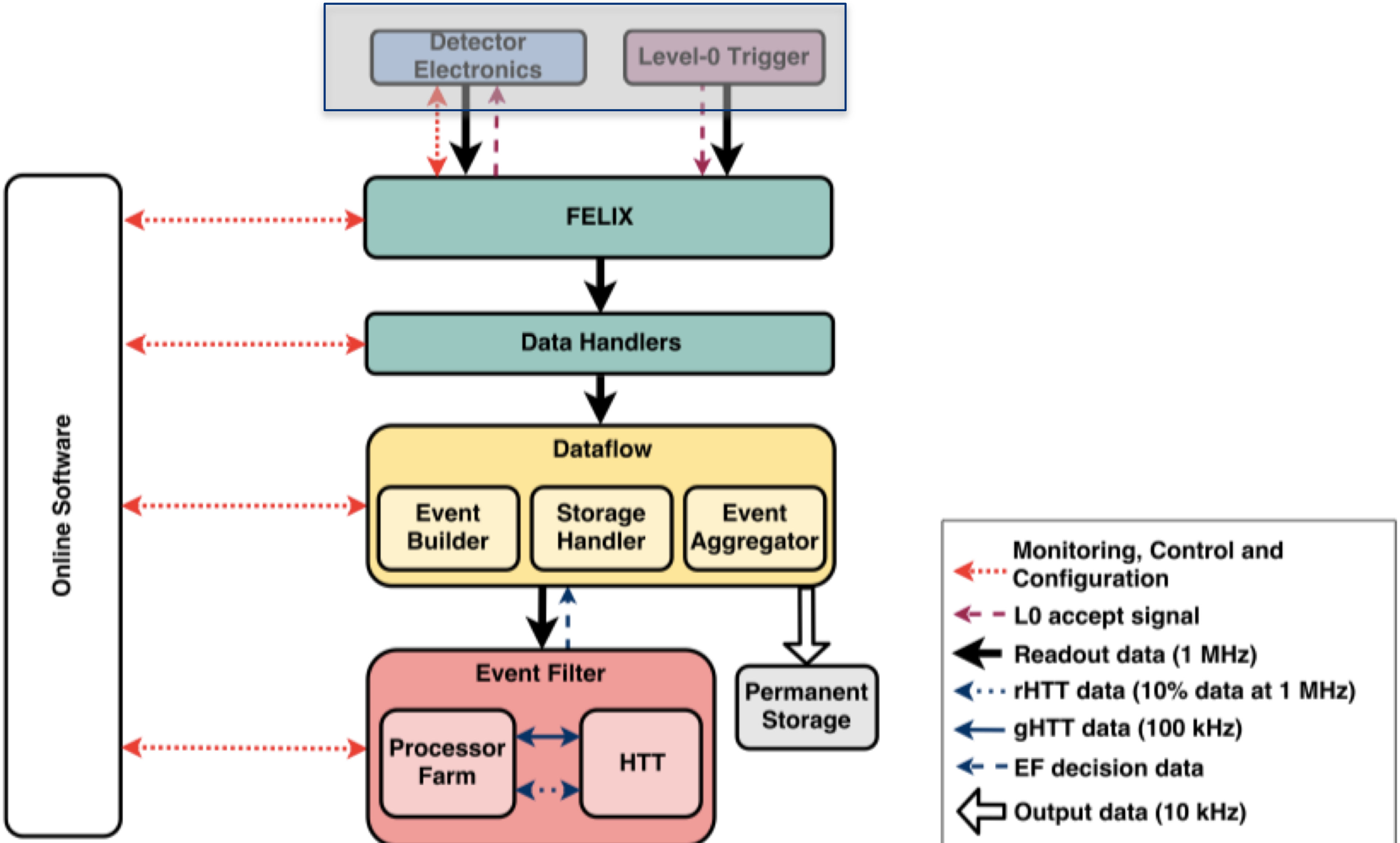
The HL-LHC DAQ Challenge

- Scale up to control/monitoring infrastructure by ~1 order of magnitude
- Increase readout rate to 750-1000 kHz
  - Today 100 kHz
- Increase the overall throughput to ~50 Tb/s
  - Today ~2 Tb/s
- Increase rate of data to permanent storage to ~7.5-10 kHz
  - Today ~1 kHz
- ATLAS and CMS both need a substantial upgrade of their respective DAQ systems
  - Relying on experience gained during Run 1-3

