Run Control, Operational Monitoring, and Configuration

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ProtoDUNE DAQ Design Review

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Introduction

- Run control
  - Suite of software managing the state of DAQ
  - Interface between shifters/operators and DAQ
- Operational monitoring
  - Monitoring of the state of DAQ processes and data flow to ensure smooth operation of the DAQ
    - DAQ process monitoring (what is running? in what state?)
    - DAQ node monitoring (are the nodes healthy? disk usage? cpu load?)
    - DAQ data flow monitoring (how much data from each node? buffer occupancies?)
- Configuration
  - Storage of DAQ configuration for online and offline use
  - Interfaces for updating/creating new configurations
  - Interfaces to run control for choosing and passing configurations to DAQ components

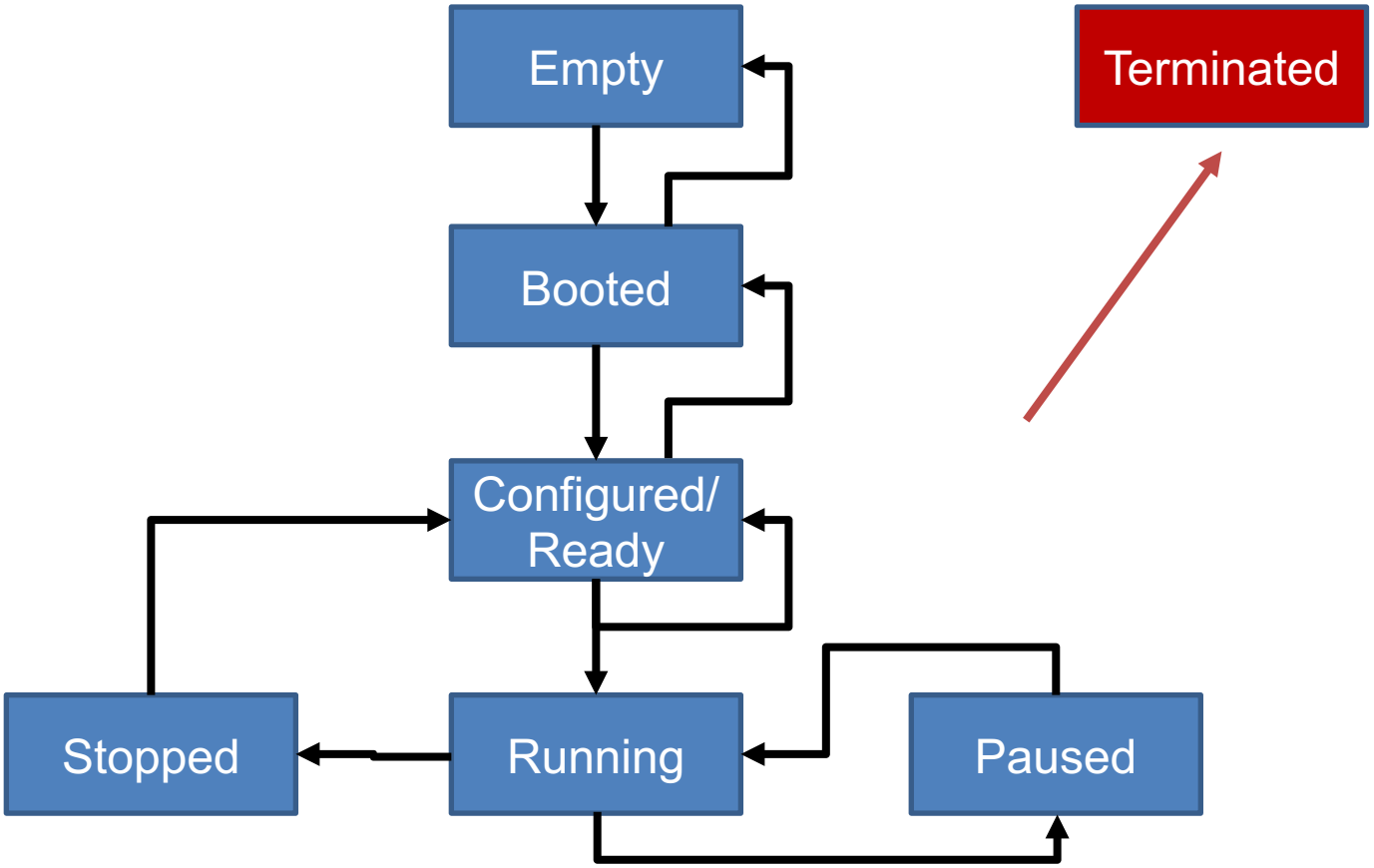
Quick detour: what is a run?

