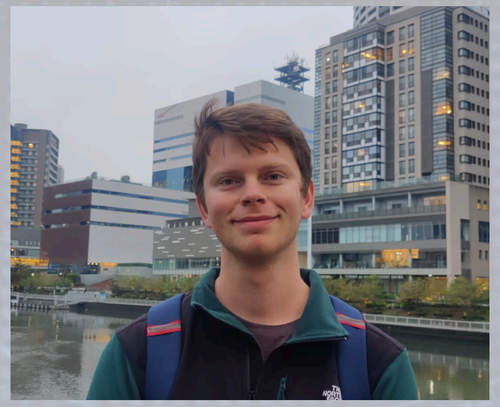

Data Acquisition and Online Monitoring for Hyper-Kamiokande

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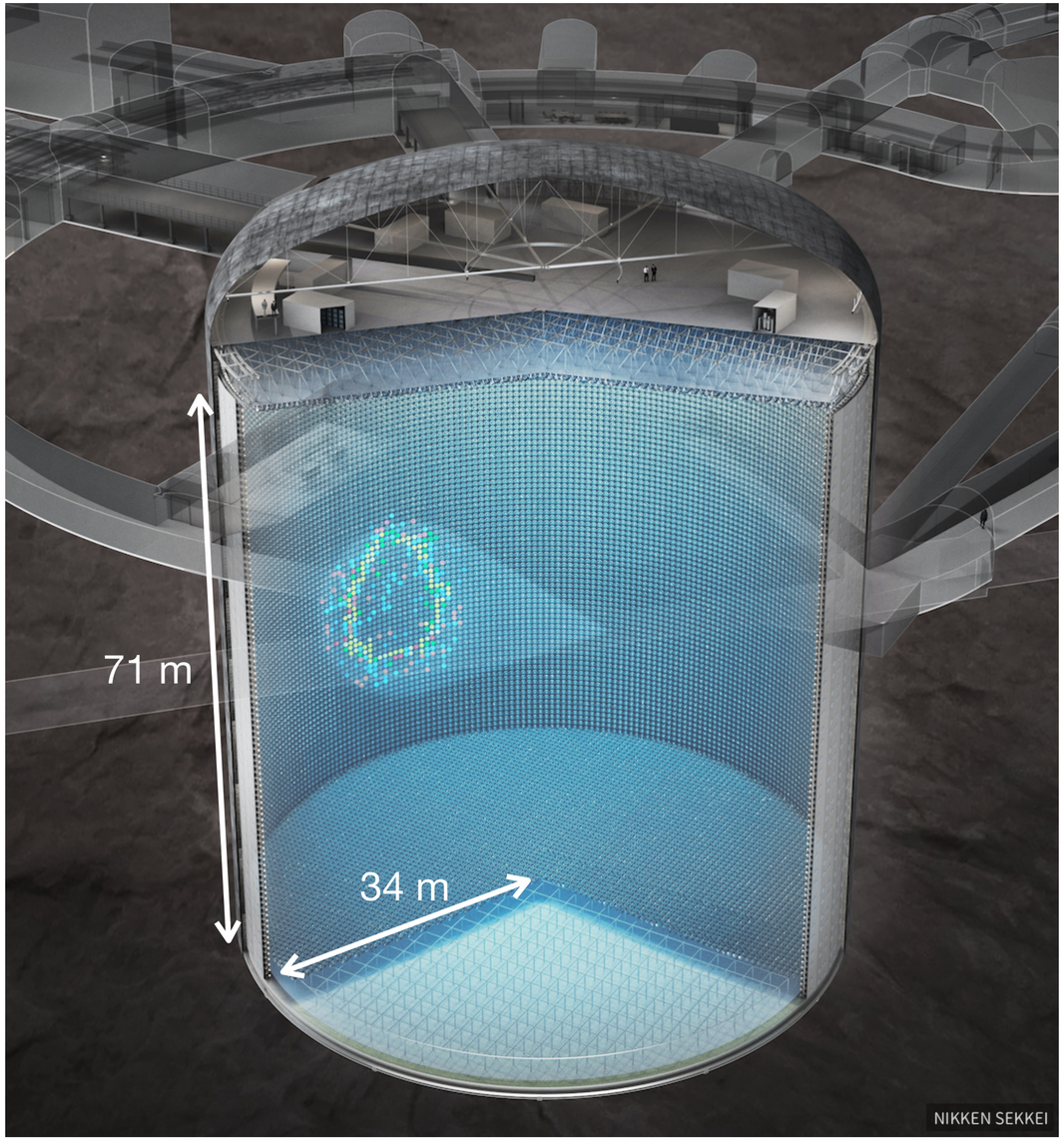
4th JENNIFER2 General Meeting (Pisa)