High level view of CMS DAQ



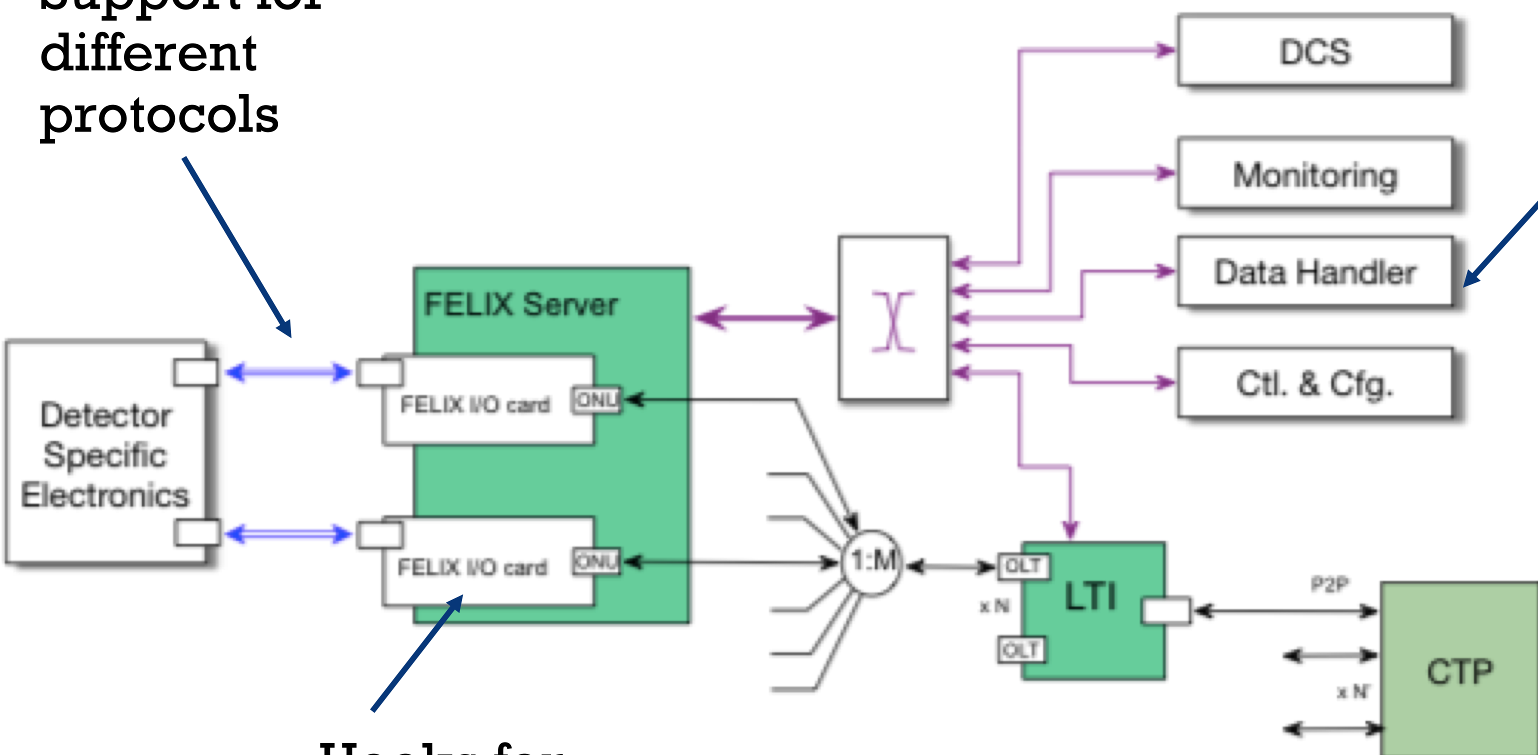
High level view of ATLAS DAQ



ATLAS Detector Interface

Support for different protocols

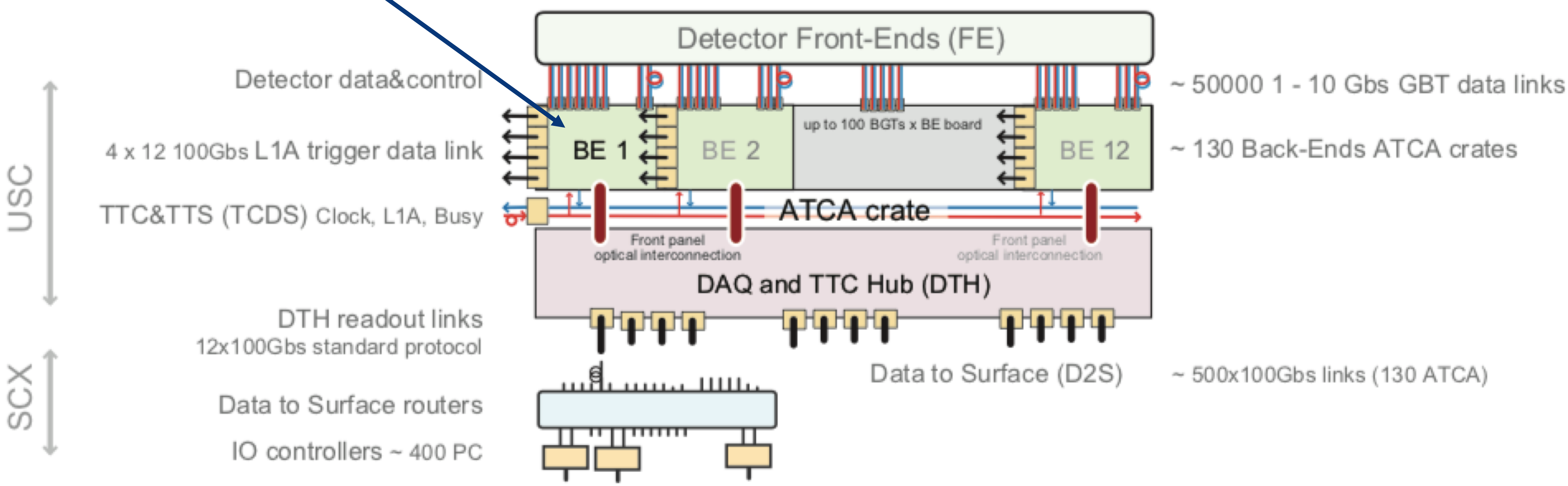
Hooks for detector specific SW



Hooks for detector specific FW

CMS Detector Interface

Common FW blocks in detector specific BE



+ The readout

CMS	ATLAS

CMS

- ATCA based
  - BE boards + DAQ & Timing hub
- Data sent to surface over reliable protocol (e.g. TCPIP) to I/O processors
- Detector specific BE boards embed DAQ firmware for data transmission via front panel