- We define a run as a period of contiguous data-taking from detector components in a static configuration state
  - Change of detector configuration → change of run
  - A run history database will provide basic information on runs taken
    - Start/end times, configuration ID/name used, run type, etc
  - Detector state/conditions can change during run
    - Operational monitoring / slow monitoring
- An event is the total collected data from a contiguous period of time during an individual run
  - For ProtoDUNE, usually defined by some triggered readout
  - Each event has a unique identifier
    - Run number and event number (with optional subrun number)
  - Each event has a unique “start” or “triggered” time

Requirements

- Provide clean interface between shifter control and existing DAQ control infrastructure
  - Integrated run control not currently provided with *artdaq*, but procedure for process management and control message passing exists
- Integrate DAQ operational monitoring with monitoring of other hardware components
  - Centralized monitoring → simpler operation and easier debugging
- Ability to alarm on DAQ status and internal data flow status
  - Interfaces for customized DAQ monitoring metrics
- Easy to maintain and modify configurations
  - Flexibility for new configuration parameters
- Configuration parameters fully accessible for offline reconstruction
  - And maintained over expected lifetime of data

artdaq State Machine



artdaq Control Processes

- Processes started using custom/simple Process Management Tool (PMT)
  - Currently started via MPI as MPI ranks used for data transfer pathway
  - Upcoming modifications: socket-based data transfer
    - More flexibility in how to start processes in PMT
- XML-RPC commands used for communication to DAQ processes
  - Check status, and pass through state transitions
- Experiment-specific long-running interface programs have previously been used for calling these processes
  - e.g. DAQInterface in 35-ton