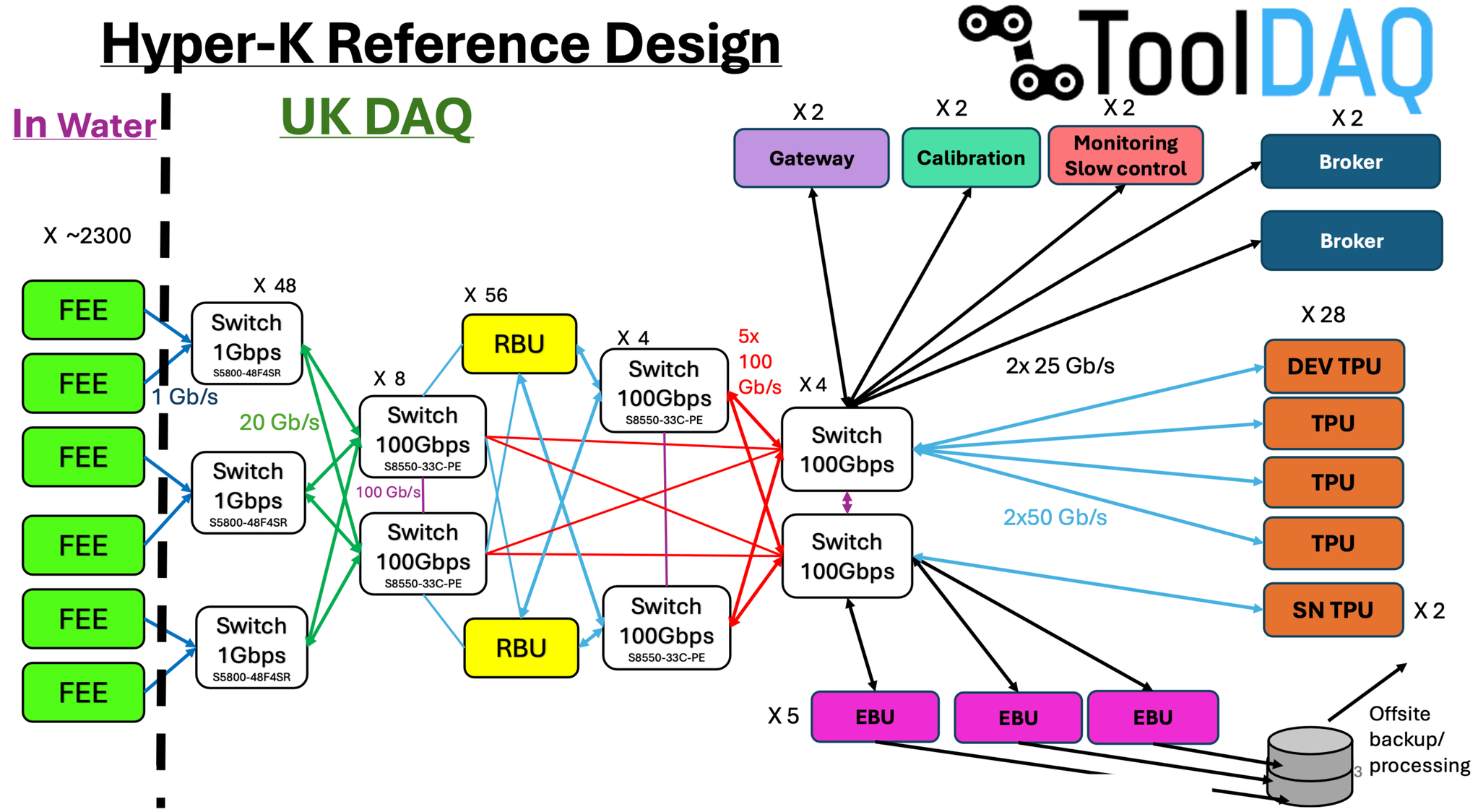
03/04/2025

Introduction

- Hyper-Kamiokande is a 260 kt water Cherenkov detector under construction in Gifu, Japan.
- ~8x fiducial mass of Super-Kamiokande.
- Physics programme: high precision neutrino oscillation measurements, supernovas, proton decay, relic neutrinos.
- The **Data Acquisition (DAQ)** for the Hyper-K far detector is used to store events; it has the following requirements:
  - Measure hits from ~50,000 photosensors of different types
  - Handle $\mathcal{O}(10^8)$ hits in ~10 s for supernovae events
  - High fault tolerance
  - Real-time trigger processing and reconstruction
  - Modularity and scalability
  - Error-correctible and adjustable mid-run
  - Last for > 20 years



Hyper-K UK DAQ

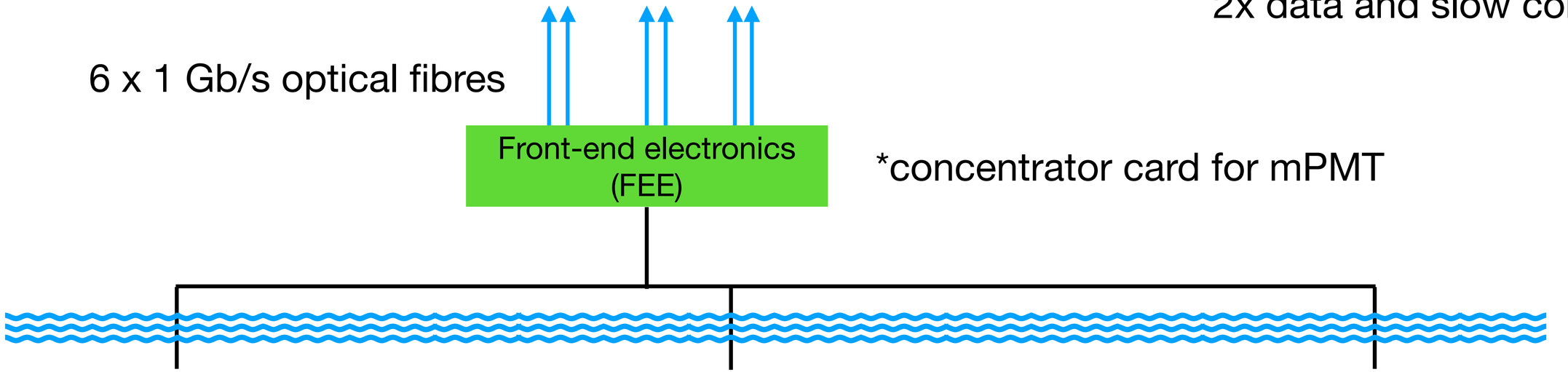


FEE: front-end electronics RBU: readout buffer unit EBU: event builder unit TPU: trigger processing unit

