DAQ, Slow control, and Software

Matthew Gerathy

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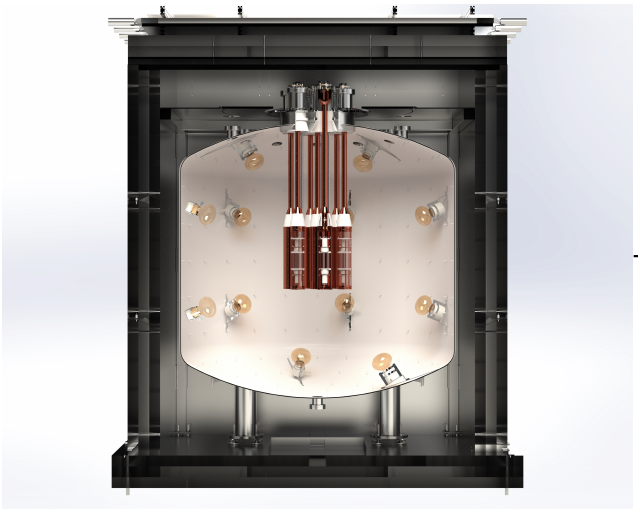
University of Melbourne
On behalf of the SABRE South Collaboration

23 November, 2022

Data pipeline



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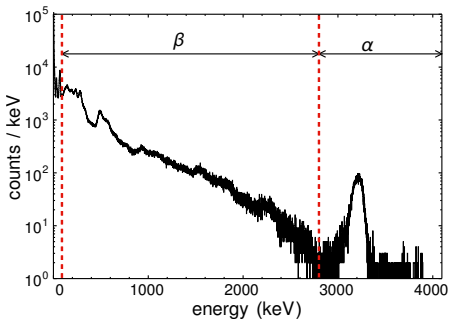
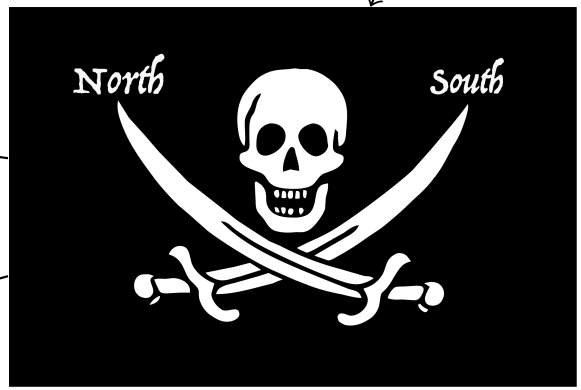
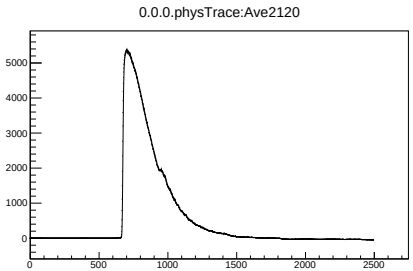
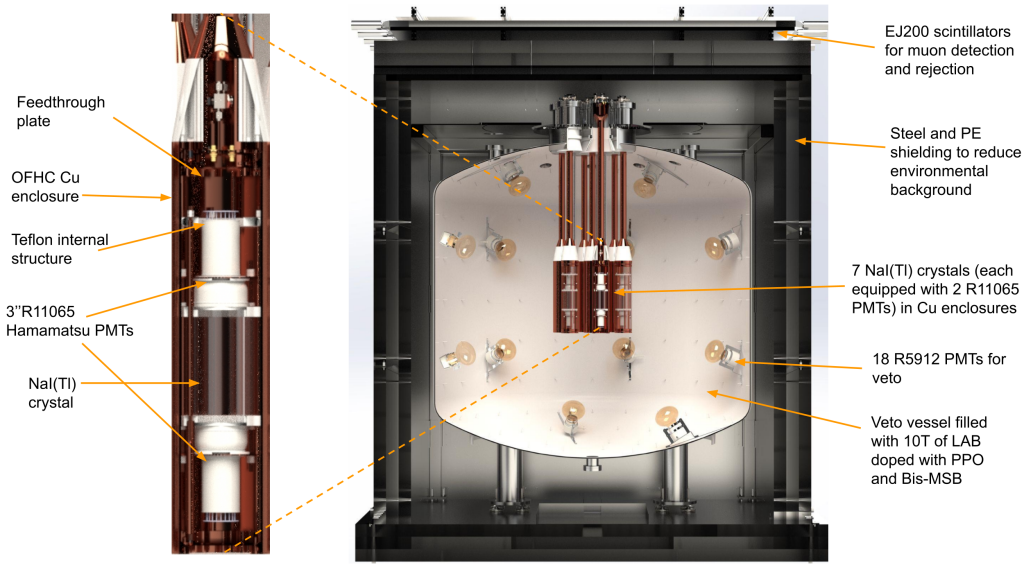




