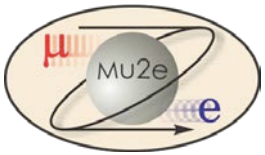
Fermilab



Mu2e CD3c Review
WBS 9.4 TDAQ Data Processing

K. Biery

Mu2e TDAQ Data Processing L3 Manager

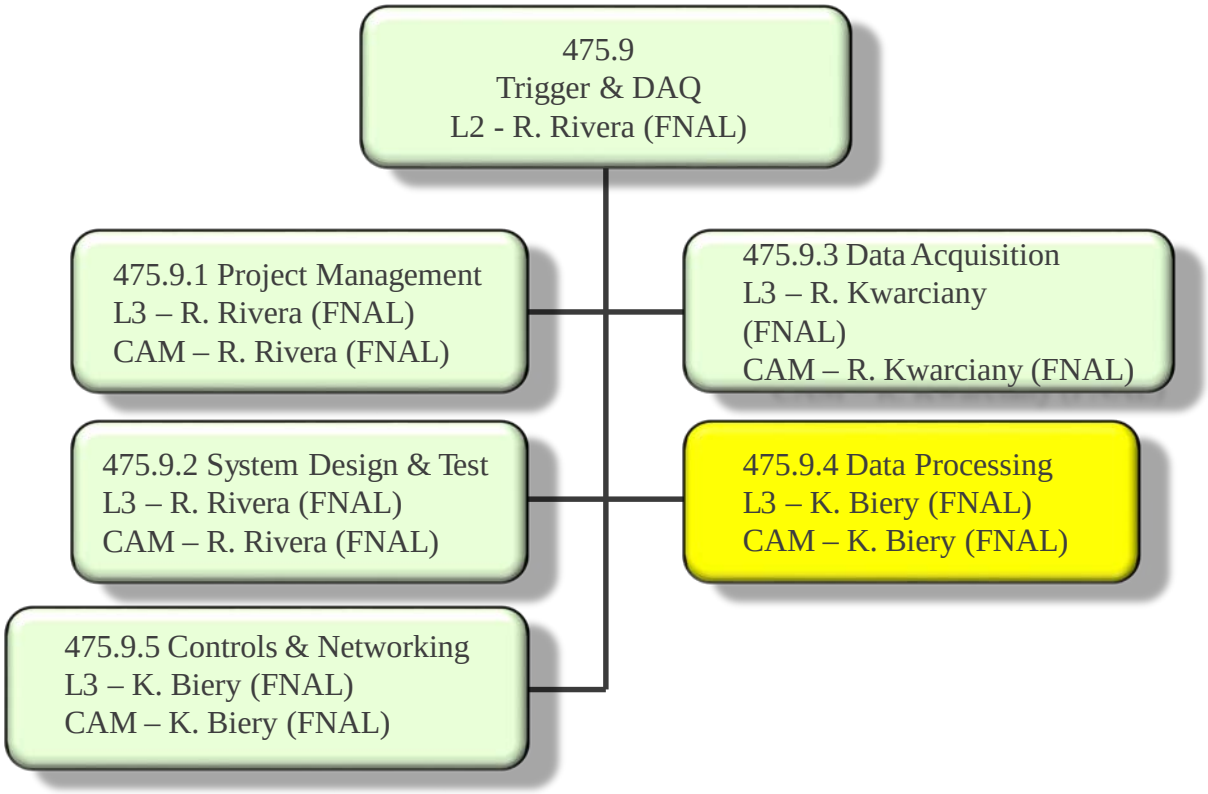
4/20/16

TDAQ Data Processing Team

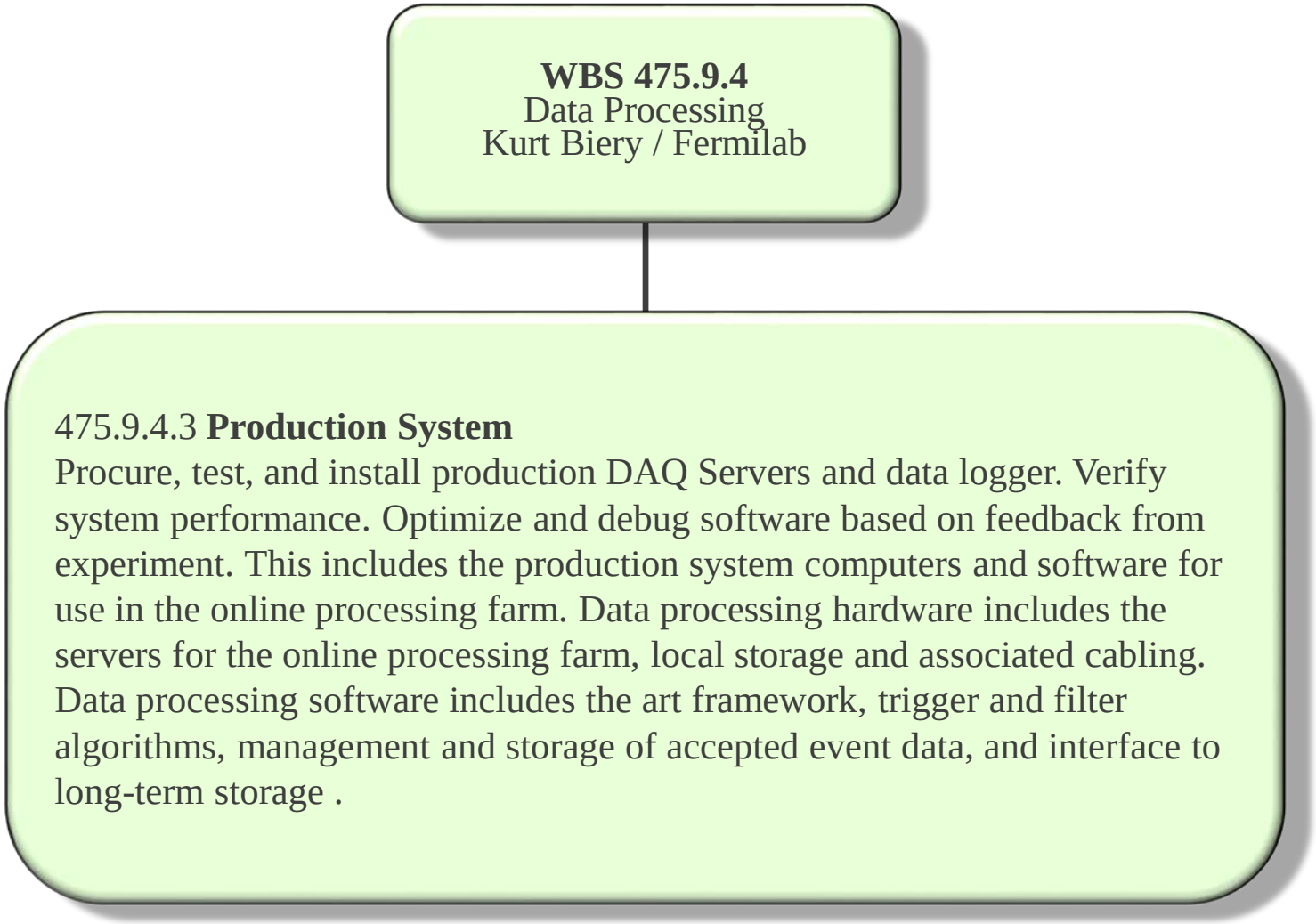
Developed frameworks and algorithms for NOvA, CDF, BTeV, uBooNE, DUNE 35-ton, DarkSide...

- Eric Flumerfelt, Ron Rechenmacher (FNAL):
  - *artdaq* developers; coordinate with *art* team
- Tomo Miyashita (Caltech):
  - Data formats, interactions with simulations groups, preparations of simulated data for online playback
- Bertrand Echenard (Caltech):
  - Trigger Coordinator
- Dave Brown (LBL), Rob Kutsche (FNAL):
  - Reconstruction and filtering algorithms