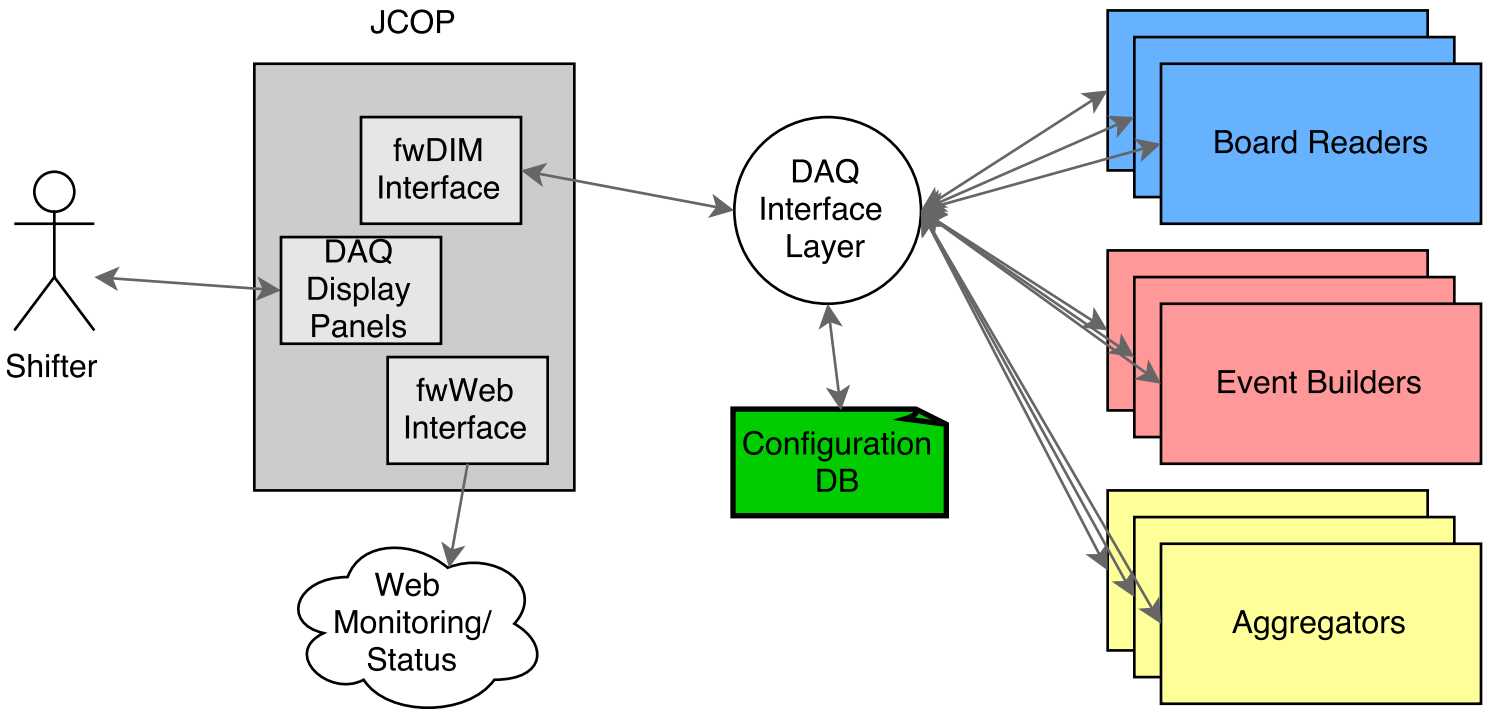
Run control: JCOP

- JCOP: Joint Controls Project
  - Grouping of representatives from CERN experiments
  - Developed framework of common software components for control systems
    - Hardware and software interfaces
  - Uses WinCC-OA for supervisory control and data acquisition
    - Control interfaces, custom data point elements, alarm capabilities, storage/archiving of controls data, and single event manager server subsystem managers
- Well-developed and common system at CERN
  - Benefit from expertise/common tools from many experiments
  - CERN support and expertise for JCOP system
- ***Decision to integrate DAQ into this system***
  - Where the significant work now is ongoing

Interface of DAQ to JCOP

- Maintain existing *artdaq* infrastructure, but build interface layer to JCOP
- Consulting experts → use CERN's DIM (Distributed Information Management System) as interface protocol
  - Simple server/client model
  - Python and C++ APIs
  - Interface from DIM to JCOP already developed (fwDIM)
- Interface plan
  - Write parent control with DIM server
  - Write DIM client to issue commands → PMT/XMLRPC
  - Write DIM client to receive back DAQ state
  - Integrate DIM client into JCOP
    - Developing DAQ process data elements with necessary state

