WP 5: DAQ R&D for HyperK

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Content

- Hyperk DAQ overview
- ToolDAQ Updates
- Hyper- K test stand
- Network topology and throughput
- Advanced triggering development
- Monitoring, Slow control and remote control
- Timing systems

Hyper-K Reference Design

ToolDAQ

In Water

X ~2300

FEE

FEE

FEE

FEE

FEE

FEE

1 Gb/s

6 X 1Gb/s optical fibres

2 x CLK
2 x Counter
2 x Data & Slow control

FEE
Front End Electronics

*Concentrator Card
For MPMT

24 X

ID

OD

X ~4

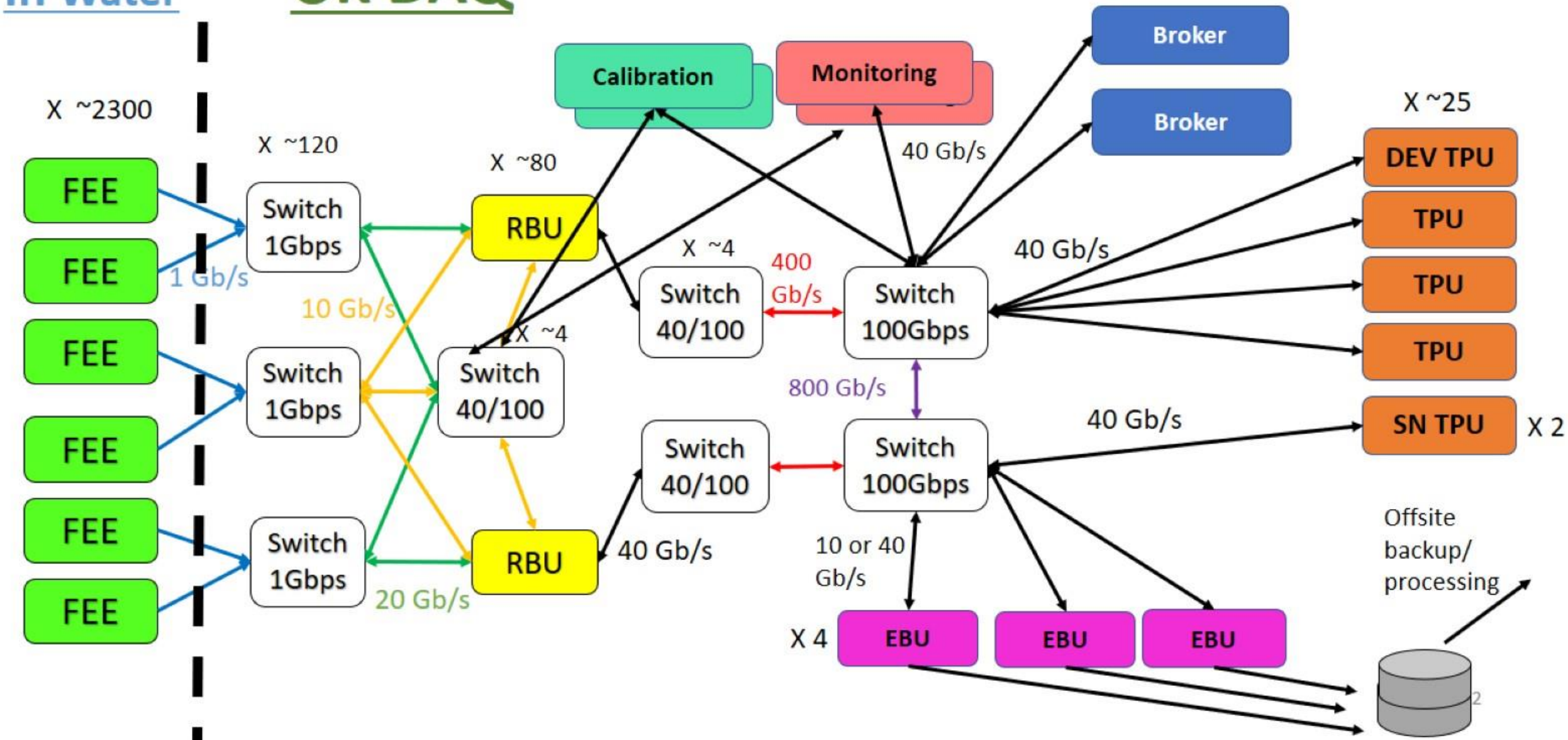
MPMT

Hyper-K Reference Design

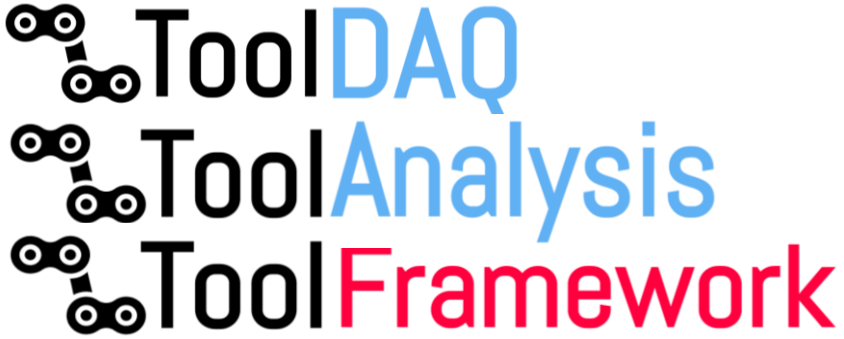
ToolDAQ

In Water

UK DAQ



Software Development



- Large improvements and expansions of DAQ software both in performance and functionality

- The software is now being actively used on 9 different experiments (ANNIE, Super-K, EGADS, Hyper-K, IWCD, WCTE, WATCHMAN, BUTTON, EOS) and many more test stands

- The ToolFramework is being used in many capacities such as DAQ, front end electronics firmware, monitoring, slow control, database systems, calibration, generation, reconstruction and analysis.

ToolDAQ is a specialisation of the ToolFramework for use with creating DAQ applications

ToolFramework is a lightweight software framework for building modular C++ applications.

Applications are constructed by producing modular Tool classes (in c++ or python) that are then chained together in Toolchains for execution, with data passing between tools via a transient data storage class.