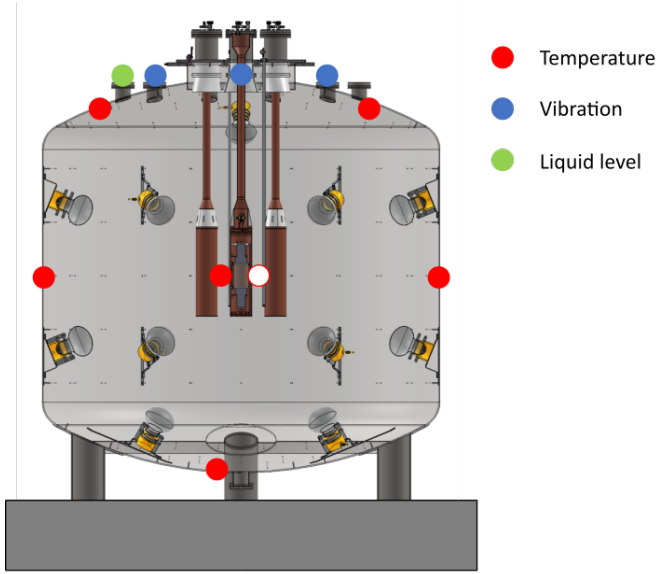


Data acquisition

- Waveforms from 48 PMTs
  - Crystals – $2 \times 7 = 14$ PMTs
  - Veto – 18 PMTs
  - Muon veto – $2 \times 8 = 16$ PMTs

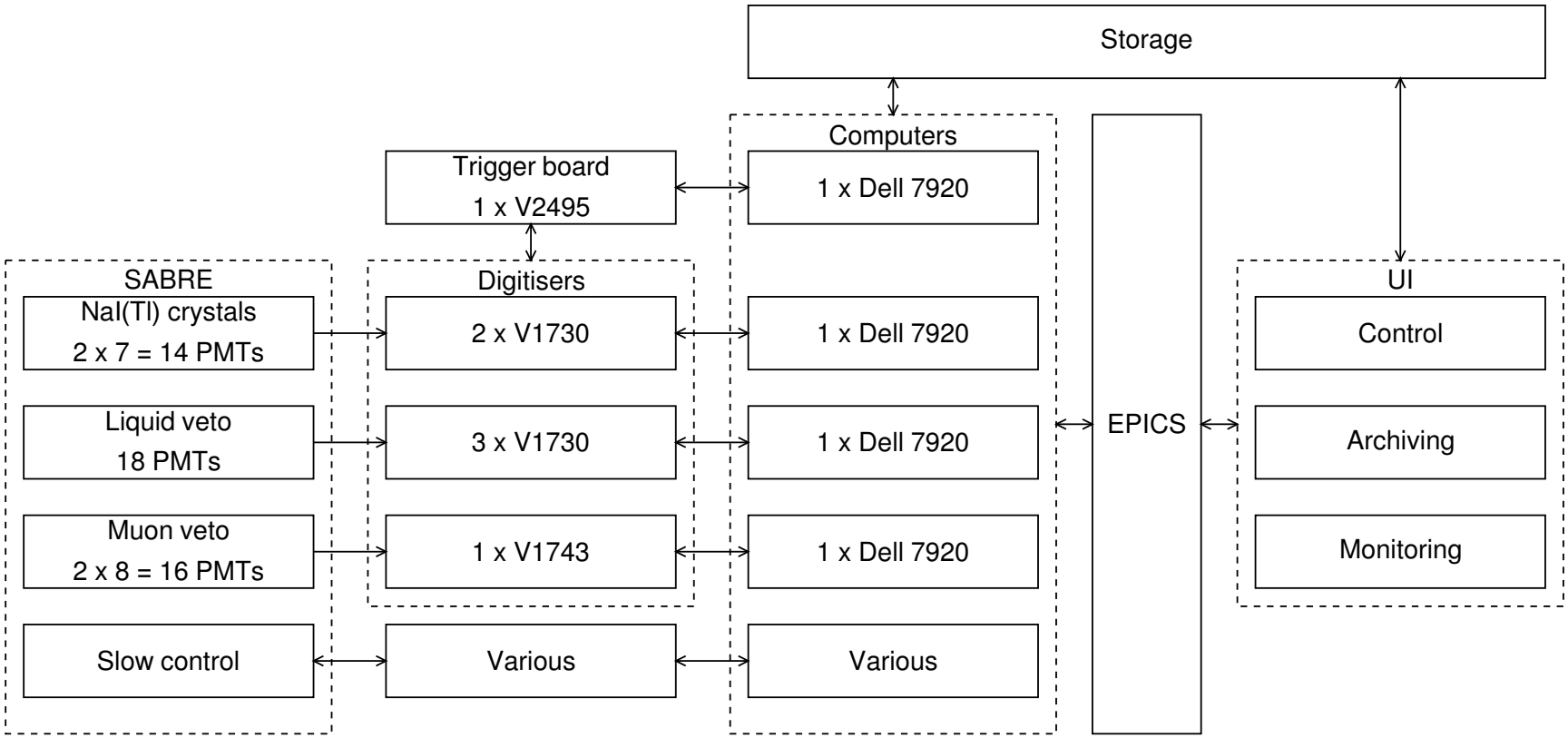


- Slow control
  - High-voltage
  - Environment monitoring
  - Calibration systems



