Mu2e CD-2 Review (Data Acquisition)

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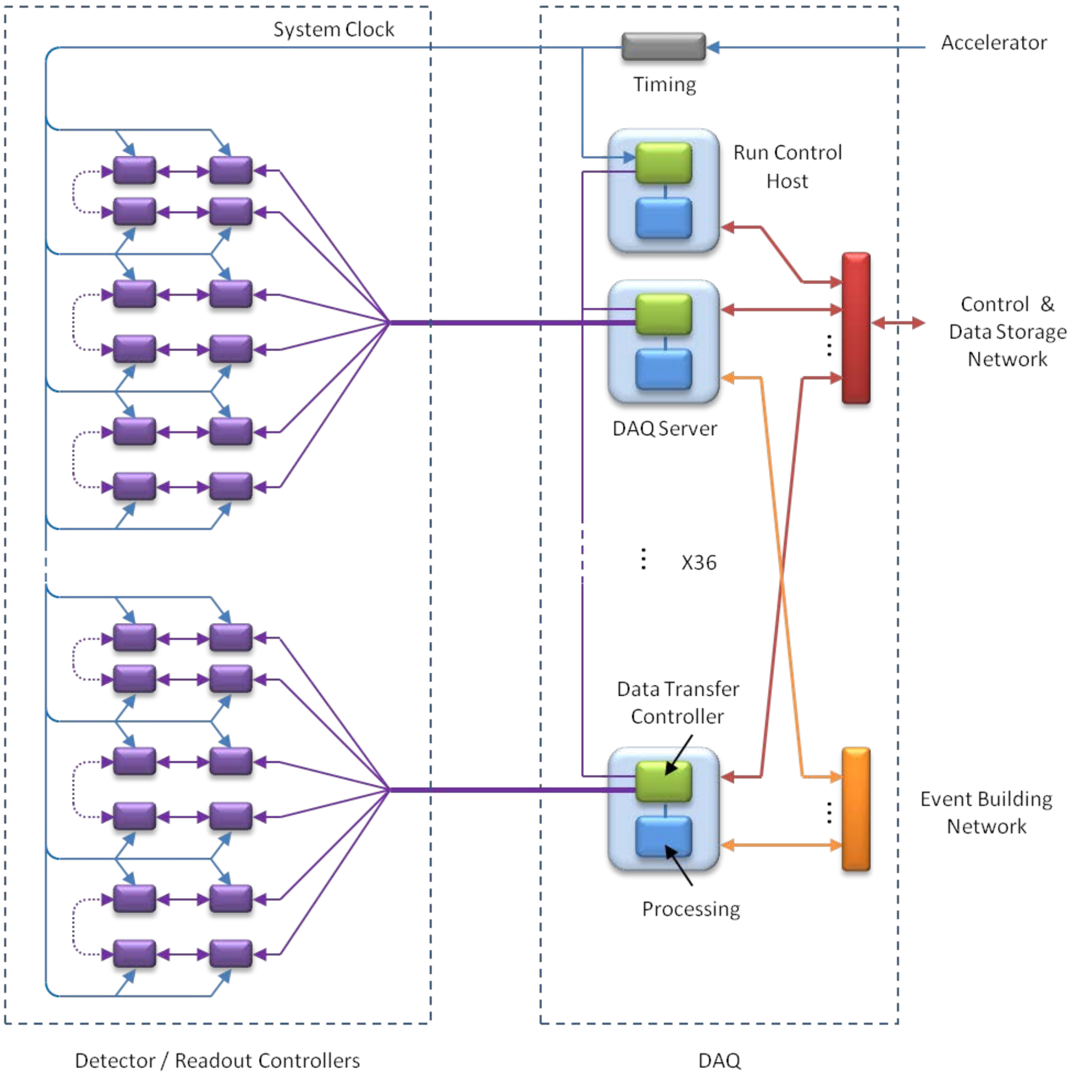
Requirements

- Combine data from ~550 readout controllers into complete events and pass them to the online reconstruction and filtering algorithms.
- Support aggregate data transfer rates from the readout controllers to the DAQ servers on the order of 22 GB/s.
- Provide a timing and control network for precise synchronization and control of the readout controllers and DAQ system.
- Provide control and monitoring of the DAQ system for all of the necessary readout modes (physics, calibration, charge injection, etc.).
- Provide infrastructure for online data quality monitoring.
- Provide data logging capability of 600 MB/s (reading & writing).
- Provide local storage for up to 48 hours of data.
- Provide the ability the partition the readout into separate systems.
- Other detailed requirements, as described in DocDB #1150.

Design – Hardware architecture



- architecture supports both streaming (Tracker, Calorimeter) and triggered (CRV) readout