ToolDAQ/ToolFramework

ToolDAQ expands upon this by adding:

- Dynamic service discovery
- Node management
- Remote control / run control
- Fault tolerant networking infrastructure
- Logging
- Many other utilities and helpful functions

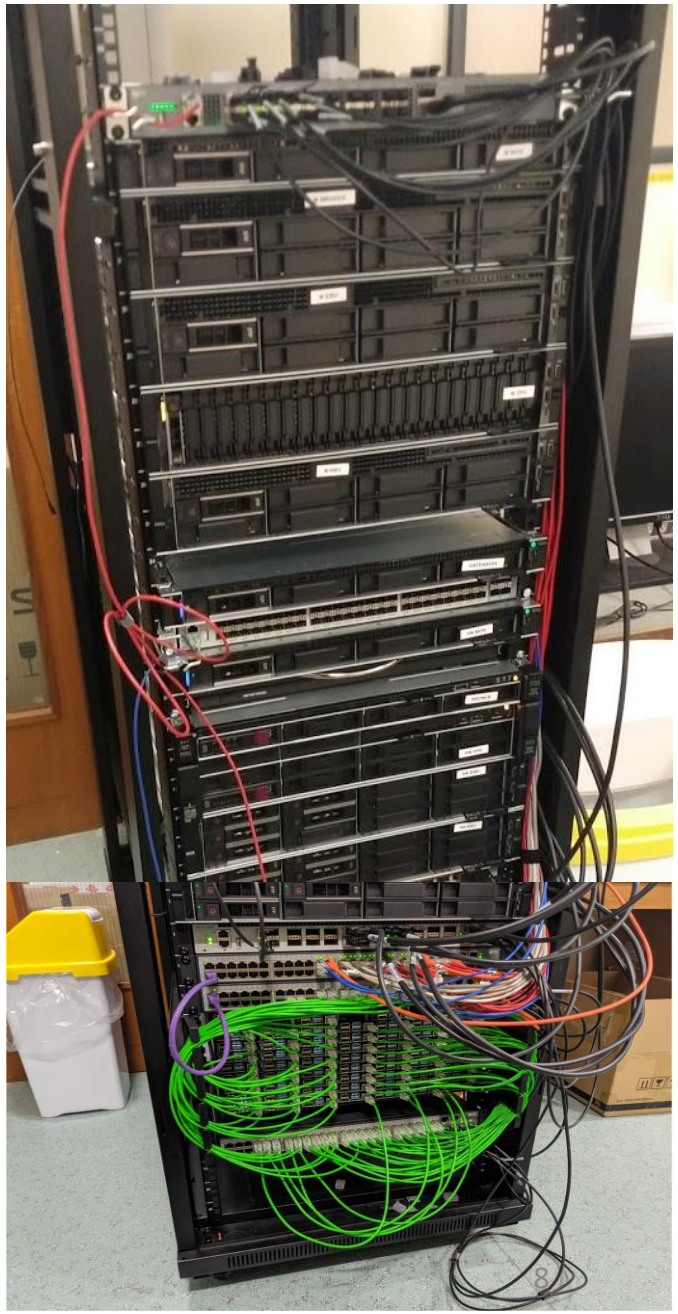
Large amounts of improvements and refactoring of code has happened recently to ease both development and adoption in a unified way

Hyper-K Test Stand

- Since last meeting we have built a hardware test stand to test each aspect of the DAQ system

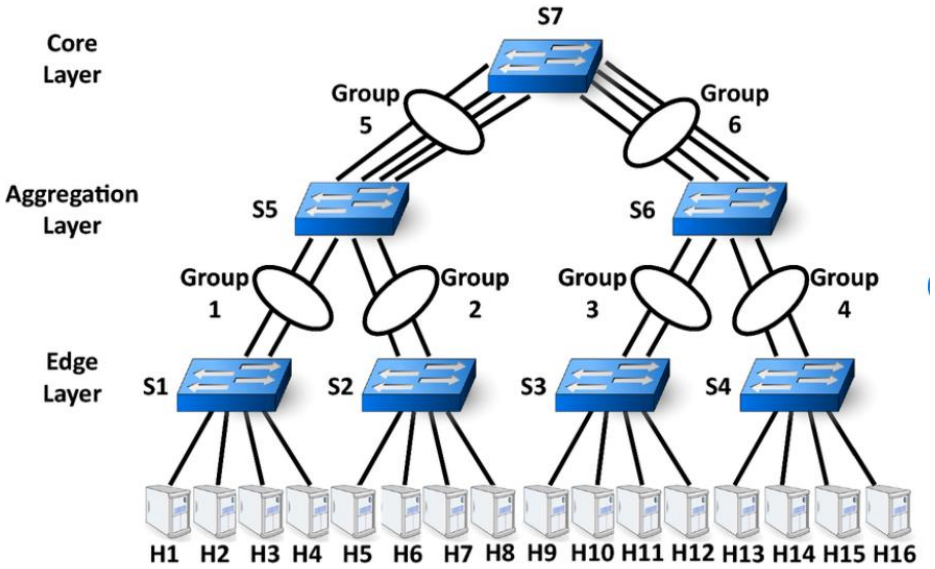
- Multiple high performance nodes
  - GPU equipped trigger processors
  - Event builders
  - Buffering and processing machines
  - 60 node cluster
- Monitoring and management development nodes
- High speed networking

* FEE equivalent low power machines



Networking

- Distributed computation development
- High speed data through put tests (up to 800Gb/s)
- Large scale network topology and failover redundancy testing
- MLAG and link aggregation testing