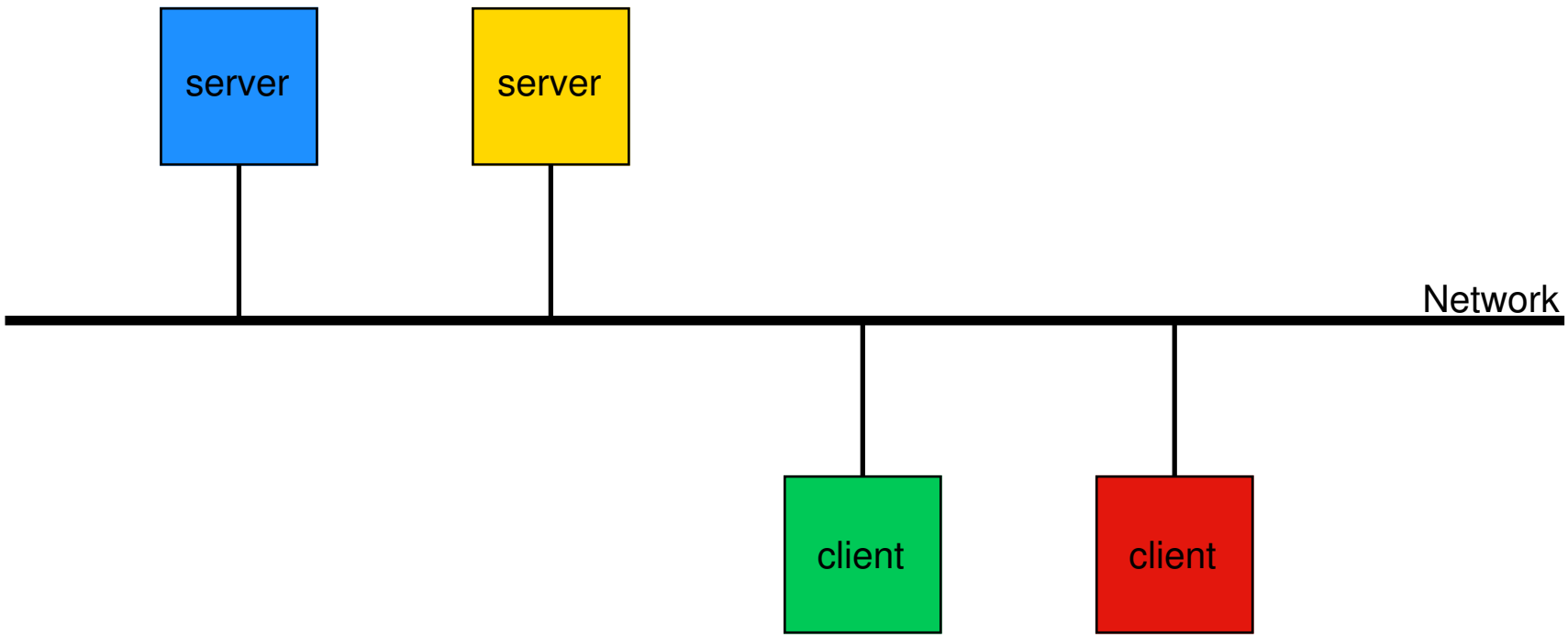
Design

- Modular design with independent sub-detectors and slow-control systems
- EPICS based control and monitoring



EPICS

- **E**xperimental **P**hysics and **I**ndustrial **C**ontrol **S**ystem
  - https://epics-controls.org/
- A set of tools that uses client/server techniques to build distributed control systems
- Adds a layer of abstraction between servers (DAQ, slow control, etc.) and clients (UI, archiving, etc.)



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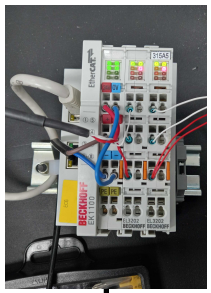
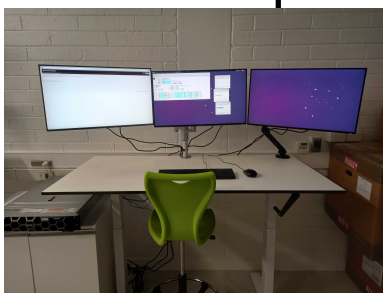
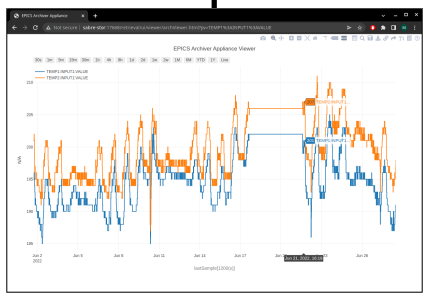