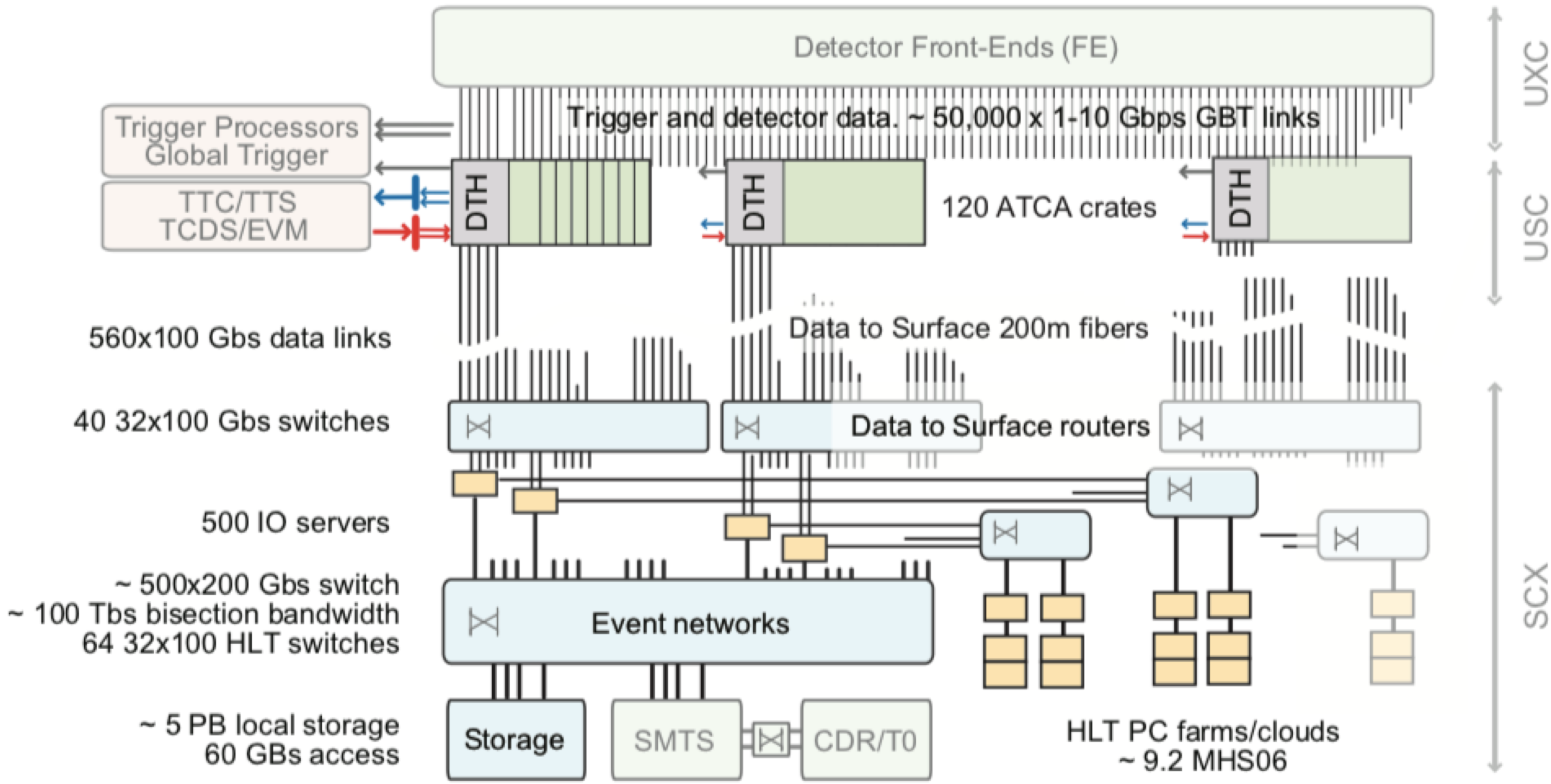
ATLAS

- PCIe based
  - FELIX cards in servers + data handler servers
- Integrated interface to event building
- Limited hooks for detector specific firmware blocks in FELIX card; Data Handler software application embedding detector specific software