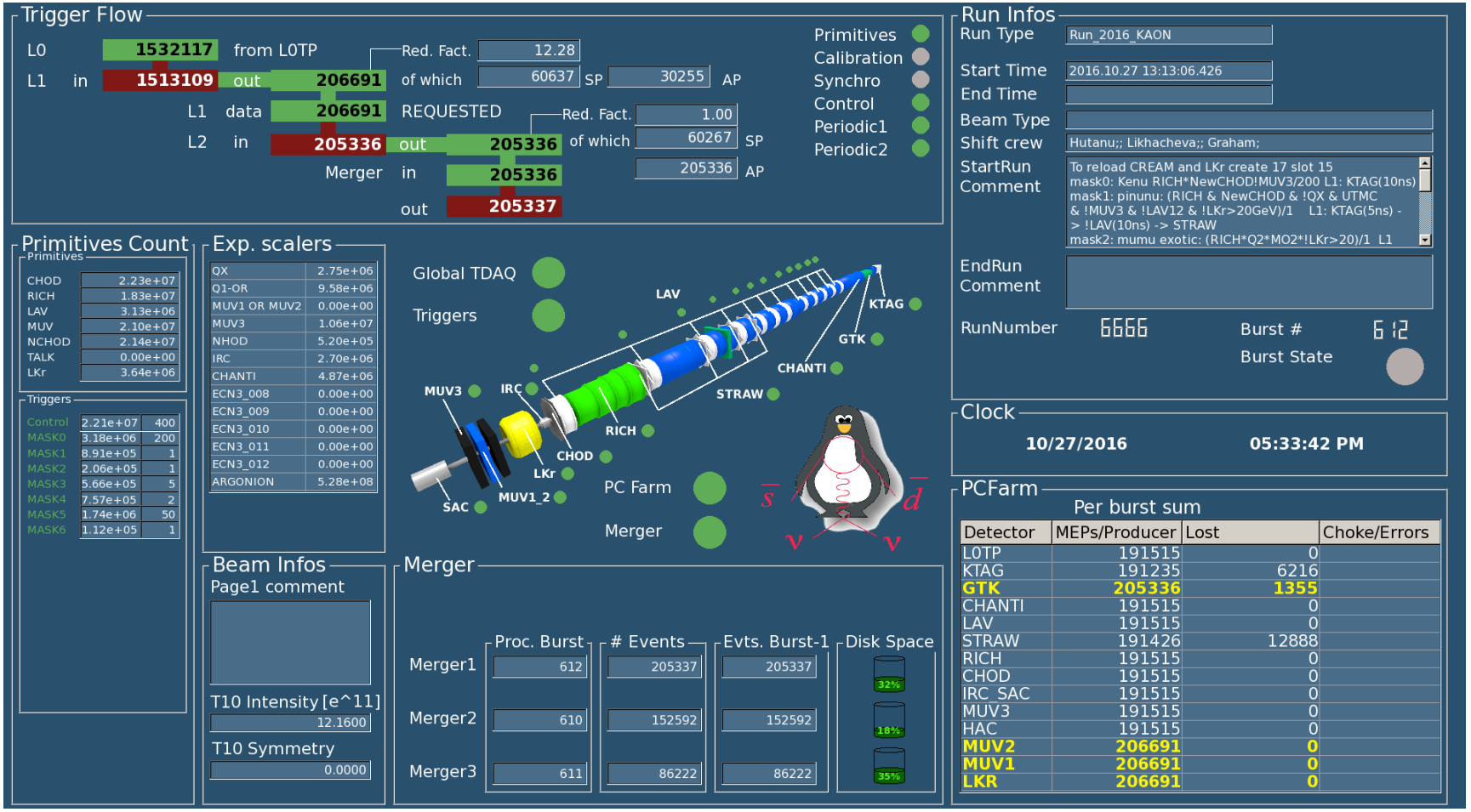
Block diagram



Operational monitoring in JCOP

- JCOP also good choice for operational monitoring
  - Integrated controls/alarming/archiving of status with other components
- *artdaq* provides simple metric manager plugins to allow display of built-in and custom monitoring metrics
  - Monitoring metrics easily defined in DAQ software code
  - Plugins exist for ganglia, graphite, text files, EPICS
  - Can run multiple monitoring plugins at same time
- Interface plan
  - Both DIM and WinCC-OA have C++ APIs, so plugins can exist for both
    - Choice of DIM would imply then interfacing DIM servers to JCOP
  - Likely start with plugin for DIM server (looks more fault-tolerant on *artdaq* side)
    - Then create data point elements in JCOP for describing DAQ monitoring metrics

JCOP at NA62



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Process logging

- Logging utilities exist in artdaq
  - TRACE debugging tool, with message type markers and accurate time-stamps per “printf”-type statement
  - Message facility, with configurable message filtering/routing and message severity levels
- Plan to use “Elastic Stack” products to store, search, and visualize log messages
  - In use at CERN, with hooks to JCOP
  - Allow for customizable queries/searches across log files
  - Customizable visualization, with different types of data representations and support for time-series metrics