- DAQ Servers handle data readout, event building and processing

- bidirectional front-end interface for fast control and readout

- large front-end buffers for uniform data transfer

- commercial DAQ hardware

- scalable…approximately 1 GByte/sec per DAQ server

Design – Hardware architecture

Commercial (off-the-shelf) hardware

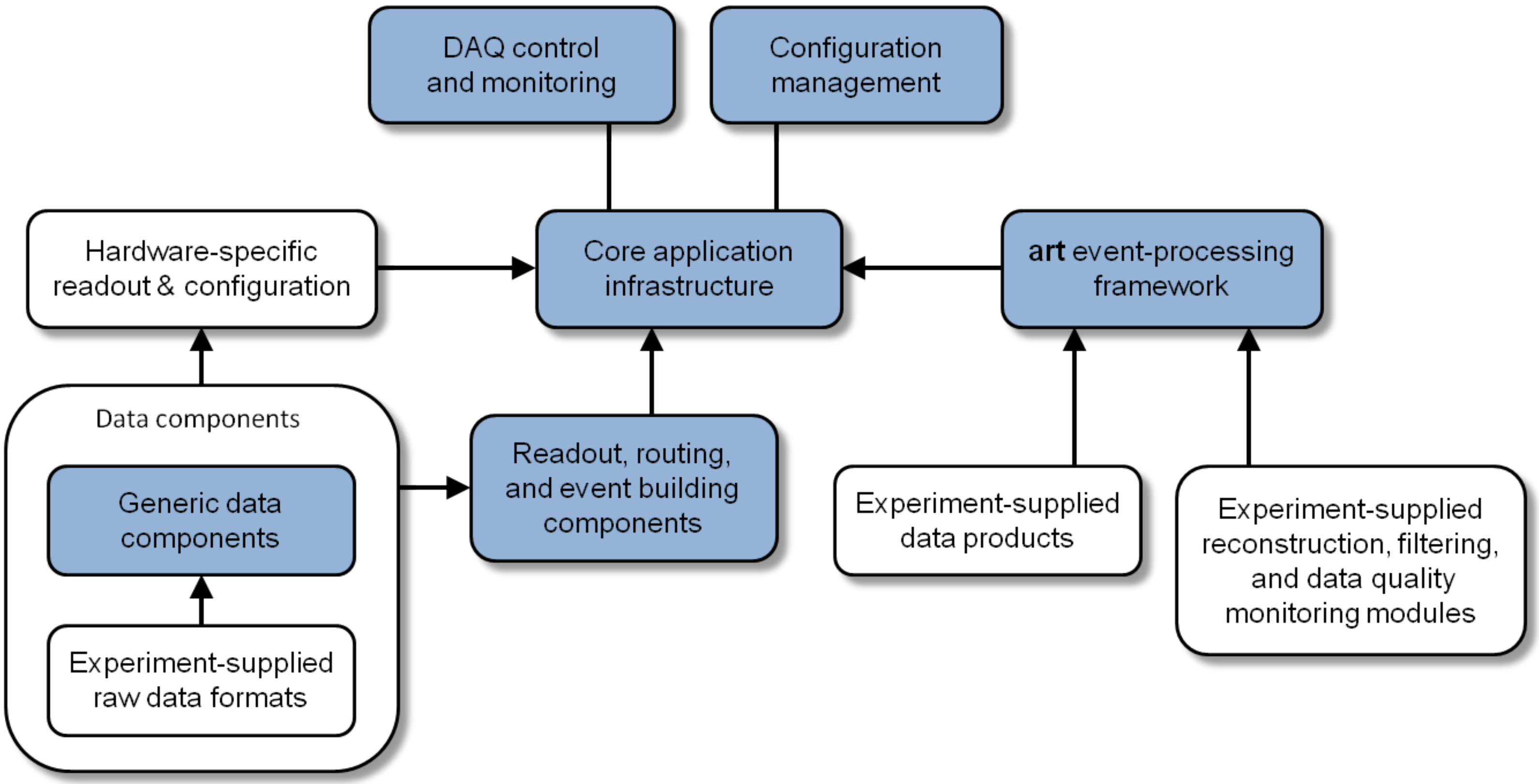
- DAQ server
  - 3U rack-mount computer
  - integrated DAQ and online processing
- Data Transfer Controller (DTC)
  - PCIe card with mid-range FPGA, memory, and an 8-port SFP+ optical interface
  - 1 GByte/sec readout bandwidth