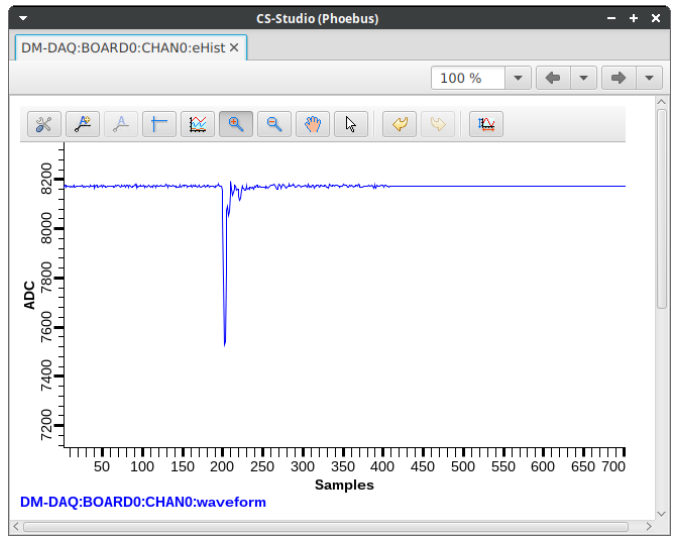
Network

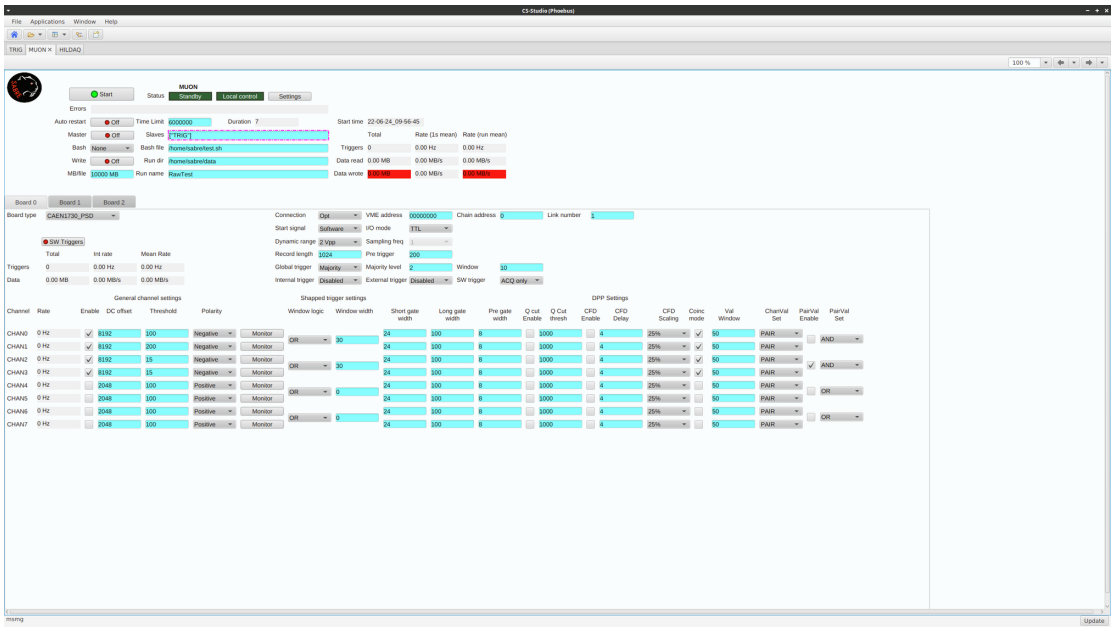


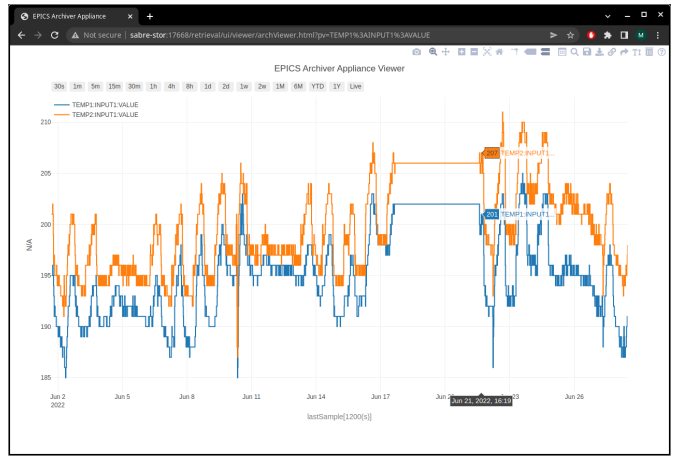


Run control/monitoring

- Utilises existing EPICS clients
- CSS-Phoebus
  - Custom SABRE UI in development
  - Common control and monitoring of and Slow control systems
- EPICS Archiver Appliance
  - Archiving for millions of EPICS variables
  - Development instance at UniMelb





