

DUNE Upstream DAQ Software

**LBNF/DUNE-UK Project Meeting
25 August 2021
(virtual Zoom meeting)**

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Outline

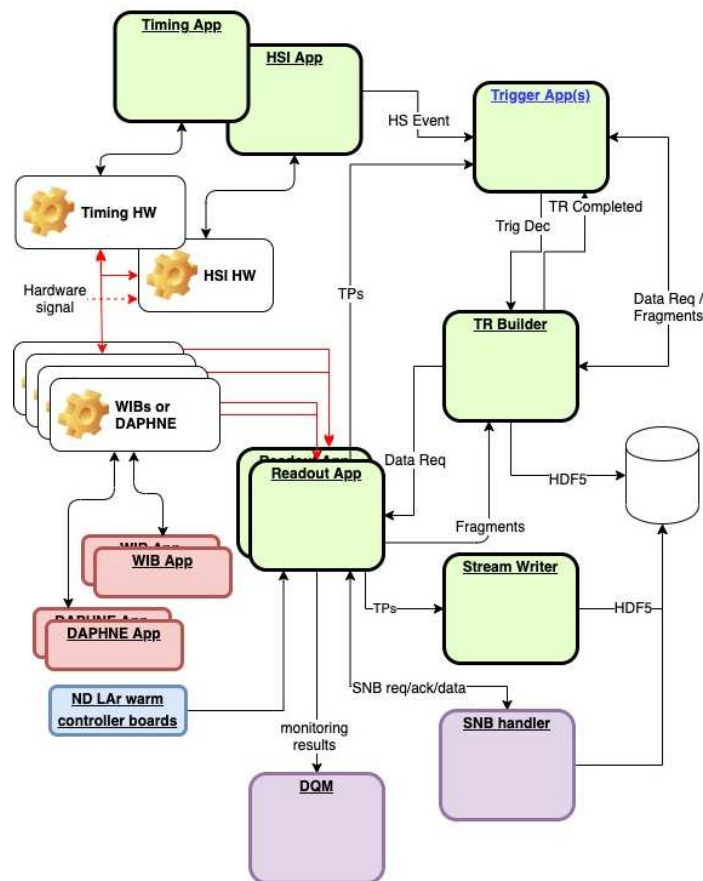
Hello! I joined the RAL DUNE group at the start of the Covid-19 pandemic. Our team contributes to the FD Upstream DAQ system. I work on the

standalone package for firmware simulation/verification (Python)

DUNE-DAQ readout software (C++)

- Towards ProtoDUNE-II operation
- Upstream DAQ planning
- Highlights from recent developments
- Summary

APA + VD Coldbox System, July 31st
- revision after 2.6



dunedaq V2.8.0.
The main feature additions are:
- the TP's flow,
- the storage of the TP stream,
- the SNB handling,
- the collection of data fragments from trigger applications,
- the introduction of DQM for readout,
- the integration with ND LAr controller boards will be implemented.

In addition, a revision of request/response patterns will be done, to simplify configuration and possibly reduce the number of modules.

Executive Summary

This meeting is taking place in the middle of a very exciting and busy period while DAQ working groups are successfully completing a major ProtoDUNE-II milestone (dunedaq v2.8) to support VD and HD coldbox detector studies starting in autumn