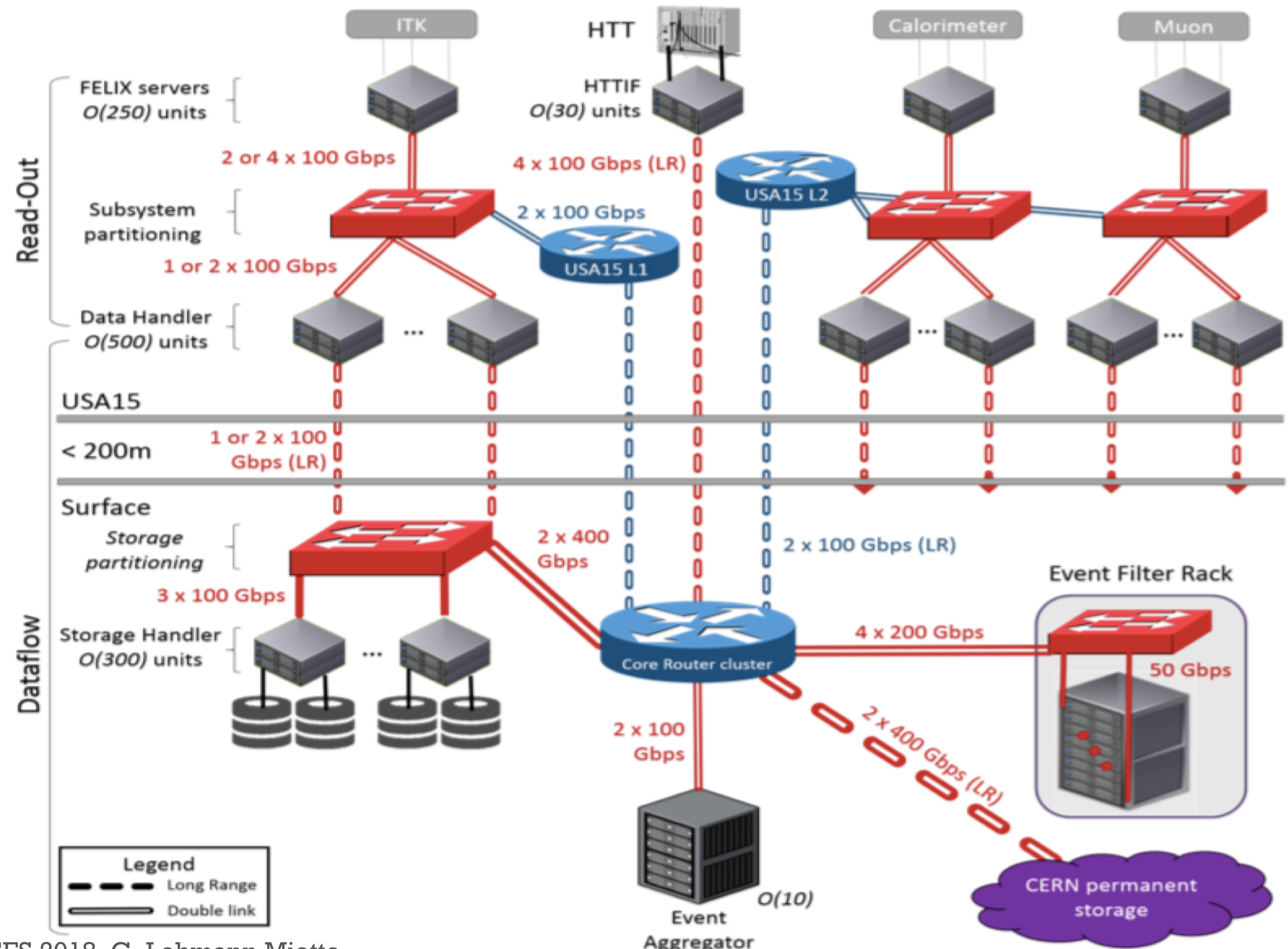
Timing, control and BUSY

CMS	ATLAS
▪ Leaf of distribution over DTH	▪ Leaf of distribution over FELIX
▪ Timing & control distributed over backplane through custom serial data stream	▪ Timing & control distributed over point-to-point optical links (lpGBT) to detector electronics
▪ Status monitoring for BUSY logics collected over the backplane	▪ BUSY ON/OFF collected over point-to-point optical links

+ Layout of CMS DAQ



+ Layout of ATLAS DAQ



Event building and temporary storage

CMS	ATLAS

CMS

- Baseline 200 Gb/s interconnects (e.g. Infiniband HDR)
- I/O servers receiving data from readout (TCP), acting both as event building sources and destinations
  - Folded event builder
- Complete events stored in high speed storage to serve HLT (~1 min)

ATLAS

- Baseline 100 Gb/s interconnects (e.g. Ethernet)
- Data injected directly from readout
- Introduction of logical event building, i.e. data fragments stored in large distributed high performance storage (~1h)
  - Event builder is the book-keeper

+ High Level Trigger

- Using respective offline sw frameworks
  - Algorithms are outside DAQ scope
- Manage large, heterogeneous farm
  - In ATLAS additional hardware based tracking for trigger
  - Possible introduction of accelerators
- Estimate power, space & network needs
  - Based on estimates of required CPU HS06
    - ATLAS 4.5 MHS06 + HTT, CMS 9.2 MHS06
  - Assume different models of evolution of computing power
- Continuous re-assessment and simulations
  - Large impact on need for refurbishing data center infrastructure at experiments