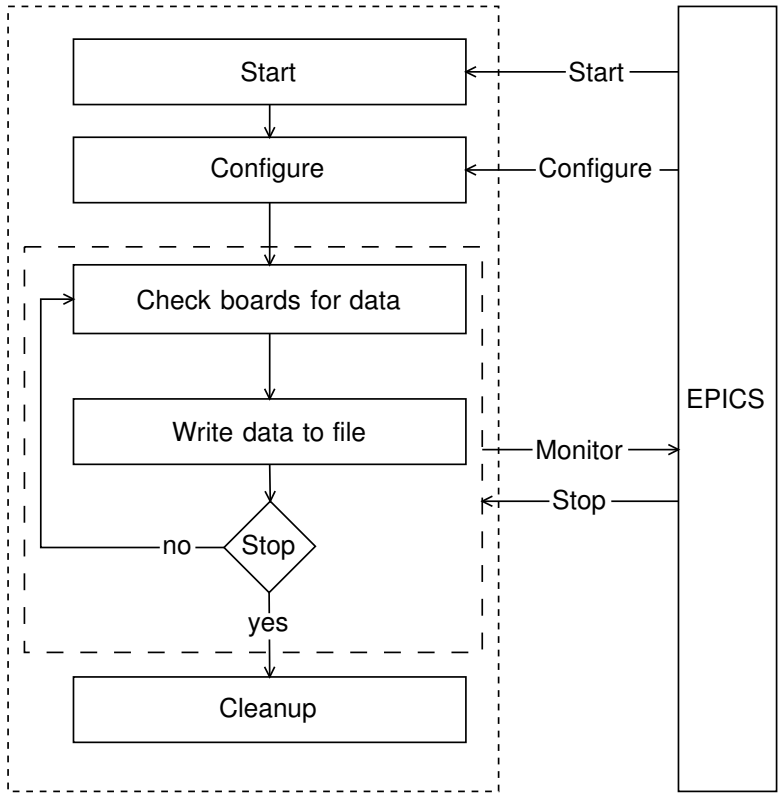


DAQ equipment

- CAEN hardware
  - 5 × 500-MS/s V1730 digitisers
  - 1 × 3.2-GS/s V1743 digitiser
  - 1 × V2495 trigger board
  - 3 × A3818 Fibre optic bridge
- CAEN firmware
  - 5 × DPP-SUP licenses
  - 2 × DPP-PSD licenses
- Computers
  - 3 × Dell 7920 servers for readout
  - 1 × Dell 7920 servers for storage and processing
  - 2 × Dell 7920 servers for control and monitoring
  - 1 × APC Smart UPS

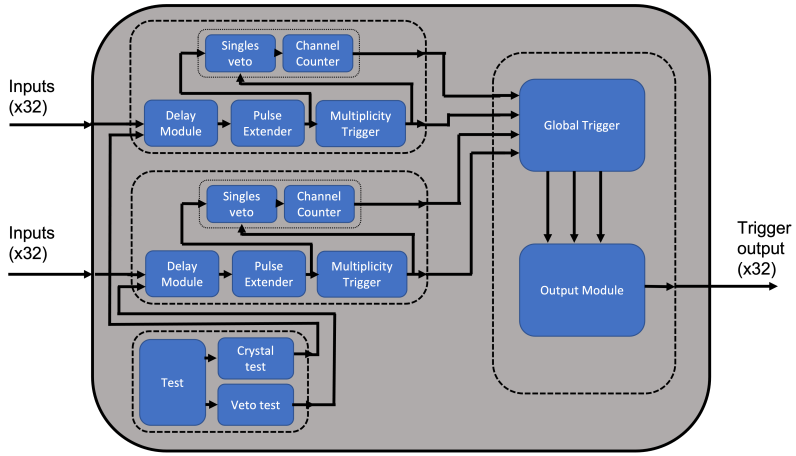
DAQ Software

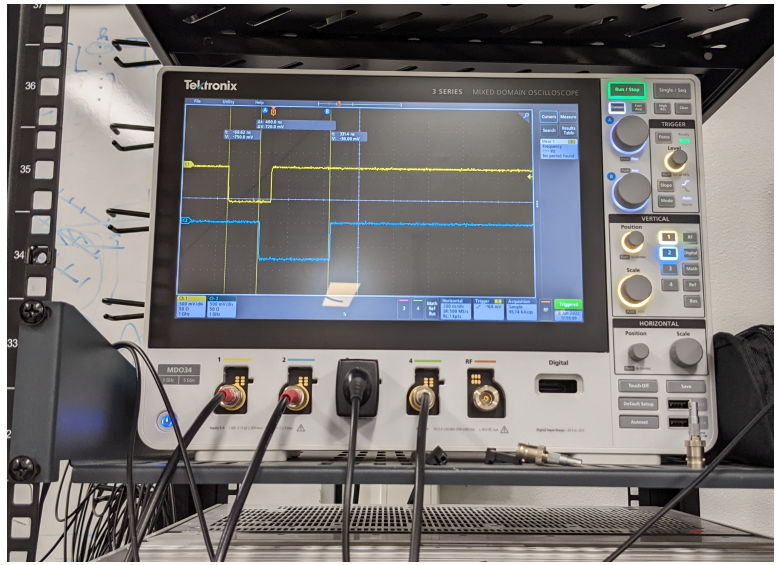
- Custom EPICS server to configure, monitor and readout DAQ
  - Abstracted control/monitoring
  - Cross-instance communication
- Developed in C++ at UniMelb
- Modular design
  - Scaleable and flexible
  - Supports various hardware (digitisers, trigger board etc.)



