artdaq & OtSDAQ Introduction

Discussion between Testbeam and RSE folks
21-Apr-2015

Kurt Biery
(On behalf of the RSE Department)

What is *artdaq*?

artdaq is a toolkit for creating data acquisition systems

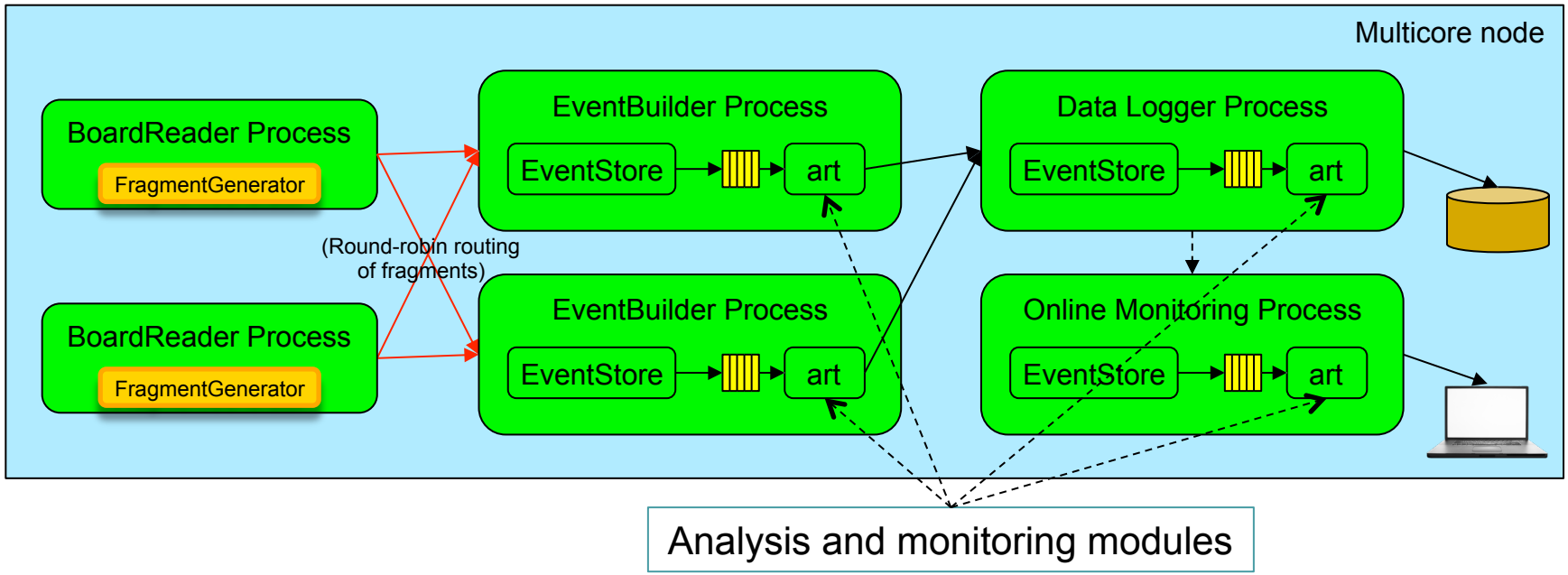
- Fermilab Scientific Computing Division's core DAQ software
  - Provides common, reusable components
  - Based on a data-streaming architecture with software event filtering
- Integrated with the *art* framework
  - Same algorithms online and offline

- It provides data transfer, event building, process management, system and process state behavior, control messaging, message logging, infrastructure for DAQ process and *art* module configuration, and writing of data to disk in ROOT format.
- The goal is to provide the common, reusable components of a DAQ system and allow experimenters to focus on the experiment-specific parts of the system. These are the software that reads out and configures the experiment-specific front-end hardware, the analysis modules that run inside of *art*, and the online data quality monitoring modules.

The *artdaq*-demo

Demo package to illustrate *artdaq* use

- Instructions for downloading, building, and running a sample system
- More information here:
  - https://cdcvs.fnal.gov/redmine/projects/artdaq-demo/wiki
- An easy way to try out *artdaq* and learn more about it



Off-the-Shelf DAQ

LDRD to investigate the use of commercial (internet-of-things) hardware modules for common DAQ functions.