Mu2e Trigger & DAQ Organization



Scope

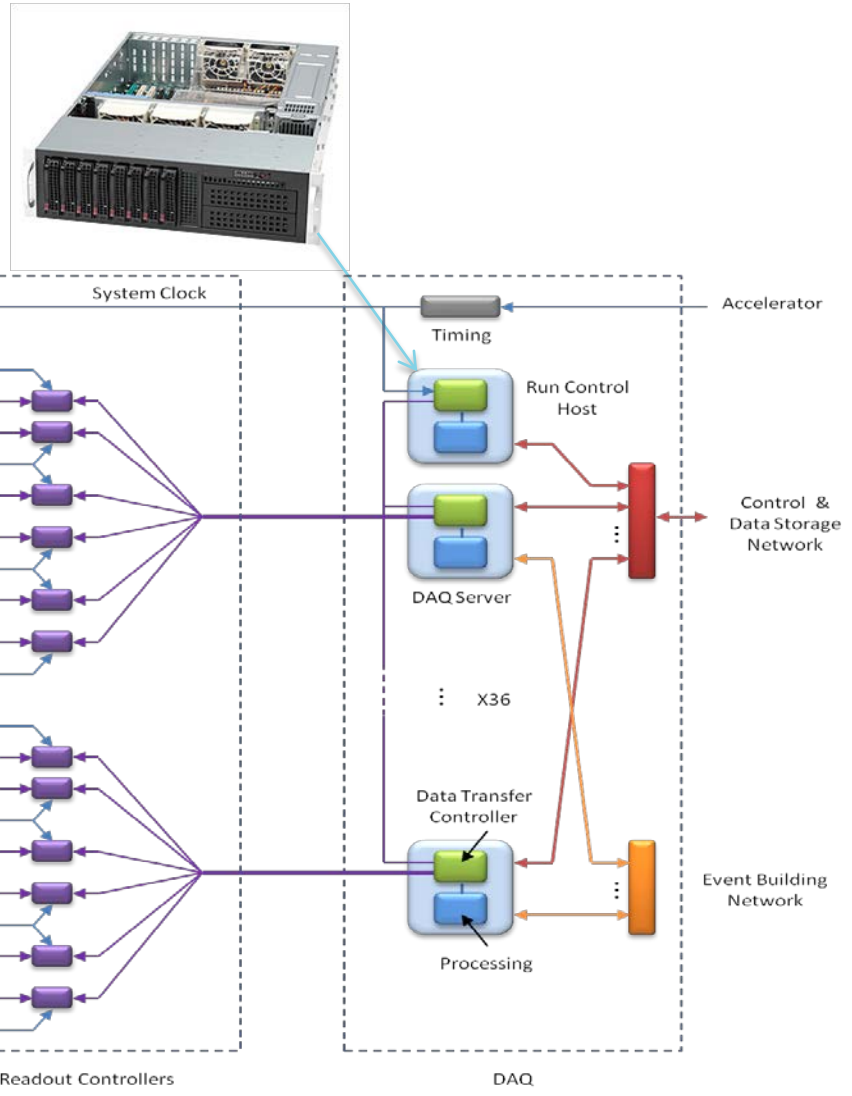

WBS 475.9.4
Data Processing
Kurt Biery / Fermilab
475.9.4.3 Production System
Procure, test, and install production DAQ Servers and data logger. Verify system performance. Optimize and debug software based on feedback from experiment. This includes the production system computers and software for use in the online processing farm. Data processing hardware includes the servers for the online processing farm, local storage and associated cabling. Data processing software includes the art framework, trigger and filter algorithms, management and storage of accepted event data, and interface to long-term storage .

Requirements

- The TDAQ requirements are described in docdb-1150
- The Data Processing subsystem must meet the following requirements:
  - Provide infrastructure for online data quality monitoring.
  - Provide at least a 48-hour live cache of experiment data.
  - Computers and networking should be isolated from campus.
  - Support the delayed readout of the CRV for TRK+CALO events that are accepted by the software filters.
  - Provide sufficient bandwidth and prevent buffer overflow.
  - Provide sufficient online processing to handle an event rate of 200,000/sec.
  - Mean-time to repair of 1 hour or less and 95% uptime.
  - At least 90% online filter efficiency.