Trigger firmware

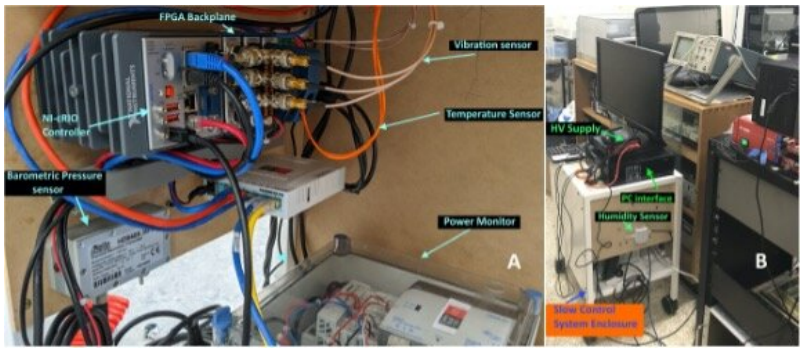
- CAEN V2495 to manage triggering and synchronisation across digitisers
- Custom VHDL firmware in development at the ANU
  - Gate-delay-generator
  - Multiplicity trigger
  - Calibration trigger
  - Start signal
- Prototype testing mid-late 2022

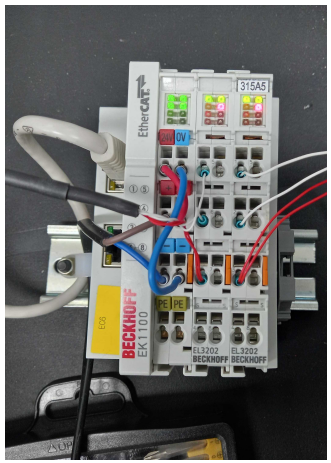




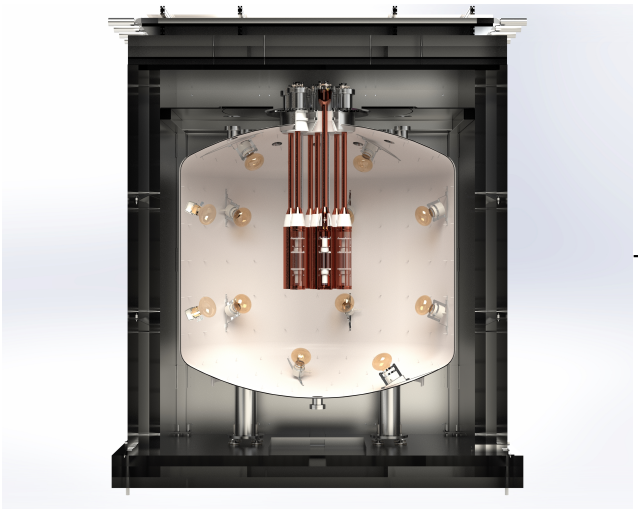
Slow control

- PMT HV
  - CAEN SY5527 built in EPICS server
- Muon calibration system
  - Festo stage – EPICS modbus support
- Veto calibration system – TBD
- Environment sensors and fluid handling
  - NI-cRIO based prototype developed at Swinburne
  - EPICS + Ethercat system under development at ANU and UniMelb





Data pipeline



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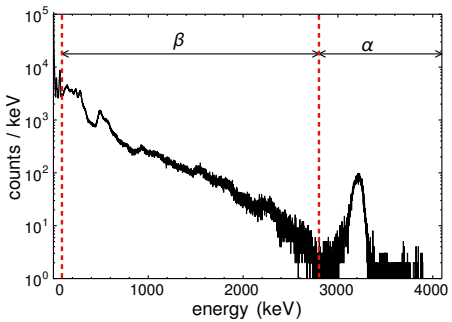
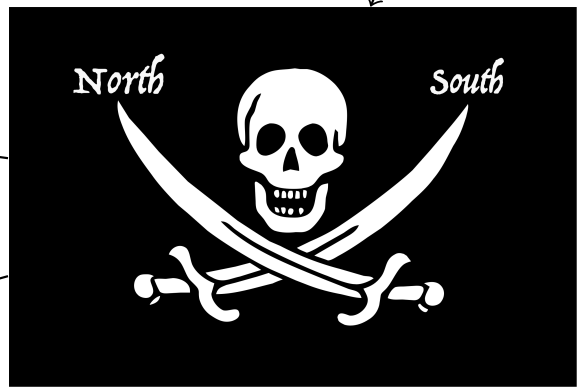
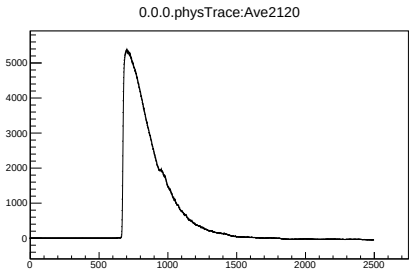
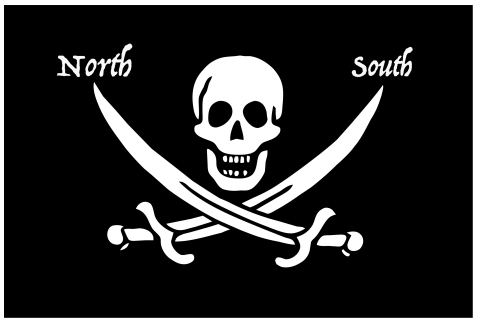