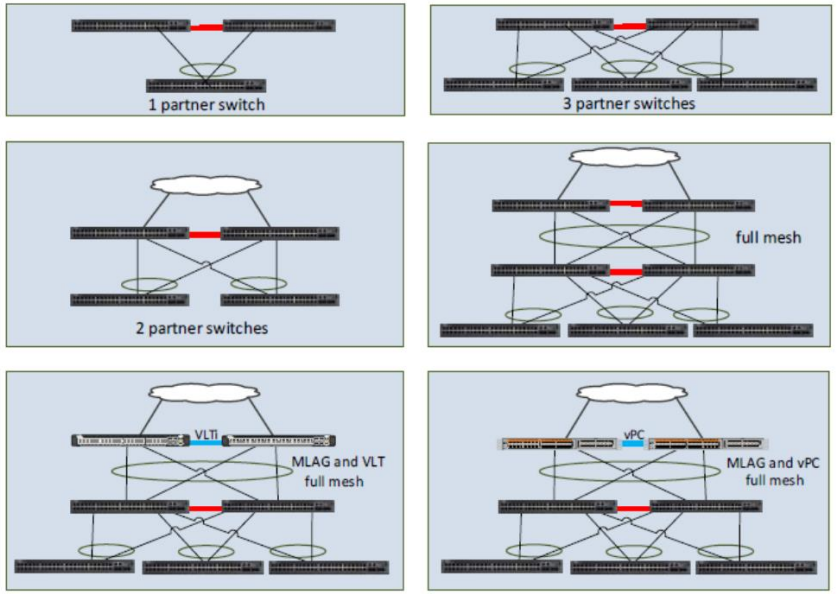
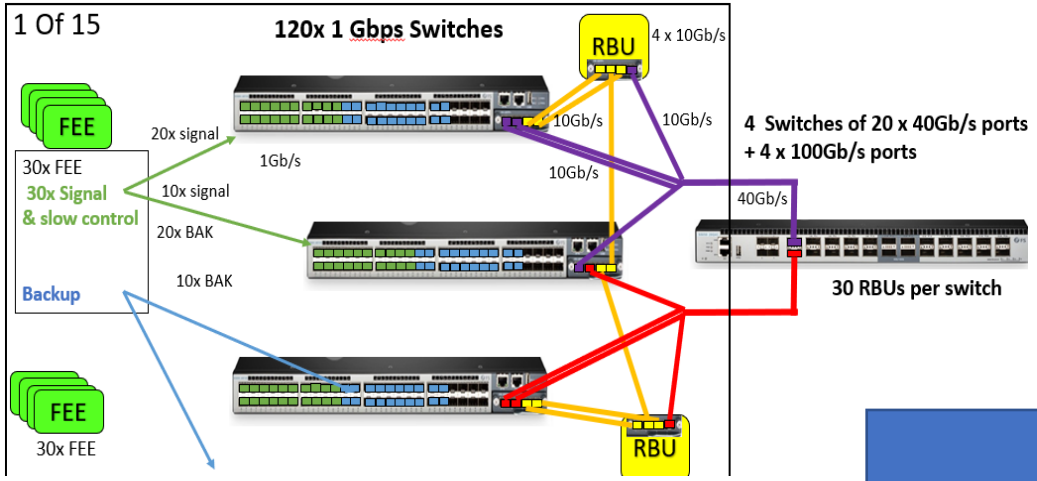
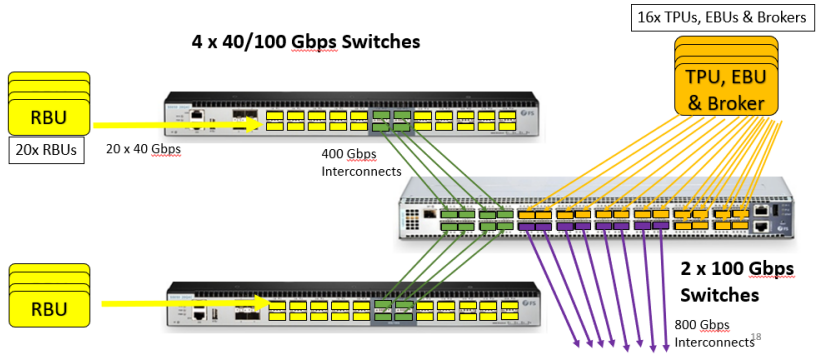