Storage of accepted events

- Both ATLAS and CMS have modular, scalable systems in place to aggregate accepted events into files and transfer them to Tier0
  - Based on Hard Disk Drives
- ATLAS foresees to use the same distributed storage system used for temporary buffering before HLT for this task in Phase II
- CMS will decide on the implementation of this subsystem later

Online software

- Both ATLAS and CMS have mature online sw frameworks
  - General evolution of sw model, introduction of new technologies and third party tools

- CMS
  - Increase homogeneity across systems
  - Creation a uniform stack providing DAQ and TCDS functionality for test-bench setups, standalone single-crate systems, small scale DAQ systems (aka miniDAQs), and global DAQ

- ATLAS
  - Introducing containers
  - New cluster orchestrator for HLT farm
  - Service oriented operational monitoring
  - Upgrade of event sampling system

Summary

- The DAQ systems for Phase II rely on the experience accumulated over many years of data taking
  - Hardware technologies
  - Communication protocols
  - Software designs & tools
- The main difference in approach between the two experiments is at the level of the detector interfaces
- Most components need to be re-implemented to sustain the increased event size and HW trigger rate
  - Active R&D is ongoing in ATLAS and CMS, sometimes in common (e.g. large distributed key-value store as temporary storage before HLT filtering)
- Only the baseline ideas were presented for both ATLAS and CMS
  - Looking into open options there is even more commonality