In-Water Electronics

2x CLK
2x counter
2x data and slow control

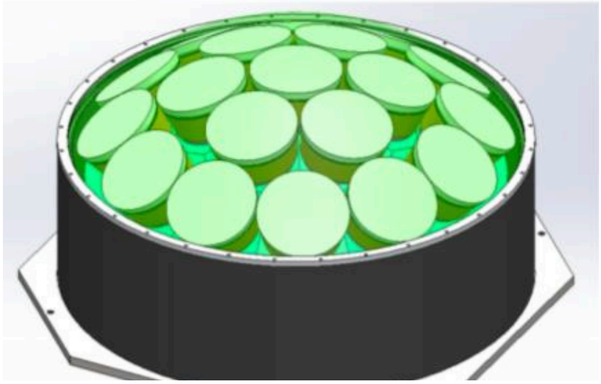
6 x 1 Gb/s optical fibres



*concentrator card for mPMT

Inner detector (ID) PMT

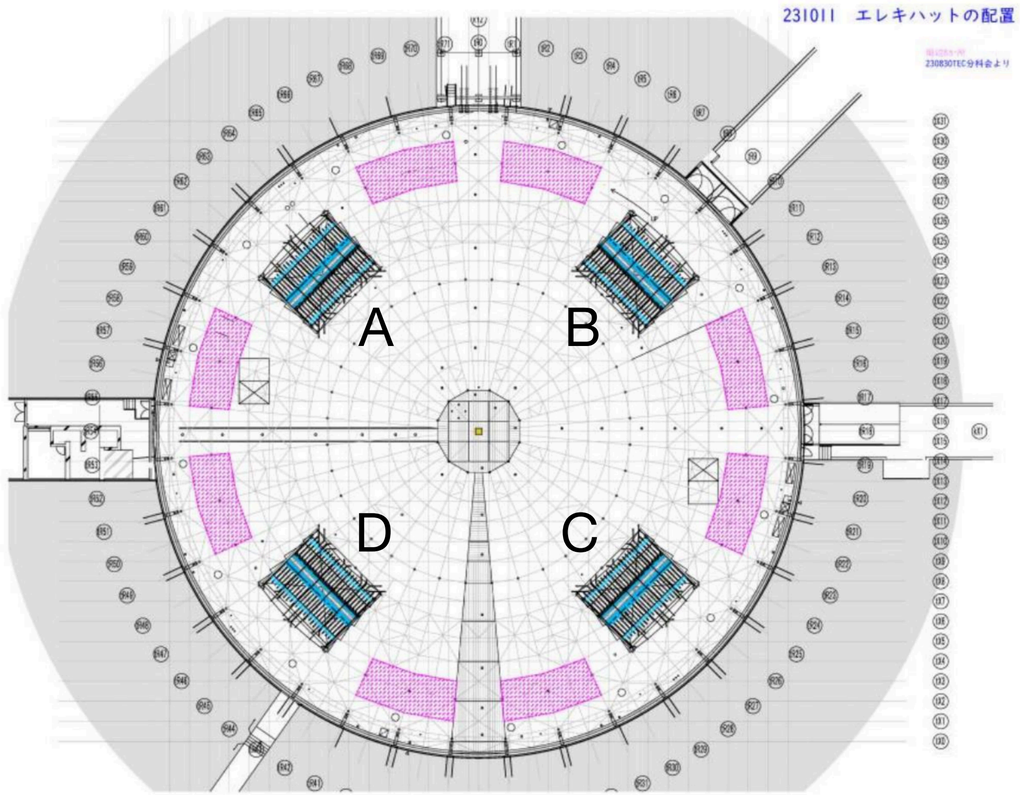
Outer detector (OD) PMT

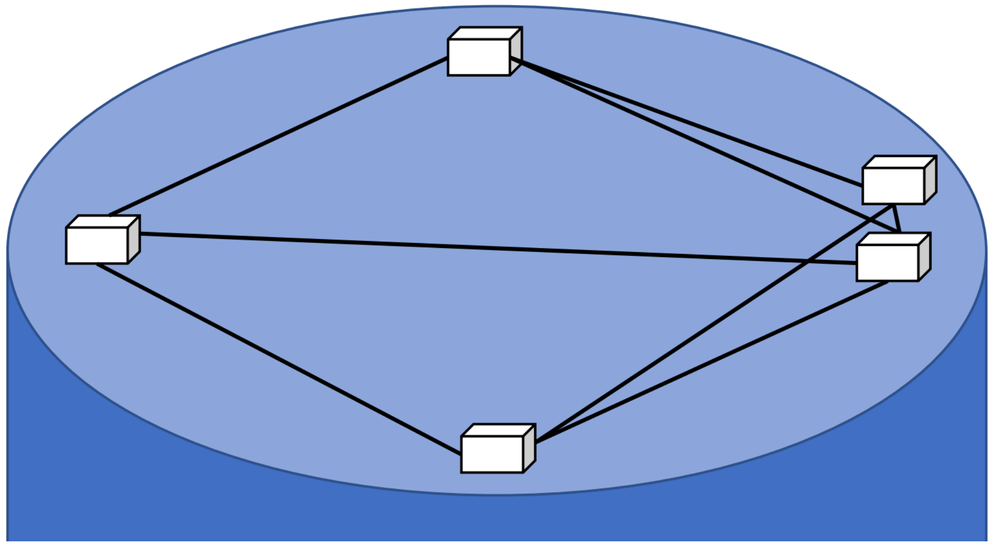


Multi (mPMT)

DAQ Deployment and Data Flow

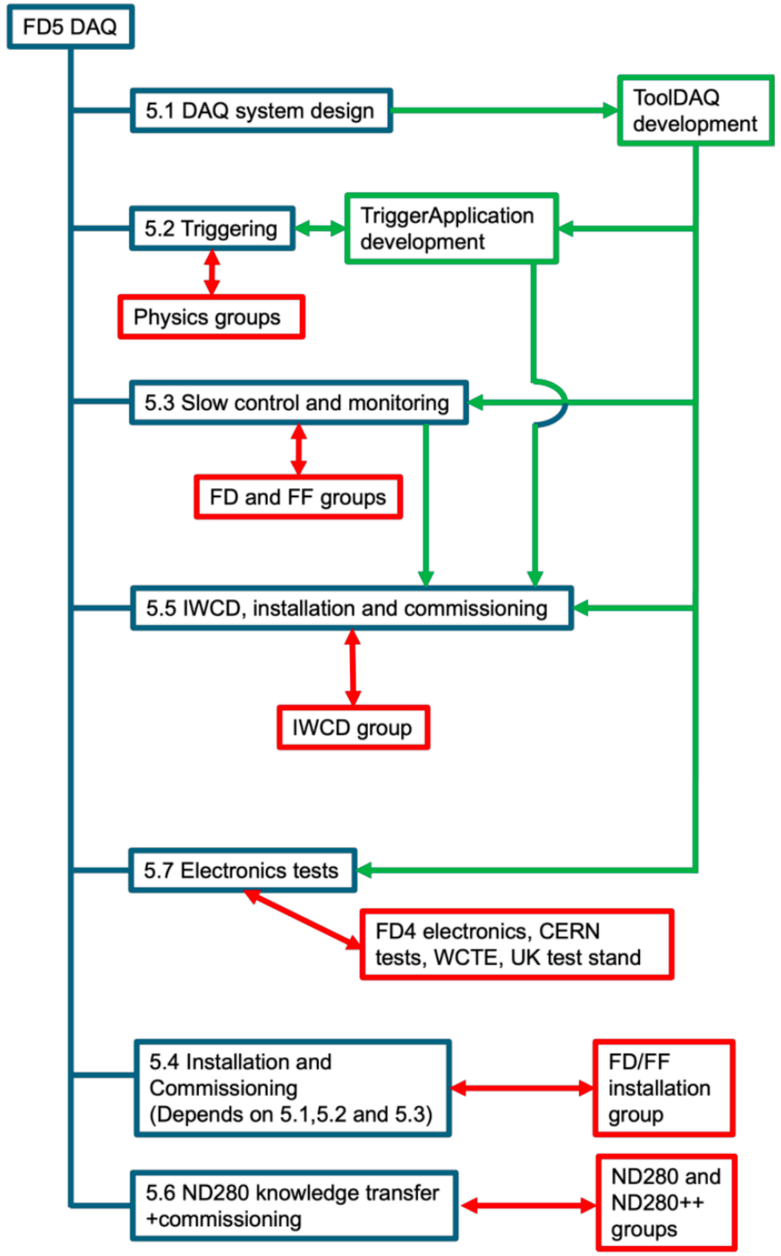
- The DAQ system will be installed and operate in five electronics huts above the target volume.
- 4x huts (A, B, C, D) connect PMTs to housing RBUs.
- 1x central hut with TPUs, EBUs and brokers.
- Interconnecting cables between huts.
- 10 racks (2x per hut).
- Data flow and triggering also organised:
  - All hits received by RBUs
  - Triggering decisions based on ~100 x 1 ms slices for standard data flow
  - Longer slices and external trigger sources studied for SN TPUs
  - Triggered data enters EBUs and is saved to disk