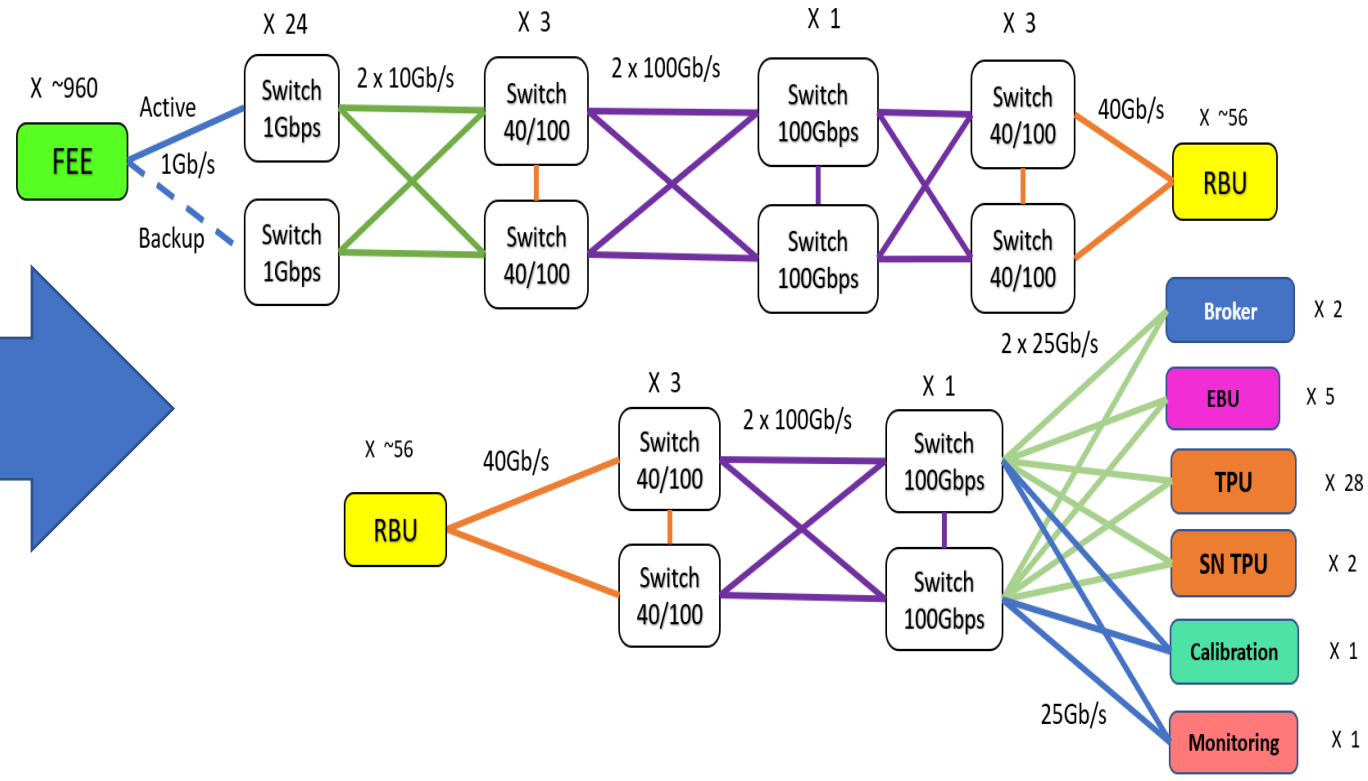
Figure 4 Examples of MLAG topologies

Redesign of Hyper-K networking

- Removed any single point of failure and fully isotropic readout



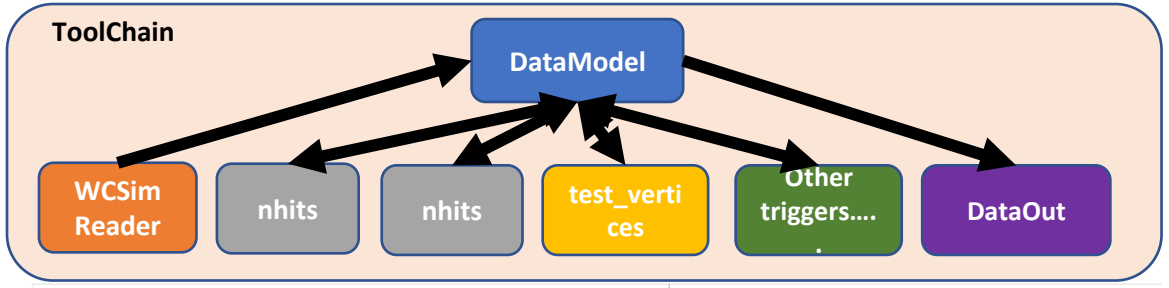


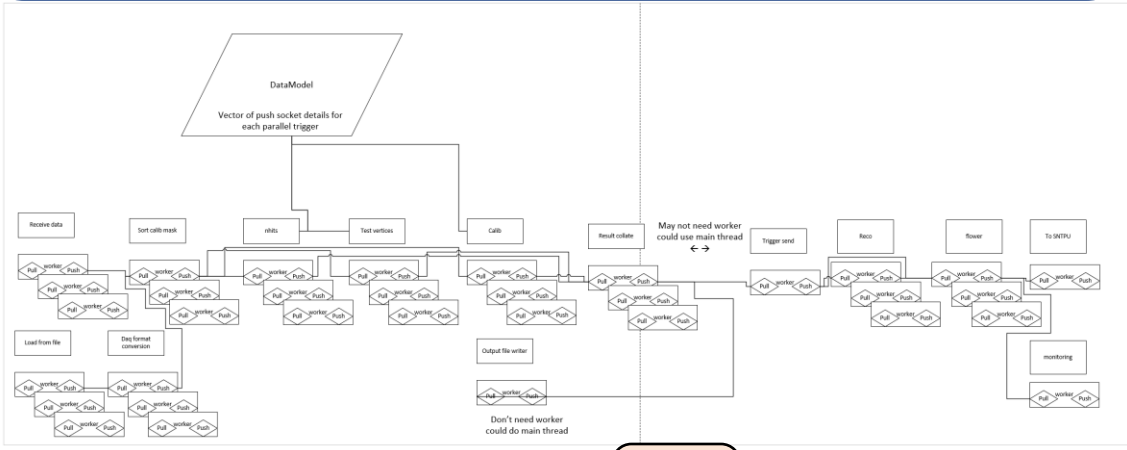


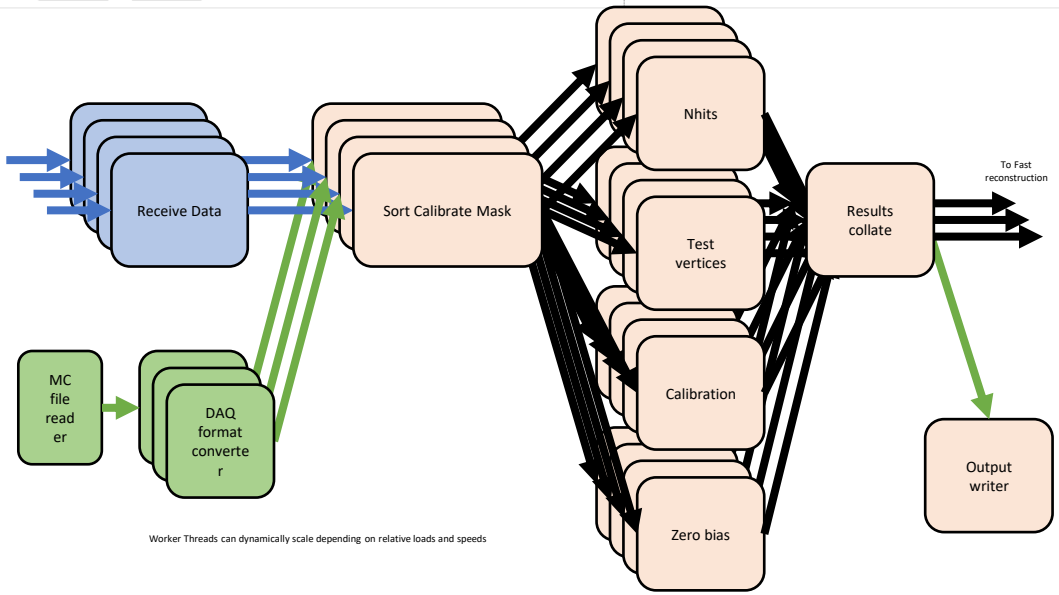
Triggering Development

- Written a new triggering application in ToolFramework to allow new triggers to be produced and tested
- With multiple parallel trigger algorithms able to run on individual nodes and distributed among a cluster

