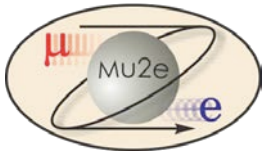
Fermilab

U.S. DEPARTMENT OF ENERGY Office of Science

Mu2e CD-2 Review (Trigger and DAQ)



Mark Bowden
DAQ L2 Manager
7/8/2014

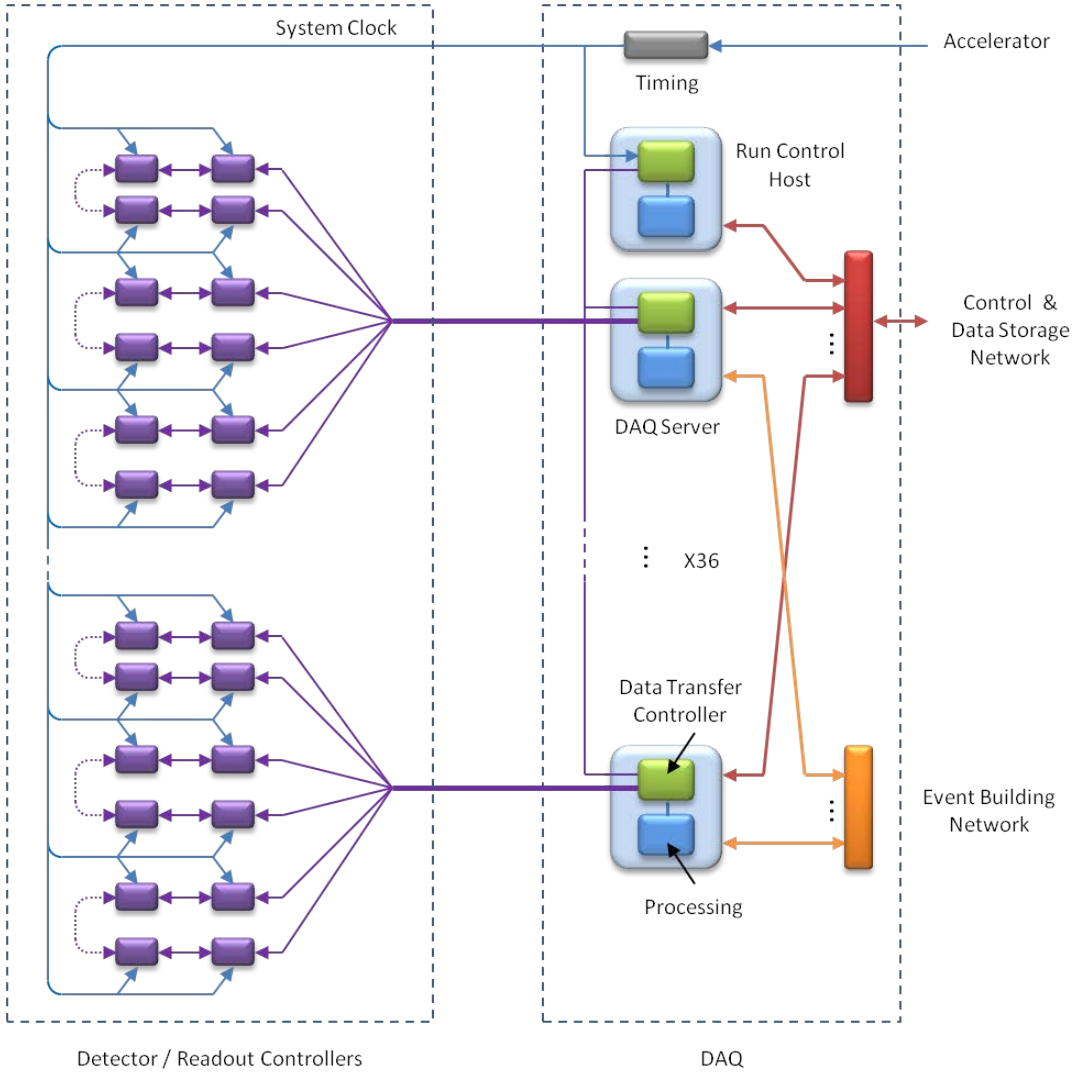
Requirements

- The requirements for the DAQ are described in Mu2e-docdb 1150.
- Collect and assemble data from the Tracker (estimated 13 GBytes/sec) and Calorimeter (estimated 8 GBytes/sec) for online analysis
- Provide online filtering to reduce data Tracker + Calorimeter data volume by ≥ 99%
- Combine with data from CRV, Extinction and Target Monitors (estimated 100 MBytes/sec) for transfer to offline storage