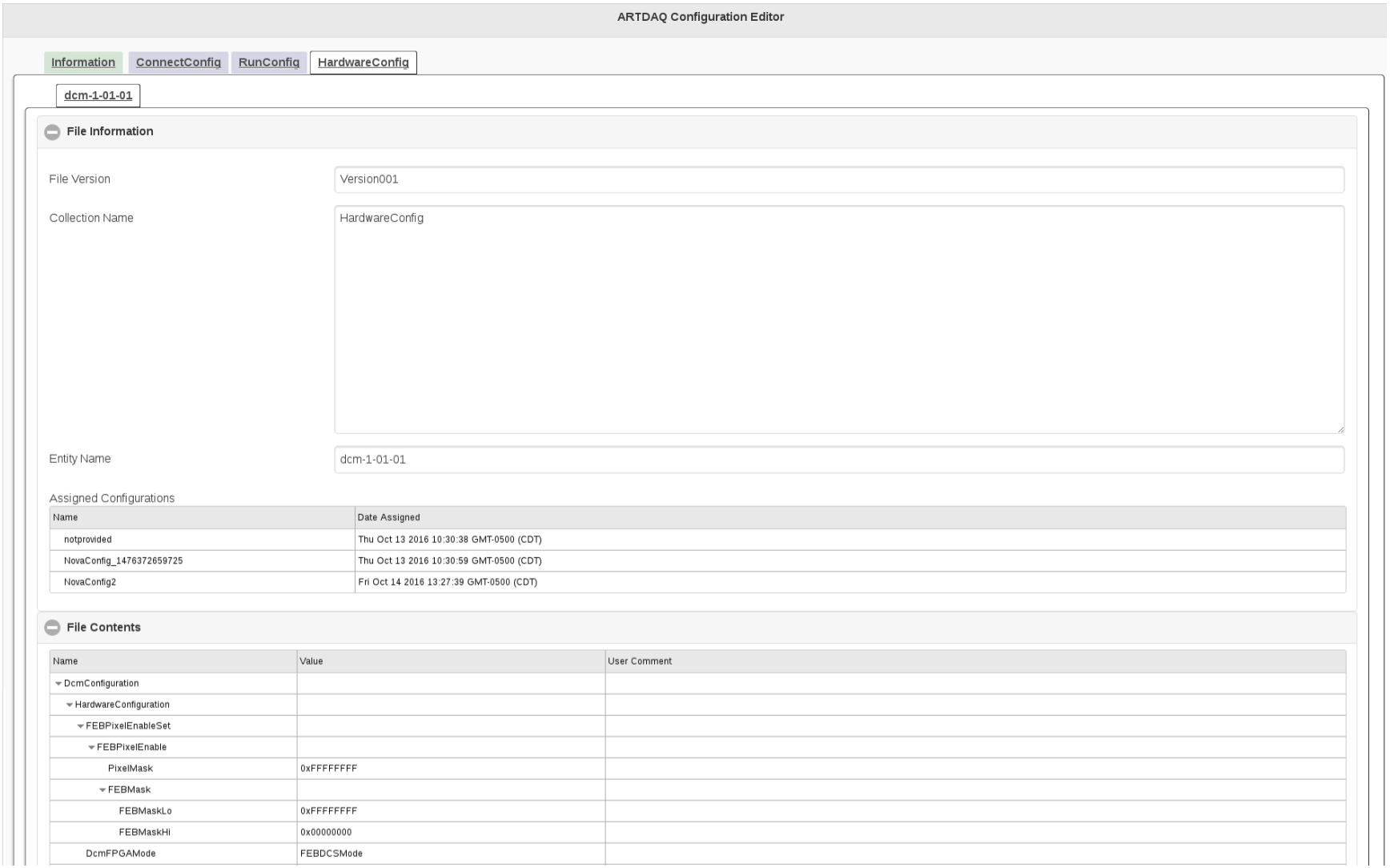
Configuration management

- *artdaq* configurations consist of three main parts
  - Architecture configuration
    - How many nodes, where, doing what?
  - Core software configuration
    - Core configuration for the BoardReaders, EventBuilders, Aggregators, and online monitoring process
      - Not dependent on experiment-specific hardware interfaces
  - “hardware” configuration
    - Configuration of the fragment generator processes that interface to hardware
- Current uses
  - Architecture configuration used at process launch time (mpirun)
  - Software and hardware configurations combined in FHiCL configuration source (one per process)

Configuration Management Tool

- *artdaq* team developing a common configuration management tool
  - MongoDB and file-system-based options for storing FHiCL configurations
    - Schema-less → very flexible/easy to change
  - Simple interfaces for uploading, downloading, and changing interfaces
    - Including graphical interface for changing single values
  - History stored in the database, and full configuration FHiCL available in final data files
    - *art* utilities allow storing of all FHiCL configurations throughout file history, so piggy-backing on that
- Will need to work out detailed interface to JCOP
  - Simplest method through same mechanisms as the run control, and maintain standalone configuration management tool

artdaq Configuration Editor (beta)



Component testing

- Run control/operational monitoring
  - Initial DIM server to DAQInterface and connection to JCOP system for process status and management in November 2016
  - Metric plugin to *artdaq* monitoring metrics in December 2016
- Configuration management
  - Initial testing versions exist and undergoing final refinement
  - Components expected to all be ready January 2017
- Testing plan:
  - Develop integrated system on *artdaq* demo project, and then translate tools to protodune DAQ as they are in final form
  - Expect *artdaq* demo demonstrator with JCOP and configuration management finalized in February 2017

Risks

- Immediate/urgent needs during commissioning to “get something working” lead to incoherent operation plan
  - Always a risk for downstream software components
  - Mitigating by…
    - Relying on solid, developed, scalable, flexible frameworks
    - Establishing system control/monitoring design with clear interfaces
      - Delivering working test system as template/guide for further development
    - Maintaining good communication across DAQ groups on needs and integration

Conclusion

- Have designs in place for run control, operational monitoring, and configuration
  - Exploiting many existing elements of *artdaq* system
  - Where we need something new or different…
    - Leveraging experience from 35-ton and other experiments to inform design
    - Leveraging CERN tools, resources, and support
- Designs will meet requirements/needs of ProtoDUNE for full-featured run control, monitoring, and configuration tools

Backup