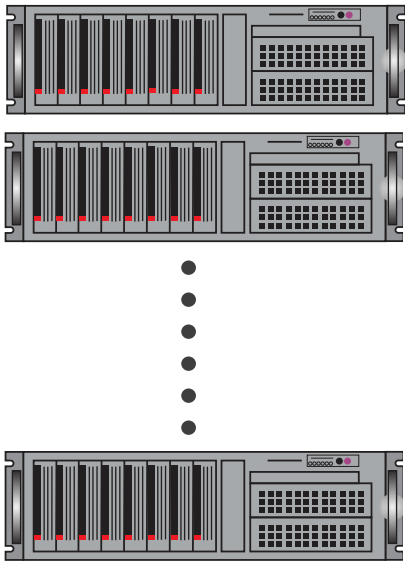
Scope

- DAQ Servers
  - 36 servers
  - ~ 200 kHz of Mu2e events
- Data Logger, DCS Host & Run Control Host
- Data Processing software running on DAQ Servers
  - Based on *art*
- Online data filters and analysis
  - Rejection of ~100

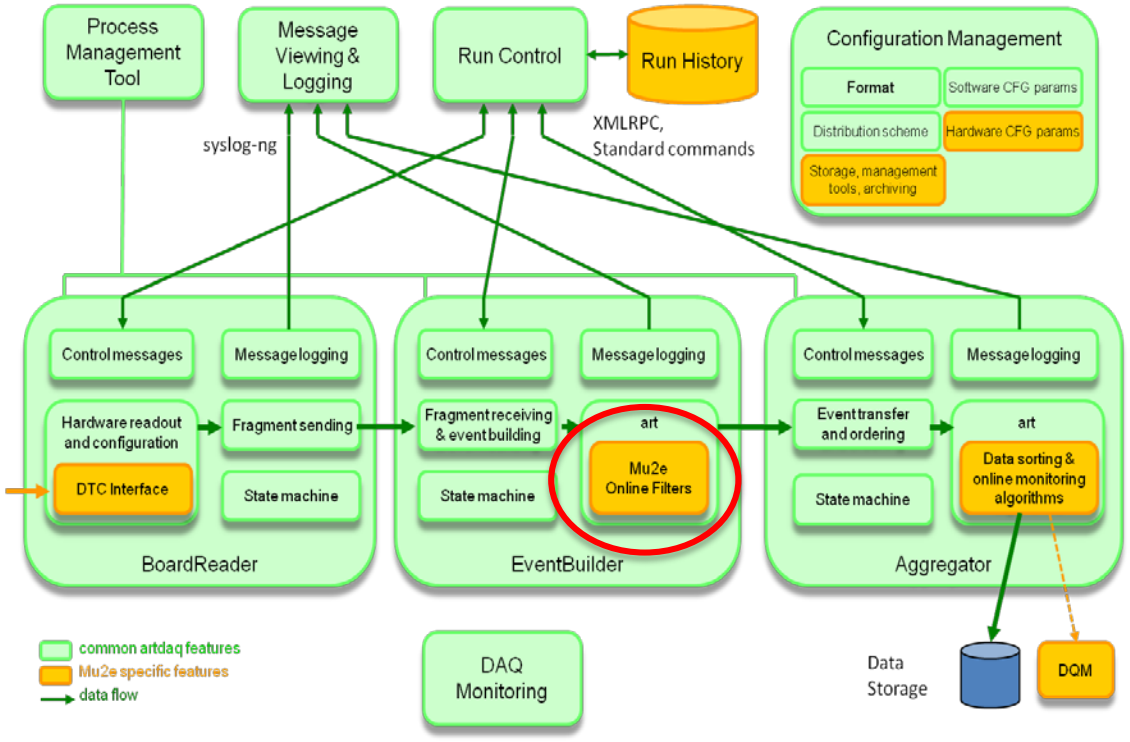


Design

- Commodity computers running *artdaq* and *art* software.
- Use of same analysis framework (*art*) online and offline has significant advantages. *art* used in many current experiments.



DAQ Servers



Performance – Data Processing Benchmark

Several algorithmic and compiler optimizations were applied to the reference Tracking filter to achieve a speedup of almost 30X. Target is 200K per second.

	XEON E5-2687v2	XEON PHI 5510P
Stereo Hits		
0) reference code (gcc compiler)	83.6 msec	-
1) algorithmic improvements (gcc compiler)	4.3 msec	-
2) Intel compiler, loop vectorization	1.4 msec	4.8 msec
Background Hits		
0) reference code (gcc compiler)	9.0 msec	-
1) Intel compiler	5.1 msec	123.0 msec
2) refactoring	3.4 msec	38.1 msec
3) double → single precision	2.1 msec	23.9 msec
Overhead		
0) reference code (gcc compiler)	0.9 msec	-
1) Intel compiler (estimated)	0.3 msec	2.0 msec
total processing time	3.8 msec	30.7 msec
events/sec (single core)	260	32
number of cores (36 servers)	720	4,320
events/sec (36 servers)	187,000	138,000

DAQ Design Review and Status

- A DAQ Design Review was held on Jan 26, 2016
  - Committee included engineers and physicists/DAQ SW experts
- Committee answered yes to all charge questions.
- Design is 90% complete.
- Primary risk to DAQ is an underestimation of detector rates
  - DAQ has been designed to be flexible, scalable and with significant headroom to mitigate this risk.
- Final report is in mu2e-docdb 6377
  - This includes the recommendations from the committee and our responses.