- Event Building network
  - 48 port 10G Ethernet switch

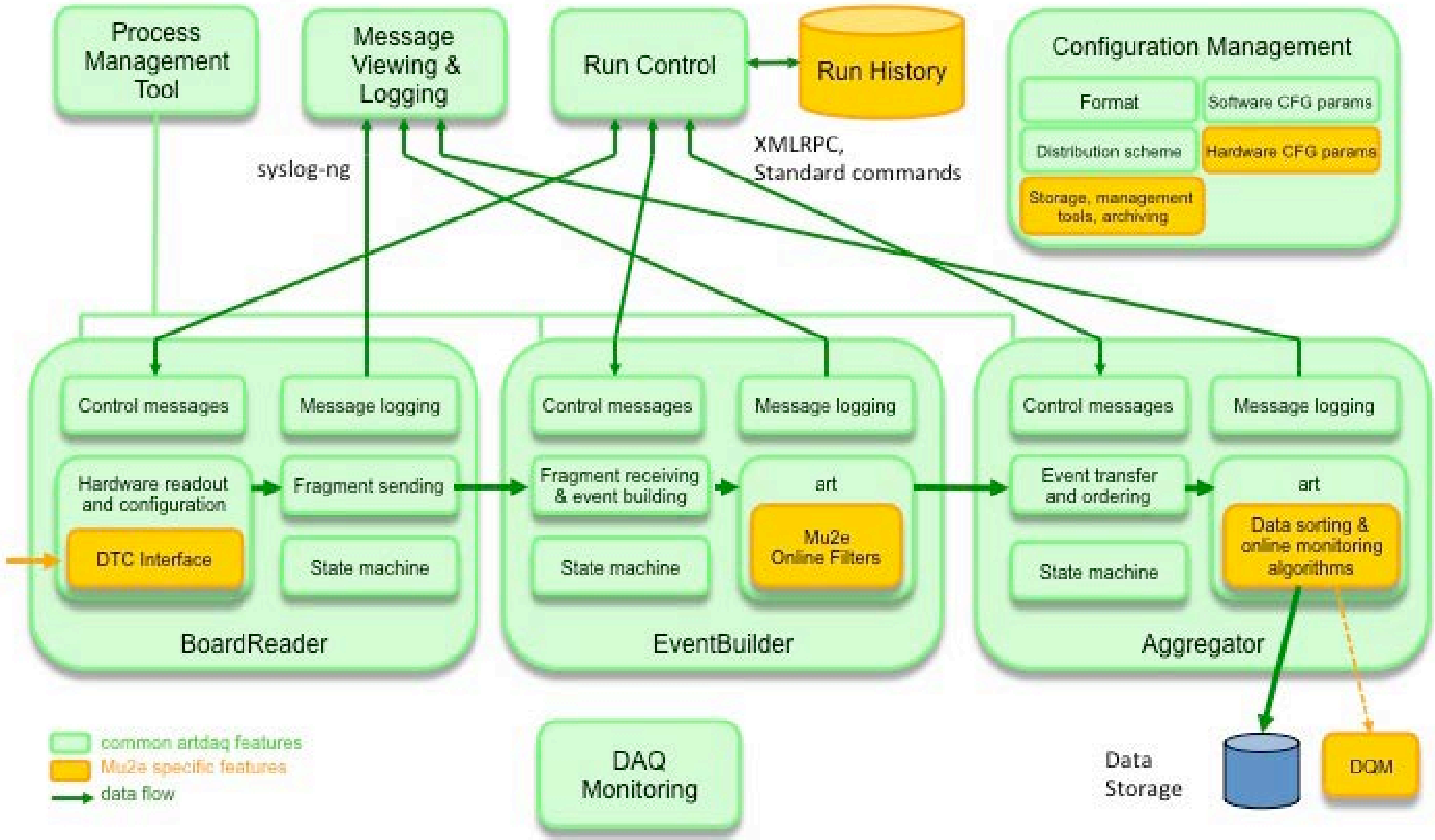
Design – Software architecture

Software based on *art* and *artdaq*

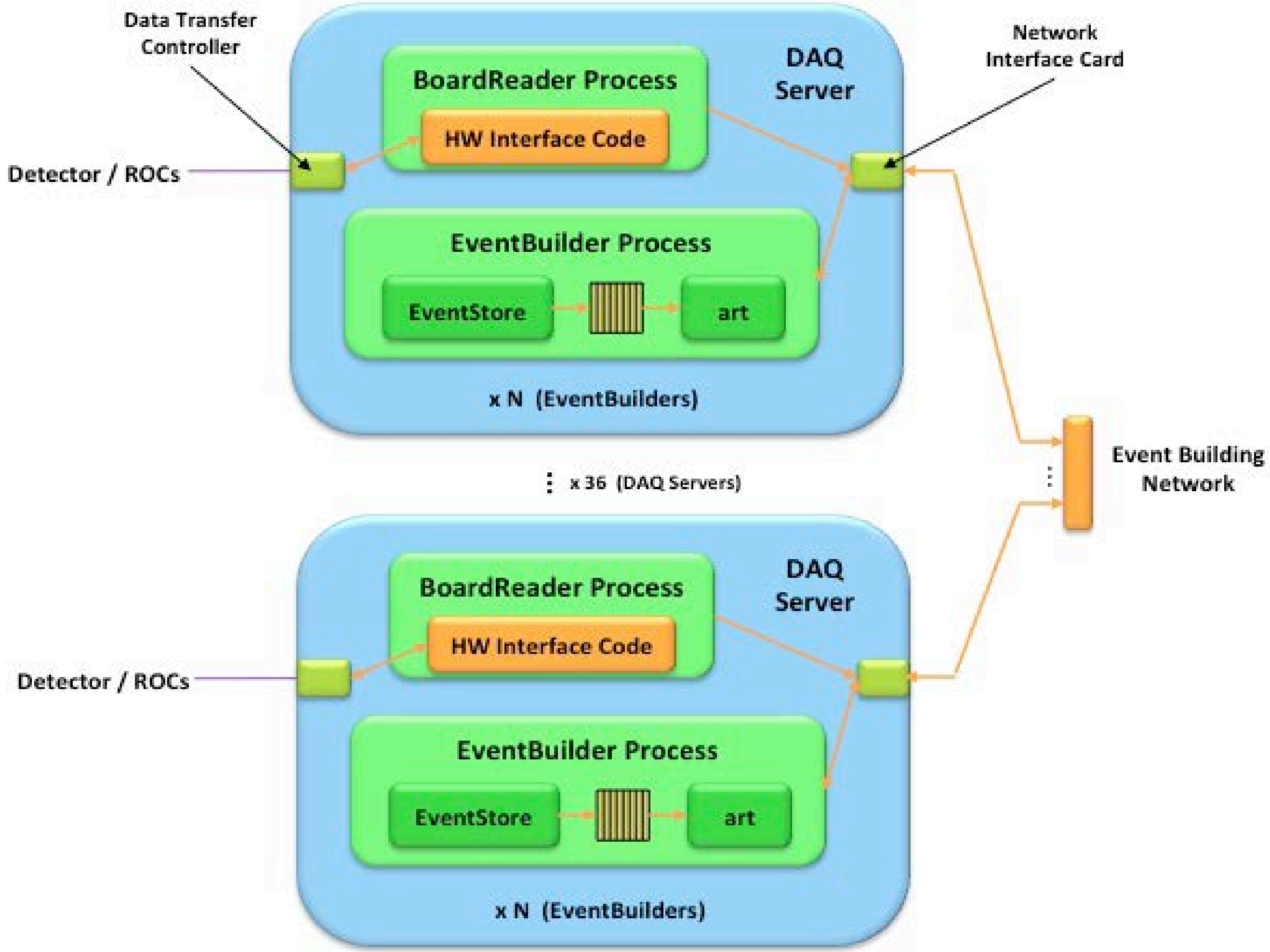
(a common DAQ & Online Processing framework developed for Mu2e and other current/future experiments)