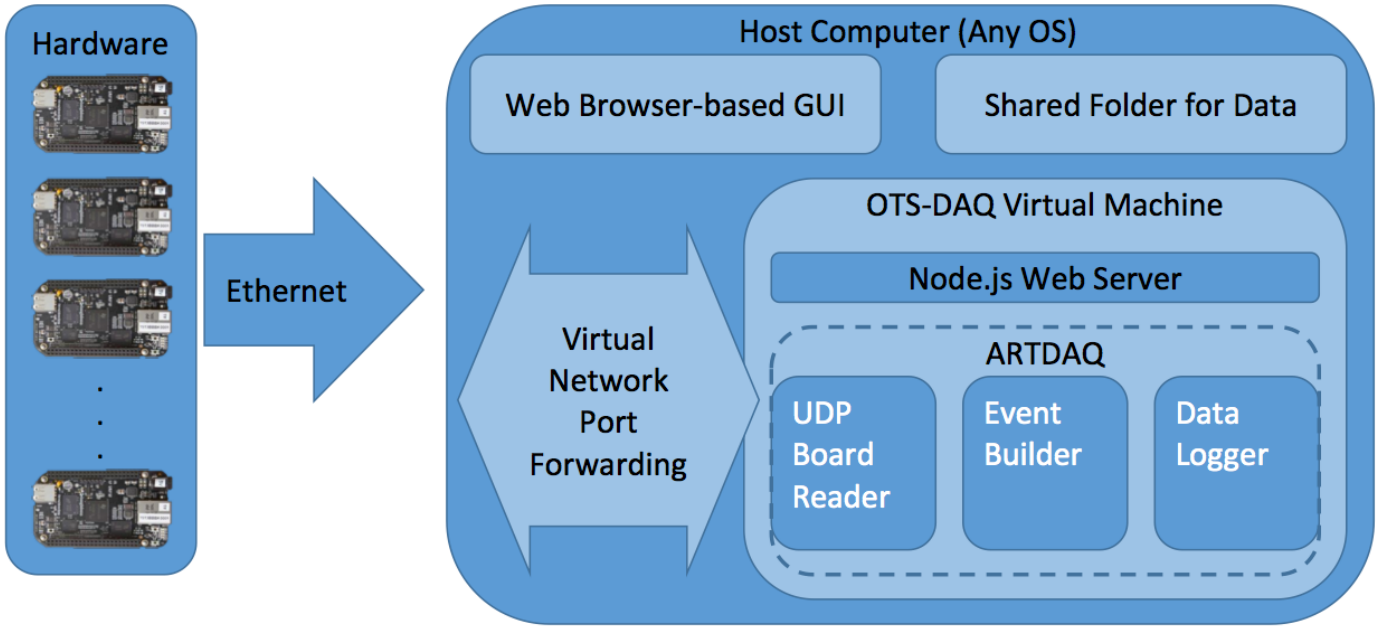
Goal is to have

- Recommended HW
- Reusable firmware
- *artdaq* and *art* SW

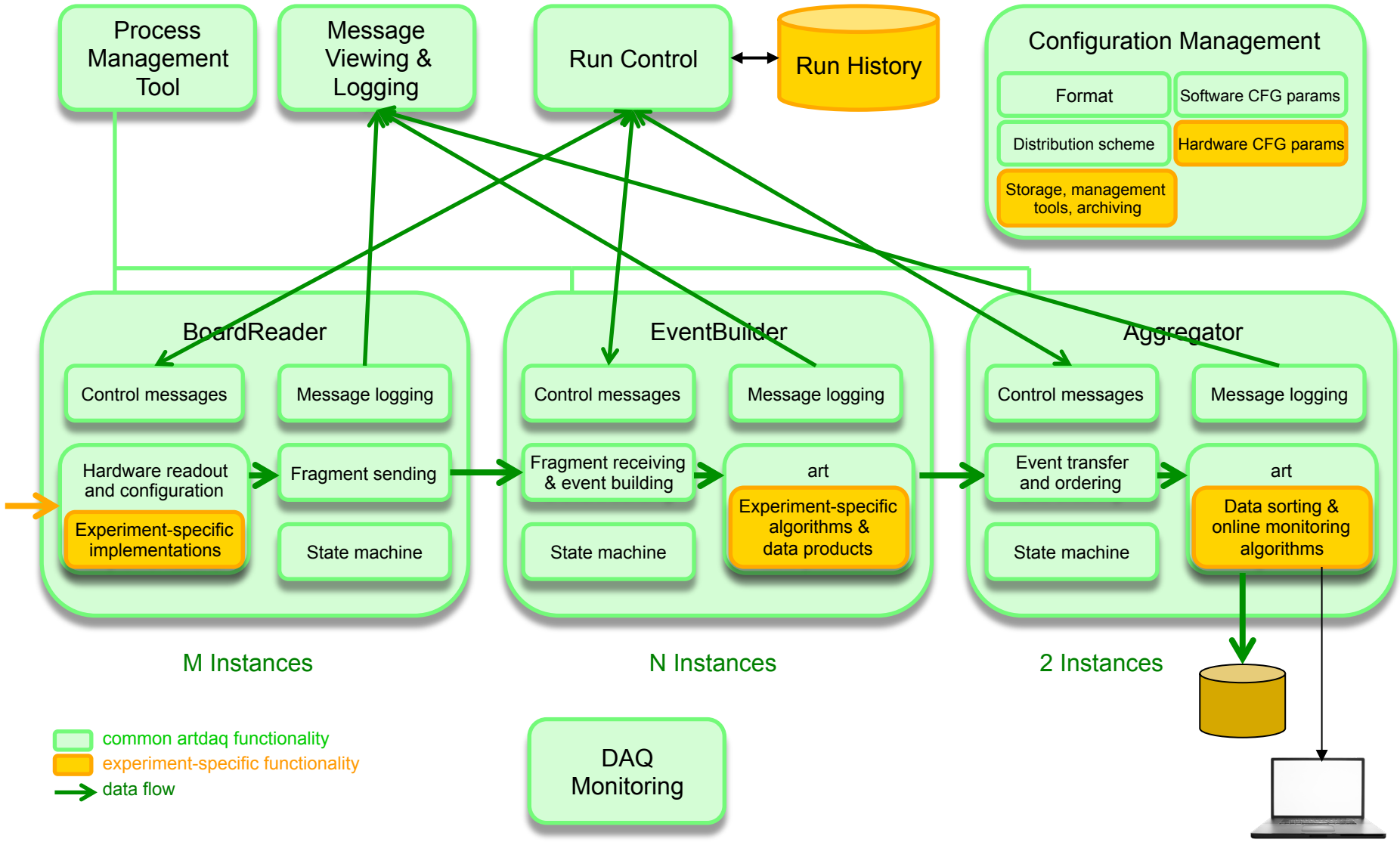
First OtS DAQ Sample Integrated System

Sample “simple” system:

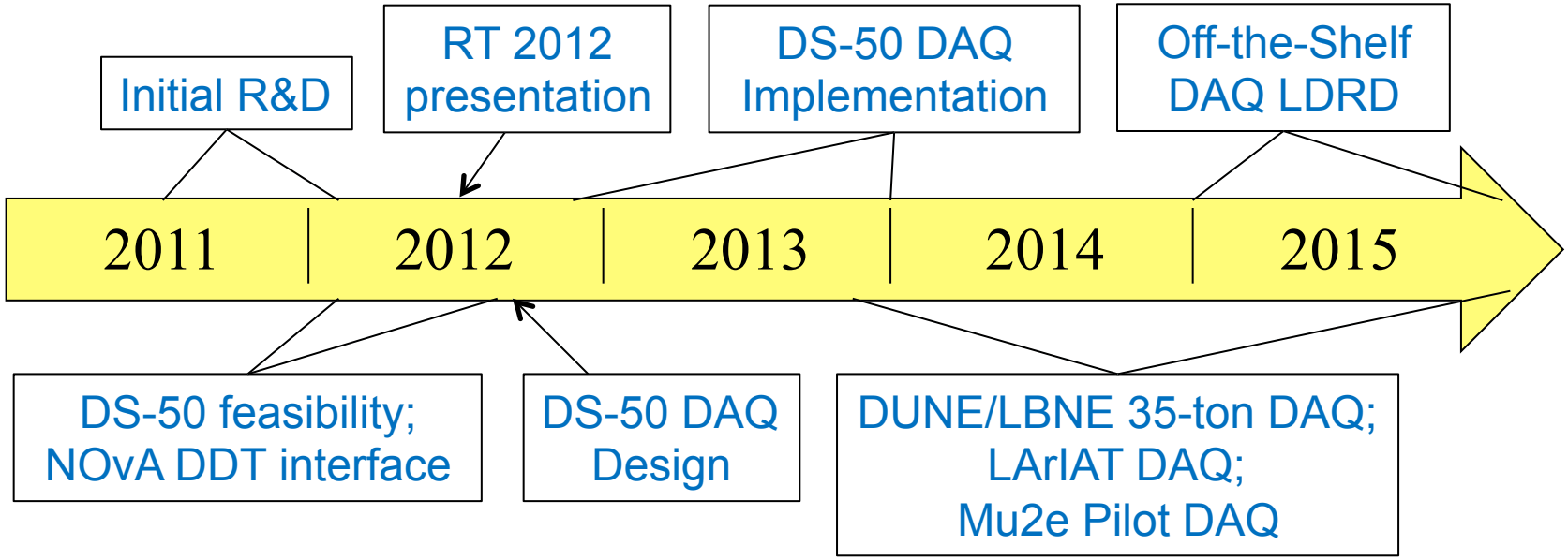
- BeagleBone Black hardware module(s)
- Windows PC
- *artdaq* software