Requirements

- Provide global timing synchronization
- Provide fast and slow control networks
- Provide connections to offline storage and site networking
- Provide control room/operator interfaces

Design



- 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

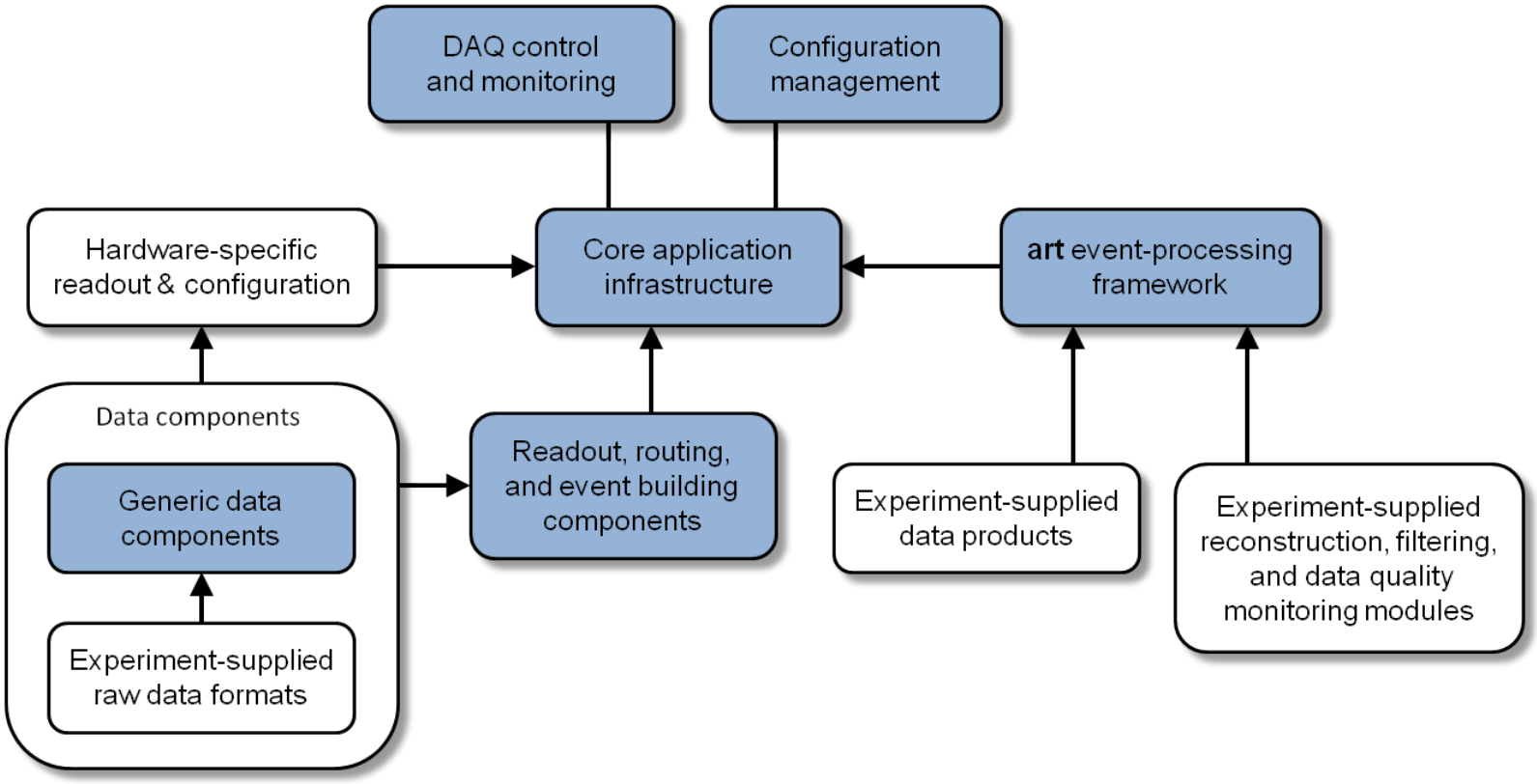
Commercial (off-the-shelf) hardware

- 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

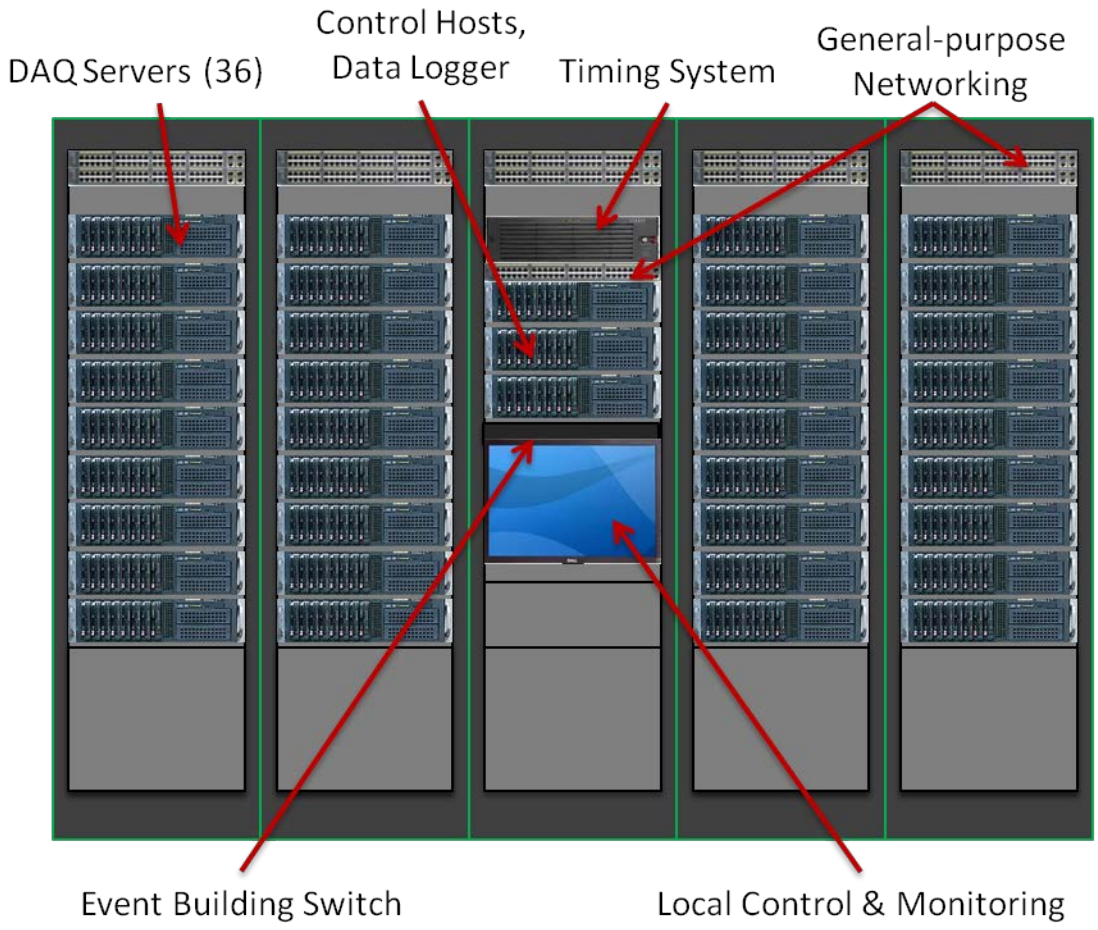
Design

Software based on *art* and *artdaq*

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



Design


DAQ Servers (36)
Control Hosts, Data Logger
Timing System
General-purpose Networking
Event Building Switch
Local Control & Monitoring

Changes since CD-1

- changes in data rate estimates due to improved background simulations
- CRV data rate increases by a factor of 10-100 depending on thresholds
- switch to a triggered CRV readout (CRV data not needed for online analysis)
- rejection rate reduced from 99.8% to 99.0% to accommodate independent Calorimeter triggers

Value Engineering since CD-1

- switch to triggered CRV readout to compensate for higher background rates

- reduction in number of DAQ servers (48 → 36) to optimize front-end configuration, use higher performance servers