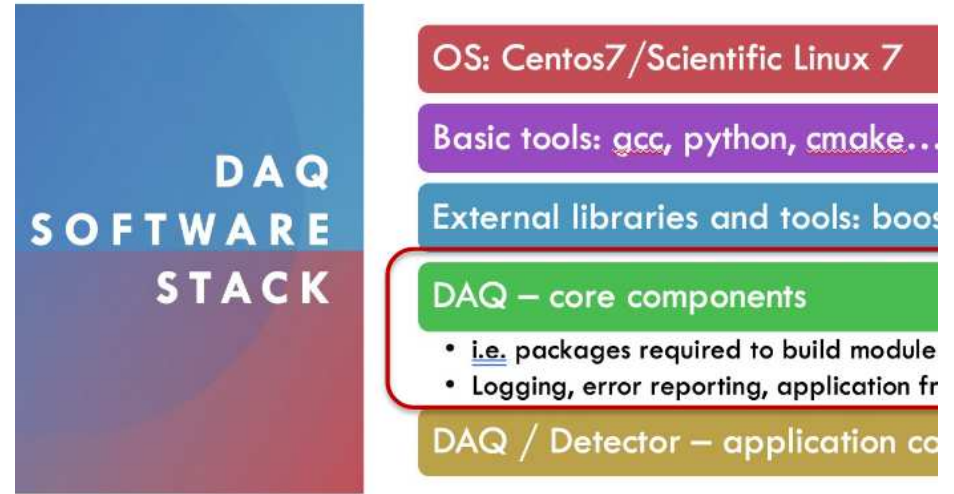
Next steps for PD-II are

Cryostat preparation, detector installation, begin operations

Upstream DAQ is a critical element needed to support this

Learning from PD-I experience and aiming to build a data acquisition system as close as possible to DUNE within the available time and resources on the timescale for PD-II

- PorotDUNE-II schedule was imminent after the end of ProtoDUNE-I in summer 2020
- Since the beginning of 2021 Upstream DAQ is working on the plan implementation
- DUNE-DAQ github repository is our "live trasuretrove" of software resources
- Thanks to everyone who contributed, every DAQ group played a role



DUNE Upstream DAQ Reminder

hardware / firmware

data

raw data from real electronics

emulated data

systems / boards

TPC / WIB

PDS / DAPHNE

μ TCA Top Drift Electronics

Near Detector

...

upstream DAQ / readout

functionality

trigger primitive generation

latency (10s) buffer

SNB (100s) buffer

data request handling

data recording (100s)

implementation

firmware + software

custom hardware + COTS

DAQ systems

data flow (DF)

data selection (DS)

trigger

event builder

calibration

monitoring

...

Upstream DAQ Team

- **Mostly UK (and CERN)**
 - Mixture of different expertise
 - **Firmware: Birmingham, Bristol, RAL, UCL**
 - **Software: CERN, Bristol, RAL (including Southampton, Sussex students)**
 - **No in-person interactions since February 2020**
- **Small**
 - **Need for task prioritisation**
 - **Developments proceed sequentially**
- **ProtoDUNE-II detailed planning presented at the beginning of 2021**
- **The Upstream DAQ working group firmware and software activities were revised and adapted**
- **Release-based development plan was adopted**
 - **Release goals aligned with HD/VD project milestones**
 - **Each release characterised by a reference system layout**
 - **Hybrid incremental/iterative development model**
 - **New elements added, existing interfaces updated**
 - **Technical details reported and discussed in weekly Upstream DAQ technical meetings**

Upstream DAQ Development Cycle

DUNE-DAQ Release Planning

Single-process "mini" DAQ

Separate Trigger and DAQ processes

Multiple readout processes

- CE integration
- HSI application
- Iceberg support at FNAL

Coldbox test release (postponed)

- TP streaming
- CE and PDS integration

Complete system

- VD TDE support
- Multiple Event Builder processes

Upstream DAQ Firmware

- Firmware release process and planning in sync with DUNE-DAQ
- Map functionality to releases
- Robust test and validation procedure
- Code management/standards
- Integration with software release schedule

Upstream DAQ Software

- Milestones and deliverables for each DUNE-DAQ release
- Code organised in packages, hosted on GitHub
- Deployed on CVMFS as UPS products
- Upstream DAQ packages: readout, flxlibs
-

Firmware Highlights

- **Trigger Primitive integration with Phase 2 FELIX - Ongoing**
 - **Highest priority task**
 - **Goal is to demonstrate ability to handle TPs from source to end**
 - **Phase 2 FLX firmware built in-house (i.e. DUNE, not ATLAS)**
 - **IPBus, and other preparations for TP integration ongoing**
 - **Tested in Bristol and CERN, baseline for dunedaq v2.8.0 release**
- **Change from GBT to AXIS 32b FLX format - Done**
- **WIB1/WIB2 data reception support - Done**
- **Debugging and testing - Ongoing**
- **New TP FLX output format - Postponed**
 - **Greatly simplifies TP handling by the readout software**
- **Configuration block - Postponed**
- **Automated testing and verification procedure in place for each release**
- **Separate induction/collection wires**
 - **After production release**