DAQ Tasks & Organisation

- Hyper-K DAQ largely under development by different UK-based universities.
- Main DAQ tasks arranged into several subgroups within the DAQ WG:
  - DAQ system design
  - Electronics tests
  - Installation and commissioning
  - Triggering
  - Online monitoring and slow control

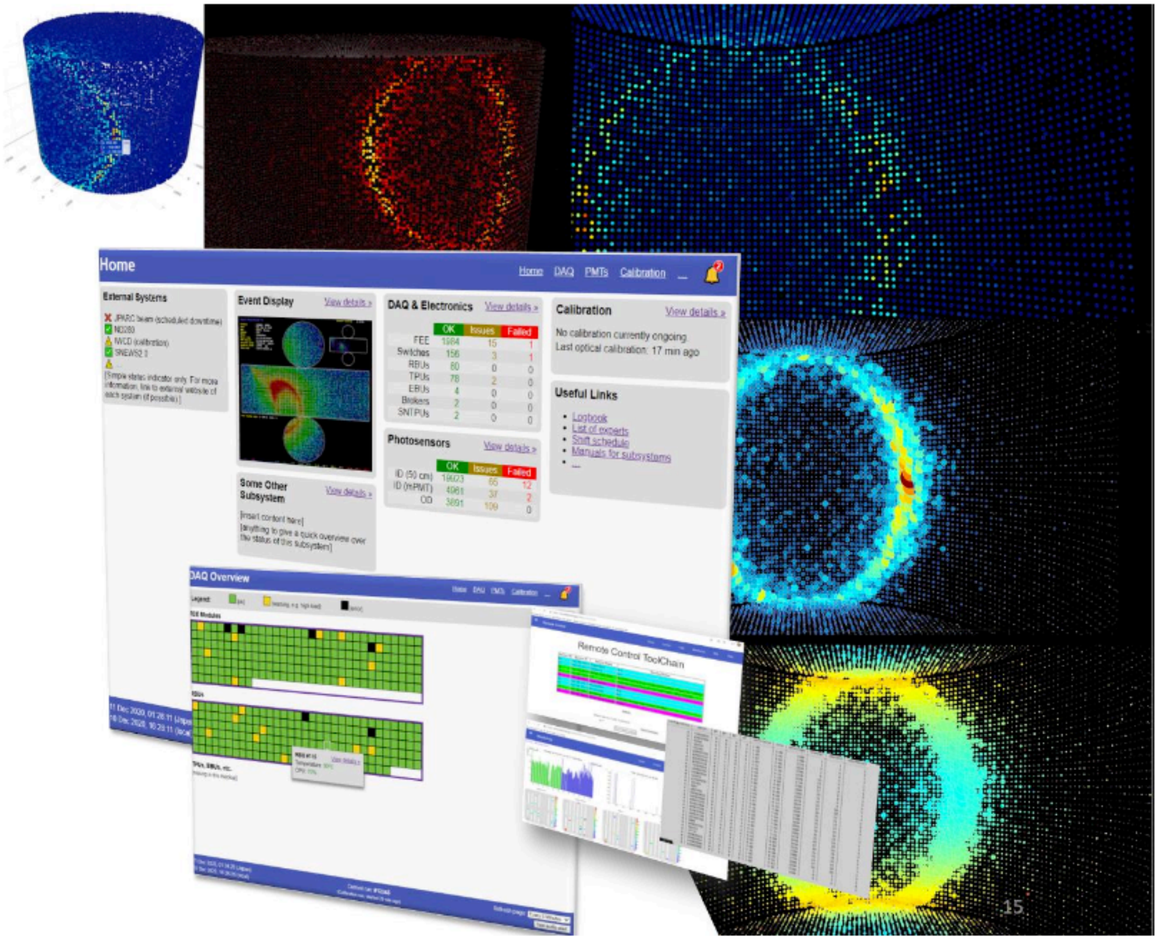


ToolDAQ & ToolFramework

- **ToolDAQFramework** is an open source DAQ framework developed by UK collaborators.
- Currently being used by ~10 particle physics experiments and will be used by Hyper-K.
- Attempts to address highly rigid, convoluted and fragmented software.
- Incorporates DAQ features while:
  - Being fast with easy modular development
  - Having dynamic service discovery and scalability
- **ToolDAQ** contains toolchains which hold dynamic tool objects (C++/Python) created from factories; these communicate through transient data storage classes.
- This allows for flexible complex structures and paradigms, multithreading, sub toolchains, worker farms.
- A full online front-end and command line comprises the centralised system.
- More information: https://doi.org/10.1051/epjconf/201921401022