Performance

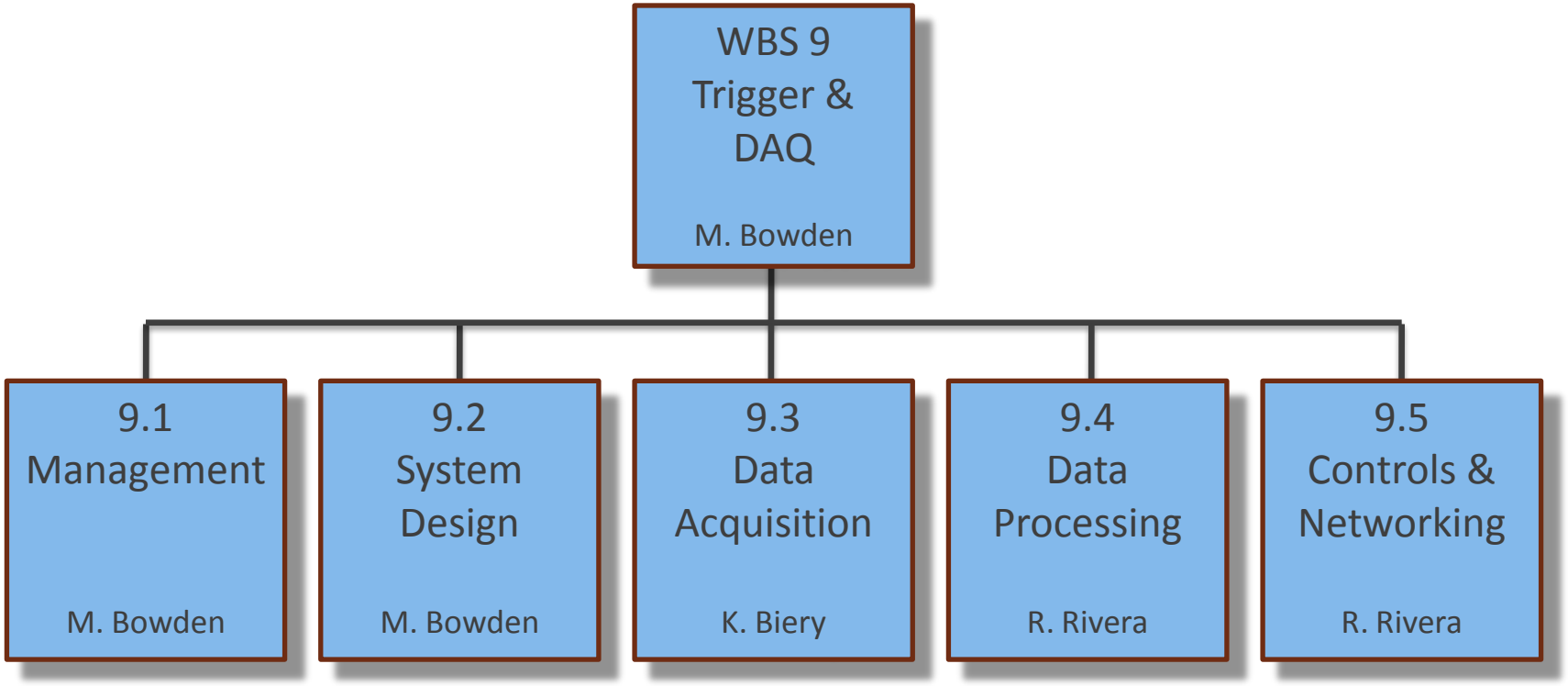
- Tests have been performed on the primary DAQ interfaces - digitizer to readout controller (LVDS), readout controller to data transfer controller (optical link), and data transfer controller to DAQ server (PCIe) to verify bandwidth requirements

- Optimized version of the online Tracker filter meets processing requirement

Remaining work before CD-3

- Completion and test of a small (15%) DAQ Pilot system (~ 1 year)
- Test preliminary Calorimeter filter
- Test interfaces between DAQ and detector Readout Controllers (ROC)
- Evaluation of next generation Intel Phi processor

Organizational Breakdown



Quality Assurance

- DAQ system can be tested to 95% CL using simulated data, prior to Cosmic Ray test
- Full DAQ system is a scaled version of the Pilot system
- In-situ testing - diagnostic features include monitoring of data link bit-error rate and optical power levels, memory and processor tests using large simulated data sets

Risks

- Insufficient manpower for DAQ software (TRIG-128)
  - Cause: uncosted labor resources are not available for scheduled tasks

    (note: Fermilab, CalTech, UFlorida, & Yale will contribute, collaboration is actively recruiting additional resources)
  - Mitigation strategy: use additional costed labor (~$500k)

- Insufficient DAQ online processing (TRIG-130)
  - Cause: limited improvement in processor performance and filter optimization
  - Mitigation strategy: add 12 DAQ servers (~$75k)