Design – Software components



Design – DAQ server processes



Changes since CD-1

- The readout of the Cosmic Ray Veto sub-detector data is now “triggered”. This means that its data is only read out of the CRV readout controllers for events that pass the software filter(s).

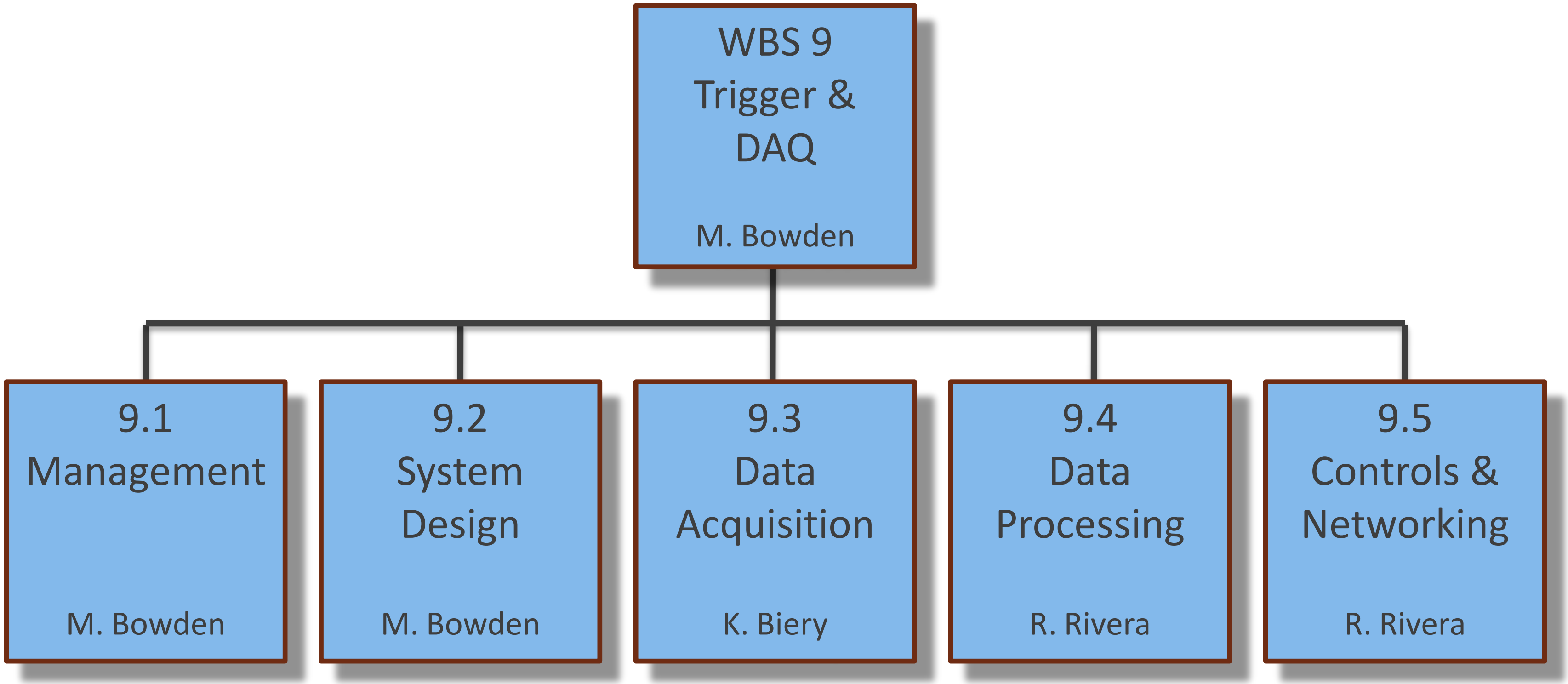
Performance

- Tests have been performed on the primary DAQ interfaces - digitizer to readout controller (LVDS), readout controller to data transfer controller (optical link), and data transfer controller to DAQ server (PCIe) - to verify bandwidth requirements.

Remaining work before CD-3

- The design of the DAQ hardware and software architecture is largely complete.
- In the “pilot” phase of the Trigger & DAQ subproject, we will
  - Purchase pilot system components
  - Develop a small test system (6 servers) with complete end-to-end readout, event building, and processing.
  - Start providing formal Mu2e *artdaq* software and system firmware releases.
  - Develop the readout controller interface and perform bandwidth tests.