- This includes:
  - Job distribution systems
  - Node failure compensation
  - Dynamic resource scaling

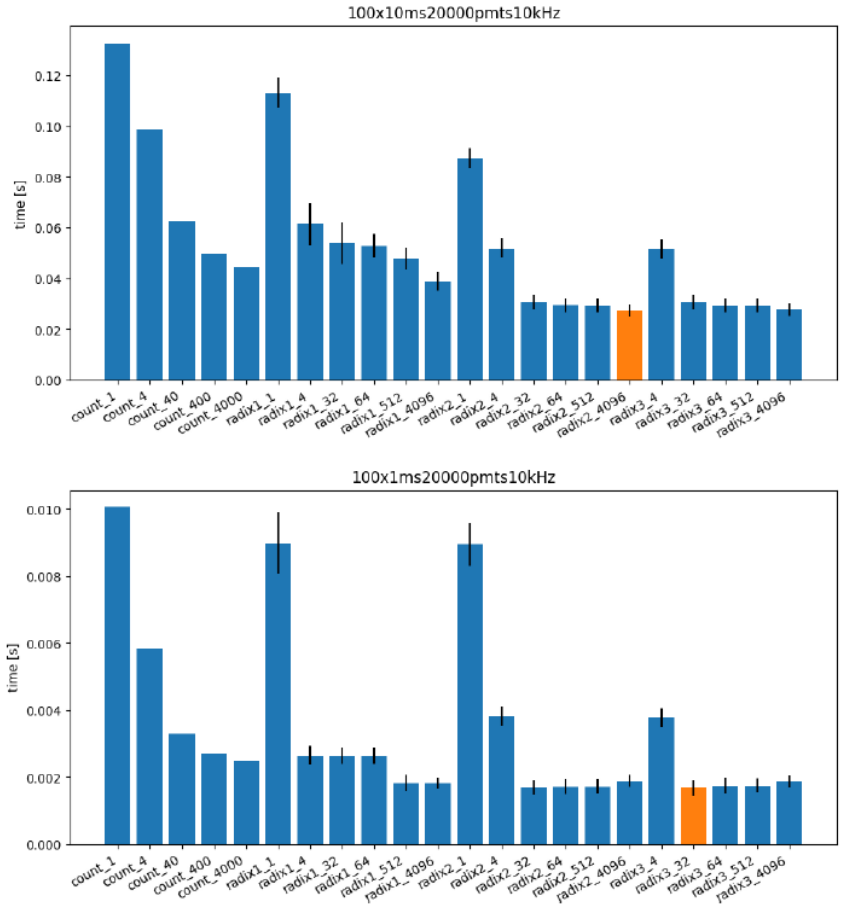






Data Processing Performance Improvements

- Created customs sorting and data processing algorithms to apply corrections and get data ready for tirggering
- CPU optimised code to give multiple orders of magnitude improvements over standard methods
- Improved CPU trigger algorithms

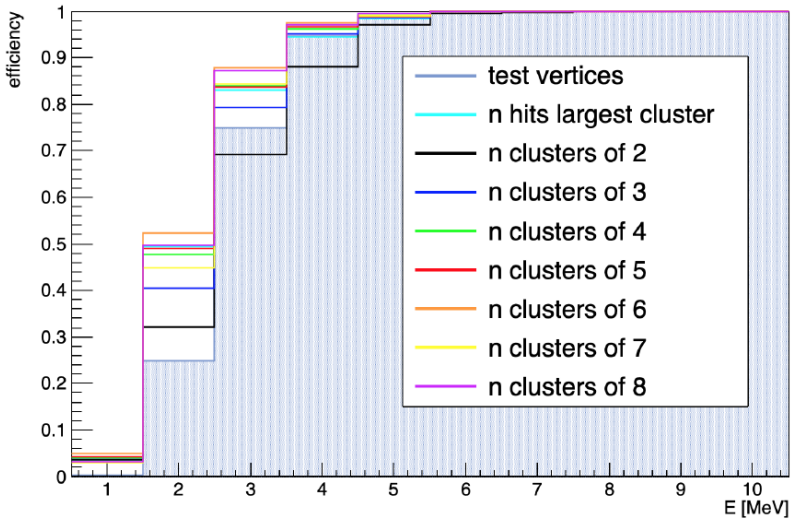


GPU Triggering

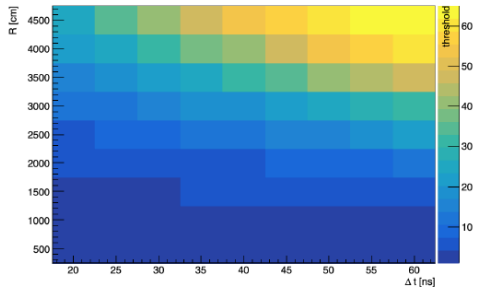
- Continued to improve our GPU based fast triggering algorithms
- Added special as well as temporal GPU based reconstruction
- Low energy performance improved giving threshold of ~2MeV
- Also started work on deep learning AI based triggers and reconstruction

optimisation result:

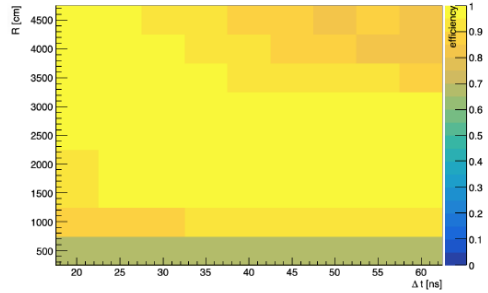
- at least $N = 1$ clusters in 400 ns
- a cluster means: $n = 10$ hits with $\Delta t < 50$ ns and distance $d < 30$ m