- Higher than expected data rates to DAQ (TRIG-131)
  - Cause: low thresholds in CRV
  - Mitigation strategy: add 6 DAQ servers, DTCs and optical links (~$70k)

ES&H

- ES&H issues are minimal
  - High voltage (208 VAC, no exposed connections)
  - Class 1 lasers (eye safe)

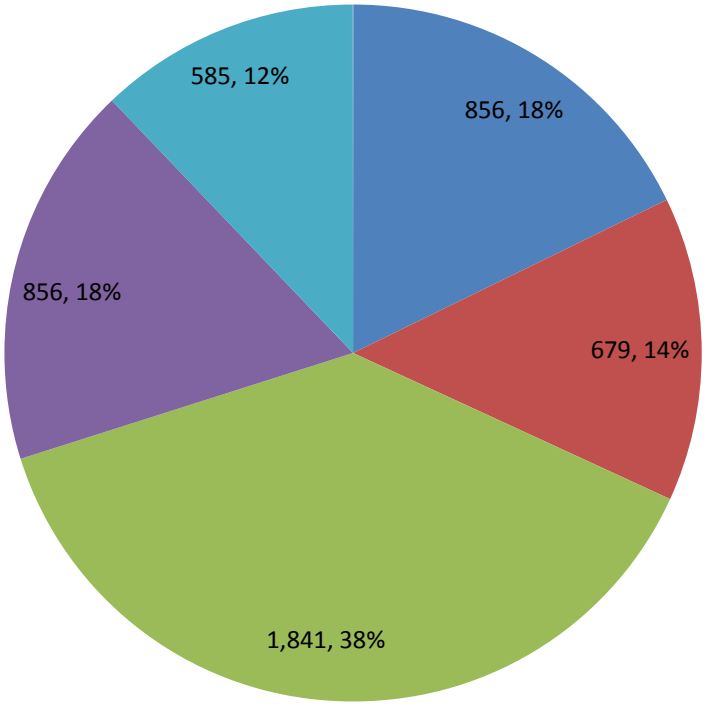
Cost Table

WBS 9 Trigger & DAQ

Costs are fully burdened in AY $k

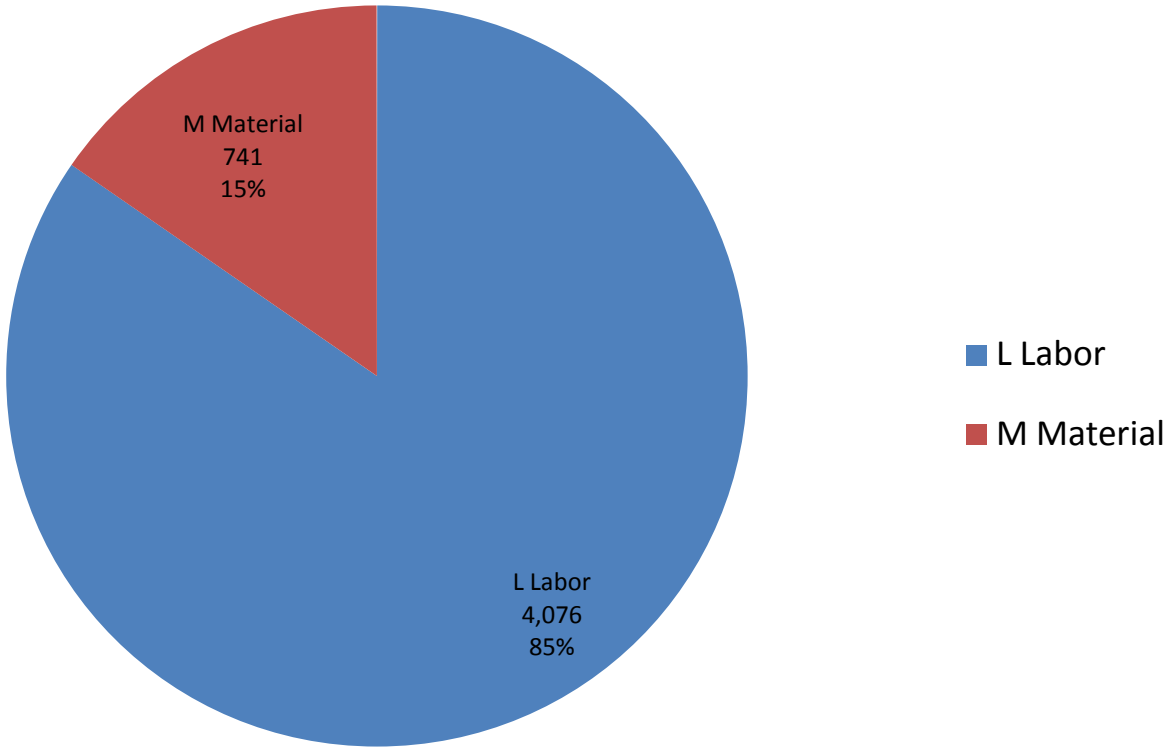
	M&S	Labor	Base Cost	Estimate Uncertainty	% Contingency on ETC	Total
475.09.01 Project Management	3	852	856	120	21%	976
475.09.02 System Design and Test		679	679	23	35%	702
475.09.03 Data Acquisition	313	1,528	1,841	463	32%	2,304
475.09.04 Data Processing	301	555	856	208	29%	1,064
475.09.05 Controls and Networking	123	461	585	155	31%	740
Risk Based Contingency				273		273
Total	741	4,076	4,816	1,243	38%	6,059