Organizational Breakdown



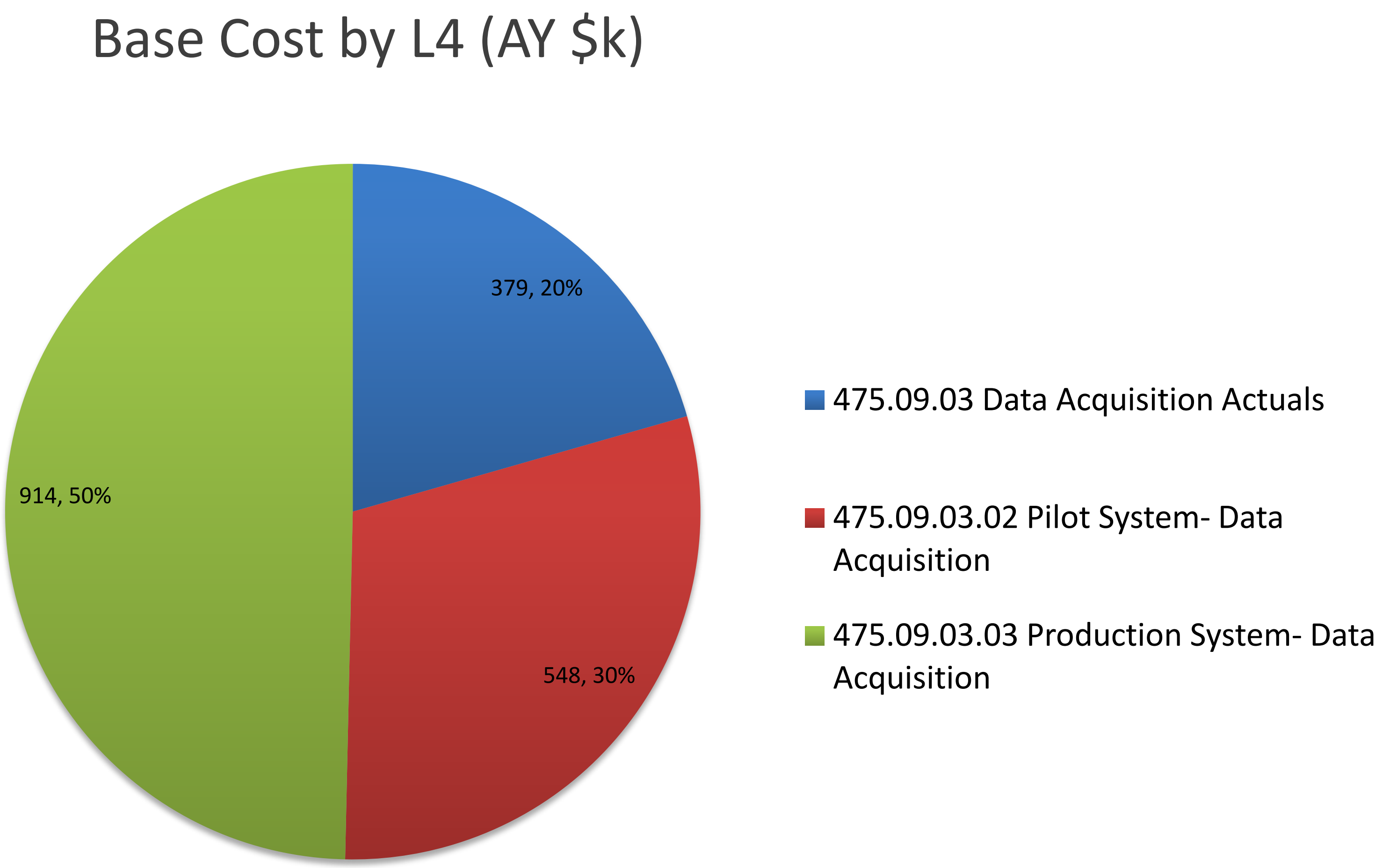
Quality Assurance

- Hardware:
  - Prior to delivery, DAQ Servers undergo initial hardware test at the vendor.
  - Following delivery, DTC cards are installed and the DAQ Servers undergo 100 hours of burn-in and loopback test.
- Software/firmware:
  - Integration and acceptance testing will be performed throughout development.