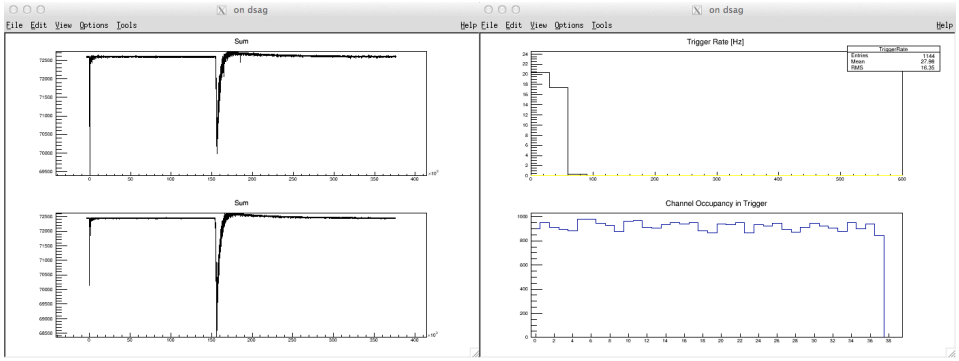


Software Components & Functions



artdaq Timeline





Sample DS-50 online monitoring histograms

Current *artdaq* Users

DarkSide-50

- First production use of *artdaq*
- CAEN VME modules, commodity computers
- DAQ running reliably; stable operation

LBNE

- 35t prototype detector running mid-2015
- Vertical slice testing of HW and SW
- Strong physicist involvement on *artdaq* customizations
- We're developing the *artdaq* interface to Run Control and helping with configuration management

Mu2e

- Pilot system under development now
- Commercial PCIe cards, commodity computers
- 30 GB/sec, filtering factor of ~1000

LArIAT

- *artdaq* used on top of original DAQ code
- Data-taking resuming now

NOvA

- *art* for enhanced triggering (data-driven triggers)
- A few pieces of *artdaq* for *art* input

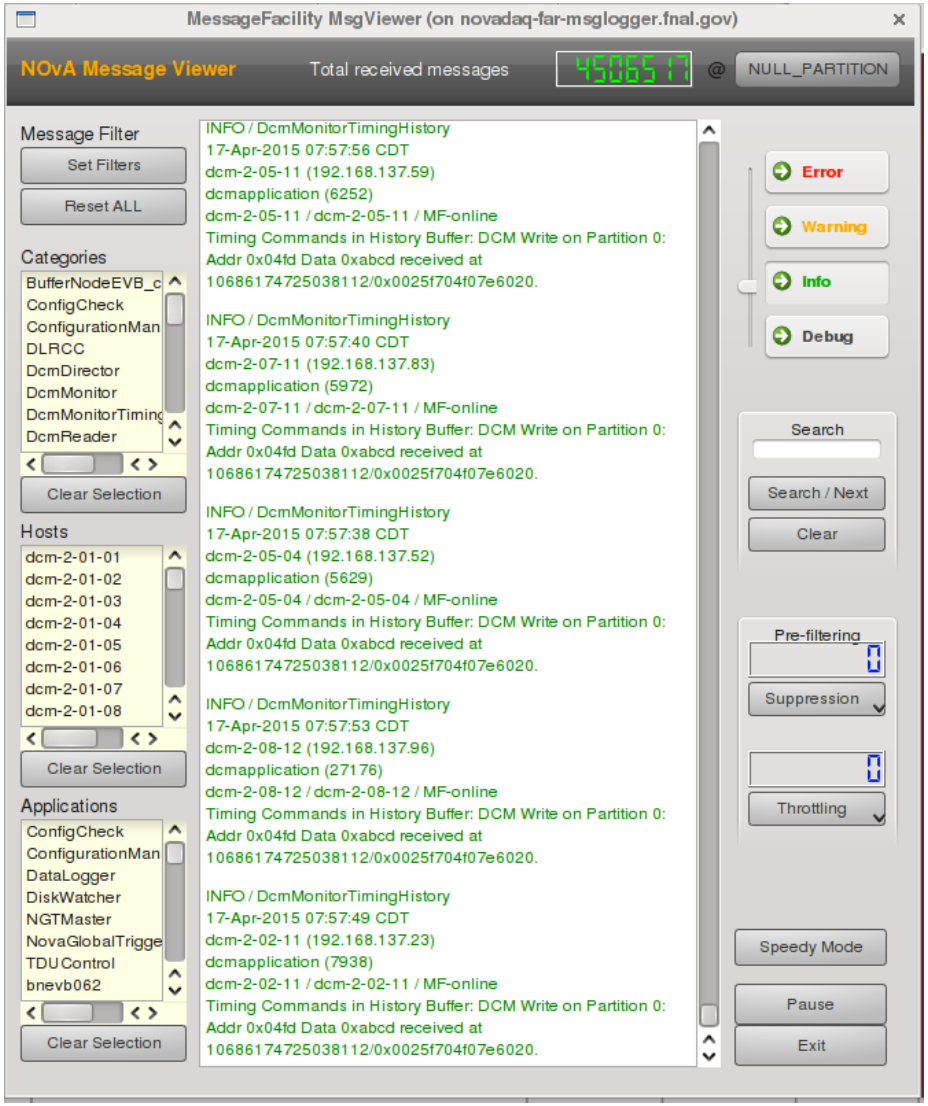
uBooNE

- Uses a number of *artdaq* utility classes

Centralized Message Viewing

MessageFacility package
- plus distributed transport
- plus reuse of the Viewer from NOvA (being generalized now)