Design Review Recommendations

Recommendations related to Data Processing:

- The committee recommends that TDAQ implement an automatic shutdown in the event of a building or life safety alarm.
  - All TDAQ electronics are located in racks in the DAQ room with rack monitoring that can shut off the power to the racks, and thus shutdown TDAQ. The rack monitoring also will have IPMI controls of the servers for gentle shutdowns.
- Recommended the writing of a plan for commissioning of the TDAQ.
  - A starting point for such a commissioning is documented in Mu2e - docdb #6377, the Final Design Report, in sections 1.5 and 1.6. As a result of this recommendation we will pursue writing a more complete commissioning plan for TDAQ.
- Suggested that such a plan should include testing of the 1/6 scale system using emulated input to ROCs, to provide a through measurement of the bandwidth capacity of the system.
  - The TDAQ Pilot system is a 1/6 scale system and we are actively working to understand bandwidth capacity at all relevant bottlenecks in the system.

Design Review Recommendations (con't)

- Recommended that the bandwidth requirement be clarified.
  - We are actively working to clarify this requirement and maintaining Mu2e-docdb #1150 in the process.
- Recommended choosing between hardware and software event building.
  - We have evaluated the development cost and determined the best course of action is to proceed with the Firmware-based event building and level-0 filtering algorithm as the baseline design. A change request has been submitted and will be considered for BCR 29.
- The 1/6th scale scaling test/stress test described above should be a top priority and finished prior to the CD3c review.
  - We are on track to finish the Pilot system stress testing in advance of the construction readiness review.

Status

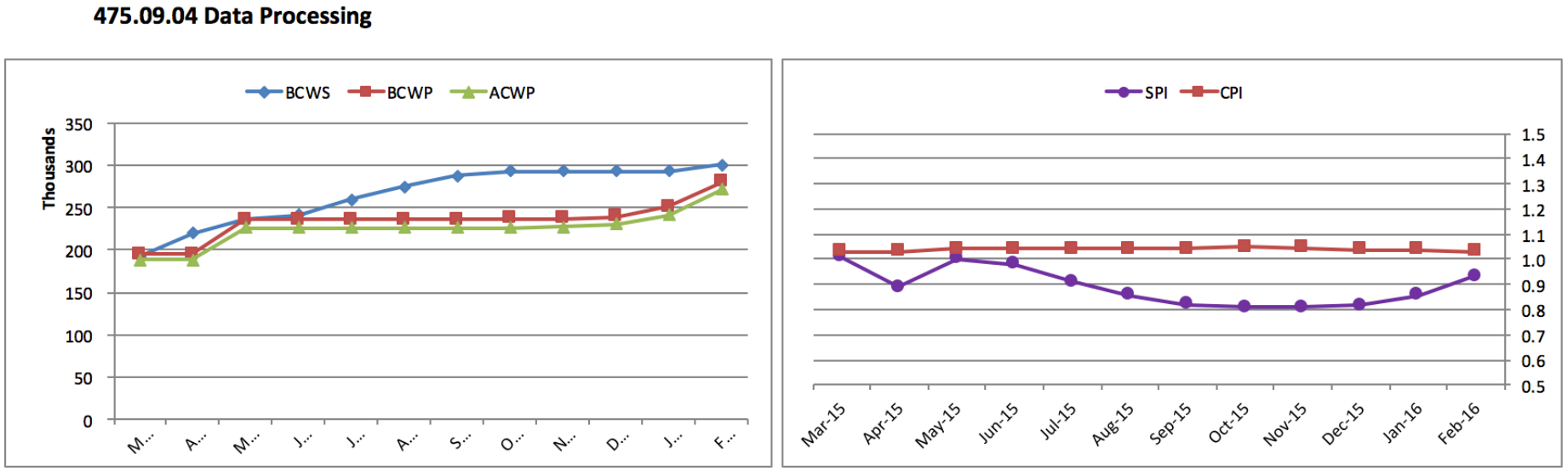
- Pilot system capable of delivering 60 kHz of simulated Mu2e events to processor nodes in playback mode (working toward ~200 kHz).
- Raw data formats are quite mature.
- Work is ongoing to obtain simulated data and simulation algorithms from physics groups to create realistic simulated data for playback.
- With this, reconstruction and filtering algorithms can be tested on the Pilot system to measure performance and look for opportunities for improvement. (Of course, some of this can be done in offline *art* jobs.)