Cost Breakdown

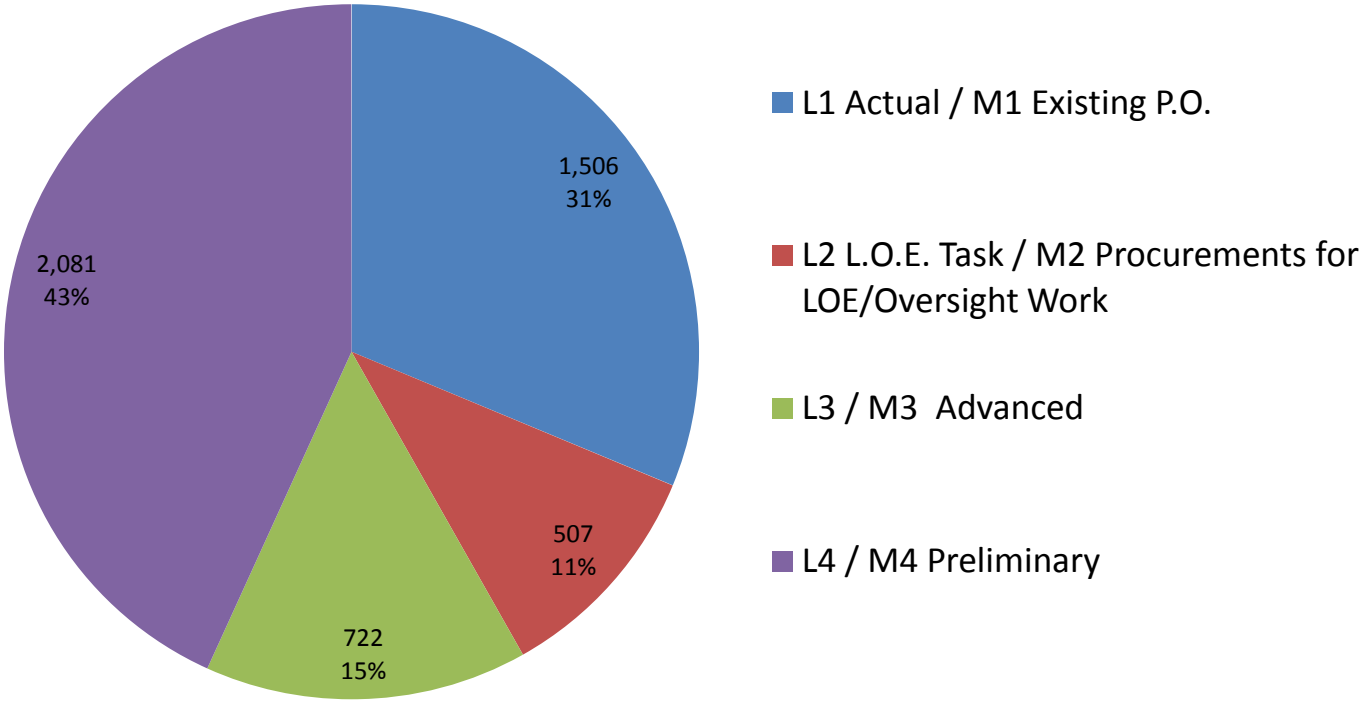


- 475.09 Trigger & DAQ 475.09.01 Project Management
- 475.09 Trigger & DAQ 475.09.02 System Design and Test
- 475.09 Trigger & DAQ 475.09.03 Data Acquisition
- 475.09 Trigger & DAQ 475.09.04 Data Processing
- 475.09 Trigger & DAQ 475.09.05 Controls and Networking