Software Highlights - readout

Major code restructuring/cleanup and new features included in dunedaq v.6 and v2.8

- **Data request handling**
 - Unified request handler model
 - Single implementation for every FE type
 - Introduction of waiting and timed out requests
 - Parallel data requests execution
- **Interfaces**
 - Support for multiple request / response channels in single module
 - Operational monitoring and error reporting improvements: per link” reporting
 - ND tests and integration: after new planned code reorganisation
- **Latency (10s) buffer**
 - FE frame error registry (missing frames)
 - Switch from position-based lookup to binary search on timestamp
 - Pre-processing pipeline: blocking and sequential
 - Post-processing pipeline: non-blocking and parallel
- **Software-generated Trigger Primitives**
 - Port of the ProtoDUNE-I AVX2 accelerated software TPG implementation (Phil R.) from artdaq to dunedaq
 - TP Sets published according to Data Selection (DS) interface requirements
 - TP chain Fully successfully integrated and tested

Software Highlights - flxlibs / Ethernet readout

Thorough FLX tools testing and consolidation done using dunedaq v.6 and v2.8

- **Integration planning**
 - Instal FLX servers at NP04 and Bristol test stand
 - Independent crosscheck and reproducibility of tests
 - Enabling integration tests with FLX + WIB2 / DAPHNE / TP firmware
- **Milestones**
 - Updated and improved user documentation
 - Substantial operational monitoring improvements
 - Configuration improvements (DMA threshold, etc.)
 - New FELIX dependencies release
- **Ethernet-based readout planning**
- **Short term goals**
 - Explore DPDK (Data Plane Development Kit) at data to-host interface
 - dpdklibs (similar to flxlibs) for data to-user-space
 - Test ASIC "intelligent" NICs
- **Medium term goals**
 - Ethernet reception block (RAL)
 - DMA over PCIe implementation
 - Integrate with dpdklibs
 - Switching studies (routing and scalability)

Upstream DAQ Links

review meetings

Ethernet based Readout for FD-VD, 2 Aug 2021

<https://indico.fnal.gov/event/50169/>

VD DAQ CDR, 18 Jun 2021

<https://indico.cern.ch/event/1038731/>

- Comprehensive overview of the whole DAQ system
- A good reference for an up-to-date documentation

General Meetings

<https://indico.fnal.gov/category/984/>

DUNE DAQ/SC Meeting

Upstream DAQ Meeting

dunedaq v2.8.0, 24 Aug, 23 Aug, 1 Jun

dunedaq v2.6.0, 4 May, 13 Apr, 23 Mar, 2 Mar

dunedaq v2.3 and v2.4 1 Mar, 2 Feb

software 26 Apr, 29 Mar

readout 10 Aug, 27 Jul, 20 Jul, 15 Jun, 8 Jun, 7 Jun, 20 Apr

Technical Meetings

Upstream DAQ Tech meeting
<https://indico.fnal.gov/category/1065/>

- New, since 2021
- Thursdays at 13:00
- Replacing Upstream DAQ Firmware meetings
- Discussing progress with respect to release planning schedule
- Developer reports added to the agenda as minutes or presentations

Summary

- **Upstream DAQ is well embedded in the development infrastructure created by the DAQ consortium in the last year (for both software and firmware)**
 - **New tools to support the development process from code checkout to products distribution**
 - **Release-based development plan is in place accounting for both HD and VD project milestones**
- **dunedaq v2.8 release provides all basic elements of DAQ which will take us to the next stage of ProtoDUNE-II**
 - **All core DAQ elements now available for extended testing by the supported systems, e.g., Iceberg, VD and HD coldboxes, PDS, ND; trigger algorithm studies using full release**
- **Next steps**
 - **v2.10 will be a consolidation release to foolproof the foundations of the readout system (instead of adding new functionality and features); design principles were found to hold so far**
 - **Development will focus on end-to-end FELIX-based demonstrator**
 - **Ethernet-based readout demonstrator at certain level desirable for DUNE DAQ PDR (Jan'22)**