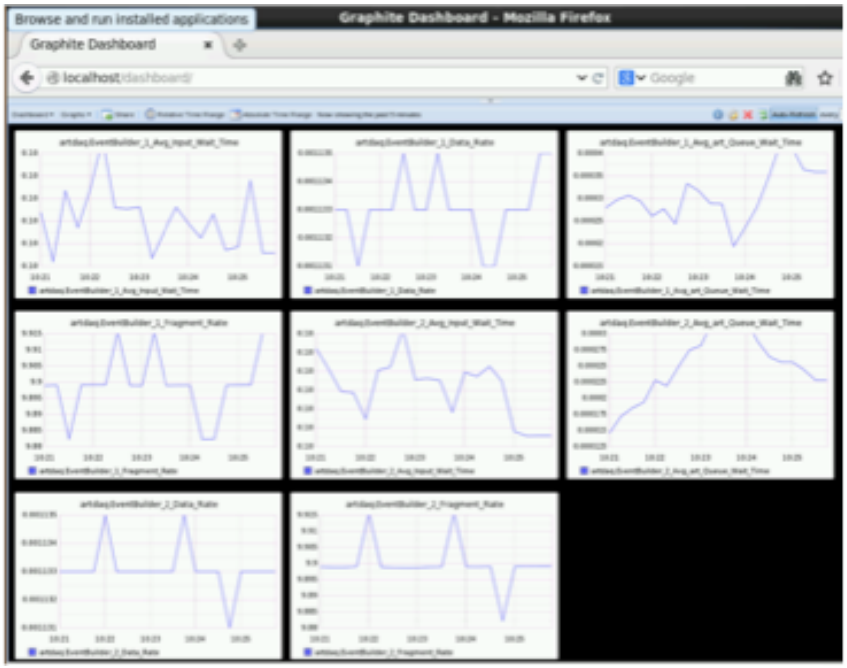
Being developed now for DUNE/LBNE 35t



DAQ Monitoring

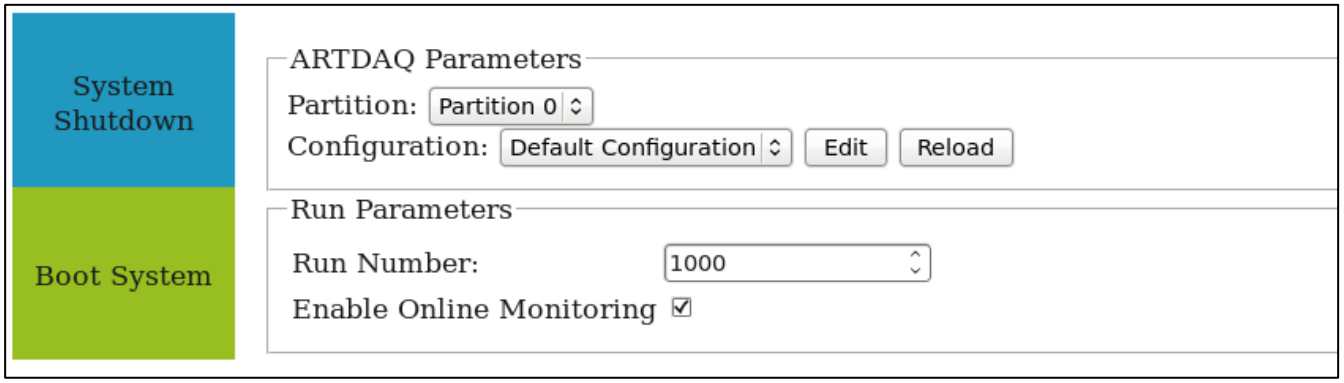
"metrics reporting" infrastructure implemented last fall.

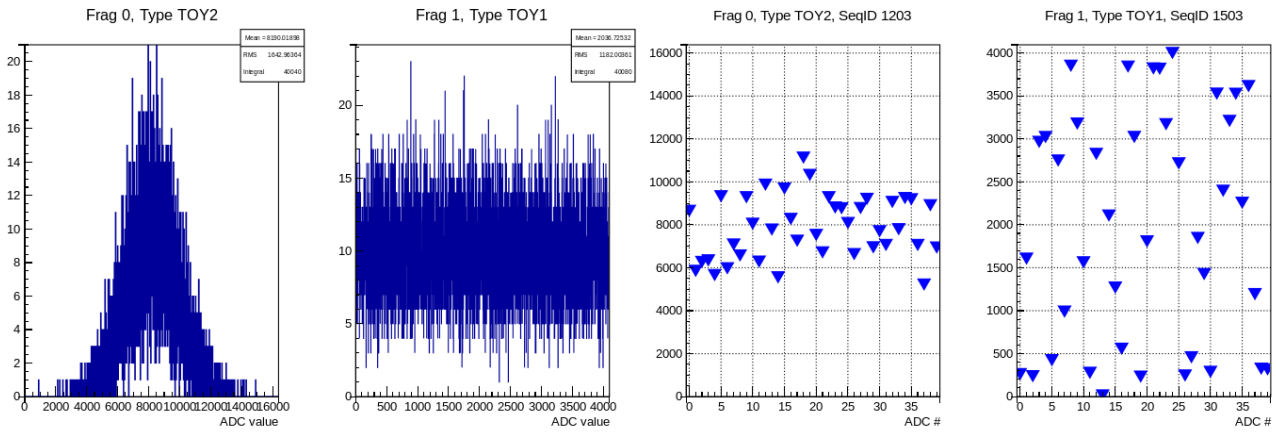
Ganglia reporting working now in the DUNE/LBNE 35t DAQ.



Web-based Control and Monitoring

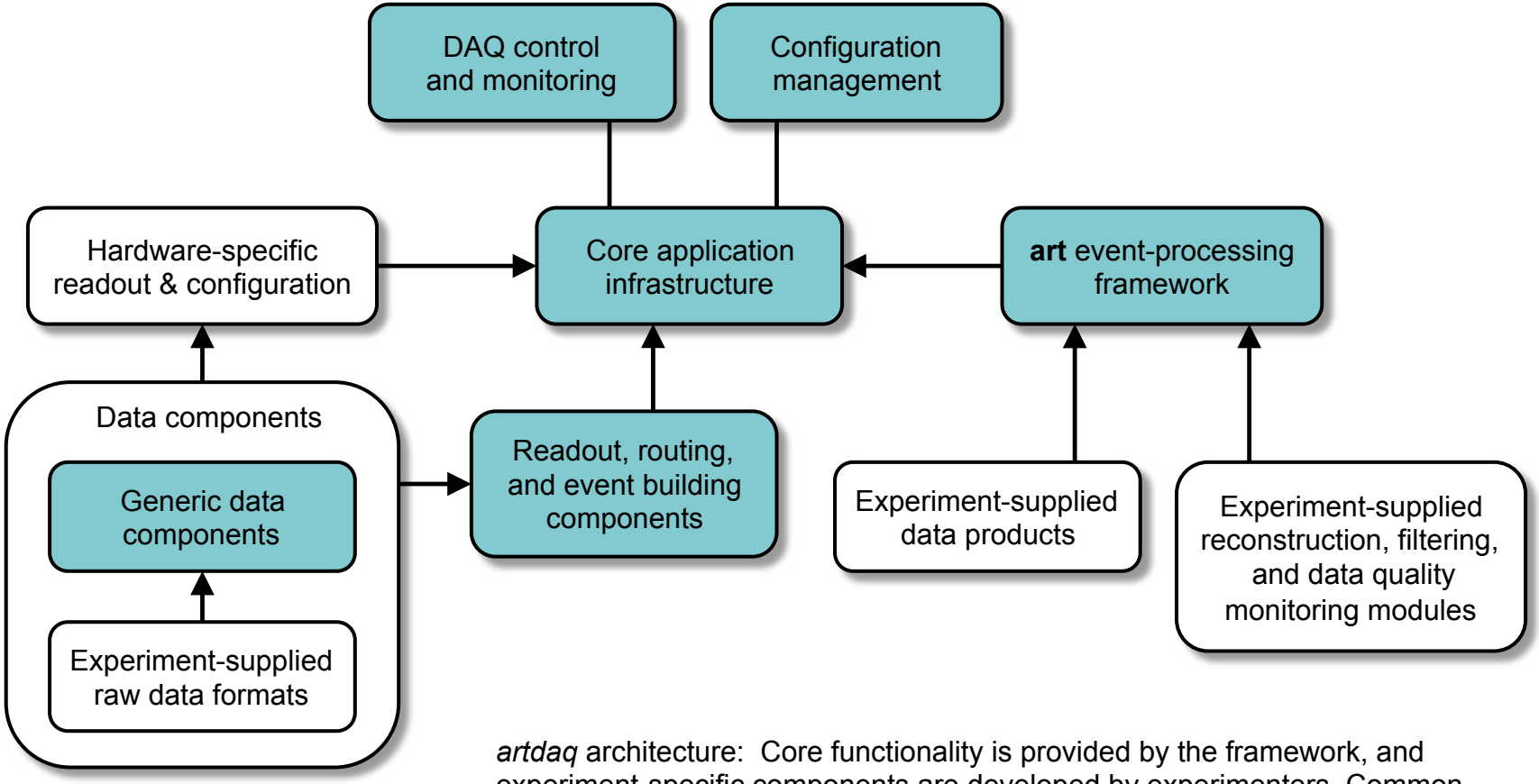
Prototype web-based tools are being developed using a Node.js web server, Javascript in the browser, and third-party Javascript libraries.