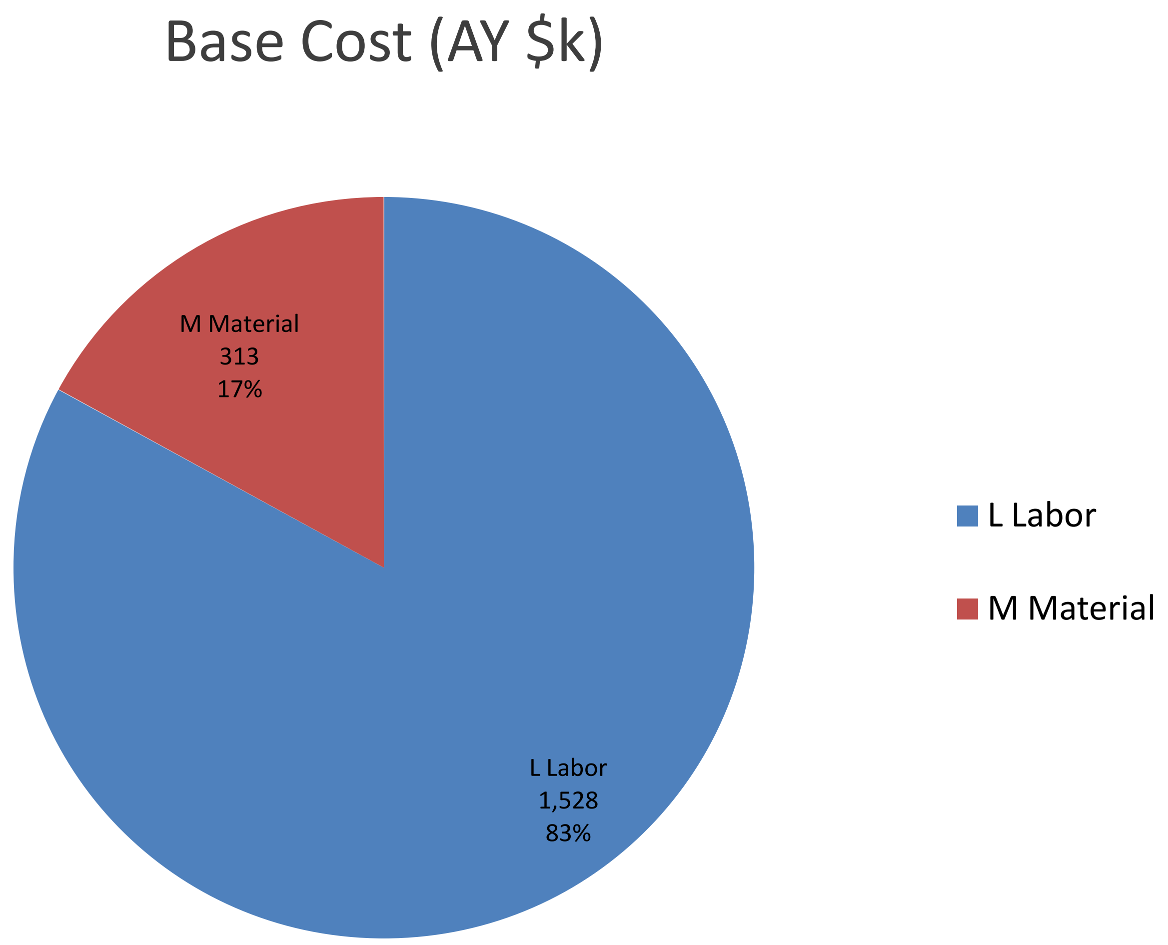
Risks

- Insufficient manpower for DAQ software (TRIG-128)
  - Causes: difficult to estimate effort for software tasks; uncosted labor resources not available for scheduled tasks.
  - Effect: increase in software development time/cost.
  - Mitigation strategy: engage additional costed or uncosted labor.
- Higher than expected data rates to DAQ (TRIG-131)
  - Cause: underestimation of particle flux and detector activity.
  - Effect: reduced data collection efficiency.
  - Mitigation strategies: expand the DAQ system by buying more DAQ Servers, cables, etc.; adjust data thresholds; implement FPGA-processing.