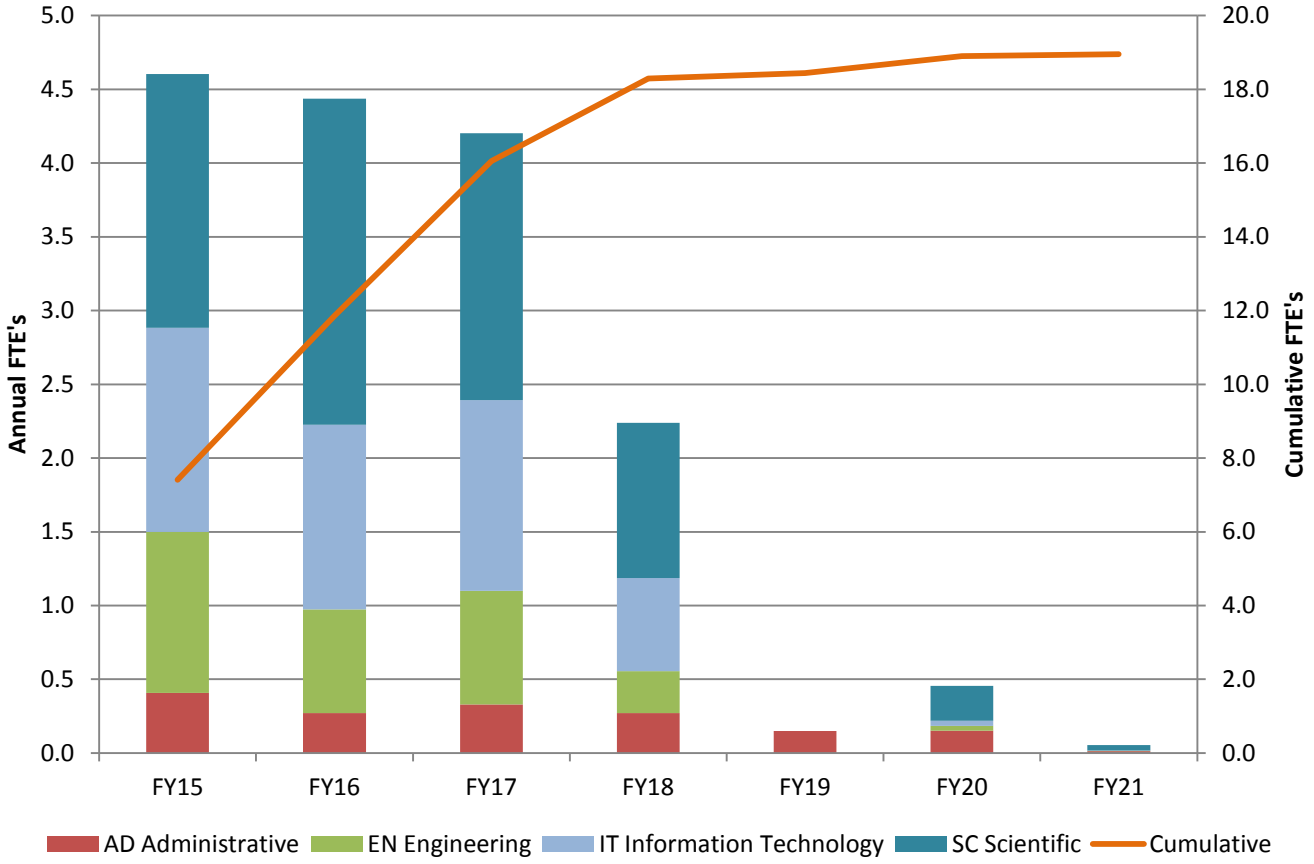
Cost Breakdown



Quality of Estimate



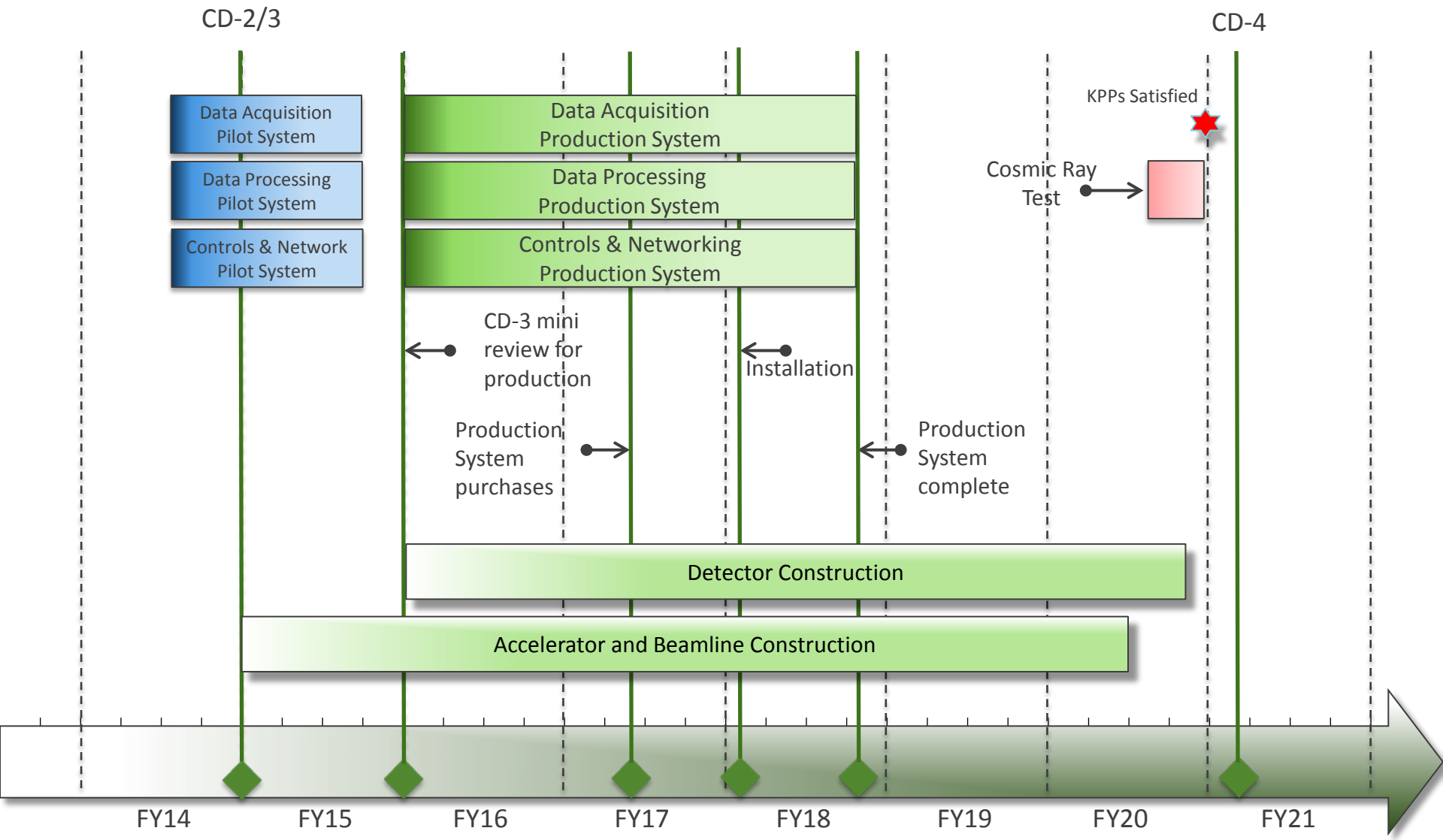
Resources by FY



Major Milestones

- Completion of Pilot System development for Data Acquisition, Data Processing, and Controls and Networking tasks (6/11/2015)
- Completion of Production System development for Data Acquisition, Data Processing, and Controls and Networking tasks (7/27/2018)
- Cosmic Ray Test (final integration with detectors and full readout test) (10/12/2020)

Schedule


CD-2/3
CD-4
Data Acquisition Pilot System
Data Processing Pilot System
Controls & Network Pilot System
Data Acquisition Production System
Data Processing Production System
Controls & Networking Production System
KPPs Satisfied
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

- Based on initial testing of DAQ components, we are confident that the system throughput and processing will meet requirements.
- 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.
- 80% of effort is in firmware/software development…this provides great flexibility, but is also difficult to estimate. Estimates are based on a top-down approach using recent experiments of similar complexity.
- Costs are reduced through the use of commercial hardware and a common software framework.