Quality

- Data Processing is included in Mu2e Quality Planning Document (DocDB 6005).

Deliverable	QA or QC Step?	QA or QC Process Documentation (DocDB #)	Inspection or Acceptance Criteria/Plan	Verification
Data Processing Computer Hardware	Acceptance tests, burn-in tests	Meet or exceed manufacturer's specifications	Incoming inspection, basic power-up functional test	72 hour continuous burn-in test (standard processor and memory pattern test software)
Data Processing Data Logging Software	Test with pattern and simulated data	Final Design Report Chapter DocDB #6377	NA	Incremental release testing
Data Processing Monitoring Software	Test with pattern and simulated data	Final Design Report Chapter DocDB #6377	NA	Incremental release testing
Data Processing Event Data Handling Software	Test with pattern and simulated data	Final Design Report Chapter DocDB #6377	NA	Incremental release testing
Subsystem Equipment that will be meet the Mu2e Requirements as specified in docDB ####	Follow the Integration guidance as specified by the Integration Teams in the Mu2e Grounding Plan, the Mu2e Radiation Testing Plan, the Mu2e Electronics Reliability Testing Plan. Mechanical and Electrical documentation and drawings will be controlled.	Mu2e Grounding Plan (docDB ####), Mu2e Electronics Testing Plan (docDB ####), and Mu2e Electronics Reliability Testing Plan (docDB ####).	Testing will follow Mu2e Integration Team guidelines.	Design satisfy specs before Construction Readiness Review.

Cost and Schedule Performance



- No significant variances.
- Small schedule variance is being reduced as we focus on Data Processing tasks now.

Cost and Schedule Performance

Report: **Mu2e_Earned Value** - Project Stoplight metrics - Control Account

Project: **Mu2e** - Mu2e Project
Status Date: 02/29/2016

Mu2e Project
February 29, 2016
Currency in: $K

	Current Period							Cumulative to Date						
Control Account, Work Package.CTC	**Budget**	**Earned**	**Actuals**	**SV ($)**	**SV (%)**	**CV ($)**	**CV (%)**	**Budget**	**Earned**	**Actuals**	**SV ($)**	**SV (%)**	**CV ($)**	**CV (%)**
475.09.04 Data Processing	8	29	30	21	272%	-1	-3%	300	280	271	-21	-7%	8	3%
475.495 475.09.04.01 Data Processing Prototype (PED)	0	0	0	0	0%	0	0%	146	146	146	0	0%	0	0%
475.496 475.09.04.02 Data Processing Pilot System (Line Item: PED)	8	29	30	21	272%	-1	-3%	154	134	125	-21	-13%	8	6%
475.497 475.09.04.03 Data Processing Production System (Line Item: Con	0	0	0	0	0%	0	0%	0	0	0	0	0%	0	0%

Control Account, Work Package.CTC	BAC	EAC	VAC	% Spent	% Complete
475.09.04 Data Processing	874	866	8	31%	32%
475.495 475.09.04.01 Data Processing Prototype (PED)	146	146	0	100%	100%
475.496 475.09.04.02 Data Processing Pilot System (Line Item: PED)	225	216	9	58%	59%
475.497 475.09.04.03 Data Processing Production System (Line Item: Con	503	504	-1	0%	0%

- No significant variances.
- Slightly behind schedule – this will catch up over the next few months.