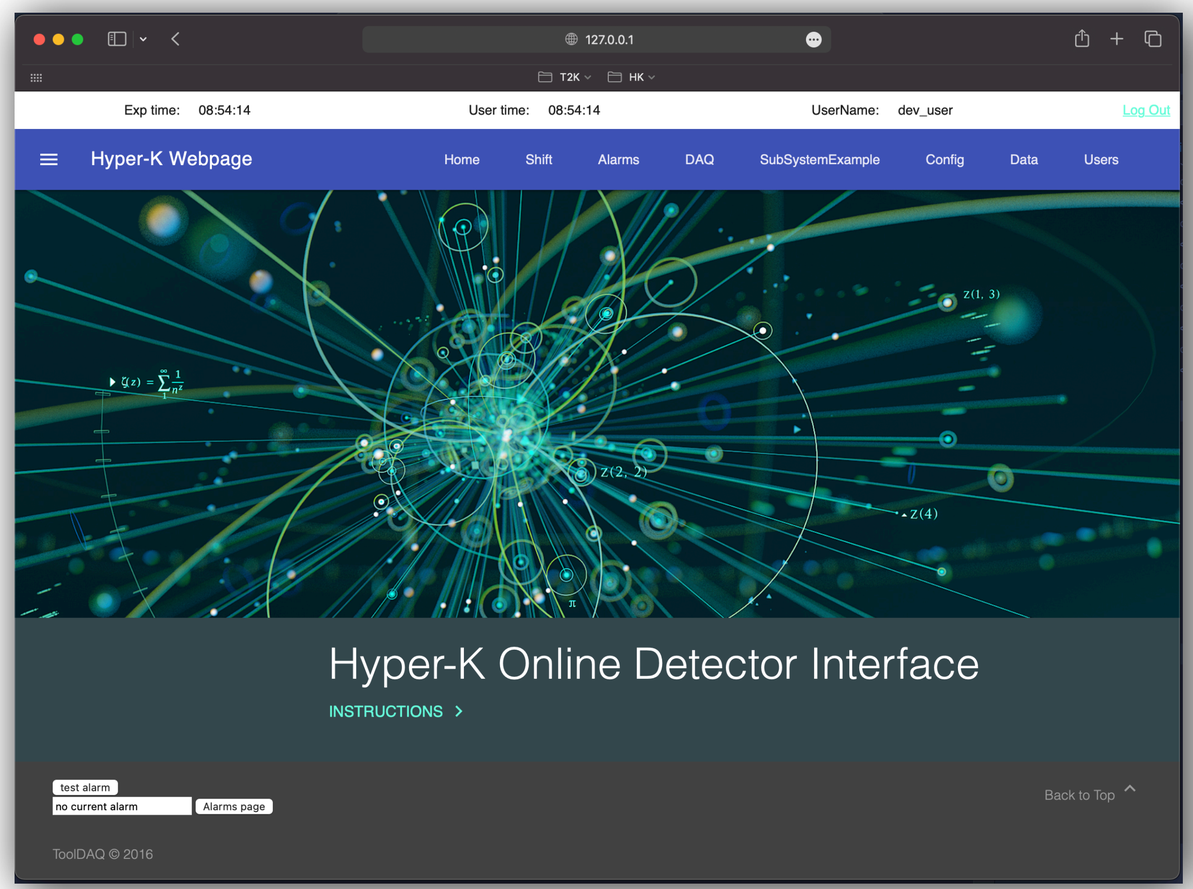
Online Monitoring and Slow Control

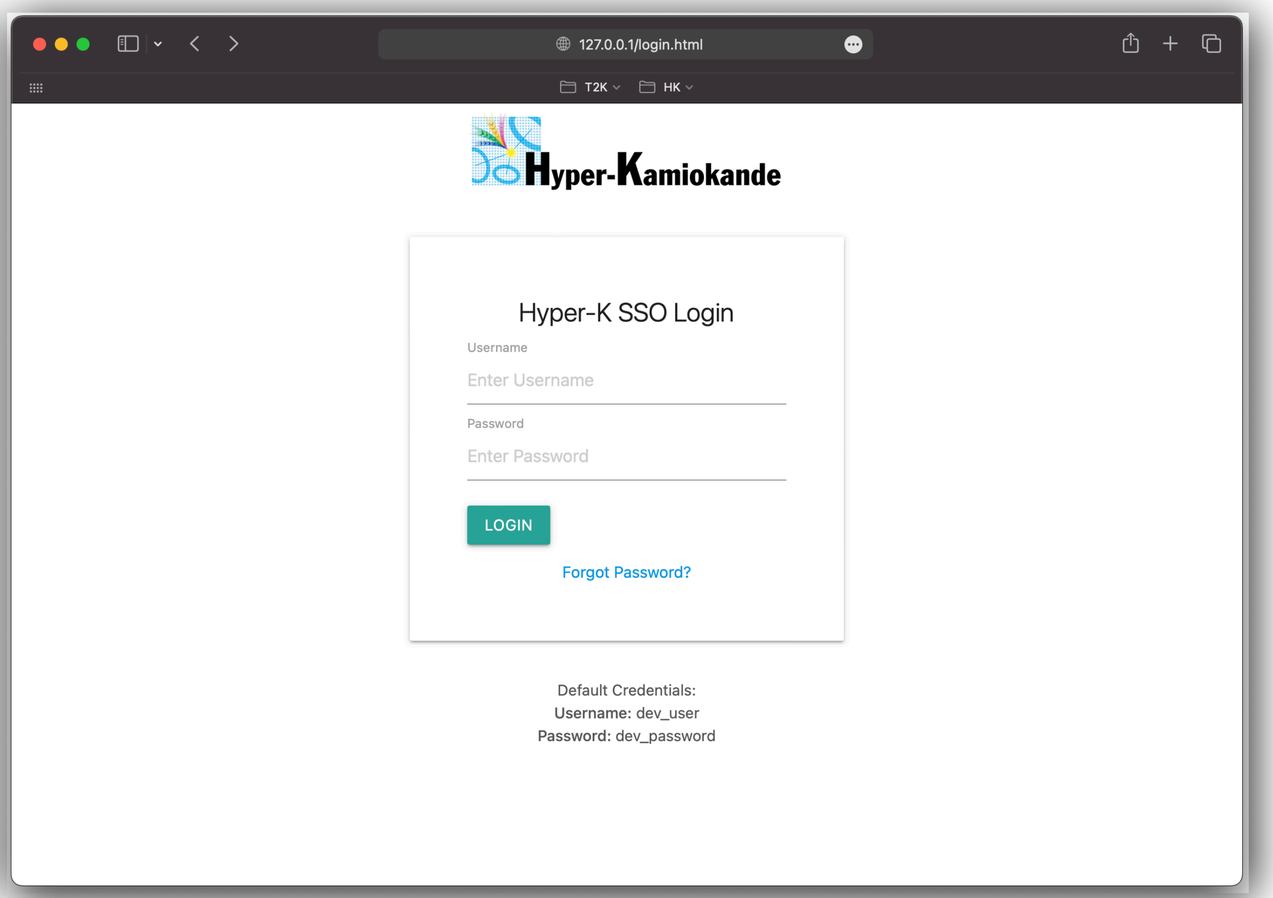
- The online monitoring (OM) system will include:
  - A unified web front-end
  - Databases
  - Configuration
  - Shift checks
  - Alarms
  - Slow control
  - Triggers
- Similar interface used at ANNIE.
- We am to learn from our experiences with Super-K and ND280.
- Tested at recent WCTE runs.