Backup slides

artdaq Architecture



artdaq architecture: Core functionality is provided by the framework, and experiment-specific components are developed by experimenters. Common functionality is shown in boxes with blue background and experiment-specific components are shown in boxes with white background.

Some Technical Details

Uses C++11 features

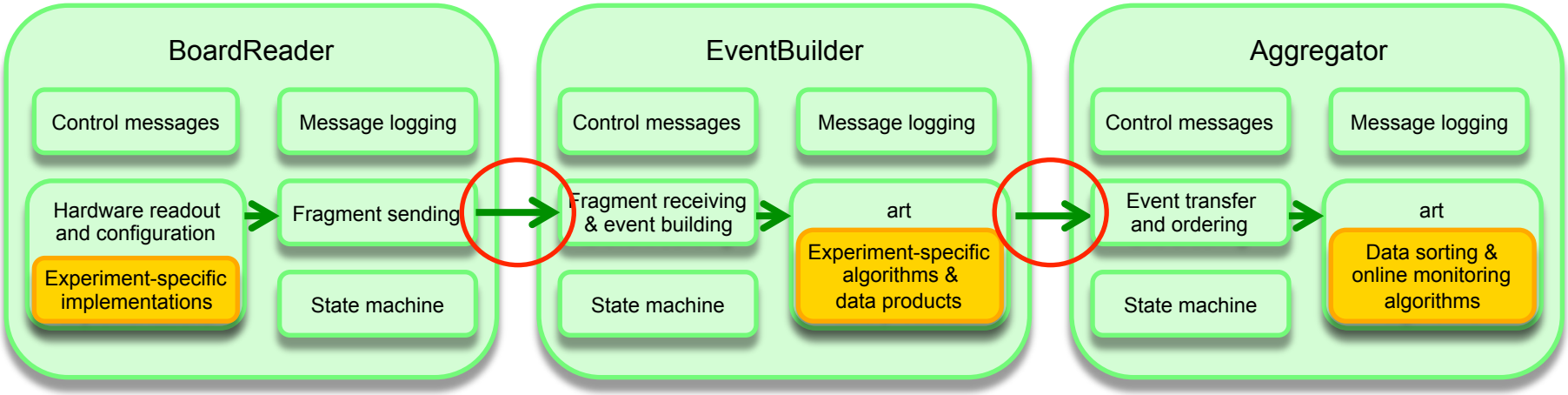
- e.g. move semantics to minimize data copies

MPI for data transfer

- Wrapper classes for sending and receiving MPI buffers

Process management

- Wrapper script around *mpirun* command



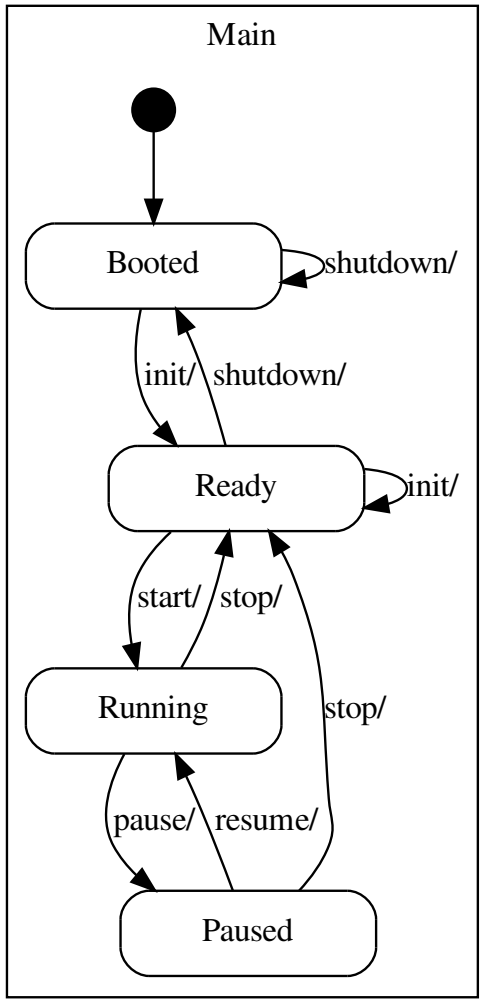
State Behavior & Control Messaging

State behavior part of *artdaq* core

- Standard states:
  - Booted, Ready (configured), Running, Paused
- Standard transitions:
  - Init(cfgString), start(runNum), stop, pause, resume, shutdown
- State Machine Compiler tools
- Overall system state managed by Run Control

Control messaging infrastructure also included

- Standard commands:
  - State transitions & status queries
- XMLRPC
- Command-line Run Control scripts provided



Simplified *artdaq* state diagram

Configuration Management

Configuration infrastructure part of core *artdaq*

- Single structured text string sent at “init” transition
  - hardware, software, system, *art* configuration
- Interpretation of software and system parameters provided in core *artdaq*
- Hardware parameters handled by experiment-specific code
- Archiving and management of configuration data – not yet part of core *artdaq* – but may be in the future

```
daq: {  # red = group identifiers
  max_fragment_size_words: 2097152
  fragment_receiver: {
    mpi_buffer_count: 40
    generator_ds50: {
      fragment_id: 2
    }    # green = software params
    generator: V1495Driver
    first_event_builder_rank: 3
    event_builder_count: 5
    rt_priority: 2  # system params
    link_type: PCIE
    link_number: 0 # hardware params
    vme_base: 0x01000000
    pulser_frequency: 0.0
    laser_frequency: 0.0
    random_triggers: false
    acquisition_gate_us: 400.0
    low_threshold: 5
  }
}
```

Sample *artdaq* BoardReader configuration (FHiCL)

Typical Analysis Tasks (*art*)