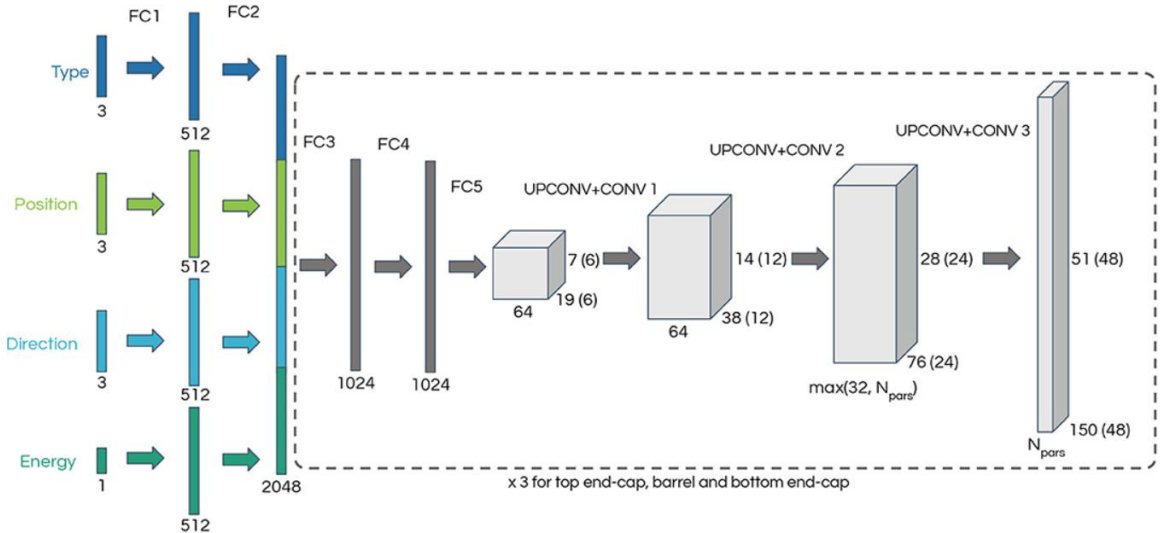


threshold for dark rate bkg:



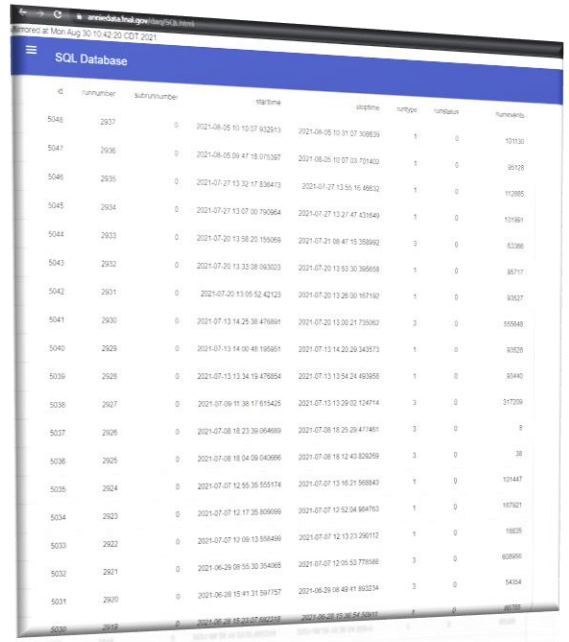
signal efficiency:

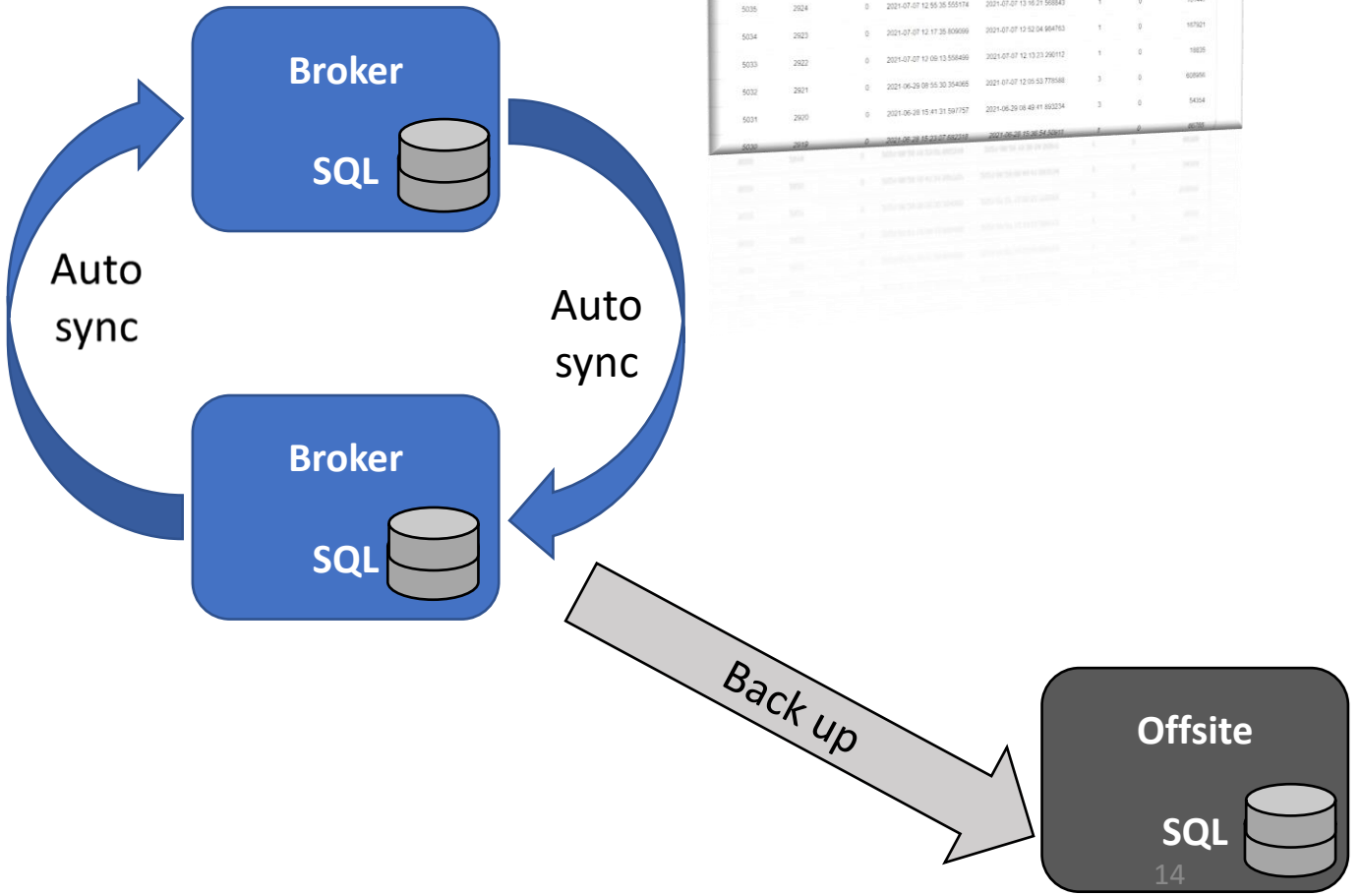




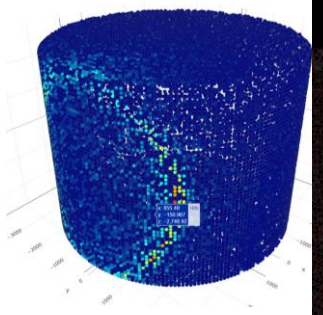
Custom SQL Database Replication

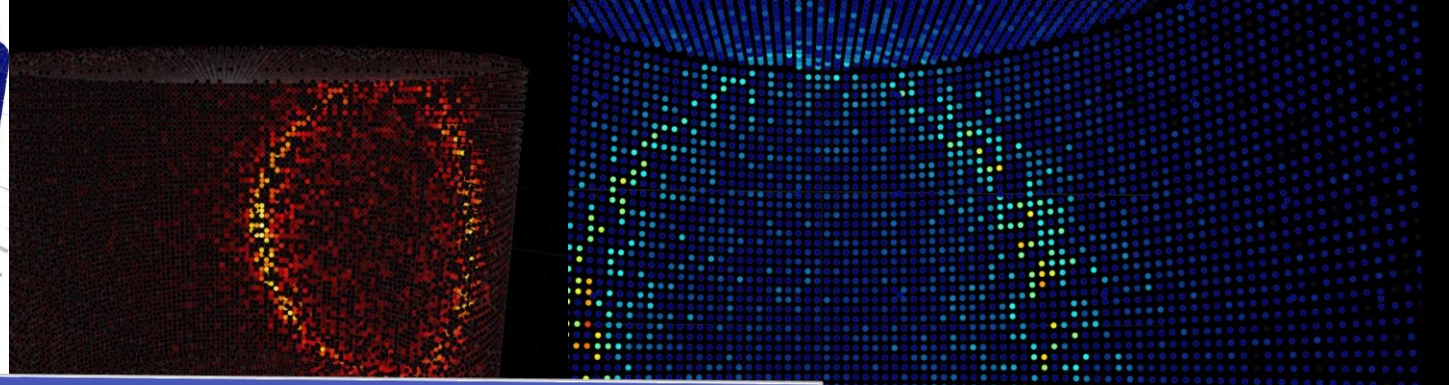
- Each of the SQL servers have a redundant partner that tacks along changes
- Custom middleware will be used to distribute operation loads between the two servers and automatically cope with single database failure
- Data will also be sent to offsite database for backup and offline use
- Databases will all be browsable via web interface





Web Interface Monitoring & Slow control





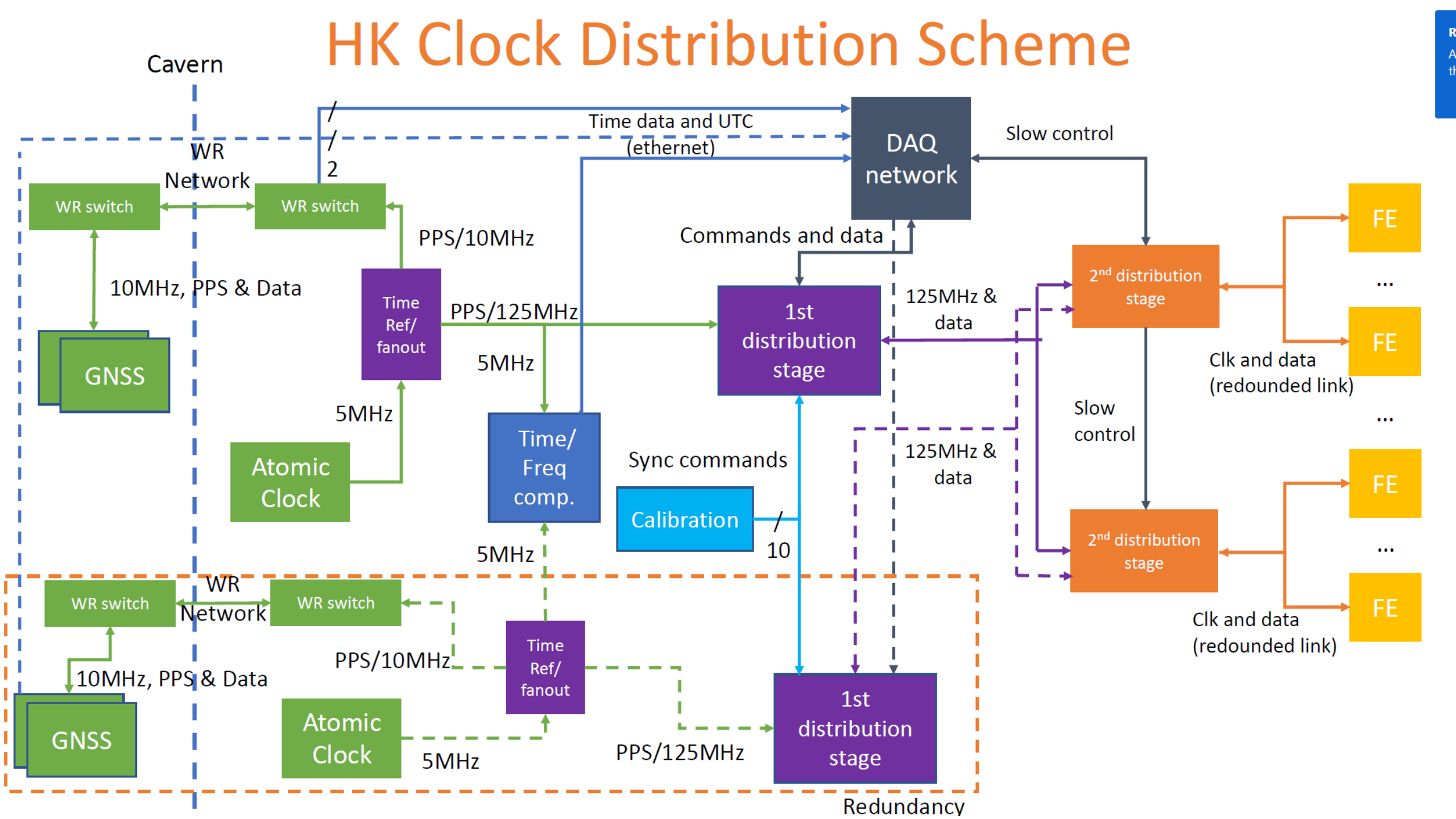
Developed and tested full web based interface:

- Run and slow control
- Interactive Event display and monitoring
- Integrated SQL database

System built on ToolDAQ allowing:

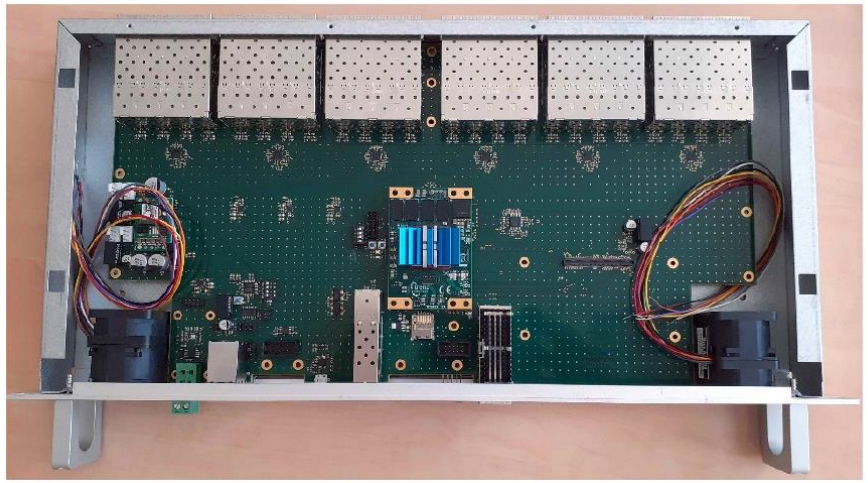
- Easy subsystem integration
- Integrated templates and
- Many concurrent users from anywhere in the world

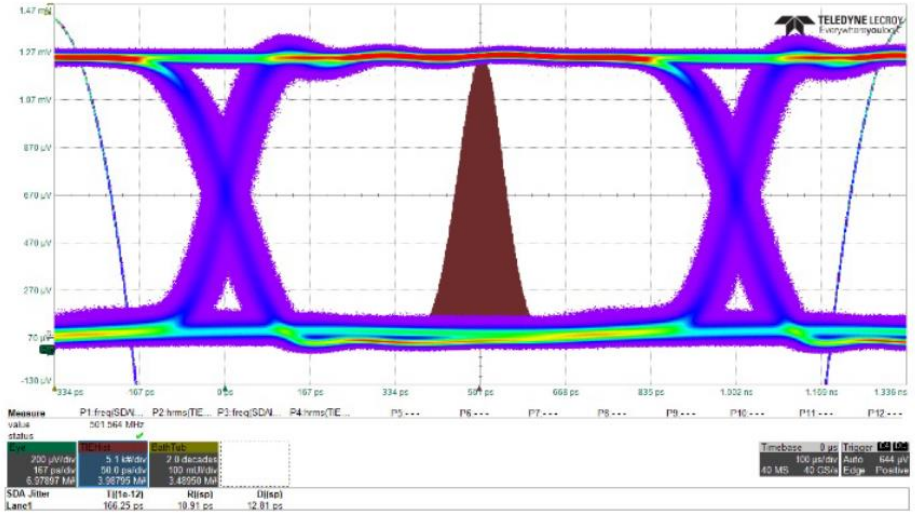
HK Clock Distribution Scheme



Clock Distribution Development

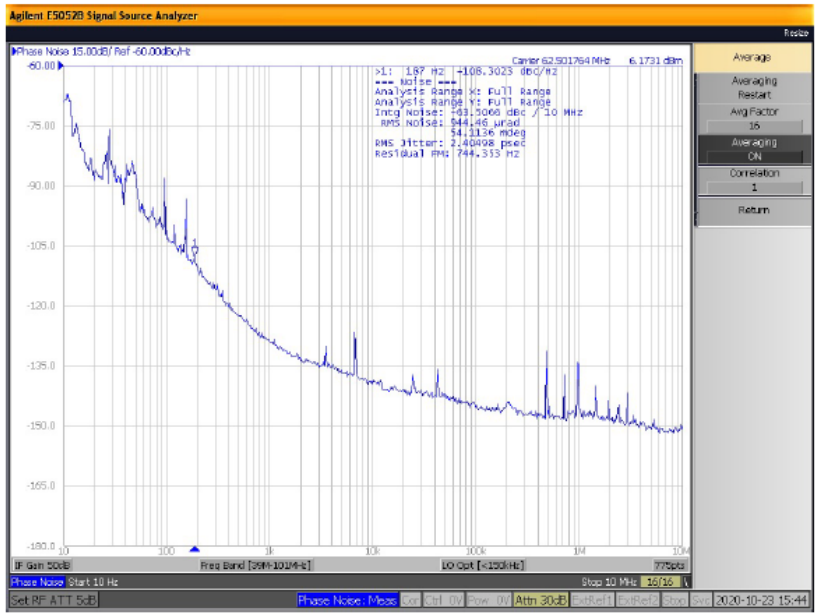
- Developed custom clock distribution hardware 48 channels
- New protocol (based on white rabbit) with jitter measured at the endpoint of 2.4 ps





Optical out – 1 Gbps data mode

Rj = 11 ps and Dj < 13 ps



Summary

A number of developments in the last 3 years in:

- Triggering
- Networking
- DAQ software
- Monitoring and slow control
- SQL replication
- Time distribution

As yet no Jenifer funds being used, but will have workshop in future