Software framework

- Processing and storage for raw SABRE data
  - Pyrate – Process raw data and convert into a more usable form
  - Mediaflux – Long-term storage of raw data
  - Database – Long-term storage of meta-data

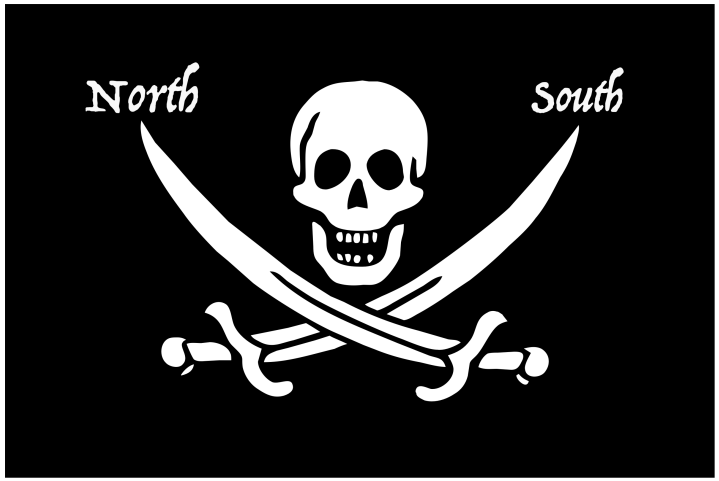


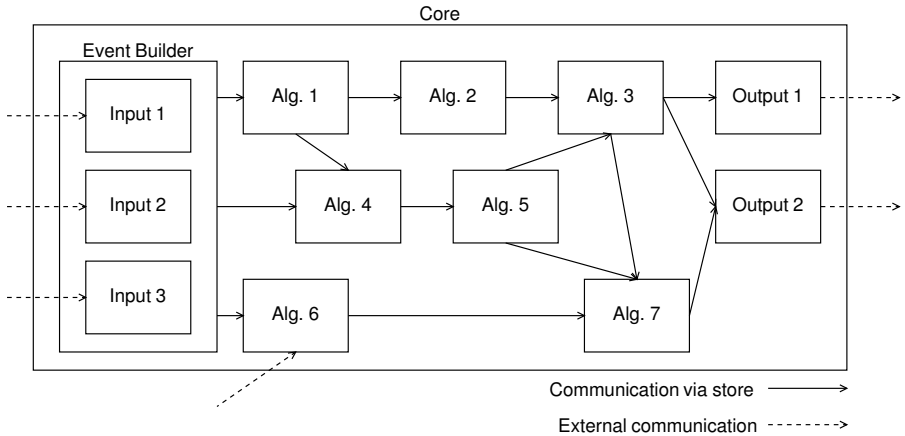
MEDIAFLUX®

PostgreSQL

Pyrate

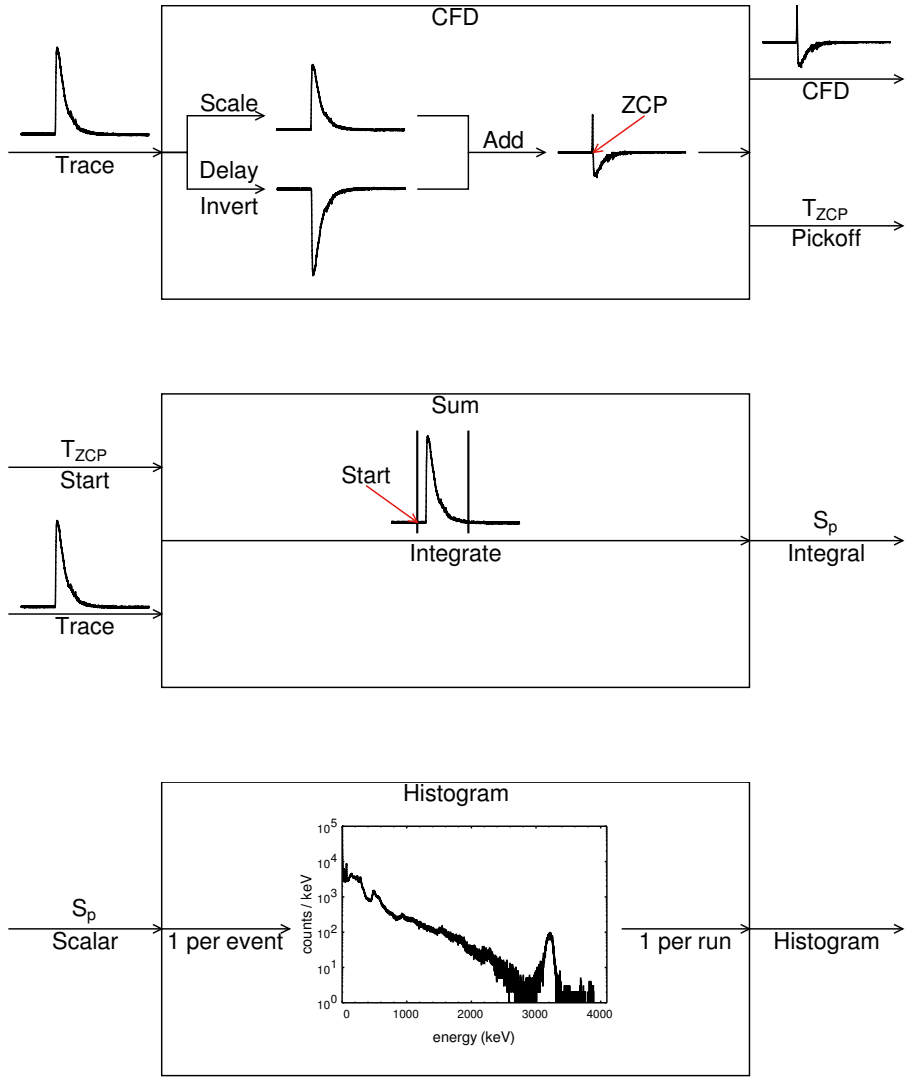
- Python package developed for the SABRE experiment to process and analysis event-based data.
- Designed using OO principles and a blackboard design pattern
- Can be used throughout an entire analysis pipeline
  - Data transformation
  - Signal processing
  - Event building and reconstruction
  - Data analysis
  - etc.