Data compression

- DarkSide-50 – factor of 5-6 reduction

Online monitoring

- DarkSide-50

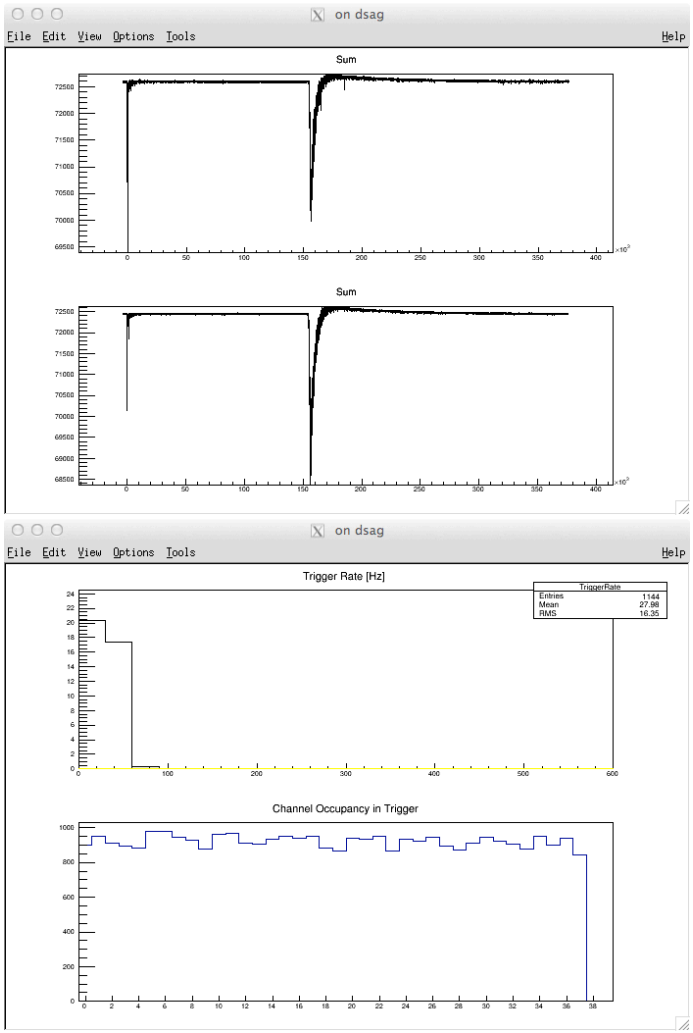
Event filtering

- Mu2e – reduction by factor ~1000

Event selection

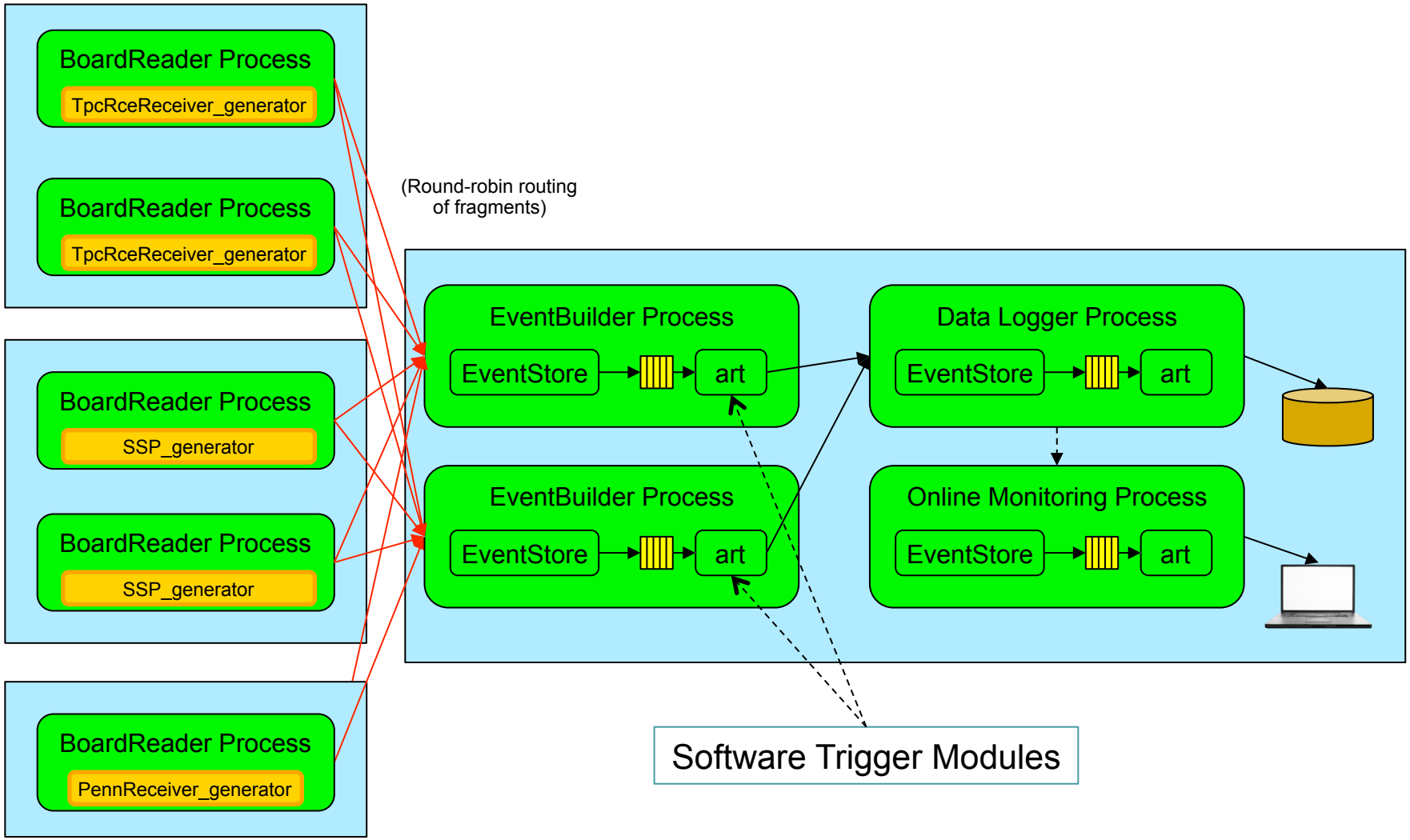
- NOvA – data driven trigger

Same code online as offline



Sample DS-50 online monitoring histograms

DUNE/LBNE 35-ton *artdaq* System



artdaq for DarkSide-50

DAQ

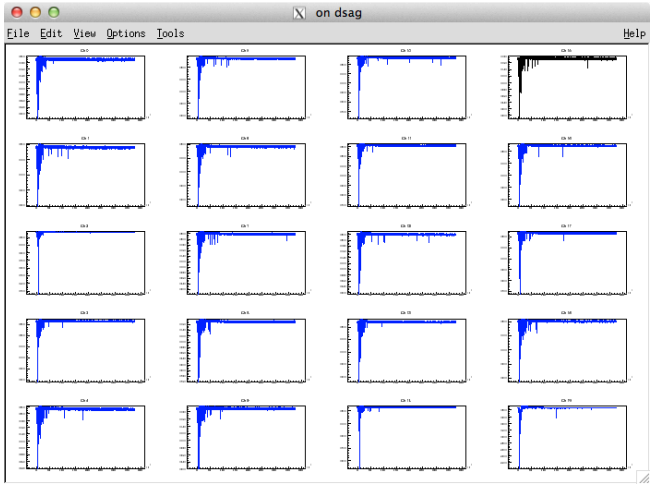
- Commercial VME modules (CAEN)
- Commodity servers and networking
- *artdaq* software (first production use)
- Typical event size ~ 10 MB
- Event rates up to 80 Hz