Change Control

Control Account	CR #	CR Description	Prior Start	Revised Start	Prior Finish	Revised Finish	Values BAC Before	Values BAC After	Cost Increase / (Decrease)
475.09.04	2	Establish internal baseline and incorporate recommendations from Director's Review.	-	-	-	-	855,950.49	858,044.54	2,094.05
	6	Corrections made to CR002	-	-	-	-	858,044.54	858,044.69	0.15
	3	New rate adjustments for labor fringe and overhead.	-	-	-	-	858,044.69	858,025.01	-19.68
	4	Cost leveling; new CD-3c strategy	-	-	-	-	858,025.01	860,114.69	2,089.68
	8	FY15 Rate changes	-	-	-	-	860,114.69	882,974.70	22,860.01
	12	Solenoids PS and DS Contract terms and Accelerator design reviews	**3/1/13**	3/1/13	**1/21/20**	4/28/20	882,974.70	885,360.04	2,385.34
	15	Establish CD-2 Baseline	**3/1/13**	3/1/13	**4/28/20**	6/29/20	885,360.04	889,122.96	3,762.91
	17	PS/DS Vendor Pay Milestones; Remote Handling Design	**3/1/13**	3/1/13	**6/29/20**	6/29/20	889,122.96	889,306.03	183.07
	18	Detector Bldg Constr Change Order; Argonne Support	**3/1/13**	3/1/13	**6/29/20**	6/9/20	889,306.03	889,004.60	-301.43
	19	Reduced Constr oversight, FFP ECPs, and TS Module fab delay	**3/1/13**	3/1/13	**6/9/20**	6/9/20	889,004.60	889,004.60	0.00
	21	Test Cryostat mods; Upstream pbar window transfer; CRV staff change	**3/1/13**	3/1/13	**6/9/20**	6/24/20	889,004.60	889,330.16	325.57
	22	Detector Bldg. changes; Award TS Module fab; Test Cryostat mods and move	**3/1/13**	3/1/13	**6/24/20**	6/30/20	889,330.16	889,478.99	148.83
	24	FY16 Rate Update	**3/1/13**	3/1/13	**6/30/20**	6/30/20	889,478.99	870,283.51	-19,195.49
	27	Constr. Changes, CD3 Review Prep	**3/1/13**	3/1/13	**6/30/20**	6/30/20	870,283.51	873,939.14	3,655.63
	28	Increase Project Office Support, Constr Rev 13, Racks & Rack Monitor	**3/1/13**	3/1/13	**6/30/20**	7/9/20	873,939.14	874,196.49	257.35
475.09.04 Total							**13,137,984.14**	**13,156,230.14**	**18,246.00**

- Additional M&S for disk storage was added in BCR27.
- The remaining changes were a consequence of changes in schedules and labor rates outside of TDAQ.

TDAQ Interfaces

- Internal and external interfaces identified and described in DAQ Interface document (docdb #1520).
- Internal interfaces between servers, timing system and general-purpose networking.
- External interfaces such as power and cooling needs and the network connection to offline storage.
- Participation in Electronics and Detector integration meetings.

Interfaces are understood and under control

Integration

- Discussions at the bi-weekly TDAQ meetings, and dedicated discussions as needed. Examples:
  - Communication and clarification of CRV triggering needs and supported modes in TDAQ.
  - Discussions of beam-off calibrations (laser flasher, radioactive source, etc.)
- Coordination with physics/simulation groups to get simulated data for testing.
- Recent appointment of Bertrand as Trigger Coordinator.
- Expect coordination with physics groups as we start to benchmark performance of candidate algorithms.

Environmental, Safety, & Health

- ESH is integrated into all phases of the Project
  - Design, Construction, Installation
- ESH requirements are clearly defined within the Project
  - FESHM, FRCM
- L2 hazards & mitigations are captured in the Project HAR
  - High voltage (208 VAC, no exposed connections)
  - Electronic racks
  - Class 1 lasers (eye safe)
- Design & installation review process includes an ESH component
- Utilize Fermilab's work planning requirements & processes
  - Hazard analysis

Summary

- The TDAQ Data Processing design is 90% complete. The risks associated with the remaining design are understood and will be tested in the Pilot system.
  - Simulated Mu2e events will be used in “playback” mode in the Pilot system to refine and validate candidate reconstruction and filtering algorithms.
  - Interfaces, risks, ES&H issues identified and under control.
  - QA/QC plans in place.
- Current design **meets** TDAQ requirements.
- TDAQ Data Processing is ready for CD-3 approval.