Online Monitoring and Slow Control

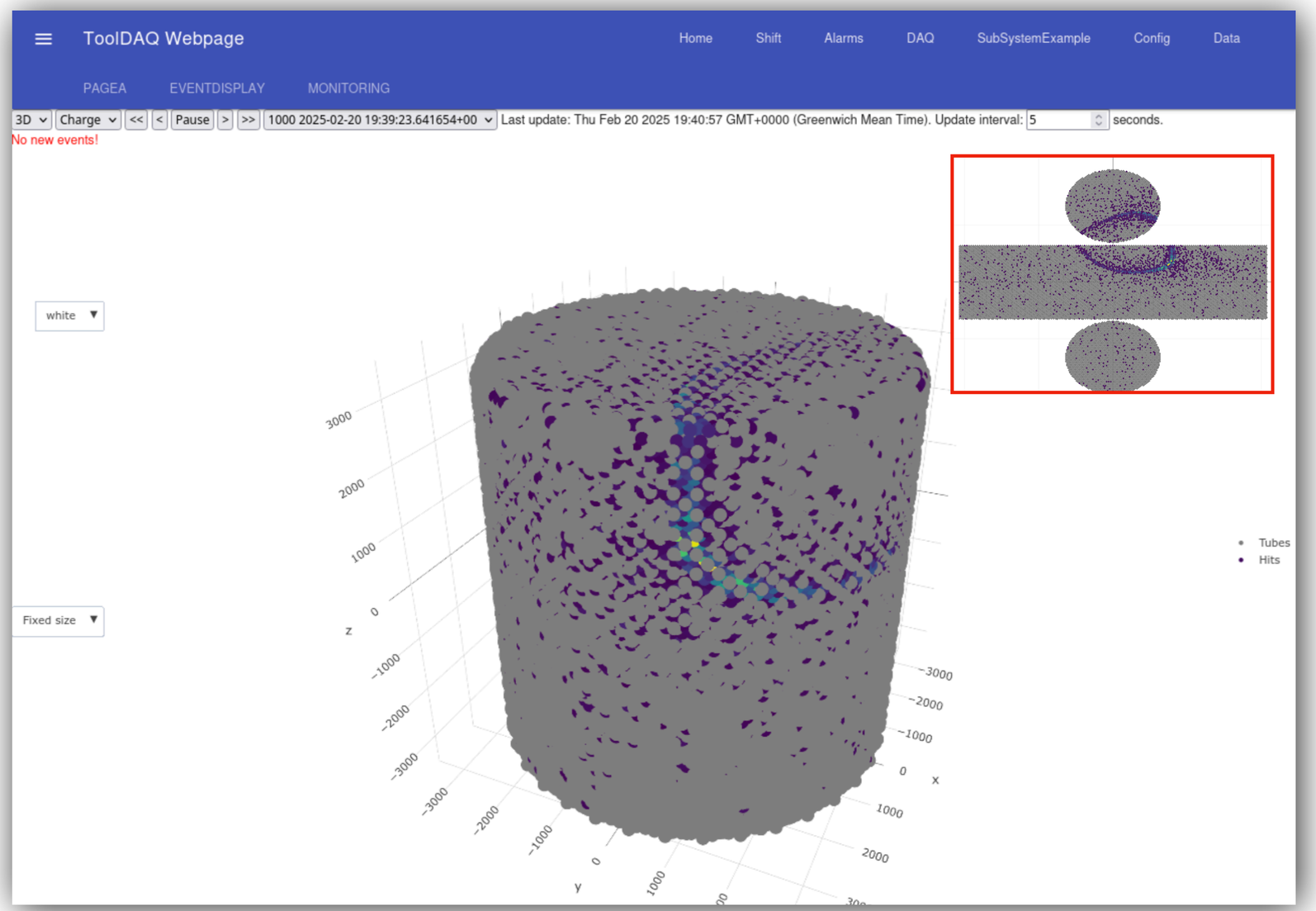
- Hyper-K bespoke login and arbitrary landing page:





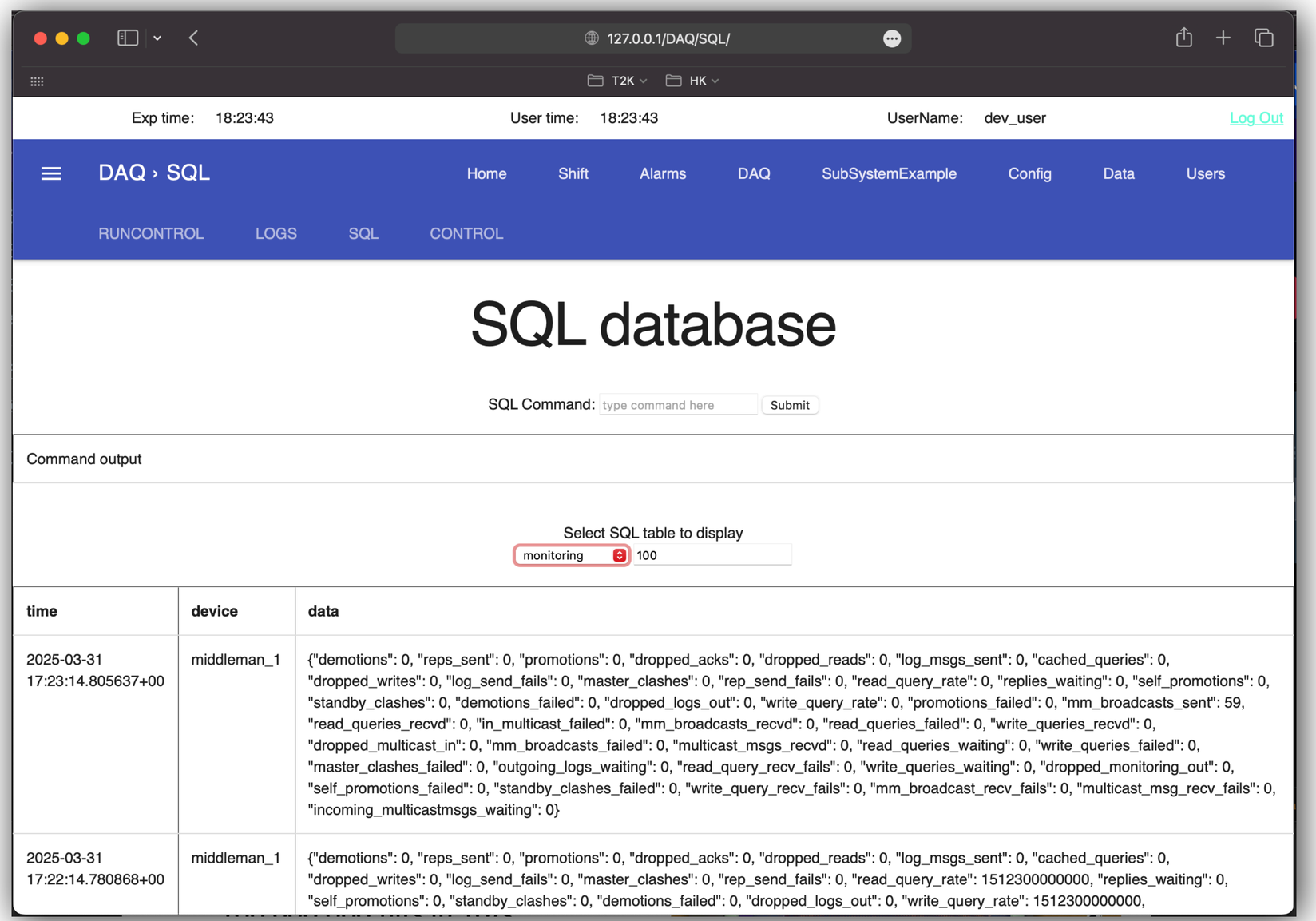
Online Monitoring and Slow Control

- Event display under development; example μ-like event generated using WCSim:



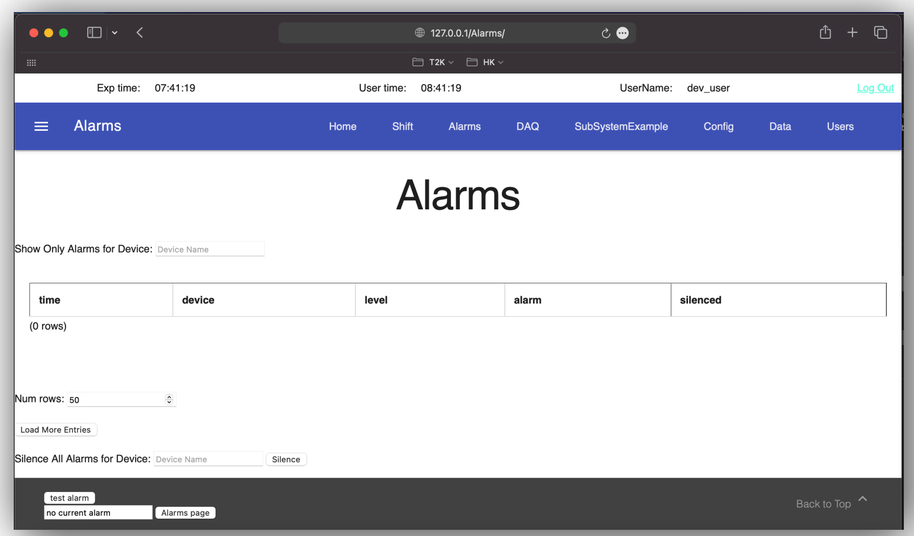
Online Monitoring and Slow Control

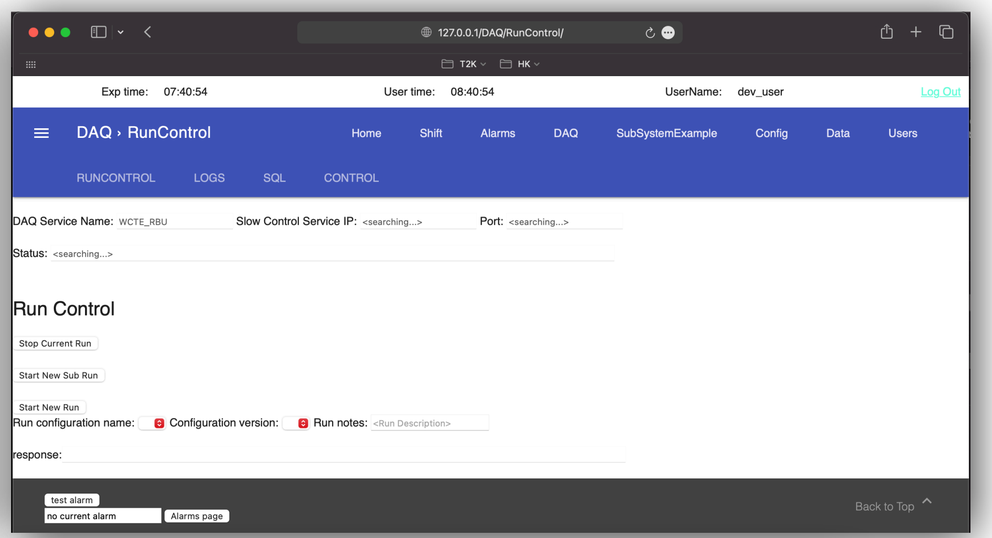
- Integrated SQL database:

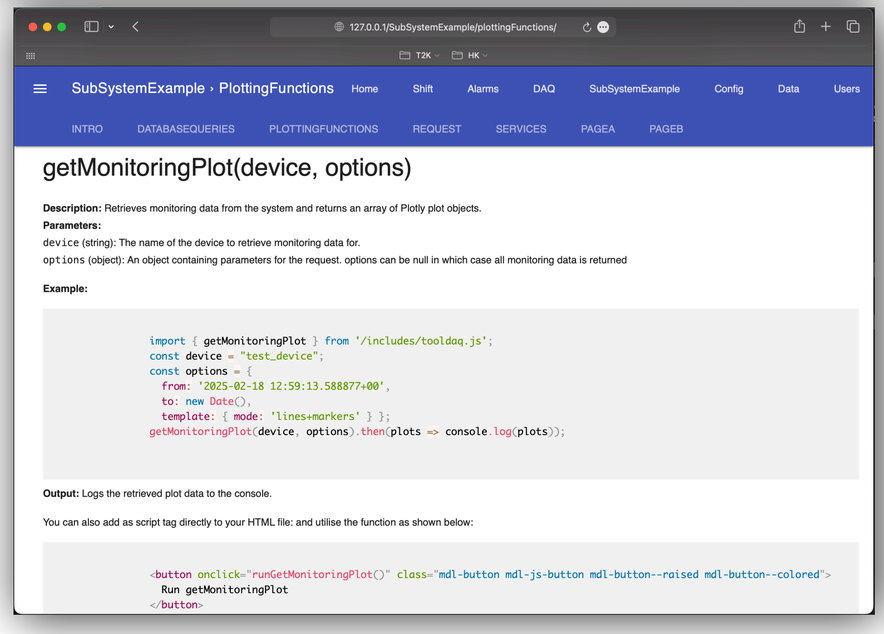


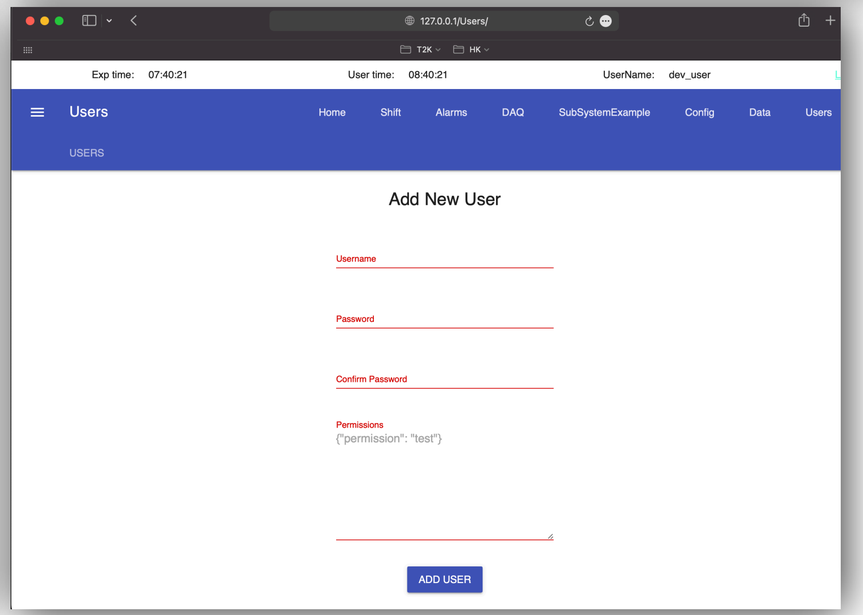
Online Monitoring and Slow Control

- Other examples:



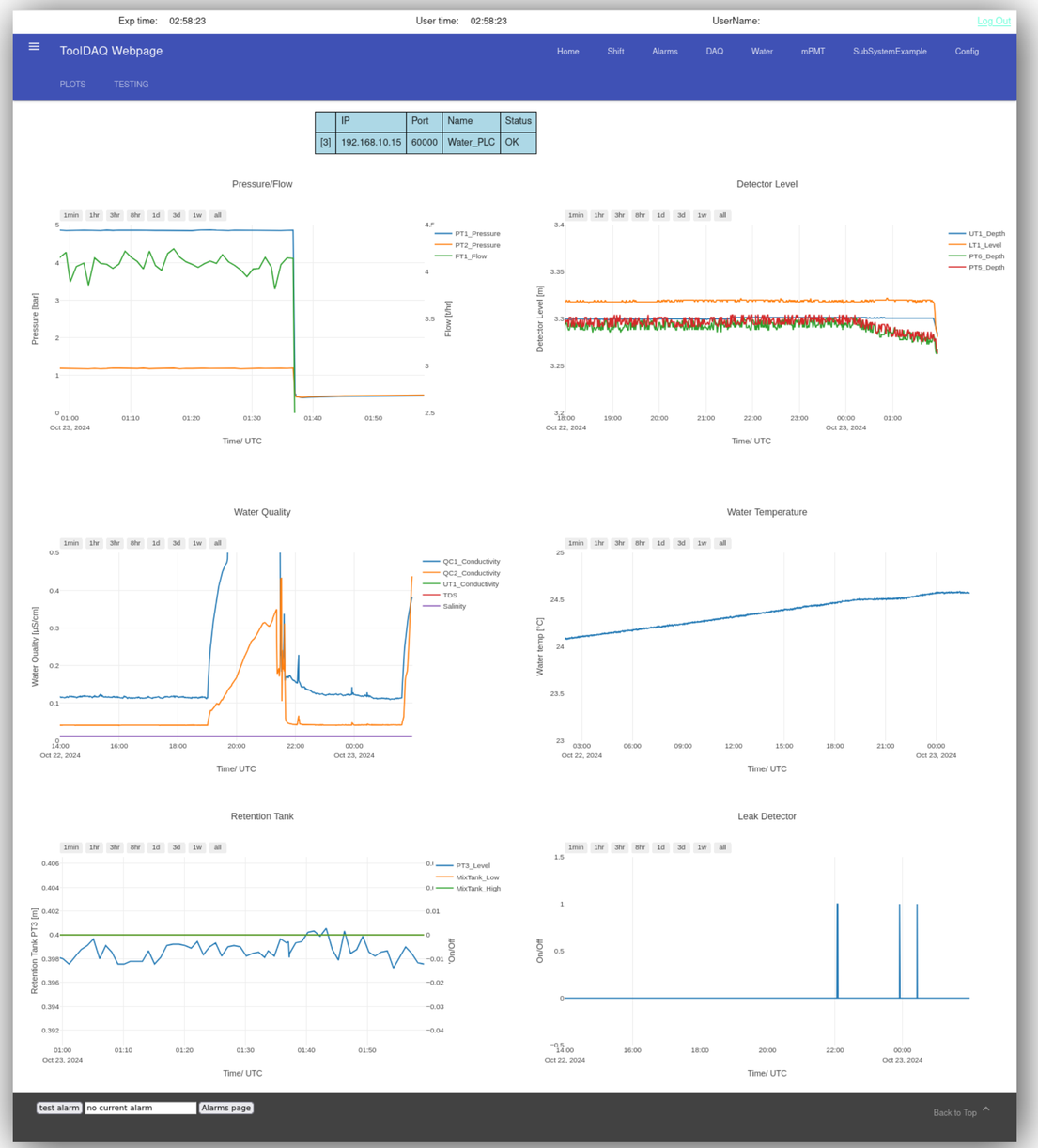






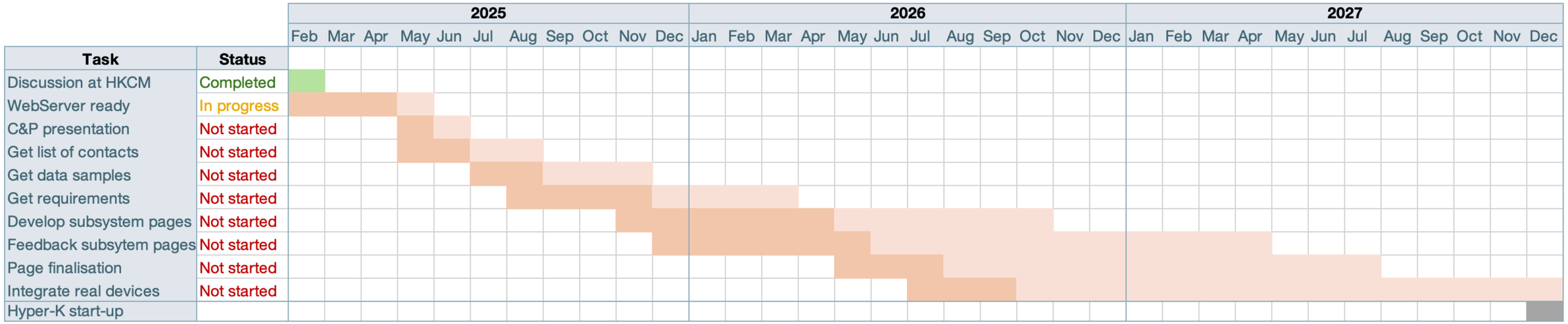
Online Monitoring and Slow Control

- Examples at WCTE:



Online Monitoring and Slow Control

- Preliminary online monitoring schedule:



- Integrating DAQ and OM requirements with other subsystems.
- Aim to have a unified service as part of the online interface, reducing need for expertise on multiple different software.

Summary

- A scalable data acquisition system is under development for Hyper-K.
- An online interface will be a key feature of the DAQ; it will connect with other subsystems and provide real-time monitoring of detector parameters.
- Testing of the online interface and DAQ systems with WCTE and ANNIE.
- Integration with other Hyper-K subsystems and further tests set to occur in the next financial year.
- Hyper-K start-up ~2028, expecting lots of work in next 2.5 years.