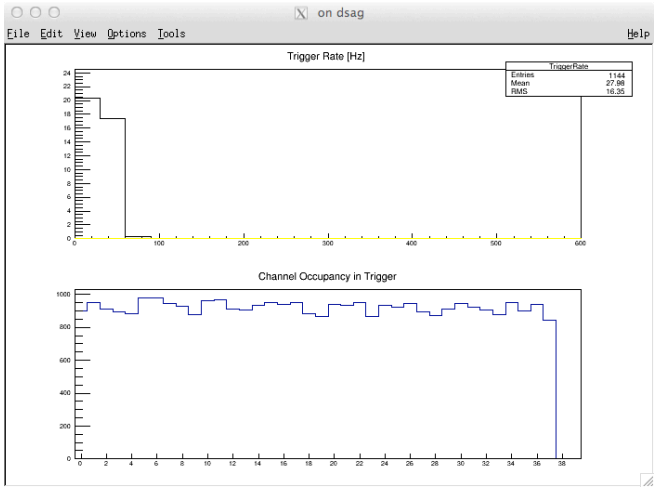
Customizations for Dark-Side

- Configuration and readout of VME modules
- Loss-less data compression
- Online monitoring

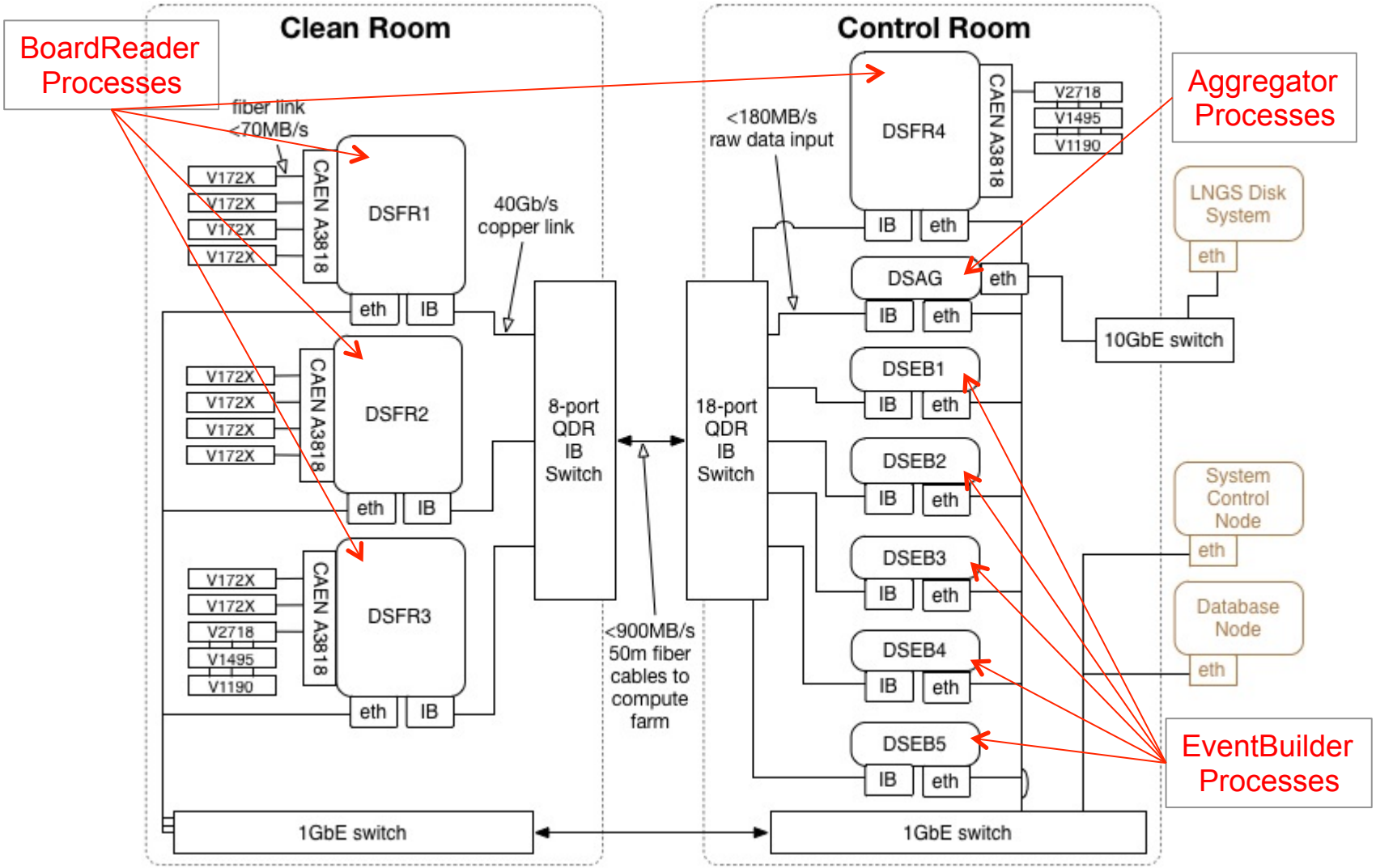
Status

- Reliable operation
- Meeting performance needs





artdaq for DarkSide-50



artdaq for Mu2e

Timeline

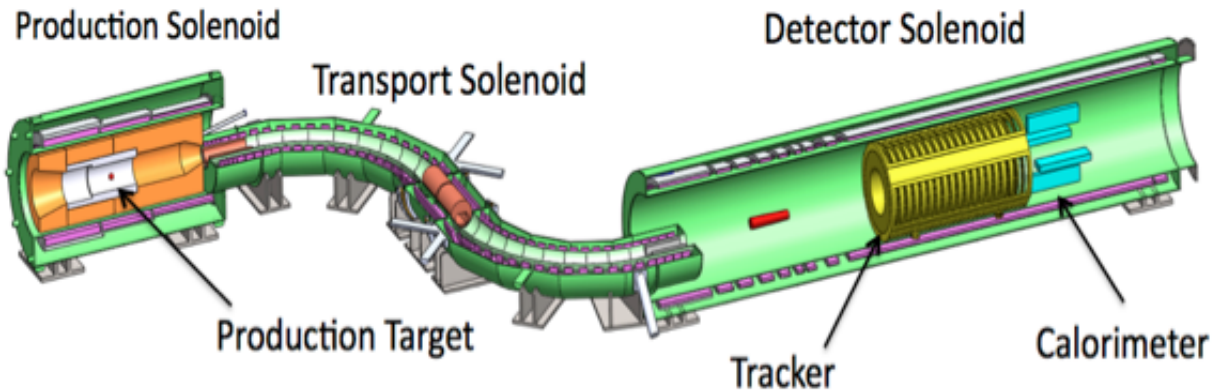
- CD-2/3 approval July 2014
- Commissioning data in 2019