Algorithms

- Algorithms are black boxes that processes and transform data
- Current algorithms include;
  - Baseline reconstruction, baseline subtraction, trapezoid filters, constant-fraction discrimination, leading-edge discrimination, charge summation, fast-Fourier transformation, calculation of moments, waveform average, histogram generation, ROOT TTree generation and more!!!

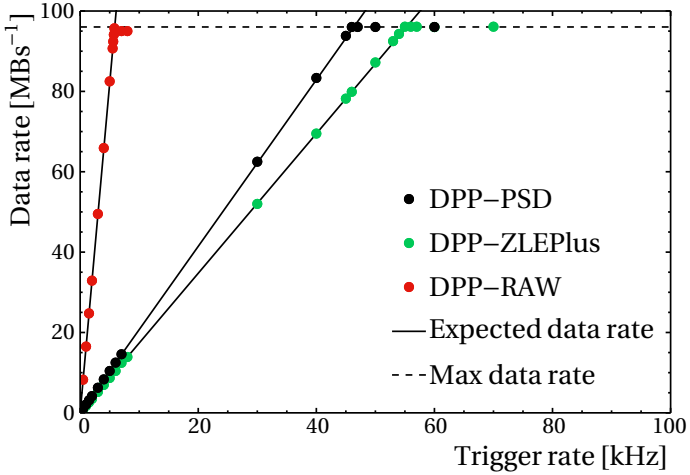


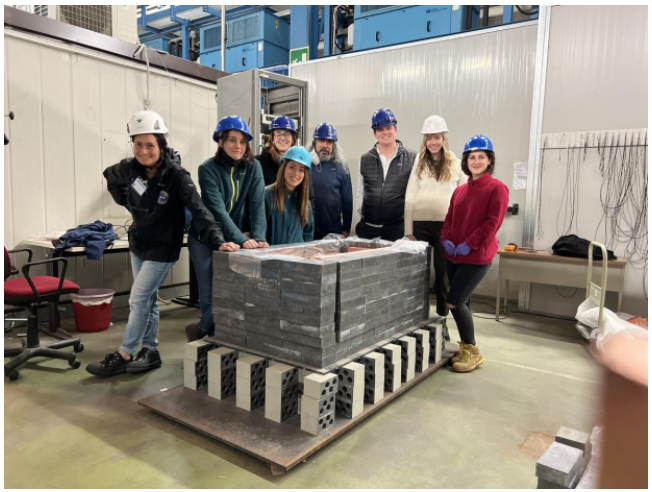
Database and storage

- Store data generated by the SABRE experiment
- Cloud based infrastructure utilising a number of tools
  - Postgreql – DBMS
  - Django – Data management
  - Grafana and prometheus – Monitoring
  - Apache airflow – automation and integration
  - Mediaflux – long-term storage
  - etc.
- See poster by J. McKenzie

Status and operations

- Performance tests
  - DAQ, slow control, pyrate
- Detector characterisation
  - PMTs, Liquid veto, Muon detectors
- Crystal characterisation
  - NaI-35 – First SABRE-South crystal
- See posters/talks for more details





Future work

TDAQ

- Trigger
  - Finalise design and implementation
- Environment monitoring and slow control
  - Sensor list
  - Veto calibration system
  - Fluid handling system
- Integration with offline computing
  - Scheduling of data processing
  - Transfer of data from SUPL to Mediaflux
- Commissioning
  - Large-scale deployment and testing

Software and offline computing

- Pyrate
  - Ongoing development
  - Performance optimisation
  - Monitoring
- Database
  - Finalise design
  - Build infrastructure
- Integration with TDAQ
  - Scheduling of data processing
  - Transfer of data from SUPL to Mediaflux
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Acknowledgements

SABRE North

INFN LNGS
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Gran Sasso

Pacific Northwest NATIONAL LABORATORY

INFN
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