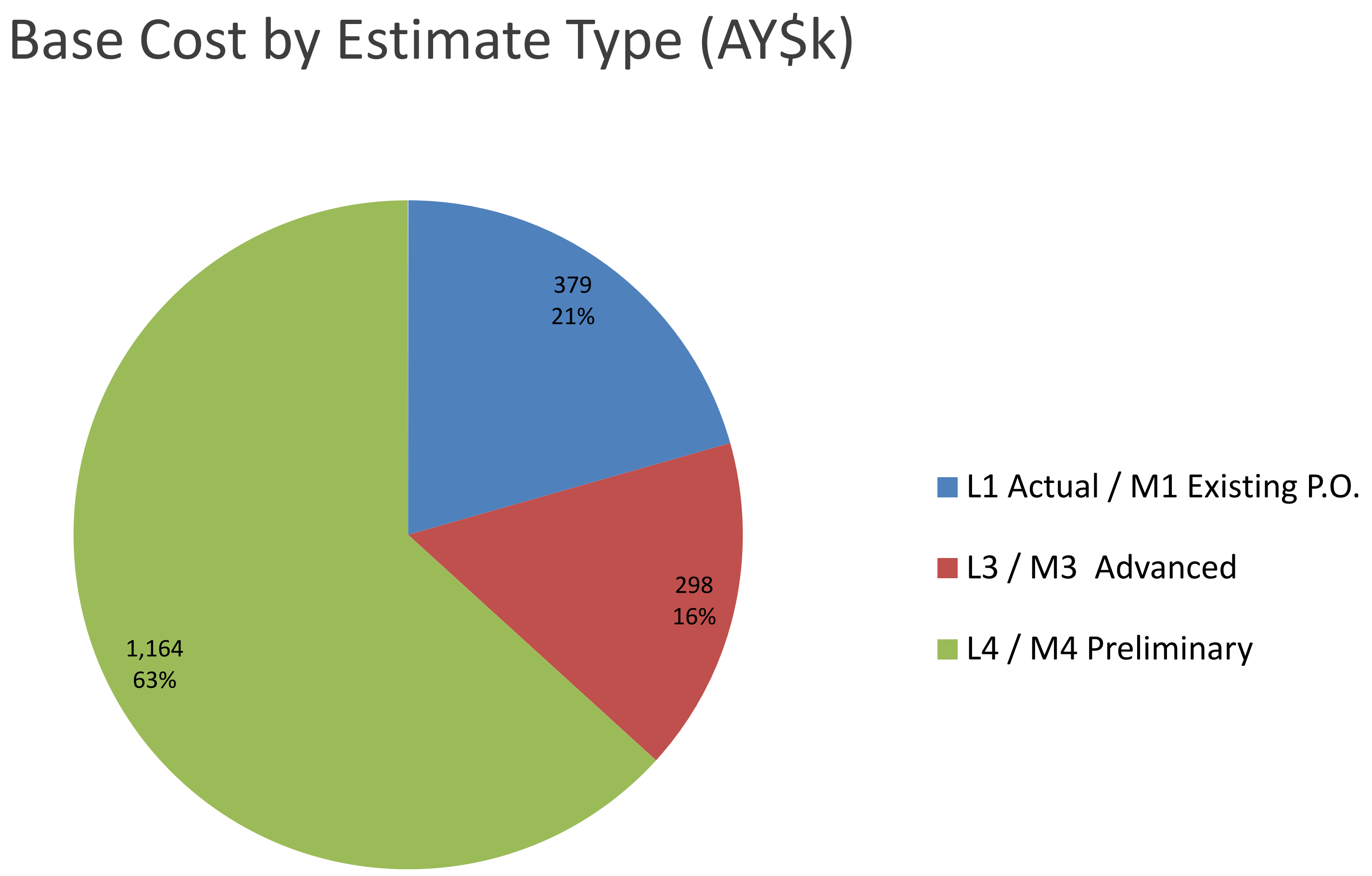
Cost Distribution by L4



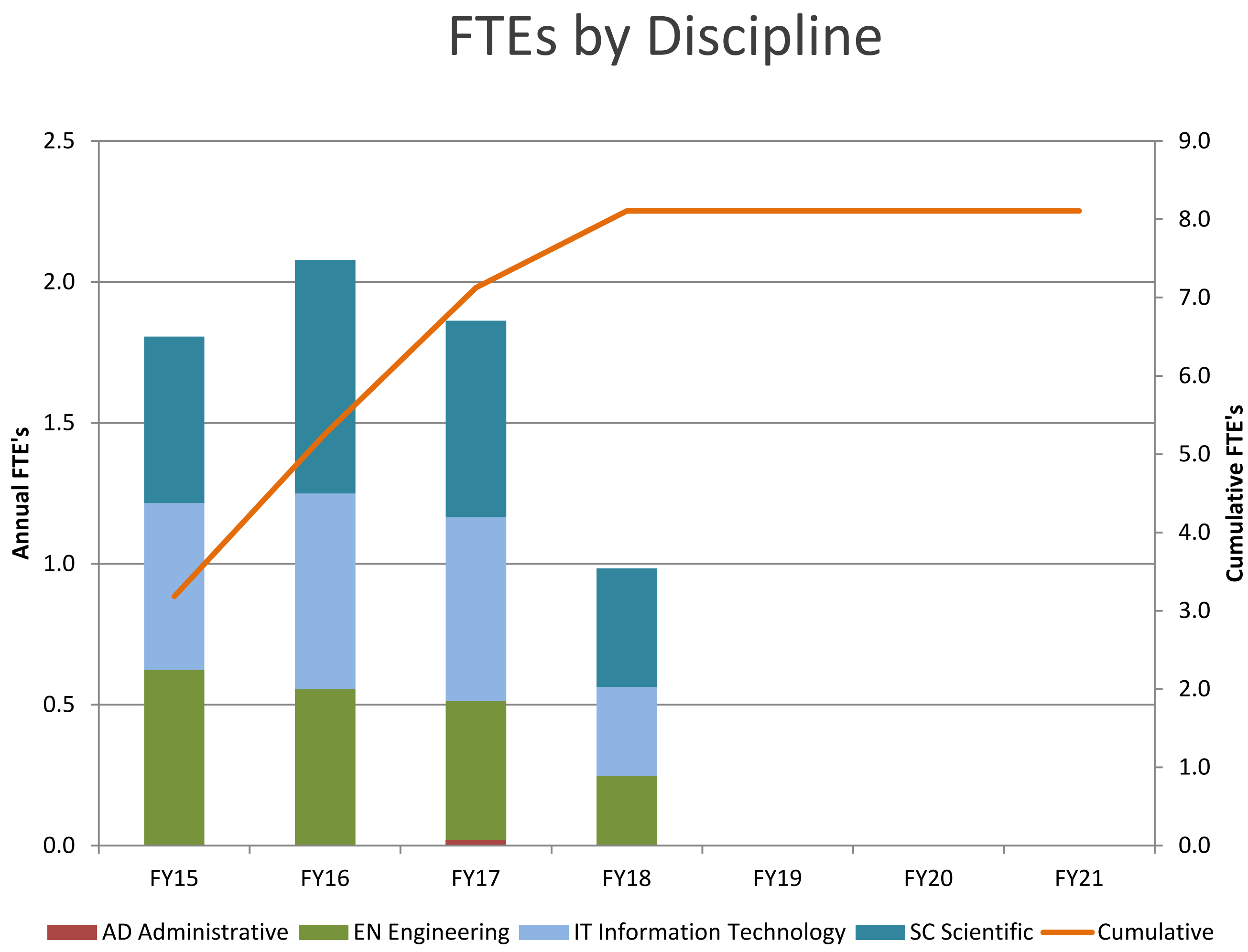
Cost Distribution by Resource Type



Quality of Estimate



Labor Resources



Cost Table

WBS 9.3 Data Acquisition

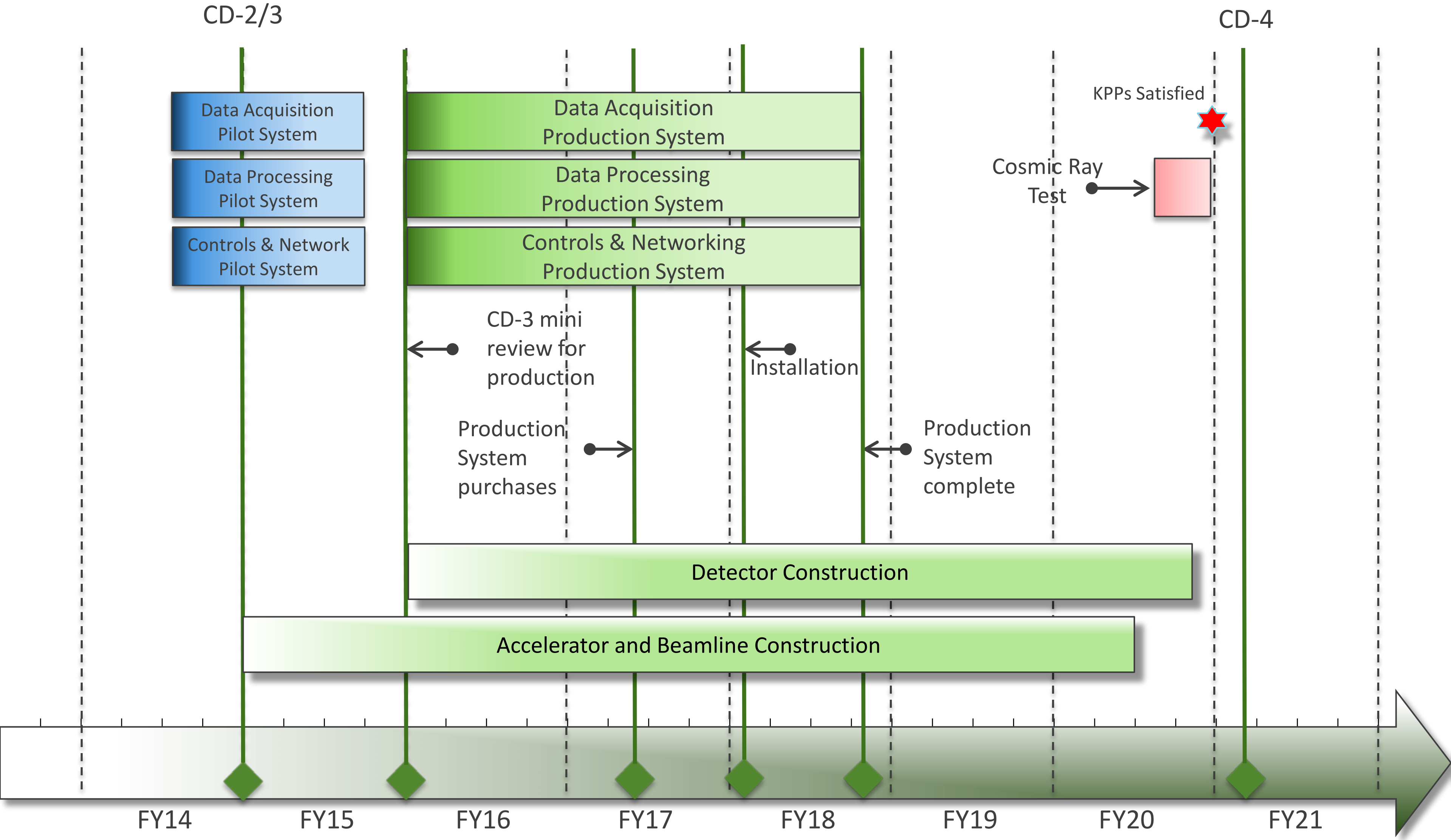
Costs are fully burdened in AY $k

	M&S	Labor	BAC	Estimate Uncertainty	% contingency on ETC	Total
475.09 Trigger & DAQ						
475.09.03 Data Acquisition						
475.09.03 Data Acquisition Actuals	16	363	379			379
475.09.03.02 Pilot System- Data Acquisition	57	491	548	179	33%	728
475.09.03.03 Production System- Data Acquisition	241	673	914	284	31%	1,198
Grand Total	313	1,528	1,841	463	32%	2,304

Major Milestones

- Complete Pilot System development (June 2015).
- Purchase order for production components (January 2017).
- Complete Production System development (June 2018).
- Cosmic ray test (Fall 2020).

Schedule


CD-2/3
CD-4
KPPs Satisfied
Data Acquisition Pilot System
Data Processing Pilot System
Controls & Network Pilot System
Data Acquisition Production System
Data Processing Production System
Controls & Networking Production System
Cosmic Ray Test
CD-3 mini review for production
Installation
Production System purchases
Production System complete
Detector Construction
Accelerator and Beamline Construction
FY14
FY15
FY16
FY17
FY18
FY19
FY20
FY21

Summary

- Currently at beginning of DAQ Pilot phase development, expected to take approximately 1 year.
- Pilot phase goal is a small (6 server) functioning DAQ system, with the basic features necessary to communicate with detector readout controllers, buffer and exchange event data between servers, and measure online filter performance.
- Costs are reduced through the use of commercial hardware and a common software framework.