Mu2e-specific development

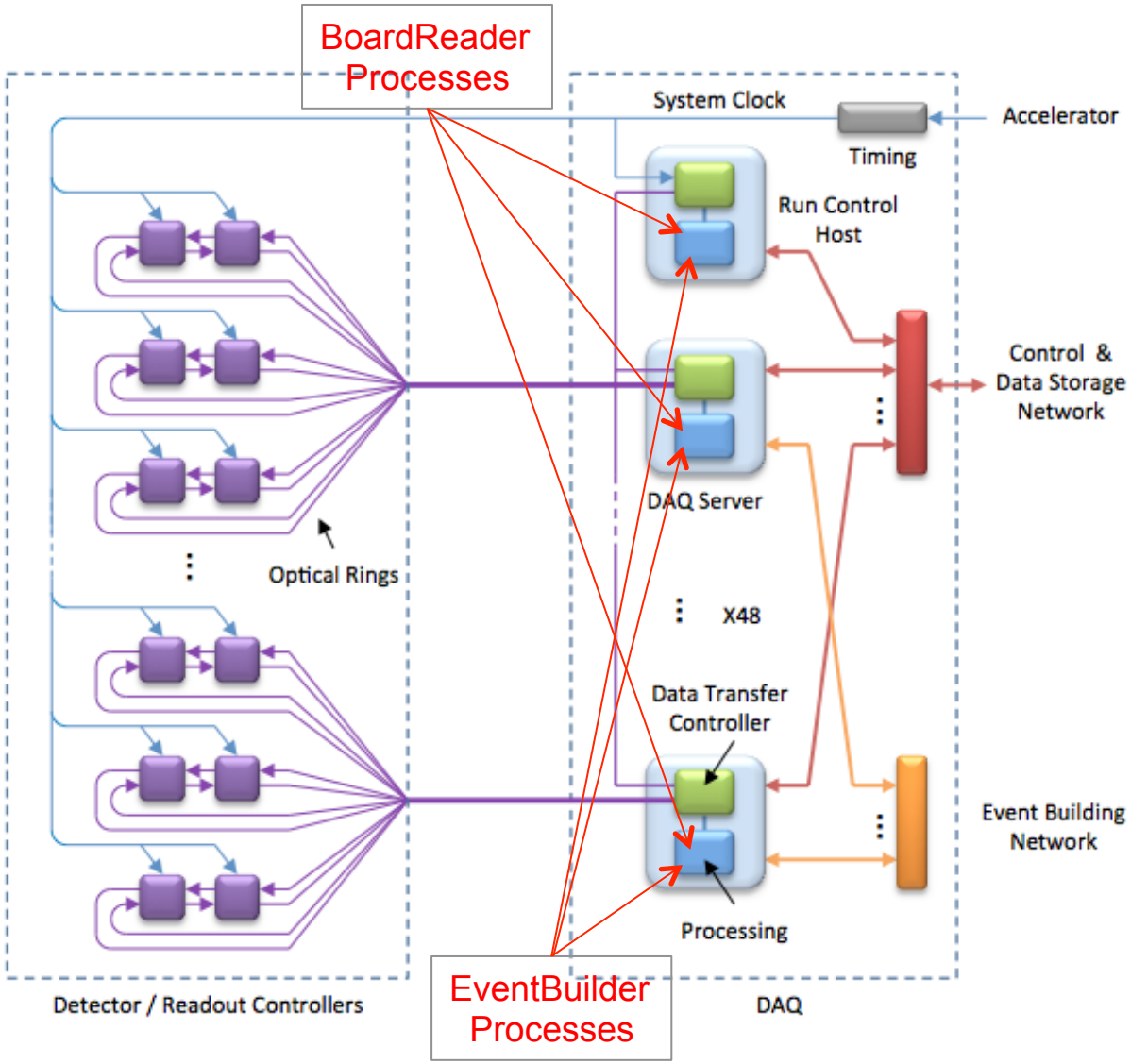
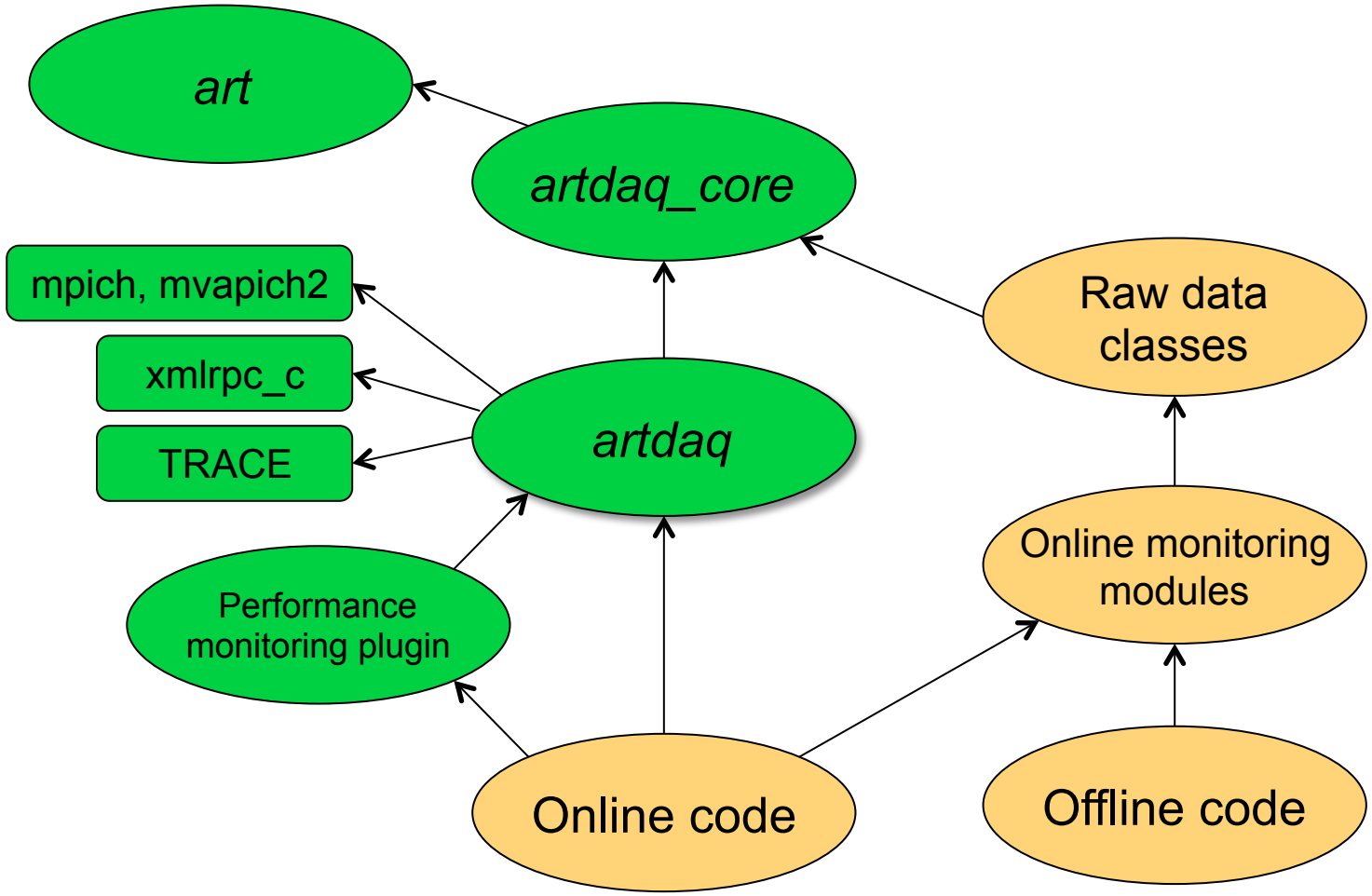
- Configuration and readout of hardware
- Reconstruction algorithm development and testing

DAQ

- Custom readout electronics
- Commodity servers and networking
- *artdaq* software & custom firmware
- Expected data rate: 30 GB/s
- Software rejection factor: 1000



artdaq for Mu2e



artdaq-related Software Packages